World Journal of Advanced Research and Reviews
eISSN: 2581-9615 CODEN (USA): WJARAI
Cross Ref DOI: 10.30574/wjarr
Journal homepage: https://wjarr.com/

(RESEARCH ARTICLE)

Check for updates

Appraisal of ionic behaviors of aqueous sodium and potassium valinate conductometrically

Mahendra B. Dhande [1,*], Kiran P. Jumde [2], Dipak T. Tayade [3] and Ajay B. Wadekar [4]

[1] *Department of Chemistry, HPT Arts and RYK Science College, Nashik, Maharashtra, India.*
[2] *Department of Chemistry, Nilkanthrao Shinde Science and Arts College, Bhadrawati, Maharashtra, India.*
[3] *Department of Chemistry, Institute of Science, Nagpur, Maharashtra, India.*
[4] *Department of Chemistry, Shri. D. M. Burungale science and arts college, Shegaon. Maharashtra, India.*

World Journal of Advanced Research and Reviews, 2023, 19(02), 1177–1184

Publication history: Received on 13 July 2023; revised on 23 August 2023; accepted on 25 August 2023

Article DOI: https://doi.org/10.30574/wjarr.2023.19.2.1655

Abstract

Dissociation of molecules, ionization and conductivity closely related to each other. Conductivity is very good tool to understand ionic behaviour of electrolytic solution. Bearing these things in mind present scheme designed as apprise ionic behaviour of sodium and potassium valinate with varying concentrations and temperatures. In this work ionic export of sodium and potassium salts of valinate is studied by conductometric method. During this work conductometric parameters (G, k and Λ) and thermodynamic parameters (ΔH, ΔS and ΔG) parameters for sodium and potassium salts of valinate were investigated at concentrations range (0.01 to 0.15) mol L^{-1} and at 298.15, 303.15, 308.15, and 313.15 K. Observed values of G, k and Λ and thermodynamic parameters values helps to understand a solute-solute, solute-solvent and solvent-solvent interaction and this information helps to understand pharmodynamics of same salts.

Keywords: Ionic behaviour; Valine; Conductometrically; Molar conductance

1. Introduction

Metal salts of amino acids received more attention of researchers at global level. These salts have various applications in different field of sciences. These salts also effectively used as CO_2 absorbent. Climatic change is a result of excessively changes atmospheric background. Day by day carbon dioxide emissions is increasing which is mostly concerning environmental issue causing global warming. The salt solution of the amino acids is developing into an efficient absorbent for CO_2 capture. Evaluation and thorough characterisation of the solvent for CO_2 collection and other industrial applications, the physicochemical properties of absorbents are required [1-4]. Solubility, ionisation and mobilization of metal salt closely related to their conductivity. Ionisation and solubility strongly influence by molecular interaction like solute-solute interaction, solute-solvent and solvent-solvent interactions. Intra and intermolecular interaction effect on these conductivity. Conductometric measurements are one of the unique non-destructive, environmentally friendly, and simple to handle research techniques. The results and thermodynamic parameters obtained in conductometric measurements will also become a useful tool to predict drug activity and drug effect in medicinal and drug chemistry. P. B. Raghuwanshi carried out Conductometric Studies of Substituted Aryl Amidinothiocarbamides In 1,4 Doxane + water binary solution [5]. Ahmadzadeh et al. [6] conductometrically investigated complexation reaction between meso-octamethylcalix 4 pyrrole with titanium cation in Acetonitrile–Ethanol binary mixtures. E. Jóna et al. [7] assessed Ni(II)-3-pyridylcarbinol (ronicol) interactions in solid halogeno and thiocyanato complexes conductometrically. Alanine have their own importance in medicinal sciences and pharmaceutical sciences due to their significant application. Metal salt of these amino acid affects the solubility and conductivity. Conductometric investigation received more attention of researchers for molecular interactions investigation at various concentration and different temperatures [8-13] by using different types of molecules.

* Corresponding author: M. B.Dhande

Ionic behavior of sodium and potassium salts valinate were not yet been discussed in the literature at a lower concentration range and different temperatures conductometrically. Therefore, bearing these things in mind presently work designed in the direction of apprise Ionic behavior of sodium and potassium salts valinate at different concentration and different temperatures. During this work conductometric properties (G, K and μ), thermodynamic behaviour (ΔH, ΔS and ΔG) and Walden product of sodium and potassium salts of valinate at concentrations range (0.01 to 0.15) mol L^{-1} and at 298.15, 303.15, 308.15, and 313.15 K.

2. Material and methods

2.1. Chemicals and solution preparation

L-Valine (Val CAS No. 72-18-4, 99% purity) was purchased from S D Fine-Chem Ltd., India. Sodium hydroxide (NaOH, CAS No. 1310-73-2, GR, 98 % purity) and potassium hydroxide (KOH, CAS No. 1310-58-3, GR, 98 % purity) were purchased from Merck.

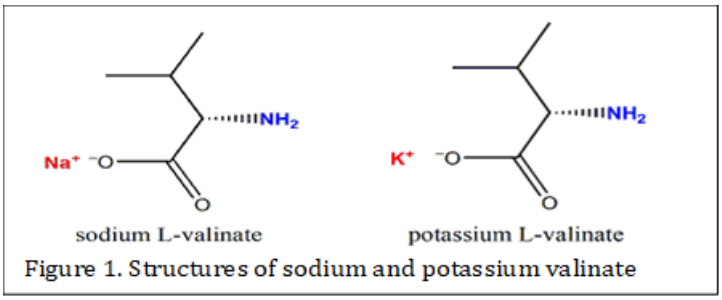

Figure 1. Structures of sodium and potassium valinate

Figure 1 Structure of sodium and potassium valinate

All the freshly prepared solutions were used for investigations. Concentrations of metal salt of valine (MSV) solutions varied from 0.01 M to 0.15 M and prepared by neutralizing the amino acids with an equimolar quantity of base (NaOH and KOH). Sodium salt of valine (SSV) and potassium salt of valine (PSV).

2.2. Conductivity measurements

All the measurements were carried out by the help of digital conductivity meter [14]. A sample of the solution was taken using a sample tube that was suspended from a stand and dipped into a transparent water bath with glass walls and an opening above the water's surface. Each sample solution was put into the sample tube in a predetermined amount. To measure the conductivity, a conductivity cell was submerged in a sample solution. A thermostat was used to maintain the thermal stability of the water bath within 0.01°K. A standard KCl solution from Merck was used to calibrate the conductivity meter. 20 mL of sample, with its temperature regulated by placing the sample tube in a water bath, were used for each measurement. The conductivity was measured for their concentrations range (0.01 to 0.15) mol.L^{-1} and at 298.15, 303.15, 308.15, and 313.15 K.

The conductivity cell was cleaned with deionised water and ethanol after each test to get rid of any adhering material, and it was then dried before being used for the following measurement. Three repeats of each measurement were made, and the average reading was used. The calculated overall measurement uncertainty was ±1.0%. At (298.15, 303.15, 308.15, and 313.15) K, conductivity measurements were taken.

3. Results and Discussion

The aqueous solutions of SSV and PSV were prepared at 0.1 M to 0.15 M concentration ranges and find out observe conductance for each concentration solutions. From the data observed conductance (G), specific conductance (k) and molar conductance (Λ) were determined by known literature method and tabulated in Table-1 to Table-2 at 298.15 K, 308.15 K, 308.15 K and 313.15 K respectively.

Table-1 and Table-2 reveals that as concentrations increases from 0.009M to 0.15 M observe conductance and specific conductance increases and molar conductance decrease for SSV and PSV solutions. When temperature increases from 298 K to 313 K the observe conductance, specific conductance and molar conductance also increases for both SSV and PSV.

Observed conductance (G), specific conductance (k) and molar conductance (Λ) values of PSV are greater than SSV solution. During this investigation it was observed that the molar conductance of PSV is more than SSV which is clearly indicates form the conductivity values of PSV and from Figure 4. Thus it has good conductivity and mobility in solution. Which is helpful for diffusion of ions or good drug effect of PSV is comparatively good than SSV. The absorption, transformation and metabolism of PSV is better than SSV will shows good drugs activity than SSV. Wherein molar conductance of potassium salt of valinate (PSV) solution having greater values than Sodium valinate.

The specific constant (Ksp), log (Ksp) and thermodynamics parameter viz. change in free energy (ΔG), change in entropy (ΔS) and change in enthalpy (ΔH) of MSV were determined by known literature method at various molar concentration and temperatures and result are cited in **Table 3** to **Table-4.**

Thermodynamic parameters like Ksp, ΔH and ΔS values tabulated in Table-3 and Table-4. These tables shows that along with increasing concentration from 0.1 M to 0.15 M Ksp, ΔH and ΔS values increases continuously while ΔG decreases for MSV solutions. While temperature increases from 298 K to 313 K Ksp, ΔH and ΔS decreases continuously while ΔG increases for MSV solutions. PSV the values of all thermodynamic parameter as well as Ksp are greatest than SSV.

Table 1 Observed Conductance (G), Specific Conductance (k) of sodium and potassium salts of valinate at different temperatures

M (mol.L^{-1})	**G 10^{-3}(S.cm^{-1})**				**M (mol.L^{-1})**	**k.10^{-3} (S.cm^{-1})**			
	298.15 K	308.15 K	308.15 K	313.15 K		298.15 K	303.15 K	308.15 K	313.15 K
Sodium Valinate					Sodium Valinate				
0.00987	0.79	0.88	0.98	1.07	0.00987	0.7791	0.8663	0.9565	1.0496
0.02573	1.94	2.09	2.34	2.57	0.02573	1.9012	2.0482	2.2952	2.5186
0.04493	3.12	3.48	3.86	4.20	0.04493	3.0576	3.4104	3.7828	4.116
0.07754	4.97	5.56	6.10	6.66	0.07754	4.8706	5.4488	5.978	6.5268
0.09694	6.02	6.76	7.43	8.12	0.09694	5.8996	6.6248	7.2814	7.9576
0.11101	6.71	7.52	8.3	9.06	0.11101	6.5758	7.3696	8.134	8.8788
0.13073	7.58	8.48	9.38	10.30	0.13073	7.4284	8.3104	9.1924	10.094
0.15147	8.52	9.54	10.51	11.57	0.15147	8.3496	9.3492	10.3	11.339
Potassium Valinate					Potassium Valinate				
0.01171	1.05	1.16	1.27	1.38	0.01171	1.0261	1.1339	1.2417	1.3504
0.02831	2.28	2.55	2.80	3.08	0.02831	2.2344	2.499	2.744	3.0184
0.05269	3.94	4.40	4.87	5.32	0.05269	3.8612	4.312	4.7726	5.2136
0.07041	5.21	5.77	6.35	6.92	0.07041	5.1058	5.6546	6.223	6.7816
0.09167	6.72	7.43	8.16	8.87	0.09167	6.5856	7.2814	7.9968	8.6926
0.11122	8.05	8.92	9.73	10.45	0.11122	7.8890	8.7416	9.5354	10.241
0.12774	9.00	9.92	10.81	11.58	0.12774	8.8200	9.7216	10.594	11.348
0.15219	10.17	11.16	12.17	13.08	0.15219	9.9666	10.937	11.927	12.818
M (mol.L^{-1})	G 10^{-3}(S.cm^{-1})				M (mol.L^{-1})	k.10^{-3} (S.cm^{-1})			
	298.15 K	308.15 K	308.15 K	313.15 K		298.15 K	303.15 K	308.15 K	313.15 K
Sodium Valinate					Sodium Valinate				
0.00987	0.79	0.88	0.98	1.07	0.00987	0.7791	0.8663	0.9565	1.0496

0.02573	1.94	2.09	2.34	2.57	0.02573	1.9012	2.0482	2.2952	2.5186
0.04493	3.12	3.48	3.86	4.20	0.04493	3.0576	3.4104	3.7828	4.116
0.07754	4.97	5.56	6.10	6.66	0.07754	4.8706	5.4488	5.978	6.5268
0.09694	6.02	6.76	7.43	8.12	0.09694	5.8996	6.6248	7.2814	7.9576
0.11101	6.71	7.52	8.3	9.06	0.11101	6.5758	7.3696	8.134	8.8788
0.13073	7.58	8.48	9.38	10.30	0.13073	7.4284	8.3104	9.1924	10.094
0.15147	8.52	9.54	10.51	11.57	0.15147	8.3496	9.3492	10.3	11.339
Potassium Valinate					Potassium Valinate				
0.01171	1.05	1.16	1.27	1.38	0.01171	1.0261	1.1339	1.2417	1.3504
0.02831	2.28	2.55	2.80	3.08	0.02831	2.2344	2.499	2.744	3.0184
0.05269	3.94	4.40	4.87	5.32	0.05269	3.8612	4.312	4.7726	5.2136
0.07041	5.21	5.77	6.35	6.92	0.07041	5.1058	5.6546	6.223	6.7816
0.09167	6.72	7.43	8.16	8.87	0.09167	6.5856	7.2814	7.9968	8.6926
0.11122	8.05	8.92	9.73	10.45	0.11122	7.8890	8.7416	9.5354	10.241
0.12774	9.00	9.92	10.81	11.58	0.12774	8.8200	9.7216	10.594	11.348
0.15219	10.17	11.16	12.17	13.08	0.15219	9.9666	10.937	11.927	12.818

Table 2 Molar Conductance (Λ) and Ksp of sodium and potassium Valinate at different temperatures.

M (mol.L^{-1})	**Λ(S.cm^2.mol^{-1})**				**M (mol.L^{-1})**	**Ksp**			
	298.15 K	**308.15 K**	**308.15 K**	**313.15 K**		**298.15 K**	**303.15 K**	**308.15 K**	**313.15 K**
Sodium Valinate					Sodium Valinate				
0.00987	78.959	87.799	96.936	106.372	0.00987	0.0001014	0.0001011	0.0001008	0.0001004
0.02573	73.877	79.589	89.185	97.867	0.02573	0.0006896	0.0006877	0.0006854	0.0006829
0.04493	68.052	75.904	84.192	91.608	0.04493	0.0021020	0.0020961	0.0020893	0.0020817
0.07754	62.815	70.272	77.097	84.175	0.07754	0.0062601	0.0062426	0.0062223	0.0061996
0.09694	60.861	68.342	75.115	82.091	0.09694	0.0097841	0.0097567	0.0097250	0.0096894
0.11101	59.234	66.384	73.270	79.979	0.11101	0.0128324	0.0127965	0.0127550	0.0127083
0.13073	56.820	63.567	70.313	77.210	0.13073	0.0177963	0.0177464	0.0176889	0.0176242
0.15147	55.124	61.723	67.999	74.858	0.15147	0.0238889	0.0238219	0.0237448	0.0236578
Potassium Valinate					Potassium Valinate				
0.01171	87.592	96.794	105.997	115.283	0.01171	0.0001429	0.0001425	0.0001420	0.0001415
0.02831	78.939	88.287	96.942	106.637	0.02831	0.0008342	0.0008319	0.0008292	0.0008262
0.05269	73.277	81.832	90.573	98.942	0.05269	0.0028911	0.0028830	0.0028736	0.0028631
0.07041	72.512	80.306	88.378	96.311	0.07041	0.0051625	0.0051480	0.0051313	0.0051125
0.09167	71.842	79.433	87.237	94.828	0.09167	0.0087494	0.0087249	0.0086966	0.0086648
0.11122	70.932	78.598	85.735	92.079	0.11122	0.0128798	0.0128437	0.0128021	0.0127552
0.12774	69.048	76.106	82.935	88.842	0.12774	0.0169895	0.0169419	0.0168870	0.0168252
0.15219	65.489	71.864	78.368	84.228	0.15219	0.0241158	0.0240482	0.0239703	0.0238826

Table 3 ΔG and ΔH values of sodium and potassium salts of valinate different temperatures.

M (mol.L^{-1})	**ΔG(J.mol^{-1})**				**M (mol.L^{-1})**	**ΔH(J.mol^{-1})**			
	298.15 K	**308.15 K**	**308.15 K**	**313.15 K**		**298.15 K**	**303.15 K**	**308.15 K**	**313.15 K**
Sodium Valinate					**Sodium Valinate**				
0.00987	22801.04	23190.49	23581.30	23973.47	0.00987	-346014.14	-357602.50	-369381.82	-
0.02573	18047.61	18357.34	18668.43	18980.89	0.02573	-345986.34	-357569.31	-369343.10	-
0.04493	15284.35	15547.75	15812.50	16078.62	0.04493	-345962.23	-357540.53	-369309.54	-
0.07754	12578.70	12796.72	13016.10	13236.85	0.07754	-345928.38	-357500.12	-369262.42	-
0.09694	11471.56	11671.01	11871.83	12074.01	0.09694	-345909.92	-357478.09	-369236.75	-
0.11101	10799.13	10987.31	11176.84	11367.75	0.11101	-345896.87	-357462.52	-369218.59	-
0.13073	9988.38	10162.96	10338.90	10516.21	0.13073	-345878.79	-357440.95	-369193.45	-
0.15147	9258.43	9420.77	9584.46	9749.53	0.15147	-345859.81	-357418.30	-369167.07	-
Potassium Valinate					Potassium Valinate				
0.01171	21950.22	22325.40	22701.94	23079.85	0.01171	-346010.04	-357597.61	-369376.12	-
0.02831	17575.51	17877.32	18180.50	18485.04	0.02831	-345982.76	-357565.03	-369338.11	-
0.05269	14494.09	14744.24	14995.73	15248.60	0.05269	-345953.65	-357530.29	-369297.60	-
0.07041	13056.66	13282.70	13510.09	13738.85	0.07041	-345935.38	-357508.48	-369272.16	-
0.09167	11748.67	11952.77	12158.23	12365.05	0.09167	-345914.87	-357484.00	-369243.63	-
0.11122	10790.00	10978.02	11167.40	11358.15	0.11122	-345896.68	-357462.29	-369218.33	-
0.12774	10103.40	10279.91	10457.78	10637.02	0.12774	-345881.53	-357444.22	-369197.27	-
0.15219	9234.99	9396.94	9560.24	9724.91	0.15219	-345859.15	-357417.52	-369166.15	-

Table 4 ΔS values of Sodium and Potassium salts of Valinate at different temperatures.

M (mol.L^{-1})	**ΔS(J.mol^{-1} K^{-1})**			
	298.15 K	308.15 K	308.15 K	313.15 K
Sodium Valinate				
0.00987	-1237.01	-1256.12	-1275.23	-
0.02573	-1220.98	-1240.07	-1259.16	-
0.04493	-1211.63	-1230.71	-1249.79	-
0.07754	-1202.44	-1221.50	-1240.56	-
0.09694	-1198.66	-1217.71	-1236.76	-
0.11101	-1196.36	-1215.40	-1234.45	-
0.13073	-1193.58	-1212.61	-1231.65	-
0.15147	-1191.07	-1210.09	-1229.11	-
Potassium Valinate				
0.01171	-1234.14	-1253.25	-1272.36	-

0.02831	-1219.38	-1238.47	-1257.56	-
0.05269	-1208.95	-1228.02	-1247.10	-
0.07041	-1204.07	-1223.13	-1242.19	-
0.09167	-1199.61	-1218.66	-1237.71	-
0.11122	-1196.33	-1215.37	-1234.42	-
0.12774	-1193.98	-1213.01	-1232.05	-
0.15219	-1190.99	-1210.01	-1229.03	-

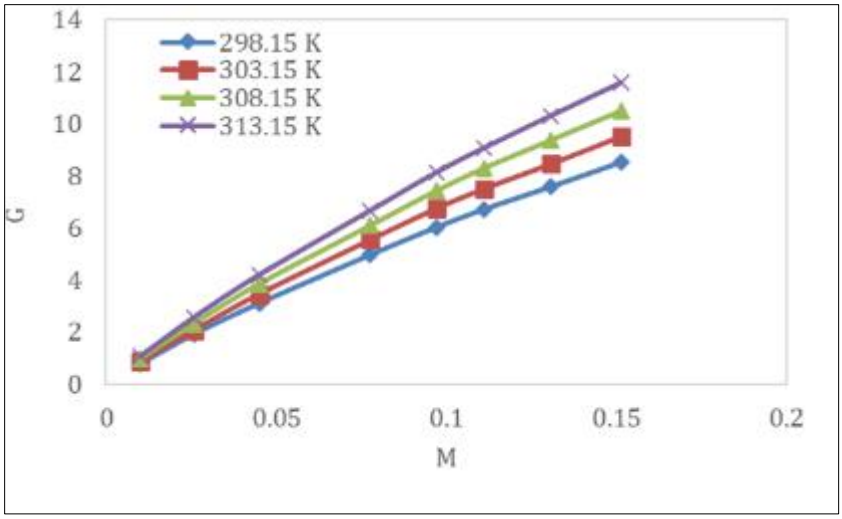

Figure 2 Plot of Conductance (G) vs molarity (M) of sodium valinate in water at different temperatures (T)

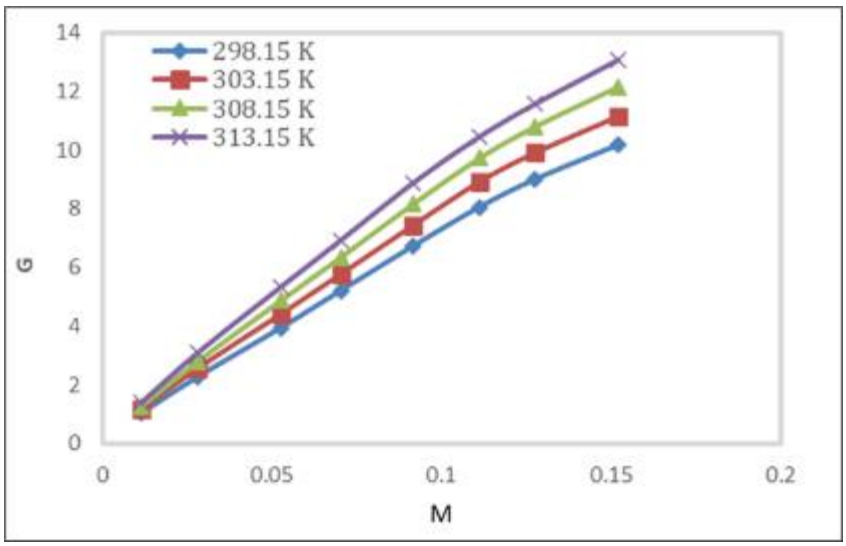

Figure 3 Plot of Conductance (G) vs molarity (M) of potassium valinate in water at different temperatures (T)

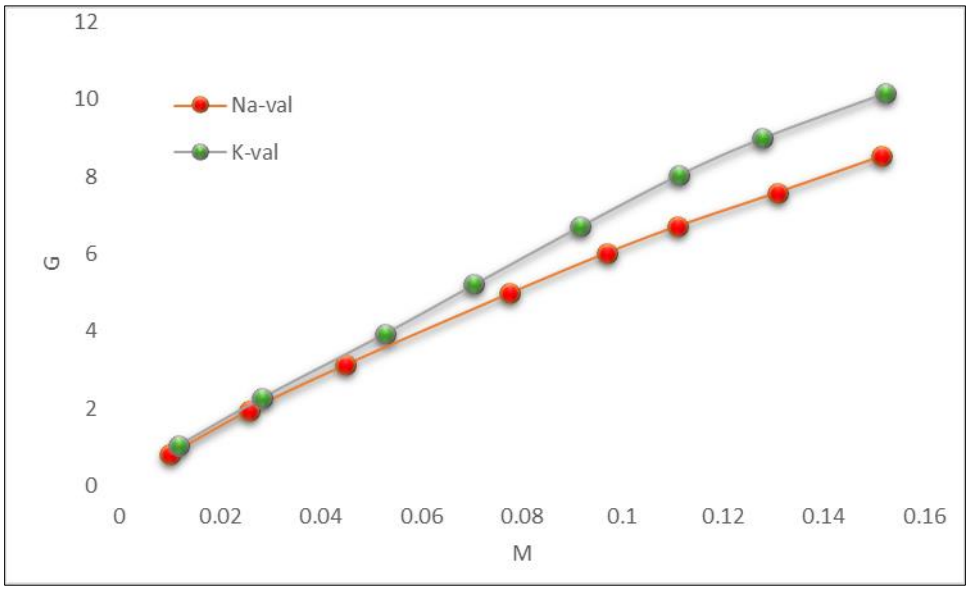

Figure 4 Plot of comparison of conductivity (G) of Na-val and K-val vs molarity (M) in water at 298.15 K.

4. Conclusion

MSV solution show good conductivity data at all temperatures, the conductivity of the PSV were found to be greater than SSV. Because in sodium salt aqueous solutions would expect that the sodium salt surrounded with more molecules of water and sodium metal hydrated in solution. This hydration affects on mobility and conductivity of solution, while the potassium slowly crystallizes with water. Sodium react with water faster than potassium which affects to ionisation of metal salts.

The structure of the drug as well as nature of that drug directly affects these parameters. The temperature molar concentrations and percentage compositions are also responsible for changing the values of these parameters. The solute (drug)-solvent interactions, solvent-solvent interactions, solvent-solvent-solute interactions and solute-solute-solvent interactions are another factor which directly hamper these parameters. The internal geometry as well as inter and intra hydrogen bonding affect these parameters. During this investigation it was observed that the molar conductance of PSV is higher than SSV.

Compliance with ethical standards

Acknowledgements

MBD thanks Director, Government Vidarbha Institute of Science and Humanities, Amravati, India and Principal, HPT Arts and RYK Science College, Nashik, India.

Disclosure of Conflict of interest

The authors that there is no conflict of interest.

References

[1] Altamash T, Nasser MS, Elhamarnah Y, Magzoub M, Ullah R, Qiblawey H, Aparicio S, Atilhan M. Gas solubility and rheological behavior study of betaine and alanine based natural deep eutectic solvents (NADES). Journal of Molecular Liquids. 2018 Apr 15;256:286-95.

[2] Zarei A, Hafizi A, Rahimpour MR, Raeissi S. Carbon dioxide absorption into aqueous potassium salt solutions of glutamine amino acid. Journal of Molecular Liquids. 2020 Mar 1;301:111743.

[3] Guo Y, Tan C, Sun J, Li W, Zhang J, Zhao C. Porous activated carbons derived from waste sugarcane bagasse for CO2 adsorption. Chemical engineering journal. 2020 Feb 1;381:122736.

[4] Dashti A, Amirkhani F, Hamedi AS, Mohammadi AH. Evaluation of CO2 Absorption by Amino Acid Salt Aqueous Solution Using Hybrid Soft Computing Methods. ACS omega. 2021 May 5;6(19):12459-69.

[5] Tambakhe S.V., Raghuwanshi P.B., Conductometric Studies Of Substituted Aryl Amidino thiocarbamides In 1,4 Doxane+Water Binbary Solution, JETIR, 2020 , 7(2).

[6] Ahmadzadeh S, Kassim A, Rezayi M, Abdollahi Y, Rounaghi GH. A conductometric study of complexation reaction between meso-octamethylcalix [4] pyrrole with titanium cation in acetonitrile–ethanol binary mixtures. International Journal of Electrochemical Science. 2011 Oct 1;6(10):4749-59.

[7] Jóna E, Kubranová M, Šimon P, Mroziński J. Thermochemical investigation: Ni (II)-3-pyridylcarbinol (ronicol) interactions in solid halogeno and thiocyanato complexes. Journal of thermal analysis. 1996 May;46:1325-37.

[8] Wadekar AB, Tayade DT, Waghmare SA, Kolhe SV. Thermodynamic study of substituted thiocarbamidonaphthol. Indo american journal of pharmaceutical sciences. 2018 Jan 1;5(1):S36-8.

[9] Boruń A. Conductance and ionic association of selected imidazolium ionic liquids in various solvents: A review. Journal of Molecular Liquids. 2019 Feb 15;276:214-24.

[10] Ghalami-Choobar B, Fallahkar TN. Thermophysical properties of 1-ethyl-3-methylimidazolium bromide ionic liquid in water+ ethylene carbonate mixtures at T=(298.2, 308.2 and 318.2) K. Fluid Phase Equilibria. 2019 Sep 15;496:42-60.

[11] Patil SU, Shelke ME, Isanka RD, Wadekar AB. Effect of different temperetures and substitution on substituted thiocarbamidonaphthol in 90% ethanol water mixture conductometrically.

[12] El-Sherif AA, Shehata MR, Shoukry MM, Barakat MH. Thermodynamic investigation and mixed ligand complex formation of 1, 4-Bis-(3-aminopropyl)-piperazine and biorelevant ligands. Bioinorganic Chemistry and Applications. 2012 Jan 1;2012.

[13] Watkins C, Jones HC. Conductivity and dissociation of some rather unusual salts in aqueous solution. Journal of the American Chemical Society. 1915 Dec;37(12):2626-36.

[14] Dhande MB, Pund DA, Lunge MS, Tayade DT. To investigate the thermodynamic parameters of Li, Na and K salt of L leucinate at various temperature and concentration by conductometric measurement.