

CLVI.—*Hydroxyoxamides. Part II.*

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SCHIFF AND MONSACCHI (*Annalen*, 1895, 288, 313) hydrolysed oxamethane with hydroxylamine, and obtained a compound to which they gave the name "hydroxylamide," and ascribed the formula, $\text{NH}_2\cdot\text{CO}\cdot\text{CO}\cdot\text{NH}\cdot\text{OH}$. At the same time, they pointed out that it decomposed at the same temperature as, and was very similar to, the compound obtained by Holleman (*Rec. trav. chim.*, 1894, 13, 84) by the action of hydrochloric acid on oxamidedioxime.

Holleman then compared the two substances (*Rec. trav. chim.*, 1896, 15, 148), showed that they were not identical, and suggested that they were stereoisomerides of the formula $\text{NH}_2\cdot\text{C}(\text{NOH})\cdot\text{CO}\cdot\text{OH}$. He gave the *syn*-formula to his own compound, since this more readily explains the formation of cyanamide when it is treated with acetic anhydride. The *anti*-configuration was given to Schiff and Monsacchi's compound, as this more readily accounts for the formation of carbon dioxide and carbamide when it is heated.

In 1901, it was shown by Pickard and Carter (*Trans.*, 79, 841) that

the compounds obtained when oxamethane and the oxamates, $R \cdot NH \cdot CO \cdot CO_2Et$, are hydrolysed with hydroxylamine, react as hydroxamic acids, the acetyl derivatives yielding biurets and allophanates, in accordance with the reactions of hydroxamic acids described by Thiele and Pickard (*Annalen*, 1899, 309, 189).

Schiff (*Annalen*, 1902, 321, 357), however, although acknowledging that these reactions are best explained by the hydroxyoxamide formula, $NH_2 \cdot CO \cdot CO \cdot NH \cdot OH$, or $R \cdot NH \cdot CO \cdot CO \cdot NH \cdot OH$, ascribed the amidoxime formula, $NH_2 \cdot C(NO) \cdot CO \cdot OH$, to the compound obtained by the hydrolysis of oxamethane, basing this opinion mainly on some titration experiments, which apparently showed that the compound in question behaved on titration like an amino- or amido-acid (compare Schiff, *Annalen*, 1901, 319, 59).

We have reinvestigated these compounds, and now bring forward fresh evidence in favour of the "hydroxyoxamide" formula.

Several new hydroxyoxamides have been prepared, namely, *o*-tolyl, *o*-, *m*-, and *p*-nitrophenyl and ethyl-hydroxyoxamides, and they all give the various reactions of hydroxamic acids (compare *loc. cit.*). The ethylhydroxyoxamide is of interest as it shows that the method which has yielded the substituted biurets with an aromatic radicle will also yield those with aliphatic radicles. The latter are not obtained when ethyl allophanate is treated with aliphatic amines (Hofmann, *Ber.*, 1871, 4, 265).

One mol. of a hydroxyoxamide, when dissolved in water or alcohol, is neutralised by 1 mol. of potassium hydroxide. We were unable to repeat under very varied conditions the experiments described by Schiff (*loc. cit.*), in which hydroxyoxamide was neutralised by the calculated quantity of potassium hydroxide only after treatment with formaldehyde, using phenolphthalein as indicator. When an oxamate is hydrolysed with 2 mols. of hydroxylamine, the hydroxylamine salt of the hydroxamic acid is first obtained, and it is possible that the hydroxyoxamide used by Schiff in his titration experiments was contaminated with the hydroxylamine salt. Hydroxyoxamide, when neutralised with ammonia and treated with a solution of silver nitrate, yields a colourless, stable silver salt; it is significant that in Schiff and Monsacchi's paper it is stated that the hydroxyoxamide is crystallised from water, whereas the silver salt is only stable when prepared from a product which has been either crystallised five or six times from water or once from dilute acetic acid. Hydroxyoxamide decomposes violently at 158° without melting, and it is noteworthy that products containing traces of the hydroxylamine salt decompose at about the same temperature.

Various types of hydroxamic acids have been titrated with decinormal solutions of caustic alkalis, using phenolphthalein as the indicator, and it has been found that they all give approximately quantitative results.

The silver salts of hydroxyoxamide and phenylhydroxyoxamide, when treated with ethyl iodide, yield esters which behave as monobasic acids when titrated with caustic alkalis. It is very difficult to understand how esters with an acid reaction could be obtained from a substance having the amidoxime constitution, $\text{NH}_2\cdot\text{C}(\text{NOH})\cdot\text{CO}_2\text{H}$, since the groups $\text{NH}_2\cdot\text{C}(\text{NOH})-$ and $\text{R}\cdot\text{NH}\cdot\text{C}(\text{NOH})-$ have a basic or neutral function, the amidoximes, $\text{C}_6\text{H}_5\cdot\text{C}(\text{NOH})\cdot\text{NH}_2$ and $\text{C}_6\text{H}_5\cdot\text{CH}(\text{OH})\cdot\text{C}(\text{NOH})\cdot\text{NH}_2$,

being neutral substances. The esters of hydroxamic acids, $\text{R}\cdot\text{C}(\text{OH})\cdot\text{N}\cdot\text{OEt}$, on the other hand, are acid by virtue of their tautomeric hydrogen atom, being soluble in caustic alkalis and reprecipitated by carbon dioxide.

The hydroxyoxamides, $\text{R}\cdot\text{NH}\cdot\text{CO}\cdot\text{CO}\cdot\text{NH}\cdot\text{OH}$, when treated with aniline, yield anilides of the type $\text{R}\cdot\text{NH}\cdot\text{CO}\cdot\text{CO}\cdot\text{NH}\cdot\text{C}_6\text{H}_5$, and when treated with an alcoholic solution of phenylhydrazine form phenylhydrazides of the type $\text{R}\cdot\text{NH}\cdot\text{CO}\cdot\text{CO}\cdot\text{NH}\cdot\text{NH}\cdot\text{C}_6\text{H}_5$. These two reactions, which are approximately quantitative, are also given by hydroxamic acids, and afford strong evidence against such formulæ as $\text{NH}_2\cdot\text{C}(\text{NOH})\cdot\text{CO}_2\text{H}$ for hydroxyoxamide (amidoximeoxalic acid), or $\text{CO}_2\text{H}\cdot\text{C}(\text{NOH})\cdot\text{NH}\cdot\text{OH}$ for malondihydroxamic acid (hydroxamoxime-malonic acid).

Ulpiani and Ferretti (*Gazzetta*, 1902, 32, i, 205) have shown that hydroxyoxamide is obtained when nitromalonamide is treated with concentrated sulphuric acid. They formulate the course of the reaction as follows: $\text{NH}_2\cdot\text{CO}\cdot\text{CH}(\text{NO}_2)\cdot\text{CO}\cdot\text{NH}_2 \rightarrow \text{NH}_2\cdot\text{CO}\cdot\text{CH}_2\cdot\text{NO}_2 \rightarrow \text{NH}_2\cdot\text{CO}\cdot\text{CH}\cdot\text{NO}\cdot\text{OH} \rightarrow \text{NH}_2\cdot\text{CO}\cdot\text{C}(\text{OH})\cdot\text{NOH}$. This reaction affords further evidence in favour of the hydroxamic nature of these compounds, and is entirely opposed to formulæ of the type $\text{NH}_2\cdot\text{C}(\text{NOH})\cdot\text{CO}_2\text{H}$.

A reinvestigation of the amidoximeoxalic acid, $\text{NH}_2\cdot\text{C}(\text{NOH})\cdot\text{CO}_2\text{H}$, confirms its general properties as described by Holleman (*loc. cit.*). It behaves as a monobasic acid when titrated with potassium hydroxide, the acidity of the carboxyl group not being masked by the NH_2 group as inferred by Schiff. Moreover, it forms a stable, crystalline ester which is neutral, thus differing from the esters of the hydroxyoxamides.

To sum up, therefore, these hydroxyoxamides behave in all respects like typical hydroxamic acids, and there is not the slightest evidence in favour of the amidoxime constitution.

EXPERIMENTAL.

Hydroxyoxamide, $\text{NH}_2\cdot\text{CO}\cdot\text{CO}\cdot\text{NH}\cdot\text{OH}$ or $\text{NH}_2\cdot\text{CO}\cdot\text{C}(\text{OH})\cdot\text{NOH}$.

When oxamethane is hydrolysed with hydroxylamine either in aqueous or alcoholic solution, at any temperature from 0° to 100° , a mixture of hydroxyoxamide and its hydroxylamine salt is obtained.

A product, which separated out when saturated aqueous solutions of oxamethane (1 mol.), hydroxylamine hydrochloride (2 mols.), and sodium carbonate (1 mol.) were mixed at 60° , contained $\text{NaCl} = 21.08$; $\text{N} = 22.68$ per cent. This analysis showed that 28.73 per cent. of the organic matter in the product was nitrogen, whereas the pure hydroxylamine salt of hydroxyoxamide, $\text{NH}_2 \cdot \text{CO} \cdot \text{CO} \cdot \text{NH} \cdot \text{OH} \cdot \text{NH}_2 \cdot \text{OH}$, contains $\text{N} = 30.65$ per cent.

0.104 Gram (1 mg.-mol.) of hydroxyoxamide, after recrystallisation from dilute acetic acid, when dissolved in alcohol or water, either at the ordinary temperature or warm, neutralises approximately 10 c.c. of *N*/10 potassium or barium hydroxide solution, using phenolphthalein as indicator. In no case did the addition of formaldehyde alter the titrations, and in every case the usual coloration was given by the solution with ferric chloride, both before and after titration.

Silver Salt.—An aqueous solution of pure hydroxyoxamide is exactly neutralised with dilute ammonia, and then precipitated with a solution of silver nitrate. The silver salt, when first precipitated, is slightly yellow, but rapidly becomes white, is quite stable when dry, and explodes when heated.

Ethyl Ester, $\text{NH}_2 \cdot \text{CO} \cdot \text{C}(\text{OH}) \cdot \text{N} \cdot \text{O} \cdot \text{C}_2\text{H}_5$.—The silver salt suspended in ethyl alcohol is boiled under a reflux condenser with the calculated quantity of ethyl iodide for three hours. After filtering off the silver iodide, the solution is evaporated to dryness and the resulting product crystallised from alcohol. The ester is thus obtained in star-shaped clusters of pearly laminae which melt at 178° .

It is not affected by boiling water and is only slightly hydrolysed by warm solutions of hydroxylamine.

0.132 Gram (1 mg.-mol.) dissolved in water required 10 c.c. of *N*/10 potassium hydroxide solution for neutralisation with phenolphthalein as indicator :

0.0712 gave 13 c.c. moist nitrogen at 15° and 752 mm. $\text{N} = 21.12$.

$\text{C}_4\text{H}_8\text{O}_3\text{N}_2$ requires $\text{N} = 21.21$ per cent.

Oxamphenylhydrazide, $\text{NH}_2 \cdot \text{CO} \cdot \text{CO} \cdot \text{NH} \cdot \text{NH} \cdot \text{C}_6\text{H}_5$.—An alcoholic solution of phenylhydrazine and hydroxyoxamide is boiled under a reflux condenser for two hours. The phenylhydrazide crystallises out from the solution on cooling, and the crystals, after successive washings with acetic acid and sodium carbonate solution and recrystallisation from alcohol, melt at 231° .*

Acetylhydroxyoxamide, $\text{NH}_2 \cdot \text{CO} \cdot \text{C}(\text{OH}) \cdot \text{NO} \cdot \text{CO} \cdot \text{CH}_3$ (Schiff and Monsacchi, *loc. cit.*).—A cold aqueous solution of 0.146 gram (1 mg.-mol.) was neutralised by 11.6 c.c. of *N*/10 potassium hydroxide solution, partial hydrolysis having taken place.

* Schleussner (*Inaug. Diss.*, Munich, 1897), gives the melting point as $230-233^{\circ}$.

When boiled with dimethylaniline, the acetyl derivative is quantitatively converted into carbamide.

Phenylhydroxyoxamide, $C_6H_5 \cdot NH \cdot CO \cdot C(OH) : NOH$.

0.180 Gram (1 mg.-mol.) of phenylhydroxyoxamide (Schiff and Monsacchi, *loc. cit.*) is neutralised by 10 c.c. of *N*/10 potassium hydroxide solution.

Phenylhydroxyoxamide, when warmed with aniline, yields oxanilide, and when boiled with an alcoholic solution of phenylhydrazine yields *oxanilphenylhydrazide*, $C_6H_5 \cdot NH \cdot CO \cdot CO \cdot NH \cdot NH \cdot C_6H_5$.^{*} This crystallises from glacial acetic acid in clusters of stellate needles, and melts and decomposes at 228°. It is insoluble in a solution of sodium carbonate, gives Bulow's reaction, and reduces Fehling's solution :

0.2525 gave 36.7 c.c. moist nitrogen at 15° and 744 mm. $N = 16.65$.

$C_{14}H_{13}O_2N_3$ requires $N = 16.47$ per cent.

The silver salt and ethyl ester were prepared as described under the analogous derivatives of hydroxyoxamide.

The *silver* salt is obtained as a white, amorphous precipitate, and leaves metallic silver on ignition.

The *ester* crystallises from alcohol in colourless, silky needles which melt at 176°. It is soluble in potassium hydroxide solution and is reprecipitated by carbon dioxide.

0.208 Gram (1 mg.-mol.) dissolved in alcohol neutralised 10.1 c.c. of *N*/10 potassium hydroxide solution :

0.1111 gave 13.5 c.c. moist nitrogen at 22° and 750 mm. $N = 13.58$.

$C_{10}H_{12}O_3N_2$ requires $N = 13.46$ per cent.

Phenylacetylhydroxyoxamide, when boiled with pyridine, decomposes violently, evolves carbon dioxide, and gives a solution which, when thrown into water, yields a mixture of phenyl- and *s*-diphenyl-carbamides.

The three nitro-phenyl-, *o*-tolyl-, and ethyl-hydroxyoxamides, their acetyl derivatives, and transformation products have been prepared from the corresponding oxamates by analogous methods to those previously described (*loc. cit.*).

^{*} Oxanilic acid, when treated under similar conditions, yielded only traces of hydrazide.

o-Nitrophenylhydroxyoxamide and Derivatives.

Ethyl o-nitrophenyloxamate, $\text{NO}_2 \cdot \text{C}_6\text{H}_4 \cdot \text{NH} \cdot \text{CO} \cdot \text{CO}_2 \cdot \text{C}_2\text{H}_5$, is obtained by the condensation of ethyl oxalate (1 mol.) and *o*-nitroaniline (1 mol.). It crystallises from alcohol or acetic acid in pale yellow needles and melts at 113° :

0.1257 gave 13.4 c.c. moist nitrogen at 22° and 752 mm. $\text{N} = 11.93$.
 $\text{C}_{10}\text{H}_{10}\text{O}_5\text{N}_2$ requires $\text{N} = 11.76$ per cent.

o-Nitrophenylhydroxyoxamide, $\text{NO}_2 \cdot \text{C}_6\text{H}_4 \cdot \text{NH} \cdot \text{CO} \cdot \text{CO} \cdot \text{NH} \cdot \text{OH}$, crystallises from glacial acetic acid in silky, white needles which melt and decompose at 153° :

0.1400 gave 22.3 c.c. moist nitrogen at 18.5° and 756 mm. $\text{N} = 18.24$.
 $\text{C}_8\text{H}_7\text{O}_5\text{N}_3$ requires $\text{N} = 18.66$ per cent.

0.225 Gram (1 mg.-mol.) dissolved in warm alcohol neutralised 10.6 c.c. of *N*/10 potassium hydroxide solution.

The *sodium*, *potassium*, *ammonium*, and *hydroxylamine* salts are yellow, crystalline substances, of which the last melts at 161° .

The *acetyl* derivative, $\text{NO}_2 \cdot \text{C}_6\text{H}_4 \cdot \text{NH} \cdot \text{CO} \cdot \text{C}(\text{OH}) \cdot \text{NO} \cdot \text{CO} \cdot \text{CH}_3$, crystallises in colourless, silky needles from acetic acid and melts at 160° . When boiled with sodium carbonate solution, it is completely decomposed, yielding *o*-nitroaniline :

0.2348 gave 32.7 c.c. moist nitrogen at 21° and 756 mm. $\text{N} = 15.76$.
 $\text{C}_{10}\text{H}_9\text{O}_6\text{N}_3$ requires $\text{N} = 15.73$ per cent.

o-Nitrophenylbiuret, $\text{NO}_2 \cdot \text{C}_6\text{H}_4 \cdot \text{NH} \cdot \text{CO} \cdot \text{NH} \cdot \text{CO} \cdot \text{NH}_2$, crystallises from hot water in beautiful, long, canary-coloured needles which melt at 181° :

0.1644 gave 37.1 c.c. moist nitrogen at 25° and 764 mm. $\text{N} = 25.31$.
 $\text{C}_8\text{H}_8\text{O}_4\text{N}_4$ requires $\text{N} = 25.00$ per cent.

o-Nitro-oxanilphenylhydrazide, $\text{NO}_2 \cdot \text{C}_6\text{H}_4 \cdot \text{NH} \cdot \text{CO} \cdot \text{CO} \cdot \text{NH} \cdot \text{NH} \cdot \text{C}_6\text{H}_5$, crystallises from acetic acid in small, yellow needles which melt and decompose at 181° . It reduces Fehling's solution and gives Bulow's reaction :

0.0827 gave 13.7 c.c. moist nitrogen at 25° and 757 mm. $\text{N} = 18.40$.
 $\text{C}_{14}\text{H}_{12}\text{O}_4\text{N}_4$ requires $\text{N} = 18.66$ per cent.

m-Nitrophenylhydroxyoxamide and Derivatives.

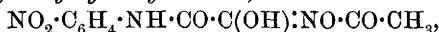
m-Nitrophenylhydroxyoxamide, $\text{NO}_2 \cdot \text{C}_6\text{H}_4 \cdot \text{NH} \cdot \text{CO} \cdot \text{CO} \cdot \text{NH} \cdot \text{OH}$, crystallises from acetic acid in colourless, silky needles which melt and decompose at 161° :

0.1517 gave 24.1 c.c. moist nitrogen at 15° and 757 mm. $N = 18.44$.
 $C_8H_7O_5N_3$ requires $N = 18.66$ per cent.

0.225 Gram (1 mg.-mol.) dissolved in alcohol was neutralised by 10 c.c. of $N/10$ potassium hydroxide solution.

The *hydroxylamine* salt was obtained as a jelly which became crystalline on shaking. It crystallises from anhydrous alcohol in lustrous, silky, yellowish needles and melts and decomposes at 188°. The *sodium*, *potassium*, and *ammonium* salts are yellow.

m-Nitrophenylacetylhydroxyoxamide,



crystallises from acetic acid in white, silky needles which melt and decompose at 184°. It is only slightly soluble in alcohol or chloroform :

0.1482 gave 20.8 c.c. moist nitrogen at 22° and 761 mm. $N = 15.91$.
 $C_{10}H_9O_6N_3$ requires $N = 15.73$ per cent.

The *sodium* and *potassium* salts are yellowish, crystalline compounds. The *ammonium* salt crystallises from alcohol in small, yellow, prismatic needles which melt and decompose at 150°.

Carbonyl di-m-nitrophenylcarbamide, $CO(NH \cdot CO \cdot NH \cdot C_6H_4 \cdot NO_2)_2$, crystallises from water in golden-yellow needles. It melts and decomposes at 142° :

0.1038 gave 20.3 c.c. moist nitrogen at 24° and 760 mm. $N = 21.93$.
 $C_{15}H_{12}O_7N_6$ requires $N = 21.64$ per cent.

m-Nitrophenylbiuret, $NO_2 \cdot C_6H_4 \cdot NH \cdot CO \cdot NH \cdot CO \cdot NH_2$, separates from a mixture of water and alcohol in canary-yellow crystals melting at 178°. It is slightly soluble in a solution of sodium hydroxide :

0.0672 gave 14.4 c.c. moist nitrogen at 21° and 760 mm. $N = 24.40$.
 $C_8H_8O_4N_4$ requires $N = 25.00$ per cent.

Ethyl m-nitrophenylallophanate, $NO_2 \cdot C_6H_4 \cdot NH \cdot CO \cdot NH \cdot CO_2 \cdot C_2H_5$, crystallises from alcohol in yellowish, silky needles, which melt at 188°. It is soluble in potassium hydroxide solution, and is reprecipitated by acids :

0.0850 gave 13 c.c. moist nitrogen at 24° and 744 mm. $N = 16.77$.
 $C_{10}H_{11}O_5N_3$ requires $N = 16.60$ per cent.

m-Nitro-oxanilphenylhydrazide, $NO_2 \cdot C_6H_4 \cdot NH \cdot CO \cdot CO \cdot NH \cdot NH \cdot C_6H_5$, crystallises from alcohol in glistening, yellow laminae, melts at 184°, and reduces Fehling's solution :

0.0791 gave 13 c.c. moist nitrogen at 20° and 749 mm. $N = 18.48$.
 $C_{14}H_{12}O_4N_4$ requires $N = 18.66$ per cent.

m-Nitro-oxanilide, $NO_2 \cdot C_6H_4 \cdot NH \cdot CO \cdot CO \cdot NH \cdot C_6H_5$, is obtained by

heating the hydroxyoxamide with aniline at 170° for four hours. It crystallises from nitrobenzene in yellowish, prismatic needles which melt at 204° :

0.1530 gave 20.6 c.c. moist nitrogen at 24° and 756 mm. $N = 15.00$.

$C_{14}H_{11}O_4N_3$ requires $N = 14.73$ per cent.

p-Nitrophenylhydroxyoxamide and Derivatives.

Ethyl p-nitrophenyloxamate, $NO_2 \cdot C_6H_4 \cdot NH \cdot CO \cdot CO_2 \cdot C_2H_5$, crystallises from acetic acid in white, prismatic needles and melts at 166° :

0.1813 gave 18.8 c.c. moist nitrogen at 22° and 764 mm. $N = 11.80$.

$C_{10}H_{10}O_5N_2$ requires $N = 11.76$ per cent.

p-Nitrophenylhydroxyoxamide, $NO_2 \cdot C_6H_4 \cdot NH \cdot CO \cdot CO \cdot NH \cdot OH$, crystallises in colourless needles from glacial acetic acid and melts at 182° :

0.1142 gave 18.8 c.c. moist nitrogen at 19° and 756 mm. $N = 18.78$.

$C_8H_7O_5N_3$ requires $N = 18.66$ per cent.

0.225 Gram (1 mg.-mol.) dissolved in alcohol required 9.8 c.c. of *N*/10 potassium hydroxide solution for neutralisation.

The *hydroxylamine* salt is a pale yellow, crystalline substance melting at 190° .

The *acetyl* derivative, $NO_2 \cdot C_6H_4 \cdot NH \cdot CO \cdot C(OH) : NO \cdot CO \cdot CH_3$, crystallises from acetic acid in silky, white needles melting with decomposition at 182° :

0.1923 gave 26.8 c.c. moist nitrogen at 22° and 756 mm. $N = 15.67$.

$C_{10}H_9O_6N_3$ requires $N = 15.73$ per cent.

It is completely decomposed when boiled with dilute sodium carbonate solution, yielding *p*-nitroaniline.

p-Nitrophenylbiuret, $NO_2 \cdot C_6H_4 \cdot NH \cdot CO \cdot NH \cdot CO \cdot NH_2$, crystallises from water in pale golden-yellow needles with water of crystallisation. It melts at 206° and is very soluble in alcohol.

Ethyl p-nitrophenylallophanate, $NO_2 \cdot C_6H_4 \cdot NH \cdot CO \cdot NH \cdot CO_2 \cdot C_2H_5$, crystallises from alcohol in white, silky needles which melt and decompose at 220° :

0.0604 gave 8.8 c.c. moist nitrogen at 18° and 751 mm. $N = 16.59$.

$C_{10}H_{11}O_5N_3$ requires $N = 16.60$ per cent.

p-Nitro-oxanilphenylhydrazide, $NO_2 \cdot C_6H_4 \cdot NH \cdot CO \cdot CO \cdot NH \cdot NH \cdot C_6H_5$, crystallises from alcohol in flat, compact, yellow needles. It melts and decomposes at 217° and reduces Fehling's solution :

0.1599 gave 25.6 c.c. moist nitrogen at 15° and 750 mm. $N = 18.52$.

$C_{14}H_{12}O_4N_4$ requires $N = 18.66$ per cent.

o-Tolylhydroxyoxamide and Derivatives.

Ethyl o-tolylloxamate, $\text{CH}_3 \cdot \text{C}_6\text{H}_4 \cdot \text{NH} \cdot \text{CO} \cdot \text{CO}_2 \cdot \text{C}_2\text{H}_5$, is erroneously described in Beilstein as a substance melting at 130° when anhydrous. Such a substance is a mixture of the oxamide and oxamate. The two are separated by extraction with ether, in which the oxamate is much the more soluble. It crystallises from dilute alcohol and melts at 40° :

0.2926 gave 18.8 c.c. moist nitrogen at 21° and 748 mm. $\text{N} = 7.18$.
 $\text{C}_{11}\text{H}_{13}\text{O}_3\text{N}$ requires $\text{N} = 6.76$ per cent.

o-Tolylhydroxyoxamide, $\text{CH}_3 \cdot \text{C}_6\text{H}_4 \cdot \text{NH} \cdot \text{CO} \cdot \text{CO} \cdot \text{NH} \cdot \text{OH}$, crystallises from dilute acetic acid in star-shaped clusters of needles and melts at 152° :

0.1880 gave 23.8 c.c. moist nitrogen at 20° and 756 mm. $\text{N} = 14.44$.
 $\text{C}_9\text{H}_{10}\text{O}_3\text{N}_2$ requires $\text{N} = 14.44$ per cent.

The *acetyl* derivative crystallises from acetic acid in needles and melts at 125° :

0.1133 gave 12 c.c. moist nitrogen at 19° and 754 mm. $\text{N} = 12.07$.
 $\text{C}_{11}\text{H}_{12}\text{O}_4\text{N}_2$ requires $\text{N} = 11.86$ per cent.

It is very easily soluble in alcohol. The *ammonium* salt crystallises from alcohol in lustrous, silvery plates which melt with decomposition at 139° . The *sodium* salt is a microcrystalline powder which begins to decompose at about 120° .

Carbonyldi-o-tolylcarbamide, $\text{CO}(\text{NH} \cdot \text{CO} \cdot \text{NH} \cdot \text{C}_6\text{H}_4 \cdot \text{CH}_3)_2$, crystallises from alcohol in needles and melts at 190° :

0.0740 gave 11 c.c. moist nitrogen at 19° and 758 mm. $\text{N} = 17.04$.
 $\text{C}_{17}\text{H}_{18}\text{O}_3\text{N}_4$ requires $\text{N} = 17.17$ per cent.

Ethyl o-tolylallophanate, $\text{CH}_3 \cdot \text{C}_6\text{H}_4 \cdot \text{NH} \cdot \text{CO} \cdot \text{NH} \cdot \text{CO}_2 \cdot \text{C}_2\text{H}_5$, crystallises from dilute alcohol in needles and melts at 137° :

0.2819 gave 31.3 c.c. moist nitrogen at 19.5° and 758 mm. $\text{N} = 12.65$.
 $\text{C}_{11}\text{H}_{14}\text{O}_3\text{N}_2$ requires $\text{N} = 12.61$ per cent.

o-Tolylbiuret, $\text{CH}_3 \cdot \text{C}_6\text{H}_4 \cdot \text{NH} \cdot \text{CO} \cdot \text{NH} \cdot \text{CO} \cdot \text{NH}_2$, separates from alcohol as a microcrystalline powder which melts at 180° :

0.0894 gave 17 c.c. moist nitrogen at 20° and 758 mm. $\text{N} = 21.67$.
 $\text{C}_9\text{H}_{11}\text{O}_2\text{N}_3$ requires $\text{N} = 21.76$ per cent.

Ethylhydroxyoxamide and Derivatives.

Ethylhydroxyoxamide, $C_2H_5 \cdot NH \cdot CO \cdot CO \cdot NH \cdot OH$, crystallises from ether in colourless laminae, melts at 138° , and is very soluble in most organic solvents.

0.132 Gram (1 mg.-mol.) of the product extracted by ether from the acidified aqueous solution of its hydroxylamine salt was neutralised by 8.6 c.c. of *N*/10 potassium hydroxide solution.

The *hydroxylamine* salt crystallises from alcohol in small, white, glistening needles melting at 156° :

0.0705 gave 16 c.c. moist nitrogen at 21° and 756 mm. $N = 25.65$.

$C_4H_{11}O_4N_3$ requires $N = 25.45$ per cent.

The *acetyl* derivative, $C_2H_5 \cdot NH \cdot CO \cdot C(OH) : NO \cdot CO \cdot CH_3$, crystallises from acetic acid in lustrous, colourless needles which melt at 138° :

0.1071 gave 15.5 c.c. moist nitrogen at 20° and 744 mm. $N = 16.24$.

$C_6H_{10}O_4N_2$ requires $N = 16.09$ per cent.

Ethylbiuret, $C_2H_5 \cdot NH \cdot CO \cdot NH \cdot CO \cdot NH_2$, crystallises from water in star-shaped clusters of prismatic needles. These melt at 153° and decompose violently a few degrees higher :

0.0447 gave 13 c.c. moist nitrogen at 22° and 748 mm. $N = 32.32$.

$C_4H_9O_2N_3$ requires $N = 32.06$ per cent.

Hydroxamic Acids.

Oxaldihydroxamic Acid, $(CO \cdot NH \cdot OH)_2$.—0.120 Gram (1 mg.-mol.) of oxaldihydroxamic acid (Hantzsch and Urbahn, *Ber.*, 1894, 27, 801) dissolved in warm water was neutralised by 18.6 c.c. of *N*/10 barium hydroxide solution. When boiled with an alcoholic solution of phenylhydrazine, a quantitative yield of oxaldiphenylhydrazide (m. p. 278°) was obtained.

Malondihydroxamic Acid, $CH_2(CO \cdot NH \cdot OH)_2$.—This was prepared according to Hantzsch and Urbahn's method (*loc. cit.*), who give the melting point as 154 — 155° . H. Schiff (*loc. cit.*) states that the purest specimen he obtained melted at 144 — 145° . We found it to crystallise from dilute acetic acid in square plates melting at 160° * (Nitrogen found, 21.08 per cent. ; calc., 20.89 per cent.)

0.134 Gram (1 mg.-mol.) dissolved in dilute alcohol neutralised 18.5 c.c. of *N*/10 barium hydroxide solution.

* In crystallising these and similar products, it is advisable to drop the powdered ammonium or hydroxylamine salt into dilute acetic acid which has been previously warmed ; on cooling, the free acid separates out. Boiling with dilute acetic acid often decomposes these hydroxamic acids.

When boiled with an alcoholic solution of phenylhydrazine, malon-dihydroxamic acid yields malondiphenylhydrazide (m. p. 186°).

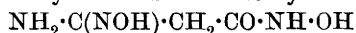
Benzhydroxamic Acid, $C_6H_5 \cdot CO \cdot NH \cdot OH$.—0.137 Gram (1 mg.-mol.) dissolved in alcohol gave a coloration with phenolphthalein after the addition of 5.2 c.c. of *N*/10 potassium hydroxide solution. This is due to the formation of the salt $C_6H_5 \cdot C(OH) : NOH, C_6H_5 \cdot C(OH) \cdot NOK$ described by Lossen (*Annalen*, 1872, 161, 347).

0.137 Gram (1 mg.-mol.) dissolved in alcohol was neutralised by 9.7 c.c. of *N*/10 barium hydroxide solution.

Benzhydroxamic acid, when boiled with an alcoholic solution of phenylhydrazine, yields benzoylphenylhydrazine (m. p. 169°).

Milligram-mols. of dibenzhydroxamic acid, acetylbenzhydroxamic acid,* benzoylpyromucylhydroxamic acid (*Trans.*, 1901, 79, 847), and *p*-tolylacetylhydroxyoxamide (*loc. cit.*) were all neutralised by 9.9—10 c.c. of *N*/10 potassium hydroxide solution.

One mg.-mol. of methyleneamidoxime-acethydroxamic acid,

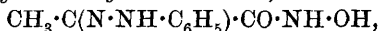


(Modeen, *Ber.*, 1891, 24, 3437), was neutralised by 9 c.c. of *N*/10 barium hydroxide solution.

Oxamates of the type $NRR' \cdot CO \cdot CO_2 \cdot C_2H_5$ are hydrolysed by an alcoholic solution of hydroxylamine, giving the secondary amine and oxaldihydroxamic acid. This was proved in the case of ethyl methyl-oxanilate,† ethyl ethyloxanilate, and ethyl piperidyloxamate.

The following hydroxamic acids were prepared for the purpose of comparison.

Pyruvylphenylhydrazonohydroxamic acid,



was obtained by treating the corresponding ester with an alcoholic solution of hydroxylamine and was isolated by means of its lead salt. It crystallises from a mixture of ethyl acetate and benzene in white needles which melt at 148°. It is very soluble in alcohol, acetone, or ethyl acetate, but only slightly so in ether :

0.0901 gave 16.8 c.c. moist nitrogen at 16° and 750 mm. $N = 21.45$
 $C_9H_{11}O_2N_3$ requires $N = 21.76$ per cent.

0.193 Gram (1 mg.-mol.) dissolved in alcohol was neutralised by 10 c.c. of *N*/10 barium hydroxide solution :

* Acetylbenzhydroxamic acid, when boiled with pyridine, gives a solution which when thrown into water, yields *s*-diphenylcarbamide.

† These oxamates were prepared by heating ethyl oxalate (1 mol.) and the amine (1 mol.) in an oil-bath at 150° for 4—5 hours. The products were washed with dilute sulphuric acid to free from excess of the amine, dried, and fractionated. Ethyl ethyloxanilate, $C_6H_5 \cdot N(C_2H_5) \cdot CO \cdot CO_2 \cdot C_2H_5$, is a pale yellow oil which boils at 215—220°.

The *acetyl* derivative crystallises from dilute acetic acid in colourless needles which melt at 113° .

0.1053 gave 16.2 c.c. moist nitrogen at 16° and 750 mm. $N = 17.73$.
 $C_{11}H_{13}O_3N_3$ requires $N = 17.87$ per cent.

The *ammonium* and *sodium* salts are soluble in alcohol, and the substance is entirely decomposed by boiling with pyridine or dimethylaniline.

Phenylglycinehydroxamic acid, $C_6H_5 \cdot NH \cdot CH_2 \cdot CO \cdot NH \cdot OH$.

An alcoholic solution of hydroxylamine is prepared in the usual way, and when quite cool the equivalent quantity of ethyl anilinoacetate (Bischoff and Hausdorfer, *Ber.*, 1892, 25, 2270) is added. On the addition of sodium (1 mol. dissolved in alcohol), an almost quantitative yield of the sodium salt of the hydroxamic acid is obtained. This is filtered off, dissolved in water, and the hydroxamic acid set free by the addition of the exact quantity of dilute sulphuric acid required. The white precipitate is filtered off and crystallised from dilute alcohol. The hydroxamic acid is thus obtained in the form of colourless, small, glistening plates which melt and decompose at 118° :

0.1688 gave 0.3580 CO_2 and 0.0923 H_2O . $C = 57.84$; $H = 6.07$.

0.2280 „ 34.7 c.c. moist nitrogen at 20° and 736 mm. $N = 16.84$.

$C_8H_{10}O_2N_2$ requires $C = 57.83$; $H = 6.02$; $N = 16.86$ per cent.

0.166 Gram (1 mg.-mol.) dissolved in alcohol was neutralised by 10.3 c.c. of $N/10$ barium hydroxide solution.

Phenylglycinehydroxamic acid is soluble in alcohol, but only slightly so in ether, benzene, or water. It is dissolved and decomposed by dilute mineral acids. Its aqueous solution gives the usual coloration with ferric chloride.

Acetyl Derivative.—The hydroxamic acid is extremely difficult to acetylate owing to its extraordinary sensitiveness towards acids. It was therefore dissolved in pyridine and kept cool while the calculated quantity of acetyl chloride was slowly added. The mixture, after standing overnight, was poured into water, and the resulting precipitate crystallised from alcohol. The acetyl derivative was thus obtained in the form of long, colourless, prismatic needles melting at 107° . It is insoluble in ether and has an acid reaction toward litmus:

0.1375 gave 16.5 c.c. moist nitrogen at 20° and 745 mm. $N = 13.45$.

$C_{10}H_{12}O_3N_2$ requires $N = 13.46$ per cent.

On neutralising an alcoholic solution with sodium ethoxide, the

sodium salt is precipitated. This salt slowly decomposes to an oil on warming its aqueous solution. No better result is obtained on treating the acetyl derivative with sodium carbonate or dilute ammonia.

Amidoximeoxalic Acid.

0.104 Gram (1 mg.-mol.) of amidoximeoxalic acid (Holleman, *loc. cit.*) dissolved in approximately 30 c.c. of water at 20° required 9.4 c.c. of *N*/10 potassium hydroxide solution for neutralisation.

Ethyl Ester, $\text{NH}_2\cdot\text{C}(\text{NOH})\cdot\text{CO}_2\cdot\text{C}_2\text{H}_5$.—The silver salt suspended in alcohol is boiled with the calculated quantity of ethyl iodide. The alcohol is then evaporated off and the oily mass extracted with ether. The ester separates from the ether in colourless, lustrous needles. These melt at 97—98° and evolve gas at 140—170°, at which temperature entire decomposition sets in. The ester is soluble in water, alcohol, or ether, and its solutions are completely neutral to litmus, and give a sienna-brown coloration with ferric chloride :

0.0963 gave 18.5 c.c. moist nitrogen at 20° and 750 mm. $\text{N} = 21.68$.
 $\text{C}_4\text{H}_8\text{O}_3\text{N}_2$ requires $\text{N} = 21.21$ per cent.

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