Ultrasonic studies of N, N-Dimethylacetamide and N-Methylacetamide with Alkoxyethanols in Carbon tetrachloride at different temperatures

R. Kubendran[1,*], F. Liakath Ali Khan[2], J. Asghar[2], M. Aravinthraj[3] and J. Udayaseelan[4]

[1,*]*Department of Physics, Priyadarshini Polytechnic College, Vaniyambadi, Tamilnadu, India*
[2]*Department of Physics, Islamiah College, Vaniyambadi, Tamilnadu, India*
[3]*Department of Physics, Sacred Heart College, Tirupattur, Tamilnadu, India*
[4]*Department of Physics, Government Arts College, Gudiyatham, Tamilnadu, India*

ABSTRACT

The ultrasonic velocity, density and viscosity have been measured for the ternary mixtures N, N-Dimethylacetamide and N-Methylacetamide with Alkoxyethanols in Carbon tetrachloride at 303, 313 and 323K. The experimental data have been used to calculate the acoustical parameters namely adiabatic compressibility (β), free length (L_f), free volume (V_f) internal pressure (π_i), Viscous relaxation time (τ) and Gibb's Free energy (ΔG). From the obtained values, molecular interactions have been found through hydrogen bonding between solute and solvent liquid mixtures.

Keywords: ternary mixtures, molecular interactions, hydrogen bonding.

INTRODUCTION

The nature and the strength of molecular interactions in the mixtures were explained based on the variation of ultrasonic velocity and other related acoustical parameters with change in composition of the components of pure liquid. In some of the liquid mixtures, a linear variation with change in composition of mixtures has been noticed. In some other liquids mixtures, a non-linear variation (maxima or minima) in the velocity and other related acoustical parameters has been noticed. Alkoxyethanols have wide use as monomers in the production of polymers and emulsion formulations. They are also of considerably interest for studying the heteroproximity effects of the etheric oxygen on the –O-H bond and hence their influence on the associated nature of the species in these molecules. The Amides are in general soluble in a variety of polar and non-polar solvents and is readily suitable to explore solute-solvent interactions. The primary amide like formamide and acetamide are excellent proton donors as well as proton acceptors and hence are strongly associated through intermolecular hydrogen bonds. Consequently, they exhibit physical properties which show strong dependence on solvent environment, temperature and concentration.

MATERIALS AND METHODS

The liquid mixtures of various concentrations in mole fraction were prepared by taking Analytic reagent grade chemicals. In all systems, the mole fraction of the second component, carbon tetrachloride ($X_2 = 0.3$) was kept constant, while the mole fractions of the remaining two (X_1 and X_3) were varied from 0.1 to 0.7 so as to have the mixtures of different compositions. The ultrasonic velocity was measured by a single crystal interferometer with a high degree of accuracy operating at a frequency of 2MHz (manufactured by Mittal) at 303K, 313K and 323K. The viscosity was measured by Ostwald's viscometer. An electronically operated constant temperature water bath is used to circulate water through the double walled measuring cell made up of steel containing the experimental solution at the desired temperature. Densities of the mixtures have been found by specific gravity bottle with 10ml capacity.

Theory and Calculation

Using the measured data, the following acoustical parameters have been calculated

$$\beta = \left(U^2\rho\right)^{-1} \dots\dots\dots\dots\dots (N^{-1}m^2) \qquad\qquad \textbf{...... (1)}$$

Intermolecular free length (L_f) has been calculated from relation,

$$L_f = K_T\beta^{\frac{1}{2}} \dots\dots\dots\dots\dots\dots (m) \qquad\qquad \textbf{...... (2)}$$

Where, K_T is a temperature dependent constant.

Free volume (V_f) has been calculated from relation,

$$V_f = \left[\frac{M_{eff}U}{K\eta}\right]^{\frac{3}{2}} \dots\dots\dots\dots\dots (m^3 mol^{-1}) \qquad\qquad \textbf{...... (3)}$$

Where, M_{eff} is the effective molecular weight ($M_{eff} = \Sigma m_i\ x_i$, in which mi and xi are the molecular weight and the mole fraction of the individual constituents respectively). K is a temperature independent constant which is equal to 4.28×10^9 for all liquids.

Internal pressure (π_i) has been calculated from relation,

$$\pi_i = bRT\left[\frac{K\eta}{U}\right]^{\frac{1}{2}}\left[\frac{\rho^{\frac{1}{3}}}{M^{\frac{7}{6}}}\right] \dots\dots (Pa) \qquad\qquad \textbf{...... (4)}$$

Where, K is a constant, T the absolute temperature, η the viscosity in Nsm^{-2}, U the ultrasonic velocity in ms^{-1}, the density in Kgm^{-3}, M_{eff} the effective molecular weight.

Viscous relaxation time (τ) is the time taken for the excitation energy to appear as translational energy and it depends on temperature and on impurities. And it can be calculated from the following relation

$$\tau = \frac{4}{3}\beta\eta \dots\dots\dots\dots\dots\dots\dots (s) \qquad\qquad \textbf{...... (5)}$$

On the basis of Eyring rate process theory, the Gibb's Free Energy (ΔG) can be computed as

$$-\Delta G = -KT log \left(\frac{h}{KT\tau}\right)..(KJmol^{-1}) \qquad\qquad ...... (6)$$

Where, K is the Boltzmann's constant and h is Planck's constant.

RESULT AND DISCUSSION

The experimental values of density, viscosity and ultrasonic velocity has been calculated for the following four ternary systems, such as:

2-Methoxy ethanol + Carbon tetrachloride + N,N-dimethylacetamide
2-Butoxy ethanol + Carbon tetrachloride + N,N-dimethylacetamide
2-Methoxy ethanol + Carbon tetrachloride + N-methylacetamide
2-Butoxy ethanol + Carbon tetrachloride + N-methylacetamide

The above ternary liquid mixtures have been mixed with of various mole fractions at 303, 313 and 323K are presented From the Tables 1. In all the four liquid systems, the values of density, viscosity and ultrasonic velocity increases with increasing molar concentration of alkoxyethanols. The variation of ultrasonic velocity in solution depends upon the increase or decrease of intermolecular free length after mixing the components, based on a model for sound propagation proposed by Eyring and Kincaud [1].

The increase in velocity is perhaps due to structural changes occurring in the mixtures resulting in increase of intermolecular forces. Further the sound speed decreases with increase in temperature leads to less disordered structure and more spacing between the molecules. The decrease in density and viscosity with temperature indicates that decrease in intermolecular forces due to increase in thermal energy of the system, which causes increase in volume expansion and hence increase in free path length. In all the systems density, viscosity and velocity vary nonlinearly with an increase in the alkoxy and alcohol mole fractions at different temperatures. The increase of above parameters indicates that increase in molecular association alkoxyethanols in presence of N-methylacetamide and N,N-dimethylacetamide. The adiabatic compressibility of alkoxy ethanols with N-methyl formamide is found to be greater than in alkoxy ethanols with N,N-dimethyl formamide due to inductive effect, which arises from the two methyl group attached with methyl formamide molecule.

It is evident from the Table 2, the adiabatic compressibility and free length decreases with increasing concentration of alcohol in all the four systems. The adiabatic compressibility shows an inverse behavior as compared to ultrasonic velocity. This indicates that there is a significant interaction between solute and solvent molecules. It can be taken as an indication for formation of complexes. The addition of interacting molecules break up the molecular clustering of the other, releasing several dipoles for interaction, which suggest that hydrogen bonded association. In view of greater forces of interaction between solute and solvent molecules forming hydrogen bonding, there will be a decrease in free length in the mixture [2,3]. The decreases in free length after mixing results in increase in ultrasonic velocity. This also in accordance with the expected increases in compressibility following a increase in ultrasonic velocity showing there by strong intermolecular interactions. Similar results were also reported in some liquid mixtures [4,5].

Table -1: The values of Density (ρ), Viscosity (η) and Velocity (U) at 303K, 313K and 323K

Mole fraction		Density (ρ) (Kg/m^3)			Viscosity (η) (10^{-3}Nsm^{-2})			Velocity (U) (ms^{-1})		
X_1	X_3	303K	313K	323K	303K	313K	323K	303K	313K	323K
2-Methoxy ethanol + Carbon tetrachloride + N, N-Dimethylacetamide										
0.000	0.705	943.09	942.54	941.53	1.5279	1.5024	1.4727	1341.12	1339.73	1336.45
0.100	0.606	945.35	944.65	943.39	1.5321	1.5132	1.4982	1362.41	1348.89	1337.07
0.197	0.498	948.14	947.25	945.97	1.5589	1.5194	1.4826	1386.16	1368.68	1351.74
0.301	0.403	950.24	949.12	947.54	1.5928	1.5518	1.5095	1411.45	1395.42	1381.78
0.399	0.297	953.14	951.27	949.38	1.6379	1.5928	1.5504	1423.15	1411.86	1397.28
0.497	0.195	957.58	956.15	954.19	1.6873	1.6446	1.6055	1431.24	1421.23	1409.54
0.607	0.104	960.13	959.21	957.11	1.7424	1.7061	1.6689	1442.52	1434.11	1424.11
0.705	0.000	964.15	962.24	959.65	1.7826	1.7643	1.7368	1454.31	1451.15	1449.31
2-Butoxy ethanol + Carbon tetrachloride + N, N-Dimethylacetamide										
0.000	0.701	902.34	898.92	896.92	1.7648	1.7458	1.7158	1308.11	1301.35	1298.16
0.102	0.604	912.14	906.54	902.73	1.9634	1.8824	1.7901	1328.17	1320.85	1313.97
0.199	0.501	922.16	916.16	913.16	2.2135	2.1254	2.0456	1342.41	1333.74	1324.65
0.305	0.398	930.18	923.38	919.57	2.3214	2.2447	2.1548	1364.47	1357.16	1344.55
0.398	0.301	935.15	929.01	924.59	2.4125	2.3366	2.2469	1387.36	1378.12	1364.19
0.504	0.200	939.14	933.21	929.21	2.5462	2.4578	2.3469	1407.86	1398.21	1386.86
0.601	0.098	941.54	935.62	932.01	2.6548	2.5717	2.4751	1426.17	1416.31	1408.15
0.700	0.000	942.65	939.23	935.42	2.7882	2.7534	2.7212	1452.15	1449.21	1445.42
2-Methoxy ethanol + Carbon tetrachloride + N-Methylacetamide										
0.000	0.700	940.02	939.06	938.38	1.5512	1.5231	1.4972	1337.19	1334.48	1330.91
0.101	0.603	941.18	938.82	936.83	1.7999	1.6658	1.5654	1340.78	1336.38	1333.69
0.203	0.501	943.77	941.06	938.48	2.1777	1.9802	1.8421	1341.83	1338.17	1334.61
0.299	0.404	948.35	944.59	941.52	2.5379	2.3176	2.1608	1344.56	1340.07	1336.65
0.403	0.308	952.47	949.41	946.15	2.7923	2.5908	2.3954	1347.54	1342.52	1338.98
0.503	0.199	956.47	953.87	951.17	2.9487	2.7458	2.5463	1350.72	1346.16	1341.69
0.599	0.104	959.52	957.34	954.74	3.0912	2.9191	2.7562	1354.14	1349.12	1345.28
0.703	0.000	962.15	960.58	958.23	3.3152	3.2546	3.1647	1358.21	1353.45	1348.22
2-Butoxy ethanol + Carbon tetrachloride + N-Methylacetamide										
0.000	0.700	899.41	897.71	895.52	2.7921	2.7552	2.7213	1306.05	1302.77	1297.64
0.101	0.603	909.15	905.23	901.65	2.8197	2.7748	2.7259	1312.12	1304.05	1299.54
0.203	0.501	915.21	912.21	909.81	2.8708	2.8199	2.7645	1322.47	1313.45	1305.28
0.299	0.404	918.68	916.45	914.21	2.9426	2.8901	2.8321	1331.36	1325.11	1319.01
0.403	0.308	921.51	919.46	917.65	3.0183	2.9628	2.8986	1338.06	1332.41	1326.76
0.503	0.199	924.65	922.87	921.24	3.1351	3.0679	3.0066	1344.87	1338.99	1333.59
0.599	0.104	927.45	925.15	923.45	3.2132	3.1732	3.1297	1351.25	1346.25	1340.87
0.703	0.000	936.85	934.24	932.66	3.2231	3.1924	3.1684	1357.12	1353.82	1349.16

571

Table -2: The values of Adiabatic compressibility (β), Free Volume (V_f), and Free Length (L_f) at 303K, 313K and 323K

Mole fraction		Adiabatic compressibility (β) $(10^{-10} N^{-1}m^2)$			Free length (L_f) $(10^{-10}m)$			Free Volume (V_f) $(10^{-7} m^3 mol^{-1})$		
X_1	X_3	303K	313K	323K	303K	313K	323K	303K	313K	323K
2-Methoxy ethanol + Carbon tetrachloride + N, N-Dimethylacetamide										
0.000	0.705	5.8953	5.9110	5.9464	0.4792	0.4798	0.4813	0.9278	0.9501	0.9754
0.100	0.606	5.6989	5.8180	5.9292	0.4711	0.4760	0.4806	0.9230	0.9263	0.9280
0.197	0.498	5.4891	5.6354	5.7854	0.4624	0.4685	0.4747	0.9007	0.9184	0.9351
0.301	0.403	5.2824	5.4108	5.5274	0.4536	0.4591	0.4640	0.8748	0.8943	0.9185
0.399	0.297	5.1801	5.2736	5.3950	0.4492	0.4532	0.4584	0.8296	0.8548	0.8763
0.497	0.195	5.0980	5.1778	5.2748	0.4456	0.4491	0.4533	0.7818	0.8039	0.8232
0.607	0.104	5.0052	5.0689	5.1517	0.4415	0.4443	0.4479	0.7368	0.7538	0.7710
0.705	0.000	4.9039	4.9350	4.9609	0.4370	0.4384	0.4396	0.7047	0.7134	0.7290
2-Butoxy ethanol + Carbon tetrachloride + N, N-Dimethylacetamide										
0.000	0.701	6.4765	6.5688	6.6159	0.5023	0.5058	0.5076	0.7200	0.7261	0.7425
0.102	0.604	6.2148	6.3227	6.4161	0.4920	0.4963	0.4999	0.6573	0.6944	0.7429
0.199	0.501	6.0176	6.1360	6.2409	0.4841	0.4889	0.4930	0.5851	0.6158	0.6455
0.305	0.398	5.7743	5.8797	6.0153	0.4742	0.4786	0.4840	0.5863	0.6116	0.6413
0.398	0.301	5.5557	5.6676	5.8116	0.4652	0.4698	0.4758	0.5969	0.6199	0.6475
0.504	0.200	5.3721	5.4812	5.5952	0.4574	0.4620	0.4668	0.5930	0.6189	0.6552
0.601	0.098	5.2217	5.3282	5.4110	0.4510	0.4556	0.4591	0.5996	0.6224	0.6535
0.700	0.000	5.0306	5.0695	5.1168	0.4427	0.4444	0.4464	0.6056	0.6153	0.6238
2-Methoxy ethanol + Carbon tetrachloride + N-Methylacetamide										
0.000	0.700	5.9494	5.9797	6.0162	0.4814	0.4826	0.4841	0.7281	0.7461	0.7625
0.101	0.603	5.9103	5.9642	6.0010	0.4798	0.4820	0.4835	0.5890	0.6583	0.7205
0.203	0.501	5.8849	5.9341	5.9822	0.4788	0.4808	0.4827	0.4462	0.5125	0.5690
0.299	0.404	5.8327	5.8952	5.9447	0.4766	0.4792	0.4812	0.3583	0.4085	0.4521
0.403	0.308	5.7818	5.8439	5.8951	0.4740	0.4771	0.4792	0.3137	0.3491	0.3911
0.503	0.199	5.7305	5.7851	5.8403	0.4729	0.4747	0.4769	0.2922	0.3235	0.3605
0.599	0.104	5.6835	5.7389	5.7874	0.4704	0.4728	0.4748	0.2752	0.2983	0.3237
0.703	0.000	5.6340	5.6830	5.7412	0.4684	0.4705	0.4729	0.2507	0.2564	0.2659
2-Butoxy ethanol + Carbon tetrachloride + N-Methylacetamide										
0.000	0.700	6.5181	6.5633	6.6315	0.5039	0.5056	0.5082	0.5155	0.5233	0.5300
0.101	0.603	6.3887	6.4961	6.5672	0.4988	0.5030	0.5058	0.4645	0.4715	0.4812
0.203	0.501	6.2475	6.3544	6.4512	0.4933	0.4975	0.5013	0.4180	0.4250	0.4337
0.299	0.404	6.1410	6.2142	6.2872	0.4891	0.4920	0.4949	0.3736	0.3811	0.3902
0.403	0.308	6.0610	6.1262	6.1906	0.4859	0.4885	0.4910	0.3342	0.3415	0.3507
0.503	0.199	5.9794	6.0437	6.1035	0.4826	0.4852	0.4876	0.2947	0.3024	0.3098
0.599	0.104	5.9052	5.9639	6.0230	0.4796	0.4820	0.4843	0.2659	0.2695	0.2734
0.703	0.000	5.7955	5.8400	5.8904	0.4751	0.4769	0.4790	0.2485	0.2512	0.2527

Table -3: The values of Internal Pressure (π_i), Viscous Relaxation Time (τ) and Gibb's free energy (ΔG) at 303K, 313K and 323K

Mole fraction		Internal pressure (π_i) (10^{-6} Pa)			Viscous Relaxation Time (τ) (10^{-12}s)			Gibb's Free Energy (ΔG) (10^{-20} KJ mol^{-1})		
X_1	X_3	303K	313K	323K	303K	313K	323K	303K	313K	323K
2-Methoxy ethanol + Carbon tetrachloride + N, N-Dimethylacetamide										
0.000	0.705	431.94	428.38	424.34	1.1218	1.1195	1.1124	0.3566	0.3747	0.3933
0.100	0.606	438.19	437.44	436.80	1.1312	1.1199	1.1152	0.3574	0.3733	0.3904
0.197	0.498	447.46	444.29	441.22	1.1409	1.1416	1.1436	0.3586	0.3724	0.3892
0.301	0.403	457.34	453.65	449.12	1.1469	1.1353	1.1291	0.3588	0.3777	0.3956
0.399	0.297	471.37	466.08	461.62	1.1628	1.1530	1.1463	0.3612	0.3772	0.3941
0.497	0.195	487.28	482.28	477.83	1.1641	1.1738	1.1844	0.3643	0.3811	0.3986
0.607	0.104	502.98	498.85	494.39	1.1655	1.1609	1.1488	0.3647	0.3812	0.3982
0.705	0.000	517.08	514.29	509.68	1.2010	1.1841	1.1676	0.3663	0.3835	0.3995
2-Butoxy ethanol + Carbon tetrachloride + N, N-Dimethylacetamide										
0.000	0.701	434.79	432.09	429.45	1.1837	1.1800	1.1706	0.3651	0.3827	0.3994
0.102	0.604	443.10	435.69	427.35	1.3669	1.3373	1.2915	0.3913	0.4062	0.4185
0.199	0.501	445.99	442.95	438.52	1.5855	1.5533	1.526	0.4182	0.4342	0.4508
0.305	0.398	453.57	445.13	435.51	1.7196	1.6963	1.6697	0.4329	0.4508	0.4682
0.398	0.301	457.63	447.76	436.78	1.8574	1.8318	1.8021	0.4469	0.4652	0.4830
0.504	0.200	458.79	450.52	442.64	2.0429	2.0108	1.9529	0.4642	0.4827	0.4985
0.601	0.098	465.92	457.67	449.27	2.1998	2.1713	2.1206	0.4925	0.4976	0.5145
0.700	0.000	470.52	460.70	452.52	2.4077	2.4115	2.4004	0.4941	0.5168	0.5385
2-Methoxy ethanol + Carbon tetrachloride + N-Methylacetamide										
0.000	0.700	514.19	509.69	505.77	1.2305	1.2143	1.2010	0.3679	0.3838	0.4004
0.101	0.603	550.58	529.65	513.23	1.4184	1.3247	1.2525	0.3947	0.4007	0.4092
0.203	0.501	603.16	574.84	554.15	1.7087	1.5667	1.4693	0.4294	0.4333	0.5330
0.299	0.404	648.98	619.57	597.71	1.9737	1.8217	1.7127	0.4572	0.4632	0.4722
0.403	0.308	678.17	653.06	627.34	2.1526	2.0187	1.8828	0.4745	0.4840	0.4924
0.503	0.199	694.15	669.76	644.82	2.2530	2.1180	1.9828	0.4844	0.4949	0.5041
0.599	0.104	707.36	687.62	667.90	2.3425	2.2336	2.1268	0.4926	0.5069	0.5187
0.703	0.000	728.66	722.45	712.62	2.4904	2.4661	2.4225	0.5044	0.5255	0.5443
2-Butoxy ethanol + Carbon tetrachloride + N-Methylacetamide										
0.000	0.700	434.49	431.77	429.26	2.4265	2.4111	2.4062	0.4928	0.5150	0.5310
0.101	0.603	472.87	469.19	464.79	2.4019	2.4033	2.3868	0.4936	0.5154	0.5363
0.203	0.501	512.17	508.24	503.9	2.3913	2.3891	2.3779	0.4955	0.5161	0.5366
0.299	0.404	553.65	549.09	543.92	2.4094	2.3946	2.3741	0.4964	0.5170	0.5378
0.403	0.308	596.78	591.64	585.67	2.4392	2.4201	2.3925	0.5002	0.5175	0.5392
0.503	0.199	645.14	638.62	632.73	2.4994	2.4722	2.4467	0.5010	0.5216	0.5423
0.599	0.104	691.23	687.05	682.85	2.5299	2.5233	2.5133	0.5031	0.5224	0.5454
0.703	0.000	734.07	730.10	727.93	2.4906	2.4858	2.4884	0.5059	0.5253	0.5474

Table 2 shows the intermolecular free length is decreases in all the systems are due to the enhancement of molecular association since the molecules become more compact and less

573

compressible as the new entities are formed. Such a continuous decreases in adiabatic compressibility with respect to the solute concentration has been qualitatively ascribed to the effect of hydrogen bonding [6]. The increases in temperature however make the free length to increase as expected due to the thermal expansion of the liquids. The free length is one of the predominating factors to the nature of ultrasonic velocity in the mixtures [7].

The values of free volume verses is decreases in all the systems, because it is well known that alkoxyethanols and alcohols form a variety of species with different degree of association in the pure state; however, polymeric liner associates are expected to be predominant in the pure state. Thus, the addition of alkoxyethanols and alcohol to butyl methacrylate may result in the following effects: The present free volume results can be interpolated qualitatively by taking into account the fact: (i) contraction due to the free volume difference of unlike molecules, (ii) contraction due to hydrogen bond formation between alkoxyethanols and amide through C=O…H-O, and (iii) specific interactions between the alkoxyethanols and amide molecules. The interaction may be considered as the reaction between alkoxyethanols as Lewis acid, and DMF as a base.

It is suggested that missing of alkoxyethanols with amide will induce substantial variations on the nature of the patterns of alkoxyethanols self aggregation in switching from the pure liquids to mixtures which contain a significant amount of amide. The addition of the pure amides in alkoxyethanols disrupts the associated structure in the latter causing free alkoxyethanols molecules. These alkoxyethanols molecules may interact with dipole-dipole forces, in addition to hydrogen bonding, with amide molecules in the mixture.

The interdependence of free length and ultrasonic velocity has been evolved from a model for sound propagation [1]. The decrease in the value of adiabatic compressibility and free length with increase in ultrasonic velocity further strengths the process of complex formation between the molecules through hydrogen due to which structural arrangement is considerable affected.

It is observed from Tables 2 and Tables 3 that as the concentration of alkoxyethanols increases, free volume decreases whereas the internal pressure increases. This suggests the close packing of the molecules inside the shield. The increase in nature pressure generally indicates association through hydrogen bonding [8-10] and hence it supports the present investigation. However, with rise in temperature, increase in free volume and decrease in internal pressure are noticed in the systems.

From the Tables 2, it is seen that the values of adiabatic compressibility, free length and internal pressure for ternary mixtures (alkoxyethanols with amides in CCl_4) are increases with increase of concentration of solute molecules. This result indicates that molecular association is taking place between alkoxyethanols and amide molecules. This association is arising from hydrogen bonding between the hydrogen atom of alkoxy ethanols molecule and the oxygen atom of the amide molecule (O-H⋯O=C) and is shown in Fig (a)
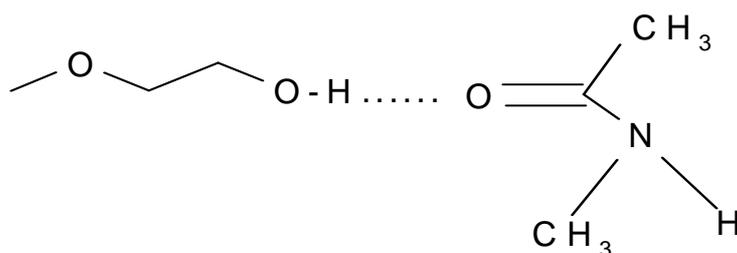
Fig (a) Hydrogen bonding between alkoxy ethanols and amides

The internal pressure (π_i) in the ternary mixture is a measure of intermolecular attraction between the components. The internal pressure values for various compositions for all the four systems have been obtained from the equation suggested by Suryanarayana [11]. The internal pressure values for all the four systems are given in the Tables 3. It is seen that the internal pressure shows the increasing trend for all the four mixtures suggesting strong intermolecular hydrogen bonding which may be due to the high polarity of etherial compounds. The slight increase in internal pressure value with concentration in other systems indicates the existence of molecular interactions in these systems.

The values of relaxation time (τ) are also given in the Table 3. The viscous relaxation time increase significantly with increase in concentration and the interaction between the molecules of components is stronger than the attractive forces between the molecules of each component. The relaxation time that is in the order of 10^{-12} s is due to the structural relaxation process showing the presence of molecular interaction. This tendency could be explained that the dipole in long alkyl chains rotate less freely compared to that in shorter alkyl chains.

Gibbs free energy confirms the same (relaxation time) from the measured values are given in the Table 3. This indicates that the need for smaller time for the cooperative process or the rearrangement of the molecules in the mixtures decreases the energy that leads to dissociation.

CONCLUSION

The various acoustical parameters such as adiabatic compressibility, relaxation time, free length, free volume, internal pressure, Viscous relaxation time, and Gibb' free energy have been evaluated from the measured ultrasonic velocity, density and viscosity values for the four ternary mixtures. From the above studies it is concluded that, a hydrogen bond formation between alkoxyethanols and amide through C=O ⋯ H-O and specific interaction between the alkoxyethanols and amide molecules. Therefore, interactions between unlike molecules are stronger in solution containing N,N-dimethylacetamide, N-methylacetamide. The magnitude increases with the alkyl chain length of the Alkoxyethanols. This hydrogen bonding formation and molecular interaction in alkoxyethanols with N, N-dimethylacetamide is greater than alkoxyethanols with N-methylacetamide.

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