[CONTRIBUTION FROM THE KENT CHEMICAL LABORATORY, UNIVERSITY OF CHICAGO]

THE C_4-SACCHARINIC ACIDS. III. THE PREPARATION OF *dl*-1,2-DIHYDROXY-ISOBUTYRIC ACID AND A STUDY OF SOME OF ITS DERIVATIVES

BY J. W. E. GLATTFELD AND LEO P. SHERMAN[1]

RECEIVED MARCH 30, 1925 PUBLISHED JUNE 5, 1925

Four C_4-saccharinic acids have, so far, been prepared and studied in this Laboratory; namely, the two 2,3-dihydroxy-butyric acids,[2] and the two 1,3-dihydroxy-butyric acids.[3] This paper is a result of the continuation of the study of the C_4-saccharinic acids and deals with *dl*-1,2-dihydroxy-*iso*butyric acid.

The general purpose of the study of this group of acids has already been pointed out in the two papers cited above. There is a distinct need of data on the physical properties and, especially, of data on the insoluble derivatives, of all of the saccharinic acids. This need is likely to be felt by workers in any field of sugar chemistry in which sugars are subjected to the prolonged action of alkalies; there is always, under such conditions, the possibility of formation of saccharinic acids. Our main object, then, in the work reported below was the careful study of 1,2-dihydroxy-*iso*-butyric acid with the hope of being able to report information that might be of value in identifying and isolating this acid.

This opportunity is taken to make a slight change in the definition of the term "saccharinic acids" that was given in the first paper of this series.[2] Because of the haziness that prevails as to exactly what constitutes an "aldo-monosaccharide" it would seem to be in the interest of accuracy to substitute the word "hydroxy-aldehyde" for "aldo-monosaccharide" in the definition previously given. By "saccharinic acid," then, in this series of papers, is meant any acid which would result[4] if the $H{-}\underset{|}{C}{=}O$ group of an hydroxy-aldehyde of the formula $C_nH_{2n}O_n$, in which each carbon atom except the one in the aldehyde group carries one hydroxyl group, were oxidized to carboxyl, at the expense of one of

---

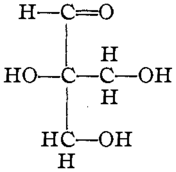
[1] The dissertation of which this paper is a condensation was presented by Leo P. Sherman in partial fulfilment of the requirements for the degree of Doctor of Philosophy in the University of Chicago. The original dissertation, which contains experimental details, is on file in the University of Chicago Library.

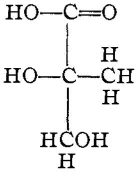
[2] Glattfeld and Miller, THIS JOURNAL, **42**, 2314 (1920).

[3] Glattfeld and Sander, *ibid.*, **43**, 2675 (1921).

[4] This definition is not to be considered as a statement of the authors' idea as to the theory of the *actual* formation of the saccharinic acids from the sugars. These acids may or may not be formed from the sugars by such a direct oxidation-reduction reaction as is implied in the definition; nevertheless, they may be *defined* as the products of such an imaginary reaction.

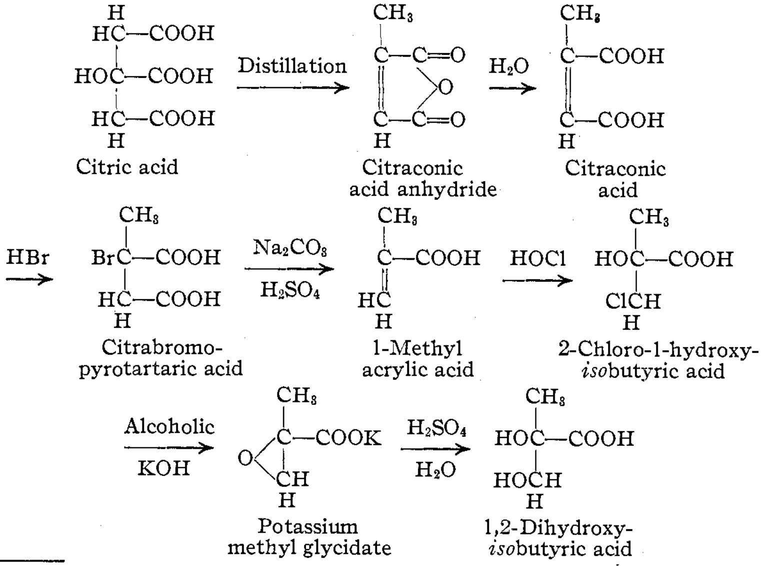
the $-\overset{|}{\underset{|}{C}}-O-H$ groups which would be reduced to a $-\overset{|}{\underset{|}{C}}-H$ group. Thus 1,2-dihydroxy-*iso*butyric acid is a saccharinic acid because it would be formed if the $H-\underset{|}{C}=O$ group of a proper aldehyde of formula $C_4H_8O_4$ were oxidized to carboxyl at the expense of one of the $-\overset{|}{\underset{|}{C}}-H-O$ groups. This relationship will be clearly understood after a comparison of the formulas which follow.


Trihydroxy-*iso*butyric aldehyde
(Hydroxy-aldehyde)


1,2-Dihydroxy-*iso*butyric acid
(Saccharinic acid)

In order to furnish the necessary background for an appreciation of exactly what new data are herein contributed to our knowledge of *dl*-1,2-dihydroxy-*iso*butyric acid and its derivatives, a brief résumé of the published work on this acid will be given. This published work consists of but two articles.[5]

Melikoff (1886) prepared the acid from 2-chloro-1-hydroxy-*iso*butyric acid, which he obtained from citric acid by means of the complicated synthesis indicated below.

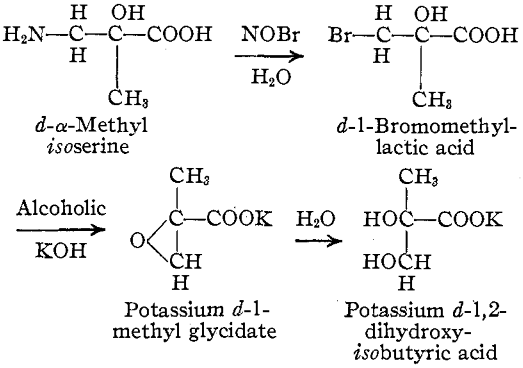


---

[5] P. Melikoff, *Ann.*, **234**, 210–233 (especially pp. 218–219) (1886). Kay, *J. Chem. Soc.*, **95**, 561 (1909).

Melikoff obtained finally a thick sirup which slowly became crystalline as it stood over sulfuric acid. The crystals (amount not given) he reports as melting at 100°, and as being easily soluble in water but soluble with difficulty in ether. Nothing further is recorded regarding properties but mention of the potassium salt, the amorphous, anhydrous calcium salt and the silver salt, is made.

In 1909, Kay prepared a very small quantity—about 0.5 g.—of the potassium salt of *d*-1,2-dihydroxy-*iso*butyric acid from *d*-α-methyl-*iso*serine by the synthesis indicated below:



Kay reported $[\alpha]_D^{20} = -4.0°$ for the potassium salt. He did not prepare the free acid.

It is thus seen that practically nothing of importance from our point of view was known about the acid under discussion at the time that the work reported below was begun. In the course of this work, two new methods of preparation of the *dl* acid were found; the acid was prepared in large quantity and carefully purified and studied; the phenyl hydrazide of the acid was prepared and analyzed; the calcium, zinc, copper, cadmium and manganese salts of the acid were prepared in crystalline form and analyzed; and, finally, a careful and extensive, but unsuccessful, attempt at resolution of the *dl* acid was made.

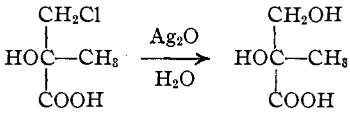
Experimental Part

Repetition of Melikoff's Synthesis.—In beginning the work reported below, it was considered best, first of all, to repeat the work of Melikoff just as this is reported in the literature. It was soon found that Melikoff's procedure was long and very time-consuming and it was discarded as soon as it had yielded acid enough for comparison with that made later by other processes.

Attention was early turned to the best method for the preparation of the 2-chloro-1-hydroxy-*iso*butyric acid needed for the Melikoff synthesis, as the method employed by Melikoff for the preparation of this substance was found to be impracticable for large-scale preparation. It was found that the method of Bischoff[6] modified according to Ultee[7] (treatment of monochloro-acetone with hydrogen cyanide, etc.) was easy of execution and yielded good results (24 to 58% of the theoretical).

After a sufficient quantity of chlorohydroxy-*iso*butyric acid had been prepared, Melikoff's synthesis was continued, but as yields were very poor, it is not thought worth while to record details here. The Melikoff procedure was carried out four times; the yields of pure product obtained, calculated on the basis of the chlorohydroxy-*iso*butyric acid used, varied from 10 to 16%. A total of 19.5 g. of pure crystalline acid was obtained. It was found to have a melting point of 104° instead of 100° as reported by Melikoff.

Preparation of the Acid by Treatment of 2-Chloro-1-hydroxy-*iso*butyric Acid with Silver Oxide.—The method indicated below was carried out only twice as the greater amount of the material needed for the proposed study had already been prepared by the method described in the next section.



$$\mathrm{HO}\underset{\substack{|\\ \mathrm{COOH}}}{\overset{\substack{\mathrm{CH_2Cl}\\ |}}{\mathrm{C}}}\mathrm{—CH_3} \xrightarrow[\mathrm{H_2O}]{\mathrm{Ag_2O}} \mathrm{HO}\underset{\substack{|\\ \mathrm{COOH}}}{\overset{\substack{\mathrm{CH_2OH}\\ |}}{\mathrm{C}}}\mathrm{—CH_3}$$

2-Chloro-1-hydroxy-*iso*butyric acid 1,2-Dihydroxy-*iso*butyric acid

To a solution of 45.5 g. of 2-chloro-1-hydroxy-*iso*butyric acid in 400 cc. of water was added the silver oxide obtained by the treatment of a solution of 112 g. of silver nitrate with a solution of 28 g. of pure sodium hydroxide. The silver oxide was thoroughly washed by decantation and added, as a suspension in water, in small amounts at a time. The mixture was thoroughly shaken after each addition of silver oxide and then "refluxed" for 12 hours on a wire gauze. The color of the insoluble matter changed during this time from white to red. A slight excess over the calculated amount of hydrochloric acid necessary to set free the acid was then added and the mixture again "refluxed" on a wire gauze for three hours. The mixture was then cooled and subjected to filtration. The filtrate was subjected to complete distillation[8] in a vacuum, finally at 100° and 14 mm. Forty-seven g. of an amber-colored gum was obtained as a residue. This was dissolved in three parts of hot ethyl acetate. The solution was seeded with the product made by the Melikoff procedure and deposited a crop of crystals as it cooled.

The acid thus obtained weighed, air-dry, 9.45 g.; melting range, 90–95°. It was recrystallized from 3.5 parts of ethyl acetate and yielded 5.4 g. of crystals, air-dry, of sharp melting point, 104°. A portion of the crystals mixed with an equal portion of those obtained by Melikoff's method melted sharply at 104°.

From 56.99 g. of 2-chloro-1-hydroxy-*iso*butyric acid a total of 15.8 g. of pure product, m. p. 104°, was obtained in two experiments; yield, 32%.

---

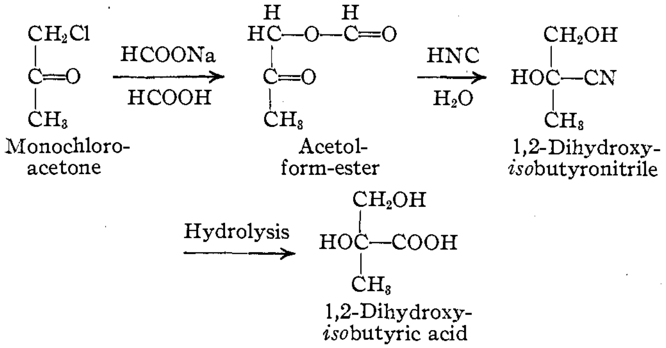
[6] Bischoff, *Ber.*, **5**, 865 (1872).

[7] Ultee, *Rec. trav. chim.*, **28**, 7 (1909); *Chem. Centr.*, **1**, 1538 (1909).

[8] By "subjected to complete distillation" is meant that the distillation was allowed to continue until, under the *final* conditions, no more drops of distillate appeared.

It might be mentioned that the "silver oxide method" is the only one of the three methods discussed in this paper which yielded a large percentage of crystalline acid without the intermediate preparation of the calcium salt. It is possible that further work with this method might prove it to be superior to the one described in the next section.

Preparation of the Acid from Acetol-form-ester.—The acetol-form-ester was prepared according to the procedure of Henry.[9] It was found advantageous for practical reasons not to use more than 200 g. of monochloro-acetone in one run. A modification of Henry's procedure which was found to be advisable was the subjection of the original reaction mixture to complete vacuum distillation[10] and the fractionation of the distillate thus obtained at atmospheric pressure.



From 1204 g. of monochloro-acetone was obtained in seven runs, and after continuing fractionation until the fraction of desired boiling range no longer increased in weight, 524 g. of acetol-form-ester of boiling range 166–169° at atmospheric pressure; yield, 39.5%.

To a mixture of 50 g. of form-ester (166–169°) and 100 cc. of water, in a 1-liter flask, was added the solution of hydrogen cyanide made by the careful addition at 15–20° of 47.6 cc. of 10.32 *N* hydrochloric acid to a solution of 31.86 g. of pure potassium cyanide in 50 cc. of water. No heat developed during the addition of the hydrocyanic acid; potassium carbonate was therefore added in small portions[7] until heat began to develop. The temperature then rose, without further addition of carbonate, to about 41°. The reaction mixture was allowed to stand for some hours. It was then refluxed on a wire gauze for eight hours with 300 cc. of hydrochloric acid (d., 1.19); the solution was cooled and the large mass of crystals of potassium chloride and ammonium chloride was removed by suction filtration. The filtrate was then subjected to complete distillation at 14 mm. finally from a boiling water-bath. A brown gummy mass which contained much potassium chloride was obtained as a residue. It was extracted as long as solution took place with small portions of hot ethyl acetate. The ethyl acetate was

---

[9] Henry, *Bull. acad. roy. med. Belg.*, **5**, 445–94 (1902); *Chem. Centr.*, (2), 928 (1902).

[10] A short-neck flask should be used in this distillation and, if a water pump is used, the neck of the flask and the side arm should be wrapped with towels. Because of the large amount of sodium chloride left as a residue much of the high-boiling distillation may be lost if the distillate is not carried to completion.

removed from the combined extracts at ordinary pressure (flask finally in boiling water); 50 g. of crude, brown gum remained as a residue.

Many attempts were made to obtain crystals of acid directly from the crude gum thus prepared, by the use of ethyl acetate as solvent, but usually crystals of the acid did not result. It was found to be advisable, therefore, to purify the crude acid gum by transformation into the calcium salt.

The 50 g. of crude gum was dissolved in 265 cc. of water (4.6 parts for the calcium salt, calculated as anhydrous material, which was to result); this solution was refluxed on a wire gauze for 12 hours with 29 g. of calcium carbonate. The hot mixture was subjected to filtration. The filtrate was cooled and seeded with a few crystals of the calcium salt of the acid made by the Melikoff procedure. Crystals were deposited in such amount as to convert the filtrate into an apparently solid mass.

The results of many such transformations of crude gum into calcium salt showed that with proper technique at least as much in weight of pure calcium salt could be obtained as a first crop from 4.6 parts of water as crude acid gum employed to make the salt, and often more. Thus 131 g., 98 g., 150 g., 125 g. of crude gum gave, respectively, 127 g., 109 g., 175 g. and 190 g. of calcium salt as first crops. It must be stated, however, that in these runs, calcium salt mother liquor from previous runs was used instead of pure water as the crystallizing solvent.

The calcium salt was shown to have the formula $(C_4H_7O_4)_2Ca.7H_2O$.

A sample of the calcium salt was twice recrystallized from 4.6 parts of water, then dried in a vacuum and subjected to analysis for calcium oxide and water of crystallization. The sample was weighed in a platinum crucible and then kept in an air-bath at approximately 100° until the weight was constant. The crucible and contents were then heated over a gas blast to constant weight.

Anal. Subs., 0.3821, 0.3974, 0.4168, 0.3270; loss in weight at 100°, 0.1188, 0.1234, 0.1294, 0.1013; ash, 0.0530, 0.0552, 0.0583, 0.0454. Calcd. for $(C_4H_7O_4)_2Ca.7H_2O$: H_2O 31.20; CaO 13.87. Found: H_2O 31.09, 31.05, 31.07, 30.98; CaO, 13.87, 13.88, 13.98, 13.88.

The free acid was next obtained from the calcium salt and found to melt at 104°.

To 70 g. of the twice recrystallized calcium salt dissolved in 350 cc. of hot water, was added a hot solution of 21.83 g. of oxalic acid. The filtrate from the calcium oxalate was subjected to complete vacuum distillation, finally at 100° and 14 mm. The gum thus obtained as a residue weighed 34.6 g., was of a clear amber color and had a faint odor. This gum was dissolved in 3.5 parts of hot ethyl acetate. The solution was filtered into a small flask, cooled and seeded with acid from the Melikoff method. Crystals appeared at once and soon the whole solution was transformed into a white, crystalline mass. The crop of crystals weighed, air-dry, 25.34 g. This crop was recrystallized from 3.5 parts of hot ethyl acetate and gave 19.2 g. of crystals with a sharp melting point of 104°.

Samples of the acid were titrated with 0.1 *N* sodium hydroxide solution and phenolphthalein as indicator; no pink color was obtained throughout the liquid until the final end-point had been reached.[11] This shows that there was no lactone present in the samples and that they were entirely "free acid."

Titration. Subs., 0.5967, 0.1855: 49.71, 15.43 cc. of 0.1 *N* alkali. Calcd. for $C_4H_8O_4$: 49.72, 15.46 cc.

Anal. Subs., 0.2979, 0.2076, 0.2146: H_2O, 0.1816, 0.1254, 0.1217; CO_2, 0.4366, 0.3073, 0.3146. Calcd. for $C_4H_8O_4$: C, 40.00; H, 6.66. Found: C, 39.95, 40.37, 40.06; H, 6.77, 6.69, 6.29.

---

[11] THIS JOURNAL, **42**, 2317 (1920), footnote 2.

Conclusion from Work on Methods of Preparation and Study of the Acid Produced

The facts, then, that crystals of the same melting point (104°) and appearance were obtained by three different procedures, all of which should, according to ordinary experience, give 1,2-dihydroxy-*iso*butyric acid; that mixtures of samples obtained by the three different methods also melted at the same point (104°); that the results of analyses of the calcium salt for water of crystallization and calcium content indicated that the calcium salt was the salt of a C_4-saccharinic acid; that titration of samples of the acid with alkali and, finally, that analyses of the acid for carbon and hydrogen also indicated that the substance was a C_4-saccharinic acid, are reasonably sufficient evidence of the fact that the acid prepared was actually 1,2-dihydroxy-*iso*butyric acid.

Derivatives of dl-1,2-Dihydroxy-isobutyric Acid

The procedure followed in the preparation of the salts of the acid was essentially the same in all cases. To a suspension of the hydroxide of the metal in water was added the calculated quantity of the acid dissolved in water. The mixture was "refluxed" until solution of the hydroxide was complete; the solution was filtered and the filtrate subjected to complete vacuum distillation. The crude salt thus obtained was weighed; it is referred to below as "residue." The crude salt was dissolved in hot water and the solution thus obtained filtered hot and then set aside in a stoppered flask to cool. The crystals were separated by suction filtration, dried on a porous plate and weighed. They are referred to below as "pure salt." The "pure salt" was analyzed for water of crystallization by the process of heating in a platinum crucible to constant weight in an oven at 105° and for metal content by an appropriate method which is indicated below.

The Copper Salt, Cu $(C_4H_7O_4)_2.2H_2O$.—The weight of the "residue" from the reaction of 2.2 g. of freshly prepared cupric hydroxide in 50 cc. of water with 5.35 g. of acid in 20 cc. of water, was 6.87 g. From 5 cc. of hot water, in the course of 24 hours, 4.23 g. of "pure salt" was obtained.

The "pure salt" was analyzed[12] for copper content. Samples were cautiously heated in a covered platinum crucible to destroy the organic matter and to convert the salt into copper oxide. The crucible was then cooled and concd. nitric acid added. The crucible was then again heated until the weight was constant.

Anal. Subs., 0.2284, 0.2777: loss in weight at 105°, 0.0238, 0.0293; CuO, 0.0524, 0.0655. Calcd. for $(C_4H_7O_4)_2Cu.2H_2O$: Cu, 18.83; H_2O, 10.66. Found: Cu, 18.35, 18.84; H_2O, 10.42, 10.56.

The Manganese Salt, $Mn(C_4H_7O_4)_2.2H_2O$.—The "residue" obtained as a result of the reaction of 1.4 g. of freshly prepared manganese hydroxide in 50 cc. of water and 3.8 g. of the acid in 20 cc. of water weighed 4.6 g. From 3 parts of hot water, 3.8 g. of faintly-pink "pure salt" was obtained. Recrystallization of the 3.8 g. of salt from 11 cc. of water yielded 2.05 g. of salt, samples of which were analyzed.

The residues from the determination of water of crystallization were analyzed for manganese by two methods. In the first method,[13] the sample in a platinum crucible

---

[12] Olsen, "Quantitative Chemical Analysis," D. Van Nostrand Co., 4th ed., **1915**, p. 71.

[13] Treadwell-Hall, "Analytical Chemistry," J. Wiley and Sons, 5th ed., **1919**, Vol. **2**, p. 120.

was treated with dil. sulfuric acid, and the mixture cautiously heated to transform the manganese salt into manganese sulfate. In the second method[14] the manganese salt was transformed into the oxide, Mn_3O_4, by the simple heating of the salt in a platinum crucible.

Anal. Subs., 0.4612, 0.4740: loss in weight in 105°, 0.0503, 0.0514; $MnSO_4$, 0.2141, 0.2149. Subs., 0.1310: heated to constant weight gave 0.0308 Mn_3O_4. Calcd. for $Mn(C_4H_7O_4)_2.2H_2O$: Mn, 16.70; H_2O, 10.94. Found: Mn, 16.88, 16.50, 16.93; H_2O, 10.90, 10.85.

The Cadmium Salt, 2 Cd $(C_4H_7O_4)_2.3H_2O$.—The "residue" obtained as a result of the reaction of a suspension of 2.42 g. of freshly-prepared cadmium hydroxide in 50 cc. of water and 4.06 g. of acid in 20 cc. of water, weighed 5.5 g. It was recrystallized from 6 cc. of water and yielded 1.45 g. of "pure salt." Analysis for cadmium content was by electrolysis[15] with a rotating anode.

Anal. Subs., 0.4353, 0.4906: loss in weight at 105°, 0.0317, 0.0354; deposits, 0.1290, 0.1464. Subs., 0.4952; deposit, 0.1472. Calcd. for 2 Cd $(C_4H_7O_4)_2.3H_2O$: Cd, 29.78; H_2O, 7.15. Found: Cd, 29.62, 29.84, 29.73; H_2O, 7.28, 7.21.

The Zinc Salt, $Zn(C_4H_7O_4)_2.2H_2O$.—This salt was formed by the addition of 2.9 g. of freshly prepared zinc hydroxide in 50 cc. of water to a solution of 7.05 g. of acid in 20 cc. of water. The "residue" weighed 7.45 g. Recrystallization from 10 cc. of water yielded 4.05 g. of "pure salt." The zinc was determined by the method of conversion into zinc oxide and weighing as such.[16]

Anal. Subs., (I) 0.4523, (II) 0.5243: loss in weight at 105°, (I) 0.0480, (II) 0.0555; ZnO, (I) 0.1082. Subs., (III) 0.4578, (IV) 0.4653: ZnO, (III) 0.1092, (IV) 0.1115. Calcd. for $Zn(C_4H_7O_4).2H_2O$: Zn, 19.26; H_2O, 10.61. Found: Zn, (I) 19.22, (III) 19.16, (IV) 19.25; H_2O, (I) 10.61, (II) 10.59.

The Phenylhydrazide, $C_4H_7O_3NHNHC_6H_5$.—To a solution of 6.5 g. of acid in 26 cc. of absolute alcohol was added 8.5 g. of phenylhydrazine and the mixture set aside for a few hours. A crystalline mass resulted. This was filtered with suction, and the crystals were washed with absolute alcohol; yield, 8.22 g. This crop was recrystallized from 16 cc. of hot absolute alcohol and yielded 5.97 g. of pure white crystals. These were dried in a vacuum desiccator over sulfuric acid to constant weight; m. p., 107°. Samples were analyzed for nitrogen.

Anal. Subs., 0.3193, 0.1818: N_2, 33.0 cc. (25.5°, 734.0 mm.) 18.64 cc. (26.2°, 733.4 mm.). Calcd. for $C_{10}H_{14}N_2O_3.2H_2O$: N, 11.38. Found: 11.43, 11.30.

Attempts to Resolve the Acid

Strychnine, quinine and brucine were tried as resolving agents. The attempts were not definitely successful although brucine gave some evidences of resolution.

Brucine as Resolving Agent.—Sixteen g. of brucine was added to a solution of 4.55 g. of acid in 300 cc. of water. The mixture was heated on the boiling water-bath until solution was complete. This solution was cooled, extracted six times with 100 cc. portions of benzene, and subjected to complete vacuum distillation finally at 60° and 14 mm. The residue—the "crude salt"—weighed 19.55 g.: $[\alpha]^{20}_{D}$ $-24.43°$ (19.55 g. of salt dissolved in water and the solution made up to 500 cc. gave α in a 2dcm. tube = $-1.91°$). Attempts were made to obtain crystals from this "crude salt" in two parts

---

[14] Ref. 13, p. 125.

[15] Smith, "Electro-Analysis," P. Blakiston, Son and Co., 6th ed., **1918**, p. 94.

[16] Ref. 13, p. 142.

and in one part of hot water but without success. The salt was recovered from the water solution by complete vacuum distillation and recrystallized from four parts of hot absolute alcohol. Six g. (air-dried) of white, needle-like crystals was thus obtained: $[\alpha]_D^{20} = -27.38°$ (4 g. made up to 100 cc. in water solution gave α in a 2dcm. tube = $-2.19°$). A second crop of 4 g. (air-dried) was obtained after the mother liquor had been concentrated somewhat: $[\alpha]_D^{20} = -26.5°$ (4 g. made up to 100 cc. in water solution gave in a 2dcm. tube $\alpha = -2.12°$).

The first crop of 6 g. ($[\alpha]_D^{20} = -27.38°$) was recrystallized from 76 cc. of hot absolute alcohol; the solution yielded 1.92 g. of crystals (air-dried). These were dissolved in 47.31 g. of water; α in a 2dcm. tube was found to be $-2.16°$; therefore[17] $[\alpha]_D^{20} = -27.39°$. The second crop of 4 g. ($[\alpha]_D^{20} = -26.5°$) was recrystallized from 35 cc. of hot absolute alcohol; 1.08 g. of air-dried crystals was obtained; $[\alpha]_D^{20} = -27.35°$ (1.08 g. of salt dissolved in 27.37 g. of water gave α in a 2dcm. tube = $-2.08°$).

The 3 g. of salt (1.92 g. of substance, $[\alpha]_D^{20} = -27.39°$, combined with 1.08 g. of substance, $[\alpha]_D^{20} = -27.35°$) was hydrolyzed in the usual way[18] and 0.73 g. of amber-colored gum was obtained. The usual care in the extraction of the filtrate from the brucine with benzene to remove dissolved brucine completely, was taken. The gum was dissolved in 18.85 g. of water and gave α in a 1dcm. tube = $-0.08°$; whence $[\alpha]_D^{20} = -2.15°$.

The work was repeated with larger amounts of material and a total of 137 g. of brucine salt of specific rotation approximately $-27.30°$ obtained. This salt was recrystallized five times from 3.5 parts of alcohol-water mixture (100:8); 137 g. when recrystallized yielded 84 g. of substance, $[\alpha]_D^{20} = -27.28°$; 84 g. yielded 50 g. of substance, $[\alpha]_D^{20} = -27.37°$; 50 g. yielded 28 g. of substance, $[\alpha]_D^{20} = -27.47°$; 28 g. yielded 19 g. of substance, $[\alpha]_D^{20} = -27.53°$; and 19 g. yielded 9.3 g. of substance, $[\alpha]_D^{20} = -27.46°$.

Fifty g. of this salt was hydrolyzed and yielded 13.00 g. of gum. This was dark colored. Therefore it was dissolved in hot water and the hot solution decolorized with purified animal charcoal. Two or three treatments were required to clear the solution to a pale color. The gum recovered from this solution by complete vacuum distillation, finally at 100° (14 mm.) weighed 10.95 g. This was made up to 250 cc. in water solution. The specific rotation of the solution was found to be —2.71° (α in a 2dcm. tube was —0.24°).

The solution was subjected to complete vacuum distillation again. It was found to be impossible to obtain crystals from 3.5 parts of hot ethyl acetate. The calcium salt was therefore made in the usual manner. The weight of the "crude calcium salt gum" was 12.0 g. Recrystallization from 4.5 parts of water yielded 6.1 g. of salt *with no rotatory power.*

The acid was freed from 5.55 g. of the recrystallized calcium salt by means of oxalic acid. The gum obtained weighed 4 g. It was dissolved in 3.5 parts of hot ethyl acetate. The solution yielded 2 g. of crystals; m. p., 102.5°. This 2 g. of crystals was recrystallized from 3.5 parts of ethyl acetate and yielded 1.02 g. of substance; m. p., 103.5°. The melting point of these crystals was not lowered by the addition of pure *dl* acid. The mother liquor from the 6.1 g. of calcium salt above was tested for rotatory power and found to be inactive.

The authors are inclined to believe that resolution was actually accomplished by brucine and that the heating of the water solution of the active acid with calcium carbonate in the preparation of the calcium salt

---

[17] The specific gravity of this and subsequent solutions was assumed to be 1.011.

[18] THIS JOURNAL, 40, 981 (1918), footnote 2.

caused the active acid to be converted into the racemic acid. This point will be studied further and reported on in a later paper.

Summary

dl-1,2-Dihydroxy-*iso*butyric acid was prepared by three different methods, two of them new. All three methods yielded a crystalline acid of melting point 104°. Mixed-melting-point determinations showed that the samples of acid from the three sources were identical substances. The phenylhydrazide, and the calcium, zinc, copper, cadmium and manganese salts were prepared and analyzed. Attempts at resolution were inconclusive although brucine gave some evidence of ability to resolve the acid.

CHICAGO, ILLINOIS

[CONTRIBUTION FROM THE PHYTOCHEMICAL LABORATORY OF THE BUREAU OF CHEMISTRY, UNITED STATES DEPARTMENT OF AGRICULTURE]

THE ODOROUS CONSTITUENTS OF THE COTTON PLANT. EMANATION OF AMMONIA AND TRIMETHYLAMINE FROM THE LIVING PLANT[1]

BY FREDERICK B. POWER AND VICTOR K. CHESNUT

RECEIVED APRIL 4, 1925 PUBLISHED JUNE 5, 1925

The investigation which is here described was undertaken at the request of Dr. L. O. Howard, Chief of the Bureau of Entomology, and the primary purpose was to ascertain the chemical character of the odorous constituents of the cotton plant. Inasmuch as this plant possesses a specific attraction for the boll weevil, it has been presumed that this was due to the emanation of some odorous substance which could be perceived by the insects at a considerable distance. It has furthermore been considered that if any odorous substance could be identified, which by chemotropic tests would be found attractive for the insects, it might be possible to produce it in sufficient quantities to permit of its use as a bait.

Some products from the cotton plant have previously been the subject of more or less extended investigations, particularly the fatty oil expressed from the seeds and also the residual press-cake. The flowers of the plant have been examined with respect to their coloring matters, chiefly by A. G. Perkin,[2] and cotton-root bark, which has been used to some extent medicinally, was examined most recently by Power and Browning,[3a] with consideration of its more important constituents.

An examination of the volatile products obtained from the cotton fiber

---

[1] Communicated in abstract to the National Academy of Sciences at a meeting held in Washington, D. C. April 27, 1925.

[2] Perkin, (a) *J. Chem. Soc.*, **75**, 825 (1899); (b) **95**, 2181 (1909); (c) **109**, 145 (1916). See also (d) Viehoever, Chernoff and Johns, *J. Agr. Research*, **13**, 345 (1918) and (e) Stanford and Viehoever, *ibid.*, **13**, 419 (1918).

[3a] Power and Browning, *Pharm. J.* (London), [4] **39**, 420 (1914).