Supplementary Material (ESI) for Organic and Biomolecular Chemistry

One-pot synthesis of benzothiazolines and napthathiazolines via cascade *ortho*-lithiation, cyclisation and elimination of N-arylsulfonyl lactams

John. D. Harling,[†] Patrick. G. Steel,[¥*] Tom. M. Woods[¥] and Dmitry S. Yufit.[¥]

Department of Chemistry, University of Durham, Science Laboratories, South Road Durham, DH1 3LE, UK and GlaxoSmithKline, Gunnels Wood Road, Stevenage, Herts. SG1 2NY, UK

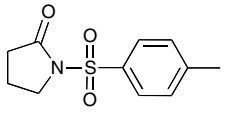
p.g.steel@durham.ac.uk

¥ Durham University. † GlaxoSmithKline.

General method for N-alkylsulfonyl protection of lactams.

To a cold (0 ^{o}C) solution of lactam (0.34 M, 1.0 eq) in dry THF was added a solution of *n*-BuLi (1.6 M, 1.1 eq) via a syringe and the reaction mixture was stirred at 0 ^{o}C for 1 h (white precipitate (salt) forms). To this was added a cold (0 ^{o}C) solution of arylsulfonyl chloride (1.0 M, 1.3 eq) in dry THF via cannula. The reaction mixture was stirred at 0 ^{o}C and followed by TLC or LCMS until all the starting material was consumed. The reaction was warmed to room temperature and concentrated in vacuo, the crude material was taken into DCM, washed with water (3x), dried over $MgSO_4$ and concentrated under reduced pressure.

N-[(4'-methylphenyl)sulfonyl]pyrrolidin-2-one **4b**

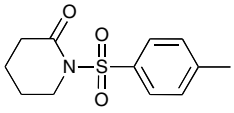


4b

Crude material collected as a pale brown/orange solid. Purification by flash chromatography ([7:3] pet. ether/ethyl acetate) afforded the title compound as a white solid (2.33 g, 9.74 mmol, 65%). mp 139-141 ^{o}C. ν_{max} (KBr) 3028, 1737 (C=O), 1598, 1359 (NSO_2), 1238, 1217, 1169 (NSO_2), 1121, 957, 662, 596, 558 cm^{-1}. δ_H (500MHz, $CDCl_3$) 2.06 (2H, t, J = 8 Hz, 4-*H*$_2$), 2.39-2.47 (5H, m, 4'-*CH*$_3$, 3-*H*$_2$), 3.88 (2H, t, J = 7 Hz, 5-*H*$_2$), 7.33 (2H, d, J = 8 Hz, 3'-*H*, 5'-*H*), 7.91 (2H, d, J = 8 Hz, 2'-*H*, 6'-*H*). δ_C (125MHz, $CDCl_3$) 18.4 (*C*-4), 21.2 (4'-*C*H$_3$), 32.5 (*C*-3), 47.5 (*C*-5), 128.3 (*C*-2'),

129.9 (*C*-3'), 135.3 (*C*-1'), 145.5 (*C*-4'), 173.7 (*C*O). *m/z* (ES^+) 240 (MH^+). HRMS (ES) found MH^+ 240.0691, $C_{11}H_{14}NO_3S$ requires M^+ 240.0689, found MNa^+ 262.0509, $C_{11}H_{13}NO_3SNa$ requires M^+ 262.0508.

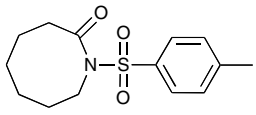
N-[(4'-methylphenyl)sulfonyl]piperidin-2-one **4c**



4c

Crude material collected as a colourless oil which solidified on standing. Purification by flash chromatography ([7:3] pet. ether/ethyl acetate) afforded the title compound as a white solid (2.02 g, 7.9 mmol, 33%). mp 136-138 °C. Found; C, 56.87; H, 5.97; N, 5.37%; Calc. for $C_{12}H_{15}NO_3S$; C, 56.90; H, 5.97; N, 5.53%. ν_{max} (KBr) 2958, 1691 (C=O), 1457, 1354 (NSO_2), 1283, 1171 (NSO_2), 1089, 969, 830, 577, 549 cm^{-1}. δ_H (400MHz, $CDCl_3$) 1.74 (2H, quintet, J = 6 Hz, 4-*H*$_2$), 1.87 (2H, quintet, J = 6 Hz, 5-*H*$_2$), 2.28-2.48 (5H, m, 3-*H*$_2$, 4'-C*H*$_3$), 3.88 (2H, t, J = 6 Hz, 6-*H*$_2$), 7.28 (2H, d, J = 8 Hz, 3'-*H*, 5'-*H*), 7.87 (2H, d, J = 8 Hz, 2'-*H*, 6'-*H*). δ_C (100MHz, $CDCl_3$) 20.6 (*C*-4), 21.9 (4'-*C*H_3), 23.5 (*C*-5), 34.3 (*C*-3), 47.2 (*C*-6), 128.9 (*C*-2'), 129.5 (*C*-3'), 136.3 (*C*-1'), 145.0 (*C*-4'), 170.5 (*C*O). *m/z* (ES^+) 254.1 (MH^+), 276.1 (MNa^+), 308.1 ($MNaMeOH^+$), 529 ($2MNa^+$). HRMS (ES) found MH^+ 254.0847, $C_{12}H_{16}NO_3S$ requires M^+ 254.0845, found MNa^+ 276.0666, $C_{12}H_{15}NO_3SNa$ requires M^+ 276.0665.

N-[(4'-methylphenyl)sulfonyl]-2-oxoazocine **4d**

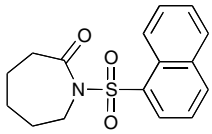


4d

Crude material collected as a brown solid. Purification by flash chromatography ([7:3] pet. ether/ethyl acetate) afforded the title compound as a white solid (3.46 g, 12.30 mmol, 80%). mp 116-118 °C. Found; C, 59.64; H, 6.82; N, 4.79%; Calc. for $C_{14}H_{19}NO_3S$; C, 59.76; H, 6.81; N, 4.98%. ν_{max} (KBr) 2938, 1687 (C=O), 1448, 1358 (NSO_2), 1211, 1167 (NSO_2), 1119, 1083, 814, 683, 634, 542 cm^{-1}. δ_H (500MHz, $CDCl_3$) 1.46 (2H, qt, J = 6 Hz, 6-*H*$_2$), 1.54 (2H, qt, J = 6 Hz, 5-*H*$_2$), 1.75 (2H, qt, J = 6 Hz, 4-*H*$_2$), 1.87 (2H, qt, J = 6 Hz, 7-*H*$_2$), 2.41 (3H, s, 4'-C*H*$_3$), 2.48 (2H, m, 3-*H*$_2$), 4.06 (2H, t, J = 6 Hz, 8-*H*$_2$), 7.28 (2H, d, J = 9 Hz, 3'-*H*, 5'-*H*), 7.90 (2H, d, J = 9 Hz, 2'-*H*, 6'-*H*). δ_C (125MHz, $CDCl_3$) 21.9 (4'-*C*H_3), 23.9 (*C*-6), 26.3 (*C*-5), 28.7 (*C*-4), 31.3

(*C*-7), 36.6 (*C*-3), 46.3 (*C*-8), 129.2, 129.4 (*C*-2', *C*-3'), 136.6 (*C*-1'), 144.8 (*C*-4'), 175.1 (*C*O). *m/z* (ES^+) 282.1 (MH^+).

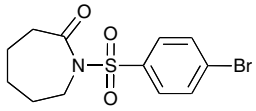
N-(1'-Napthylsulfonyl)-2-oxoazepane **4e**



4e

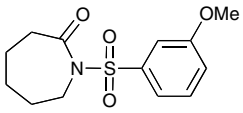
Crude material collected as a brown solid. Purification by flash chromatography ([7:3] pet. ether/ethyl acetate) afforded the title compound as a white solid (1.46 g, 4.81 mmol, 49%). mp 132-134 ^oC. Found; C, 63.10; H, 5.61; N, 4.42%; Calc. for $C_{16}H_{17}NO_3S$; C, 63.34; H, 5.65; N, 4.62%. ν_{max} (KBr) 3028, 2944, 1699 (C=O), 1510, 1354 (NSO_2), 1210, 1165 (NSO_2), 1134, 880, 690, 506 cm^{-1}. δ_H (500MHz, $CDCl_3$) 1.71 (2H, qt, J = 6 Hz, 4-*H*$_2$), 1.77 (2H, qt, J = 6 Hz, 5-*H*$_2$), 1.98 (2H, qt, J = 6 Hz, 6-*H*$_2$), 2.47 (2H, m, 3-*H*$_2$), 4.26 (2H, m, 7-*H*$_2$), 7.59 (1H, t, J = 8 Hz, 6'-*H*), 7.62 (1H, t, J = 8 Hz, 3'-*H*), 7.66 (1H, t, J = 8 Hz, 7'-*H*), 7.95 (1H, d, J = 9 Hz, 5'-*H*), 8.10 (1H, d, J = 9 Hz, 4'-*H*), 8.35 (1H, d, J = 9 Hz, 8'-*H*), 8.53 (1H, d, J = 8 Hz, 2'-*H*). δ_C (125MHz, $CDCl_3$) 23.2 (*C*-4), 29.5 (*C*-5), 29.7 (*C*-6), 39.0 (*C*-3), 46.3 (*C*-7), 123.7 (*C*-8'), 124.5 (*C*-3'), 126.9 (*C*-6'), 128.4 (*C*-8''), 128.5 (*C*-7'), 129.6 (*C*-5'), 133.1 (*C*-2'), 134.3 (*C*-4''), 134.8 (*C*-1'), 135.3 (*C*-4'), 175.1 (*C*O). *m/z* (ES^+) 304.1 (MH^+).

N-([4'-Bromophenyl]sulfonyl)-2-oxoazepane **4f**



4f

Purification on the Horizon automated chromatography system (1. 15 %, 2. 30 % ethyl acetate/cyclohexane) afforded the desired product as a white solid (1.43 g, 4.30 mmol, 49 %). mp 111-113 ^oC. ν_{max} (KBr) 2931, 2857, 1691 (NC=O), 1574, 1469, 1389, 1338 (SO_2), 1161 (SO_2), 1117, 1084, 1069, 1010, 960, 881, 820, 769, 743 (C-Br), 703 cm^{-1}. δ_H (400MHz, $CDCl_3$) 1.63-1.76 (4H, m, 4-*H*$_2$, 5-*H*$_2$), 1.76-1.84 (2H, m, 6-*H*$_2$), 2.52 (2H, m, 3-*H*$_2$), 3.99 (2H, m, 7-*H*$_2$), 7.62 (2H, d, J = 9 Hz, 3'-*H*, 5'-*H*), 7.84 (2H, d, J = 9 Hz, 2'-*H*, 6'-*H*). δ_C (100MHz, $CDCl_3$) 22.9 (*C*-4), 28.9 (*C*-5), 29.6 (*C*-6), 38.9 (*C*-3), 46.9 (*C*-7), 128.6 (*C*-4'), 130.1 (*C*-2'), 131.9 (*C*-3'), 138.7 (*C*-1'), 175.0 (*C*-2). *m/z* (ES^+) 332.2 ($MH[Br^{79}]^+$), 334.2 ($MH[Br^{81}]^+$). HRMS (ES) found MH^+ 331.9953, $C_{12}H_{15}NO_3SBr^{79}$ requires M^+ 331.9951.

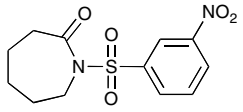


4g

N-([3'-Methoxyphenyl]sulfonyl)-2-oxoazepane **4g**

Purification on the Horizon automated chromatography system (1. 15 %, 2. 30 % ethyl acetate/cyclohexane) afforded the desired product as a clear oil. (1.16 g, 4.11 mmol, 46 %). ν_{max} (KBr) 2942, 2863, 1698 (NC=O), 1599, 1484, 1465, 1435, 1354 (SO_2), 1254, 1167 (SO_2), 1122, 1090, 1078, 1037, 577, 517 cm^{-1}. δ_H (400MHz, $CDCl_3$) 1.64-1.79 (4H, m, 4-*H*$_2$, 5-*H*$_2$), 1.85 (2H, m, 6-*H*$_2$), 2.55 (2H, m, 3-*H*$_2$), 3.86 (3H, s, OC*H*$_3$), 4.01 (2H, m, 7-*H*$_2$), 7.12 (1H, ddd, J_1 = 8 Hz, J_2 = 3 Hz, J_3 = 1 Hz, 4'-*H*), 7.40 (1H, t, J = 8 Hz, 5'-*H*), 7.53 (2H, m, 2'-*H*, 6'-*H*). δ_C (100MHz, $CDCl_3$) 23.2 (*C*-4), 29.4 (*C*-5), 29.6 (*C*-6), 39.0 (*C*-3), 46.8 (*C*-7), 55.9 (O*C*H$_3$), 113.5 (Ar*C*H), 120.2 (*C*-4'), 120.4 (Ar*C*H), 129.9 (*C*-5'), 140.9 (*C*-1'), 159.6 (*C*-3'), 175.1 (*C*-2). *m/z* (ES^+) 284.2 (MH^+), 306.2 (MNa^+), 589.3 ($2MNa^+$). HRMS (ES) found MH^+ 284.0953, $C_{13}H_{19}NO_4S$ requires M^+ 284.0951.

N-([3'-Nitrophenyl]sulfonyl)-2-oxo-azepane **4h**



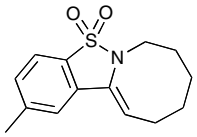
4h

Purification on the Horizon automated chromatography system (1. 30 %, 2. 50 % ethyl acetate/cyclohexane) afforded the desired product as a white solid (0.20 g, 0.66 mmol, 15 %). mp 126-128 ^oC. Found; C, 48.28; H, 4.78; N, 9.31%; Calc. for $C_{12}H_{14}N_2O_5S$; C, 48.31; H, 4.73; N, 9.39%. ν_{max} (KBr) 2958, 2872, 1700 (NC=O), 1607, 1537, 1463, 1353 (SO_2), 1179 (SO_2), 1123, 1080 cm^{-1}. δ_H (400MHz, $CDCl_3$) 1.66-1.81 (4H, m, 4-*H*$_2$, 5-*H*$_2$), 1.81-1.90 (2H, m, 6-*H*$_2$), 2.55 (2H, m, 3-*H*$_2$), 4.06 (2H, m, 7-*H*$_2$), 7.35 (1H, t, J = 8 Hz, 5'-*H*), 8.34 (1H, d, J = 8 Hz, 6'-*H*), 8.43 (1H, d, J = 8 Hz, 4'-*H*), 8.75 (1H, s, 2'-*H*). δ_C (100MHz, $CDCl_3$) 23.2 (*C*-4), 29.5 (*C*-5), 29.9 (*C*-6), 39.0 (*C*-3), 46.2 (*C*-7), 124.0 (*C*-2'), 128.3 (*C*-4'/6'), 130.4 (*C*-5'), 134.8 (*C*-4'/6'), 142.0 (*C*-1'), 148.3 (*C*-3'), 175.5 (*C*-2). *m/z* (ES^+) 299.2 (MH^+), 316.2 (MH_2O^+), 614.2 ($2MH_2O^+$).

General method for cyclisation of N-alkylsulfonyl protected lactams.

To a cold solution (0.08 M, -78 °C) of N-sulfonyl lactam (1 eq) and TMEDA (1.3 eq) in dry THF was added a cold solution of LDA (1.3 eq) via cannula. The resulting reaction mixture was stirred at -78 °C for 2 h after which time a cold (0.2 M, -78 °C) solution of diphenylphosphonic chloride (1.2 eq) in dry THF was added via cannula. The reaction mixture was stirred at -78 °C for 1 h then warmed to room temperature and quenched with $NH_4Cl_{(aq)}$. The mixture was concentrated in vacuo and the aqueous layer extracted with ethyl acetate. The organic phase was washed with $NaHCO_{3(aq)}$ then brine, dried over $MgSO_4$ and concentrated in vacuo affording crude material.

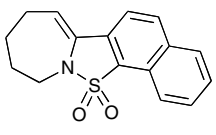
1,2,3,4,5-Quintahydro-8-methylazocine[1,2-b][1,2]benzothiazole-11,11-dioxide **5d**



5d

Purification on a Horizon® column chromatography system (1. 20% ethyl acetate/pet. ether, 2. 40% ethyl acetate/pet.ether) afforded the title compound as a clear oil (0.09 g, 0.34 mmol, 18%) and phosphonite (0.21 g, 0.44 mmol, 25%). ν_{max} (KBr) 2925, 2854, 1651, 1601, 1455, 1289, 1171, 1142, 1050, 1016, 896, 819, 802 cm^{-1}. δ_H (400MHz, $CDCl_3$) 1.71 (2H, m, 3-*H*$_2$), 1.79 (2H, m, 4-*H*$_2$), 2.02 (2H, quint, J = 7 Hz, 2-*H*$_2$), 2.46 (3H, s, 8-C*H*$_3$), 2.59 (2H, m, J = 7 Hz, 5-*H*$_2$), 4.02 (2H, t, J = 7 Hz, 1-*H*$_2$), 5.55 (1H, t, J = 9 Hz, 6-*H*), 7.30 (1H, d, J = 8 Hz, 8-*H*), 7.44 (1H, s, 7-*H*), 7.67 (1H, d, J = 8 Hz, 9-*H*). δ_C (100MHz, $CDCl_3$) 22.3 (8-*C*H$_3$), 22.5 (*C*-3), 23.6 (*C*-5), 28.6 (*C*-4), 30.5 (*C*-2), 40.3 (*C*-1), 100.6 (*C*-6), 120.9 (*C*-7), 121.1 (*C*-10), 128.9 (*C*-10a), 130.6 (*C*-9), 132.1 (*C*-6b), 134.0 (*C*-6a), 143.9 (*C*-8). *m/z* (ES^+) 264.1 (MH^+), 286.1 (MNa^+), 318.1 ($MMeOHNa^+$), 549.3 ($2MNa^+$). HRMS (ES) found MH^+ 264.1052, $C_{14}H_{18}NO_2S$ requires M^+ 264.1053.

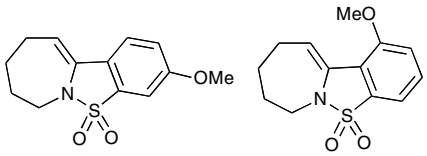
1,2,3,4-Tetrahydroazepino[1,2-b][1,2]napthathiazole-12,12-dioxide **5e**



5e

Purification on the Horizon column chromatography system (20% ethyl acetate/pet. ether) afforded the title compound as a white solid (0.35 g, 1.23 mmol, 26%), recovered starting material (41%) and phosphonite (0.17 g, 0.34 mmol, 17%). mp 183-186 ^{o}C. ν_{max} (KBr) 2930, 2868, 1657, 1626, 1592, 1512, 1288, 1154, 1131, 1074, 1005, 936, 826, 807, 761. δ_H (500MHz, $CDCl_3$) 1.83 (2H, quint, J = 6 Hz, 3-*H*$_2$), 2.05 (2H, m, 2-*H*$_2$), 2.50 (2H, q, J = 6 Hz, 4-*H*$_2$), 3.67 (2H, m, 1-*H*$_2$), 5.93 (1H, t, J = 6 Hz, 5-*H*), 7.57-7.63 (2H, m, 6-*H*, 9-*H*), 7.70 (1H, t, J = 8 Hz, 10-*H*), 7.91 (1H, d, J = 8 Hz, 8-*H*), 7.98 (1H, d, J = 9 Hz, 7-*H*), 8.37 (1H, d, J = 9 Hz, 11-*H*). δ_C (125MHz, $CDCl_3$) 27.0 (*C*-3), 27.6 (*C*-4), 29.0 (*C*-2), 45.5 (*C*-1), 108.5 (*C*-5), 117.3 (Ar*C*H), 123.5 (*C*-11), 125.5 (*C*-11a), 126.2 (*C*-11b), 127.9 (Ar*C*H), 128.9 (*C*-8), 129.4 (*C*-10), 131.2 (*C*-5b), 133.5 (*C*-7a), 134.0 (*C*-7), 136.5 (*C*-5a). *m/z* (ES^+) 286.1 (MH^+), 308.1 (MNa^+), 340.1 ($MMeOHNa^+$), 593.3 ($2MNa^+$), 878.4 ($3MNa^+$). HRMS (ES) found MH^+ 286.0899, $C_{16}H_{16}NO_2S$ requires 286.0896.

1,2,3,4-Tetrahydro-6/8-methoxyazepino[1,2-b][1,2]benzothiazole-10,10-dioxide **5g**

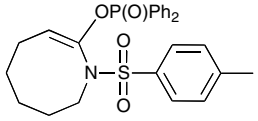


5g

The crude material was collected as a pale brown oil which was purified by flash chromatography (1. 10% EtOAc/Pet. ether, 2. 15% EtOAc/Pet. ether, 3. 50% EtOAc/Pet. ether) affording a mixture of isomers and phosphonite. The initial fraction provided *1,2,3,4-Tetrahydro-6-methoxyazepino[1,2-b][1,2]benzothiazole-10,10-dioxide* as a colourless oil. (0.067 g, 0.25 mmol, 25%). ν_{max} (KBr) 2941, 1647, 1595, 1485, 1440, 1304, 1273, 1212, 1171, 1158, 1044.cm^{-1}. δ_H (400MHz, $CDCl_3$) 1.81 (2H, quint, J = 6 Hz, 3-*H*$_2$), 1.95 (2H, quint, J = 6 Hz, 2-*H*$_2$), 2.44 (2H, q, J = 6 Hz, 4-*H*$_2$), 3.59 (2H, m, 1-*H*$_2$), 3.95 (3H, s, O*C*H$_3$), 6.52 (1H, t, J = 6 Hz, 5-*H*), 7.08 (1H, m, ArC*H*), 7.34-7.44 (2H, m, 8-C*H*, ArC*H*). δ_C (100MHz, $CDCl_3$) 26.2 (*C*-3), 27.2 (*C*-4), 29.2 (*C*-2), 45.5 (*C*-1), 56.1 (O*C*H$_3$), 113.2 (Ar*C*), 114.5 (*C*-5), 114.7 (Ar*C*), 120.0 (*C*-5b), 130.5 (*C*-8), 133.8 (*C*-9a), 135.9 (*C*-5a), 155.7 (*C*-6). *m/z* (ES^+) 266.2 (MH^+). HRMS (ES) found MH^+ 266.08454, $C_{13}H_{16}NO_3S$ requires M^+ 266.08483**.** Further elution then afforded *1,2,3,4-Tetrahydro-8-methoxyazepino[1,2-b][1,2]benzothiazole-10,10-dioxide* as a colourless oil. (0.017 g, 0.06 mmol, 6%). ν_{max} (KBr) 2941, 1664, 1611, 1495, 1464, 1441, 1303, 1274, 1168, 1056, 1027 cm^{-1}. δ_H (400MHz, $CDCl_3$) 1.80 (2H, quint, J = 6 Hz, 3-*H*$_2$), 1.98 (2H, m, 2-*H*$_2$), 2.42 (2H, q, J = 6 Hz, 4-*H*$_2$), 3.59 (2H, m, 1-*H*$_2$), 5.65 (1H, t, J = 6 Hz, 5-*H*), 7.13 (1H, m, 7-*H*), 7.19 (1H, s, 9-*H*), 7.50

(1H, d, J = 9 Hz, 6-*H*). δ_C (100MHz, $CDCl_3$) 27.1, 27.2 (*C*-4, *C*-3), 28.9 (*C*-2), 45.4 (*C*-1), 56.1 (OCH_3), 103.3 (*C*-9), 104.9 (*C*-5), 122.0 (*C*-6), 122.3 (*C*-7), 124.9 (*C*-5b), 132.4 (*C*-9a), 135.7 (*C*-5a), 160.9 (*C*-8). ***m/z*** (ES^+) 266.2 (MH^+). HRMS (ES) found MH^+ 266.08480, $C_{13}H_{16}NO_3S$ requires M^+ 266.08454.

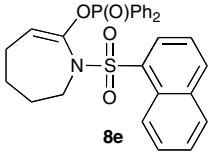
1-Tosyl-4,5,6,7,8-quintahydro-1H-azepin-2-yl diphenylphosphinate **8d**



8d

mp 199-200 °C. HPLC r.t. = 6.02 min, 98.13%. ν_{max} (KBr) 2928, 2851, 1671, 1593, 1440, 1348, 1235, 1156, 1126, 1076, 1006, 961, 874, 829, 730 cm^{-1}. δ_H (400MHz, $CDCl_3$) 1.43-1.60 (6H, m, 5-*H*$_2$, 6-*H*$_2$, 7-*H*$_2$), 2.13 (2H, m, 4-*H*$_2$), 2.36 (3H, s, 4''-CH_3), 3.31 (2H, m, 8-*H*$_2$), 5.54 (1H, dt, J_P = 2 Hz, J_H = 8 Hz, 3-*H*), 7.09 (2H, d, J = 8 Hz, 3''-*H*, 5''-*H*), 7.38-7.45 (4H, m, Ar-*H*), 7.51-7.57 (2H, m, 4'-*H*), 7.63-7.70 (4H, m, Ar-*H*), 7.73 (2H, d, J = 8 Hz, 2''-*H*, 6''-*H*). δ_C (100MHz, $CDCl_3$) 21.9 (4''-*C*H_3), 26.2 (*C*-4), 26.9 (*C*-6), 27.2 (*C*-7), 28.8 (*C*-5), 50.3 (*C*-8), 119.3 (*C*-3), 128.1 (*C*-2''), 128.8 (Ar*C*H), 129.8 (*C*-3''), 130.5 (Ar*C*), 132.1 (Ar*C*H), 132.8 (*C*-4'), 137.7 (Ar*C*), 138.4 (Ar*C*), 143.6 (*C*-2). δ_P (162MHz, $CDCl_3$) 32.4. ***m/z*** (ES^+) 482.1 (MH^+), 980.4 ($2MH_2O^+$). HRMS (ES) found MH^+ 482.1554, $C_{26}H_{29}N_1O_4S_1P_1$ requires M^+ 482.1550, found MNa^+ 504.1367, $C_{26}H_{28}N_1O_4S_1P_1Na_1$ requires M^+ 504.1369.

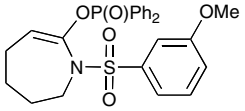
1-(1''-Napthylsulfonyl-4,5,6,7-tetrahydro-1H-azepin-2-yl diphenylphosphinate **8e**



8e

Pure material isolated as a colourless oil. ν_{max} (KBr) 3064, 2943, 1672, 1440, 1338, 1226, 1200, 1160, 1133, 1097, 1062, 803 cm^{-1}. δ_H (500MHz, $CDCl_3$) 1.29 (2H, m, 5-*H*$_2$), 1.47 (2H, quint, J = 6 Hz, 6-*H*$_2$), 1.86 (2H, q, J = 7 Hz, 4-*H*$_2$), 3.26 (2H, m, 7-*H*$_2$), 5.64 (1H, dt, J_1 = 7 Hz, J_2 = 3 Hz, 3-*H*), 7.31-7.39 (5H, m, 3''-*H*, 3'-*H*, 5'-*H*), 7.46-7.59 (4H, m, 4'-*H*, 7''-*H*, 6''-*H*), 7.70 (4H, m, 2'-*H*, 6'-*H*), 7.90 (1H, d, J = 8 Hz, 5''-*H*), 7.98 (1H, d, J = 8 Hz, 4''-*H*), 8.25 (1H, m, 2''-*H*), 8.70 (1H, d, J = 8.5 Hz, 8''-*H*). δ_C (125MHz, $CDCl_3$) 23.9 (*C*-5), 24.2 (*C*-4), 29.9 (*C*-6), 49.6 (*C*-7), 114.1 (*C*-3), 124.4 (*C*-3''), 125.5 (*C*-8''), 127.4, 128.4 (*C*-6'', *C*-7''), 128.6, 128.7 (*C*-3'), 129.0 (*C*-5''), 129.6 (*C*-2''), 130.1, 131.2 (2 x Ar*C*), 132.1 (Ar*C*), 132.2 (*C*-2'), 132.6 (*C*-4'), 134.4 (*C*-4''), 134.5 (Ar*C*), 136.4 (Ar*C*), 143.6 (d, *C*-2). δ_P (162MHz, $CDCl_3$) 31.2. ***m/z*** (ES^+) 504.1 (MH^+), 526.1 (MNa^+), 1029.4 ($2MNa^+$). HRMS (ES) found MH^+ 504.1401, $C_{28}H_{27}NO_4PS$ requires M^+ 504.1393.

1-(3'-Methoxyphenyl)-4,5,6,7-tetrahydro-1H-azepin-2-yl diphenylphosphinate **8g**



8g

Pure material collected as a clear oil. ν_{max} (KBr) 3065, 2943, 1673, 1599, 1484, 1440, 1360, 1240, 1158, 1131, 1105, 1049 cm^{-1}. δ_H (500MHz, $CDCl_3$) 1.35 (2H. m, 5-*H*$_2$), 1.66 (2H, quint, J = 6 Hz, 6-*H*$_2$), 1.87 (2H, q, J = 7 Hz, 4-*H*$_2$), 3.19 (2H, m, 7-*H*$_2$), 3.67 (3H, s, 3''-OC*H*$_3$), 5.55 (1H, dt, J_1 = 7 Hz, J_2 = 3 Hz, 3-*H*), 7.00 (1H, m, Ar-*H*), 7.21 (1H, t, J = 8 Hz, 5''-*H*), 7.36 (1H, m, 2''-*H*), 7.38-7.46 (5H, m, 3'-*H*, 5'-*H*, Ar-*H*), 7.54 (2H, m, 4'-*H*), 7.81 (4H, m, 2'-*H*, 6'-*H*). δ_C (125MHz, $CDCl_3$) 23.9 (*C*-5), 24.3 (*C*-4), 30.0 (*C*-6), 49.5 (*C*-7), 55.7 (*C*H_3), 111.9 (*C*-2''), 113.9 (*C*-3), 119.5, 119.7 (*C*-4'', *C*-6''), 128.7, 128.8 (*C*-3'), 130.2 (*C*-5''), 131.2 (*C*-1'), 132.1, 132.2 (*C*-2'), 132.7 (*C*-4'), 142.2 (*C*-1''), 143.6 (d, *C*-2), 160.0 (*C*-3''). δ_P (162MHz, $CDCl_3$) 31.4. *m/z* (ES^+) 484.2 (MH^+), 506.2 (MNa^+), 988.8 ($2MNa^+$). HRMS (ES) found MH^+ 484.1345, $C_{25}H_{27}NO_5PS$ requires M^+ 484.1342, found MNa^+ 506.1165, $C_{25}H_{26}NO_5PSNa$ requires M^+ 506.1162.