Ruthenium-Catalyzed *N*-Alkylation of Amines and Sulfonamides Using Borrowing Hydrogen Methodology

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Supporting Information

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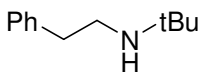
General Methods: Reactions which required the use of anhydrous, inert atmosphere techniques were carried out under an atmosphere of nitrogen. All reactions were carried out in oven-dried, nitrogen-purged glassware. In most cases, solvents were obtained by passing through anhydrous alumina columns using an Innovative Technology Inc. PS-400-7 solvent purification system. All other solvents were purchased anhydrous from Sigma Aldrich. TLC using polythene or glass backed plates precoated with Macherey-Nagel Sil G/UV_{254nm} neutral silica were used to monitor reactions where appropriate. Visualisation of these plates was by 254 nm UV light and/or $KMnO_4$ or Ninhydrin dip followed by gentle warming. Organic layers were routinely dried with anhydrous $MgSO_4$ and evaporated using a Büchi rotary evaporator. Where necessary, further drying was facilitated by high vacuum. Flash column chromatography was carried out using Davisil LC 60 Å silica gel (35-70 micron) purchased from Fluorochem. Purification by Kugelrohr distillation refers to the use of Kugelrohr distillation apparatus under high vacuum, at a pressure between 0.3 – 0.1 mmHg, and a temperature between 120 – 175 °C. IR spectra were recorded on a Perkin-Elmer 1600 FT IR spectrometer with only selected absorbances quoted as ν in cm^{-1}. NMR spectra were run in $CDCl_3$ on either a Bruker Avance 250 (250 MHz), Bruker Avance 300 (300 MHz), Bruker Avance 400 (400 MHz) or Bruker Avance 500 (500 MHz) instrument and recorded at the following frequencies: proton (^1H – 250/300/400/500 MHz), carbon (^{13}C – 62.9/75.4/100.6/125.8 MHz). The following abbreviations are used: s, singlet; d, doublet; t, triplet; app. t, apparent triplet; q, quartet;

app. q, apparent quartet; dd, doublet of doublets; m, multiplet and br, broad. Structural assignments of both protons and carbons were achieved with comparisons from analogous literature compounds; references are given in most cases.

A micrOTOF electrospray time-of-flight (ESI-TOF) mass spectrometer (Bruker Daltonik GmbH, Bremen, Germany) was used; this was coupled to an Agilent 1200 LC system (Agilent Technologies, Waldbronn, Germany). The LC system was used as an autosampler only. 10 μL of sample was injected into a 30:70 flow of water:acetonitrile at 0.6 mL/min to the mass spectrometer. For each acquisition 10 μL of a calibrant of 5 mM sodium formate was injected after the sample. The observed mass and isotope pattern perfectly matched the corresponding theoretical values as calculated from the expected elemental formula. Optical rotations were recorded on an Optical Activity, AA-10 Automatic polarimeter. Unless preparative details are provided, all reagents were commercially available and purchased from either Acros Organics, Sigma Aldrich, Alfa Aesar, Avocado, Fluka, Lancaster, Maybridge or Strem chemical companies.

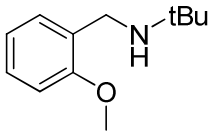
Experimental Methods:

Representative procedure 1.1 - for the alkylation of primary amine with alcohols: To an oven-dried, nitrogen purged carousel tube containing [Ru(*p*-cymene)Cl_2]$_2$ (7.7 mg, 0.0125 mmol), dppf (13.9 mg, 0.025 mmol) and activated 3 Å molecular sieves (activated by heating overnight in an oven of temperature 150 °C) (0.52 g) was added the representative amine (1 mmol), the representative alcohol (1 mmol) followed by anhydrous toluene (1 mL). The reaction mixture was allowed to stir under a nitrogen atmosphere in the closed vessel at room temperature for 10 minutes and then heated to reflux for 24 h. The crude reaction mixture was concentrated *in vacuo* and purified by column chromatography [petroleum ether (b.p. 40-60 ºC)/ethyl acetate or diethyl ether] to give the corresponding secondary amine in good yields.

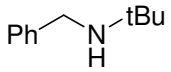


***tert*-Butyl(2-phenylethyl)amine[1] (Entry 1, Table 1):** According to representative procedure **1.1**, using t-butylamine (105 μL, 1 mmol), 2-phenethyl alcohol (119 μL, 1 mmol) and K_2CO_3 (13.8 mg, 0.01 mmol), the title compound was obtained and purified by column chromatography eluting with diethyl ether, R_f = 0.05 to give a pale brown liquid (0.16 g, 88%). ^{1}H NMR (250 MHz, $CDCl_3$): δ 7.36 – 7.22 (5H, m, Ph), 2.91 – 2.80 (4H, m, CH_2), 1.12 (9H, s, CH_3). ^{13}C NMR (75.4 MHz,

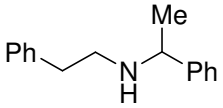
$CDCl_3$): δ 140.2, 128.7, 128.4, 50.3, 44.1, 37.2, 29.0. HRMS(ESI-TOF) calcd for $C_{12}H_{19}NH^+$: 178.1596. Found: 178.1588. (MH^+).



***tert*-Butyl-(2-methoxybenzyl)amine (Entry 2, Table 1):** According to representative procedure **1.1**, using t-butylamine (105 μL, 1 mmol), 2-methoxy benzyl alcohol (133 μL, 1 mmol) and NO molecular sieves, the title compound was obtained and purified by column chromatography eluting with dichloromethane/methanol (9:1), R_f = 0.24 to give a pale yellow liquid (0.16 g, 68%). ^{1}H NMR (250 MHz, $CDCl_3$): δ 7.33 – 7.22 (2H, m, Ph), 6.92 (1H, t, *J* = 6.5 Hz, Ph), 6.85 (1H, d, *J* = 8.1 Hz, Ph), 3.85 (3H, s, CH_3), 3.74 (2H, s, CH_2), 1.20 (9H, s, CH_3). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 157.5, 129.9, 128.8, 128.1, 120.6, 110.2, 55.2, 51.1, 42.4, 28.9. ν_{max} /cm^{-1} (neat): 3435, 2965, 2836, 1641, 1603, 1590, 1464, 1362, 1243, 1176, 1119, 1032, 753. HRMS(ESI-TOF) calcd for $C_{12}H_{19}NOH^+$: 194.1545. Found: 194.1539. (MH^+).

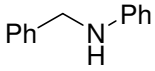


***N*-(*tert*-Butyl)benzylamine[2] (Entry 3, Table 1):** According to representative procedure **1.1**, using t-butylamine (105 μL, 1 mmol), benzyl alcohol (103 μL, 1 mmol) and NO molecular sieves, the title compound was obtained and purified by column chromatography eluting with dichloromethane/methanol (9:1), R_f = 0.19 to give a pale yellow liquid (0.10 g, 60%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.35 – 7.21 (5H, m, Ph), 3.72 (2H, s, CH_2), 1.17 (9H, s, CH_3). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 141.2, 128.4, 128.3, 126.8, 50.8, 47.2, 29.1. HRMS(ESI-TOF) calcd for $C_{11}H_{17}NH^+$: 164.1439. Found: 164.1439. (MH^+).

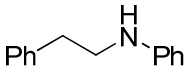


***N*-Phenethyl-1-phenylethanamine[3] (Entry 4, Table 1):** According to representative procedure **1.1**, using α-methylbenzylamine (129 μL, 1 mmol) 2-phenethyl alcohol (119 μL, 1 mmol) and K_2CO_3 (13.8 mg, 0.01 mmol), the title compound was obtained and purified by column

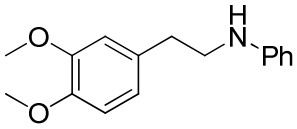
chromatography eluting with petroleum ether (b.p. 40-60 ºC)/ethyl acetate (3:2), R_f = 0.20, to give a yellow liquid (0.21g, 93%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.34 – 7.15 (10H, m, Ph), 3.78 (1H, q, *J* = 6.6 Hz, CH), 2.82 – 2.67 (4H, m, CH_2), 1.34 (3H, d, *J* = 6.6 Hz, CH_3). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 140.0, 128.7, 128.41, 128.39, 126.9, 126.5, 126.1, 58.2, 48.9, 36.4, 24.2. HRMS(ESI-TOF) calcd for $C_{16}H_{19}NH^+$: 226.1596. Found: 226.1586. (MH^+).



***N*-Benzylaniline[4] (Entry 5, Table 1):** According to representative procedure **1.1**, using benzyl alcohol (103 μL, 1 mmol), aniline (91 μL, 1 mmol) and K_2CO_3 (13.8 mg, 0.01 mmol), the title compound was obtained and purified by column chromatography eluting with petroleum ether (b.p. 40-60 ºC)/ethyl acetate (20:1), R_f = 0.24, to give a white crystalline solid (0.15 g, 80%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.41 – 7.17 (7H, m, Ph), 6.76 – 6.71 (1H, m, Ph), 6.67 – 6.64 (2H, m, Ph), 4.34 (2H, s, CH_2). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 148.0, 139.3, 129.2, 128.6, 127.5, 127.2, 117.6, 112.8, 48.3. HRMS(ESI-TOF) calcd for $C_{13}H_{13}NH^+$: 184.1126. Found: 184.1124. (MH^+).

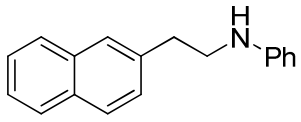


(2-Phenylethyl)aniline[5] (Entry 6, Table 1): According to representative procedure **1.1**, using 2-phenethyl alcohol (119 μL, 1 mmol), aniline (91 μL, 1 mmol) and NO molecular sieves, the title compound was obtained and purified by column chromatography eluting with hexane/ethyl acetate (20:1), R_f = 0.18, to give a colourless liquid (0.17 g, 84%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.32 – 7.16 (10H, m, Ar), 3.79 (2H, s, CH_2), 2.92-2.79 (4H, m, CH_2). ^{13}C NMR (75.5 MHz, $CDCl_3$, 25 °C): δ 140.2, 140.0, 128.7, 128.4, 128.4, 128.1, 126.9, 126.1, 53.9, 50.5, 36.4. HRMS(ESI-TOF) calcd for $C_{15}H_{16}NH^+$: 212.1439. Found: 212.1416. (MH^+).

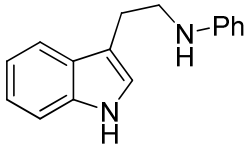


***N*-(2-(3,4-Dimethoxyphenyl)ethyl)aniline[6] (Entry 7, Table 1):** According to representative procedure **1.1**, using 3,4-dimethoxyphenethyl alcohol (0.18 g, 1 mmol), aniline (91 μL, 1 mmol) and K_2CO_3 (13.8 mg, 0.01 mmol), the title compound was obtained and purified by column

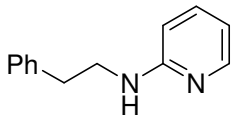
chromatography eluting with petroleum ether (b.p. 40-60 ºC)/ethyl acetate (9:1), R_f = 0.12, to give an orange liquid (0.22 g, 87%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.24 – 7.19 (2H, m, Ph), 6.87 – 6.63 (6H, m, Ph), 3.90 (3H, s, CH_3), 3.89 (3H, s, CH_3), 3.41 (2H, t, *J* = 6.9 Hz, CH_2), 2.89 (2H, t, *J* = 6.9 Hz, CH_2). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 148.9, 147.9, 147.5, 131.7, 129.1, 120.6, 117.3, 112.9, 111.9, 111.3, 77.4, 77.0, 76.6, 55.8, 55.7, 45.0, 34.9. HRMS(ESI-TOF) calcd for $C_{16}H_{19}NO_2H^+$: 258.1494. Found: 258.1490. (MH^+).



***N*-(2-(2-Naphthyl)ethyl)aniline[7] (Entry 8, Table 1):** According to representative procedure **1.1**, using 2-napthalene ethanol (0.17 g, 1 mmol), aniline (91 μL, 1 mmol) and NO molecular sieves, the title compound was obtained and purified by column chromatography eluting with hexane/ethyl acetate (20:1), R_f = 0.18 to give a colourless liquid (0.22 g, 89%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.87 – 7.82 (3H, m, Ph), 7.70 (1H, s, Ph), 7.52 – 7.48 (m, 2H, Ph), 7.40 (1H, dd, *J* = 8.4, 1.6 Hz, Ph), 7.27 – 7.20 (m, 2H, Ph), 6.76 (1H, t, *J* = 7.3 Hz, Ph), 6.67 (2H, d, , *J* = 8.6 Hz, Ph), 3.53 (2H, t, *J* = 6.9 Hz, CH_2), 3.11 (2H, t, *J* = 6.9 Hz, CH_2). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 147.8, 136.7, 133.5, 132.2, 129.3, 128.2, 127.6, 127.4, 127.2, 127.1, 126.1, 125.5, 117.6, 113.1, 44.9, 35.5. HRMS(ESI-TOF) calcd for $C_{18}H_{17}NH^+$: 258.1494. Found: 258.1490. (MH^+).

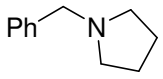


***N*-(2-Indol-3-yl-ethyl)aniline (Entry 9, Table 1):** According to representative procedure **1.1**, using tryptophol (0.16 g, 1 mmol), aniline (91 μL, 1 mmol) and K_2CO_3 (13.8 mg, 0.01 mmol), the title compound was obtained and purified by column chromatography eluting with dichloromethane/hexane (9:1), R_f = 0.49 to give a colourless liquid (0.16 g, 70%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.01 (br s, 1H, NH), 7.65 (1H, d, *J* = 7.8, Ph), 7.40 (1H, d, *J* = 8.1, Ph), 7.27 – 7.13 (m, 4H, Ph), 7.13 (1H, s, Ph), 6.73 (1H, t, *J* = 7.3 Hz, Ph), 6.65 (2H, d, , *J* = 7.7 Hz, Ph), 3.50 (2H, t, *J* = 6.8 Hz, CH_2), 3.12 (2H, t, *J* = 6.8 Hz, CH_2). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 148.0, 136.3, 129.2, 127.4, 122.2, 122.0, 119.4, 118.8, 117.4, 113.4, 113.1, 111.2, 44.0, 25.0. HRMS(ESI-TOF) calcd for $C_{16}H_{16}N_2H^+$: 237.1392. Found: 237.1381. (MH^+).

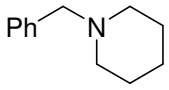


2-Phenylethylaminopyridine[8] (Entry 10, Table 1): According to representative procedure **1.1**, using 2-phenethyl alcohol (119 μL, 1 mmol), 2-aminopyridine (94.1 mg, 1 mmol) and NO molecular sieves, the title compound was obtained and purified by column chromatography eluting with dichloromethane/hexane (99:1), R_f = 0.31 to give a pale brown liquid (0.16 g, 78%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.07 (1H, dd, *J* = 5.0, 1.1 Hz, py), 7.42 – 7.30 (1H, m, py), 7.29 – 7.18 (5H, m, Ph), 6.55 (1H, ddd, *J* = 7.1 Hz, 5.0, 0.9 Hz, py), 6.35 (1H, d, *J* = 8.4 Hz, py), 4.52 (1H, br s, NH), 3.54 (2H, app. q, *J* = 6.9 Hz, CH_2), 2.91 (2H, t, CH_2). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 158.5, 148.1, 139.2, 137.4, 128.8, 128.6, 126.4, 112.9, 106.8, 43.3, 35.7. HRMS(ESI-TOF) calcd for $C_{13}H_{14}N_2H^+$: 199.1235. Found: 199.1230.

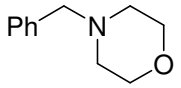
Representative procedure 1.2 - for the amination of benzyl alcohol with secondary amines: To an oven-dried, nitrogen purged carousel tube containing [Ru(*p*-cymene)Cl_2]$_2$ (7.7 mg, 0.0125 mmol), dppf (13.9 mg, 0.025 mmol) and activated molecular sieves (activated by heating overnight in an oven of temperature 150 °C) (0.52 g, 3 Å) was added the representative amine (1 mmol), benzyl alcohol (103 μL, 1 mmol) followed by anhydrous toluene (1 mL) dropwise. The reaction mixture was allowed to stir under a nitrogen atmosphere in the closed vessel at room temperature for 10 minutes and then heated to reflux for 24 h. The crude reaction mixture was concentrated *in vacuo*. The crude product was purified by column chromatography [petroleum ether (b.p. 40-60 ºC)/ethyl acetate or diethyl ether] to give the corresponding tertiary amine in good yields.



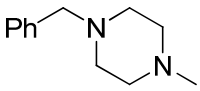
***N*-Benzylpyrrolidine[9] (Entry 1, Table 2):** According to representative procedure **1.2**, using pyrrolidine (83 μL, 1mmol), the title compound was obtained and purified by column chromatography eluting with diethyl ether, R_f = 0.05 to give a reddish-brown oil (0.11 g, 71%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.23 – 7.37 (5H, m, Ph), 3.63 (2H, s, CH_2), 2.49 – 2.55 (m, 4H, CH_2), 1.75 – 1.83 (4H, m, CH_2). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 139.4, 128.9, 128.2, 126.8, 60.8, 54.2, 23.4. HRMS(ESI-TOF) calcd for $C_{11}H_{15}NH^+$: 162.1200. Found: 162.1287. (MH^+).



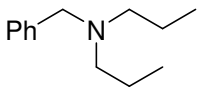
***N*-Benzylpiperidine[9] (Entry 2, Table 2):** According to representative procedure **1.2**, using piperidine (99 μL, 1 mmol), the title compound was obtained and purified by column chromatography eluting with petroleum ether (b.p. 40-60 ºC)/ethyl acetate (5:1), R_f = 0.09 to give a light orange oil (0.13 g, 72%). ^{1}H NMR (250 MHz, $CDCl_3$): δ 7.21 – 7.40 (5H, m, Ph), 3.49 (2H, s, CH_2), 2.37 – 2.39 (4H, m, CH_2), 1.55 – 1.63 (4H, m, CH_2), 1.43 – 1.48 (2H, m, CH_2). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 129.3, 128.1, 126.9, 63.8, 54.5, 25.9, 24.3. HRMS(ESI-TOF) calcd for $C_{12}H_{17}NH^+$: 176.1400. Found: 176.1435. (MH^+).



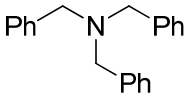
***N*-Benzylmorpholine[10] (Entry 3, Table 2):** According to representative procedure **1.2**, using morpholine (87 μL, 1 mmol), the title compound was obtained and purified by column chromatography eluting with petroleum ether (b.p. 40-60 ºC)/ethyl acetate (4:1), R_f = 0.16 to give a clear colourless oil (0.15 g, 84%). ^{1}H NMR (250 MHz, $CDCl_3$): δ 7.21 – 7.29 (5H, m, Ph), 3.67 (4H, t, *J* = 4.8 Hz, CH_2), 2.40 (4H, t, *J* = 4.6 Hz, CH_2), 3.46 (2H, s, CH_2). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 137.7, 129.2, 128.2, 127.1, 67.0, 63.5, 53.6. HRMS(ESI-TOF) calcd for $C_{11}H_{15}NOH^+$: 178.1200. Found: 178.1223. (MH^+).



1-Benzyl-4-methylpiperazine (Entry 4, Table 2): According to representative procedure **1.2**, using *N*-methylpiperazine (111 μL, 1 mmol), the title compound was obtained and purified by column chromatography eluting with dichloromethane/methanol (9:1), R_f = 0.16 to give a pale yellow liquid (0.16 g, 80%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.32 – 7.24 (5H, m, Ph), 3.51 (2H, s, CH_2), 2.48 (8H, br s, CH_2), 2.29 (3H, s, CH_3). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 138.1, 129.2, 128.2, 127.0, 63.0, 55.1, 52.9, 45.9. HRMS(ESI-TOF) calcd for $C_{12}H_{18}N2H^+$: 191.1548. Found: 191.1544. (MH^+).

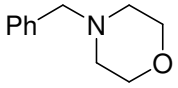


***N*-*N*-Dipropylbenzylamine[11] (Entry 5, Table 2):** According to representative procedure **1.2**, using dipropylamine (137 μL, 1 mmol), the title compound was obtained and purified by column chromatography eluting with petroleum ether (b.p. 40-60 ºC)/ethyl acetate (9:1), R_f = 0.24 to give a colourless oil (0.17 g, 87%). ^{1}H NMR (250 MHz, $CDCl_3$): δ 7.23 – 7.37 (5H, m, Ph), 3.57 (2H, s, CH_2), 2.34 (4H, t, *J* = 7.4 Hz, CH_2), 1.42 – 1.57 (4H, sextet, *J* = 7.4 Hz, CH_2CH_3), 0.87 (6H, t, *J* = 7.3 Hz, CH_3). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 128.0, 126.6, 58.6, 55.8, 20.2, 11.9. HRMS(ESI-TOF) calcd for $C_{13}H_{21}NH^+$: 192.1700. Found: 192.1740. (MH^+).

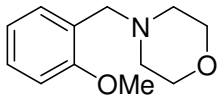


Tribenzylamine (Entry 6, Table 2): According to representative procedure **1.2**, using dibenzylamine (192 μL, 1 mmol), the title compound was obtained and purified by column chromatography eluting with petroleum ether (b.p. 40-60 ºC)/diethyl ether (98:2), R_f = 0.17, to give a white solid (0.13 g, 44%). m.p. 93-94 ºC. ^{1}H NMR (250 MHz, $CDCl_3$): δ 7.43 – 7.21 (15H, m, Ar), 3.57 (6H, s, CH_2). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 140.1, 129.2, 128.6, 127.3, 58.3. HRMS(ESI-TOF) calcd for $C_{21}H_{21}NH^+$: 288.1752. Found: 288.1750. (MH^+).

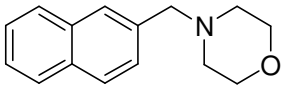
Representative procedure 1.3 - for the alkylation of morpholine with alcohols: To an oven-dried, nitrogen purged carousel tube containing [Ru(*p*-cymene)Cl_2]$_2$ (7.7 mg, 0.0125 mmol), dppf (13.9 mg, 0.025 mmol) and activated molecular sieves (activated by heating overnight in an oven of temperature 150 °C) (0.52 g, 3 Å) was added morpholine (87 μL, 1 mmol), the representative alcohol (1 mmol) followed by anhydrous toluene (1 mL) dropwise. The reaction mixture was allowed to stir under a nitrogen atmosphere in the closed vessel at room temperature for 10 minutes and then heated to reflux for 24 h. The crude reaction mixture was concentrated *in vacuo*. The crude product was purified by column chromatography [petroleum ether (b.p. 40-60 ºC)/ethyl acetate to yield the corresponding alkylated morpholine products in good yields.



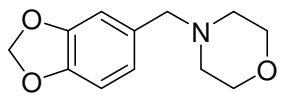
***N*-Benzylmorpholine[10] (Entry 1, Table 3):** According to representative procedure **1.3**, using benzyl alcohol (103 μL, 1 mmol), the title compound was obtained and purified by column chromatography eluting with petroleum ether (b.p. 40-60 ºC)/ethyl acetate (4:1), R_f = 0.16 to give a clear colourless oil (0.15 g, 84%). Spectroscopy data was consistent with that of **Entry 3, Table 2** above.



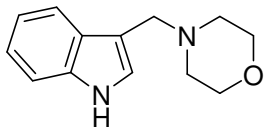
4-(2-Methoxybenzyl)morpholine (Entry 2, Table 3): According to representative procedure **1.3**, using 2-methoxybenzyl alcohol (133 μL, 1mmol), the title compound was obtained and purified by column chromatography eluting with petroleum ether (b.p. 40-60 ºC)/ethyl acetate (5:1), R_f = 0.07 to give a clear pale yellow oil (0.15 g, 74%). ^{1}H NMR (250 MHz, $CDCl_3$,): δ 7.37 (1H, d, *J* = 7.4, Ar), 7.28 – 7.22 (1H, m Ar), 6.94 (1H, t, *J* = 7.4 Hz, Ar), 6.89 (1H, d, *J* = 8.2 Hz, Ar), 3.84 (3H, s, CH_3), 3.74 (4H, t, *J* = 4.7 Hz, CH_2), 3.58 (2H, s, CH_2), 2.52 (4H, t, *J* = 4.6 Hz, CH_2). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 157.9, 130.6, 128.2, 125.7, 120.3, 110.5, 67.0, 56.4, 55.4, 53.6. HRMS(ESI-TOF) calcd for $[C_{12}H_{17}NO_2]^+$: 208.1300. Found: 208.1332. (M^+).



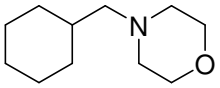
***N*-(Naphthylmethyl)morpholine or 4-napthalen-2-ylmethylmorhpholine[12] (Entry 3, Table 3):** According to representative procedure **1.3**, using 2-naphthalenemethanol (0.16 g, 1 mmol), the title compound was obtained and purified by column chromatography eluting with petroleum ether (b.p. 40-60 ºC)/ethyl acetate (2:1), R_f = 0.28 to give a clear yellowish-brown liquid (0.18 g, 78%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.81 – 7.85 (3H, m, Ar), 7.76 (1H,s, Ar), 7.46 – 7.54 (3H, m, Ar), 3.74 (4H, t, *J* = 4.5 Hz, CH_2), 3.68 (2H,s, CH_2), 2.51 (4H, t, *J* = 4.5 Hz, CH_2). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 135.7, 133.7, 133.2, 128.4, 128.2, 128.1, 127.8, 126.4, 64.0, 54.1. HRMS(ESI-TOF) calcd for $C_{15}H_{17}NOH^+$: 228.1300. Found: 228.1380. (MH^+).



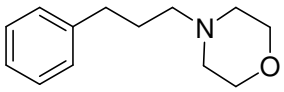
Piperonylmorpholine[13] (Entry 4, Table 3): According to representative procedure **1.3**, using piperonyl alcohol (0.15 g, 1 mmol), the title compound was obtained and purified by column chromatography eluting with petroleum ether (b.p. 40-60 ºC)/ethyl acetate (2:1), R_f = 0.29 to give a clear pale yellow liquid (0.20 g, 89%). ^{1}H NMR (250 MHz, $CDCl_3$): δ 6.87 (1H, s, Ar), 6.754 (1H, s, Ar), 6.751 (1H, s, Ar), 5.95 (2H, s, CH_2), 3.71 (4H, t, *J* = 4.6 Hz, CH_2), 3.41 (2H,s, CH_2), 2.43 (4H, t, *J* = 4.5 Hz, CH_2). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 147.6, 146.6, 131.7, 122.2, 109.5, 107.8, 100.9, 67.1, 63.2, 53.4. HRMS(ESI-TOF) for $C_{12}H_{15}NO_3H^+$: 222.1100. Found: 222.1144. (MH^+).



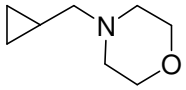
3-Morpholin-4-ylmethyl-indole[14] (Entry 5, Table 3): According to representative procedure **1.3**, using indole-3-carbinol (0.15g, 1 mmol) the title compound was obtained and purified by column chromatography eluting with petroleum ether (b.p. 40-60 ºC)/ethyl acetate (1:2), R_f = 0.12 to give a pale brown solid (0.18 g, 85%). m.p. 119-120 ºC. ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.15 (1H, br s, -NH), 7.78 (1H, d, *J* = 7.8 Hz, Ar), 7.38 (1H, d, *J* = 8.4 Hz, CH), 7.12 – 7.25 (3H, m, Ar), 3.73 (2H,s, CH_2), 3.71 – 3.74 (4H, m, CH_2), 2.52 (4H, t, *J* = 4.6 Hz, CH_2). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 136.3, 127.9, 123.6, 122.1, 119.6, 119.5, 112.3, 111.0, 67.1, 54.0, 53.6. HRMS(ESI-TOF) calcd for $C_{13}H_{16}N_2OH^+$: 217.1300. Found: 217.1330. (MH^+).



***N*-(Cyclohexylmethyl)morpholine[15,16] (Entry 6, Table 3):** According to representative procedure **1.3**, using cyclohexylmethanol (123 μL, 1 mmol), the title compound was obtained and purified by column chromatography eluting with petroleum ether (b.p. 40-60 ºC)/ethyl acetate (3:4), R_f = 0.49 to give a clear pale brown oil (0.11 g, 62%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 3.71 (4H, t, *J* = 4.7 Hz, CH_2), 2.38 (4H, t, *J* = 4.5 Hz, CH_2), 2.12 (2H, d, *J* = 7.2 Hz, CH_2), 1.69-1.80 (4H, m, CH_2), 1.42 – 1.56 (1H, m, CH_2), 1.14 – 1.29 (4H, m, CH_2), 0.82 – 0.94 (2H, m, CH_2). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 67.1, 66.2, 54.2, 34.7, 31.8, 26.8, 26.1. HRMS(ESI-TOF) calcd for $C_{11}H_{21}NOH^+$: 184.1700. Found: 184.1695. (MH^+).



4-(3-Phenyl-propyl)-morpholine[17] (Entry 7, Table 3): According to representative procedure **1.3**, using 3-phenylpropanol (135 μL, 1 mmol), the title compound was obtained and purified by column chromatography eluting with petroleum ether (b.p. 40-60 ºC)/ethyl acetate (1:1), R_f = 0.24 gave a pale brown liquid (0.16 g, 77%) ^{1}H NMR (250 MHz, $CDCl_3$): δ 7.11 – 7.27 (5H, m, Ph), 3.68 (4H, t, 4.7 Hz, CH_2), 2.61 (2H, t, *J* = 7.7 Hz, CH_2), 2.38 – 2.41 (4H, m, CH_2), 2.33 (2H, t, *J* = 7.6 Hz, CH_2), 1.72-1.84 (2H, m, CH_2). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 142.0, 128.4, 128.3, 125.8, 67.0, 58.4, 53.7, 33.6, 28.2. HRMS(ESI-TOF) calcd for $C_{13}H_{19}NOH^+$: 206.1500. Found: 206.1544. (MH^+).



4-(3-Phenyl-propyl)-morpholine[18] (Entry 8, Table 3): According to representative procedure **1.3**, using cyclopropanemethanol (81 μL, 1 mmol), the title compound was obtained and purified by column chromatography eluting with petroleum ether (b.p. 40-60 ºC)/ethyl acetate (1:2), R_f = 0.06 to give a clear pale yellowish-brown oil (0.12 g, 85%). ^{1}H NMR (250 MHz, $CDCl_3$): δ 3.73 – 3.77 (4H, m, CH_2), 2.51 – 2.55 (4H, m, CH_2), 2.25 (2H, d, *J* = 6.5 Hz, CH_2), 0.79 – 0.94 (1H, m, CH), 0.49 – 0.56 (2H, m, CH_2), 0.10 – 1.14 (2H, m, CH_2). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 66.9, 64.1, 53.8, 30.9, 8.1, 3.8. HRMS(ESI-TOF) calcd for $C_8H_{15}NOH^+$: 142.1200. Found: 142.1250. (MH^+).

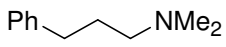
Example Procedure for the Use of Dimethylammonium Acetate:

To an oven-dried, nitrogen purged Schlenk tube containing [Ru(*p*-cymene)Cl_2]$_2$ (15.3 mg, 0.025 mmol), dppf (27.7 mg, 0.05 mmol), dimethylammonium chloride (0.16 g, 2 mmol) and activated molecular sieves (0.52 g, 3 Å) was added benzyl alcohol (103 μL, 1 mmol) and triethylamine (279 μL, 2 mmol) followed by anhydrous toluene (1 mL) dropwise. The reaction mixture was allowed to stir under a nitrogen atmosphere at room temperature for 10 minutes and then heated to reflux for 24 hours. The solvent was then removed *in vacuo*.

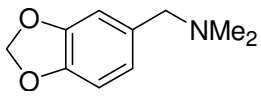
Preparation of dimethylamine solution in toluene:

To an oven-dried, nitrogen-purged Schlenk tube containing liquefied dimethylamine gas (1.64 mL, condensed at -78 ˚C) was added anhydrous toluene (20 mL). The dimethylamine-toluene mixture was sealed and shaken, then stored cold. Concentration was found to be 1.5 mmol of Me_2NH / 1 mL of toluene (confirmed by comparison of the methyl groups signal by ^1H NMR spectroscopy).

Representative procedure 1.4 - for the dimethylamination of primary alcohol: To an oven-dried, nitrogen-purged Schlenk tube containing $[Ru(p\text{-cymene})Cl_2]_2$ (3.1 mg, 0.005 mmol) (note: 0.5 mol% dimer is 1.0 mol % Ru) and DPEphos (6.6 mg, 0.012 mmol) was added alcohol (1 mmol) followed by a 1.4 M Me_2NH solution in toluene (1 mL) dropwise. The reaction mixture was stirred under a nitrogen atmosphere at room temperature in the closed vessel for 10 minutes and then heated to reflux for 24 h. On completion the reaction was allowed to cool to room temperature, diluted with dichloromethane, and the solvent removed *in vacuo.* The crude product was purified by column chromatography on silica gel eluting with dichloromethane/methanol, furnishing the corresponding dimethylamino compounds.

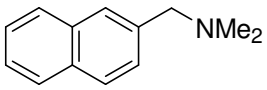


***N,N*-Dimethyl-3-phenylpropylamine[19] (Entry 1, Table 4):** According to representative procedure **1.4**, using 3-phenyl-1-propanol (135 μL, 1 mmol), the title compound was obtained and purified by column chromatography eluting with dichloromethane/methanol (92:8), R_f = 0.15 to give a colourless oil (0.14 g, 83%). ^1H NMR (300 MHz, $CDCl_3$): δ 7.32 – 7.37 (2H, m, Ph), 7.24 – 7.26 (3H, m, Ph), 2.70 (2H, t, *J* = 7.8 Hz, CH_2), 2.37 (2H, t, *J* = 7.5 Hz, CH_2), 2.23 (6H, s, CH_3), 1.86 (2H, tt, *J* = 7.8, 7.4 Hz, CH_2). ^{13}C NMR (75.4 MHz, $CDCl_3$,): δ 142.3, 128.4, 128.3, 125.7, 59.3, 45.5, 33.7, 29.4. HRMS(ESI-TOF) calcd for $C_{11}H_{18}NH^+$: 164.1434. Found: 164.1425. (MH^+).

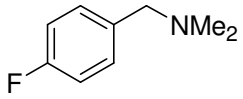


***N,N*-Dimethyl-3,4-(methylenedioxy)benzylamine[20] (Entry 2, Table 4):** According to representative procedure **1.4**, using piperonyl alcohol (0.15 g, 1 mmol), the title compound was obtained and purified by column chromatography eluting with dichloromethane/methanol (92:8), R_f = 0.15 to give an oil (0.15 g, 85%). ^1H NMR (250 MHz, $CDCl_3$): δ 6.84 (1H, s, Ph), 6.75 (2H, s, Ph), 5.95 (2H, s, CH_2), 3.34 (2H, s, CH_2), 2.23 (6H, s, CH_3). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 147.6,

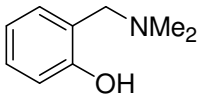
146.6, 132.7, 122.2, 109.5, 107.9, 100.9, 64.1, 45.2. HRMS(ESI-TOF) calcd for $C_{10}H_{14}NO_2H^+$: 180.1025. Found: 180.1024. (MH^+).



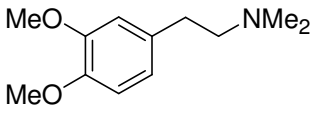
***N,N*-Dimethyl-2naphthalenemethanamine[21] (Entry 3, Table 5):** According to representative procedure **1.4**, using 2-naphthalenemethanol (0.16 g, 1 mmol), the title compound was obtained and purified by column chromatography eluting with dichloromethane/methanol (9:1), R_f = 0.34 to give a colourless oil (0.18 g, 97%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.45 – 7.86 (7H, m, Ph), 3.60 (2H, s, CH_2), 2.31 (6H, s, CH_3). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 136.4, 133.3, 132.8, 127.9, 127.7, 127.6, 127.5, 127.3, 125.9, 125.6, 64.5, 45.5. HRMS(ESI-TOF) calcd for $C_{13}H_{16}NH^+$: 186.1283. Found: 186.1271. (MH^+).



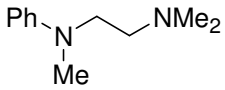
***N,N*-Dimethyl-4-fluorobenzylamine[21] (Entry 4, Table 4):** According to representative procedure **1.4**, using 4-fluorobenzyl alcohol (108 μL, 1 mmol), the title compound was obtained and purified by column chromatography eluting with dichloromethane/methanol (92:8), R_f = 0.16 to give a light yellow oil (0.09 g, 60%). ^{1}H NMR (250 MHz, $CDCl_3$): δ 7.24 – 7.30 (2H, m, Ph), 6.97 – 7.04 (2H, m, Ph), 3.39 (2H, s, CH_2), 2.24 (6H, s, CH_3). ^{13}C NMR (100.6 MHz, $CDCl_3$): δ 162.0 (d, $J_{C\text{-}F}$ = 244.9 Hz), 134.4 (d, $J_{C\text{-}F}$ = 3.2 Hz), 130.6 (d, $J_{C\text{-}F}$ = 8 Hz), 115.0 (d, $J_{C\text{-}F}$ = 21.2 Hz), 63.5, 45.2. HRMS(ESI-TOF) calcd for $C_9H_{13}FNH^+$: 154.1032. Found: 154.1023. (MH^+).



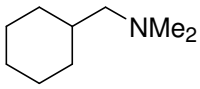
2-[(Dimethylamino)methyl]phenol[22] (Entry 5, Table 4): According to representative procedure **1.4**, using 2-hydroxybenzyl alcohol (0.12 g, 1 mmol), the title compound was obtained and purified by column chromatography eluting with dichloromethane/methanol (95:5), R_f = 0.17 to give a light yellow oil (0.13 g, 88%). ^{1}H NMR (300 MHz, $CDCl_3$): δ = 6.75 – 7.21 (4H, m, Ph), 3.66 (2H, s, CH_2), 2.35 (6H, s, CH_3). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 158.1, 128.8, 128.4, 121.8, 119.0, 116.1, 62.7, 44.4. HRMS(ESI-TOF) calcd for $C_9H_{13}NOH^+$: 152.1075. Found: 152.1061. (MH^+).



***N*-[2-(3,4-Dimethoxyphenyl)ethyl]dimethylamine[23] (Entry 6, Table 4):** According to representative procedure **1.4**, using 3,4-dimethoxyphenethyl alcohol (0.182 g, 1 mmol), the title compound was obtained and purified by column chromatography eluting with dichloromethane/methanol (9:1), R_f = 0.11 to give an oil (0.18 g, 94%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 6.74 – 6.82 (3H, m, Ph), 3.88 (3H, s, CH_3), 3.86 (3H, s, CH_3), 2.74 – 2.79 (2H, m, CH_2), 2.53 – 2.58 (2H, m, CH_2), 2.34 (6H, s, CH_3). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 148.8, 147.3, 132.6, 120.4, 111.8, 111.2, 61.6, 55.9, 55.8, 45.4, 33.8. HRMS(ESI-TOF) calcd for $C_{12}H_{19}NO_2H^+$: 210.1494. Found: 210.1473. (MH^+).

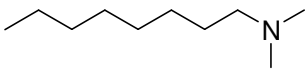


***N,N,N′*-Trimethyl-*N′*-phenyl-ethylenediamine[24] 22 (Entry 7, Table 4):** According to representative procedure **1.4**, using 2-(methylphenylamino)ethanol **23** (143 μL, 1 mmol) at 2.5 mol % Ru, the title compound was obtained and purified by column chromatography eluting with dichloromethane/methanol (95:5), R_f = 0.11 to give an oil (0.13 g, 75%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.21 – 7.27 (2H, m, Ph), 6.67 – 6.74 (3H, m, Ph), 3.47 (2H, t, *J* = 7.6 Hz, CH_2), 2.96 (3H, s, CH_3), 2.49 (2H, t, *J* = 7.6 Hz, CH_2), 2.31 (6H, s, CH_3). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 149.1, 129.2, 116.1, 112.0, 55.9, 51.1, 45.9, 38.5. HRMS(ESI-TOF) calcd for $C_{11}H_{18}N_2H^+$: 179.1548. Found: 179.1541. (MH^+).

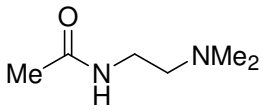


***N,N*-Dimethylcyclohexylmethylamine[25] (Entry 8, Table 4):** According to representative procedure **1.4**, using cyclohexylmethanol (0.123 mL, 1 mmol) at 2.5 mol % Ru, the title compound was obtained and purified by column chromatography eluting with dichloromethane/methanol (9:1), R_f = 0.1 to give a brown oil (0.11 g, 77%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 2.28 (6H, s, CH_3), 2.17 (2H, app. t, *J* = 3.6 Hz, CH_2), 0.85 – 1.82 (11H, m, CH_2, CH). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 66.7,

45.6, 35.4, 31.7, 26.6, 26.0. HRMS(ESI-TOF) calcd for $C_9H_{19}NH^+$: 142.1596. Found: 142.1589. (MH^+).

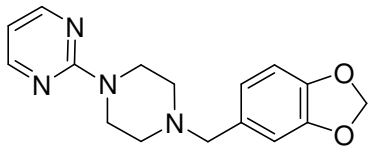


***N,N*-Dimethyloctylamine[26] (Entry 9, Table 4):** According to representative procedure **1.4**, using 1-octanol (0.157 μL, 1 mmol) at 2.5 mol % Ru, the title compound was obtained and purified by column chromatography eluting with dichloromethane/methanol (9:1), R_f = 0.19 to give a colourless oil (0.12 g, 76%). ν_{max} /cm^{-1}(neat) 2929, 2856, 2763, 1466, 1379, 1261. ^{1}H NMR (300 MHz, $CDCl_3$): δ 2.19 – 2.27 (8H, m, CH_3, CH_2), 0.86 – 1.48 (15H, m, CH_2, CH_3). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 60.0, 45.6, 31.9, 29.6, 29.3, 27.8, 27.6, 22.7, 14.2. HRMS(ESI-TOF) calcd for $C_{10}H_{23}NH^+$: 158.1903. Found: 158.1904. (MH^+).



***N*-(2-Dimethylaminoethyl)acetamide[27] (Entry 10, Table 4):** According to representative procedure **1.4**, using *N*-acetylaminoethanolamine (92 μL, 1 mmol) at 5.0 mol % Ru, the title compound was obtained and purified by column chromatography eluting with dichloromethane/methanol (80:20), R_f = 0.05 to give a pale yellow oil (0.094 g, 72%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 3.32 (2H, app. q, *J* = 5.9 Hz, CH_2), 2.42 (2H, t, *J* = 5.9 Hz, CH_2), 2.34 (6H, s, CH_3), 1.98 (3H, s, CH_3). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 170.2, 57.8, 45.0, 36.7, 23.2. HRMS(ESI-TOF) calcd for $C_6H_{14}N_2OH^+$: 131.1184. Found: 131.1176. (MH^+).

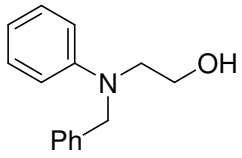
Preparation of Piribedil[28] 11



2-[4-(1,3-Benzodioxol-5-ylmethyl)piperazin-1-yl]pyrimidine[28] or Piribedil 11: To an oven-dried, nitrogen purged carousel tube containing [Ru(*p*-cymene)Cl_2]$_2$ (7.7 mg, 0.0125 mmol), dppf (13.9 mg, 0.025 mmol), piperonyl alcohol **10** (152.2 mg, 1 mmol) and activated molecular sieves

(0.52 g, 3 Å) was added 1-(2-pyrimidyl)piperazine **9** (142 µL, 1 mmol) followed by anhydrous toluene (1 mL) dropwise. The reaction mixture was allowed to stir under a nitrogen atmosphere in the closed vessel at room temperature for 10 minutes and then heated to reflux for 24 h. The resulting crude was evaporated *in vacuo.* Purification by column chromatography petroleum ether (b.p. 40-60 ºC)/ethyl acetate (2:1), R_f = 0.17, afforded Piribedil **11** as a pale yellow solid (0.25 g, 87%). m.p. 95-96 ºC; ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.30 (2H, d, *J* = 4.7 Hz, Ar), 6.90 (1H, s, Ar), 6.77 (2H, s, Ar), 6.47 (1H, t, *J* = 4.7 Hz, Ar), 5.96 (2H, s, CH_2), 3.83 (4H, t, *J* = 5.1 Hz, CH_2), 3.46 (2H, s, CH_2), 2.49 (4H, t, *J* = 5.1 Hz, CH_2). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 161.7, 157.7, 147.7, 146.7, 131.9, 122.2, 109.7, 109.5, 107.9, 100.9, 62.9, 52.8, 43.7. HRMS(ESI-TOF) calcd for $C_{16}H_{18}N_4O_2H^+$: 299.1500. Found: 299.1506. (MH^+).

Preparations of 2-(*N*-benzyl-*N*-phenylamino)ethanol[29] 12

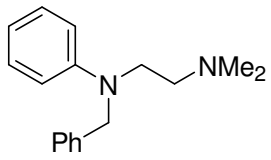


Synthesis of 2-(*N*-benzyl-*N*-phenylamino)ethanol 12 *via* conventional alkylation reaction[29] (Scheme 5): To a two-necked round bottom flask was added 2-bromoethanol (0.774 mL, 0.011 mol), acetonitrile (2.5 mL) and potassium iodide (1.82 g, 0.011 mol) and left to stir for 5 minutes to form a yellow solution. In another two-necked round bottom flask was added *N*-benzylaniline (2.00 g, 0.011 mol), acetonitrile (5 mL) and $NaHCO_3$ (0.92 g) and left to stir for 5 minutes and the 2-bromoethanol mixture was added to it. The mixture was heated to reflux for 17 h. An NMR sample was taken which showed unreacted starting material. Therefore, another portion of bromoethanol /MeCN/KI mixture (the same quantities as used above) was added and reflux was continued for another 17 h. After being allowed to cool, the solvent was then removed *in vacuo* and HCl (1.5 M, 80 mL) was added to the crude mixture and then extracted two times with CH_2Cl_2 (90 mL). In order to isolate the aminoalcohol, the combined aqueous HCl layers were neutralized with NaOH (1.5 M, 90 mL, pH = 14) and then extracted two times with CH_2Cl_2 (90 mL). The combined organic layers were washed with brine (200 mL) and dried over anhydrous $MgSO_4$ and the solvent was removed *in vacuo* to form a colourless oil (1.01 g, 40%). ^{1}H NMR (300 MHz, $CDCl_3$: δ 7.18 – 7.34 (7H, m, Ph), 6.71 – 6.81 (3H, m, Ph), 4.63 (2H, s, CH_2), 3.84 (2H, m, CH_2), 3.62 (2H, t, *J* = 5.8 Hz, CH_2). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 148.8, 138.6, 129.3, 128.6, 126.9, 126.6, 117.1,

113.0, 60.3, 55.1, 53.4. HRMS(ESI-TOF) calcd for $C_{15}H_{17}NOH^+$: 228.1388. Found: 228.1385. (MH^+).

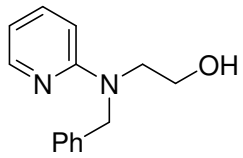
Synthesis of 2-(*N*-benzyl-*N*-phenylamino)ethanol 12 *via* Borrowing Hydrogen[30] (Scheme 6): To an oven-dried, nitrogen-purged Schlenk tube containing [Ru(*p*-cymene)Cl_2]$_2$ (15.3 mg, 0.025 mmol) (note: 2.5 mol% dimer is 5.0 mol% Ru) and DPEphos (26.9 mg, 0.05 mmol) was added *N*-benzylaniline **20** (0.183g, 1 mmol) followed by ethylene glycol (0.279 μL, 5 mmol). Anhydrous toluene (1 mL) was then added dropwise. The reaction mixture was stirred under a nitrogen atmosphere at room temperature for 10 minutes and then heated to reflux for 3 days. On completion the reaction was allowed to cool to room temperature, diluted with dichloromethane, and the solvent removed *in vacuo.* The crude product was purified by column chromatography on silica gel eluting with petroleum ether/diethyl ether (1:1), to give a colourless oil (0.16 g, 70%). Spectroscopic data is consistent with the above values.

Preparation of Antergan[31] 16



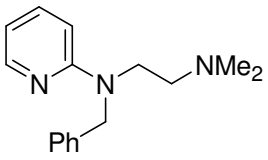
***N*-Benzyl-*N′*,*N′*-dimethyl-*N*-phenyl-ethylenediamine or Antergan[31] 16:** According to representative procedure **1.4**, using *N*-benzyl-2-anilinoethanol **12** (0.227 g, 1 mmol) at 5.0 mol % Ru, the title compound was obtained and purified by column chromatography eluting with dichloromethane/methanol (95:5), R_f = 0.28 to give an oil (0.19 g, 75%). ν_{max} /cm^{-1}(neat) 3027, 2943, 2768, 1598, 1506, 1452, 1356. ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.17 – 7.34 (7H, m, Ph), 6.67 – 6.73 (3H, m, Ph), 4.58 (2H, s, CH_2), 3.58 (2H, t, *J* = 7.6 Hz, CH_2), 2.59 (2H, t, *J* = 7.6 Hz, CH_2), 2.32 (6H, s, CH_3). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 148.3, 138.8, 129.3, 128.6, 126.8, 126.6, 116.4, 112.2, 56.2, 54.8, 49.3, 45.7. HRMS(ESI-TOF) calcd for $C_{17}H_{24}N_2H^+$: 255.1861. Found: 255.1862. (MH^+).

Preparation of 2-(*N*-benzyl-pyridin-2-yl-amino)ethanol[32] 13



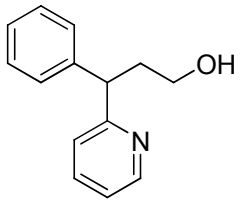
2-(*N*-Benzyl-pyridin-2-yl-amino)ethanol[32] 13: To a two-necked round bottom flask was added 2-bromopyridine (1.2 mL, 0.0126 mol) and 2-benzylaminoethanol (3.6 mL, 0.025 mol). The mixture was heated to reflux at 173 ˚C in a silicon oil-bath for 19 h. After being allowed to cool, the mixture was dissolved in chloroform (10 mL) and transferred to a separating funnel. The chloroform solution was shaken with 20 mL of saturated potassium carbonate solution to neutralize the hydrogen bromide formed in the reaction. The chloroform solution was dried over potassium carbonate and the solvent removed *in vacuo.* The residue was purified by column chromatography eluting with petroleum ether 40-60/diethyl ether (1:1), R_f = 0.09 to give a pale-brown oil (0.84 g, 29%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.08 – 8.10 (1H, m, py), 7.21 – 7.42 (6H, m, Ph, py), 6.60 (1H, dd, *J* = 7.1, 5.1 Hz, py), 6.47 (1H, d, *J* = 8.7 Hz, py), 4.67 (2H, s, CH_2), 3.80 – 3.89 (4H, m, CH_2). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 159.1, 146.9, 137.9, 137.5, 128.8, 127.1, 126.3, 112.7, 107.0, 63.3, 53.7, 52.9. HRMS(ESI-TOF) calcd for $C_{14}H_{16}N_2OH^+$: 229.1342. Found: 229.1337. (MH^+).

Preparation of Tripelennamine[33] 17



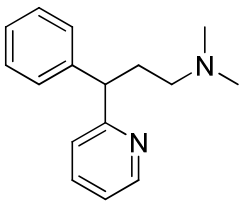
***N*-Pyridyl-*N′*,*N′*-dimethyl-*N*-phenyl-ethylenediamine or Tripelennamine[33] 17:** According to representative procedure **1.4**, using *N*-benzyl-2-aminopyridylethanol **13** (0.230 g, 1 mmol) at 5.0 mol % Ru, the title compound was obtained and purified by column chromatography eluting with dichloromethane/methanol (9:1), R_f = 0.17 to give a white solid (0.19 g, 75%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.15 – 8.17 (1H, m, py), 7.40 (1H, , dd, *J* = 8.9 Hz, 7.1 Hz, py), 7.22 – 7.34 (5H, m, Ph), 6.57 (1H, dd, *J* = 7.1 Hz, 5.0 Hz, py), 6.48 (1H, d, *J* = 8.6 Hz, py), 4.77 (2H, s, CH_2), 3.79 (2H, t, *J* = 7.3 Hz, CH_2), 2.70 (2H, t, *J* = 7.1 Hz, CH_2), 2.41 (6H, s, CH_3). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 158.0, 148.0, 138.5, 137.3, 128.6, 127.0, 126.8, 112.1, 106.0, 56.3, 52.2, 46.0, 45.2. HRMS(ESI-TOF): calcd for $C_{16}H_{21}N_3H^+$: 256.1814. Found: 256.1806. (MH^+).

Preparation of 2-benzylpyridine-propan-1-ol [34,35] 14



2-benzylpyridine-propan-1-ol [34,35] 14: To an oven-dried, nitrogen purged Schlenk tube containing tetrahydrofuran (30 mL) at -78 °C was added 2-benzylpyridine (1.62 mL, 10 mmol). The Schlenk tube was then purged with argon before *n*-butyllithium (1.6 M in hexanes) (7.5 mL, 11 mmol) was added dropwise, affording a deep red solution. In a separate oven-dried, nitrogen purged Schlenk tube containing tetrahydrofuran (10 mL) at -78 °C was added 2-bromoethanol (0.71 mL, 10 mmol). This Schlenk was also purged with argon before *n*-butyllithium (1.6 M in hexanes) (7.5 mL, 11 mmol) was added dropwise. After 15 minutes of stirring at -78 °C, the solution of deprotonated 2-benzylpyridine was added dropwise to the solution of deprotonated 2-bromoethanol *via* cannula. The reaction mixture was then allowed to warm to room temperature and stir for 24 h. After this time, distilled water (10 mL) was added to quench the reaction mixture, and solvent was removed *in vacuo* to obtain a dark brown oil. Distilled water (30 mL) was added and the mixture was extracted with dichloromethane (2 x 30 mL). The combined organic layers were washed with brine (10 mL) and concentrated *in vacuo* giving a brown oil. The title compound was purified by column chromatography eluting with dichloromethane/methanol (96:4), R_f = 0.24 to give a yellow oil (1.54 g, 75%). ^{1}H NMR (250 MHz, $CDCl_3$): δ 8.60 (1H, d, *J* = 5.9 Hz, CH), 7.70 – 7.80 (3H, m, py), 7.10 – 7.40 (5H, m, Ph), 4.40 (1H, dd, *J* = 6.8, 8.7 Hz, CH), 3.80 (2H, m, CH_2), 2.40 – 2.60 (2H, m, CH_2), 2.30 (1H, s, OH).

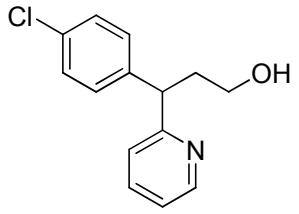
Preparation of Pheniramine[35] 18



***N*,*N*-Dimethyl-3-phenyl-3-pyridin-2-yl-propan-1-amine[35] or Pheniramine 18:** According to representative procedure **1.4**, using 2-benzylpyridine-propan-1-ol **14** (0.08 g, 0.4 mmol), the title compound was obtained and purified by column chromatography eluting with

dichloromethane/methanol (90.5:9.5), R_f = 0.19 to give a brown oil (81.1 mg, 84%). ^{1}H NMR (250 MHz, $CDCl_3$): δ 8.50 (1H, d, *J* = 1.0 Hz, CH), 7.60 – 7.70 (2H, m, py), 7.01 – 7.30 (4H, m, Ph), 4.15 (1H, t, *J* = 7.3 Hz, CH), 2.45 (2H, t, *J* = 3.3 Hz, CH_2), 2.35 (6H, s, CH_3), 2.20 – 2.30 (2H, m, CH_2). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 149.6, 136.8, 128.9, 128.4, 126.9, 123.3, 121.7, 77.8, 77.6, 77.4, 77.0, 58.1, 51.7, 45.6, 32.8. HRMS(ESI-TOF) calcd for $C_{16}H_{20}N_2H^+$: 241.1700. Found: 241.1690. (MH^+).

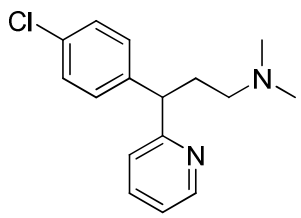
Preparation of 3-(4-chlorophenyl)-3-pyridin-2-yl-propan-1-ol[34] 15



3-(4-chlorophenyl)-3-pyridin-2-yl-propan-1-ol[34] 15: To an oven-dried, nitrogen purged Schlenk tube containing tetrahydrofuran (15 mL) at -78 °C was added diisopropylamine (1.54 mL, 12 mmol). The Schlenk tube was then purged with argon before *n*-butyllithium (1.6 M in hexanes) (7.5 mL, 11 mmol) was added dropwise. The resulting solution of LDA was stirred at -78 °C for 30 minutes. To this solution was added 2-(4-chlorobenzyl)-pyridine (1.75 mL, 10 mmol) obtaining a bright red/orange solution. Meanwhile, to a second oven-dried, nitrogen purged Schlenk tube containing tetrahydrofuran (10 mL) at -78 °C was added 2-bromoethanol (0.71 mL, 10 mmol). This Schlenk tube was then purged with argon before *n*-butyllithium (1.6 M in hexanes) (7.5 mL, 11 mmol) was added dropwise. Both solutions were stirred for a further 30 minutes at -78 °C. After this time, the solution of deprotonated 2-bromoethanol was added dropwise to the deprotonated solution of 2-(4-chlorobenzyl)pyridine *via* cannula. The reaction mixture was then allowed to warm to room temperature and stir for 24 h. After this time, distilled water (10 mL) was added to quench the reaction mixture, and solvent was removed *in vacuo* to obtain a dark brown oil. Distilled water (30 mL) was added and the mixture was extracted with dichloromethane (2 x 30 mL). The combined organic layers were washed with brine (10 mL) and concentrated *in vacuo* giving a brown oil. The title compound was purified by column chromatography eluting with diethyl ether, R_f = 0.17 to give a white solid (1.67 g, 68%). ^{1}H NMR (250 MHz, $CDCl_3$): δ 8.60 (1H, d, *J* = 2.1 Hz, CH), 7.60 (2H, t, *J* = 8.2 Hz, CH), 7.20 – 7.30 (2H, m, Ph), 7.10 – 7.15 (3H, m, py), 4.30 (1H, t, *J* = 6.3 Hz, CH), 3.06 – 3.70 (2H, m, CH_2), 2.30 – 2.55 (2H, m, CH_2), 2.20 (1H, s, OH). ^{13}C NMR

(75.4 MHz, $CDCl_3$): δ 163.1, 149.1, 142.2, 137.4, 132.8, 130.0, 129.1, 123.8, 122.1, 77.8, 77.6, 77.4, 77.0, 60.8, 50.3, 37.9. HRMS(ESI-TOF) calcd for $C_{14}H_{14}NOClH^+$: 248.0840. Found: 248.0830. (MH^+).

Preparation of Chloropheniramine 19

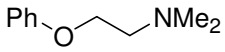


3-(4-Chlorophenyl)-*N*,*N*,dimethyl-3-pyridin-2-yl-propan-1-amine or Chloropheniramine 19: According to representative procedure **1.4**, using 3-(4-chlorophenyl)-3-pyridin-2-yl-propan-1-ol **15** (0.28 g, 1 mmol), the title compound was obtained and purified by column chromatography eluting with dichloromethane/methanol (90:10), R_f = 0.20 to give a brown oil (0.32 g, 81%). ^{1}H NMR (250 MHz, $CDCl_3$): δ 8.50 (1H, *J* = 2.6 Hz, CH), 7.60 – 7.70 (3H, m, py), 7.0 – 7.5 (4H, m, Ar), 4.15 (1H, t, *J* = 4.3 Hz, CH), 2.45 (2H, t, *J* = 4.4 Hz, CH_2), 2.35 (6H, s, CH_3), 2.20 – 2.30 (2H, m, CH_2). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 149.4, 142.1, 129.4, 128.6, 122.9, 77.5, 77.0, 76.5, 57.6, 50.5, 45.3. HRMS(ESI-TOF) calcd for $C_{16}H_{19}N_2ClH^+$: 275.1320. Found: 275.1320. (MH^+).

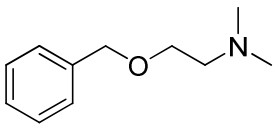
Procedure for the addition of *N,N*-dimethylaminoethanol to *N*-methylaniline 20 (Scheme 6): To an oven-dried, nitrogen-purged Schlenk tube containing [Ru(*p*-cymene)Cl_2]$_2$ (7.7 mg, 0.0125 mmol) and DPEphos (13.5 mg, 0.025 mmol) was added *N*-methylaniline **20** (108 μL, 1 mmol) followed by *N,N*-dimethylaminoethanol (101 μL, 1 mmol). Anhydrous toluene (1 mL) was then added dropwise. The reaction mixture was stirred under a nitrogen atmosphere in the closed vessel at room temperature for 10 minutes and then heated to reflux for 24 hours. On completion the reaction was allowed to cool to room temperature, diluted with dichloromethane, and the solvent removed *in vacuo.* Conversion was determined by analysis of the peak integral ratios characteristic of amine product **22** (for spectral data see **Entry 7, Table 4**) and alcohol **23** in the ^{1}H NMR spectrum of the crude reaction mixture.

Procedure for Mechanistic Study (Scheme 7): To an oven-dried, nitrogen purged Schlenk tube containing [Ru(*p*-cymene)Cl_2]$_2$ (15.4 mg, 0.05 mmol Ru) and DPEphos (27.0 mg, 0.05 mmol) was

added anhydrous toluene (1 mL), followed by *N,N,N'*-Trimethyl-*N'*-phenyl-ethylenediamine **22** (178 mg, 1 mmol) and water (36 μL, 2 mmol). The reaction mixture was stirred under a nitrogen atmosphere at room temperature for 10 minutes, then heated to reflux for 24 h. On completion, the reaction was allowed to cool to room temperature, diluted with dichloromethane, and the solvent removed *in vacuo*. The crude mixture was analyzed by ^{1}H NMR and no trace of 2-(methylphenylamino)alcohol **23** was seen.

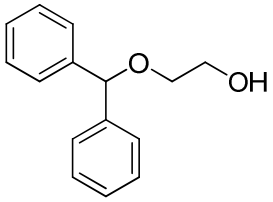


Dimethyl-(2-phenoxyethyl)amine[36] 29: According to representative procedure **1.4**, using ethylene glycol phenyl ether **25** (125 μL, 1 mmol) at 5.0 mol % Ru, the title compound was obtained and purified by column chromatography eluting with dichloromethane/methanol (9:1), R_f = 0.27 to give a brown oil (0.13 g, 77%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.26-7.32 (2H, m, Ph), 6.92-6.98 (3H, m, Ph), 4.09 (2H, t, *J* = 5.7 Hz, CH_2), 2.77 (2H, t, *J* = 5.7 Hz, CH_2), 2.37 (6H, s, CH_3). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 158.7, 129.4, 120.8, 114.5, 65.7, 58.3, 45.8. HRMS(ESI-TOF) calcd for $C_{10}H_{15}NOH^+$: 166.1231. Found: 166.1226. (MH^+).

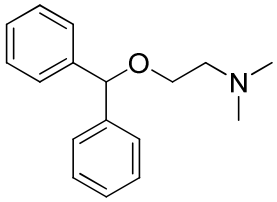


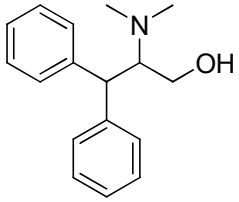
2-Benzyloxyethyldimethylamine[37] 30: According to representative procedure **1.4**, using 2-benzyloxyethanol **26** (142 μL, 1 mmol) at 5.0 mol % Ru, the title compound was obtained and purified by column chromatography eluting with dichloromethane/methanol (9:1), R_f = 0.48 to give a brown liquid (0.05 g, 29%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.32 – 7.36 (5H, m, Ph), 4.55 (2H, s, CH_2), 3.57 (2H, t, *J* = 5.9 Hz, CH_2), 2.56 (2H, t, *J* = 5.9 Hz, CH_2), 2.29 (6H, s, CH_3). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 138.3, 128.3, 127.7, 127.6, 73.2, 68.0, 58.8, 45.8. HRMS(ESI-TOF) calcd for $C_{11}H_{17}NOH^+$: 180.1383. Found: 180.1389. (MH^+).

Preparation of 2-Benzhydryloxyethanol[38] 27



2-Benzhydryloxyethanol[38] 27: To a 250 mL round bottomed flask containing benzhydrol (11.04 g, 60 mmol) and *para*-toluene sulfonic acid (0.09 g, 0.48 mmol) was added ethylene glycol (120 mL, 2.2 mmol). The reaction was heated to 130 ºC for 3 h. Once the reaction had cooled, it was added to water (600 mL) containing sodium hydroxide (2M) (30 mL). This was then extracted with diethyl ether (2 x 150 mL). The combined organic extracts were then washed with water (2 x 150 mL), dried over $MgSO_4$, filtered and concentrated *in vacuo* to approximately 60 mL. Petroleum ether was then added to crystallise the product. The product was recrystallized by dissolving in hot diethyl ether and layering with petroleum ether whilst cooling. The supernatant liquid was decanted and the crystals rinsed with petroleum ether to give the product as colourless blocks (6.95 g, 55%). ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.23 – 7.36 (10H, m, Ph), 5.41 (1H, s, CH), 3.79 (2H, m, CH_2), 3.60 (2H, t, *J* = 4.6 Hz, CH_2), 2.00 (1H, t, *J* = 6.3 Hz, OH). ^{13}C NMR (100.6 MHz, $CDCl_3$): δ 141.9, 128.5, 127.6, 127.0, 84.1, 70.4, 62.1. HRMS(ESI-TOF) calcd for $C_{15}H_{16}O_2H^+$: 229.1200. Found: 229.1234. (MH^+).



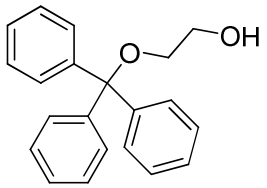


2-(Benzhydryloxy)-*N*,*N*-dimethylethanamine[39] 31 and 2-(Dimethylamino)-3,3-diphenylpropan-1-ol 32: According to representative procedure **1.4**, using 2-benzhydroloxyethanol **27** (1.14 g, 5 mmol) at 2.5 mol % Ru, the title compounds were obtained in 11% and 74% conversion respectively. The title compounds were obtained and purified by column chromatography. 2-(Benzhydryloxy)-*N*,*N*-dimethylethanamine **31** was obtained first eluting with dichloromethane/methanol (9:1), R_f = 0.28 to give a brown liquid (0.10 g, 10%). 2-(Dimethylamino)-3,3-diphenylpropan-1-ol **32** was obtained second eluting with dichloromethane/methanol (93:7), R_f = 0.30 to give a sticky brown liquid which solidified on standing (0.66 g, 67%).

2-(Benzhydryloxy)-*N*,*N*-dimethylethanamine[39] 31: ^{1}H NMR (300 MHz, $CDCl_3$): δ 6.97 – 7.14 (10H, m, Ph), 5.10 (1H, s, CH), 3.40 (2H, t, *J* = 5.6 Hz, CH_2), 2.56 (2H, t, *J* = 5.6 Hz, CH_2), 2.19 (6H, s, CH_3). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 142.3, 129.1, 128.8, 128.6, 127.8, 127.7, 127.3, 84.6, 58.5, 45.4. HRMS(ESI-TOF) calcd for $C_{17}H_{20}NOH^+$: 256.1700. Found: 256.1701. (MH^+).

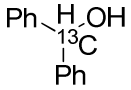
2-(Dimethylamino)-3,3-diphenylpropan-1-ol 32: m.p. 53 – 55 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.16 – 7.47 (10H, m, Ph), 3.98 (1H, d, *J* = 11.1 Hz, CH), 3.70 (1H, dt, *J* = 4.9, 10.6 Hz, CH), 3.27 (1H, dd, *J* = 4.7, 6.0 Hz, CH), 3.12 (1H, t, *J* = 10.5 Hz, CH), 2.26 (6H, s, CH_3). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 142.5 (C, Ph), 129.2 (CH, Ph), 129.0 (CH, Ph), 128.8 (CH, Ph), 128.2 (CH, Ph), 127.1 (CH, Ph), 67.6 (CH, -*C*HNMe$_2$), 60.8 (CH_2, -*C*H$_2$OH), 52.5 (CH, (Ph)$_2$*C*H-), 41.2 (CH_3, -N(*C*H$_3$)$_3$). HRMS(ESI-TOF) calcd for $C_{17}H_{20}NOH^+$: 256.1701. Found: 256.1686. (MH^+).

Preparation of 2-(Trityloxy)ethanol[40] 28



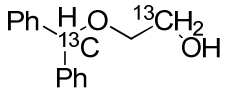
2-(Trityloxy)ethanol[40] 28: To a round bottomed flask containing trityl chloride (16.7 g, 60 mmol) were added ethylene glycol (5.0 mL, 90 mmol) and pyridine (240 mL). The reaction was stirred at room temperature for 24 h. Toluene was then added and the pyridine was removed (*via* azeotroping) *in vacuo*. This process (of adding toluene and concentrating *in vacuo*) was repeated several times in order to remove the pyridine. The azeotrope process was then repeated but using ethyl acetate and dichloromethane to remove any residual solvent. From these processes a white solid was obtained. The title compound was obtained and purified by column chromatography. A gradient eluent system was employed. The column was first subjected to neat *iso*-hexane (500 mL) in order to remove any residual pyridine. Then 95:5 *iso*-hexane/ethyl acetate (500 mL) was used, followed by 85:15 *iso*-hexane/ethyl acetate (500 mL) to obtain the title compound as a white solid, R_f = 0.15, (5.02 g, 24%). ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.23 – 7.47 (15H, m, Ar), 3.74 – 3.78 (2H, m, CH_2), 3.28 (2H, t, *J* = 4.7 Hz, CH_2), 1.94 (1H, t, *J* = 6.3 Hz, OH). ^{13}C NMR (100.6 MHz, $CDCl_3$): δ 144.0, 128.7, 128.0, 127.9, 127.1, 64.9, 62.4. HRMS(ESI-TOF) calcd for $(C_{19}H_{15})^+$: 243.1200. Found: 243.1200. [$(Ph_3C)^+$].

Preparation of ^{13}C-labelled Benzhydrol



^{13}C-labelled Benzhydrol: To an oven-dried, argon purged tube containing benzaldehyde-α-^{13}C (0.25 g, 2.33 mmol) and diethyl ether (4 mL) at 0 °C, was added phenylmagnesium bromide (3.0 M solution in diethyl ether) (1.17 mL, 3.50 mmol) dropwise over 20 minutes. The reaction was then allowed to warm to room temperature and left to stir overnight. Saturated aqueous NH_4Cl (10 mL) was then added slowly and stirred until the fizzing subsided. Diethyl ether (10 mL) was then added and the layers were separated. The aqueous layer was extracted with diethyl ether (2 x 20 mL) and then the combined organic extracts were washed with water (20 mL) and brine (20 mL), then dried over Na_2SO_4, filtered and concentrated *in vacuo* to give a pale yellow liquid which solidified on standing. The compound was isolated in quantitative yield and required no further purification before being used in the next step. ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.24 – 7.42 (10H, m, Ph), 5.86 (1H, dd, *J* = 3.5 and 143.9 Hz, CH), 2.25 (1H, t, *J* = 2.4 Hz, OH). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 143.8 (d, *J* = 47.3 Hz), 128.5 (d, *J* = 3.8 Hz), 127.6, 126.5 (d, *J* = 2.9 Hz), 76.3.

Preparation of doubly ^{13}C-labelled 2-Benzhydryloxyethanol 27



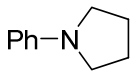
Doubly ^{13}C-labelled 2-Benzhydryloxyethanol 27: To an oven-dried, argon purged tube containing sodium hydride (95% dry) (0.06 g, 2.45 mmol) in diethyl ether (10 mL) at 0 °C was added ^{13}C-labelled benzhydrol (0.43 g, 2.33 mmol) in diethyl ether (10 mL) dropwise over 30 minutes. The reaction was then warmed to 30 °C and stirred for 2 h. After this time, the reaction was cooled to 0 °C and ethyl bromoacetate-2-^{13}C (0.39 g, 2.33 mmol) in diethyl ether (5 mL) was added dropwise over 20 – 25 minutes. The reaction was then warmed to room temperature and left to stir overnight. Water (20 mL) was added slowly until any observed fizzed had stopped. Diethyl ether (20 mL) was added and the layers separated. The aqueous layer was extracted with diethyl ether (2 x 20 mL) and then the combined organic layers were washed with brine (2 x 20 mL), dried over Na_2SO_4, filtered and concentrated *in vacuo* to give a pale yellow liquid. By analysis of ^{1}H NMR, the conversion of the reaction was seen to be 47%. The crude reaction mixture was used directly in the next step.

To an oven-dried, argon purged tube containing lithium aluminium hydride (0.15 g, 4.00 mmol) in diethyl ether (5 mL) at 0 °C was added the crude reaction mixture in diethyl ether (5 mL) dropwise over 20 minutes. The reaction was then warmed to room temperature for 2 h. After this time, diethyl ether (10 mL) was added and the reaction was cooled to 0 °C. Water (0.2 mL) was then added slowly until any observed fizzing had stopped, followed by 15% aqueous NaOH solution (0.2 mL) and water (0.6 mL). A white precipitate was observed on the addition of NaOH. The reaction was warmed to room temperature and stirred for 15 minutes. $MgSO_4$ was added and the reaction was left to stir overnight. The white solids were filtered off and washed through with diethyl ether, then concentrated *in vacuo*. The desired product was isolated and purified by column chromatography eluting with ether (b.p. 40-60 ºC)/ethyl acetate (5:1), R_f = 0.09 to give a colourless liquid which solidified on standing (0.22 g, 42%). ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.24 – 7.35 (10H, m, Ph), 5.42 (1H, d, *J* = 141.5 Hz, CH), 3.80 (2H, dm, *J* = 141.5 Hz, CH_2), 3.62 (2H, m, CH_2), 2.01 (1H, dt, *J* = 3.3 and 6.0 Hz, OH). ^{13}C NMR (125.8 MHz, $CDCl_3$): δ 128.5 (d, *J* = 3.5 Hz), 127.6, 126.9 (d, *J* = 2.6 Hz), 84.1 (d, *J* = 3.6 Hz), 62.1 (d, *J* = 3.7 Hz), 61.5.

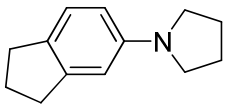
Procedure for crossover experiment (Scheme 8): To an oven-dried, nitrogen purged Schlenk carousel tube containing [Ru(*p*-cymene)Cl_2]$_2$ (6.7 mg, 0.025 mmol), DPEphos (11.7 mg, 0.025 mmol) and unlabelled 2-benzhydryloxyethanol **27** (0.1 g, 0.43 mmol) was added doubly ^{13}C-labelled 2-Benzhydryloxyethanol **27** (0.1 g, 0.43 mmol) in toluene (0.5 mL) and 3.0 M Me_2NH solution in toluene (0.45 mL). The reaction mixture was stirred under a nitrogen atmosphere in the closed vessel at room temperature for 10 minutes and then heated to reflux for 24 h. On completion the reaction was allowed to cool to room temperature, diluted with dichloromethane, and the solvent removed *in vacuo.* By analysis and comparison of the ^{1}H and ^{13}C spectra, the amount of crossover was calculated to be 18%.

Procedure for labelled experiment (Scheme 8): To an oven-dried, nitrogen purged Schlenk carousel tube containing [Ru(*p*-cymene)Cl_2]$_2$ (3.3 mg, 0.025 mmol) and DPEphos (5.9 mg, 0.025 mmol) was added doubly ^{13}C-labelled 2-Benzhydryloxyethanol **27** (0.1 g, 0.43 mmol) in toluene (0.5 mL) and 3.0 M Me_2NH solution in toluene (0.25 mL). The reaction mixture was stirred under a nitrogen atmosphere at room temperature for 10 minutes and then heated to reflux for 24 h. On completion the reaction was allowed to cool to room temperature, diluted with dichloromethane, and the solvent removed *in vacuo.*

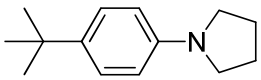
Representative procedure 1.5 - for the *N*-heterocyclisation of diols with primary amines: To an oven-dried, nitrogen purged carousel tube containing $[Ru(p\text{-cymene})Cl_2]_2$ (15.3 mg, 0.025 mmol) and DPEphos (26.9 mg, 0.050 mmol) were added the representative amine (1 mmol), the representative diol (1.2 mmol) and triethylamine (14 μl, 0.1 mmol) followed by anhydrous toluene (1 mL) dropwise. The reaction mixture was allowed to stir under a nitrogen atmosphere at room temperature for 10 minutes in the closed vessel and then heated to reflux for 24 h. The resulting crude was evaporated *in vacuo*. The crude product was purified by column chromatography to give the corresponding tertiary amines in good yields.



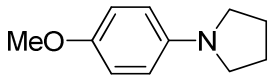
1-Phenylpyrrolidine[9] (Entry 1, Table 5): According to representative procedure **1.5**, using aniline (91 μL, 1 mmol) and 1,4-butanediol (106 μL, 1.2 mmol), the title compound was obtained and purified by column chromatography eluting with hexanes/ethyl acetate (20:1) to give a yellow oil, R_f = 0.52 (0.12 g, 78%). ^{1}H NMR ($CDCl_3$, 300 MHz): δ 7.23 – 7.30 (2H, m, Ph), 6.60 – 6.73 (3H, m, Ph), 3.30 – 3.35 (4H, m, CH_2), 2.01 – 2.06 (4H, m, CH_2). ^{13}C NMR ($CDCl_3$, 75.4 MHz) δ 148.1, 129.2, 115.5, 111.8, 47.7, 25.6. HRMS(ESI-TOF) calcd for $C_{10}H_{13}NH^+$: 148.1126. Found: 148.1129. (MH^+).



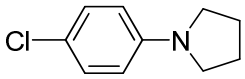
1-(2,3-Dihydro-1*H*-inden-5-yl)pyrrolidine[41] (Entry 2, Table 5): According to representative procedure **1.5**, using 5-aminoindan (91 μL, 1 mmol) and 1,4-butanediol (106 μL, 1.2 mmol), the title compound was obtained and purified by column chromatography eluting with hexanes/ethyl acetate (20:1) to give a colourless solid, R_f = 0.35 (0.14 g, 74%). ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.12 (1H, d, *J* = 8.4 Hz, Ar), 6.54 (1H, s, Ar), 6.44 (1H, dd, *J* = 8.1, 2.1 Hz, Ar), 3.28 – 3.32 (4H, m, CH_2), 2.84 – 2.94 (4H, m, CH_2), 2.00 – 2.13 (6H, m, CH_2). ^{13}C NMR ($CDCl_3$, 75.4 MHz) δ 147.4, 145.4, 131.1, 124.7, 110.7, 108.0, 48.1, 33.5, 32.0, 25.9, 25.5. HRMS(ESI-TOF) calcd for $C_{13}H_{17}NH^+$: 188.1439. Found: 188.1425. (MH^+).



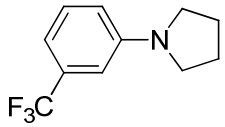
1-(4-*tert*-Butylphenyl)pyrrolidine[42] (Entry 3, Table 5): According to representative procedure **1.5**, using 4-*tert*-butylaniline (159 μL, 1 mmol) and 1,4-butanediol (106 μL, 1.2 mmol), the title compound was obtained and purified by column chromatography eluting with hexanes/ethyl acetate (20:1) to give a colourless solid, R_f = 0.31 (0.17 g, 85%). ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.31 – 7.34 (2H, m, Ar), 6.58 – 6.61 (2H, m, Ar), 3.30 – 3.34 (4H, m, CH_2), 2.01 – 2.05 (4H, m, CH_2), 1.35 (9H, s, CH_3). ^{13}C NMR ($CDCl_3$, 75.4 MHz) δ 146.0, 138.1, 126.0, 111.5, 47.8, 33.9, 31.7, 31.6, 25.6. HRMS(ESI-TOF) calcd for $C_{14}H_{22}NH^+$: 204.1752. Found: 204.1747. (MH^+).



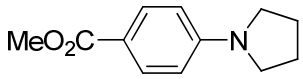
1-(4-Methoxyphenyl)pyrrolidine[9] (Entry 4, Table 5): According to representative procedure **1.5**, using *p*-anisidine (0.12 g, 1 mmol) and 1,4-butanediol (106 μL, 1.2 mmol), the title compound was obtained and purified by column chromatography eluting with dichloromethane/hexanes (2:1) to give a colourless solid, R_f = 0.39 (0.12 g, 70%). ^{1}H NMR ($CDCl_3$, 300 MHz) δ 6.85 – 6.90 (2H, m, Ar), 6.54 – 6.59 (2H, m, Ar), 3.78 (3H, s, CH_3), 3.23 – 3.28 (4H, m, CH_2), 1.95 – 2.05 (4H, m, CH_2). ^{13}C NMR ($CDCl_3$, 75.4 MHz) δ 150.9, 143.4, 115.1, 112.7, 56.1, 48.4, 25.5. HRMS(ESI-TOF) calcd for $C_{11}H_{16}NOH^+$: 178.1232. Found: 178.1219. (MH^+).



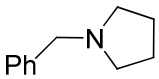
1-(4-Chlorophenyl)pyrrolidine[43] (Entry 5, Table 5): According to representative procedure **1.5**, using *p*-chloroaniline (0.13 g, 1 mmol) and 1,4-butanediol (106 μL, 1.2 mmol), the title compound was obtained and purified by column chromatography eluting with hexanes/ethyl acetate (20:1) to give a colourless solid, R_f = 0.29 (0.16 g, 87%). ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.14 – 7.19 (2H, m, Ar), 6.45 – 6.50 (2H, m, Ar), 3.23 – 3.30 (4H, m, CH_2), 2.00 – 2.07 (4H, m, CH_2). ^{13}C NMR ($CDCl_3$, 75.4 MHz) δ 146.6, 129.0, 120.2, 112.8, 47.9, 25.6. HRMS(ESI-TOF) calcd for $C_{10}H_{13}NClH^+$: 182.0737. Found: 182.0722. (MH^+).



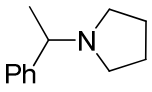
1-(3-(Trifluoromethyl)phenyl)pyrrolidine[44] (Entry 6, Table 5): According to representative procedure **1.5**, using 3-trifluoromethylaniline (125 μL, 1 mmol) and 1,4-butanediol (106 μL, 1.2 mmol), the title compound was obtained and purified by column chromatography eluting with hexanes/ethyl acetate (20:1) to give a colourless oil, R_f = 0.42 (0.13 g, 60%). ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.29 – 7.32 (1H, m, Ph), 6.87 – 6.89 (1H, m, Ph), 6.67 – 6.74 (2H, m, Ph), 3.29 – 3.33 (4H, m, CH_2), 2.01 – 2.06 (4H, m, CH_2). ^{13}C NMR ($CDCl_3$, 75.4 MHz) δ 147.8, 131.3 (d, *J* = 31 Hz), 129.4, 124.6 (d, *J* = 272 Hz), 114.5 (d, *J* = 1 Hz), 111.5 (q, *J* = 4 Hz), 107.8 (q, *J* = 4 Hz), 47.6, 25.4. HRMS(ESI-TOF) calcd for $C_{11}H_{13}NF_3H^+$: 216.0998. Found: 216.1000. (MH^+).



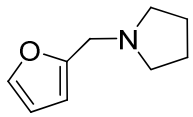
Methyl-4-(pyrrolidin-1-yl)benzoate (Entry 7, Table 5): According to representative procedure **1.5**, using methyl-4-aminobenzoate (0.151g, 1 mmol) and 1,4-butanediol (106 μL, 1.2 mmol), the title compound was obtained and purified by column chromatography eluting with hexanes/ethyl acetate (20:1) to give a colourless solid, R_f = 0.32 (0.07 g, 33%). ν_{max} /cm^{-1}(neat) 3376, 2950, 2847, 1693, 1607, 1526, 1438. ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.88 – 7.91 (2H, m, Ph), 6.49 – 6.52 (2H, m, Ph), 3.85 (3H, s, OCH_3), 3.32 – 3.37 (4H, m, CH_2), 2.00 – 2.05 (4H, m, CH_2). ^{13}C NMR ($CDCl_3$, 75.4 MHz) δ 167.6, 150.8, 131.3, 116.2, 51.3, 47.5, 25.4. HRMS(ESI-TOF) calcd for $C_{12}H_{15}NO_2H^+$: 206.1181. Found: 206.1166. (MH^+). *Anal. Calc.* for $C_{12}H_{15}NO_2$: C, 70.22 %; H, 7.37 %; N, 6.82; Found: C, 70.0 %; H, 7.26 %; N, 6.62 %.



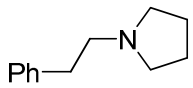
1-Benzylpyrrolidine[9] (Entry 8, Table 5): According to representative procedure **1.5**, using benzylamine (109 μL, 1 mmol) and 1,4-butanediol (106 μL, 1.2 mmol), the title compound was obtained and purified by kugelrohr distillation to give a colourless oil (0.12 g, 72%). Spectroscopy data was consistent with that given above in **Entry 1, Table 2**.



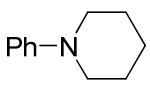
1-(1-Phenylethyl)pyrrolidine[45] (Entry 9, Table 5): According to representative procedure **1.5**, using α-methylbenzylamine (129 μL, 1 mmol) and 1,4-butanediol (106 μL, 1.2 mmol), the title compound was obtained and purified by column chromatography eluting with hexanes/ethyl acetate (2:1) to give a colourless oil, R_f = 0.23 (0.14 g, 82%). ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.22 – 7.36 (5H, m, Ph), 3.18 (1H, q, *J* = 7.8 Hz, CH), 2.52 – 2.58 (2H, m, CH_2), 2.35 – 2.40 (2H, m, CH_2), 1.74 – 1.79 (4H, m, CH_2), 1.41 (3H, d, *J* = 7.8 Hz, CH_3). ^{13}C NMR ($CDCl_3$, 75.4 MHz) δ 145.8, 128.3, 127.3, 126.9, 66.1, 53.1, 23.5, 23.3. HRMS(ESI-TOF) calcd for $C_{12}H_{17}NH^+$: 176.1439. Found: 176.1427. (MH^+).



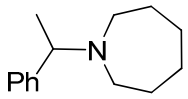
1-(Furan-2-ylmethyl)pyrrolidine[46] (Entry 10, Table 5): According to representative procedure **1.5**, using furfurylamine (88 μL, 1 mmol) and 1,4-butanediol (106 μL, 1.2 mmol), the title compound was obtained and purified by kugelrohr distillation to give a colourless oil (0.10 g, 63%). ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.35 – 7.36 (1H, m, Ar), 6.29 – 6.31 (1H, m, Ar), 6.17 – 6.18 (1H, m, Ar), 3.63 (2H, s, CH_2), 2.51 – 2.57 (4H, m, CH_2), 1.74 – 1.82 (4H, m, CH_2). ^{13}C NMR ($CDCl_3$, 75.4 MHz) δ 153.1, 141.9, 110.1, 107.6, 54.0, 52.2, 23.6. HRMS(ESI-TOF) calcd for $C_9H_{13}NOH^+$: 152.1075. Found: 152.1071. (MH^+).



1-(Phenethyl)pyrrolidine[9] (Entry 11, Table 5): According to representative procedure **1.5**, using 2-phenethylamine (126 μL, 1 mmol) and 1,4-butanediol (106 μL, 1.2 mmol), the title compound was obtained and purified by kugelrohr distillation to give a colourless oil (0.12 g, 69%). ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.18 – 7.34 (5H, m, Ph), 2.84 – 2.90 (2H, m, CH_2), 2.69 – 2.75 (2H, m, CH_2), 2.58 – 2.63 (4H, m, CH_2), 1.81 – 1.86 (4H, m, CH_2). ^{13}C NMR ($CDCl_3$, 75.4 MHz) δ 140.6, 128.7, 128.5, 126.1, 58.5, 54.3, 36.0, 23.6. HRMS(ESI-TOF) calcd for $C_{11}H_{15}NH^+$: 176.1439. Found: 176.1430. (MH^+).

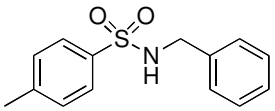


1-Phenylpiperidine[47] (Entry 12, Table 5): According to representative procedure **1.5**, using aniline (91 μL, 1 mmol) and 1,5-pentanediol (126 μL, 1.2 mmol), the title compound was obtained and purified by column chromatography eluting with hexanes/ethyl acetate (20:1) to give a yellow oil, R_f = 0.45 (0.12 g, 72%). ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.25 – 7.32 (2H, m, Ph), 6.97 – 7.00 (2H, m, Ph), 6.83 – 6.89 (1H, m, Ph), 3.19 (4H, t, *J* = 5.4 Hz, CH_2), 1.71 – 1.79 (4H, m, CH_2), 1.57 – 1.65 (2H, m, CH_2). ^{13}C NMR ($CDCl_3$, 75.4 MHz) δ 152.4, 129.1, 119.3, 116.6, 50.8, 26.0, 24.5. HRMS(ESI-TOF) calcd for $C_{11}H_{15}NH^+$: 162.1283. Found: 162.1270. (MH^+).



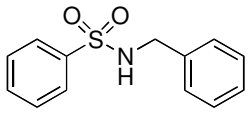
1-(1-Phenylethyl)azepane[48] (Entry 13, Table 5): According to representative procedure **1.5**, using α-methylbenzylamine (129 μL, 1 mmol) and 1,6-hexanediol (0.14 g, 1.2 mmol), the title compound was obtained and purified by column chromatography eluting with hexanes/ethyl acetate (10:1) to give a yellow oil, R_f = 0.19 (0.13 g, 65%). ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.18 – 7.38 (5H, m, Ph), 3.73 – 3.80 (1H, q, *J* = 6.8 Hz, CH), 2.63 (4H, br s, CH_2), 1.58 (8H, br s, CH_2), 1.35 – 1.37 (3H, d, *J* = 6.6 Hz, CH_3). ^{13}C NMR ($CDCl_3$, 75.4 MHz) δ 145.1, 128.1, 127.7, 126.6, 63.4, 52.2, 29.1, 27.2, 18.4. HRMS(ESI-TOF) calcd for $C_{14}H_{21}NH^+$: 204.1752. Found: 204.1735. (MH^+).

Representative procedure 1.6 - for the alkylation of sulfonamides with alcohols: To an oven-dried, nitrogen purged carousel tube containing [Ru(*p*-cymene)Cl_2]$_2$ (15.3 mg, 0.025 mmol), DPEphos (26.9 mg, 0.05 mmol), and K_2CO_3 (14 mg, 0.1 mmol) were added the representative sulphonamide (1 mmol), the representative alcohol (1 mmol) followed by anhydrous xylene (1 mL). The reaction mixture was allowed to stir under a nitrogen atmosphere at room temperature for 10 minutes in the closed vessel and then heated to 150 ºC for 24 h. After 24 h the solvent was removed under vacuum and the resulting residue purified by column chromatography [DCM/methanol 99:1] to give the corresponding sulfonamides in good yields.

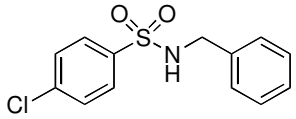


***N*-Benzyl-4-methylbenzenesulfonamide[49] (Entry 1, Table 6):** The title compound was obtained and purified according to representative procedure **1.6**, using 4-toluenesulfonamide (0.17 g, 1

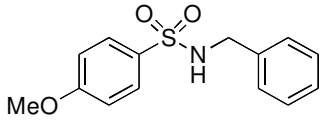
mmol) and benzyl alcohol (103 μL, 1 mmol). R_f = 0.36 (0.22 g, 84%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.62 (2H, d, *J* = 8.3 Hz, Ar), 7.11 (7H, m, Ar), 5.17 (1H, t, *J* = 6.2 Hz, NH), 3.97 (2H, d, *J* = 6.3 Hz, CH_2), 2.30 (3H, s, CH_3). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 143.9, 137.3, 136.9, 130.1, 129.5, 129.0, 128.3, 128.1, 127.6, 127.5, 47.6, 22.0. HRMS(ESI-TOF) calcd for $C_{14}H_{15}NSO_2Na^+$: 284.0721. Found: 284.0714. (M+Na). *Anal. Calc.* for $C_{14}H_{15}NO_2S$: C, 64.34 %; H, 5.79 %; N, 5.36; Found: C, 64.0 %; H, 5.61 %; N, 5.53 %.



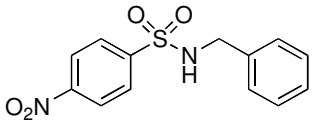
***N*-Benzylbenzenesulfonamide[50] (Entry 2, Table 6):** The title compound was obtained and purified according to representative procedure **1.6**, using benzenesulfonamide (0.16 g, 1 mmol) and benzyl alcohol (103 μL, 1 mmol). R_f = 0.38 (0.20 g, 79%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.70 (2H, d, *J* = 7.4 Hz, Ar), 7.35 (3H, m, Ar), 7.04 (5H, m, Ar), 5.38 (1H, t, *J* = 6.2 Hz, NH), 3.97 (2H, d, *J* = 6.3 Hz, CH_2). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 140.3, 136.8, 133.1, 129.6, 129.0, 128.7, 128.3, 128.2, 127.9, 127.5, 47.6. HRMS(ESI-TOF) calcd for $C_{13}H_{13}NSO_2H^+$: 248.0745. Found: 248.0719. (MH^+). *Anal. Calc.* for $C_{13}H_{13}NO_2S$: C, 63.13 %; H, 5.30 %; N, 5.66; Found: C, 63.0 %; H, 5.30 %; N, 5.67 %.



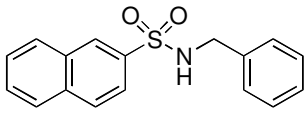
***N*-Benzyl-4-chlorobenzenesulfonamide[51] (Entry 3, Table 6):** The title compound was obtained and purified according to representative procedure **1.6**, using 4-chlorobenzenesulfonamide (0.19 g, 1 mmol) and benzyl alcohol (103 μL, 1 mmol). R_f = 0.35 (0.22 g, 78%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.62 (2H, m, Ar), 7.28 (2H, m, Ar), 7.10 (5H, m, Ar), 5.36 (1H, t, *J* = 6.2 Hz, NH), 4.00 (2H, d, *J* = 6.2 Hz, CH_2). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 139.5, 138.9, 136.5, 129.8, 129.6, 128.1, 129.0, 128.8, 127.5, 128.3, 47.6. HRMS(ESI-TOF) calcd for $C_{13}H_{12}ClNSO_2Na^+$: 304.0174. Found: 304.0163. (M+Na). *Anal. Calc.* for $C_{13}H_{12}ClNO_2S$: C, 55.42 %; H, 4.29 %; N, 4.97; Found: C, 55.7 %; H, 4.32 %; N, 5.23 %.



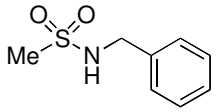
***N*-Benzyl-4-methoxybenzenesulfonamide[52] (Entry 4, Table 6):** The title compound was obtained and purified according to representative procedure **1.6.**, using 4-methoxysulfonamide (0.19 g, 1 mmol) and benzyl alcohol (103 μL, 1 mmol). R_f = 0.38 (0.26 g, 92%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.70 (2H, m, Ar), 7.14 (5H, m, Ar), 6.86 (2H, m, Ar), 4.88 (1H, t, *J* = 6.2 Hz, NH), 4.01 (2H, d, *J* = 6.2 Hz, CH_2), 3.78 (3H, s, CH_3). ^{13}C NMR (300 MHz, $CDCl_3$): δ 163.3, 136.8, 131.9, 129.7, 129.1, 128.3, 128.2, 114.7, 56.0, 47.6. HRMS(ESI-TOF) calcd for $C_{14}H_{15}NSO_3Na^+$: 300.0670. Found: 300.0652. (M+Na). *Anal. Calc.* for $C_{14}H_{15}NO_3S$: C, 60.63 %; H, 5.45 %; N, 5.05; Found: C, 60.20 %; H, 5.36 %; N, 5.00 %.



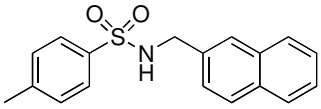
***N*-Benzyl-4-nitrobenzenesulfonamide[53] (Entry 5, Table 6):** The title compound was obtained and purified according to representative procedure **1.6**, using 4-nitrobenzenesulfonamide (0.20 g, 1 mmol) and benzyl alcohol (103 μL, 1 mmol). R_f = 0.39 (0.19 g, 66%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.17 (2H, m, Ar), 7.87 (2H, m, Ar), 7.14 (5H, m, Ar), 5.32 (1H, m, NH), 4.12 (2H, d, *J* = 5.7 Hz, CH_2). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 150.3, 146.4, 136.0, 129.2, 128.7, 128.6, 128.3, 124.7, 47.8. HRMS(ESI-TOF) calcd for $C_{13}H_{12}N_2SO_4Na^+$: 315.0415. Found: 315.0493. (M+Na). *Anal. Calc.* for $C_{13}H_{12}N_2O_4S$: C, 53.42 %; H, 4.14 %; N, 9.58; Found: C, 53.70 %; H, 4.10 %; N, 9.38 %.



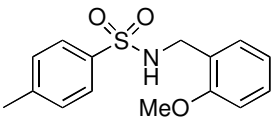
***N*-Benzylnaphthalene-2-sulfonamide[54] (Entry 6, Table 6):** The title compound was obtained and purified according to representative procedure **1.6**, using naphthalene-2-sulfonamide (0.21 g, 1 mmol) and benzyl alcohol (103 μL, 1 mmol). R_f = 0.36 (0.25 g, 83%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.35 (1H, m, Ar), 7.76 (4H, m, Ar), 7.54 (2H, m, Ar), 7.11 (5H, m, Ar), 4.97 (1H, t, *J* = 6.1 Hz, NH), 4.07 (2H, d, *J* = 6.2 Hz, CH_2). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 137.1, 136.6, 135.2, 132.6, 130.0, 129.7, 129.2, 129.1, 129.0, 128.3, 128.0, 122.7, 47.8. HRMS(ESI-TOF) calcd for $C_{17}H_{15}NSO_2Na^+$: 320.0721 Found: 320.0735. (M+Na). *Anal. Calc.* for $C_{17}H_{15}NO_2S$: C, 68.66 %; H, 5.08 %; N, 4.71; Found: C, 68.60 %; H, 5.02 %; N, 4.70 %.



***N*-Benzylmethanesulfonamide[55] (Entry 7, Table 6):** The title compound was obtained and purified according to representative procedure **1.6**, using methanesulfonamide (0.10 g, 1 mmol) and benzyl alcohol (103 μL, 1 mmol). R_f = 0.40 (0.14 g, 76%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.19 (5H, m, Ar), 5.31 (1H, t, *J* = 6.1 Hz, NH), 4.14 (2H, d, *J* = 6.3 Hz, CH_2), 2.66 (3H, s, CH_3). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 137.4, 129.2, 128.4, 47.5, 41.2. HRMS(ESI-TOF) calcd for $C_8H_{11}NSO_2Na^+$: 208.0408. Found: 208.0392. (M+Na). *Anal. Calc.* for $C_8H_{11}NO_2S$: C, 51.87 %; H, 5.99 %; N, 7.56; Found: C, 51.9 %; H, 5.98 %; N, 7.48 %.

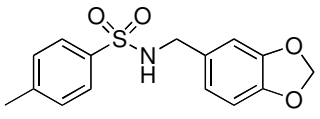


4-Methyl-*N*-(naphthalen-2-ylmethyl)benzenesulfonamide[56] (Entry 8, Table 6): The title compound was obtained and purified according to representative procedure **1.6**, using 4-toluenesulfonamide (0.17 g, 1 mmol) and naphthalene-2-methanol (0.16 g, 1 mmol). R_f = 0.38 (0.25 g, 80%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.67 (5H, m, Ar), 7.49 (1H, m, Ar), 7.36 (2H, m, Ar), 7.18 (3H, m, Ar), 4.90 (1H, m, NH), 4.17 (2H, d, *J* = 6.2 Hz, CH_2), 2.29 (3H, s, CH_3). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 143.9, 137.4, 134.1, 133.6, 133.3, 130.1, 128.9, 128.2, 128.1, 127.6, 127.1, 126.7, 126.6, 126.1, 47.9, 21.9. HRMS(ESI-TOF) calcd for $C_{18}H_{17}NSO_2H^+$: 312.1058. Found: 312.1051. (MH^+).

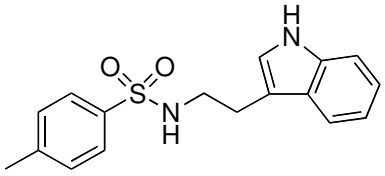


***N*-(2-Methoxybenzyl)-4-methylbenzenesulfonamide[57] (Entry 9, Table 6):** The title compound was obtained and purified according to representative procedure **1.6**, using 4-toluenesulfonamide (0.17 g, 1 mmol) and (2-methoxyphenyl)methanol (133 μL, 1 mmol). R_f = 0.38 (0.21 g, 72%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.58 (2H, m, Ar), 7.11 (3H, m, Ar), 6.98 (1H, m, Ar), 6.70 (2H, m, Ar), 5.10 (1H, br s, NH), 4.05 (2H, d, *J* = 6.4 Hz, CH_2), 3.65 (3H, s, CH_3), 2.30 (3H, s, CH_3). ^{13}C NMR

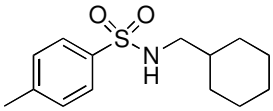
(75.4 MHz, $CDCl_3$): δ 157.6, 143.4, 137.7, 130.2, 129.8, 129.6, 127.5, 124.8, 120.9, 110.5, 55.6, 44.4, 21.9. HRMS(ESI-TOF) calcd for $C_{15}H_{17}NSO_3H^+$: 292.1007. Found: 292.0999. (MH^+). *Anal. Calc.* for $C_{15}H_{17}NO_3S$: C, 61.83 %; H, 5.88 %; N, 4.81; Found: C, 62.0 %; H, 5.89 %; N, 4.70 %.



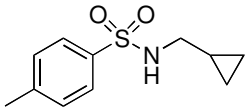
***N*-(Benzo[*d*][1,3]dioxol-5-ylmethyl)-4-methylbenzenesulfonamide[58] (Entry 10, Table 6):** The title compound was obtained and purified according to representative procedure **1.6**, using 4-toluenesulfonamide (0.17 g, 1 mmol) and piperonyl alcohol (0.15 g, 1 mmol). R_f = 0.36 (0.27 g, 88%). ^1H NMR (300 MHz, $CDCl_3$): δ 7.67 (2H, d, *J* = 8.3 Hz, Ar), 7.23 (2H, d, *J* = 8.0 Hz, Ar), 6.58 (3H, m, Ar), 5.84 (2H, s, CH_2), 4.66 (1H, br s, NH), 3.93 (2H, d, *J* = 6.1 Hz, CH_2), 2.36 (3H, s, CH_3). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 148.3, 147.7, 143.9, 137.3, 130.5, 130.1, 127.6, 121.8, 108.9, 108.6, 47.6, 22.0. HRMS(ESI-TOF) calcd for $C_{15}H_{15}NSO_4H^+$: 306.0800. Found: 306.0801. (MH^+).



***N*-((1*H*-Indol-2-yl)methyl)-4-methylbenzenesulfonamide (Entry 11, Table 6):** The title compound was obtained and purified according to representative procedure **1.6**, using 4-toluenesulfonamide (0.17 g, 1 mmol) and 2-indonylethanol (0.16 g, 1 mmol). R_f = 0.34 (0.23 g, 78%): ^1H NMR (300 MHz, $CDCl_3$): δ 8.05 (1H, m, NH), 7.54 (2H, br s, Ar), 7.26 (2H, m, Ar), 6.97 (5H, m, Ar), 4.54 (1H, br s, NH), 3.14 (2H, q, *J* = 6.5 Hz, CH_2), 3.14 (2H, t, *J* = 6.6 Hz, CH_2), 2.27 (3H, s, CH_3). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 143.8, 137.1, 136.9, 130.1, 127.4, 127.3, 123.2, 122.6, 119.9, 118.9, 111.9, 111.8, 43.6, 25.9, 21.9. HRMS(ESI-TOF) calcd for $C_{17}H_{18}N_2SO_2H^+$: 315.1167. Found: 315.1156. (MH^+).

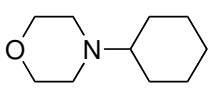


***N*-(Cyclohexylmethyl)-4-methylbenzenesulfonamide[59] (Entry 12, Table 6):** The title compound was obtained and purified according to representative procedure **1.6**, using 4-toluenesulfonamide (0.17 g, 1 mmol) and cyclohexylmethanol (125 μL, 1 mmol). R_f = 0.42 (0.23 g, 84%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.75 (2H, m, Ar), 7.30 (2H, m, Ar), 4.74 (1H, m, NH), 2.75 (2H, t, *J* = 6.6 Hz, CH_2), 2.43 (3H, s, C*H*$_3$), 1.65 (5H, m, CH_2), 1.40 (1H, m, CH), 1.13 (3H, m, CH_2), 0.84 (2H, m, CH_2). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 143.6, 137.5, 130.1, 127.5, 49.8, 38.2, 31.0, 26.7, 26.1, 21.9. HRMS(ESI-TOF) calcd for $C_{14}H_{21}NSO_2Na^+$: 290.1191. Found: 290.1171. (M+Na). *Anal. Calc.* for $C_{14}H_{21}NO_2S$: C, 62.89 %; H, 7.92 %; N, 5.24; Found: C, 62.90 %; H, 7.95 %; N, 5.23 %.

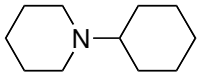


***N*-(Cyclopropylmethyl)-4-methylbenzenesulfonamide[60] (Entry 13, Table 6):** The title compound was obtained and purified according to representative procedure **1.6**, using 4-toluenesulfonamide (0.17 g, 1 mmol) and cyclopropylmethanol (81 μL). R_f = 0.40 (0.21 g, 92%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.76 (2H, m, Ar), 7.29 (2H, m, Ar), 4.83 (1H, br s, NH), 2.80 (2H, dd, *J* = 7.1, 6.0 Hz, CH_2), 2.41 (3H, s, CH_3), 0.86 (1H, s, CH), 0.43 (2H, s, CH_2), 0.04 (2H, s, CH_2). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 143.2, 137.1, 129.6, 127.0, 48.3, 21.5, 10.6, 3.5. HRMS(ESI-TOF) calcd for $C_{11}H_{15}NSO_2H^+$: 226.0902. Found: 226.0887. (MH^+). *Anal. Calc.* for $C_{11}H_{15}NO_2S$: C, 58.64 %; H, 6.71 %; N, 6.22; Found: C, 58.60 %; H, 6.78 %; N, 6.17 %.

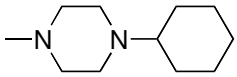
Representative procedure 1.7 - for the alkylation of amines using secondary alcohols: To an oven-dried, nitrogen purged carousel tube containing [Ru(*p*-cymene)Cl_2]$_2$ (15.3 mg, 0.025 mmol) and DPEphos (26.9 mg, 0.05 mmol) were added the representative amine (1 mmol), the representative alcohol (1 mmol) followed by anhydrous xylene (1 mL). The reaction mixture was allowed to stir under a nitrogen atmosphere at room temperature for 10 minutes in the closed vessel and then heated to 150 ºC for 24 h. After 24 h the solvent was removed under vacuum and the resulting residue purified by Kugelrohr distillation to give the corresponding amines in good yields.



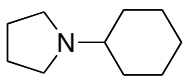
4-Cyclohexylmorpholine[61] (Entry 1, Table 7): The title compound was obtained and purified according to representative procedure **1.7**, using morpholine (87 μL, 1 mmol) and cyclohexanol (104 μL, 1 mmol). (0.14 g, 84%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 3.64 (4H, m, CH_2), 2.49 (4H, m, CH_2), 2.13 (1H, m, CH), 1.77 (5H, m, CH_2), 1.17 (5H, m, CH_2). ^{13}C NMR (75.4, $CDCl_3$): δ 67.8, 64.1, 50.1, 29.3, 26.7, 26.1. HRMS(ESI-TOF) calcd for $C_{10}H_{19}NOH^+$: 170.1544. Found: 170.1538. (MH^+).



1-Cyclohexylpiperidine[62] (Entry 2, Table 7): The title compound was obtained and purified according to representative procedure **1.7**, using piperidine (99 μL, 1 mmol) and cyclohexanol (104 μL, 1 mmol) (0.16 g, 98%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 2.51 (4H, m, CH_2), 2.22 (1H, m, CH), 1.80 (4H, m, CH_2), 1.56 (5H, m, CH_2), 1.41 (2H, m, CH_2), 1.20 (5H, m, CH_2). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 64.7, 50.4, 29.1, 26.9, 26.8, 26.5, 25.3. HRMS(ESI-TOF) calcd for $C_{11}H_{21}NH^+$: 168.1752. Found: 168.1746. (MH^+).

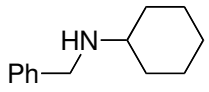


1-Cyclohexyl-4-methylpiperazine[63] (Entry 3, Table 7): The title compound was obtained and purified according to representative procedure **1.7**, using *N*-methyl piperazine (111 μL, 1 mmol) and cyclohexanol (104 μL, 1 mmol) (0.14 g, 75%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 2.58 (7H, m, CH_2), 2.21 (3H, s, CH_3), 2.19 (1H, m, CH), 1.79 (4H, m, CH_2), 1.58 (1H, m, CH_2), 1.19 (5H, m, CH_2). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 63.8, 56.0, 49.2, 46.4, 29.4, 26.7, 26.3. HRMS(ESI-TOF) calcd for $C_{11}H_{22}N_2H^+$: 183.1861. Found: 183.1846. (MH^+).

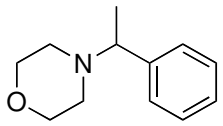


1-Cyclohexylpyrrolidine[64] (Entry 4, Table 7): The title compound was obtained and purified according to representative procedure **1.7**, using pyrrolidine (84 μL, 1 mmol) and cyclohexanol (104 μL, 1 mmol) (0.12 g, 81%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 2.54 (4H, m, CH_2), 1.92 (3H, m, CH_2), 1.72 (6H, m, CH_2), 1.55 (1H, m, CH), 1.17 (5H, m, CH_2). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ

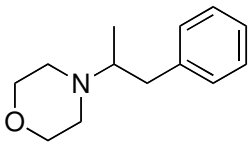
64.2, 51.8, 32.4, 26.4, 25.6, 23.6. HRMS(ESI-TOF) calcd for $C_{10}H_{19}NH^+$: 154.1596. Found: 154.1595. (MH^+).



N-Benzylcyclohexanamine[64] (Entry 5, Table 7): The title compound was obtained and purified according to representative procedure **1.7**, using benzylamine (109 μL, 1 mmol) and cyclohexanol (104 μL, 1 mmol) (0.12 g, 63%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.24 (5H, m, Ar), 3.74 (2H, s, CH_2), 2.41 (1H, m, CH), 1.64 (6H, m, CH_2, NH), 1.11 (5H, m, CH_2). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 141.4, 128.8, 128.5, 127.2, 56.6, 51.5, 34.0, 26.6, 25.4. HRMS(ESI-TOF) calcd for $C_{13}H_{19}NH^+$: 190.1596. Found: 190.1586. (MH^+).

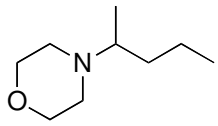


4-(1-Phenylethyl)morpholine[65] (Entry 1, Table 8): The title compound was obtained and purified according to representative procedure **1.7**, using morpholine (87 μL, 1 mmol) and 1-phenylethanol (120 μL, 1 mmol). (0.12 g, 65%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.19 (5H, m, Ar), 3.61 (4H, m, CH_2), 3.22 (1H, q, J = 6.7 Hz, CH), 2.40 (2H, s, CH_2), 2.29 (2H, s, CH_2), 1.28 (3H, d, J = 6.7 Hz, CH_3). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 128.7, 128.0, 127.4, 67.7, 65.8, 51.7, 20.2. HRMS(ESI-TOF) calcd for $C_{12}H_{17}NOH^+$: 192.1388. Found: 192.1375. (MH^+).

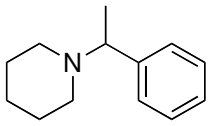


4-(1-Phenylpropan-2-yl)morpholine[66] (Entry 2, Table 8): The title compound was obtained and purified according to representative procedure **1.7**, using morpholine (87 μL, 1 mmol) and 1-phenylpropan-2-ol (140 μL, 1 mmol). (0.18 g, 86%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.18 (5H, m, Ar), 3.66 (4H, m, CH_2), 2.94 (1H, dd, J = 12.9, 4.2 Hz, CH), 2.69 (1H, m, CH), 2.55 (4H, m, CH_2), 2.33 (1H, dd, J = 12.9, 9.6 Hz, CH), 0.88 (3H, d, J = 6.5 Hz, CH_3). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ

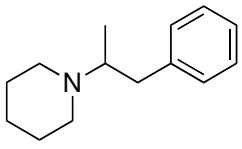
140.8, 129.7, 128.7, 126.3, 67.8, 62.1, 49.5, 39.7, 14.8. HRMS(ESI-TOF) calcd for $C_{13}H_{19}NOH^+$: 206.1544. Found: 206.1528. (MH^+).



4-(Pentan-2-yl)morpholine[67] (Entry 3, Table 8): The title compound was obtained and purified according to representative procedure **1.7**, using morpholine (87 μL, 1 mmol) and 2-pentanol (109 μL, 1 mmol). (0.14 g, 88%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 3.64 (4H, m, CH_2), 2.48 (5H, m, CH_2), 1.29 (4H, m, CH_2), 0.96 (3H, d, J = 6.5 Hz, CH_3), 0.88 (3H, t, J = 6.8 Hz, CH_3). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 67.8, 59.6, 49.3, 35.9, 20.3, 14.6. HRMS(ESI-TOF) calcd for $C_9H_{19}NOH^+$: 158.1545. Found: 158.1556. (MH^+).

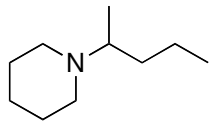


1-(1-Phenylethyl)piperidine[68] (Entry 4, Table 8): The title compound was obtained and purified according to representative procedure **1.7**, using piperidine (99 μL, 1 mmol) and 1-phenylethanol (120 μL, 1 mmol) (0.131 g, 69%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.33 (5H, m, Ar), 3.42 (1H, q, ^3J = 6.8 Hz, CH), 2.40 (4H, m, CH_2), 1.58 (4H, m, CH_2), 1.41 (3H, d, ^3J = 6.8 Hz, CH_3), 1.40 (4H, m, CH_2). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 144.2, 128.4, 128.2, 127.1, 65.7, 51.9, 26.7, 25.0, 19.9. HRMS(ESI-TOF) calcd for $C_{13}H_{19}NH^+$: 190.1596. Found: 190.1593. (MH^+).

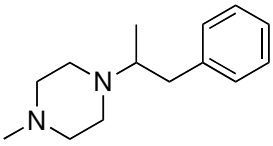


1-(1-Phenylpropan-2-yl)piperidine[69] (Entry 5, Table 8): The title compound was obtained and purified according to representative procedure **1.7**, using piperidine (99 μL, 1 mmol) and 1-phenylpropan-2-ol (140 μL, 1 mmol) (0.19 g, 91%). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.11 (5H, m, Ar), 2.95 (1H, dd, ^2J = 12.7 Hz, ^3J = 3.7 Hz, CH_2), 2.72 (1H, m, CH), 2.50 (4H, m, CH_2), 2.31 (1H, dd, ^2J = 12.7 Hz, ^3J = 10.1 Hz, CH_2), 1.54 (4H, m, CH_2), 1.39 (2H, m, CH_2), 0.86 (3H, d, ^2J = 6.6

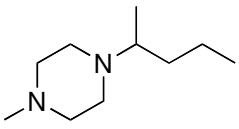
Hz, CH_3). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 141.4, 129.7, 128.6, 126.1, 62.5, 50.1, 39.6, 26.9, 25.4, 14.7. HRMS(ESI-TOF) calcd for $C_{14}H_{21}NH^+$: 204.1752. Found: 204.1735. (MH^+).



1-(Pentan-2-yl)piperidine[70] (Entry 6, Table 8): The title compound was obtained and purified according to representative procedure **1.7**, using piperidine (99 μL, 1 mmol) and pentan-2-ol (109 μL, 1 mmol) (0.13 g, 85%). ^1H NMR (300 MHz, $CDCl_3$): δ 2.47 (4H, m, CH_2), 2.19 (1H, bs, CH), 1.43 (10H, m, CH_2), 0.96 (6H, m, CH_2). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 60.0, 49.8, 36.0, 26.8, 25.3, 20.8, 14.7, 14.4. HRMS(ESI-TOF) calcd for $C_{10}H_{21}NH^+$: 156.1752. Found: 156.1750. (MH^+).

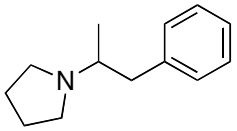


1-Methyl-4-(1-phenylpropan-2-yl)piperazine[71] (Entry 8, Table 8): The title compound was obtained and purified according to representative procedure **1.7**, using *N*-methyl piperazine (111 μL, 1 mmol) and 1-phenylpropan-2-ol (140 μL, 1 mmol) (0.18 g, 82%). ^1H NMR (300 MHz, $CDCl_3$): δ 7.22 (5H, m, Ar), 3.03 (1H, dd, ^2J = 12.9 Hz, ^3J = 4.0 Hz, CH_2), 2.82 (1H, m, CH), 2.68 (4H, m, CH_2), 2.45 (5H, m, CH_2), 2.31 (3H, s, CH_3), 0.96 (3H, d, ^2J = 6.5 Hz, CH_3). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 141.1, 129.6, 128.6, 126.2, 61.7, 56.0, 48.7, 46.5, 39.7, 14.9. HRMS(ESI-TOF) calcd for $C_{14}H_{22}N_2H^+$: 219.1861. Found: 219.1849. (MH^+).

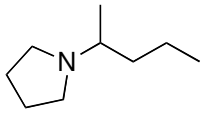


1-Methyl-4-(pentan-2-yl)piperazine (Entry 9, Table 8): The title compound was obtained and purified according to representative procedure **1.7**, using *N*-methyl piperazine (111 μL, 1 mmol) and pentan-2-ol (109 μL, 1 mmol) (0.14 g, 80%). ^1H NMR (300 MHz, $CDCl_3$): δ 2.56 (8H, m, CH_2), 2.29 (3H, s, CH_2), 1.39 (4H, m, CH_2, CH), 0.98 (3H, d, ^3J = 6.5 Hz, CH_3), 0.91 (3H, t, ^3J =

6.7 Hz, CH_3). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 59.1, 56.1, 48.5, 46.5, 36.2, 20.5, 14.7, 14.6. HRMS(ESI-TOF) calcd for $C_{10}H_{22}N_2H^+$: 171.1861. Found: 171.1850. (MH^+).

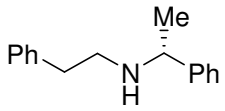


1-(Pentan-2-yl)pyrrolidine[72] (Entry 11, Table 8): The title compound was obtained and purified according to representative procedure **1.7**, using pyrrolidine (84 μL, 1 mmol) and 1-phenylpropan-2-ol (140 μL, 1 mmol) (0.13 g, 69%). ^1H NMR (300 MHz, $CDCl_3$): δ 7.12 (5H, m, Ar), 3.08 (1H, dd, ^2J = 12.6 Hz, ^3J = 3.2 Hz, CH_2), 2.61 (4H, m, CH_2), 2.44 (1H, m, CH), 2.34 (1H, dd, ^2J = 12.6 Hz, ^3J = 10.1 Hz, CH_2), 1.75 (4H, m, CH_2), 0.91 (3H, d, ^3J = 6.0 Hz, CH_3). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 140.7, 129.8, 128.6, 126.3, 61.4, 51.8, 42.3, 23.9, 18.0. HRMS(ESI-TOF) calcd for $C_{13}H_{19}NH^+$: 190.1596. Found: 190.1586. (MH^+).



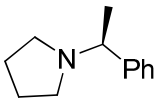
1-(1-Phenylpropan-2-yl)pyrrolidine[73] (Entry 12, Table 8): The title compound was obtained and purified according to representative procedure **1.7**, using pyrrolidine (84 μL, 1 mmol) and pentan-2-ol (109 μL, 1 mmol) (0.10 g, 72%). ^1H NMR (300 MHz, $CDCl_3$): δ 2.48 (4H, m, CH_2), 2.16 (1H, m, CH), 1.70 (4H, m, CH_2), 1.52 (2H, m, CH_2), 1.24 (2H, m, CH_2), 0.99 (3H, d, ^3J = 6.3 Hz, CH_3), 0.84 (3H, d, ^3J = 6.8 Hz, CH_3). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 59.6, 51.7, 37.9, 23.8, 19.6, 18.2, 14.8. HRMS(ESI-TOF) calcd for $C_9H_{19}NH^+$: 142.1596. Found: 142.1589. (MH^+).

Procedure for the reversible reaction: To an oven-dried, nitrogen purged carousel tube containing [Ru(*p*-cymene)Cl_2]$_2$ (7.7 mg, 0.0125 mmol) and DPEphos (13.5 mg, 0.025 mmol) was added 1-methyl-4-(1-phenylpropan-2-yl)piperazine (see **Entry 9, Table 8**) (0.5 mmol) followed by anhydrous xylene (0.8 mL) and water (0.2 mL). The reaction mixture was allowed to stir under a nitrogen atmosphere at room temperature for 10 minutes in the closed vessel and then heated to 150 ºC for 24 h. After 24 h the solvent was removed under vacuum and the resulting residue analysed for traces of secondary alcohol formation.



(*R*)-α-Phenethyl-(1-phenylethyl)amine[74] 47: According to representative procedure **1.1**, using (*R*)-(+)-α-Methylbenzylamine **43** (127 μL, 1 mmol) and K_2CO_3 (13.8 mg, 0.01 mmol), the title compound was obtained and purified by column chromatography eluting with petroleum ether (b.p. 40-60 ºC)/ethyl acetate (3:2), R_f = 0.23, to give a yellowish-brown liquid (0.16 g, 70%, ee = 97%). $[\alpha]_D^{25}$ +54.2 (*c* 2.84, $CHCl_3$). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.34 – 7.15 (10H, m, Ph), 3.78 (1H, q, *J* = 6.6 Hz, CH), 2.82-2.67 (4H, m, C*H*$_2$), 1.34 (3H, d, *J* = 6.6 Hz, CH_3). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 140.0, 128.7, 128.41, 128.39, 126.9, 126.5, 126.1, 58.2, 48.9, 36.4, 24.2. HRMS(ESI-TOF) calcd for $C_{16}H_{19}NH^+$: 226.1596. Found: 226.1578. (MH^+).

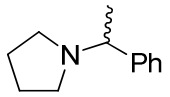
Enantiomeric resolution[75] was achieved *via* 1:1 salt formation with (*S*)-(+)-O-acetylmandelic acid: (*R*)-α-Phenethyl-(1-phenylethyl)amine (0.0101 g, 0.0448 mmol) and (*S*)-(+)-O-acetylmandelic acid (0.0087 g, 0.0448 mmol) were dissolved in $CDCl_3$ (0.6 mL). Analysis of the ^{1}H NMR (250 MHz, 25 °C) spectrum shows a quartet at δ 4.00 allowing a rough integration of 1.000:0.022 for enantiomers. Since the original spectrum was difficult to resolve, we irradiated at δ 1.55 to give 2 singlets at an integration of 1.000:0.016 from which the ee was calculated. Found 97% ee.



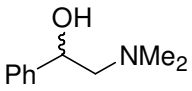
(*S*)-1-(1-Phenylethyl)pyrrolidine[76] 48: According to representative procedure **1.5**, using (*S*)-(-)-α-methylbenzylamine (129 μL, 1 mmol) and 1,4-butanediol (106 μL, 1.2 mmol), the title compound was obtained and purified by column chromatography eluting with hexanes/ethyl acetate (2:1) to give a colourless oil, R_f = 0.23 (0.14 g, 82%). $[\alpha]_D^{26}$ -66.5° (*c* 2.0, $CHCl_3$). ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.22 – 7.36 (5H, m, Ph), 3.18 (1H, q, *J* = 7.8 Hz), 2.52 – 2.58 (2H, m, CH_2), 2.35 – 2.40 (2H, m, CH_2), 1.74-1.79 (4H, m, CH_2), 1.41 (3H, d, *J* = 7.8 Hz, CH_3). ^{13}C NMR ($CDCl_3$, 300 MHz) δ 145.8, 128.3, 127.3, 126.9, 66.1, 53.1, 23.5, 23.3. HRMS(ESI-TOF) calcd for $C_{12}H_{17}NH^+$: 176.1439. Found: 176.1427. (MH^+).

Enantiomeric resolution[75] was achieved *via* 1:1 salt formation with (*S*)-(+)-O-acetylmandelic acid: (*S*)-1-(1-phenylethyl)pyrrolidine (0.0175 g, 0.1 mmol) and (*S*)-(+)-O-acetylmandelic acid (0.0194 g, 0.1 mmol) were dissolved in $CDCl_3$ (0.6 mL). Analysis of the ^{1}H NMR (250 MHz, 25 °C)

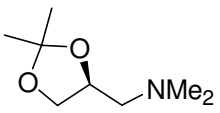
spectrum shows a doublet at δ 1.60, this is shifted downfield from the original doublet at δ1.41. As no other signal was visible for the other enantiomer, a racemic sample was run for comparison. This displayed a clear difference showing two peaks, one at δ 1.62 and the other at δ 1.54. This lead to the conclusion that no racemisation of the stereocentre had occurred allowing the ee to be calculated from the starting material. Found >98% ee.



1-(1-Phenylethyl)pyrrolidine[76] 48: The title compound was obtained and purified according to representative procedure **1.7**, using pyrrolidine (83 μL, 1 mmol) and (*S*)-(-)-α-methylbenzylamine (129 μL, 1 mmol). (0.06 g, 37%). Spectral data was consistent with that shown above.
Enantiomeric resolution[75] was achieved *via* salt formation with (*S*)-(+)-O-acetylmandelic acid. Analysis of the ^{1}H NMR spectrum and comparison with the racemic product revealed the splitting of the methyl peak (previously a doublet) enabling the calculation of the ee. Found 0% ee.



(±)-2-Dimethylamino-1-phenylethanol[77] 50: According to representative procedure **1.4**, using (*R*)-(-)-1-phenyl-1,2-ethanediol **45** (0.138 g, 1 mmol) at 1.0 mol % Ru, the title compound was obtained and purified by column chromatography eluting with dichloromethane/methanol (9:1), R_f = 0.06 to give a pale brown oil (0.13 g, 80%). $[\alpha]_D^{25}$ 0 (*c* 1.00, $CHCl_3$). ^{1}H NMR (250 MHz, $CDCl_3$): δ 7.28 – 7.42 (5H, m Ph), 4.74 (1H, dd, *J* = 10.5, 3.5 Hz, CH), 4.16 (1H, br s, OH), 2.38 – 2.59 (2H, m, CH_2), 2.40 (6H, s, CH_3). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ 142.1, 128.3, 127.5, 125.8, 69.4, 67.4, 45.2. HRMS(ESI-TOF) calcd for $C_{10}H_{15}NOH^+$: 166.1232. Found: 166.1209. (MH^+).



(*S*)-[2,2-Dimethyl-1,3-dioxolan-4-yl)methyl]dimethyl amine[78] 51: According to representative procedure **1.4**, using (*S*)-(+)-1,2-isopropylideneglycerol **46** (0.124 mL, 1 mmol) at 1.0 mol % Ru, the title compound was obtained and purified by column chromatography eluting with

dichloromethane/methanol (9:1), R_f = 0.16 to give an oil (0.11 g, 70%). ^{1}H NMR (500 MHz, $CDCl_3$): δ 4.24 (1H, m, CH), 4.08 (1H, dd, *J* = 8.1, 6.2 Hz, CH_2), 3.59 (1H, dd, *J* = 8.0, 7.0 Hz, CH_2), 2.50 (1H, dd, *J* = 12.6, 7.0 Hz, CH_2), 2.36 (1H, dd, *J* = 12.6, 5.2 Hz, CH_2), 2.29 (6H, s, CH_3), 1.42 (3H, s, CH_3), 1.36 (3H, s, CH_3). ^{13}C NMR (75.4 MHz, $CDCl_3$): δ = 109.2, 73.9, 68.4, 62.6, 46.1, 26.9, 25.5. HRMS(ESI-TOF) calcd for $C_8H_{17}NO_2H^+$: 160.1338. Found: 160.1329. (MH^+).
Enantiomeric resolution[75] was achieved *via* 1:1 salt formation with (*S*)-(+)-O-acetylmandelic acid: (*S*)-[2,2-dimethyl-1,3-dioxolan-4-yl)methyl]dimethyl amine (0.009 g, 0.06 mmol) and (*S*)-(+)-O-acetylmandelic acid (0.011 g, 0.06 mmol) were dissolved in $CDCl_3$ (0.6 mL). Analysis of the ^{1}H NMR (500 MHz, $CDCl_3$) spectrum and comparison with the racemic product revealed the splitting of the six proton dimethylamino peak and ee was calculated. Found: 28% ee.

Representative procedure for the d_2 labelling experiment (Scheme 13): To an oven-dried, nitrogen purged carousel tube containing [Ru(*p*-cymene)Cl_2]$_2$ (15.3 mg, 0.025 mmol) and DPEphos (26.9 mg, 0.05 mmol) were added deuterated (d_2) benzyl alcohol (0.5 mmol) and ^{13}C labelled benzyl alcohol (0.5 mmol) to morpholine (1 mmol) followed by anhydrous toluene (1 mL). The reaction mixture was allowed to stir under a nitrogen atmosphere at room temperature for 10 minutes and then heated to 110 ºC for 24 h. After 24 h the solvent was removed under vacuum and the crude mixture analysed.
The resulting ^{1}H and ^{13}C NMR spectra clearly show that scrambling of the respective labels has occurred. The deuterium incorporation of the final products was calculated from the integration of the individual product signals in the ^{1}H NMR spectrum.

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