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Interaction of Sodium Sulphate with Saccharide (Sucrose) Solution: A Thermo-Acoustical Approach

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ABSTRACT

Measurement ultrasonic velocity (U) and density (ρ) of different compositions (0.001-0.1mol/kg) of the sodium sulphate has been carried out by usingdigital ultrasonic interferometer operated at 2 MHz. in the solution of (0.2 and 0.5 mol/kg) of aqueous sucrose as function of temperature. The different acoustical and volumetrical parameters have been calculated from the data of ultrasonic velocity and density. This kind of information data provides the information requirely the different properties (like mechanical, thermal and elastic) of the liquid system in view from number of aspect.

KEYWORDS: Acoustical parameters, density, distilled water, ultrasonic velocity and sodium sulphate.

INTRODUCTION

To study the liquid state the ultrasonic velocity measurements provides a tool. The molecular interaction in pure liquid and its various composition and mixture with other liquid are study with help of ultrasonic characterization.[1] As ultrasonic speed along with density make available for use wealth of information regarding nature and strength of molecular interaction exit in the liquid and liquid mixture. The evidence delivers about kind of interaction prevailing in the liquid mixture which computed in utilizing density and ultrasonic speed data numerous mechanical, thermal and elastic parameters such as bulk modulus, internal pressure, surface tension, thermal conductivity, isothermal compressibility.[2] Ultrasonic sound refers to instantaneous sound pressure with a high frequency than human audible sound frequency (20 Hz to 20 KHz). Different acoustical parameter which calculating from thevalues determined by the ultrasonic velocity and density. [3] More application gives in distinguish thermodynamic and physiochemical behavior of liquid mixture by non-destructive techniques resourceful or all around.[4]

Sodium sulphate is the inorganic compound with formula Na_2SO_4. All form are white solid that are highly soluble in water. Its molecular weightis 142.04 g/mol sodium sulphate in the anhydrous. [5] For the mixture, Sucrose is a disaccharide and is a sugar composed of glucose andfructose of sucrose $C_{12}H_{22}O_{11}$ and its molecular weight 342.30g/mol. It is also soluble in water just used to Na_2SO_4. Sucrose is extracted and refined from either sugarcane or sugar bat for human consumption. Thus, the interaction of these two compound plays a vital role in human body and helps the pharmaceutical industries, to make some more effective drugs related to their (Sucrose + Na_2SO_4) application.

MATERIAL AND METHOD

In the present work, we have used analytical reagent (AR) grade with 99% purity of Sucrose {[CAS No- 57-50-14] [molecular wt. – 342.3 g/mol]} used as solute, Sodium Sulphate with 99% purity of {[CAS No-7757-82-6][molecular wt-142.04 g/mol]} and fresh distilled water having [molecular wt. 18.01528 g/mol with density – 1000 kg/m^3] used as a pure universal solvent and this work was done at different temperatures (i.e.283.15K, 288.15K, 293.15K and 298.15K) and different concentrations.

1. This experiment was carried out at different temperatures which were maintained constant by a digital water bath.
2. The measurement of weight was done by using a digital weighing machine having an accuracy of ±0.1mg.
3. Ultrasonic velocity was measured with the help of digital ultrasonic velocity interferometer with a 2MHz frequency having an accuracy of 0.1%.
4. The density of this solution was accurately determined by using a 10ml specific gravity density bottle.
5. Using the measured data, other acoustical parameters have been calculated usingcstandard relation.

DEFINING RELATION

1. **Surface Tension (σ):** Surface tension [6] is the tendency of liquid surface at rest to shrink intothe minimum surface area possible.
   $\sigma = (6.3*10^{-4})dC^{3/2}$
2. **Internal Pressure (πi):** Internal Pressure [7] is a significant parameter which is used to understand structure and nature of intermolecular interaction in the liquid molecules.
   $\Pi i = \{ T*\alpha/kT\}$
3. **Isothermal Compressibility (k_T):** Isothermal compressibility is used to determined the compressible properties of water supply.
   a. Mc' Gowan Method [8] $k_{T1} = 1.33*10^{-8}/(6.4*10^{-4}C^{3/2}d)^{3/2}$
   b. Pandey et al. Method [9] $k_{T2}= 17.1*10^{4}/(T^{4/9}C^{2}d^{1/3})$
4. **Bulk Modulus (k):** Bulk modulus[10] is the reciprocal of adiabatic compressibility, it is used tomeasure the ability of substance.
   $k = 1/\beta$
5. **Thermal Conductivity (k):** Thermal conductivity [11] is refer to the ability of material or substanceto conduct or transfer heat.
   $k = \{ 3.0*(dNA/M)^{2/3}k_BC\}$

RESULT AND DISCUSSION

The obtained variation of experimentally determined values of ultrasonic velocity, density and other calculated parameter of sodium sulphate at different temperature and concentration as shown in fig.1-8.

Ultrasonic velocity is most important parameter that gives information concerning the nature of molecular interaction and is affected by concentration and temperature. The ultrasonic velocity of the system with increases with the increasing temperature as well as concentration. Shown in fig.1. This represent the association in the molecule of solute and solvent, due to dipole-dipole, ion-dipole interaction.[12] As shown in fig.2 density of aqueous sucrose has been measured at different temperature. By increasing pressure on material can increase the density while increasing temperature result in decrease in density of material. The density(ρ) of sodium sulphate in aqueous sucrose solution increases with increase in concentration due to elaboration in compactness or structure of solvent by the addition of solute molecules in the solution. This shows association occur between solute and solvent molecule. The increase in density result increase in molar volume indicates the association in the components of the constituents molecules and contracts the structural rearrangement.[13]

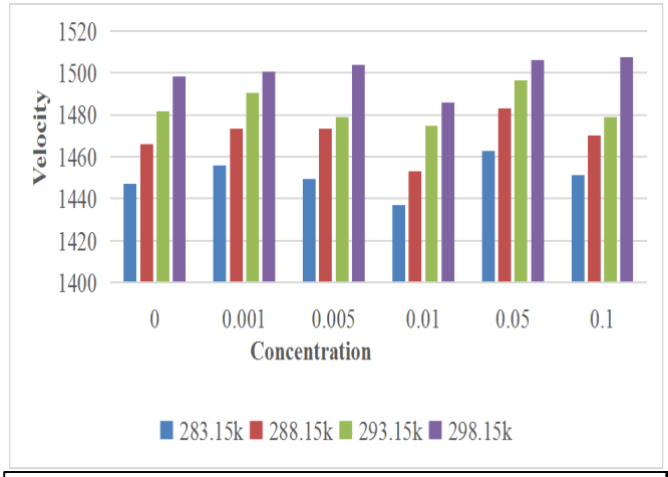

Fig.1 Variation of ultrasonic velocity with concentration and temperature

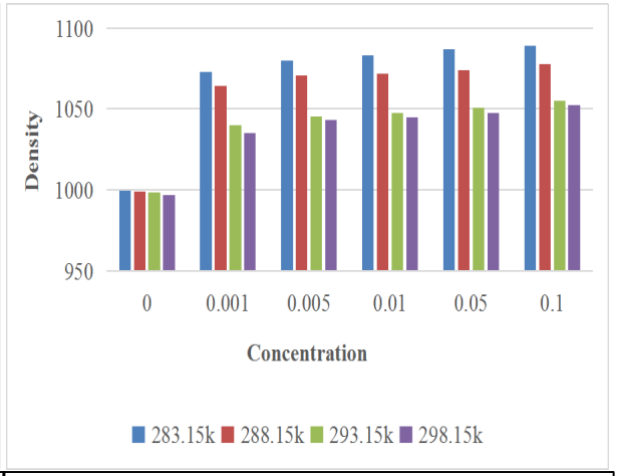

Fig.2 Variation of density with concentration and temperature

Surface tension is used to study the surface composition of aqueous solution of the mixture. Addition of solute increases the surface tension of solution. The increasing trend ofsurface tension is graphically represented in fig.3 with different concentration but at 0.01 concentration, the surface tension is slightly decreases. The solute confirms migration of constituent molecules and strong interaction in the system. From fig.4, in the present system the internal pressure (πi) increases in concentration at various temperatures. This behavior of the solution indicates intermolecular space decreases with addition sodium sulphate in sucrose solutions and interaction increases which supports the association among the constituent molecules of the solute and solvent.[13]

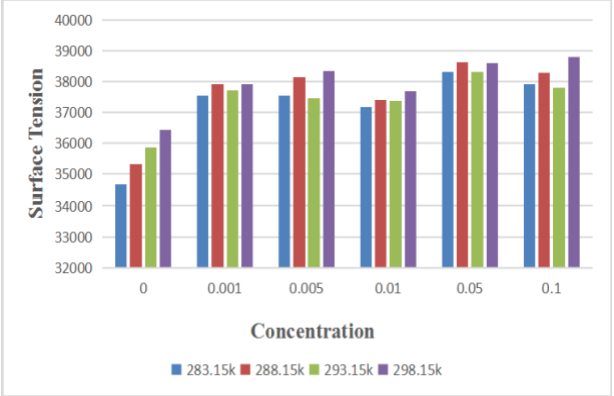

Fig.3 Variation of Surface tension with concentration and temperature

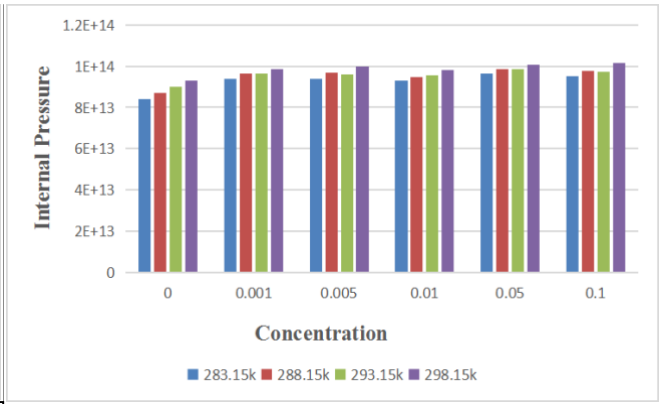

Fig.4 Variation of Internal Pressure with concentration and temperature

The bulk modulus of sodium sulphate in aqueous sucrose solution increases with increase in concentration and temperature as shown in fig.5 which observed that the hydrogen bonding between the unlike components in the solution increases.[14] By observing graph ofthermal conductivity as shown in fig.6 of water is increases with increase in temperature. As compare to the concentration it is observed that the thermal conductivity slightly increases with concentration and temperature. It is clear that the energy is flow when the molecules are close to each other. This means in the given system intermolecular interaction takes place.[15]

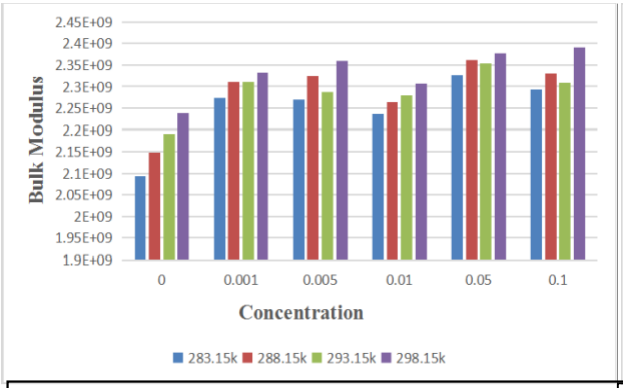

Fig.5 Variation of Bulk modulus with concentration and temperature

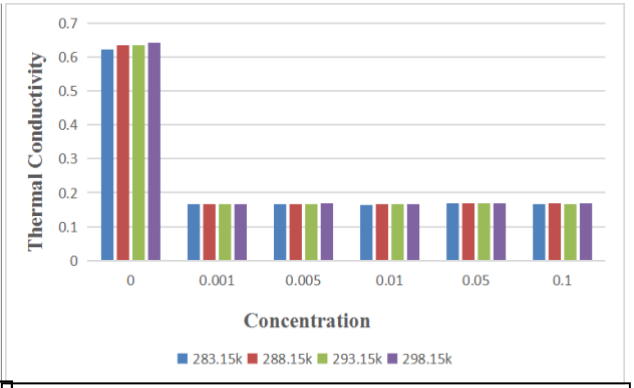

Fig.6 Variation of Thermal conductivity with concentration and temperature

The isothermal compressibility are as shown in fig.8. The isothermal compressibility has been found to be decreasing with increase in concentration seems to be the result of corresponding decreases in average kinetic energy and free volume of the constituent solute- solvent molecules in the aqueous sucrose solution.[7]

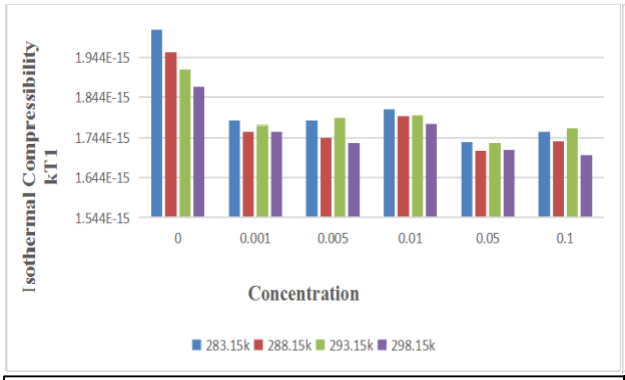

Fig.7. Variation of Isothermal compressibility k_{T1} with concentration and temperature

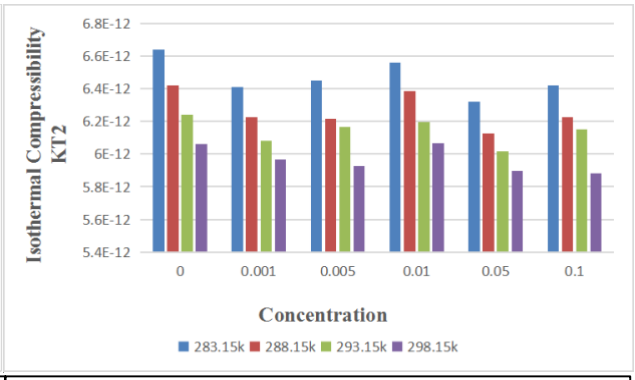

Fig.8. Variation of Isothermal compressibility k_{T2} with concentration and temperature

CONCLUSION

In present work, the solution/mixture of sodium sulphate + water + sucrose (0.2 mol/kg) different property like mechanical, thermal and elastic parameter were calculated from measured data of density and ultrasonic velocity as a function of temperature and concentration. The mechanical property (surface tension and internal pressure) of sodium sulphate confirms that migration of constituent molecules and interaction increases which supports the association among the constituent molecules of the solute and solvent. Elastic property indicates that the hydrogen bonding between the unlike components in the solution increases. Thermal property is concluded that the energy is flow when the molecules are close to each other. This means in the given system intermolecular interaction take place.

Thus, the interaction of these solute and solvent (sodium sulphate and sucrose) plays a vital role in human body and helps the pharmaceutical industries, to make some more effective drugs related to their (Sucrose + Na_2SO_4) application.

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