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Physicochemical Studies of Homoeopathic Formulations of Ammonium Aceticum by using Volumetric, Acoustic and Viscometric Measurements at Different Temperatures

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Abstract

The homoeopathic medicines are obtained through the combination of two processes, viz., a dilution of 1:100 followed by succussion and these "extremely diluted solutions" show anomalous behavior in medicinal efficacy. The densities, ρ, ultrasonic speeds, u and viscosities, η ethanol control and 32 formulations of ammonium aceticum with potencies ranging from 1C to 200C (with intervals of 2C up to 30C and then with intervals of 10 C up to 200 C) have been measured at 293.15, 298.15, 303.15, 308.15, 313.15 and 318.15 K and atmospheric pressure. From these experimental data, the isentropic compressibilities, intermolecular free length, acoustic impedance, relative association, deviations in isentropic compressibility, deviations in intermolecular free length, deviations in acoustic impedance, and deviations in viscosity, have been calculated. The variations of these parameters with potency indicate anomalous change at certain potencies. The results have been qualitatively discussed in terms of interactions/physicochemical behavior of these ammonium aceticum homoeopathic formulations. The results show that even in extreme dilutions (≈ 200C) the molecules of ammonium aceticum may be present in these homoeopathic formulations.

Keywords: Density; Ultrasonic Speed; Viscosity; Homoeopathic Medicines; Ammonium Aceticum; Extremely Diluted Solutions

Introduction

Homoeopathy is one of the traditional and most widespread alternative systems of medicine after conventional therapy. The efficacy of homoeopathic medicines is well supported by research evidence; however, there are controversies regarding implausibility in biological activity of homoeopathic medicines in which the source drug is diluted beyond Avagadro's limit, i.e., the highly diluted medicine formulation must be identical to the solvent. There have been a few research studies pertaining to explore the presence of drug in extremely diluted formulations [1-7] and its mechanism of action, but the question still remains answered acceptably. The measurements of physicochemical properties and derived parameters of aqueous and mixed-aqueous solutions of amino acids, carbohydrates, drugs, etc. have been supportive in characterizing the solute-solute and solute-solvent interactions, which are subsequently useful in understanding of solute-solvation/hydration behavior of solute and preferential solvation of solute by the solvent [8-15]. Since homoeopathic formulations are extremely dilute solutions, their physicochemical properties, like density, ultrasonic speed, viscosity, refractive index, etc. can be measured easily as a function of concentration/potency and temperature.

The physicochemical properties calculated from these experimental data can deliver valuable information on the understanding of physicochemical behavior and mechanism of drug action. Recently, there have been few physicochemical studies on extremely diluted solutions of inorganic salts [16-21] and homoeopathic medicines [2,3,22-28] by using physicochemical methods. These studies provided interesting and convincing information on the behavior of these extremely diluted solutions.

To the best of our information, very few physicochemical studies on homoeopathic medicines using volumetric, acoustic, viscometric and optical methods have been reported in the literature [2,3,22]. These considerations led us to undertake the present study on the physicochemical behavior of extremely diluted homoeopathic formulations of ammonium aceticum. Ammonium aceticum dilution is helpful in the treatment of many types of conditions, viz., heavy feeling of the head and scraping sensation of

the throat, stomach and reducing sweat. It also helps in reducing urination urge.

The homoeopathic medicine formulations are generally obtained through the combination of two processes: a dilution of 1:100 in mass followed by succussion. In the present study, the densities, ρ, ultrasonic speeds, u and viscosities, η of pure ethanol control (91% ethanol in water) and 33 formulations of ammonium aceticum with potencies ranging from 1C to 200C (with intervals of 2C till 30C, and then with intervals of 10C till 200C) at 293.15, 298.15, 303.15, 308.15, 313.15 and 318.15 K and atmospheric pressure. From these experimental data, the isentropic compressibilities κ_s, intermolecular free length, L_f, acoustic impedance, Z, relative association, R_A, deviations in isentropic compressibility, deviations in intermolecular free length, deviations in acoustic impedance, and deviations in viscosity, have been calculated. The results have been qualitatively discussed in terms of interactions/physicochemical behavior of ammonium aceticum in these homoeopathic formulations.

Experimental

Ethanol control and homoeopathic formulations of various potencies of ammonium aceticum used in the study were procured from Dr. Wilmer Schwabe India Pvt. Limited, India. The densities and ultrasonic speeds of the samples were measured by using high precision digital vibrating tube Density and Sound Analyzer (DSA 5000M, Anton Paar, Austria). This two-in-one instrument is equipped with both density and ultrasonic cells, with reproducibility of ±1 × 10^{-3} kg·m^{-3} and ±1 × 10^{-2} m·s^{-1} for density and ultrasonic speed, respectively. The temperature for both cells was kept constant by using built in peltier thermostat within ±0.01 K. The calibration of instrument was done by using triply-distilled, degassed water and with dry air at atmospheric pressure and 293.15 K [11]. The operating working frequency used for ultrasonic speed measurements is 3 MHz. The principle used in density measurement is based upon oscillating U-tube principle while the speed of sound is measured using a propagation time technique. The standard uncertainties related to the measurements of density, ultrasonic speed and temperature were found within ±0.05 kg·m^{-3}, ±0.5 m·s^{-1} and ±0.01 K, respectively.

The viscosity measurements were done by using microviscometer (Lovis 2000M, Anton Paar, Austria) at temperatures, (293.15 – 318.15) K, and atmospheric pressure p = 101 kPa. The temperature was controlled to ±0.02 K by an automatic build in Peltier technique . The rolling ball principle was used in the measurement of viscosity, having a calibrated glass capillary with a steel ball as supplied by manufacturer. The calibration of capillary was accomplished by using viscosity standard fluids. The relative standard uncertainty in viscosity measurements was found to be within ±0.5 %.

Results

The experimental values of densities, ρ, ultrasonic speeds, u and viscosities, η of ammonium aceticum formulations as function of potency (in centesimal) at different temperatures are listed in Tables 1-3, and are presented graphically in Figures 1-3, respectively. The values of the isentropic compressibility, intermolecular free length, acoustic impedance, Z and relative association, R_A have been calculated by using the following relations

$$\kappa_s = 1/u^2\rho \quad (1)$$

$$L_f = K'/u\rho^{1/2} \quad (2)$$

$$Z = u.\rho \quad (3)$$

$$R_A = (\rho/\rho_o)(u_o/u)^{1/3} \quad (4)$$

Table 1: The densities, ρ/(kg m^{-3}) of ethanol control (0 potency, 91% ethanol in water) and 33 formulations of ammonium aceticum in ethanol control, as function of potency, C of ammonium aceticum (in centesimal) at the temperatures (293.15–318.15) K and atmospheric pressure.

Potency (C)	T/K					
	293.15	298.15	303.15	308.15	313.15	318.15
0	808.248	804.277	800.155	796.005	791.621	787.436
1	851.871	847.675	843.374	838.989	834.542	830.014
2	826.436	822.082	817.675	813.221	808.706	804.129
4	825.754	821.396	816.994	812.541	808.026	803.449
6	825.675	821.327	816.922	812.464	807.942	803.366
8	827.326	822.97	818.568	814.113	809.602	805.027
10	827.299	822.94	818.534	814.074	809.559	804.982
12	827.013	822.663	818.262	813.806	809.287	804.711
14	827.331	822.972	818.568	814.11	809.587	805.016
16	827.244	822.888	818.483	814.023	809.506	804.925
18	827.006	822.646	818.246	813.792	809.275	804.695
20	827.739	823.388	818.985	814.529	810.012	805.433
22	827.442	823.08	818.674	814.212	809.696	805.115
24	827.004	822.653	818.25	813.79	809.269	804.691

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26	827.304	822.946	818.546	814.088	809.571	804.992
28	827.089	822.734	818.323	813.872	809.355	804.775
30	827.245	822.886	818.483	814.022	809.5	804.913
40	828.48	824.122	819.713	815.143	810.625	806.046
50	828.597	824.246	819.85	815.4	810.889	806.318
60	828.326	823.972	819.567	815.107	810.583	806.009
70	828.321	823.966	819.561	815.103	810.585	806.005
80	828.411	824.058	819.651	815.193	810.676	806.095
90	828.22	823.867	819.464	815.005	810.491	805.913
100	828.218	823.862	819.456	814.996	810.481	805.902
110	828.217	823.862	819.455	814.996	810.475	805.886
120	828.371	824.015	819.611	815.152	810.635	806.054
130	828.364	824.008	819.604	815.145	810.628	806.047
140	828.245	823.887	819.481	815.029	810.516	805.936
150	828.413	824.059	819.654	815.194	810.677	806.096
160	828.231	823.874	819.458	815.008	810.492	805.912
170	828.623	824.271	819.866	815.406	810.888	806.306
180	828.452	824.095	819.689	815.23	810.711	806.121
190	844.791	840.517	836.243	831.969	827.695	823.421
200	849.234	845.151	840.768	836.344	831.855	827.299

Table 2: The ultrasonic speeds, $u/(\mathrm{m\ s^{-1}})$ of ethanol control (0 potency, 91% ethanol in water) and 33 formulations of ammonium aceticum in ethanol control, as function of potency, C of ammonium aceticum (in centesimal) at the temperatures (293.15–318.15) K and atmospheric pressure.

Potency (C)	T/K					
	293.15	298.15	303.15	308.15	313.15	318.15
0	1165.93	1149.76	1133.54	1117.33	1101.38	1084.91
1	1317.91	1302.67	1286.93	1271.05	1255.07	1238.93
2	1260.84	1244.16	1227.66	1210.87	1194.01	1177.11
4	1256.11	1240.01	1223.9	1207.08	1190.22	1173.32
6	1258.85	1242.56	1225.77	1208.92	1192.03	1175.13
8	1262.99	1246.51	1230.1	1213.38	1196.56	1179.72
10	1263.05	1246.46	1229.67	1212.84	1196.28	1179.45
12	1262.31	1245.93	1229.2	1212.39	1195.54	1178.64
14	1262.96	1246.45	1229.69	1212.9	1196.07	1179.2
16	1262.87	1246.21	1229.41	1212.59	1195.73	1178.82
18	1262.27	1245.89	1229.16	1212.35	1195.5	1178.62
20	1264.06	1247.83	1231.09	1214.29	1197.44	1180.57
22	1263.37	1246.69	1229.89	1213.07	1196.22	1179.33
24	1262.33	1245.94	1229.2	1212.38	1195.52	1178.62
26	1263.02	1246.37	1229.58	1212.75	1195.9	1179.04
28	1262.57	1245.94	1229.15	1212.32	1195.47	1178.57
30	1262.93	1246.31	1229.53	1212.71	1195.85	1178.99
40	1266.06	1249.46	1232.69	1215.86	1198.99	1182.12
50	1266.48	1249.85	1233.06	1216.22	1199.37	1182.49
60	1265.49	1248.96	1232.2	1215.41	1198.56	1181.69
70	1265.54	1248.9	1232.15	1215.35	1198.52	1181.64
80	1265.69	1249.06	1232.3	1215.51	1198.68	1181.79
90	1265.34	1248.98	1232.28	1215.51	1198.67	1181.81
100	1265.31	1248.68	1231.91	1215.1	1198.27	1181.42

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110	1265.33	1248.68	1231.9	1215.11	1198.27	1181.38
120	1265.71	1249.06	1232.3	1215.5	1198.67	1181.8
130	1265.52	1248.86	1232.32	1215.52	1198.7	1181.3
140	1265.39	1248.75	1232.3	1215.55	1198.74	1181.86
150	1265.79	1249.16	1232.4	1215.61	1198.78	1181.91
160	1265.33	1248.69	1231.94	1215.14	1198.31	1181.43
170	1266.32	1249.7	1232.96	1216.17	1199.35	1182.46
180	1265.94	1249.28	1232.51	1215.72	1198.89	1182.01
190	1293.01	1274.81	1257.25	1241.06	1222.39	1204.61
200	1315.14	1296.57	1278.99	1263.06	1246.76	1230.33

Table 3: The viscosities, $\eta/(10^{-3}$ N s $m^{-2})$ of ethanol control (0 potency, 91% ethanol in water) and 33 formulations of ammonium aceticum in ethanol control, as function of potency, C of ammonium aceticum (in centesimal) at the temperatures (293.15–318.15) K and atmospheric pressure.

Potency	T/K					
(C)	293.15	298.15	303.15	308.15	313.15	318.15
0	1.2072	1.0957	0.994	0.9055	0.8316	0.7642
1	1.8468	1.6465	1.4671	1.3162	1.1839	1.0729
2	1.7456	1.5481	1.3788	1.2383	1.1004	0.997
4	1.6751	1.5008	1.3321	1.1894	1.0649	0.9568
6	1.727	1.5296	1.36	1.2163	1.0923	0.9841
8	1.7826	1.5942	1.4223	1.2781	1.1366	1.0333
10	1.7787	1.5836	1.4176	1.2576	1.131	1.0281
12	1.778	1.5882	1.4142	1.2607	1.1336	1.0278
14	1.7772	1.5866	1.4169	1.258	1.1343	1.0241
16	1.7795	1.5848	1.4153	1.2537	1.1293	1.0287
18	1.7801	1.583	1.4137	1.2596	1.1313	1.0276
20	1.7805	1.5849	1.4163	1.2564	1.1297	1.0256
22	1.7812	1.5798	1.4198	1.2617	1.1328	1.0237
24	1.7499	1.5409	1.3691	1.2241	1.0975	0.9882
26	1.7323	1.5276	1.3545	1.2086	1.0809	0.9709
28	1.7627	1.5555	1.389	1.2362	1.1072	0.9989
30	1.8135	1.6204	1.4422	1.2928	1.1609	1.048
40	1.8095	1.6046	1.4288	1.2695	1.14	1.0311
50	1.8112	1.6055	1.4286	1.2708	1.1449	1.0316
60	1.8122	1.6076	1.4272	1.2743	1.1444	1.0305
70	1.8106	1.6063	1.4202	1.2745	1.1418	1.0265
80	1.8069	1.598	1.4182	1.2688	1.1353	1.0264
90	1.8092	1.5981	1.4162	1.269	1.133	1.0258
100	1.8043	1.596	1.4206	1.2709	1.1392	1.0261
110	1.8061	1.5943	1.4166	1.2679	1.1385	1.0252
120	1.8019	1.5902	1.4124	1.2701	1.1409	1.0239
130	1.7954	1.584	1.4061	1.2671	1.1353	1.0283
140	1.7924	1.5804	1.4091	1.2721	1.1353	1.0283
150	1.7908	1.5859	1.4111	1.2702	1.1373	1.0222
160	1.7894	1.5871	1.4097	1.2598	1.1327	1.0267
170	1.7846	1.5829	1.408	1.2604	1.1376	1.0279
180	1.7813	1.5876	1.4025	1.2567	1.1401	1.0341

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190	1.8223	1.6112	1.4439	1.2989	1.1684	1.0586
200	2.1161	1.8399	1.6109	1.4241	1.2715	1.1396

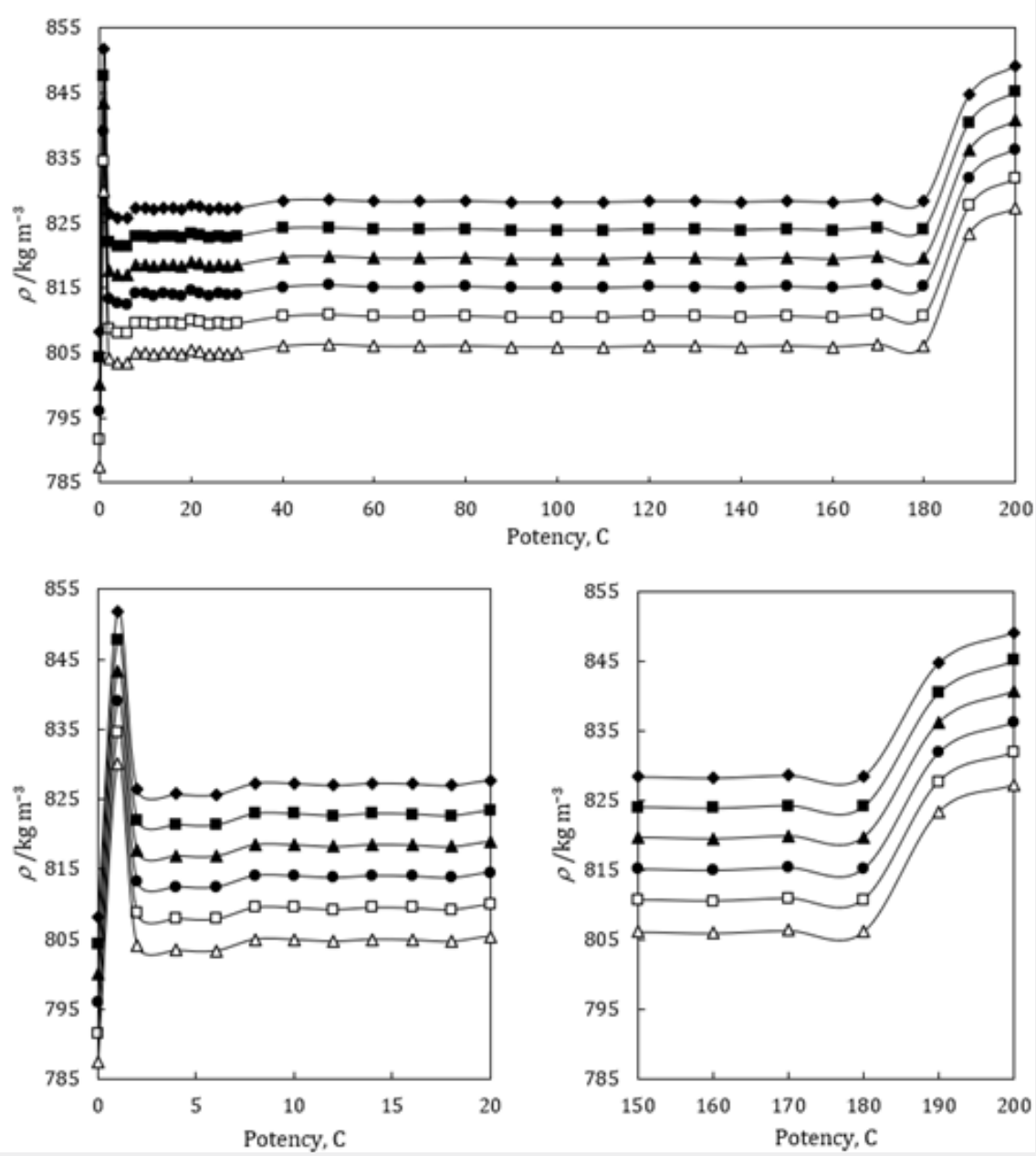

Figure 1: Plots of densities, ρ vs. potency, C of ammonium aceticum for homoeopathic formulations of ammonium aceticum at temperatures, 293.15 K, •; 298.15 K, ■; 303.15 K, ▲; 308.15 K, ●; 313.15 K, □; and 318.15 K, Δ.

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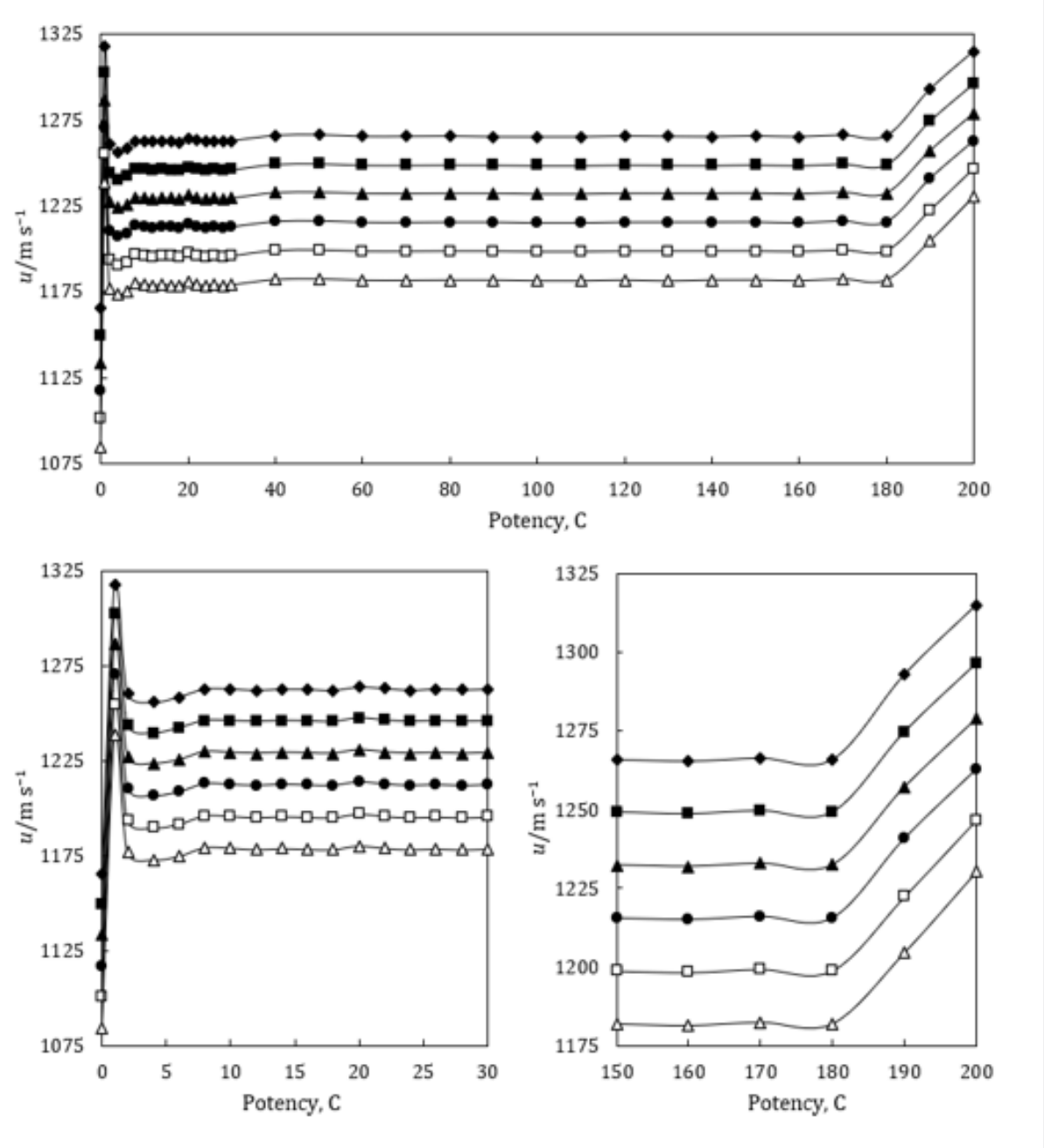

Figure 2: Plots of ultrasonic speeds, *u* vs. potency, C of ammonium aceticum for homoeopathic formulations of ammonium aceticum at temperatures, 293.15 K, •; 298.15 K, ■; 303.15 K, ▲; 308.15 K, ●; 313.15 K, □; and 318.15 K, Δ.

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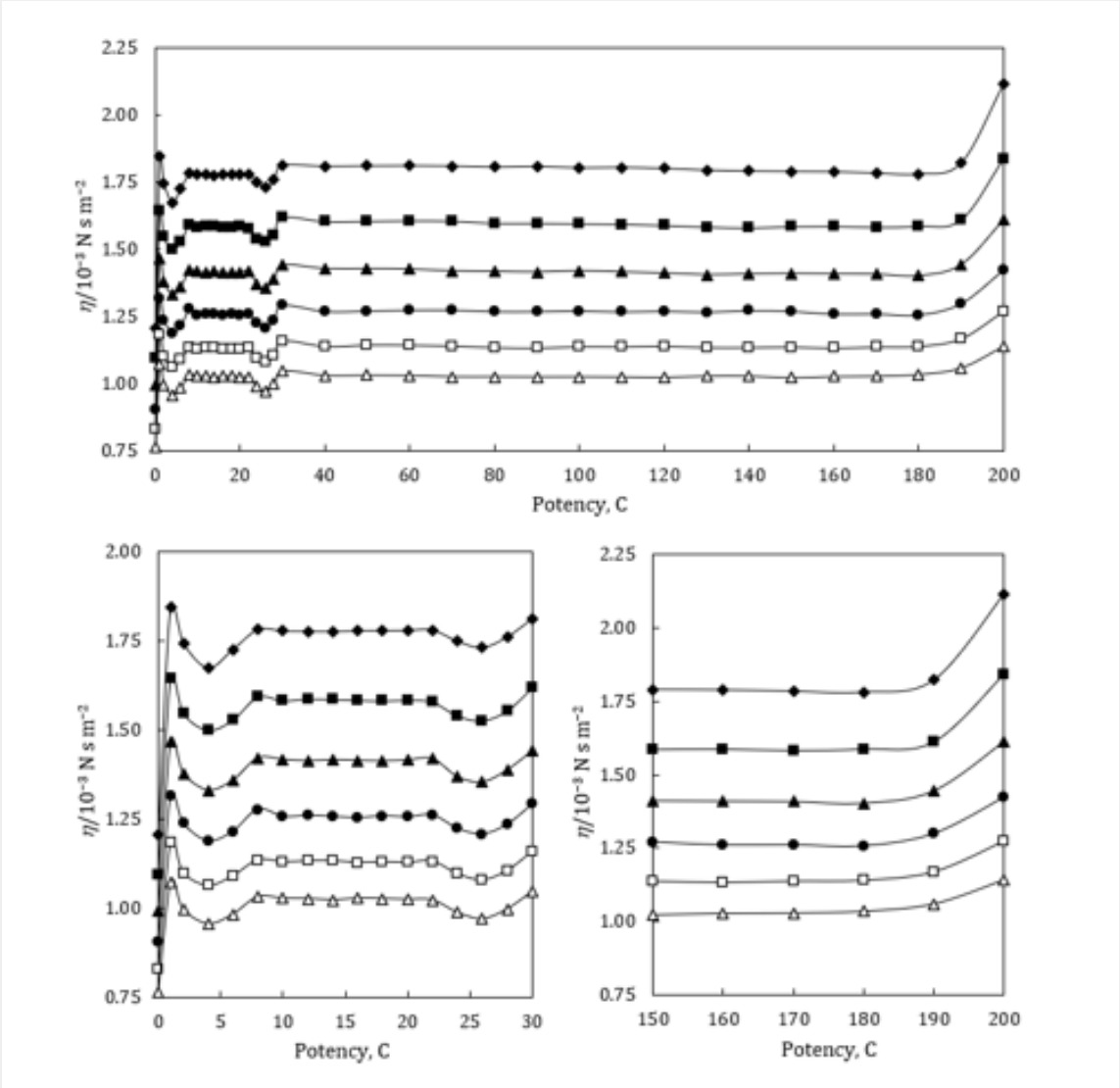

Figure 3: Plots of viscosities, η vs. potency, C of ammonium aceticum for homoeopathic formulations of ammonium aceticum at temperatures, 293.15 K, •; 298.15 K, ■; 303.15 K, ▲; 308.15 K, ●; 313.15 K, □; and 318.15 K, Δ.

where K' is temperature dependent constant [= (93.875 + 0.375T) × 10^{-8}]; T is the absolute temperature, ρ_o, ρ, u_o and u are the densities and ultrasonic speeds of the solvent and the solution, respectively. The values of κ_s, L_f, Z and R_A are given in Tables 4-7. The deviations in κ_s, L_f, Z, η and n_D of ethanol due to addition of ammonium aceticum with dilution and succussion are represented by deviation values of these properties. The deviations in isentropic compressibility, $\Delta\kappa_s$, deviations in intermolecular free length, ΔL_f, deviations in acoustic impedance, ΔZ and deviations in viscosity, $\Delta\eta$ have been calculated by using the following standard relations

$$\Delta\kappa_s = \kappa_s - \kappa_s^o \quad (5)$$

$$\Delta L_f = L_f - L_f^o \quad (6)$$

$$\Delta Z = Z - Z^o \quad (7)$$

$$\Delta\eta = \eta - \eta^o \quad (8)$$

where the superscript 'o' represents the values for pure ethanol control (91% ethanol in water). The variations of $\Delta\kappa_s$, ΔL_f, ΔZ and $\Delta\eta$ with potency, C of ammonium aceticum and temperature are presented graphically in Figures 4-7, respectively.

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Table 4: Isentropic compressibilities, κ_s /(10^{-10} m^2 N^{-1}) of ethanol control (0 potency, 91% ethanol in water) and 33 formulations of ammonium aceticum in ethanol controls, as function of potency, C of ammonium aceticum (in centesimal) at the temperatures (293.15–318.15) K and atmospheric pressure.

Potency	T/K					
(C)	293.15	298.15	303.15	308.15	313.15	318.15
0	9.101	9.405	9.726	10.063	10.414	10.789
1	6.759	6.952	7.159	7.378	7.607	7.849
2	7.612	7.858	8.115	8.387	8.673	8.975
4	7.675	7.918	8.171	8.447	8.736	9.041
6	7.643	7.886	8.147	8.422	8.711	9.014
8	7.577	7.82	8.074	8.343	8.627	8.925
10	7.577	7.821	8.08	8.351	8.631	8.93
12	7.588	7.831	8.088	8.36	8.645	8.945
14	7.578	7.821	8.079	8.35	8.634	8.933
16	7.58	7.825	8.083	8.355	8.64	8.94
18	7.589	7.831	8.089	8.36	8.646	8.946
20	7.561	7.8	8.056	8.326	8.61	8.908
22	7.572	7.817	8.075	8.346	8.631	8.93
24	7.588	7.83	8.089	8.36	8.646	8.946
26	7.577	7.822	8.081	8.352	8.637	8.936
28	7.585	7.83	8.088	8.36	8.645	8.946
30	7.579	7.824	8.082	8.353	8.638	8.938
40	7.53	7.773	8.028	8.298	8.581	8.878
50	7.524	7.767	8.022	8.291	8.573	8.869
60	7.538	7.78	8.036	8.305	8.588	8.885
70	7.538	7.781	8.037	8.306	8.588	8.886
80	7.535	7.778	8.034	8.303	8.585	8.882
90	7.541	7.781	8.036	8.305	8.587	8.884
100	7.542	7.785	8.041	8.31	8.593	8.89
110	7.541	7.785	8.041	8.31	8.593	8.891
120	7.535	7.779	8.035	8.303	8.586	8.883
130	7.538	7.781	8.034	8.303	8.585	8.89
140	7.54	7.784	8.036	8.304	8.586	8.883
150	7.534	7.777	8.033	8.301	8.584	8.881
160	7.541	7.784	8.041	8.31	8.592	8.89
170	7.526	7.768	8.023	8.292	8.573	8.87
180	7.532	7.775	8.031	8.3	8.582	8.879
190	7.08	7.321	7.565	7.804	8.086	8.369
200	6.808	7.038	7.271	7.495	7.734	7.985

Table 5: Intermolecular free lengths, L_f /(10^{-10} m) of ethanol control (0 potency, 91% ethanol in water) and 33 formulations of ammonium aceticum in ethanol control, as function of potency, C of ammonium aceticum (in centesimal) at the temperatures (293.15–318.15) K.

Potency	T/K					
(C)	293.15	298.15	303.15	308.15	313.15	318.15
0	6.149	6.308	6.473	6.644	6.819	7.002
1	5.298	5.423	5.554	5.689	5.828	5.973
2	5.623	5.766	5.912	6.065	6.223	6.387
4	5.646	5.788	5.933	6.087	6.246	6.41

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6	5.634	5.776	5.924	6.078	6.236	6.4
8	5.61	5.752	5.898	6.049	6.206	6.369
10	5.61	5.752	5.9	6.052	6.208	6.371
12	5.614	5.756	5.903	6.055	6.213	6.376
14	5.61	5.752	5.899	6.052	6.209	6.372
16	5.611	5.754	5.901	6.054	6.211	6.374
18	5.614	5.756	5.903	6.056	6.213	6.376
20	5.604	5.744	5.891	6.043	6.2	6.363
22	5.608	5.751	5.898	6.05	6.208	6.371
24	5.614	5.756	5.903	6.055	6.213	6.376
26	5.61	5.753	5.9	6.052	6.21	6.373
28	5.613	5.755	5.903	6.055	6.213	6.376
30	5.611	5.753	5.901	6.053	6.211	6.373
40	5.593	5.734	5.881	6.033	6.19	6.352
50	5.59	5.732	5.879	6.03	6.187	6.349
60	5.596	5.737	5.884	6.035	6.192	6.354
70	5.596	5.737	5.884	6.036	6.193	6.355
80	5.595	5.736	5.883	6.035	6.191	6.354
90	5.597	5.737	5.884	6.035	6.192	6.354
100	5.597	5.739	5.886	6.037	6.194	6.356
110	5.597	5.739	5.886	6.037	6.194	6.357
120	5.595	5.736	5.883	6.035	6.192	6.354
130	5.595	5.737	5.883	6.035	6.191	6.356
140	5.596	5.738	5.884	6.035	6.192	6.354
150	5.594	5.736	5.883	6.034	6.191	6.353
160	5.597	5.739	5.885	6.037	6.194	6.356
170	5.591	5.733	5.879	6.031	6.187	6.349
180	5.593	5.735	5.882	6.033	6.19	6.352
190	5.423	5.565	5.709	5.851	6.009	6.167
200	5.318	5.457	5.597	5.734	5.876	6.024

Table 6: Specific acoustic impedances, $Z/(10^6$ kg m^{-2} $s^{-1})$ of ethanol control (0 potency, 91% ethanol in water) and 33 formulations of ammonium aceticum in ethanol control, as function of potency, C of ammonium aceticum (in centesimal) at the temperatures (293.15–318.15) K.

Potency	T/K					
(C)	293.15	298.15	303.15	308.15	313.15	318.15
0	0.9424	0.9247	0.907	0.8894	0.8719	0.8543
1	1.1227	1.1042	1.0854	1.0664	1.0474	1.0283
2	1.042	1.0228	1.0038	0.9847	0.9656	0.9465
4	1.0372	1.0185	0.9999	0.9808	0.9617	0.9427
6	1.0394	1.0205	1.0014	0.9822	0.9631	0.9441
8	1.0449	1.0258	1.0069	0.9878	0.9687	0.9497
10	1.0449	1.0258	1.0065	0.9873	0.9685	0.9494
12	1.0439	1.025	1.0058	0.9867	0.9675	0.9485
14	1.0449	1.0258	1.0066	0.9874	0.9683	0.9493
16	1.0447	1.0255	1.0063	0.9871	0.968	0.9489
18	1.0439	1.0249	1.0058	0.9866	0.9675	0.9484
20	1.0463	1.0274	1.0082	0.9891	0.9699	0.9509
22	1.0454	1.0261	1.0069	0.9877	0.9686	0.9495

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24	1.044	1.025	1.0058	0.9866	0.9675	0.9484
26	1.0449	1.0257	1.0065	0.9873	0.9682	0.9491
28	1.0443	1.0251	1.0058	0.9867	0.9676	0.9485
30	1.0448	1.0256	1.0063	0.9872	0.968	0.949
40	1.0489	1.0297	1.0105	0.9911	0.9719	0.9528
50	1.0494	1.0302	1.0109	0.9917	0.9726	0.9535
60	1.0482	1.0291	1.0099	0.9907	0.9715	0.9525
70	1.0483	1.0291	1.0098	0.9906	0.9715	0.9524
80	1.0485	1.0293	1.0101	0.9909	0.9717	0.9526
90	1.048	1.029	1.0098	0.9906	0.9715	0.9524
100	1.048	1.0287	1.0095	0.9903	0.9712	0.9521
110	1.048	1.0287	1.0095	0.9903	0.9712	0.9521
120	1.0485	1.0292	1.01	0.9908	0.9717	0.9526
130	1.0483	1.0291	1.01	0.9908	0.9717	0.9522
140	1.0481	1.0288	1.0098	0.9907	0.9716	0.9525
150	1.0486	1.0294	1.0101	0.991	0.9718	0.9527
160	1.048	1.0288	1.0095	0.9903	0.9712	0.9521
170	1.0493	1.0301	1.0109	0.9917	0.9725	0.9534
180	1.0488	1.0295	1.0103	0.9911	0.972	0.9528
190	1.0923	1.0715	1.0514	1.0325	1.0118	0.9919
200	1.1169	1.0958	1.0753	1.0564	1.0371	1.0179

Table 7: The relative associations, R_A of ethanol control (0 potency, 91% ethanol in water) and 33 formulations of ammonium aceticum in ethanol control, as function of potency, C of ammonium aceticum (in centesimal) at the temperatures (293.15–318.15) K.

Potency	T/K					
(C)	293.15	298.15	303.15	308.15	313.15	318.15
1	1.0118	1.011	1.0104	1.0097	1.0093	1.0084
2	0.9962	0.9956	0.9951	0.9946	0.9945	0.9938
4	0.9966	0.9959	0.9953	0.9948	0.9947	0.994
6	0.9958	0.9951	0.9947	0.9942	0.9941	0.9934
8	0.9967	0.9961	0.9955	0.995	0.9948	0.9942
10	0.9966	0.996	0.9956	0.9951	0.9949	0.9942
12	0.9965	0.9958	0.9954	0.9949	0.9947	0.9941
14	0.9967	0.9961	0.9956	0.9951	0.995	0.9943
16	0.9966	0.996	0.9956	0.9951	0.995	0.9943
18	0.9965	0.9958	0.9954	0.9949	0.9947	0.9941
20	0.9969	0.9962	0.9958	0.9953	0.9951	0.9944
22	0.9967	0.9961	0.9957	0.9952	0.9951	0.9944
24	0.9965	0.9958	0.9954	0.9949	0.9947	0.9941
26	0.9966	0.9961	0.9956	0.9952	0.995	0.9943
28	0.9965	0.9959	0.9955	0.995	0.9948	0.9942
30	0.9966	0.996	0.9956	0.9951	0.9949	0.9942
40	0.9973	0.9967	0.9962	0.9956	0.9954	0.9948
50	0.9973	0.9967	0.9963	0.9958	0.9956	0.995
60	0.9972	0.9966	0.9962	0.9957	0.9955	0.9948
70	0.9972	0.9966	0.9962	0.9957	0.9955	0.9949
80	0.9973	0.9967	0.9962	0.9958	0.9956	0.9949
90	0.9971	0.9965	0.996	0.9955	0.9954	0.9947

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100	0.9971	0.9966	0.9961	0.9956	0.9955	0.9948
110	0.9971	0.9966	0.9961	0.9956	0.9954	0.9948
120	0.9972	0.9966	0.9962	0.9957	0.9955	0.9949
130	0.9973	0.9967	0.9962	0.9957	0.9955	0.995
140	0.9972	0.9966	0.996	0.9955	0.9954	0.9947
150	0.9973	0.9967	0.9962	0.9957	0.9956	0.9949
160	0.9972	0.9966	0.9961	0.9956	0.9955	0.9948
170	0.9974	0.9968	0.9963	0.9958	0.9957	0.995
180	0.9973	0.9967	0.9962	0.9957	0.9956	0.9949
190	1.0098	1.0097	1.0096	1.0092	1.0099	1.0098
200	1.0094	1.0096	1.0093	1.0086	1.0083	1.0075

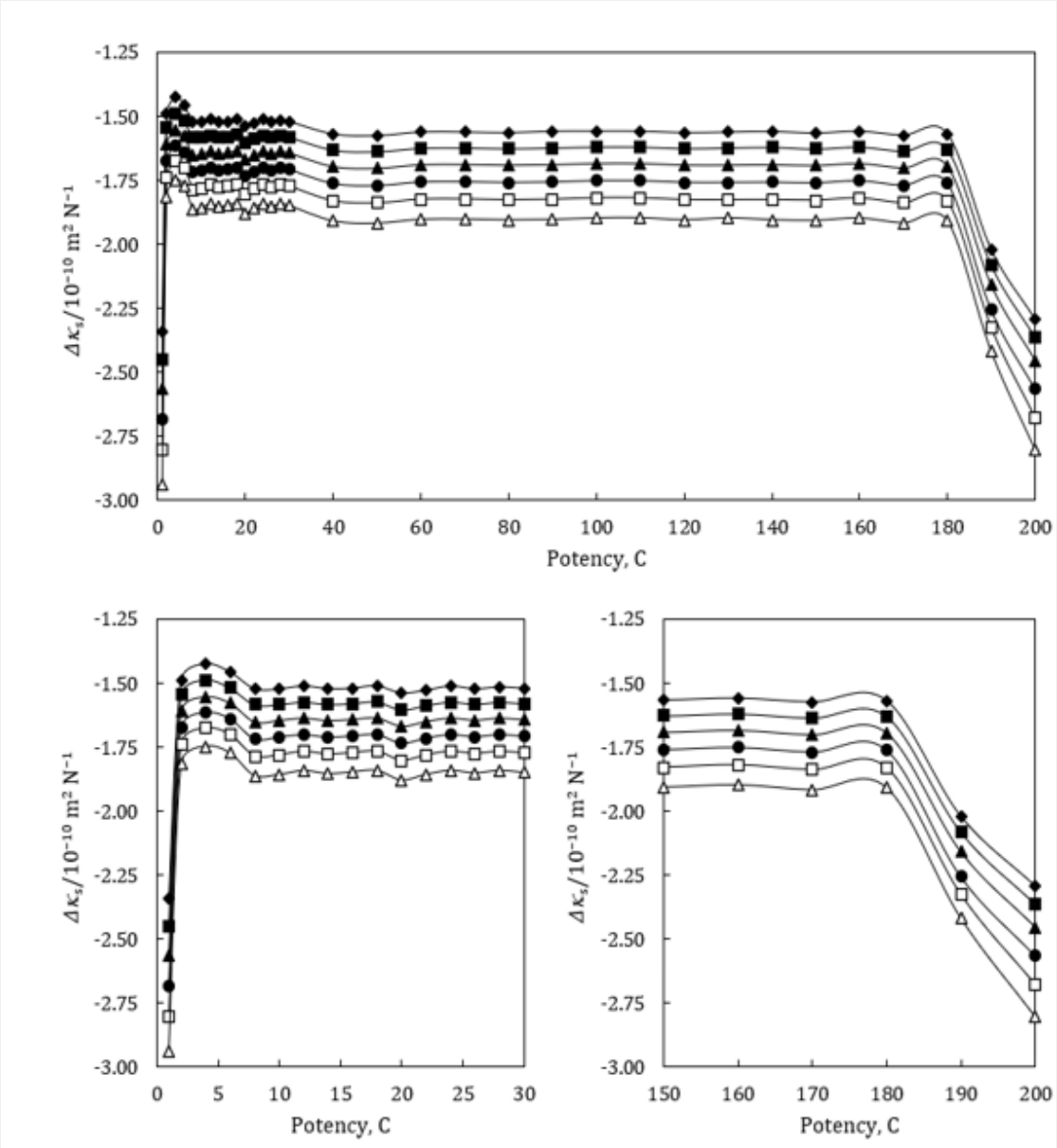

Figure 4: Plots of deviations in isentropic compressibility, $\Delta\kappa_s$ *vs.* potency, C of ammonium aceticum for homoeopathic formulations of ammonium aceticum at temperatures, 293.15 K, •; 298.15 K, ■; 303.15 K, ▲; 308.15 K, ●; 313.15 K, □; and 318.15 K, Δ.

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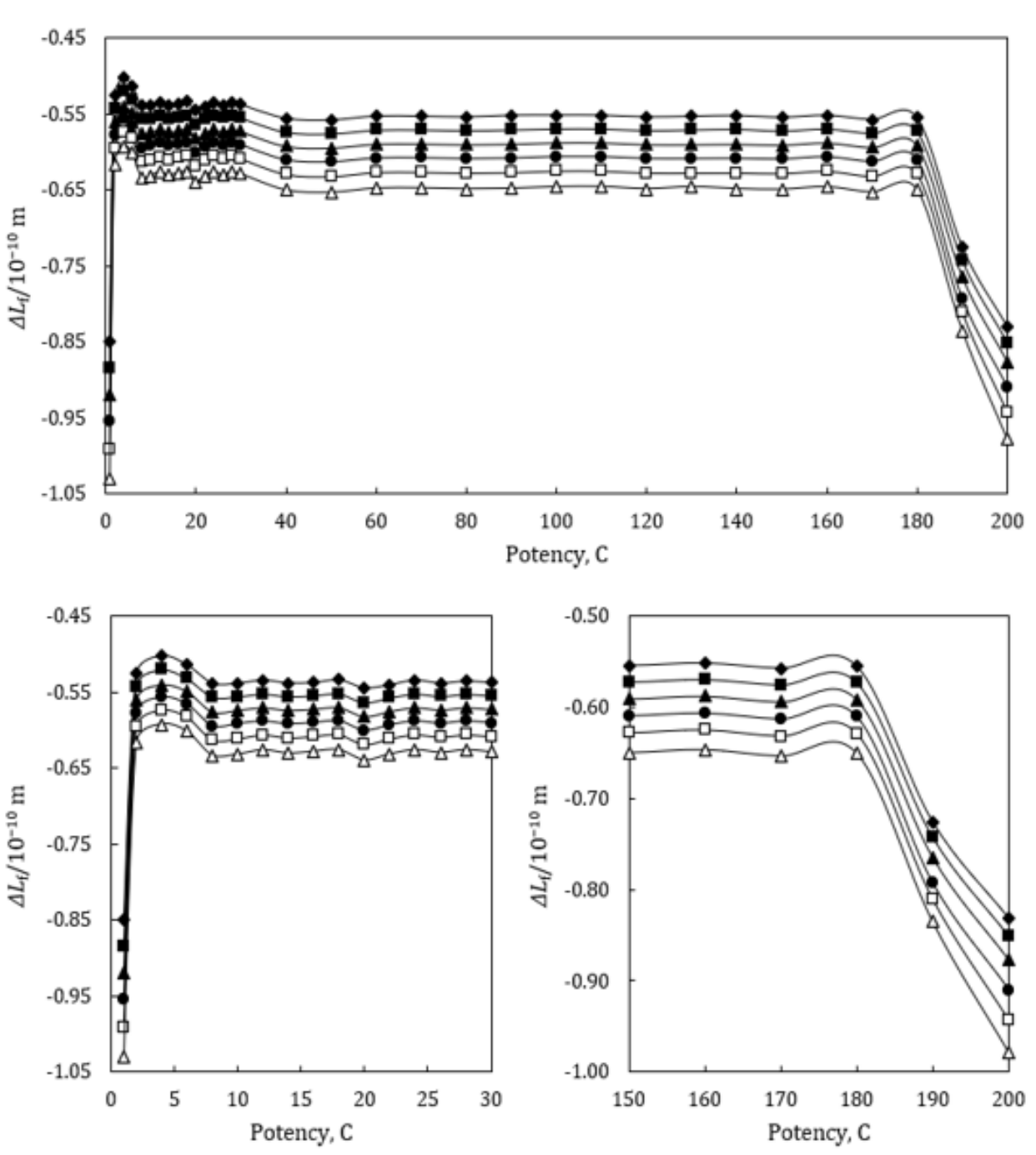

Figure 5: Plots of deviations in intermolecular free length, $^{\Delta L_f}$ *vs*. potency, C of ammonium aceticum for homoeopathic formulations of ammonium aceticum at temperatures, 293.15 K, •; 298.15 K, ■; 303.15 K, ▲; 308.15 K, ●; 313.15 K, □; and 318.15 K, Δ.

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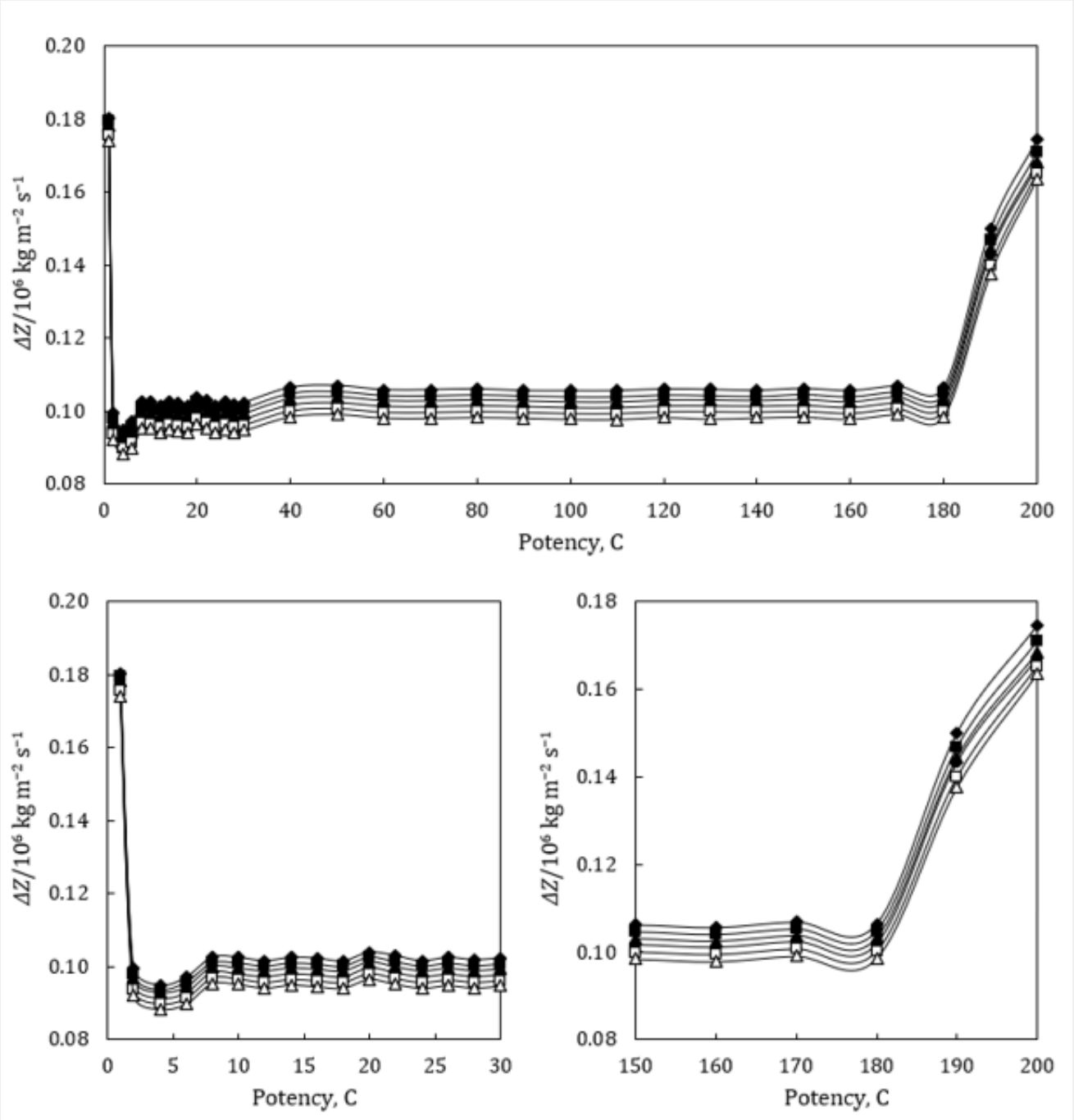

Figure 6: Plots of deviations in specific acoustic impedance, ΔZ *vs.* potency, C of ammonium aceticum for homoeopathic formulations of ammonium aceticum at temperatures, 293.15 K, •; 298.15 K, ■; 303.15 K, ▲; 308.15 K, ●; 313.15 K, □; and 318.15 K, Δ.

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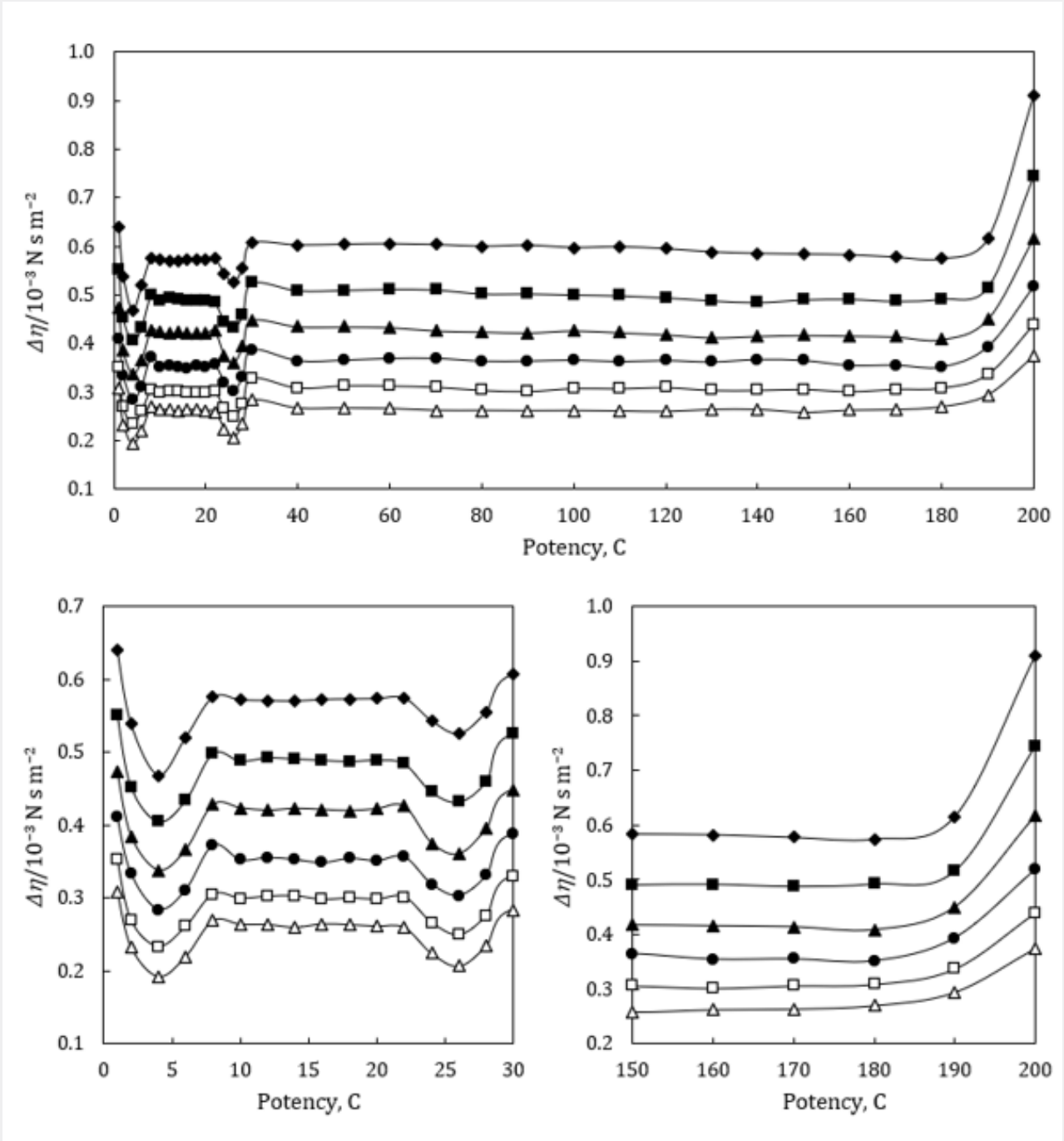

Figure 7: Plots of deviations in viscosity, $^{\Delta\eta}$ *vs*. potency, C of ammonium aceticum for homoeopathic formulations of ammonium aceticum at temperatures, 293.15 K, •; 298.15 K, ■; 303.15 K, ▲; 308.15 K, ●; 313.15 K, □; and 318.15 K, △.

Discussion

A close perusal of Tables 1-3 and Figures 1-3 indicates that the values of ρ and u and η of ammonium aceticum in ethanol are more than those of ethanol control for all the potencies (1C to 200C) at each investigated temperature and the values decrease with increase in temperature. The values of ρ and u are maximum at 1C and then decrease significantly in presence of ammonium aceticum for simple successive dilution to the potency 4C and after that these values increase slightly till 8C and remain nearly constant up to potency 22C and then decrease and exhibit a minimum at 26C and thereafter 30C the values remain nearly constant up to 180C, and thereafter, again increase significantly after potency 180C up to 200C (Figures 1 & 2). The values of values of η are maximum at 1C decrease significantly in presence of ammonium aceticum for simple successive dilutions from potency 1C to 4C and then increase up to 8C and thereafter remain nearly constant

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up to potency 22C and then decrease and exhibit a minimum at 26C and then after 30C the values remain nearly constant up to 180C. Thereafter, values of η again increase after potency 180C up to 200C (Figure 3). The observed anomalous trends in ρ, u and η at certain potencies, viz., 1C to 4C, 22C to 30C and 180C to 200C indicate that these potencies exhibit different solution structure as compared to other potencies and ethanol control.

A close perusal of Tables 4 & 5 indicate that the values of κ_s and L_f for ammonium aceticum potencies are less than those of ethanol controls for all the potencies at each investigated temperature and these values increase with increase in temperature, which indicates significant interaction between ammonium aceticum and ethanol molecules. The values of κ_s and L_f decrease significantly in presence of ammonium aceticum for simple successive dilutions up to potency 4C and after that value pass through maxima/minima at some potencies with dilution and these values again decrease after potency 180C up to 200C (Tables 4 & 5). These variations in κ_s and L_f are expressed in terms of deviations in isentropic compressibility, $\Delta\kappa_s$ and deviations in intermolecular free length, ΔL_f and are shown graphically in Figures 4 & 5.

Figures 4 & 5 indicate that the values of $\Delta\kappa_s$ and ΔL_f are negative and these values are minimum for potency 1C and then increase till potency 4C and after that values decrease till potency 8C and then remain nearly constant on more dilution till 22C, thereafter these values increase and exhibit a maximum at 26C and then after 30C the values remain nearly constant up to 180C, finally decrease again after potency 180C up to 200C. This indicates that at potencies 2C to 6C, 24C to 28C are more compressible and 1C, 190C to 200C are less compressible than the other potencies, indicating that the potencies 2C to 6C, 24C to 28C exhibit less compact solution structure and the potencies 1C, 190C to 200C exhibit less compact solution structure as compared to other potencies and ethanol control. The minimum in $\Delta\kappa_s$ and ΔL_f values at potencies 1C, 190C and 200C indicate that these have most compact solution structure as compared to other potencies, hence, these potencies may have different behavior in terms of efficacy when used in practice.

A close perusal of Table 6 and Figure 6 indicate that the acoustic impedances, Z of potencies of ammonium aceticum are more than those of ethanol control for all the potencies at each investigated temperature and the values decrease with increase in temperature, which indicates significant interaction between ammonium aceticum and ethanol molecules. These variations in Z are expressed in terms of deviations in acoustic impedance, ΔZ and are shown in Figure 6. it indicates that ΔZ values are positive, i.e., Z values for ammonium aceticum are more than those of ethanol control. These ΔZ values are maximum for potency 1C and then decrease till potency 4C and after that values increase till potency 8C and then remain nearly constant on more dilution till 22C, thereafter these values decrease and exhibit a minimum at 26C and then after from 30C the values remain nearly constant up to 180C, finally increase again after potency 180C up to 200C. This indicates that at potencies 2C to 6C, 24C to 28C offer less impedance to sound waves due to less compact structure and 1C, 190C to 200C offer more impedance to sound waves due to more compact structure than the other potencies and ethanol control. The variations in values of Z and ΔZ of these potencies may be due interaction between ammonium aceticum and ethanol molecules.

A close perusal of Table 7 and Figure 7 indicate that the viscosities, η of potencies of ammonium aceticum are more than those of ethanol control for all the potencies at each investigated temperature and the values decrease with increase in temperature, which indicates substantial interaction between ammonium aceticum and ethanol molecules. These variations in η are expressed in terms of deviations in acoustic impedance, $\Delta\eta$ and are shown in Figure 7. it indicates that $\Delta\eta$ values are positive, i.e., η values for ammonium aceticum are more than those of ethanol control. These $\Delta\eta$ values are maximum for potency 1C and then decrease till potency 4C and after that values increase till potency 8C and then remain nearly constant on more dilution till 22C, thereafter these values decrease and exhibit a minimum at 26C and thereafter from 30C the values remain nearly constant up to 180C, finally increase again after potency 180C up to 200C. The variations in values of η and $\Delta\eta$ of these potencies may be due interaction between ammonium aceticum and ethanol molecules. It is observed that the variations observed in the values of measured properties, ρ and u and η ; and calculated parameters, κ_s , L_f , $\Delta\kappa_s$, ΔL_f , ΔZ and $\Delta\eta$ support each other.

A close perusal of Table 7 indicates that the values of R_A for 1C, 190C and 200C potencies of ammonium aceticum are more than 1 while for all other potencies the values are less than 1, and other potencies show varying values with slight variations at certain potencies. The changes in values of R_A of solution in presence of ammonium aceticum are due to different extents of breaking/formation of hydrogen-bonded associates in ethanol controls and their interaction with ammonium aceticum with successive dilutions and succussion.

Conclusion

The densities, ultrasonic speeds and viscosities of ethanol control, 33 formulations of ammonium aceticum in ethanol control are measured for potencies from 1C to 200C (with an interval of 2C up to 30C and then of 10C up to 200C) at six different temperatures and atmospheric pressure. From these experimental data, various physicochemical parameters, viz., κ_s , L_f , Z , $\Delta\kappa_s$, ΔL_f , ΔZ , $\Delta\eta$ and R_A have been calculated. The results have been qualitatively discussed in terms of interactions/physicochemical behavior of these extremely dilute homoeopathic formulations of ammonium aceticum in ethanol. The potencies 2C to 6C, 24C to 28C exhibit less compact solution structure and the potencies 1C, 190C to 200C exhibit less compact solution structure as compared to other potencies and ethanol control. Hence, these potencies may have different behavior in terms of efficacy when used in practice. It can be qualitatively concluded that even in

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extreme dilutions the molecules of ammonium aceticum may be present in these homoeopathic formulations, however it needs to be confirmed from other techniques.

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