potassium bicarbonate, etc. The writer hopes soon to be in a position to carry forward such an extension of this investigation.

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THE PRECIPITATION OF COLLOIDS BY MEANS OF ALUMINIUM HYDROXIDE.

BY JOHN MARSHALL AND WILLIAM H. WELKER.

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It has long been common knowledge among chemists that when precipitation of aluminium hydroxide is induced in solutions, or when freshly precipitated aluminium hydroxide is added to solutions containing substances in suspension, and also to liquids containing various substances in solution, these substances are carried down in association with the aluminium hydroxide. Because of this property it is used in industrial chemistry to clarify liquids and to precipitate organic coloring matters. The mordanting property of aluminium salts in the process of dyeing may be attributed to the action of aluminium hydroxide produced in the process.

It also comes into use in mechanical water filters, in sugar analysis and in water analysis as a clarifying and decolorizing agent.

This investigation was undertaken with the view of determining whether aluminium hydroxide had wide application as a precipitating agent in respect to inorganic and organic colloids.

While there are many references in literature respecting the behavior of aluminium hydroxide as a precipitant of various substances, Rohland[1] is the only investigator who apparently has taken up the question of the behavior of aluminium hydroxide as a precipitant of colloids. This investigator, while briefly stating that aluminium hydroxide among other hydroxides precipitates certain colloids, confines his investigations largely to the behavior of clays on colloidal solutions.

The aluminium hydroxide used in our experiments was prepared by precipitating it with dilute ammonium hydroxide from dilute solutions of ammonium alum contained in large glass cylinders. The ammonium hydroxide was slowly added with constant stirring of the solution with a glass rod until finally the liquid yielded a faint odor of ammonia. The precipitate was allowed to subside and was washed several times by decantation with distilled water. It was then collected on a filter and washed several times until the filtrate was fairly free from salts and then transferred to a glass cylinder and again washed by decantation until

[1] *Z. anorg. Chem.*, **41**, 325 (1904); *Ibid.*, **56**, 46 (1907); *Ibid.*, **60**, 366 (1908); *Ibid.*, **77**, 116 (1912) *Z. Chem. Ind. Kolloid.*, **2**, 177 (1907).

500 cc. of the supernatant liquid evaporated to dryness practically left no residue. The sedimental aluminium hydroxide in the form of a thin jelly constituted the reagent used in the experiments.

In making the experiments a volume of the jelly equivalent to the volume of the colloidal solution to be tested was placed in a test tube and the colloidal solution was added. The contents were thoroughly mixed by closing the end of the tube with the thumb and vigorously shaking for a few seconds. The mixture was then poured on a filter paper. Filtration proceeded very rapidly whenever sufficient of the reagent had been added to cause a quantitative removal of the colloid. Appropriate tests were applied to the filtrate to determin whether all of the colloid had been removed.

In the case of each of the proteins the solution was tested for the presence of biuret reacting material before and after treatment with aluminium hydroxide. Portions of the filtrate in every case failed to indicate the presence of biuret reacting material. To another portion of the filtrate a drop of the original untreated solution was added and the biuret test was applied with a positive results in each case.

The following solutions were subjected to the treatment with aluminium hydroxide. In each case the colloidal material was removed absolutely quantitatively.

	Colloidal Solutions.
Copper	Water emulsion of fat (mechanical entangling of fat globules)
Gold	
Platinum	Soap
Sulfur	Emulsion of fat in soap solution (including fat and soap)
Nickel sulfide	Egg albumin
Cobalt sulfide	Globulin (Edestin in 5% NaCl)
Cupric hydroxide in NaOH	Gelatin
Prussian blue	Casein (in $^1/_2$ saturated lime water)
Congo red (indicator sol.)	Glutenin (in 0.5% Na_2CO_3)
Azolitmin	Nucleoprotein (in 0.5% Na_2CO_3)
Litmus, neutral	Gliadin (in 70% alcohol)
Litmus, red	Ovomucoid
Litmus, alkaline	Acid metaprotein (in 0.1% HCl)
Starch paste	Primary proteose
Soluble starch	Secondary proteose
Erythrodextrin	Milk (including fat and protein)
Starch iodide	Blood serum (protein)

Oxyhemoglobin is the only protein tested by us that aluminium hydroxide failed to remove. The use of aluminium hydroxide, therefore, would appear to be well adapted for preparing oxyhemoglobin from erythrocytes because it removes protein from the blood serum mingled with the dissolved sedimented erythrocytes and also the precipitable

protein of these cells themselves, yielding a filtrate from which, as we have found by experiment, oxyhemoglobin more readily crystallizes and in a much purer state than by any other known method.

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THE PRECIPITATION OF ENZYMES FROM THEIR SOLUTIONS BY MOIST ALUMINIUM HYDROXIDE.

BY WM. H. WELKER AND JOHN MARSHALL.

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These experiments were undertaken to determin whether or not solutions of enzymes when treated with aluminium hydroxide jelly and filtered would retain their enzyme activity. The aluminium hydroxide was prepared as described by us in a previous paper.[1] Equal volumes of enzyme solution and the reagent were shaken vigorously in a test tube for a few seconds and then filtered. Appropriate tests were made on the filtrates to determin enzyme action.

Enzyme Solutions Employed:

Peroxydase (water extract of potato)	Precipitated.
Oxydase (water extract of potato)	Precipitated.
Amylase (saliva)	Incompletely precipitated.
Pepsin (water solution of commercial pepsin)	Precipitated.
Pepsin (0.2% HCl solution of commerical pepsin)	Precipitated.
Rennin (water solution of commercial rennin)	Precipitated.
Trypsin (water solution of commercial trypsin)	Precipitated.
Trypsin (0.5% Na_2CO_3 solution of commercial trypsin)	Precipitated.
Trypsin (30% alcohol extract of pancreas)	Precipitated.
Trypsin (30% alcohol extract of pancreas + equal vol. 1% Na_2CO_3 sol.)	Precipitated.
Amylase (30% alcohol extract of pancreas)	Precipitated.
Lipase (30% alcohol extract of pancreas)	Precipitated.

The incomplete removal of the amylase from saliva is peculiar in that the enzyme activity retained by the filtrate readily converts starch paste into soluble starch but further hydrolysis proceeds with difficulty or may not take place at all.

The enzymes studied, with one exception (amylase) are quantitatively removed from their solutions by aluminium hydroxide. The only zymogen studied was pepsinogen (prepared by extracting the mucous membrane of the stomach of pigs with 50% glycerol solution) which in 10% and in 25% glycerol solution is removed quantitatively only with the greatest difficulty.

[1] THIS JOURNAL, 35, 820.
