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ULTRASONIC AND VISCOMETRIC INVESTIGATION OF TERNARY LIQUID MIXTURES OF GLYCOLS IN METHANOL SOLUTION OF METHYLPARABEN AT DIFFERENT TEMPERATURES

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Abstract

The different acoustical parameters like acoustic impedance, intermolecular free length, adiabatic compressibility, relaxation time, ultrasonic attenuation and Gibb's free energy of ethylene and propylene glycols in methanol solution of methylparaben have been studied from 20^0 C to 35^0C from the density, speed of sound and viscosity data. The relative viscosity has also been evaluated from the viscosity data at different temperatures and at various concentrations. The viscosity increases with rise in the concentration of glycols and methylparaben and falls with surge in temperature which shows that the interactions within fragments increases with increase in the molar mass of glycols. Graphs for various acoustical parameters against the concentration are plotted and linear variation is found for most of the acoustic parameters which implies the absence of complex formation in ternary system studied. There is decrease in the value of impedance with regard to temperature and increment with respect to concentration. The adiabatic compressibility and intermolecular free length possess the same behaviour as depicted by their formula which is in agreement with experimental results; on the other hand, the acoustic impedance behaves oppositely with respect to adiabatic compressibility and intermolecular free length. The existence of sturdy molecular interaction has been concluded from the various acoustical parameters.

Keywords: Density; speed of sound; viscosity; acoustic impedance; intermolecular free length.

Introduction

The evaluation of molecular interaction (Sharma *et al*., 2018; Sonika *et al*., 2018; Thakur *et al*., 2019) among the polar and non-polar fragments which are existing in the solution mixture have been widely done by employing ultrasonic method (Elangovan *et al*., 2012). The acoustic method has been widely employed to know the nature and properties of associations occurring in the system (Chakraborty *et al*., 2018; Chakraborty *et al*., 2010). The inspection of organic liquids through ultrasonic computation stimulates the scientific and practical interest (Ali, A *et al*., 2005). The volumetric and viscometric (Sharma *et al*., 2018; Parmar *et al*., 2006). properties of liquid mixture give the confirmation to inspect the structural property of liquids (Rawat *et al*., 2008; Ali *et al*., 2008; Oswal *et al*., 2008; Saravanakumar *et al*., 2012; Peralta *et al*., 2002; Naidu *et al*., 2003; Sharma *et al*., 2018; Parmar *et al*., 2006).

The solute and solvent associations lead to the disruption and binding of the structure of fragments in the system (Thakur *et al*., 2015; Thakur *et al*., 2015). he behaviour of molecular interaction and physio-chemical nature in solution mixture has been interpreted with the help of ultrasonic speed computation (Pandey *et al*; Pankaj *et al*., 1991) It helps in depicting the molecular association and dissociation. These are of considerable importance for determining the thermo-acoustical or physico-chemical behavior of liquid mixtures and the respective measurements are used to evaluate the molecular interaction among the liquids (Singh *et al*., 2010) It plays a significant role in understanding the strength and nature of molecular interactions in binary or ternary mixtures. To estimate the different associations in the aqueous and non-aqueous systems, the partial mole volume has been considered as very beneficial instrument (Thakur *et al*., 2014; Thakur *et al*., 2015; Thakur *et al*., 2016Different kind of liquid mixtures show various usual or unusual characteristics which gains substantial attention (Mistry *et al*., 2010; Dikko *et al*., 2015). To estimate the different associations in the aqueous and non-aqueous systems, the partial mole volume has been considered as very beneficial instrument (Thakur *et al*., 2014; Thakur *et al*., 2015)

The investigation of glycols has become the wide area for various scientists (Kaur *et. al*., 2018). PEG is an ethylene oxide and water condensing polymer. In many organic solvents and water, it is soluble (Kaur *et al*., 2018; Kumar *et al*., 2015). In medical science, the waves are being used for medical diagnosis, for detection of cancer tumors, bone fractures and physiotherapy, gynecology, bloodless surgery, cardiology, etc. The thermodynamic (Thakur *et al*., 2015; Saini *et al*., 2015) and ultrasonic studies of molecular interactions are of huge importance in developing theoretical models as well as its application in industry and engineering (Dikko *et al*., 2015) Weak molecular interactions can also be detected by ultrasonic technique. The structural arrangement is influenced by the mutual interactions as well as the shape of the molecules (Gupta *et al*., 2009). The departure from linearity in the acoustical parameter versus concentration in the liquid mixture is considered as the proof of existence of molecular interactions between various species (Deshmukh *et al*., 2014; Dash *et al*., 2014; Dash *et al*., 2013) The compressibility nature of solutes is a very sensitive indicator of molecular interactions and provides useful information (Dash *et al*., 2014) The thermodynamic and speed of sound variable has been utilized to analyze multiple types of connections, movement of fragments, interaction forms and their abilities (Dikko *et al*., 2015; Praharaj *et al*., 2018). Parabens in cosmetics and pharmaceuticals are a class of frequently utilized preservatives. They are chemically the

sequence of parahydroxybenzoates. Parabens are widely applied as preservatives in particular care product, pharmaceuticals, food and beverages (Oishi, 2004; Nunez *et al*., 2010; Oishi, 2008; Kuklenyik Ye *et al*., 2009; Nicoli *et al*., 2008; Sequeira *et al*., 2017; Thakur *et al*., 2020; Thakur *et al*., 2019; Thakur *et al*., 2019). PEGs are utilized as basis in various skin creams (Kaur *et. al*., 2018). Multiple researches has been done on thermo-physical characteristics of glycols and parabens mixtures but no work is done on intermolecular interaction study of ternary mixture of ethylene and propylene glycol with paraben. In the present research the nature of ternary mixtures of glycols in methylparaben methanol solutions has been investigated with the help of density, ultrasonic velocity and viscosity data at different temperatures. The various acoustical parameters are derived from the measured data and hence results are interpreted in terms of molecular interactions in the present studied system. The computed parameters have been indexed in the form of tables (Pathania *et al*., 2015).

Chemicals and Technique

Chemicals

Ethylene glycol and propylene glycol with the molecular mass 62.07 and 76.09 and methyl paraben with molecular mass 152.15 of 99% AR grade has been utilized in the present investigation. All the chemicals were received from Loba chemie Pvt. Ltd. India. The data for density and ultrasonic speed were measured with the help of Anton Paar DSA 5000 M density and sound velocity meter on the other hand the viscosity has been measured by Oswald's viscometer. In order to study the effect of temperature all the viscosity measurements were carried out in water thermostat with an accuracy of ±0.001 K.

The molal concentration has been converted to molar concentration by utilizing following formula:

$$c = m\rho 1000/1000+mM$$

Where m is the molal concentration, c is the molar concentration, ρ is the density of the sample, M is the molar mass of methylparaben.

Methods

The acoustical parameters namely acoustic impedance, intermolecular free length, adiabatic compressibility, relaxation time, ultrasonic attenuation, relative strength, and Gibb's free energy are derived from the following formula:

Acoustic impedance $Z = \rho \times U$

Adiabatic compressibility $\beta = 1/ (U^2 \times \rho)$

Intermolecular free length $Lf = K_B \times \beta^{1/2}$

Where, K_B = Jacobson constant

Ultrasonic Attenuation $\alpha/f^2 = 8\pi^2\eta /3\rho U^3$

Relaxation Time $\tau = 4\beta\eta/3$

Relative strength $r = 1-[U/U_{\infty}]$

Gibb's Free Energy $\Delta G = K_B T \ln (KB T \tau/ h)$

Viscosity measurement

The Oswald's viscometer was employed to find the viscosity of ternary liquid mixtures of PEGs 200 and 600 in aqueous solution of sodium methylparaben at 25^0C by evaluating time of flow through capillary of constant volume of mixture. The stop watch was utilized having the accuracy of 0.1 seconds. The viscosity measurement is done with the help of following expression:

$$\eta_2 = \eta_1 (t_2/t_1) (\rho_2/\rho_1)$$

Where, η_1 = viscosity of water, η_2 = viscosity of experimental solution, ρ_1 = density of water, ρ_2 = density of experimental solution, t_1 = time of flow of water, t_2 = time of flow of experimental solution.

To find the interaction parameters in aqueous solutions the data of viscosity at various concentrations has been employed.

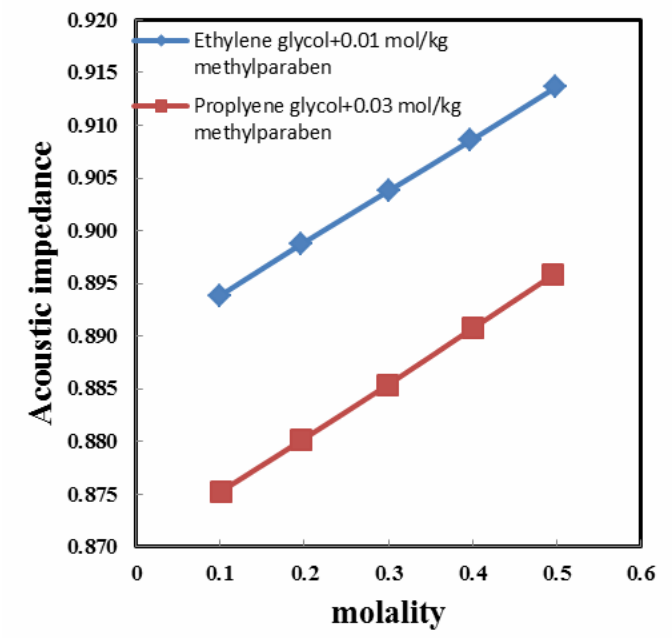
Results and Discussion

The viscosity for ternary mixtures of ethylene glycol and propylene glycol in methanol (0.01 and 0.03) mol.kg^{-1} methyl paraben at different concentrations and at different temperatures are measured with the help of Oswald's viscometer. The data of density and speed of sound of glycols in methanol solution of methylparaben at different temperatures and various concentrations has been taken from our earlier paper (A Thakur *et al*., 2019). From the measured parameters various acoustical parameters such as acoustic impedance, adiabatic compressibility, intermolecular free length, Gibb's free energy, viscosity, relative viscosity, relaxation time and ultrasonic attenuation are computed and are presented in the form of tables. The propagation and reflection of acoustic waves are affected by this significant factor in mixture and fragments of solvent. The data of acoustic impedance at different concentration and different temperatures is indexed in Table 1.

Table 1 : Computed Values of Acoustic impedance (Z) for ternary liquid mixture at different temperatures.

m (mol·kg^{-1})	Impedance (Z) kg m^{-2} s^{-1} × 10^5			
	20^{0}C	25^{0}C	30^{0}C	35^{0}C
Ethylene glycol + 0.01 mol·kg^{-1} methylparaben				
0.09986	0.894	0.875	0.853	0.840
0.19552	0.899	0.880	0.855	0.845
0.30041	0.904	0.885	0.857	0.850
0.39780	0.909	0.890	0.859	0.855
0.49906	0.914	0.895	0.861	0.861
Ethylene glycol + 0.03 mol·kg^{-1} methylparaben				
0.10375	0.897	0.884	0.861	0.844
0.20032	0.902	0.889	0.865	0.849
0.30210	0.907	0.894	0.871	0.854
0.39976	0.912	0.899	0.875	0.859
0.50190	0.917	0.904	0.880	0.864
Propylene glycol + 0.01 mol·kg^{-1} methylparaben				
0.10096	0.894	0.875	0.858	0.840
0.19642	0.899	0.880	0.862	0.845
0.29903	0.904	0.885	0.868	0.850
0.40085	0.909	0.891	0.873	0.856
0.49594	0.914	0.896	0.878	0.861
Propylene glycol + 0.03 mol·kg^{-1} methylparaben				
0.10151	0.897	0.879	0.861	0.842
0.20210	0.902	0.884	0.866	0.847
0.30056	0.907	0.889	0.871	0.852
0.39985	0.912	0.894	0.875	0.859
0.49429	0.917	0.899	0.881	0.865

The value of impedance varies linearly with concentration indicating the occurrence of strong interaction between liquid mixtures inspected. There is decrease in the value of impedance with regard to temperature and increment with respect to concentration. Figure 1 (a) and (b) represents the plot of acoustic impedance with molal concentration of ethylene glycol and propylene glycol at 25^0 C. It has been observed that the value of impedance increases from ethylene glycol to propylene glycol with the concentration indicating that the fragments in propylene glycol are strongly interacted as compared to ethylene glycol. The values of impedance is higher for 0.03 mol/kg methylparaben-methanol solution as compared to 0.01mol/kg methylparaben-methanol solution whuch signifies that the molecules are strongly in interacted in 0.03 mol/kg methylparaben-methanol solution.



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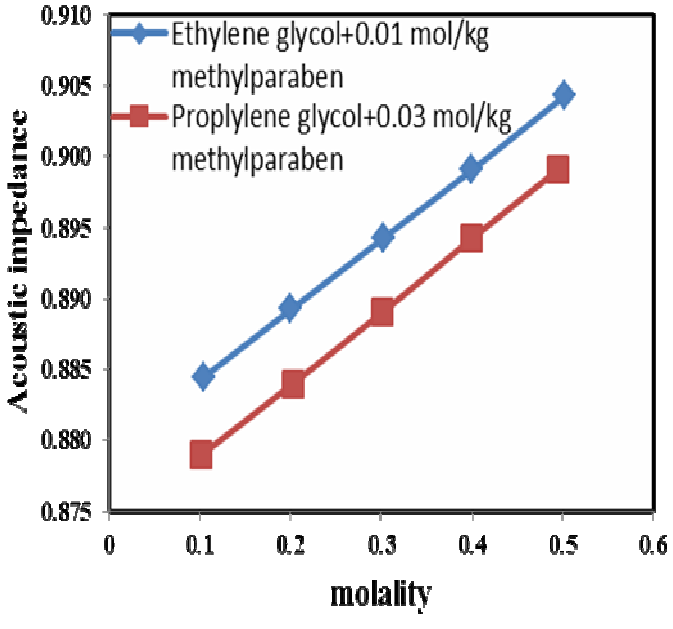


(b)

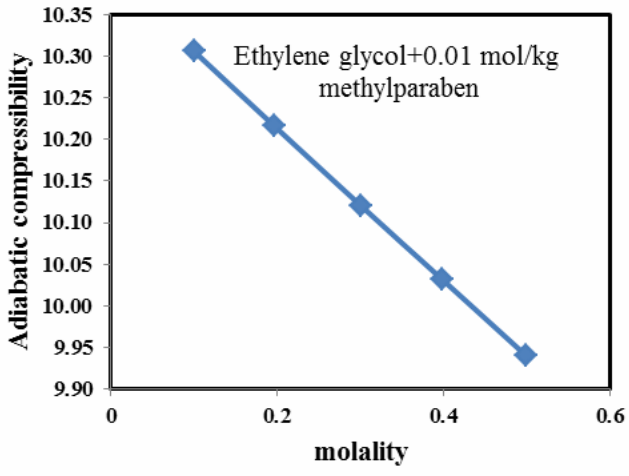
Fig. 1 : Variation of acoustic impedance with molal concentration at 25^0C.

The value of adiabatic compressibility is listed in Table 2 which shows that the value of adiabatic compressibility decreases with rise in the concentration and increases with rise in the temperature.

It indicates that fragments of the investigated solution mixture are tightly bounded with each other. It indicates that the molecules of propylene glycol are tightly bound with each other as compared to ethylene glycol. Hence, adiabatic compressibility is behaving oppositely with respect to ultrasonic speed therefore, supporting the mathematical expression. The value of adiabatic compressibility for 0.01mol/kg methylparaben-methanol solution is more as compared to 0.03 mol/kg methylparaben-methanol solution which implies that molecules of 0.03 mol/kg methylparaben-methanol solution is more tightly bound in comparison to 0.01mol/kg methylparaben-methanol system at differ temperatures. The values of adiabatic compressibility with respect to 0.01 and 0.03 molal concentration at 25^0C temperature are plotted in Figure 2.

Table 2 : Computed Values of Adiabatic compressibility (β) for ternary liquid mixture at different temperatures.

m **(mol·kg^{-1})**	**Adiabatic compressibility (β) N/m^2 × 10^{-7}**			
	20^0C	25^0C	30^0C	35^0C
Ethylene glycol + 0.01 mol·kg^{-1} methylparaben				
0.09986	9.940	10.305	10.781	11.056
0.19552	9.856	10.217	10.757	10.955
0.30041	9.769	10.120	10.730	10.841
0.39780	9.689	10.032	10.704	10.739
0.49906	9.605	9.940	10.678	10.628
Ethylene glycol + 0.03 mol·kg^{-1} methylparaben				
0.10375	9.880	10.171	10.611	10.972
0.20032	9.798	10.085	10.518	10.867
0.30210	9.714	9.996	10.422	10.762
0.39976	9.635	9.911	10.331	10.663
0.50190	9.555	9.821	10.240	10.559
Propylene glycol + 0.01 mol·kg^{-1} methylparaben				
0.10096	9.939	10.299	10.666	11.049
0.19642	9.850	10.209	10.571	10.945
0.29903	9.760	10.113	10.470	10.832
0.40085	9.676	10.016	10.374	10.720
0.49594	9.592	9.926	10.286	10.615
Propylene glycol + 0.03 mol·kg^{-1} methylparaben				
0.10151	9.878	10.229	10.608	10.994
0.20210	9.789	10.137	10.507	10.883
0.30056	9.707	10.045	10.416	10.780
0.39985	9.625	9.954	10.325	10.649
0.49429	9.540	9.869	10.230	10.546



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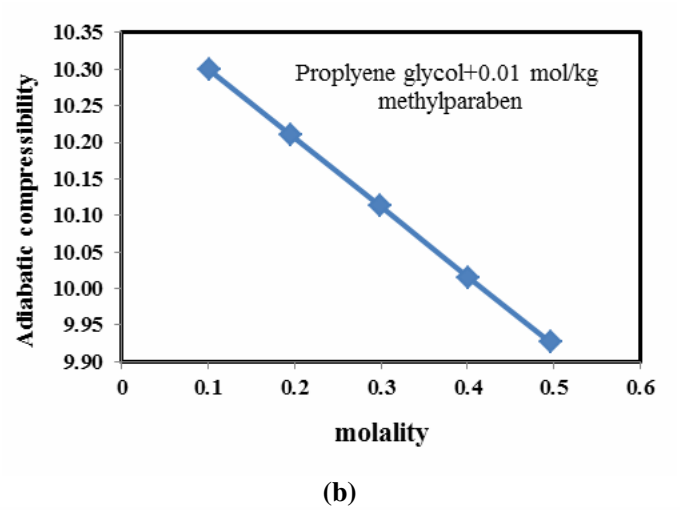

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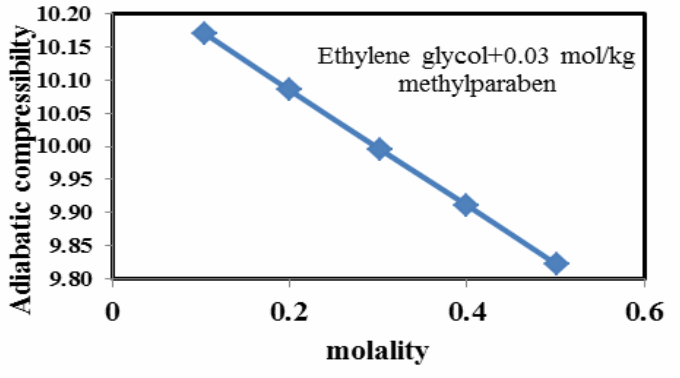

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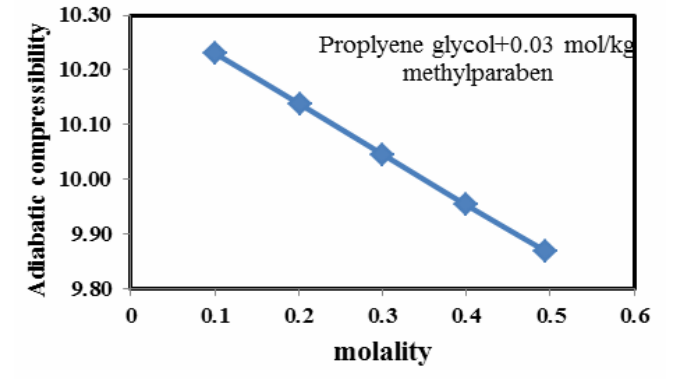

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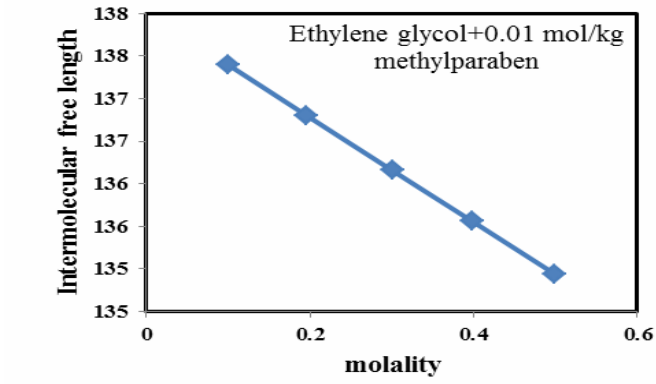
Fig. 2 : Variation of adiabatic compressibility against molality at 25^0 C

The intermolecular free length is helpful in evaluating the interactions occurring in the solution mixture. This factor is dependent of interaction phenomenon and hence, tells about the association strength existing in the liquid mixture (Miecznik P *et al*., 2004; Kharat S J *et al*., 2007). The value of intermolecular free length is listed in Table 3.

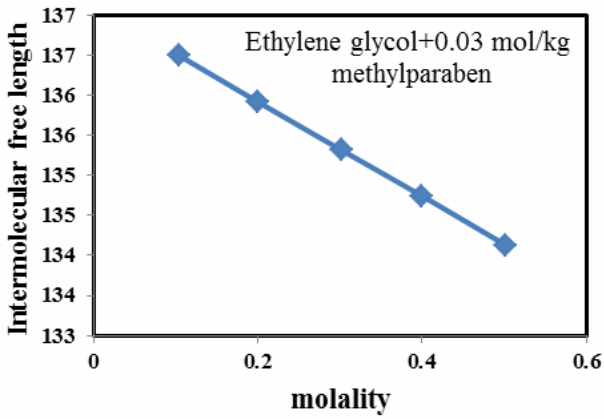
Table 3 : Computed Values of Intermolecular free length (L_f) for ternary liquid mixture at different temperatures.

m (mol·kg^{-1})	Intermolecular free length (L_f) Å x 10^{-10}			
	20^0C	25^0C	30^0C	35^0C
Ethylene glycol + 0.01 mol·kg^{-1} methylparaben				
10.09986	134.9404	137.3970	140.5333	142.3102
0.19552	134.3681	136.8032	140.3756	141.6603
0.30041	133.7730	136.1566	140.1975	140.9245
0.39780	133.2236	135.5615	140.0301	140.2556
0.49906	132.6461	134.9407	139.8576	139.5308
Ethylene glycol + 0.03 mol·kg^{-1} methylparaben				
0.10375	134.5331	136.4996	139.4176	141.7734
0.20032	133.9722	135.9185	138.8047	141.0913
0.30210	133.3958	135.3155	138.1699	140.4085
0.39976	132.8511	134.7452	137.5675	139.7606
0.50190	132.2970	134.1299	136.9595	139.0768
Propylene glycol + 0.01 mol·kg^{-1} methylparaben				
0.10096	134.9308	137.3564	139.7783	142.2687
0.19642	134.3233	136.7557	139.1556	141.5953
0.29903	133.7083	136.1086	138.4890	140.8618
0.40085	133.1371	135.4504	137.8558	140.1365
0.49594	132.5589	134.8470	137.2666	139.4461
Propylene glycol + 0.03 mol·kg^{-1} methylparaben				
0.10151	134.5188	136.8884	139.3989	141.9113
0.20210	133.9112	136.2691	138.7374	141.1976
0.30056	133.3472	135.6529	138.1334	140.5270
0.39985	132.7802	135.0306	137.5303	139.6706
0.49429	132.1974	134.4582	136.8913	138.9922

The intermolecular free length decreases with escalation in concentration of methylparaben and glycols. There is increment in the value of intermolecular free length with temperature. Both adiabatic compressibility and intermolecular free length possess same behaviour as depicted by their formula which is in agreement with experimental results. Figure 3 represents the variation of intermolecular free length with 0.01 and 0.03 molal concentration at 25^0C temperature.



(a)



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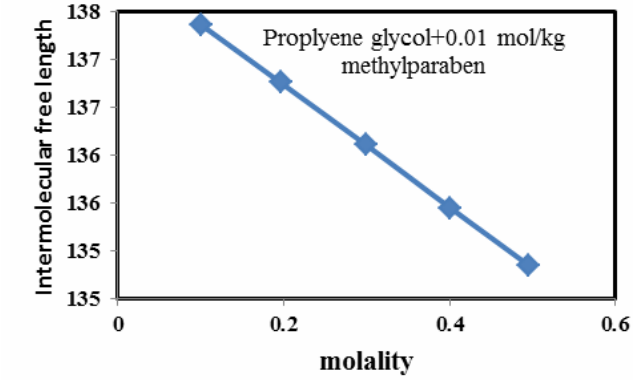

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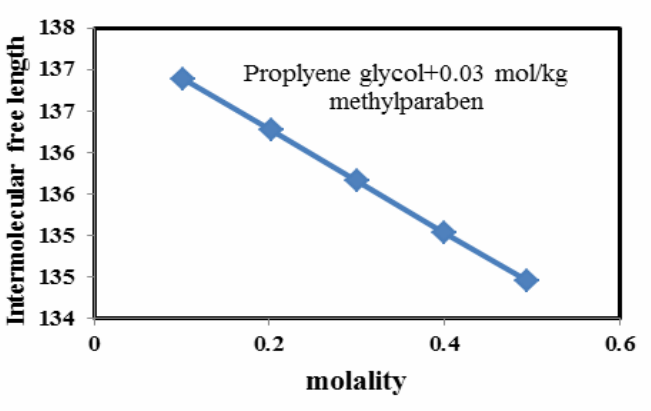

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Fig. 3 : Variation of intermolecular free length with molality at 25^0C.

The value of viscosity is indexed in Table 4. It shows that the values of viscosity surges with surge in the concentration of glycols and methylparaben and decreases with upsurge in temperature. It implies that the interactions among the molecule increases with increase in the molar mass of glycols.

The interaction of molecules is strongly interacted in case of propylene glycol as compared to ethylene glycol. The value of viscosity for propylene in 0.03 molal concentration is higher in comparison to 0.01 molal concentration which indicate the sturdy association among the fragments of molecules for propylene glycol in 0.03 molal concentration as compared to 0.01 molal concentration.

Table 4 : Computed Values of viscosity (η) for ternary liquid mixture at different temperatures

m (mol·kg^{-1})	viscosity (η)			
	20^0C	25^0C	30^0C	35^0C
Ethylene glycol + 0.01 mol·kg^{-1} methylparaben				
0.09986	0.615	0.567	0.536	0.510
0.19552	0.656	0.539	0.562	0.524
0.30041	0.661	0.626	0.589	0.555
0.39780	0.681	0.639	0.616	0.581
0.49906	0.692	0.665	0.643	0.599
Ethylene glycol + 0.03 mol·kg^{-1} methylparaben				
0.10375	0.646	0.587	0.569	0.530
0.20032	0.663	0.626	0.577	0.562
0.30210	0.688	0.653	0.614	0.582
0.39976	0.695	0.659	0.626	0.610
0.50190	0.718	0.679	0.648	0.623
Propylene glycol + 0.01 mol·kg^{-1} methylparaben				
0.10096	0.681	0.614	0.577	0.553
0.19642	0.690	0.639	0.600	0.581
0.29903	0.724	0.667	0.630	0.601
0.40085	0.742	0.694	0.657	0.620
0.49594	0.782	0.721	0.670	0.647
Propylene glycol + 0.03 mol·kg^{-1} methylparaben				
0.10151	0.695	0.643	0.606	0.581
0.20210	0.713	0.661	0.628	0.596
0.30056	0.739	0.696	0.661	0.614
0.39985	0.788	0.719	0.686	0.647
0.49429	0.803	0.733	0.709	0.676

The ultrasonic attenuation and relaxation time relates with intensity loss of acoustic wave when it travels through the mixture. The value of ultrasonic attenuation and relaxation time is enlisted in Table 5 and 6. Table 5 signifies that the values of relaxation time decreases with upsurge in temperature.

Table 5 : Computed Values of Relaxation time (τ) for ternary liquid mixture at different temperatures.

m (mol·kg^{-1})	Relaxation time (τ) s x 10^{-5}			
	20^0C	25^0C	30^0C	35^0C
Ethylene glycol + 0.01 mol·kg^{-1} methylparaben				
0.09986	8.1509	7.7955	7.7060	7.5141
0.19552	8.6163	7.3384	8.0646	7.6603
0.30041	8.6157	8.4513	8.4266	8.0254
0.39780	8.7971	8.5507	8.7918	8.3225
0.49906	8.8655	8.8087	9.1504	8.4856
Ethylene glycol + 0.03 mol·kg^{-1} methylparaben				
0.10375	8.5100	7.9601	8.0508	7.7506
0.20032	8.6640	8.4177	8.0950	8.1428
0.30210	8.9102	8.6981	8.5337	8.3472
0.39976	8.9243	8.7068	8.6291	8.6680
0.50190	9.1459	8.8957	8.8492	8.7679
Propylene glycol + 0.01 mol·kg^{-1} methylparaben				
0.10096	9.0253	8.4374	8.2055	8.1464
0.19642	9.0603	8.7006	8.4501	8.4820
0.29903	9.4151	8.9903	8.8006	8.6826
0.40085	9.5768	9.2677	9.0895	8.8654
0.49594	9.9988	9.5434	9.1899	9.1510
Propylene glycol + 0.03 mol·kg^{-1} methylparaben				
0.10151	9.1529	8.7753	8.5759	8.5097
0.20210	9.3126	8.9377	8.7934	8.6461
0.30056	9.5644	9.3235	9.1753	8.8206
0.39985	10.1133	9.5426	9.4508	9.1814
0.49429	10.2116	9.6449	9.6766	9.5056

Table 6 : Computed Values of Ultrasonic Attenuation (α/f^2) for ternary liquid mixture at different temperatures.

m (mol·kg^{-1})	Ultrasonic Attenuation (α/f^2) s^2 m^{-1} × 10^{-12}			
	20^0C	25^0C	30^0C	35^0C
Ethylene glycol + 0.01 mol·kg^{-1} methylparaben				
0.09986	14.281	13.862	13.977	13.760
0.19552	15.049	13.008	14.627	13.979
0.30041	15.000	14.929	15.284	14.587
0.39780	15.270	15.055	15.946	15.073
0.49906	15.341	15.458	16.597	15.307
Ethylene glycol + 0.03 mol·kg^{-1} methylparaben				
0.10375	14.878	14.120	14.498	14.151
0.20032	15.101	14.885	14.530	14.812
0.30210	15.482	15.331	15.266	15.128
0.39976	15.461	15.299	15.388	15.656
0.50190	15.798	15.579	15.730	15.778
Propylene glycol + 0.01 mol·kg^{-1} methylparaben				
0.10096	15.811	14.999	14.802	14.912
0.19642	15.819	15.416	15.191	15.469
0.29903	16.382	15.873	15.765	15.772
0.40085	16.612	16.304	16.228	16.042
0.49594	17.289	16.734	16.358	16.497
Propylene glycol + 0.03 mol·kg^{-1} methylparaben				
0.10151	15.999	15.558	15.441	15.533
0.20210	16.223	15.793	15.774	15.720
0.30056	16.610	16.418	16.407	15.979
0.39985	17.509	16.748	16.846	16.571
0.49429	17.622	16.875	17.189	17.093

The high value of relaxation time and viscosity along with the structural relaxation process is responsible for increase in the value of ultrasonic attenuation with concentration. Hence, decrease in data of relaxation time indicates that there is less loss of energy due to less absorption of acoustic wave. The Gibb's free energy provides

the information about change in the energy concerned with the chemical reaction which can be utilized to do work. It can be found from the data that the values of Gibb's free energy increases with rise in the concentration of solute and temperature indicate increase in energy change.

Table 7 : Computed Values of Gibb's free energy (ΔG) for ternary liquid mixture at different temperatures.

m (mol·kg^{-1})	Gibb's free energy (ΔG) KJ mol^{-1} × 10^{-20}			
	20^{0}C	25^{0}C	30^{0}C	35^{0}C
Ethylene glycol + 0.01 mol·kg^{-1} methylparaben				
0.09986	1.2471	1.2680	1.2893	1.3105
0.19552	1.2478	1.2672	1.2899	1.3108
0.30041	1.2478	1.2690	1.2905	1.3114
0.39780	1.2480	1.2692	1.2911	1.3119
0.49906	1.2481	1.2696	1.2916	1.3121
Ethylene glycol + 0.03 mol·kg^{-1} methylparaben				
0.10375	1.2476	1.2683	1.2899	1.3109
0.20032	1.2478	1.2690	1.2900	1.3116
0.30210	1.2482	1.2694	1.2907	1.3119
0.39976	1.2482	1.2694	1.2908	1.3124
0.50190	1.2485	1.2697	1.2911	1.3125
Propylene glycol + 0.01 mol·kg^{-1} methylparaben				
0.10096	1.2484	1.2690	1.2902	1.3116
0.19642	1.2484	1.2694	1.2905	1.3121
0.29903	1.2489	1.2698	1.2911	1.3124
0.40085	1.2491	1.2702	1.2915	1.3127
0.49594	1.2496	1.2706	1.2916	1.3131
Propylene glycol + 0.03 mol·kg^{-1} methylparaben				
0.10151	1.2485	1.2695	1.2907	1.3121
0.20210	1.2488	1.2698	1.2911	1.3124
0.30056	1.2491	1.2703	1.2916	1.3126
0.39985	1.2498	1.2706	1.2920	1.3132
0.49429	1.2499	1.2707	1.2923	1.3136

The relative viscosity data has been indexed in Table 8. It shows that the value of relative viscosity increases with increase in the concentration of glycols and methylparaben indicating the presence of sturdy association among the molecules of Propylene glycol in comparison to ethylene glycol.

Table 8 : Computed Values of relative viscosity (η_0 / η) and concentration for ternary liquid mixture at 25^{0}C.

Concentration	$\sqrt{C}$ mol$^{1/2}$dm$^{-3/2}$	η_0 / η
Ethylene glycol + 0.01 mol·kg^{-1} methylparaben		
0.0777	0.2788	1.0099
0.1535	0.3918	1.0638
0.2275	0.4770	1.1181
0.2996	0.5474	1.1725
0.3702	0.6084	1.2273
Ethylene glycol + 0.03 mol·kg^{-1} methylparaben		
0.0778	0.2790	1.0957
0.1537	0.3921	1.1355
0.2278	0.4773	1.1756
0.3001	0.5478	1.2156
0.3707	0.6089	1.2561
Propylene glycol + 0.01 mol·kg^{-1} methylparaben		
0.0777	0.2788	1.1315
0.1534	0.3918	1.1771
0.2274	0.4769	1.2279
0.2996	0.5474	1.2781
0.3701	0.6084	1.3279
Propylene glycol + 0.03 mol·kg^{-1} methylparaben		
0.0778	0.2790	1.1847
0.1537	0.3921	1.2280
0.2277	0.4773	1.2714
0.3000	0.5478	1.3153
0.3706	0.6088	1.3592

Figure 4 shows the variation of relative viscosity with molar concentration at 25^{0}C temperature.

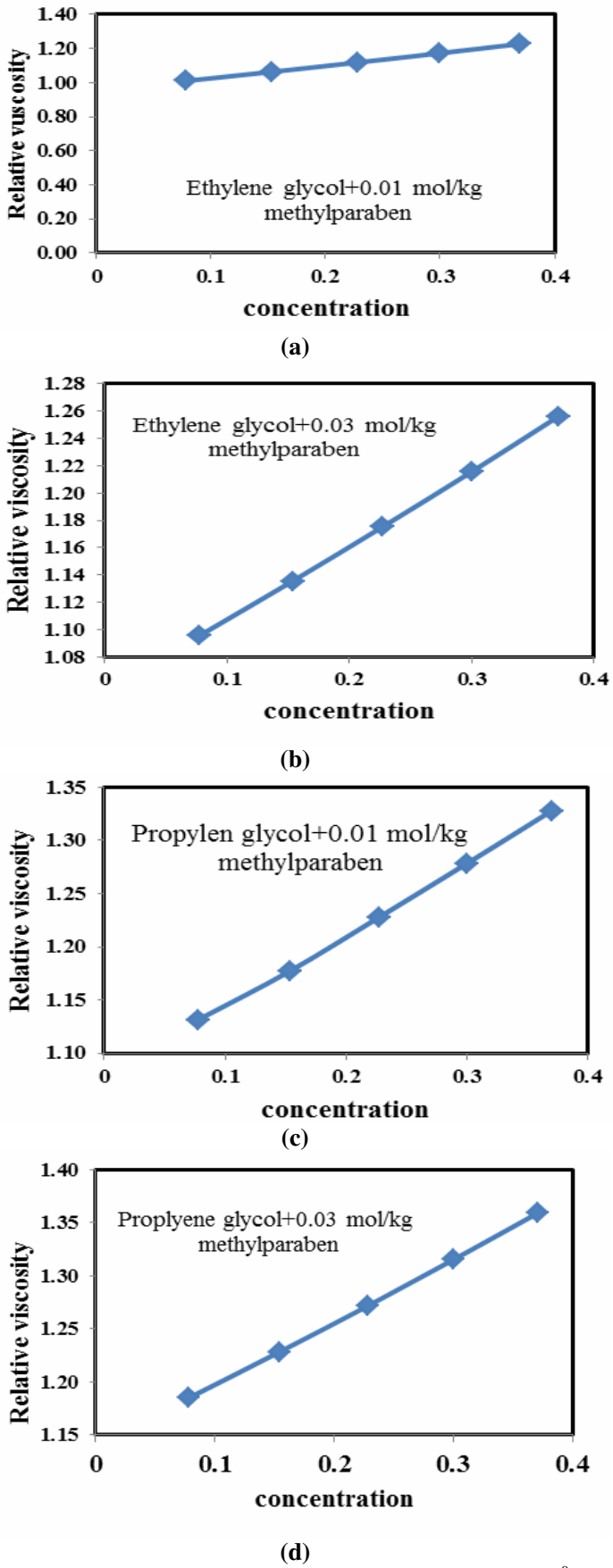

Fig. 4 : Variation of relative viscosity with concentration at 25^{0}C.

Conclusion

The occurrence of molecular interactions between the molecules of mixture is predicted by ultrasonic study of ternary fluid mixtures of glycols in methylparaben – methanol solution. The ultrasonic speed escalates with increase in the concentration as a result of decrease in intermolecular free length of the mode studied. Acoustic impedance, relaxation time, ultrasonic attenuation, Gibb's free energy and viscosity rising with surge in the concentration. All these acoustical parameters are varying linearly with respect to concentration suggesting the non-existence of complex formation in the system. The existence of sturdy associations in propylene glycol as compared to ethylene glycol has been concluded from the evaluation of acoustical parameters.

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