left to cool for some hours after filtration, if necessary, a colorless solid was formed. Recrystallized from acetone-water mixture as colorless needles, this solid melted with decomposition at 225°, and did not depress the m. p. of an authentic sample of hydrindantine. It gave the blue coloration with sodium hydroxide solution that is characteristic of hydrindantine; yield 0.5 g.

Action of *peri*-Naphthindanetrione Hydrate on Ethylamine, Butylamine and Benzylamine.—*peri*-Naphthindanetrione hydrate (1 g.) and ethylamine (3.5 g.) or butylamine (3 g.) or benzylamine (2.5 g.) were mixed in the distilling flask in presence of water (100 cc.) and the same procedure was carried out as in the case of ninhydrin. Acetaldehyde 2,4-dinitrophenylhydrazone, butyraldehyde 2,4-dinitrophenylhydrazone and benzaldehyde 2,4-dinitrophenylhydrazone were isolated and identified as above. The yield in all these cases is about 30%. At the end of the reaction the contents of the distilling flask were acidified and cooled. Dihydroxyketo-*peri*-naphthindene separated as silky red crystals which melted at 255°, did not depress the melting point of an authentic specimen and gave the characteristic blue color with sodium hydroxide solution; yield 0.4 g.

Action of *m*-Nitro-*peri*-naphthindanetrione Hydrate on Ethylamine, Butylamine or Benzylamine.—*m*-Nitro-*peri*-naphthindanetrione hydrate (1 g.) and ethylamine (3.5 g.), butylamine (3 g.) or benzylamine (2.5 g.) were treated in the same way as above and the corresponding aldehydes were isolated and identified as above. When the reaction mixture was acidified with hydrochloric acid and left to cool for several minutes, *m*-nitrodihydroxyketo-*peri*-naphthindene recrystallized from alcohol as silky red needles, melted at 265° and did not degress the melting point of an authentic sample; yield 0.6 g.

Action of Ninhydrin, *peri*-Naphthindanetrione Hydrate and *m*-Nitro-*peri*-naphthindanetrione Hydrate on *s*-Butylamine.—When ninhydrin (0.5 g.), *peri*-naphthindane trione hydrate (0.7 g.) or *m*-nitro-*peri*-naphthindanetrione hydrate (0.8 g.) and *s*-butylamine (3 g.) in water (50 cc.) were treated as above, methyl ethyl ketone was obtained in the form of 2,4-dinitrophenylhydrazone which melted at 115° and did not depress the melting point of an authentic sample. The yield was about 30% with all these triketones. The reaction mixture in the distilling flask was acidified and left to cool, whereupon hydrindantine (after some hours), dihydroxyketo-*peri*-naphthindene and *m*-nitro-dihydroxyketo-*peri*-naphthindene were formed, respectively, and identified as above.

Action of Ninhydrin, *peri*-Naphthindanetrione Hydrate and *m*-Nitro-*peri*-naphthindanetrione Hydrate on 1,3-Diaminopropane, Putresine, Histamine, Cadaverine, Glucosamine, Spermine or Insulin.—When any of the triketones (1 g.), water (100 cc.) and any of the amines (1 g.) were mixed together, intensive blue coloration developed immediately. The mixture, heated on a boiling water-bath for thirty minutes, then cooled, acidified with hydrochloric acid and left to cool gave rise to hydrindantine, dihydroxyketo-*peri*-naphthindene or *m*-nitrodihydroxyketo-*peri*-naphthindene which could be isolated and identified by their m. ps. and their effects on the melting points of authentic samples.

Summary

1. The interaction between cyclic triketones and amines is discussed. The amine gives the corresponding aldehyde and ammonia and the triketone is converted to the corresponding reduction product.

2. A mechanism concerning the nature of the color reaction of the cyclic triketones and primary amines is advanced.

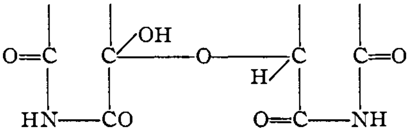
CAIRO, EGYPT RECEIVED MAY 31, 1949

[CONTRIBUTION FROM THE DEPARTMENT OF CHEMISTRY, FACULTY OF SCIENCE, FOUAD-I UNIVERSITY, CAIRO, EGYPT]

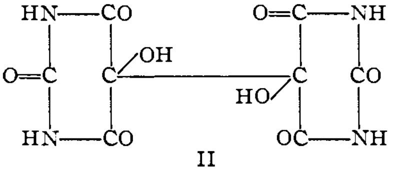
Reactions of Alloxan and Alloxantine. Structure of Alloxantine and Hydrindantine

BY RADWAN MOUBASHER AND ABDEL MAGID OTHMAN

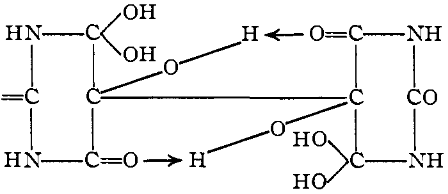
Of the various structural formulas proposed for alloxantine, the hemiacetal formula (I) and the pinacol formula (II) have received the most support. Davidson and Epstein[1] comparatively recently have presented evidence favoring the latter and Nightingale[2] and Winslow[3] independently presented evidence favoring the former.



I

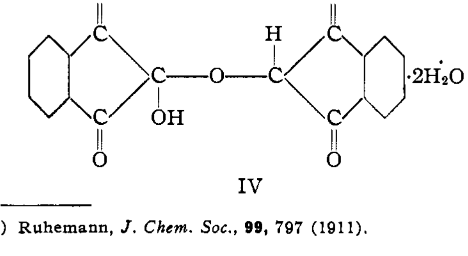


II



III

Similarity between hydrindantine and alloxantine (I) has been frequently pointed out[4] and owing to this similarity hydrindantine has been formulated as (IV).



IV

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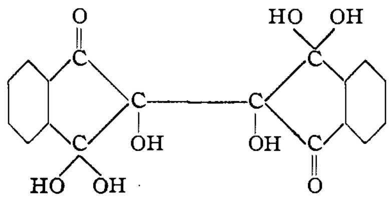
[1] Davidson and Epstein, *J. Org. Chem.*, **1**, 306 (1936).

[2] Nightingale, THIS JOURNAL, **59**, 802 (1937).

[3] Winslow, *ibid.*, **61**, 2089 (1939).

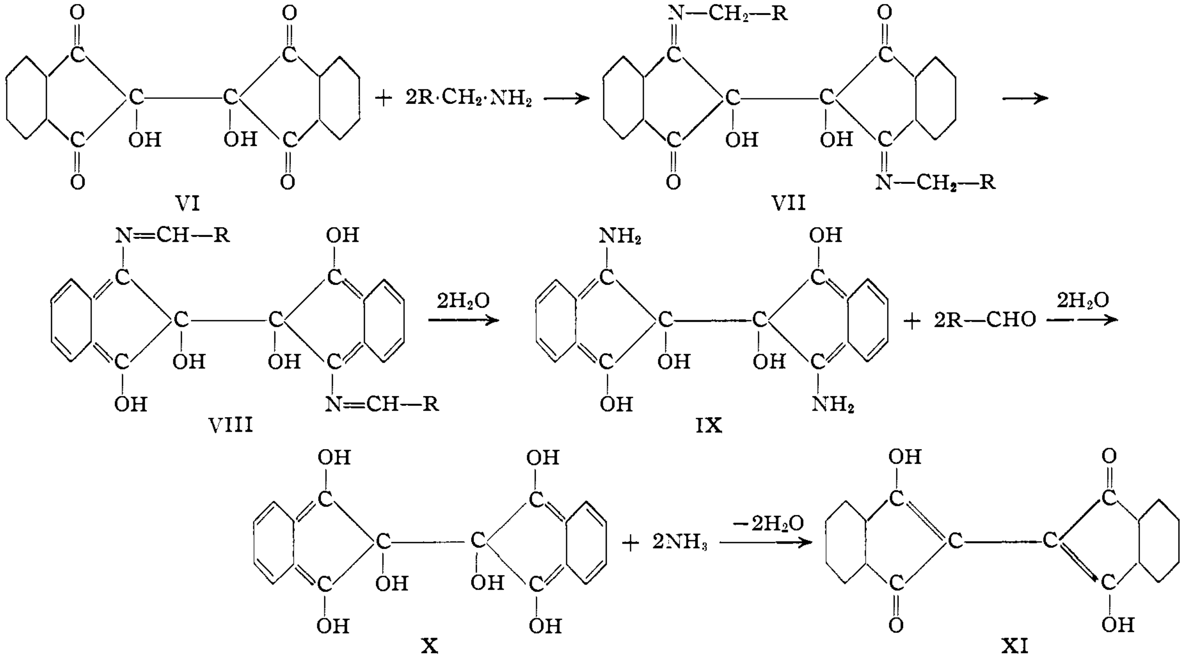
[4] Ruhemann, *J. Chem. Soc.*, **99**, 797 (1911).



V

But recently Schönberg and Moubasher[5] have shown that hydrindantine is not (IV), but in reality (V), and the anhydrous 2,2′-dihydroxy-bis-diketohydrindene (VI) has been prepared. Therefore, the pinacol formula (II) for alloxantine has to be accepted. Moreover, this pinacol formula is in full agreement with the fact that alloxantine may be obtained when anhydrous alloxan in isopropyl alcohol is exposed to sunlight and the reaction product is crystallized from a medium containing water.

It is a well-known fact that pinacols may be obtained from ketones under these conditions.[6] The stability of the two hydroxy groups attached to one carbon atom being due to resonance and chelation (III).



Alloxantine reacts with α-amino acids with the formation of the same violet coloration obtained as with alloxan, and dialuric acid is formed. The α-amino acids are degraded to the corresponding aldehydes with one carbon atom less, carbon dioxide and ammonia.

The mechanism of this reaction is based on the fact that alloxantine is dissociated into alloxan and dialuric acid (Biilmann and Bentzon).[7] The former reacts with α-amino acids according to Strecker's observation.[8] Similarly, it reacts with primary amines which have at least one hydrogen atom on the α-carbon atom, giving the corresponding aldehyde and ammonia. The reaction between hydrindantine and α-amino acids has been discussed by Moubasher and Ibrahim[9] and the reaction with primary amines follows a similar course, yielding the bis-1,3-indanedione (XI) via several colored intermediate stages.

Experimental

Photochemical Reaction between Anhydrous Alloxan and Isopropyl Alcohol.—Freshly prepared alloxan (0.5 g.), prepared by heating alloxan trihydrate in vacuum (4 mm.) at 150° for half an hour, was suspended in freshly distilled isopropyl alcohol (20 g.), dried over calcium chloride in a closed tube filled with carbon dioxide. When the tube was exposed to sunlight for fifteen days, the violet-red substance gradually disappeared and a colorless solid was formed. The excess of isopropyl alcohol was then removed in a vacuum and the residue crystallized from hot water. The photo-product showed the properties of alloxantine, melting at 235°, and showing no depression of the m. p. when mixed with an authentic sample. It gave the characteristic violet color with barium hydroxide solution.

Reaction of Alloxantine with α-Amino Acids.—A suspension of alloxantine (0.7 g.) in water (50 cc.) was placed in a reaction flask fitted with a reflux condenser in series with a Liebig condenser. A solution of alanine (0.05 g.), valine (0.4 g.) or leucine (0.4 g.) in water (25 cc.) was added. The contents of the flask were boiled for twenty minutes while a stream of carbon dioxide was passed through the apparatus. The distillate was allowed to react with a solution of 2,4-dinitrophenylhydrazine (0.5 g.) in 10 cc. of alcohol placed in a receiver. The contents of the receiver were treated with concd. hydrochloric acid (5 cc.) and then left to cool in ice. Acetaldehyde 2,4-

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[5] Schönberg and Moubasher, *J. Chem. Soc.*, 212 (1949).

[6] Schönberg and Mostafa, *Chem. Revs.*, **40**, 181 (1947).

[7] Biilmann and Bentzon, *Ber.*, **51**, 522 (1918).

[8] Strecker, *Ann.*, **123**, 363 (1862).

[9] Moubasher and Ibrahim, *J. Chem. Soc.*, 702 (1949).

dinitrophenylhydrazone, isobutyraldehyde 2,4-dinitrophenylhydrazone and isovaleraldehyde 2,4-dinitrophenylhydrazone, identified by the m. p. and the m. p. of mixtures with authentic samples, were thus obtained from the three amino acids, respectively; yield about 20%. A solid formed in the reaction flask proved to be uramil. When a mixture of alanine (0.2 g.) and alloxantine (0.5 g.) in water (50 cc.) was heated, carbon dioxide was detected, as well as ammonia if excess of sodium hydroxide was added.

Reaction of Alloxantine with Amines.—Alloxantine (1 g.), ethylamine (3 g.), butylamine (2.7 g.), benzylamine (2.5 g.) or *s*-butylamine (0.4 g.) and water (100 cc.) were boiled for forty minutes in a stream of carbon dioxide following the procedure used with the α-amino acids. At the end of the reaction, the contents of the receiver were warmed for some time and treated with 5 cc. of hydrochloric acid and then cooled. Acetaldehyde, butyraldehyde, benzaldehyde and methyl ethyl ketone were obtained in about 15% yield as the 2,4-dinitrophenylhydrazones. They were identified by the m. p. and the m. p. of mixtures with authentic samples.

Uramil was precipitated from the intense blue reaction mixture by cooling in ice. No reaction was detected when alloxantine was treated with *t*-butylamine.

Reaction of Hydrindantine with Amines.—Hydrindantine was treated with each of the amines listed in the preceding section, using 1.5-g. samples of hydrindantine following the same procedure as was used for testing alloxantine. The aldehyde corresponding to each of the amines again was isolated and identified. Treatment of the intensely violet reaction mixture with hydrochloric acid discharged the color, and precipitated violet bis-1,3-indandione; m. p. 298°, undepressed by mixing with authentic sample; yield 20%.

Summary

1. Structure of alloxantine is discussed and it is concluded that the evidence available favors the pinacol, rather than hemiacetal, formula.

2. Some new reactions of alloxantine and hydrindantine with amines and amino acids are described.

CAIRO, EGYPT RECEIVED MAY 31, 1949

[CONTRIBUTION FROM THE MORLEY CHEMICAL LABORATORY, WESTERN RESERVE UNIVERSITY]

The Reaction of 1-Phenyl-1,3-butadiene with Hypochlorous Acid[1]

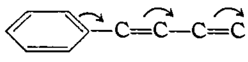
BY OLIVER GRUMMITT AND ROBERT M. VANCE[2]

As part of a study of the effect of the phenyl group on the behavior of a 1,3-butadiene side chain,[3] the addition of hypochlorous acid to 1-phenyl-1,3-butadiene has been investigated.

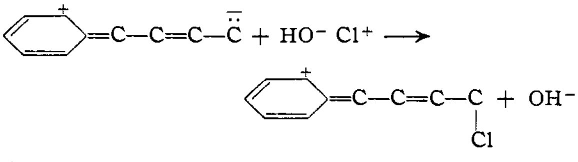
The reaction with one mole of acid can theoretically yield six structural isomers, since the 1,2, 3,4, and 1,4 modes of addition can each give a pair of isomers. In 1930 Muskat and Grimsley[4] reported that 3,4 addition gave 1-phenyl-3-hydroxy-4-chloro-1-butene (VII, Chart 2). Although the chlorohydrin was too unstable to isolate in pure form, it was ozonized to the expected benzaldehyde[5] and dehydrochlorinated to an epoxide whose structure was thought to be 1-phenyl-3,4-epoxy-1-butene. Further proof of 3,4 addition came from the dehydration of the crude chlorohydrin to 1-phenyl-4-chloro-1,3-butadiene (X), the structure of which was shown by (a) oxidation with silver oxide to γ-phenylisocrotonic acid (XIII), (b) independent synthesis by 3,4 addition of chlorine to phenylbutadiene followed by dehydrochlorination, and (c) the identity of the aniline derivatives, 1-phenyl-4-anilido-1,3-butadiene, made from the 4-chloro compounds obtained from the chlorohydrin and the dichloride.

Thus the 3,4 addition of hypochlorous acid to phenylbutadiene was generally accepted until 1937 when Abragam and Deux[6] reported only 1,2 addition. Again the crude chlorohydrin resisted purification but dehydrochlorination yielded 1-phenyl-1,2-epoxy-3-butene (III), based on (a) hydrolysis of the epoxide to a glycol, 1-phenyl-1,2-dihydroxy-3-butene (V), (b) hydrogenation to 1-phenyl-1-butanol, and (c) catalytic isomerization to α-phenylcrotonaldehyde. Whether the chlorohydrin had the 1-hydroxy-2-chloro- (I) or the 1-chloro-2-hydroxy structure (II), or was a mixture, was not established.

Because the electronic mechanism for this addition reaction points clearly to 1,4 and 3,4 addition, it seemed desirable to explore this reaction further. On theoretical grounds the activation of the butadiene side chain in the presence of a polar reagent involves a displacement of electrons out of the ring



The anionic terminal carbon atom reacts with the positively charged chlorine from hypochlorous acid



As a resonance hybrid, the positive charge in this activated intermediate would be distributed to the ortho and para carbon atoms in the ring but mostly to the first and third carbon atoms of the

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(1) Presented before the Division of Organic Chemistry at the San Francisco meeting of the American Chemical Society, April 31, 1949.

(2) Sherwin-Williams Research Fellow in Organic Chemistry, 1946–1948. Present address: Sherwin-Williams Company, Chicago, Illinois.

(3) Grummitt and Becker, THIS JOURNAL, **70**, 149 (1948).

(4) Muskat and Grimsley, *ibid.*, **52**, 1574 (1930); **55**, 3762 (1933); Muskat and Huggins, **51**, 2496 (1929).

(5) This is not incontrovertible evidence for 3,4 addition because a 1,2 or 1,4 chlorohydrin, because of the allylic alcohol structure, might dehydrate very readily to re-establish the double bond adjacent to the ring and thus be oxidized to benzaldehyde.

(6) Abragam and Deux, *Compt. rend.*, **205**, 285 (1937).