

## THE BENZOPHENANTHRIDINE ALKALOIDS

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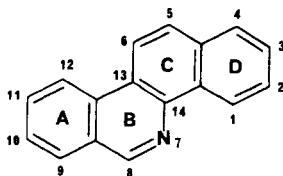
The first reported isolations of benzophenanthridine alkaloids, albeit in impure form, date back to the first half of the 19th century (208). Since then, several other benzophenanthridines have been found in plants, so that presently, nearly 80 naturally occurring compounds of this type are known.

The proposed structures and absolute configurations of a number of benzophenanthridine alkaloids have undergone revisions in recent years. Using a variety of spectral methods, the structural assignments for (+)-corynoline (**67**) (297) and related compounds, (+)-chelidonine (**57**) (293), as well as chelirubine (**2**), chelilutine (**9**), sanguirubine (**10**), and sanguilutine (**14**), have been modified. The structure of (+)-isocorynoline (**78**) and its identity with the compound known as (+)-epicorynoline has been determined (40).

Some of the benzophenanthridines with C-8 substituents listed here may be artifacts; although some others, especially if optically active due to such a substituent, are true natural products. Avicine (**15**), which has been investigated for its pharmacological activity, is rather unstable and disproportionates into its dihydro- and oxy-derivatives (6). Nitidine (**16**) tends to follow a similar pathway.

The present collection of spectral data has been hampered by the low solubility of most of the quaternary salts. In such cases, the inclusion of  $^1\text{H}$ -nmr data for the more soluble pseudocyanide derivatives has been necessary.

There is no universally accepted numbering system for the benzophenanthridines, but the numbering system indicated below, based upon biogenetic considerations, has been adopted throughout this review. The names of some of the alkaloids have been revised to conform to this system.



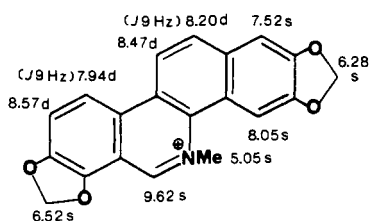
Some members of the benzophenanthridines and their derivatives have been studied extensively for their nematocidal, antitumor, and cytotoxic activity (38, 39, 199). Fagaronine (**17**) and nitidine (**16**) have exhibited antileukemic activity (199). Sanguinarine (**1**), as a contaminant in cooking oil, has been implicated in outbreaks of heart disease, glaucoma, cancer, and other illnesses in the Indian population (101, 102).

Ultraviolet wavelengths are in nm and are followed by log  $\epsilon$  values between parentheses; the values quoted are for  $\lambda$  max, unless specified otherwise; ir values are in  $\text{cm}^{-1}$ ; the  $^1\text{H}$ -nmr chemical shifts are given as  $\delta$  values. Chemical shifts possessing identical superscripts are interchangeable. All  $^1\text{H}$ -nmr values are at 60 MHz unless

otherwise indicated, and TMS is the internal reference standard unless HMDS (hexamethyldisiloxane) is noted. In citing the mass spectral data, the numbers in parentheses following the mass fragment data are percentages of the base peak.

Botanical sources are listed as cited in the original references. It should be noted, however, that *Fagara* is synonymous with *Xanthoxylum* or *Zanthoxylum* (Rutaceae), while *Bocconia* is synonymous with *Macleaya* (Papaveraceae). Finally, it should be pointed out that most of the benzophenanthridine alkaloids are found within three plant families only, namely, the Papaveraceae, Fumariaceae, and Rutaceae.

**1. SANGUINARINE**  
( $\psi$ -chelerythrine)  
(pseudochelerythrine)



$C_{20}H_{14}NO_4^+$ : 332.33888

MP: ( $Cl^-$ ) 264-266° (Et<sub>2</sub>O) (234)

( $Cl^-$ ) 273° (CHCl<sub>3</sub>-MeOH) (309)

( $Cl^-$ ) 286-288° (Me<sub>2</sub>CO-conc. HCl) (188)

( $\psi$ -CN) 236-237° (256)

( $\psi$ -CN) 244-245° (CHCl<sub>3</sub>-EtOH) (266)

See also 24, 98, 105c, 137, 161, 188, 237, 240, 244, 251, 252, 254, 257, 259, 262, 264, 265, 270, 274, 275, 302, 303.

UV: ( $Cl^-$ ) (EtOH) 236 (4.49), 285 (4.53), 328 (4.25), 352 sh (3.85), 400 (3.07), 476 (3.12);  $\lambda_{min}$  255 (4.25), 308 (4.12), 376 (2.99), 435 (2.99) (108)

See also 105c, 130, 234, 266, 302, 304, 309, 312.

IR: ( $Cl^-$ ) 3560, 3360, 1662, 1647, 1617, 1595, 1537, 1524, 1499, 1331, 1307, 1278, 1251, 1234, 1220, 1205, 1176, 1160, 1126, 1105, 1030, 1008, 978, 965, 915, 868, 843, 834, 804, 789 (105c)

<sup>1</sup>H-NMR: ( $Cl^-$ ) (TFA-*d*) (150)

See also 130, 151, 234, 247, 312.

MS: ( $Cl^-$ ) 347 (18), 333 (30), 332 (10), 317 (100) (75)

See also 153, 247, 302.

LCAO: (150)

Sources:

Fumariaceae: *Corydalis* (11, 12, 35, 102, 110, 129, 136, 161, 162, 201, 210, 233, 301, 302, 303, 304, 305)

*Dicentra* (45, 110, 238)

*Fumaria* (55)

Papaveraceae: *Argemone* (13, 14, 20, 26, 52, 97, 98, 99, 100, 102, 171, 213, 251, 260, 269, 271, 273, 282, 284, 286)

*Bocconia* (53, 54, 93, 94, 142, 149, 155, 157, 164, 187, 189, 264, 266, 288, 306, 307)

*Chelidonium* (16, 18, 46, 79, 82, 95, 130, 152, 168, 219, 220, 226, 237, 252, 265, 267, 329)

*Dicranostigma* (157, 259, 272, 274)

*Eschscholtzia* (57, 110, 220, 248, 253, 263, 268)

*Glaucium* (25, 32, 58, 137, 144, 184, 236, 240, 243, 255, 256, 262, 270, 276, 331)

*Hunnemannia* (249, 275)

*Hylomecon* (246)

*Hypecoum* (258, 330)

*Macleaya* (34, 110, 143, 151, 254, 266, 300)

*Meconopsis* (103, 241)

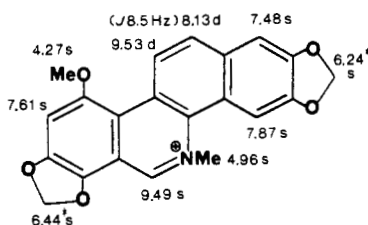
*Papaver* (23, 75, 102, 110, 153, 165, 174, 197)

*Platystemon* (245, 261)

*Romneya* (283)*Sanguinaria* (96, 140, 145, 215, 219, 246, 257, 309, 310)*Stylomecon* (246)*Stylophorum* (157, 217, 244)Rutaceae: *Zanthoxylum* (146)Sapindaceae: *Pteridophyllum* (109)**2. CHELIRUBINE**

(bocconine)

(base B)

 $C_{21}H_{16}NO_5^+$ : 362.36537MP: ( $Cl^-$ ) 282-283° (257)( $Cl^-$ ) 299-302° (dec) ( $H_2O$ ) (121, 127)( $\psi$ -CN) 269-270° ( $CHCl_3$ -EtOH) (237, 254, 259, 266)( $\psi$ -CN) 273-274° ( $CHCl_3$ -EtOH) (257, 262)

See also 240, 244, 250, 274.

UV: ( $Cl^-$ ) (EtOH) 231.5 (4.50), 281 (4.46), 305 sh (3.99), 341 (4.24), 353.5 (4.25), 413 (2.91), 508 (3.17);  $\lambda_{min}$  254 (4.16), 312 (3.95), 347 (4.23), 403 (2.90), 444 (2.85) (108)

See also 104c, 234, 250, 266.

IR: ( $Cl^-$ ) 3350, 1648, 1605, 1555, 1520, 1511, 1486, 1328, 1305, 1285, 1260, 1224, 1209, 1192, 1128, 1038, 1018, 980, 964, 937, 908, 875, 828, 790 (104c) $^1H$ -NMR: ( $Cl^-$ ) 100 MHz (TFA-*d*) (127)

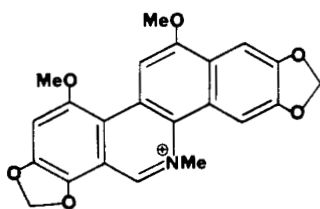
See also 234, 247.

Sources:

Fumariaceae: *Dicentra* (238)Papaveraceae: *Bocconia* (149, 187, 189, 288, 306)*Chelidonium* (226, 237, 252, 267)*Dicranostigma* (259, 272, 274)*Eschscholtzia* (110, 248, 253, 263, 268)*Glaucium* (32, 184, 236, 240, 243, 255, 256, 257, 262, 270, 276)*Hunnemannia* (249, 275)*Hylomecon* (246)*Hypocoum* (258)*Macleaya* (110, 254, 266, 300, 306)*Papaver* (110)*Platystemon* (245, 261)*Sanguinaria* (242, 246, 257)*Stylophorum* (244)

For structure revision, see 113.

For identity with bocconine, see 250.

**3. MACARPINE** $C_{22}H_{18}NO_6^+$ : 392.39186MP: ( $Cl^-$ ) 283-285° (268, 300)( $\psi$ -CN) 236-237° ( $CHCl_3$ -EtOH) (244, 268)

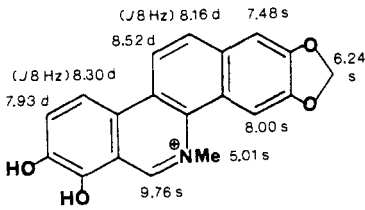
See also 254, 263, 266.

UV: (MeOH) 285 (4.4), 342 (4.2);  $\lambda_{min}$  254 (4.1), 307 (4.0) (268)

Sources:

Papaveraceae: *Eschscholtzia* (248, 263, 268)*Macleaya* (254, 266, 300)*Stylophorum* (244)

4. 9,10-DEMETHYLENE-SANGUINARINE

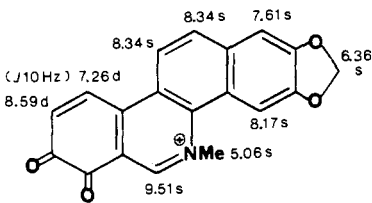


$C_{19}H_{14}NO_4^+$ : 320.32773  
 MP:  $(CF_3COO^-)$  217.5-220° (151)  
 226-227° (151)  
 $^1H$ -NMR: 100 MHz (TFA-*d*) (151)

Sources:

Papaveraceae: *Macleanya* (151)

5. 9,10-DEMETHYLENE-9,10-DEHYDROSANGUINARINE

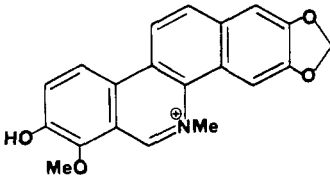


$C_{19}H_{12}NO_4^+$ : 318.31179  
 MP: 183° ( $CHCl_3$ ) (151)  
 $^1H$ -NMR: 100 MHz (TFA-*d*) (151)

Sources:

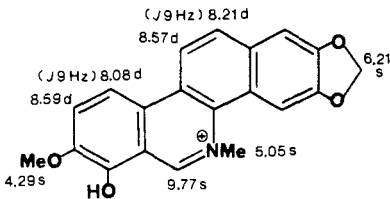
Papaveraceae: *Macleanya* (151)

6. N-METHYLDECARINE



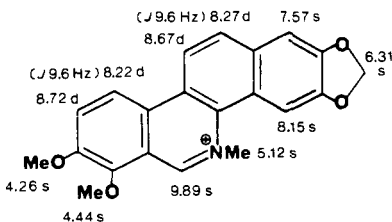
$C_{20}H_{16}NO_4^+$ : 334.35482  
 MP:  $(Cl^-)$  137-139° (EtOH-N HCl) (322)  
 UV:  $(Cl^-)$  (EtOH) 223, 256, 276, 289, 325 (322)  
 IR:  $(Cl^-)$  3300, 1460, 1360, 1237, 1205, 830, 755 (322)  
 MS: 333.1000 ( $M-1$ )<sup>+</sup> (322)  
 Sources: Synthetic (322)

7. FAGARIDINE



$C_{20}H_{16}NO_4^+$ : 334.35482  
 MP: 269-270° (MeOH) (317)  
 UV: (EtOH) 228 (4.55), 284 (4.65), 322 sh (4.14);  
 $\lambda_{min}$  252 (4.16) (317)  
 IR:  $(KBr)$  3420 (br), 3040, 2915, 2870, 1610, 1550, 1485, 1350, 1280, 950, 725 (317)  
 $^1H$ -NMR: 100 MHz (TFA-*d*) (317)  
 MS: 334 ( $M^+$ ), 333, 319, 318, 304 (317)  
 Sources:  
 Rutaceae: *Fagara* (2, 196, 316, 317)

8. CHELERYTHRINE  
 (roddaline)  
 (heleritrine)



$C_{21}H_{18}NO_4^+$ : 348.38191  
 MP:  $(Cl^-)$  193° (Et<sub>2</sub>O-EtOH) (28)  
 $(Cl^-)$  202-203° (MeOH-2 N HCl) (68, 69, 71, 72)  
 $(Cl^-)$  207 ( $CHCl_3$ -MeOH) (159)  
 $(Cl^-)$  215° (104g)  
 $(NO_3^-)$  234-236° (EtOH-2 N HNO<sub>3</sub>) (70)  
 $(NO_3^-)$  246-247° (148)  
 $(\psi-CN)$  229-233° (Me<sub>2</sub>CO) (216)  
 $(\psi-CN)$  243-244° ( $CHCl_3$ -EtOH) (245)  
 $(\psi-CN)$  260-261° ( $CHCl_3$ -EtOH) (252, 257, 262, 275)  
 $(AcO^-)$  235° (312)  
 (picrate) 236° (EtOH) (33)  
 See also 19, 28, 51, 59, 60, 61, 65, 66, 98, 118, 137, 161, 188, 216, 234, 237, 240, 251, 254, 256, 259, 264, 266, 274, 314, 324, 325.

UV: (Cl<sup>-</sup>) (EtOH) 228 (4.26), 272 (4.54), 283 sh (4.47), 302 sh (4.37), 343 (4.17) (68)  
See also 28, 61, 65, 70, 104g, 108, 118, 130, 234, 266, 306, 312.

IR: (Cl<sup>-</sup>) (nujol) 1605, 1425, 1278, 1175, 946, 863 (226)

See also 104g, 312.

<sup>1</sup>H-NMR: (Cl<sup>-</sup>) (TFA-d) (150)

See also 118, 130, 151, 234, 247, 312, 317.

MS: (ψ-CN) (247)

Sources:

Fumariaceae: *Corydalis* (35, 129, 161, 201)

*Dicentra* (238)

Papaveraceae: *Argemone* (13, 14, 20, 26, 27, 52, 97, 98, 99, 100, 102, 251, 269, 271, 273, 286, 330)

*Bocconia* (15, 53, 54, 93, 106, 149, 155, 159, 164, 172, 187, 221, 264, 288, 306, 307)

*Chelidonium* (16, 46, 84, 95, 130, 152, 159, 168, 207, 208, 219, 220, 223, 226, 237, 252, 257, 267, 279, 326)

*Dicranostigma* (157, 259, 272, 274)

*Eschscholtzia* (15, 57, 220, 248, 253, 263, 268)

*Glaucium* (25, 32, 58, 137, 144, 184, 209, 220, 236, 240, 243, 255, 256, 262, 270, 276, 331)

*Hunnemannia* (249, 275)

*Hylomecon* (246)

*Hypocoum* (258, 330)

*Macleaya* (34, 110, 151, 254, 266)

*Papaver* (102, 174)

*Platystemon* (245, 261)

*Sanguinaria* (56, 140, 219, 222, 246, 257, 310)

*Stylomecon* (246)

*Stylophorum* (157, 217)

Rutaceae: *Fagara* (2, 19, 28, 37, 59, 65, 66, 68, 69, 70, 71, 72, 73, 147, 148, 195, 216, 315, 318, 319)

*Toddalia* (49, 50, 90, 91, 142)

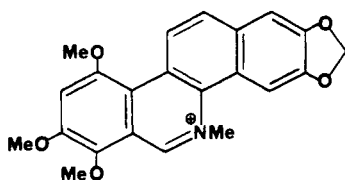
*Xanthoxylum* (33, 118, 126, 325)

*Zanthoxylum* (30, 33, 48, 51, 59, 60, 61, 63, 67, 146, 216, 281, 314, 322, 324, 327)

Sapindaceae: *Pteridophyllum* (109)

For identity with toddaline, see 90.

## 9. CHELILUTINE



C<sub>22</sub>H<sub>20</sub>NO<sub>5</sub><sup>+</sup>: 378.4084

MP: (Cl<sup>-</sup>) 184-186° (121)

(Cl<sup>-</sup>) 197-198° (dec) (dil. HCl) (138)

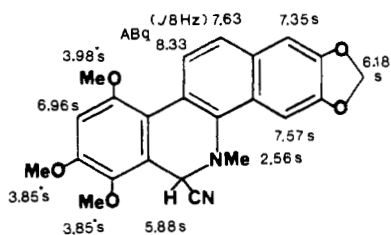
(Cl<sup>-</sup>) 229-230° (95)

(ψ-CN) 270.5-271° (CHCl<sub>3</sub>-EtOH) (257)

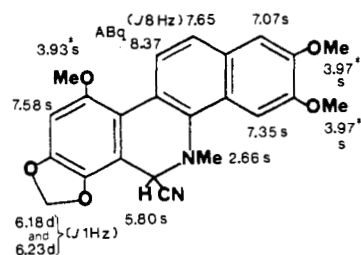
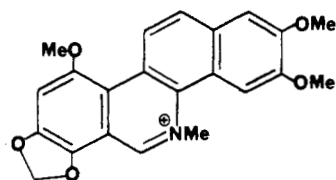
See also 104b, 262, 266, 275.

UV: (Cl<sup>-</sup>) (EtOH) 230 (4.45), 241 sh (4.39), 280.5 (4.56), 340 (4.29), 420 sh (3.41), 470 (3.55);  
λ<sub>min</sub> 253 (4.23), 305 (4.01), 384 (3.30) (108)  
See also 104b, 234, 266.

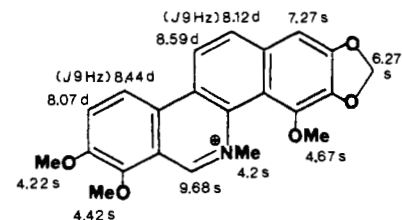
IR: (Cl<sup>-</sup>) 3640, 3580, 3370, 3260, 1660, 1567, 1549, 1508, 1493, 1330, 1302, 1268, 1237, 1218, 1210, 1143, 1133, 1095, 1078, 1044, 1032, 1018, 990, 954, 941, 918, 888, 872,



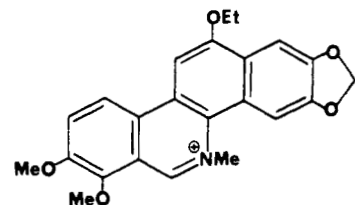
## 10. SANGUIRUBINE



11. 2,3-METHYLENEDIOXY-1,9,10-TRIMETHOXYBENZO[*c*]-PHENANTHRIDINE N-METHO SALT  
(2,3-methylenedioxy-4,7,8-trimethoxybenzo[*c*]phenanthridine N-metho salt)



12. 5-ETHOXYCHELERYTHRINE  
(6-ethoxychelerythrine)  
(alkaloid C)



863, 846, 818, 784, 755, 745, 733, 722, 709  
(104b)

$^1\text{H-NMR}$ : ( $\psi\text{-CN}$ ) (DMSO- $d_6$ ) (247)

Sources:

Fumariaceae: *Dicentra* (238)

Papaveraceae: *Chelidonium* (95, 226, 252, 257, 267)

*Eschscholtzia* (253, 263, 268)

*Glaucium* (262)

*Hunnemannia* (249, 275)

*Hylomecon* (246)

*Macleaya* (40, 254, 266)

*Sanguinaria* (242, 257)

$\text{C}_{22}\text{H}_{20}\text{NO}_5^+$ : 378.4084

MP: 224-225° (CHCl<sub>3</sub>-EtOH) (257)

252-253° (Et<sub>2</sub>O) (257)

(Cl<sup>-</sup>) 275-276° (CHCl<sub>3</sub>-EtOH or H<sub>2</sub>O) (257)

( $\psi\text{-CN}$ ) 237-238 (CHCl<sub>3</sub>-EtOH) (257)

UV: (Cl<sup>-</sup>) (EtOH) 230.5 (4.49), 281 (4.48), 343 sh (4.24), 353 (4.25), 422 (2.98), 510 (3.23);  $\lambda_{\text{min}}$  255 (4.23), 311 (3.90), 400 (2.90), 450 (2.94) (108)

See also 105b.

IR: (Cl<sup>-</sup>) 3340, 1648, 1612, 1550, 1500, 1300, 1273, 1212, 1183, 1156, 1126, 1075, 1040, 994, 963, 930, 843 (105b)

$^1\text{H-NMR}$ : ( $\psi\text{-CN}$ ) (DMSO- $d_6$ ) (247)

Sources:

Papaveraceae: *Sanguinaria* (242, 257)

$\text{C}_{22}\text{H}_{20}\text{NO}_5^+$ : 378.4084

MP: (Cl<sup>-</sup>) 158-161° (hexane-EtOH) (186)

UV: (Cl<sup>-</sup>) (EtOH) 229 (4.42), 254 (4.34), 288 (4.73), 323 (4.03), 355 (3.65) (186)

$^1\text{H-NMR}$ : (Cl<sup>-</sup>) (TFA-*d*) (186)

Sources: Synthetic (186)

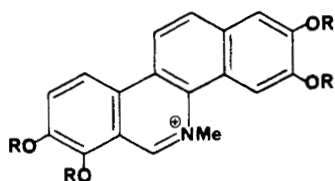
$\text{C}_{23}\text{H}_{22}\text{NO}_5^+$ : 392.43549

Sources:

Rutaceae: *Zanthoxylum* (321)

(The original literature was not available to the reviewers.)

## 13. PUNCTATINE



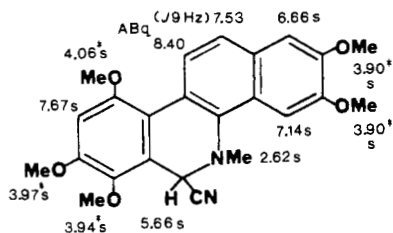
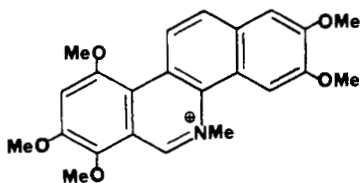
R = 3 x Me, 1 x H

 $C_{21}H_{20}NO_4^+$ : 350.39785UV: (EtOH- $H^+$ ) 270, 280 sh, 305 sh, 318, 325 sh, 340 sh, 390,  $\lambda_{min}$  295, 355; (EtOH- $OH^-$ ) 255, 288, 302, 335 sh (285)MS: 350 ( $M^+$ ), 349, 333, 319 (100), 304, 276 (285)

Sources:

Rutaceae: *Zanthoxylum* (285)

## 14. SANGUILUTINE

 $C_{23}H_{24}NO_5$ : 394.45143MP: ( $Cl^-$ ) 137-138° (138)( $Cl^-$ ) 163-164° ( $CHCl_3$ -EtOH or  $H_2O$ ) (257)211-212° ( $CHCl_3$ -EtOH) (257)246-247° ( $Et_2O$ ) (257)253-254° ( $Et_2O$ ) (257)( $\psi$ -CN) 232-233° ( $CHCl_3$ -EtOH) (257)UV: ( $Cl^-$ ) (EtOH) 229 (4.47), 279 (4.58), 336 (4.29), 435 sh (3.31), 472 (3.41);  $\lambda_{min}$  253 (4.27), 305 (4.02), 385 (3.08) (108)

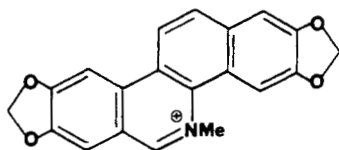
See also 105a.

IR: ( $Cl^-$ ) 3280, 1608, 1535, 1323, 1302, 1263, 1254, 1220, 1181, 1137, 1118, 1099, 1061, 1042, 1030, 1012, 923, 867, 841, 811, 798, 743, 732, 720 (105a) $^1H$ -NMR: ( $\psi$ -CN) ( $CDCl_3$ ) (247)

Sources:

Papaveraceae: *Papaver* (198)*Sanguinaria* (242, 257)

## 15. AVICINE

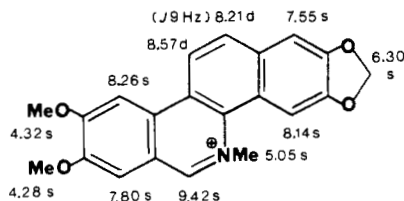
 $C_{20}H_{14}NO_4^+$ : 332.33888MP: ( $CH_3COO^-$ ) 160° (dec) (EtOH) (6, 126)( $\psi$ -CN) >340° (EtOH) (6, 126)

Sources:

Rutaceae: *Xanthoxylum* (126)*Zanthoxylum* (6)

## 16. NITIDINE

(angolinine)

 $C_{21}H_{18}NO_4^+$ : 348.38191MP: ( $Cl^-$ ) 220° (324)( $Cl^-$ ) 238-240° (EtOH) (59)( $Cl^-$ ) 278-283° (dec) (MeOH) (123)( $NO_3^-$ ) 239° (EtOH- $HNO_3$ ) (64, 323)( $NO_3^-$ ) 276-278° (EtOH-2 N  $HNO_3$ ) (66, 68)( $\psi$ -CN) 215-218° (dec) (4)( $\psi$ -CN) 236-237° (148)( $I^-$ ) 284-285° (EtOH) (135)

See also 41, 60, 61, 63, 65, 70, 89, 124, 126, 199, 332, 333.

UV: ( $Cl^-$ ) (MeOH) 231 (4.42), 272 (4.49), 281 sh (4.48), 303 sh (4.40), 329 (4.38) (28)

See also 61, 63, 65, 68, 70, 89, 126, 234, 332.

 $^1H$ -NMR: ( $Cl^-$  (TFA-*d*) (150)

See also 41, 123, 315, 317.

MS: 333 (100), 52 (18), 50 (60) (41)

See also 63, 332.

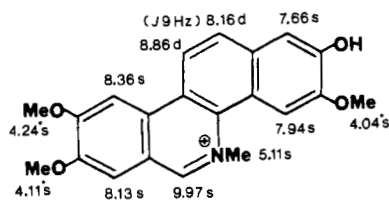
Sources:

Rutaceae: *Fagara* (2, 28, 29, 37, 65, 66, 68, 69, 70,

71, 72, 73, 123, 147, 148, 192, 193, 315)  
*Xanthoxylum* (63, 117, 123, 124, 125, 126)  
*Zanthoxylum* (4, 5, 8, 59, 60, 61, 63, 64, 67, 89,  
 281, 321, 322, 323, 324, 327)

For identity with angolinine, see 65  
 For a review on nitidine, see 199.

### 17. FAGARONINE



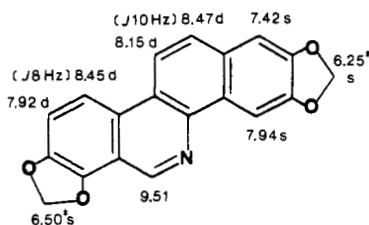
$C_{21}H_{20}NO_4^+$ : 350.39785  
 MP: ( $Cl^-$ ) 202°, then 255° (EtOAc-MeOH) (167)  
 UV: ( $Cl^-$ ) 233 (4.29), 272 (4.55), 305 sh (4.44);  
 (+0.01 N NaOH) 346 (4.31) (167)  
 IR: ( $Cl^-$ ) (KBr) 3500-3200 (167)  
 $^1H$ -NMR: (DMSO) (167)  
 MS: 350 ( $M^+$ ), 349, 348, 335 (100), 334, 320, 306,  
 292, 167.5 (167)

Sources:

Rutaceae: *Fagara* (167, 308)

For a review on fagaronine, see 199.

### 18. NORSANGUINARINE



$C_{19}H_{11}NO_4$ : 317.30382  
 MP: 278-280° (dec) ( $CHCl_3$ -EtOH) (75, 109, 130)  
 285-287° ( $CHCl_3$ -MeOH) (97, 100)  
 UV: (EtOH) 212 (4.33), 243 (4.67), 251 sh (4.50),  
 275 sh (4.50), 281 (4.55), 293 sh (4.41), 328  
 (4.22), 341 sh (4.00), 382 (3.60), 399 (3.65);  
 $\lambda_{min}$  222 (4.24), 263 (4.36), 320 (4.20), 366  
 (3.50), 385 (3.58) (100)  
 See also 75, 109, 130.  
 IR: (KBr) 1640, 1590, 1495, 1450, 1280, 1238,  
 1182, 1038 (75)  
 See also 109.  
 $^1H$ -NMR: (TFA-*d*) (130)  
 See also 75, 109.  
 MS: 317 ( $M^+$ , 100), 316 (7), 289 (6), 288 (6), 287  
 (4), 286 (3), 261 (12), 260 (11), 259 (16), 258  
 (4), 233 (8), 232 (8), 231 (9), 230 (9), 229 (8),  
 204 (11), 203 (20), 202 (24), 201 (43), 200 (11),  
 176 (14), 175 (20), 174 (27), 158.5 (11), 158  
 (12), 157.5 (12), 150 (10), 101 (12) (100)  
 See also 75, 109, 130.

Sources:

Fumariaceae: *Corydalis* (110)

*Dicentra* (110)

Papaveraceae: *Argemone* (52, 97, 100, 271)

*Chelidonium* (110, 130)

*Eschscholtzia* (110)

*Glaucium* (32)

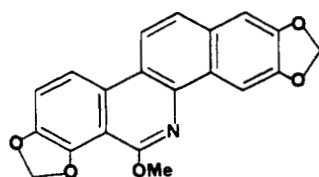
*Hypocoum* (92)

*Macleaya* (110)

*Papaver* (75, 110)

Sapindaceae: *Pteridophyllum* (109, 110)

### 19. PANCORINE



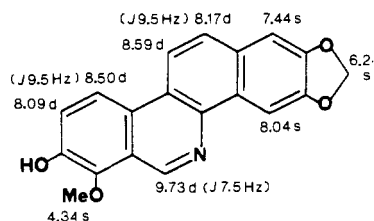
$C_{20}H_{13}NO_5$ : 347.33031

Sources:

Fumariaceae: *Corydalis* (3)



## 20. DECARINE

C<sub>19</sub>H<sub>13</sub>NO<sub>4</sub>: 319.31976

MP: 244-246° (MeOH-N HCl) (322)

248-251° (CHCl<sub>3</sub>-MeOH) (123)

See also 118, 328.

UV: (EtOH) 249 (4.54), 257 (4.55), 277 (4.67), 285 sh (4.52), 326 (4.20), 335 sh (4.11), 384 (3.46); (EtOH+NaOH) 253 (4.31), 297 (4.37), 330 (4.06), 384 (3.46) (328)

See also 22, 123, 322.

IR: (KBr) 2920, 1590, 880, 860 (328)

<sup>1</sup>H-NMR: 100 MHz (TFA-*d*) (123)

See also 22, 322, 328.

NOE: (328)

MS: 320 (38), 319 (M<sup>+</sup>, 100), 305 (23), 304 (69), 290 (8), 287 (10), 286 (92), 276 (92), 247 (6), 218 (15) (22)

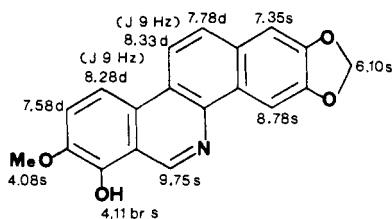
See also 123, 322, 328.

Sources:

Rutaceae: *Xanthoxylum* (118, 123)*Zantboxylum* (22, 116, 322, 328)

For structure confirmation, see 120.

## 20A. ISODECARINE

C<sub>19</sub>H<sub>13</sub>NO<sub>4</sub>: 319.31976MP: 234° (CHCl<sub>3</sub>) (319a)

UV: (EtOH) 249, 257, 271 sh, 277, 287 sh, 326; (EtOH+NaOH) 228, 253, 297, 338 (319a)

<sup>1</sup>H-NMR: (CDCl<sub>3</sub>+C<sub>6</sub>D<sub>6</sub>) (319a)MS: 319 (M<sup>+</sup>, 100), 304 (54), 276 (29), 82 (48) (319a)

Sources:

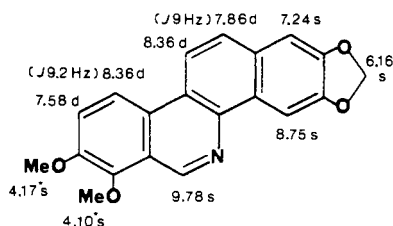
Rutaceae: *Xanthoxylum* (319a)

## 21. NORCHELERYTHRINE

(N-norchelerythrine)

(des-N-methylchelerythrine)

(O-methyldecarine)

C<sub>20</sub>H<sub>15</sub>NO<sub>4</sub>: 333.34685

MP: 211-213° (EtOH) (10, 14)

215-216° (EtOH) (130)

217-221° (CHCl<sub>3</sub>-MeOH) (118)220-221° (C<sub>6</sub>H<sub>6</sub>-CHCl<sub>3</sub>) (91)

See also 97, 99, 100, 114, 123, 216, 277, 328.

UV: (EtOH) 211 (4.30), 243 (4.57), 256 (4.54), 276 (4.67), 287 sh (4.51), 324 (4.18), 338 sh (4.00), 363 sh (3.56), 385 (4.49); λ<sub>min</sub> 226 (4.26), 251 (4.42), 260 (4.53), 314 (4.16), 376 (3.46) (100)

See also 10, 91, 114, 130, 328.

IR: (KBr) 2910, 2850, 1575, 850 (328)

See also 114.

<sup>1</sup>H-NMR: 100 MHz (CDCl<sub>3</sub>) (277)

See also 91, 130, 328.

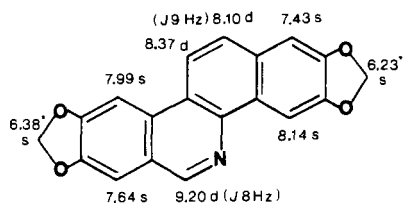
MS: 333.1000 (M<sup>+</sup>, 100), 319 (6), 318 (28), 317 (13), 291 (10), 290 (49), 275 (19), 274 (6), 232 (8), 217 (5), 189 (6), 188 (7), 116.5 (8), 164 (7), 144.5 (11), 136 (3), 94.5 (4), 87 (4), 81 (3), 57 (3), 43 (4) (100)

See also 91, 114, 130, 328.

Sources:

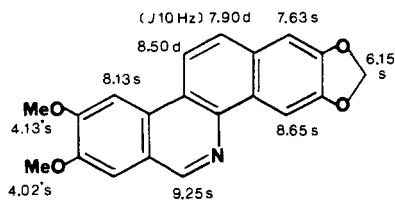
Papaveraceae: *Argemone* (14, 52, 97, 99, 100)*Chelidonium* (130)Rutaceae: *Toddalia* (91, 230)*Xanthoxylum* (114, 118, 123)*Zantboxylum* (321)

**22. DES-N-METHYLAVICINE**  
(6,7,2',3'-bismethylenedioxy-  
1,2-benzophenanthridine)



$C_{19}H_{11}NO_4$ : 317.30382  
MP: 209-295° (CHCl<sub>3</sub>) (123)  
325° (dec) (C<sub>5</sub>H<sub>5</sub>N) (88)  
UV: 230 (4.59), 275 (4.86), 327 sh (4.26), 370  
(3.50) (88)  
<sup>1</sup>H-NMR: 100 MHz (TFA-*d*) (123)  
MS: 317 (M<sup>+</sup>, 100) (123)  
Sources:  
Rutaceae: *Xanthoxylum* (123)

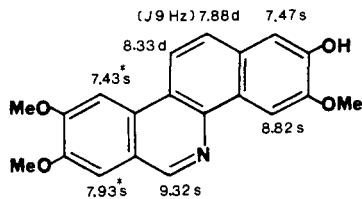
**23. N-NORNITIDINE**



$C_{20}H_{15}NO_4$ : 333.34685  
MP: 273° (C<sub>5</sub>H<sub>5</sub>N) (7)  
278-280° (dec) (C<sub>5</sub>H<sub>5</sub>N-EtOH) (332)  
See also 22, 87.  
UV: (EtOH) 229 (4.36), 274 (4.73), 278 sh (4.71),  
311 (4.15), 330 sh (3.89), 348 (3.60), 367  
(3.46) (332)  
See also 22, 87.  
<sup>1</sup>H-NMR: 150 MHz (acetone-*d*<sub>6</sub>) (22)  
MS: 334 (2), 333 (10), 236 (17), 223 (33), 205 (37),  
186 (33), 177 (20), 149 (100) (22)  
See also 332.

Sources:  
Rutaceae: *Zanthoxylum* (22)

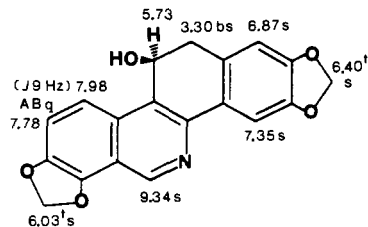
**24. N-DEMETHYLFGARONINE**



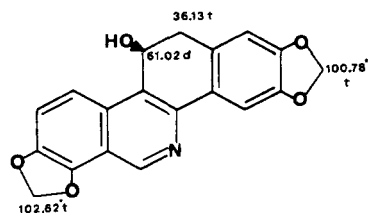
3 methoxyls at  $\delta$  4.07, 4.17 and 4.18

$C_{20}H_{17}NO_4$ : 335.36279  
MP: 250° (308)  
271-273° (175)  
274-276° (85)  
UV: 227 (4.30), 272 (4.67), 280 (4.67), 315 sh  
(4.04) (308)  
IR: (nujol) 3540, 1615 (175)  
See also 308.  
<sup>1</sup>H-NMR: (CDCl<sub>3</sub>) (308)  
See also 175.  
MS: 335 (M<sup>+</sup>), 334, 320, 306, 292 (175, 308)  
Sources: Synthetic (85, 175, 308)

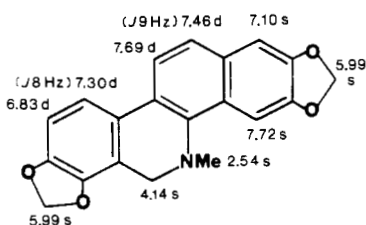
**25. LUGUINE**



$C_{19}H_{13}NO_5$ : 335.31916  
MP: 282-284° (EtOAc) (32)  
[ $\alpha$ ]<sup>20</sup><sub>D</sub>: +172° (c=0.05, dioxane) (32)  
UV: (dioxane) 255 (4.44) 334 (4.36), 345 (4.39), 384  
(3.65); (dioxane-0.1 N HCl) 250 (4.33), 269  
(4.29), 352 (4.27), 362 (4.30), 458 (3.80) (32)  
IR: (KBr) 3400-3150, 1650 (32)  
<sup>1</sup>H-NMR: 80 MHz (CDCl<sub>3</sub>-TFA-*d*) (32)  
<sup>13</sup>C-NMR: (DMSO-*d*<sub>6</sub>) (32)  
MS: 335 (M<sup>+</sup>), 317 (100) (32)  
Sources:  
Papaveraceae: *Glaucium* (32)



## 26. DIHYDROSANGUINARINE

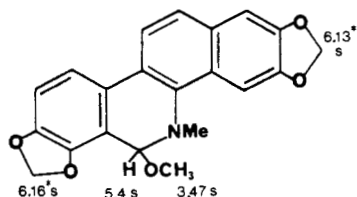
C<sub>20</sub>H<sub>15</sub>NO<sub>4</sub>: 333.34685MP: 188-189° (CHCl<sub>3</sub>-MeOH) (129, 227, 265, 306)  
191-193° (C<sub>6</sub>H<sub>6</sub>-EtOH) (24)  
195-196° (136)See also 104d, 137, 188, 213, 283, 295, 301,  
302, 303, 304, 305.UV: (EtOH) 237 (4.55), 284 (4.57), 322 (4.21), 335  
sh (4.12), 350 sh (3.72); (EtOH-0.1 N HCl) 238  
(4.53), 250 sh (4.49), 265 (4.40), 274 (4.40),  
307 (4.20), 321 (4.36), 338 (4.20), 355 (4.30);  
(EtOH-0.1 N KOH in EtOH-H<sub>2</sub>O [1:1]) 235  
(4.53), 282 (4.56), 322 (4.23), 335 sh (4.12),  
350 sh (3.72) (24)See also 104d, 108, 115, 119, 227, 265, 301,  
302, 304, 306, 310.IR: (CHCl<sub>3</sub>) 2780, 1253 (24)

See also 104d, 227.

<sup>1</sup>H-NMR: 100 MHz (CDCl<sub>3</sub>) (185)See also 24, 113, 115, 136, 137, 156, 227, 302,  
304.MS: 333 (M<sup>+</sup>), 332, 318, 274, 239, 201 (302)

See also 137, 247, 304.

## Sources:

Fumariaceae: *Corydalis* (110, 129, 136, 162, 302,  
304)*Dicentra* (110)Papaveraceae: *Argemone* (52, 213, 271, 273)*Bocconia* (156)*Chelidonium* (110, 265, 295)*Eschscholtzia* (110)*Glaucium* (31, 137, 228)*Macleaya* (110)*Papaver* (75, 110)*Romneya* (283)Sapindaceae: *Pteridophyllum* (109, 110)27. (-)-8-METHOXYDIHYDRO-  
SANGUINARINE  
(sanguinarine pseudomethanolate)

6 aromatic protons between δ 6.71-8

C<sub>21</sub>H<sub>17</sub>NO<sub>5</sub>: 363.37334

MP: 195-197° (MeOH) (194)

216-219° (CHCl<sub>3</sub>-MeOH) (283)220-222° (CH<sub>2</sub>Cl<sub>2</sub>-MeOH) (170)[α]<sub>D</sub>: -237.8° (c=0.084, CHCl<sub>3</sub>) (194)UV: 210 (4.16), 235 (4.23), 280 (4.28), 327 (4.12)  
(194)

See also 170.

<sup>1</sup>H-NMR: 90 MHz (194)

See also 170.

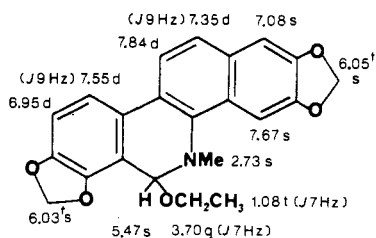
MS: 363.1100 (M<sup>+</sup>, 10), 332.0924 (100),  
317.0684 (39), 194.0805 (18), 149 (34), 111  
(23), 97 (33), 83 (27), 71 (35), 57 (55) (194)

See also 170, 173.

## Sources:

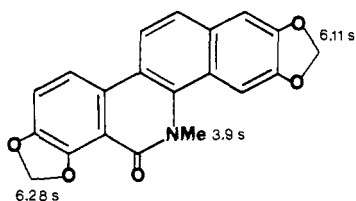
Fumariaceae: *Fumaria* (194)Papaveraceae: *Hunnemannia* (170)*Hypocoum* (92)

**28. ETHOXYDIHYDRO-SANGUINARINE**  
(sanguinarine pseudoethanolate)



$C_{22}H_{19}NO_5$ : 377.40043  
 MP: 207-209° ( $CH_2Cl_2$ -MeOH) (170)  
 UV: 234 (4.30), 281 (4.39), 322 (3.91) (170)  
 $^1H$ -NMR: 100 MHz ( $CDCl_3$ ) (170)  
 See also 313.  
 MS: 377.1369 ( $M^+$ , 11), 333.1002 (100), 332.0941, 317.0696 (66.4) (170)  
 CI/MS: ( $CH_4-NH_3$ ) 378 (7), 334 (100), 332 (70), 318 (10) (170)  
 Sources:  
 Papaveraceae: *Hunnemannia* (170)

**29. OXYSANGUINARINE**

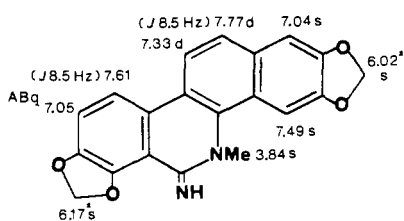


6 aromatic protons between  $\delta$  7.17-8.15

$C_{20}H_{13}NO_5$ : 347.33031  
 MP: 300-308 (dec) (acidic  $Et_2O$ ) (174)  
 347-349° (dec) ( $Et_2O$ ) (229)  
 360-362° (MeOH) (206)  
 366-368° (194)  
 See also 136, 156, 257, 302, 306.  
 UV: (EtOH) 241 (4.27), 281 sh (4.61), 289 (4.70), 331 (4.17), 348 (4.18), 370 (4.06), 385 (4.02) (229)  
 See also 108, 136, 156, 194, 302.  
 IR: (KBr) 1655 (156)  
 See also 105d, 136, 194, 229.  
 $^1H$ -NMR: 90 MHz ( $CDCl_3$ ) (194)  
 See also 302.  
 MS: 347 ( $M^+$ , 100), 346 (62), 318 (25), 289 (14), 203 (9), 159 (11), 69 (12), 44 (34) (194)  
 See also 75, 156, 302.

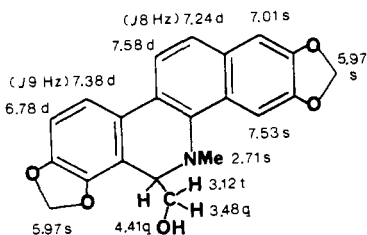
Sources:  
 Fumariaceae: *Corydalis* (110), 136, 202, 206, 302)  
*Dicentra* (110)  
*Fumaria* (194)  
 Papaveraceae: *Bocconia* (53, 156, 306)  
*Chelidonium* (110, 214, 235, 265)  
*Dicranostigma* (259)  
*Eschscholtzia* (110)  
*Glaucium* (32)  
*Hypecoum* (92)  
*Macleaya* (110)  
*Papaver* (75, 110, 165, 166, 174, 203, 204, 205, 212)  
*Sanguinaria* (257, 280)  
 Sapindaceae: *Pteridophyllum* (109, 110)

**30. 8-IMINOSANGUINARINE**  
(6-iminosanguinarine)



$C_{20}H_{14}N_2O_4$ : 346.34558  
 MP: 241-242° ( $CHCl_3$ -EtOH) (31)  
 IR: (KBr) 3360, 1610, 1575 (31)  
 $^1H$ -NMR: 80 MHz ( $CDCl_3$ ) (31)  
 MS: 346 ( $M^+$ , 78) (31)  
 Sources:  
 Papaveraceae: *Glaucium* (31)  
 This compound has been stated (31) to be probably an artifact.

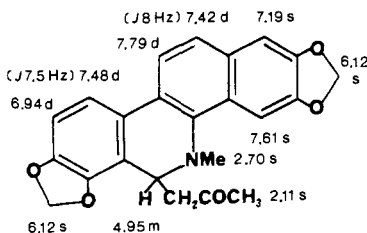
**31. 8-HYDROXYMETHYLDIHYDRO-SANGUINARINE**  
(6-hydroxymethyl dihydrosanguinarine)



$C_{21}H_{17}NO_5$ : 363.37334  
MP: 249-251.5° (CHCl<sub>3</sub>-EtOH) (130)  
UV: (MeOH) 212 (4.24), 235 (4.39), 284 (4.42), 322 (4.02), 350 sh (3.54) (130)  
IR: (KBr) 3400, 1460, 1440, 1258, 1240, 1182, 1040 (130)  
<sup>1</sup>H-NMR: (CDCl<sub>3</sub>) (130)  
MS: 363 (M<sup>+</sup>, 16), 333 (43), 332 (100), 317 (16), 166 (17) (130)

Sources:  
Papaveraceae: *Chelidonium* (130)

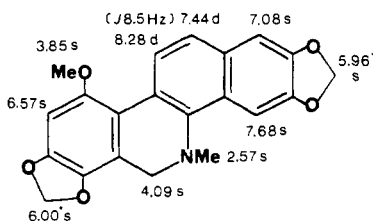
**32. 8-ACETONYLDIHYDRO-SANGUINARINE**  
(6-acetonylsanguinarine)  
(6-acetonyldihydrosanguinarine)



$C_{23}H_{19}NO_5$ : 389.41158  
MP: 194-195.5° (CHCl<sub>3</sub>-MeOH) (75)  
UV: (EtOH) 240 (4.43), 288 (4.47), 325 (3.60); λ<sub>min</sub> 220 (4.34), 258 (4.06), 313 (3.99) (75)  
IR: (KBr) 1710, 1475, 1460, 1440, 1258, 1190, 1042 (75)  
<sup>1</sup>H-NMR: (CDCl<sub>3</sub>) (75)  
MS: 389.126 (35), 332 (100), 317 (19) (75)

Sources:  
Papaveraceae: *Argemone* (52)  
*Glaucium* (31)  
*Hypecoum* (92)  
*Papaver* (75)

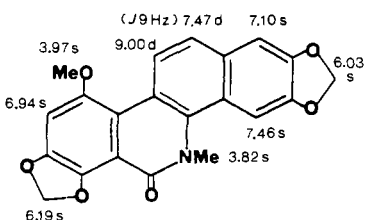
**33. DIHYDROCHELIRUBINE**  
(dihydroboconine)



$C_{21}H_{17}NO_5$ : 363.37334  
MP: 198-199° (CHCl<sub>3</sub>-MeOH) (265)  
205-207° (CHCl<sub>3</sub>) (127)  
206-207° (MeOH) (185)  
UV: (MeOH) 231 (4.59), 280 (4.52), 338 (4.30); λ<sub>min</sub> 255 (4.26), 315 (4.09) (265)  
IR: (nujol) 1640, 1615, 935 (127)  
<sup>1</sup>H-NMR: 100 MHz (CDCl<sub>3</sub>) (113)  
See also 186.  
NOE: 100 MHz (CDCl<sub>3</sub>) (185)  
12-OCH<sub>3</sub> irr., H-11 (47%)

Sources:  
Papaveraceae: *Chelidonium* (265)

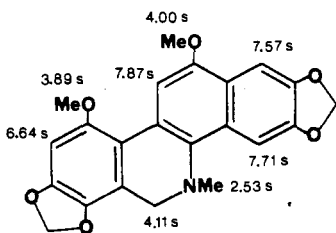
**34. OXYCHELIRUBINE**  
(oxyboconine)



$C_{21}H_{15}NO_6$ : 377.3568  
MP: 295-296° (CHCl<sub>3</sub>-Me<sub>2</sub>CO) (185)  
307-308° (CHCl<sub>3</sub>-MeOH or CHCl<sub>3</sub>-Me<sub>2</sub>CO) (127)  
See also 113.  
IR: (KBr) 1655 (127)  
<sup>1</sup>H-NMR: 100 MHz (CDCl<sub>3</sub>) (185)  
See also 127.

Sources:  
Papaveraceae: *Glaucium* (31)

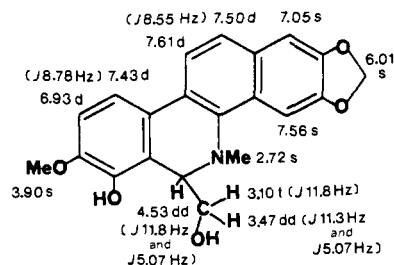
## 35. DIHYDROMACARPINE

C<sub>22</sub>H<sub>19</sub>NO<sub>6</sub>: 393.39983

MP: 178-179° (300)

<sup>1</sup>H-NMR: (CDCl<sub>3</sub>) (300)NOE: (CDCl<sub>3</sub>) (300)5-OCH<sub>3</sub> irr., H-4 (16%), H-6 (47%)12-OCH<sub>3</sub> irr., H-6 (13%), H-11 (48%)MS: 393.119 (M<sup>+</sup>) (300)

Sources: Synthetic (300)

36. 7,8-DIHYDRO-8-HYDROXY-METHYLCFAGARIDINE  
(5,6-dihydro-6-hydroxymethyl-fagaridine)C<sub>21</sub>H<sub>19</sub>NO<sub>5</sub>: 365.38928

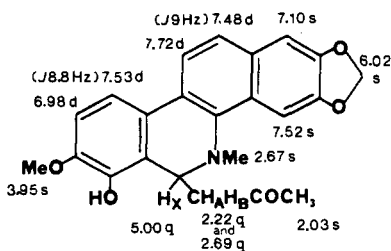
UV: (EtOH) 228, 284, 324 sh, 353 sh; (EtOH-HCl)

223, 255, 268 sh, 277, 307, 321, 339, 356;

OH<sup>-</sup>) 236, 268, 295, 336 (22)<sup>1</sup>H-NMR: 150 MHz (CDCl<sub>3</sub>) (22)MS: 365.1258 (M<sup>+</sup>, 10), 334 (100), 319 (80), 304

(10), 284 (10), 276 (10), 245 (15), 227 (24) (22)

Sources:

Rutaceae: *Zanthoxylum* (22)37. O-DESMETHYLDIHYDRO-CHELERYTHRINYL-8-ACETONE  
(O-desmethyldihydrochelerythrinyll-11-acetone)  
(ZT<sub>3</sub>)C<sub>23</sub>H<sub>21</sub>NO<sub>5</sub>: 391.42752

MP: 201-205° (MeOH) (47)

[α]<sub>D</sub>: 0° (47)

UV: (EtOH) 229 (4.55), 284 (4.62), 320 (4.17);

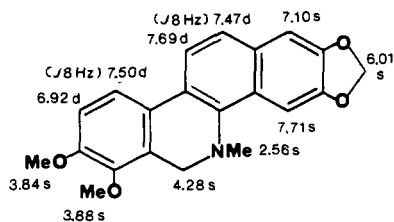
(EtOH-NaOH) 234 (4.48), 297 (4.52), 338

(4.33) (47)

IR: (CHCl<sub>3</sub>) 3400, 3260, 1715 (47)<sup>1</sup>H-NMR: (CDCl<sub>3</sub>) (47)

MS: 391, 334 (100), 319, 304, 290, 276 (47)

Sources:

Rutaceae: *Xanthoxylum* (47)38. DIHYDROCHELERYTHRINE  
(Toddalinine)C<sub>21</sub>H<sub>19</sub>NO<sub>4</sub>: 349.38988MP: 161-162° (CHCl<sub>3</sub>-MeOH) (265)

164-165° (EtOH) (325)

169-171° (C<sub>6</sub>H<sub>6</sub>) (188)

See also 24, 49, 59, 62, 148, 216, 231, 306.

UV: (EtOH) 227 (4.53), 282 (4.65), 318 (4.18), 350

sh (3.52); (EtOH-0.1 N HCl) 231 (4.48), 255 sh

(4.47), 265 (4.58), 273 (4.62), 291 sh (4.16),

304 (4.31), 317 (4.39), 335 (4.13), 352 (4.25);

(EtOH-0.1 N KOH in EtOH-H<sub>2</sub>O) 281 (4.65),

318 (4.21), 350 sh (3.54) (24)

See also 62, 108, 115, 119, 265, 306.

IR: (CHCl<sub>3</sub>) 2780, 1270, 1243 (24)<sup>1</sup>H-NMR: 100 MHz (CDCl<sub>3</sub>) (185)

See also 24, 62, 115, 119, 126, 156.

MS: 349 (100), 348 (80), 347 (6), 333 (6), 332 (7),  
318 (6), 305 (1), 304 (5), 290 (9) (315)

Sources:

Papaveraceae: *Argemone* (271, 273)

*Bocconia* (1m)

*Chelidonium* (265)

*Glaucium* (31, 228)

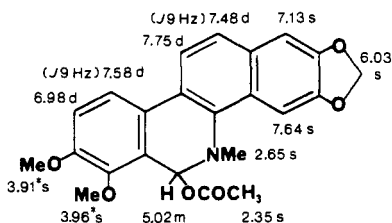
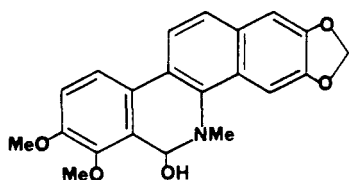
Rutaceae: *Fagara* (37, 44, 216, 315, 319)

*Toddalia* (49, 90, 91, 231)

*Xanthoxylum* (325)

*Zanthoxylum* (62)

**39. 8-HYDROXYDIHYDRO-  
CHELERYTHRINE\***



$C_{21}H_{19}NO_5$ : 365.38928

MP: 145° ( $CH_2Cl_2-Et_2O$ ) (232)

UV: (EtOH) 235, 287, 325 (232)

IR: (KBr) 1720, 1600, 1460 (232)

$^1H$ -NMR: 90 MHz ( $CDCl_3$ ) (HMDS) (232)

MS: 407 ( $M^+$ , 10), 376 (5), 348 (100), 333 (34), 318  
(16), 290 (22), 275 (8) (232)

Sources:

Rutaceae: *Toddalia* (232)

\*This alkaloid was isolated and elucidated as the acetate ester (232). All physical and spectral data for this compound, therefore, belong to the acetate.

**40. ANGOLINE**

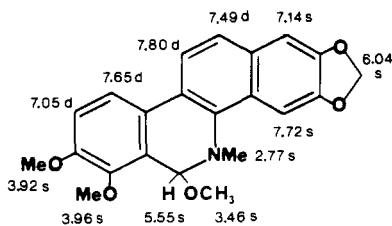
(9-methoxychelerythrine)

(8-methoxydihydrochelerythrine)

(6-O-methylidihydrochelerythrine)

(11-O-methylidihydrochelerythrine)

(P-61)



$C_{22}H_{21}NO_5$ : 379.41637

MP: 176° (230)

210° ( $CHCl_3-MeOH$ ) (159)

$[\alpha]_D$ : 0° (74)

UV: (EtOH) 210 (4.43), 226 (4.47), 282 (4.55), 320  
(4.10) (230)

See also 74, 170.

IR: 1480, 1345, 1280, 1270, 1070, 1042, 940 (74)

$^1H$ -NMR: 100 MHz ( $CDCl_3$ ) (156)

See also 74, 170, 230.

MS: 379 ( $M^+$ ), 348 (100) (230)

See also 74, 170, 247.

Sources:

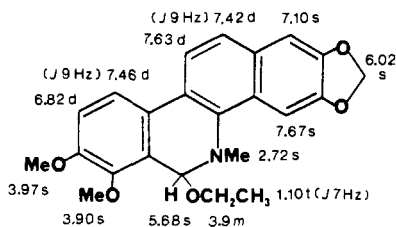
Papaveraceae: *Bocconia* (156, 159)

*Hunnemannia* (170)

Rutaceae: *Fagara* (2, 29, 74, 192, 193)

*Toddalia* (230)

**41. 8-ETHOXYDIHYDRO-  
CHELERYTHRINE**  
(9-ethoxychelerythrine)  
(chelerythrine pseudoethanolate)  
(alkaloid A2)

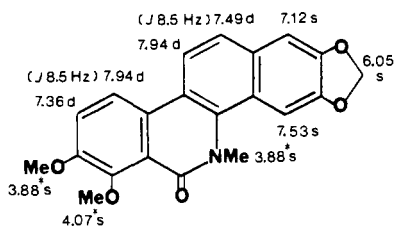


$C_{23}H_{23}NO_5$ : 393.44346  
 MP: 175-200°, then 239-242° (EtOH) (216)  
 200-202°, then 239-242° (318)  
 233-236° (216)  
 $[\alpha]_D$ : 0° (318)  
 UV: (EtOH) 228 (4.53), 284 (4.67), 320 sh (4.18);  
 $\lambda_{min}$  252 (4.18) (318)  
 See also 170.  
 IR: 2850, 2780, 1460, 1335, 944, 723 (318)  
 $^1H$ -NMR: (CDCl<sub>3</sub>) (170)  
 See also 313, 318.  
 MS: 393 (M<sup>+</sup>, 12), 348 (100), 347 (1), 333 (6), 332  
 (7), 318 (6), 305 (1), 304 (5), 290 (12) (315)  
 See also 170, 247.

## Sources:

Papaveraceae: *Hunnemannia* (170)Rutaceae: *Fagara* (44, 196, 318, 319)

**42. OXYCHELERYTHRINE**  
(9-oxochelerythrine)

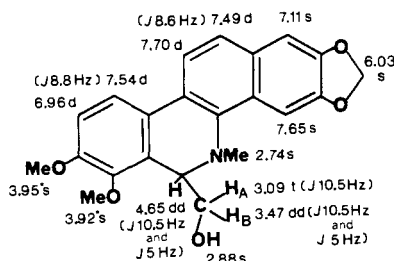


$C_{21}H_{17}NO_5$ : 363.37334  
 MP: 197-198° (MeOH) (306)  
 199-201° (MeOH) (216)  
 202-205° (C<sub>6</sub>H<sub>6</sub>-MeOH) (118)  
 UV: (EtOH) 242 (4.53), 282 sh (4.61), 291 (4.70),  
 330 (4.21), 375 (3.93);  $\lambda_{min}$  260 (4.30), 311  
 (4.18) (108)  
 See also 306.  
 IR: (nujol) 1655 (118)  
 $^1H$ -NMR: (CDCl<sub>3</sub>) (118)  
 See also 185.

## Sources:

Rutaceae: *Xanthoxylum* (118)*Zanthoxylum* (321)

**43. BOCCONOLINE**  
(6-hydroxymethyl-dihydrochelerythrine)  
(base C)



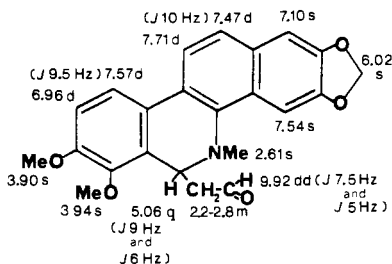
$C_{22}H_{21}NO_5$ : 379.41637  
 MP: 215-218° (CHCl<sub>3</sub>-MeOH) (184)  
 221-222° (CHCl<sub>3</sub>-EtOH) (184)  
 223-224° (CHCl<sub>3</sub>) (119)  
 228-231° (CHCl<sub>3</sub>-EtOH) (130)  
 232-233° (MeOH) (115, 119)  
 UV: (MeOH) 230 (4.52), 283 (4.61), 320 (4.11);  
 $\lambda_{min}$  255 (4.17), 314 (4.10) (184)  
 See also 115, 119, 130.  
 IR: (KBr) 3440, 1600, 1460, 1410, 1265, 1238,  
 1182, 1023 (130)  
 See also 115, 119.  
 $^1H$ -NMR: 100 MHz (CDCl<sub>3</sub>) (119)  
 See also 115, 130.  
 MS: 379 (M<sup>+</sup>, 8.9), 348 (100), 333 (11.2), 310 (9.1)  
 (119)  
 See also 115, 130, 184.

## Sources:

Papaveraceae: *Bocconia* (115, 306)*Chelidonium* (130)*Glaucium* (31, 184)Rutaceae: *Fagara* (119)

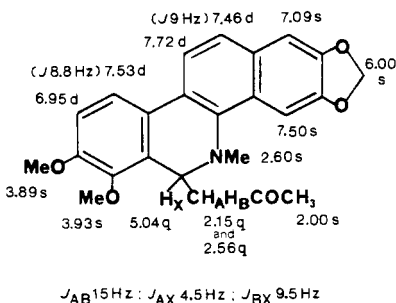


44. DIHYDROCHELERYTHRINYL-8-ACETALDEHYDE  
(dihydrochelerythrinyll-11-acetaldehyde)  
(dihydrochelerythrinyll-6-acetaldehyde)  
(ZT<sub>2</sub>)



C<sub>23</sub>H<sub>21</sub>NO<sub>5</sub>: 390-42752  
MP: 206-210° (CHCl<sub>3</sub>-MeOH) (47)  
[α]<sub>D</sub>: 0° (47)  
UV: (EtOH) 230 (4.54), 284 (4.63), 320 sh (1.16) (47)  
IR: (KBr) 2720, 1730 (47)  
<sup>1</sup>H-NMR: (CDCl<sub>3</sub>) (47)  
MS: 348 (100) (47)  
Sources:  
Papaveraceae: *Glaucium* (31)  
Rutaceae: *Zanthoxylum* (47)

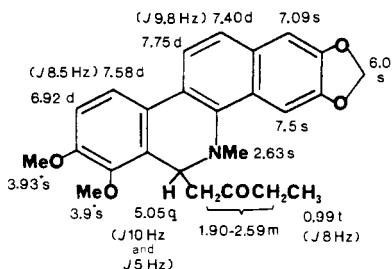
45. 8-ACETONYLDIHYDRO-CHELERYTHRINE  
(11-acetonyldihydrochelerythrine)  
(ZT<sub>1</sub>)



C<sub>24</sub>H<sub>23</sub>NO<sub>5</sub>: 405.45461  
MP: 193-194° (49, 231)  
195-202° (sublimes) (CH<sub>2</sub>Cl<sub>2</sub>-MeOH) (47)  
199° (Me<sub>2</sub>CO) (156)  
UV: (EtOH) 231 (4.53), 284 (4.62), 319 sh (4.16) (47)  
See also 49.  
IR: 1715, 1610 (49)  
See also 47, 156.  
<sup>1</sup>H-NMR: (CDCl<sub>3</sub>) (47)  
See also 49, 156.  
NOE: 100 MHz (CDCl<sub>3</sub>) (156)  
NCH<sub>3</sub> irr., H-1 (30%), H-8 (23%)  
OCH<sub>3</sub> irr., H-11 (24%); H-4 irr., H-5 (27%)  
MS: 405 (M<sup>+</sup>), 348, 299.5 (49)  
See also 47, 156.

Sources:  
Rutaceae: *Toddalia* (49, 91, 231)  
*Xylocarpus* (37)  
*Zanthoxylum* (47, 146)

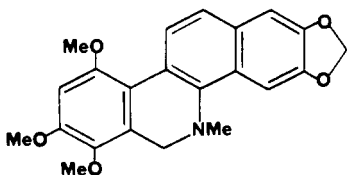
46. 8-(2'-KETOBUTANE)-DIHYDRO-CHELERYTHRINE  
(11-(2'-ketobutane)-dihydrochelerythrine)



C<sub>25</sub>H<sub>25</sub>NO<sub>5</sub>: 419.4817  
MP: 206-208.5° (EtOAc) (9)  
<sup>1</sup>H-NMR: (CDCl<sub>3</sub>) (9)  
MS: 419 (M<sup>+</sup>, 12), 349 (22), 348 (100), 333, 332 (17), 318 (12), 304, 290 (15), 276, 261, 247, 233, 218 (9)

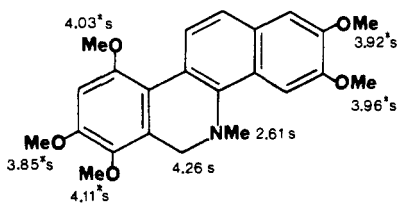
Sources:  
Rutaceae: *Fagara* (9)  
A better name for this compound would be 8-(propionylmethyl)dihydrochelerythrine.

47. DIHYDROCHELILUTINE



C<sub>22</sub>H<sub>21</sub>NO<sub>5</sub>: 379.41637  
MP: 132-135° (265)  
136-137° (CHCl<sub>3</sub>-MeOH) (265)  
UV: (MeOH) 230 (4.52), 280 (4.56), 325 (4.21);  
λ<sub>min</sub> 255 (4.21), 309 (4.11) (265)  
Sources:  
Papaveraceae: *Chelidonium* (265)

## 48. DIHYDROSANGUILUTINE



5 aromatic protons between  $\delta$  7.0-7.7 (m)

$C_{23}H_{25}NO_5$ : 395.4594

MP: 154-155° (140)

155-157° (CHCl<sub>3</sub>-MeOH) (265)

UV: (MeOH) 238 (4.21), 262 (4.38), 275 (4.42), 325 (4.22) (140)

See also 265.

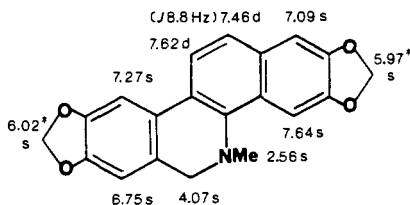
<sup>1</sup>H-NMR: (CDCl<sub>3</sub>) (140)

MS: 395 (30), 394 (100), 379 (20) (140)

Sources:

Papaveraceae: *Sanguinaria* (140)

## 49. DIHYDROAVICINE



$C_{20}H_{15}NO_4$ : 333.34685

MP: 211-212.5° (EtOH) (6)

212-213° (C<sub>6</sub>H<sub>6</sub>-Et<sub>2</sub>O) (176)

See also 60, 126, 230.

UV: (EtOH) 232 (4.60), 278 (4.50), 322 (4.33) (6)

See also 108, 126.

<sup>1</sup>H-NMR: 100 MHz (CDCl<sub>3</sub>) (126)

See also 115.

MS: 333 (M<sup>+</sup>), 318, 274, 260, 246, 233, 216, 201, 189 (230)

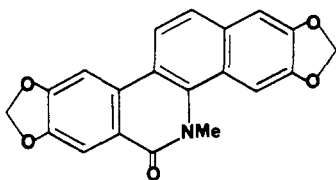
See also 60, 126.

Sources:

Rutaceae: *Toddalia* (230)

*Zanthoxylum* (60)

## 50. OXYAVICINE



$C_{20}H_{13}NO_5$ : 347.33031

MP: 257-259° then 275-277° (EtOH) (6)

276-277° (EtOH) (88)

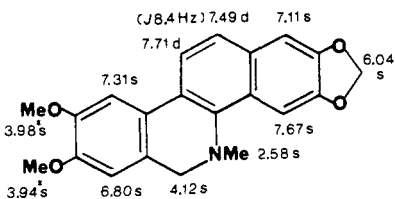
278-283° (CHCl<sub>3</sub>-EtOH) (176)

UV: (EtOH) 248 (4.50), 278 (4.70), 289 (4.76), 322 (4.21), 332 (4.19) (16)

IR: (nujol) 1631, 9838 (176)

Sources: Oxyavicine is produced by disproportionation of avicine, when the latter is liberated from its salts (6).

## 51. DIHYDRONITIDINE



$C_{21}H_{19}NO_4$ : 349.38988

MP: 208° (MeOH) (59)

216-217° (EtOH) (17)

220-221° (C<sub>5</sub>H<sub>5</sub>N-MeOH) (89)

223.5-224° (Me<sub>2</sub>CO) (126)

See also 4, 7, 8, 63, 87, 123, 124, 125, 176.

UV: (EtOH) 229.5 (4.65), 280.5 (4.59), 312 (4.34) (126)

See also 5, 87, 89, 108, 124, 230.

<sup>1</sup>H-NMR: 100 MHz (CDCl<sub>3</sub>) (126)

See also 115, 230, 315.

MS: 350, 349 (M<sup>+</sup>, 26), 348 (100), 347, 334, 333 (4), 332 (8), 318 (7), 304 (5), 290 (7), 174.5 (M<sup>++</sup>), 167, 166.5, 140, 123, 111, 109, 97, 94, 85, 83, 81, 71, 69, 57, 55 (315)

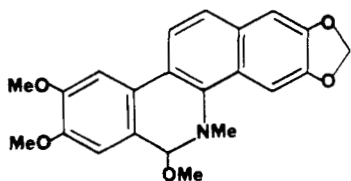
See also 126, 135, 323.

Sources:

Rutaceae: *Toddalia* (230)

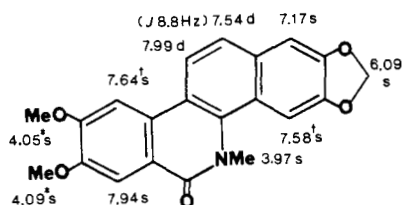
*Zanthoxylum* (323)

52. 7,8-DIHYDRO-8-METHOXYNITIDINE  
(5,6-dihydro-6-methoxynitidine)  
(6-methoxy-5,6-dihydranitidine)



$C_{22}H_{21}NO_5$ : 379.41637  
MP: 189-191° (MeOH) (332)  
UV: (CHCl<sub>3</sub>) 238 (4.53), 283 (4.60), 310 (4.40), 325 sh (4.29) (332)  
MS: 379 (M<sup>+</sup>, 12.9), 348 (100), 333 (17) (332)  
Sources:  
Rutaceae: *Fagara* (320)

53. OXYNITIDINE

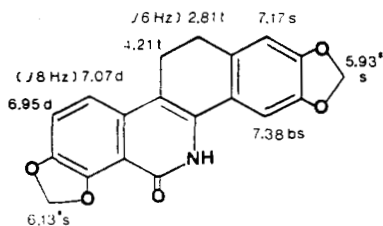


$C_{21}H_{17}NO_5$ : 363.37334  
MP: 284-285° (EtOH) (4, 5, 8, 89, 135)  
290-293° (CHCl<sub>3</sub>-MeOH) (123)  
See also 17, 125, 126, 148, 176.  
UV: (EtOH) 251 (4.59), 268 sh (4.66), 277 (4.71), 288 (4.81), 321 (4.19), 335 (4.16), 367.5 (3.62) (126)  
See also 5, 135.  
IR: (KBr) 1640 (135)  
See also 125, 126, 176.  
<sup>1</sup>H-NMR: 100 MHz (CDCl<sub>3</sub>) (126)  
See also 17, 135.  
MS: 363 (100), 362 (47), 348 (34) (135)  
See also 126.

Sources:

Rutaceae: *Fagara* (135)  
*Xanthoxylum* (123, 125, 126)  
*Zanthoxylum* (4, 5, 321)

54. N-DEMETHYL-5,6-DIHYDROOXY-SANGUINARINE  
(N-demethyl-9,10-dihydrooxy-sanguinarine)

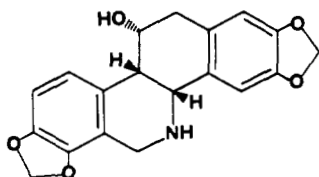


$C_{19}H_{13}NO_5$ : 335.31916  
MP: 291-292° (CHCl<sub>3</sub>-MeOH) (265)  
304-306° (265)  
UV: (MeOH) 225 (4.08), 258 sh (3.96), 347 (4.39), 378 (4.13), 400 sh (3.98); λ<sub>min</sub> 295 (3.71), 371 (4.10) (265)  
IR: (CHCl<sub>3</sub>) 3100, 2890, 1650, 1595, 1505, 1485, 1060, 1040, 940, 880, 865, 840, 815 (265)  
<sup>1</sup>H-NMR: 100 MHz (CDCl<sub>3</sub>) (HMDS) (265)

Sources:

Papaveraceae: *Chelidonium* (265)

55. (-)-NORCHELIDONINE  
(*(l)*-norchelidonine)  
(N-des-methyl(-)-chelidonine)



$C_{19}H_{17}NO_5$ : 339.35104  
MP: 198-199° (Et<sub>2</sub>O or CHCl<sub>3</sub>-EtOH) (239)  
See also 104f.  
[α]<sup>22</sup><sub>D</sub>: -100° ± 3° (c=0.50, CHCl<sub>3</sub>) (239)  
[α]<sub>D</sub>: -112° ± 3° (c=0.40, EtOH) (239)  
[α]<sub>D</sub>: -130° (c=0.5, C<sub>5</sub>H=N) (211)  
See also 104f.  
UV: (EtOH) 239 (3.86), 288 (3.91); λ<sub>min</sub> 230 (3.83), 257 (2.95) (104f, 278)  
See also 267.  
IR: (CHCl<sub>3</sub>) 3344, 3288, 3285, 3200 (211)  
See also 104f.

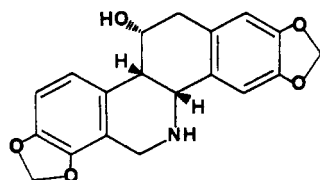
CD: (EtOH)  $\Delta\epsilon_{nm}$  +1.08<sub>297</sub>, +0.76<sub>286(i)}</sub>,  
 -1.96<sub>240</sub>, negative at shorter wavelengths;  
 (MeOH-N/2 HCl)  $\Delta\epsilon_{nm}$  +0.61<sub>298</sub>, -2.98<sub>229</sub>,  
 -57<sub>208</sub> (278)

Sources:

Papaveraceae: *Glaucium* (32, 184, 239, 256)

For absolute configuration, see 211, 278.

### 56. ( $\pm$ )-NORCHELIDONINE



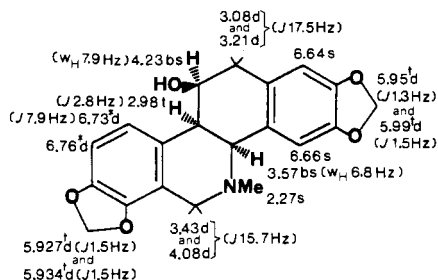
$C_{19}H_{17}NO_5$ : 339.35104

MP: 212-217° (191)

Remaining physical properties resemble those of (-)-  
 norchelidonine (excluding  $[\alpha]_D$  and CD)

Sources: Synthetic (191)

### 57. (+)-CHELIDONINE (stylophorine)



$C_{20}H_{19}NO_5$ : 353.37813

MP: 135-136° (EtOH) (237, 244)

137° (Et<sub>2</sub>O) (158)

See also 104a, 137, 211, 226, 287.

$[\alpha]_D^{23}$ : +115° ± 3° (c=0.50, EtOH) (244)

See also 104a, 211, 226.

UV: (EtOH) 206 (4.85), 238 (3.96), 289 (3.90);  $\lambda_{min}$   
 228 (3.92), 257 (2.98) (278)

See also 104a, 227, 287.

IR: (CHCl<sub>3</sub>) 3210, 3206 (211)

See also 21, 36, 104a, 163, 173, 296.

<sup>1</sup>H-NMR: 360 (CDCl<sub>3</sub>) (42)

See also 36, 173, 189, 227, 287, 296.

<sup>13</sup>C-NMR: 22.6 MHz (CDCl<sub>3</sub>) (296)

MS: 353 (M<sup>+</sup>, 65), 352 (30), 336 (30), 335 (100)  
 (287)

CD: (EtOH)  $\Delta\epsilon_{nm}$  -1.63<sub>298</sub>, -0.79<sub>284(i)}</sub>, +1.72<sub>242</sub>  
 (i), +27.8<sub>209</sub>, negative at shorter wavelengths;  
 (EtOH-1% HCl) -1.62<sub>298</sub>, -1.27<sub>287(i)}</sub>,  
 +0.89<sub>253</sub>, +2.62<sub>227(i)}</sub>, +40.3<sub>210</sub>, -20<sub>198</sub>;  
 (C<sub>6</sub>H<sub>12</sub>) -1.63<sub>299</sub>, +1.63<sub>245</sub>, -1.06<sub>230</sub>,  
 +22.6<sub>208</sub>, -6<sub>196</sub> (278)

X-RAY: (293)

Sources:

Caprifoliaceae: *Symphoricarpos* (287)

Fumariaceae: *Dicentra* (45)

Papaveraceae: *Chelidonium* (81, 86, 207, 211, 218,  
 219, 220, 226, 267, 326)

*Dicranostigma* (158)

*Glaucium* (137)

*Stylophorum* (158, 218, 219, 224, 244)

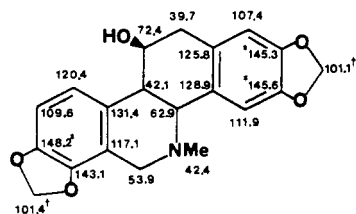
The following contain data for chelidonine with no  
 stereochemical designation:

Papaveraceae: *Chelidonium* (16, 46, 84, 95, 152, 168,  
 223, 237, 265, 295)

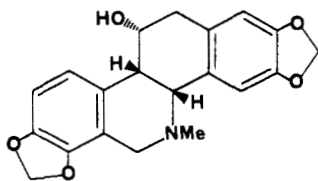
*Glaucium* (228)

*Hylomecon* (246)

*Stylophorum* (217)



**58. (-)-CHELIDONINE**  
(*l*-chelidonine)



$C_{20}H_{19}NO_5$ : 353.37813

MP: 135-136° (EtOH) (239, 255, 256)

$[\alpha]^{22}_D$ :  $-112^\circ \pm 3^\circ$  ( $c=0.20$ , EtOH) (256)

$[\alpha]_D$ :  $-138^\circ$  ( $c=0.5$ ,  $C_5H_5N$ ) (211)

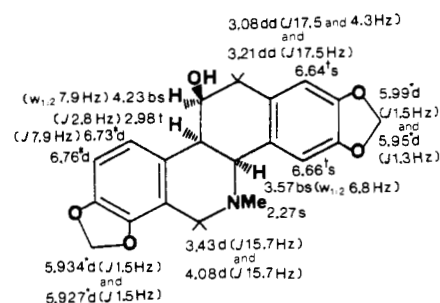
See also 239, 255.

Sources:

Papaveraceae: *Glauicum* (184, 255, 256)

**59. ( $\pm$ )-CHELIDONINE**

(*dl*-chelidonine)  
(diphylline)



$C_{20}H_{19}NO_5$ : 353.37813

MP: 213-214° ( $CHCl_3$ -MeOH) (331)

215-216° ( $CHCl_3$ -EtOH) (267)

217-218° ( $CHCl_3$ -EtOH) (270)

See also 43, 83, 191, 244, 256.

$[\alpha]^{23}_D$ :  $0^\circ \pm 3^\circ$  ( $c=0.10$ ,  $CHCl_3$ ) (244)

See also 270, 331.

UV: (MeOH) 238 (4.0), 290 (3.0);  $\lambda$  258 (3.0) (270)

See also 331.

IR: 3600-3350, 1500, 1040, 935 (331)

$^1H$ -NMR: 360 MHz ( $CDCl_3$ ) (43)

See also 42, 83, 331.

MS: 353 ( $M^+$ ), 352, 335, 322, 304, 294 (331)

See also 83.

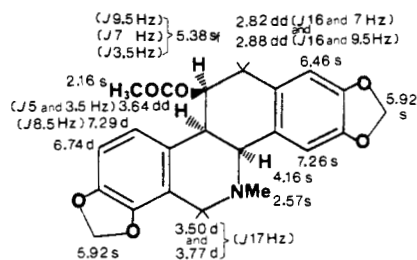
Sources:

Papaveraceae: *Chelidonium* (267)

*Glauicum* (83, 255, 270, 331)

*Stylophorum* (217, 244)

**60. (+)-ACETYLCHELIDONINE**



$C_{22}H_{21}NO_6$ : 395.41577

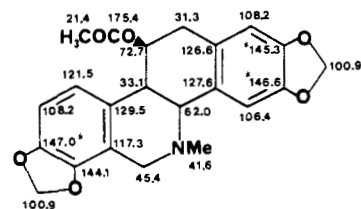
IR: ( $CHCl_3$ ) 2800, 2775 (296)

$^1H$ -NMR: ( $CDCl_3$ ) (296)

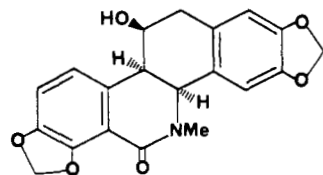
See also 173.

$^{13}C$ -NMR: 22.6 MHz ( $CDCl_3$ ) (296)

Sources: Synthetic (296)



**61. OXYCHELIDONINE**



$C_{20}H_{17}NO_6$ : 367.36159

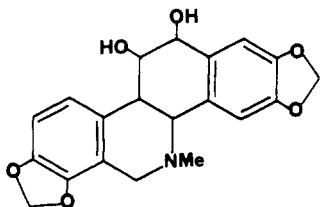
MP:  $>285^\circ$  (AcOH or  $CHCl_3$ ) (80)

$[\alpha]_D$ :  $+102.5^\circ$  ( $CHCl_3$ -EtOH) (80)

Sources:

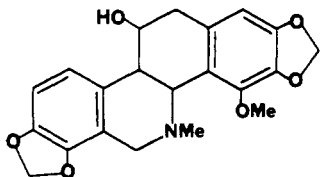
Papaveraceae: *Chelidonium* (76, 80)

62. CHELAMINE  
(10-hydroxychelidinine)



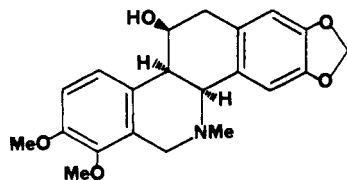
$C_{20}H_{19}NO_6$ : 369.37753  
 MP: 203-204° (EtOH) (267)  
 $[\alpha]^{20}_D$ : +107° ± 2° (c=0.28,  $CHCl_3$ ) (267)  
 UV: 287 (3.8);  $\lambda_{min}$  260 (3.2) (267)  
 IR: 3600, 3400-3200, 1625, 1600, 1300-1000 (267)  
 Sources:  
 Papaveraceae: *Chelidonium* (267)

63. METHOXYCHELIDONINE



$C_{21}H_{21}NO_6$ : 383.40461  
 MP: 221° (78, 234)  
 See also 1a.  
 $[\alpha]_D$ : +115.48° (78)  
 See also 81.  
 Sources:  
 Papaveraceae: *Chelidonium* (78, 81, 95)

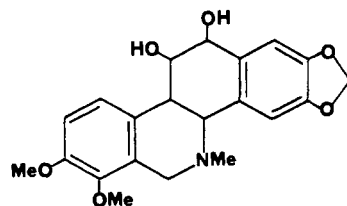
64. (+)-HOMOCHLIDONINE  
( $\alpha$ -homochelidonine)  
(*d*-homochelidonine)



$C_{21}H_{23}NO_5$ : 369.42116  
 MP: 169-170° (EtOH) (326)  
 182° (AcOH) (104e, 225)  
 192-193.5° (177)  
 $[\alpha]_D$ : +128° (EtOH) (104e)  
 See also 200.  
 UV: (EtOH) 286 (3.74) (104e)  
 See also 267.  
 IR: 3355, 3300, 3270, 1625, 1603, 1520, 1507,  
 1305, 1287, 1251, 1194, 1143, 1125, 1100,  
 1089, 1059, 1050, 1028, 1010, 975, 958, 941,  
 932, 921, 913, 883, 831, 826, 798, 748, 722  
 (104e)  
 See also 21.  
 Sources:

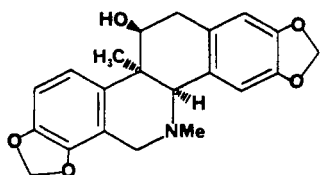
Papaveraceae: *Bocconia* (169)  
*Chelidonium* (159, 219, 223, 226, 267)

65. CHELAMIDINE  
(10-hydroxyhomochelidonine)  
(alkaloid XV)



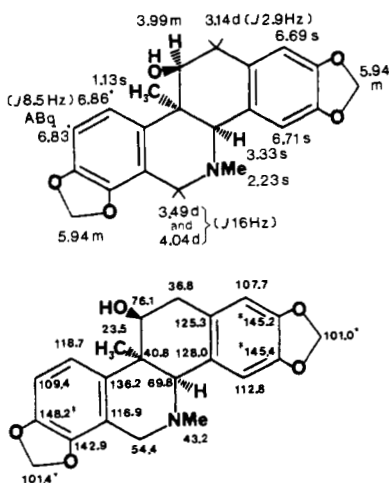
$C_{21}H_{23}NO_6$ : 385.42056  
 MP: 225-226° ( $CHCl_3$ -EtOH) (267)  
 $[\alpha]^{21}_D$ : +123° ± 2° (c=0.50,  $CHCl_3$ ) (267)  
 UV: 287 (3.9);  $\lambda_{min}$  259 (3.3) (267)  
 IR: 3330 (267)  
 Sources:  
 Papaveraceae: *Chelidonium* (267)

66. (+)-CORYNOLINE

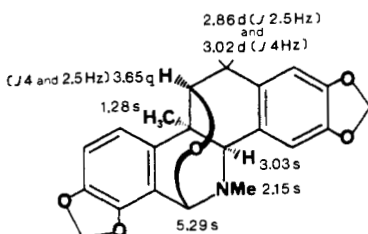


$C_{21}H_{21}NO_5$ : 367.40522  
 MP: 178-179° ( $Et_2O$ - $Me_2CO$ ) (297)  
 180-181° ( $Et_2O$ - $MeOH$ ) (131)  
 $[\alpha]^{20}_D$ : +116.4° (c=1.7,  $CHCl_3$ ) (297)  
 $[\alpha]^{23}_D$ : +132° (c=2.64,  $CHCl_3$ ) (131)  
 IR: (nujol) 3150 (297)  
 MS: 367 ( $M^+$ ), 349 (100), 334, 318, 307, 202, 190  
 (297)

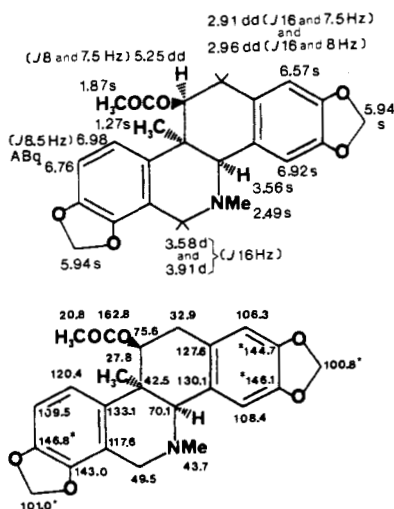
67. (±)-CORYNOLINE  
(base I)



68. CORYNOLOXINE  
(base V)



69. (±)-ACETYLCORYNOLINE  
(±)-corynoline acetate  
(corynoline-O-acetate)



Sources:

Fumariaceae: *Corydalis* (295, 297)

For absolute configuration, see 297.

$C_{21}H_{21}NO_5$ : 367.40522

MP: 215-216° (CHCl<sub>3</sub>-MeOH) (291)

217-218° (MeOH) (134)

218-220° (Et<sub>2</sub>O-MeOH) (179)

See also 183, 297, 305.

[α]<sub>D</sub>: 0° (c=1.00, CHCl<sub>3</sub>) (183)

UV: (MeOH) 238 (4.06), 289 (3.97) (183)

See also 289, 305.

IR: (KBr) 3240, 922 (183)

See also 132, 173, 290, 296.

<sup>1</sup>H-NMR: (CDCl<sub>3</sub>) (296)

See also 131, 173, 183, 189.

<sup>13</sup>C-NMR: 22.6 MHz (CDCl<sub>3</sub>) (296)

See also 131.

MS: 367 (M<sup>+</sup>), 349, 334, 318, 202, 190, 176, 162 (134)

See also 179.

X-RAY: (p-bromobenzoate) (132, 133)

Sources:

Fumariaceae: *Corydalis* (134, 160, 173, 289, 295, 297, 305)

$C_{21}H_{19}NO_5$ : 365.38928

MP: 204-206° (MeOH) (291)

209-210° (CHCl<sub>3</sub>-MeOH) (291, 296)

See also 134, 305.

<sup>1</sup>H-NMR: (CDCl<sub>3</sub>) (173)

See also 291.

MS: 365 (M<sup>+</sup>), 336, 306, 280, 202, 189, 188, 175 (134)

Sources:

Fumariaceae: *Corydalis* (134, 173, 291, 305)

$C_{23}H_{23}NO_6$ : 409.44286

MP: 158-159° (MeOH) (183)

159-160° (MeOH) (134, 305)

[α]<sub>D</sub>: 0° (c=1.06, CHCl<sub>3</sub>) (183)

UV: (MeOH) 236 sh(3.95), 290 (3.86) (183)

IR: (KBr) 1740, 937 (183)

See also 296, 305.

<sup>1</sup>H-NMR: (CDCl<sub>3</sub>) (296)

See also 173, 183.

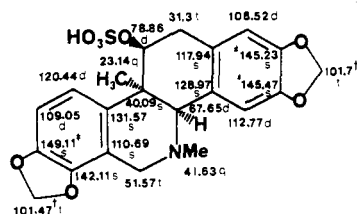
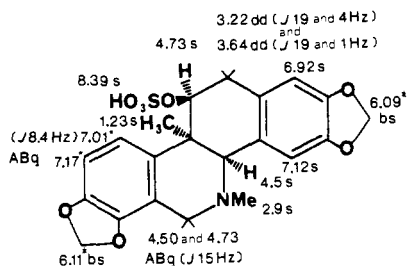
<sup>13</sup>C-NMR: 22.6 MHz (CDCl<sub>3</sub>) (296)

MS: 409 (M<sup>+</sup>), 366, 349, 334, 318, 202, 190, 176, 162 (134)

Sources:

Fumariaceae: *Corydalis* (134, 183, 295)

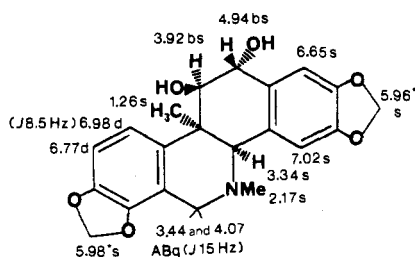
**70. (+)-CORYNOLINE-6-O-SULFATE**  
 ((+)-corynoline-11-O-sulfate)



$C_{21}H_{21}NO_8S$ : 447.46742  
 MP: 253-254° (CHCl<sub>3</sub>-MeOH) (131)  
 $[\alpha]^{23}_D$ : +67° (c=0.19, MeOH) (131)  
 UV: (MeOH) 237 (4.13), 289 (4.02) (131)  
 IR: (nujol) 3100 (131)  
<sup>1</sup>H-NMR: 90 MHz (DMSO-*d*<sub>6</sub>) (131)  
<sup>13</sup>C-NMR: 22.6 MHz (DMSO-*d*<sub>6</sub>) (131)  
 MS: 367 (M<sup>+</sup>-SO<sub>3</sub>, weak), 365, 363, 349, 334, 318 (131)

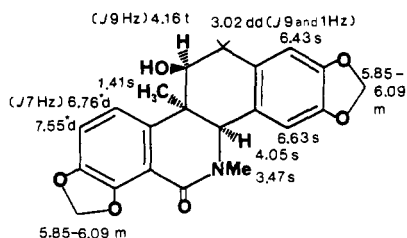
Sources:  
 Fumariaceae: *Corydalis* (131)

**71. (±)-5-HYDROXYCORYNOLINE**  
 ((±)-12-hydroxycorynoline)



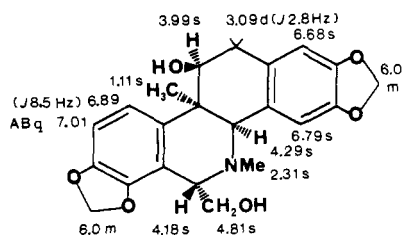
$C_{21}H_{21}NO_6$ : 383.40461  
 MP: 238-240° (CHCl<sub>3</sub>-MeOH) (178, 179)  
 245-246.5° (CHCl<sub>3</sub>-MeOH) (181)  
 $[\alpha]^{17}_D$ : 0° (c=0.14, CHCl<sub>3</sub>) (181)  
 UV: (MeOH) 240 (3.84), 289 (3.75) (181)  
 IR: (KBr) 3300 (181)  
<sup>1</sup>H-NMR: (CDCl<sub>3</sub>) (181)  
 MS: 383.135 (M<sup>+</sup>) (181)  
 Sources:  
 Fumariaceae: *Corydalis* (181)

**72. 8-OXOCORYNOLINE**  
 (6-oxocorynoline)



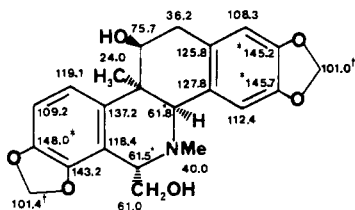
$C_{21}H_{19}NO_6$ : 381.38868  
 MP: >295° (181)  
 IR: (KBr) 3490, 1640 (181)  
<sup>1</sup>H-NMR: (CDCl<sub>3</sub>) (181)  
 Sources:  
 Fumariaceae: *Corydalis* (181)

**73. (±)-CORYNOLAMINE**

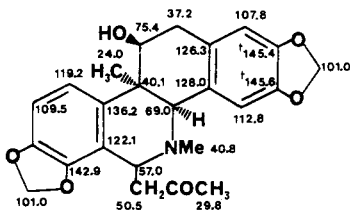
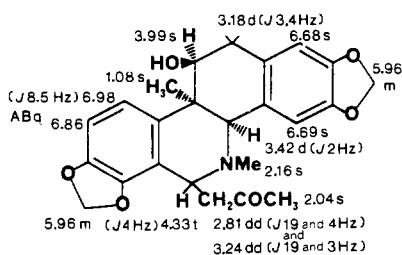


$C_{22}H_{23}NO_6$ : 397.43171  
 MP: 198-199° (CHCl<sub>3</sub>-MeOH) (294)  
 $[\alpha]^{20}_D$ : 0° (294)  
 UV: (MeOH) 288 (3.24), 237 (3.25) (294)  
 IR: (nujol) 3540, 3330 (294)  
 See also 296.  
<sup>1</sup>H-NMR: (CDCl<sub>3</sub>) (296, 294)  
<sup>13</sup>C-NMR: 22.6 MHz (CDCl<sub>3</sub>) (296)  
 MS: 397 (M<sup>+</sup>), 366 (100) (294)  
 Sources:  
 Fumariaceae: *Corydalis* (294)





74. (±)-8-eg'-ACETONYLCORYNO-  
LINE



$C_{24}H_{25}NO_6$ : 423.46995

MP: 200.5-201.5° (CHCl<sub>3</sub>-MeOH) (296)

IR: (nujol) 3150, 2780, 1708 (296)

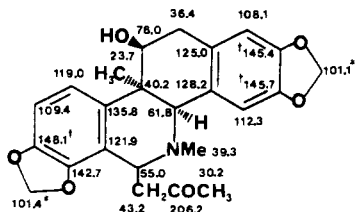
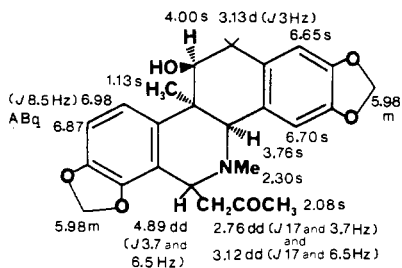
<sup>1</sup>H-NMR: (CDCl<sub>3</sub>) (296)

<sup>13</sup>C-NMR: (CDCl<sub>3</sub>) (296)

Sources: Synthetic (296).

There is a report of the isolation of 8-acetylcorynoline from *Corydalis delavayi* (154). However, the original reference was not available to the reviewers.

75. (±)-8-ax'-ACETONYLCORYNOLINE



$C_{24}H_{25}NO_6$ : 423.46995

MP: 202-203° (Et<sub>2</sub>O-MeOH) (296)

UV: (MeOH) 237 (3.30), 288 (3.20) (296)

IR: (nujol) 3160, 1712 (296)

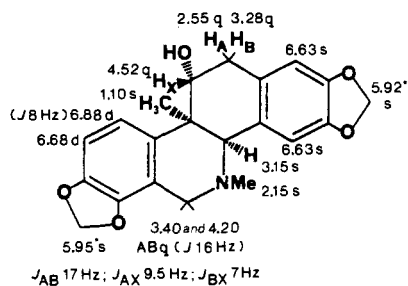
<sup>1</sup>H-NMR: (CDCl<sub>3</sub>) (296)

<sup>13</sup>C-NMR: (CDCl<sub>3</sub>) (296)

MS: 423 (M<sup>+</sup>), 366 (296)

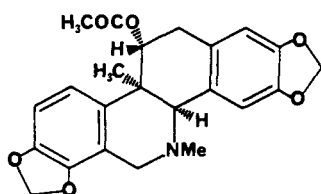
Sources: Synthetic (296)

76. (±)-6-EPICORYNOLINE  
(±)-11-epicorynoline



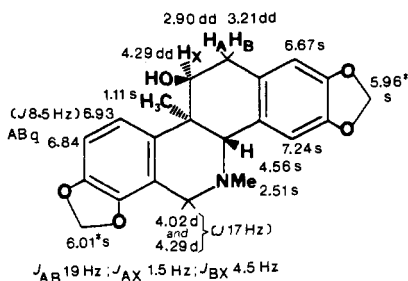
C<sub>21</sub>H<sub>21</sub>NO<sub>5</sub>: 367.40522  
MP: 182.5-183° (MeOH) (179)  
195.5-196.5° (CHCl<sub>3</sub>-MeOH) (181)  
[α]<sup>17</sup><sub>D</sub>: 0° (c=0.5, CHCl<sub>3</sub>) (181)  
UV: (MeOH) 238 sh (4.03), 290 (3.95) (181)  
IR: (KBr) 3600 (181)  
<sup>1</sup>H-NMR: (CDCl<sub>3</sub>) (181)  
MS: 367.142 (M<sup>+</sup>) (181, 179)  
Sources:  
Fumariaceae: *Corydalis* (181)

77. ACETYL-6-EPICORYNOLINE  
(6-epicorynoline acetate)

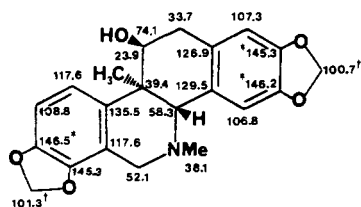


C<sub>23</sub>H<sub>23</sub>NO<sub>6</sub>: 409.44286  
MP: 218-219° (CHCl<sub>3</sub>-MeOH) (292)  
Sources: Synthetic (292)

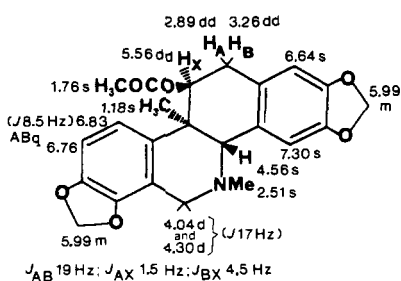
78. (+)-ISOCORYNOLINE  
(+)-14-epicorynoline  
(base II)



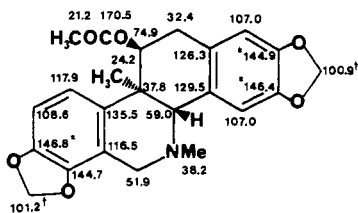
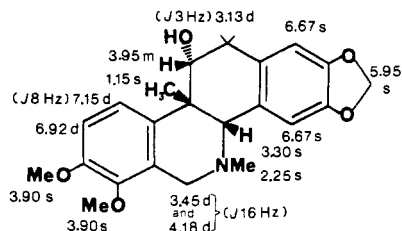
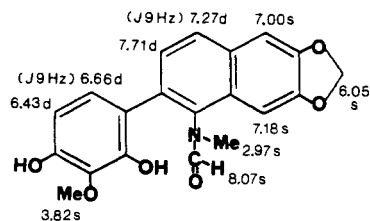
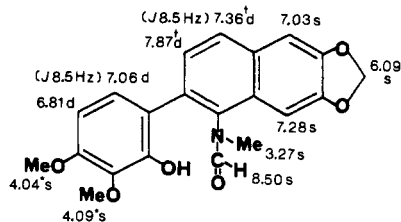
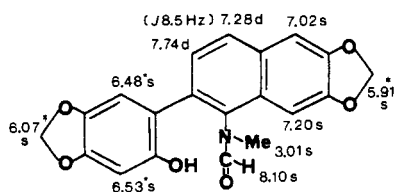
C<sub>21</sub>H<sub>21</sub>NO<sub>5</sub>: 367.40522  
MP: 232-233° (CHCl<sub>3</sub>-MeOH) (183)  
234-235° (MeOH) (134)  
[α]<sup>25</sup><sub>D</sub>: +125° (c=0.12, MeOH) (134)  
[α]<sub>D</sub>: +99.6° (c=0.953, CHCl<sub>3</sub>) (183)  
UV: (MeOH) 237, 290 (183)  
IR: (KBr) 3140, 937 (183)  
See also 296.  
<sup>1</sup>H-NMR: (CDCl<sub>3</sub>) (296)  
See also 134, 292.  
<sup>13</sup>C-nmr: 22.6 MHz (CDCl<sub>3</sub>) (296)  
MS: 367 (M<sup>+</sup>), 349, 334, 318, 307, 202, 190, 176,  
162 (134)  
X-RAY: (bromoacetate) (298, 299)  
Sources:  
Fumariaceae: *Corydalis* (134, 181, 183, 292)



79. (+)-ACETYLISOCORYNOLINE  
(+)-14-epicorynoline acetate)



C<sub>23</sub>H<sub>23</sub>NO<sub>6</sub>: 409.44286  
MP: 204-206° (MeOH) (292)  
207-208° (292)  
210-211° (134)  
[α]<sub>D</sub>: +93.1° (c=0.821, CHCl<sub>3</sub>) (183)  
[α]<sup>28</sup><sub>D</sub>: +62.8 (C=0.32, CHCl<sub>3</sub>) (134)  
UV: (MeOH) 237 (3.86), 289 (3.85) (183)  
IR: (KBr) 1732, 1230, 932 (183)  
See also 296.  
<sup>1</sup>H-NMR: (CDCl<sub>3</sub>) (296)  
See also 134, 183.  
<sup>13</sup>C-NMR: 22.6 MHz (CDCl<sub>3</sub>) (296)  
MS: 409.153 (M<sup>+</sup>) (183)

**80. NO NAME****81. IWAMIDE****82. ARNOTTIANAMIDE****83. INTEGRIAMIDE**

Sources:

Fumariaceae: *Corydalis* (181, 183, 295) $C_{22}H_{25}NO_5$ ; 383.44825

MP: 194-196° (190)

IR: (CCl<sub>4</sub>) 3190 (190)<sup>1</sup>H-NMR: (CDCl<sub>3</sub>) (190)

Sources: Synthetic (190)

 $C_{20}H_{17}NO_6$ ; 367.36159

MP: 267-268.5° (128)

271-273° (CHCl<sub>3</sub>-MeOH) (118)

IR: (KBr) 3480, 1646 (118, 128)

<sup>1</sup>H-NMR: 100 MHz (CDCl<sub>3</sub>-CD<sub>3</sub>OD) (118, 128)MS: 367.1039 (M<sup>+</sup>) (118)

Sources:

Rutaceae: *Xanthoxylum* (118) $C_{21}H_{19}NO_6$ ; 381.38868MP: 264-267° (CHCl<sub>3</sub>-MeOH) (123)267-269° (CHCl<sub>3</sub>-MeOH) (118)

271-273° (EtOAc-MeOH) (111)

See also 122, 232.

UV: (EtOH) 236 (4.73), 280 sh (4.01), 321 sh (3.63),

324 (3.65), 332 (3.81) (122, 123)

IR: (nujol) 3450-3200, 1663 (123)

See also 118, 122.

<sup>1</sup>H-NMR: 100 MHz (TFA-*d*) (123, 118, 122)MS: 381.1190 (M<sup>+</sup>, 100) (118)

See also 122, 123, 232.

Sources:

Rutaceae: *Fagara* (37)*Toddalia* (232)*Xanthoxylum* (118, 122, 123)*Zanthoxylum* (111) $C_{20}H_{15}NO_6$ ; 365.34565MP: 294-296° (CHCl<sub>3</sub>-MeOH) (112)302-304° (CHCl<sub>3</sub>-MeOH) (111, 112)

IR: (KBr) 1695 (111)

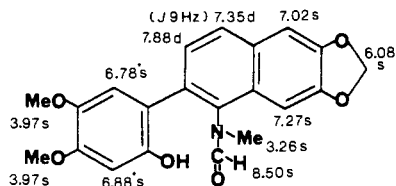
See also 112.

<sup>1</sup>H-NMR: 100 MHz (CDCl<sub>3</sub>-CD<sub>3</sub>OD) (111, 112)

Sources:

Rutaceae: *Xanthoxylum* (111, 112)

## 84. ISOARNOTTIANAMIDE


 $C_{21}H_{19}NO_6$ : 381.38868
MP: 254-257° (dec) ( $CHCl_3$ ) (123)

UV: (MeOH) 237.5 (4.73), 290 (4.00), 332 (3.86) (122, 123)

IR: (KBr) 1670 (122, 123)

 $^1H$ -NMR: 100 MHz (TFA-*d*) (122, 123)MS: 381 ( $M^+$ , 100) (122, 123)

Sources:

Rutaceae: *Xanthoxylum* (122, 123)

## 85. (+)-SANGUIDIMERINE

((+)-1,3-bis(8-hydrosanguinarinyl)-acetone)

((+)-1,3-bis(11-hydrosanguinarinyl)-acetone)

 $C_{43}H_{32}N_2O_9$ : 720.74249
MP: 174° ( $CHCl_3$ -MeOH) (309)

See also 310.

[ $\alpha$ ] $^{26}_D$ : +21.2° (c=0.5,  $C_5H_5N$ ) (309, 310)

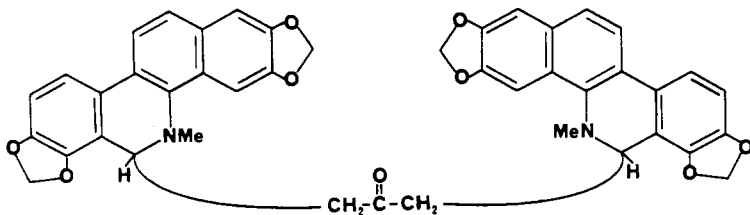
UV: (EtOH) 235 (4.65), 284 (4.63), 323 (4.23) (309)

IR: (KBr) 2900, 1710, 1600, 1440, 1355, 1250, 1040, 940, 855, 795, 740 (309)

MS: 720.21226 ( $M^+$ , 4), 389.1261 (2), 362.1011 (2), 332.0929 (100), 317 (12), 316 (2), 274 (4), 259 (3), 201 (3) (310)

See also 309.

Sources:

Papaveraceae: *Sanguinaria* (198, 309, 310)

## 86. (±)-CHELIDIMERINE

(meso-1,3-bis(11-hydrosanguinarinyl)-acetone)

(CM-1)

 $C_{43}H_{32}N_2O_9$ : 720.74249
MP: 258-260° ( $CHCl_3$ -MeOH) (139, 311)[ $\alpha$ ] $^{24}_D$ : 0° (c=0.5,  $CHCl_3$ ) (311)

UV: (MeOH) 232 (4.59), 285 (4.43), 324 (3.89) (139)

See also 311.

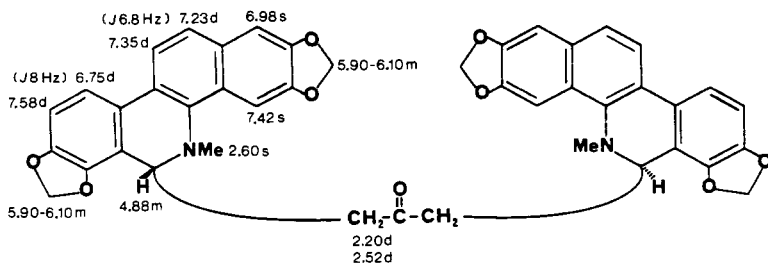
IR: (KBr) 2924, 1712, 1610, 1439, 1360, 1250, 1041, 943, 862, 800, 752 (139)

 $^1H$ -NMR: ( $CDCl_3$ ) (311)MS: 720.2089 ( $M^+$ , 9.1), 389.1272 (5.5), 374.1017 (3.7), 362.1011 (4.1), 333 (48.8), 332.0929 (100), 331 (5.4), 318 (7.8), 317 (23.4), 316 (4.0), 274 (6.5), 259 (5.2), 216 (3.9), 201 (5.3), 189 (4.4), 166 (5.3) (311)

See also 139.

X-RAY: (311)

Sources:

Papaveraceae: *Chelidonium* (139, 311)

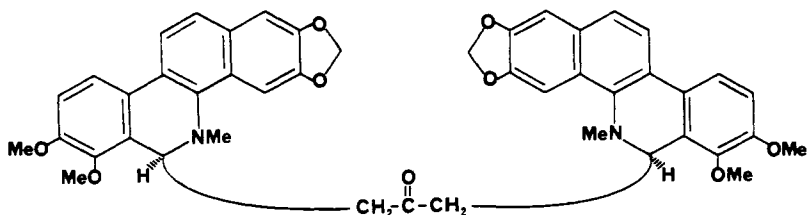
**87. CHELERYTHRIDIMERINE**C<sub>45</sub>H<sub>40</sub>N<sub>2</sub>O<sub>9</sub>: 752.82855MP: 304° (CHCl<sub>3</sub>-Me<sub>2</sub>CO) (156)

(1,3-bis(8-hydrochelerythriny)-acetone) IR: 1710 (156)

(1,3-bis(6-hydrochelerythriny)-acetone) MS: 752.2759 (M<sup>+</sup>), 405.1583, 348.1265 (100)

(1,3-bis(11-hydrochelerythriny)-acetone) (156)

Sources:

Papaveraceae: *Bocconia* (156)**88. TODDALIDIMERINE**

(1,3-(8-hydrochelerythriny-8'-hydro-N-norchelerythriny)-acetone)

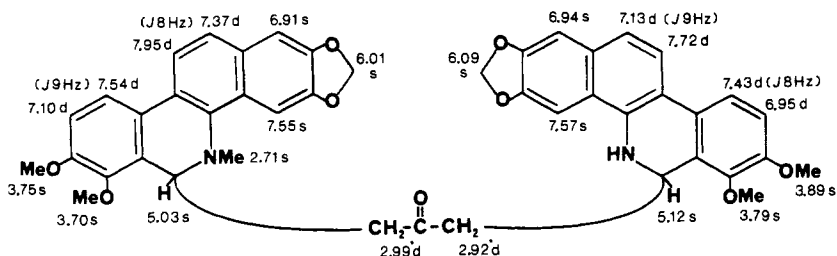
C<sub>44</sub>H<sub>38</sub>N<sub>2</sub>O<sub>9</sub>: 738.80146MP: 307° (CH<sub>2</sub>Cl<sub>2</sub>-Et<sub>2</sub>O) (231)(α)<sup>20</sup><sub>D</sub>: +60° (c=2, CHCl<sub>3</sub>) (231)

UV: (EtOH) 232 (5.68), 286 (5.71), 325 (5.16) (231)

IR: (KBr) 3470, 1710, 1600 (231)

<sup>1</sup>H-NMR: 90 MHz (CDCl<sub>3</sub>) (HMDS) (231) (\*\*)MS: 738.2567 (M<sup>+</sup>, 4), 391.1410 (6), 348.1237 (100), 333.1004 (30), 318.0769 (12), 304.0623 (6), 290.0826 (16) (231)

Sources:

Rutaceae: *Toddalia* (231)

\*\*The absolute configuration as well as the specific site of N-methylation are unknown.

## Alphabetical List of the Benzophenanthridines

Angoline (40)

Arnottianamide (82)

Avicine (15)

(±)-8-eq'-Acetonycorynoline (74)

(±)-8-ax'-Acetonycorynoline (75)

8-Acetyldihydrochelerythrine (45)

8-Acetyldihydrosanguinarine (32)

(+) -Acetylchelidonine (60)

(±)-Acetylcorynoline (69)

Acetyl-6-epicorynoline (77)

(+) -Acetylisocorynoline (79)

Bocconoline (43)

Chelamidine (65)

Chelamine (62)

Chelerythridimerine (87)

Chelerythrine (8)

(±)-Chelidimerine (86)

(+) -Chelidonine (57)

(-) -Chelidonine (58)

(±)-Chelidonine (59)

Chelilutine (9)

Chelirubine (2)

(±)-Corynoline (73)

(+) -Corynoline (66)

- (±)-Corynoline (67)  
 (+)-Corynoline-6-O-sulfate (70)  
 Corynoloxine (68)  
 Decarine (20)  
 N-Demethyl-5,6-dihydrooxysanguinarine (54)  
 N-Demethylfagarone (24)  
 9,10-Demethylene-9,10-dihydrosanguinarine (5)  
 9,10-Demethylenesanguinarine (4)  
 Des-N-methylavicine (22)  
 O-Desmethyl-dihydrochelerythriny-8-acetone (37)  
 Dihydroavicine (49)  
 Dihydrochelerythrine (38)  
 Dihydrochelerythriny-8-acetaldehyde (44)  
 Dihydrochelirubine (33)  
 Dihydrochelilutine (47)  
 7,8-Dihydro-8-hydroxymethylfagaridine (36)  
 Dihydromacarpine (35)  
 7,8-Dihydro-8-methoxynitidine (52)  
 Dihydrinitidine (51)  
 Dihydrosanguilutine (48)  
 Dihydrosanguinarine (26)  
 (±)-6-Epicorynoline (76)  
 6-Ethoxychelerythrine (12)  
 8-Ethoxydihydrochelerythrine (41)  
 Ethoxydihydrosanguinarine (28)  
 Fagaridine (7)  
 Fagaronine (17)  
 (+)-Homochelidonine (64)  
 (±)-5-Hydroxycorynoline (71)  
 8-Hydroxydihydrochelerythrine (39)  
 8-Hydroxymethyl-dihydrosanguinarine (31)  
 8-Iminosanguinarine (30)  
 Integriamide (83)  
 Isoarnottianamide (84)  
 (+)-Isocorynoline (78)  
 Isodecarine (20A)  
 Iwamide (81)  
 8-(2'-Ketobutane)-dihydrochelerythrine (46)  
 Luguine (25)  
 Macarpine (3)  
 2,3-Methylenedioxy-1,9,10-trimethoxybenzo-  
 [c]phenanthridine N-metho salt (11)  
 Methoxychelidonine (63)  
 (-)-8-Methoxydihydrosanguinarine (27)  
 N-Methyldecarine (6)  
 Nitidine (16)  
 Norchelerythrine (21)  
 (-)-Norchelidonine (55)  
 (±)-Norchelidonine (56)  
 N-Nornitidine (23)  
 Norsanguinarine (18)  
 8-Oxocorynoline (72)  
 Oxyavicine (50)  
 Oxychelerythrine (42)  
 Oxychelidonine (61)  
 Oxychelirubine (34)  
 Oxynitidine (53)  
 Oxysanguinarine (29)  
 Pancorine (19)  
 Punctatine (13)  
 (+)-Sanguidimerine (85)  
 Sanguilutine (14)  
 Sanguinarine (1)  
 Sanguirubine (10)  
 Toddalidimerine (88)

## Botanical Distribution of the Benzophenanthridines

- Angoline (40)  
 Papaveraceae: *Bocconia* (156, 159)  
*Hunnemannia* (170)  
 Rutaceae: *Fagara* (2, 29, 74, 192, 193)  
*Toddalia* (230)
- Arnottianamide (82)  
 Rutaceae: *Fagara* (37)  
*Toddalia* (232)  
*Xanthoxylum* (118, 122, 123)  
*Zanthoxylum* (111)
- Avicine (15)  
 Rutaceae: *Xanthoxylum* (126)  
*Zanthoxylum* (6)
- 8-Acetyldihydrochelerythrine (45)  
 Rutaceae: *Toddalia* (49, 91, 231)  
*Xylocarpus* (37)  
*Zanthoxylum* (47, 146)
- 8-Acetyldihydrosanguinarine (32)  
 Papaveraceae: *Argemone* (52)  
*Glaucium* (31)  
*Hypocoum* (92)  
*Papaver* (75)
- (±)-Acetylcorynoline (69)  
 Fumariaceae: *Corydalis* (134, 183, 295)
- (+)-Acetylisocorynoline (79)  
 Fumariaceae: *Corydalis* (181, 183, 295)
- Bocconoline (43)  
 Papaveraceae: *Bocconia* (115, 306)  
*Chelidonium* (130)  
*Glaucium* (31, 184)  
 Rutaceae: *Fagara* (119)
- Chelamidine (65)  
 Papaveraceae: *Chelidonium* (267)
- Chelamine (62)  
 Papaveraceae: *Chelidonium* (267)
- Chelerythridimerine (87)  
 Papaveraceae: *Bocconia* (156)
- Chelerythrine (8)  
 Fumariaceae: *Corydalis* (35, 129, 161, 201)  
*Dicentra* (238)  
 Papaveraceae: *Argemone* (13, 14, 20, 26, 27, 52, 97, 98, 99, 100, 102,

- 251, 269, 271, 273, 286, 330)  
*Bocconia* (15, 53, 54, 93, 106, 149, 155, 159, 164, 172, 187, 221, 264, 288, 306, 307)  
*Chelidonium* (16, 46, 84, 95, 130, 152, 159, 168, 207, 208, 219, 220, 223, 226, 237, 252, 257, 267, 279, 326)  
*Dicranostigma* (157, 259, 272, 274)  
*Eschscholtzia* (15, 57, 220, 248, 253, 263, 268)  
*Glaucium* (25, 32, 58, 137, 144, 184, 209, 220, 236, 240, 243, 255, 256, 262, 270, 276, 331)  
*Hunnemannia* (249, 275)  
*Hylomecon* (246)  
*Hypecoum* (258, 330)  
*Macleaya* (34, 110, 151, 254, 266)  
*Papaver* (102, 174)  
*Platystemon* (245, 261)  
*Sanguinaria* (56, 140, 219, 222, 246, 257, 310)  
*Stylomecon* (246)  
*Stylophorum* (157, 217)  
Rutaceae: *Fagara* (2, 19, 28, 37, 59, 65, 66, 68, 69, 70, 71, 72, 73, 147, 148, 195, 216, 315, 318, 319)  
*Toddalia* (49, 50, 90, 91, 142)  
*Xanthoxylum* (33, 118, 126, 325)  
*Zanthoxylum* (30, 33, 48, 51, 59, 60, 61, 63, 67, 146, 216, 281, 314, 322, 324, 327)  
Sapindaceae: *Pteridophyllum* (109)
13. (±)-Chelidimerine (**86**)  
Papaveraceae: *Chelidonium* (139, 311)
14. (+)-Chelidonine (**57**)  
Caprifoliaceae: *Symphoricarpos* (287)  
Fumariaceae: *Dicentra* (45)  
Papaveraceae: *Chelidonium* (81, 86, 207, 211, 218, 219, 220, 226, 267, 326)  
*Dicranostigma* (158)  
*Glaucium* (137)  
*Stylophorum* (158, 218, 219, 224, 244)
15. (-)-Chelidonine (**58**)  
Papaveraceae: *Glaucium* (184, 255, 256)
16. (±)-Chelidonine (**59**)  
Papaveraceae: *Chelidonium* (367)  
*Glaucium* (83, 255, 270, 331)  
*Stylophorum* (217, 244)
17. Chelilutine (**9**)  
Fumariaceae: *Dicentra* (238)  
Papaveraceae: *Chelidonium* (95, 226, 252, 257, 267)  
*Eschscholtzia* (253, 263, 268)  
*Glaucium* (262)  
*Hunnemannia* (249, 275)  
*Hylomecon* (246)  
*Macleaya* (40, 254, 266)  
*Sanguinaria* (242, 257)
18. Chelirubine (**2**)  
Fumariaceae: *Dicentra* (238)  
Papaveraceae: *Bocconia* (149, 187, 189, 288, 306)  
*Chelidonium* (226, 237, 252, 267)  
*Dicranostigma* (259, 272, 274)  
*Eschscholtzia* (110, 248, 253, 263, 268)  
*Glaucium* (32, 184, 236, 240, 243, 255, 256, 257, 262, 270, 276)  
*Hunnemannia* (249, 275)  
*Hylomecon* (246)  
*Hypecoum* (258)  
*Macleaya* (110, 254, 266, 300, 306)  
*Papaver* (110)  
*Platystemon* (245, 261)  
*Sanguinaria* (242, 246, 257)  
*Stylophorum* (244)
19. (±)-Corynolamine (**73**)  
Fumariaceae: *Corydalis* (294)
20. (+)-Corynoline (**66**)  
Fumariaceae: *Corydalis* (295, 297)
21. (±)-Corynoline (**67**)  
Fumariaceae: *Corydalis* (134, 160, 173, 289, 295, 297, 305)
22. (+)-Corynoline-6-O-sulfate (70)  
Fumariaceae: *Corydalis* (131)
23. Corynoloxine (**68**)  
Fumariaceae: *Corydalis* (134, 173, 291, 305)
24. Decarine (**20**)  
Rutaceae: *Xanthoxylum* (118, 123)  
*Zanthoxylum* (22, 116, 322, 328)
25. N-Demethyl-5,6-dihydrooxysanguinarine (**54**)  
Papaveraceae: *Chelidonium* (265)
26. 9,10-Demethylene-9,10-dihydro-sanguinarine (**5**)  
Papaveraceae: *Macleaya* (151)
27. 9,10-Demethylenesanguinarine (**4**)  
Papaveraceae: *Macleaya* (151)
28. Des-N-methylavicine (**22**)  
Rutaceae: *Xanthoxylum* (123)
29. O-Desmethyldihydrochelerythrinyl-8-acetone (**37**)  
Rutaceae: *Zanthoxylum* (47)
30. Dihydroavicine (**49**)  
Rutaceae: *Toddalia* (230)  
*Zanthoxylum* (30)
31. Dihydrochelerythrine (**38**)  
Papaveraceae: *Argemone* (271, 273)  
*Bocconia* (1m)  
*Chelidonium* (265)  
*Glaucium* (31, 228)  
Rutaceae: *Fagara* (37, 44, 216, 315, 319)  
*Toddalia* (49, 90, 91, 231)  
*Xanthoxylum* (325)  
*Zanthoxylum* (62)

32. Dihydrochelerythrinyl-8-acetaldehyde (44)  
Papaveraceae: *Glaucium* (31)  
Rutaceae: *Zanthoxylum* (47)
33. Dihydrochelirubine (33)  
Papaveraceae: *Chelidonium* (265)
34. Dihydrochelilutine (47)  
Papaveraceae: *Chelidonium* (265)
35. 7,8-Dihydro-8-hydroxymethylfagaridine (36)  
Rutaceae: *Zanthoxylum* (22)
36. 7,8-Dihydro-8-methoxynitidine (52)  
Rutaceae: *Fagara* (320)
37. Dihydrionitidine (51)  
Rutaceae: *Toddalia* (230)  
*Zanthoxylum* (323)
38. Dihydrosanguilutine (48)  
Papaveraceae: *Sanguinaria* (140)
39. Dihydrosanguinarine (26)  
Fumariaceae: *Corydalis* (110, 129, 136, 162, 302, 304)  
*Dicentra* (110)  
Papaveraceae: *Argemone* (52, 213, 271, 273)  
*Bocconia* (156)  
*Chelidonium* (110, 265, 295)  
*Eschscholtzia* (110)  
*Glaucium* (31, 137, 228)  
*Macleaya* (110)  
*Papaver* (75, 110)  
*Romneya* (283)  
Sapindaceae: *Pteridophyllum* (109, 110)
40. (±)-6-Epicorynoline (76)  
Fumariaceae: *Corydalis* (181)
41. 5-Ethoxychelerythrine (12)  
Rutaceae: *Zanthoxylum* (321)
42. 8-Ethoxydihydrochelerythrine (41)  
Papaveraceae: *Hunnemannia* (170)  
Rutaceae: *Fagara* (44, 196, 318, 319)
43. Ethoxydihydrosanguinarine (28)  
Papaveraceae: *Hunnemannia* (170)
44. Fagaridine (7)  
Rutaceae: *Fagara* (2, 196, 316, 317)
45. Fagaronine (17)  
Rutaceae: *Fagara* (167, 308)
46. (+)-Homochelidonine (64)  
Papaveraceae: *Bocconia* (169)  
*Chelidonium* (159, 219, 223, 226, 267)
47. (±)-5-Hydroxycorynoline (71)  
Fumariaceae: *Corydalis* (181)
48. 8-Hydroxydihydrochelerythrine (39)  
Rutaceae: *Toddalia* (232)
49. 8-Hydroxymethyldihydrosanguinarine (31)  
Papaveraceae: *Chelidonium* (130)
50. 8-Iminosanguinarine (30)  
Papaveraceae: *Glaucium* (31)
51. Integriamide (83)  
Rutaceae: *Xanthoxylum* (111, 112)
52. Isoarnottianamide (84)  
Rutaceae: *Xanthoxylum* (122, 123)
53. (+)-Isocorynoline (78)  
Fumariaceae: *Corydalis* (134, 181, 183, 292)
- 53A. Isodecarine (20A)  
Rutaceae: *Xanthoxylum* (319a)
54. Iwamide (81)  
Rutaceae: *Xanthoxylum* (118)
55. 8-(2'-Kerobutane)-dihydrochelerythrine (46)  
Rutaceae: *Fagara* (9)
56. Luguine (25)  
Papaveraceae: *Glaucium* (32)
57. Macarpine (3)  
Papaveraceae: *Eschscholtzia* (248, 263, 268)  
*Macleaya* (254, 266, 300)  
*Strylaphorum* (244)
58. Methoxychelidonine (63)  
Papaveraceae: *Chelidonium* (78, 81, 95)
59. (-)-8-Methoxydihydrosanguinarine (27)  
Fumariaceae: *Fumaria* (194)  
Papaveraceae: *Hunnemannia* (170)  
*Hypecoum* (92)
60. Nitidine (16)  
Rutaceae: *Fagara* (2, 28, 29, 37, 65, 66, 68, 69, 70, 71, 72, 73, 123, 147, 148, 192, 193, 315)  
*Xanthoxylum* (63, 117, 123, 124, 125, 126)  
*Zanthoxylum* (4, 5, 8, 59, 60, 61, 63, 64, 67, 89, 281, 321, 322, 323, 324, 327)
61. Norchelerythrine (21)  
Papaveraceae: *Argemone* (14, 52, 97, 99, 100)  
*Chelidonium* (130)  
Rutaceae: *Toddalia* (91, 230)  
*Xanthoxylum* (14, 118, 123)  
*Zanthoxylum* (321)
62. (-)-Norchelidonine (55)  
Papaveraceae: *Glaucium* (32, 184, 239, 256)
63. N-Nornitidine (23)  
Rutaceae: *Zanthoxylum* (22)
64. Norsanguinarine (18)  
Fumariaceae: *Corydalis* (110)  
*Dicentra* (110)  
Papaveraceae: *Argemone* (52, 97, 100, 271)  
*Chelidonium* (110, 130)  
*Eschscholtzia* (110)  
*Glaucium* (32)  
*Hypecoum* (92)  
*Macleaya* (110)  
*Papaver* (75, 110)  
Sapindaceae: *Pteridophyllum* (109, 110)
65. 8-Oxocorynoline (72)  
Fumariaceae: *Corydalis* (181)
66. Oxychelerythrine (42)



- Rutaceae: *Xanthoxylum* (118)  
*Zanthoxylum* (321)
67. Oxychelidonine (**61**)  
 Papaveraceae: *Chelidonium* (76, 80)
68. Oxychelirubine (**34**)  
 Papaveraceae: *Glaucium* (31)
69. Oxynitidine (**53**)  
 Rutaceae: *Fagara* (315)  
*Xanthoxylum* (123, 125, 126)  
*Zanthoxylum* (4, 5, 321)
70. Oxysanguinarine (**29**)  
 Fumariaceae: *Corydalis* (110, 136, 202, 206, 302)  
*Dicentra* (110)  
*Fumaria* (194)  
 Papaveraceae: *Bocconia* (53, 156, 306)  
*Chelidonium* (110, 214, 235, 265)  
*Dicranostigma* (259)  
*Eschscholtzia* (110)  
*Glaucium* (32)  
*Hypecoum* (92)  
*Macleaya* (110)  
*Papaver* (75, 110, 165, 166, 174, 203, 204, 205, 212)  
*Sanguinaria* (257, 280)  
 Sapindaceae: *Pteridophyllum* (109, 110)
71. Pancorine (**19**)  
 Fumariaceae: *Corydalis* (3)
72. Punctatine (**13**)  
 Rutaceae: *Zanthoxylum* (285)
73. (+)-Sanguidimerine (**85**)  
 Papaveraceae: *Sanguinaria* (198, 309, 310)
74. Sanguilutine (**14**)  
 Papaveraceae: *Papaver* (198)  
*Sanguinaria* (242, 257)
75. Sanguinarine (**1**)  
 Fumariaceae: *Corydalis* (11, 12, 35, 102, 110, 129, 136, 161, 162, 201, 210, 233, 301, 302, 303, 304, 305)  
*Dicentra* (45, 110, 238)  
*Fumaria* (55)  
 Papaveraceae: *Argemone* (13, 14, 20, 26, 52, 97, 98, 99, 100, 102, 171, 213, 251, 260, 269, 271, 273, 282, 284, 286)  
*Bocconia* (53, 54, 93, 94, 142, 149, 155, 157, 164, 187, 189, 264, 266, 288, 306, 307)  
*Chelidonium* (16, 18, 46, 79, 82, 84, 95, 130, 152, 168, 219, 220, 226, 237, 252, 265, 267, 329)  
*Dicranostigma* (157, 259, 272, 274)  
*Eschscholtzia* (57, 110, 220, 248, 253, 263, 268)  
*Glaucium* (25, 32, 58, 137, 144, 184, 236, 240, 243, 255, 256, 262, 270, 276, 331)  
*Hunnemannia* (249, 275)  
*Hylomecon* (246)  
*Hypecoum* (258, 330)  
*Macleaya* (34, 110, 143, 151, 254, 266, 300)  
*Meconopsis* (103, 241)  
*Papaver* (23, 75, 102, 110, 153, 165, 174, 197)  
*Platystemon* (245, 261)  
*Romneya* (383)  
*Sanguinaria* (96, 140, 145, 215, 219, 246, 257, 309, 310)  
*Stylomecon* (246)  
*Stylophorum* (157, 217, 244)  
 Rutaceae: *Zanthoxylum* (146)  
 Sapindaceae: *Pteridophyllum* (109)
76. Sanguirubine (**10**)  
 Papaveraceae: *Sanguinaria* (242, 257)
77. Toddalidimerine (**88**)  
 Rutaceae: *Todalia* (231)

## Occurrence of the Benzophenanthridines by Plant Sources

- Caprifoliaceae  
*Symphoricarpos*  
 (+)-Chelidonine (**57**)
- Fumariaceae  
*Corydalis*  
 8-Acetonilcorynoline (**74, 75**)  
 (±)-Acetylcorynoline (**69**)  
 (+)-Acetylisocorynoline (**79**)  
 Chelerythrine (**8**)  
 (±)-Corynolamine (**73**)  
 (+)-Corynoline (**66**)  
 (±)-Corynoline (**67**)  
 (+)-Corynoline-6-O-sulfate (**70**)  
 Corynoloxine (**68**)  
 Dihydrosanguinarine (**26**)  
 (±)-6-Epicorynoline (**76**)  
 (±)-5-Hydroxycorynoline (**71**)
- (+)-Isocorynoline (**78**)  
 Norsanguinarine (**18**)  
 8-Oxocorynoline (**72**)  
 Oxysanguinarine (**29**)  
 Pancorine (**19**)  
 Sanguinarine (**1**)
- Dicentra*  
 Chelerythrine (**8**)  
 Chelilutine (**9**)  
 Chelirubine (**2**)  
 Dihydrosanguinarine (**26**)  
 Norsanguinarine (**18**)  
 Oxysanguinarine (**29**)  
 Sanguinarine (**1**)
- Fumaria*  
 (+)-Chelidonine (**57**)  
 (+)-8-Methoxydihydrosanguinarine (**27**)

- Oxysanguinarine (29)  
Sanguinarine (1)
- Papaveraceae*
- Argemone*
- 8-Acetylaldihydrosanguinarine (32)  
Chelerythrine (8)  
Dihydrochelerythrine (38)  
Dihydrosanguinarine (26)  
Norchelerythrine (21)  
Norsanguinarine (18)  
Sanguinarine (1)
- Bocconia*
- Angoline (40)  
Bocconoline (43)  
Chelerythridimerine (87)  
Chelerythrine (8)  
Chelirubine (2)  
Dihydrochelerythrine (38)  
Dihydrosanguinarine (26)  
(+)-Homochelidonine (64)  
Oxysanguinarine (29)  
Sanguinarine (1)
- Chelidonium*
- Bocconoline (43)  
Chelamidine (65)  
Chelamine (62)  
Chelerythrine (8)  
(±)-Chelidimerine (86)  
(+)-Chelidonine (57)  
(±)-Chelidonine (59)  
Chelilutine (9)  
Chelirubine (2)  
N-Demethyl-5,6-dihydrooxysanguinarine (54)  
Dihydrochelerythrine (38)  
Dihydrochelirubine (33)  
Dihydrochelilutine (47)  
Dihydrosanguinarine (26)  
(+)-Homochelidonine (64)  
8-Hydroxymethyldihydrosanguinarine (31)  
Methoxychelidonine (63)  
Norchelerythrine (21)  
Norsanguinarine (18)  
Oxychelidonine (61)  
Oxysanguinarine (29)  
Sanguinarine (1)
- Dicranostigma*
- Chelerythrine (8)  
(+)-Chelidonine (57)  
Chelirubine (2)  
Oxysanguinarine (29)  
Sanguinarine (1)
- Eschscholtzia*
- Chelerythrine (8)  
Chelilutine (9)  
Chelirubine (2)  
Dihydrosanguinarine (26)  
Macarpine (3)  
Norsanguinarine (18)  
Oxysanguinarine (29)  
Sanguinarine (1)
- Glaucium*
- 8-Acetylaldihydrosanguinarine (32)  
Bocconoline (43)  
Chelerythrine (8)  
(+)-Chelidonine (57)  
(-)-Chelidonine (58)  
(±)-Chelidonine (59)  
Chelilutine (9)  
Chelirubine (2)  
Dihydrochelerythrine (38)  
Dihydrochelerythrinyl-8-acetaldehyde (44)  
Dihydrosanguinarine (26)  
8-Iminosanguinarine (30)  
Luguine (25)  
(-)-Norchelidonine (55)  
Norsanguinarine (18)  
Oxychelirubine (34)  
Oxysanguinarine (29)  
Sanguinarine (1)
- Hunnemannia*
- Angoline (40)  
Chelerythrine (8)  
Chelilutine (9)  
Chelirubine (2)  
8-Ethoxydihydrochelerythrine (41)  
Ethoxydihydrosanguinarine (28)  
(-)-8-Methoxydihydrosanguinarine (27)  
Sanguinarine (1)
- Hylomecon*
- Chelerythrine (8)  
Chelidonine (57)  
Chelilutine (9)  
Chelirubine (2)  
Sanguinarine (1)
- Hypecoum*
- 8-Acetylaldihydrosanguinarine (32)  
Chelerythrine (8)  
Chelirubine (2)  
8-Methoxydihydrosanguinarine (27)  
Norsanguinarine (18)  
Oxysanguinarine (29)  
Sanguinarine (1)
- Macleaya*
- Chelerythrine (8)  
Chelilutine (9)  
Chelirubine (2)  
9,10-Demethylene-9,10-dihydro-sanguinarine (5)  
9,10-Demethylenesanguinarine (4)  
Dihydrosanguinarine (26)  
Macarpine (3)  
Norsanguinarine (18)  
Oxysanguinarine (29)  
Sanguinarine (1)
- Meconopsis*
- Sanguinarine (1)
- Papaver*
- 8-Acetylaldihydrosanguinarine (32)  
Chelerythrine (8)  
Chelirubine (2)  
Dihydrosanguinarine (26)

- Norsanguinarine (18)  
 Oxsanguinarine (29)  
 Sanguilutine (14)  
 Sanguinarine (1)  
*Platystemon*  
 Chelerythrine (8)  
 Chelirubine (2)  
 Sanguinarine (1)  
*Romneya*  
 Dihydrosanguinarine (26)  
 Sanguinarine (1)  
*Sanguinaria*  
 Chelerythrine (8)  
 Chelilutine (9)  
 Chelirubine (2)  
 Dihydrosanguilutine (48)  
 Oxsanguinarine (29)  
 (+)-Sanguidimerine (85)  
 Sanguilutine (14)  
 Sanguinarine (1)  
 Sanguirubine (10)  
*Stylomecon*  
 Chelerythrine (8)  
 Sanguinarine (1)  
*Stylophorum*  
 Chelerythrine (8)  
 (+)-Chelidonine (57)  
 (±)-Chelidonine (59)  
 Chelirubine (2)  
 Macarpine (3)  
 Sanguinarine (1)  
 Rutaceae  
*Fagara*  
 Angoline (40)  
 Arnottianamide (82)  
 Bocconoline (43)  
 Chelerythrine (8)  
 Dihydrochelerythrine (38)  
 7,8-Dihydro-8-methoxynitidine (52)  
 8-Ethoxydihydrochelerythrine (41)  
 Fagaridine (7)  
 Fagaronine (17)  
 8-(2'-Ketobutane)-dihydrochelerythrine (46)  
 Nitidine (16)  
 Oxynitidine (53)  
*Toddalia*  
 Angoline (40)  
 Arnottianamide (82)  
 8-Acetyldihydrochelerythrine (45)  
 Chelerythrine (8)  
 Dihydroavicine (49)  
 Dihydrochelerythrine (38)  
 Dihydranitidine (51)  
 8-Hydroxydihydrochelerythrine (39)  
 Norchelerythrine (21)  
 Toddalidimerine (88)  
*Xanthoxylum* (see also *Zanthoxylum*)  
 Arnottianamide (82)  
 Avicine (15)  
 Chelerythrine (8)  
 Decarine (20)  
 Des-N-methylavicine (22)  
 Dihydrochelerythrine (38)  
 Integriamide (83)  
 Isoarnottianamide (84)  
 Isodecarine (20A)  
 Iwamide (81)  
 Nitidine (16)  
 Norchelerythrine (21)  
 Oxchelerythrine (42)  
 Oxynitidine (53)  
*Xylocarpus*  
 8-Acetyldihydrochelerythrine (45)  
*Zanthoxylum* (see also *Xanthoxylum*)  
 Arnottianamide (82)  
 Avicine (15)  
 8-Acetyldihydrochelerythrine (45)  
 Chelerythrine (8)  
 Decarine (20)  
 O-Desmethyldihydrochelerythriny-8-acetone (37)  
 Dihydroavicine (49)  
 Dihydrochelerythrine (38)  
 Dihydrochelerythriny-8-acetaldehyde (44)  
 7,8-Dihydro-8-hydroxymethylfagaridine (36)  
 Dihydranitidine (51)  
 5-Ethoxychelerythrine (12)  
 Nitidine (16)  
 Norchelerythrine (21)  
 N-Nornitidine (23)  
 Oxchelerythrine (42)  
 Oxynitidine (53)  
 Punctatine (13)  
 Sanguinarine (1)  
 Sapindaceae  
*Pteridophyllum*  
 Chelerythrine (8)  
 Dihydrosanguinarine (26)  
 Norsanguinarine (18)  
 Oxsanguinarine (29)  
 Sanguinarine (1)

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