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Ultrasonic Velocities in, and Adiabatic Compressibilities for, Binary Liquid Mixtures of Acetone with Benzene, Toluene, *p*-Xylene, and Mesitylene at 308.15 K

Jagan Nath* and Atma Prakash Dixit

Chemistry Department, Gorakhpur University, Gorakhpur 273001, India

Measurements of ultrasonic velocities (u) and adiabatic compressibilities (k_s) have been made for binary liquid mixtures of acetone with benzene, toluene, *p*-xylene, and mesitylene at 308.15 ± 0.01 K. The values of the quantity Δk_s, which refers to the deviations of the experimental values of the adiabatic compressibilities, k_s, for the mixtures from the mole fraction mixture law values, have been calculated and have been fitted by the method of least squares to the equation $\Delta k_s = x_1x_2[A_0 + A_1(x_1 - x_2) + A_2(x_1 - x_2)^2]$ where x_1 and x_2 refer to the mole fractions of acetone and the aromatic hydrocarbon, respectively, and A_0, A_1, and A_2 are constants characteristic of a system. The values of Δk_s have been found to be negative for acetone–benzene, acetone–toluene, and acetone–*p*-xylene and positive for acetone–mesitylene. The negative values of Δk_s for the systems of acetone with benzene, toluene, and *p*-xylene suggest the existence of specific interaction between acetone and aromatic hydrocarbons.

Introduction

Recently Nath and Dixit (*1*) reported the excess volumes, V^E, for binary liquid mixtures of acetone with benzene, toluene, *p*-xylene, and mesitylene at 298.15 and 308.15 K, and for binary mixtures of acetone with cyclohexane at 298.15 K. Results of V^E for these systems suggest the existence of specific interactions between acetone and the aromatic hydrocarbons. Adiabatic compressibilities as determined from ultrasonic velocities in binary liquid mixtures are known (*2–4*) to provide an estimate of the strength of interaction between unlike molecules. To gain further insight into the interactions between acetone and the aromatic hydrocarbons, we have measured the ultrasonic velocities in, and adiabatic compressibilities for, binary liquid mixtures of acetone with benzene, toluene, *p*-xylene, and mesitylene at 308.15 K.

Experimental Section

Materials. The methods of purifying the various components and checking their purity have been described earlier (*1*).

Method. The ultrasonic velocities, u, in pure liquids and their binary mixtures were measured with a single-crystal interferometer (supplied by Mittal Enterprises, New Delhi) at a frequency of 2 MHz s^{-1}. The values of u are accurate to ±1.0 m s^{-1}. The adiabatic compressibilities, k_s, were calculated from the relation (*2*, *3*)

$$k_s = u^{-2}\rho^{-1} \qquad (1)$$

where ρ refers to the density. The densities used to calculate k_s for pure liquids at 308.15 K were obtained from the data reported by Timmermans (*5*), whereas the densities used to calculate k_s for mixtures were estimated from the densities of pure liquids and the excess volumes, as reported earlier (*1*). The working of the interferometer was tested in a manner similar to that described earlier (*3*, *6*). The uncertainty in the values of k_s is of the order of ±0.15%.

Results and Discussion

The experimental values of the ultrasonic velocities in, and

Table I. Experimental Values of Ultrasonic Velocities in, and Adiabatic Compressibilities for, the Various Systems of Acetone at 308.15 K

x_1	u, m s^{-1}	$10^{12}k_s$, Pa^{-1}	$10^{12}\Delta k_s$, Pa^{-1}
	Acetone–Benzene		
0.0000	1255	736	
0.1120	1246	754	−15
0.1326	1242	760	−15
0.2213	1235	775	−26
0.2840	1234	779	−33
0.3405	1222	800	−36
0.3740	1218	808	−38
0.4530	1208	828	−41
0.5068	1200	844	−41
0.5835	1190	866	−42
0.5868	1189	867	−42
0.7039	1168	911	−32
0.7141	1166	915	−31
0.8275	1148	958	−21
0.9160	1134	993	−12
1.0000	1120	1030	
	Acetone–Toluene		
0.0000	1265	733	
0.1536	1250	757	−22
0.2089	1245	766	−29
0.2279	1242	771	−30
0.2597	1237	779	−31
0.4115	1218	813	−42
0.5163	1205	839	−47
0.5218	1204	841	−47
0.5860	1195	859	−48
0.6407	1186	877	−46
0.7202	1172	906	−41
0.7946	1161	932	−37
0.8253	1156	944	−34
0.8686	1147	964	−27
0.8965	1143	974	−25
0.9230	1135	992	−15
1.0000	1120	1030	
	Acetone–*p*-Xylene		
0.0000	1272	729	
0.1453	1254	756	−17
0.2268	1245	770	−27
0.2932	1237	784	−33
0.3123	1235	787	−36
0.3883	1225	805	−41
0.5076	1209	834	−48
0.5713	1201	850	−51
0.8704	1148	962	−29
0.8729	1147	964	−28
0.9310	1134	994	−15
1.0000	1120	1030	
	Acetone–Mesitylene		
0.0000	1298	698	
0.0553	1291	708	8
0.1714	1276	729	26
0.2812	1262	751	40
0.3182	1253	764	40
0.3368	1250	768	42
0.4658	1230	802	51
0.4903	1225	810	51
0.5260	1219	820	53
0.5304	1218	822	52
0.5349	1217	824	52
0.7348	1179	896	46
0.9581	1128	1009	7
1.0000	1120	1030	

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Table II. Values of the Constants A_0, A_1, and A_2 of Eq 2, and the Standard Deviations $\delta(\Delta k_s)$, for the Various Systems at 308.15 K

system	$10^{12}A_0$, Pa^{-1}	$10^{12}A_1$, Pa^{-1}	$10^{12}A_2$, Pa^{-1}	$10^{12}\delta(\Delta k_s)$, Pa^{-1}
acetone-benzene	−164.51	−5.91	32.66	1.4
acetone-toluene	−186.00	−45.93	−27.69	1.5
acetone-p-xylene	−195.44	−75.12	12.78	1.1
acetone-mesitylene	209.97	20.43	−50.91	2.1

adiabatic compressibilities for, binary mixtures of acetone with benzene, toluene, *p*-xylene, and mesitylene at 308.15 K are given in Table I, where x_1 refers to the mole fraction of acetone. The values of Δk_s, which refers to the deviations of the experimental values of k_s from the mole fraction mixture law values, are also given in Table I and have been fitted by least squares to the following equation:

$$\Delta k_s = x_1x_2[A_0 + A_1(x_1 - x_2) + A_2(x_1 - x_2)^2] \qquad (2)$$

The values of the constants A_0, A_1, and A_2 along with the standard deviations $\delta(\Delta k_s)$ are given in Table II.

The values of Δk_s can be discussed (*2*, *4*) from the viewpoint of the existence of specific interactions between the components of a system. The data show that the values of Δk_s are negative for acetone-benzene, acetone-toluene, and acetone-*p*-xylene and positive for acetone-mesitylene. At $x_1 = 0.5$, the values of Δk_s have the sequence

mesitylene > benzene > toluene > *p*-xylene

The above sequence along with the negative values of Δk_s for acetone-benzene, acetone-toluene, and acetone-*p*-xylene further supports earlier findings (*1*) that the dipole interaction between the components is not the only cause of the deviations, and the electron donor and acceptor properties of the components also play an important part. There is a likelihood of the formation of a weak hydrogen bond due to interaction between the H atom of the aromatic ring and the lone-pair electrons of acetone. The positive values of Δk_s for the system acetone-mesitylene can be attributed to the fact that the dispersion forces are predominant between the components of this system.

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Registry No. Acetone, 67-64-1; benzene, 71-43-2; toluene, 108-88-3; *p*-xylene, 106-42-3; mesitylene, 108-67-8.

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Liquid-Liquid Equilibria for the System Benzene-Water-Methanol

Jaime O. Triday

Departamento de Procesos Químicos, Universidad Têcnica Federico Santa Maria, Valparaíso 110-V, Chile

Liquid-liquid equilibrium data for the system benzene-water-methanol were obtained at 293 K. Tie lines were established by correlating the refractive index of the binodal curve as a function of composition. Data were reduced by the Abrams and Prausnitz (UNIQUAC) equation. The experimental and UNIQUAC plait points were calculated by the Hand coordinates method.

Introduction

The liquid-liquid equilibrium for the system benzene-water-methanol has been previously investigated by Udovenko and Mazanko (*1*). However, equilibrium data at 293 K were not found in the literature (*2*). Most of the reported data for this system are on mutual solubility but little is known on tie-line data (*2*).

The aim of this work was to provide equilibrium data for this ternary system at 293 K.

This paper reports the results of these measurements and their correlation by the Abrams and Prausnitz equation (UNIQUAC) (*3*).

Table I. Physical Properties of Chemicals at 293 K

	density/(g cm^{-3})		refractive index	
	exptl	lit.	exptl	lit.
benzene	0.8790	0.879 03^b	1.5011	1.501 10^b
methanol	0.7911	0.791 31^a	1.3290	1.328 40^a
water	0.9983	0.998 20^b	1.3330	1.332 99^b

^{a}Reference *7*. ^{b}Reference *8*.

Experimental Section

Materials. Benzene was Merck analytical-grade reagent used without any further purification. The certified minimum purity of this chemical was 99.5%. Methanol was AnalaR; it was used after distillation in a high-efficiency packed column. Water was deionized and distilled in an all-glass distillation unit prior to use. Some physical properties of the reagents are listed in Table I together with literature values.

Binodal-Curve Determination. Depending upon the region of the binodal curve (i.e., whether benzene- or water-rich phase), homogeneous samples of known compositions were titrated in a thermostated glass-stoppered bottle. The thermo-

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