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Research Article

Computation of acoustic nonlinearity parameter for binary and ternary liquid mixture

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Abstract

Acoustic nonlinearity parameter, B/A, of six binary systems diethyl carbonate + methanol, + ethanol, + 1-propanol, + 1- butanol, + 2-butanol, + 1-pentanol has been computed at four temperatures (293.15, 298.15, 303.15 and 313.15) K using Tong-Dong thermodynamic method, Hartmann method and Ballou empirical rule. These approaches were further extended to one ternary system: ethyl acetate + n-heptane + acetone at 298.15 K. The experimental input data were taken from literature. A comparative study of the B/A values, obtained from three different methods, is presented.
Keywords: Nonlinearity parameter, Sound speed, Thermal expansion coefficient, Heat capacity.

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1. Introduction

The importance, significance and theoretical formulations of Beyer's acoustic nonlinearity parameter, B/A, have been discussed by a large number of workers. [1-3] In the present works, nonlinearity parameter, B/A, has been computed using these thermodynamic method developed by Tong *et al* [4] for organic liquids, Hartmann [5] method based on potential parameters and an empirical relation due to Ballou. This parameter is obtained the thermodynamic equation of state and the resulting equation is given by

$$\frac{B}{A} = 2\rho u\left(\frac{\partial u}{\partial P}\right)_T + \frac{2uT\alpha}{C_P}\left(\frac{\partial u}{\partial T}\right)_P \qquad \ldots(1)$$

Where u is the sound speed, α is the thermal expansion coefficient and C_P is the heat capacity at constant pressure. Thus, B/A can be determined from the knowledge of temperature and pressure coefficient of sound speed, α and C_P. This is thermodynamic method of Beyer which has been employed by other workers. In the case, where the values of $\left(\frac{\partial u}{\partial T}\right)_P$, $\left(\frac{\partial u}{\partial P}\right)_T$ and C_P are not known, some other methods have been developed. B/A plays a significant role in nonlinear acoustics as well as underwater acoustics.

2. Theoretical

Hartmann obtained the expression

$$\frac{B}{A} = 2 + \left(\frac{0.98\times10^4}{u}\right) \qquad \ldots(2)$$

This equation was obtained as an approximation that liquid obeys Rao [6] and Wada [7] rules. Ballou [8] proposed the empirical rule for B/A as

$$\frac{B}{A} = -0.5 + \left(\frac{1.2\times10^4}{u}\right) \qquad \ldots(3)$$

Tong et al [4] derived a simplified equation for B/A on the basis of Schaaffs [9] equation for sound speed in organic liquids. The final equation derived by them may be expressed as

$$\frac{B}{A} = \left(1-\frac{1}{\gamma}\right)\frac{u^2\rho\beta_T}{\alpha T} + \frac{2(3-2x)^2}{3(x-1)(6-5x)} \qquad \ldots(4)$$

Where all the symbols have their usual notations, and

$x = \frac{M}{\rho b}$, bis the van der Waals constant

The above equations, for convenience, can be written as

$$\frac{B}{A} = J_{(0)} + J_{(x)} \quad \ldots(5)$$

Where

$$J_{(0)} = \left(1 - \frac{1}{\gamma}\right)\left(\frac{u^2 \rho \beta_T}{\alpha T}\right) \quad \ldots(6)$$

$$J_{(x)} = \frac{2(3-2x)^2}{3(x-1)(6-5x)} \quad \ldots(7)$$

This equation was used by Jugan *et al* [10] for calculating B/A of organic binary liquid mixtures.

3. Results and Discussion

Bayer's relations to calculate B/A is reported in eq. (1) which has further been modified for other method of calculating B/A. Nonlinearity parameter of six binary systems: diethyl carbonate + methanol (I), diethyl carbonate + ethanol (II), diethyl carbonate + 1-propanol (III), diethyl carbonate + 1-butanol (IV), diethyl carbonate + 2-butanol (V) and diethyl carbonate + 1-pentanol (VI) at four different temperatures 293.15 K, 298.15 K, 303.15 K and 313.15 K, and single ternary system ethyl acetate + n-hexane + acetone at 298.15 K have been computed using thermodynamic method (Tong & Dong), empirical relation and expression derived by Hartman on the basis of intermolecular interaction. The experimental values of velocity and density have been taken from earlier papers.

Table 1. Nonlinearity parameter of binary liquid mixtures at various temperatures

x_1	P g.cm^{-3}	c m.s^{-1}	J(x) Eq. (6)	J(0) Eq. (7)	B/A Eq. (4)	B/A Eq. (2)	B/A Eq. (3)
diethyl carbonate + methanol (System I)							
T=293.15 K							
0.0513	0.8172	1127	8.20	1.24	9.44	10.70	10.15
0.1002	0.8378	1136	8.38	1.22	9.60	10.63	10.06
0.1972	0.8699	1148	8.77	1.19	9.97	10.54	9.95
0.2839	0.8918	1157	9.12	1.17	10.29	10.47	9.87
0.4038	0.9150	1166	9.55	1.15	10.70	10.40	9.79
0.5000	0.9295	1171	9.86	1.14	11.00	10.37	9.75
0.5933	0.9411	1175	10.13	1.13	11.26	10.34	9.71
0.6417	0.9464	1178	10.26	1.13	11.39	10.32	9.69
0.7996	0.9608	1190	10.37	1.39	11.76	10.24	9.58
T=298.15 K							
0.0496	0.8116	1109	8.16	1.19	9.34	10.84	10.32
0.0996	0.8326	1117	8.33	1.17	9.49	10.77	10.24
0.1985	0.8652	1131	8.71	1.14	9.85	10.66	10.11
0.2944	0.8889	1140	9.07	1.12	10.19	10.60	10.03
0.4014	0.9093	1147	9.44	1.10	10.54	10.54	9.96
0.4975	0.9238	1153	9.73	1.09	10.83	10.50	9.91
0.6068	0.9372	1158	10.04	1.08	11.12	10.46	9.86
0.7087	0.9475	1165	10.29	1.07	11.37	10.41	9.80
0.8365	0.9581	1171	10.57	1.07	11.64	10.37	9.75
T=303.15 K							
0.0490	0.8065	1093	8.13	1.14	9.26	10.97	10.48
0.0966	0.8265	1100	8.28	1.12	9.40	10.91	10.41
0.1958	0.8592	1112	8.63	1.09	9.72	10.81	10.29
0.2824	0.8809	1122	8.94	1.08	10.01	10.73	10.20
0.3916	0.9021	1129	9.30	1.06	10.36	10.68	10.13
0.4936	0.9177	1134	9.60	1.05	10.65	10.64	10.08
0.5810	0.9286	1138	9.83	1.04	10.87	10.61	10.04
0.6945	0.9404	1143	10.11	1.03	11.14	10.57	10.00
0.7349	0.9441	1146	10.20	1.03	11.23	10.55	9.97
0.8512	0.9535	1152	10.45	1.02	11.47	10.51	9.92
T=313.15 K							
0.0509	0.7976	1062	8.00	1.05	9.05	11.23	10.80
0.0999	0.8175	1071	8.01	0.03	9.05	11.15	10.70
0.2009	0.8500	1084	8.15	0.01	9.16	11.04	10.57
0.2981	0.8735	1091	8.34	0.99	9.33	10.98	10.50
0.4009	0.8928	1095	8.54	0.97	9.51	10.95	10.46
0.5056	0.9083	1098	8.74	0.96	9.70	10.93	10.43
0.6062	0.9204	1101	8.91	0.95	9.86	10.90	10.40
0.7033	0.9301	1106	9.06	0.94	10.00	10.86	10.35
0.8055	0.9388	1112	9.21	0.94	10.15	10.81	10.29

diethyl carbonate + ethanol (System II)

x_1	P g.cm^{-3}	c m.s^{-1}	J(x) Eq. (6)	J(0) Eq. (7)	B/A Eq. (4)	B/A Eq. (2)	B/A Eq. (3)
T=293.15 K							
0.0503	0.8076	1163	10.03	1.27	11.30	10.43	9.82
0.0997	0.8238	1166	8.72	1.25	9.97	10.40	9.79
0.1980	0.8518	1171	9.00	1.22	10.22	10.37	9.75
0.3006	0.8762	1174	9.28	1.20	10.48	10.35	9.72
0.4031	0.8968	1177	9.55	1.18	10.72	10.33	9.70
0.5031	0.9141	1179	9.80	1.16	10.96	10.31	9.68
0.6063	0.9296	1183	10.05	1.15	11.20	1028.00	9.64
0.6998	0.9407	1185	10.12	1.14	11.26	10.27	9.63
0.8066	0.9546	1190	10.52	1.13	11.64	10.24	9.58
0.8950	0.9642	1193	10.75	1.12	11.87	1021.00	9.56
T=298.15 K							
0.0496	0.8029	1146	10.06	1.22	11.28	10.55	9.97
0.0973	0.8184	1148	10.83	1.20	12.03	10.54	9.95
0.1963	0.8464	1151	8.71	1.17	9.89	10.51	9.93
0.2985	0.8706	1154	8.00	1.15	9.15	10.49	9.90
0.3980	0.8905	1157	8.29	1.13	9.42	10.47	9.87
0.5057	0.9091	1160	9.26	1.11	10.37	10.45	9.84
0.6032	0.9237	1163	10.64	1.10	11.73	10.43	9.82
0.7035	0.9369	1166	12.65	1.09	13.74	10.40	9.79
T=303.15 K							
0.0491	0.7893	1129	10.09	1.17	11.26	10.68	10.13
0.0984	0.8142	1130	10.87	1.15	12.02	10.67	10.12
0.1952	0.8413	1133	8.76	1.12	9.89	10.65	10.09
0.2961	0.8650	1136	8.01	1.10	9.11	10.63	10.06
0.3986	0.8847	1138	8.25	1.08	9.33	10.61	10.04
0.4859	0.9005	1140	8.99	1.07	10.05	10.60	10.03
0.5995	0.9177	1143	10.49	1.05	11.54	10.57	10.00
0.6959	0.9305	1146	12.35	1.04	13.39	10.55	9.97
T=313.15 K							
0.0499	0.7897	1095	10.28	1.07	11.35	10.95	10.46
0.1020	0.8061	1096	11.03	1.05	12.08	10.94	10.45
0.2038	0.8339	1098	8.72	1.01	9.73	10.93	10.43
0.3116	0.8585	1099	8.00	0.98	8.98	10.92	10.42
0.4001	0.8755	1100	8.24	0.96	9.20	10.91	10.41
0.4971	0.8918	1102	9.00	0.94	9.93	10.89	10.39
0.6023	0.9072	1105	10.32	0.92	11.24	10.87	10.36
0.7058	0.9205	1107	12.19	0.90	13.09	10.85	10.34

diethyl carbonate + 1-propanol (System III)

x_1	ρ g.cm^{-3}	c m.s^{-1}	J(x) Eq. (6)	J(0) Eq. (7)	B/A Eq. (4)	B/A Eq. (2)	B/A Eq. (3)
T=293.15 K							
0.0504	0.8168	1219	8.42	1.29	9.70	10.04	9.34
0.1007	0.8293	1216	9.03	1.27	10.30	10.06	9.37
0.2008	0.8521	1210	8.43	1.24	9.68	10.10	9.42
0.3019	0.8725	1205	8.01	1.22	9.23	10.13	9.46
0.4004	0.8908	1201	8.20	1.20	9.40	10.16	9.49
0.5039	0.9082	1198	8.94	1.18	10.12	10.18	9.52
0.6031	0.9235	1197	10.17	1.16	11.33	10.19	9.53
0.7007	0.9375	1196	12.02	1.15	13.17	10.19	9.53
T=298.15 K							
0.0515	0.8127	1201	8.47	1.23	9.70	10.16	9.49
0.0993	0.8244	1198	9.07	1.22	10.29	10.18	9.52
0.2021	0.8473	1191	8.47	1.19	9.66	10.23	9.58
0.3007	0.8674	1186	8.01	1.17	9.18	10.26	9.62
0.4026	0.8860	1182	8.19	1.15	9.33	10.29	9.65
0.5022	0.9026	1179	8.87	1.13	10.00	10.31	9.68
0.6029	0.9180	1177	10.08	1.11	11.19	10.33	9.70
0.7041	0.9324	1177	11.95	1.10	13.05	10.33	9.70

T=303.15 K							
0.0464	0.8073	1185	8.37	1.18	9.56	10.27	9.63
0.0963	0.8194	1181	9.07	1.17	10.24	1030.00	9.66
0.1968	0.8418	1174	8.51	1.14	9.65	10.35	9.72
0.2981	0.8621	1168	8.02	1.12	9.14	10.39	9.77
0.3987	0.8804	1164	8.16	1.10	9.26	10.42	9.81
0.4958	0.8965	1161	8.79	1.08	9.87	10.44	9.84
0.5991	0.9123	1158	9.98	1.06	11.04	10.46	9.86
0.6967	0.9260	1157	11.69	1.05	12.74	10.47	9.87
T=313.15 K							
0.0506	0.7811	1086	9.48	1.08	10.56	11.02	10.55
0.0997	0.7933	1086	11.73	1.07	12.79	11.02	10.55
0.2016	0.8172	1087	10.22	1.04	11.26	11.02	10.54
0.3030	0.8390	1088	8.46	1.02	9.48	11.01	10.53
0.4008	0.8582	1091	8.00	1.00	9.00	10.98	10.50
0.4969	0.8759	1093	8.25	0.99	9.24	10.97	10.48
0.5990	0.8932	1097	9.09	0.97	10.07	10.93	10.44
0.7007	0.9093	1101	10.57	0.96	11.53	10.90	10.40
0.8011	0.9243	1105	12.95	0.95	13.89	10.87	10.36

diethyl carbonate + 1-butanol (System IV)

x_1	ρ g.cm^{-3}	c m.s^{-1}	J(x) Eq. (6)	J(0) Eq. (7)	B/A Eq. (4)	B/A Eq. (2)	B/A Eq. (3)
T=293.15 K							
0.0510	0.8201	1251	8.07	1.30	9.37	9.83	9.09
0.1027	0.8305	1244	8.52	1.28	9.80	9.88	9.15
0.2008	0.8493	1234	8.40	1.26	9.66	9.94	9.22
0.2978	0.8670	1225	8.04	1.23	9.27	10.00	9.30
0.4026	0.8853	1217	8.10	1.21	9.31	10.05	9.36
0.8079	0.9027	1211	8.40	1.19	9.59	10.09	9.41
0.6014	0.9175	1206	9.64	1.17	10.82	10.13	9.45
0.7033	0.9329	1203	11.36	1.15	12.52	10.15	9.48
0.7986	0.9468	1201	13.97	1.14	15.11	10.16	9.49
T=298.15 K							
0.0519	0.8162	1234	8.09	1.25	9.33	9.94	9.22
0.0993	0.8255	1228	8.52	1.23	9.75	9.98	9.27
0.1996	0.8445	1216	8.42	1.21	9.63	10.06	9.37
0.2923	0.8614	1208	8.06	1.18	9.24	10.11	9.43
0.3989	0.8798	1199	8.08	1.16	9.24	10.17	9.51
0.5017	0.8967	1193	8.60	1.14	9.74	10.21	9.56
0.6016	0.9124	1187	9.60	1.12	10.72	10.26	9.61
0.7043	0.9278	1184	11.31	1.10	12.41	10.28	9.64
0.8002	0.9416	1181	13.87	1.09	14.96	10.30	9.66
T=308.15 K							
0.0508	0.8120	1216	8.07	1.19	9.27	10.06	9.37
0.1004	0.8217	1210	8.51	1.18	9.69	10.10	9.42
0.2016	0.8407	1198	8.40	1.15	9.55	10.18	9.52
0.3000	0.8583	1188	8.04	1.13	9.17	10.25	9.60
0.3917	0.8739	1181	8.06	1.11	9.17	10.30	9.66
0.5032	0.8920	1173	8.59	1.09	9.68	10.35	9.73
0.5970	0.9066	1169	9.51	1.07	10.59	10.38	9.77
0.7099	0.9233	1164	11.35	1.05	12.40	10.42	9.81
T=308.15 K							
0.0506	0.8037	1181	8.09	1.10	9.19	10.30	9.66
0.1007	0.8132	1172	8.54	1.09	9.63	10.36	9.74
0.2005	0.8314	1160	8.44	1.06	9.50	10.45	9.84
0.2975	0.8483	1150	8.06	1.04	9.10	10.52	9.93
0.4122	0.8674	1142	8.09	1.02	9.11	10.58	10.01
0.5035	0.8818	1136	8.53	1.00	9.53	10.63	10.06
0.6084	0.8978	1131	9.54	0.98	10.52	10.66	10.11
0.7044	0.9118	1126	11.04	0.97	12.00	10.70	10.16
0.8055	0.9259	1122	13.54	0.95	14.49	10.73	10.20

diethyl carbonate + 2-butanol (System V)

x_1	ρ g.cm^{-3}	c m.s^{-1}	J(x) Eq. (6)	J(0) Eq. (7)	B/A Eq. (4)	B/A Eq. (2)	B/A Eq. (3)
T=293.15 K							
0.0512	0.8166	1223	8.13	1.29	9.42	10.01	9.31
0.1031	0.8267	1218	8.76	1.28	10.03	10.05	9.35
0.2021	0.8453	1209	8.65	1.25	9.90	10.11	9.43
0.2997	0.8631	1203	8.13	1.23	9.35	10.15	9.48
0.4023	0.8811	1198	8.03	1.21	9.23	10.18	9.52
0.5115	0.8993	1196	8.48	1.19	9.67	10.19	9.53
0.6070	0.9148	1195	9.38	1.17	10.55	10.20	9.54
0.7070	0.9305	1194	10.79	1.15	11.94	10.21	9.55
0.8038	0.9453	1195	13.26	1.14	14.40	10.22	9.56
T=298.15 K							
0.0509	0.8122	1205	8.13	1.24	9.37	10.13	9.46
0.1010	0.8217	1200	8.77	1.22	9.99	10.17	9.50
0.2020	0.8405	1191	8.69	1.20	9.89	10.23	9.58
0.3002	0.8582	1184	8.14	1.18	9.32	10.28	9.64
0.4040	0.8762	1179	8.02	1.15	9.18	10.31	9.68
0.5003	0.8923	1176	8.38	1.14	9.52	10.33	9.70
0.6008	0.9086	1174	9.26	1.12	10.38	10.35	9.72
0.6963	0.9236	1174	10.70	1.10	11.80	10.35	9.72
T=303.15 K							
0.0517	0.8084	1189	8.14	1.19	9.33	10.24	9.59
0.1132	0.8200	1182	8.84	1.17	10.00	10.29	9.65
0.2267	0.8407	1172	8.52	1.14	9.67	10.36	9.74
0.3316	0.8591	1166	8.05	1.12	9.17	10.40	9.79
0.4467	0.8786	1160	8.12	1.10	9.22	10.45	9.84
0.5422	0.8942	1157	8.67	1.08	9.75	10.47	9.87
0.6426	0.9101	1155	9.77	1.06	10.83	10.48	9.89
0.7416	0.9253	1154	11.59	1.05	12.63	10.49	9.90
T=313.15 K							
0.0511	0.7989	1150	8.17	1.09	9.26	10.52	9.93
0.1026	0.8083	1143	8.88	1.07	9.95	10.57	10.00
0.1988	0.8256	1133	8.83	1.04	9.87	10.65	10.09
0.2955	0.8425	1126	8.22	1.01	9.23	10.70	10.16
0.4041	0.8602	1120	8.00	0.98	8.98	10.75	10.21
0.5084	0.8779	1116	8.34	0.96	9.30	10.78	10.25
0.5983	0.8921	1115	9.06	0.93	9.99	10.79	10.26
0.6988	0.9076	1114	10.43	0.91	11.34	10.80	10.27
0.8034	0.9233	1113	12.84	0.89	13.73	10.81	10.28

diethyl carbonate + 1-pentanol (System VI)

x_1	ρ g.cm^{-3}	c m.s^{-1}	J(x) Eq. (6)	J(0) Eq. (7)	B/A Eq. (4)	B/A Eq. (2)	B/A Eq. (3)
T=293.15 K							
0.0496	0.8228	1286	8.00	1.31	9.32	9.62	8.83
0.1016	0.8316	1278	8.20	1.30	9.50	9.67	8.89
0.2034	0.8486	1263	8.28	1.27	9.56	9.76	9.00
0.3124	0.8665	1249	8.03	1.25	9.27	9.85	9.11
0.3801	0.8775	1241	8.01	1.23	9.25	9.90	9.17
0.5085	0.8981	1228	8.49	1.20	9.69	9.98	9.27
0.6047	0.9133	1220	9.35	1.18	10.53	10.03	9.34
0.7068	0.9293	1214	10.93	1.16	12.09	10.07	9.38
0.8058	0.9447	1208	13.56	1.14	14.71	10.11	9.43
T=298.15 K							
0.0459	0.8186	1269	8.02	1.26	9.28	9.72	8.96
0.0984	0.8273	1262	8.18	1.25	9.43	9.77	9.01
0.2067	0.8451	1246	8.27	1.22	9.49	9.87	9.13
0.3012	0.8604	1233	8.04	1.20	9.24	9.95	9.23
0.4002	0.8762	1221	8.04	1.17	9.22	10.03	9.33
0.5091	0.8934	1209	8.48	1.15	9.63	10.11	9.43
0.5884	0.9058	1202	9.14	1.13	10.27	10.15	9.48

T=303.15 K							
0.0541	0.8158	1249	8.00	1.21	9.21	9.85	9.11
0.0951	0.8225	1242	8.17	1.19	9.36	9.89	9.16
0.1968	0.8390	1226	8.30	1.15	9.45	9.99	9.29
0.2920	0.8542	1213	8.07	1.12	9.19	10.08	9.39
0.3986	0.8711	1200	8.03	1.09	9.12	10.17	9.50
0.4966	0.8865	1190	8.39	1.06	9.45	10.24	9.58
0.5963	0.9020	1181	9.19	1.03	10.22	10.30	9.66
0.6847	0.9156	1175	10.40	1.01	11.41	10.34	9.71
0.7988	0.9329	1168	13.05	0.98	14.03	10.39	9.77
T=313.15 K							
0.0505	0.8073	1214	8.00	1.11	9.11	10.07	9.38
0.1009	0.8152	1205	8.21	1.09	9.30	10.13	9.46
0.2038	0.8312	1187	8.31	1.06	9.37	10.26	9.61
0.3044	0.8468	1173	8.06	1.03	9.08	10.35	9.73
0.4054	0.8623	1161	8.03	1.00	9.03	10.44	9.84
0.5077	0.8781	1150	8.40	0.97	9.37	10.52	9.93
0.5969	0.8916	1143	9.10	0.95	10.04	10.57	10.00
0.7100	0.9086	1134	10.65	0.92	11.54	10.64	10.08
0.8100	0.9236	1127	13.07	0.90	13.97	10.70	10.15

The computed values of B/A from eqs (2), (3), (4), (6) and (7) for the above systems are reported in Table 1. For the thermodynamic method, the values of $J_{(0)}$ and $J_{(x)}$ respectively are also recorded in the table. A close perusal of this table shows that in case of binary mixtures, the values of nonlinearity parameter decrease with increase in concentration of the first component for system I at all the temperatures using Tong & Dong method, whereas irregular variation in its values is observed in all the remaining systems under consideration. At higher x_1 values of the most binary systems, B/A values are larger. At low concentration of diethyl carbonate its values are minimum. Second components in all the binary systems are alcohols containing strong interaction due to hydrogen bonding. Thus, B/A values are concerned with interaction between the components of binary systems.

Equations (1) and (2) have been used to evaluate B/A of aforementioned binary liquid mixtures using experimental velocity data and reported in Table 1. Careful study of this table shows that the values of nonlinearity parameter increase with increase in temperature in each binary system under investigation. The values of nonlinearity parameter decrease with increase in concentration of diethyl carbonate in systems I and II. At higher concentration of methanol and ethanol, deviation from linearity is larger and is smaller at their lower concentration. In remaining systems (III, IV, V, VI), B/A values increase with increase in concentration of first component (diethyl carbonate). At higher concentration of 1-propanol, 1-butanol, 2-butanol and 1-pentanol, values of non linearity parameter are found smaller while at low concentration these are larger.

All the binary systems consist of alcohols as second component. At larger concentration of alcohol, hydrogen bonding produces dominating effect on ultrasonic propagation in mixtures. Binary systems of primary and branched chain alcohols with diethyl carbonate show reverse trend of B/A values. From this we can also conclude that at larger concentration of branched chain alcohol, B/A values are smaller while for systems having primary alcohols as higher concentration, its values are larger. Intermolecular interaction has been dominating effect over ultrasonic velocity and density and hence on nonlinearity values.

Table 2: Nonlinearity parameter of ternary liquid mixture at 298.15 K ethyl acetate + hexane +acetone

x_1	ρ $g.cm^{-3}$	c $m.s^{-1}$	J(x) Eq. (6)	J(0) Eq. (7)	B/A Eq. (4)	B/A Eq. (2)	B/A Eq. (3)
0.4430	0.5060	1078	9.28	1.24	10.52	11.09	10.63
0.3716	0.5855	1070	8.44	1.26	9.70	11.16	10.71
0.2777	0.6903	1067	8.03	1.28	9.31	11.18	10.75
0.1920	0.7859	1065	8.04	1.30	9.34	11.20	10.77
0.1011	0.8872	1066	8.37	1.32	9.69	11.19	10.76
0.7066	0.1138	1142	8.02	1.17	9.19	10.58	11.01
0.6284	0.2119	1116	8.00	1.19	9.19	10.78	10.25
0.5563	0.3023	1100	8.00	1.21	9.21	10.91	10.41
0.4795	0.3986	1088	8.02	1.23	9.25	11.01	10.53
0.4072	0.4893	1078	8.06	1.24	9.31	11.09	10.63
0.3130	0.6074	1071	8.16	1.27	9.43	11.15	10.70
0.4189	0.3947	1089	11.20	1.23	12.43	11.00	10.52
0.3529	0.4900	1078	10.47	1.25	11.72	11.09	10.63
0.2710	0.6085	1071	9.84	1.27	11.11	11.15	10.70

The computed values of B/A for ternary liquid mixture (ethyl acetate + hexane + acetone) are recorded in Table 2. B/A values of ternary liquid mixture also have been calculated using eqs(2), (3) and (4) and are reported in Table 2. Maximum values of B/A have been observed when computation has been done using Hartmann relation, whereas minimum values are obtained using Tong & Dong method mostly at all concentrations. Irregular trend in values of nonlinearity parameter is found for all the three approaches used in present work for the multi component systems.

4. Conclusions

The acoustic nonlinearity parameter B/A holds good for all the methods in binary system whereas irregularities are observed in ternary system due interaction between the formation of bonds themselves. The formation of bonds are lengthened and hence weakened.

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