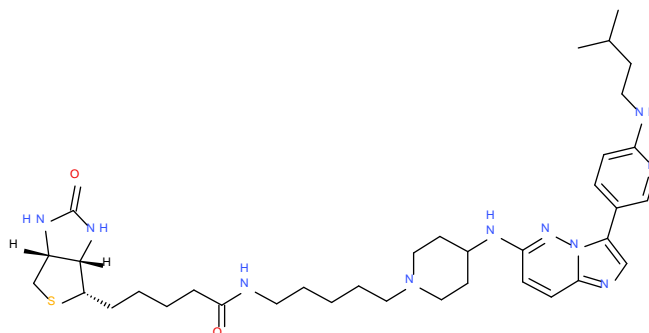


Supplementary Information 1: Synthesis of biotinylated compound D

5-[(3a*S*,4*S*,6a*R*)-2-Oxo-1,3,3a,4,6,6a-hexahydrothieno[3,4-*d*]imidazol-4-yl]-*N*-[5-[4-[[3-[6-(isopentylamino)-3-pyridyl]imidazo[1,2-*b*]pyridazin-6-yl]amino]-1-piperidyl]pentyl]pentanamide



***tert*-Butyl 4-[(3-bromoimidazo[1,2-*b*]pyridazin-6-yl)amino]piperidine-1-carboxylate**

A solution of 3-bromo-6-chloroimidazo[1,2-*b*]pyridazine (3.00 g, 12.9 mmol 1.0 eq) in NMP (5 mL) was treated with *tert*-butyl 4-aminopiperidine-1-carboxylate (5.10 g, 25.8 mmol, 2.0 eq), DIPEA (5.60 mL, 32.3 mmol, 2.5 eq) and heated at 140°C for 8 hours. The reaction mixture was diluted with EtOAc (100 mL) and washed with de-ionised water (4 x 100 mL) and brine (100mL). The separated organic was dried (MgSO₄), concentrated *in vacuo* and column chromatography (50-100% EtOAc in pet. ether) gave an off-white solid (2.07 g, 40%); ¹H NMR (400 MHz, DMSO-*d*₆) δ = 7.71 (d, *J*=9.6 Hz, 1 H), 7.48 (s, 1 H), 7.10 (d, *J*=7.3 Hz, 1H), 6.68 (d, *J*=10.1 Hz, 1H), 3.87-3.82 (m, 3H), 3.02-2.93 (m, 2H), 2.02-1.98 (m, 2H), 1.41 (s, 9H), 1.40-1.31 (m, 2H); *m/z* (ES+APCI)⁺: 396/398 [M+H]⁺.

3-[6-(Isopentylamino)-3-pyridyl]-*N*-(4-piperidyl)imidazo[1,2-*b*]pyridazin-6-amine

A mixture of *tert*-butyl 4-[(3-bromoimidazo[1,2-*b*]pyridazin-6-yl)amino]piperidine-1-carboxylate (1.00 g, 2.52 mmol, 1.0 eq), 2-isopentylamino-5-pyridineboronic acid pinacol ester (876 mg, 3.02 mmol, 1.2 eq), Pd(dppf)Cl₂ (238 mg, 0.29 mmol, 0.1 eq), Cs₂CO₃ (3.28 g, 10.08 mmol, 4.0 eq), water (1 mL) and THF (10 mL) was heated at 90°C for 4 hours. The mixture was allowed to cool, then concentrated to dryness and purified by chromatography on silica gel (50-100% EtOAc in pet. ether) to give 223 mg of the protected intermediate which was treated with 4M HCl in Dioxane and purification by prep-HPLC gave the product as a white solid (140 mg, 15%); ¹H NMR (400MHz, DMSO-*d*₆) δ = 8.70 (d, *J*=2.3 Hz, 1H), 8.07 (dd, *J*=2.5, 8.9 Hz, 1H), 7.69 (d, *J*=9.6 Hz, 1H), 7.67 (s, 1H), 6.93 (d, *J*=6.9 Hz, 1H), 6.67-6.63 (m, 1H), 6.61 (d, *J*=9.6 Hz, 1H), 6.52 (d, *J*=8.2 Hz, 1H), 3.76-3.58 (m, 1H), 3.34-3.22 (m, 2H),

3.07-2.96 (m, 2H), 2.65-2.55 (m, 2H), 2.07-1.95 (m, 2H), 1.76-1.57 (m, 1H), 1.51-1.40 (m, 2H), 1.40-1.29 (m, 2H), 0.91 (d, $J=6.9$ Hz, 6H); m/z (ES+APCI)⁺: 380 [M+H]⁺.

Benzyl N-(5-bromopentyl)carbamate

To a solution of benzyl N-(5-hydroxypentyl)carbamate (1.00 g, 4.21 mmol, 1.0 eq) in DCM was added tetrabromomethane (1.53 g, 4.63 mmol, 1.1 eq) and triphenylphosphine (2.20 g, 8.42 mmol, 2.0 eq) and the reaction mixture was stirred overnight at RT. The solution was concentrated *in vacuo* and purification by column chromatography (10-50% EtOAc in pet. ether) gave the product as a white solid (1.10 g, 87%); ¹H NMR (400MHz, CDCl₃) δ = 7.42-7.27 (m, 5H), 5.08 (s, 2H), 4.77 (br. s, 1H), 3.39 (t, $J=6.6$ Hz, 2H), 3.20 (q, $J=6.4$ Hz, 2H), 1.86 (quin, $J=7.0$ Hz, 2H), 1.59-1.39 (m, 4H).

N-[1-(5-Aminopentyl)-4-piperidyl]-3-[6-(isopentylamino)-3-pyridyl]imidazo[1,2-b]pyridazin-6-amine

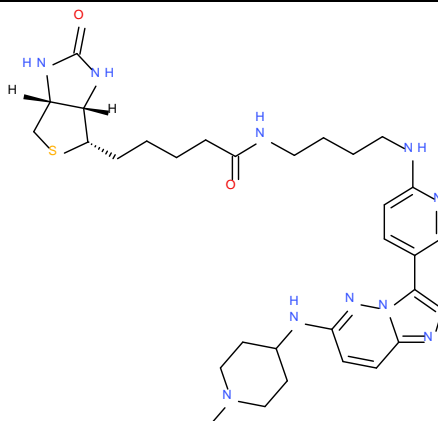
To a solution of 3-[6-(isopentylamino)-3-pyridyl]-N-(4-piperidyl)imidazo[1,2-b]pyridazin-6-amine (140 mg, 0.368 mmol, 1.0 eq) in EtOH (2 mL) was added Et₃N (102 μ L, 0.736 mmol, 2.0 eq) and benzyl N-(5-bromopentyl)carbamate (110 mg, 0.368 mmol, 1.0 eq) and stirred overnight at RT. The reaction mixture was concentrated *in vacuo* and purification by column chromatography (5-25% MeOH in DCM) to give the protected intermediate which was hydrogenated on an H-Cube (10% Pd/C, Full H₂, 50°C) to give the product as an off-white solid (44 mg, 26%); ¹H NMR (400MHz, DMSO-d₆) δ = 8.73 (s, 1H), 8.72 (s, 1H), 8.05 (d, $J=8.2$ Hz, 1H), 7.71-7.67 (m, 1H), 7.67 (s, 1H), 6.92 (d, $J=6.2$ Hz, 1H), 6.66 (t, $J=5.7$ Hz, 1H), 6.61 (d, $J=9.6$ Hz, 1H), 6.52 (d, $J=9.0$ Hz, 1H), 4.10 (m, 2H), 3.58 (m, 1H), 3.37-3.26 (m, 2H), 2.85 (d, $J=11.4$ Hz, 2H), 2.75-2.70 (m, 2H), 2.28-2.25 (m, 2H), 2.08-1.94 (m, 4H), 1.71-1.62 (m, 1H), 1.54-1.39 (m, 8H), 1.35-1.23 (m, 2H), 0.92 (d, $J=6.9$ Hz, 6H).

5-[(3aS,4S,6aR)-2-Oxo-1,3,3a,4,6,6a-hexahydrothieno[3,4-d]imidazol-4-yl]-N-[5-[4-[[3-[6-(isopentylamino)-3-pyridyl]imidazo[1,2-b]pyridazin-6-yl]amino]-1-piperidyl]pentyl]pentanamide

To a solution of biotin (21 mg, 0.086 mmol, 1.0 eq) in DMF (1 mL) and Et₃N (60 μ L, 0.43 mmol, 5.0 eq) was added TBTU (30 mg, 0.095 mmol, 1.1 eq) and the mixture stirred at RT for 10 minutes before adding N-[1-(5-aminopentyl)-4-piperidyl]-3-[6-(isopentylamino)-3-pyridyl]imidazo[1,2-b]pyridazin-6-amine (44 mg, 0.095 mmol, 1.1 eq). The reaction mixture was stirred for 2 hours at RT, concentrated *in vacuo* and purification by prep-HPLC gave the product as a yellow solid (26 mg, 40%); ¹H NMR (400MHz, DMSO-d₆) δ = 8.71 (s, 1H), 8.06 (d, $J=8.2$ Hz, 1H), 7.77-7.66 (m, 3H), 6.92 (d, $J=6.0$ Hz,

1H), 6.66 (t, $J=5.5$ Hz, 1H), 6.61 (d, $J=10.1$ Hz, 1H), 6.52 (d, $J=8.9$ Hz, 1H), 6.43 (s, 1H), 6.36 (s, 1H), 4.31-4.27 (m, 1H), 4.14-4.09 (m, 1H), 3.55 (m, 1H), 3.33-3.30 (m, 2H), 3.12-2.99 (m, 3H), 2.81 (m, 3H), 2.59-2.52 (m, 1H), 2.26 (br. s, 2H), 2.11-1.95 (m, 6H), 1.71-1.53 (m, 2H), 1.52-1.36 (m, 11H), 1.34-1.23 (m, 4H), 0.92 (d, $J=6.4$ Hz, 6H); m/z (ES+APCI)⁺: 691 [M+H]⁺.

5-[(3a*S*,4*S*,6a*R*)-2-Oxo-1,3,3a,4,6,6a-hexahydrothieno[3,4-*d*]imidazol-4-yl]-*N*-[4-[[5-[6-[(1-methyl-4-piperidyl)amino]imidazo[1,2-*b*]pyridazin-3-yl]-2-pyridyl]amino]butyl]pentanamide



3-(6-Chloro-3-pyridyl)-*N*-(1-methyl-4-piperidyl)imidazo[1,2-*b*]pyridazin-6-amine

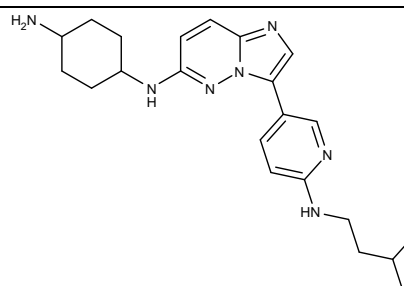
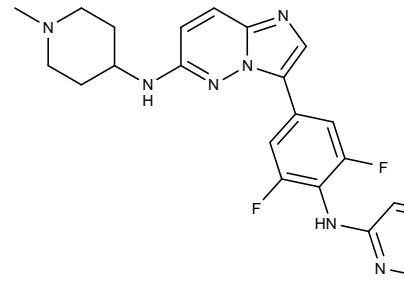
A mixture of 3-bromo-*N*-(1-methyl-4-piperidyl)imidazo[1,2-*b*]pyridazin-6-amine (1.00 g, 3.22 mmol, 1.0 eq), (6-chloro-3-pyridyl)boronic acid (608 mg, 3.86 mmol, 1.2 eq), Pd(dppf)Cl₂ (262 mg, 0.32 mmol, 0.1 eq), Cs₂CO₃ (4.2 g, 12.88 mmol, 4.0 eq), water (1 mL) and THF (10 mL) was combined and heated at 80°C for 4 hours. The mixture was allowed to cool, then concentrated to dryness and purified by column chromatography (50-100% EtOAc in pet. ether) to give the crude product as a yellow solid (853 mg, 77%) which was used without further purification; ¹H NMR (400MHz, DMSO-*d*₆) δ = 9.21 (d, $J=3.2$ Hz, 1H), 8.55 (dd, $J=2.5, 8.5$ Hz, 1H), 8.02 (s, 1H), 7.76 (d, $J=9.6$ Hz, 1H), 7.58 (d, $J=9.2$ Hz, 1H), 7.11 (d, $J=6.3$ Hz, 1H), 6.74-6.63 (m, 1H), 3.65-3.48 (m, 1H), 2.85-2.68 (m, 2H), 2.21 (s, 3H), 2.19-2.07 (m, 2H), 2.05-1.94 (m, 2H), 1.56-1.39 (m, 2H).

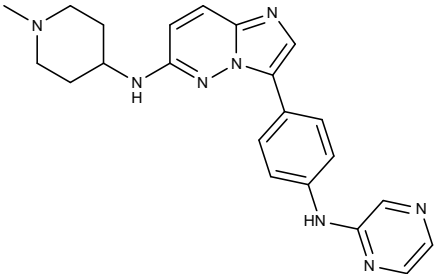
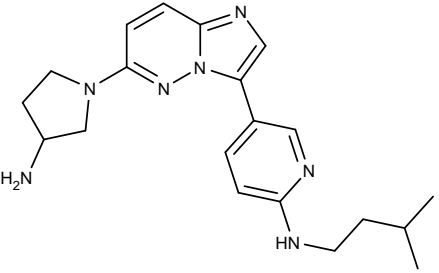
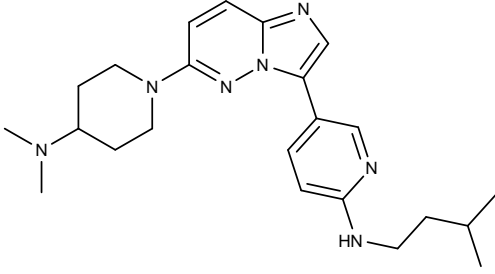
5-[(3a*S*,4*S*,6a*R*)-2-Oxo-1,3,3a,4,6,6a-hexahydrothieno[3,4-*d*]imidazol-4-yl]-*N*-[4-[[5-[6-[(1-methyl-4-piperidyl)amino]imidazo[1,2-*b*]pyridazin-3-yl]-2-pyridyl]amino]butyl]pentanamide

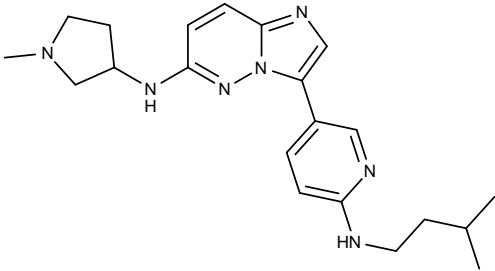
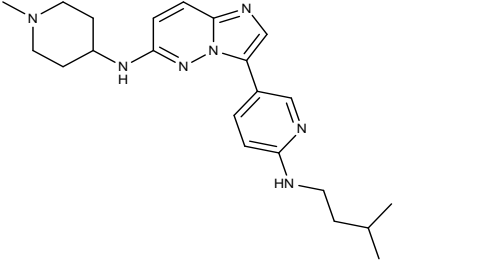
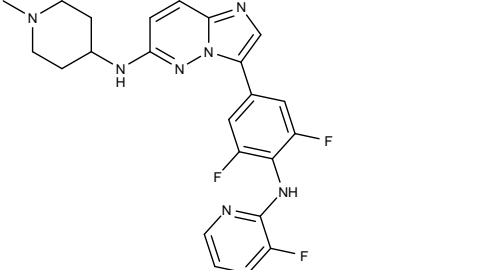
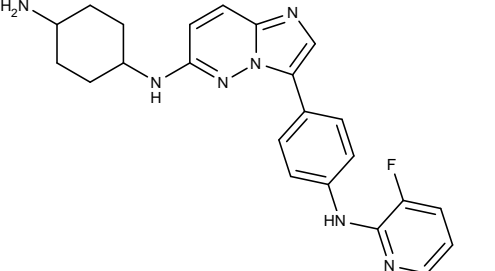
To a solution of Pd(OAc)₂ (4 mg, 0.014 mmol, 0.5 eq) in DME (0.5 mL) was added CyPF^tBu (8 mg, 0.014 mmol, 0.5 eq). The solution was allowed to stand for 2 minutes then added to a solution of 3-(6-chloro-3-pyridyl)-*N*-(1-methyl-4-piperidyl)imidazo[1,2-*b*]pyridazin-6-amine (100 mg, 0.291 mmol, 1.0

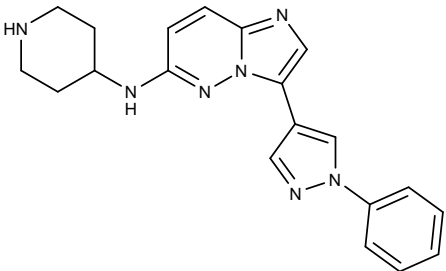
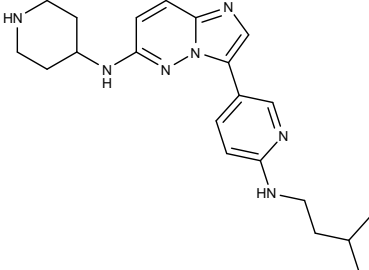
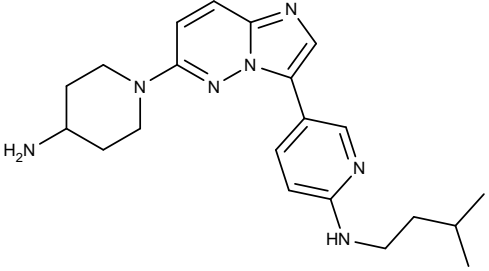
eq) and NaO^tBu (39 mg, 0.408 mmol, 1.4 eq) in DME (1.5 mL). The reaction mixture was stirred for 5 minutes before adding *tert*-butyl *N*-(4-aminobutyl)carbamate (78 μL, 0.408 mmol, 1.4 eq) and stirring for a further 2 hours at 90°C. The reaction mixture was concentrated *in vacuo* and purification by column chromatography (0-10% MeOH in DCM with 1% NH₄OH) gave *tert*-butyl *N*-[4-[[5-[6-[(1-methyl-4-piperidyl)amino]imidazo[1,2-*b*]pyridazin-3-yl]-2-pyridyl]amino]butyl]carbamate as a yellow solid (122 mg, 0.247 mmol, 1.0 eq) which was treated with 4 M HCl in dioxane (1 mL). The reaction mixture was stirred at RT for 2 hours before concentrating *in vacuo*. The resulting solid was dissolved in DMF (1 mL) and treated with Et₃N (178 μL, 1.235 mmol, 5.0 eq) then added to a pre-mixed solution of biotin (72 mg, 0.296 mmol, 1.2 eq) and TBTU (95 mg, 0.296 mmol, 1.2 eq) in DMF (1 mL). The reaction mixture was stirred overnight at RT, concentrated *in vacuo* and purification by prep HPLC gave the product as an off-white solid (8 mg, 5%); ¹H NMR (400MHz, DMSO-*d*₆) δ = 8.68 (d, *J*=2.3 Hz, 1H), 8.09 (dd, *J*=2.3, 8.8 Hz, 1H), 7.77 (t, *J*=5.6 Hz, 1H), 7.70 – 7.67 (m, 2H), 6.91 (d, *J*=6.1 Hz, 1H), 6.70 (t, *J*=5.4 Hz, 1H), 6.61 (d, *J*=9.8 Hz, 1H), 6.53 (d, *J*=8.9 Hz, 1H), 6.42 (s, 1H), 6.35 (s, 1H), 4.29-4.25 (m, 1H), 4.16-4.04 (m, 1H), 3.57 – 3.53 (m, 1H), 3.28-3.25 (m, 2H), 3.10-2.98 (m, 3H), 2.82-2.72 (m, 3H), 2.59-2.52 (m, 1H), 2.18 (s, 3H), 2.08-1.98 (m, 6H), 1.63-1.40 (m, 10H), 1.37-1.23 (m, 2H); *m/z* (ES+APCI)⁺: 621 [M+H]⁺.

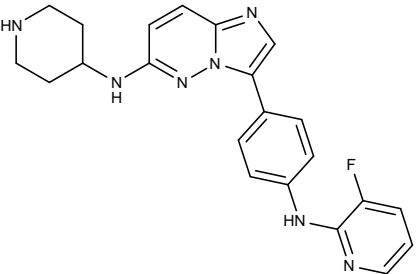
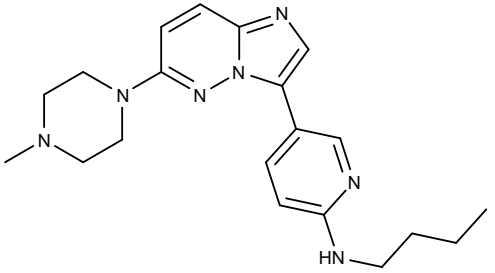
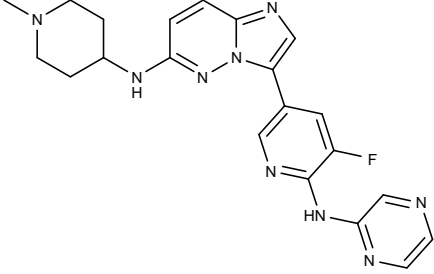
Table S1. EC₅₀ values of compounds determined using the SYBR Green I assay following treatment of parasite cultures with serial dilutions of the compounds for 48 h or 96 h, and stage of action determined by microscopy for a subset of compounds. Values are from a single experiment with duplicate samples for each compound, unless indicated by the presence of the standard deviation of the mean in parentheses after the EC₅₀ value. Where this is present, the EC₅₀ given is the mean of triplicate independent experiments.

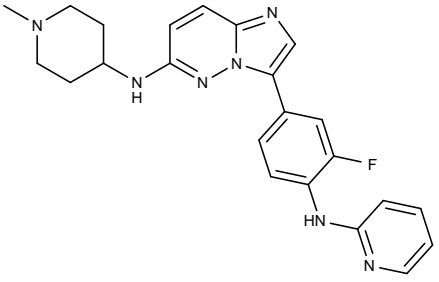
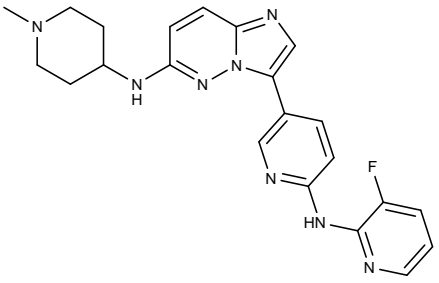
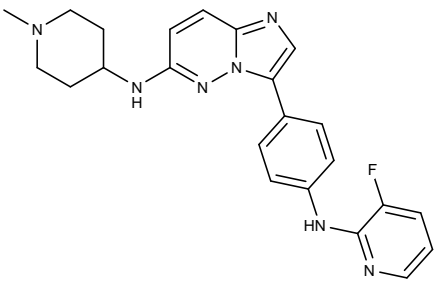
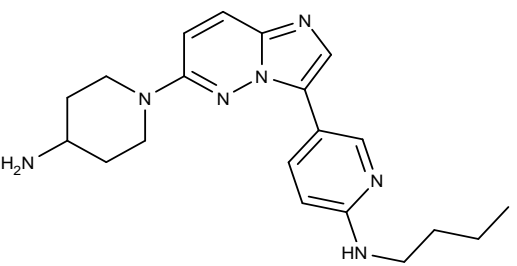
Compound	Structure	Aromatic linker	EC ₅₀ (μM)		ratio EC ₅₀ 48:EC ₅₀ 96	^a Stage of action (before or after DNA synthesis)
			48 hours	96 hours		
1		pyridine	0.29	0.29	1.0	
2		difluorophenyl	1.28	1.04	1.2	

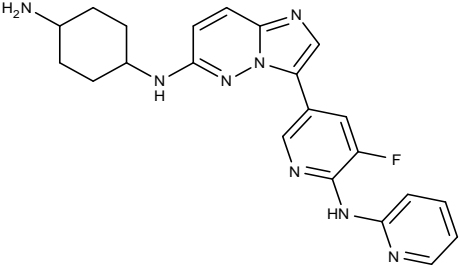
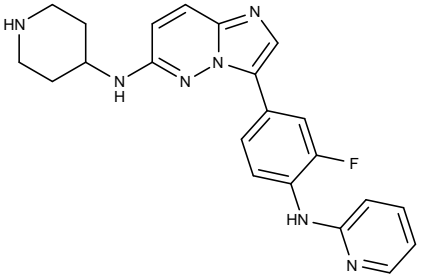
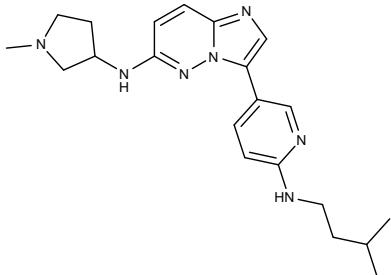
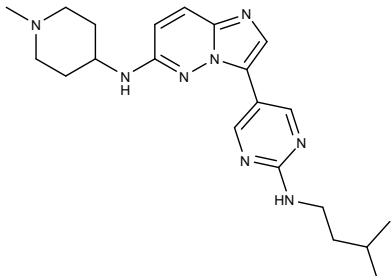
3		phenyl	0.76	0.61	1.3
4		pyridine	0.30	0.22	1.4
5		pyridine	0.54	0.39	1.4

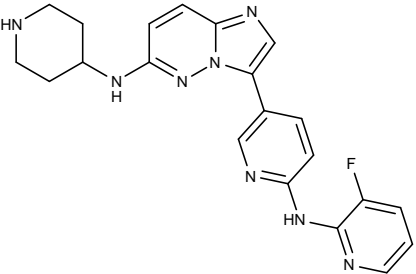
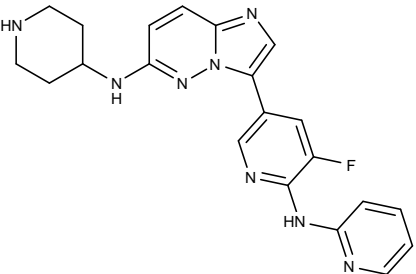
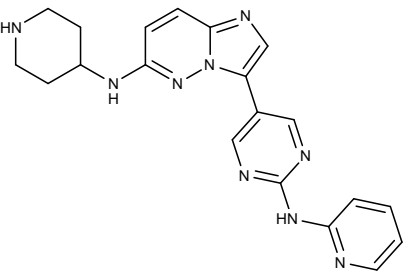
6		pyridine	0.59	0.42	1.4
7 Cpd D		pyridine	0.36(0.08)	0.31(0.10)	1.1 trophozoite (before)
8		difluorophenyl	0.99	0.66	1.5
9		phenyl	0.62	0.40	1.6

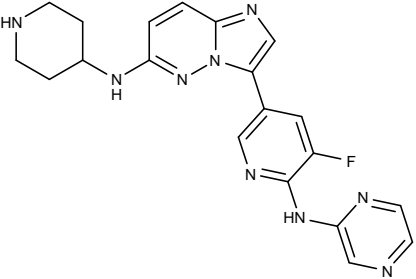
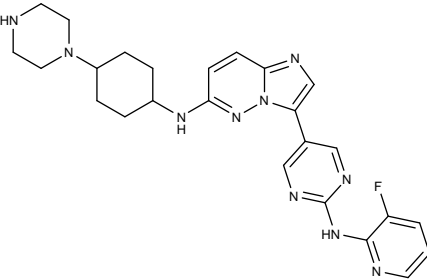
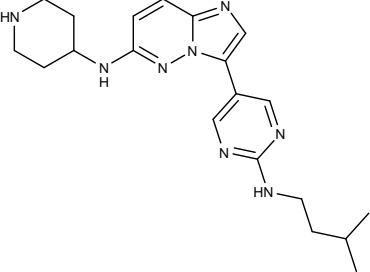
10		pyrazole	0.72	0.46	1.6
11		pyridine	0.96	0.60	1.6
12		pyridine	0.41	0.25	1.6

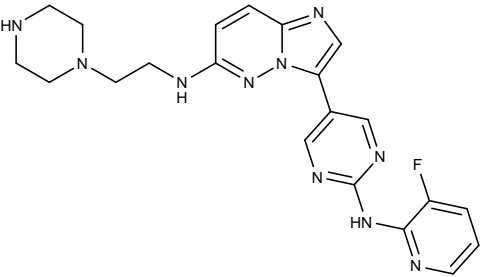
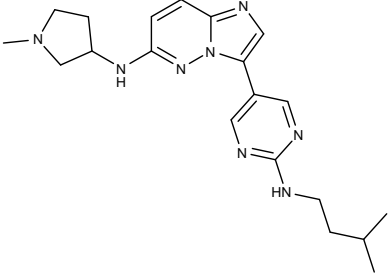
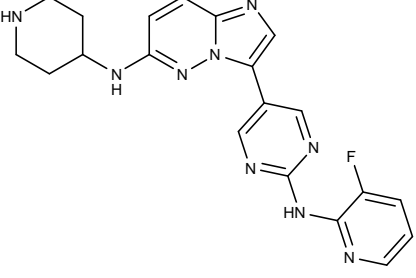
13		phenyl	1.25	0.76	1.7
14		pyridine	2.10	1.18	1.8
15		fluoropyridine	1.74	0.96	1.9

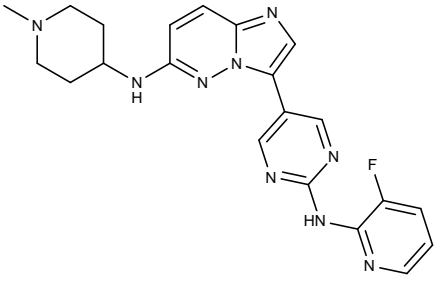
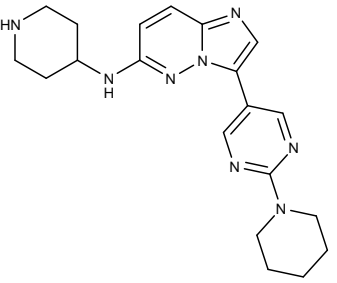
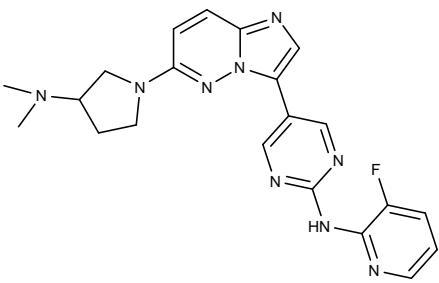
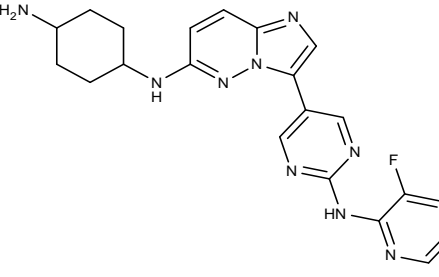
16		fluorophenyl	0.80	0.40	2.0
17		pyridine	1.15	0.58	2.0
18		phenyl	1.22	0.60	2.0
19		pyridine	0.57	0.26	2.2

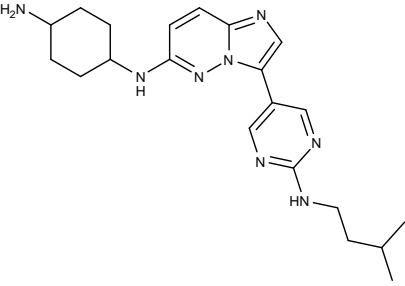
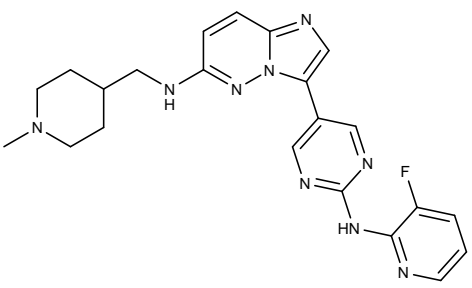
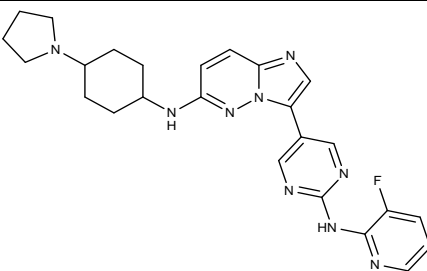
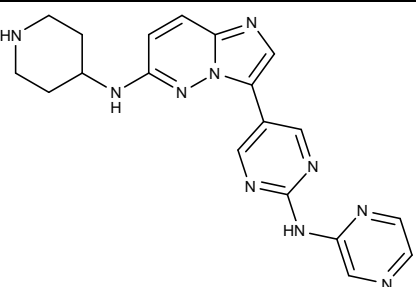
<p>20 Cpd. E</p>		<p>fluoropyridine</p>	<p>0.30(0.07)</p>	<p>0.14(0.02)</p>	<p>2.1</p>	<p>trophozoite (before)</p>
<p>21</p>		<p>fluorophenyl</p>	<p>1.63</p>	<p>0.69</p>	<p>2.4</p>	
<p>22</p>		<p>pyridine</p>	<p>0.55(0.08)</p>	<p>0.30(0.14)</p>	<p>1.8</p>	<p>trophozoite (before)</p>
<p>23</p>		<p>pyrimidine</p>	<p>2.49</p>	<p>0.99</p>	<p>2.5</p>	

24		pyridine	2.45	0.71	3.4
25		fluoropyridine	1.96	0.54	3.6
26		pyrimidine	0.83	0.20	4.2

27		fluoropyridine	4.30	0.84	5.1
28		pyrimidine	0.17(0.01)	0.04(0.01)	4.4 late schizont (after)
29		pyrimidine	3.46	0.64	5.4

30		pyrimidine	0.31	0.05	6.0
31		pyrimidine	1.66(0.65)	0.24(0.05)	7.0 late schizont (after)
32		pyrimidine	1.79	0.11	16.6

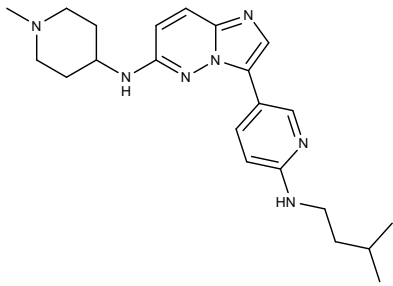
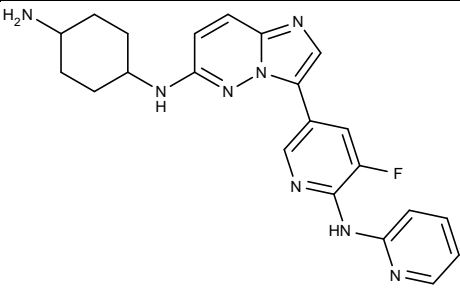
33		pyrimidine	100	0.03	>1000
34		pyrimidine	> 1000	1.18	> 847
35		pyrimidine	> 1000	0.81(0.45)	> 1000 late schizont (after)
36 Cpd A		pyrimidine	> 1000	0.02(0.01)	> 1000 late schizont (after)

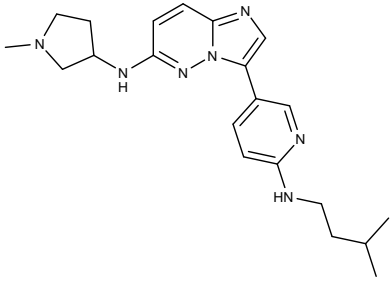
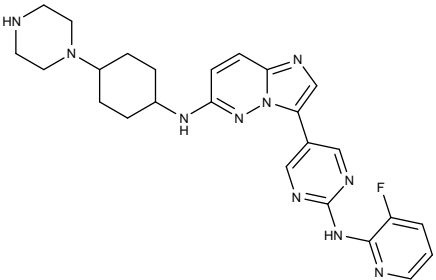
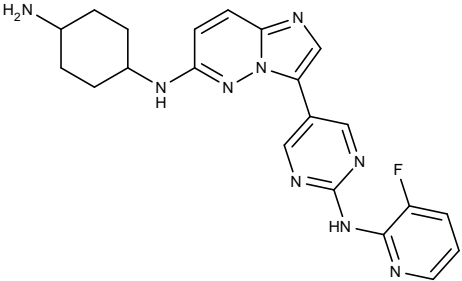
37		pyrimidine	> 1000	0.65	> 1000
38		pyrimidine	> 1000	0.05(0.02)	> 1000 late schizont (after)
39 Cpd. B		pyrimidine	> 1000	0.02(0.01)	> 1000 late schizont (after)
40		pyrimidine	> 1000	1.23	> 813

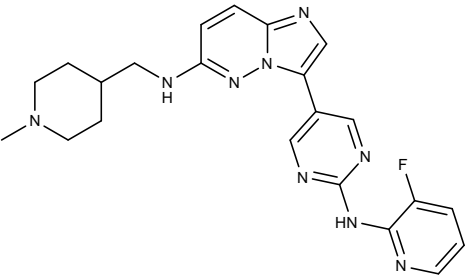
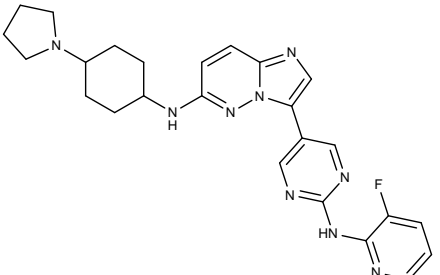
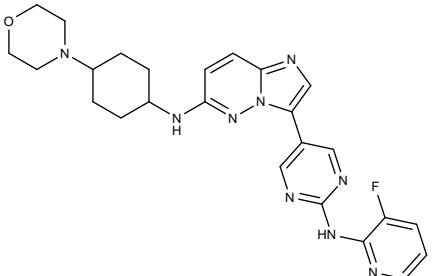
41 Cpd. C		pyrimidine	> 1000	0.04(0.01)	> 1000	late schizont (after)
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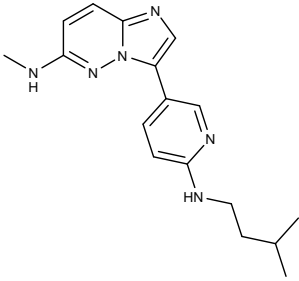
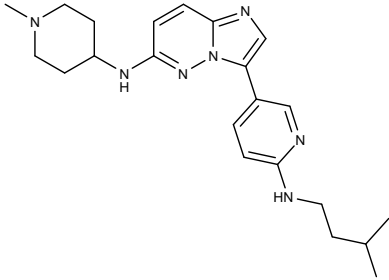
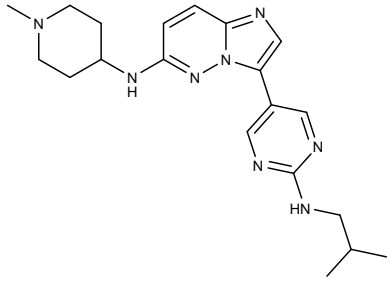
^aring-stage parasites treated with 10x EC₅₀ concentration of compound for 48h followed by microscopic examination of Giemsa-stained parasite smears.

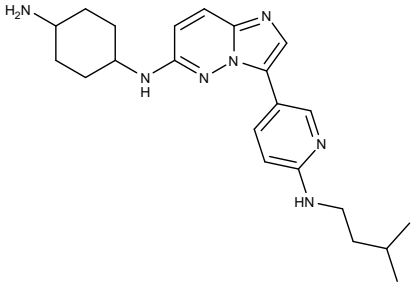
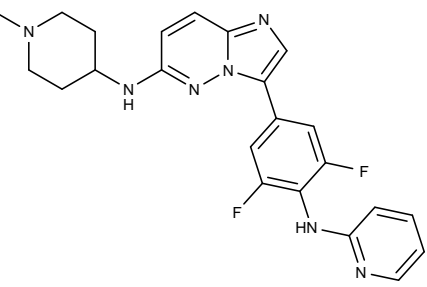
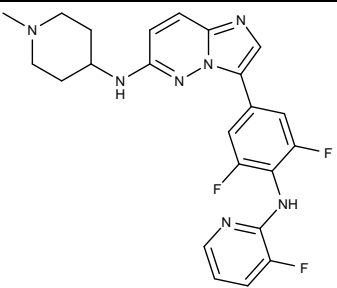
Table S2. Substituting the gatekeeper residue of PKG with a large glutamine residue results in a loss of potency of class 1, pyrimidine-linked compounds. Data shown are from a single experiment other than where the standard deviation from the mean of two independent experiments is indicated in parentheses after the mean EC₅₀.

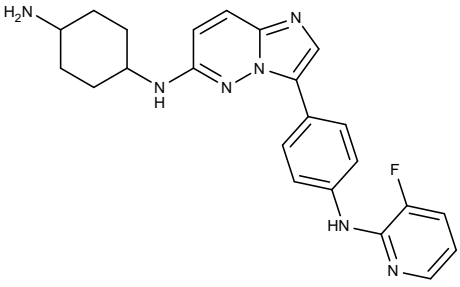
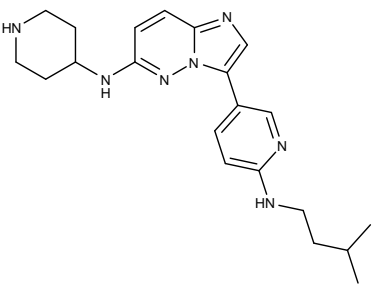
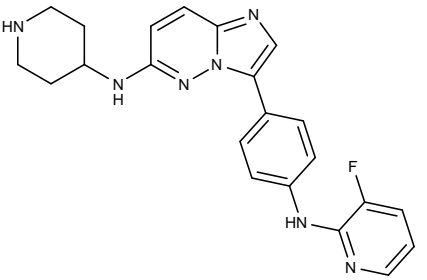
Compound	Structure	Enzyme inhibition IC ₅₀ (μM)			Selectivity PKG T618Q/ PKG	Parasite inhibition EC ₅₀ (μM)		Ratio 3D7PKG T618Q/ 3D7
		CDPK1	PKG	PKG T618Q		3D7	3D7 PKG T618Q	
7 (Cpd D)		0.013	0.484	15.51	32	0.427 (0.045)	0.477 (0.180)	1
20 (Cpd E)		0.008	0.012	15.33	1325	0.210	0.386	2

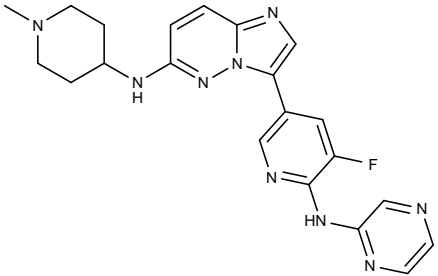
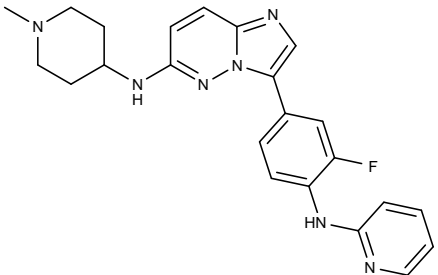
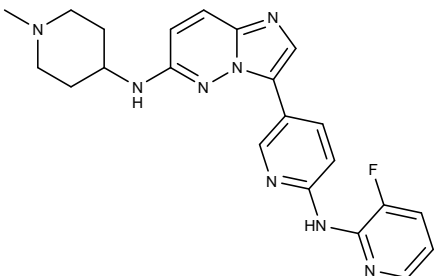
<p>22</p> 	<p>0.074 >1 37.53 <38</p>	<p>0.215 0.303 1</p>
<p>28</p> 	<p>0.012 0.003 31.69 12100</p>	<p>0.059 0.640 11</p>
<p>36 (Cpd A)</p> 	<p>0.008 0.002 10.96 5641</p>	<p>0.034 (0.006) 0.901 (0.483) 27</p>

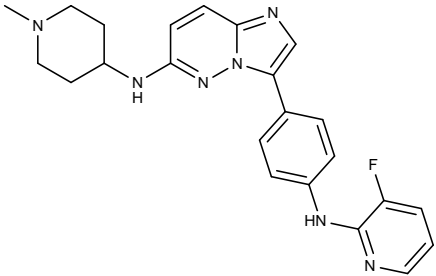
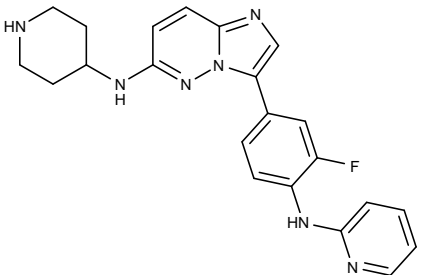
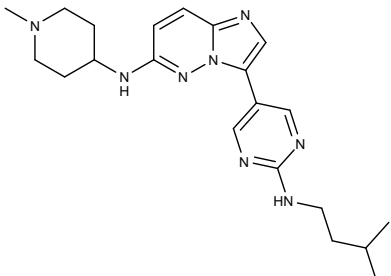
<p>38</p> 	<p>0.008 0.004 43.52 12187</p>	<p>0.073 0.859 12</p>
<p>39 (Cpd B)</p> 	<p>0.009 0.002 25.54 16520</p>	<p>0.034 0.982 29</p>
<p>41 (Cpd C)</p> 	<p>0.011 0.013 12.70 957</p>	<p>0.042 (0.018) 0.923 (0.226) 22</p>

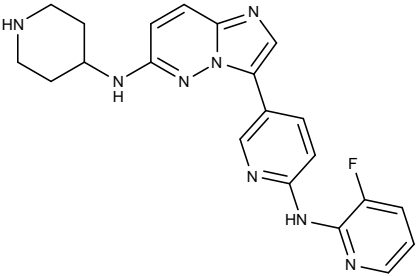
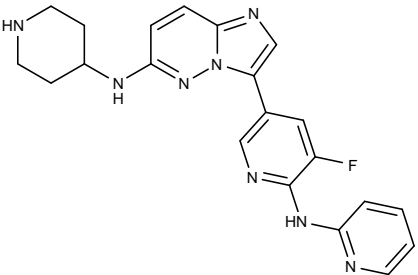
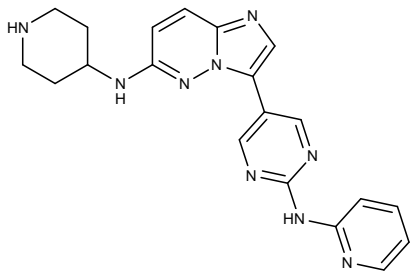
<p>42</p> 	<p>0.081 nd nd —</p>	<p>0.836 1.231 1</p>
<p>43</p> 	<p>0.088 nd nd —</p>	<p>0.079 0.093 1</p>
<p>44</p> 	<p>0.065 nd nd —</p>	<p>0.236 0.477 2</p>

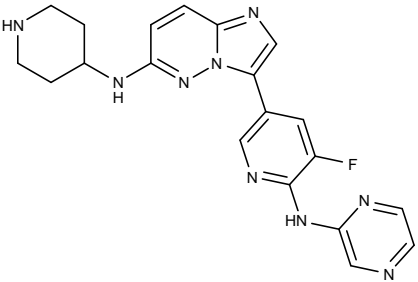
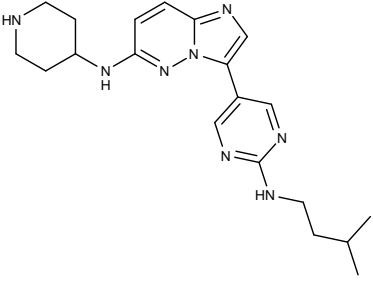
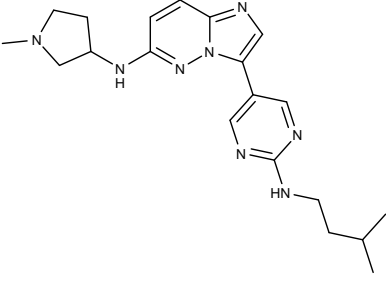
<p>1</p> 	<p>0.010 0.109 6.236 57</p>	
<p>2</p> 	<p>0.026 0.069 12.810 186</p>	
<p>8</p> 	<p>0.017 0.237 64.64 272</p>	

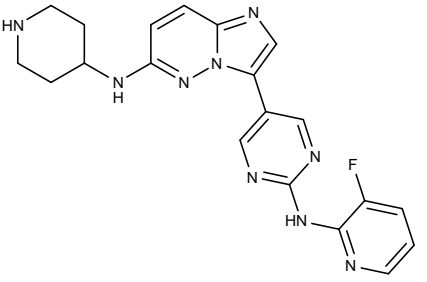
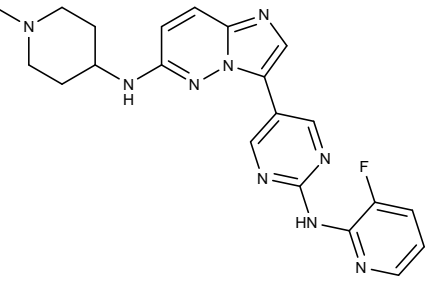
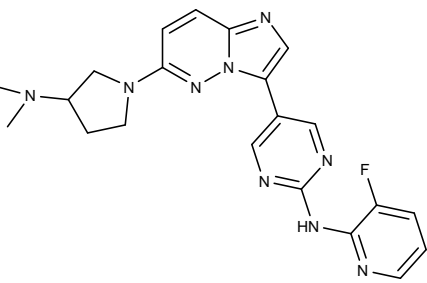
<p>9</p> 	<p>0.034 0.048 16.84 349</p>	
<p>11</p> 	<p>0.015 0.256 256.30 1000</p>	
<p>13</p> 	<p>0.014 0.162 3.68 23</p>	

15		0.020 0.249 51.27 206
16		0.011 0.088 10.61 121
17		0.009 0.118 12.06 102

<p>18</p> 	<p>0.016 0.404 15.67 39</p>	
<p>21</p> 	<p>0.010 0.087 3.77 44</p>	
<p>23</p> 	<p>0.014 0.160 4.76 30</p>	

24		0.011 0.062 1.25 20
25		0.013 0.054 9.93 182
26		0.009 0.020 3.28 161

<p>27</p> 	<p>0.017 0.101 10.01 99</p>	
<p>29</p> 	<p>0.018 0.093 0.88 10</p>	
<p>31</p> 	<p>0.093 0.287 5.95 21</p>	

<p>32</p> 	<p>0.010 0.007 6.16 931</p>	
<p>33</p> 	<p>0.013 0.005 10.04 2071</p>	
<p>35</p> 	<p>0.017 0.050 528.20 10653</p>	

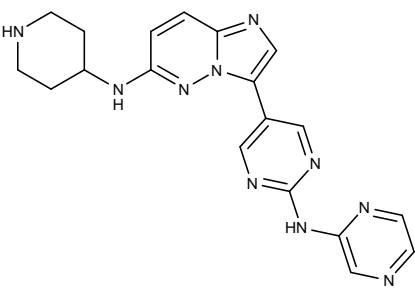
<p>37</p> 	<p>0.016 0.044 2.10 48</p>	
<p>40</p> 	<p>0.014 0.034 4.04 120</p>	

Table S3 Summary of proteins affinity purified with compound D resin, identified by LC-MS/MS.

Accession	Description	MW [kDa]	% Coverage	Unique Peptides	compound A resin		control resin	
PF3D7_0708400	heat shock protein 90 (HSP90)	86.1	29.93	24	1.249E6	2.092E6	0.000E0	0.000E0
PF3D7_1357000	elongation factor 1-alpha	48.9	10.61	4	4.296E6	1.649E6	0.000E0	0.000E0
PF3D7_1325100	phosphoribosylpyrophosphate synthetase	49.4	10.76	4	7.729E5	1.187E6	0.000E0	0.000E0
PF3D7_1008700	tubulin beta chain	49.7	5.39	2	3.230E5	4.011E5	0.000E0	0.000E0