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DENSITIES, VISCOSITIES AND CONDUCTANCE BEHAVIOUR OF TRIMETHYL AMMONIUM HYDROCHLORIDE IN ACETONE AND WATER MIXTURE AT VARIOUS CONCENTRATIONS AND TEMPERATURES

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ABSTRACT

Densities, viscosities and conductance of trimethyl ammonium hydrochloride in acetone - water mixtures were measured as a function of the composition of various concentration (0.02, 0.04, 0.06 and 0.08 M) at 298, 303, 308, 313 and 318 K. The obtained results were then analysed by the Masson's equation, Jones-Dole equation, Debye-Huckel-Onsager and Krauss-Bay equation. The results indicating presence of ion-ion and ion-solvent interactions making them salt structure makers. The studied Walden product increased with increase in amount of co-solvent with water.

Key words: Density, Viscosity, Conductance, Debye-Huckel-Onsager equation.

INTRODUCTION

The thermodynamic properties of multi-component liquid mixtures and their analysis are important in an industrial process. The densities, viscosities and conductance enable us to get a clear understanding of the intermolecular interactions in binary[1-3] and tertiary[4-7] liquid mixtures. The apparent molar volumes of electrolyte at infinite dilution, B parameter of Jones-Dole equation, molar conductance at infinite dilution and Walden product studies give us a further understanding on the nature of solute-solvent interactions[8]. In this paper, we have reported experimental data of densities (ρ), viscosities (η) and conductance (λ) of tertiary mixtures of acetone - water - trimethyl ammonium hydrochloride at different temperatures of 298, 303, 308, 313 and 318 K and at various concentrations of 0.02, 0.04, 0.06 and 0.08 M. These models are studied with the purpose to provide new information about these mixtures and to give a qualitative interpretation in terms of

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molecular interactions of Masson's equation, Jones-Dole equation, Debye-Huckel-Onsager equation and Krauss-Bay equation.

EXPERIMENTAL

Acetone and trimethyl ammonium hydrochloride used were AR grade (sd fine Chem.) chemicals. These chemicals were used without further purification. The water used was double-distilled, deionised water and filtered twice. The solvent mixtures (0 to 100% by weight) and solutions of various concentrations of electrolytes (0.02, 0.04, 0.06 and 0.08 M) were prepared by using digital electronic balance with an accuracy of 0.0001 g.

Viscosities were measured using a Cannon-Ubbelhode viscometer with an accuracy of ± 0.1%. A thoroughly cleaned and perfectly dried viscometer filled with liquid was placed vertically in a glass-sided water thermostat. An electronic digital stop-watch with readability of ± 0.01 sec. was used for the flow time measurements.

Densities of solutions were measured with the help of a pycknometer with a bulb of capacity 7.5 cc with an accuracy of ± 0.0001 g.

Conductance was measured by using precision digital conductivity meter (ELICO make). All measurements were made in a thermostat maintained at 298, 303, 308, 313 and 318 K (± 0.05^{o}C).

RESULTS AND DISCUSSION

The measured densities, viscosities and conductance at different concentrations (0.02, 0.04, 0.06 and 0.08 M) and temperatures (298, 303, 308, 313 and 318 K) were further analysed with the following equations.

(i) Debye-Huckel-Onsager equation

$$\lambda_m = \lambda^o_m - (A - B\,\lambda^o_m)\sqrt{c}$$

where, λ_m is molar conductance, λ^o_m is limiting molar conductance at infinite dilution, c is molar concentration.

(ii) Krauss- Bay equation

$$\frac{1}{\lambda_m} = \frac{1}{\lambda^o_m} + \frac{c}{{\lambda^o_m}^2}\,\frac{\lambda_m}{K_e}$$

(iii) Masson's equation

$$\varphi_v = \varphi_v^o + S_v^* \sqrt{c}$$

where, φ_v is apparent molar volume, φ_v^o is limiting apparent molar volume, S_v^* is slope and c is molar concentration.

(iv) Jone's – Dole Equation

$$\frac{(\eta/\eta_o - 1)}{\sqrt{c}} = A + B\sqrt{c}$$

where, η and η_o are viscosities of solution and solvent respectively, A is intercept, B is slope and c is molal concentration.

The experimental values of density (ρ) and viscosity (η) and equivalent conductance (λ_m) for tertiary liquid systems (Acetone – H_2O – TMAH) at 298, 303, 308, 313 and 318 K have been given in Tables 1, 2 and 3. The values of φ_v^o and S_v^* are recorded in Table 4. The slope S_v^* in Masson's equation may be attributed to be as a measure of ion-ion or solute-solute interactions[9-11]. The high and positive values account for strong solute-solute interactions in acetone – water – TMAH solutions.

The parameters A and B of Jones – Dole Equation are stated in Table 5. Parameter A represents the contribution from solute-solute interactions[12]. The positive values of A indicate strong solute-solute interactions. The B parameter measures the structure making or structure breaking capacity of an electrolyte in solution and is responsible for solute-solvent interactions in a solvent[13]. The values of B coefficient are positive at all temperatures suggesting ion-solvent interactions.

The limiting molar conductance at infinite dilution (λ_{0m}) for various compositions at different temperatures is given in Table 6. Table 7 and 8 give us the values of K_c from Krauss Bay equation and Walden product, respectively. The dissociation constant K_c is calculated from the slope of Kraus Bay linear plot of $1/\lambda_m$ versus c λ_m. The K_c values show a general decrease with increase in temperature. The variation of K_c with percentage composition and temperature is primarily due to change in dielectric constant and it also indicates that the electrolytes cause a reduction in thickness of the ionic atmosphere surrounding ionic species.

Walden product shows the dependence of conductance on the viscosity of the medium. It increased with increase in amount of co-solvent with water. It is maximum at 50% and decreases slowly further. The Walden product values also increase regularly with rise in temperature.

Table 1: Densities of THF – H_2O – Monomethyl ammonium hydrochloride at temperature 298, 303, 308, 313 and 318 K at 0.02, 0.04, 0.06, 0.08 M concentrations

	0.02 M						0.06 M				
% wt.	ρ_{298}	ρ_{303}	ρ_{308}	ρ_{313}	ρ_{318}	**% wt.**	ρ_{298}	ρ_{303}	ρ_{308}	ρ_{313}	ρ_{318}
10	0.9852	0.9847	0.9842	0.9812	0.9752	**10**	0.9858	0.9853	0.9849	0.9819	0.9759
20	0.9761	0.9706	0.9678	0.9644	0.9614	**20**	0.9768	0.9713	0.9684	0.9651	0.9621
30	0.9639	0.9544	0.9511	0.9509	0.9493	**30**	0.9646	0.9551	0.9518	0.9516	0.95
40	0.9557	0.9444	0.9427	0.9416	0.9366	**40**	0.9562	0.9451	0.9434	0.9423	0.9374
50	0.9462	0.9356	0.9343	0.9339	0.9286	**50**	0.9469	0.9363	0.935	0.9346	0.9294
60	0.9319	0.9282	0.9261	0.9208	0.9139	**60**	0.9326	0.9289	0.9268	0.9215	0.9146
70	0.9188	0.9152	0.913	0.9112	0.9031	**70**	0.9195	0.9159	0.9137	0.912	0.9039
80	0.8999	0.8964	0.8936	0.8918	0.8758	**80**	0.9006	0.8971	0.8945	0.8926	0.8766
90	0.8696	0.8662	0.8629	0.8611	0.8371	**90**	0.8704	0.867	0.8637	0.8619	0.8379

	0.04 M						0.08 M				
% wt.	ρ_{298}	ρ_{303}	ρ_{308}	ρ_{313}	ρ_{318}	**% wt.**	ρ_{298}	ρ_{303}	ρ_{308}	ρ_{313}	ρ_{318}
10	0.9855	0.985	0.9846	0.9816	0.9756	**10**	0.9862	0.9857	0.9853	0.9822	0.9763
20	0.9765	0.9709	0.9681	0.9647	0.9618	**20**	0.9771	0.9716	0.9688	0.9654	0.9625
30	0.9643	0.9548	0.9514	0.9512	0.95	**30**	0.9649	0.9555	0.9521	0.952	0.9504
40	0.9559	0.9447	0.943	0.942	0.937	**40**	0.9566	0.9454	0.9437	0.9427	0.9377
50	0.9466	0.936	0.9346	0.9342	0.929	**50**	0.9473	0.9367	0.9354	0.935	0.9297
60	0.9322	0.9286	0.9265	0.9212	0.9143	**60**	0.9329	0.9293	0.9272	0.9219	0.915
70	0.9191	0.9155	0.9134	0.9116	0.9035	**70**	0.9198	0.9162	0.9141	0.9123	0.9042
80	0.9003	0.8967	0.8939	0.8922	0.8762	**80**	0.9010	0.8975	0.8949	0.893	0.877
90	0.87	0.8666	0.8633	0.8615	0.8375	**90**	0.8708	0.8673	0.864	0.8623	0.8384

Table 2: Viscosities of Acetone – H_2O – Trimethyl ammonium hydrochloride at temperature 298, 303, 308, 313 and 318 K at 0.02, 0.04, 0.06, 0.08 M concentrations

			0.02 M						0.06 M		
% wt.	η_{298}	η_{303}	η_{308}	η_{313}	η_{318}	**% wt.**	η_{298}	η_{303}	η_{308}	η_{313}	η_{318}
10	1.0724	1.0674	1.0529	1.0485	1.0449	**10**	1.0873	1.0828	1.0697	1.0665	1.0603
20	1.1374	1.1258	1.1069	1.0951	1.0850	**20**	1.1482	1.1405	1.1265	1.1123	1.1044
30	1.2229	1.2025	1.1945	1.1749	1.1643	**30**	1.2361	1.2226	1.2161	1.1985	1.1910
40	1.2935	1.2892	1.2775	1.2808	1.2629	**40**	1.3107	1.3016	1.2947	1.3094	1.2914
50	1.3502	1.3431	1.3308	1.3283	1.3189	**50**	1.3648	1.3552	1.3468	1.3422	1.3311
60	1.3838	1.3745	1.3613	1.3527	1.3454	**60**	1.4006	1.3891	1.3770	1.3695	1.3607
70	1.3296	1.3144	1.3014	1.2901	1.2738	**70**	1.3494	1.3350	1.3237	1.3142	1.3048
80	1.2306	1.2103	1.1969	1.1916	1.1733	**80**	1.2545	1.2322	1.2340	1.2244	1.2105
90	1.0404	1.0317	1.0013	0.9930	0.9638	**90**	1.0578	1.0462	1.0326	1.0268	0.9974
			0.04 M						**0.08 M**		
% wt.	η_{298}	η_{303}	η_{308}	η_{313}	η_{318}	**% wt.**	η_{298}	η_{303}	η_{308}	η_{313}	η_{318}
10	1.0798	1.0751	1.0614	1.0575	1.0502	**10**	1.0913	1.0906	1.0782	1.0755	1.0704
20	1.1412	1.1331	1.1186	1.1036	1.0947	**20**	1.1519	1.1478	1.1345	1.1208	1.1142
30	1.2296	1.2158	1.2052	1.1867	1.1781	**30**	1.2735	1.2328	1.2269	1.2141	1.2001
40	1.3020	1.2953	1.2875	1.2951	1.2791	**40**	1.3168	1.3077	1.3012	1.3237	1.3035
50	1.3589	1.3492	1.3402	1.3352	1.3232	**50**	1.3707	1.3614	1.3534	1.3493	1.3388
60	1.3921	1.3832	1.3706	1.3627	1.3531	**60**	1.4063	1.3951	1.3834	1.3763	1.3684
70	1.3408	1.3261	1.3141	1.3005	1.2893	**70**	1.3607	1.3439	1.3364	1.3278	1.3202
80	1.2426	1.2227	1.2169	1.2098	1.1939	**80**	1.2665	1.2447	1.2476	1.2391	1.2271
90	1.0507	1.0390	1.0169	1.0099	0.9829	**90**	1.0681	1.0533	1.0443	1.0396	1.0120

Table 3: Equivalent conductance (λ_m) of Acetone - H_2O - Monomethyl ammonium hydrochloride

Temp. (K)	Conc. (M)	298	303	308	313	318
Wt. (%)		$\lambda_{m_{298}}$	$\lambda_{m_{303}}$	$\lambda_{m_{308}}$	$\lambda_{m_{313}}$	$\lambda_{m_{318}}$
10.00	0.02	11.16	12.32	13.23	13.84	14.34
	0.04	10.66	11.16	11.87	12.63	13.74
	0.06	9.33	10.13	10.99	11.83	12.52
	0.08	8.98	9.75	10.50	11.36	12.27
20.00	0.02	10.10	11.16	12.32	12.78	13.23
	0.04	9.70	9.87	10.63	11.39	12.45
	0.06	8.45	9.33	10.13	10.98	11.48
	0.08	8.13	8.84	9.66	10.50	10.87
30.00	0.02	9.70	10.61	11.26	11.67	12.22
	0.04	8.94	9.39	9.85	10.66	11.72
	0.06	7.63	8.47	9.33	10.13	10.66
	0.08	7.22	7.99	8.74	9.63	10.00
40.00	0.02	9.24	10.10	10.66	11.11	11.77
	0.04	8.41	8.69	9.19	10.15	11.14
	0.06	6.95	7.61	8.42	9.33	10.13
	0.08	6.45	7.25	7.99	8.86	9.25
50.00	0.02	8.64	9.75	10.10	10.71	11.31
	0.04	7.85	8.16	8.69	9.62	10.68
	0.06	6.46	6.78	7.61	8.43	9.34
	0.08	6.11	6.86	7.58	8.51	8.84
60.00	0.02	8.18	8.79	9.34	9.80	10.10
	0.04	7.32	7.58	7.85	8.69	9.67
	0.06	6.09	6.48	7.12	7.81	8.62
	0.08	5.83	6.59	7.35	8.26	8.60

Cont…

Temp. (K)	Conc. (M)	298	303	308	313	318
Wt. (%)		$\lambda_{m_{298}}$	$\lambda_{m_{303}}$	$\lambda_{m_{308}}$	$\lambda_{m_{313}}$	$\lambda_{m_{318}}$
70.00	0.02	7.73	8.13	8.69	9.14	9.80
	0.04	6.87	7.12	7.37	8.13	8.64
	0.06	5.79	6.13	6.75	7.10	7.95
	0.08	5.32	6.33	7.12	7.99	8.35
80.00	0.02	7.27	7.78	8.28	8.69	9.14
	0.04	6.64	6.94	7.12	7.42	8.13
	0.06	5.40	5.59	6.26	6.78	7.29
	0.08	4.97	5.98	6.70	7.59	7.98
90.00	0.02	7.07	7.88	8.08	8.59	9.09
	0.04	6.11	6.36	6.67	6.94	7.58
	0.06	4.90	5.08	5.61	5.96	6.41
	0.08	4.57	5.57	6.34	7.23	7.60

Table 4: The values of φ_v^o and S_v^* for Trimethyl ammonium chloride – acetone – H_2O

% wt.	$ø^*_{v298}$	$ø^*_{v303}$	$ø^*_{v308}$	$ø^*_{v313}$	$ø^*_{v318}$	S^*_{v298}	S^*_{v303}	S^*_{v308}	S^*_{v313}	S^*_{v318}
10	15.182	15.190	32.517	22.771	15.649	208.04	208.15	146.52	181.56	202.35
20	22.890	15.910	15.456	16.012	15.874	182.51	206.90	211.79	208.23	205.25
30	14.496	24.763	16.236	16.649	26.446	212.37	178.93	211.15	207.17	175.79
40	15.334	16.352	25.262	16.208	34.688	222.46	212.65	184.85	209.57	149.55
50	16.130	25.261	26.870	26.882	25.973	208.55	182.53	178.62	178.70	179.44
60	16.571	25.463	25.887	16.575	25.861	215.50	183.99	187.05	214.31	186.87
70	16.808	16.874	25.887	17.281	26.707	218.58	219.44	187.05	212.02	184.51
80	26.264	28.008	22.699	19.105	29.014	189.78	186.18	190.69	208.36	181.84
90	29.221	18.180	18.250	29.505	41.898	183.14	223.05	223.90	184.97	149.72

Table 5: The values of A and B obtained from Jones – Dole equation

% wt.	A_{298}	B_{298}	A_{303}	B_{303}	A_{308}	B_{308}	A_{313}	B_{313}	A_{318}	B_{318}
10	0.0346	0.2280	0.0184	0.3206	0.0109	0.3771	0.0240	0.3759	0.0178	0.3589
20	0.0399	0.1259	0.0987	0.0927	0.1037	0.1788	0.0982	0.1613	0.1117	0.1872
30	0.0267	0.5180	0.1178	0.1408	0.1266	0.1555	0.1263	0.2485	0.1291	0.2289
40	0.0450	0.2038	0.0602	0.0968	0.0900	0.1031	0.1891	0.1179	0.1323	0.2355
50	0.0008	0.2564	0.0515	0.1042	0.0047	0.2775	0.0528	0.1381	0.0168	0.2077
60	0.0761	0.0997	0.0882	0.0436	0.0902	0.0607	0.0574	0.1601	0.0878	0.0769
70	0.0613	0.2414	0.0888	0.1697	0.1035	0.2000	0.0912	0.2711	0.1052	0.3669
80	0.1130	0.2230	0.1155	0.1973	0.1560	0.3686	0.2040	0.1989	0.2675	0.1564
90	0.1044	0.1915	0.1230	0.0590	0.2289	0.2079	0.2225	0.2940	0.2477	0.2780

Table 6: The limiting molar conductance at infinite dilution (λ_{0m}) for various compositions at different temperatures

Wt. %	$\lambda_{0m\ 298}$	$\lambda_{0m\ 303}$	$\lambda_{0m\ 308}$	$\lambda_{0m\ 313}$	$\lambda_{0m\ 318}$
10	13.65	14.93	15.89	16.26	16.65
20	12.37	13.33	14.71	14.83	15.71
30	12.40	13.21	13.60	13.61	14.67
40	12.29	12.93	13.19	13.38	14.46
50	11.41	12.65	12.60	12.99	14.06
60	10.70	11.01	11.17	11.31	11.83
70	10.27	9.98	10.09	10.32	11.15
80	9.81	9.77	9.81	9.63	10.28
90	9.71	10.18	9.76	9.77	10.51

Table 7: Calculated K_c values from Kraus Bay equation

Wt. %	K_{c298}	K_{c303}	K_{c308}	K_{c313}	K_{c318}
10	0.048	0.042	0.034	0.025	0.018
20	0.058	0.048	0.041	0.028	0.028
30	0.098	0.074	0.052	0.033	0.034
40	0.149	0.107	0.074	0.048	0.045
50	0.162	0.131	0.086	0.056	0.055
60	0.174	0.116	0.073	0.043	0.040
70	0.225	0.110	0.064	0.036	0.039
80	0.264	0.131	0.080	0.036	0.037
90	0.366	0.187	0.097	0.042	0.045

Table 8: Calculated walden product ($\lambda_0\eta_0$) for Acetone – H_2O – MMAH at different temperatures and varying compositions

Wt. %	$\lambda_0\eta_{0298}$	$\lambda_0\eta_{0303}$	$\lambda_0\eta_{0308}$	$\lambda_0\eta_{0313}$	$\lambda_0\eta_{0318}$
10	14.50	15.79	16.58	16.86	17.21
20	13.95	14.77	15.99	15.96	16.72
30	14.91	15.58	15.90	15.62	16.70
40	15.74	16.50	16.61	16.64	17.98
50	15.33	16.83	16.66	17.08	18.42
60	14.62	14.93	15.00	15.13	15.69
70	13.47	12.91	12.89	13.07	13.89
80	11.83	11.59	11.41	11.11	11.59
90	9.92	10.31	9.43	9.35	9.74

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