**Molecular Interaction Study of Polyethylene Glycol with Water**

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**Abstract**

Ultrasonic velocity has been measured of aqueous solution of Polyethylene glycol at 1MHz frequency. Experimental values have been calculated at different concentration and at 45 °C temperature. Different acoustical values have been calculated like adiabatic compressibility, intermolecular free length and relaxation time. These values are used to understand the molecular interaction between solute and solvent.

**Keywords:** Ultrasonic velocity, adiabatic compressibility, intermolecular free length.

1. **Introduction**

For the investigation of structure and molecular interactions in multi component systems, ultrasonic study has become an interesting tool in research in the field of Polymers. Polyethylene glycol is widely used in rubber, textiles, pharmaceuticals and leather industry. Liquid, liquid mixtures and solutions have been found wide applications in the chemicals, textiles, leather and nuclear industries that is very well explained by Acree [1] and Praunitz et al. [2] V K Syal et. al. [3] studied the ultrasonic velocity, viscosity and density of Polyethylene glycols in acetonitrile and water mixture. In recent years the measurements of ultrasonic velocity have been adequately used to study the nature of molecular systems and Physio- chemical behaviour in liquid mixtures. A survey of literature of binary and ternary mixtures [4-7] shows that studies of ultrasonic velocity and adiabatic compressibility are found useful to understand the molecular interaction study of solute and solvent. Acoustical properties of polymer solutions have shown that ultrasonic velocity and its derived parameters provide much information on molecular interactions, that are of utmost importance for processes involving polymer production and their uses [8]. S Kalyanasundaram et. al. [9] studied the ultrasonic study of hydration of Polyethylene glycol using Shio model. Many researchers [10-14] have calculated the ultrasonic parameters for Polyethylene glycol. But for Polyethylene glycol of molecular weight approximately 200, literature available is very few. Therefore, in present investigation Polyethylene glycol of molecular weight 200 is used to elaborate the data.

1. **Experimental Detail**

In present investigation polyethylene glycol (molecular weight ≈ 200 Da) in liquid form is used with water. The solutions were prepared by adding known volume of polyethylene glycol to fixed volume of water stirring under reflex until a clear solution was obtained. The concentration range studied in solution is 1%, 0.8%, 0.6%, 0.5%,0.4% and 0.3% in the temperature45° C at 1 MHz frequency. Ultrasonic velocity is measured by using variable path Ultrasonic interferometer with reproducibility of ± 4 m/s at 30⁰C. The temperature of the solution has been kept constant by circulating water from the electronically operated digital constant temperature with an accuracy of ± 0.1⁰ C) through the outer jacket of the double walled measuring cell containing experimental liquid. The densities at different temperatures were measured using 10 ml specific gravity bottle and single pan micro balance. The uncertainty in density measurements was found to be 0.5 kg/m3. The viscosity of the mixtures was determined by using Ostwald’s viscometer, which was kept inside a double walled jacket, in which water from thermostat water bath was circulated. Inner cylinder of this double wall glass jacket was filled with water of desired temperature so as to establish and maintain the thermal equilibrium. In each measurement the uncertainty was measured to be 0.01MPa.s. The acoustical parameters are calculated by using standard formulae given below [15-17].

1. **Result and Discussion**

In the present work density, viscosity and ultrasonic velocity have been measured at different temperature and concentration of Polyethylene glycol, which is shown in Table 1, 2 and 3 respectively. By using these values for PEG-200 intermolecular free length, relaxation time and adiabatic compressibility have been calculated by using well-known relations and results have been presented in Table 1, 2 and 3 respectively. By using these values for PEG-200, intermolecular free length, relaxation time and adiabatic compressibility have been calculated by well-known relations and results have been presented in Table 4, 5 and 6 respectively. The variation of these parameters with respect to temperature and concentration have been shown in Fig. 1-Fig-6 respectively.

Table -1 and Fig. 1 represents the variation of density with concentration. Density decreases with increase in concentration. It may be due to electro striction in that solution. This electro striction decreases the volume and hence increases the density as a number of solute molecules increases the electrostriction and density. It is evident from Table -2 and Fig.2 that, viscosity decreases with increases concentration of PEG – 200. The variation of ultrasonic velocity with concentration have been shown in Table-3 and Fig.3. Ultrasonic velocity decreases with increase in concentration of PEG. Similar increase in velocity with increase in concentration has also been reported by S K Syal V K et. al.3. This indicates interaction between PEG and solvent molecules. This indicated interactions between contributing molecules. Intermolecular free length is predominant factor as it determines the sound velocity in the condensed and fluid state. The increase in the solute concentration leads to decrease in the gap between two species and this is ideally observed in present work. It is clear from Fig. 4 and Table-4 that intermolecular free length decreases with increase in concentration (Fig 4). It is in similar trend reports by earlier workers [18]. It is clear from Table-5 and Fig5 that adiabatic compressibility increases with increase in temperature and Fig. 5 shows the variation of adiabatic compressibility with concentration. It decreases with increase in concentration. These results are in agreement with earlier workers9. It may be due to that when solute molecules towards themselves by wrenching the molecules from bulk of the solvent, they attract certain solvent due to forces of electro striction because of this available solvent molecule for the next incoming solute gets decreased. Table-6, Fig. 6 show the variation of relaxation time with concentration. Relaxation time increases with increase in concentration. This may be due to kinetic theory of fluid.

1. **Conclusion**

From the above study it is concluded that there is association between polyethylene glycol and water because of interaction between solvent and solute may be responsible for increase in ultrasonic velocity and in turns affects other parameters. It may be because of polymer molecules come close to solvent molecules leaving sufficient space round them. It also shows the nature of Polymer in solvent at different concentration and temperature and to study the molecular interactions. Those in turns are useful for production and uses of polymers in Pharmaceuticals and industry.

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**Table 1: Density (x103Kgm-3) at 45 C and at different concentration at MHz foe PEG**

|  |  |
| --- | --- |
| **Concentration (%)** | **Density** |
| **1.0** | **1.506** |
| **0.8** | **1.321** |
| **0.6** | **0.986** |
| **0.5** | **0.932** |
| **0.4** | **0.971** |
| **0.3** | **0.970** |

**Fig.1: variation of density with concentration at 45C**

**Table 2: Viscosity (Pa.s) at 45 temperature and concentration at 1MHz for PEG**

|  |  |
| --- | --- |
| **Concentration (%)** | **Viscosity** |
| **1.0** | **.045** |
| **0.8** | **0.029** |
| **0.6** | **0.026** |
| **0.5** | **0.018** |
| **0.4** | **0.010** |
| **0.3** | **0.007** |

**Fig.2: variation of viscosity with concentration at 45C**

**Table 3: Ultrasonic velocity (ms-1) at 450C temperature and concentration at 1MHz for PEG**

|  |  |
| --- | --- |
| **Concentration (%)** | **Ultrasonic velocity** |
| **1.0** | **1249.6** |
| **0.8** | **1245.2** |
| **0.6** | **1241.9** |
| **0.5** | **1189.6** |
| **0.4** | **1162.4** |
| **0.3** | **1120.4** |

**Fig.3: variation of ultrasonic velocity with concentration at 45C**

**Table 4: Intermolecular Free Length (x10-10m) at different temperature and concentration at 1MHz for PEG**

|  |  |
| --- | --- |
| **Concentration (%)** | **Intermolecular Free length** |
| **1.0** | **0.0026** |
| **0.8** | **0.0028** |
| **0.6** | **0.0035** |
| **0.5** | **0.0037** |
| **0.4** | **0.0038** |
| **0.3** | **0.0039** |

**Fig.4: variation of intermolecular free length with concentration at 45C**

**Table 5: Adiabatic compressibility(x10-10Kg-1ms2) at different temperature and concentration at 1MHz for PVA**

|  |  |
| --- | --- |
| **Concentration (%)** | **Intermolecular Free length** |
| **1.0** | **4.25** |
| **0.8** | **6.32** |
| **0.6** | **6.45** |
| **0.5** | **6.72** |
| **0.4** | **7.08** |
| **0.3** | **7.75** |

**Fig.5: variation of adiabatic compressibility with concentration at 45C**

**Table 6: Relaxation time (x10-12s) at different temperature and concentration at 1MHz for PVA**

|  |  |
| --- | --- |
| **Concentration (%)** | **Relaxation time** |
| **1.0** | **2.61** |
| **0.8** | **1.78** |
| **0.6** | **1.59** |
| **0.5** | **1.04** |
| **0.4** | **0.97** |
| **0.3** | **0.79** |

**Fig.6: variation of relaxation time with concentration at 45C**