Stereoselective synthesis of (±)-indolizidines 167B and 209D and their *trans*-isomers based on the reductive allylboration of pyridine

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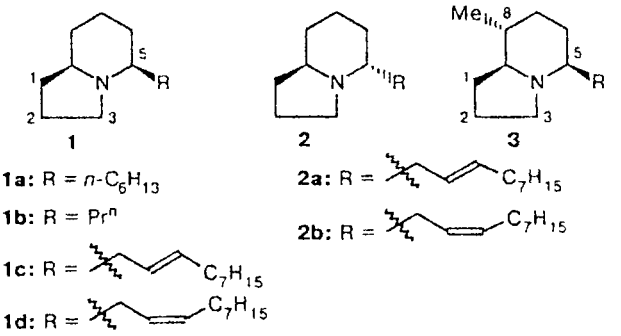
A general method for the synthesis of 5-substituted indolizidines based on intramolecular cyclization of *trans*- and *cis*-2-allyl-6-R-1,2,3,6-tetrahydropyridines, obtained from pyridine and triallylborane, has been elaborated. The closure of the five-membered ring is carried out by hydroboration—oxidation followed by cyclization of the resulting δ-amino alcohols in the presence of the Ph_3P—CBr_4—Et_3N system. $(Pr_2BH)_2$ and Pr_3B are used as the hydroborating reagents, and H_2O_2 in an acid medium is used for the oxidation of 2-[3-(dipropylboryl)propyl]-Δ^3-piperideines formed. This method has been used for the synthesis of two natural alkaloids: indolizidine 209D (*cis*-5-hexylindolizidine) and its *trans*-isomer were prepared from *cis*- and *trans*-2-allyl-6-hexyl-1,2,3,6-tetrahydropiridine, respectively; indolizidine 167B and *trans*-5-propylindolizidine were synthesized from *cis*- and *trans*-2,6-diallyl-1,2,3,6-tetrahydropyridine, respectively.

Key words: pyridine, reactions with hexyllithium and triallylborane; allylboration; *trans*- and *cis*-2-allyl-6-hexyl-1,2,3,6-tetrahydropyridines, *trans*—*cis* isomerization, hydroboration—oxidation, cyclization of δ-amino alcohols; (±)-indolizidines 167 B and 209D.

The skin secretions of frogs of the *Dendrobatidae* family, which are widespread in Central America, were found to contain a series of indolizidine alkaloids of similar structure, namely, 5-substituted indolizidines (**1** and **2**)[1—4] and 5-R-8-methylindolizidines (**3**),[5] also named bicyclic gephyrotoxins.[2,5] They act as blockers of neuromuscular transmission,[2] and extracts of frog skin have long been used by Indians as arrow poison. Isomeric indolizidines, *i.e.*, piclavines A1—A4 (**1c,d**, **2a,b**), have been isolated from extracts of the tunicate (*Clavelina picta*), a marine chordate.[4] The latter possess antimicrobial properties against some fungi and Gram-positive bacteria.[4] It should be noted that the alkaloids specified above are produced by live organisms in very small quantities and generally as complex mixtures. The identification of separate components has been mostly carried out by GC-MS, and only in some cases was the amount of a compound isolated from a natural source sufficient for its characterization, *e.g.*, by NMR spectroscopy.[5] The structures and absolute configurations of a number of key indolizidines were confirmed by independent syntheses (for example, see Ref. 5).

In recent years, several specific and general methods for the synthesis of bicyclic gephirotoxins have been described. Two compounds of this class, namely, indolizidines 167B (**1b**) and 209D (**1a**), have been synthesized (in 10 to 13 stages) both in the racemic[6] and in the optically active forms.[7]



In the present work, we suggest a new general method for the stereoselective construction of 5-substituted indolizidines **1** and **2** (Scheme 1) based on the intramolecular cyclization of *trans*-(**4**)[8,9] and *cis*-2-allyl-6-R-1,2,3,6-tetrahydropyridines (**5**)[9,10] obtained from pyridine and triallylborane.

The closure of the five-membered cycle was performed by hydroboration—oxidation of the terminal double bond followed by treatment of the resulting amino alcohol by the CBr_4—Ph_3P—Et_3N system. The

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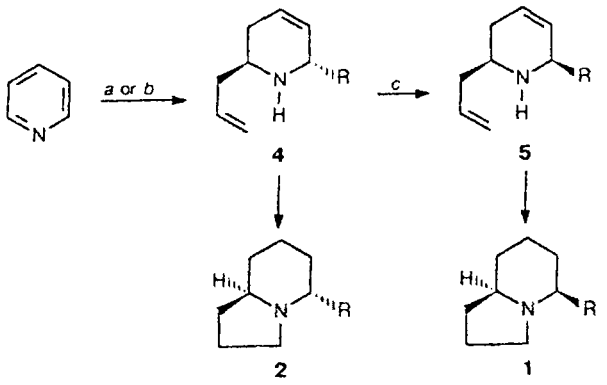
Scheme 1



R = Alk, All, Ar

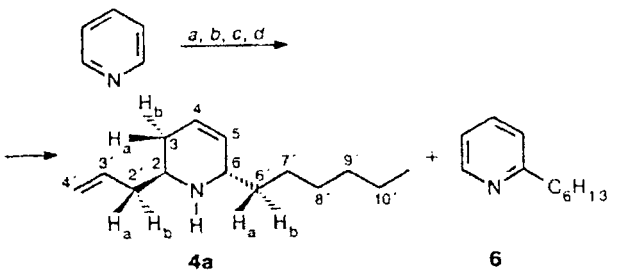
Reagents and conditions: *a*. (1) RLi, (2) All_3B, (3) MeOH; *b*. (1) All_3B, (2) MeOH; *c*. All_3B, Δ.

efficiency of this method is demonstrated by the synthesis of indolizidines 167B and 209D, as well as their *trans*-isomers.

Synthesis of (±)-indolizidine 209D and its trans-isomer

trans-2-Allyl-6-hexyl-1,2,3,6-tetrahydropyridine (**4a**), which was synthesized (one-pot procedure) by successive treatment of pyridine with hexyllithium, triallylborane, methanol, and a solution of NaOH,[8,9] was used as the starting compound for the synthesis of indolizidine 209D (**1a**) and its *trans*-isomer.

Scheme 2

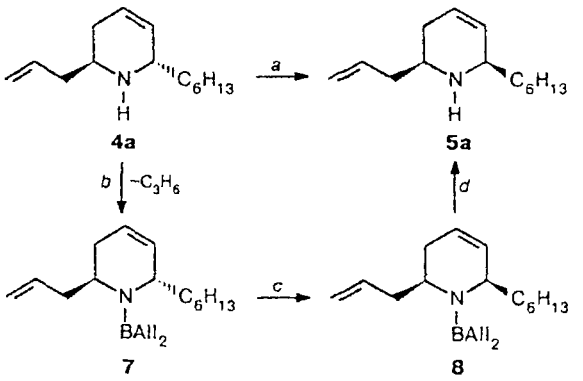


Reagents and conditions: *a*. *n*-$C_6H_{13}Li$, hexane—ether (1 : 5), −45 °C; *b*. All_3B, −45 → 15 °C; *c*. MeOH, −30 → 20 °C; *d*. NaOH (20%), H_2O—hexane, refluxing (8 h).

According to GLC analysis data, the raw amine **4a** obtained in this way (yield 90%) contained 9% of 2-hexylpyridine (**6**). The latter was easily separated from amine **4a** by treatment of a solution of the above mixture in hexane with a 2 *N* solution of HCl (0.95 equiv. with respect to the content of **4a** in the mixture). The water solubility of the hydrochlorides that formed differs markedly: the well-soluble salt, **6** · HCl, is transferred into the aqueous layer, while the solid hydrochloride **4a** · HCl is filtered off and treated with a solution of an alkali. The yield of pure amine **4a** was 53%.

Heating *trans*-amine **4a** with triallylborane at 195 °C (3 h) followed by deboration gave *cis*-2-allyl-6-hexyl-1,2,3,6-tetrahydropyridine **5a** (yield 80%) (Scheme 3).

Scheme 3



Reagents and conditions: *a*. (1) All_3B, Δ, (2) MeOH, KOH; *b*. All_3B, Δ; *c*. 195 °C, 3 h; *d*. MeOH, KOH.

It should be noted that the isomerization involves not amine **4a** but its boron derivative **7**, which is formed in 83% yield due to protolytic cleavage of one B—C bond in triallylborane. The reaction is accompanied by the elimination of propylene (1 mol) and is completed in 1.5 h (110 → 150 °C). Distillation of the aminolysis product (150 °C, 1 Torr) gave a mixture of aminoboranes **7** and **8** in the 85 : 15 ratio; hence, the **7** → **8** isomerization occurs even at 150—160 °C, although the process is slow. As in the case of homologs of aminoborane **7**,[9,10] the isomerization at 195 °C is completed in 3 h. The **7** : **8** ratio of 5 : 95 is probably the equilibrium ratio (Table 1). Deboration of the resulting mixture of

Table 1. Conditions of isomerization of *trans*-amine **7** into *cis*-isomer **8**

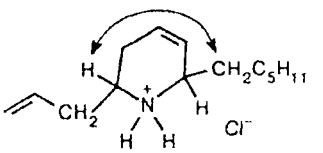
T/°C	Heating duration/h	**7** : **8** ratio (%)
150[a]	0.5	85 : 15[b]
175	2	10 : 90[b]
195	3	5 : 95[b]
195	5	5 : 95[b,c]

[a] Temperature of distillation of aminoboranes **7** and **8** at 1 Torr.
[b] Found from ^{13}C NMR spectra of the raw mixture of aminoboranes **7** and **8**.
[c] According to GLC analysis of the deborated product (amines **4a** and **5a**).

aminoboranes (**7** and **8**) with a methanolic solution of KOH followed by chromatography on a column with Al_2O_3 (hexane—ether, 10 : 1, as the eluent) gave pure *cis*-amine **5a**.

The mechanism of *trans*—*cis*-isomerization of α-allylated amines of the type **4a** has been considered previously.[9,10]

The structures of amines **4a** and **5a** were confirmed by elemental analyses and by physicochemical methods (^1H and ^{13}C NMR and IR spectroscopy, mass spectrometry). The signals in the ^1H NMR spectra of compound **4a** were assigned on the basis of ^1H—^1H COSY spectra. The configuration was established by two-dimensional phase-sensitive 2D NOESY spectroscopy.



4a·HCl

The presence of a positive cross-peak of the H(2) atom with protons of the hexyl group in hydrochloride **4a** · HCl indicates unambiguously the *trans*-arrangement of the substituents with respect to the ring in the molecule of amine **4a**.

Hydroboration of *cis*-amine **5a** on treatment with tetrapropyldiborane $(Pr_2BH)_2$ (2 : 1) in THF followed by oxidation with H_2O_2 in an acid medium gave a mixture of alcohol **9** (80%) and two diols **10** (20%), which was separated by chromatography on Al_2O_3. The yield of *cis*-amino alcohol **9** (m.p. 35—37 °C) was 51% (Scheme 4). The hydroboration and its completion were monitored by ^{13}C NMR spectroscopy, *i.e.*, by following the decrease and disappearance of the signals at δ 117 and 135 (CH_2=CH).

Treatment of amino alcohol **9** with the Ph_3P/CBr_4 system[5] and then with Et_3N results in intramolecular cyclization of the former; subsequent purification on a column with SiO_2 gives *cis*-1,2,3,5,8,8a-hexahydro-5-hexylindolizine (**12**) in 50% yield. Alkoxyphosphinic salt **11** is an intermediate in the cyclization (closure of the five-membered cycle).

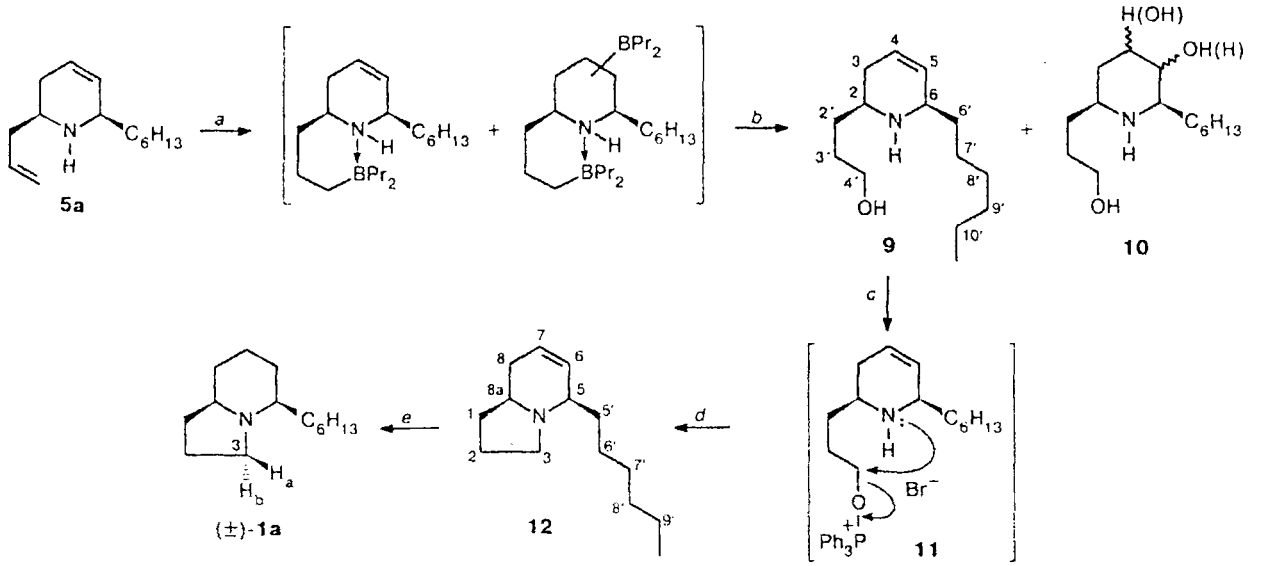
Hydrogenation of unsaturated bicyclic compound **12** in acetic acid over Raney nickel in an autoclave (100 °C, 100 atm of H_2, 10 h) gave the (±)-indolizidine 209D (**1a**) in 90% yield; the spectroscopic characteristics of this compound are similar to those reported previously.[7c]

The *trans*-isomer of indolizidine 209D, *viz.*, bicyclic compound **16**, was synthesized in a similar way from *trans*-2-allyl-6-hexyl-1,2,3,6-tetrahydropyridine **4a** (Scheme 5). As in the case of compound **5a**, anti-Markovnikov hydration of the terminal double bond in *trans*-amine **4a** was carried out in two stages, *i.e.*, by hydroboration—oxidation, but the reagents (**4a** and $(Pr_2BH)_2$) were used in a 1 : 1 ratio. Oxidation of the hydroboration products (H_2SO_4, H_2O_2) gave a mixture of alcohol **13** and isomeric diols **14**. Chromatography of this mixture on Al_2O_3 gave the target amino alcohol **13** in 49% yield.

Cyclization of amino alcohol **13** (Ph_3P/CBr_4, then Et_3N) gave *trans*-1,2,3,5,8,8a-hexahydro-5-hexylindolizine (**15**) in 45% yield after column chromatography on SiO_2. Hydrogenation of this compound over Raney nickel in acetic acid gave (±)-*trans*-5-hexylindolizidine (**16**) (yield 68%), the spectroscopic characteristics of which were similar to those reported previously.[7c]

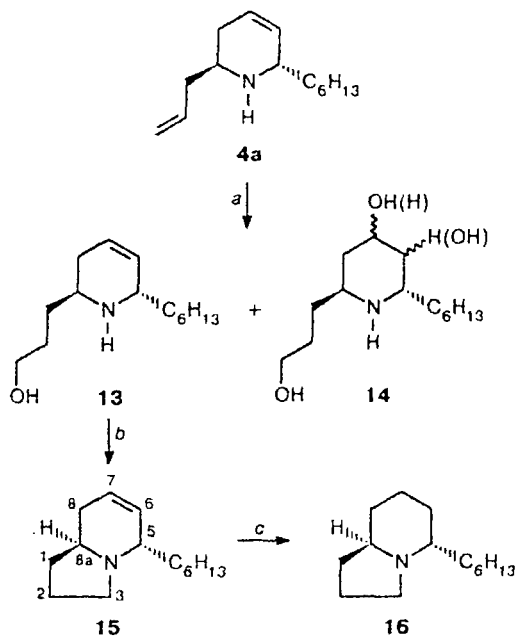
It should be pointed out that we were unable to obtain amino alcohols **9** and **13** by the standard oxidation of the products of dehydroboration of amines **4a** and **5a** (H_2O_2,

Scheme 4



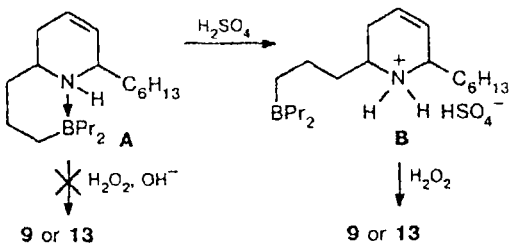
Reagents and conditions: *a*. 0.5 $(Pr_2BH)_2$, 0 °C; *b*. H_2SO_4, H_2O_2; *c*. Ph_3P, CBr_4; *d*. Et_3N; *e*. H_2, Ni, AcOH.

Scheme 5



Reagents and conditions: *a*. (1) $(Pr_2BH)_2$, THF, 0—20 °C, (2) H_2SO_4, 0 °C, then H_2O_2, (3) H_2O, OH^-; *b*. (1) Ph_3P, CBr_4, (2) Et_3N; *c*. H_2, Ni, AcOH.

OH^-). This was probably caused by the stability of intracomplex compounds **A** formed (the stereochemistry is not specified), which are not decomposed completely even upon prolonged refluxing with 30% H_2O_2.

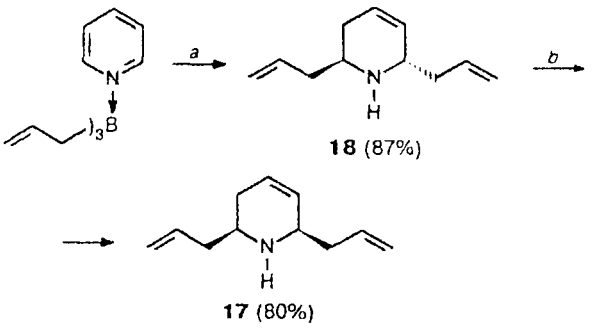


In an acid medium (H_2SO_4), the B←N coordination bond in structure **A** is cleaved to give the corresponding ammonium salt of the type **B**, the boryl group in which is readily transformed into a hydroxyl group on treatment with H_2O_2.

Synthesis of (±)-indolizidine 167B and its trans-isomer

We used the methodology for constructing a five-membered cycle described above for the synthesis of indolizidine 167B (**1b**) and its *trans*-isomer. The *cis*-(**17**) and *trans*-2,6-diallyl-1,2,3,6-tetrahydropyridines (**18**), which can easily be obtained from triallylborane and pyridine[11] (Scheme 6), were used as the starting compounds.

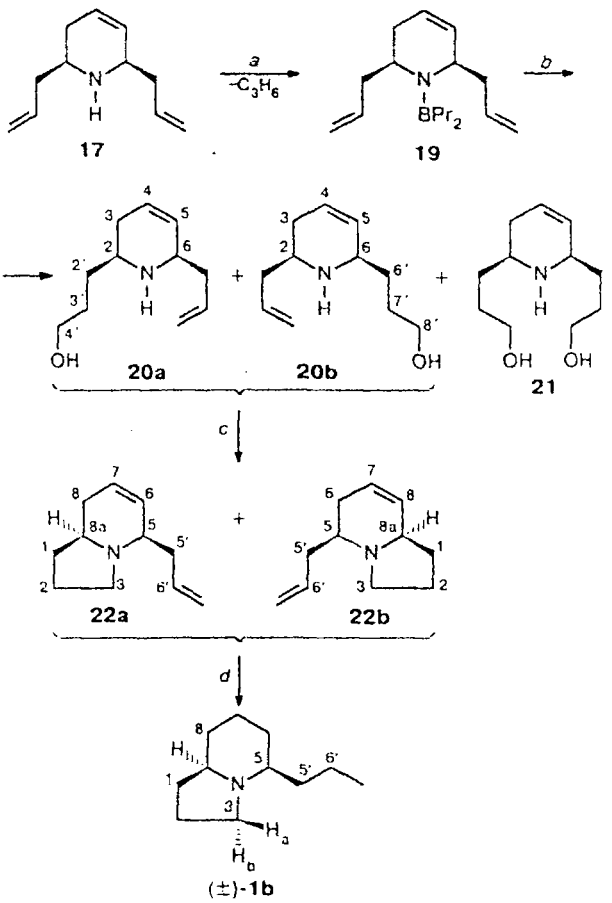
Scheme 6



Reagents and conditions: *a*. Pr^iOH; *b*. (1) All_3B, 130 °C, (2) OH^-.

Not amine **17** but its *N*-dipropylboryl derivative **19**, obtained in 75% yield by heating compound **17** with allyl(dipropyl)borane at 130 °C, was hydroborated in the synthesis of alkaloid **1b** (Scheme 7).

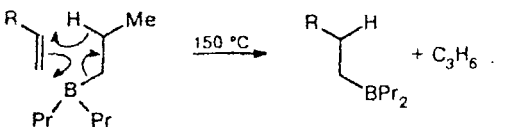
Scheme 7



Reagents and conditions: *a*. $AllBPr_2$; *b*. (1) $(Pr_2BH)_2$, THF, (2) H_2O_2, H^+; *c*. (1) Ph_3P, CBr_4, (2) Et_3N; *d*. H_2, Ni, AcOH.

The reaction of aminoborane **19** with tetrapropyldiborane (0.5 mol) followed by oxidation (H_2SO_4, H_2O_2) gave a mixture of isomeric alcohols **20a** and **20b** and diol **21** in 2 : 1 ratio. Chromatography of the mixture on a column with SiO_2 resulted in a mixture of alcohols **20a** and **20b** (yield 48% of the theoretically possible amount), which was successively treated with CBr_4, Ph_3P, and Et_3N without their separation. Chromatography of the products on a column with SiO_2 gave a mixture of hexahydroindolizines **22a** and **22b** (46%). Catalytic hydrogenation of this mixture (**22a** and **22b**) over Raney nickel gave (±)-indolizidine 167B **1b** (yield 59%). The spectroscopic characteristics of the alkaloid synthesized, (±)-**1b**, are similar to those reported previously.[7c]

Hydration of the double bond in *trans*-amine **18** was performed using tripropylborane as the hydroborating reagent. This method is based on the ability of trialkylboranes to undergo transalkylation according to the scheme[12]



Heating of *trans*-diallyl compound **18** with Pr_3B followed by oxidation (H_2SO_4, H_2O_2) gave a mixture of amino alcohols **23a** and **23b** and diol **24** (Scheme 8). Standard cyclization (CBr_4, Ph_3P, and Et_3N) of amino alcohols **23a** and **23b** isolated by chromatography on SiO_2 gave a mixture of isomeric bicyclic compounds **25a** and **25b** (46%), hydrogenation of which produced (±)-*trans*-5-propylindolizidine (**26**) (yield 63%). Its spectroscopic characteristics were similar to those reported previously.[7c]

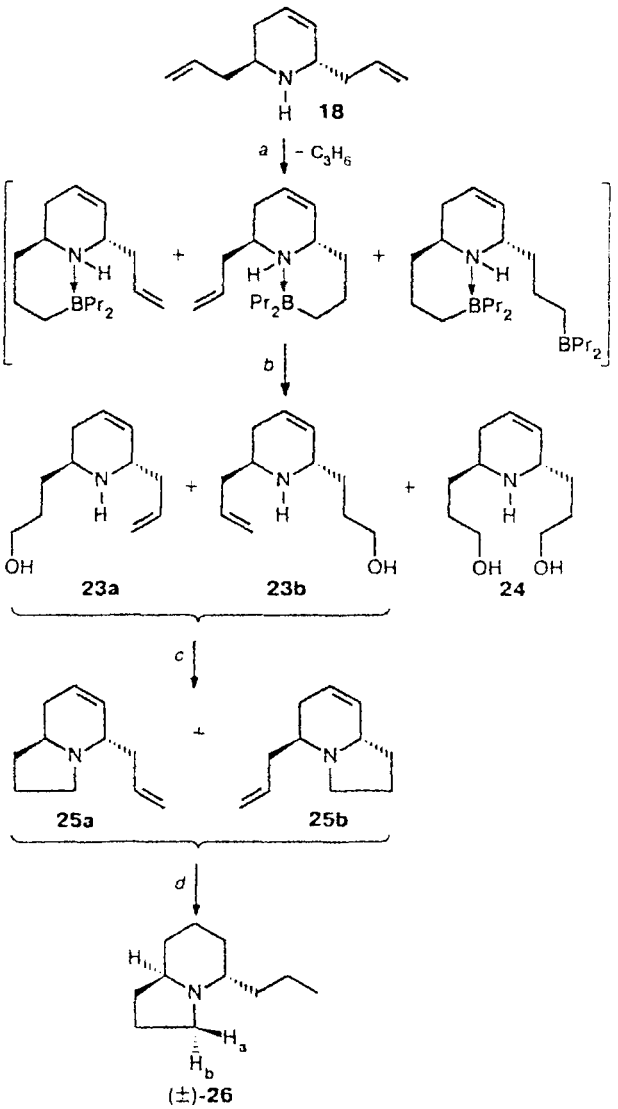
The structures of the compounds obtained were confirmed by elemental analyses and by a combination of physicochemical methods (^1H and ^{13}C NMR and IR spectroscopy and mass spectrometry). The mass spectra (EI) of indolizidines 167B (**1b**), 209D (**1a**), and their *trans*-isomers display an intense peak with m/z 124 ($[M-C_3H_7]^+$ for compounds **1b** and **26**, $[M-C_6H_{13}]^+$ for **1a** and **16**), which is the main peak characterizing 5-substituted indolizidines.[7c]

It should be emphasized that the methodology for the synthesis of indolizidines from pyridine is of general applicability and can be used for obtaining many other compounds of this series with various substituents at position 5 and certain stereochemistry.

Experimental

All operations with organoboron compounds were carried out in a dry argon atmosphere. ^1H and ^{13}C NMR spectra were recorded on a Bruker AC-200P spectrometer in $CDCl_3$. ^1H–^1H COSY and 2D NOESY spectra were obtained on a Bruker AMX-400 instrument using $SiMe_4$ as the internal standard.

Scheme 8



Reagents and conditions: *a*. Pr_3B, 160 °C; *b*. H_2SO_4, H_2O_2; *c*. (1) Ph_3P, CBr_4, (2) Et_3N; *d*. H_2, Ni, AcOH.

^{11}B NMR spectra were recorded on a Bruker AC-200P instrument in $CDCl_3$ relative to $BF_3 \cdot OEt_2$. IR spectra were obtained on a UR-20 spectrophotometer. Mass spectra were obtained on a Kratos MS-30 spectrometer. GLC analyses were performed on a Khrom-5 instrument with an OV-1 column (1 m), Chromaton as the stationary phase, and helium as the carrier gas.

***trans*-2-Allyl-6-hexyl-1,2,3,6-tetrahydropyridine (4a).** A 2.78 *N* solution of *n*-hexyllithium (70 mL, 194.4 mmol) in hexane and anhydrous ether (260 mL) was placed in a three-necked flask equipped with a thermometer, a reflux condenser, a dropping funnel, and an inlet for argon. Pyridine (15.64 mL, 194.4 mmol) was added at −45 °C, and the solution was stirred for 1 h at this temperature. Triallylborane (33.9 mL,

26.05 g, 194.4 mmol) was added, and the mixture was heated to 15 °C. Anhydrous MeOH (32 mL, 792 mmol) was then cautiously added at −30 °C. The mixture was stirred for 1 h, and a 20% NaOH solution (81 mL) was added. The low-boiling compounds were distilled off *in vacuo*, anhydrous hexane (60 mL) and a 20% NaOH solution (60 mL) were added to the residue, and the mixture was refluxed for 8 h. The organic layer was separated, and the aqueous layer was extracted with ether (3×35 mL). The combined organic fractions were washed with a saturated solution of NaCl. According to GLC data, the organic layer contained 90% of compound **4a** and ~9% of 2-hexylpyridine **6**. The solvents were distilled off. Hexane (50 mL) and 2 *N* HCl (85 mL; 95% with respect to the content of compound **4a** in the mixture) were added. The precipitate of salt **4a** · HCl, which is poorly soluble in hexane and water, was filtered off and washed with hexane. The salt **4a** · HCl that was separated and NaOH (10 g) were added to water (50 mL), the mixture was stirred for 2 h, and the free amine **4a** that formed was extracted with ether (3×10 mL). The extract was dried with K_2CO_3, and the solvent was evaporated *in vacuo*. Distillation of the residue gave 21.3 g (53%) of piperideine **4a**, b.p. 104—106 °C (1 Torr), n_D^{19} 1.4748. IR (pure compound), ν/cm^{-1}: 3300 (br), 3020, 2920, 2860, 1640, 1460, 1380, 1095, 995, 915, 710, 640. ^{1}H NMR (200 MHz), δ: 0.97 (t, 3 H, CH_3); 1.2—1.65 (m, 11 H, CH_2 (C_6H_{13}), NH); 1.80—1.95 (m, 1 H, H_a(3)); 2.05—2.3 (m, 3 H, H_b(3), H(2′)); 2.90—3.0 (m, 1 H, H(2)); 3.25—3.35 (m, 1 H, H(6)); 5.05—5.15 (m, 2 H, H(4′)); 5.65—5.85 (m, 3 H, —CH=). ^{13}C NMR, δ: 13.69 (CH_3); 22.25 (C(10′)); 26.06 (C(9′)); 28.98 (C(8′)); 31.28, 31.47 (C(7′), C(3)); 35.09 (C(6′)); 39.91 (C(2′)); 46.49 (C(2)); 51.84 (C(6)); 116.83 (C(4′)); 123.91 (C(4)); 129.99 (C(5)); 135.22 (C(3′)). MS, *m/z* (I_{rel} (%)): 166 $[M-C_3H_5]^+$ (70), 122 $[M-C_6H_{13}]^+$ (100), 81 $[M-(C_3H_5+C_6H_{13})]^+$ (26).

***trans*-2-Allyl-6-hexyl-1,2,3,6-tetrahydropyridine hydrochloride (4a · HCl)** was synthesized by treatment of compound **4a** with an ethereal solution of HCl, m.p. 125.5—126.5 °C (from a hexane—chloroform mixture). Found (%): C, 68.91; H, 10.80; N, 5.35; Cl, 15.02. $C_{14}H_{26}ClN$. Calculated (%): C, 68.96; H, 10.75; N, 5.75; Cl, 14.54. IR (KBr pellets), ν/cm^{-1}: 3400 (br), 2920, 2860, 2720, 2550, 2470, 2400, 1640, 1595, 1580, 1465, 1440, 1430, 1380, 1370, 1285, 1055, 1000, 815, 730, 690, 630, 520. ^{1}H NMR (400 MHz), δ: 0.65 (t, 3 H, CH_3); 1.12 (m, 6 H, H(8′), H(9′), H(10′)); 1.3 (m, 2 H, H(7′)); 1.56 (m, 1 H, H_b(6′)); 1.95 (m, 1 H, H_a(6′)); 2.12 (dm, 1 H, H_a(3), ^3J = 17.5 Hz); 2.32 (m, 2 H, H_b(3), H_b(2′)); 2.79 (m, 1 H, H_a(2′)); 3.30 (m, 1 H, H(2)); 3.62 (m, 1 H, H(6)); 4.98 (m, 2 H, H(4′)); 5.62 (m, 3 H, —CH=); 9.4 (br.s, 2 H, NH). ^{13}C NMR, δ: 13.12 (CH_3); 21.60 (C(10′)); 24.59 (C(9′)); 25.46 (C(8′)); 28.09 (C(3)); 30.65 (C(7′)); 31.93 (C(6′)); 34.83 (C(2′)); 48.18 (C(2)); 50.31 (C(6)); 118.44 (C(4′)); 123.00 (C(4)); 123.77 (C(5)); 131.30 (C(3′)).

***trans*-2-Allyl-1-diallylboryl-6-hexyl-1,2,3,6-tetrahydropyridine (7).** Amine **4a** (13.78 g, 66.46 mmol) was placed in a two-necked flask, and triallylborane (10.68 g, 13.89 mL, 79.7 mmol) was added cautiously. The mixture was heated at 110 °C for 1.5 h. During this time, 66.4 mmol of propylene evolved. The excess triallylborane was distilled off. Distillation gave 16.9 g (85%) of aminoborane **7**, b.p. 150—152 °C (1 Torr), n_D^{19} 1.4914. The distillation caused partial **7** → **8** isomerization; the content of compound **8** in the mixture was ~15%. ^{1}H NMR (200 MHz), δ: 0.85—1.05 (t, 3 H, CH_3); 1.2—1.7 (m, 10 H, CH_2 (C_6H_{13})); 1.7—2.0 (m, 4 H, B—CH_2—); 2.05—2.5 (m, 4 H, H(2′), H(3)); 3.75—4.1 (m, 2 H, H(2), H(6)); 4.8—5.1 (m, 6 H, CH_2=); 5.6—6.1 (m, 5 H, —CH=). ^{13}C NMR, δ: 14.00 (CH_3); 22.64 (C(10′)); 26.43 (C(9′)); 27.09 (B—CH_2—); 27.61 (C(8′)); 29.43, 31.85 (C(7′), C(3)); 40.66 (C(6′)); 42.34 (C(2′)); 53.0 (C(2)); 53.62 (C(6)); 113.48, 113.60 (B—CH_2—CH=$\underline{C}H_2$); 116.30 (C(4′)); 124.36 (C(4)); 131.91 (C(5)); 136.23 (C(3′)); 136.91, 137.08 (B—CH_2—$\underline{C}$H=). ^{11}B NMR, δ: 45.10.

Isomerization of *trans*-2-allyl-1-diallylboryl-6-hexyl-1,2,3,6-tetrahydropyridine (7) into *cis*-2-allyl-1-diallylboryl-6-hexyl-1,2,3,6-tetrahydropyridine (8). Aminoborane **7** (16.9 g) was placed in a three-necked flask equipped with a thermometer, a reflux condenser, and an inlet for argon. Heating for 5 h at 195 °C gave compound **8** (the content of isomer **7** was ~5%), n_D^{19} 1.4933. ^{1}H NMR (200 MHz), δ: 0.8—1.0 (t, 3 H, CH_3); 1.1—2.0 (m, 14 H, CH_2 (C_6H_{13}), B—CH_2); 2.0—2.4 (m, 4 H, H(2′), H(3)); 3.85—4.0 (m, 2 H, NCH); 4.75—5.1 (m, 6 H, CH_2=); 5.6—6.0 (m, 5 H, —CH=). ^{13}C NMR, δ: 14.00 (CH_3); 22.59 (C(10′)); 26.33, 26.42 (B—CH_2—); 27.27 (C(9′)); 28.68 (C(8′)); 29.45, 31.82 (C(7′), C(3)); 39.99, 40.23 (C(6′), C(2′)); 50.74 (C(2)); 53.61 (C(6)); 113.36, 113.55 (B—CH_2—CH=$\underline{C}H_2$); 116.34 (C(4′)); 121.44 (C(4)); 127.65 (C(5)); 136.57, 136.76, 136.82 (—CH=). ^{11}B NMR, δ: 43.78.

***cis*-2-Allyl-6-hexyl-1,2,3,6-tetrahydropyridine (5a).** A mixture of anhydrous MeOH (20 mL) and KOH (7 g, 124.6 mmol) was added at 0 °C to the reaction mixture obtained after the isomerization of compound **7** into **8** (the content of isomer **7** was ~5%), and the mixture was refluxed for 3 h with vigorous stirring. Water (30 mL) was added, and the mixture was extracted with ether (3×20 mL). The ethereal layer was washed with a saturated NaCl solution and dried with K_2CO_3. Distillation gave 11.46 g (83% with respect to compound **4a**) of amine **5a** with b.p. 92—94 °C (1 Torr). The admixture of *trans*-isomer **4a** (~5%) was separated on a column with Al_2O_3 (hexane—ether, 10 : 1, as the eluent), n_D^{19} 1.4735. Found (%): C, 81.25; H, 11.95; N, 6.85. $C_{14}H_{25}N$. Calculated (%): C, 81.09; H, 12.15; N, 6.76. IR (pure compound), ν/cm^{-1}: 3400 (br), 3070, 3020, 2920, 2860, 1640, 1450, 1380, 1320, 1120, 995, 915, 730. ^{1}H NMR (200 MHz), δ: 0.8—1.0 (t, 3 H, CH_3); 1.2—1.5 (m, 10 H, CH_2 (C_6H_{13})); 1.6—1.75 (br.s, 1 H, NH); 1.80—2.0 (m, 2 H, H(3)); 2.05—2.35 (m, 2 H, H(2′)); 2.7—2.9 (m, 1 H, H(2)); 3.25—3.4 (m, 1 H, H(6)); 5.0—5.2 (m, 2 H, H(4′)); 5.5—5.9 (m, 3 H, —CH=). ^{13}C NMR, δ: 13.80 (CH_3); 22.34 (C(10′)); 25.54 (C(9′)); 29.17 (C(8′)); 31.55, 32.27 (C(7′), C(3)); 36.38 (C(6′)); 40.91 (C(2′)); 52.12 (C(2)); 54.91 (C(6)); 117.19 (C(4′)); 124.65 (C(4)); 130.67 (C(5)); 135.02 (C(3′)). MS, *m/z* (I_{rel} (%)): 207 $[M]^+$ (77), 166 $[M-C_3H_5]^+$ (100), 149 $[M-C_4H_{10}]^+$ (76), 122 $[M-C_6H_{13}]^+$ (74), 96 $[M-(C_3H_5+C_5H_{10})]^+$ (42), 81 $[M-(C_3H_5+C_6H_{13})]^+$ (46), 79 $[M-(C_3H_6+C_6H_{14})]^+$ (66).

***cis*-2-Allyl-6-hexyl-1,2,3,6-tetrahydropyridine hydrochloride (5a · HCl)** was synthesized by treatment of compound **5a** with an ethereal solution of HCl, m.p. 158.5—159.5 °C (from a hexane—CH_2Cl_2 mixture). IR (KBr pellets), ν/cm^{-1}: 3400 (br), 2930, 2850, 2800, 2740, 2610, 2530, 2480, 1640, 1580, 1465, 1425, 1390, 1030, 995, 920, 760, 700, 490. ^{1}H NMR (200 MHz), δ: 0.7—1.05 (t, 3 H, CH_3); 1.1—1.6 (m, 9 H, CH_2 (C_6H_{13}), H_b(6′)); 1.7—2.0 (m, 1 H, H_a(6′)); 2.05—2.8 (m, 3 H, H(3), H_b(2′)); 3.05—3.35 (m, 2 H, H_a(2′), H(2)); 3.65—3.9 (m, 1 H, H(6)); 5.05—5.3 (m, 2 H, H(4′)); 5.6—6.0 (m, 3 H, —CH=); 9.4 (br.s, 1 H, NH); 10.0 (br.s, 1 H, NH). ^{13}C NMR, δ: 13.80 (CH_3); 22.34 (C(10′)); 25.24 (C(9′)); 27.81 (C(8′)); 28.91 (C(3)); 31.50 (C(7′)); 32.34 (C(6′)); 37.22 (C(2′)); 54.13 (C(2)); 55.45 (C(6)); 119.11 (C(4′)); 123.62 (C(4)); 125.54 (C(5)); 131.61 (C(3′)).

***cis*-6-Hexyl-2-(3-hydroxypropyl)-1,2,3,6-tetrahydropyridine (9).** A solution of amine **5a** (5.61 g, 27.1 mmol) in anhydrous THF (20 mL) was placed in a three-necked flask equipped with a thermometer, a reflux condenser, a dropping funnel, and an inlet for argon. A 1.29 *N* solution of $(Pr_2BH)_2$ (13.5 mL, 17.4 mmol) in THF was slowly added at 0 °C, and the mixture was stirred for 5 h at ~20 °C (the reaction and its completion were monitored by ^{13}C NMR spectroscopy, *i.e.*, until the allyl group signals disappeared). MeOH (5 mL) was added in order to decompose the excess $(Pr_2BH)_2$, and the solvents were then distilled off *in vacuo*. A 8 *N* solution of H_2SO_4 (76 mL) was added to the white viscous residue, and 30% H_2O_2 (15.3 mL, 150 mmol) was then added at 0 °C with vigorous stirring. The solution was stirred until the complex decomposed completely (TLC monitoring). The solution was washed with ether. NaOH (14.5 g) was added at 0 °C to the aqueous layer; the mixture was stirred for 5 h and then extracted with ether (3×30 mL). The extract was dried with K_2CO_3. The solvents were distilled off to give a mixture containing 80% of alcohol **9** and 20% of diols **10** (according to ^1H and ^{13}C NMR spectroscopic data). The diols were separated on a column with Al_2O_3 (hexane—ether (1 : 1) → ether as the eluents) to give 3.08 g (51%) of amino alcohol **9**, which upon freeze-precipitation from hexane formed crystals with m.p. 35—37 °C. Found (%): C, 74.69; H, 12.30; N, 6.48. $C_{14}H_{27}NO$. Calculated (%): C, 74.61; H, 12.08; N, 6.21. IR (pure compound), ν/cm^{-1}: 3370 (br), 3260, 3120, 3030, 2920, 2860, 1655, 1480, 1465, 1380, 1100, 1070, 935, 855, 685. ^1H NMR (200 MHz), δ: 0.8—1.0 (t, 3 H, CH_3); 1.2—2.1 (m, 18 H, C—CH_2—C, OH, NH); 2.6—2.8 (m, 1 H, H(2)); 3.2—3.4 (m, 1 H, H(6)); 3.45—3.7 (m, 2 H, CH_2—O); 5.55—5.8 (m, 2 H, —CH=). ^{13}C NMR, δ: 13.73 (CH_3); 22.28 (C(10′)); 25.32 (C(9′)); 29.06 (C(8′)); 30.65, 31.36, 32.04 (C(7′), C(3), C(3′)); 35.39, 35.88 (C(6′), C(2′)); 53.30, 54.43 (C(2), C(6)); 62.10 (C(4′)); 125.12 (C(4)); 130.86 (C(5)). MS, *m/z* (I_{rel} (%)): 225 $[M]^+$ (2), 166 $[M-C_3H_6OH]^+$ (41), 141 $[M-C_6H_{12}]^+$ (28), 140 $[M-C_6H_{13}]^+$ (100), 122 $[M-(C_6H_{13}+H_2O)]^+$ (25), 96 $[M-(C_3H_6OH+C_5H_{10})]^+$ (33), 79 $[C_5H_5N]^+$ (29), 71 $[C_5H_{11}]^+$ (37).

***cis*-1,2,3,5,8,8a-Hexahydro-5-hexylindolizine (12).** Amino alcohol **9** (1.43 g, 6.35 mmol) and a solution of CBr_4 (2.64 g, 8 mmol) in CH_2Cl_2 (19 mL) were placed in a three-necked flask equipped with a thermometer, a reflux condenser, a dropping funnel, and an inlet for argon. Triphenylphosphine (2.49 g, 9.5 mmol) was added at 0 °C to the solution, and the mixture was stirred for 1 h. Triethylamine (14.6 mL) was then added, and the mixture was stirred for 5 h. The low-boiling compounds were distilled off *in vacuo*, pentane (20 mL) was added to the residue, and the precipitate that formed was filtered off. Purification on a column with SiO_2 (CH_2Cl_2—MeOH, 25 : 1, + 1 drop of aqueous NH_3 per 100 mL of the solution as the eluent) followed by distillation gave 0.65 g (50%) of indolizine **12**, b.p. 78—80 °C (1 Torr), n_D^{19} 1.4811. Found (%): C, 80.93; H, 12.09; N, 6.81. $C_{14}H_{25}N$. Calculated (%): C, 81.09; H, 12.15; N, 6.76. IR (pure compound), ν/cm^{-1}: 3440 (br), 3020, 2950, 2930, 2860, 2780, 2710, 1640, 1460, 1380, 1330, 1225, 1170, 1135, 1080, 1045, 815, 730, 690, 640. ^1H NMR (200 MHz), δ: 0.8—1.05 (t, 3 H, CH_3); 1.2—2.1 (m, 16 H, C—CH_2—C); 2.1—2.35 (m, 2 H, NCH); 2.6—2.75 (m, 1 H, NCH); 3.3—3.45 (m, 1 H, H(5)); 5.55—5.8 (m, 2 H, —CH=). ^{13}C NMR, δ: 13.91 (CH_3); 20.71 (C(2)); 22.46 (C(9′)); 25.08 (C(8′)); 29.52 (C(7′)); 30.57, 31.65, 32.30, 33.81 (C(6′), C(5′), C(8), C(1)); 52.41 (C(3)); 60.22 (C(8a)); 63.24 (C(5)); 124.66 (C(7)); 129.52 (C(6)). MS, *m/z* (I_{rel} (%)): 207 $[M]^+$ (4), 164 $[M-C_3H_7]^+$ (16), 151 $[M-C_4H_8]^+$ (12), 136 $[M-C_5H_{11}]^+$ (22), 123 $[M-C_6H_{12}]^+$ (26), 122 $[M-C_6H_{13}]^+$ (100), 70 $[C_4H_8N]^+$ (30).

(±)-Indolizidine 209D (*cis*-5-hexylindolizidine) (1a). A mixture of indolizine **12** (0.14 g, 0.68 mmol), glacial acetic acid (1 mL), and Raney nickel (0.01 g) were placed in an 0.15-liter autoclave. The autoclave was filled with hydrogen to 100 atm pressure and heated for 10 h at 100 °C. After the pressure was relieved, the catalyst was filtered off and washed with water. NaOH (20%) was added to the combined filtrates until total neutralization of the acid, and the mixture was extracted with ether. The solvents were distilled off *in vacuo* to give 0.15 g (90%) of indolizidine **1a**, n_D^{19} 1.4728. IR (pure compound), ν/cm^{-1}: 3400 (br), 2930, 2930, 2860, 2800, 1730, 1660, 1640, 1575, 1455, 1380, 1300, 1240, 1130, 1030, 730. ^1H NMR (200 MHz), δ: 0.8—1.0 (t, 3 H, CH_3); 1.1—2.05 (m, 23 H); 3.2—3.35 (m, 1 H, H_a(3)). ^{13}C NMR, δ: 13.86 (CH_3); 20.19, 22.42, 24.51 (C(9′), C(2), C(7)); 25.59 (C(8′)); 29.55, 30.34, 30.65, 30.80, 31.64 (C(7′), C(6′), C(1), C(6), C(8)); 34.44 (C(5′)); 51.33 (C(3)); 63.67 (C(5)); 64.78 (C(8a)). MS, *m/z* (I_{rel} (%)): 209 $[M]^+$ (7), 180 $[M-C_2H_5]^+$ (5), 166 $[M-C_3H_7]^+$ (13), 138 $[M-C_5H_{11}]^+$ (11), 125 $[M-C_6H_{12}]^+$ (22), 124 $[M-C_6H_{13}]^+$ (100), 96 $[M-(C_6H_{13}+C_2H_4)]^+$ (16), 82 $[M-(C_6H_{13}+C_3H_6)]^+$ (8), 70 $[C_4H_8N]^+$ (15).

***trans*-6-Hexyl-2-(3-hydroxypropyl)-1,2,3,6-tetrahydropyridine (13).** A solution of amine **4a** (3.23 g, 15.6 mmol) in anhydrous THF (10 mL) was placed in a three-necked flask equipped with a thermometer, a reflux condenser, a dropping funnel, and an inlet for argon. A 1.29 *N* solution of $(Pr_2BH)_2$ (12 mL, 15.5 mmol) in THF was added dropwise at 0 °C, and the mixture was stirred for 5 h at ~20 °C. The solvents were distilled off *in vacuo*. 8 *N* H_2SO_4 (45 mL) and 30% H_2O_2 (8.8 mL, 86.5 mmol) were added to the residue at 0 °C with vigorous stirring, and the mixture was stirred for 3 h. NaOH (8.5 g) and H_2O (10 mL) were added at 0 °C, and stirring was continued for 5 h. The mixture was extracted with ether (3×20 mL), and the extract was dried with K_2CO_3 to give a mixture containing 80% of alcohol **13** and 20% of diols **14** (according to the ^1H and ^{13}C NMR spectra). The diols were separated on a column with Al_2O_3 (with ether → ether+MeOH as the eluent) to give 1.45 g (49%) of amino alcohol **13**, n_D^{19} 1.4843. IR (pure compound), ν/cm^{-1}: 3260 (br), 3020, 2920, 2860, 1465, 1455, 1360, 1065, 710. ^1H NMR (200 MHz), δ: 0.8—1.0 (t, 3 H, CH_3); 1.15—1.9 (m, 18 H, C—CH_2—C, OH, NH); 2.75—2.9 (m, 1 H, H(2)); 3.2—3.35 (m, 1 H, H(6)); 3.4—3.75 (m, 2 H, CH_2—O); 5.65—5.7 (m, 2 H, —CH=). ^{13}C NMR, δ: 13.90 (q, CH_3, J = 123.5 Hz); 22.47 (C(10′)); 26.38 (C(9′)); 29.21 (C(8′)); 31.00, 31.59, 31.90 (C(7′), C(3), C(3′)); 34.97, 35.17 (C(6′), C(2′)); 48.06 (d, C(2), J = 133.4 Hz); 52.03 (d, C(6), J = 132 Hz); 62.50 (t, C(4′), J = 142 Hz); 124.54 (d, C(4), J = 163 Hz); 130.30 (d, C(5), J = 159 Hz). MS, *m/z* (I_{rel} (%)): 225 $[M]^+$ (5), 184 $[M-C_3H_5]^+$ (82), 166 $[M-C_3H_6OH]^+$ (68), 141 $[M-C_6H_{12}]^+$ (34.5), 140 $[M-C_6H_{13}]^+$ (100), 122 $[M-(C_6H_{13}+H_2O)]^+$ (83), 113 $[M-(C_3H_6OH+C_4H_5)]^+$ (23), 96 $[M-(C_3H_6OH+C_5H_{10})]^+$ (23).

***trans*-6-Hexyl-2-(3-hydroxypropyl)-1,2,3,6-tetrahydropyridine hydrochloride (13 · HCl)** was synthesized by treatment of compound **13** with an ethereal solution of HCl. The hydrochloride is hygroscopic. ^1H NMR (200 MHz), δ: 0.8—1.1 (t, 3 H, CH_3); 1.2—2.6 (m, 16 H, C—CH_2—C); 3.3—3.6 (m, 1 H, H(2)); 3.6—4.0 (m, 3 H, H(6), CH_2—O); 4.75 (br.s, 1 H, OH); 5.7—6.0 (m, 2 H, —CH=); 9.25 (br.s, 1 H, NH); 9.6 (br.s, 1 H, NH). ^{13}C NMR, δ: 13.84 (CH_3); 22.34 (C(10′)); 25.35 (C(9′)); 27.55, 28.33, 28.83, 29.14 (C(8′), C(7′), C(3), C(3′)); 31.39, 32.72 (C(6′), C(2′)); 49.54 (C(2)); 51.42 (C(6)); 61.24 (C(4′)); 123.77 (C(4)); 124.70 (C(5)).

***trans*-1,2,3,5,8,8a-Hexahydro-5-hexylindolizine (15)** was obtained by analogy with the synthesis of compound **12** from amino alcohol **13** (1.24 g, 5.5 mmol), CBr_4 (2.29 g, 6.9 mmol), CH_2Cl_2 (16 mL), triphenylphosphine (2.16 g, 8.2 mmol), and triethylamine (12.6 mL). Purification on a column with SiO_2 (CH_2Cl_2—MeOH, 10 : 1, + 1 mL of aqueous NH_3 per 100 mL of the solution as the eluent) followed by distillation gave 0.51 g (45%) of indolizine **15**, b.p. 90—91 °C (1 Torr), n_D^{19} 1.4831. Found (%): C, 81.06; H, 12.30; N, 6.53. $C_{14}H_{25}N$. Calculated (%): C, 81.09; H, 12.15; N, 6.76. IR (pure compound), ν/cm^{-1}: 3380 (br), 3020, 2950, 2920, 2860, 2800, 1630, 1465, 1375, 1140, 710. ^1H NMR (200 MHz), δ: 0.8—1.1 (t, 3 H, CH_3); 1.15—2.2 (m, 16 H, C—CH_2—C); 2.65—3.0 (m, 3 H, H(3), H(8a)); 3.25—3.4 (m, 1 H, H(5)); 5.65—5.9 (m, 2 H, —CH=). ^{13}C NMR, δ: 13.88 (CH_3); 21.13 (C(2)); 22.45 (C(9′)); 26.58 (C(8′)); 29.57 (C(7′)); 30.30, 30.61, 30.65, 31.65 (C(6′), C(5′), C(8), C(1)); 48.56 (C(3)); 51.19 (C(8a)); 55.71 (C(5)); 124.12 (C(7)); 129.62 (C(6)). MS, *m/z* (I_{rel} (%)): 207 $[M]^+$ (8), 168 $[M-C_3H_3]^+$ (25), 137 $[M-C_5H_{10}]^+$ (10), 123 $[M-C_6H_{12}]^+$ (58), 122 $[M-C_6H_{13}]^+$ (100), 94 $[M-(C_6H_{13}+C_2H_4)]^+$ (20), 79 $[C_5H_5N]^+$ (21), 70 $[C_4H_8N]^+$ (49).

***trans*-5-Hexylindolizidine (16)** was obtained by analogy with the synthesis of (±)-indolizidine 209D (**1a**) by hydrogenation of indolizine **15** (0.22 g, 1.1 mmol) over Raney nickel. The reaction gave 0.15 g (68%) of indolizidine **16**, n_D^{19} 1.4707. ^1H NMR (200 MHz), δ: 0.7—2.0 (m, 23 H, CH_3, C—CH_2—C); 2.35—3.05 (m, 4 H, N—CH). ^{13}C NMR, δ: 14.06 (CH_3); 19.20 (C(7)); 20.77 (C(2)); 22.61 (C(9′)); 23.36 (C(8′)); 27.43, 27.57 (C(6), C(8)); 29.63 (C(7′)); 30.47 (C(6′)); 31.05, 31.84 (C(5′), C(1)); 48.66 (C(3)); 55.13 (C(8a)); 55.42 (C(5)). MS, *m/z*: 209 $[M]^+$, 166 $[M-C_3H_7]^+$, 138 $[M-C_5H_{11}]^+$, 125 $[M-C_6H_{12}]^+$, 124 $[M-C_6H_{13}]^+$.

***cis*-2,6-Diallyl-1-dipropylboryl-1,2,3,6-tetrahydropyridine (19).** *cis*-2,6-Diallyl-1,2,3,6-tetrahydropyridine **17** (10.8 g, 66.2 mmol) and allyldipropylborane (11 g, 79.7 mmol, 14.7 mL) were placed in a distilling flask and heated at 130 °C until the evolution of propylene ceased. The excess allyldipropylborane was distilled off. Distillation of the residue gave 12.8 g (75%) of aminoborane **19**, b.p. 101—103 °C (1 Torr), n_D^{19} 1.4891. ^1H NMR (200 MHz), δ: 0.75—1.1 (m, 10 H, CH_3, B—CH_2—); 1.2—1.55 (m, 4 H, $C\underline{H}_2$—CH_3); 2.0—2.5 (m, 6 H, $C\underline{H}_2$—CH=); 3.85—4.15 (m, 2 H, NCH); 4.9—5.25 (m, 4 H, CH_2=); 5.6—6.1 (m, 4 H, —CH=). ^{13}C NMR, δ: 18.00 (CH_3); 19.13 ($\underline{C}H_2$—CH_3); 21.77, 22.92 (B—CH_2); 29.04 (C(3)); 40.48, 44.55 (—CH_2— (All)); 50.54 (C(2)); 52.91 (C(6)); 116.26, 116.58 (CH_2=); 121.8 (C(4)); 127.73 (C(5)); 136.0, 137.04 (—CH= (All)). ^{11}B NMR ($CDCl_3$), δ: 46.79.

Mixture of *cis*-6-allyl-2-(3-hydroxypropyl)-1,2,3,6-tetrahydropyridine (20a) and *cis*-2-allyl-6-(3-hydroxypropyl)-1,2,3,6-tetrahydropyridine (20b). Aminoborane **19** (12.8 g, 49.4 mmol) and anhydrous THF (40 mL) were placed in a three-necked flask equipped with a thermometer, a reflux condenser, a dropping funnel, and an inlet for argon. A 1.29 *N* solution of $(Pr_2BH)_2$ (19.2 mL, 24.7 mmol) in THF was added at 0 °C. The mixture was stirred for 1 h and kept overnight. The solvents were distilled off *in vacuo*. 8 *N* H_2SO_4 (58 mL) was cautiously added at 0 °C, and 30% H_2O_2 (30 mL, 271.3 mmol) was added dropwise. The mixture was stirred for 2 h at ~20 °C, then 10 *N* NaOH (75 mL) was added, and stirring was continued for 2 h. The mixture was extracted with ether. The ethereal layer was washed with a saturated solution of NaCl and dried with K_2CO_3. The solvents and the unreacted *cis*-2,6-diallyl-1,2,3,6-tetrahydropyridine **17** were distilled off in the vacuum of an oil pump (1 Torr) to give a mixture of alcohols **20a**, **20b** and diol **21** (according to the ^{13}C NMR spectra). The diol was separated on a column with SiO_2 (ether → MeOH as the eluents) to give 2.17 g (48% of the stoichiometrically possible yield) of a mixture of alcohols **20a** and **20b**. ^1H NMR (200 MHz), δ: 1.0—2.2 (m, 9 H, C—CH_2—C, NH); 2.5—2.8 (m, 1 H, H(2)); 3.15—4.25 (m, 4 H, H(6), CH_2OH); 4.85—5.15 (m, 2 H, CH_2=); 5.35—5.8 (m, 3 H, —CH=). ^{13}C NMR, δ: 28.43, 31.25, 34.07 (**20b**: H(3), H(6′), H(7′)); 30.25, 31.78, 34.83 (**20a**: H(3), H(2′), H(3′)); 39.80 (**20a**: —CH_2— (All)); 40.44 (**20b**: —CH_2— (All)); 51.83 (**20b**: C(2)); 53.10, 53.65 (**20a**: C(2), C(6)); 53.90 (**20b**: C(6)); 61.83 (**20b**: CH_2OH); 61.97 (**20a**: CH_2OH); 117.64 (CH_2=); 125.38 (**20b**: C(4)); 125.8 (**20a**: C(4)); 129.58 (**20b**: C(5)); 129.85 (**20a**: C(5)); 134.13 (**20a**: —CH= (All)); 134.35 (**20b**: —CH= (All)).

Mixture of *cis*-5-allyl-1,2,3,5,8,8a-hexahydroindolizine (22a) and *cis*-5-allyl-1,2,3,5,6,8a-hexahydroindolizine (22b). This was obtained by analogy with the synthesis of compound **12** from the mixture of alcohols **20a** and **20b** (2.07 g, 11.4 mmol), CBr_4 (4.8 g, 14.5 mmol), CH_2Cl_2 (35 mL), triphenylphosphine (4.5 g, 17.2 mmol), and Et_3N (26.5 mL). Purification on a column with SiO_2 (CH_2Cl_2—MeOH, 10 : 1, + 1 mL of aqueous NH_3 per 100 mL of the solution as the eluent) gave 0.85 g (46%) of a mixture of bicycles **22a** and **22b**, b.p. 50—60 °C (6 Torr). ^1H NMR (200 MHz), δ: 1.0—2.6 (m, 10 H, —CH_2—); 2.65—3.0 (m, 1 H, NCH); 3.15—3.5 (m, 1 H, NCH); 4.9—5.2 (m, 2 H, CH_2=); 5.5—6.0 (m, 3 H, —CH=). ^{13}C NMR, δ: 20.47 (**22a**: C(2)); 21.27 (**22b**: C(2)); 27.81, 28.70 (**22b**: C(1), C(6)); 30.24, 31.96 (**22a**: C(1), C(8)); 38.27 (**22a**: C(5′)); 39.21 (**22b**: C(5′)); 45.45 (**22b**: C(3)); 52.08 (**22a**: C(3)); 56.07 (**22b**: C(5)); 59.89 (**22a**: C(8a)); 60.66 (**22b**: C(8a)); 62.33 (**22a**: C(5)); 116.09 (**22b**: CH_2=); 116.23 (**22a**: CH_2=); 124.42 (**22b**: C(7)); 124.68 (**22a**: C(7)); 128.65 (**22a**: C(6)); 128.88 (**22b**: C(8)); 134.91 (**22a**: C(6′)); 135.05 (**22b**: C(6′)).

(±)-Indolizidine 167B (*cis*-5-propylindolizidine) (1b) was obtained similarly to the synthesis of (±)-indolizidine 209D (**1a**) by hydrogenation of the mixture of amines **22a** and **22b** (0.52 g, 3.2 mmol) over Raney nickel. The reaction gave 0.31 g (59%) of indolizidine **1b**, b.p. 76—79 °C (8 Torr), n_D^{19} 1.4739. IR (pure compound), ν/cm^{-1}: 3420 (br), 2960, 2930, 2870, 2780, 2710, 2600, 1655, 1450, 1440, 1380, 1330, 1320, 1290, 1250, 1225, 1210, 1180, 1130, 1110, 1080, 1060, 1020, 925, 915, 890, 830, 810, 740. ^1H NMR (200 MHz), δ: 0.75—1.05 (t, 3 H, CH_3); 1.05—2.1 (m, 17 H, CH_2, NCH); 3.15—3.4 (m, 1 H, H_a(3)). ^{13}C NMR, δ: 14.22 (CH_3); 18.78, 20.11, 24.42 (C(6′), C(2), C(7)); 30.26, 30.53, 30.69 (C(1), C(6), C(8)); 36.62 (C(5′)); 51.24 (C(3)); 63.41 (C(5)); 64.72 (C(8a)). MS, *m/z* (I_{rel} (%)): 167 $[M]^+$ (21), 166 $[M-H]^+$ (18), 138 $[M-C_2H_5]^+$ (13), 126 $[M-C_3H_5]^+$ (14), 125 $[M-C_3H_6]^+$ (32), 124 $[M-C_3H_7]^+$ (100), 110 $[M-(C_2H_5+C_2H_4)]^+$ (19), 96 $[M-(C_3H_7+C_2H_4)]^+$ (42), 83 $[M-2C_3H_6]^+$ (30), 70 $[C_4H_8N]^+$ (30).

Mixture of *trans*-6-allyl-2-(3-hydroxypropyl)-1,2,3,6-tetrahydropyridine (23a) and *trans*-2-allyl-6-(3-hydroxypropyl)-1,2,3,6-tetrahydropyridine (23b). *trans*-2,6-Diallyl-1,2,3,6-tetrahydropyridine **18** (4.36 g, 26.7 mmol) and tripropylborane (3.74 g, 5.2 mL, 26.7 mmol) were placed in a three-necked flask equipped with a thermometer and a reflux condenser, and the mixture was heated for 20 h at 160 °C on an oil bath. The unreacted compounds were distilled off in the vacuum of an oil pump (1 Torr). 8 *N* H_2SO_4 (31 mL) was added at 0 °C to the resulting mixture of boron complexes, 30% H_2O_2 (9.9 mL, 96.5 mmol) was added cautiously, and the mixture was stirred for 3 h. 10 *N* NaOH (38 mL) was added, and stirring was continued for 2 h. The mixture was extracted with ether; the

ethereal extract was washed with a saturated NaCl solution and dried with K_2CO_3 to give a mixture of alcohols **23a**, **23b** and diol **24** (according to ^{13}C NMR spectroscopic data). The diol was separated on a column with SiO_2 ($CHCl_3$—EtOH, 20 : 1, + 10 drops of aqueous NH_3 per 100 mL of the solution as the eluent) to give 1.12 g (46% of the stoichiometrically possible yield) of a mixture of alcohols **23a** and **23b**. ^1H NMR (200 MHz), δ: 1.15—2.35 (m, 9 H, C—CH_2—C, NH); 2.75—3.05 (m, 1 H, H(2)); 3.25—4.2 (m, 4 H, H(6), CH_2OH); 5.0—5.2 (m, 2 H, CH_2=); 5.6—5.95 (m, 3 H, —CH=). ^{13}C NMR, δ: 29.86, 30.32, 32.75 (**23b**: H(3), H(6′), H(7′)); 30.16, 31.29, 33.39 (**23a**: H(3), H(2′), H(3′)); 39.14 (**23b**: —CH_2— (All)); 39.39 (**23a**: —CH_2— (All)); 46.39 (**23a**: C(2)); 47.22 (**23b**: C(2)); 51.25 (**23b**: C(6)); 51.77 (**23a**: C(6)); 61.84 (CH_2OH); 117.17 (**23a**: CH_2=); 117.27 (**23b**: CH_2=); 124.25 (**23b**: C(4)); 124.87 (**23a**: C(4)); 129.01 (**23a**: C(5)); 129.91 (**23a**: C(5)); 134.48 (**23b**: —CH= (All)); 135.11 (**23a**: —CH= (All)).

Mixture of *trans*-5-allyl-1,2,3,5,8,8a-hexahydroindolizine (25a) and *trans*-5-allyl-1,2,3,5,6,8a-hexahydroindolizine (25b). This was obtained by analogy with the synthesis of compound **12** from the mixture of alcohols **23a** and **23b** (1.1 g, 6.1 mmol), CBr_4 (2.55 g, 7.7 mmol), CH_2Cl_2 (19 mL), triphenylphosphine (2.39 g, 9.1 mmol), and Et_3N (14 mL). Purification on a column with SiO_2 (CH_2Cl_2—EtOH, 20 : 1, + 5 drops of aqueous NH_3 per 100 mL of the solution as the eluent) gave 0.45 g (46%) of a mixture of bicycles **25a** and **25b**.

Compound **25a**: ^1H NMR (200 MHz), δ: 1.2—1.6 (m, 2 H, H(2)); 1.65—2.3 (m, 6 H, H(1), H(5′), H(8)); 2.35—2.6 (m, 1 H, NCH); 2.7—3.0 (m, 2 H, NCH); 3.4—3.6 (m, 1 H, H(5)); 4.95—5.2 (m, 2 H, CH_2=); 5.6—6.0 (m, 3 H, —CH=). ^{13}C NMR, δ: 20.99 (C(2)); 30.45, 30.86 (C(8), C(1)); 34.43 (C(5′)); 48.36 (C(3)); 51.09 (C(8a)); 55.64 (C(5)); 115.90 (CH_2=); 124.38 (C(7)); 129.01 (C(6)); 135.94 (C(6′)).

Compound **25b**: ^1H NMR (200 MHz), δ: 1.0—1.5 (m, 2 H, H(2)); 1.55—2.45 (m, 6 H, H(1), H(5′), H(6)); 2.6—2.95 (m, 3 H, H(8a), H(3)); 3.35—3.65 (m, 1 H, H(5)); 4.8—5.15 (m, 2 H, CH_2=); 5.4—5.9 (m, 3 H, —CH=). ^{13}C NMR, δ: 21.85 (C(2)); 22.90 (C(1)); 29.34 (C(6)); 36.89 (C(5′)); 49.40 (C(3)); 52.51 (C(8a)); 53.33 (C(5)); 115.51 (CH_2=); 121.96 (C(7)); 129.23 (C(8)); 135.95 (C(6′)).

***trans*-5-Propylindolizidine (26)** was obtained by analogy with the synthesis of (±)-indolizidine 209D (**1a**) from the mixture of amines **25a** and **25b** (0.45 g, 2.8 mmol), glacial acetic acid (2.6 mL), and Raney nickel (0.02 g). The reaction gave 0.29 g (63%) of indolizidine **26**, b.p. 70—72 °C (10 Torr), n_D^{19} 1.4780. IR (pure compound), ν/cm^{-1}: 3400 (br), 2960, 2930, 2870, 2800, 2720, 1695, 1460, 1380, 1360, 1265, 1230, 1200, 1170, 1155, 1140, 1095, 1080, 900, 820, 740. ^1H NMR (200 MHz), δ: 0.85—1.05 (t, 3 H, CH_3); 1.1—1.95 (m, 14 H, C—CH_2—C); 2.4—2.55 (m, 1 H, H(8a)); 2.55—2.7 (m, 1 H, H_b(3)); 2.75—3.0 (m, 2 H, H(5), H_a(3)). ^{13}C NMR, δ: 14.05 (CH_3); 19.01, 20.51, 20.55 (C(2), C(7), C(6′)); 25.47, 27.22 (C(6), C(8)); 30.29, 30.85 (C(5′), C(1)); 48.43 (C(3)); 54.79 (C(8a)); 54.90 (C(5)). MS (EI, 70 eV), *m/z* (I_{rel} (%)): 167 $[M]^+$ (22), 166 $[M-H]^+$ (14), 138 $[M-C_2H_5]^+$ (11), 126 $[M-C_3H_5]^+$ (12), 125 $[M-C_3H_6]^+$ (32), 124 $[M-C_3H_7]^+$ (100), 96 $[M-(C_3H_7+C_2H_4)]^+$ (38), 70 $[C_4H_8N]^+$ (23).

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