Research Journal of Chemical Sciences ISSN 2231-606X
Vol. **15(2),** 41-65, June **(2025)** *Res. J. Chem. Sci.*

Unveiling the physicochemical behaviour of homoeopathic dilutions of *acidum phosphoricum* at different temperatures by using volumetric, acoustic and viscometric properties

Anil Kumar Nain[1]* Soumya[1], Debadatta Nayak[2] and Raj Kumar Manchanda[3]
[1]Department of Chemistry, Dyal Singh College, University of Delhi, New Delhi – 110 003, India
[2]Central Council for Research in Homeopathy, Ministry of AYUSH, New Delhi – 110 058, India
[3]Nehru Homoeopathic Medical College & Hospital, University of Delhi, New Delhi – 110024, India
ak_nain@yahoo.co.in

Available online at: www.isca.in, www.isca.me
Received 16th March 2025, revised 29th April 2025, accepted 19th May 2025

Abstract

The physicochemical studies of homoeopathic medicines can provide better understanding regarding the presence and mechanism of their action in ultra-dilutions. The physicochemical behaviour of dilutions of acidum phosphoricum have been investigated from the measurements of densities, ρ, ultrasonic speeds, u and viscosities, η of pure ethanol control and 33dilutions of acidum phosphoricum of potencies ranging from 1C to 200C (with intervals of 2C up to 30C and then with intervals of 10 C up to 200 C) at six different temperatures and atmospheric pressure. From the experimental data, a number of physicochemical parameters, viz., the isentropic compressibilities, κ_s, intermolecular free length, L_f, acoustic impedance, Z, relative association, R_A, 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 evaluated. These parameters show anomalous behaviour at certain potencies, viz., 1C, 6C, 8C, 12C, 22C, 70C, 80C, 100C, 120C and 170C to 180C, of these homoeopathic dilutions. The results have been qualitatively discussed in terms of interactions between H^+/phosphate ions and dissipative structures of ethanol-water molecules in these acidum phosphoricum dilutions. The results indicated that that even in extreme dilutions the molecules of acidum phosphoricum may be present in these homoeopathic dilutions.

Keywords: Density; Ultrasonic speed; Viscosity; Homoeopathic medicines; *Acidumphosphoricum*; molecular interactions.

Introduction

Homoeopathy has been one of the most extensively practiced alternative medicine with all-inclusive curative approach. The potency of a homoeopathic medicine increases with dilution followed by succession (potentization), which posed two main challenges to the Homoeopathic community, (i) the preparation of homeopathic medicines includes ultra-high dilutions, which raises questions concerning the existence of active medicine molecules at such ultra-dilutions, and (ii) the effectiveness of homoeopathic medicines is well supported by the reported evidences; however, there are disputes regarding doubtfulness in biological activity of these medicines wherein the source drug is diluted beyond Avagadro's limit, *i.e.*, the ultra-diluted medicine may be similar to the solvent. There have been few researches in order to reconnoiter the existence of drug in ultra-high dilutions[1–5], but the query is still unanswered.

The physicochemical properties and derived parameters of electrolytes, amino acids, carbohydrates, drugs, *etc.* in aqueous and mixed-aqueous solutions of have been helpful in illustrating the interactions, which are subsequently useful in understanding of solute-solvation/hydration behaviour of solute and preferential solvation of solute by the solvents[6–9]. The homoeopathic medicines are dilute solutions, hence, their physical properties, like density, ultrasonic speed, viscosity, *etc.* can be measured with varying potency and temperature. The physicochemical parameters derived from these experimental data provide valuable information regarding of physicochemical behaviour and mechanism of drug action of these homoeopathic medicines. Recently, there have been few physicochemical studies on extremely diluted solutions of inorganic salts[10–15] and homoeopathic medicines[16,17] by using physicochemical methods. These studies provided interesting and convincing information on the behaviour of these extremely diluted solutions. To the best of our information, very few physicochemical studies on homoeopathic medicines using volumetric, acoustic and viscometric have been reported in the literature[18–20]. In continuation to ongoing research on the physicochemical behaviour of ultra-diluted homoeopathic medicines, here we report the results of our study on the physicochemical behaviour of homoeopathic dilutions of *acidum phosphoricum*. *Acidum phosphoricum* dilution is a highly beneficial homoeopathic remedy which is used to treat multiple health disorders. It effectively treats physical as well as mental weakness caused due to grief or trauma. It helps improve memory and concentration and is helpful in treating weakness and exhaustion caused due to loss of vital fluids. Loss of fluids can also cause hair loss and *acidum phosphoricum* effectively treats and prevents hair fall.

In the present study, the densities, ρ, ultrasonic speeds, u and viscosities, η of pure ethanol control (91% ethanol in water) and 33 dilutions of *acidum phosphoricum* with potencies 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. Using these experimental data, the isentropic compressibilities, κ_s, intermolecular free length, L_f, acoustic impedance, Z, relative association, R_A, 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. The results have been discussed qualitatively in terms of interactions/physicochemical behaviour of *acidum phosphoricum* in these homoeopathic dilutions.

Materials and Methods

Materials: The phosphoric acid (s.d. fine chemicals, India, mass fraction purity > 0.99) was used for preparation of various potencies of *acidum phosphoricum*. The ethanol control (91% ethanol in water) was prepared by using the ethanol (E. Merck, India, mass fraction purity > 0.995) and triple distilled water. The homoeopathic formulations of various potencies of *acidum phosphoricum* used in the study were prepared by using the method introduced by Dr. Hahnemann using centesimal scale, as described in the Homoeopathic Pharmacopia of India[21]. The potencies ranging from 1C to 200C (with intervals of 2C till 30C, and then with intervals of 10C till 200C) have been prepared. The homoeopathic formulations of *acidum phosphoricum* were prepared by successive dilution of 1:100 followed by ten successions for each potency. The successions for preparing various potencies were performed by using a hammer type mini-potentizer (A.R.P. Industries, India). The prepared potencies were stored in Amber glass bottles and were kept in dark space.

Methods: Density and ultrasonic speed measurements: The densities and ultrasonic speeds of the samples were measured by using Density and Sound Analyzer (DSA 5000M, Anton Paar, Austria). The principle used in density measurement is based upon oscillating U-tube principle while the ultrasonic speed measurement is based on propagation time technique. This equipment is furnished with both density and ultrasonic cells, with reproducibility of $\pm 1\times10^{-3}$ kg·m^{-3} and $\pm 1\times10^{-2}$ 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 equipment was calibrated with triply distilled degassed water and with dry air at atmospheric pressure[7,8]. The ultrasonic speed measurements were done at a frequency of 3 MHz. The standard uncertainties associated with 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.

Viscosity measurements: The viscosities of the samples were measured by using micro viscometer (Lovis 2000M, Anton Paar, Austria) at temperatures, (293.15 − 318.15) K, and at atmospheric pressure. The measurement of viscosity is based on rolling ball principle, having a calibrated glass capillary with a steel ball as supplied by manufacturer. The calibration of capillary was done by using viscosity standard fluids supplied by manufacturer. The temperature of the sample in capillary was kept constant by using built in Peltier thermostat within ±0.02 K. The standard uncertainties for viscosity measurements and temperature were estimated to be within ±0.5% and ±0.02 K.

Results and Discussion

The experimental values of densities, ρ, ultrasonic speeds, u and viscosities, η of *acidum phosphoricum* dilutions as function of potency (in centesimal) at different temperatures have been measured using the methodology mentioned above and listed in Tables 1−3 and shown graphically in Figures 1−3, respectively.

The values of the isentropic compressibility, κ_s, intermolecular free length, L_f, acoustic impedance, Z, relative association, R_A, relaxation time, τ, ultrasonic absorption, (α/f^2) and pseudo-Grüneisen parameter, Γ have been calculated by using the relations[18–20,22].

$$\kappa_s = 1/u^2\rho \tag{1}$$

$$L_f = K'/u\rho^{1/2} \tag{2}$$

$$Z = u.\rho \tag{3}$$

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

$$\tau = (4/3)/\kappa_s\eta \tag{5}$$

$$(\alpha/f^2) = 8\pi^2\eta/3\rho u^3 \tag{6}$$

$$\Gamma = \alpha_p/\kappa_T \tag{7}$$

where K' is temperature dependent constant [= $(93.875 + 0.375T) \times 10^{-8}$]; T is the absolute temperature; ρ_o and u_o are the density and ultrasonic speed of the ethanol control, respectively; α_p is the isobaric expansivity and k_T is the isothermal compressibility. The values of α_p and k_T are calculated using the relations[18,22]

$$\alpha_p = (-1/\rho)(\partial\rho/\partial T)_p \tag{8}$$

$$k_T = (1.71\times10^{-3})/(T^{4/9}u^2\rho^{4/3}) \tag{9}$$

The values of κ_s, L_f, Z, R_A, τ, (α/f^2) and $\Gamma$are given in the Tables 4–10, respectively.

Table-1: The densities, ρ/(kgm^{-3}) of ethanol control and *acidum phosphoricum* potencies, as function of potency, *C* of *acidum phosphoricum* (in centesimal) at temperatures (293.15–318.15) K and atmospheric pressure.

Potency	Temperature, *T*/K					
(C)	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	840.386	836.505	832.110	827.659	823.154	818.587
2	827.682	823.336	818.930	814.470	809.951	805.360
4	826.183	821.830	817.428	812.970	808.453	803.876
6	830.035	825.864	821.285	816.830	812.314	807.735
8	829.793	825.462	821.061	816.605	812.088	807.512
10	827.281	822.932	818.528	814.067	809.545	804.965
12	830.435	826.088	821.684	817.224	812.705	808.127
14	827.221	822.876	818.473	814.015	809.499	804.919
16	826.957	822.617	818.211	813.753	809.236	804.654
18	826.781	822.434	818.031	813.573	808.955	804.277
20	826.420	822.065	817.658	813.199	808.682	804.103
22	829.863	825.675	821.295	816.848	812.335	807.766
24	825.255	820.909	816.506	812.047	807.531	802.950
26	825.452	821.108	816.704	812.246	807.728	803.154
28	825.838	821.500	817.104	812.650	808.137	803.559
30	826.308	821.966	817.563	813.104	808.588	804.009
40	826.304	821.963	817.556	813.097	808.581	804.001
50	825.967	821.623	817.218	812.756	808.240	803.661
60	826.230	821.884	817.478	813.022	808.507	803.929
70	830.247	825.902	821.499	817.041	812.522	807.942
80	831.266	826.920	822.516	818.056	813.538	808.957
90	825.644	821.302	816.896	812.439	807.922	803.345
100	827.335	822.995	818.591	814.129	809.611	805.033
110	825.526	821.174	816.768	812.309	807.792	803.213
120	829.221	824.875	820.472	816.013	811.496	806.918

130	825.479	821.129	816.726	812.269	807.752	803.173
140	824.893	820.546	816.137	811.676	807.159	802.581
150	824.665	820.412	815.906	811.549	806.934	802.358
160	824.416	820.061	815.658	811.203	806.687	802.109
170	824.319	819.977	815.572	811.114	806.597	802.020
180	828.289	823.939	819.537	815.079	810.562	805.981
190	824.977	820.629	816.225	811.767	807.250	802.673
200	824.608	820.256	815.854	811.397	806.881	802.304

Table-2: The ultrasonic speeds, $u/(\mathrm{ms}^{-1})$ of ethanol control and *acidum phosphoricum* potencies, as function of potency, *C* of *acidum phosphoricum* (in centesimal) at temperatures (293.15–318.15) K and atmospheric pressure.

Potency	Temperature, *T*/K					
(C)	293.15	298.15	303.15	308.15	313.15	318.15
0	1195.93	1179.76	1163.54	1147.33	1131.38	1114.91
1	1272.98	1256.88	1240.31	1223.64	1206.94	1190.23
2	1264.08	1247.74	1230.98	1214.16	1197.30	1180.42
4	1260.57	1244.16	1227.39	1210.56	1193.69	1176.80
6	1270.22	1253.90	1237.26	1220.50	1203.69	1186.86
8	1269.53	1253.51	1237.04	1220.43	1203.68	1186.85
10	1263.33	1247.01	1230.29	1213.48	1196.48	1179.72
12	1271.42	1255.16	1238.54	1221.79	1204.99	1187.70
14	1263.38	1247.03	1230.31	1213.50	1196.64	1179.54
16	1263.52	1247.16	1230.44	1213.63	1196.78	1179.77
18	1263.96	1247.53	1230.76	1214.15	1197.39	1180.31
20	1264.73	1248.18	1231.44	1214.88	1198.20	1181.16
22	1270.82	1253.83	1237.11	1220.51	1203.70	1186.83
24	1258.25	1241.89	1225.09	1208.32	1191.32	1174.40
26	1258.44	1242.18	1225.48	1208.57	1192.20	1175.35
28	1259.61	1243.43	1226.72	1210.04	1193.41	1176.53
30	1260.70	1244.49	1227.76	1210.93	1194.06	1177.16

40	1260.83	1244.48	1227.68	1210.83	1193.97	1177.07
50	1260.62	1244.17	1227.35	1210.56	1193.68	1176.66
60	1260.83	1244.39	1227.53	1210.67	1193.81	1176.91
70	1270.95	1254.64	1237.96	1221.18	1204.38	1187.52
80	1273.49	1257.33	1240.75	1224.05	1207.26	1190.44
90	1259.13	1242.86	1226.06	1209.22	1192.33	1175.42
100	1263.60	1247.35	1230.66	1213.87	1197.03	1180.15
110	1258.75	1242.58	1225.86	1209.03	1192.16	1175.25
120	1268.14	1251.98	1235.36	1218.60	1201.80	1184.96
130	1259.45	1243.13	1226.34	1209.49	1192.63	1175.73
140	1257.44	1241.17	1224.41	1207.52	1190.63	1173.63
150	1256.46	1240.08	1223.45	1206.47	1189.86	1172.79
160	1255.64	1239.46	1222.85	1205.90	1189.19	1172.05
170	1255.81	1239.50	1222.72	1205.84	1188.95	1172.00
180	1265.95	1249.59	1232.85	1216.07	1199.22	1182.33
190	1257.61	1241.09	1224.28	1207.40	1190.50	1173.55
200	1257.48	1241.06	1224.13	1207.25	1190.34	1173.36

Table-3: The viscosities, $\eta/(10^{-3}\ \mathrm{N\ sm^{-2}})$ of ethanol control and *acidum phosphoricum* potencies, as function of potency, C of *acidum phosphoricum* (in centesimal) at temperatures (293.15–318.15) K and atmospheric pressure.

Potency	Temperature, T/K					
(C)	293.15	298.15	303.15	308.15	313.15	318.15
0	1.4935	1.3239	1.1844	1.0616	0.9548	0.8677
1	1.9563	1.7200	1.5230	1.3540	1.2120	1.0890
2	1.7543	1.5492	1.3766	1.2300	1.1050	0.9952
4	1.7341	1.5320	1.3616	1.2184	1.0921	0.9892
6	1.7921	1.5797	1.3996	1.2506	1.1193	1.0146
8	1.7947	1.5817	1.4021	1.2541	1.1245	1.0219
10	1.7518	1.5466	1.3729	1.2268	1.1002	0.9964

12	1.8159	1.5993	1.4180	1.2631	1.1325	1.0267
14	1.7576	1.5520	1.3790	1.2317	1.1058	0.9964
16	1.7635	1.5561	1.3787	1.2316	1.1042	0.9979
18	1.7681	1.5612	1.3882	1.2400	1.1093	1.0008
20	1.7773	1.5689	1.3993	1.2461	1.1151	1.0054
22	1.8206	1.6107	1.4357	1.2891	1.1581	1.0493
24	1.7331	1.5346	1.3623	1.2185	1.0903	0.9806
26	1.7307	1.5317	1.3569	1.2176	1.0918	0.9823
28	1.7415	1.5376	1.3647	1.2235	1.0974	0.9877
30	1.7467	1.5428	1.3707	1.2241	1.0987	0.9879
40	1.7400	1.5362	1.3645	1.2188	1.0933	0.9850
50	1.7258	1.5248	1.3552	1.2120	1.0866	0.9786
60	1.7407	1.5364	1.3686	1.2236	1.0952	0.9870
70	1.8008	1.5858	1.4049	1.2529	1.1208	1.0085
80	1.8051	1.5891	1.4079	1.2552	1.1222	1.0092
90	1.7339	1.5319	1.3622	1.2179	1.0933	0.9844
100	1.7570	1.5515	1.3826	1.2357	1.1066	0.9967
110	1.7316	1.5311	1.3630	1.2197	1.0961	0.9874
120	1.7880	1.5760	1.3977	1.2465	1.1165	1.0032
130	1.7366	1.5344	1.3688	1.2171	1.0907	0.9810
140	1.7570	1.5504	1.3791	1.2319	1.1014	0.9912
150	1.7157	1.5165	1.3530	1.2071	1.0809	0.9742
160	1.7199	1.5203	1.3555	1.2092	1.0838	0.9783
170	1.7874	1.5759	1.3966	1.2451	1.1143	1.0014
180	1.7632	1.5562	1.3821	1.2332	1.1076	0.9962
190	1.7086	1.5104	1.3482	1.2059	1.0790	0.9728
200	1.7025	1.5068	1.3445	1.2037	1.0764	0.9698

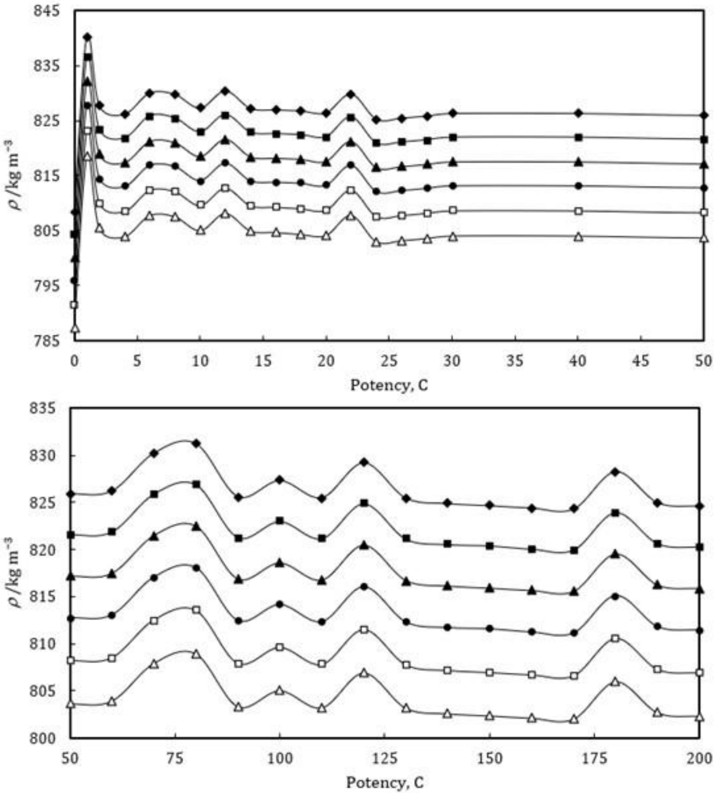

Figure-1: Plots of densities, ρ *vs.* potency, *C* of *acidum phosphoricum* for homoeopathic dilutions of *acidum phosphoricum* at temperatures, 293.15 K, ♦; 298.15 K, ■; 303.15 K, ▲; 308.15 K, ●; 313.15 K, □; and 318.15 K, Δ.

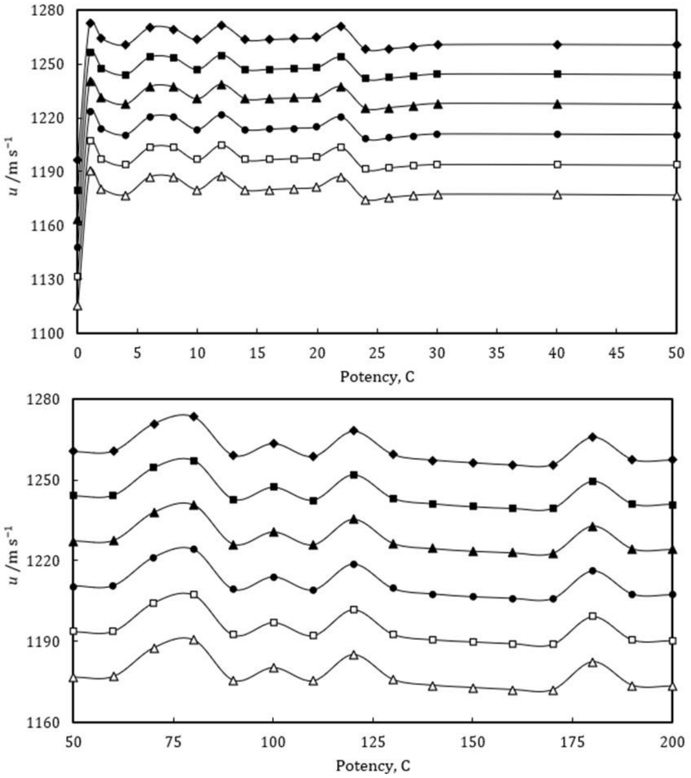

Figure-2: Plots of ultrasonic speeds, *u vs.* potency, *C* of *acidum phosphoricum* for homoeopathic dilutions of *acidum phosphoricum* at temperatures, 293.15 K, ♦; 298.15 K, ■; 303.15 K, ▲; 308.15 K, ●; 313.15 K, □; and 318.15 K, Δ.

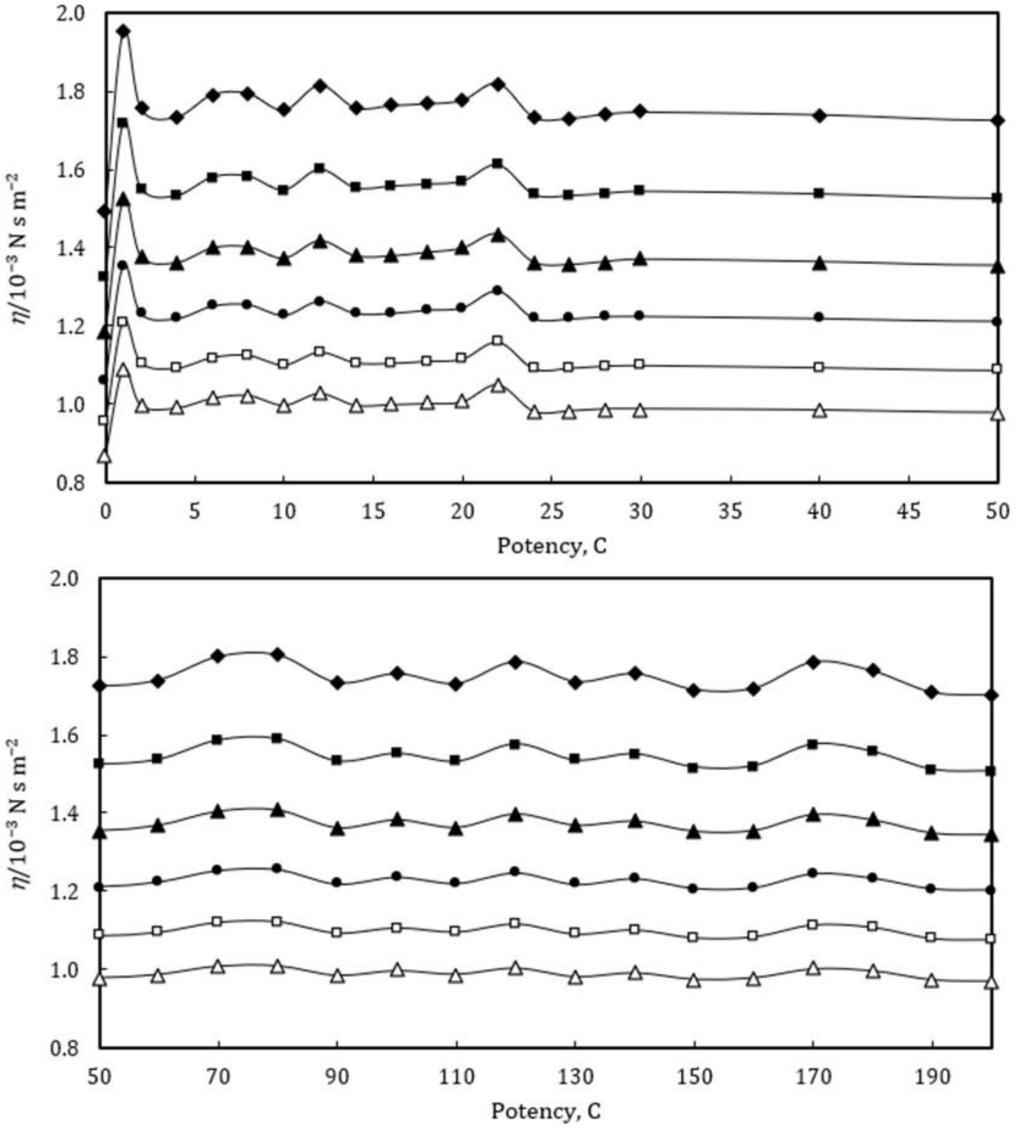

Figure-3: Plots of viscosities, η *vs.* potency, *C* of *acidum phosphoricum* for homoeopathic dilutions of *acidum phosphoricum* at temperatures, 293.15 K, ♦; 298.15 K, ■; 303.15 K, ▲; 308.15 K, ●; 313.15 K, □; and 318.15 K, Δ.

Table-4: Isentropic compressibilities, $\kappa_S/(10^{-10}\ \mathrm{m}^2\ \mathrm{N}^{-1})$ of ethanol control and *acidum phosphoricum* potencies, as function of potency, *C* of *acidum phosphoricum* (in centesimal) at temperatures (293.15–318.15) K and atmospheric pressure.

Potency	Temperature, *T*/K					
(C)	293.15	298.15	303.15	308.15	313.15	318.15
0	8.6506	8.9332	9.2313	9.5435	9.8688	10.2166
1	7.3431	7.5674	7.8119	8.0694	8.3396	8.6233
2	7.5611	7.8014	8.0584	8.3286	8.6126	8.9112
4	7.6171	7.8608	8.1205	8.3937	8.6808	8.9827
6	7.4670	7.7013	7.9540	8.2185	8.4966	8.7889

8	7.4773	7.7099	7.9590	8.2217	8.4991	8.7914
10	7.5738	7.8144	8.0714	8.3421	8.6288	8.9262
12	7.4493	7.6838	7.9337	8.1972	8.4742	8.7722
14	7.5737	7.8147	8.0717	8.3423	8.6269	8.9294
16	7.5745	7.8155	8.0726	8.3432	8.6277	8.9289
18	7.5708	7.8126	8.0702	8.3379	8.6219	8.9249
20	7.5649	7.8080	8.0650	8.3318	8.6132	8.9140
22	7.4615	7.7040	7.9558	8.2182	8.4963	8.7890
24	7.6538	7.8984	8.1603	8.4344	8.7254	9.0298
26	7.6497	7.8928	8.1531	8.4289	8.7104	9.0129
28	7.6319	7.8732	8.1326	8.4042	8.6883	8.9903
30	7.6144	7.8553	8.1143	8.3872	8.6740	8.9757
40	7.6128	7.8555	8.1154	8.3886	8.6754	8.9772
50	7.6185	7.8626	8.1232	8.3959	8.6833	8.9872
60	7.6135	7.8574	8.1182	8.3916	8.6785	8.9804
70	7.4565	7.6919	7.9429	8.2072	8.4847	8.7768
80	7.4177	7.6496	7.8975	8.1587	8.4337	8.7229
90	7.6395	7.8823	8.1435	8.4178	8.7064	9.0097
100	7.5701	7.8096	8.0660	8.3361	8.6201	8.9189
110	7.6452	7.8871	8.1474	8.4218	8.7103	9.0138
120	7.4989	7.7342	7.9864	8.2524	8.5320	8.8260
130	7.6372	7.8805	8.1415	8.4158	8.7038	9.0069
140	7.6670	7.9111	8.1730	8.4495	8.7395	9.0458
150	7.6811	7.9263	8.1882	8.4655	8.7533	9.0613
160	7.6935	7.9376	8.1987	8.4771	8.7658	9.0756
170	7.6923	7.9379	8.2013	8.4789	8.7703	9.0774
180	7.5333	7.7727	8.0281	8.2963	8.5786	8.8756
190	7.6642	7.9113	8.1739	8.4502	8.7404	9.0460
200	7.6692	7.9153	8.1796	8.4561	8.7468	9.0531

Table-5: Intermolecular free lengths, $L_f/(10^{-10}$ m) of ethanol control and *acidum phosphoricum* potencies, as function of potency, *C* of *acidum phosphoricum* (in centesimal) at temperatures (293.15–318.15) K and atmospheric pressure.

Potency	Temperature, *T*/K					
(C)	293.15	298.15	303.15	308.15	313.15	318.15
0	5.9943	6.1475	6.3062	6.4699	6.6381	6.8140
1	5.5228	5.6580	5.8012	5.9492	6.1022	6.2602
2	5.6042	5.7449	5.8920	6.0440	6.2013	6.3638
4	5.6249	5.7667	5.9146	6.0676	6.2258	6.3893
6	5.5692	5.7079	5.8537	6.0040	6.1594	6.3200
8	5.5730	5.7111	5.8555	6.0051	6.1603	6.3209
10	5.6089	5.7497	5.8967	6.0489	6.2071	6.3692
12	5.5626	5.7014	5.8462	5.9962	6.1512	6.3140
14	5.6088	5.7498	5.8968	6.0490	6.2064	6.3703
16	5.6091	5.7501	5.8972	6.0494	6.2067	6.3701
18	5.6078	5.7490	5.8963	6.0474	6.2046	6.3687
20	5.6056	5.7473	5.8944	6.0452	6.2015	6.3648
22	5.5671	5.7089	5.8543	6.0038	6.1592	6.3200
24	5.6384	5.7805	5.9291	6.0823	6.2417	6.4060
26	5.6369	5.7784	5.9265	6.0803	6.2364	6.4000
28	5.6303	5.7712	5.9190	6.0714	6.2285	6.3920
30	5.6239	5.7647	5.9124	6.0653	6.2233	6.3868
40	5.6233	5.7648	5.9128	6.0658	6.2238	6.3873
50	5.6254	5.7674	5.9156	6.0684	6.2266	6.3909
60	5.6235	5.7654	5.9138	6.0669	6.2249	6.3885
70	5.5653	5.7044	5.8496	5.9998	6.1550	6.3156
80	5.5508	5.6887	5.8328	5.9821	6.1365	6.2962
90	5.6331	5.7746	5.9230	6.0763	6.2349	6.3989
100	5.6075	5.7479	5.8947	6.0468	6.2040	6.3666
110	5.6352	5.7763	5.9244	6.0778	6.2363	6.4003
120	5.5810	5.7201	5.8656	6.0163	6.1722	6.3333

130	5.6323	5.7739	5.9222	6.0756	6.2340	6.3979
140	5.6433	5.7851	5.9337	6.0877	6.2468	6.4117
150	5.6485	5.7907	5.9392	6.0935	6.2517	6.4172
160	5.6530	5.7948	5.9430	6.0977	6.2562	6.4222
170	5.6526	5.7949	5.9440	6.0983	6.2578	6.4229
180	5.5938	5.7343	5.8809	6.0323	6.1890	6.3511
190	5.6422	5.7852	5.9340	6.0880	6.2471	6.4118
200	5.6441	5.7867	5.9361	6.0901	6.2494	6.4143

Table-6: Specific acoustic impedances, $Z/(10^6\ \mathrm{kgm}^{-2}\mathrm{s}^{-1})$ of ethanol control and *acidum phosphoricum* potencies, as function of potency, C of *acidum phosphoricum* (in centesimal) at temperatures (293.15–318.15) K and atmospheric pressure.

Potency	Temperature, T/K					
(C)	293.15	298.15	303.15	308.15	313.15	318.15
0	9.6661	9.4885	9.3101	9.1328	8.9562	8.7792
1	10.6979	10.5139	10.3207	10.1276	9.9350	9.7431
2	10.4626	10.2731	10.0809	9.8890	9.6975	9.5066
4	10.4146	10.2249	10.0330	9.8415	9.6504	9.4600
6	10.5433	10.3555	10.1614	9.9694	9.7777	9.5867
8	10.5345	10.3472	10.1569	9.9661	9.7749	9.5840
10	10.4513	10.2620	10.0703	9.8785	9.6860	9.4963
12	10.5583	10.3687	10.1769	9.9848	9.7930	9.5981
14	10.4509	10.2615	10.0698	9.8781	9.6868	9.4943
16	10.4488	10.2594	10.0676	9.8760	9.6848	9.4931
18	10.4502	10.2601	10.0680	9.8780	9.6863	9.4930
20	10.4520	10.2609	10.0690	9.8794	9.6896	9.4977
22	10.5461	10.3526	10.1603	9.9697	9.7781	9.5868
24	10.3838	10.1948	10.0029	9.8121	9.6203	9.4298
26	10.3878	10.1996	10.0085	9.8166	9.6297	9.4399
28	10.4023	10.2148	10.0236	9.8334	9.6444	9.4541
30	10.4173	10.2293	10.0377	9.8461	9.6550	9.4645
40	10.4183	10.2292	10.0370	9.8452	9.6542	9.4637

50	10.4123	10.2224	10.0301	9.8389	9.6478	9.4564
60	10.4174	10.2274	10.0348	9.8430	9.6520	9.4615
70	10.5520	10.3621	10.1698	9.9775	9.7859	9.5945
80	10.5861	10.3971	10.2054	10.0134	9.8215	9.6301
90	10.3959	10.2076	10.0156	9.8242	9.6331	9.4427
100	10.4542	10.2656	10.0741	9.8825	9.6913	9.5006
110	10.3913	10.2037	10.0124	9.8211	9.6302	9.4398
120	10.5157	10.3273	10.1358	9.9439	9.7526	9.5617
130	10.3965	10.2077	10.0158	9.8243	9.6335	9.4431
140	10.3725	10.1844	9.9929	9.8012	9.6103	9.4193
150	10.3616	10.1738	9.9822	9.7911	9.6014	9.4100
160	10.3517	10.1643	9.9743	9.7823	9.5930	9.4011
170	10.3519	10.1636	9.9722	9.7807	9.5900	9.3997
180	10.4857	10.2959	10.1037	9.9119	9.7204	9.5294
190	10.3750	10.1847	9.9929	9.8013	9.6103	9.4198
200	10.3693	10.1799	9.9871	9.7956	9.6046	9.4139

The deviations in κ_s, L_f, Z, η and Γ of ethanol control due to addition of *acidum phosphoricum* with dilution and success ion are signified by the deviation in the values of these properties, *i.e.*, the deviations in isentropic compressibility, $\Delta\kappa_s$, deviations in intermolecular free length, ΔL_f, deviations in acoustic impedance, ΔZ, deviations in pseudo-Grüneisen parameter, $\Delta\Gamma$ and deviations in viscosity, $\Delta\eta$ have been calculated by using the relations[18]

$$\Delta\kappa_s = \kappa_s - \kappa_s^o \tag{10}$$

$$\Delta L_f = L_f - L_f^o \tag{11}$$

$$\Delta Z = Z - Z^o \tag{12}$$

$$\Delta\eta = \eta - \eta^o \tag{13}$$

$$\Delta\Gamma = \Gamma - \Gamma^\circ \tag{14}$$

where the superscript '^{o}' represents the values for pure ethanol control (91% ethanol in water). The variations of $\Delta\kappa_s$, ΔL_f, ΔZ, $\Delta\eta$, τ, (α/f^2) and $\Delta\Gamma$ with potency, C of *acidum phosphoricum* and temperature are presented graphically in Figure-4 to 10, respectively.

A close examination of Table-1 to 3 and Figure-1 to 3 indicates that the values of ρ and u and η of *acidum phosphoricum* in ethanol are greater than those of ethanol control for all the potencies (1C to 200C) at each investigated temperature and these values decrease with increase in temperature. The values of ρ, u and η are maximum at 1C and then decrease significantly in presence of *acidum phosphoricum* for simple successive dilution to the potency 4C and after that these values increase to maxima at 6C–8C, thereafter, these values decrease till 10C, then these values increase up to 12C, and again decrease till 14C and thereafter, these values are decrease slightly up to 20C with successive dilutions. After 20C these values increase to 22C and then decrease to 24C, thereafter these values increase up to 30C (Figure-1 to 3). After 30C these values decrease slightly till 200C, except exhibiting maximums at potencies 70C to 80C, 100C, 120C and 180C (Figure-1 to 3). Additionally, the values of values of η exhibit a maximum at 170C (-), which is not observed in case of ρ and u values (Figure-1 and 2). The observed anomalous trends in ρ, u and η at the potencies, *viz.*, 1C, 6C, 12C, 22C, 70C to 80C, 100C, 120C and 180C indicate that these potencies exhibit different solution structure as compared to other potencies and ethanol control.

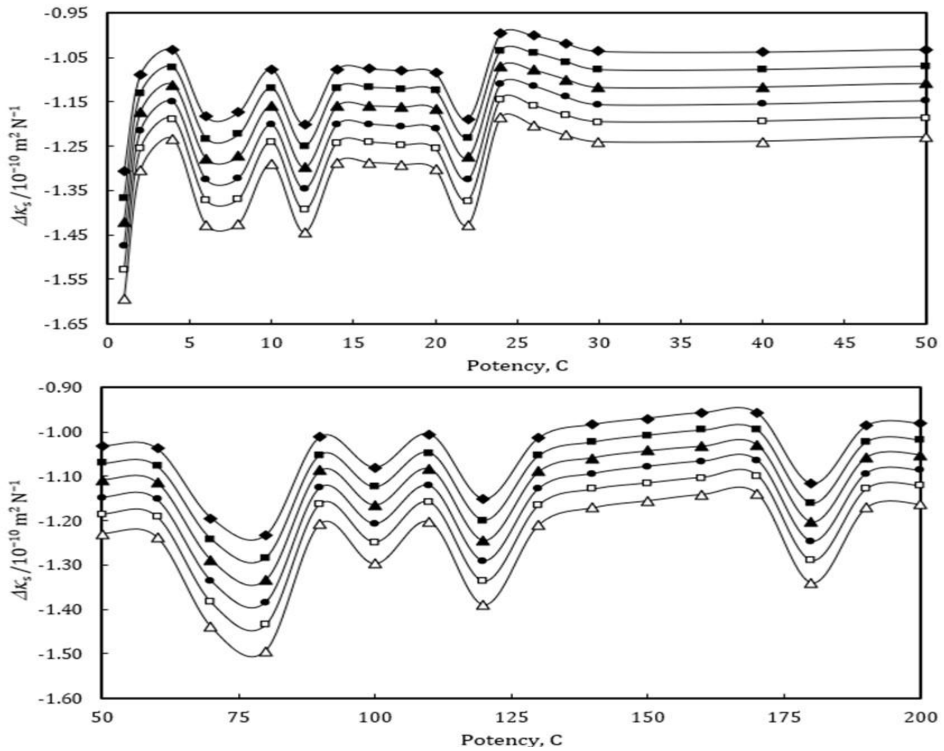

Figure-4: Plots of deviations in isentropic compressibility, $\Delta\kappa_S$ *vs.* potency, *C* of *acidum phosphoricum* for homoeopathic dilutions of *acidum phosphoricum* at temperatures, 293.15 K, ♦; 298.15 K, ■; 303.15 K, ▲; 308.15 K, ●; 313.15 K, □; and 318.15 K, Δ.

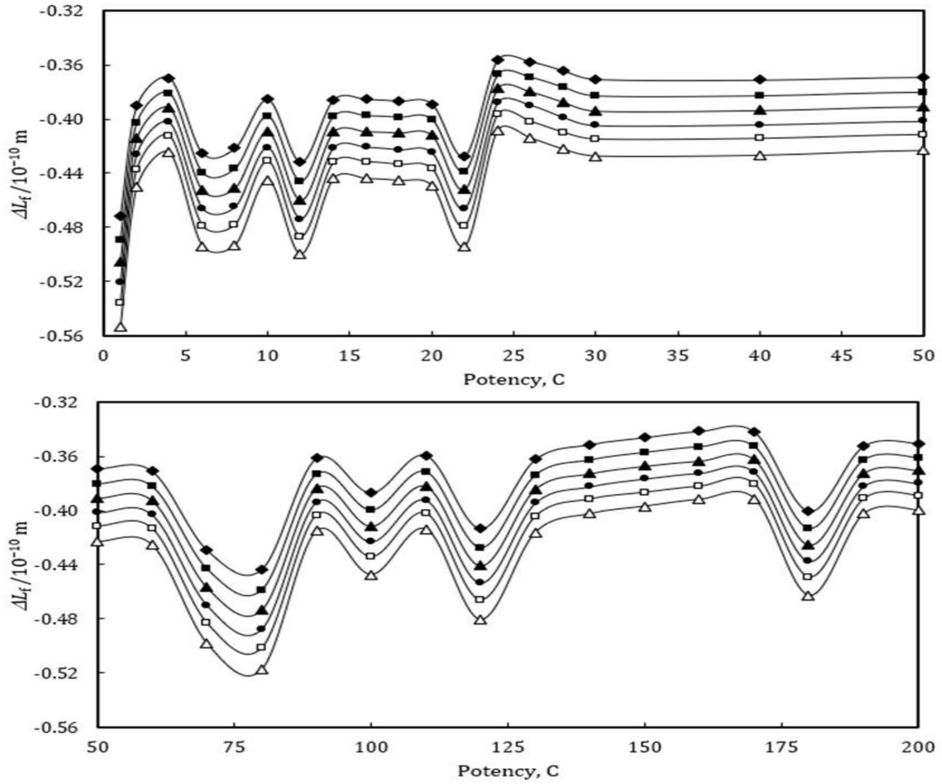

Figure-5: Plots of deviations in intermolecular free length, ΔL_f *vs.* potency, *C* of *acidum phosphoricum* for homoeopathic dilutions of *acidum phosphoricum* at temperatures, 293.15 K, ♦; 298.15 K, ■; 303.15 K, ▲; 308.15 K, ●; 313.15 K, □; and 318.15 K, Δ.

The 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 Figure-4 and 5. Figure-4 and 5 indicate that the values of $\Delta\kappa_s$ and ΔL_f are negative and these values are minimum at 1C and then increase significantly in presence of *acidum phosphoricum* for simple successive dilution to the potency 4C and after that these values decrease exhibiting minima at 6C to 8C, thereafter, these values increase till 10C, then these values decrease up to 12C, and again increase till 14C and thereafter, these values are increase slightly up to 20C with successive dilutions. After 20C these values decrease to 22C and then increase to 24C, thereafter these values decrease up to 30C (Figure-4 and 5). After 30C these values increase slightly till 200C, except exhibiting minimums at potencies 70C to 80C, 100C, 120C and 180C (Figure-4 and 5). This indicates that at potencies 1C, 6C, 8C, 12C, 22C, 70C, 80C, 100C, 120C and 180C are less compressible than the other potencies, indicating that the potencies 1C, 6C, 8C, 12C, 22C, 70C, 80C, 100C, 120C and 180C exhibit more compact solution structure as compared to other potencies. The minimum in $\Delta\kappa_s$ and ΔL_f values at potencies 1C, 6C, 8C, 12C, 22C, 70C, 80C, 100C, 120C and 180C indicate that these have most compact solution structure, hence, these potencies show diverse behaviour which may be due interaction between *acidum phosphoricum* and ethanol-water molecules.

A close perusal of Table-6 indicates that the acoustic impedances, Z of potencies of *acidum phosphoricum* 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 *acidum phosphoricum* and ethanol/water molecules. Figure-6 indicates that ΔZ values are positive, *i.e.*, Z values for *acidum phosphoricum* are more than those of ethanol control. These ΔZ values are maximum for maximum at 1C and then decrease significantly in presence of *acidum phosphoricum* for simple successive dilution to the potency 4C and after that these values increase to maxima at 6C– 8C, thereafter, these values decrease till 10C, then these values increase up to 12C, and again decrease till 14C and thereafter, these values are decrease slightly up to 20C with successive dilutions. After 20C these values increase to 22C and then decrease to 24C, thereafter these values increase up to 30C (Figure-6). After 30C these values decrease slightly till 200C, except exhibiting maximums at potencies 70C to 80C, 100C, 120C and 180C (Figure-6). This indicates that at potencies 1C, 6C, 8C, 12C, 22C, 70C, 80C, 100C, 120C and 180C offer more resistance to the propagation of sound waves through the solution due to more compact structure the other potencies. The variations in values of Z and ΔZ of these potencies may be due interaction between *acidum phosphoricum* and ethanol-water molecules.

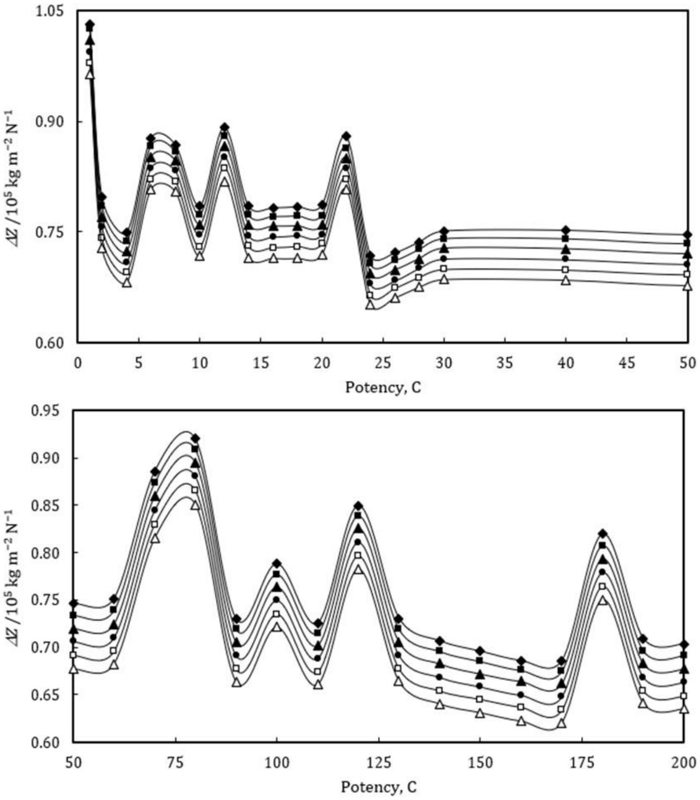

Figure-6: Plots of deviations in specific acoustic impedance ΔZ *vs.* potency, *C* of *acidum phosphoricum* for homoeopathic dilutions of *acidum phosphoricum* at temperatures, 293.15 K, ♦; 298.15 K, ■; 303.15 K, ▲; 308.15 K, ●; 313.15 K, □; and 318.15 K, Δ.

Table-7: The relative associations, R_A of ethanol control and *acidum phosphoricum* potencies, as function of potency, *C* of *acidum phosphoricum* (in centesimal) at temperatures (293.15–318.15) K and atmospheric pressure.

Potency	Temperature, *T*/K					
(C)	293.15	298.15	303.15	308.15	313.15	318.15
1	1.0183	1.0183	1.0180	1.0177	1.0177	1.0172
2	1.0053	1.0048	1.0044	1.0041	1.0040	1.0035
4	1.0044	1.0039	1.0036	1.0032	1.0032	1.0027
6	1.0065	1.0062	1.0056	1.0052	1.0052	1.0046
8	1.0064	1.0058	1.0054	1.0050	1.0049	1.0043
10	1.0050	1.0045	1.0041	1.0038	1.0037	1.0032
12	1.0067	1.0061	1.0057	1.0054	1.0053	1.0049
14	1.0049	1.0044	1.0040	1.0037	1.0036	1.0032
16	1.0046	1.0040	1.0037	1.0033	1.0033	1.0028
18	1.0042	1.0037	1.0034	1.0030	1.0028	1.0022
20	1.0036	1.0031	1.0027	1.0023	1.0022	1.0017
22	1.0062	1.0060	1.0057	1.0053	1.0052	1.0047
24	1.0039	1.0034	1.0031	1.0027	1.0027	1.0022
26	1.0041	1.0035	1.0032	1.0029	1.0027	1.0022
28	1.0042	1.0037	1.0033	1.0030	1.0029	1.0023
30	1.0045	1.0040	1.0036	1.0033	1.0032	1.0027
40	1.0045	1.0040	1.0036	1.0033	1.0033	1.0027
50	1.0041	1.0036	1.0033	1.0029	1.0029	1.0024
60	1.0044	1.0039	1.0036	1.0032	1.0032	1.0027
70	1.0066	1.0060	1.0057	1.0053	1.0052	1.0047
80	1.0072	1.0066	1.0062	1.0058	1.0057	1.0051
90	1.0041	1.0036	1.0033	1.0029	1.0029	1.0024
100	1.0050	1.0044	1.0041	1.0037	1.0037	1.0032
110	1.0041	1.0035	1.0032	1.0028	1.0028	1.0023
120	1.0061	1.0055	1.0051	1.0047	1.0047	1.0041
130	1.0039	1.0033	1.0030	1.0026	1.0026	1.0021

140	1.0037	1.0031	1.0028	1.0025	1.0024	1.0019
150	1.0037	1.0032	1.0028	1.0026	1.0024	1.0019
160	1.0036	1.0030	1.0026	1.0023	1.0022	1.0018
170	1.0034	1.0029	1.0026	1.0022	1.0022	1.0017
180	1.0055	1.0050	1.0047	1.0043	1.0042	1.0037
190	1.0037	1.0032	1.0029	1.0026	1.0026	1.0021
200	1.0033	1.0028	1.0025	1.0022	1.0022	1.0017

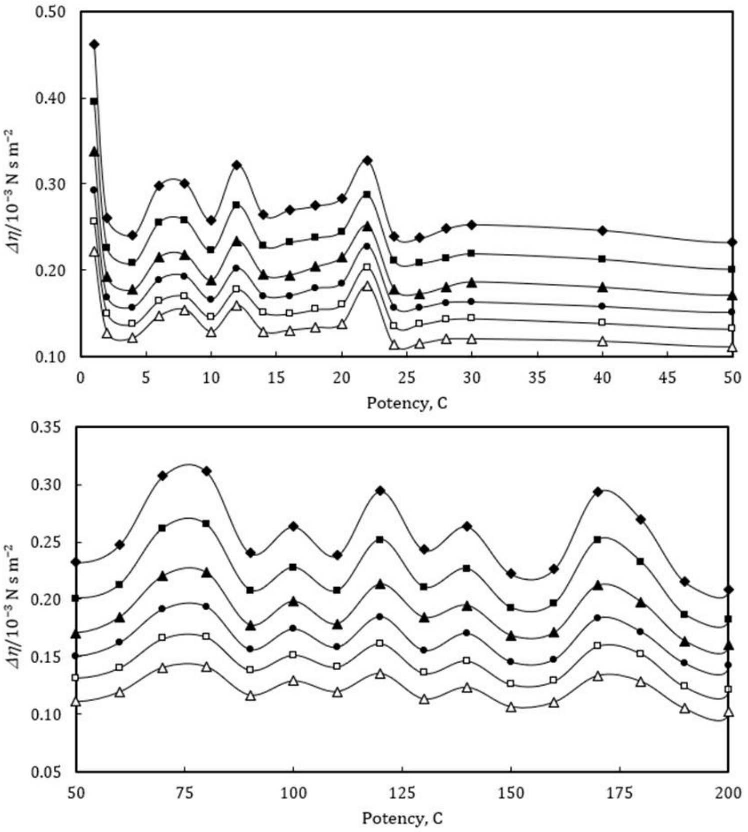

Figure-7: Plots of deviations in viscosity, $\Delta\eta$ *vs.* potency, *C* of *acidum phosphoricum* for homoeopathic dilutions of *acidum phosphoricum* at temperatures, 293.15 K, ♦; 298.15 K, ■; 303.15 K, ▲; 308.15 K, ●; 313.15 K, □; and 318.15 K, Δ.

A close perusal of Figure-3 indicates that the viscosities, η of potencies of *acidum phosphoricum* 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 *acidum phosphoricum* and ethanol molecules. Figure-7 indicates that $\Delta\eta$ values are positive, *i.e.*, η values for *acidum phosphoricum* are more than those of ethanol control. These $\Delta\eta$ values are maximum for potency 1C and then decrease significantly in presence of *acidum phosphoricum* for simple successive dilution to the potency 4C and after that these values increase to maxima at 6C–8C, thereafter, these values decrease till 10C, then these values increase up to 12C, and again decrease till 14C and thereafter, these values are decrease slightly up to 20C with successive dilutions. After 20C these values increase to 22C and then decrease to 24C, thereafter these values increase up to 30C (Figure-7). After 30C these values decrease slightly till 200C, except exhibiting maximums at potencies 70C to 80C, 100C, 120C, 170 to 180C (Figure-7). This indicates that at potencies 1C, 6C, 8C, 12C, 22C, 70C, 80C, 100C, 120C and 170C to 180C potencies may be due interaction between *acidum phosphoricum* and ethanol-water molecules.

A close perusal of Table-7 indicates that the values of R_A for 1C, 6C, 8C, 12C, 22C, 70C, 80C, 100C, 120C and 170C to 180C potencies of *acidum phosphoricum*a re more than 1 and exhibit maximums at these potencies, other potencies show varying values. The values of R_A decrease with increase in temperature. The changes in values of R_A of solution in presence of *acidum phosphoricum* are due to different extents of breaking/formation of hydrogen-bonded associates in ethanol controls and their interaction with *acidum phosphoricum* with successive dilutions and success ions. The values of R_A decrease with increase in temperature that may due breaking of associations/interactions between the component molecules.

Table-8: The relaxation time, $\tau/(10^{-12}$ s) of ethanol control and *acidum phosphoricum* potencies, as function of potency, *C* of *acidum phosphoricum* (in centesimal) at temperatures (293.15–318.15) K and atmospheric pressure.

Potency	Temperature, *T*/K					
(C)	293.15	298.15	303.15	308.15	313.15	318.15
0	1.7226	1.5769	1.4578	1.3509	1.2564	1.1820
1	1.9154	1.7354	1.5863	1.4568	1.3477	1.2521
2	1.7686	1.6115	1.4791	1.3659	1.2689	1.1825
4	1.7612	1.6057	1.4743	1.3636	1.2640	1.1847
6	1.7842	1.6221	1.4843	1.3704	1.2680	1.1890
8	1.7893	1.6260	1.4879	1.3748	1.2743	1.1979
10	1.7690	1.6114	1.4775	1.3645	1.2658	1.1859
12	1.8036	1.6385	1.5000	1.3805	1.2796	1.2009
14	1.7749	1.6171	1.4841	1.3700	1.2720	1.1863
16	1.7810	1.6216	1.4840	1.3701	1.2702	1.1880
18	1.7848	1.6263	1.4937	1.3785	1.2752	1.1909
20	1.7927	1.6333	1.5047	1.3843	1.2806	1.1949
22	1.8113	1.6545	1.5230	1.4125	1.3119	1.2296
24	1.7686	1.6161	1.4822	1.3703	1.2684	1.1806
26	1.7652	1.6119	1.4751	1.3684	1.2680	1.1805
28	1.7721	1.6141	1.4798	1.3710	1.2713	1.1840
30	1.7733	1.6159	1.4830	1.3689	1.2707	1.1823
40	1.7662	1.6090	1.4765	1.3632	1.2646	1.1790
50	1.7531	1.5985	1.4678	1.3568	1.2580	1.1727
60	1.7670	1.6096	1.4814	1.3691	1.2673	1.1818
70	1.7904	1.6264	1.4879	1.3710	1.2680	1.1802

80	1.7853	1.6208	1.4825	1.3654	1.2619	1.1737
90	1.7662	1.6100	1.4791	1.3669	1.2692	1.1826
100	1.7734	1.6155	1.4869	1.3735	1.2719	1.1853
110	1.7651	1.6101	1.4807	1.3696	1.2730	1.1867
120	1.7877	1.6252	1.4883	1.3715	1.2701	1.1806
130	1.7684	1.6123	1.4859	1.3657	1.2658	1.1781
140	1.7961	1.6354	1.5029	1.3879	1.2834	1.1955
150	1.7571	1.6027	1.4771	1.3625	1.2615	1.1770
160	1.7643	1.6090	1.4818	1.3667	1.2667	1.1838
170	1.8332	1.6679	1.5272	1.4076	1.3030	1.2120
180	1.7710	1.6128	1.4794	1.3641	1.2669	1.1789
190	1.7460	1.5932	1.4693	1.3587	1.2575	1.1733
200	1.7409	1.5902	1.4663	1.3572	1.2553	1.1706

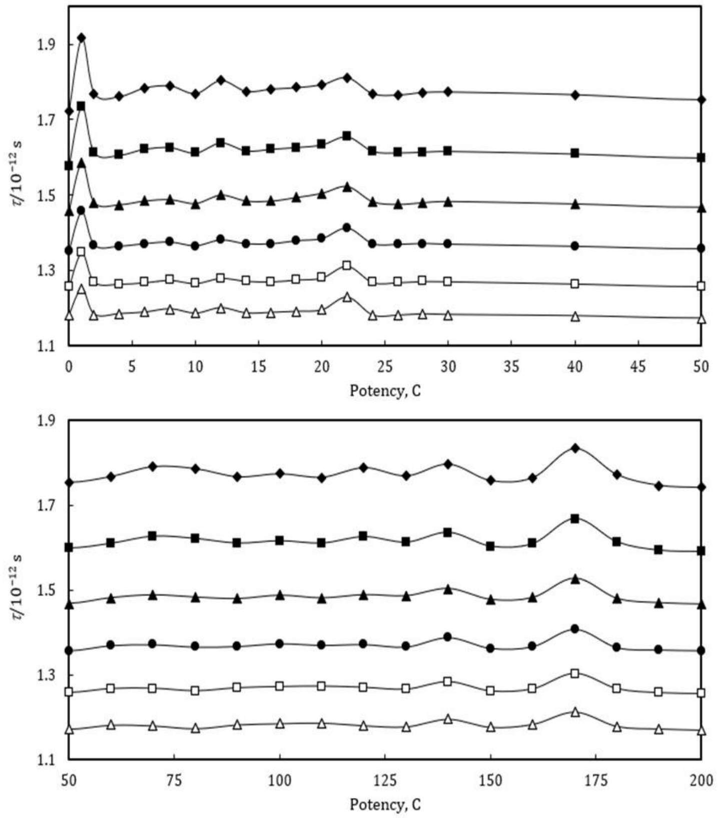

Figure-8: Plots of relaxation time, τ *vs.* potency, *C* of *acidum phosphoricum* for homoeopathic dilutions of *acidum phosphoricum* at temperatures, 293.15 K, ♦; 298.15 K, ■; and 303.15 K, ▲; 308.15 K, ●; 313.15 K, □; and 318.15 K, Δ.

A close perusal of Table-8 and Figure-8 indicates that the relaxation time, τ for *acidum phosphoricum* potencies is more than those of ethanol controls for all the potencies at each investigated temperature and these values decrease with increase in temperature. The τ value is the time in which the structural deformation caused by propagation of ultrasonic wave is restored in the medium through translational motion, which indicates significant interaction between *acidum phosphoricum* and ethanol-water molecules. These τ values decrease from 1C and then decrease significantly in presence of *acidum phosphoricum* for simple successive dilution to the potency 4C and after that these values increase to maxima at 6C–8C, thereafter, these values decrease till 10C, then these values increase up to 12C, and again decrease till 14C and thereafter, these values are decrease slightly up to 20C with successive dilutions. After 20C these values increase to 22C and then decrease to 24C, thereafter these values increase up to 30C (Figure-8). After 30C these values decrease slightly till 200C, except exhibiting maximums at potencies 70C to 80C, 100C, 120C and 170C (Figure-8). This indicates that at potencies 1C, 6C, 8C, 12C, 22C, 70C, 80C, 100C, 120C and 170C possess more compact solution structure as compared to other potencies. The maximum in the values of τ for 1C, 6C, 8C, 12C, 22C, 70C, 80C, 100C, 120C and 170C potencies indicate that the structural deformation by propagation of ultrasonic wave is restored slowly, which may be due substantial interaction between *acidum phosphoricum* and water-ethanol molecules.

Table-9: The ultrasonic absorption, (α/f^2)/(10^{-11} Np s^{-2} m^{-1}) of ethanol control and *acidum phosphoricum* potencies, as function of potency, *C* of *acidum phosphoricum* (in centesimal) at temperatures (293.15–318.15) K and atmospheric pressure.

Potency	Temperature, *T*/K					
(C)	293.15	298.15	303.15	308.15	313.15	318.15
0	3.3969	3.1095	2.8747	2.6638	2.4775	2.3308
1	3.7770	3.4222	3.1281	2.8727	2.6575	2.4690
2	3.4875	3.1777	2.9167	2.6934	2.5022	2.3317
4	3.4729	3.1663	2.9071	2.6889	2.4926	2.3361
6	3.5183	3.1987	2.9270	2.7023	2.5005	2.3445
8	3.5283	3.2063	2.9340	2.7110	2.5128	2.3621
10	3.4884	3.1776	2.9135	2.6908	2.4960	2.3384
12	3.5566	3.2310	2.9579	2.7223	2.5233	2.3680
14	3.4999	3.1888	2.9266	2.7016	2.5082	2.3393
16	3.5120	3.1976	2.9263	2.7017	2.5048	2.3427
18	3.5195	3.2069	2.9455	2.7184	2.5147	2.3484
20	3.5350	3.2208	2.9672	2.7297	2.5253	2.3563
22	3.5716	3.2625	3.0031	2.7854	2.5870	2.4247
24	3.4876	3.1869	2.9228	2.7021	2.5013	2.3281
26	3.4809	3.1786	2.9087	2.6984	2.5004	2.3278
28	3.4945	3.1829	2.9181	2.7035	2.5069	2.3347
30	3.4969	3.1864	2.9243	2.6994	2.5057	2.3314
40	3.4828	3.1728	2.9115	2.6881	2.4938	2.3249
50	3.4569	3.1522	2.8944	2.6755	2.4807	2.3124
60	3.4845	3.1740	2.9212	2.6997	2.4990	2.3305
70	3.5304	3.2071	2.9340	2.7036	2.5003	2.3272
80	3.5205	3.1961	2.9234	2.6925	2.4884	2.3145

90	3.4827	3.1748	2.9166	2.6955	2.5027	2.3319
100	3.4970	3.1857	2.9321	2.7083	2.5080	2.3372
110	3.4807	3.1750	2.9197	2.7008	2.5102	2.3401
120	3.5253	3.2048	2.9349	2.7046	2.5046	2.3280
130	3.4871	3.1792	2.9300	2.6931	2.4960	2.3231
140	3.5418	3.2248	2.9635	2.7367	2.5308	2.3574
150	3.4649	3.1604	2.9128	2.6867	2.4876	2.3210
160	3.4790	3.1728	2.9220	2.6951	2.4979	2.3344
170	3.6150	3.2890	3.0115	2.7757	2.5695	2.3900
180	3.4923	3.1803	2.9173	2.6900	2.4982	2.3247
190	3.4430	3.1417	2.8974	2.6792	2.4796	2.3137
200	3.4329	3.1358	2.8915	2.6762	2.4754	2.3084

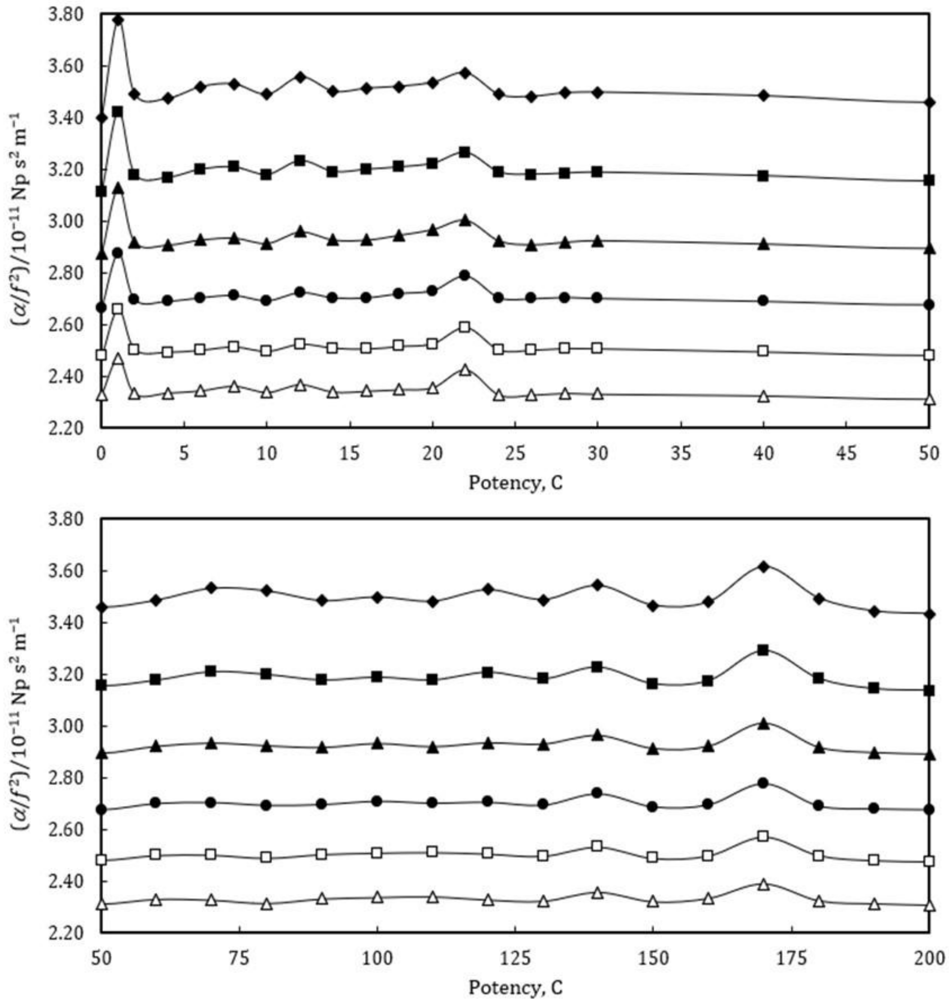

Figure-9: Plots of ultrasonic absorption, (α/f^2) *vs.* potency, *C* of *acidum phosphoricum* for homoeopathic dilutions of *acidum phosphoricum* at temperatures, 293.15 K, ♦; 298.15 K, ■; and 303.15 K, ▲; 308.15 K, ●; 313.15 K, □; and 318.15 K, Δ.

The loss of energy of ultrasonic waves by the concerned medium is called ultrasonic absorption or attenuation (α/f^2). The (α/f^2) values for *acidum phosphoricum* potencies are more than those of ethanol controls for all the potencies at each investigated temperature and these values decrease with increase in temperature (Table-9 and Figure-9). As expected, the trends of ultrasonic absorption resemble with the relaxation time (Figure-9). The viscosity appears to be the main factor accountable for ultrasonic absorption in these homoeopathic dilutions. The (α/f^2) values decrease from 1C and then decrease significantly in presence of *acidum phosphoricum* for simple successive dilution to the potency 4C and after that these values increase to maxima at 6C–8C, thereafter, these values decrease till 10C, then these values increase up to 12C, and again decrease till 14C and thereafter, these values are decrease slightly up to 20Cwith successive dilutions. After 20C these values increase to 22C and then decrease to 24C, thereafter these values increase up to 30C (Figure-9). After 30C these values decrease slightly till 200C, except exhibiting maximums at potencies 70C to 80C, 100C, 120C and 180C (Figure-9). The enhancement in (α/f^2) values for 1C, 6C, 8C, 12C, 22C, 70C, 80C, 100C, 120C and 170C potencies reflect a more ordered structure and significant interactions among the constituents may be due the presence of physical interaction because of hydrogen bonding.

Table 10: The pseudo-Grüneisen parameter, $\Gamma/(10^6)$ of ethanol control and *acidum phosphoricum* potencies, as function of potency, *C* of *acidum phosphoricum* (in centesimal) at temperatures (293.15–318.15) K and atmospheric pressure.

Potency	Temperature, *T*/K					
(C)	293.15	298.15	303.15	308.15	313.15	318.15
0	8.1269	7.9552	7.7821	7.6087	7.4381	7.2613
1	9.7955	9.6065	9.4077	9.2069	9.0052	8.8031
2	9.7807	9.5846	9.3812	9.1765	8.9708	8.7646
4	9.7143	9.5177	9.3149	9.1107	8.9055	8.7000
6	9.9094	9.7129	9.5093	9.3041	9.0977	8.8908
8	9.8583	9.6667	9.4673	9.2652	9.0606	8.8545
10	9.7661	9.5704	9.3678	9.1633	8.9557	8.7515
12	9.9008	9.7050	9.5028	9.2981	9.0923	8.8789
14	9.7602	9.5642	9.3617	9.1574	8.9520	8.7429
16	9.7624	9.5662	9.3637	9.1594	8.9541	8.7463
18	9.8498	9.6508	9.4458	9.2428	9.0368	8.8258
20	9.7838	9.5844	9.3815	9.1807	8.9778	8.7693
22	9.8134	9.6086	9.4067	9.2061	9.0019	8.7966
24	9.6746	9.4791	9.2761	9.0732	8.8665	8.6609
26	9.6764	9.4824	9.2810	9.0759	8.8786	8.6739
28	9.6866	9.4939	9.2924	9.0908	8.8896	8.6845
30	9.7146	9.5211	9.3188	9.1146	8.9095	8.7038
40	9.7186	9.5228	9.3195	9.1150	8.9100	8.7042
50	9.7153	9.5181	9.3145	9.1108	8.9056	8.6981
60	9.7165	9.5194	9.3153	9.1106	8.9057	8.7000
70	9.8911	9.6946	9.4916	9.2866	9.0809	8.8741
80	9.9365	9.7419	9.5401	9.3358	9.1298	8.9231

90	9.6880	9.4938	9.2908	9.0867	8.8815	8.6759
100	9.7656	9.5711	9.3690	9.1649	8.9597	8.7538
110	9.6866	9.4938	9.2919	9.0879	8.8829	8.6772
120	9.8426	9.6488	9.4471	9.2428	9.0375	8.8314
130	9.6939	9.4989	9.2959	9.0916	8.8868	8.6813
140	9.6647	9.4706	9.2682	9.0635	8.8585	8.6517
150	9.6576	9.4621	9.2614	9.0556	8.8544	8.6465
160	9.6309	9.4384	9.2387	9.0334	8.8314	8.6229
170	9.6319	9.4375	9.2353	9.0311	8.8264	8.6208
180	9.8061	9.6094	9.4063	9.2020	8.9963	8.7899
190	9.6635	9.4656	9.2626	9.0582	8.8531	8.6472
200	9.6592	9.4629	9.2582	9.0538	8.8486	8.6423

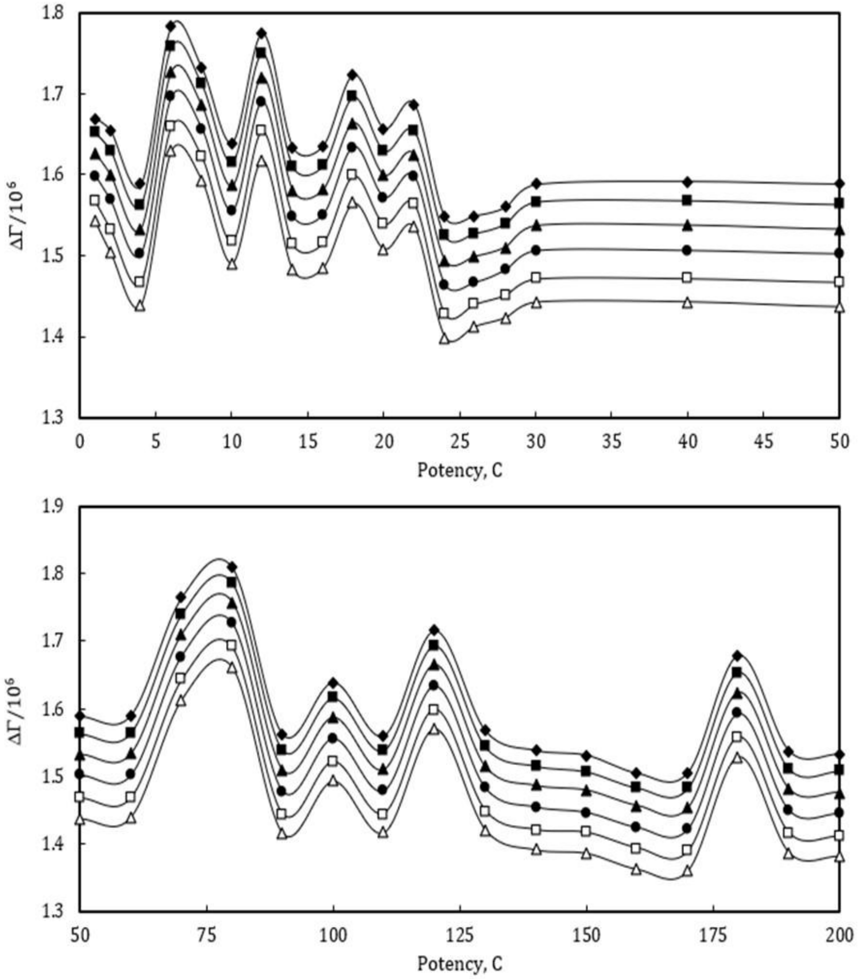

Figure-10: Plots of deviations in pseudo-Gruneisen parameter, ΔΓ *vs.* potency, *C* of acidum phosphoricum for homoeopathic dilutions of *acidum phosphoricum* at temperatures, 293.15 K, ♦; 298.15 K, ■; and 303.15 K, ▲; 308.15 K, ●; 313.15 K, □; and 318.15 K, Δ.

A close perusal of Table-10 and Figure-10 indicates that the pseudo-Grüneisen parameters, Γ for *acidum phosphoricum* potencies is more than those of ethanol controls for all the potencies at each investigated temperature and these values increase with increase in temperature, which indicates substantial interaction between *acidum phosphoricum* and ethanol-water molecules. Figure-10 indicates that ΔΓvalues are positive, *i.e.*, ΔΓ values for *acidum phosphoricum* potencies are more than those of ethanol control. These ΔΓ values are maximum for potency 1C and then decrease significantly in presence of *acidum phosphoricum* for simple successive dilution to the potency 4C and after that these values increase to maxima at 6C–8C, thereafter, these values decrease till 10C, then these values increase up to 12C, and again decrease till 14C and thereafter, these values are decrease slightly up to 20C with successive dilutions. After 20C these values increase to 22C and then decrease to 24C, thereafter these values increase up to 30C (Figure-10). After 30C these values decrease slightly till 200C, except exhibiting maximums at potencies 70C to 80C, 100C, 120C, 170 to 180C (Figure-10). The maximum in the values of ΔΓ for 1C, 6C, 8C, 12C, 22C, 70C, 80C, 100C, 120C and 180C potencies may be due substantial interaction between *acidum phosphoricum* and water-ethanol molecules.

It has been observed from the analysis of the studied physicochemical parameters, *viz.*, κ_s, L_f, Γ, $\Delta\kappa_s$, ΔL_f, ΔZ, $\Delta\eta$, τ, (α/f^2) and ΔΓ that all the potencies show more compact solution structure in comparison to pure ethanol control; and the potencies 1C, 6C, 8C, 12C, 22C, 70C, 80C, 100C, 120C and 170C to 180C exhibit more compact solution structure than the other studied potencies. The difference in the physicochemical properties of these *acidum phosphoricum* dilutions in ethanol control (91% ethanol in water) clearly specify that the presence of medicine which results in substantial structural modifications in solution for all the potencies and it is more distinct in certain potencies. The results can be qualitatively discussed in terms of interactions prevailing in these *acidum phosphoricum* dilutions in ethanol-water controls. The key factors which can affect the solution structure, are the nature of solute, the presence of medicine molecules and the potentization process.

It is well-known fact that hydrogen bonding is one of the most important weak interactions amongst the molecules in solution leading to the formation of well-defined molecular aggregates, called as dissipative structures[12,14]. It has been reported[23] that potentization process permanently alters the physicochemical properties of the solution. The succession process excites the formation of dissipative structures and these dissipative structures are exaggerated by presence of ethanol and medicine molecules[23] (phosphoric acid dissociated into H^+ and phosphate ions). The results may be understood by considering the interactions that can take place between H^+ and phosphate ions and the molecular aggregates of water-ethanol molecules, *i.e.*, dissipative structures[12]. The hydrogen bonding in ethanol-water will be significantly affected by the presence of H^+ and phosphate ions in solution and it can be assumed that the effect of medicine molecules is likely to alter after each successive dilution and succession on moving from one potency to another next potency. A qualitative comparison between various potencies can be considered due to the nature of driving force that leads to formation of aggregates (due to solvation of these ions by polar ethanol/water dipoles) between H^+/phosphate ions and dissipative structures of ethanol-water molecules[13,24]. This driving force is supplied by the succession process in which a vast amount of mechanical energy (~404.3 Newton-meter by 10 strokes)[25] is transferred. This transfer of energy due to successive dilution and succession process is responsible for different/anomalous behaviour of *acidum phosphoricum* of different potencies. It had also been reported in literature[4,5] that same medicine of different potency displays diverse behaviour due to vehicle-molecule structure (ethanol-water aggregates) generated by potentization process.

Conclusion

It may be concluded from the variations of physicochemical parameters, *viz.*, κ_s, L_f, Γ, $\Delta\kappa_s$, ΔL_f, ΔZ, $\Delta\eta$, τ, (α/f^2) and ΔΓ have been calculated. The results have been qualitatively discussed in terms of interactions/physicochemical behaviour of these extremely dilute homoeopathic dilutions of *acidum phosphoricum* in ethanol control. The potencies 1C, 6C, 8C, 12C, 22C, 70C, 80C, 100C, 120C and 170C to 180C exhibit more compact solution structure as compared to other potencies and ethanol control. It is found that the interactions can take place between H^+ and phosphate ions and the molecular aggregates of water-ethanol, *i.e.*, dissipative structures. Hence, these potencies might have diverse behaviour in terms of properties and efficacy when utilized in practice. It can be qualitatively concluded that even in high dilutions the molecules of *acidum phosphoricum* might be present in these homoeopathic dilutions, however it needs to be confirmed from other more precise spectroscopic and other techniques.

Acknowledgement

The authors are thankful to Central Council for Research in Homeopathy (CCRH), Ministry of AYUSH, Govt. of India for providing financial assistance to carry out this collaborative study.

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