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Novel Routes to Indoles, Indolines, Quinolines and Tetrahydroquinolines from *N*-(Cyclohexylidene)amines

Norbert De Kimpe* and Marian Keppens

Department of Organic Chemistry, Faculty of Agricultural and Applied Biological Sciences, University of Gent, Coupure Links 653, B-9000 Gent, Belgium

Abstract : Cyclohexanones have been converted into a variety of bicyclic azaheterocycles of different oxidation level *via* a sequence of reactions involving (a) imination, (b) α-alkylation with N,N-disilyl-protected ω-bromoamines, (c) transimination, (d) α-chlorination of the resulting bicyclic imines and (e) dehydrochlorination and/or dehydrogenation. Appropriate choice of the reaction conditions selectively led the reactions to indoles, 7-chloroindoles, 7-chloroindolines, 4,5,6,7-tetrahydroindoles, 8-chloro-1,2,3,4-tetrahydroquinolines, 8-chloroquinolines or quinolines.

INTRODUCTION

Indoles, quinolines and their tetrahydro derivatives are very important compounds as they occur in a large number of natural products and display a variety of physiological activities.[1,2] Many simple indole derivatives have been found to have antimicrobial or fungistatic activity,[1] while 7-halogenated indoles have been used as drug intermediates[3] and as precursor of 7-substituted indole alkaloids.[4] On the other hand, 1,2,3,4-tetrahydroquinoline derivatives are useful synthetic intermediates for drugs,[5] agrochemicals[6] and dyes.[7]

The construction of these skeletons by annelation of a pyrrole or pyridine moiety onto a cyclohexanone derivative is very attractive because of the ready availability of the latter, allowing the introduction of substituents of choice. Cyclic imines are accessible in a straightforward way from aldehydes or ketones *via* imination, subsequent α-alkylation with 1-(ω-bromoalkyl)-2,2,5,5-tetramethyl-1-aza-2,5-disilacyclopentanes[8] and following transimination.[9] In the present report, this synthetic methodology is applied to cyclohexanones to give bicyclic imines, which are selectively converted *via* chlorination, dehydrochlorination or dehydrogenation processes into a large variety of functionalized indole and quinoline derivatives.

RESULTS AND DISCUSSION

Cyclohexanone (**1a**) and 4-methylcyclohexanone (**1b**) were converted into the corresponding N-isopropyl imines **2a,b** by reaction with isopropylamine (4 equiv.) in the presence of titanium(IV) chloride (0.6 equiv.). Deprotonation of *N*-(cyclohexylidene)amines **2** with lithium diisopropylamide in THF at 0°C and subsequent reaction of the resulting 1-azaallylic anions with 1-(2-bromoethyl)-2,2,5,5-tetramethyl-1-aza-2,5-disilacyclopentane[8] gave the corresponding α-alkylated imines, which underwent N-deprotection with potassium carbo-

nate in methanol under reflux. The transient γ-amino imines underwent spontaneous intramolecular transimination to afford 3,3a,4,5,6,7-hexahydro-2*H*-indoles **3** in 76-77% yield.

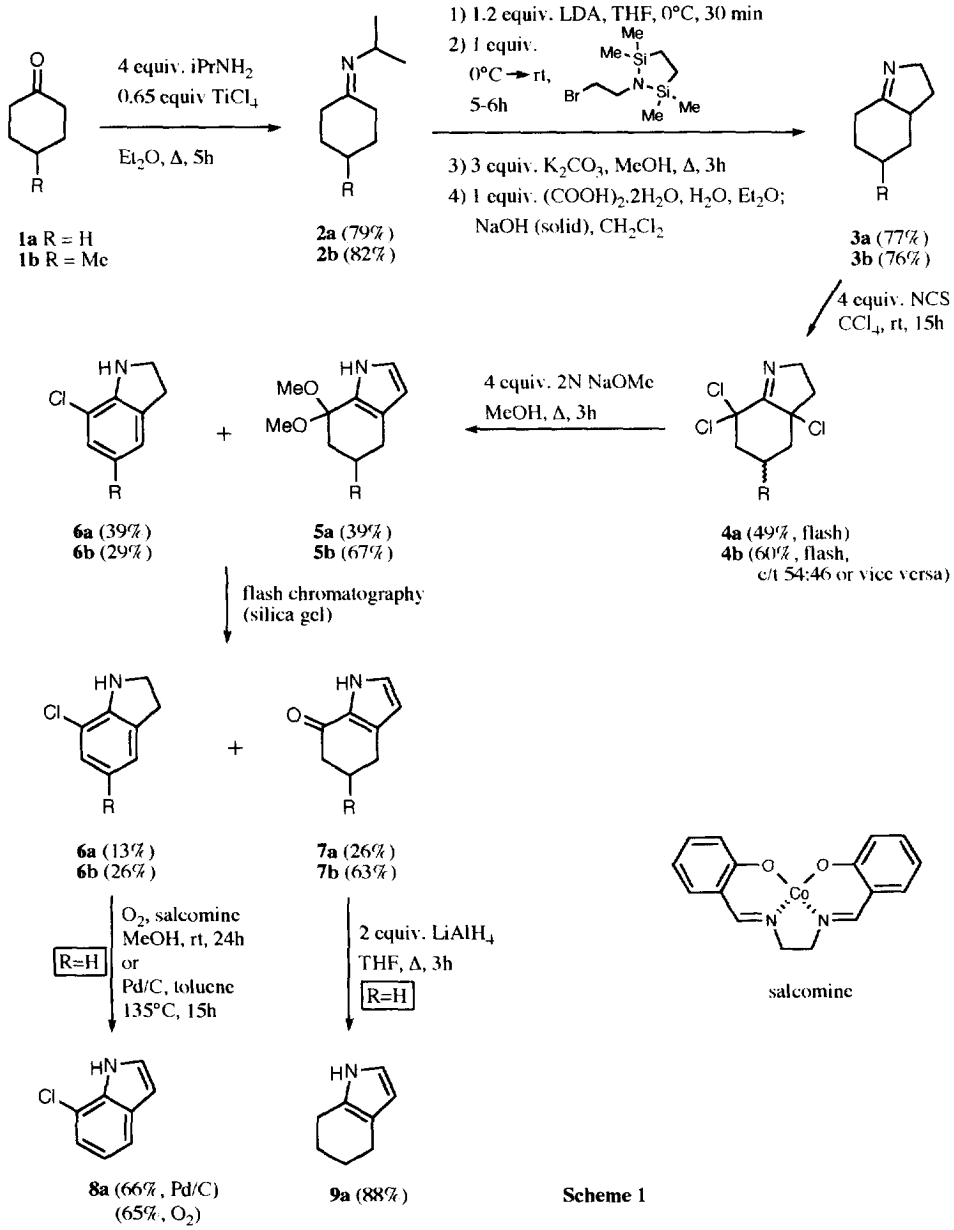
It proved to be advantageous to treat the reaction mixture with aqueous oxalic acid in a biphase system water diethyl ether in order to remove the organosilicon side product [$MeOSi(Me_2)CH_2CH_2Si(Me_2)OMe$] from the acidic extract. Basification with sodium hydroxide regenerated the bicyclic ketimines **3**, which are stable compounds (contrary to 2,3,4,4a,5,6,7,8-octahydroquinolines **11**; *vide infra*). Bicyclic ketimines **3** were smoothly α,α,α'-trichlorinated with excess of N-chlorosuccinimide in CCl_4 at room temperature to afford 3a,7,7-trichloro-3,3a,4,5,6,7-hexahydro-2*H*-indoles **4** in 49-60% yield after purification. Compound **4b** consisted of a mixture of *cis*- and *trans*-isomers in a 54:46 ratio (or *vice versa*). These trichlorinated bicyclic imines **4** were converted into indolines and tetrahydroindoles by reaction with base (Scheme 1).

Reaction of 3a,7,7-trichloro-3,3a,4,5,6,7-hexahydro-2*H*-indoles **4** with excess 2N sodium methoxide in methanol under reflux for 3h gave rise to either aromatization of the azaheterocyclic moiety or aromatization of the six-membered carbocyclic part. Under these conditions, compound **4a** afforded a 1:1 mixture of 7,7-dimethoxy-4,5,6,7-tetrahydroindole (**5a**) and 7-chloroindoline (**6a**) (combined yield 78%). Upon flash chro-matography, acetal **5a** was converted into the ketone, i.e. 7-oxo-4,5,6,7-tetrahydroindole (**7a**), which was cleanly separated from 7-chloroindoline (**6a**). On the other hand, the *cis*- and *trans*-4-methyl-bicyclic imine **4b** reacted with excess 2N sodium methoxide in methanol (reflux 3h) to afford a 7:3 mixture of acetal **5b** and indoline **6b** (combined yield 96%). This mixture led to 26% 7-chloro-5-methylindoline (**6b**) and 63% 7-oxo-5-methyl-4,5,6,7-tetrahydroindole (**7b**) after flash chromatography.

7-Oxo-4,5,6,7-tetrahydroindole (**7a**) was converted in good yield into 4,5,6,7-tetrahydroindole (**9a**) with lithium aluminium hydride in tetrahydrofuran under reflux for 3 h. Oxidation of indoline **6a** into 7-chloroindole (**8a**) was accomplished using either oxygen in methanol in the presence of salcomine (N,N'-bis(salicylidene)ethylenediaminocobalt (II))[4] at room temperature or palladium on carbon (10%) in toluene at 135°C for 15h. Not unexpectedly, 7-chloro-5-methylindoline (**6b**) did not give a straightforward oxidation with palladium on carbon in toluene or xylene under reflux for 3 days, as it resulted in the desired 7-chloro-5-methylindole (**8b**) and the dehalogenated 5-methylindole (**10b**) in a 4:1 ratio with toluene as solvent, and in a 3:2 ratio with o-xylene as solvent (Scheme 2). Both indoles **8b** and **10b** were separated by flash chromatography. A similar reaction with palladium on carbon has recently been reported in the literature. In the latter report, the hydrobromide salts of several substituted indolines were converted into the corresponding indole derivatives by reaction with palladium on carbon in aqueous alkaline solution in the presence of disodium fumarate.[10] The direct conversion of bicyclic imine **3b** into 5-methylindole (**10b**) with palladium on carbon in o-xylene for 2 days under reflux proceeded in poor yield giving the pure indole in only 17% after flash chromatography (Scheme 2). The dehydrochlorination of trichloroimine **4a** with several bases under a variety of conditions led only to degradation products (selected reaction conditions : KOt-Bu, t-BuOH, reflux; K_2CO_3, DMSO, 90°C; NaOEt, EtOH, reflux; DBU, benzene, reflux; Et_3N, chlorobenzene, reflux), while the reaction with palladium on carbon in benzene (reflux 3 h) gave complete recovery of starting material. Also heating of compound **4a** in chlorobenzene or 1,2-dichlorobenzene under reflux did not form cleanly aromatization products.

In order to have access to functionalized quinolines and its derivatives, *N*-(cyclohexylidene)amines **2** were deprotonated with LDA, subsequently reacted with 1-(3-bromopropyl)-2,2,5,5-tetramethyl-1-aza-2,5-

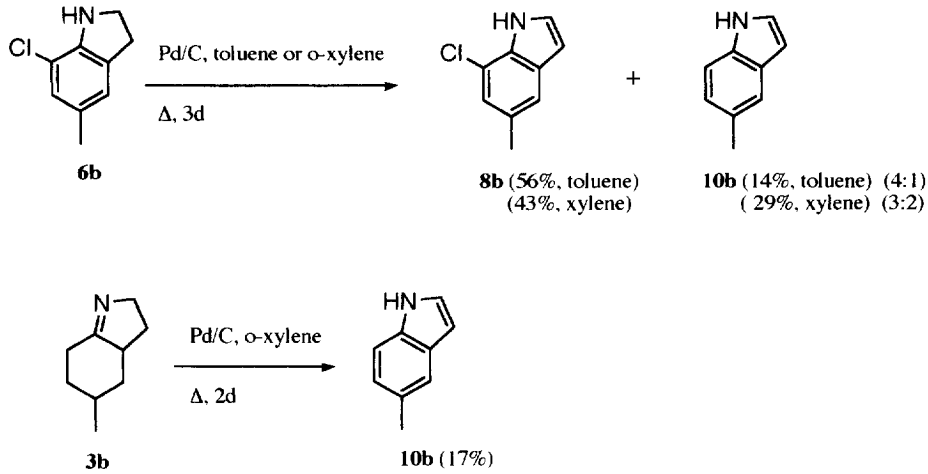
disilacyclopentane,[8] and N-desilylated with potassium carbonate in methanol to give a transient δ-amino imine which underwent transimination to afford 2,3,4,4a,5,6,7,8-octahydroquinolines **11** in 74-78% yield. The bicyclic imine **11a** proved to be very sensitive to oxygen as, on standing at room temperature, it was



Scheme 1

spontaneously oxygenated at the α-position to produce the hydroxy derivative **12a**,[11-13] which was already present for 10% in the initial reaction mixture. Compound **11a** could not be purified by flash chromatography on silica gel as it was completely α-hydroxylated during the chromatography (isolated yield of **12a** : 28%).

Vacuum distillation gave access to the bicyclic imine **11a** in low yield (24%). Therefore, the crude **11a** was used as such in the next chlorination step. Reaction of crude **11a**, i.e. containing 10% of α-hydroxy imine **12a**, with excess (4 equiv.) N-chlorosuccinimide in CCl_4 at room temperature for 15h furnished a reaction



Scheme 2

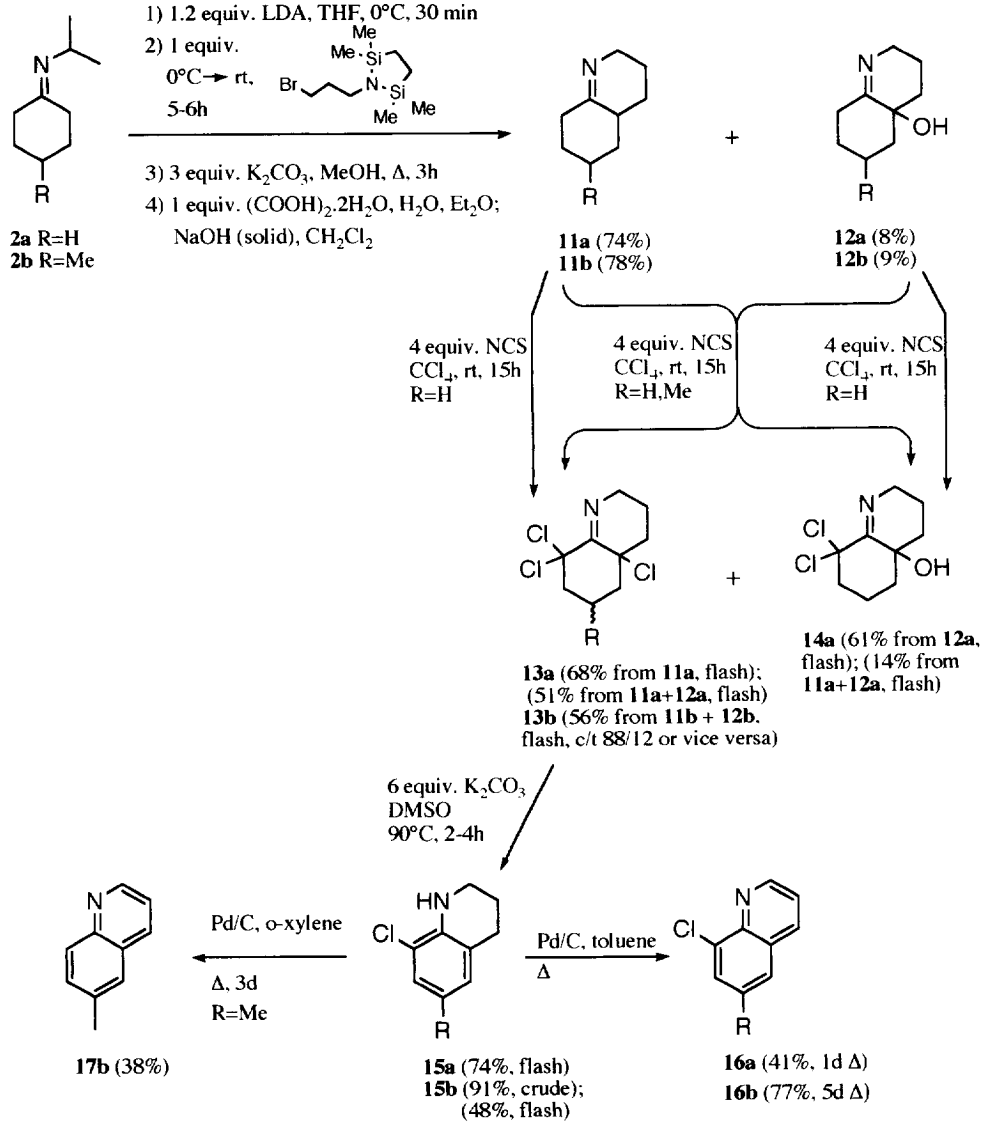
mixture containing mainly trichlorinated imine **13a** and about 20% α,α-dichloro-α'-hydroxy imine **14a**. The α-hydroxylation apparently went on during the α-chlorination process. Compounds **13a** and **14a** were separated by flash chromatography, yielding 51% of pure and stable trichlorinated imine **13a** and 14% of pure α,α-dichloro-α'-hydroxy imine **14a** (Scheme 3). The purified compounds **11a** and **12a** were also reacted, each separately, with excess N-chlorosuccinimide under the same reaction conditions as described above, affording 68% of trichloroimine **13a** and 61% of dichloroimine **14a**, respectively, after purification by flash chromatography.

In similar way, but without taking much notice of the presence of α-hydroxy imine **12b** (10% contamination of imine **11b**), the synthesis and purification of trichlorinated imine **13b** was accomplished in 56% isolated yield. This compound consisted of a mixture of *cis*- and *trans*-isomers (ratio 88:12 or vice versa), which were not separated.

Trichlorinated bicyclic imines **13** were selectively converted into 1,2,3,4-tetrahydroquinolines **15** by reaction with excess potassium carbonate in dimethyl sulfoxide at 90°C for 2-4 h. No trace of any pyridine or quinoline derivative was observed, pointing to a selective dehydrochlorination process. Again here, bicyclic compound **13a** afforded only degradation products on reaction with potassium t-butoxide, or did not give any reaction on treatment with palladium on carbon in benzene under reflux.

Surprisingly, 4a,8,8-trichloro-2,3,4,4a,5,6,7,8-octahydroquinoline (**14a**) is an extremely stable compound, which was left untouched on treatment with excess 2N sodium methoxide in methanol under reflux, or mesyl chloride in pyridine under reflux, or potassium carbonate in DMSO at 90°C, or p-toluenesulfonic acid in benzene at room temperature for 16h. However, it decomposes with potassium t-butoxide in THF under reflux to a mixture of unidentified compounds.

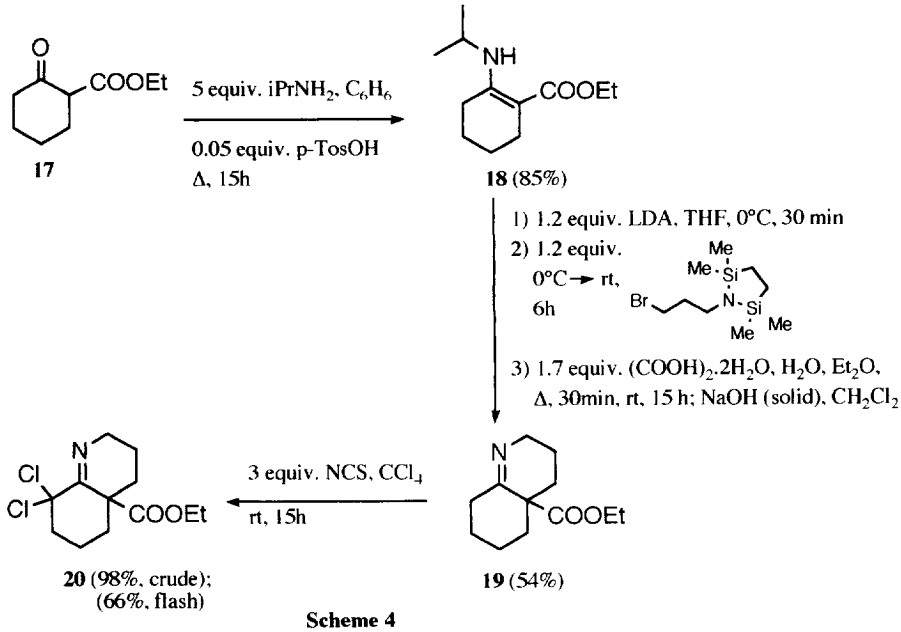
8-Chloro-1,2,3,4-tetrahydroquinoline (**15a**) was cleanly converted into 8-chloroquinoline (**16a**) on treatment with palladium on carbon in toluene under gentle reflux for one day. The 6-methyl analogue **15b** underwent a similar oxidation into 8-chloro-6-methylquinoline (**16b**) (77%) under analogous reaction conditions (5 days reflux in toluene), but afforded the dechlorinated quinoline **16b** upon reflux for three days in o-xylene (Scheme 3).



Scheme 3

Finally, the use of ethyl 8,8-dichloro-2,3,4,4a,5,6,7,8-octahydroquinolyl-5-carboxylate (**20**) in the synthesis of azaheterocycles was verified. Compound **20** was synthesized from β-keto ester **17** *via* enamino ester

18. The alkylation of the latter compound with 1-(3-bromopropyl)-2,2,5,5-tetramethyl-1-aza-2,5-disilacyclopentane was executed as described above, except that aqueous oxalic acid was used in the N-deprotection and transimination step because the standard procedure utilizing potassium carbonate in methanol led to mixtures of ethyl and methyl esters by transesterification. Bicyclic compound **19** has also recently been synthesized



Scheme 4

via an alkyl azide radical cyclization.[14] The dichlorination of bicyclic imine **19** with excess N-chlorosuccinimide was executed in nearly quantitative yield. Ethyl 8,8-dichloro-2,3,4,4a,5,6,7,8-octahydroquinolyl-5-carboxylate (**20**) remained stable upon treatment with bases (selected reaction conditions : 4-6 equivalents of 2N NaOMe in MeOH, 4-20h reflux; 6 equivalents of K_2CO_3 in DMSO, 4h reflux).

EXPERIMENTAL

Melting points (mp, uncorrected) : Büchi 535 melting point determinator. TLC : Merck silicagel 60 F254, layer thickness 0.25 mm. Flash chromatography : Merck silicagel 60, particle size 40-63 μm. IR spectra : Perkin Elmer 1310 spectrometer. Mass spectra (MS) : Varian MAT 112 mass spectrometer (70 eV) with GC-MS coupling, unless otherwise stated. ^{1}H- and ^{13}C-NMR spectra : JEOL JNM-EX270 NMR spectrometer (270 MHz for ^{1}H-NMR, 68 MHz for ^{13}C-NMR). The DEPT sequence and 2D H-C correlation spectroscopy was used for the ^{13}C-NMR assignments. Dry solvents : dichloromethane and tetrachloromethane were dried over calciumhydride; ether was dried and distilled from sodium wire, while tetrahydrofuran (THF) was dried and distilled from sodium benzophenone ketyl.

Preparation of *N*-(cyclohexylidene)amines **2**[15]. The imination of cyclohexanones **1** with isopropylamine and titanium(IV) chloride was performed according to an earlier literature report.[15] The reaction conditions

applied for the syntheses of imines **2** as well as the yields after distillation are given in Scheme 1.

General Procedure for the Preparation of 3,3a,4,5,6,7-hexahydro-2*H*-indoles **3** and 2,3,4,4a,5,6,7,8-octahydroquinolines **11**. To a stirred, cooled (0°C) solution of diisopropylamine (1.3 equivalents) in dry THF (10% w/v) was added n-BuLi (2.5 M solution in hexane; 1.2 equivalents) under a nitrogen atmosphere. A solution of one equivalent of *N*-(cyclohexylidene)amine **2** in THF was then added slowly *via* a syringe. The reaction mixture was subsequently stirred at 0°C for 30 minutes, after which a solution of one equivalent of 1-(ω-bromoalkyl)-2,2,5,5-tetramethyl-1-aza-2,5-disilacyclopentane[8] in THF was added. Stirring was continued for a period of 5-6h, during which the mixture warmed up to room temperature. The solution was poured into a 0.5 N aqueous solution of NaOH and extracted three times with ether. After drying of the organic layers and evaporation of the solvent, the residue was dissolved in methanol (10% w/v), and after adding 3 equivalents of K_2CO_3, the resulting suspension was stirred under gentle reflux for 3h. The reaction mixture was poured into water and extracted with dichloromethane. The organic layers were dried, the solvents evaporated, and the residue was dissolved in ether (10% w/v). After addition of a 10% (w/v) aqueous solution of oxalic acid dihydrate (one equivalent), the two layer system thus formed was shaken thoroughly in a separatory funnel, and the aqueous phase was isolated. After washing this phase two times more with ether, dichloromethane was added and solid NaOH pellets were added until alkaline. The two layer system was shaken thoroughly and the organic layer was isolated. After extraction of the aqueous phase with dichloromethane two times more, the combined organic layers were dried. Evaporation of the solvent afforded the crude bicyclic imines **3** and **11**.

3,3a,4,5,6,7-Hexahydro-2*H*-indole (3a). Yield : 77%. The crude bicyclic imine **3a** (purity 97%; GC, ^{1}H- and ^{13}C-NMR) was purified by flash chromatography (CH_2Cl_2 : MeOH 96:4; Rf 0.23). MS m/z (%) : 123 (M^+, 92); 122 (50); 96(24); 95(100); 94(33); 67(42); 55(56); 41(30). IR (NaCl) : 1650 cm^{-1} (C=N). ^{1}H-NMR ($CDCl_3$) : δ 1.0-2.7 (11H, m, $(CH_2)_4CHCH_2$); 3.4-3.9 (2H, m, CH_2N). ^{13}C-NMR ($CDCl_3$) : δ 25.39, 26.76, 29.70, 31.81 and 34.64 (each CH_2); 48.01 (CH); 59.01 (NCH_2); 179.66 (C=N).

5-Methyl-3,3a,4,5,6,7-hexahydro-2*H*-indole (3b). Yield : 76%. The crude material (purity 96%; GC, ^{1}H and ^{13}C-NMR) was purified by flash chromatography (CH_2Cl_2 : MeOH 95:5; Rf 0.27). MS m/z (%) : 137 (M^+, 77); 122 (36); 109(41); 95(77); 94(32); 81(34); 67(45); 55(100); 41(45). IR (NaCl) : 1653 cm^{-1} (C=N). ^{1}H-NMR ($CDCl_3$) : δ 0.95 (3H, d, J=6.6 Hz, Me); 1.1-1.5, 1.6-2.3 and 2.6-2.7 (10H, m); 3.6-3.7 and 3.8-4.0 (2H, m, NCH_2). ^{13}C-NMR ($CDCl_3$) : δ 22.35 (Me); 30.40 and 31.71 (each CH_2); 32.45 (CHMe); 35.63 and 43.55 (each CH_2); 48.31 (CHC=N); 60.03 (NCH_2); 180.19 (C=N).

2,3,4,4a,5,6,7,8-Octahydroquinoline (11a). The crude residue consisted of 90% **11a** (yield 74%) and 10% 2,3,4,4a,5,6,7,8-octahydroquinoline-4a-ol (**12a**) (yield 8%). Bicyclic imine **11a** could be purified by distillation (yield 24%). Bp. 22-25°C/0.04 mmHg (Lit.[16] bp. 35-40°C/0.2 mmHg). IR (NaCl) : 1659 cm^{-1} (C=N). ^{1}H-NMR ($CDCl_3$) : δ 1.2-2.4 (12H, m); 3.3-3.6 (2H, m, NCH_2). ^{13}C-NMR ($CDCl_3$) : δ 21.33, 25.91, 27.46, 27.89 and 34.95 (each CH_2); 38.71 (CH); 39.23 (CH_2); 49.54 (NCH_2); 173.73 (C=N).

2,3,4,4a,5,6,7,8-Octahydroquinoline-4a-ol (12a). 1-Hydroxyimine **12a** was isolated from the crude reaction mixture by flash chromatography (CH_2Cl_2 : MeOH 13:2; Rf 0.23; Yield 28%). Mp. 110°C (Lit.[16] mp. 115-115,5°C). MS m/z (%) : 153 (M^+, 100); 136(75); 125(50); 97(42); 96(44); 83(40); 68(59); 67(40); 58(90); 55(48); 44(43); 43(65); 41(85). IR (NaCl) : 3000-3600 (OH); 1655 cm^{-1} (C=N). ^{1}H-NMR ($CDCl_3$) : δ 1.4-

2.0 (10H, m); 2.1-2.3 and 2.5-2.8 (2H, m, $CH_2C=N$); 2.8-3.7 (3H, m, CH_2N and OH). ^{13}C-NMR ($CDCl_3$) : δ 19.34, 21.08, 27.28, 35.15, 36.62 and 40.77 (each CH_2); 49.65 (NCH_2); 67.49 (O-Cquat); 173.31 (C=N).

6-Methyl-2,3,4,4a,5,6,7,8-octahydroquinoline (11b). The crude residue consisted mainly of bicyclic imine **11b** (yield 78%), contaminated with 10% of hydroxy imine **12b** (yield 9%). The pure bicyclic imine **11b** could be obtained by vacuum distillation. Bp. 29°C/0,04 mmHg. IR (NaCl) : 1657 cm^{-1} (C=N). ^{1}H-NMR ($CDCl_3$) : δ 0.95 (3H, d, J=6.0 Hz, Me); 1.0-2.5 (12H, m); 3.4-3.8 (2H, m, NCH_2). ^{13}C-NMR ($CDCl_3$) : δ 21.42 (CH_2); 21.83 (Me); 27.92 (CH_2); 32.27 (CH); 35.69 (CH_2); 37.74 (CH); 38.78 and 43.36 (each CH_2); 49.69 (NCH_2); 172.67 (C=N).

Preparation of Ethyl 2-(Isopropylamino)-1-cyclohexene-1-carboxylate (**18**). β-Enamino ester **18** was synthesized following an analogous procedure described in the literature.[16] To a solution of 5.10 g (30 mmol) of β-keto ester **17** in 100 mL of benzene was added 8.85 g (150 mmol) of isopropylamine and 0.29 g (1.5 mmol) of p-toluenesulfonic acid. The flask was equipped with a Dean Stark apparatus, and the reaction mixture was stirred under gentle reflux for 20h. In order to avoid amide formation, the temperature of the oil bath was kept below 100°C. After evaporation of the solvent, the residue was dissolved in 100 mL of ether and dried with $MgSO_4$. After filtration and evaporation, the crude β-enamino ester was distilled, which yielded 5.40 g of pure β-enamino ester **18** (yield 85%). Bp. 68-75°C/0.04 mmHg.

Ethyl 2-(Isopropylamino)-1-cyclohexene-1-carboxylate (18). MS m/z (%) : 211 (M^+, 38); 196(19); 182(13); 168(28); 166(25); 164(27); 150(100); 138(57); 122(26); 96(22); 94(14); 81(21); 79(14); 67(14); 58(17); 41(23). IR (NaCl) : 3200-3300 (NH); 1645 (C=O); 1594 cm^{-1} (C=C). ^{1}H-NMR ($CDCl_3$) : δ 1.18 (3H, d, J=6.6 Hz, Me); 1.19 (3H, d, J=6.3 Hz, Me); 1.26 and 1.27 (each 3H, each t, each J=7.10 Hz, each $OCH_2\underline{CH_3}$); 1.5-1.7 (4H, m, $(CH_2)_2$); 2.27 (2H, t, J=5.94 Hz, $CH_2C=$); 2.35 (2H, t, J=6.1 Hz, $CH_2C=$); 3.6-3.75 (1H, m, NHC$\underline{H}$); 4.11 and 4.12 (each 2H, each q, each J=7.10 Hz, each OCH_2); 8.92 (1H, broad d, J=7.59 Hz, NH). ^{13}C-NMR ($CDCl_3$) : δ 14.74 ($OCH_2\underline{C}H_3$); 22.43, 22.82 and 23.86 (each CH_2); 24.42 (Me_2); 26.25 (CH_2); 43.20 (CHNH); 58.54 (OCH_2); 89.06 ($\underline{C}_{quat}$-COOEt); 158.72 (=C-NH); 170.92 ($\underline{C}$OOEt).

Synthesis of Ethyl 2,3,4,4a,5,6,7,8-Octahydroquinolyl-5-carboxylate (**19**). The alkylation of ethyl 2-(isopropylamino)cyclohex-1-ene-1-carboxylate (**18**) with 1-(3-bromopropyl)-2,2,5,5-tetramethyl-1-aza-2,5-disilacyclopentane[13] was executed as described above for the syntheses of bicyclic imines **11**. The alkylating reagent was added in a slight excess (1.2 equivalents) in order to obtain complete alkylation. In the following N-deprotection step, aqueous oxalic acid was used instead of the usual methanolysis. The residue obtained after alkylation was therefore dissolved in ether (10% w/v), and an aqueous 10% (w/v) solution of oxalic acid dihydrate (1.7 equivalents) was added. The resulting two layer system was refluxed for 30 minutes under vigourous stirring, after which it was stirred at room temperature for 15h. The aqueous layer was isolated, washed two times more with ether, and was subsequently basified with sodium hydroxide pellets. The resulting aqueous phase was extracted three times with dichloromethane, after which the combined dichloromethane layers were dried. Evaporation of the solvent afforded bicyclic imine **19** (purity 98%; GC, ^{1}H- and ^{13}C-NMR) in 54% yield.

Ethyl 2,3,4,4a,5,6,7,8-Octahydroquinolyl-5-carboxylate (19). Bicyclic imine **19** was purified by flash chromatography (CH_2Cl_2 : MeOH 9:1; Rf 0.39). MS m/z (%) : 209 (M^+, 7); 137(15); 136(100); 108(8); 68(9); 67(14); 55(10); 49(7); 44(12); 41(17). IR (NaCl) : 1720 (C=O); 1654 cm^{-1} (C=N). ^{1}H-NMR ($CDCl_3$) : δ 1.27 (3H, t, J=7.26 Hz, Me); 1.4-2.0 and 2.3-2.4 (12H, m); 3.4-3.7 (2H, m, CH_2N); 4.21 (2H, q, J=7.26 Hz, OCH_2). ^{13}C-NMR ($CDCl_3$) : δ 14.25 (Me); 19.32, 23.41, 27.22, 33.44, 38.10 and 38.22 (each CH_2); 49.38 (C-COOEt); 49.47 (NCH_2); 61.06 (OCH_2); 169.38 (C=N); 174.19 (COOEt).

General Procedure for the Preparation of Chlorinated Bicyclic Imines **4**, **13**, **14a** and **20**. To a stirred, cooled (0°C) solution of bicyclic imine (**3**, **11**, **12a** or **19**; 1 equivalent) in dry CCl_4 was added, portionwise, N-chlorosuccinimide (4 equivalents for imines **3**, **11** and **12a**; 3 equivalents for imine **19**). The resulting suspension was stirred at room temperature for 15h, after which stirring was stopped and the mixture was cooled to 0°C. Succinimide was filtered off and washed twice with cold CCl_4 (0°C). Evaporation of the filtrate afforded the crude chlorinated imines (**4**, **13**, **14a** or **20**). The latter imines were purified by flash chromatography in order to eliminate all traces of residual succinimide, present in the crude reaction mixture (5-10%).

3a,7,7-Trichloro-3,3a,4,5,6,7-hexahydro-2*H*-indole (4a). Yield after flash chromatography : 49% (hexane : EtOAc; 7:3; Rf 0.30). Mp. 69°C. MS m/z (%) : 225/27/29/31 (M^+, 24); 190/2/4(100); 154/6(67); 127 (14); 119(13); 118(33); 93(12); 91(27); 89(13); 65(14); 53(15); 41(15). IR (KBr) : 1630 cm^{-1} (C=N). ^{1}H-NMR ($CDCl_3$) : δ 1.8-3.0 (8H, m); 3.98 (1H, dxdxd, J_1=16.50 Hz, J_2=9.24 Hz, J_3=5.94 Hz, CH_AH_BN); 4.20 (1H, dxd, J_1=16.50 Hz, J_2=7.76 Hz, CH_AH_BN). ^{13}C-NMR ($CDCl_3$) : δ 20.13, 40.90, 44.85, 48.10 and 57.09 (each CH_2); 73.26 and 82.28 (each $C_{quat.}$); 171.44 (C=N). Anal. calcd. for $C_8H_{10}Cl_3N$: Cl, 46.95; N, 6.18. Found : Cl, 46.83; N, 6.07.

3a,7,7-Trichloro-5-methyl-3,3a,4,5,6,7-hexahydro-2*H*-indole (4b) c/t. Yield after flash chromatography : 60% (hexane : EtOAc 4:1; Rf_1 0.25, Rf_2 0.21). *Isomer with higher Rf (Rf_1 0.25)* : MS m/z (%) : direct inlet : 239/41/3/5 (M^+, 31); 204/6/8(100); 168/70(82); 132(68); 117(24); 107(17); 105(18); 91(26); 89(30); 81(20); 79(19); 77(28); 65(28); 63(19); 55(24); 53(51); 51(24); 41(39). IR (NaCl) : 1638 cm^{-1} (C=N). ^{1}H-NMR ($CDCl_3$) : δ 1.20 (3H, d, J=6.60 Hz, Me); 2.0-2.2 (3H, m, CHMe, CH_2 and $CH_AH_{A'}$); 2.59 (1H, dxd, J_1=14.19 Hz, J_2=5.45 Hz, $CH_BH_{B'}$); 2.72 (1H, dxd, J_1=14.19 Hz, J_2=4.45 Hz, $CH_BH_{B'}$); 2.96 (1H, dxd, J_1=14.51 Hz, J_2=10.89 Hz, $CH_AH_{A'}$); 4.06 (1H, dxdxd, J_1=16.49 Hz, J_2=8.91 Hz, J_3=5.28 Hz, $NCH_CH_{C'}$); 4.19 (1H, dxd, J_1=16.49 Hz, J_2=7.59 Hz, $NCH_CH_{C'}$). ^{13}C-NMR ($CDCl_3$) : δ 21.74 (Me); 25.77 (CHMe); 42.86, 44.87 and 49.52 (each CH_2); 58.06 (NCH_2); 73.51 (CClC=N); 80.16 (CCl_2); 173.98 (C=N). *Isomer with lower Rf (Rf_2 0.21)* : mp. 48.5-50°C. MS m/z (%) : 239/41/3/5 (M^+, 29); 204/6/8 (100); 169/71(18); 168/70 (77); 132(53); 117(21); 107(18); 105(16); 91(19); 89(25); 81(17); 79(16); 77(21); 65(21); 55(18); 53(39); 51(18); 41(28). IR (KBr) : 1630 cm^{-1} (C=N). ^{1}H-NMR ($CDCl_3$) : δ 1.07 (3H, d, J=6.60 Hz, Me); 1.54 (1H, dxd, J_1=14.52 Hz, J_2=11.88 Hz, $CH_AH_{A'}$); 2.1-2.3 (2H, m, $CH_BH_{B'}$ and $CH_CH_{C'}$); 2.5-2.7 (3H, m, $CH_AH_{A'}$, CHMe and $CH_CH_{C'}$); 2.85 (1H, dxt, J_1=14.19 Hz, J_2=2.64 Hz, $CH_BH_{B'}$); 4.00 (1H, dxdxd, J_1= 16.49 Hz, J_2=9.23 Hz, J_3=5.61 Hz, $NCH_DH_{D'}$); 4.22 (1H, dxd, J_1=16.49 Hz, J_2=7.58 Hz, $NCH_DH_{D'}$). ^{13}C-NMR ($CDCl_3$) : δ 19.93 (Me); 26.67 (CHMe); 44.98, 48.86, 55.83 and 57.39 (each CH_2); 73.01 (CClC=N); 81.62 (CCl_2); 171.26 (C=N). *Cis*:*trans* ratio 54:46 (or *vice versa*). Anal. calcd. for $C_9H_{12}Cl_3N$: Cl, 44.22. Found : Cl, 44.34.

4a,8,8-Trichloro-2,3,4,4a,5,6,7,8-octahydroquinoline (13a). Yield after flash chromatography : 68% (CH_2Cl_2 : MeOH 96:4; Rf 0.78). Mp. 114-116°C. MS m/z (%) : 239/41/3/5 (M^+, 21); 204/6/8(100); 176/8/80(16); 168/70(78); 132(14); 105(10); 99(17); 79(12); 77(22); 75(13); 69(11); 67(14); 65(14); 59(14); 58(12); 56(15); 53(17); 51(21); 45(12); 43(34); 41(34). IR (KBr) : 1650 cm^{-1} (C=N). ^{1}H-NMR ($CDCl_3$) : δ 1.6-2.6 and 2.9-3.1 (10H, m); 3.81 (1H, dxdxd, J_1=19.80 Hz, J_2=11.55 Hz, J_3=5.94 Hz, $NC\underline{H}_AH_{A'}$); 4.22 (1H, dxd, J_1=19.80 Hz, J_2=5.94 Hz, $NCH_A\underline{H}_{A'}$). ^{13}C-NMR ($CDCl_3$) : δ 18.01, 18.51, 37.97, 40.58, 47.22 and 50.55 (each CH_2); 61.47 and 87.65 (each $C_{quat.}$); 162.21 (C=N). Anal. Calcd. for $C_9H_{12}Cl_3N$: Cl, 44.22; N, 5.82. Found : Cl, 44.40; N, 5.72.

4a,8,8-Trichloro-6-methyl-2,2,4,4a,5,6,7,8-octahydroquinoline (13b) (c/t). Yield after flash chromatography : 56% (CH_2Cl_2 : MeOH 99:1; Rf 0.66). Mp. (c/t) 108.5-109.5°C. MS m/z (%) : 253/5/7/9 (M^+, 13); 218/20/2(79); 182/4(100); 146(42); 91(28); 77(41); 67(35); 65(35); 55(30); 53(42); 44(87); 41(91). IR (KBr) : 1642 cm^{-1} (C=N). ^{1}H-NMR ($CDCl_3$) : δ 1.05 (3H, d, J=6.93 Hz, Me of major isomer); 1.24 (3H, d, J=6.60 Hz, Me of minor isomer); 1.53 (1H, dxd, J_1=14.69 Hz, J_2=11.72 Hz, $C\underline{H}_AH_{A'}$); 1.5-2.4 and 2.6-3.0 (8H, m); 3.83 (1H, dxdxd, J_1=19.80 Hz, J_2=11.55 Hz, J_2=5.94 Hz, $NC\underline{H}_BH_{B'}$); 4.23 (1H, dxd, J_1=19.80 Hz, J_2=5.94 Hz, $NCH_B\underline{H}_{B'}$). ^{13}C-NMR ($CDCl_3$) : δ *major isomer* : 17.77 (CH_2); 20.20 (Me); 24.98 (<u>C</u>HMe); 38.04, 50.03 and 50.62 (each CH_2); 56.19 (NCH_2); 60.66 (C-Cl); 87.60 (CCl_2); 161.45 (C=N); δ *minor isomer* : 17.68 (CH_2); 22.57 (Me); 24.22 (<u>C</u>HMe); 37.21, 41.26 and 48.01 (each CH_2); 50.22 (NCH_2); 60.75 (C-Cl); 85.70 (CCl_2); 164.76 (C=N). *Cis:trans* ratio 88:12 (or *vice versa*). Anal. Calcd. for $C_{10}H_{14}Cl_3N$: Cl, 41.78. Found : Cl, 41.67.

8,8-Dichloro-2,3,4,4a,5,6,7,8-octahydroquinoline-4a-ol (14a). Yield after flash chromatography : 61% (hexane : EtOAc 3:2; Rf 0.28). Mp. 61-63°C. MS m/z (%) : 221/3/5 (M^+, 17); 186/8(30); 185/7(20); 168 (70); 158 (39); 150(31); 132(30); 130(20); 97(27); 80(24); 77(26); 69(22); 67(29); 57(26); 56(28); 55(71); 53(33); 44(100); 43(53); 42(53); 41(100). IR (NaCl) : 3100-3600 (OH); 1640 cm^{-1} (C=N). ^{1}H-NMR ($CDCl_3$) : δ 1.4-2.5 (8H, m); 2.8-3.0 (2H, m, CH_2CCl_2); 3.67 (1H, dxdxd, J_1=19.14 Hz, J_2=11.55 Hz, J_3=5.28 Hz, $NC\underline{H}_AH_{A'}$); 4.13 (1H, dxd broad, J_1=19.14 Hz, J_2=5.28 Hz, $NCH_A\underline{H}_{A'}$); OH invisible. ^{13}C-NMR ($CDCl_3$) : δ 18.04, 18.36, 35.79, 39.57, 48.32 and 51.21 (each CH_2); 68.32 (C-OH); 90.46 (CCl_2); 163.88 (C=N). Anal. Calcd. for $C_9H_{13}Cl_2NO$: N, 6.31. Found : N, 6.19.

Ethyl 8,8-Dichloro-2,3,4,4a,5,6,7,8-octahydroquinolyl-5-carboxylate (20). Yield after flash chromatography : 66% (hexane : EtOAc 4:1, Rf 0.23). MS m/z (%) : 277/9/81 (M^+, 2); 242/4(8); 241/3(9); 168/70 (100); 140(5); 134(12); 132(12); 79(7); 77(8); 68(6); 67(6); 54(5); 53(5); 44(8); 41(13). IR (NaCl) : 1729 (C=O); 1660 cm^{-1} (C=N). ^{1}H-NMR ($CDCl_3$) : δ 1.20 (3H, t, J=7.26 Hz, Me); 1.3-2.4 (8H, m); 2.42 (1H, dxm, J=13.86 Hz, $C\underline{H}_AH_{A'}CCl_2$); 2.70 (1H, dxm, J=13.86 Hz, $CH_A\underline{H}_{A'}CCl_2$); 3.6-3.8 (1H, m, $NC\underline{H}_BH_{B'}$); 3.9-4.2 (3H, m, $NCH_B\underline{H}_{B'}$ and $OC\underline{H}_2$). ^{13}C-NMR ($CDCl_3$) : δ 13.98 (Me); 18.40, 20.20, 34.36, 35.87, 48.09 and 49.79 (each CH_2); 47.03 (C_{quat}); 61.40 (OCH_2); 90.96 (<u>C</u>Cl_2); 161.74 (C=N); 172.23 (<u>C</u>OOEt). Anal. Calcd. for $C_{12}H_{17}Cl_2NO_2$: Cl, 25.49; N, 5.04. Found : Cl, 25.41; N, 5.10.

<u>Reaction of Trichloroimines **4** with Sodium Methoxide in Methanol</u>. As a typical procedure the reaction of trichloroimine **4a** with NaOMe in methanol is described. 4 ML (8 mmol) of a 2N solution of NaOMe in methanol was added dropwise to 0.45 g (2 mmol) of 3a,7,7-trichloro-3,3a,4,5,6,7-hexahydro-2*H*-indole (**4a**). The resulting solution was stirred under reflux for 3h, after which the mixture was poured into 20 mL of water and extracted three times with 5 mL of dichloromethane. The extracts were dried, and evaporation

of the solvent afforded 0.26 g of a 1:1 mixture of 7,7-dimethoxy-4,5,6,7-tetrahydroindole (**5a**) and 7-chloroindoline (**6a**) (combined yield 78%). Without full characterization of the intermediate dimethoxy compound **5a**, the crude reaction mixture was subjected to flash chromatography, which led to the isolation of 40 mg of 7-chloroindoline (**6a**) and 70 mg of 7-oxo-4,5,6,7-tetrahydroindole (**7a**). The reaction of trichloroimine **4b** with NaOMe in methanol was performed in a completely similar way, leading to a 7:3 reaction mixture of compounds **5b** and **6b**, respectively, in a combined crude yield of 96%. Flash chromatography of the latter reaction mixture afforded the pure bicyclic compounds **6b** and **7b**.

7-Chloroindoline (6a). Yield after flash chromatography : 13% (hexane : EtOAc 4:1; Rf 0.51). MS m/z (%) : 153/5 (M^+, 79); 152/4(92); 151(14); 118(24); 117(100); 116(15); 91(10); 90(14); 89(27); 63(17); 58 (40); 44(10). IR (NaCl) : ν_{max} : 3120-3420 (NH); 1606; 1467; 1130; 755 cm^{-1}. ^{1}H-NMR ($CDCl_3$) : δ 3.09 (2H, t, J=8.58 Hz, CH_2); 3.60 (2H, t, J=8.58 Hz, NCH_2); 6.61 (1H, t, J=7.75 Hz, C<u>H</u>=CH-CCl); 6.9-7.0 (2H, m, C<u>H</u>=CH-C<u>H</u>=CCl); NH invisible. ^{13}C-NMR ($CDCl_3$) : δ 30.55 (CH_2); 47.08 (NCH_2); 114.90 (C_{quat}); 119.26, 122.77 and 126.97 (each CH=); 130.80 and 148.64 (each C_{quat}). The ^{1}H-NMR and IR spectral data were in complete accordance with literature data.[4]

7-Oxo-4,5,6,7-tetrahydroindole (7a). Yield after flash chromatography : 26% (hexane : EtOAc 4:1; Rf 0.18). Mp. 97°C (Lit.[17] mp. 95°C). MS m/z (%) : 135 (M^+, 100); 120(12); 118(12); 107(42); 106(16); 93(30); 80(14); 79(95); 77(11); 53(16); 52(34); 51(19). IR (KBr) : 3100-3350 (NH); 1623 cm^{-1} (C=O). ^{1}H-NMR ($CDCl_3$) : δ 2.12 (2H, pent., J=6.11 Hz, CH_2); 2.77 and 2.51 (each 2H, each t, each J=6.11 Hz, CH_2C=O and CH_2C=C); 6.11 (1H, ~t, CH=); 7.03 (1H, t, J=2.64 Hz, =C<u>H</u>-NH); 9.97 (1H, broad s, NH). ^{13}C-NMR ($CDCl_3$) : δ 23.31, 25.28 and 37.75 (each CH_2); 108.61 and 125.71 (each CH=); 128.08 and 137.34 (each=C_{quat}); 188.86 (C=O).

7-Chloro-5-methylindoline (6b). Yield after flash chromatography : 29% (hexane : EtOAc 4:1; Rf 0.41). MS m/z (%) : 167/9 (M^+, 100); 166/8(92); 132(26); 131(83); 130(55); 77(19); 64(37); 51(22); 44(79). IR (NaCl) : ν_{max} : 3150-3440 (NH); 2910; 2850; 1582; 1488; 1472; 1323; 1260; 1106; 850 cm^{-1}. ^{1}H-NMR ($CDCl_3$) : δ 2.22 (3H, s, Me); 3.06 (2H, t, J=8.25 Hz, C<u>H</u>$_2$$CH_2$N); 3.59 (2H, t, J=8.25 Hz; CH_2C<u>H</u>$_2$N); 6.82-6.83 (2H, m, =CH's); NH invisible. ^{13}C-NMR9X($CDCl_3$)δ 20.58 (Me); 30.64 (CH_2); 47.26 (NCH_2); 114.91 (C_{quat}); 123.75 and 127.11 (each =CH); 129.45 and 131.18 (each =C_{quat}); 145.91 (=C_{quat} Cl). Anal. Calcd. for $C_9H_{10}ClN$: N, 8.36. Found : N, 8.47.

5-Methyl-7-oxo-4,5,6,7-tetrahydroindole (7b). Yield after flash chromatography : 63% (hexane : EtOAc 4:1; Rf 0.15). Mp. 142.5°C. MS m/z (%) : 149 (M^+, 84); 134(10); 132(10); 107(52); 106(16); 80(36); 79(90); 53(13); 52(24); 51(12); 44(100); 42(15). IR (KBr) : ν_{max} : 3220; 1630; 1404; 1121; 1048; 778 cm^{-1}. ^{1}H-NMR ($CDCl_3$) : δ 1.13 (3H, d, J=4.95 Hz, Me); 2.2-2.9 (5H, m, C<u>H</u>$_2$C<u>H</u>MeC<u>H</u>$_2$); 6.07 (1H, broad s, C<u>H</u>=CHN); 7.07 (1H, t, J=2.64 Hz, NCH=); 10.92 (1H, broad s, NH). ^{13}C-NMR ($CDCl_3$) : δ 21.35 (Me); 31.75 (CH_2); 33.19 (CH); 46.04 (<u>C</u>H_2C=O); 108.43 (=CH); 126.63 (NCH=); 127.80 and 137.32 (each=C_{quat}); 188.68 (C=O). Anal. Calcd. for $C_9H_{11}NO$: C, 72.46; H, 7.43; N, 9.39. Found : C, 72.31; H, 7.49; N, 9.45.

<u>Synthesis of 4,5,6,7-Tetrahydroindole (9a)</u>. To a stirred, cooled (0°C) solution of 0.20 g (1.5 mmol) 7-oxo-4,5,6,7-tetrahydroindole (**7a**) in 3 mL of dry THF was added 0.11 g (3 mmol) of lithium aluminium hydride. After stirring of the resulting suspension under reflux for 3h, 0.17 g of water was added very slowly under

vigourous stirring at 0°C. The slurry thus formed was filtered, washed twice with THF, and the filtrate was dried. Evaporation of the solvent afforded 0.18 g of 4,5,6,7-tetrahydroindole (**9a**) (yield 88%; purity 96%; ^{1}H- and ^{13}C-NMR). Flash chromatography yielded the pure compound **9a** (hexane : EtOAc 95:5; Rf 0.12).

4,5,6,7-Tetrahydroindole (9a). MS m/z (%) : 121 (M^+, 51); 120(15); 118(8); 117(5); 103(5); 93(100); 91 (7); 80(8); 77(6); 66(6); 65(8); 58(7); 53(5); 52(6); 51(6); 44(16). IR (NaCl) : ν_{max} : 3360; 2910; 2838; 1442; 1313; 1087; 711 cm^{-1}. ^{1}H-NMR ($CDCl_3$) : δ 1.6-1.8 (4H, m, $(CH_2)_2$); 2.4-2.5 (4H, m, 2xCH_2C=); 5.89 (1H, t, J=2.64 Hz, C<u>H</u>=CHN); 6.50 (1H, t, J=2.64 Hz, =CH-N); 7.4-7.6 (1H, broad s, NH). ^{13}C-NMR ($CDCl_3$) : δ 22.66, 22.81, 23.38 and 23.78 (each CH_2); 107.22 (d, J=4.8 Hz, HC=); 115.54 (d, J=4.8 Hz, NCH=); 116.69 and 126.79 (each =C_{quat}). The ^{1}H-NMR and IR spectral data were consistent with literature data.[18]

<u>Preparation of 1,2,3,4-Tetrahydroquinolines **15**</u>. To a solution of trichlorinated bicyclic imine **13** (1 equivalent) in dimethyl sulfoxide (5% w/v) was added K_2CO_3 (6 equivalents). The suspension was stirred at 90°C for a period of 2-4h, after which it was poured into water and extracted three times with ether. After drying of the organic layers and evaporation of the solvent, the crude 1,2,3,4-tetrahydroquinolines **15** were obtained, which were purified by flash chromatography.

8-Chloro-1,2,3,4-tetrahydroquinoline (15a). Yield after flash chromatography : 74% (hexane : EtOAc 95:5; Rf 0.37). MS m/z (%) : 167/9 (M^+, 95); 166/8(100); 132(36); 131(52); 130(50); 117(28); 77(30); 65(35); 64(43); 51(28); 44(23). IR (NaCl) : ν_{max} : 3400-3420 (NH); 1600; 1498; 1355; 1299 cm^{-1}. ^{1}H-NMR ($CDCl_3$) : δ 2.00 (2H, ~pent., J=5.94 Hz, CH_2); 2.84 (2H, t, J=6.27 Hz, CH_2C=); 3.45 (2H, txd, J_1=5.45 Hz, J_2=2.31 Hz, CH_2N); 4.01 (1H, broad s, NH); 6.57 (1H, t, J=7.59 Hz, =C<u>H</u>-CH=C_{quat}); 6.91 (1H, d, J=7.25 Hz, CH=C_{quat}); 7.12 (1H, dxt, J_1=7.92 Hz, J_2=0.66 Hz, CH=C_{quat}). ^{13}C-NMR ($CDCl_3$) : δ 21.62 (CH_2); 27.19 (CH_2C=); 41.78 (CH_2N); 116.24 (CH=); 118.02 and 122.60 (each =C_{quat}); 126.75 and 127.64 (each H<u>C</u>=C_{quat}); 140.70 (=CCl). Lit.[19] bp. 95-110°C.

8-Chloro-6-methyl-1,2,3,4-tetrahydroquinoline (15b). Yield after flash chromatography : 48% (hexane : MeOH 99:1; Rf 0.19). MS m/z (%) : 181/3 (M^+, 100); 180/2(74); 146(22); 145(32); 144(35); 131(23); 130(16); 115(9); 91(13); 89(15); 77(9); 71(29); 65(14); 58(11); 51(11); 44(36). IR (NaCl) : ν_{max} : 3380-3430 (NH); 2918; 2835; 1500; 1322; 1298; 1188. ^{1}H-NMR ($CDCl_3$) : δ 2.03 (2H, ~pent., J=5.61 Hz, CH_2); 2.29 (3H, s, Me); 2.85 (2H, t, J=6.27 Hz, CH_2C=); 3.46 (2H, t, J=5.61 Hz, NCH_2); 4.2 (1H, broad s, NH); 6.79 and 7.00 (each 1H, each broad s, each =CH). ^{13}C-NMR ($CDCl_3$) : δ 20.13 (Me); 21.94 and 27.19 (each CH_2); 41.89 (NCH_2); 117.91, 122.55 and 125.71 (each =C_{quat}); 127.04 and 128.41 (each CH=); 138.36 (=C_{quat} Cl). Anal. Calcd. for $C_{10}H_{12}ClN$: N, 7.71. Found : N, 7.79.

<u>General Procedure for the Reaction of Azabicyclic Compounds **3b**, **6**, **13** and **15** with Palladium on Carbon (Pd/C)</u>. To a solution of azabicyclic compound (**3b**, **6**, **13** or **15**) in toluene or xylene (10% w/v) was added a catalytic amount of palladium, 10% on carbon. This suspension was stirred under very gentle reflux for several days. The exact reaction conditions (solvent, reaction period) are given in schemes 1, 2 and 3. The warm reaction mixture was filtered and washed two times with dichloromethane, after which the solvents of the filtrate were evaporated. The resulting residue was analyzed by ^{1}H- and ^{13}C-NMR spectrometry, and purified by flash chromatography.

7-Chloroindole (8a). Yield after flash chromatography : 66% (CH_2Cl_2 : hexane 1:1; Rf 0.48). This compound was also synthesized utilizing a methodology reported in the literature[4] by bubbling a stream of oxygen through a methanolic solution of **6a** containing a catalytic amount of salcomine (yield after flash chromatography 65%). MS m/z (%) : 151/3 (M^+, 100); 124/6(12); 116(24); 115(20); 114(8); 89(29); 88(10); 75(17); 63(15); 62(11); 57(10). IR (NaCl) : ν_{max} : 3395-3400 (NH); 1900; 1705; 1617; 1663; 1486; 1432; 1330; 1190; 1140; 1063; 938; 781; 721. ^{1}H-NMR ($CDCl_3$) : δ 6.51 (dxd, J_1=3.14 Hz, J_2=2.15 Hz, HC_5=); 6.94-7.00 and 7.10-7.17 (3H, m, HC_3=, HC_4= and HC_6=); 7.47 (1H, d, J=7.92 Hz, NCH=); 8.27 (1H, broad s, NH). ^{13}C-NMR ($CDCl_3$) : δ 103.65 (HC=); 116.55 (=C_{quat}); 119.32, 120.54 and 121.29 (each =CH); 129.25 and 133.12 (each =C_{quat}). The ^{1}H-NMR spectra were consistent with reported literature data.[4]

7-Chloro-5-methylindole (8b). Crude yield : 56% (toluene) - 43% (xylene). Indole **8b** was separated from the dehalogenated compound **10b** by flash chromatography (CH_2Cl_2 : hexane 1:4; Rf 0.24). MS m/z (%) : 165/7 (M^+, 100); 164/6(59); 130(96); 128(16); 102(13); 101(16); 77(13); 64(13); 51(16). IR (NaCl) : ν_{max} : 3350-3500 (NH); 1568; 1332; 1321; 867; 842; 722 cm^{-1}. ^{1}H-NMR ($CDCl_3$) : δ 2.39 (3H, s, Me); 6.46 (1H, t, J=2.64 Hz, C<u>H</u>=CHN); 7.02 (1H, broad s, C<u>H</u>=CMe); 7.10 (1H, t, J=2.64 Hz, CH=C<u>H</u>N); 8.12 (1H, broad s, NH). ^{13}C-NMR ($CDCl_3$) : δ 21.20 (Me); 103.05 (CH=); 116.03 (=C_{quat}); 119.03, 122.77 and 124.87 (each HC=); 129.41, 130.22 and 131.43 (each =C_{quat}). Lit.[20] bp. 130-134°C/14 mmHg.

5-Methylindole (10b). Crude yield from **6b** : 14% (toluene) - 29% (xylene); from **3b** : 17% (xylene). Indole **10b** was isolated by flash chromatography (CH_2Cl_2 : hexane 1:4; Rf 0.12). Mp. 58.3-60.2°C (Lit.[21] mp. 58.5°C). MS m/z (%) : 131 (M^+, 88); 130(100); 103(12); 102(6); 77(16); 65(6); 64(6); 52(5); 51(8). IR (NaCl) : ν_{max} : 3250-3500 (NH); 1578; 1415; 1321; 1093; 802 cm^{-1}. ^{1}H-NMR ($CDCl_3$) : δ 2.43 (3H, s, Me); 6.42 (1H, broad s, C<u>H</u>=CHN); 6.97-7.05 (2H, m, CH=C<u>H</u>N and CH=C<u>H</u>-C_{quat} Me); 7.17 (1H, d, J=8.25 Hz, C<u>H</u>=CH-C_{quat} Me); 7.41 (1H, broad s, =C<u>H</u> C_{quat} Me); 7.83 (1H, broad s, NH). ^{13}C-NMR ($CDCl_3$) : 21.40 (Me); 101.89, 110.69, 120.27, 123.52 and 124.27 (each =CH); 128.05, 128.89 and 134.03 (each =C_{quat}).

8-Chloroquinoline (16a). Crude yield : 41% (toluene). 8-Chloroquinoline (**16a**) was purified by flash chromatography (CH_2Cl_2 : hexane 4:1; Rf 0.19). MS m/z (%) : 163/5 (M^+, 100); 136/8(9); 128(30); 127(13); 101(13); 75(13); 74(9); 68(11); 51(9); 50(12); 44(51). IR (NaCl) : ν_{max} : 1593; 1490; 1459; 1380; 1304; 1209; 1062; 980; 823; 784 cm^{-1}. ^{1}H-NMR ($CDCl_3$) : δ 7.4-7.5 (2H, m, =C_3H and =C_6H); 7.77 (1H, dxd, J_1=8.25 Hz, J_2=0.99 Hz, =C_4H); 7.86 (1H, dxd, J_1=7.59 Hz, J_2=1.32 Hz, =C_7H); 8.21 (1H, dxd, J_1=8.25 Hz, J_2=1.65 Hz, =C_3H); 9.07 (1H, dxd, J_1=4.29 Hz, J_2=1.65 Hz, =C_2H). ^{13}C-NMR ($CDCl_3$) : δ 121.91, 126.49, 126.95, 129.54 and 129.58 (each =CH); 133.42 (=C_{quat}); 136.51 (=CH); 144.42 (=C_{quat} N); 151.00 (NCH=). Lit.[19] bp. 110°C/1 mmHg.

8-Chloro-6-methylquinoline (16b). Crude yield : 77% (toluene). Quinoline **16b** was purified by flash chromatography (hexane : EtOAc 7:3; Rf 0.29). MS m/z (%) : 177/9 (M^+, 1); 143(100); 142(54); 141(10); 140 (5); 117(5); 116(7); 115(17); 114(4); 89(7); 72(7); 71(6); 63(6); 59(9); 58(4); 51(4). IR (NaCl) : ν_{max} : 2910; 1592; 1484; 1360; 1322; 1262; 990; 917; 861; 782; 732 cm^{-1}. ^{1}H-NMR ($CDCl_3$) : δ 2.54 (3H, s, Me); 7.48 (1H, dxd, J_1=8.25 Hz, J_2=4.29 Hz, NCH=C<u>H</u>); 7.55 (1H, s, C<u>H</u>=CCl); 7.73 (1H, d, J=1.65 Hz, C_{quat}C<u>H</u>CMe); 8.15 (1H, dxd, J_1=8.24 Hz, J_2=1.65 Hz, NCHC<u>H</u>CH); 9.03 (1H, dxd, J_1=4.29 Hz, J_2=1.65 Hz, NC<u>H</u>). ^{13}C-NMR ($CDCl_3$) : δ 21.42 (Me); 121.94 and 125.91 (each =CH); 125.98, 128.53 and 129.58 (each =C_{quat}); 131.98 and 136.37 (each =CH); 137.03 (=C_{quat}); 149.95 (NCH=).

6-Methylquinoline (17b). Crude yield : 38%. 6-Methylquinoline (**17b**) was purified by flash chromatography (CH_2Cl_2 : hexane 9:1; Rf 0.19). MS m/z (%) : 143 (M^+, 100); 142(47); 115(29); 89(23); 71(20); 63 (20); 57(29); 55(18); 44(26); 43(39); 41(27). IR (NaCl) : ν_{max} : 1655; 1590; 1554; 1497; 1114; 828 cm^{-1}. ^{1}H-NMR ($CDCl_3$) : δ 2.54 (3H, s, Me); 7.36 (1H, dxd, J_1=8.25 Hz, J_2=4.29 Hz, $=C_3H$); 7.53-7.57 (2H, m, $=C_8H$ and $=C_4H$); 8.00 (1H, d, J=8.57 Hz, $=C_7H$); 8.07 (1H, d, J=8.25 Hz, $=C_4H$); 8.85 (1H, ~d, J=3.30 Hz, $NC_2H=$). ^{13}C-NMR ($CDCl_3$) : δ 21.58 (Me); 121.08, 126.59, 129.07, 131.77 and 135.42 (each CH=); 128.32; 136.40 and 146.84 (each $=C_{quat}$); 149.50 (CH=N). Lit.[21] bp. 240-257°C/760 mmHg.

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