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Study of Transport properties of Aqueous Lithium, Sodium and Potassium salt solutions of Alanine Conductometrically

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Abstract : Alkali metal salts of various amino acids received more attention by researches because of their various industrial applications. Recently they are investigated for their used as carbon dioxides chemical absorption agents. These salts have conductance which closely depends on number of ions in solution, size of ions and mobility of ions in solution. Present work regards with conductometric study of lithium, sodium and potassium salts of alanine. In the present work conductometric parameters, observed conductance was measured and further, specific conductance, molar conductance and thermodynamic parameters (change in free energy, change in entropy and change in enthalpy) were calculated for their concentrations range of (0.01 to 0.15) M and at temperatures 298.15, 303.15, 308.15 and 313.15 K. Observed values of conductometric and thermodynamic parameters values helps to understand a solute-solute, solute-solvent and solvent-solvent interaction and this information will be helpful to evaluate their role in carbon dioxide removal and other industrial applications.

Keywords: **Salts of alanine, Ionisation, Molecular interaction, conductometrically.**

I. Introduction

Human civilisation is suffering through various health and environmental problem now a day due to climatic change, which is a result of excessively changes atmospheric background. Climatic change is mostly cause by global warming. Carbon dioxide emissions is main contributor for global warming-a most concerning environmental issue. CO_2 capture using post-combustion technique is mostly used in the chemical processing industries[1].Alkali metal salt solution of the amino acid is developing into an absorbent for CO_2 capture. For evaluation and thorough characterisation of the solvent for CO_2 collection and other industrial applications, the physicochemical properties of solvents are required[2-5]. 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 conductivities. 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. Navarro *et al.*[6] studied the physicochemical properties such as densities, refractive indices, electrical conductivity and viscosities of aqueous potassium and sodium salt solutions of serine at normal atmospheric pressure and at various temperatures. Tirona *et al.*[7] reported the densities, viscosities, refractive indexes, and electrical conductivities of aqueous alkali (potassium or sodium) salts of the alanine at various temperatures but at higher concentrations. They used experimental validation to correlate the density, refractive index, and electrical conductivity of the amino acid salt solutions with temperature and amino acid salt concentration. This gave average absolute deviation values of 0.03%, studied densities, viscosity, refractive index and electrical conductivity of aqueous alkali salts of the α-alanine at various temperatures and concentrations for that an empirical equation was applied to correlate the density, refractive index and electrical conductivity of the amino acid salt solutions with temperature and concentration, which gave average absolute deviation values of 0.03%, 0.01%, and 0.6%, respectively.

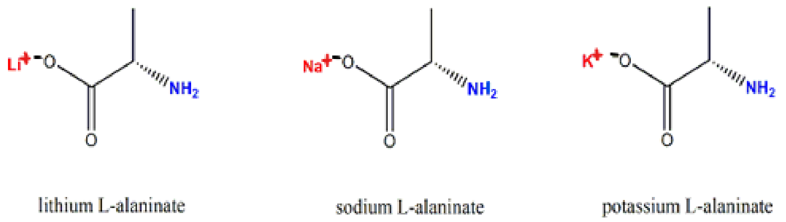
Alanine have their own importance in medicinal sciences and pharmaceutical sciences due to their significant application. Metal salt of these amino acid affects the solubility and conductivity. Conductometric investigation received more attention of researchers for molecular interactions investigation at various concentration and different temperatures[8-14] by using different types of molecules.

Thermodynamic and conductometric properties for aqueous sodium, lithium and potassium salt solutions of L-alanine have not yet been discussed in the literature at a lower concentration range and different temperatures. Therefore, bearing these things in mind presently work designed this scheme deals with the study of conductometric properties such as observed conductance (G), ahead specific conductance (k) and molar conductance (Λ), thermodynamic behaviour (ΔG, ΔH, and ΔS) and Walden product of lithium, sodium and potassium salts of L-alaninate different concentrations and different temperature. 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.

II. EXPERIMENTAL

All AR grade chemicals and solutions were used through this work. L-alanine (Ala CAS No. 56-41-7, 99% purity) was supplied by S D Fine-Chem Ltd, India. Lithium hydroxide (LiOH, CAS No. 1310-65-2, GR, % purity) was purchased from Sigma Aldrich, while 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. All the freshly prepared solutions were used for investigations. Concentrations of alanine solutions varied from 0.01 M to 0.15 M. Aqueous solutions of lithium alaninate (LA), sodium alaninate (SA), potassium alaninate (PA) were prepared by neutralising the amino acid with an equimolar quantity of base LiOH, NaOH, and KOH, respectively.

Figure 1. Structures of LA, SA, And PA.



III. METHODS AND METHODOLOGY: CONDUCTIVITY MEASUREMENTS

Measurements of electrical conductivity of each sample were done with a digital conductivity metre. 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 $\pm$0.01 K. A standard KCl solution from Merck was used to calibrate the conductivity metre. 20 mL of sample, with its temperature regulated by placing the sample tube in a water bath, were used for each measurement. Following each assessment, the conductivity. The conductivity was measured for their concentrations range (0.01 to 0.15) m and at 298.15, 303.15, 308.15, and 313.15 K. Further, molality is converted into molarity for molar conductance calculations.

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 measurements were made and the average reading was used. The calculated overall measurement uncertainty was ±1.0%.

IV. RESULTS AND DISCUSSION

For aqueous solutions of LA, SA and PA electrical conductivity were recorded for 0.1 to 0.15 m concentration. From the data observed conductance (G), ahead specific conductance (k) and molar conductance (Λ) were determined by known literature method and tabulated in Table-1 and Table-2 at 298.15 K, 308.15 K, 308.15 K and 313.15 K respectively

Table-1, Table-2, Figure 2, Figure 3 and Figure 4 reveals that along with increase in a concentration from 0.009 to 0.15 m observe conductance and specific conductance increases while molar conductance decreases for LA, SA and PA solutions. As temperature increases from 298 K to 313 K observe conductance, specific conductance and molar conductance increases same metal salts solution. From **Figure** 5 it is observed as Observe conductance increases from Li-salt to Na-salt and from Na-salt to K-salt for a particular amino acid. Similar trend is observed for specific conductance and molar conductance.

$$LA(G / k / \Lambda) < SA(G / k / \Lambda) < PA(G / k / \Lambda)$$

During this investigation it was also observed that the observed conductance (G), specific conductance (k) and molar conductance (Λ) values of PA are greater than SA and for SA greater than LA solutions, which clearly indicates that PA has good conductivity and mobility in solutions. This could be as a result of the creation of hydration spheres around metal ions that, depending on their size, impede the mobility of the ions in solution. This information is helpful for diffusion of ions or good drug effect of PA is comparatively good than SA and LA.

The (Ksp) and thermodynamics parameter viz. change in free energy (ΔG), change in entropy (ΔS) and change in enthalpy (ΔH) of MSA were determined by known literature method at various molar concentration and temperatures and result are presented in **Table 2, Table 3** and **Table-4.** From these tables it is observed as along with increasing concentration Ksp values increases continuously while decreases with the temperature. ΔG values shows exactly opposite trend to that of Ksp. As temperature increases from 298 K to 313 K, ΔG increases and decreases continuously with concentration of the solution. All the studied systems have positive ΔG values suggest that in the solvent, the dissociation process is favoured over the association process. The negative values of ΔH and ΔS suggest the dissociation process is exothermic and decrease in randomness in the solvent, respectively[15].

V. CONCLUSION

It was observed that the observed conductance (G), specific conductance (k) and molar conductance (Λ) values of PA are greater than SA and for SA greater than LA solutions. ΔG values exhibit an identical reversal of the Ksp trend. With the concentration of the solution, ΔG constantly increases and lowers as temperature rises. The fact that all of the systems under study have positive ΔG values indicates that the dissociation process is preferred to the attachment process in the solvent. The exothermic nature of the dissociation process and the decrease in solvent randomness, respectively, are suggested by the negative values of ΔH and ΔS.

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-solvent interactions, and solute-solute interactions can be studied from the above data. The internal geometry as well as internal and intra hydrogen bonding also affect these parameters. These experimental values as a function of temperature and concentration using suitable correlations, could be useful for the design of processes utilizing the studied solutions as solvents.

Table-1. Observed Conductance (G) and Specific Conductance (k) of LA, SA and PA 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
LA					**LA**				
0.00982	0.75	0.84	0.95	1.05	0.00979	0.735	0.823	0.932	1.025
0.02905	1.90	2.15	2.44	2.68	0.02896	1.862	2.107	2.391	2.626
0.05094	2.96	3.33	3.71	4.07	0.05079	2.901	3.263	3.636	3.989
0.06990	3.64	4.10	4.53	4.99	0.06969	3.567	4.018	4.439	4.890
0.09129	4.39	4.89	5.41	5.97	0.09102	4.302	4.792	5.302	5.851
0.11086	5.05	5.62	6.21	6.82	0.11053	4.949	5.508	6.086	6.684
0.13040	5.72	6.34	7.01	7.72	0.13001	5.606	6.213	6.870	7.566
0.15069	6.35	7.10	7.84	8.64	0.15024	6.223	6.958	7.683	8.467
SA					**SA**				
0.01004	0.82	0.92	1.02	1.12	0.01001	0.804	0.902	1.000	1.098
0.02963	2.35	2.62	2.88	3.15	0.02955	2.303	2.568	2.822	3.087
0.05123	3.79	4.22	4.63	5.07	0.05108	3.714	4.136	4.537	4.969
0.07307	5.18	5.75	6.34	6.92	0.07285	5.076	5.635	6.213	6.782
0.09265	6.43	7.14	7.86	8.61	0.09238	6.301	6.997	7.703	8.438
0.10831	7.43	8.21	9.06	9.92	0.10799	7.281	8.046	8.879	9.722
0.13476	8.94	9.92	10.95	11.95	0.13436	8.761	9.722	10.731	11.711
0.15057	9.73	10.74	11.89	12.98	0.15012	9.535	10.525	11.652	12.720
PA					**PA**				
0.01000	0.94	1.04	1.15	1.26	0.00997	0.921	1.019	1.127	1.235
0.03163	2.66	2.95	3.22	3.50	0.03154	2.607	2.891	3.156	3.430
0.05155	4.23	4.66	5.08	5.54	0.05139	4.145	4.567	4.9784	5.429
0.07331	5.77	6.35	6.95	7.60	0.07309	5.655	6.223	6.811	7.446
0.08932	6.95	7.65	8.40	9.12	0.08905	6.811	7.497	8.232	8.938
0.10603	8.11	8.92	9.75	10.56	0.10571	7.948	8.742	9.555	10.349
0.13095	9.65	10.58	11.58	12.59	0.13056	9.457	10.368	11.348	12.338
0.15514	11.10	12.25	13.39	14.50	0.15468	10.878	12.005	13.122	14.210

Table-2. Molar Conductance (Λ) and Ksp of LA, SA and PA 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
LA					**LA**				
0.00979	75.069	84.078	95.188	104.697	0.00979	0.0998	0.0995	0.0992	0.0989
0.02896	64.287	72.745	82.558	90.678	0.02896	0.8735	0.8711	0.8682	0.8651
0.05079	57.115	64.254	71.586	78.532	0.05079	2.6859	2.6784	2.6697	2.6599
0.06969	51.185	57.653	63.699	70.168	0.06969	5.0574	5.0432	5.0269	5.0085
0.09102	47.267	52.650	58.249	64.279	0.09102	8.6261	8.6019	8.5741	8.5427
0.11053	44.775	49.828	55.060	60.468	0.11053	12.7209	12.6852	12.6441	12.5979
0.13001	43.116	47.789	52.839	58.191	0.13001	17.6003	17.5510	17.4942	17.4301
0.15024	41.420	46.312	51.139	56.357	0.15024	23.5035	23.4377	23.3617	23.2762
SA					**SA**				
0.01001	80.286	90.078	99.869	109.660	0.01001	0.1043	0.1040	0.1037	0.1033
0.02955	77.948	86.903	95.527	104.483	0.02955	0.9089	0.9064	0.9034	0.9001
0.05108	72.720	80.970	88.837	97.279	0.05108	2.7163	2.7087	2.6999	2.6900
0.07285	69.678	77.346	85.282	93.084	0.07285	5.5267	5.5112	5.4933	5.4732
0.09238	68.212	75.744	83.382	91.338	0.09238	8.8860	8.8611	8.8323	8.8000
0.10799	67.427	74.506	82.220	90.024	0.10799	12.1424	12.1084	12.0692	12.0250
0.13436	65.208	72.357	79.869	87.163	0.13436	18.7961	18.7434	18.6827	18.6143
0.15012	63.517	70.110	77.617	84.733	0.15012	23.4665	23.4007	23.3249	23.2395
PA					**PA**				
0.00997	92.393	102.222	113.034	123.846	0.00997	0.1035	0.1032	0.1029	0.1025
0.03154	82.651	91.662	100.051	108.752	0.03154	1.0358	1.0329	1.0295	1.0258
0.05139	80.658	88.857	96.866	105.637	0.05139	2.7503	2.7426	2.7338	2.7237
0.07309	77.360	85.136	93.180	101.868	0.07309	5.5631	5.5476	5.5296	5.5093
0.08905	76.483	84.186	92.440	100.363	0.08905	8.2574	8.2342	8.2075	8.1775
0.10571	75.182	82.691	90.385	97.894	0.10571	11.6363	11.6037	11.5661	11.5238
0.13056	72.432	79.413	86.919	94.500	0.13056	17.7496	17.6999	17.6425	17.5780
0.15468	70.327	77.613	84.836	91.869	0.15468	24.9116	24.8418	24.7613	24.6707

Table-3. ΔG values of LA, SA and PA at 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
LA					**LA**				
0.00979	22839.46	23229.55	23621.00	24013.82	0.00979	-346014.31	-357602.71	-369382.06	-
0.02896	17461.46	17761.36	18062.62	18365.25	0.02896	-345981.86	-357563.96	-369336.87	-
0.05079	14676.61	14929.81	15184.37	15440.30	0.05079	-345955.72	-357532.75	-369300.47	-
0.06969	13107.65	13334.54	13562.79	13792.41	0.06969	-345936.10	-357509.33	-369273.16	-
0.09102	11783.85	11988.54	12194.59	12402.01	0.09102	-345915.48	-357484.73	-369244.48	-
0.11053	10820.78	11009.32	11199.22	11390.48	0.11053	-345897.31	-357463.05	-369219.21	-
0.13001	10015.83	10190.87	10367.27	10545.04	0.13001	-345879.45	-357441.74	-369194.37	-
0.15024	9298.75	9461.76	9626.13	9791.88	0.15024	-345860.94	-357419.65	-369168.63	-
SA					SA				
0.01001	22730.17	23118.43	23508.05	23899.03	0.01001	-346013.81	-357602.11	-369381.36	-
0.02955	17362.91	17661.16	17960.77	18261.75	0.02955	-345981.08	-357563.03	-369335.78	-
0.05108	14648.71	14901.44	15155.54	15411.00	0.05108	-345955.40	-357532.38	-369300.03	-
0.07285	12887.65	13110.85	13335.41	13561.33	0.07285	-345932.96	-357505.59	-369268.80	-
0.09238	11710.27	11913.73	12118.54	12324.73	0.09238	-345914.20	-357483.20	-369242.69	-
0.10799	10936.16	11126.64	11318.47	11511.67	0.10799	-345899.66	-357465.85	-369222.47	-
0.13436	9852.87	10025.17	10198.84	10373.87	0.13436	-345875.48	-357437.00	-369188.85	-
0.15012	9302.66	9465.74	9630.17	9795.98	0.15012	-345861.05	-357419.78	-369168.78	-
PA					SA				
0.00997	22749.39	23137.97	23527.91	23919.22	0.00997	-346013.90	-357602.21	-369381.48	-
0.03154	17039.02	17331.84	17626.01	17921.56	0.03154	-345978.45	-357559.88	-369332.11	-
0.05139	14617.82	14870.04	15123.61	15378.55	0.05139	-345955.06	-357531.96	-369299.55	-
0.07309	12871.33	13094.26	13318.55	13544.20	0.07309	-345932.73	-357505.31	-369268.47	-
0.08905	11892.17	12098.68	12306.54	12515.78	0.08905	-345917.34	-357486.94	-369247.06	-
0.10571	11041.72	11233.96	11427.56	11622.53	0.10571	-345901.76	-357468.35	-369225.40	-
0.13056	9994.89	10169.58	10345.63	10523.04	0.13056	-345878.95	-357441.14	-369193.67	-
0.15468	9154.50	9315.09	9477.04	9640.37	0.15468	-345856.86	-357414.79	-369162.97	-

Table 4.4. ΔS values of LA, SA and PA 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
LA				
0.00979	-1237.14	-1256.25	-1275.36	-
0.02896	-1218.99	-1238.08	-1257.18	-
0.05079	-1209.57	-1228.64	-1247.72	-
0.06969	-1204.24	-1223.30	-1242.37	-
0.09102	-1199.73	-1218.78	-1237.84	-
0.11053	-1196.44	-1215.48	-1234.52	-
0.13001	-1193.68	-1212.71	-1231.74	-
0.15024	-1191.21	-1210.23	-1229.25	-
SA				
0.01001	-1236.77	-1255.88	-1274.99	-
0.02955	-1218.66	-1237.75	-1256.84	-
0.05108	-1209.47	-1228.55	-1247.62	-
0.07285	-1203.49	-1222.55	-1241.62	-
0.09238	-1199.48	-1218.53	-1237.58	-
0.10799	-1196.83	-1215.87	-1234.92	-
0.13436	-1193.12	-1212.15	-1231.18	-
0.15012	-1191.22	-1210.24	-1229.27	-
PA				
0.00997	-1236.84	-1255.95	-1275.06	-
0.03154	-1217.57	-1236.65	-1255.75	-
0.05139	-1209.37	-1228.44	-1247.52	-
0.07309	-1203.43	-1222.50	-1241.56	-
0.08905	-1200.10	-1219.15	-1238.21	-
0.10571	-1197.19	-1216.24	-1235.28	-
0.13056	-1193.61	-1212.64	-1231.67	-
0.15468	-1190.71	-1209.73	-1228.75	-

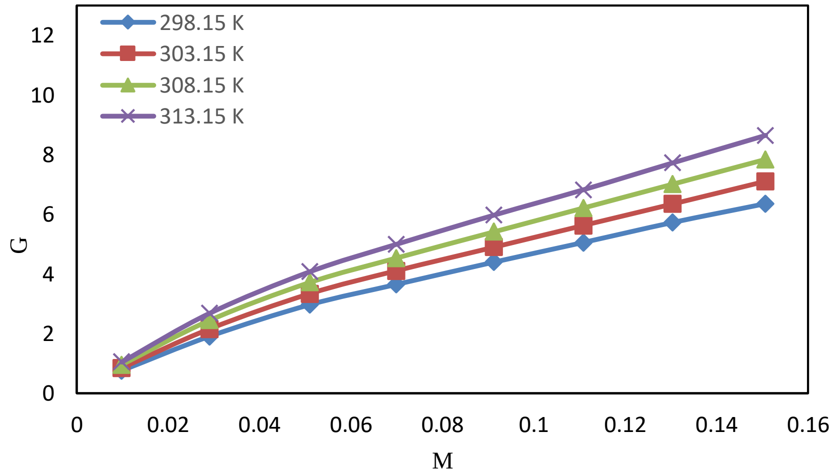


Figure 2. Plot of Conductance (G) vs molality (*m*) of lithium alaninate in water at different temperatures (*T*)

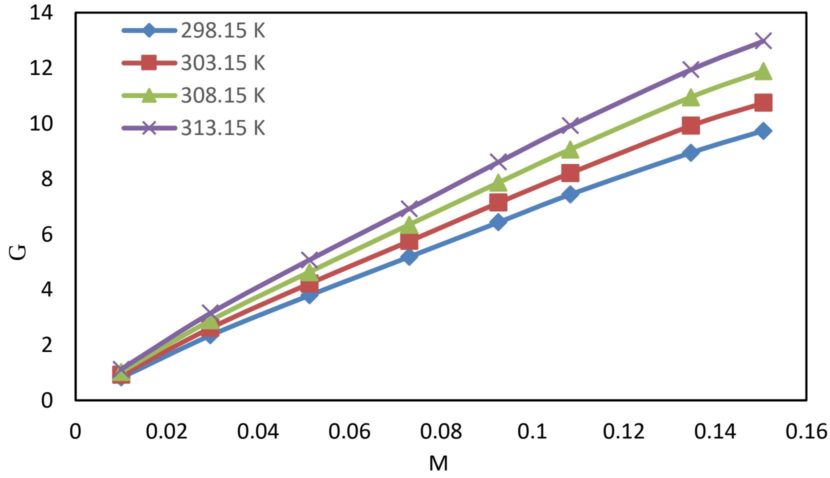


Figure 3. Plot of Conductance (G) vs molarity (*M*) of sodium alaninate in water at different temperatures (*T*)

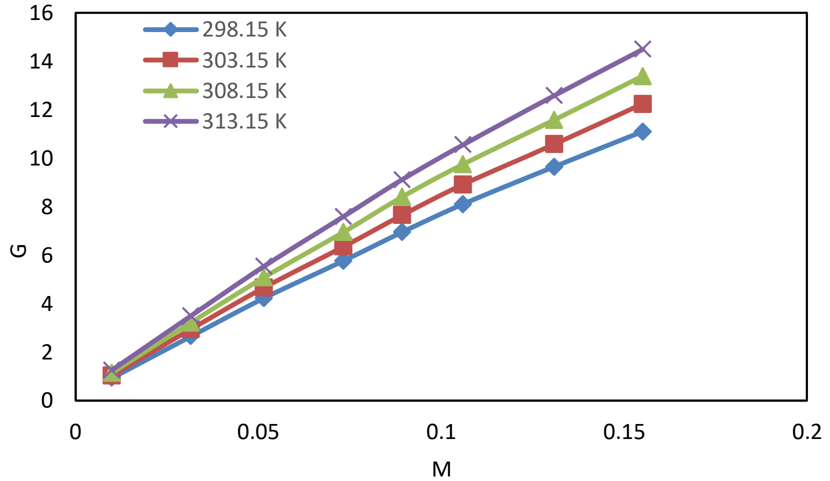


Figure 4. Plot of Conductance (G) vs molarity (*M*) of potassium alaninate in water at different temperatures (*T*)

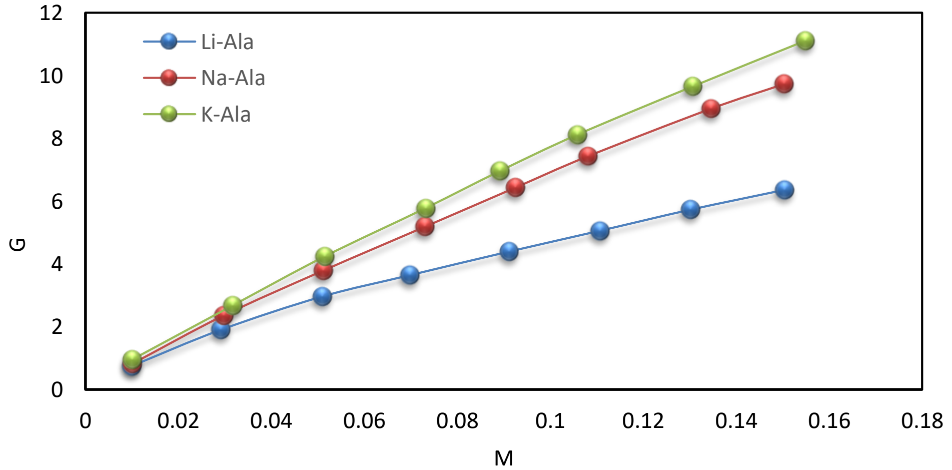


Figure 5. Plot of comparison of conductivity (G) of Li-ala, Na-ala and K-ala vs molarity (*M*) in water at 298.15 K.

IV. Acknowledgment

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