nilic acid. The residue of 0.95 g. was acridone. When treated with alcoholic ammonia in a bomb tube, it is unchanged at 120° for five hours (unlike the 8-ring anhydride of Schroeter). As has been previously stated, it can be completely hydrolyzed to phenylanthranilic acid.

*Anal.* Calcd. for $2M-H_2O$: C, 76.43; H, 4.95. Found: C, 76.85; H, 5.17. *Mol. wt.* B. p. in chloroform = 1.0 M; f. p. in acetic acid = 1.1 M; f. p. in camphor = 1.5 M.

The nearest analog of this compound is anthranoylo-N-phenylanthranilic acid described by Schroeter[1b] and prepared by the reduction of the nitro compound. In encountering the yellow anhydrides it was naturally suspected that they would correspond to the $2M-2H_2O$ compounds of Schroeter and that the white acids were formed by hydrolysis. The molecular weight determinations are curious, lower than expected and much lower than the consistently normal results by Schroeter. A possibility of unknown N-arylanthranils could not be overlooked, nor molecular combinations of previously described dehydration products of the anthranilic acids. The complexities are illustrated by a test preparation in isoquinoline, leading to a compound analyzing $2M-H_2O$ + isoquinoline, from which the isoquinoline could be recovered. One might well expect, therefore, analyses $3M-H_2O$ for other members of this series. The carbon figure is the only significant variant (by about 1%) for the different possibilities. The results given here are supported by other results with N-arylanthranilic acids to be given later.

## Summary

1. An argument for the acyl anhydride formula for certain dehydration products of N-arylanthranilic acids.

2. The transformations of N-phenylanthranilic anhydride by heat to acridone, by ammonia to N-phenylanthranilic amide, by solution in certain media to (probably) N-phenylanthranoylo-N-phenylanthranilic acid.

NEW YORK CITY

RECEIVED JUNE 27, 1933
PUBLISHED OCTOBER 6, 1933

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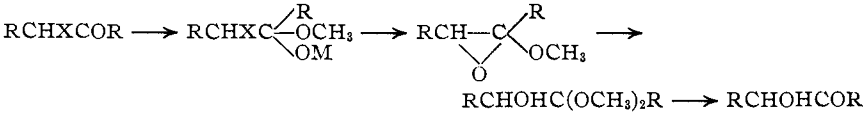
[CONTRIBUTION FROM THE CONVERSE MEMORIAL LABORATORY OF HARVARD UNIVERSITY]

# The Reactions of Halogenated Ketones.
# II. The Action of Potassium Cyanide on Desyl Chloride

BY E. P. KOHLER AND F. W. BROWN

Recent investigations have indicated that the formation of alpha hydroxy ketones from the corresponding halogen compounds occurs in a series of steps which may be represented as follows[1]



In view of these and similar results it seems not improbable that the carbonyl group participates in most of the reactions of alpha halogenated

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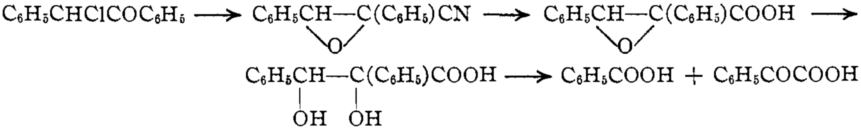
[1] Ward, *J. Chem. Soc.*, 1541 (1929); Kohler and Addinall, THIS JOURNAL, **52**, 3728 (1930); Bergmann and Miekeley, *Ber.*, **64**, 802 (1931).

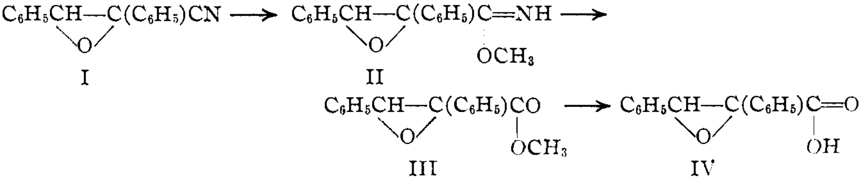
ketones and that the direct replacement of the halogen atom occurs rarely if ever. In order to secure more information on the subject and in particular to isolate the hypothetical intermediate oxides we have studied the reaction between potassium cyanide and desyl chloride. If this reaction involved direct replacement of the halogen it would result in the formation of an alpha cyano ketone which is known, and if it began with the addition to carbonyl it would be expected to lead to an oxide which would be sufficiently stable for isolation. The reaction gives rise to a considerable number of products but neither the cyano ketone nor any substance derived from it could be found. In this case, therefore, there is no direct replacement of the halogen.

Among the products of the reaction between the cyanide and the halogenated ketone are two substances which have the composition of the cyano ketone but which have quite different properties. By suitable manipulations these substances can be converted into the corresponding acids. These acids combine with water to form dihydroxy acids and each of them can be oxidized to equivalent quantities of benzoic and phenylglyoxylic acids. The dihydroxy acids must come from oxido acids and the oxidation products show that the phenyl groups are in their original positions. In this case, therefore, the reaction involves the carbonyl group and the proof of intermediate oxides is explicit.



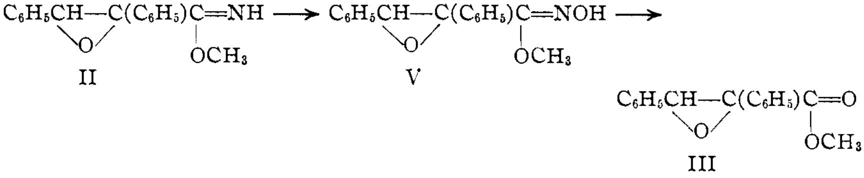
$$C_6H_5CHClCOC_6H_5 \longrightarrow C_6H_5\underset{\diagdown O \diagup}{CH{-}C}(C_6H_5)CN \longrightarrow C_6H_5\underset{\diagdown O \diagup}{CH{-}C}(C_6H_5)COOH \longrightarrow$$
$$C_6H_5\underset{\overset{|}{OH}}{CH}{-}\underset{\overset{|}{OH}}{C}(C_6H_5)COOH \longrightarrow C_6H_5COOH + C_6H_5COCOOH$$

The stereoisomeric oxido nitriles which are formed in this manner are comparatively stable substances. They do not readily undergo the usual rearrangement of oxides to ketones, presumably because they contain no active hydrogen, and they also show no tendency to polymerize. Their behavior is that of uncommonly active nitriles. In feebly alkaline solutions, for example, they combine with alcohols, and since addition to the cyanogen group is much more rapid than to the oxide ring, they are thus converted into imino ethers in which the ring is intact. Like other imino ethers these substances are readily hydrolyzed to esters, and the esters in turn can be hydrolyzed to the corresponding oxido acids



$$\underset{\text{I}}{C_6H_5\underset{\diagdown O \diagup}{CH{-}C}(C_6H_5)CN} \longrightarrow \underset{\text{II}}{C_6H_5\underset{\diagdown O \diagup}{CH{-}C}(C_6H_5)}\underset{OCH_3}{C{=}NH} \longrightarrow$$
$$\underset{\text{III}}{C_6H_5\underset{\diagdown O \diagup}{CH{-}C}(C_6H_5)}\underset{\overset{|}{OCH_3}}{CO} \longrightarrow \underset{\text{IV}}{C_6H_5\underset{\diagdown O \diagup}{CH{-}C}(C_6H_5)}\underset{\overset{|}{OH}}{C{=}O}$$

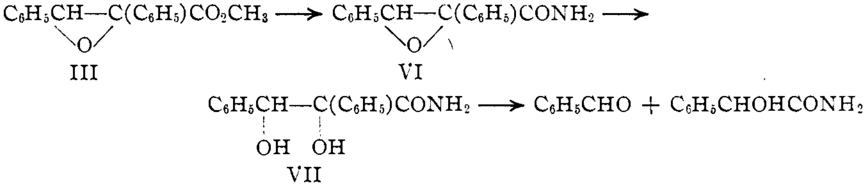
Like some other imino ethers, also, these substances can be converted into hydroxyimino ethers which likewise are hydrolyzed to the corresponding esters, but which cannot be regenerated from the esters



$$\underbrace{C_6H_5CH—C}_{O}(C_6H_5)\overset{}{C}(OCH_3)=NH \longrightarrow \underbrace{C_6H_5CH—C}_{O}(C_6H_5)C(OCH_3)=NOH \longrightarrow \underbrace{C_6H_5CH—C}_{O}(C_6H_5)C(OCH_3)=O$$

II V III

In all the foregoing transformations in which the ring is left intact the isomers behave alike and the stereoisomerism is maintained, each isomer giving rise to a single product. Under more vigorous treatment the ring is opened but here the isomers, as would be expected, react with unequal ease and, since the reactions involve the asymmetric carbon atoms, the isomerism at times becomes confused. Thus concentrated aqueous ammonia converts the higher melting ester into the amide of a dihydroxy acid, although its action on the lower melting isomer stops with the formation of the oxido amide. And when either the oxido amide or the dihydroxy amide is digested with dilute sulfuric acid it is transformed into an isomeric dihydroxy amide. In this case, therefore, the final product from both esters is the same



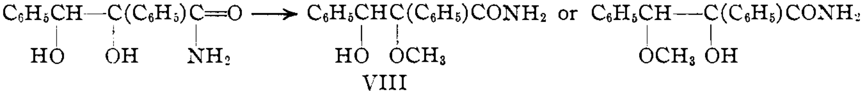
$$\underbrace{C_6H_5CH—C}_{O}(C_6H_5)CO_2CH_3 \longrightarrow \underbrace{C_6H_5CH—C}_{O}(C_6H_5)CONH_2 \longrightarrow$$

III VI

$$C_6H_5CH(OH)—C(OH)(C_6H_5)CONH_2 \longrightarrow C_6H_5CHO + C_6H_5CHOHCONH_2$$

VII

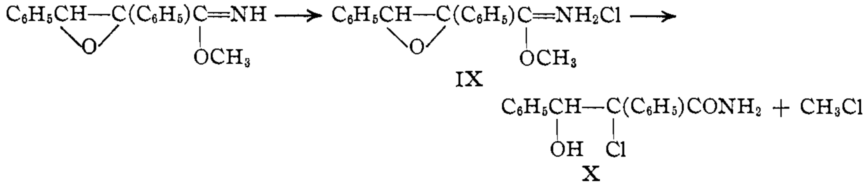
Methyl alcoholic acid converts each of the isomeric dihydroxy amides into the same mixture of mono methylated amides. Although it is not clear whether these isomeric methylation products are structural or spatial isomers, it is evident that both amides cannot form the same mixture without the isomerization of at least one of them



$$C_6H_5CH(HO)—C(OH)(C_6H_5)C(NH_2)=O \longrightarrow C_6H_5CH(HO)C(OCH_3)(C_6H_5)CONH_2 \text{ or } C_6H_5CH(OCH_3)—C(OH)(C_6H_5)CONH_2$$

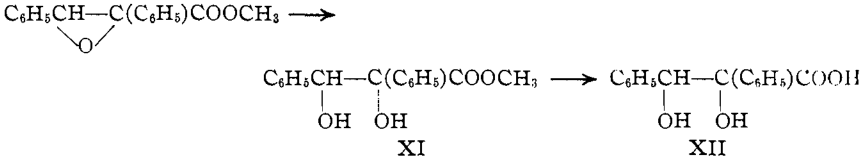
VIII

Possibly a similar difference in the ease with which the ring is opened in the case of the isomeric imino ethers is responsible for the difference in the behavior of these substances toward hydrogen chloride but it seems more probable that here relative solubilities play a major role. In ether the higher melting imino ether rapidly forms a sparingly soluble hydrochloride which very slowly loses methyl chloride, redissolves, and forms a chloro hydroxy amide. Under the same conditions the isomeric imino ether is rapidly transformed into an isomeric chlorohydroxy amide.



We have not succeeded in determining whether the isomerism of these chlorohydrins is structural or spatial. They are both very reactive; even a very dilute base rapidly changes the one (180°) into a dihydroxy amide (135°), and the other into the oxido amide (124°) which could not be obtained from the corresponding ester.

Naturally, the oxido compounds are most easily changed into the corresponding open chained esters and acids. This can be accomplished both with acids and bases; but when the oxido esters are turned into dihydroxy esters with acids, there is probably no change in configuration because each ester gives a single product, while treatment of the esters or acids with bases may lead to a mixture of dihydroxy acids:



As will be seen from the foregoing account, these oxido compounds, which belong to a type that it would be difficult to secure in any other manner, differ from other oxido compounds which contain an additional functional group mainly in two respects; they do not undergo rearrangement to isomeric oxido compounds and they show no tendency to polymerize.

## Experimental Part

In order to secure adequate concentrations of both reactants it is necessary to carry out the reaction between potassium cyanide and desyl chloride in aqueous alcoholic solutions. Since these solutions contain appreciable quantities of hydroxide and alcoholate, some of the desyl chloride is inevitably transformed into by-products. These were isolated in part but they need not be considered here because they have been described in the meanwhile by Madelung and Oberwegner.[2] In addition to these by-products there are also secondary products which are due to the reaction between the oxido nitriles and alcohol in the slightly alkaline medium—mainly the imino ethers. Since these imino ethers are formed under all conditions, are useful intermediates in the conversion of the nitriles into other substances and are the only organic compounds which can be separated from the reacting mixture without distillation, we generally found it expedient to allow the reaction to run until most of the oxido nitriles had disappeared. Our procedure thus became as follows.

A mixture obtained by pouring together a solution of one mole of desyl chloride in three times its weight of alcohol and a solution of 1.5 moles of potassium cyanide in a

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(2) Madelung and Oberwegner, *Ann.*, **490**, 201 (1931).

minimum quantity of water, was left to itself at the ordinary temperature for four days. It was then diluted with several times its volume of water and extracted with ether. The extract, when dried and evaporated, left a solid suspended in a red or brown oil.

The solid was recrystallized from benzene–petroleum ether and thus eventually separated into the two imino ethers melting at 110 and 85°. The oily liquid was fractionated under diminished pressure. The lowest boiling fraction (100–110°, 4 mm.) was composed largely of methyl benzoate; the second fraction (150–155°) yielded the lower melting oxido nitrile which after recrystallization from petroleum ether melted at 52°; the third fraction (160–165°) contained the isomeric oxido nitrile which after purification melted at 72°, and the highest fraction was composed largely of benzamide and desoxybenzoin. The yield of the principal product—the imino ether melting at 110°—was about 30% and the total yield of nitriles and imino ethers about 50%.

The relation between the nitriles and the imino ethers was established by converting the one into the other. This conversion was readily accomplished by dissolving a small quantity of the nitrile in dry methyl alcohol, adding an equal weight of dry potassium cyanide and setting the mixture aside for several days. The yield was almost quantitative and each nitrile gave a single imino ether, the lower melting ether being formed from the lower melting nitrile. The corresponding hydroxy imino ethers were obtained with equal ease by first converting the nitriles into imino ethers and then digesting the ethers with methyl alcoholic hydroxylamine.

As was to be expected, both imino ethers were very rapidly hydrolyzed to the corresponding oxido esters. We employed for the purpose dilute solutions of sulfuric acid in dry methyl alcohol and obtained almost quantitative yields. Here also each isomer gave a single product and the lower melting methyl ester was formed from the lower melting ether.

The oxido esters were hydrolyzed to the corresponding oxido acids without difficulty by warming them gently with a slight excess of dilute methyl alcoholic potassium hydroxide. The yields were excellent and each ester gave a single acid, the lower melting acid corresponding to the lower melting ester.

The corresponding pair of isomeric oxido amides was not obtained quite so easily. For while concentrated aqueous ammonia turns the lower melting oxido ester into the amide it converts the higher melting isomer into an open-chained compound. In order to obtain the isomeric amide it was necessary first to transform the higher melting ester into an open chained compound by passing hydrogen chloride through its solution in ether or benzene until the precipitated hydrochloride redissolved, and then to reclose the ring by treating the resulting chlorohydrin with dilute sodium carbonate.

None of the foregoing oxido compounds reduced permanganate but the oxido esters and the oxido acids rapidly reduced the usual solutions of chromic oxide in glacial acetic acid. The esters were thus oxidized to phenylglyoxylic ester and a mixture of benzoic and phenylglyoxylic acids and the acids were oxidized to equivalent quantities of benzoic and phenylglyoxylic acids.

The analytical results and the melting points of the oxido compounds are shown in the following table in which the substances which have the same configuration are grouped together.

The manner in which the various oxido compounds were transformed into the corresponding open-chained derivatives has been outlined in the introduction. In general the oxide ring can be opened equally well by digesting the substance with a strong acid or a strong base and the choice of the agent depends on the character of the functional group. Since the isolation of the open-chained compound presents no complications it is unnecessary to describe the experiments in detail. The melting points and the composition of the various compounds, and the oxido compounds from which they were obtained (sources), are shown in the following table.

TABLE I

| Formulas Empirical | Structural | M. p., °C. | Calculated M | Calculated C | Calculated H | Calculated N | Calculated OCH₃ | Found M | Found C | Found H | Found N | Found OCH₃ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $C_{15}H_{11}ON$ | I | 52 | 221 | 81.4 | 5.0 | | | 220 | 81.4 | 5.2 | | |
| $C_{16}H_{15}O_2N$ | II | 85 | 253 | 75.9 | 6.0 | 5.5 | 12.3 | 243 | 75.9 | 6.0 | 5.7 | 12.1 |
| $C_{16}H_{14}O_3$ | III | 35 | 254 | 75.6 | 5.5 | | 12.2 | 240 | 75.5 | 5.6 | | 12.1 |
| $C_{15}H_{12}O_3$ | IV | 90 | 240 | 75.0 | 4.8 | | | | 75.1 | 4.9 | | |
| $C_{16}H_{15}O_3N$ | V | 150 | | 71.4 | 5.6 | | | | 71.3 | 5.5 | | |
| $C_{15}H_{13}O_2N$ | VI | 205 | | 75.3 | 5.4 | 5.9 | | | 75.2 | 6.0 | 6.1 | |
| $C_{15}H_{11}ON$ | I | 74 | 221 | 81.4 | 5.0 | | | 222 | 81.2 | 5.2 | | |
| $C_{16}H_{15}O_2N$ | II | 110 | 253 | 75.9 | 6.0 | 5.5 | 12.3 | 241 | 75.8 | 5.9 | 5.7 | 12.0 |
| $C_{16}H_{14}O_3$ | III | 80 | 254 | 75.6 | 5.5 | | 12.2 | 240 | 75.5 | 5.5 | | |
| $C_{15}H_{12}O_3$ | IV | 121 | 240 | 75.0 | 4.8 | | | 241 | 74.8 | 5.4 | | |
| $C_{16}H_{15}O_3N$ | V | 172 | 240 | 71.4 | 5.6 | | 11.52 | | 71.4 | 5.4 | | 11.3 |
| $C_{15}H_{13}O_2N$ | VI | 124 | | 75.3 | 5.4 | | | | 75.3 | 5.8 | | |

TABLE II

| Formulas Empirical | Structural | M. p. °C. | Calculated M | Calculated C | Calculated H | Calculated N | Calculated OCH₃ | Found M | Found C | Found H | Found N | Found OCH₃ | Source |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| $C_{15}H_{15}O_3N$ | VII | 135 | | 70.0 | 5.9 | 5.5 | | | 69.9 | 5.7 | 5.6 | | II |
| $C_{16}H_{15}O_3N$ | VII | 235 | | 70.0 | 5.9 | | | | 69.8 | 6.1 | | | |
| $C_{16}H_{17}O_3N$ | VIII | 178 | | 70.8 | 6.2 | | 11.4 | | 70.8 | 6.1 | | 11.3 | VI, VII |
| $C_{16}H_{17}O_3N$ | VIII | 250 | | 70.8 | 6.2 | | 11.4 | | 70.9 | 6.1 | | 11.4 | VI, VII |
| $C_{15}H_{14}O_2NCl$ | X | 180 | | 65.4 | 5.1 | | | | 65.4 | 5.0 | | | II (85°) |
| $C_{15}H_{14}O_2NCl$ | X | 210 | 276 | 65.4 | 5.1 | 12.9 | 11.4 | 280 | 65.5 | 5.0 | 12.4 | | II (110°) |
| $C_{16}H_{16}O_4$ | XI | 144 | | 70.6 | 5.9 | | 11.3 | | 70.4 | 5.8 | 11.1 | | III (35°) |
| $C_{16}H_{16}O_4$ | XI | 153 | | 70.6 | 5.9 | | | | 70.5 | 5.8 | | | III (80°) |
| $C_{15}H_{14}O_4$ | XII | 184 | | 69.8 | 5.4 | | | | 69.6 | 5.5 | | | III, XI |
| $C_{15}H_{14}O_4$ | XII | 204 | | 69.8 | 5.4 | | | | 69.2 | 5.8 | | | III, XI |

## Summary

The action of potassium cyanide on desyl chloride involves the carbonyl group and results in the formation of two stereoisomeric oxido nitriles. No substances formed by direct replacement of chlorine could be detected among the products of the reaction.

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RECEIVED JUNE 28, 1933
PUBLISHED OCTOBER 6, 1933