I. HYDROXAMIC ACIDS RELATED TO α-HYDROXY ACIDS AND TO ACRYLIC ACID AND A STUDY OF THEIR REARRANGEMENTS

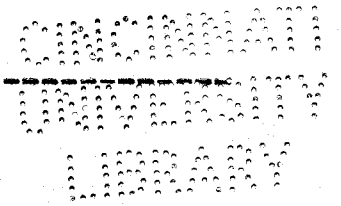
AND

II. THE PREPARATION OF ALKYL HYDROXYUREA CHLORIDES AND THEIR RELATION TO ESTERS OF CARBON DIOXIDE OXIME, R-O-N=C=O

A D I S S E R T A T I O N

Submitted to the Faculty of the Graduate School of the University of Cincinnati in part fulfillment of the requirements for the degree of Doctor of Philosophy

Department of Chemistry



By

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I. HYDROXAMIC ACIDS RELATED TO -HYDROXY ACIDS AND TO ACRYLIC ACID AND A STUDY OF THEIR REARRANGEMENTS.

Since Lossen[1] in 1869, prepared oxalohydroxamic acid by the action of hydroxylamine on oxalic ethyl ester and distinguished a class of compounds having the "structure of amides and the character of acids," many representatives of the hydroxamic acids have been prepared. The principle work on hydroxamic acids containing aromatic groups was done by Lossen[2] and his colaborators, who described the preparation and properties of many of the acids themselves as well as of their acyl esters and alkyl derivatives.

The chemistry of the hydroxamic acids of the aliphatic series has been developed to some extent by Hoffmann[3] who prepared acethydroxamic acid, by Moilati[4] and by Bamberger[5] Jones has described the preparation of hydroxamic acids of the aliphatic series from salts of nitroparaffines[6] from hydroxylamine salts

1. Ann. 150, 314 (1869)
2. Ann. 175, 284 (1875)
   178, 213 (1874)
   205, 273 (1880)
3. Ber. 22, 2854 (1889)
4. Ber. 25, 700 (1892)
5. Ber. 35, 45 (1902)
6. Am. Ch. J. 20, 1 (1898)

21Ja25 g

of organic acids[1], and from acid esters and free hydroxylamine[2]. The behavior of the hydroxamic acids of the aliphatic series, and of their salts and esters towards hydrolyzing agents and toward heat has been studied by Jones[3], by Biddle[4], by Wieland[5], and by Thiele and Picard[6]. The products obtained were isocyanates, which, in the presence of water, were converted into symmetrical disubstituted ureas or into the corresponding amines and carbon dioxide. An explanation of these reactions, based upon the electronic conception of valence, has been offered, and the relation between hydroxamic acids and the isocyanates pointed out by Jones[7] and by Stieglitz[8]. That this decomposition into isocyanates and the subsequent formation of an amine derivative is characteristic of hydroxamic acids of the aliphatic series, is further emphasized by results obtained in this laboratory by Jones and Sneed.

The purpose of the present paper is to describe some new hydroxamic acids of the aliphatic series, namely, those related to propionic[9], lactic, mandelic, and acrylic acids, and some of their derivatives. A study of the changes suffered by these compounds under

1. Am. Ch. J. 42, 515 (1909)
2. Am. Ch. J. 20, 28 (1898)
3. Am. Ch. J. 20, 1 (1898)
4. Ann. 310, 15 (1899)
5. Am. Ch. J. 48, 18 (1912) or "Die Knallsauer." P. 32 (1909)
6.
7. Am. Ch. J. 50, 414 (1913)
8.
9. The propionhydroxamic acid obtained showed a different

the influence of hydrolyzing agents, and of heat, has been made.

By the action of optically active alkaloids upon lact- and mandel-hydroxamic acids and upon their acyl esters, attempts were made to prepare optically active hydroxamic acids. The attempts were not successful but the work will be continued.

EXPERIMENTAL PART.

I. PROPIONHYDROXAMIC ACID AND ITS DERIVATIVES.

(a) Propionhydroxamic Acid.

Fifteen g. of propionic ethyl ester were added to 4.86 g. of free hydroxylamine. The mixture was made homogenous by addition of methyl alcohol and allowed to stand over night. After the solvent had been removed in vacuo, the resulting oil was allowed to stand for three weeks, when it solidified to a white crystalline mass. Upon recrystallization from acetic ether, 8.7 g. of a white crystalline solid, melting at 92.5°- 93°, were obtained. It gave a deep red coloration with ferric chloride.

Propionhydroxamic acid was found to be soluble in alcohol, in hot acetone, and in water, but was insoluble in chloroform, in ligroine, in ether, and in benzene. With copper acetate it formed a bluish green copper salt, and caused no effervescence with calcium carbonate. When heated above its melting point it suffered gentle decomposition and gave a strong odor of isocyanate.

.2110 g. gave 30 c.c. N_2 at 23.5° and 741.3 mm.

Calc. for $C_3H_7NO_2$: N, 15.73. Found: N, 15.68.

melting point from the one described by Miolati, Ber. 25, 700 (1892)

(b) Sodium Salt of Propionhydroxamic Acid.

Two g. of propionhydroxamic acid were dissolved in absolute alcohol and treated with .516 g. of sodium in absolute alcohol. When ether was added to the alkaline solution a white crystalline solid separated at once, which, when recrystallized, weighed 2.2 g. When a water solution of the sodium salt was treated with copper acetate, a stable green copper salt precipitated, with mercuric chloride a pale yellow salt, and with silver nitrate and lead acetate white salts were formed. The sodium salt was slightly hygroscopic and was stable when heated strongly.

.2034 g. gave .1294 g. Na_2SO_4.

Calc. for $C_3H_6NO_2Na$: Na, 20.74. Found: Na, 20.61.

(c) Potassium salt of Propionhydroxamic Acid.

The alcoholic solution of 2 g. of propionhydroxamic acid was treated with 1.25 g. of potassium hydroxide in alcohol. By the addition of absolute ether, the potassium salt was precipitated as a white crystalline solid. The recrystallized product weighed 2.5 g. Like the sodium salt, it suffered no decomposition when heated to high temperature.

.1921 g. gave .1306 g. K_2SO_4.

Calc. for $C_3H_6NO_2K$: K, 30.78. Found: K, 30.52.

(d) Benzoyl Ester of Propionhydroxamic Acid.

Five g. of the hydroxamic acid dissolved in water were treated with 3.14 g. of potassium hydroxide dissolved in water, and 7.68 g. of benzoyl chloride were added slowly, while the solution was cooled

and vigorously shaken. After several minutes, a white solid separated, which was filtered off, dried, extracted several times with boiling ligroine to remove benzoic acid, and recrystallized from absolute ether by the addition of ligroine. Nine g. of the ester, fine needle-like crystals, were obtained which melted at 115°- 116°, and decomposed at 125°- 130° giving an odor of iso-Cyanate. The benzoyl ester of propionhydroxamic acid was soluble in chloroform, in ether, in benzene, and in alcohol, but insoluble in ligroine and in water. It was acid to litmus. When suspended in water it gave an intense red coloration with ferric chloride, showing that it was readily hydrolyzed.

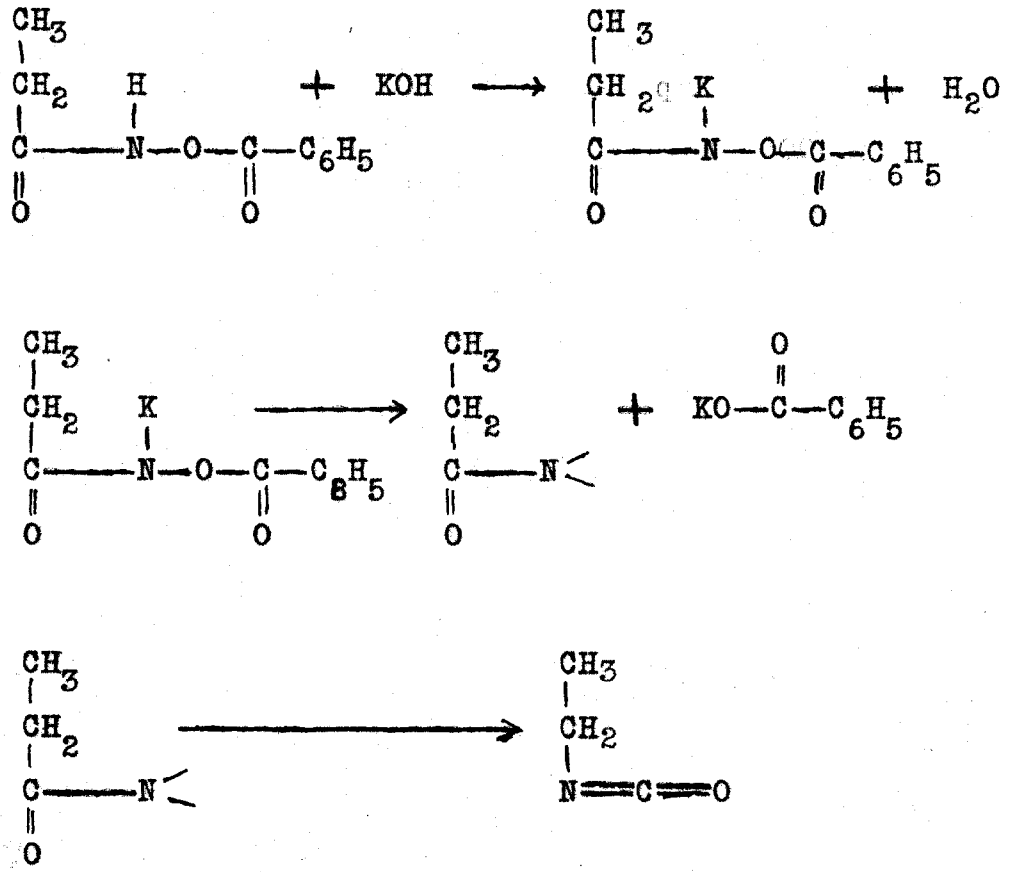
.2295 g. gave 14.9 c.c. N_2 at 23.5° and 740.5 mm.

Calc. for $C_{10}H_{11}NO_3$: N, 7.25. Found: N, 7.14.

Hydrolysis of the Benzoyl Ester of Propionhydroxamic Acid.

Three and eighty-one hundredths g. of the benzoyl ester and 1.02 g. of potassium hydroxide dissolved in water were sealed in a tube and heated on a water-bath for about six hours. The tube was opened and its contents distilled into a dilute hydrochloric acid solution. The residue in the flask was found to be potassium benzoate by dissolving it in water, acidifying the solution, and determining the melting point of the precipitate formed. Two and one tenth g. of benzoic acid were obtained. When the hydrochloric acid solution was evaporated, a white residue was left, which, upon purification, was found to be slightly deliquescent and to melt at 80°-82°. It responded to the isocyanide test for primary amines and corresponded in properties to ethyl ammonium chloride. The

following interpretation to account for the results obtained is offered: The benzoyl ester was first converted to its potassium salt, which by loss of potassium benzoate and by subsequent Beckmann rearrangement, was converted to ethyl isocyanate. This was hydrolyzed to give ethyl amine and carbon dioxide:



This decomposition and rearrangement is wholly analogous to the behavior of hydroxamic acids toward alkalies, described by Jones[1].

(e) Sodium Salt of the Benzoyl Ester of Propionhydroxamic Acid.

One g. of the benzoyl ester of propionhydroxamic acid was

1. Am. Ch. J. 20, 1 (1898)

dissolved in alcohol and treated with .119 g. of sodium dissolved in alcohol. When ether was added slowly to the resulting solution, a white, crystalline solid precipitated at once which was recrystallized from alcohol by addition of ether. Almost the theoretical quantity (1.02 g.) of the sodium salt of the benzoyl ester of propionhydroxamic acid was obtained. When this compound was heated in a glycerine bath and the temperature reached 86°, it decomposed with almost explosive violence, with the evolution of vapors which posessed a strong odor of isocyanate.

.1084 g. gave .0379 g. Na_2SO_4.

Calc. for $C_{10}H_{10}NO_3Na$: Na, 10.71. Found: Na, 11.32.

(f) Potassium Salt of the Benzoyl Ester of Propionhydroxamic Acid.

By mixing together 1 g. of the benzoyl ester in absolute alcohol and .29 g. of potassium hydroxide dissolved in alcohol, and adding ether to the resulting solution, the potassium salt was obtained as a white crystalline precipitate. When heated in a glycerine bath to 120°- 124°, it decomposed with a sudden puff, giving a strong odor of isocyanate.

.1976 g. gave .0751 g. K_2SO_4.

Calc. for $C_{10}H_{10}NO_3K$: K, 16.93. Found: K, 17.15.

(g) Silver Salt of the Benzoyl Ester of Propionhydroxamic Acid.

Five tenths g. of the sodium salt of the benzoyl ester of propionhydroxamic acid were dissolved in water and treated with silver nitrate solution until no further precipitation occured. The silver salt was filtered off in a dark cupboard and dried in an amber desiccator. It was soluble in hot chloroform, insoluble in benzene, in alcohol and in ether, and was very stable even when exposed to light for a considerable time. When heated strongly, it decomposed giving an odor of isocyanate.

.1026 g. gave .0371 g. Ag.

Calc. for $C_{10}H_{10}NO_3Ag$: Ag, 35.97. Found: Ag, 36.15.

(h) Acetyl Ester of Propionhydroxamic Acid.

Five tenths g. of propionhydroxamic acid and .57 g. of acetic anhydride were heated on a water-bath until the mixture no longer responded to the ferric chloride test for hydroxamic acids. The product was allowed to stand in a vacuum disiccator until a white solid formed. It crystallized from ether by addition of ligroine, forming glistening plates which melted at 72.5°- 73°. It was soluble in chloroform, in alcohol, in benzene, in ether, and in water. Above 75° it decomposed giving a strong isocyanate odor. It gave no precipitate with copper acetate.

.1133 g. gave 10.95 c.c. N_2 at 20° and 746.8 mm.

.1160 g. gave .1949 g. CO_2; .07308 g. H_2O.

Calc. for $C_5H_9NO_3$:	N, 10.68.	Found: N, 10.76.
	H, 6.92.	H, 6.99.
	C, 45.77.	C, 45.82.

(i) Sodium Salt of the Acetyl Ester of Propionhydroxamic Acid.

One tenth g. of the acetyl ester was dissolved in alcohol and treated with .017 g. of sodium in alcohol. Upon addition of ether a white crystalline solid was obtained, which was very hygroscopic, and from the water solution of which a fairly stable silver salt was precipitated by addition of silver nitrate solution.

.1101 g. gave .0520 g. Na_2SO_4.

Calc. for $C_5H_8NO_3Na$: Na, 15.05. Found: Na, 15.29.

(j) Potassium salt of the Acetyl Ester of Propionhydroxamic Acid.

This was prepared by the treatment of .14 g. of the acetyl ester in alcohol with .06 g. of potassium hydroxide dissolved in alcohol. Absolute ether caused the precipitation of the salt. When recrystallized from alcohol and ether, it formed flaky, shining plates, was not hygroscopic, and, when heated strongly, decomposed giving an odor of isocyanate.

.1210 g. gave .0615 g. K_2SO_4.

Calc. for $C_5H_8NO_3K$: K, 23.13. Found: K, 22.82.

II. LACTHYDROXAMIC ACID AND ITS DERIVATIVES.

(a) Lacthydroxamic Acid.

A mixture was made of 30.4 g. of lactic ethyl ester and 8.4 g. of free hydroxylamine. Sufficient methyl alcohol was added to produce a homogenous solution. Tested at intervals with ferric chloride, it showed a red coloration which increased in intensity

as the mixture was allowed to stand. After two days the solvent was removed by evaporation in a desiccator. The product was a thick, colorless oil which did not solidify after standing several weeks. Eighteen g. of the oil were obtained which gave the following figures on analysis:

.5827 g. gave 71 c.c. N_2 at 21° and 749.5 mm.

Calc. for $C_3H_7NO_3$: N, 13.33. Found: N, 13.70.

(b) Benzoyl Ester of Lactohydroxamic Acid.

To a solution of 5 g. of lactohydroxamic acid in water and 2.66 g. of potassium hydroxide, 6.68 g. of benzoyl chloride were added slowly while the mixture was cooled and shaken. A white solid separated in large quantity. When dried, a small amount of benzoic acid was separated from it by repeated extraction with boiling ligroine. The yield was 7.81 g. The benzoyl ester of lactohydroxamic acid melted at 124.5°- 126°, was soluble in alcohol, but insoluble in cold water, in ligroine, and in chloroform.

.3002 g. gave 17.7 c.c. N_2 at 30° and 747.1 mm.

Calc. for $C_{10}H_{11}NO_4$: N, 6.70. Found: N, 6.34.

Hydrolysis of the Benzoyl Ester of Lactohydroxamic Acid.

Five g. of the benzoyl ester of lactohydroxamic acid were heated with water for three hours on a boiling water-bath. The containing flask was attached to a reflux condenser from the top of which a glass tube extended into an ice-cooled vessel containing ether. This, in turn, was connected with a vessel containing a calcium

hydroxide solution. At the end of the process, dry ammonia gas was passed into the ether solution from which .278 g. of aldehyde ammonia, corresponding to .2 g. of acetaldehyde, were obtained. From the calcium hydroxide solution, .1064 g. of calcium carbonate corresponding to .0468 g. of carbon dioxide, was obtained. When the contents of the flask were cooled, a slightly brownish, crystalline solid deposited. This solid was filtered off and separated into .37 g. of benzoic acid and .34 g. of the unchanged benzoyl ester. The filtrate possessed a strong odor of benzoic ethyl ester, and when boiled with alkalies, evolved ammonia. It was distilled under diminished pressure. The distillate showed the presence of benzoic ethyl ester, and responded to a test for alcohol. A white solid (1.73 g.) remained in the distilling flask. This substance crystallized in well-developed, shining plates from alcohol, when ether was added. It melted at 196°- 197°.

.0769 g. gave 7.2 c.c. N_2 at 23° and 751 mm.

Calc. for $C_{15}H_{12}N_2O_3$: N, 10.45. Found: N, (1) 10.48.
(2) 10.38.

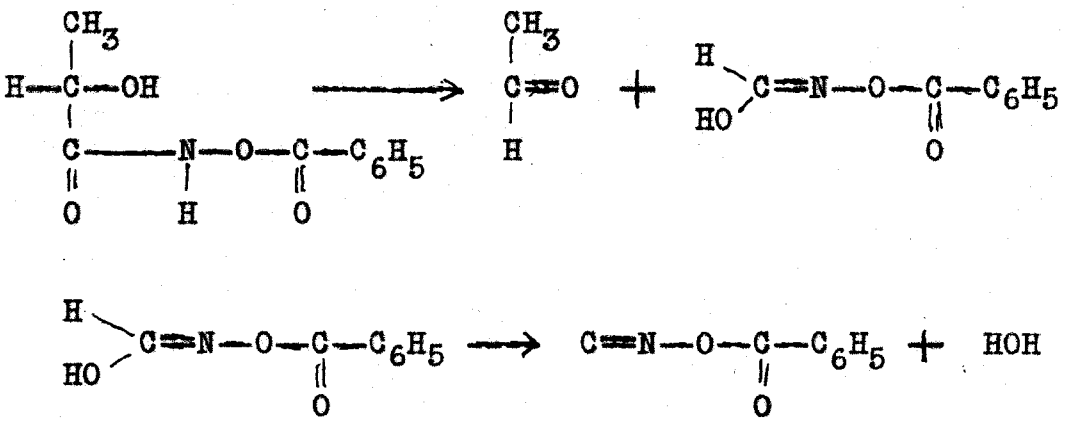
One and five tenths g. of the solid melting at 196°- 197° were sealed in a tube with dilute hydrochloric acid and heated for six hours on a water-bath. From the reaction-mixture, 1 g. of pure benzoic acid, .496 g. of ammonium chloride and .15 g. of carbon dioxide were isolated. The ammonium chloride was converted to the chlorplatinate.

Calc. for $(NH_4)_2 PtCl_6$: Pt, 43.94. Found: Pt, 43.67.

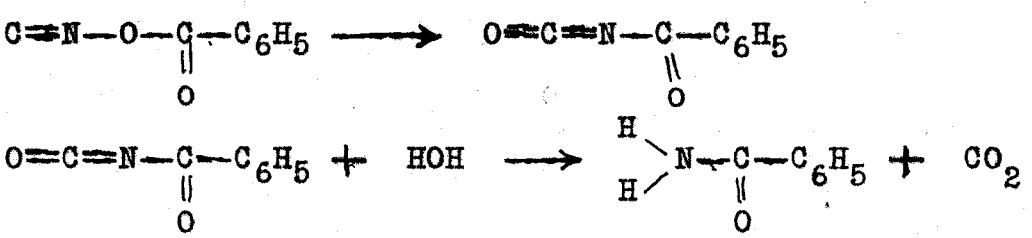
Since the white solid, melting at 196°- 197°, corresponded in

physical properties, in behavior toward acid hydrolysing agents, and in nitrogen content to symmetrical dibenzoyl urea, the following interpretation of the results obtained upon hydrolyzing the benzoyl ester of lacthydroxamic acid is offered;

Jones[1] has shown the probability of the existance of the benzoyl ester of formhydroxamic acid in two forms. If the benzoyl ester of lacthydroxamic acid first decomposes into acetaldehyde and the benzoyl ester of formhydroximic acid, a fulminic acid derivative might be formed by the loss of water.

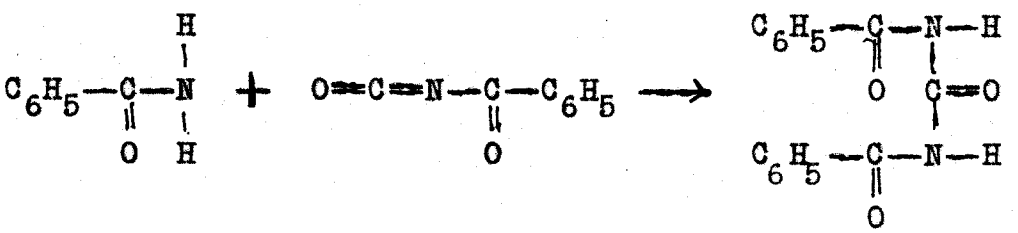


This fulminic acid derivative would rearrange to give an isocyanate which would be converted partially into benzamide and carbon dioxide:

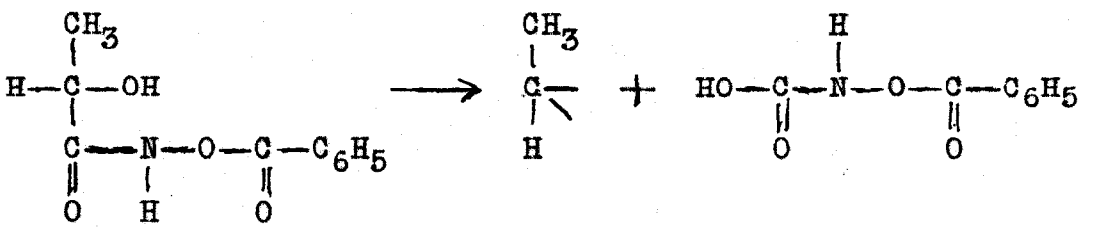


1. Am. Ch. J. 20, 31 (1898)

The benzamide, then, by uniting with a second molecular quantity of the benzoyl isocyanate, would form dibenzoyl urea:



This interpretation is offered tentatively in view of the fact that the ethyl benzoate and alcohol noted during the course of the experiment are not taken into account. Their formation, however, may be due to a dissociation of the original benzoyl ester, with ethylidene as one product. If the ethylidene is oxidized to acetaldehyde in the presence of water and the acetaldehyde then reduced, alcohol and benzoic ethyl ester could be accounted for:



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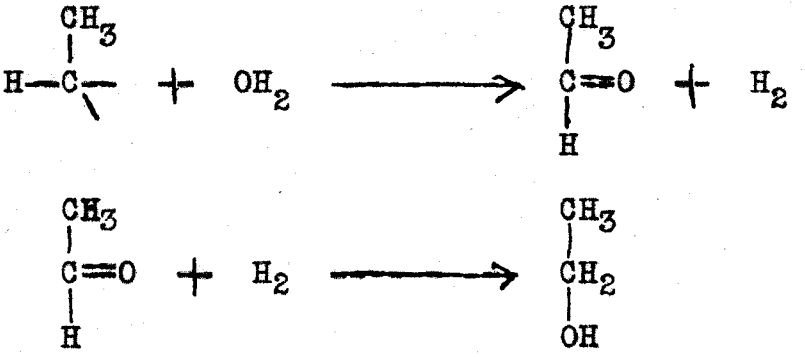
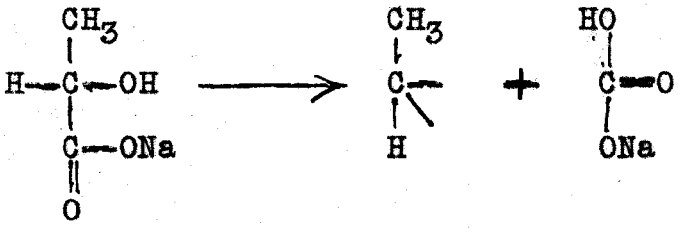
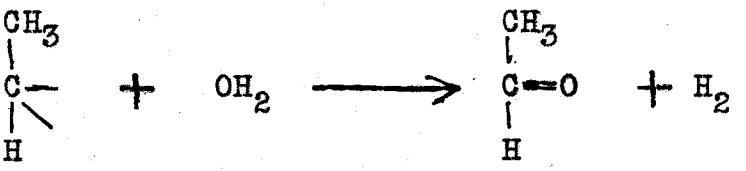
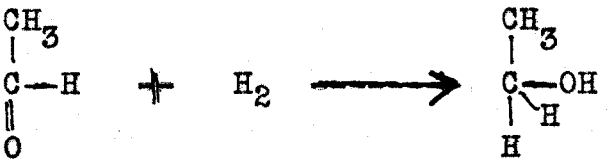


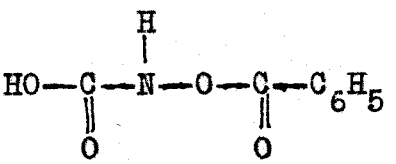
This is consistent with Nef's[1] explanation of the formation of acetaldehyde and ethyl alcohol from the sodium salt of lactic acid.







Although the quantities of alcohol and ethyl benzoate observed in our experiment were small, it is believed that investigations now being made will result in the identification of substances which would be expected as decomposition products of the compound of the formula,



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(c) Potassium Salt of the Benzoyl Ester of Lacthydroxamic Acid.

One g. of benzoyl ester was dissolved in alcohol and treated with an alcoholic solution of .267 g. of potassium hydroxide. Ether was added and a fine precipitate of the potassium salt was obtained. It was recrystallized from alcohol and ether and weighed .8 g. When heated strongly it decomposed, leaving a charred residue. .1511 g. gave .0528 g. of K_2SO_4.

Calc. for C H NO K: K, 15.83. Found: K, 15.68.

III. MANDELHYDROXAMIC ACID AND ITS DERIVATIVES.

(a) Mandelhydroxamic Acid.

A mixture of 10 g. of mandelic ethyl ester and 1.82 g. of hydroxylamine was made homogeneous by the addition of a small amount of methyl alcohol. The product gave with ferric chloride a red coloration which increased in intensity with time. In a day, a large quantity of well-formed white crystals separated from the alcohol solution. When recrystallized from ether and alcohol by addition of ligroine, 7.4 g. were obtained. Mandelhydroxamic acid melted at 143.3° and decomposed immediately above its melting point to give products which had a strong odor of benzaldehyde.

.1472 g. gave 11.1 c.c. N_2 at 25° and 744 mm.

Calc. for $C_8H_9NO_3$: N, 8.38. Found: N, 8.28.

(b) Benzoyl Ester of Mandelhydroxamic Acid.

A mixture of .5 g. of mandelhydroxamic acid dissolved in water and .16 g. of potassium hydroxide in water was treated with .44 g. of benzoyl chloride added slowly while the mixture was cooled and

shaken. A white solid separated which, when filtered off immediately, washed with boiling ligroine, and crystallized from a small amount of boiling alcohol, melted at 101°- 102°. The yield was .4 g. When heated alone or when allowed to stand in contact with water it gave a strong odor of benzaldehyde.

.1701 g. gave 8.4 c.c. N_2 at 25° and 739.1 mm.

Calc. for $C_{15}H_{13}NO_4$: N, 5.17. Found: N, 5.38.

If, however, the white solid was allowed to stand for even a short time in contact with the solution from which it precipitated the mixture gave a strong odor of benzaldehyde and none of the ester could be isolated. By addition of an acetic acid solution of phenylhydrazine to a part of the water solution, a white precipitate was formed which was recrystallized from alcohol and found to melt at 155°- 156°. The recorded melting point of benzaldehyde phenylhydrazine is 156°. The remainder of the water solution was distilled under diminished pressure. A white residue remained in the distilling flask. This was found to consist of a mixture of potassium chloride and a substance which dissolved in alcohol and was reprecipitatedby ether. The latter was identical with the white solid melting at 196°- 197° isolated in the hydrolysis of the benzoyl ester of lacthydroxamic acid.

IV. ACRYLHYDROXAMIC ACID.

Two g. of acrylic ethyl ester and .66 g. of hydroxylamine were mixed while cooled with ice. In a short time an oily white solid

formed which gave an intense red coloration with ferric chloride. It was recrystallized from alcohol by the addition of ether. Almost the theoretical yield, 1.52 g. , of a flaky crystalline solid, melting at 115°- 116°, was obtained. It was difficultly soluble in acetic ether.

.1725 g. gave 25.4 c.c. N_2 at 27° and 740.5 mm.

Calc. for $C_3H_5NO_2$: N, 16.09. Found: N, 15.93.

An investigation of the behavior of hydroxamic acids containing a double bond between carbon atoms toward heat and toward hydrolyzing agents will be made at a later time.

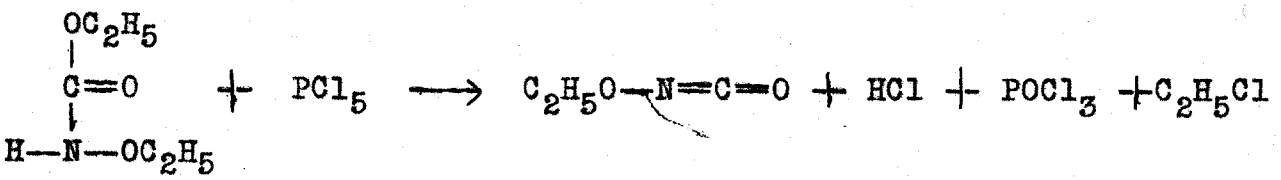
SUMMARY.

Some new hydroxamic acids of the aliphatic series have been prepared by the action of free hydroxylamine on the esters of propionic, lactic, mandelic, and acrylic acids. Their salts, their benzoyl and acetyl esters, and the salts of their acyl esters have been described. Those compounds prepared from esters containing an α hydroxyl group showed a behavior toward heat and toward hydrolyzing agents which differed from the behavior of those prepared from the esters of ordinary fatty acids. The former yield aldehydes and symmetrical di-acyl ureas, while the latter give first isocyanates and finally carbon dioxide and amines.

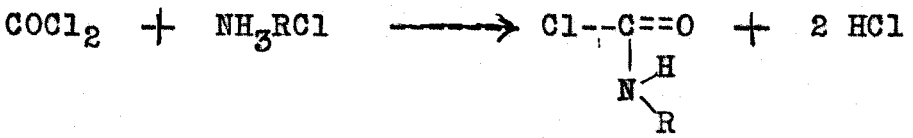
II. THE PREPARATION OF ALKYL HYDROXYUREA CHLORIDES AND THEIR RELATION TO ESTERS OF CARBON DIOXIDE OXIME, R-O-N=C=O.

In the course of investigations with nitro paraffines and fulminates, Nef believed that he had prepared the first derivative of the oxime of carbon dioxide[1]. By the action of mercuric chloride on sodium isonitromethane, a yellow salt was obtained to which Nef assigned the formula, $Hg\begin{matrix}O\\O\end{matrix}\!\!>C{=}N{-}Ohg$[2]. He supposed it to be a basic mercury salt of carbon dioxide oxime, H—O—N=C=O, but attempts to prepare the alkyl esters of this acid by the action of alkyl iodides on the yellow mercury salt proved unsuccessful. Later Jones[3] showed that Nef's salt was probably a basic mercury salt of formhydroximic acid, Attempts were then made by Jones[4] to prepare the derivatives of carbon dioxide oxime by removing alcohol from the salts and esters of hydroxyurethane. The work was based on the assumption that Lossen's formula for the hydroximic acids[5], $R{-}C\begin{matrix}OH\\ \Vert \\ N{-}OH\end{matrix}$, was correct; but the desired esters were not obtained. However, experiments with the ethyl ester of hydroxyurethane and phosphorus pentachloride undoubtedly resulted in the formation of the ethyl ester of carbon dioxide oxime, C_2H_5—O—N=C=O, although the ester itself was not isolated.

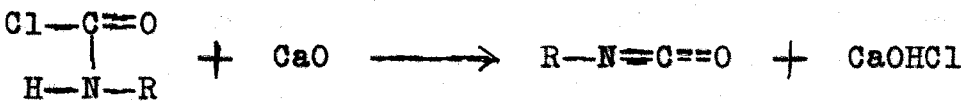
1. Ann. 280, (1894)
2. hg represents a half atom of bivalent mercury.
3. Am. Ch. J. 20, 1 (1898)
4. Am. Ch. J. 20, 1 (1898)
5. Ann. 281, 295 (1895)



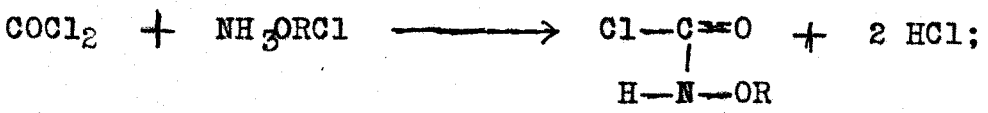
Gattermann and Schmidt[1], in the preparation of urea chlorides, have described the action of phosgene on ammonium chloride and on alkyl ammonium chlorides. By passing phosgene gas over these heated chlorides, urea chloride itself, as well as the mono- and di- methyl and ethyl urea chlorides were obtained.



From the urea chlorides thus prepared, Gattermann and Schmidt[2] obtained esters of isocyanic acid by treatment with lime:



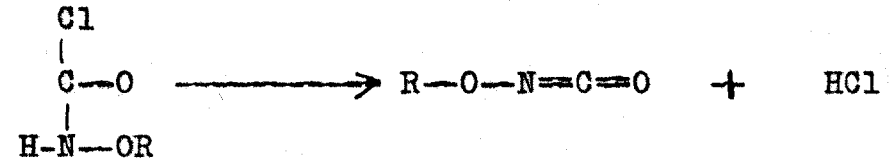
It was to be expected, therefore, that hydroxylamine or hydroxylammonium chloride and the substituted derivatives of these compounds would react with phosgene in a similar manner:



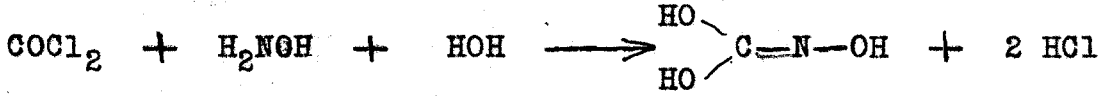
and that by treatment of the resulting substituted hydroxyurea

1. and 2. Ber. 20, 118, 858 (1887)

chlorides withnsuitable reagents, hydrochloric acid would be removed and the esters of the oxime of carbon dioxide would result.



Hantzsch and Sauer[1] treated a water solution of two molecules of hydroxylammonium chloride and six molecules of sodium hydroxide with sufficient phosgene gas to react with one molecule of hydrochloride, and obtained a water solution of carbonic monohydroxamic acid, hydroxy carbamic acid.



If only one molecule of hydrochloric acid were lost, the course of the reaction would be represented by the equation:

Thewe reactions are exactly analogous to those which occured in the preparation of isocyanic esters by Gattermann and Schmidt, and to those suggested for the preparation of the oximes of carbon dioxide by the use of phosgene.

The purpose of this paper is to describe experiments carried out with phosphorus pentachloride and alky hydroxyurethanes, and experiments with phosgene and substituted hydroxylamines and their chlorides, in an attempt directly or indirectly to isolate the esters

1. Ann. 299, 91 (1898)

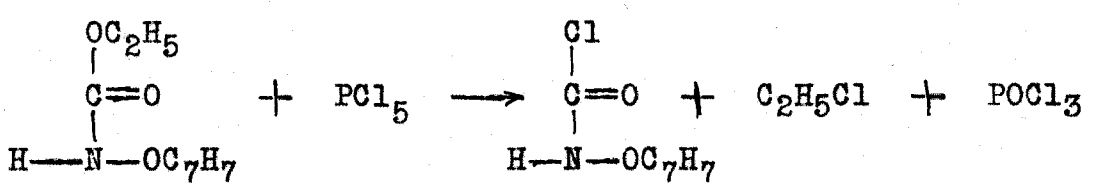
of the oxime of carbon dioxide, R-O-N=C=O.

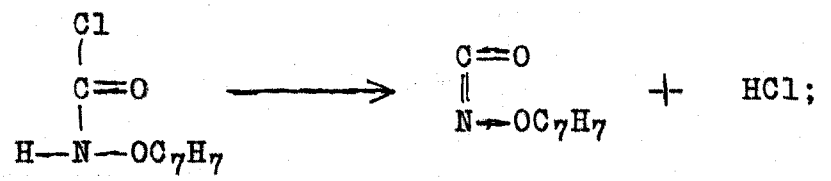
EXPERIMENTAL PART.

I. THE ACTION OF PHOSPHORUS PENTACHLORIDE ON THE ESTERS OF HYDROXYURETHANE.

(a) Phosphorus Pentachloride and α - Benzyl Hydroxyurethane.

Five g. of α -benzyl hydroxyurethane were treated with 5.26 g. of phosphorus pentachloride, added slowly while the mixture was cooled. A reaction began almost immediately and was hastened by gently heating the mixture on a water-bath. Both hydrogen chloride and ethyl chloride were evolved. All the phosphorus pentachloride was used up when the temperature of the bath reached 50°. A little above 50°, the reaction mixture suffered a sudden change, turned brown with a sudden puff, and considerable heat was evolved. A dark brown liquid remained which was distilled under diminished pressure. The phosphorus oxychloride present was first removed, and, then, a light yellow oil distilled, which investigation showed to contain no nitrogen and which resembled benzyl chloride in properties. The results were very similar to those obtained by Jones with α - ethyl hydroxyurethane. Indications are that the course of the reaction was as follows;





and that the product, $C_7H_7ON{=}C{=}O$, probably polymerized in part, or decomposed above 50° by intramolecular oxidation to give, among other products, benzyl chloride.

(b) Phosphorus Pentachloride and ∝- Secondary Butyl Hydroxyurethane.

Five and nine tenths g. of ∝- secondary butyl hydroxyurethane were treated with 7.8 g. of phosphorus pentachloride. Reaction began at once and both hydrogen chloride and ethyl chloride were evolved. The reaction-mixture, a clear liquid, was poured into the water. Some carbon dioxide was given off and a yellow oil separated which was extracted with ether. The extraction was dried with anhydrous sodium sulphate and the ether removed in a vacuum desiccator. Two and one tenth g. of the oil were obtained. It contained chlorine and was analyzed for nitrogen with the following result;

.1262 g. gave 10.6 c.c. of N_2 at 21° and 740 mm.

Calc. for $C_5H_{10}NO_2Cl$: N, 9.25. Found N, 9.34.

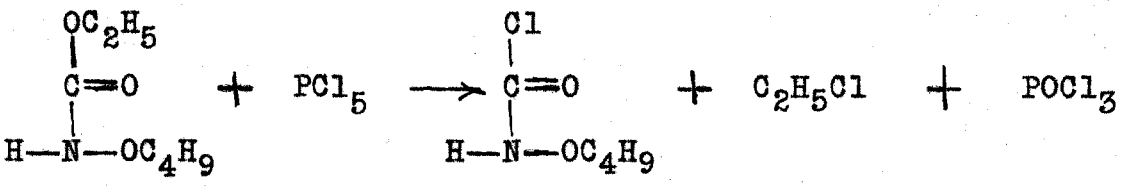
The water solution from which the oil had been separated was made alkaline by adding sodium hydroxide and the product was distilled into dilute hydrochloric acid. When the hydrochloric solution was evaporated to dryness, a white solid remained, which, upon extraction with absolute alcohol, was found to be a mixture of a small amount

of ammonium chloride and ∝ - secondary butyl hydroxlammonium chloride. The latter was converted to the chlorplatinate and gave the following analysis.

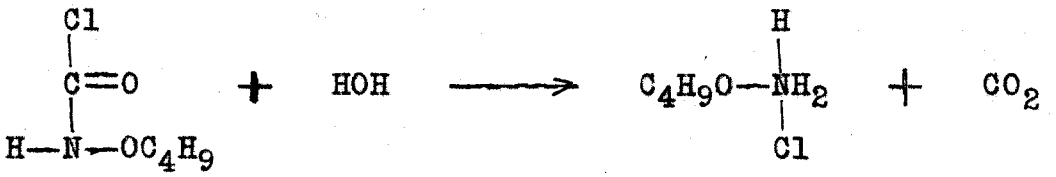
.0964 g. gave .0315 g. Pt.

Calc. for $C_8H_{24}N_2O_2PtCl_6$; Pt, 33.14. Found: Pt, 32.67.

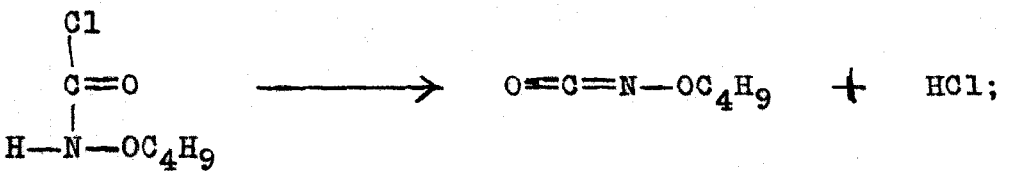
These results show that the action of phosphorus pentachloride on ∝ - secondary butyl hydroxyurethane gave, first, the secondary butyl derivative of hydroxyurea chloride:



When poured into water, this substance separated partially as an oil and a part of it was decomposed by water according to the equation;



The formation of hydrogen chloride, evolved with ethyl chloride in the beginning of the experiment, may be accounted for by assuming a partial dissociation of the principle product of the reaction;



A decomposition which is perfectly analogous to the dissociation of alkyl ureachlorides into hydrogen chlorides and an ester of isocyanic

acid, as observed by

The secondary butyl ester of carbon dioxide oxime may be assumed to have existed in contact with the water solution and to have been hydrolyzed to give the hydroxylamine derivative and carbon dioxide, just as isocyanates give amines and carbon dioxide.

(c) Phosphorus Pentachloride and α - Ethyl β - Secondary Butyl Hydroxyurethane.

Five g. of α - ethyl β - secondary butyl hydroxyurethane were treated with 5.51 g. of phosphorus pentachloride. Ethyl chloride was evolved. The product was poured into water and an oil separated. No evolution of carbon dioxide was noted. The oil was extracted with ether, the extraction dried, and the oil recovered by evaporation of the solvent. The product responded readily to a test for chlorine. When it was distilled under diminished pressure, 1.2 g. of a clear, colorless liquid, boiling at 80° under 25 mm. pressure, were obtained. Above 80°, rapid decomposition took place in the distilling flask. The distillate, which still contained chlorine, was analyzed for nitrogen.

.1270 g. gave 9.7 c.c. N_2 at 28° and 739 mm.

Calc. for $C_7H_{14}NO_2Cl$: N,7.80. Found: N, 8.19.

The water solution, which remained after the ether extraction mentioned above, was made alkaline with sodium hydroxide and distilled into dilute hydrochloric acid. Upon evaporation of the acid solution, a small amount of a white solid was obtained which was found to be ammonium chloride. In this case none of the substituted hydroxylammonium chloride was recovered.

(d) Phosphorus Pentachloride and α, β Diethyl Hydroxyurethane.

Eighteen g. α, β diethyl hydroxyurethane were treated with 23.27 g. of phosphorus pentachloride. All of the phosphorus pentachloride was used up and again ethyl chloride was evolved. When the reaction mixture was poured into water, some carbon dioxide was evolved and an oil separated in large quantity, When this was removed from the water solution, dried, and distilled under diminished pressure 5.1 g. were obtained which boiled at 74°- 76° at 25 mm. It contained chlorine and posessed a sharp, penetrating odor. It was analyzed for nitrogen.

.2732 g. gave 21.5 c.c. N_2 at 24.5° and 749 mm.

Calc. for $C_5H_{10}NO_2Cl$: N, 9.24. Found: N, 8.72

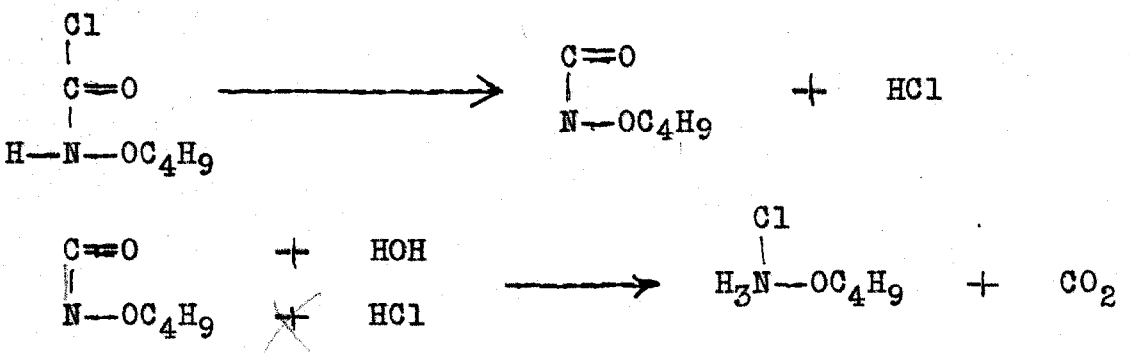
The water solution was made alkaline with sodium hydroxide and distilled into dilute hydrochloric acid. From the acid solution a white solid was obtained, which, when separated from a small amount of ammonium chloride by means of absolute alcohol, weighed 5.8 g. This was converted to a yellow crystalline solid by means of chloroplatinic acid and gave the following figures on analysis:

.1129 g. gave .0735 g. Pt.

Calc. for $C_8H_{24}N_2O_2PtCl_6$: Pt, 33.14. Found: Pt, 33.21.

We conclude that the reactions between phosphorus pentachloride and the ester of hydroxyurethane result in the formation of substituted hydroxyurea chlorides, which, in some cases, are more readily decomposed in the presence of water into hydroxylamine derivatives

and carbon dioxide than in others. When the latter reaction occurs, the intermediate formation of esters of the oxime of carbon dioxide may be assumed, at least in the case of mono-alkyl derivatives.



II. THE ACTION OF PHOSGENE ON SUBSTITUTED HYDROXYLAMINES, AND ON THEIR HYDROCHLORIDES.

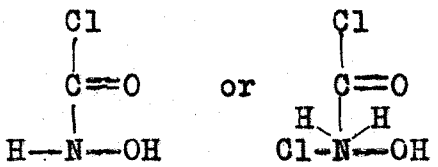
(a) Phosgene and Hydroxylammonium Chloride.

Dry phosgene gas was passed over hydroxylammonium chloride until all air was expelled from the system, and the solid was then heated gradually to 100°. At this temperature reaction was apparent. A clear liquid was formed which began to distil when a violent explosion bursted the containing flask, due undoubtedly to the fact that the temperature of reaction was about the same as the decomposition temperature of hydroxylammonium chloride in an atmosphere of phosgene. Attempts were made to combine hydroxylammonium chloride, suspended in toluene and in carbon tetrachloride, with phosgene, but no apparent reactions occured.

(b) Phosgene and Hydroxylamine.

Dry phosgene was passed for two and one half hours over 4 g. of

free hydroxylamine warmed on a water-bath to 45°. A slightly oily white solid was formed, part of which was found to be hydroxylammonium chloride. The remainder was a white crystalline solid, insoluble in alcohol and ether, and soluble in water. It melted at 79.5°- 81°, with decomposition, but did not sublime, above 80°. It contained chlorine, gave a purple coloration with ferric chloride solution and formed a green copper salt with copper acetate. Attempts to establish the identity of this substance have been unsuccessful so far, but indications were that it corresponded to the formula,



or

or some compound closely related to these.

(c) Phosgene and - Ethyl Hydroxylammonium Chloride.

Dry phosgene gas was lead over 3 g. of dry α ethyl hydroxylammonium chloride heated gradually to 200°. Slight charring occured and a clear,,colorless oil distilled when the temperature was between 190°- 200°. When no more liquid distilled, the apparatus was disconnected and a small amount of unchanged α ethyl hydroxylammonium chloride was recovered from the charred contents of the flask in which the reaction occured. The colorless oil was found to contain chlorine and gave the following analysis for nitrogen;

.1821 g. gave 14.7 c.c. N_2 at 20.5° and 741.2 mm.

Calc. for $C_3H_7NO_2Cl_2$: N, 8.75. Found:N, 9.02.

Investigations are now being made for the purpose of establishing

the constitution of this compound and of others of a similar nature. It is observed, however, that the compound having the empirical formula, $C_3H_7NO_2Cl_2$, consists of molecular proportions of phosgene and α ethyl hydroxylamine.

(d) Phosgene and α Ethyl Hydroxylamine.

Fifteen g. of α ethyl hydroxylamine, dried with potassium hydroxide, was dissolved in ether and poured gradually into an excess of liquid phosgene, cooled in a freezing mixture. Vigorous reaction occurred. Six and eighty four hundredths g. of a white solid formed, which was found to be α ethyl hydroxylammonium chloride. This was separated from the ether solution which gave a thick, colorless oil upon evaporation of the ether in a desiccator. The oil was allowed to stand for some time to remove all traces of the solvent. It was again extracted with absolute ether. A small amount of - ethyl hydroxylammonium chloride remained undissolved. Upon evaporation of the ether again, a clear, colorless oil was obtained, which gave a strong test for chlorine.

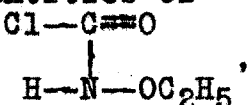
.2131 g. gave 30.3 c.c. N_2 at 27° and 740.5 mm.

Calc. for $C_5H_{13}N_2O_3Cl$: N, 15.18. Found: N, 15.38.

The following equation accounts for the resultd obtained:

$$COCl_2 + 3\ NH_2OC_2H_5 \longrightarrow C_5H_{13}N_2O_3Cl + C_2H_5ONH_3Cl$$

The amount of α ethyl hydroxylammonium chloride which should be formed according to this equation is 7.9 g. Six and eighty four hundredths g. were obtained.

Investigations, so far, have established only the facts mentioned. The compound formed according to the equation, consists however, of equimolecular quantities of α - ethyl hydroxylamine and a compound of the formula,  , which is analogous to the substances prepared by the action of phosphorus pentachloride on esters of hydroxyurethane.

(e) Phosgene and α Benzyl Hydroxylammonium Chloride.

Phosgene gas was passed over 1.77 g. of α - benzyl hydroxylammonium chloride which was gradually heated to 180° in the air bath for four hours. Most of the original solid was converted to a liquid. Little charring occurred. The excess phosgene used and the hydrogen chloride liberated during the reaction were passed into a barium hydroxide solution. A precipitate of barium carbonate was formed which was collected and weighed. The chlorine in the solution was precipitated as silver chloride and weighed. The reaction mixture was extracted with ether. A slightly brown solid weighing .1008 g. remained undissolved. Upon evaporation of the ether, a yellow oil was obtained which weighed 2.16 g. When an attempt was made to distil this oil under diminished pressure, a small amount of a clear liquid, boiling at 97.5°- 100° at 49 mm, passed over into the receiver. Much decomposition occurred above 100°. The distillate contained chlorine and was analyzed for nitrogen:

.2221 g. gave 13.6 c.c. N_2 at 28.5° and 740 mm.

Calc. for $C_8H_9NO_2Cl_2$: N, 6.31. Found: N, 6.57.

The equation which best represents the results obtained is:

$$C_7H_7—ONH_3Cl + COCl_2 \longrightarrow C_8H_9NO_2Cl_2 + HCl$$