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Photochemistry of Pyridine 1-Oxides having Nitro, Nitroso, or Hydroxyamino Group in Their 4-Position[*1,2]

In an earlier communication,[1] we reported that ultraviolet irradiation of an ethanol or isopropanol solution of 4-nitropyridine 1-oxide (I) in nitrogen atmosphere afforded the corresponding 4-hydroxyaminopyridine 1-oxide (Ⅱ) in almost quantitative yield.

However, irradiation of I under the same condition, but in the presence of oxygen has now been found to give the nitrate (Ⅲ) of 4-hydroxypyridine 1-oxide as the only detectable and major product. It is the purpose of this communication to report the proof for the structure of Ⅲ and some related photochemistry of 4-nitroso- and 4-hydroxyamino-pyridine 1-oxides (Ⅳ and Ⅱ).

Irradiation of a solution of I in ethanol or isopropanol (10^{-5}～$10^{-2}M$) with a light from a high-pressure Hanovia immersion lamp (Pyrex filter was used to eliminate the light of wavelength shorter than 300 mμ), under bubbling of oxygen, resulted in the formation of a crystalline compound (Ⅲ), m.p. 98～100° (decomp.), $C_5H_6O_5N_2$, UV λ_{max}^{EtOH} mμ (log ε) : 244 (3.70), 267 (3.97); $\lambda_{max}^{5\%K_2CO_3}$: 273 (4.25), $\lambda_{max}^{5\%H_2SO_4}$: 241 (3.96); IR ν_{max}^{Nujol} cm^{-1} : 2800～2400, 1645, 1590, 1300, 1200, 1180, 1040, 850, 775. The product, obtained in a yield of 60～65%, was isolated by direct crystallization of the concentrated residue of the irradiated solution from ether-ethanol mixture (1:1 v/v). The treatment of Ⅲ with equimolar amounts of 10% aq. potassium carbonate solution followed by evaporation and recrystallization from absolute ethanol afforded, in a high yield, 4-hydroxypyridine 1-oxide[*3] (V), m.p. 238～240° (decomp.), $C_5H_5O_2N$; UV λ_{max}^{EtOH} mμ (log ε) : 269 (4.21); IR ν_{max}^{KBr} cm^{-1} : 3400, 3050, 1630, 1440, 1290, 835, 770. The NMR spectrum of Ⅲ in trifluoroacetic acid showed two sets of doublets (J=7.8 c.p.s) of equal intensity centered at 1.54τ and 2.62τ, and was superimposable with that of V. These experimental data on Ⅲ and its elemental analysis clearly indicate that Ⅲ is the nitrate of V. The correctness of the structure of Ⅲ was finally provided by its direct synthesis by dissolution of V in equimolar amounts of conc. nitric acid (62%) followed by concentration under reduced pressure, and recrystallization from ether-ethanol mixture. Identity of the two samples was assured by mixed melting point determination and their superimposable infrared (IR), ultraviolet (UV), and nuclear magnetic resonance (NMR) spectra.

By these experiments, together with those reported in our previous paper,[1] it has now become clear that the photochemical reaction of I in ethanol or isopropanol[*4] could take two different courses, depending on the presence or absence of oxygen in the irradiated solution, one giving Ⅲ and the other giving Ⅱ. As far as we are aware the conversion of I to Ⅲ is a rare example of a photochemical Nef-type reaction found in aromatic nitro compounds[*5] and it appears plausible that this conversion involves

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[*1] Part Ⅶ in the series entitled "Studies on the N-Oxides of π-Deficient N-Heteroaromatics." Part Ⅵ. C. Kaneko, I. Yokoe, S. Yamada, M. Ishikawa : This Bulletin, **14**, 1316 (1966).

[*2] This work was reported at the Symposium on Photochemistry, Abstracts of Papers, p. 51 (Osaka, October 1966).

[*3] 4-Hydroxypyridine 1-oxide was prepared by the method described by H. J. den Hertog and W. P. Combé (Rec. trav. chim., **71**, 745 (1952)).

[*4] Two types of photochemical reactions of I mentioned did not proceed in aqueous solution.

[*5] The only example is the photochemical conversion of 2,6-diphenyl-4-nitrophenol to 2,6-diphenyl-*p*-quinone which was reported by E. C. S. Jones and J. Kenner (J. Chem. Soc., **1931**, 1842).

[1] C. Kaneko, S. Yamada, I. Yokoe, N. Hata, Y. Ubukata : Tetrahedron Letters, No. 39, 4729 (1966).

initial rearrangement of R-NO_2 (I) to R-ONO (VI) as a key step.*[6] Homolytic fission of O-NO bond as in the case of well-known Barton reaction[2] may then give VII and nitric oxide (NO), and the latter is then oxidized to nitrogen dioxide (NO_2) which then recombines with VII to give VIII.*[7] These processes can be formulated as shown below.

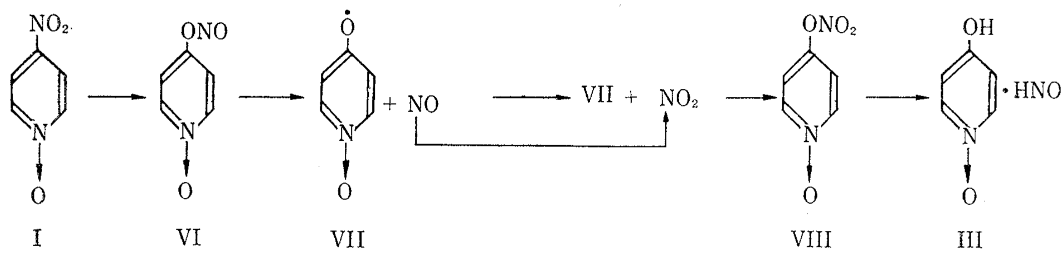

Chart 1.

If these assumptions are correct, III should be formed from VIII by hydrolysis which occurs probably in the isolation process. This fits well with the observation that the final spectrum of the irradiated solution of I in oxygen atmosphere showed only one absorption maximum at 269 mμ and differed with those (244 and 267 mμ) of III. As an illustration, the spectral change of the appropriately diluted solution of the irradiation mixture is shown in Fig. 1. The peak at 269 mμ was stable if the solution was stored in completely anhydrous condition below 10°, but if no such protection was taken it was replaced gradually with two absorption maxima at 244 and 267 mμ corresponding to those of III.

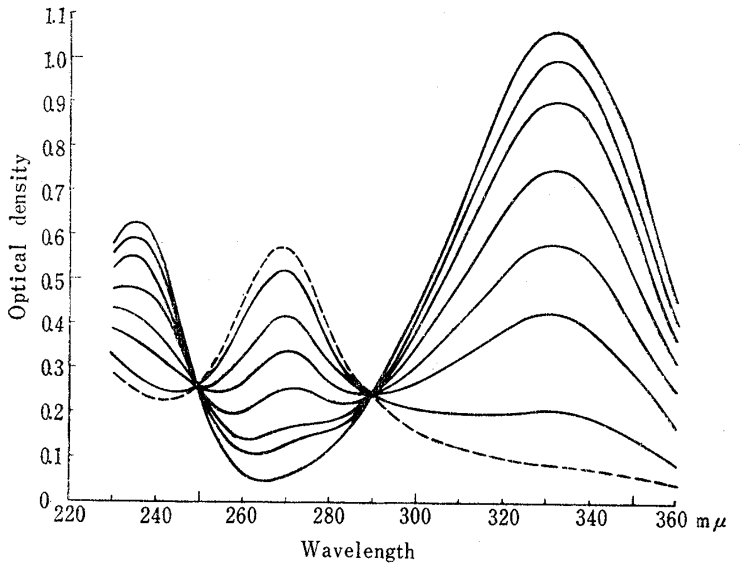

Fig. 1. The Progressive Change of the Spectrum of 4-Nitropyridine 1-Oxide on 3130 Å. Irradiation in Absolute Ethanol under Oygen Atmosphere.
Numbers refer to irradiation time in minutes, and the dotted line denotes a spectrum of the photo-product at room temperature.

While the precise mechanism of the reaction and structural determination of the direct reactoin product are under investigation, the related photochemistry of 4-hydroxyamino- and 4-nitrosopyridine-1-oxides (II and IV) deserves comment.

As reported already,[1] II was found to be stable in the above-described solvents at room temperature, in nitrogen atmosphere. However, if oxygen is present in the dilute ($8 \times 10^{-5} M$) solution, II becomes unstable both thermally and photochemically. In the dark reaction, if oxygen is passed through the solution, 4,4′-azoxypyridine 1,1′-dioxide[1] (IX), m.p. 234°, UV λ_{max}^{EtOH} mμ (log ε) : 244 (3.78), 395 (4.10) is formed in a quantitative yield. However, under the same condition but with the solution

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*[6] Similar reaction sequences have been reported in the photochemistry of nitro-olefins. O. L. Chapman, P. G. Cleveland, E. D. Hoganson : Chem. Comm., **1966**, 101. See also, J. T. Pinhey, E. Rizzardo : Chem. Comm., **1965**, 362.

*[7] Photochemical conversion of methyl nitrite(CH_3ONO) to methyl nitrate(CH_3ONO_2) in the presence of oxygen was described by P. L. Hanst and J. G. Calvert (J. Phys. Chem., **63**, 2071 (1959)).

2) M. Akhtar : Adv. Photochem., 2, 263 (1964).

irradiated by light, 4-nitropyridine 1-oxide (I) is formed exclusively, which is in turn subjected to further photoisomerization as described above. In a higher concentration of II (ca. $10^{-2}M$), both dark and light reactions result in the formation of IX. These facts can be understood if the rate of the dark reaction to form IX is dependent on the concentration and it becomes faster as the concentration of II increases, and thus, the following reaction mechanism[*8] in which the rate is second-order to II could be postulated :

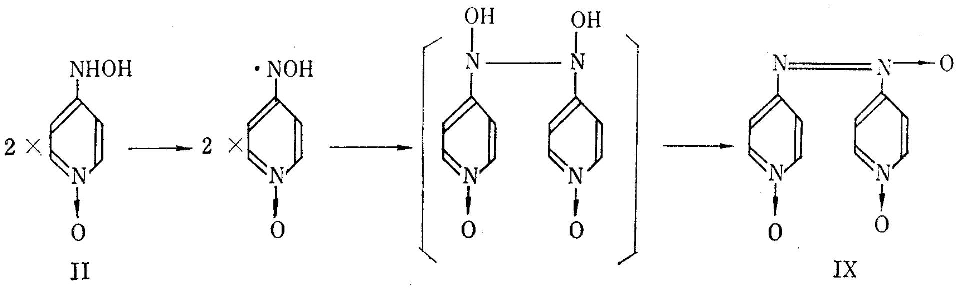

Chart 2.

Though the exact photochemical process from II to I is unknown, its rate should be first-order to II and is very slow compared to that of I to II, which is confirmed in the comparative experiment under exactly the same condition. 4-Nitrosopyridine 1-oxide[3] (IV), m.p. 139°; UV $\lambda_{\max}^{\mathrm{EtOH}}$ mμ (log ε) : 250 (3.81), 370 (4.12), on the contrary, is reduced to II by its light reaction, either in the presence or absence of oxygen. However, this process also proceeds with much slower rate than that of I to II, and in this case, the concentration of IV has no effect on the product formation ($10^{-5}\sim10^{-2}M$). These experiments on IV rationally exclude the possibility that the photochemical reaction of 4-nitropyridine 1-oxide (*e.g.* I to II) involves IV as an intermediate.

The mechanisms shown in this paper are at present without direct proof, however, and more experimental data will have to be obtained before the obviously complex mechanisms of the photolysis of I and its related N-oxides (II and IV) can be understood.

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[*8] Stable radical formation from 4-hydroxyaminoquinoline 1-oxide by molecular oxygen was reported by C. Nagata, N. Kataoka, A. Imamura, Y. Kawazoe, G. Chihara (GANN, **57**, 323 (1966)).

3) E. Ochiai, H. Mitarashi : Ann. Rept. ITSUU Lab., **14**, 17 (1965). See also F. Parisi, P. Bovina, A. Quilico : Gaz. chim. ital., **90**, 903 (1960); *Idem* : *Ibid.*, **92**, 1138 (1962).

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Structure of Leucomycin A_1

Evidences have been presented that leucomycins[1] are composed of six components, leucomycin A_1, A_2, B_1, B_2, B_3 and B_4,[2] and the major component A_1 having the highest

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1) T. Hata, Y. Sano, O. Ohki, Y. Yokoyama, A. Matsumae, S. Ito: J. Antibiotics, Ser., **A6**, 87 (1953).

2) T. Watanabe : Bull. Chem. Soc. Japan, **33**, 1101, 1105 (1960), *Ibid.*, **34**, 15 (1961).