

# DIMERIC APORPHINE-BENZYLISOQUINOLINE AND APORPHINE-PAVINE ALKALOIDS

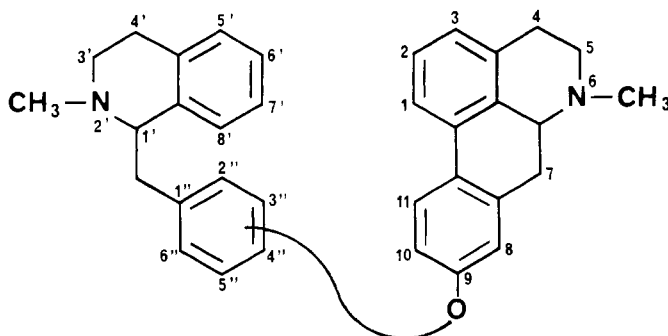
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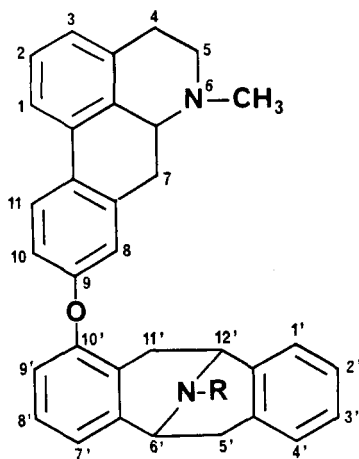
Aporphine-benzylisoquinoline dimers represent a small group of alkaloids; they have been found only in three genera, *Thalictrum* (Ranunculaceae), *Hernandia* (Hernandiaceae) and *Berberis* (Berberidaceae). At the present time, only two dimeric aporphine-pavine alkaloids have been found in *Thalictrum*. The first aporphine-benzylisoquinoline alkaloid to be fully characterized was thalicarpine by Kupchan (13) in 1963. The dimeric alkaloids found in the genus *Thalictrum* have been discussed in reviews on *Thalictrum* alkaloids by Schiff and Doskotch (34) in 1970, Mollov *et al.* (17) in 1971 and Tomimatsu (35) in 1965, 1967 and 1976. At the present time, more than 20 dimeric alkaloids are known.

The present review is concerned with a presentation of a complete listing of the dimeric aporphine-benzylisoquinoline and aporphine-pavine alkaloids together with their physical and spectral data as well as their sources. Hernandaline and related alkaloids, intermediate to the aporphine-benzylisoquinoline dimers, are not included in this review since they have been included in the aporphine alkaloids review.<sup>1</sup>

The dimeric aporphine-benzylisoquinoline alkaloids are divided into three groups: the *thalicarpine-type* in which the ether linkage is between C-9 of the aporphine and C-2'' of the disubstituted 4'',5''-benzylisoquinoline unit; the *fetidine-type* in which the ether linkage is between C-9 of the aporphine and C-2'' of the disubstituted 3'',4''-benzylisoquinoline moiety; and the *pakistanine-type* in which the ether linkage lies between C-9 of the aporphine and C-4'' of an arme-pavine residue. Within each section, the material has been arranged according to an ascending order of substitution pattern. For each alkaloid the description includes the structure, the molecular formula and molecular weight, the melting point and specific rotation, and when available the uv, ir, nmr, and mass spectral data, as well as the circular dichroism curve. The numbering of the skeleton is according to the accepted ruling.



<sup>1</sup>H. GUINAUDEAU, M. LÉBOEUF and A. CAVÉ. Aporphine Alkaloids. *Lloydia*, **38**: 275 (1975); H. GUINAUDEAU, M. LÉBOEUF and A. CAVÉ. Aporphine Alkaloids, II. To be published.



Unless stated otherwise, the uv (nm, log  $\epsilon$ ) spectra were obtained in ethanol; the ir ( $\text{cm}^{-1}$ ) spectra in nujol; and the nmr spectra in deuteriochloroform (60 MHz). Chemical shifts are in  $\delta$  units, and the coupling constants are in Hz.

### 1 THALICTROGAMINE

 $\text{C}_{39}\text{H}_{44}\text{O}_3\text{N}_2$ 

668.309743

 $[\alpha]_{25}^{\text{D}}: +135^\circ$  ( $c=0.2$ ,  $\text{CH}_3\text{OH}$ ) (24)

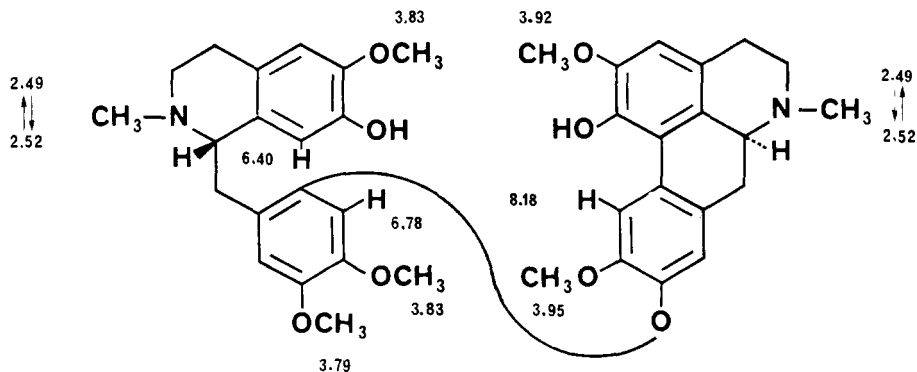
UV: 230 sh (4.39), 277 (4.11), 298 sh (3.98), 307 sh (3.82) (24)

IR: 3520 (24)

NMR: (24) (25) (32)

 MASS: 668 ( $\text{M}^+$ ), 476, 326, 309, 192 (base) (24)

 CD: ( $\text{CH}_3\text{OH}$ ) $[\theta]_{233}+186000$ ,  $[\theta]_{275}-19300$ ,  $[\theta]_{310}-28200$  (42)

 SOURCES: *Thalictrum polygamum* (24), *Thalictrum dioicum* (31), *Thalictrum revolutum* (42)


4 aromatic H at 6.51, 6.57 (3 H) .

### 2 PENNSYLVANAMINE

 $\text{C}_{36}\text{H}_{44}\text{O}_3\text{N}_2$ 

668.309743

MP: 128–129° (acetone-ether), 107–108° (ether) (25)

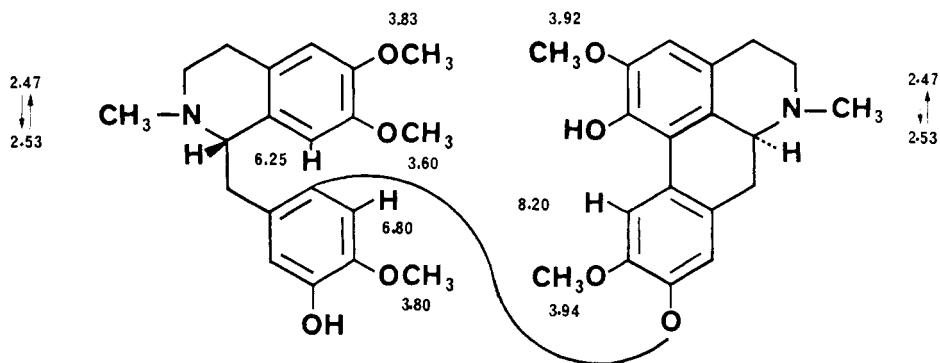
 $[\alpha]_{25}^{\text{D}}: +119^\circ$  ( $c=0.94$ ,  $\text{CH}_3\text{OH}$ ) (25)

 UV: ( $\text{CH}_3\text{OH}$ ) 276 sh (4.07), 284 (4.17), 297 sh (4.11), 312 sh (4.06) (25)

NMR: (25)

 MASS: 668 ( $\text{M}^+$ ), 462, 326, 325, 309, 206 (base) (25)

 SOURCES: *Thalictrum polygamum* (25) (26)



4 aromatic H at 6.55 (2H), 6.58 (2H).

### 3 THALICTROPINE

 $C_{40}H_{46}O_8N_2$ 

682.325392

MP: 167° (24)

$[\alpha]^{25}_D$ : +120° (c=0.3, CH<sub>3</sub>OH) (24)

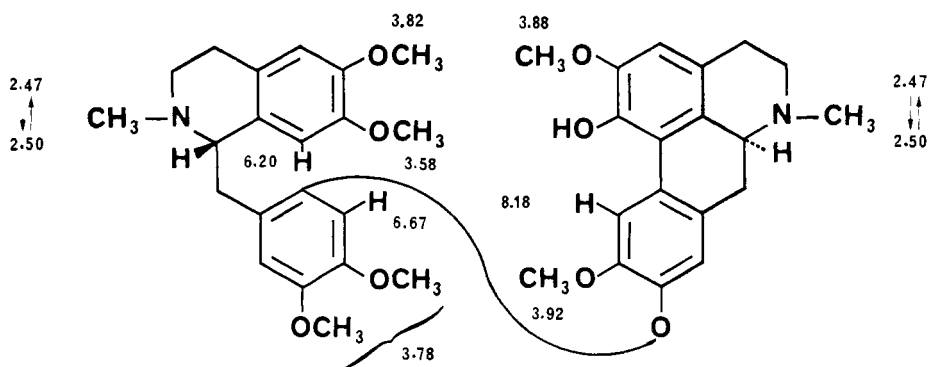
UV: 225 (4.46), 278 (4.12), 298 sh (3.88), 310 sh (3.70) (24)

IR: (CHCl<sub>3</sub>) 3500 (24)

NMR: (24) (25) (32)

MASS: 682 (M<sup>+</sup>), 476, 326, 310, 206 (base) (24)

SOURCES: *Thalictrum polygamum* (24), *Thalictrum dioicum* (31)



4 aromatic H at 6.55 (3H), 6.59 .

### 4 THALILUTIDINE

 $C_{40}H_{46}O_8N_2$ 

682.325392

$[\alpha]^{25}_D$ : +74 (c=0.11, CH<sub>3</sub>OH) (44)

UV: (CH<sub>3</sub>OH) 280 (4.38), 304 sh (4.21) (44)

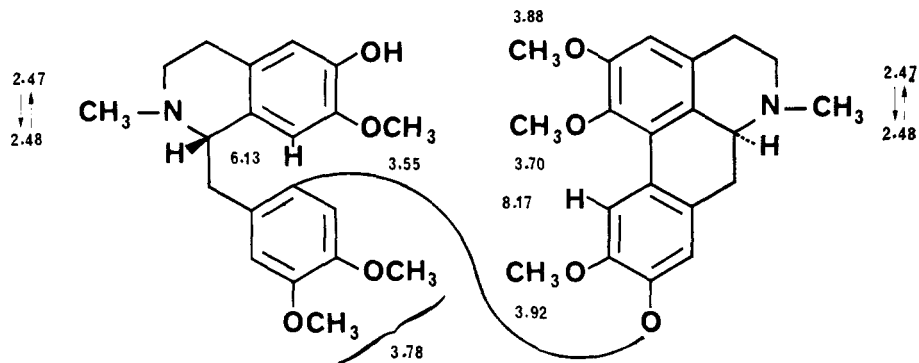
IR: (CHCl<sub>3</sub>) 3540 (44)

NMR: (44)

MASS: 682 (M<sup>+</sup>), 490, 340, 324, 192 (base) (44)

CD:  $[\theta]^{238} +180000$ ,  $[\theta]^{274} -16100$ ,  $[\theta]^{306} -13900$  (44)

SOURCES: *Thalictrum revolutum* (44)



5 aromatic H at 6.50 - 6.70 .

### 5 THALIPINE

 $C_{29}H_{44}O_5N_2$ 

668.309743

$[\alpha]^{25}_D$ : +141° ( $c=0.19$ ,  $CH_3OH$ ) (42)

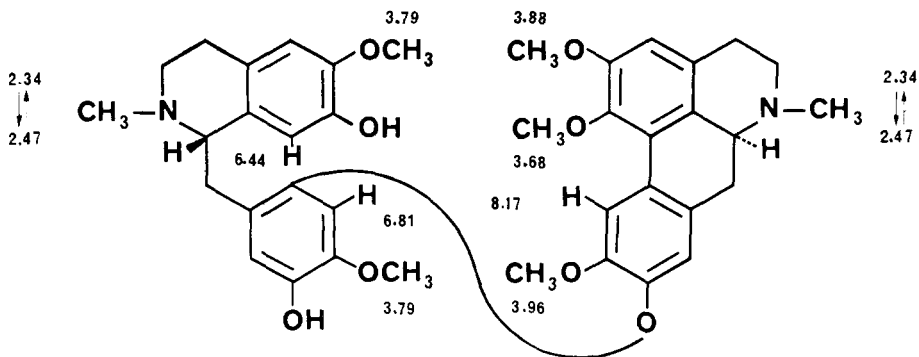
UV: 282 (4.49), 303 sh (4.34), 316 sh (4.19) (42)

NMR: (90 MHz) (42)

MASS: 668 ( $M^+$ ), 476, 340, 324, 192 (base) (42)

CD: ( $CH_3OH$ )  $[\theta]_{235}^{25}+214000$ ,  $[\theta]_{271}^{25}-19000$ ,  $[\theta]_{302}^{25}-14800$  (42)

SOURCES: *Thalictrum polygamum* (28), *Thalictrum revolutum* (40) (42)



4 aromatic H at 6.49 (2H), 6.59 (2H).

### 6 THALMELATINE

 $C_{40}H_{46}O_5N_2$ 

682.325392

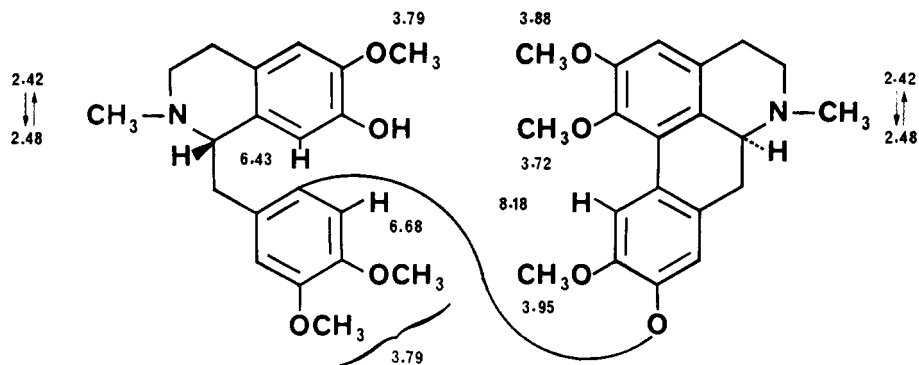
MP: 131-135° (15)

$[\alpha]^{21}_D$ : +110° ( $c=1$ ,  $C_2H_5OH$ ) (15)

NMR: (25) (32)

MASS: 682 ( $M^+$ ), 490, 324, 293, 192 (base), 190 (17)

SOURCES: *Thalictrum minus* var. *elatum* (15) (16) (18), *Thalictrum dioicum* (31), *Thalictrum revolutum* (41)



4 aromatic H at 6.52 , 6.55 , 6.60 (2 H) .

### 7 DEHYDROTHALMELATINE

 $C_{40}H_{44}O_8N_2$ 

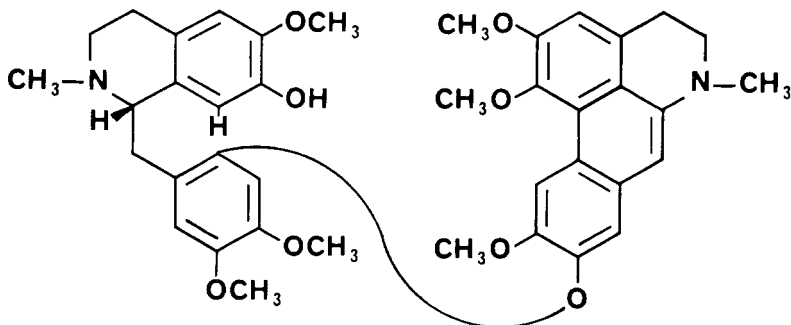
680.309743

MP: 126–128° (5)

 $[\alpha]^{19}_D: +31.9$  (c=0.15,  $CHCl_3$ ) (5)

UV: 268 (4.57), 330 (4.15) (5)

SOURCES: Synthesis (5)



### 8 THALIDOXINE

 $C_{40}H_{46}O_8N_2$ 

682.325392

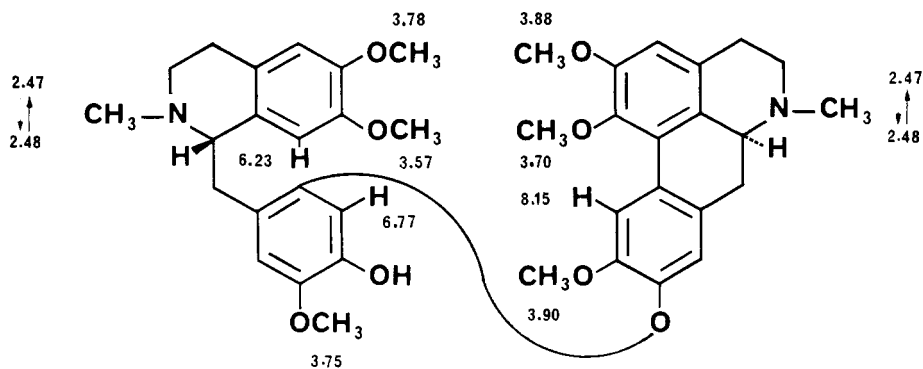
 $[\alpha]^{25}_D: +113^\circ$  (c=0.2,  $CH_3OH$ ) (32)

 UV: ( $CH_3OH$ ) 275 (4.23), 296 sh (4.08), 310 sh (4.02) (32)

 IR: ( $CHCl_3$ ) 3540 (32)

NMR: (25) (32)

 MASS: 682 ( $M^+$ ), 476, 340, 324, 206 (base) (32)

 SOURCES: *Thalictrum dioicum* (32). In a subsequent reinvestigation of *Thalictrum dioicum*, no thalidoxine was obtained (31).


4 aromatic H at 6.50 (3 H) , 6.57 .

**9 PENNSYLVANINE**C<sub>40</sub>H<sub>46</sub>O<sub>8</sub>N<sub>2</sub>

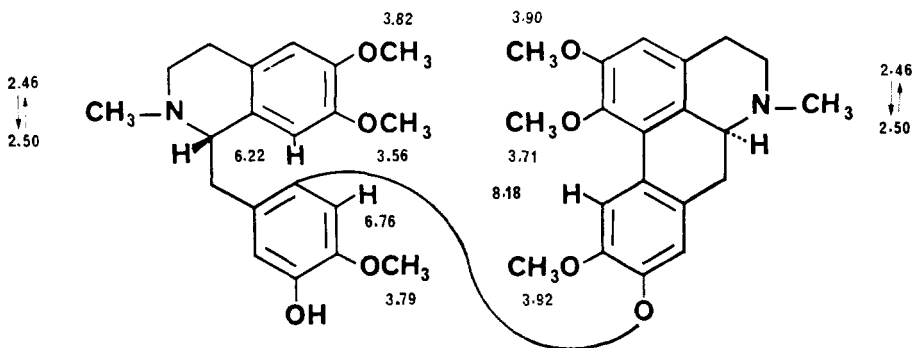
682.325392

MP: 112–113° (25)

[α]<sub>D</sub><sup>24</sup>: +131° (c=0.7, CH<sub>3</sub>OH) (25)

UV: 284 (4.26), 304 (4.18), 320 sh (4.05) (25)

NMR: (25)

MASS: 682 (M<sup>+</sup>), 476, 340, 324, 206 (base) (25)CD: (CH<sub>3</sub>OH) [θ]<sub>237</sub>+235000, [θ]<sub>270</sub>-8900, [θ]<sub>305</sub>-6500 (42)SOURCES: *Thalictrum polygamum* (25) (26), *Thalictrum dioicum* (31), *Thalictrum revolutum* (42) (45)**10 THALICARPINE**C<sub>41</sub>H<sub>45</sub>O<sub>8</sub>N<sub>2</sub>

696.341041

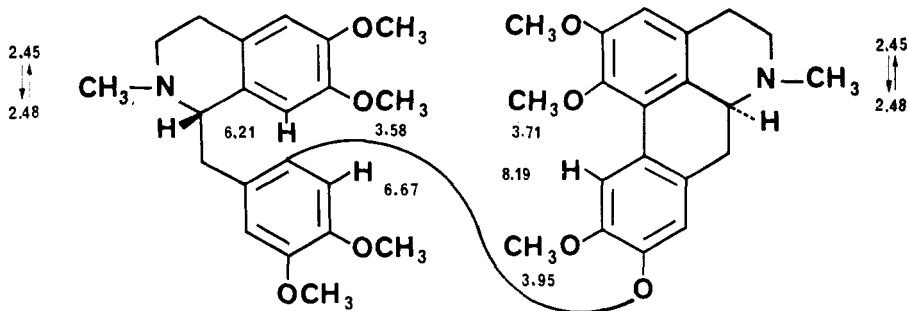
MP: 153–155° (38)

[α]<sub>D</sub><sup>27</sup>: +78° (c=1, CHCl<sub>3</sub>) (38)

UV: 282 (4.33), 301 (4.22) (37)

IR: 2935, 1600, 1505, 1460, 1060, 950 (39)

NMR: (32)

MASS: 696 (M<sup>+</sup>), 490, 324, 293, 206 (base), 204 (17)SOURCES: *Thalictrum dasycarpum* (11) (13) (36) (21), *Thalictrum dioicum* (31), *Thalictrum fendleri* (33), *Thalictrum flavum* (39), *Thalictrum foetidum* (1), *Thalictrum minus* (19), *Thalictrum minus* ssp. *elatum* (18), *Thalictrum minus* race B (7), *Thalictrum polygamum* (8), *Thalictrum revolutum* (36) (41), *Hernandia ovigera* (6) (38) (47).**11 OXOTHALICARPINE**C<sub>40</sub>H<sub>40</sub>O<sub>9</sub>N<sub>2</sub>

692.2733

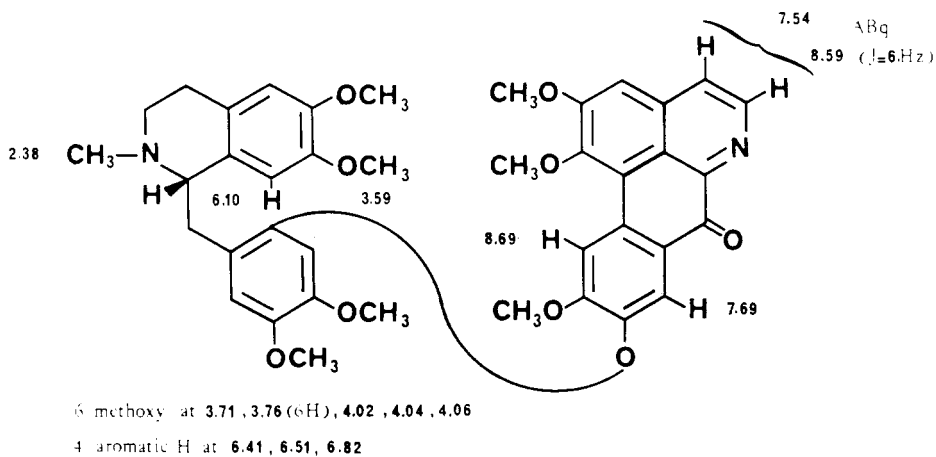
MP: 219–220° (dec.) (46)

[α]<sub>D</sub><sup>25</sup>: +115° (c=0.1, CHCl<sub>3</sub>) (46)

UV: 237 (4.52), 271 (4.44), 285 sh (4.34), 343 (3.93) (46)

IR: 1020, 1200, 1600, 1660, 2815 (46)

NMR: (46)

SOURCES: *Hernandia ovigera* (46)**12 DEHYDROTHALICARPINE (Thalictrucarpine)** $C_{41}H_{46}O_5N_2$ 

694.325392

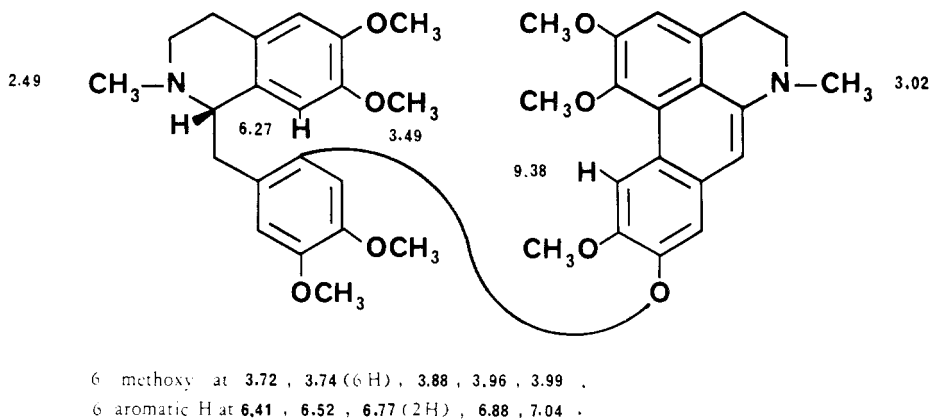
MP: 186–187° (12)

 $[\alpha]^{22}_D$ : +54° (c=1,  $CHCl_3$ ) (4)

UV: 268 (4.82), 331 (4.34) (4)

IR: 2817, 2762, 1613, 1464, 1250, 1124 (12)

NMR: (4)

MASS: 694 ( $M^+$ ), 488, 338, 206 (base), 204, 150 (17)SOURCES: *Thalictrum minus* ssp. *elatum* (4), *Thalictrum dasycarpum* (12), *Hernandia ovigera* (47)**13 THALILUTINE** $C_{41}H_{45}O_5N_2$ 

712.335955

 $[\alpha]^{20}_D$ : +92° (c=0.175,  $CH_3OH$ ) (44)

UV: 282 (4.40), 303 sh (4.28), 312 sh (4.23) (44)

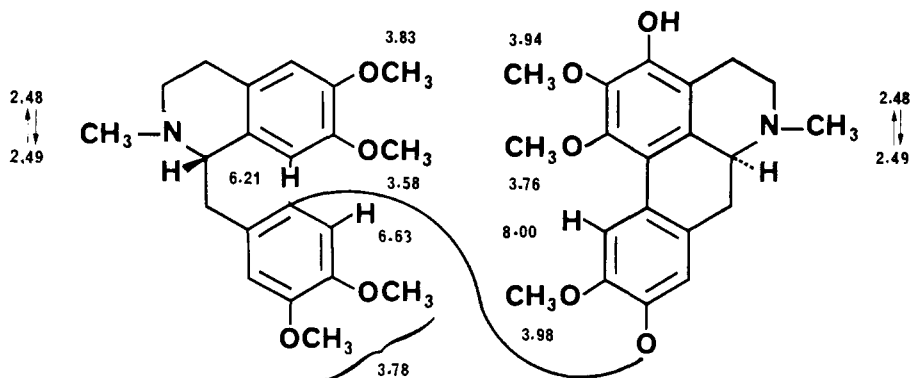
IR: ( $CHCl_3$ ) 3530 (44)

NMR: (44)

MASS: 712 ( $M^+$ ), 506, 372, 356, 340, 206 (base) (44)

CD:  $[\theta]_{233} +198000$ ,  $[\theta]_{276} -19300$ ,  $[\theta]_{307} -15900$  (44)

SOURCES: *Thalictrum revolutum* (44)



3 aromatic H at 6.53, 6.56, 6.58.

**14 O-DESMETHYL-ADIANTIFOLINE\***

$C_{41}H_{48}O_9N_2$

712.335955

MP: 125–126° (19)

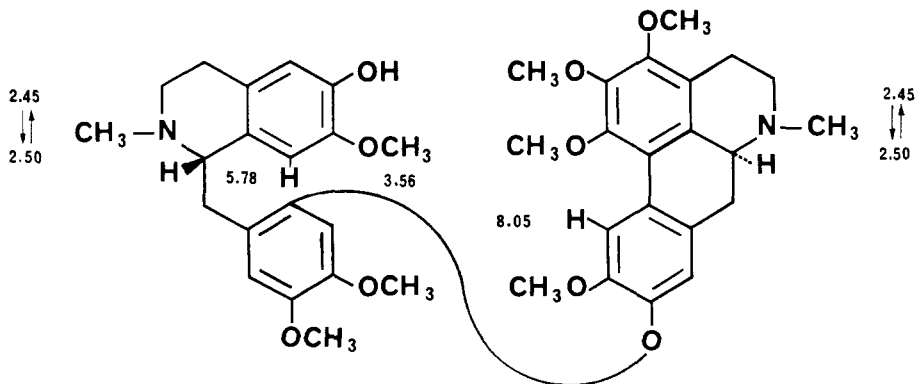
$[\alpha]_{22}^{20}D$ : +18° ( $c=0.4$ ,  $CHCl_3$ ) (19)

IR: 3505 (19)

NMR: (19)

SOURCES: *Thalictrum minus* (19), *Thalictrum minus* race B (14)

\*Revised structure (14).



6 methoxy at 3.77, 3.80(6H), 3.83, 3.96(6H).

4 aromatic H at 6.43, 6.50, 6.60 (2H).

**15 THALIADANINE**

$C_{41}H_{48}O_9N_2$

712.335955

$[\alpha]_{26}^{20}D$ : +81° ( $c=0.41$ ,  $CH_3OH$ ) (14)

UV: 281 (4.33), 302 (4.18), 312 (4.11) (no shift in base) (14)

IR: ( $CHCl_3$ ) 3540 (14)

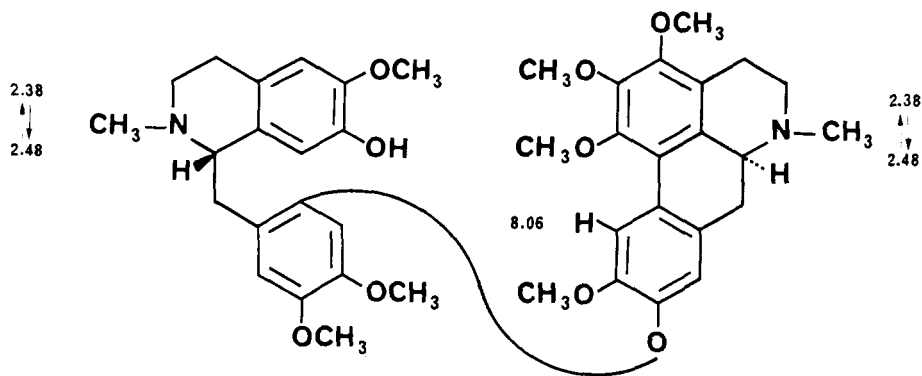
NMR: (14)

MASS: 712 ( $M^+$ ), 520, 370, 354, 192 (base) (14)

CD:  $[\theta]_{241} +166000$ ,  $[\theta]_{276} -17600$ ,  $[\theta]_{308} -15900$  (14)

SOURCES: *Thalictrum minus* race B (14)





methoxy at 3.79 (12H), 3.89, 3.96 (6H).

aromatic H at 6.45, 6.51, 6.56, 6.58, 6.68 .

**16 ADIANTIFOLINE** $C_{42}H_{50}O_9N_2$ 

726.351604

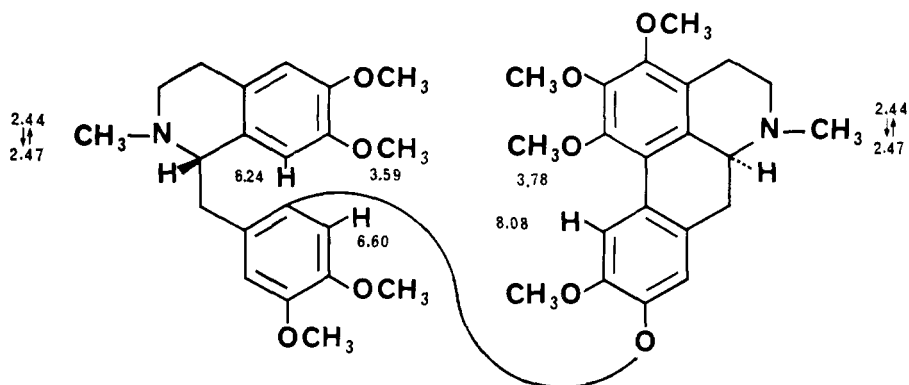
MP: 143–144° (2)

 $[\alpha]^{28}_D$ : +90° (c=0.11, CH<sub>3</sub>OH) (2)

UV: 283 (4.51), 302 (4.39), 312 (4.34) (2)

NMR: (32)

MASS: 521, 520, 519, 206 (base) (2)

CD:  $[\theta]_{241} +234000$ ,  $[\theta]_{275} -31200$ ,  $[\theta]_{305} -33800$  (3)SOURCES: *Thalictrum minus* var. *adiantifolium* (2, 3), *Thalictrum minus* race B (7, 14), *Thalictrum minus* (19)

aromatic H at 6.55 (2H), 6.60 .

methoxy at 3.78 (6H), 3.82, 3.89, 3.94, 3.96 .

**17 THALMINELINE** $C_{42}H_{50}O_{10}N_2$ 

742.346518

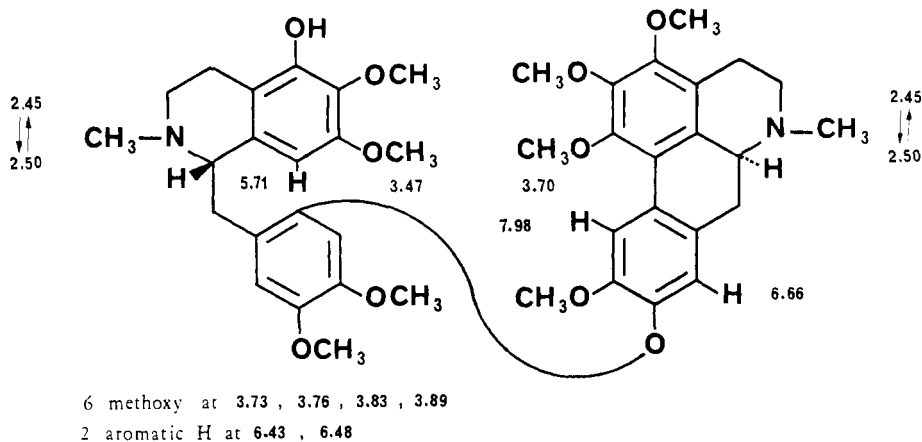
MP: 96–98° (ether-heptane), 108–110° (C<sub>2</sub>H<sub>5</sub>OH) (22) $[\alpha]^{24}_D$ : +22° (c=0.9, CH<sub>3</sub>OH) (22)

UV: 283 (5.46?) (22)

IR: 3480, 2970, 1620, 1590, 1525, 1480, 1425, 1405, 1350, 1275, 1230, 1215, 1200, 1125, 1060, 1025, 880, 780 (22)

NMR: (100 MHz) (22)

MASS: 742 (M<sup>+</sup>), 521, 520, 519, 222, 206 (22)SOURCES: *Thalictrum minus* var. *elatum* (22)

**18 THALMELATIDINE** $C_{42}H_{48}O_{10}N_2$ 

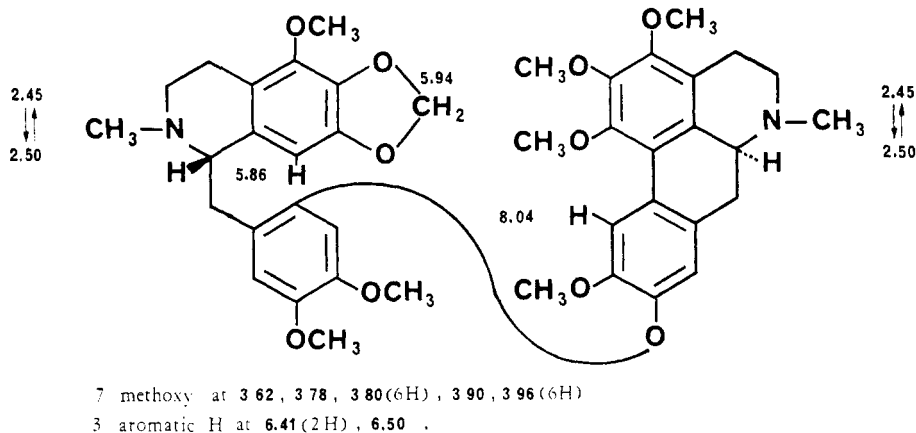
740.330869

MP: 120–122° (20)

[ $\alpha$ ] $^{19}D$ : +47° (c=1, CHCl<sub>3</sub>) (20)

IR: 950 (20)

NMR: (20)

SOURCES: *Thalictrum minus* (19), *Thalictrum minus* ssp. *elatum* (20)**19 FETIDINE (Foetidine)\*** $C_{40}H_{46}O_8N_2$ 

682.325392

MP: 132–135° (23)

[ $\alpha$ ] $^{15}D$ : +121 (c=2.57, CH<sub>3</sub>OH) (23)

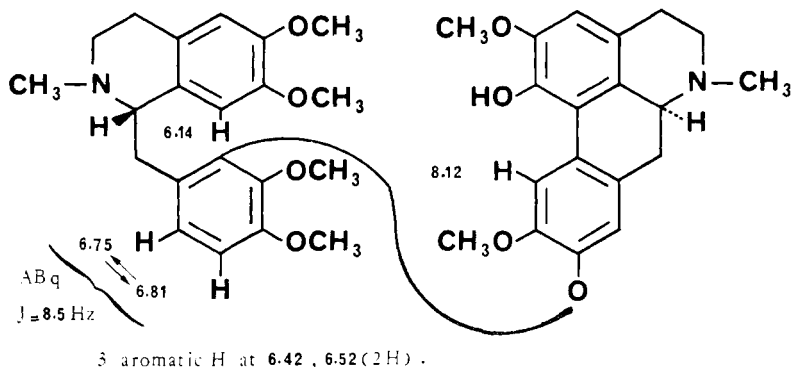
UV: 220 (4.80), 280 (4.36), 305 (4.24) (9)

IR: 3400, 2830, 2800, 1605, 1580, 1515 (9)

NMR: (220 MHz) (1)

MASS: 476, 341 (M<sup>++</sup>), 327, 284, 206 (base), 191, 177 (10)SOURCES: *Thalictrum foetidum* (9) (23)

\*Revised structure (1).

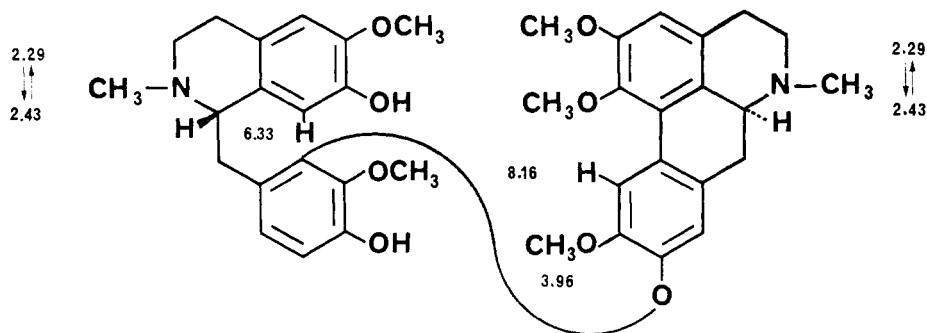
**20 REVOLUTOPINE** $C_{38}H_{44}O_8N_2$ 

668.309743

 $[\alpha]_{25}^{25}D: +126^\circ$  ( $c=0.1$ ,  $CH_3OH$ ) (42)UV: ( $CH_3OH$ ) 281 (4.40), 302 (4.24), 314 sh (4.15) (42)

IR: (KBr) 3410 (42)

NMR: (40) (42)

MASS: 668 ( $M^+$ ), 667, 476, 340, 324, 192 (base) (42)CD: ( $CH_3OH$ )  $[\theta]_{240} +43000$ ,  $[\theta]_{275} -5300$ ,  $[\theta]_{305} -4700$  (42)SOURCES: *Thalictrum revolutum* (40) (42)**21 THALIREVOLINE** $C_{40}H_{46}O_8N_2$ 

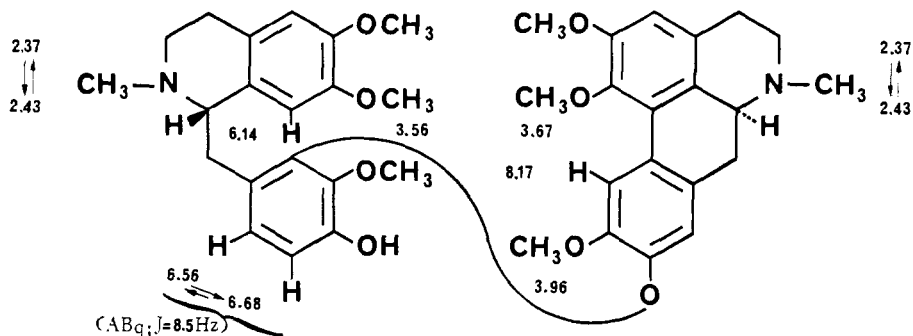
682.325392

MP: 123-125° (44)

 $[\alpha]_{20}^{20}D: +95^\circ$  ( $c=0.1$ ,  $CH_3OH$ ) (44)UV: ( $CH_3OH$ ) 270 sh (4.31), 280 (4.40), 301 (4.24), 310 sh (4.18) (44)

NMR: (44)

MASS: 682 ( $M^+$ ), 476, 341, 340, 324, 206 (base) (44)CD:  $[\theta]_{246} +122000$ ,  $[\theta]_{277} -12800$ ,  $[\theta]_{300} -11700$  (44)SOURCES: *Thalictrum revolutum* (42) (44)



3 methoxy at 3.80 , 3.87 (6H) .

3 aromatic H at 6.46 , 6.52 , 6.57 .

## 22 THALIREVOLUTINE

 $\text{C}_{41}\text{H}_{48}\text{O}_8\text{N}_2$ 

696.341041

MP: 105–108° (44)

$[\alpha]_{20}^{\text{D}}$ : +134 ( $c=0.1$ ,  $\text{CH}_3\text{OH}$ ) (44)

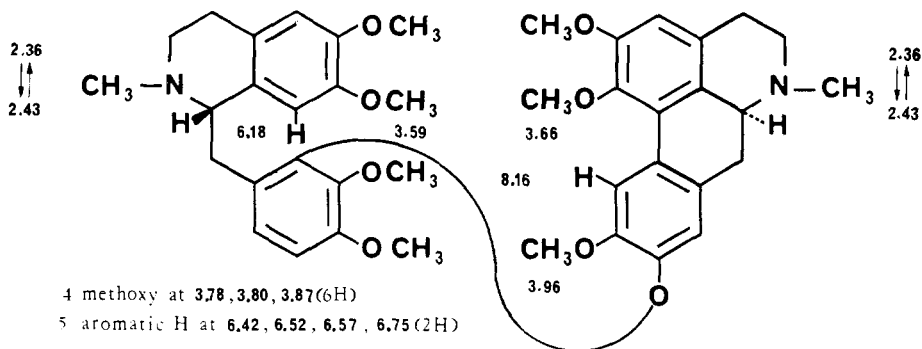
UV: 270 sh (4.31), 280 (4.38), 302 (4.21), 315 sh (4.10) (44)

NMR: (44)

MASS: 696 ( $\text{M}^+$ ), 490, 355, 340, 324, 206 (base) (44)

CD:  $[\theta]_{240}+240000$ ,  $[\theta]_{277}-26100$ ,  $[\theta]_{300}-20200$  (44)

SOURCES: *Thalictrum revolutum* (44)



## 23 PAKISTANINE

 $\text{C}_{37}\text{H}_{40}\text{O}_6\text{N}_2$ 

608.288617

MP: 154–156° (30)

$[\alpha]_{25}^{\text{D}}$ : +106° ( $c=0.57$ ,  $\text{CH}_3\text{OH}$ ) (30)

UV: 206 (4.69), 218 (4.61), 270 sh (4.13), 277 (4.21), 307 (4.07) (30)

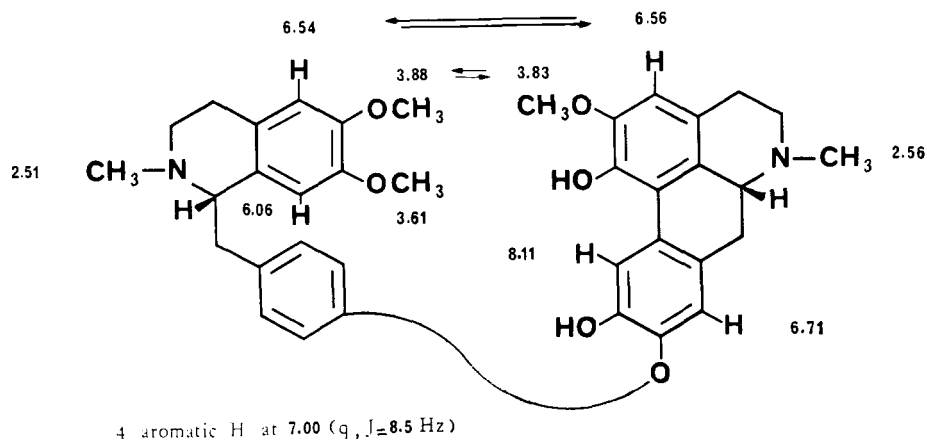
IR: 3450, 2860, 2800 (30)

NMR: (30)

MASS: 608 ( $\text{M}^+$ ), 402, 312, 296, 206 (base), 107 (30)

ORD: ( $\text{CH}_3\text{OH}$ )  $\alpha_{260}+226^\circ$ ,  $\alpha_{315}+2736^\circ$ ,  $\alpha_{252}-11208^\circ$ ,  $\alpha_{240}-6698^\circ$  (30)

SOURCES: *Berberis baluchistanica* (29) (30)

**24 1-O-METHYL-PAKISTANINE** $C_{38}H_{42}O_6N_2$ 

622.304266

MP: 117° (30)

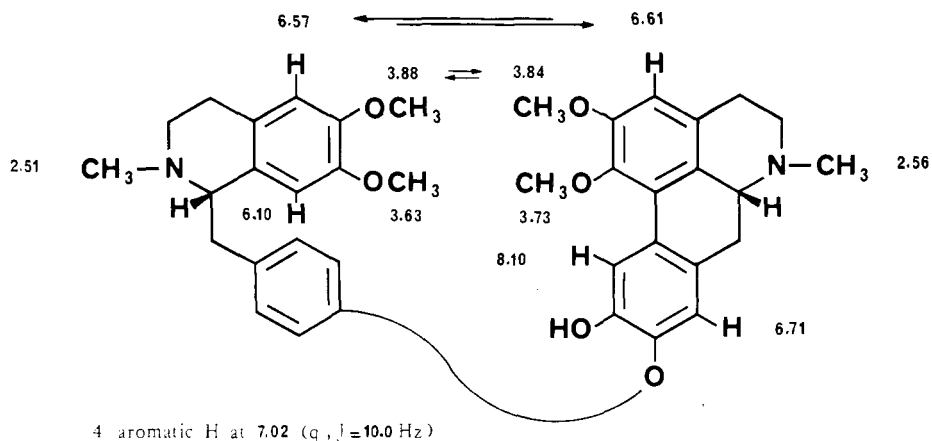
 $[\alpha]^{25}_D$ : +85° (c=0.40, CH<sub>3</sub>OH) (30)

UV: 207 (4.88), 225 sh (4.75), 270 sh (4.28), 277 (4.37), 304 (4.16) (30)

NMR: (30)

MASS: 622 (M<sup>+</sup>), 416, 326, 310, 267, 206 (base), 190 (30)ORD: (CH<sub>3</sub>OH)  $\alpha_{360}+130^\circ$ ,  $\alpha_{310}+1507^\circ$ ,  $\alpha_{245}-11087^\circ$ ,  $\alpha_{240}-10884^\circ$  (30)

SOURCES: Synthesis (30)

**25 1,10-DI-O-METHYL-PAKISTANINE** $C_{38}H_{44}O_6N_2$ 

636.319915

MP: 139-141° (30)

 $[\alpha]^{25}_D$ : +66° (c=0.40, CH<sub>3</sub>OH) (30)

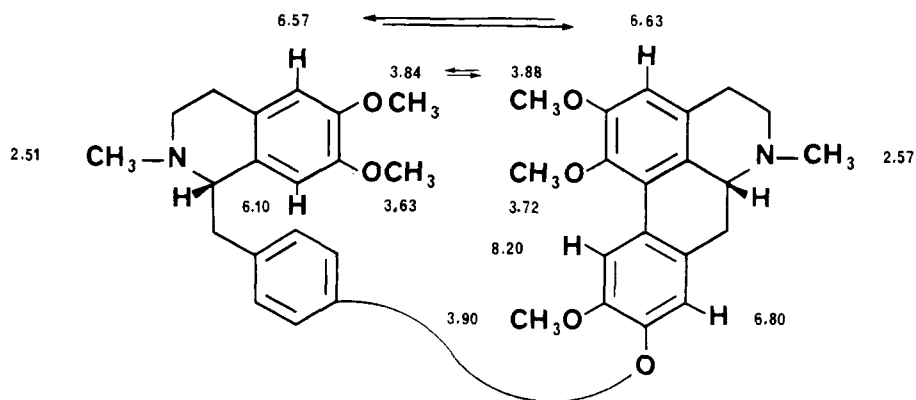
UV: 215 (4.60), 270 sh (4.27), 277 (4.29), 301 (4.09) (30)

IR: (CHCl<sub>3</sub>) 2855, 2800 (30)

NMR: (30)

MASS: 636 (M<sup>+</sup>), 430, 340, 324, 206 (base), 190, 107 (30)ORD: (CH<sub>3</sub>OH)  $\alpha_{246}-6066^\circ$ ,  $\alpha_{250}-7049^\circ$ ,  $\alpha_{360}-607^\circ$ ,  $\alpha_{320}+246^\circ$  (30)

SOURCES: Synthesis (29) (30)



4 aromatic H at 7.00 (q,  $J=9.5$  Hz)

### 26 PAKISTANAMINE\*

 $C_{35}H_{42}O_6N_2$ 

622.3042

MP: 215° (HCl) (30)

$[\alpha]^{25}_D$ : +20° ( $c=0.34$ , CH<sub>3</sub>OH) (30)

UV: 206 (4.86), 225 sh (4.63), 280 (4.12), 310 sh (3.61) (30)

IR: 1640, 1670 (30)

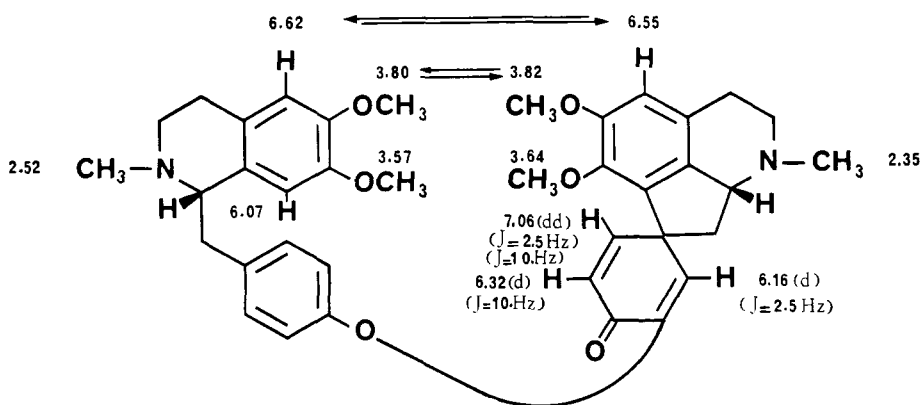
NMR: (30)

MASS: 622 ( $M^+$ ), 608, 416, 326, 310, 267, 206 (base), 190, 107, 91 (30)

ORD: (CH<sub>3</sub>OH)  $\alpha_{240} -2333^\circ$ ,  $\alpha_{285} +2200^\circ$ ,  $\alpha_{360} +82^\circ$  (30)

SOURCES: *Berberis baluchistanica* (29) (30)

\*Pakistanamine is a proaporphine-benzylisoquinoline; since it is the precursor of pakistanine and closely related to it, pakistanamine has been included in this review.



4 aromatic H at 7.02

### 27 PENNSYLPVAVINE

 $C_{40}H_{44}O_8N_2$ 

680.3097

MP: 122–123° (26)

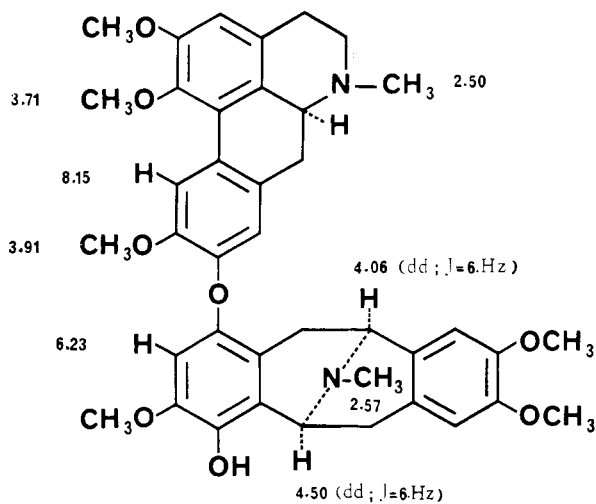
$[\alpha]^{25}_D$ : -174° ( $c=0.6$ , CH<sub>3</sub>OH) (26)

UV: 230 (4.62), 280 sh (4.38), 288 (4.40), 308 sh (4.23), 320 sh (4.15) (26)

NMR: (26)

MASS: 680, 649, 648, 637, 529, 475, 355, 340, 204 (base) (26)

SOURCES: *Thalictrum polygamum* (26)

**28 PENNSYLPVAVOLINE** $C_{39}H_{42}O_8N_2$ 

666.2941

MP: 145–146° (26)

 $[\alpha]^{25}_D$ : -245° ( $c=0.66$ ,  $CH_3OH$ ) (26)

UV: 230 (4.47), 280 sh (4.06), 288 (4.13), 306 sh (4.01), 320 sh (3.96) (26)

NMR: (26)

MASS: 666, 515, 461, 355, 326, 204 (base) (26)

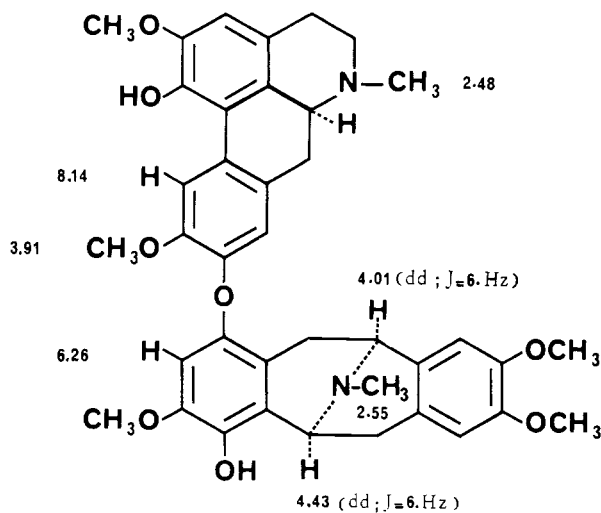
SOURCES: *Thalictrum polygamum* (26)

TABLE 1. *Calculated molecular weights of aporphine-benzylisoquinoline dimers and aporphine-pavine dimers.*

608.2886	$C_{37}H_{40}O_6N_2$	Thalidoxine 8	
Pakistanine 23		Pennsylvanine 9	
622.3043	$C_{35}H_{42}O_6N_2$	Fetidine 19	
1- <i>O</i> -methylpakistanine 24		Thalirevoline 21	
*Pakistanamine 26		692.2733	$C_{40}H_{40}O_9N_2$
636.3199	$C_{39}H_{44}O_6N_2$	Oxothalicarpine 11	
1,10-Di- <i>O</i> -methylpakistanine 25		694.3254	$C_{41}H_{46}O_8N_2$
666.2941	$C_{39}H_{42}O_8N_2$	Dehydrothalicarpine 12	
Pennsylvavoline 28		696.3410	$C_{41}H_{45}O_8N_2$
668.3097	$C_{39}H_{44}O_8N_2$	Thalicarpine 10	
Thalictrogamine 1		Thalirevolutine 22	
Pennsylvanamine 2		712.3359	$C_{41}H_{48}O_9N_2$
Thalipine 5		Thalilutine 13	
Revolutopine 20		<i>O</i> -Desmethyladiantifoline 14	
680.3097	$C_{40}H_{44}O_8N_2$	Thaliadanine 15	
Dehydrothalmelatine 7		726.3516	$C_{42}H_{50}O_9N_2$
Pennsylvanine 27		Adiantifoline 16	
682.3254	$C_{40}H_{46}O_8N_2$	740.3309	$C_{42}H_{48}O_{10}N_2$
Thalictropine 3		Thalmelatidine 18	
Thalilutidine 4		742.3465	$C_{42}H_{50}O_{10}N_2$
Thalmelatine 6		Thalmineline 17	

\*Proaporphine-benzylisoquinoline.

TABLE 2. *Names and synonyms of aporphine-benzylisoquinoline dimers and aporphine-pavine dimers.*

Adiantifoline 16	Revolutopine 20
Dehydrothalicarpine 12	Thaliadanine 15
Dehydrothalmelatine 7	Thalicarpine 10
<i>O</i> -Desmethyladiantifoline 14	Thalictrogamine 1
1,10-Di- <i>O</i> -methylpakistanine 25	Thalictropine 3
Fetidine 19	Thalictrucarpine 12
Foetidine 19	Thalidoxine 8
1- <i>O</i> -methylpakistanine 24	Thalilutidine 4
Oxothalicarpine 11	Thalilutine 13
Pakistanine 23	Thalipine 5
*Pakistanamine 26	Thalirevoline 21
Pennsylvanine 27	Thalirevolutine 22
Pennsylvavoline 28	Thalmelatidine 18
Pennsylvanamine 2	Thalmelatine 6
Pennsylvanine 9	Thalmineline 17

\*Proaporphine-benzylisoquinoline.

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