CORRELATION FOR THE CALCULATION OF THE SPEED OF SOUND OF BINARY MIXTURES

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Сделана попытка установить взаимосвязь между скоростью звука в чистых веществах, исследованных в настоящей работе и их двойных смесях.

Attempt to establish interrelation between speed of a sound in the pure substances investigated in the present work and their double mixes is made

This work is the part of a research program whose objective it is to measure experimentally thermodynamic properties for binary systems.

Study of molecular interactions in liquids and liquid mixtures has been the subject of renewed interest in recent years in view of its importance in theoretical research and applied areas such as distillation, liquid separation, design operations, etc.

We have measured the speed of sound of methanol, benzene and methanol + benzene at temperatures between (290-530) K and pressures in the range (0.1 to 60) Mpa.

We lead attempts to install interrelation between speed of sound in clean substances researched in the true work and their binary mixtures.

Consequently, the speeds of sound in methanol and benzene at atmospheric and high pressure have been reported [1-6]. However, measurements of the liquid phase speed of sound of (methanol + benzene) mixtures are absent from the literature.

A large number of experimental studies on the sound speed for these compounds have been reported in the literature, but there is no example of research which 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 research in this future field.

The speed of sound were determined with a pulse-echo method, that has been described in detail elsewhere [6,7-10], with an uncertainty of ±0.08%.

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 pressures greater than 0.1 MPa while a differential manometer was used for atmospheric pressure. In accordance with the recommendations of [11], the experimental uncertainties are for temperature ±3mK, pressure greater than $\pm 5\cdot 10^{-2}$ MPa and $\pm 5\cdot 10^{-4}$ MPa for atmospheric pressure, and $\pm 3\cdot 10^{-4}$ $kg\cdot m^{-3}$ 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 [12].

Liquid mixtures were prepared gravimetrically with a analytical balance.

The results speed of sound of methanol and benzene and methanol + benzene are listed in table 1.

The results reported in table 1 have been fitted by the following equation

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

and A, B, C are represent by

$$A = \sum_{i=0}^{3} a_i p^i ,\ B = \sum_{i=0}^{3} b_i p^i ,\ C = \sum_{i=0}^{3} c_i p^i . \qquad (2)$$

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

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

Coefficient a_{ij}, b_{ij}, and c_{ij} from the equation (3) are listed in table 2.

Using the received values coefficient a_{ij}, b_{ij}, and c_{ij}, it is possible to define with satisfactory accuracy values speed of sound mixtures at various pressure, temperatures and concentration.

The executed comparisons (3) values calculated on the equation with skilled data show speed of sound of the binary mixtures studied in the presence work that the equation (3) approximates results of measurements within less then 0.9%.

Table 1

Speed of sound of methanol and benzene and (methanol + benzene) at temperature *T* and pressures *p*, *W/(m/s)*

T/K	*p/Mpa*							
	0.1	5	9.9	19.7	29.5	39.3	49.1	58.9
				Methanol				
298.15	1103	1132	1163	1214	1260	1305	1348	1386
323.15	1021	1055	1090	1147	1198	1243	1289	1329
348.15		982	1018	1081	1138	1185	1233	1275
373.15		906	946	1018	1078	1132	1181	1224
398.15		823	871	950	1018	1078	1129	1176
423.15		730	787	877	954	1016	1074	1126
448.15		619	691	796	883	953	1016	1072
473.15		476	578	707	807	885	954	1016
498.15		312	436	614	726	814	890	957
523.15				513	644	743	824	896
				x=0.25				
298.15	1251	1275	1299	1343	1384	1421	1459	1493
323.15	1136	1162	1191	1240	1286	1328	1368	1406
348.15	1023	1055	1084	1141	1191	1238	1279	1320
373.15		953	988	1052	1106	1155	1201	1244
398.15		853	894	967	1023	1074	1120	1162
423.15		758	808	892	951	1003	1051	1095
448.15		665	723	821	881	936	984	1029
473.15		573	648	757	821	877	926	968
498.15		489	578	698	765	832	871	917
523.15		406	515	642	717	775	824	871
				x=0.50				
298.15	1201	1225	1249	1293	1334	1371	1409	1443
323.15	1086	1112	1141	1190	1236	1278	1318	1356
348.15	973	1005	1034	1091	1141	1188	1229	1270
373.15		903	938	1002	1056	1105	1151	1194
398.15		803	844	917	973	1024	1070	1112
423.15		708	758	842	901	953	1001	1045
448.15		615	673	771	831	886	934	979
473.15		523	598	707	771	827	876	918
498.15		439	528	648	715	782	821	867
523.15		356	465	592	667	725	774	821
				x=0.75				
298.15	1153	1177	1201	1245	1286	1323	1361	1395
323.15	1038	1064	1093	1142	1188	1230	1270	1308
348.15	925	957	986	1043	1093	1140	1181	1222
373.15		855	890	954	1008	1057	1103	1146
398.15		756	797	870	926	977	1023	1065
423.15		660	710	794	853	905	953	997
448.15		567	625	723	783	838	886	931
473.15		475	550	659	723	779	828	870
498.15		391	480	600	667	734	773	819
523.15		308	417	544	619	677	726	773
				Benzene				
298.15	1298	1322	1346	1390	1431	1468	1506	1540
323.15	1183	1209	1238	1287	1333	1375	1415	1453
348.15	1070	1102	1131	1188	1238	1281	1326	1367
373.15		1000	1035	1099	1153	1202	1248	1291
398.15		900	941	1014	1070	1121	1167	1209
423.15		805	855	939	998	1050	1098	1142
448.15		712	770	868	928	983	1031	1076
473.15		620	695	804	868	924	973	1015
498.15		536	625	745	812	879	918	964
523.15		453	562	689	764	822	871	918

Table 2.

Coefficients of equations (3)

i			*j*		
	0	1	2	3	4
			a		
0	3199.97	-12.2191	-1.14672	0.0390	-0.000301349
1	-20.226	2.30705	0.0213125	-0.00167803	0.0000147254
2	0.781951	-0.0859459	-0.0000769373	0.0000423031	-4.00528E-07
3	-0.00841739	0.000846447	-0.00000101156	-3.66762E-07	3.57937 E-09
			b		
0	-7.95031	0.0078999	0.00847612	-0.000243153	0.00000179203
1	0.127177	-0.0133102	-0.000212507	0.0000122146	-1.03555 E-07
2	-0.00459972	0.000494797	0.00000354248	-3.31219E-07	2.94949 E-09
3	0.0000506493	-0.00000487	-2.42205E-08	2.95982E-09	-2.68305 E-11
			c		
0	0.00525828	-0.0000249449	-0.0000121753	3.55649E-07	-2.63529 E-09
1	-0.000141551	0.0000186472	4.74758E-07	-2.21195E-08	1.81836 E-10
2	0.00000637433	-6.94547E-07	-1.08003E-08	6.29772E-10	-5.35035 E-12
3	-7.38736E-08	6.83533E-09	8.98785E-11	-5.73500E-12	4.92632 E-14

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Received:10.02.2007