The use of α -chlorinated *N*-(*tert*-butanesulfinyl)imines in the synthesis of chiral aziridines

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General methods

α -Chloro aldehydes **5** were prepared as previously described.^{S1} The α -chloro aldehydes were distilled. Boiling point, ¹H and ¹³C NMR spectra were identical to literature (S1).

R-(+)-*tert*-Butanesulfinamide was obtained from commercial sources (Advanced Asymmetrics) in $\geq 98\%$ purity and $\geq 98\%$ de.

^{S1} Stevens, C.; De Kimpe, N. *Org. Prep. Proced. Int.* **1990**, 22, 589.

General procedure for the synthesis of α -chloro *N*-sulfinyl aldimines (*R_S*)-6

In a flame-dried 100 mL round-bottom flask was made a 0.5 M-solution of **5** (11 mmol) and Ti(OEt)₄ (tech. grade, ~20% Ti; 1.2-2.0 equiv) in dry THF under nitrogen atmosphere. *tert*-Butanesulfinamide (10 mmol) was added in one portion and allowed to stir for 4 hours at reflux temperature. After completion the reaction mixture was cooled to 0 °C and poured in an equal volume of brine with EtOAc (1:1-mixture), while rapidly stirring. The suspension was filtered over Celite and the solids were washed with EtOAc (2 x 10 mL) and extracted with EtOAc (3 x 20 mL). The combined organic fractions were dried (MgSO₄), filtrated and concentrated. Extractive isolation provided analytically pure material.

(*R_S*)-(-)-*N*-(2-Chloro-2-methyl-1-propylidene)-*tert*-butanesulfinamide [(*R_S*)-**6a**]

Viscous white oil, 92%. [α]_D -256° (c 0.15, CHCl₃). IR: 1093, 1366, 1623. MS: *m/z* = [M+H] 210.1/212.1 (70%); 154.0/156.0 (100%). δ_{H} (300 MHz, CDCl₃) 1.18 (9H, s), 1.73 (3H, s), 1.74 (3H, s), 7.98 (1H, s). δ_{C} (75 MHz, CDCl₃) 22.5, 29.3, 29.8, 57.6, 66.7, 168.2. Anal. Calcd for C₈H₁₆ClNOS: C, 45.81; H, 7.69; N, 6.68. Found: C, 45.98; H, 7.58; N, 6.50.

(*R_S*)-(-)-*N*-(2-Chloro-2-ethyl-1-butyldiene)-*tert*-butanesulfinamide [(*R_S*)-**6b**]

Yellow oil, 87%. [α]_D -185° (c 0.7, CHCl₃). IR: 1093, 1364, 1620. MS: *m/z* = [M+H] 238.0/240.1 (80%); 182.0/184.0 (100%). δ_{H} (300 MHz, CDCl₃) 0.73 (3H, t, *J* 7.4 Hz), 0.80 (3H, t, *J* 7.4 Hz), 0.98 (9H, s), 1.60-1.85 (4H, m), 8.18 (1H, s). δ_{C} (75 MHz, CDCl₃) 8.7, 22.3, 31.6, 31.8, 57.2, 75.9, 168.3. Anal. Calcd for C₁₀H₂₀ClNOS: C, 50.51; H, 8.48; N, 5.89. Found: C, 50.65; H, 8.41; N, 5.80.

(*R_S*)-(-)-*N*-(1-Chlorocyclohexyl)methylidene)-*tert*-butanesulfinamide [(*R_S*)-**6c**]

White solid product (mp 43.5±0.5 °C), 95%. [α]_D -156° (c 0.45, CHCl₃). IR: 1090, 1363, 1615. MS: *m/z* = [M+H] 250.1/252.1 (100%); 194.0/196.0 (70%); 158.0 (33%). δ_{H} (300 MHz, CDCl₃) 1.23 (9H, s), 1.24-1.43 (1H, m), 1.53-1.93 (5H, m), 1.94-2.14 (4H, m), 7.99 (1H, s). δ_{C} (75 MHz, CDCl₃) 22.1, 22.6, 25.1, 36.7, 36.8, 57.6, 71.7, 168.3. Anal. Calcd for C₁₁H₂₀ClNOS: C, 52.89; H, 8.07; N, 5.61. Found: C, 52.76; H, 8.13; N, 5.49.

General procedure for the synthesis of β -chloro *N*-sulfonamides (*R_S*,*R*)-9.

In a flame-dried round-bottom flask was made a solution of (*R_S*)-6 (5 mmol) in dry CH₂Cl₂ (20 mL) under nitrogen atmosphere. The stirred solution was cooled down to -97 °C (*R*' = Ph) or -78 °C (*R*' ≠ Ph) before 1.1 equiv of the Grignard reagent (1-2 M in THF) was added drop wise. The temperature was raised to -78 °C and then the reaction was prolonged at this temperature for 4-5 hours. Then, the reaction mixture was quenched by the addition of aq NH₄Cl (5 mL) and diluted with saturated aqueous KHCO₃ (20 mL) and EtOAc (20 mL) at room temperature. The aqueous layer was extracted with EtOAc (2 x 20 mL). The combined organic layers were dried over MgSO₄ with trace of K₂CO₃, filtered and concentrated. The compounds were purified by flash chromatography.

(*R_S*,1*R*)-(-)-*N*-(2-Chloro-1-ethyl-2-methylpropyl)-*tert*-butanesulfonamide [(*R_S*,*R*)-9a]

Petroleum ether/EtOAc (75/25) *R_f* 0.15. Yellow crystals (mp 71.4±0.3 °C), 76%. [α]_D -31° (c 0.05, MeOH). IR: 1056, 1364, 1459, 2962, 3238. MS: *m/z* = [*M*+*H*] 240.1/242.1 (100%). δ_{H} (300 MHz, CDCl₃) 1.00 (3H, t, *J* 7.4 Hz), 1.28 (9H, s), 1.41-1.59 (1H, m), 1.64 (3H, s), 1.72 (3H, s), 1.79-1.94 (1H, m), 3.04 (1H, ddd, *J* 9.6 Hz, 7.7 Hz, 2.8 Hz), 3.76 (1H, d (broad), *J* 9.6 Hz). δ_{C} (75 MHz; CDCl₃) 11.6, 23.1, 25.5, 30.5, 31.5, 56.8, 67.4, 74.8. Anal. Calcd for C₁₀H₂₂ClNOS: C, 50.08; H, 9.25; N, 5.84. Found: C, 49.91; H, 9.35; N, 6.01. ESI-HRMS: calcd. for C₁₀H₂₂ClNOS-H⁺: 240.11834, found 240.11857.

(*R_S*,1*R*)-(-)-*N*-(2-Chloro-2-methyl-1-phenylpropyl)-*tert*-butanesulfonamide [(*R_S*,*R*)-9b]

Petroleum ether/EtOAc (75/25) *R_f* 0.12. White crystals (mp 90.1±0.2 °C), 73%. [α]_D -105° (c 0.3, MeOH). IR: 1075, 1368, 1456, 1493, 1594, 2926, 3282. MS: *m/z* = [*M*+*H*] 288.3/290.3 (100%). δ_{H} (300 MHz, CDCl₃) 1.25 (9H, s), 1.52 (3H, s), 1.56 (3H, s), 4.41 (1H, s (broad)), 4.54 (1H, d, *J* 2.2 Hz), 7.27-7.40 (5H, m). δ_{C} (75 MHz; CDCl₃) 22.7, 26.8, 31.4, 55.9, 67.6, 74.1, 128.1, 128.5, 129.7, 136.6. Anal. Calcd for C₁₄H₂₂ClNOS: C, 58.42; H, 7.70; N, 4.87. Found: C, 58.49; H, 7.80; N, 4.74.

(*R_S*,1*R*)-(-)-*N*-[1-(1-Chloro-1-methylethyl)-2-propenyl]-*tert*-butanesulfonamide [(*R_S*,*R*)-9c]

Petroleum ether/EtOAc (75/25) *R_f* 0.15. Colorless oil, 69%. [α]_D -69° (c 0.2, MeOH). IR: 1069, 1370, 1459, 1641, 2979, 3220. MS: *m/z* = [*M*+*H*] 238.3/240.3 (100%). δ_{H} (300 MHz, CDCl₃) 1.25 (9H, s), 1.54 (3H, s), 1.64 (3H, s), 2.79 (1H, dd, *J* 8.7 Hz, 3.3 Hz), 4.07 (1H, s (broad)), 5.38-5.43 (2H, m), 5.59-5.70 (1H, m). δ_{C} (75 MHz; CDCl₃) 22.7, 27.1, 30.8, 55.8,

67.3, 73.1, 121.9, 133.8. Anal. Calcd for C₁₀H₂₀ClNOS: C, 50.51; H, 8.48; N, 5.89. Found: C, 50.66; H, 8.40; N, 6.02.

N-(1-Allyl-2-chloro-2-methylpropyl)-*tert*-butanesulfinamide [**9d**] (62(*M*):38(*m*))-mixture of diastereomers

Colorless crystals (mp 60.6±0.3 °C), 99%. IR: 1048, 1069, 1386, 1457, 1619, 2929, 3436. MS: *m/z* = [M+H] 252.3/254.3 (100%). δ_H (300 MHz, CDCl₃) 1.25 (*m* 9H, s), 1.26 (*M* 9H, s), 1.58 (*M* 3H, s), 1.61 (*M* 3H, s), 1.66 (*m* 3H, s), 1.73 (*m* 3H, s), 2.23-2.80 (*mM* 2H, m), 3.26-3.32 (*m* 1H, m), 3.27-3.38 (*M* 1H, m), 3.48 (*M* 1H, d (broad), *J* 7.2 Hz), 3.78 (*m* 1H, d (broad), *J* 8.3 Hz), 5.07-5.21 (*mM* 2H, m), 5.77-5.90 (*m* 1H, m), 5.87-6.03 (*M* 1H, m). δ_C (75 MHz; CDCl₃) 22.9 (*M*), 23.0 (*m*), 29.8 (*M*), 30.3 (*M*), 30.4 (*m*), 31.3 (*m*), 36.7 (*M*), 37.1 (*m*), 56.7 (*M*), 57.0 (*m*), 64.1 (*M*), 65.4 (*m*), 73.5 (*M*), 74.4 (*m*), 117.6 (*m*), 118.7 (*M*), 134.8 (*M*), 135.4 (*m*).

General procedure for the synthesis of β-chloro *N*-sulfinamide (*R_S*)-**10a**.

In a flame-dried round-bottom flask was made a solution of (*R_S*)-**6a** (5 mmol) in dry CH₂Cl₂ (20 mL) under nitrogen atmosphere. The stirred solution was cooled down to −97 °C before 1.1 equiv of *i*-PrMgCl (2 M in THF) was added drop wise. The temperature was raised to −78 °C and then the reaction was continued at this temperature for 5 hours. Then, the reaction mixture was quenched by the addition of aq NH₄Cl (5 mL) and diluted with saturated aqueous KHCO₃ (20 mL) and EtOAc (20 mL) at room temperature. The aqueous layer was extracted with EtOAc (2 x 20 mL). The combined organic layers were dried over MgSO₄ with trace of K₂CO₃, filtered and concentrated to afford the pure β-chloro *N*-sulfinamide **10a**.

(*R_S*)-(-)-*N*-(2-Chloro-2-methylpropyl)-*tert*-butanesulfinamide [(*R_S*)-**10a**]

Colorless crystals (mp 88.6±0.2° C), 95%. [α]_D -11° (c 0.05, MeOH). IR: 1057, 1369, 1457, 2973, 3210. MS: *m/z* = [M+H] 212.2/214.2 (100%). δ_H (300 MHz, CDCl₃) 1.27 (9H, s), 1.58 (3H, s), 1.61 (3H, s), 3.17 (1H, dd, *J* 13.5 Hz, 8.9 Hz), 3.45 (1H, dd, *J* 13.5 Hz, 5.2 Hz), 3.73 (1H, dd (broad), *J* 8.9 Hz, 5.5 Hz). δ_C (75 MHz, CDCl₃) 22.7, 29.6, 30.4, 56.4, 57.9, 70.0. Anal. Calcd for C₈H₁₈ClNOS: C, 45.38; H, 8.57; N, 6.61. Found: C, 45.48; H, 8.62; N, 6.56.

General procedure for the ring closure of β -chloro *N*-sulfinamides (*R_S*,*R*)-9 towards *N*-sulfinyl aziridines (*R_S*,*R*)-8

Ring closure of β -chloro *N*-sulfinamide (*R_S*,*R*)-9 towards the corresponding *N*-sulfinyl aziridine (*R_S*,*R*)-8 upon treatment with base: optimisation

Entry	Substrate	base	equiv	solvent	t(h) [°C] (rt)	yield % ¹
a	9b	BuLi	1.1	THF	4 [-78] 16 (rt)	58
b	9b	NaH	1.1	THF	4 [-78] 16 (rt)	77
c	9b	LDA	1.1	THF	4 [-78] 16 (rt)	41
d	9b	K ₂ CO ₃	5	Acetone	1[-78] 24 (Δ)	12
e	9b	K ₂ CO ₃ /NaI	3/10	DMF	60 [60]	78
f	9b	KOH	3	H ₂ O/THF (1/1)	24 [50]	98 ²
g	9a	KOH	3	H ₂ O/THF (1/1)	24 [50]	100 ²
h	9c	KOH	3	H ₂ O/THF (1/1)	24 [50]	100 ²
i	9d	KOH	3	H ₂ O/THF (1/1)	24 [50]	100 ²

¹ Determined by a mass balance after chromatography.

² Determined by a mass balance of the reaction mixture.

In a 50 mL round-bottom flask was made a solution (5 mmol) of **9** in a 1:1-mixture H₂O/THF (20 mL). 3 Equivalents of KOH (0.84 g) was added to the stirred solution. The mixture was warmed to 50 °C and allowed to stir for 24 h. When complete, the reaction mixture was cooled down to 0 °C. The organic layer was removed and the aqueous layer was extracted with Et₂O (3 x 10 mL). The combined organic layers were dried over MgSO₄ with a trace of K₂CO₃, filtered and concentrated. The compounds were purified by flash chromatography.

(*R_S*,3*R*)-(-)-*N*-(*tert*-Butylsulfinyl)-3-ethyl-2,2-dimethylaziridine [(*R_S*,*R*)-8a]

Petroleum ether/EtOAc (80/20) R_f 0.20. Colorless viscous oil, 76%. [α]_D -89° (c 0.6, MeOH). IR: 1081, 1111, 1361, 1376, 1460, 2964. MS: m/z = [M+H] 204.2 (100%). δ _H (300 MHz, CDCl₃) 0.99 (3H, t, *J* 7.4 Hz), 1.24 (9H, s), 1.26 (3H, s), 1.43 (1H, dq, *J* 7.9 Hz, 7.4 Hz), 1.59 (3H, s), 1.62 (1H, qd, *J* 7.4 Hz, 5.8 Hz), 2.25 (1H, dd, *J* 7.9 Hz, 5.8 Hz). δ _C (75 MHz, CDCl₃) 11.3, 21.6, 22.0, 22.3, 22.7, 47.5, 49.8, 55.9. Anal. Calcd for C₁₀H₂₁NOS: C, 59.07; H, 10.41; N, 6.89. Found: C, 58.88; H, 10.52; N, 6.92.

(*R_S*,3*R*)-(-)-*N*-(*tert*-Butylsulfinyl)-3-phenyl-2,2-dimethylaziridine [(*R_S*,*R*)-8b]

Petroleum ether/EtOAc (87/13) R_f 0.17. Colorless crystals (mp 94.8-95.2 °C), 73%. [α]_D -135° (c 0.1, MeOH). IR: 1070, 1363, 1456, 1496, 1595, 2870, 3061. MS: m/z = [M+H]

252.2 (100%). δ_{H} (300 MHz, CDCl_3) 1.08 (3H, s), 1.28 (9H, s), 1.76 (3H, s), 3.45 (1H, s), 7.24-7.61 (5H, m). δ_{C} (75 MHz, CDCl_3) 21.1, 21.7, 22.6, 49.9, 50.7, 56.6, 127.4, 127.52, 128.2, 135.6. Anal. Calcd for $\text{C}_{14}\text{H}_{21}\text{NOS}$: C, 66.89; H, 8.42; N, 5.57. Found: C, 67.04; H, 8.54; N, 5.72. ESI-HRMS: calcd. for $\text{C}_{14}\text{H}_{21}\text{NOS-H}^+$: 252.14166, found 252.14215.

(R_S,3R)-(-)-N-(tert-Butylsulfinyl)-2,2-dimethyl-3-vinylaziridine [(R_S,R)-8c]

Petroleum ether/EtOAc (85/15) R_f 0.15. Yellow viscous oil, 69%. $[\alpha]_{\text{D}}^{-35^\circ}$ (c 0.1, MeOH). IR: 1112, 1362, 1456, 1476, 1639, 2962, 3086. MS: $m/z = [\text{M}+\text{H}]$ 202.2 (100%). δ_{H} (300 MHz, CDCl_3) 1.24 (9H, s), 1.27 (3H, s), 1.63 (3H, s), 2.78 (1H, d, J 7.4 Hz), 5.28-5.45 (2H, ddd, J 17.3 Hz, 10.2 Hz, 1.7 Hz), 5.58-5.72 (1H, ddd, J 17.3 Hz, 10.2 Hz, 7.4 Hz). δ_{C} (75 MHz, CDCl_3) 21.5, 21.9, 22.4, 47.9, 50.9, 56.4, 119.8, 133.2. Anal. Calcd for $\text{C}_{10}\text{H}_{19}\text{NOS}$: C, 59.66; H, 9.51; N, 6.96. Found: C, 59.80; H, 9.42; N, 6.85.

(R_S,3R)-(-)-3-Allyl-N-(tert-butylsulfinyl)-2,2-dimethylaziridine [(R_S,R)-8d]

Petroleum ether/EtOAc (87/13) R_f 0.18. Colorless viscous oil, 57%. $[\alpha]_{\text{D}}^{-163^\circ}$ (c 0.1, MeOH). IR: 1079, 1361, 1460, 1642, 2957, 3080. MS: $m/z = [\text{M}+\text{H}]$ 216.2 (100%). δ_{H} (300 MHz, CDCl_3) 1.20 (9H, s), 1.21 (3H, s), 1.42 (3H, s), 2.04-2.52 (2H, m), 2.56 (1H, dd, J 9.1 Hz, 4.7 Hz), 5.05-5.15 (2H, m), 5.78-5.91 (1H, m). δ_{C} (75 MHz, CDCl_3) 20.8, 20.9, 22.6, 33.1, 40.0, 43.0, 55.9, 116.6, 134.5. Anal. Calcd for $\text{C}_{11}\text{H}_{21}\text{NOS}$: C, 61.35; H, 9.83; N, 6.50. Found: C, 61.22; H, 9.76; N, 6.67.

(R_S,3S)-(-)-3-Allyl-N-(tert-butylsulfinyl)-2,2-dimethylaziridine [(R_S,S)-8d]

Petroleum ether/EtOAc (87/13) R_f 0.14. Colorless viscous oil, 10%. $[\alpha]_{\text{D}}^{-88^\circ}$ (c 0.2, MeOH). IR: 1081, 1361, 1459, 1641, 2959, 3078. MS: $m/z = [\text{M}+\text{H}]$ 216.2 (100%). δ_{H} (300 MHz, CDCl_3) 1.25 (9H, s), 1.28 (3H, s), 1.61 (3H, s), 2.03-2.43 (3H, m), 5.07-5.17 (2H, m), 5.76-5.90 (1H, m). δ_{C} (75 MHz, CDCl_3) 21.7, 22.1, 22.6, 33.0, 43.0, 47.2, 56.0, 116.7, 134.3.

One-Pot Synthesis of *N*-sulfinyl aziridines (*R_S,R*)-8.

In a flame-dried 50 mL round-bottom flask was made a solution of (*R_S*)-**7** (5 mmol) in dry CH_2Cl_2 (20 mL) under nitrogen atmosphere. The stirred solution was cooled down to -78°C ($R' \neq \text{Ph}$) and 1.1 equiv of the Grignard reagent was added drop wise and was allowed to stir for 4 h at this temperature. Then, the mixture was gradually warmed to ambient temperature while stirring overnight. After 12 h the mixture was cooled down to 0°C and quenched by the addition of aq NH_4Cl (5 mL) and diluted with saturated aqueous KHCO_3 .

(20 mL) and EtOAc (20 mL). The aqueous layer was extracted with EtOAc (2 x 20 mL). The combined organic layers were dried over MgSO₄ with trace of K₂CO₃, filtered and concentrated. The compounds were purified by flash chromatography (*vide supra*).

General procedure for the synthesis of β -chloro *N*-sulfinamides (*R_S*,*R*)-**11**,**13**.

In a flame-dried 50 mL round-bottom flask was made a solution of (*R_S*)-**6** (5 mmol) in dry CH₂Cl₂ (THF for **11a**) (20 mL). The stirred solution was cooled down to -78 °C (*R'* ≠ Ph) or to -97 °C (*R'* = Ph) and 1.1 equiv (2 equiv for **11a**) of the Grignard reagent was added drop wise. The mixture was allowed to warm to -78 °C and was allowed to stir for 4 h at this temperature (*R'* = Et; imine **6b**) or the reaction was prolonged at -40 °C for 6 hours (*R'* = Ph, imine **6b**; *R'* = Et, imine **6c**). Then, the reaction mixture was quenched by the addition of aq NH₄Cl (5 mL) and diluted with saturated aqueous KHCO₃ (20 mL) and EtOAc (20 mL). The aqueous layer was extracted with EtOAc (2 x 20 mL) and concentrated. The compounds were purified by flash chromatography.

(*R_S*,1*R*)-(-)-*N*-(2-Chloro-1,2-diethylbutyl)-*tert*-butanesulfinamide (*R_S*,*R*)-**11a**

Petroleum ether/EtOAc (75/25) *R_f* 0.17. Colorless oil, 8%. [α]_D -36° (c 0.02, MeOH). IR: 1075, 1364, 1459, 2975, 3337. MS: *m/z* = [M+H] 268.2/270.2 (100%). δ_{H} (300 MHz, CDCl₃) 0.94 (3H, t, *J* 7.4 Hz), 0.96 (3H, t, *J* 7.4 Hz), 1.00 (3H, t, *J* 7.4 Hz), 1.28 (9H, s), 1.45-2.15 (6H, m), 3.19 (1H, ddd, *J* 10.0 Hz, 8.0 Hz, 2.8 Hz), 3.87 (1H, d (broad), *J* 8.0 Hz). δ_{C} (75 MHz; CDCl₃) 8.6, 8.7, 11.5, 23.2, 24.9, 30.1, 30.3, 56.9, 63.7, 83.6. Anal. Calcd for C₁₂H₂₆ClNOS: C, 53.81; H, 9.78; N, 5.23. Found: C, 54.00; H, 9.89; N, 5.11.

(*R_S*,1*R*)-(-)-*N*-(2-Chloro-2-ethyl-1-phenylbutyl)-*tert*-butanesulfinamide (*R_S*,*R*)-**11b**

Petroleum ether/EtOAc (75/25) *R_f* 0.17. Brown oil, 53%. [α]_D -77° (c 0.05, MeOH). IR: 1073, 1364, 1456, 1495, 1619, 2925, 3282. MS: *m/z* = [M+H] 316.3/318.3 (100%). δ_{H} (300 MHz, CDCl₃) 0.98 (3H, t, *J* 7.4 Hz), 1.07 (3H, t, *J* 7.4 Hz), 1.18 (9H, s), 1.53-2.15 (4H, m), 4.30 (1H, d (broad), *J* 4.4 Hz), 4.61 (1H, d, *J* 4.4 Hz), 7.31-7.49 (5H, m). δ_{C} (75 MHz; CDCl₃) 8.8, 9.0, 22.6, 29.7, 30.7, 55.9, 64.5, 82.6, 128.0, 128.1, 129.5, 137.9. Anal. Calcd for C₁₆H₂₆ClNOS: C, 60.83; H, 8.30; N, 4.43. Found: C, 60.67; H, 8.21; N, 4.35.

(*R_S*,1*R*)-(-)-*N*-[1-(1-Chlorocyclohexyl)propyl]-*tert*-butanesulfinamide (*R_S*,*R*)-13a

Petroleum ether/EtOAc (75/25) *R_f* 0.20. Colorless crystals (mp 66.4±0.1 °C), 25%. [α]_D -37° (c 2.5, MeOH). IR: 1046, 1369, 1459, 2932, 3243. MS: *m/z* = [M+H] 280.1/282.1 (100%). δ_{H} (300 MHz, CDCl₃) 0.99 (3H, t, *J* 7.4Hz), 1.27 (9H, s), 1.45-2.33 (12H, m), 3.07 (1H, ddd, *J* 9.1 Hz, 8.0 Hz, 2.8 Hz), 3.85 (1H, d (broad), *J* 2.8 Hz). δ_{C} (75 MHz; CDCl₃) 11.4, 22.0, 22.3, 23.2, 24.7, 25.1, 37.6, 38.5, 56.9, 67.1, 79.8. Anal. Calcd for C₁₃H₂₆ClNOS: C, 55.79; H, 9.36; N, 5.00. Found: C, 55.71; H, 9.34; N, 5.08.

General procedure for the synthesis of *N*-sulfinyl aziridines (*R_S*,*R*)-12,14

In a flame-dried 50 mL round-bottom flask was made a solution of (*R_S*)-6 (5 mmol) in dry CH₂Cl₂ (20 mL). The stirred solution was cooled down to -97 °C before 1.1 equiv of the Grignard reagent (1-2 M in THF) was added drop wise. The temperature was raised, first to -78 °C and then the reaction was prolonged at -40 °C for 6 hours. Then, the reaction mixture was quenched by the addition of aq NH₄Cl (5 mL) and diluted with saturated aqueous KHCO₃ (20 mL) and EtOAc (20 mL). The aqueous layer was extracted with EtOAc (2 x 20 mL) and concentrated. The latter mixture was dissolved in a 1:1-mixture H₂O/THF (20 mL). 3 Equivalents of KOH (0.84 g) was added to the stirred solution. The mixture was warmed to 50 °C and allowed to stir overnight. When complete, the reaction mixture was cooled down. The organic layer was removed and the aqueous layer was extracted with Et₂O (3 x 10 mL). The combined organic layers were dried over MgSO₄ with a trace of K₂CO₃, filtered and concentrated. The compounds were purified by flash chromatography.

(*R_S*,3*R*)-(-)-*N*-(*tert*-Butylsulfinyl)-2,2,3-triethylaziridine [(*R_S*,*R*)-12a]

Petroleum ether/EtOAc (85/15) *R_f* 0.22. Yellow viscous oil, 66%. [α]_D -105° (c 0.3, MeOH). IR: 1077, 1092, 1361, 1459. MS: *m/z* = [M+H] 232.2 (100%). δ_{H} (300 MHz, CDCl₃) 0.97 (3H, t, *J* 7.4 Hz), 1.01 (3H, t, *J* 7.4 Hz), 1.02 (3H, t, *J* 7.4 Hz), 1.22 (9H, s), 1.13-2.16 (6H, m), 2.19 (1H, dd, *J* 9.2 Hz, 4.4 Hz). δ_{C} (75 MHz, CDCl₃) 9.2, 11.4, 11.5,

22.2, 21.3, 22.4, 25.0, 52.1, 53.8, 55.8. Anal. Calcd for C₁₂H₂₅NOS: C, 62.29; H, 10.89; N, 6.05. Found: C, 62.17; H, 10.96; N, 6.14.

(R_S,3R)-(-)-N-(tert-Butylsulfinyl)-3-phenyl-2,2-diethylaziridine [(R_S,R)-12b]

Petroleum ether/EtOAc (85/15) R_f 0.18. Colorless crystals (86.9±0.3 °C), 57%. [α]_D -130° (c 0.3, MeOH). IR: 1095, 1360, 1458, 1602, 2968, 3061. MS: m/z = [M+H] 280.2 (100%). δ_H (300 MHz, CDCl₃) 0.88 (3H, t, *J* 7.4 Hz), 1.15 (3H, t, *J* 7.4 Hz), 1.24 (9H, s), 1.17-1.41 (2H, m), 1.90 (1H, dq, *J* 14.2 Hz, 7.4 Hz), 2.22 (1H, dq, *J* 14.2 Hz, 7.4 Hz), 3.42 (1H, s), 7.24-7.37 (5H, m). δ_C (75 MHz, CDCl₃) 9.1, 11.3, 21.8, 22.2, 24.6, 52.1, 56.4, 56.6, 127.3, 127.5, 128.2, 135.3. Anal. Calcd for C₁₆H₂₅NOS: C, 68.77; H, 9.02; N, 5.01. Found: C, 68.82; H, 9.15; N, 4.92.

(R_S,3R)-(-)-N-(tert-Butylsulfinyl)-3-vinyl-2,2-diethylaziridine [(R_S,R)-12c]

Petroleum ether/EtOAc (85/15) R_f 0.25. Colorless viscous oil, 62%. [α]_D -68° (c 0.2, MeOH). IR: 1096, 1363, 1460, 1666, 2925, 3061. MS: m/z = [M+H] 230.2 (100%). δ_H (300 MHz, CDCl₃) 0.98 (3H, t, *J* 7.4 Hz), 1.08 (3H, t, *J* 7.4 Hz), 1.19 (9H, s), 1.51 (1H, dq, *J* 14.6 Hz, 7.4 Hz), 1.58 (1H, dq, *J* 14.6 Hz, 7.4 Hz), 1.75 (1H, dq, *J* 14.6 Hz, 7.4 Hz), 2.03 (1H, dq, *J* 14.6 Hz, 7.4 Hz), 2.73 (1H, d, *J* 8.0 Hz), 5.26-5.38 (2H, m), 5.66-5.78 (1H, m). δ_C (75 MHz, CDCl₃) 9.3, 10.7, 22.2, 23.2, 24.8, 51.9, 54.8, 56.4, 119.7, 133.2. Anal. Calcd for C₁₂H₂₃NOS: C, 62.83; H, 10.11; N, 6.11. Found: C, 63.04; H, 9.87; N, 5.87.

(R_S,3R)-(-)-3-Allyl-N-(tert-butylsulfinyl)-2,2-diethylaziridine [(R_S,R)-12d]

Petroleum ether/EtOAc (85/15) R_f 0.23. Yellowish viscous oil, 45%. [α]_D -114° (c 0.3, MeOH). IR: 1081, 1361, 1460, 1642, 2970, 3079. MS: m/z = [M+H] 244.3 (100%). δ_H (300 MHz, CDCl₃) 0.95 (3H, t, *J* 7.4 Hz), 1.00 (3H, t, *J* 7.4 Hz), 1.21 (9H, s), 1.33 (1H, dq, *J* 14.2 Hz, 7.4 Hz), 1.47 (1H, dq, *J* 14.2 Hz, 7.4 Hz), 1.65 (1H, dq, *J* 14.2 Hz, 7.4 Hz), 1.86 (1H, dq, *J* 14.2 Hz, 7.4 Hz), 2.06-2.49 (2H, m), 2.53 (1H, dd, *J* 9.1 Hz, 4.7 Hz), 5.05-5.16 (2H, m), 5.74-5.87 (1H, m). δ_C (75 MHz, CDCl₃) 9.0, 11.2, 22.5, 22.6, 23.8, 32.8, 41.4, 51.0, 56.3, 116.8, 134.5. Anal. Calcd for C₁₃H₂₅NOS: C, 64.15; H, 10.35; N, 5.75. Found: C, 64.06; H, 10.41; N, 5.88.

(R_S,3S)-(-)-3-Allyl-N-(tert-butylsulfinyl)-2,2-diethylaziridine [(R_S,S)-12d]

Petroleum ether/EtOAc (85/15) R_f 0.20. Yellowish viscous oil, 21%. [α]_D -107° (c 0.2, MeOH). IR: 1091, 1362, 1460, 1674, 2931, 3081. MS: m/z = [M+H] 244.3 (100%). δ_H (300 MHz, CDCl₃) 1.02 (3H, t, *J* 7.4 Hz), 1.03 (3H, t, *J* 7.4 Hz), 1.23 (9H, s), 1.30 (1H, dq, *J* 14.2 Hz, 7.4 Hz), 1.60 (1H, dq, *J* 14.2 Hz, 7.4 Hz), 1.70 (1H, dq, *J* 14.2 Hz, 7.4 Hz), 2.13 (1H, dq, *J* 14.2 Hz, 7.4 Hz), 2.08-2.47 (2H, m), 2.31 (1H, dd, *J* 8.8 Hz, 4.4 Hz), 5.06-5.16 (2H, m), 5.71-5.84 (1H, m). δ_C (75 MHz, CDCl₃) 9.2, 11.2, 22.2, 22.8, 25.1, 32.6, 49.6, 53.7, 55.9, 117.1, 134.3.

(*R_S*,2*R*)-(-)-*N*-(*tert*-Butylsulfinyl)-2-ethyl-1-azaspiro[2.5]octane [(*R_S*,*R*)-**14a**]

Petroleum ether/EtOAc (87/13) *R_f* 0.23. Yellow viscous oil, 63%. [α]_D -114° (c 0.1, MeOH). IR: 1082, 1361, 1455, 2930. MS: *m/z* = [M+H] 244.2 (100%). δ_{H} (300 MHz, CDCl₃) 1.04 (3H, t, *J* 7.4 Hz), 1.24 (9H, s), 1.24-2.03 (12H, m), 2.23 (1H, dd, *J* 7.7 Hz, 5.5 Hz). δ_{C} (75 MHz, CDCl₃) 11.9, 21.3, 22.6, 25.3, 25.7, 26.1, 31.9, 33.5, 50.3, 53.1, 56.0. Anal. Calcd for C₁₃H₂₅NOS: C, 64.15; H, 10.35; N, 5.75. Found: C, 64.02; H, 10.42; N, 5.90.

(*R_S*,2*R*)-(-)-*N*-(*tert*-Butylsulfinyl)-2-phenyl-1-azaspiro[2.5]octane [(*R_S*,*R*)-**14b**]

Petroleum ether/EtOAc (87/13) *R_f* 0.28. Colorless viscous oil, 20%. [α]_D -138° (c 3.5, MeOH). IR: 1095, 1361, 1453, 1497, 1595, 2930, 3061. MS: *m/z* = [M+H] 292.3 (100%). δ_{H} (300 MHz, CDCl₃) 0.83-2.22 (10H, m), 1.27 (9H, s), 3.47 (1H, s), 7.24-7.36 (5H, m). δ_{C} (75 MHz, CDCl₃) 22.5, 24.4, 25.4, 26.3, 30.8, 32.7, 50.7, 55.0, 56.5, 127.3, 127.5, 128.1, 135.3. Anal. Calcd for C₁₇H₂₅NOS: C, 70.06; H, 8.65; N, 4.81. Found: C, 69.96; H, 8.77; N, 4.98.

(*R_S*,2*R*)-(-)-*N*-(*tert*-Butylsulfinyl)-2-vinyl-1-azaspiro[2.5]octane [(*R_S*,*R*)-**14c**]

Petroleum ether/EtOAc (87/13) *R_f* 0.28. Yellow viscous oil, 56%. [α]_D -64° (c 2.5, MeOH). IR: 1096, 1361, 1452, 1637, 2930, 3085. MS: *m/z* = [M+H] 242.2 (100%). δ_{H} (300 MHz, CDCl₃) 1.23 (9H, s), 1.24-2.08 (10H, m), 2.76 (1H, d, *J* 7.7 Hz), 5.27-5.40 (2H, m), 5.66-5.77 (1H, m). δ_{C} (75 MHz, CDCl₃) 22.4, 24.8, 25.5, 25.9, 32.0, 32.7, 50.7, 53.1, 56.4, 119.7, 133.0. Anal. Calcd for C₁₃H₂₃NOS: C, 64.68; H, 9.60; N, 5.80. Found: C, 64.54; H, 9.64; N, 5.70.

(*R_S*,2*R*)-(-)-*N*-(*tert*-Butylsulfinyl)-2-allyl-1-azaspiro[2.5]octane [(*R_S*,*R*)-**14d**]

Petroleum ether/EtOAc (87/13) *R_f* 0.27. Colorless viscous oil, 41%. [α]_D -24° (c 0.1, MeOH). IR: 1075, 1364, 1452, 1480, 2932, 3080. MS: *m/z* = [M+H] 256.2 (100%). δ_{H} (300 MHz, CDCl₃) 1.43 (9H, s), 1.35-2.51 (12H, m), 2.82 (1H, dd, *J* 8.5 Hz, 5.0 Hz), 5.06-5.20 (2H, m), 5.79-5.92 (1H, m). δ_{C} (75 MHz, CDCl₃) 24.1, 25.1, 25.4, 26.0, 31.2, 33.0, 32.2, 50.9, 55.7, 59.5, 117.5, 133.8. Anal. Calcd for C₁₄H₂₅NOS: C, 65.83; H, 9.87; N, 5.48. Found: C, 66.09; H, 9.79; N, 5.37.

Treatment of β -chloro *N*-sulfonamides (*R_S*,*R*)-9,13** and *N*-sulfinyl aziridines (*R_S*,*R*)-**8,12,14** with HCl towards the corresponding deprotected HCl salts**

In a 50 mL round-bottom flask equipped with a magnetic stirring bar was made a solution (5 mmol) of compound (*R_S*,*R*)-**9,13** or (*R_S*,*R*)-**8,12,14** in dry 1,4-dioxane (20 mL). The flask was placed in a water bath before the freshly prepared saturated dioxane.HCl was added (dropwise). The mixture was allowed to stir for several minutes (5 min). Then the reaction mixture was concentrated in vacuo. When crystallization started the mixture was placed under high vacuum. The collected crystals were washed with Et₂O (5 mL) and dried in vacuo.

(3*R*)-2-Chloro-2-methyl-3-pentanaminium chloride [(*R*)-18a**]**

White crystals (mp 72.4±0.2 °C), 97%. [α]_D +6° (c 0.02, MeOH). IR: 1030, 1398, 1462, 1514, 2593, 2977, 3401. MS: m/z = [M+H] 136.1/138.1 (100%). δ _H (300 MHz, CD₃OD) 1.11 (3H, t, *J* 7.4 Hz), 1.55-2.04 (1H, m), 1.63 (3H, s), 1.73 (3H, s), 3.30 (1H, m). δ _C (75 MHz, CD₃OD) 11.1, 23.5, 28.1, 31.0, 64.3, 71.3.

(*R*)-1-(1-Chlorocyclohexyl)-1-propanaminium chloride [(*R*)-19a**]**

White crystals (75 °C, decomposition), 98%. [α]_D +8° (c 0.3, MeOH). IR: 1029, 1452, 1600, 2563, 2864, 2936. MS: m/z = [M+H] 176.2/178.2 (50%), 140.5 (100%). δ _H (300 MHz, CD₃OD) 1.14 (3H, t, *J* 7.4 Hz), 1.53-2.11 (12H, m), 2.92 (1H, dd, *J* 7.8 Hz, 6.3 Hz). δ _C (75 MHz, CD₃OD) 11.3, 22.7, 22.7, 22.8, 35.9, 37.9, 25.8, 64.2, 76.6.

(3*R*)-2,2,3-Triethylaziridinium chloride [(*R*)-16a**]**

White crystals (88 °C, decomposition), 97%. [α]_D +7° (c 0.25, MeOH). IR: 1030, 1461, 2069, 2208, 2974. MS: m/z = [M+H] 128.5 (100%). δ _H (300 MHz, CD₃OD) 1.02-1.16 (9H, m), 1.61-1.94 (6H, m), 2.95 (1H, dd, *J* 6.6 Hz, 6.6 Hz). δ _C (75 MHz, CD₃OD) 7.9, 8.1, 10.2, 18.1, 19.1, 25.8, 49.8, 54.0.

(3*R*)-2,2-Dimethyl-3-phenylaziridinium chloride [(*R*)-15b**]**

White crystals (65 °C, decomposition), 92%. [α]_D +7° (c 0.1, MeOH). IR: 1460, 1589, 2169, 2882, 2978. MS: m/z = [M+H] 148.5 (100%). δ _H (300 MHz, CD₃OD) 1.35 (3H, s),

1.73 (3H, s), 4.34 (1H, s), 7.41-7.53 (5H, m). δ_{C} (75 MHz, CD_3OD) 16.5, 21.5, 49.1, 58.1, 127.4, 128.8, 129.0, 129.9.

(3*R*)-2,2-Diethyl-3-phenylaziridinium chloride [(*R*)-16b**]**

White crystals (mp 150.3 ± 0.1 °C), 100%. $[\alpha]_{\text{D}} +5^\circ$ (c 0.3, MeOH). IR: 1461, 1569, 2079, 1602, 2782, 2978. MS: $m/z = [\text{M}+\text{H}]$ 176.5 (100%). δ_{H} (300 MHz, CD_3OD) 1.00 (3H, t, J 7.4 Hz), 1.19 (3H, t, J 7.4 Hz), 1.39 (1H, dq, J 14.5 Hz, 7.4 Hz), 1.64 (1H, dq, J 14.5 Hz, 7.4 Hz), 1.82 (1H, dq, J 14.9 Hz, 7.4 Hz); 2.05 (1H, dq, J 14.9 Hz, 7.4 Hz), 4.37 (1H, s), 7.38-7.51 (5H, m). δ_{C} (75 MHz, CD_3OD) 7.6, 8.1, 20.5, 25.3, 49.8, 54.6, 127.1, 128.8, 128.9, 129.2.

(2*R*)-2-Phenyl-1-azoniaspiro[2.5]octane chloride [(*R*)-17a**]**

White crystals (70 °C, decomposition), 98%. $[\alpha]_{\text{D}} +5^\circ$ (c 0.3, MeOH). IR: 1029, 1452, 1600, 2563, 2864, 2936. MS: $m/z = [\text{M}+\text{H}]$ 188.2 (100%). δ_{H} (300 MHz, CD_3OD) 1.47-2.16 (10H, m), 4.87 (1H, s), 7.42-7.51 (5H, m). δ_{C} (75 MHz, CD_3OD) 25.3, 25.5, 28.6, 31.2, 33.7, 51.0, 53.3, 129.8, 130.1, 130.2, 130.5.

X-ray crystallography of (*R*_S,3*R*)-(-)-*N*-(*tert*-butylsulfinyl)-3-phenyl-2,2-dimethylaziridine [(*R*_S,*R*)-8b**]**

^1H and ^{13}C NMR spectra of compounds 6a-c, 8-19a

^1H and ^{13}C NMR spectra of compounds 6a-c, 8-19a

^1H and ^{13}C NMR spectra of compounds 6a-c, 8-19a

^1H and ^{13}C NMR spectra of compounds 6a-c, 8-19a

^1H and ^{13}C NMR spectra of compounds 6a-c, 8-19a

^1H and ^{13}C NMR spectra of compounds 6a-c, 8-19a

^1H and ^{13}C NMR spectra of compounds 6a-c, 8-19a

^1H and ^{13}C NMR spectra of compounds 6a-c, 8-19a

^1H and ^{13}C NMR spectra of compounds 6a-c, 8-19a

^1H and ^{13}C NMR spectra of compounds 6a-c, 8-19a

^1H and ^{13}C NMR spectra of compounds 6a-c, 8-19a

^1H and ^{13}C NMR spectra of compounds 6a-c, 8-19a

11a

X : parts per Million : 1H

^1H and ^{13}C NMR spectra of compounds 6a-c, 8-19a

^1H and ^{13}C NMR spectra of compounds 6a-c, 8-19a

^1H and ^{13}C NMR spectra of compounds 6a-c, 8-19a

^1H and ^{13}C NMR spectra of compounds 6a-c, 8-19a

13a

^1H and ^{13}C NMR spectra of compounds 6a-c, 8-19a

^1H and ^{13}C NMR spectra of compounds 6a-c, 8-19a

^1H and ^{13}C NMR spectra of compounds 6a-c, 8-19a

^1H and ^{13}C NMR spectra of compounds 6a-c, 8-19a

^1H and ^{13}C NMR spectra of compounds 6a-c, 8-19a

^1H and ^{13}C NMR spectra of compounds 6a-c, 8-19a

^1H and ^{13}C NMR spectra of compounds 6a-c, 8-19a

^1H and ^{13}C NMR spectra of compounds 6a-c, 8-19a

^1H and ^{13}C NMR spectra of compounds 6a-c, 8-19a