have been able to use this method is to about 5% of the total figure; that is to 0.005% when the reading is 0.10% CO_2 and to 0.20% when the reading is 4% CO_2.

The above solutions were standardized for temperatures of 20° to 25°. If the temperature is higher, the percentages as read are too low; if the temperature is lower, the percentages are too high. A temperature of 15° gave readings about 10% too high and one of 30°, 10% too low. This difficulty may be obviated by immersing the tubes in water at 20–25°, and blowing the air through the bicarbonate solution thus immersed. Changes in humidity do not affect the readings.

As the color of the standard bicarbonate solutions varies according to the carbon dioxide pressure of the air passing through it, in places where the barometer reads higher than 800 mm. or lower than 730 mm. a correction must be applied to the percentages given on the standard tubes. Variations of the barometer from day to day are negligible. The corrected percentage would be $\frac{\text{barometer}}{760} \times \%\ CO_2$ read.

The method is not applicable in the presence of acid or ammonia fumes. As outdoor air always contains practically the same percentage (0.03%) of CO_2, the bicarbonate solution "A" may be easily checked.

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STUDIES IN DIALYSIS.

II. THE HOT DIALYSIS OF THE CHLORIDES OF FERRIC IRON, CHROMIUM AND ALUMINIUM, AND THE RAPID PREPARATION OF THEIR COLLOIDAL HYDROUS OXIDES.

BY MARKS NEIDLE AND JACOB BARAB.

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The primary object of the present research was the application of the method of hot dialysis[1] to the rapid preparation of the colloidal hydrous oxides of ferric iron, chromium and aluminium. Incidentally we have studied the "cold dialysis" of the chlorides of these three metals, with continuous changing of diffusate, and contrasted our results with those of previous investigators. An attempt has also been made, as far as possible, to standardize the methods employed by furnishing sufficient details to enable others to approximately reproduce our results.

In general, when one wishes to prepare a hydrosol fairly free from electrolytes by the usual method of dialysis, it is necessary to dialyze for about thirty days. Some investigators have permitted their dialyses to extend for greater periods, in several cases as long as six months.[2]

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[1] Neidle, THIS JOURNAL, **38**, 1270 (1916).

[2] Pappadà, *Z. Ind. Chem. Koll.*, **9**, 233 (1911).

This tedium of the process of dialysis, on the one hand, has kept many chemists from entering the field of colloid chemistry, and on the other hand, has been responsible for erroneous conclusions as to the properties of some colloidal solutions because they had not been sufficiently dialyzed.

As an instance of the latter we will quote from Biltz:[1]

> "Behavior of the prepared colloids towards some electrolytes (0.2 *N* solutions employed unless otherwise stated). The most stable is thorium hydroxide: 5 cc. remain clear even on addition of 5 cc. *N* sodium chloride; several drops of dilute sulfuric acid do not cause precipitation, while it is precipitated by a saturated sodium chloride or 30% ammonium sulfate. Colloidal chromic hydroxide is also comparatively stable towards electrolytes; sodium chloride or barium chloride does not produce cloudiness; equally little a few drops of hydrochloric acid; sulfuric acid and saturated sodium chloride, however, produce pronounced turbidity and precipitation. The sols of ferric hydroxide and stannic hydroxide behave similarly."

He prepared the sols of hydrous ferric and chromic oxides by dialyzing the normal nitrate solutions in the cold for eight days, through parchment paper thimbles, with intermittent changing of the diffusate.

Our precipitation data, given in Table I, remembering that potassium and sodium chlorides have about equal precipitating powers, demonstrate that the stability of Biltz's sols was unquestionably due to their high electrolyte content, resulting from the insufficiency of eight days' dialysis as conducted by him.

TABLE I.

	Composition in g. equivalents per liter.		0.1 *N* KCl required to precipitate 10 cc. of sol.	
Sol.	Oxide.	HCl.	Cc.	Remarks.
$Fe_2O_3.xH_2O$	0.728	0.027	1.00	All sols were perfectly clear by both transmitted and reflected light. $Cr_2O_3.xH_2O$ sol No. 2 rendered perfectly stable toward 0.1 *N* KCl, by addition of 0.5 cc. 0.1 *N* $CrCl_3$ to 10 cc. of sol.
1 $Cr_2O_3.xH_2O$	0.0693	Trace	0.37	
2 $Cr_2O_3.xH_2O$	0.0984	0.0020	3.00	
3 $Cr_2O_3.xH_2O$	0.0888	0.0058	30.0 failed to precipitate	

In the first paper[2] of this series it was shown that it is possible to conduct the intermittent dialysis of a colloidal solution of hydrous chromic oxide in chromic chloride so that finally little or no colloid will remain in the membrane. It was also shown that intermittent dialysis was less favorable than continuous dialysis to the growth of the colloidal particles. Graham's[3] failure to obtain the hydrous oxide sols by dialysis of normal aluminium and chromic chloride solutions may, therefore, be attributed to his method of dialysis which was intermittent.

Biltz[4] thought it desirable to prepare the sols of the hydrous oxides of the polyvalent metals by dialysis of their pure salts. He chose the

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[1] *Ber.*, **35**, 4431 (1902).

[2] THIS JOURNAL, **38**, 967 (1916).

[3] *Phil. Mag.*, [4] **23**, 290 (1862).

[4] *Ber.*, **35**, 4431 (1902).

nitrates, principally because he believed that the chloride solutions when dialyzed would yield no colloid unless first treated with the corresponding hydrous oxide. Van Bemmelen[1] obtained a hydrous ferric oxide sol by dialysis of a ferric chloride solution for 2–3 weeks. He used the chloride in preference to the nitrate because hydrochloric acid is easier to determine than nitric acid. He was primarily interested in adsorption, and said nothing definite about his method of dialysis, or about the nature and quantity of the colloid obtained.

The hydrolysis of aqueous solutions of ferric iron, aluminium and chromic chlorides, upon which the formation of colloids from them depends, is well shown by their diffusion in gelatin jelly containing phenolphthalein just tinged with sodium carbonate.[2] The hydrochloric acid is seen to diffuse much faster than any of the other products of hydrolysis or the unhydrolyzed solute. In dialysis, likewise, the hydrochloric acid passes through the membrane most rapidly. This will contine if the diffusate is constantly changed; otherwise, the diffusion of the hydrochloric acid will slacken down, and the other products of hydrolysis will continue to diffuse until the composition on both sides of the membrane will be the same. A continuous flow of distilled water into the diffusate, *i. e.*, continuous dialysis, will be most conducive to progressive hydrolysis and colloid formation.

The temperature coefficients of the hydrolysis of the chlorides of aluminium, ferric iron and chromium are very considerable.[3] The hydrolysis effect added to the other factors introduced in hot dialysis,[4] would lead us to expect that the dialysis of ferric, chromic and aluminium chloride solutions will proceed at a far greater rate and more colloid will be formed if they are heated during the process.

Methods and Results.—All membranes were of parchment paper[5] and were prepared by moistening discs of 38 cm. diameter, folding into a bag, and tying to the flanged end of a glass tube (15 cm. long and 2 cm. in diameter).

Commercial C. P. chlorides were employed in all except a few experiments, in which, specially prepared green chromic chloride[6] was used. The commercial aluminium and ferric chlorides were crystalline and seemed pure enough for our purposes, but the commercial C. P. chromic chloride was lumpy. It had the appearance of pitch and gave results as follows when analyzed: Chromium, 100 equivalents ($^1/_3$ Cr); chlorine, 90 equiva-

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[1] *Z. anorg. Chem.*, **36**, 380 (1903).

[2] Proctor and Law, *J. Soc. Chem. Ind.*, **28**, 297 (1909).

[3] Bjerrum, *Z. physik. Chem.*, **59**, 343 (1907).

[4] Neidle, THIS JOURNAL, **38**, 1270 (1916).

[5] No. 40, unless stated otherwise, Genuine Vegetable Parchment, Glen Mills Paper Co., Philadelphia.

[6] Higley, THIS JOURNAL, **26**, 613 (1904).

lents (1 Cl); sulfate, 3.3 equivalents ($^1/_2$ SO_4). Since really C. P. chromic chloride cannot be readily obtained, it was decided to use the commercial product as it was, feeling that the impurities would have little influence on the results.

I. Dialysis in the Cold.—The salt was made up to about 300 cc. and placed in the dialyzer. The membrane was supported in a glass bowl through which distilled water percolated at the rate of about two liters per hour for the first twenty four hours, and thereafter at about one liter per hour. (See diagram in first paper.[1])

Table II.

Substance.	Mols in 300 cc.	Length of dialysis. Days.	Length of dialysis. Hrs.	Volume of sol. at the end of dialysis.	% of chloride transformed to colloid.	Ratio equiv. metal / equiv. Cl in colloid.	Remarks.
$AlCl_3.6H_2O$	0.0621	14	21	255	2.17	27.73	Sol perfectly clear.
$FeCl_3.6H_2O$	0.0444	18	0	280	66.1	44.3	Sol brownish red, clear in transmitted light, turbid in reflected light. Slight yellowish brown sediment on standing.
$CrCl_3$ (commercial)	0.0216	11	3	310	7.72	41.3	Sol perfectly clear both in reflected and transmitted light.
$CrCl_3.6H_2O$ (spec.)	0.0188	5	1	320	0.52	2.5	Sol practically colorless.

The results in Table II show that the colloidal hydrous oxides of ferric iron, aluminium and chromium may be obtained by the continuous dialysis in the cold of solutions of the pure chlorides of aluminium and ferric iron,[2] and the commercial chloride of chromium.

Very little colloid is obtained by dialyzing, in the cold, a solution of specially prepared, green chromic chloride. The relatively high percentage of colloid formed in the case of the commercial chromic chloride is due to the presence of a little colloid in the original solution, which accelerates the hydrolysis of the chromic chloride.[3]

Other conditions being equal, one would expect the yield of colloid obtainable to be proportional to the degree of hydrolysis. But since the colloidal hydrous oxide accelerates the hydrolysis of the chloride, the amount of colloid formed will increase more rapidly than the degree of hydrolysis. This will help to explain the great difference between the yields of colloidal hydrous oxides of aluminium and ferric iron. It will also be seen later

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[1] This Journal, 38, 1963 (1916).

[2] A ferric nitrate solution, whose concentration was equivalent to the chloride solution, gave a clearer sol, but the yield of colloid was slightly less.

[3] Goodwin and Grover, *Phys. Rev.*, 11, 193 (1900).

that hydrous aluminium oxide like hydrous chromic oxide may pass through the membrane, but this phenomenon has not been observed in the case of hydrous ferric oxide.

The formation of the colloidal hydrous oxide by dialysis of the chloride of a trivalent metal, is conditioned by hydrolysis into the free hydroxide, either directly or in steps.

$$MCl_3 + 3H_2O \rightleftarrows M(OH)_3 + 3HCl.$$

$$2M(OH)_3 + (x - 3)H_2O \rightleftarrows M_2O_3.xH_2O.$$

Green chromic chloride dissociates in aqueous solution like a salt of a monovalent metal, or only one of the chlorine atoms becomes ionic. Such salts diffuse completely through dialysis membranes. Therefore, no colloidal hydrous chromic oxide can be obtained by dialyzing a solution of the green chloride, but no sooner is such a solution prepared than there is a change to the violet chloride, until a dynamic equilibrium between the two forms exists. The violet chloride does hydrolyze into the free hydroxide and, therefore, should be capable of yielding colloid. When the dialysis was stopped at the end of five days and one hour, a "trace" of colloid was found in the membrane. This small yield of colloid is partly due to the fact that the particles of hydrous chromic oxide can diffuse through the membrane as long as the ratio of chromium to chlorine in the sol is less than a certain value depending on the concentration of chromic oxide.

The transformation of the green into the violet form of chromic chloride, in aqueous solution, requires appreciable time. Consequently dialysis of a solution of the green chloride immediately upon preparation, as was the case in the experiment recorded in Table II, will yield a minimum of colloid. If we hasten the establishment of equilibrium by heating to boiling, and then dialyze when the solution has cooled, we should expect a higher yield of colloid. This was done, and the yield of colloid from the same concentration of chromic chloride, dialyzed for the same length of time, was 4% instead of 0.52%. The purity, however, was slightly lower.

II. Hot Dialysis.—All solutes were made up to 400 cc. in a 2 liter low form beaker. The membrane is about three-quarters filled with distilled water which percolates through it at the rate of about two liters per hour, the level being kept constant by means of an automatic siphon.[1] Before starting a dialysis, the solution in the beaker is heated somewhat above the temperature at which the process is to be conducted, to allow for cooling which takes place when the solution is brought into contact with the membrane and its cool contents. The beaker is now raised, so that the membrane enters the solution until the level

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[1] THIS JOURNAL, 38, 1270 (1916).

inside the membrane is 1–2 cm. higher than that in the beaker. The required temperature is maintained within 5° by means of a gas flame or electrically. In general, the temperatures inside the membrane and of the solution in the beaker differed by 15 to 20°.

The process may be permitted to continue, with but little attention, day and night, evaporation being compensated by diffusion of water through the membrane. Occasionally a little water must be poured into the beaker to maintain the original volume. Only the solutions containing aluminium chloride had a tendency to clog up the pores of the parchment paper, and evaporate considerably overnight.

The temperature of dialysis was between 75 and 80° in all except two cases. In these, where the solutions were maintained at the boiling temperature, it was necessary to replenish the loss due to excessive evaporation by occasional additions of hot water.

A. Dialysis of the Chloride Solutions at 75–80°.

TABLE III.

Substance.		Mols in 400 cc.	Length of dialysis. Hours.	% of chloride transformed into colloid.	Ratio $\frac{\text{equivalents metal}}{\text{equivalents Cl}}$ in colloid.	
$AlCl_3.6H_2O$		0.0207	37.0	9.45	23.4	
		0.0622	38.5	9.16	14.1	
		0.1037	45.0	7.68	8.9	
		0.2073	53.0	3.41	7.7	
$CrCl_3.?H_2O$	(1)	0.0108	42.5	57.1	> 1500	
	(2)	0.0216	56.0	49.4	> 1500	
(commercial)	(3)	0.0541	48.0	35.4	198.1	
	(4)	0.1082	41.5	19.9	104.0	
	(5)	0.2165	49.5	18.6	48.1	
$CrCl_3.6H_2O$	(6)	0.0188	72.0	31.6	444	(99.7% Cr_2O_3)
(special)						(0.3% HCl)
$FeCl_3.6H_2O$		0.0185	32.5	80.7	29.5	
		0.0925	32.5	70.1	30.9	
		0.1850	52.0	59.9	28.3	
		0.2775	54.0	51.5	22.3	
		0.3700	25.0	50.7	12.3	

Description of Sols Obtained at 75–80°.—The hydrous aluminium oxide sols were all opalescent and turbid, and a slight sediment settled out on standing.

The hydrous chromic oxide sols varied in appearance and stability as follows:

(1) Perfectly mobile, homogeneous and clear green after standing nine days. It gelled in the bottle at the surface of the solution in contact with the glass. When examined about a month after its preparation, the sol was found to have gelled to a homogeneous, clear green, thin jelly, which broke up on shaking, yielding a gelatinous precipitate and a colorless mother liquid.

(2) Towards the end of the dialysis, when the sol was exceedingly pure, small, white, fiber-like strands were formed in the solution. (A similar phenomenon was observed in the hot dialysis of a colloidal solution of hydrous ferric oxide.) The sol was homogeneous, mobile and faintly turbid when prepared, but, on standing, gelled partly.

(3) Perfectly clear green, mobile sol. No tendency to gel after standing for ten days.

(4) Perfectly clear, deep green, viscid sol when prepared, but on standing changed to homogeneous fairly consistent gel.

(5) Clear sol, and after standing two months showed no tendency to gel.

(6) Clear and mobile when prepared; gelled on standing.

The hydrous ferric oxide sols were all of the yellow ochre variety All had a tendency to settle, especially the last, which may be considered a suspension. In very dilute solution, all these sols were yellow, opalescent and more stable.

The fact that the very pure hydrous chromic oxide sols are stable while hot and gel rather slowly at room temperature, leads to the following conclusions:

1. The higher the temperature the less electrolyte is necessary for the stability of a sol.

2. Attainment of adsorption equilibrium requires considerable time at room temperature.

Our observations on the very pure hydrous chromic oxide sols also show that *the concentration of electrolyte necessary for stability at a given temperature increases with increase in concentration of colloid.*

Observations on Results in Table III.—(*a*) By comparison with Table II, we see that the yield of colloid is far greater in hot solutions than in cold ones, which, in consideration of the high temperature coefficient of hydrolysis, is to be expected.

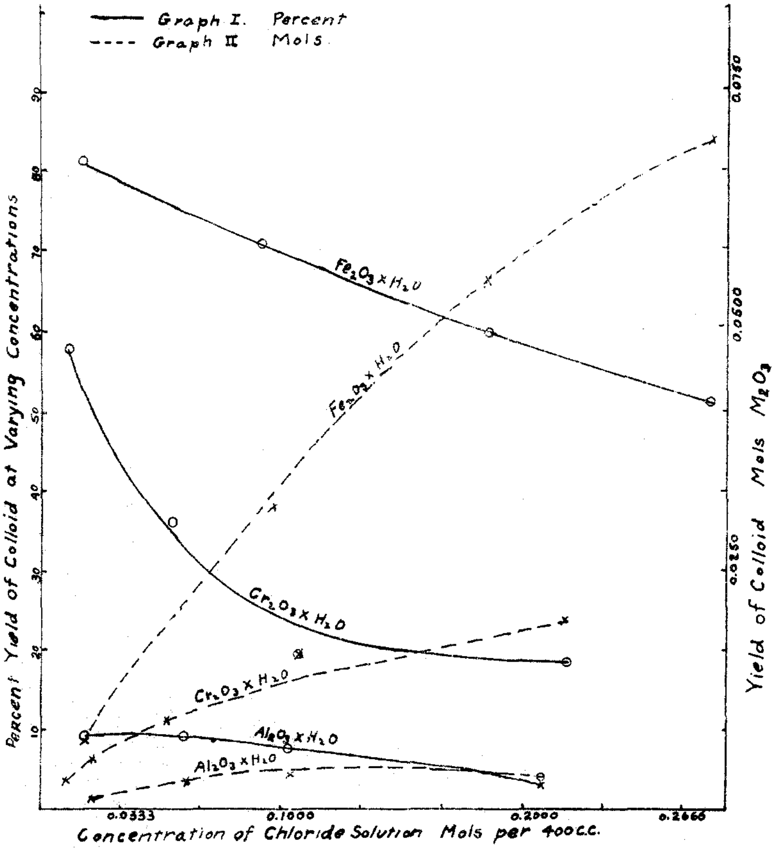
(*b*) For a given volume of chloride solution, the percentage yield of colloid decreases with increasing concentration, although the amount of colloid obtained increases, or sols of higher concentrations are obtained from the more concentrated solutions. For equal periods of dialysis, the purity of the colloid decreases with increase in concentration, *i. e.*, to obtain a sol of a given purity, the length of dialysis must be greater the higher the concentration.

(*c*) The dialysis for 42 hours of commercial C. P. chromic chloride solutions up to 0.25 *M* yields a sol purer than any hitherto obtained.

The specially prepared green chromic chloride in 0.047 *M* concentration gave 31.6% of colloid of remarkable purity (ratio of Cr : Cl in equivalents 444 or 99.7% Cr_2O_3, 0.3% HCl) in three days. The yield, though excellent, considering that cold dialysis gave only a trace of colloid, was not as high as for a solution of the commercial chloride of the same concentration. This may again be explained by the initial presence of colloid in the commercial chloride, which accelerates the hydrolysis.

(*d*) From our data, we may say that a 0.05 *M* solution of C. P. aluminium chloride will give a sol of high purity in two days.

3. The yellow ochre variety of colloidal hydrous ferric oxide is obtained by the hot dialysis of ferric chloride solutions. Dialysis for two days, of ferric chloride solutions up to 0.45 *M* will yield over 50% of colloid of great purity.


Yield of Colloid from Hot Dialysis of the Chlorides of Aluminium, Chromium and Ferric Iron.

Graph I shows the relationship between the percentage yield of colloid and the concentration of the solution dialyzed. The curves for aluminium and iron are normal, and show the effect on the yield of colloid of greater hydrolysis in the dilute solutions. The curve for chromium owes its peculiar form to the fact that chromic chloride solutions contain the green and violet forms in equilibrium. The percentage of the violet form is greater the more dilute the solution. And since only the violet form can give colloid, the percentage yield of colloid increases more rapidly with decrease of concentration than is the case for iron and aluminium.

From Graph II one may read of the quantity of colloid formed, starting with a given amount of salt contained in 400 cc. of solution.

B. Preparation of the Hydrous Oxide Sols by Addition of Ammonium Hydroxide to the Chloride Solutions, and Dialyzing at 75–80°.

A general method for the preparation of the colloidal hydrous oxides is to dissolve the freshly pecipitated hydrous oxide in the chloride, and dialyze. Hot dialysis may be applied to such solutions of aluminium and chromium, but if we wish to prepare the clear, brownish red, colloidal hydrous ferric oxide, we must dialyze first in the cold until no more iron passes through the membrane. Then the temperature may be raised to 75–80° or even to boiling, without affecting the nature of the colloid. If the solution is heated at the start, the yellow ochre variety of hydrous ferric oxide will be formed.

Ordway[1] has shown that when ammonium hydroxide is added to aqueous solutions of the salts of trivalent metals up to a certain point, the precipitate which forms redissolves on shaking or standing. The resulting solutions are simply solutions of the hydrous oxides in the chlorides, containing also ammonium chloride. The use of these solutions, instead of those above, for the preparation of the hydrous oxide sols, seemed desirable since two operations (filtering precipitated hydrous oxide and dissolving in chloride) would thus be eliminated.

This method for preparing the hydrous oxide sols is also preferable to the dialysis of the pure chlorides, for the percentage yield of colloid is greater, and the ferric and aluminium oxide sols, thus obtained, are clearer.

The following data may serve as directions for the rapid preparation of the hydrous oxide sols of ferric iron, aluminium and chromium:

1. Colloidal Hydrous Ferric Oxide.—Twenty-five grams of ferric chloride ($FeCl_3.6H_2O$) were dissolved in 250 cc. of water and 127 cc. of 1.365 *N* ammonium hydroxide, sufficient to react with 62.5% of the ferric chloride, were added. After shaking vigorously, the mixture was allowed to stand several hours or overnight. The perfectly clear, brownish red solution obtained was diluted to 400 cc. and dialyzed in the cold for $23^1/_2$ hours, and then for $23^1/_2$ hours at 75–80°. This combination of cold and hot dialysis, as stated above, is necessary for the rapid preparation of the perfectly clear sol. The entire dialysis is caried out in the "hot dialyzer."

The yield of colloid was 89.9%. Analysis of the sol showed the following ratios:

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[1] *Am. J. Sci.*, [2] **26**, 197 (1858).

$$\frac{\text{Equivalents Fe (ic)}}{\text{Equivalents Cl}} = 38.7; \quad \frac{\text{Equivalents Fe (ic)}}{\text{Equivalents } NH_4} = 208$$

2. Colloidal Hydrous Aluminium Oxide.—Two hundred and fifty cubic centimeters of a solution containing 15 g. of aluminium chloride ($AlCl_3.6H_2O$) were brought to boiling, and 93 cc. of normal ammonium hydroxide, sufficient to react with 50% of the aluminium chloride, were slowly added, and boiling continued for a few minutes. The clear solution thus obtained was diluted to 400 cc. and immediately dialyzed for 31 hours at 75–80°. The slightly opalescent sol contained 30.3% of the aluminium, and the ratio of aluminium to chlorine, in equivalents, was 11.2.

In a similar experiment, using 17.5 g. of aluminium chloride and 192 cc. of normal ammonium hydroxide, and dialyzing at 75–80° for 192 hours, the yield was 53.3%, while the ratio of aluminium to chlorine was 290.

It will be observed in both of these preparations of hydrous aluminium oxide sol, that the yield of colloid is less than the quantity of hydrous oxide in the original "mixture." This leads to the conclusion that *colloidal hydrous aluminium oxide, like colloidal chromic oxide,*[1] *can pass through parchment paper.*

3. Colloidal Hydrous Chromic Oxide.—Normal ammonium hydroxide (49 cc.) sufficient to react with 41.3% of the chromic chloride, were added to 162 cc. of normal chromic chloride, with vigorous shaking. After standing for twenty minutes, the precipitate entirely disappeared, when the clear green solution was diluted to 400 cc. and dialyzed for 34 hours at 75–80°. A perfectly clear, green sol was obtained, containing 59.1% of the chromium. The ratio of chromium to chlorine in equivalents was 65.1.

The residual ammonium in this and the preceding experiments (2) could not have been more than a trace, and was certainly less than in the first experiment.

C. Dialysis at the Boiling Temperature.—Two dialyses were run at the boiling temperature in order to see to what extent the yield of colloid may be increased, and the purity that can be reached in the relatively short period of ten hours.

TABLE IV.—DIALYSIS AT THE BOILING TEMPERATURE FOR TEN HOURS.

Substance.	Mols in 400 cc.	Per cent. transformed into colloid.	Ratio $\frac{\text{equivalents Cr}}{\text{equivalents Cl}}$ in colloid.
$AlCl_3.6H_2O$...........	0.0207	16.45	5.57
$CrCl_3.?H_2O$ (com.)....	0.0206	5.67	78.2

It will be seen from Table IV, comparing with corresponding data in Table III, that the yield of colloidal hydrous chromic oxide was increased

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[1] Neidle and Barab, THIS JOURNAL, **38**, 1961 (1916).

about 15%, and that of hydrous aluminium oxide over 40% by raising the temperature of dialysis 20°.

The purity of the hydrous chromic oxide sol, obtained at the boiling temperature in 10 hours, is greater than that obtained by dialyzing a solution of hydrous chromic oxide in chromic chloride, in the cold, for 73 days.

D. Comparison of Parchment Papers of Different Thicknesses (Weights). —A Chromic chloride solution was dialyzed at 75–80° in three parchment paper membranes of different thicknesses or weights, all other conditions being practically equal. The results are given in Table V.

TABLE V.—DIALYSIS AT 75–80° OF 0.02165 MOL $CrCl_3$ (COM.) IN 400 CC. FOR 29 HOURS.

Paper.	% of chloride transformed into colloid.	Ratio $\frac{\text{equivalents Cr}}{\text{equivalents Cl}}$.
30 lb.	31.6	> 1500
40 lb.	49.3	54.3
50 lb.	51.4	15.4

The yield of colloid increases, while the purity for a given period of dialysis decreases with increase in weight of parchment paper. The heavier the parchment paper, the lower the rate of diffusion through the membrane. This will result in a greater percentage of the chromic chloride being hydrolyzed, since hydrolysis is a time reaction, and hence the greater yield of colloid.

The higher purity, obtained by use of the lighter parchment paper, may be readily explained. Assuming that chromium ceases to pass through the membrane after equal periods, although it is more likely that this happens first with the lightest paper, the amount of electrolyte remaining in the membrane at that time, evidently is greater the heavier the paper. This residual electrolyte, after a given period, is not only smaller in quantity the lighter the paper, but it diffuses faster; hence the great influence of the weight or thickness of the paper on the purity of the colloid for a given time of dialysis.

When this investigation was begun, the parchment papers of different weights at our disposal were examined, and that selected for the bulk of the work, which looked and felt like the German product. The comparison of the three weights of parchment paper, which seemed to us suitable for dialysis, demonstrates that the forty pound paper is best suited for a combination of speed and yield, while the lightest (30 lb.) paper makes the most rapid dialyzer. If it is desired to prepare the purest hydrosol in the shortest time, the latter paper should be used and dialysis carried out at the boiling temperature.

In this way one can obtain, within ten hours, sols of a purity which would require many months' dialysis by the old method.

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