THE SPEED OF SOUND OF BINARY MIXTURES OF N-ALKANES

V.H. HASANOV, J.Y. NAZIYEV, Y.M. NAZIYEV
Department of Heat and Refrigeration Techniques, Azerbaijan Technical University,
AZ-1073 Baku, Azerbaijan, H. Javid av. , 25

Speeds of sound in liquid n-heptane, n-octane and its binary solutions were measured at temperatures T=(293.15 to 523.15) K and pressures up to 60 MPa. The pulse-echo method with a frequency of 8 MHz, with an uncertainty of ±0.08% was used. Measured values were fitted to a polynomial equation as functions of temperature and pressure, and the reliability of the present results is compared with the published data.

INTRODUCTION

If low frequency and low power acoustic ware exited in the sample is propagated isentropically, then the speed of sound, W, has a close relation to the derivative.

$$\left(\frac{\partial p}{\partial \rho}\right)_S = W^2, \tag{1}$$

where ρ is density, p is pressure, and s is entropy. The equation is extremely important in obtaining isentropic compressibility, $k_s=1/(\rho W^2)$ directly. Compared to other thermodynamic properties, such as the thermal expansion coefficient and specific heat capacity, the speed of sound in a fluid can be measured accurately in wide ranges of temperature and pressure. Consequently, the speed of sound of n-heptane and n-octane has been reported at atmospheric and high pressure [1-13]. The literature also contains measurements of the viscosity, speed of sound, heat capacity and density for mixtures of alcohols with hydrocarbon [1-4, 7, 8]. However, measurements of the liquid phase speed of sound of (n-heptane + n-octane) mixtures are not in the literature.

During previous years an experimental techniques for the measurements of speed of sound were developed in the wide ranges of temperature and pressure. However, the mechanical determination of the acoustic path length, $l_{p,t}$, required to obtain the speed of sound, W $\left(W = 2Fl_{p,t} - \Delta W_{dif.}\right.$, where $l_{p,t} = l_{20}(1+\alpha(t-20))[1-(1-2\mu)(p/E)])$ is the path length, taking into account the factor of linear expansion α and E the modulus of elasticity and the factor Poisson coefficient for a tube, μ. F is the frequency of the impulses send into the fluid sample, $\Delta W_{dif.}$ is the correction for diffraction [14].

In this work, the speed of sound in liquid mixture (n-heptane +n-octane) at temperatures T=(293.15 to 523.15) K and pressures up to 60 MPa are reported. A large number of experimental studies on the sound speed for these compounds have been reported in the literature, but there are not correlated and evaluated the latest experimental results, especially those in the compressed liquid. A confirmation of the reliability for new experimental values with the selected reference data will contribute to improve of experimental results in this field.

EXPERIMENTAL

The speed of sound was determined with a pulse-echo method, that has been described in detail elsewhere [14-17] and shown schematically in fig. 1, with an uncertainty of ±0.08%. Only the important features are described here.

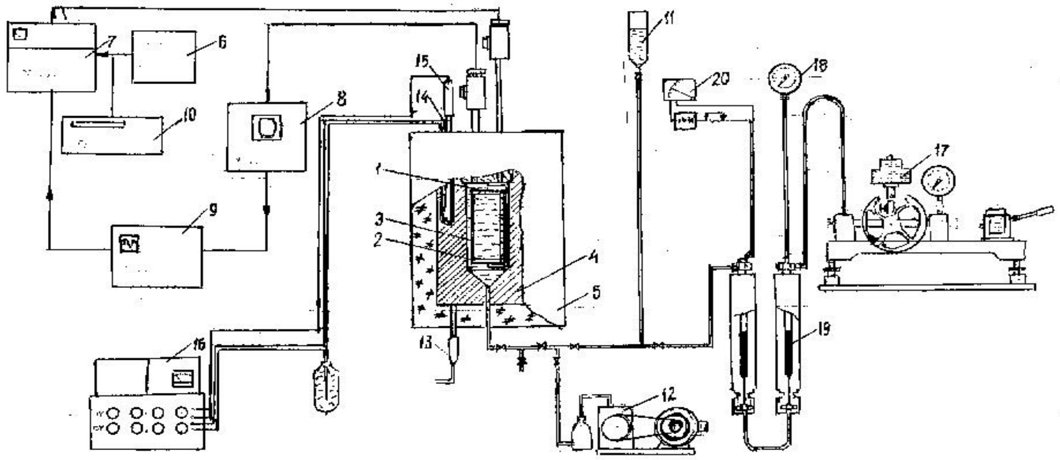


Fig.1. The experimental setup for measuring of the speed of sound in liquids: 1, acoustic sensor; 2 - autoclave (Br.M5); 3,4,5,16,17,18- systems for creating, maintaining and measuring the temperature and pressure; 9, oscilloscope S1-70; 10, frequency meter F5041; 11, system theme for the installation of a liquid filling; 12, vacuum pump; 19, mercury manometer; 18, manometer; 20, deaerator; 7, pulse generator G5-27A; 6, generator G3-118; 8, wide amplifier DUK-66.

Main part of installation is acoustic sensor, which implements the technique of measurement echo impulse. The acoustic sensor uses a pulse echo technique, because it is - the preferred method to measure the speed of sound in liquids. The basic principle of measuring the flight time of short beep for precisely known distance in the model fluid. If the audio signal reproduced as plane wave, the speed of sound, simply defined as the distance divided by the time the signal must travel the distance.

Temperature was measured with a platinum resistance thermometer with an accuracy of ±0.01 K. Pressures were generated and measured with a dead weight gauge at high pressures and a differential manometer on the ambient pressure. In accordance to the recommendations, [18] the experimental uncertainties are: ±3 mK for temperature, $0.1\pm5\cdot10^{-2}$ MPa for high pressure and $\pm5\cdot10^{-4}$ MPa for atmospheric pressure, and $\pm3\cdot10^{-4}$ $kg\cdot m^{-3}$ for density. The reliability of the data obtained was verified by measurements of the speed of sound apparatus and the results found to deviate by less than the anticipated uncertainties [19].

The n-heptane and n-octane were supplied by the Novocherkassk plant of Synthetic Products, Russia, with the following mole fraction purities: n-heptane >0.9998, and n-octane >0.9997. The chemicals were degassed in an ultrasonic cleaner and used without further purification. The speed of sound and densities in the pure components are compared with literature data in Table 1. The mixtures were prepared by mass. The balance accuracy was $\pm6\cdot10^{-4}$ g. From the balance accuracy, the uncertainty in the mole fraction of the solutions was estimated to be $\pm3\cdot10^{-6}$ (in the most unfavorable case).

Table 1.

Comparison of the speeds of sound and densities obtained in this work for pure components at *T*=298.15 K under atmospheric pressure with those reported in the literature

Component	exp.		lit.
n-heptane	$W/m\cdot s^{-1}$ $\rho/kg\cdot m^{-3}$	1130 679.6	1130.1,[1] 1130.18,[2] 1129.85,[3] 1129.92,[4] 1136.30,[5] 679.5,[6] 679.57,[7] 679.60,[2] 679.70,[1] 679.81,[8], 679.68[4]
n-octane	$W/m\cdot s^{-1}$ $\rho/kg\cdot m^{-3}$	1173 698.6	1173,[9] 1172.7[10] 1172.6[11] 698.6,[12] 698.6,[13] 698.58[10]

RESULTS AND DISCUSSION

The results speed of sound of *n*-heptane and *n*-octane and its binary solutions are listed in Table 2 and fitted by the following equation [20].

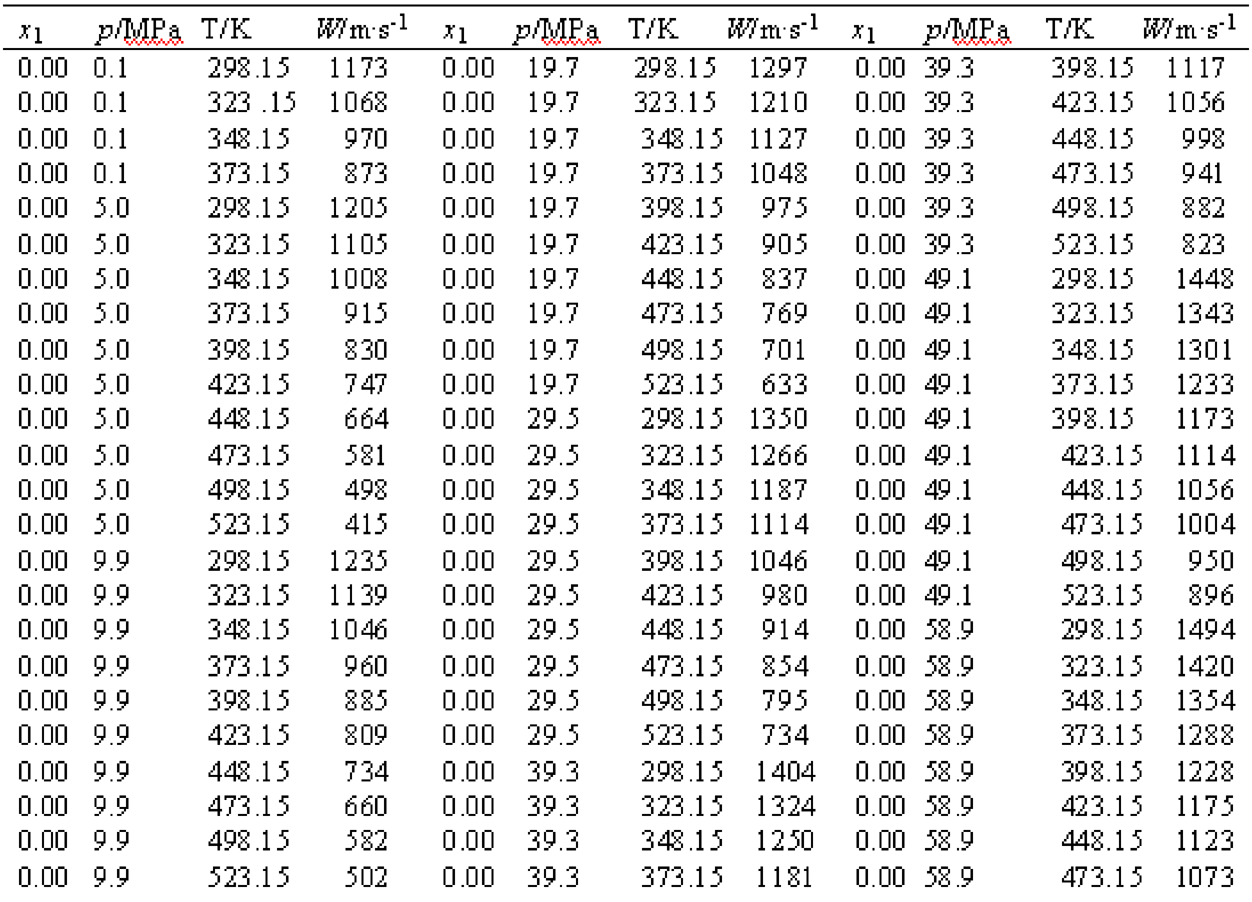
$$W = A + B\cdot T + C\cdot T^2, \qquad (1)$$

and *A, B, C* are the coefficients of (1) as follow

$$A=\sum_{i=0}^{5}a_i p^i;\ B=\sum_{i=0}^{5}b_i p^i;\ C=\sum_{i=0}^{5}c_i p^i; \qquad (2)$$

Table 2.

Speed of sound in n-heptane (1) + n-octane (2) mixtures measured at pressures up to 60 MPa within the temperature range 298.15 K to 523.15 K (x_1=the mole fraction of n-heptane)



x_1	p/MPa	T/K	$W/m\cdot s^{-1}$	x_1	p/MPa	T/K	$W/m\cdot s^{-1}$	x_1	p/MPa	T/K	$W/m\cdot s^{-1}$
0.00	0.1	298.15	1173	0.00	19.7	298.15	1297	0.00	39.3	398.15	1117
0.00	0.1	323 .15	1068	0.00	19.7	323.15	1210	0.00	39.3	423.15	1056
0.00	0.1	348.15	970	0.00	19.7	348.15	1127	0.00	39.3	448.15	998
0.00	0.1	373.15	873	0.00	19.7	373.15	1048	0.00	39.3	473.15	941
0.00	5.0	298.15	1205	0.00	19.7	398.15	975	0.00	39.3	498.15	882
0.00	5.0	323.15	1105	0.00	19.7	423.15	905	0.00	39.3	523.15	823
0.00	5.0	348.15	1008	0.00	19.7	448.15	837	0.00	49.1	298.15	1448
0.00	5.0	373.15	915	0.00	19.7	473.15	769	0.00	49.1	323.15	1343
0.00	5.0	398.15	830	0.00	19.7	498.15	701	0.00	49.1	348.15	1301
0.00	5.0	423.15	747	0.00	19.7	523.15	633	0.00	49.1	373.15	1233
0.00	5.0	448.15	664	0.00	29.5	298.15	1350	0.00	49.1	398.15	1173
0.00	5.0	473.15	581	0.00	29.5	323.15	1266	0.00	49.1	423.15	1114
0.00	5.0	498.15	498	0.00	29.5	348.15	1187	0.00	49.1	448.15	1056
0.00	5.0	523.15	415	0.00	29.5	373.15	1114	0.00	49.1	473.15	1004
0.00	9.9	298.15	1235	0.00	29.5	398.15	1046	0.00	49.1	498.15	950
0.00	9.9	323.15	1139	0.00	29.5	423.15	980	0.00	49.1	523.15	896
0.00	9.9	348.15	1046	0.00	29.5	448.15	914	0.00	58.9	298.15	1494
0.00	9.9	373.15	960	0.00	29.5	473.15	854	0.00	58.9	323.15	1420
0.00	9.9	398.15	885	0.00	29.5	498.15	795	0.00	58.9	348.15	1354
0.00	9.9	423.15	809	0.00	29.5	523.15	734	0.00	58.9	373.15	1288
0.00	9.9	448.15	734	0.00	39.3	298.15	1404	0.00	58.9	398.15	1228
0.00	9.9	473.15	660	0.00	39.3	323.15	1324	0.00	58.9	423.15	1175
0.00	9.9	498.15	582	0.00	39.3	348.15	1250	0.00	58.9	448.15	1123
0.00	9.9	523.15	502	0.00	39.3	373.15	1181	0.00	58.9	473.15	1073

Table 2. Continued

x_1	p/MPa	T/K	W/m·s^{-1}	x_1	p/MPa	T/K	W/m·s^{-1}	x_1	p/MPa	T/K	W/m·s^{-1}
0.00	58.9	498.15	1024	0.25	9.9	523.15	489	0.25	39.3	373.15	1170
0.00	58.9	523 .15	976	0.25	19.7	298.15	1286	0.25	39.3	398.15	1106
0.25	0.1	298.15	1162	0.25	19.7	323.15	1199	0.25	39.3	423.15	1045
0.25	0.1	323.15	1056	0.25	19.7	348.15	1116	0.25	39.3	448.15	987
0.25	0.1	348.15	958	0.25	19.7	373.15	1037	0.25	39.3	473.15	930
0.25	5.0	298.15	1194	0.25	19.7	398.15	964	0.25	39.3	498.15	871
0.25	5.0	323.15	1093	0.25	19.7	423.15	894	0.25	39.3	523.15	812
0.25	5.0	348.15	997	0.25	19.7	448.15	826	0.25	49.1	298.15	1437
0.25	5.0	373.15	904	0.25	19.7	473.15	758	0.25	49.1	323.15	1362
0.25	5.0	398.15	819	0.25	19.7	498.15	690	0.25	49.1	348.15	1290
0.25	5.0	423.15	736	0.25	19.7	523.15	622	0.25	49.1	373.15	1222
0.25	5.0	448.15	653	0.25	29.5	298.15	1339	0.25	49.1	398.15	1162
0.25	5.0	473.15	570	0.25	29.5	323.15	1255	0.25	49.1	423.15	1103
0.25	5.0	498.15	487	0.25	29.5	348.15	1176	0.25	49.1	448.15	1045
0.25	5.0	523.15	404	0.25	29.5	373.15	1103	0.25	49.1	473.15	993
0.25	9.9	298.15	1224	0.25	29.5	398.15	1035	0.25	49.1	498.15	939
0.25	9.9	323.15	1128	0.25	29.5	423.15	969	0.25	49.1	523.15	885
0.25	9.9	348.15	1035	0.25	29.5	448.15	903	0.25	58.9	298.15	1483
0.25	9.9	373.15	949	0.25	29.5	473.15	843	0.25	58.9	323.15	1404
0.25	9.9	398.15	874	0.25	29.5	498.15	784	0.25	58.9	348.15	1343
0.25	9.9	423.15	798	0.25	29.5	523.15	723	0.25	58.9	373.15	1277
0.25	9.9	448.15	723	0.25	39.3	298.15	1393	0.25	58.9	398.15	1217
0.25	9.9	473.15	647	0.25	39.3	323.15	1313	0.25	58.9	423.15	1164
0.25	9.9	498.15	569	0.25	39.3	348.15	1239	0.25	58.9	448.15	1112

Table 2. Continued

x_1	p/MPa	T/K	W/m·s^{-1}	x_1	p/MPa	T/K	W/m·s^{-1}	x_1	p/MPa	T/K	W/m·s^{-1}
0.25	58.9	473.15	1062	0.50	9.9	498.15	558	0.50	39.3	348.15	1228
0.25	58.9	498 .15	1013	0.50	9.9	523.15	478	0.50	39.3	373.15	1159
0.25	58.9	523.15	965	0.50	19.7	298.15	1275	0.50	39.3	398.15	1095
0.50	0.1	298.15	1151	0.50	19.7	323.15	1188	0.50	39.3	423.15	1034
0.50	0.1	323.15	1045	0.50	19.7	348.15	1105	0.50	39.3	448.15	976
0.50	0.1	348.15	947	0.50	19.7	373.15	1026	0.50	39.3	473.15	919
0.50	5.0	298.15	1183	0.50	19.7	398.15	953	0.50	39.3	498.15	860
0.50	5.0	323.15	1084	0.50	19.7	423.15	883	0.50	39.3	523.15	801
0.50	5.0	348.15	986	0.50	19.7	448.15	815	0.50	49.1	298.15	1426
0.50	5.0	373.15	893	0.50	19.7	473.15	747	0.50	49.1	323.15	1351
0.50	5.0	398.15	808	0.50	19.7	498.15	679	0.50	49.1	348.15	1279
0.50	5.0	423.15	725	0.50	19.7	523.15	611	0.50	49.1	373.15	1211
0.50	5.0	448.15	642	0.50	29.5	298.15	1328	0.50	49.1	398.15	1151
0.50	5.0	473.15	559	0.50	29.5	323.15	1244	0.50	49.1	423.15	1092
0.50	5.0	498.15	476	0.50	29.5	348.15	1165	0.50	49.1	448.15	1034
0.50	5.0	523.15	393	0.50	29.5	373.15	1092	0.50	49.1	473.15	982
0.50	9.9	298.15	1213	0.50	29.5	398.15	1024	0.50	49.1	498.15	928
0.50	9.9	323.15	1117	0.50	29.5	423.15	958	0.50	49.1	523.15	874
0.50	9.9	348.15	1024	0.50	29.5	448.15	892	0.50	58.9	298.15	1472
0.50	9.9	373.15	938	0.50	29.5	473.15	832	0.50	58.9	323.15	1398
0.50	9.9	398.15	863	0.50	29.5	498.15	773	0.50	58.9	348.15	1332
0.50	9.9	423.15	787	0.50	29.5	523.15	712	0.50	58.9	373.15	1266
0.50	9.9	448.15	712	0.50	39.3	298.15	1382	0.50	58.9	398.15	1206
0.50	9.9	473.15	636	0.50	39.3	323.15	1302	0.50	58.9	423.15	1153

Table 2. Continued

x_1	p/MPa	T/K	W/m·s^{-1}	x_1	p/MPa	T/K	W/m·s^{-1}	x_1	p/MPa	T/K	W/m·s^{-1}
0.50	58.9	448.15	1101	0.75	9.9	473.15	625	0.75	39.3	323.15	1291
0.50	58.9	473 .15	1051	0.75	9.9	498.15	547	0.75	39.3	348.15	1217
0.50	58.9	498.15	1002	0.75	9.9	523.15	467	0.75	39.3	373.15	1148
0.50	58.9	523.15	954	0.75	19.7	298.15	1264	0.75	39.3	398.15	1084
0.75	0.1	298.15	1140	0.75	19.7	323.15	1177	0.75	39.3	423.15	1023
0.75	0.1	323.15	1033	0.75	19.7	348.15	1094	0.75	39.3	448.15	965
0.75	0.1	348.15	935	0.75	19.7	373.15	1015	0.75	39.3	473.15	908
0.75	5.0	298.15	1172	0.75	19.7	398.15	942	0.75	39.3	498.15	849
0.75	5.0	323.15	1072	0.75	19.7	423.15	872	0.75	39.3	523.15	790
0.75	5.0	348.15	975	0.75	19.7	448.15	804	0.75	49.1	298.15	1415
0.75	5.0	373.15	882	0.75	19.7	473.15	736	0.75	49.1	323.15	1320
0.75	5.0	398.15	797	0.75	19.7	498.15	668	0.75	49.1	348.15	1268
0.75	5.0	423.15	714	0.75	19.7	523.15	600	0.75	49.1	373.15	1200
0.75	5.0	448.15	631	0.75	29.5	298.15	1317	0.75	49.1	398.15	1140
0.75	5.0	473.15	548	0.75	29.5	323.15	1233	0.75	49.1	423.15	1081
0.75	5.0	498.15	465	0.75	29.5	348.15	1154	0.75	49.1	448.15	1023
0.75	5.0	523.15	382	0.75	29.5	373.15	1081	0.75	49.1	473.15	971
0.75	9.9	298.15	1202	0.75	29.5	398.15	1013	0.75	49.1	498.15	917
0.75	9.9	323.15	1106	0.75	29.5	423.15	947	0.75	49.1	523.15	863
0.75	9.9	348.15	1013	0.75	29.5	448.15	881	0.75	58.9	298.15	1461
0.75	9.9	373.15	927	0.75	29.5	473.15	821	0.75	58.9	323.15	1387
0.75	9.9	398.15	852	0.75	29.5	498.15	762	0.75	58.9	348.15	1321
0.75	9.9	423.15	776	0.75	29.5	523.15	701	0.75	58.9	373.15	1255
0.75	9.9	448.15	701	0.75	39.3	298.15	1371	0.75	58.9	398.15	1195

Table 2. Continued

x_1	p/MPa	T/K	W/m·s^{-1}	x_1	p/MPa	T/K	W/m·s^{-1}	x_1	p/MPa	T/K	W/m·s^{-1}
0.75	58.9	423.15	1142	1.00	9.9	448.15	690	1.00	39.3	298.15	1360
0.75	58.9	448 .15	1090	1.00	9.9	473.15	614	1.00	39.3	323.15	1280
0.75	58.9	473.15	1040	1.00	9.9	498.15	536	1.00	39.3	348.15	1206
0.75	58.9	498.15	991	1.00	9.9	523.15	456	1.00	39.3	373.15	1137
0.75	58.9	523.15	943	1.00	19.7	298.15	1253	1.00	39.3	398.15	1073
1.00	0.1	298.15	1130	1.00	19.7	323.15	1166	1.00	39.3	423.15	1012
1.00	0.1	323.15	1022	1.00	19.7	348.15	1083	1.00	39.3	448.15	954
1.00	0.1	348.15	924	1.00	19.7	373.15	1004	1.00	39.3	473.15	897
1.00	5.0	298.15	1161	1.00	19.7	398.15	931	1.00	39.3	498.15	838
1.00	5.0	323.15	1061	1.00	19.7	423.15	861	1.00	39.3	523.15	779
1.00	5.0	348.15	964	1.00	19.7	448.15	793	1.00	49.1	298.15	1404
1.00	5.0	373.15	871	1.00	19.7	473.15	725	1.00	49.1	323.15	1329
1.00	5.0	398.15	786	1.00	19.7	498.15	657	1.00	49.1	348.15	1257
1.00	5.0	423.15	703	1.00	19.7	523.15	589	1.00	49.1	373.15	1189
1.00	5.0	448.15	620	1.00	29.5	298.15	1306	1.00	49.1	398.15	1131
1.00	5.0	473.15	537	1.00	29.5	323.15	1222	1.00	49.1	423.15	1070
1.00	5.0	498.15	454	1.00	29.5	348.15	1143	1.00	49.1	448.15	1012
1.00	5.0	523.15	371	1.00	29.5	373.15	1070	1.00	49.1	473.15	960
1.00	9.9	298.15	1191	1.00	29.5	398.15	1002	1.00	49.1	498.15	906
1.00	9.9	323.15	1095	1.00	29.5	423.15	936	1.00	49.1	523.15	852
1.00	9.9	348.15	1002	1.00	29.5	448.15	876	1.00	58.9	298.15	1450
1.00	9.9	373.15	916	1.00	29.5	473.15	816	1.00	58.9	323.15	1376
1.00	9.9	398.15	841	1.00	29.5	498.15	757	1.00	58.9	348.15	1310
1.00	9.9	423.15	765	1.00	29.5	523.15	696	1.00	58.9	373.15	1244
1.00	58.9	398.15	1184	1.00	58.9	448.15	1079	1.00	58.9	498.15	980
1.00	58.9	423 .15	1131	1.00	58.9	473.15	1029	1.00	58.9	523.15	932

The values of a_i, b_i and c_i are listed in Table 3. Equations (1) to (2) describe the experimental results within less then ±0.08%.

Table 3.

Coefficients of equations (1) to (2) for (n-heptane + n-octane)

i	a	b_1	c_1 $_i$
	n-octane		
0	2725.35	-6.16625	$3.21241\cdot10^{-3}$
1	-64.3166	0.359581	$-4.27694\cdot10^{-4}$
2	5.33892	-0.0292391	$3.96324\cdot10^{-5}$
3	-0.187854	$1.04717\cdot10^{-3}$	$-1.46461\cdot10^{-6}$
4	$2.9643\cdot10^{-3}$	$-1.67138\cdot10^{-5}$	$2.37052\cdot10^{-8}$
5	$-1.71639\cdot10^{-5}$	$9.75554\cdot10^{-8}$	$-1.39514\cdot10^{-10}$
	25%n-heptane + 75%n-octane		
0	3048.03	-8.23512	$6.40084\cdot10^{-3}$
1	-158.367	0.940787	$-1.32108\cdot10^{-3}$
2	13.5151	-0.0797109	$1.17156\cdot10^{-4}$
3	-0.490156	$2.91243\cdot10^{-3}$	$-4.3289\cdot10^{-6}$
4	$7.95133\cdot10^{-3}$	$-4.74779\cdot10^{-5}$	$7.09431\cdot10^{-8}$
5	$-4.73672\cdot10^{-5}$	$2.83853\cdot10^{-7}$	$-4.25566\cdot10^{-10}$
	50%n-heptane + 50%n-octane		
0	3037.56	-8.23735	$6.40316\cdot10^{-3}$
1	-157.198	0.935891	$-1.31599\cdot10^{-3}$
2	13.3583	-0.0790537	$1.16472\cdot10^{-4}$
3	-0.483163	$2.88313\cdot10^{-3}$	$-4.29842\cdot10^{-6}$
4	$7.82322\cdot10^{-3}$	$-4.69411\cdot10^{-5}$	$7.03846\cdot10^{-8}$
5	$-4.65379\cdot10^{-5}$	$2.80378\cdot10^{-7}$	$-4.21951\cdot10^{-10}$
	75%n-heptane + 25%n-octane		
0	3114.7	-8.76968	$7.19663\cdot10^{-3}$
1	-182.144	1.08534	$-1.53752\cdot10^{-3}$
2	15.5475	-0.0921189	$1.35787\cdot10^{-4}$
3	-0.564763	$3.36907\cdot10^{-3}$	$-5.01571\cdot10^{-6}$
4	$9.17793\cdot10^{-3}$	$-5.49975\cdot10^{-5}$	$8.22652\cdot10^{-8}$
5	$-5.47827\cdot10^{-5}$	$3.29364\cdot10^{-7}$	$-4.94142\cdot10^{-10}$
	n-heptane		
0	3193.44	-9.30597	$7.99685\cdot10^{-3}$
1	-206.791	1.23347	$-1.75984\cdot10^{-3}$
2	17.6275	-0.104669	$1.54712\cdot10^{-4}$
3	-0.637711	$3.80957\cdot10^{-3}$	$-5.68132\cdot10^{-6}$
4	0.0103057	$-6.18069\cdot10^{-5}$	$9.25698\cdot10^{-8}$
5	$-6.1161\cdot10^{-5}$	$3.67870\cdot10^{-7}$	$-5.52505\cdot10^{-10}$

The analysis of coefficients of the equation (1) depending on concentration has allowed to offer the following equations transferring concentration dependences for all investigated binary systems:

$$W=\sum_{i=0}^{5}\sum_{j=0}^{4}a_{ij}p^{i}\left(100-x\right)^{j}+\sum_{i=0}^{5}\sum_{j=0}^{4}b_{ij}p^{i}\left(100-x\right)^{j}\cdot T+\sum_{i=0}^{5}\sum_{j=0}^{4}c_{ij}p^{i}\left(100-x\right)^{j}\cdot T^{2}, \qquad (3)$$

Coefficient a_{ij}, b_{ij} and c_{ij} of the eqn. (3) are listed in Table 4.

Table 4.

Coefficient of equations (3)

i	j				
	0	1	2	3	4
			a		
0	2725.35	30.248	-0.974759	0.0125964	$-5.40555\cdot10^{-5}$
1	-64.3166	-8.76188	0.281592	$-3.65821\cdot10^{-3}$	$1.57598\cdot10^{-5}$
2	5.33892	0.767435	-0.0248413	$3.24056\cdot10^{-4}$	$-1.40098\cdot10^{-6}$
3	-0.187854	-0.0285345	$9.28844\cdot10^{-4}$	$-1.21663\cdot10^{-5}$	$5.28142\cdot10^{-8}$
4	$2.9643\cdot10^{-3}$	$4.72834\cdot10^{-4}$	$-1.54628\cdot10^{-5}$	$2.03302\cdot10^{-7}$	$-8.86157\cdot10^{-10}$
5	$-1.71639\cdot10^{-5}$	$-2.87401\cdot10^{-6}$	$9.43461\cdot10^{-8}$	$-1.24456\cdot10^{-9}$	$5.44505\cdot10^{-12}$
			b		
0	-6.16625	-0.18994	$6.02082\cdot10^{-3}$	$-7.76646\cdot10^{-5}$	$3.33107\cdot10^{-7}$
1	0.359581	0.053804	$-1.71839\cdot10^{-3}$	$2.22359\cdot10^{-5}$	$-9.55852\cdot10^{-8}$
2	-0.0292391	$-4.69703\cdot10^{-3}$	$1.50783\cdot10^{-4}$	$-1.95717\cdot10^{-6}$	$8.43615\cdot10^{-9}$
3	$1.04717\cdot10^{-3}$	$1.74337\cdot10^{-4}$	$-5.62184\cdot10^{-6}$	$7.32322\cdot10^{-8}$	$-3.16851\cdot10^{-10}$
4	$-1.67138\cdot10^{-5}$	$-2.885851\cdot10^{-6}$	$9.34278\cdot10^{-8}$	$-1.22128\cdot10^{-9}$	$5.30499\cdot10^{-12}$
5	$9.75557\cdot10^{-8}$	$1.75289\cdot10^{-8}$	$-5.694\cdot10^{-10}$	$7.46662\cdot10^{-12}$	$-3.2552\cdot10^{-14}$
			c		
0	$3.21241\cdot10^{-3}$	$2.9106\cdot10^{-4}$	$-9.22258\cdot10^{-6}$	$1.1861\cdot10^{-7}$	$-5.0791\cdot10^{-10}$
1	$-4.27694\cdot10^{-4}$	$-8.22155\cdot10^{-5}$	$2.60954\cdot10^{-6}$	$-3.36158\cdot10^{-8}$	$1.44099\cdot10^{-10}$
2	$3.96324\cdot10^{-5}$	$7.16047\cdot10^{-6}$	$-2.28101\cdot10^{-7}$	$2.94507\cdot10^{-9}$	$-1.26502\cdot10^{-11}$
3	$-1.46461\cdot10^{-6}$	$-2.65454\cdot10^{-7}$	$8.48731\cdot10^{-9}$	$-1.09925\cdot10^{-10}$	$4.73812\cdot10^{-13}$
4	$2.37052\cdot10^{-8}$	$4.39109\cdot10^{-9}$	$-1.40876\cdot10^{-10}$	$1.83052\cdot10^{-12}$	$-7.92006\cdot10^{-15}$
5	$-1.39514\cdot10^{-10}$	$-2.66595\cdot10^{-11}$	$8.57857\cdot10^{-13}$	$-1.118E\cdot10^{-14}$	$4.85447\cdot10^{-17}$

Using the obtained values of coefficients a_{ij}, b_{ij} and c_{ij}, it is possible to define values of speed of sound solutions with satisfactory accuracy at high pressures, temperatures and concentrations.

The uncertainty of eqn. (3) is ±0,35% (in some places up to 3.4%).

Speed of sound in liquids increases monotonically at a pressure of 40MPa and different temperatures, depending on the mass concentration n-heptane, as illustrated graphically in fig. 2, at T=498.15 K and different pressures fig. 3.

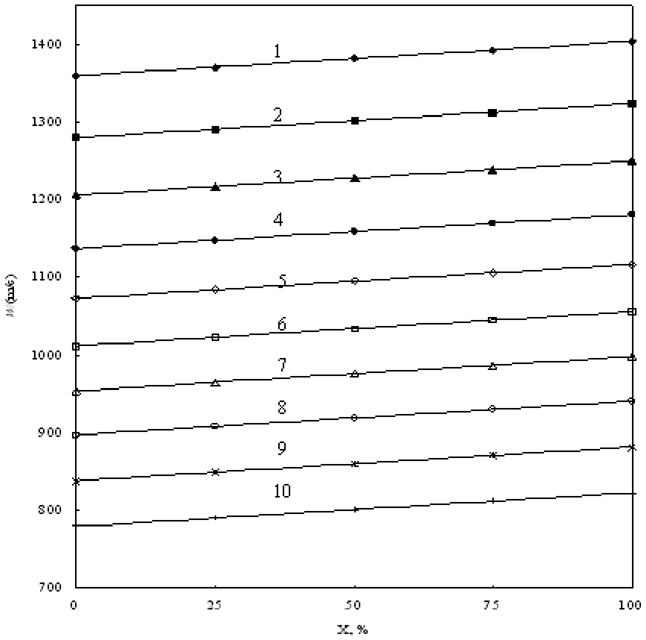


Fig.2. The speed of sound of binary liquid mixtures *n*-heptane +n-octane at p= 40MPa and different temperatures, depending on the mass concentration n-heptane: 1 - 298.15 K; 2-323,15; 3-348,15; 4-373,15 ; 5-398,15; 6-423,15; 7-448,15; 8-473,15; 9-498,15; 10-523,15.

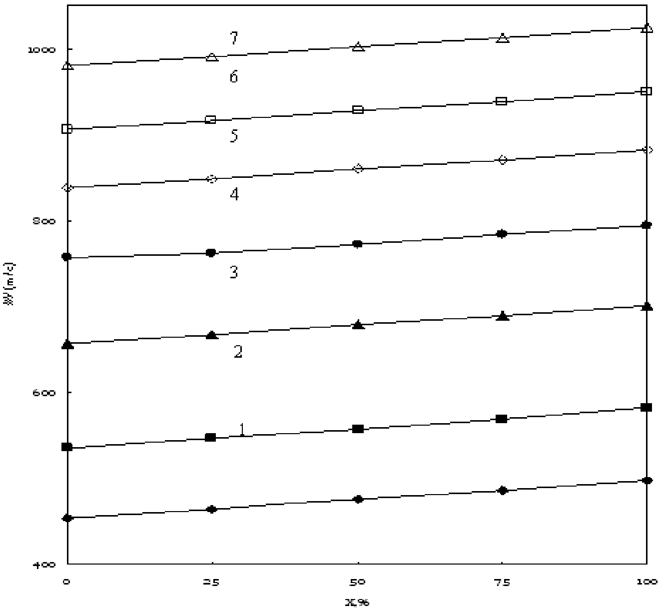


Fig.3. The speed of sound of binary liquid mixtures n-heptane +*n*-octane at a temperature of 498.15 K and different pressures, depending on the mass concentration n-heptane: 1-5 MPa, 2-9,9; 3-19,7 ; 4-29,5; 5-39,3; 6-49,1; 7-58,9.

CONCLUSION

The speed of sound in liquid n-heptane and n-octane and mixtures (n-heptane + n-octane) were measured at temperatures from T=(298.15 to 523.15)K and pressure up to 60 MPa. The uncertainty of the results is estimated to be within ±0.2 percent in the whole experimental range taking into account uncertainties of temperature and pressure. The comparison of the measured data with the literature values recently supports the fact that both the experimental setup and the method employed for the measurements are capable for accurate measurements of speed of sound in liquids and binary mixtures in extended ranges temperature and pressure.

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V.H. Həsənov, C.Y. Naziyev, Y.M. Naziyev

n- ALKANLARIN BİNAR QARIŞIQLARINDA SƏS SÜRƏTİ

Səs sürəti T=(293,15-523,15) K temperaturlarda və 60 MPA-a qədər təzyiqlərdə *n*-heptanda, *n*-oktanda və onların qarışıqlarında ölçülüb. 8MHz tezliklərində exo-impuls metodu, ±0,08% xəta ilə ölçüdə istifadə edilib. Ölçü qiymətləri polinom tənliklərlə temperaturlardan və təzyiqlərdən asılı olaraq ümumiləşdirilib və onlar etibarlı ədəbiyyat məlumatları ilə müqayisə edilib.

В.Г. Гасанов, Дж.Я. Назиев, Я.М. Назиев

СКОРОСТЬ ЗВУКА В БИНАРНЫХ СМЕСЯХ *n*-АЛКАНОВ

Скорость звука в жидких *n*-гептане, *n*-октане и их бинарных смесях измерена при температурах T=(293,15-523,15) К и давлениях до 60 МПа. Метод эхо-импульса с частотой 8 МГц, с погрешностью ±0,08% был применен в измерениях. Измеряемые значения обобщены полиномными уравнениями как функции температуры и давления, и сравнены с достоверными литературными данными.

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