In the decomposition of the polyuronides, the simple uronic acids are first produced; these are then decomposed further by the organism.

Different fungi vary in the rate and nature of decomposition of the uronic acid complexes.

These fungi produce pectolytic enzymes which hydrolyze pectin and polygalacturonic acid.

It is proposed to designate as a unit of pectolytic enzyme that amount of enzyme which will hydrolyze 1 milligram of polygalacturonic acid in one hour at 40° and at $P_{\rm H}$ 4.0 to 6.0. Using this unit of measurement, 1 g. of a dry enzyme preparation of certain fungi contained about 4000 pectolytic units.

As a result of the action of the enzyme upon pectin and polygalacturonic acid, a small amount of sediment is formed which seems to contain either a lignin-like complex or a higher polyuronide not hydrolyzed by cold 80% sulfuric acid or by hot 5% sulfuric acid.

NEW BRUNSWICK, NEW JERSEY

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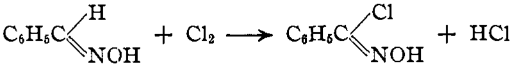
Anisohydroxamyl Chloride

BY CORLISS R. KINNEY, E. WESTLEY SMITH, BERNE L. WOOLLEY AND ALLAN R. WILLEY

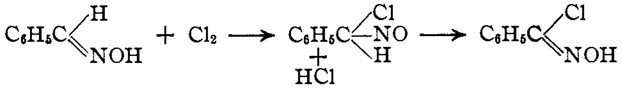
Werner and Buss[1] prepared the first aromatic hydroxamyl chloride by chlorinating benzaldoxime in chloroform solution.



$$C_6H_5C\begin{matrix}\diagup H\\ \diagdown NOH\end{matrix} + Cl_2 \longrightarrow C_6H_5C\begin{matrix}\diagup Cl\\ \diagdown NOH\end{matrix} + HCl$$

Contrary to their expectations, based on the Hantzsch–Werner theory, the two isomeric benzaldoximes did not yield two isomeric hydroxamyl chlorides.

Later, Piloty and Steinbock[2] discovered that the benzaldoximes could be chlorinated in a fairly concentrated hydrochloric acid solution. A blue intermediate was observed which was unstable and which quickly changed into the benzohydroxamyl chloride isolated by Werner and Buss. Since the intermediate compound had a blue color and since the chlorination mixture, following Werner and Buss's procedure, took on a blue-green color Piloty and Steinbock assumed that the intermediate in the chlorination reaction had a nitroso structure, as follows



$$C_6H_5C\begin{matrix}\diagup H\\ \diagdown NOH\end{matrix} + Cl_2 \longrightarrow \underset{\begin{matrix}+\\ HCl\end{matrix}}{C_6H_5C}\begin{matrix}\diagup Cl\\ -NO\\ \diagdown H\end{matrix} \longrightarrow C_6H_5C\begin{matrix}\diagup Cl\\ \diagdown NOH\end{matrix}$$

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[1] Werner and Buss, *Ber.*, **27**, 2193 (1894).

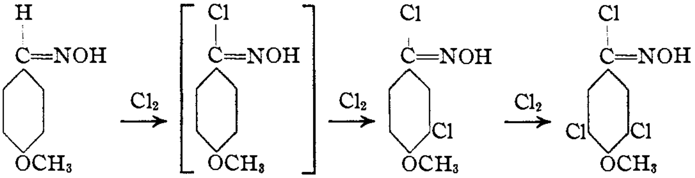
[2] Piloty and Steinbock, *ibid.*, **35**, 3112 (1902).

Recently, Rheinboldt and students[3] have found that nitrosyl chloride attacks aryl aldoximes producing as an end-product hydroxamyl chlorides. In several cases intermediates were observed which in solution showed a blue color and following the work of Piloty and Steinbock, Rheinboldt also assigned nitroso structures to the intermediates observed in the reaction with nitrosyl chloride.

Weygand and Bauer[4] have repeated some of Rheinboldt's work and have reported similar observations excepting that on anisaldoxime. Upon treating that oxime with nitrosyl chloride they obtained an anisohydroxamyl chloride melting at 89–90° instead of at 120° which Rheinboldt and students had observed, and were unable to account for the difference.

In view of the fact that stereoisomeric hydroxamyl chlorides have not been reported and the possibility that Weygand and Bauer had such an isomeric hydroxamyl chloride we have studied the direct chlorination of the anisaldoximes and have re-investigated the action of nitrosyl chloride on the anisaldoximes.

The direct chlorination of anisaldoxime in chloroform following the method used by Werner and Buss gave anisohydroxamyl chlorides with chlorine substituted in the aromatic nucleus. By altering the procedure somewhat, both *m*-chloro and *m*,*m*′-dichloro anisohydroxamyl chloride were isolated.



The position of the chlorine in the nucleus was determined by hydrolyzing the acid chlorides to the corresponding chloro anisic acids, which are known substances. The acid chlorides were also converted into furazane oxides (furoxans) by sodium carbonate, a reaction characteristic of hydroxamyl chlorides.

In order to prevent the substitution in the aromatic ring it was found necessary to limit the available chlorine to exactly one molecular equivalent and to keep the reaction mixture cold. The product was the anisohydroxamyl chloride reported by Weygand and Bauer melting at 88–89°. The same substance was always obtained no matter which anisaldoxime was used.

Upon repeating the reaction with nitrosyl chloride a colorless intermediate was isolated and studied. The product melted at about 50° and was unstable, decomposing in from ten minutes to an hour. The substance could not be recrystallized because in solution it changed into the

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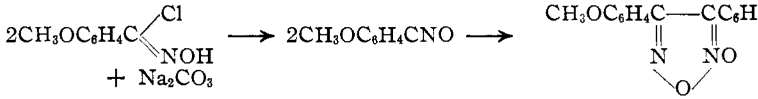
(3) Rheinboldt and co-workers, *Ann.*, **451**, 161 (1926).

(4) Weygand and Bauer, *ibid.*, **459**, 142 (1927).

hydroxamyl chloride identical with that obtained by the direct chlorination. The substance was best kept under dry ether, but even under these conditions it slowly passed into solution from which only the anisohydroxamyl chloride melting at 88–89° could be isolated. The substance was rather insoluble in most solvents, but such solutions exhibited a light blue color indicating the presence of a nitroso compound.

Following Rheinboldt and students' method of isolating the anisohydroxamyl chloride the product again melted at 88–89° and a mixed melting point with the product obtained by direct chlorination showed no depression. Rheinboldt's method requires considerable time for the mixture to crystallize and consequently we suspect that the high melting point reported by him was due to the presence of some product of hydrolysis, perhaps anisic acid. When small amounts of anisic acid were mixed with the pure acid chloride melting at 88–89° no difficulty was experienced in obtaining a mixture melting at about 120°. In no other way were we able to prepare a substance melting in that neighborhood. Furthermore, the product reported by Rheinboldt crystallized in fine needles while all of our preparations melting at 88–89° crystallized in flakes.

Anisohydroxamyl chloride when treated with sodium carbonate yielded di-(*p*-methoxyphenyl)-furazane oxide.



The nitrile oxide intermediate in the reaction of alkali on benzohydroxamyl chloride has been carefully studied[5] while the structure of the furazane oxides has been determined to be that given above.[6,7]

Although α-nitrosoanisyl chloride, the intermediate in the reaction of nitrosyl chloride on the anisaldoximes, might be expected to yield the same product with sodium carbonate as anisohydroxamyl chloride because the former substance is transformed into the latter spontaneously, we have treated the nitroso compound with sodium carbonate in the hope of getting a different reaction, but were unsuccessful, the product being di-(*p*-methoxyphenyl)-furazane oxide.

Experimental Part

The Action of Chlorine on the Anisaldoximes. Anisohydroxamyl Chloride.—A one-liter flask was placed in a freezing mixture and filled with chlorine (from a cylinder). Into the flask a cold solution of 5.2 g. of the α-oxime dissolved in sodium-dried ether was introduced. The flask was stoppered and shaken while still in the freezing mixture. The ether solution became a deep blue-green and a precipitate of the hydrochloride of the β-oxime formed. After filtering out the hydrochloride, the ether solution was evaporated in a vacuum desiccator over sulfuric acid. When nearly all of the ether had evapo-

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[5] Wieland, *Ber.*, **40**, 418 (1907); *ibid.*, **42**, 803 (1909).

[6] Meisenheimer, Lange and Lamparter, *Ann.*, **444**, 94 (1925).

[7] Kinney, This Journal, **51**, 1592 (1929).

rated, the residue turned yellow. At this point the material was removed from the desiccator and swirled about the sides of the dish, inducing crystallization.

The acid chloride was purified by dissolving the crude material in dry chloroform at room temperature and then adding low boiling petroleum ether. By repeated recrystallizations the melting point was raised to 88–89°, where it remained constant. The yield was 2.9 g. or 45%. However, 3.1 g. of the β-oxime hydrochloride was recovered. Basing the yield on the amount of oxime unrecovered, the yield was over 80%. The same acid chloride was obtained by chlorinating the β-oxime.

Anal. Calcd. for $C_8H_8O_2NCl$: Cl, 19.13. Found: Cl, 19.00.

Chlorinating the oximes in a benzene solution lowered the yield to 30%, based on the material used up. When an undried chloroform solution was used, the product turned red as the solvent was evaporated and none of the acid chloride could be isolated. The material evolved hydrogen chloride and turned into a red paste consisting largely of anisic acid.

The acid chloride was not perfectly stable under ordinary conditions. A sample that had been kept in a stoppered test-tube for several weeks was extracted with ether, removing the acid chloride. The residue was treated with water and again extracted with ether. The ether was evaporated and the solid residue recrystallized from alcohol. The first crop of crystals melted at 179° with decomposition. A mixed melting point with a sample of dianisenyl azoxime oxide prepared by the method of Robin[8] showed no depression. From the alcoholic solution another substance was obtained melting at 143°. The properties of the substance corresponded to the anisoyl anishydroximic acid (dianishydroximic acid) of Lossen[9] obtained in another way. A nitrogen analysis confirmed the identity of the compound.

Anal. Calcd. for $C_8H_9O_3N$: N, 8.38. Found: N, 8.50.

Boiling 6 *N* hydrochloric acid or sodium hydroxide rapidly hydrolyzed the chloride to anisic acid.

Rheinboldt and co-workers[3] treated their liquid reaction product with dilute alkali and obtained di-(*p*-methoxyphenyl)-furazane oxide, but apparently did not try the reaction with their product melting at 120°. Weygand and Bauer[4] also did not carry out this reaction with their preparation, but our acid chloride melting at 88–89° was readily converted into the furazane oxide, the identity being confirmed by a mixed melting point with a sample prepared by the oxidation of the dioximes of *p,p'*-dimethoxybenzil.[10] The furazane oxide was also obtained by treating the acid chloride with silver nitrate.

Anisohydroxamyl chloride when heated in a dry ether solution with silver benzoate yielded 27.5% of the benzoate of anisohydroxamic acid, m. p. 148°. Lossen[11] prepared this substance in another way.

Anal. Calcd. for $C_{15}H_{13}O_4N$: N, 5.16. Found: N, 5.02.

In addition a 37.5% yield of di-(*p*-methoxyphenyl)-furazane oxide (m. p. 112°) was obtained. The two substances were separated by fractional crystallization from acetone and petroleum ether.

The amide[12] of anisohydroxamic acid was obtained by passing dry ammonia into a solution of the acid chloride in dry ether. The ether solution was filtered from a precipitate and evaporated. The residue was recrystallized from boiling alcohol to which a little water was added while the solution was hot. More of the amide was ob-

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(8) Robin, *Compt. rend.*, **169**, 341, 695 (1919); **171**, 1150 (1920).

(9) Lossen, *Ann.*, **175**, 287 (1874).

(10) The method given by Kinney, THIS JOURNAL, **51**, 1597 (1929), for the monomethoxy derivatives was used.

(11) Lossen, *Ann.*, **175**, 287 (1874).

(12) Miller, *Ber.*, **22**, 2791 (1889), prepared the amide in another way.

tained from the precipitate filtered out above by warming it with sodium carbonate. The amide was then extracted with ether and purified from alcohol solution. The substance melted at 121–122° and the yield was about 50%. The identity of the amide was confirmed by a nitrogen analysis.

Anal. Calcd. for $C_8H_{10}O_2N_2$: N, 16.86. Found: N, 16.95.

***m*-Chloro-*p*-methoxybenzohydroxamyl Chloride.**—Chlorine from a cylinder was bubbled through a solution of twenty grams of the α-oxime of anisaldehyde in 100 cc. of chloroform until the blue-green color produced at first had changed to yellow. At this point an increase in the flow of chlorine caused the blue-green color to reappear transiently around the bubbles of chlorine. The chlorination was continued until the blue-green color could not be made to appear.

The solution was evaporated about one-half under reduced pressure. Upon adding petroleum ether 18.5 g. (63%) of crude *m*-chloro-*p*-methoxybenzohydroxamyl chloride precipitated. The chloride was recrystallized from boiling chloroform to which a little petroleum ether was added. It crystallized in bunches of small needles. The yield was 10.5 g. (36%). The melting point was 106.5°. It was soluble in chloroform, ether, alcohol and benzene; slightly soluble in carbon tetrachloride and insoluble in petroleum ether and water.

Anal. Calcd. for $C_8H_7O_2NCl_2$: Cl, 32.22. Found: Cl, 32.17.

Di-(*m*-chloro-*p*-methoxyphenyl)-furazane Oxide.—*m*-Chloro-*p*-methoxybenzohydroxamyl chloride was refluxed with 7.5% sodium carbonate until no more carbon dioxide was evolved. The material liquefied and after a short time solidified. The solid was recrystallized from boiling alcohol by diluting slightly with water. Di-(*m*-chloro-*p*-methoxyphenyl)-furazane oxide crystallized in small needles tinged with yellow, m. p. 165°.

Anal. Calcd. for $C_{16}H_{10}O_4N_2Cl_2$: Cl, 19.32. Found: Cl, 19.37.

Hydrolysis of *m*-Chloro-*p*-methoxybenzohydroxamyl Chloride.—Upon heating *m*-chloro-*p*-methoxybenzohydroxamyl chloride with water for fifteen minutes in the attempt to make the hydroxamic acid, the product on recrystallization from ether melted at 156–159°. The substance was not hydrolyzed by boiling 3 *N* hydrochloric acid. A mixed melting point determination with pure di-(*m*-chloro-*p*-methoxyphenyl)-furazane oxide showed the product to be that substance.

Other methods of hydrolysis failed to produce *m*-chloro-*p*-methoxybenzohydroxamic acid. Boiling 3 *N* hydrochloric acid or sodium hydroxide rapidly hydrolyzed the acid chloride to *m*-chloro-anisic acid, m. p. 213° with decomposition.

***m,m'*-Dichloro-*p*-methoxybenzohydroxamyl Chloride.**—Ten grams of the α-oxime of anisaldehyde was dissolved in 75 cc. of chloroform and chlorine passed through the solution until no more reacted. About two hours were required. The solution became a golden-yellow and the air in the flask was entirely displaced by chlorine. The solution was then cooled in the freezing mixture, whereupon the *m,m'*-dichloro-*p*-methoxybenzohydroxamyl chloride crystallized out. The crude material weighed 10 g. (60%). It was recrystallized from chloroform. No petroleum ether was used as the dichloro derivative was more soluble in the chloroform–petroleum ether mixture than in chloroform. Furthermore, the addition of petroleum ether caused some of the monochloro compound to crystallize out. The yield of pure acid chloride was fairly soluble in chloroform, ether, benzene and alcohol, and slightly soluble in carbon tetrachloride and petroleum ether.

Anal. Calcd. for $C_8H_6O_2NCl_3$: Cl, 41.81. Found: Cl, 41.79.

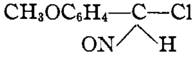
Di-(*m,m'*-dichloro-*p*-methoxyphenyl)-furazane Oxide.—*m,m'*-Dichloro-*p*-methoxybenzohydroxamyl chloride was boiled with 7.5% sodium carbonate until no more gas was evolved. The solid product was filtered out and crystallized from boiling alcohol to which a little water was added after the alcohol had been saturated. The product, di-(*m,m'*-dichloro-*p*-methoxyphenyl)-furazane oxide, crystallized in small needles with a faint yellowish tinge. The melting point was 146°.

Anal. Calcd. for $C_{16}H_8O_4N_2Cl_4$: Cl, 32.53. Found: Cl, 32.42.

Hydrolysis of *m,m'*-Dichloro-*p*-methoxybenzohydroxamyl Chloride.—*m,m'*-Dichloro-*p*-methoxybenzohydroxamyl chloride was boiled with water for fifteen minutes. The solid product was recrystallized from ether and melted at 143–145°. A mixed melting point with di-(*m,m'*-dichloro-*p*-methoxyphenyl)-furazane oxide (m. p. 146°) showed the product to be the furazane oxide.

No method was found for hydrolyzing the acid chloride into the hydroxamic acid. Boiling 3 *N* hydrochloric acid and sodium hydroxide hydrolyzed the chloride to *m,m'*-dichloro-anisic acid, m. p. 196° with decomposition.

The Reaction of Nitrosyl Chloride on Anisaldoxime. α-Nitrosoanisyl Chloride.—α-Nitrosoanisyl chloride, the intermediate in the reaction of nitrosyl chloride on anisaldoxime, was best obtained as follows. A solution of 3 g. of the α-oxime dissolved in 40 cc. of dry ether was cooled in a freezing mixture of ice and salt. To the well-cooled solution 3 to 4 g. of nitrosyl chloride prepared by Skinner's method[13] was added. The mixture was shaken in the freezing bath and assumed a clear deep green color. When the nitrosyl chloride was quite pure only a trace of a precipitate formed upon adding the nitrosyl chloride. This precipitate immediately dissolved, followed by the separation of a yellowish voluminous precipitate. The precipitation was complete in about fifteen minutes, when the solution was filtered. The compound after being washed well with dry ether was nearly colorless and melted with decomposition in the neighborhood of 50° depending on the rate of heating. When left in air or in a vacuum desiccator over sulfuric acid the substance invariably decomposed in from ten minutes to an hour. The decomposition began suddenly at some point and spread rapidly throughout the mass of material. The substance was little soluble in most solvents and all attempts at recrystallization were frustrated by conversion of the substance into anisohydroxamyl chloride melting at 88–89°, which mixed with the product obtained by direct chlorination showed no depression. Solutions of the substance took on a light blue color which, however, soon disappeared. Upon evaporating the resulting solution only the hydroxamyl chloride melting at 88–89° could be isolated. Several attempts to analyze the compound by the Carius method were unsuccessful due to explosion of the tubes, caused no doubt by the rapid liberation of gas when the substance decomposed and reacted with the nitric acid. By refluxing the compound with fuming nitric acid in a Kjeldahl flask with silver nitrate the following value was obtained. Since the analysis was made on the crude product the high value obtained was not surprising.

Anal. Calcd. for α-Nitrosoanisyl Chloride,  $CH_3OC_6H_4{-}\underset{ON\diagup\ \diagdown H}{C}{-}Cl$, or $C_8H_8O_2NCl$: Cl, 19.1. Found: Cl, 20.3.

Upon evaporating the ether filtrate from the reaction of nitrosyl chloride on the oxime a yellow oil remained which turned red-brown on standing and later yellow again. After eighteen hours crystals which had separated were filtered out and found to melt at 175°. A mixed melting point with anisic acid showed no depression. The residue when treated with sodium carbonate yielded small amounts of di-(*p*-methoxyphenyl)-furazane oxide, demonstrating that the hydroxamyl chloride was present in addition to the anisic acid. Suspecting that the product melting at 120° reported by Rheinboldt might be a mixture of anisohydroxamyl chloride and anisic acid we tried mixing the two substances and found that a mixture containing a relatively small amount of anisic acid could be prepared which melted at 120°.

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[13] Skinner, THIS JOURNAL, **46**, 737 (1924).

The intermediate compound, α-nitrosoanisyl chloride, was treated with hot sodium carbonate solution. The material liquefied and then partially solidified. Upon separating the product and recrystallizing it from alcohol it was identified as the di-(*p*-methoxyphenyl)-furazane oxide by mixed melting point. Anisohydroxamyl chloride when treated in a similar way gave identical results.

Summary

Stereoisomeric anisohydroxamyl chlorides were not obtained by chlorinating the anisaldoximes either with chlorine gas or with nitrosyl chloride. In the latter reaction an unstable nitroso intermediate was isolated and studied. By chlorinating with an excess of chlorine, *m*-chloro and *m*,*m*'-dichloroanisohydroxamyl chlorides were prepared.

SALT LAKE CITY, UTAH RECEIVED APRIL 8, 1933
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[CONTRIBUTION FROM THE CHEMICAL LABORATORY OF THE UNIVERSITY OF ILLINOIS]

The Cleavage of Carbonyl Compounds by Alkalies. X. Trihalomethylketonic Acids[1]

BY BENTON A. BULL AND REYNOLD C. FUSON

In the preparation and cleavage of the hindered trihalomethyl ketones previously reported, the question has arisen as to whether the insolubility of these compounds in the aqueous solutions used might not have an important influence on the rates at which the reactions proceed. The use of alcohol and pyridine as solvents has disclosed some evidence which supports this point of view.[2] In order to subject this idea to a crucial test, 3,5-dimethyl-4-acetylbenzoic acid (V) has been synthesized and studied. Since this compound and the trihalomethylketonic acids derived from it are soluble in aqueous alkalies, the insolubility factor is eliminated.

As the starting point for the synthesis of the ketonic acid, dimethylterephthalic acid (I)[3] was used. Esterification with methanol gave the half ester (II), which was then converted into the corresponding acid chloride (III) by the action of thionyl chloride. Treatment with methylzinc iodide, followed by hydrolysis, transformed the acid chloride into the desired keto acid (V).

3,5-Dimethyl-4-acetylbenzoic acid when dissolved in solutions of sodium hypochlorite and sodium hypobromite gave, respectively, 3,5-dimethyl-4-trichloroacetylbenzoic acid (VI) and 3,5-dimethyl-4-tribromoacetylbenzoic acid (VII). This synthesis of these trihalomethylketonic acids *in alkaline solution* demonstrates that they are moderately stable toward alkalies. Moreover, when dissolved in sodium hydroxide solutions at 0° they could

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(1) Eighth paper on the haloform reaction. For references to previous articles see Fuson, Bertetti and Ross, THIS JOURNAL, **54**, 4380 (1932).

(2) Fuson, Lewis and Du Puis, *ibid.*, **54**, 1114 (1932).

(3) Noyes, *Am. Chem. J.*, **20**, 809 (1898); Hufferd and Noyes, THIS JOURNAL, **43**, 928 (1921).