Thioalkylation of Enolates, III[1]
Stereoselective Synthesis of Steroids and Related Compounds, II[2]

α-Thioalkylation of Zinc Dienolates to 4-Substituted 1-*tert*-Butoxy-7a-methyl-hexahydroinden-5-ones

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α-Alkylation of the α,β-unsaturated ketone **1** at C-4 has been achieved by thioalkylation of the corresponding zinc dienolate with α-chlorosulfides of type **2**. The desulfurization of the β-(phenylthio) ketones **4** leads directly to the 4-substituted hexahydroinden-5-ones **5**.

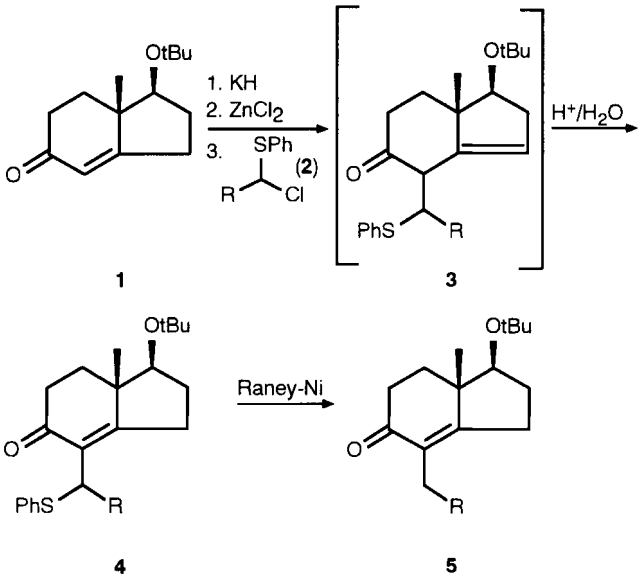
4-Substituted octahydroinden-5-ones and the corresponding hexahydroindene derivatives are important intermediates in the stereoselective synthesis of 19-norsteroids[3]. Moreover, they can serve as intermediates for the synthesis of 5,6,7,7a-tetrahydro-4*H*-indenes, which have been successfully employed as chiral templates in the asymmetric synthesis of allylic alcohols by Diels-Alder reaction, diastereoselective adduct transformation and retro Diels-Alder reaction sequence[4].

Recently, we reported the synthesis of enantiomerically pure estradiol-3-methyl-17-*tert*-butyl diether via the zinc chloride mediated thioalkylation[1] of an aluminium enolate, which was generated by a diastereoselective 1,4-reduction[2] of the Hajos-Wiechert ketone **1**[5].

Nevertheless, the 1,4-reduction of the α,β-unsaturated ketone **1** remains cumbersome since the toxic and carcinogenic HMPTA is still necessary for the activation of the 1,4-reducing agent. All attempts to replace HMPTA by other cosolvents like TMEDA or DMPU failed[2].

Therefore, the substituent at C-4 should be introduced prior to the hydrogenation of the C-3a–C-4 double bond. The hydrogenation of 4-substituted hexahydroinden-5-ones **5** can usually be achieved highly diastereoselectively[6,7]. Until now, a base-induced alkylation of the α,β-unsaturated ketone **1** affords the 4-substituted hexahydroinden-5-ones **5** in only moderate yields[7] due to the high basicity of the corresponding alkali dienolates[7b]. Moreover, the undesirable *O*-alkylation cannot be avoided[7a,c,e]. Usually, the *C*- and *O*-alkylated products are formed in a 3:1 ratio. Only the use of highly S_N2-reactive[8] electrophiles like α-bromoacetophenone affords the 4-substituted hexahydroinden-5-ones **5** in reasonable yields[9].

Consequently, we were interested in employing the thioalkylation method[1] for the preparation of 4-substituted hexahydroinden-5-ones **5**. This method allows the alkylation of zinc enolates under mild acidic conditions in a S_N1 fashion.

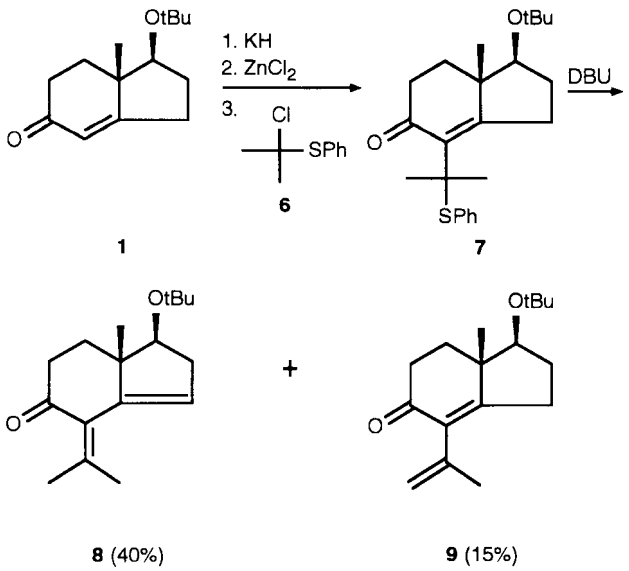


2 - 5	R	Yield of **5** (%, based on **1**)[a]
a	CH_3	76
b	C_2H_5	69
c	n-C_3H_7	77
d	n-C_5H_{11}	75

[a] In addition, 11-23 % of **1** could be recovered.

Deprotonation of the α,β-unsaturated ketone **1** was performed with potassium hydride. It turned out, that this reaction had to be carried out at room temp. over a period of 4 h in order to achieve complete formation of the potassium dienolate. At lower temperature the deprotonation was incomplete, whereas at higher reaction temperature considerable decomposition took place. The transmetalation to the

corresponding zinc dienolate was performed with 1.3 equivalents of zinc chloride at −50°C. The transmetalation was completed within 30 min. The excess of zinc chloride promotes the subsequent Lewis acid catalyzed thioalkylation. 1.1 Equivalents of the α-chlorosulfides **2** or **6** were added at −70°C and the reaction mixture was allowed to warm up slowly to room temp. According to TLC analysis the thioalkylation takes place at −30°C to −20°C. Exclusively α-thioalkylated compounds are formed. ^{1}H-NMR spectroscopical analysis of the crude product **3a** indicates that β,γ-unsaturated ketones **3** are formed initially. Moreover, there is no evidence for the formation of any *O*-alkylated product. Upon aqueous acidic work-up the double bond of these β,γ-unsaturated ketones **3** isomerized back into conjugation with the carbonyl group to afford the more stable α,β-unsaturated ketones **4**. These β-(phenylthio) ketones **4** turned out to be slightly sensitive towards silica gel. Only the β-(phenylthio) ketones **4a** and **c** were purified by silica gel chromatography to afford these compounds in 68 and 70% yield. Therefore, the crude β-(phenylthio) ketones **4** were directly submitted to reductive desulfurization with Raney nickel in order to obtain optimal yields of the 4-substituted hexahydroinden-5-ones **5**. This reaction was carried out by using moderately active Raney nickel[10] in the solvent acetone/ethanol (9:1)[11] to yield 69−77% of the 4-substituted hexahydroinden-5-ones **5** after chromatographical purification. In addition, the Hajos-Wiechert ketone **1**, the starting material of this synthesis, could be recovered in 11−23% yield. The use of other solvents like ethanol or acetone/water (9:1) for the reductive desulfurization leads to a partial reduction of the C-5 keto function.



The zinc dienolate of the α,β-unsaturated ketone **1** could also be thioalkylated with tertiary chlorosulfides such as **6** to afford the β-(phenylthio) ketone **7** in 67% yield. Upon reductive desulfurization with Raney nickel as described above, the corresponding 4-isopropyl-substituted hexahydroinden-5-one was isolated in only 9% yield. Predominantly the dienone **8** was formed by elimination of thiophenol. The formation of compound **8** could be optimized by treating the crude β-(phenylthio) ketone **7** with DBU. Besides 15% of the regioisomer **9** the dienone **8** was isolated in 40% yield.

By employing dienones like compound **8** or their corresponding C-1′ monosubstituted derivatives in steroid synthesis, the pharmaceutically important 7-mono- or 7-disubstituted 19-norsteroids should be available, since an 1,4-addition of benzyl magnesium bromides should afford the corresponding *seco* steroidal ketones, which should yield upon Friedel-Crafts cyclization the desired 7-substituted 19-norsteroids[2].

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Experimental

IR Spectra: Perkin-Elmer 298 spectrometer. − NMR Spectra: Varian XL 200 or a VXR 200 spectrometer for ^{1}H and ^{13}C NMR. Chemical shifts are given in parts per million (δ), tetramethylsilane was the internal standard. − Mass spectra: Varian MAT 731 or 311 A. − Optical rotations: Perkin-Elmer Mod. 141 polarimeter. − TLC Analyses: Polygram Sil G/UV$_{254}$ silica gel plates. Silica gel (0.030−0.060 mm) from Baker was used for flash chromatography. − Combustion analyses: Microanalytical laboratory of the University of Göttingen. − All reactions were carried out under argon except those involving desulfurization. All reagents were purified and dried if necessary before use. THF was freshly distilled from $LiAlH_4$ prior to use. CCl_4 was distilled from P_4O_{10}. The ethereal $ZnCl_2$ solution was purchased from Aldrich. The phenyl sulfides were prepared from the corresponding halides or mesylates with thiophenol and K_2CO_3 in acetone.

1-Chlorosulfides **2a−d** *and* **6**. − *General Procedure: N*-Chlorosuccinimide (1.47 g, 11 mmol) was added in a single portion to a stirred solution of the corresponding alkylphenyl sulfide (10 mmol) in CCl_4 (20 ml) at 2°C and stirring was continued at this temperature for 16 h. The succinimide was filtered off and the filtrate was concentrated in vacuo to afford the moisture-sensitive 1-chlorosulfides in almost quantitative yield. These chlorosulfides **2a−d** and **6** were used after drying in vacuo (0°C, 0.01 Torr) without further purification.

4-(Phenylthioalkyl)-hexahydro-5H-inden-5-ones **4**. − *General Procedure:* Potassium hydride (0.53 g of a 35% suspension in mineral oil, 4.6 mmol) was washed three times with pentane (10 ml each) and suspended in THF (20 ml). A solution of the α,β-unsaturated ketone **1** (0.88 g, 4.0 mmol) in THF (5 ml) was added at room temp. and stirring was continued for 4 h. A solution of zinc chloride in diethyl ether (1.0 M, 5.2 ml, 5.2 mmol) was slowly added at −50°C and stirring was continued for 30 min. The reaction mixture was cooled down to −78°C, a solution of the 1-chlorosulfide **2** or **6** (4.4 mmol) in THF (2 ml) was added and the solution was allowed to warm up to room temp. within 16 h. Diethyl ether (300 ml) was added and the organic layer extracted with a saturated aqueous NaCl solution (100 ml). The aqueous layer was reextracted with diethyl ether (100 ml), the combined organic layers were dried with $MgSO_4$ and the solvent was removed in vacuo (25°C/12 Torr). The residue (the crude products **4a−d** and **7**) were used directly for the desulfurization to the ketones **5a−d** and for the elimination of

7 to the α,β-unsaturated ketones **8/9**. In two cases the crude products **4a** and **c** were purified by chromatography on silica gel.

(1S,1'RS,7aS)-1-tert-Butoxy-7a-methyl-4-[1'-(phenylthio)-ethyl]-1,2,3,6,7,7a-hexahydro-5H-inden-5-one (**4a**): 1-Chloroethyl phenyl sulfide (**2a**) (1.57 g, 9.1 mmol, 91% yield) was prepared from *N*-chlorosuccinimide (1.47 g, 11 mmol) and ethyl phenyl sulfide (1.38 g, 10 mmol). According to the general procedure, potassium hydride (0.34 g, 8.5 mmol), the hexahydro-indenone **1** (1.11 g, 5 mmol), a zinc chloride solution (1.0 M in diethyl ether, 9 ml, 9 mmol) and the 1-chloroethyl phenyl sulfide (**2a**) (1.38 g, 8.0 mmol) were used to afford 1.22 g (68%) of the ketone **4a** as a pale yellow liquid after chromatography with diethyl ether/petroleum ether (1:3) on silica gel (60 g, deactivated with 6 ml H_2O); R_f = 0.35. – Diastereomeric ratio: 1.3:1. – IR (neat): $\tilde{\nu}$ = 3040 (aromat. CH), 1660 (C=O), 1645 (C=C), 1580 cm^{-1} (aromat. C=C). – ^1H NMR (200 MHz, $CDCl_3$): δ = [0.96] and 1.00 (s; 3H, 7a-CH_3), 1.15 [s; 9H, $OC(CH_3)_3$], 1.50 (d, *J* = 7.1 Hz; 3H, CH_3-CH), [1.54] (d, *J* = 7.3 Hz; 3H, CH_3-CH), 0.80–2.70 (m; 8H, CH_2), [3.32] and 3.41 (dd, *J* = 7.6 and 10.3 Hz; 1H, 1-H), 4.31 (q, *J* = 7.1 Hz; 1H, 1'-H), [4.48] (q, *J* = 7.3 Hz; 1H, 1'-H), 7.20–7.51 (m; 5H, C_6H_5); signals of the minor diastereomer in brackets. – ^{13}C NMR (50 MHz, $CDCl_3$): δ = 15.74 (7a-CH_3), 18.95 and [19.39] (C-2'), 28.47 [$OC(CH_3)_3$], 25.57, [25.69], [29.45], 29.57, 33.19, [33.43], 33.51 and [33.84] (C-2, C-3, C-6 and C-7), 40.08 and [40.58] (C-1'), [45.04] and 45.22 (C-7a), 72.77 [$OC(CH_3)_3$], 79.11 and [79.26] (C-1), 126.91 and [127.03] (C-4/Phenyl), 128.38 and [128.42] (C-2/Phenyl), 132.80 and [132.97] (C-3/Phenyl), 132.72, [132.97], 135.88 and [136.03] (C-4 and C-1/Phenyl), 169.61 and [169.89] (C-3a), 196.79 and [197.04] (C-5); signals of the minor diastereomer in brackets. – MS (70 eV): *m/z* (%) = 358 (16) [M^+], 193 (40) [$M^+ - C_4H_8 - C_6H_5S$], 137 (100) [$C_8H_9^+$], 109 (20) [$C_6H_5S^+$], 57 (12) [$C_4H_9^+$]. – $C_{22}H_{30}O_2S$ (358.3): calcd. C 73.68, H 8.44; found C 73.29, H 8.23.

(1S,1'RS,7aS)-1-tert-Butoxy-7a-methyl-4-[1'-(phenylthio)-butyl]-1,2,3,6,7,7a-hexahydro-5H-inden-5-one (**4c**): 1-Chlorobutyl phenyl sulfide (**2c**) (1.80 g, 9.0 mmol, 90% yield) was prepared from *N*-chlorosuccinimide (1.47 g, 11.0 mmol) and butyl phenyl sulfide (1.66 g, 10.0 mmol). According to the general procedure, potassium hydride (0.10 g, 2.5 mmol), the hexahydro-indenone **1** (0.49 g, 2.2 mmol), a zinc chloride solution (1.0 M in diethyl ether, 2.9 ml, 2.9 mmol) and 1-chlorobutyl phenyl sulfide **2c** (0.46 g, 2.4 mmol) were used to afford 0.60 g (70%) of the ketone **4c** as a pale yellow liquid after chromatography with diethyl ether/petroleum ether (1:6) on silica gel (62 g, deactivated with 6 mol H_2O); R_f = 0.38. – Diastereomeric ratio: 1.4:1. – IR (nujol): $\tilde{\nu}$ = 3050 (aromat. CH), 1660 (C=O), 1640 (C=C), 1620 and 1575 cm^{-1} (aromat. C=C). – ^1H NMR (200 MHz, $CDCl_3$): δ = 0.87 (t, *J* = 7.0 Hz; 3H, CH_2-CH_3), 0.99 (s; 3H, 7a-CH_3), 1.15 [s; 9H, $OC(CH_3)_3$], 0.70–2.70 (m; 13H, CH_2 and 1'-H), [3.28] and 3.38 (dd, *J* = 7.0 and 8.5 Hz; 1H, 1-H), 7.15–7.45 (m; 5H, SC_6H_5); signals of the minor diastereomer in brackets. – ^{13}C NMR (50 MHz, $CDCl_3$): δ = 13.92 (C-4'), [15.92] and 15.94 (7a-CH_3), 28.65 [$OC(CH_3)_3$], 21.31, [21.51], 25.78, [25.83], [29.47], 29.75, [33.42], 33.64, 34.07, [35.29], 35.62, 40.03 and [40.31] (C-2, C-3, C-6, C-7, C-1', C-2' and C-3'), [45.24] and 45.47 (C-7a), 72.96 [$OC(CH_3)_3$], [79.33] and 79.53 (C-1), [127.09] and 127.16 (C-4/Phenyl), [128.54] and 128.58 (C-2/Phenyl), 131.83 (C-4), 132.06 (C-1/Phenyl), 133.31 (C-3/Phenyl), 170.25 and [179.34] (C-3a), 197.25 and [197.56] (C-5); signals of the minor diastereomer in brackets. – MS (70 eV): *m/z* (%) = 386 (44) [M^+], 277 (23) [$M^+ - SC_6H_5$], 221 (97) [$M^+ - SC_6H_5 - C_4H_8$] 57 (100) [$C_4H_9^+$]. – $C_{24}H_{34}O_2S$ (386.4): calcd. C 74.55, H 8.87; found C 74.27, H 8.56.

4-Alkyl-hexahydro-5H-inden-5-ones **5**. – *General Procedure:* Raney nickel (18 g) was washed 10 times with 96% ethanol (10 ml each), 5 more times with anhydrous ethanol (10 ml each) and suspended in acetone/ethanol (9:1, 20 ml). A solution of the crude β-phenylthio ketone **4** in acetone/ethanol (9:1, 5 ml) was added under stirring at room temp. According to a TLC analysis the desulfurization was completed within 10–15 min. The suspension was filtered through a short plug of silica gel in order to remove the Raney nickel. The silica gel was flushed with diethyl ether (200 ml) and immediately after this operation poured into 100 ml of 2 N HCl since the diethyl-ether-contaminated Raney nickel/silica gel mixture proved to be pyrophoric. The organic layers were combined and the solvent was removed in vacuo (20°C/12 Torr). The residue, the crude ketone **5**, was purified by chromatography on silica gel.

(1S,7aS)-1-tert-Butoxy-4-ethyl-7a-methyl-1,2,3,6,7,7a-hexahydro-5H-inden-5-one (**5a**): 1-Chloroethyl phenyl sulfide (**2a**) (1.57 g, 9.1 mmol, 91% yield) was prepared from *N*-chlorosuccinimide (1.47 g, 11 mmol) and ethyl phenyl sulfide (1.38 g, 10 mmol). According to the general procedure potassium hydride (0.18 g, 4.5 mmol), the hexahydro-indenone **1** (0.88 g, 4 mmol), a zinc chloride solution (1.0 M in diethyl ether, 5 ml, 5 mmol), 1-chloroethyl phenyl sulfide (**2a**) (0.76 g, 4.4 mmol) and Raney nickel (18 g) were used to afford 0.76 g (76%) of the ketone **5a** as a colorless solid after chromatography with diethyl ether/petroleum ether (1:6) on silica gel (65 g); R_f = 0.44. 0.15 g (17%) of the starting material **1** was recovered as a colorless solid; R_f = 0.11. – $[\alpha]_D^{20}$ = +38.1 (*c* = 1.0, $CHCl_3$). – M.p. 47°C. – IR (nujol): $\tilde{\nu}$ = 1655 (C=O), 1640 cm^{-1} (C=C). – ^1H NMR (200 MHz, $CDCl_3$): δ = 0.92 (t, *J* = 7.5 Hz; 3H, CH_2-CH_3), 1.08 (s; 3H, 7a-CH_3), 1.18 [s; 9H, $OC(CH_3)_3$], 2.15 (q, *J* = 7.5 Hz; 2H, CH_2-CH_3), 1.50–2.70 (m; 8H, CH_2), 3.55 (dd, *J* = 7.5 and 10.0 Hz; 1H, 1-H). – ^{13}C NMR (50 MHz, $CDCl_3$): δ = 12.84 (C-2'), 15.77 (7a-CH_3), 18.50 (C-1'), 28.50 [$OC(CH_3)_3$], 25.02, 29.71, 33.42 and 34.00 (C-2, C-3, C-6 and C-7), 44.34 (C-7a), 72.75 [$OC(CH_3)_3$], 79.78 (C-1), 134.28 (C-4), 167.48 (C-3a), 198.30 (C-5). – MS (70 eV): *m/z* (%) = 250 (3) [M^+], 194 (100) [$M^+ - C_4H_8$], 166 (42) [$M^+ - C_4H_8 - CO$], 57 (52) [$C_4H_9^+$]. – $C_{16}H_{26}O_2$ (250.4): calcd. C 76.75, H 10.47; found C 76.62, H 10.55.

(1S,7aS)-1-tert-Butoxy-7a-methyl-4-propyl-1,2,3,6,7,7a-hexahydro-5H-inden-5-one (**5b**): 1-Chloropropyl phenyl sulfide (**2b**) (0.95 g, 4.6 mmol, 92% yield) was prepared from *N*-chlorosuccinimide (0.77 g, 5.8 mmol) and propyl phenyl sulfide (0.76 g, 5 mmol). According to the general procedure, potassium hydride (0.10 g, 2.5 mmol), the hexahydro-indenone **1** (0.49 g, 2.2 mmol), a zinc chloride solution (1.0 M in diethyl ether, 3 ml, 3 mmol), 1-chloropropyl phenyl sulfide (**2b**) (0.47 g, 2.5 mmol) and Raney nickel (10 g) were used to afford 0.40 g (69%) of the ketone **5b** as a pale yellow oil after chromatography with diethyl ether/petroleum ether (1:6) on silica gel (45 g); R_f = 0.38. 0.12 g (23%) of the starting material **1** was recovered as a colorless solid; R_f = 0.11. – $[\alpha]_D^{20}$ = +39.6 (*c* = 1.0, $CHCl_3$). – IR (neat): $\tilde{\nu}$ = 1660 (C=O), 1640 cm^{-1} (C=C). – ^1H NMR (200 MHz, $CDCl_3$): δ = 0.87 (t, *J* = 7.0 Hz; 3H, CH_2-CH_3), 1.08 (s; 3H, 7a-CH_3), 1.18 [s; 9H, $OC(CH_3)_3$], 1.34 (tq, *J* = 7.4 and 7.6 Hz; 2H, CH_2-CH_3), 1.45–2.70 (m; 10H, CH_2), 3.54 (dd, *J* = 7.4 and 10.2 Hz; 1H, 1-H). – ^{13}C NMR (50 MHz, $CDCl_3$): δ = 14.16 (C-3'), 16.02 (7a-CH_3), 28.69 [$OC(CH_3)_3$], 21.71, 25.53, 27.44, 29.89, 33.61 and 34.20 (C-2, C-3, C-6, C-7, C-1' and C-2'), 44.62 (C-7a), 72.90 [$OC(CH_3)_3$], 79.96 (C-1), 132.94 (C-4), 168.20 (C-3a), 198.53 (C-5). – MS (70 eV): *m/z* (%) = 264 (22) [M^+], 208 (100) [$M^+ - C_4H_8$], 57 (71) [$C_4H_9^+$]. – $C_{17}H_{28}O_2$ (264.4): calcd. C 77.22, H 10.67; found C 77.08, H 10.64.

(1S,7aS)-1-tert-Butoxy-4-butyl-7a-methyl-1,2,3,6,7,7a-hexahydro-5H-inden-5-one (**5c**): 1-Chlorobutyl phenyl sulfide (**2c**)

(1.80 g, 9.0 mmol, 90% yield) was prepared from *N*-chlorosuccinimide (1.47 g, 11.0 mmol) and butyl phenyl sulfide (1.66 g, 10.0 mmol). According to the general procedure potassium hydride (92 mg, 2.3 mmol), the hexahydro-indenone **1** (0.47 g, 2.1 mmol), a zinc chloride solution (1.0 M in diethyl ether, 3 ml, 3 mmol), 1-chlorobutyl phenyl sulfide (**2c**) (0.46 g, 2.3 mmol) and Raney nickel (9 g) were used to afford 0.45 g (77%) of the ketone **5c** as a colorless oil after chromatography with diethyl ether/petroleum ether (1:6) on silica gel (65 g); R_f = 0.45. 79 mg (17%) of the starting material **1** was recovered as a colorless solid; R_f = 0.11. – $[\alpha]_D^{20}$ = +57.7 (*c* = 1.0, $CHCl_3$). – IR (neat): $\tilde{\nu}$ = 1660 (C=O), 1640 cm^{-1} (C=C). – ^1H NMR (200 MHz, $CDCl_3$): δ = 0.89 (t, *J* = 6.6 Hz; 3H, CH_2-CH_3), 1.08 (s; 3H, 7a-CH_3), 1.18 [s; 9H, $OC(CH_3)_3$], 0.70–2.68 (m; 14H, CH_2), 3.54 (dd, *J* = 7.4 and 10.2 Hz; 1H, 1-H). – ^{13}C NMR (50 MHz, $CDCl_3$): δ = 14.05 (C-4'), 16.01 (7a-CH_3), 28.71 [$OC(CH_3)_3$], 22.91, 25.31, 25.47, 29.91, 30.83, 33.64 and 34.22 (C-2, C-3, C-6, C-7, C-1', C-2' and C-3'), 44.61 (C-7a), 72.93 [$OC(CH_3)_3$], 79.99 (C-1), 133.24 (C-4), 167.97 (C-3a), 198.61 (C-5). – MS (70 eV): *m/z* (%) = 278 (3) [M^+], 222 (100) [$M^+ - C_4H_8$], 165 (34) [$M^+ - C_4H_8 - C_4H_9$], 57 (67) [$C_4H_9^+$]. – $C_{18}H_{30}O_2$ (278.4): calcd. C 77.65, H 10.86; found C 77.70, H 10.83.

(1S,7aS)-1-tert-Butoxy-4-hexyl-7a-methyl-1,2,3,6,7,7a-hexahydro-5H-inden-5-one (**5d**): 1-Chlorohexyl phenyl sulfide (**2d**) (1.00 g, 4.4 mmol, 87% yield) was prepared from *N*-chlorosuccinimide (0.77 g, 5.8 mmol) and hexyl phenyl sulfide (0.97 g, 5.0 mmol). According to the general procedure, potassium hydride (0.12 g, 3.0 mmol), the hexahydro-indenone **1** (0.62 g, 2.8 mmol), a zinc chloride solution (1.0 M in diethyl ether, 3.5 ml, 3.5 mmol), 1-chlorohexyl phenyl sulfide (**2d**) (0.71 g, 3.1 mmol) and Raney nickel (12 g) were used to afford 0.64 g (75%) of the ketone **5d** as a colorless oil after chromatography with diethyl ether/petroleum ether (1:6) on silica gel (65 g); R_f = 0.37. 68 mg (11%) of the starting material **1** was recovered as a colorless solid; R_f = 0.11. – $[\alpha]_D^{20}$ = +35.1 (*c* = 1.1, $CHCl_3$). – IR (neat): $\tilde{\nu}$ = 1660 (C=O), 1640 cm^{-1} (C=C). – ^1H NMR (200 MHz, $CDCl_3$): δ = 0.87 (t, *J* = 6.6 Hz; 3H, CH_2-CH_3), 1.08 (s; 3H, 7a-CH_3), 1.18 [s; 9H, $OC(CH_3)_3$], 1.20–2.70 (m; 18H, CH_2), 3.55 (dd, *J* = 7.3 Hz and 10.3 Hz; 1H, 1-H). – ^{13}C NMR (50 MHz, $CDCl_3$): δ = 14.09 (C-6'), 15.99 (7a-CH_3), 28.69 [$OC(CH_3)_3$], 22.62, 25.47, 25.55, 28.55, 29.49, 29.90, 31.75, 33.62 and 34.21 (C-2, C-3, C-6, C-7, C-1', C-2', C-3', C-4' and C-5'), 44.60 (C-7a), 72.91 [$OC(CH_3)_3$], 79.97 (C-1), 133.27 (C-4), 167.92 (C-3a), 198.56 (C-5). – MS (70 eV): *m/z* (%) = 306 (4) [M^+], 250 (100) [$M^+ - C_4H_8$], 193 (27) [$M^+ - C_4H_8 - C_4H_9$], 57 (27) [$C_4H_9^+$]. – $C_{20}H_{34}O_2$ (306.5): calcd. C 78.38, H 11.18; found C 78.22, H 11.27.

(1S,7aS)-1-tert-Butoxy-4-isopropylidene-7a-methyl-1,2,4,6,7,7a-hexahydro-5H-inden-5-one (**8**) *and (1S,7aS)-1-tert-Butoxy-4-isopropenyl-7a-methyl-1,2,3,6,7,7a-hexahydro-5H-inden-5-one* (**9**): (1-Chloro-1-methylethyl) phenyl sulfide (**6**) (0.63 g, 3.4 mmol, 85% yield) was prepared from *N*-chlorosuccinimide (0.60 g, 4.6 mmol) and 1-methylethyl phenyl sulfide (0.61 g, 4.0 mmol). According to the general procedure for the preparation of 4-phenylthioalkyl-hexahydro-5*H*-indenones, potassium hydride (88 mg, 2.2 mmol), the hexahydro-indenone **1** (0.44 g, 2.0 mmol), a zinc chloride solution (1.0 M in diethyl ether, 2.5 ml, 2.5 mmol), and **6** (0.41 g, 2.2 mmol) were used to afford 0.35 g (67%) of the 4-(phenylthioalkyl)-hexahydroinden-5-one **7** as a yellow oil. The β-(phenylthio) ketone **7** was dissolved in toluene (25 ml), DBU (0.31 g, 2.0 mmol) was added under stirring at room temp. and stirring was continued for 1 h. The reaction mixture was extracted once with 1 N HCl, twice with a saturated aqueous NaCl solution (5 ml each) and dried with $MgSO_4$. The solvent was removed in vacuo (25°C/12 Torr) to afford 0.21 g (40%) of the ketone **8** and 80 mg (15%) of the ketone **9** as colorless oils after chromatography with diethyl ether/petroleum ether (1:20) on silica gel (38 g). Moreover, 0.16 g (35%) of the starting material **1** was recovered as a colorless solid; R_f = 0.09 (diethyl ether/pentane, 1:6).

8: R_f = 0.46 (diethyl ether/pentane, 1:6). – $[\alpha]_D^{20}$ = −88.4 (*c* = 0.9, $CHCl_3$). – IR (neat): $\tilde{\nu}$ = 1680 (C=O), 1590 cm^{-1} (C=C). – ^1H NMR (200 MHz, $CDCl_3$): δ = 1.03 (s; 3H, 7a-CH_3), 1.19 [s; 9H, $OC(CH_3)_3$], 1.95 and 2.14 [2 s; 6H, $C=(CH_3)_2$], 0.80–2.60 (m; 6H, CH_2), 3.89 (dd, *J* = 8.4 and 8.4 Hz; 1H, 1-H), 5.35 (dd, *J* = 2.2 and 2.8 Hz; 1H, 3-H). – ^{13}C NMR (50 MHz, $CDCl_3$): δ = 18.03 (7a-CH_3), 22.69 and 24.34 [$C=(CH_3)_2$], 28.73 [$OC(CH_3)_3$], 33.26, 39.05 and 39.06 (C-2, C-6 and C-7), 48.08 (C-7a), 72.74 [$OC(CH_3)_3$], 79.63 (C-1), 124.56 (C-3), 131.10 and 145.73 (C-4 and C-1'), 146.77 (C-3a), 202.66 (C-5). – MS (70 eV): *m/z* (%) = 262 (44) [M^+], 206 (30) [$M^+ - C_4H_8$], 163 (22) [$M^+ - C_4H_8 - C_3H_7$], 57 (100) [$C_4H_9^+$]. – $C_{17}H_{26}O_2$ (262.2): calcd. C 77.80, H 9.99; found C 77.69, H 9.94.

9: R_f = 0.24 (diethyl ether/pentane, 1:6). – IR (neat): $\tilde{\nu}$ = 1660 (C=O), 1640 (C=C), 1620 cm^{-1} (C=C). – ^1H NMR (200 MHz, $CDCl_3$): δ = 1.12 (s; 3H, 7a-CH_3), 1.19 [s; 9H, $OC(CH_3)_3$], 1.81 (t, ^4J = 1.0 Hz; 3H, 1'-CH_3), 0.80–2.70 (m; 8H, CH_2), 3.57 (dd, *J* = 7.6 and 10.0 Hz; 1H, 1-H), 4.67 (q, ^4J = 1.0 Hz; 1H, olefinic CH), 5.14 (m; 1H, olefinic CH). – ^{13}C NMR (50 MHz, $CDCl_3$): δ = 15.80 (7a-CH_3), 22.66 (1'-CH_3), 28.70 [$OC(CH_3)_3$], 26.15, 29.81, 33.68 and 33.98 (C-2, C-3, C-6 and C-7), 44.58 (C-7a), 73.01 [$OC(CH_3)_3$], 79.92 (C-1), 115.76 ($C=CH_2$), 136.65 (C-4), 140.69 (C-1'), 168.52 (C-3a), 197.63 (C-5). – MS (70 eV): *m/z* (%) = 262 (25) [M^+], 206 (100) [$M^+ - C_4H_8$], 57 (92) [$C_4H_9^+$]. – $C_{17}H_{26}O_2$ (262.2): calcd. C 77.80, H 9.99; found C 77.61, H 9.87.

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