[Chem. Pharm. Bull. 27(9)2076—2083(1979)]

UDC 547.943.04 : 541.14.04

Utilization of Protopine and Related Alkaloids. XI.[1] Photolysis of 7,8-Dimethoxy-2-methyl-3-(4',5'-methylenedioxy-2'-vinylphenyl)isocarbostyril and Its Application to the Preparation of Oxychelerythrines

MASAYUKI ONDA and HIROKO YAMAGUCHI

School of Pharmaceutical Sciences, Kitasato University[2]

(Received February 6, 1979)

Photolysis of the isocarbostyril (5) gives predominantly the regioisomeric dimers (7) and (8). Attempts to trap the initial photo-product (14) with dienophiles are made and the formation mechanisms of the resulting products are discussed. The 4b,12-epoxyimino compound (18) resulted from trapping with nitrosobenzene is smoothly converted into oxychelerythrines.

Keywords——oxychelerythrines; photolysis; cycloaddition; Diels-Alder addition; ene reaction; nuclear magnetic resonance

We have previously reported the formation of 5,6,11,12-tetrahydrochelerythrine (**4**) by the photocyclization of the dihydroisoquinoline (**2**) obtained from dihydroberberine metho salt (**1**), which was derived from α-allocryptopine or berberinium chloride.[3] It was observed that the initial photo-product (**3**) was exclusively converted into **4** by the 10b-H shift instead of the 11-H shift. One difficulty in this procedure is that it is necessary to obtain **2** in moderate yield and to transfer it rapidly to the next reaction because of its instability. Since, in general, isocarbostyrils are known to be stable, we attempted to synthesize the isocarbostyril (**5**) and utilize it for the synthesis of the benzo[*c*]phenanthridine alkaloid. We herein wish to report, in full, the photocyclization of **5** obtained from **2**, which has been described in our preliminary communication,[1] together with its application to the preparation of oxychelerythrines.

The dihydroisoquinoline (**2**), which was derived from **1** ($X=MeSO_4$) by the Hofmann degradation, was oxidized without purification by 2,3-dichloro-5,6-dicyano-1,4-benzoquinone (DDQ) to give **5** in 44% overall yield after several unsuccessful attempts with usual oxidizing agents.

Photolysis of **5** gave 11,12-dihydrooxychelerythrine (**6**), and the regioisomeric dimers (**7**) and (**8**) in 30, 38 and 29% yields, respectively. The proton magnetic resonance (PMR) spectrum of **6** shows a four-proton singlet for the 11-H_2 and 12-H_2 at δ 2.72, establishing the structure of **6**.[4] The molecular formulae of **7** and **8**, $C_{42}H_{38}N_2O_{10}$, are obtained from their mass spectra (MS) and they are clearly dimers of **5**. Their carbon-13 magnetic resonance (CMR) spectra are very similar and show the characteristic signals of two methylene carbons, four methine carbons and two tetrasubstituted olefin carbons (Table I). If the dimerizations are assumed to occur *via* interactions between four double bonds without collapse of the framework of **5**, these data lead to structures containing a bicyclo[6.4.0]dodecatriene system, in which one benzene moiety fuses with one six-membered ring, and one benzene moiety and one olefin group fuse with one eight-membered ring. Allowing for uncrowded geometry as a whole and for a stable conformation of the eight-membered ring, the structures (**7a**) and (**8a**)

---

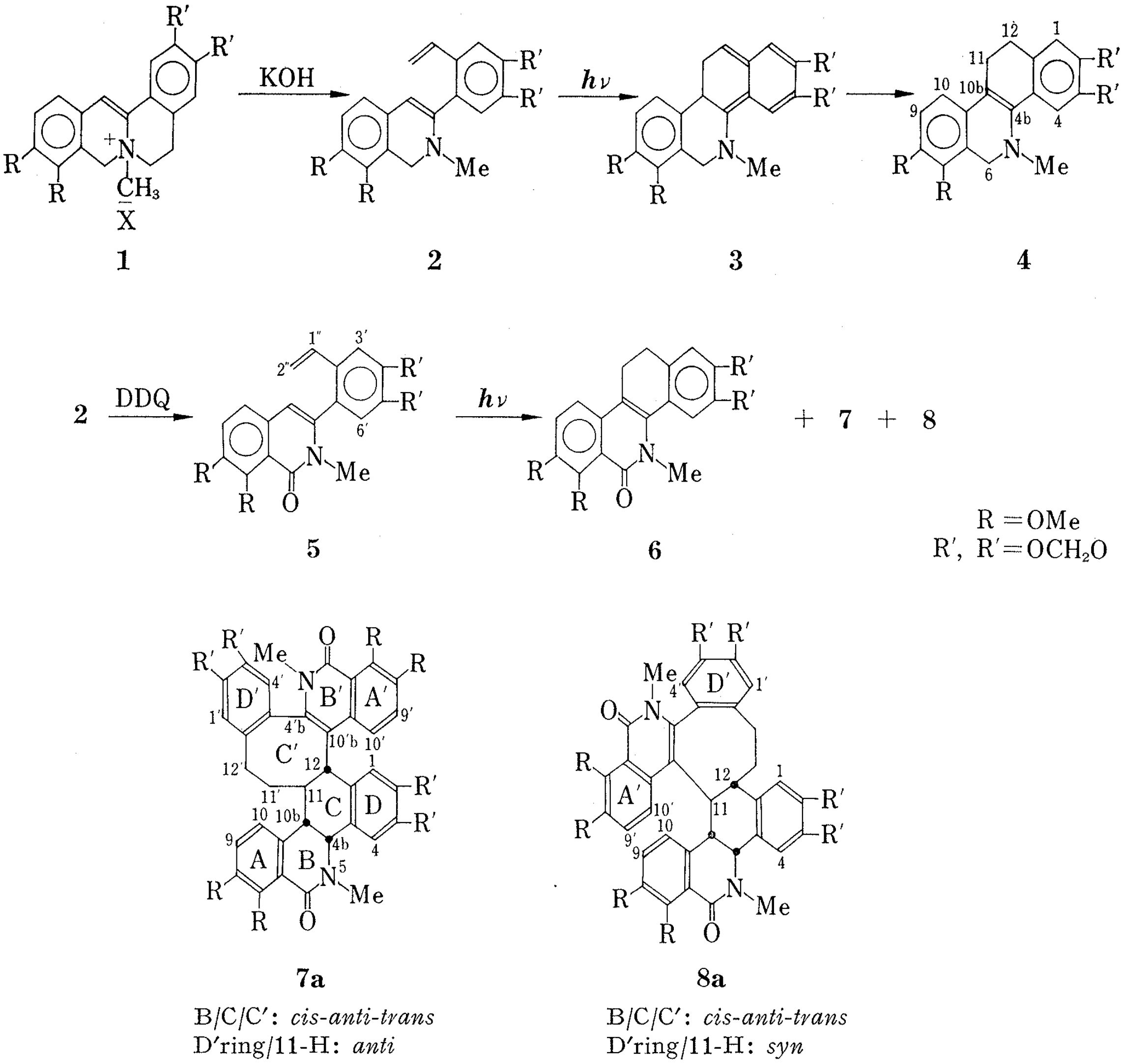
[1] Part X: M. Onda and H. Yamaguchi, *Heterocycles*, 9, 449 (1978).

[2] Location: *Minato-ku, Tokyo 108, Japan.*

[3] M. Onda, K. Yonezawa, and K. Abe, *Chem. Pharm. Bull.* (Tokyo), 19, 31 (1971).

[4] I. Ninomiya, O. Yamamoto, and T. Naito, *Heterocycles*, 7, 131 (1977).

seem appropriate for the dimers. Their PMR spectra (Table II) are instructive to deduce these structures.[5] The B/C ring fusions in both dimers are *cis* on the basis of the coupling constants of the 4b-H's. The Dreiding model of **7a** indicates an approach of the 1-H to the vicinity of the shielding zone of the double bond at the C-4'b and C-10'b, corresponding to a



B/C/C': *cis-anti-trans*
D'ring/11-H: *anti*

B/C/C': *cis-anti-trans*
D'ring/11-H: *syn*

Chart 1

Table I. The CMR Spectra of **7** and **8**

	C-7, -8, -7', -8'		C-2, -3, -2', -3'		C-4a, -6a, -10a, -12a, -4'a, -6'a, -10'a, -12'a, -4'b, -10'b					C-1, -4, -9, -10, -1', -4', -9', -10'			
7	152.5	151.9	146.9	146.6	136.0	133.5	133.1	131.3	130.6	120.3	118.4	117.8	115.0
	150.0	149.8	146.3	146.3	128.7	124.6	123.2	119.9	112.3	109.3	109.1	107.5	107.0
8	152.6	151.9	147.4	147.0	136.0	133.7	133.2	131.0	130.7	120.3	118.4	117.6	115.0
	150.0	149.9	146.3	146.2	128.9	124.7	123.1	119.8	112.7	108.8	108.6	108.5	106.7

	C-10b, -11, -12			C-4b	C-11', -12'		NMe (2)		OMe (4)		OCH$_2$O (2)		CO (2)	
7	43.1	37.7	34.6	60.1	28.2	27.7	37.7	36.4	61.5 56.7	61.5 56.0	101.4	101.1	162.8	162.0
8	44.2	37.9	33.6	59.6	26.4	25.1	38.4	36.9	61.6 56.7	61.4 56.0	101.4	101.1	162.7	162.2

---

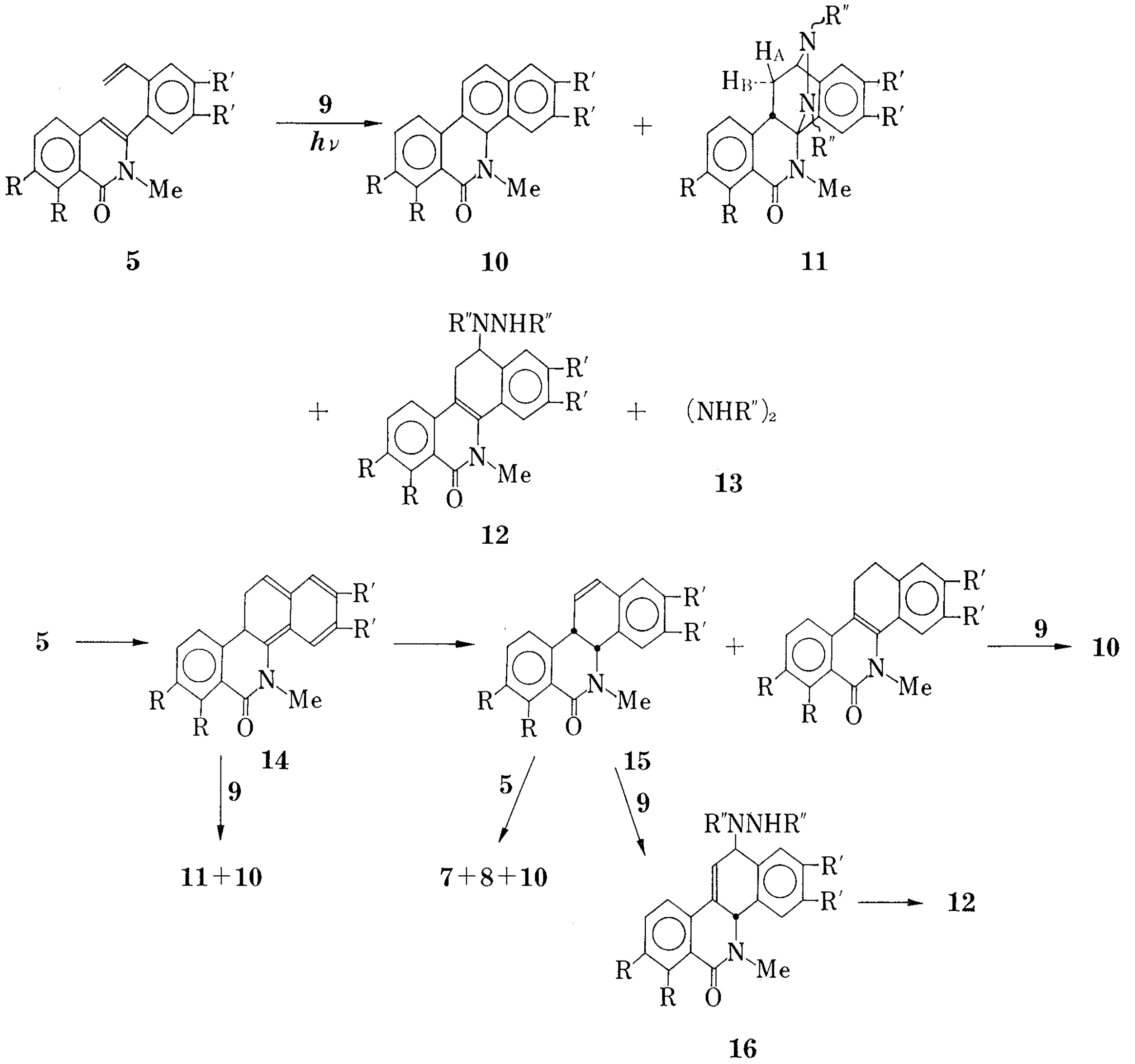
[5] Assignments were performed by comparisons with the PMR data of the related compounds in our hands.

one-proton singlet at δ 6.29. Also, the 5-Me group exists in a close proximity to the A′ ring and this would be responsible for the deshieldings of the 5-Me group (δ 3.12), 9′-H (δ 7.34) and 10′-H (δ 7.41). For **8a**, the 10-H (δ 6.47), 4′-H (δ 6.39) and 10′-H (δ 7.26) lie in the shielding zones of the A′, A and D rings, respectively. Based on these data, **7** and **8** are tentatively assigned the structures (**7a**) and (**8a**), respectively.

Compared with the photolysis of **2**, which gives **4** as a sole product, in the case of **5**, the dimers (**7**) and (**8**) are the main products rather than **6** corresponding to **4**. In order to determine the reason for this difference, attempts to trap the initial photo-product with dienophiles were undertaken.

Table II. The PMR Spectra of **7** and **8**

	1-H	4-H	1′-H	4′-H	9-H	10-H	9′-H	10′-H	4b-H	NMe (2)
7	6.29	6.91	6.60	6.72	6.75, d *J* 8 Hz	6.84, d *J* 8 Hz	7.34, d *J* 8 Hz	7.41, d *J* 8 Hz	4.54, d *J* 4 Hz	3.70 3.12
8	6.62	6.93	6.62	6.39	6.84, d *J* 8 Hz	6.47, d *J* 8 Hz	7.26, s	7.26, s	4.45, d *J* 4 Hz	3.70 3.01

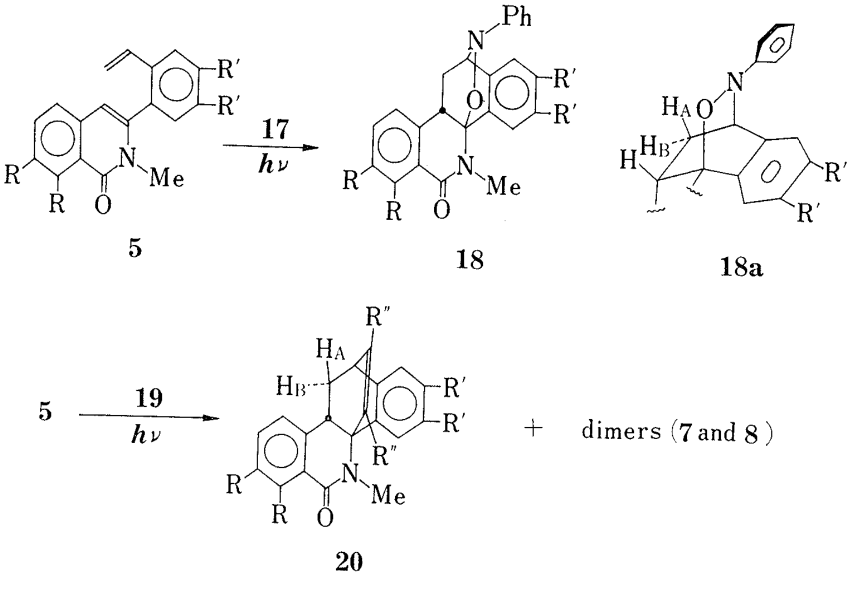


R=OMe R′,R′=OCH$_2$O R″=CO$_2$Et

Chart 2

Photolysis of **5** in the presence of diethyl azodicarboxylate (**9**) afforded oxychelerythrine (**10**) (38%),[6] the 4b, 12-hydrazo compound (**11**) (13%), the 12-hydrazo compound (**12**) (25%) and diethyl hydrazodicarboxylate (**13**) in an amount corresponding to that of **10**. The PMR spectrum of **11** exhibits the signals for the 12-H at δ 5.22 (dd, J 4 and 2 Hz), 10b-H at δ *ca.* 4.00, 11-H_A at δ 2.65 (ddd, J 14, 10 and 4 Hz) and 11-H_B at δ 2.14 (ddd, J 14, 6 and 2 Hz). The H_A and H_B at the C-11 are assigned on the basis of the assumption that the nitrogen lone pair[7] or ethoxycarbonyl group deshields the 11-H_A and the D ring shields the 11-H_B.[8] The 10b-H appears to be *cis* to the 11-H_A on the basis of the coupling constants and, accordingly, the B/C ring fusion in **11** would be *cis*.[9] The Dreiding model of **11** reveals the 4-H to lie in the shielding zone of the double bond of the lactam group. This would be responsible for the 4-H shielding (δ 6.52). The structure of **12** is also deduced from its PMR spectrum showing the signals for the 12-H at δ 5.42 (dd, J 8 and 3 Hz), 11-H_2 at δ 3.20—3.00 and NH at δ 1.74 (br s).

Thus, we deduce that **5** gives the initial photo-product (**14**) which is converted into *cis*-4b,10b-dihydrooxychelerythrine (**15**) and **6** by the 11-H and 10b-H shifts, respectively. Cycloaddition of **5** to **15** may give **7** and **8** in the head-to-tail and head-to-head modes, respectively, by the $[2_a+6_a]$cycloaddition followed by the 10′b-H shift. The product ratio of **6**, **7** and **8** shows that the 11-H shift in **14**, in contrast to that in **3**, is predominant. In the presence of **9**, the Diels-Alder addition of **9** to **14** leads to **11**.[10] The ene reaction of **9** with **15** affords the 12-hydrazo compound (**16**) which subsequently isomerizes to **12**.[10] This provides a plausible explanation for the formation of **12**. Since photolysis of **6** in the presence of **9** gave **10** as a sole product, a route to **10** is confirmed. Since **15** is the predominant product rather than **6** from **14** in the photolysis of **5** in the absence of **9**, as mentioned above,



R=OMe R′,R′=OCH_2O R″=CO_2Me

Chart 3

---

6) C. Tani and N. Takao, *Yakugaku Zasshi*, **82**, 755 (1962); M. Onda, K. Abe, and K. Yonezawa, *Chem. Pharm. Bull.* (Tokyo), **18**, 1435 (1970).

7) E.J. Shellard and K. Sarpong, *Tetrahedron*, **27**, 1725 (1971).

8) H. Hart, S.K. Ramaswami, and R. Willer, *J. Org. Chem.*, **44**, 1 (1979).

9) M. Onda, K. Yonezawa, and K. Abe, *Chem. Pharm. Bull.* (Tokyo), **19**, 31 (1971); M. Onda, K. Yonezawa, K. Abe, H. Toyama, and T. Suzuki, *ibid.*, **19**, 317 (1971).

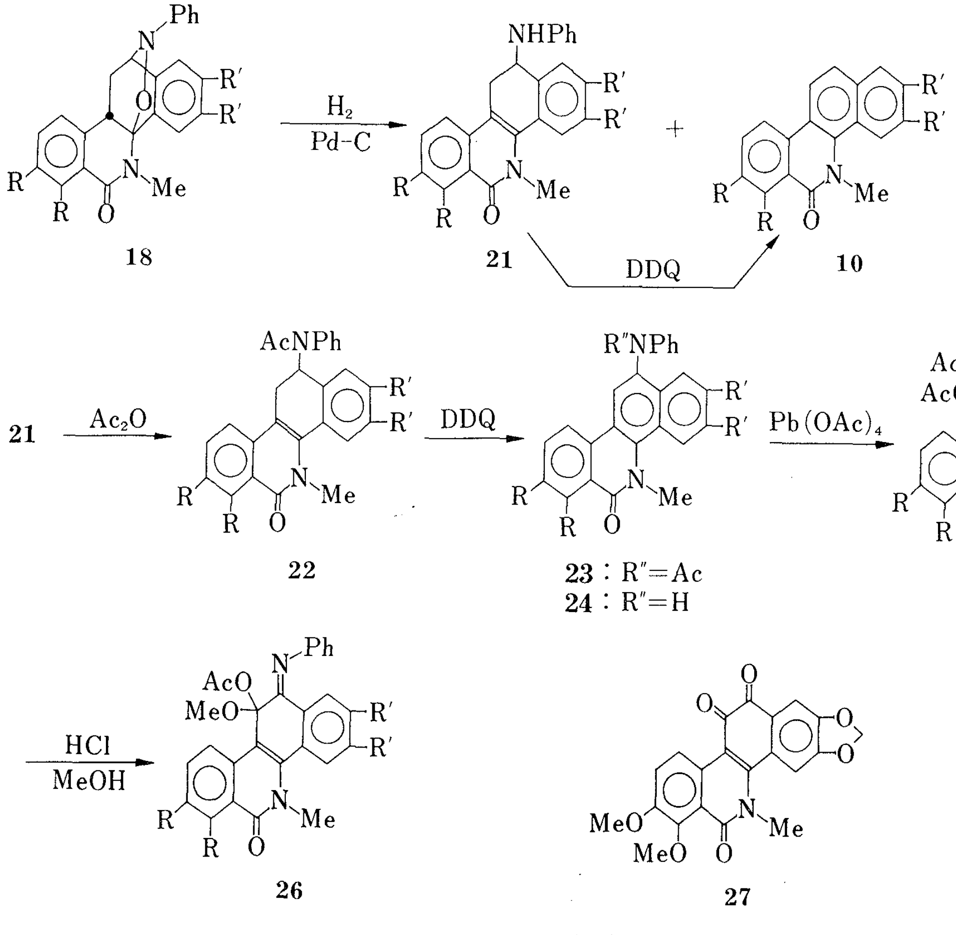
10) R. Huisgen and H. Pohl, *Chem. Ber.*, **93**, 527 (1960); B. Franzus, *J. Org. Chem.*, **28**, 2958 (1963); R. Askani, *Chem. Ber.*, **98**, 2551 (1965); H.M. Hoffmann, *Angew. Chem. Int. Ed. Engl.*, **8**, 556 (1969).

the formation of **10** is considered to be to a large extent compared with that of **12**. Accordingly, other pathways to **10** from **14** and **15** should be taken into consideration.

As seen above, the difference in the photolysates of **2** and **5** can be ascribed to the difference in the hydrogen shifts of **3** and **14**. Although the slightly flattened conformation of the B ring in **14** compared with that in **3** is thought to favor the 11-H shift over the 10b-H shift in 14, further investigation is required of this point.

Photolysis of **5** in the presence of nitrosobenzene (**17**) gave the 4b,12-epoxyimino compound (**18**) (86%) as a sole product by the Diels-Alder addition of **14** to **17**. The regioselectivity of this reaction is clear from the structure of the compound obtained by the next reaction. The B/C ring fusion in **18** is suggested to be *cis* on the basis of its PMR signals for the 12-H at δ 4.77 (dd, J 4 and 2 Hz), 10b-H at δ *ca.* 3.87, 11-H_A at δ 3.09 (ddd, J 14, 10 and 4 Hz), 11-H_B at δ 1.95 (ddd, J 14, 6 and 2 Hz) and 4-H at δ 6.54 (a) or 6.44 (s) by analogy with that of **11**. The preferential conformation (**18a**) of the N-Ph group would be *cis* to the D ring owing to steric interaction with the 11-H_A. This would explain why the 1-H (δ 6.54 or 6.44) is shielded by the N-Ph group.[8]

Photolysis of **5** in the presence of dimethyl acetylenedicarboxylate (**19**) under the same conditions (see Experimental) gave complex products. However, the use of a 20 W low pressure mercury lamp afforded the 4b,12-etheno compound (**20**) (30%) and a mixture of **7** and **8** (40%). The *cis* B/C ring fusion in **20** is confirmed by the PMR data (see Experimental) by analogy with those of **11**, **18** and a similar compound reported by one of us (M. O.).[9] Although the formation of **6** was monitored by thin-layer chromatography (TLC), in this case, its amount was too small for isolation.



R=OMe R′,R′=OCH_2O

Chart 4

The B/C ring fusion in the photo-adducts obtained above were deduced to be *cis* and no compound with the trans B/C ring fusion was detected. Since the 10b-H and 11-H_B in **14** are oriented axially on the upper and lower faces, respectively, and the steric surroundings of the C-4b and C-12 on both faces are nearly the same for the approach of the dienophiles, "steric approach control" may not be involved. Photo-adducts with the *trans* B/C ring fusion would be sterically hindered due to a close approach of the 4-H and 5-Me group compared to the case of the *cis* B/C. Thus, the trapping of **14** with the dienophiles should occur exclusively under "product development control" to afford stereoselectively the photo-adducts with the *cis* B/C ring fusion.

Among the photo-adducts obtained above, **18** is a potential intermediate for the preparation of oxychelerythrines. Hydrogenation of **18** over palladium-carbon in the presence of hydrochloric acid afforded the 12-anilino compound (**21**) (46%) and **10** (29%). The formula of **21**, $C_{27}H_{24}N_2O_5$, indicates that the anilino group is still present and the oxygen atom of the epoxyimino group is eliminated as water during the hydrogenation. The structure of **21** is established from its PMR spectrum showing the signals for the 12-H at δ 4.65 (dd, *J* 10 and 5 Hz), 11-H at δ 3.12 (dd, *J* 16 and 10 Hz), 11-H at δ 2.69 (dd, *J* 16 and 5 Hz) and NH at δ *ca.* 4.02. The positions of the nitrogen and oxygen atoms in **18** at this stage are thus determined. Oxidation of 21 with DDQ gave **10** (63%) by loss of aniline. DDQ oxidation of the acetate (**22**) derived in nearly quantitative yield from **21** gave the 12-acetanilide (**23**) (82%) whose structure was confirmed by its PMR signal for the 11-H at δ 7.96 (s).

On hydrolysis (→**24**) and oxidation with lead tetraacetate **23** afforded the diacetate (**25**) in 40% overall yield. Its infrared (IR) spectrum shows two carbonyl bands of the acetoxy groups at 1756 and 1710 cm^{-1} in addition to the lactam carbonyl band at 1645 cm^{-1}. These data and the PMR spectrum (see Experimental) are in accord with structure of **25**. Heating of **25** in methanol under acidic conditions furnished the acetate (**26**) (45%) instead of the quinone (**27**). The presence of the acetoxy and newly introduced methoxyl groups in **26** is supported by its PMR signals at δ 1.73 and 3.88, respectively.

Experimental

Melting points were determined on a micro hot-stage and are not corrected. IR spectra were recorded on a JASCO IR-G in chloroform solution. PMR and CMR spectra were taken on a JEOL JNM PS-100 at 100 and 25.1 MHz, respectively, in deuterochloroform solution. MS were measured with a JEOL JMS-OIS. Photolyses were carried out with a 100 W medium pressure mercury lamp unless otherwise stated under nitrogen. Preparative TLC's were performed on silica gel plates using benzene: ethyl acetate=1:1, v/v as a solvent unless otherwise noted.

7,8-Dimethoxy-2-methyl-3-(4′,5′-methylenedioxy-2′-vinylphenyl)isocarbostyril (**5**)——A solution of **1** ($X=MeSO_4$) (1.0 g) in 25% KOH–MeOH solution (9 ml) was refluxed for 3 min. After cooling, the reaction mixture was poured onto ice-water. The precipitate was collected by filtration and dissolved in benzene. The benzene solution was washed with water and dried over Na_2SO_4 for 30 min. Removal of benzene *in vacuo* gave 7,8-dimethoxy-2-methyl-3-(4′,5′-methylenedioxy-2′-vinylphenyl)-1,2-dihydroisoquinoline (**2**) (*ca.* 790 mg) as a syrup, which was immediately used without purification. A solution of **2** (*ca.* 790 mg) and DDQ (500 mg) in chloroform (120 ml) was stirred at room temperature overnight. After filtration, the chloroform solution was washed with 5% aq. NaOH solution and water, then dried over Na_2SO_4. The chloroform solution afforded a syrup (800 mg), and column chromatography (neutral alumina, grade III; 50 g) gave light yellow crystals (383 mg) from the eluate with benzene: ethyl acetate (95:5, v/v). Further purification was performed by preparative TLC to give **5** (341 mg, 44%), *Rf* 0.51, as light yellow needles of mp 179—180° (from EtOH). IR ν_{max} cm^{-1}: 1645 (NC=O). PMR δ: 7.29 (1H, d, *J* 9 Hz, 5-H), 7.17 (1H, d, *J* 9 Hz, 6-H), 7.10 (1H, s, 6′-H), 6.69 (1H, s, 3′-H), 6.25 (1H, s, 4-H), 6.22 (1H, dd, *J* 17 and 11 Hz, 1″-H), 6.00 (2H, s, OCH_2O), 5.56 (1H, dd, *J* 17 and 1 Hz, 2″-H), 5.10 (1H, dd, *J* 11 and 1 Hz, 2″-H), 4.00 (3H, s, 8-OMe), 3.92 (3H, s, 7-OMe), 3.20 (3H, s, 2-Me). *Anal.* Calcd. for $C_{21}H_{19}NO_5$: C, 69.03; H, 5.24; N, 3.83. Found: C, 68.71; H, 5.37; N, 3.75. MS *m/e*: M^+, 365.127 (M, 365.126).

Photolysis of 5——A solution of **5** (104 mg) in anhyd. benzene (165 ml) was irradiated for 10 min. The reaction mixture was evaporated *in vacuo* to give an oil which was purified by preparative TLC (ethyl acetate). The zone with *Rf* 0.60 gave **6** (31 mg, 30%) as light yeloow needles of mp 208—209° (from EtOH). IR ν_{max} cm^{-1}: 1637 (NC=O). PMR δ: 7.41 (1H, d, *J* 9 Hz, 10-H), 7.29 (1H, d, *J* 9 Hz, 9-H), 6.87 (1H, s, 4-H), 6.76 (1H, s, 1-H), 5.95 (2H, s, OCH_2O), 4.01 (3H, s, 7-OMe), 3.92 (3H, s, 8-OMe), 3.65 (3H, s, 5-Me), 2.72 (4H, s, 11- and 12-H$_2$). MS *m/e*: M$^+$, 365.126. Calcd. for $C_{21}H_{19}NO_5$: M, 365.126. The zone with *Rf* 0.24 gave the dimer (**7**) (39 mg, 38%) as colorless pillars of mp 204—206° (from benzene). IR ν_{max} cm^{-1}: 1640 (NC=O). MS *m/e*: M$^+$, 730.252. Calcd. for $C_{42}H_{38}N_2O_{10}$: M, 730.253. The zone with *Rf* 0.20 yielded the dimer (**8**) (30 mg, 29%) as light yellow pillars of mp 198—200° (from benzene). IR ν_{max} cm^{-1}: 1640 (NC=O). MS *m/e*: M$^+$, 730.252. Calcd. for $C_{42}H_{38}N_2O_{10}$: M, 730.253.

Photolysis of 5 in the Presence of 9——A solution of **5** (101 mg) and **9** (60 mg) in anhyd. benzene (180 ml) was irradiated for 15 min. Work-up gave an oil which was purified by column chromatography (neutral alumina, grade III; 10 g). The eluate with benzene/ethyl acetate (20: 1, v/v) afforded **10** (38 mg, 38%) as colorless pillars of mp 199.5—201° (from benzene). MS *m/e*: M$^+$, 363.110. Calcd. for $C_{21}H_{17}NO_5$: M, 363.111. This compound was identified with an authentic sample[6] by comparisons of the IR, PMR spectra and mp. The eluate with benzene: ethyl acetate (5: 1, v/v) gave an oil (92 mg), and preparative TLC yielded three compounds.

4b,12-Dicarboethoxyhydrazo-4b,10b,11,12-tetrahydrooxychelerythrine (**11**): 19 mg (13%), *Rf* 0.20, colorless crystals of mp 121.5—123° (from benzene). IR ν_{max} cm^{-1}: 1720 (OC=O), 1650 (NC=O). PMR δ: 6.79 (1H, d, *J*8 Hz, 10-H), 6.68 (1H, s, 1-H), 6.52 (1H, s, 4-H), 6.48 (1H, d, *J*8 Hz, 9-H), 5.84 and 5.81 (1H each, d, *J*1.5 Hz, OCH$_2$O), 5.22 (1H, dd, *J*4 and 2 Hz, 12-H), 4.27 and 4.03 (2H each, q, *J*7 Hz, 2×OCH$_2$Me), *ca.* 4.00 (1H, m, 10b-H), 3.93 (3H, s, 7-OMe), 3.76 (3H, s, 8-OMe), 3.33 (3H, s, 5-Me), 2.65 (1H, ddd, *J*14, 10 and 4 Hz, 11-H$_A$), 2.14 (1H, ddd, *J*14, 6 and 2 Hz, 11-H$_B$), 1.30 and 1.14 (3H each, t, *J*7 Hz, 2×OCH$_2$Me). MS *m/e*: M$^+$, 539.189. Calcd. for $C_{21}H_{29}N_3O_9$: M, 539.190.

12-(1′,2′-Dicarboethoxyhydrazo)-11,12-dihydrooxychelerythrine (**12**): 37 mg (25%), *Rf* 0.40, light yellow crystals of mp 121—123.5° (from benzene). IR ν_{max} cm^{-1}: 3400 (NH), 1750 and 1710 (OC=O), 1640 (NC=O). PMR δ: 7.43 (1H, d, *J*8 Hz, 10-H), 7.33 (1H, s, 1-H), 7.30 (1H, d, *J*8 Hz, 9-H), 6.92 (1H, s, 4-H), 5.99 (2H, s, OCH$_2$O), 5.42 (1H, dd, *J*8 and 3 Hz, 12-H), 4.23 and 3.92 (2H each, q, *J*7 Hz, 2×OCH$_2$Me), 4.00 (3H, s, 7-OMe), 3.92 (3H, s, 8-OMe), 3.64 (3H, s, 5-Me), 3.20—3.00 (2H, m, 11-H$_2$), 1.74 (1H, br s, NH),[11] 1.28 and 1.12 (3H each, t, *J*7 Hz, 2×OCH$_2$Me). MS *m/e*: M$^+$, 539.190. Calcd. for $C_{21}H_{29}N_3O_9$: M, 539.190.

Diethyl hydrazodicarboxylate (**13**): 19 mg, *Rf* 0.54, colorless needles of mp 85—89° (from benzene). IR ν_{max} cm^{-1}: 3450 (NH), 1736 (OC=O). MS *m/e*: M$^+$, 176.081. Calcd. for $C_6H_{12}N_2O_4$: M, 176.080.

Photolysis of 6 in the Presence of 9——A solution of **6** (10 mg) and **9** (6 mg) in anhyd. benzene (150 ml) was irradiated for 15 min. Work-up gave **10** (7 mg, 70%) as colorless pillars of mp 199.5—201° (from benzene).

Photolysis of 5 in the Presence of 17——A solution of **5** (103 mg) and **17** (35 mg) in anhyd. benzene (120 ml) was irradiated for 10 min. Work-up afforded a syrup, and preparative TLC yielded 4b,12-N-phenylepoxyimino-4b,10b,11,12-tetrahydrooxychelerythrine (**18**) (114 mg, 86%), *Rf* 0.56, as colorless plates of mp 138.5—139.5° (from ether). IR ν_{max} cm^{-1}: 1655 (NC=O). PMR δ: 7.16—7.08 (2H, m, 2×*m*-H of Ph group), 6.91—6.83 (3H, m, 2×*o*- and *p*-H of Ph group), 6.91 (1H, d, *J*8 Hz, 10-H), 6.63 (1H, d, *J*8 Hz, 9-H), 6.54 (1H, s, 4-H),[12] 6.44 (1H, s, 1-H),[12] 5.76 and 5.73 (1H each, d, *J*1.5 Hz, OCH$_2$O), 4.77 (1H, dd, *J*4 and 2 Hz, 12-H), 3.98 (3H, s, 7-OMe), *ca.* 3.87 (1H, m, 10b-H), 3.76 (3H, s, 8-OMe), 3.42 (3H, s, 5-Me), 3.09 (1H, ddd, *J*14, 10 and 4 Hz, 11-H$_A$), 1.95 (1H, ddd, *J*14, 6 and 2 Hz, 11-H$_B$). *Anal.* Calcd. for $C_{27}H_{24}N_2O_6$: C, 68.63; H, 5.12; N, 5.93. Found: C, 68.35; H, 5.58; N, 5.58. MS *m/e*: M$^+$, 472.161 (M, 472.163).

Photolysis of 5 in the Presence of 19——A solution of **5** (100 mg) and **19** (155 mg) in anhyd. MeOH (80 ml) was irradiated with a 20 W low pressure mercury lamp under N$_2$ for 1 hr. Work-up gave an oil, and preparative TLC afforded 4b,12-dicarbomethoxyetheno-4b,10b,11,12-tetrahydrooxychelerythrine (**20**) (41 mg, 30%), *Rf* 0.45, as light yellow crystals of mp 135.5—137° (from ether). IR ν_{max} cm^{-1}: 1722 (OC=O), 1645 (NC=O). PMR δ: 6.82 (1H, d, *J*8 Hz, 10-H), 6.72 (1H, s, 1-H), 6.57 (1H, d, *J*8 Hz, 9-H), 6.44 (1H, s, 4-H), 5.80 and 5.77 (1H each, d, *J*1 Hz, OCH$_2$O), 4.45 (1H, dd, *J*4 and 2 Hz, 12-H), 3.93 (3H, s, 7-OMe), 3.83 (3H, s, 8-OMe), 3.78 and 3.75 (3H each, s, 2×COOMe), 3.63 (1H, dd, *J*10 and 7 Hz, 10b-H), 3.26 (3H, s, 5-Me), 2.45 (1H, ddd, *J*13, 10 and 4 Hz, 11-H$_A$), 1.75 (1H, ddd, *J*13, 7 and 2 Hz, 11-H$_B$). MS *m/e*: M$^+$, 507.153. Calcd. for $C_{27}H_{25}NO_9$: M, 507.153. In addition, **5** (27 mg, 27%) and a mixture of **7** and **8** (40 mg, 40%) were isolated from the zones with *Rf* 0.51 and 0.22, respectively.

Hydrogenation of 18——A solution of **18** (50 mg) and conc. HCl (one drop) in MeOH (5 ml) was shaken with H$_2$ over 10% Pd-C (10 mg) for 8 min. Work-up gave an oil which was purified by preparative TLC to afford 12-anilino-11,12-dihydrooxychelerythrine (**21**) (22 mg, 46%), *Rf* 0.34, as yellow pillars of mp 135—136° (from EtOH). IR ν_{max} cm^{-1}: 3420 (NH), 1638 (NC=O). PMR δ: 7.37 (1H, d, *J*8 Hz, 10-H), 7.28 (1H, d, *J*8 Hz, 9-H), 7.12—6.67 (7H, m, 1-, 4-H and 5×H of Ph group), 5.97 (2H, s, OCH$_2$O), 4.65 (1H, dd, *J*10 and 5 Hz, 12-H), 4.02 (4H, s, 7-OMe and NH),[10] 3.92 (3H, s, 8-OMe), 3.70 (3H, s, 5-Me), 3.12 (1H, dd, *J*16 and 5 Hz, 11-H), 2.69 (1H, dd, *J*16 and 10 Hz, 11-H). MS *m/e*: M$^+$, 456.166. Calcd. for $C_{27}H_{24}N_2O_5$: M, 456.169. In addition, from the zone with *Rf* 0.46 **10** (11 mg, 29%) was obtained as colorless pillars of mp 199.5—201° (from benzene).

---

[11] On addition of D$_2$O, this signal disappeared.

[12] Assignment may be reversed.

DDQ Oxidation of 21——A solution of **21** (20 mg) and DDQ (10 mg) in dioxane (1 ml) was refluxed for 20 min, and the reaction mixture was extracted with chloroform. Work-up gave an oil, and preparative TLC afforded **10** (10 mg, 63%), *Rf* 0.46, as colorless pillars of mp 199.5—201° (from benzene).

12-Acetanilido-11,12-dihydrooxychelerythrine (22)——A mixture of **21** (51 mg) and acetic anhydride (0.3 ml) was stirred at room temperature for 2 hr. The reaction mixture was made alkaline with aq. Na_2CO_3 solution to extract with benzene. Work-up gave an oil, and preparative TLC (benzene: ethyl acetate = 1: 2, v/v) provided **22** (54 mg, 96%), *Rf* 0.21, as light yellow prisms of mp 223.5—224° (from ether). IR ν_{max} cm^{-1}: 1638 and 1622 (NC=O). PMR δ: 7.42 (1H, d, *J*8 Hz, 10-H), 7.28 (1H, d, *J*8 Hz, 9-H), 7.13—6.77 (3H, m, 2 × *m*- and *p*-H of Ph group),[11] 6.98 (1H, s, 4-H), 6.60 (1H, s, 1-H), 6.50 (2H, dt, *J*8 and 1 Hz, 2 × *o*-H of Ph group),[13] 6.00 and 5.95 (1H each, d, *J*1 Hz, OCH_2O), 5.93 (1H, dd, *J*6 and 3 Hz, 12-H), 3.95 (3H, s, 7-OMe), 3.92 (3H, s, 8-OMe), 3.49 (1H, dd, *J*16 and 3 Hz, 11-H), 2.91 (3H, s, 5-Me), 2.88 (1H, dd, *J*16 and 6 Hz, 11-H), 1.71 (3H, s, NCOMe). MS *m/e*: M^+, 498.180. Calcd. for $C_{29}H_{26}N_2O_6$: M, 498.179.

12-Acetanilidooxychelerythrine (23)——A solution of **22** (54 mg) and DDQ (25 mg) in dioxane (3 ml) was refluxed for 2.5 hr. After removal of dioxane *in vacuo* and addition of aq. Na_2CO_3 solution, the reaction mixture was extracted with chloroform to afford **23** (44 mg, 82%) as colorless crystals of mp 304—305° (dec.) (from chloroform). IR ν_{max} cm^{-1}: 1645 (NC=O). PMR δ: 7.96 (1H, s, 11-H), 7.85 (1H, d, *J*9 Hz, 10-H), 7.56 (1H, s, 4-H), 7.51 (1H, d, *J*9 Hz, 9-H), 7.48—7.15 (6H, m, 1-H and 5 × H of Ph group), 6.10 (2H, s, OCH_2O), 4.05 (3H, s, 7-OMe), 3.97 (3H, s, 8-OMe), 3.89 (3H, s, 5-Me), 2.08 (3H, s, NCOMe). MS *m/e*: M^+, 496.163. Calcd. for $C_{29}H_{24}N_2O_6$: M, 496.163.

12-Anilinooxychelerythrine (24)——To a suspension of **23** (30 mg) in dioxane (7 ml) was added 25% KOH–MeOH solution (1.5 ml) and the reaction mixture was refluxed for 30 min. After removal of dioxane *in vacuo* and addition of water, the reaction mixture was extracted with chloroform. Work-up afforded an oil, and preparative TLC gave **24** (18 mg, 64%), *Rf* 0.26, as light orange crystals of mp 131.5—132° (from ether). IR ν_{max} cm^{-1}: 3400 (NH), 1640 (NC=O). PMR δ: 7.90 (1H, s, 11-H), 7.79 (1H, d, *J*8 Hz, 10-H), 7.52 (1H, s, 4-H), 7.39 (1H, s, 1-H), 7.30 (1H, d, *J*8 Hz, 9-H), 7.30—7.15 (2H, m, 2 × *m*-H of Ph group), 6.91—6.73 (3H, m, 2 × *o*- and *p*-H of Ph group), 6.05 (2H, s, OCH_2O), 5.66 (1H, br s, NH),[10] 4.06 (3H, s, 7-OMe), 3.94 (3H, s, 8-OMe), 3.88 (3H, s, 5-Me). MS *m/e*: M^+, 454.152. Calcd. for $C_{27}H_{22}N_2O_5$: M, 454.153.

11,11-Diacetoxy-12-phenylimino-11,12-dihydrooxychelerythrine (25)——To a solution of **24** (36 mg) in acetic acid (0.15 ml) was added lead tetraacetate (85 mg) over 45 min with stirring. After addition of ethylene glycol (0.005 ml), the reaction mixture was stirred at room temperature for 10 min and then made alkaline with aq. Na_2CO_3 solution to extract with benzene. Work-up gave brown crystals, and preparative TLC afforded **25** (28 mg, 62%), *Rf* 0.30, as yellow crystals of mp 160—160.5° (from MeOH). IR ν_{max} cm^{-1}: 1756 and 1710 (OC=O), 1645 (NC=O). PMR δ: 8.38 (1H, d, *J*9 Hz, 10-H), 7.40—7.12 (6H, m, 9-H and 5 × H of Ph group), 6.85 (1H, s, 4-H), 6.41 (1H, s, 1-H), 5.89 and 5.86 (1H each, d, *J*1 Hz, OCH_2O), 4.00 (3H, s, 7-OMe), 3.92 (3H, s, 8-OMe), 3.72 (3H, s, 5-Me), 2.30 and 1.66 (3H each, s, 2 × 11-OCOMe). MS *m/e*: M^+, 570.163. Calcd. for $C_{31}H_{26}N_2O_9$: M, 570.164.

11-Acetoxy-11-methoxy-12-phenylimino-11,12-dihydrooxychelerythrine (26)——A solution of **25** (20 mg) and conc. HCl (one drop) in MeOH (3 ml) was refluxed for 15 min. After removal of MeOH *in vacuo*, the reaction mixture was made alkaline with aq. Na_2CO_3 solution to extract with benzene. The benzene residue was purified by preparative TLC to afford **26** (9 mg, 45%), *Rf* 0.32, as yellow crystals of mp 281—281.5° (from MeOH). IR ν_{max} cm^{-1}: 1712 (OC=O), 1652 (NC=O). PMR δ: 8.20 (1H, d, *J*9 Hz, 10-H), 7.39 (1H, d, *J*9 Hz, 9-H), 7.34—7.11 (5H, m, 5 × H of Ph group), 6.82 (1H, s, 4-H), 6.70 (1H, s, 1-H), 5.82 (2H, s, OCH_2O), 3.99 (3H, s, 7-OMe), 3.93 (3H, s, 8-OMe), 3.88 (3H, s, 11-OMe), 3.72 (3H, s, 5-Me), 1.73 (3H, s, 11-OCOMe). *Anal.* Calcd. for $C_{30}H_{26}N_2O_8$: C, 66.41; H, 4.83; N, 5.16. Found: C, 66.11; H, 4.92; N, 5.29. MS *m/e*: M^+, 542.170 (M, 542.169).

---

[13] Assignment was referred to the PMR spectrum of acetanilide.