The Oxidative-Rearrangement of Nitrogen Heterocycles with Lead Tetraacetate and *t*-Butyl Hypochlorite

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Mechanisms for the lead tetraacetate and *t*-butyl hypochlorite oxidation of 1,4-dihydro-3(2H)-cinnolinones and 1-amino-2-indolinones are discussed. Evidence for the lack of a nitrene intermediate is given.
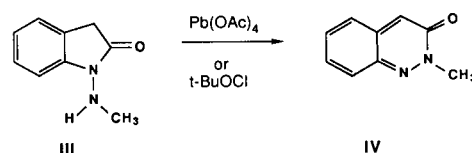
Lead Tetraacetate Oxidation.

The oxidative-rearrangement of 1-amino-2-indolinone (1-aminooxindole) (**I**) to 3(2H)-cinnolinone (**II**) with lead tetraacetate was reported [1] as part of the reinvestigation of the structure of "Neber's Lactam" **I**. Two possible mechanisms were suggested and these have been modified and shown in more detail in a later report [2] (Sequences A and B, Scheme I). A third mechanism was also suggested by Baumgarten, Wittman and Lehmann [2] (Sequence C, Scheme I).

SCHEME I
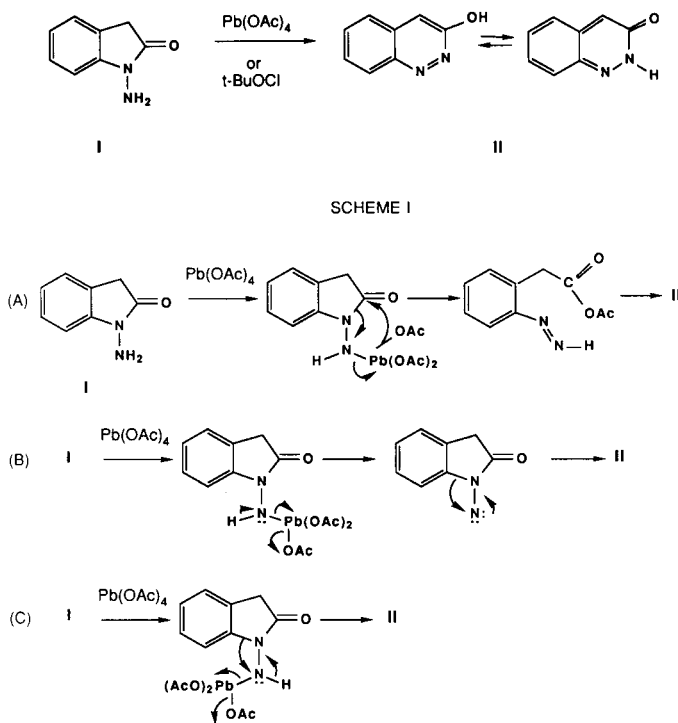
1-(*N*-Methylamino)-2-indolinone (**III**) has also been found to undergo an oxidative-rearrangement to 2-methyl-3(2H)-cinnolinone (**IV**) with lead tetraacetate. A nitrene intermediate is not possible with this compound and thus the mechanism in Sequence B, Scheme I, can be ruled out. Likewise, the methyl group in **IV** rules out Sequence C, Scheme I as a possible mechanism.

III   IV

1,4-Dihydro-3(2H)-cinnolinone (**V**) and 1,4-dihydro-2-methyl-3(2H)-cinnolinone (**VI**) undergo oxidation to 3(2H)-cinnolinone (**II**) and 2-methyl-3(2H)-cinnolinone (**IV**) respectively with lead tetraacetate. Again mechanisms similar to those shown in Sequences B and C, Scheme I, cannot be operative. Sequence A, Scheme I, is a permissible mechanism from the standpoint of bond rearrangement, but the stereochemistry of the intermediate places some doubt on its validity. It is apparent that -Pb(OAc)₃ is a good leaving group [3] and the mechanism shown (Scheme II) is more plausible.

V: R=H   II: R=H
VI: R=CH₃   IV: R=CH₃

SCHEME II

V or VI   II or IV
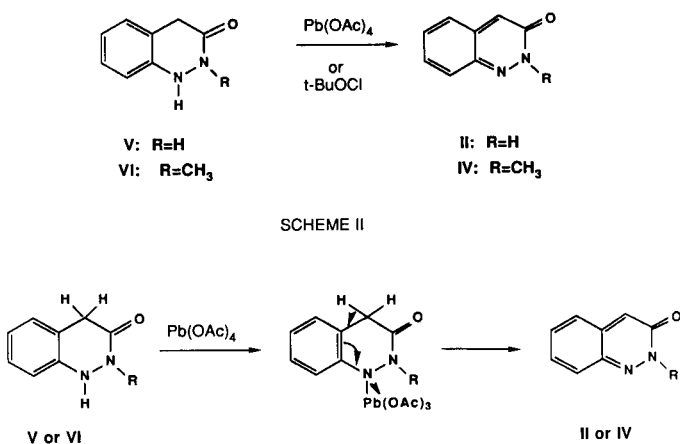
t-Butyl Hypochlorite Oxidation.

Baumgarten, Wittman and Lehman [2] have also reported the oxidative-rearrangement of **I** to **II** with *t*-butyl hypochlorite. Using these same conditions, **III** has been oxidized to **IV** eliminating the possibility of a nitrene intermediate (Sequence B, Scheme I) as well as the mechanism in Sequence C, Scheme I. A mechanism analogous to Sequence A, Scheme I, would involve a four-membered intermediate **VII**. The mechanism shown (Sequence A, Scheme III) or its concerted counterpart (Sequence B, Scheme III) suggests, perhaps, more logical pathways for

the oxidative-rearrangement with *t*-butyl hypochlorite. This mechanism is also consistent with the results obtained in the oxidative-rearrangement with lead tetraacetate.

VII

SCHEME III

1,4-Dihydro-3(2*H*)-cinnolinone (**V**) and 1,4-dihydro-2-methyl-3(2*H*)-cinnolinone (**VI**) also undergo oxidation with *t*-butyl hypochlorite to **II** and **IV** respectively. The mechanism shown in Scheme II can also be operative in this reaction.

Summary.

It is suggested that the mechanism of the lead tetraacetate oxidative-rearrangement of 1-amino-2-indolinones **I** and **III** is analogous to the *t*-butyl hypochlorite oxidative-rearrangement. It is evident that a nitrene intermediate is not involved in the rearrangement of **III** and is probably not involved in the rearrangement of **I** either. Two alternative mechanisms have been suggested (Sequence A and B, Scheme III). It appears that the oxidation of the 1,4-dihydro-3(2*H*)-cinnolinones **V** and **VI** may occur by a pathway (Scheme II) different from that of the 1-amino-2-indolinones, but it should be noted that a mechanism similar to Sequence A, Scheme III can be drawn (Scheme IV).

SCHEME IV

EXPERIMENTAL

Melting points were determined in open capillary tubes and are uncorrected. The ir spectra [4] were determined in potassium bromide pellets.

1-Amino-2-indolinone (**I**).

The procedure described by Baumgarten, Creger, and Zey [1] for the reduction of 3(2*H*)-cinnolinone was used.

3(2*H*)-Cinnolinone (**II**).

This material, used as a starting material and for infrared comparison, was prepared from isatin by the procedure previously reported by this author [5].

1-(*N*-Methylamino)-2-indolinone (**III**).

This material was prepared from 1-(*N*-methylacetamido)-2-indolinone by the procedure previously reported by this author [6].

2-Methyl-3(2*H*)-cinnolinone (**IV**).

This material was prepared from 3(2*H*)-cinnolinone by the procedure previously reported by this author [6].

1,4-Dihydro-3(2*H*)-cinnolinone (**V**).

This material was prepared from 3(2*H*)-cinnolinone by the procedure previously reported by this author [6].

1,4-Dihydro-2-methyl-3(2*H*)-cinnolinone (**VI**).

This material was prepared from 2-methyl-3(2*H*)-cinnolinone by the procedure of Alford and Schofield [7].

Oxidation with Lead Tetraacetate.

The procedure used in all lead tetraacetate oxidations was similar to that described by Baumgarten, Creger, and Zey [1] for the oxidative-rearrangement of 1-amino-2-indolinone (**I**) to 3(2*H*)-cinnolinone (**II**).

(a) Oxidation of 1-(*N*-Methylamino)-2-indolinone (**III**).

2-Methyl-3(2*H*)-cinnolinone (**IV**) was prepared in 29% yield, mp 131-133°. Its infrared spectrum was identical with that of an authentic sample.

(b) Oxidation of 1,4-Dihydro-3(2*H*)-cinnolinone (**V**).

3(2*H*)-Cinnolinone (**II**) was prepared in 86% yield, mp 198-200°. Its infrared spectrum was identical with that of an authentic sample.

(c) Oxidation of 1,4-Dihydro-2-methyl-3(2*H*)-cinnolinone (**VI**).

2-Methyl-3(2*H*)-cinnolinone (**IV**) was prepared in 80% yield, mp 132.5-134°. Its infrared was identical with that of an authentic sample.

Oxidation with *t*-Butyl Hypochlorite.

The procedure used in all *t*-butyl hypochlorite oxidations was similar to that described by Baumgarten, Wittman, and Lehmann [2] for the oxidative-rearrangement of 1-amino-2-indolinone (**I**) to 3(2*H*)-cinnolinone (**II**).

(a) Oxidation of 1-(*N*-Methylamino)-2-indolinone (**III**).

3-Hydroxy-2-methylcinnolinium chloride was prepared in 73% yield, mp 179° dec (lit [8] mp 168° dec). The infrared spectrum was identical with that of a sample prepared by adding hydrogen chloride gas to a solution of 2-methyl-3(2*H*)-cinnolinone (**IV**). The material was dissolved in water, neutralized with sodium hydroxide, and extracted with chloroform to give a quantitative yield of 2-methyl-3(2*H*)-cinnolinone, mp 131-133°. The infrared spectrum was identical with that of an authentic sample.

(b) Oxidation of 1,4-Dihydro-3(2*H*)-cinnolinone (**V**).

3(2*H*)-Cinnolinone (**II**) was prepared in 66% yield, mp 199-201°. Its infrared spectrum was identical with that of an authentic sample.

(c) Oxidation of 1,4-Dihydro-2-methyl-3(2*H*)-cinnolinone (**VI**).

3-Hydroxy-2-methylcinnolinium chloride was prepared in 93% yield, mp 179-181° dec. The infrared was identical with that of an authentic sample. The material was converted to 2-methyl-3(2H)-cinnolinone (VI) by the procedure described above for the oxidation of 1-(N-methylamino)-2-indolinone (III).

REFERENCES AND NOTES

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[3] Cf. J. B. Aylward and R. O. C. Norman, J. Chem. Soc., (C), 2399 (1968).

[4] R. L. Zey, Doc. Mol. Spectros., 63, nos. 23076 (I), 23096 (II), 23077 (III), 23092 (IV), 23090 (V), 23091 (VI) (1972).

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[8] D. E. Ames and H. Z. Kucharska, ibid., 4924 (1963).