C–H Methylation of Heteroarenes Inspired by Radical SAM Methyl Transferase

Jinghan Gui[†,§], Qianghui Zhou[†,§], Chung-Mao Pan[†], Yuki Yabe[†], Aaron C. Burns[‡], Michael R. Collins[‡], Martha A. Ornelas[‡], Yoshihiro Ishihara[†] and Phil S. Baran[†,*]

[†]Department of Chemistry, The Scripps Research Institute, 10550 North Torrey Pines Road, La Jolla, California 92037

[‡]Department of Chemistry, Pfizer Pharmaceuticals, La Jolla Laboratories, 10770 Science Center Drive, La Jolla, California 92121

Supporting Information

Part 1: Experimental Procedures and Characterization Data

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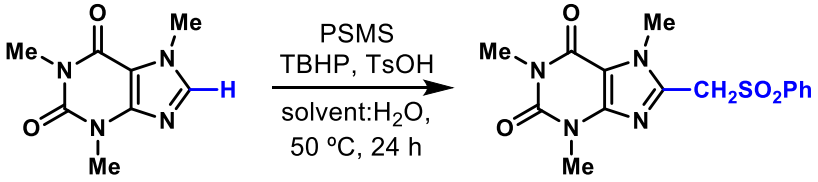
1. General Procedures:

Reagents were purchased at the highest commercial quality and used without further purification, unless otherwise stated. Yields refer to chromatographically and spectroscopically (^{1}H NMR) homogeneous material, unless otherwise stated. Reactions were monitored by thin layer chromatography (TLC) carried out on 0.25 mm E. Merck silica plates (60F-254), using UV light as the visualizing agent and $KMnO_4$ or acidic solution of *p*-anisaldehyde and heat as a developing agent. Flash silica gel chromatography was performed using E. Merck silica gel (60, particle size 0.043–0.063 mm). NMR spectra were recorded on Bruker DRX-600, DRX-500, AMX-400, and Varian INOVA-399 instruments and were calibrated using residual undeuterated solvent as an internal reference ($CDCl_3$ @ 7.26 ppm ^{1}H NMR, 77.2 ppm ^{13}C NMR; CD_3OD @ 3.31 ppm ^{1}H NMR, 49.0 ppm ^{13}C NMR; $(CD_3)_2CO$ @ 2.05 ppm ^{1}H NMR, 29.8 ppm ^{13}C NMR; $(CD_3)SO$ @ 2.50 ppm ^{1}H NMR, 39.5 ppm ^{13}C NMR). The following abbreviations were used to explain multiplicities: s = singlet, d = doublet, t = triplet, q = quartet, sept = septet, m = multiplet, br = broad. High resolution mass spectra (HRMS) were recorded on an Agilent LC/MSD TOF mass spectrometer by electrospray ionization time-of-flight reflectron experiments. IR experiments were recorded on a Perkin-Elmer Spectrum BX FTIR spectrometer. Melting points were recorded on a Fisher-Johns 12-144 melting point apparatus and were uncorrected. The UCSD small molecule X-ray facility collected and analyzed the X-ray diffraction data (for PSMS). Enantiomeric excesses (ee) were determined on a Hitachi LaChrow Elite HPLC system using HPLC chiralcel AD-H column (10% isopropanol in hexanes, 0.5 mL/min).

2. **Reaction condition optimization**:

Screening of solvents for the reaction, leading to even milder conditions than originally sought.

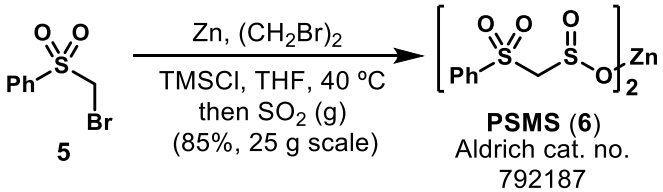


caffeine (**7a**) **7b**

entry	solvent	**7a**:**7b**[a]
1	$ClCH_2CH_2Cl$	2.3 : 1
2	DMSO	4.0 : 1
3	acetone	6.0 : 1
4	anisole	2.4 : 1
5	THF	trace
6	EtOAc	2.6 : 1 (27%)[b]
7	MeOH	5.0 : 1
8	$C_6H_5CH_3$	2.5 : 1 (30%)[b]
9	**$C_6H_5CF_3$**	**0.5 : 1 (32%)**[b,c]
10	$C_6F_5CF_3$	1.9 : 1 (33%)[b]
11	**$C_6H_5CF_3$**	**1.28 : 1 (43%)**[b,d]

Reaction conditions: **7a** (0.025 mmol, 1.0 equiv.), PSMS (3.0 equiv.), TBHP (5.0 equiv.), TsOH (1.0 equiv.), solvent/H_2O (0.2 mL/0.08 mL), 50 °C , 24 h. [a]crude ^1H NMR ratio. [b]isolated yield of **7b**. [c]A significant amount of desulfonylation product (direct methylation product) was obtained. [d]Modified reaction conditions (no acid, less heat): **7a** (0.025 mmol, 1 equiv.), PSMS (1.5 equiv.), TBHP (5.0 equiv.), $PhCF_3/H_2O$ (0.2 mL/0.08 mL), rt, 24 h; 43% isolated yield, 99% based on recovered starting material.

3. **Preparation of zinc bis(phenylsulfonylmethanesulfinate) (PSMS, 6):**



5 **PSMS** (**6**)
Aldrich cat. no.
792187

An oven-dried, argon-filled flask was charged with zinc dust (13.8 g, 0.213 mol) and THF (100 mL). This grey suspension was heated to 40 °C, and 1,2-dibromoethane (4.3 mL, 50 mmol) and a solution of TMSCl (6.7 mL, 53.0 mmol) in THF (25 mL) was added dropwise. After 30 min.

bromomethyl phenyl sulfone (25 g, 0.11 mol) was added as a solution in THF (50 mL). The temperature was maintained at 40 ºC for an additional 30 min and then cooled to rt. The organozinc reagent was then transferred to a heat gun-dried, argon-filled round bottom flask and purged with SO_2 gas at rt for 45 min and allowed to stir for 2 h. Upon completion, the reaction mixture was extracted with water and diethyl ether. The aqueous layer was concentrated, and the obtained white solid was washed with DCM/EtOAc solution (5 L; ratio = 1:1) to afford PSMS (**6**) (25 g, 85%) as a white solid.

Physical state: white powder;

Melting Point: 120 – 122 ºC;

$\mathbf{R_f}$ = 0.30 (silica gel, 4:1 DCM:MeOH);

^{1}H NMR (400 MHz, D_2O): δ 10.42 (d, J = 7.4 Hz, 4H), 10.26 (t, J = 7.5 Hz, 2H), 10.15 (t, J = 8.0 Hz, 4H), 6.61 (s, 4H) ppm;

^{13}C NMR (101 MHz, D_2O): δ 138.1, 134.8, 129.5, 127.7, 80.2 ppm;

IR (neat): ν = 2921, 2852, 2360, 2336, 1302, 745 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_7H_7O_4S_2$ [$PhSO_2CH_2SO_2^-$, M^-] 218.9791, found 218.9792.

Elem. Anal.: $C_{14}H_{26}O_{14}S_4Zn$ (PSMS·$6H_2O$), calc'd: C, 27.48; H, 4.28; S, 20.96; found: C, 27.63; H, 4.14; S, 20.87; Br, 0.00 (demonstrating that there is no residual $ZnBr_2$).

4. Typical procedure for the reaction of PSMS (6) with heterocycles:

To a solution of substrate (0.2 mmol, 1 equiv.) and PSMS (**6**) (151 mg, 0.3 mmol, 1.5 equiv.) in $PhCF_3/H_2O$ (1 mL/0.4 mL) was added 70% TBHP (aq.) (136 μL, 1 mmol, 5 equiv.) at 0 ^oC. After stirring at 0 ^oC for 5 min, the reaction system was warmed to room temperature and stirred at this temperature for 24 h [for substrates that were not completely consumed in 24 h, a second addition of PSMS (**6**) (151 mg, 0.3 mmol, 1.5 equiv.) and 70% TBHP (aq.) 136 μL (1 mmol, 5 equiv.) at 0 ºC was performed; the reaction mixture was stirred for 5 min at 0 ºC, then warmed to room temperature and stirred until the reaction was deemed to be complete (TLC or LCMS monitoring)]. Then the reaction was quenched with sat. $NaHCO_3$ solution and 5% EDTA-2Na solution, and the aqueous layer was extracted with DCM (3 times). The combined organic layers were washed with brine and dried over Na_2SO_4. Removal of the solvent and purification of the crude mixture by column chromatography or PTLC gave the desired product. (For reactions that do not work well in $PhCF_3/H_2O$, $DMSO/H_2O$ or H_2O could be used as solvent.)

5. Photographic guide to the reaction of PSMS (6) with heterocycles:

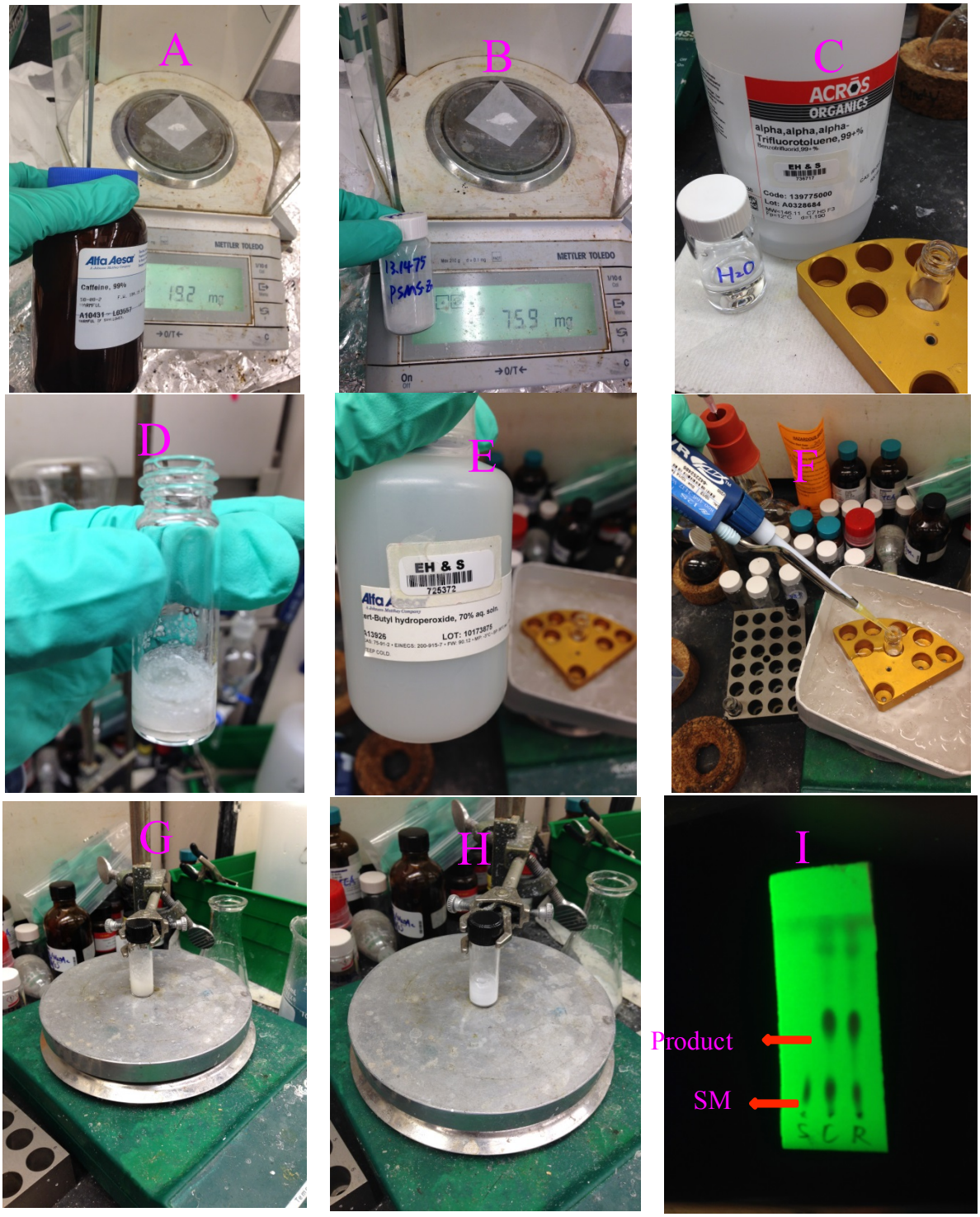
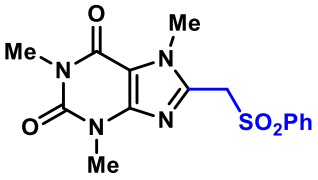


Figure S1. **A**. Weighing substrate (caffeine, 1 equiv.); **B**. Weighing PSMS (1.5 equiv.); **C** and **D**: Addition of solvent ($PhCF_3/H_2O$, 2.5/1); **E** and **F**. Addition of 70% TBHP (aq.) (5 equiv.) at 0 ^oC; **G**. Warmed to room temperature after 5 min; **H** and **I**: reaction system after 24 h and the TLC plate visualized under short-wave UV light.

6. Characterization data for compounds 7b to 32b:

1,3,7-Trimethyl-8-((phenylsulfonyl)methyl)-3,7-dihydro-1*H*-purine-2,6-dione



7b

Physical state: white powder;

Melting point: 243 – 245 ºC (decomposed);

R_f = 0.60 (silica gel, 20:1 EtOAc:MeOH);

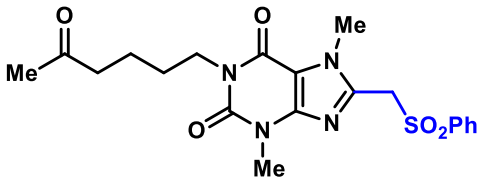
^{1}H NMR (400 MHz, $CDCl_3$): δ 7.76 (d, *J* = 7.8 Hz, 2H), 7.70 (t, *J* = 7.3 Hz, 1H), 7.55 (t, *J* = 7.8 Hz, 2H), 4.56 (s, 2H), 4.06 (s, 3H), 3.40 (s, 3H), 3.36 (s, 3H) ppm;

^{13}C NMR (151 MHz, $CDCl_3$): δ 155.4, 151.5, 147.7, 141.2, 137.9, 134.7, 129.4, 128.7, 109.1, 54.7, 33.0, 29.7, 28.2 ppm;

IR (neat): ν = 2360, 2340, 1702, 1657, 1152, 980, 751 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{15}H_{17}N_4O_4S$ $[M+H^+]$ 349.0965, found 349.0968.

3,7-Dimethyl-1-(5-oxohexyl)-8-((phenylsulfonyl)methyl)-3,7-dihydro-1*H*-purine-2,6-dione



8b

Physical state: white solid;

Melting point: 150–152 ºC;

R_f = 0.50 (silica gel, 20:1 EtOAc:MeOH);

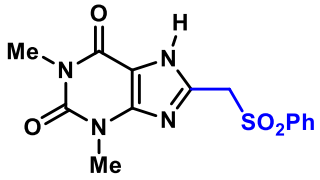
^{1}H NMR (400 MHz, $CDCl_3$): δ 7.77 (dd, *J* = 8.4, 1.3 Hz, 2H), 7.70 (ddt, *J* = 8.6, 7.1, 1.3 Hz, 1H), 7.55 (dd, *J* = 8.2, 7.4 Hz, 2H), 4.55 (s, 2H), 4.04 (s, 3H), 3.99 (t, *J* = 6.8 Hz, 2H), 3.34 (s, 3H), 2.49 (t, *J* = 6.8 Hz, 2H), 2.14 (s, 3H), 1.65 (tt, *J* = 8.8, 6.0 Hz, 4H) ppm;

^{13}C NMR (151 MHz, $CDCl_3$): δ 209.0, 155.1, 151.2, 147.6, 141.2, 137.7, 134.7, 129.4, 128.7, 109.0, 54.6, 43.3, 41.0, 32.9, 30.2, 29.6, 27.4, 21.0 ppm;

IR (neat): ν = 2360. 2339, 1700, 1655, 1321, 1151 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{20}H_{25}N_4O_5S$ [M+H$^+$] 433.1540, found 433.1542.

1,3-Dimethyl-8-((phenylsulfonyl)methyl)-3,7-dihydro-1*H*-purine-2,6-dione



9b

Physical state: white powder;

Melting point: 260 – 262 ºC (decomposed);

R_f = 0.70 (silica gel, 10:1 EtOAc:MeOH);

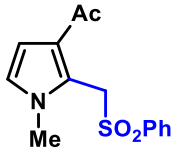
^{1}H NMR (600 MHz, $CDCl_3$): δ 7.76 (d, *J* = 7.8 Hz, 2H), 7.63 (t, *J* = 7.4 Hz, 1H), 7.51 (t, *J* = 7.6 Hz, 2H), 4.65 (s, 2H), 3.49 (s, 6H) ppm;

^{13}C NMR (151 MHz, $CDCl_3$): δ156.2, 151.3, 149.0, 142.0, 138.0, 134.5, 129.4, 128.6, 108.4, 56.5, 30.4, 28.7 ppm;

IR (neat): ν = 2360, 1700, 1647, 1153, 762 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{14}H_{15}N_4O_4S$ [M+H$^+$] 335.0809, found 335.0809.

1-(1-Methyl-2-((phenylsulfonyl)methyl)-1*H*-pyrrol-3-yl)ethan-1-one



10b

Physical state: light yellow solid;

Melting point: 150 – 152 ºC;

R_f = 0.70 (silica gel, 1:1 EtOAc:hexanes);

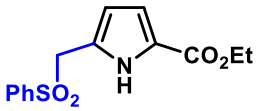
^{1}H NMR (600 MHz, $CDCl_3$): δ 7.64 (d, *J* = 7.5 Hz, 2H), 7.57 (t, *J* = 7.4 Hz, 1H), 7.42 (t, *J* = 7.8 Hz, 2H), 6.64 (d, *J* = 3.0 Hz, 1H), 6.38 (d, *J* = 3.0 Hz, 1H), 5.02 (s, 2H), 3.81 (s, 3H), 2.02 (s, 3H) ppm;

^{13}C NMR (151 MHz, $CDCl_3$): δ 194.0, 137.8, 133.7, 129.1, 128.6, 124.3, 124.0, 123.6, 110.5, 52.5, 34.9, 27.8 ppm;

IR (neat): ν = 2923, 2360, 2339, 1654, 1149, 778 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{14}H_{16}NO_3S$ [M+H$^+$] 278.0845, found 278.0837.

Ethyl 5-((phenylsulfonyl)methyl)-1*H*-pyrrole-2-carboxylate



11b

Physical state: white solid;

Melting point: 105 – 107 ºC;

R_f = 0.35 (silica gel, 1:2 EtOAc:hexanes);

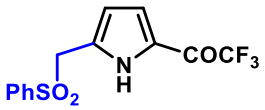
^{1}H NMR (600 MHz, $CDCl_3$): δ 9.59 (s, 1H), 7.66 (d, J = 7.7 Hz, 2H), 7.62 (t, J = 7.5 Hz, 1H), 7.48 (t, J = 7.7 Hz, 2H), 6.75 (s, 1H), 5.86 (s, 1H), 4.38 (s, 2H), 4.33 (q, J = 7.1 Hz, 2H), 1.37 (t, J = 7.1 Hz, 3H) ppm;

^{13}C NMR (151 MHz, $CDCl_3$): δ 160.9, 137.6, 134.3, 129.3, 128.6, 124.9, 123.1, 115.6, 113.2, 60.8, 55.8, 14.6 ppm;

IR (neat): ν = 2924, 2360, 2339, 1698, 1306, 1149, 746 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{14}H_{16}NO_4S$ [M+H$^+$] 294.0795, found 294.0793.

2,2,2-Trifluoro-1-(5-((phenylsulfonyl)methyl)-1H-pyrrol-2-yl)ethan-1-one



12b

Physical state: white solid;

Melting point: 140 – 142 ºC;

R_f = 0.45 (silica gel, 1:2 EtOAc:hexanes);

^{1}H NMR (600 MHz, $CDCl_3$): δ 10.21 (s, 1H), 7.79 – 7.69 (m, 2H), 7.66 (t, J = 7.5 Hz, 1H), 7.52 (t, J = 7.8 Hz, 2H), 7.08 (dd, J = 4.1, 2.2 Hz, 1H), 6.10 (dd, J = 4.2, 2.4 Hz, 1H), 4.48 (s, 2H) ppm;

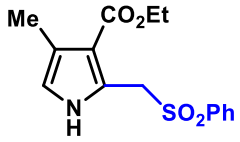
^{13}C NMR (151 MHz, $CDCl_3$): δ 170.4 (q, J_{CF} = 36.8 Hz), 137.5, 134.6, 130.0, 129.5, 128.5, 127.1, 121.8(q, J_{CF} = 3.5 Hz), 116.9 (q, J_{CF} = 288.9 Hz), 114.0, 55.5 ppm;

^{19}F NMR (376 MHz, $CDCl_3$): δ –72.8 ppm;

IR (neat): ν = 3309, 2360, 2339, 1670, 1083, 729 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{13}H_{11}NO_3F_3S$ [M+H$^+$] 318.0406, found 318.0406.

Ethyl 4-methyl-2-((phenylsulfonyl)methyl)-1*H*-pyrrole-3-carboxylate



13b'

Physical state: brown solid;

Melting point: 104 – 107 ºC;

R_f = 0.33 (silica gel, 2:3 EtOAc:hexanes);

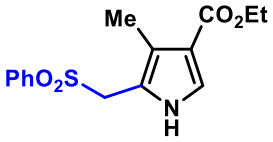
^{1}H NMR (400 MHz, $CDCl_3$): δ 9.00 (s, 1H), 7.66 – 7.53 (m, 3H), 7.50 – 7.35 (m, 2H), 6.59 (s, 1H), 4.92 (s, 2H), 3.98 (q, *J* = 7.1 Hz, 2H), 2.14 (s, 3H), 1.18 (t, *J* = 7.1 Hz, 3H) ppm;

^{13}C NMR (151 MHz, $CDCl_3$): δ 164.9, 137.7, 133.9, 128.9, 128.4, 124.0, 122.0, 118.4, 114.5, 59.5, 54.1, 14.4, 12.6 ppm;

IR (neat): ν = 2922, 2853, 2359, 2339, 1687, 1119, 722 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{15}H_{18}NO_4S$ [M+H$^+$] 308.0951, found 308.0953.

Ethyl 4-methyl-5-((phenylsulfonyl)methyl)-1*H*-pyrrole-3-carboxylate



13b''

Physical state: brown oil;

R_f = 0.25 (silica gel, 2:3 EtOAc:hexanes);

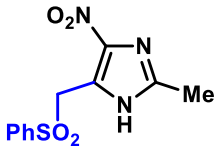
^{1}H NMR (500 MHz, $CDCl_3$): δ 8.76 (s, 1H), 7.62 (t, *J* = 7.4 Hz, 1H), 7.58 (d, *J* = 7.6 Hz, 2H), 7.47 (t, *J* = 7.8 Hz, 2H), 7.44 (d, *J* = 3.2 Hz, 1H), 4.28 (s, 2H), 4.23 (q, *J* = 7.1 Hz, 2H), 1.65 (s, 3H), 1.31 (t, *J* = 7.1 Hz, 3H) ppm;

^{13}C NMR (151 MHz, $CDCl_3$): δ 165.0, 137.2, 134.3, 129.3, 128.4, 125.5, 122.4, 116.4, 115.4, 59.6, 53.6, 14.6, 9.4 ppm;

IR (neat): ν = 3339, 2922, 2854, 1685, 1068, 686 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{15}H_{18}NO_4S$ [M+H$^+$] 308.0951, found 308.0951.

2-Methyl-4-nitro-5-((phenylsulfonyl)methyl)-1*H*-imidazole



14b

Physical state: yellow solid;

Melting point: 173 – 175 ºC;

R_f = 0.50 (silica gel, 20:1 EtOAc:MeOH);

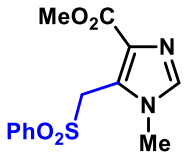
^{1}H NMR (600 MHz, DMSO-d_6): δ 7.74 (t, J = 7.3 Hz, 1H), 7.66 (d, J = 7.6 Hz, 2H), 7.59 (t, J = 7.7 Hz, 2H), 4.98 (s, 2H), 2.32 (s, 3H);

^{13}C NMR (151 MHz, DMSO-d_6): δ 144.6, 144.3, 137.7, 134.5, 129.5, 127.9, 120.0, 52.5, 13.8 ppm;

IR (neat): ν = 2922, 2359, 2339, 1540, 1141, 668 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{11}H_{12}N_3O_4S$ [M+H$^+$] 282.0543, found 282.0551.

Methyl 1-methyl-5-((phenylsulfonyl)methyl)-1*H*-imidazole-4-carboxylate



15b

Physical state: colorless oil;

R_f = 0.45 (silica gel, 20:1 EtOAc:MeOH);

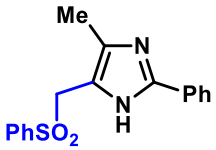
^{1}H NMR (400 MHz, $CDCl_3$): δ 7.69 – 7.60 (m, 3H), 7.57 (s, 1H), 7.52 – 7.44 (m, 2H), 4.90 (s, 2H), 3.89 (s, 3H), 3.52 (s, 3H);

^{13}C NMR (151 MHz, $CDCl_3$): δ 162.4, 139.7, 137.2, 134.2, 132.5, 129.0, 129.0, 126.3, 51.6, 51.5, 33.0 ppm;

IR (neat): ν = 2923, 2360, 2338, 1712, 1127, 689 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{13}H_{15}N_2O_4S$ [M+H$^+$] 295.0747, found 295.0756.

4-Methyl-2-phenyl-5-((phenylsulfonyl)methyl)-1*H*-imidazole



16b

Physical state: colorless oil;

R_f = 0.60 (silica gel, 20:1 EtOAc:MeOH);

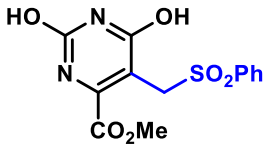
^{1}H NMR (400 MHz, DMSO-d_6): δ 7.88 – 7.70 (m, 5H), 7.59 (m, 2H), 7.39 (m, 2H), 7.29 (m, J = 7.3 Hz, 1H), 4.51 (s, 2H), 1.96 (s, 3H) ppm;

^{13}C NMR (151 MHz, DMSO-d_6): δ 143.9, 139.1, 133.5, 130.5, 129.0, 128.6, 128.5, 128.2, 127.8, 125.6, 124.4, 54.9, 9.0 ppm;

IR (neat): ν = 2360, 2337, 1447, 1303, 1141, 1082, 773, 687, 551, 526 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{17}H_{17}N_2O_2S$ [M+H$^+$] 313.1005, found 313.1006.

Methyl 2,6-dihydroxy-5-((phenylsulfonyl)methyl)pyrimidine-4-carboxylate



17b

To a solution of methyl 2,6-dihydroxypyrimidine-4-carboxylate (85 mg, 0.5 mmol) and PSMS (378 mg, 0.75 mmol) in DMSO:H_2O (2:1, 3 mL) at room temperature was added 70% TBHP (aq.) (415 µL, 3 mmol) portionwise. The reaction was stirred at room temperature for 16 h. The LC-MS showed complete conversion. The reaction was diluted with water and the obtained solid was filtered. The resulting cake was dried in a vacuum oven for 16 h. The cake was triturated in acetone, filtered and the remaining solids washed with acetone and discarded. The filtrate was evaporated to give the product as a white solid (83 mg, 51%).

Physical state: white powder;

Melting point: 250 – 252 °C;

R_f = 0.37 (silica gel, EtOAc);

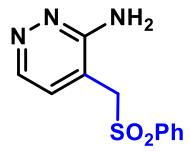
^{1}H NMR (400 MHz, DMSO-d_6): δ 11.54 (s, 1H), 11.34 (s, 1H), 7.81 – 7.68 (m, 3H), 7.68 – 7.33 (m, 2H), 4.56 (s, 2H), 3.79 (s, 3H) ppm;

^{13}C NMR (151 MHz, DMSO-d_6): δ 162.8, 161.2, 149.5, 142.0, 138.5, 134.0, 129.3, 128.0, 102.3, 53.3, 50.4 ppm;

IR (neat): ν = 3729, 2360, 2339, 1679, 1299, 670 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{13}H_{13}N_2O_6S$ [M+H$^+$] 325.0489, found 325.0487.

4-((Phenylsulfonyl)methyl)pyridazin-3-amine



18b

To a vial charged with 3-aminopyridazine (25 mg, 0.26 mmol, 1.0 equiv.) were added DMSO (500 µL), TFA (20 µL, 0.26 mmol, 1.0 equiv.), and 70% TBHP (aq.) (180 µL, 1.3 mmol, 5.0 equiv.). The vial was placed in a pre-heated sandbath (50 ºC) and a solution of PSMS (**6**) (197 mg, 0.39 mmol, 1.5 equiv., in 500 µL DMSO, warmed gently with a heat gun to solubilize) was added portionwise in four 30 min intervals (ca. 150 µL each). After the last addition of PSMS, the reaction mixture was allowed to stir for an additional 18 h at 50 ºC, cooled to room temperature, quenched with sat. aq. $NaHCO_3$ (ca. 10 mL), and filtered. The resultant aqueous phase was extracted with EtOAc (5 x 25 mL) and dried over anhydrous Na_2SO_4. Concentration provided the crude material, which was purified using a Biotage 25g HP column (5% EtOH in EtOAc) to afford 27 mg (41% yield) of 4-((phenylsulfonyl)methyl)pyridazin-3-amine **18b** as an off-white amorphous solid. The material contains ~10% (by NMR integration) of an isomeric compound.

Physical state: off-white amorphous solid;

Melting point: 110 – 113 °C;

R_f = 0.20 (silica gel, 19:1 EtOAc:EtOH);

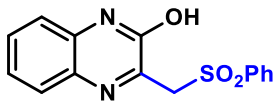
^{1}H NMR (600 MHz, DMSO-d_6): δ 8.37 (d, J = 4.6 Hz, 1 H), 7.80 (d, J = 7.3, 2 H), 7.75 (t, J = 7.4 Hz, 1 H), 7.62 (t, J = 7.9 Hz, 2 H), 6.98 (d, J = 4.8 Hz, 1 H), 6.38 (s, 2 H), 4.71 (s, 2H) ppm;

^{13}C NMR (151 MHz, DMSO-d_6) δ 159.9, 142.4, 138.3, 134.2, 129.7, 129.2, 128.2, 112.7, 55.0 ppm;

IR (neat): ν = 3732, 2360, 2339, 1148, 684 cm^{-1};

HRMS (ESI-TOF) calc'd for $C_{11}H_{12}N_3O_2S$ [M+H$^+$] 250.0645, found 250.0646.

3-((Phenylsulfonyl)methyl)quinoxalin-2-ol



19b

Physical state: white solid;

Melting point: 150 – 152 ºC;

R_f = 0.60 (silica gel, 1:1 EtOAc:DCM);

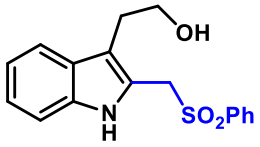
^{1}H NMR (500 MHz, $CDCl_3$): δ 7.89 (d, *J* = 7.3 Hz, 2H), 7.75 (d, *J* = 8.1 Hz, 1H), 7.62 (t, *J* = 7.4 Hz, 1H), 7.58 (t, *J* = 7.1 Hz, 1H), 7.51 (t, *J* = 7.7 Hz, 2H), 7.36 (t, *J* = 7.7 Hz, 1H), 7.27 (d, *J* = 8.0 Hz, 1H), 4.86 (s, 2H) ppm;

^{13}C NMR (151 MHz, DMSO-d_6): δ 154.1, 150.4, 139.4, 134.0, 132.2, 131.5, 131.3, 129.3, 128.7, 128.2, 123.7, 115.6, 57.5 ppm;

IR (neat): ν = 2922, 2852, 2360, 2339, 1668, 1149, 687 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{15}H_{13}N_2O_3S$ [M+H$^+$] 301.0641, found 301.0643.

2-(2-((Phenylsulfonyl)methyl)-1*H*-indol-3-yl)ethan-1-ol



20b

Physical state: light yellow oil;

R_f = 0.42 (silica gel, 1:1 EtOAc:hexanes);

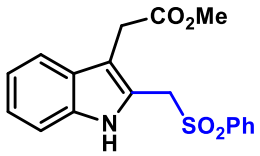
^{1}H NMR (600 MHz, $CDCl_3$): δ 8.80 (br s, 1H), 7.73 (d, *J* = 7.5 Hz, 2H), 7.63 (t, *J* = 7.5 Hz, 1H), 7.50 (d, *J* = 7.9 Hz, 1H), 7.47 (t, *J* = 7.8 Hz, 2H), 7.38 (d, *J* = 8.2 Hz, 1H), 7.24 (t, *J* = 7.6 Hz, 1H), 7.12 (t, *J* = 7.4 Hz, 1H), 4.57 (s, 2H), 3.57 (t, *J* = 6.2 Hz, 2H), 2.61 (t, *J* = 6.2 Hz, 2H) ppm;

^{13}C NMR (151 MHz, $CDCl_3$): δ 137.9, 136.7, 134.3, 129.4, 128.4, 127.5, 123.4, 122.2, 119.9, 119.0, 114.4, 111.5, 62.4, 54.3, 27.4 ppm;

IR (neat): ν = 3379, 2924, 2360, 2339, 1447, 1303, 1146, 738 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{17}H_{18}NO_3S$ [M+H$^+$] 316.1002, found 316.0994.

Methyl 2-(2-((phenylsulfonyl)methyl)-1*H*-indol-3-yl)acetate



21b

Physical state: light yellow solid;

Melting point: 134 – 136 ºC;

R_f = 0.4o (silica gel, 1:2 EtOAc:hexanes);

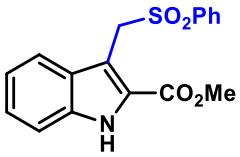
^{1}H NMR (500 MHz, $CDCl_3$): δ 8.75 (s, 1H), 7.66 (d, *J* = 7.9 Hz, 2H), 7.61 (t, *J* = 7.5 Hz, 1H), 7.50 (d, *J* = 7.9 Hz, 1H), 7.44 (t, *J* = 7.8 Hz, 2H), 7.36 (d, *J* = 8.2 Hz, 1H), 7.23 (t, *J* = 7.6 Hz, 1H), 7.13 (t, *J* = 7.5 Hz, 1H), 4.60 (s, 2H), 3.54 (s, 3H), 3.21 (s, 2H) ppm;

^{13}C NMR (151 MHz, $CDCl_3$): δ 171.5, 137.7, 136.3, 134.2, 129.3, 128.4, 127.3, 123.4, 122.8, 120.3, 119.1, 111.4, 110.1, 54.3, 52.2, 29.4 ppm;

IR (neat): ν = 3360, 2922, 2852, 2360, 2339, 1728, 1306, 1147, 742 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{18}H_{18}NO_4S$ [M+H$^+$] 344.0951, found 344.0956.

Methyl 3-((phenylsulfonyl)methyl)-1*H*-indole-2-carboxylate



22b

Physical state: white solid;

Melting point: 177 – 179 ºC;

R_f = 0.28 (silica gel, 1:2 EtOAc:hexanes);

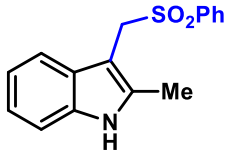
^{1}H NMR (400 MHz, $CDCl_3$): δ 9.01 (s, 1H), 7.70 (d, *J* = 8.2 Hz, 1H), 7.64 (d, *J* = 8.2 Hz, 2H), 7.56 (t, *J* = 7.5 Hz, 1H), 7.46 – 7.31 (m, 4H), 7.18 (t, *J* = 7.4 Hz, 1H), 5.02 (s, 2H), 3.65 (s, 3H) ppm;

^{13}C NMR (151 MHz, $CDCl_3$): δ 161.4, 138.4, 135.6, 133.6, 128.8, 128.7, 127.7, 126.3, 125.5, 121.7, 121.6, 112.0, 109.7, 53.6, 52.0 ppm;

IR (neat): ν = 3336, 2923, 2360, 2337, 1709, 1149, 791 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{17}H_{16}NO_4S$ [M+H$^+$] 330.0795, found 330.0793.

2-Methyl-3-((phenylsulfonyl)methyl)-1*H*-indole



23b

Physical state: yellow solid;

Melting point: 173 – 175 ºC;

R_f = 0.28 (silica gel, 1:2 EtOAc:hexanes);

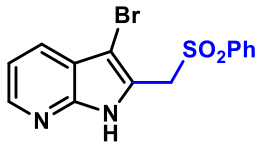
^{1}H NMR (400 MHz, $CDCl_3$): δ 7.97 (s, 1H), 7.64 (d, *J* = 8.0 Hz, 2H), 7.54 (t, *J* = 7.5 Hz, 1H), 7.37 (t, *J* = 7.7 Hz, 2H), 7.23 (d, *J* = 8.1 Hz, 1H), 7.14 (d, *J* = 7.9 Hz, 1H), 7.08 (t, *J* = 7.6 Hz, 1H), 6.96 (t, *J* = 7.5 Hz, 1H), 4.48 (s, 2H), 2.12 (s, 3H) ppm;

^{13}C NMR (151 MHz, $CDCl_3$): δ 138.4, 136.0, 134.9, 133.6, 129.0, 128.8, 128.2, 121.8, 120.3, 118.0, 110.4, 99.3, 54.0, 11.6 ppm;

IR (neat): ν = 2923, 2361, 2339, 1134, 740 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{16}H_{16}NO_2S$ [M+H$^+$] 286.0896, found 286.0901.

3-Bromo-2-((phenylsulfonyl)methyl)-1*H*-pyrrolo[2,3-*b*]pyridine



24b

To a solution of 3-bromo-1*H*-pyrrolo[2,3-*b*]pyridine (90 mg, 0.46 mmol, 1.0 equiv.) and PSMS (345 mg, 0.685 mmol) in DMSO/H_2O (2:1, 3 mL) at room temperature, 70% TBHP (aq.) (327 µL, 2.28 mmol, 5 equiv.) was added portionwise. The reaction was stirred at room temperature for 16 h. By LC-MS, 60% conversion was observed. Another portion of PSMS (**6**) (345 mg, 0.685 mmol, 1.5 equiv.) in DMSO:H_2O (2:1, 3 mL) and 70% TBHP (aq.) (327 µL, 2.28 mmol, 5 equiv.) were added. The reaction was stirred at room temperature for 2 h. The LC-MS showed that most of the starting material was consumed. The reaction was diluted with water and the solids obtained were filtered. The resulting cake was washed with acetone and the insoluble

solids were discarded. The filtrate was evaporated to give the product in ~ 95 % purity. The aqueous layer was saturated with sodium chloride and extracted with ethyl acetate (3 x 20 mL). The organic layers were combined and washed with water (3 x 20 mL), dried over Na_2SO_4 and evaporated to give a second batch of product. The combined batches were dissolved in DCM/MeOH and silica gel was added to the solution. The suspension was filtered through a silica plug and washed with dichloromethane/methanol (20%, v/v). The solvent was removed to give the product as a yellow solid, which was recrystallized in acetone/water to give product **24b** (63 mg, 39 %).

Physical state: yellow solid;

Melting point: 210 ^{o}C (decomposed);

R_f = 0.62 (silica gel, EtOAc);

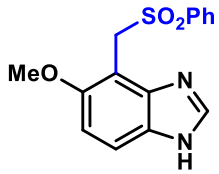
^{1}H NMR (400 MHz, DMSO-d_6): δ 12.32 (br s, 1H), 8.37 (d, J = 3.6 Hz, 1H), 7.93 – 7.70 (m, 4H), 7.70 – 7.51 (m, 2H), 7.22 (dd, J =4.6, 7.6 Hz, 1H), 4.82 (s, 2H) ppm;

^{13}C NMR (101 MHz, DMSO-d_6): δ 147.1, 144.8, 138.1, 134.2, 129.4, 128.1, 126.8, 125.0, 118.8, 116.7, 90.9, 54.1 ppm;

IR (neat): ν = 3732, 3704, 2360, 2339, 1307, 685 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{14}H_{12}N_2O_2SBr$ [M+H$^+$] 350.9797, found 350.9789.

5-Methoxy-4-((phenylsulfonyl)methyl)-1*H*-benzo[*d*]imidazole



25b

Physical state: white solid;

Melting point: 182 – 184 ºC;

R_f = 0.60 (silica gel, 10:1 DCM:MeOH);

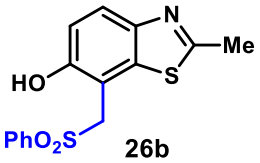
^{1}H NMR (600 MHz, $CDCl_3$): δ 8.05 (s, 1H), 7.72 – 7.63 (m, 1H), 7.58 (d, J = 7.7 Hz, 2H), 7.55 (t, J = 7.5 Hz, 1H), 7.38 (t, J = 7.6 Hz, 2H), 6.68 (d, J = 8.6 Hz, 1H), 4.80 (s, 2H), 3.40 (s, 3H);

^{13}C NMR (151 MHz, DMSO-d_6): δ 153.5, 142.0, 139.0, 137.7, 134.8, 133.7, 128.8, 128.2, 120.0, 106.2, 99.4, 55.7, 53.1 ppm;

IR (neat): ν = 2924, 2849, 2360, 2339, 1303, 1137, 740 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{15}H_{15}N_2O_3S$ [M+H$^+$] 303.0798, found 303.0795.

2-Methyl-7-((phenylsulfonyl)methyl)benzo[*d*]thiazol-6-ol



26b

Physical state: colorless oil;

R_f = 0.30 (silica gel, 2:1 EtOAc:hexanes);

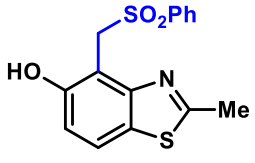
^{1}H NMR (600 MHz, acetone-d_6) δ 8.76 (s, 1H), 7.68 (m, 4H), 7.51 (t, J = 7.5 Hz, 2H), 6.92 (d, J = 8.7 Hz, 1H), 4.69 (s, 2H), 2.72 (s, 3H);

^{13}C NMR (151 MHz, acetone-d_6): δ 164.5, 154.4, 148.4, 140.5, 140.3, 134.5, 129.7, 129.4, 124.1, 115.6, 109.0, 58.0, 19.7 ppm;

IR (neat): ν = 2921, 2854, 1447, 1135, 728 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{15}H_{14}NO_3S_2$ [M+H$^+$] 320.0410, found 320.0412.

2-Methyl-4-((phenylsulfonyl)methyl)benzo[*d*]thiazol-5-ol



27b

Physical state: white powder;

Melting point: 185 – 187 ºC;

R_f = 0.80 (silica gel, 1:1 EtOAc:hexanes);

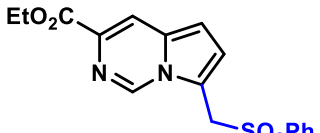
^{1}H NMR (600 MHz, $CDCl_3$): δ 7.71 (d, J = 7.8 Hz, 2H), 7.62 (d, J = 8.6 Hz, 1H), 7.52 (s, 1H), 7.49 (t, J = 7.5 Hz, 1H), 7.34 (t, J = 7.7 Hz, 2H), 7.11 (d, J = 8.6 Hz, 1H), 5.08 (s, 2H), 2.55 (s, 3H) ppm;

^{13}C NMR (151 MHz, $CDCl_3$): δ 167.9, 154.7, 154.0, 137.1, 133.9, 128.9, 128.6, 128.0, 122.6, 117.4, 109.4, 55.1, 20.0 ppm;

IR (neat): ν = 3407, 2359, 2335, 1302, 1132, 733 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{15}H_{14}NO_3S_2$ [M+H$^+$] 320.0410, found 320.0417.

Ethyl 7-((phenylsulfonyl)methyl)pyrrolo[1,2-*c*]pyrimidine-3-carboxylate



28b

Physical state: light yellow solid;

Melting point: 162 – 164 ºC;

R_f = 0.30 (silica gel, 1:1 EtOAc:hexanes);

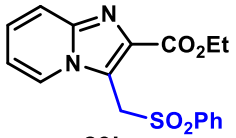
^{1}H NMR (400 MHz, $CDCl_3$): δ 8.87 (s, 1H), 8.18 (s, 1H), 7.64 – 7.60 (m, 3H), 7.45 (t, *J* = 7.8 Hz, 2H), 6.67 (d, *J* = 4.1 Hz, 1H), 6.63 (d, *J* = 4.0 Hz, 1H), 4.77 (s, 2H), 4.44 (q, *J* = 7.1 Hz, 2H), 1.43 (t, *J* = 7.1 Hz, 3H) ppm;

^{13}C NMR (151 MHz, $CDCl_3$): δ 165.0, 137.5, 136.0, 134.5, 132.9, 131.5, 129.4, 128.4, 121.4, 117.6, 113.2, 105.3, 61.8, 54.3, 14.6 ppm;

IR (neat): ν = 2923, 2360, 2339, 1712, 1151, 782 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{17}H_{17}N_2O_4S$ $[M+H^+]$ 345.0904, found 345.0910.

Ethyl 3-((phenylsulfonyl)methyl)imidazo[1,2-*a*]pyridine-2-carboxylate



29b

Physical state: yellow oil;

R_f = 0.60 (silica gel, 1:10 MeOH:DCM);

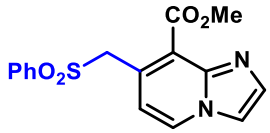
^{1}H NMR (400 MHz, $CDCl_3$): δ 8.55 – 8.36 (m, 1H), 7.71 (dd, *J* = 9.1, 1.0 Hz, 1H), 7.59 (ddd, *J* = 7.1, 2.8, 1.5 Hz, 3H), 7.48 – 7.41 (m, 2H), 7.40 – 7.34 (m, 1H), 7.03 (td, *J* = 6.9, 1.2 Hz, 1H), 5.27 (s, 2H), 4.12 (q, *J* = 7.1 Hz, 2H), 1.26 (t, *J* = 7.1 Hz, 3H) ppm;

^{13}C NMR (151 MHz, $CDCl_3$): δ 162.8, 145.6, 137.1, 135.5, 134.2, 129.0, 128.9, 127.4, 125.2, 119.2, 117.1, 114.5, 61.3, 51.8, 14.4 ppm;

IR (neat): ν = 2360, 2339, 1709, 1308, 1214, 1130, 733, 523 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{17}H_{17}N_2O_4S$ $[M+H^+]$ 345.0904, found 345.0903.

Methyl 7-((phenylsulfonyl)methyl)imidazo[1,2-*a*]pyridine-8-carboxylate



30b'

Physical state: yellow foam;

R_f = 0.50 (silica gel, 1:10 MeOH:DCM);

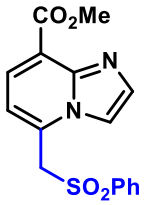
^{1}H NMR (600 MHz, $CDCl_3$): δ 8.20 (d, *J* = 7.0 Hz, 1H), 7.76 (s, 1H), 7.75 – 7.71 (m, 2H), 7.65 (s, 1H), 7.63 (t, *J* = 7.5 Hz, 1H), 7.49 (t, *J* = 7.9 Hz, 2H), 6.91 (d, *J* = 7.0 Hz, 1H), 4.83 (s, 2H), 3.86 (s, 3H) ppm;

^{13}C NMR (151 MHz, acetone-d_6): δ 166.6, 143.1, 139.9, 135.5, 135.0, 130.3, 129.4, 128.7, 125.5, 124.4, 115.8, 114.8, 58.9, 53.0;

IR (neat): ν = 2360, 2339, 1716, 1308, 1147, 1083, 728, 527 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{16}H_{15}N_2O_4S$ [M+H$^+$] 331.0747, found 331.0752.

Methyl 5-((phenylsulfonyl)methyl)imidazo[1,2-*a*]pyridine-8-carboxylate



30b''

Physical state: yellow foam;

R_f = 0.40 (silica gel, 1:10 MeOH:DCM);

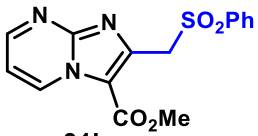
^{1}H NMR (600 MHz, $CDCl_3$): δ 7.85 (d, *J* = 7.3 Hz, 1H), 7.76 (d, *J* = 1.3 Hz, 1H), 7.70 – 7.66 (m, 3H), 7.66 – 7.62 (m, 1H), 7.53 – 7.42 (m, 2H), 6.57 (d, *J* = 7.4 Hz, 1H), 4.73 (s, 2H), 4.06 (s, 3H) ppm;

^{13}C NMR (151 MHz, acetone-d_6): δ 165.9, 143.5, 139.5, 135.4, 135.0, 132.1, 130.4, 129.5, 128.1, 121.3, 116.2, 113.6, 59.6, 52.7 ppm;

IR (neat): ν = 2360, 2339, 1720, 1301, 1209, 1149, 1083, 744, 527 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{16}H_{15}N_2O_4S$ [M+H$^+$] 331.0747, found 331.0752.

Methyl 2-((phenylsulfonyl)methyl)imidazo[1,2-*a*]pyrimidine-3-carboxylate



31b

Physical state: white solid;

Melting point: 280 ºC (decomposed);

R_f = 0.75 (silica gel, 1:10 MeOH:DCM);

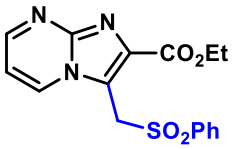
^{1}H NMR (400 MHz, $CDCl_3$): δ 8.84 (dd, *J* = 7.0, 2.0 Hz, 1H), 8.79 (dd, *J* = 4.1, 2.0 Hz, 1H), 7.69 – 7.55 (m, 3H), 7.51 – 7.42 (m, 2H), 7.11 (dd, *J* = 7.0, 4.0 Hz, 1H), 5.25 (s, 2H), 3.67 (s, 3H) ppm;

^{13}C NMR (151 MHz, DMSO-d_6): δ 162.3, 153.8, 147.3, 137.1, 135.1 (2C), 134.3, 129.2, 128.2, 116.2, 110.0, 51.6, 50.3 ppm;

IR (neat): ν = 2361, 2340, 1717, 1309, 1230, 689, 667 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{15}H_{13}N_3NaO_4S$ [M+H$^+$] 354.0519, found 354.0523.

Ethyl 3-((phenylsulfonyl)methyl)imidazo[1,2-*a*]pyrimidine-2-carboxylate



32b

Physical state: white powder;

Melting point: 208 °C (decomposed);

R_f = 0.45 (silica gel, 10:1 EtOAc:MeOH);

^{1}H NMR (600 MHz, $CDCl_3$): δ 8.85 (d, *J* = 6.9 Hz, 1H), 8.77 (d, *J* = 4.0 Hz, 1H), 7.62 (t, *J* = 7.4 Hz, 1H), 7.58 (d, *J* = 7.7 Hz, 2H), 7.45 (t, *J* = 7.7 Hz, 2H), 7.10 (dd, *J* = 6.9, 4.0 Hz, 1H), 5.27 (s, 2H), 4.12 (q, *J* = 7.1 Hz, 2H), 1.25 (t, *J* = 7.1 Hz, 3H) ppm;

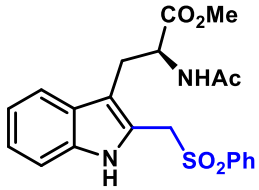
^{13}C NMR (151 MHz, $CDCl_3$): δ 162.5, 153.4, 148.2, 136.7, 136.4, 134.4, 133.5, 129.2, 128.8, 116.0, 110.5, 61.5, 51.4, 14.3 ppm;

IR (neat): ν = 2924, 2359, 2340, 1715, 1226, 687 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{16}H_{16}N_3O_4S$ [M+H$^+$] 346.0856, found 346.0863.

7. Characterization data for biologically relevant substrates 33b to 36b

Methyl (*S*)-2-acetamido-3-(2-((phenylsulfonyl)methyl)-1*H*-indol-3-yl)propanoate



L-**33b**

Physical state: white foam;

$[\alpha]_{25}^{D}$ = +11.1° (*c* = 1.0, $CHCl_3$);

R_f = 0.50 (silica gel, 4:1 EtOAc:hexanes);

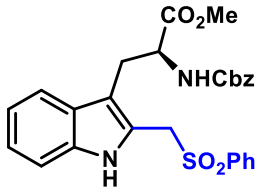
^{1}H NMR (600 MHz, $CDCl_3$): δ 8.75 (s, 1H), 7.80 – 7.73 (m, 2H), 7.65 (td, *J* = 7.5, 1.4 Hz, 1H), 7.50 (t, *J* = 7.6 Hz, 2H), 7.46 (d, *J* = 8.0 Hz, 1H), 7.35 (d, *J* = 8.2 Hz, 1H), 7.22 (dd, *J* = 8.3, 6.9 Hz, 1H), 7.11 (t, *J* = 7.5 Hz, 1H), 6.40 (d, *J* = 7.2 Hz, 1H), 4.70 (q, *J* = 6.5 Hz, 1H), 4.62 – 4.37 (m, 2H), 3.63 (s, 3H), 2.89 (ddd, *J* = 48.7, 14.9, 6.2 Hz, 2H), 1.94 (s, 3H) ppm;

^{13}C NMR (151 MHz, $CDCl_3$): δ 172.6, 170.3, 137.9, 136.6, 134.5, 129.5, 128.4, 127.6, 123.5, 122.5, 120.2, 119.1, 112.3, 111.5, 53.9, 53.1, 52.7, 26.4, 23.1 ppm;

IR (neat): ν = 2360, 2339, 1742, 1651, 1304, 1145, 741, 670 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{21}H_{23}N_2O_5S$ $[M+H^+]$ 415.1322, found 415.1325.

Methyl (*S*)-2-(((benzyloxy)carbonyl)amino)-3-(2-((phenylsulfonyl)methyl)-1*H*-indol-3-yl)-propanoate



L-**34b**

Physical state: colorless oil;

$[\alpha]_{25}^{D}$ = +13.2° (*c* = 1.0, $CHCl_3$);

R_f = 0.3 (silica gel, 2:1 EtOAc:hexanes);

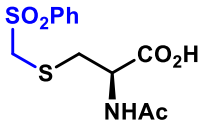
^{1}H NMR (400 MHz, $CDCl_3$): δ 8.73 (s, 1H), 7.66 (d, *J* = 7.6 Hz, 2H), 7.59 (d, *J* = 7.5 Hz, 1H), 7.44 – 7.28 (m, 9H), 7.21 (t, *J* = 7.6 Hz, 1H), 7.07 (t, *J* = 7.5 Hz, 1H), 5.43 (d, *J* = 7.6 Hz, 1H), 5.15 – 5.01 (m, 2H), 4.53 – 4.34 (m, 3H), 3.57 (s, 3H), 2.80 (qd, *J* = 14.9, 5.7 Hz, 2H) ppm;

^{13}C NMR (151 MHz, $CDCl_3$): δ 172.1, 155.8, 137.7, 136.5, 136.3, 134.3, 129.3, 128.7, 128.4 (2C), 128.2, 127.6, 123.4, 122.9, 120.2, 119.0, 111.9, 111.5, 67.1, 54.6, 53.9, 52.6, 26.7 ppm;

IR (neat): ν = 3350, 1709, 1446, 1306, 1147, 876, 737 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{27}H_{27}N_2O_6S$ $[M+H^+]$ 507.1584, found 507.1589;

***N*-Acetyl-*S*-((phenylsulfonyl)methyl)-L-cysteine**



35b

Physical state: white solid;

$[\alpha]_{25}^{D}$ = +16.9° (*c* = 0.55, MeOH);

Melting point: 105 – 107 ºC;

R_f = 0.20 (silica gel, 1:20 H_2O: acetone);

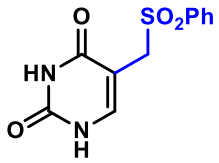
^{1}H NMR (600 MHz, CD_3OD): δ 8.00 – 7.94 (m, 2H), 7.78 – 7.72 (m, 1H), 7.67 – 7.61 (m, 2H), 4.70 – 4.62 (m, 1H), 4.32 (d, *J* = 15.0 Hz, 1H), 4.26 (d, *J* = 15.0 Hz, 1H), 3.29 (dd, *J* = 13.8, 4.9 Hz, 1H), 3.00 (dd, *J* = 13.8, 8.4 Hz, 1H), 2.00 (s, 3H) ppm;

^{13}C NMR (151 MHz, CD_3OD): δ 173.3, 173.1, 139.1, 135.3, 130.3, 130.0, 56.6, 53.2, 35.4, 22.4 ppm;

IR (neat): ν = 2360, 2339, 1732, 1540, 1304, 1149, 686 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{12}H_{16}NO_5S_2$ $[M+H^+]$ 318.0464, found 318.0465.

5-((Phenylsulfonyl)methyl)pyrimidine-2,4(1*H*,3*H*)-dione



36b

Physical state: white solid;

Melting point: 172 – 175 ºC;

R_f = 0.60 (silica gel, 1:4 MeOH:DCM);

^{1}H NMR (600 MHz, CD_3OD): δ 7.88 – 7.83 (m, 2H), 7.74 – 7.70 (m, 1H), 7.63 – 7.59 (m, 2H), 7.42 (s, 1H), 4.22 (s, 2H) ppm;

^{13}C NMR (151 MHz, CD_3OD): δ165.0, 152.9, 144.8, 139.8, 135.2, 130.4, 129.7, 102.4, 53.3 ppm;

IR (neat): ν = 2361, 2340, 1653, 1299, 1145, 671 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{11}H_{11}N_2O_4S$ $[M+H^+]$ 267.0434, found 267.0441.

8. Typical procedure for the desulfonylation to reveal the methyl group

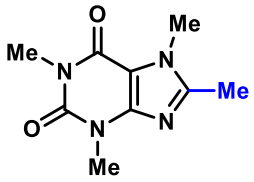
Procedure A (Mg, MeOH): To a solution of phenylsulfonylmethyl substrate (1.0 equiv.) in dry MeOH (ca. 0.05 M) was added **freshly activated** Mg turnings (40.0 equiv.). After heating at 50 ^oC for 1.5 h, a white slurry was formed and the reaction was completed. Filtration of the reaction mixture through a short pad of silica gel and concentration of the filtrate gave the crude mixture. Purification of the crude mixture by column chromatography or PTLC gave the desired product.

Procedure B (SmI_2, THF/H_2O): A solution of phenylsulfonylmethyl substrate (1 equiv.) in THF/H_2O (10/1, 0.05 M) was degassed for 20 min at room temperature. Then a solution of SmI_2 in THF (ca. 0.03 M, 6 equiv.) was added to the reaction mixture and the resulting deep purple-dark solution was stirred at room temperature for 30 min. The reaction was quenched with saturated $NaHCO_3$ solution and extracted with EtOAc (3 times). The combined organic phase was washed with brine and dried over Na_2SO_4. Purification by column chromatography or PTLC gave the desired desulfonylation product.

Procedure C (Raney-Nickel, EtOH): A suspension of phenylsulfonylmethyl substrate (1 equiv.) and Raney-Nickel (activated catalyst, 50% slurry in water) (pre-triturated with EtOH 3 times, 100 mg for 5 mg substrate) in EtOH (0.05 M) was refluxed for 2 h. The catalyst was filtered through a short pad of silica gel and concentration of the filtrate afforded the crude product, which was purified by column chromatography or PTLC gave the desired desulfonylation product.

9. Characterization data for methylated products 7c to L-33c

1,3,7,8-Tetramethyl-3,7-dihydro-1*H*-purine-2,6-dione



7c

Physical state: white powder;

Melting point: 189 – 191 ºC

R_f = 0.40 (silica gel, 20:1 EtOAc:MeOH);

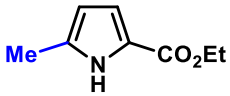
^{1}H NMR (600 MHz, $CDCl_3$): δ 3.90 (s, 3H), 3.56 (s, 3H), 3.39 (s, 3H), 2.46 (s, 3H) ppm;

^{13}C NMR (151 MHz, $CDCl_3$): δ 155.4, 151.8, 150.8, 148.0, 107.6, 32.0, 29.8, 28.0, 13.2 ppm;

IR (neat): ν = 2925, 2360, 2339, 1707, 1650, 1220, 747 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_9H_{13}N_4O_2$ [M+H$^+$] 209.1033, found 209.1040.

Ethyl 5-methyl-1H-pyrrole-2-carboxylate (spectroscopic data match those previously reported[1])



11c

Physical state: colorless oil;

R_f = 0.22 (silica gel, 1:5 EtOAc:hexanes);

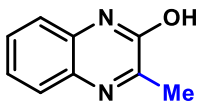
^{1}H NMR (600 MHz, $CDCl_3$): δ 9.07 (br s, 1H), 6.81 (t, *J* = 3.0 Hz, 1H), 5.95 (t, *J* = 3.0 Hz, 1H), 4.30 (q, *J* = 7.2 Hz, 1H), 2.31 (s, 3H), 1.35 (t, *J* = 7.2 Hz, 1H) ppm;

^{13}C NMR (151 MHz, $CDCl_3$): δ 161.4, 133.8, 121.5, 116.2, 109.0, 60.2, 14.6, 13.3 ppm;

IR (neat): ν = 3287, 2922, 2361, 1667, 1220, 802 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_8H_{12}NO_2$ [M+H$^+$] 154.0863, found 154.0867.

3-Methylquinoxalin-2-ol



19c

Physical state: white powder;

[1] Curran, T. P.; Keaney, M. T., *J. Org. Chem.*, **1996**, *61,* 9068–9069.

Melting point: 195 – 197 ºC (decomposed);

R_f = 0.55 (silica gel, 1:2 EtOAc:hexanes);

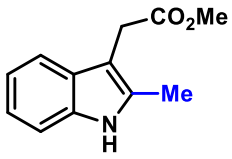
^{1}H NMR (600 MHz, $CDCl_3$): δ 7.82 (d, *J* = 7.8 Hz, 1H), 7.49 (t, *J* = 7.8 Hz, 1H), 7.34 (t, *J* = 7.8 Hz, 1H), 7.32 (d, *J* = 7.8 Hz, 1H), 2.64 (s, 3H) ppm;

^{13}C NMR (151 MHz, $CDCl_3$): δ 159.1, 156.7, 132.9, 131.2, 129.8, 128.8, 124.4, 115.6, 20.9 ppm;

IR (neat): ν = 2915, 2360, 2338, 1665, 1565, 752 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_9H_9N_2O$ [M+H$^+$] 161.0709, found 161.0712.

Methyl 2-(2-methyl-1H-indol-3-yl)acetate (spectroscopic data match those previously reported[2])



21c

Physical state: light yellow oil;

R_f = 0.53 (silica gel, 1:2 EtOAc:hexanes);

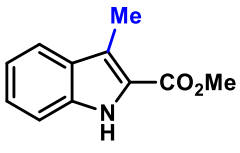
^{1}H NMR (500 MHz, $CDCl_3$): δ 7.84 (br s, 1H), 7.52-7.53 (m, 1H), 7.26 – 7.28 (m, 1H), 7.08 – 7.14 (m, 2H), 3.70 (s, 2H), 3.67 (s, 3H), 2.42 (s, 3H) ppm;

^{13}C NMR (151 MHz, $CDCl_3$): δ 172.6, 135.2, 132.7, 128.6, 121.4, 119.7, 118.2, 110.4, 104.7, 52.1, 30.4, 11.9;

IR (neat): ν = 3392, 2360, 2339, 1721, 1165, 738 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{12}H_{14}NO_2$ [M+H$^+$] 204.1019, found 204.1026.

Methyl 3-methyl-1*H*-indole-2-carboxylate (spectroscopic data match those previously reported[3])



22c

Physical state: light brown solid;

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[2] Varvaresou, A.; Siatra-Papastaikoudi, T.; Tsotinis, A.; Tsantili-Kakoulidou, A.; Vamvakides, A. Il, *Farmaco*, **1998**, *53*, 320-326;

[3] García-Rubia, A.; Urones, B.; Gómez Arrayás, R.; Carretero, J. C. *Angew. Chem. Int. Ed.* **2011**, *50*, 10927-10931.

Melting point: 123 – 125 ºC;

R_f = 0.50 (silica gel, 1:5 EtOAc:hexanes);

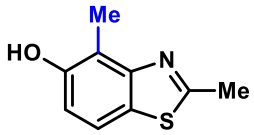
^{1}H NMR (600 MHz, $CDCl_3$): δ 8.66 (br s, 1H), 7.67 (d, *J* = 8.4 Hz, 1H), 7.36 (d, *J* = 8.4 Hz, 1H), 7.33 (t, *J* = 7.8 Hz, 1H), 7.15 (t, *J* = 7.8 Hz, 1H), 3.96 (s, 3H), 2.62 (s, 3H) ppm;

^{13}C NMR (151 MHz, $CDCl_3$): δ 163.2, 136.0, 128.7, 125.8, 123.3, 121.0, 120.5, 120.1, 111.8, 51.8, 10.1 ppm;

IR (neat): ν = 3318, 2950, 1683, 1257, 737 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{11}H_{12}NO_2$ [M+H$^+$] 190.0863, found 190.0857.

2,4-Dimethylbenzo[*d*]thiazol-5-ol



27c

Physical state: light yellow solid;

Melting point: 155 – 157 ºC;

R_f = 0.60 (silica gel, 1:2 EtOAc:hexanes);

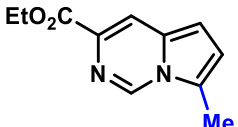
^{1}H NMR (600 MHz, $CDCl_3$): δ 7.49 (d, *J* = 8.5 Hz, 1H), 6.90 (d, *J* = 8.5 Hz, 1H), 4.97 (s, 1H), 2.82 (s, 3H), 2.62 (s, 3H) ppm;

^{13}C NMR (151 MHz, $CDCl_3$): δ 167.5, 154.1, 152.2, 127.6, 118.7, 117.1, 114.0, 20.4, 11.3 ppm;

IR (neat): ν = 2922, 2853, 2360, 2338, 1291, 669 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_9H_{10}NOS$ [M+H$^+$] 180.0478, found 180.0477.

Ethyl 7-methylpyrrolo[1,2-*c*]pyrimidine-3-carboxylate



28c

Physical state: yellow oil;

R_f = 0.25 (silica gel, 1:1 EtOAc:hexanes);

^{1}H NMR (600 MHz, $CDCl_3$): δ 8.69 (s, 1H), 8.20 (s, 1H), 6.75 (d, *J* = 3.7 Hz, 1H), 6.72 (d, *J* = 3.8 Hz, 1H), 4.45 (q, *J* = 7.1 Hz, 2H), 2.60 (s, 3H), 1.43 (t, *J* = 7.2 Hz, 3H) ppm;

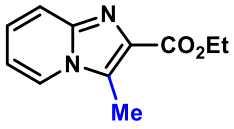
^{13}C NMR (151 MHz, $CDCl_3$): δ 165.4, 135.4, 130.5, 129.0, 122.9, 117.9, 117.4, 104.9, 61.6,

14.6, 11.5 ppm;

IR (neat): ν = 2921, 2853, 1702, 1525, 778 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{11}H_{13}N_2O_2$ [M+H^+] 205.0972, found 205.0969.

Ethyl 3-methylimidazo[1,2-*a*]pyridine-2-carboxylate



29c

Physical state: yellow oil;

R_f = 0.75 (silica gel, 1:15 MeOH:DCM, run up twice);

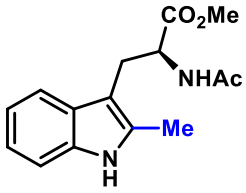
^{1}H NMR (600 MHz, CD_3OD): δ 8.26 (dt, *J* = 7.0, 1.2 Hz, 1H), 7.57 (dt, *J* = 9.2, 1.1 Hz, 1H), 7.43 – 7.36 (m, 1H), 7.04 (td, *J* = 6.9, 1.2 Hz, 1H), 4.42 (q, *J* = 7.1 Hz, 2H), 2.80 (s, 3H), 1.43 (t, *J* = 7.1 Hz, 3H) ppm;

^{13}C NMR (151 MHz, CD_3OD): δ 165.1, 145.2, 132.4, 127.9, 125.7, 118.4, 114.9, 111.4, 61.8, 14.7, 9.4 ppm;

IR (neat): ν = 2360, 2340, 1703, 1220, 1095, 753 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{11}H_{13}N_2O_2$ [M+H^+] 205.0972, found 205.0973.

Methyl (*S*)-2-acetamido-3-(2-methyl-1*H*-indol-3-yl)propanoate (spectroscopic data match those previously reported[4])



L-**33c**

$[\alpha]_{25}^{D}$ = +37.1° (*c* = 0.35, $CHCl_3$);

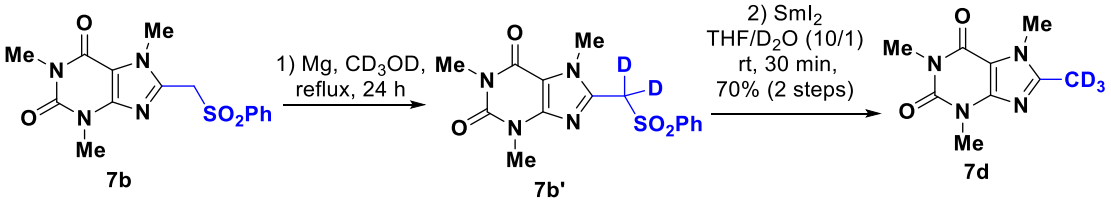
^{1}H NMR (600 MHz, $CDCl_3$): δ 7.92 (brs, 1H), 7.41 (d, *J* = 8.5 Hz, 1H), 7.26 (d, *J* = 7.4 Hz, 1H), 7.11 (ddd, *J* = 8.1, 7.1, 1.3 Hz, 1H), 7.07 (ddd, *J* = 8.1, 7.1, 1.2 Hz, 1H), 6.00 (d, *J* = 8.0 Hz, 1H), 4.90 (ddd, *J* = 8.0, 6.0, 4.7 Hz, 1H), 3.67 (s, 3H), 3.32 – 3.22 (m, 2H), 2.34 (s, 3H), 1.94 (s, 3H) ppm;

[4] Angelini, E.; Balsamini, C.; Bartoccini, F.; Lucarini, S.; Piersanti, G. *J. Org. Chem.* **2008**, *73*, 5654-5657.

^{13}C NMR (151 MHz, $CDCl_3$): δ172.7, 169.7, 135.3, 132.9, 129.2, 121.5, 119.7, 117.9, 110.5, 105.9, 53.1, 52.5, 27.0, 23.4, 11.8 ppm;

10. Experimental procedure and characterization data for compounds 7d to 7g

1,3,7-Trimethyl-8-(methyl-d$_3$)-3,7-dihydro-1*H*-purine-2,6-dione



To a solution of **7b** (10.5 mg, 0.03 mmol, 1 equiv.) in CD_3OD (1 mL) was added freshly activated Mg turnings (28.8 mg, 1.2 mmol, 40 equiv.) and the reaction system was heated to reflux for 24 h. By LC-MS, 100% conversion of **7b** to dideuterated product **7b'** was observed but desired product **7d** was not obtained. At this time, the reaction mixture was filtered through a short pad of silica gel and concentration of the filtrate gave the crude product **7b'**. This crude product was dissolved in THF/D_2O (1 mL/0.1 mL) and degassed for 20 min. Then a solution of SmI_2 in THF (0.15 mmol, 5 equiv.) was added. After stirred at room temperature for 30 min, the reaction system was quenched with sat. $NaHCO_3$ solution, and the aqueous layer was extracted with EtOAc (3 times). The combined organic layers were washed with brine and dried over Na_2SO_4. Removal of the solvent and purification of the crude mixture by PTLC (EtOAc/MeOH = 20/1) gave the desired product **7d** (4.4 mg, 70% over two steps, 91% D incorporation as shown by ^{1}H NMR).

Physical state: white powder;

Melting point: 202 – 204 ºC;

R_f = 0.40 (silica gel, 20:1 EtOAc:MeOH);

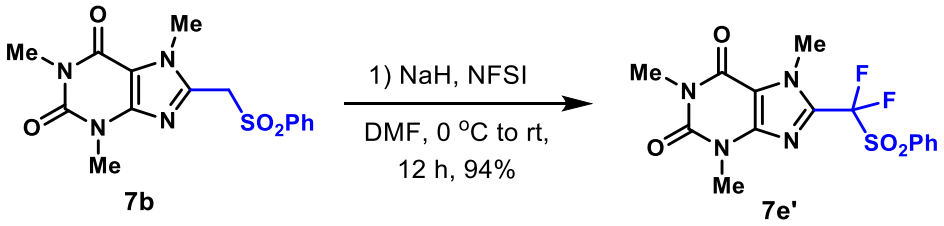
^{1}H NMR (600 MHz, $CDCl_3$): δ 3.90 (s, 3H), 3.56 (s, 3H), 3.39 (s, 3H) ppm;

^{13}C NMR (151 MHz, $CDCl_3$): δ 155.4, 151.8, 150.8, 148.0, 107.6, 32.0, 29.8, 28.0, 12.7 (sept, J_{CD} = 4.7 Hz) ppm;

IR (neat): ν = 2922, 2360, 2339, 1712, 1649, 1439, 745 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_9H_{10}D_3N_4O_2$ [M+H$^+$] 212.1221, found 212.1223.

8-(Difluoro(phenylsulfonyl)methyl)-1,3,7-trimethyl-3,7-dihydro-1*H*-purine-2,6-dione



To a solution of **7b** (10.5 mg, 0.03 mmol, 1 equiv.) in dry DMF (0.5 mL) was added 95% NaH (7.2 mg, 0.3 mmol, 10 equiv.) at 0 °C. After 20 min, NFSI (47.3 mg, 0.15 mmol, 5 equiv.) was added to the reaction system and the resulting slurry was warmed to room temperature naturally. After stirring at room temperature for 12 h, the reaction system was quenched with sat. NH_4Cl solution, and the aqueous layer was extracted with EtOAc (3 times). The combined organic layers were washed with brine and dried over Na_2SO_4. Removal of the solvent and purification of the crude mixture by PTLC (6:1 DCM:acetone) gave the desired product **7e'** (10.9 mg, 94%) as a white solid.

Physical state: white solid;

Melting point: 189 – 191 ºC;

R_f = 0.40 (silica gel, 1:1 EtOAc:hexanes);

^{1}H NMR (400 MHz, $CDCl_3$): δ 8.03 (d, J = 7.8 Hz, 2H), 7.84 (t, J = 7.6 Hz, 1H), 7.67 (t, J = 7.7 Hz, 2H), 4.30 (s, 3H), 3.55 (s, 3H), 3.43 (s, 3H) ppm;

^{13}C NMR (151 MHz, $CDCl_3$): δ 154.9, 150.8, 146.7, 136.7 (t, J_{CF} = 27.5 Hz), 135.7, 131.4, 130.6, 129.2, 116.5 (t, J_{CF} = 288.7 Hz), 110.4, 33.8, 29.5, 27.8 ppm;

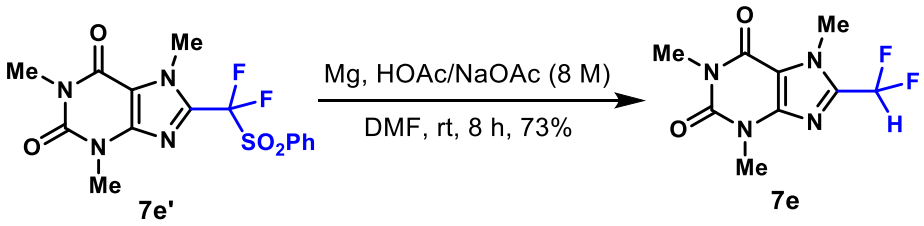
^{19}F NMR (376 MHz, $CDCl_3$) δ –101.1 ppm.

IR (neat): ν = 2360, 2339, 1708, 1664, 1169, 729 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{15}H_{15}N_4O_4F_2S$ [M+H$^+$] 385.0777, found 385.0783.

8-(Difluoromethyl)-1,3,7-trimethyl-3,7-dihydro-1*H*-purine-2,6-dione
(spectroscopic data match those previously reported[5])

[5] Fujiwara, Y.; Dixon, J. A.; Rodriguez, R. A.; Baxter, R. D.; Dixon, D. D.; Collins, M. R.; Blackmond, D. G.; Baran, P. S. *J. Am. Chem. Soc.* **2012**, *134*, 1494-1497.



To a solution of **7e'** (5.4 mg, 0.014 mmol, 1 equiv.) in DMF (0.5 mL) and HOAc/NaOAc (1:1) buffer solution (8 mol/L, 0.2 mL) was added freshly activated Mg turnings (10 mg, 0.42 mmol, 30 equiv.) and the reaction system was stirred at room temperature for 8 h. Then, the reaction system was quenched with water and extracted with EtOAc (3 times). The combined organic layers were washed with sat. $NaHCO_3$ solution, brine and dried over Na_2SO_4. Removal of the solvent and purification of the crude mixture by PTLC (2:1 hexanes:EtOAc) gave the desired product **7e** (2.5 mg, 73%) as a white solid.

Physical state: white solid;

Melting point: 159 – 161 ºC;

R_f = 0.50 (silica gel, 1:2 EtOAc:hexanes);

^{1}H NMR (600 MHz, $CDCl_3$): δ 6.74 (t, J = 52.2 Hz, 1H), 4.15 (s, 3H), 3.56 (s, 3H), 3.41 (s, 3H) ppm;

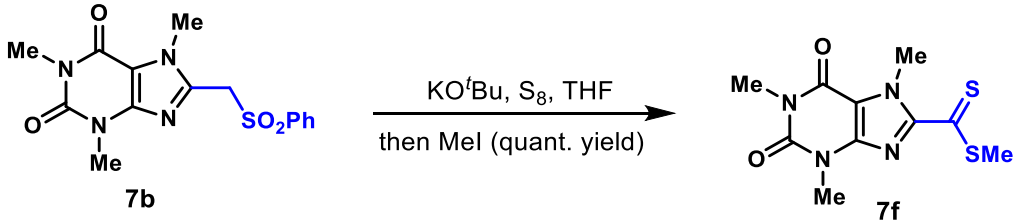
^{13}C NMR (101 MHz, $CDCl_3$): δ 155.7, 151.6, 147.1, 142.9 (t, J_{CF} = 27.3 Hz), 109.9 (t, J_{CF} = 238.9 Hz), 109.6, 33.0, 29.9, 28.3 ppm;

^{19}F NMR (376 MHz, $CDCl_3$) δ –115.3 ppm.

IR (neat): ν = 2360, 2339, 1710, 1666, 1040, 745 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_9H_{11}N_4O_2F_2$ [M+H$^+$] 245.0845, found 245.0844.

Methyl 1,3,7-trimethyl-2,6-dioxo-2,3,6,7-tetrahydro-1*H*-purine-8-carbodithioate



A mixture of sulfone **7b** (10 mg, 0.029 mmol) and elemental sulfur (22.0 mg, 0.086 mmol, 3.0 equiv.) was placed into THF (0.5 mL) under magnetic stirring. After addition of *t*-BuOK (9.7 mg, 0.086 mmol, 3.0 equiv.), the color of the solution changed to dark brown. The reaction was

stirred at r.t. for 1 h. Then, CH_3I (0.005 mL, 0.086 mmol, 3.0 equiv.) was added to the solution and the stirring was continued for 1 h. Upon completion, the solvent was removed under vacuum, and the residue, dissolved in CH_2Cl_2 (0.5 mL), was directly purified by chromatography on silica gel (1:10 EtOAc:hexanes), afforded pure dithioester **7f** (8.1 mg, 99%).

Physical state: orange solid;

Melting point: 161 – 163 ºC;

R_f = 0.20 (silica gel, 1:4 EtOAc:hexanes);

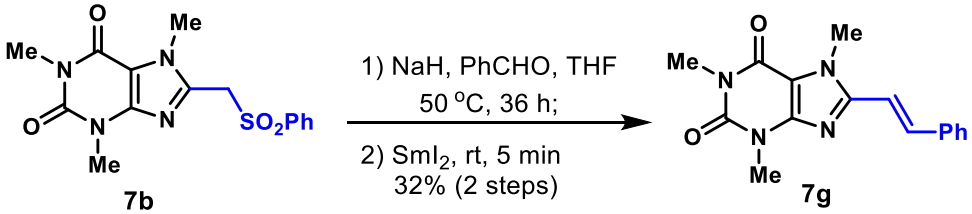
^{1}H NMR (400 MHz, $CDCl_3$): δ 4.33 (s, 3H), 3.64 (s, 3H), 3.43 (s, 3H), 2.72 (s, 3H) ppm;

^{13}C NMR (151 MHz, $CDCl_3$): δ 212.0, 155.9, 151.6, 148.5, 146.5, 111.2, 35.7, 30.1, 28.4, 19.7 ppm;

IR (neat): ν = 2360, 2339, 1704, 1665, 1543, 1098 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{10}H_{13}N_4O_2S_2$ [M+H$^+$] 285.0474, found 285.0472.

(*E*)-1,3,7-Trimethyl-8-styryl-3,7-dihydro-1*H*-purine-2,6-dione



To a solution of **7d** (10.0 mg, 28.7 μmol, 1 equiv.) in THF (1 mL) was added 95% NaH (2.2 mg, 86.1 μmol, 3 equiv.) at room temperature and after 10 min of stirring, benzaldehyde (8.7 μL, 3 equiv.) was added to the reaction mixture. The reaction mixture was stirred at 50 °C for 36 h, quenched with H_2O, and extracted with EtOAc. The organic layers were combined, washed with brine, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. Purification by preparative TLC (SiO_2, 1:1 EtOAc:hexanes) gave sulfonylalkene (4.3 mg, 9.8 μmol, 34%). To a solution of sulfonylalkene (1.9 mg, 4.35 μmol, 1 equiv.), DMPU (10.5 μL, 87.0 μmol, 20 equiv.), MeOH (3.5 μL, 87.0 μmol, 20 equiv.) in THF (0.5 mL) was added SmI_2 (0.03 M in THF) (1.2 mL, 34.8 μmol, 8 equiv.). The reaction was stirred at room temperature for 5 min, quenched with $NaHCO_3$ and then extracted with EtOAc. The organic layers were combined, washed with brine, dried over Na_2SO_4, filtered, and concentrated under reduced pressure. Purification by preparative TLC (SiO_2, 1:1 EtOAc:hexanes) gave 7**g** (1.2 mg, 9.1 μmol, 93%) as a white solid.

Spectroscopic data match those previously reported[6].

^{1}H NMR (500 MHz, $CDCl_3$): δ 7.82 (d, *J* = 15.8 Hz, 1H), 7.59 (d, *J* = 7.5 Hz, 2H), 7.43 – 7.35 (m, 3H), 6.93 (d, *J* = 15.8 Hz, 1H), 4.07 (s, 3H), 3.64 (s, 3H), 3.42 (s, 3H) ppm;

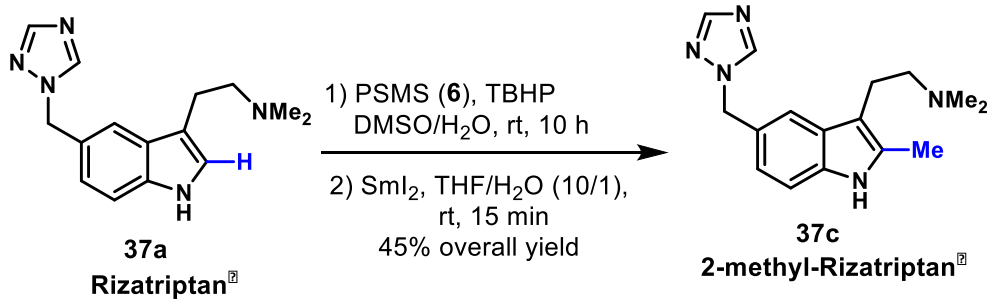
^{13}C NMR (151 MHz, $CDCl_3$): δ 155.3, 151.8, 149.9, 148.6, 138.4, 135.5, 129.5, 129.0, 127.4, 111.2, 107.9, 31.5, 29.8, 27.9 ppm;

IR (neat): ν = 3729, 3626, 2360, 2340, 2217, 2156, 2043, 1986, 1694, 1665, 1542, 1275;

HRMS (ESI-TOF): calc'd for $C_{16}H_{17}N_4O_2$ [M+H$^+$] 297.1352, found 297.1347.

11. Experimental procedure and characterization data for biologically important substrates 37c to 39c

2-Methyl-Rizatriptan®



37a
Rizatriptan®

37c
2-methyl-Rizatriptan®

On a 0.05 mmol (19.6 mg) scale, the typical procedure for the reaction of PSMS (**6**) with heterocycles was followed, employing DMSO/H_2O (0.4/0.16 mL) as the solvent instead. The reaction was conducted at room temperature for 10 h to yield the desired 2-phenylsulfonylmethyl-Rizatriptan® **37b** (12.6 mg, 60% yield).

On a 0.0064 mmol (2.7 mg) scale, intermediate **37b** was desulfonylated using the typical procedure B for the desulfonylation, affording 1.3 mg of desired 2-methyl-Rizatriptan® **37c** (72%, 45% overall yield over two steps).

2-Methyl-Rizatriptan®

Physical state: white foam;

R_f = 0.40 (silica gel (pre-treated with Et_3N), 1:1 EtOAc:MeOH);

[6] Sahnoun, S.; Messaoudi, S.; Brion, J.-D.; Alami, M. *Eur. J. Org. Chem.* **2010**, *31*, 6097-6102.

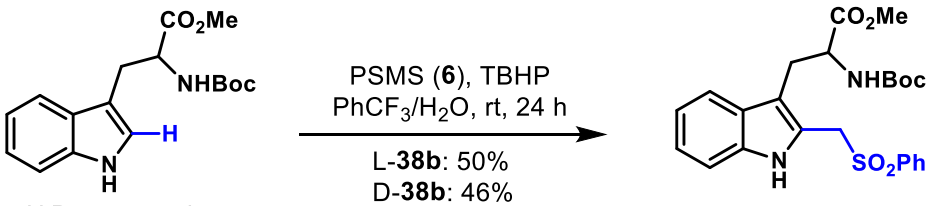
^{1}H NMR (600 MHz, DMSO-d_6): δ 10.74 (s, 1H), 8.59 (s, 1H), 7.93 (s, 1H), 7.36 (d, J = 1.6 Hz, 1H), 7.18 (d, J = 8.2 Hz, 1H), 6.93 (dd, J = 8.2, 1.7 Hz, 1H), 5.40 (s, 2H), 2.71 (t, J = 7.8 Hz, 2H), 2.34 (t, J = 7.8 Hz, 2H), 2.29 (s, 3H), 2.19 (s, 6H) ppm;

^{13}C NMR (151 MHz, DMSO-d_6): δ 151.3, 143.7, 134.7, 132.5, 128.2, 125.7, 120.1, 117.3, 110.5, 108.4, 60.1, 53.1, 45.2, 22.1, 11.3 ppm;

IR (neat): ν = 3328, 2921, 2852, 2360, 2339, 1085, 678 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{16}H_{22}N_5$+ [M+H$^+$] 284.1870, found 284.1878.

***N*-Boc-2-methyl-L/D-tryptophan methyl ester**



N-Boc-tryptophan methyl ester (**L-38a** and **D-38a**)

N-Boc-tryptophan methyl ester analogue (**L-38b** and **D-38b**)

On a 0.2 mmol scale, the typical procedure for the reaction of PSMS with heterocycles was followed, affording L-**38b** in 50% yield and **D-38b** in 46% yield, respectively.

Physical state: colorless oil (for L-**38b** and D-**38b**);

$[\alpha]_{25}^{D}$ = +26.0^o (c = 1.0, $CHCl_3$, for L-**38b**) and –26.2^o (c = 1.0, $CHCl_3$, for D-**38b**);

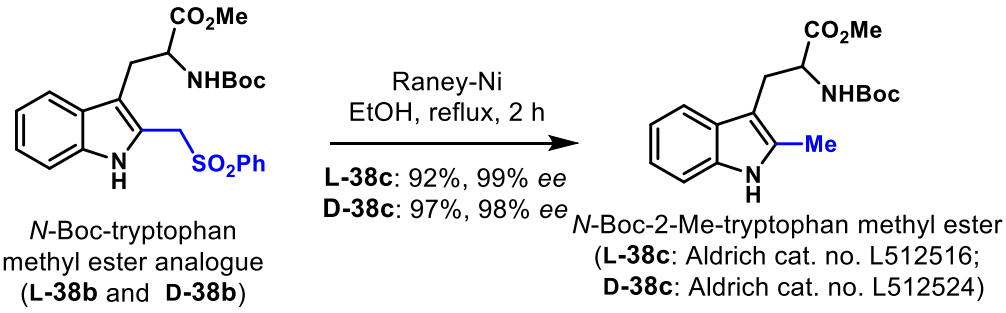
R_f = 0.7 (silica gel, 2:1 EtOAc:hexanes);

^{1}H NMR (600 MHz, $CDCl_3$): δ 8.86 (s, 1H), 7.68 (d, J = 7.6 Hz, 2H), 7.60 (t, J = 7.4 Hz, 1H), 7.49 – 7.37 (m, 3H), 7.35 (d, J = 8.2 Hz, 1H), 7.21 (d, J = 7.4 Hz, 1H), 7.08 (t, J = 7.4 Hz, 1H), 5.12 (d, J = 7.2 Hz, 1H), 4.64 – 4.48 (m, 2H), 4.39 – 4.27 (m, 1H), 3.55 (s, 3H), 2.85 – 2.65 (m, 2H), 1.42 (s, 9H) ppm;

^{13}C NMR (151 MHz, $CDCl_3$): δ 172.3, 155.1, 137.7, 136.4, 134.3, 129.3, 128.4, 127.7, 123.3, 123.1, 120.1, 119.1, 112.14, 111.40, 80.2, 54.3, 54.0, 52.5, 28.45, 26.6 ppm;

IR (neat): ν = 3364, 2977, 1695, 1502, 1306, 1260, 1147, 734 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{24}H_{28}N_2NaO_6S^+$ [M+Na$^+$] 495.1560, found 495.1560;



N-Boc-tryptophan methyl ester analogue (**L-38b** and **D-38b**)

N-Boc-2-Me-tryptophan methyl ester (**L-38c**: Aldrich cat. no. L512516; **D-38c**: Aldrich cat. no. L512524)

On a 13 mg scale, intermediate **L-38b** and **D-38b** was desulfonylated using the typical procedure C for the desulfonylation, affording desired 2-methyl-tryptophan **L-38c** in 92% yield (99% *ee*) and **D-38c** in 97% yield (98% *ee*).

Physical state: colorless oil (for L-**38c** and D-**38c**);

$[\alpha]_{25}^{D}$ = +32.5° (c = 1.0, $CHCl_3$, for L-**38c**) and –32.3 ° (c = 1.0, $CHCl_3$, for D-**38d**);

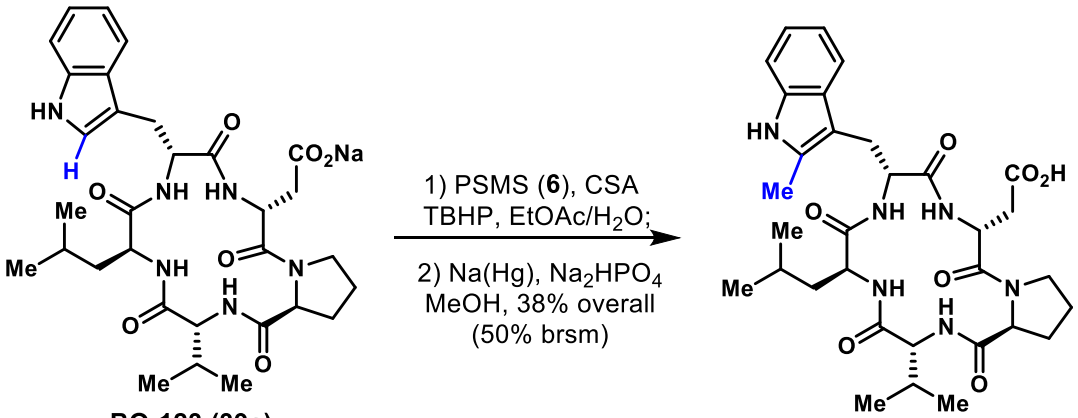
R_f = 0.6 (silica gel, 2:1 EtOAc:hexanes);

^{1}H NMR (600 MHz, $CDCl_3$): δ 7.86 (s, 1H), 7.43 (d, *J* = 7.7 Hz, 1H), 7.25 (d, *J* = 8.1 Hz, 1H), 7.08 (dt, *J* = 23.6, 7.1 Hz, 2H), 5.07 (d, *J* = 7.7 Hz, 1H), 4.60 (q, *J* = 5.5 Hz, 1H), 3.64 (s, 3H), 3.23 (d, *J* = 5.3 Hz, 2H), 2.35 (s, 3H), 1.42 (s, 9H) ppm;

^{13}C NMR (151 MHz, $CDCl_3$): δ 172.9, 155.2, 135.3, 132.9, 129.0, 121.3, 119.6, 118.2, 110.3, 106.1, 79.9, 54.3, 52.4, 28.5, 27.4, 11.9 ppm;

IR (neat): ν = 3348, 1695, 1365, 1216, 1164, 859, 742, 669 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{18}H_{24}N_2NaO_4^+$ [M+Na^+] 355.1628, found 355.1628.



BQ-123 (39a) sodium salt

39c

On a 0.02 mmol (12.6 mg) scale, the typical procedure for the reaction of PSMS (**6**) with heterocycles was followed, employing EtOAc/H_2O(0.3/0.15 mL) as the solvent instead, and camphorsulfonic acid (5.1 mg, 1.1 equiv) as an acid additive. The reaction was conducted at room temperature for 10 h to yield the desired 2-phenylsulfonylmethyl-BQ-123 (**39b**) (6.7 mg, 44% yield, 58% b.r.s.m).

To a solution of **39b** (6.0 mg, 7.8 μmol) and anhydrous disodium hydrogen phosphate (24.0 mg, 169 μmol) in 0.2 ml of dry methanol at room temperature was added pulverized 5% sodium amalgam (60 mg). The mixture was stirred at the same temperature for 40 min to achieve full conversion (monitored by TLC and LC-MS). Upon completion, the reaction mixture was poured into brine, and acidified to pH = 2.0 by 1 M HCl, then extracted with EtOAc (5 mL × 2). The combined organic phase was dried over Na_2SO_4, concentrated *in vacuo*, and the residue was purified by PTLC (DCM:MeOH:AcOH = 90:9:0.6) to afforded **39c** (4.2 mg, 86% yield).

2-methyl-BQ-123 (**39c**)

Physical state: white foam;

$[\alpha]_{25}^{D}$ = +15.0° (*c* = 0.42, MeOH);

R_f = 0.60 (silica gel, 3:0.3:0.02 DCM:MeOH:AcOH);

^{1}H NMR (600 MHz, CD_3OD): δ 8.55 (d, *J* = 5.4 Hz, 1H), 8.13 (d, *J* = 8.5 Hz, 1H), 7.91 (d, *J* = 8.9 Hz, 1H), 7.76 (d, *J* = 10.0 Hz, 1H), 7.50 (dt, *J* = 7.9, 1.0 Hz, 1H), 7.22 (dt, *J* = 8.1, 0.9 Hz, 1H), 7.00 (ddd, *J* = 8.1, 7.0, 1.2 Hz, 1H), 6.94 (ddd, *J* = 8.0, 7.0, 1.1 Hz, 1H), 5.13 (ddd, *J* = 9.7, 8.1, 4.1 Hz, 1H), 4.71 (ddd, *J* = 10.3, 8.5, 4.1 Hz, 1H), 4.09 (dd, *J* = 10.0, 8.0 Hz, 1H), 3.93 (td, *J* = 7.7, 5.3 Hz, 1H), 3.56 – 3.49 (m, 1H), 3.42 (dd, *J* = 14.9, 4.1 Hz, 1H), 3.39 – 3.32 (m, 2H), 3.04 (dd, *J* = 14.9, 10.3 Hz, 1H), 2.98 (dd, *J* = 16.5, 10.4 Hz, 1H), 2.50 (dd, *J* = 16.5, 4.1 Hz, 1H), 2.41 (s, 3H), 2.40 – 2.34 (m, 1H), 2.08 – 2.00 (m, 2H), 1.86 – 1.79 (m, 1H), 1.79 – 1.71 (m, 1H), 1.28 – 1.20 (m, 2H), 0.94 (d, *J* = 6.7 Hz, 3H), 0.91 (d, *J* = 6.7 Hz, 3H), 0.89 – 0.85 (m, 1H), 0.63 (d, *J* = 6.5 Hz, 3H), 0.61 (d, *J* = 6.6 Hz, 3H) ppm;

^{13}C NMR (151 MHz, CD_3OD): δ 174.9, 174.4, 173.6, 173.55, 173.1, 171.5, 137.2, 134.0, 129.7, 121.5, 119.7, 118.6, 111.4, 106.9, 60.3, 60.2, 56.1, 54.9, 49.6, 47.0, 39.8, 36.7, 31.9, 27.0, 25.5, 25.5, 25.4, 22.8, 22.5, 19.6, 19.0, 11.7 ppm;

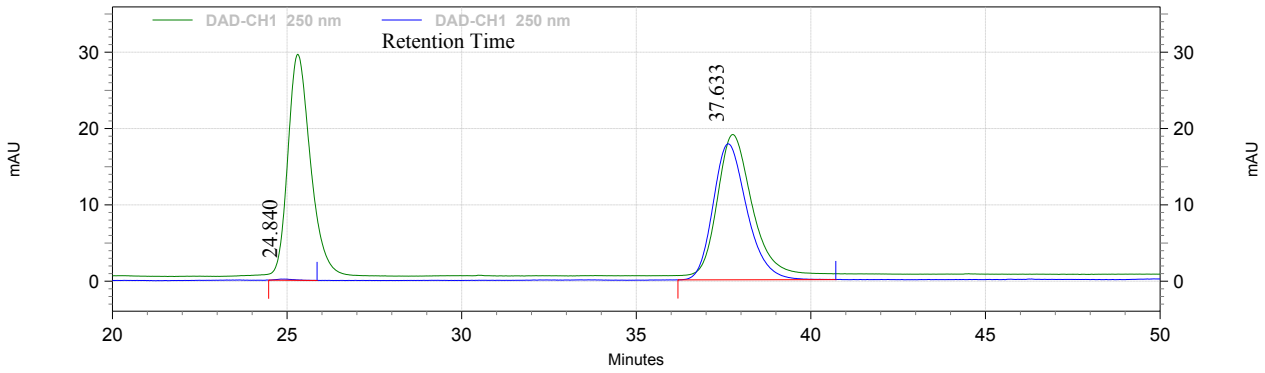
IR (neat): ν = 3271, 2960, 2361, 2339, 1636, 1538, 1453, 1395 cm^{-1};

HRMS (ESI-TOF): calc'd for $C_{32}H_{45}N_6O_7$ [M+H^+] 625.3344, found 625.3347.

12. HPLC analysis of *N*-Boc-2-methyl-D/L-tryptophan methyl ester (L-38c and D-38c)

Enantiomeric excesses (*ee*) were determined on a Hitachi LaChrow Elite HPLC system using HPLC chiralcel AD-H column (10% isopropanol in hexanes, 0.5 mL/min) tr = 24.840 min (minor), 37.633 min (major): 99% ee.

Area % Report (for *N*-Boc-2-methyl-L-tryptophan methyl ester, L-38c)



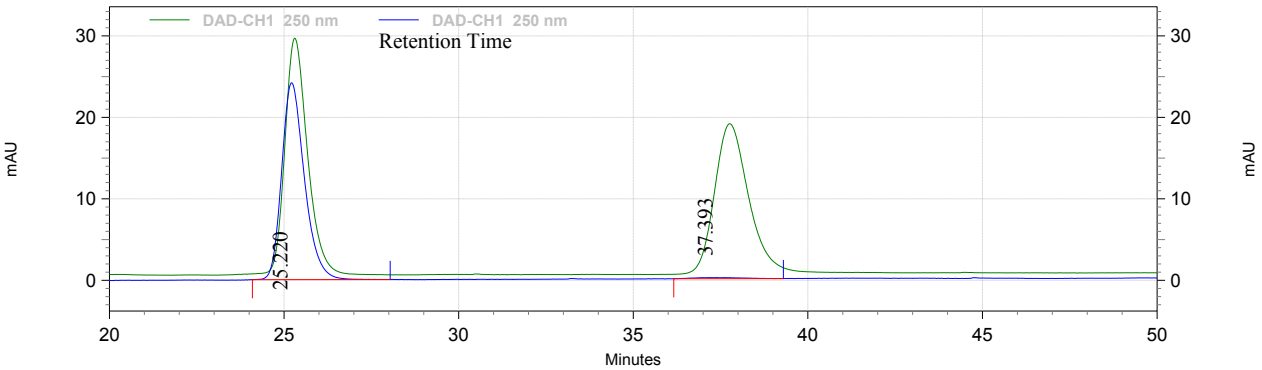
(**green trace**: racemic *N*-Boc-2-methyl-DL-tryptophan methyl ester;
blue trace: obtained *N*-Boc-2-methyl-L-tryptophan methyl ester L-**38c**)

DAD-CH1
250 nm Results

Retention Time	Area	Area %	Height	Height %
24.840	22553	0.47	612	0.85
37.633	4794201	99.53	71261	99.15
Totals	4816754	100.00	71873	100.00

Enantiomeric excesses (*ee*) were determined on a Hitachi LaChrow Elite HPLC system using HPLC chiralcel AD-H column (10% isopropanol in hexanes, 0.5 mL/min) tr = 25.220 min (major), 37.393 min (minor): 98% ee.

Area % Report (for N-Boc-2-methyl-D-tryptophan methyl ester, D-38c)



(**green trace**: racemic N-Boc-2-methyl-DL-tryptophan methyl ester;
blue trace: obtained N-Boc-2-methyl-D-tryptophan methyl ester D-**38c**)

DAD-CH1
250 nm Results

Retention Time	Area	Area %	Height	Height %
25.220	4378354	98.81	96658	99.45
37.393	52510	1.19	533	0.55

Totals	4430864	100.00	97191	100.00

13. X-ray crystallographic data for PSMS (6):

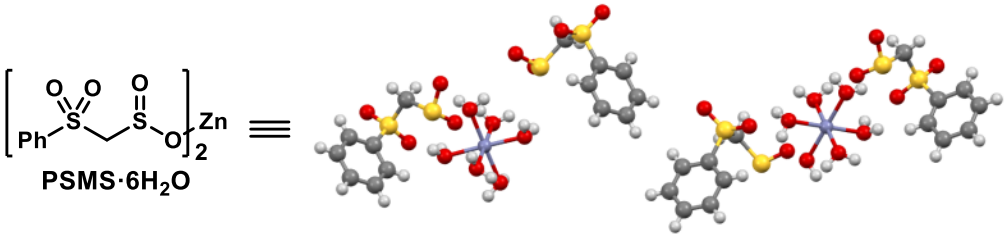


Table S1. Crystal data and structure refinement for CCDC # 982543.

Identification code	CCDC # 982543	
Empirical formula	C14 H26 O14 S4 Zn	
Molecular formula	Zn(H2O)6, C14 H14 O8	
Formula weight	611.96	
Temperature	100(2) K	
Wavelength	0.71073 Å	
Crystal system	Monoclinic	
Space group	P2(1)	
Unit cell dimensions	a = 8.2053(5) Å	α= 90°.
	b = 32.8177(19) Å	β= 92.858(3)°.
	c = 8.8796(5) Å	γ = 90°.
Volume	2388.1(2) $Å^3$	
Z	4	
Density (calculated)	1.702 Mg/m^3	
Absorption coefficient	1.444 mm^{-1}	
F(000)	1264	
Crystal size	0.10 x 0.08 x 0.05 mm^3	
Crystal color, habit	colorless / plate	
Theta range for data collection	2.30 to 26.61°.	
Index ranges	-9<=h<=9, -41<=k<=39, -11<=l<=9	
Reflections collected	15248	
Independent reflections	7586 [R(int) = 0.0473]	
Completeness to theta = 25.00°	90.7 %	
Absorption correction	multi-scan / sadabs	
Max. and min. transmission	0.9313 and 0.8691	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	7586 / 37 / 608	
Goodness-of-fit on F^2	1.025	

Final R indices [I>2sigma(I)]	R1 = 0.0598, wR2 = 0.1419
R indices (all data)	R1 = 0.0830, wR2 = 0.1536
Absolute structure parameter	0.00(3)
Largest diff. peak and hole	1.073 and -1.034 e.Å^{-3}

Table S2. Atomic coordinates (x 10^4) and equiv.alent isotropic displacement parameters (Å^{2}x 10^3) for CCDC # 982543. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
Zn(1)	7555(1)	8193(1)	3666(1)	16(1)
Zn(2)	7447(2)	3192(1)	1333(1)	18(1)
S(1)	7599(3)	9653(1)	1397(2)	18(1)
S(2)	8180(3)	9061(1)	-1189(2)	16(1)
S(3)	6339(3)	4636(1)	3642(2)	17(1)
S(4)	7004(3)	4051(1)	6290(2)	18(1)
S(5)	1417(3)	6758(1)	973(2)	17(1)
S(6)	2104(3)	7332(1)	3628(2)	18(1)
S(7)	2453(3)	1735(1)	4079(2)	17(1)
S(8)	3062(3)	2321(1)	1485(2)	16(1)
O(1)	6414(8)	9953(2)	1857(7)	22(2)
O(2)	8109(8)	9341(2)	2456(6)	24(2)
O(3)	7072(8)	8960(2)	-2548(6)	19(2)
O(4)	8266(8)	8710(2)	-111(7)	16(2)
O(5)	6661(8)	4299(2)	2629(6)	21(2)
O(6)	5178(7)	4942(2)	3111(7)	18(2)
O(7)	6702(8)	3688(2)	5343(6)	21(2)
O(8)	6117(7)	4012(2)	7752(6)	19(1)
O(9)	222(8)	6458(2)	468(7)	25(2)
O(10)	1810(8)	7084(2)	-29(7)	23(2)
O(11)	1215(7)	7376(2)	5076(6)	21(2)
O(12)	1790(8)	7709(2)	2682(7)	25(2)
O(13)	1238(8)	1450(2)	4523(7)	25(2)
O(14)	3015(9)	2038(2)	5164(7)	27(2)
O(15)	1962(7)	2431(2)	131(6)	18(1)

O(16)	3141(8)	2683(2)	2565(7)	23(2)
O(17)	6174(7)	8435(2)	1842(6)	17(1)
O(18)	7500(8)	7623(2)	2676(7)	25(2)
O(19)	9725(7)	8350(2)	2672(6)	22(2)
O(20)	7686(9)	8764(2)	4668(7)	24(2)
O(21)	5401(7)	8040(2)	4673(6)	20(2)
O(22)	8959(7)	7939(2)	5502(6)	17(1)
O(23)	6229(7)	2926(2)	-534(6)	20(2)
O(24)	7218(8)	2616(2)	2362(7)	22(2)
O(25)	9707(7)	3047(2)	556(6)	20(2)
O(26)	7663(8)	3769(2)	322(6)	17(1)
O(27)	5152(8)	3336(2)	2119(7)	24(2)
O(28)	8653(7)	3455(2)	3183(6)	15(1)
C(1)	9219(13)	10275(3)	85(10)	17(2)
C(2)	10617(13)	10469(4)	-372(11)	28(3)
C(3)	12116(14)	10282(3)	-103(11)	23(2)
C(4)	12216(14)	9907(3)	553(11)	28(3)
C(5)	10864(12)	9712(3)	1036(10)	19(2)
C(6)	9322(12)	9903(3)	784(10)	14(2)
C(7)	6794(11)	9419(3)	-233(10)	21(2)
C(8)	8198(15)	5257(4)	4800(11)	29(3)
C(9)	9669(14)	5449(4)	5130(13)	33(3)
C(10)	11100(14)	5257(4)	4868(11)	30(3)
C(11)	11141(13)	4878(3)	4204(11)	23(2)
C(12)	9627(12)	4676(4)	3855(11)	24(2)
C(13)	8210(13)	4875(3)	4165(10)	17(2)
C(14)	5632(11)	4441(3)	5317(9)	17(2)
C(15)	4741(12)	6680(3)	1195(10)	18(2)
C(16)	6151(15)	6491(4)	1609(11)	34(3)
C(17)	6145(15)	6113(4)	2380(12)	36(3)
C(18)	4681(15)	5938(4)	2714(12)	30(3)
C(19)	3182(13)	6133(3)	2257(10)	25(2)
C(20)	3241(13)	6509(3)	1508(10)	17(2)
C(21)	745(11)	6968(3)	2679(10)	18(2)
C(22)	5672(14)	1628(3)	3749(11)	26(3)
C(23)	7058(15)	1428(4)	3279(12)	37(3)

C(24)	6872(15)	1061(4)	2512(13)	37(3)
C(25)	5324(14)	902(4)	2261(12)	31(3)
C(26)	3940(15)	1096(3)	2759(11)	28(3)
C(27)	4203(12)	1473(3)	3497(10)	20(2)
C(28)	1650(11)	1977(3)	2414(9)	15(2)

Table S3. Bond lengths [Å] and angles [°] for CCDC # 982543.

Zn(1)-O(18)	2.067(7)	S(5)-O(10)	1.437(6)
Zn(1)-O(20)	2.074(6)	S(5)-O(9)	1.447(7)
Zn(1)-O(21)	2.082(6)	S(5)-C(20)	1.751(11)
Zn(1)-O(17)	2.088(6)	S(5)-C(21)	1.776(9)
Zn(1)-O(19)	2.091(6)	S(6)-O(12)	1.509(6)
Zn(1)-O(22)	2.120(5)	S(6)-O(11)	1.516(6)
Zn(2)-O(28)	2.064(6)	S(6)-C(21)	1.813(9)
Zn(2)-O(25)	2.067(6)	S(7)-O(13)	1.438(7)
Zn(2)-O(23)	2.085(6)	S(7)-O(14)	1.443(6)
Zn(2)-O(27)	2.094(6)	S(7)-C(27)	1.772(10)
Zn(2)-O(26)	2.107(6)	S(7)-C(28)	1.776(9)
Zn(2)-O(24)	2.113(7)	S(8)-O(15)	1.511(6)
S(1)-O(2)	1.438(6)	S(8)-O(16)	1.525(7)
S(1)-O(1)	1.456(7)	S(8)-C(28)	1.842(9)
S(1)-C(7)	1.740(9)	O(17)-H(17A)	0.8703
S(1)-C(6)	1.744(10)	O(17)-H(17B)	0.8701
S(2)-O(4)	1.497(6)	O(18)-H(18A)	0.8700
S(2)-O(3)	1.511(6)	O(18)-H(18B)	0.8700
S(2)-C(7)	1.868(9)	O(19)-H(19A)	0.8701
S(3)-O(6)	1.445(6)	O(19)-H(19B)	0.8700
S(3)-O(5)	1.458(6)	O(20)-H(20A)	0.8700
S(3)-C(14)	1.746(9)	O(20)-H(20B)	0.8699
S(3)-C(13)	1.765(11)	O(21)-H(21C)	0.8701
S(4)-O(7)	1.470(6)	O(21)-H(21D)	0.8700
S(4)-O(8)	1.525(6)	O(22)-H(22A)	0.8700
S(4)-C(14)	1.885(8)	O(22)-H(22B)	0.8701

O(23)-H(23A)	0.8701	C(11)-C(12)	1.429(14)
O(23)-H(23B)	0.8703	C(11)-H(11)	0.9500
O(24)-H(24A)	0.8702	C(12)-C(13)	1.374(15)
O(24)-H(24B)	0.8703	C(12)-H(12)	0.9500
O(25)-H(25A)	0.8700	C(14)-H(14A)	0.9900
O(25)-H(25B)	0.8701	C(14)-H(14B)	0.9900
O(26)-H(26A)	0.8704	C(15)-C(16)	1.346(15)
O(26)-H(26B)	0.8704	C(15)-C(20)	1.394(14)
O(27)-H(27A)	0.8700	C(15)-H(15)	0.9500
O(27)-H(27B)	0.8702	C(16)-C(17)	1.416(16)
O(28)-H(28C)	0.8701	C(16)-H(16)	0.9500
O(28)-H(28D)	0.8701	C(17)-C(18)	1.377(17)
C(1)-C(6)	1.370(13)	C(17)-H(17)	0.9500
C(1)-C(2)	1.391(14)	C(18)-C(19)	1.427(15)
C(1)-H(1)	0.9500	C(18)-H(18)	0.9500
C(2)-C(3)	1.385(15)	C(19)-C(20)	1.404(14)
C(2)-H(2)	0.9500	C(19)-H(19)	0.9500
C(3)-C(4)	1.363(13)	C(21)-H(21A)	0.9900
C(3)-H(3)	0.9500	C(21)-H(21B)	0.9900
C(4)-C(5)	1.368(14)	C(22)-C(27)	1.318(15)
C(4)-H(4)	0.9500	C(22)-C(23)	1.395(17)
C(5)-C(6)	1.420(14)	C(22)-H(22)	0.9500
C(5)-H(5)	0.9500	C(23)-C(24)	1.389(17)
C(7)-H(7A)	0.9900	C(23)-H(23)	0.9500
C(7)-H(7B)	0.9900	C(24)-C(25)	1.381(17)
C(8)-C(13)	1.374(14)	C(24)-H(24)	0.9500
C(8)-C(9)	1.380(16)	C(25)-C(26)	1.393(16)
C(8)-H(8)	0.9500	C(25)-H(25)	0.9500
C(9)-C(10)	1.363(16)	C(26)-C(27)	1.412(15)
C(9)-H(9)	0.9500	C(26)-H(26)	0.9500
C(10)-C(11)	1.378(15)	C(28)-H(28A)	0.9900
C(10)-H(10)	0.9500	C(28)-H(28B)	0.9900

O(18)-Zn(1)-O(20)	178.3(3)	O(18)-Zn(1)-O(17)	90.9(2)
O(18)-Zn(1)-O(21)	87.9(3)	O(20)-Zn(1)-O(17)	90.2(2)
O(20)-Zn(1)-O(21)	93.5(3)	O(21)-Zn(1)-O(17)	89.2(2)

O(18)-Zn(1)-O(19)	92.6(3)	O(6)-S(3)-C(13)	109.2(4)
O(20)-Zn(1)-O(19)	86.1(3)	O(5)-S(3)-C(13)	108.5(4)
O(21)-Zn(1)-O(19)	179.5(3)	C(14)-S(3)-C(13)	105.1(4)
O(17)-Zn(1)-O(19)	91.1(2)	O(7)-S(4)-O(8)	110.2(4)
O(18)-Zn(1)-O(22)	88.3(2)	O(7)-S(4)-C(14)	102.0(4)
O(20)-Zn(1)-O(22)	90.6(2)	O(8)-S(4)-C(14)	98.5(4)
O(21)-Zn(1)-O(22)	90.9(2)	O(10)-S(5)-O(9)	119.0(4)
O(17)-Zn(1)-O(22)	179.2(3)	O(10)-S(5)-C(20)	107.5(4)
O(19)-Zn(1)-O(22)	88.9(2)	O(9)-S(5)-C(20)	108.8(4)
O(28)-Zn(2)-O(25)	87.7(2)	O(10)-S(5)-C(21)	109.2(4)
O(28)-Zn(2)-O(23)	179.9(3)	O(9)-S(5)-C(21)	107.1(4)
O(25)-Zn(2)-O(23)	92.3(2)	C(20)-S(5)-C(21)	104.3(4)
O(28)-Zn(2)-O(27)	92.5(2)	O(12)-S(6)-O(11)	108.6(4)
O(25)-Zn(2)-O(27)	179.7(3)	O(12)-S(6)-C(21)	101.4(4)
O(23)-Zn(2)-O(27)	87.5(2)	O(11)-S(6)-C(21)	98.4(4)
O(28)-Zn(2)-O(26)	85.2(2)	O(13)-S(7)-O(14)	117.9(4)
O(25)-Zn(2)-O(26)	88.2(3)	O(13)-S(7)-C(27)	110.3(5)
O(23)-Zn(2)-O(26)	94.8(2)	O(14)-S(7)-C(27)	107.0(5)
O(27)-Zn(2)-O(26)	92.0(3)	O(13)-S(7)-C(28)	106.7(4)
O(28)-Zn(2)-O(24)	94.5(2)	O(14)-S(7)-C(28)	109.9(4)
O(25)-Zn(2)-O(24)	92.2(3)	C(27)-S(7)-C(28)	104.3(4)
O(23)-Zn(2)-O(24)	85.4(2)	O(15)-S(8)-O(16)	108.6(4)
O(27)-Zn(2)-O(24)	87.5(3)	O(15)-S(8)-C(28)	97.9(4)
O(26)-Zn(2)-O(24)	179.5(3)	O(16)-S(8)-C(28)	101.8(4)
O(2)-S(1)-O(1)	118.3(4)	Zn(1)-O(17)-H(17A)	109.1
O(2)-S(1)-C(7)	108.4(4)	Zn(1)-O(17)-H(17B)	109.5
O(1)-S(1)-C(7)	107.5(4)	H(17A)-O(17)-H(17B)	109.5
O(2)-S(1)-C(6)	109.0(5)	Zn(1)-O(18)-H(18A)	109.9
O(1)-S(1)-C(6)	109.4(4)	Zn(1)-O(18)-H(18B)	108.6
C(7)-S(1)-C(6)	103.2(5)	H(18A)-O(18)-H(18B)	109.5
O(4)-S(2)-O(3)	110.5(4)	Zn(1)-O(19)-H(19A)	109.7
O(4)-S(2)-C(7)	101.8(4)	Zn(1)-O(19)-H(19B)	109.1
O(3)-S(2)-C(7)	98.3(4)	H(19A)-O(19)-H(19B)	109.5
O(6)-S(3)-O(5)	117.5(4)	Zn(1)-O(20)-H(20A)	109.5
O(6)-S(3)-C(14)	106.9(4)	Zn(1)-O(20)-H(20B)	109.3
O(5)-S(3)-C(14)	108.9(4)	H(20A)-O(20)-H(20B)	109.5

Zn(1)-O(21)-H(21C)	109.4	C(4)-C(5)-C(6)	118.3(9)
Zn(1)-O(21)-H(21D)	109.3	C(4)-C(5)-H(5)	120.9
H(21C)-O(21)-H(21D)	109.5	C(6)-C(5)-H(5)	120.9
Zn(1)-O(22)-H(22A)	109.1	C(1)-C(6)-C(5)	119.9(9)
Zn(1)-O(22)-H(22B)	109.7	C(1)-C(6)-S(1)	121.8(8)
H(22A)-O(22)-H(22B)	109.5	C(5)-C(6)-S(1)	118.2(8)
Zn(2)-O(23)-H(23A)	109.2	S(1)-C(7)-S(2)	116.2(5)
Zn(2)-O(23)-H(23B)	109.7	S(1)-C(7)-H(7A)	108.2
H(23A)-O(23)-H(23B)	109.4	S(2)-C(7)-H(7A)	108.2
Zn(2)-O(24)-H(24A)	108.7	S(1)-C(7)-H(7B)	108.2
Zn(2)-O(24)-H(24B)	109.6	S(2)-C(7)-H(7B)	108.2
H(24A)-O(24)-H(24B)	109.4	H(7A)-C(7)-H(7B)	107.4
Zn(2)-O(25)-H(25A)	109.6	C(13)-C(8)-C(9)	118.6(11)
Zn(2)-O(25)-H(25B)	109.0	C(13)-C(8)-H(8)	120.7
H(25A)-O(25)-H(25B)	109.5	C(9)-C(8)-H(8)	120.7
Zn(2)-O(26)-H(26A)	109.9	C(10)-C(9)-C(8)	120.3(12)
Zn(2)-O(26)-H(26B)	109.0	C(10)-C(9)-H(9)	119.9
H(26A)-O(26)-H(26B)	109.4	C(8)-C(9)-H(9)	119.9
Zn(2)-O(27)-H(27A)	109.6	C(9)-C(10)-C(11)	122.1(11)
Zn(2)-O(27)-H(27B)	108.9	C(9)-C(10)-H(10)	119.0
H(27A)-O(27)-H(27B)	109.5	C(11)-C(10)-H(10)	119.0
Zn(2)-O(28)-H(28C)	109.7	C(10)-C(11)-C(12)	118.2(10)
Zn(2)-O(28)-H(28D)	109.3	C(10)-C(11)-H(11)	120.9
H(28C)-O(28)-H(28D)	109.5	C(12)-C(11)-H(11)	120.9
C(6)-C(1)-C(2)	120.5(10)	C(13)-C(12)-C(11)	118.0(11)
C(6)-C(1)-H(1)	119.7	C(13)-C(12)-H(12)	121.0
C(2)-C(1)-H(1)	119.7	C(11)-C(12)-H(12)	121.0
C(3)-C(2)-C(1)	119.0(11)	C(8)-C(13)-C(12)	122.7(11)
C(3)-C(2)-H(2)	120.5	C(8)-C(13)-S(3)	119.3(9)
C(1)-C(2)-H(2)	120.5	C(12)-C(13)-S(3)	118.0(8)
C(4)-C(3)-C(2)	120.6(11)	S(3)-C(14)-S(4)	115.1(5)
C(4)-C(3)-H(3)	119.7	S(3)-C(14)-H(14A)	108.5
C(2)-C(3)-H(3)	119.7	S(4)-C(14)-H(14A)	108.5
C(3)-C(4)-C(5)	121.6(10)	S(3)-C(14)-H(14B)	108.5
C(3)-C(4)-H(4)	119.2	S(4)-C(14)-H(14B)	108.5
C(5)-C(4)-H(4)	119.2	H(14A)-C(14)-H(14B)	107.5

C(16)-C(15)-C(20)	121.1(11)	C(25)-C(26)-C(27)	116.1(11)
C(16)-C(15)-H(15)	119.5	C(25)-C(26)-H(26)	122.0
C(20)-C(15)-H(15)	119.5	C(27)-C(26)-H(26)	121.9
C(15)-C(16)-C(17)	120.7(11)	C(22)-C(27)-C(26)	122.3(11)
C(15)-C(16)-H(16)	119.6	C(22)-C(27)-S(7)	120.7(9)
C(17)-C(16)-H(16)	119.7	C(26)-C(27)-S(7)	117.0(8)
C(18)-C(17)-C(16)	119.6(11)	S(7)-C(28)-S(8)	115.6(5)
C(18)-C(17)-H(17)	120.2	S(7)-C(28)-H(28A)	108.4
C(16)-C(17)-H(17)	120.2	S(8)-C(28)-H(28A)	108.4
C(17)-C(18)-C(19)	120.1(11)	S(7)-C(28)-H(28B)	108.4
C(17)-C(18)-H(18)	120.0	S(8)-C(28)-H(28B)	108.4
C(19)-C(18)-H(18)	120.0	H(28A)-C(28)-H(28B)	107.5
C(20)-C(19)-C(18)	118.6(10)		
C(20)-C(19)-H(19)	120.7		
C(18)-C(19)-H(19)	120.7		
C(15)-C(20)-C(19)	120.0(10)		
C(15)-C(20)-S(5)	120.6(8)		
C(19)-C(20)-S(5)	119.4(8)		
S(5)-C(21)-S(6)	116.2(5)		
S(5)-C(21)-H(21A)	108.2		
S(6)-C(21)-H(21A)	108.2		
S(5)-C(21)-H(21B)	108.2		
S(6)-C(21)-H(21B)	108.2		
H(21A)-C(21)-H(21B)	107.4		
C(27)-C(22)-C(23)	121.3(12)		
C(27)-C(22)-H(22)	119.3		
C(23)-C(22)-H(22)	119.3		
C(24)-C(23)-C(22)	118.9(12)		
C(24)-C(23)-H(23)	120.5		
C(22)-C(23)-H(23)	120.5		
C(25)-C(24)-C(23)	119.0(12)		
C(25)-C(24)-H(24)	120.5		
C(23)-C(24)-H(24)	120.5		
C(24)-C(25)-C(26)	122.3(12)		
C(24)-C(25)-H(25)	118.9		
C(26)-C(25)-H(25)	118.9		

Symmetry transformations used to generate equiv.alent atoms:

Table S4. Anisotropic displacement parameters ($Å^2$x 10^3) for CCDC # 982543. The anisotropic displacement factor exponent takes the form: $-2\pi^2[h^2 a^{*2}U^{11} + ... + 2 h k a^* b^* U^{12}]$

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
Zn(1)	14(1)	22(1)	13(1)	-1(1)	2(1)	1(1)
Zn(2)	15(1)	25(1)	16(1)	1(1)	3(1)	1(1)
S(1)	20(1)	20(1)	15(1)	0(1)	3(1)	-2(1)
S(2)	15(1)	21(1)	13(1)	0(1)	5(1)	0(1)
S(3)	13(1)	24(1)	15(1)	0(1)	3(1)	1(1)
S(4)	10(1)	26(1)	18(1)	1(1)	3(1)	-1(1)
S(5)	15(1)	21(1)	16(1)	0(1)	1(1)	-2(1)
S(6)	13(1)	25(1)	17(1)	-2(1)	4(1)	0(1)
S(7)	16(1)	21(1)	14(1)	1(1)	3(1)	0(1)
S(8)	12(1)	22(1)	16(1)	2(1)	5(1)	2(1)
O(1)	20(4)	21(4)	26(4)	-4(3)	7(3)	6(3)
O(2)	34(4)	22(4)	16(3)	4(3)	-4(3)	0(3)
O(3)	27(4)	23(4)	9(3)	-6(2)	9(3)	-5(3)
O(4)	16(4)	15(3)	19(3)	-3(2)	3(3)	3(3)
O(5)	23(4)	27(4)	14(3)	-8(3)	1(3)	3(3)
O(6)	11(4)	20(4)	24(4)	1(3)	-3(3)	5(3)
O(7)	33(4)	24(4)	9(3)	-2(3)	8(3)	5(3)
O(8)	14(4)	27(4)	15(3)	-3(3)	5(3)	-3(3)
O(9)	24(4)	27(4)	23(4)	-2(3)	-6(3)	-1(3)
O(10)	19(4)	30(4)	20(4)	3(3)	1(3)	-2(3)
O(11)	21(4)	32(4)	11(3)	-7(3)	2(3)	8(3)
O(12)	24(4)	23(4)	30(4)	8(3)	6(3)	3(3)
O(13)	20(4)	36(4)	19(4)	3(3)	11(3)	2(3)
O(14)	39(5)	24(4)	18(3)	-2(3)	7(3)	-2(3)
O(15)	15(4)	25(4)	14(3)	1(3)	3(3)	5(3)
O(16)	21(4)	25(4)	24(4)	-7(3)	9(3)	-7(3)
O(17)	17(4)	26(4)	9(3)	-4(2)	4(3)	2(3)

O(18)	27(5)	38(4)	11(3)	-4(3)	5(3)	2(3)
O(19)	18(4)	32(4)	16(3)	2(3)	0(3)	-1(3)
O(20)	51(5)	13(4)	10(3)	3(3)	12(3)	-7(3)
O(21)	17(4)	29(4)	15(3)	2(3)	8(3)	1(3)
O(22)	11(4)	21(4)	18(3)	3(2)	-6(3)	-5(3)
O(23)	18(4)	18(3)	23(4)	2(3)	-11(3)	-3(3)
O(24)	21(4)	24(4)	23(4)	-6(3)	9(3)	-3(3)
O(25)	14(4)	23(4)	23(3)	-4(3)	6(3)	3(3)
O(26)	12(4)	15(4)	24(3)	6(3)	-3(3)	1(3)
O(27)	19(4)	21(4)	31(4)	-2(3)	-2(3)	0(3)
O(28)	8(3)	26(3)	11(3)	-2(2)	8(2)	-1(2)
C(1)	9(4)	20(4)	23(4)	-5(3)	3(3)	4(3)
C(2)	30(7)	28(7)	26(6)	8(4)	15(5)	-5(5)
C(3)	29(7)	17(5)	24(5)	2(4)	6(5)	-4(4)
C(4)	24(7)	29(6)	30(6)	11(5)	-1(5)	8(5)
C(5)	16(6)	19(5)	23(5)	2(4)	7(4)	10(4)
C(6)	9(4)	18(4)	17(4)	0(3)	4(3)	-1(3)
C(7)	19(5)	24(5)	20(5)	1(4)	-4(4)	2(4)
C(8)	30(7)	30(6)	26(6)	-9(5)	1(5)	3(5)
C(9)	24(7)	19(7)	55(7)	-5(5)	-4(6)	2(5)
C(10)	14(6)	51(8)	24(6)	7(5)	-5(5)	-8(5)
C(11)	10(6)	28(6)	33(6)	5(5)	5(5)	1(5)
C(12)	11(5)	30(6)	30(6)	-1(5)	-9(4)	5(5)
C(13)	10(6)	24(6)	17(5)	6(4)	5(4)	-2(5)
C(14)	10(5)	31(6)	9(4)	-1(4)	-3(4)	7(4)
C(15)	13(4)	26(4)	17(4)	-7(3)	6(3)	4(3)
C(16)	22(7)	66(9)	14(5)	-14(5)	10(5)	4(6)
C(17)	34(8)	28(7)	46(7)	-17(5)	-5(6)	18(6)
C(18)	32(8)	19(6)	37(6)	-8(4)	-8(5)	9(5)
C(19)	16(4)	29(4)	28(4)	-4(3)	-1(3)	-5(4)
C(20)	14(6)	25(6)	14(5)	-5(4)	3(4)	-4(4)
C(21)	6(5)	21(5)	27(5)	-6(4)	10(4)	2(4)
C(22)	31(7)	21(6)	25(6)	6(4)	-2(5)	-1(5)
C(23)	22(7)	61(9)	29(6)	24(6)	0(5)	5(6)
C(24)	24(7)	41(8)	45(7)	-2(5)	-1(6)	19(6)
C(25)	28(7)	22(7)	41(7)	-3(5)	-5(6)	5(5)

C(26)	31(7)	20(6)	35(6)	-7(5)	9(5)	3(5)
C(27)	10(6)	36(6)	13(5)	8(4)	-1(4)	11(4)
C(28)	12(4)	20(4)	14(3)	0(3)	8(3)	1(3)

Table S5. Hydrogen coordinates (x 10^4) and isotropic displacement parameters ($Å^2$x 10^3) for CCDC # 982543.

	x	y	z	U(eq)
H(17A)	5384	8581	2178	26
H(17B)	5769	8238	1286	26
H(18A)	7308	7646	1707	37
H(18B)	6725	7481	3058	37
H(19A)	9511	8434	1754	33
H(19B)	10356	8137	2659	33
H(20A)	6847	8799	5215	36
H(20B)	7686	8950	3970	36
H(21C)	5068	7802	4347	30
H(21D)	4660	8222	4441	30
H(22A)	8315	7874	6213	25
H(22B)	9674	8116	5845	25
H(23A)	5458	3089	-873	30
H(23B)	5804	2695	-275	30
H(24A)	7379	2428	1695	34
H(24B)	6242	2590	2691	34
H(25A)	9985	2803	857	30
H(25B)	10423	3222	914	30
H(26A)	8619	3872	559	26
H(26B)	6910	3929	644	26
H(27A)	4464	3143	1875	35
H(27B)	4817	3564	1708	35
H(28C)	9558	3324	3396	22
H(28D)	8036	3443	3951	22

H(1)	8185	10401	-88	21
H(2)	10544	10726	-862	33
H(3)	13082	10417	-377	28
H(4)	13250	9777	677	33
H(5)	10955	9455	1528	23
H(7A)	6448	9634	-962	25
H(7B)	5804	9266	24	25
H(8)	7198	5386	5007	34
H(9)	9685	5716	5543	40
H(10)	12100	5388	5152	36
H(11)	12149	4754	3983	28
H(12)	9600	4411	3422	29
H(14A)	4550	4315	5095	20
H(14B)	5478	4670	6022	20
H(15)	4770	6933	682	22
H(16)	7160	6613	1381	41
H(17)	7144	5982	2666	43
H(18)	4670	5688	3249	36
H(19)	2165	6010	2455	30
H(21A)	558	6741	3385	22
H(21B)	-319	7103	2459	22
H(22)	5790	1881	4262	31
H(23)	8112	1541	3480	45
H(24)	7796	921	2165	44
H(25)	5198	651	1731	37
H(26)	2881	981	2612	34
H(28A)	673	2135	2668	18
H(28B)	1288	1764	1683	18

Table S6. Torsion angles [°] for CCDC # 982543.

C(6)-C(1)-C(2)-C(3)	-0.4(15)
C(1)-C(2)-C(3)-C(4)	2.3(16)
C(2)-C(3)-C(4)-C(5)	-3.4(16)

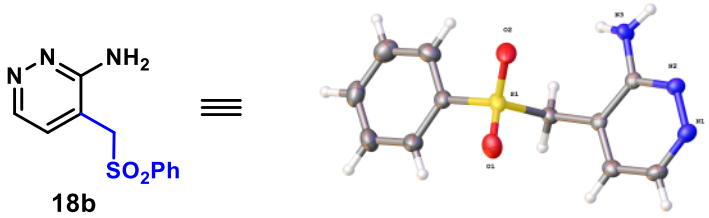
C(3)-C(4)-C(5)-C(6)	2.5(16)
C(2)-C(1)-C(6)-C(5)	-0.4(15)
C(2)-C(1)-C(6)-S(1)	179.1(8)
C(4)-C(5)-C(6)-C(1)	-0.6(14)
C(4)-C(5)-C(6)-S(1)	179.9(8)
O(2)-S(1)-C(6)-C(1)	-163.0(8)
O(1)-S(1)-C(6)-C(1)	-32.2(9)
C(7)-S(1)-C(6)-C(1)	82.0(9)
O(2)-S(1)-C(6)-C(5)	16.5(9)
O(1)-S(1)-C(6)-C(5)	147.3(7)
C(7)-S(1)-C(6)-C(5)	-98.5(8)
O(2)-S(1)-C(7)-S(2)	-57.8(6)
O(1)-S(1)-C(7)-S(2)	173.2(5)
C(6)-S(1)-C(7)-S(2)	57.6(6)
O(4)-S(2)-C(7)-S(1)	71.0(6)
O(3)-S(2)-C(7)-S(1)	-175.9(5)
C(13)-C(8)-C(9)-C(10)	-1.8(17)
C(8)-C(9)-C(10)-C(11)	3.3(18)
C(9)-C(10)-C(11)-C(12)	-3.2(16)
C(10)-C(11)-C(12)-C(13)	1.7(14)
C(9)-C(8)-C(13)-C(12)	0.5(16)
C(9)-C(8)-C(13)-S(3)	-176.6(8)
C(11)-C(12)-C(13)-C(8)	-0.4(15)
C(11)-C(12)-C(13)-S(3)	176.7(7)
O(6)-S(3)-C(13)-C(8)	34.8(9)
O(5)-S(3)-C(13)-C(8)	164.0(8)
C(14)-S(3)-C(13)-C(8)	-79.7(9)
O(6)-S(3)-C(13)-C(12)	-142.5(8)
O(5)-S(3)-C(13)-C(12)	-13.3(9)
C(14)-S(3)-C(13)-C(12)	103.1(8)
O(6)-S(3)-C(14)-S(4)	-177.1(4)
O(5)-S(3)-C(14)-S(4)	54.9(6)
C(13)-S(3)-C(14)-S(4)	-61.1(6)
O(7)-S(4)-C(14)-S(3)	-75.4(6)
O(8)-S(4)-C(14)-S(3)	171.7(5)
C(20)-C(15)-C(16)-C(17)	-0.2(15)

C(15)-C(16)-C(17)-C(18)	-0.2(15)
C(16)-C(17)-C(18)-C(19)	1.3(15)
C(17)-C(18)-C(19)-C(20)	-1.9(15)
C(16)-C(15)-C(20)-C(19)	-0.4(14)
C(16)-C(15)-C(20)-S(5)	179.6(7)
C(18)-C(19)-C(20)-C(15)	1.5(14)
C(18)-C(19)-C(20)-S(5)	-178.6(7)
O(10)-S(5)-C(20)-C(15)	11.8(9)
O(9)-S(5)-C(20)-C(15)	141.9(7)
C(21)-S(5)-C(20)-C(15)	-104.1(8)
O(10)-S(5)-C(20)-C(19)	-168.1(7)
O(9)-S(5)-C(20)-C(19)	-38.0(9)
C(21)-S(5)-C(20)-C(19)	76.0(8)
O(10)-S(5)-C(21)-S(6)	-53.9(6)
O(9)-S(5)-C(21)-S(6)	176.0(5)
C(20)-S(5)-C(21)-S(6)	60.8(7)
O(12)-S(6)-C(21)-S(5)	77.3(6)
O(11)-S(6)-C(21)-S(5)	-171.7(5)
C(27)-C(22)-C(23)-C(24)	0.9(16)
C(22)-C(23)-C(24)-C(25)	-1.1(17)
C(23)-C(24)-C(25)-C(26)	-0.4(18)
C(24)-C(25)-C(26)-C(27)	2.0(17)
C(23)-C(22)-C(27)-C(26)	0.8(16)
C(23)-C(22)-C(27)-S(7)	-179.1(8)
C(25)-C(26)-C(27)-C(22)	-2.2(15)
C(25)-C(26)-C(27)-S(7)	177.7(8)
O(13)-S(7)-C(27)-C(22)	-146.1(8)
O(14)-S(7)-C(27)-C(22)	-16.7(9)
C(28)-S(7)-C(27)-C(22)	99.8(8)
O(13)-S(7)-C(27)-C(26)	34.0(9)
O(14)-S(7)-C(27)-C(26)	163.4(7)
C(28)-S(7)-C(27)-C(26)	-80.2(8)
O(13)-S(7)-C(28)-S(8)	-173.7(5)
O(14)-S(7)-C(28)-S(8)	57.4(6)
C(27)-S(7)-C(28)-S(8)	-57.0(6)
O(15)-S(8)-C(28)-S(7)	176.5(5)

O(16)-S(8)-C(28)-S(7)	-72.5(6)

Symmetry transformations used to generate equivalent atoms:

14. X-ray crystallographic data for 18b:



18b

Table S7. Crystal data and structure refinement for CCDC # 982544.

Identification code	CCDC # 982544	
Empirical formula	C12 H15 Cl N3 O3 S	
Molecular formula	C11 H11 N3 O2 S, 0.5(C2 H4 Cl2), H2 O	
Formula weight	316.78	
Temperature	100.0 K	
Wavelength	0.71073 Å	
Crystal system	Monoclinic	
Space group	C 1 2/c 1	
Unit cell dimensions	a = 33.464(4) Å	α= 90°.
	b = 5.2123(6) Å	β= 101.711(4)°.
	c = 16.8968(17) Å	γ = 90°.
Volume	2885.9(6) $Å^3$	
Z	8	
Density (calculated)	1.458 Mg/m^3	
Absorption coefficient	0.420 mm^{-1}	
F(000)	1320	
Crystal size	0.157 x 0.035 x 0.008 mm^3	
Crystal color, habit	Colorless Blade	
Theta range for data collection	1.243 to 25.782°.	
Index ranges	-40<=h<=40, -6<=k<=6, -20<=l<=20	
Reflections collected	41812	
Independent reflections	2768 [R(int) = 0.0865]	
Completeness to theta = 25.000°	100.0 %	
Absorption correction	Semi-empirical from equivalents	
Max. and min. transmission	0.0921 and 0.0670	
Refinement method	Full-matrix least-squares on F^2	
Data / restraints / parameters	2768 / 7 / 209	

Goodness-of-fit on F^2	1.072
Final R indices [I>2sigma(I)]	R1 = 0.0518, wR2 = 0.1127
R indices (all data)	R1 = 0.0801, wR2 = 0.1285
Extinction coefficient	n/a
Largest diff. peak and hole	0.443 and -0.416 e.$Å^{-3}$

Table S8. Atomic coordinates (x 10^4) and equivalent isotropic displacement parameters ($Å^2$x 10^3) for CCDC # 982544. U(eq) is defined as one third of the trace of the orthogonalized U^{ij} tensor.

	x	y	z	U(eq)
S(1)	3828(1)	6431(2)	8953(1)	27(1)
O(1)	4113(1)	7616(5)	9603(1)	35(1)
O(2)	3766(1)	3717(4)	8993(2)	38(1)
N(1)	2958(1)	6777(5)	11100(2)	26(1)
N(2)	2833(1)	5125(5)	10490(2)	22(1)
N(3)	2804(1)	3736(5)	9204(2)	23(1)
C(1)	3187(1)	8764(7)	11005(2)	28(1)
C(2)	3318(1)	9220(6)	10284(2)	25(1)
C(3)	3200(1)	7581(6)	9654(2)	20(1)
C(4)	2946(1)	5493(6)	9779(2)	20(1)
C(5)	3346(1)	7973(6)	8877(2)	22(1)
C(6)	3970(1)	7177(6)	8029(2)	27(1)
C(7)	3840(1)	5619(7)	7360(2)	36(1)
C(8)	3960(1)	6208(8)	6644(2)	41(1)
C(9)	4206(1)	8289(8)	6596(2)	40(1)
C(10)	4335(1)	9838(8)	7273(2)	41(1)
C(11)	4216(1)	9284(7)	7990(2)	35(1)
Cl(1S)	4992(1)	3928(3)	8776(1)	63(1)
C(1S)	5071(2)	5750(20)	9680(10)	36(4)
C(1SB)	4940(3)	3710(20)	9813(14)	55(6)
O(1S)	2662(1)	5672(5)	12455(1)	35(1)

Table S9. Bond lengths [Å] and angles [°] for CCDC # 982544.

S(1)-O(1)	1.439(3)	C(1SB)-C(1SB)#1	1.50(3)
S(1)-O(2)	1.434(3)	C(1SB)-H(1SC)	0.9900
S(1)-C(5)	1.784(3)	C(1SB)-H(1SD)	0.9900
S(1)-C(6)	1.765(3)	O(1S)-H(1S)	0.895(19)
N(1)-N(2)	1.344(4)	O(1S)-H(1SE)	0.91(2)
N(1)-C(1)	1.317(4)	O(1S)-H(1SF)	0.90(2)
N(2)-C(4)	1.345(4)		
N(3)-H(3A)	0.872(18)	O(1)-S(1)-C(5)	108.08(15)
N(3)-H(3B)	0.887(18)	O(1)-S(1)-C(6)	109.00(15)
N(3)-C(4)	1.349(4)	O(2)-S(1)-O(1)	117.84(16)
C(1)-H(1)	0.9500	O(2)-S(1)-C(5)	108.04(15)
C(1)-C(2)	1.396(5)	O(2)-S(1)-C(6)	109.12(16)
C(2)-H(2)	0.9500	C(6)-S(1)-C(5)	103.85(15)
C(2)-C(3)	1.359(4)	C(1)-N(1)-N(2)	120.6(3)
C(3)-C(4)	1.423(4)	N(1)-N(2)-C(4)	119.6(3)
C(3)-C(5)	1.505(4)	H(3A)-N(3)-H(3B)	120(3)
C(5)-H(5A)	0.9900	C(4)-N(3)-H(3A)	119(3)
C(5)-H(5B)	0.9900	C(4)-N(3)-H(3B)	118(2)
C(6)-C(7)	1.388(5)	N(1)-C(1)-H(1)	118.9
C(6)-C(11)	1.381(5)	N(1)-C(1)-C(2)	122.2(3)
C(7)-H(7)	0.9500	C(2)-C(1)-H(1)	118.9
C(7)-C(8)	1.382(5)	C(1)-C(2)-H(2)	120.5
C(8)-H(8)	0.9500	C(3)-C(2)-C(1)	118.9(3)
C(8)-C(9)	1.375(6)	C(3)-C(2)-H(2)	120.5
C(9)-H(9)	0.9500	C(2)-C(3)-C(4)	116.9(3)
C(9)-C(10)	1.395(5)	C(2)-C(3)-C(5)	120.2(3)
C(10)-H(10)	0.9500	C(4)-C(3)-C(5)	122.9(3)
C(10)-C(11)	1.381(5)	N(2)-C(4)-N(3)	115.2(3)
C(11)-H(11)	0.9500	N(2)-C(4)-C(3)	121.7(3)
Cl(1S)-C(1S)	1.773(18)	N(3)-C(4)-C(3)	123.1(3)
Cl(1S)-C(1SB)	1.80(2)	S(1)-C(5)-H(5A)	109.9
C(1S)-C(1S)#1	1.49(3)	S(1)-C(5)-H(5B)	109.9
C(1S)-H(1SA)	0.9900	C(3)-C(5)-S(1)	109.0(2)
C(1S)-H(1SB)	0.9900	C(3)-C(5)-H(5A)	109.9

C(3)-C(5)-H(5B)	109.9
H(5A)-C(5)-H(5B)	108.3
C(7)-C(6)-S(1)	119.7(3)
C(11)-C(6)-S(1)	119.1(3)
C(11)-C(6)-C(7)	121.2(3)
C(6)-C(7)-H(7)	120.5
C(8)-C(7)-C(6)	119.0(3)
C(8)-C(7)-H(7)	120.5
C(7)-C(8)-H(8)	119.6
C(9)-C(8)-C(7)	120.7(4)
C(9)-C(8)-H(8)	119.6
C(8)-C(9)-H(9)	120.1
C(8)-C(9)-C(10)	119.7(3)
C(10)-C(9)-H(9)	120.1
C(9)-C(10)-H(10)	119.9
C(11)-C(10)-C(9)	120.2(4)
C(11)-C(10)-H(10)	119.9
C(6)-C(11)-C(10)	119.2(3)
C(6)-C(11)-H(11)	120.4
C(10)-C(11)-H(11)	120.4
Cl(1S)-C(1S)-H(1SA)	109.8
Cl(1S)-C(1S)-H(1SB)	109.8
C(1S)#1-C(1S)-Cl(1S)	109.4(12)
C(1S)#1-C(1S)-H(1SA)	109.8
C(1S)#1-C(1S)-H(1SB)	109.8
H(1SA)-C(1S)-H(1SB)	108.2
Cl(1S)-C(1SB)-H(1SC)	110.5
Cl(1S)-C(1SB)-H(1SD)	110.5
C(1SB)#1-C(1SB)-Cl(1S)	106.3(15)
C(1SB)#1-C(1SB)-H(1SC)	110.5
C(1SB)#1-C(1SB)-H(1SD)	110.5
H(1SC)-C(1SB)-H(1SD)	108.7
H(1S)-O(1S)-H(1SE)	100(3)
H(1S)-O(1S)-H(1SF)	102(3)

Symmetry transformations used to generate equivalent atoms:

#1 -x+1,-y+1,-z+2

Table S10. Anisotropic displacement parameters ($Å^2 x\ 10^3$) for CCDC # 982544. The anisotropic displacement factor exponent takes the form: $-2\pi^2[\ h^2\ a^{*2}U^{11} + ... \ + 2\ h\ k\ a^*\ b^*\ U^{12}\ ]$

	U^{11}	U^{22}	U^{33}	U^{23}	U^{13}	U^{12}
S(1)	26(1)	21(1)	36(1)	5(1)	12(1)	2(1)
O(1)	25(1)	45(2)	34(1)	4(1)	4(1)	1(1)
O(2)	46(2)	18(1)	58(2)	7(1)	28(1)	4(1)
N(1)	30(2)	25(2)	23(1)	0(1)	6(1)	3(1)
N(2)	26(1)	21(1)	21(1)	1(1)	4(1)	1(1)
N(3)	27(2)	23(2)	21(1)	3(1)	6(1)	-5(1)
C(1)	35(2)	22(2)	27(2)	-3(1)	4(1)	1(2)
C(2)	26(2)	18(2)	32(2)	3(1)	6(1)	2(1)
C(3)	20(2)	18(2)	22(2)	5(1)	4(1)	6(1)
C(4)	20(2)	17(2)	22(2)	4(1)	5(1)	5(1)
C(5)	22(2)	18(2)	27(2)	3(1)	6(1)	-1(1)
C(6)	27(2)	21(2)	35(2)	2(1)	12(1)	3(1)
C(7)	38(2)	27(2)	43(2)	2(2)	9(2)	-6(2)
C(8)	51(2)	39(2)	34(2)	-2(2)	9(2)	3(2)
C(9)	39(2)	43(2)	43(2)	6(2)	21(2)	9(2)
C(10)	40(2)	39(2)	52(2)	1(2)	25(2)	-8(2)
C(11)	39(2)	25(2)	44(2)	-4(2)	18(2)	-5(2)
Cl(1S)	44(1)	81(1)	67(1)	-27(1)	20(1)	-11(1)
C(1S)	25(4)	29(5)	52(9)	-11(4)	6(4)	-2(3)
C(1SB)	36(5)	42(7)	83(14)	-17(7)	5(5)	-7(5)
O(1S)	46(2)	40(2)	22(1)	-2(1)	12(1)	3(1)

Table S11. Hydrogen coordinates (x 10^4) and isotropic displacement parameters ($Å^2$x 10^3) for CCDC # 982544.

	x	y	z	U(eq)
H(3A)	2836(11)	4000(70)	8711(13)	35(10)
H(3B)	2622(8)	2610(50)	9302(19)	28(9)
H(1)	3266	9927	11442	34
H(2)	3486	10652	10234	31
H(5A)	3373	9830	8776	27
H(5B)	3146	7239	8420	27
H(7)	3672	4171	7392	43
H(8)	3871	5163	6182	50
H(9)	4288	8672	6103	48
H(10)	4505	11277	7241	50
H(11)	4301	10340	8452	42
H(1SA)	5364	6164	9855	43
H(1SB)	4917	7381	9584	43
H(1SC)	4654	3302	9844	66
H(1SD)	5120	2352	10099	66
H(1S)	2785(12)	5820(80)	12033(18)	62(14)
H(1SE)	2670(30)	7340(60)	12620(40)	93
H(1SF)	2550(30)	4080(90)	12380(50)	93

Table S12. Hydrogen bonds for CCDC # 982544 [Å and °].

D-H...A	d(D-H)	d(H...A)	d(D...A)	<(DHA)
N(3)-H(3A)...O(1S)#2	0.872(18)	2.09(2)	2.912(3)	157(3)
N(3)-H(3B)...N(2)#3	0.887(18)	2.164(19)	3.051(4)	178(3)
O(1S)-H(1S)...N(1)	0.895(19)	1.86(2)	2.734(3)	166(4)
O(1S)-H(1SE)...N(3)#4	0.91(2)	2.68(8)	2.912(3)	96(5)

O(1S)-H(1SE)...O(1S)#5	0.91(2)	2.06(6)	2.839(2)	143(9)
O(1S)-H(1SF)...O(1S)#6	0.90(2)	1.96(2)	2.839(2)	164(7)

Symmetry transformations used to generate equivalent atoms:

#1 -x+1,-y+1,-z+2 #2 x,-y+1,z-1/2 #3 -x+1/2,-y+1/2,-z+2

#4 x,-y+1,z+1/2 #5 -x+1/2,y+1/2,-z+5/2 #6 -x+1/2,y-1/2,-z+5/2