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Behaviour of nanomaterials in water using ultrasonic interferometer

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Abstract

Liquid state study of nanomaterials-water binary mixture is carried out by using Ultrasonic interferometer and their data's are correlated using Concentration, Density, Ultrasonic velocity, Acoustic Impedance, Free length, Adiabatic compressibility and Relaxation time. The data's explained the molecular interaction of nanomaterial -water molecule system.

Keywords

Concentration, Density, Ultrasonic velocity, Acoustic Impedance, Free length, Adiabatic compressibility and Relaxation time.

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Contents

1. Introduction

Ultrasonic studies are used to information about nature and strength of molecular interactions of electrolytic solutions in liquid state. Ultrasonic velocity measurement had been adequately employed to understand the nature of the molecular interaction in binary mixture [1-6] and ionic interaction in electrolytic solution [7]. Measurement of ultrasonic velocity and other acoustical properties can be related to physic - chemical behavior and molecular interaction [8-15] in a number of binary systems. The investigations are carried out on the nanomaterial -water system by ultrasonic method [16-18]. The investigation and ultrasonic studies on water system at 35^oC was carried. The acoustic parameters have been calculated for these two binary mixtures at different concentration of nanomaterials-water solution.

2. Experimental

Nanomaterials (AR grade) and water (De-Ionized) are used. Nanomaterials were dissolved in water of various ratio's to prepare different concentration 0.2M, 0.4M, 0.6M, 0.8M, and 1M [19-21]. The ultrasonic velocity (U) had been measured using ultrasonic interferometer (Model F81) supplied by Mittal Enterprises, New Delhi operating frequency of 2 MHz with accuracy of + 0.1%. The viscosities (η) of pure compounds and their binary mixture were determined using Oswald viscometer by calibrating with de-ionised water. The densities (ρ) of nanomaterials and water were measure accurately using 10ml specific gravity bottle in an digital balance precisely and the accuracy in weighing is + 0.01 mg. The temperature of the pure solution and the binary mixture were maintained at 35^oC with + 0.1^oC accuracy using a thermostat. The acoustical parameters were calculated from U, ρ, and η [22- 26] using following relation.

2.1 Adiabatic Compressibility (β)

The structural changes of the molecules in the mixture take place due to existence of electrostatic field between interacting molecules.

The structural arrangements of molecules results in a considerable changes in a adiabatic compressibility, which can be express as

$$\beta = 1/\ U^2\rho\ Kg^{-1}ms^2$$

Where U is ultrasonic velocities and ρ is density of liquid mixtures.

2.2 Free Length (Lf)

The free length is the distance covered by sound wave between the surfaces of the neighbouring molecules and is related to ultrasonic velocity and density as $L_f = K / (\rho U)^{1/2} m$

2.3 Acoustic Impedance (Z)

The specific acoustic impedance is related to density and ultrasonic velocity.

$$Z=U\rho\ Kgm^{-2}S^{-1}$$

2.4 Relaxation Time.(τ)

Relaxation time and adsorption coefficient are directly correlated. The adsorption of sound wave is the result of time lag between the passing of ultrasonic wave and return of molecular to their equilibrium position. It is computed using the relation $\tau = 4\eta / 3\ \rho U^2$ sec

2.5 Attenuation coefficient (α/f^2)

Attenuation coefficient or absorption coefficient is a characteristic parameter of medium and it depended on the external conditions like temperature, pressure and frequency of measurement is given by $(\alpha/f2) = 8\Pi^2\eta/[3\rho U^3].Npm^{-1}s^2$

2.6 Free Volume

The concept of free volume is an extension of the idea that its neighbours enclose each molecule. The free volume is broadly defined as the average volume in which the molecules can move inside the hypothetical cell due to the repulsion of the surrounding molecules.

$$V_f=V(V_g/U)^3$$
$$V_g=(\gamma RT/M)^{3/2}$$

3. Results and discussion

3.1 Concentration and Density

The measured Ultrasonic Velocity (U), Density (ρ) and Viscosity (?) with increase in concentration of nanomaterials with water $35^{\circ}C$ temperatures is given in table-1.The Density of nanomaterials -water system increases with increases in concentration. It is clearly shows the straight line which is proportional to density and given table-1 and shown in graph-1 Ultrasonic velocity, Density, Viscosity increases with increase in concentration of histidine-water system at 35○C. This trend suggests that the dipole-dipole interaction is high at higher concentration of histidine - water binary mixture, and is given in the table-1 and shown in graph-1 to 3. This trend reveals that at higher concentration the molecular interaction between the components is high.

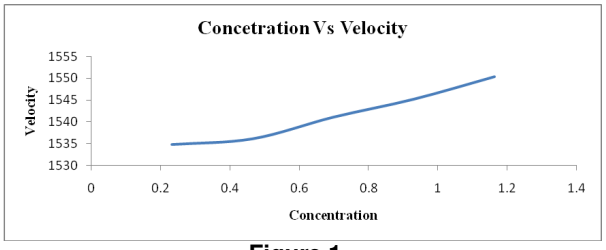

Figure 1.

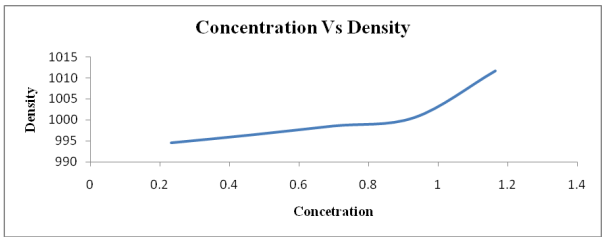

Figure 2.

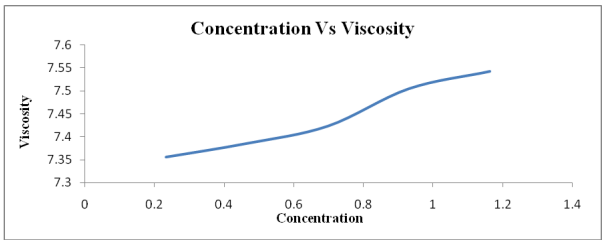

Figure 3.

Table 1.

Concentration	Velocity	Density	Viscosity	Adiabatic Compressibility	Relaxation Time $\tau = 4\eta/(3\rho u^2)$	Specific Acoustic Impedance $(z) = \rho u$	Free length $(L_F) = k(u/rho^{1/2})$	Free Volume $(V_f) = (mu/k)^{3/2}$
0.2327	1534.9	994.6	6.255	4.26768E-10	4.16257E-06	1526612	2.2327	4.15E-07
0.4655	1536.2	996.5	6.385	4.25233E-10	4.17247E-06	1530823	88258.67	4.16E-07
0.6982	1541.1	998.6	6.423	4.21645E-10	4.16732E-06	1538942	87885.49	4.18E-07
0.931	1545.2	1000.6	6.505	4.18572E-10	4.19102E-06	1546127	*87564.65*	4.19E-07
1.1637	1550.3	1011.7	6.543	4.1126E-10	4.18457E-06	1571266	86796.49	4.21E-07

3.2 Adiabatic Compressibility

As the concentration increases from 0.2M to 1.2 M, the adiabatic compressibility decreases since the molecules are closer so the arrangements are compact is given in the table-1 and shown in graph-4.

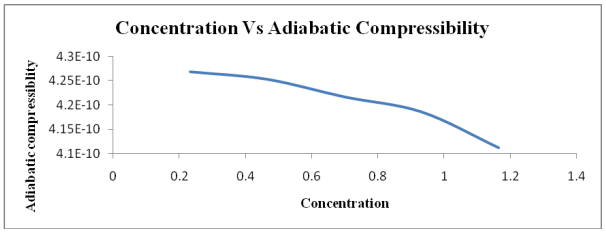

Figure 4.

3.3 Free length

The Free length of a system is a measure of interaction attraction between the components in a binary mixture. This increase in free length indicates the weakening of the intermolecular attraction. The concentration increases from 0.2M to 1.2M, the free length of molecule also decreases which shows dipole-dipole interaction is high at higher concentration., is given in the table-1 and shown in grap-5.

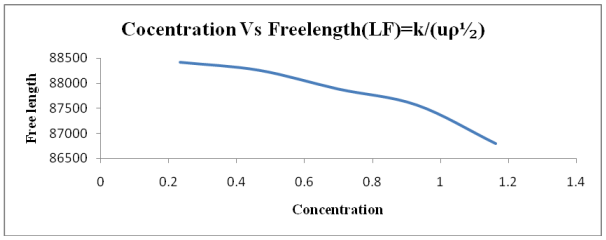

Figure 5.

3.4 Acoustic Impedance

The increase in acoustic impedance with can be explained on the basis of lyophobic interaction between solute and solvent molecule. The plot of acoustic impedance verses concentration is given in the table-1 and graph-6, As the concentration increases from 0.2M to 1.2M, the Specific Acoustic Impedence decreases.

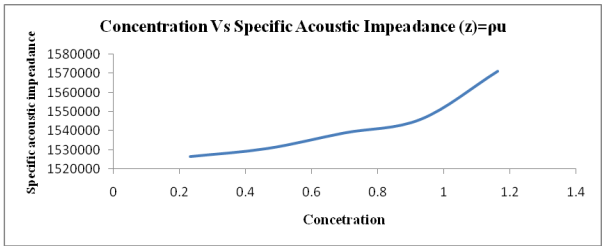

Figure 6.

3.5 Ultrasonic attenuation

As the concentration increases from 0.2M to 1.2M, the Absorption coefficient also increases, which indicates the molecular interaction will be more at lower concentration, is given in the table-1 and shown in graph-7.

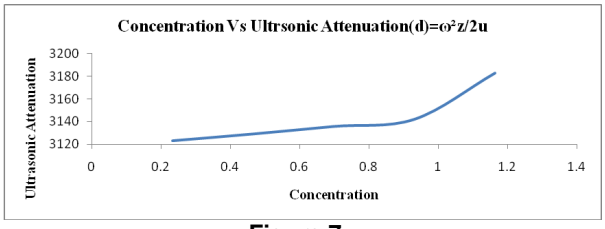

Figure 7.

3.6 Relaxation time

The relaxation times values for two system increases with concentration uniformly from 02M to 0.5M and 0.7M to 1M. This chows that the molecular interaction is strong at lower concentration and relatively weak at higher concentration. But the relaxation time decrease with increasing concentration from 0.5M to 0.7M and 1.0M to 1.2 M. As the concentration increases from .5M to 0.7M and 1.0M to 1.2 M the relaxation time also increases, is given in the table-1 and shown in graph-7.

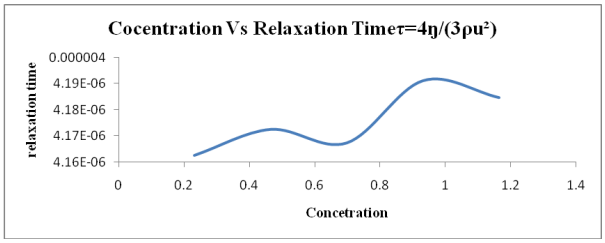

Figure 8.

4. Conclusion

In the present work, it can be explain that there are interaction among the component of the binary mixture, leading to the possible hydrogen oxygen bond formation, between the two components Histidine and water.

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