Syntheses of Pyrrolotropone Derivatives from Benzocycloheptene-5,6-dione Monoarylhydrazones. II.[1,2] Syntheses of Benzo[5,6]cyclohept[1,2-*b*]-indole-6,11,12-triones

Kunihide FUJIMORI and Kameji YAMANE

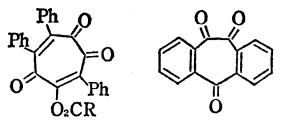
Department of Chemistry, Faculty of Science, Shinshu University, Matsumoto 390

(Received January 16, 1974)

Benzo[5,6]cyclohept[1,2-*b*]indole-6,11,12-triones (benzoindolotropoquinones)(VIIIa—c) were prepared by the oxidation of 11,12-dihydrobenzo[5,6]cyclohept[1,2-*b*]indol-6-ones (Va—c) with sodium dichromate in acetic acid. Compound VIIIa was rearranged by means of a concd sodium hydroxide solution into a known benzocarbazole-1,4-quinone. The pyrrolotropolone derivative (VII) was also obtained through the ring closure of the 5-hydrazinotropolone derivative (VI).

Cyclohepta-3,6-diene-1,2,5-trione(*p*-tropoquinone) has been of interest as an *o*- and *p*-quinone-type compound with a seven-membered ring, but it was not successfuly synthesized until quite recently in spite of many attempts to do so.[3]

5-Nitrosotropolone and 5-arylazotropolone, however, have long been known to have the structures of monooxime and monoarylhydrazone respectively, and tropoquinone trioxime has been obtained from the former.[3]



(I) (II)

Wittmann *et al.*[4] prepared the triphenylhydroxy derivative (I) and Ito *et al.*[5a] performed a successful synthesis of tropoquinone itself by the photosensitized oxidation of 2,5-substituted tropones. Improving its synthetic procedure, the latter[5b] later obtained tropoquinone quantitatively by the oxidation of 5-hydroxytropolone with DDQ in absolute methanol.

On the other hand, dibenzotropoquinone (II) had been obtained earlier.[6]

The present authors will describe the syntheses of benzoindolotropoquinones (VIII) by means of the oxidation of 11,12-dihydrobenzo[5,6]cyclohept[1,2-*b*]indol-6-ones (V) with dichromate.

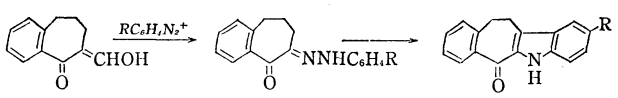
Results and Discussion

Benzocycloheptene-5,6-dione monoarylhydrazones (IV) were obtained by treating a hydroxymethylene compound (III) of benzosuberone with a solution of aryldiazonium salts (Japp-Klingermann reaction). It was described in a previous paper[7] that those hydrazones (IV) could also be obtained by the reaction of benzocycloheptene-5,6-dione with arylhydrazines.

The resulting hydrazones (IVc and IVe), by analogy with IVa, *etc.*,[7] underwent Fischer indolization to form 11,12-dihydrobenzo[5,6]indol-6-ones (Vc and Ve).

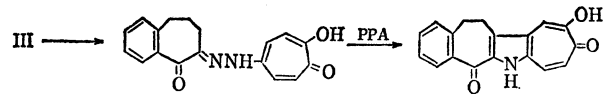
The reaction of Compound III with diazonium salt from 5-aminotropolone led to the corresponding hydrazone (VI), which was then converted into the pyrrolotropolone derivative (VII) by ring closure with PPA.

The Oxidation of V with Sodium Dichromate. On treatment with NBS, Compounds Va—d were converted into benzo[5,6]cyclohept[1,2-*b*]indol-6-ones(ben-



(III) (IV) (V)

a: R=H, b: R=Br, c: R=Cl, d: R=CH_3, e: R=NO_2



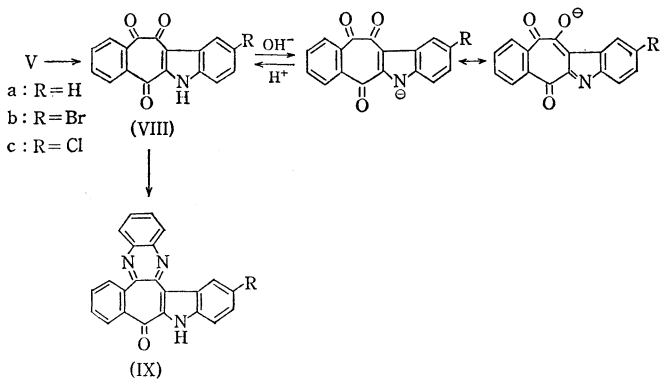
(VI) (VII)

zoindolotropones),[7] but the oxidation of V with selenium dioxide or chloranil resulted in the recovery of the unchanged starting materials. However, when Compound Va was treated with sodium dichromate in acetic acid, orange micro needles (mp 318—320 °C (dec)) were obtained.

The IR spectrum shows absorption bands at 3290 cm^{-1} (NH st.), and at 1680, 1641, and 1623 cm^{-1} (C–O st.). The elemental analysis revealed a composition with the formula of $C_{17}H_9NO_3$.

Further, the compound reacted with *o*-phenylenediamine to give the corresponding quinoxaline derivative. Therefore, the compound may be considered to have the structure of benzo[5,6]cyclohept[1,2-*b*]indole-6,11,12-trione(benzoindolotropoquinone) (VIIIa).

In the same way as with Compound VIIIa, VIIIb, and VIIIc were prepared by the dichromate oxidation of Vb and Vc; those compounds gave the corresponding quinoxaline derivatives, IXb and IXc respectively.



The UV spectra of VIIIa–c display the same absorption pattern in neutral and acidic media, but in an

alkaline medium they show more yellow color and the absorption maxima are shifted to longer wave lengths than in neutral and acidic media.

On changing to an acidic medium from an alkaline medium, the spectra returned to that in neutral and acidic media.

It was, therefore, supposed that VIIIa—c exsited in enolate ions in an alkaline medium.

The absorption spectra in an aprotic solvent such as chloroform or dimethyl sulfoxide are different from those in a protic solvent such as alcohol, so the formation of hemiketal can be taken into consideration in alcohol, by analogy with tropoquinone.[5]

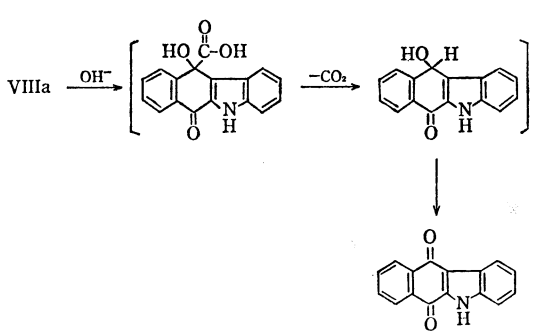
TABLE 1. ULTRAVIOLET AND VISIBLE ABSORPTION MAXIMA

Compound	λ_{max}, nm(log ε)
VIII a	257(4.40), 265^{sh}(4.39), 295(3.85), 351(4.01)
VIII b	252(4.42), 257^{sh}(4.41), 269^{sh}(4.38), 356(4.05)
VIII c	252(4.42), 257^{sh}(4.42), 266^{sh}(4.39), 355(4.06)
	in CH_3OH or CH_3OH-0.1M HCl
VIII a	270(4.35), 285^{sh}(4.30), 375(3.89)
VIII b	276(4.37), 287^{sh}(4.36), 387(3.97)
VIII c	275(4.38), 286^{sh}(4.37), 387(3.97)
	in CH_3OH-0.1M NaOH

The NMR spectra were unable to measure since VIIIa—c were only slightly soluble in common organic solvents.

The Treatment of VIIIa with a Concd Sodium Hydroxide Solution. As has been mentioned above, VIIIa–c are considered to exist as enolate ions in slightly alkaline conditions. When VIIIa was heated in concd sodium hydroxide solution, the solution turned a greenish purple and gave orange micro needles (mp 280 °C). The results of the elemental analysis of the compound accord with the formula of $C_{16}H_9O_2N$, and the IR spectrum is identical with that for the known benzocarbazole-1,4-quinone (X).

The reaction process is supposed to cause a benzilic-acid rearrangement, followed by its decarboxylation and oxidation as well, thus producing stable benzocarbazole-1,4-quinone.



(X)

Experimental*

All the melting points are uncorrected.

General Procedure for the Preparation of Benzocycloheptene-5,6-dione Monoarylhydrazones(IV). Into a solution of aryldiazonium salt, prepared from arylamine and sodium nitrite in dilute sulfuric acid, the hydroxymethylene derivative (III) of benzocyclohepten-5-one was stirred, drop by drop, at 0 °C. When the stirring was continued, oily products solidified. The resulting solid was collected and recrystallized from ethanol.

Benzocycloheptene-5,6-dione Monophenylhydrazone(IVa). Orange needles; yield, 44%; mp 111—112 °C. The mixed melting point with monophenylhydrazone, obtained by the reaction of benzocycloheptene-5,6-dione with phenylhydrazine, was not depressed.

Benzocycloheptene-5,6-dione Mono-p-tolylhydrazone(IVb). Orange needles; yield, 22%; mp 160—161 °C. The mixed melting point with mono-*p*-tolylhydrazone, obtained by the reaction of benzocycloheptene-5,6-dione with *p*-tolylhydrazine, was not depressed.

Benzocycloheptene-5,6-dione Mono-p-bromophenylhydrazone(IVc). Orange needles; yield, 36%; mp 160—161 °C. The mixed melting point with mono-*p*-bromophenylhydrazone, obtained by the reaction of benzocycloheptene-5,6-dione with *p*-bromophenylhydrazine, was not depressed.

Benzocycloheptene-5,6-dione Mono-p-chlorophenylhydrazone(IVd). Orange needles; yield, 69%; mp 165—166 °C. Found: C, 68.42; H, 5.16; N, 9.66%. Calcd for $C_{17}H_{15}ON_2Cl$: C, 68.34; H, 5.06; N, 9.38%.

Benzocycloheptene-5,6-dione Mono-p-nitrophenylhydrazone(IVe). Yellow needles; yield, 46%; mp 205—207 °C. Found: C 66.11; H, 4.87; N, 13.99%. Calcd for $C_{17}H_{15}N_3O_3$: C, 66.00; H, 4.89; N, 13.59%.

2-Chloro-11,12-dihydrobenzo[5,6]cyclohept[1,2-b]indol-6-one(Vc). A mixture of IVc (2.0 g) and concd hydrochloric acid (3 ml) in acetic acid (50 ml) was refluxed for 3 hr. After cooling, the reaction mixture was diluted with water and the resulting material was collected by filtration. Recrystallization from ethanol gave yellow micro needles (1.7 g, 90%); mp 232—233 °C. IR(KBr): ν_{NH} 3305, $\nu_{conjugated\ C=O}$ 1612 cm^{-1}. UV: $\lambda_{max}^{CH_3OH}$ 258(log ε=4.08) and 339(4.33) nm. Found: C, 72.69; H, 4.27; N, 5.13%. Calcd for $C_{17}H_{12}ONCl$: C, 72.47; H, 4.29; N, 4.97%.

2-Nitro-11,12-dihydrobenzo[5,6]cyclohept[1,2-b]indol-6-one(Ve). A mixture of IVe (0.19 g) and PPA (2 ml) was heated at 100 °C for 3 hr. After cooling, the reaction mixture was diluted with water. The resulting material was collected by filtration and dried. Recrystallization from acetic acid gave yellow needles (0.16 g, 89%); mp 280—282 °C. IR (KBr): ν_{NH} 3296, $\nu_{conjugated\ C=O}$ 1615 cm^{-1}. UV: $\lambda_{max}^{CH_3OH}$ 236(log ε=4.03), 260(3.96), and 313(4.49) nm. Found: C, 70.05; H, 4.18; N, 9.84%. Calcd for $C_{17}H_{12}N_2O_3$: C, 69.85; H, 4.14; N, 9.58%.

Benzocycloheptene-5,6-dione Mono-4,5-tropolonylhydrazone(VI). Into a solution of diazonium salt, prepared from 5-aminotropolone (1.0 g), III (1.4 g) was stirred, drop by drop, at 0 °C. The reaction mixture was then extracted with benzene, and the extract was dried over anhydrous sodium sulfate and condensed to leave a residue. Recrystallization from ethanol gave deep ruby red, scale-like crystals (0.28 g, 12%); mp 185—186 °C.

* The authors are grateful to the Sankyo Co., Ltd., for carrying out a part of the elemental analysis.

Found: C, 70.16; H, 5.28; N, 9.08%. Calcd for $C_{18}H_{16}N_2O_3$: C, 70.11; H, 5.23; N, 9.09%.

Pyrrolotropolone Derivative(VII). A mixture of the hydrazone (0.1 g) described above and PPA (2 ml) was heated at 120 °C for 3 hr. After cooling, the reaction mixture was diluted with water. The resulting material was collected by filtration and recrystallized to give yellowish-green micro crystals (0.05 g, 53%); mp>280 °C. UV: $\lambda_{max}^{CH_3OH}$ 240(log ε=4.19), 271(4.34), 299(4.37), 320(4.27), and 288 (4.27) nm. IR(KBr): ν_{OH} 3283, ν_{NH} 3258, $\nu_{conjugated\ C=O}$ 1611, 1591 cm^{-1}.

Found: C, 74.15; H, 4.70; N, 4.76%. Calcd for $C_{18}H_{13}O_3N$: C, 74.21; H, 4.50; N, 4.81%.

*Benzo[5,6]cyclohept[1,2-*b*]indole-6,11,12-trione(VIIIa).* A solution of Va (1.0 g) in acetic acid (30 ml) was heated at 100 °C, and then sodium dichromate (2.3 g) was added little by little. After the mixture has been refluxed for 30 min, the reaction mixture was stirred at room temperature for 2 hr. Water (5 ml) was then added, and the resulting material was collected by filtration. Recrystallization from acetic acid gave orange micro needles (0.24 g, 22%); mp 318—320 °C (dec).

Found: C, 74.15; H, 3.38; N, 4.56%. Calcd for $C_{17}H_9NO_3$: C, 74.18; H, 3.30; N, 5.09%.

Monophenylhydrazone: Reddish-brown needles; mp>280 °C IR(KBr): ν_{NH} 3283, 3238 cm^{-1}. Found: C, 75.69; H, 4.16; N, 11.30%. Calcd for $C_{23}H_{15}N_3O_2$: C, 75.60; H, 4.14; N, 11.50%.

Quinoxaline Derivative: Orange micro needles; mp>280 °C. UV: $\lambda_{max}^{CH_3OH}$ 242(log ε=4.49), 253(4.48), 277(4.58), and 427(4.09) nm. IR(KBr): ν_{NH} 3311, $\nu_{conjugated\ C=O\ or\ C=C}$ 1611, 1593 cm^{-1}. Found: C, 79.77; H, 3.85; N, 12.02%. Calcd for $C_{23}H_{13}N_3O$: C, 79.52; H, 3.77; N, 12.10%.

*2-Bromobenzo[5,6]cyclohept[1,2-*b*]indole-6,11,12-trione(VIIIb).* Compound was obtained from Vb (1.0 g) in acetic acid (60 ml) and sodium dichromate (1.89 g) by a method similar to that used for the preparation of VIIIa.

Recrystallization from acetic acid gave orange-yellow micro needles (0.26 g, 24%); mp>280 °C. UV: $\lambda_{max}^{CH_3OH}$ 242 (log ε=4.39), 253(4.40), 277(4.46), and 420(3.99) nm. IR(KBr): ν_{NH} 3305, $\nu_{conjugated\ C=O}$ 1680, 1638, and 1633 cm^{-1}.

Found: C, 57.67; H, 2.33; N, 4.15%. Calcd for $C_{17}H_8O_3NBr$: C, 57.65; H, 2.28; N, 3.96%.

Quinoxaline Derivative: Yellow micro needles; mp>280 °C. IR(KBr): ν_{NH} 3305, $\nu_{conjugated\ C=O\ or\ C=C}$ 1622 and 1590 cm^{-1}. Found: C, 64.88; H, 3.11; N, 9.68%. Calcd for $C_{23}H_{12}ON_3Br$: C, 64.80; H, 2.84; N, 9.86%.

*2-Chlorobenzo[5,6]cyclohept[1,2-*b*]indole-6,11,12-trione(VIIIc).* Compound was obtained from Vc (1.0 g) in acetic acid (50 ml) and sodium dichromate (2.6 g) by a method similar to that used for the preparation of VIIIa. Recrystallization from acetic acid gave yellow micro needles (0.26 g, 24%); mp>280 °C. UV: $\lambda_{max}^{CH_3OH}$ 242(log ε=4.41), 253(4.43), 277 (4.49), and 422(4.03) nm. IR(KBr): ν_{NH} 3236, $\nu_{C=O}$ 1683, 1643, and 1633 cm^{-1}. Found: C, 66.10; H, 2.64; N, 4.82%. Calcd for $C_{17}H_8O_3NCl$: C, 65.92; H, 2.60; N, 4.52%.

Quinoxaline Derivative: Yellow micro needles; mp>280 °C. Found: C, 72.42; H, 3.18; N, 10.96%. Calcd for $C_{23}H_{12}ON_3Cl$: C, 72.35; H, 3.17; N, 11.01%.

The Treatment of VIIIa with a Concd Sodium Hydroxide Solution. A suspension of VIIIa (1.0 g) in a 50% sodium hydroxide solution (50 ml) was heated on a water bath for 15 min. The reaction mixture turned a greenish purple and gave orange crystals. The resulting crystals were collected by filtration and recrystallized from ethanol to give orange prisms (0.05 g, 56%); mp 280 °C. The IR spectrum was identical with that of benzocarbazole-1,4-quinone which had been obtained by the oxidation of benzocarbazole with chromic anhydride. Found: C, 77.45; H, 3.65; N, 5.76%. Calcd for $C_{16}H_9O_2N$: C, 77.72; H, 3.67; N, 5.67%.

The authors wish to express their thanks to Professor Emeritus Tetsuo Nozoe of Tohoku University for his kind guidance. This research was supported by a grant from the Ministry of Education.

References

1) Part I of this series: Ref. 7.
2) Presented at the 28th Annual Meeting of the Chemical Society of Japan, Tokyo April, 1973.
3) T. Nozoe, K. Takase, and H. Matsumura, in "Dai-Yukikagaku (Comprehensive Organic Chemistry)," ed. M. Kotake, Asakura Shoten, Tokyo (1959), p. 274.
4) H. Wittman, V. Illi, H. Rathmayer, H. Sterk, and E. Zieglar, *Z. Naturforsch.*, **276**, 524—527 (1972).
5) a) Y. Shoji, N. Abe, H. Takeshita, and S. Ito, Preprints for the 5th Symposium on Non-benzenoid Aromatic Chemistry, Nagoya, October, 1972, p. 81. b) Y. Shoji and S. Ito, Preprints for the 6th Symposium on Non-benzenoid Aromatic Chemistry, Fukuoka, October, 1973, p. 132.
6) J. Rigaudy and L. Nédélec, *Bull. Soc. Chim. Fr.*, **1959**, 638.
7) K. Yamane and K. Fujimori, This Bulletin, **45**, 269 (1972).