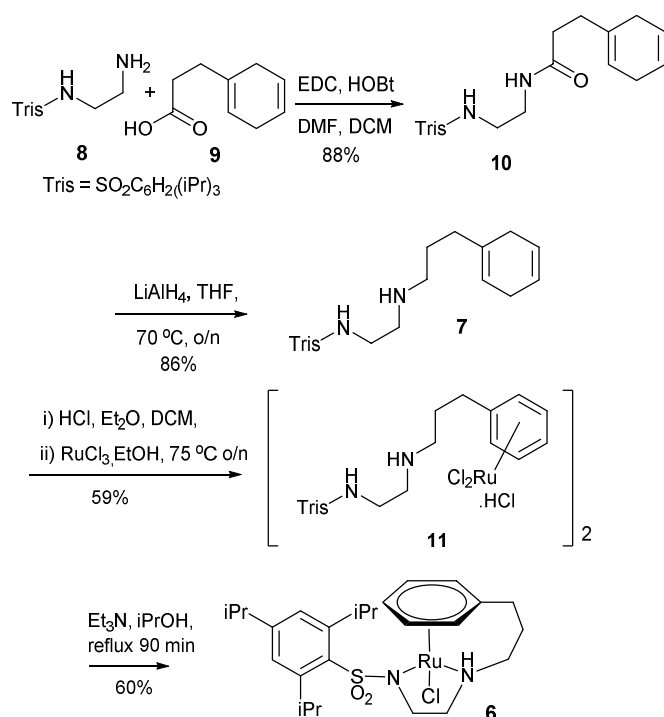


**An Alternative Route To Tethered Ru(II) Asymmetric Transfer Hydrogenation catalysts**

Roy Hodgkinson, Václav Jurčík, Antonio Zanolli-Gerosa, Hans Nedden, Andrew Blackaby and Martin Wills.\*

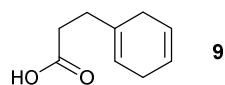
*Supporting Information.*

Experimental procedures and characterisation data.



**Scheme 2. Amide route to racemic tethered complex 6 via amides 10 and 13.**

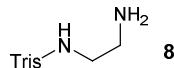
*3-(1,4-Cyclohexadien-1-yl)-1-propanoic acid.*



A flask was fitted with a Dewar condenser and a stop cock attached to a nitrogen inlet. To the flask was added ammonia (100 mL) at  $-78^\circ\text{C}$ , followed by 3-phenylpropanoic acid (3.00 g, 20 mmol) as a methanol (100 mL) solution. Once all the acid had gone into solution, sodium (24 g, 1.04 mol) was added over a 2h period. Once the addition was completed a further 19 g of sodium (19g, 0.83 mol) was added and the temperature increased to reflux ( $-33^\circ\text{C}$ ). Further methanol (50 mL) was added to facilitate stirring; a further 10g of sodium was added at reflux over 1h. The condenser was removed to allow the ammonia to evaporate. Once the ammonia was removed from the mixture 100 mL of ammonium chloride was added careful to quench the reaction. The methanol was removed, and the reaction was acidified to pH 6, then extracted with EtOAc (3 x 150 mL). The combined organic extracts were washed with aq.  $\text{NaHCO}_3$  (3 x 150 mL) and the organic layer was dried with  $\text{Na}_2\text{SO}_4$ . The EtOAc was removed under reduced pressure to yield the diene acid as a white solid (500 mg, 3 mmol, 16%). Mp:  $58\text{--}60^\circ\text{C}$ ;  $\nu_{\text{max}}$  3290.1, 3023.1, 2954.8, 2924.0, 2866.1, 2826.8, 1694.2, 1682.2, 1682.2, 1646.6, 1601.1, 1516.8, 1434.5, 1411.8, 1360.8, 1321.9, 1288.5, 1218.4, 1151.4, 1104.4, 1085.0, 1068.4  $\text{cm}^{-1}$ ;  $\delta_{\text{H}}$  (400 MHz,  $\text{CDCl}_3$ ) 11.92 (1H, br. s, OH), 5.60–5.80 (2H, m,  $\text{CH}=\text{CH}$ ), 5.45 (1H, br. s,  $\text{C}=\text{CH}$ ), 2.65–2.69 (2H, m,  $\text{CH}_2$ ), 2.56–2.60 (2H, m,  $\text{CH}_2$ ), 2.49 (2H, t,  $J = 7.5$ ,  $\text{CH}_2$ ), 2.28 (2H, t,  $J = 7.8$ ,  $\text{CH}_2$ );  $\delta_{\text{C}}$  (100 MHz,  $\text{CDCl}_3$ ) 180.3, 133.1, 124.2, 124.0, 119.1, 32.2, 31.9, 29.0, 26.7;

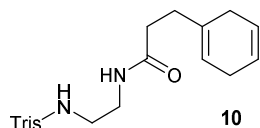
$m/z$ (ESI<sup>-</sup>): 151.1 (M – H, 100%). The method was taken from the literature and all data was in agreement with that reported; Snider, B. B.; Kirk, T. C. *J. Am. Chem. Soc.*, **1983**, *105*, 2364-2368.

*N*-(2-Aminoethyl)-2,4,6-triisopropyl benzene sulfonamide, *Tris-EN 8*.



A solution of tris(isopropyl)benzenesulfonyl chloride (10.0 g, 33.8 mmol) in DCM (100 mL) was slowly added dropwise at room temperature over ~10 min to a stirred solution of ethylenediamine (19.8 g, 22.0 mL, 330 mmol) in DCM (100 mL). The resulting mixture was stirred for 15 min (if the reaction is left too long di-addition to ethylenediamine is observed). The mixture was then washed twice with water (100 mL) and dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed *in vacuo* to yield the sulfonamide **8** (9.12 g, 28.0 mmol, 83%), which was used directly in the next step without further purification. Mp: 118-120 °C;  $\nu_{\max}$  3042, 2952, 1593, 1562, 1459, 1422, 1398, 1381, 1361, 1313, 1294, 1252, 1193, 1152, 1120, 1093, 1072 cm<sup>-1</sup>;  $\delta_{\text{H}}$  (400 MHz, CDCl<sub>3</sub>) 7.17 (2H, s, ArH), 4.15-4.22 (2H, m, *o*-CH(Me)<sub>2</sub>), 2.98-3.01 (2H, m, CH<sub>2</sub>NH), 2.87-2.93 (1H, m, *p*-CH(Me)<sub>2</sub>), 2.82-2.85 (2H, m, CH<sub>2</sub>NH<sub>2</sub>), 1.25-1.28 (18H, m, CH(CH<sub>3</sub>)<sub>2</sub>), the NH protons were not observed;  $\delta_{\text{C}}$  (100 MHz, CDCl<sub>3</sub>) 152.6 (2C), 150.3, 132.1, 123.8 (2C), 45.0, 40.9, 34.1, 29.6 (2C), 24.9 (4C), 23.6 (2C);  $m/z$  (ESI) 327.1 (M+H)<sup>+</sup>, 100). Spectroscopic data was in agreement with that reported: Tan, J.; Tang, W.; Sun, Y.; Jiang, Z.; Chen, F.; Xu, L.; Fan, Q.; Xiao, J. *Tetrahedron* **2011**, *67*, 6206-6213.

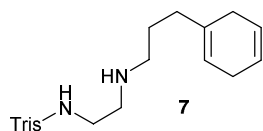
*3*-(Cyclohexa-1,4-dien-1-yl)-*N*-[2-([2,4,6-tri(propan-2-yl)phenyl]sulfonylamino) ethyl]-propanamide **10**.



To a round bottom flask were added 3-(cyclohexa-1,4-dien-1-yl)-propionic acid (200 mg, 1.32 mmol), HOBt (195 mg, 1.44 mmol) and TrisEN **8** (457 mg, 1.40 mmol). The reagents were dissolved in anhydrous DMF (4 mL) and anhydrous DCM (4 mL). The solution was cooled to 0 °C, then EDC (242 mg, 276  $\mu$ L, 1.56 mmol) was added. The temperature was maintained at 0 °C for 1h. The reaction then allowed to warm to rt and left overnight. Water (50 mL) was added and the resulting mixture was extracted using EtOAc (3 x 50 mL). The combined organic extracts were washed with water (3 x 100 mL) and brine (3 x 100 mL), dried with Na<sub>2</sub>SO<sub>4</sub> and concentrated to give the amide as a white solid (530 mg, 1.16 mmol, 88%). Mp: 118-120 °C; (found: [M-H]<sup>+</sup>, 459.2685. C<sub>26</sub>H<sub>39</sub>N<sub>2</sub>O<sub>3</sub>S requires M, 459.2687);  $\nu_{\max}$  3297.9, 2955.6, 2925.5, 2867.6, 1654.8, 1634.6, 1600.5, 1516.9, 1460.0, 1424.1, 1383.2, 1359.6, 1320.7, 1293.3, 1255.6, 1233.6, 1233.6, 1216.7, 1192.9, 1151.1, 1103.9, 1089.4, 1058.6, 1038.5 cm<sup>-1</sup>;  $\delta_{\text{H}}$  (400 MHz, CDCl<sub>3</sub>) 7.17 (2H, s, ArH), 6.77 (1H, t, *J* = 5.5, NH), 5.77 (1H, t, *J* = 6.0, NH), 5.64 (2H, s, CH=CH), 5.39 (1H, br. s, C=CH), 4.06-4.18 (2H, m, *o*-Pr(CH)),

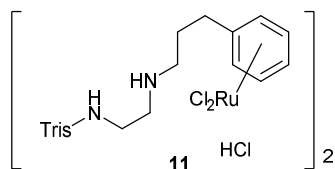
3.37-3.44 (2H, m,  $\text{CH}_2$ ), 3.06-3.10 (2H, m,  $\text{CH}_2$ ), 3.00-3.05 (1H, m,  $p$ - $\text{Pr}(\text{CH})$ ), 2.85-2.76 (2H, m,  $\text{CH}_2$ ), 2.59-2.66 (2H, m,  $\text{CH}_2$ ), 2.47-2.55 (2H, m,  $\text{CH}_2$ ), 2.22-2.32 (2H, m,  $\text{CH}_2$ ), 1.25 (18H, d,  $J = 6.5$ ,  $\text{Pr}(\text{CH}_3)$ );  $\delta_{\text{C}}$  (100 MHz,  $\text{CDCl}_3$ ) 174.1, 153.0, 150.3 (2C), 133.5, 131.8, 129.9 (2C), 121.6, 119.1 (2C), 42.5, 38.2, 34.5, 34.2, 33.0, 29.6 (2C), 28.9, 27.0, 24.9 (4C), 23.6 (2C);  $m/z$ (ESI):  $[\text{M}-\text{H}]^+$ , 459.2 (100%).

*N*-[2-(3-Cyclohexa-1,4-dienyl-propylamino)-ethyl]-2,4,6-triisopropyl- benzene sulphonamide **7**.



To a solution of 2M  $\text{LiAlH}_4$  in THF (1.3 mL, 2.6 mmol) was added 3-(cyclohexa-1,4-dien-1-yl)-*N*-[2-([2,4,6-tri(isopropyl)phenyl]sulfonylamino)ethyl] propanamide **10** (300 mg, 0.652 mmol), in dry THF (4 mL). The mixture was then heated to reflux (70 °C) and left overnight. The reaction was cooled to room temperature. Water (1 mL) was added with 10% NaOH solution (1 mL). The mixture was then filtered through a plug of celite, washing the plug with DCM (50 mL). The aqueous layer was then extracted using DCM (3 x 50 mL) and dried with  $\text{Na}_2\text{SO}_4$ . The DCM was then concentrated to give **7** as a white solid (250 mg, 0.561 mmol, 86%). Found (ESI):  $[\text{M}+\text{H}]^+$ , 447.3025.  $\text{C}_{26}\text{H}_{43}\text{N}_2\text{O}_2\text{S}$  requires: 447.3040;  $\nu_{\text{max}}$  3296.9, 3229.7, 3024.5, 2958.8, 2929.5, 2868.3, 2822.2, 1649.1, 1599.9, 1561.2, 1460.7, 1424.3, 1384.6, 1361.4, 1332.9, 1315.0, 1297.3, 1254.0, 1242.8, 1194.2, 1162.2, 1153.6, 1118.7, 1107.3, 1069.9, 1031.6  $\text{cm}^{-1}$ ;  $\delta_{\text{H}}$  (400 MHz,  $\text{CDCl}_3$ ) 7.17 (2H, s, ArH), 5.70 (2H, s,  $\text{CH}=\text{CH}$ ), 5.41 (1H, br. s,  $\text{CH}=\text{C}$ ), 4.14-4.20 (2H, m,  $o$ - $\text{CH}(\text{Me})_2$ ), 3.03-3.06 (2H, m,  $\text{CH}_2\text{NH}$ ), 2.88-2.93 (1H, m,  $p$ - $\text{CH}(\text{Me})_2$ ), 2.78-2.80 (2H, m,  $\text{CH}_2\text{NH}_2$ ), 2.66-2.70 (2H, m,  $\text{CH}_2$ ), 2.55-2.59 (4H, m,  $\text{CH}_2$ ), 1.97 (2H, t,  $J = 8.0$ ,  $\text{CH}_2$ ), 1.57 (2H, quint,  $J = 8.0$ ,  $\text{CH}_2$ ), 1.25-1.28 (18H, m,  $\text{CH}(\text{CH}_3)_2$ );  $\delta_{\text{C}}$  (100 MHz,  $\text{CDCl}_3$ ) 152.7 (2C), 152.7 (2C), 150.3, 134.3, 132.2, 124.3, 124.2, 123.8 (2C), 118.8, 49.0, 48.0, 41.9, 35.0, 34.2, 28.9, 29.7 (2C), 27.3, 26.8, 24.9 (4C), 23.6 (2C);  $m/z$  (ESI) 447.3 ( $[\text{M}+\text{H}]^+$ , 100).

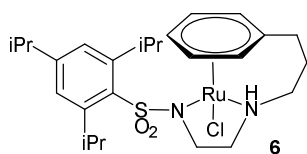
*Di-μ-chlorodichlorobis*[*N*-[ 2-[[3-( $\eta^6$ -phenyl)propyl](3-phenylpropyl)amino]ethyl]-4-2,4,6-triisopropylbenzene sulfonamide]diruthenium (II) hydrochloride, *Tris-EN RuCl<sub>2</sub> dimer 13*.



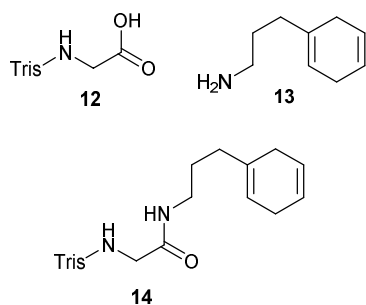
Aqueous acidic  $\text{RuCl}_3$  solution (140 mg, 0.54 mmol) in ethanol (30 mL) was placed in a round bottom flask. To this a solution of *N*-[2-(3-cyclohexa-1,4-dienyl-propylamino)-ethyl]-2,4,6-triisopropyl-benzenesulfonamide **7** (300 mg, 0.67 mmol) and 2M HCl in ether (2.7 mL, 5.4 mmol) in DCM (20 mL) was added slowly at room temperature. The reaction mixture was heated at 75 °C

overnight. The solvent was removed to generate the ruthenium dimer **11** (429 mg, 0.32 mmol, 59%) as a brown solid. Mp: 117-119 °C (dec); (found(EI):  $[\frac{1}{2}\text{M}-\text{Cl}]^+$ , 545.1781; requires:  $\text{C}_{26}\text{H}_{39}\text{N}_2\text{O}_2\text{RuS}$ , 545.1776);  $\nu_{\text{max}}$  2955.9, 2866.9, 1559.7, 1459.6, 1361.3, 1313.9, 1151.6, 1119.9, 939.9  $\text{cm}^{-1}$ ,  $\delta_{\text{H}}$  (400 MHz, DMSO- $d_6$ ) 9.14 (2H, br. s, NH), 7.85 (2H, br. s, NH), 7.24 (4H, s, Tris(ArH)), 6.00 (2H, br. s, Ru-ArH), 5.79 (4H, s, Ru-ArH), 4.12-4.08 (4H, m, CH- $o$ -( $i$ Pr)), 3.12 (4H, br. s,  $\text{CH}_2\text{NH}_2$ ), 2.96-3.03 (6H, m,  $\text{CH}_2\text{NH}_2\text{C}$  and  $p$ -CH(CH $_3$ ) $_2$ ), 2.50 (4H, s, CH $_2$ ), 1.96 (4H, s, CH $_2$ ), 1.15-1.25 (36H, m, CH $_3$ ( $i$ Pr));  $\delta_{\text{C}}$  (100 MHz, DMSO- $d_6$ ) 153.2, 149.7 (2C), 132.5, 123.6 (2C), 105.9, 88.7 (2C), 85.2 (2C), 83.6, 46.3, 46.1, 38.0, 33.3, 29.3, 28.8, 24.9 (2C), 24.8 (4C), 23.4 (2C);  $m/z$  (ESI): 545.2 ( $[\frac{1}{2}\text{M}-\text{Cl}]^+$ , 100%).

*Chloro*[N-[2-[(S)-[3-( $\eta^6$ -phenyl)propyl]amino- $\kappa$ N]ethyl]-2,4,6-triisopropyl benzene sulfonamidato- $\kappa$ N]-ruthenium (II), [TrisEN-teth RuCl] **6**.

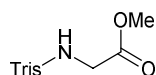


Tris-EN RuCl $_2$  dimer **11** (300 mg, 0.22 mmol) and triethylamine (136 mg, 179  $\mu\text{L}$ .) were mixed in  $i$ -PrOH (20 mL). The flask was heated to reflux and stirred for 90 min. The reaction was cooled to rt, the solvent was concentrated under reduced pressure, then DCM (50 mL) was added and the solution was washed with water (3 x 100 mL) and dried over sodium sulphate. DCM was removed under reduced pressure and the desired monomeric complex was isolated as a brown solid. Purification was by column chromatography in DCM to 90% DCM/10% MeOH to yield monomer **6** (153 mg, 0.26 mmol, 60%). Mp: 113-115 °C; (found(EI):  $[\text{M}-\text{Cl}]^+$ , 545.1783. requires:  $\text{C}_{26}\text{H}_{39}\text{N}_2\text{O}_2\text{RuS}$ , 545.1777);  $\nu_{\text{max}}$  3045.0, 2956.4, 2867.1, 2838.8, 1599.5, 1562.3, 1495.5, 1458.9, 1422.1, 1381.9, 1361.3, 1314.0, 1294.9, 1249.6, 1192.8, 1151.6, 1151.6, 1119.9, 1104.7, 1073.3, 1058.8, 1037.6  $\text{cm}^{-1}$ ;  $\delta_{\text{H}}$  (400 MHz, CDCl $_3$ ) 7.09 (2H, s, TrisCH), 6.67 (1H, t,  $J$  = 6.0, Ru-ArH), 6.02 (1H, t,  $J$  = 6.0, Ru-ArH), 5.87 (1H, t,  $J$  = 6.0, Ru-ArH), 5.17 (1H, d,  $J$  = 8.0, Ru-ArH), 4.98 (1H, d,  $J$  = 4.0, Ru-ArH), 4.47-4.53 (2H, m,  $o$ -(CH)(CH $_3$ ) $_2$ ), 3.86 (1H, br. s, NH), 3.26-3.32 (1H, m,  $p$ -(CH)(CH $_3$ ) $_2$ ), 2.82-2.90 (2H, m, CH $_2$ ), 2.66-2.74 (2H, m, CH $_2$ ), 2.46-2.63 (4H, m, CH $_2$ ), 2.23-2.36 (2H, m, CH $_2$ ), 1.21-1.28 (18H, m, (CH)(CH $_3$ ) $_2$ );  $\delta_{\text{C}}$  (100 MHz, CDCl $_3$ ) 150.7, 150.6 (2C), 133.9, 123.2 (2C), 98.1, 92.5, 89.7, 79.4, 77.0, 73.9, 57.3, 52.2, 47.2, 34.0, 29.5, 29.0, 25.4 (2C), 25.0 (4C), 23.7 (2C);  $m/z$  (ESI): 545.2 ( $[\text{M}-\text{Cl}]^+$ , 100%).



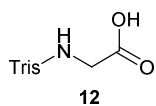
Compounds for alternative approach to ligand **7** via a glyciny amide intermediate.

*Methyl N-[2,4,6-tri(propan-2-yl)phenyl]sulfonyl-glycinate.*



Glycine methyl ester (10.4 g, 82.5 mmol) was added to a flask to which methanol (100 mL) was added. Triethylamine (16.7 g, 23 mL, 165 mmol) was added to the flask, which was left to stir for 10 min. 2,4,6-Tri-isopropylbenzene sulfonyl chloride (5.0 g, 16.5 mmol) was added in one portion. The solution was left to stir overnight at room temperature to yield the glycinate product (2.96 g, 8.34 mmol, 51%) as an off-white solid. mp: 120-122 °C; found (EI):  $[M+Na]^+$ , 378.1706.  $C_{18}H_{29}NNaO_4S$  requires: 378.1710.  $\nu_{max}$  3342.2, 2958.0, 2932.4, 2869.9, 1739.3, 1600.2, 1558.3, 1462.1, 1438.9, 1408.9, 1386.1, 1364.8, 1336.0, 1303.3, 1290.0, 1259.7, 1237.8, 1198.5, 1157.0, 1118.5, 1073.7, 1062.0, 1036.2  $cm^{-1}$ ;  $\delta_H$  (400 MHz,  $CDCl_3$ ) 7.17 (2H, s, TrisArH), 5.00 (1H, t,  $J = 5.0$ , NH), 4.13 (2H, sept,  $J = 6.7$ ,  $o-(CH)(CH_3)_2$ ), 3.79 (2H, d,  $J = 5.5$ ,  $CH_2$ ), 3.69 (3H, s,  $OCH_3$ ), 2.90 (1H, spt,  $J = 6.9$ ,  $p-(CH)(CH_3)_2$ ), 1.15 - 1.33 (18H, m,  $-(CH)(CH_3)_2$ );  $\delta_C$  (100 MHz,  $CDCl_3$ ) 169.4, 153.1, 150.5 (2C), 131.7, 123.9 (C2), 52.6, 43.8, 34.2, 29.8 (C2), 24.9 (C4), 23.6 (C2);  $m/z$ (ESI): 354.1 ( $[M - H]^+$ , 100%).

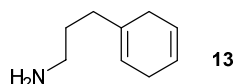
*N-[2,4,6-Tri(propan-2-yl)phenyl]sulfonyl-glycine 12.*



To a stirred solution of methyl N-[2,4,6-tri(propan-2-yl)phenyl]sulfonyl-glycinate (1.00 g, 2.81 mmol) in methanol/water (1:2 v/v, 24 mL) was added potassium hydroxide (1.57 g, 28.0 mmol) in methanol/water (1:2 v/v, 12 mL). The reaction was heated to 70 °C under reflux. After stirring for 2h, the reaction was mixture cooled to 0 °C and acidified using 2M HCl aq. solution (~ 10 mL) to pH 7. The resulting mixture was washed with ethyl acetate (3 x 100 mL). The combined organic extracts were washed with brine (3 x 50 mL) and dried with  $Na_2SO_4$ . The solvent was removed under vacuum to yield a white solid (885 mg, 2.6 mmol, 93%). Mp: 141-143 °C; (found (ESI):  $[M+Na]^+$ , 364.1556.  $C_{17}H_{27}NNaO_4S$  requires: 364.1558);  $\nu_{max}$  3297.9, 2953.3, 2922.9, 2863.1, 1709.7, 1599.9, 1459.5, 1421.2, 1383.0, 1358.0, 1320.7, 1286.4, 1249.3, 1226.5, 1151.7, 1101.7, 1072.9, 1062.5, 1042.2  $cm^{-1}$ ;

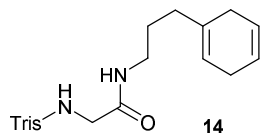
$\delta_H$  (400 MHz,  $CDCl_3$ ) 10.33 (1H, br. s, OH), 7.17 (2H, s, TrisArH), 5.13 (1H, t,  $J = 5.5$ ,  $CH_2$ ), 4.10 (2H, spt,  $J = 6.0$ ,  $o-(CH)(CH_3)_2$ ), 3.84 (2H, d,  $J = 5.5$ ,  $CH_2$ ), 2.90 (1H, spt,  $J = 6.0$ ,  $p-(CH)(CH_3)_2$ ), 1.26 (12H, d,  $J = 7.0$ ,  $o-(CH)(CH_3)_2$ ), 1.25 (6H, d,  $J = 8.0$ ,  $p-(CH)(CH_3)_2$ );  $\delta_C$  (100 MHz,  $CDCl_3$ ) 174.1, 153.3, 150.5 (2C), 131.4, 124.0 (2C), 43.6, 34.2, 29.8 (2C), 24.8 (4C), 23.5 (2C);  $m/z$ (ESI): 340.1 ( $[M - H]^+$ , 100%).

**3-(Cyclohexa-1,4-dien-1-yl)propan-1-amine 13.**



3-Phenylpropylamine (2.76 g, 20 mmol) and EtOH (30 mL) were placed in a 250 mL round bottom flask equipped with a magnetic stirrer and a dry ice cooling finger. The flask was placed in an acetone/dry ice bath ( $-78^\circ C$ ) and ammonia (ca. 70 mL) was condensed into the flask. Lithium (1.23 g, 176 mmol) was added in portions to the reaction mixture and the mixture turned deep blue. After the blue colour disappeared, additional lithium was added (0.4 g, 67 mmol) to the flask. The reaction mixture was stirred for an additional 1 h during which time the dark blue colour disappeared again. Sat.  $Na_2SO_4$  (50 mL) was added to quench the reaction. The cooling was removed and ammonia was allowed to evaporate. The remaining residue was dissolved in water (100 mL) and extracted with DCM (3 x 50 mL). The combined organic phases were washed with brine (50 mL), dried over  $MgSO_4$  and the solvent was evaporated to give the title compound as a colourless liquid (2.7 g, 19.8 mmol, 98%).  $\delta_H$  (400 MHz,  $CDCl_3$ ) 5.68-5.57 (2 H, m,  $CH=CH$ ), 5.41-5.31 (1H, m,  $C=CH$ ), 2.67-2.57 (4H, m,  $CH_2$ ), 2.57-2.48 (2H, m,  $CH_2$ ), 1.97-1.86 (2H, m,  $CH_2$ ), 1.56-1.44 (2H m,  $CH_2$ ), 1.25 (bs, 2H,  $NH_2$ );  $\delta_C$  (100 MHz,  $CDCl_3$ ) 134.6, 124.3, 118.5, 42.0, 34.8, 31.4, 28.9, 26.8. Spectroscopic data was in agreement with that reported; Fujimoto, R. A.; Boxer, J.; Jackson, R. H.; Simke, J. P.; Neale, R. F.; Snowhill, E. W.; Barbaz, B. J.; Williams, M.; Sills, M. A. *J. Med. Chem.* 1989, 32, 1259–1265

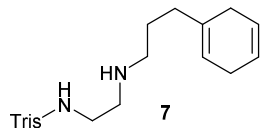
**N-(3-Cyclohexa-1,4-dienyl-propyl)-2-(2,4,6-triisopropyl-benzenesulfonyl)glycinamide 14.**



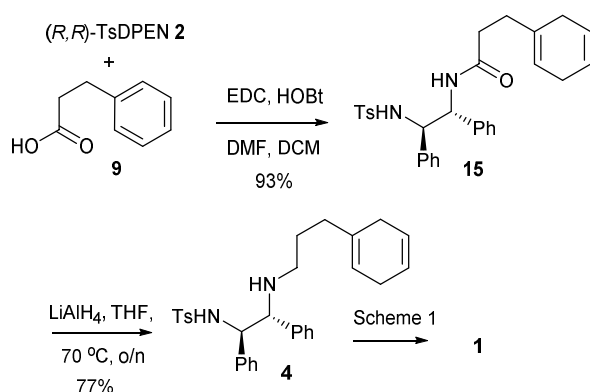
N-[2,4,5-Tri]propan-2-yl]phenyl]sulfonyl-glycine (3.41g, 10.0 mmol) was dissolved in dry Me-THF (30 mL) and N-methylmorpholine (1.01 mL, 10.0 mmol) was added. The reaction mixture was cooled down to  $-15^\circ C$  and a solution of *i*-butyl chloroformate (1.36 g, 1.30 mL, 10.0 mmol) in THF (5 mL) was added dropwise over a period of 15 min. After addition was completed, the mixture was stirred at  $-15^\circ C$  for another 15 min and 3-(cyclohexa-1,4-dien-1-yl)propan-1-amine (1.37 g, 10.0 mmol, 1 eq) was added at once. The cooling was then removed and the reaction mixture was allowed to warm up to rt and stirred overnight. The solvent was removed under reduced pressure and the residue was

diluted with EtOAc (40 mL), washed with 10% Na<sub>2</sub>CO<sub>3</sub> (50 mL), 0.1 M HCl (50 mL) and dried over MgSO<sub>4</sub>. The solvent was removed under reduced pressure to give the amide as a white gummy solid (5.0 g) which was used directly in the next step.

*N*-[2-(3-Cyclohexa-1,4-dienyl-propylamino)-ethyl]-2,4,6-triisopropyl- benzene sulphonamide **7**.

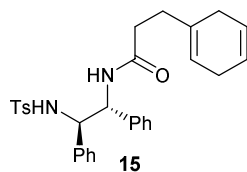


*N*-(3-Cyclohexa-1,4-dienyl-propyl)-2-(2,4,6-triisopropyl-benzenesulfonyl)-glycinamide **14** (4.6 g, from previous step) was dissolved in Me-THF (100 mL) and LiAlH<sub>4</sub> (759 mg, 20.0 mmol, 2 eq) was added as one pellet. After the addition was completed, the reaction mixture was heated to 80 °C for 16h. The reaction mixture was cooled down to 0 °C (ice bath) and carefully quenched with water (50 mL). The resulting precipitate was filtered off (2 cm pad of celite on sinter), washed with EtOAc (100 mL) and the resulting organic phases were washed with 1 M NaOH (20 mL), dried (K<sub>2</sub>CO<sub>3</sub>) and the solvent was removed under reduced pressure to give the corresponding diamine as a colourless oil. The data matched that for the product previously isolated.



**Scheme 3.** New route to hindered asymmetric tethered complexes via an amide.

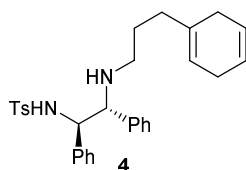
*3-Cyclohexa-1,4-dienyl- N-(1R,2R)-[1,2-diphenyl-2-(toluene-4-sulfonylamino)-ethyl]-propionamide 15.*



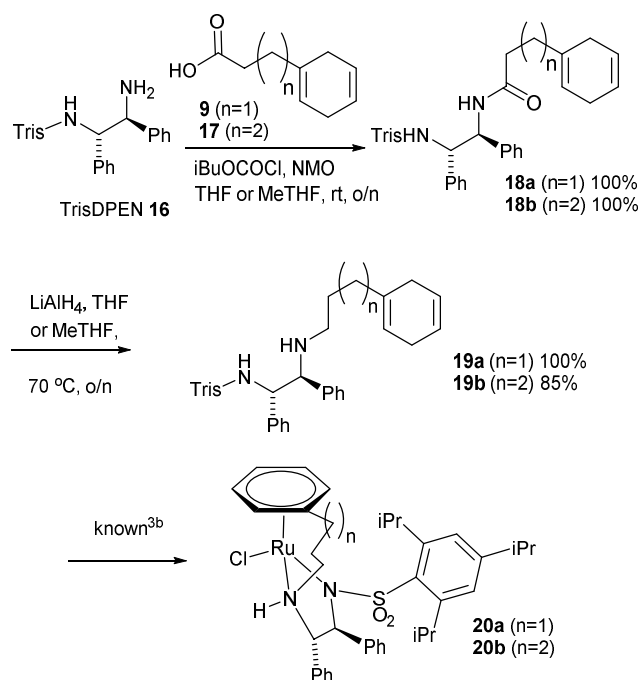
In a round bottom flask, 3-cyclohexa-1,4-dienyl-propionic acid **9** (200 mg, 1.32 mmol), HOBt (195 mg, 1.44 mmol) and (*R,R*)-TsDPEN (513 mg, 1.40 mmol) which were dissolved in anhydrous DCM (4 mL) and DMF (4 mL). The solution was cooled to 0°C, then EDC (242 mg, 1.56 mmol) was added.

The temperature was maintained for 1h. The reaction was then allowed to warm to rt and left overnight. Water (50 mL) was added and the resulting mixture was extracted using EtOAc (3 x 50 mL). The combined organic extracts were washed with water (3 x 100 mL) and brine (3 x 100 mL), and then dried with Na<sub>2</sub>SO<sub>4</sub> and concentrated to give **15** as an off white-solid (613 mg, 1.23 mmol, 93%). Mp: 184-186°C (dec.); [ $\alpha$ ]<sub>D</sub><sup>26</sup> + 10.8 (c 0.53 in CHCl<sub>3</sub>); (found(EI): [M+Na]<sup>+</sup>, 521.1855. C<sub>30</sub>H<sub>30</sub>N<sub>2</sub>NaO<sub>3</sub>S requires M, 521.1869);  $\nu_{\max}$  3289.9, 3061.9, 3029.4, 2925.5, 1645.6, 1645.6, 1599.1, 1528.7, 1494.2, 1453.8, 1374.9, 1322.0, 1230.8, 1183.8, 1152.6, 1116.8, 1087.2, 1065.5, 1027.9 cm<sup>-1</sup>;  $\delta_{\text{H}}$  (400 MHz, CDCl<sub>3</sub>) 7.42 (2H, d,  $J$  = 8.5, TsArH), 7.13-7.19 (4H, m, ArH), 6.93 (2H, d,  $J$  = 8.5, TsArH), 6.88-6.89 (6H, m, ArH), 5.84 (2H, br. s, CH=CH), 5.32-5.36 (2H, m, C=CH and CH(Ph)), 4.66 (1H, t,  $J$  = 9.3, CH(Ph)), 2.57-2.61 (2H, m, CH<sub>2</sub>), 2.47-2.52 (2H, m, CH<sub>2</sub>), 2.34-2.40 (2H, m, CH<sub>2</sub>), 2.27-2.32 (2H, m, CH<sub>2</sub>), 2.22 (3H, s, TsCH<sub>3</sub>);  $\delta_{\text{C}}$  (100 MHz, CDCl<sub>3</sub>) 173.9, 142.6, 139.2, 138.0, 137.8, 133.5, 129.2 (2C), 128.5, 128.4, 128.3 (2C), 128.0 (2C), 127.6 (2C), 127.3, 126.8 (2C), 124.2, 124.1 (2C), 119.2, 63.0, 58.8, 34.6, 32.9, 29.0, 26.8, 21.4;  $m/z$ (ESI) 521.1 ([M+Na]<sup>+</sup>, 100%).

*N*-(1*R*,2*R*)-[2-(3-Cyclohexa-1,4-dienyl-propylamino)-1,2-diphenyl-ethyl]-4-methyl-benzene sulphonamide **4**.

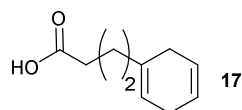


To a solution of 2M LiAlH<sub>4</sub> in THF (0.80 mL, 1.6 mmol) was added 3-cyclohexa-1,4-dienyl-N-[1,2-diphenyl-2-(toluene-4-sulfonylamino)-ethyl]-propionamide **15** (200 mg, 0.40 mmol) in dry THF (4 mL). The mixture was then heated to reflux and left overnight. The reaction was cooled to room temperature, and water (1 mL) was added, together with 10% NaOH solution (1 mL). The mixture was then filtered through a plug of celite, washing the plug with DCM (50 mL). The aqueous layer was then extracted using DCM (3 x 50 mL) and the combined organic extracts were dried with Na<sub>2</sub>SO<sub>4</sub>. The solution was then concentrated to give **4** as a white solid (150 mg, 0.31 mmol, 77%). Spectroscopic data is in agreement with literature: a) Hayes, A. M.; Morris, D. J.; Clarkson, G. J.; Wills, M. *J. Am. Chem. Soc.*, **2005**, *127*, 7318-7319. b) Jolley, K. E.; Zanotti-Gerosa, A.; Hancock, F.; Dyke, A.; Grainger, D. M.; Medlock, J. A.; Nedden, H. G.; Le Paih, J. J. M.; Roseblade, S. J.; Seger, A.; Sivakumar, V.; Prokes, I.; Morris, D. J.; M. Wills, M. *Adv. Synth. Catal.*, **2012**, *354*, 2545-2555.. The synthetic steps to prepare [Ts-Dpen-teth RuCl] **1** are described in the references above.



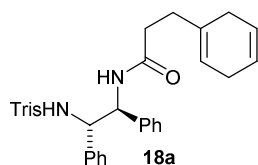
**Scheme 4.** New route to hindered asymmetric tethered complexes via an amide.

*4-(Cyclohexa-1,4-dien-1-yl)butanoic acid 17.*



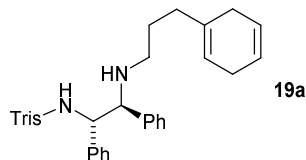
4-Phenylbutyric acid (3.28 g, 20.0 mmol) and *t*-BuOH (10.6 g) were placed in a 250 mL round bottom flask equipped with a magnetic stirrer and dry ice cooling finger. The flask was placed in acetone/dry ice bath and ammonia (70 mL) was condensed into the flask, Lithium (1.23 g, 176 mmol) was gradually added to the reaction flask. The reaction mixture was stirred at -78 °C for 5 h and sat.  $\text{NH}_4\text{Cl}$  (50 mL) was added to quench the reaction. The cooling bath was then removed and the ammonia was allowed to evaporate. The residues was dissolved in water (100 mL) and the pH was adjusted to 2-3 using 10% HCl. The product was extracted with *t*-BuOMe (3 x 50 mL), and the combined phases were washed with brine (50 mL), dried over  $\text{MgSO}_4$  and the solvent was removed to give **17** as a white solid (3.5 g, *quant*).  $\delta_{\text{H}}$  (400 MHz,  $\text{CDCl}_3$ ) 5.78-5.65 (2H, m,  $\text{CH}=\text{CH}$ ), 5.50-5.43 (1H, m,  $\text{C}=\text{CH}$ ), 2.76-2.55 (4H, m,  $\text{CH}_2$ ), 2.43-2.32 (2H, m,  $\text{CH}_2$ ), 2.10-1.97 (2H, m,  $\text{CH}_2$ ), 1.86-1.73 (2H, m,  $\text{CH}_2$ );  $\delta_{\text{C}}$  (100 MHz,  $\text{CDCl}_3$ ) 179.8, 1133.7, 124.23, 124.19, 119.4, 36.6, 33.4, 28.7, 26.7, 22.2. The data matched that reported for this compound; Stodt, R.; Gencaslan, S.; Müller, I. M.; Sheldrick, W. S. *Eur. J. Inorg. Chem.* **2003**, 1873-1882.

*3-Cyclohexa-1,4-dienyl-N-(1S,2S)-[1,2-diphenyl-2-(2,4,6-triisopropyl-benzene sulfonylamino-ethyl)-propionamide 18a.*



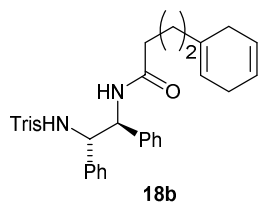
3-Cyclohexa-1,4-dienyl-propionic acid **9** (1.52 g, 10.0 mmol) was dissolved in dry THF (30 mL) and N-methylmorpholine (1.01 mL, 10.0 mmol) was added. The reaction mixture was cooled down to -15 °C and a solution of *i*-butyl chloroformate (1.36 g, 1.30 mL, 10.0 mmol) in THF (5 mL) was added dropwise over a period of 15 min. After addition was completed, the mixture was stirred at -15 °C for another 15 min and (*S,S*)-TrisDPEN **16** (4.78g, 10.0 mmol) was added at once. The cooling was then removed and the reaction was allowed to warm up to rt and was stirred overnight. The solvent was removed under reduced pressure and the residue was diluted with EtOAc (40 mL), washed with 10% Na<sub>2</sub>CO<sub>3</sub> (50 mL), 0.1 M HCl (50 mL), brine (50 mL) and dried over magnesium sulfate. The solvent was removed under reduced pressure to give **18a** as a white solid (6.19 g, 6.0 mmol, 100%).  $\delta_{\text{H}}$  (400 MHz, CDCl<sub>3</sub>) 7.10-7.05 (3H, m, ArH), 6.95-6.90 (5H, m, ArH), 8.86 (3H, t,  $J = 7.3$  Hz, ArH), 6.62-6.57 (2H, m, ArH), 5.87 (1 H, d,  $J = 7.7$  Hz, NH), 5.65-5.60 (2H, m, CH=CH), 5.43-5.39 (1H, m, C=CH), 5.17 (1H, dd,  $J = 11.0, 7.6$  Hz, CH(Ph)), 4.40 (1H, dd,  $J = 11.0, 7.6$  Hz, CH(Ph)), 3.98-3.85 (2H, m, CH(CH<sub>3</sub>)<sub>2</sub>), 2.80-2.70 (1H, m, CH(CH<sub>3</sub>)<sub>2</sub>), 2.64-2.50 (4H, m, CH<sub>2</sub>), 2.49-2.24 (4H, m CH<sub>2</sub>), 1.10 (12H, dd,  $J = 6.3, 7.2$ , CH(CH<sub>3</sub>)<sub>2</sub>), 0.90 (6H, d,  $J = 6.7$ , CH(CH<sub>3</sub>)<sub>2</sub>).

*N*- (1*S*,2*S*)-[2-(3-Cyclohexa-1,4-dienyl-propylamino)-1,2-diphenyl-ethyl]-2,4,6-triisopropyl-benzene sulphonamide **19a**.



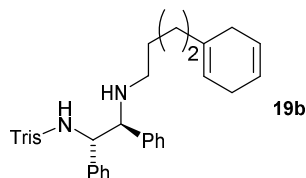
3-Cyclohexa-1,4-dienyl-N-[1,2-diphenyl-2-(2,4,6-triisopropyl-benzenesulfonylamine)-ethyl]-propionamide **18a** (6.19 g, 10.0 mmol) was dissolved in dry THF (100 mL) and LiAlH<sub>4</sub> (759 mg, 20.0 mmol) was added as a single pellet. After the addition was completed, the mixture was refluxed for 16h. The reaction mixture was cooled down to 0 °C (ice bath) and carefully quenched with water (50 mL). The precipitate which formed was filtered off (2 cm pad of celite on a sinter), washed with EtOAc (100 mL) and the combined organic phases were washed with 1 M NaOH (20 mL), dried (K<sub>2</sub>CO<sub>3</sub>) and the solvent was removed under reduced pressure to give **19a** as a colourless oil (6.1 g, 10.0 mmol, 100%). The characterisation data fully matched that reported for this compound; Hodgkinson, R. C.; Jurčík, V.; Zanoliti-Gerosa, A.; Nedden, H. G.; Blackaby, A.; Clarkson, G. J.; Wills, M. *Organometallics* **2014**, *33*, 5517-5524.

4-(Cyclohexa-1,4-dien-1-yl)-N-(1*S*,2*S*)-1,2-diphenyl-2-(2,4,6-triisopropylphenylsulfonamido)ethyl butanamide **18b**.



4-Cyclohexa-1,4-dienyl-butanoic acid **17** (1.66 g, 10.0 mmol) was dissolved in dry Me-THF (30 mL) and N-methylmorpholine (1.01 mL, 10.0 mmol) was added. The reaction mixture was cooled down to -15 °C and a solution of *i*-butyl chloroformate (1.36g, 1.30 mL, 10.0 mmol) in THF (5 mL) was added dropwise over a period of 15 min. After addition was completed, the mixture was stirred at -15 °C for another 15 min and (*S,S*)-TrisDPEN **16** (4.78g, 10.0 mmol) 1 eq.) in Me-THF ((20 mL) was added at once. The cooling bath was then removed and the reaction mixture was allowed to warm up to rt and stirred overnight. The solvent was removed under reduced pressure and the remaining mature was diluted with EtOAc (40 mL), washed with 10% Na<sub>2</sub>CO<sub>3</sub> (50 mL), 0.1M HCl (50 mL), brine (50 mL) and dried over MgSO<sub>4</sub>. The solvent was removed under reduced pressure to give **18b** as a white solid (6.46 g, 10 mmol, 100%).  $\delta_H$  (400 MHz, CDCl<sub>3</sub>) 7.10-7.05 (3H, m, ArH), 6.95-6.90 (5H, m, ArH), 6.90-6.82 (2H, m, ArH), 6.62-6.56 (2H, m, ArH), 5.84 (1H, d  $J$  = 8.1, NH), 5.67-5.58 (2H, m, CH=CH), 5.38-5.34 (1H, m, C=CH), 5.17 (1H, dd,  $J$  = 11.0, 7.6, CHPh), 4.40 (1H, dd,  $J$  = 11.0, 7.6, CHPh), 3.97-3.84 (2H, m, CH(CH<sub>3</sub>)<sub>2</sub>), 2.70-2.68 (1H, m, CH(CH<sub>3</sub>)<sub>2</sub>), 2.64-2.48 (4H, m, CH<sub>2</sub>), 2.34-2.17 (2H, m, CH<sub>2</sub>), 2.00-1.92 (2H, m, CH<sub>2</sub>), 1.83-1.72 (4H, m, CH<sub>2</sub>), 1.10 (12H, dd,  $J$  = 6.3, 7.2, CH(CH<sub>3</sub>)<sub>2</sub>), 0.90 (6H,  $J$  = 6.7, CH(CH<sub>3</sub>)<sub>2</sub>);  $\delta_C$  (100 MHz, CDCl<sub>3</sub>) 174.4 (NHCO), 152.7, 149.9, 138.9, 138.2, 134.1, 133.2, 128.5, 128.2, 127.7, 127.4, 127.3, 124.4, 124.2, 123.5, 119.2, 62.9, 58.4, 36.8, 36.1, 24.1, 29.7, 28.7, 26.7, 25.0, 24.3, 23.6, 23.6, 23.0.

N-((1*S*,2*S*)-2-[(4-(cyclohexa-1,4-dien-1-yl)butylamino)-1,2-diphenylethyl]-2,4,6-triisopropylbenzenesulfonamide **19b**.



4-(Cyclohexa-1,4-dien-1-yl)-N-(1*S*,2*S*)-1,2-diphenyl-2-(2,4,6 triisopropylphenylsulfonamido)ethyl butanamide **18b** (6.26 g, 10.0 mmol) was dissolved in dry Me-THF (100 mL) and LiAlH<sub>4</sub> (759 mg, 20.0 mmol) was added as a single pellet. After the addition was complete, the reaction mixture was refluxed for 16h, The reaction mixture was cooled down to 0 °C (ice bath) and carefully quenched with water (50 mL). The precipitate which formed was filtered off (2 cm pad of celite on a sinter), washed with EtOAc (100 mL) and the combined organic phases were washed with 1 M NaOH (20

mL), dried ( $\text{K}_2\text{CO}_3$ ) and the solvent was removed under reduced pressure to give the diamine product as a colourless oil (5.2 g, 8.5 mmol, 85%). The characterisation data fully matched that reported for this compound; Hodgkinson, R. C.; Jurčik, V.; Zanolli-Gerosa, A.; Nedden, H. G.; Blackaby, A.; Clarkson, G. J.; Wills, M. *Organometallics* **2014**, *33*, 5517-5524.

### **Procedure for the reduction of ketones and aldehydes.**

#### Transfer hydrogenation with FA/TEA.

Catalyst (0.0030 mol, 500:1) was weighed in to a round bottom flask, the flask was then flushed with nitrogen. Then FA/TEA (5:2) (1 mL) and ketone (1.5 mmol) was added to flask and the mixture was heated to 40°C. Work-up for GC analysis; a sample was taken from the flask and dissolved in EtOAc and  $\text{NaHCO}_3$  aq. solution was added. The EtOAc was separated and dried with  $\text{Na}_2\text{SO}_4$  and the GC spectrum of this was obtained. Products were isolated by adding EtOAc (20 mL) and sat.  $\text{Na}_2\text{CO}_3$  (20 mL) to the reaction and separating the organic layer. The aqueous layer was extracted with EtOAc (2 x 20 mL) and the combined organic layers were dried with  $\text{Na}_2\text{SO}_4$ , filtered and the solvent removed to yield the alcohol product.

#### Hydrogenation with isopropanol/KOH.

Catalyst (1.5 mg, 0.0025 mol, 400:1) was weighed in to a round bottom flask, the flask was then flushed with nitrogen. Then isopropanol (10 mL), KOH (0.3 mg, 0.005 mmol)\* and ketone (1.0 mmol) were added to the flask and the mixture was heated to 40°C. Work-up for GC analysis; a sample was taken from flask and dissolved in EtOAc and  $\text{NaHCO}_3$  aq. solution was added. The EtOAc was separated and dried with  $\text{Na}_2\text{SO}_4$  and the GC spectrum of this was obtained. Products were isolated by adding EtOAc (20 mL) and sat.  $\text{Na}_2\text{CO}_3$  (20 mL) to the reaction and separating the organic layer. The aqueous layer was extracted with EtOAc (2 x 20 mL) and the combined organic layers were dried with  $\text{Na}_2\text{SO}_4$ , filtered and the solvent removed to yield the alcohol product. \*A stock solution of 3 mg in 100 mL MeOH was used.

#### Hydrogenation with hydrogen gas.

Catalyst (0.005 mol) was weighed into a glass reaction tube. The tubes were placed in a Parr hydrogenator and flushed with nitrogen. Acetophenone was added, followed by MeOH. The reaction was purged with hydrogen gas, heated and pressurised. The reaction was heated for the time indicated then analysed by GC following the procedure outlined for the other reduction methods. Products were isolated by adding EtOAc (20 mL) and sat.  $\text{Na}_2\text{CO}_3$  (20 mL) to the reaction and separating the organic layer. The aqueous layer was extracted with EtOAc (2 x 20 mL) and the combined organic layers were dried with  $\text{Na}_2\text{SO}_4$ , filtered and the solvent removed to yield the alcohol product.

### **Reduction Products.**

*Phenylethanol.*

Conversion determined by GC analysis: Chrompac Chirasil-Dex CB 25m x 0.25 mm x 0.25  $\mu$ m, T = 110 °C, P = 18psi He, det = FID 220°C, inj = 220°C, ketone 6.0 min., *R* isomer 14.5 min., *S* isomer 16.0 min.;  $\delta_{\text{H}}$  (400 MHz, CDCl<sub>3</sub>) 7.29 (4H, d, *J* = 4.0, Ar*H*), 7.21-7.25 (1H, m, Ar*H*), 4.78 (1H, q *J* = 6.5, CHOH), 3.74 (1H, br s, OH), 1.42 (3H, d *J* = 6.5, CH<sub>3</sub>);  $\delta_{\text{C}}$  (100 MHz, CDCl<sub>3</sub>) 145.8, 128.5, 127.5, 125.5, 70.4, 25.1. Reference to compound: J. Hannedouche, G. J. Clarkson and M. Wills, *J. Am. Chem. Soc.*, 2004, **126**, 986-987. Reference to rotation: J. E. D. Martins, G. J. Clarkson and M. Wills, *Org. Lett.*, 2009, **11**, 847-850.

*Benzyl alcohol.*

Conversion determined by GC analysis: Chrompac Chirasil-Dex CB 25m x 0.25 mm x 0.25  $\mu$ m, T = 100 °C, P = 18psi; He, det = FID 220°C, inj = 220°C, ketone 5.70 min., alcohol 21.29 min.;  $\delta_{\text{H}}$  (300 MHz, CDCl<sub>3</sub>) 7.24 (5H, m, Ar*H*), 4.54 (2H, s, CH<sub>2</sub>), 3.71 (1H, br. s, OH);  $\delta_{\text{C}}$  (75 MHz, CDCl<sub>3</sub>) 140.1, 128.0 (2C), 127.0, 126.5 (2C), 64.5.

*(4-Bromophenyl)-methanol.*

Conversion determined by GC analysis: Chrompac Chirasil-Dex CB 25m x 0.25 mm x 0.25  $\mu$ m, T = 150 °C, P = 18psi; He, det = FID 220°C, inj = 220°C, ketone 4.99 min., alcohol 11.34 min.;  $\delta_{\text{H}}$  (300 MHz, CDCl<sub>3</sub>) 7.48 (2H, d, *J* = 8.3, Ar*H*), 7.23 (2H, d, *J* = 8.3, Ar*H*), 4.64 (2H, s, CH<sub>2</sub>), 1.97 (1H, br. s, OH);  $\delta_{\text{C}}$  (75 MHz, CDCl<sub>3</sub>) 139.1, 131.0 (2C), 128.0 (2C), 120.8, 63.9.

*4-(Nitrophenyl)-methanol.*

Conversion determined by GC analysis: Chrompac Chirasil-Dex CB 25m x 0.25 mm x 0.25  $\mu$ m, T = 180 °C, P = 18psi; He, det = FID 220°C, inj = 220°C, ketone 3.95 min., alcohol 11.43 min.;  $\delta_{\text{H}}$  (300 MHz, CDCl<sub>3</sub>) 8.21 (2H, d, *J* = 8.7, Ar*H*), 7.53 (2H, d, *J* = 9.0, Ar*H*), 4.84 (2H, s, CH<sub>2</sub>), 2.17 (1H, br. s, OH);  $\delta_{\text{C}}$  (75 MHz, CDCl<sub>3</sub>) 147.6, 126.4 (2C), 123.1 (2C), 63.4.

*[4-(Propan-2-yl)phenyl]methanol.*

Conversion determined by GC analysis: Chrompac Chirasil-Dex CB 25m x 0.25 mm x 0.25  $\mu$ m, T = 130 °C, P = 18psi; He, det = FID 220°C, inj = 220°C, Aldehyde 7.72 min., alcohol 15.52 min.;  $\delta_{\text{H}}$  (300 MHz, CDCl<sub>3</sub>) 7.22 (4H, q, *J* = 8.3, Ar*H*), 4.56 (2H, s, CH<sub>2</sub>), 2.89 (1H, spt, *J* 6.9, (CH)(CH<sub>3</sub>)<sub>2</sub>), 2.58 (1H, br. s, OH), 1.23 (6H, d, *J* = 6.8, (CH)(CH<sub>3</sub>)<sub>2</sub>);  $\delta_{\text{C}}$  (75 MHz, CDCl<sub>3</sub>) 148.4, 138.4, 127.3(2C), 126.6(2C), 65.1, 33.9, 24.1.

*(4-Methoxyphenyl)methanol.*

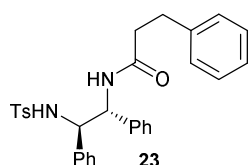
Conversion determined by GC analysis: Chrompac Chirasil-Dex CB 25m x 0.25 mm x 0.25  $\mu$ m, T = 130 °C, P = 18psi; He, det = FID 220°C, inj = 220°C, ketone 8.01 min., alcohol 16.80 min.;  $\delta_{\text{H}}$  (300

MHz, CDCl<sub>3</sub>) 7.21 (2H, d,  $J$  = 8.3, ArH), 6.83 (2H, d,  $J$  = 8.7, ArH), 4.50 (2H, s, CH<sub>2</sub>), 3.75 (3H, s, OCH<sub>3</sub>), 2.94 (1H, br. s, OH);  $\delta_C$  (75 MHz, CDCl<sub>3</sub>) 159.0, 133.2, 128.7 (2C), 113.9 (2C), 64.6, 55.3.

*(2E)-3-Phenylprop-2-en-1-ol.*

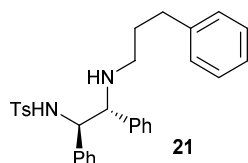
Conversion determined by GC analysis: Chrompac Chirasil-Dex CB 25m x 0.25 mm x 0.25  $\mu$ m, T = 130 °C, P = 18psi; He, det = FID 220°C, inj = 220°C, ketone 10.22 min., alcohol 18.16 min.;  $\delta_H$  (300 MHz, CDCl<sub>3</sub>) 7.20-7.37 (5H, m, ArH), 5.59 (1H, d,  $J$  = 15.8, PhCH=CH), 6.29-6.36 (1H, m, CH=CHCH<sub>2</sub>) 4.29 (2H, d,  $J$  = 4.1, CH<sub>2</sub>OH), 2.26 (1H, br. s, OH);  $\delta_C$  (75 MHz, CDCl<sub>3</sub>) 136.1, 130.5, 128.0 (2C), 128.0 (2C), 127.1, 125.9, 63.1.

*N-(1R,2R)-[1,2-Diphenyl-2-(toluene-4-sulfonylamino)-ethyl]-3-phenyl-propionamide 23.*



The preparation followed the method described for compound **10**, using 3-phenyl-propanoic acid (1.00 g, 6.66 mmol), TsDPEN (2.68 g, 7.32 mmol), HOBT (0.99 g, 7.33 mmol) and EDC (1.23 g, 7.93 mmol) in anhydrous DCM (20 mL) and anhydrous DMF (20 mL). The amide **23** was obtained as an off-white solid (3.07g, 6.16 mmol, 93%).  $\nu_{\max}$  3304.5, 3031.8, 2924.9, 2854.4, 1645.2, 1601.0, 1527.5, 1494.1, 1453.7, 1431.5, 1382.3, 1347.0, 1328.1, 1302.1, 1225.4, 1201.7, 1185.5, 1155.9, 1086.3, 1058.9, 1029.7, 1002.3 cm<sup>-1</sup>; mp: 195-197°C;  $[\alpha]_D^{26}$  +15.6 ( $c$  0.59 in CHCl<sub>3</sub>); (found(EI):  $[M+Na]^+$  521.1872. requires: C<sub>30</sub>H<sub>30</sub>N<sub>2</sub>NaO<sub>3</sub>S 521.1869);  $\delta_H$  (400 MHz, CDCl<sub>3</sub>) 7.44 (2H, d,  $J$  = 8.0, TsArH), 7.12-7.23 (9H, m, ArH), 7.01 (2H, d,  $J$  = 9.0, TsArH), 6.90-6.96 (4H, m, ArH), 6.79-6.81 (2H, m, ArH), 6.62 (2H, t,  $J$  = 9.0, NH), 5.22 (1H, dd,  $J$  = 10.0 and 8.0, CH(Ph)), 4.56 (1H, t,  $J$  = 8.0, CH(Ph)), 2.98 (2H, t,  $J$  = 7.5, CH<sub>2</sub>), 2.49-2.65 (2H, m, CH<sub>2</sub>), 2.27 (3H, s, CH<sub>3</sub>);  $\delta_C$  (100 MHz, CDCl<sub>3</sub>) 173.6, 142.9, 140.6, 138.3, 137.9, 137.7, 129.2 (2C), 128.6 (2C), 128.5 (2C), 128.4 (2C), 128.1 (2C), 127.8 (2C), 127.5 (3C), 126.8 (2C), 126.2, 63.3, 58.8, 38.3, 31.5, 21.4;  $m/z$ (ESI): 521.1 ( $[M+Na]^+$ , 100%).

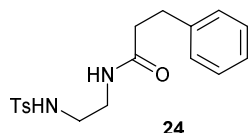
*N-(1R,2R)-[2-(3-phenyl-propylamino)-1,2-diphenyl-ethyl]-4-methyl -benzene sulphonamide 21.*



Prepared using the method described for compound **7** using N-(1R,2R)-[2-(3-phenyl-propylamido)-1,2-diphenyl-ethyl]-4-methyl benzenesulfonamide **23** (1.00g, 2.01 mmol) and 2M LiAlH<sub>4</sub> in THF (4 mL, 8.0 mmol) in anhydrous THF (20mL). The product **21** was obtained as an off-white solid (644

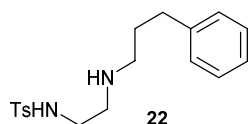
mg, 1.33 mmol, 66%). Spectroscopic data is in accordance with literature: a) J. E. D Martins, D. J.; Morris, M. Wills, *Tetrahedron Lett.* **2009**, *50*, 688-692. The synthetic steps to prepare [Ts-Dpen-teth RuCl] **1** are described in the literature: Soni, R.; Jolley, K. E.; Wills, M. *Org. Lett.* **2013**, *15*, 5110-5113.

*3-Phenyl-N-[2-(2,4,6-triisopropyl-benzenesulfonylamino)-ethyl]-propionamide 24.*



The preparation followed the method described for compound **10** using 3-phenylpropanoic acid (1.00 g, 6.66 mmol), TrisEN **8** (2.38 g, 7.30 mmol), HOBT (0.99 g, 7.33 mmol) and EDC (1.23 g, 7.93 mmol). The product **24** was obtained as a white solid (2.15 g, 4.69 mmol, 71%). Found (EI):  $[M+Na]^+$ , 481.2492.  $C_{26}H_{38}N_2NaO_3S$  requires: 481.2495;  $\nu_{max}$  3295.0, 2958.2, 2929.4, 2869.2, 1636.7, 1601.5, 1545.3, 1494.3, 1455.6, 1431.0, 1382.8, 1362.0, 1312.2, 1290.6, 1271.4, 1255.3, 1220.4, 1194.3, 1149.5, 1091.2, 1073.2, 1057.3, 1038.4, 1004.7  $cm^{-1}$ ;  $\delta_H$  (400 MHz,  $CDCl_3$ ) 7.21-7.26 (2H, m, ArH), 7.13-7.16 (5H, m, ArH), 6.37 (1H, t,  $J = 5.8$ , NHCO), 5.31 (1H, t,  $J = 6.3$ , NHS), 4.11 (2H, sept,  $J = 6.0$ , o-(CH)(CH<sub>3</sub>)<sub>2</sub>), 3.35-3.39 (2H, m, CH<sub>2</sub>N), 3.00-3.3.04 (2H, m, CH<sub>2</sub>NCO), 2.68-2.94 (3H, m, CH<sub>2</sub> and p-(CH)(CH<sub>3</sub>)<sub>2</sub>), 2.47 (2H, t,  $J = 15.6$ , CH<sub>2</sub>), 1.15-1.25 (18H, d,  $J = 6.5$ , (CH)(CH<sub>3</sub>)<sub>2</sub>);  $\delta_C$  (100 MHz,  $CDCl_3$ ) 173.2, 153.0, 150.3 (2C), 140.8, 131.8, 128.5 (2C), 128.4 (2C), 126.2, 123.9 (2C), 42.6, 39.5, 38.2, 34.2, 31.7, 29.6 (4C), 24.9 (2C), 23.6 (2C);  $m/z$ (ESI): 481.2 ( $[M+Na]^+$ , 100%).

*2,4,6-Triisopropyl-N-[2-(3-phenyl-propylamino)-ethyl]-benzenesulfonamide 22.*



Prepared using the method described for compound **7** using 3-phenyl-N-[2-(2,4,6-triisopropyl-benzenesulfonylamino)-ethyl]-propionamide **24** (1.00 g, 2.18 mmol) and 2M LiAlH<sub>4</sub> in THF (4.4 mL, 8.8 mmol) in anhydrous THF (20 mL) to yield **22** as an off-white solid (1.04 g, quant.). Mp: 70-72 °C; found (EI):  $[M+Na]^+$ , 467.2709.  $C_{26}H_{40}N_2NaO_2S$  requires: M, 467.2703;  $\nu_{max}$  3306.1, 2956.0, 2865.3, 1601.2, 1496.6, 1487.3, 1464.7, 1425.4, 1383.8, 1361.5, 1319.1, 1254.3, 1232.5, 1194.7, 1152.6, 1133.5, 1120.4, 1107.0, 1091.1, 1073.5, 1060.6, 1041.0  $cm^{-1}$ ;  $\delta_H$  (400 MHz,  $CDCl_3$ ) 7.25-7.29 (2H, m, ArH), 7.14-7.19 (3H, m, ArH), 7.16 (2H, s, TrisArH), 4.18 (2H, spt,  $J = 6.8$ , o-(CH)(CH<sub>3</sub>)<sub>2</sub>), 2.99-3.02 (2H, m, CH<sub>2</sub>N), 2.89 (1H, sept,  $J = 6.9$ , p-(CH)(CH<sub>3</sub>)<sub>2</sub>), 2.72 (2H, dd,  $J = 6.3$  and 4.8, CH<sub>2</sub>), 2.61 (2H, t,  $J = 15.6$ , CH<sub>2</sub>), 2.55 (2H, t,  $J = 7.0$ , CH<sub>2</sub>), 1.70-1.78 (2H, m, CH<sub>2</sub>), 1.24-1.27 (18H, m, (CH)(CH<sub>3</sub>)<sub>2</sub>);  $\delta_C$  (100 MHz,  $CDCl_3$ ) 152.6, 150.3 (2C), 141.9, 132.3, 128.4 (2C), 128.3 (2C), 125.9,

123.8 (2C), 48.9, 48.0, 42.2, 34.1, 33.6, 31.7, 29.7 (4C), 24.9 (2C), 23.6 (2C);  $m/z$ (ESI): 445.2 ( $[M+H]^+$ , 100%).