[Chem. Pharm. Bull. 19(6)1150—1157(1971)]

UDC 547.94.07 : 547.562.1.04

Phenolic Cyclization. IX.[1] Syntheses of Benz[*c*]phenanthridine and Related Compounds (Studies on the Syntheses of Heterocyclic Compounds. CDIX[2])

Tetsuji Kametani,[3a] Kazuo Kigasawa, Mineharu Hiiragi, Osamu Kusama, Emiko Hayashi, and Haruhide Ishimaru[3b]

Pharmaceutical Institute, Tohoku University[3a] *and Research Laboratories, Grelan Pharmaceutical Co., Ltd.*[3b]

(Received November 30, 1970)

Trans-1-Amino-1,2,3,4-tetrahydro-2-(3-methoxyphenyl)naphthalene (IV) was synthesized by the reduction of oxime (VIII). Mannich reaction of IV with formalin and acetaldehyde afforded benz[*c*]phenanthridines, XI and XII, respectively. The amine (IV) was treated with pyridine hydrochloride to give phenolic base (V). The condensation of V with carbonyl compounds was investigated to give the corresponding benz[*c*]phenanthridine derivatives (XV—XX). In the case of benzaldehyde, cyclization was found to occur at both positions, *para* and *ortho* to the hydroxyl group to give XVII, XVIII, and XX. Furthermore, acetylation of these phenolic benz[*c*]phenanthridines and an alternative synthesis of XII were also described.

In the previous papers,[1,4,5] we have reported on the syntheses of substituted phenanthridine derivatives (I) and II by phenolic cyclization[6] of 2-(3-hydroxyphenyl)cyclohexylamine (III) with several kinds of carbonyl compounds. We have currently investigated the syntheses of benz[*c*]phenanthridine derivatives by the condensation of the amine (IV and V) with carbonyl compounds. Most of the benz[*c*]phenanthridine alkaloids such as chelidonine (VI)[7] and corynoline (VII)[8] take *cis*-fusion at the B-C ring juncture and have two methylenedioxy groups at the $C_{2,3}$ and $C_{7,8}$ positions and an alcoholic hydroxyl group at the C_{11} position. However, we obtained *trans*-benz[*c*]phenanthridine derivatives. Herein, we wish to describe these results.

First of all, preparation of the amine (IV) was investigated with the use of the oxime (VIII) obtained from 2-(3-methoxyphenyl)-2(1H)-naphthalenone (IX).[4,5] Since reduction of VIII with lithium aluminum hydride gave hydroxylamine (X), VIII was treated with sodium in ethanol by Masamune's method[9] to give the desired amine (IV). The configuration of the amino group was considered to be *trans* to the phenyl group since Masamune[9] had already obtained *trans*-2-phenylcyclohexylamine from 2-phenylcyclohexanone oxime in a similar way. The nuclear magnetic resonance (NMR) spectrum of the free base (IV) supported this result from the point of Karplus equation[10] to show a doublet ($J=10.0$ cps) at 3.90 ppm due to methine proton adjacent to the amino group. The catalytic hydrogenation

1) Part VIII: T. Kametani, K. Fukumoto, K. Kigasawa, M. Hiiragi, H. Ishimaru, and K. Wakisaka, *J. Chem. Soc.* (*C*), in press.
2) Part CDVIII: T. Kometani, M. Ihara, T. Honda, H. Shimanouchi, and Y. Sasada, *J. Chem. Soc.* (*C*), **1971**, *in Pres.*
3) Location: *a*) *Aobayama, Sendai*; *b*) *Sakurashinmachi 3-chome, Setagaya, Tokyo.*
4) T. Kametani, S. Noguchi, I. Agata, T. Aono, K. Kigasawa, M. Hiiragi, T. Hayasaka, and O. Kusama, *J. Chem. Soc.* (*C*), **1971**, 1047.
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7) F. Šantavý, M. Horák, M. Maturová, and J. Brabence, *Collction Czech. Chem. Commun*, **25**, 1344 (1960).
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9) T. Masamune, M. Ohno, M. Koshi, S. Ohuchi, and T. Iwadare, *J. Org. Chem.*, **29**, 1419 (1964).
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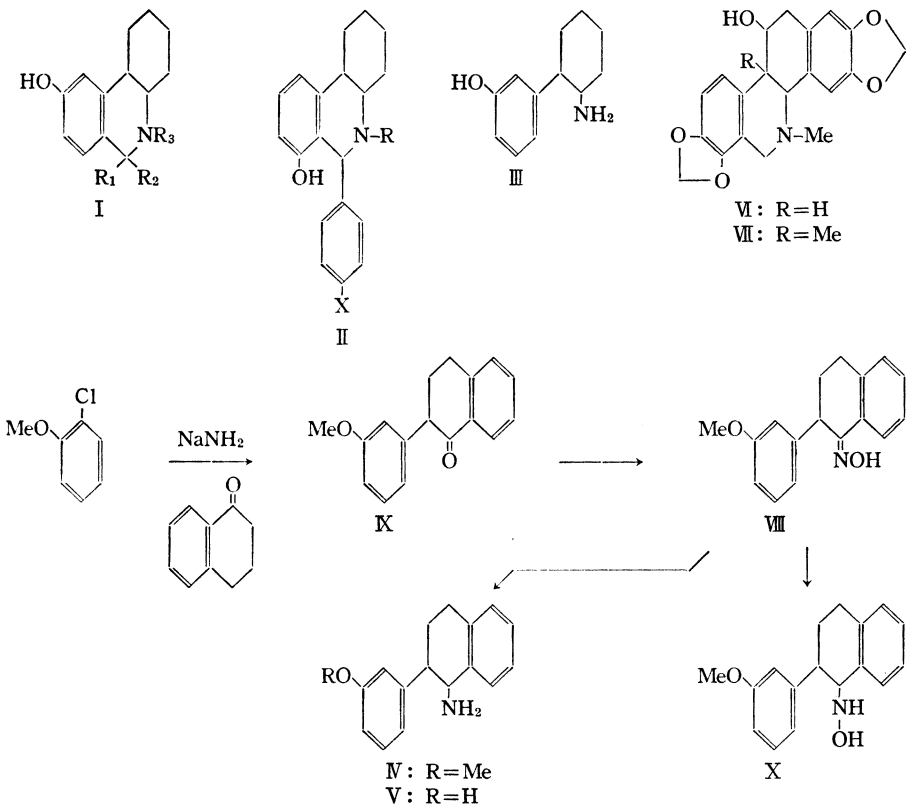

Chart 1

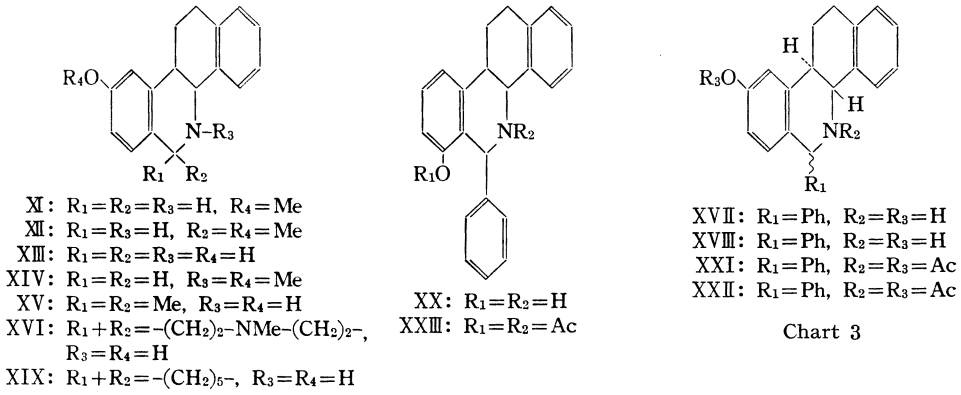

Chart 2 Chart 3

of the oxime (VIII) with Adams' catalyst also afforded a single product whose NMR spectrum and gas chromatographic data[11] were indentical with those of IV and no formation of *cis*-isomer was observed.

The amine (IV) thereby obtained was submitted to the Mannich reaction with formalin and acetaldehyde in the presence of hydrochloric acid to give 9-methoxy-4b,5,6,10b,11,12-

11) Gas chromatography was measured with Hitachi gas chromatography type-063 by using 5% Silicone DC-QF-1 on Chromosob W, 10% SE-30 on Gas chrom P and 5% PEG Succinate on Chromosorb W.

hexahydrobenz[*c*]phenanthridine (XI) and 9-methoxy-6-methyl-4b,5,6,10b,11,12-hexahydrobenz[*c*]phenanthridine (XII), respectively. Demethylation of XI with hydrobromic acid afforded 9-hydroxy derivative (XIII) and, on the other hand, XI was converted to N-methyl derivative (XIV) by the Eschweiler–Clarke reaction using formic acid and formalin.

Secondly, we investigated phenolic cyclization of 1-amino-1,2,3,4-tetrahydro-2-(3-hydroxyphenyl)naphthalene (V), which was obtained through the fusion of IV with pyridine hydrochloride by the method of Gates.[12] The phenolic base (V) was heated with acetone, benzaldehyde, cyclohexanone, and N-methyl-4-piperidone in ethanol to give the corresponding benz[*c*]phenanthridines (XV—XX) in moderate yields, and these results were shown in Table I. In all cases cyclization occurred at the *para* position to the hydroxyl group. However, in the case of benzaldehyde, cyclization was found to occur not only at the *para* position but also the *ortho* position to the hydroxyl group as in the case of phenolic cyclization of III with benzaldehyde.[1] Condensation products of V with benzaldehyde were separated by column chromatography on silicic acid to give two 9-hydroxy-diastereoisomers (XVII and XVIII) and 7-hydroxy-6-phenyl-4a,5,6,10b,11,12-hexahydrobenz[*c*]phenanthridine (XX). 7-Hydroxy-isomer (XX) was distinguished from the 9-hydroxy-isomers (XVII and XVIII) by the Gibbs reagent and spectroscopic data as follows. Although XVII and XVIII were negative to the Gibbs reagent, XX exhibited a blue color. Although XVII and XVIII showed the UV maximum at 281 mμ as that of 3,4-dimethylphenol, XX exhibited the same absorption at 275 mμ as that of 2,3-dimethylphenol. Acetylation of these three products (XVII, XVIII and XX) gave N,O-diacetates (XXI, XXII, and XXIII), respectively. NMR spectra of these three N,O-diacetates showed a serious difference in the region of the methyl signal of the acetoxyl group because of the anisotropy due to the benzene ring at the C_6-position. XXIII showed a singlet due to the C_7-acetoxyl group at 1.85 ppm, however, in the case of XXI and XXII, a singlet due to the C_9-acetoxyl group appeared at 2.15 and 2.18 ppm, respectively. Thus, the cyclization was found to occur at both positions, *ortho* and *para* to the hydroxyl group. The formation of XX would be due to the interaction[13] of the hydroxyl group with π electrons

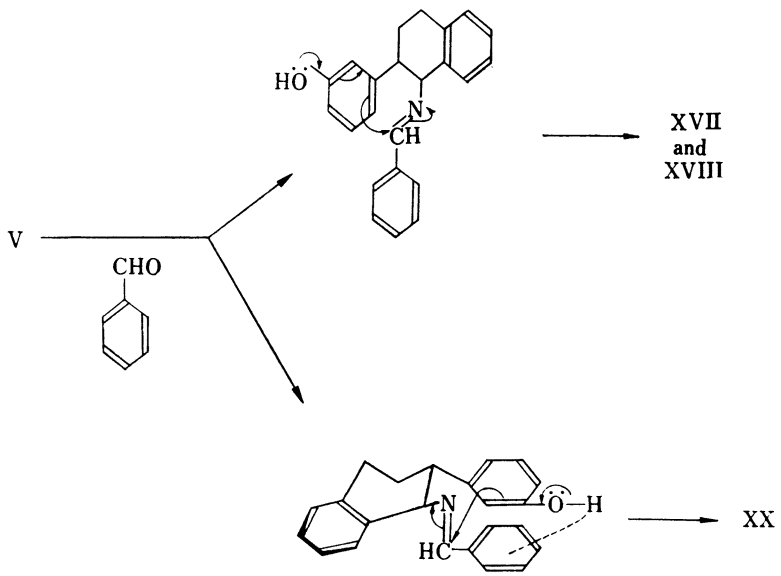

Chart 4

12) M. Gates and O.K. Klein, *J. Med. Chem.*, **10**, 382 (1967).
13) M. Oki and M. Iwamura, *J. Am. Chem. Soc.*, **89**, 576 (1967).

on the benzene ring by the approach of both aromatic rings in a Schiff base as shown in Chart 4.

The phenolic amine (V) was heated with cyclohexanone to afford the Schiff base which was converted to the desired product (XIX) with hydrochloric acid.

Finally, in order to prove the structure we investigated an alternative synthesis of these compounds. Acetylation of the amine (IV) with pyridine–acetic anhydride afforded the amide (XXIV), whose Bischler–Napieralski reaction with phosphoryl chloride in benzene yielded 9-methoxy-6-methyl-4b,10b,11,12-tetrahydrobenz[*c*]phenanthridine (XXV). Reduction of XXV with sodium borohydride gave the desired product (XII) which was identical with that obtained by Mannich cyclization of IV with acetaldehyde by comparisons of spectroscopic data. Further we examined the dehydrative cyclization of the benzamide (XXVI), which was obtained by the Schotten–Baumann reaction of IV with benzoyl chloride. The Bischler–Napieralski reaction of XXVI with phosphoryl chloride in chloroform, benzene, and xylene gave the undesired result, 3,4-dihydro-2-(3-methoxyphenyl)naphthalene (XXVIII) and benzamide (XXIX). The authentic sample of the former was obtained by dehydration

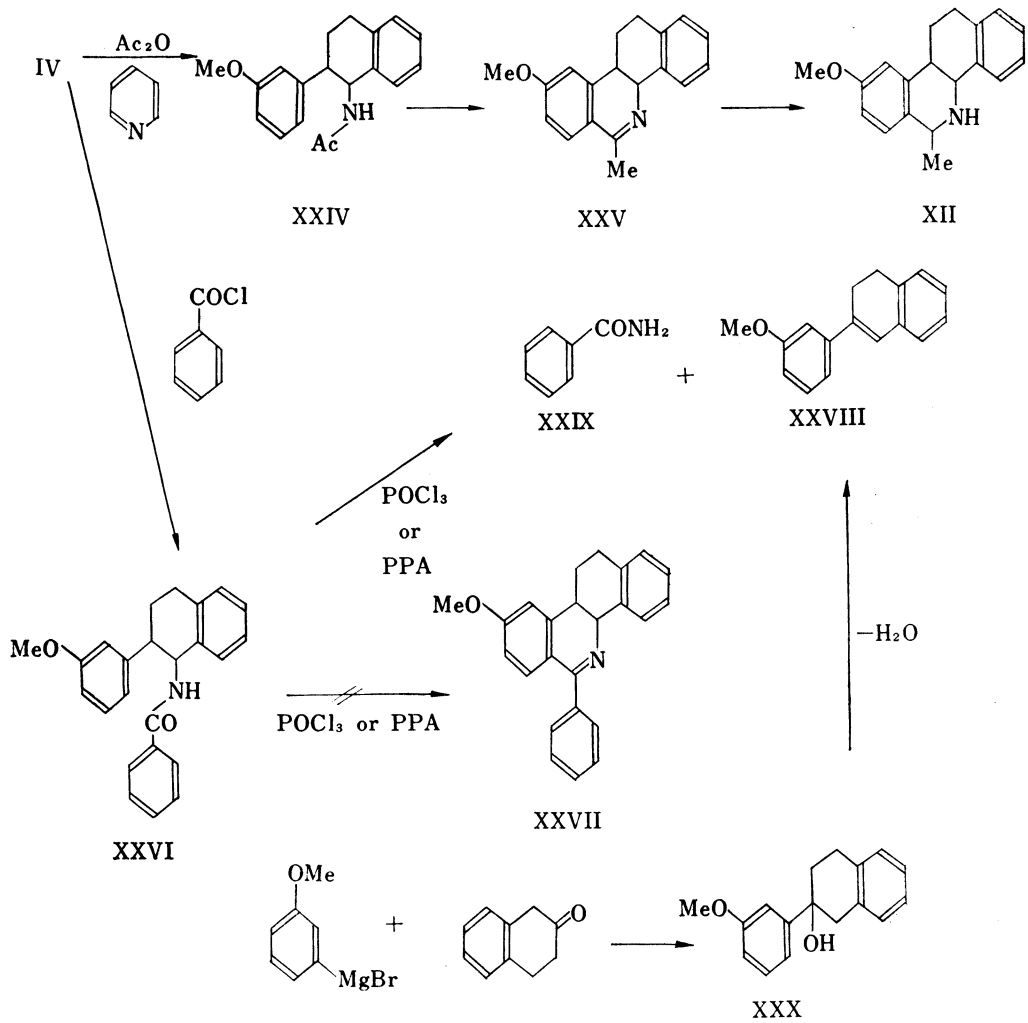

Chart 5

of the alcohol (XXX) which was obtained by Grignard reaction[14] of 3-bromoanisole with β-tetralone. Both specimens thus obtained were identified by comparison of spectroscopic data. Bischler–Napieralski reaction of XXVI with polyphosphoric acid afforded the same results as with phosphoryl chloride. Thus dehydrative cyclization of XXVI was unsuccessful.

As mentioned above, phenolic cyclization of 1-amino-1,2,3,4-tetrahydro-2-(3-hydroxyphenyl)naphthalene (V) with carbonyl compounds yielded *trans*-benz[*c*]phenanthridines and the cyclization was found to occur at the *ortho*-position besides *para* to the hydroxyl group, on the condensation of V with benzaldehyde, by the interaction between the phenolic hydroxyl group and the π electron on the benzene ring.

Pharmacological activity of these compounds is under investigation.

Table I. The Reaction of Carbonyl Compounds with 1-Amino-1,2,3,4-tetrahydro-2-(3-hydroxyphenyl)naphthalene (V)

Compound No.	Carbonyl compounds g	Amine (X) g	Yield g (%)	Character	Microanalyses Calcd. C	H	N	Found C	H	N	UV λ_{max}^{EtOH} (log ε)
XV	acetone 8 g	1.0	0.15 (12.9)	colorless prisms (benzene) mp 165—166°	81.68	7.58	5.01	81.91	7.70	5.17	278 (3.06)
XVI	N-methyl-4-piperidone 0.37 g	0.7	0.75 (76.7)	colorless prisms (acetone) mp >250°	79.00	7.84	8.38	79.16	7.72	8.52	278 (3.29)
XVII[a]	benzaldehyde 0.9 g	2.0	0.5 (18.3)	colorless prisms (acetone) mp >250°	84.37	6.47	4.28	84.61	6.26	4.48	281 (3.51)
XVIII	benzaldehyde 0.9 g	2.0	0.4 (14.6)	colorless prisms (EtOH) mp 195—196°	84.37	6.47	4.28	84.72	6.38	4.54	281 (3.54)
XX	benzaldehyde 0.9 g	2.0	0.3 (10.9)	colorless prisms (EtOH) mp 201—202°	84.37	6.47	4.28	83.91	6.54	4.45	273 (3.63)
XIX[b]	cyclohexanone 0.31 g	0.5	0.25 (37.4)	colorless prisms (EtOH) mp 187—188°	82.72	7.89	4.38	82.37	7.80	4.53	276 (3.50)

a) The compounds (XVII, XVIII, and XX) were separated by silicic acid column chromatography using $CHCl_3$ as eluant.
b) After 25 hours' refluxing, only Schiff base, mp 212—214° (*Anal.* Calcd. for $C_{23}H_{23}ON$: C, 82.72; H, 7.89; N, 4.38. Found: C, 83.02; H, 7.76; N, 4.57) was obtained, but when it was refluxed for an additional 2 hr in the presence of conc. HCl XIX was given.

Table II. Acetyl Derivatives of 6-Phenylbenz[*c*]phenanthridines

Compound No.	Character	Microanalyses Calcd. C	H	N	Found C	H	N	IR ν_{max}^{KBr} cm^{-1} Amide C=O	Ester C=O	NMR δ in $CDCl_3$ $NCOCH_3$	$OCOCH_3$
XXI	colorless prisms (benzene–*n*-hexane) mp 224—226°	78.81	6.12	3.40	78.58	5.94	3.61	1650	1750	2.20	2.15
XXII	colorless prisms (benzene) mp 172—173.5°	78.81	6.12	3.40	78.63	6.10	3.67	1650	1760	2.20	2.18
XXIII	colorless prisms (benzene) mp 138—140°	78.81	6.12	3.40	79.00	6.12	3.72	1640	1770	2.25	1.85

14) T.R. Govindachari, K. Nagarajan, B.R. Pai, and U.V. Sundararajan, *Chem. Ber.*, **91**, 2053 (1958).

Experimental[15]

2-(3-Methoxyphenyl)-3,4-dihydro-1(2H)-naphthalenone (IX)——To a stirred solution of 11 g of $NaNH_2$ in dry tetrahydrofuran (300 ml) was added 20 g of α-tetralone and 10 g of 2-chloroanisole. After the mixture had been refluxed for 8 hr under stirring, the excess $NaNH_2$ was decomposed with an aqueous ammonium chloride solution and then the organic layer was separated. The aqueous layer was extracted with benzene. The extract was combined with the above organic layer, washed with 15% HCl and H_2O, and dried over $MgSO_4$. Evaporation of the solvent, followed by distillation of the resulting residue, afforded a pale yellowish oil, bp 160—170° (0.8 mmHg), which solidified on trituration with EtOH. Recrystallization from EtOH gave 10.6 g (60%) of IX as colorless needles mp 95—96°. IR cm^{-1} (KBr): $\nu_{C=O}$ 1690. NMR (δ in $CDCl_3$): 3.58 (1H, triplet, $J=6$ cps, methine proton), 3.62 (3H, singlet, OCH_3).

Oxime (VIII)——A solution of 6 g of the above ketone (IX), 3.4 g of hydroxylamine hydrochloride, 30 ml of pyridine, and 70 ml of EtOH was refluxed for 3 hr on a water bath, and EtOH and pyridine were evaporated. The resulting residue was recrystallized from EtOH to give 5.8 g (84.2%) of VIII as colorless prisms, mp 130—131.5°. IR cm^{-1} (KBr): 3250 (OH), 1645 (-C=N-). NMR (δ in $CDCl_3$): 3.56 (1H, triplet, $J=6$ cps, methine proton), 3.65 (3H, singlet, OCH_3), 5.63 (1H, broad singlet, OH). *Anal.* Calcd. for $C_{17}H_{17}O_2N$: C, 76.38; H, 6.41; N, 5.24. Found: C, 75.96; H, 6.42; N, 5.50.

1,2,3,4-Tetrahydro-1-hydroxyamino-2-(3-methoxyphenyl)naphthalene (X)——To a stirred suspension of 1 g of $LiAlH_4$ in 50 ml of dry tetrahydrofuran was added a solution of 1 g of the oxime (VIII) in tetrahydrofuran, and the resulting mixture was then refluxed for 3 hr. After the decomposition of the excess $LiAlH_4$ the solvent was separated, dried, and evaporated. The hydrochloride prepared from the remaining residue in the usual manner was recrystallized from EtOH–ether to give 0.3 g of X·HCl as colorless needles, mp 236—238° (decomp.). IR cm^{-1} (KBr): 3100 (NH). NMR (δ in $CDCl_3$): 1.5—1.7 (2H, broad singlet, NHOH, disappeared with D_2O), 3.65 (3H, singlet, OCH_3). *Anal.* Calcd. for $C_{17}H_{19}O_2N\cdot HCl$: C, 66.77; H, 6.59; N, 4.58. Found: C, 66.84; H, 6.56; N, 4.48.

1-Amino-1,2,3,4-tetrahydro-2-(3-methoxyphenyl)naphthalene (IV)——To a solution of 6.5 g of the above oxime in 100 ml of EtOH was added 5.6 g of Na metal in small portions. The mixture was refluxed for 1 hr and then acidified with conc. HCl under cooling. After the removal of NaCl precipitated, the solvent was evaporated to give a residue which was made basic with 20% NaOH and extracted with ether. The extract was washed with H_2O and dried over K_2CO_3. Evaporation of the solvent gave 3.7 g of IV as a pale yellowish oil. NMR (δ in $CDCl_3$): 1.15 (2H, singlet, $-NH_2$, disappeared with D_2O), 3.62 (3H, singlet, OCH_3), 3.90 (1H, doublet, $J=10$ cps, $>CH-NH_2$). Recrystallization of the hydrochloride of IV from EtOH–ether afforded colorless needles, mp 203—204°. *Anal.* Calcd. for $C_{17}H_{19}ON\cdot HCl$: C, 70.45; H, 6.96; N, 4.83. Found: C, 70.09; H, 6.50; N, 5.08.

9-Methoxy-4b,5,6,10b,11,12-hexahydrobenz[*c*]phenanthridine (XI)——A mixture of 1 g of the amine (IV) hydrochloride, 5 ml of 37% HCHO, 1 ml of conc. HCl, 10 ml of H_2O, and 10 ml of EtOH was refluxed for 2.4 hr. After evaporation of the solvent, the remaining oil was basified with 10% NaOH and extracted with $CHCl_3$. The extract was washed with H_2O and dried over K_2CO_3. Evaporation of the solvent, followed by the recrystallization of the resulting residue from benzene–hexane, afforded 450 mg of XI as colorless prisms, mp 244°. IR cm^{-1} (KBr): 3300 (NH). NMR (δ in $CDCl_3$): (3.75 3H, singlet, OCH_3), 3.92 (1H, triplet, $J=12$ cps, C_{10b}–H), 4.36 (2H, singlet, C_6–H), 4.50 (1H, doublet, $J=12$ cps, C_{4b}–H), 5.50 (1H, broad signal, NH, disappeared with D_2O). UV λ_{max}^{EtOH} mμ (log ε): 282 (3.32). *Anal.* Calcd. for $C_{18}H_{19}ON$: C, 81.47; H, 7.22; N, 5.28. Found: C, 81.13; H, 7.02; N, 5.52.

9-Hydroxy-4b,5,6,10b,11,12-hexahydrobenz[*c*]phenanthridine (XIII)——A mixture of 300 mg of XI, 1.5 ml of 48% HBr, and 1.5 ml of AcOH was refluxed at 140—145° for 1 hr. Evaporation of the solvent, followed by recrystallization of the resulting residue from MeOH, gave 200 mg of XIII·HBr as colorless needles, mp>250°. *Anal.* Calcd. for $C_{17}H_{17}ON\cdot HBr$: C, 61.45; H, 5.46; N, 4.22. Found: C, 61.75; H, 5.67; N, 4.38.

9-Methoxy-5-methyl-4b,5,6,10b,11,12-hexahydrobenz[*c*]phenanthridine (XIV)——A mixture of 500 mg of XI, 3 ml of 37% HCHO, and 3 ml of HCOOH was heated on a water bath for 4.5 hr. After evaporation of the solvent, the residue was basified with 10% NaOH and extracted with $CHCl_3$. The extract was washed with H_2O, dried over K_2CO_3, and evaporated. Recrystallization of the resulting residue from EtOH afforded 350 mg of XIV as colorless needles, mp 130—131°. NMR (δ in $CDCl_3$): 2.15 (3H, singlet, $N-CH_3$), 3.75 (3H, singlet, OCH_3). UV λ_{max}^{EtOH} mμ (log ε): 282 (3.44). *Anal.* Calcd. for $C_{19}H_{21}ON$: C, 81.68; H, 7.58; N, 5.01. Found: C, 81.33; H, 7.36; N, 5.45.

9-Methoxy-6-methyl-4b,5,6,10b,11,12-hexahydrobenz[*c*]phenanthridine (XII)——a) A mixture of 0.5 g of IV·HCl, 2.5 ml of acetaldehyde, 0.5 ml of conc. HCl, 5 ml of H_2O and 5 ml of EtOH was refluxed on a

15) All melting points were uncorrected. NMR spectra were measured in deuteriochloroform with JNM-MH-60 at 60 Mc and tetramethylsilane was used as the internal reference. IR spectra were taken with the Simazu IR-27; UV spectra with a Hitachi recording spectrometer.

water bath for 4 hr. After the evaporation of the solvent, the mixture was made basic with 10% NaOH and extracted with $CHCl_3$. The extract was washed with H_2O, dried over K_2CO_3, and evaporated to afford 0.9 g of a pale yellowish oil, which was chromatographed on 18 g of silicic acid using $CHCl_3$ as eluant. Removal of 3rd—5th fractions (each fraction 20 ml) afforded XII. NMR (δ in $CDCl_3$): 1.33 (3H, doublet, $J=7$ cps, C_6–CH_3), 3.64 (3H, singlet, OCH_3). The hydrochloride formed in the usual manner was recrystallized from EtOH–ether to give colorless prisms, mp>250°. UV λ_{max}^{EtOH} mμ (log ε): 277 (3.36). *Anal.* Calcd. for $C_{19}H_{21}ON \cdot HCl$: C, 72.24; H, 7.02; N, 4.44. Found: C, 72.68; H, 7.00; N, 4.40.

b) To a stirred solution of 10 mg of XXI, described below, in 3 ml of MeOH containing 1 drop of H_2O was added 100 mg of $NaBH_4$. The mixture was further stirred for 0.5 hr at room temperature and then extracted with $CHCl_3$. The extract was washed with water, dried over $MgSO_4$ and evaporated to give an oil, whose spectroscopic data were identical with those of the authentic specimen obtained by the method (a). The hydrochloride formed by the usual way was recrystallized from EtOH–ether to give 6 mg of colorless prisms, mp>250°.

1-Amino-1,2,3,4-tetrahydro-2-(3-hydroxyphenyl)naphthalene (V)——A mixture of 10 g of IV·HCl and 50 g of pyridine hydrochloride was heated at 250° under stirring and the stirring was continued for 0.5 hr at 210°. After the mixture had been diluted with water and basified with 20% NaOH, the resulting solution was washed with ether. The aqueous layer was acidified with 15% HCl, then basified with NH_4OH, and extracted with benzene. The extract was washed with water, and dried over $MgSO_4$. Evaporation of the solvent, followed by the recrystallization of the resulting residue from EtOH, afforded 4.9 g (59.7%) of V as colorless prisms, mp 203—204°. *Anal.* Calcd. for $C_{16}H_{17}ON$: C, 80.30; H, 7.16; N, 5.85. Found: C, 80.06; H, 7.03; N, 6.10.

The Reaction of 1-Amino-1,2,3,4-tetrahydro-2-(3-hydroxyphenyl)naphthalene (V) with Carbonyl Compounds——A mixture of V and carbonyl compounds in EtOH was refluxed for 20—25 hr. The solvent was evaporated and the remaining residue was recrystallized or chromatographed on silicic acid to give benz[*c*]phenanthridine derivatives (XV—XX). The results are shown in Table I.

Acetylation of Benz[*c*]phenanthridine Derivatives——A mixture of benz[*c*]phenanthridines obtained as above, an excess of Ac_2O, and pyridine was heated on a water bath for 3 hr. The mixture was poured into ice–water and extracted with $CHCl_3$. The extract was washed with 28% NH_4OH and H_2O, and dried over $MgSO_4$. Removal of the solvent, followed by recrystallization of the crude product, yielded N,O-diacetates. These results were shown in Table II.

1-(N-Acetylamino)-1,2,3,4-tetrahydro-2-(3-methoxyphenyl)naphthalene (XXIV)——A mixture of 2.7 g of IV, 9 ml of Ac_2O, and 0.5 ml of pyridine was heated on a water bath for 3 hr. The mixture was poured into ice–water and extracted with $CHCl_3$. The extract was washed with 10% NaOH, H_2O, 10% HCl, and then H_2O and dried over $MgSO_4$. Evaporation of the solvent yielded the crude product, which was recrystallized from benzene to give 2.5 g (79.4%) of XXIV as colorless needles, mp 149.5—151°. IR cm^{-1} (KBr): 3300 (NH), 1635 (C=O). NMR (δ in $CDCl_3$): 1.68 (3H, singlet, NH–$COCH_3$), 3.78 (3H, singlet, OCH_3). *Anal.* Calcd. for $C_{19}H_{21}O_2N$: C, 77.26; H, 7.17; N, 4.74. Found: C, 77.06; H, 7.17; N, 5.05.

9-Methoxy-6-methyl-4b,10b,11,12-tetrahydrobenz[*c*]phenanthridine (XXV)——To a solution of 1.3 g of the amide (XXIV) in 30 ml of benzene was added 3 ml of $POCl_3$ and refluxed on a water bath for 2 hr. After evaporation of the solvent, the resulting residue was diluted with water. The aqueous layer was washed with ether, made basic with 10% NaOH, and extracted with ether. The extract was washed with H_2O, dried over $MgSO_4$ and evaporated. Recrystallization of the crude product from EtOH afforded 20 mg of XXV as colorless needles, mp 150—152°. IR cm^{-1} (KBr): 1630 (C=N). NMR (δ in $CDCl_3$): 2.45 (3H, singlet, C_6–CH_3), 3.83 (3H, singlet, OCH_3). *Anal.* Calcd. for $C_{17}H_{19}ON$: C, 82.28; H, 6.91; N, 5.05. Found: C, 82.58; H, 6.61; N, 5.34.

1-N-Benzoylamino-1,2,3,4-tetrahydro-2-(3-methoxyphenyl)naphthalene (XXVI)——To a stirred mixture of 3.7 g of the amine (IV), 50 ml of $CHCl_3$ and 50 ml of 10% NaOH was added a solution of 2.5 g of benzoyl chloride in $CHCl_3$ under cooling. After the mixture had been stirred for an additional 1 hr at room temperature, the organic layer was separated, washed with 10% NaOH, H_2O, 10% HCl, and H_2O, and dried over $MgSO_4$. Evaporation of the solvent, followed by recrystallization of the crude product from EtOH, yielded 4.5 g (87%) of XXVI as colorless needles, mp 181—182°. IR cm^{-1} (KBr): 3300 (NH), 1640 (C=O). NMR (δ in $CDCl_3$): 3.79 (3H, singlet, OCH_3). *Anal.* Calcd. for $C_{24}H_{23}O_2N$: C, 80.64; H, 6.49; N, 3.92. Found: C, 80.24; H, 6.68; N, 4.17.

Bischler-Napieralski Reaction of XXVI——a) A solution of 1 g of XXVI and 2 ml of $POCl_3$ in 20 ml of benzene (or $CHCl_3$ or xylene) was refluxed on a water bath or in an oil-bath. After the reaction, the solvent was evaporated to give a residue, whose aqueous solution was washed with ether. The resultant aqueous layer was made basic with 10% NaOH and extracted with ether. The solvent was washed with H_2O, dried over $MgSO_4$ and evaporated, but no detectable substance was found. The above ethereal washing was washed with H_2O, dried over $MgSO_4$ and evaporated to give 0.4 g of a pale yellowish oil, which was distilled to give 0.25 g of 3,4-dihydro-2-(3-methoxyphenyl)naphthalene (XXVIII), bp 180—185° (0.8 mmHg). Its spectroscopic data were identical with those of the authentic specimen obtained as described later. IR cm^{-1} (liquid): 1630 (C=C). NMR (δ in $CDCl_3$): 3.58 (3H, singlet, OCH_3), 6.68 (1H, doublet, $J=1.0$ cps, C_1–H).

b) A mixture of 1.5 g of XXVI and 6 g of PPA [prepared from 3 g of 85% phosphoric acid and 3 g of phosphorous pentoxide] was heated on a water bath for 6 hr. The mixture was poured into ice–H_2O and washed with ether. The extract was washed with H_2O, dried over $MgSO_4$ and evaporated. Recrystallization of the remaining residue from EtOH afforded 200 mg of benzamide (XXIX) as colorless needles, mp 129—130°, which were identical with the authentic specimen in all respects. The filtrate was evaporated and the resulting residue was distilled to give 0.5 g of XXVIII as a pale yellowish oil, bp 180—185° (0.8 mm Hg), whose spectroscopic data were identical with those of the authentic specimen.

3,4-Dihydro-2-(3-methoxyphenyl)naphthalene (XXVIII)——To a solution of Grignard reagent [prepared from 6.5 g of 3-bromoanisole and 1.5 g of Mg in 100 ml of dry ether] was added dropwise a solution of 4.7 g of β-tetralone in 50 ml of ether. After the addition, the mixture was refluxed under stirring for 18 hr and then acidified with 10% HCl. The organic layer was washed with H_2O, dried over $MgSO_4$ and evaporated to give 4.4 g of 1,2,3,4-tetrahydro-2-hydroxy-2-(3-methoxyphenyl)naphthalene (XXX), which was used without further purification. A mixture of 4.4 g of XXX and 5 ml of 50% H_2SO_4 was refluxed in an oil-bath for 1 hr and extracted with ether. The extract was washed with H_2O, dried over $MgSO_4$ and evaporated to give 3.5 g of an oil, which was distilled to yield 1.7 g of XXVIII as a pale yellowish oil, bp 180—182° (0.8 mmHg). IR cm^{-1} (liquid): 1630 (C=C). NMR (δ in $CDCl_3$): 3.56 (3H, singlet, OCH_3), 6.65 (1H, doublet, $J=1.0$ cps, C_1–H). *Anal.* Calcd. for $C_{17}H_{16}O$: C, 86.40; H, 6.83. Found: C, 86.86; H, 6.78.

Acknowledgement We thank President A. Yanagisawa and Director O. Takagi, Grelan Pharmaceutical Co., Ltd., for their grateful encouragement. We also thank Miss A. Kawakami, Miss C. Yoshida, and Miss R. Kato for microanalysis and spectral determination. Furthermore, we are grateful to Dr. S. Shibuya, Pharmaceutical Institute, Tohoku University, for his helpful suggestions.