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STUDY OF DENSITIES AND VISCOSITIES OF BINARY MIXTURES OF PROPYL ACETATE WITH BUTAN-1-OL,PENTAN-1-OL AND HEXAN-1-OL AT 298.15, 303.15, 308.15 and 313.15 K

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ABSTRACT

The experimental value of densities and viscosities of binary mixtures of propyl acetate With butan-1-ol, pentan-1-ol and hexan-1-ol have been measured over the entire range of composition at (298.15, 303.15, 308.15 and 313.15) K and at atmospheric pressure. From these value of density and viscosity the excess molar volume (V^E), deviation in viscosity ($\Delta\eta$) have been calculated. The excess molar volumes and deviations in viscosity are fitted to Redlich – Kister polynominal equation.

Key words: Excess molar volumes, deviations in viscosity, propyl acetate, butan-1-ol, pentan-1-ol, hexan-1-ol.

INTRODUCTION

When propyl acetate is mixed with butan-1-ol, pentan-1-ol and hexan-1-ol mixing properties with varying intermolecular interaction may be generated. Studies on thermodynamics and transport properties of binary liquid mixtures provide information on the nature of interactions in the constituents binaries, In the present paper we report density and viscosity data for binary mixtures of propyl acetate with butan-1-ol, pentan-1-ol and hexan-1-ol at 298.15, 303.15, 308.15 and 313.15 K.

Study on the effect of molecular size, shape chain length and degree of moleculer association of normal alkanols and branched alkanols, on the volumetric, viscometric and acoustic properties of binary mixtures containing acetonitrile,ethyl acetate, toluene and benzonitrile have been reported earlier by Nikam *et al.* [1-5] and by Gill *et al.* [6].

EXPERIMENTAL

Butan-1-ol (E. merck, purity 99.5%), Pentan-1-ol (S.D. fine chemicals , purity 99%), Hexan-1-ol (S.D. fine chemicals , purity 99%) and propyl acetate (S.D. fine chemicals , purity 99%) were used after single distillation. The purity of the solvent after purification, was ascertained by compairing their densities and viscosities with corresponding literature value at 298.15, 303.15, 308.15 and 313.15 K. Binary mixtures were prepared by mixing known mass of each liquid in an airtight stoppered glass bottle, the masses were recorded on Adairdutt balance to an accuracy of ± 0.0001 g. Care was taken to avoid contamination during mixing.

The density of pure liquids and binary mixtures were measured by using 15 cm^3 double arm pycnometer as discribe earlier[4-5]. The pycnometer was calibrated by using conductivity water with 0.99705 g/cm^3 as its density[12] at 298.15 K . The pycnometer fitted with air bubble free experimental liquid was kept in transparent walled waterbath for 10–15 min. to attain thermal equilibrium, the position of liquid levels in the two arms were recorded. The estimated uncertainty in density measurement of solvent and binary mixtures was 0.00005 g/cm^3 .

The dynamic viscosities were measured using Ubbehole suspended level viscometer[7], calibrated with conductivity water. An electronic digital stopwatch with readability of ± 0.01 sec. was used for the flow time measurement, at least three repetitious of each data reproducible to ±0.05 sec. were obtained and the result were averaged. Since all flow time were greater than 200 sec. and capillary redius (0.5 mm) was far less than its length (50 to 60 mm). The kinetic energy and corrections,

respectivity were found to be negligible. The uncertainties in dynamic viscosities are of the order ± 0.003 m Pa s.

RESULTS AND DISCUSSION

Experimental values of densities (r) and viscosity (h) of binary mixtures of propyl acetate with butan-1-ol, pentan-1-ol and hexan-1-ol at 298.15, 303.15, 308.15 and 313.15 K. are listed as a function of mole fraction in Table - 1. (A,B,C) The density value have been used to calculate excess molar volumes (V^E) using following equation.

$$V^E\ cm^3.mole^{-1} = (x_1 M_1 + x_2 M_2) / \rho_{mix} - (x_1 M_1 /\rho_1) - (x_2 M_2/\rho_2) \quad (1)$$

Where ρ_{mix} is the density of mixture and x_1, M_1, ρ_1 and x_2, M_2, ρ_2 are the mole fraction, molecular weight and density of pure components 1 and 2 respectively.

The viscosity deviation ($\Delta\eta$) were calculated by using the equations

$$\Delta\eta = \eta_{mix} - x_1 \eta_1 - x_2 \eta_2 \quad (2)$$

Where η_{mix} is the viscosity of binary mixture and x_1 η_1 and x_2 η_2 are the mole fraction and viscosity of pure components 1 and 2 respectively.

The variation of V^E and $\Delta\eta$ with mole fraction of propyl acetate (x_1) for the systems are presented in Figs. 1-2 respectively, at 298.15 K. Similar plots are obtained at other temperatures. The V^E value are positive for binary mixtures of propyl acetate with butan-1-ol, pentan-1-ol and hexan-1-ol.

Treszczanowicz *et al.*[7], suggested that V^E is the resultant contribution from several opposing effects. These may be divided arbitrarily in to three type, namely chemical, physical and structural. Physical contribution that is nonspecific interactions between the real species present in the mixture, contributes possitive term to V^E. The chemical or specific interaction result in a volume decrease, and these include charge transfer type forces and other complex forming interactions. This effect contributes negative value to V^E. The structural contributions are mostly negative and arises from several effect, specially from intertitial accommodation and change in free volume. In other words structural contribution arising from geometrical fitting (intertitial accommodation) of one component into another due to the differences in the free volume and molar volume between components lead to a negative contribution to V^E.

The extent of hydrogen bonding and intertitial fittings decrease, therefore positive excess molar volumes are expected. The $\Delta\eta$ values are negative for all the binary mixtures thereby suggesting the presence of dispersive forces. The result of V^E and $\Delta\eta$ are fitted to Redlich-Kister equation[10].

$$Y = x_1 x_2 \sum ai\ (x_1 - x_2)\ i \quad (3)$$

Where Y refers to V^E $cm^3.mole^{-1}$ or $\Delta\eta$ m Pa s, and the coefficient ai were obtained by fitting equation 3 to experimental result using a least squares regression method. In each case, the optimum number of coefficient is ascertained from the examination of the variation in standard deviation in V^E and $\Delta\eta$.

The σ was calculated using

$$\sigma(Y) = \sum (Yexp - Ycal)/ (n-m)^{1/2} \quad (4)$$

Where n is number of data point and m is the number of coefficient. The calculated value of ai along with standard deviation (σ) are given in Table - 2.

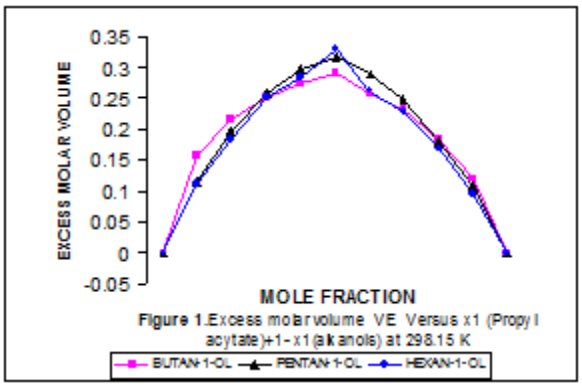

Figure 1.Excess molar volume VE Versus x1 (Propyl acytate)+1-x1(alkanols) at 298.15 K

Table - 1(A): Density, viscosity, excess molar volume and deviation in viscosity for propyl acetate with butan-1-ol

System - 4	Propyl Acetate-Butan-1-ol				
Temp K	x_1 g/ cm^3	ρ_{mix} m Pa.s	η_{mix} cm^3/ mol	V^E m Pa. s	$\Delta\eta$
298.15	0.0000	0.80580	0.025646	0.0000	0.0000
	0.1022	0.80805	0.021180	0.1557	-0.2418
	0.2048	0.81096	0.017451	0.2145	-0.4088
	0.3000	0.81365	0.014494	0.2499	-0.5134
	0.4002	0.81643	0.012053	0.2726	-0.5564
	0.5002	0.81908	0.010052	0.2908	-0.5559
	0.6008	0.82197	0.008453	0.2588	-0.5139
	0.7011	0.82467	0.007440	0.2307	-0.4139
	0.8008	0.82735	0.006754	0.1835	-0.2824
	0.8983	0.82996	0.006254	0.1202	-0.1367
	1.0000	0.83292	0.005577	-0.0001	0.0000
303.15	0.0000	0.80213	0.022670	0.0000	0.0000
	0.1022	0.80443	0.018654	0.1587	-0.2240
	0.2048	0.80739	0.015415	0.2194	-0.3694
	0.3000	0.81015	0.012802	0.2530	-0.4650
	0.4002	0.81289	0.010691	0.2879	-0.5017
	0.5002	0.81555	0.008973	0.3119	-0.4995
	0.6008	0.81860	0.007734	0.2649	-0.4484
	0.7011	0.82135	0.006855	0.2360	-0.3617
	0.8008	0.82408	0.006281	0.1877	-0.2456
	0.8983	0.82674	0.005843	0.1226	-0.1198
	1.0000	0.82975	0.005268	-0.0001	0.0000
308.15	0.0000	0.79825	0.019758	0.0000	0.0000
	0.1022	0.80060	0.016080	0.1632	-0.2167
	0.2048	0.80362	0.013281	0.2258	-0.3446
	0.3000	0.80641	0.011004	0.2639	-0.4313
	0.4002	0.80926	0.009282	0.2933	-0.4550
	0.5002	0.81185	0.008003	0.3348	-0.4348
	0.6008	0.81507	0.007053	0.2724	-0.3808
	0.7011	0.81788	0.006344	0.2425	-0.3031
	0.8008	0.82072	0.005791	0.1854	-0.2107
	0.8983	0.82344	0.005420	0.1180	-0.1034
	1.0000	0.82646	0.004945	-0.0001	0.0000
313.15	0.0000	0.79434	0.017816	0.0000	0.0000
	0.1022	0.79674	0.014580	0.1675	-0.1888
	0.2048	0.79981	0.012081	0.2331	-0.3032
	0.3000	0.80266	0.010064	0.2717	-0.3792
	0.4002	0.80552	0.008503	0.3080	-0.4029
	0.5002	0.80821	0.007285	0.3445	-0.3926
	0.6008	0.81149	0.006415	0.2810	-0.3467
	0.7011	0.81436	0.005780	0.2499	-0.2777
	0.8008	0.81726	0.005351	0.1909	-0.1890
	0.8983	0.82004	0.005053	0.1210	-0.0900
	1.0000	0.82312	0.004607	0.0000	0.0000

Table - 1(B): Density, viscosity, excess molar volume and deviation in viscosity for propyl acetate with pentan-1-ol

System -5	PropylAcetate – Pentan-1-ol				
Temp K	x_1 g/ cm^3	ρ_{mix} m Pa. s	η_{mix} cm^3/ mol	V^E m Pa.s	$\Delta\eta$
298.15	0.0000	0.81110	0.035060	0.0000	0.0000
	0.1022	0.81273	0.028504	0.1156	-0.3547
	0.2000	0.81448	0.023205	0.1944	-0.5962
	0.2997	0.81634	0.018704	0.2577	-0.7524
	0.4000	0.81834	0.015003	0.2968	-0.8268
	0.5002	0.82042	0.012005	0.3173	-0.8312
	0.5996	0.82278	0.009602	0.2882	-0.7784
	0.7001	0.82519	0.008004	0.2474	-0.6419
	0.8000	0.82773	0.007121	0.1781	-0.4357
	0.9001	0.83022	0.006470	0.1086	-0.2056
	1.0000	0.83292	0.005577	-0.0001	0.0000
303.15	0.0000	0.80741	0.029604	0.0000	0.0000
	0.1022	0.80909	0.024310	0.1176	-0.2810
	0.2000	0.81089	0.019952	0.1977	-0.4788
	0.2997	0.81280	0.016415	0.2622	-0.5899
	0.4000	0.81485	0.013441	0.3021	-0.6432
	0.5002	0.81693	0.010914	0.3302	-0.6521
	0.5996	0.81938	0.008915	0.2953	-0.6101
	0.7001	0.82181	0.007470	0.2587	-0.5100
	0.8000	0.82445	0.006675	0.1815	-0.3464
	0.9001	0.82700	0.006072	0.1098	-0.1631
	1.0000	0.82975	0.005268	-0.0001	0.0000
308.15	0.0000	0.80354	0.025112	0.0000	0.0000
	0.1022	0.80528	0.020641	0.1193	-0.2413
	0.2000	0.80714	0.016904	0.2001	-0.4178
	0.2997	0.80911	0.013933	0.2652	-0.5138
	0.4000	0.81118	0.011482	0.3111	-0.5566
	0.5002	0.81319	0.009472	0.3579	-0.5555
	0.5996	0.81589	0.007865	0.2949	-0.5158
	0.7001	0.81841	0.006841	0.2530	-0.4155
	0.8000	0.82113	0.006143	0.1715	-0.2838
	0.9001	0.82366	0.005634	0.1101	-0.1329
	1.0000	0.82646	0.004945	-0.0001	0.0000
313.15	0.0000	0.79970	0.021390	0.0000	0.0000
	0.1022	0.80149	0.017374	0.1212	-0.2303
	0.2000	0.80340	0.014192	0.2030	-0.3844
	0.2997	0.80542	0.011690	0.2689	-0.4673
	0.4000	0.80749	0.009673	0.3226	-0.5006
	0.5002	0.80954	0.008025	0.3714	-0.4973
	0.5996	0.81239	0.006844	0.2931	-0.4486
	0.7001	0.81493	0.006032	0.2550	-0.3611
	0.8000	0.81767	0.005521	0.1769	-0.2445
	0.9001	0.82027	0.005124	0.1116	-0.1162
	1.0000	0.82312	0.004607	0.0000	0.0000

Table - 1(C): Density, viscosity, excess molar volume and deviation in viscosity for propyl acetate with hexan-1-ol

System - 6		PropylAcetate-Hexan-1-ol			
Temp K	x_1 g/ cm^3	ρ_{mix} m Pa.s	η_{mix} cm^3/ mol	V^E m Pa. s	$\Delta\eta$
298.15	0.0000	0.81536	0.045887	0.0000	0.0000
	0.1022	0.81639	0.037282	0.1118	-0.4490
	0.2001	0.81761	0.031560	0.1836	-0.6266
	0.2994	0.81889	0.026278	0.2505	-0.7545
	0.3998	0.82041	0.021584	0.2844	-0.8192
	0.5002	0.82186	0.016964	0.3299	-0.8765
	0.5988	0.82404	0.013594	0.2615	-0.8160
	0.7006	0.82606	0.010243	0.2272	-0.7408
	0.7994	0.82820	0.008135	0.1687	-0.5533
	0.8990	0.83047	0.006490	0.0947	-0.3163
	1.0000	0.83292	0.005577	-0.0001	0.0000
303.15	0.0000	0.81184	0.038602	0.0000	0.0000
	0.1022	0.81290	0.031505	0.1134	-0.3695
	0.2001	0.81416	0.025673	0.1847	-0.6263
	0.2994	0.81547	0.021103	0.2527	-0.7523
	0.3998	0.81698	0.017231	0.2938	-0.8048
	0.5002	0.81839	0.013713	0.3510	-0.8220
	0.5988	0.82073	0.010874	0.2629	-0.7772
	0.7006	0.82278	0.007690	0.2293	-0.7563
	0.7994	0.82496	0.006814	0.1696	-0.5145
	0.8990	0.82726	0.006164	0.0959	-0.2475
	1.0000	0.82975	0.005268	-0.0001	0.0000
308.15	0.0000	0.80814	0.032892	0.0000	0.0000
	0.1022	0.80924	0.026591	0.1145	-0.3449
	0.2001	0.81054	0.021505	0.1862	-0.5799
	0.2994	0.81189	0.017492	0.2548	-0.7036
	0.3998	0.81333	0.013974	0.3133	-0.7749
	0.5002	0.81478	0.011033	0.3710	-0.7884
	0.5988	0.81727	0.008750	0.2653	-0.7411
	0.7006	0.81936	0.007234	0.2317	-0.6082
	0.7994	0.82158	0.006404	0.1717	-0.4151
	0.8990	0.82392	0.005805	0.0977	-0.1966
	1.0000	0.82646	0.004945	-0.0001	0.0000
313.15	0.0000	0.80443	0.028693	0.0000	0.0000
	0.1022	0.80556	0.023413	0.1164	-0.2822
	0.2001	0.80689	0.019065	0.1896	-0.4812
	0.2994	0.80827	0.015510	0.2597	-0.5975
	0.3998	0.80971	0.012551	0.3243	-0.6516
	0.5002	0.81114	0.010034	0.3914	-0.6615
	0.5988	0.81374	0.008042	0.2732	-0.6232
	0.7006	0.81587	0.006653	0.2390	-0.5169
	0.7994	0.81813	0.005905	0.1781	-0.3537
	0.8990	0.82051	0.005344	0.1032	-0.1699
	1.0000	0.82312	0.004607	0.0000	0.0000

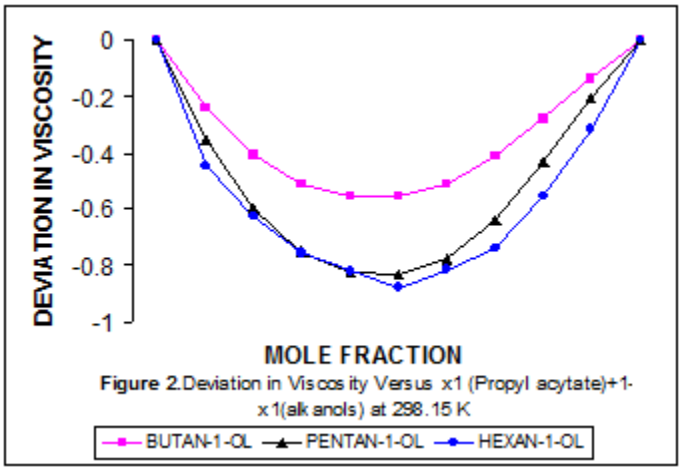

Figure 2. Deviation in Viscosity Versus x1 (Propyl acytate)+1-x1(alkanols) at 298.15 K

Table - 2: Parameters and standard deviation of the systems

Para-meter	Temp T / K	a_0		a_1		a_2		a_3		σ	
		V^E cm³/mol	Δη mPa s	V^E cm³/mol	Δη mPa s	V^E cm³/mol	Δη mPa s	V^E cm³/mol	Δη mPa s	V^E mPas	Δη
System 4	298.15	1.0767	-2.241	-0.191	0.5010	0.613	0.2722	-	0.3383	0.012	0.0038
	303.15	1.1240	-1.991	-0.196	0.5371	0.573	0.1914	-	0.2641	0.016	0.0030
	308.15	1.1757	-1.740	-0.245	0.7388	0.483	0.0011	-	-	0.020	0.0049
	313.15	1.2182	-1.568	-0.257	0.5285	0.477	0.0811	-	0.2141	0.020	0.0038
System 5	298.15	1.2169	-3.365	-0.054	0.5644	-0.018	0.4314	-	0.6707	0.0074	0.0066
	303.15	1.2542	-2.639	-0.050	0.4232	-0.051	0.2714	-	0.5858	0.008	0.0084
	308.15	1.2183	-2.251	-0.085	0.5511	-0.118	0.2741	-	0.2909	0.018	0.0073
	313.15	1.3116	-1.990	-0.087	0.6065	-0.134	0.1209	-	0.2577	0.021	0.0037
System 6	298.15	1.1808	-3.374	-0.108	-0.179	-0.124	-1.182	-	1.663	0.0164	0.0200
	303.15	1.2144	-3.410	-0.113	-0.120	-0.170	-0.106	-	1.343	0.0224	0.0379
	308.15	1.2584	-3.174	-0.115	0.480	-0.232	0.298	-	0.849	0.0278	0.0084
	313.15	1.3020	-2.679	-0.887	0.415	-0.258	0.288	-	0.557	0.0327	0.0081

System-4 propyl acetate+ butan-1-ol. System-5 propyl acetate+ pentan-1-ol. System-6 propyl acetate+ hexan-1-ol.

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