

# On the Double Salts of Stannous and Potassium Chlorides.

By

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It is well known that stannous chloride forms several double and complex salts,<sup>1</sup> but the statement in literature concerning those with alkali chlorides are partly conflicting. The comparatively recent investigation of Remsen and Richardson<sup>1</sup> has ascertained, concerning those with potassium chloride, the existence of the following two double salts:  $\text{Cl}_2\text{Sn}.\text{ClK}.\text{H}_2\text{O}$  and  $\text{Cl}_2\text{Sn}.2\text{ClK}.2\text{H}_2\text{O}$ . From the stand point of heterogeneous equilibrium a further study of the double salts has been undertaken in order to verify their existence and moreover to determine the conditions for it.

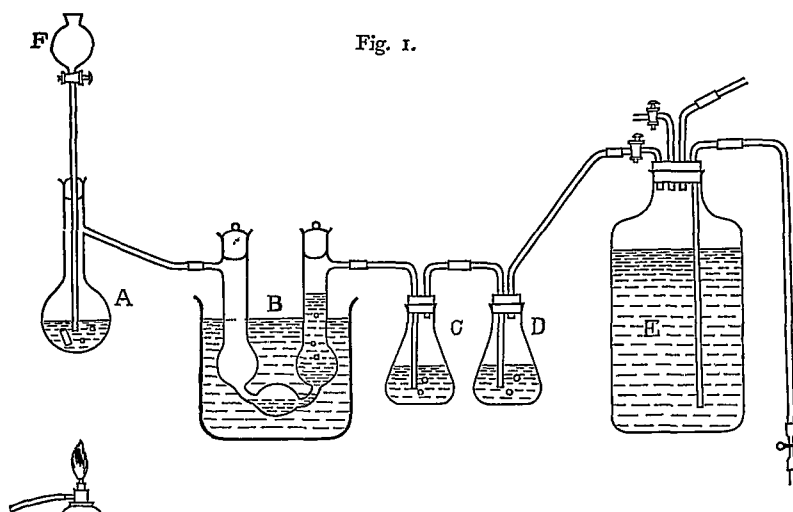
"Extra pure" potassium chloride from C. Merk was recrystallised for use. Stannous chloride ("White Crystal") from the same factory, was dissolved in water free from air, granulated tin and hydrochloric acid were added and the mixture was warmed. On cooling the solution gave crystals. Most of the mother liquor was decanted off; and the crystals were placed in a sieve funnel in an atmosphere of nitrogen; and the rest of the mother liquor was removed by sucking nitrogen through the funnel and then pressing between folded filter paper. This process was repeated; and the final preparation contained 99.5% salt. Its melting point was 39.5°.

The experiments were begun on one side with water and stannous chloride, and on the other with water and potassium chloride, potassium chloride or stannous chloride, respectively, being added in gradually increasing quantities; and the experiments were carried out in the following way. Some boiled water was added to a mixture of the two salts; and the mixture was heated in a current of nitrogen until a complete

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<sup>1</sup> Amer. Chem. J., 14, 89 (1892).

dissolution took place. The solution was allowed to cool; and in a thermostat at  $25.0^{\circ}\text{C}$ . it was made to rotate for about two hours, as it was ascertained that in that period of time equilibrium would be attained. It was then further allowed to stand in the thermostat; and, when the crystals subsided, a portion of the clear mother liquor was taken out for analysis with a pipette warmed to above  $25^{\circ}\text{C}$ . The residue was taken out with a seive spoon and pressed between folded filter paper in the same thermostat in order to remove as much as possible the adhering mother liquor. The crystals, still wet with mother liquor, were subjected to analysis.



The composition of the solution and the wet residue was estimated by determining tin and the total chloride, the former by iodometry in the usual way and the latter by the following somewhat complicated method.

A portion of the sample was weighed in a small glass tube and put into a flask with a side tube and a well fitted glass stopper provided with a funnel as shown in Fig. 1. About 30 cc. of water and some potassium permanganate in crystals were added. Then the apparatus was set up as seen in the figure; and, while the aspirator *E* was in action, tolerably concentrated sulphuric acid was poured slowly into the flask *A* through the funnel *F*. The mixture of chlorine thus produced and the air entering through *F* passed through the vessels *B* and *C* both of which contained potassium iodide solution. After a period of about one hour *A* was warmed to such a

degree that no oxygen was liberated, and the aspirator was in action still about two hours. During the process *B* and *C* were kept cold to prevent any decomposition of potassium iodide by heat and to make easy the absorption of gas. Then the flask *A* was heated somewhat strongly for about half an hour; and thus after cooling air was again passed through the apparatus for about one hour. Thus the operation ended; and the iodine, liberated by chlorine in *B* and *C*, was titrated by sodium thiosulphate as usual. The flask *D*, which also contained potassium iodide solution, remained always colourless, testifying to the complete absorption of chlorine in *B* and *C*.

To verify the procedure a known mixture of stannous and potassium chlorides was analysed with the following result:

Sample taken.		Chlorine in it.	Chlorine found.
Potassium chloride	0.2730	0.1298	—
Stannous chloride	0.8827	0.1883	—
Total	1.1557	0.3181	0.3168

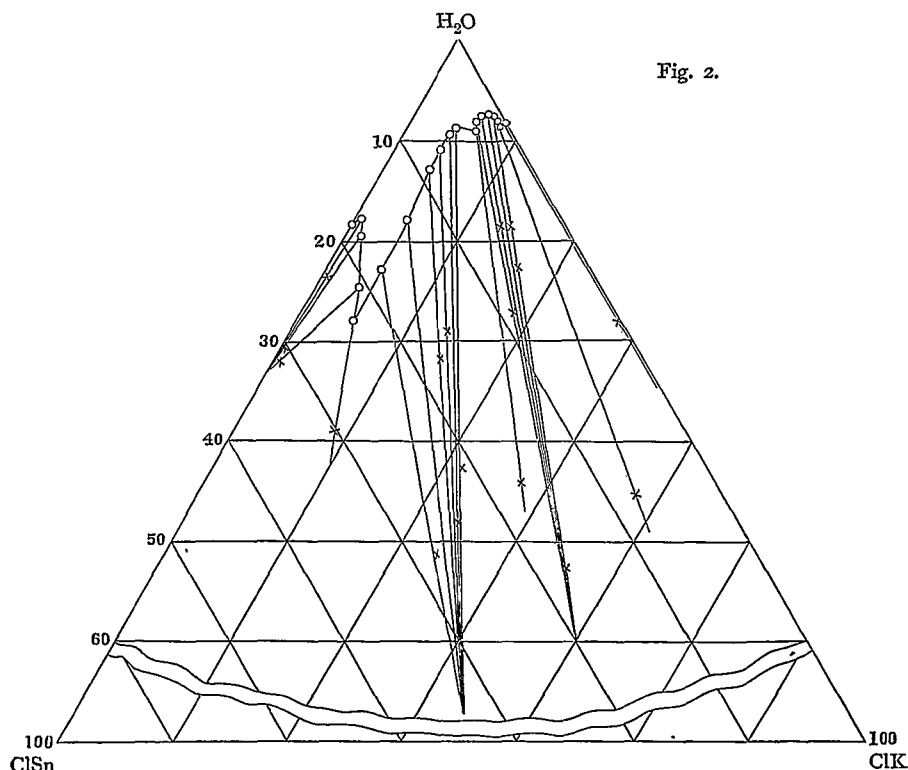


Fig. 2.

From the results of analysis, which was repeated two or three times for the same sample, Table I was calculated, while in Fig. 2 these values are represented graphically. In Fig. 2, the three points, to any of which the lines connecting the points representing the solutions and the corresponding wet residues converge, are those representing  $\text{Cl}_2\text{Sn} \cdot 2\text{H}_2\text{O}$ ,  $\text{Cl}_2\text{Sn} \cdot \text{ClK} \cdot \text{H}_2\text{O}$  and  $\text{Cl}_2\text{Sn} \cdot 2\text{ClK} \cdot 2\text{H}_2\text{O}$  respectively.

TABLE I.

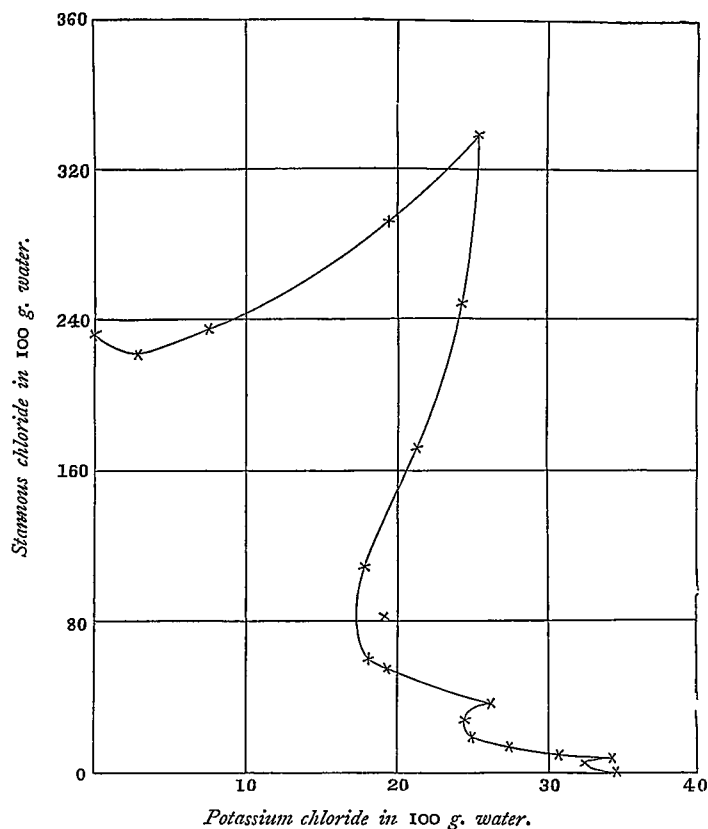
No.	Solution. (In molar percentage.)			Residue wet. (In molar percentage.)		
	Stannous chloride.	Potassium chloride.	Water.	Stannous chloride.	Potassium chloride.	Water.
1	18.17	—	81.83	—	—	—
2	17.33	0.57	82.10	23.80	0.12	76.08
3	18.04	1.22	80.74	30.12	0.24	69.64
4	20.78	3.77	75.45	31.41	0.15	68.44
5	23.10	4.68	72.22	30.08	8.29	62.63
6	18.11	4.78	77.11	27.94	23.55	48.51
7	13.34	4.45	82.21	14.71	6.16	79.13
8	8.90	3.94	87.16	17.41	14.03	88.56
9	6.89	4.30	88.81	15.61	13.55	70.84
10	5.04	4.12	90.84	24.35	23.62	52.03
11	4.67	4.49	90.84	20.76	21.40	57.84
12	2.96	6.01	91.03	16.85	27.40	55.75
13	2.43	5.70	91.87	8.88	18.12	73.00
14	1.53	5.81	92.66	5.87	12.88	81.25
15	0.90	6.43	92.67	6.23	15.15	78.62
16	0.51	7.19	92.30	4.70	13.65	81.65
17	0.52	7.43	92.05	16.90	35.82	47.28
18	0.38	7.94	91.68	7.61	38.00	54.39
19	0.25	7.54	92.21	0.19	27.42	72.38
20	—	8.11	91.89	—	—	—

The compositions of the solution were recalculated in grams solute per 100 grams water and are given in Table 2 and Fig. 3.

TABLE 2.

No.	Stannous chloride.	Potassium chloride.	Residue.
1	234.05	—	} $\text{Cl}_2\text{Sn}.2\text{H}_2\text{O}$
2	222.55	2.73	
3	235.50	7.49	
4	290.30	19.66	
5	337.20	25.51	} $\text{Cl}_2\text{Sn}. \text{ClK}. \text{H}_2\text{O}$
6	247.50	24.38	
7	170.70	21.26	
8	107.65	17.79	
9	81.78	19.06	} $\text{Cl}_2\text{Sn}.2\text{ClK}.2\text{H}_2\text{O}$
10	58.48	17.85	
11	54.19	19.45	
12	34.28	5.99	
13	27.88	24.40	} $\text{Cl}_2\text{Sn}.2\text{ClK}.2\text{H}_2\text{O}$
14	17.42	24.68	
15	10.24	27.30	
16	5.83	30.65	
17	5.95	31.76	} $\text{ClK}$
18	4.37	34.08	
19	2.86	32.17	
20	—	34.73	

Fig. 3.



### Summary.

1. The solubility of stannous and potassium chlorides in the presence of each other, at 25°, has been determined.
2. The two kinds of their double salts already known, and no more, have been found to exist at 25°.
3. The conditions under which they can exist at 25° under solutions have been determined.

I desire to express my indebtedness to Prof. Y. Osaka for the suggestion of the subject and advice throughout this investigation.