Oriental Journal of Chemistry Vol. **26**(3), 865-877 (2010)

Conductance studies of metal salts in aqueous ethanolic solution at 25°C in presence of medicinal drugs

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(Received: April 27, 2010; Accepted: June 15, 2010)

ABSTRACT

The interactions between drugs (Fluoxetine hydrochloride, cyproheptadine hydrochloride and Metformin hydrochloride) and additives were studied by conductometric technique. Increase in conductance is observed as the percentage of ethanol decreases in ethanol-water mixture. However, when the additives NaCl, KCl, $CuCl_2$, $NiCl_2$ and glucose, are added, the magnitude of conductance differs for different additives. The Walden product decreases with increase in percentage of ethanol in mixture. The Walden product in presence of NaCl and KCl is observed to be less than the Walden product in presence of $NiCl_2$ and $CuCl_2$.

Key words: Fluoxetine- HCl, Metformin HCl, cyproheptadine HCl, Conductance in binary solvent.

INTRODUCTION

The studies of conductivity behavior of substances in aqueous and non aqueous media have received considerable importance in recent years[1-3] due to its varied applications in various electrochemical investigations. Conductivity study is one of the important and simplest tools to understand the transport behavior in general and solvation behavior in specific[4]. Hence we decided to study the conductance study of salts in binary solvent of ethanol water and in presence and absence of medicinal drugs.

EXPERIMENTAL

A series of binary solvent mixtures (10%-90%) in ethanol-water is prepared. The salts KCl, NaCl, $NiCl_2$, $CuCl_2$ and nonelectrolyte glucose used were of A R grade. Water used was double distilled over alkaline $KMnO_4$ in quick fit glass assembly (conductance 2 x10^{-6} mhos). Commercial alcohol was refluxed with lime for two hours and then distilled using long fractionating column. The binary solvent was used to prepare 0.001 to 0.1M salt solution.

RESULTS AND DISCUSSION

The present paper deals with electrolyte-solvent- nonelectrolyte interactions. It has been observed that non-electrolyte moiety interacts with the ions of the electrolytes in solution. We selected KCl, NaCl $CuCl_2$ and $NiCl_2$ as electrolyte and glucose as nonelectrolyte additives. The following drugs are selected for conductance studies

Fluoxetine hydrochloride (ft) is antidepressant, cyproheptadine hydrochloride (chd) is antihistaminic agent, and Metformin hydrochloride (mfm) is antidiabetic drug

Specific Conductance: It is observed that specific conductance and equivalent conductance of salts in binary solvent decreases with increase in percentage of ethanol (table 1a-1d).The conductance decreases, in water rich region, with the addition of salt. The changes of conductance of drug- electrolyte solution were attributed to the obstruction of the electrical migration of ions by the environmental non electrolyte entities. The decrease in conductance with increasing ethanol in binary solvent is due to decrease in dielectric constant, thereby increasing intermolecular attraction between solvent molecules and hence decreasing conductance values. The specific conductance of salt solution depends on various factors; the contributions of different factors cannot be assigned easily. In our study, we observed that conductance in mixed solvent varies with drug. The general trend shows that conductance values of salt solution in presence of chd is high, since this drug does not posses any specific functional group, its binding capacity is also less, the hydrochloride molecule attached to it dissociates completely and hence shows maximum conductance. Equimolar solution of above drugs in absence of additive showed following order, ft < mfm< chd.

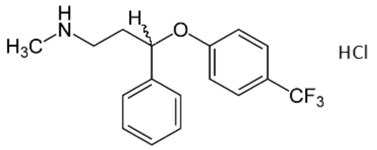
ft has three fluorine atoms hence there is a greater probability of formation of hydrogen bonds with either alcohol or water which may retard their mobility and hence it should have least conductance. The change in the order of conductance in presence of additives alters this sequence, which may be due to complex formation particularly with Cu (II) and Ni (II) ions. It is a fact that degree of solvation is correlated to solute solvent polarity only, irrespective of the exact nature -electrovalent or covalent of the solvation bond. The solvation depends on several factors; one of the factors is ponderal effect. The term ponderal stands for mass with size, which is a structural effect, different from isotope effect where change in mass does not create corresponding change in size. Ponderal effect opposes solvation. Hence solvation largely depends on solute and solvent.

Most of the physical and chemical properties depend on extent of solvation. When a solvent mixture is present, physical properties depend on differential solvation. Hence, it can be concluded that conductance of these non-electrolyte drugs in presence of electrolytes (salts) mostly affected by electrostatic interaction or complex formation between them.

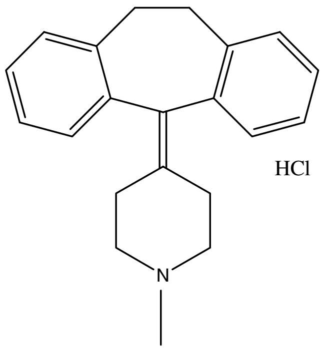
The difference in conductance decreased with increase in percentage of ethanol. This indicates the strong interaction between ions and drug molecules which retard the speed of ions towards respective electrode. In presence of $NiCl_2$ the specific conductance of solution increases which indicate that ions are free and having more mobility. ft in additive was found to be high. In the case of $NiCl_2$, ft has low conductance compared to other drugs, may be due to Complexation between Ni (II) and ft.

Limiting equivalent conductance

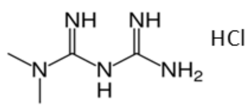
It is clear that in absence of drug, the Λo values in general increase with decrease of EtOH content i.e. with the increase of dielectric constant for all studied drugs.



Fluoxetine Hydrochloride



Cyproheptadine Hydrochloride



Metformin Hydrochloride

Table 1a: Specific and equivalent conductance values (mS) (Without Drug)

%	Additive: KCl									
	0.002 M		0.004 M		0.006 M		0.008 M		0.01 M	
EtOH	k	Λ	k	Λ	k	Λ	k	Λ	k	Λ
10	303.107	151.5535	539.7520	134.9380	797.5440	132.9240	1048.2870	131.0359	1309.1000	130.9100
20	249.736	124.8680	461.2060	115.3015	671.6690	111.9448	891.1950	111.3994	1109.7140	110.9714
30	210.463	105.2315	362.5200	90.6300	631.6960	88.6160	667.6410	83.4551	828.7610	82.8761
40	147.928	73.9642	291.3251	72.8313	427.9750	71.3292	547.8080	68.4760	679.7250	67.9725
50	148.029	74.0145	251.7500	62.9375	367.5550	61.2592	478.3250	59.7906	594.1300	59.4130
60	118.625	59.3123	227.5820	56.8955	332.3100	55.3850	439.0520	54.8815	511.5560	51.1556
70	99.995	49.9976	192.1356	48.0339	275.9180	45.9863	359.4990	44.9374	439.0520	43.9052
80	92.644	46.3220	172.1970	43.0493	245.7080	40.9513	318.2120	39.7765	381.6530	38.1653
90	85.696	42.8479	165.2487	41.3122	230.6030	38.4338	288.0020	36.0003	355.4710	35.5471
Additive: NaCl										
10	251.7500	125.8750	459.1920	114.7980	681.7390	113.6232	891.1950	111.3994	1107.7000	110.7700
20	203.4140	101.7070	397.7650	99.4413	539.7520	89.9587	714.9700	89.3713	881.1250	88.1125
30	168.8739	84.4370	311.1630	77.7908	445.0940	74.1823	550.8290	68.8536	676.7040	67.6704
40	129.8023	64.9012	254.7710	63.6928	370.5760	61.7627	481.3460	60.1683	597.1510	59.7151
50	129.1981	64.5991	231.6100	57.9025	336.3380	56.0563	430.9960	53.8745	525.6540	52.5654
60	102.3112	51.1556	197.5734	49.3934	291.0230	48.5038	380.6460	47.5808	468.2550	46.8255
70	91.0328	45.5164	174.2110	43.5528	248.7290	41.4548	319.2190	39.9024	390.7160	39.0716
80	88.1125	44.0563	163.5368	40.8842	234.6310	39.1052	293.0370	36.6296	359.4990	35.9499
90	82.0705	41.0353	153.4668	38.3667	216.5050	36.0842	281.9600	35.2450	347.4150	34.7415
Additive: $NiCl_2$										
10	488.3950	244.1975	961.6850	240.4213	1419.8700	236.6450	1862.9500	232.8688	2306.0300	230.6030
20	389.7090	194.8545	749.2080	187.3020	1042.2450	173.7075	1262.7780	157.8473	1566.8920	156.6892
30	300.0860	150.0430	552.8430	138.2108	791.5020	131.9170	1013.0420	126.6303	1217.4630	121.7463
40	236.6450	118.3225	441.0660	110.2665	644.4800	107.4133	797.5440	99.6930	991.8950	99.1895
50	212.4770	106.2385	379.6390	94.9098	561.9060	93.6510	736.1170	92.0146	916.3700	91.6370
60	176.8292	88.4146	310.1560	77.5390	436.0310	72.6718	568.9550	71.1194	662.6060	66.2606
70	156.0850	78.0425	260.8130	65.2033	380.6460	63.4410	489.4020	61.1753	604.2000	60.4200
80	141.2821	70.6411	235.6380	58.9095	325.2610	54.2102	402.8000	50.3500	453.1500	45.3150

90	113.1868	56.5934	199.9902	49.9976	269.8760	44.9793	330.2960	41.2870	399.7790	39.9779
Additive: $CuCl_2$										
10	475.3040	237.6520	857.9640	214.4910	1248.6800	208.1133	1620.2630	202.5329	2019.0350	201.9035
20	376.6180	188.3090	720.0050	180.0013	976.7900	162.7983	1277.8830	159.7354	1550.7800	155.0780
30	283.9740	141.9870	522.6330	130.6583	755.2500	125.8750	962.6920	120.3365	1167.1130	116.7113
40	255.7780	127.8890	413.8770	103.4693	601.1790	100.1965	800.5650	100.0706	975.7830	97.5783
50	230.6030	115.3015	388.7020	97.1755	562.9130	93.8188	681.7390	85.2174	836.8170	83.6817
60	186.8992	93.4496	341.3730	85.3433	488.3950	81.3992	614.2700	76.7838	735.1100	73.5110
70	151.2514	75.6257	268.8690	67.2173	362.5200	60.4200	463.2200	57.9025	550.8290	55.0829
80	123.8610	61.9305	218.5190	54.6298	279.9460	46.6577	359.4990	44.9374	432.0030	43.2003
90	91.7377	45.8689	159.2067	39.8017	206.4350	34.4058	252.7570	31.5946	306.1260	30.6128
Additive: Glucose										
10	13.4132	6.7066	12.7184	3.1796	12.5069	2.0845	6.3139	0.7892	6.0017	0.6002
20	4.1287	2.0644	4.7128	1.1785	3.8467	0.6411	5.0350	0.6294	5.2666	0.5267
30	2.9002	1.4501	3.9877	0.9969	3.6252	0.6042	2.8196	0.3525	3.0512	0.3051
40	2.1953	1.0976	2.4772	0.6193	1.9536	0.3256	2.5679	0.3210	2.8800	0.2880
50	2.2859	1.1429	2.3161	0.5790	2.7793	0.4632	1.8227	0.2278	1.9536	0.1954
60	1.8126	0.9063	1.6948	0.4237	2.5779	0.4297	1.2910	0.1614	1.5649	0.1565
70	1.2487	0.6243	1.5739	0.3935	1.0735	0.1789	1.1762	0.1470	1.4652	0.1465
80	0.7704	0.3852	0.9325	0.2331	1.1480	0.1913	1.3141	0.1643	1.4400	0.1440
90	0.8600	0.4300	1.2144	0.3036	1.2185	0.2031	1.2487	0.1561	1.2718	0.1272

Table 1b: Specific and equivalent conductance values (mS)[chd-HCl]

%	Additive: KCl									
	0.002 M		0.004 M		0.006 M		0.008 M		0.01 M	
EtOH	k	Λ	k	Λ	k	Λ	k	Λ	k	Λ
10	392.7300	196.3650	614.2700	153.5675	829.7680	138.2947	1019.0840	127.3855	1268.8200	126.8820
20	327.2750	163.6375	505.5140	126.3785	687.7810	114.6302	851.9220	106.4903	1035.1960	103.5196
30	256.7850	128.3928	417.9050	104.4763	553.8500	92.3083	690.8020	86.3503	853.9360	85.3936
40	195.8615	97.9308	352.4500	84.1125	458.1850	76.3642	568.9550	71.1194	693.8230	69.3823
50	185.2880	92.6440	319.2190	79.8048	430.9960	71.8327	550.8290	68.8536	666.6340	66.6634
60	178.2390	89.1195	284.9810	71.2453	386.6880	64.4480	486.3810	60.7976	563.9200	56.3920
70	155.0780	77.5390	248.7290	62.1823	331.3030	55.2172	416.8980	52.1123	491.4160	49.1416
80	141.9870	70.9935	222.5470	55.6368	299.0790	49.8465	364.5340	45.5668	445.0940	44.5094
90	133.9310	66.9655	223.5540	55.8885	263.8340	43.9723	323.2470	40.4059	373.5970	37.3597
(Additive NaCl)										
10	374.6040	187.3020	530.6890	132.6723	714.9700	119.1617	896.2300	112.0288	1075.4760	107.5476
20	283.9740	141.9870	436.0310	109.0078	587.0810	97.8468	728.0610	91.0076	877.0970	87.7097
30	208.4490	104.2245	352.4500	88.1125	473.2900	78.8817	612.2560	76.5320	713.9630	71.3963
40	191.0279	95.5140	320.2260	80.0565	398.7720	66.4620	506.5210	63.3151	589.0950	58.9095
50	173.2040	86.6020	273.9040	68.4760	378.6320	63.1053	480.3390	60.0424	566.9410	56.6941
60	161.1200	80.5600	283.9740	70.9935	342.3800	57.0633	436.0310	54.5039	504.5070	50.4507
70	154.0710	77.0355	240.6730	60.1683	327.2750	54.5458	403.8070	50.4759	478.3250	47.3825
80	138.9660	69.4830	215.4980	53.8745	271.8900	45.3150	352.4500	44.0563	420.9260	42.0926
90	125.8750	62.9375	198.3790	49.5948	260.8130	43.4688	322.2400	40.2800	372.5900	37.2590
(Additive NiCl2)										
10	1196.3160	598.1580	1328.2330	332.0583	1419.8700	236.6450	1503.4510	187.9314	1785.4110	178.5411
20	408.8420	204.4210	702.8860	175.7215	941.5450	156.9242	1214.4420	151.8053	1460.1500	146.0150
30	319.2190	159.6095	577.0110	144.2528	775.3900	129.2317	964.7060	120.5883	1177.1830	117.7183
40	285.9880	142.9940	482.3530	120.5883	642.4660	107.0777	811.6420	101.4553	949.6010	94.9601
50	265.8480	132.9240	446.1010	111.5253	614.2700	102.3783	788.4810	98.5601	944.5660	94.4566
60	211.4700	105.7350	372.5900	93.1475	506.5210	84.4202	630.3820	78.7978	749.2080	74.9208
70	203.4140	101.7070	325.2610	81.3153	432.0030	72.0005	539.7520	67.4690	641.4590	64.1459

80	170.1830	85.0915	276.9250	69.2313	371.5830	61.9305	455.1640	56.8955	531.6960	53.1696
90	147.0220	73.5110	217.5120	54.3780	282.9670	47.1612	345.4010	43.1751	407.8350	40.7835
(Additive CuCl2)										
10	562.9130	281.4565	867.0270	216.7568	1192.2880	198.7147	1511.5070	188.9384	1824.6840	182.4684
20	411.8630	205.9315	705.9070	176.4768	948.5940	158.0990	1218.4700	152.3088	1460.1500	146.0150
30	350.4360	175.2180	579.0250	144.7563	787.4740	131.2457	966.7200	120.8400	1174.1620	117.4162
40	277.6520	138.9660	461.2060	115.3015	610.2420	101.7070	800.5650	100.0706	960.6780	96.0678
50	237.6520	118.8260	450.1290	112.5323	607.2210	101.2035	742.1590	92.7699	896.2300	89.6230
60	218.5190	109.2595	404.8140	101.2035	516.5910	86.0985	643.4730	80.4341	798.5510	79.8551
70	200.3900	100.1965	333.3170	83.3293	442.0730	73.6788	556.8710	69.6089	643.4730	64.3473
80	176.2250	88.1125	238.6590	59.6648	317.2050	52.8675	392.7300	49.0913	452.1430	45.2143
90	121.8470	60.9235	192.3370	48.0843	245.7080	40.9513	295.0510	36.8814	337.3450	33.7345
(Additive Glucose)										
10	156.0850	78.0425	159.1060	39.7765	160.1130	26.6855	157.0920	19.6365	158.0990	15.8099
20	126.8820	63.4410	125.8750	31.4688	122.8540	20.4757	123.8610	15.4826	119.8330	11.9833
30	102.7140	51.3570	97.6790	24.4198	104.7280	17.4547	101.7070	12.7134	104.7280	10.4728
40	88.6160	44.3080	88.6160	22.1540	89.6230	14.9372	88.6160	11.0770	89.6230	8.9623
50	84.5880	42.2940	79.6537	19.9134	78.5460	13.0910	77.5390	9.6924	79.9558	7.9956
60	75.6257	37.8129	77.2369	19.3092	76.5320	12.7553	76.2299	9.5287	77.3376	7.7338
70	73.1082	36.5541	73.5110	18.3778	72.8061	12.1344	72.8061	9.1008	71.8998	7.1900
80	71.5977	35.7989	69.7851	17.4463	69.5837	11.5973	71.3963	8.9245	70.1879	7.0188
90	69.0802	34.5401	62.9375	15.7344	61.8298	10.3050	60.7221	7.5903	59.4130	5.9413

Table 1c: Specific and equivalent conductance values (mS)[ft]

%	Additive: KCl									
	0.002 M		0.004 M		0.006 M		0.008 M		0.01 M	
EtOH	k	Λ	k	Λ	k	Λ	k	Λ	k	Λ
10	356.4780	178.2390	563.9200	140.9800	782.4390	130.4065	970.7480	121.3435	1170.1340	117.0134
20	286.9950	143.4975	446.1010	111.5253	614.2700	102.3783	778.4110	97.3014	938.5240	93.8524
30	247.7220	123.8610	401.7930	100.4483	534.7170	89.1195	690.8020	86.3503	831.7820	83.1782
40	192.6391	96.3196	332.3100	83.0775	464.2270	77.3712	590.1020	73.7628	696.8440	69.6844
50	177.7355	88.8678	289.0090	72.2523	386.6880	64.4480	488.3950	61.0494	595.1370	59.5137
60	154.7759	77.3880	247.7220	61.9305	361.5130	60.2522	473.2900	59.1613	527.6680	52.7668
70	152.3591	76.1796	232.6170	58.1543	307.1350	51.1892	379.6390	47.4549	458.1850	45.8185
80	139.8723	69.9362	208.4490	52.1123	278.9390	46.4898	344.3940	43.0493	412.8700	41.2870
90	132.0177	66.0089	198.8825	49.7206	257.7920	42.9653	316.1980	39.5248	372.5900	37.2590
(Additive NaCl)										
10	326.2680	163.1340	522.6330	130.6583	696.8440	116.1407	861.9920	107.7490	1030.1610	103.0161
20	247.7220	123.8610	441.0660	110.2665	538.7450	89.7908	668.6480	83.5810	806.6070	80.6607
30	216.5050	108.2525	349.4290	87.3573	471.2760	78.5460	597.1510	74.6439	704.9000	70.4900
40	197.4727	98.7364	294.0440	73.5110	421.9330	70.3222	522.6330	65.3291	614.2700	61.4270
50	165.2487	82.6244	261.8200	65.4550	352.4500	58.7417	443.0800	55.3850	537.7380	53.7738
60	154.7759	77.3880	237.6520	59.4130	315.1910	52.5318	411.8630	51.4829	498.4650	49.8465
70	136.3478	68.1739	217.5120	54.3780	292.0300	48.6717	359.4990	44.9374	427.9750	42.7975
80	135.4415	67.7208	203.4140	50.8535	267.8620	44.6437	339.3590	42.4199	396.7580	39.6758
90	126.9827	63.4914	187.7048	46.9262	242.6870	40.4478	293.0370	36.6296	345.4010	34.5401
(Additive NiCl2)										
10	465.2340	232.6170	794.5230	198.6308	1063.3920	177.2320	1364.4850	170.5606	1693.3960	163.9396
20	375.6110	187.8055	630.3820	157.5955	866.0200	144.3367	1093.6020	136.7003	1329.2400	132.9240
30	334.3240	167.1620	545.7940	136.4485	745.1800	124.1967	914.3560	114.2945	1141.9380	114.1938
40	276.9250	138.4625	471.2760	117.8190	625.3470	104.2245	788.4810	98.5601	936.5100	93.6510
50	233.6240	116.8120	398.7720	99.6930	531.6960	88.6160	690.8020	86.3503	818.6910	81.8691
60	218.5190	109.2595	349.4290	87.3573	459.1920	76.5320	595.1370	74.3921	684.7600	68.4760
70	196.9692	98.4846	294.0440	73.5110	412.8700	68.8117	515.5840	64.4480	606.2140	60.6214
80	178.0376	89.0188	263.8340	65.9585	345.4010	57.5668	441.0660	55.1333	525.6540	52.5654

90	147.9283	73.9642	219.5260	54.8815	281.9600	46.9933	344.3940	43.0493	412.8700	41.2870
(Additive CuCl2)										
10	475.3040	237.6520	809.6280	202.4070	1105.6860	184.2810	1402.7510	175.3439	1694.7810	169.4781
20	386.6880	193.3440	640.4520	160.1130	893.2090	148.8682	1123.8120	140.4765	1339.3100	133.9310
30	318.2120	159.1060	540.7590	135.1898	769.3480	128.2247	972.7620	121.5953	1153.0150	115.3015
40	276.9250	138.4625	466.2410	116.5603	633.4030	105.5672	799.5580	99.9448	966.7200	96.6720
50	256.7850	128.3928	391.7230	97.9308	520.6190	86.7698	677.7110	84.7139	793.5160	79.3516
60	210.4630	105.2315	340.3660	85.0915	447.1080	74.5180	566.9410	70.8676	665.6270	66.5627
70	190.3230	95.1615	292.0300	73.0075	387.6950	64.6158	473.2900	59.1613	553.8500	55.3850
80	154.0710	77.0355	247.7220	61.9305	326.2680	54.3780	396.7580	49.5948	460.1990	46.0199
90	121.8470	60.9235	174.5131	43.6283	218.5190	36.4198	258.7990	32.3499	313.1770	31.3177
(Additive Glucose)										
10	150.1437	75.0719	147.7269	36.9317	147.1227	24.5205	139.6709	17.4589	140.6779	14.0678
20	117.2148	58.6074	122.5519	30.6380	120.9407	20.1568	122.9547	15.3693	122.5519	12.2552
30	100.2972	50.1486	95.4636	23.8659	98.3839	16.3973	95.3629	11.9204	91.8384	9.1838
40	84.7894	42.3947	82.0705	20.5176	80.9628	13.4938	83.2789	10.4099	79.7544	7.9754
50	77.0355	38.5178	77.1362	19.2841	73.8131	12.3022	73.9138	9.2392	72.2019	7.2202
60	70.3893	35.1947	71.5977	17.8994	69.8858	11.6476	65.2536	8.1567	67.1669	6.7167
70	63.4410	31.7205	65.8578	16.4645	63.9445	10.6574	63.5417	7.9427	64.9515	6.4952
80	61.9305	30.9653	60.8228	15.2057	62.9375	10.4896	60.5207	7.5651	60.3193	6.0319
90	59.0102	29.5051	59.5137	14.8784	60.0172	10.0029	59.5137	7.4392	58.6074	5.8607

Table 1d: Specific and equivalent conductance values (mS)[ft]

	Additive: KCl									
%	0.002 M		0.004 M		0.006 M		0.008 M		0.01 M	
EtOH	k	Λ	k	Λ	k	Λ	k	Λ	k	Λ
10	366.5480	183.2740	602.1860	150.5465	841.8520	140.3087	1040.2310	130.0289	1222.4980	122.2498
20	318.2120	159.1060	508.5350	127.1338	660.5920	110.0987	811.6420	101.4553	987.8670	98.7867
30	255.7780	127.8890	409.8490	102.4623	563.9200	93.9867	669.6550	83.7069	830.7750	83.0775
40	223.5540	111.7770	339.3590	84.8398	466.2410	77.7068	607.2210	75.9026	690.8020	69.0802
50	190.7258	95.3629	303.1070	75.7768	423.9470	70.6578	508.5350	63.5669	599.1650	59.9165
60	184.4824	92.2412	276.9250	69.2313	375.6110	62.6018	457.1780	57.1473	548.8150	54.8815
70	174.4124	87.2062	249.7360	62.4340	333.3170	55.5528	391.7230	48.9654	466.2410	46.6241
80	154.4738	77.2369	228.5890	57.1473	294.0440	49.0073	357.4850	44.6856	415.8910	41.5891
90	139.9730	69.9865	203.4140	50.8535	262.8270	43.8045	320.2260	40.0283	369.5690	36.9569
(Additive NaCl)										
10	359.4990	179.7495	556.8710	139.2178	714.9700	119.1617	906.3000	113.2875	1063.3920	106.3392
20	293.0370	146.5185	468.2550	117.0638	604.2000	100.7000	759.2780	94.9098	856.9570	85.6957
30	250.7430	125.3715	371.5830	92.8958	503.5000	83.9167	620.3120	77.5390	724.5390	72.4033
40	217.5120	108.7560	326.2680	81.5670	418.9120	69.8187	507.5280	63.4410	601.1790	60.1179
50	178.2390	89.1195	277.9320	69.4830	357.4850	59.5808	454.1570	56.7696	541.7660	54.1766
60	161.0193	80.5097	233.6240	58.4060	329.2890	54.8815	399.7790	49.9724	467.2480	46.7248
70	148.3311	74.1656	220.5330	55.1333	286.9950	47.8325	366.5480	45.8185	422.9400	42.2940
80	143.4975	71.7488	208.4490	52.1123	276.9250	46.1542	338.3520	42.2940	397.7650	39.7765
90	138.9660	69.4830	213.4840	53.3710	280.9530	46.8255	336.3380	42.0423	401.7930	40.1793
(Additive NiCl2)										
10	517.5980	258.7990	841.8520	210.4630	1185.2390	197.5398	1482.3040	185.2880	1802.5300	180.2530
20	428.9820	214.4910	677.7110	169.4278	929.4610	154.9102	1184.2320	148.0290	1418.8630	141.8863
30	378.6320	189.3160	593.1230	148.2808	791.5020	131.9170	1007.0000	125.8750	1177.1830	117.7183
40	300.0860	150.0430	588.0880	147.0220	661.5990	110.2665	830.7750	103.8469	1017.0700	101.7070
50	260.8130	130.4065	425.9610	106.4903	573.9900	95.6650	664.6200	83.0775	825.7400	82.5740
60	220.5330	110.2665	372.5900	93.1475	506.5210	84.4202	611.2490	76.4061	675.6970	67.5697
70	202.4070	101.2035	316.1980	79.0495	412.8700	68.8117	510.5490	63.8186	609.2350	60.9235
80	204.4210	102.2105	263.8340	65.9585	343.3870	57.2312	407.8350	50.9794	490.4090	49.0409

90	147.4248	73.7124	211.4700	52.8675	271.8900	45.3150	318.2120	39.7765	383.6670	38.3667
(Additive CuCl2)										
10	538.7450	269.3725	886.1600	221.5400	1198.3300	199.7217	1482.3040	185.2880	1800.5160	180.0516
20	402.8000	201.4000	615.2770	153.8193	855.9500	142.6583	1083.5320	135.4415	1283.9250	128.3925
30	327.2750	163.6375	539.7520	134.9380	729.0680	121.5113	953.6290	119.2036	1111.7280	111.1728
40	277.9320	138.9660	460.1990	115.0498	559.8920	93.3153	706.9140	88.3643	858.9710	85.8971
50	254.7710	127.3855	421.9330	105.4833	550.8290	91.8048	654.5500	81.8188	800.5650	80.0565
60	224.5610	112.2805	352.4500	88.1125	471.2760	78.5460	588.0880	73.5110	659.5850	65.9585
70	199.2853	99.6427	300.0860	75.0215	392.7300	65.4550	473.2900	59.1613	562.9130	56.2913
80	175.8222	87.9111	255.7780	63.9445	324.2540	54.0423	390.7160	48.8395	447.1080	44.7108
90	129.6009	64.8005	180.4544	45.1136	214.4910	35.7485	254.7710	31.8464	300.0860	30.0086
(Additive Glucose)										
10	158.1997	79.0999	166.0543	41.5136	170.8879	28.4813	165.1480	20.6435	171.6935	17.1694
20	134.9380	67.4690	129.5002	32.3751	129.1981	21.5330	126.8820	15.8603	129.8023	12.9802
30	110.0651	55.0326	103.1168	25.7792	106.7420	17.7903	109.0581	13.6323	106.3392	10.6339
40	93.6510	46.8255	81.3656	20.3414	84.8901	14.1484	91.3349	11.4169	92.4426	9.2443
50	78.8481	39.4241	80.3586	20.0897	77.4383	12.9064	76.8341	9.6043	83.7824	8.3782
60	73.5110	36.7555	70.8928	17.7232	74.8201	12.4700	74.0145	9.2518	77.5390	7.7539
70	70.7921	35.3961	69.6844	17.4211	72.4033	12.0672	72.3026	9.0378	74.0145	7.4015
80	70.5907	35.2954	70.3893	17.5973	73.2089	12.2015	75.2229	9.4029	73.5110	7.3511
90	70.4900	35.2450	68.6774	17.1694	68.3753	11.3959	69.1809	8.6476	66.5627	6.6563

[k is specific conductance and Λ is equivalent conductance]

Table 2: Limiting Equivalent Molar Conductance & Walden product (Without Drug)

%	KCl		NaCl		$NiCl_2$		$CuCl_2$		Glucose	
η_0	Λ_0	$\Lambda_0\eta_0$	Λ_0	$\Lambda_0\eta_0$	Λ_0	$\Lambda_0\eta_0$	Λ_0	$\Lambda_0\eta_0$	Λ_0	$\Lambda_0\eta_0$
7.9591	162.5555	1293.7955	134.6222	1071.4716	255.8750	2036.5347	260.5584	2073.8104	10.9177	86.8951
9.8880	133.2298	1316.3104	114.3310	1129.5903	231.6027	2288.2347	217.0705	2144.6565	3.0790	30.4205
11.2824	119.5997	1349.3717	98.0207	1105.9087	171.4019	1933.8248	160.1777	1807.1889	2.3756	26.8025
12.7350	79.7192	1015.2240	69.6375	886.8336	133.9063	1705.2967	143.1352	1822.8268	1.6295	20.7517
14.1950	82.1810	1166.5593	72.7764	1033.0610	114.2551	1621.8511	137.2431	1948.1658	2.1872	31.0473
14.3500	65.4009	938.5029	54.4657	781.5828	103.5174	1485.4747	108.7898	1561.1336	1.4066	20.1847
13.6000	54.9796	747.7226	50.9782	693.3035	88.2205	1199.7988	91.3120	1241.8432	0.9805	13.3348
13.0910	52.4799	687.0144	50.6119	662.5604	88.7315	1161.5841	76.6408	1003.3047	0.5371	7.0312
12.6910	49.6932	630.6564	45.8836	582.3088	69.8485	886.4473	57.9949	736.0133	0.6640	8.4268
[chd-HCl]										
7.9591	242.5617	1930.5728	235.0676	1870.9265	868.6001	6913.2751	342.6539	2727.2167	118.2747	841.3602
9.8880	202.6397	2002.0802	177.1121	1749.8675	246.2279	2432.7317	248.7684	2457.8318	96.3093	951.5359
11.2824	158.4319	1787.4921	127.1738	1434.8257	193.9212	2187.8965	216.3911	2441.4109	76.6785	865.1175
12.7350	121.7370	1550.3207	123.1783	1568.6757	177.8484	2264.8994	167.8025	2136.9648	66.8801	851.7181
14.1950	111.3670	1580.8546	105.8975	1503.2150	158.7668	2253.6947	145.6144	2066.9964	63.6707	903.8056
14.3500	111.1217	1594.5964	105.2879	1510.8814	129.5656	1859.2664	135.4970	1944.3820	57.2490	821.5232
13.6000	96.9542	1318.5771	96.4884	1312.2422	127.5413	1734.5617	125.9887	1713.4463	55.3989	753.4250
13.0910	89.1063	1166.4906	87.7450	1148.6698	107.9027	1412.5542	114.0258	1492.7117	53.8720	705.2384
12.6910	90.5309	1148.9277	80.8040	1025.4836	95.2533	1208.8596	80.7368	1024.6307	52.1935	662.3877
[ft]										
7.9591	218.1443	1736.2323	204.8650	1630.5410	281.7313	2242.3276	285.8325	2274.9695	114.2041	908.9619
9.8880	174.4690	1723.7537	160.4669	1585.4130	225.6716	2229.6354	233.3388	2305.3873	88.8080	877.4230
11.2824	150.8568	1702.0268	133.6754	1508.1793	203.8874	2300.3392	188.4271	2125.9099	75.8296	855.5399
12.7350	115.0256	1464.8510	120.9854	1540.7491	171.5032	2184.0933	167.9014	2138.2243	64.0032	815.0808
14.1950	108.8771	1545.5104	101.7076	1443.7394	141.5010	2008.6067	158.9025	2255.6210	58.6833	833.0094
14.3500	91.6066	1314.5547	94.3049	1353.2753	136.5625	1959.6719	132.0522	1894.9491	53.8529	772.7891
13.6000	96.3271	1310.0486	85.7124	1165.6886	121.4433	1651.6289	122.1461	1661.1870	48.2104	655.6614
13.0910	88.3392	1156.4485	85.7298	1122.2888	111.8944	1464.8096	99.4025	1301.2781	46.8100	612.7897
12.6910	85.8605	1089.6556	83.0013	1053.3695	95.8516	1216.4527	80.9524	1027.3669	44.4213	563.7507

[mfm-HCl]										
7.9591	225.1729	1792.1736	229.3623	1825.5175	309.8410	2466.0555	332.3378	2645.1098	119.6393	952.2212
9.8880	201.9659	1995.4231	189.6141	1873.3873	260.5605	2574.3377	246.0151	2430.6292	101.7145	1004.9393
11.2824	159.3781	1798.1675	159.2102	1796.2732	236.3657	2666.7724	197.8832	2232.5974	82.2766	928.2275
12.7350	137.4853	1750.8753	142.0046	1808.4286	119.3457	1519.8675	179.1675	2281.6981	68.7593	875.6497
14.1950	119.6661	1698.6603	112.7004	1599.7822	166.3712	2361.6392	163.5481	2321.5653	59.4938	844.5146
14.3500	116.5024	1671.8094	101.3669	1454.6150	142.5920	2046.1952	143.8054	2063.6075	54.7777	786.0600
13.6000	113.8102	1547.8187	94.5604	1286.0214	128.9113	1753.1937	128.9536	1753.7690	52.9966	720.7538
13.0910	101.2836	1325.9036	92.3096	1208.4250	134.6015	1762.0682	117.3693	1536.4815	52.8911	692.3974
12.6910	91.8446	1165.5998	89.8274	1139.9995	97.5160	1237.5756	88.5031	1123.1928	53.2965	676.3859

[h0 is viscosity of binary solvent Λ0 is molar equivalent conducatance]

The apparent difference in the behavior of drugs in the presence of electrolytes viz. KCl, NaCl, $NiCl_2$ and $CuCl_2$ can be viewed by the difference in magnitude of Ëo values, which can be accounted for hydrophobic and electrostatic interactions. The manner in which the electrolyte ions modify the environment of drugs is markedly dependent upon the nature of the constituent ions, for e.g. salts, such as alkali metal halides which modify the environment mainly by polar forces. As the ion size decreases, its first solvation sheath also contracts and therefore the friction between this layer and the ion increases. We observed that Λ_0 decrease for all the drugs as the percentage of ethanol increases.

Walden product

P. Walden has formulated its rule for 1:1 electrolyte in the following form

$$\Lambda_0 \eta_0 = 0.82 \quad \frac{1}{rs^+} + \frac{1}{rs^-}$$

The factor $\left[\frac{1}{rs^+} + \frac{1}{rs^-}\right]$ is a measure of the hydrodynamic radii of the ions and in turn, could be used to get information about ion-solvent interaction. The Walden product (Λo ηo) shows a maximum at a particular solvent composition and then decreases monotonously. The Walden product (Λo ηo), which are informative from the point of view of ion-solvent interaction is decreasing with increase in percentage of ethanol. (Table 2) The product of ion conductance by the viscosity of the medium should be independent of the solvent nature. Hence the Walden product is expected to be constant for a given electrolyte in a series of solvent mixture in which the ion-solvent interactions are uniform.

The equivalence conductance and Walden product for ethanol-water was found to be in the order of $CuCl_2$ > $NiCl_2$ > KCl > NaCl. In all the cases Walden product for alkali halides is less than the transition metal halide which is obvious because ionization (dissociation) of salt depends on solvent properties, particularly dielectric constant. But in chd, the Λ_0 values for $NiCl_2$ are higher than $CuCl_2$, it may be due to complex formation. The mobility of ions decreases with increase in percentage of ethanol and hence the Λ_0 and Walden product in all the cases we studied decreases.

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