stable at room temperature. We attribute this stability, first, to the extended conjugation present, and, second, to the fact that it is a triplet with "nowhere to go". Either dimerization of the triplet or valence isomerization of the singlet (for example, a reaction like the isomerization of *m*-quinodimethane to a bicyclo[3.1.0] system[5]) would lead to highly strained products.[19] The biradical is, however, very sensitive to oxygen, and as soon as the sample tube is opened, there is an instant oxidation and the bright blue color of the starting material **2** is restored.

Acknowledgment. We thank the SERC for financial assistance and N. Taylor for assistance with the cyclic voltammetry.

(19) A referee has suggested that Coulombic factors may also contribute in making dimerization unfavorable.

A New, General Synthetic Pathway to *Strychnos* Indole Alkaloids. First Total Synthesis of (±)-Echitamidine

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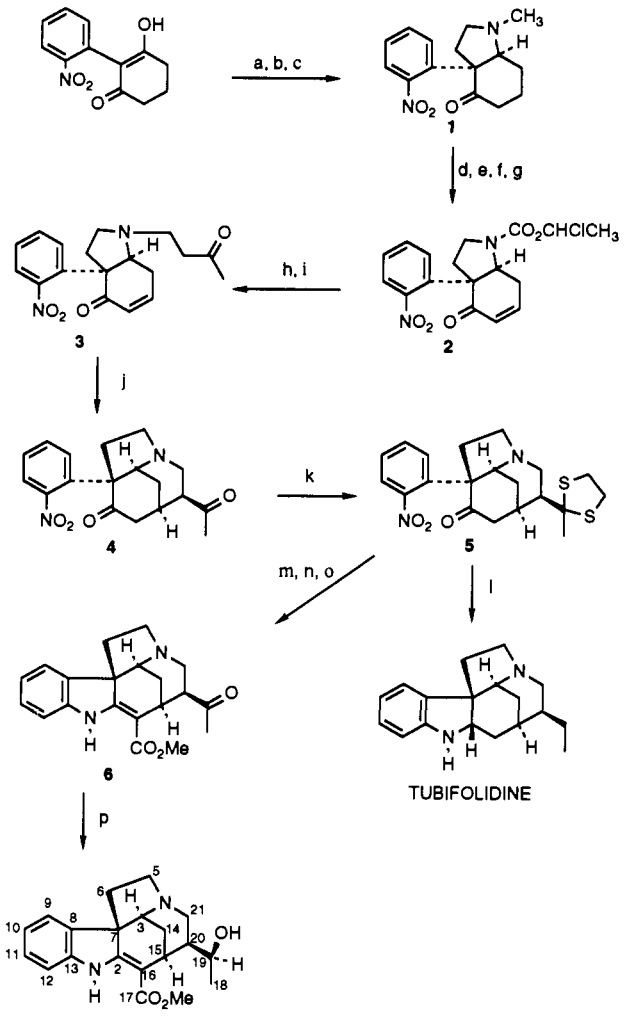
New strategies for the synthesis of pentacyclic *Strychnos* indole alkaloids have appeared during the last two years,[1] showing a renewed interest in this area since the initial synthetic work by Harley-Mason.[2] However, only about 10 of the vast array of alkaloids with this skeletal type have been synthesized so far.[3]

We report now a new, general synthetic entry to *Strychnos* alkaloids of both the norcuran (tubifolidine,[4] for instance) and the curan (echitamidine,[5] for instance) skeleton through a synthetic sequence with a high degree of flexibility involving the *o*-nitrophenyl azatricyclic ketone **4** as a pivotal intermediate. Two important features of **4** are (i) the presence of a two-carbon chain at C-20 which can be elaborated to the variety of C-20 substituents present in *Strychnos* alkaloids and (ii) the activation at C-16, which allows the introduction of the C-17 oxidized one-carbon appendage characteristic of curan alkaloids.

The crucial steps of the synthesis (Scheme I) are (i) the elaboration of the *cis*-3a-(*o*-nitrophenyl)octahydroindolone **1** through a double (inter- and intramolecular) reductive amination from a symmetric cyclohexanedione derivative,[6] (ii) closure of the piperidine ring by an intramolecular Michael process, and (iii) formation of the indoline ring in the last synthetic steps by reductive cyclization.[7]

Scheme I[a]



[a] (a) $BrCH_2CH{=}CH_2$ (1.1 equiv), K_2CO_3 (4 equiv), acetone, reflux, 3 h. (b) Toluene, sealed tube, 180 °C, 12 h. (c) O_3 (1 equiv), CH_2Cl_2, −78 °C, 2 h; then $CH_3NH_2{\cdot}HCl$ (4 equiv), $NaBH_3CN$, MeOH, room temperature, 4 h. (d) $ClCO_2CHClCH_3$ (1 equiv), $ClCH_2CH_2Cl$, reflux, 3 h. (e) HMDS (3 equiv), $ISiMe_3$ (2 equiv), CH_2Cl_2/pentane (1:1), −20 °C, 6 h. (f) PhSeCl (1 equiv), $(PhSe)_2$ (1 equiv), THF, −35 °C, 90 min. (g) O_3 (1 equiv), CH_2Cl_2, −78 °C, 3 min; then iPr_2NH (1 equiv), 15 min. (h) MeOH, reflux, 3 h. (i) Methyl vinyl ketone (1.1 equiv), Et_3N (1.1 equiv), MeOH, room temperature, 1 h, 45 min. (j) (*R*)-α-methylbenzylamine (2 equiv), 3-Å molecular sieves, THF, room temperature, 4 days; then aqueous AcOH (20%), room temperature, 4 h. (k) $(HSCH_2)_2$ (8 equiv), AcOH, $BF_3{\cdot}Et_2O$ (5 equiv), room temperature, 24 h. (l) Bu_3SnH (15 equiv), AIBN, benzene, 80 °C, 16 h. (m) LDA (2.1 equiv), HMPA (5 equiv), THF, −78 °C, 30 min; then $CNCO_2Me$, room temperature, 3 h. (n) HgO (2 equiv), $BF_3{\cdot}Et_2O$ (4 equiv), H_2O/THF, room temperature, 30 min. (o) H_2, Pd/C, HCl (1 equiv), MeOH, room temperature. (p) $NaBH_4$ (2 equiv), MeOH, room temperature, 3 h.

Starting from the multigram available octahydroindolone **1**,[6] formation of the corresponding chloroethyl carbamate,[8] followed by selenation at the ketone α-position via a silyl enol ether and further oxidation, gave the enone **2** in 50% yield from **1**. Deprotection of the pyrrolidine nitrogen of **2** gave a secondary amine, which was treated with methyl vinyl ketone to provide the alkylated hexahydroindolone **3** in 74% yield. Base-catalyzed cyclization of **3** gave (67%) a 4:1 mixture of **4**, having the natural relative stereochemistry, and its epimer at C-20. The latter was transformed into **4** by treatment with KF/MeOH. Tricyclic ketone

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(5) (a) Isolation: Goodson, J. A. *J. Chem. Soc.* **1932**, 2626. (b) Constitution: Djerassi, C.; Nakagawa, Y.; Budzikiewicz, H.; Wilson, J. M.; LeMen, J.; Poisson, J.; Janot, M.-M. *Tetrahedron Lett.* **1962**, 653. (c) Configuration: Zèches, M.; Ravao, T.; Richard, B.; Massiot, G.; LeMen-Olivier, L.; Guilhem, J.; Pascard, C. *Tetrahedron Lett.* **1984**, *25*, 659.

(6) Solé, D.; Bonjoch, J. *Tetrahedron Lett.* **1991**, *32*, 5183. The minor trans isomer could be converted to the cis isomer by treatment of the corresponding *N*-oxide with TFAA and further $NaCNBH_3$ reduction of the resulting iminium salt.

(7) For an approach to the pentacyclic *Strychnos* framework by elaboration of the indolenine nucleus in the last step, see ref 1d. For a previous unsuccessful approach by Fischer indolization, see: Bonjoch, J.; Casamitjana, N.; Quirante, J.; Rodriguez, M.; Bosch, J. *J. Org. Chem.* **1987**, *52*, 267.

(8) All new compounds were characterized by IR, ^1H NMR, ^{13}C NMR, HRMS, and/or microanalysis.

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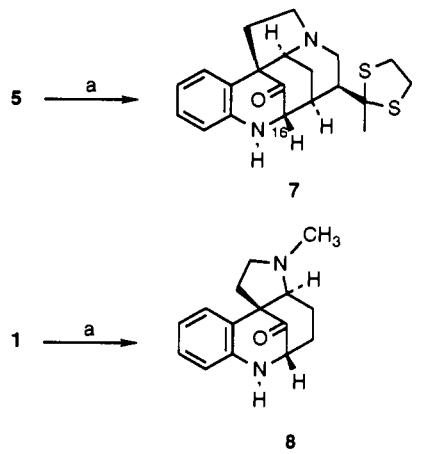
Scheme II[a]



[a] (a) $CH(NMe_2)_3$ (5 equiv), THF, reflux, 5 h.

4 was converted into dithioacetal **5** (80%), which was then treated with Bu_3SnH to give the alkaloid tubifolidine (50%)[9] in a single step involving desulfurization and simultaneous closure of the indoline ring by reduction of the α-(*o*-nitrophenyl) ketone moiety.[10]

Methoxycarbonylation of the key azatricyclic intermediate **5** rendered the corresponding β-keto ester (50%), with recovery of all the unreacted starting material. Deprotection of the C-19 carbonyl group (85%) followed by catalytic hydrogenation in the presence of 1 equiv of acid[11] furnished the pentacyclic compound **6** (75%). Finally, $NaBH_4$ reduction of the acetyl side chain took place diastereoselectively to give the alkaloid echitamidine (80%). The ^1H NMR and ^{13}C NMR spectra of synthetic (±)-echitamidine were identical with those reported for the natural product.[5c,12]

Surprisingly, attempts to introduce a formyl substituent at C-16 in compound **5** using $CH(NMe_2)_3$[13] in THF led to the pentacyclic tetrahydroquinoline **7** (72%) (Scheme II). This unprecedented reductive cyclization implies that the amidinium cation generated by loss of a dimethylamide anion from $CH(NMe_2)_3$ acts as a reducing instead of a formylating agent (tetramethylurea was isolated)[14] to give an intermediate nitroso derivative.[15] Intramolecular nucleophilic attack of the enolate at C-16 to the nitroso group, followed by further reduction, would lead to **7**. The scope of this new reaction seems to be quite general as, under the same reaction conditions, nitro ketone **1** provided (92%) the bridged tetrahydroquinoline **8**.[16]

Acknowledgment. This work was supported by the DGICYT (Projects PB88-0316 and PB91-0800).

Supplementary Material Available: NMR spectra of the synthesized compounds and HRMS of compounds **7** and **8** (29 pages). Ordering information is given on any current masthead page.

(9) This synthetic compound was identical with tubifolidine previously synthesized by a different procedure.[1a]

(10) In contrast, aliphatic nitro groups suffer a reductive cleavage by Bu_3SnH. For a review, see: Ono, N.; Kaji, A. *Synthesis* **1986**, 693.

(11) Hydrogenation under basic (Li_2CO_3) or neutral conditions afforded the corresponding carbinolamine, whereas in the presence of an excess of acid partial epimerization at C-20 was observed.

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(13) For a review of the chemistry of tris(dimethylamino)methane and related formamide acetals, see: Abdulla, R. F.; Brinkmeyer, R. S. *Tetrahedron* **1979**, *35*, 1675.

(14) We thank a reviewer for this suggestion and Prof. Julio Delgado (University of La Laguna) for helpful discussion regarding the structures of **7** and **8**.

(15) For a related reduction of a nitro group, see: Dickinson, W. B. *J. Am. Chem. Soc.* **1964**, *86*, 3580.

(16) For the NMR analysis of aspernomine, a fungal metabolite with a similar bridged tetrahydroquinoline moiety, see: Staub, G. M.; Gloer, J. B.; Wicklow, D. T.; Dowd, P. F. *J. Am. Chem. Soc.* **1992**, *114*, 1015.

The First Stable Stannanethione in Solution Derived from a Kinetically Stabilized Diarylstannylene

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The chemistry of double-bond compounds between group 14 metals and heavier chalcogen atoms has continued to occupy the attention of chemists in various fields. Although there have been some examples of silanethione,[1] silaneselone,[1] and germanethiones[2] stabilized by taking advantage of electronic stabilization, stannanethiones, i.e., a tin analogue of thioketones, such as $t\text{-}Bu_2Sn{=}S$ and $Ph_2Sn{=}S$ are known only as transient species, undergoing ready oligomerization to give the corresponding dimer and trimer, respectively.[3,4] We report herein the synthesis of diarylstannanethione Tb(Tip)Sn=S (**1a**, Tip = 2,4,6-triisopropylphenyl), the first stable stannanethione in solution at room temperature, via kinetically stabilized diarylstannylene Tb(Tip)Sn: (**2a**) by taking advantage of an excellent steric protection group, 2,4,6-tris[bis(trimethylsilyl)methyl]phenyl (denoted as Tb hereafter),[5] which was developed in the course of our study on the sterically congested molecules.

Stannylene **2a** was readily obtained by the treatment of a THF solution of TbLi with an ether suspension of stannous chloride (1.0 equiv) at −78 °C for 2 h followed by the addition of a THF solution of an equimolar amount of TipLi at the same temperature.[6] Under inert atmosphere, stannylene **2a** was found to be quite stable even at 60 °C, and it showed a deep purple color (λ_{max} = 561 nm) after the solvent exchange into hexane. ^{119}Sn NMR spectra of **2a** in toluene-d_8 showed only one signal at 2208 ppm, attributable to the chemical shift of a divalent organotin compound.[7] The formation of **2a**, which was also confirmed by the trapping experiments using 2,3-dimethyl-1,3-butadiene and benzil giving the expected [1 + 4] adducts **3**[6] and **4**[6] (37 and 22%) as shown in Scheme I, is of great interest since it represents a monomeric diarylstannylene stable without any intramolecular coordination by heteroatoms.[8] The remarkable stability of this sterically protected stannylene **2a** prompted us to examine its sulfurization, which is expected to lead to the formation of stable stannanethione **1a**.

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(6) Experimental details for the formation of **1a**, **2a**, and **7** and the physical properties of **3–9** are described in the supplementary material.

(7) The bandwidth and the chemical shift of **2a** were almost unchanged between −30 and 60 °C in toluene-d_8, indicating the absence of a monomer–dimer equilibrium in this temperature range. Recently, Kira et al. reported the synthesis of a stable, monomeric dialkylstannylene, 2,2,5,5-tetrakis(trimethylsilyl)-1-stannacyclopentane-1,1-diyl, the ^{119}Sn NMR spectrum of which showed a sharp singlet at 2323 ppm without any temperature dependence: Kira, M.; Yauchibara, R.; Hirano, R.; Kabuto, C.; Sakurai, H. *J. Am. Chem. Soc.* **1991**, *113*, 7785. Bis[bis(trimethylsilyl)methyl]stannylene has been reported to show δ_{Sn} at 2315 (toluene-d_8, 375 K): Zilm, K. W.; Lawless, G. A.; Merrill, R. M.; Millar, J. M.; Webb, G. G. *J. Am. Chem. Soc.* **1987**, *109*, 7236. See also Cotton, J. D.; Davidson, P. J.; Lappert, M. F. *J. Chem. Soc., Dalton Trans.* **1976**, 2275.

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