ELECTRICAL CONDUCTIVITIES OF THE SALT SOLUTIONS CONTAINING AGAR.

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The fact that the gelatine-sol containing salt does not change its electric conductivity on gelatinisation was already noticed by Arrhenius(1). Laing and McBain(2) observed that there is no distinction in electric conductivity between soap sol and gel at the same concentration and temperature. Soap, however, is a so-called colloidal electrolyte and differs somewhat from a hydrophile colloid. Hatschek and Humphry(3) have recently reported that the conductivity of agar, water and copper sulphate mixture exhibits on gelatinising a slight but measurable alteration. My experiments have been undertaken to test such a case, and are described in the following lines.

Powdered agar from Merck was dispersed in distilled water or in aqueous salt solution by heating in a vessel provided with a condenser on a water bath. Special precaution was taken to prevent the evaporation of the water during the dispersion and the measurement. The electrodes of the conductivity cell were made of moderately thick well platinized platinum plates and wires. The measurements were carried out in a thermostat of $50°\pm0.05°C$. Being cooled by water from outside of the conductivity cell, sol was transformed into gel always in the same condition. Two percent $CuSO_4 \cdot 5H_2O$ solution prepared at 30° was diluted up to 1/32 percent. 25 c.c. of these aqueous salt solutions were taken, and 0.5 gr. agar was added to each of them and dispersed as above mentioned. The conductivities were measured of these aqueous solutions and agar solutions in sol and gel states. The results are shown in Table 1.

TABLE 1.

Grams of $CuSO_4 \cdot 5H_2O$ in 100 c.c. of water	Specific conductivity (mho $\times 10^5$)			
	Aqueous solution	Agar solution		
		Sol	Gel	Difference
2	1011	1016	1020	4
1	598.8	606.9	609.7	2.8
1/2	353.4	388.1	390.6	2.5
1/4	209.1	252.9	255.4	2.5
1/8	122.9	170.6	171.8	1.2
1/16	70.71	122.7	123.6	0.9
1/32	40.70	100.1	101.3	1.2
Distilled water	3.039			

(1) Arrhenius, *Oefvers Stockholm Akad.*, **6** (1887), 121.
(2) Laing and McBain, *J. Chem. Soc.*, **117** (1920), 1506.
(3) Hatschek and Humphry, *Trans. Faraday Soc.*, **20** (1924), 18.

The same experiments were undertaken for other salts than $CuSO_4$, viz. K_2SO_4, KCl, KI, NaCl and KCNS solutions and the results are shown in Tables 2, 3, 4, 5, and 6 respectively. The data given in Table 2 are depicted in Fig. 1.

TABLE 2.

Conc. of K_2SO_4 normal	Specific conductivity (mho × 10^5)		
	Aqueous solution	Agar solution	
		Sol	Gel
0.2	3014	—	—
0.175	2685	—	—
0.15	2353	2270	—
0.125	2011	—	—
0.1	1656	1596	—
0.075	1289	—	—
0.05	898.5	869.2	—
0.025	481.7	486.6	490.0

TABLE 3.

Conc. of KCl millimol/litre	Specific conductivity (mho × 10^5)			
	Aqueous solution	Agar solution		
		Sol	Gel	Difference
20.0	417.6	465.8	468.3	2.5
17.5	366.2	—	—	—
15.0	315.1	369.0	370.7	1.7
12.5	264.2	—	—	—
10.0	213.6	273.0	275.2	2.2
7.5	164.2	—	—	—
5.0	109.6	176.2	177.6	1.4
2.5	57.11	126.2	127.5	1.3
1.25	29.09	99.06	100.2	1.1
0.625	15.60	—	—	—

TABLE 4.

Conc. of KI millimol/litre	Specific conductivity (mho × 10^5)			
	Aqueous solution	Agar solution		
		Sol	Gel	Difference
20.0	418.3	463.9	465.9	2.0
17.5	269.2	415.4	417.4	2.0
15.0	317.7	367.7	370.0	2.3
12.5	266.6	—	—	—
10.0	216.2	272.6	274.3	1.7
7.5	162.6	—	—	—
5.0	110.4	175.9	176.7	0.8
2.5	56.20	126.6	127.4	0.8
1.25	31.35	101.7	102.5	0.8
0.625	15.50	—	—	—

TABLE 5.

Conc. of NaCl millimol/litre	Specific conductivity (mho × 10^5)			
	Aqueous solution	Agar solution		
		Sol	Gel	Difference
20.0	356.0	409.1	410.7	1.6
17.5	313.1	366.7	369.1	2.4
15.0	269.1	—	—	—
12.5	226.4	285.0	285.8	0.8
10.0	183.5	245.3	246.3	1.0
7.5	138.8	—	—	—
5.0	94.08	160.4	161.2	0.8
2.5	48.90	117.7	118.4	0.7
1.25	25.76	96.25	97.10	0.7
0.625	13.87	—	—	—

TABLE 6.

Conc. of KCNS millimol/litre	Specific conductivity (mho × 10^5)			
	Aqueous solution	Agar solution		
		Sol	Gel	Difference
20.14	393.4	440.5	442.8	2.3
17.6225	345.5	—	—	—
15.105	298.5	352.3	354.8	2.5
12.5875	250.2	—	—	—
10.07	201.2	259.4	261.0	1.6
7.5525	152.9	—	—	—
5.035	103.2	168.7	169.9	1.2
2.5175	52.92	—	—	—
1.2588	27.30	96.74	97.07	0.3
0.6294	15.70	—	—	—

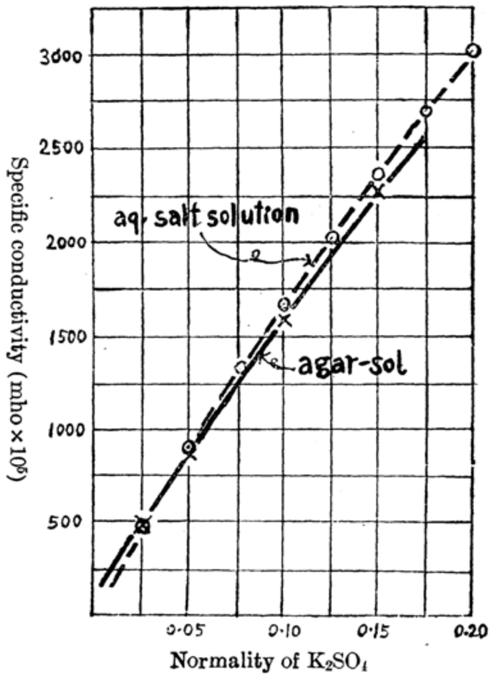

Fig. 1.

The conductivity of agar dispersed in distilled water has also been measured and the results are as follows. On ignition the agar has left ashes amounting from 3.5 to 4.0 percent.

TABLE 7.

Gram of agar in 25 c. c. of water	Specific conductivity (mho × 10^5)		
	Sol	Gel	Difference
0.1	18.45	18.19	−0.26
0.2	33.34	33.09	−0.25
0.3	47.53	47.38	−0.15
0.4	61.14	61.29	+0.15
0.5	73.77	74.47	+0.70
0.7	95.94	97.36	+1.42
1.0	130.0	132.5	+2.5

All the measurements, in which 0.5 gr. agar were dispersed in 25 c.c. of salt solutions, have confirmed the results observed by Hatschek and Humphry with regard to conductivity alteration on sol-gel transformation, and at the same time support Prof. P.P. von Weimarn's opinion on this phenomena[(1)], which read " by the aggregation or growth of particles during gelation and the consequent reduction in surface, adsorbed electrolyte might be liberated, which would account for the higher conductivity of the gel." When we assume the agar sol and gel are heterogeneous system and the conductivity of agar-water-salt system is almost all ascribed to the dissolved salt, then we are capable of calculating the quantity of electrolyte adsorbed on the surface of agar particles. The value of conductivity of agar dispersed in pure water was subtracted from that of agar dispersed in salt solution, and the salt concentration corresponding to this conductivity value can be obtained from the curve of conductivity–salt concentration in pure aqueous solution which we can easily draw by the direct determination. The difference between the salt concentration thus obtained and that of the original may

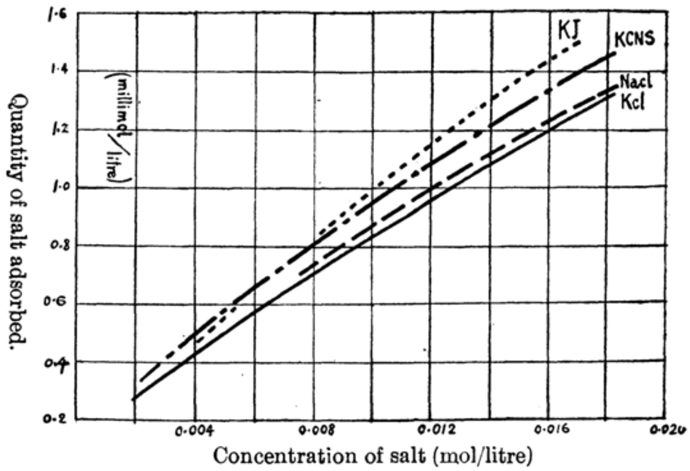

Fig. 2.

(1) *Trans. Faraday Soc.* 20 (1924), 29.

be regarded as the adsorbed quantity of the salt on the agar particles. Fig. 2 shows the adsorption of salts due to two percent agar sols.

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