Supporting Information

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General Procedure for Salt Preparation from Corresponding Bromide\(^1\) (Method X)

To a rapidly stirred solution of sulfide \(\text{I}^2\) (1.8 g, 7.1 mmol) in freshly distilled alkyl bromide (85 mmol) was added silver tetrafluoroborate in the dark (2.2 g, 10.6 mmol) under an argon atmosphere at 0 °C. The reaction was allowed to warm to room temperature, stirred for 48 h and dichloromethane (10 mL) added. The resulting silver bromide precipitate was filtered, washed with dichloromethane and the filtrate concentrated \textit{in vacuo}. The resulting oil was purified by column chromatography eluting with dichloromethane to 5% methanol/CH\(_2\)Cl\(_2\) to give a pale yellow solid. This was dissolved in ethanol, stirred for 0.5 h at 40 °C over activated charcoal, filtered through celite and the filtrate concentrated \textit{in vacuo} to give a white solid.

General Procedure for Salt Preparation from Corresponding Alcohol\(^3,4\) (Method Y)

A solution of HBF\(_4\) in Et\(_2\)O (54% Wt., 1.35 mL, 9.0 mmol) was slowly added to a solution of alcohol (10.0 mmol) and sulfide \(\text{I}\) (500 mg, 2.0 mmol) in Et\(_2\)O (5 mL) under nitrogen. After 12 h, the precipitate was collected by filtration. The salt was washed with Et\(_2\)O (3 × 10 mL) and dried in \textit{vacuo} to afford a white powder.
(1S,3S,4R)-2-benzyl-3-[(1S,4R)-7,7-dimethyl-2-oxobicyclo[2.2.1]hept-1-yl]-2-
thioniabicyclo[2.2.1]heptane tetrafluoroborate (2a) (Method X)

White powder (92 %); Rf = 0.33 (5 % MeOH in CH2Cl2); νmax/cm⁻¹ 2968, 1736, 1056; m.p. 143-
145 °C (EtOH); [α]D²⁵ = -36.0 (c = 1.0 in CHCl₃); ¹H NMR (400 MHz, CDCl₃) 1.08 (3H, s, CH₃),
1.17 (3H, s, CH₃), 1.20-1.37 (2H, m, 2 × CHH), 1.53-1.69 (2H, m, C⁵H₂), 1.81 (1H, dt, J 23.5 Hz
and 2.0 Hz, CHH), 1.92 (1H, d, 19.0 Hz, C³HH), 1.94-2.05 (1H, m, CHH), 2.04-2.20 (3H, m, C⁴H,
2 × CHH), 2.23 (1H, d, J 13.0 Hz, C¹²HH), 2.54 (1H, ddd, J 19.0, 5.0 and 3.0 Hz, C³HHH), 2.81 (1H,
d, J 13.0 Hz, C¹²HH), 3.20 (1H, br. s, C⁸H), 4.21 (1H, d, J 5.0 Hz, C¹¹H), 4.32 (1H, d, J 2.5 Hz,
C⁷H), 4.39 (1H, d, J 13.0 Hz, SCHHPh), 4.66 (1H, d, J 13.0 Hz, SCHHPh), 7.35-742 (3H, m,
ArHmeta/para), 7.44-7.50 (2H, m, ArHortho); ¹³C NMR (63 MHz, CDCl₃) 19.1, 21.9, 24.4, 26.6, 26.7,
33.3, 41.1, 43.5, 44.0, 45.1, 47.9, 49.9, 58.0, 60.0, 68.8, 128.6, 129.7, 129.9, 130.5, 215.6; m/z
(ES⁺) 341 (M⁺-BF₄⁻, 47%), 217 (100), (Found: M⁺-BF₄⁻, 341.1939. C₂₂H₂₉SO requires M⁺-BF₄⁻,
341.1927).
(1S,3S,4R)-2-allyl-3-[(1S,4R)-7,7-dimethyl-2-oxobicyclo[2.2.1]hept-1-yl]-2-thioniabicyclo[2.2.1]heptane tetrafluoroborate (2b) (Method X)

Pale yellow powder (83 %); Rf = 0.45 (5 % MeOH in CH2Cl2); \( \nu_{\text{max}}/\text{cm}^{-1} \) 2938, 1735, 1038; m.p. 159-159.5 °C (CH2Cl2/Et2O); [\( \alpha \])D = -50.0 (c = 1.0 in CHCl3); \( ^1\)H NMR (400 MHz, CDCl3) 1.13 (3H, s, CH3), 1.22 (3H, s, CH3), 1.38-1.46 (1H, m, \( \text{C}^3\)H), 1.54-1.72 (3H, m, \( \text{C}^5\)H, \( \text{C}^7\)H), 1.98 (1H, d, \( J = 20.0 \text{ Hz, } \text{C}^3\)H), 2.06-2.28 (6H, m, \( \text{C}^4\)H, \( \text{C}^{12}\)H, \( 4 \times \text{CH} \)), 2.59 (1H, ddd, \( J = 20.0 \text{ Hz, } \text{C}^3\)H), 2.64 (1H, d, \( J = 14.0 \text{ Hz, } \text{C}^{12}\)H), 3.19 (1H, br. s, \( \text{C}^8\)H), 3.88 (1H, ddd, \( J = 13.5 \text{ and } 7.5 \text{ Hz } \text{SCHH} \)), 4.07 (1H, dd, \( J = 13.5 \text{ and } 7.5 \text{ Hz, } \text{SCHH} \)), 4.24 (1H, d, \( J = 2.0 \text{ Hz, } \text{C}^7\)H), 4.34 (1H, d, \( J = 4.5 \text{ Hz, } \text{C}^{11}\)H), 5.55 (1H, d, \( J = 10.0 \text{ Hz, } \text{H_b} \)), 5.73 (1H, d, \( J = 16.0 \text{ Hz, } \text{H_a} \)), 5.80-5.93 (1H, m, CH=CH2); \( ^{13}\)C NMR (100 MHz, CDCl3) 19.3, 22.0, 24.0, 26.8, 34.3, 41.1, 43.3, 44.1, 45.2, 46.3, 50.0, 57.7, 60.0, 68.9, 125.4, 126.9, 215.6; m/z (CI) 291 (\( M^+\)-\( \text{BF}_4^- \), 28%), 250 (30%), 217 (100%), (Found: \( M^+\)-\( \text{BF}_4^- \) 291.1787. \( \text{C}_{18}\)H_{27}SO requires \( M^+\)-\( \text{BF}_4^- \) 291.1783).

(1S,3S,4R)-3-[(1S,4R)-7,7-dimethyl-2-oxobicyclo[2.2.1]hept-1-yl]-2-(2-methyl-2-propenyl)-2-thioniabicyclo[2.2.1]heptane tetrafluoroborate (2c) (Method X)

White powder (91 %); Rf = 0.41 (5 % MeOH in CH2Cl2); (Found C, 58.05; H, 7.79; S, 7.99; \( \text{C}_{19}\)\( \text{H}_{29}\)\( \text{BF}_4\)OS requires C, 58.17; H, 7.45; S, 8.17 %); \( \nu_{\text{max}}/\text{cm}^{-1} \) 2932, 1734, 1029; m.p. 175-177 °C
(decom.)(CH$_2$Cl$_2$/petrol); $[\alpha]_D^{24} = -53.5$ (c = 1.0 in MeOH); $^1$H NMR (400 MHz, CDCl$_3$) 1.13 (3H, s, CH$_3$), 1.21 (3H, s, CH$_3$), 1.38-1.48 (1H, m, $CHH$), 1.48-1.57 (1H, m, $CHH$), 1.57-1.76 (2H, m, $C^5H_2$), 1.90 (3H, s, $CH_3C=CH_2$), 1.99 (1H, d, $J$ 19.0 Hz, $C^4HH$), 2.05-2.30 (6H, m, $C^4H$, $C^{11H}$, 4 $\times$ $CHH$), 2.56-2.69 (2H, m, $C^3HH$, $C^{12HH}$), 3.20 (1H, br. s, $C^8H$), 3.80 (1H, d, $J$ 13.0 Hz, SCH), 4.06 (1H, d, $J$ 13.0 Hz, SCH), 4.21 (1H, d, $J$ 2.0 Hz, $C^7H$), 4.28 (1H, d, $J$ 4.5 Hz, $C^{11H}$), 5.22 (1H, s, $C=CHH$), 5.40 (1H, s, $C=CHH$); $^{13}$C NMR (100 MHz, CDCl$_3$) 19.2, 21.5, 21.9, 24.4, 26.8, 26.9, 33.8, 41.2, 43.4, 44.2, 45.2, 50.0, 51.3, 58.3, 60.1, 69.3, 121.9, 133.9, 215.4; m/z (FAB) 305 ($M^+\text{-BF}_4^-$, 100%), 217 (25%).

$f{(1S,3S,4R)-3-[(1S,4R)-7,7-dimethyl-2-oxobicyclo[2.2.1]hept-1-yl]-2-[(2E)-2-methyl-3-phenyl-2-propenyl]-2-thioniabicyclo[2.2.1]heptane tetrafluoroborate (2d) (Method Y)\}$

![Structure of 2d](image)

White powder (86 %); $R_f = 0.35$ (5 % MeOH in CH$_2$Cl$_2$); (Found C, 64.49; H, 7.05; S, 6.50; C$_{23}$H$_{33}$BF$_4$OS requires C, 64.10; H, 7.10; S, 6.85 %); $\nu_{max}/$cm$^{-1}$ 2980, 1734, 1053, 1035; m.p. 136-138 °C; $[\alpha]_D^{24} = -95.7$ (c = 1.0 in CH$_2$Cl$_2$); $^1$H NMR (400 MHz, CDCl$_3$) 1.11 (3H, s, CH$_3$), 1.21 (3H, s, CH$_3$), 1.32-1.43 (1H, m, $C^5H$), 1.45-1.55 (1H, m, $C^5HH$), 1.55-1.70 (3H, m, CH$_2$CCH$_3$), 1.90-2.32 (9H, m, $C^{12HH}$, $C^3HH$, $C^4H$, 6 $\times$ $CHH$), 2.58 (1H, d, $J$ 19.0 Hz, $C^3HH$), 2.73 (1H, d, $J$ 12.5 Hz, $C^{12HH}$), 3.21 (1H, br. s, $C^8H$), 3.97 (1H, d, $J$ 13.0 Hz, SCH), 4.24 (1H, d, $J$ 13.0 Hz, SCH), 4.27 (1H, br. s, $C^{11H}$), 4.33 (1H, d, $J$ 2.5 Hz, $C^7H$), 6.89 (1H, s, $C=CHPh$), 7.24-7.38 (5H, m, ArH), $^{13}$C NMR (100 MHz, CDCl$_3$) 17.7, 19.3, 21.9, 24.5, 26.8, 27.0, 33.9, 41.4, 43.4, 44.2, 45.2, 50.0, 54.9, 58.3, 60.2, 68.9, 125.9, 127.9, 128.5, 129.1, 135.8, 136.0, 215.6; m/z (FAB) 381 ($M^+\text{-BF}_4^-$, 46%), 131 (100%).
(1S,3S,4R)-3-[(1S,4R)-7,7-dimethyl-2-oxobicyclo[2.2.1]hept-1-yl]-2-(3,3-diphenyl-2-propenyl)-
2-thioniabicyclo[2.2.1]heptane tetrafluoroborate (2e) (Method Y)

White solid (64 %); \( R_f = 0.35 \) (5 % MeOH in CH\(_2\)Cl\(_2\)); \nu_{max}/cm\(^{-1}\): 2964, 1732, 1495, 1445, 764, 707;
m.p. 160-161 °C (CH\(_2\)Cl\(_2\)/Et\(_2\)O); \([\alpha]D^{25}_D = -64.4\) (c = 1.9 in CH\(_2\)Cl\(_2\)); \(^1\)H NMR (400 MHz, CDCl\(_3\))
1.06 (3H, s, CH\(_3\)), 1.12 (1H, m, CH\(_2\)), 1.16 (3H, s, CH\(_3\)), 1.29 (1H, m, CH\(_2\)), 1.58 (2H, m, C\(^5\)H\(_2\)),
1.90-2.23 (7H, m, C\(^{12}\)HH, C\(^3\)HH, C\(^4\)H, 4 × CH\(_2\)), 2.44 (1H, d, J 13.0 Hz, C\(^{12}\)HH), 2.55 (1H, ddd, J
17.5, 5.5 and 2.0 Hz, C\(^3\)HH), 3.08 (1H, br. s, C\(^8\)H), 3.87 (1H, dd, J 13.0 and 8.5 Hz, SCH\(_2\)CH),
4.08 (1H, d, J 5.0 Hz, C\(^{11}\)H), 4.20 (2H, m, C\(^7\)H and SCH\(_2\)CH), 6.27 (1H, t, J 8.5 Hz, HC=C(Ph)\(_2\)),
7.18-7.48 (10H, m, ArH); \(^13\)C NMR (100 MHz, CDCl\(_3\)) 19.3, 21.9, 24.4, 26.8, 27.1, 33.1, 41.0,
42.9, 43.0, 44.1, 45.1, 49.9, 56.8, 60.3, 68.3, 113.6, 127.6, 128.6, 128.6, 129.1, 129.3, 129.5, 137.4,
139.6, 153.3; m/z (FAB) 443 (M\(^+\)-BF\(_4\)^-, 40%), 193 (100%).

Tetrahydro-1-(phenylmethyl)-thiophenium tetrafluoroborate\(^4\) (method Y)

White solid (95%); \( R_f = 0.15 \) (5% MeOH/CH\(_2\)Cl\(_2\)); m.p. 76.5-78 °C (EtOH) [lit.,\(^4\) 79-79.5 °C
(H\(_2\)O/EtOH/EtOAc); \(^1\)H NMR (400 MHz, CDCl\(_3\)) 2.21-2.37 (4H, m, CH\(_2\)), 3.39-3.60 (4H, m, CH\(_2\)),
4.55 (2H, s, CH\(_2\)Ph), 7.37-7.49 (5H, m, ArH).

General Procedure for Epoxidation Using KOH as Base (Method A)\(^5\)

To a stirred solution of the sulfonium salt (200 mg, 0.47 mmol) in a 9:1 acetonitrile/water mixture
(1.25 mL) at room temperature was added the freshly distilled aldehyde or ketone (0.47 mmol)
followed by powdered KOH (50.2 mg, 0.93 mmol). The reaction was then allowed to stirred at
room temperature for 2 hours. Water (2 mL) was added and the aqueous phase extracted with
dichloromethane (3 x 5 mL), the combined organic layers washed with water (2 mL), dried over MgSO₄ and concentrated in vacuo. The residue was then purified by column chromatography.

**General Procedure for Epoxidation at Low Temperature using P₂ Base (Method B)**

To a solution of the sulfonium salt (0.1 g, 0.23 mmol) in anhydrous solvent (0.8 mL) was added N,N,N’,N’’,N’-tetramethyl-N”-[tris(dimethylamino)phosphoralidene]phosphoric triamide ethylimine[7] (0.23 mmol) at −78 °C. After stirring for 10–15 min the desired aldehyde or ketone (0.23 mmol) was added dropwise and the reaction stirred for 1 hour (aldehydes) or 2 days (ketones) at −78 °C. After addition of a saturated solution of NaCl in water (1 mL), the organic phase was separated and the aqueous phase extracted with CH₂Cl₂ (3 x 5 mL). The organic phases were combined, filtered over MgSO₄, and concentrated in vacuo.

**General Procedure for Epoxidation at Low Temperature using KHMDS as Base (Method C)**

To a rapidly stirred suspension of the sulfonium salt (65 mg, 0.15 mmol) in anhydrous THF (0.6 mL) under an N₂ atmosphere at −78 °C, was added KHMDS (0.5 M in toluene, 300 µL, 0.15 mmol), at which point the sulfonium salt dissolved. The reaction mixture then was stirred at −78 °C for 2 h before addition of the desired carbonyl compound (0.15 mmol). Stirring was continued at −78 °C for 5 h and then a saturated solution of NaCl in water (1 mL) was added. The organic phase was separated and the aqueous phase extracted with CH₂Cl₂ (3 x 5 mL). The organic phases were combined, filtered over MgSO₄, and concentrated in vacuo.

**General Purification Method for Epoxides**

The crude epoxides were generally purified by flash column chromatography on silica gel (Merck Kieselgel 60F₂₅₄, 230-400 mesh). For the acid sensitive vinyl epoxides, the crude materials were purified by basic aluminum oxide (grade 5) [prepared by addition of 15% H₂O to Fluka type 5016 A basic alumina] eluting with 1% EtOAc in petroleum ether or by Kugelröhr distillation.
2,3-Diphenyloxirane (Table 1, entry 1)²

Purified by column chromatography eluting with 2% EtOAc/petrol. Trans isomer: White solid; R₇ = 0.40 (5% EtOAc/petrol); m.p. 65-66 °C (petrol) [Lit.,⁸ 65-67 °C (petrol)]; ¹H NMR (270 MHz, CDCl₃) 3.87 (2H, s, 2 × CH), 7.30-7.43 (10H, m, ArH). Cis isomer (not isolated): R₇ = 0.36 (5% EtOAc/petrol); ¹H NMR (270 MHz, CDCl₃) 4.39 (2H, s, 2 × CH), 7.16-7.19 (10H, m, ArH).

2-[(2R,3R)-3-phenyloxiran-2-yl]pyridine (Table 1, entry 2)⁹,¹⁰

Purified by column chromatography eluting with 10% EtOAc/petrol then 20% EtOAc/petrol. Trans isomer: white solid; R₇ = 0.22 (20% EtOAc/petrol); m.p. 51-53 °C [Lit.,⁹,¹⁰ 51-53 °C]; ¹H NMR (400 MHz, CDCl₃) 4.05 (1H, d, J 1.5 Hz, PhCHCH), 4.07 (1H, d, J 1.5 Hz, PhCH), 7.24-7.28 (2H, m, H₃, H₅), 7.31-7.40 (5H, m, ArH), 7.69-7.76 (1H, dt, J 8.0 and 2.0 Hz, H₄), 8.60 (1H, d m, J 5.0 Hz, H₆); ¹³C NMR (100 MHz) 61.9, 62.9, 120.2, 123.3, 125.8, 128.5, 128.6, 136.7, 136.9, 156.5. Cis isomer: colourless oil; R₇ = 0.10 (20% EtOAc/petrol); [α]₂₅⁰ (cis isomer, 80% ee) = +25.0 (c = 0.36, benzene) [Lit.,⁹ [α]₂₅⁰ (99.9% ee) = +82.0 (c = 0.36, benzene); ¹H NMR (270 MHz, CDCl₃) 4.46 (1H, d, J 5.5 Hz, PhCHCH), 4.49 (1H, d, J 5.5 Hz, PhCH), 7.02-7.12 (2H, m, H₃, H₅), 7.12-7.30 (5H, m, ArH), 7.40-7.50 (1H, dt, J 8.0, and 2.5 Hz, H₄), 8.45 (1H, d m, 5.5 and 1.0 Hz, H₆).

3-(3-phenyloxiranyl)-pyridine (Table 1, entry 3)⁹,¹⁰

Purified by column chromatography using eluting with 10% EtOAc/petrol to 30% EtOAc/petrol. Trans isomer: Colourless oil; R₇ = 0.28 (30% EtOAc/petrol); ¹H NMR (270 MHz, CDCl₃) 3.89 (1H,
d, $J$ 2.0 Hz, PhCHCH), 3.91 (1H, d, $J$ 2.0 Hz, PhCH), 7.30-7.44 (6H, m, ArH + H$_3$), 7.65 (1H, dt, $J$ 7.5 and 2.0 Hz, H$_5$), 8.59 (1H, dd, $J$ 4.5 and 2.0 Hz, H$_6$), 8.64 (1H, d, $J$ 2.0 Hz, H$_2$); $^{13}$C NMR (100 MHz, CDCl$_3$) 60.7, 62.8, 123.5, 125.5, 128.7, 132.7, 136.4, 140.0, 147.8, 149.7. Cis isomer (not isolated, observed in crude reaction mixture); $R_f$ = 0.40 (30% EtOAc/ petrol); $^1$H NMR (400 MHz, CDCl$_3$) 4.36 (1H, d, $J$ 4.5 Hz, PhCHCH), 4.44 (1H, d, $J$ 4.5 Hz, PhCH), 7.02-7.21 (6H, m, ArH and H$_5$), 7.30-7.48 (1H, m, H$_4$), 8.40 (1H, m, H$_6$), 8.49 (1H, m, H$_2$).

2-Butyl-3-phenyloxirane (Table 1, entry 4)$^2$

Purified by column chromatography eluting with 1% EtOAc/petrol to 10% EtOAc/petrol. Mixture of trans and cis isomers. Trans isomer: colourless oil; $R_f$ = 0.57 (10% EtOAc/petrol); $^1$H NMR (400 MHz, CDCl$_3$) 0.74-0.98 (3H, m, CH$_3$), 1.18-1.76 (6H, m, 3 × CH$_2$), 2.95 (1H, td, $J$ 5.5 and 2.0 Hz, CH$_2$CH), 3.60 (1H, d, $J$ 2.0 Hz, PhCHCH), 7.23-7.39 (5H, m, ArH). Cis isomer: colourless oil; $R_f$ = 0.51 (10% EtOAc/petrol); $^1$H NMR (400 MHz, CDCl$_3$) 0.74-0.98 (3H, m, CH$_3$), 1.18-1.76 (6H, m, 3 × CH$_2$), 3.20 (1H, m, CH$_2$CH), 4.07 (1H, d, $J$ 4.0 Hz, PhCHCH), 7.23-7.39 (5H, m, ArH).

2-Phenyl-3-vinyloxirane (Table 1, entry 5 and 13)$^6,11,12$

Purified by Kugelröhr distillation at 50 °C / 2 mmHg. Isolated as a cis/trans mixture; Trans isomer: colourless oil; $R_f$ = 0.60 (20% EtOAc/petrol); [$\alpha$]$_D^{25}$ (trans isomer, 99% ee) = +89.0 (c = 0.3, CHCl$_3$) [Lit.,$^{11}$ [S,S] enantiomer, [$\alpha$]$_D^{25}$ = -14.2 (c = 0.88, CHCl$_3$); $^1$H NMR (270 MHz, CDCl$_3$) 3.36 (1H, dd, $J$ 7.5 and 2.0 Hz, PhCHCH), 3.77 (1H, d, $J$ 2.0 Hz, PhCH), 5.34 (1H, dd, $J$ 10.5 and 1.5 Hz, CH=CHH), 5.52 (1H, dd, $J$ 17.0 and 1.5 Hz, CH=CHH), 5.65-5.85 (1H, m, CH=CH$_2$), 7.10-7.45 (5H, m, ArH); $^{13}$C NMR (67.5 MHz, CDCl$_3$) 60.22, 62.9, 119.5, 125.5, 128.2, 128.5, 135.1. Cis isomer (not isolated observed in crude reaction mixture from table 1, entry 5 method A); $^1$H NMR (400 MHz, CDCl$_3$) 3.67 (1H, dd, $J$ 6.0 and 4.0 Hz, PhCHCH), 4.25 (1H, d, $J$ 4.0 Hz, PhCH), 5.20-5.85 (3H, m, CH=CH$_2$, CH=CH$_2$), 7.10-7.45 (5H, m, ArH).
2-Phenyl-3-isopropenyloxirane (Table 1, entry 6 and 14)\textsuperscript{12,13}

Purified by Kugelröhrr distillation at 50 °C / 2 mmHg. Isolated as a cis/trans mixture; Trans isomer: colourless oil; $R_f = 0.34$ (5% EtOAc/petrol). $^1$H NMR (270 MHz, CDCl$_3$) 1.75 (3H, t, $J$ 1.5 Hz, CH$_3$), 3.37 (1H, d, $J$ 2.0 Hz, PhCHCH), 3.81 (1H, d, $J$ 2.0 Hz, PhCH), 5.04-5.08 (1H, m, C=CHH), 5.17-5.20 (1H, m, C=CHH), 7.27-7.41 (5H, m, ArH); $^1^3$C NMR (100 MHz, CDCl$_3$) 17.0, 58.4, 64.9, 114.2, 125.6, 128.2, 128.5, 137.5, 141.1; cis isomer (not isolated observed in crude reaction mixture from table 1, entry 6 method A): $R_f = 0.34$ (5% EtOAc/petrol); $^1$H NMR (270 MHz, CDCl$_3$) 1.45-1.54 (3H, m, CH$_3$), 3.67 (1H, d, $J$ 5.5 Hz, PhCHCH), 4.19 (1H, d, $J$ 5.5 Hz, PhCH), 4.86-4.89 (1H, m, C=CHH), 4.99-5.02 (1H, m, C=CHH), 7.27-7.41 (5H, m, ArH).

2-Phenyl-3-[(E)-1-propenyl]oxirane (Table 1, entry 7)\textsuperscript{2,12}

Purified by Kugelröhr distillation at 75 °C / 2 mmHg. Isolated as a cis/trans mixture; Trans isomer: colourless oil; $R_f = 0.30$ (5% EtOAc / 1% NEt$_3$ / petroleum ether); $[\alpha]_D^{25}$ (95% ee) = +87.0 (c = 0.21 in CHCl$_3$); $^1$H NMR (270 MHz, CDCl$_3$) 1.76 (3H, dd, $J$ 7.0 and 2.0 Hz, CH$_3$), 3.32 (1H, dd, $J$ 8.0 and 2.0 Hz PhCHCH), 3.76 (1H, d, $J$ 2.0 Hz, PhCH), 5.35 (1H, ddq, $J$ 15.5, 7.0 and 2.0 Hz, CH=CHCH$_3$), 5.98 (1H, dq, $J$ 15.5 and 6.5 Hz, CH=CHCH$_3$), 7.24-7.40 (5H, m, ArH). Cis isomer; observed in crude reaction mixture from table 1, entry 7 method A); $^1$H NMR (400 MHz, CDCl$_3$) 1.65 (3H, dd, $J$ 7.0 and 2.0 Hz, CH$_3$), 3.64 (1H, dd, $J$ 9.0 and 4.0 Hz PhCHCH), 4.21 (1H, d, $J$ 4.0 Hz, PhCH), 5.03 (1H, ddq, $J$ 15.5, 9.0 and 2.0 Hz, CH=CHCH$_3$), 5.94-6.04 (1H, m, CHCHCH$_3$), 7.24-7.40 (5H, m, ArH).

Tris(1-methylethyl)[(3-phenyloxiranyl)ethynyl]-silane (Table 1, entry 8)\textsuperscript{14}

Purified by column chromatography eluting with petrol to 2% EtOAc/petrol. Mixture of trans and cis isomers. The pure trans isomer and a cis/trans mixture were isolated by chromatography. Trans isomer: colourless oil; $R_f = 0.63$ (2% EtOAc/petrol); $[\alpha]_D^{25}$ (trans isomer, 99% ee) = +96.0 (c = 0.07, CH$_2$Cl$_2$); $\nu_{\text{max}}$(film)/cm$^{-1}$ 3066, 3035, 2942, 2171; $^1$H NMR (400 MHz, CDCl$_3$), 1.09 (21H, s, 3xPr$_i$), 3.38 (1H, d, $J$ 2.0 Hz, PhCHCH), 4.00 (1H, d, $J$ 2.0 Hz, PhCH), 7.25-7.45 (5H, m, ArH); cis
isomer: \( R_f = 0.55 \) (2% EtOAc/petrol); \(^1\text{H NMR} (400 \text{ MHz, CDCl}_3) 0.93 \) (21H, s, 3 × i-Pr), 3.77 (1H, d, \( J \approx 3.9 \text{ Hz, PhCHCH} \)), 4.11 (1H, d, \( J \approx 3.9 \text{ Hz, PhCH} \)), 7.25-7.45 (5H, m, ArH).\(^{13}\text{C NMR} \) [mixture of trans and cis 1.2:1] (100 MHz, CDCl\(_3\)) 11.1, 11.2, 18.4, 18.6, 48.5, 49.7, 59.1, 60.4, 86.1, 88.0, 101.1, 103.1, 125.7, 126.9, 127.9, 128.2, 128.6, 134.1, 135.8, 137.0; \( m/z \) (EI) 300 (\( M^+ \), 46%), 84 (100), (Found \([M^+H]^+\) 301.1918 \( C_{19}H_{28}OSi \) requires \( m/z \) 301.1943).

\((2R)-2\)-Phenyl-1-oxaspiro[2.5]octane (Table 1, entry 9)\(^{15-17}\)

Purified by column chromatography eluting with 2% EtOAc/petrol to 10% EtOAc/petrol. Colourless oil, \( R_f = 0.29 \) (5% EtOAc/petrol); \( [\alpha]_D^{25} = +68.0 \) (c = 2.5, pentane) [Lit.,\(^{15}\) (S) enantiomer, \( [\alpha]_D^{25} \) (92% ee) = -26.5 (c = 2.5, pentane); \(^1\text{H NMR} (400 \text{ MHz, CDCl}_3) 1.21-1.90 \) (10H, m, \( 5 \times CH_2 \)), 3.86 (1H, s, PhCH), 7.24-7.37 (5H, m, ArH); \(^{13}\text{C NMR} (100 \text{ MHz, CDCl}_3) \) 24.6, 25.4, 25.6, 28.5, 35.5, 64.6, 65.5, 126.4, 127.3, 128, 136.4.

\(6\)-t-Butyl-2-phenyl-1-oxa- spiro[2.5]octane (Table 1, entry 10).

White solid; \( R_f = 0.35 \) (5% EtOAc in petroleum ether); (Found C, 83.52; H, 10.20; \( C_{17}H_{24}O \) requires C, 83.55; H, 9.90 %); \( \nu_{\text{max}}/\text{cm}^{-1} \) 2953, 1367, 742, 697; m.p. 61-63 °C; \( [\alpha]_D^{25} (>99\% \text{ ee}) = -6.8 \) (c = 1.0 in MeOH); \(^1\text{H NMR} (400 \text{ MHz, CDCl}_3) 0.89 \) (9H, s, \( 3 \times CH_3 \)), 1.02-0.13 (1H, m, \( CH \)), 1.22-1.39 (3H, m, \( CH \)), 1.39-1.53 (2H, m, \( 2 \times CH \)), 1.69-1.80 (1H, m, \( CH \)), 1.80-1.88 (1H, m, \( CH \)), 1.91-2.01 (1H, m, \( CH \)), 3.90 (1H, s, PhCH), 7.24-7.37 (5H, m, ArH); \(^{13}\text{C NMR} (100 \text{ MHz, CDCl}_3) \) 24.9, 25.1, 27.7, 28.5, 32.6, 35.2, 47.8, 64.2, 65.0, 126.4, 127.3, 128.0, 136.5. \( m/z \) (EI) 244 (\( M^+ \), 13%), 226 (7), 215 (8), 169 (49), 141 (13), 128 (6), 115 (8), 105 (19), 91 (64), 84 (100), 57 (41); (Found \( M^+ \) 244.1834 \( C_{17}H_{24}O \) requires \( m/z \) 244.1827).

\(2\)-Methyl-2,3-diphenyloxirane (Table 1, entry 11)\(^{18,19}\)

Colourless oil; major product cis; confirmed by nOe experiment. Purified by chromatography on aluminium oxide (grade 5) eluting with 2% EtOAc/petroleum ether as the trans isomer was
unstable on silica gel. Mixture of trans and cis isomers was isolated. **Trans isomer:** \( R_f = 0.45 \) (10% EtOAc in petroleum ether); \(^1\)H NMR (400 MHz, CDCl\(_3\)) 1.47 (3H, s, CH\(_3\)), 3.98 (1H, s, CH), 7.30 – 7.50 (10H, m, ArH); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)) 16.7, 63.0, 67.0, 126.5, 126.9, 127.4, 127.6, 128.1, 128.4, 135.9, 142.3; **cis isomer:** observed in crude reaction mixture from table 1, entry 11 method B); \( R_f = 0.42 \) (10% EtOAc in petroleum ether); \(^1\)H NMR (400 MHz, CDCl\(_3\)) 4.15 (1H, s, CH), 7.00 – 7.20 (10H, m, ArH); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)) 126.5, 65.5, 65.9, 125.1, 126.4, 127.0, 127.2, 127.5, 127.7, 135.5, 138.4.

**2S,3R)-2-Methyl-2-(4-nitrophenyl)-3-phenyloxirane (Table 1, entry 12)**\(^{17}\)

Purified by column chromatography eluting with 10% EtOAc/petrol to 20% EtOAc/petrol. Cis configuration confirmed by nOe experiment. White crystalline solid; \( R_f = 0.42 \) (20% EtOAc/petrol); m.p. 74-75 °C (EtOAC/petrol)[Lit.(racemate),\(^{17}\) (126-128 °C)]; \([\alpha]_D^{25}\) (cis isomer, 71% ee) = -49.0 (c = 1.0, CHCl\(_3\)); \(^1\)H NMR (400 MHz, CDCl\(_3\)) 1.82 (3H, s, CH\(_3\)), 4.25 (1H, s, PhCH), 7.0 – 7.42 (7H, m, ArH), 8.02-8.07 (2H, m, ArH); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)) 123.2, 126.3, 127.8, 127.9, 128.0, 134.6, 145.9, 147.1.

**2R,3R)-2-[(E)-1-Methyl-2-phenylethenyl]-3-phenyl-oxirane (Table 1, entry 15)**

Purified by chromatography on aluminium oxide (grade 2) eluting with petroleum ether to petroleum ether/CH\(_2\)Cl\(_2\) (7:3) as epoxide was unstable on silica gel. **Trans isomer:** Colourless oil; \( R_f = 0.38 \) (5% EtOAc in petroleum ether); \( \nu_{\text{max}} \) (film) cm\(^{-1}\) 3025, 2985, 1600, 1495, 1455, 1013, 845, 750, 695; \([\alpha]_D^{25}\) (trans isomer) = +337.3 (c = 1.0 in CH\(_2\)Cl\(_2\)); \(^1\)H NMR (400 MHz, CDCl\(_3\)) 1.88 (3H, d, \( J = 1.3 \) Hz, CH\(_3\)), 3.49 (1H, dd, \( J = 1.3 \) Hz, 1.9 Hz, CH), 3.89 (1H, \( J = 1.9 \) Hz, CH), 6.68 (1H, br. s, CH), 7.30-7.37 (10H, m, ArH); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)) 12.8, 58.5, 66.7, 125.6, 126.9, 128.3, 128.6, 128.7, 129.0, 133.7, 137.1, 137.5; \( m/z \) (CI) 237 (\( M^+ +1 \), 25 %); (Found [M+H]\(^+\) 237.1278. \( C_{17}H_{17}O \) requires \( m/z \), 237.1279).
2-(2,2-Diphenylethenyl)-3-phenyl-oxirane (Table 1, entry 16)²

Purified by chromatography on aluminium oxide (grade 5) eluting with 1 % CH₂Cl₂/petroleum ether as the epoxide isomer was unstable on silica gel. Yellow crystalline solid; Rᵥ = 0.53 (20 % EtOAc in petroleum ether); m.p. 71-74 °C; ¹H NMR (400 MHz, CDCl₃) Trans isomer: 3.46 (1H, dd, J = 8.9, 2.1 Hz, OCH), 3.95 (1H, d, J = 2.1 Hz, OCHPh), 5.85 (1H, d, J = 8.5 Hz, CH), 7.20-7.45 (15H, m, ArH); ¹³C NMR (63 MHz, CDCl₃) 60.6, 60.8, 126.4, 127.6, 128.4, 136.8, 138.5, 141.4, 148.0; ¹H NMR (400 MHz, CDCl₃); cis isomer: 3.72 (1H, dd, J = 9.2, 4.5 Hz, OCH), 4.25 (1H, d, J = 4.3 Hz, OCHPh), 5.61 (1H, d, J = 9.2 Hz, CH), 7.20-7.45 (15H, m, ArH); ¹³C NMR (63 MHz, CDCl₃) 57.4, 60.0, 121.9, 127.6-128.4, 135.3, 138.8, 149.5; m/z (CI) 299 (M⁺1, 20%); (Found [M+H]⁺ 299.1421 C₂₂H₁₈O requires m/z, 299.1426).

Total Synthesis of CDP-840

3-Hydroxy-4-methoxybenzaldehyde²⁰

Isovanillin (1 g, 6.5 mmol) and oven dried potassium carbonate (1.38 g, 10 mmol) were added to DMF (6 mL) at room temperature. The mixture was heated to 60 °C and cyclopentyl bromide (1.12 mL, 10.5 mmol) was added slowly. The mixture was stirred overnight at the same temperature and then cooled to room temperature. Water was added and the aqueous layer was extracted with petroleum ether (3 × 10 mL). The organic layer was dried over MgSO₄, filtered, and concentrated in vacuo. The residual oil was purified by flash chromatography (10 % EtOAc in petroleum ether, Rᵥ = 0.11) to give the aldehyde as a yellow oil (1.38 g, 97 %); νₘₐₓ(film)/cm⁻¹ 2958, 1683, 1507, 1259, 1237, 1130; ¹H NMR (400 MHz, CDCl₃) 1.55-2.10 (8H, m, 4 x CH₂), 3.93 (3H, s, OCH₃), 4.86 (1H, m, CH), 6.96 (1H, d, J = 8 Hz, ArH), 7.37-7.46 (2H, m, ArH), 9.84 (1H, s, CHO); ¹³C NMR (100 MHz, CDCl₃) 24.1, 32.8, 56.2, 80.6, 110.9, 112.4, 126.3, 130.1, 148.4, 155.5, 191.0; m/z (EI) 220 (M⁺, 11 %), 168 (30), 152 (100), 137 (7), 123 (9), 109 (11), 95 (11), 84 (82), 69 (19), 57 (24).
[3-(Cyclopentyloxy)-4-methoxyphenyl]methanol (6)

To a MeOH (5 mL) solution of 3-hydroxy-4-methoxybenzaldehyde (880 mg, 4.0 mmol), NaBH₄ (150 mg, 4.0 mmol) was slowly added at 0 °C. The solution was stirred for 1 h, and then the solvent was evaporated. Water (10 mL) was added and the aqueous layer extracted with EtOAc (3 × 10 mL). The organic layer was dried over MgSO₄, filtered, and concentrated in vacuo. Flash chromatography (33 % EtOAc in petroleum ether) gave 5 as a colorless oil (890 mg, 100 %); Rᵥ = 0.41 (50 % EtOAc in petroleum ether); (Found C, 70.32; H, 8.33; C₁₃H₁₈O₃ requires C, 70.24; H, 8.16); νₘₐₓ(film)/cm⁻¹ 3379, 1511, 1257, 1232, 1157, 1024, 990; ¹H NMR (400 MHz, CDCl₃) 1.65-2.00 (8H, m, 4 × CH₂), 3.84 (3H, s, OCH₃), 4.60 (2H, s, ArCH₂OH), 4.79 (1H, m, CH), 6.84(1H, d, J = 8.1 Hz, ArH), 6.87 (1H, d, J = 8.1, 1.2 Hz, ArH), 6.92 (1H, d, J = 1.2 Hz, ArH); ¹³C NMR (100 MHz, CDCl₃) 24.0, 32.9, 56.2, 65.3, 65.4, 80.5, 112.1, 114.3, 119.3, 133.6, 147.9, 149.8; m/z (EI) 222 (M⁺, 14 %), 154 (92), 137 (26), 125 (22), 93 (24), 84 (100), 67 (20); (Found M⁺ 222.1256 C₁₃H₁₈O₃ requires m/z 222.1256).

2-(3-Cyclopentyloxy-4-methoxybenzyl)-3-[(1S)-7,7-dimehtyl-2-oxo-bicyclo[2.2.1]hept-1-yl]- (3R)-2-thionia-bicyclo[2.2.1]heptane tetrafluoroborate (5)

A 54 wt % HBF₄ solution in Et₂O (105 μL, 0.75 mmol) was slowly added to a solution of alcohol 5 (111 mg, 0.5 mmol) and sulfide ent-1 (250 mg, 1.0 mmol) in Et₂O (3 mL) under nitrogen. After 4 h, the precipitated was collected by filtration. The salt was washed with Et₂O (3 × 5 mL) and then dried under vacuum. Salt 4 was obtained as a white solid (217 mg, 80%); Rᵥ = 0.14 (10 % MeOH in CH₂Cl₂); (Found C, 61.78; H, 7.19; S, 5.83; C₂₈H₃₉BF₄SO₃ requires C, 61.99; H, 7.25; S, 5.91 %); νₘₐₓ/cm⁻¹ 2956, 1740, 1515, 1263, 1027; m.p. 133-135 °C (decom.); [α]D²⁴ = +40.4 (c = 1 in CH₂Cl₂); ¹H NMR (400 MHz, CDCl₃) 1.09 (3H, s, CH₃), 1.16 (3H, s, CH₃), 1.15-1.32 (2H, m), 1.50-2.30 (17H, m), 2.54 (1H, ddd, J = 18.6, 4.4, 2.7 Hz, COCHH), 2.77 (1H, d, J = 12.7 Hz, SCHCHH), 3.19 (1H, br s, SCHCH), 3.82 (3H, s, OCH₃), 4.21(1H, d, J = 4.4 Hz, SCHCH₂), 4.24 (1H, d, J = 1.5 Hz, SCHCH), 4.36 (1H, d, J = 13.2 Hz, ArCHHS), 4.60 (1H, d, J = 13.2 Hz,
ArCH(HS), 4.84 (1H, m, OCH), 6.81 (1H, d, J = 8.3 Hz, ArH), 6.95-7.05 (2H, m, ArH); $^{13}$C NMR (100 MHz, CDCl$_3$) 19.1, 21.9, 24.1, 24.5, 26.7, 26.8, 32.8, 33.5, 41.2, 43.5, 44.1, 45.3, 48.5, 49.8, 56.2, 58.0, 60.1, 68.7, 80.8, 112.6, 116.5, 120.5, 123.2, 148.6, 151.4, 215.4; m/z (FAB) 455 ($M^+\cdot BF_4^-$, 10 %) 205 (100).

4-{3-[3-(Cyclopentyloxy)-4-methoxyphenyl]oxiran-2-yl}pyridine (4)

To a stirred solution of 4 (240 mg, 0.44 mmol) in CH$_2$Cl$_2$ (5 mL) was added N,N,N$'$,N$'$,N$''$-tetramethyl-N$''$-[tris(dimethylamino)phosphoralidene]phosphoric triamide ethylimine (142 µL, 0.44 mmol) at −78 °C under nitrogen. After 10 min, 4-pyridinecarboxaldehyde (150 µL, 0.45 mmol) was added to the solution. After an additional 1 h stirring, the mixture was warmed to room temperature and then saturated NaCl solution (10 mL) was added. The organic layer was separated and the aqueous layer extracted with EtOAc (3 × 5 mL). The combined organic layers were dried over Na$_2$SO$_4$, filtered, and concentrated in vacuo. The crude mixture was purified on basic alumina (grade 5) (5% EtOAc in petroleum ether) to give a mixture of trans:cis = 7:3 (120 mg, 89 %); R$_f$ = 0.30 (2% EtOAc in petroleum ether on Al$_2$O$_3$); (Found C, 73.10; H, 6.62; N, 4.31; C$_{19}$H$_{21}$NO$_3$ requires C, 73.29; H, 6.80; N, 4.50 %); $\nu_{\text{max}}$/cm$^{-1}$ 2958, 1513, 1257, 1133; $^1$H NMR trans isomer : 1.48-2.01 (8H, m, 4 × CH$_2$), 3.78 (1H, d, J = 1.6 Hz CH), 3.83 (1H, d, J = 1.6 Hz CH), 3.86 (3H, s, OCH$_3$), 4.79 (1H, m, CH), 6.83 (1H, s, ArH), 6.87 (1H, d, J = 8.1 Hz, ArH), 6.89 (1H, dd, J = 8.1, 1.3 Hz, ArH), 7.27 (2H, d, J = 5.8Hz, ArH), 8.61 (2H, d, J = 5.8Hz, ArH); cis isomer : 1.48-2.01 (8H, m, 4 × CH$_2$), 3.75 (3H, s, OCH$_3$), 4.26 (1H, d, J = 4.2 Hz, CH), 4.36 (1H, d, J = 4.2 Hz, CH), 4.57 (1H, m, CH), 6.59 (1H, d, J = 1.6 Hz, ArH), 6.69 (1H, d, J = 8.1 Hz, ArH), 6.73 (1H, dd, J = 8.1, 1.6 Hz, ArH), 7.12 (2H, d, J = 6.1 Hz, ArH), 8.43 (2H, d, J = 6.1 Hz, ArH); $^{13}$C NMR (100 MHz, CDCl$_3$) 24.0, 32.8, 32.9, 56.0, 56.2, 58.5, 59.7, 61.1, 63.1, 80.5, 80.7, 111.6, 111.8, 112.1, 113.6, 118.4, 119.5, 120.4, 121.9, 122.2, 125.7, 128.6, 143.9, 146.3, 147.3, 148.2, 149.3, 149.9, 150.0, 150.1, 150.7, 151.3; m/z (EI) 311($M^+$, 65 %), 282 (24), 271 (33), 214 (24), 137 (61), 84 (100); (Found $M^+$ 311.1521 C$_{19}$H$_{21}$NO$_3$ requires m/z 311.1521).
(2R)-2-[3-(Cyclopentyloxy)-4-methoxyphenyl]-2-phenyl-1-(4-pyridyl)ethanol (3)\textsuperscript{20}

To a stirred solution of CuI (19 mg, 0.1 mmol) in THF (1 mL) was slowly added PhMgBr (1.0 mL, 1.0M solution in THF) at −40 °C under nitrogen. After 10 min, 3 (120 mg, 0.39 mmol) in THF (2 mL) was slowly added via canula. The stirring was continued for 15 h during which time the reaction mixture was allowed to rise to room temperature. A saturated NH\textsubscript{4}Cl solution/35 % NH\textsubscript{4}OH solution (2:1, 10 mL) was added and the mixture stirred for an additional 1 h. The organic layer was separated and the aqueous layer extracted with EtOAc (3 × 5 mL). The combined organic layers were dried over MgSO\textsubscript{4}, filtered and concentrated \textit{in vacuo}. The crude mixture was purified by flash chromatography (EtOAc) to give the alcohol as an oil (\textit{syn:anti} = 3:7), (130 mg, 85 %); \textit{Rf} = 0.29 (EtOAc); \textit{ν}_{\text{max}}(film)/cm\textsuperscript{-1} 3028, 2957, 1602, 1509, 1260, 1137, 728, 700; \textit{\textit{1H NMR}} (400 MHz, CDCl\textsubscript{3}) \textit{anti isomer}: 1.50-1.92 (8H, m, 4 × CH\textsubscript{2}), 3.60 (1H, br, O\textit{H}), 3.79 (3H, s, OCH\textsubscript{3}), 4.09 (1H, d, \textit{J} = 7.8 Hz, CH), 4.68 (1H, m, CH), 5.29 (1H, d, \textit{J} = 7.8 Hz, CH), 6.76-6.88 (3H, m, ArH), 7.00–7.40 (7H, m, ArH), 8.30 (2H, br s, ArH) \textit{syn isomer}: 1.50-1.92 (8H, m, 4 × CH\textsubscript{2}), 3.73 (3H, s, OCH\textsubscript{3}), 4.07 (1H, d, \textit{J} = 9.0 Hz, CH), 4.56 (1H, m, CH), 5.26 (1H, d, \textit{J} = 9.0 Hz, CH), 6.58 (1H, d, \textit{J} = 1.5 Hz, ArH), 6.61 (1H, dd, \textit{J} = 8.3, 1.5 Hz, ArH), 6.65 (1H, d, \textit{J} = 8.3 Hz, ArH), 7.00 – 7.40 (7H, m, ArH), 8.30 (2H, br s, ArH); \textit{\textit{13C NMR}} (100 MHz, CDCl\textsubscript{3}) 24.1, 32.7, 32.8, 32.9, 59.2, 59.4, 75.4, 75.7, 80.6, 112.1, 112.3, 116.2, 116.5, 120.9, 121.2, 121.9, 122.0, 122.1, 126.8, 126.9, 127.1, 128.5, 128.8, 128.9, 132.1, 133.4, 140.5, 141.3, 147.4, 147.8, 149.0, 149.1, 149.4, 152.1; \textit{m/z} (EI) 389 (\textit{M}\textsuperscript{+}, 28 %), 281 (100), 213 (72), 181 (30), 152 (40), 86 (42), 84 (50); (Found \textit{M}\textsuperscript{+} 389.2000 C\textsubscript{25}H\textsubscript{27}NO\textsubscript{3} requires \textit{m/z} 389.1991).

(2R)-1-[3-(Cyclopentyloxy)-4-methoxyphenyl]-1-phenyl-2-(4-pyridyl)ethane, CDP 840\textsuperscript{21}

Triethylamine (100 µL, 0.65 mmol) was added to (2R)-2-[3-(cyclopentyloxy)-4-methoxyphenyl]-2-phenyl-1-(4-pyridyl)ethanol (130 mg, 0.33 mmol) in CH\textsubscript{2}Cl\textsubscript{2} (3 mL) at 0 °C. Methanesulfonyl chloride (40 µL) was added to this stirring solution and the solution was aged 30 min. The solvent was evaporated \textit{in vacuo}, the residue was dissolved in acetic acid (1 mL), and zinc dust (65 mg,
1.0 mmol) was added. The mixture was stirred at room temperature for 5 h and was then diluted with methyl \(t\)-butyl ether (5 mL) and water (5 mL). A 5N NaOH solution was added dropwise until pH 11 and the organic phase was concentrated in vacuo. The residual oil was purified by flash chromatography (33 % EtOAc in petroleum ether), to give CDP-840 as a colourless oil (97 mg, 79 %). \(R_f = 0.29 \) (EtOAc); \(\nu_{\max}\) (film)/cm\(^{-1}\) 2954, 1507, 1258, 1135, 699; \([\alpha]_D^{23} = +38.6 \) (c = 1.0 in MeOH); [Lit., +37.0 (c = 1.5 in EtOH)]\(^{22}\); \(^1\)H NMR (400 MHz, CDCl\(_3\)) 1.48-1.64 (2H, m, \(CH_2\)), 1.70-1.89 (6H, m, 3 \(\times CH_2\)), 3.31 (2H, d, \(J = 7.3\) Hz, \(CH_2\)), 3.78 (3H, s, O\(CH_3\)), 4.14 (1H, t, \(J = 7.7\) Hz, \(CH\)), 4.65 (1H, m, \(CH\)), 6.65 (1H, d, \(J = 1.7\) Hz, Ar\(H\)), 6.68 (1H, dd, \(J = 8.3, 1.7\) Hz, Ar\(H\)), 6.74 (1H, d, \(J = 8.3\) Hz, Ar\(H\)), 6.92 (2H, d, \(J = 5.3\)Hz, Ar\(H\)), 7.14-7.30 (5H, m, Ar\(H\)), 8.38 (2H, d, \(J = 5.3\) Hz, Ar\(H\)); \(^{13}\)C NMR (100 MHz, CDCl\(_3\)) 24.1, 32.8, 32.9, 41.7, 51.6, 56.1, 80.6, 112.1, 115.6, 120.1, 124.6, 126.5, 127.8, 128.6, 136.1, 144.0, 147.5, 148.9, 149.5; \(m/z\) (EI) 373 (\(M^+\), 24 %), 305 (10), 281 (42), 213 (100), 197 (6), 181 (22), 169 (6), 165 (12), 152 (30), 141 (14), 115 (12), 93 (6), 69 (12), 65 (6)
### [α]D and HPLC Conditions for Determining Absolute Configuration.

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<td>30.7[c] (2R, 3R)</td>
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<td>1.0 99:1 OD</td>
<td>11.8[b]</td>
</tr>
<tr>
<td><img src="image6" alt="Image" /></td>
<td>0.5 99.5:0.5 OD</td>
<td>12.1 (2S, 3S)</td>
<td>16.8[b] (2R, 3R)</td>
<td>+ 89.0 (c=0.3, CHCl3)</td>
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<td></td>
</tr>
<tr>
<td><img src="image7" alt="Image" /></td>
<td>1.0 98:2 OD</td>
<td>4.7 (2S, 3S)</td>
<td>6.1[k] (2R, 3R)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><img src="image8" alt="Image" /></td>
<td>0.5 99.5:0.5 OD</td>
<td>13.5 (2S, 3S)</td>
<td>22.8[c] (2R, 3R)</td>
<td>+ 87.0 (c=0.21, CHCl3)</td>
<td></td>
<td></td>
</tr>
<tr>
<td><img src="image9" alt="Image" /></td>
<td>0.7 99.9:0.1 OD</td>
<td>12.4 (2S, 3S)</td>
<td>13.5[c] (2R, 3R)</td>
<td>+ 96.0 (c=0.07, CH3Cl2)</td>
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<td></td>
</tr>
<tr>
<td><img src="image10" alt="Image" /></td>
<td>0.5 99:1 OD</td>
<td>10.1 (S)</td>
<td>11.8[b] (R)</td>
<td>+ 68.0 (R) (c=2.5, pentane)</td>
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<table>
<thead>
<tr>
<th>Entry</th>
<th>Ratio</th>
<th>Solvent</th>
<th>Retention Time (min)</th>
<th>Configuration</th>
<th>Absolute Configuration</th>
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<tr>
<td>1</td>
<td>1.5</td>
<td>99.5:0.5</td>
<td>OD</td>
<td>14.8</td>
<td>12.1[^c] (S)</td>
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<td>-6.8 (c=1, MeOH)</td>
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<tr>
<td>2</td>
<td>1.0</td>
<td>99:1</td>
<td>OJ[^d]</td>
<td>11.4</td>
<td>16.1[^a] (2S, 3S)</td>
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<td>(2R, 3R)</td>
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<td>OJ[^d]</td>
<td>13.0</td>
<td>7.6[^c] (2R, 3S)</td>
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<td>OD-H[^d]</td>
<td>14.2</td>
<td>12.4[^c] (2R, 3S)</td>
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<td>OD</td>
<td>10.7</td>
<td>15.8[^c] (2S, 3S)</td>
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<td>(2R, 3R)</td>
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<tr>
<td>6</td>
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<td>99:1</td>
<td>OD</td>
<td>14.6</td>
<td>11.7[^c] (2S, 3S)</td>
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<td>7</td>
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<td>95:5</td>
<td>OD</td>
<td>15.6</td>
<td>22.9[^c] (2R, 3S)</td>
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<tr>
<td>8</td>
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<td>95:5</td>
<td>OD</td>
<td>14.5</td>
<td>12.9[^c] (2R, 3S)</td>
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<tr>
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<td>90:10</td>
<td>OD</td>
<td>14.3</td>
<td>12.3[^b] (S)</td>
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<td>(R)</td>
</tr>
</tbody>
</table>

[^a] Absolute configuration assigned by comparison of HPLC retention times with literature.

[^b] Absolute configuration assigned by comparison of optical rotation with literature.

[^c] Absolute configuration assigned by analogy with other epoxides given in table.

[^d] Adequate separation could not be obtained using OD column.


HPLC traces

(2R, 3R)-2,3-Diphenyloxirane

![Chemical structure of (2R, 3R)-2,3-Diphenyloxirane](image)

OD Chiralcel. 2mL/min. 99:1 hexane:IPA, 20 °C.

Racemic

Asymmetric, 98% ee
2-[(2R,3R)-3-Phenyloxiran-2-yl]pyridine

ODH Chiralcel. 1mL/min. 90:10 Hexane:IPA, 20 °C.

Racemic

Asymmetric, 99% ee
2-[(2S,3R)-3-Phenylloxiran-2-yl]pyridine

OJ Chiralcel. 1mL/min. 98:2 Hexane:IPA, 10 °C.

Racemic

Asymmetric, 80% ee
3-[(2R,3R)-3-Phenyloxiran-2-y]pyridine

ODH Chiralcel. 1mL/min. 90:10 Hexane:IPA, 20 °C.

Racemic

Asymmetric, >99% ee
(2R,3R)-2-\textit{n}-Butyl-3-phenyl-oxirane

\[
\begin{align*}
\text{Ph} & \quad \text{O} \\
\text{O} & \quad \text{Ph}
\end{align*}
\]

OD Chiralcel. 1 mL/min. 99.5\:0.5 Hexane:IPA, 20 °C.

Racemic

Asymmetric, 97\% ee
(2R,3R)-2-Phenyl-3-vinylloxirane

OD Chiralcel. 0.5 mL/min. 99.5:0.5 Hexane:IPA, 20 °C.

Racemic

Asymmetric, >99% ee
(2R,3R)-2-Phenyl-3-isopropenyloxirane

OD Chiralcel. 1 mL/min. 98:2 Hexane:IPA, 20 °C.

Racemic

Asymmetric, 96% ee
(2R,3R)-2-Phenyl-3-[(E)-1-propenyl]oxirane

\[
\begin{array}{c}
\text{Ph} \\
\text{O} \\
\text{\_\_\_\_\_\_\_\_}\end{array}
\]

OD Chiralcel. 0.5 mL/min. 99.5:0.5 Hexane:IPA, 20 °C.

Racemic

Asymmetric, 90% ee
Tris(1-methylethyl)[[(2R,3R)-3-phenyloxiranyl]ethynyl]-silane

OD-H Chiralcel. 0.7 mL/min. 99.9:0.1 Hexane:IPA, 10 °C.

Racemic

Asymmetric, 95 % ee KOH
Asymmetric, 99 % ee EtP₂

Related TMS and TBDMS acetylenic epoxides have also been separated on a chiralcel OD column. In both cases the $R,R$-epoxide has a greater retention time than the $S,S$ enantiomer.
(2R)-2-Phenyl-1-oxaspiro[2.5]octane

\[
\begin{array}{c}
\text{Ph} \\
\text{O} \\
\end{array}
\]

OD Chiralcel. 0.5 mL/min. 99:1 Hexane:IPA, 20 °C.

Racemic

Asymmetric, 92% ee
(2R)-6-(1,1-Dimethylethyl)-2-phenyl-1-oxaspiro[2.5]octane

OD Chiralcel. 1.5 mL/min. 99.5:0.5 Hexane:IPA 20 °C.

Racemic

Asymmetric, >99 % ee
2-Methyl-2,3-diphenyloxirane

HPLC Conditions

Column: Chiralcel OD (Column No.OD00CE-GL031)
Chiral Technologies Inc.
Eluent: Hexane/IPA (80/20)
Flow rate: 1.0 mL/min
Detection: UV 254 nm


OD Chiralcel. 1.0 mL/min. 80:20 Hexane:IPA, 20 °C.
Asymmetric (2:1 cis:trans)

A: UV of peak at 4.1 (R,R), B: UV of peak at 4.4 (cis + S,S), C: UV of peak at 7.9 (cis).

OJ Chiralcel. 1.0 mL/min. 99:1 Hexane:IPA 20 °C. (2:1 cis:trans)
trans: 93% ee, cis: 50% ee

HPLC of the 2:1 cis:trans mixture using literature conditions for the trans epoxide resulted in overlapping. Using the OD column the (R, R) trans epoxide eluted at 7.9 minutes. The (S, S) trans epoxide eluted at 4.1 minutes together with the cis epoxide.

Separation of the cis and trans epoxides was achieved using an OJ column. Assignment of cis and trans epoxides was accomplished by comparison of UV traces from the OJ column with the UV traces from the OD column. This was clarified by independent synthesis of a racemic trans sample that also eluted at 11.4 and 16.1 minutes on the OJ column. The peaks at 7.6 and 13.0 minutes therefore correspond to the cis epoxide.

(2S,3R)-2-Methyl-2-(4-nitrophenyl)-3-phenyloxirane
ODH Chiracel. 1 mL/min. 99:1 Hexane:IPA, 10 °C.

Racemic

Asymmetric, 71% ee
(2R,3R)-2-[(E)-1-Methyl-2-phenylethenyl]-3-phenyl-oxirane

OD Chiralcel. 1.0 mL/min. 99:1 Hexane:IPA 20 °C.

Racemic

Asymmetric, 90 % ee
(2R,3R)-2-(2,2-Diphenylethenyl)-3-phenyl-oxirane

\[
\begin{array}{c}
\text{Ph} \\
\text{O} \\
\text{Ph}
\end{array}
\]

OD Chiralcel. 1.0 mL/min. 99:1 Hexane:IPA 20 °C.

Racemic

Asymmetric, 90 % ee

This material is difficult to purify. Peaks at 11.7 and 14.6 correspond to the trans epoxide and we believe that the peaks at 7.4 and 9.9 correspond to the cis epoxide.
4-[3-[3-(Cyclopentyloxy)-4-methoxyphenyl]oxiran-2-yl]pyridine

OD Chiralcel. 1.5 mL/min. 95:5 Hexane:IPA 20 °C.

Racemic

Asymmetric trans : 99 % ee, cis : 99 % ee

The peaks at 12.9 and 14.5 correspond to the cis epoxide and the peaks at 15.6 and 22.9 correspond to the trans epoxide.
(2R)-1-[3-(Cyclopentyloxy)-4-methoxyphenyl]-1-phenyl-2-(4-pyridyl)ethane, CDP-840

OD Chiralcel. 1 mL/min. 90:10 Hexane:IPA 20 °C.

91:9 enantiomeric mixture

Asymmetric, 99 % ee
References

(7) N, N',N'-tetramethyl-N''-[tris(dimethylamino)phosphonalidene]phosphoric triamide ethyleneimine is commercially available and is used without further purification.
(22) Celltech Therapeutics Ltd US Patent No. 5, 977.