Electronic Supporting Information

for

Direct C-H amination and C-H chloroamination of 7-deazapurines

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1. Experimental section

General

6-Chloro-7-deazapurine, boronic acid, arylsulfochlorides were purchased from commercial suppliers and used without any further purification. Dry solvents were used as received from supplier. All compounds were fully characterized by NMR and spectra were recorded on a Bruker Avance II 600 ($^1$H at 600.1 MHz, $^{13}$C at 150.9 MHz) or on a Bruker Avance II 500 (499.8 or 500.0 MHz for $^1$H and 125.7 MHz for $^{13}$C) spectrometer. $^1$H and $^{13}$C resonances were assigned using H,C-HSQC and H,C-HMBC spectra. The samples were measured in CDCl$_3$ and chemical shifts (in ppm, δ-scale) were referenced to solvent signal (δ ($^1$H) = 7.26 ppm, δ ($^1$H) = 77.0 ppm) or in (CD$_3$)$_2$CO (δ ($^1$H) = 2.05 ppm, δ ($^1$H) = 29.8 ppm) Coupling constants (J) are given in Hz. All compounds were isolated in pure form and crystallized. Any unassigned peaks in NMR spectra come either from minor traces of solvents used for crystallization (hexane and/or ethyl acetate in the spectra compounds 5a, 6a, 7a and 7b) or are inherent signals of deuterated solvents used for NMR (acetone and water in the spectra of compound 10a). IR spectra were recorded on Nicolet Avatar 370 FT-IR using KBr method. Wavenumbers are given in cm$^{-1}$. High resolution mass spectra were measured on a LTQ Orbitrap XL (Thermo Fisher Scientific) spectrometer using EI ionization technique. Melting points were determined on a Kofler block and are uncorrected. X-ray diffraction experiment of single crystals was carried out on an Xcalibur X-ray diffractometer by monochromatized CuK$_\alpha$ radiation ($\lambda$=1.54180 Å) at 180 K.
1.1. Preparation of starting compounds:

Compounds 1a, 1d, 1e were synthetized according the previously published methods.\(^1\)

Compounds 2-4 were prepared according the published protocol\(^2\) from N-methyl-arylsulfonamides.\(^3\)

7-Benzyl-4-methoxy-7H-pyrrolo[2,3-d]pyrimidine

(6-methoxy-9-benzyl-7-deazapurine) (1b)

6-Chloro-9-benzyl-7-deazapurine (729 mg, 3 mmol) dissolved in methanol (9 ml) and then NaOMe 25 % (~4.4 M) solution in methanol was added dropwise and the mixture was stirred for 3 h at r.t., then quenched with H₂O (9 mL), extracted with EtOAc (20 ml), dried over anhydrous sodium sulphate, filtered and evaporated under reduced pressure. Product was isolated as a white solid (705 mg, 98 %).

M.p. 78-79 °C. \(^1\)H NMR (500 MHz, CDCl₃): 4.13 (s, 3H, CH₃O); 5.43 (s, 2H, CH₂-Ph); 6.55 (d, 1H, \(J_{5,6} = 3.5\) Hz, H-5); 7.00 (d, 1H, \(J_{6,5} = 3.5\) Hz, H-6); 7.19 (m, 2H, H-o-Bn); 7.25 – 7.34 (m, 3H, H-\(m\)-Bn, H-p-Bn); 8.51 (s, 1H, H-2). \(^{13}\)C NMR (125.7 MHz, CDCl₃): 48.19 (CH₂-Ph); 53.62 (CH₃O); 98.78 (CH-5); 105.37 (C-4a); 125.71 (CH-6); 127.45 (CH-o-Bn); 127.83 (CH-p-Bn); 128.79 (CH-\(m\)-Bn); 137.08 (C-\(i\)-Bn); 151.05 (CH-2); 151.94 (C-7a); 163.10 (C-4). IR(KBr): 3120, 3093, 1582, 1459, 1256, 1026, 698. HRMS (ESI) calculated for C₁₄H₁₄ON₃: 240.1131; found 240.1131.
7-Benzyl-4-methyl-7H-pyrrolo[2,3-d]pyrimidine
(6-methyl-9-benzyl-7-deazapurine) (1c)

6-Chloro-9-benzyl-7-deazapurine (972 mg, 4 mmol) Pd(PPh$_3$)$_4$ (0.2 mmol) were placed in an argon-purged vial and then THF (80 mL) was added. To this stirred reaction mixture, Me$_3$Al (2M solution in toluene, 4 mL, 8 mmol) was added dropwise at r.t.. The mixture was then stirred at 75 ° C for 8 h. After cooling to r.t., the reaction mixture was poured onto a mixture of H$_2$O (400 mL), NH$_4$Cl (4 g) and Na$_2$EDTA (1 g) and then extracted with chloroform (3 × 400 mL). The collected organic layers were dried with anhydrous Mg$_2$SO$_4$, filtered and evaporated under reduced pressure. The crude product was purified by column chromatography on silica gel, eluting with hexanes/EtOAc 5:1 to 1:2. Product was isolated as orange oil (760 mg, 85 %).

$^1$H NMR (500 MHz, CDCl$_3$): 2.75 (s, 3H, CH$_3$); 5.46 (s, 2H, CH$_2$-Ph); 6.57 (d, 1H, $J_{5,6} = 3.6$ Hz, H-5); 7.13 (d, 1H, $J_{6,5} = 3.6$ Hz, H-5); 7.21 (m, 2H, H-o-Bn); 7.27 – 7.35 (m, 3H, H-m,p-Bn); 8.80 (s, 1H, H-2). $^{13}$C NMR (150.9 MHz, CDCl$_3$): 21.43 (CH$_3$); 47.92 (CH$_2$-Ph); 99.70 (CH-5); 117.80 (C-4a); 127.55 (CH-o-Bn); 127.63 (CH-6); 127.94 (CH-p-Bn); 128.85 (CH-m-Bn); 136.88 (C-i-Bn); 150.35 (C-7a); 151.40 (CH-2); 159.31 (C-4). IR(KBr): 3120, 3090, 1577, 1452, 1260, 1060, 630. HRMS (ESI) calculated for C$_{14}$H$_{14}$N$_3$: 224.1191; found 224.1191.
Chlorination of 6-phenyl-9-benzyl-7-deazapurine.

Method A: A mixture of 6-phenyl-7-deazapurine 1a (285 mg, 1 mmol) and NCS (141 mg, 1.05 mmol) in DMF (1.5 mL) was stirred at r.t. for 90 h and then the mixture was evaporated under vacuum. The residue was purified by column chromatography on silica gel eluting with hexanes/EtOAc 5:1 to 2:1 to give product 9a (272 mg, 85%) as a colorless solid.

Method B: A mixture of 6-phenyl-7-deazapurine 1a (285 mg, 1 mmol) and 4 (376, 1.5 mmol) in 1,4-dioxane (4 mL) was stirred at r.t. for 45 h and then evaporated under vacuum. The residue was purified by column chromatography on silica gel eluting with hexanes/EtOAc 5:1 to 2:1 to give product 9a (250 mg, 78%) as a colourless solid.

7-Benzyl-5-chloro-4-phenyl-7H-pyrrolo[2,3-d]pyrimidine
(6-phenyl-7-chloro-9-benzyl-7-deazapurine) (9a)

M.p. 117-118 °C. $^1$H NMR (500 MHz, CDCl$_3$): 5.49 (s, 2H, CH$_2$-Ph); 7.19 (s, 1H, H-6); 7.29 (m, 2H, H-o-Bn); 7.30 – 7.39 (m, 3H, H-m,p-Bn); 7.49 – 7.54 (m, 3H, H-m,p-Ph); 7.83 (m, 2H, H-o-Ph); 9.00 (s, 1H, H-2). $^{13}$C NMR (125.7 MHz, CDCl$_3$): 48.05 (CH$_2$-Ph); 104.27 (C-5); 113.14 (C-4a); 125.88 (C-6); 127.86 and 127.87 (CH-o-Bn, CH-m-Ph); 128.30 (CH-p-Bn); 129.00 (CH-m-Bn); 129.72 (CH-p-Ph); 130.30 (CH-o-Ph); 136.09 (C-i-Bn); 136.71 (C-i-Ph); 150.39 (C-7a); 151.92 (CH-2); 159.70 (C-4). IR(KBr): 3099, 3058, 1550, 1465, 1145, 976, 704. HRMS (ESI) calculated for C$_{19}$H$_{15}$N$_3$Cl : 320.0950; found 320.0949.
General procedures for C-H amination and C-H chloroamination of 7-deazapurines:

**General procedure for C-H amination of 7-deazapurines**
7-Deazapurine 1a-1e (0.5 mmol), Pd(OAc)$_2$ (0.025 mmol), Cu(acac)$_2$ (0.05 mmol), bpy (0.05 mmol), Na$_2$CO$_3$ (3.5 mmol) and chlorosulfonamide (1-1.75 mmol) were placed in a vial which was purged with argon. Then 1,4-dioxane (2 mL) was added and the reaction mixture was stirred for 24 h at r.t., quenched with H$_2$O (2 mL), extracted with ethyl acetate (3 x 20 mL) and washed with brine (2 mL). The organic phases were combined and dried over sodium sulphate, filtered, and evaporated under vacuum. The crude product was purified by column chromatography on silica gel, eluting with hexanes/EtOAc (5:1 to 1:2) to afford the corresponding product.

**General procedure for C-H chloroamination of 7-deazapurines**
7-Deazapurine 1a-1e (0.5 mmol), Pd(OAc)$_2$ (0.0125 mmol), CuCl (0.05 mmol), LiCl (1.0 mmol), Ag$_2$CO$_3$ (1.0 mmol) and chlorosulfonamide (1.5-1.75 mmol) were placed in a vial which was purged with argon. Then 1,4-dioxane (2 mL) was added and the reaction mixture was stirred for 24 h at r.t., quenched with H$_2$O (2 mL), extracted with ethyl acetate (3 x 20 mL) and washed with brine (2 mL). The organic phases were combined and dried over sodium sulphate, filtered, and evaporated under vacuum. The crude product was purified by column chromatography on silica gel, eluting with hexanes/EtOAc (5:1 to 1:2) to afford the corresponding product.
Table S1. Optimization for Palladium-Copper catalyzed C-H amination and C-H chloroamination of 6-phenyl-9-benzyl-7-deazapurine (1a) with N-chloro-N-methyl-2-nitrobenzenesulfonamide (4)

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<th>Pd(OAc)(_2) (equiv.)</th>
<th>Cu source (equiv.)</th>
<th>Additive (equiv.)</th>
<th>Base, (equiv.)</th>
<th>NMR conversion, (%)</th>
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<td>2</td>
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<tr>
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<td>2</td>
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<td>19 16</td>
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<td>LiCl (2)</td>
<td>Ag(_2)CO(_3) (2)</td>
<td>8 50</td>
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\(^a\) 70 °C. \(^b\) in THF. \(^c\) in toluene.
N-(7-Benzyl-4-phenyl-7H-pyrrolo[2,3-d]pyrimidin-6-yl)-N-methyl-4-methylbenzenesulfonamide (5a)

6-phenyl-8-[N-(4-methylbenzenesulfonyl)-N-(methyl)amino]-9-benzyl-7-deazapurine (5a)

6-Phenyl-9-benzyl-7-deazapurine 1a (285 mg, 1 mmol) and N-chloro-N-methyl-4-methylbenzenesulfonamide 2 (1098 mg, 5.0 mmol) were used as starting compounds to give product 5a (334 mg, 68%) as white needles after chromatography with hexanes/EtOAc 5:1 to 1:1 and crystallization from EtOAc/hexane.

M.p. 226-227 °C. \( ^1 \)H NMR (500.0 MHz, CDCl\( _3 \)): 2.51 (s 3H, CH\(_3\)-Ts); 2.78 (s, 3H, CH\(_3\)N); 5.73 (bs, 2H, CH\(_2\)Ph); 6.04 (s, 1H, H-5); 7.23-7.33 (m, 5H, H-o,m,p-Bn); 7.38 (m, 2H, H-m-Ts); 7.46-7.51 (m, 3H, H-m,p-Ph); 7.66 (m, 2H, H-o-Ts); 7.92 (m, 2H, H-o-Ph); 9.06 (s, 1H, H-2). \( ^13 \)C NMR (125.7 MHz, CDCl\( _3 \)): 21.67 (CH\(_3\)-Ts); 39.77 (CH\(_3\)N); 45.25 (CH\(_2\)Ph); 96.99 (CH-5); 114.12 (C-4a); 127.65 (CH-p-Bn); 127.90 (CH-o-Bn); 128.57 (CH-o-Ts); 128.68 (CH-m-Bn); 128.76 (CH-o,m-Ph); 129.57 (CH-m-Ts); 130.20 (CH-p-Ph); 132.67 (C-i-Ts); 136.84 (C-i-Bn); 137.16 (C-i-Ph); 138.65 (C-6); 144.73 (C-p-Ts); 150.20 (C-7a); 152.45 (CH-2); 157.37 (C-4). IR(KBr): 2976, 2930, 2817, 1470, 1382, 1355, 1341, 1322, 1186, 1164, 1314, 852, 823, 691. HRMS (ESI) calculated for C\(_{27}\)H\(_{24}\)N\(_4\)O\(_2\)S: 469.1693; found 469.1693.
$N$-(7-benzyl-4-phenyl-7$H$-pyrrolo[2,3-$d$]pyrimidin-6-yl)-$N$-methyl-4-nitrobenzenesulfonamide (6a)

9-benzyl-8-[$N$-(4-nitrophenylsulfonyl)-$N$-(methyl)amino]-6-phenyl-7-deazapurine (6a)

![Chemical Structure]

1a (285 mg, 1 mmol) and $N$-chloro-$N$-methyl-2-nitrobenzenesulfonamide 3 (877 mg, 3.0 mmol) were used as starting compounds to give product 6a (235 mg, 47%) as yellowish needles after chromatography with hexanes/EtOAc 5:1 to 1:1 and crystallization from EtOAc/hexane.

M.p. 231-232 °C. $^1$H NMR (500 MHz, CDCl$_3$): 2.97 (s, 3H, CH$_3$N); 5.74 (bs, 2H, CH$_2$-Ph); 6.04 (s, 1H, H-5); 7.28 (m, 2H, H-o-Bn); 7.28 – 7.35 (m, 3H, H-p,m-Bn); 7.46 – 7.52 (m, 3H, H-m,p-Ph); 7.90 (m, 2H, H-o-Ph); 7.97 (m, 2H, H-o-C$_6$H$_4$NO$_2$); 7.41 (m, 2H, H-m-C$_6$H$_4$NO$_2$); 9.08 (s, 1H, H-2). $^{13}$C NMR (125.7 MHz, CDCl$_3$): 39.91 (CH$_3$-N); 45.34 (CH$_2$-Ph); 97.21 (CH-5); 113.95 (C-4a); 124.21 (CH-m-C$_6$H$_4$NO$_2$); 127.86 (CH-o,p-Bn); 128.61 (CH-o-Ph); 128.81 (CH-m-Bn); 128.92 (CH-m-Ph); 129.64 (CH-o-C$_6$H$_4$NO$_2$); 130.46 (CH-p-Ph); 136.85 (C-i-Bn); 137.24 (C-6); 137.48 (C-i-Ph); 141.52 (C-i-C$_6$H$_4$NO$_2$); 150.37 (C-7a); 150.67 (C-p-C$_6$H$_4$NO$_2$); 152.98 (CH-2); 158.02 (C-4). IR(KBr): 2825, 1537, 1374, 1366, 1362, 1340, 1321, 1305, 1177, 1158, 921. HRMS (ESI) calculated for C$_{26}$H$_{22}$N$_5$O$_4$S : 500.1386; found 500.1387.
N-(7-benzyl-4-phenyl-7H-pyrrolo[2,3-d]pyrimidin-6-yl)-N-methyl-2-nitrobenzenesulfonamide

9-benzyl-8-[N-(2-nitrophenylsulfonyl)-N-(methyl)amino]-6-phenyl-7-deazapurine (7a)

1a (285 mg, 1 mmol) and N-chloro-N-methyl-2-nitrobenzenesulfonamide 4 (877 mg, 3.5 mmol) were used as starting compounds to give product 7a (310 mg, 62 %) as colourless crystals after chromatography with hexanes/EtOAc 5:1 to 1:1 and crystallization from EtOAc/hexane.

M.p. 102-103 °C. 1H NMR (500.0 MHz, CDCl3): 2.94 (s, 3H, CH3N); 5.67 (bs, 2H, CH2Ph); 6.45 (s, 1H, H-5); 7.22 (m, 2H, H-o-Bn); 7.27 (m, 1H, H-p-Bn); 7.30 (m, 2H, H-m-Bn); 7.50-7.53 (m, 3H, H-m,p-Ph); 7.61 (ddd, 1H, J5,6 = 8.1, J5,4 = 7.5, J5,3 = 1.3, H-5-C6H4NO2); 7.67 (ddd, 1H, J3,4 = 8.0, J3,5 = 1.3, J3,6 = 0.5, H-3-C6H4NO2); 7.76 (ddd, 1H, J6,5 = 8.1, J6,4 = 1.4, J6,3 = 0.5, H-6-C6H4NO2); 7.77 (ddd, 1H, J4,3 = 8.0, J4,5 = 7.5, J4,6 = 1.4, H-4-C6H4NO2); 7.97 (m, 2H, H-o-Ph); 9.10 (s, 1H, H-2). 13C NMR (125.7 MHz, CDCl3): 40.53 (CH3N); 45.29 (CH2Ph); 96.40 (CH-5); 113.91 (C-4a); 124.12 (CH-3-C6H4NO2); 127.65 (CH-o-Bn); 127.89 (CH-p-Bn); 128.85 (CH-m-Ph, CH-o-Bn); 128.94 (CH-m-Ph); 130.16 (C-1-C6H4NO2); 130.64 (CH-p-Ph); 131.26 (CH-5-C6H4NO2); 132.23 (CH-6-C6H4NO2); 134.62 (CH-4-C6H4NO2); 136.54 (C-i-Bn); 136.86 (C-i-Ph); 137.04 (C-6); 148.55 (C-2-C6H4NO2); 150.56 (C-7a); 152.40 (CH-2); 157.48 (C-4). IR(KBr): 2821, 1545, 1376, 1368, 1360, 1343, 1318, 1309, 1180, 1163, 924. HRMS (ESI) calculated for C28H22N5O4S : 500.1387; found 500.1387.
6-methoxy-9-Bn-7-deazapurine $\mathbf{1b}$ (240 mg, 1 mmol) and $N$-chloro-$N$-methyl-2-nitrobenzenesulfonamide $\mathbf{4}$ (501 mg, 2 mmol) were used as starting compounds to give product $\mathbf{7b}$ (274 mg, 60%) as white needles after chromatography with hexanes/EtOAc 5:1 to 1:1 and crystallization from EtOAc/hexane.

M.p. 219-220°C. $^1$H NMR (500 MHz, CDCl$_3$): 2.88 (s, 3H, CH$_3$N); 4.09 (s, 3H, CH$_3$O); 5.59 (bs, 2H, CH$_2$-Ph); 6.13 (s, 1H, H-5); 7.17 (m, 2H, H-o-Bn); 7.21 - 7.30 (m, 3H, H-m,p-Bn); 7.61 (ddd, 1H, $J_{5,6} = 8.0$ Hz, $J_{5,4} = 7.4$ Hz, $J_{5,3} = 1.3$ Hz, H-5-C$_6$H$_4$NO$_2$); 7.64 (bddd, 1H, $J_{3,4} = 8.0$ Hz, $J_{3,5} = 1.3$ Hz, H-3-C$_6$H$_4$NO$_2$); 7.71 (bddd, 1H, $J_{6,5} = 8.0$ Hz, $J_{6,4} = 1.4$ Hz, H-6-C$_6$H$_4$NO$_2$); 7.75 (ddd, 1H, (ddd, 1H, $J_{4,3} = 8.0$ Hz, $J_{4,5} = 7.4$ Hz, $J_{4,6} = 1.4$ Hz, H-4-C$_6$H$_4$NO$_2$); 8.57 (s, 1H, H-2). $^{13}$C NMR (125.7 MHz, CDCl$_3$): 40.61 (CH$_3$N); 45.32 (CH$_2$-Ph); 53.77 (CH$_3$-O); 97.07 (CH-5); 103.94 (C-4a); 123.96 (CH-3-C$_6$H$_4$NO$_2$); 127.55 (CH-o-Bn); 127.68 (CH-p-Bn); 128.74 (CH-m-Bn); 130.29 (C-1-C$_6$H$_4$NO$_2$); 131.26 (CH-5-C$_6$H$_4$NO$_2$); 132.22 (CH-6-C$_6$H$_4$NO$_2$); 133.50 (C-6); 134.39 (CH-4-C$_6$H$_4$NO$_2$); 136.99 (C-i-Bn); 148.57 (C-2-C$_6$H$_4$NO$_2$); 150.54 (C-7a); 152.42 (CH-2); 163.04 (C-4). IR(KBr): 3090, 1580, 1549, 1377, 1352, 1262, 1160, 1030, 824, 516. HRMS (ESI) calculated for C$_{21}$H$_{20}$N$_5$O$_5$S : 454.1180; found 454.1179.
N-(7-benzyl-4-methyl-7H-pyrrolo[2,3-d]pyrimidin-6-yl)-N-methyl-2-nitrobenzenesulfonylamide

9-benzyl-6-methyl-8-[N-(2-nitrophenylsulfonyl)-N-(methyl)amino]-7-deazapurine (7c)

6-methyl-9-Bn-7-deazapurine 1c (223 mg, 1 mmol) and N-chloro-N-methyl-2-nitrobenzenesulfonylamide 4 (501 mg, 2 mmol) were used as starting compounds to give product 7c (180 mg, 41%) as yellowish crystals after chromatography with hexanes/EtOAc 5:1 to 1:1 and crystallization from EtOAc/hexane.

M.p. 186-187 °C. 1H NMR (500 MHz, CDCl3): 2.65 (s, 3H, CH3-4); 2.92 (s, 3H, CH3N); 5.59 (bs, 2H, CH2-Ph); 6.18 (s, 1H, H-5); 7.17 (m, 2H, H-o-Bn); 7.21 – 7.30 (m, 3H, H-p,Bn); 7.61 (ddd, 1H, J5.6 = 8.0 Hz, J5.4 = 7.4 Hz, J5.3 = 1.3 Hz, H-5-C6H4NO2); 7.66 (dd, 1H, J3.4 = 8.0 Hz, J3.5 = 1.3 Hz, H-3-C6H4NO2); 7.72 (dd, 1H, J6.5 = 8.0 Hz, J6.4 = 1.4 Hz, H-6-C6H4NO2); 7.76 (ddd, 1H, J4.3 = 8.0 Hz, J4.5 = 7.4 Hz, J4.6 = 1.4 Hz, H-4-C6H4NO2); 8.87 (s, 1H, H-2). 13C NMR (125.7 MHz, CDCl3): 21.48 (CH3-4); 40.57 (CH3-N); 45.06 (CH2-Ph); 97.91 (CH-5); 116.18 (C-4a); 124.07 (CH-3-C6H4NO2); 127.58 (CH-o-Bn); 127.77 (CH-p-Bn); 128.79 (CH-m-Bn); 130.38 (C-1-C6H4NO2); 131.22 (CH-5-C6H4NO2); 132.24 (CH-6-C6H4NO2); 134.51 (CH-4-C6H4NO2); 135.44 (C-6); 136.80 (C-i-Bn); 148.56 (C-2-C6H4NO2); 149.15 (C-7a); 152.80 (CH-2); 159.85 (C-4). IR(KBr): 3063, 1891, 1550, 1377, 1359, 1237, 1201, 1069, 1165, 893, 600. HRMS (ESI) calculated for C21H20N5O4S: 438.1232; found 438.1230.
N-(7-benzyl-5-chloro-4-phenyl-7H-pyrrolo[2,3-d]pyrimidin-6-yl)-N-methyl-2-nitrobenzenesulfonamide

9-benzyl-7-chloro-8-[N-(2-nitrophenylsulfonyl)-N-(methyl)amino]-6-phenyl-7-deazapurine (8a)

Method A, C-H chloroamination: 1a (285 mg, 1 mmol) and 4 (877 mg, 3.5 mmol) were used as starting compounds to give product 8a (273 mg, 51 %) as white crystals after chromatography with hexanes/EtOAc 5:1 to 1:1 and crystallization from EtOAc/hexane.

Method B, C-H amination: 9a (285 mg, 1 mmol) and 4 (752 mg, 3.0 mmol) were used as starting compounds to give product 8a (225 mg, 41 %) as white crystals after chromatography with hexanes/EtOAc 5:1 to 1:1 and crystallization from EtOAc/hexane.

M.p. 215-216 °C. \( ^1 \text{H} \) NMR (500 MHz, CDCl\(_3\)): 2.91 (s, 3H, CH\(_3\)N); 5.42 (d, 1H, \( J_{\text{gem}} = 15.3 \) Hz, CH\(_2\)-a-Ph); 6.16 (d, 1H, \( J_{\text{gem}} = 15.3 \) Hz, CH\(_2\)-b-Ph); 7.26 – 7.31 (m, 3H, H-o,p-Bn); 7.33 (m, 2H, H-m-Bn); 7.42 – 7.50 (m, 3H, H-m,p-Ph); 7.58 – 7.63 (m, 2H, H-3,5-C\(_6\)H\(_4\)NO\(_2\)); 7.71 (m, 2H, H-o-Ph); 7.73 (ddd, 1H, \( J_{4,3} = J_{4,5} = 7.7 \) Hz, \( J_{4,6} = 1.4 \) Hz, H-4-C\(_6\)H\(_4\)NO\(_2\)); 7.84 (m, 1H, H-6-C\(_6\)H\(_4\)NO\(_2\)); 9.09 (s, 1H, H-2). \( ^{13} \text{C} \) NMR (125.7 MHz, CDCl\(_3\)): 38.28 (CH\(_3\)-N); 45.68 (CH\(_2\)-Ph); 103.08 (C-5); 112.02 (C-4a); 124.00 (CH-3-C\(_6\)H\(_4\)NO\(_2\)); 127.84 (CH-m-Ph); 128.09 (CH-p-Bn); 128.11 (CH-o-Bn); 128.95 (CH-m-Bn); 129.86 (CH-p-Ph); 130.20 (CH-o-Ph); 131.45 (CH-5-C\(_6\)H\(_4\)NO\(_2\)); 131.62 (C-1-C\(_6\)H\(_4\)NO\(_2\)); 131.65 (CH-6-C\(_6\)H\(_4\)NO\(_2\)); 131.89 (C-6); 134.49 (CH-4-C\(_6\)H\(_4\)NO\(_2\)); 136.48 (C-i-Bn); 136.62 (C-i-Ph); 148.56 (C-2-C\(_6\)H\(_4\)NO\(_2\)); 148.78 (C-7a); 153.18 (CH-2); 160.20 (C-4). IR(KBr): 3050, 1583, 1545, 1374, 1345, 1165, 826, 558. HRMS (ESI) calculated for C\(_{26}\)H\(_{21}\)N\(_5\)O\(_4\)Cl : 534.0998; found: 534.0997.
N-(7-benzyl-5-chloro-4-methoxy-7H-pyrrolo[2,3-d]pyrimidin-6-yl)-N-methyl-2-nitrobenzenesulfonamide

9-benzyl-7-chloro-6-methoxy-8-[N-(2-nitrophenylsulfonyl)-N-(methyl)amino]-7-deazapurine (8b)

1b (240 mg, 1 mmol) and 4 (752 mg, 3.5 mmol) were used as starting compounds to give product 8b (205 mg, 42%) as white crystals after chromatography with hexanes/EtOAc 5:1 to 1:1 and crystallization from EtOAc/hexane.

M.p. 177-179 °C. $^1$H NMR (500 MHz, CDCl$_3$): 2.87 (s, 3H, CH$_3$N); 4.11 (s, 3H, CH$_3$O); 5.36 (d, 1H, $J_{gem} = 15.4$ Hz, CH$_2$a-Ph); 5.99 (d, 1H, $J_{gem} = 15.4$ Hz, CH$_2$b-Ph); 7.21 (m, 2H, H-o-Bn); 7.24 – 7.33 (m, 3H, H-p,m-Bn); 7.61 (m, 1H, H-3-C$_6$H$_4$NO$_2$); 7.62 (m, 1H, H-5-C$_6$H$_4$NO$_2$); 7.74 (bt, 1H, $J_{4,3} = J_{4,5} = 7.8$ Hz, H-4-C$_6$H$_4$NO$_2$); 7.81 (bd, 1H, $J_{6,5} = 7.9$ Hz, H-6-C$_6$H$_4$NO$_2$); 8.57 (s, 1H, H-2). $^{13}$C NMR (125.7 MHz, CDCl$_3$): 38.30 (CH$_3$-N); 45.74 (CH$_2$-Ph); 54.07 (CH$_3$O); 102.24 (C-4a); 102.49 (C-5); 123.91 (CH-3-C$_6$H$_4$NO$_2$); 127.89 (CH-o-Bn); 127.94 (CH-p-Bn); 128.71 (C-6); 128.85 (CH-m-Bn); 131.51 (C-1-C$_6$H$_4$NO$_2$); 131.69 (CH-5-C$_6$H$_4$NO$_2$); 131.76 (CH-6-C$_6$H$_4$NO$_2$); 134.38 (CH-4-C$_6$H$_4$NO$_2$); 136.70 (C-i-Bn); 148.40 (C-2-C$_6$H$_4$NO$_2$); 148.66 (C-7a); 153.06 (CH-2); 163.08 (C-4). IR(KBr): 3068, 1580, 1374, 1352, 1262, 1160, 1030, 853, 517. HRMS (ESI) calculated for C$_{21}$H$_{15}$N$_5$O$_5$SCl : 488.0790; found 534.0789.
Deprotection of \( N-(7\text{-benzyl-4-phenyl-7H-pyrrolo[2,3-d]pyrimidin-6-yl})-N\text{-methyl-2-nitrobenzenesulfonamide} \) (7a)

Compound 7a (250 mg, 0.5 mmol) and Cs\(_2\)CO\(_3\) (163 mg, 0.5 mmol) were dissolved in dry MeCN (4 mL) under Ar. Then, thiophenol (55 mg (0.051 ml), 0.5 mmol) was added dropwise to the stirred reaction mixture at r.t. and the stirring was continued for 1 h. Then the mixture was filtered and evaporated under vacuum. The residue was purified by column chromatography on silica gel eluting with hexanes/EtOAc 5:1 to 1:1 to get product 10a 118 mg (75 \%) as a yellow solid.

One pot C-H amination/deprotection

6-Phenyl-9-benzyl-7-deazapurine 1a (285 mg, 1 mmol), Pd(OAc)\(_2\) (0.05 mmol), Cu(acac)\(_2\) (0.05 0.1 mmol), bpy (0.1 mmol), Na\(_2\)CO\(_3\) (7 mmol) and \( N\)-chloro-\( N\)-methyl-2-nitrobenzenesulfonamide 4 (877 mg, 3.5 mmol) were placed in an argon-purged vial and then 1,4-dioxane (4 mL) was added. The reaction mixture was then stirred for 24 h at r.t., quenched with H\(_2\)O (4 mL), extracted with ethyl acetate (3 x 40 mL) and washed with brine (4 mL). The organic phases were combined and dried over sodium sulphate, filtered, and evaporated under vacuum. The crude intermediate was combined with Cs\(_2\)CO\(_3\) (326 mg, 1 mmol) in an argon-purged vial and dissolved in dry MeCN (8 mL). Thiophenol (110 mg, 0.102 ml, 1 mmol) was added dropwise through septum to the stirred reaction mixture at r.t. and the stirring was continued for 1 h. The mixture was then quenched with H\(_2\)O (4 mL), extracted with ethyl acetate (3 x 40 mL) and washed with brine (4 mL). The organic phases were combined and dried over sodium sulphate, filtered, and evaporated under vacuum. The residue was purified by column chromatography on silica gel eluting with hexanes/EtOAc 5:1 to 1:1 to get product 10a 110 mg (35 \% in two steps) as a yellow solid.
7-Benzyl-N-methyl-4-phenyl-7H-pyrrolo[2,3-d]pyrimidin-6-amine
(9-benzyl-8-methylamino-6-phenyl-7-deazapurine) (10a)

M.p. 154-155 °C. $^1$H NMR (500.0 MHz, acetone-$d_6$): 2.94 (d, 3H, $J = 5.0$, CH$_3$N); 5.48 (s, 2H, CH$_2$Ph); 5.68 (bq, 1H, $J = 5.0$, MeNH); 5.82 (d, 1H, $J = 0.6$, H-5); 7.20 (m, 2H, H-o-Bn); 7.24 (m, 1H, H-p-Bn); 7.30 (m, 2H, H-m-Bn); 7.44 (m, 1H, H-p-Ph); 7.53 (m, 2H, H-m-Ph); 8.25 (m, 2H, H-o-Ph); 8.57 (s, 1H, H-2). $^{13}$C NMR (125.7 MHz, acetone-$d_6$): 30.97 (CH$_3$N); 43.94 (CH$_2$Ph); 74.20 (CH-5); 117.98 (C-4a); 127.65 (CH-o-Bn); 128.13 (CH-p-Bn); 129.00 (CH-o-Ph); 129.22 (CH-m-Ph); 129.37 (CH-m-Bn); 129.54 (CH-p-Ph); 138.14 (C-i-Bn); 140.35 (C-i-Ph); 148.33 (CH-2); 149.71 (C-4); 150.64 (C-6); 152.97 (C-7a). IR(KBr): 3416, 3220, 3061, 3031, 2820, 1604, 1583, 1570, 1495, 1452, 1344, 1181. HRMS (ESI) calculated for C$_{20}$H$_{19}$N : 315.1604; found 315.1604.
2. Single crystal X-ray structure analysis.

Crystallographic data for compounds 5a, 7a, 7b, 8a were obtained from Xcalibur X-ray diffractometer by monochromatized CuKα radiation (λ=1.54180 Å) at 180 K (7a, 8a), 200 K 5a and 7b 290 K. The structures were solved by direct methods (SIR92)¹ (3c, 3d, 4c) and by charge flipping (SUPERFLIP)² compound 5a. They were all refined by full-matrix least-squares based on F with (CRYSTALS)³. The hydrogen atoms were found on difference Fourier map, recalculated into idealized positions and refined with riding constraints. All other atoms were refined anisotropically.

Crystal data for 5a (colourless, 0.09 x 0.18 x 0.37 mm):

C_{27}H_{24}N_{4}O_{2}S_{1}, monoclinic, space group C2/c, a = 20.7725(4) Å, b = 10.3703(3) Å, c = 22.3779(5) Å, β = 104.039(2)°, V = 4676.61(18) Å³, Z = 8, M = 468.58, 24824 reflections measured, 4828 independent reflections. Final R = 0.043, wR = 0.045, GoF = 1.109 for 3729 reflections with I > 2σ(I) and 307 parameters. CCDC 1014819.

![Figure 1. An ORTEP view of compounds 5a shown with 50 % probability displacement ellipsoids.](image)
**Crystal data for 7a** (orange, 0.45 x 0.68 x 0.72 mm):

\[ \text{C}_{26}\text{H}_{21}\text{N}_{5}\text{O}_{4}\text{S}_{1}, \text{triclinic, space group } P-1, a = 12.8359(2) \, \text{Å}, b = 14.6425(2) \, \text{Å}, c = 16.3039(3) \, \text{Å}, \alpha = 81.5862(13)^\circ, \beta = 70.0238(15)^\circ, \gamma = 67.3666(15)^\circ, V = 2657.75(8) \, \text{Å}^3, Z = 4, M = 499.54, 10790 \text{ reflections measured, } 10790 \text{ independent reflections. Final } R = 0.042, \, wR = 0.040, GoF = 0.968 \text{ for } 9618 \text{ reflections with } I > 2\sigma(I) \text{ and 650 parameters. CCDC 1014820.} \] The asymmetric unit consists of two molecules of 7a. Furthermore, it contains solvent molecules – disordered ethyl acetate and partially occupied water molecules. These were not included in the refinement and the disordered density was taken into account using the SQUEEZE procedure (from PLATON).
Crystal data for 8a (colourless, 0.48 x 0.53 x 0.79 mm):
C_{26}H_{20}Cl_{1}N_{5}O_{4}S_{1}, monoclinic, space group P2_1/n, a = 10.3204(3) Å, b = 10.7781(2) Å, c = 22.4546(7) Å, β = 103.112(3)°, V = 2432.59(12) Å^3, Z = 4, M = 533.99, 17639 reflections measured, 4993 independent reflections. Final R = 0.035, wR = 0.039, GoF = 1.033 for 4759 reflections with I > 2σ(I) and 335 parameters. CCDC 1014817.

Figure 3. An ORTEP view of compounds 8a shown with 50 % probability displacement ellipsoids.
Crystal data for 7b (colourless, 0.21 x 0.30 x 0.83 mm):
C$_{21}$H$_{19}$N$_{5}$O$_{5}$S$_{1}$, triclinic, space group P-1, $a = 8.0254(2)$ Å, $b = 8.5175(2)$ Å, $c = 16.5553(4)$ Å, $\alpha = 76.069(2)^\circ$, $\beta = 76.692(2)^\circ$, $\gamma = 76.024(2)^\circ$, $V = 1047.92(5)$ Å$^3$, $Z = 2$, $M =$ 453.48, 18491 reflections measured, 4263 independent reflections. Final $R = 0.036$, $wR = 0.042$, $GoF = 0.820$ for 3984 reflections with $I > 2\sigma(I)$ and 290 parameters. CCDC 1014818.

Figure 4. An ORTEP view of compounds 7b shown with 50 % probability displacement ellipsoids.
3. Copies of NMR spectra
References:


