Photocyclisation of Enamides. Part 15.[1] Syntheses of the Basic Structures of Corynoline and Related Alkaloids [2]

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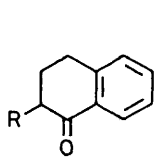
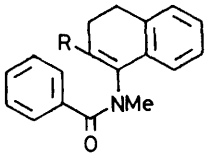
10b-Substituted 4b,5,6,10b,11,12-hexahydro-5-methylbenzo[*c*]phenanthridines (III) and (IV) were prepared by photocyclisation of the enamide (II). Isomerisation of the *trans*-benzo[*c*]phenanthridones (III) into the *cis*-isomers (IVa and b) and stereoselective introduction of a hydroxy group into the 11- and 12-positions by peracid provided a route towards the corynoline group of alkaloids.

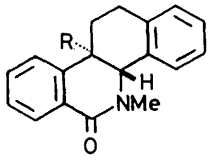
BENZO[*c*]PHENANTHRIDINE alkaloids [3] are structurally divided into two main classes, the one is the BC-hexahydro-alkaloids as exemplified by chelidonine and corynoline and the other the fully aromatised alkaloids such as nitidine and fagaronine, which are of synthetic interest due to their remarkable antileukemic activity.[4] There have been few synthetic studies of the saturated alkaloids apart from the total synthesis of chelidonine by Oppolzer *et al.*[5] In the course of a study aimed at the total synthesis of these hexahydro-alkaloids involving the use of enamide photocyclisation,[6] we exploited a stereoselective route towards the corynoline group of alkaloids by preparing their basic structures (VIII).



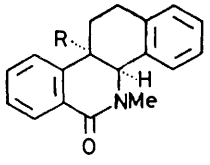
(I) a; R = Me
b; R = CO_2Me



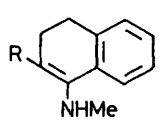
(II) a; R = Me
b; R = CO_2Me
c; R = CONHMe



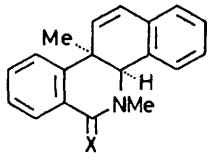
(III) a; R = Me
b; R = CONHMe



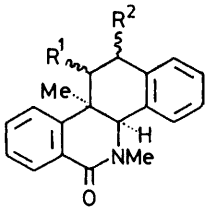
(IV) a; R = Me
b; R = CONHMe
c; R = CO_2H
d; R = COCl
e; R = CH_2OH
f; R = CH_2OMs



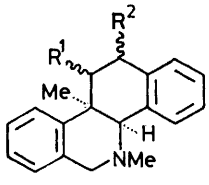
(V) a; R = CO_2Me
b; R = CONHMe



(VI) a; X = O
b; X = H_2



(VII) a; R^1, R^2 = ····O····
b; R^1 = ···· OH, R^2 = ⁻OH



(VIII) a; R^1 = ····OH, R^2 = H
b; R^1 = ···· OH, R^2 = ⁻OH
c; R^1 = ⁻OH, R^2 = ···· OH
d; R^1 = ⁻OH, R^2 = H

Although Onda *et al.*[7] succeeded in converting the protoberberine alkaloid berberine into an analogue of corynoline, their synthetic route could not be applied to total synthesis of natural alkaloids because of the low natural abundance of the starting alkaloid stylopine.[3]

There are two crucial problems to overcome in the synthesis of the corynoline group of alkaloids, the formation of the BC-*cis*-hexahydrobenzo[*c*]phenanthridine skeleton and the stereoselective introduction of a hydroxy group into the 11- and 12-positions.

Formation of the BC-*Hexahydrobenzo*[c]*phenanthridine Skeleton.*—The imine, prepared from 2-methyl-1-tetralone and dry methylamine in the presence of titanium tetrachloride, was acylated smoothly with benzoyl chloride to afford the enamide (IIa) in good yield, $\nu_{max.}$ 1 630 (NCO) cm^{-1}, δ 3.20 (s, NMe) and 1.57 (s, CMe).

A methanolic solution of the enamide (IIa) was irradiated [6] for 40 h to give two photocyclised products, *trans*-lactam (IIIa) (1%) and *cis*-lactam (IVa) (7%), which were separated by chromatography on alumina. Prolonged irradiation (70 h) of the enamide (IIa) and also irradiation of the *trans*-lactam (IIIa) afforded the *cis*-lactam (IVa) as the sole product. The spectral data for two lactams (IIIa) and (IVa) were not sufficient to establish their stereochemistries but conversion into the basic structures (VII) and (VIII) of the alkaloids and the comparisons of the R_F values on t.l.c. and the g.l.c. retention times provided proof.

In order to improve the yield of the *cis*-lactam (IVa), we investigated the preparation of the enamide of the keto-ester (Ib), which was expected to undergo smooth photocyclisation due to the presence of an *ortho*-ester group in the enamide, as in the case of that prepared from 2-ethoxycarbonylcyclohexanone.[8] Attempted synthesis of the enamide (IIb) which carries an *ortho*-ester group, was unsuccessful when the keto-ester (Ib) was heated in an autoclave in the presence of a large excess of methylamine. The product was the carbamoylenamine (Vb), which, however, can be acylated with benzoyl chloride to afford the enamide (IIc) in overall 58% yield. This exists as a mixture of two rotational isomers [9] at room temperature as indicated by the n.m.r. spectrum but at elevated temperatures the n.m.r. spectrum shows only one isomer.

Photocyclisation of the enamide (IIc) proceeded smoothly to afford the *trans*-lactam (IIIb) in 78% yield. Isomerisation of the *trans*-lactam (IIIb) to the *cis*-lactam (IVb) was readily accomplished in methanol either by irradiation or by heating under reflux in the presence of 20% hydrochloric acid or 5% potassium hydroxide for 3 h. Isomerisation of the *trans*-lactams (IIIa and b) into the *cis*-isomers (IVa and b) proceeded irreversibly and was specific to the benzo[*c*]phenanthridone skeleton so far as investigated,[10] though a mechanistic explanation is not available at the moment.

Conversion of the *trans*-carbamoyl-lactam (IIIb) into the *cis*-10b-methyl-lactam (IVa) was undertaken as follows. Prolonged heating of the *trans*-lactam (IIIb) in the presence of 20% hydrochloric acid (43 h) yielded the *cis*-acid (IVc) as a result of hydrolysis, and this was then transformed into the 10b-methyl-lactam (IVa) *via* the acid chloride (IVd), the alcohol (IVe), and the mesylate (IVf) in overall 18% yield from the *trans*-lactam (IIIb).

Stereoselective Introduction of Hydroxy Group.—In order to introduce a hydroxy group into the 11- and 12-positions of the lactam (IVa), a double bond was first introduced into the 11,12-position by dehydrogenation with DDQ.[7] The 11,12-didehydrolactam (VIa) was thus obtained in 40% yield as the sole product and its structure was established from its n.m.r. spectrum, δ 6.58 and 6.27 (2 H, ABq, *J* 10 Hz, 11- and 12-H).

Inspection of the structure of the *cis*-lactam (VIa) using Dreiding models clearly suggested that the 11,12-double bond is susceptible to attack by electrophiles from the less hindered α-side, thus creating the possibility of stereoselective introduction of an oxygen function preferentially from the α-side. Treatment of the lactam (VIa) with *m*-chloroperbenzoic acid in chloroform yielded the epoxide (VIIa) in 80% yield, δ 4.17 and 4.07 (2 H, ABq, *J* 4 Hz, 11- and 12-H), demonstrating the formation of an α-oxiran ring as expected. The epoxide (VIIa) was then reduced regiospecifically with lithium aluminium hydride to afford the amino-alcohol (VIIIa). The formation of a 11α-hydroxy group was readily established from the spectral data, thus providing stereochemistry identical with that of 11-epicorynoline.[11,12]

Furthermore, treatment of the 11,12-didehydrolactam (VIa) with performic acid yielded the *trans*-glycol (VIIb) (60%), which was then reduced with lithium aluminium hydride to give the amino-glycol (VIIIb), $\nu_{max.}$ 3 610 and 3 400 cm^{-1} (OH), δ 4.46 (2 H, s, 11- and 12-H) and 3.70 (2 H, s, 2 × OH). Hydrogenolysis of the amino-glycol (VIIIb) with 40% palladium on charcoal afforded the amino-alcohol (VIIIa) (32%), identical with the sample obtained from (VIIa).

The reaction of the 11,12-didehydro-amine (VIb), readily prepared from the lactam (VIa) by reduction with lithium aluminium hydride, with peracid was then investigated. Treatment of the 11,12-didehydro-amine (VIb) with performic acid as above afforded the amino-glycol (VIIIc) (33%), $\nu_{max.}$ 3 620 and 3 200 cm^{-1} (OH), δ 5.06 (1 H, m, $W_{1/2}$ 5 Hz, 12-H) and 4.00 (1 H, t, *J* 1.5 Hz, 11-H), thus suggesting it had the same skeleton of 12-hydroxycorynoline.[11] Hydrogenolysis of the amino-glycol (VIIIc) with 40% palladium on charcoal afforded the corresponding amino-alcohol (VIIId) (61%), $\nu_{max.}$ 3 200vbr (bonded OH) cm^{-1}, δ 4.20 (1 H, m, 11-H), 3.70 (1 H, s-like, OH), and 3.29 (3 H, m, 4b- and 12-H_2). This indicated it had the same basic structure as the alkaloid corynoline.[13]

Compared with the behaviour of the lactam (VIa) towards peracids, the marked difference in the stereochemistry of the course of the reaction of the corresponding amine (VIb) can be explained in terms of a bonding interaction between the protonated form of a basic nitrogen and an oxidizing agent. This restricts attack of peracid even from the less hindered α-side as in the case of the oxidation of some allylic alcohols.[14] Cleavage of an intermediate epoxide at the benzylic position gives the 11β,12α-glycol (VIIIc).

The synthesis of compounds (VIIIa, c, and d), which have the basic structures of the corynoline group of alkaloids, offer a promising approach to the total synthesis of natural alkaloids.

EXPERIMENTAL

^{1}H N.m.r. spectra were measured for solutions in deuteriochloroform with JEOL PMX-60 and Varian A-60D instruments (tetramethylsilane as internal reference), i.r. spectra for solutions in chloroform unless otherwise mentioned, and mass spectra with a JEOL JMS O1SG machine. M.p.s were determined with a Kofler-type hot-stage apparatus and are uncorrected. Photochemical reactions were carried out as described in Part 2.[6]

N-(3,4-*Dihydro*-2-*methyl*-1-*naphthyl*)-N-*methylbenzamide* (IIa).—Anhydrous methylamine gas was bubbled into a solution of 2-methyl-1-tetralone (14 g) in anhydrous chloroform (50 ml) for 30 min with ice-cooling. The resulting mixture was added dropwise to a solution of titanium tetrachloride (6 ml) in anhydrous chloroform (20 ml) with ice-cooling. After refluxing for 1 h, the precipitate was filtered off and washed with chloroform. The combined extract was evaporated to dryness *in vacuo*. The residue was dissolved in dry benzene and the solution filtered. The filtrate was condensed to give a yellow oil. To an ice-cooled solution of the resulting oil and triethylamine (13 g) in anhydrous benzene (100 ml), a solution of benzoyl chloride (12.5 g) in anhydrous benzene (50 ml) was added dropwise with ice-cooling. After refluxing for 2 h, the solution was cooled and filtered to remove triethylamine hydrochloride. The filtrate was evaporated to give a solid. Recrystallisation from n-hexane afforded the *enamide* (IIa) (18.3 g, 76%), m.p. 98—100°, $\nu_{max.}$ 1 630 (NCO) cm^{-1}; δ 3.20 (3 H, s, NMe) and 1.57 (3 H, s, CMe) (Found: C, 82.45; H, 7.05; N, 5.0. $C_{19}H_{19}NO$ requires C, 82.3; H, 6.9; N, 5.05%).

Photocyclisation of the Enamide (IIa).—A 0.02M-solution of the enamide (IIa) (4.45 g) in methanol (800 ml) was irradiated for 40 h. The reaction was monitored by g.l.c. The solvent was removed and the residue was chromatographed on alumina with benzene–chloroform as eluant. The residue from the first fraction was purified by preparative t.l.c., and recrystallised from ether–n-hexane to give trans-4b,10b,11,12-*tetrahydro*-5,10b-*dimethylbenzo*[c]-

phenanthridin-6(5H)-*one* (IIIa) (45 mg, 1%), m.p. 133—134°, $\nu_{max.}$ 1 640 (NCO) cm^{-1}, δ 8.17 (1 H, m, 7-H), 5.02 (1 H, s, 4b-H), 3.16 (3 H, s, NMe), and 1.09 (3 H, s, CMe) (Found: C, 82.2; H, 6.95; N, 5.15. $C_{19}H_{19}NO$ requires C, 82.3; H, 6.9; N, 5.05%). The second fraction afforded the cis-*lactam* (IVa) (310 mg, 7%), m.p. 155—156° (from ether), $\nu_{max.}$ 1 645 (NCO) cm^{-1}; δ 7.97 (1 H, m, 7-H), 4.30 (1 H, s, 4b-H), 3.48 (3 H, s, NMe), and 1.38 (3 H, s, CMe) (Found: C, 82.4; H, 7.00; N, 4.95. $C_{19}H_{19}NO$ requires C, 82.3; H, 6.9; N, 5.05%).

3,4-*Dihydro*-N-*methyl*-1-(N-*methylbenzamido*)-2-*naphthamide* (IIc).—Anhydrous methylamine gas was bubbled into a solution of the keto-ester (Ib) (14.6 g) in anhydrous ethanol (190 ml) for 2 h with ice-cooling. This solution was heated at 100° for 8 h in an autoclave. Evaporation of the solvent gave a yellow oil (Vb), $\nu_{max.}$ 3 550 and 3 500 (NH × 2), 1 670, and 1 620 (OC–C=C–N) cm^{-1}.

As described in the case of (IIa), acylation of the resulting oil with benzoyl chloride afforded the *enamide* (IIc) (13.3 g, 58%), m.p. 174.5—176° (from ethanol), $\nu_{max.}$ 3 450 (NH), 1 650 (CO–NHMe), and 1 640 (NCO) cm^{-1}; δ 6.80 (0.3 H, m, NH), 5.43 (0.7 H, m, NH), 3.27 (2 H, s, NMe), 3.10 (1 H, s, NMe), 2.83 (1 H, d, *J* 5 Hz, NH*Me*), and 2.68 (2 H, d, *J* 5 Hz, NH*Me*); δ([$^2H_6$]DMSO; 100°) 3.14 (3 H, s, NMe) and 2.62 (3 H, d, *J* 5 Hz, NH*Me*) (Found: C, 74.85; H, 6.3; N, 8.7. $C_{20}H_{20}N_2O_2$ requires C, 74.95; H, 6.3; N, 8.75%).

trans-4b,5,6,10b,11,12-*Hexahydro*-5,N-*dimethyl*-6-*oxobenzo*[c]*phenanthridine*-10b-*carboxamide* (IIIb).—By the procedure given for (IIa), a 0.02M-solution of the enamide (IIc) (5 g) in methanol (800 ml) was irradiated for 16 h. The solvent was removed and the residue was recrystallised from ethanol to give the trans-*lactam* (IIIb) (3.9 g, 78%), m.p. 259—261°, $\nu_{max.}$ 3 450 (NH), 1 670 (CONHMe), and 1 640 (NCO) cm^{-1}; δ 8.17 (1 H, m, 7-H), 5.20 (1 H, m, NH), 5.15 (1 H, s, 4b-H), 3.18 (3 H, s, NMe), and 2.53 (3 H, d, *J* 5 Hz, NH*Me*) (Found: C, 75.05; H, 6.35; N, 8.75. $C_{20}H_{20}N_2O_2$ requires C, 74.95; H, 6.3; N, 8.75%).

cis-4b,5,6,10b,11,12-*Hexahydro*-5-*methyl*-6-*oxobenzo*[c]-*phenanthridine*-10b-*carboxylic Acid* (IVc).—A mixture of the *trans*-lactam (IIIb) (3.5 g) and 20% hydrochloric acid (630 ml) was refluxed for 43 h. After cooling, the precipitate was filtered off and dissolved in aqueous sodium hydrogencarbonate. After filtration, the filtrate was acidified by adding concentrated hydrochloric acid to give a solid, which was recrystallised from ethanol to afford the cis-*carboxylic acid* (IVc) (2.5 g, 77%), m.p. 243—245°; $\nu_{max.}$ (Nujol) 1 700 (CO_2H) and 1 635 (NCO) cm^{-1} (Found: C, 73.45; H, 5.8; N, 4.5. $C_{19}H_{17}NO_3$,1/6H_2O requires C, 73.55; H, 5.95; N, 4.5%).

cis-4b,10b,11,12-*Tetrahydro*-10b-*hydroxymethyl*-5-*methylbenzo*[c]*phenanthridin*-6(5H)-*one* (IVe).—A solution of the carboxylic acid (IVc) (2 g) in freshly distilled thionyl chloride (10 ml) was warmed at 50° for 1 h. Excess of the reagent was distilled off to leave a solid (IVd), $\nu_{max.}$ 1 775 (COCl) cm^{-1}, which was dissolved in anhydrous tetrahydrofuran (50 ml). A solution of sodium borohydride (1.5 g) in anhydrous tetrahydrofuran (100 ml) was added dropwise to the above and the resulting mixture was refluxed for 3.5 h. After evaporation of the solvent, excess of the reagent was decomposed by adding water under cooling. The aqueous layer was extracted with chloroform. The combined extract was washed with water, dried, and evaporated to give a solid, which was recrystallised from benzene to afford the *alcohol* (IVe) (1 g, 53%), m.p. 209—211°, $\nu_{max.}$ (Nujol) 3 400 (OH) and 1 630 (NCO) cm^{-1}; δ 8.00 (1 H, m, 7-H), 4.75 (1 H, s, 4b-H), 3.78 and 3.60 (2 H, ABq, *J* 10.5 Hz, CH_2OH), and 3.50 (3 H, s, NMe) (Found: M^+, 293.141. $C_{19}H_{19}NO_2$ requires *M*, 293.142).

cis-4b,10b,11,12-*Tetrahydro*-10b-*mesyloxy*-5-*methylbenzo*-[c]*phenanthridin*-6(5H)-*one* (IVf).—To a solution of the alcohol (IVe) (1 g) and triethylamine (1.5 ml) in anhydrous chloroform (200 ml), methanesulphonyl chloride (590 mg) was added dropwise with stirring under cooling. After stirring at room temperature for 2 h, the mixture was diluted with chloroform. The chloroform layer was washed with 10% hydrochloric acid, aqueous sodium hydrogencarbonate and water successively, dried, and evaporated to give a solid, which was recrystallised from methanol to give the mesylate (IVf) (1 g, 80%), m.p. 200—201°, $\nu_{max.}$ 1 645 (NCO), 1 430, and 1 175 (OMs) cm^{-1} (Found: C, 64.7; H, 5.65; N, 3.55. $C_{20}H_{21}NO_4S$ requires C, 64.65; H, 5.70; N, 3.75%).

Conversion of the Mesylate (IVf) *into the* cis-*Lactam* (IVa).—To a solution of the mesylate (IVf) (500 mg) in hexamethylphosphoramide (20 ml), sodium cyanoborohydride (340 mg) was added portionwise with ice-cooling. After heating at 100° for 7 h, the solvent was removed under reduced pressure while keeping the temperature below 100° to give a residue which was extracted with chloroform. The chloroform layer was washed with water, dried, and evaporated to afford a solid, which was recrystallised from ether–n-hexane to give the lactam (IVa) (265 mg, 53%), identical with a sample prepared by the photocyclisation of (IIa) (i.r., n.m.r., and t.l.c.).

Photoisomerisation of the trans-*Lactam* (IIIa).—A 0.004M solution of the *trans*-lactam (IIIa) (55 mg) in methanol (50 ml) was irradiated for 2 h. The solvent was removed and the residue was recrystallised from ether–n-hexane to give the *cis*-lactam (IVa) (54 mg, 99%), m.p. 155—156°, identical with a sample prepared by the photocyclisation of (IIa) (i.r., n.m.r., and t.l.c.).

Isomerisation of the trans-*Lactam* (IIIb).—(a) *By irradiation.* By the procedure given for (IIIa), irradiation of the *trans*-lactam (IIIb) afforded the cis-*lactam* (IVb) quantitatively, m.p. 251—252° (from ethanol); $\nu_{max.}$ 3 470 (NH) and 1 665—1 645 (CONHMe and NCO) cm^{-1}; δ 8.03 (1 H, m, 7-H), 5.30 (1 H, s, 4b-H), 5.17 (1 H, m, NH), 3.45 (3 H, s, NMe), and 2.70 (3 H, d, *J* 5 Hz, NH*Me*) (Found: C, 74.8; H, 6.35; N, 8.65. $C_{20}H_{20}N_2O_2$ requires C, 74.95; H, 6.3; N, 8.75%).

(b) *By heating in the presence of hydrochloric acid or potassium hydroxide.* A mixture of the *trans*-lactam (IIIb) (30 mg) in either 20% hydrochloric acid (5 ml) or 5% potassium hydroxide in methanol (4 ml) was refluxed for 3 h. The usual work-up including recrystallisation from ethanol gave the *cis*-lactam (IVb) (quantitatively in each case), identical with the sample obtained in (a).

cis-4b,10b-*Dihydro*-5,10b-*dimethylbenzo*[c]*phenanthridin*-6(5H)-*one* (VIa). A mixture of the *cis*-lactam (IVa) (300 mg) and 2,3-dichloro-5,6-dicyano-1,4-benzoquinone (600 mg) and dioxan (20 ml) was refluxed for 88 h. The solvent was removed and the residue was extracted with chloroform. The extract was washed with 10% sodium hydroxide and water, dried, and evaporated to give a residue, which was purified by preparative t.l.c. and recrystallised from ether–n-hexane to give (VIa) (120 mg, 40%), m.p. 145—146°, $\nu_{max.}$ 1 650 (NCO) cm^{-1}; δ 7.97 (1 H, m, 7-H), 6.58 and 6.27 (2 H, ABq, *J* 10 Hz, 11- and 12-H), 4.50 (1 H, s, 4b-H), 3.42 (3 H, s, NMe), and 1.53 (3 H, s, CMe) (Found: C, 82.8;

H, 6.45; N, 5.05. $C_{19}H_{17}NO$ requires C, 82.9; H, 6.2; N, 5.1%).

(4bα,10bα,11α,12α)-11,12-*Epoxy*-4b,10b,11,12-*tetrahydro*-5,10b-*dimethylbenzo*[c]*phenanthridin*-6(5H)-*one* (VIIa).—To a solution of the didehydrolactam (VIa) (100 mg) in anhydrous chloroform (40 ml), a solution of *m*-chloroperbenzoic acid (110 mg) in anhydrous chloroform (5 ml) was added dropwise at room temperature. After stirring at room temperature for 4 h, the solution was diluted with chloroform and washed with 10% sodium thiosulphate, 10% potassium carbonate, and water, dried, and evaporated to give a solid, which was recrystallised from methanol to give the *epoxide* (VIIa) (85 mg, 80%), m.p. 181.5—183°; $\nu_{max.}$ 1 645 (NCO) cm^{-1}; δ 7.98 (1 H, m, 7-H), 4.41 (1 H, s, 4b-H), 4.17 and 4.07 (2 H, ABq, *J* 4 Hz, 11- and 12-H), 3.46 (3 H, s, NMe), and 1.71 (3 H, s, CMe) (Found: M^+, 291.124. $C_{19}H_{17}NO_2$ requires *M*, 291.126. Found: C, 77.45; H, 6.0; N, 4.8. $C_{19}H_{17}NO_2,1/6H_2O$ requires C, 77.55; H, 5.95; N, 4.75%).

(4bα,10bα,11α)-4b,5,6,10b,11,12-*Hexahydro*-11-*hydroxy*-5,10b-*dimethylbenzo*[c]*phenanthridine* (VIIIa).—To a solution of the epoxide (VIIa) (60 mg) in anhydrous tetrahydrofuran (20 ml), excess of lithium aluminium hydride was added in small portions with cooling. The mixture was refluxed for 5 h and the solvent was removed. After excess of hydride was decomposed by adding water with ice-cooling, ether was added and the aqueous layer was extracted with ether. The combined ethereal extracts were washed with brine, dried, and evaporated. Recrystallisation of the residue from n-hexane gave the *amine* (VIIIa) (50 mg, 96%), m.p. 126.5—127°, $\nu_{max.}$ 3 620 (OH) cm^{-1}; δ 4.65 (1 H, dd, *J* 9.5 and 7 Hz, 11-H), 3.32 (1 H, s, 4b-H), 3.32 (1 H, dd, *J* 9.5 and 7 Hz, 12β-H), 2.70 (1 H, dd, *J* 17.5 and 9.5 Hz, 12α-H), 2.08 (3 H, s, NMe), 1.67 (1 H, s, OH), and 1.12 (3 H, s, CMe). The n.m.r. spectrum, particularly the signals due to the protons at the 4b, 11, and 12 positions, closely resembles that of the alkaloid 11-epicorynoline [11,12] (Found: C, 81.35; H, 7.6; N, 5.05. $C_{19}H_{21}NO,1/20H_2O$ requires C, 81.4; H, 7.6; N, 5.0%).

(4bα,10bα,11α,12β)-4b,10b,11,12-*Tetrahydro*-11,12-*dihydroxy*-5,10b-*dimethylbenzo*[c]*phenanthridin*-6(5H)-*one* (VIIb).—To a solution of the didehydrolactam (VIb) (100 mg) in 85% formic acid (5 ml), a solution of performic acid freshly prepared from 85% formic acid (5 ml) and 30% hydrogen peroxide (0.6 ml) was added at room temperature with stirring. After standing at room temperature for 1 h, 10% sodium thiosulphate was added and the excess of formic acid was removed *in vacuo*. To the residue, methanol (10 ml) and 20% sodium hydroxide were added to make the solution alkaline. The mixture was refluxed for 2 h and methanol was removed. A chloroform extract of the residue was washed with water, dried, and evaporated to give a solid which was recrystallised from ethanol to give the *glycol* (VIIb) (67 mg, 60%), m.p. 289—290°, $\nu_{max.}$ 3 400 and 3 250 (OH), and 1 645 (NCO) cm^{-1} (Found: C, 73.65; H, 6.3; N, 4.5. $C_{19}H_{19}NO_3$ requires C, 73.75; H, 6.2; N, 4.55%). The attempted preparation of the acetonide of the glycol (VIIb) by a known method was unsuccessful.

(4bα,10bα,11α,12β)-4b,5,6,10b,11,12-*Hexahydro*-11,12-*dihydroxy*-5,10b-*dimethylbenzo*[c]*phenanthridine* (VIIIb).—By the procedure given for (VIIIa), reduction of the lactam (VIIb) (50 mg) with lithium aluminium hydride for 2 h gave a yellow *oil* (VIIIb) (40 mg, 80%), $\nu_{max.}$ 3 610 and 3 400 (OH) cm^{-1}, δ 4.46 (2 H, s, 11- and 12-H), 3.70 (2 H, s, OH × 2), 3.22 (1 H, s, 4b-H), 1.97 (3 H, s, NMe), and 1.08 (3 H, s, CMe) (Found: M^+, 295.158. $C_{19}H_{21}NO_2$ requires *M*, 295.157).

Conversion of the Glycol (VIIIb) *into the Alcohol* (VIIIa).—A solution of the glycol (VIIIb) (50 mg) in 10% hydrochloric acid (10 ml) containing 70% perchloric acid (2 drops) was stirred in the presence of 40% palladium on charcoal (25 mg) at 50° and 5 atm. for 12 h. After filtration of the catalyst, the filtrate was made alkaline by adding potassium carbonate and extracted with chloroform. The combined extract was washed with water, dried, and evaporated to give an oil, which was purified by preparative t.l.c. to afford the alcohol (VIIIa) (15 mg, 32%), identical with a sample prepared by reduction of (VIIa).

cis-4b,5,6,10b-*Tetrahydro*-5,10b-*dimethylbenzo*[c]*phenanthridine* (VIb).—By the procedure given for (VIIIa), reduction of the lactam (VIa) (200 mg) with lithium aluminium hydride (200 mg) gave a yellow *oil* (VIb) (170 mg, 90%), δ 6.42 (1 H, d, *J* 9.5 Hz, 12-H), 6.00 (1 H, dd, *J* 9.5 and 1.5 Hz, 11-H), 3.92 and 3.74 (2 H, ABq, *J* 15 Hz, 6-H_2), 3.30 (1 H, d, *J* 1.5 Hz, 4b-H), 2.07 (3 H, s, NMe), and 1.28 (3 H, s, CMe) (Found: M^+, 261.151. $C_{19}H_{19}N$ requires *M*, 261.152).

(4bα,10bα,11β,12α)-4b,5,6,10b,11,12-*Hexahydro*-11,12-*dihydroxy*-5,10b-*dimethylbenzo*[c]*phenanthridine* (VIIIc).—By the procedure given for (VIIb), oxidation of the didehydroamine (VIb) (100 mg) with performic acid followed by preparative t.l.c. gave the glycol (VIIIc) (37 mg, 33%), m.p. 211—213° (from ethanol), $\nu_{max.}$ 3 620 and 3 200 (OH) cm^{-1}; δ 5.06 (1 H, m, $W_{1/2}$ 5 Hz, 12-H), 4.00 (1 H, t, *J* 1.5 Hz, 11-H), 3.45 (1 H, d, *J* 1.5 Hz, 4b-H), 2.16 (3 H, s, NMe), and 1.27 (3 H, s, CMe). The n.m.r. spectrum, particularly the signals due to the protons at the 4b-, 11-, and 12-positions, resembles that of the alkaloid 12-hydroxycorynoline.[11]

(4bα,10bα,11β)-4b,5,6,10b,11,12-*Hexahydro*-11-*hydroxy*-5,10b-*dimethylbenzo*[c]*phenanthridine* (VIIId).—By the procedure given for (VIIIa), hydrogenolysis of the glycol (VIIIc) (50 mg) gave a yellow glassy solid (VIIId) (30 mg, 61%), $\nu_{max.}$ 3 200br (OH) cm^{-1}; δ 4.31 and 3.96 (2 H, ABq, *J* 16 Hz, 6-H_2), 4.20 (1 H, m, 11-H), 3.70 (1 H, s-like, OH), 3.29 (3 H, m, 4b-H and 12-H_2), 2.38 (3 H, s, NMe), and 1.24 (3 H, s, CMe). The n.m.r. spectrum, particularly the signals due to the protons at the 4b-, 11-, and 12-positions resembles that of the alkaloid corynoline [13] (Found: M^+, 279.161. $C_{19}H_{21}NO$ requires *M*, 279.162).

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