$\bar{V}_e$	decrease in volume due to electrostriction
V_f°	limiting effective flow volume
$\bar{V}_{int}$	intrinsic volume of the amino acid
V_s	shrinkage volume
V_v	volume associated with void
V_{vW}	van der Waals volume
V_{sh}	volume of solvation sheath

Greek Letters

ϕ_v	apparent molar volume
$\phi_v{}^\circ$	limiting apparent molar volume or infinite-dilution partial molar volume
$\phi_v{}^\circ$(tr)	change in partial molar volume when amino acid is transferred from water to aqueous NH_4Cl solution
η	viscosity of solution
η_0	viscosity of pure solvent
η_r	relative viscosity (η/η_0)
ρ	density of solution
ρ_0	density of pure solvent

Literature Cited

(1) Enea, O.; Jolicoeur, C. *J. Phys. Chem.* **1982**, *86*, 3870.
(2) Kauzmann, W. *Adv. Protein Chem.* **1979**, *14*, 1.
(3) Edsall, J. T.; McKenzie, H. A. *Adv. Biophys.* **1983**, *16*, 53.
(4) Perutz, M. F. *Science* **1978**, *201*, 1187.
(5) Nandi, P. K.; Robinson, D. R. *J. Am. Chem. Soc.* **1972**, *94*, 1229-1315.
(6) Bull, H. B.; Breese, K. *Arch. Biochem. Biophys.* **1970**, *137*, 299.
(7) Kelley, B. P.; Lilley, T. H. *J. Chem. Soc., Faraday Trans. 1* **1978**, *74*, 2771.
(8) Larson, J. W.; Morrison, D. G. *J. Phys. Chem.* **1976**, *80*, 1449.
(9) Bhat, R.; Ahluwalia, J. C. *J. Phys. Chem.* **1985**, *89*, 1099.
(10) Bhat, R.; Ahluwalia, J. C. *Int. J. Pept. Protein Res.* **1987**, *30*, 145.
(11) Rajiv Bhat; Nand Kishore; Ahluwalia, J. C. *J. Chem. Soc., Faraday Trans. 1* **1988**, *84*, 2651.
(12) Ogawa, T.; Mizutani, K.; Yasuda, M. *Bull. Chem. Soc. Jpn.* **1984**, *57*, 2064.
(13) Sandhu, J. S.; Urmila Kashyap. *J. Electrochem. Soc. India* **1987**, *36*, 267.
(14) Sandhu, J. S.; Urmila Kashyap. *Ind. J. Chem., Sect. A* **1987**, *26*, 952.
(15) Sandhu, J. S.; Gurbir Singh. *J. Ind. Chem. Soc.* **1988**, *65*, 173.
(16) Rao, Mandapati, V. R.; Atreyi, Mahalakshmi; Rajeswari, Moganty, R. *Can. J. Chem.* **1988**, *66*, 487.
(17) Badley, R. A.; Carruthers, L.; Philips, M. C. *Biochim. Biophys. Acta* **1977**, *110*, 495.
(18) Weast, R. C., Ed. *Handbook of Chemistry and Physics*; Chemical Rubber: Cleveland, OH, 1969.
(19) Kell, G. S. *J. Chem. Eng. Data* **1967**, 12, 66.
(20) Ellis, A. J. *J. Chem. Soc. A* **1966**, 1579.
(21) Stokes, R. H. *Aust. J. Chem.* **1975**, *28*, 2109.
(22) Jolicoeur, C.; Riedl, B.; Desrochers, D.; Lemelin, L.; Zamojska, R.; Enea, O. *J. Solution Chem.* **1986**, *15*, 109.
(23) Goldsack, D. E.; Franchetto, R. *Can. J. Chem.* **1978**, *56*, 1442.
(24) Lilley, T. H. *The Chemistry and Biochemistry of Amino Acids*; Barrett, G. C., Ed.; Chapman & Hall: London, 1985; Chapter 23.
(25) Millero, F. J.; Lo Surdo, A.; Shin, C. *J. Phys. Chem.* **1978**, *82*, 784.
(26) Stokes, R. H.; Mills, R. Viscosity of Electrolytes and Related Properties. *International Encyclopedia of Physical Chemistry and Chemical Physics*; Pergamon: London, 1965.
(27) Tyrrell, H. J. V.; Kennerley, M. *J. Chem. Soc. A* **1968**, 2724.
(28) Friedman, H. L.; Krishnan, C. V. *Water, A Comprehensive Treatise*; Franks, F., Ed.; Plenum Press: New York, 1973; Vol. 3, Chapter 1.
(29) Mishra, A. K.; Prasad, K. P.; Ahluwalia, J. C. *Biopolymers* **1983**, *22*, 2397.
(30) Shahidi, F.; Farrell, P. G.; Edwards, J. T. *J. Solution Chem.* **1976**, *5*, 807.
(31) Ogawa, T.; Yasuda, M.; Mizutani, K. *Bull. Chem. Soc. Jpn.* **1984**, *57*, 662.
(32) Meena, N. Volumetric and Transport Studies of Some Amino Acids in Aqueous Electrolyte Solutions. Ph.D. Thesis, University of Delhi, 1986.
(33) Phang, S. *Aust. J. Chem.* **1977**, *30*, 1605.
(34) Vand, V. *J. Phys. Chem.* **1948**, *52*, 277.
(35) Cohn, E. J.; Edsall, J. T. *Proteins, Amino Acids and Peptides*; Reinhold: New York, 1965.
(36) Berlin, E.; Pallansch, M. J. *J. Phys. Chem.* **1968**, *72*, 1887.
(37) Devine, W.; Lowe, B. M. *J. Chem. Soc. A* **1971**, 2113.
(38) Desnoyers, J. E.; Arel, M.; Leduc, P. A. *Can. J. Chem.* **1969**, *47*, 547.
(39) Desnoyers, J. E.; Perron, G. *J. Solution Chem.* **1972**, *1*, 199.

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Supplementary Material Available: Tables of detailed density and viscosity data for different amino acids as a function of concentration in aqueous ammonium chloride solutions (15 pages). Ordering information is given on any current masthead page.

Viscosity and Density of Ternary Mixtures of Toluene, Bromobenzene, 1-Hexanol, and 1-Octanol

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Mixture viscosities and densities of the ternary mixtures of toluene, bromobenzene, 1-hexanol, and 1-octanol were measured at 30, 40, 50, and 60 °C. The nonidealities reflected in mixture viscosities are expressed and discussed in terms of excess viscosities, which were negative in most of the cases. The ternary η-X-T data were fitted in a Redlich-Kister-type equation along with a ternary contribution term.

Introduction

Extending our earlier work (*1*-*8*) on viscosities and dielectric constants of liquid mixtures, the present paper reports the viscosities and the densities for the ternary mixtures of toluene, bromobenzene, 1-hexanol, and 1-octanol in the temperature range from 30 to 60 °C.

Experimental Section

Materials. Toluene (BDH), 1-hexanol (BDH), and 1-octanol (Ferak Berlin) were fractionally distilled and dried while bromobenzene (E. Merck) after repeated fractional distillation was collected at 156 ± 0.5 °C and retained for use. The mean values of repeat density, viscosity, and refractive index measurements of the liquids so purified did not deviate from the corresponding literature values beyond allowable limits (Table IV). Redistilled deionised and degassed water (electrical conductivity $< 7.0 \times 10^{-7}\ \Omega^{-1}\ cm^{-1}$) was used in each case for checking the instruments and calibrating the pycnometers.

Experimental Measurements. Ternary mixtures were prepared by weight with an accuracy of 0.0001 g, taking care that the resulting ternary compositions represent the data points suitably distributed away from the vertices and also located in

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Table I. Experimental Densities ρ_m and Viscosities η_m for the Ternary Mixture Toluene (1)–Bromobenzene (2)–1-Octanol (3) at Different Temperatures

no.	X_1	X_2	t, °C	ρ_m, g mL^{-1}	η_m, cP
1	0.9033	0.0580	30	0.894 81	0.5587
			40	0.888 85	0.5034
			50	0.882 85	0.4584
			60	0.878 13	0.4255
2	0.0561	0.9058	30	1.421 7	0.9434
			40	1.414 3	0.8550
			50	1.411 1	0.7844
			60	1.409 2	0.7109
3	0.0782	0.0796	30	0.862 59	4.293
			40	0.858 12	3.201
			50	0.855 45	2.485
			60	0.853 49	1.970
4	0.7518	0.1488	30	0.940 19	0.7752
			40	0.935 83	0.6775
			50	0.932 58	0.6087
			60	0.929 14	0.5585
5	0.1446	0.7552	30	1.311 7	1.055
			40	1.304 6	0.9341
			50	1.301 0	0.8397
			60	1.299 1	0.7585
6	0.1814	0.1847	30	0.922 21	2.541
			40	0.916 70	2.024
			50	0.914 29	1.637
			60	0.911 85	1.355
7	0.3707	0.3774	30	1.058 7	1.111
			40	1.052 2	0.9722
			50	1.048 2	0.8615
			60	1.044 8	0.7766
8	0.5960	0.2423	30	0.992 43	0.8902
			40	0.985 94	0.7820
			50	0.981 65	0.6958
			60	0.978 47	0.6252
9	0.4567	0.4650	30	1.136 4	0.7753
			40	1.129 4	0.6802
			50	1.123 5	0.6360
			60	1.118 7	0.6051
10	0.2364	0.6029	30	1.201 7	1.022
			40	1.194 0	0.8939
			50	1.190 4	0.8023
			60	1.188 0	0.7275
11	0.1294	0.5222	30	1.123 7	1.495
			40	1.117 3	1.253
			50	1.113 3	1.084
			60	1.111 4	0.9470
12	0.2687	0.2737	30	0.978 63	1.700
			40	0.971 94	1.408
			50	0.967 99	1.192
			60	0.965 44	1.008
13	0.5164	0.1326	30	0.913 79	1.245
			40	0.908 44	1.045
			50	0.905 97	0.8901
			60	0.903 51	0.7809

Table II. Experimental Densities ρ_m and Viscosities η_m for the Ternary Mixture Toluene (1)–1-Hexanol (2)–1-Octanol (3) at Different Temperatures

no.	X_1	X_2	t, °C	ρ_m, g mL^{-1}	η_m, cP
1	0.9479	0.0290	30	0.858 69	0.5190
			40	0.852 63	0.4586
			50	0.847 32	0.4209
			60	0.842 04	0.3911
2	0.0389	0.9347	30	0.818 05	3.587
			40	0.813 45	2.655
			50	0.811 27	2.167
			60	0.809 74	1.757
3	0.0479	0.0411	30	0.823 97	5.337
			40	0.819 51	3.927
			50	0.816 80	3.026
			60	0.815 22	2.367
4	0.0825	0.6372	30	0.820 79	3.646
			40	0.816 37	2.833
			50	0.813 55	2.270
			60	0.811 21	1.776
5	0.4176	0.0717	30	0.834 64	1.894
			40	0.829 86	1.541
			50	0.826 55	1.281
			60	0.823 62	1.081
6	0.6442	0.3071	30	0.842 86	0.8856
			40	0.837 09	0.7670
			50	0.832 07	0.6770
			60	0.828 13	0.5943
7	0.3941	0.3382	30	0.831 47	1.841
			40	0.825 19	1.519
			50	0.822 13	1.312
			60	0.820 01	1.141
8	0.1655	0.4972	30	0.823 77	3.171
			40	0.818 37	2.435
			50	0.815 03	1.924
			60	0.812 90	1.578
9	0.2384	0.5456	30	0.826 26	2.507
			40	0.821 67	1.937
			50	0.818 67	1.543
			60	0.815 26	1.285
10	0.3331	0.2144	30	0.831 23	2.181
			40	0.826 55	1.715
			50	0.823 56	1.422
			60	0.821 38	1.178
11	0.4811	0.1376	30	0.836 69	1.555
			40	0.831 34	1.315
			50	0.828 85	1.116
			60	0.826 19	0.9454
12	0.5182	0.3812	30	0.837 52	1.211
			40	0.831 79	1.008
			50	0.827 63	0.8550
			60	0.824 41	0.7372
13	0.5939	0.2548	30	0.840 18	1.054
			40	0.833 14	0.8946
			50	0.827 94	0.7658
			60	0.824 78	0.6768

extreme corners near the vertices of the triangular composition diagram.

Ostwald viscometers were used with necessary precautions for viscometric measurements (*9*). The standard deviations in the time of flow was found not to exceed 0.1%. For density measurements (*9*), the pyconometers used were calibrated with water with 0.997 07 g mL^{-1} as its density at 25 °C.

For temperature control, a Toshniwal Model GL-15 precision thermostat, with the bath temperature monitored to 0.01 °C with a standardized Beckmann thermometer, was used. During experiments, the bath temperature did not fluctuate beyond ±0.1 °C and also the evaporation of experimental liquids was checked to a minimum and remained insignificant.

The viscosities and densities were considered significant to four figures.

Results and Discussions

The viscosity and density data for the ternary mixtures toluene (1)–bromobenzene (2)–1-octanol (3), toluene (1)–1-hexanol (2)–1-octanol (3), and bromobenzene (1)–1-hexanol (2)–1-octanol (3) at 30, 40, 50, and 60 °C are presented in Tables I–III. The component mole fractions were chosen in such a way that the experimental region so identified was expected to provide convenient and meaningful data leading to suitable correlations and useful conclusions.

The experimental measurements of viscosities and densities were made at 30, 40, 50, and 60 °C. The increment in temperature level was kept regular at 10 °C to ensure measurable effects of temperature change on experimental observations.

Table III. Experimental Densities ρ_m and Viscosities η_m for the Ternary Mixture Bromobenzene (1)-1-Hexanol (2)-1-Octanol (3) at Different Temperatures

no.	X_1	X_2	t, °C	ρ_m, g mL^{-1}	η_m, cP
1	0.9488	0.0286	30	1.4422	0.9735
			40	1.4342	0.8621
			50	1.4290	0.7812
			60	1.4219	0.7111
2	0.0396	0.9340	30	0.83923	3.618
			40	0.83435	2.760
			50	0.83234	2.166
			60	0.83165	1.734
3	0.0487	0.0411	30	0.85210	5.490
			40	0.84077	4.000
			50	0.83889	3.071
			60	0.83860	2.412
4	0.0839	0.6363	30	0.86371	3.793
			40	0.85907	2.909
			50	0.85536	2.258
			60	0.85274	1.815
5	0.4220	0.0711	30	1.0444	2.498
			40	1.0385	2.001
			50	1.0333	1.646
			60	1.0287	1.376
6	0.6483	0.3036	30	1.2200	1.371
			40	1.2136	1.178
			50	1.2099	1.019
			60	1.2072	0.9144
7	0.3984	0.3358	30	1.0423	2.156
			40	1.0331	1.735
			50	1.0249	1.463
			60	1.0166	1.217
8	0.1680	0.4957	30	0.90832	3.473
			40	0.90175	2.672
			50	0.89853	2.119
			60	0.89794	1.733
9	0.2417	0.5433	30	0.95304	2.897
			40	0.94710	2.295
			50	0.94451	1.814
			60	0.94285	1.486
10	0.3371	0.2131	30	1.0010	2.824
			40	0.99470	2.248
			50	0.99081	1.808
			60	0.98894	1.472
11	0.4856	0.1364	30	1.0889	2.071
			40	1.0838	1.719
			50	1.0800	1.432
			60	1.0776	1.219
12	0.5227	0.3776	30	1.1319	1.700
			40	1.1252	1.401
			50	1.1204	1.200
			60	1.1165	1.030
13	0.5982	0.2521	30	1.1697	1.553
			40	1.1663	1.315
			50	1.1639	1.126
			60	1.1619	0.9719

The highest temperature level was restricted to 60 °C in order to avoid errors due to evaporation losses during the experimental work.

The molecules of one or more of the components forming the ternaries are either polar or associating and accordingly show nonideal behaviors in mixtures. The nonidealities as reflected in mixture viscosities are expressed in terms of excess viscosity η^E given by the following equation

$$\eta^E = \eta_m - \sum X_i \eta_i \qquad (1)$$

where η is the viscosity, X is the component mole fraction while superscript E stands for excess and subscript i and m stand for pure component and the mixture, respectively. With η–X_i–T data from Tables I–IV and eq 1, the corresponding η^E–X_i–T data were calculated.

Figures 1–3 show the plots of η^E vs η_m. Negative values of η^E in most of the cases are the consequence of lower viscosity contributions of similar nonspecific interactions and H-bonding effects of molecular species in real mixtures rather than those in the corresponding ideal mixtures.

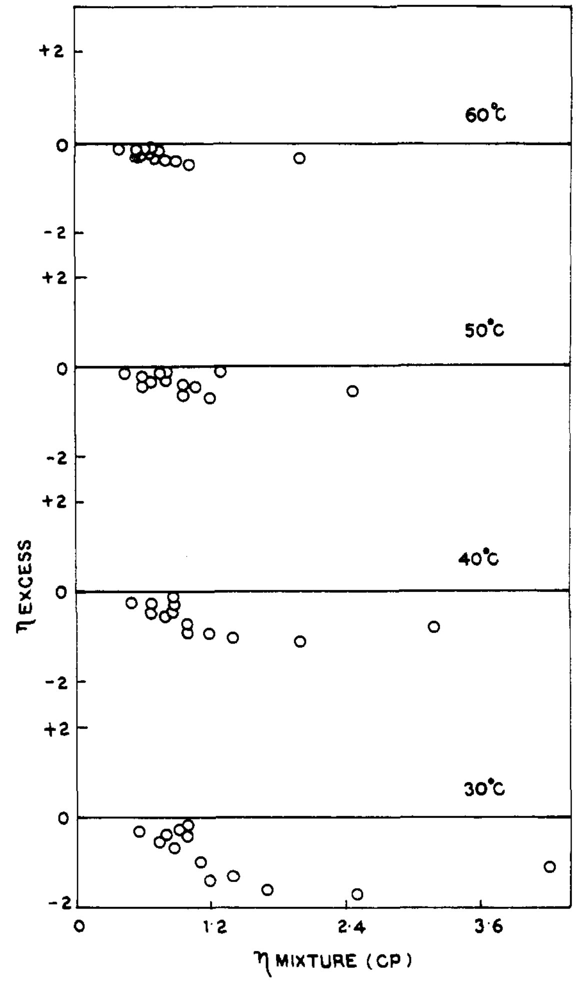

Figure 1. Plot of excess viscosity against corresponding mixture viscosity for the ternary toluene (1)-bromobenzene (2)-1-octanol (3) at 30, 40, 50, and 60 °C.

Table IV. Experimental Densities and Viscosities for Pure Components of the Ternaries

pure component	t, °C	ρ, g mL^{-1}	η, cP	ref
toluene	25	0.8623 (0.86231)	0.5520 (0.5516)	12
	30	0.86696	0.5372	
	40	0.85473	0.4851	
	50	0.84969	0.4272	
	60	0.84750	0.3905	
bromobenzene	25	1.4965 (1.48820)	1.045 (1.0430)	12
	30	1.4889	0.9850	
	40	1.4748	0.8744	
	50	1.4610	0.7819	
	60	1.4470	0.7129	
1-hexanol	25	0.8160 (0.81590)	4.590 (4.5920)	12
	30	0.81353	3.765	
	40	0.81050	2.934	
	50	0.80650	2.169	
	60	0.80340	1.655	
1-octanol	25	0.8262 (0.82209)	6.298^a (6.125^a)	12
	30	0.82392	6.298	
	40	0.81926	4.577	
	50	0.81472	3.428	
	60	0.81039	2.678	

^{a} At 30 °C.

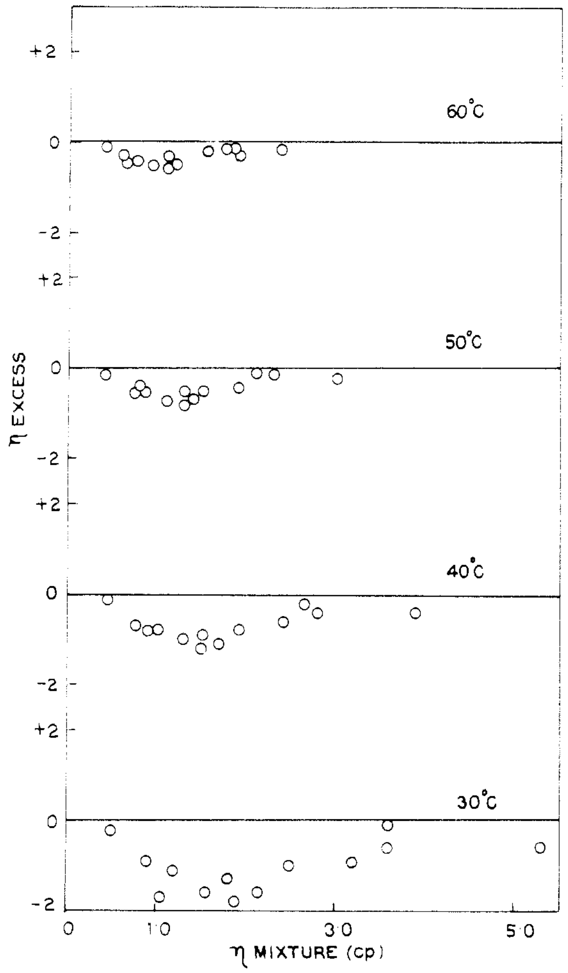

Figure 2. Plot of excess viscosity against corresponding mixture viscosity for the ternary toluene (1)-1-hexanol (2)-1-octanol (3) at 30, 40, 50, and 60 °C.

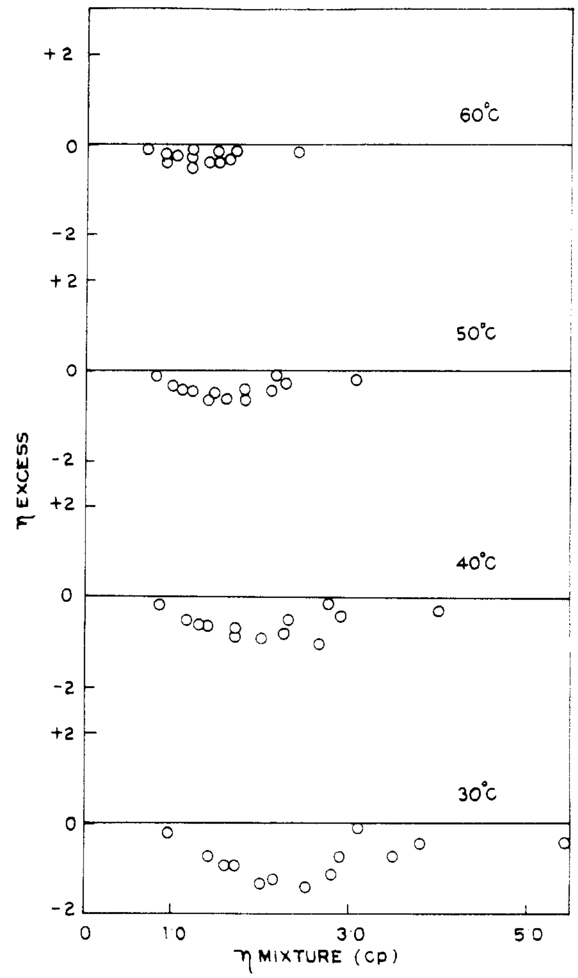

Figure 3. Plot of excess viscosity against corresponding mixture viscosity for the ternary bromobenzene (1)-1-hexanol (2)-1-octanol (3) at 30, 40, 50, and 60 °C.

Table V. Values of Binary Polynomial Constants A_{ij}, B_{ij}, C_{ij} and Additional Ternary Constant A^*_{ijk} Used in Equation 2 at Different Temperatures[a]

systems	parameter	30 °C	40 °C	50 °C	60 °C
toluene (1)-bromobenzene (2)[b]	A_{12}	-0.2687	-0.2215	-0.1252	-0.1535
	B_{12}	-0.4618	-0.4316	-0.3819	-0.1741
	C_{12}	0.6807	0.6537	0.5806	-0.5685
bromobenzene (1)-1-octanol (2)	A_{12}	-7.0851	-4.7740	-3.3477	-2.6436
	B_{12}	1.2492	0.3444	-0.3452	-0.6920
	C_{12}	-3.7390	-3.5998	-2.8254	-2.4515
toluene (1)-1-octanol (2)	A_{12}	-7.3819	-4.8729	-3.3106	-2.5434
	B_{12}	3.3259	2.1651	1.3623	0.9412
	C_{12}	0.9632	-0.9081	-0.5458	-0.6506
toluene (1)-1-hexanol (2)	A_{12}	-3.8947	-2.9628	-2.0096	-1.5114
	B_{12}	1.3869	1.2676	0.7865	0.2333
	C_{12}	-3.8947	-0.6250	-0.5634	-0.0897
1-hexanol (1)-1-octanol (2)	A_{12}	-0.0023	-0.0855	-0.0801	0.0999
	B_{12}	2.2728	1.2523	1.5697	1.5038
	C_{12}	1.1830	1.1972	1.3014	0.8312
bromobenzene (1)-1-hexanol (2)	A_{12}	-3.0760	-2.2790	-1.3397	-0.7798
	B_{12}	0.8089	0.8572	0.1168	-0.1247
	C_{12}	-0.0898	-0.6156	0.1474	0.1338
toluene (1)-bromobenzene (2)-1-octanol (3)	A^*_{123}	11.652	9.620	7.836	8.425
toluene (1)-1-hexanol (2)-1-octanol (3)	A^*_{123}	-3.522	-3.564	-0.451	1.273
bromobenzene (1)-1-hexanol (2)-1-octanol (3)	A^*_{123}	1.964	2.894	3.394	3.329

[a] Reference 11. [b] If binary toluene (1)-bromobenzene (2) is changed to bromobenzene (1)-toluene (2), then the values of A_{ij} and C_{ij} will remain the same. The value of B_{ij} will remain the same but its sign will change.

The ternary η-X-T data were fitted in eq 2, which includes the contributions of each constituent binary as calculated by a three-parameter Redlich-Kister-type equation (*10*, *11*) along with a ternary contribution term besides the contribution on an ideal mixture basis. The A_{ij}, B_{ij}, and C_{ij} were determined by

$$\eta_m = \sum_{i}^{3} X_i\eta_i + \sum_{i \neq j}^{3} X_iX_j[A_{ij} + B_{ij}(X_j - X_i) + C_{ij}(X_j - X_i)^2] + X_iX_jX_kA^*_{ijk} \quad (2)$$

least-squares method for the constituent binary using corre-

Table VI. Root Mean Square (rms) Deviations for Different Ternary Systems with Use of Equation 2 at Different Temperatures

	rms[a]				
	30 °C	40 °C	50 °C	60 °C	mean
toluene (1)-bromobenzene (2)-1-octanol (3)	0.0845	0.0787	0.0796	0.0911	0.0835
toluene (1)-1-hexanol (2)-1-octanol (3)	0.0606	0.0423	0.0351	0.0449	0.0457
bromobenzene (1)-1-hexanol (2)-1-octanol (3)	0.0465	0.0434	0.0499	0.0547	0.0485

[a] rms deviation = $[\sum di^2/n]^{1/2}$ where n is the number of observations and $d = [(\eta_{\mathrm{exptl}} - \eta_{\mathrm{calcd}})/\eta_{\mathrm{exptl}}]$.

sponding binary η_m-X-T data (*11*). A^*_{ijk} of eq 2 is the additional ternary constant to be evaluated by experimental ternary η_m-X-T data by the least-squares method. Such values of A_{ij}, B_{ij}, C_{ij}, and A^*_{ijk} are listed in Table V. The parameters included in Table IV were used as input in eq 2 for calculating η-X-T data showing root mean square deviations as listed in Table VI.

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Glossary

T	temperature, K
t	temperature, °C
X	mole fraction

Greek Letters

η	absolute viscosity, cP
ρ	density, g mL^{-1}

Subscripts

i	component in a mixture
m	mixture
1,2,3	component number in a mixture

Superscript

E	excess quantity

Literature Cited

(1) Singh, R. P.; Sinha, C. P. *J. Chem. Eng. Data* **1982**, *27*, 283.
(2) Singh, R. P.; Sinha, C. P. *J. Chem. Eng. Data* **1985**, *30*, 38.
(3) Singh, R. P.; Sinha, C. P. *Indian J. Chem., Sect. A* **1982**, *21A*, 96.
(4) Singh, R. P.; Sinha, C. P. *Indian J. Chem., Sect. A* **1983**, *22A*, 282.
(5) Singh, R. P.; Sinha, C. P. *Z. Phys. Chem.* (*Leipzig*) **1982**, *263*, 1075.
(6) Singh, R. P.; Sinha, C. P. *Z. Phys. Chem.* (*Leipzig*) **1984**, *265*, 583.
(7) Singh, R. P.; Sinha, C. P.; Das, J. C.; Ghosh, P. *J. Chem. Eng. Data* **1989**, *34*, 335.
(8) Singh, R. P.; Sinha, C. P.; Das, J. C. *Z. Phys. Chem.* (*Leipzig*), in press.
(9) Daniels, F.; Williams, J. W.; Bender, P.; Alberty, A. R.; Cornwell, C. D.; Harriman, J. E. *Experimental Physical Chemistry*, 6th ed.; McGraw-Hill-Kogakusha: New York, 1970.
(10) Redlich, O., Kister, A. T. *Ind. Eng. Chem.* **1948**, *40*, 345.
(11) Das, J. C. Correlations of Certain Physico-Chemical Properties of some Ternary Liquid Mixtures with Selected Parameters of Corresponding Pure Components. Ph.D. Thesis submitted to North Bengal University, Darjeeling, India, 1989.
(12) Riddick, A.; Bunger, W. B. *Organic Solvents*; Wiley-Interscience: New York, 1970; Vol. 2.

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NEW COMPOUNDS

Synthesis of 1-Aryl-2-hydrazino-4-phenyl-1,6-dihydro-1,3,5-triazine-6-thiones and Related Thiosemicarbazides

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Different 1-aryl-2-(benzylthio)-4-phenyl-1,6-dihydro-1,3,5-triazine-6-thiones have been synthesized by known methods. These triazines on treatment with hydrazine hydrate under suitable conditions afforded corresponding hydrazino derivatives. 1-Aryl-2-hydrazino-4-phenyl-1,6-dihydro-1,3,5-triazine-6-thione on interaction with aryl/alkyl isothiocyanates gave related thiosemicarbazides.

The presence of antituberculous (*1*, *2*), antibacterial, antiviral (*3*), and antifungal (*4*) activity in some substituted thiosemicarbazides prompted us to search for new members of this series containing the triazinyl moiety.

The present paper deals with the synthesis of 1-aryl-2-hydrazino-4-phenyl-1,6-dihydro-1,3,5-triazine-6-thiones (II) and *N*-aryl/alkyl-*N''*-(1-aryl-4-phenyl-1,6-dihydro-6-thioxo-1,3,5-triazin-2-yl)thiosemicarbazides (III). The precursor 1-aryl-2-(benzylthio)-4-phenyl-1,6-dihydro-1,3,5-triazine-6-thione (I) was obtained by condensation of benzoyl isothiocyanate (*5*) and

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