CAMPARITIVE STUDY OF INTERFEROMETRIC PROPERTIES OF SUBSTITUTED PYRIDINE-2-AMINE SCHIFF BASE DERIVATIVES IN BINARY MIXTURES OF 1,4-DIOXANE AND ETHANOL AT 293K, 297K AND 300 K

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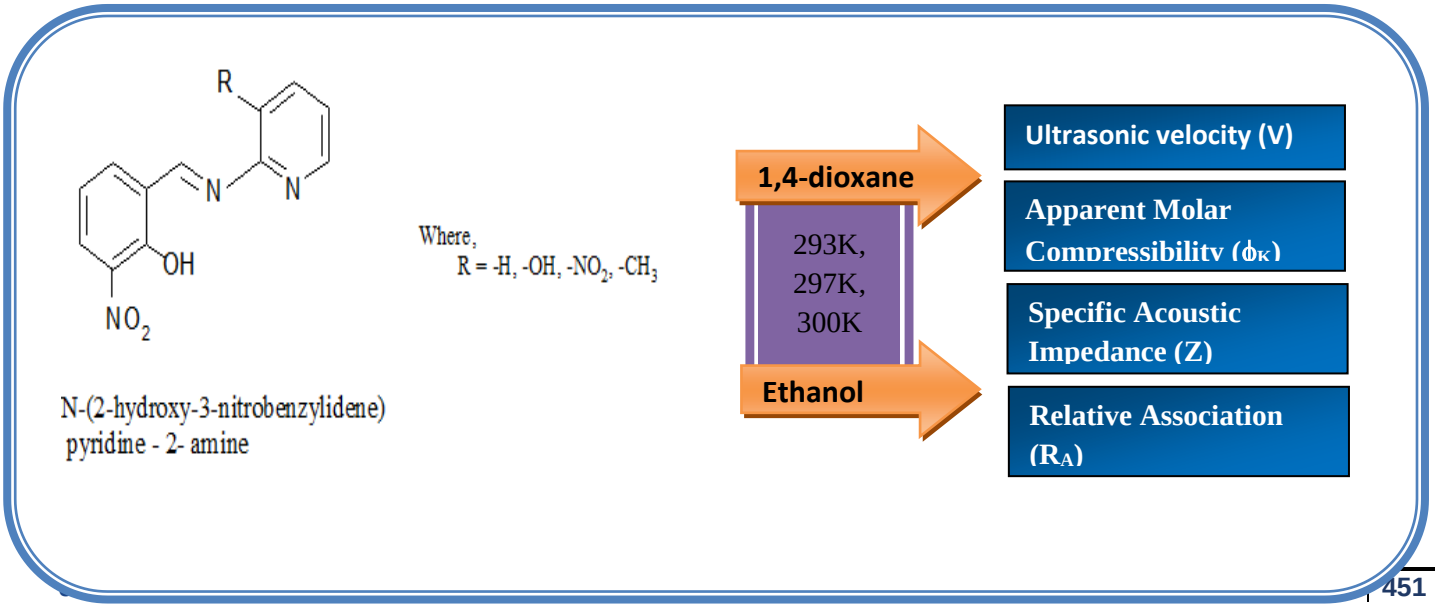
Abstract:

Ultrasonic velocity and density measurement at different concentrations of N-(2'-hydroxy-3'-nitrobenzylidene) -3-substituted pyridine-2-amine Schiff base derivatives were carried out in the mixture of water with the solvents 1,4-dioxane and ethanol for investigating solute-solvent interactions. From the experimental recordings obtained during the study, various acoustic parameters like apparent molar compressibility (ϕ_k), specific acoustic impedance (Z) and relative association (R_A) were determined. These parameters have been used to explore the interactions between N-(2'-hydroxy-3'-nitrobenzylidene) -3-substituted pyridine-2-amine Schiff base derivatives in different compositions of water-1,4-dioxane and water- ethanol system at 293K, 297K and 300K.

Keywords: Solute, interactions, Interferometer, Schiff base, acoustic, dioxane and ethanol.

Graphical Abstract:



1. Introduction

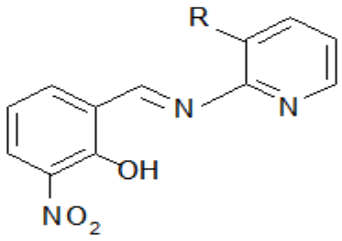
The compound containing azomethine group (-C=N-) known as Schiff Bases has great synthesis flexibility and diverse structural aspects. Schiff bases are used as an efficient reagent in trace analysis of some metal cations[1](Yamada S. (1999)). Substituted Schiff bases play an important role in analytical, medicinal, pharmaceutical, industrial and biochemical field. Moreover, Schiff bases derived from various heterocycles have been reported to possess cytotoxic, anticonculsant, antiproliferative, antimicrobials and antifungal activity[2-3](Adsule S. *et al* (2006), Aggarwal N. *et al* (2009)). The acoustic parameters by ultrasonic interferometric measurements provide a wealth of information about molecular interactions, its nature and strength of interactions. In recent years, much effort has been made to study ultrasonic properties of liquid mixtures[4](Ali A. *et al* (2006)), pure liquids[5] (Verma R.P *et al* (2000) and electrolytic solution[6] (Upadhyay S.K. (2000)).

In last few years, we have carried on studies on acoustical properties of synthesized Schiff Bases in various solvents[7-10](Mahajan M.M *et al* (2016), Mahajan M.M *et al* (2017), Deshmukh A.O *et al* (2010), Mahajan M.M *et al* (2019)). Thus in continuation to these studies, the present paper reports ultrasonic velocity and density measurement at different concentrations of N-(2'-hydroxy-3'-nitrobenzylidene) -3-substituted pyridine-2-amine Schiff base derivatives in the mixture of water with the solvents 1,4-dioxane and ethanol for investigating solute-solvent interactions at 293K, 297K and 300K. The Schiff bases and its derivatives used in the study was synthesized by a greener and cleaner way using microwave irradiations and were reported to show promising antimicrobial activity[11](Mahajan M.M *et al* (2016)). Hence, it was thought to be of utmost significance, to study acoustic parameters and compare it with respect to solvents, in order to investigate solute-solvent, solute-solute interactions.

In the present study, following substituted Schiff bases were used to study the molecular interactions with 1,4-dioxane – water and ethanol – water mixture at different concentrations by acoustical interferometric measurements at 293K, 297K and 300K.

1. N-(2'-hydroxy-3'-nitrobenzylidene) pyridine-2-amine (B_1)
2. N-(2'-hydroxy-3'-nitrobenzylidene)-3-hydroxy pyridine-2-amine (B_2)
3. N-(2'-hydroxy-3'-nitrobenzylidene)-3-nitropyridine-2-amine (B_3)
4. N-(2'-hydroxy-3'-nitrobenzylidene)-3-methylpyridine-2-amine (B_4)

Following is the structure of the Schiff Base –



Where,
R = -H, -OH, $-NO_2$, $-CH_3$

N-(2-hydroxy-3-nitrobenzylidene)
pyridine - 2- amine

2. Materials and Methods

2.1 Experimental

In present investigation, ultrasonic velocity and density of N-(2'-hydroxy-3'-nitrobenzylidene) -3-substituted pyridine-2-amine Schiff base derivatives have been studied at 0.01 M concentration at different percentage (75%, 80%, 85%, 90%, 95% and 100%) of 1,4-dioxane-water and ethanol-water mixture at 293K, 297K and 300K. From these values, various acoustic parameters like apparent molar compressibility (ϕ_k), specific acoustic impedance (Z) and relative association (R_A) were determined.

L.R. Grade chemicals were used for the synthesis. The product obtained was re-crystallized using alcohol and the formation of Schiff bases was confirmed by melting point (M.P) and spectral studies. All the working solutions were freshly prepared from the deionized water. 0.01 M concentration solution of the base under study was prepared at different percentage (75%, 80%, 85%, 90%, 95% and 100%) of 1,4-dioxane-water and ethanol-water mixture and the ultrasonic velocity and density was measured at 293K, 297K and 300K.

2.2 Instrumentation

In the present study, the ultrasonic interferometer from Mittal enterprises, New Delhi, Model MX-3 was used to measure the ultrasonic velocity in liquid mixtures and solutions, having the working frequency of 1 MHz with accuracy of ±0.03%. The weighing was made on Citizen CY 104 one pan digital balance. The densities of the solution were determined by standardize capillary pyknometer having a bulb of volume of about 10 cm^3 and capillary having an internal diameter of 1 mm.

Fig. 1: Ultrasonic Interferometer

In this method, standing waves are produced in liquid between the source and reflector. Movement of the reflector by half wavelength allows the determination of wavelength (λ) of ultrasonic wave in liquid under measurement. The velocity can be calculated as -

$V = \lambda \times f$,

where 'V' is ultrasonic velocity and 'f' is frequency of ultrasonic waves.

3. Result and Discussion

The 0.01M solution of each ligand (B_1-B_4) was prepared in different percentage (75%, 80%, 85%, 90%, 95% and 100%) of 1,4-dioxane-water and ethanol-water mixture and the ultrasonic velocity and density was measured. From these data, acoustic parameters like apparent molar compressibility (ϕ_k), specific acoustic impedance (Z) and relative association (R_A) were determined. The value of these acoustic parameters has been used to discuss an important role in understanding the molecular interaction between the components of the mixtures and provides an insight into the physico-chemical properties of liquid mixtures. The results are given in following table no. 1 to 12.

3.1 Apparent molar compressibility (ϕ_k)

Apparent molar compressibility (ϕ_k) is an important acoustic parameter, which explains the solute-solvent and solute-solute interactions in solutions. Thus, the structure of solute and the number of atoms present in it will have direct effect on ϕ_k values. From table 1-12 and fig. 2-4, it is observed that the ϕk values are negative for ligand solution in 95% dioxane medium and 90% ethanol medium. Negative value of (ϕ_k) shows that interactions are insensitive to solvent. It could be also explained by postulating the polar -OH group interacts with the surrounding organic solvent through dipole-dipole interaction in such a way that the surrounding solvent molecule loses its own compressibility to a certain extent[12](Dhanlakshmi A. *et al* (1999)). The positive values of (ϕ_k) show that electrostatic force in the vicinity of ion causes solvation of solute[13](Thirumaran S. et al (2012)).

An addition of polar solute having a partial positive charge on hydrogen atom, there is every likelihood that there can be a weak interaction between this positive charge and negative charge on oxygen atom (due to electronegativity) of dioxane. This weak interaction of the Vander Wall forces is expected to introduce structurdness in the solution i.e. specific arrangement of dioxane molecule may be occurring due to attached solute molecules. Thus spaces may be created making the solution more compressible as it appears from the higher apparent molar compressibility values in dioxane solvent. The apparent molar compressibility shows the increased association but at the same time structuredness of the solution is also shown by higher (ϕ_k) values.

In ethanol structuredness is already there, the addition of polar solute may break this structuredness of the solvent and from bulk of solute-solvent, as is seen from the lower apparent molar compressibility value.

3.2 Relative association (R_A)

Relative association is an acoustic property for understanding the interactions, which are influenced by the breaking up of the solvent molecules on addition of electrolyte to it, and solvation of the solute that is simultaneously present by the free solvent molecules[14](Erying H. *et al* (1977)).

The former effect results in the decrease in R_A values while the latter resulting in increase of R_A values. From table no. 1 to 12 and fig. 5 to 7, it can be easily seen that the R_A values in dioxane are higher than in alcohol for the ligands -

L - Dioxane > L - Ethanol

The alcohol molecules are well known to be associated as compared to dioxane, which are not associated due to hydrogen bonding. As soon as solute is added to alcohol as well as dioxane, the probability of solute forming association with alcohol will be lesser as compared to dioxane as the existing association in alcohol will render less probability of forming association with solute than dioxane.

3.3 Specific acoustic impedance (Z)

Specific acoustic impedance (Z) is useful for the studying the molecular interactions in the solution. The complex ratio of the effective sound pressure at a point to the effective particle velocity at that point gives the conventional approach based on compressibility[15](Parkar S.P. (1982)).

From table no. 1-12 and fig. 8-10, it can be seen that the values of Z changes on changing the structures of Schiff base and in dioxane solvent the values are slight higher than in ethanol solvent indicating hydrogen bonding in ethanol. This indicates that the specific acoustic impedance depends upon the structure of the solvent and the molecular packing in the medium.

Measurement of ultrasonic velocity is the best tool to investigate solute-solvent, solute-solute and ion-solvent interactions.

4. Conclusion

In the present study, acoustic properties like ϕ_k, Z and R_A was determined which explains how the solute-solvent interaction occurs and breaking and making of the structure in the solution takes place in a particular solvent with different concentration and at different temperatures. This helps to find out the stability of the Schiff base ligands in the solution which will further help in deciding the use of the respective Schiff base derivatives in biological, chemical and medicinal sciences. Thus it was thought to be of utmost significance, to study acoustic parameters and compare it with respect to solvents, in order to

investigate solute-solvent, solute-solute interactions. Present investigation concludes that the N-(2'-hydroxy-3'-nitrobenzylidene) -3-substituted pyridine-2-amine Schiff base derivatives were studied for solute-solvent interactions in the solvents 1,4-dioxane - water and ethanol-water and on comparison, is it found that values of apparent molar compressibility (ϕ_k), relative association (R_A) and specific acoustic impedance (Z) are higher showing increased association and structuredness of the solution. The alcohol molecules are well known to be associated as compared to dioxane, which are not associated due to hydrogen bonding

Acknowledgement

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Table 1: Acoustic Parameters at different percentages of 1,4-dioxane-water and ethanol-water mixture.

System: Ligand – B_1 Temp. = 293 K

	1,4-dioxane-water				Ethanol-water			
% Conc.	V x 10^3 (m sec^{-1})	ϕ_k x 10^{-10} (m^3 mol^{-1} pa^{-1})	R_A	Z x 10^6 (kg m^{-2} sec^{-1})	V x 10^3 (m sec^{-1})	ϕ_k x 10^{-10} (m^3 mol^{-1} pa^{-1})	R_A	Z x 10^6 (kg m^{-2} sec^{-1})
75	1.7592	24212.93	1.2523	1.7608	2.37	13326.66	1.1743	2.0722
80	1.7642	21648.19	1.2013	1.7648	2.0464	18447.70	1.1499	1.7458
85	1.8002	10524.06	1.0686	1.7989	2.029	14836.42	1.0823	1.6871
90	1.8018	14195.92	1.1074	1.7994	2.1622	-33853.80	0.8721	1.7701
95	1.8118	-773.23	0.9962	1.8071	2.0558	20882.53	1.1706	1.6791
100	1.9582	16040.75	1.1699	1.9525	2.2162	16414.55	1.1311	1.7781

Table 2: Acoustic Parameters at different percentages of 1,4-dioxane-water and ethanol-water mixture.

System: Ligand – B_2 Temp. = 293 K

	1,4-dioxane-water				Ethanol-water			
% Conc.	V x 10^3 (m sec^{-1})	ϕ_k x 10^{-10} (m^3 mol^{-1} pa^{-1})	R_A	Z x 10^6 (kg m^{-2} sec^{-1})	V x 10^3 (m sec^{-1})	ϕ_k x 10^{-10} (m^3 mol^{-1} pa^{-1})	R_A	Z x 10^6 (kg m^{-2} sec^{-1})
75	2.1388	13720.99	1.1744	2.1426	2.009	22564.33	1.2391	1.7541
80	2.1496	11090.64	1.1262	2.1530	2.1756	14219.56	1.1353	1.8703
85	2.0262	3910.71	1.0293	2.0286	2.0438	14225.44	1.0813	1.7021
90	2.026	7719.15	1.0651	2.0236	2.1926	-34916.79	0.8707	1.8004
95	2.0022	-6306.86	0.9631	1.9962	2.1906	17176.16	1.1365	1.7743
100	2.0064	14818.72	1.1600	1.9997	1.9764	24935.31	1.1700	1.5787

Table 3: Acoustic Parameters at different percentages of 1,4-dioxane-water and ethanol-water mixture.

System: Ligand – B_3 Temp. = 293 K

	1,4-dioxane-water				Ethanol-water			
% Conc.	V x 10^3 (m sec^{-1})	ϕ_k x 10^{-10} (m^3 mol^{-1} pa^{-1})	R_A	Z x 10^6 (kg m^{-2} sec^{-1})	V x 10^3 (m sec^{-1})	ϕ_k x 10^{-10} (m^3 mol^{-1} pa^{-1})	R_A	Z x 10^6 (kg m^{-2} sec^{-1})
75	1.86	20807.95	1.2295	1.8620	1.8506	29046.05	1.2628	1.6022
80	1.6162	27807.98	1.2373	1.6172	1.9326	22873.81	1.1654	1.6394
85	1.6304	17281.80	1.1052	1.6302	1.8518	21909.99	1.1158	1.5399
90	1.7726	15302.20	1.1124	1.7685	1.9938	-28827.20	0.9035	1.6459
95	1.774	550.97	1.0034	1.7698	2.0114	23331.92	1.1659	1.6245
100	1.8176	20315.24	1.1987	1.8113	1.9852	23924.48	1.1781	1.5992

Table 4: Acoustic Parameters at different percentages of 1,4-dioxane-water and ethanol-water mixture.

System: Ligand – B_4 Temp. = 293 K

	1,4-dioxane-water				Ethanol-water			
% Conc.	V x 10^3 (m sec^{-1})	ϕ_k x 10^{-10} (m^3 mol^{-1} pa^{-1})	R_A	Z x 10^6 (kg m^{-2} sec^{-1})	V x 10^3 (m sec^{-1})	ϕ_k x 10^{-10} (m^3 mol^{-1} pa^{-1})	R_A	Z x 10^6 (kg m^{-2} sec^{-1})
75	2.131	13998.00	1.1727	2.1291	1.8328	29362.01	1.2738	1.5956
80	2.0046	14461.01	1.1497	2.0026	1.7762	28850.02	1.2106	1.5218
85	1.9882	4973.21	1.0333	1.9857	1.8032	24341.02	1.1241	1.4972
90	1.9686	9269.22	1.0733	1.9625	1.8384	-22105.77	0.9260	1.5139
95	1.8574	-2183.28	0.9867	1.8503	1.7934	32281.51	1.2221	1.4613
100	1.9858	15399.22	1.1627	1.9769	1.9508	25653.01	1.1800	1.5648

Table 5: Acoustic Parameters at different percentages of 1,4-dioxane-water and ethanol-water mixture.

System: Ligand – B_1 Temp. = 297 K

	1,4-dioxane-water				Ethanol-water			
% Conc.	V x 10^3 (m sec^{-1})	ϕ_k x 10^{-10} (m^3 mol^{-1} pa^{-1})	R_A	Z x 10^6 (kg m^{-2} sec^{-1})	V x 10^3 (m sec^{-1})	ϕ_k x 10^{-10} (m^3 mol^{-1} pa^{-1})	R_A	Z x 10^6 (kg m^{-2} sec^{-1})
75	1.7748	23572.94	1.2501	1.7785	1.9650	25835.28	1.2165	1.6721
80	1.7564	21943.14	1.2029	1.7567	1.8360	28250.05	1.1664	1.5323
85	1.6254	17591.59	1.1050	1.6232	1.7770	26247.58	1.1225	1.4662
90	1.6030	22449.12	1.1500	1.5989	1.7822	-17648.36	0.9194	1.4421
95	1.8166	-848.72	0.9939	1.8094	1.6404	42780.88	1.2442	1.3209
100	1.7762	21842.88	1.2060	1.7673	1.5992	45736.50	1.2597	1.2816

Table 6: Acoustic Parameters at different percentages of 1,4-dioxane-water and ethanol-water mixture.

System: Ligand – B_2 Temp. = 297 K

	1,4-dioxane-water				Ethanol-water			
% Conc.	V x 10^3 (m sec^{-1})	ϕ_k x 10^{-10} (m^3 mol^{-1} pa^{-1})	R_A	Z x 10^6 (kg m^{-2} sec^{-1})	V x 10^3 (m sec^{-1})	ϕ_k x 10^{-10} (m^3 mol^{-1} pa^{-1})	R_A	Z x 10^6 (kg m^{-2} sec^{-1})
75	1.8206	22073.80	1.2381	1.8223	1.9852	25040.74	1.2137	1.6911
80	1.9800	15070.69	1.1548	1.9786	1.9510	22817.76	1.1514	1.6404
85	1.8012	10567.84	1.0672	1.7978	1.9880	16623.49	1.0850	1.6460
90	1.8152	13827.42	1.1032	1.8104	1.8324	-20987.30	0.9184	1.4950
95	1.9786	-5692.19	0.9667	1.9722	1.9282	26828.41	1.1802	1.5543
100	1.8600	18985.34	1.1883	1.8518	1.6386	43095.20	1.2468	1.3104

Table 7: Acoustic Parameters at different percentages of 1,4-dioxane-water and ethanol-water mixture.

System: Ligand – B_3 Temp. = 297 K

	1,4-dioxane-water				Ethanol-water			
% Conc.	V x 10^3 (m sec^{-1})	ϕ_k x 10^{-10} (m^3 mol^{-1} pa^{-1})	R_A	Z x 10^6 (kg m^{-2} sec^{-1})	V x 10^3 (m sec^{-1})	ϕ_k x 10^{-10} (m^3 mol^{-1} pa^{-1})	R_A	Z x 10^6 (kg m^{-2} sec^{-1})
75	1.8088	22445.47	1.2414	1.8114	2.2348	17206.58	1.1763	1.9193
80	1.7984	20515.94	1.1924	1.7971	2.4200	9842.43	1.0703	2.0322
85	1.8506	8921.67	1.0580	1.8477	2.2452	8454.15	1.0452	1.8649
90	1.9514	9760.68	1.0760	1.9445	1.9892	-27917.82	0.8953	1.6261
95	1.8122	-663.15	0.9943	1.8043	2.0104	23621.56	1.1623	1.6183
100	1.9558	16222.72	1.1681	1.9463	1.9846	24727.26	1.1667	1.5831

Table 8: Acoustic Parameters at different percentages of 1,4-dioxane-water and ethanol-water mixture.

System: Ligand – B_4 Temp. = 297 K

	1,4-dioxane-water				Ethanol-water			
% Conc.	V x 10^3 (m sec^{-1})	ϕ_k x 10^{-10} (m^3 mol^{-1} pa^{-1})	R_A	Z x 10^6 (kg m^{-2} sec^{-1})	V x 10^3 (m sec^{-1})	ϕ_k x 10^{-10} (m^3 mol^{-1} pa^{-1})	R_A	Z x 10^6 (kg m^{-2} sec^{-1})
75	1.9652	17820.66	1.2063	1.9660	1.6216	41616.40	1.3097	1.3934
80	1.8548	18645.28	1.1802	1.8535	1.7616	29949.04	1.2088	1.5028
85	1.9842	5109.09	1.0333	1.9804	1.6212	34618.50	1.1681	1.3501
90	1.7736	15273.49	1.1118	1.7690	1.7588	-18443.29	0.9436	1.4543
95	1.7880	122.15	0.9995	1.7815	1.6184	43700.19	1.2569	1.3106
100	1.8152	20472.92	1.1975	1.8064	1.6410	42385.57	1.2520	1.3184

Table 9: Acoustic Parameters at different percentages of 1,4-dioxane-water and ethanol-water mixture.

System: Ligand – B_1 Temp. = 300 K

	1,4-dioxane-water				Ethanol-water			
% Conc.	V x 10^3 (m sec^{-1})	ϕ_k x 10^{-10} (m^3 mol^{-1} pa^{-1})	R_A	Z x 10^6 (kg m^{-2} sec^{-1})	V x 10^3 (m sec^{-1})	ϕ_k x 10^{-10} (m^3 mol^{-1} pa^{-1})	R_A	Z x 10^6 (kg m^{-2} sec^{-1})
75	1.5922	31499.40	1.2922	1.5907	2.0376	23769.06	1.1940	1.7224
80	1.7858	21011.63	1.1939	1.7825	2.0372	20213.85	1.1270	1.7008
85	1.7800	11353.25	1.0706	1.7753	2.1536	11039.04	1.0583	1.7861
90	1.6412	20678.75	1.1405	1.6362	1.9888	-28189.11	0.8986	1.6315
95	1.7842	240.33	1.0004	1.7780	1.9514	25212.21	1.1847	1.5854
100	1.7972	21026.10	1.2027	1.7902	1.9728	24587.09	1.1778	1.5855

Table 10: Acoustic Parameters at different percentages of 1,4-dioxane-water and ethanol-water mixture.

System: Ligand – B_2 Temp. = 300 K

	1,4-dioxane-water				Ethanol-water			
% Conc.	V x 10^3 (m sec^{-1})	ϕ_k x 10^{-10} (m^3 mol^{-1} pa^{-1})	R_A	Z x 10^6 (kg m^{-2} sec^{-1})	V x 10^3 (m sec^{-1})	ϕ_k x 10^{-10} (m^3 mol^{-1} pa^{-1})	R_A	Z x 10^6 (kg m^{-2} sec^{-1})
75	2.0264	16369.02	1.1918	2.0235	1.8648	29238.01	1.2467	1.5981
80	1.9628	15571.11	1.1571	1.9596	1.7900	30107.34	1.1812	1.5002
85	1.8110	10292.13	1.0642	1.8058	1.6460	32974.67	1.1622	1.3708
90	1.9810	8943.82	1.0711	1.9749	1.6424	-11272.51	0.9635	1.3554
95	1.9996	-6208.97	0.9629	1.9923	1.5676	47290.08	1.2729	1.2720
100	1.8270	20032.85	1.1958	1.8195	1.5922	46830.13	1.2560	1.2704

Table 11: Acoustic Parameters at different percentages of 1,4-dioxane-water and ethanol-water mixture.

System: Ligand – B_3 Temp. = 300 K

	1,4-dioxane-water				Ethanol-water			
% Conc.	V x 10^3 (m sec^{-1})	ϕ_k x 10^{-10} (m^3 mol^{-1} pa^{-1})	R_A	Z x 10^6 (kg m^{-2} sec^{-1})	V x 10^3 (m sec^{-1})	ϕ_k x 10^{-10} (m^3 mol^{-1} pa^{-1})	R_A	Z x 10^6 (kg m^{-2} sec^{-1})
75	2.0044	16881.68	1.1970	2.0029	1.8144	31813.91	1.2529	1.5483
80	2.0122	14300.58	1.1478	2.0093	1.9668	21688.66	1.1570	1.6661
85	2.0306	3950.02	1.0256	2.0272	1.8132	23276.10	1.1295	1.5156
90	2.1490	5072.58	1.0427	2.1431	1.7956	-19860.94	0.9321	1.4768
95	2.0404	-7224.90	0.9569	2.0339	1.5946	44431.80	1.2742	1.3026
100	2.0048	14882.66	1.1599	1.9975	1.5816	46574.78	1.2700	1.2732

Table 12: Acoustic Parameters at different percentages of 1,4-dioxane-water and ethanol-water mixture.

System: Ligand – B_4 Temp. = 300 K

	1,4-dioxane-water				Ethanol-water			
% Conc.	V x 10^3 (m sec^{-1})	ϕ_k x 10^{-10} (m^3 mol^{-1} pa^{-1})	R_A	Z x 10^6 (kg m^{-2} sec^{-1})	V x 10^3 (m sec^{-1})	ϕ_k x 10^{-10} (m^3 mol^{-1} pa^{-1})	R_A	Z x 10^6 (kg m^{-2} sec^{-1})
75	1.5794	32163.47	1.2955	1.5776	1.7676	33989.08	1.2646	1.5094
80	1.7576	22026.29	1.2004	1.7546	1.7432	32058.84	1.1977	1.4683
85	1.7298	13248.42	1.0806	1.7248	1.6106	35269.98	1.1715	1.3422
90	1.6326	21106.88	1.1421	1.6271	1.6102	-8932.62	0.9687	1.3272
95	1.7982	-229.58	0.9975	1.7915	1.6388	42021.94	1.2542	1.3298
100	1.7740	21874.05	1.2075	1.7665	1.7712	34466.49	1.2175	1.4195

Graphs

(DW – dioxane-water system; EW – ethanol-water system)

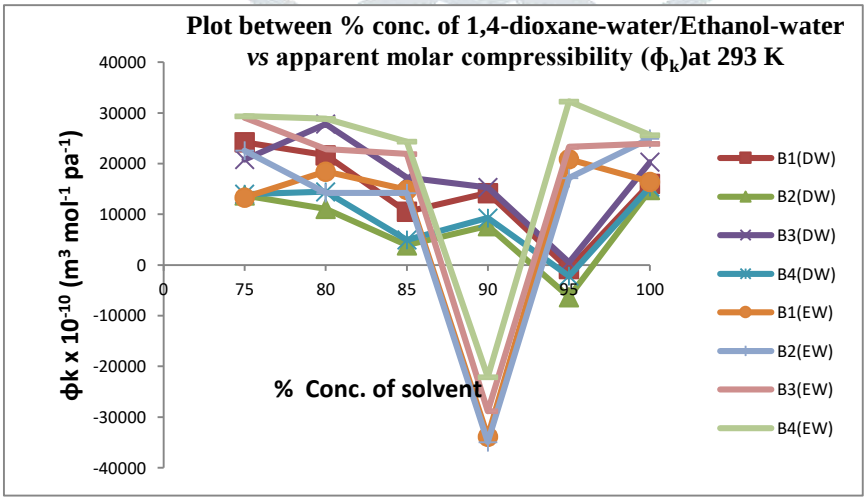

Fig 2: Plot between % conc. of 1,4-dioxane-water/Ethanol-water *vs* apparent molar compressibility (ϕ_k)at 293 K

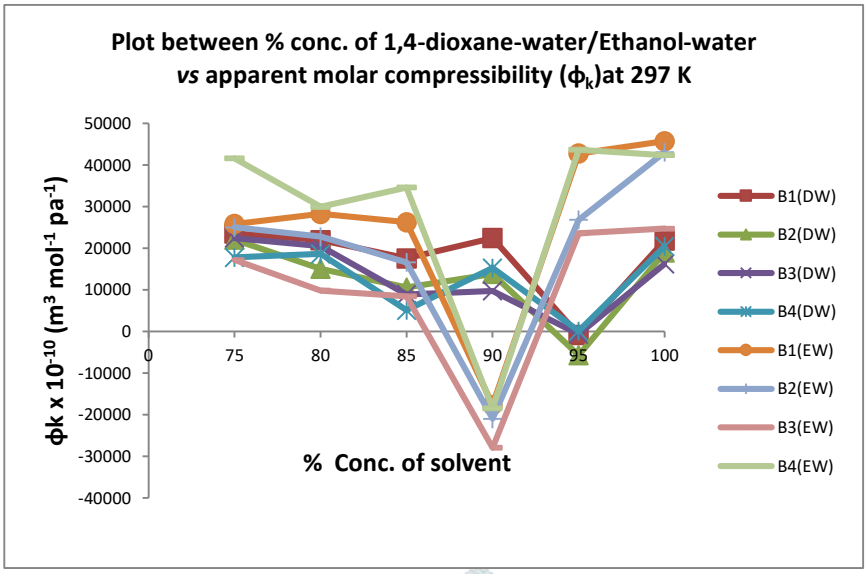

Fig 3: Plot between % conc. of 1,4-dioxane-water/Ethanol-water *vs* apparent molar compressibility (ϕ_k)at 297 K

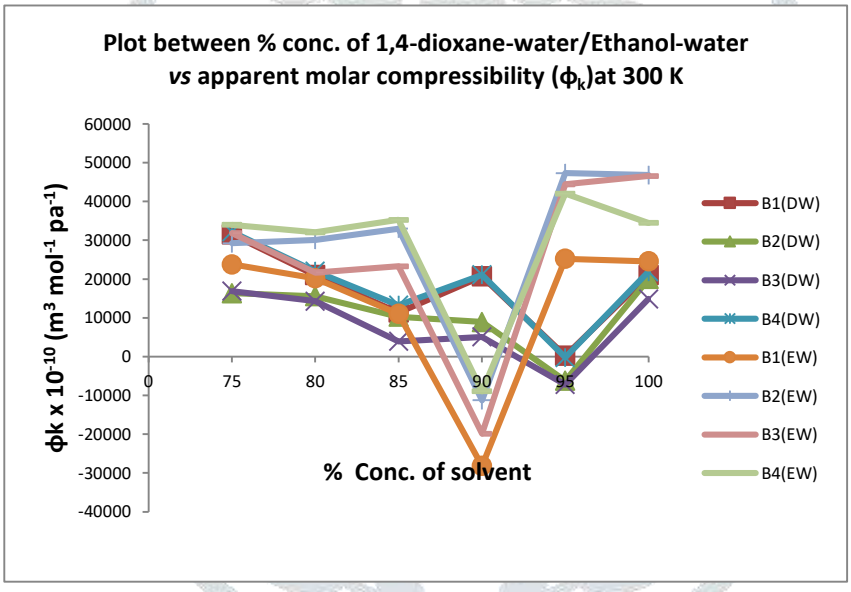

Fig 4: Plot between % conc. of 1,4-dioxane-water/Ethanol-water *vs* apparent molar compressibility (ϕ_k)at 300 K

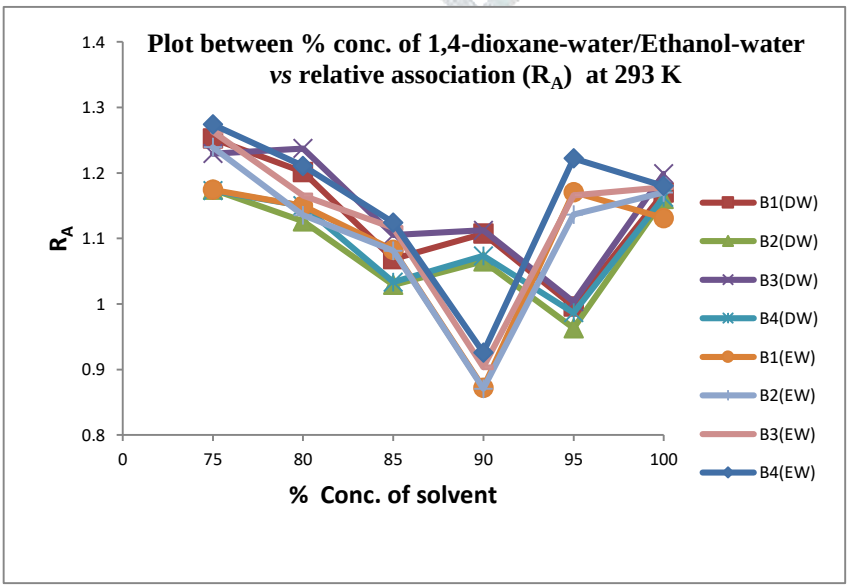

Fig 5: Plot between % conc. of 1,4-dioxane-water/Ethanol-water *vs* relative association (R_A) at 293 K

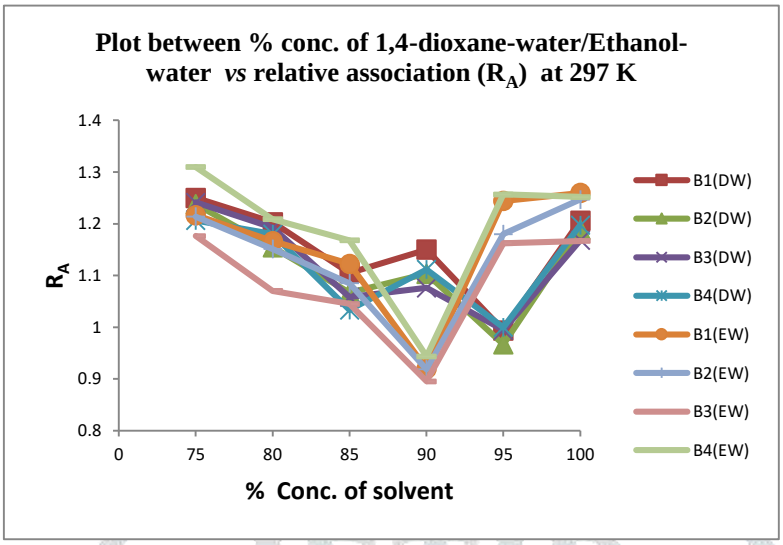

Fig. 6: Plot between % conc. of 1,4-dioxane-water/Ethanol-water *vs* relative association (R_A) at 297 K

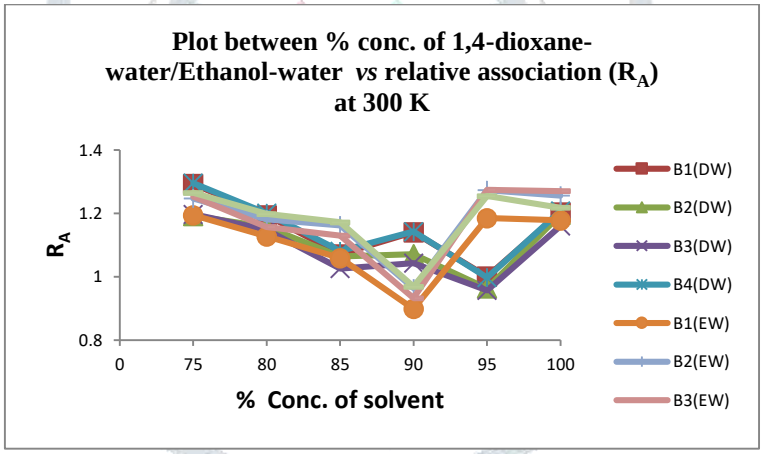

Fig. 7: Plot between % conc. of 1,4-dioxane-water/Ethanol-water *vs* relative association (R_A) at 300 K

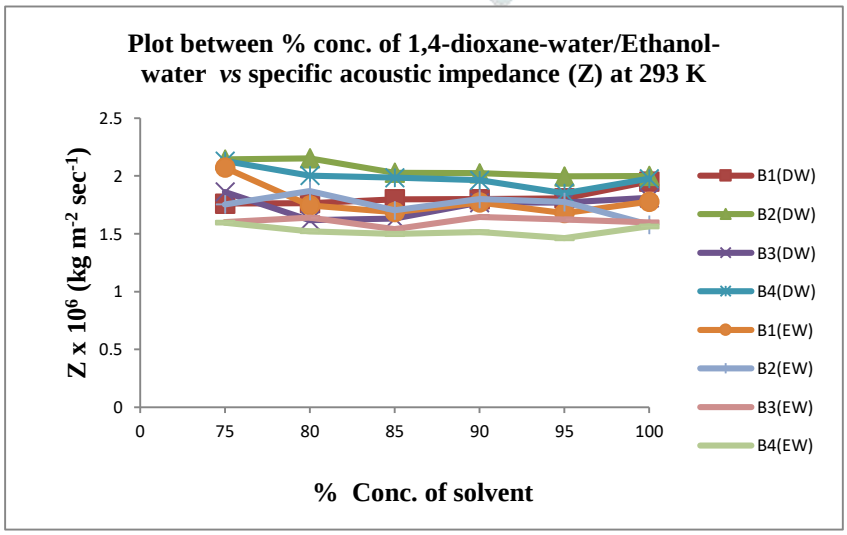

Fig. 8: Plot between % conc. of 1,4-dioxane-water/Ethanol-water *vs* specific acoustic impedance (Z) at 293 K

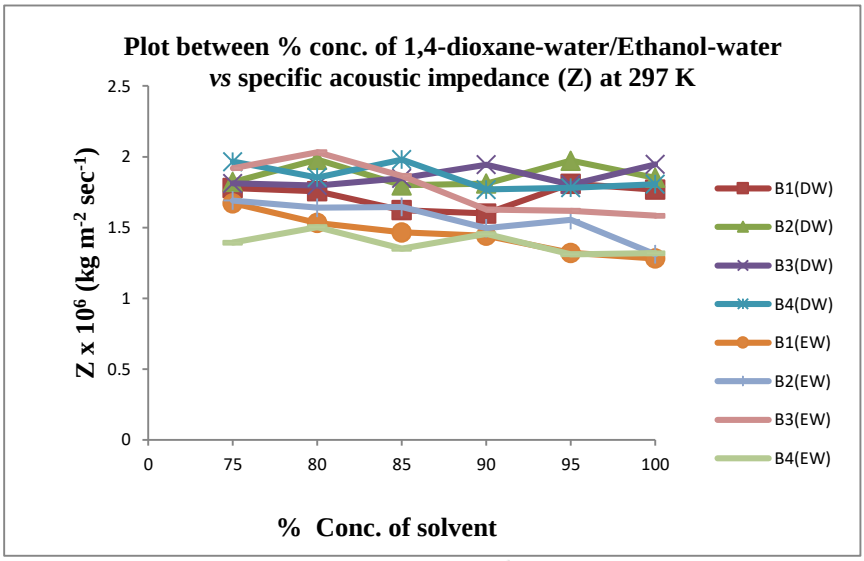

Fig 9: Plot between % conc. of 1,4-dioxane-water/Ethanol-water *vs* specific acoustic impedance (Z) at 297 K

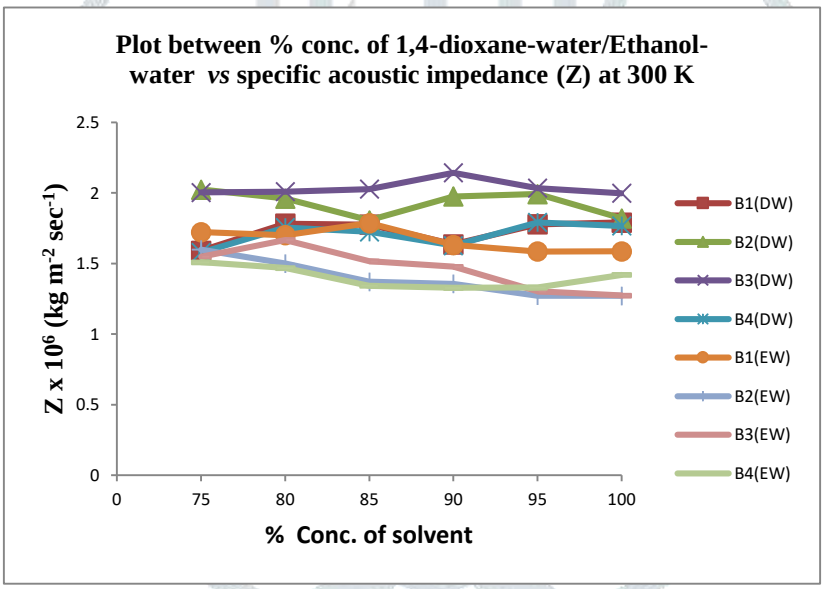

Fig 10: Plot between % conc. of 1,4-dioxane-water/Ethanol-water *vs* specific acoustic impedance (Z) at 300 K

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