156. Synthesis of *Aristotelia*-Type Alkaloids

Part VIII[1])

Synthesis of (±)-Aristolasicone

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The revised structure of the indole alkaloid aristolasicone (**2**) was confirmed through a convergent total synthesis of the racemic form of this metabolite. The key step involves a one-pot condensation/cyclization reaction between 1-(4-methoxyphenylsulfonyl)-1*H*-indole-2-acetaldehyde (**9**) and (±)-*trans*-5-(2,6-difluorobenzyloxy)-*p*-menth-1-en-8-amine ((±)-**7**). The resulting allohobartine derivative (±)-**13**, obtained in 84% yield, was deprotected and oxidized to (±)-alloserratenone ((±)-**15**) which cyclized smoothly to the target molecule (±)-**2** upon exposure to $BF_3 \cdot Et_2O$.

1. Introduction. – Recently, we disclosed a synthesis of (±)-aristotelin-19-one ((±)-**1**) *via* the key intermediates (±)-**3** and (±)-**5** [1]. The latter was prepared by condensation of the readily accessible building blocks (±)-**7** and **8** (*Scheme 1*). Since the spectroscopic properties of synthetic (±)-**1** turned out to be quite different from the reported data of the alkaloid (+)-aristolasicone for which exactly this structure had been proposed [3], we postulated that this natural product actually possesses structure **2**[3]). With the intention to verify this hypothesis, we developed the following straightforward route to (±)-**2**.

According to our general strategy towards the synthesis of *Aristotelia* alkaloids [5], (±)-**2** can be traced back retrosynthetically to (±)-allohobartin-19-one[4]) ((±)-**4**) and from this point to the doubly protected imine (±)-**6**. This intermediate was planned to be assembled *via* condensation of (±)-**7** [1] with aldehyde **9**.

2. Results and Discussion. – The required aldehyde **9** was prepared as shown in *Scheme 2* [2]: *p*-Mps (= *p*-methoxyphenylsulfonyl)-protected indole **10** was lithiated in the 2-position (for precedents, see [6]), transmetallated with $CuBr \cdot Me_2S$ [7][5]), and alkyl-

[1]) Part VII: [1].

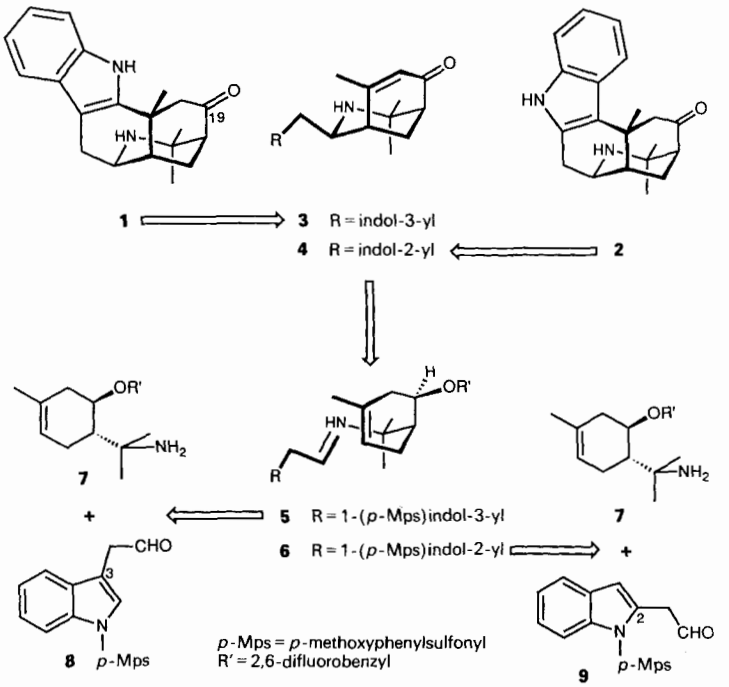
[2]) Taken in part from the diploma thesis of *M.D.* [2].

[3]) Natural (+)-aristolasicone has since been subjected to a single-crystal X-ray analysis [4] which fully confirmed the revised structure proposal **2**.

[4]) For reasons discussed before [1], we propose to designate *Aristotelia* alkaloids formally derived from 2-(indol-2-yl)ethylamine, such as **2** and **4**, by the prefix 'allo'.

[5]) The lithiated species could be acylated, but failed to react with alkylating agents (for similar observations, see [8]). The corresponding magnesium derivative [9], prepared by transmetallation with $MgBr_2 \cdot 2Et_2O$ [10], in combination with a catalytic amount of $[PdCl_2(PPh_3)_2]$ [11], gave a 33% yield of the desired product **12** [2].

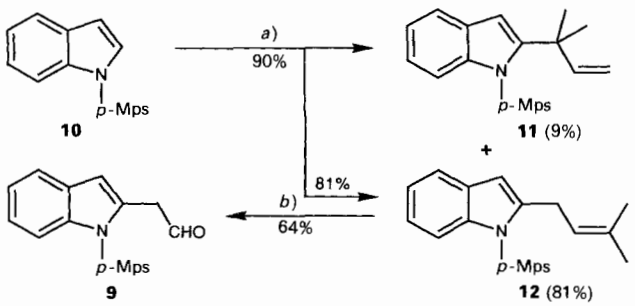
Scheme 1



ated with 3,3-dimethylallyl bromide to give a 9:1 mixture **12**/**11** (90% combined yield). The required aldehyde **9**, which turned out to be a stable crystalline compound, was obtained in 64% yield *via* ozonolysis of **12**, followed by reductive workup with dimethyl sulfide [12].

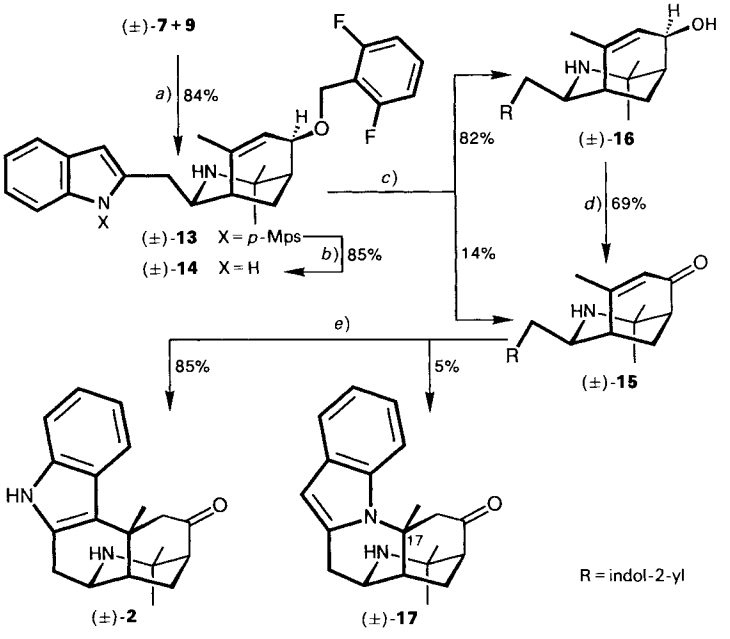
The condensation/cyclization of the two components (±)-**7** [1] and **9** worked well, giving the expected product (±)-**13** in 84% yield (see *Scheme 3*). Whereas the chemoselective mono-deprotection of (±)-**13** to (±)-**14** with 6% Na/Hg in MeOH [13] presented no

Scheme 2



a) 1. Lithium diisopropylamide (LDA), *N,N,N',N'*-tetramethylethylenediamine (TMEDA); 2. $CuBr \cdot Me_2S$; 3. 3,3-dimethylallyl bromide. *b*) 1. O_3, CH_2Cl_2, –78°; 2. Me_2S.

Scheme 3



a) 1. $CHCl_3$, 4 Å molecular sieves; 2. HCOOH. *b*) 6% Na/Hg, MeOH. *c*) Li, 4,4′-di(*tert*-butyl)biphenyl, THF. *d*) PCC on alumina, CH_2Cl_2. *e*) $BF_3 \cdot Et_2O$, CH_2Cl_2.

problems, we encountered some difficulties when we attempted to remove both protecting groups simultaneously. Eventually, the method of choice turned out to be a reductive treatment of (±)-**13** with Li and 4,4′-di(*tert*-butyl)biphenyl in THF at −70° [14][6]). Application of this procedure furnished (±)-**16** in 82% yield, together with some 14% of (±)-**15**[7]).

Allohobartin-19-ol ((±)-**16**) was oxidized with pyridinium chlorochromate (PCC) on alumina [15] to (±)-alloserratenone ((±)-**15**)[8]) which cyclized smoothly to racemic aristolasicone ((±)-**2**) upon exposure to $BF_3 \cdot Et_2O$ in CH_2Cl_2 (85% yield). The ^1H- and ^{13}C-NMR data of synthetic (±)-**2** coincide within experimental limits with the reported values of natural (+)-aristolasicone [3].

A minor product of the above BF_3 treatment is isomeric with **2**, but is lacking the familiar indole NH unit. Since it is endowed with 5 aromatic protons which give rise to 5 *d* and, consequently, to only 3 *s* in the low-field section of its ^{13}C-NMR spectrum, we propose structure (±)-**17** for this side product. This hypothesis is corroborated by the

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[6]) This method was brought to our attention by Prof. *P. DeShong*, University of Maryland, MD, who also provided us with additional experimental details [14b].

[7]) The (reproducible!) formation of this by-product under the reducing reaction conditions is surprising, but not without precedent [1].

[8]) (−)-Serratenone (**15**; R = indol-3-yl) was isolated from *Aristotelia serrata* by *Bick et al.* [16].

observation that C(17) of (±)-**17** shows up at 59.7 ppm, as compared to 37.7 ppm in (±)-**2** and 37.1 ppm in (±)-**1** [1].

3. Conclusion. – The straightforward 4-step synthesis of racemic aristolasicone ((±)-**2**), proceeding with an overal yield of 50%, provides unambiguous evidence that the recently revised allostructure is indeed correct. In addition, the efficiency of the chosen approach bodes well for future syntheses of additional alkaloids belonging to the allo-series, should they eventually be discovered in *Aristotelia* plants.

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Experimental Part

General. See [17] [1].

1-(4-Methoxyphenylsulfonyl)-1H-indole (**10**). Degreased NaH, prepared from 3.14 g of a 50% suspension in oil (*Fluka, puriss.*) by 4 washings with hexane, was covered with 30 ml of dry DMSO (*Fluka, puriss.*) and heated (80°) under Ar for 90 min. To the resulting mixture was added a soln. of 7.32 g (62.5 mmol) of 1*H*-indole (*Fluka, puriss.*) in 30 ml of Et_2O at 10°. After stirring for 30 min at r.t., a soln. of 19.9 g (62.5 mmol) of 4-methoxybenzenesulfonyl chloride (*Fluka, purum*) in 30 ml of Et_2O was added and stirring was continued for 1 h at r.t. Then the mixture was poured onto 100 g of crushed ice. The resulting precipitate of crude **10** (12.2 g) was removed by filtration, and the filtrate was extracted with Et_2O/AcOEt 2:1. Evaporation of the org. phase furnished an additional 5.8 g of crude **10**. Recrystallization of the combined crops from AcOEt/Et_2O at 4° gave 13.32 g (74%) of pure, colorless **10**. An anal. sample was prepared by sublimation (100°/0.01 Torr). M.p. 117°. IR (KBr): 1595, 1498, 1366, 1215, 1172, 1131, 1097, 682, 580, 547. ^{1}H-NMR (400 MHz, $CDCl_3$): 7.99 (*dq*, *J* = 8.3, 0.9, 1 H); 7.81 (*m*, 2 H); 7.55 (*d*, *J* = 3.7, 1 H); 7.52 (*ddd*, *J* = 7.8, 1.3, 0.9, 1 H); 7.30 (*ddd*, *J* = 8.3, 7.3, 1.3, 1 H); 7.21 (*ddd*, *J* = 7.8, 7.3, 1.0, 1 H); 6.86 (*m*, 2 H); 6.64 (*dd*, *J* = 3.7, 0.8, 1 H); 3.77 (*s*, 3 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 163.7 (*s*); 134.8 (*s*); 130.7 (*s*); 129.8 (*s*); 129.0 (2*d*); 126.3 (*d*); 124.5 (*d*); 123.2 (*d*); 121.4 (*d*); 114.4 (2*d*); 113.5 (*d*); 108.9 (*d*); 55.6 (*q*). MS: 287 (95, $M^{+\cdot}$), 173 (29), 172 (46), 171 (100), 155 (19), 123 (67), 117 (26), 116 (71), 108 (23), 107 (89), 92 (16), 77 (71), 64 (37), 63 (48), 39 (16). Anal. calc. for $C_{15}H_{13}NO_3S$ (287.33): C 62.70, H 4.56, N 4.87; found: C 62.68, H 4.58, N 4.83.

1-(4-Methoxyphenylsulfonyl)-2-(3-methylbut-2-enyl)-1H-indole (**12**). To a soln. of 3.1 g (30.6 mmol) of $(i\text{-Pr})_2NH$ (*Fluka, puriss.*, dist. from CaH_2) and 7.1 g (61.2 mmol) of TMEDA (*Fluka, puriss.*) in 100 ml of dry THF were added 30.6 mmol of BuLi (*Fluka, pract.*; 1.6M in hexane) at −20° under Ar. After stirring for 20 min, a soln. of 8.0 g (27.8 mmol) of **10** in 50 ml of THF was added. After stirring for 30 min at r.t., the orange soln. was cooled to −80°. Then were added 5.73 g (28.9 mmol) of $CuBr \cdot Me_2S$ (*Fluka, purum*), and stirring was continued for 20 min at −80°. Then were added 8.31 g (28.9 mmol) of freshly distilled 3,3-dimethylallyl bromide (*Fluka, pract.*). The mixture was allowed to reach r.t., and stirring was continued for 12 h. Workup with AcOEt and aq. 2N NH_4Cl furnished 11.2 g of brown oil. FC (AcOEt/hexane 1:3) gave 9.16 g (90%) of a 9:1 mixture **12**/**11**, from which pure **12** was obtained *via* fractional crystallization at −20°.

Data for **12**: M.p. 61–62°. IR (CCl_4): 1598, 1451, 1356, 1168, 1067. ^{1}H-NMR (400 MHz, $CDCl_3$): 8.17 (*dm*, *J* = 8.1, 1 H); 7.70 (*m*, 2 H); 7.39 (*dm*, *J* = 7.7, 1 H); 7.24 (*ddd*, *J* = 8.1, 7.5, 1.4, 1 H); 7.18 (*ddd*, *J* = 7.7, 7.5, 1.2, 1 H); 6.85 (*m*, 2 H); 6.66 (*td*, *J* = 1.3, 0.8, 1 H); 5.39 (*dsept.*, *J* = 7.2, 1.4, 1 H); 3.78 (*s*, 3 H); 3.67 (br. *d*, *J* = 7.2, 2 H); 1.78 (*d*, *J* = 1.4, 3 H); 1.63 (br. *s*, 3 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 163.5 (*s*); 141.2 (*s*); 137.3 (*s*); 134.8 (*s*); 130.9 (*s*); 129.7 (*s*); 128.5 (2*d*); 123.7 (*d*); 123.3 (*d*); 120.1 (*d*); 119.8 (*d*); 114.7 (*d*); 114.3 (2*d*); 108.8 (*d*); 55.6 (*q*); 27.9 (*t*); 25.7 (*q*); 17.8 (*q*). MS: 355 (89, $M^{+\cdot}$), 185 (28), 184 (93), 183 (75), 182 (72), 171 (42), 169 (57), 168 (100), 167 (41), 154 (40), 130 (23), 77 (47). Anal. calc. for $C_{20}H_{21}NO_3S$ (355.46): C 67.58, H 5.95, N 3.94; found: C 67.29, H 6.02, N 3.75.

In the spectra of crude **12**/**11** the following signals were attributed to the minor isomer *2-(1,1-dimethylprop-2-enyl)-1-(4-methoxyphenylsulfonyl)-1H-indole* (**11**): ^{1}H-NMR (400 MHz, $CDCl_3$): 7.99 (*m*, 1 H); 7.57 (*m*, 2 H); 7.42 (*m*, 1 H); 7.18 (*m*, 2 H); 6.76 (*m*, 2 H); 6.66 (br. *s*, 1 H); 6.29 (*dd*, *J* = 17.5, 10.6, 1 H); 5.04 (*dd*, *J* = 10.6, 1.0, 1 H); 5.02 (*dd*, *J* = 17.5, 1.0, 1 H); 3.75 (*s*, 3 H); 1.66 (*s*, 6 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 163.1 (*s*); 150.2 (*s*); 147.1 (*s*); 138.4 (*s*); 131.4 (*s*); 128.8 (2*d*); 124.2 (*d*); 123.4 (*d*); 120.4 (*d*); 115.8 (*d*); 113.8 (2*d*); 112.1 (*t*); 110.8 (*d*); 55.5 (*q*); 40.0 (*s*); 35.6 (2*q*).

*1-(4-Methoxyphenylsulfonyl)-1*H*-indole-2-acetaldehyde* (**9**). A soln. of 7.1 g (19.9 mmol) of **12** in 300 ml of CH_2Cl_2 was cooled to −80° and treated with 20.9 mmol of O_3 (0.418 mmol/min in O_2). After addition of 20 ml of Me_2S (*Fluka, purum*), the mixture was stirred at −80° for 1 h and then allowed to reach r.t. The soln. was washed with H_2O (3 × 50 ml), dried ($MgSO_4$), and evaporated: 8.04 g of brown oil. Crystallization from AcOEt/Et_2O yielded 3.01 g of pale yellow crystals. FC (AcOEt/hexane 1:3) of the mother liquors furnished another 1.20 g of **9** (combined yield: 4.21 g (64%)). M.p. 126–127°. IR (KBr): 2745, 1724, 1593, 1496, 1451, 1369, 1270, 1170, 581. ^{1}H-NMR (400 MHz, $CDCl_3$): 9.83 (*t*, *J* = 1.4, 1H); 8.06 (*ddd*, *J* = 8.3, 1.0, 0.6, 1H); 7.72 (*m*, 2H); 7.47 (*ddd*, *J* = 7.6, 1.4, 0.6, 1H); 7.30 (*ddd*, *J* = 8.3, 7.3, 1.4, 1H); 7.23 (*ddd*, *J* = 7.6, 7.3, 1.0, 1H); 6.88 (*m*, 2H); 6.56 (*d*, *J* = 0.7, 1H); 4.10 (*dd*, *J* = 1.4, 0.7, 2H); 3.80 (*s*, 3H). ^{13}C-NMR (75 MHz, $CDCl_3$): 197.1 (*d*); 163.9 (*s*); 136.9 (*s*); 132.0 (*s*); 130.3 (*s*); 129.2 (*s*); 128.8 (2*d*); 124.7 (*d*); 123.7 (*d*); 120.7 (*d*); 114.54 (*d*); 114.53 (2*d*); 112.5 (*d*); 55.6 (*q*); 43.3 (*t*). MS: 329 (74, $M^{+\cdot}$), 301 (26), 236 (50), 171 (100), 158 (24), 130 (77), 129 (41), 123 (38), 107 (85), 103 (22), 92 (35), 81 (22), 77 (72), 69 (42). Anal. calc. for $C_{17}H_{15}NO_4S$ (329.37): C 61.97, H 4.59, N 4.25; found: C 61.71, H 4.56, N 4.30.

*(±)-19-*exo*-(2,6-Difluorobenzyloxy)-1-(4-methoxyphenylsulfonyl)allohobartine* (= *(1*RS,*4*SR,*8*SR*)-8-(2,6-Difluorobenzyloxy)-4-{[1-(4-methoxyphenylsulfonyl)-1*H*-indol-2-yl]methyl}-2,2,6-trimethyl-3-azabicyclo[3.3.1]-non-6-ene;* (±)-**13**). A mixture of 814.4 mg (2.75 mmol) of (±)-**7** [1], 1.026 g (3.115 mmol) of **9** and 7 g of 4 Å molecular sieves (*Chemische Fabrik Uetikon*, CH–8707 Uetikon; type *4A-8/2*, ∅ 2–3 mm; activated at 320°/0.01 Torr for 24 h) was dried at r.t./0.005 Torr for 4 h. Then were added 21 ml of $CHCl_3$ (passed through basic alumina (*Woelm*, act. I) immediately before use), and the mixture was stirred gently under Ar for 3 h. The suspension was cooled to −18° and treated with 42 ml of anh. HCOOH. The dark brown mixture was stirred at r.t. for 48 h and then poured onto crushed ice. The pH was adjusted to 9 by adding 12% aq. NH_3 soln. Workup with CH_2Cl_2 (4 × 200 ml) furnished 1.614 g of a yellow foam which was purified by FC (benzene/Et_2O/hexane/Et_2NH 50:60:30:1): 1.406 g (84%) of (±)-**13** and 49 mg of starting (±)-**7**. M.p. 84.5° (dec.; $CHCl_3$). IR (KBr): 1628, 1596, 1499, 1471, 1452, 1369, 1268, 1170, 1093, 1060, 1049, 750, 578, 554. ^{1}H-NMR (400 MHz, $CDCl_3$): 8.14 (*dm*, *J* = 8.5, 1H); 7.65 (*m*, 2H); 7.41 (*dm*, *J* = 7.6, 1H); 7.29–7.17 (*m*, 3H); 6.88 (*m*, 1H); 6.81 (*m*, 2H); 6.50 (*d*, *J* = 0.5, 1H); 5.74 (*m*, 1H); 4.61 (*m*, 2H); 3.95 (*d*, *J* = 3.0, 1H); 3.78 (*s*, 3H); 3.49 (*ddd*, *J* = 8.8, 4.5, 2.5, 1H); 3.22 (*ddd*, *J* = 15.8, 4.5, 0.5, 1H); 2.70 (*dd*, *J* = 15.8, 8.8, 1H); 2.19 (*dm*, *J* = 2.6, 1H); 1.96 (*dt*, *J* = 12.9, 2.8, 1H); 1.88 (*dt*, *J* = 12.9, 3.2, 2H); 1.86 (*t*, *J* = 1.3, 3H); 1.64 (*m*, 1H); 1.22 (*s*, 3H); 1.13 (*s*, 3H). ^{13}C-NMR (100 MHz, $CDCl_3$): 163.6 (*s*); 162.0 (2*s*) [*dd*, *J* = 250, 8]; 139.6 (*s*); 138.8 (*s*); 137.3 (*s*); 130.7 (*s*); 130.0 (*d*) [*t*, *J* = 10.3]; 129.7 (*s*); 128.5 (2*d*); 125.2 (*d*); 124.0 (*d*); 123.5 (*d*); 120.3 (*d*); 114.9 (*d*); 114.5 (*s*) [*t*, *J* = 19]; 114.4 (2*d*); 111.5 (*d*); 111.4 (2*d*) [*dd*, *J* = 19, 7]; 72.9 (*d*); 58.2 (*t*) [*t*, *J* = 3]; 55.6 (*q*); 53.0 (*d*); 51.7 (*s*); 40.2 (*d*); 39.4 (*d*); 35.3 (*t*); 29.5 (*q*); 26.1 (*q*); 25.7 (*t*); 25.5 (*q*). MS: 606 (2, $M^{+\cdot}$), 578 (5), 532 (4), 462 (5), 369 (37), 306 (61), 236 (52), 198 (63), 183 (38), 171 (24), 162 (32), 158 (22), 143 (30), 130 (37), 111 (61), 97 (95), 83 (96), 71 (84), 55 (100), 43 (96).

*(±)-19-*exo*-(2,6-Difluorobenzyloxy)allohobartine* (= *(1*RS,*4*SR,*8*SR*)-8-(2,6-Difluorobenzyloxy)-4-[(1*H*-indol-2-yl)methyl]-2,2,6-trimethyl-3-azabicyclo[3.3.1]non-6-ene;* (±)-**14**). To a soln. of 250 mg (0.412 mmol) of (±)-**13** in 2 ml of MeOH were added 128.5 mg (1.07 mmol) of NaH_2PO_4 and 2.65 g (6.9 mmol Na) of 6% Na/Hg. After stirring for 5 h at r.t., the mixture was decanted from the liquid Hg and evaporated. FC (benzene/Et_2O/Et_2NH 200:300:6) furnished 152.7 mg (84.9%) of (±)-**14** as brownish foam. IR ($CHCl_3$): 3462, 3317, 1627, 1594, 1551, 1471, 1457, 1270, 1061, 1045, 912. ^{1}H-NMR (400 MHz, $CDCl_3$): 9.99 (br. *s*, 1H); 7.51 (*dm*, *J* = 7.8, 1H); 7.31 (*dt*, *J* = 8.0, 0.9, 1H); 7.26 (*m*, 1H); 7.10 (*ddd*, *J* = 8.0, 7.1, 1.3, 1H); 7.04 (*ddd*, *J* = 7.8, 7.1, 1.1, 1H); 6.89 (*m*, 2H); 6.18 (br. *s*, 1H); 5.78 (*dq*, *J* = 4.1, 1.3, 1H); 4.63 (*dt*, *J* = 11.0, 1.3, 1H); 4.59 (*dt*, *J* = 11.0, 1.3, 1H); 3.94 (*m*, 1H); 3.30 (*dt*, *J* = 11.1, 2.3, 1H); 2.85 (*dd*, *J* = 15.1, 2.3, 1H); 2.44 (br. *dd*, *J* = 15.1, 11.1, 1H); 2.11 (*m*, 1H); 1.94 (*t*, *J* = 3.1, 2H); 1.83 (*t*, *J* = 1.3, 3H); 1.65 (*m*, 1H); 1.25 (*s*, 3H); 1.24 (*s*, 3H). ^{13}C-NMR (100 MHz, $CDCl_3$): 162.0 (2*s*) [*dd*, *J* = 250, 8.1]; 139.00 (*s*); 138.96 (*s*); 135.7 (*s*); 130.1 (*d*) [*t*, *J* = 10.5]; 128.4 (*s*); 125.1 (*d*); 120.8 (*d*); 119.7 (*d*); 119.3 (*d*); 114.4 (*s*) [*t*, *J* = 19.3]; 111.3 (2*d*) [*dd*, *J* = 19.1, 6.1]; 110.7 (*d*); 99.2 (*d*); 72.6 (*d*); 58.3 (*t*) [*t*, *J* = 3.3]; 54.6 (*d*); 51.6 (*s*); 40.1 (*d*); 39.3 (*d*); 34.1 (*t*); 29.7 (*q*); 26.3 (*q*); 25.5 (*t*); 25.3 (*q*). MS: 436 (16, $M^{+\cdot}$), 307 (34), 306 (100), 199 (28), 178 (13), 162 (14), 158 (16), 144 (12), 143 (19), 132 (19), 131 (19), 130 (52), 127 (71), 117 (30), 43 (23), 41 (21).

*(±)-Allohobartin-19-*exo*-ol* (= *(1*RS,*4*SR,*8*SR*)-4-[(1*H*-Indol-2-yl)methyl]-2,2,6-trimethyl-3-azabicyclo-[3.3.1]non-6-en-8-ol;* (±)-**16**). To a soln. of 706 mg (2.65 mmol) of di(*tert*-butyl)biphenyl (*Fluka, purum*) in 50 ml of dry THF was added an excess Li (15 cm of wire, cut in 10 pieces, washed with hexane and MeOH) at 0° under Ar. After stirring at 10° for 1 h, the dark green soln. was cooled to −80°. Then a soln. of 93 mg (0.153 mmol) of (±)-**13** in 3 ml of THF was added slowly. After stirring at −80° for 90 min, the excess Li metal was removed with tweezers, and the still green mixture was quenched by addition of sat. aq. NH_4Cl soln. The colorless mixture was adjusted to pH 10 with 10% aq. NH_3 soln. and worked up with $CHCl_3$ (4 × 80 ml). The crude product was chromatographed (benzene/Et_2O/Et_2NH 80:40:10): 6.6 mg (14%) of (±)-**15** (see below) and 41.3 mg (82%) of (±)-**16**. UV (EtOH):

289 (3.85), 281 (3.94), 278 (3.94), 272 (3.95), 221 (4.60). IR ($CHCl_3$): 3605, 3470, 3320, 1617, 1582, 1551, 1456, 1430, 1410, 1287, 1000, 976, 940, 920. ^{1}H-NMR (400 MHz, $CDCl_3$): 10.0 (br. *s*, 1 H); 7.52 (*d*, *J* = 7.6, 1 H); 7.31 (*dd*, *J* = 7.8, 0.8, 1 H); 7.10 (*ddd*, *J* = 7.8, 7.1, 1.2, 1 H); 7.04 (*ddd*, *J* = 7.6, 7.1, 0.8, 1 H); 6.18 (*s*, 1 H); 5.83 (*dq*, *J* = 4.1, 1.3, 1 H); 4.23 (br. *d*, *J* = 3.3, 1 H); 3.30 (*dt*, *J* = 11.2, 2.4, 1 H); 2.85 (*dd*, *J* = 15.0, 2.4, 1 H); 2.44 (*ddd*, *J* = 15.0, 11.2, 1.0, 1 H); 2.12 (*q*, *J* = 2.8, 1 H); 1.97 (*dt*, *J* = 13.1, 2.8, 1 H); 1.89 (*dt*, *J* = 13.1, 3.3, 1 H); 1.85 (*t*, *J* = 1.3, 3 H); 1.52 (*m*, 1 H); 1.26 (*s*, 3 H); 1.22 (*s*, 3 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 138.9 (*s*); 138.8 (*s*); 135.7 (*s*); 128.3 (*s*); 126.9 (*d*); 120.6 (*d*); 119.7 (*d*); 119.3 (*d*); 110.7 (*d*); 99.2 (*d*); 65.3 (*d*); 54.6 (*d*); 51.6 (*s*); 43.1 (*d*); 40.1 (*d*); 34.1 (*t*); 29.8 (*q*); 26.3 (*q*); 25.2 (*q*); 25.0 (*t*). MS: 310 (4, M^+), 199 (9), 160 (51), 132 (24), 131 (28), 130 (92), 117 (27), 95 (20), 93 (21), 91 (27), 77 (43), 69 (47), 58 (32), 55 (52), 43 (84), 41 (100).

(±)-Alloserratenone (= *(1*RS,*4*SR*)-4-[(1*H*-Indol-2-yl)methyl]-2,2,6-trimethyl-3-azabicyclo[3.3.1]non-6-en-8-one*; (±)-**15**). To a mixture of 43 mg (0.139 mmol) of (±)-**16** and 615 mg of PCC/Alox [15] (equivalent to *ca.* 0.62 mmol of PCC), which had been dried for 3 h at 25°/0.005 Torr, were rapidly added 10 ml of dry CH_2Cl_2 with vigorous stirring. After 30 min, the brown-black mixture was passed through silica gel (CH_2Cl_2/MeOH 10:1) and purified by FC (benzene/Et_2O/Et_2NH 160:80:17): 4 mg (9%) of starting material and 25 mg (60%) of (±)-**15** as brown resin. UV (EtOH): 289 (3.75), 281 (3.86), 268 (3.89), 221 (4.54). IR ($CHCl_3$): 1659, 1618, 1453, 1386, 1372, 1336, 1307, 1299, 1285, 922. ^{1}H-NMR (400 MHz, $CDCl_3$): 9.73 (br. *s*, 1 H); 7.54 (*dm*, *J* = 7.6, 1 H); 7.33 (*ddm*, *J* = 8.0, 0.8, 1 H); 7.13 (*ddd*, *J* = 7.6, 7.2, 1.2, 1 H); 7.06 (*ddd*, *J* = 8.0, 7.2, 1.1, 1 H); 6.23 (br. *s*, 1 H); 6.10 (br. *t*, *J* = 1.1, 1 H); 3.56 (*dt*, *J* = 11.1, 2.5, 1 H); 2.93 (*dd*, *J* = 15.0, 2.3, 1 H); 2.50 (*ddd*, *J* = 15.0, 11.1, 1.0, 1 H); 2.40 (*dt*, *J* = 5.5, 2.8, 1 H); 2.31 (*m*, 2 H); 2.08 (*d*, *J* = 1.4, 3 H); 2.04 (*t*, *J* = 3.0, 1 H); 1.59 (br. *s*, 1 H); 1.27 (*s*, 3 H); 1.15 (*s*, 3 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 201.4 (*s*); 161.2 (*s*); 137.7 (*s*); 135.7 (*s*); 130.1 (*d*); 128.2 (*s*); 121.1 (*d*); 119.8 (*d*); 119.5 (*d*); 110.8 (*d*); 99.7 (*d*); 53.7 (*d*); 50.5 (*s*); 50.1 (*d*); 41.6 (*d*); 34.0 (*t*); 32.6 (*t*); 29.9 (*q*); 25.6 (*q*); 25.1 (*q*). MS: 308 (55, M^+), 199 (37), 182 (10), 179 (45), 178 (100), 158 (24), 143 (27), 132 (23), 131 (44), 130 (73), 122 (31), 117 (30), 110 (60), 107 (20), 91 (20), 77 (20).

(±)-Aristolasicone (= *(3*RS,*4a*RS,*5*SR,*11a*SR*)-2,3,4,4a,5,10,11,11a-Octahydro-2,2,5-trimethyl-3,5-ethano-1*H*-pyrido[2,3-*b*]carbazol-13-one*; ((±)-**2**). To a soln. of 27 mg (0.088 mmol) of (±)-**15** in 2.1 ml of dry CH_2Cl_2 were added 0.5 ml of freshly dist. $BF_3 \cdot Et_2O$ (*Fluka, pract.*). The turbid mixture was stirred gently under Ar at r.t. for 20 h. Then it was poured onto 4 ml of cold aq. 6% NH_3 soln. and worked up with CH_2Cl_2. The crude product was chromatographed to give 23 mg (85%) of (±)-**2** and 0.8 mg (5%) of (±)-**17**.

*Data of (±)-***2**: UV (EtOH): 290 (3.44), 283 (3.53), 226 (4.38). IR ($CHCl_3$): 3467, 1691, 1683 (sh), 1456, 1384, 1369, 1249, 1090, 1039. ^{1}H-NMR (400 MHz, $CDCl_3$): 7.73 (br. *s*, 1 H); 7.63 (*dm*, *J* = 7.9, 1 H); 7.29 (*ddd*, *J* = 7.9, 1.3, 0.7, 1 H); 7.11 (*ddd*, *J* = 7.9, 7.0, 1.3, 1 H); 7.06 (*ddd*, *J* = 7.9, 7.0, 1.3, 1 H); 3.73 (*ddd*, *J* = 5.4, 2.4, 1.1, 1 H); 3.28 (*dd*, *J* = 16.9, 5.4, 1 H); 3.06 (*d*, *J* = 15.8, 1 H); 2.92 (*d*, *J* = 15.8, 1 H); 2.52 (*dd*, *J* = 16.9, 1.1, 1 H); 2.32 (*dt*, *J* = 14.3, 3.2, 1 H); 2.26 (*dt*, *J* = 14.3, 3.1, 1 H); 2.16 (*m*, 1 H); 1.79 (*m*, 1 H); 1.63 (*s*, 3 H); 1.50 (br. *s*, 1 H); 1.35 (*s*, 3 H); 0.94 (*s*, 3 H); agreement with the reported data for natural (+)-**2** [3b] (±0.03 ppm). ^{13}C-NMR (100 MHz, $CDCl_3$): 213.7 (*s*); 136.5 (*s*); 129.6 (*s*); 125.7 (*s*); 121.0 (*d*); 119.8 (*d*); 119.3 (*d*); 117.3 (*s*); 110.7 (*d*); 54.9 (*s*); 4.7 (*d*); 51.6 (*s*); 50.0 (*d*); 39.9 (*d*); 37.7 (*s*); 31.0 (*t*); 29.1 (*q*); 27.6 (*q*); 26.9 (*t*); 26.0 (*q*, agreement with the reported data for natural (+)-**2** [3b] (±0.3 ppm). MS: 308 (100, M^+), 307 (27), 294 (26), 293 (83), 252 (11), 251 (50), 250 (12), 238 (16), 237 (27), 236 (47), 208 (16), 198 (16), 195 (41), 194 (91), 183 (45), 182 (92), 181 (64), 180 (58), 178 (44), 167 (50), 126 (30), 110 (32), 96 (41), 84 (28), 70 (28), 58 (35).

*Data for (3*RS,*4a*SR,*5*SR,*12a*SR*)-1,2,3,4,4a,5,12,12a-Octahydro-2,2,5-trimethyl-3,5-ethanoindolo[1,2-g][1,6]naphthyridin-14-one* ((±)-**17**): UV (EtOH): 223 (4.04), 281 (3.63), 289 (3.46). IR ($CHCl_3$): 1706, 1700 (sh), 1453, 1444, 1388, 1363, 1301, 1261, 1127, 1111, 1098, 1021. ^{1}H-NMR (400 MHz, $CDCl_3$): 7.54 (*m*, 1 H); 7.51 (*m*, 1 H); 7.07 (*m*, 2 H); 6.23 (*t*, *J* = 0.7, 1 H); 3.64 (*dt*, *J* = 4.4, 2.0, 1 H); 3.32 (*d*, *J* = 15.7, 1 H); 3.30 (*ddd*, *J* = 16.7, 4.4, 1.6, 1 H); 3.09 (*d*, *J* = 15.7, 1 H); 2.93 (*dd*, *J* = 16.7, 2.0, 1 H); 2.35 (*dt*, *J* = 15.2, 3.5, 1 H); 2.19 (*dt*, *J* = 15.3, 3.1, 1 H); 2.18 (*m*, 1 H); 2.09 (*m*, 1 H); 2.00 (*s*, 3 H); 1.34 (*s*, 3 H); 0.92 (*s*, 3 H). ^{13}C-NMR (100 MHz, $CDCl_3$): 210.7 (*s*); 134.4 (*s*); 129.8 (*s*); 129.0 (*s*); 120.2 (*d*); 119.9 (*d*); 119.5 (*d*); 113.0 (*d*); 99.7 (*d*); 59.7 (*s*); 54.2 (*t*); 53.9 (*d*); 51.5 (*s*); 47.8 (*d*); 40.7 (*d*); 31.8 (*t*); 29.0 (*q*); 28.3 (*q*); 26.9 (*t*); 25.5 (*q*). MS: 308 (98, M^+), 293 (21), 251 (57), 236 (18), 194 (40), 183 (21), 182 (65), 181 (43), 178 (100), 167 (29), 131 (26), 130 (45), 110 (21), 58 (21).

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