Our results are in rather good agreement with that of Harbour, *et al.*, by taking into consideration that the different solvents are used. However, they have reported that in the HO_2 radical adduct, it is still uncertain as to whether DMPO traps O_2^- directly (followed by protonation) or traps the HO_2 radical which is in equilibrium with O_2^-.[8b] In this point, our results suggest that DMPO traps the HO_2 radical in equilibrium with O_2^- directly, but does not trap O_2^-. This is supported by the fact that, when the O_2^- solution is added to an acetonitrile solution containing a small amount of HCl and DMPO, the same ESR spectrum as shown in Fig. 3[13] can be observed.

Acknowledgement The authors are indebted to Associate Prof. H. Yamamoto, Faculty of Pharmaceutical Sciences, Hokkaido University, for his helpful advice. We are also grateful to Dr. Y. Kirino, Faculty of Pharmaceutical Sciences, The University of Tokyo, for the gift of DMPO and for his valuable suggestion.

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[13] The ESR spectrum in Fig. 3 was, of course, not observed when HCl was added to the mixture of O_2^- and DMPO.

Chem. Pharm. Bull.
26(8)2575—2578(1978)

UDC 547.416.04 : 547.298.71.04

Reaction of 1-Methoxyimino-6-nitrohexa-2,4-diene, Resulting from the Reaction of N-Methoxypyridinium Iodide with Nitromethane

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(Received February 15, 1978)

Chemical transformations of 1-methoxyimino-6-nitrohexa-2,4-diene (II), resulted from the reaction of N-methoxypyridinium iodide (I) with nitromethane, were examined in relation to the nitro-aci-nitro prototropy. II reacted with diazomethane to afford methyl 1-methoxyimino-hexa-2,4-diene-6-acinitronate (III), with acetic anhydride and with benzoyl chloride to give O-acetate and O-benzoate of 1-methoxyimino-hexa-2,4-diene-6-hydroxamic acid (VI) respectively. The ultraviolet spectra of them were correlated to their structures.

Keywords——N-methoxypyridinium salt; pyridine ring opening; nitro-acinitro prototropy; nitroalkane; hydroxamic acid; UV spectra

In the previous paper,[2] it was found that the reaction of N-methoxypyridinium iodide (I) with nitromethane in the presence of sodium ethoxide proceeded *via* nucleophilic attack of nitromethane anion at the 2-position and subsequent N-C bond scission of the pyridine nucleus affording 1-methoxyimino-6-nitrohexa-2,4-diene (II). This paper deals with the reactions of II with some reagents and the spectral data of the products.

Treatment of II with ethereal diazomethane afforded a fairly stable monomethylated compound, mp 122—123° (dec.), $C_8H_{12}N_2O_3$, the structure of which was determined as depitched in Chart 1, since the infrared (IR) spectrum did not show any nitro stretching band but $\nu_{\mathrm{N=C}}^{+}$ at 1608 cm^{-1} and the nuclear magnetic resonance (NMR) spectrum in deuteriochloroform ex-

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[2] H. Takayama and T. Okamoto, *Chem. Pharm. Bull.* (Tokyo), **26**, 2422 (1978).

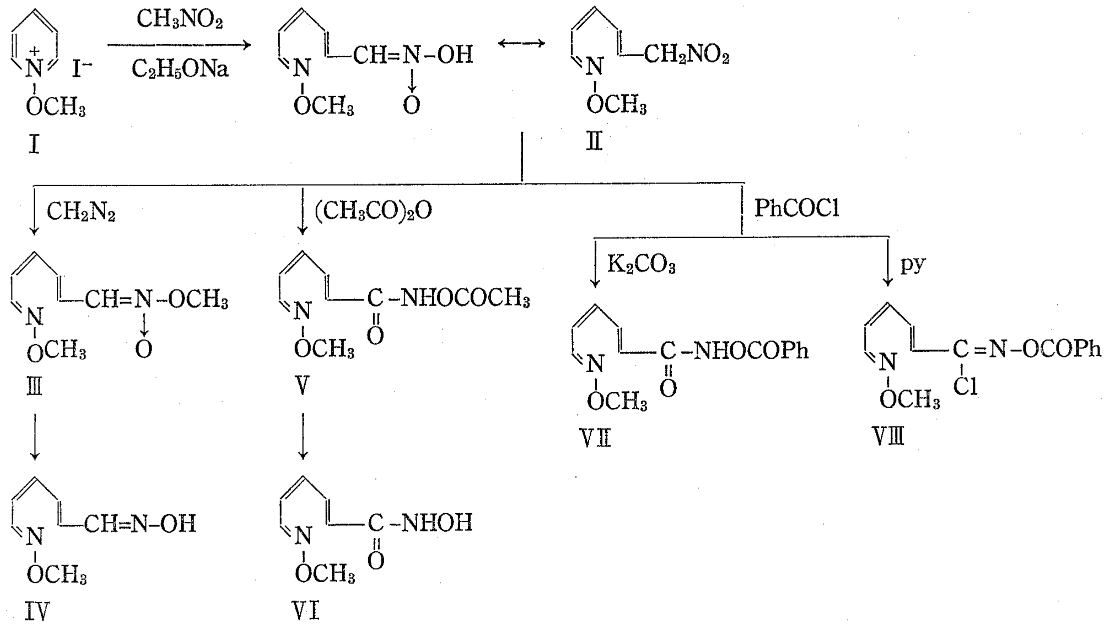

Chart 1

hibited two kinds of methyl protons (τ: 6.17, s; 6.28, s) and the methylene protons (τ: 5.06, d, 2H) neighbouring to nitro group presented in the spectrum of II disappeared. Further, when heated on steam bath, III liberated formaldehyde to give the oxime (IV), mp 173—174° (dec.), $C_7H_{10}N_2O_2$. This oxime retained the conjugated system as proved by the pattern of the ultraviolet (UV) spectrum.

Reaction of II with acetic anhydride at room temperature afforded colorless needles (V), mp 151° (dec.), $C_9H_{12}N_2O_4$. IR absorption bands of V at 3200, 1780—1790 (split), 1660 and 1180 cm^{-1} (KBr) suggested that V had a hydroxamic acid monoacetate group (-CONHO-COCH$_3$). Again, this compound still possessed a conjugated system as evidenced from the UV spectrum. Hydrolysis of V in aq. 2 N NaOH solution gave the hydroxamic acid (VI), mp 173—174° (dec.), $C_7H_{10}N_2O_3$, which colored reddish violet with ferric chloride solution.

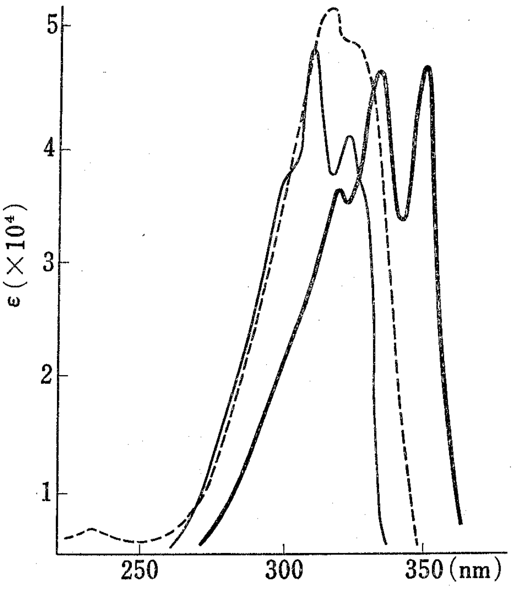

Fig. 1. UV Spectra of III, IV, VIII in EtOH

———, III; ———, IV; -----------, VIII.

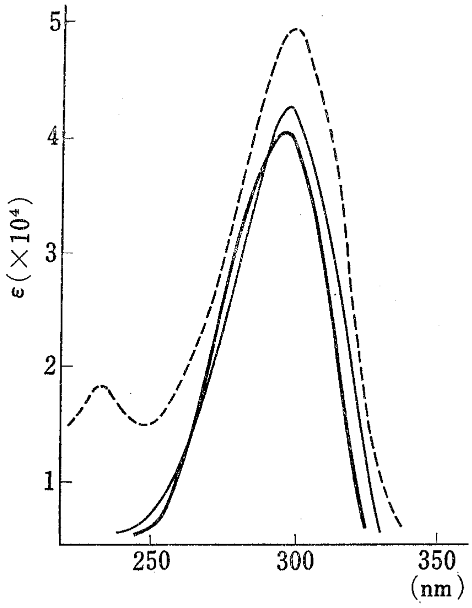

Fig. 2. UV Spectra of V, VI, VII in EtOH

———, V; ———, VI; -----------, VII.

The IR absorption bands at 3200, 3120, and 1639 cm^{-1} (KBr) of VI corresponded to the characteristic bands of -CONHOH group. The position of an acetyl group on the hydroxamic acid in V was remained to be determined,[3] but an O-acetyl structure seems to be most likely both from UV spectrum and from the assumed mechanism for the analogous reaction of pyridine 1-oxide with acetic anhydride.[4]

Finally, the reaction of II with benzoyl chloride was examined. When II was reacted with benzoyl chloride in chloroform in the presence of potassium carbonate, colorless needles (VII), mp 164—165° (dec.), $C_{14}H_{14}O_4N_2$ were obtained. The product (VII) was identified with the monobenzoate of VI, since not only its UV spectrum was quite resemble to that of V, but also its IR spectrum showed the strong absorption bands at 3220, 1780, 1650—1670 (split), 1620 and 1250 cm,$^{-1}$ all of these corresponded to the characteristic absorption bands of hydroxamic acid monoacylate. As expected, VII afforded VI on hydrolysis. On the other hand, when II was reacted with benzoyl chloride in pyridine at room temperature, a product containing a chlorine atom was formed as colorless needles, mp 130—131° (dec.), $C_{14}H_{13}ClN_2O_3$. The structure of this product was deduced as VIII, since its IR spectrum exhibited a band at 1772 cm^{-1} and the pattern of the UV spectrum of VIII has close resemblance to those of III and IV, but rather different from those of V, VI, and VII.

All of the transformations of II reported in this note provide further supporting evidences for its proposed structure as depicted in Chart 1.

Experimental

Reaction of 1-Methoxyimino-6-nitrohexa-2,4-diene (II) with Diazomethane——To a solution of 510 mg of II in ether was added an excess of ethereal diazomethane. The reaction mixture was allowed to stand for 3 hr and the ether was removed under a reduced pressure to give 530 mg of crude crystals (mp 118—120° (dec.)). Recrystallization from methanol gave pale yellow needles (III), mp 122—123° (dec.). *Anal.* Calcd. for $C_8H_{12}N_2O_3$: C, 52.16; H, 6.57; N, 15.21; Found: C, 52.31; H, 6.42; N, 15.26; UV. λ_{max}^{EtOH} nm (ε): 245 (4800). 317 (36200), 330 (46700), 347 (47200), λ_{min}^{EtOH} (ε): 258 (3500), 321 (35600), 339 (33000). IR(KBr) cm^{-1}: $\nu_{C=N}^{+}$ 1609, δ_{CH} 1043, 990, 895; NMR ($CDCl_3$) τ: 2.32 (1H, q), 3.57 (5H, m), 6.17 (3H, s), 6.28 (3H, s).

Thermal Decomposition of III——Heating 100 mg of III in a flask equipped with gas trap on a steam bath for 2.5 hr gave crystalline mass, which was recrystallized from methanol to afford 65 mg of colorless long needles (IV), mp 173—174° (dec.). *Anal.* Calcd. for $C_7H_{10}N_2O_2$: C, 54.53; H, 6.54; N, 18.17; Found: C, 54.23; H, 6.52; N, 17.23; UV. λ_{max}^{EtOH} nm (ε): 295 (sh) (35400), 307 (48600), 320 (41400), λ_{min}^{EtOH} nm (ε): 315 (37800). IR(KBr)cm^{-1}: ν_{OH} 2600—3200 (broad), δ_{CH} 905, 993, 1043; The trapped gas in dimedon alcoholic solution formed a precipitate, which was recrystallized from ethanol to give 2 mg of colorless needles, mp 189—191° (dec.) of formaldehyde dimethon.

Reaction of II with Acetic Anhydride——In 2 ml of acetic anhydride was dissolved 300 mg of II, the reaction mixture was allowed to stand for 4 hr at room temperature. The colorless crystals thereby formed were collected, washed with cold ether, and recrystallized from methanol to give 220 mg of colorless needles (V), mp 151—152° (dec.). *Anal.* Calcd. for $C_9H_{12}N_2O_4$: C, 50.94; H, 5.07; N, 13.20; Found: C, 50.63; H, 5.38; N, 13.12; UV. λ_{max}^{EtOH} nm (ε): 297.5 (42700), IR(KBr) cm^{-1}: δ_{CH} 1046, 1004, 914; 1780—1790 (split), 1660, 1620 (–CONHOCOR).

Hydrolysis of V——i) In 1 ml of aq. 2 N NaOH solution was dissolved 100 mg of V and the solution was heated on a steam bath for 10 minutes and cooled below −10° to give a crystalline mass, which was recrystallized from water, affording 48 mg of pale yellow needles, mp 197° (dec.) of sodium salt of VI. *Anal.* Calcd. for $C_7H_9N_2O_3Na \cdot H_2O$: C, 40.00; H, 5.28; N, 13.33; Found: C, 39.93; H, 5.38; N, 12.96; UV. λ_{max}^{EtOH} nm (δ): 296 (39400). A solution of the sodium salt in 0.5 ml of water was neutralized with aq. 2 N HCl to give crude crystals which were recrystallized from methanol to afford 21 mg of cubiform crystals, mp 173—174° (dec.). *Anal.* Calcd. for $C_7H_{10}N_2O_3$: C, 49.40; H, 5.92; N, 16.46; Found: C, 49.43; H, 5.90; N, 17.13; UV. λ_{max}^{EtOH} nm (δ): 295 (40800), IR(KBr) cm^{-1}: δ_{CH} 910, 1006, 1050; 1608, 1639, 3200 (broad) (CONHOH). ii) In 1 ml of aq. 2 N NaOH solution was dissolved 100 mg of V and the solution was heated for 10 minutes,

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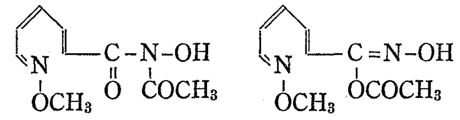
[3] Other possible structures of V:



[4] E. Ochiai, "Aromatic Amine Oxides," Elsevier Publishing Company, Amsterdam London New York, 1967, p. 310.

cooled, and neutralized with aq. 2 N HCl solution. The precipitate thereby formed was extracted with chloro form. The chloroform solution was dried over anhyd. Na_2SO_4 and evaporated to give crystals which were recrystallized from methanol affording 62 mg of VI.

Reaction of II with Benzoyl Chloride——i) To a mixture of 850 mg (5 mmol) of II and 690 mg (5 mmol) of powdered K_2CO_3 in 5 ml of chloroform, was added 840 mg (6 mmol) of benzoyl chloride dropwise during 15 minutes. The temperature of the reaction mixture was maintained below $-5°$. After stirred for 1 hr at room temperature, the reaction mixture was poured into cold water and the whole was extracted with chloroform. The chloroform solution was washed with water, dried over anhyd. Na_2SO_4. On removing chloroform, the residue was recrystallized from methanol to afford 240 mg of colorless needles (VII), mp 164—165° (dec.), *Anal.* Calcd. for $C_{14}H_{14}N_2O_4$: C, 61.31; H, 5.15; N, 10.21; Found: C, 61.29; H, 5.17; N, 10.28; UV. λ_{max}^{EtOH} nm (ε): 232 (18500), 297.5 (49600), λ_{min}^{EtOH} nm (ε): 247 (14900). IR(KBr) cm^{-1}: 3220, 1780, 1650—1670 (split), 1620 (–CONHOCO), δ_{CH} 1043—1060 (split), 993, 915. ii) To a solution of 850 mg (5 mmol) of II in 2 ml of pyridine, was added dropwise during 15 minutes 840 mg (6 mmol) of benzoyl chloride. The temperature of the reaction mixture was maintained below $-5°$. After stirring for 1 hr room temperature, the whole was further allowed to stand overnight. The reaction mixture was poured into ice-water and extracted with chloroform. The chloroform solution was washed with aq. 5% $NaHCO_3$ solution and then with water, dried over Na_2SO_4. After removal of chloroform, the residual oil was chromatographed on alumina column, The fractions eluted with chloroform afford a pale yellow solid, which was recrystallized from methanol giving 175 mg of colorless needles (VIII), mp 130—131° (dec.), *Anal.* Calcd. for $C_{14}H_{13}ClN_2O_3$: C, 57.44; H, 4.44; N, 9.57; Found: C, 57.67; H, 4.87; N, 9.17; UV. λ_{max}^{EtOH} nm (ε): 235 (7000), 312.5 (52100), 323 (sh) (49000); λ_{min}^{EtOH} nm (ε): 252.5 (5900) IR(KBr) cm^{-1}: 1770, 1252 (–O–CO–), δ_{CH} 1050, 1000, 898.

Hydrolysis of VII——A solution of VII (100 mg) in 1 ml of aq. 2 N NaOH solution was heated on a steam bath for 10 minutes. The reaction mixture was neutralized with aq. 2 N HCl solution and the whole was extracted with chloroform. The chloroform solution was dried over anhyd. Na_2SO_4 and concentrated to dryness, affording a crystalline mass. Recrystallization of this residue from methanol resulted with formation of 48 mg of colorless cubiform crystals (VI), mp 174° (dec.).

Acknowledgement The author is grateful to the members of the Central Analytical Laboratories of this Faculty for the measurements of UV, IR and NMR spectra.

[Chem. Pharm. Bull. 26(8)2578—2581(1978)]

UDC 547.655.6.04 : 547.673.5.057

Synthesis of Polycyclines. I. Diels-Alder Reaction of 5-Nitronaphthoquinone with Unsymmetrical Butadienes

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(Received February 17, 1978)

Diels-Alder reaction of 5-nitro-1,4-naphthoquinone (1) and unsymmetrical butadienes was carried out. Reaction of 1 and 2-methyl-1,3-butadiene gave 1,4,4a,9a-tetrahydro-2-methyl-5-nitro-anthraquinone (2) and its 3-methyl analogue (3) at the ratio of 9.2:1. Reaction of 1 and 1,3-pentadiene gave 1,4,4a,9a-tetrahydro-1-methyl-8-nitroanthraquinone (8) and its 5-nitro analogue (9) at the ratio of 10:7. Their structures have been determined by aromatization to methyl-nitroanthraquinones.

Keywords——Diels-Alder reaction; teterahydro-anthraquinone; butadiene; 1,4-naphthoquinone; aromatization

Although there are many reports on the Diels-Alder reaction of symmetrical naphthoquinones and butadienes, relatively a few has been reported on the reaction of unsymmetrical naphthoquinones and butadienes.[2] As the basic study for the synthesis of linear polycyclines,

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[2] L.W. Butz and A.W. Rytina, "Organic Reactions," Vol. 5. ed. by R. Adams, John Wiley and Sons, Inc., New York, 1949, pp. 136—192.