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PHYSIO- CHEMICAL STUDY ON BINARY MIXTURE OF POLYETHYLENE GLYCOL

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Abstract

The molecular interaction of Polyethylene glycol of molecular weight 200 with water has been made at different concentration and at different temperature. Experimental values of density, viscosity, and ultrasonic velocity has been calculated. Various parameters like, adiabatic compressibility acoustic impedance and intermolecular free length have been calculated at different temperatures and at 0.50% concentration. The present study is helpful to understand the physio-chemical behavior of macro molecules with change in temperature.

Introduction

Polyethylene Glycol is a condensation polymer of ethylene and water. Polyethylene glycol has wide range of applications like in preparation of detergents, soaps, pharmaceuticals preparations, metal costing process and cosmetics[1]. Polyethyleneglycol finds enormous use in the fields of microbiology, biochemistry, drug delivery, gas chromatography and pharmaceutical industry[2,3]. Polyethylene glycol has a simple molecular structure and is a very good object for the investigation of structural effects due to the presence of hydrogen and etheric bonds that are capable to form hydrogen bonds with water molecules. Another advantage of this polymer, when, examining the hydration of molecules, is the dependence of its properties upon temperature of water solutions. The ultrasonic studies are extensively used to estimate the thermodynamic properties and predict the intermolecular interactions at binary mixtures. The velocity of sound is one of those physical properties that help in understanding the nature of liquid state.

Using measured values of ultrasonic velocity,density and viscosity, different acoustical parameters can be calculated. Ultrasonic studies in polymeric solution have drawn the attention of many researchers in the recent years[4,5,6]. Kondaiah et al have studied the ultrasonic and volumetric study of aqueous solution of ethylene glycol, propylene glycol in iso-propanol[7]. Ultrasonic studies of molecular interactions in polymer solution of the polyisobutylene and benzene have been studied by Arun Upmanyu et. al. [8] Some of the researchers studied the ultrasonic characteristics of aqueous solution of polyethylene glycol [9,10,11]. Aqueous solutions play a very important role for many geological processes in the various environment, such as geothermal and magmatic hydrothermal settings. The

molecular interaction present in polymer and solvent in a polymer solution system is of great significance for engineering applications of polymers. They also provide substantial information on the processes involving polymer production and their uses [12,13]. Abdul Samad Khan1 4 studied the effect of ultrasonic vibration on structural and physical properties of resin based dental composites. P Babu et. al.[15] recently measured the density and ultrasonic velocity of ternary mixture of water + Iso-Propanol + Pyridine at 303.15 K. In present paper an attempt has been made to understand molecular interaction between Polyethylene glycol and water by calculating different acoustical parameters like acoustic impedance, adiabatic compressibility, intermolecular free length and relaxation time by measured value of ultrasonic velocity, density and viscosity.

Experimental detail

In the present investigation polyethylene glycolof molecular weight approximately (200 Da) in liquid form is used. The solutions were prepared by adding known weight of polyethylene glycol to fixed volume of water and stirring under reflex, until a clear solution was obtained. The concentration studied in the solution is 0.4% (v/v). Different acoustical parameters like, adiabatic compressibility, acoustic impedance and intermolecular free length were calculated at 30^0C, 35^0C, 40^0C, 45^0C, 50^0C, 55^0C, 60^0C and 65^0C temperature and at 0.5% concentration at 1MHz. The ultrasonic speeds were measured by using variable path ultrasonic interferometer with reproducibility of ±0.4m/s at 35°C. The temperature of the solution has been kept constant by circulating water from the thermostatically controlled (±0.1°C) water bath. The densities at different temperature were measured using10 ml specific gravity bottle and single pan microbalance. The uncertainty in density measurements was found to be about 0.5kg/m^3. 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. The accuracy in the viscosity measurements is within ±0.5%. These parameters are calculated by using standard relations[16,17,18].

Table:1 Density(x10^3kg/m^3) of polyethyleneglycol (PEG) at different temperature at 1 MHz frequency

Temperature	Density
30	0.97989
35	0.9696
40	0.9435
45	0.9384
50	0.9257
55	0.9163
60	0.8755
65	0.8644

Table: 2 Viscosity (x10^{-1}Pa.sec) of polyethylene glycol (PEG) at different temperature at 1MHz frequency

Temperature	Viscosity
30	2.68
35	2.56
40	1.84
45	1.51
50	0.982
55	0.895
60	0.862
65	0.823

Table: 3 Ultransonic velocity (m/s) ofpolyethylene glycol (PEG) at different temperature at 1MHz frequency

Temperature	Ultrasonic velocity
30	1598.5
35	1596.4
40	1591.2
45	1588.5
50	1576.6
55	1571.4
60	1570.2
65	1565.2

Table: 4 Adiabatic compressibility (x$10^{-10}$$kg^{-1}$$ms^2$) at different temperature 1MHz for polyethylene glycol (PEG)-

Temperature	Adiabatic compressibility
30	4.105
35	4.132
40	4.215
45	4.301
50	4.402
55	4.452
60	4.566
65	4.687

Table: 5 Acoustic impedance ($x10^3 kgm^2s^{-1}$) atdifferent temperature at 1MHz for polyethylene glycol (PEG)

Temperature	Acoustic impedance
30	1545.6
35	1536.2
40	1498.2
45	1486.2
50	1465.4
55	1434.8
60	1386.6
65	1366.2

Table: 6- Intermolecular Free Length ($x10^{-13}m$) at different temperature at 1MHz forpolyethylene glycol (PEG)

Temperature	Intermolecular free length
30	2.736
35	2.748
40	2.788
45	2.824
50	2.855
55	2.864
60	2.932
65	2.955

Result and Discussion

The solution property parameters namely, density, viscosity and ultrasonic velocity, adiabatic compressibility, acoustic impedance and intermolecular free length for aqueous solution of Polyethylene glycol at 30^0C, 35^0C, Table-1 and Fig 1 represent the variation of density of polyethylene glycol with temperature at 0.50% concentration. It is clear from Fig 1that density decreases, with increase in temperature at 0.50% 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, increase the electro striction and density. Present results are in agreement with earlier workers[19]. Viscosity decreases with increase intemperature and at 0.50% concentration of PEG-200(Table 2, Figure 2). It may be due to more frictional force that is developed between thelayers of the solution [20].Ultrasonic velocity decreases with increase intemperature of PEG in the solution (Table 3,Figure 3). Velocity studies show that as the polymer concentration increases a more rigid molecular structure is formed perhaps by bonding between the large polymer molecules.

The variation of ultrasonic velocity in a mixture depends upon increase or decrease of intermolecular freelength after mixing components. On the basis of a model, for sound propagation proposed by Erything and Kincaid[21], ultrasonic velocity should decrease, if theintermolecular free length increase and vice- versa. This is in fact observed in the present investigation. This increase or decrease in value of ultrasonic velocity with composition indicatesinteractions between contributing molecules.This behaviour is in agreement with the behaviorreported by earlier workers[22]. Table 4 and Fig. 4 reports the variation ofadiabatic compressibility with temperature. It is clearly seen that adiabatic compressibility increases with temperature of polyethylene glycol in solution (Table 4 and Fig 4). Similar results are reported by other workers[23]. Variation of acoustic impedance with temperature is shown in (Table 5 and Fig.5) it is seen that it decreases with increase in temperature. These results also support the conclusions drawn from deviation in ultrasonic velocity. Intermolecular free length increases with increase in temperature (Table 6 and Fig.6) this is result of decrease in ultrasonic velocity with increase in temperature.

Conclusion

The ultrasonic technique is a powerful and effective tool for the investigation of polymer solutions. The molecular interactions present in aqueous solution of polyethylene glycol have been investigated by density, viscosity andultrasonic velocities. The result show higher degree of interaction between solute and solvent at higher temperature

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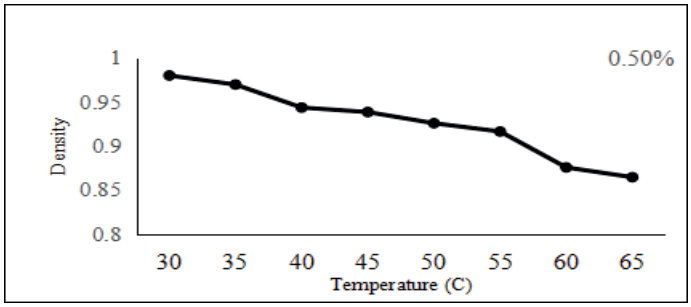

Fig.1: variation of density with temperature

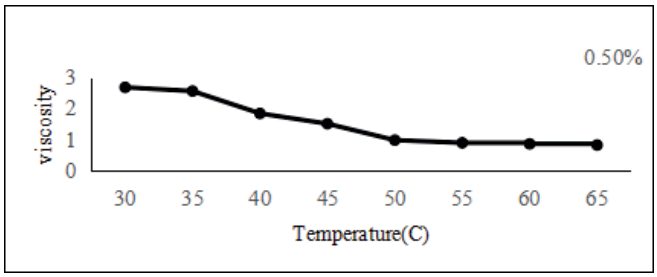

Fig.2: variation of viscosity with temperature

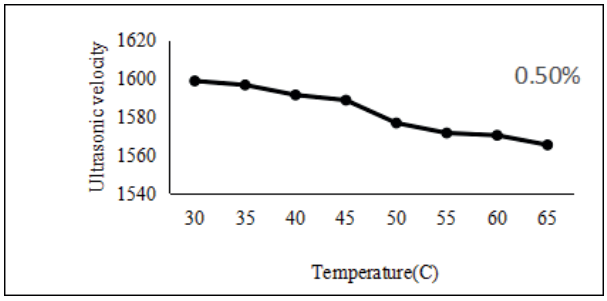

Fig 3: variation of ultrasonic velocity with temperature

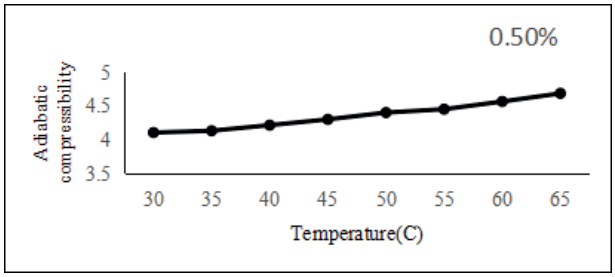

Fig 4: variation of adiabatic compressibility with temperature

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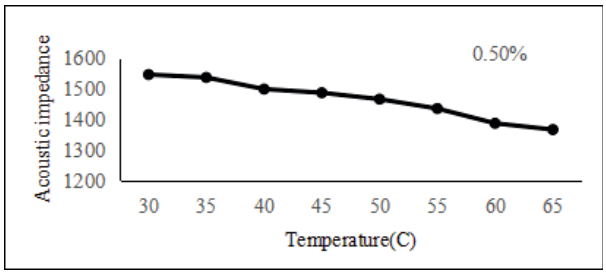

Fig.5: variation of acoustic impedance with temperature

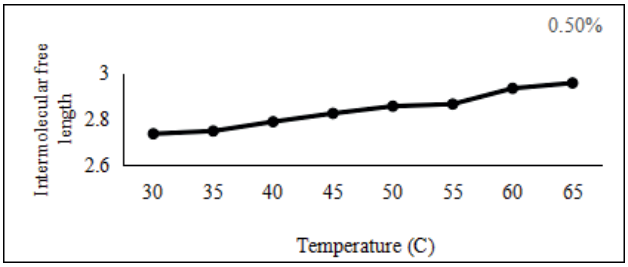

Fig.6: variation of intermolecular free length with temperature