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Density & Viscosity studies of cyproheptadine-HCl in mixed binary solvent in presence of additives

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ABSTRACT

The densities and viscosities of cyproheptadine-HCl are determined in binary solvent ethanol-water containing salt NaCl, KCl, $NiCl_2$, $CuCl_2$ and a non electrolyte Glucose. The values are used to calculate excess viscosities, excess molar volume, excess Gibbs free energy of viscous flow and d_{12}, T_{12} and H_{12} parameters. The result reveals that there are specific interaction between drug-metal ion, drug-water, drug-ethanol and water-ethanol.

KEYWORDS

Density;
Viscosity;
Binary solvent;
Cyproheptadine-HCl;
Excess properties;
Thermodynamic properties.

INTRODUCTION

Solvent system is very important since chemical processes, mechanism of reaction, solubility of substances depend on solvent used. The density and viscosity values of mixture are used to calculate thermodynamic properties. Various papers appears on the viscosity and density measurements of drug in single or binary solvent system[1-3].

EXPERIMENTAL

Materials

The salts KCl, NaCl, $NiCl_2$, $CuCl_2$ and nonelectrolyte glucose used were of AR grade. Water used was double distilled over alkaline $KMnO_4$ in quick fit glass assembly (Conductance=$2x10^{-6}$ mhos) Commercial alcohol was refluxed with lime for two hours and then distilled using long fractionating column. The purity of water and ethanol was checked by comparing their measured densities and viscosities with those reported in the literature. The purity of cpd-HCl was checked by its mp.

Apparatus and procedure

A set of solutions of binary solvent mixture (10 to 90% V/V) was prepared. In each solution definite quantity of cpd-HCl and additives were added. The density of different solution mixtures were measured with a set of three pyknometers with single arm capillary and single pan electronic balance (Contech CA, Mumbai) with a precision of 0.0001g. Weighing was repeated thrice to ensure the accuracy in weights with a little interval of time. Reproducibility of the result was close to 100%. Viscosity measurements were performed by using Ostwald's viscometer. The viscometer was clamped vertically in a thermo statistically controlled water bath,

whose temperature was maintained constant at 301.15K (± 0.02). The measurement of flow time of the solution between the two points on the viscometer was performed at least five times for each solution and the result was averaged.

RESULT AND DISCUSSION

Drug profile

The molecular formula of cpd-HCl is $C_{21}H_{21}N$-HCl $3/2H_2O$; its molecular weight is 350.88. The IUPAC name of cpd-HCl is given as 4-(5 H-dibenzo [a, d] cyclohepten-5-ylidene)-1-methylpiperidine Hydrochloride (Figure 1).

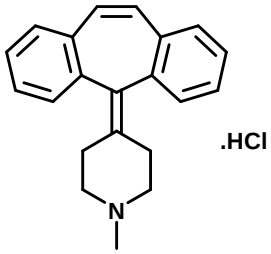

Figure 1 : Cyproheptadine

Excess parameters

The ion solvent interaction cannot be calculated appropri nor can they be experimentally determined. Naturally extra thermodynamic methods are necessary to get ideas about the ion-solvent interaction. The excess volume of binary solvent, in presence of drug and salt solution was calculated by equation,

$$V^E = V_{mix} - X_1V_1 - X_2V_2 \quad (1)$$

Over entire range of concentration for binary system V^E values are found to be negative and changes in parabolic manner with mole fraction of ethanol. V^E depend on the drug, its size, shape and the number of non polar groups attached to it. Liquid mixtures containing hydrogen bonded molecules such as water, alcohols, phenols etc., show pronounced non ideal thermodynamic behavior. The negative values of V^E indicate the packing effect and/or strong interactions between unlike components. The excess viscosities of solution containing cpd-HCl along with additives KCl, NaCl, $NiCl_2$,$CuCl_2$ and Glucose increases and then decreases. The excess volumes are found to be negative (TABLE 1). The very slight negative V^E indicates that the combined effect of specific interactions & free volume contributions is counterbalanced by the dispersion interactions. The large magnitude of V^E may be due to dipole-dipole interactions & n- π type interaction. The n-π interaction is possible if the π- electron of C=C interact with the loan pair of either O– or N – atom in the second component[4]. The negative value of V^E for water + acetonitrile + dimethylsulfoxide over entire range of the mole fraction may be attributed to the difference in size & shape of the component molecules[5]. There are several semi-empirical relations used to correlate the viscosity of binary liquid mixtures. The Grunberg-Nissan interactions parameter, d_{12}, which is regarded as a measure of the strength of interactions between two dissimilar molecules were calculated as,

$$d_{12} = \left[\frac{1n\eta - X1\ln\eta_1 - X_2\ln\eta_2}{X_1X_2}\right] \quad (2)$$

Tamura and Kurata developed the following equations for the viscosity of binary liquid mixtures.

$$\eta = \sum_{i=1}^{2} X_i\phi_i\eta_i + 2T_{12}\prod_{i=1}^{2}(X_i\phi_i)^{1/2} \quad (3)$$

where ϕ_i is the volume fraction. Hind suggested following equation for the viscosity of binary liquid mixtures.

$$\eta = \sum_{i=1}^{2} X_i^2\eta_i + 2H_{12}\prod_{i=1}^{2} X_i \quad (4)$$

where H_{12} is the interaction parameter for a given solution. Among d_{12}, T_{12}, H_{12}, the Grunberg-Nissan parameter provides the best measure to ascertain the strength of interaction for any binary mixture. These parameters decrease with increase in percentage of ethanol. The trend for the Grunberg-Nissan and other excess parameters for the 10% aqueous ethanol in the presence of additives at the 0.002M concentration was found to follow the order $NiCl_2$ < KCl < NaCl < $CuCl_2$ < glucose. The order among these parameters was found to be. $d_{12} < T_{12} < H_{12}$.

Excess free energy

The excess free energy of activation, ΔG^{*E} is given by the difference between the free energy of activation of the mixture and the free energy of activation of the ideal mixture.

$$\Delta G^{-E} = RT(lnnM - x_1\ln n_1M_1 - x_2\ln n_2M_2) \quad (5)$$

where η & M are the viscosity of mixture and the average molecular weight of the components in the mixture

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TABLE 1 : Density, viscosity, excess properties and other thermodynamic parameters of Cyproheptadine hydrochloride

% EtOH	ρ (g cm^{-3})	η (m Pa. s)	η^E (cm^3 mol^{-1})	v^E (J mol^{-1})	ΔG^E	d_{12}	T_{12}	H_{12}
0.002M KCl								
10	0.9754	10.3838	3.3056	-0.2009	16.6624	11.9024	39.5529	59.3563
20	0.9642	13.8378	6.6626	-0.4148	30.0961	9.8484	41.0820	57.9397
30	0.9520	16.7115	9.4224	-0.6473	40.1928	8.0351	40.8078	53.5824
40	0.9347	19.1290	11.7043	-0.7972	49.6940	6.6960	40.5719	49.3423
50	0.9191	20.3370	12.7483	-1.0319	55.7716	5.4921	38.8714	43.4397
60	0.8980	19.7621	11.9709	-1.1450	57.8557	4.3367	35.1405	35.8216
70	0.8763	19.1792	11.1317	-1.2645	60.5598	3.6103	33.5165	31.0796
80	0.8491	16.7450	8.3627	-1.1645	55.5341	2.8476	29.9487	25.1736
90	0.8233	14.6529	5.8145	-1.0854	48.3383	2.6532	30.9291	23.2474
0.004M KCl								
10	0.9752	10.1654	3.087	0.1969	15.6561	11.2450	37.5287	55.9794
20	0.9635	13.5421	6.366	0.3997	29.0754	9.5262	39.6544	55.7341
30	0.9514	16.4753	9.186	0.6332	39.4971	7.8981	40.0084	52.4459
40	0.9383	19.2026	11.7779	0.8908	49.2375	6.7230	40.7710	49.6008
50	0.9178	19.2184	11.6297	0.9939	52.2671	5.1798	36.2429	40.3516
60	0.8964	19.2957	11.5045	1.0915	56.4650	4.2266	34.1188	34.7472
70	0.8759	18.6437	10.5962	1.2490	58.2723	3.4941	32.3331	29.9811
80	0.8478	16.9241	8.5418	1.1040	57.0094	2.8907	30.3992	25.5362
90	0.8245	14.5751	5.7367	1.1537	47.2586	2.6258	30.6345	23.0467
0.006M KCl								
10	0.9754	10.3835	3.3053	0.2009	16.6610	11.9015	39.5501	59.3517
20	0.9642	13.7234	6.5482	0.4148	29.6661	9.7245	40.5297	57.0864
30	0.9514	16.4752	9.1861	0.6332	39.4967	7.8980	40.0080	52.4454
40	0.9363	19.3723	11.9476	0.8389	50.1551	6.7848	41.2300	50.1966
50	0.9179	19.8680	12.2793	0.9968	54.4723	5.3633	37.7694	42.1450
60	0.8970	19.2007	11.4095	1.1116	55.9474	4.2039	33.9106	34.5284
70	0.8754	19.2647	11.2172	1.2295	61.1948	3.6285	33.7055	31.2549
80	0.8472	16.4020	8.0197	1.0760	54.1134	2.7638	29.0860	24.4793
90	0.8235	14.4584	5.6200	1.0968	46.6981	2.5843	30.1927	22.7455
0.008M KCl								
10	0.9754	10.4920	3.4138	0.2009	16.6610	12.2230	40.5557	61.0293
20	0.9655	13.9710	6.7958	0.4427	29.6661	9.9913	41.7251	58.9332
30	0.9510	16.6939	9.4048	0.6238	39.4967	8.0249	40.7483	53.4977
40	0.9370	18.9653	11.5406	0.8571	50.1551	6.6357	40.1292	48.7675
50	0.9164	19.5058	11.9171	0.9528	54.4723	5.2617	36.9183	41.1450
60	0.8968	19.3043	11.5131	1.1049	55.9474	4.2287	34.1376	34.7670
70	0.8571	18.3110	10.2635	0.5031	61.1948	3.4202	31.5978	29.2986
80	0.8521	17.1124	8.7301	1.3036	54.1134	2.9355	30.8728	25.9173
90	0.8233	14.6529	5.8145	1.0854	46.6981	2.6532	30.9291	23.2474
0.01M KCl								
10	0.9750	10.1633	3.0851	-0.1929	15.6691	11.2386	37.5093	55.9470
20	0.9638	13.9464	6.7712	-0.4061	30.5577	9.9650	41.6063	58.7497
30	0.9503	17.0197	9.7306	-0.6073	41.4954	8.2109	41.8510	41.8510
40	0.9366	18.9045	11.4798	-0.8467	48.6122	6.6131	39.9647	48.5540
50	0.9164	19.5058	11.9171	-0.9528	53.5656	5.2617	36.9183	41.1450
60	0.8966	19.6232	11.8320	-1.0982	57.6758	4.3042	34.8362	35.5017
70	0.8752	18.5236	10.4761	-1.2218	57.9221	3.4676	32.0677	29.7347
80	0.8513	16.9940	8.6117	-1.2666	56.2670	2.9074	30.5750	25.6777
90	0.8247	14.4790	5.6406	-1.1651	46.4096	2.5916	30.2707	22.7987
0.002M NaCl								
10	0.9754	10.3849	3.3067	0.2009	16.6675	11.9057	39.5631	59.3733
20	0.9631	13.7078	6.5326	0.3910	29.7621	9.7076	40.4544	56.9701
30	0.9522	16.9408	9.6517	0.6520	40.9200	8.1662	41.5840	54.6857
40	0.9369	18.6470	11.2223	0.8545	47.7220	6.5168	39.2683	47.6499
50	0.9178	19.8141	12.2254	0.9939	54.3121	5.3483	37.6427	41.9962
60	0.8976	20.1850	12.3938	1.1316	59.5388	4.4342	36.0670	36.7958
70	0.8775	20.0496	12.0021	1.3110	63.9750	3.7924	35.4401	32.8650
80	0.8490	17.2544	8.8721	1.1599	58.5191	2.9689	31.2299	26.2048
90	0.8243	14.3238	5.4854	1.1423	45.3012	2.5360	29.6831	22.3982
0.004M NaCl								
10	0.9760	10.2820	3.2038	0.2128	16.1160	11.5977	38.6094	57.7823
20	0.9624	13.5837	6.4085	0.3759	29.3889	9.5719	39.8552	56.0444
30	0.9515	16.7026	9.4135	0.6355	40.2456	8.0300	40.7777	53.5395
40	0.9363	19.0038	11.5791	0.8389	48.9878	6.6499	40.2333	48.9027
50	0.9176	20.4454	12.8567	0.9880	56.4573	5.5215	39.1261	43.7390
60	0.8982	20.3066	12.5154	1.1517	59.8376	4.4619	36.3333	37.0760
70	0.8769	19.6305	11.5830	1.2877	62.3589	3.7057	34.5139	32.0053
80	0.8485	16.3259	7.9436	1.1366	53.2318	2.7450	28.8946	24.3252
90	0.8236	14.3612	5.5228	1.1025	45.8708	2.5495	29.8247	22.4947
0.006M NaCl								
10	0.9753	10.3827	3.3045	0.1989	16.6689	11.8991	39.5427	59.3393
20	0.9623	13.3540	6.178	0.3737	28.5179	9.3175	38.7463	54.3311
30	0.9513	16.6991	9.4100	0.6308	40.2670	8.0279	40.7659	53.5227
40	0.9373	18.9714	11.5467	0.8649	48.6933	6.6379	40.1457	48.7890
50	0.9171	20.6235	13.0348	0.9734	57.1490	5.5694	39.5446	44.2307
60	0.8974	20.0720	12.2808	1.1249	59.1689	4.4083	35.8194	36.5355
70	0.8755	19.3722	11.3247	1.2334	61.6383	3.6514	33.9431	31.4755
80	0.8498	17.0663	8.6840	1.1971	57.1761	2.9245	30.7568	25.8240
90	0.8243	14.3734	5.5350	1.1423	45.7053	2.5539	29.8708	22.5262
0.008M NaCl								
10	0.9752	10.3817	3.3035	-0.1969	16.6758	11.8961	39.5334	59.3238
20	0.9640	13.8349	6.6597	-0.4104	30.1135	9.8453	41.0680	57.9181
30	0.9513	16.5863	9.2972	-0.6308	39.8885	7.9627	40.3841	52.9799

TABLE 1 : Density, viscosity, excess properties and other thermodynamic parameters of Cyproheptadine hydrochloride

% EtOH	ρ (g cm^{-3})	η (m Pa. s)	η^E (cm^3 mol^{-1})	v^E (J mol^{-1})	ΔG^E	d_{12}	T_{12}	H_{12}
40	0.9366	18.7466	11.3219	-0.8467	48.1026	6.5542	39.5377	47.9996
50	0.9170	21.0624	13.4737	-0.9704	58.5831	5.6857	40.5759	45.4424
60	0.8978	19.7577	11.9665	-1.1383	57.8887	4.3356	35.1309	35.8115
70	0.8753	19.7888	11.7413	-1.2257	63.5017	3.7387	34.8637	32.3300
80	0.8520	17.0080	8.6257	-1.2990	56.1191	2.9107	30.6102	25.7060
90	0.8247	14.3803	5.5419	-1.1651	45.6103	2.5563	29.8970	22.5440
0.01M NaCl								
10	0.9756	10.2777	3.1995	0.2049	16.1419	11.5848	38.5695	57.7158
20	0.9625	13.8134	6.6382	0.3781	30.2449	9.8221	40.9642	57.7577
30	0.9526	16.7220	9.4329	0.6614	40.1288	8.0411	40.8434	53.6329
40	0.9366	18.7466	11.3219	0.8467	48.1026	6.5542	39.5377	47.9996
50	0.9160	20.4887	12.9000	0.9411	56.9525	5.5332	39.2279	43.8585
60	0.8993	20.0070	12.2158	1.1883	58.4527	4.3934	35.6770	36.3858
70	0.8757	19.7979	11.7504	1.2412	63.4249	3.7406	34.8838	32.3487
80	0.8478	16.6183	8.2360	1.1040	55.2105	2.8168	29.6300	24.9171
90	0.8250	14.5840	5.7456	1.1821	47.1401	2.6289	30.6682	23.0696
0.002M $NiCl_2$								
10	0.9752	10.0529	2.9747	0.1969	15.1171	10.9009	36.4860	54.2400
20	0.9644	14.0695	6.8943	0.4191	30.9278	10.0961	42.2006	59.6679
30	0.9520	17.1631	9.8740	0.6473	41.6807	8.2917	42.3364	55.7553
40	0.9371	18.8619	11.4372	0.8597	48.3799	6.5973	39.8495	48.4045
50	0.9174	19.7430	12.1543	0.9822	54.1584	5.3285	37.4756	41.7999
60	0.8989	20.1062	12.3150	1.1750	58.9216	4.4162	35.8943	36.6143
70	0.8756	18.7427	10.6952	1.2373	58.8066	3.5158	32.5519	30.1842
80	0.8523	17.6280	9.2457	1.3128	59.5349	3.0556	32.1696	26.9611
90	0.8226	14.6405	5.8021	1.0455	48.5065	2.6489	30.8821	23.2154
0.004M $NiCl_2$								
10	0.9753	10.2746	3.1964	0.1989	16.1620	11.5755	38.5408	57.6679
20	0.9635	13.4850	6.3098	0.3997	28.8564	9.4631	39.3787	55.3082
30	0.9510	16.3555	9.0664	0.6238	39.1552	7.8279	39.6029	51.8694
40	0.9374	18.2355	10.8108	0.8675	46.2726	6.3601	38.1553	46.2050
50	0.9181	19.8732	12.2845	1.0026	54.4462	5.3648	37.7816	42.1593
60	0.8970	19.7401	11.948	1.1116	58.0210	4.3315	35.0923	35.7710
70	0.8753	18.4204	10.3729	1.2257	57.4196	3.4447	31.8396	29.5230
80	0.8520	17.4178	9.0355	1.2990	58.4565	3.0071	31.6409	26.5356
90	0.8244	14.4392	5.6008	1.1480	46.2015	2.5774	30.1200	22.6960
0.006M $NiCl_2$								
10	0.9764	10.2862	3.2080	-0.2208	16.0895	11.6104	38.6483	57.8572
20	0.9650	13.5059	6.3307	-0.4320	28.7269	9.4862	39.4796	55.4641
30	0.9510	16.4683	9.1792	-0.6238	39.5391	7.8940	39.9847	52.4122
40	0.9381	18.3546	10.9299	-0.8856	46.5359	6.4058	38.4774	46.6232
50	0.9177	19.6438	12.0551	-0.9909	53.7555	5.3007	37.2425	41.5260

TABLE 1 : Density, viscosity, excess properties and other thermodynamic parameters of Cyproheptadine hydrochloride

% EtOH	ρ (g cm^{-3})	η (m Pa. s)	η^E (cm^3 mol^{-1})	v^E (J mol^{-1})	ΔG^E	d_{12}	T_{12}	H_{12}
60	0.8981	19.8723	12.0811	-1.1483	58.2465	4.3623	35.3819	36.0755
70	0.8749	18.8320	10.7845	-1.2101	59.4092	3.5353	32.7492	30.3673
80	0.8526	17.3276	8.9453	-1.3267	57.7497	2.9861	31.4140	26.3530
90	0.8226	14.7395	5.9011	-1.0455	49.2961	2.6836	31.2569	23.4708
0.008M $NiCl_2$								
10	0.9755	10.2767	3.1985	0.2029	16.1488	11.5818	38.5603	57.7003
20	0.9648	13.7320	6.5568	0.4277	29.6142	9.7339	40.5712	57.1506
30	0.9518	17.2724	9.9833	0.6426	42.0683	8.3528	42.7063	56.2812
40	0.9387	18.5775	11.1528	0.9012	47.1549	6.4906	39.0803	47.4059
50	0.9180	19.5399	11.9512	0.9997	53.3352	5.2714	36.9984	41.2392
60	0.8971	19.4700	11.6788	1.1149	56.9650	4.2680	34.5006	35.1488
70	0.8745	18.7191	10.6716	1.1945	59.0124	3.5107	32.4997	30.1358
80	0.8519	17.1084	8.7261	1.2943	56.7297	2.9345	30.8627	25.9092
90	0.8229	14.6458	5.8074	1.0626	48.4343	2.6507	30.9022	23.2291
0.01M $NiCl_2$								
10	0.9757	10.4952	3.4170	0.2069	17.1441	12.2324	40.5854	61.0788
20	0.9655	13.8565	6.6813	0.4427	29.9828	9.8685	41.1723	58.0792
30	0.9516	17.2586	9.9695	0.6379	42.0571	8.3451	42.6596	56.2148
40	0.9380	19.4075	11.9828	0.8830	49.9387	6.7975	41.3252	50.3202
50	0.9176	19.6417	12.0530	0.9880	53.7701	5.3001	37.2376	41.5202
60	0.8979	20.1918	12.4006	1.1416	59.4889	4.4358	36.0819	36.8115
70	0.8758	19.2735	11.2260	1.2451	61.1188	3.6304	33.7249	31.2730
80	0.8526	17.2250	8.8427	1.3267	57.1671	2.9620	31.1560	26.1453
90	0.8239	14.6636	5.8252	1.1196	48.1948	2.6570	30.9696	23.2750
0.002M $CuCl_2$								
10	0.9765	11.0030	3.9248	0.2228	19.3363	13.6935	45.2918	68.9303
20	0.9649	13.6190	6.4438	0.4298	29.1725	9.6106	40.0257	56.3077
30	0.9508	16.1265	8.8374	0.6191	38.4003	7.6922	38.8278	50.7675
40	0.9381	18.3546	10.9299	0.8856	46.5359	6.4058	38.4774	46.6232
50	0.9177	19.6438	12.0551	0.9909	53.7555	5.3007	37.2425	41.5260
60	0.9879	19.8679	12.0767	3.8727	37.9184	4.3613	35.3723	36.0654
70	0.8751	19.0477	11.0002	1.2179	60.3191	3.5821	33.2259	30.8098
80	0.8511	16.9900	8.6077	1.2573	56.3092	2.9064	30.5649	25.6696
90	0.8216	14.2275	5.3891	0.9883	45.5327	2.5012	29.3185	22.1498
0.004M $CuCl_2$								
10	0.9751	10.8715	3.7933	0.1949	18.9204	13.3217	44.0730	66.8971
20	0.9652	13.7377	6.5625	0.4363	29.5795	9.7401	40.5987	57.1931
30	0.9521	16.3744	9.0853	0.6496	39.0393	7.8390	39.6668	51.9604
40	0.9378	18.7706	11.3459	0.8778	47.9524	6.5632	39.6026	48.0839
50	0.9172	19.0816	11.4929	0.9763	51.9178	5.1403	35.9215	39.9739
60	0.8962	19.8302	12.0390	1.0848	58.5614	4.3525	35.2897	35.9785
70	0.8740	19.0237	10.9762	1.1750	60.5268	3.5769	33.1729	30.7606

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TABLE 1 : Density, viscosity, excess properties and other thermodynamic parameters of Cyproheptadine hydrochloride

% EtOH	ρ (g cm^{-3})	η (m Pa. s)	η^E (cm^3 mol^{-1})	v^E (J mol^{-1})	ΔG^E	d_{12}	T_{12}	H_{12}
80	0.8501	17.1846	8.8023	1.2110	57.7572	2.9525	31.0544	26.0635
90	0.8243	14.0760	5.2376	1.1423	43.2609	2.2260	28.7449	21.7589
0.006M $CuCl_2$								
10	0.9756	10.9928	3.9146	0.2049	19.398	13.6649	45.1972	68.7726
20	0.9653	13.6264	6.4512	0.4384	29.1446	9.6187	40.0614	56.3629
30	0.9515	16.5898	9.3007	0.6355	39.8673	7.9647	40.3959	52.9968
40	0.938	18.8801	11.4554	0.8830	48.2673	6.6040	39.8987	48.4684
50	0.9169	19.1856	11.5969	0.9675	52.3470	5.1703	36.1659	40.2610
60	0.8984	19.9870	12.1958	1.1583	58.6020	4.3888	35.6332	36.3397
70	0.8757	19.2713	11.2238	1.2412	61.1378	3.6299	33.7201	31.2685
80	0.8491	16.5412	8.1589	1.1645	54.3279	2.7980	29.4361	24.7610
90	0.8236	14.3612	5.5228	1.1025	45.8708	2.5495	29.8247	22.4947
0.008M $CuCl_2$								
10	0.9759	10.9962	3.9180	0.2108	19.3777	13.6744	45.2287	68.8252
20	0.9649	13.5045	6.3293	0.4298	28.7355	9.4847	39.4729	55.4537
30	0.9524	16.7185	9.4294	0.6567	40.1501	8.0391	40.8315	53.6160
40	0.9374	18.4464	11.0217	0.8675	46.9706	6.4408	38.7257	46.9455
50	0.9174	19.637	12.0483	0.9822	53.7976	5.2987	37.2266	41.5072
60	0.8982	19.7665	11.9753	1.1517	57.8226	4.3377	35.1501	35.8318
70	0.8758	19.1682	11.1207	1.2451	60.6541	3.6079	33.4922	31.0570
80	0.8503	16.8718	8.4895	1.2203	55.8844	2.8781	30.2676	25.4303
90	0.8240	14.1699	5.3315	1.1253	44.1511	2.4803	29.1005	22.0011
0.01M $CuCl_2$								
10	0.9759	11.2277	4.1495	0.2108	20.3861	14.3187	47.3743	72.4046
20	0.9649	13.6190	6.4438	0.4298	29.1725	9.6106	40.0257	56.3077
30	0.9534	16.9622	9.6731	0.6801	40.7917	8.1784	41.6564	54.7886
40	0.9374	18.3409	10.9162	0.8675	46.6224	6.4006	38.4404	46.5751
50	0.9137	19.0712	11.4825	0.8733	52.6383	5.1373	35.8971	39.9452
60	0.8983	19.4440	11.6528	1.1550	56.5684	4.2619	34.4436	35.0889
70	0.8757	18.7448	10.6973	1.2412	58.7878	3.5163	32.5565	30.1885
80	0.8498	16.7597	8.3774	1.1971	55.3918	2.8511	29.9857	25.2034
90	0.8237	14.2630	5.4246	1.1082	45.0302	2.5141	29.4529	22.2414
0.002M Glucose								
10	0.9735	11.3097	4.2315	0.1630	21.0277	14.5437	48.1343	73.6725
20	0.9615	14.0223	6.8471	0.3564	31.1663	10.0460	41.9727	59.3158
30	0.9492	17.0104	9.7213	0.5813	41.6484	8.2057	41.8195	55.0206
40	0.9358	19.7773	12.352	0.8258	51.5095	6.9301	42.3253	51.6187
50	0.9181	19.8571	12.2684	1.0026	54.3919	5.3603	37.7437	42.1149
60	0.8952	19.6937	11.9025	1.0512	58.2934	4.3207	34.9907	35.6641
70	0.8741	18.1492	10.1017	1.1789	56.4985	3.3838	31.2402	28.9667
80	0.8536	17.1961	8.8138	1.3727	56.6754	2.9552	31.0833	26.0868

TABLE 1 : Density, viscosity, excess properties and other thermodynamic parameters of Cyproheptadine hydrochloride

% EtOH	ρ (g cm^{-3})	η (m Pa. s)	η^E (cm^3 mol^{-1})	v^E (J mol^{-1})	ΔG^E	d_{12}	T_{12}	H_{12}
90	0.8261	14.7022	5.8638	1.2445	47.6650	2.6706	31.1157	23.3746
0.004M Glucose								
10	0.9740	11.3155	4.2373	-0.1730	20.9921	14.5596	48.1881	73.7622
20	0.9625	14.3937	7.2185	-0.3781	32.3802	10.4359	43.7658	62.0860
30	0.9506	17.3879	10.0988	-0.6143	42.6415	8.4169	43.0973	56.8370
40	0.9354	20.0001	12.5754	-0.8154	52.2686	7.0088	42.9279	52.4010
50	0.9141	20.3355	12.7468	-0.8852	56.8690	5.4917	38.8679	43.4356
60	0.8970	19.8996	12.1084	-1.1116	58.6233	4.3686	35.4417	36.1384
70	0.8737	18.4649	10.4174	-1.1633	58.0777	3.4546	31.9379	29.6143
80	0.8525	17.2793	8.8970	-1.3221	57.5087	2.9748	31.2925	26.2552
90	0.8148	14.1990	5.3606	-0.5958	47.8948	2.4909	29.2105	22.0762
0.006M Glucose								
10	0.9750	11.4476	4.3694	-0.1929	21.4337	14.9185	49.4124	75.8047
20	0.9631	14.7598	7.5846	-0.3910	33.5964	10.8106	45.5333	64.8167
30	0.9516	17.9942	10.7051	-0.6379	44.3871	8.7467	45.1494	59.7543
40	0.9353	19.9979	12.5732	-0.8128	52.2814	7.0080	42.9220	52.3933
50	0.9169	20.1711	12.5824	-0.9675	55.7059	5.4469	38.4816	42.9817
60	0.8959	19.5984	11.8072	-1.0747	57.7552	4.2983	34.7819	35.4445
70	0.8764	18.6302	10.5827	-1.2684	58.0693	3.4911	32.3032	29.9534
80	0.8534	17.1921	8.8098	-1.3635	56.7180	2.9543	31.0732	26.0787
90	0.8139	13.9821	5.1437	-0.5434	46.4190	2.4114	28.3893	21.5166
0.008M Glucose								
10	0.9753	11.5717	4.4935	-0.1989	21.9196	15.2519	50.5626	77.7235
20	0.9639	14.7125	7.5373	-0.4083	33.3142	10.7627	45.3050	64.4639
30	0.9515	17.6396	10.3505	-0.6355	43.2929	8.5552	43.9492	58.0481
40	0.9378	20.1673	12.7426	-0.8778	52.3074	7.0672	43.3802	52.9881
50	0.9170	20.6266	13.0379	-0.9704	57.1812	5.5702	39.5519	44.2393
60	0.8980	19.8663	12.0751	-1.1450	58.2488	4.3609	35.3688	36.0617
70	0.8741	18.5814	10.5339	-1.1789	58.4988	3.4804	32.1954	29.8533
80	0.8528	17.0746	8.6923	-1.3359	56.2415	2.9265	30.7777	25.8408
90	0.8154	14.2094	5.3710	-0.6307	47.7504	2.4946	29.2499	22.1031
0.01M Glucose								
10	0.9756	11.5752	4.4970	-0.2049	21.8977	15.2613	50.5950	77.7777
20	0.9642	14.8958	7.7206	-0.4148	33.9122	10.9474	46.1899	65.8311
30	0.9530	17.9029	10.6138	-0.6708	43.8666	8.6978	44.8404	59.3150
40	0.9391	19.3828	11.9581	-0.9115	49.6508	6.7886	41.2584	50.2335
50	0.9169	20.6244	13.0357	-0.9675	57.1962	5.5696	39.5467	44.2332
60	0.9010	20.3781	12.5869	-1.2448	59.4001	4.4781	36.4900	37.2407
70	0.8779	19.0961	11.0486	-1.3264	59.7359	3.5925	33.3329	30.9091
80	0.8525	16.6471	8.2648	-1.3221	53.8517	2.8239	29.7025	24.9754
90	0.8161	14.1208	5.2824	-0.6713	46.7427	2.4624	28.9145	21.8745

TABLE 2 : Limiting apparent molar volumes in ethanol

Conc. (M)	KCl		NaCl		$NiCl_2$		$CuCl_2$		Glucose	
	ϕ_v^0	S_v	ϕ_v^0	S_v	ϕ_v^0	S_v	ϕ_v^0	S_v	ϕ_v^0	S_v
0.002	44.6361	0.6596	44.7476	0.6444	44.6395	0.6514	43.7612	0.5595	45.9350	0.5415
0.004	44.7241	0.6542	44.6991	0.6554	44.8401	0.6341	44.5408	0.6691	45.2016	0.6481
0.006	44.5979	0.6726	44.9481	0.6324	44.2356	0.6882	44.3791	0.6804	44.7138	0.6801
0.008	44.3893	0.7256	44.8462	0.6333	44.4324	0.6727	44.3353	0.6789	44.4283	0.6983
0.01	45.0019	0.6266	44.7624	0.6489	44.3952	0.6673	44.3177	0.6886	44.1761	0.6990

TABLE 3 : A- and B- coefficient values

%	KCl		NaCl		$NiCl_2$		$CuCl_2$		Glucose	
	A	B	A	B	A	B	A	B	A	B
10	-67.0203	9.3157	-67.7893	11.6896	-50.5261	7.9283	-79.1113	11.4576	-85.4311	12.6769
20	-83.0287	11.9421	-82.3274	9.9786	-94.469	12.7569	-85.6398	11.9041	-77.2731	12.4982
30	-61.3766	8.9356	-73.927	14.6214	-80.1925	10.7539	-45.5448	7.525	-63.9715	10.1757
40	-114.4352	15.8394	-103.0292	12.0695	-98.2234	14.0947	-99.2951	14.0472	-124.906	17.4635
50	-100.9997	13.2418	-76.9416	12.9025	-89.4022	12.316	-86.7159	11.7585	-79.1543	12.0927
60	-84.6739	11.5043	-94.8459	14.5336	-89.2584	12.2792	-88.9395	12.1635	-76.2668	11.2484
70	-98.5366	12.9552	-106.5171	9.5546	-75.9747	11.1747	-90.1068	12.5569	-63.5571	9.975
80	-58.4464	8.4924	-71.4805	3.8319	-86.5723	10.6466	-70.8398	9.5184	-76.1423	10.1551
90	-32.6785	4.6351	-25.4377	11.6896	-31.8466	4.5771	-25.302	3.6265	-41.4544	4.9441

respectively η_1, x_1 & M_1 represent the viscosity, mole fraction & the molecular weight of the i^{th} component.

The Gibbs free energy in KJ/mole increases up to 70% ethanol and then decreases in presence of different additives table. For alkali metal ions it is almost constant ΔG^{*E} values of these drug is found to be higher in Cu^{+2} compare to Ni^{+2}, which may be attributed to atomic size of these ions .The free energy change for cpd-HCl in the presence of glucose is found to be high and these might be due to co-valent type of non-electrostatic interaction among the components of the system.

Apparent molar volume

The apparent molar volume of cpd-HCl in 0.002, 0.004, 0.006, 0.008 and 0.01M salt, prepared in binary solvent, have been calculated from density data by using eq. (6).

$$\phi_v = \frac{M_2}{\rho^\circ} - \frac{1000(\rho - \rho^\circ)}{m\rho\rho^\circ} \quad (6)$$

where ρ^o is the density of binary solvent, ρ is the density of solution, m is the molality of solution and M_2 is the molecular weight of cpd-HCl. These values are used to calculate the limiting apparent volume. (TABLE 2).

$$\phi_{v=} \phi^o_v + S_v C^{1/2} \quad (7)$$

where ϕ^o_v and S_v are calculated from the intercept and slope of the extrapolation of ϕ_v versus $C^{1/2}$ (not shown).

The Sv in above equation can be attributed to be as a measure of ion-ion or solute-solute interactions.

Jones-Doles parameters

The viscosity data was used to calculate Jones-Dole parameters.

$$\eta_r - 1 = AC + B \quad (8)$$

In the eq. (8), B is called as B-viscosity coefficient. This coefficient is a measure of the effective hydrodynamic volume of the solvated ions and it denote the order or disorder introduced by the ions into solvent structure. A-coefficient represents the contribution from interionic electrostatic force. For the present study it was observed that A-coefficient varies with composition of solvent, it decreases up to 70% ethanol but increases for KCl, but for other system no regular trend was observed (TABLE 4). The B-coefficient values are found to be positive but the trend is not regular. The values of B-coefficient of cpd-HCl with $CuCl_2$ and $NiCl_2$ salts are greater than cpd-HCl with alkali metal salt solutions. This leads to a conclusion that Cu (II) & Ni (II), d-block elements, may have greater electrostatic

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TABLE 4 :Density and Viscosity of Cyproheptadine-HCl in absence of Additives in ethanol- water binary solvent system

% Ethanol-water	ρ	η
0	0.9775	3.8678
10	0.9651	4.9274
20	0.9441	5.8654
30	0.9406	7.2247
40	0.9261	8.1366
50	0.9083	8.4282
60	0.8845	8.4296
70	0.8621	7.7210
80	0.8521	7.1782
90	0.8196	6.1373
100	0.7946	5.1387

interactions, and hence the greater is the size of solvation. These values indicate that A-coefficient is negative and B- coefficient is positive (TABLE 3) .The B coefficient first increases and then decreases with percentage of ethanol. The values of A-coefficient are observed to be negative and B-coefficients are positive for amino acids in aqueous 1,4-butanediol solutions[6]

Fahimuddin et.al.[7] measured viscosity of KCl & CsCl in water - butanol solvent mixture. The viscosity data obtained fitted to Jones-Dole equation showed that the value of A is low at low butanol content, may be due to the fact that the degree of hydration is greater than the ion-ion interaction. The B- coefficient values are positive for KCl & increased with increase in percent composition of the mixture. Butanol is generally considered a bulkier, less structural than water; it does not show strong H- bonding. The variation of B–values with change in percentage composition represents the electrostatic ion-solvent interaction in aqueous butanol.

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