with silver salt, and then placed in the steam jacket. After five minutes of heating, the ethyl iodide was let in. The expected green patch appeared at the open end, and then the decomposition proceeded through the tube as in the boat.

Another tube was half filled with silver salt, a layer of sand was placed on it, four or five millimeters in thickness, and the rest of the tube was then filled with more silver salt. The reaction proceeded to the sand only.

In another tube, even less sand was used, the layer being but two or three millimeters thick, in order to avoid contact between the two divisions of the salt. The action again ceased at the sand.

Several samples of these residues were combined and extracted with benzene. This solution was treated with fullers' earth, filtered, and ligroin was added to the reddish solution, when a pink precipitate was obtained. This was redissolved in benzene and reprecipitated six times, and the final product, still slightly pink, was analyzed for halogen.

Subst. 0.1655 and 0.1595; AgBr 0.2179 and 0.2100.

Calc. for $C_6H(OCH_3)Br_2O$: Br. 57.11. Found: 56.03, 56.03.

### Effect of Other Substances.

The following substances, in small amounts, were found to cause the decomposition of preheated salt: Propyl bromide, chloroformic ester, concentrated hydrochloric acid, fuming nitric acid, iodine, and bromine.

MINNEAPOLIS, MINNESOTA.

## HYDRAZINO DIACIDS.

BY J. R. BAILEY AND L. A. MIKESKA.

Received June 12, 1916.

### Introduction.

The first hydrazino diacid, hydrazinodiacetic acid, $NH_2N(CH_2COOH)_2$, was discovered in the Heidelberg laboratory by Curtius and Hussong.[1] The method of preparing this substance was improved by Bailey and Read and its reactions further investigated.[2] Darapsky and Prabhakar have announced the discovery of hydrazinodimalonic acid,[3] the second hydrazino diacid thus far reported, but the work described in this article shows that the proofs deduced for the constitution of this substance are not valid.

Hydrazinodiacetic acid is readily made by the action of monochloroacetic acid on hydrazine in alkaline solution, and as the product is difficultly soluble in water, its isolation presents no difficulty. It might be expected that other halogen acids would produce similar results with hydrazine, and that the solubilities in water of the hydrazino diacids thus formed

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[1] *J. prakt. Chem.*, [2] 83, 249 (1911).

[2] THIS JOURNAL, 36, 1748 (1914).

[3] Moreshwar Prabhakar, *Dissertation*, Heidelberg, 1912.

would also render them easily separated from the inorganic admixtures produced in their preparation. The other common $\alpha$-halogen acids react beyond question on hydrazine in alkaline solution, but on neutralizing the reaction mixtures there is no separation of the expected hydrazino diacids. It might be supposed that, even were the hydrazino diacids readily soluble in water, their isolation could be effected by converting them to the corresponding benzylidene compounds, since all hydrazines, as a rule, readily condense with aldehydes and ketones in the well-known way. However, Curtius and Hussong failed to produce a reaction between hydrazinodiacetic acid and aldehydes as is evidenced by the following quotation from the article referred to above:

> "Alle Versuche, die Säure mit Aldehyden zu kondensieren, verliefen ohne Ergebnis. Angewandt wurden: Benzaldehyd, Salicylaldehyd, *m*-Chlorbenzaldehyd, und *m*-Nitrobenzaldehyd. Weder in neutraler, noch in saurer oder alkalischer wässriger Lösung, weder beim unmittelbaren Zusammenbringen der Körper bei gewöhnlicher Temperatur, noch beim Erwärmen trat Kondensation ein."[1]

This peculiar anomaly of hydrazinodiacetic acid, as reported by the German investigators, induced us to institute experiments aimed at establishing conditions under which hydrazinodiacetic acid could be made to react normally with aldehydes. Contrary to the observation of Curtius and Hussong, we find that benzaldehyde reacts smoothly and normally with hydrazinodiacetic acid in aqueous solution, giving a practically quantitative yield of benzylidenehydrazinodiacetic acid, while in potassium hydroxide solution both benzaldehyde and salicylaldehyde condense with this hydrazine, giving hydrazones that can be isolated in the form of the difficultly soluble monopotassium salts. Attention may be directed to the fact that, if neutral potassium hydrazinodiacetate be condensed in water solution with benzaldehyde and then sufficient sulfuric acid added to neutralize all the potassium, the hydrazone separates partly as monopotassium hydrazinodiacetate,

$$C_6H_5CH = NN(CH_2COOH)CH_2COOK,$$

and partly as the free hydrazone acid. The hydroxybenzylidene compound, prepared similarly, separates only in the form of its monopotassium salt. In other words, these potassium salts are stable in the presence of a mineral acid.

The discovery of hydrazone derivatives of hydrazinodiacetic acid gave an incentive to attempts in the preparation of other hydrazino diacids. The method of Curtius and Hussong, as modified and improved by Bailey and Read,[2] can be extended to the preparation of other hydrazino diacids than the diacetic acid derivative, where the acid rest is of a single type. In the case of mixed hydrazino diacids, such as hydrazinoacetic-propionic

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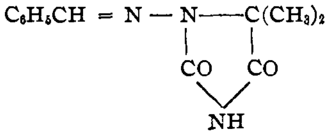
[1] *J. prakt. Chem.*, [2] 83, 275 (1911).

[2] *Loc. cit.*

acid, the method, for obvious reasons, would not be available. This latter purpose can be effected, as shown in this article, by the reduction of mixed nitrosimino diacids, a reaction employed by Bailey and Snyder[1] in the conversion of nitrosiminodiacetic acid to hydrazinodiacetic acid. Furthermore, in the experimental part of this article it is shown that benzylidenehydrazino monoacids are very reactive in alkaline solution toward α-halogen acids. By this method both benzylidenehydrazinoacetic-propionic acid, and benzylidenehydrazinodipropionic acid were prepared from benzylidenehydrazinopropionic acid, $C_6H_5CH = NNHCH(CH_3)COOH$. Benzylidenehydrazino-*i*-butyric acid, $C_6H_5CH = NNHC(CH_3)_2COOH$, was converted similarly by this process to benzylidenehydrazinoacetic-isobutyric acid.

Bailey and Read,[2] and before them Busch and Walter,[3] showed that the imino hydrogen in hydrazones is reactive; the former added cyanic acid on to benzylidenehydrazino-*i*-butyric acid, producing 5-dimethyl-1-benzylideneaminohydantoin,



$$\begin{array}{l} C_6H_5CH = N - N \text{——} C(CH_3)_2 \\ \qquad\qquad\qquad\;\; | \qquad\;\; | \\ \qquad\qquad\qquad CO \quad CO \\ \qquad\qquad\qquad\quad \diagdown \diagup \\ \qquad\qquad\qquad\quad\; NH \end{array}$$

while the latter investigators with carbonyl chloride and benzylidenephenylhydrazine made benzylidenephenylhydrazinocarboxylic acid chloride, $C_6H_5CH = NN(COCl)C_6H_5$. In this article it is shown that cyanic acid in glacial acetic acid with benzylidenehydrazinopropionic acid yields methylbenzylideneaminohydantoic acid, $C_6H_5 - CH = NN(CONH_2)CH(COOH)CH_3$. This observation may lead to a serviceable method of preparing unsymmetrical substitution products of phenylhydrazine, by the introduction of various acid rests on the α-nitrogen.

In the work herein described the very unexpected observation has been made that the benzylidene compounds of the hydrazino diacids, with the exception of hydrazinodiacetic acid, on being precipitated from alkaline solution, even with a mineral acid in excess, retain a *half atom* of alkali metal. Benzylidenehydrazinoacetic-propionic acid, benzylidenehydrazinoacetic-isobutyric acid, and benzylidenehydrazinodipropionic acid, when precipitated from either potassium or sodium hydroxide solution, give beautifully crystallizing, snow white substances, on which careful determinations of C, H, N, and K, or Na, give concordant results for the above constitution. These peculiar alkali derivatives, which separate in the presence of an excess of mineral acid, can be recrystallized from glacial acetic acid unchanged. In an experiment with the potassium

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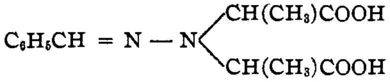
[1] THIS JOURNAL, **37**, 935 (1915).

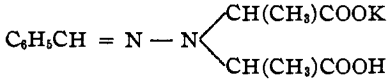
[2] *Ibid.*, **37**, 1892 (1915).

[3] *Ber.*, **36**, 1359 (1903).

compound of benzylidenehydrazinoacetic-isobutyric acid the hydrazone was suspended in water, the calculated amount of sulfuric acid added to convert all the potassium present to potassium sulfate and solution effected by boiling. The solution was boiled for half an hour with steam passing through it. A part of the benzaldehyde in this process was eliminated, but on cooling a large part of the unchanged potassium salt crystallized out. As was to be expected, the liquid proved strongly acid toward congo paper. The formulas of these alkali derivatives, which are similar to potassium tetroxalate in their constitution, may be exemplified by the following interpretation of the potassium salt of benzylidenehydrazinodipropionic acid:



$$C_6H_5CH = N - N\left\langle\begin{matrix}CH(CH_3)COOH\\CH(CH_3)COOH\end{matrix}\right.$$



$$C_6H_5CH = N - N\left\langle\begin{matrix}CH(CH_3)COOK\\CH(CH_3)COOH\end{matrix}\right.$$

Experiments to obtain the three new hydrazino diacids in a form suitable for analysis were abandoned, because of their hygroscopic nature. Preliminary experiments have shown that they can be prepared in solution by converting the alkali salts of the benzylidene derivatives into the alcohol soluble sulfates of the hydrazinodiacids and removing the sulfuric acid in the usual way. When precipitated from an alcoholic solution with ether, these hydrazines quickly deliquesce on exposure to air. Their hydrazine nature is revealed by the fact that they condense normally with benzaldehyde like hydrazinodiacetic acid. The structure of hydrazinodipropionic acid has also been confirmed by converting it to ethyl semicarbazinodipropionate,

$$NH_2CO - NH - N = [CH(CH_3)COOC_2H_5]_2.$$

The benzylidene derivatives of three new hydrazino diacids have been prepared. They are all very readily purified by recrystallization from alcohol and uniformly contain a half atom of alkali metal in the molecule.

Conditions have been established for the preparation of benzylidene hydrazinoacetic-isobutyric acid. In contrast to most hydrazones, this substance is very soluble in water even at room temperature, which fact, coupled with the difficult solubility of the acid alkali salts, offers in part an explanation of why the alkali salts are formed exclusively on acidifying an alkaline solution of this hydrazone. The difference in the solubility of benzylidenehydrazinodiacetic acid and its alkali acid salts is not very marked, although the latter are more soluble in water than the former. Conductivity determinations carried out by Mr. W. A. Felsing, of this laboratory, show the benzylidenehydrazinodiacids to be comparatively strong electrolytes, *e. g.*, the ionization of benzylidenehydrazinodiacetic acid is about one-half that of oxalic acid.[1] The association of

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[1] Conductivity determinations on benzylidenehydrazinodiacetic acid were made at 25° with the assumed ionization of only one H from the two carboxyls. The conduc-

four carboxyls in the alkali salts of three of the hydrazones of the hydrazino diacids discussed, plays no doubt an important rôle in determining their stability in the presence of mineral acids. Attention has been called to the fact that *hydroxy*benzylidenehydrazinodiacetic acid, in contrast to the simple benzylidenehydrazone, precipitates from an alkaline solution in the presence of a free mineral acid *only* in combination with the alkali metal. Here the acidifying influence of the OH group is self-evident.

As a further proof of the constitution of the peculiar alkali salts of the benzylidenehydrazino diacids, the synthesis of hydrazinodipropionic acid from hydrazinomonopropionic acid and α-bromopropionic acid in alkaline solution was carried out. In this reaction the hydrazinodipropionic acid was isolated as the potassium salt of the benzylidene derivative and the latter proved identical with the preparation referred to above from benzylidenehydrazinopropionic acid and α-bromopropionic acid. The interesting observation was made that not only is the unsymmetrical hydrazinodipropionic acid formed here but also the symmetrical

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tivity at infinite dilution used in the calculations below is taken as 457 ohms, this factor being deduced from the conductivity determinations carried out on the monopotassium salt.

| | | | | |
|---|---|---|---|---|
| Concentration | 0.002 *M* | 0.001 | 0.0005 | 0.0002 |
| Conductivity | 200.5 | 229.0 | 283.0 | 350.0 |
| Ionization | 43.86% | 50.05 | 61.93 | 76.60 |

Conductivity determinations on the monopotassium salt of benzylidenehydrazinodiacetic acid from two stock solutions of 0.05 molar were carried out and the determinations made in duplicate showed uniformity.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Concentration | 0.05 *M* | 0.02 | 0.01 | 0.005 | 0.002 | 0.001 | 0.0005 |
| Conductivity | 87.8 | 95.1 | 100.1 | 105.7 | 118.7 | 132.4 | 150.1 |
| Ionization | 47.72% | 51.40 | 54.10 | 57.15 | 64.15 | 71.60 | 81.20 |

Here the conductivity at infinite dilution was obtained by two methods: first, by plotting conductivity against concentration, which yielded the value 185; second, by the method of Noyes and Coolidge (*Carnegie Inst. Publ.*, No. 63, 50) of plotting $1/L$ against $(CL)^{n-1}$. The best straight line was obtained with the $n$ value at 1.625, yielding an $L_o$ value of 188.7.

In order to determine the conductivity of the *free acid* at infinite dilution, the method was as usual:

$L_o$ salt — $L_oK^+ + L_oH^+ = L_o$ acid, or substituting the two values of $L_o$ for the potassium salt found above

$$185 - 74.8 + 347 = 457.2$$
$$188.7 - 74.8 + 347 = 460.9$$

By employing the method of Derick (THIS JOURNAL, 36, 2268 (1914)) for calculating the conductivity of weak acids at infinite dilution from measurements below a concentration of 0.02 *N*, the $L_o$ value for benzylidenehydrazinodiacetic acid from the conductivity measurements at the two concentrations, 0.0005 and 0.0002 molar, was found to be 456. Of these three closely agreeing values, 456, 457.2 and 460.9, obtained by three independent methods, the number 457, as stated above, was employed in calculating the ionization of the free benzylidenehydrazinodiacetic acid at different concentrations.—W. A. FELSING.

isomeric diacid hydrazine, hydrazopropionic acid, $CH_3CH(COOH)NHNHCH(COOH)CH_3$. As both hydrazinopropionic acid and benzylidenehydrazinopropionic acid are difficult to obtain, it is best to start with hydrazine hydrate, which we have found yields on treatment with $\alpha$-bromopropionic acid in alkaline solution the two diacid derivatives of hydrazine, hydrazinodipropionic acid and hydrazopropionic acid, and in addition hydrazino*mono*propionic acid.

Above, attention has been called to the fact that Darapsky and Prabhakar interpreted the constitution of the reaction product of monobromomalonic acid on hydrazine as hydrazinodimalonic acid, $NH_2N[CH(CO_2H)_2]_2$. They considered the possibility of this being hydrazomalonic acid but gave preference to the hydrazine formula for reasons given in the following quotation:

> "Für obige Hydrazino-dimalonsäure kommen zwei Formeln in Betracht:
>
> I. $(CO_2H)_2CH — NH — NH — CH(CO_2H)_2$. II. $NH_2 — N[CH(CO_2H)_2]_2$.
>
> Nach der symmetrischen Formel (I) enthält die Säure keine freie $NH_2$-Gruppe mehr und sollte sich darum nicht mit Benzaldehyd kondensieren. Indessen liefert auch die der asymmetrischen Formel (II) entsprechende und in analoger Weise entstehende Hydrazino-diessigsäure, $NH_2 — N(CH_2COOH)_2$, von Curtius und Hussong keine Benzalverbindung. Da ferner nach Harries und Haga auch bei der Einwirkung von Jodmethyl auf Hydrazinhydrat nur eine Amidogruppe in Reaktion tritt, und da in ähnlicher Weise nach Busch und Weiss aus Benzylchlorid und Hydrazinhydrat asymmetrisches Dibenzylhydrazin, $NH_2N(CH_2C_6H_5)_2$ ensteht, dürfte auch obiger Hydrazinodimalonsäure die asymmetrische Formel (II) zukommen. Das schwer lösliche Bis-diammoniumsalz der Säure wäre sonach folgendermassen zu formulieren: $2N_2H_4.NH_2 — N[CH(COOH)_2]_2$."

Attention might be called to the fact M. Busch has shown that ethyl chloroacetate reacts with phenylhydrazine to produce both symmetrical and unsymmetrical ethyl phenylhydrazinoacetate:

> "Der Essigesterest vermag unter den gleichen Bedingungen sowohl an den $\alpha$-wie $\beta$-Stickstoff des Hydrazins zu treten; es entstehen beide Hydrazinoessigester neben einander, und zwar vorwiegend die asymmetrischen Verbindung." It is true, however, that free chloroacetic acid with phenylhydrazine produces "ausschliesslich die asymm.-Phenylhydrazinoessigsäure."[1]

Darapsky and Prabhakar claim that hydrazinodimalonic acid will not condense with aldehydes, but do not consider this an argument against the hydrazine nature of their malonic acid derivative, because of the supposed resistance of hydrazinodiacetic acid toward condensation with aldehydes. If their substance in reality be hydrazinodimalonic acid, it is probable that in alkaline solution with benzaldehyde it will condense normally and thus furnish an affirmative proof of its constitution. The isolation of hydrazopropionic acid, although in small amount, among the reaction products of monobromopropionic acid on hydrazine or hydrazinopropionic acid, along with the observation of Busch cited above, suggests

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[1] *Ber.*, 36, 3878 (1903).

the possibility that some $\alpha$-halogen acids may be found to react with hydrazine forming exclusively hydrazo compounds.

The wide divergence between the solubility in water of hydrazinodiacetic acid and the other hydrazino diacids thus far investigated suggests the possibility of hydrazinodiacetic acid being a polymer. An attempt by Mr. W. A. Felsing in this laboratory to determine the molecular weight of hydrazinodiacetic acid in aqueous solution by the boiling-point method led to the discovery of a peculiar decomposition of this substance, which proceeds with a vigorous evolution of prussic acid and carbon dioxide, when the boiling of the solution is effected by the platinum resistance method. Another product of the decomposition is ammonia. A tentative explanation of the mechanism of the reactions involved is evident from the following equations:

$$(1)\ NH_2N(CH_2COOH)_2 + H_2O = NH_3 + HON(CH_2COOH)_2$$

$$(2)\ HON(CH_2COOH)_2 = HON(CH_3)CH_2COOH + CO_2$$

$$(3)\ HON(CH_3)CH_2COOH = HCN\quad HCOOH + CH_3OH$$

In the above experiment, after boiling produces no further evolution of prussic acid and all volatile products have been removed, the solution shows a strong reducing action toward permanganate. Furthermore, if the distillate obtained from the solution be passed over a heated copper oxide spiral, a test for formaldehyde can be obtained. These facts point to the formation of formic acid and methyl alcohol rather than their equivalent, acetic acid. It is contemplated to study this peculiar behavior of hydrazinodiacetic acid quantitatively and, if possible, synthesize the assumed intermediary product, methylhydroxylaminoacetic acid.

A second plausible explanation of the processes that go on in the disruption of the hydrazinodiacetic acid molecule under the catalytic action of platinum presents itself in the assumption of oximinoacetic acid, HON : CHCOOH, as an intermediary product. Hydroxylaminodiacetic acid could pass in this oxime by the elimination of a molecule of acetic acid or the equivalent of acetic acid plus water, formic acid and methyl alcohol.

$$HON(CH_2COOH)_2 = HON : CHCOOH + CH_3COOH.$$

$$HON(CH_2COOH)_2 + H_2O = HON : CHCOOH + HCOOH + CH_3OH.$$

Oximinoacetic acid was discovered by C. Cramer, who reports that the substance decomposes at 120° into HCN, $CO_2$, and $H_2O$ in aqueous solution.[2] Hantzsch and Wild's "oximidoessigacetsäure," COOHCH:NOCH$_2$-COOH, undergoes a similar decomposition into HCN, $CO_2$, and $HOCH_2COOH$.[3] It will be interesting to determine whether platinum

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[1] *J. prakt. Chem.*, **83**, 256 (1911); THIS JOURNAL, **36**, 1750 (1914).

[2] *Ber.*, **25**, 715 (1892).

[3] *Ann.*, **289**, 301 and 302 (1896).

will exert an accelerating influence in the decomposition of these oximes similar to its catalytic action on hydrazinodiacetic acid.

If the supposed hydrazinodimalonic acid of Darapsky and Prabhakar, be in reality a hydrazine, its solubility in water, along with the observation we have made in this respect on our three hydrazino diacids, indicates that the hydrazino diacids in the aliphatic series will prove to be hygroscopic substances, difficult to obtain in a form suitable for analysis.

## Experimental Part.

**Benzylidenehydrazinodiacetic Acid,** $C_6H_5CH = N — N(CH_2COOH)_2$.—Hydrazinodiacetic acid is dissolved in two mols of 2 *N* potassium hydroxide and a little less than the calculated amount of benzaldehyde added. On vigorous shaking the aldehyde disappears and on adding the calculated amount of hydrochloric acid, the benzylidene compound, mixed with its acid potassium salt, immediately separates in the form of a copious white precipitate. The hydrazone acid is very soluble in alcohol, ether, and glacial acetic acid, slightly soluble in benzene and chloroform and practically insoluble in ligroin and petrolic ether. From benzene it crystallizes sparingly in the form of long, slender prisms. For analysis it can be purified by precipitation from an ether solution with petrolic ether. On being heated, the substance begins to soften at 115°, turning brown, and finally melts with gas evolution at 123°. The hydrazone readily dissolves in hot water with hydrolysis and, on steaming off the benzaldehyde, hydrazinodiacetic acid, melting with decomposition at 176°, crystallizes out. The lead, barium, and calcium salts of the benzylidene compound, prepared from a solution of the diammonium salt, were found to be difficultly soluble in water but were not further investigated.

| | | | |
|---|---|---|---|
| Calc. for $C_{11}H_{12}O_4N_2$: | C, 55.93%; | H, 5.08%; | N, 11.86%. |
| Found: | C, 56.28; | H, 5.25; | N, 11.95. |

**Monopotassium Benzylidenehydrazinodiacetate.**—The monopotassium salt of hydrazinodiacetic acid, as prepared above, can be separated from the admixed free hydrazone acid by extraction of the latter with ether. The salt, recrystallized from absolute alcohol, is obtained in characteristic aggregates of microscopic needles, which decompose on heating between 210° and 215°. The same salt is obtained by treating benzylidenehydrazinodiacetic acid in alcoholic solution with one mol of potassium hydroxide, or directly from monopotassium hydrazinodiacetate in concentrated aqueous solution by treatment with the calculated amount of benzaldehyde.

| | | | | |
|---|---|---|---|---|
| Calc. for $C_{11}H_{11}O_4N_2K$: | C, 48.18%; | H, 4.01%; | N, 10.22%; | K, 14.23%. |
| Found: | C, 48.24; | H, 4.11; | N, 10.20, 10.26; | K, 14.24, 14.21. |

A normal condensation of benzaldehyde with *free* hydrazinodiacetic acid can also be readily effected with a practically quantitative yield as follows: The hydrazine is dissolved in boiling water and to the hot solution one mol of benzaldehyde, emulsified in a little water, added. The solution is now vigorously shaken with cooling under a flowing hydrant. After a few minutes the hydrazone separates, free of admixture with the original hydrazine, and can be extracted with ether. On adding petrolic ether to the ether solution, the beautifully crystallizing benzylidenehydrazinodiacetic acid separates in radiating bunches of short needles.

**Monosodium Benzylidenehydrazinodiacetate.**—If benzylidenehydrazinodiacetic acid be dissolved in a little alcohol and one mol of 2 *N* sodium hydroxide added, the liquid solidifies after a few minutes. On recrystallization from alcohol the salt is obtained in microscopic, long, slender needles, which decompose at 338°. This salt is more difficultly soluble in alcohol than the corresponding potassium salt and contains one mol of water of crystallization. The same substance is obtained by treatment of a concentrated aqueous solution of monosodium hydrazinodiacetate with the calculated amount of benzaldehyde, when the addition of alcohol at the end of the reaction effects an almost quantitative precipitation of the hydrazone salt. For analysis it was found advisable to dry the salt at 70°, as on heating to a temperature sufficiently high to expel the water of crystallization, a slight decomposition results.

Calc. for $C_{11}H_{11}O_4N_2Na.H_2O$: C, 47.83%; H, 4.71%; N, 10.14%; Na, 8.33%.
Found: C, 47.42; H, 4.76; N, 10.23; Na, 8.22, 8.34.

**Monopotassium *o*-Hydroxybenzylidenehydrazinodiacetate.**—Free hydrazinodiacetic acid condenses with salicylaldehyde, but the reaction proceeds more slowly than it does between the hydrazine and benzaldehyde. The hydroxybenzylidenehydrazone is obtained as an oil which on standing solidifies. However, no attempt was made to prepare it in a form suitable for analysis. The condensation of hydrazinodiacetic acid with salicylaldehyde is best effected by operating with the dipotassium salt of the former: the hydrazine acid is dissolved in two mols of 2 *N* KOH, one mol of salicylaldehyde added, and the solution allowed to stand one hour for completion of the reaction. The requisite amount of standard sulfuric acid to neutralize *all* the potassium is then added, because, if only the calculated amount of acid to liberate the monopotassium salt be used, it effects a very incomplete precipitation. The monopotassium salt, which separates in excellent yield from the acid solution, free as far as our observation goes from any admixed hydroxybenzylidenehydrazinodiacetic acid, is best purified by recrystallization from absolute alcohol. It is thus obtained with a faint yellow tinge in microscopic needles, which decompose at 212°. This hydrazone salt contains $^1/_2$ mol of water of crystallization. For analysis it was dried at 75°, since it is not possible to eliminate the water without the substance undergoing a slight decomposition.

Calc. for $C_{11}H_{11}O_5N_2K.{}^1/_2\ H_2O$: C, 44.15%; H, 4.01%; N, 9.36%, K, 13.04%.
Found: C, 44.16, 44.38; H, 4.24, 4.36; N, 9.54, 9.70, 9.31; K, 12.89, 12.85, 12.77.

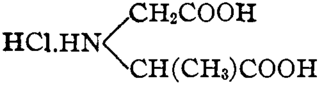
**The Sodium Salt of Benzylidenehydrazinoacetic-propionic Acid from the Ethyl Ester of Nitrosiminoacetic-propionic Acid.**—10.6 g. (1 mol) of monochloroacetic acid in 50 cc. of water are treated with 22.75 g. potassium carbonate (0.5 mol). After effervescence ceases, 10 g. of alanine are added, the solution boiled for three hours under a return condenser, and then evaporated to dryness. In order to isolate the reaction product, 100 cc. of methyl alcohol are poured on the residue and esterification effected by passing hydrochloric acid gas through the boiling solution. After removal of the alcohol, the residue is dissolved in a little water and a slight excess of sodium nitrite added, whereupon the nitrosamine separates as a yellow oil in good yield. The reduction of the nitroso compound is effected in 50% alcoholic solution with 3% sodium amalgam. The amalgam, 200 g. for 8 g. of the nitrosamine, is added in small amounts with cooling. Twenty-four hours are required for the completion of the reduction. The solution is then boiled for half an hour to saponify the ester, concentrated to remove the alcohol, and finally shaken out with benzaldehyde. On acidifying, a good yield of the hydrazone, 6 g. from 8 g. of the nitrosamine, is obtained. For analysis the substance was recrystallized from glacial acetic acid and then from alcohol. From either solvent it separates in the form of characteristic rectangular, thin plates as seen under the microscope, which begin to turn brown at about 220° and decompose completely at 330°.

Calc. for $C_{24}H_{27}O_8N_4Na$: C, 55.17%; H, 5.17%; N, 10.73%; Na, 4.41%.
Found: C, 55.18; H, 5.18; N, 10.93; Na, 4.18.

Salicylaldehyde also reacts with this hydrazine forming a hydrazone which has an alkali content similar to the benzylidene compound. Recrystallized from alcohol it melts at 222°.

Calc. for $C_{24}H_{27}O_{10}N_4Na$: N, 10.11%; Na, 4.15%. Found: N, 10.23; Na, 4.10.

**Hydrochloride of Iminoacetic-propionic Acid,**



$$HCl.HN\begin{cases}CH_2COOH\\CH(CH_3)COOH\end{cases}$$

.—The hydrochloride of iminoacetic-propionic acid is obtained by boiling the nitroso compound, described in the above preparation, for half an hour with an excess of dilute acid under a return condenser. The solution is next evaporated to dryness, the residue dissolved in alcohol, and the salt precipitated from the alcoholic solution with ether. It melts with decomposition at 223°.

Calc. for $C_5H_{10}O_4NCl$: N, 7.65%. Found: N, 7.66.

**The Potassium Salt of Benzylidenehydrazinoacetic-isobutyric Acid.**—To 24.7 g. of benzylidenehydrazinoisobutyric acid in 160 cc. of water, 32 g. of potassium carbonate are added with cooling and the solution boiled two hours under a return condenser. Upon treatment of the solution with a slight excess of acetic acid, a mixture of the unchanged benzylidenehydrazinoacetic-isobutyric acid separates out. The former is removed from the precipitate by alcohol-ether treatment and the potassium salt recrystallized from alcohol. It is thus obtained in radiating bunches of long, slender prisms, which decompose at 209°.

Calc. for $C_{26}H_{31}O_8N_4K$: C, 55.12%; H, 5.48%; N, 9.89%; K, 6.89%.
Found: C, 54.78; H, 5.72; N, 9.84; K, 6.60.

**Benzylidenehydrazinoacetic-isobutyric Acid,** $C_6H_5CH = N — N(CH_2COOH)(C(CH_3)_2COOH)$.—Two grams of benzylidenehydrazino-isobutyric acid are suspended in a little water, 2.5 g. of monochloroacetic acid and 4.5 g. of potassium carbonate added, and the solution boiled half an hour under a return condenser. In order to convert all the potassium to sulfate, 4 cc. of concentrated sulfuric acid are added and the benzaldehyde steamed off. The solution is then made alkaline with ammonia, and the dissolved hydrazino acid reconverted to the benzylidene derivatives by treatment with the calculated amount of benzaldehyde. On acidifying the solution with glacial acetic acid the benzylidenehydrazinoacetic-isobutyric acid, mixed with the ether soluble benzylidenehydrazino-isobutyric acid, separates. As benzylidenehydrazinoacetic-isobutyric acid is exceptionally soluble in water, it is necessary to operate in concentrated solution. It is very sparingly soluble in ether, chloroform, and benzene, and recrystallizes from alcohol in a matted mass of short, slender needles, which melt at 202° with decomposition. The potassium salt of benzylidenehydrazinoacetic-isobutyric acid dissolves in KOH and is reprecipitated unchanged on acidifying. On the other hand, if it be dissolved in concentrated ammonia, sulfuric acid precipitates the alkali free hydrazone just described.

Calc. for $C_{13}H_{16}O_4N_2$: N, 10.61%. Found: N, 10.60.

**The Potassium Salt of Benzylidenehydrazionodipropionic Acid from Hydrazinopropionic Acid or from Benzylidenehydrazinopropionic Acid.**— A mixture of one mol of hydrazinopropionic acid, one mol of α-bromopropionic acid, and two mols of potassium carbonate in 10 cc. of water for every gram of the hydrazinopropionic acid used is boiled two hours under a return condenser. The solution is then treated with one mol of benzaldehyde and, after the reaction is complete, the excess of aldehyde is extracted with ether. On acidifying the solution with hydrochloric acid, a mixture of the potassium salt of benzylidenehydrazinodipropionic acid and benzylidenehydrazinopropionic acid is obtained. The separation of these two substances is described further on under the action of α-bromopropionic acid on hydrazine hydrate. In the action of bromopropionic acid on hydrazinopropionic acid, there is also formed a small amount of hydrazopropionic acid, the isolation of which may be effected through the ethyl ester by the process described later.

The potassium salt of hydrazinodipropionic acid can also be obtained by the action of α-bromopropionic acid on benzylidenehydrazinopropionic acid in potassium carbonate solution by employing the method used in the preparation of the potassium salt of benzylidenehydrazinoacetic-isobutyric acid from benzylidenehydrazinoisobutyric acid, described above.

**Action of Bromopropionic Acid on Hydrazine Hydrate.**—To a solution of 20 g. (2 mols) of bromopropionic acid in 20 cc. of water, 6 g. (1 mol) of hydrazine hydrate are added slowly from a dropping funnel with cooling 18 g. of solid potassium carbonate are next added with cooling and finally the solution warmed on the water bath as long as carbon dioxide is given off. The reaction is then completed by boiling for two hours under a return condenser. The solution is now shaken out with 12 cc. of benzaldehyde, ethered out in order to remove the excess of benzaldehyde, and finally neutralized with hydrochloric acid. A yellow oil, consisting of a mixture of benzylidenehydrazinopropionic acid and the potassium salt of benzylidenehydrazinodipropionic acid, separates and solidifies on stirring. The solution is filtered and the precipitate washed with water. To obtain the potassium salt of the benzylidenehydrazinodipropionic acid free from benzylidenehydrazinopropionic acid, the latter is extracted with ether. The potassium salt is then recrystallized from absolute alcohol in the form of thin plates, melting at 210° with decomposition. The three methods of preparation of monopotassium benzylidenehydrazinodipropionate, which have been described, yield products in every way identical.

Calc. for $C_{26}H_{31}O_8N_4K$: C, 55.12%; H, 5.48%; N, 9.89%; K, 6.89%.
Found: C, 54.81; H, 5.89; N, 10.01; K, 6.60.

To isolate the benzylidenehydrazinopropionic acid, the ether solution obtained above is shaken out with strong potassium hydroxide and the aqueous layer neutralized with HCl. The hydrazone separates in the form of a yellow oil which solidifies on stirring. Recrystallized from benzene, the substance is obtained colorless but turns slightly yellow on exposure to air. It is soluble in all common organic solvents with the exception of petrolic ether and melts with decomposition at 106°, as described by Traube and Longinescu.[1]

Calc. for $C_{10}H_{12}O_2N_2$: N, 14.58%. Found: N, 14.50.

If the crude benzylidenehydrazinopropionic acid, described above, be subjected to steam distillation, it dissolves only partially while a part separates as a smear. When the solution, filtered from the smear, is

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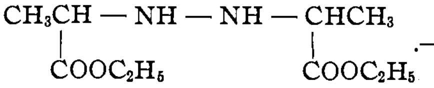
[1] *Ber.*, **29**, 672 (1907).

concentrated on a water bath and allowed to drop slowly into alcohol, the hydrazinopropionic acid separates in the form of a white granular powder. Purified by a second precipitation from water solution with alcohol, the hydrazine melts with decomposition at 180° and agrees in all its properties with the same preparation from ethyl semicarbazinopropionate.[1]

Calc. for $C_3H_8O_2N_2$: N, 26.92%. Found: N, 26.82.

The smear referred to above solidifies on cooling. In this impure state it melts at about 90° and decomposes at approximately 105°. It is soluble in all common organic solvents but insoluble in water, alkalies, and mineral acids. All attempts to crystallize the substance failed. An analysis of the crude material gave 14.47% nitrogen.

**Ethyl Hydrazopropionate,**



$$\underset{COOC_2H_5}{\underset{|}{CH_3CH}} - NH - NH - \underset{COOC_2H_5}{\underset{|}{CHCH_3}}$$

.—The isolation of hydrazopropionic acid in small amount among the reaction products of potassium bromopropionate on hydrazine can be effected as follows: The filtrate, obtained above from the benzylidenehydrazinomono- and dipropionic acids, is evaporated to dryness and the residue esterified according to the method of Thiele and Bailey.[2] In this way a substance is obtained which was carefully compared with ethyl hydrazopropionate, prepared from hydrazopropionitrile, and the two preparations were found in every respect identical. However, as this substance, especially when impure, quickly changes to an oil, it has thus far not been possible to accumulate sufficient for an analysis. Our preparation melted at 76° to a clear liquid and a mixed sample of the two preparations gave the same result. From petrolic ether both preparations separated in the form of long prisms.

**Ethyl Semicarbazinodipropionate,** $NH_2CONHN(CH(CH_3)COOC_2H_5)_2$.—The potassium salt of benzylidene hydrazinodipropionic acid is suspended in water, a little dilute hydrochloric acid added, and the benzaldehyde removed by steam distillation. The solution is next evaporated *in vacuo* to dryness, the residue covered with saturated alcoholic HCl and this allowed to stand twelve hours. The alcohol is then distilled off *in vacuo*, the residue taken up with a little water and the solution treated with a slight excess of KCNO with cooling. At first an oil separates, probably some of the unchanged ester, and finally the ethyl semicarbazinodipropionate crystallizes out in poor yield. The ester is soluble in hot benzene, from which it separates on cooling, more difficultly soluble in hot ether, readily soluble in alcohol and chloroform, slightly soluble in cold water, and practically insoluble in petrolic ether. After recrystallization from

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[1] *Ann.*, 303, 85 (1898).

[2] *Ibid.*, 303, 87 (1898).

benzene, the substance melts at 159° with decomposition. It reduces permanganate in sulfuric acid solution, giving an oxidation product which crystallizes beautifully from alcohol. This oxidation product, while it melts at the same temperature as the expected ethyl semicarbazinopyruvate, $NH_2CO - NHN = C(CH_3)COOC_2H_5$,[1] and has the same solubilities, differs from it in crystalline form.[2] Our limited supply of material did not permit a further study of this compound to determine whether a case of stereoisomerism is involved.

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|---|---|---|---|
| Calc. for $C_{11}H_{21}O_5N_3$: | C, 48.00%; | H, 7.64%; | N, 15.27%. |
| Found: | C, 48.16; | H, 7.83; | N, 15.56. |

Bailey and Read prepared semicarbazinodiacetic acid by the action of potassium chloroacetate on semicarbazide in alkaline solution and their work suggested the possibility of employing a similar process for the preparation of semicarbazinodipropionic acid. Prolonged heating of one mol of semicarbazide and three mols of bromopropionic acid in the presence of three mols of KOH in aqueous solution at a temperature of 60° was tried.[3] The isolation of the reaction products was carried out by the esterification process, employed by Bailey and Read in their preparation of semicarbazinomono- and diacetic acids. However, the propionic acid rest enters only once in the semicarbazide molecule under the conditions followed above. Here the ethylsemicarbazinopropionate obtained in poor yield, gave the correct melting point and proved identical with a sample of this substance in stock.

Calc. for $C_6H_{13}O_3N_3$: N, 24.10%. Found: N, 23.84.

**Methylbenzylideneaminohydantoic Acid,** $C_6H_5CH = N - N(CONH_2)$-$CH(CH_3)COOH$.—Two grams of benzylidenehydrazinopropionic acid, dissolved in 10 cc. of glacial acetic acid, are treated with 1 g. of finely powdered potassium cyanate, the solution allowed to stand two hours, and then the mixture diluted with water to eight times its volume. The hydantoic acid crystallizes out slowly, colored slightly yellow. It is difficultly soluble in all common organic solvents except alcohol, from which it crystallizes in radiating bunches of short, thick, diamond-shaped crystals, melting at 180°. The substance in dilute sulfuric acid solution readily splits off benzaldehyde, yielding a beautifully crystallizing compound, which is probably 5-methyl-1-aminohydantoin.

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|---|---|---|---|
| Calc. for $C_{11}H_{13}O_3N_3$: | C, 56.17%; | H, 5.53%; | N, 17.87%. |
| Found: | C, 56.12, 56.04; | H, 5.93, 5.71; | N. 17.81 |

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[1] *Ann.*, 303, 87 (1898).

[2] See THIS JOURNAL, 36, 1760 (1914).

[3] See *Ann.*, 289, 285 (1896).