Arabian Journal of Chemistry (2016) 9, S373–S378

King Saud University
Arabian Journal of Chemistry
www.ksu.edu.sa
www.sciencedirect.com

ORIGINAL ARTICLE

Metallic and non-metallic anionic interaction activities estimated with sound velocity and refractive index

Man Singh *, R.K. Ameta, B.S. Kitawat, R.K. Kale

School of Chemical Sciences, Central University of Gujarat, Gandhinagar 382030, India

Received 3 February 2011; accepted 6 May 2011
Available online 14 May 2011

KEYWORDS
Sound velocity;
Light velocity;
Refractive index;
Solute solvent interaction;
Adiabatic compressibility;
Apparent molal compressibility

Abstract Density ($\rho \pm 10^{-3}$ kg m^{-3}), sound velocity ($V_S \pm 10^{-2}$ ms^{-1}) as acoustic property and refractive index ($\mu_{ri} \pm 10^{-4}$) for 0.01–0.1 m $K_2Cr_2O_7$, K_2HPO_4, $KMnO_4$, KH_2PO_4, KCl, and KOH aqueous salts with compressibility attained with ion–solvent interaction (ISI) are reported at 0.01 interval and 293.15 K. Ionic internal pressure generated with ISI is expressed as adiabatic compressibility (β, pa^{-1}) with relative change ($\Delta\beta/\beta_0$) and apparent molal compressibility (ϕk, m^{2}N^{-1}) with specific ionic activities for metallic and non-metallic anions. Linear regression generated V_S^0, μ_{ri}^0, ϕk^0, and β^0 as limiting data for analysis of speed of light and sound. The V_S^0 as $KH_2PO_4 > K_2HPO_4 > KOH > K_2Cr_2O_7 > KCl > KMnO_4$ denoted a minimum V_S^0 metallic anions. With concentrations, the sound velocity and refractive index are noted as ISI functions where the sound and light waves were in opposite trends. The Mn^0 and Cr^0 transitional metals with anions of the $K_2Cr_2O_7$ and $KMnO_4$ have affected the compressibility as $K_2Cr_2O_7 > KMnO_4$ due to $2Cr^{+6}$. The V_S^0, μ_{ri}^0, ϕk^0, and β^0 analyzed their ionic strengths in comparison to HPO_4^-, $H_2PO_4^-$, Cl^-, and OH^- as non-metallic anions considering the interactions as sensors. A molionic model of ion–water interaction was proposed to generalize ion-molecular interactions in industrial mixtures.

1. Introduction

The V_S of ionic liquids (ILs) as a physicochemical indicator does analyze several internal properties, such as residual stress, hardness, grain size micro structure, elastic constant, medicinal engineering, and agriculture (Sumathi and Varalakshmi, 2010). Conceptually, the sound as energy travels through a medium such as air or water, as a compressed phase, where pressure variations bring changes and its waves travel through particles of interacting species within fixed interfaces. The ionic or internal activities significantly cause interruptions in travel due to ISI, where a cycle of wave varies with the compressibility. The compressibility as function of the type and nature of bonds critically furnish useful information about ionic–molecular interactions. Recently, the V_S data are used to elucidate an interpreted ISI in liquid medium (Baluja and Oza, 2005; Rawat and

* Corresponding author. Tel.: +91 079 23260210; fax: +91 079 23260076.
E-mail addresses: mansingh50@hotmail.com (M. Singh), ametarakesh40@gmail.com (R.K. Ameta).
Peer review under responsibility of King Saud University.

ELSEVIER Production and hosting by Elsevier

http://dx.doi.org/10.1016/j.arabjc.2011.05.007
1878-5352 © 2011 Production and hosting by Elsevier B.V. on behalf of King Saud University.

Sangeeta, 2008; Ali and Nain, 1996; Ogawa and Murakami, 1987) as the salts disrupt hydrogen bonding forming new structural reorientation. Thus the data infer ion–solvent configurations with different ionic pressure due to intrinsic hydration structures. Therefore, the ionic interactions exerted internal pressure which is also studied with Debye–Hückel ionic theory (Debye and Hückel, 1923), and fitted in present study. For understanding a role of ion polar interaction force, several parameters, such as β, $\Delta\beta$, $\Delta\beta/\beta_0$, and ϕk were studied to find structural arrangements with relative strength of various types of intermolecular or inter ionic interactions. Thus, the ISI created a compressed medium for traveling velocities.

The μ_{ri} is an optical in nature for analyzing optical properties of materials whose values are often required to interpret spectroscopic data (Singh, 2002). Light absorbing capacity as characteristic feature develops a mediate light accepter device to design physically, biologically and chemically stability of the compounds or solutions. The μ_{ri} is a most authentic optical data plays key role in various areas of material science for designing thin film technology and others. Similarly, the μ_{ri} data are widely used for determination of solution concentrations (Subedi et al., 2006). Thus the μ_{ri} study exhibits efficient optical functions for developing an optical device with such liquids which are studied in the present work. The present study showed that the ISI increased the μ_{ri} and decreased the speed of light in water due to compressibility. The V_S and μ_{ri} in the present study for salts solution offered understanding the behavior of AIL. Knowledge of the V_S and μ_{ri} of electrolyte solutions is extremely important to identify their internal and external properties. Such structural ionic activities with corresponding state of hydrogen bonding could be studied with the V_S and μ_{ri}. For example, observed V_S^0 values as KH_2PO_4 > K_2HPO_4 > KOH > $K_2Cr_2O_7$ > KCl > $KMnO_4$ and μ_{ri}^0 as $KMnO_4$ > KH_2PO_4 > KOH > K_2HPO_4 > KCl > $K_2Cr_2O_7$ inferred comparative analysis of the ionic interactions in our study. The V_S and μ_{ri} parameters on HPO_4^-, $H_2PO_4^-$, Cl^-, OH^-, and $Cr_2O_7^-$ MnO_4^-, and similar others could act as authentic non-metallic and metallic anionic interaction sensors, respectively. The study predicted that the number of anionic metals with oxidation states plays an effective role to produce internal pressure and affected the V_S which is less than μ_{ri}. An interesting property of solution as wave conservation is studied. Thus the metallic and non-metallic anionic studies are highly significant but are not reported yet. Interestingly more and more ionic liquid systems if are subjected to such studies then their data trends and magnitudes do illustrate the nature and size of the ions with respect to medium and polarity. Thus the $K_2Cr_2O_7$, K_2HPO_4, $KMnO_4$, KH_2PO_4, KCl, and KOH aqueous mixtures were chosen to exactly investigate the effect of metallic and nonmetallic ions on water structures vis-a-vis the acoustic property of the mixtures.

2. Experimental methods

2.1. Chemicals and solvents

Chemicals (99.99%, AR, $K_2Cr_2O_7$, K_2HPO_4, $KMnO_4$, KH_2PO_4, KCl, KOH, Ranbaxy, India) were used as received. Milli-Q water was used as a solvent.

2.2. Analytical conditions

The experiment was done at 293.15 K. Solutions w/w were prepared with Milli-Q water of 10^{-6} μ S cm^{-1} conductance with electronic Kern ABS 220-4 model balance with ±0.01 mg accuracy. The ρ and V_S data with 10^{-3}kg m^{-3} and 10^{-2} ms^{-1}, respectively, were measured with density and sound velocity meter DSA 5000M whose quartz U tube was cleaned with acetone after each measurement. The equipment works on a theory of oscillation periods of U tube for air, solvent and solutions (Pal et al., 2010). The μ_{ri} was measured with ± 10^{-4} using Rudolph Research analytical J series Refractometer model 57. Its sample plate was properly cleaned and dried each time with acetone. The measurements for water values were repeated several times to ensure calibration and reproducibility of the equipment. The μ_{ri} literature value of the water was 1.3328 which very closely matched with experimental values of water. The precision and reproducibility of measured data along with 95.5% confidence variance were noted with highly reproducibility. Similarly the V_S experimental value was 1482.69 ms^{-1} for water and had shown striking agreements with literature values.

3. Calculations

Densities were applied for adiabatic compressibility (Mason, 1929) calculation with Eq. (1).

$$\beta = 1/V_S \times \rho^0 \tag{1}$$

The V_S and ρ^0 are sound velocity and density of solution and solvent, respectively. A variation in compressibility and relative change in adiabatic compressibility were calculated with Eqs. 2 and 3, respectively.

$$\Delta\beta = \beta - \beta_0 \tag{2}$$

$$\Delta\beta/\beta_0 \tag{3}$$

The β_0 a water adiabatic compressibility = 4.56×10^7 pa^{-1} was calculated with Eq. (1). The apparent molal compressibility was calculated with Eq. (4).

$$\Phi k = 1000/m \cdot \rho^0(\rho^0\beta - \beta_0\rho) + \beta_0 \cdot M/\rho \tag{4}$$

The ρ^0 and ρ are densities of solvent and solution, respectively, m is molality and M is molecular mass. The velocity of light (V_L) is calculated with μ_{ri} = V_L (vacuum)/V_L (medium) as the $V_L = 2.99 \times 10^8 = 3.00 \times 10^8$ m/s in vacuum (Newcomb, 1886) was used.

4. Results and discussion

4.1. The V_S, V_L, and V_S^0, μ_{ri}^0 and concentration study for comparative ionic interactions

The concentration effect on V_S and μ_{ri} was analyzed from data given in Table 1 and showed increases in V_S and μ_{ri} with increase in concentration and V_L was decreased. The V_S and μ_{ri} directly determined internal pressure and ionic hydration with salt's interactions which formed a high compact continuous medium through which the sound and light waves traveled. Thus the ISI forces developed a denser medium that manifolded the sound speed with a decrease in light velocity. The ISI created anion-hydration and partly the unengaged

Table 1 Molality (m), density ($\rho \pm 10^{-3}$ kg m^{-3}), sound velocity ($V_S \pm 10^{-2}$ ms^{-1}), $\%V_S \pm 10^2$, adiabatic compressibility ($\beta \pm 10^{-4}$ pa^{-1}), change in adiabatic compressibility ($\Delta\beta \pm 10^{-4}$ pa^{-1}), relative change in adiabatic compressibility ($\Delta\beta/\beta_0 \pm 10^{-4}$), apparent molal compressibility ($\phi k \pm$ m^{2}N^{-1}), refractive index ($\mu_{ri} \pm 10^4$), velocity of light ($V_L \pm 10^3$ ms^{-1}), % of light velocity ($\%V_L \pm 10^2$).

m	ρ	V_S	$\%V_S$	$\beta \times 10^7$	$-\Delta\beta \times 10^9$	$-\Delta\beta/\beta_0$	$-\phi k \times 10^5$	μ_{ri}	$V_L \times 10^8$	$\%V_L$
$K_2Cr_2O_7$										
0.01	1.000141	1483.10	0.03	4.5457	1.1200	0.0025	6.5305	1.3333	2.250	0.03
0.02	1.002287	1483.80	0.07	4.5317	2.5212	0.0055	8.4544	1.3339	2.249	0.08
0.03	1.004207	1484.50	0.12	4.5187	3.8140	0.0084	8.3909	1.3344	2.248	0.12
0.04	1.006180	1485.20	0.17	4.5056	5.1251	0.0112	8.4651	1.3349	2.247	0.15
0.05	1.008154	1485.70	0.20	4.4938	6.3100	0.0138	8.2581	1.3354	2.247	0.19
0.06	1.010119	1486.41	0.25	4.4807	7.6125	0.0167	8.3094	1.3360	2.246	0.24
0.07	1.012228	1487.12	0.30	4.4671	8.9729	0.0197	8.5226	1.3365	2.245	0.27
0.08	1.014140	1487.73	0.34	4.4551	1.0181	0.0223	8.3793	1.3370	2.244	0.31
0.09	1.016366	1488.39	0.38	4.4414	1.1551	0.0253	8.6073	1.3375	2.243	0.35
0.10	1.018346	1489.07	0.43	4.4287	1.2819	0.0281	8.5757	1.3380	2.242	0.38
K_2HPO_4										
0.01	0.999689	1484.16	0.10	4.5412	1.5639	0.0034	14.384	1.3332	2.250	0.03
0.02	1.001121	1485.90	0.22	4.5241	3.2748	0.0072	15.04	1.3334	2.250	0.04
0.03	1.002710	1487.66	0.34	4.5063	5.0599	0.0111	15.744	1.3338	2.249	0.07
0.04	1.004105	1489.03	0.43	4.4917	6.5137	0.0143	15.047	1.3340	2.249	0.09
0.05	1.005566	1490.79	0.55	4.4746	8.2247	0.0180	15.203	1.3342	2.249	0.10
0.06	1.007164	1492.62	0.67	4.4566	1.0029	0.0220	15.568	1.3345	2.248	0.12
0.07	1.008591	1493.92	0.76	4.4425	1.1434	0.0251	15.145	1.3348	2.248	0.15
0.08	1.010258	1495.85	0.89	4.4238	1.3311	0.0292	15.555	1.3351	2.247	0.17
0.09	1.011613	1497.44	0.99	4.4085	1.4841	0.0326	15.331	1.3353	2.247	0.18
0.10	1.012980	1498.68	1.08	4.3952	1.6164	0.0355	14.95	1.3356	2.246	0.21
$KMnO_4$										
0.01	0.999230	1482.76	0.00	4.5519	4.9826	0.0011	2.3833	1.3332	2.250	0.03
0.02	1.000350	1482.99	0.02	4.5454	1.1466	0.0025	3.3713	1.3336	2.250	0.06
0.03	1.001440	1483.23	0.04	4.539	1.7910	0.0039	3.6584	1.3339	2.249	0.08
0.04	1.002620	1483.73	0.07	4.5306	2.6294	0.0058	4.3793	1.3342	2.249	0.10
0.05	1.003560	1483.90	0.08	4.5253	3.1574	0.0069	3.9749	1.3346	2.248	0.13
0.06	1.005220	1484.10	0.10	4.5166	4.0274	0.0088	4.8244	1.3349	2.247	0.15
0.07	1.007310	1484.58	0.13	4.5043	5.2528	0.0115	6.2135	1.3351	2.247	0.17
0.08	1.008820	1484.98	0.15	4.4951	6.1724	0.0135	6.5502	1.3353	2.247	0.18
0.09	1.009120	1485.06	0.16	4.4933	6.3540	0.0139	5.3742	1.3357	2.246	0.21
0.10	1.011110	1485.52	0.19	4.4817	7.5160	0.0165	6.1858	1.3359	2.246	0.23
KH_2PO_4										
0.01	0.999230	1483.62	0.06	4.5466	1.0249	0.0022	8.6427	1.3331	2.250	0.02
0.02	1.000200	1484.60	0.13	4.5362	2.0662	0.0045	8.6403	1.3333	2.250	0.03
0.03	1.001170	1485.57	0.19	4.5259	3.0955	0.0068	8.5903	1.3335	2.250	0.05
0.04	1.002100	1486.50	0.26	4.5161	4.0798	0.0090	8.4082	1.3336	2.250	0.06
0.05	1.003060	1487.49	0.32	4.5057	5.1146	0.0112	8.4348	1.3338	2.249	0.07
0.06	1.004050	1488.47	0.39	4.4953	6.1528	0.0135	8.4793	1.3339	2.249	0.08
0.07	1.004840	1489.26	0.44	4.4871	6.9799	0.0153	8.0734	1.3341	2.249	0.09
0.08	1.005900	1490.35	0.52	4.4758	8.1091	0.0178	8.3051	1.3343	2.248	0.11
0.09	1.007000	1491.41	0.59	4.4646	9.2315	0.0203	8.4951	1.3344	2.248	0.12
0.10	1.007950	1492.36	0.65	4.4547	1.0222	0.0224	8.4501	1.3346	2.248	0.13
KCl										
0.01	0.998680	1483.09	0.03	4.5524	4.4750	0.0010	3.1484	1.3330	2.251	0.01
0.02	0.999120	1483.71	0.07	4.5466	1.0305	0.0023	3.803	1.3331	2.250	0.02
0.03	0.999610	1484.34	0.11	4.5405	1.6386	0.0036	4.1718	1.3332	2.250	0.03
0.04	1.000090	1484.96	0.15	4.5345	2.2349	0.0049	4.3155	1.3333	2.250	0.03
0.05	1.000500	1485.41	0.18	4.5299	2.6940	0.0059	4.0613	1.3334	2.250	0.04
0.06	1.001050	1486.24	0.24	4.5224	3.4493	0.0076	4.496	1.3335	2.250	0.05
0.07	1.001660	1486.79	0.28	4.5163	4.0581	0.0089	4.6338	1.3336	2.250	0.06
0.08	1.001970	1487.12	0.30	4.5129	4.3982	0.0097	4.2311	1.3337	2.249	0.06
0.09	1.002460	1487.70	0.34	4.5072	4.9709	0.0109	4.2681	1.3338	2.249	0.07
0.10	1.003570	1489.03	0.43	4.4941	6.2747	0.0138	5.3128	1.3340	2.249	0.09
KOH										
0.01	0.998580	1483.50	0.05	4.5503	6.5536	0.0014	5.631	1.3330	2.251	0.01
0.02	0.999070	1484.19	0.10	4.5439	1.3013	0.0029	5.883	1.3331	2.250	0.02
0.03	0.999490	1484.94	0.15	4.5374	1.9496	0.0043	5.8636	1.3332	2.250	0.03
0.04	0.999890	1485.63	0.20	4.5314	2.5518	0.0056	5.7184	1.3333	2.250	0.03
0.05	1.000320	1486.48	0.26	4.5242	3.2654	0.0072	5.8839	1.3334	2.250	0.04
0.06	1.000740	1487.13	0.30	4.5184	3.8505	0.0084	5.7711	1.3335	2.250	0.05
0.07	1.001220	1488.03	0.36	4.5108	4.6119	0.0101	5.9795	1.3336	2.250	0.06
0.08	1.001650	1488.86	0.42	4.5038	5.3104	0.0117	6.0332	1.3337	2.249	0.06
0.09	1.002110	1489.56	0.46	4.4975	5.9392	0.0130	6.0093	1.3337	2.249	0.06
0.10	1.002580	1490.43	0.52	4.4901	6.6765	0.0147	6.1059	1.3338	2.249	0.07

water with the similar molecules as a homogeneous medium. Thus a pattern of ion-hydration is different with each salt and inferred interaction as important information about a medium characterization that increased V_S and decreased V_L. It is observed that an increase in concentration is accompanied with an increase in internal pressure. For example, V_S is 343.2 m/s in air and 1482.69 m/s with water while V_L is 3×10^8 m/s in vacuum but V_L in water is 2.5209 m/s. Thus, the $K_2Cr_2O_7$, K_2HPO_4, $KMnO_4$, KH_2PO_4, KCl, and KOH interactions have increased and decreased V_S and V_L, respectively (Table 1). It inferred that the ISI enhanced and exerted a higher internal pressure where an increase in V_S is accompanied with a decrease in V_L, depicted in Fig. 1. Both V_S and V_L are mutually inversely proportional due to an additional resistance and compressibility, respectively, with concentration. With salts Table 1 shows a percentage increase in V_S with approximately equal decrease in V_L. It is similar to energy conservation as partly the energy is consumed and the same amount of energy is appeared in another form. Thereby it seems an interesting property of solution that inferred absorption of a certain amount of a particular wave and the same amount of another form is exhibited as wave conservation.

The V_S^0 with $KH_2PO_4 > K_2HPO_4 > KOH > K_2Cr_2O_7 > KCl > KMnO_4$ sequence inferred higher internal pressure with the KH_2PO_4 and lowest for $KMnO_4$ (Table 2). It is explained with pressure $p = 1/\text{volume v}$ (Boyle's law) relation where the density $\rho = \text{mass m/v}$. It marked the KH_2PO_4 with higher density that caused stronger ionic interactions and the $KMnO_4$ with lower density due to weaker ionic interactions. Such observation inferred that a metallic anion weakened the ionic interactions and the non-metallic anion strengthened the same. Similarly, the μ_{ri}^0 as $KMnO_4 > KH_2PO_4 > KOH > K_2HPO_4 > KCl > K_2Cr_2O_7$, with highest values with $KMnO_4$ and lowest with $K_2Cr_2O_7$ (Table 2) inferred that the MnO_4^- a metallic anion with weaker internal pressure and also the $Cr_2O_7^-$ with two metallic anion with

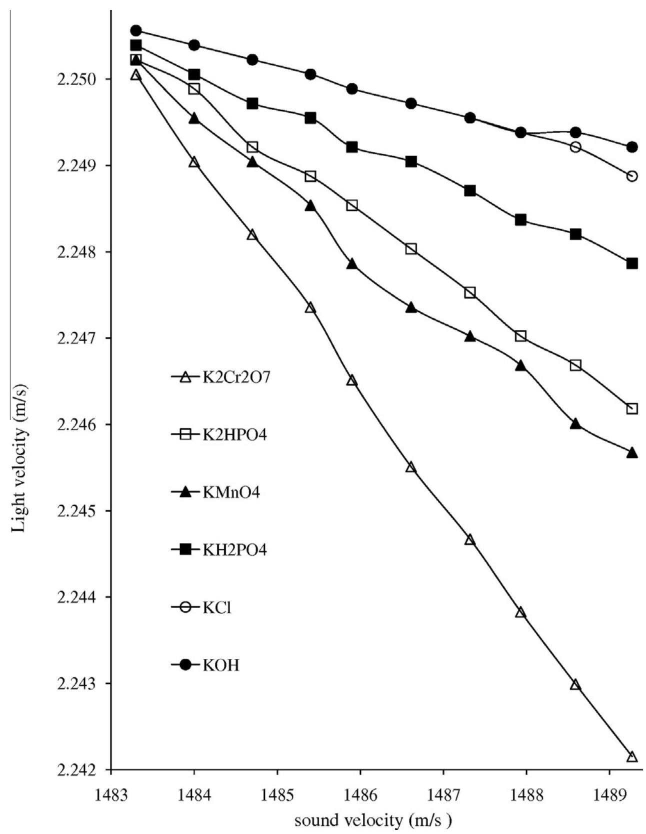

Figure 1 Relation between sound and light velocity.

Table 2 Linear regression data for sound velocity $V_S^0 \pm 10^{-2}\,s^{-1}$, $S_{V_S} \pm 10^{-2}\,ms^{-1}\,kg\,mol^{-1}$, refractive index $\mu_{ri}^0 \pm 10^{-4}$, $S_{\mu_{ri}} \pm 10^{-4}\,kg\,mol^{-1}$, adiabatic compressibility $\beta^0 \pm 10^4\,pa^{-1}$, $S_\beta \pm 10^4\,pa^{-1}\,kg\,mol^{-1}$, and apparent molal compressibility $\phi k^0 \pm m^2N^{-1}$, $S\phi k \pm m^2N^{-1}\,kg\,mol^{-1}$.

	V_S^0	S_{V_S}	μ_{ri}^0	$S_{\mu_{ri}}$	$-\phi k^0 \times 10^5$	$S\phi k \times 10^{-4}$	$\beta^0 \times 10^7$	$S_\beta \times 10^7$
$K_2Cr_2O_7$	1482.49	65.75	1.33283	0.0520	7.5946	11.905	4.5579	−1.2919
K_2HPO_4	1482.64	162.98	1.33292	0.0267	14.969	4.1485	4.5565	−1.6400
$KMnO_4$	1482.39	30.81	1.33301	0.0296	2.3897	41.851	4.5618	−0.7901
KH_2PO_4	1482.65	96.66	1.33297	0.0162	8.6231	−3.1125	4.5567	−1.0159
KCl	1482.45	61.58	1.33288	0.0105	3.4301	14.801	4.5590	−0.6064
KOH	1482.63	72.22	1.33293	0.0090	5.6653	4.0465	4.5575	−0.6680

Table 3 Rationalized V_S^0 and μ_{ri}^0.

	$K_2Cr_2O_7$	K_2HPO_4	$KMnO_4$	KH_2PO_4	KCl	KOH
V_S^0 ratio	1.000067	1.000169	1.000000	1.000175	1.000040	1.000162
μ_{ri}^0 ratio	1.000000	1.000068	1.000135	1.000105	1.000038	1.000075

variable valence inferred weaker shear stress and strain due to moderately weaker ionic interaction. The V_S^0 values of the $K_2Cr_2O_7$, K_2HPO_4, KH_2PO_4, KCl and KOH are rationalized w.r.t. those of the $KMnO_4$ with the 1.000067, 1.000169, 1.000175, 1.000040, and 1.000162 times higher than of the $KMnO_4$, respectively. Similarly, the μ_{ri}^0 of the K_2HPO_4, $KMnO_4$, KH_2PO_4, KCl, and KOH are rationalized w.r.t. the $K_2Cr_2O_7$ and noted 1.000068, 1.000135, 1.000105, 1.000038 and 1.000075 times higher than of the $K_2Cr_2O_7$, respectively (Table 3). In comparison to the K_2HPO_4 and KH_2PO_4, there is no specific effect of 1 and 2 K^+ on V_S and μ_{ri} while the PO_4^{3-} anions are the same because both V_S and μ_{ri} for the KH_2PO_4 are higher than of the K_2HPO_4. However, in comparison to $K_2Cr_2O_7$ and $KMnO_4$ the V_S are higher with $K_2Cr_2O_7$ and μ_{ri} with $KMnO_4$ due to an effect of anionic metals on V_S and μ_{ri}. The two anionic metallic atoms such as Cr in the $K_2Cr_2O_7$ has increased V_S more than single anionic metallic atom such as Mn in the $KMnO_4$ that decreased the μ_{ri}. The Mn and Cr are in +7 and +6 oxidation states in $KMnO_4$ and $K_2Cr_2O_7$, respectively, so another information is also important that the metal having high oxidation number decreased V_S and increased μ_{ri} while the metal having low oxidation number increased V_S and decreased μ_{ri}. In comparison of $K_2Cr_2O_7$ and KCl, the effect of ionic size and symmetrical arrangement of the ISI existed. The metallic anion such as $K_2Cr_2O_7$ increased V_S more than of the KCl where the K^+ and Cl^- have the same sizes due to the same electronic configuration such as $1s^2$, $2s^2$, $2p^6$, $3s^2$, $3p^6$. These variations could be due to the same sizes of the ions which might have created symmetrical arrangement of the ISI while the different size of the ions such as the K^+ and $Cr_2O_7^{2-}$ with metallic anionic property developed unsymmetrical ISI which increased the compressibility. This effect is opposite for the μ_{ri} such as the KCl increased μ_{ri} higher than of $K_2Cr_2O_7$.

4.2. Adiabatic (β) and apparent molal compressibilities (ϕk)

The negative values of the ϕk, $\Delta\beta$, and $\Delta\beta/\beta_0$ (Sumathi and Varalakshmi, 2010; Anwar, 1998; Anwar and Anil Kumar, 2002) given in Table 1 which is due to ISI, where the $\Delta\beta$ and $\Delta\beta/\beta_0$ values increased with increase in salts concentration. It may be attributed to an overall increase in the cohesive forces in the solution (Sumathi and Varalakshmi, 2010; Pandey and Akhatar, 1996). These cohesive forces may result into interaction between water–water, salt–water and salt–water adjacent molecules, where the β values decreased with increase in concentration (Table 1). The β^0 are as $KMnO_4$ > KCl > $K_2Cr_2O_7$ > KOH > KH_2PO_4 > K_2HPO_4 (Table 2) shows that $KMnO_4$ has the highest and K_2HPO_4 has the lowest β^0 value with 0.0053 pa^{-1} difference in their values due to creating high adiabatic compress medium (ACM). A decrease in β^0 is due to an increase in ion-dipolicstriction where the salts caused a compression with the decrease in the compressibility (Riyazudden and Khan, 2009). A comparison of KH_2PO_4 and K_2HPO_4 salts inferred that a replacement of an H^+ from K_2HPO_4 caused a weaker ISI with contribution of K^+ for creating ACM. Thus the cations matter a lot toward an ACM effect on the water structure. Thus KH_2PO_4 with only single K^+ created a stronger ACM while K_2HPO_4 with $2K^+$ caused a weaker ACM. Thus the K_2HPO_4 interaction is two times weaker effective for ACM than of the KH_2PO_4. The difference of their β^0 values are very low with 0.0002 pa^{-1} which has obtained from (KH_2PO_4–K_2HPO_4) that inferred the more cation numbers had partially caused ACM effect. Similarly the $KMnO_4$ has created stronger ACM than of the $K_2Cr_2O_7$ due to the number of cation and number of transitional metal in their anions. It inferred that the low number of a metal such as Mn (+7) in MnO_4^- caused stronger ACM than of the high number of a metal such as Cr (+6). Thus extensively and explicitly constituted a concept of molionic mixtures where nature of salts had caused structural impacts on the water structure with variable resultants values of V_S, β and ϕk. The ratio of their β^0 values is 1.0008 pa^{-1} derived from ($KMnO_4$/$K_2Cr_2O_7$) had inferred the partially affected ACM by less number of anionic metals. A linear fitting of the ϕk^0 with the composition are found as K_2HPO_4 > KH_2PO_4 > $K_2Cr_2O_7$ > KOH > KCl > $KMnO_4$ (Table 2) due to a reverse relation of ϕk^0 with β^0 except KOH and $K_2Cr_2O_7$. It inferred that those factors which are accountable for strong β^0 or ACM such as numbers of cation or anionic metals are weaker for ϕk. The similar trend of V_S and ϕk with opposite trends of the β^0 showed a special relationship among V_S, β, and ϕk as $V_S = \phi k/\beta$ as such as relation among the density = mass/volume.

5. Conclusion

The study distinguished concentration effect on V_S and μ_{ri} with ISI and even when the MnO_4^-, $Cr_2O_7^-$ anions with transitional metals were present with potassium in salts. The V_S and μ_{ri} are increased and V_L is decreased for aqueous potassium salts solution. The opposite relation of V_S and V_L is found with increasing internal pressure generated with ISI. The study concluded that the salts contribution with metallic anions (Cr^{+6} and Mn^{+7}) as ISI did decrease sound velocity in a certain proportion then it increased the light velocity with a similar proportion for the same solution. It is exactly fitted in natural trends of first law of thermodynamics as energy conservation because the light and sound velocities are forms of energy.

Acknowledgment

The authors are highly thankful to Central university of Gujarat, Gandhinagar, for providing financial, infrastructural support and experimental facilities.

References

Sumathi, T., Varalakshmi, M., 2010. Rasayan J. Chem. 3, 550–555.
Baluja, S., Oza, S., 2005. Fluid Phase Equilib 200 (1), 49–54.
Rawat, M.K., Sangeeta, 2008. Indian J. Pure Appl. Phy. 46, 187–192.

Ali, A., Nain, A.K., 1996. Acoustics Lett. 19, 53.
Ogawa, H., Murakami, S.J., 1987. J. Solution Chem.. 16, 315.
Debye, P.W., Hückel, E., 1923. Phys. Z. 24, 185.
Singh, Shyam, 2002. Physics Scripta. 65, 167–180.
Subedi, D.P., Adhikari, D.R., Joshi, U.M., Poudel, H.N., Niraula, B., 2006. J. Sci. Eng. Technol. 2, 1.
Pal, A., Kumar, H., Sharma, S., Maan, R., Sharma, H.K., 2010. Chem. Eng. 55, 1424–1429.
Mason, D.O., 1929. Philos. Mag. 8, 218.
Newcomb, S., 1886. The velocity of light. Nature 34, 29–32.
Anwar, Ali., 1998. J. Pure Appl. Ultrason. 20, 82.
Anwar, Ali, Anil Kumar, Nainar, 2002. J. Pure Appl. Ultrason. 24, 27.
Pandey, D., Akhatar, Y., 1996. J. Pure Appl. Ultrason. 18, 108.
Riyazudden, Khan, Imran, 2009. J. Thermodyn. Acta. 483, 45.