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Ben H. Peterson  
*Coe College*

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## THE SIMULTANEOUS ADSORPTION OF SALTS BY COLLOIDAL ALUMINIUM HYDROXIDE

BEN H. PETERSON

In a series of studies on the adsorption of electrolytes by colloidal suspensions of metallic hydroxides, Sen (1) and his collaborators have measured the adsorption of a large number of electrolytes by various hydroxides. In determining the adsorption of acids by colloidal Ferric Hydroxide, he precipitated the colloid by means of KCl and  $\text{NH}_4\text{Cl}$  inasmuch as the acids tended to stabilize the sol. The effect of the salts was considered to be negligible upon the adsorption of the acids. Gelasco (2) by measuring the adsorption of various salts by colloidal  $\text{MnO}_2$  concluded that the logarithms of the adsorption curves for all salts were parallel. In another investigation Mehrota and Sen (3) showed that the presence of one salt did not materially effect the adsorption of another by colloidal  $\text{MnO}_2$ . This had also been repeatedly observed by Weiser (4). But both authors have also found that the adsorption of pairs of electrolytes simultaneously is not equivalent to the sum of either alone, being in some cases greater and in some cases less.

It seemed to be of interest therefore to test quantitatively the effect of one salt on the adsorption of another, using salts which could be measured accurately in very small concentrations. From this study it may be possible to determine the mechanism of the antagonistic behavior of certain salts on the coagulation of colloidal suspensions.

### EXPERIMENTAL

Colloidal Aluminium Hydroxide was prepared by precipitation from a solution of  $\text{AlCl}_3$  with  $\text{NH}_4\text{OH}$ . This was washed until dispersion took place and then dialyzed by Bradfield's method. The suspension so prepared gave no reaction for the chloride ion. This was diluted with water, stabilized with a little HCl and stored for twenty days. The storage was to eliminate any changes in adsorption capacity during the progress of the experiment. The sol so prepared was uniform and apparently very stable. Fifty cc. samples were then put in each of four series of bottles, eight in each series. To each series was added the coagulating electrolyte in

increasing quantities. Then to series 2, 3 and 4 was added the second electrolyte, a constant amount for each series. The bottles were agitated at regular intervals for several hours and allowed to stand until the coagulated sol settled out. The supernatant liquid was then analyzed for the salt content and the amount of adsorption was calculated as the difference between the added and residual electrolyte. In the low concentrations where the colloid did not coagulate the sol was filtered off by means of a Berkefeld filter cone.

RESULTS

The Effect of Sulfate Ion on the Adsorption of Ferricyanide Ion.

Conc. of sol as  $Al_2O_3$ -----0.03427 gms. per sample

*Milligrams  $K_3Fe(CN)_6$  and  $K_2SO_4$  added*

SERIES	SAMPLE	A	B	C	D
	1	0.4			
	2	0.8			
	3	1.0	Same as A with the $K_2SO_4$ added as shown		
	4	1.6	2.5 mg. 5.0 mg. 10.0 mg.		
	5	2.0			
	6	2.8			
	7	4.0			
	8	4.8			

*Milligrams  $K_3Fe(CN)_6$  Left in Each Sample*

SERIES	SAMPLE	A	B	C	D
	1	0.00	0.13	0.19	0.22
	2	0.00	0.21	0.45	0.55
	3	0.00	0.38	0.59	0.68
	4	0.16	0.73	1.05	1.21
	5	0.32	1.08	1.38	1.52
	6	0.94	1.77	2.04	2.13
	7	2.00	2.71	3.02	3.05
	8	2.64	3.27	3.53	3.78

*Milligrams Adsorbed*

SERIES	SAMPLE	A	B	C	D
	1	0.40	0.27	0.21	0.18
	2	0.80	0.59	0.35	0.25
	3	1.00	0.62	0.41	0.32
	4	1.44	0.87	0.55	0.39
	5	1.68	0.92	0.62	0.48
	6	1.86	1.03	0.76	0.67
	7	2.00	1.29	0.98	0.95
	8	2.16	1.53	1.27	1.02

These results are shown plotted in Figures I and II in which the concentrations are expressed as millimols.

Figure I

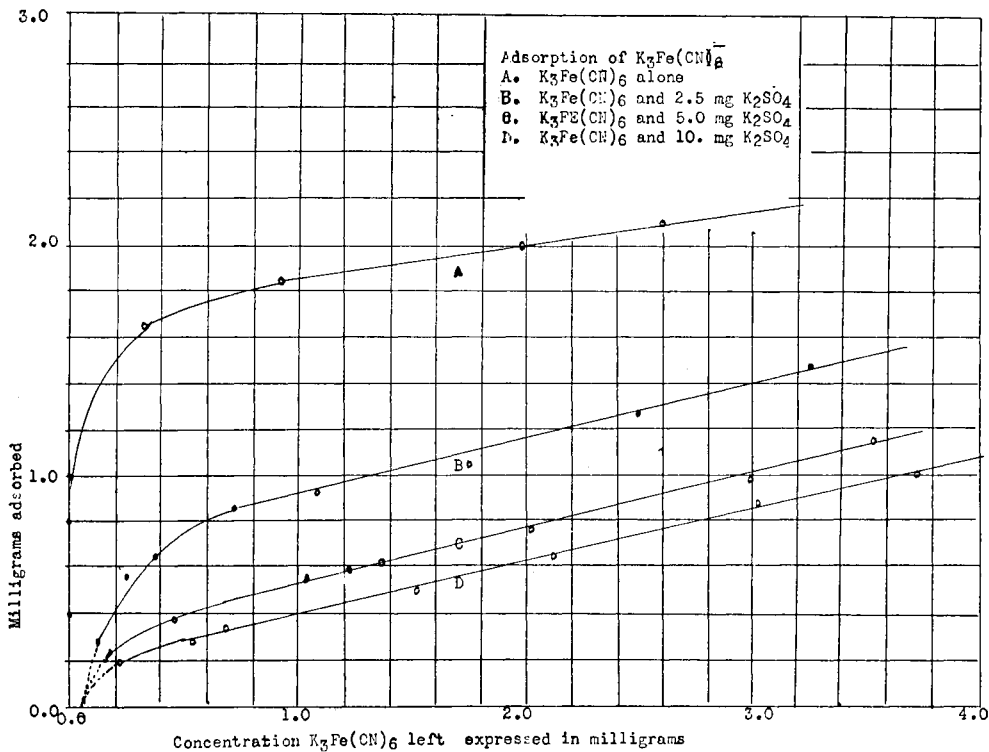
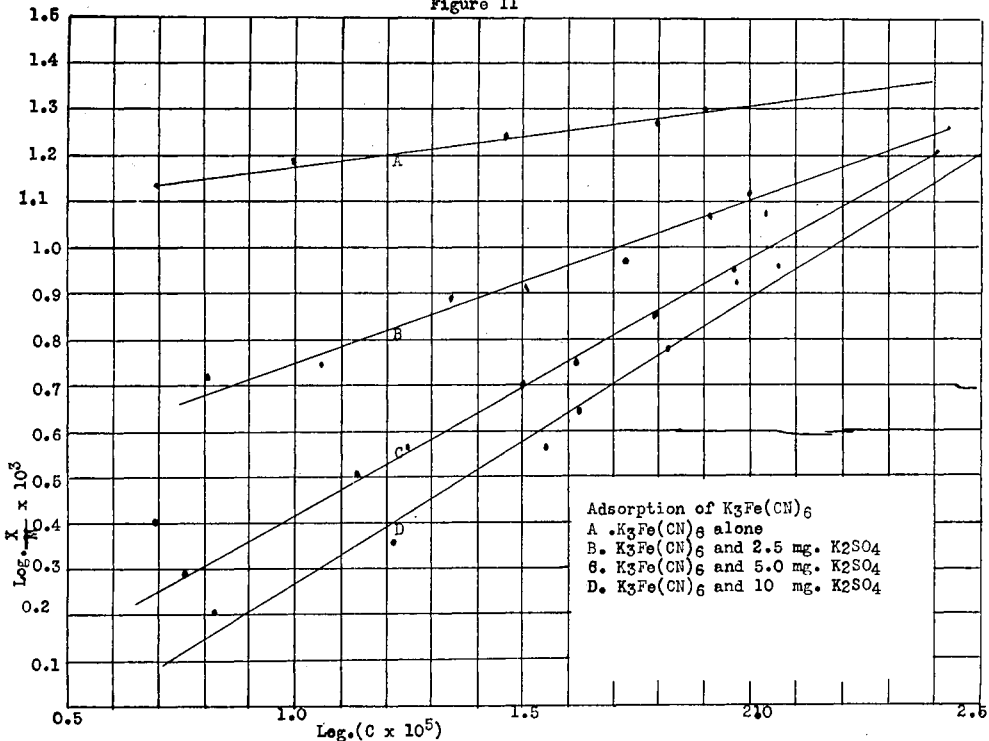


Figure II



DISCUSSION OF RESULTS

The results as plotted show fair accord with the Freundlich adsorption isotherm within the range of complete coagulation, the sulfate ion changing the constants of the equation. Contrary to Sen's observation the additional ion does change the adsorption of a salt. In figure II the results are plotted according to the equation

$$n \log \left( \frac{X}{M} \right) = \text{Log } C + \text{Log } K$$

in which  $\log C$  is plotted against  $\log \left( \frac{X}{M} \right)$ .  $C$  is the concentration of  $K_3Fe(CN)_6$  left in the bottle expressed as millimols,  $X$  is the amount adsorbed and  $M$  is the mass of the colloid as  $Al_2O_3$ . The curves are fairly representative of the adsorption isotherms of salts by hydrous oxides. If, however, the adsorption values of uncoagulated sol are included a sharp break in the log curve occurs. This would seem to indicate that the type of adsorption by the material in the colloidal form or the coagulation adsorption differs from that of the coagulated material. The slope of the curves varies with the sulphate content. This might be interpreted as showing that the effect on the adsorption of the ferricyanide is not uniform but depends also upon the concentration of the ferricyanide. If the sulphate was absorbed to a certain uniform degree the slopes would have been constant, the curves differing only by the value of the Constant  $K$ . This may throw some light on many conflicting observations on coagulation concentrations. If the amount of electrolyte required is relatively large the addition of another salt will have a different effect than if the amount required is small.

This work is being extended to include mono, di and tetra valent ions.

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COE COLLEGE,  
 CEDAR RAPIDS.