Stereoselective Introduction of Oxygen Functionalities at the 11β-Position of Erythrinan Skeleton: Total Syntheses of (±)-Erythristemine and (+)-Erythrartine[1,2]

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Oxidation of 8-oxoerythrinan and 8-oxo-1,7-cycloerythrinan derivatives with 2 mol eq of ceric ammonium nitrate in alcohols or acetic acid gave the corresponding 11β-alkoxy or acetoxy compounds in moderate yield. Thus, (±)-3,3,15,16-tetramethoxy-1,7-cycloerythrinan-2,8-dione and (+)-erysotramidine gave the corresponding 11β-methoxy and 11β-acetoxy derivatives on oxidation in methanol and in acetic acid, respectively. Those compounds were respectively converted into (±)-erythristemine and (+)-erythrartine in several steps, thus achieving the total synthesis of these alkaloids.

Keywords *Erythrina* alkaloid; ceric ammonium nitrate; methoxylation; acetoxylation; erythristemine; erythrartine

In a previous paper,[3] we have clarified that ceric ammonium nitrate (CAN) regioselectively oxidizes methoxy-isochromans and -isochromanones at the benzylic position *para* to the methoxy group already present on the benzene ring to give methoxylated products in acceptable yields. In this paper, this oxidation is applied to erythrinan derivatives to test 1) if the introduction of a methoxy group is stereoselective, 2) if this method is applicable to obtain other oxygenated functionalities, and 3) if this oxidation method is applicable to compounds carrying a double bond(s) supposedly susceptible to oxidation. If the above requirements are satisfied, synthesis of erythrinan alkaloids bearing an oxygenated function at C-11 would be feasible. These alkaloids occur in the plants of *Erythrina* species in relatively small quantities and all those characterized so far have the 11β-configuration.[4] Previous attempts[5] to synthesize these alkaloids from more abundant 11-non-oxygenated alkaloids have only resulted in either formation of the 11α-isomer or production of the desired 11β-acetoxy alkaloids in very low yield.

All substrates used for CAN oxidation in this paper are 8-oxo derivatives, which are not only synthetic intermediates of the natural *Erythrina* alkaloids[6] but also are suitably protected for oxidation at the lactam nitrogen.

Results and Discussion

CAN Oxidation of 8-Oxoerythrinans Oxidation of 15,16-dimethoxy-8-oxo-*cis*-erythrinan (**1**)[7] with 2 mol eq of CAN in methanol at room temperature for 30 min gave the 11β-methoxy derivative (**2a**) in 73% yield, together with the 11α-methoxy derivative (**3a**, 3%), 11-oxo derivative (**4**, 6%) and, unexpectedly, the seco derivative (**5**, 7%). The structures of **2a**, **3a** and **4** were determined spectroscopically. Compound **5** was identical with the seco compound[8] obtained by ozonolysis of **1**. The configuration of the methoxy group in **2a** and **3a** was elucidated by comparisons of their ^{1}H-NMR spectra with that of the natural alkaloid, erythristemine [(+)-**32**],[9] whose structure has been established by an X-ray analysis.[10] The major product (**2a**) exhibited the H-11 signal at δ 4.20 with small couplings (dd, $J=3$, 2 Hz), being compatible to the couplings of H-11 in erythristemine (t, $J=4$ Hz). On the other hand, H-11 of the minor product (**3a**) appeared at δ 4.44 with large couplings (dd, $J=9$, 7 Hz). The couplings of H-11 (δ 3.39, d, $J=4$ Hz) in the derived amine, prepared by $LiAlH_4$ reduction of **2a**, also supported the above conclusion, the coupling with one of H-10 being nearly zero.

The above evidence indicates that methoxylation at the benzylic position of the erythrinan skeleton occurred stereoselectively to yield the 11β-methoxy derivative as a major product. The β-face preference in this reaction is explained by assuming involvement of the C-11 carbocation intermediate (**C**) formed by two one-electron transfer steps (Chart 1). The α-face of this cation is obviously hindered by the presence of ring A, so the β-face approach of methanol predominates, giving rise to the 11β-methoxylated derivative as a major product.

Next, similar oxidation in other alcoholic solvents, such as *n*-propanol, isopropanol, and *tert*-butanol, was carried out in order to examine the steric influence of the introduced anion on the stereoselectivity of the reaction. The β/α ratio of the 11-alkoxy derivatives, however, was not improved by changing the alkyl group from methyl to *tert*-butyl. Typically, the reaction in *tert*-butanol was slow, occurred in low yield, and was less stereoselective. This may be rationalized as follows. Although the β-face (axial) introduction of the anion is kinetically favored, retardation of this step for steric reasons will produce an increase of the relative rate of the competitive thermodynamic process, thus giving rise to an increase of the equatorial 11α-isomer.

CAN oxidation of **1** in acetic acid gave, as expected, the corresponding 11β-*O*-acetate (**2e**) as a major product (71%) and the 11α-isomer (**3e**) as a minor product (16%) (acetonitrile was used as a co-solvent in this oxidation, because CAN was insoluble in acetic acid). The 11-oxo derivative (**4**) was not detected in this case. The stereochemistry of the 11-OAc group in the products was again

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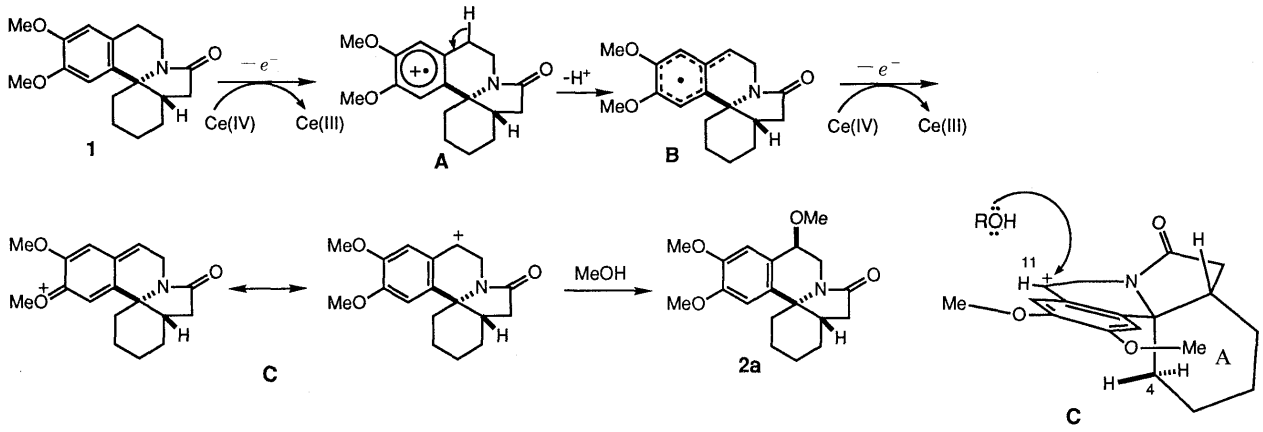

Chart 1

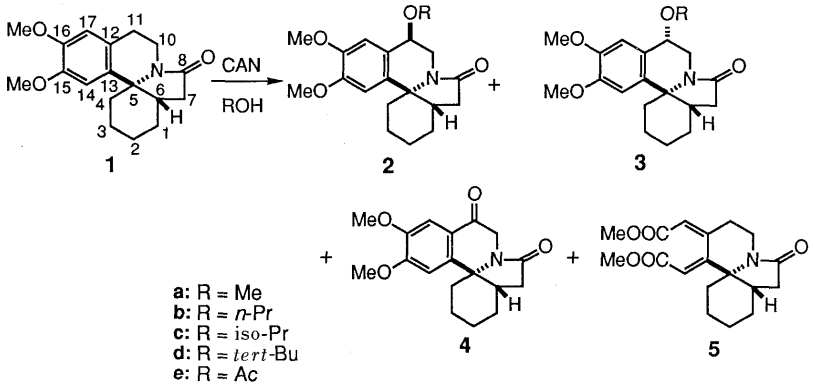

Chart 2

TABLE I. CAN Oxidation of the 8-Oxo-*cis*-erythrinan (**1**) in Various Alcohols (ROH)[a]

ROH	Product (yield, %)[b]			
MeOH	**2a** (73)	**3a** (3)	**4** (6)	**5** (7)
n-PrOH[c]	**2b** (50)	**3b** (8)	**4** (10)	
iso-PrOH[c]	**2c** (58)	**3c** (9)	**4** (11)	
tert-BuOH[c]	**2d** (19)	**3d** (4)	**4** (9)	

a) CAN (2.2 mol eq), room temperature. *b*) Isolated yield. *c*) MeCN was used as a co-solvent.

elucidated from the couplings of H-11: doublet of $J=3$ Hz for **2e** (δ 5.76) and triplet of $J=8$ Hz for **3e** (δ 6.02).

The oxidation of 15,16-methylenedioxy-8-oxo-*cis*-erythrinan (**6**)[11] in methanol gave a different result: the orthoester (**7**) was produced as the major product, and the expected 11β-OMe derivative (**8**) and the 11-oxo derivative (**9**) as minor products. Apparently the methylene group bearing two oxygens was the most vulnerable to this oxidation, thus changing the reaction path.

CAN Oxidation of 8-Oxo-1,7-cycloerythrinans 1,7-Cycloerythrinans were also smoothly methoxylated in a similar oxidation. Thus, oxidation of 15,16-dimethoxy-1,7-cyclo-*cis*-erythrinan-2,8-dione (**10**)[12] in methanol gave **11a**, **13**, and **14** in yields of 68, 13, and 8%, respectively. The 11α-methoxy derivative (**12a**) was not detected in this case. Again a methoxy group was introduced stereoselectively at the 11β-position, with greater selectivity than in the oxidation of **1**.

Similarly, oxidation of 3,3,15,16-tetramethoxy-1,7-cyclo-*cis*-erythrinan-2,8-dione (**15**)[13] gave the corresponding 11β-methoxy derivative (**16a**), the 11-oxo derivative (**18**), the the seco derivative (**19**) in 63, 28, and 8% yields, respectively. It is noteworthy that the acid-labile dimethyl acetal group was not affected in this oxidation.

CAN Oxidation of 8-Oxoerythrinan-1-enes Oxidation of an unsaturated compound, 3α,15,16-trimethoxy-8-oxo-*cis*-erythrinan-1-ene (**20**)[13] in methanol also gave 11β-methoxy and 11α-methoxy derivatives (**21** and **22**), but in lower yields, 38 and 4%, respectively. Although these products were not purified thoroughly, their structures were confirmed by comparison of the ^{1}H-NMR data with those of the compound synthesized *via* an alternative route (see below) and the β/α ratio was calculated from the ^{1}H-NMR spectrum of the crude product.

CAN Oxidation of 8-Oxoerythrinan-1,6-dienes Oxidation of the synthetic (±)-8-oxoerysotrine [(±)-**23**][13,14] in methanol gave the corresponding 11β-methoxy and 11α-methoxy derivatives (**24a** and **25a**) in 41 and 11% yields, respectively, revealing that this methoxylation is useful even for compounds having a dienoid system in the molecule. The decrease of stereoselectivity may be attributed to the fact that introduction of a diene at the 1(2) and 6(7) positions reduced the steric hindrance to the α-face of the molecule. The structure of **24a** was proved by an alternative synthesis (see below).

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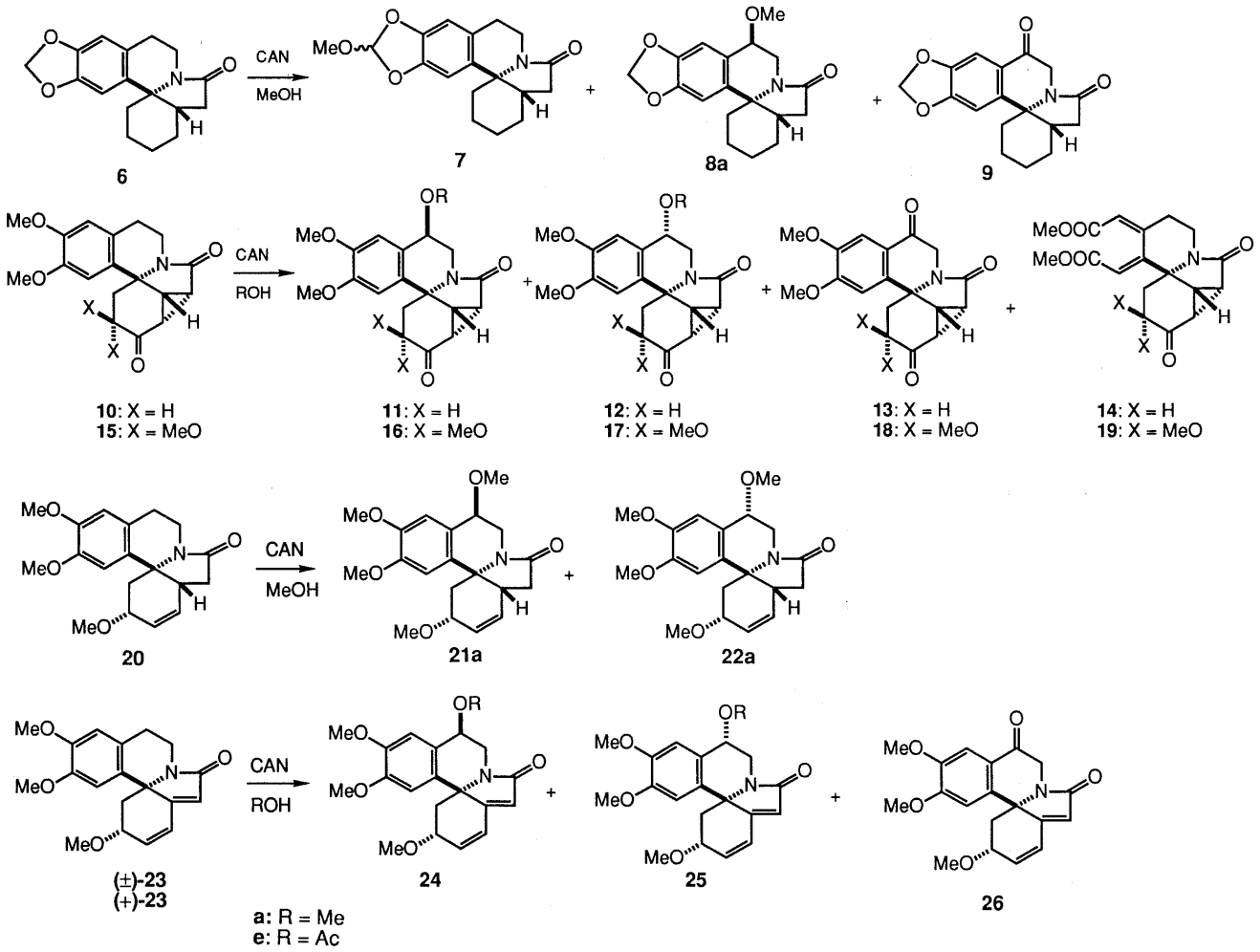

Chart 3

Similarly, oxidation of optically active (+)-8-oxoerysotrine [erysotramidine, (+)-**23**][15] in acetic acid afforded the corresponding 11β-acetoxy derivative [(+)-**24e**] in 50% yield and the 11α-acetoxy derivative [(+)-**25e**] in 33% yield. The configuration of the acetoxy group in each product was again elucidated on the basis of the coupling pattern of H-11 in the ^{1}H-NMR spectra: dd of J=3.5 and 2 Hz for the 11β- and dd of J=7.5 and 2.5 Hz for the 11α-isomer.

Synthesis of the Natural Alkaloids, Erythristemine and Erythrartine The above-synthesized 11β-methoxycycloerythrinan derivative (**16a**) was converted into the natural alkaloid, erythristemine, by the method[13] well established in the total synthesis of the corresponding non-methoxy analog, erysotrine, as follows.

Reduction of **16a** with $NaBH_4$ followed by dithiocarbonylation of the resulting alcohol (**27**) gave the dithiodicarbonate (**28**), which, on reduction with tributyltin hydride followed by acid treatment gave the enone (**29**) in a quantitative yield from **16a**. This was reduced with cerium(III) chloride and $NaBH_4$ in methanol to give a mixture of the 3α-alcohol (**30**) and 3β-alcohol (**31**) in the ratio of 2 : 1. After separation of these by chromatography, the 3α-alcohol (**30**) was methylated with methyl iodide to afford **21a** in 91% yield. Compound **21a** was identical with the above product obtained by CAN oxidation of **20**. Phenylselenenylation of **21a** with lithium diisopropylamide (LDA)–diphenylselenide and oxidation of the resulting phenylselenenyl derivative gave the dienoid lactam (**24a**) as a gum in 83% yield. Compound **24a** was again identical with the CAN oxidation product of (±)-erysotramidine in methanol. Reduction of **24a** with lithium aluminum hydride (LAH)–$AlCl_3$ gave the amine (**32**) in 73% yield. The ^{1}H-NMR spectrum of **32** was identical with the reported spectrum of erythristemine [(+)-**32**],[9] thus confirming the total synthesis of the 11β-methoxy natural erythrinan alkaloid in a racemic form.

Conversion of 11β-acetoxyerysotramidine [(+)-**24e**] into the optically active natural alkaloid, erythrartine (11β-hydroxyerysotrine),[16] was achieved by reduction of (+)-**24e** with LAH–$AlCl_3$ in tetrahydrofuran (THF). The hydroxy-amine [(+)-**33**] was obtained in 47% yield, together with (+)-erysotrine (**34**) and the hydroxy-lactam (**35**). All physical and spectral data of (+)-**33** were identical with those of erythrartine provided by Prof. Furukawa.

Next, synthesis of erythrascine, for which the structure **36** had been proposed by Ghosal,[17] was attempted. Acetylation of (+)-**33** with acetic anhydride and pyridine gave the acetate as a pale yellow oil. All spectral data supported by expected structure of 11β-acetoxyerysotrine (**36**). However, the ^{1}H-NMR data of **36** were not compatible with those reported for erythrascine, suggesting

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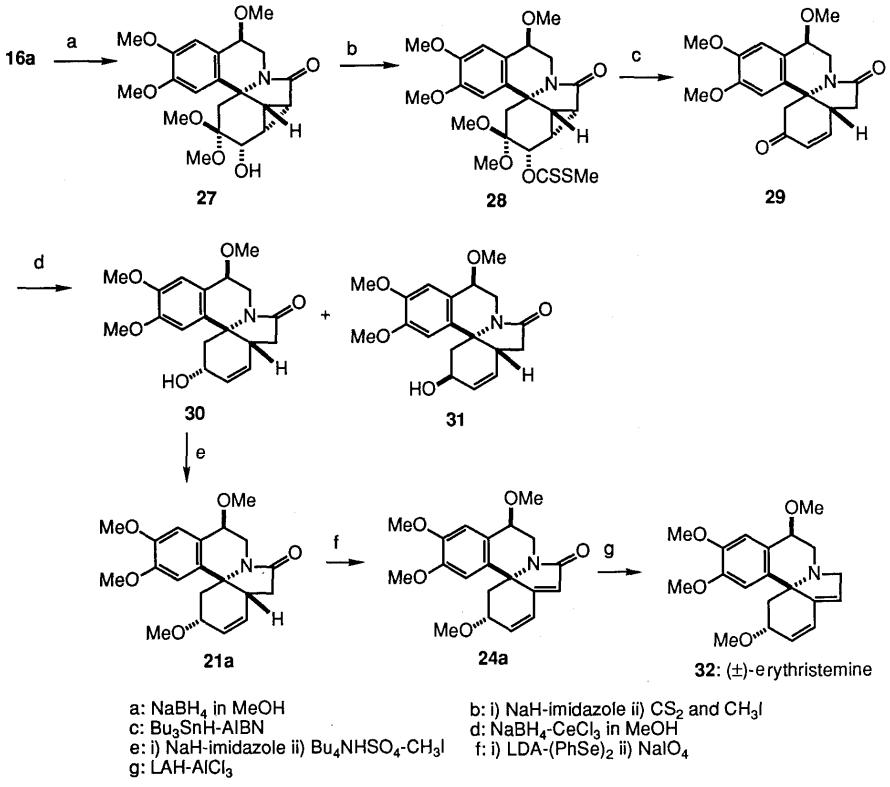

Chart 4

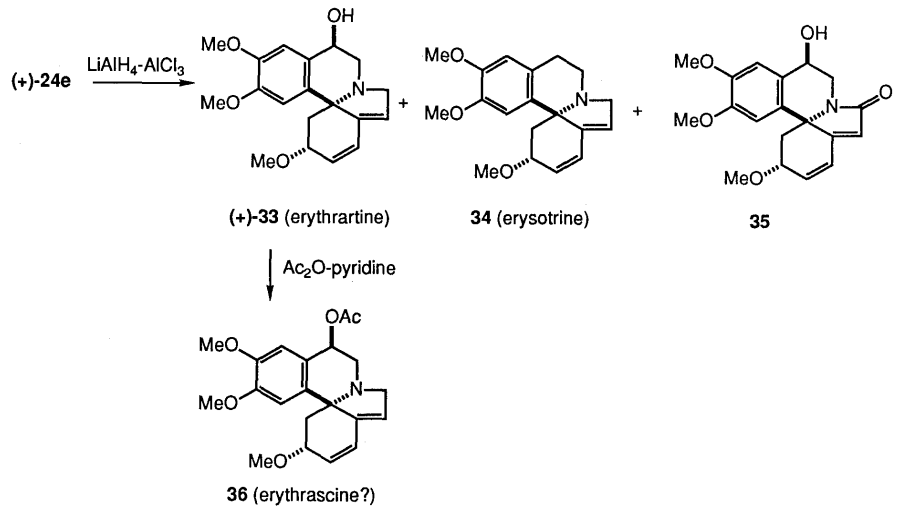

Chart 5

that either the structure is incorrect or the reported NMR data[17] are questionable. Since an authentic sample of erythrascine was not available, the above problem remains to be solved.

Conclusion

Stereoselective introduction of the 11β-position of the erythrinan skeleton by CAN oxidation in hydroxylic solvents provides a useful method to synthesize *Erythrina* alkaloids bearing a variety of oxygen functionalities at the 11 position: the oxidation in methanol gave an 11β-methoxy derivative and that in acetic acid afforded an 11β-acetoxy derivative, each in good yield. This oxidation is also applicable to compounds having a double bond(s) as well as a dimethyl acetal. By application of this method to erysotramidine, two natural *Erythrina* alkaloids, erythristemine and erythrartine, were synthesized. Since the synthesis of erysotramidine (**23**) has been achieved in an optically active form,[18] the transformations described above represent formal total syntheses of the above alkaloids.

Experimental

Unless otherwise stated, the following procedures were adopted. Melting points were determined on a Yanagimoto melting point apparatus and are uncorrected. IR spectra were taken in $CHCl_3$ solution,

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recorded on a JASCO IR-810 spectrophotometer, and are given in cm^{-1}. ^{1}H-NMR spectra were recorded on a Hitachi R-600 (60 MHz) or a JEOL FX-100 (100 MHz) spectrometer in $CDCl_3$ with tetramethylsilane as an internal standard and are given in δ.[19] High-resolution mass spectra (HRMS) were determined with a JEOL JMS D-300 spectrometer and M^+ is given in *m/z*. Ultraviolet (UV) spectra were measured in EtOH and values are given in λ_{max} nm (log ε). Thin layer chromatography (TLC) was performed on precoated Kieselgel 60 F_{254} plates and spots were monitored by UV (254 nm), then developed by spraying 0.5% $Ce(SO_4)_2$–0.5% $(NH_4)_6Mo_7O_{24}$ in 5% H_2SO_4 and heating the plates at 100°C until coloration took place. Column chromatography was performed on Wakogel C-200 (silica gel). For medium-pressure liquid chromatography (MPLC), a Kusano CPS-HS-221-1 with a silica gel column (22 mm i.d. × 100 mm) was used. All organic extracts were washed with brine and dried over anhydrous $MgSO_4$ before concentration. Identities were confirmed by comparison of melting point (for crystalline compounds), TLC behavior, IR, and ^{1}H-NMR spectra.

CAN Oxidation of 8-Oxoerythrinan Derivatives (General Procedure) CAN (2.2 mol eq) was added to a solution of 8-oxoerythrinans (1 mol eq) in ROH (and MeCN, if necessary) and the mixture was stirred at room temperature for an appropriate time. Amounts of materials and reaction times are given for each individual experiment. After dilution with CH_2Cl_2, the solution was washed with brine and water, dried over $MgSO_4$, and concentrated. The residue was purified by MPLC with AcOEt or AcOEt–hexane.

Oxidation of 15,16-Dimethoxy-8-oxo-*cis*-erythrinan (1) 1) In MeOH Compound **1** (500 mg, 1.66 mmol) was oxidized with CAN (2.0 g, 3.65 mmol) in MeOH (50 ml) for 30 min as described in the general procedure. MPLC of the product with AcOEt gave **2a** (401 mg, 73%), **3a** (17 mg, 3%), **4** (32 mg, 6%), and **5** (40 mg, 7%).

2a: Gum. IR: 1675. ^{1}H-NMR: 6.94, 6.80 (each 1H, s, ArH), 4.53 (1H, dd, J=14, 2 Hz, H-10), 4.20 (1H, dd, J=3, 2 Hz, H-11), 3.90, 3.89, 3.46 (each 3H, s, OMe), 3.10 (1H, dd, J=14, 3 Hz, H-10). HRMS: Calcd for $C_{19}H_{25}NO_4$: 331.1784. Found: 331.1816.

3a: Gum. IR: 1675. ^{1}H-NMR: 6.97, 6.85 (each 1H, s, ArH), 4.57 (1H, dd, J=13, 7 Hz, H-10), 4.44 (1H, dd, J=9, 7 Hz, H-11), 3.90, 3.89, 3.54 (each, 3H, s, OMe), 3.01 (1H, dd, J=13, 9 Hz, H-10). HRMS: Calcd for $C_{19}H_{25}NO_4$: 331.1784. Found: 331.1798.

4: Colorless prisms from AcOEt, mp 178—182 °C. IR (KBr): 1700, 1670. ^{1}H-NMR: 7.50, 6.84 (each 1H, s, ArH), 4.86, 3.79 (each 1H, d, J=19 Hz, H-10), 4.00, 3.92 (each 3H, s, OMe). HRMS: Calcd for $C_{18}H_{21}NO_4$: 315.1469. Found: 315.1456.

5: Colorless prisms from AcOEt, mp 92 °C (lit. 92 °C).[8]

2) In *n*-Propanol, Isopropanol, or *tert*-Butanol A solution of CAN (548 mg, 1 mmol) in MeCN (10 ml) was added to a solution of **1** (150 mg, 0.5 mmol) in the respective alcohol (15 ml) and stirred for 2 h at room temperature. MPLC of the product with AcOEt–hexane (2 : 1) gave the following compounds in the yields shown in Table I.

2b: Gum. IR: 1670. ^{1}H-NMR: 6.93, 6.81 (each 1H, ArH), 4.45 (1H, dd, J=14, 2 Hz, H-10), 4.30 (1H, dd, J=3, 2 Hz, H-11), 3.89, 3.87 (each 3H, s, OMe), 3.13 (1H, dd, J=14, 3 Hz, H-10), 3.54 (2H, m, $OC\underline{H}_2CH_3$), 1.01 (3H, t, J=7 Hz, $CH_2C\underline{H}_3$). HRMS: Calcd for $C_{21}H_{29}NO_4$: 359.2094. Found: 359.2099.

3b: Gum. IR: 1670. ^{1}H-NMR: 7.01, 6.84 (each 1H, ArH), 4.50 (1H, dd, J=12, 7 Hz, H-11), 4.53 (1H, dd, J=16, 7 Hz, H-10), 3.89, 3.87 (each 3H, s, OMe), 3.65 (2H, m, $OC\underline{H}_2CH_3$), 2.99 (1H, dd, J=16, 12 Hz, H-10), 1.01 (3H, t, J=7 Hz, $CH_2C\underline{H}_3$). HRMS: Calcd for $C_{21}H_{29}NO_4$: 359.2094. Found: 359.2090.

2c: Gum. IR: 1670. ^{1}H-NMR: 6.93, 6.76 (each 1H, s, ArH), 4.34 (1H, dd, J=3, 2 Hz, H-11), 4.35 (1H, dd, J=14, 2 Hz, H-10), 3.9 (1H, m, OCH), 3.88 (6H, s, 2 × OMe), 3.13 (1H, dd, J=14, 3 Hz, H-10), 1.25 (6H, t, J=6 Hz, 2 × Me). HRMS: Calcd for $C_{21}H_{29}NO_4$: 359.2094. Found: 359.2096.

3c: Gum. IR: 1675. ^{1}H-NMR: 6.98, 6.83 (each 1H, s, ArH), 4.52 (1H, dd, J=11, 7 Hz, H-11), 4.50 (1H, dd, J=15, 7 Hz, H-10), 4.0 (1H, m, OCH), 3.88, 3.87 (each 3H, s, OMe), 1.31, 1.29 (each 3H, d, J=6 Hz, Me). HRMS: Calcd for $C_{21}H_{29}NO_4$: 359.2094. Found: 359.2101.

2d: Colorless prisms from AcOEt–hexane, mp 69—71 °C. IR: 1670. ^{1}H-NMR: 6.93 (2H, s, ArH), 4.61 (1H, t, J=5 Hz, H-11), 3.91, 3.43 (each 1H, J=13, 5 Hz, H-10), 3.89, 3.88 (each 3H, s, OMe), 1.35 (9H, s, *tert*-Bu). HRMS: Calcd for $C_{21}H_{29}NO_4$: 359.2094. Found: 359.2098.

3d: Colorless prisms from AcOEt–hexane, mp 138—140 °C. IR: 1690. ^{1}H-NMR: 6.99, 6.80 (each 1H, s, ArH), 4.65—4.55 (2H, m, H-10, 11), 3.88, 3.86 (each 3H, s, OMe), 2.95 (1H, dd, J=12, 9 Hz, H-10), 1.39 (9H, s, *tert*-Bu). HRMS: Calcd for $C_{21}H_{29}NO_4$: 359.2094. Found: 359.2091.

3) In AcOH Compound **1** (200 mg, 0.66 mmol) in AcOH (16 ml) was added to a solution of CAN (801 mg, 1.46 mmol) in MeCN (4 ml) and the mixture was stirred for 30 min at room temperature. Dilution of the reaction mixture with CH_2Cl_2 afforded yellow precipitates, which were removed by filtration. The filtrate was washed with saturated $NaHCO_3$ solution and water, dried over $MgSO_4$, and concentrated. The residue was purified by MPLC with AcOEt–hexane (4 : 1) to give **2e** (207 mg, 71%) and **3e** (40 mg, 16%).

2e: Colorless prisms from AcOEt–Et_2O, mp 142—143 °C. IR (KBr): 1730, 1680. ^{1}H-NMR: 6.94, 6.77 (each 1H, s, ArH), 5.76 (1H, d, J=3 Hz, H-11), 4.44 (1H, d, J=15 Hz, H-10), 3.92, 3.86 (each 3H, s, OMe), 3.24 (1H, dd, J=15, 3 Hz, H-10), 2.05 (3H, s, Ac). HRMS: Calcd for $C_{20}H_{25}NO_5$: 359.1730. Found: 359.1720.

3e: Gum. IR: 1730, 1680. ^{1}H-NMR: 6.88, 6.75 (each 1H, s, ArH), 6.02 (1H, t, J=8 Hz, H-11), 4.55 (1H, dd, J=14, 8 Hz, H-10), 3.91, 3.85 (each 3H, s, OMe), 3.13 (1H, dd, J=14, 7.5 Hz, H-10), 2.14 (3H, s, Ac). HRMS: Calcd for $C_{20}H_{25}NO_5$: 359.1730. Found: 359.1721.

Oxidation of 15,16-Methylenedioxy-8-oxo-*cis*-erythrinan (6) in MeOH Compound **6** (300 mg, 1.05 mmol) was oxidized in MeOH (30 ml) for 1 h as described in the general procedure. MPLC of the product with AcOEt–hexane (4 : 1) gave **7** (153 mg, 46%), **8a** (100 mg, 30%), and **9** (13 mg, 4%).

7: Gum. IR: 1670. ^{1}H-NMR: 6.85, 6.75 (each, 1H, s, ArH), 6.55 (1H, s, $HC(O\text{–})_3$), 3.33 (3H, s, OMe). HRMS: Calcd for $C_{18}H_{21}NO_4$: 315.1469. Found: 315.1459. ^{13}C-NMR: 174.3 (s), 144.7 (s), 144.6 (s), 136.1 (s), 127.0 (s), 119.3 (d), 108.7 (d), 104.7 (d), 62.8 (s), 50.4 (q), 37.9 (d), 36.5 (t), 36.0 (t), 35.1 (t), 27.6 (t), 26.9 (t), 20.7 (t), 20.2 (t).

8a: Gum. IR: 1680. ^{1}H-NMR: 6.92, 6.77 (each 1H, s, ArH), 5.96, 5.93 (each 1H, d, J=3 Hz, OCH_2O), 4.48 (1H, dd, J=14, 2 Hz, H-10), 4.14 (1H, dd, J=3, 2 Hz, H-11), 3.44 (3H, s, OMe), 3.08 (1H, dd, J=14, 3 Hz, H-10). HRMS: Calcd for $C_{18}H_{21}NO_4$: 315.1470. Found: 315.1485.

9: Colorless prisms from AcOEt, mp 158—161 °C. IR ($CHCl_3$): 1683, 1680. ^{1}H-NMR: 7.44, 6.88 (each 1H, s, ArH), 6.05 (2H, s, OCH_2O), 4.84, 3.76 (each 1H, d, J=19 Hz, H-10). HRMS: Calcd for $C_{17}H_{17}NO_4$: 299.1158. Found: 299.1162.

Oxidation of 15,16-Dimethoxy-1,7-cyclo-*cis*-erythrinan-2,8-dione (10) 1) In MeOH Compound **10** (150 mg, 0.48 mmol) in MeOH (15 ml) was oxidized with CAN (578 mg, 1.05 mmol) for 10 min as described in the general procedure. MPLC of the product with AcOEt gave **11a** (111 mg, 68%), **13** (20 mg, 13%), and **14** (13 mg, 8%).

11a: Colorless prisms from AcOEt, mp 199—201 °C. IR (KBr): 1690, 1670. ^{1}H-NMR: 6.82, 6.77 (each 1H, s, ArH), 4.61 (1H, dd, J=14, 1 Hz, H-10), 4.20 (1H, br t, J=2 Hz, H-11), 3.93, 3.92, 3.51 (each 3H, s, OMe), 2.99 (1H, t, J=7 Hz, H-1), 2.88 (1H, dd, J=14, 2 Hz, H-10), 2.51 (1H, dd, J=10, 7 Hz, H-7), 2.50—2.30 (2H, m, H-3), 2.17—2.02 (3H, m, H-4, 6). HRMS: Calcd for $C_{19}H_{21}NO_5$: 343.1418. Found: 343.1429.

13: Colorless prisms from AcOEt, mp 287—290 °C. IR (KBr): 1710, 1690, 1670. ^{1}H-NMR: 7.59, 6.88 (each 1H, s, ArH), 4.89 (1H, d, J=19 Hz, H-10), 4.03, 3.96 (3H, s, OMe), 3.57 (1H, d, J=19 Hz, H-10), 3.14 (1H, t, J=7 Hz, H-1), 2.6—2.0 (6H, m, H-3, 4, 6, 7). HRMS: Calcd for $C_{18}H_{17}NO_5$: 327.1107. Found: 327.1086.

14: Colorless prisms from AcOEt, mp 178—184 °C. IR (KBr): 1710, 1690. ^{1}H-NMR: 6.10, 6.07 (each 1H, s, olefinic H), 3.69, 3.66 (each 3H, s, OMe). HRMS: Calcd for $C_{18}H_{19}NO_6$: 345.1213. Found: 345.1198.

2) In AcOH–MeCN Compound **10** (100 mg, 0.32 mmol) in AcOH (8 ml) was oxidized with CAN (386 mg, 0.70 mmol) in MeCN (2 ml) for 2 h at room temperature. Work-up of the mixture gave **11e** (78 mg, 67%) and **12e** (5 mg, 4%).

11e: Colorless prisms from AcOEt, mp 235—240 °C. IR (KBr): 1740, 1710, 1690. ^{1}H-NMR: 6.84, 6.80 (each 1H, s, ArH), 5.78 (1H, br s, H-11), 4.47 (1H, dd, J=15, 1 Hz, H-10), 3.94, 3.89 (each 3H, s, OMe), 3.01 (1H, dd, J=15, 3 Hz, H-10), 3.01 (1H, t, J=7 Hz, H-1), 2.06—2.10 (6H, m, H-3, 4, 6, 7), 2.07 (3H, s, Ac). HRMS: Calcd for $C_{20}H_{21}NO_6$: 371.1366. Found: 371.1354.

12e: Gum. IR (CH_2Cl_2): 1740, 1710. ^{1}H-NMR: 6.75 (2H, s, ArH), 6.02 (1H, dd, J=10, 9 Hz, H-11), 4.67 (1H, dd, J=13, 9 Hz, H-10), 3.93, 3.87 (each 3H, s, OMe), 2.97 (1H, t, J=7 Hz, H-1), 2.91 (1H, dd, J=13, 10 Hz, H-10), 2.70—2.10 (6H, m, H-3, 4, 6, 7), 2.18 (3H, s, Ac). HRMS: Calcd for $C_{20}H_{21}NO_6$: 371.1366. Found: 371.1348.

Oxidation of 3,3,15,16-Tetramethoxy-1,7-cyclo-*cis*-erythrinan-2,8-dione (15) 1) In MeOH Compound **15** (150 mg, 0.40 mmol) in MeOH (15 ml) was oxidized with CAN (485 mg, 0.88 mmol) for 1 h as described

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in the general procedure. MPLC of the product with AcOEt gave **16a** (102 mg, 63%), **18** (45 mg, 28%), and **19** (13 mg, 8%).

16a: Colorless prisms from AcOEt, mp 207—209 °C. IR (Nujol): 1720, 1695. ^{1}H-NMR: 6.81, 6.77 (each 1H, s, ArH), 4.47 (1H, d, J=15 Hz, H-10), 4.15 (1H, br s, H-11), 3.94, 3.91, 3.49, 3.23, 3.22 (each 3H, s, OMe), 2.93 (1H, t, J=7 Hz, H-1), 2.92 (1H, dd, J=15, 3 Hz, H-10), 2.45 (1H, dd, J=10, 7 Hz, H-7), 2.24, 2.51 (each 1H, d, J=5 Hz, H-4), 2.25 (1H, dd, J=10, 7 Hz, H-6). HRMS: Calcd for $C_{21}H_{25}NO_7$: 403.1631. Found: 403.1642.

18: Colorless prisms from AcOEt, mp 206—207 °C. IR (KBr): 1710, 1695, 1670. ^{1}H-NMR: 7.56, 6.89 (each 1H, s, ArH), 4.73, 3.71 (each 1H, d, J=19 Hz, H-10), 4.04, 3.95, 3.24, 3.22 (each 3H, s, OMe), 3.11 (1H, t, J=7 Hz, H-1), 2.7—2.2 (4H, m, H-4, 6, 7). HRMS: Calcd for $C_{20}H_{21}NO_7$: 387.1317. Found: 387.1340.

19: Colorless prisms from Et_2O–AcOEt, mp 117—119 °C. IR (KBr): 1730, 1720, 1690, 1670. ^{1}H-NMR: 6.05 (2H, s, olefinic H), 3.67 (6H, s, 2×OMe), 3.26, 3.18 (each 3H, s, OMe). HRMS: Calcd for $C_{20}H_{23}NO_8$: 405.1422. Found: 405.1403.

2) In AcOH–MeCN Compound **15** (100 mg, 0.27 mmol) in AcOH (8 ml) was oxidized with CAN (323 mg, 0.59 mmol) in MeCN (2 ml) and the mixture was stirred for 2 h at room temperature. MPLC of the product with AcOEt–hexane (3 : 1) gave **16e** (97 mg, 83%) and **17e** (12 mg, 10%).

16e: Colorless prisms from AcOEt–Et_2O, mp 193—194 °C. IR (KBr): 1740, 1710, 1700. ^{1}H-NMR: 6.81, 6.80 (each 1H, s, ArH), 5.72 (1H, br s, H-11), 4.32 (1H, br d, J=15 Hz, H-10), 3.95, 3.89, 3.23, 3.22 (each 3H, s, OMe), 3.09 (1H, dd, J=15, 3 Hz, H-10), 2.95 (1H, t, J=7 Hz, H-1), 2.49 (2H, s, H-4), 2.46 (1H, dd, J=10, 7 Hz, H-7), 2.28 (1H, dd, J=10, 7 Hz, H-6), 2.05 (3H, s, Ac). HRMS: Calcd for $C_{22}H_{25}NO_8$: 431.1580. Found: 431.1575.

17e: Colorless prisms from AcOEt, mp 196—199 °C. IR (KBr): 1740, 1720, 1700. ^{1}H-NMR: 6.76, 6.74 (each 1H, s, ArH), 5.98 (1H, dd, J=9, 7 Hz, H-11), 4.48 (1H, dd, J=14, 7 Hz, H-10), 3.94, 3.86, 3.24, 3.23 (each 3H, s, OMe), 2.88 (1H, dd, J=14, 9 Hz, H-10), 2.17 (3H, s, Ac). HRMS: Calcd for $C_{22}H_{25}NO_8$: 431.1580. Found: 431.1588.

Oxidation of 3α,15,16-Trimethoxy-8-oxo-Δ^{1}-*cis*-erythrinan (20) in MeOH Compound **20** (17 mg, 0.05 mmol) was oxidized with CAN (62 mg, 0.11 mmol) in MeOH (2 ml) for 10 min as described in the general procedure. MPLC of the product with AcOEt gave the 11β-methoxy derivative **21a** (7 mg, 38%), which was identical with the specimen described below. The ^{1}H-NMR spectrum of the crude product showed the presence of the 11α-isomer (**22a**) (*ca.* 4%): δ 6.97, 6.67 (each 1H, s, ArH), 6.09 (2H, s, H-1, 2), 3.91, 3.79, 3.52, 3.93 (each 3H, s, OMe).

Oxidation of (±)-3α-15,16-Trimethoxy-8-oxo-$\Delta^{1,6}$-erythrinan [(±)-23] in MeOH Compound (±)-**23** (46 mg, 0.14 mmol) was oxidized with CAN (177 mg, 0.32 mmol) in MeOH (5 ml) for 30 min as described in the general procedure. MPLC of the product gave **24a** (25 mg, 41%), **25a** (7 mg, 11%), and **26** (18 mg, 31%). Compound **24a** was identical with (±)-11β-methoxyerysotramidine (see below).

(±)-11α-Methoxyerysotramidine [(±)-**25a**]: Gum. IR: 1675. ^{1}H-NMR: 6.90 (2H, s, ArH), 6.89 (1H, dd, J=10, 2 Hz, H-1), 6.36 (1H, d, J=10 Hz, H-2), 6.01 (1H, s, H-7), 4.48 (1H, dd, J=13, 7 Hz, H-10), 4.45 (1H, dd, J=7, 4 Hz, H-11), 3.96—3.88 (1H, m, H-3), 3.89, 3.78, 3.45, 3.34 (each 3H, s, OMe), 3.60 (1H, dd, J=13, 4 Hz, H-10), 3.30—3.22 (1H, m, H-4), 1.69 (1H, dd, J=11, 10 Hz, H-4). ^{1}H-NMR (C_6D_6): 6.85, 6.62 (each 1H, s, ArH), 6.20 (1H, dd, J=10, 2 Hz, H-1), 5.94 (1H, d, J=10 Hz, H-2), 5.82 (1H, s, H-7), 4.57 (1H, dd, J=14, 7 Hz, H-10), 4.06 (1H, dd, J=7, 4 Hz, H-11), 3.75 (1H, m, H-3), 3.51 (1H, dd, J=14, 4 Hz, H-10), 3.36, 3.33, 2.99, 2.89 (each 3H, s, OMe), 3.18 (1H, dd, J=12, 5 Hz, H-4), 1.67 (1H, dd, J=12, 10 Hz, H-4). HRMS: Calcd for $C_{20}H_{23}NO_5$: 357.1574. Found: 357.1566.

(±)-11-Oxoerysotramidine (**26**): Colorless prisms from AcOEt–Et_2O, mp 198—200 °C. IR (KBr): 1681, 1595. ^{1}H-NMR: 7.55, 6.98 (each 1H, s, ArH), 6.98 (1H, dd, J=10, 2 Hz, H-1), 6.42 (1H, d, J=10 Hz, H-2), 6.13 (1H, s, H-7), 5.05, 4.02 (each 1H, d, J=20 Hz, H-10), 3.93, 3.86, 3.35 (each 3H, s, OMe). HRMS: Calcd for $C_{19}H_{21}NO_5$: 343.1419. Found: 343.1425.

Oxidation of (+)-Erysotramidine [(+)-23] in AcOH–MeCN Erysotramidine (36 mg, 0.11 mmol)[15] in AcOH (3 ml) was added to a solution of CAN (133 mg, 0.24 mmol) in MeCN (0.4 ml) and the mixture was stirred for 1 h. MPLC of the product with AcOEt–hexane (4 : 1) gave (+)-**24e** (21 mg, 50%) and (+)-**25e** (14 mg, 33%).

(+)-11β-Acetoxyerysotramidine [(+)-**24e**]: Pale yellow gum, $[\alpha]_D^{20}$ +43.8° (c=0.29, $CHCl_3$). UV: 212 (4.46), 241 (4.20), 257 (4.08), 291 (3.48). IR: 1727, 1683. ^{1}H-NMR (400 MHz): 7.02, 6.81 (each 1H, s, ArH), 6.94 (1H, dd, J=10, 2.5 Hz, H-1), 6.39 (1H, br d, J=10 Hz, H-2), 6.06 (1H, s, H-7), 5.82 (1H, dd, J=3.5, 2 Hz, H-11), 4.55 (1H, dd, J=15, 2 Hz, H-10β), 4.14 (1H, m, H-3), 3.86, 3.80, 3.38 (each 3H, s, OMe), 3.55 (1H, dd, J=15, 3.5 Hz, H-10α), 2.76 (1H, dd, J=12, 5.5, H-4), 2.07 (3H, s, Ac), 1.71 (1H, dd, J=12, 10 Hz, H-4). ^{13}C-NMR (100 MHz): 171.0 (s), 170.2 (s), 156.9 (d), 149.0 (s), 148.9 (s), 136.3 (d), 129.2 (s), 125.1 (s), 123.8 (s), 120.5 (d), 113.0 (d), 107.7 (d), 74.5 (d), 68.2 (d), 65.0 (s), 56.4 (q), 56.0 (q), 55.9 (q), 41.8 (t), 40.0 (t), 21.3 (q). MS: 385 (M^+, 84), 292 (100). HRMS: Calcd for $C_{21}H_{23}NO_6$: 385.1526. Found: 385.1495.

(+)-11α-Acetoxyerysotramidine [(+)-**25e**]: Pale yellow gum, $[\alpha]_D^{20}$ +156.6° (c=0.295, $CHCl_3$). UV: 211 (4.52), 243 (4.26), 256 (4.18), 291 (3.60). IR: 1733, 1679. ^{1}H-NMR (400 MHz): 6.96, 6.88 (each 1H, s, ArH), 6.91 (1H, dd, J=10, 2.5 Hz, H-1), 6.38 (1H, br d, J=10 Hz, H-2), 6.16 (1H, dd, J=7.5, 2.5 Hz, H-11), 6.04 (1H, s, H-7), 4.54 (1H, dd, J=14.4, 7.5 Hz, H-10β), 3.89 (1H, m, H-3), 3.87, 3.78, 3.36 (each 3H, OMe), 3.57 (1H, dd, J=14.5, 2.5 Hz, H-10α), 3.22 (1H, dd, J=11.5, 5 Hz, H-4), 2.12 (3H, s, Ac), 1.76 (1H, dd, J=11.5, 10 Hz, H-4). ^{13}C-NMR: 170.3 (s), 170.1 (s), 157.5 (d), 148.9 (s), 148.8 (s), 137.4 (d), 130.9 (s), 124.2 (s), 124.0 (s), 120.0 (d), 113.0 (d), 108.0 (d), 74.9 (d), 68.0 (d), 65.7 (s), 56.3 (q), 56.0 (q), 56.0 (q), 42.3 (t), 42.0 (t), 21.5 (q). MS: 385 (M^+, 59), 292 (100). HRMS: Calcd for $C_{21}H_{23}NO_6$: 385.1526. Found: 385.1518.

Transformation of 16a to the Enone 29 Compound **16a** (123 mg) was dissolved in MeOH (6 ml) and reduced with $NaBH_4$ (14 mg) for 15 min at 0 °C. The mixture was poured into water and extracted with CH_2Cl_2. Concentration of the dried extract gave the alcohol (**27**) (134 mg).

A mixture of **27**, NaH (60% oil dispersion, 67 mg), and imidazole (6 mg) in THF (10 ml) was heated under reflux for 1 h under an Ar atmosphere. Carbon disulfide (2 ml) and iodomethane (2 ml) were added successively, and the mixture was heated for a further 50 min. The cooled mixture was brought to pH 6 by addition of AcOH and water, and extracted with CH_2Cl_2. Concentration of the dried extract gave the dithiocarbonate (**28**) (206 mg).

A mixture of **28**, tributyltin hydride (1.8 ml) and 2,2′-azobis(isobutyronitrile) (10 mg) in toluene (15 ml) was heated under reflux for 2.5 h under an Ar atmosphere. The cooled mixture was poured onto a silica gel column and the column was washed with benzene to remove tin compounds. Elution of the column with $CHCl_3$–MeOH (6 : 1) gave a gum, which was treated with 1 N HCl–acetone (6 ml) for 10 min at room temperature. Concentration of the mixture and extraction with CH_2Cl_2 gave the enone (**29**) (116 mg, 100% from **16a**), as colorless prisms from AcOEt–Et_2O, mp 165—167 °C. IR (KBr): 1690, 1675. ^{1}H-NMR: 7.10 (1H, dd, J=10, 5 Hz, H-1), 6.75, 6.65 (each 1H, s, ArH), 6.33 (1H, dd, J=10, 2 Hz, H-2), 4.63 (1H, dd, J=12, 2 Hz, H-10β), 4.18 (1H, d, J=2 Hz, H-11), 3.88, 3.73, 3.47 (each 3H, s, OMe). MS: 343 (M^+), 310 (100). *Anal.* Calcd for $C_{19}H_{21}NO_5$: C, 66.46; H, 6.16; N, 4.08. Found: C, 66.42; H, 6.24; N, 4.19.

Hydride Reduction of the Enone (29) $NaBH_4$ (49 mg) was added to a stirred solution of **29** (175 mg) and $CeCl_3 \cdot 7H_2O$ (2.37 mg) in MeOH (15 ml) at 0 °C, and stirring was continued for 20 min. The mixture was diluted with water and extracted with $CHCl_3$. MPLC of the product with acetone–benzene (2 : 1) gave the alcohols, **30** (100 mg, 57%) and **31** (53 mg, 30%).

The 3α-Alcohol (**30**): Colorless needles from CH_2Cl_2–Et_2O, mp 147—149 °C. IR (KBr): 3400, 1650. ^{1}H-NMR: 6.75, 6.58 (each 1H, s, ArH), 5.99 (2H, s, H-1, 2), 4.45 (1H, dd, J=15, 2 Hz, H-10β), 4.28 (1H, m, H-3), 4.20 (1H, dd, J=3, 2 Hz, H-11), 3.82, 3.72, 3.38 (each 3H, s, OMe), 3.19 (1H, dd, J=15, 3 Hz, H-10α). MS: 345 (M^+), 314 (base peak). *Anal.* Calcd for $C_{19}H_{23}NO_5 \cdot 1/2CH_2Cl_2$: C, 60.39; H, 6.24; N, 3.61. Found: C, 59.64; H, 6.45; N, 3.49. HRMS: Calcd for $C_{19}H_{23}NO_5$: 345.1577. Found: 345.1574.

The 3β-Alcohol (**31**): Colorless prisms from AcOEt–CH_2Cl_2, mp 161—162 °C. IR (KBr): 3425, 1695. ^{1}H-NMR: 6.76, 6.70 (each 1H, s, ArH), 5.97 (1H, d, J=10 Hz, H-2), 5.84 (1H, ddd, J=10, 4, 2 Hz, H-1), 4.60 (1H, dd, J=15, 2 Hz, H-10β), 4.28 (1H, m, H-3), 4.12 (1H, dd, J=3, 2 Hz, H-11), 3.89, 3.87, 3.47 (each 3H, s, OMe), 3.16 (1H, dd, J=15, 3 Hz, H-10α). MS: 345 (M^+), 314 (100). *Anal.* Calcd for $C_{19}H_{23}NO_5$: C, 66.07; H, 6.71; N, 4.06. Found: C, 65.80; H, 6.85; N, 4.22.

Methylation of the 3α-Alcohol (30) A mixture of **30** (87 mg), NaH (60% oil dispersion, 200 mg), and a catalytic amount of imidazole in THF (13 ml) was heated at 50 °C for 50 min, then n-Bu_4NHSO_4 (85 mg,

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1 mol eq) and iodomethane (4 ml) were added and the mixture was stirred at 60 °C for 2 h. The cooled mixture was acidified with 1 N HCl, and extracted with $CHCl_3$. Concentration of the extract and chromatography of the residue gave the methyl ether (**21a**) (82 mg, 91%), as colorless prisms from Et_2O, mp 134—136 °C. IR (KBr): 1680. ^{1}H-NMR: 6.83, 6.67 (each 1H, s, ArH), 6.10 (2H, s, H-1, 2), 4.52 (1H, dd, J=14.5, 2 Hz, H-10β), 4.29 (1H, dd, J=3, 2 Hz, H-11), 3.90, 3.79, 3.44, 3.34 (each 3H, s, OMe). MS: 359 (M^+), 314 (base peak). *Anal.* Calcd for $C_{20}H_{25}NO_5$: C, 66.83; H, 7.01; N, 3.90. Found: C, 66.55; H, 7.17; N, 3.90.

(±)-11β-Methoxyerysotramidine (24a) Compound **21a** (40 mg, 0.11 mmol) in THF (4 ml) was treated with LDA (1.5 M THF/heptane solution, 0.27 ml, 0.41 mmol) in THF (2 ml) at −78°C for 30 min under an Ar atmosphere, then $(PhSe)_2$ (81 mg) in THF (2 ml) was added and the mixture was stirred for 25 min. The mixture was acidified with 1 N HCl and extracted with $CHCl_3$. Concentration of the extract gave a gum, which was dissolved in MeOH (5 ml) and treated with $NaIO_4$ (280 mg) in H_2O (3 ml) for 30 min at 0 °C. The mixture was poured into saturated $NaHCO_3$ solution and extracted with $CHCl_3$. Purification of the dried extract by chromatography gave the dienoid lactam (**24a**) (33 mg, 83%), as a colorless oil. IR: 1680. ^{1}H-NMR (C_6D_6): 6.94, 6.86 (each 1H, s, ArH), 6.29 (1H, dd, J=10, 2.5 Hz, H-1), 5.94 (1H, br d, J=10 Hz, H-2), 5.86 (1H, s, H-7), 4.47 (1H, dd, J=14, 4 Hz, H-10β), 4.17 (1H, t, J=4 Hz, H-11), 3.86 (1H, m, H-3), 3.42, 3.40, 3.33, 2.96 (each 3H, s, OMe), 2.52 (1H, dd, J=12, 5.5 Hz, H-4β), 1.66 (1H, dd, J=12, 10 Hz, H-4α). MS: 357 (M^+, 100). HRMS: Calcd for $C_{20}H_{23}NO_5$: 357.1577. Found: 357.1573.

(±)-Erythristemine (11β-Methoxyerysotrine) (32) $AlCl_3$ (sublimed, 46 mg) in ether (3 ml) was added to a solution of $LiAlH_4$ (40 mg) in ether (3 ml) at −78 °C and the mixture was stirred for 1 h at room temperature. The resulting solution (1 ml) was added to a stirred solution of **24a** (20 mg) in THF (2 ml). Stirring was continued for 30 min at 0 °C, then the mixture was diluted with ether and the excess reagent was decomposed by addition of 5% aqueous NH_4OH. The ethereal layer was extracted with 1 N HCl, then the HCl layer was basified with NH_4OH and extracted with $CHCl_3$. The extract was concentrated to give the amine **32** (14 mg, 73%) as a colorless oil. IR: 1610. ^{1}H-NMR (C_6D_6): 7.03 (2H, s, ArH), 6.38 (1H, dd, J=10, 2 Hz, H-1), 5.98 (1H, d, J=10 Hz, H-2), 5.43 (1H, br s, H-7), 41.4 (1H, m, H-3), 4.01 (1H, t, J=4 Hz, H-11), 3.76 (1H, dd, J=15, 4 Hz, H-10β), 3.48 (6H, s, 2 × OMe), 3.26, 3.08 (each 3H, s, OMe), 2.60 (1H, dd, J=10.5, 5.5 Hz, H-4β), 2.08 (1H, t, J=10.5 Hz, H-4α). MS: 343 (M^+), 311 (base peak). HRMS: Calcd for $C_{20}H_{25}NO_4$: 343.1785 (M^+). Found: 343.1751. The ^{1}H-NMR spectrum of **32** was identical with that of (+)-erythristemine.[9]

Reduction of (+)-11β-Acetoxyerysotramidine [(+)-24e] 1) With $LiAlH_4$–$AlCl_3$ (3:1) $AlCl_3$(sublimed, 145 mg) in ether (6 ml) was added to a suspension of $LiAlH_4$ (124 mg) in THF (4 ml) at −15 °C and the mixture was stirred for 1 d. The resulting solution (2 ml) was added to a stirred solution of **24e** (10 mg) in THF (1 ml). Stirring was continued for 1 h at room temperature. The solution was diluted with Et_2O and made basic with 28% NH_4OH. The ethereal layer was washed with water, dried over anhydrous K_2CO_3, and concentrated. Flash chromatography ($CHCl_3$: MeOH = 9 : 1) of the product gave **33** (4 mg, 47%), **34** (2.1 mg, 24%), and **35** (0.9 mg, 10%).

2) With $LiAlH_4$–$AlCl_3$ (1:1) $AlCl_3$ (sublimed, 88 mg) in ether (5 ml) was added to a suspension of $LiAlH_4$ (25 mg) in THF (3 ml) at −15 °C and the mixture was stirred for 40 min. The resulting solution (1 ml) was added to a solution of **24e** (4 mg) in THF (1 ml). Stirring was continued for 1 h at room temperature and the mixture was worked up as described above. Flash chromatography ($CHCl_3$: MeOH = 9 : 1) of the product gave **33** (1.6 mg, 43%) and **35** (1 mg, 28%).

(+)-Erythrartine [(+)-11β-Hydroxyerysotrine] (**33**): Pale yellow oil, $[\alpha]_D^{20}$ +136.4° (c=0.075, $CHCl_3$) (lit. $[\alpha]_D^{20}$ +135° (c=0.05, $CHCl_3$)). UV: 211 (4.30), 231 (4.07), 287 (3.38). IR: 3350. ^{1}H-NMR (400 MHz): 6.99, 6.84 (each 1H, s, ArH), 6.60 (1H, dd, J=10, 2 Hz, H-1), 6.05, (1H, br d, J=10 Hz, H-2), 5.75 (1H, br s, H-7), 4.77 (1H, t, J=4 Hz, H-11α), 4.07 (1H, m, H-3), 3.91, 3.78, 3.32 (each 3H, s, OMe), 3.64, 3.21 (each 1H, dd, J=14.5, 4 Hz, H-10), 2.43 (1H, dd, J=11, 5.5 Hz, H-4). MS: 329 (M^+). HRMS: Calcd for $C_{19}H_{23}NO_4$: 329.1628. Found: 329.1612. ^{1}H-NMR data are identical with those of erythrartine.[16]

(+)-Erysotrine (**34**): Pale yellow oil. ^{1}H-NMR (400 MHz): 6.80, 6.65 (each 1H, s, ArH), 6.58 (1H, dd, J=10, 2 Hz, H-1), 6.05 (1H, br d, J=10 Hz, H-2), 5.74 (1H, br s, H-7), 4.05 (1H, m, H-3), 3.87, 3.76, 3.32 (each 3H, s, OMe), 2.54 (1H, dd, J=11, 5 Hz, H-4). MS: 313 (M^+), 282 (100). ^{1}H-NMR data are identical with those of erysotrine.

(+)-11β-Hydroxyerysotramidine (**35**): Pale yellow oil, $[\alpha]_D^{20}$ +193.4° (c=0.05, $CHCl_3$). UV: 210 (4.38), 238 (4.15), 258 (4.0), 289 (3.6). IR: 1675. ^{1}H-NMR: 7.01, 6.92 (each 1H, s, ArH), 6.95 (1H, dd, J=10, 2.5 Hz, H-1), 6.39 (1H, br d, J=10 Hz, H-2), 6.06 (1H, s, H-7), 4.84 (1H, br s, H-11), 4.38 (1H, dd, J=14, 2 Hz, H-10β), 4.06 (1H, m, H-3), 3.89, 3.79, 3.37 (each 3H, s, OMe), 3.67 (1H, dd, J=14, 3.5 Hz, H-10α), 2.73 (1H, dd, J=11.5, 5.5 Hz, H-4), 1.71 (1H, dd, J=11.5, 10 Hz, H-4). MS: 343 (M^+, base peak). HRMS: Calcd for $C_{19}H_{21}NO_5$: 343.1420. Found: 343.1467.

***O*-Acetylerythrartine (36) (Erythrascine ?)** Acetylation of erythrartine (+)-**33** (1.6 mg) with pyridine (12 drops) and acetic anhydride (6 drops) for 14 h at room temperature gave the acetate (**36**) (1.5 mg, 83%) as a pale yellow oil, $[\alpha]_D^{20}$ +66° (c=0.05, $CHCl_3$). UV: 212 (4.37), 233 (4.13), 283 (3.53). IR: 1714. ^{1}H-NMR (400 MHz): 6.88, 6.79 (each 1H, s, ArH), 6.61 (1H, dd, J=10, 2 Hz, H-1), 6.08 (1H, br d, J=10 Hz, H-2), 5.88 (1H, m, H-11), 5.76 (1H, br s, H-7), 3.85, 3.78, 3.35 (each 3H, s, OMe), 2.11 (3H, s, Ac). MS: 371 (M^+, 24), 340 (23), 311 (83), 296 (58), 280 (100). HRMS: Calcd for $C_{21}H_{25}NO_5$: 371.1731. Found: 371.1694.

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