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VISCOSITIES OF BINARY LIQUID SYSTEMS OF PEG 200 AND PEG 400 WITH ISOBUTANOL AND ISO–AMYL ALCOHOL AT 303 K, 308 K AND 318 K

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ABSTRACT

The viscosity of binary systems of PEG 200 and PEG 400 with isobutanol and iso–amyl have been observed. The excess viscosities (η^E) have been calculated at 303 K, 308 K and 313 K for binary liquid systems over the entire range of composition by using the viscosity data. The excess viscosity (η^E) has been calculated from the viscosity data. The negative excess viscosities (η^E) have been observed for all the systems. The temperature effect has been studied in the light of specific interaction phenomena.

Key words : Viscosities, PEG 200, PEG 400, Isobutanol, Iso–amyl alcohol, Binary liquid systems.

INTRODUCTION

Several researchers[1–8] have studied the viscosities of liquid systems to understand the molecular interaction in liquids. The viscosities of PEG 200 and PEG 400 with isobutanol and iso–amyl alcohol have been reported in this paper. The results have provided additional information on molecular interaction of liquids.

EXPERIMENTAL

PEG 200, PEG 400, isobutanol and iso–amyl alcohol (E. Merck Grade) have been purified by conventional methods[9]. The purities of liquids have been further checked by measuring the viscosities at 303 K and they are in close agreement with the literature values[10,11]. The viscosity data has been corrected upto ± 0.0002 cP. The liquids have been weighed in ground stoppered flasks on a precision balance accurate upto 0.001 units to prepare binary liquid systems by taking due precautions to minimize evaporations. The time flow has been measured by using suspended type Ostwald viscometer. The time flow has been corrected upto ± 0.01 second. The temperature of the water thermostat bath has been controlled upto ± 0.1K.

RESULTS AND DISCUSSION

The viscosities have been measured at 303 K, 308 K and 313 K for binary liquid systems of PEG 200 and PEG 400 with isobutanol and iso–amyl alcohol over the entire range of composition. The excess viscosities (η^E) have been calculated by using the equation,

$$\eta^E = \eta_{12} - X_1\eta_1 - X_2\eta_2 \quad ...(1)$$

where X and η indicate the mole fraction and viscosity at temperature T, respectively. The subscripts 1, 2 and 12 represent the pure liquid and binary liquid systems, respectively. The viscosity values have been reported in Tables 1, 2, 3 and 4.

Table 1. Experimental viscosities (η_{expt}) (cP), calculated viscosities ($\eta_{cal.}$) (cP) and excess viscosities (η^E) (cP) for PEG 200 with isobutanol at 303 K, 308 K and 313 K

	303 K			308 K			313 K		
X_1	η_{expt}	η_{cal}	η^E	η_{expt}	η_{cal}	η^E	η_{expt}	η_{cal}	η^E
0.0000	3.2229	–	–	3.1121	–	–	2.9887	–	–
0.1963	7.9555	7.9602	−8.1812	6.6573	6.4114	−8.0802	5.6400	5.9052	−7.9848
0.2651	10.0909	10.2757	−8.2831	8.3454	8.4863	−8.1822	6.9804	5.7813	−8.0879
0.3025	11.2070	11.0874	−8.3822	9.2170	9.1435	−8.2871	7.6602	7.3127	−8.1821
0.4890	17.1796	15.1519	−8.4829	13.9563	13.1759	−8.3815	11.4701	11.4933	−8.2813
0.5353	18.6858	18.6956	−8.4847	15.1659	15.2906	−8.3862	12.4400	12.3799	−8.2851
0.6579	22.6711	22.3496	−8.4837	18.3504	18.7943	−8.3887	15.0000	15.3493	−8.2860
0.7910	27.0941	27.2546	−8.3891	21.8973	21.7757	−8.2870	17.8901	17.0652	−8.1836
0.8611	29.4822	28.6688	−8.2811	23.8278	23.3688	−8.1823	19.4509	19.4509	−8.0827
0.9101	31.6152	31.1452	−8.1800	25.2409	25.3478	−8.0812	20.5800	20.5800	−7.9800
1.0000	35.7534	–	–	29.0862	–	–	23.9146	–	–

Table 2. Experimental viscosities (η_{expt}) (cP), calculated viscosities ($\eta_{cal.}$) (cP) and excess viscosities (η^E) (cP) for PEG 400 with isobutanol at 303 K, 308 K and 313 K

	303 K			308 K			313 K		
X_1	η_{expt}	η_{cal}	η^E	η_{expt}	η_{cal}	η^E	η_{expt}	η_{cal}	η^E
0.0000	3.2229	–	–	3.1121	–	–	2.9887	–	–
0.1161	7.5222	6.6270	−7.1822	6.5988	6.6933	−7.0802	6.3801	6.2319	−6.9848
0.2413	13.7866	14.8201	−7.2830	11.8733	11.2704	−7.1820	11.4712	11.4569	−7.0879
0.3417	18.7886	19.6789	−7.3829	16.0878	15.1650	−7.2861	15.5295	14.8661	−7.1821
0.4605	24.7132	23.1519	−7.4820	21.0866	19.6850	−7.3800	20.3423	17.6773	−7.2813
0.5600	29.7938	29.6531	−7.4800	25.3614	26.7602	−7.3852	24.4623	22.7795	−7.2851
0.6898	36.3950	38.8442	−7.4827	30.9400	31.1080	−7.3886	28.8354	28.4532	−7.2860
0.7597	40.0491	42.8724	−7.3892	34.0424	33.9184	−7.2811	32.8300	32.6430	−7.1836
0.8038	42.3872	43.6471	−7.2801	36.0327	38.2858	−7.1813	34.7512	33.4709	−7.0827
0.9192	48.3565	48.8271	−7.1822	41.0858	41.4192	−7.0819	39.6256	38.6430	−6.9800
1.0000	54.0684	–	–	46.0639	–	–	44.3743	–	–

Table 3. Experimental viscosities (η_{expt}) (cP), calculated viscosities ($\eta_{cal.}$) (cP) and excess viscosities (η^E) (cP) for PEG 200 with iso –amyl alcohol at 303 K, 308 K and 313 K.

	303 K			308 K			313 K		
X_1	η_{expt}	η_{cal}	η^E	η_{expt}	η_{cal}	η^E	η_{expt}	η_{cal}	η^E
0.0000	2.4993	–	–	2.1714	–	–	1.5932	–	–
0.1908	7.1116	7.5846	–4.1819	5.8742	5.7651	–4.0809	4.9223	3.9052	–3.9842
0.2097	7.6424	8.0636	–4.2836	6.2828	6.1157	–4.1825	5.2372	5.1336	–4.0875
0.3060	10.7390	11.4834	–4.3824	8.7724	9.1716	–4.2873	7.2597	8.4666	–4.1822
0.4854	16.5106	16.7040	–4.4825	13.5022	13.2721	–4.3814	11.1203	10.9297	–4.2815
0.5176	18.5759	19.3676	–4.4841	15.1735	15.3682	–4.3863	12.4924	11.4826	–4.2854
0.6199	20.9801	21.4828	–4.4837	17.1194	16.9510	–4.3886	14.0863	14.5588	–4.2861
0.7414	25.2162	26.9568	–4.3893	20.4905	21.3909	–4.2871	16.8687	16.7511	–4.1834
0.8431	28.7039	28.3269	–4.2811	23.3302	24.9018	–4.1828	19.2155	19.0178	–4.0826
0.9581	33.4310	34.9550	–4.1803	27.2197	28.2089	–4.0814	22.3578	22.1201	–3.9805
1.0000	35.7534	–	–	29.0862	–	–	23.9148	–	–

Table 4. Experimental viscosities (η_{expt}) (cP), calculated viscosities ($\eta_{cal.}$) (cP) and excess viscosities (η^E) (cP) for PEG 400 with iso –amyl alcohol at 303 K, 308 K and 313 K

	303 K			308 K			313 K		
X_1	η_{expt}	η_{cal}	η^E	η_{expt}	η_{cal}	η^E	η_{expt}	η_{cal}	η^E
0.0000	2.4993	–	–	2.1714		–	1.8435	–	–
0.1826	7.8346	8.5846	–3.1815	6.4056	8.5172	–3.0803	6.3268	5.3297	–2.9845
0.2178	9.5480	9.7221	–3.2833	7.9840	9.5072	–3.1827	7.7227	6.3740	–3.0871
0.3510	16.3156	16.2528	–3.3829	13.6938	14.5109	–3.2877	13.2862	12.8604	–3.1822
0.4597	21.8218	21.3712	–3.4825	18.3653	17.1582	–3.3813	17.8104	15.4229	–3.2815
0.5372	25.8145	26.1047	–3.4846	21.7629	21.9244	–3.3830	21.1024	21.8619	–3.2852
0.6375	30.8824	32.0373	–3.4832	26.1640	28.6526	–3.3889	25.3663	24.0031	–3.2861
0.7228	35.4894	36.0837	–3.3892	30.0126	30.3700	–3.2871	29.0997	29.6087	–3.1832
0.8399	41.6257	40.8032	–3.2812	35.2509	34.1556	–3.1830	34.1776	35.9801	–3.0826
0.9183	45.7704	45.0884	–3.1802	38.7935	37.3569	–3.0814	37.6147	38.2090	–2.9802
1.0000	54.0684	–	–	46.0639	–	–	44.3743	–	—

The viscosity values have been fitted to an empirical equation,

$$\ln(\eta_s V_s) = X_1 \ln(\eta_1 V_1) + X_2 \ln(\eta_2 V_2) + X_1 X_2 W_{visc.} / RT \quad ...(2)$$

where W_{visc} is an empirical parameter.

The graphs of excess viscosities (η^E) against mole fractions (X_1) have been plotted at 303 K, 308 K and 313 K for all the systems and have been represented by Figures 1, 2, 3 and 4.

The excess viscosities (η^E) for all the systems at mole fraction ($X_1 = X_2 = 0.5$) at 303 K, 308 K and 313 K have been reported in Table 5.

Table 5. Excess viscosities (η^E) for binary liquid systems at 303 K, 308 K and 313 K at mole fraction ($X_1 = X_2 = 0.5$)

Binary liquid systems	303 K	308 K	313 K
PEG 200 with isobutanol	–8.4637	–8.3652	–8.2671
PEG 400 with isobutanol	–7.4610	–7.3622	–7.2641
PEG 200 with iso–amyl alcohol	–4.4721	–4.3723	–4.2724
PEG 400 with iso–amyl alcohol	–3.4736	–3.3743	–3.2792

The excess viscosities (η^E) for all the systems over the entire composition at 303 K, 308 K and 313 K have negative values. The observed negative values are due to the depolymerization of pure glycol aggregates, specific interaction between the components and size of the molecules of the two components.

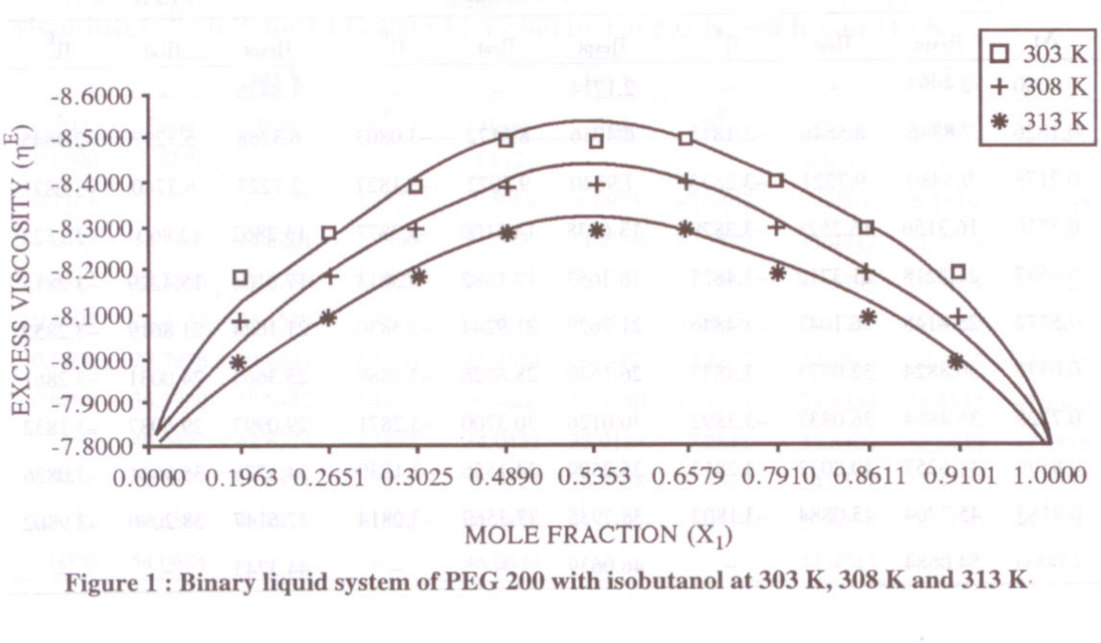

Figure 1 : Binary liquid system of PEG 200 with isobutanol at 303 K, 308 K and 313 K

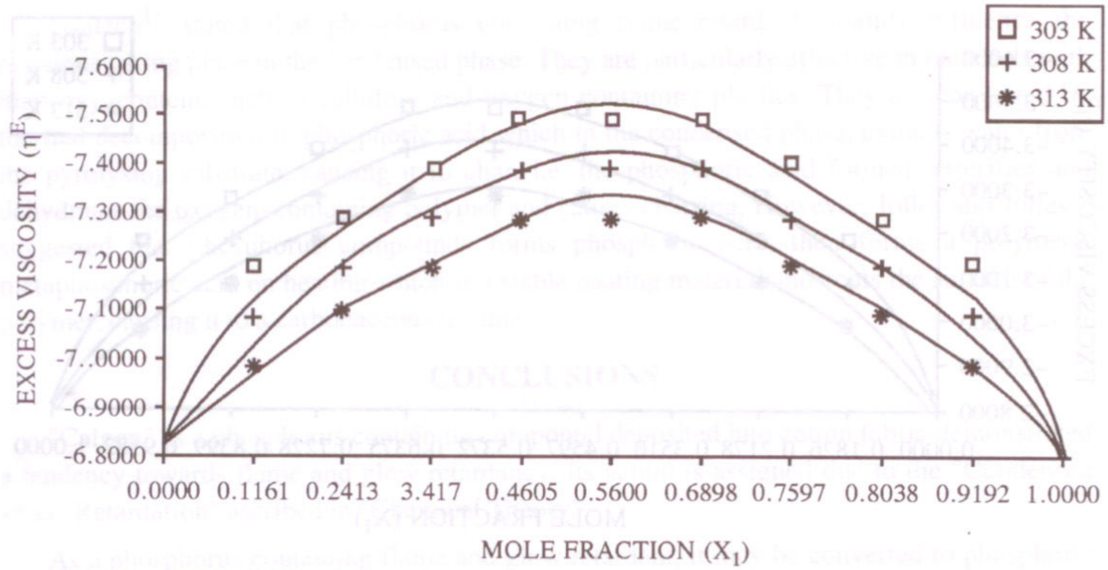

Figure 2 : Binary liquid system of PEG 400 with isobutanol at 303 K, 308 K and 313 K.

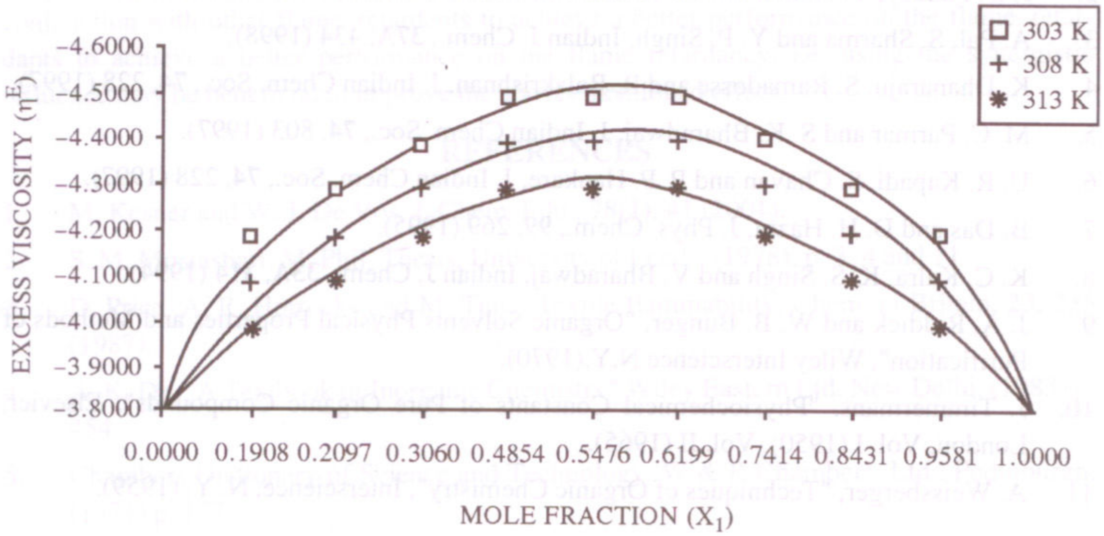

Figure 3 : Binary liquid system of PEG 200 with iso–amyl alcohol at 303 K, 308 K and 313 K

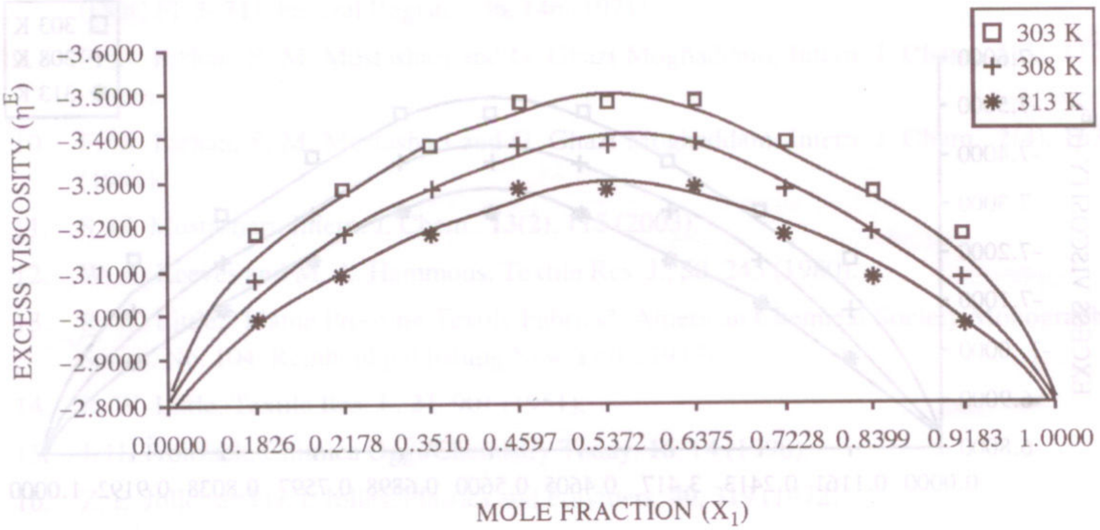

Figure 4 : Binary liquid system of PEG 400 with iso–amyl alcohol at 303K, 308K and 313 K

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