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Sound speeds and densities for binary liquid combinations at various temperatures: According to experimental data

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Abstract: The experimental work carried out during the present investigations consists of measurements of density and speed of sound u of the following liquid mixtures at T = (288.15, 293.15, 298.15, 303.15 and 308.15) K and atmospheric pressure over the entire range of composition. In the present project report we report the densities and speeds of sound for binary mixtures tert-butyl methyl ether (1) + propyl amine (2); +dipropylamine (2) mixtures at T = (288.15, 293.15, 298.15, 303.15 and 308.15) K and atmospheric pressure over the entire range of composition using an AntonPaar DSA 5000 densimeter. Here in this section, the work is mainly concerned with the study of changes arising due to increase in the alkyl part of amine molecule. With these experimental values of densities and speeds of sound, we have reported the deviations in speeds of sound and deviations in isentropic compressibility.
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Introduction: Liquid state properties are very useful in chemical analysis where knowledge of the thermodynamic and ultrasonic properties of the multi-component systems is essential in chemical industries for design calculation. The intermolecular forces are important from the view point of its application in many branches of science and chemistry and its applications are significant in such fields as molecular biology, polymer science and surface chemistry. Thermodynamic and transport properties in liquid mixtures have been extensively used to study the departure of a real liquid mixture from ideality. In addition, these properties have been extensively used to study the intermolecular interaction between the species present in the liquid mixtures. The properties of multi component liquid mixtures can be predicted either from a knowledge of the properties of their pure components as developed by Hirschfelder, Eyring , and Eichinger and Flory or from the properties of their contributing binary systems as advanced by Bertrand et al . Excess thermodynamic functions (VE, HE , UE , KE s P E int, VE f , etc.) have been used as a qualitative and quantitative guide to predict the extent of complex formation in binary liquid mixtures. Knowledge of viscosity of liquid mixtures at varying temperature and composition also gives a very close insight on the problems concerning heat transfer, mass transfer and fluid flow. Various thermodynamic and transport properties depend upon the precision of density measurements. This parameter is used to deduce a number of other thermodynamic properties that are not easily accessible by other methods. The experimental techniques for the density measurements of liquid mixtures have been discussed in early years by Parker and Parker. Later, the effect of certain factors like temperature, pressure, composition of dissolved gases, etc. was studied by Brown and Lane. The study of thermo physical properties of liquid mixtures is significant for many purposes such as to explore molecular interactions between the components of liquid mixture, in developing the new theoretical models, and also in carrying out engineering applications in the process industry. The mixing of different components give rise to a solution that generally does not behave ideally. The deviation from ideality is expressed by many thermodynamic variables, particularly by excess thermodynamic properties. Excess thermodynamic properties of liquid mixtures correspond to the difference between the actual property of the liquid mixture and the property if the system behaves ideally and, thus, are useful in the study of molecular interactions and arrangements. In particular, they reflect the interactions that take place between solute-solute, solute-solvent, and solvent-solvent species.

Materials and Methods:

The experimental work carried out during the present investigations consists of measurements of density and speed of sound u of the following liquid mixtures at T = (288.15, 293.15, 298.15, 303.15 and 308.15) K and atmospheric pressure over the entire range of composition

Propylamine

Tert-butyl methyl ether +

Dipropylamine

Table 3.2: Sources and grades of chemicals.

Chemical	**Source**	*Grade*
Propylamine	Merck-Schuchardt, Germany	zur-Synthese GC > 99 %
Dipropylamine	Merck-Schuchardt, Germany	zur-Synthese GC > 99 %
Tert-butyl methyl ether	Fluka	GC > 99 %
Cyclohexane	S.D. Finechem., Mumbai	HPLC and Spectroscopic grade, min. assay (GLC) 99.7 %
Benzene	S.D. Finechem., Mumbai	HPLC and Spectroscopic grade, min. assay (GLC) 99.8 %
Molecular Sieves	S.D. Finechem., Mumbai	

Results:

In the present project report we report the densities and speeds of sound for binary mixtures tert-butyl methyl ether (1) + propyl amine (2); +dipropylamine (2) mixtures at T = (288.15, 293.15, 298.15, 303.15 and 308.15) K and atmospheric pressure over the entire range of composition using an AntonPaar DSA 5000 densimeter. Here in this section, the work is mainly concerned with the study of changes arising due to increase in the alkyl part of amine molecule. With these experimental values of densities and speeds of sound, we have reported the deviations in speeds of sound and deviations in isentropic compressibility.

Experimental densities,ρ, for binary mixtures of tert-buytl methyl ether (1) + propyl amine (2); +dipropylamine (2) mixtures at T = (288.15, 293.15, 298.15, 303.15 and 308.15) K are listed in Table 4.1. Excess molar volumes were calculated from our measured densities according to the following equation

$$V_m^E = (x_1M_1 + x_2M_2) / \rho - x_1M_1 / \rho_1 - x_2M_2 / \rho_2 \quad (1.1)$$

where x_1 and x_2 are mole fractions, M_1 and M_2 are molar masses and ρ_1 and ρ_2 are the densities of pure components 1 and 2, respectively. ρ is the density of .

the binary mixtures. The values of V_m^E are also reported in Table 1.1.gives our measured values of speeds of sound at T = (288.15, 293.15, 298.15, 303.15 and 308.15) K for all binary mixtures over the whole composition range.

Isentropic compressibilities κ_S were obtained from the relation

$$\kappa_S = (\rho u^2)^{-1} = V_m (Mu^2)^{-1} \quad (1.2)$$

where ρ is the density of the mixture.

Deviations in speeds of sound Δu were calculated by

$$\Delta u = u_m - (x_1u_1 + x_2u_2) \quad (1.3)$$

Defining the ideal isentropic solution property κ_S^{id} in terms of the volume fraction average

$$\kappa_S^{id} = \phi_1\kappa_{S,1} + \phi_2\kappa_{S,2} \quad (1.4)$$

Where $\kappa_{S,i}$ is the isentropic compressibility of pure components 1 and 2

Table.1 Experimental densities and speeds of sound for binary liquid mixtures at different temperatures

	$\rho \times 10^3$ (kg m^{-3})					$V_m^E \times 10^6$ (m^{3}mol^{-1})				
x_1	288.15 K	293.15 K	298.15 K	303.15 K	308.15 K	288.15 K	293.15 K	298.15 K	303.15 K	308.15 K
Tert-butyl methyl ether (1) + propylamine (2)										
0.0000	0.725080	0.719859	0.714586	0.709269	0.703911	0.0000	0.0000	0.0000	0.0000	0.0000
0.0709	0.727856	0.722621	0.717583	0.712014	0.706643	-0.0658	-0.0649	-0.0645	-0.0643	-0.0636
0.0971	0.72903	0.723784	0.718729	0.713152	0.707762	-0.1122	-0.1106	-0.1098	-0.1082	-0.1057
0.2112	0.73300	0.727745	0.722617	0.717065	0.711678	-0.2097	-0.208	-0.2037	-0.2013	-0.2003
0.2915	0.734914	0.729567	0.724408	0.718869	0.713452	-0.1946	-0.1806	-0.1747	-0.1698	-0.1641
0.3956	0.737188	0.731938	0.726763	0.721277	0.715895	-0.1709	-0.1684	-0.1635	-0.1608	-0.1594
0.5551	0.740109	0.734863	0.729642	0.724214	0.718801	-0.1027	-0.099	-0.0917	-0.0893	-0.0817
0.7171	0.742564	0.737327	0.732071	0.726691	0.721338	-0.0066	-0.0022	0.0071	0.0104	0.0110
0.7747	0.743456	0.738220	0.732941	0.727578	0.722269	0.0152	0.0200	0.0316	0.0348	0.0290
0.8604	0.744503	0.739270	0.733994	0.728673	0.723302	0.0807	0.0864	0.0962	0.0970	0.1020
0.9268	0.745600	0.740382	0.735117	0.729806	0.724452	0.0811	0.0847	0.0909	0.0925	0.0948
1.0000	0.747273	0.742072	0.736826	0.731532	0.726185	0.0000	0.0000	0.0000	0.0000	0.0000

Tert-butyl methyl ether (1) + dipropylamine (2)

0.0000	0.745064	0.740501	0.735924	0.731333	0.726732	0.0000	0.0000	0.0000	0.0000	0.0000
0.0455	0.744529	0.739961	0.735381	0.730779	0.726199	0.1129	0.1106	0.1076	0.1058	0.0974
0.0993	0.743741	0.739141	0.734529	0.729903	0.725268	0.2732	0.2732	0.2724	0.2709	0.2684
0.1886	0.743725	0.739088	0.734436	0.729765	0.725081	0.3045	0.3024	0.2995	0.2963	0.2921
0.304	0.744015	0.739319	0.734607	0.729854	0.725082	0.2903	0.2865	0.2814	0.2794	0.2767
0.3981	0.744373	0.739628	0.73496	0.730165	0.725325	0.2588	0.2533	0.2295	0.223	0.2199
0.4954	0.74492	0.740107	0.735272	0.73041	0.725531	0.1978	0.193	0.1868	0.1799	0.1705
0.5839	0.74536	0.74049	0.735593	0.730664	0.725713	0.1543	0.149	0.1428	0.1363	0.1275
0.7057	0.745893	0.740912	0.735904	0.730891	0.725831	0.1096	0.1089	0.1069	0.0992	0.0926
0.7685	0.746206	0.741193	0.736153	0.731058	0.725925	0.0815	0.0787	0.0741	0.0721	0.0692
0.8876	0.746684	0.741588	0.736455	0.731289	0.726066	0.0495	0.0463	0.0423	0.0365	0.032
0.9337	0.746947	0.741806	0.736641	0.731421	0.726159	0.0254	0.0238	0.0192	0.016	0.0113
1.0000	0.747273	0.742072	0.736826	0.731532	0.726185	0.0000	0.0000	0.0000	0.0000	0.0000

The deviations in the isentropic compressibility $\Delta\kappa_S$ from the ideal mixing values can be estimated from the following equation

$$\Delta\kappa_S = \kappa_S^{mix} - (\phi_1\kappa_{S,1} + \phi_2\kappa_{S,2}) \quad (1.5)$$

From the Table 1.1, it is observed that V_m^E values for tert-butyl methyl ether (1) + propyl amine (2) shows negative and positive deviations. On the other hand V_m^E values are positive for tert-butyl methyl ether (1) + dipropyl amine (2) mixtures at all temperatures. The magnitude of V_m^E values decrease with increase in temperature for all mixtures studied.

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1/2/2023