

Supplementary Information

Stereodivergent Access to α - and β -Azanucleosides via Catalyst-Free, Achiral Modulator-Controlled Iodocyclization: A Concise Synthesis of Forodesine

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Table of contents

1. General Information.....	2
2. Experimental Procedures.....	3
2.1 Asymmetric α -alkylation.....	3
2.2 Synthesis of 3a-3c , 3f-3g	6
2.3 Synthesis of base 4a , 4i-4m , 4p-4u	9
2.4 Synthesis of substrate 5a-u	17
2.5 Iodocyclization of 5a-u	27
2.6 Derivatizations and applications.....	46
3. Supplementary Discussion.....	55
4. Supplementary Crystallographic Data.....	58
5. Computational Details.....	59
6. Supplementary NMR spectra.....	86
7. Supplementary HPLC Data.....	202
8. Supplementary References.....	224

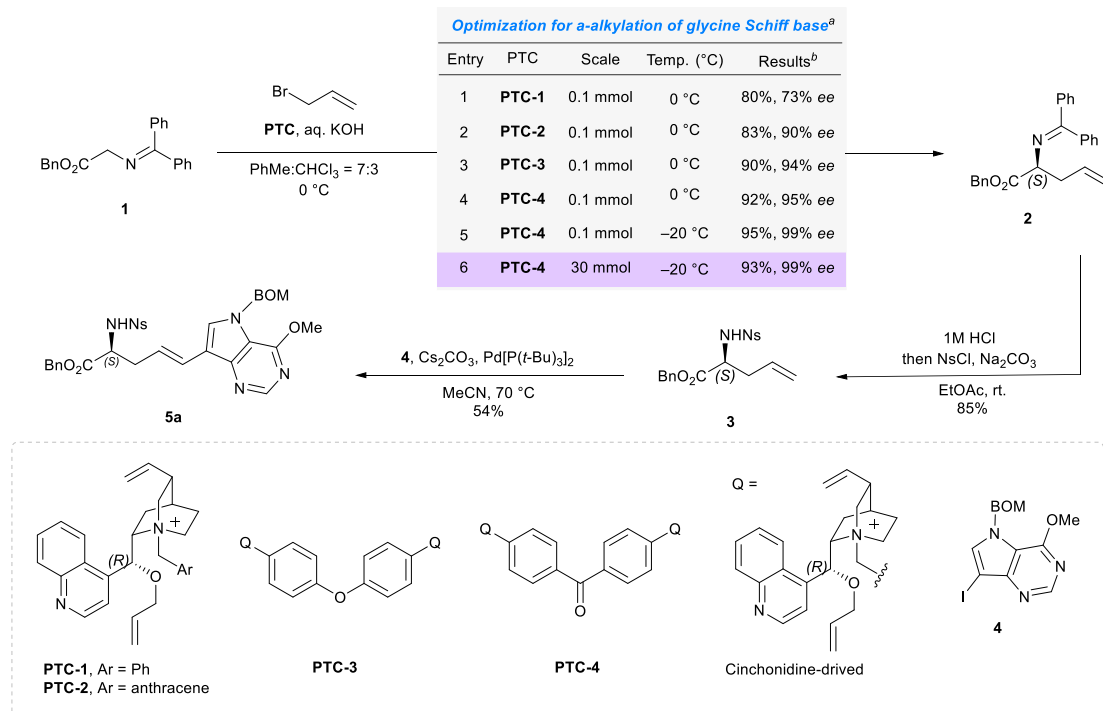
1. General Information

All commercially available reagents (with CAS numbers indicated) were used without further purification. Tetrahydrofuran (THF) and toluene (PhMe) were distilled from sodium/benzophenone ketyl. Acetonitrile (MeCN) and dichloromethane (CH₂Cl₂) were distilled from CaH₂. Chromatography was conducted by using 200–300 mesh silica gel. All new compounds gave satisfactory spectroscopic analyses (¹H NMR, ¹³C NMR, HRMS, melting point). NMR spectra were recorded on a 400 MHz NMR or 600 MHz NMR spectrometer. Reference values for residual solvents were taken as δ = 7.26 (CDCl₃) ppm, δ = 3.31 (CD₃OD) ppm, δ = 2.50 ((CD₃)₂SO) ppm, δ = 4.70 (D₂O), δ = 2.05 ((CD₃)₂CO) ppm for ¹H NMR and δ = 77.16 (CDCl₃) ppm, δ = 49.00 (CD₃OD) ppm, δ = 39.52 ((CD₃)₂SO) ppm, δ = 29.84, 206.26 ((CD₃)₂CO) ppm for ¹³C NMR. Coupling constants (*J*) were given in Hz and were uncorrected and multiplicities for coupled signals were denoted as: s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, br = broad and dd = double doublet etc. High-resolution mass spectra (HRMS) were recorded on a Bruker micro TOF Q III by the ESI method. Melting point (MP, for solid) was recorded on an SRS-optic melting point apparatus. Optical rotation was obtained from Rudolph Research Analytical Autopol VI automatic polarimeter. X-ray diffraction analysis was carried out by Dr. Meng Yang (Sichuan University). HPLC was performed using CHIRALCEL IA (4.6 x 250 mm), CHIRALCEL OD-H (4.6 x 250 mm) and CHIRALCEL AD-H (4.6 x 250 mm) analytical column. Unless otherwise noted, all products are isolated yields.

Tetrahydrofuran (THF)	Toluene (PhMe)
Dichloromethane (CH ₂ Cl ₂)	Acetonitrile (MeCN)
Chloroform (CHCl ₃)	1,8-Diazabicyclo[5.4.0]undec-7-ene (DBU)
<i>N,N</i> -Diisopropylethylamine (DIPEA)	Chloromethyl methyl ether (MOMCl)
Dimethyl sulfoxide (DMSO)	Benzyl chloromethyl ether (BOMCl)
Azodiisobutyronitrile (AIBN)	Potassium tert-butoxide (<i>t</i> -BuOK)
<i>N</i> -methylmorpholine <i>N</i> -oxide (NMO)	Trifluoroacetic acid (TFA)
<i>N</i> -iodosuccinimide (NIS)	Benzyl bromide (BnBr)
4-Nitrobenzenesulfonyl chloride (NsCl)	Sodium Methoxide (MeONa)
Phase transfer catalyst (PTC)	Diisobutylaluminium hydride (DIBAL-H)

2. Experimental Procedures

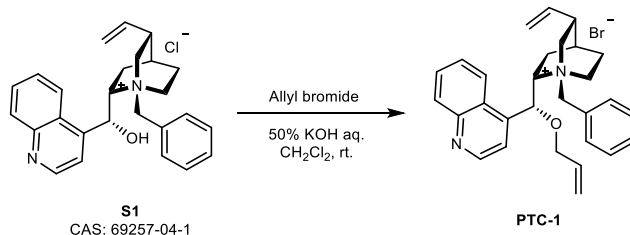
2.1 Asymmetric α -alkylation



Scheme 1. The synthesis of halocyclization substrate **5a**. ^aReaction conditions: **1** (0.1 mmol), allyl bromide (0.12 mmol), 50% KOH aq. (0.25 mL) in PhMe:CHCl₃ (v:v = 7:3, 0.75 mL), 0 °C, 8 h. ^bisolated yield, *ee* values were determined by chiral HPLC.

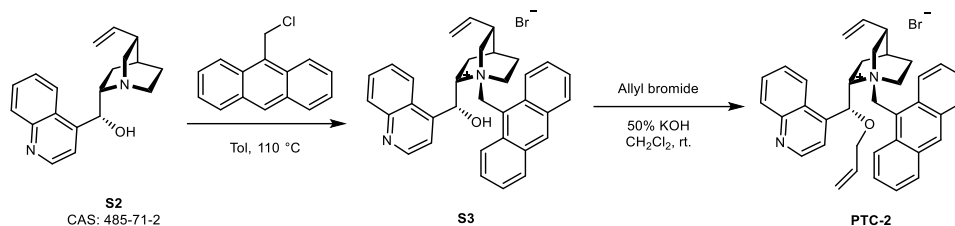
2.1.1 Synthesis of phase transfer catalysis (PTC1-4)

The phase-transfer catalysts were synthesized according to references¹⁻⁴.

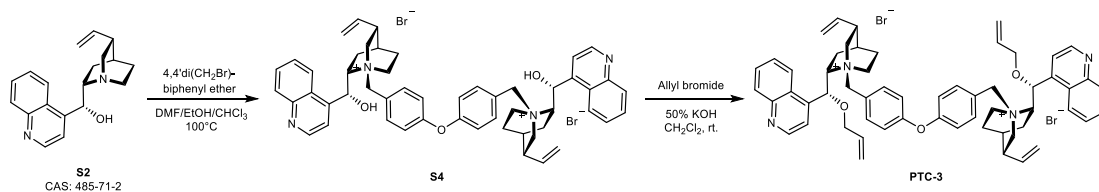


PTC-1. R_f = 0.4 (silica gel, CH₂Cl₂:MeOH = 20:1, UV). white solid (1.04 g, 87% yield). ¹H NMR (400 MHz, CDCl₃) δ 8.97 (d, *J* = 4.6 Hz, 1H), 8.85 (d, *J* = 8.6 Hz, 1H), 8.14 (d, *J* = 8.4 Hz, 1H), 8.00 – 7.85 (m, 3H), 7.77 (t, *J* = 7.8 Hz, 1H), 7.68 (s, 1H), 7.53 – 7.43 (dd, *J* = 5.2, 1.8 Hz, 3H), 6.55 (d, *J* = 11.8 Hz, 1H), 6.24 (s, 1H), 6.19 – 6.01 (m, 1H), 5.71 (ddd, *J* = 17.1, 10.6, 6.4 Hz, 1H), 5.46 – 5.26 (m, 3H), 5.04 – 4.88 (m, 2H), 4.78 – 4.59 (m, 2H), 4.41 – 4.31 (m, 1H), 4.28 (dd, *J* = 12.6, 5.2 Hz, 1H), 4.05 (dd, *J* = 12.5, 6.8 Hz, 1H), 3.42 (td, *J* = 11.8, 4.2 Hz, 1H), 3.31 – 3.17 (m, 1H), 2.62 (dd, *J* = 10.2, 5.8 Hz, 1H), 2.27 – 2.04 (m, 3H), 1.83 (td, *J* = 12.0, 5.2 Hz, 1H), 1.53 –

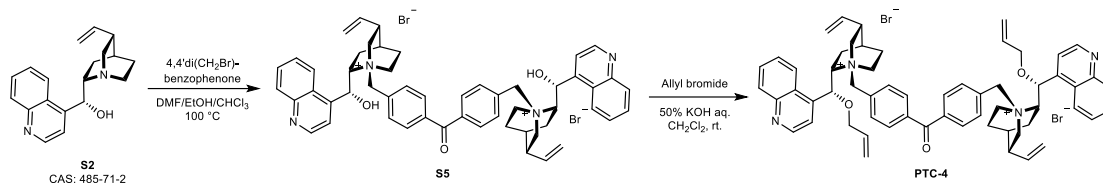
1.37 (m, 1H). ^{13}C NMR (100 MHz, CDCl_3) δ 148.6, 147.5, 138.9, 135.2, 133.1 (2), 131.5, 129.6, 129.2, 129.0, 128.2 (2), 128.0, 126.2, 124.3, 123.8, 119.0 (2), 117.4, 73.2, 69.4, 65.2, 61.3, 58.6, 50.3, 36.8, 26.0, 24.3, 21.8.



PTC-2. R_f = 0.3 (silica gel, CH_2Cl_2 :MeOH = 20:1, UV). white solid (429 mg, 71% yield over 2 steps). ^1H NMR (400 MHz, MeOD) δ 9.04 (d, J = 4.6 Hz, 1H), 8.89 (d, J = 3.6 Hz, 1H), 8.75 (t, J = 8.8 Hz, 1H), 8.57 (t, J = 8.0 Hz, 1H), 8.45 (d, J = 9.2 Hz, 1H), 8.28 – 8.19 (m, 3H), 7.98 – 7.90 (m, 3H), 7.83 – 7.72 (m, 2H), 7.69 – 7.61 (m, 2H), 6.94 (s, 1H), 6.40 (ddt, J = 16.8, 10.8, 4.8 Hz, 2H), 5.90 (dd, J = 14.0, 5.8 Hz, 1H), 5.75 – 5.63 (m, 2H), 5.55 (dd, J = 10.5, 1.4 Hz, 1H), 5.00 (d, J = 10.8 Hz, 1H), 4.97 (d, J = 5.4 Hz, 1H), 4.58 – 4.39 (m, 4H), 3.83 – 3.73 (m, 1H), 3.23 (t, J = 11.6 Hz, 1H), 2.96 – 2.84 (m, 1H), 2.50 – 2.38 (m, 2H), 2.24 – 2.12 (m, 1H), 1.97 (s, 1H), 1.61 (q, J = 10.8 Hz, 2H). ^{13}C NMR (100 MHz, MeOD) δ 151.1, 149.4, 142.9, 138.5, 134.8, 134.7, 134.6, 133.9 (2), 133.1, 133.1, 131.5, 131.3, 131.2, 130.7, 129.5, 129.3, 127.1, 126.7, 126.6, 125.3 (2), 124.9 (2), 121.7, 119.1, 117.8, 79.5, 71.5, 70.2, 63.6, 57.5, 53.7, 39.5, 27.3, 26.3, 23.3.

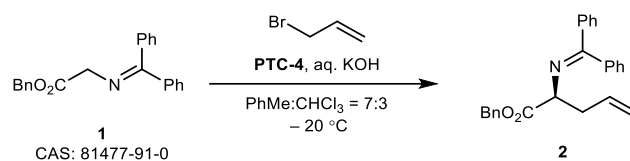


PTC-3. R_f = 0.5 (silica gel, PE:EtOAc = 10:1, UV). white solid (738 mg, 72% yield over 2 steps). ^1H NMR (400 MHz, CDCl_3) δ 9.00 – 8.94 (t, J = 4.8 Hz, 2H), 8.90 – 8.78 (m, 2H), 8.15 (d, J = 9.2 Hz, 2H), 7.99 (d, J = 8.6 Hz, 4H), 7.82 (t, J = 7.8 Hz, 2H), 7.75 (q, J = 8.0 Hz, 2H), 7.67 (s, 2H), 7.13 (d, J = 8.4 Hz, 4H), 6.52 (d, J = 11.8 Hz, 2H), 6.28 (s, 2H), 6.12 (td, J = 10.8, 5.6 Hz, 2H), 5.66 (ddd, J = 16.9, 10.6, 6.2 Hz, 2H), 5.46 – 5.34 (p, J = 6.6 Hz, 6H), 4.96 (d, J = 10.6 Hz, 2H), 4.83 (d, J = 12.6 Hz, 2H), 4.67 (t, J = 11.2 Hz, 4H), 4.37 – 4.29 (m, 2H), 4.27 (dd, J = 12.4, 5.2 Hz, 2H), 4.10 (dd, J = 12.1, 6.8 Hz, 2H), 3.53 (t, J = 10.8 Hz, 2H), 3.35 – 3.22 (m, 2H), 2.72 (s, 2H), 2.16 (q, J = 13.6 Hz, 4H), 2.09 – 2.05 (m, 2H), 2.02 – 1.92 (m, 2H), 1.41 (d, J = 13.8 Hz, 2H). ^{13}C NMR (100 MHz, CDCl_3) δ 158.4 (2), 149.3 (2), 148.2 (2), 140.5 (2), 136.4 (2), 136.0 (4), 132.6 (4), 130.2 (2), 129.6 (2), 128.9 (2), 125.3 (2), 124.5 (2), 122.5 (2), 119.8 (2), 119.6 (4), 118.1 (2), 70.3 (2), 66.3 (2), 61.8 (2), 59.5 (2), 51.1 (2), 37.6 (2), 26.9 (2), 25.2 (2), 22.7 (2), 21.3 (2).



PTC-4. R_f = 0.5 (silica gel, PE:EtOAc = 10:1, UV). white solid (664 mg, 64% yield over 2 steps). **^1H NMR** (400 MHz, CDCl_3) δ 8.97 (d, J = 4.6 Hz, 2H), 8.83 (d, J = 8.4 Hz, 2H), 8.14 (d, J = 7.6 Hz, 6H), 7.83 (d, J = 8.0 Hz, 4H), 7.81 – 7.56 (m, 6H), 6.74 (d, J = 11.4 Hz, 2H), 6.28 (s, 2H), 6.14 (ddt, J = 16.6, 11.0, 5.8 Hz, 2H), 5.63 (ddd, J = 16.8, 10.6, 6.2 Hz, 2H), 5.50 – 5.32 (m, 6H), 4.98 (d, J = 10.6 Hz, 4H), 4.80 (d, J = 11.6 Hz, 2H), 4.71 (t, J = 10.2 Hz, 2H), 4.41 – 4.33 (m, 2H), 4.28 (dd, J = 12.4, 5.4 Hz, 2H), 4.16 (dd, J = 12.4, 6.6 Hz, 2H), 3.62 – 3.53 (m, 2H), 3.44 – 3.36 (m, 2H), 2.72 (s, 2H), 2.27 – 2.00 (m, 8H), 1.18 – 1.39 (m, 2H). **^{13}C NMR** (100 MHz, CDCl_3) δ 195.8, 149.6 (2), 148.5 (2), 140.2 (2), 138.8 (2), 136.5 (2), 134.3 (4), 132.7 (2), 132.0 (2), 130.5 (4), 130.2 (2), 130.0 (2), 128.9 (2), 125.3 (2), 124.5 (2), 119.9 (4), 118.2 (2), 70.4 (2), 66.7 (2), 61.6 (2), 59.7 (2), 51.6 (2), 50.6 (2), 37.6 (2), 26.8 (2), 25.1 (2), 22.7 (2).

2.1.2 Asymmetric α -alkylation of **1**

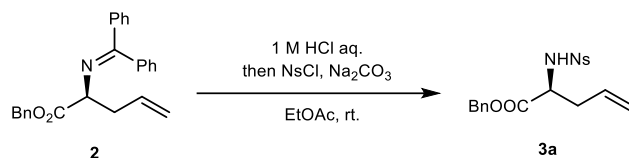


A mixture of *N*-(diphenylmethylene) glycine benzyl ester **1** (10.0 g, .30.4 mmol), allyl bromide (3.2 mL, 36.5 mmol) and **PTC-4** (0.16 g, 0.15 mmol) was dissolved in PhMe/ CHCl_3 (7:3, 225 mL). The solution was cooled to $-20\text{ }^\circ\text{C}$, purged with argon (10 min), and 50% KOH aq. (75 mL) was added. The solution was stirred for 12 h, then diluted with H_2O (100 mL) and EtOAc (100 mL). The layers were separated, and the aqueous layer was extracted with EtOAc (50 mL x 5). The combined organic layer was washed with brine (100 mL x 3), dried over Na_2SO_4 and filtered, concentrated in vacuo. The crude product was purified by column chromatography to afford **2**. Enantioselectivity was determined by chiral HPLC analysis (DAICEL Chiralcel OD, *n*-hexane/2-propanol (100:1), flow rate 0.5 mL/min, $25\text{ }^\circ\text{C}$, λ = 254 nm, retention times: *R* (minor) 14.1 min, *S* (major) 20.2 min, 99% *ee*). The absolute configuration was confirmed by comparison of the HPLC retention time with the sample synthesized by the reported procedure⁵.

Benzyl (*S*)-2-((diphenylmethylene)amino)pent-4-enoate (2**).** R_f = 0.3 (silica gel, PE:EtOAc = 100:1, UV). colorless oil (10.4 g, 93% yield). **^1H NMR** (400 MHz, CDCl_3) δ 7.71 – 7.60 (m, 2H), 7.46 – 7.27 (m, 11H), 7.17 – 7.07 (m, 2H), 5.74 – 5.60 (m, 1H), 5.16 (q, J = 12.4 Hz, 2H), 5.09 – 4.97 (m, 2H), 4.18 (dd, J = 7.7, 5.4 Hz, 1H), 2.79 – 2.61 (m, 2H). **^{13}C NMR** (100 MHz, CDCl_3) δ 171.6, 170.8, 139.5, 136.4, 135.9, 134.3, 130.4, 128.9 (2), 128.6, 128.5 (2), 128.5 (2), 128.2 (3),

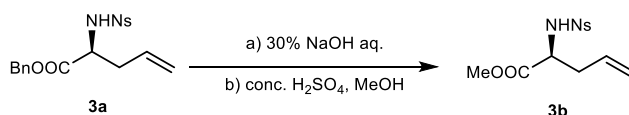
128.0 (2), 127.9 (2), 117.7, 66.5, 65.3, 38.0. **HRMS** (ESI): m/z calcd. for $C_{25}H_{23}NO_2Na$ $[M+Na]^+$ 392.1632, found 392.1621.

2.2 Synthesis of 3a-3c and 3f-3g.



Compound **2** (5.0 g, 13.6 mmol) was dissolved in 1 M HCl aq. (30 ml) and stirred at room temperature for 4 h. The reaction mixture was diluted with EtOAc (30 mL), cooled to 0 °C, and treated portionwise with Na_2CO_3 (3.18 g, 30 mmol). After complete addition, NsCl (6.0 g, 27.2 mmol) was added and the resulting mixture was stirred at room temperature for 2 h. The solution was diluted with EtOAc (20 mL) and 1 M HCl aq. (10 mL). The layers were separated and the aqueous layer was extracted with EtOAc (20 mL x 3). The combined organic layer was washed with brine (20 mL x 3), dried over Na_2SO_4 and filtered, concentrated in vacuo. The crude material was purified via silica gel column chromatography to obtain **3a**.

Benzyl (*S*)-2-((4-nitrophenyl)sulfonamido)pent-4-enoate (3a**).** R_f = 0.50 (silica gel, PE: EtOAc = 2:1, UV). white solid (4.49 g, 85% yield). MP: 74.4 – 75.2 °C. $[\alpha]_D^{25} = +19.53$ (c = 0.40, CH_2Cl_2). **1H NMR** (400 MHz, $CDCl_3$) δ 8.26 – 8.15 (m, 2H), 8.00 – 7.91 (m, 2H), 7.38 – 7.28 (m, 3H), 7.24 – 7.16 (m, 2H), 5.68 – 5.52 (m, 1H), 5.51 – 5.33 (m, 1H), 5.17 – 5.04 (m, 2H), 5.04 – 4.91 (m, 2H), 4.16 (dt, J = 9.2, 5.8 Hz, 1H), 2.57 – 2.49 (m, 2H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 170.4, 150.1, 145.7, 134.6, 130.7, 128.9, 128.7 (2), 128.5 (2), 128.3 (2), 124.2 (2), 120.4, 67.7, 55.5, 37.6. **HRMS** (ESI) m/z calcd. for $C_{18}H_{18}N_2O_6SNa$ $[M+Na]^+$: 413.0778, found: 413.0768.

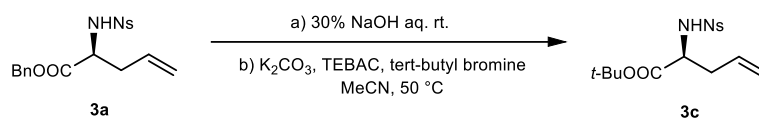


Compound **3a** (1.0 g, 2.6 mmol) was dissolved in THF (10 mL) and 30% NaOH aq. (1 mL), and the resulting mixture was stirred at room temperature for 12 h. Acidify the solution to pH = 1 by 1 M HCl aq. Extract the aqueous layers with EtOAc (3 x 15 mL) and wash the combined organic layers with brine (3 x 15 mL). The organic layer was dried over Na_2SO_4 and filtered, concentrated in vacuo. The crude product was obtained as the deprotected intermediate without purification.

The deprotected intermediate was dissolved in MeOH (10 mL), treated dropwise with conc. H_2SO_4 (30 μ L, 0.52 mmol) at room temperature and stirred for 12 h. The resulting mixture was diluted with EtOAc (20 mL) and washed sequentially with saturated $NaHCO_3$ aq. (15 mL x 3) to neutralize residual acid, followed by brine (15 mL x 2). The combined organic layer was dried over Na_2SO_4 and filtered, concentrated in vacuo. The crude product was purified by column

chromatography to obtain **3b**.

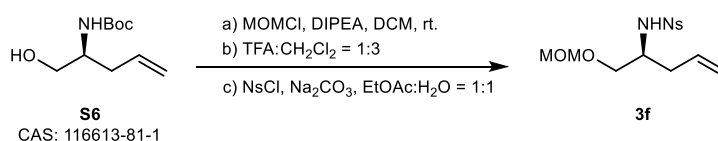
Methyl (S)-2-((4-nitrophenyl)sulfonamido)pent-4-enoate (3b). R_f = 0.50 (silica gel, PE: EtOAc = 2:1, UV). white solid (580 mg, 72% yield over 2 steps). **MP:** 108.5 – 109.7 °C. $[\alpha]_D^{25} = +24.71$ (c = 0.40, CH₂Cl₂). **¹H NMR** (400 MHz, CDCl₃) δ 8.41 – 8.31 (m, 2H), 8.09 – 8.01 (m, 2H), 5.68 – 5.54 (m, 1H), 5.35 (d, J = 9.0 Hz, 1H), 5.19 – 5.08 (m, 2H), 4.13 (dt, J = 9.0, 5.8 Hz, 1H), 3.59 (s, 3H), 2.52 (t, J = 6.6 Hz, 2H). **¹³C NMR** (100 MHz, CDCl₃) δ 171.0, 150.2, 145.9, 130.9, 128.5 (2), 124.3 (2), 120.4, 55.4, 52.7, 37.5. **HRMS** (ESI) m/z calcd. for C₁₂H₁₅N₂O₆S [M+H]⁺: 315.0646, found: 315.0658.



Compound **3a** (1.0 g, 2.6 mmol) was dissolved in THF (10 mL) and 30% NaOH aq. (1 mL), and the resulting mixture was stirred at room temperature for 12 h. Acidify the solution to pH = 1 by 1 M HCl aq. Extract the aqueous layers with EtOAc (3 x 15 mL) and wash the combine organic layers with brine (3 x 15 mL). The organic layer was dried over Na₂SO₄ and filtered, concentrated in vacuo. The crude product was obtained as the deprotected intermediate without purification.

Under an atmosphere of argon, a mixture of crude intermediate, K₂CO₃ (1.80 g, 13 mmol) and TEBAC (0.59 g, 2.6 mmol) was dissolved in MeCN (30 mL) at room temperature. After adding tert-butyl bromide (1.78 g, 13 mmol), the reaction was heated to 50 °C and stirred for 12 h. The solution was quenched with 1 M HCl aq. (20 mL) and EtOAc (20 mL). The layers were separated, and the aqueous layer was extracted with EtOAc (10 mL x 3). The combined organic layer was washed with brine (20 mL x 3), dried over Na₂SO₄ and filtered, concentrated in vacuo. The crude product was purified by column chromatography to afford **3c**.

Tert-butyl (S)-2-((4-nitrophenyl)sulfonamido)pent-4-enoate (3c). R_f = 0.50 (silica gel, PE: EtOAc = 2:1, UV). colorless oil (431 mg, 47% yield over 2 steps). $[\alpha]_D^{25} = +26.03$ (c = 0.40, CH₂Cl₂). **¹H NMR** (400 MHz, MeOD) δ 8.42 – 8.32 (m, 2H), 8.12 – 8.02 (m, 2H), 5.74 – 5.68 (m, 1H), 5.15 – 5.02 (m, 2H), 3.92 (dd, J = 7.5, 5.8 Hz, 1H), 2.53 – 2.31 (m, 2H), 1.28 (s, 9H). **¹³C NMR** (100 MHz, MeOD) δ 169.9, 150.0, 147.0, 132.4, 128.3 (2), 123.9 (2), 117.7, 81.8, 56.3, 37.2, 26.7 (3). **HRMS** (ESI) m/z calcd. for C₁₅H₂₁N₂O₆S [M+H]⁺: 357.1115, found: 357.1121.



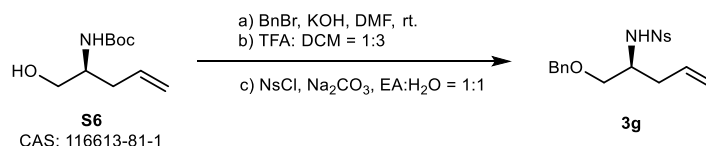
Under an atmosphere of argon, a mixture of **S6** (1.01 g, 5.0 mmol) and DIPEA (1.29 g, 10.0 mmol) was dissolved in anhydrous CH₂Cl₂ (20 mL) and stirred at 0 °C for 10 min. After adding

MOMCl (0.48 g, 6.0 mmol), the reaction mixture was warmed up to room temperature and stirred for 4 h. Upon completion, the reaction was quenched with saturated NaHCO₃ (10 mL), and extracted with CH₂Cl₂ (10 mL x 3). The combined organic layer was washed with brine (10 mL x 3), dried over Na₂SO₄ and filtered, concentrated in vacuo.

The crude MOM-protected intermediate was dissolved in TFA (2 mL) and CH₂Cl₂ (6 mL), and stirred at 0 °C for 4h. The mixture was concentrated under reduced pressure, azeotroped with toluene (3 mL x 2) to remove residual TFA, and dried in vacuo to afford the amine salt.

The amine salt was dissolved in EtOAc (5 mL) and H₂O (5 mL). Na₂CO₃ (1.1 g, 10.0 mmol) and NsCl (1.7 g, 7.5 mmol) were added sequentially at room temperature, and the resulting mixture was stirred for 4 h. The reaction was quenched by the addition of 1 M HCl aq. (15 mL), and extracted with EtOAc (15 mL x 3). The combined organic layer was washed with brine (10 mL x 3), dried over Na₂SO₄ and filtered, concentrated in vacuo. The crude product was purified by column chromatography to afford **3f**.

(S)-N-(1-(methoxymethoxy)pent-4-en-2-yl)-4-nitrobenzenesulfonamide (3f). R_f = 0.50 (silica gel, PE: EtOAc = 3:1, UV). colorless oil (1.19g, 72% yield over 3 steps). $[\alpha]_D^{25} = -8.05$ (*c* = 0.40, CH₂Cl₂). ¹H NMR (400 MHz, CDCl₃) δ 8.42 – 8.28 (m, 2H), 8.15 – 8.00 (m, 2H), 5.66 – 5.48 (m, 1H), 5.19 (d, *J* = 7.8 Hz, 1H), 5.04 (d, *J* = 6.4 Hz, 1H), 5.01 (s, 1H), 4.52 – 4.42 (m, 2H), 3.57 – 3.45 (m, 2H), 3.45 – 3.37 (m, 1H), 3.29 (s, 3H), 2.37 – 2.19 (m, 2H). ¹³C NMR (100 MHz, CDCl₃) δ 150.0, 147.0, 133.0, 128.3 (2), 124.2 (2), 119.1, 96.8, 69.1, 55.5, 53.6, 36.8. HRMS (ESI) *m/z* calcd. for C₁₃H₁₉N₂O₆S [M+H]⁺: 331.0959, found: 331.0964.



Under an atmosphere of argon, a mixture of **S6** (1.01 g, 5.0 mmol) and KOH (0.56 g, 10.0 mmol) was dissolved in anhydrous DMF (20 mL) and stirred at 0 °C for 10 min. After adding BnBr (1.03 g, 6.0 mmol), the reaction mixture was warmed up to room temperature and stirred for 4 h. Upon completion, the solution was quenched with 1M HCl aq. (5 ml) and extracted with EtOAc (15 mL x 3). The combined organic layer was washed with brine (10 mL x 3), dried over Na₂SO₄ and filtered, concentrated in vacuo.

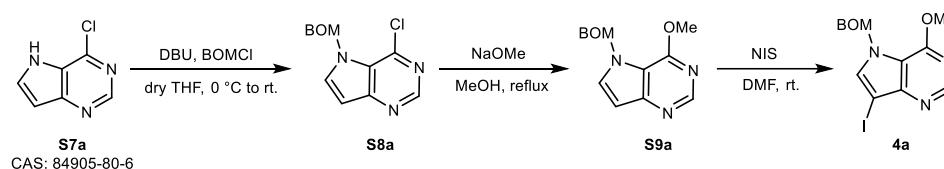
The crude Bn-protected intermediate was dissolved in TFA (2 mL) and CH₂Cl₂ (6 mL), and stirred at 0 °C for 4h. The mixture was concentrated under reduced pressure, azeotroped with toluene (3 mL x 2) to remove residual TFA, and dried in vacuo to afford the amine salt.

The crude intermediate was dissolved in EtOAc (5 mL) and H₂O (5 mL). Na₂CO₃ (1.1 g, 10.0 mmol) and NsCl (1.7 g, 7.5 mmol) were added sequentially at room temperature, and the resulting

mixture was stirred for 4 h. The reaction was quenched by the addition of 1 M HCl aq. (15 mL), and extracted with EtOAc (15 mL x 3). The combined organic layer was washed with brine (10 mL x 3), dried over Na₂SO₄ and filtered, concentrated in vacuo. The crude product was purified by column chromatography to afford **3g**.

(S)-N-(1-(benzyloxy)pent-4-en-2-yl)-4-nitrobenzenesulfonamide (3g). R_f = 0.50 (silica gel, PE: EtOAc = 3:1, UV). colorless oil (1.15 g, 61% yield over 3 steps). $[\alpha]_D^{25} = -3.94$ (c = 0.40, CH₂Cl₂). **¹H NMR** (400 MHz, CDCl₃) δ 8.26 – 8.14 (m, 2H), 8.03 – 7.91 (m, 2H), 7.36 – 7.28 (m, 3H), 7.20 – 7.14 (m, 2H), 5.70 – 5.50 (m, 1 H), 5.13 – 4.97 (m, 3H), 4.40 – 4.30 (m, 2H), 3.56 – 3.47 (m, 1H), 3.42 – 3.29 (m, 2H), 2.38 – 2.26 (m, 2H). **¹³C NMR** (100 MHz, CDCl₃) δ 149.8, 146.8, 137.3, 133.0, 128.5 (2), 128.2 (2), 128.1, 127.8 (2), 124.1 (2), 119.0, 73.3, 70.7, 53.6, 37.0. **HRMS** (ESI) m/z calcd. for C₁₈H₂₀N₂O₅SNa [M+Na]⁺: 399.0985, found: 399.0987.

2.3 Synthesis of base 4a, 4i-4m, 4p-4u.



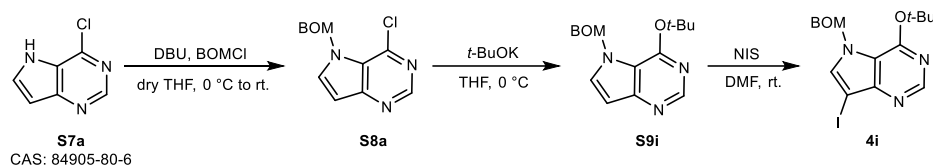
Under an atmosphere of argon, a mixture of **S7a** (20.0 g, 131 mmol) and DBU (39.5 g, 260 mmol) was dissolved in anhydrous THF (300 mL) and stirred at 0 °C for 10 min. After adding BOMCl (40.7 g, 260 mmol), the reaction mixture was warmed up to room temperature and stirred for 12 h. Then the solvent was removed under reduced pressure to give crude compound **S8a**, which was used directly in the next step without purification.

A mixture of crude compound **S8a** and NaOMe (48 mL, 260 mmol, 5.4 M in MeOH) was dissolved in anhydrous MeOH (150 mL) and stirred at 65 °C for 4 h. Then the solvent was evaporated under reduced pressure to give crude compound **S9a**, which was used directly in the next step without purification.

NIS (29.3 g, 130 mmol) was added in small portion to a solution of crude compound **S9a** in anhydrous DMF (200 mL) at room temperature, and the mixture was stirred for 8 h. Quench the reaction with saturated Na₂S₂O₃ aq. (150 mL) and EtOAc (100 mL). The layers were separated, and the aqueous layer was extracted with EtOAc (50 mL x 5). The combined organic layer was washed with brine (100 mL x 3), dried over Na₂SO₄ and filtered, concentrated in vacuo. The crude product was purified by column chromatography to afford **4a**.

5-((benzyloxy)methyl)-7-iodo-4-methoxy-5H-pyrrolo[3,2-d]pyrimidine (4a). R_f = 0.50 (silica gel, PE: EtOAc = 3:1, UV). white solid (39.9 g, 77% yield over 3 steps). **MP**: 120.8 – 122.1 °C. **¹H NMR** (400 MHz, CDCl₃) δ 8.63 (s, 1H), 7.49 (s, 1H), 7.39 – 7.20 (m, 5H), 5.72 (s, 2H), 4.49 (s,

2H), 4.12 (s, 3H). ¹³C NMR (100 MHz, CDCl₃) δ 156.4, 151.6, 151.1, 136.6, 136.1, 128.5 (2), 128.1, 127.7 (2), 115.9, 77.3, 70.5, 59.5, 53.9. HRMS (ESI) m/z calcd. for C₁₅H₁₄IN₃O₂Na [M+Na]⁺: 418.0023, found: 418.0025.

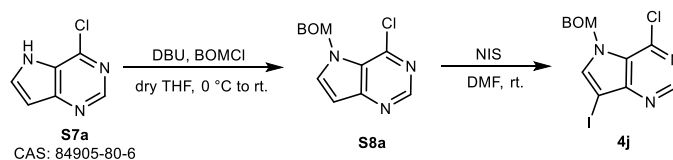


Under an atmosphere of argon, a mixture of **S7a** (4.59 g, 30.0 mmol) and DBU (9.12 g, 60.0 mmol) was dissolved in anhydrous THF (50 mL) and stirred at 0 °C for 10 min. After adding BOMCl (9.40 g, 60.0 mmol), the reaction mixture was warmed up to room temperature and stirred for 12 h. Then the solvent was removed under reduced pressure to give crude compound **S8a**, which was used directly in the next step without purification.

A mixture of crude compound **S8a** and *t*-BuOK (6.72 g, 60 mmol) was dissolved in anhydrous THF (100 mL) and stirred at 0 °C for 4 h. Then the solvent was evaporated under reduced pressure to give crude compound **S9i**, which was used directly in the next step without purification.

NIS (6.75 g, 30.0 mmol) was added in small portion to a solution of crude compound **S9i** in anhydrous DMF (100 mL) at room temperature, and the mixture was stirred for 8 h. Quench the reaction with saturated Na₂S₂O₃ aq. (50 mL) and EtOAc (50 mL). The layers were separated, and the aqueous layer was extracted with EtOAc (30 mL x 5). The combined organic layer was washed with brine (50 mL x 3), dried over Na₂SO₄ and filtered, concentrated in vacuo. The crude product was purified by column chromatography to afford **4i**.

5-((benzyloxy)methyl)-4-(tert-butoxy)-7-iodo-5H-pyrrolo[3,2-d]pyrimidine (4i). R_f = 0.50 (silica gel, PE: EtOAc = 3:1, UV). yellow oil (7.34 g, 56% yield over 3 steps). ¹H NMR (400 MHz, CDCl₃) δ 8.58 (s, 1H), 7.47 (s, 1H), 7.33 – 7.26 (m, 3H), 7.24 – 7.18 (m, 2H), 5.74 (s, 2H), 4.48 (s, 2H), 1.68 (s, 9H). ¹³C NMR (100 MHz, CDCl₃) δ 155.8, 151.3, 150.6, 136.7, 135.5, 128.4 (2), 127.9, 127.3 (2), 116.8, 83.4, 77.1, 70.1, 59.2, 28.5 (3). HRMS (ESI) m/z calcd. for C₁₈H₂₀IN₃O₂Na [M+Na]⁺: 460.0492, found: 460.0498.

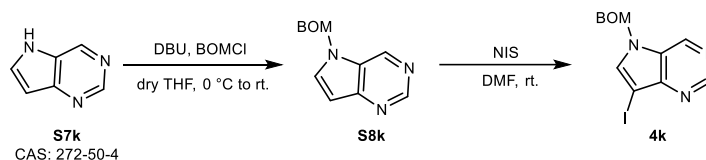


Under an atmosphere of argon, a mixture of **S7a** (4.59 g, 30.0 mmol) and DBU (9.12 g, 60.0 mmol) was dissolved in anhydrous THF (50 mL) and stirred at 0 °C for 10 min. After adding BOMCl (9.40 g, 60.0 mmol), the reaction mixture was warmed up to room temperature and stirred for 12 h. Then the solvent was removed under reduced pressure to give crude compound **S8a**, which

was used directly in the next step without purification.

NIS (6.75 g, 30.0 mmol) was added in small portion to a solution of crude compound **S8a** in anhydrous DMF (100 mL) at room temperature, and the mixture was stirred for 8 h. Quench the reaction with saturated Na₂S₂O₃ aq. (50 mL) and EtOAc (50 mL). The layers were separated, and the aqueous layer was extracted with EtOAc (30 mL x 5). The combined organic layer was washed with brine (50 mL x 3), dried over Na₂SO₄ and filtered, concentrated in vacuo. The crude product was purified by column chromatography to afford **4j**.

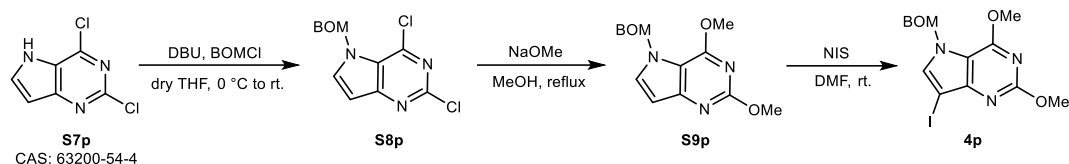
5-((benzyloxy)methyl)-4-chloro-7-iodo-5H-pyrrolo[3,2-d]pyrimidine (4j). R_f = 0.50 (silica gel, PE: EtOAc = 3:1, UV). white solid (7.43 g, 62% yield over 2 steps). **MP**: 114.6 – 115.5 °C. **¹H NMR** (400 MHz, CDCl₃) δ 8.82 (s, 1H), 7.63 (s, 1H), 7.30 – 7.21 (m, 5H), 5.84 (s, 2H), 4.55 (s, 2H). **¹³C NMR** (100 MHz, CDCl₃) δ 153.2, 151.0, 142.9, 140.1, 136.0, 128.5 (2), 128.3, 127.6 (2), 124.2, 76.9, 70.9, 59.5. **HRMS** (ESI) m/z calcd. for C₁₄H₁₁ClIN₃ONa [M+Na]⁺: 421.9527, found: 421.9510.



Under an atmosphere of argon, a mixture of **S7k** (3.57 g, 30.0 mmol) and DBU (9.12 g, 60.0 mmol) was dissolved in anhydrous THF (50 mL) and stirred at 0 °C for 10 min. After adding BOMCl (9.40 g, 60.0 mmol), the reaction mixture was warmed up to room temperature and stirred for 12 h. Then the solvent was removed under reduced pressure to give crude compound **S8k**, which was used directly in the next step without purification.

NIS (6.75 g, 30.0 mmol) was added in small portion to a solution of crude compound **S8k** in anhydrous DMF (100 mL) at room temperature, and the mixture was stirred for 8 h. Quench the reaction with saturated Na₂S₂O₃ aq. (50 mL) and EtOAc (50 mL). The layers were separated, and the aqueous layer was extracted with EtOAc (30 mL x 5). The combined organic layer was washed with brine (50 mL x 3), dried over Na₂SO₄ and filtered, concentrated in vacuo. The crude product was purified by column chromatography to afford **4k**.

5-((benzyloxy)methyl)-7-iodo-5H-pyrrolo[3,2-d]pyrimidine (4k). R_f = 0.50 (silica gel, PE: EtOAc = 3:1, UV). white solid (7.77 g, 71% yield over 2 steps). **MP**: 136.7-137.5 °C. **¹H NMR** (400 MHz, CDCl₃) δ 9.13 (s, 1H), 8.88 (s, 1H), 7.61 (s, 1H), 7.39 – 7.28 (d, *J* = 5.8 Hz, 3H), 7.26 – 7.19 (m, 2H), 5.59 (s, 2H), 4.47 (s, 2H). **¹³C NMR** (100 MHz, CDCl₃) δ 162.1, 153.6, 141.9, 138.4, 135.8, 128.7 (2), 128.5, 128.0 (2), 124.7, 76.0, 70.5, 55.0. **HRMS** (ESI) m/z calcd. for C₁₄H₁₂IN₃ONa [M+Na]⁺: 387.9917, found: 387.9930.

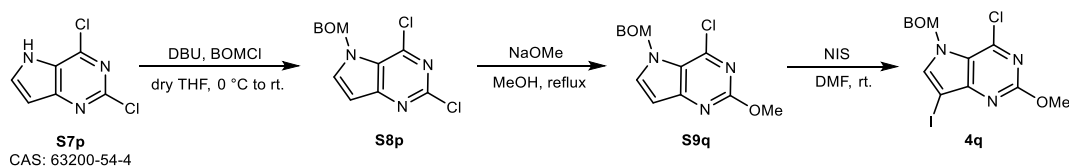


Under an atmosphere of argon, a mixture of **S7p** (5.64 g, 30 mmol) and DBU (9.12 g, 60.0 mmol) was dissolved in anhydrous THF (200 mL) and stirred at 0 °C for 10 min. After adding BOMCl (9.40 g, 60.0 mmol), the reaction mixture was warmed up to room temperature and stirred for 12 h. Then the solvent was removed under reduced pressure to give crude compound **S8p**, which was used directly in the next step without purification.

A mixture of crude compound **S8p** and NaOMe (17 mL, 90 mmol, 5.4 M in MeOH) was dissolved in anhydrous MeOH (100 mL) and stirred at 65 °C for 4 h. Then the solvent was evaporated under reduced pressure to give crude compound **S9p**, which was used directly in the next step without purification.

NIS (6.75 g, 30.0 mmol) was added in small portion to a solution of crude compound **S9p** in anhydrous DMF (100 mL) at room temperature, and the mixture was stirred for 8 h. Quench the reaction with saturated Na₂S₂O₃ aq. (100 mL) and EtOAc (50 mL). The layers were separated, and the aqueous layer was extracted with EtOAc (50 mL x 5). The combined organic layer was washed with brine (100 mL x 3), dried over Na₂SO₄ and filtered, concentrated in vacuo. The crude product was purified by column chromatography to afford **4p**.

5-((benzyloxy)methyl)-7-iodo-2,4-dimethoxy-5H-pyrrolo[3,2-d]pyrimidine (4p). R_f = 0.50 (silica gel, PE: EtOAc = 3:1, UV). white solid (6.01 g, 47% yield over 3 steps). **MP**: 92.9 – 93.8 °C. **¹H NMR** (400 MHz, CDCl₃) δ 7.36 (s, 1H), 7.34 – 7.17 (m, 5H), 5.61 (s, 2H), 4.44 (s, 2H), 4.08 (s, 3H), 4.07 (s, 3H). **¹³C NMR** (100 MHz, CDCl₃) δ 160.7, 157.8, 152.9, 136.6, 136.3, 128.5 (2), 128.0, 127.7 (2), 112.4, 77.0, 70.2, 58.1, 54.8, 54.0. **HRMS** (ESI) m/z calcd. for C₁₆H₁₆IN₃O₃Na [M+Na]⁺: 448.0128, found: 448.0161.

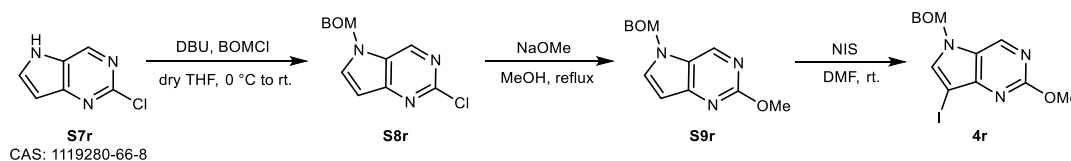


Under an atmosphere of argon, a mixture of **S7p** (5.64 g, 30 mmol) and DBU (9.12 g, 60.0 mmol) was dissolved in anhydrous THF (200 mL) and stirred at 0 °C for 10 min. After adding BOMCl (9.40 g, 60.0 mmol), the reaction mixture was warmed up to room temperature and stirred for 12 h. Then the solvent was removed under reduced pressure to give crude compound **S8p**, which was used directly in the next step without purification.

A mixture of crude compound **S8p** and NaOMe (6 mL, 30 mmol, 5.4 M in MeOH) was dissolved in anhydrous MeOH (100 mL) and stirred at 65 °C for 4 h. Then the solvent was evaporated under reduced pressure to give crude compound **S9q**, which was used directly in the next step without purification.

NIS (6.75 g, 30.0 mmol) was added in small portion to a solution of crude compound **S9q** in anhydrous DMF (100 mL) at room temperature, and the mixture was stirred for 8 h. Quench the reaction with saturated Na₂S₂O₃ aq. (100 mL) and EtOAc (50 mL). The layers were separated, and the aqueous layer was extracted with EtOAc (50 mL x 5). The combined organic layer was washed with brine (100 mL x 3), dried over Na₂SO₄ and filtered, concentrated in vacuo. The crude product was purified by column chromatography to afford **4q**.

5-((benzyloxy)methyl)-4-chloro-7-iodo-2-methoxy-5H-pyrrolo[3,2-d]pyrimidine (4q). R_f = 0.50 (silica gel, PE:EtOAc = 3:1, UV). white solid (7.35 g, 57% yield over 3 steps). **MP**: 126.2 – 127.9 °C. **¹H NMR** (400 MHz, CDCl₃) δ 7.46 (s, 1H), 7.34 – 7.25 (m, 3H), 7.24 – 7.14 (m, 2H), 5.66 (s, 2H), 4.48 (s, 2H), 4.11 (s, 3H). **¹³C NMR** (100 MHz, CDCl₃) δ 156.9, 153.3, 151.7, 137.5, 136.3, 128.5 (2), 128.2, 127.6 (2), 114.6, 77.2, 70.6, 58.3, 54.8. **HRMS** (ESI) m/z calcd. for C₁₅H₁₃ClIN₃O₂Na [M+Na]⁺: 451.9633, found: 451.9635.

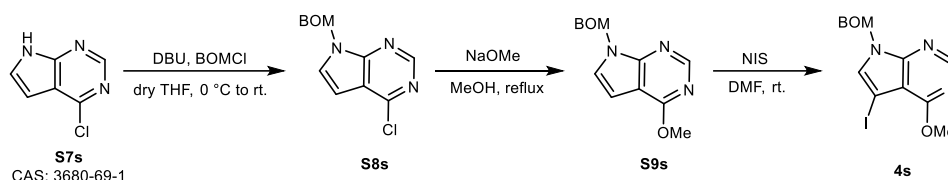


Under an atmosphere of argon, a mixture of **S7r** (4.59 g, 30 mmol) and DBU (9.12 g, 60.0 mmol) was dissolved in anhydrous THF (200 mL) and stirred at 0 °C for 10 min. After adding BOMCl (9.40 g, 60.0 mmol), the reaction mixture was warmed up to room temperature and stirred for 12 h. Then the solvent was removed under reduced pressure to give crude compound **S8r**, which was used directly in the next step without purification.

A mixture of crude compound **S8r** and NaOMe (11 mL, 60 mmol, 5.4 M in MeOH) was dissolved in anhydrous MeOH (100 mL) and stirred at 65 °C for 4 h. Then the solvent was evaporated under reduced pressure to give crude compound **S9r**, which was used directly in the next step without purification.

NIS (6.75 g, 30.0 mmol) was added in small portion to a solution of crude compound **S9r** in anhydrous DMF (100 mL) at room temperature, and the mixture was stirred for 8 h. Quench the reaction with saturated Na₂S₂O₃ aq. (100 mL) and EtOAc (50 mL). The layers were separated, and the aqueous layer was extracted with EtOAc (50 mL x 5). The combined organic layer was washed with brine (100 mL x 3), dried over Na₂SO₄ and filtered, concentrated in vacuo. The crude product was purified by column chromatography to afford **4r**.

5-((benzyloxy)methyl)-7-iodo-2-methoxy-5H-pyrrolo[3,2-d]pyrimidine (4r). R_f = 0.50 (silica gel, PE: EtOAc = 3:1, UV). yellow solid (7.82 g, 66% yield over 3 steps). **MP:** 95.5 – 96.8 °C. **¹H NMR** (400 MHz, CDCl₃) δ 8.65 (s, 1H), 7.51 (s, 1H), 7.38 – 7.28 (m, 3H), 7.25 – 7.19 (m, 2H), 5.51 (s, 2H), 4.44 (s, 2H), 4.11 (s, 3H). **¹³C NMR** (100 MHz, CDCl₃) δ 162.1, 153.5, 141.9, 138.4, 135.8, 128.7 (2), 128.5, 128.0 (2), 124.7, 76.0, 70.5, 57.3, 55.0. **HRMS** (ESI) m/z calcd. for C₁₅H₁₄IN₃O₂Na [M+Na]⁺: 418.0023, found: 418.0029.

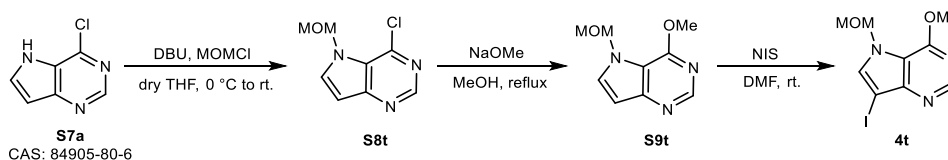


Under an atmosphere of argon, a mixture of **S7s** (4.59 g, 30 mmol) and DBU (9.12 g, 60.0 mmol) was dissolved in anhydrous THF (200 mL) and stirred at 0 °C for 10 min. After adding BOMCl (9.40 g, 60.0 mmol), the reaction mixture was warmed up to room temperature and stirred for 12 h. Then the solvent was removed under reduced pressure to give crude compound **S8s**, which was used directly in the next step without purification.

A mixture of crude compound **S8s** and NaOMe (11 mL, 60 mmol, 5.4 M in MeOH) was dissolved in anhydrous MeOH (100 mL) and stirred at 65 °C for 4 h. Then the solvent was evaporated under reduced pressure to give crude compound **S9s**, which was used directly in the next step without purification.

NIS (6.75 g, 30.0 mmol) was added in small portion to a solution of crude compound **S9s** in anhydrous DMF (100 mL) at room temperature, and the mixture was stirred for 8 h. Quench the reaction with saturated Na₂S₂O₃ aq. (100 mL) and EtOAc (50 mL). The layers were separated, and the aqueous layer was extracted with EtOAc (50 mL x 5). The combined organic layer was washed with brine (100 mL x 3), dried over Na₂SO₄ and filtered, concentrated in vacuo. The crude product was purified by column chromatography to afford **4s**.

7-((benzyloxy)methyl)-5-iodo-4-methoxy-7H-pyrrolo[2,3-d]pyrimidine (4s). R_f = 0.50 (silica gel, PE: EtOAc = 3:1, UV). white solid (6.41 g, 54% yield over 3 steps). **MP:** 102.6 – 103.4 °C. **¹H NMR** (400 MHz, CDCl₃) δ 8.48 (s, 1H), 7.35 – 7.19 (m, 6H), 5.64 (s, 2H), 4.49 (s, 2H), 4.14 (s, 3H). **¹³C NMR** (100 MHz, CDCl₃) δ 163.1, 152.3, 151.8, 136.7, 130.6, 128.4 (2), 128.0, 127.8 (2), 107.3, 73.0, 71.1, 53.8, 50.9. **HRMS** (ESI) m/z calcd. for C₁₅H₁₄IN₃O₂Na [M+Na]⁺: 418.0023, found: 418.0039.

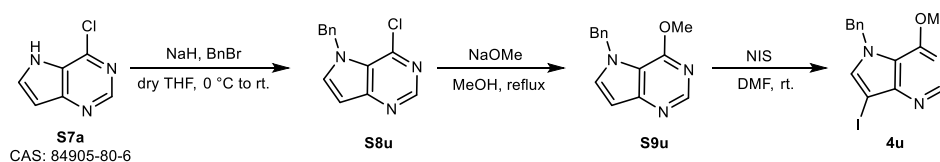


Under an atmosphere of argon, a mixture of **S7a** (4.59 g, 30 mmol) and DBU (9.12 g, 60.0 mmol) was dissolved in anhydrous THF (200 mL) and stirred at 0 °C for 10 min. After adding MOMCl (4.83 g, 60.0 mmol), the reaction mixture was warmed up to room temperature and stirred for 12 h. Then the solvent was removed under reduced pressure to give crude compound **S8t**, which was used directly in the next step without purification.

A mixture of crude compound **S8t** and NaOMe (11 mL, 60 mmol, 5.4 M in MeOH) was dissolved in anhydrous MeOH (100 mL) and stirred at 65 °C for 4 h. Then the solvent was evaporated under reduced pressure to give crude compound **S9t**, which was used directly in the next step without purification.

NIS (6.75 g, 30.0 mmol) was added in small portion to a solution of crude compound **S9t** in anhydrous DMF (100 mL) at room temperature, and the mixture was stirred for 8 h. Quench the reaction with saturated Na₂S₂O₃ aq. (100 mL) and EtOAc (50 mL). The layers were separated, and the aqueous layer was extracted with EtOAc (50 mL x 5). The combined organic layer was washed with brine (100 mL x 3), dried over Na₂SO₄ and filtered, concentrated in vacuo. The crude product was purified by column chromatography to afford **4t**.

7-iodo-4-methoxy-5-(methoxymethyl)-5H-pyrrolo[3,2-d]pyrimidine (4t). *R_f* = 0.50 (silica gel, PE: EtOAc = 3:1, UV). yellow solid (7.08 g, 74% yield over 3 steps). **MP**: 149.5 – 152.3 °C. **¹H NMR** (400 MHz, CDCl₃) δ 8.62 (s, 1H), 7.50 (s, 1H), 5.61 (s, 2H), 4.17 (s, 3H), 3.28 (s, 3H). **¹³C NMR** (100 MHz, CDCl₃) δ 156.38, 151.62, 151.11, 136.18, 115.89, 79.51, 59.28, 56.18, 54.00. **HRMS** (ESI) *m/z* calcd. for C₉H₁₁IN₃O₂ [M+H]⁺: 319.9891, found: 319.9892.

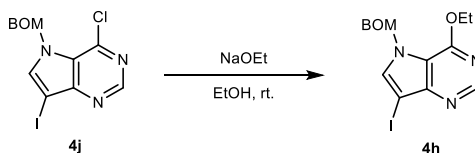


Under an atmosphere of argon, a mixture of **S7a** (4.59 g, 30 mmol) and NaH (60% dispersion in mineral oil, 2.40 g, 60.0 mmol) was dissolved in anhydrous THF (200 mL) and stirred at 0 °C for 10 min. After adding BnBr (10.26 g, 60.0 mmol), the reaction mixture was warmed up to room temperature and stirred for 12 h. Then the reaction mixture was quenched with saturated NH₄Cl aq. (10 mL), the THF was removed under vacuo and the aqueous layer was extracted with EtOAc (10 mL x 3). The combined organic layer was washed with brine (10 mL x 3), dried over Na₂SO₄ and filtered, concentrated in vacuo. The crude **S8u** was used directly in the next step without purification.

A mixture of crude compound **S8u** and NaOMe (11 mL, 60 mmol, 5.4 M in MeOH) was dissolved in anhydrous MeOH (100 mL) and stirred at 65 °C for 4 h. Then the solvent was evaporated under reduced pressure to give crude compound **S9u**, which was used directly in the next step without purification.

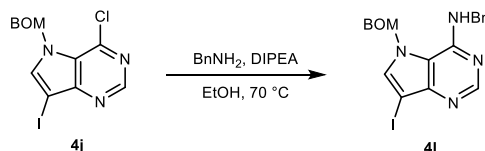
NIS (6.75 g, 30.0 mmol) was added in small portion to a solution of crude compound **S9u** in anhydrous DMF (100 mL) at room temperature, and the mixture was stirred for 8 h. Quench the reaction with saturated Na₂S₂O₃ aq. (100 mL) and EtOAc (50 mL). The layers were separated, and the aqueous layer was extracted with EtOAc (50 mL x 5). The combined organic layer was washed with brine (100 mL x 3), dried over Na₂SO₄ and filtered, concentrated in vacuo. The crude product was purified by column chromatography to afford **4u**.

5-benzyl-7-iodo-4-methoxy-5H-pyrrolo[3,2-d]pyrimidine (4u). *R*_f = 0.50 (silica gel, PE: EtOAc = 3:1, UV). yellow solid (7.01 g, 64% yield over 3 steps). **MP**: 127.9 – 129.1 °C. **¹H NMR** (400 MHz, CDCl₃) δ 8.60 (s, 1H), 7.36 – 7.14 (m, 4H), 7.21 – 7.08 (m, 2H), 5.53 (s, 2H), 4.19 – 4.04 (m, 3H). **¹³C NMR** (100 MHz, CDCl₃) δ 156.5, 151.2, 150.8, 137.0, 136.1, 129.1 (2), 128.3, 127.4 (2), 116.2, 57.5, 53.9, 53.3. **HRMS** (ESI) *m/z* calcd. for C₁₄H₁₃IN₃O [M+H]⁺: 366.0098, found: 366.0091.



To a solution of **4j** (1.0 g, 2.5 mmol) in EtOH (10 mL), NaOEt (1 mL, 20 wt% in EtOH) was added at room temperature. The mixture was stirred for 10 h at room temperature and quenched with saturated NH₄Cl aq. (10 mL), the EtOH was removed under vacuo and the aqueous layer was extracted with EtOAc (10 mL x 3). The combined organic layer was washed with brine (10 mL x 3), dried over Na₂SO₄ and filtered, concentrated in vacuo. The crude residue was purified by flash column chromatography to afford **4h**.

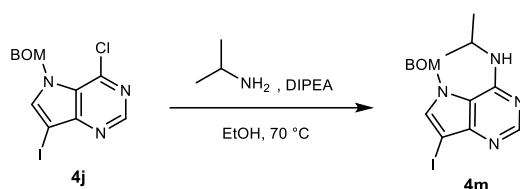
5-((benzyloxy)methyl)-4-ethoxy-7-iodo-5H-pyrrolo[3,2-d]pyrimidine (4h). *R*_f = 0.50 (silica gel, PE: EtOAc = 2:1, UV). white solid (810 mg, 79% yield). **MP**: 123.8 – 124.6 °C. **¹H NMR** (400 MHz, CDCl₃) δ 8.60 (s, 1H), 7.50 (s, 1H), 7.32 – 7.20 (m, 5H), 5.75 (s, 2H), 4.61 (q, *J* = 7.1 Hz, 2H), 4.50 (s, 2H), 1.43 (t, *J* = 7.1 Hz, 3H). **¹³C NMR** (100 MHz, CDCl₃) δ 156.1, 151.5, 151.1, 136.6, 136.1, 128.5 (2), 128.1, 127.6 (2), 115.9, 77.3, 70.5, 62.8, 59.5, 14.5. **HRMS** (ESI) *m/z* calcd. for C₁₆H₁₆IN₃O₂Na [M+Na]⁺: 432.0179, found: 432.0179.



Under an atmosphere of argon, a mixture of **4j** (1.0 g, 2.5 mmol), benzylamine (402 mg, 3.76 mmol) and *N,N*-diisopropylethylamine (DIPEA, 485 mg, 3.76 mmol) was dissolved in anhydrous EtOH (5 mL) and stirred at 70 °C for 10 h. After cooling to room temperature, the solution was

quenched with saturated NH_4Cl aq. (50 mL), the EtOH was removed under vacuo and the aqueous layer was extracted with EtOAc (50 mL x 3). The combined organic layer was washed with brine (10 mL x 3), dried over Na_2SO_4 and filtered, concentrated in vacuo. The crude residue was purified by flash column chromatography to afford **4l**.

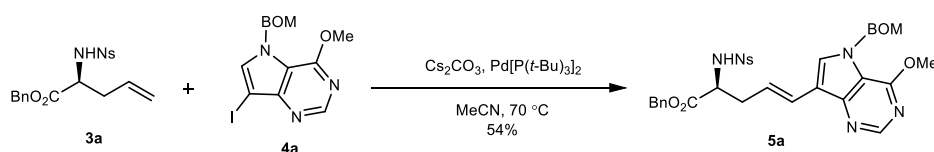
N-benzyl-5-((benzyloxy)methyl)-7-iodo-5H-pyrrolo[3,2-d]pyrimidin-4-amine (4l). R_f = 0.50 (silica gel, PE: EtOAc = 2:1, UV). white solid (1.06 g, 90% yield). **MP**: 128.3 – 129.1 °C. **^1H NMR** (400 MHz, CDCl_3) δ 8.56 (s, 1H), 7.36 – 7.30 (m, 3H), 7.29 – 7.22 (m, 5H), 7.21 – 7.14 (m, 3H), 6.93 (br, 1H), 5.46 (s, 2H), 4.75 (d, J = 5.4 Hz, 2H), 4.54 (s, 2H). **^{13}C NMR** (100 MHz, CDCl_3) δ 152.7, 150.6, 150.2, 138.6, 134.9, 134.1, 128.8 (2), 128.7, 128.7 (2), 128.3 (2), 127.6 (2), 127.4, 115.6, 77.2, 70.2, 58.9, 44.9. **HRMS** (ESI) m/z calcd. for $\text{C}_{21}\text{H}_{19}\text{IN}_4\text{ONa}$ $[\text{M}+\text{Na}]^+$: 493.0496, found: 493.0501.



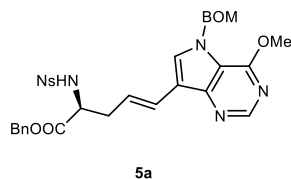
Under an atmosphere of argon, a mixture of **4j** (1.0 g, 2.5 mmol), isopropylamine (0.22 g, 3.76 mmol) and *N,N*-diisopropylethylamine (DIPEA, 0.49 g, 3.76 mmol) was dissolved in anhydrous EtOH (5 mL) and stirred at 70 °C for 10 h. After cooling to room temperature, the solution was quenched with saturated NH_4Cl aq. (50 mL), the EtOH was removed under vacuo and the aqueous layer was extracted with EtOAc (50 mL x 3). The combined organic layer was washed with brine (10 mL x 3), dried over Na_2SO_4 and filtered, concentrated in vacuo. The crude residue was purified by flash column chromatography to afford **4m**.

5-((benzyloxy)methyl)-7-iodo-N-isopropyl-5H-pyrrolo[3,2-d]pyrimidin-4-amine (4m). R_f = 0.50 (silica gel, PE: EtOAc = 2:1, UV). white solid (973 mg, 92% yield). **MP**: 129.2 – 130.7 °C. **^1H NMR** (400 MHz, CDCl_3) δ 8.52 (s, 1H), 7.44 – 7.34 (m, 3H), 7.3 – 7.26 (m, 2H), 7.16 (s, 1H), 6.55 (d, J = 7.2 Hz, 1H), 5.48 (s, 2H), 4.60 (s, 2H), 4.42 – 4.30 (m, 6.6 Hz, 1H), 1.17 (d, J = 6.4 Hz, 6H). **^{13}C NMR** (100 MHz, CDCl_3) δ 152.8, 150.2, 149.9, 135.1, 133.8, 128.8 (2), 128.8, 128.4 (2), 115.6, 77.2, 70.1, 58.8, 42.4, 22.7 (2). **HRMS** (ESI) m/z calcd. for $\text{C}_{17}\text{H}_{20}\text{IN}_4\text{O}$ $[\text{M}+\text{H}]^+$: 423.0681, found: 423.0681.

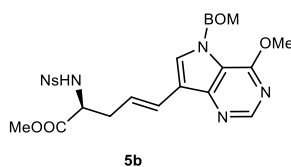
2.4 Synthesis of substrate 5a-5u.



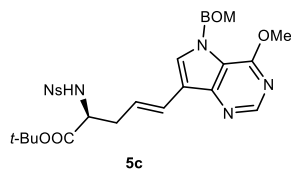
Under an atmosphere of argon, the reaction mixture of **3a** (3.9 g, 10 mmol), **4a** (4.74 g, 12 mmol), Cs₂CO₃ (9.75 g, 30 mmol), and Pd[P(*t*-Bu)₃]₂ (0.51 mg, 1 mmol) in anhydrous MeCN (150 ml) was stirred at 70 °C for 8 h. The solution was diluted with 1M HCl aq. (45 mL). The layers were separated, and the aqueous layer was extracted with EtOAc (50 mL x 3). The combined organic layer was washed with brine (50 mL x 3), dried over Na₂SO₄ and filtered, concentrated in vacuo. The crude material was purified via silica gel column chromatography to obtain **5a**. According to this procedure, compounds **5b-5c**, **5f-5g**, **5i-5m** and **5p-5u** were synthesized at 2 mmol scale.



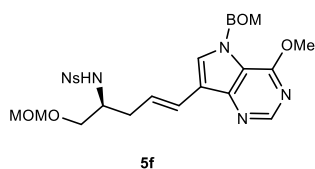
Benzyl (S,E)-5-(5-((benzyloxy)methyl)-4-methoxy-5H-pyrrolo[3,2-d]pyrimidin-7-yl)-2-((4-nitrophenyl)sulfonamido)pent-4-enoate (5a). R_f = 0.30 (silica gel, PE: EtOAc = 1:1, UV). white solid (3.55 g, 54% yield). **MP**: 134.5 – 135.3 °C. [α]_D²⁵ = –10.03 (*c* = 0.40, CH₂Cl₂). **¹H NMR** (400 MHz, CDCl₃) δ 8.54 (s, 1H), 8.09 – 7.98 (m, 2H), 7.97 – 7.85 (m, 2H), 7.36 – 7.20 (m, 11H), 6.56 – 6.41 (m, 2H), 5.78 (d, *J* = 9.4 Hz, 1H), 5.72 – 5.64 (d, *J* = 23.6 Hz, 2H), 5.08 – 5.00 (d, *J* = 2.2 Hz, 2H), 4.48 (s, 2H), 4.30 – 4.22 (m, 1H), 4.12 (s, 3H), 2.82 – 2.59 (m, 2H). **¹³C NMR** (100 MHz, CDCl₃) δ 170.7, 156.4, 150.3, 149.7, 148.6, 146.0, 136.8, 134.8, 130.4, 128.7, 128.6 (2), 128.5 (2), 128.5 (2), 128.3 (2), 128.1, 127.7 (2), 124.8, 124.0 (2), 123.1, 116.3, 115.3, 77.0, 70.3, 67.7, 56.1, 53.7, 37.5. **HRMS** (ESI) *m/z* calcd. for C₃₃H₃₂N₅O₈S [M+H]⁺: 658.1966, found: 658.1965.



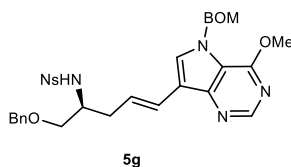
Benzyl (S,E)-5-(5-((benzyloxy)methyl)-4-methoxy-5H-pyrrolo[3,2-d]pyrimidin-7-yl)-2-((4-nitrophenyl)sulfonamido)pent-4-enoate (5b). R_f = 0.30 (silica gel, PE: EtOAc = 1:1, UV). white solid (441 mg, 38% yield). **MP**: 125.7 – 126.3 °C. [α]_D²⁵ = +3.32 (*c* = 0.40, CH₂Cl₂). **¹H NMR** (400 MHz, CDCl₃) δ 8.53 (s, 1H), 8.13 – 8.05 (m, 2H), 8.02 – 7.93 (m, 2H), 7.36 – 7.22 (m, 6H), 6.50 – 6.40 (m, 2H), 5.74 (d, *J* = 8.8 Hz, 1H), 5.71 – 5.66 (m, 2H), 4.48 (s, 2H), 4.26 – 4.17 (m, 1H), 4.12 (s, 3H), 3.67 (s, 3H), 2.77 – 2.55 (m, 2H). **¹³C NMR** (100 MHz, CDCl₃) δ 171.4, 156.3, 150.4, 149.7, 148.8, 146.1, 136.8, 130.3, 128.5 (2), 128.4 (2), 128.1, 127.7 (2), 124.8, 124.0 (2), 123.1, 116.3, 115.3, 77.0, 70.3, 56.0, 53.7, 52.8, 37.3. **HRMS** (ESI) *m/z* calcd. for C₂₇H₂₇N₅O₈SNa [M+Na]⁺: 604.1472, found: 604.1488.



Tert-butyl (S,E)-5-(5-((benzyloxy)methyl)-4-methoxy-5H-pyrrolo[3,2-d]pyrimidin-7-yl)-2-((4-nitrophenyl)sulfonamido)pent-4-enoate (5c). R_f = 0.30 (silica gel, PE:EtOAc = 1:1, UV). white solid (300 mg, 24% yield). **MP:** 138.2 – 139.2 °C. $[\alpha]_D^{25} = -57.12$ (c = 0.40, CH₂Cl₂). **¹H NMR** (400 MHz, Acetone) δ 8.44 (s, 1H), 8.26 – 8.17 (m, 2H), 8.13 – 8.05 (m, 2H), 7.64 (s, 1H), 7.38 (d, J = 9.4 Hz, 1H), 7.34 – 7.22 (m, 5H), 6.75 – 6.65 (m, 1H), 6.51 (d, J = 15.8 Hz, 1H), 5.79 (s, 2H), 4.55 (s, 2H), 4.11 (s, 3H), 4.09 – 4.03 (m, 1H), 2.68 – 2.56 (m, 2H), 1.35 (s, 9H). **¹³C NMR** (100 MHz, Acetone) δ 170.6, 157.0, 150.7, 150.4, 149.7, 148.1, 138.6, 132.2, 129.1 (2), 129.0 (2), 128.3, 128.3 (2), 124.9, 124.8 (3), 116.9, 116.0, 82.3, 78.0, 70.7, 57.9, 53.8, 38.0, 27.9 (3). **HRMS** (ESI) m/z calcd. for C₃₀H₃₃N₅O₈SNa $[M+Na]^+$: 646.1942, found: 646.1965.

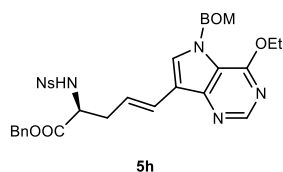


(S,E)-N-(5-(5-((benzyloxy)methyl)-4-methoxy-5H-pyrrolo[3,2-d]pyrimidin-7-yl)-1-(methoxymethoxy)pent-4-en-2-yl)-4-nitrobenzenesulfonamide (5f). R_f = 0.30 (silica gel, PE:EtOAc = 1:1, UV). yellow oil (728 mg, 61% yield). $[\alpha]_D^{25} = -1.13$ (c = 0.60, CH₂Cl₂). **¹H NMR** (400 MHz, CDCl₃) δ 8.52 (s, 1H), 7.96 (s, 4H), 7.36 – 7.26 (m, 5H), 7.20 (s, 1H), 6.47 – 6.32 (m, 2H), 5.69 (s, 2H), 5.25 (d, J = 7.8 Hz, 1H), 4.60 (s, 2H), 4.49 (s, 2H), 4.13 (s, 3H), 3.72 – 3.56 (m, 3H), 3.37 (s, 3H), 2.54 – 2.33 (m, 2H). **¹³C NMR** (100 MHz, CDCl₃) δ 156.4, 150.3, 149.3, 148.6, 146.8, 136.8, 130.0, 128.5 (2), 128.2 (2), 128.1, 127.7 (2), 125.8, 123.9 (2), 123.6, 116.4, 115.5, 96.9, 77.0, 70.3, 70.2, 55.6, 54.4, 53.7, 36.6. **HRMS** (ESI) m/z calcd. for C₂₈H₃₁N₅O₈SNa $[M+Na]^+$: 620.1785, found: 620.1786.

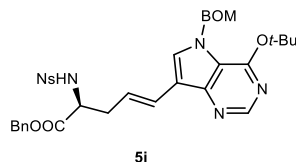


(S,E)-N-(1-(benzyloxy)-5-(5-((benzyloxy)methyl)-4-methoxy-5H-pyrrolo[3,2-d]pyrimidin-7-yl)pent-4-en-2-yl)-4-nitrobenzenesulfonamide (5g). R_f = 0.30 (silica gel, PE:EtOAc = 1:1, UV). yellow foamy solid (735 mg, 57% yield). $[\alpha]_D^{25} = +4.43$ (c = 1.00, CH₂Cl₂). **¹H NMR** (400 MHz, CDCl₃) δ 8.52 (s, 1H), 7.90 (s, 4H), 7.37 – 7.22 (m, 10H), 7.20 (s, 1H), 6.51 – 6.31 (m, 2H), 5.68 (s, 2H), 5.22 (d, J = 8.2 Hz, 1H), 4.48 (s, 2H), 4.45 (s, 2H), 4.12 (s, 3H), 3.67 – 3.58 (m, 1H), 3.58

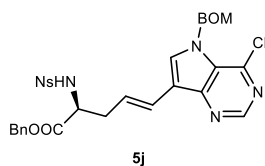
– 3.46 (m, 2H), 2.60 – 2.34 (m, 2H). ^{13}C NMR (100 MHz, CDCl_3) δ 156.3, 150.3, 149.3, 148.6, 146.7, 137.6, 136.8, 130.0, 128.5 (2), 128.5 (2), 128.2 (2), 128.0, 127.9, 127.8 (2), 127.7 (2), 125.8, 123.8 (2), 123.5, 116.3, 115.6, 76.9, 73.4, 72.0, 70.2, 54.4, 53.7, 36.8. HRMS (ESI) m/z calcd. for $\text{C}_{33}\text{H}_{33}\text{N}_5\text{O}_7\text{SNa}$ $[\text{M}+\text{Na}]^+$: 666.1993, found: 666.1997.



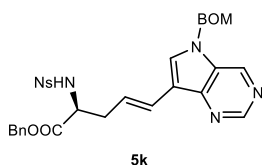
Benzyl (S,E)-5-(5-((benzyloxy)methyl)-4-ethoxy-5H-pyrrolo[3,2-d]pyrimidin-7-yl)-2-((4-nitrophenyl)sulfonamido)pent-4-enoate (5h). R_f = 0.30 (silica gel, PE:EtOAc = 1:1, UV). colorless oil (504 mg, 39% yield). $[\alpha]_D^{25} = -10.53$ (c = 0.40, CH_2Cl_2). ^1H NMR (400 MHz, CDCl_3) δ 8.49 (s, 1H), 8.03 – 7.95 (m, 2H), 7.95 – 7.87 (m, 2H), 7.35 – 7.17 (m, 11H), 6.50 – 6.42 (m, 2H), 6.27 (d, J = 8.2 Hz, 1H), 5.69 (d, J = 2.2 Hz, 2H), 5.03 (s, 2H), 4.60 (q, J = 7.2 Hz, 2H), 4.48 (s, 2H), 4.27 (q, J = 7.2 Hz, 1H), 2.76 – 2.63 (m, 2H), 1.44 (t, J = 7.2 Hz, 3H). ^{13}C NMR (100 MHz, CDCl_3) δ 170.7, 156.1, 150.4, 149.6, 148.6, 146.1, 136.9, 134.8, 130.3, 128.7, 128.6 (2), 128.5 (2), 128.4 (2), 128.3 (2), 128.0, 127.6 (2), 124.8, 124.0 (2), 123.0, 116.3, 115.3, 77.1, 70.3, 67.6, 62.6, 56.1, 37.4, 14.5. HRMS (ESI) m/z calcd. for $\text{C}_{34}\text{H}_{34}\text{N}_5\text{O}_8\text{S}$ $[\text{M}+\text{H}]^+$: 672.2123, found: 672.2122.



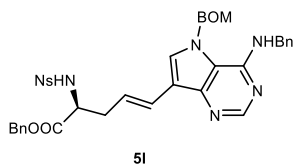
Benzyl (S,E)-5-(5-((benzyloxy)methyl)-4-(tert-butoxy)-5H-pyrrolo[3,2-d]pyrimidin-7-yl)-2-((4-nitrophenyl)sulfonamido)pent-4-enoate (5i). R_f = 0.30 (silica gel, PE:EtOAc = 1:1, UV). colorless oil (410 mg, 29% yield). $[\alpha]_D^{25} = -6.25$ (c = 0.40, acetone). ^1H NMR (400 MHz, Acetone) δ 8.39 (s, 1H), 8.11 – 8.00 (m, 4H), 7.59 (d, J = 9.0 Hz, 1H), 7.54 (s, 1H), 7.35 – 7.21 (m, 10H), 6.64 (dt, J = 15.8, 7.4 Hz, 1H), 6.47 (dt, J = 15.6, 1.2 Hz, 1H), 5.80 (s, 2H), 5.05 (s, 2H), 4.55 (s, 2H), 4.27 (td, J = 8.6, 5.4 Hz, 1H), 2.72 – 2.68 (m, 1H), 2.65 – 2.54 (m, 1H), 1.73 (s, 9H). ^{13}C NMR (100 MHz, Acetone) δ 171.5, 156.7, 150.4, 150.4, 150.0, 148.0, 138.8, 136.7, 132.1, 129.2 (2), 129.1 (2), 129.1 (2), 129.0, 129.0 (2), 128.4, 128.2 (2), 125.3, 124.9 (2), 124.5, 117.9, 115.8, 83.4, 78.2, 70.5, 67.5, 57.6, 37.7, 28.9 (3). HRMS (ESI) m/z calcd. for $\text{C}_{36}\text{H}_{37}\text{N}_5\text{O}_8\text{SNa}$ $[\text{M}+\text{Na}]^+$: 722.2255, found: 722.2261.



Benzyl (S,E)-5-(5-((benzyloxy)methyl)-4-chloro-5H-pyrrolo[3,2-d]pyrimidin-7-yl)-2-((4-nitrophenyl)sulfonamido)pent-4-enoate (5j). R_f = 0.30 (silica gel, PE:EtOAc = 1:1, UV). white solid (580 mg, 44% yield). **MP:** 147.3 – 148.1 °C. $[\alpha]_D^{25} = -3.56$ (c = 0.40, CH₂Cl₂). **¹H NMR** (400 MHz, CDCl₃) δ 8.73 (s, 1H), 8.12 – 8.07 (m, 2H), 7.96 – 7.90 (m, 2H), 7.37 (s, 1H), 7.35 – 7.26 (m, 7H), 7.26 – 7.19 (m, 3H), 6.62 – 6.52 (m, 1H), 6.47 (d, J = 15.8 Hz, 1H), 5.83 – 5.74 (m, 2H), 5.65 (d, J = 9.2 Hz, 1H), 5.02 (s, 2H), 4.53 (s, 2H), 4.27 (dt, J = 9.2, 5.8 Hz, 1H), 2.73 (t, J = 6.4 Hz, 2H). **¹³C NMR** (100 MHz, CDCl₃) δ 170.5, 150.6, 150.4, 149.9, 145.8, 142.7, 136.2, 134.6, 134.1, 128.8, 128.6 (2), 128.6 (2), 128.5 (2), 128.3 (2), 128.3, 127.7 (2), 124.6, 124.2, 124.1 (2), 123.8, 114.9, 76.6, 70.6, 67.8, 55.9, 37.6. **HRMS** (ESI) m/z calcd. for C₃₂H₂₈ClN₅O₇SNa [M+Na]⁺: 684.1290, found: 684.1290.

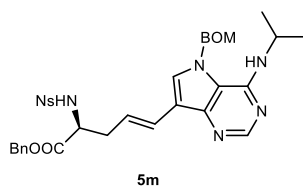


Benzyl (S,E)-5-(5-((benzyloxy)methyl)-5H-pyrrolo[3,2-d]pyrimidin-7-yl)-2-((4-nitrophenyl)sulfonamido)pent-4-enoate (5k). R_f = 0.30 (silica gel, PE:EtOAc = 1:1, UV). yellow oil (461 mg, 37% yield). $[\alpha]_D^{25} = -2.25$ (c = 0.60, CH₂Cl₂). **¹H NMR** (400 MHz, CDCl₃) δ 9.00 (s, 1H), 8.87 (s, 1H), 8.07 (d, J = 8.4 Hz, 2H), 7.95 (d, J = 8.4 Hz, 2H), 7.40 – 7.10 (m, 11H), 6.71 – 6.56 (m, 1H), 6.47 (d, J = 15.8 Hz, 1H), 6.34 (d, J = 9.0 Hz, 1H), 5.48 (s, 2H), 5.04 (s, 2H), 4.43 (s, 2H), 4.36 – 4.25 (m, 1H), 2.75 (t, J = 6.6 Hz, 2H). **¹³C NMR** (150 MHz, CDCl₃) δ 170.5, 151.4, 149.7, 148.6, 146.0, 138.9, 135.9, 134.7, 132.4, 128.7 (3), 128.6 (2), 128.5 (3), 128.3 (2), 128.2, 128.0 (2), 124.2, 124.0 (2), 123.8, 114.5, 75.5, 70.5, 67.7, 55.9, 37.7. **HRMS** (ESI) m/z calcd. for C₃₂H₂₉N₅O₇SNa [M+Na]⁺: 650.1680, found: 650.1683.

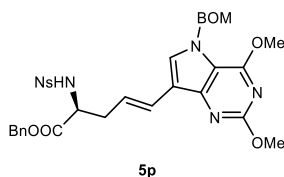


Benzyl (S,E)-5-(4-(benzylamino)-5-((benzyloxy)methyl)-5H-pyrrolo[3,2-d]pyrimidin-7-yl)-2-((4-nitrophenyl)sulfonamido)pent-4-enoate (5l). R_f = 0.30 (silica gel, PE:EtOAc = 1:1, UV). yellow oil (280 mg, 20 % yield). $[\alpha]_D^{25} = -0.54$ (c = 0.20, Acetone). **¹H NMR** (400 MHz, CDCl₃) δ 8.48 (s, 1H), 8.08 – 7.99 (m, 2H), 7.98 – 7.89 (m, 2H), 7.40 – 7.27 (m, 10H), 7.25 – 7.14 (m, 4H), 6.90 (s, 2H), 6.54 – 6.37 (m, 2H), 5.91 (br, 1H), 5.47 – 5.34 (m, 2H), 5.10 – 4.98 (m, 2H), 4.76 (d, J = 5.4 Hz, 2H), 4.52 (s, 2H), 4.26 (s, 1H), 2.76 – 2.60 (m, 2H). **¹³C NMR** (100 MHz, CDCl₃) δ 170.7, 151.9, 150.6, 149.7, 146.0, 138.7, 135.1, 134.8, 128.8 (2), 128.7, 128.7 (3), 128.6 (3), 128.4 (2), 128.3 (5), 127.6 (2), 127.3, 124.8, 124.0 (2), 122.7, 116.0, 114.2, 77.1, 70.0, 67.7, 56.1, 44.8,

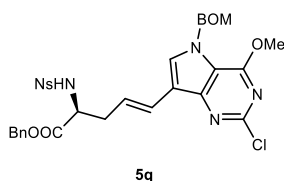
37.5. **HRMS** (ESI) m/z calcd. for $C_{39}H_{37}N_6O_7S$ $[M+H]^+$: 733.2439, found: 733.2436.



Benzyl (S,E)-5-(5-((benzyloxy)methyl)-4-(isopropylamino)-5H-pyrrolo[3,2-d]pyrimidin-7-yl)-2-((4-nitrophenyl)sulfonamido)pent-4-enoate (5m). R_f = 0.30 (silica gel, PE:EtOAc = 1:1, UV). yellow foamy solid (317 mg, 24% yield). $[\alpha]_D^{25} = -3.50$ (c = 1.00, Acetone). **1H NMR** (400 MHz, $CDCl_3$) δ 8.43 (s, 1H), 8.05 – 7.99 (m, 2H), 7.96 – 7.89 (m, 2H), 7.40 – 7.34 (m, 3H), 7.32 – 7.26 (m, 5H), 7.25 – 7.20 (m, 2H), 6.88 (s, 1H), 6.52 (d, J = 7.2 Hz, 1H), 6.45 – 6.40 (m, 2H), 6.13 (br, 1H), 5.48 – 5.37 (m, 2H), 5.11 – 4.97 (m, 2H), 4.57 (s, 2H), 4.44 – 4.32 (m, 1H), 4.25 (dd, J = 6.9, 5.0 Hz, 1H), 2.75 – 2.61 (m, 2H), 1.21 – 1.15 (m, 6H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 170.7, 152.0, 150.3, 149.7, 147.0, 146.1, 135.3, 134.8, 128.8 (2), 128.7, 128.6, 128.6 (2), 128.4 (2), 128.4 (2), 128.3, 128.3 (2), 124.9, 124.0 (2), 122.6, 116.1, 114.1, 77.2, 69.9, 67.6, 56.2, 42.2, 37.4, 22.7, 22.7. **HRMS** (ESI) m/z calcd. for $C_{35}H_{37}N_6O_7S$ $[M+H]^+$: 685.2439, found: 685.2441.

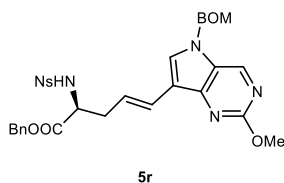


Benzyl (S,E)-5-(5-((benzyloxy)methyl)-2,4-dimethoxy-5H-pyrrolo[3,2-d]pyrimidin-7-yl)-2-((4-nitrophenyl)sulfonamido)pent-4-enoate (5p). R_f = 0.30 (silica gel, PE:EtOAc = 1:1, UV). white solid (671 mg, 50 % yield). **MP**: 137.7 – 138.5 °C. $[\alpha]_D^{25} = -9.75$ (c = 0.40, CH_2Cl_2). **1H NMR** (400 MHz, $CDCl_3$) δ 8.04 (d, J = 8.8 Hz, 2H), 7.92 (d, J = 8.8 Hz, 2H), 7.36 – 7.29 (m, 5H), 7.28 – 7.16 (m, 5H), 7.14 (s, 1H), 6.56 (dt, J = 14.9, 7.4 Hz, 1H), 6.41 (d, J = 15.8 Hz, 1H), 5.64 – 5.52 (m, 2H), 5.53 (s, 1H), 5.08 – 4.98 (m, 2H), 4.46 (s, 2H), 4.28 – 4.20 (m, 1H), 4.09 (s, 3H), 4.00 (s, 3H), 2.76 – 2.60 (m, 2H). **^{13}C NMR** (150 MHz, $CDCl_3$) δ 170.7, 160.3, 157.7, 150.0, 149.6, 145.9, 136.8, 134.7, 131.0, 128.7, 128.6 (2), 128.5 (2), 128.4 (2), 128.2 (2), 128.0, 127.7 (2), 125.2, 124.0 (2), 122.3, 114.3, 113.0, 76.8, 70.1, 67.6, 56.0, 54.7, 53.9, 37.5. **HRMS** (ESI) m/z calcd. for $C_{34}H_{34}N_5O_9S$ $[M+H]^+$: 688.2072, found: 688.2080.

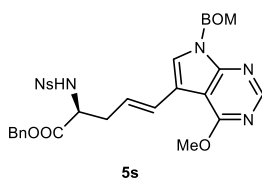


Benzyl (S,E)-5-(5-((benzyloxy)methyl)-2-chloro-4-methoxy-5H-pyrrolo[3,2-d]pyrimidin-7-yl)-2-((4-nitrophenyl)sulfonamido)pent-4-enoate (5q). R_f = 0.30 (silica gel, PE:EtOAc = 1:1,

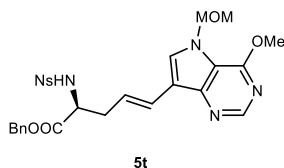
UV). yellow solid (639 mg, 46% yield). **MP**: 130.9 – 132.3 °C. $[\alpha]_{\text{D}}^{25} = +1.24$ ($c = 0.20$, CH_2Cl_2). **^1H NMR** (400 MHz, CDCl_3) δ 8.11 – 8.01 (m, 2H), 7.99 – 7.90 (m, 2H), 7.36 – 7.23 (m, 11H), 6.47 – 6.34 (m, 2H), 5.72 – 5.58 (m, 3H), 5.06 (s, 2H), 4.47 (s, 2H), 4.27 – 4.20 (m, 1H), 4.12 (s, 3H), 2.73 – 2.56 (m, 2H). **^{13}C NMR** (100 MHz, CDCl_3) δ 170.6, 156.8, 151.0, 150.4, 149.7, 145.9, 136.6, 134.7, 131.3, 128.7, 128.6 (2), 128.5 (4), 128.3 (2), 128.2, 127.7 (2), 124.1 (2), 124.0, 123.5, 115.1, 115.0, 76.9, 70.4, 67.8, 56.0, 54.6, 37.3. **HRMS** (ESI) m/z calcd. for $\text{C}_{33}\text{H}_{30}\text{ClN}_5\text{O}_8\text{SNa}$ $[\text{M}+\text{Na}]^+$: 714.1396, found: 714.1397.



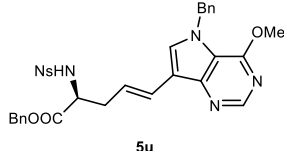
Benzyl (S,E)-5-(5-((benzyloxy)methyl)-2-methoxy-5H-pyrrolo[3,2-d]pyrimidin-7-yl)-2-((4-nitrophenyl)sulfonamido)pent-4-enoate (5r). $R_f = 0.30$ (silica gel, PE:EtOAc = 1:1, UV). yellow oil (726mg, 55% yield). $[\alpha]_{\text{D}}^{25} = +2.24$ ($c = 0.60$, CH_2Cl_2). **^1H NMR** (400 MHz, CDCl_3) δ 8.66 (s, 1H), 8.05 (d, $J = 8.8$ Hz, 2H), 7.93 (d, $J = 8.8$ Hz, 2H), 7.38 – 7.19 (m, 11H), 6.64 (dt, $J = 15.1$, 7.4 Hz, 1H), 6.42 (d, $J = 15.8$ Hz, 1H), 5.88 (d, $J = 9.6$ Hz, 1H), 5.44 (s, 2H), 5.01 (s, 2H), 4.41 (s, 2H), 4.30 – 4.22 (m, 1H), 4.02 (s, 3H), 2.71 (t, $J = 6.8$ Hz, 2H). **^{13}C NMR** (100 MHz, CDCl_3) δ 170.6, 161.5, 150.9, 149.8, 145.9, 141.3, 136.0, 134.7, 133.1, 128.7, 128.7 (2), 128.6 (2), 128.4, 128.4 (2), 128.3 (2), 128.0 (2), 125.4, 124.5, 124.0 (2), 123.1, 113.5, 75.7, 70.3, 67.6, 56.0, 54.8, 37.5. **HRMS** (ESI) m/z calcd. for $\text{C}_{33}\text{H}_{31}\text{N}_5\text{O}_8\text{SNa}$ $[\text{M}+\text{Na}]^+$: 680.1785, found: 680.1789.



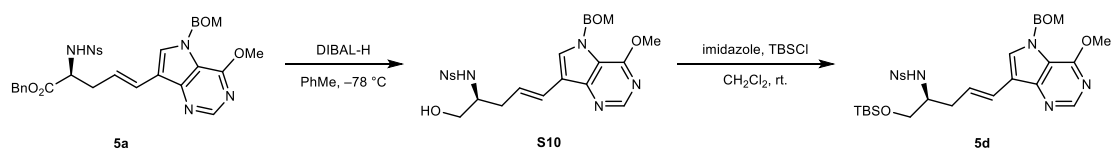
Benzyl (S,E)-5-(7-((benzyloxy)methyl)-4-methoxy-7H-pyrrolo[2,3-d]pyrimidin-5-yl)-2-((4-nitrophenyl)sulfonamido)pent-4-enoate (5s). $R_f = 0.30$ (silica gel, PE:EtOAc = 1:1, UV). white solid (512 mg, 39% yield). **MP**: 140.8 – 141.6 °C. $[\alpha]_{\text{D}}^{25} = -0.75$ ($c = 0.40$, CH_2Cl_2). **^1H NMR** (400 MHz, CDCl_3) δ 8.48 (s, 1H), 8.17 – 8.07 (m, 2H), 7.99 – 7.91 (m, 2H), 7.34 – 7.25 (m, 8H), 7.24 – 7.17 (m, 2H), 7.07 (s, 1H), 6.59 (d, $J = 15.8$ Hz, 1H), 5.98 (dt, $J = 15.5$, 7.4 Hz, 1H), 5.70 (d, $J = 9.4$ Hz, 1H), 5.65 (s, 2H), 5.05 – 4.97 (m, 2H), 4.50 (s, 2H), 4.27 (dt, $J = 9.3$, 5.6 Hz, 1H), 4.09 (s, 3H), 2.76 – 2.66 (m, 2H). **^{13}C NMR** (100 MHz, CDCl_3) δ 170.5, 163.6, 152.8, 151.7, 149.9, 145.8, 137.0, 134.6, 128.9, 128.7 (2), 128.5 (4), 128.3 (2), 128.0, 127.9 (2), 126.6, 124.1 (2), 122.8, 121.6, 114.3, 103.4, 73.1, 71.0, 67.7, 55.8, 53.8, 37.2. **HRMS** (ESI) m/z calcd. for $\text{C}_{33}\text{H}_{31}\text{N}_5\text{O}_8\text{SNa}$ $[\text{M}+\text{Na}]^+$: 680.1785, found: 680.1795.



Benzyl (S,E)-5-(4-methoxy-5-(methoxymethyl)-5H-pyrrolo[3,2-d]pyrimidin-7-yl)-2-((4-nitrophenyl)sulfonamido)pent-4-enoate (5t). R_f = 0.30 (silica gel, PE:EtOAc = 1:1, UV). yellow foamy solid (505 mg, 43% yield). $[\alpha]_D^{25} = -4.95$ ($c = 1.00$, CH_2Cl_2). **^1H NMR** (400 MHz, CDCl_3) δ 8.53 (s, 1H), 8.06 – 7.98 (m, 2H), 7.97 – 7.87 (m, 2H), 7.34 – 7.27 (m, 3H), 7.26 – 7.21 (m, 2H), 7.20 (s, 1H), 6.55 – 6.39 (m, 2H), 6.02 (d, $J = 9.2$ Hz, 1H), 5.61 – 5.47 (m, 2H), 5.04 (d, $J = 1.8$ Hz, 2H), 4.30 – 4.22 (m, 1H), 4.17 (s, 3H), 3.27 (s, 3H), 2.77 – 2.60 (m, 2H). **^{13}C NMR** (100 MHz, CDCl_3) δ 170.7, 156.3, 150.4, 149.6, 148.8, 146.0, 134.8, 130.3, 128.7, 128.6 (2), 128.4 (2), 128.3 (2), 124.8, 124.0 (2), 122.9, 116.2, 115.1, 79.2, 67.7, 56.1, 56.1, 53.8, 37.4. **HRMS** (ESI) m/z calcd. for $\text{C}_{27}\text{H}_{27}\text{N}_5\text{O}_8\text{SNa}$ $[\text{M}+\text{Na}]^+$: 604.1472, found: 604.1478.



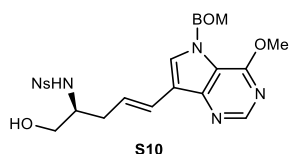
Benzyl (S,E)-5-(5-benzyl-4-methoxy-5H-pyrrolo[3,2-d]pyrimidin-7-yl)-2-((4-nitrophenyl)sulfonamido)pent-4-enoate (5u). R_f = 0.30 (silica gel, PE:EtOAc = 1:1, UV). yellow oil (717 mg, 57% yield). $[\alpha]_D^{25} = -3.75$ ($c = 1.00$, CH_2Cl_2). **^1H NMR** (400 MHz, CDCl_3) δ 8.49 (s, 1H), 8.00 – 7.86 (m, 4H), 7.37 – 7.21 (m, 8H), 7.13 (d, $J = 6.2$ Hz, 2H), 7.04 (s, 1H), 6.49 – 6.28 (m, 2H), 6.04 (d, $J = 9.2$ Hz, 1H), 5.50 – 5.35 (m, 2H), 5.02 (s, 2H), 4.30 – 4.20 (m, 1H), 4.11 (s, 3H), 2.72 – 2.57 (m, 2H). **^{13}C NMR** (100 MHz, CDCl_3) δ 170.9, 156.4, 150.1, 149.6, 148.1, 146.1, 137.4, 134.9, 130.4, 129.0 (2), 128.7, 128.6 (2), 128.5 (2), 128.3 (2), 128.1, 127.3 (2), 125.1, 124.0 (2), 122.1, 116.4, 114.3, 67.7, 56.2, 53.6, 52.6, 37.4. **HRMS** (ESI) m/z calcd. for $\text{C}_{32}\text{H}_{29}\text{N}_5\text{O}_7\text{SNa}$ $[\text{M}+\text{Na}]^+$: 650.1680, found: 650.1682.



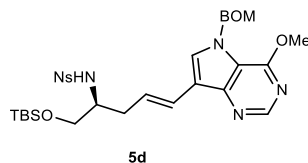
Under an atmosphere of argon, add DIBAL-H (4.0 mL, 4.0 mmol, 1 M in hexanes) dropwise to a solution of benzyl **5a** (1.31 g, 2.0 mmol) in anhydrous PhMe (10 mL) at -78 °C, and stirred for 12 h. The reaction mixture was quenched carefully at -78 °C by sequential addition of MeOH (1 mL), then Rochelle's salt aq. (10 mL), then warmed to room temperature, and extracted with EtOAc (10 mL x 3). The combined organic layer was washed with brine (10 mL x 3), dried Na_2SO_4 and filtered, concentrated in vacuo. The crude product was purified by column chromatography to afford

S10.

Under an atmosphere of argon, a mixture of **S10** (553 mg, 1 mmol) and imidazole (82 mg, 1.2 mmol) was dissolved in anhydrous CH₂Cl₂ (10 mL) and stirred at 0 °C for 10 min. After adding TBDPSCl (412 mg, 1.5 mmol), the reaction was warmed up to room temperature and stirred for 8 h. The solution was diluted with CH₂Cl₂ (20 mL) and saturated NH₄Cl aq. (20 mL). The layers were separated, and the aqueous layer was extracted with CH₂Cl₂ (10 mL x 3). The combined organic layer was washed with brine (10 mL x 3), dried over Na₂SO₄ and filtered, concentrated in vacuo. The crude material was purified via silica gel column chromatography to obtain **5d**. According to this procedure, compound **5e** were synthesized.

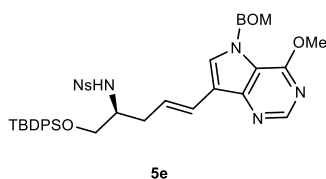


(*S,E*)-N-(5-(5-((benzyloxy)methyl)-4-methoxy-5H-pyrrolo[3,2-d]pyrimidin-7-yl)-1-hydroxypent-4-en-2-yl)-4-nitrobenzenesulfonamide (S10**).** R_f = 0.2 (silica gel, PE:EtOAc = 1:1, UV). white foamy solid (840 mg, 76% yield). $[\alpha]_D^{25} = +10.07$ (c = 0.20, CH₂Cl₂). **¹H NMR** (400 MHz, CDCl₃) δ 8.49 (s, 1H), 8.05 – 7.84 (m, 4H), 7.36 – 7.24 (m, 5H), 7.20 (s, 1H), 6.38 (d, J = 15.6 Hz, 1H), 6.25 (dt, J = 15.5, 7.8 Hz, 1H), 6.12 (br, 1H), 5.75 – 5.59 (m, 2H), 4.48 (s, 2H), 4.13 (s, 3H), 3.84 – 3.70 (m, 2H), 3.58 – 3.48 (m, 1H), 2.49 – 2.33 (m, 2H). **¹³C NMR** (100 MHz, CDCl₃) δ 156.5, 150.3, 149.4, 148.4, 146.5, 136.8, 130.1, 128.5 (2), 128.3 (2), 128.1, 127.7 (2), 125.7, 123.9 (2), 123.7, 116.4, 115.4, 77.2, 70.3, 65.1, 56.0, 53.8, 36.0. **HRMS** (ESI) m/z calcd. for C₂₆H₂₇N₅O₇SNa [M+Na]⁺: 576.1523, found: 576.1535.

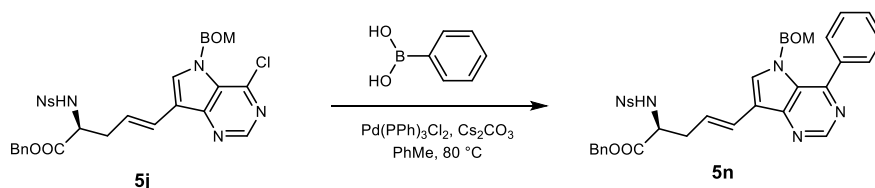


(*S,E*)-N-(5-(5-((benzyloxy)methyl)-4-methoxy-5H-pyrrolo[3,2-d]pyrimidin-7-yl)-1-((tert-butyldimethylsilyl)oxy)pent-4-en-2-yl)-4-nitrobenzenesulfonamide (5d**).** R_f = 0.40 (silica gel, PE:EtOAc = 1:1, UV). colorless oil (605 mg, 91% yield). $[\alpha]_D^{25} = +6.54$ (c = 0.40, CH₂Cl₂). **¹H NMR** (400 MHz, CDCl₃) δ 8.51 (s, 1H), 7.94 (s, 4H), 7.36 – 7.19 (m, 5H), 7.18 (s, 1H), 6.46 – 6.31 (m, 2H), 5.75 – 5.63 (m, 2H), 5.03 (d, J = 8.2 Hz, 1H), 4.49 (s, 2H), 4.14 (s, 3H), 3.73 (dd, J = 10.0, 3.4 Hz, 1H), 3.64 (dd, J = 10.0, 5.0 Hz, 1H), 3.50 – 3.40 (m, 1H), 2.50 – 2.42 (m, 1H), 2.39 – 2.28 (m, 1H), 0.90 (s, 9H), 0.07 (s, 3H), 0.06 (s, 3H). **¹³C NMR** (100 MHz, CDCl₃) δ 155.4, 149.3, 148.3, 147.6, 145.7, 135.8, 128.9, 127.5 (2), 127.2 (2), 127.0, 126.7 (2), 125.2, 122.8 (2), 122.3, 115.3, 114.6, 75.9, 69.2, 64.3, 54.8, 52.7, 35.2, 24.9 (3), 17.3, –6.4, –6.5. **HRMS** (ESI) m/z calcd. for

C₃₂H₄₁N₅O₇SSiNa [M+Na]⁺: 690.2388, found: 690.2385.



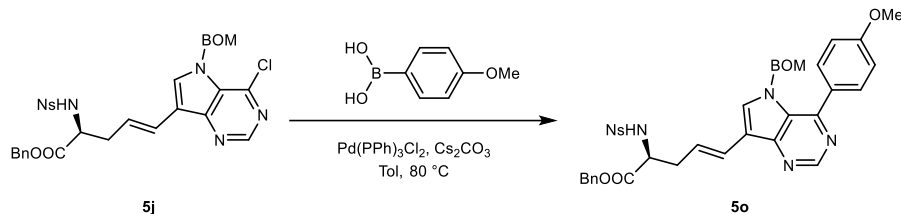
(*S,E*)-N-(5-(5-((benzyloxy)methyl)-4-methoxy-5H-pyrrolo[3,2-d]pyrimidin-7-yl)-1-((tert-butyl) diphenylsilyl)oxy)pent-4-en-2-yl)-4-nitrobenzenesulfonamide (5e). *R*_f = 0.40 (silica gel, PE:EtOAc = 1:1, UV). white foamy solid (688 mg, 87% yield). $[\alpha]_D^{25} = -5.54$ (*c* = 0.40, CH₂Cl₂). ¹H NMR (400 MHz, CDCl₃) δ 8.52 (s, 1H), 7.93 – 7.81 (m, 4H), 7.65 – 7.58 (m, 4H), 7.47 – 7.25 (m, 11H), 7.18 (s, 1H), 6.50 – 6.32 (m, 2H), 5.77 – 5.64 (m, 2H), 5.03 (d, *J* = 8.4 Hz, 1H), 4.49 (s, 2H), 4.14 (s, 3H), 3.75 (dd, *J* = 10.3, 3.6 Hz, 1H), 3.64 (dd, *J* = 10.2, 5.4 Hz, 1H), 3.52 – 3.44 (m, 1H), 2.63 – 2.35 (m, 2H), 1.07 (s, 9H). ¹³C NMR (100 MHz, CDCl₃) δ 156.4, 150.3, 149.3, 148.6, 146.7, 136.8, 135.6 (2), 135.6 (2), 132.9, 132.8, 130.0, 130.0, 129.9, 128.5 (2), 128.1 (2), 128.1, 127.9 (2), 127.8 (2), 127.7 (2), 126.0, 123.9 (2), 123.5, 116.4, 115.6, 77.0, 70.2, 65.8, 55.8, 53.7, 36.3, 26.9 (3), 19.3. **HRMS** (ESI) *m/z* calcd. for C₄₂H₄₅N₅O₇SSiNa [M+Na]⁺: 814.2701, found: 814.2717.



Under an atmosphere of argon, a mixture of the **5j** (661 mg, 1 mmol), phenylboronic acid (183 mg, 1.5 mmol), Pd(PPh₃)₂Cl₂ (140 mg, 0.2 mmol), and Cs₂CO₃ (650 mg, 2 mmol) in anhydrous PhMe (10 mL) was degassed by bubbling argon for 10 min. The reaction was warmed up to 80 °C for 12 h. After cooling to room temperature, the solution was diluted with EtOAc (20 mL) and saturated NH₄Cl aq. (20 mL). The layers were separated, and the aqueous layer was extracted with EtOAc (10 mL x 3). The combined organic layer was washed with brine (10 mL x 3), dried over Na₂SO₄ and filtered, concentrated in vacuo. The crude material was purified via silica gel column chromatography to obtain **5n**.

Benzyl (*S,E*)-5-(5-((benzyloxy)methyl)-4-phenyl-5H-pyrrolo[3,2-d]pyrimidin-7-yl)-2-((4-nitrophenyl)sulfonamido)pent-4-enoate (5n). *R*_f = 0.30 (silica gel, PE:EtOAc = 1:1, UV). colorless oil (610 mg, 87% yield). $[\alpha]_D^{25} = -6.75$ (*c* = 0.40, CH₂Cl₂). ¹H NMR (400 MHz, CDCl₃) δ 9.05 (s, 1H), 8.08 – 8.01 (m, 2H), 7.98 – 7.91 (m, 2H), 7.69 – 7.61 (m, 2H), 7.56 – 7.48 (m, 3H), 7.37 (s, 1H), 7.31 – 7.21 (m, 8H), 7.11 – 7.05 (m, 2H), 6.66 – 6.56 (m, 1H), 6.51 (d, *J* = 16.0 Hz, 1H), 5.92 (d, *J* = 9.4 Hz, 1H), 5.16 (s, 2H), 5.04 (s, 2H), 4.28 (ddd, *J* = 9.2, 6.6, 5.2 Hz, 1H), 4.08 (s, 2H), 2.71

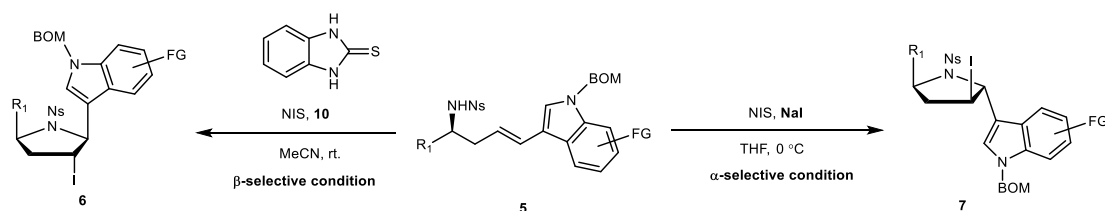
(*tq*, $J = 13.8, 7.4$ Hz, 2H). ^{13}C NMR (100 MHz, CDCl_3) δ 170.6, 151.1, 151.1, 150.0, 149.8, 146.0, 137.1, 136.3, 134.7, 133.9, 129.8, 128.9 (2), 128.7, 128.6 (2), 128.6 (2), 128.5 (2), 128.5 (2), 128.3 (2), 128.1, 127.5 (2), 126.1, 124.2, 124.1 (2), 123.7, 114.8, 76.5, 70.3, 67.7, 56.1, 37.5. HRMS (ESI) m/z calcd. for $\text{C}_{38}\text{H}_{33}\text{N}_5\text{O}_7\text{SNa}$ $[\text{M}+\text{Na}]^+$: 726.1993, found: 726.1994.



Under an atmosphere of argon, a mixture of the **5j** (661 mg, 1 mmol), 4-methoxy phenylboronic acid (228 mg, 1.5 mmol), $\text{Pd}(\text{PPh}_3)_2\text{Cl}_2$ (140 mg, 0.2 mmol), and Cs_2CO_3 (650 mg, 2 mmol) in anhydrous PhMe (10 mL) was degassed by bubbling argon for 10 min. The reaction was warmed up to 80 °C for 12 h. After cooling to room temperature, the solution was diluted with EtOAc (20 mL) and saturated NH_4Cl aq. (20 mL). The layers were separated, and the aqueous layer was extracted with EtOAc (10 mL x 3). The combined organic layer was washed with brine (10 mL x 3), dried over Na_2SO_4 and filtered, concentrated in vacuo. The crude material was purified via silica gel column chromatography to obtain **5o**.

Benzyl (S,E)-5-(5-((benzyloxy)methyl)-4-(4-methoxyphenyl)-5H-pyrrolo[3,2-d]pyrimidin-7-yl)-2-((4-nitrophenyl)sulfonamido)pent-4-enoate (5o). $R_f = 0.30$ (silica gel, PE:EtOAc = 1:1, UV). white foamy solid (542 mg, 74% yield). $[\alpha]_{\text{D}}^{25} = -8.25$ ($c = 0.40$, CH_2Cl_2). ^1H NMR (400 MHz, CDCl_3) δ 9.03 (s, 1H), 8.05 (d, $J = 8.8$ Hz, 2H), 7.94 (d, $J = 8.8$ Hz, 2H), 7.62 (d, $J = 8.6$ Hz, 2H), 7.39 (s, 1H), 7.30 – 7.24 (m, 7H), 7.18 – 7.05 (m, 3H), 7.02 (d, $J = 8.8$ Hz, 2H), 6.65 – 6.55 (m, 1H), 6.51 (d, $J = 15.8$ Hz, 1H), 5.90 (d, $J = 9.2$ Hz, 1H), 5.24 (s, 2H), 5.04 (s, 2H), 4.28 (dt, $J = 9.2, 6.0$ Hz, 1H), 4.14 (s, 2H), 3.88 (s, 3H), 2.78 – 2.65 (m, 2H). ^{13}C NMR (100 MHz, CDCl_3) δ 170.6, 161.0, 151.0, 150.9, 149.9, 149.8, 146.0, 136.3, 134.7, 133.9, 130.5 (2), 129.2, 128.7, 128.6 (2), 128.5 (2), 128.5 (2), 128.3 (2), 128.1, 127.5 (2), 126.2, 124.2, 124.1 (2), 123.7, 114.9, 114.1 (2), 76.5, 70.4, 67.7, 56.1, 55.4, 37.5. HRMS (ESI) m/z calcd. for $\text{C}_{39}\text{H}_{35}\text{N}_5\text{O}_8\text{SNa}$ $[\text{M}+\text{Na}]^+$: 756.2098, found: 756.2097.

2.5 Synthesis of 6a-u, 7a-7u

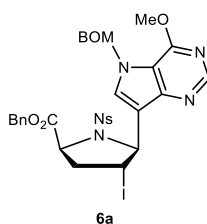


β -selective condition:

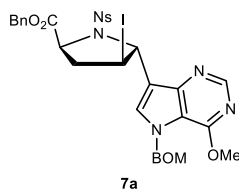
Taking the synthesis of **6a** as an example: a mixture of 2-Mercaptobenzimidazole **10** (28.6 mg, 0.20 mmol) and NIS (90 mg, 0.40 mmol) was dissolved in anhydrous MeCN (5 ml) at 0 °C, then **5a** (120 mg, 0.20 mmol) was added in the solution and stirred for 30 min. The solution was diluted with EtOAc (5 mL) and saturated NaHSO₃ aq (5 mL). The layers were separated, and the aqueous layer was extracted with EtOAc (5 mL x 3). The combined organic layer was washed with brine (5 mL x 3), dried over Na₂SO₄ and filtered, concentrated in vacuo. The crude material was purified via silica gel column chromatography to obtain **6a**. According to this procedure, compounds **6a-u** were synthesized.

α -selective condition:

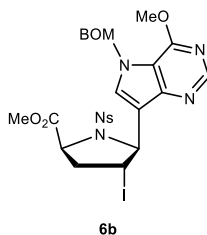
Taking the synthesis of **7a** as an example: a mixture of NaI (28.6 mg, 0.20 mmol) and NIS (90 mg, 0.40 mmol) was dissolved in anhydrous THF (5 ml) at 0 °C, then **5a** (120 mg, 0.20 mmol) was added in the solution and stirred for 30 min. The solution was diluted with EtOAc (5 mL) and saturated NaHSO₃ aq (5 mL). The layers were separated, and the aqueous layer was extracted with EtOAc (5 mL x 3). The combined organic layer was washed with brine (5 mL x 3), dried over Na₂SO₄ and filtered, concentrated in vacuo. The crude material was purified via silica gel column chromatography to obtain **7a**. According to this procedure, compounds **7a-u** were synthesized.



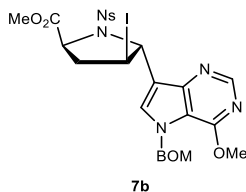
Benzyl (2*S*,4*R*,5*S*)-5-(5-((benzyloxy)methyl)-4-methoxy-5H-pyrrolo[3,2-d]pyrimidin-7-yl)-4-iodo-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (6a). R_f = 0.50 (silica gel, PE:EtOAc = 3:1, UV). white solid (145 mg, 93% yield, β : α = 25:1). **MP:** 150.7 – 151.2 °C. $[\alpha]_D^{25}$ = –38.06 (c = 0.40, CH₂Cl₂). **¹H NMR** (400 MHz, CDCl₃) δ 8.49 (s, 1H), 8.27 – 8.20 (m, 2H), 8.06 – 7.98 (m, 2H), 7.77 (d, J = 1.0 Hz, 1H), 7.44 – 7.35 (m, 5H), 7.32 – 7.24 (m, 5H), 5.49 (s, 2H), 5.42 (dd, J = 1.9, 1.0 Hz, 1H), 5.28 (d, J = 1.4 Hz, 2H), 4.77 (dt, J = 5.0, 2.6 Hz, 1H), 4.71 (dd, J = 8.8, 7.2 Hz, 1H), 4.44 (q, J = 12.2 Hz, 2H), 4.09 (s, 3H), 2.57 – 2.45 (m, 2H). **¹³C NMR** (100 MHz, CDCl₃) δ 170.0, 155.3, 149.4, 149.3, 147.1, 141.6, 135.8, 134.0, 132.1, 128.4 (2), 127.8 (2), 127.8, 127.6 (2), 127.5 (2), 127.0, 126.7 (2), 123.1 (2), 115.0, 114.9, 76.2, 69.3, 67.4, 67.0, 60.6, 52.7, 39.4, 22.9. **HRMS** (ESI) m/z calcd. for C₃₃H₃₀IN₅O₈SN_a [M+Na]⁺: 806.0752, found: 806.0768.



Benzyl (2*S*,4*S*,5*R*)-5-(5-((benzyloxy)methyl)-4-methoxy-5H-pyrrolo[3,2-d]pyrimidin-7-yl)-4-iodo-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (7a). R_f = 0.50 (silica gel, PE:EtOAc = 3:1, UV). white solid (148 mg, 95% yield, α : β = 19:1). **MP**: 138.7 – 139.5 °C. $[\alpha]_D^{25}$ = +56.75 (c = 0.40, CH₂Cl₂). **¹H NMR** (400 MHz, CDCl₃) δ 8.05 (s, 1H), 7.66 – 7.59 (m, 2H), 7.52 – 7.28 (m, 13H), 5.67 – 5.56 (m, 2H), 5.37 – 5.29 (m, 2H), 5.28 (d, J = 7.2 Hz, 1H), 5.13 (q, J = 7.6 Hz, 1H), 4.86 (dd, J = 8.2, 6.0 Hz, 1H), 4.62 (d, J = 3.4 Hz, 2H), 3.99 (s, 3H), 3.41 (dt, J = 13.6, 7.8 Hz, 1H), 2.62 (ddd, J = 13.8, 8.0, 6.0 Hz, 1H). **¹³C NMR** (100 MHz, CDCl₃) δ 170.4, 154.8, 148.9, 147.5, 147.4, 144.4, 135.4, 134.2, 133.9, 127.7 (2), 127.6 (4), 127.5, 127.3, 126.9 (2), 126.8 (2), 121.4 (2), 114.5, 109.2, 76.1, 69.8, 66.8, 65.7, 61.9, 52.8, 40.3, 19.0. **HRMS** (ESI) m/z calcd. for C₃₃H₃₀IN₅O₈SNa [M+Na]⁺: 806.0752, found: 806.0780.

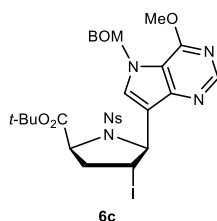


Methyl (2*S*,4*R*,5*S*)-5-(5-((benzyloxy)methyl)-4-methoxy-5H-pyrrolo[3,2-d]pyrimidin-7-yl)-4-iodo-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (6b). R_f = 0.50 (silica gel, PE:EtOAc = 3:1, UV). white solid (130 mg, 92% yield, β : α = 24:1). **MP**: 135.3 – 136.2 °C. $[\alpha]_D^{25}$ = –14.67 (c = 0.60, CH₂Cl₂). **¹H NMR** (400 MHz, CDCl₃) δ 8.50 (s, 1H), 8.28 (d, J = 8.8 Hz, 2H), 8.06 (d, J = 8.8 Hz, 2H), 7.89 (s, 1H), 7.38 – 7.27 (m, 5H), 5.73 – 5.59 (m, 2H), 5.42 (d, J = 2.2 Hz, 1H), 4.82 – 4.75 (m, 1H), 4.68 (t, J = 8 Hz, 1H), 4.58 – 4.46 (m, 2H), 4.10 (s, 3H), 3.87 (s, 3H), 2.59 – 2.41 (m, 2H). **¹³C NMR** (100 MHz, CDCl₃) δ 171.76, 156.30, 150.38, 150.34, 148.09, 142.72, 136.80, 133.14, 129.46 (2), 128.50 (2), 128.03, 127.81 (2), 124.09 (2), 116.00, 115.96, 77.23, 70.40, 68.27, 61.36, 53.71, 52.96, 40.46, 23.97. **HRMS** (ESI) m/z calcd. for C₂₇H₂₆IN₅O₈SNa [M+Na]⁺: 730.0439, found: 730.0498.

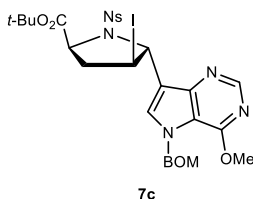


Methyl (2*S*,4*S*,5*R*)-5-(5-((benzyloxy)methyl)-4-methoxy-5H-pyrrolo[3,2-d]pyrimidin-7-yl)-4-iodo-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (7b). R_f = 0.50 (silica gel, PE:EtOAc

= 3:1, UV). white solid (136 mg, 96% yield, $\alpha:\beta$ = 17:1). **MP**: 113.4 – 114.3 °C. $[\alpha]_D^{25}$ = +71.33 (c = 0.30, CH₂Cl₂). **¹H NMR** (400 MHz, CDCl₃) δ 8.05 (s, 1H), 7.67 – 7.59 (m, 2H), 7.46 (s, 1H), 7.42 – 7.28 (m, 7H), 5.67 – 5.55 (m, 2H), 5.28 (d, J = 7.4 Hz, 1H), 5.15 (dt, J = 8.1, 7.4 Hz, 1H), 4.82 (dd, J = 8.0, 6.2 Hz, 1H), 4.67 – 4.58 (m, 2H), 3.99 (s, 3H), 3.91 (s, 3H), 3.41 (dt, J = 13.7, 7.8 Hz, 1H), 2.64 (ddd, J = 13.6, 8.1, 6.2 Hz, 1H). **¹³C NMR** (100 MHz, CDCl₃) δ 171.0, 154.8, 148.9, 147.5, 147.4, 144.4, 135.4, 133.9, 127.7 (2), 127.3, 126.9 (2), 126.7 (2), 121.5 (2), 114.5, 109.2, 76.1, 69.8, 65.6, 61.9, 52.8, 51.9, 40.4, 19.0. **HRMS** (ESI) m/z calcd. for C₂₇H₂₆IN₅O₈SNa [M+Na]⁺: 730.0439, found: 730.0491.

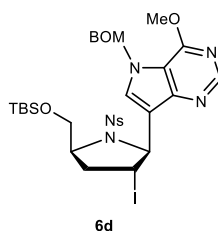


Tert-butyl (2*S*,4*R*,5*S*)-5-(5-((benzyloxy)methyl)-4-methoxy-5H-pyrrolo[3,2-*d*]pyrimidin-7-yl)-4-iodo-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (6c). R_f = 0.50 (silica gel, PE:EtOAc = 3:1, UV). white solid (135 mg, 90% yield, $\beta:\alpha$ = 13:1). **MP**: 158.7 – 159.5 °C. $[\alpha]_D^{25}$ = –16.05 (c = 0.40, CH₂Cl₂). **¹H NMR** (400 MHz, CDCl₃) δ 8.52 (s, 1H), 8.37 – 8.28 (m, 2H), 8.13 – 8.06 (m, 2H), 7.96 (d, J = 1.0 Hz, 1H), 7.36 – 7.26 (m, 5H), 5.72 – 5.59 (m, 2H), 5.43 (t, J = 1.4 Hz, 1H), 4.76 – 4.72 (m, 1H), 4.57 – 4.47 (m, 3H), 4.11 (s, 3H), 2.44 (dd, J = 8.1, 3.4 Hz, 2H), 1.56 (s, 9H). **¹³C NMR** (150 MHz, CDCl₃) δ 170.2, 156.3, 150.4, 150.4, 148.1, 142.5, 136.8, 133.1, 129.5 (2), 128.5 (2), 128.0, 127.9 (2), 124.2 (2), 116.7, 116.0, 83.0, 77.0, 70.2, 68.5, 62.4, 53.7, 40.3, 28.0 (3), 24.6. **HRMS** (ESI) m/z calcd. for C₃₀H₃₂IN₅O₈SNa [M+Na]⁺: 772.0908, found: 772.0916.

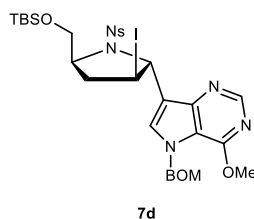


Tert-butyl (2*S*,4*S*,5*R*)-5-(5-((benzyloxy)methyl)-4-methoxy-5H-pyrrolo[3,2-*d*]pyrimidin-7-yl)-4-iodo-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (7c). R_f = 0.50 (silica gel, PE:EtOAc = 3:1, UV). white solid (139 mg, 93%, $\alpha:\beta$ = 9:1). **MP**: 138.4 – 139.3 °C. $[\alpha]_D^{25}$ = +21.05 (c = 0.20, CH₂Cl₂). **¹H NMR** (400 MHz, CDCl₃) δ 8.07 (s, 1H), 7.65 – 7.59 (m, 2H), 7.45 (s, 1H), 7.42 – 7.30 (m, 7H), 5.68 – 5.54 (m, 2H), 5.24 (d, J = 7.5 Hz, 1H), 5.19 (q, J = 7.5 Hz, 1H), 4.68 (dd, J = 8.4, 5.8 Hz, 1H), 4.66 – 4.57 (m, 2H), 3.99 (s, 3H), 3.41 (ddd, J = 13.5, 8.2, 7.5 Hz, 1H), 2.57 (ddd, J = 13.5, 7.6, 5.8 Hz, 1H), 1.61 (s, 9H). **¹³C NMR** (100 MHz, CDCl₃) δ 170.6, 155.8, 149.9, 148.5, 148.4, 145.8, 136.5, 135.1, 128.7 (2), 128.3, 127.9 (2), 127.7 (2), 122.4 (2), 115.5, 110.1, 82.9, 77.1, 70.8, 66.5, 64.0, 53.7, 41.3, 28.0 (3), 20.2. **HRMS** (ESI) m/z calcd. for

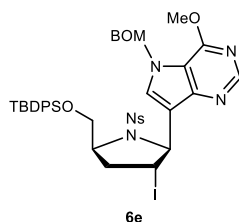
C₃₀H₃₂IN₅O₈SNa [M+Na]⁺: 772.0908, found: 772.0919.



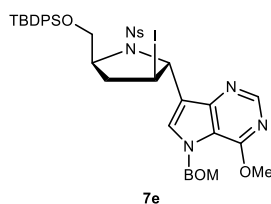
5-((benzyloxy)methyl)-7-((2*S*,3*R*,5*S*)-5-(((tert-butyldimethylsilyl)oxy)methyl)-3-iodo-1-((4-nitrophenyl)sulfonyl)pyrrolidin-2-yl)-4-methoxy-5H-pyrrolo[3,2-d]pyrimidine (6d). *R*_f = 0.50 (silica gel, PE:EtOAc = 3:1, UV). colorless oil (127 mg, 80% yield, β:α = 18:1). [α]_D²⁵ = −11.56 (*c* = 0.20, CH₂Cl₂). ¹H NMR (400 MHz, CDCl₃) δ 8.45 (s, 1H), 8.19 – 8.12 (m, 2H), 7.94 – 7.87 (m, 2H), 7.51 (d, *J* = 0.8 Hz, 1H), 7.37 – 7.27 (m, 5H), 5.69 – 5.58 (m, 2H), 5.21 (d, *J* = 5.0 Hz, 1H), 5.03 – 4.95 (m, 1H), 4.55 – 4.44 (m, 2H), 4.19 – 4.08 (m, 3H), 4.07 (s, 3H), 2.68 – 2.62 (m, 1H), 2.33 – 2.27 (m, 1H), 0.92 (s, 9H), 0.13 (s, 3H), 0.11 (s, 3H). ¹³C NMR (100 MHz, CDCl₃) δ 156.2, 150.1, 149.9, 148.3, 143.4, 136.6, 132.9, 129.1 (2), 128.6 (2), 128.1, 127.9 (2), 123.7 (2), 116.0, 115.0, 76.9, 70.3, 68.3, 64.7, 62.1, 53.6, 39.8, 25.9 (3), 23.4, 18.4, −5.3 (2). HRMS (ESI) *m/z* calcd. for C₃₂H₄₀IN₅O₇SSiNa [M+Na]⁺: 816.1354, found: 816.1358.



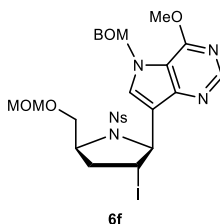
5-((benzyloxy)methyl)-7-((2*R*,3*S*,5*S*)-5-(((tert-butyldimethylsilyl)oxy)methyl)-3-iodo-1-((4-nitrophenyl)sulfonyl)pyrrolidin-2-yl)-4-methoxy-5H-pyrrolo[3,2-d]pyrimidine (7d). *R*_f = 0.50 (silica gel, PE:EtOAc = 3:1, UV). colorless oil (140 mg, 88% yield, α:β = 2:1). [α]_D²⁵ = +12.05 (*c* = 0.20, CH₂Cl₂). ¹H NMR (400 MHz, CDCl₃) δ 8.06 (s, 1H), 7.68 – 7.62 (m, 2H), 7.43 – 7.30 (m, 8H), 5.62 (q, *J* = 10.0 Hz, 2H), 5.21 (d, *J* = 6.2 Hz, 1H), 4.98 (dt, *J* = 7.5, 6.4 Hz, 1H), 4.66 – 4.56 (m, 2H), 4.48 – 4.39 (m, 1H), 4.29 (dd, *J* = 9.8, 7.4 Hz, 1H), 4.14 (dd, *J* = 9.8, 3.6 Hz, 1H), 3.99 (s, 3H), 3.26 (dt, *J* = 14.0, 7.8 Hz, 1H), 2.69 (ddd, *J* = 14.1, 6.6, 4.6 Hz, 1H), 0.99 (s, 9H), 0.19 (s, 3H), 0.17 (s, 3H). ¹³C NMR (100 MHz, CDCl₃) δ 155.8, 149.9, 148.4, 148.4, 145.7, 136.5, 134.6, 128.7 (2), 128.3, 127.9 (2), 127.7 (2), 122.5 (2), 115.4, 111.5, 77.1, 70.8, 68.1, 65.5, 63.9, 53.7, 39.6, 26.0 (3), 21.9, 18.3, −5.2 (2). HRMS (ESI) *m/z* calcd. for C₃₂H₄₀IN₅O₇SSiNa [M+Na]⁺: 816.1354, found: 816.1350.



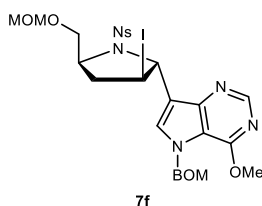
5-((benzyloxy)methyl)-7-((2*S*,3*R*,5*S*)-5-(((tert-butyldiphenylsilyl)oxy)methyl)-3-iodo-1-((4-nitrophenyl)sulfonyl)pyrrolidin-2-yl)-4-methoxy-5H-pyrrolo[3,2-d]pyrimidine (6e). $R_f = 0.50$ (silica gel, PE:EtOAc = 3:1, UV). colorless oil (150 mg, 82% yield, $\beta:\alpha = 14:1$). $[\alpha]_D^{25} = -13.54$ ($c = 0.20$, CH_2Cl_2). **^1H NMR** (400 MHz, CDCl_3) δ 8.31 (s, 1H), 8.06 – 7.98 (m, 2H), 7.73 – 7.66 (m, 4H), 7.65 – 7.58 (m, 2H), 7.52 – 7.26 (m, 11H), 7.25 – 7.23 (m, 1H), 5.64 – 5.42 (m, 2H), 5.17 (d, $J = 5.2$ Hz, 1H), 4.98 (dt, $J = 6.7, 5.4$ Hz, 1H), 4.44 (q, $J = 12.2$ Hz, 2H), 4.22 – 4.10 (m, 3H), 4.06 (s, 3H), 2.70 (dt, $J = 13.8, 5.4$ Hz, 1H), 2.42 – 2.30 (m, 1H), 1.07 (s, 9H). **^{13}C NMR** (100 MHz, CDCl_3) δ 156.2, 150.0, 149.7, 148.2, 143.4, 136.6, 135.7 (2), 135.6 (2), 133.3, 133.2, 133.0, 130.0, 129.9, 128.9 (2), 128.6 (2), 128.1, 127.9 (2), 127.8 (4), 123.6 (2), 116.0, 114.6, 76.9, 70.3, 68.2, 65.4, 61.8, 53.6, 40.1, 27.0 (3), 23.2, 19.3. **HRMS** (ESI) m/z calcd. for $\text{C}_{42}\text{H}_{44}\text{IN}_5\text{O}_7\text{SSiNa}$ $[\text{M}+\text{Na}]^+$: 940.1667, found: 940.1650.



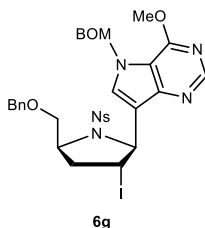
5-((benzyloxy)methyl)-7-((2*R*,3*S*,5*S*)-5-(((tert-butyldiphenylsilyl)oxy)methyl)-3-iodo-1-((4-nitrophenyl)sulfonyl)pyrrolidin-2-yl)-4-methoxy-5H-pyrrolo[3,2-d]pyrimidine (7e). $R_f = 0.50$ (silica gel, PE:EtOAc = 3:1, UV). colorless oil (165 mg, 90% yield, $\alpha:\beta = 6:1$). $[\alpha]_D^{25} = +8.07$ ($c = 0.20$, CH_2Cl_2). **^1H NMR** (400 MHz, CDCl_3) δ 8.07 (s, 1H), 7.79 – 7.72 (m, 4H), 7.63 – 7.57 (m, 2H), 7.52 – 7.40 (m, 6H), 7.40 – 7.28 (m, 6H), 7.18 – 7.13 (m, 2H), 5.62 (q, $J = 10.0$ Hz, 2H), 5.26 (d, $J = 5.8$ Hz, 1H), 4.91 (dt, $J = 7.4, 6.2$ Hz, 1H), 4.63 – 4.57 (m, 2H), 4.43 – 4.35 (m, 1H), 4.34 – 4.28 (m, 1H), 4.23 (dd, $J = 9.9, 3.8$ Hz, 1H), 4.01 (s, 3H), 3.28 (dt, $J = 14.8, 7.6$ Hz, 1H), 2.80 (ddd, $J = 14.1, 6.4, 4.8$ Hz, 1H), 1.15 (s, 9H). **^{13}C NMR** (100 MHz, CDCl_3) δ 154.8, 148.9, 147.4, 147.4, 144.5, 135.5, 134.8 (2), 134.8 (2), 133.3, 132.5, 132.1, 128.8 (2), 127.7 (2), 127.3, 126.9 (2), 126.8 (2), 126.8 (2), 126.6 (2), 121.5 (2), 114.4, 111.0, 76.1, 69.8, 67.5, 64.9, 62.2, 52.7, 38.9, 26.0 (3), 20.7, 18.3. **HRMS** (ESI) m/z calcd. for $\text{C}_{42}\text{H}_{44}\text{IN}_5\text{O}_7\text{SSiNa}$ $[\text{M}+\text{Na}]^+$: 940.1667, found: 940.1624.



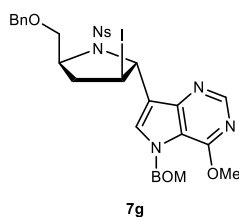
5-((benzyloxy)methyl)-7-((2*S*,3*R*,5*S*)-3-iodo-5-((methoxymethoxy)methyl)-1-((4-nitrophenyl)sulfonyl)pyrrolidin-2-yl)-4-methoxy-5H-pyrrolo[3,2-*d*]pyrimidine (6f). R_f = 0.50 (silica gel, PE:EtOAc = 3:1, UV). yellow oil (116 mg, 80% yield, β : α = 13:1). $[\alpha]_D^{25} = -5.23$ (c = 0.60, CH₂Cl₂). **¹H NMR** (400 MHz, CDCl₃) δ 8.45 (s, 1H), 8.21 – 8.12 (m, 2H), 7.95 – 7.87 (m, 2H), 7.60 (s, 1H), 7.37 – 7.26 (m, 5H), 5.66 (d, J = 2.4 Hz, 2H), 5.28 (d, J = 4.6 Hz, 1H), 4.94 (q, J = 5.4 Hz, 1H), 4.72 – 4.64 (m, 2H), 4.55 – 4.45 (m, 2H), 4.32 – 4.24 (m, 1H), 4.11 (dd, J = 10.0, 6.6 Hz, 1H), 4.08 (s, 3H), 4.01 (dd, J = 10.2, 3.8 Hz, 1H), 3.36 (s, 3H), 2.62 (dt, J = 13.8, 5.8 Hz, 1H), 2.35 (ddd, J = 13.4, 7.1, 5.6 Hz, 1H). **¹³C NMR** (100 MHz, CDCl₃) δ 155.2, 149.1, 148.9, 147.0, 142.2, 135.6, 131.9, 128.2 (2), 127.5 (2), 127.1, 126.8 (2), 122.7 (2), 115.0, 114.3, 95.8, 76.1, 69.3, 68.1, 67.3, 59.3, 54.5, 52.7, 39.0, 22.6. **HRMS** (ESI) m/z calcd. for C₂₈H₃₀IN₅O₈SNa [M+Na]⁺: 746.0752, found: 746.0771.



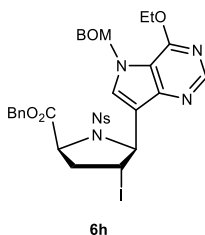
5-((benzyloxy)methyl)-7-((2*R*,3*S*,5*S*)-3-iodo-5-((methoxymethoxy)methyl)-1-((4-nitrophenyl)sulfonyl)pyrrolidin-2-yl)-4-methoxy-5H-pyrrolo[3,2-*d*]pyrimidine (7f). R_f = 0.50 (silica gel, PE:EtOAc = 3:1, UV). yellow solid (127 mg, 88% yield, α : β = 10:1). **MP**: 112.7 – 113.8 °C. $[\alpha]_D^{25} = +42.05$ (c = 0.60, CH₂Cl₂). **¹H NMR** (400 MHz, CDCl₃) δ 8.04 (s, 1H), 7.65 (d, J = 8.8 Hz, 2H), 7.43 (s, 1H), 7.42 – 7.28 (m, 7H), 5.63 (q, J = 9.8 Hz, 2H), 5.26 (d, J = 5.6 Hz, 1H), 4.87 (dt, J = 7.4, 5.8 Hz, 1H), 4.77 (s, 2H), 4.62 (s, 2H), 4.59 – 4.52 (m, 1H), 4.28 (dd, J = 9.8, 7.6 Hz, 1H), 4.15 (dd, J = 9.8, 3.8 Hz, 1H), 4.00 (s, 3H), 3.48 (s, 3H), 3.42 – 3.32 (m, 1H), 2.77 – 2.61 (m, 1H). **¹³C NMR** (100 MHz, CDCl₃) δ 155.8, 149.9, 148.5, 148.2, 145.2, 136.6, 134.3, 128.7 (2), 128.3, 127.9 (2), 127.7 (2), 122.5 (2), 115.4, 111.9, 97.0, 77.2, 70.8, 70.1, 68.3, 61.9, 55.7, 53.8, 40.5, 21.9. **HRMS** (ESI) m/z calcd. for C₂₈H₃₀IN₅O₈SNa [M+Na]⁺: 746.0752, found: 746.0770.



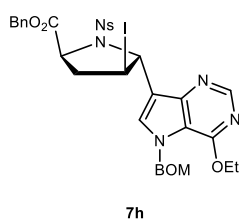
5-((benzyloxy)methyl)-7-((2*S*,3*R*,5*S*)-5-((benzyloxy)methyl)-3-iodo-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-yl)-4-methoxy-5H-pyrrolo[3,2-*d*]pyrimidine (6g). R_f = 0.50 (silica gel, PE:EtOAc = 3:1, UV). yellow oil (125 mg, 81% yield, β : α = 9:1). $[\alpha]_D^{25} = -13.87$ (c = 1.00, CH₂Cl₂). **¹H NMR** (400 MHz, CDCl₃) δ 8.43 (s, 1H), 8.14 (d, J = 8.8 Hz, 2H), 7.90 (d, J = 8.8 Hz, 2H), 7.53 (s, 1H), 7.37 – 7.23 (m, 10H), 5.50 – 5.26 (m, 2H), 5.31 (s, 1H), 4.83 (q, J = 4.8 Hz, 1H), 4.58 (q, J = 11.4 Hz, 2H), 4.46 – 4.32 (m, 2H), 4.30 – 4.22 (m, 1H), 4.15 (dd, J = 9.8, 5.8 Hz, 1H), 4.06 (s, 3H), 3.93 (dd, J = 9.8, 3.6 Hz, 1H), 2.70 – 2.60 (m, 1H), 2.34 – 2.24 (m, 1H). **¹³C NMR** (100 MHz, CDCl₃) δ 155.2, 149.1, 148.9, 147.2, 142.3, 136.8, 135.7, 132.1, 128.1 (2), 127.5 (2), 127.5 (2), 127.0, 126.9 (2), 126.9, 126.8 (2), 122.8 (2), 114.8, 114.5, 75.9, 72.6, 70.3, 69.1, 67.2, 59.5, 52.6, 38.6, 23.1. **HRMS** (ESI) m/z calcd. for C₃₃H₃₂IN₅O₇SNa [M+Na]⁺: 792.0959, found: 792.0966.



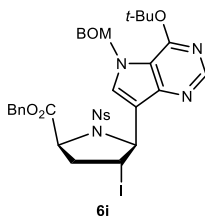
5-((benzyloxy)methyl)-7-((2*R*,3*S*,5*S*)-5-((benzyloxy)methyl)-3-iodo-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-yl)-4-methoxy-5H-pyrrolo[3,2-*d*]pyrimidine (7g). R_f = 0.50 (silica gel, PE:EtOAc = 3:1, UV). yellow oil (134 mg, 87% yield, α : β = 5:1). $[\alpha]_D^{25} = +40.57$ (c = 1.00, CH₂Cl₂). **¹H NMR** (400 MHz, CDCl₃) δ 8.03 (s, 1H), 7.63 (d, J = 8.8 Hz, 2H), 7.44 – 7.29 (m, 13H), 5.62 (q, J = 10.0 Hz, 2H), 5.26 (d, J = 5.4 Hz, 1H), 4.82 (dt, J = 7.5, 5.6 Hz, 1H), 4.65 (d, J = 3.2 Hz, 2H), 4.61 (s, 2H), 4.56 – 4.48 (m, 1H), 4.18 – 4.09 (m, 2H), 3.99 (s, 3H), 3.33 (dt, J = 14.9, 7.8 Hz, 1H), 2.68 (dt, J = 14.2, 5.4 Hz, 1H). **¹³C NMR** (100 MHz, CDCl₃) δ 154.8, 148.9, 147.5, 147.2, 144.2, 137.1, 135.5, 133.1, 127.7 (2), 127.4 (2), 127.3, 126.9 (2), 126.8 (2), 126.8, 126.7 (2), 121.4 (2), 114.4, 111.2, 76.1, 72.4, 71.1, 69.8, 67.4, 60.8, 52.7, 39.6, 21.0. **HRMS** (ESI) m/z calcd. for C₃₃H₃₂IN₅O₇SNa [M+Na]⁺: 792.0959, found: 792.0963.



Benzyl (2*S*,4*R*,5*S*)-5-(5-((benzyloxy)methyl)-4-ethoxy-5*H*-pyrrolo[3,2-*d*]pyrimidin-7-yl)-4-iodo-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (6h). R_f = 0.50 (silica gel, PE:EtOAc = 3:1, UV). colorless oil (147 mg, 92% yield, $\beta:\alpha$ = 8:1). $[\alpha]_D^{25} = -19.50$ (c = 0.10, CH₂Cl₂). **¹H NMR** (400 MHz, Acetone) δ 8.37 (s, 1H), 8.31 – 8.28 (m, 2H), 8.13 – 8.09 (m, 2H), 7.84 (s, 1H), 7.52 – 7.48 (m, 2H), 7.44 – 7.37 (m, 3H), 7.31 – 7.23 (m, 5H), 5.67 (s, 2H), 5.40 (d, J = 2.8 Hz, 1H), 5.33 (s, 2H), 4.88 (q, J = 4.4 Hz, 1H), 4.83 (t, J = 7.8 Hz, 1H), 4.62 – 4.56 (m, 2H), 4.52 (d, J = 3.4 Hz, 2H), 2.71 – 2.62 (m, 2H), 1.43 (t, J = 7.2 Hz, 3H). **¹³C NMR** (100 MHz, Acetone) δ 171.7, 156.7, 151.3, 150.8, 149.3, 143.9, 138.6, 136.7, 134.2, 130.4 (2), 129.4 (2), 129.2 (3), 129.0 (2), 128.4, 128.3 (2), 124.9 (2), 116.5, 116.2, 78.3, 70.9, 68.8, 68.1, 63.0, 62.4, 41.2, 24.7, 14.7. **HRMS** (ESI) m/z calcd. for C₃₄H₃₂IN₅O₈SNa [M+Na]⁺: 820.0908, found: 820.0918.

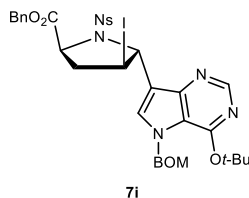


Benzyl (2*S*,4*S*,5*R*)-5-(5-((benzyloxy)methyl)-4-ethoxy-5*H*-pyrrolo[3,2-*d*]pyrimidin-7-yl)-4-iodo-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (7h). R_f = 0.50 (silica gel, PE:EtOAc = 3:1, UV). colorless oil (135 mg, 85% yield, $\alpha:\beta$ = 8:1). $[\alpha]_D^{25} = +36.25$ (c = 0.40, CH₂Cl₂). **¹H NMR** (400 MHz, CDCl₃) δ 8.03 (s, 1H), 7.65 – 7.59 (m, 2H), 7.50 – 7.30 (m, 13H), 5.69 – 5.57 (m, 2H), 5.37 – 5.29 (m, 2H), 5.28 (d, J = 7.2 Hz, 1H), 5.13 (q, J = 7.6 Hz, 1H), 4.86 (dd, J = 8.1, 6.0 Hz, 1H), 4.67 – 4.58 (m, 2H), 4.50 – 4.40 (m, 2H), 3.41 (dt, J = 13.7, 7.8 Hz, 1H), 2.62 (ddd, J = 13.8, 7.9, 6.2 Hz, 1H), 1.43 (t, J = 7.2 Hz, 3H). **¹³C NMR** (100 MHz, CDCl₃) δ 171.4, 155.6, 150.0, 148.6, 148.4, 145.4, 136.5, 135.3, 134.8, 128.7 (2), 128.6 (4), 128.5, 128.3, 127.8 (2), 127.8 (2), 122.4 (2), 115.5, 110.2, 77.2, 70.8, 67.8, 66.7, 63.0, 62.8, 41.4, 20.1, 14.4. **HRMS** (ESI) m/z calcd. for C₃₄H₃₂IN₅O₈SNa [M+Na]⁺: 820.0908, found: 820.0915.

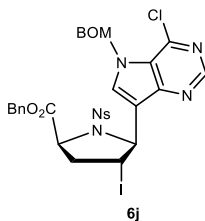


Benzyl (2*S*,4*R*,5*S*)-5-(5-((benzyloxy)methyl)-4-(tert-butoxy)-5*H*-pyrrolo[3,2-*d*]pyrimidin-7-yl)-4-iodo-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (6i). R_f = 0.50 (silica gel, PE:EtOAc = 3:1, UV). colorless oil (152 mg, 92% yield, $\beta:\alpha$ = 12:1). $[\alpha]_D^{25} = -16.25$ (c = 0.40, acetone). **¹H NMR** (400 MHz, Acetone) δ 8.35 (s, 1H), 8.33 – 8.28 (m, 2H), 8.14 – 8.10 (m, 2H), 7.82 (s, 1H), 7.52 – 7.46 (m, 2H), 7.44 – 7.36 (m, 3H), 7.32 – 7.22 (m, 5H), 5.69 – 5.62 (m, 2H),

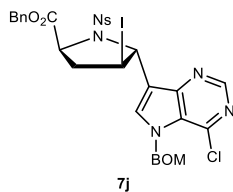
5.40 (d, $J = 2.8$ Hz, 1H), 5.32 (s, 2H), 4.88 – 4.84 (m, 1H), 4.82 (t, $J = 7.8$ Hz, 1H), 4.53 – 4.45 (m, 2H), 2.71 – 2.58 (m, 2H), 1.70 (s, 9H). ^{13}C NMR (100 MHz, Acetone) δ 171.7, 156.5, 151.2, 150.3, 149.3, 143.9, 138.6, 136.6, 134.0, 130.3 (2), 129.4 (2), 129.1, 129.1 (2), 129.0 (2), 128.3, 128.1 (2), 124.9 (2), 117.4, 116.0, 83.5, 78.2, 70.5, 68.8, 68.1, 62.4, 41.2, 28.7 (3), 24.8. **HRMS** (ESI) m/z calcd. for $\text{C}_{36}\text{H}_{36}\text{IN}_5\text{O}_8\text{SNa}$ $[\text{M}+\text{Na}]^+$: 848.1221, found: 848.1228.



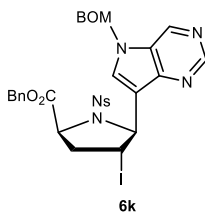
Benzyl (2*S*,4*S*,5*R*)-5-(5-((benzyloxy)methyl)-4-(tert-butoxy)-5H-pyrrolo[3,2-d]pyrimidin-7-yl)-4-iodo-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (7i). $R_f = 0.50$ (silica gel, PE:EtOAc = 3:1, UV). colorless oil (140 mg, 85% yield, $\alpha:\beta = 10:1$). $[\alpha]_D^{25} = +22.75$ ($c = 0.40$, acetone). ^1H NMR (400 MHz, Acetone) δ 7.83 (s, 1H), 7.68 (s, 1H), 7.63 – 7.59 (m, 2H), 7.43 – 7.39 (m, 2H), 7.33 – 7.18 (m, 9H), 7.16 – 7.11 (m, 1H), 5.69 (s, 2H), 5.19 (s, 2H), 5.14 (d, $J = 6.8$ Hz, 1H), 5.08 (q, $J = 7.2$ Hz, 1H), 4.89 (dd, $J = 8.3, 5.6$ Hz, 1H), 4.55 (s, 2H), 3.50 – 3.43 (m, 1H), 2.46 – 2.39 (m, 1H), 1.51 (s, 9H). ^{13}C NMR (100 MHz, Acetone) δ 172.1, 156.2, 149.8, 149.6, 149.4, 146.8, 138.6, 136.8, 136.6, 129.2 (2), 129.2 (2), 129.1 (2), 128.9, 128.8 (2), 128.5, 128.2 (2), 123.3 (2), 116.9, 110.2, 83.7, 78.3, 70.8, 67.8, 67.7, 63.6, 42.2, 28.5 (3), 21.8. **HRMS** (ESI) m/z calcd. for $\text{C}_{36}\text{H}_{36}\text{IN}_5\text{O}_8\text{SNa}$ $[\text{M}+\text{Na}]^+$: 848.1221, found: 848.1222.



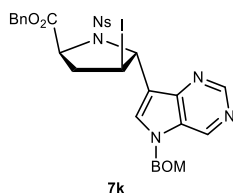
Benzyl (2*S*,4*R*,5*S*)-5-(5-((benzyloxy)methyl)-4-chloro-5H-pyrrolo[3,2-d]pyrimidin-7-yl)-4-iodo-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (6j). $R_f = 0.50$ (silica gel, PE:EtOAc = 3:1, UV). yellow foamy solid (148 mg, 94% yield, $\beta:\alpha = 5:1$). $[\alpha]_D^{25} = -24.06$ ($c = 0.60$, CH_2Cl_2). ^1H NMR (400 MHz, CDCl_3) δ 8.68 (s, 1H), 8.41 – 8.31 (m, 2H), 8.11 – 8.06 (m, 2H), 8.06 (s, 1H), 7.44 – 7.35 (m, 5H), 7.33 – 7.24 (m, 5H), 5.64 – 5.51 (m, 2H), 5.42 (s, 1H), 5.33 – 5.25 (m, 2H), 4.74 – 4.68 (m, 1H), 4.65 (dd, $J = 9.4, 6.8$ Hz, 1H), 4.57 – 4.35 (m, 2H), 2.53 – 2.38 (m, 2H). ^{13}C NMR (100 MHz, CDCl_3) δ 170.0, 149.5, 149.3, 148.5, 141.9, 140.8, 136.0, 135.3, 133.9, 128.5 (2), 127.8 (3), 127.6 (2), 127.5 (2), 127.1, 126.8 (2), 123.4 (2), 123.4, 115.3, 75.8, 69.3, 67.2, 67.1, 60.7, 39.3, 22.5. **HRMS** (ESI) m/z calcd. for $\text{C}_{32}\text{H}_{27}\text{ClIN}_5\text{O}_7\text{SNa}$ $[\text{M}+\text{Na}]^+$: 810.0356, found: 810.0257.



Benzyl (2*S*,4*S*,5*R*)-5-(5-((benzyloxy)methyl)-4-chloro-5H-pyrrolo[3,2-d]pyrimidin-7-yl)-4-iodo-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (7j). R_f = 0.50 (silica gel, PE:EtOAc = 3:1, UV). white solid (139 mg, 88% yield, α : β = 6:1). **MP**: 138.2 – 140.1 °C. $[\alpha]_D^{25}$ = +42.05 (c = 0.60, CH₂Cl₂). **¹H NMR** (400 MHz, CDCl₃) δ 8.31 (s, 1H), 7.70 – 7.65 (m, 2H), 7.65 (s, 1H), 7.51 – 7.28 (m, 12H), 5.86 – 5.66 (m, 2H), 5.37 – 5.26 (m, 3H), 5.07 (q, J = 7.4 Hz, 1H), 4.88 (dd, J = 8.2, 5.8 Hz, 1H), 4.66 (q, J = 11.6 Hz, 2H), 3.38 (dt, J = 13.7, 7.8 Hz, 1H), 2.63 (ddd, J = 13.6, 7.6, 5.8 Hz, 1H). **¹³C NMR** (100 MHz, CDCl₃) δ 170.2, 148.9, 148.9, 147.8, 144.3, 141.9, 137.7, 134.9, 134.1, 127.8 (2), 127.6 (2), 127.6 (2), 127.6, 127.5, 127.1 (2), 126.8 (2), 123.0, 121.7 (2), 109.3, 75.6, 69.8, 66.9, 65.3, 61.8, 40.1, 18.4. **HRMS** (ESI) m/z calcd. for C₃₂H₂₇ClIN₅O₇SNa [M+Na]⁺: 810.0356, found: 810.0258.

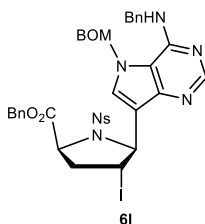


Benzyl (2*S*,4*R*,5*S*)-5-(5-((benzyloxy)methyl)-5H-pyrrolo[3,2-d]pyrimidin-7-yl)-4-iodo-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (6k). R_f = 0.50 (silica gel, PE:EtOAc = 3:1, UV). yellow solid (135 mg, 90% yield, β : α = 3:1). **MP**: 169.2 – 171.9 °C. $[\alpha]_D^{25}$ = –11.35 (c = 0.60, CH₂Cl₂). **¹H NMR** (400 MHz, CDCl₃) δ 8.99 (s, 1H), 8.87 (s, 1H), 8.41 – 8.26 (m, 2H), 8.16 – 8.04 (m, 2H), 7.98 (s, 1H), 7.52 – 7.18 (m, 10H), 5.47 (s, 1H), 5.41 – 5.22 (m, 4H), 4.80 (s, 1H), 4.67 (t, J = 8.2 Hz, 1H), 4.46 – 4.30 (m, 2H), 2.49 (dd, J = 8.2, 3.4 Hz, 2H). **¹³C NMR** (100 MHz, CDCl₃) δ 170.1, 150.5, 149.6, 146.9, 141.1, 138.6, 135.0, 134.0, 134.0, 128.5 (2), 127.8 (3), 127.6 (4), 127.4, 127.0 (3), 123.4 (2), 114.7, 75.0, 69.6, 67.4, 67.1, 60.7, 39.4, 22.7. **HRMS** (ESI) m/z calcd. for C₃₂H₂₈IN₅O₇SNa [M+Na]⁺: 776.0646, found: 776.0640.

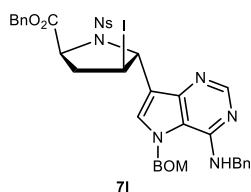


Benzyl (2*S*,4*S*,5*R*)-5-(5-((benzyloxy)methyl)-5H-pyrrolo[3,2-d]pyrimidin-7-yl)-4-iodo-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (7k). R_f = 0.50 (silica gel, PE:EtOAc = 3:1, UV). white foamy solid (134 mg, 89% yield, α : β = 9:1). $[\alpha]_D^{25}$ = +39.25 (c = 0.60, CH₂Cl₂). **¹H NMR**

(400 MHz, CDCl₃) δ 8.65 (s, 1H), 8.60 (s, 1H), 7.66 (s, 1H), 7.63 (d, J = 5.8 Hz, 2H), 7.51 – 7.45 (m, 2H), 7.44 – 7.31 (m, 10H), 5.52 (s, 2H), 5.37 – 5.29 (m, 3H), 5.09 (q, J = 7.4 Hz, 1H), 4.91 (dd, J = 8.3, 5.8 Hz, 1H), 4.58 (s, 2H), 3.42 (dt, J = 13.7, 7.8 Hz, 1H), 2.64 (ddd, J = 13.6, 7.6, 5.8 Hz, 1H). **¹³C NMR** (100 MHz, CDCl₃) δ 170.3, 149.8, 147.9, 147.2, 144.5, 138.1, 135.9, 134.6, 134.6, 134.1, 127.9 (2), 127.7, 127.6 (2), 127.6 (2), 127.6, 127.0 (2), 126.8 (2), 121.8 (2), 108.7, 74.5, 69.9, 66.9, 65.6, 61.8, 40.1, 18.9. **HRMS** (ESI) m/z calcd. for C₃₂H₂₈IN₅O₇SNa [M+Na]⁺: 776.0646, found: 776.0648.

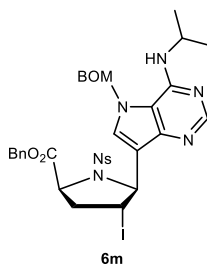


Benzyl (2*S*,4*R*,5*S*)-5-(4-(benzylamino)-5-((benzyloxy)methyl)-5H-pyrrolo[3,2-d]pyrimidin-7-yl)-4-iodo-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (6l). R_f = 0.40 (silica gel, PE:EtOAc = 3:1, UV). yellow foamy solid (156 mg, 94% yield, β : α = 11:1). $[\alpha]_D^{25}$ = -7.75 (c = 0.60, Acetone). **¹H NMR** (400 MHz, CDCl₃) δ 8.43 (s, 1H), 8.40 – 8.31 (m, 2H), 8.16 – 8.07 (m, 2H), 7.53 (s, 1H), 7.45 – 7.26 (m, 13H), 7.20 – 7.13 (m, 2H), 6.82 (t, J = 5.4 Hz, 1H), 5.41 (s, 1H), 5.33 – 5.08 (m, 4H), 4.84 – 4.78 (m, 1H), 4.71 (d, J = 5.4 Hz, 2H), 4.65 (dd, J = 9.4, 6.8 Hz, 1H), 4.47 – 4.33 (m, 2H), 2.56 – 2.48 (m, 2H). **¹³C NMR** (100 MHz, CDCl₃) δ 171.2, 151.8, 150.5, 150.4, 146.5, 142.1, 138.6, 135.1, 135.1, 131.0, 129.6 (2), 128.9 (2), 128.8, 128.8 (2), 128.7 (2), 128.7 (2), 128.6, 128.6 (2), 127.6 (2), 127.3, 124.3 (2), 115.7, 115.6, 77.2, 70.2, 68.8, 68.0, 61.8, 44.7, 40.3, 24.5. **HRMS** (ESI) m/z calcd. for C₃₉H₃₅IN₆O₇SNa [M+H]⁺: 859.1406, found: 859.1405.

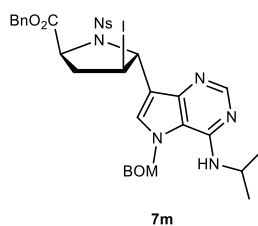


Benzyl (2*S*,4*S*,5*R*)-5-(4-(benzylamino)-5-((benzyloxy)methyl)-5H-pyrrolo[3,2-d]pyrimidin-7-yl)-4-iodo-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (7l). R_f = 0.40 (silica gel, PE:EtOAc = 3:1, UV). yellow oil (147 mg, 88% yield, α : β = 2.5:1). $[\alpha]_D^{25}$ = $+19.75$ (c = 0.60, Acetone). **¹H NMR** (400 MHz, Acetone) δ 7.90 (s, 1H), 7.87 – 7.80 (m, 2H), 7.64 (s, 1H), 7.57 – 7.49 (m, 4H), 7.46 – 7.36 (m, 3H), 7.36 – 7.22 (m, 10H), 6.79 (br, 1H), 5.90 – 5.69 (m, 2H), 5.32 (s, 2H), 5.30 – 5.21 (m, 2H), 5.04 (dd, J = 8.3, 5.6 Hz, 1H), 4.77 – 4.62 (m, 3H), 4.44 (dd, J = 14.7, 4.4 Hz, 1H), 3.70 – 3.60 (m, 1H), 2.60 – 2.50 (m, 1H). **¹³C NMR** (150 MHz, Acetone) δ 172.3, 151.5, 150.6, 149.7, 146.6, 140.1, 137.3, 137.0, 134.9, 129.4 (2), 129.3 (4), 129.2 (2), 129.0, 128.9, 128.9 (2), 128.7 (3), 128.5 (2), 127.9, 123.3 (2), 115.8, 109.5, 78.6, 71.2, 68.0, 67.8, 63.9, 45.1, 42.5,

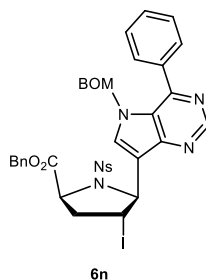
22.1. **HRMS** (ESI) m/z calcd. for $C_{39}H_{36}IN_6O_7S$ $[M+H]^+$: 859.1406, found: 859.1409.



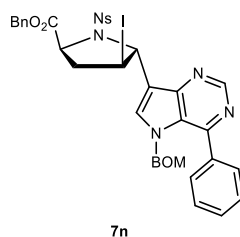
Benzyl (2*S*,4*R*,5*S*)-5-(5-((benzyloxy)methyl)-4-(isopropylamino)-5H-pyrrolo[3,2-*d*]pyrimidin-7-yl)-4-iodo-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (6m). R_f = 0.40 (silica gel, PE:EtOAc = 3:1, UV). yellow oil (153 mg, 94% yield, β : α = 5:1). $[\alpha]_D^{25} = -4.07$ (c = 0.40, MeOH). **1H NMR** (400 MHz, MeOD) δ 8.32 – 8.25 (m, 2H), 8.17 (s, 1H), 8.11 – 8.03 (m, 2H), 7.54 (s, 1H), 7.50 – 7.35 (m, 5H), 7.33 – 7.20 (m, 5H), 5.39 (d, J = 2.6 Hz, 1H), 5.36 – 5.24 (m, 4H), 4.78 – 4.72 (m, 1H), 4.59 – 4.54 (m, 1H), 4.45 (q, J = 11.4 Hz, 2H), 4.26 – 4.18 (m, 1H), 2.67 – 2.50 (m, 2H), 1.13 (d, J = 6.6 Hz, 6H). **^{13}C NMR** (100 MHz, MeOD) δ 171.3, 150.8, 150.5, 149.9, 145.4, 142.6, 135.9, 135.6, 131.5, 129.4 (2), 128.5 (2), 128.4 (2), 128.3, 128.3 (2), 128.3 (2), 128.1, 123.8 (2), 115.2, 114.7, 77.5, 70.2, 67.5, 67.4, 61.7, 42.1, 40.1, 23.6, 21.4, 21.4. **HRMS** (ESI) m/z calcd. for $C_{35}H_{36}IN_6O_7S$ $[M+H]^+$: 811.1406, found: 811.1408.



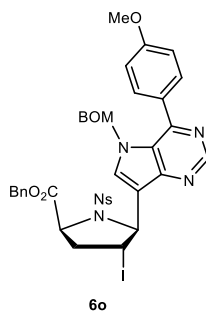
Benzyl (2*S*,4*S*,5*R*)-5-(5-((benzyloxy)methyl)-4-(isopropylamino)-5H-pyrrolo[3,2-*d*]pyrimidin-7-yl)-4-iodo-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (7m). R_f = 0.40 (silica gel, PE:EtOAc = 3:1, UV). yellow oil (143 mg, 88% yield, α : β = 5:1). $[\alpha]_D^{25} = +6.48$ (c = 0.40, MeOH). **1H NMR** (400 MHz, MeOD) δ 7.84 – 7.74 (m, 3H), 7.57 – 7.24 (m, 13H), 5.76 – 5.49 (m, 2H), 5.30 (d, J = 2.2 Hz, 2H), 5.18 (d, J = 7.8 Hz, 1H), 5.09 (q, J = 7.8 Hz, 1H), 4.97 (dd, J = 8.2, 6.2 Hz, 1H), 4.76 – 4.61 (m, 2H), 4.10 – 4.00 (m, 1H), 3.43 (dt, J = 13.5, 7.8 Hz, 1H), 2.54 – 2.44 (m, 1H), 1.15 (d, J = 6.6 Hz, 3H), 1.06 (d, J = 6.6 Hz, 3H). **^{13}C NMR** (100 MHz, MeOD) δ 172.2, 150.3, 149.3, 148.9, 145.9, 145.5, 136.1, 135.6, 134.2, 128.3 (2), 128.2 (2), 128.2 (2), 128.1, 128.1 (2), 128.0, 127.9 (2), 122.2 (2), 115.1, 108.0, 77.5, 70.6, 67.2, 66.8, 63.0, 42.1, 41.1, 21.4 (2), 19.7. **HRMS** (ESI) m/z calcd. for $C_{35}H_{35}IN_6O_7SNa$ $[M+Na]^+$: 833.1225, found: 833.1222.



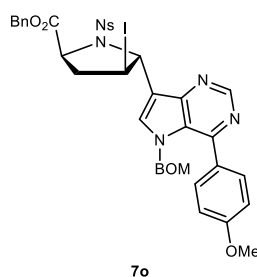
Benzyl (2*S*,4*R*,5*S*)-5-(5-((benzyloxy)methyl)-4-phenyl-5H-pyrrolo[3,2-d]pyrimidin-7-yl)-4-iodo-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (6n). R_f = 0.50 (silica gel, PE:EtOAc = 3:1, UV). colorless oil (149 mg, 90% yield, β : α = 8:1). $[\alpha]_D^{25}$ = -9.10 (c = 0.40, CH_2Cl_2). **^1H NMR** (400 MHz, CDCl_3) δ 9.01 (s, 1H), 8.31 – 8.27 (m, 2H), 8.09 – 8.06 (m, 2H), 8.00 (s, 1H), 7.64 – 7.60 (m, 2H), 7.53 (dd, J = 5.2, 1.8 Hz, 3H), 7.43 – 7.35 (m, 5H), 7.30 – 7.26 (m, 3H), 7.10 (dd, J = 7.3, 2.0 Hz, 2H), 5.51 (s, 1H), 5.33 – 5.25 (m, 2H), 5.08 – 5.01 (m, 2H), 4.86 – 4.82 (m, 1H), 4.71 (dd, J = 8.8, 7.2 Hz, 1H), 4.11 – 4.03 (m, 2H), 2.58 – 2.46 (m, 2H). **^{13}C NMR** (100 MHz, CDCl_3) δ 171.1, 151.4, 151.0, 150.5, 149.3, 142.3, 137.0, 136.6, 136.4, 135.0, 129.8, 129.5 (2), 128.9 (2), 128.8 (3), 128.6 (2), 128.5 (2), 128.5 (2), 128.0, 127.5 (2), 125.7, 124.3 (2), 115.9, 76.7, 70.2, 68.4, 68.1, 61.7, 40.5, 23.7. **HRMS** (ESI) m/z calcd. for $\text{C}_{38}\text{H}_{32}\text{IN}_5\text{O}_7\text{SNa}$ $[\text{M}+\text{Na}]^+$: 852.0959, found: 852.0957.



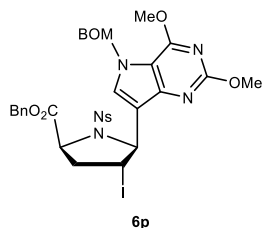
Benzyl (2*S*,4*S*,5*R*)-5-(5-((benzyloxy)methyl)-4-phenyl-5H-pyrrolo[3,2-d]pyrimidin-7-yl)-4-iodo-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (7n). R_f = 0.50 (silica gel, PE:EtOAc = 3:1, UV). colorless oil (136 mg, 82% yield, α : β = 7:1). $[\alpha]_D^{25}$ = $+79.25$ (c = 0.40, CH_2Cl_2). **^1H NMR** (400 MHz, CDCl_3) δ 8.55 (s, 1H), 7.65 (s, 1H), 7.62 – 7.51 (m, 7H), 7.51 – 7.47 (m, 2H), 7.45 – 7.27 (m, 8H), 7.23 – 7.16 (m, 2H), 5.38 (d, J = 7.2 Hz, 1H), 5.38 – 5.30 (m, 2H), 5.23 – 5.14 (m, 3H), 4.91 (dd, J = 8.1, 5.8 Hz, 1H), 4.18 – 4.04 (m, 2H), 3.45 (dt, J = 13.8, 7.8 Hz, 1H), 2.67 (ddd, J = 13.6, 7.7, 5.8 Hz, 1H). **^{13}C NMR** (100 MHz, CDCl_3) δ 171.3, 151.1, 150.5, 149.8, 148.8, 145.5, 138.8, 136.5, 136.0, 135.2, 130.0, 128.7 (4), 128.7 (2), 128.7 (2), 128.7 (2), 128.6, 128.4, 128.0 (2), 128.0 (2), 125.1, 122.8 (2), 109.9, 76.6, 70.6, 67.9, 66.7, 62.9, 41.4, 19.8. **HRMS** (ESI) m/z calcd. for $\text{C}_{38}\text{H}_{32}\text{IN}_5\text{O}_7\text{SNa}$ $[\text{M}+\text{Na}]^+$: 852.0959, found: 852.0958.



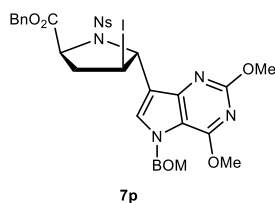
Benzyl (2*S*,4*R*,5*S*)-5-(5-((benzyloxy)methyl)-4-(4-methoxyphenyl)-5H-pyrrolo[3,2-*d*]pyrimidin-7-yl)-4-iodo-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (6o). R_f = 0.50 (silica gel, PE:EtOAc = 3:1, UV). colorless oil (148 mg, 86% yield, β : α = 3:1). $[\alpha]_D^{25}$ = -19.50 (c = 0.10, CH_2Cl_2). ^1H NMR (400 MHz, CDCl_3) δ 8.98 (s, 1H), 8.29 (d, J = 8.8 Hz, 2H), 8.07 (d, J = 8.8 Hz, 2H), 7.99 (s, 1H), 7.59 (d, J = 8.8 Hz, 2H), 7.43 – 7.35 (m, 5H), 7.31 – 7.26 (m, 3H), 7.15 – 7.08 (m, 2H), 7.03 (d, J = 8.8 Hz, 2H), 5.50 (s, 1H), 5.29 (s, 2H), 5.11 (s, 2H), 4.86 – 4.80 (m, 1H), 4.71 (t, J = 8.0 Hz, 1H), 4.18 – 4.08 (m, 2H), 3.89 (s, 3H), 2.56 – 5.50 (m, 2H). ^{13}C NMR (150 MHz, CDCl_3) δ 171.1, 160.9, 151.1, 151.0, 150.5, 149.2, 142.2, 136.6, 136.5, 135.0, 130.4 (2), 129.5 (2), 129.2, 128.8 (3), 128.6 (2), 128.4 (2), 128.0, 127.5 (2), 125.8, 124.3 (2), 116.0, 114.0 (2), 76.6, 70.3, 68.4, 68.1, 61.7, 55.4, 40.4, 23.8. **HRMS** (ESI) m/z calcd. for $\text{C}_{39}\text{H}_{34}\text{IN}_5\text{O}_8\text{SNa}$ $[\text{M}+\text{Na}]^+$: 882.1065, found: 882.1067.



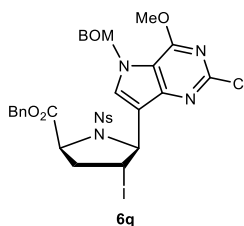
Benzyl (2*S*,4*S*,5*R*)-5-(5-((benzyloxy)methyl)-4-(4-methoxyphenyl)-5H-pyrrolo[3,2-*d*]pyrimidin-7-yl)-4-iodo-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (7o). R_f = 0.50 (silica gel, PE:EtOAc = 3:1, UV). colorless oil (144 mg, 84% yield, α : β = 8:1). $[\alpha]_D^{25}$ = $+107.67$ (c = 0.30, CH_2Cl_2). ^1H NMR (400 MHz, Acetone) δ 8.45 (s, 1H), 8.08 (s, 1H), 7.78 – 7.70 (m, 2H), 7.64 – 7.59 (m, 2H), 7.59 – 7.53 (m, 2H), 7.52 – 7.20 (m, 10H), 7.17 – 7.09 (m, 2H), 5.56 – 5.46 (m, 2H), 5.42 – 5.30 (m, 4H), 5.08 (dd, J = 8.4, 5.6 Hz, 1H), 4.42 – 4.22 (m, 2H), 3.93 (s, 3H), 3.71 – 3.59 (m, 1H), 2.61 (ddd, J = 13.6, 7.2, 5.6 Hz, 1H). ^{13}C NMR (100 MHz, Acetone) δ 172.1, 161.9, 151.5, 150.9, 150.6, 149.6, 146.8, 140.7, 138.0, 136.9, 131.4 (2), 130.1, 129.3 (2), 129.2 (2), 129.1 (2), 129.0, 128.9 (2), 128.6, 128.5 (2), 125.8, 123.6 (2), 114.5 (2), 110.1, 77.8, 71.0, 67.8, 67.7, 63.7, 55.8, 42.3, 21.5. **HRMS** (ESI) m/z calcd. for $\text{C}_{39}\text{H}_{34}\text{IN}_5\text{O}_8\text{SNa}$ $[\text{M}+\text{Na}]^+$: 882.1065, found: 882.1072.



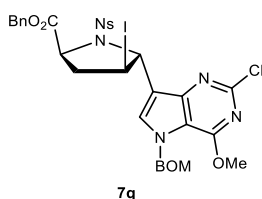
Benzyl (2*S*,4*R*,5*S*)-5-(5-((benzyloxy)methyl)-2,4-dimethoxy-5H-pyrrolo[3,2-d]pyrimidin-7-yl)-4-iodo-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (6p). R_f = 0.50 (silica gel, PE:EtOAc = 3:1, UV). white foamy solid (159 mg, 98% yield, β only). $[\alpha]_D^{25} = -26.05$ ($c = 0.40$, CH_2Cl_2). **^1H NMR** (400 MHz, CDCl_3) δ 8.31 – 8.19 (m, 2H), 8.10 – 8.00 (m, 2H), 7.60 (d, $J = 0.8$ Hz, 1H), 7.44 – 7.23 (m, 10H), 5.47 – 5.36 (m, 2H), 5.33 (d, $J = 2.4$ Hz, 1H), 5.26 (d, $J = 1.8$ Hz, 2H), 4.85 (dt, $J = 5.2, 3.0$ Hz, 1H), 4.72 (dd, $J = 8.6, 7.2$ Hz, 1H), 4.49 – 4.34 (m, 2H), 4.06 (s, 3H), 4.00 (s, 3H), 2.61 – 2.44 (m, 2H). **^{13}C NMR** (100 MHz, CDCl_3) δ 171.0, 160.1, 157.8, 150.2, 149.5, 142.9, 136.9, 135.1, 133.4, 129.4 (2), 128.8 (2), 128.7, 128.5 (2), 128.5 (2), 128.0, 127.8 (2), 124.0 (2), 114.5, 112.5, 77.0, 70.1, 68.5, 67.9, 61.6, 54.7, 53.9, 40.4, 23.7. **HRMS** (ESI) m/z calcd. for $\text{C}_{34}\text{H}_{32}\text{IN}_5\text{O}_9\text{SNa}$ $[\text{M}+\text{Na}]^+$: 836.0857, found: 836.0855.



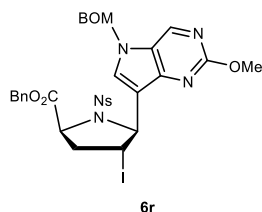
Benzyl (2*S*,4*S*,5*R*)-5-(5-((benzyloxy)methyl)-2,4-dimethoxy-5H-pyrrolo[3,2-d]pyrimidin-7-yl)-4-iodo-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (7p). R_f = 0.50 (silica gel, PE:EtOAc = 3:1, UV). white foamy solid (135 mg, 83% yield, $\alpha:\beta = 8:1$). $[\alpha]_D^{25} = -0.25$ ($c = 0.40$, CH_2Cl_2). **^1H NMR** (400 MHz, CDCl_3) δ 7.72 – 7.65 (m, 2H), 7.51 – 7.45 (m, 2H), 7.45 – 7.30 (m, 11H), 5.54 (q, $J = 10.0$ Hz, 2H), 5.37 – 5.28 (m, 2H), 5.21 (d, $J = 7.2$ Hz, 1H), 5.02 (q, $J = 7.6$ Hz, 1H), 4.82 (dd, $J = 8.0, 6.2$ Hz, 1H), 4.60 (d, $J = 3.0$ Hz, 2H), 3.98 (s, 3H), 3.82 (s, 3H), 3.37 (dt, $J = 13.6, 7.8$ Hz, 1H), 2.61 (ddd, $J = 13.8, 8.0, 6.2$ Hz, 1H). **^{13}C NMR** (100 MHz, CDCl_3) δ 171.3, 159.4, 157.2, 150.3, 148.6, 145.4, 136.5, 135.4, 135.2, 128.7 (2), 128.6 (2), 128.6 (2), 128.5, 128.3, 127.9 (2), 127.9 (2), 122.4 (2), 112.1, 109.2, 77.0, 70.7, 67.9, 66.7, 63.0, 54.6, 54.0, 41.4, 20.1. **HRMS** (ESI) m/z calcd. for $\text{C}_{34}\text{H}_{32}\text{IN}_5\text{O}_9\text{SNa}$ $[\text{M}+\text{Na}]^+$: 836.0857, found: 836.0868.



Benzyl (2*S*,4*R*,5*S*)-5-(5-((benzyloxy)methyl)-2-chloro-4-methoxy-5*H*-pyrrolo[3,2-*d*]pyrimidin-7-yl)-4-iodo-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (6q). R_f = 0.50 (silica gel, PE:EtOAc = 3:1, UV). white foamy solid (153 mg, 94% yield, β : α = 9:1). $[\alpha]_D^{25}$ = -9.07 (c = 0.40, CH₂Cl₂). ¹H NMR (400 MHz, CDCl₃) δ 8.31 – 8.23 (m, 2H), 8.06 – 7.99 (m, 2H), 7.84 (s, 1H), 7.44 – 7.22 (m, 10H), 5.50 – 5.40 (d, J = 2.2 Hz, 2H), 5.33 (d, J = 2.2 Hz, 1H), 5.32 – 5.24 (d, J = 2.8 Hz, 2H), 4.72 – 4.65 (m, 2H), 4.51 – 4.37 (m, 2H), 4.11 (s, 3H), 2.60 – 2.42 (m, 2H). ¹³C NMR (100 MHz, CDCl₃) δ 171.0, 156.8, 151.0, 150.4, 149.7, 142.4, 136.6, 135.0, 134.6, 129.5 (2), 128.8 (2), 128.8, 128.6 (2), 128.5 (2), 128.1, 127.8 (2), 124.2 (2), 115.6, 114.7, 77.1, 70.4, 68.0, 67.9, 61.6, 54.6, 40.4, 23.7. **HRMS** (ESI) m/z calcd. for C₃₃H₂₉ClIN₅O₈SNa [M+Na]⁺: 840.0362, found: 840.0361.

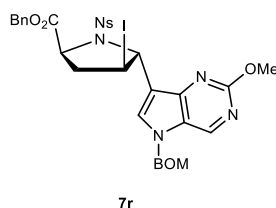


Benzyl (2*S*,4*S*,5*R*)-5-(5-((benzyloxy)methyl)-2-chloro-4-methoxy-5*H*-pyrrolo[3,2-*d*]pyrimidin-7-yl)-4-iodo-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (7q). R_f = 0.50 (silica gel, PE:EtOAc = 3:1, UV). yellow solid (142 mg, 87% yield, α : β = 4:1). **MP**: 148.0 – 151.2 °C. $[\alpha]_D^{25}$ = +3.50 (c = 0.40, CH₂Cl₂). ¹H NMR (400 MHz, CDCl₃) δ 7.77 – 7.70 (m, 2H), 7.50 – 7.45 (d, J = 7.2 Hz, 3H), 7.44 – 7.30 (m, 10H), 5.64 – 5.52 (m, 2H), 5.37 – 5.29 (m, 2H), 5.22 (d, J = 7.4 Hz, 1H), 4.91 (q, J = 7.6 Hz, 1H), 4.83 (dd, J = 8.0, 6.2 Hz, 1H), 4.62 (d, J = 1.6 Hz, 2H), 4.00 (s, 3H), 3.36 (dt, J = 13.6, 7.8 Hz, 1H), 2.60 (ddd, J = 14.0, 8.1, 6.2 Hz, 1H). ¹³C NMR (100 MHz, CDCl₃) δ 171.0, 156.8, 151.0, 150.4, 149.7, 142.4, 136.6, 135.0, 134.6, 129.5 (2), 128.8 (2), 128.8, 128.6 (2), 128.5 (2), 128.1, 127.8 (2), 124.2 (2), 115.6, 114.7, 77.1, 70.4, 68.0, 67.9, 61.6, 54.6, 40.4, 23.7. **HRMS** (ESI) m/z calcd. for C₃₃H₂₉ClIN₅O₈SNa [M+Na]⁺: 840.0362, found: 840.0362.

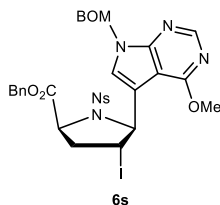


Benzyl (2*S*,4*R*,5*S*)-5-(5-((benzyloxy)methyl)-2-methoxy-5*H*-pyrrolo[3,2-*d*]pyrimidin-7-yl)-4-iodo-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (6r). R_f = 0.50 (silica gel, PE:EtOAc = 3:1, UV). white foamy solid (135 mg, 86% yield, β : α = 12:1). $[\alpha]_D^{25}$ = -24.35 (c = 0.60, CH₂Cl₂). ¹H NMR (400 MHz, CDCl₃) δ 8.56 (s, 1H), 8.25 (d, J = 8.8 Hz, 2H), 8.01 (d, J = 8.8 Hz, 2H), 7.76 (s, 1H), 7.37 – 7.21 (m, 8H), 7.21 – 7.14 (m, 2H), 5.31 (s, 1H), 5.27 – 5.12 (m, 4H), 4.76 (s, 1H), 4.60 (t, J = 8.2 Hz, 1H), 4.36 – 4.19 (m, 2H), 3.96 (s, 3H), 2.48 – 2.38 (m, 2H). ¹³C NMR (100

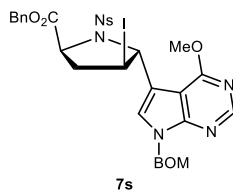
MHz, CDCl₃) δ 170.0, 160.2, 149.5, 149.0, 141.3, 140.7, 135.1, 134.6, 134.0, 128.5 (2), 127.8 (3), 127.7 (2), 127.6 (2), 127.3, 127.0 (2), 124.0, 123.3 (2), 113.3, 75.1, 69.4, 67.4, 67.0, 60.7, 53.8, 39.4, 22.6. **HRMS** (ESI) m/z calcd. for C₃₃H₃₀IN₅O₈SNa [M+Na]⁺: 806.0752, found: 806.0754.



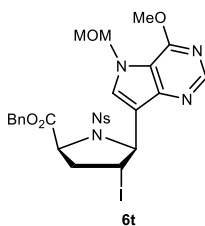
Benzyl (2*S*,4*S*,5*R*)-5-(5-((benzyloxy)methyl)-2-methoxy-5H-pyrrolo[3,2-*d*]pyrimidin-7-yl)-4-iodo-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (7r). R_f = 0.50 (silica gel, PE:EtOAc = 3:1, UV). white foamy solid (119 mg, 76% yield, α : β = 4:1). $[\alpha]_D^{25} = -16.50$ (c = 0.40, CH₂Cl₂). **¹H NMR** (400 MHz, CDCl₃) δ 8.41 (s, 1H), 7.74 – 7.65 (m, 2H), 7.55 (s, 1H), 7.49 – 7.44 (m, 2H), 7.44 – 7.29 (m, 10H), 5.46 (s, 2H), 5.32 (d, J = 2.6 Hz, 2H), 5.24 (d, J = 7.6 Hz, 1H), 5.03 (q, J = 7.8 Hz, 1H), 4.85 (dd, J = 8.2, 6.2 Hz, 1H), 4.57 (s, 2H), 3.86 (s, 3H), 3.34 (dt, J = 13.6, 7.8 Hz, 1H), 2.59 (ddd, J = 14.1, 8.2, 6.2 Hz, 1H). **¹³C NMR** (100 MHz, CDCl₃) δ 170.3, 159.3, 149.9, 147.8, 144.5, 140.0, 136.9, 134.7, 134.1, 127.9 (2), 127.6 (3), 127.6 (2), 127.5, 127.0 (2), 126.8 (2), 123.7, 121.7 (2), 106.9, 74.7, 69.7, 66.9, 65.5, 61.7, 53.8, 40.0, 18.9. **HRMS** (ESI) m/z calcd. for C₃₃H₃₀IN₅O₈SNa [M+Na]⁺: 806.0752, found: 806.0754.



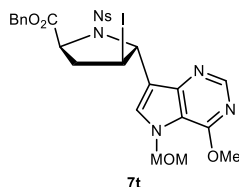
Benzyl (2*S*,4*R*,5*S*)-5-(7-((benzyloxy)methyl)-4-methoxy-7H-pyrrolo[2,3-*d*]pyrimidin-5-yl)-4-iodo-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (6s). R_f = 0.50 (silica gel, PE:EtOAc = 3:1, UV). colorless oil (146 mg, 93% yield, β : α = 14:1). $[\alpha]_D^{25} = -27.25$ (c = 0.40, CH₂Cl₂). **¹H NMR** (400 MHz, CDCl₃) δ 8.48 (s, 1H), 8.37 – 8.29 (m, 2H), 8.11 – 8.02 (m, 2H), 7.57 (d, J = 1.4 Hz, 1H), 7.47 – 7.37 (m, 5H), 7.31 – 7.23 (m, 5H), 5.51 (s, 1H), 5.50 – 5.41 (m, 2H), 5.30 (s, 2H), 4.70 (dd, J = 9.4, 7.6 Hz, 1H), 4.47 (s, 2H), 4.43 (dd, J = 4.4, 2.1 Hz, 1H), 4.13 (s, 3H), 2.51 – 2.39 (m, 2H). **¹³C NMR** (100 MHz, CDCl₃) δ 171.0, 162.8, 152.9, 152.0, 150.5, 142.5, 137.1, 135.0, 129.6 (2), 128.9 (3), 128.7 (2), 128.4 (2), 127.8, 127.7 (2), 125.6, 124.3 (2), 115.3, 103.1, 73.2, 71.0, 70.2, 68.1, 62.0, 54.1, 39.4, 25.9. **HRMS** (ESI) m/z calcd. for C₃₃H₃₀IN₅O₈SNa [M+Na]⁺: 806.0752, found: 806.0773.



Benzyl (2*S*,4*S*,5*R*)-5-(7-((benzyloxy)methyl)-4-methoxy-7*H*-pyrrolo[2,3-*d*]pyrimidin-5-yl)-4-iodo-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (7s). R_f = 0.50 (silica gel, PE:EtOAc = 3:1, UV). colorless oil (136 mg, 87% yield, α : β = 4:1). $[\alpha]_D^{25} = -10.50$ (c = 0.20, CH₂Cl₂). **¹H NMR** (400 MHz, Acetone) δ 8.15 (s, 1H), 7.80 (d, J = 9.0 Hz, 2H), 7.66 (s, 1H), 7.58 – 7.52 (m, 2H), 7.49 (d, J = 8.6 Hz, 2H), 7.46 – 7.30 (m, 7H), 7.30 – 7.25 (m, 1H), 5.83 – 5.71 (m, 2H), 5.32 (d, J = 2.0 Hz, 3H), 4.97 (dd, J = 8.0, 6.2 Hz, 1H), 4.80 – 4.65 (m, 3H), 3.99 (s, 3H), 3.40 (dt, J = 13.8, 8.2 Hz, 1H), 2.58 (ddd, J = 13.6, 8.2, 6.2 Hz, 1H). **¹³C NMR** (100 MHz, Acetone) δ 172.3, 162.6, 154.0, 151.8, 149.8, 147.0, 138.6, 136.8, 130.7, 129.3 (2), 129.2 (2), 129.2 (2), 129.1 (2), 129.0, 128.5, 128.5 (2), 123.5 (2), 110.0, 104.2, 74.0, 71.7, 68.9, 67.8, 63.7, 54.2, 41.9, 24.2. **HRMS** (ESI) m/z calcd. for C₃₃H₃₀IN₅O₈SNa [M+Na]⁺: 806.0752, found: 806.0765.

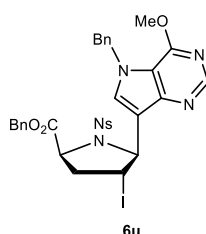


Benzyl (2*S*,4*R*,5*S*)-4-iodo-5-(4-methoxy-5-(methoxymethyl)-5*H*-pyrrolo[3,2-*d*]pyrimidin-7-yl)-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (6t). R_f = 0.50 (silica gel, PE:EtOAc = 3:1, UV). white foamy solid (120 mg, 85% yield, β : α = 17:1). $[\alpha]_D^{25} = -19.25$ (c = 1.00, CH₂Cl₂). **¹H NMR** (400 MHz, CDCl₃) δ 8.50 (s, 1H), 8.31 – 8.22 (m, 2H), 8.08 – 7.99 (m, 2H), 7.73 (s, 1H), 7.52 – 7.35 (m, 5H), 5.44 (s, 1H), 5.42 – 5.24 (m, 4H), 4.79 (s, 1H), 4.74 (dd, J = 8.8, 7.4 Hz, 1H), 4.13 (s, 3H), 3.20 (s, 3H), 2.59 – 2.46 (m, 2H). **¹³C NMR** (100 MHz, CDCl₃) δ 171.1, 156.3, 150.4, 150.3, 148.2, 142.6, 135.0, 133.1, 129.4 (2), 128.8 (2), 128.8, 128.6 (2), 124.1 (2), 115.9, 115.8, 79.4, 68.3, 68.0, 61.7, 56.1, 53.8, 40.3, 24.1. **HRMS** (ESI) m/z calcd. for C₂₇H₂₆IN₅O₈SNa [M+Na]⁺: 730.0439, found: 730.0439.

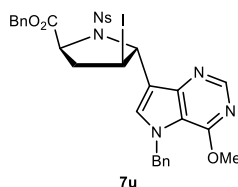


Benzyl (2*S*,4*S*,5*R*)-4-iodo-5-(4-methoxy-5-(methoxymethyl)-5*H*-pyrrolo[3,2-*d*]pyrimidin-7-yl)-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (7t). R_f = 0.50 (silica gel, PE:EtOAc = 3:1, UV). white foamy solid (128 mg, 91% yield, α : β = 16:1). $[\alpha]_D^{25} = +36.75$ (c = 1.00, CH₂Cl₂).

¹H NMR (400 MHz, CDCl₃) δ 8.06 (s, 1H), 7.72 – 7.65 (m, 2H), 7.52 – 7.45 (m, 3H), 7.44 – 7.33 (m, 5H), 5.52 (s, 2H), 5.33 (d, *J* = 3.4 Hz, 2H), 5.29 (d, *J* = 7.2 Hz, 1H), 5.12 (q, *J* = 7.6 Hz, 1H), 4.88 (dd, *J* = 8.1, 6.0 Hz, 1H), 4.03 (s, 3H), 3.46 – 3.38 (m, 4H), 2.66 – 2.58 (m, 1H). **¹³C NMR** (100 MHz, CDCl₃) δ 171.4, 155.8, 149.9, 148.6, 148.4, 145.4, 135.2, 134.9, 128.6 (2), 128.6 (2), 128.5, 127.8 (2), 122.4 (2), 115.4, 110.1, 79.4, 67.8, 66.7, 62.9, 56.5, 53.8, 41.3, 20.2. **HRMS** (ESI) *m/z* calcd. for C₂₇H₂₆IN₅O₈SNa [M+Na]⁺: 730.0439, found: 730.0435.



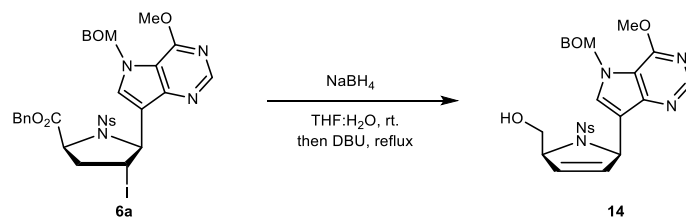
Benzyl (2*S*,4*R*,5*S*)-5-(5-benzyl-4-methoxy-5H-pyrrolo[3,2-d]pyrimidin-7-yl)-4-iodo-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (6u). *R_f* = 0.50 (silica gel, PE:EtOAc = 3:1, UV). colorless oil (136 mg, 90% yield, β:α = 47:1). [α]_D²⁵ = −7.75 (*c* = 1.00, CH₂Cl₂). **¹H NMR** (400 MHz, CDCl₃) δ 8.44 (s, 1H), 8.19 – 8.06 (m, 2H), 8.03 – 7.87 (m, 2H), 7.66 (s, 1H), 7.47 – 7.27 (m, 8H), 7.16 – 7.02 (m, 2H), 5.44 (d, *J* = 2.6 Hz, 1H), 5.36 – 5.17 (m, 4H), 4.83 (s, 1H), 4.76 (t, *J* = 7.8 Hz, 1H), 4.05 (s, 3H), 2.67 – 2.43 (m, 2H). **¹³C NMR** (100 MHz, CDCl₃) δ 171.1, 156.2, 150.1, 149.9, 147.4, 142.9, 137.4, 135.0, 133.0, 129.3 (2), 128.8 (2), 128.8 (2), 128.7, 128.5 (2), 128.0, 127.0 (2), 123.9 (2), 116.0, 114.6, 68.4, 67.9, 61.6, 53.5, 52.8, 40.4, 24.2. **HRMS** (ESI) *m/z* calcd. for C₃₂H₂₈IN₅O₇SNa [M+Na]⁺: 776.0646, found: 776.0647.



Benzyl (2*S*,4*S*,5*R*)-5-(5-benzyl-4-methoxy-5H-pyrrolo[3,2-d]pyrimidin-7-yl)-4-iodo-1-((4-nitrophenyl)sulfonyl)pyrrolidine-2-carboxylate (7u). *R_f* = 0.50 (silica gel, PE:EtOAc = 3:1, UV). white solid (125 mg, 83% yield, α:β = 15:1). **MP**: 152.1 – 154.5 °C. [α]_D²⁵ = +27.50 (*c* = 1.00, CH₂Cl₂). **¹H NMR** (400 MHz, CDCl₃) δ 8.01 (s, 1H), 7.49 – 7.33 (m, 13H), 7.13 (d, *J* = 9.0 Hz, 2H), 5.52 – 5.34 (m, 2H), 5.32 (d, *J* = 3.0 Hz, 2H), 5.25 (d, *J* = 7.2 Hz, 1H), 5.10 (q, *J* = 7.6 Hz, 1H), 4.86 (dd, *J* = 8.2, 6.0 Hz, 1H), 4.03 (s, 3H), 3.42 (dt, *J* = 13.6, 7.8 Hz, 1H), 2.66 – 2.57 (m, 1H). **¹³C NMR** (100 MHz, CDCl₃) δ 171.4, 155.8, 149.4, 148.5, 147.6, 145.3, 136.9, 135.3, 134.3, 129.2 (2), 128.8, 128.6 (4), 128.5, 128.1 (2), 127.8 (2), 122.2 (2), 115.4, 109.2, 67.8, 66.8, 63.0, 53.6, 52.9, 41.4, 20.5. **HRMS** (ESI) *m/z* calcd. for C₃₂H₂₈IN₅O₇SNa [M+Na]⁺: 776.0646, found: 776.0644.

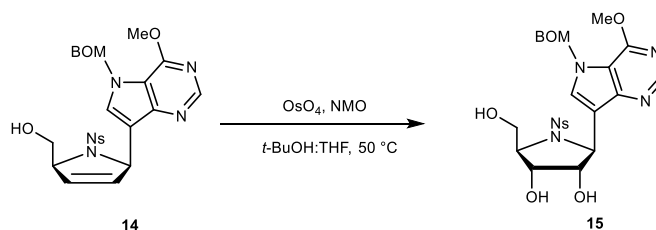
2.6 Derivatizations and applications

2.6.1 Derivatizations of β -nucleoside **6a**.



A mixture of **6a** (7.83 g, 10 mmol) and NaBH₄ (0.57 g, 15 mmol) was dissolved in THF (75 mL) and H₂O (25 mL) at 0 °C and stirred for 3 h. After that, 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU, 15 mmol) was added to the reaction mixture which was warmed to 65 °C and stirred for 3 h. After that, the solution was quenched with saturated NH₄Cl aq. (50 mL), the THF was removed under vacuo and the aqueous layer was extracted with EtOAc (50 mL x 3). The combined organic layer was washed with brine (50 mL x 3) and dried over Na₂SO₄ and filtered, concentrated in vacuo. The crude material was purified via silica gel column chromatography to obtain **14**.

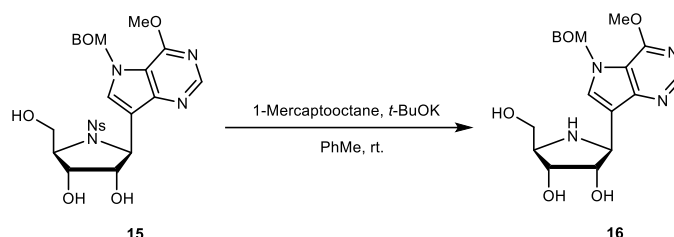
((2*S*,5*R*)-5-(5-((benzyloxy)methyl)-4-methoxy-5H-pyrrolo[3,2-*d*]pyrimidin-7-yl)-1-((4-nitrophenyl)sulfonyl)-2,5-dihydro-1H-pyrrol-2-yl)methanol (14**).** *R*_f = 0.30 (silica gel, PE:EtOAc = 1:2, UV). white solid (4.14 g, 75% yield). **MP**: 149.5 – 151.0 °C. [α]_D²⁵ = +92.05 (*c* = 0.40, CH₂Cl₂). **¹H NMR** (400 MHz, CDCl₃) δ 8.23 (s, 1H), 7.93 – 7.81 (m, 2H), 7.69 – 7.57 (m, 2H), 7.42 – 7.27 (m, 6H), 5.92 – 5.82 (m, 2H), 5.75 – 5.71 (d, *J* = 6.4 Hz, 1H), 5.63 (s, 2H), 5.10 (s, 1H), 4.55 (s, 2H), 4.39 (d, *J* = 12.6 Hz, 1H), 4.03 (s, 3H), 3.97 (dd, *J* = 12.7, 2.4 Hz, 1H). **¹³C NMR** (150 MHz, CDCl₃) δ 156.3, 149.6, 149.1, 147.4, 145.0, 136.5, 131.8, 129.2, 128.6 (2), 128.3, 128.1 (2), 127.7 (2), 127.4, 123.0 (2), 116.2, 114.5, 77.0, 70.6, 70.5, 64.3, 63.9, 54.0. **HRMS** (ESI) *m/z* calcd. for C₂₆H₂₅N₅O₇SNa [M+Na]⁺: 574.1367, found: 574.1377.



Adding OsO₄ (1% in water, 1.25 mL) to the reaction mixture of **14** (2.75 g, 5.0 mmol) and NMO (1.17 g, 10.0 mmol) in THF (35 mL) and *t*-BuOH (5 mL). The reaction mixture was stirred for 24 h at 50 °C. The solution was quenched with Na₂S₂O₃ (20 mL) and diluted with EtOAc (20 mL). The layers were separated, and the aqueous layer was extracted with EtOAc (20 mL x 3). The combined organic layer was washed with brine (20 mL x 3), dried over Na₂SO₄ and filtered, concentrated in vacuo. The crude product was purified by column chromatography to afford **15**.

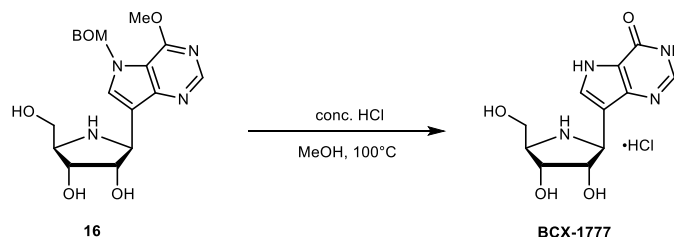
(2*S*,3*S*,4*R*,5*R*)-2-(5-((benzyloxy)methyl)-4-methoxy-5H-pyrrolo[3,2-*d*]pyrimidin-7-yl)-5-

(hydroxymethyl)-1-((4-nitrophenyl)sulfonyl)pyrrolidine-3,4-diol (15). R_f = 0.30 (silica gel, CH_2Cl_2 :MeOH = 20:1, UV). white solid (2.70 g, 92% yield). **MP:** 166.3 – 167.1 °C. $[\alpha]_D^{25} = +41.17$ ($c = 0.20$, CDCl_3). **$^1\text{H NMR}$** (400 MHz, CDCl_3) δ 7.96 – 7.87 (m, 2H), 7.78 (s, 1H), 7.64 – 7.54 (m, 2H), 7.44 – 7.29 (m, 6H), 5.67 – 5.57 (m, 2H), 4.78 (dd, $J = 8.6, 4.0$ Hz, 1H), 4.59 (s, 2H), 4.51 (d, $J = 8.4$ Hz, 1H), 4.44 (br, 1H), 4.22 (s, 1H), 4.17 (d, $J = 4.0$ Hz, 1H), 4.11 (d, $J = 14.6$ Hz, 1H), 3.96 (s, 3H), 3.80 (d, $J = 14.8$ Hz, 1H), 2.93 (brs, 1H). **$^{13}\text{C NMR}$** (100 MHz, CDCl_3) δ 156.0, 149.2, 148.5, 146.6, 143.6, 136.5, 133.2, 128.7 (2), 128.4 (2), 128.3, 128.0 (2), 123.0 (2), 116.0, 113.7, 77.0, 76.1, 73.5, 70.6, 69.1, 64.3, 60.2, 53.8. **HRMS** (ESI) m/z calcd. for $\text{C}_{26}\text{H}_{27}\text{N}_5\text{O}_9\text{SNa}$ $[\text{M}+\text{Na}]^+$: 608.1421, found: 608.1425.



Adding 1-mercaptooctane (877 mg, 6 mmol) to the reaction mixture of **15** (1.76 g, 3.0 mmol) and t -BuOK (504 mg, 4.5 mmol) in PhMe (30 mL). The reaction mixture was stirred for 16 h at room temperature. The solution was diluted with saturated NH_4Cl aq. (20 mL) and EtOAc (20 mL). The layers were separated, and the aqueous layer was extracted with EtOAc (20 mL x 3). The combined organic layer was washed with brine (20 mL x 3), dried over Na_2SO_4 and filtered, concentrated in vacuo. The crude product was purified by column chromatography to afford **16**.

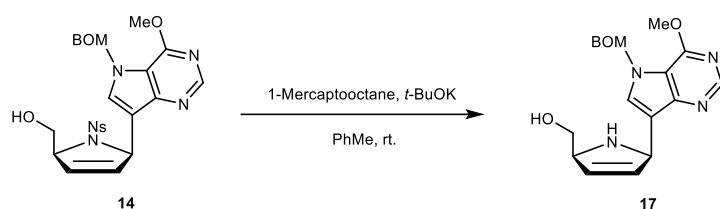
(2S,3S,4R,5R)-2-(5-((benzyloxy)methyl)-4-methoxy-5H-pyrrolo[3,2-d]pyrimidin-7-yl)-5-(hydroxymethyl)pyrrolidine-3,4-diol (16). R_f = 0.20 (silica gel, CH_2Cl_2 :MeOH = 10:1, UV). yellow oil (1.12 g, 93% yield). $[\alpha]_D^{25} = -1.25$ ($c = 0.40$, CH_2Cl_2). **$^1\text{H NMR}$** (400 MHz, MeOD) δ 8.43 (s, 1H), 7.74 (s, 1H), 7.31 – 7.18 (m, 5H), 5.79 (s, 2H), 4.55 (s, 2H), 4.45 (d, $J = 7.6$ Hz, 1H), 4.29 (dd, $J = 7.5, 5.6$ Hz, 1H), 4.17 (dd, $J = 5.6, 4.2$ Hz, 1H), 4.13 (s, 3H), 3.82 (dd, $J = 4.4, 2.4$ Hz, 2H), 3.38 – 3.34 (m, 1H). **$^{13}\text{C NMR}$** (100 MHz, MeOD) δ 156.5, 149.2, 148.9, 137.3, 132.0, 127.9 (2), 127.4, 127.2 (2), 115.9, 115.2, 77.2, 76.4, 72.3, 70.1, 65.9, 61.7, 58.8, 52.9. **HRMS** (ESI) m/z calcd. for $\text{C}_{20}\text{H}_{24}\text{N}_4\text{O}_5\text{Na}$ $[\text{M}+\text{Na}]^+$: 423.1639, found: 423.1635.



Adding concentrated hydrochloric acid (12 M, 6 mL) to a solution of **16** (200 mg, 0.5 mmol) in MeOH (1mL). The reaction mixture was heated under reflux for 24 h. After the completion of

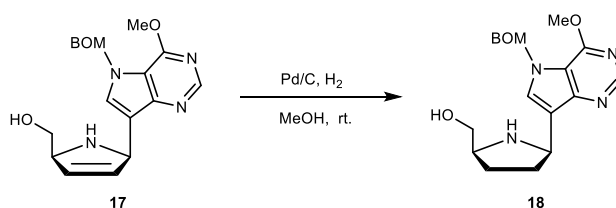
reaction, the solvent was removed under reduced pressure to afford a brownish red solid. This solid was dissolved in H₂O (1 mL), then ethanol (5 mL) was added slowly. The mixture was cooled to 0 °C and maintained at this temperature for 1 h. The resulting solid was obtained by filtration.

7-((2*S*,3*S*,4*R*,5*R*)-3,4-dihydroxy-5-(hydroxymethyl)pyrrolidin-2-yl)-3,5-dihydro-4*H*-pyrrolo[3,2-*d*]pyrimidin-4-one (BCX-1777). white solid (118 mg, 78% yield). $[\alpha]_{\text{D}}^{25} = -10.50$ ($c = 0.20$, MeOH). **¹H NMR** (400 MHz, (CD₃)₂SO) δ 12.40 (d, $J = 3.2$ Hz, 1H), 12.19 (s, 1H), 10.33 (s, 1H), 8.37 (s, 1H), 7.94 (s, 1H), 7.63 (d, $J = 3.0$ Hz, 1H), 4.64 (q, $J = 6.8$ Hz, 1H), 4.48 – 4.40 (m, 1H), 4.17 (t, $J = 4.6$ Hz, 1H), 3.73 (d, $J = 4.8$ Hz, 2H), 3.48 (q, $J = 5.2$ Hz, 1H). **¹³C NMR** (100 MHz, (CD₃)₂SO) δ 153.5, 142.7, 142.4, 127.5, 118.2, 109.2, 74.0, 70.5, 65.2, 58.6, 56.7. **HRMS** (ESI) m/z calcd. for C₁₁H₁₅N₄O₄ [M+H]⁺: 267.1088, found: 267.1093.



Add 1-mercaptooctane (0.59 g, 4 mmol) to the reaction mixture of **14** (1.10 g, 2.0 mmol) and *t*-BuOK (0.34 g, 3.0 mmol) in PhMe (30 mL). The reaction mixture was stirred for 16 h at room temperature. The solution was diluted with saturated NH₄Cl aq. (20 mL) and EtOAc (20 mL). The layers were separated, and the aqueous layer was extracted with EtOAc (20 mL x 3). The combined organic layer was washed with brine (20 mL x 3), dried over Na₂SO₄ and filtered, concentrated in vacuo. The crude product was purified by column chromatography to afford **17**.

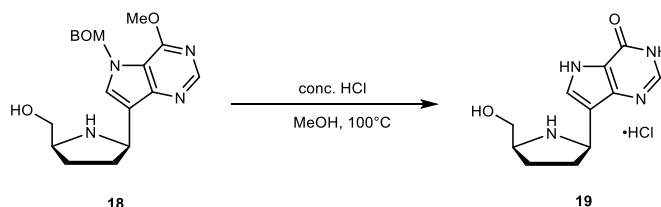
((2*S*,5*R*)-5-(5-((benzyloxy)methyl)-4-methoxy-5*H*-pyrrolo[3,2-*d*]pyrimidin-7-yl)-2,5-dihydro-1*H*-pyrrol-2-yl)methanol (17). $R_f = 0.20$ (silica gel, CH₂Cl₂:MeOH = 10:1, UV). yellow oil (637 mg, 87% yield). $[\alpha]_{\text{D}}^{25} = +56.33$ ($c = 0.20$, MeOH). **¹H NMR** (400 MHz, MeOD) δ 8.40 (s, 1H), 7.59 (s, 1H), 7.29 – 7.16 (m, 5H), 6.07 – 5.93 (m, 2H), 5.75 (s, 2H), 5.50 – 5.45 (m, 1H), 4.51 (s, 2H), 4.28 – 4.21 (m, 1H), 4.11 (s, 3H), 3.66 (dd, $J = 4.7, 1.4$ Hz, 2H). **¹³C NMR** (100 MHz, MeOD) δ 156.5, 149.3, 148.5, 137.4, 131.9, 131.6, 129.4, 127.9 (2), 127.4, 127.2 (2), 118.5, 115.9, 77.2, 70.2, 67.4, 64.4, 59.6, 52.9. **HRMS** (ESI) m/z calcd. for C₂₀H₂₃N₄O₃ [M+H]⁺: 367.1765, found: 367.1778.



A mixture of **17** (366 mg, 1.0 mmol) and 10% Pd/C (36.6 mg, 10 wt% relative to substrate) in

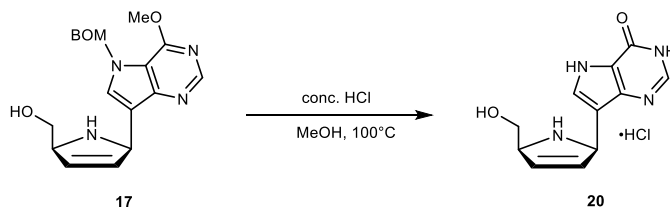
MeOH (5 mL) was stirred under a hydrogen atmosphere (balloon) at room temperature for 12 h. Upon completion, the mixture was filtered through a Celite pad, washed with MeOH, and concentrated in vacuo. The crude product was purified by column chromatography to afford **18**.

((2*S*,5*R*)-5-(5-((benzyloxy)methyl)-4-methoxy-5*H*-pyrrolo[3,2-*d*]pyrimidin-7-yl)pyrrolidin-2-yl)methanol (18**)**. R_f = 0.40 (silica gel, CH₂Cl₂:MeOH = 10:1, UV). white foamy solid (338 mg, 92% yield). $[\alpha]_D^{20}$ = +5.56 (c = 0.20, MeOH). **¹H NMR** (400 MHz, MeOD) δ 8.44 (s, 1H), 7.74 (s, 1H), 7.40 – 7.10 (m, 5H), 5.78 (s, 2H), 4.65 (dd, J = 9.1, 6.8 Hz, 1H), 4.53 (s, 2H), 4.12 (s, 3H), 3.81 – 3.63 (m, 2H), 3.62 – 3.53 (m, J = 6.7, 3.4 Hz, 1H), 2.46 – 2.29 (m, 1H), 2.25 – 2.06 (m, 2H), 1.97 – 1.83 (m, 1H). **¹³C NMR** (100 MHz, MeOD) δ 158.0, 151.0, 150.2, 138.8, 133.0, 129.3 (2), 128.8, 128.6 (2), 117.3, 116.5, 78.7, 71.6, 64.4, 62.2, 56.2, 54.4, 32.2, 27.9. **HRMS** (ESI) m/z calcd. for C₂₀H₂₅N₄O₅ [M+H]⁺: 369.1921, found: 369.1931.



Add concentrated hydrochloric acid (12 M, 1.2 mL) to a solution of **18** (110 mg, 0.3 mmol) in MeOH (0.2 mL). The reaction mixture was heated under reflux for 24 h. After the completion of reaction, the solvent was removed under reduced pressure to afford a brownish red solid. This solid was dissolved in water (0.3 mL), then ethanol (1.5 mL) was added slowly. The mixture was cooled to 0 °C and maintained at this temperature for 1 h. The resulting solid was obtained by filtration.

7-((2*R*,5*S*)-5-(hydroxymethyl)pyrrolidin-2-yl)-3,5-dihydro-4*H*-pyrrolo[3,2-*d*]pyrimidin-4-one (19**)**. white solid (53 mg, 65% yield). **¹H NMR** (400 MHz, MeOD) δ 8.02 (s, 1H), 7.60 (s, 1H), 4.95 (t, J = 8.8 Hz, 1H), 3.96 – 3.83 (m, 2H), 3.75 (dd, J = 11.8, 7.4 Hz, 1H), 2.49 (q, J = 8.0 Hz, 2H), 2.38 – 2.25 (m, 1H), 2.01 – 2.11 (m, 1H). **¹³C NMR** (100 MHz, MeOD) δ 154.1, 142.3, 142.1, 127.1, 118.6, 110.1, 61.8, 60.6, 55.8, 29.5, 25.3. **HRMS** (ESI) m/z calcd. for C₁₁H₁₅N₄O₂ [M+H]⁺: 235.1190, found: 235.1167.

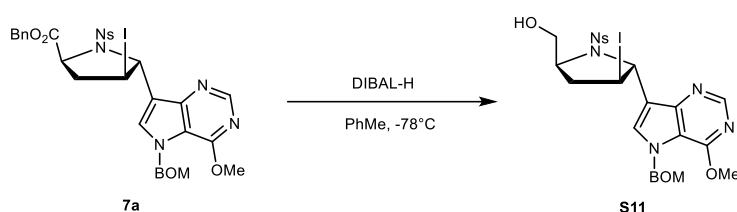


Adding concentrated hydrochloric acid (12 M, 1.2 mL) to a solution of **17** (100 mg, 0.3 mmol) in MeOH (0.2 mL). The reaction mixture was heated under reflux for 24 h. After the completion of reaction, the solvent was removed under reduced pressure to afford a brownish red solid. This solid

was dissolved in water (0.3 mL), then ethanol (1.5 mL) was added slowly. The mixture was cooled to 0 °C and maintained at this temperature for 1 h. The resulting solid was obtained by filtration.

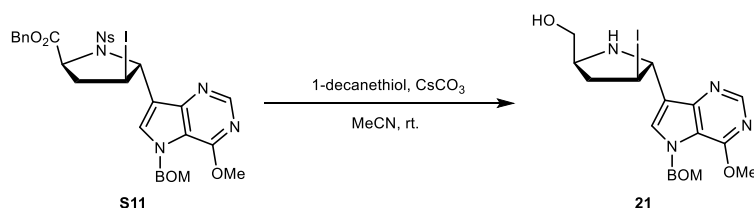
7-((2*R*,5*S*)-5-(hydroxymethyl)-2,5-dihydro-1*H*-pyrrol-2-yl)-3,5-dihydro-4*H*-pyrrolo[3,2-*d*]pyrimidin-4-one (20). white solid (58 mg, 72% yield). $[\alpha]_D^{20} = +12.59$ ($c = 0.20$, MeOH). **¹H NMR** (400 MHz, MeOD) δ 8.87 (s, 1H), 7.71 (s, 1H), 6.22 – 6.05 (m, 2H), 6.00 (s, 1H), 4.72 (s, 1H), 3.96 – 3.76 (m, 2H). **¹³C NMR** (100 MHz, MeOD) δ 153.2, 146.4, 134.5, 131.9, 130.0, 129.5, 120.0, 110.0, 69.9, 61.4, 61.3. **HRMS** (ESI) m/z calcd. for C₁₁H₁₃N₄O₂ [M+H]⁺: 233.1033, found: 233.1035.

2.6.2 Derivatizations of β -nucleoside 7a.



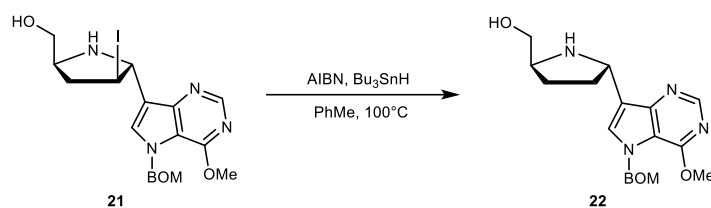
Under an atmosphere of argon, add DIBAL-H (6.0 mL, 6 mmol, 1.0 M in PhMe) dropwise to a solution of **7a** (2.35 g, 3 mmol) in anhydrous PhMe (30 mL) at –78 °C, and stirred for 12 h. The reaction mixture was quenched carefully at –78 °C by sequential addition of MeOH (2 mL), then Rochelle's salt aq. (30 mL), warmed to room temperature, and extracted with EtOAc (20 mL x 3). The combined organic layer was washed with brine (20 mL x 3), dried with Na₂SO₄, filtered and concentrated in vacuo. The crude product was purified by column chromatography to afford **S11**.

((2*S*,4*R*,5*R*)-5-(5-((benzyloxy)methyl)-4-methoxy-5*H*-pyrrolo[3,2-*d*]pyrimidin-7-yl)-4-iodo-1-((4-nitrophenyl)sulfonyl)pyrrolidin-2-yl)methanol (S11). $R_f = 0.30$ (silica gel, PE: EtOAc = 2:1, UV). white solid (1.67 g, 82% yield). **MP**: 171.3 – 172.1 °C. $[\alpha]_D^{25} = -77.05$ ($c = 0.20$, CH₂Cl₂). **¹H NMR** (400 MHz, CDCl₃) δ 7.99 (s, 1H), 7.66 – 7.62 (m, 2H), 7.43 (s, 1H), 7.42 – 7.27 (m, 7H), 5.72 – 5.55 (m, 2H), 5.25 (d, $J = 6.6$ Hz, 1H), 4.88 – 4.78 (m, 1H), 4.69 – 4.59 (m, 2H), 4.47 (br, 1H), 4.25 – 4.15 (m, 1H), 4.13 – 4.05 (m, 1H), 4.00 (s, 3H), 3.22 (t, $J = 7.2$ Hz, 1H), 3.12 (dt, $J = 13.5, 6.8$ Hz, 1H), 2.62 (dt, $J = 13.2, 8.4$ Hz, 1H). **¹³C NMR** (100 MHz, CDCl₃) δ 155.9, 150.0, 148.6, 148.4, 144.7, 136.5, 134.4, 128.7 (2), 128.3, 127.9 (2), 127.5 (2), 122.6 (2), 115.5, 112.0, 77.2, 70.9, 68.8, 65.4, 64.3, 53.8, 42.1, 20.7. **HRMS** (ESI) m/z calcd. for C₂₆H₂₆IN₅O₇SNa [M+Na]⁺: 702.0490, found: 702.0497.



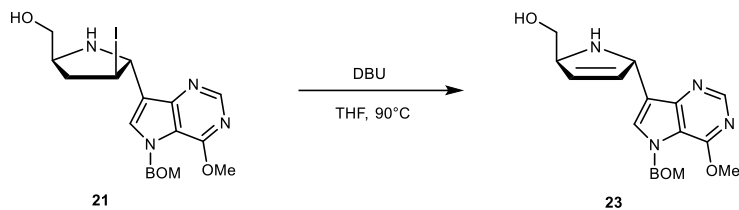
Add 1-decanethiol (697 mg, 4 mmol) to the reaction mixture of **S11** (1.56 g, 2 mmol) and *t*-BuOK (1.3 g, 4 mmol) in MeCN (30 mL). The reaction mixture was stirred for 16 h at room temperature. The solution was diluted with saturated NH₄Cl aq. (30 mL) and EtOAc (30 mL). The layers were separated, and the aqueous layer was extracted with EtOAc (30 mL x 3). The combined organic layer was washed with brine (20 mL x 3), dried over Na₂SO₄ and filtered, concentrated in vacuo. The crude product was purified by column chromatography to afford **21**.

((2*S*,4*S*,5*R*)-5-(5-((benzyloxy)methyl)-4-methoxy-5*H*-pyrrolo[3,2-*d*]pyrimidin-7-yl)-4-iodopyrrolidin-2-yl)methanol (21). *R*_f = 0.30 (silica gel, CH₂Cl₂:MeOH = 20:1, UV). white foamy solid (869 mg, 88% yield). $[\alpha]_{\text{D}}^{25} = -6.67$ (*c* = 0.10, CH₂Cl₂). ¹H NMR (400 MHz, CDCl₃) δ 8.47 (s, 1H), 7.47 (s, 1H), 7.42 – 7.19 (m, 5H), 5.78 – 5.66 (m, 2H), 4.55 – 4.43 (m, 2H), 4.43 – 4.35 (m, 1H), 4.31 (d, *J* = 10.2 Hz, 1H), 4.11 (s, 3H), 3.75 – 3.65 (dd, *J* = 7.6, 4.2 Hz, 1H), 3.59 – 3.53 (m, 1H), 3.50 (br, 1H), 3.48 – 3.42 (m, 1H), 2.76 (dt, *J* = 13.3, 7.6 Hz, 1H), 2.07 – 1.95 (m, 1H). ¹³C NMR (100 MHz, CDCl₃) δ 156.5, 149.9, 148.8, 136.7, 132.6, 128.6 (2), 128.1, 127.9 (2), 116.3, 110.8, 77.0, 70.3, 65.3, 63.5, 59.8, 53.8, 40.3, 26.3. HRMS (ESI) *m/z* calcd. for C₂₀H₂₄N₄O₃ [M+H]⁺: 495.0888, found: 495.0897.



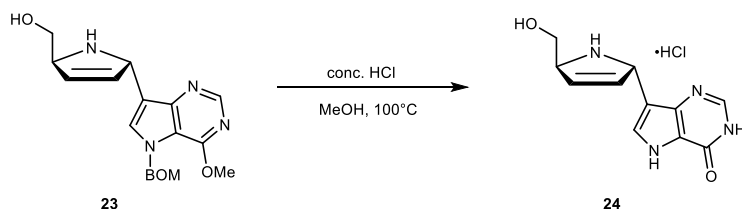
Under an atmosphere of argon, compound **21** (247 mg, 0.5 mmol) and azodiisobutyronitrile (AIBN, 66 mg, 0.4 mmol) was dissolved in anhydrous PhMe (5 mL). After adding Bu₃SnH (233 mg, 0.8 mmol), the reaction mixture was warmed up to 110 °C and stirred for 5 h. The solution was quenched with H₂O (2 mL) and diluted with EtOAc (5 mL). The layers were separated, and the aqueous layer was extracted with EtOAc (5 mL x 3). The combined organic layer was washed with brine (5 mL x 3), dried over Na₂SO₄ and filtered, concentrated in vacuo. The crude material was purified via silica gel column chromatography to obtain **22**.

((2*S*,5*S*)-5-(5-((benzyloxy)methyl)-4-methoxy-5*H*-pyrrolo[3,2-*d*]pyrimidin-7-yl)pyrrolidin-2-yl)methanol (22). *R*_f = 0.20 (silica gel, CH₂Cl₂:MeOH = 20:1, UV). white foamy solid (155 mg, 84% yield). $[\alpha]_{\text{D}}^{25} = -126.25$ (*c* = 0.10, CH₂Cl₂). ¹H NMR (400 MHz, CDCl₃) δ 8.48 (s, 1H), 7.40 (s, 1H), 7.32 – 7.22 (m, 5H), 5.68 (s, 2H), 4.52 (d, *J* = 7.0 Hz, 1H), 4.49 (s, 2H), 4.20 (brs, 2H), 4.10 (s, 3H), 3.75 – 3.67 (m, 1H), 3.64 (dd, *J* = 11.2, 3.8 Hz, 1H), 3.49 (dd, *J* = 11.1, 7.4 Hz, 1H), 2.30 – 2.20 (m, 1H), 2.12 – 2.02 (m, 2H), 1.69 – 1.59 (m, 1H). ¹³C NMR (100 MHz, CDCl₃) δ 156.3, 149.7, 149.2, 136.9, 130.3, 128.5 (2), 128.0, 127.7 (2), 117.4, 116.1, 77.1, 70.4, 64.2, 59.7, 54.4, 53.6, 33.4, 27.7. HRMS (ESI) *m/z* calcd. for C₂₀H₂₄N₄O₃Na [M+Na]⁺: 391.1740, found: 391.1749.



A mixture of **21** (990 mg, 2.0 mmol) and DBU (456 mg, 3 mmol) in anhydrous THF (5 mL) was stirred at 90 °C for 3 h. The solution was quenched with saturated NH₄Cl aq. (5 mL) and diluted with EtOAc (5 mL). The layers were separated, and the aqueous layer was extracted with EtOAc (5 mL x 3). The combined organic layer was washed with brine (5 mL x 3), dried over Na₂SO₄ and filtered, concentrated in vacuo. The crude material was purified via silica gel column chromatography to obtain **23**.

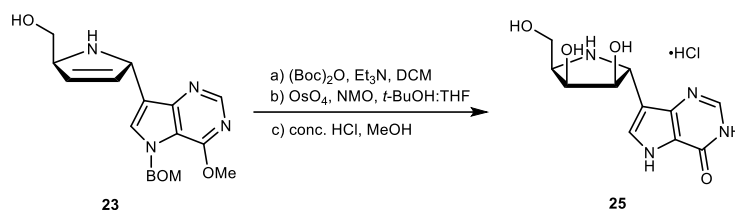
((2*S*,5*S*)-5-(5-((benzyloxy)methyl)-4-methoxy-5*H*-pyrrolo[3,2-*d*]pyrimidin-7-yl)-2,5-dihydro-1*H*-pyrrol-2-yl)methanol (23). white foamy solid (733 mg, 74% yield). $[\alpha]_D^{25} = -3.30$ ($c = 0.20$, CH₂Cl₂). ¹H NMR (400 MHz, MeOD) δ 8.51 (s, 1H), 7.77 (s, 1H), 7.28 – 7.18 (m, 5H), 6.18 (dt, $J = 6.3, 2.2$ Hz, 1H), 6.09 (dt, $J = 6.3, 2.0$ Hz, 1H), 5.89 – 5.85 (m, 1H), 5.80 (d, $J = 2.2$ Hz, 2H), 4.76 – 4.70 (m, 1H), 4.56 (s, 2H), 4.14 (s, 3H), 3.95 – 3.88 (m, 1H), 3.81 – 3.74 (m, 1H). ¹³C NMR (100 MHz, MeOD) δ 156.7, 150.3, 148.5, 137.3, 133.0, 129.0, 127.9 (2), 127.8, 127.5, 127.2 (2), 116.1, 110.8, 77.5, 70.4, 67.5, 60.4, 59.9, 53.1. HRMS (ESI) m/z calcd. for C₂₀H₂₃N₄O₃ [M+H]⁺: 367.1765, found: 367.1785.



Add concentrated hydrochloric acid (12 M, 1.2 mL) to a solution of **23** (110 mg, 0.3 mmol) in MeOH (0.2 mL). The reaction mixture was heated under reflux for 24 h. After the completion of reaction, the solvent was removed under reduced pressure to afford a brownish red solid. This solid was dissolved in water (0.3 mL), then ethanol (1.5 mL) was added slowly. The mixture was cooled to 0 °C and maintained at this temperature for 1 h. The resulting solid was obtained by filtration.

7-((2*S*,5*S*)-5-(hydroxymethyl)-2,5-dihydro-1*H*-pyrrol-2-yl)-3,5-dihydro-4*H*-pyrrolo[3,2-*d*]pyrimidin-4-onehydrogenchloride (24). white solid (56 mg, 70% yield). $[\alpha]_D^{25} = -5.67$ ($c = 0.10$, MeOH). ¹H NMR (400 MHz, MeOD) δ 7.94 (s, 1H), 7.50 (s, 1H), 6.18 (dt, $J = 6.3, 2.2$ Hz, 1H), 6.06 (dt, $J = 6.3, 2.2$ Hz, 1H), 5.87 (dt, $J = 3.7, 2.2$ Hz, 1H), 4.77 – 4.73 (m, 1H), 3.93 (dd, $J = 12.0, 3.8$ Hz, 1H), 3.78 (dd, $J = 11.9, 5.8$ Hz, 1H). ¹³C NMR (100 MHz, MeOD) δ 155.8, 144.5, 143.7, 130.6, 128.7, 128.6, 120.3, 112.1, 68.9, 61.6, 61.5. HRMS (ESI) m/z calcd. for C₁₁H₁₃N₄O₂

[M+H]⁺: 233.1033, found: 233.1034.



Under an atmosphere of argon, a mixture of **23** (366 mg, 1 mmol) and Et₃N (151 mg, 1.5 mmol) was dissolved in anhydrous CH₂Cl₂ (10 mL) and stirred at 0 °C for 10 min. After adding Boc₂O (262 mg, 1.2 mmol), the reaction mixture was warmed up to room temperature and stirred for 24 h. The solution was quenched with saturated NH₄Cl aq. (10 mL) and diluted with EtOAc (10 mL). The layers were separated, and the aqueous layer was extracted with EtOAc (10 mL x 3). The combined organic layer was washed with brine (10 mL x 3), dried over Na₂SO₄ and filtered, concentrated in vacuo. The crude material was purified via silica gel column chromatography to obtain Boc-protected intermediate.

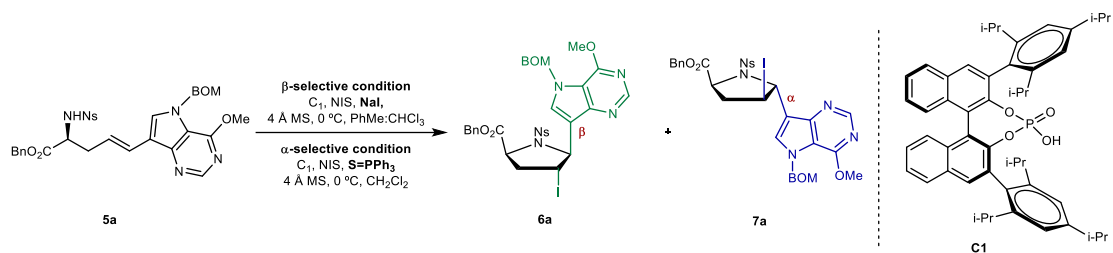
Adding OsO₄ (1% in water, 0.25 mL) to the reaction mixture of Boc-protected intermediate and NMO (234 mg, 2.0 mmol) in THF (3.5 mL) and *t*-BuOH (0.5 mL). The reaction mixture was stirred for 24 h at 50°C. The solution was quenched with Na₂S₂O₃ (5 mL) and diluted with EtOAc (5 mL). The layers were separated, and the aqueous layer was extracted with EtOAc (5 mL x 3). The combined organic layer was washed with brine (5 mL x 3), dried over Na₂SO₄ and filtered, concentrated in vacuo. The crude product was purified by column chromatography to obtain dihydroxylated product.

Add concentrated hydrochloric acid (12 M, 1.2 mL) to a solution of dihydroxylated product obtained in the previous steps in MeOH (0.2 mL). The reaction mixture was heated under reflux for 24 h. After the completion of reaction, the solvent was removed under reduced pressure to afford a brownish red solid. This solid was dissolved in water (0.3 mL), then ethanol (1.5 mL) was added slowly. The mixture was cooled to 0 °C and maintained at this temperature for 1 h. The resulting solid was obtained by filtration.

7-((2*R*,3*S*,4*R*,5*R*)-3,4-dihydroxy-5-(hydroxymethyl)pyrrolidin-2-yl)-3,5-dihydro-4*H*-pyrrolo [3,2-*d*]pyrimidin-4-one (25**).** white solid (139 mg, 46% yield over 3 steps). [α]_D²⁵ = -24.17 (*c* = 0.10, MeOH). ¹H NMR (400 MHz, MeOD) δ 7.93 (s, 1H), 7.59 (s, 1H), 4.88 (dd, *J* = 9.1, 3.6 Hz, 1H), 4.75 (d, *J* = 9.2 Hz, 1H), 4.35 (t, *J* = 3.4 Hz, 1H), 4.10 (ddd, *J* = 8.2, 4.8, 3.0 Hz, 1H), 4.05 – 3.90 (m, 2H). ¹³C NMR (100 MHz, MeOD) δ 155.8, 144.9, 143.3, 129.3, 120.4, 111.1, 77.0, 72.0, 64.0, 59.4, 57.9. HRMS (ESI) *m/z* calcd. for C₁₁H₁₅N₄O₄ [M+H]⁺: 267.1088, found: 267.1097.

3. Supplementary Discussion

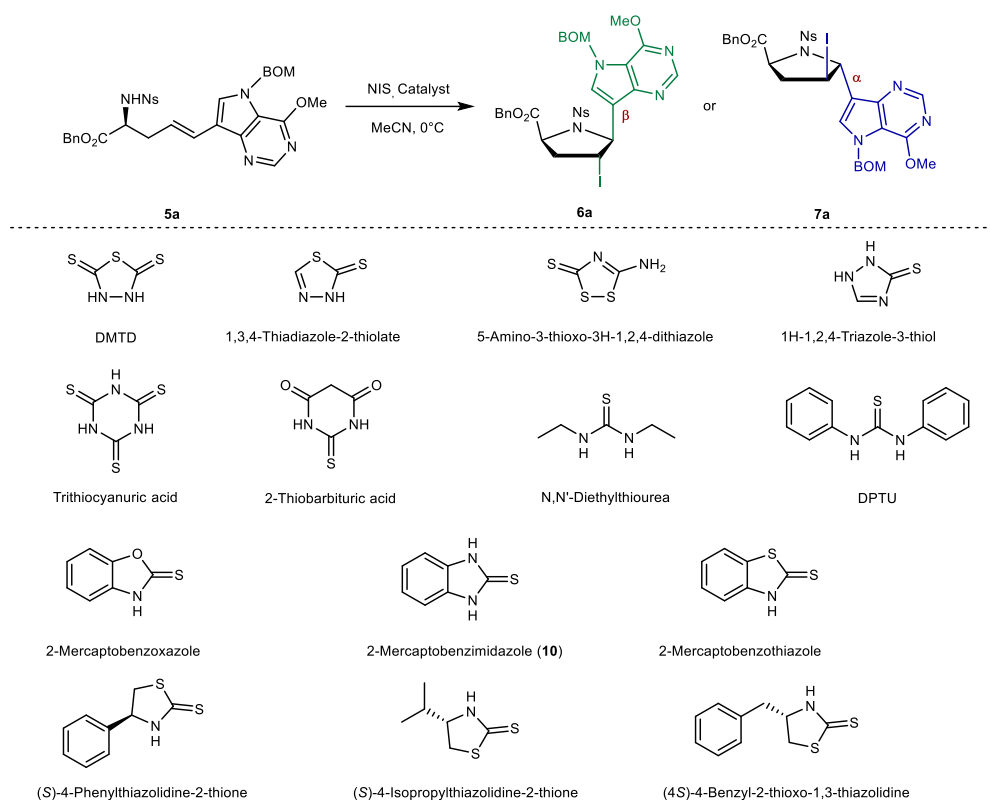
Supplementary Table 1. Application of our previous strategy to azanucleoside synthesis^a.



Entry	Conditions	Yield (%) ^b	β : α (6a:7a) ^c
1	β -selective condition	85	1:1.5
2	α -selective condition	89	1:2

^aAll reactions were performed on 0.05 mmol scale at 20 mM for 1 h; ^bisolated yield; ^c*dr* determined by NMR.

Supplementary Table 2. Screening of thiocarbonyl-containing catalysts^a.



Entry	Catalyst (1eq)	Yield (%) ^b	β:α (6a:7a) ^c
1	S=PPh ₃	92	5:1
2	O=PPh ₃	81	2:1
3	DMSO	84	1:1
4	DMTD	90	11:1
5	1,3,4-thiadiazole-2-thiolate	92	6:1
6	5-Amino-3-thioxo-3H-1,2,4-dithiazole	77	8:1
7	1H-1,2,4-Triazole-3-thiol	73	2:1
8	Trithiocyanuric acid	87	2:1
9	2-Thiobarbituric acid	90	3:1
10	N, N'-Diethylthiourea	NR	/
11	DPTU	NR	/
12	2-Mercaptobenzoxazole	93	11:1
13	2-Mercaptobenzimidazole (10)	95	25:1
14	2-Mercaptobenzothiazole	95	10:1
15	(S)-4-Phenylthiazolidine-2-thione	47	5:1
16	(S)-4-Isopropylthiazolidine-2-thione	48	7:1
17	(4S)-4-Benzyl-2-thioxo-1,3-thiazolidine	60	9:1

^aAll reactions were performed on 0.05 mmol scale at 20 mM for 1 h; ^bisolated yield; ^cdr determined by NMR.

Supplementary Table 3. Screening the solvent of α -selective condition^a.

5a **6a** **7a**

Entry	Catalyst (1eq)	Solvent	Yield (%) ^b	β : α (6a:7a) ^c
1	NaI	MeCN	85	1:10
2	KI	MeCN	79	1:10
3	LiI	MeCN	77	1:5
4	NaI	Dioxane	56	1:23
5	NaI	CH ₂ Cl ₂	88	1:3
6	NaI	CHCl ₃	84	1:4
7	NaI	MeOH	90	1:9
8	NaI	EtOAc	53	1:12
9	NaI	PhMe	65	1:9
10	NaI	Et ₂ O	90	1:15
11	NaI	Hexane	46	1:16
12	NaI	THF	93	1:19

^aAll reactions were performed on 0.05 mmol scale at 20 mM for 1 h; ^bisolated yield; ^c*dr* determined by NMR.

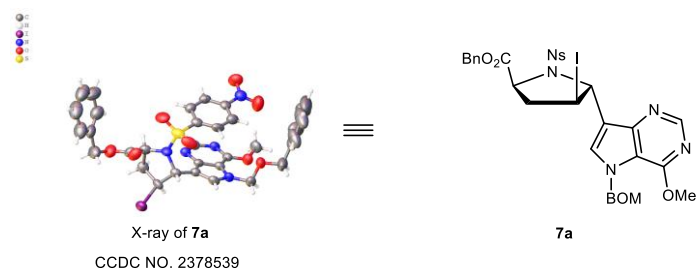
Supplementary Table 4. Screening the equivalents of catalysts^a.

5a **6a** **7a**

Entry	Catalyst	Equivalent	Solvent	Yield (%) ^b	β : α (6a:7a) ^c
1	NaI	0.2	THF	93	1:19
2	NaI	0.5	THF	92	1:19
3	NaI	1	THF	92	1:19
4 ^d	NaI	2	THF	42	1:19
5	10	0.2	MeCN	84	14:1
6	10	0.5	MeCN	90	15:1
7	10	1	MeCN	95	25:1
8 ^e	10	2	MeCN	39	25:1

^aAll reactions were performed on 0.05 mmol scale at 20 mM for 1 h; ^bisolated yield; ^c*dr* determined by NMR. ^{d,e}the starting material (**5a**) was not fully consumed after 10 h.

4. Supplementary Crystallographic Data



Supplementary Figure 1. X-ray of R-**7a**.

Supplementary Table 5. Crystallographic data of compound **7a**.

Empirical formula	C ₃₃ H ₃₀ IN ₅ O ₈ S
Formula weight	783.58
Temperature/K	255.0
Crystal system	orthorhombic
Space group	P2 ₁ 2 ₁ 2 ₁
a/Å	7.3460(4)
b/Å	26.0025(15)
c/Å	34.850(2)
α/°	90
β/°	90
γ/°	90
Volume/Å ³	6656.8(7)
Z	8
ρ _{calc} /cm ³	1.564
μ/mm ⁻¹	1.084
F(000)	3168.0
Crystal size/mm ³	0.48 × 0.08 × 0.02
Radiation	MoKα (λ = 0.71073)
2θ range for data collection/°	3.84 to 55.374
Index ranges	-9 ≤ h ≤ 9, -33 ≤ k ≤ 33, -45 ≤ l ≤ 45
Reflections collected	94520
Independent reflections	15499 [R _{int} = 0.0973, R _{sigma} = 0.0692]
Data/restraints/parameters	15499/0/867
Goodness-of-fit on F ²	1.031
Final R indexes [I ≥ 2σ (I)]	R ₁ = 0.0437, wR ₂ = 0.0703
Final R indexes [all data]	R ₁ = 0.0923, wR ₂ = 0.0849
Largest diff. peak/hole / e Å ⁻³	0.36/-0.57
Flack parameter	-0.008(9)

These data can be obtained free of charge from The Cambridge Crystallographic Data Centre via:

<https://www.ccdc.cam.ac.uk/mystructures/structuredetails/164e3c40-0367-ec11-96a5-00505695281c>

5. Computational details

All the species are fully optimized at the PBE0 Level⁶, the 6-31G(d,p)⁷ basis set is used for H, C, N, O, S, Na atom, and the LANL2DZ basis set⁸ is used for I atom. Frequency analyses are performed at the same level to confirm that the characteristics of the structures are minima (without imaginary frequencies) or transition states (only one imaginary frequency). Calculations of the intrinsic reaction coordinates (IRC)^{9,10} are calculated to ensure that the transition states indeed have connected two minima. The thermodynamic corrections and vibrational frequencies were obtained at 273.15 K to match the experimental reaction conditions. The single-point energies in THF and MeCN solvent are calculated at PBE0 Level⁵, the 6-311G(d,p)⁷ level basis set is used for H, C, N, O, S, Na atom, and the def2-TZVP¹¹ basis set is used for I atom. The single-point energies are added to the Gibbs free energy correction to obtain the Gibbs free energies (ΔG). Interaction Region Indicator (IRI)¹² was performed by Multiwfn¹³ and VMD¹⁴. All of the three-dimensional molecular diagrams of the molecules were generated with CYLView¹⁵. All these calculations are performed with Gaussian 16 program¹⁶.

1a

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H	1.42209900	0.44742000	2.84972000
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NIS

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Int1

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C	-2.49130000	4.22767100	0.26531400
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N	3.68933400	-5.72492000	1.44034900
O	3.03942900	-6.38646000	2.23393000
O	4.61336300	-6.14541600	0.76617600
H	1.33043600	0.28069100	-3.00630800
C	-0.81832600	-5.21541600	0.23230600
C	0.55984900	-4.02823600	-1.22164700
C	0.29603600	-6.17460100	-0.15405100
C	1.08303700	-5.45153000	-1.24552300
H	0.89671100	-6.36782100	0.74131700
H	-0.13934700	-7.12721200	-0.46277300
H	2.16641700	-5.45091400	-1.11055600
H	0.88332600	-5.85516900	-2.24370200
N	-0.56322700	-4.00836600	-0.42711600
O	-1.73940600	-5.41879300	0.97980000
O	1.03275100	-3.07248500	-1.80929500
H	1.00860100	-1.15027300	-1.32526800
I	1.60100300	5.15228100	0.80908800
Na	3.45385700	3.09334800	0.20905300

TS1

E= -3091.997052

C	-2.53129600	-0.84767800	-1.33008600
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H	-2.76475700	-0.77516800	-2.39164400
C	-1.21562100	-0.52899700	-0.89806600
H	-1.06128900	-0.45178500	0.17705900
C	-0.31195800	0.37055000	-1.69912600
H	-0.68788300	0.47106200	-2.72286600
H	-0.41035400	1.36402800	-1.24257900
I	-0.56357400	-2.71910200	-1.27397500
S	1.78159000	-0.00459300	0.85307600
O	3.21240000	0.90022900	-2.61355400
O	0.54070300	-0.29995100	1.56849100
O	2.17120700	1.40908700	0.73890700
O	1.55124200	2.35690500	-2.22700200
N	1.84524200	-0.62892900	-0.66411300
C	3.09049400	-0.93634800	1.59841100
C	1.18513600	-0.00685900	-1.80594600
C	4.48335400	2.80610100	-1.76633200
C	4.06799500	2.00919000	-2.97192900
C	4.28580500	-0.29441200	1.90805200
C	2.88830800	-2.29855900	1.80951600
C	1.98683000	1.22042300	-2.23322800
C	5.23458500	2.20378500	-0.75357300
C	4.09960800	4.14355400	-1.62866400
C	5.59089400	2.92740000	0.38082900
C	5.32250100	-1.04703500	2.44365300
C	3.93713000	-3.05508000	2.31709500
C	4.44802700	4.86760600	-0.48768200
C	5.19243100	4.25638000	0.52065200
C	5.12946500	-2.41217800	2.62639600
H	4.92192300	1.52702400	-3.45107700
H	3.54899200	2.63912600	-3.69912000
H	4.39132700	0.76931100	1.72295800
H	1.95453200	-2.79441600	1.55906100
H	5.52809500	1.16158500	-0.85230900
H	3.50390600	4.61469600	-2.40689300
H	6.27434500	-0.60371200	2.71087300
H	3.82768900	-4.12443800	2.45368800
H	4.12270100	5.89842000	-0.38366200
H	5.46277500	4.81668200	1.41054000
H	6.18687500	2.45681800	1.15838200
O	-4.98921000	-0.11485800	3.34402000
O	-7.95549200	-1.63986500	1.11898800
N	-4.92434900	-1.38988400	1.34539200
N	-5.47965900	-1.27160000	-2.15528100
N	-7.64492700	-1.52480900	-1.16509200

C	-5.76536900	-1.42542200	0.24379500
C	-5.32198000	-1.32193200	2.75443100
C	-4.98208000	-1.28202800	-0.91030400
C	-3.65828900	-1.18593500	0.91859200
C	-3.62125100	-1.11543100	-0.47411900
C	-7.14942700	-1.53759300	0.05875000
C	-5.58215700	1.03040800	2.72356500
C	-4.68987200	1.63105100	1.66667000
C	-6.79493000	-1.39976300	-2.20040700
C	-5.15873900	1.89878100	0.38144000
C	-3.36223900	1.93865300	1.98663400
C	-4.31820700	2.47665600	-0.57036700
C	-2.52755100	2.52788700	1.04437900
C	-3.00632100	2.80269200	-0.23761000
C	-9.35638200	-1.74004200	0.85259200
H	-6.39755300	-1.52558200	2.77702900
H	-4.78388900	-2.09725100	3.30612900
H	-2.85668800	-1.07565400	1.63618100
H	-5.73944900	1.74436300	3.53833900
H	-6.56679900	0.77287000	2.30712900
H	-7.25531500	-1.40016800	-3.18559600
H	-6.18728300	1.65730700	0.12110400
H	-2.99316200	1.72640400	2.98691400
H	-4.69722500	2.68636400	-1.56658100
H	-1.51762900	2.82748400	1.31037700
H	-2.35872500	3.31266800	-0.94604300
H	-9.57316600	-2.62752000	0.25331100
H	-9.71208700	-0.85700100	0.31633200
H	-9.82865600	-1.81201800	1.83186400
N	6.24386300	-3.20938600	3.15836400
O	6.06828500	-4.40905900	3.27348900
O	7.27006200	-2.61532900	3.44389900
H	1.32928300	-0.76406800	-2.59105000
C	2.36791500	-4.68765000	-0.45372100
C	2.57589100	-3.50781500	-2.38303800
C	3.51630500	-5.37524500	-1.19539000
C	3.61903900	-4.61628400	-2.51316700
H	4.41679500	-5.30638600	-0.57706200
H	3.28522300	-6.43876700	-1.30229400
H	4.59787900	-4.16691600	-2.70090500
H	3.37269100	-5.22211800	-3.39074200
N	1.88562800	-3.63823000	-1.20098300
O	1.97289400	-5.00363600	0.65693700
O	2.40204200	-2.61657300	-3.20186400

H	1.91632700	-1.65697200	-0.70115700
I	-0.08137700	5.59003300	0.29211100
Na	1.72596600	3.46719800	-0.13261900

Int2

E= -3092.053724

C	-1.59809500	2.19628900	0.47873300
H	-1.98104200	2.68172700	1.37440200
C	-0.17619300	2.37473600	0.13014800
H	0.10808400	1.79384300	-0.74554900
C	0.77440600	2.14803200	1.28572300
H	0.79002800	2.99720500	1.97401300
H	0.33213000	1.32398200	1.85788900
I	-0.09324700	4.48207700	-0.60208300
S	1.53461600	-0.63351400	0.08175500
O	4.25835400	1.15484600	1.86680700
O	0.07277300	-0.62294300	-0.17038200
O	1.89425900	-1.26097600	1.38766600
O	2.46752800	1.20753200	3.20780800
N	2.27137600	0.73556600	-0.18348300
C	2.23683100	-1.65868100	-1.19319100
C	2.19317400	1.75778500	0.85038400
C	4.68137500	-0.75531800	3.32945100
C	5.02752000	0.66769300	2.98571900
C	3.17283100	-2.62666500	-0.84340200
C	1.80132300	-1.49101200	-2.50729200
C	2.96943800	1.34975700	2.10367600
C	4.97869200	-1.78281900	2.43338600
C	4.03321500	-1.06422000	4.52816500
C	4.62576000	-3.09700800	2.72465500
C	3.70376000	-3.44338000	-1.83326600
C	2.33475600	-2.30317300	-3.49898800
C	3.67558400	-2.37965200	4.82128500
C	3.96677700	-3.39813800	3.91429800
C	3.27670200	-3.26279000	-3.14364100
H	6.06102400	0.75599000	2.64547000
H	4.87004700	1.32722000	3.84369400
H	3.46032600	-2.73237300	0.19720400
H	1.05373300	-0.74041300	-2.75152500
H	5.47411700	-1.54510400	1.49533200
H	3.80250000	-0.26485300	5.22809400
H	4.43339000	-4.21350800	-1.61300000
H	2.02967300	-2.21138200	-4.53446600

H	3.18236300	-2.61086000	5.76185600
H	3.69101000	-4.42392500	4.14040100
H	4.86648800	-3.89117700	2.02316000
O	-2.02125500	-1.76665800	-2.89136600
O	-6.02232700	-1.28719700	-1.46234500
N	-3.22136700	-0.10940000	-1.70253800
N	-4.59381800	1.62494200	1.07414800
N	-6.30366400	0.10880500	0.35569700
C	-4.27711300	0.17202900	-0.82134300
C	-3.23112500	-1.14008400	-2.77698700
C	-3.84828000	1.14529900	0.07985900
C	-2.16419700	0.61971300	-1.39130900
C	-2.46529900	1.44192400	-0.25951600
C	-5.56076200	-0.34909000	-0.64031800
C	-1.65001900	-2.75093000	-1.88206700
C	-2.70381300	-3.07213200	-0.86151100
C	-5.79265300	1.05932900	1.15064000
C	-3.71766000	-3.99475200	-1.14375000
C	-2.69439600	-2.42914600	0.38164500
C	-4.71336300	-4.25857400	-0.20801600
C	-3.69074200	-2.69080200	1.31865200
C	-4.70312500	-3.60135800	1.02218000
C	-7.28789300	-1.86324600	-1.13520000
H	-4.06983100	-1.79870000	-2.53889700
H	-3.41701400	-0.62371300	-3.72313900
H	-1.23955000	0.52731100	-1.94887000
H	-0.76289900	-2.35358600	-1.38569200
H	-1.37613000	-3.64550000	-2.45012800
H	-6.44147700	1.40147600	1.95297300
H	-3.72092400	-4.50977300	-2.10242600
H	-1.90412100	-1.72004900	0.62170800
H	-5.49274100	-4.98114400	-0.43487500
H	-3.65994800	-2.17232900	2.27344300
H	-5.47825900	-3.80857800	1.75526300
H	-8.07430600	-1.10516300	-1.14812700
H	-7.24788000	-2.32633700	-0.14670900
H	-7.46354600	-2.61662900	-1.90242300
N	3.83456100	-4.12443900	-4.18963400
O	3.44279800	-3.95020600	-5.33187900
O	4.65570000	-4.96163400	-3.85185000
H	2.72038600	2.62460400	0.42660600
C	1.10884800	2.11650500	-3.34993300
C	2.99094500	3.25277200	-2.66644400
C	1.22711400	3.27906700	-4.31880400

C	2.48530500	4.02442400	-3.87717700
H	1.27727700	2.88566900	-5.33809700
H	0.31502500	3.87771400	-4.24679300
H	3.27294200	4.04431100	-4.63561700
H	2.30040100	5.05827400	-3.57509600
N	2.18095500	2.13921900	-2.50772000
O	0.19745600	1.30143700	-3.31359000
O	3.91472500	3.54508200	-1.94392900
H	2.27558100	1.48261100	-1.68000800
I	-1.76142000	0.13333900	3.42719100
Na	1.06931900	-0.69263800	3.38833200

PS

E= -3092.097286

S	-0.73246200	-2.45522000	0.58021200
O	-4.16057100	0.93679900	0.74995300
O	-1.85416900	-3.09048700	-0.13126800
O	-0.43602200	-2.90696400	1.93237800
O	-3.38775800	-0.31016300	-0.95001000
N	-1.08584700	-0.80267200	0.49298100
C	-2.36656200	-0.53981300	1.20660300
C	-2.02252500	0.28224500	2.46890900
C	-0.49725200	0.27176400	2.49962700
C	-0.14937700	0.25681800	1.01939000
C	-3.34754800	0.06789600	0.21784700
C	0.70910500	-2.68748100	-0.42738400
C	0.75351800	-2.16845300	-1.71828200
C	1.73811800	-3.45909100	0.10623700
C	-5.27730300	1.38781200	-0.07317800
C	1.91323100	-2.33383900	-2.46035500
C	2.88711300	-3.65293900	-0.65014400
C	-4.85393500	2.41498500	-1.08173500
C	2.96755200	-3.04694000	-1.89768600
C	-4.61432800	3.73153800	-0.68348800
C	-4.68628500	2.06831500	-2.42356800
C	-4.20875500	4.68720400	-1.60844700
C	-4.28431500	3.02279500	-3.35353200
C	-4.04495300	4.33441400	-2.94654100
H	-2.85985900	-1.48005500	1.49358800
H	-2.46574800	-0.15292200	3.36513100
H	-2.39926200	1.30114800	2.35837400
H	-0.06467100	-0.58629700	3.01623600
H	-0.57337800	1.16914000	0.58094200

H	1.65278700	-3.84759900	1.11455900
H	-5.72926600	0.50087700	-0.52470500
H	-5.96868600	1.80202600	0.66131500
H	2.00291600	-1.90334900	-3.45057200
H	3.73262600	-4.20924500	-0.26503800
H	-4.73643800	4.00469000	0.36143200
H	-4.86302800	1.04209200	-2.73053900
H	-4.02364900	5.70777300	-1.28680400
H	-4.16607100	2.74463100	-4.39728000
H	-3.74360300	5.08402500	-3.67382000
H	-0.07303300	-1.60755800	-2.13950000
N	4.23905200	-3.10519200	-2.62335600
O	4.36004100	-2.37933600	-3.59693600
O	5.10116600	-3.85460000	-2.19640200
I	0.31072600	2.00952500	3.52968500
O	3.55403900	2.16315300	-2.26963500
O	5.57714300	-1.11887500	-0.49432500
N	2.98525000	0.35671800	-0.88143900
N	2.50213100	-1.24346300	2.24493900
N	4.72508400	-1.80931500	1.54195500
C	3.43086900	-0.40477400	0.17030200
C	3.69146100	0.78861800	-2.08122600
C	2.38111600	-0.53472600	1.10497400
C	1.69573900	0.70471400	-0.62316400
C	1.25794300	0.16362400	0.56408900
C	4.60748400	-1.11634200	0.42651500
C	4.58701700	2.95684400	-1.67250300
C	4.84517100	2.64991900	-0.22158300
C	3.67948200	-1.81941900	2.39610700
C	6.04048100	2.04324700	0.16577100
C	3.87044600	2.90807600	0.74750800
C	6.26087800	1.69160700	1.49614900
C	4.08066300	2.54523100	2.07172300
C	5.27678900	1.93403600	2.44828000
C	6.74419700	-1.88515700	-0.19731400
H	4.72953600	0.45801200	-1.99061100
H	3.23470700	0.30344200	-2.94912400
H	1.16746200	1.33465200	-1.31793600
H	4.24728500	3.98813100	-1.80527000
H	5.51307200	2.82800100	-2.25034900
H	3.83170600	-2.39019300	3.30959400
H	6.80063500	1.83193100	-0.58271300
H	2.92780000	3.36463800	0.45563600
H	7.19443000	1.21650400	1.78378800

H	3.30377800	2.72108600	2.80809400
H	5.43433600	1.64302500	3.48252200
H	6.49017300	-2.93894300	-0.06512600
H	7.22640700	-1.51260500	0.71006800
H	7.39402000	-1.76251200	-1.06308700
C	-1.21143100	2.36434300	-1.74953700
C	-0.44868100	0.93168100	-3.41004000
C	-0.43355700	3.24900900	-2.70480200
C	0.14863900	2.28927000	-3.74471500
H	-1.13608700	3.97336300	-3.12712100
H	0.32008300	3.80816800	-2.14482300
H	-0.10141500	2.54189900	-4.77819800
H	1.24040300	2.21733700	-3.68502100
N	-1.23702300	1.09193800	-2.29220300
O	-1.68852800	2.66462500	-0.67758800
O	-0.25124000	-0.12370200	-3.97633000
H	-1.77217500	0.34146800	-1.85464600
Na	-3.86284600	-2.62889400	-1.03223400
I	-6.07849400	-2.37136100	0.73198600

thiol

E= -777.511820

S	-3.25377600	0.00000000	-0.00007700
N	-0.75835200	1.08375900	-0.00005300
N	-0.75835200	-1.08375900	-0.00008800
C	0.56985900	0.70264700	0.00003100
C	0.56985900	-0.70264800	0.00001000
C	1.75384000	1.42543300	0.00005900
C	1.75384000	-1.42543300	0.00001600
C	-1.59569300	0.00000000	0.00008200
C	2.94386100	0.69875300	0.00010200
C	2.94386000	-0.69875300	0.00008100
H	-1.12222700	2.02187900	-0.00011900
H	-1.12222800	-2.02187800	-0.00018700
H	1.75343200	2.51049300	0.00005000
H	1.75343200	-2.51049300	-0.00002600
H	3.88919300	1.23189800	0.00012900
H	3.88919300	-1.23189800	0.00009200

Int3

E= -3695.887156

C	-1.93156100	0.10703700	-1.51157400
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H	-1.31772700	0.03606300	-0.61673200
C	-1.46869000	0.76764000	-2.58020600
H	-2.07698300	0.80404900	-3.48452100
C	-0.20159300	1.57214800	-2.57711600
H	-0.23884200	2.33126000	-3.36222700
H	-0.11734900	2.12428100	-1.63452600
I	-0.82034200	-3.24232400	-0.10188400
S	1.60824100	0.29830500	-0.16627200
O	3.46339200	1.20334200	-2.87237600
O	0.45493200	0.13429100	0.71377600
O	2.19932400	1.64060400	-0.26650100
O	2.08462400	2.92699800	-3.30272800
N	1.38237300	-0.17229500	-1.71212400
C	2.83246800	-0.88033400	0.36177900
C	1.10355400	0.78477600	-2.76475700
C	4.77979600	2.76217600	-1.56506800
C	4.59275200	2.11685400	-2.90714500
C	3.99314000	-1.01359200	-0.39839700
C	2.60066900	-1.62698300	1.51115800
C	2.26042800	1.77102200	-2.98868700
C	5.48270300	2.09719200	-0.55872800
C	4.16657900	3.98276200	-1.27270500
C	5.53207000	2.61417900	0.73151400
C	4.96154300	-1.91454100	0.01455700
C	3.55664000	-2.55657900	1.90892900
C	4.22214700	4.50629600	0.01520000
C	4.88973900	3.81501500	1.02419900
C	4.71659400	-2.67607400	1.15433500
H	5.43796600	1.47844200	-3.17267800
H	4.42424400	2.85305600	-3.69627400
H	4.10453400	-0.43359700	-1.30798400
H	1.67617400	-1.49299200	2.06248400
H	5.98094500	1.15657300	-0.78199100
H	3.61579000	4.49906300	-2.05269000
H	5.88525300	-2.05666900	-0.53390800
H	3.41046100	-3.18721000	2.77790500
H	3.72278800	5.44502400	0.23712400
H	4.90229600	4.20589900	2.03726600
H	6.06227000	2.07659700	1.51204700
O	-7.13569100	1.01482800	-0.08276900
O	-7.25857100	-2.16320600	0.27053100
N	-5.57216700	-0.28017400	-1.33843400
N	-3.17675000	-2.40464100	0.16196500
N	-5.29157000	-3.14743300	0.96765100

C	-5.20682300	-1.33692400	-0.53907100
C	-6.86388600	0.38222100	-1.29188100
C	-3.80125300	-1.43477500	-0.54517400
C	-4.41819700	0.29085600	-1.80786300
C	-3.29631500	-0.38050400	-1.36924800
C	-5.92960000	-2.23554400	0.24892000
C	-6.48405900	2.26059300	0.12990900
C	-5.04007800	2.15618600	0.55729000
C	-3.95901500	-3.19578000	0.88292300
C	-4.08108300	3.02051000	0.02617100
C	-4.64625300	1.20464100	1.50054500
C	-2.74771400	2.93345000	0.41839200
C	-3.31146100	1.10635200	1.88293700
C	-2.35758100	1.96953100	1.34474600
C	-7.93965700	-3.07378400	1.13334600
H	-6.88510700	1.08554000	-2.13662500
H	-7.63907500	-0.37424000	-1.41639100
H	-4.45976700	1.20739800	-2.37908500
H	-7.07589100	2.74549800	0.91410900
H	-6.56422500	2.88688700	-0.77316200
H	-3.46288800	-3.97310900	1.45870900
H	-4.37603800	3.76435000	-0.71212900
H	-5.38865400	0.52526400	1.91093900
H	-2.01320100	3.60514400	-0.01490500
H	-3.00824600	0.34670900	2.59782500
H	-1.31331300	1.86851300	1.62575100
H	-7.62491100	-2.93340400	2.17044000
H	-7.74087500	-4.10813300	0.84177400
H	-8.99743500	-2.83831100	1.01951200
N	5.71573200	-3.67509100	1.54825500
O	5.39084600	-4.48945100	2.39787100
O	6.79934600	-3.63651900	0.99123300
N	1.33044200	3.64559500	1.46680300
N	0.08763000	4.73692600	2.87266700
C	0.55751100	4.50145700	0.71368900
C	-0.24851500	5.21339400	1.62079300
C	0.48212400	4.72029600	-0.65637200
C	-1.16147600	6.16261100	1.18342300
C	-0.43998300	5.67273200	-1.09338800
C	1.04990900	3.75955500	2.79472700
C	-1.24531100	6.37874100	-0.19309100
H	1.93219500	2.92495800	1.07720000
H	1.10842300	4.17053600	-1.35146900
H	-1.79072200	6.70677200	1.88014600

H	-0.52953500	5.86760300	-2.15769900
H	-1.95147100	7.11228400	-0.56987000
S	1.71798200	2.90844600	4.05746600
H	1.04160100	0.17931100	-3.67796700
H	-0.30808600	5.00999700	3.75636800
C	1.55278200	-5.18431200	0.46814400
C	1.97189600	-3.82432100	-1.35215200
C	2.91044000	-5.62740800	-0.05332600
C	3.14113500	-4.79206800	-1.30907700
H	3.64852500	-5.45056500	0.73495400
H	2.88425900	-6.70533200	-0.23045400
H	4.07351100	-4.22314300	-1.31099200
H	3.12205700	-5.38255300	-2.23032700
N	1.10047400	-4.14531800	-0.34659300
O	0.96251300	-5.62865800	1.42154700
O	1.83581800	-2.91603600	-2.15760800
H	1.24108100	-1.17536400	-1.86998400

TS2

E= -3695.820488

C	-1.90130600	-1.13367100	-0.25607200
H	-1.49148200	-0.96484200	0.74006100
C	-1.07561600	-0.76825100	-1.36962900
H	-1.51445400	-0.92585700	-2.35562800
C	-0.09470200	0.37446400	-1.29519400
H	-0.49677900	1.15549800	-1.95020700
H	-0.09221000	0.78541300	-0.28352700
I	-0.05955400	-2.79255400	-0.96217000
S	2.15775900	-0.02450700	0.78163200
O	3.24238400	1.48955800	-2.24649100
O	1.00380100	-0.57840000	1.48883400
O	2.30312800	1.44162700	0.78273500
O	1.23407700	2.19656400	-2.96567300
N	2.24826500	-0.49475800	-0.79497200
C	3.63127800	-0.78186900	1.40981400
C	1.35591600	0.11275800	-1.76795700
C	3.54705000	3.89339700	-1.97774100
C	3.82592200	2.67547600	-2.81528400
C	4.69898200	0.02689600	1.78732700
C	3.67616800	-2.17153500	1.48694500
C	1.92418400	1.39537500	-2.37108300
C	3.74922600	3.85025700	-0.59625900
C	3.07707700	5.06874100	-2.56322100

C	3.47449400	4.96501100	0.18886400
C	5.85878600	-0.57762300	2.25263600
C	4.84715000	-2.77670400	1.92471100
C	2.81922300	6.19084500	-1.78014300
C	3.01274800	6.13921000	-0.40253200
C	5.91098100	-1.96666000	2.30285000
H	4.89405300	2.44653300	-2.84700600
H	3.45463600	2.81060400	-3.83504100
H	4.61138100	1.10569800	1.71788300
H	2.84205800	-2.79934000	1.18709600
H	4.07893000	2.92435500	-0.13679600
H	2.89430900	5.09771100	-3.63449100
H	6.71953000	0.00025900	2.56653400
H	4.92794000	-3.85655600	1.95667800
H	2.44480200	7.09899200	-2.24354200
H	2.79039700	7.00688100	0.21148000
H	3.61174500	4.91403800	1.26520700
O	-7.19086000	-0.14663200	-1.15173300
O	-7.59144600	-2.77138200	0.73963700
N	-5.39927400	-1.70659100	-1.04639500
N	-3.67646400	-2.41554700	1.97265100
N	-5.97119000	-2.98306100	2.37551000
C	-5.36163600	-2.16737500	0.26019200
C	-6.61424800	-1.27152400	-1.72535800
C	-4.04846800	-2.06861800	0.73285900
C	-4.14605400	-1.32131100	-1.39395800
C	-3.25784600	-1.52834400	-0.34361000
C	-6.32862400	-2.65271200	1.14762000
C	-6.55106800	1.09381700	-1.42742700
C	-5.31671800	1.36212400	-0.59862100
C	-4.67696800	-2.84847500	2.72214500
C	-4.20096400	1.97989600	-1.16875500
C	-5.28623500	1.01905200	0.75530800
C	-3.06357500	2.23533500	-0.40647800
C	-4.14069700	1.24634100	1.51200400
C	-3.02440900	1.84685700	0.93179300
C	-8.53436400	-3.24026800	1.70467600
H	-6.34549500	-1.10952200	-2.77899400
H	-7.35008000	-2.07129700	-1.64171800
H	-3.96911400	-0.86053200	-2.35583300
H	-7.31737200	1.84786800	-1.21834900
H	-6.30920300	1.16353600	-2.49988600
H	-4.43513200	-3.13282400	3.74347900
H	-4.22136100	2.26774700	-2.21849300

H	-6.15571100	0.54500600	1.20212900
H	-2.21098200	2.74074500	-0.85117800
H	-4.11077000	0.94583600	2.55520800
H	-2.13093200	2.01507100	1.52529200
H	-8.57206900	-2.56896400	2.56615100
H	-8.26897700	-4.24232800	2.05056400
H	-9.49253900	-3.25281800	1.18609200
N	7.15124600	-2.60103100	2.76814300
O	7.18497700	-3.81876200	2.79051700
O	8.06759200	-1.86633400	3.09926200
N	0.35481600	3.34286000	1.68568400
N	-1.28910300	4.43593600	2.59616100
C	-0.21634300	4.09890100	0.68003100
C	-1.28297800	4.80384800	1.26529000
C	0.08023700	4.22627600	-0.66939500
C	-2.09425100	5.64406200	0.51561700
C	-0.73640500	5.06917700	-1.42312400
C	-0.29325900	3.53026800	2.87364000
C	-1.80409900	5.76252300	-0.84416000
H	1.11541800	2.67540900	1.56538500
H	0.91466900	3.70617000	-1.12136500
H	-2.92367100	6.17933600	0.96630600
H	-0.52404200	5.18649900	-2.48108800
H	-2.41974500	6.41007700	-1.46102100
S	0.01569200	2.81466000	4.33968400
H	1.36135900	-0.60609000	-2.60499300
H	-1.92287700	4.74658200	3.31307400
C	3.23670800	-4.47096900	-0.99694900
C	2.81751200	-3.20838000	-2.82220700
C	4.12333600	-5.08353500	-2.08461800
C	3.81405700	-4.25304800	-3.32378500
H	5.16619300	-5.02052200	-1.75945000
H	3.88467600	-6.14640500	-2.18249200
H	4.68143300	-3.74141700	-3.75038700
H	3.34900600	-4.82162000	-4.13509700
N	2.53957400	-3.39651500	-1.49437700
O	3.17768600	-4.87708300	0.15398300
O	2.34492800	-2.31581100	-3.51862000
H	2.41714800	-1.50803100	-0.91911400

PR

E= -3695.947564

C	-0.19443100	0.29177600	-1.99050600
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H	-0.70847100	-0.09948900	-2.87614900
C	1.16746000	0.88612800	-2.40485100
H	1.53097600	1.59819200	-1.66662200
C	2.12646900	-0.31430000	-2.52669700
H	2.56503900	-0.42657000	-3.51866100
H	2.94303300	-0.22277600	-1.80333900
I	0.98115000	2.08945600	-4.21917400
S	0.73231100	-0.69992000	0.34125100
O	1.00886800	-3.72799100	-1.47304000
O	1.40532000	0.58740400	0.50824300
O	1.45444500	-1.92293100	0.69081600
O	3.11503000	-2.93451900	-1.67722200
N	0.19444300	-0.95408000	-1.25414500
C	-0.79262600	-0.66083600	1.24084000
C	1.23003800	-1.50015100	-2.16635300
C	1.57748500	-4.84596300	0.58754700
C	1.48282800	-4.97473400	-0.90249200
C	-1.08929700	0.45557900	2.01299900
C	-1.64440500	-1.75761500	1.14556000
C	1.92224400	-2.76630400	-1.70563300
C	0.40914600	-4.80577500	1.35261000
C	2.81218800	-4.64475100	1.20327200
C	0.47592600	-4.52856900	2.71329300
C	-2.32413100	0.51438600	2.64554400
C	-2.87547100	-1.70361600	1.77910700
C	2.88053800	-4.37823600	2.56863700
C	1.71059500	-4.30590900	3.32235200
C	-3.20004600	-0.55401200	2.49337700
H	0.72863000	-5.70418100	-1.20540400
H	2.44335400	-5.22205900	-1.35947900
H	-0.39988000	1.28689300	2.07696200
H	-1.36905900	-2.63134800	0.57009300
H	-0.55781600	-4.95613800	0.87472400
H	3.71797400	-4.67088400	0.60311100
H	-2.61860400	1.39246500	3.20672700
H	-3.58157900	-2.52092400	1.69720300
H	3.84511100	-4.21588700	3.04184900
H	1.76031400	-4.07962100	4.38368800
H	-0.43698000	-4.47662000	3.29936200
O	-1.33714900	3.65264600	2.10529700
O	-4.84158200	2.82662900	1.00641300
N	-1.98900400	2.84481400	0.00467200
N	-3.28992900	-0.14677800	-1.38762500
N	-5.08742400	0.84016000	-0.14267100

C	-3.01261300	1.94832900	-0.20559800
C	-1.99083000	3.97731800	0.90450200
C	-2.52237100	0.89795400	-1.00689700
C	-0.87077600	2.36527900	-0.62380800
C	-1.13904300	1.17300000	-1.25364900
C	-4.34385000	1.86827200	0.22402700
C	-0.29276800	4.54858700	2.49667800
C	0.84823600	4.55862800	1.51483000
C	-4.52734700	-0.09554500	-0.92913400
C	1.00147700	5.60165000	0.59656700
C	1.69810200	3.45207500	1.43223900
C	1.96752000	5.53148800	-0.40516900
C	2.66124700	3.37632700	0.42958400
C	2.79184400	4.41249900	-0.49501200
C	-6.18791100	2.65818000	1.45974600
H	-1.49477700	4.80964700	0.39466100
H	-3.03343400	4.23171500	1.10405100
H	0.05945100	2.91030400	-0.55060600
H	0.03150200	4.17290100	3.47062200
H	-0.69351200	5.56277800	2.63684700
H	-5.19133000	-0.91051500	-1.21136600
H	0.35382800	6.47381000	0.66318200
H	1.58184300	2.62984700	2.13464900
H	2.06827900	6.34307600	-1.11978600
H	3.29079800	2.49521100	0.35733700
H	3.53345200	4.34457700	-1.28586700
H	-6.26949900	1.77336800	2.09453600
H	-6.87192300	2.56695800	0.61275000
H	-6.40589700	3.55673800	2.03652600
N	-4.54163700	-0.44849000	3.07133600
O	-5.28957700	-1.40169500	2.94661500
O	-4.83269800	0.59965700	3.62943700
N	3.21485000	-0.72606200	2.59565100
N	3.94545300	1.28369700	2.96177400
C	4.20523800	-0.49845600	1.66042400
C	4.69719800	0.79237600	1.91020500
C	4.67658700	-1.26296000	0.60357700
C	5.70258700	1.34926200	1.13089300
C	5.67550700	-0.69905400	-0.18890500
C	2.98818700	0.38431300	3.35063700
C	6.18547900	0.57726400	0.07384700
H	2.56989100	-1.50438200	2.56249600
H	4.24993400	-2.23188900	0.37624200
H	6.08044700	2.34831900	1.32331900

H	6.05247200	-1.26388800	-1.03563900
H	6.96519500	0.98283000	-0.56345200
S	1.77749100	0.64007200	4.46754900
H	0.64262800	-1.80108400	-3.04708800
H	3.98475000	2.20880300	3.35597100
C	-2.86675800	-3.85724400	-1.35284300
C	-2.17454400	-2.66460300	-3.21393300
C	-4.13090800	-3.59563400	-2.14945300
C	-3.68091400	-2.75476700	-3.34525100
H	-4.56326500	-4.55974000	-2.43364100
H	-4.85523400	-3.10056700	-1.49888000
H	-3.93428200	-3.18675600	-4.31661000
H	-4.06108600	-1.73100900	-3.31820400
N	-1.81229500	-3.34899200	-2.07308500
O	-2.77156200	-4.41123400	-0.27553900
O	-1.39897600	-2.10373500	-3.96021000
H	-0.84671000	-3.38926800	-1.74877600

4.27916700 2.88457900 1.04281700

H	2.57791300	0.78293700	0.72447500
H	5.58535900	0.79815400	4.15386700
H	6.43709000	0.57223200	2.61417600
H	7.30506100	-2.25223700	-2.58852500
H	6.37299600	-1.73110200	1.99339400
H	2.86579500	0.08848100	3.65856900
H	5.10572700	-3.81962600	1.60062500
H	1.58748200	-1.99432900	3.26406900
H	2.71068000	-3.95993900	2.23263500
H	9.31654200	1.31331200	-1.20990600
H	9.51662500	0.20953100	0.16534200
H	9.49278700	1.98224500	0.44632400
N	-5.91631800	3.26392600	2.09238900
O	-5.54436300	4.35302500	2.49313000
O	-7.07069200	2.96511200	1.83506100
H	-0.68933100	-1.34325500	-2.14409500
C	-1.83093400	2.80646500	-1.15335800
C	-1.81651400	1.18345100	-2.85537600
C	-3.28121200	2.59112400	-1.53725200
C	-3.27207300	1.42602300	-2.52363700
H	-3.86026100	2.40192200	-0.63153200
H	-3.65030300	3.52344900	-1.97611600
H	-3.62767000	0.49484700	-2.07121100
H	-3.83434400	1.59829300	-3.44391000
N	-1.06987200	2.03628700	-2.03532100

O	-1.38992200	3.49614800	-0.26820300
O	-1.35566000	0.38735500	-3.63463800
H	-0.52090100	-0.00043900	-0.32803900

TS1'

E= -2918.298186

C	-2.66005300	-0.62221400	-1.48129900
H	-3.00702700	-0.78551500	-2.49963800
C	-1.31125500	-0.23519600	-1.24800600
H	-1.09979100	0.10261100	-0.23445300
C	-0.41372300	0.37560000	-2.27931800
H	-0.71721400	0.09141900	-3.29121800
H	-0.56040500	1.45910100	-2.19650300
I	-0.78590700	-2.46799700	-1.06326200
S	1.39457600	0.74660700	0.52030000
O	3.22196900	0.98331100	-2.49950200
O	0.26111400	0.38232800	1.37991200
O	1.45435000	2.10982600	-0.00714600
O	1.45477500	2.09786900	-3.36520100
N	1.55277800	-0.25835100	-0.76447300
C	2.87054500	0.33125900	1.41180300
C	1.09236400	0.06693100	-2.10099600
C	4.61030900	2.85399500	-1.88581000
C	4.14095900	1.97011800	-3.00498700
C	3.96327800	1.18880000	1.34150400
C	2.90661000	-0.88690500	2.09050700
C	1.92410200	1.18861300	-2.71957800
C	5.87993500	2.69105200	-1.33072700
C	3.75229900	3.82430800	-1.35870300
C	6.29513800	3.48898900	-0.26640300
C	5.14021000	0.81456800	1.97664500
C	4.09185600	-1.26748400	2.70528900
C	4.16072600	4.61445500	-0.28941100
C	5.43345900	4.44966700	0.25798500
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H	6.54635700	1.93069300	-1.73072700
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H	4.17386900	-2.21457200	3.22496200

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H	4.55524700	-3.92143300	-1.70882800
H	3.49943900	-5.29031800	-2.03261100
N	1.67710400	-3.25784300	-0.61641500
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Int2'

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H	-4.66969900	5.51422300	-0.46427300
N	-3.58445700	2.74110200	0.35386600
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PS'

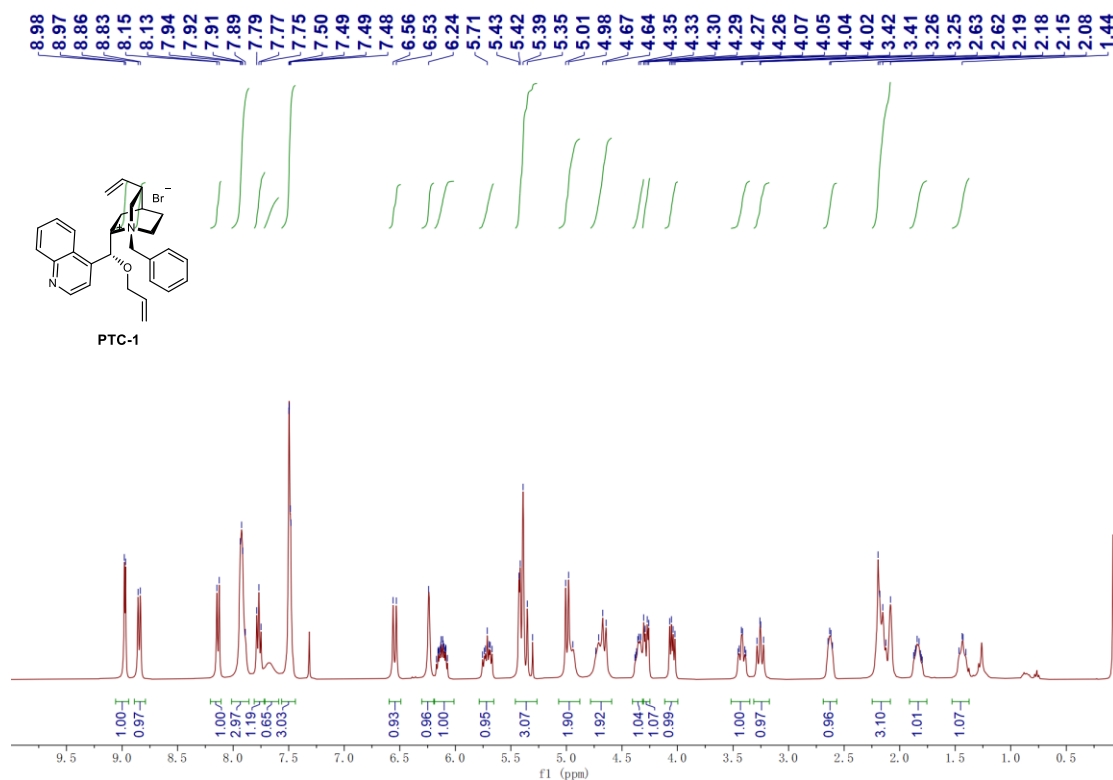
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C	2.63771200	1.59738800	-2.14107900
C	1.20236900	1.92321500	-1.73673500
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C	-0.94725700	-1.86752300	-2.28871300
C	-0.69410200	-2.70648900	-1.20706200
C	-2.22949900	-1.67613500	-2.79789900
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C	-1.76803100	-3.28411100	-0.54458200
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C	6.07666300	-0.76614000	0.26646300
C	-3.05294600	-3.03631900	-1.01871700
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C	6.37296900	0.45672400	2.33150900
C	5.86286400	-1.89990300	2.39157000
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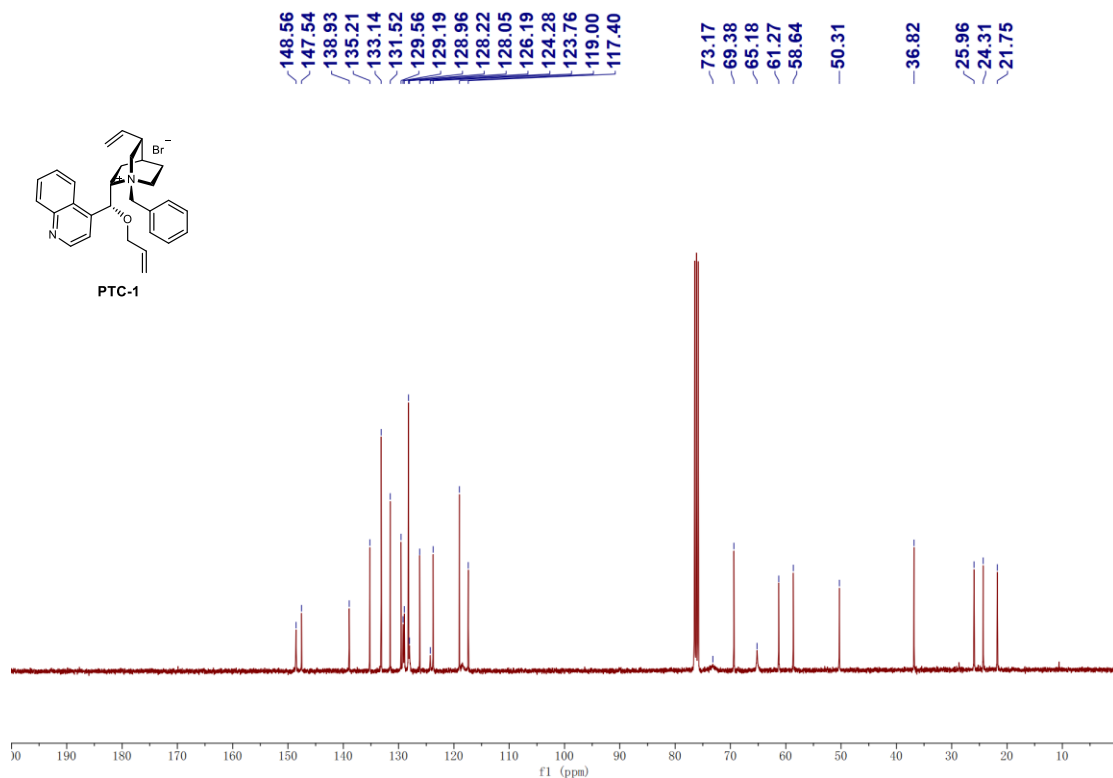
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H	6.03113400	-1.81631000	-1.61145200
H	6.89173300	-0.25436200	-1.66238600
H	-1.60794900	-3.89171200	0.33827100
H	-4.32128300	-2.13005600	-2.49278400
H	6.53036700	1.33374500	0.37399300
H	5.58694700	-2.84571500	0.47475700
H	6.57894200	1.38943700	2.84798700
H	5.67759500	-2.81119300	2.95382600
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H	0.31393000	-2.87192700	-0.84530700
N	-4.19518400	-3.52272800	-0.24357100
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O	-5.30276300	-3.43797900	-0.74854000
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N	-2.04682300	-0.38463500	1.06883000
N	-2.23661200	1.49096500	-1.93439700
N	-4.49383400	0.90379700	-1.36672500
C	-2.75432000	0.22324100	0.06124000
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C	-1.84014700	0.81869800	-0.83586200
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C	-0.52942700	0.51764600	-0.34679800
C	-4.10793200	0.25795000	-0.28481100
C	-2.75600400	0.48842400	4.00896600
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H	-3.91069700	2.04707000	-2.98336100
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H	-5.74412100	3.06167600	1.51176900
H	-1.56306100	3.97830400	1.15151500
H	-3.91959000	4.41175800	0.50549300
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H	-6.88027900	-1.01467300	0.76436400
C	2.62825400	-0.70984600	1.93380700
C	1.35666000	-2.65061600	2.00111700
C	2.22364500	-0.86422300	3.38851500
C	1.30083700	-2.08423300	3.41235900
H	3.13875300	-1.00011500	3.97294700
H	1.75126700	0.06010900	3.72955200
H	1.60097900	-2.86172100	4.11938500
H	0.26156200	-1.82203400	3.64176400
N	2.17820700	-1.82921000	1.25818700
O	3.19368500	0.23022900	1.41905800
O	0.75823000	-3.61368600	1.57059100
H	2.40502800	-1.97447800	0.27052800

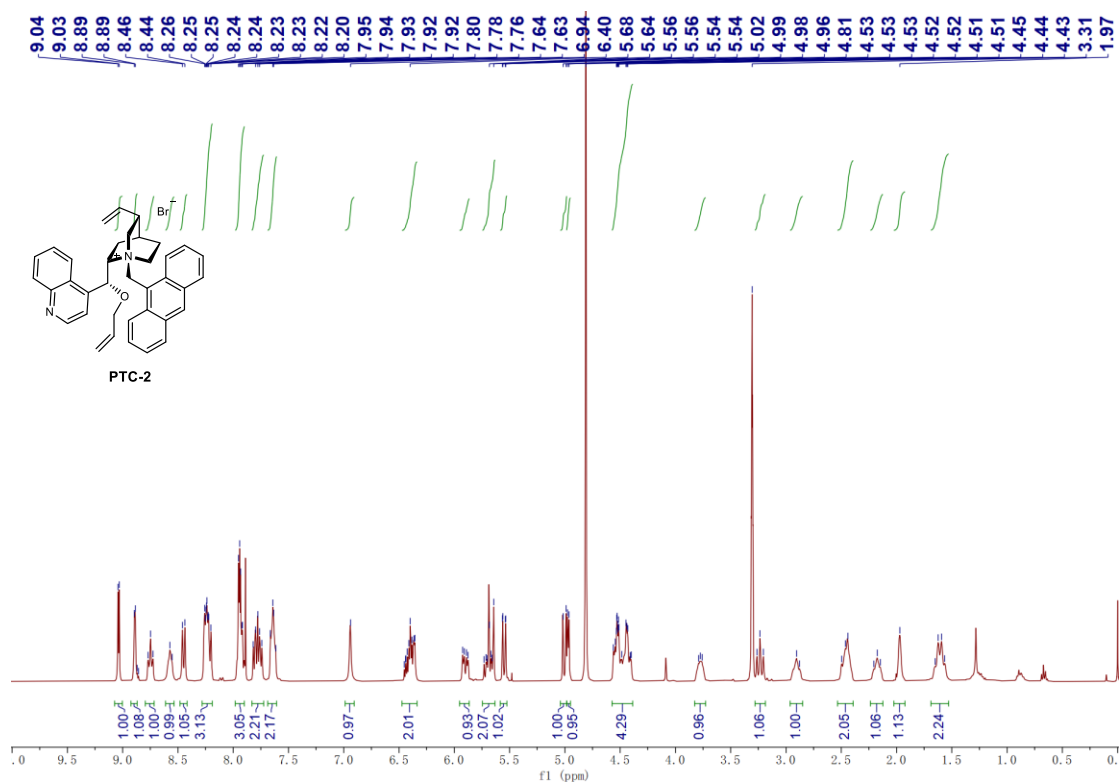
6. Supplementary NMR spectra



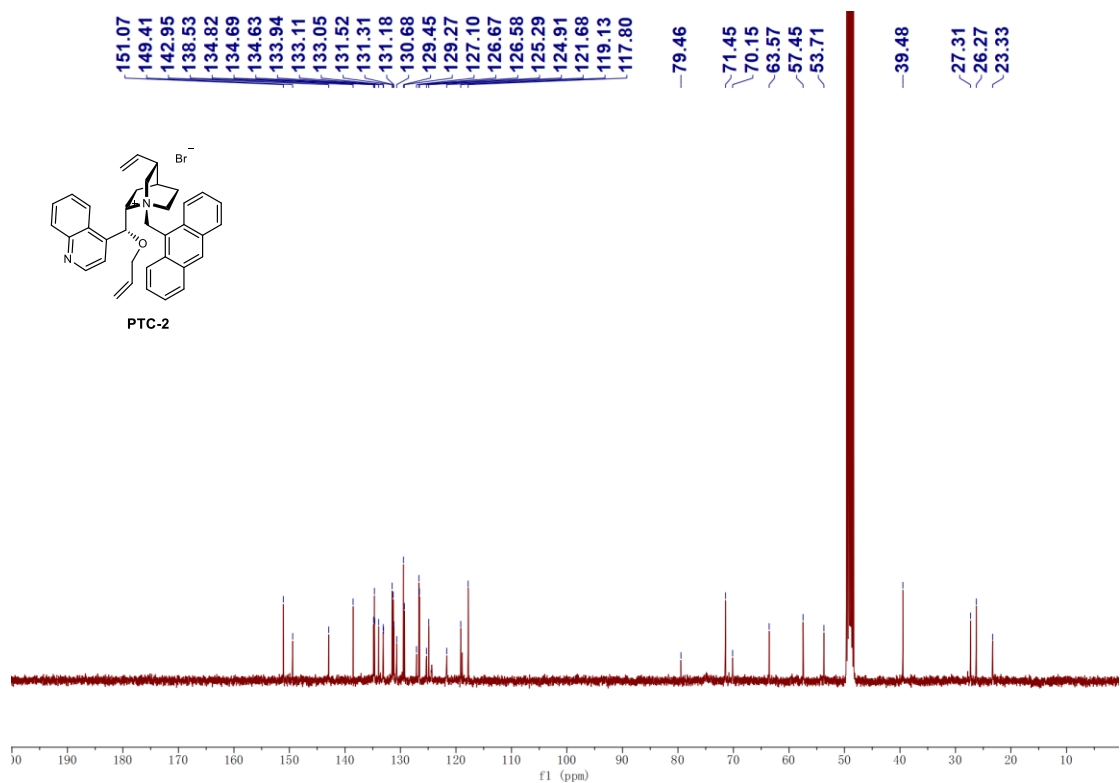
Supplementary Figure 2. ¹H NMR (400 MHz, CDCl₃) of compound PTC-1.



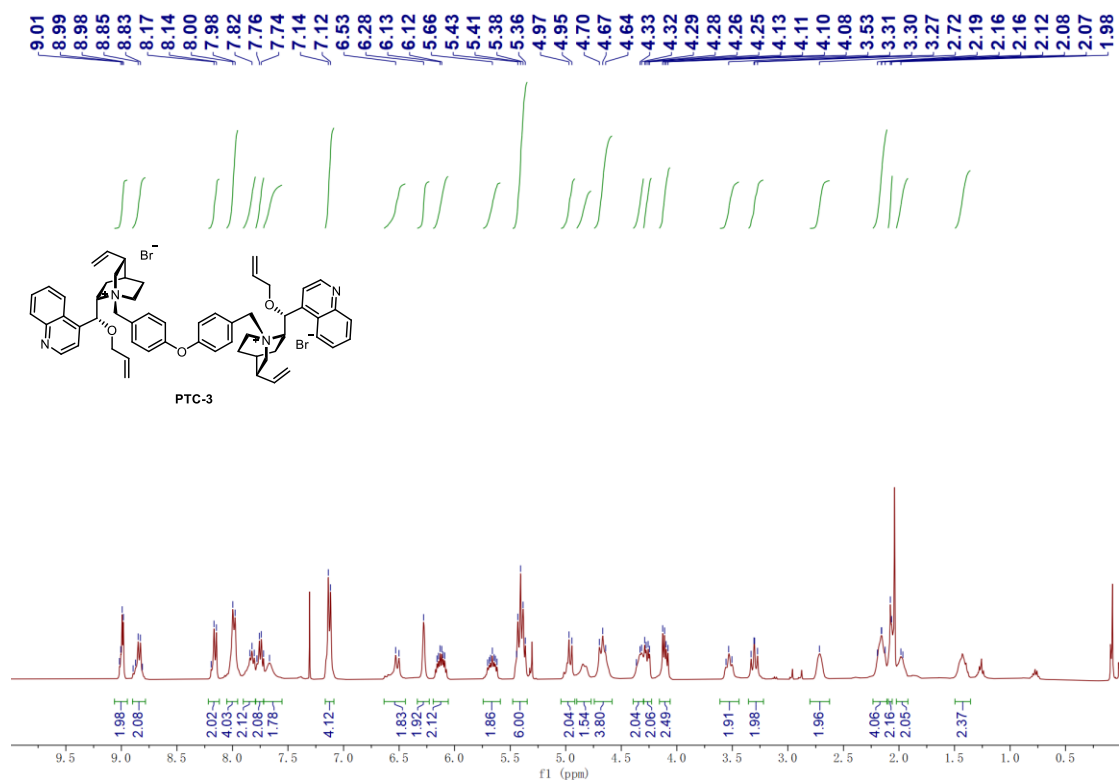
Supplementary Figure 3. ¹³C NMR (100 MHz, CDCl₃) of compound PTC-1



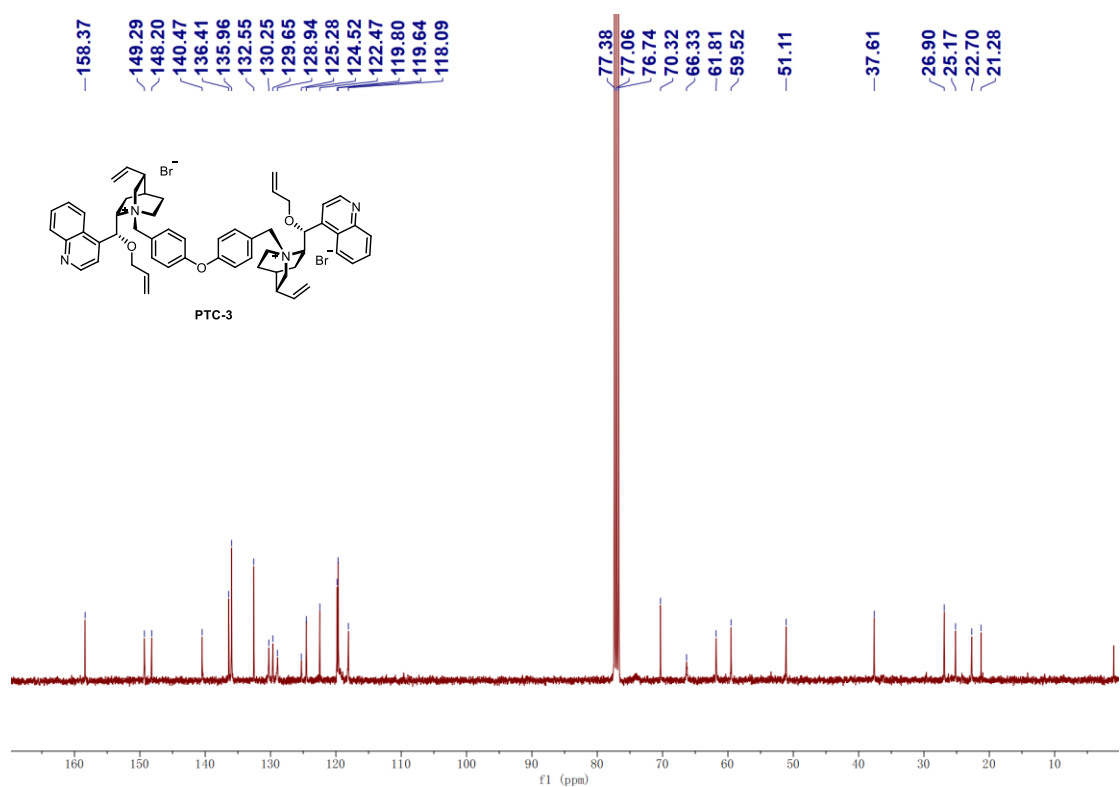
Supplementary Figure 4. ¹H NMR (400 MHz, MeOD) of compound **PTC-2**.



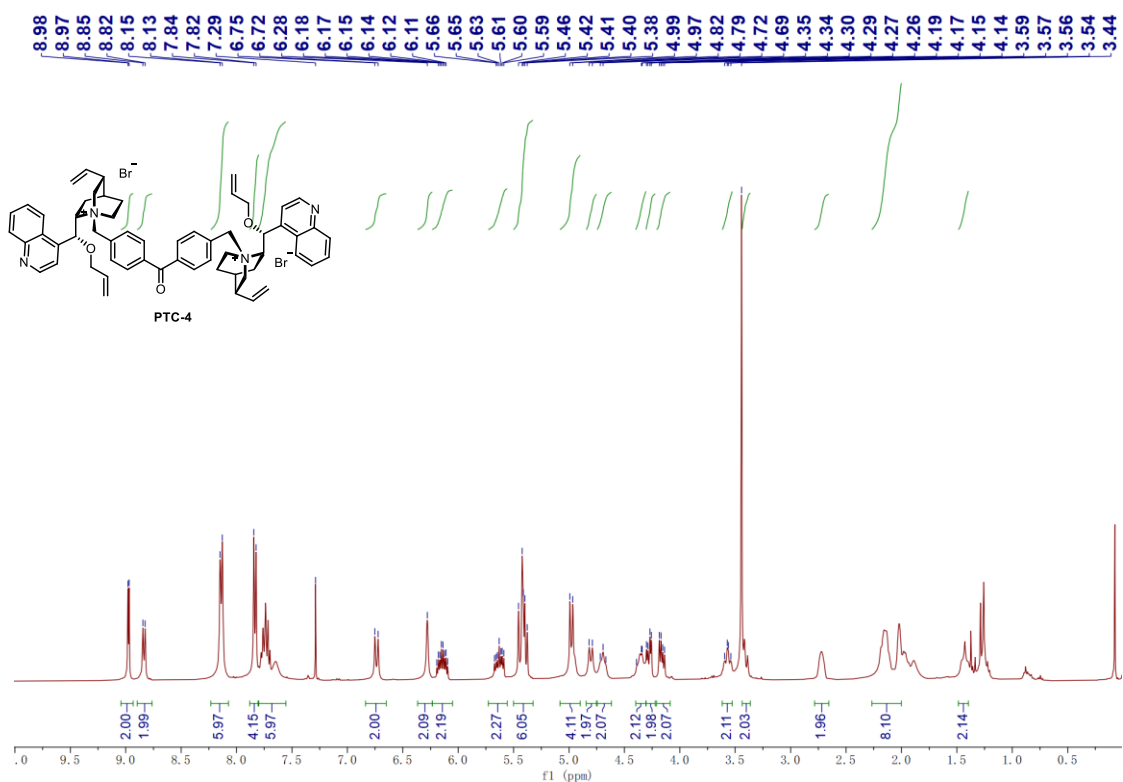
Supplementary Figure 5. ¹³C NMR (100 MHz, MeOD) of compound **PTC-2**



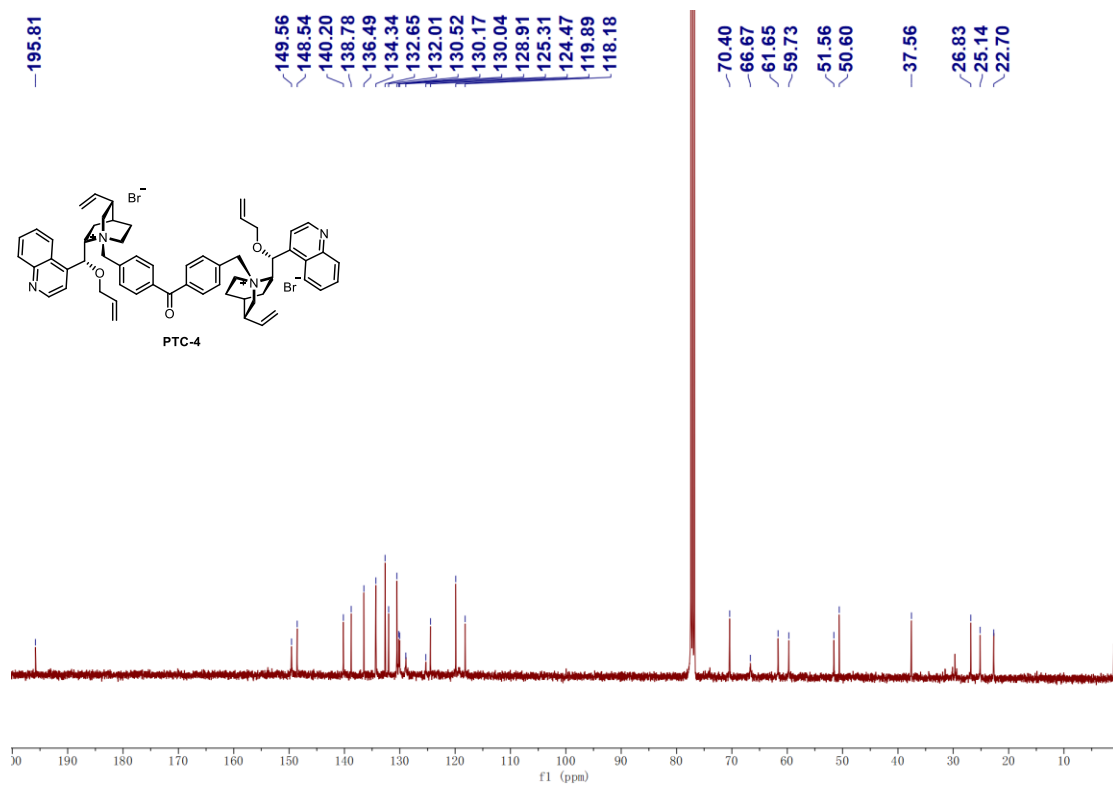
Supplementary Figure 6. ^1H NMR (400 MHz, CDCl_3) of compound PTC-3.



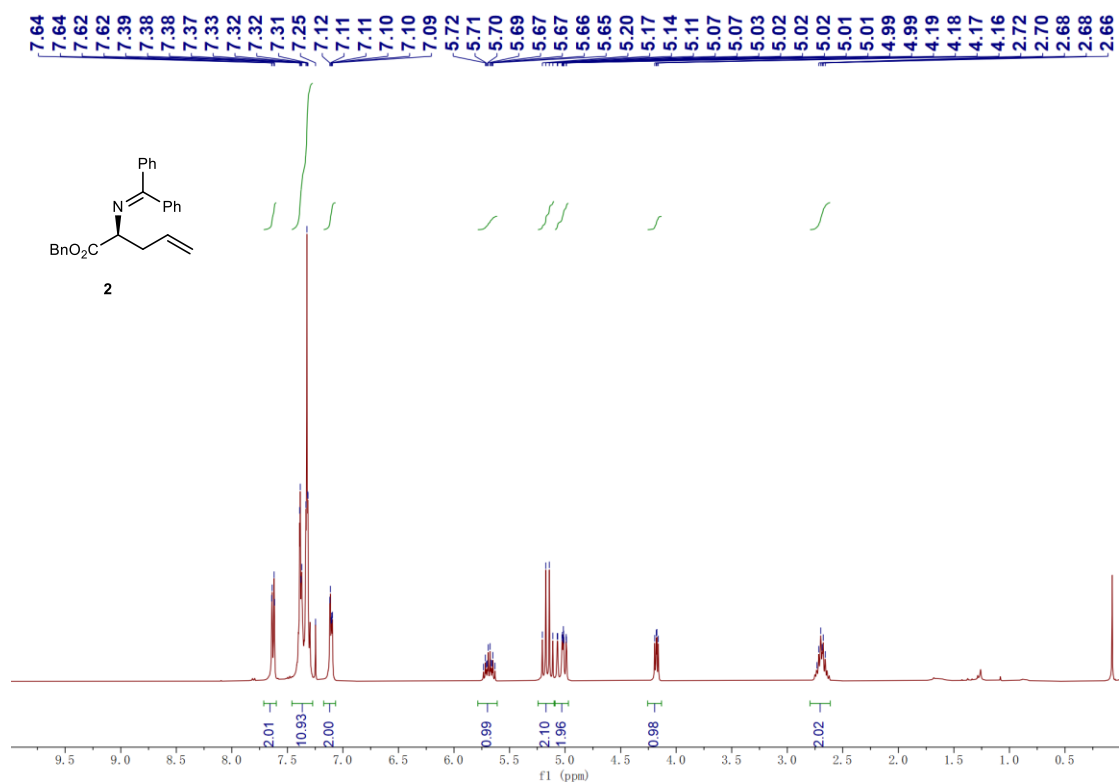
Supplementary Figure 7. ^{13}C NMR (100 MHz, CDCl_3) of compound PTC-3



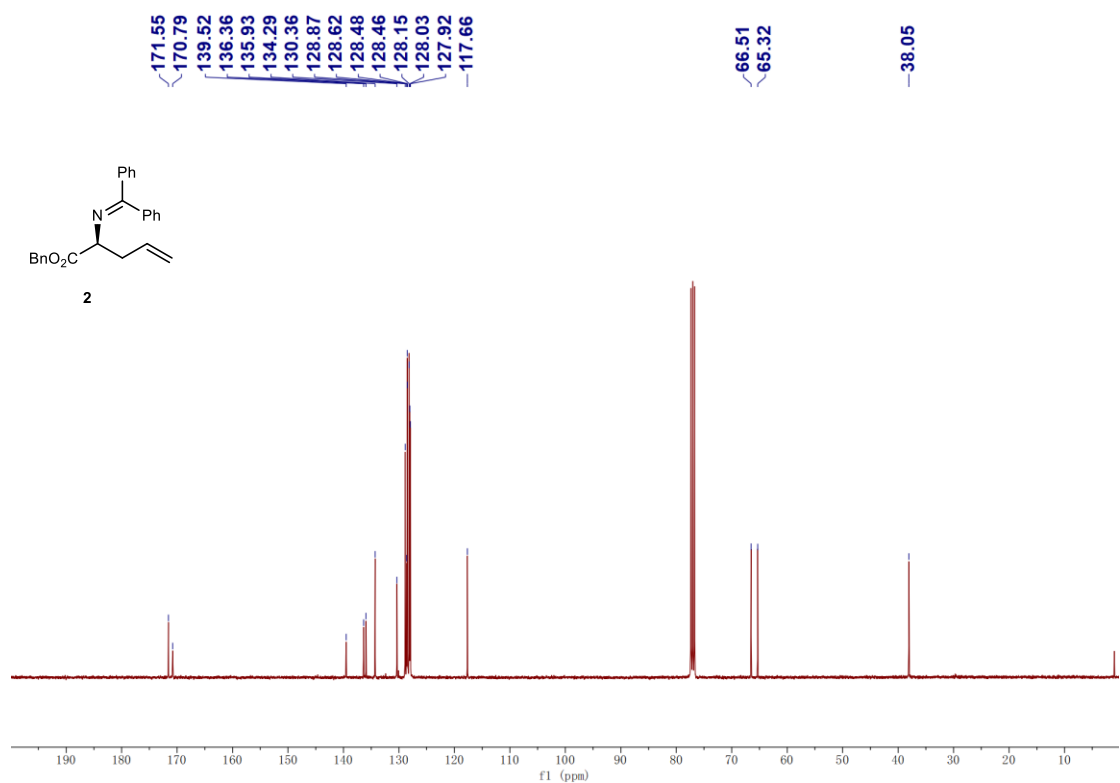
Supplementary Figure 8. ^1H NMR (400 MHz, CDCl_3) of compound PTC-4.



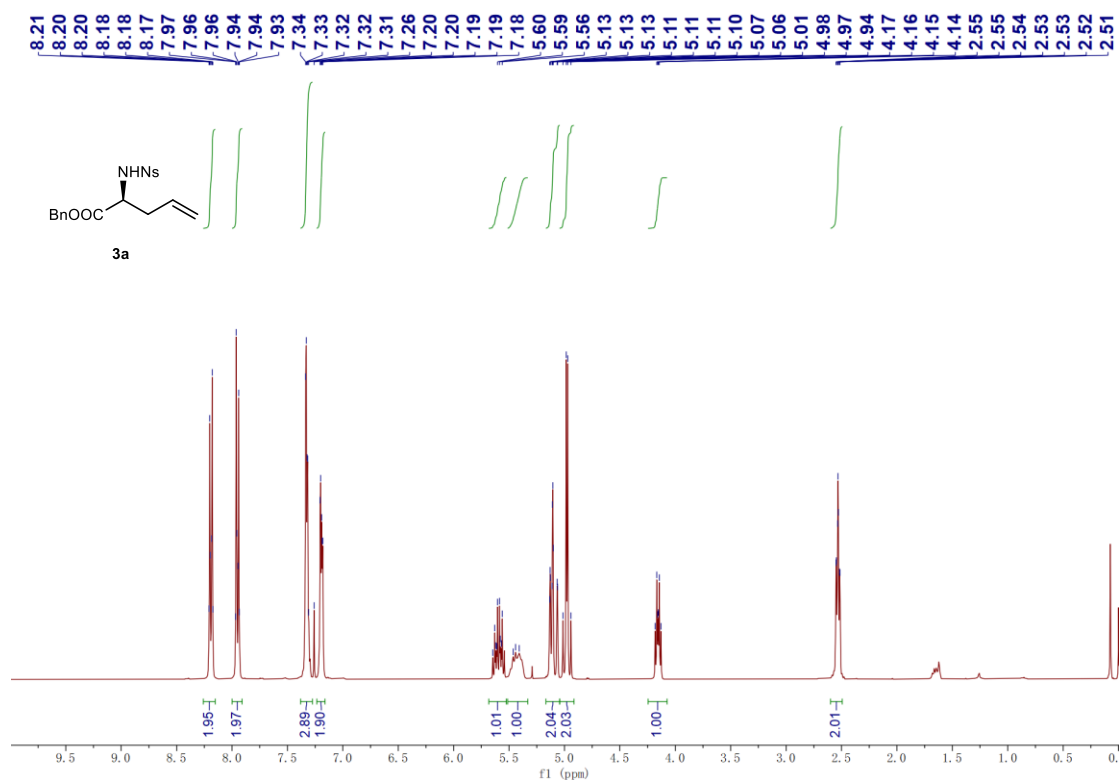
Supplementary Figure 9. ^{13}C NMR (100 MHz, CDCl_3) of compound PTC-4



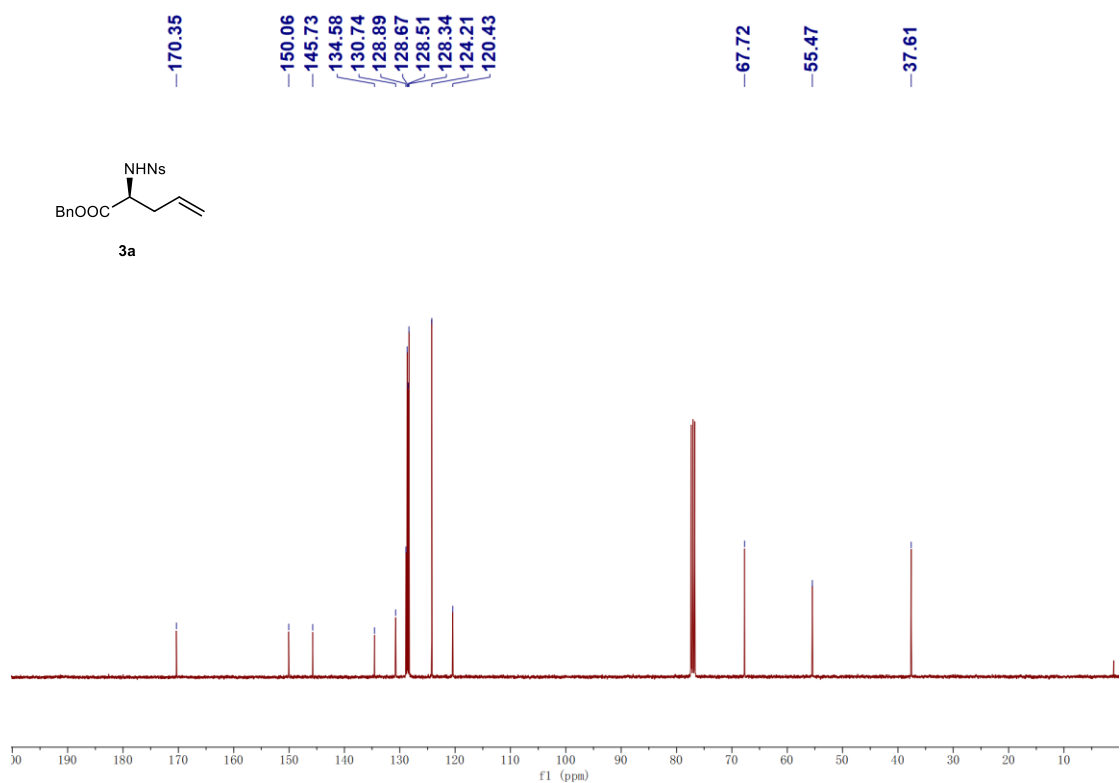
Supplementary Figure 10. ¹H NMR (400 MHz, CDCl₃) of compound **2**.



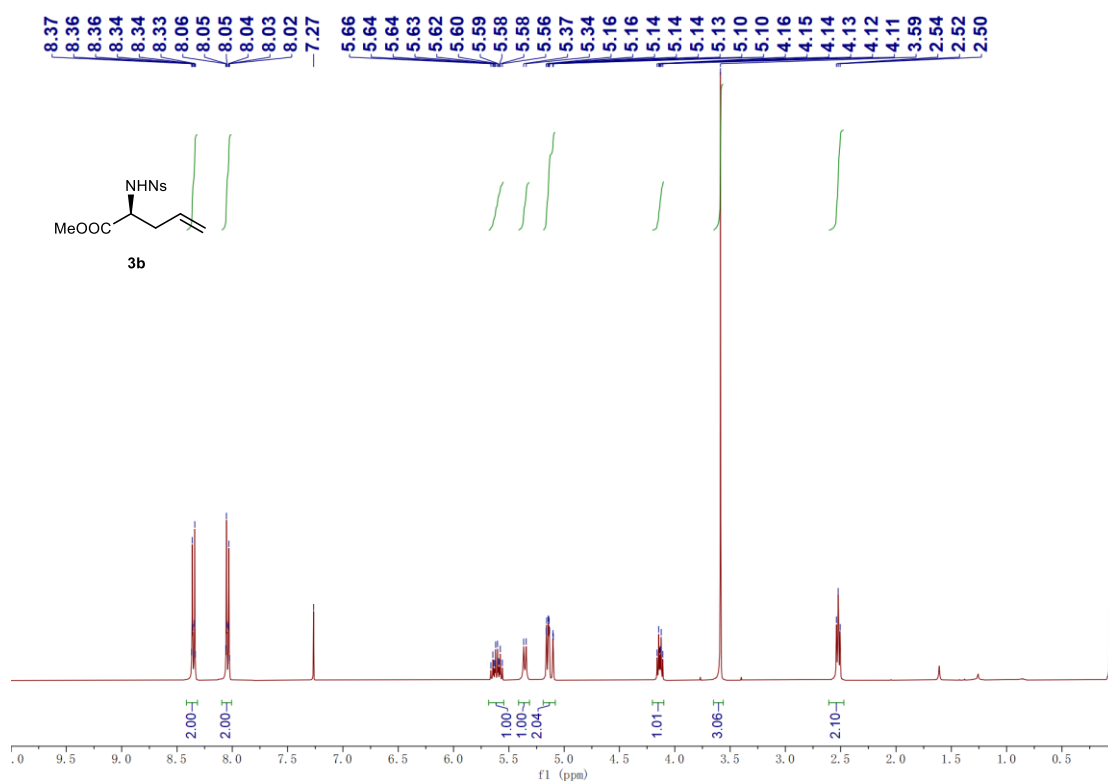
Supplementary Figure 11. ¹³C NMR (100 MHz, CDCl₃) of compound **2**.



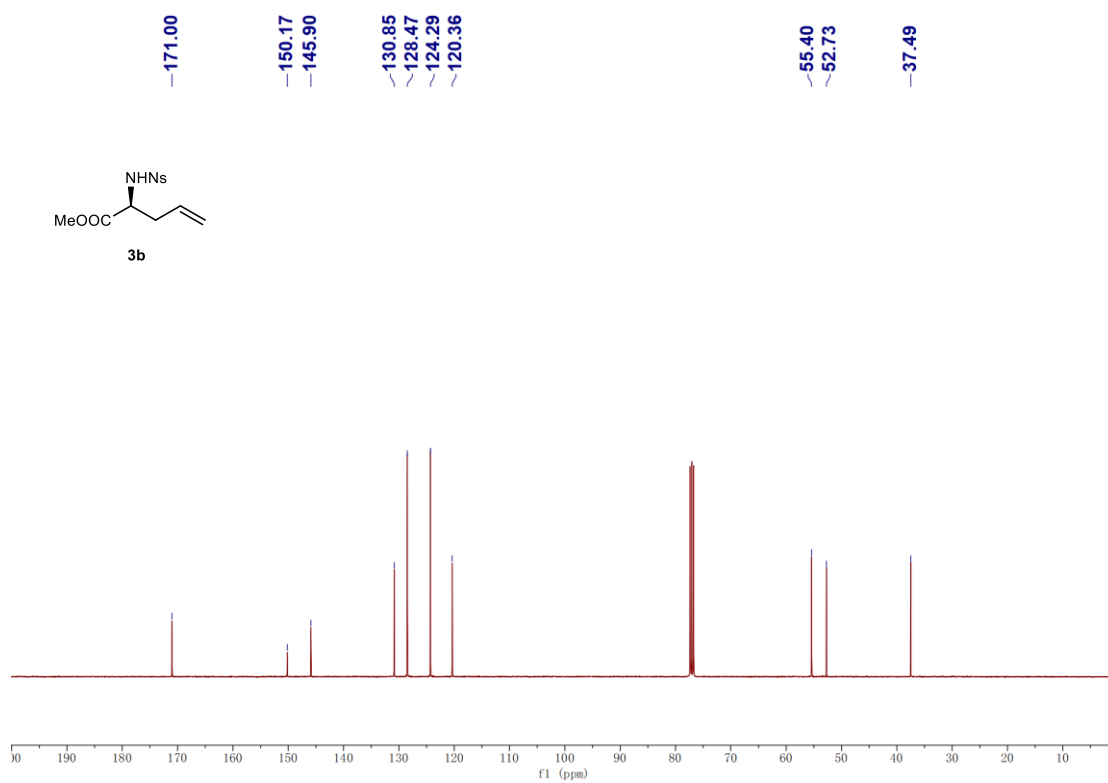
Supplementary Figure 12. ^1H NMR (400 MHz, CDCl_3) of compound **43a**.



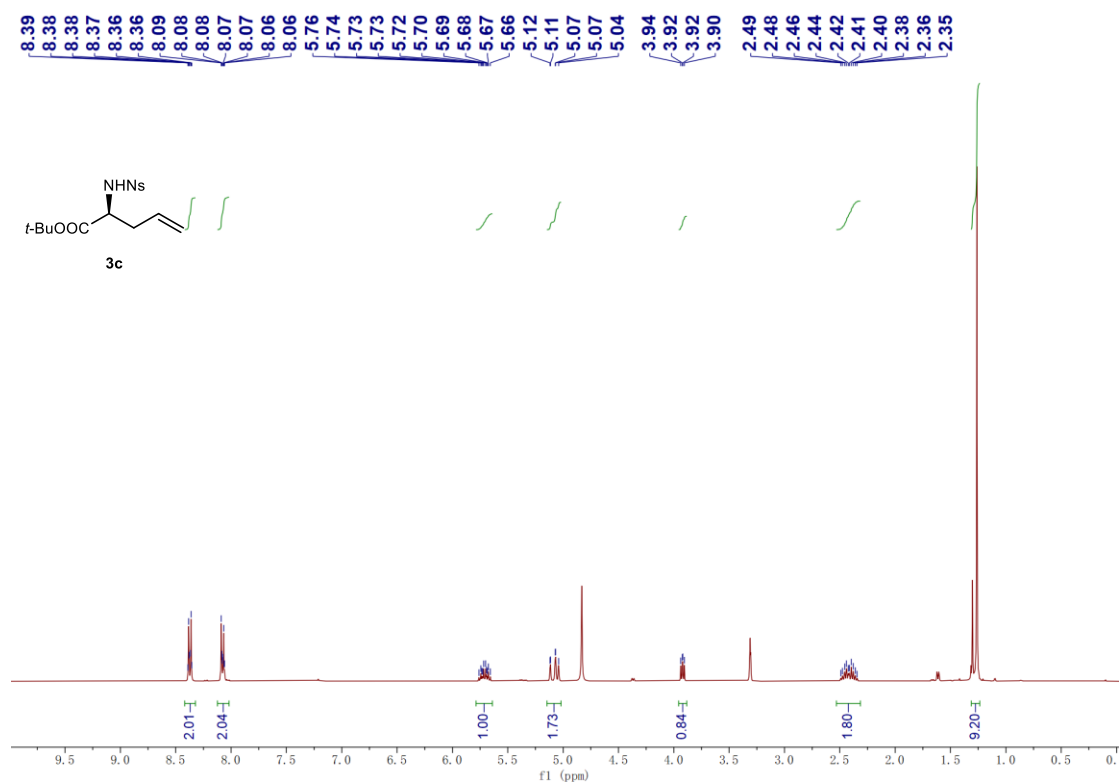
Supplementary Figure 13. ^{13}C NMR (100 MHz, CDCl_3) of compound **3a**.



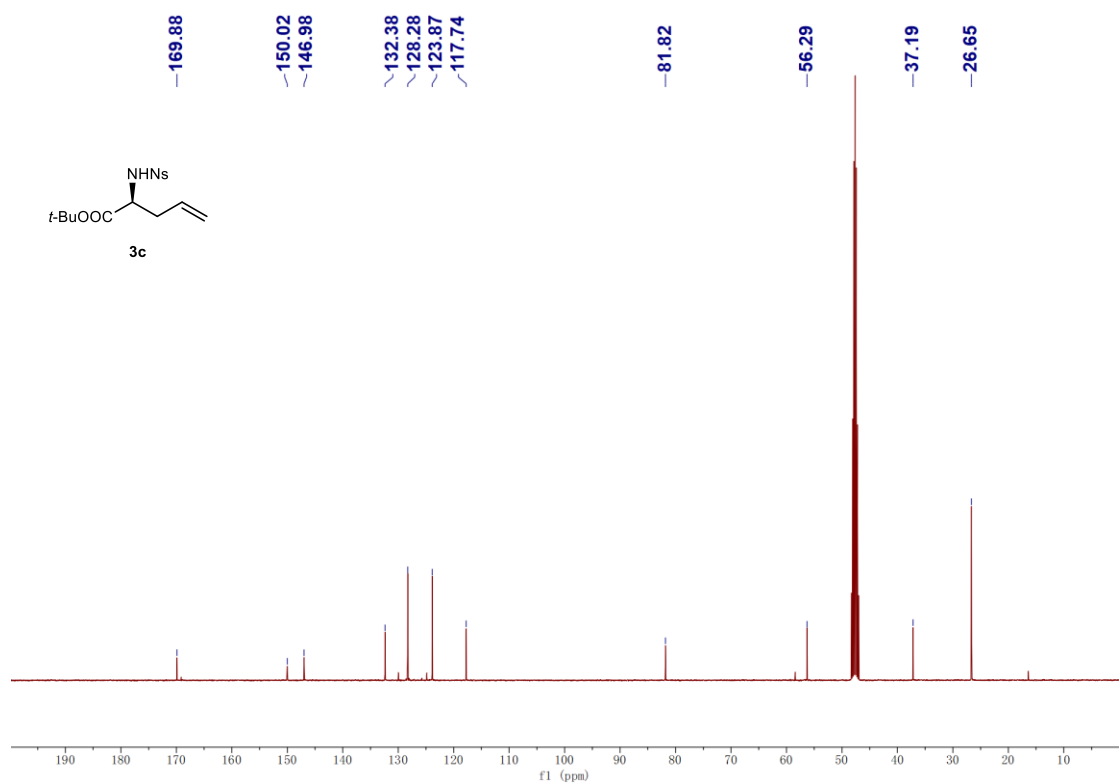
Supplementary Figure 14. ¹H NMR (400 MHz, CDCl₃) of compound **3b**.



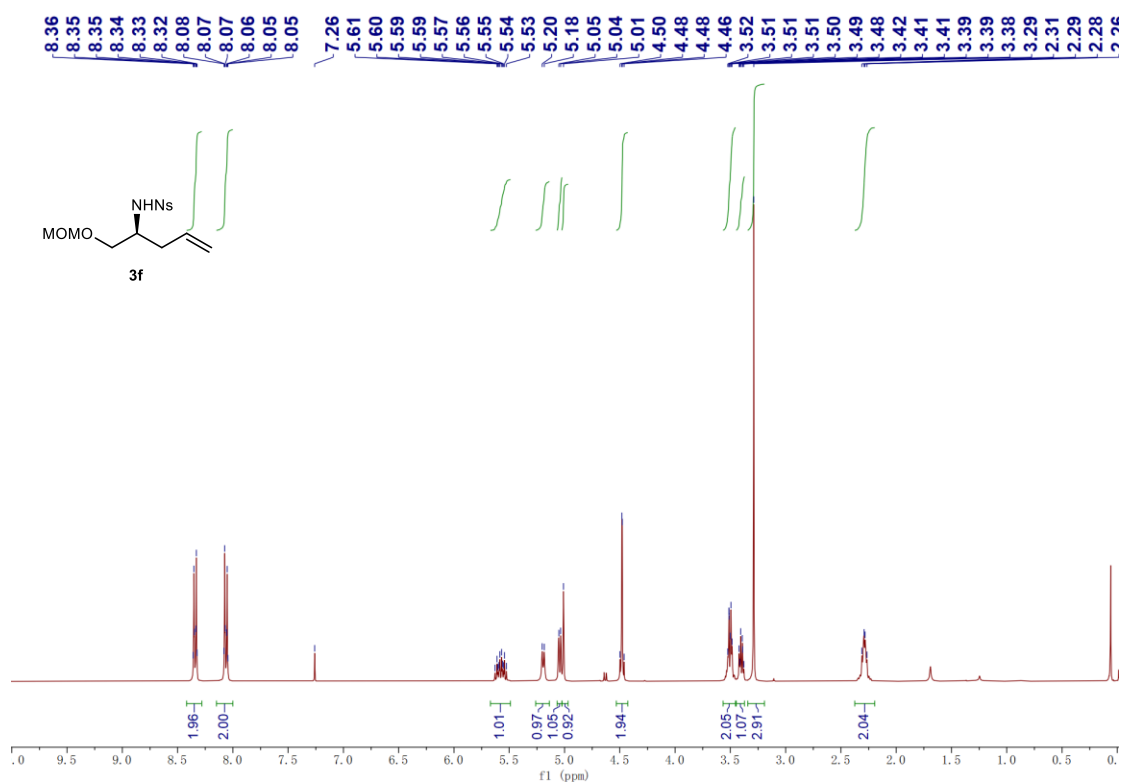
Supplementary Figure 15. ¹³C NMR (100 MHz, CDCl₃) of compound **3b**.



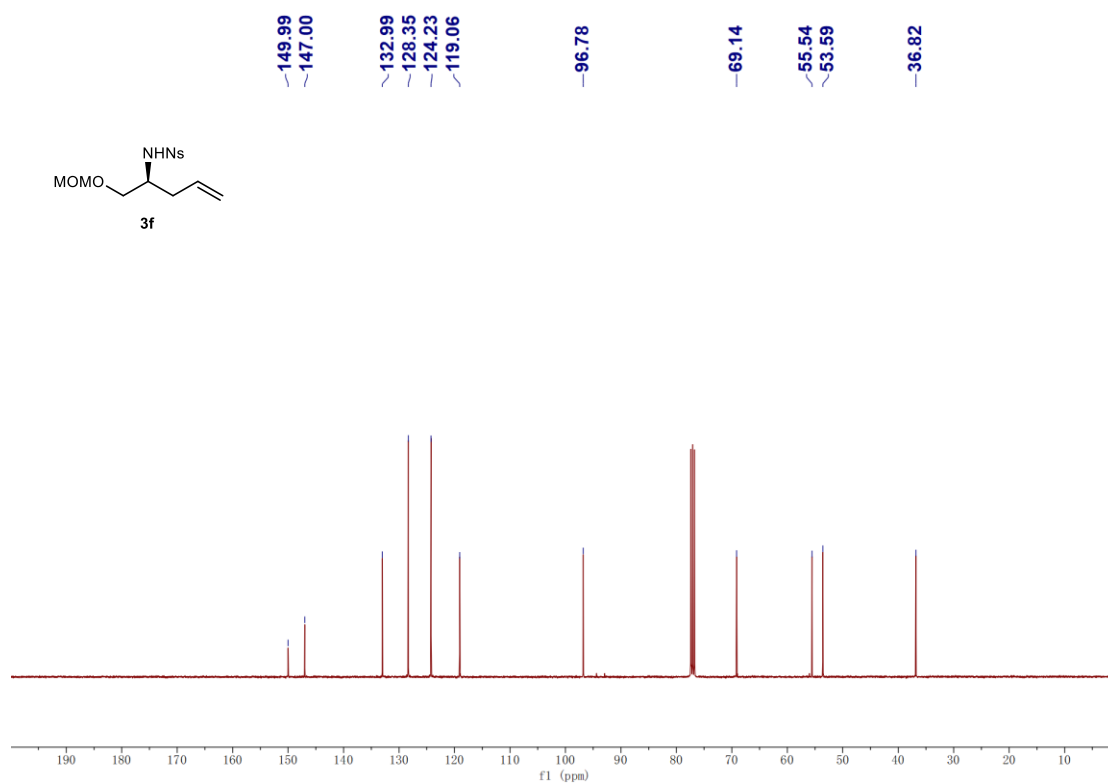
Supplementary Figure 16. ¹H NMR (400 MHz, MeOD) of compound **3c**.



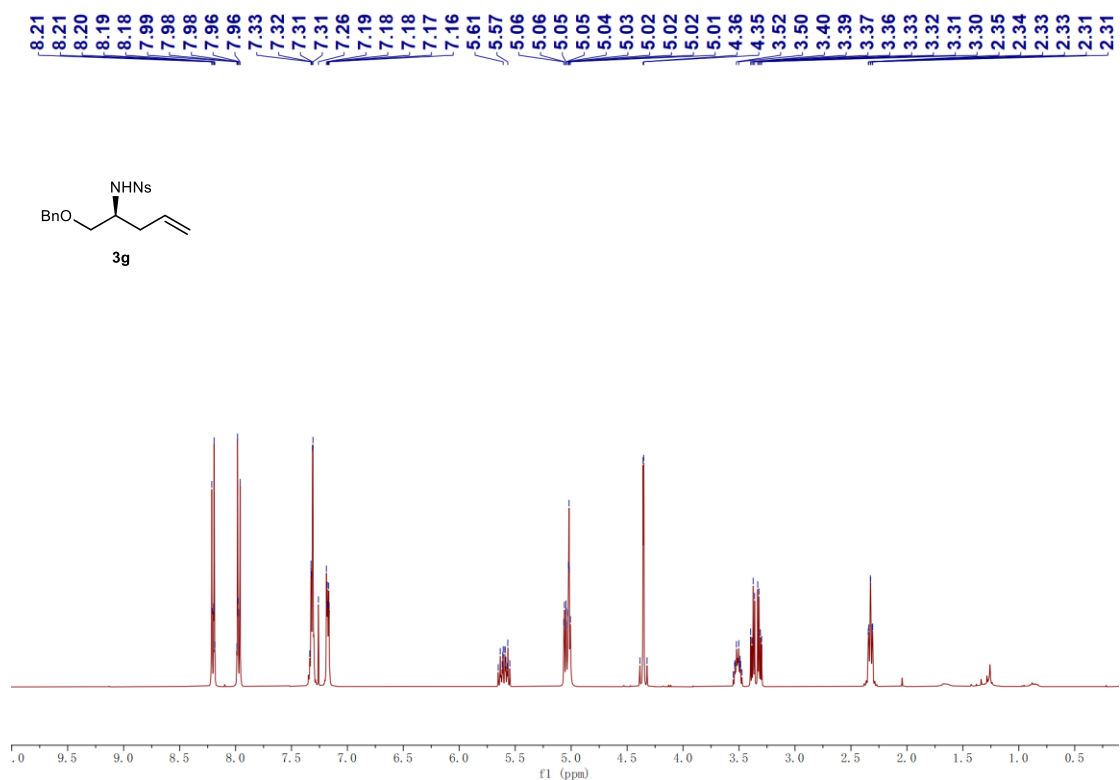
Supplementary Figure 17. ¹³C NMR (100 MHz, MeOD) of compound **3c**.



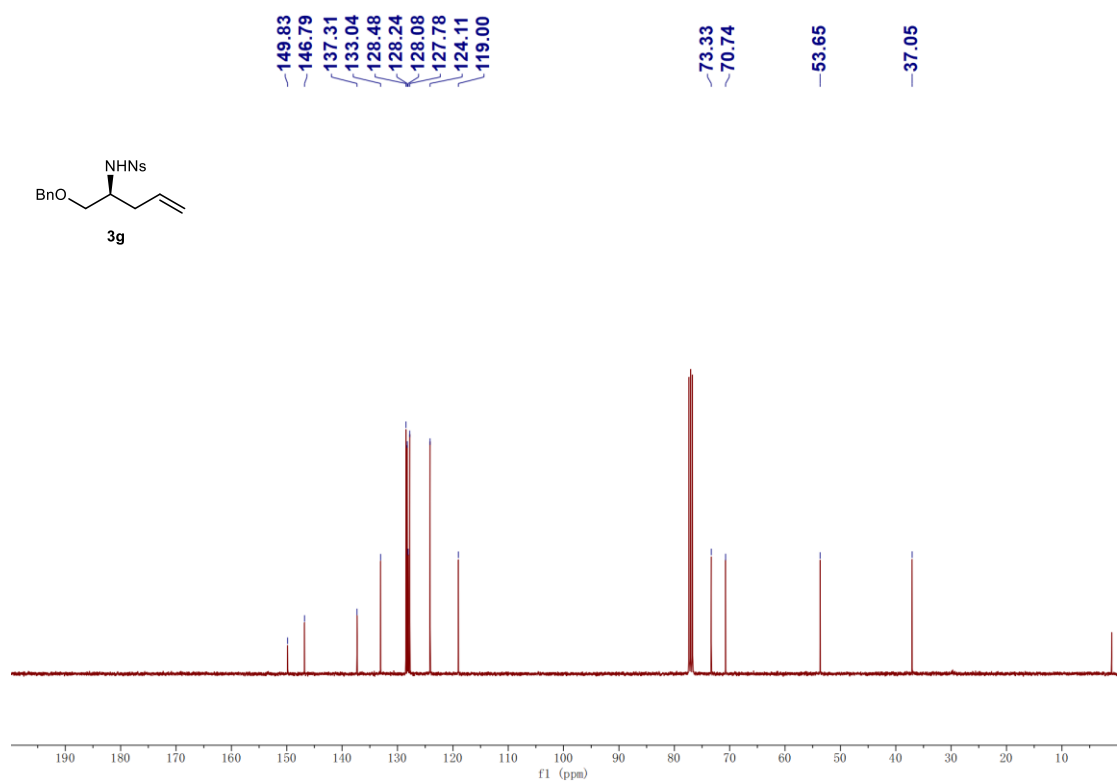
Supplementary Figure 18. ¹H NMR (400 MHz, CDCl₃) of compound **3f**.



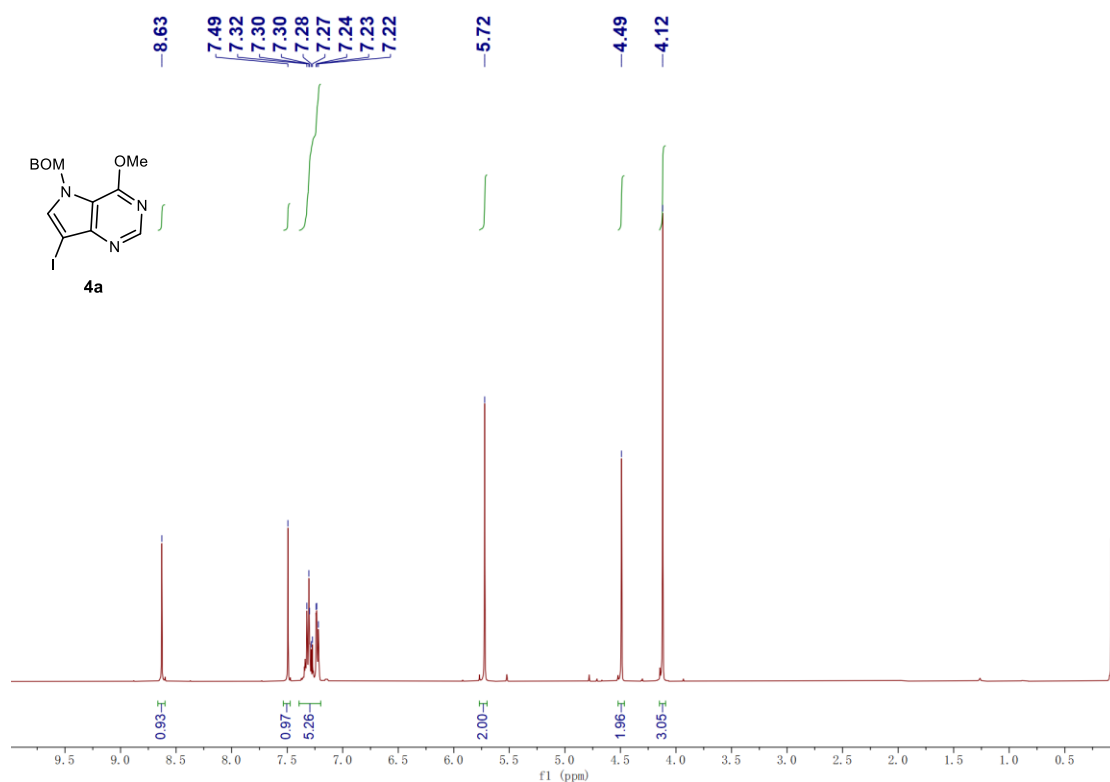
Supplementary Figure 19. ¹³C NMR (100 MHz, CDCl₃) of compound **3f**.



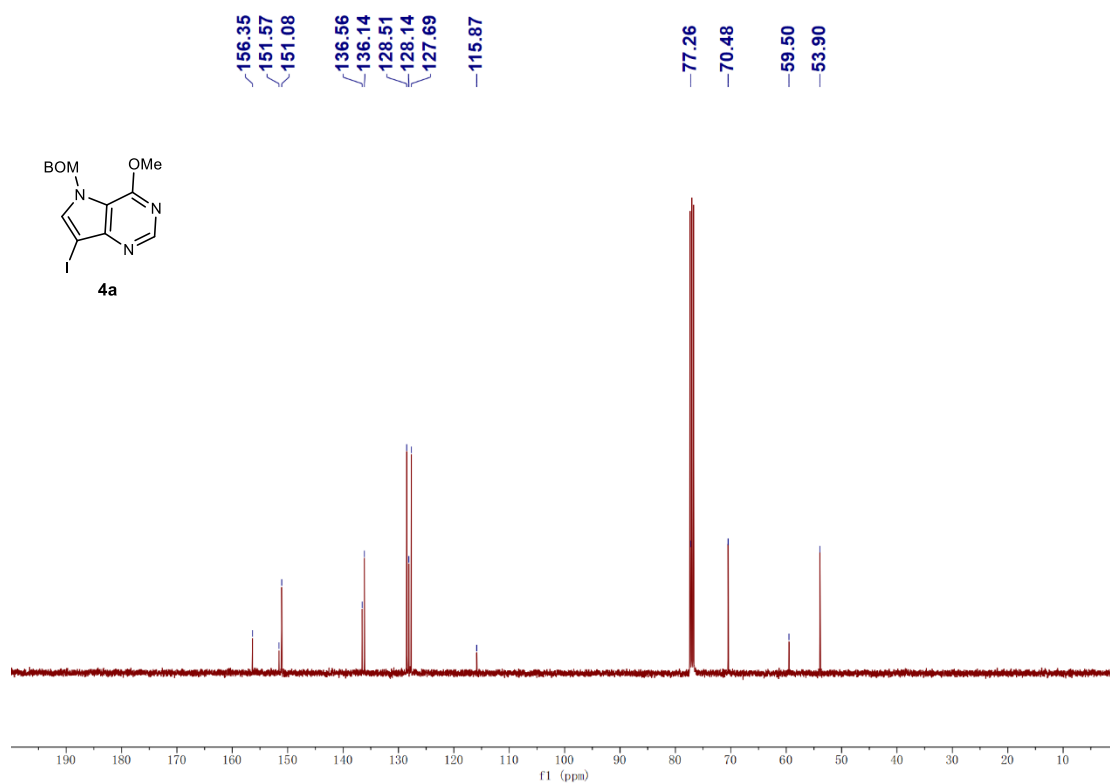
Supplementary Figure 20. ¹H NMR (400 MHz, CDCl₃) of compound **3g**.



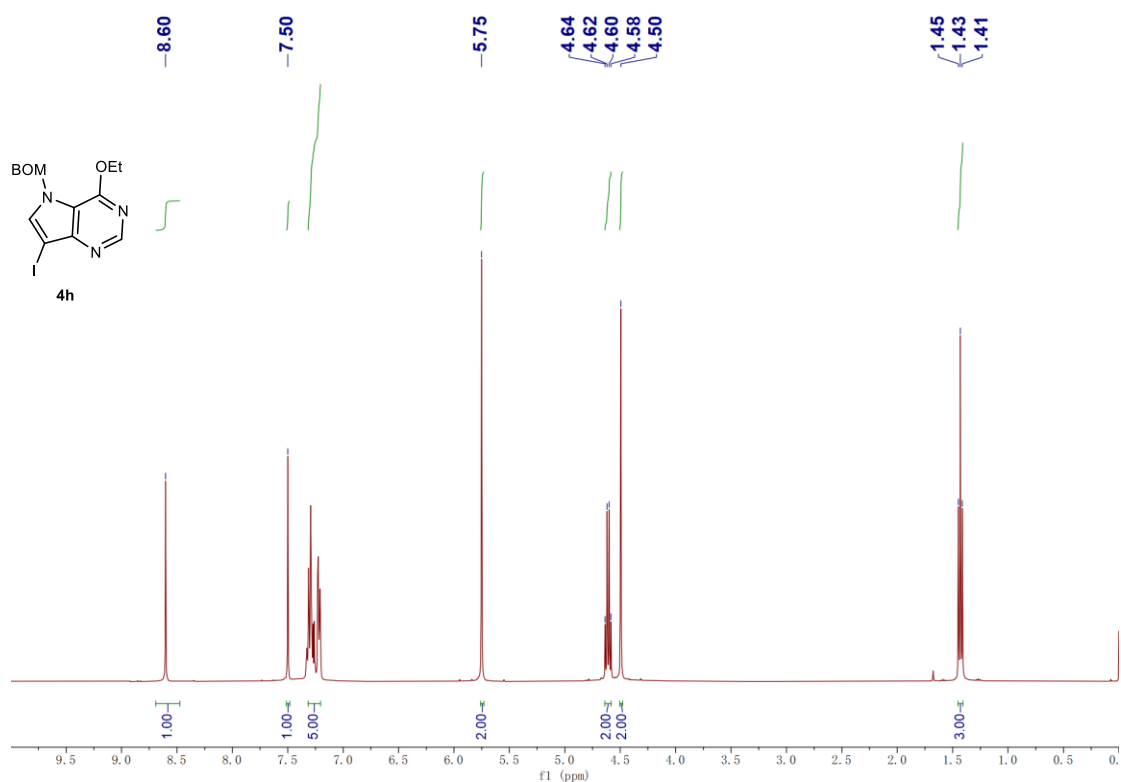
Supplementary Figure 21. ¹³C NMR (100 MHz, CDCl₃) of compound **3g**.



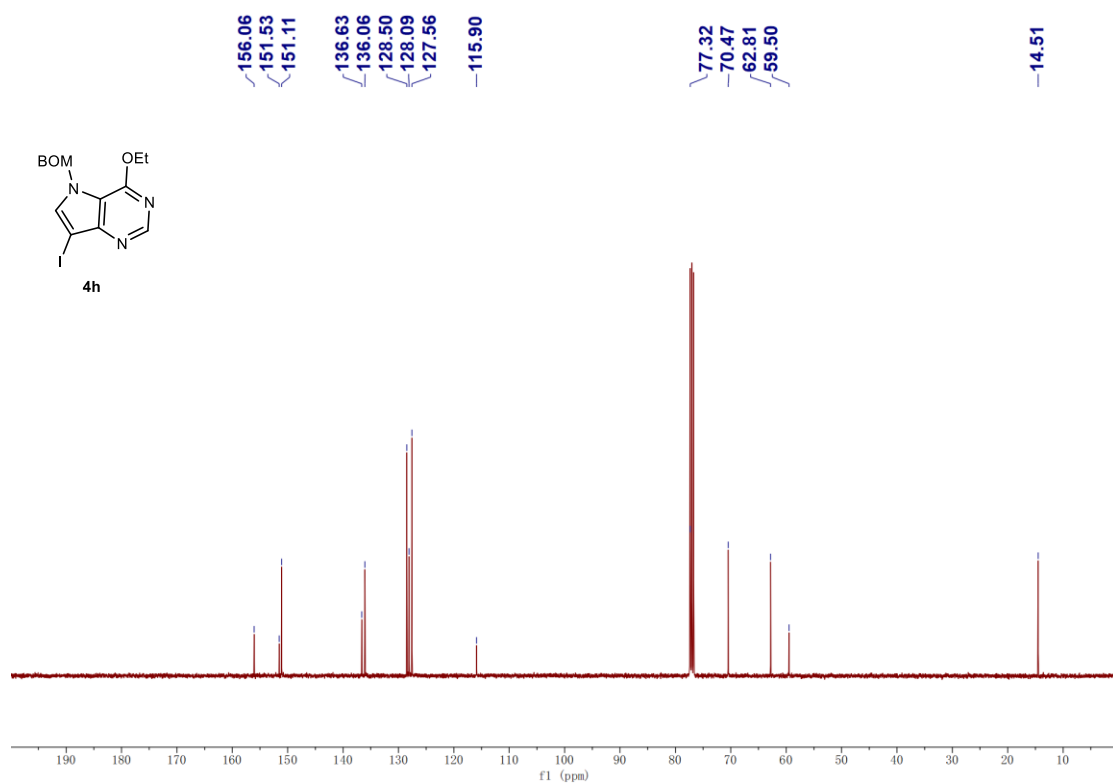
Supplementary Figure 22. ¹H NMR (400 MHz, CDCl₃) of compound **4a**.



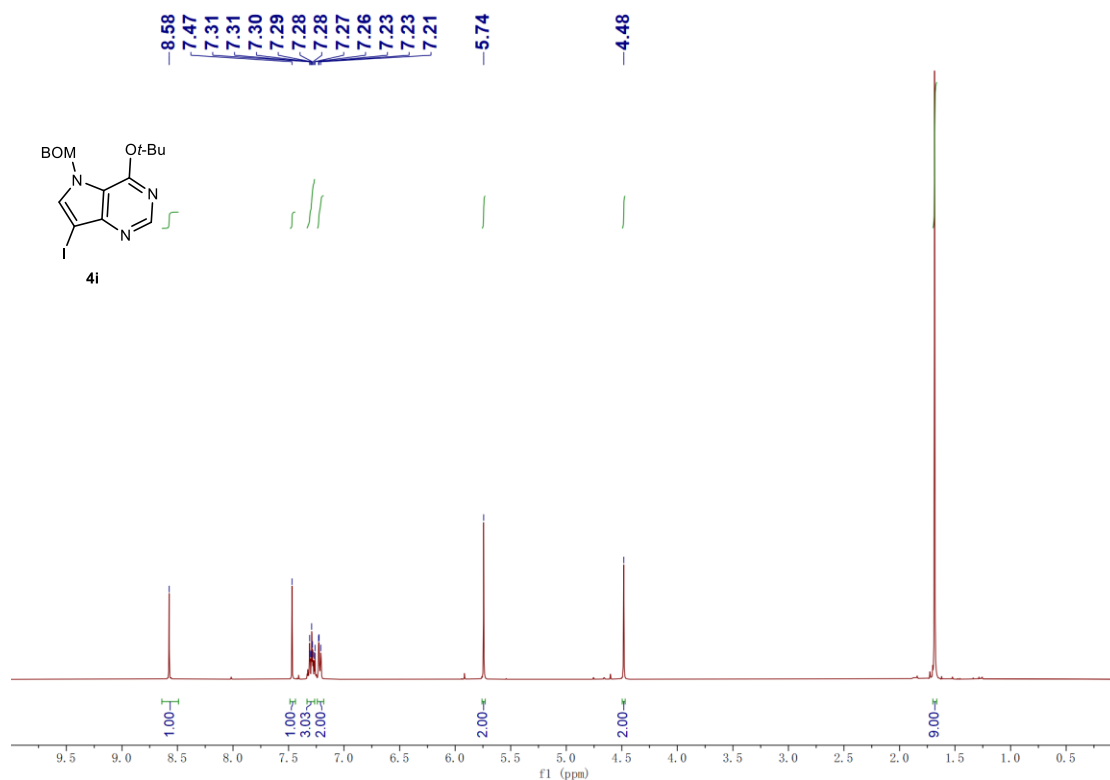
Supplementary Figure 23. ¹³C NMR (400 MHz, CDCl₃) of compound **4a**.



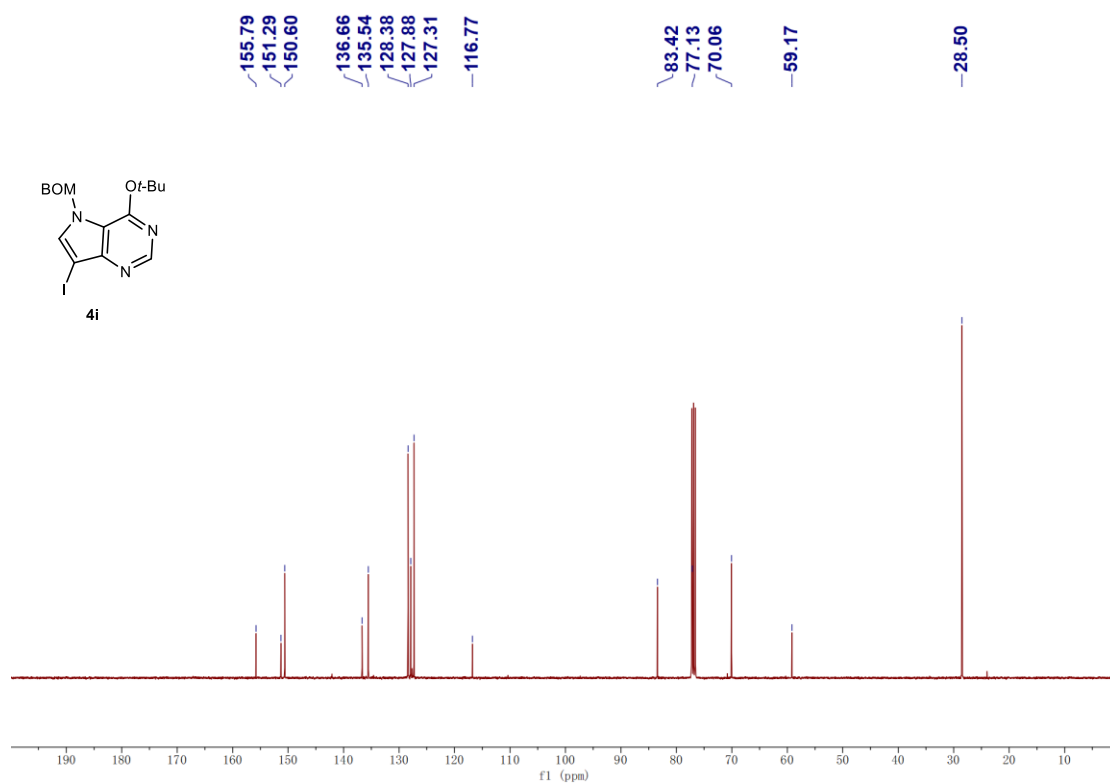
Supplementary Figure 24. ¹H NMR (400 MHz, CDCl₃) of compound **4h**.



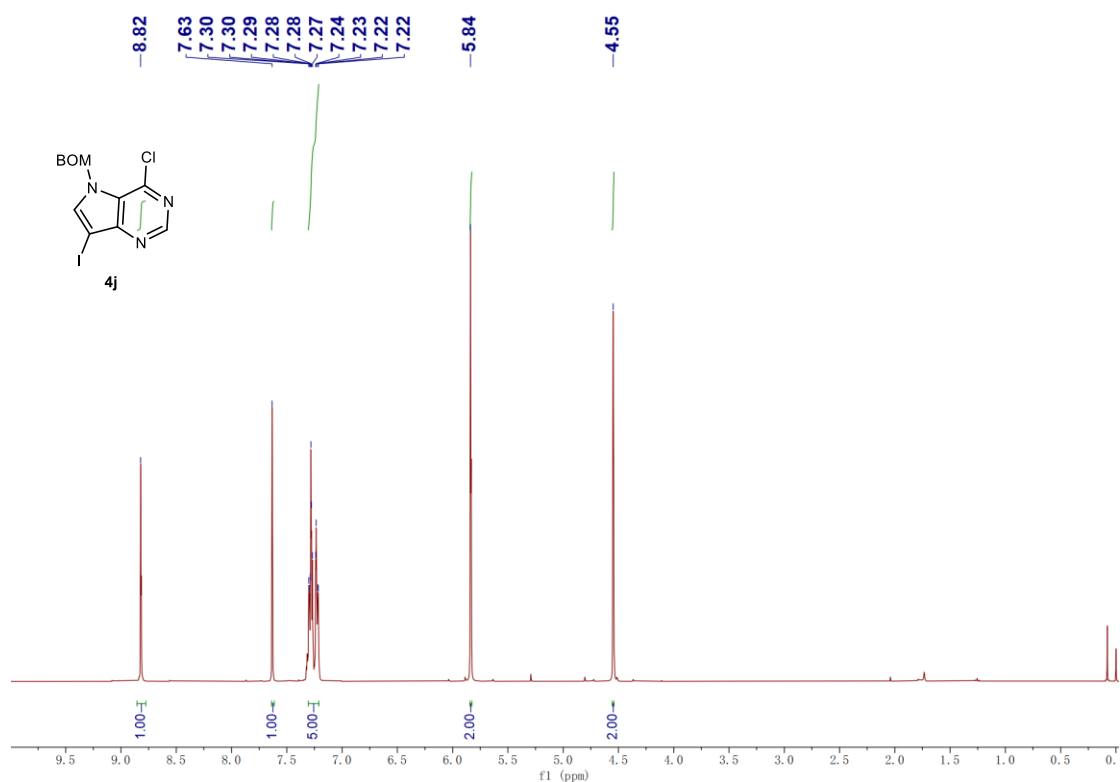
Supplementary Figure 25. ¹³C NMR (400 MHz, CDCl₃) of compound **4h**.



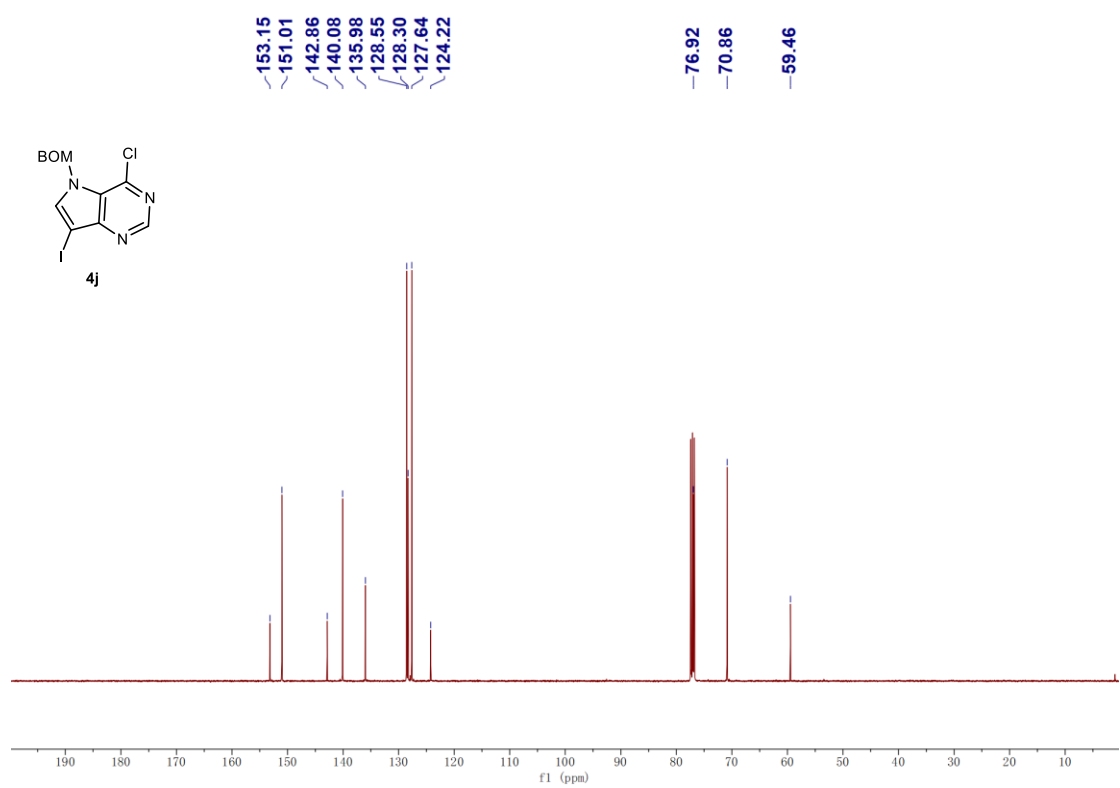
Supplementary Figure 26. ¹H NMR (400 MHz, CDCl₃) of compound **4i**.



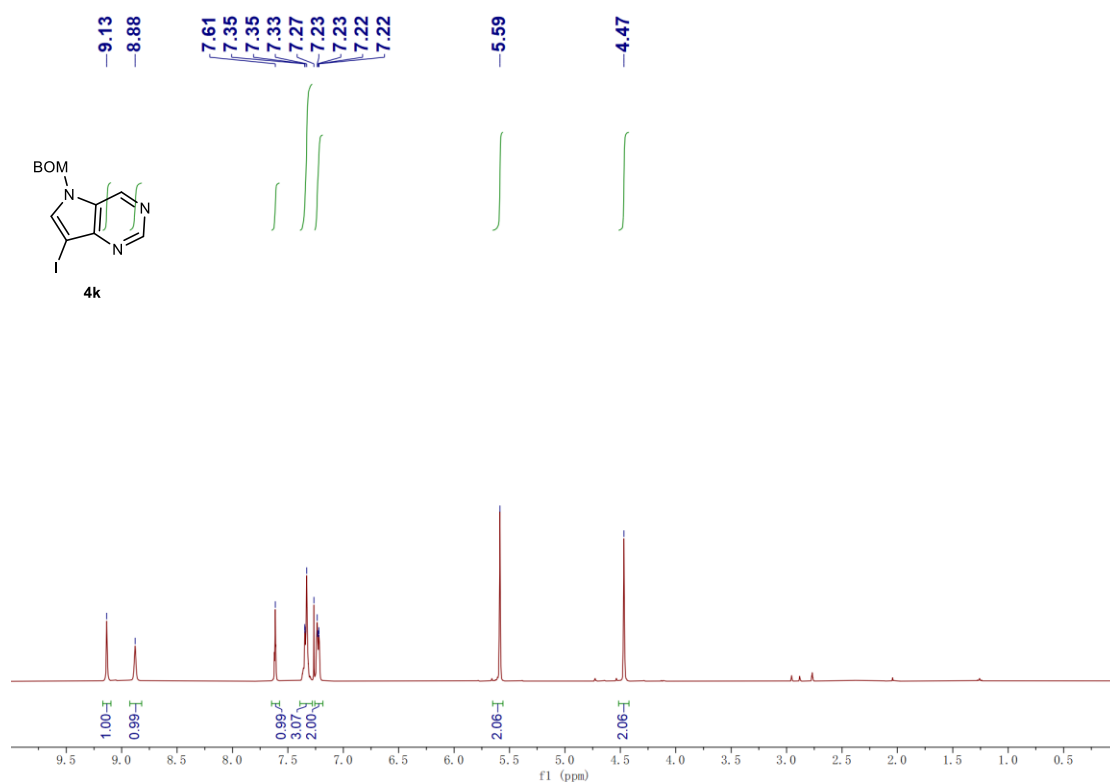
Supplementary Figure 27. ¹³C NMR (400 MHz, CDCl₃) of compound **4i**.



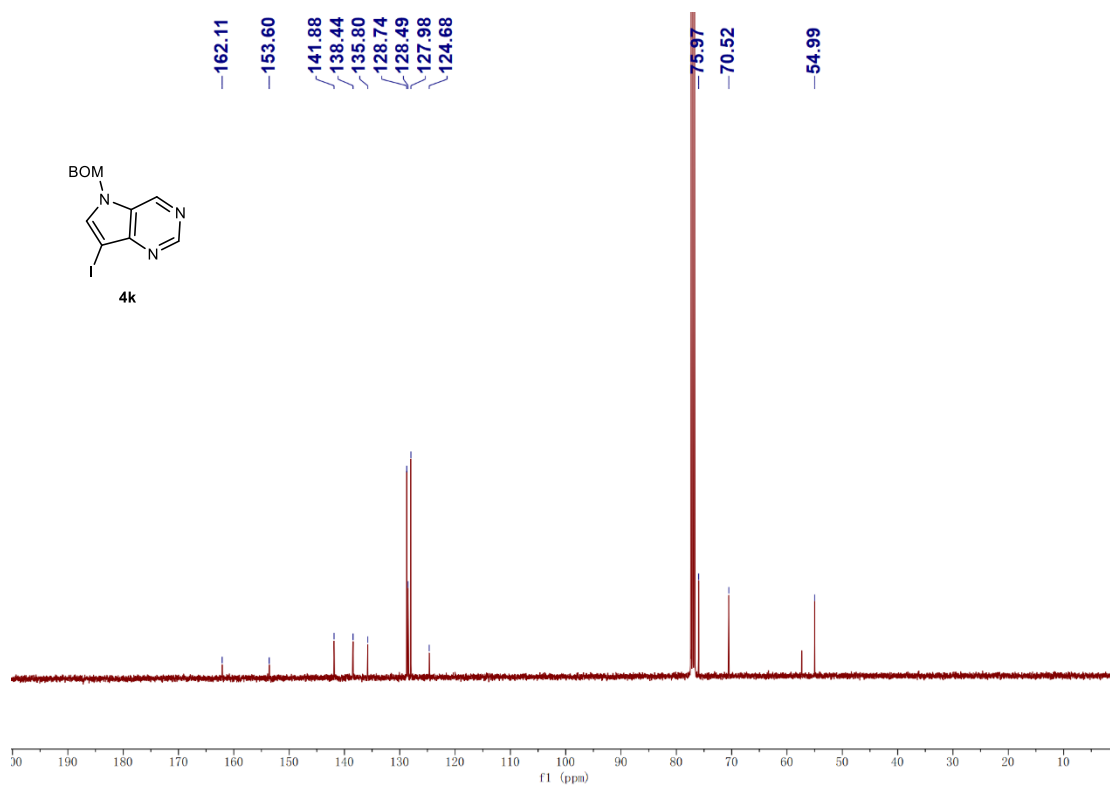
Supplementary Figure 28. ¹H NMR (400 MHz, CDCl₃) of compound **4j**.



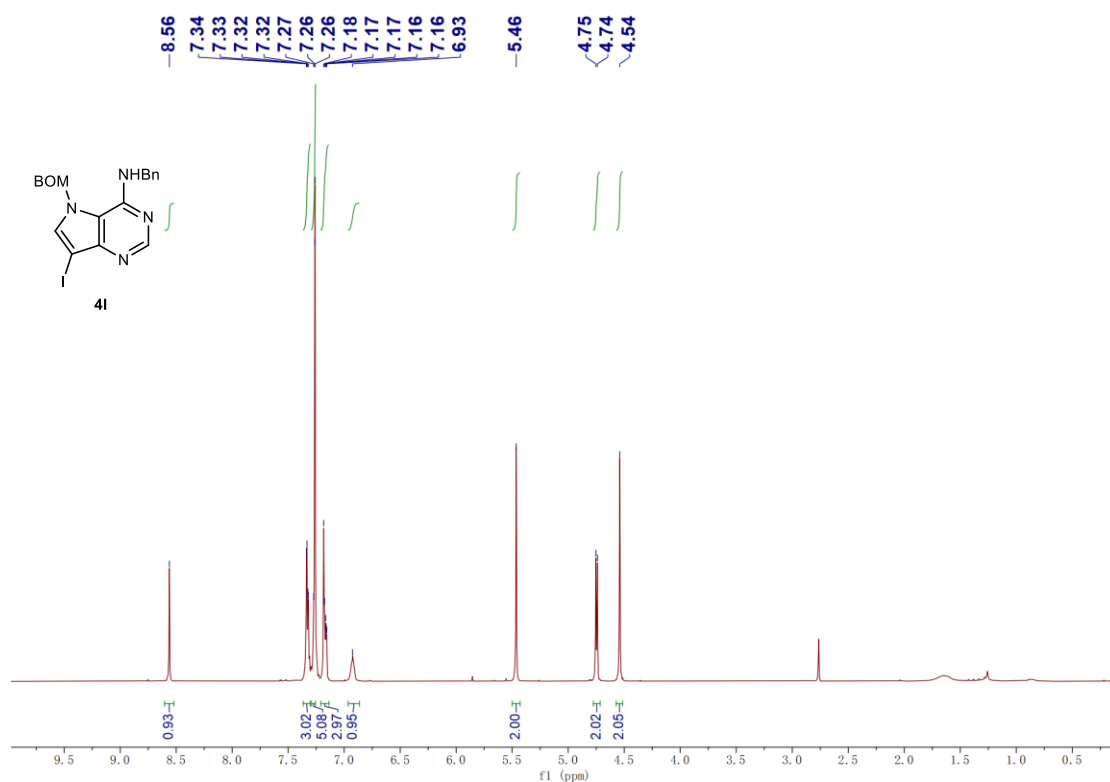
Supplementary Figure 29. ¹³C NMR (100 MHz, CDCl₃) of compound **4j**.



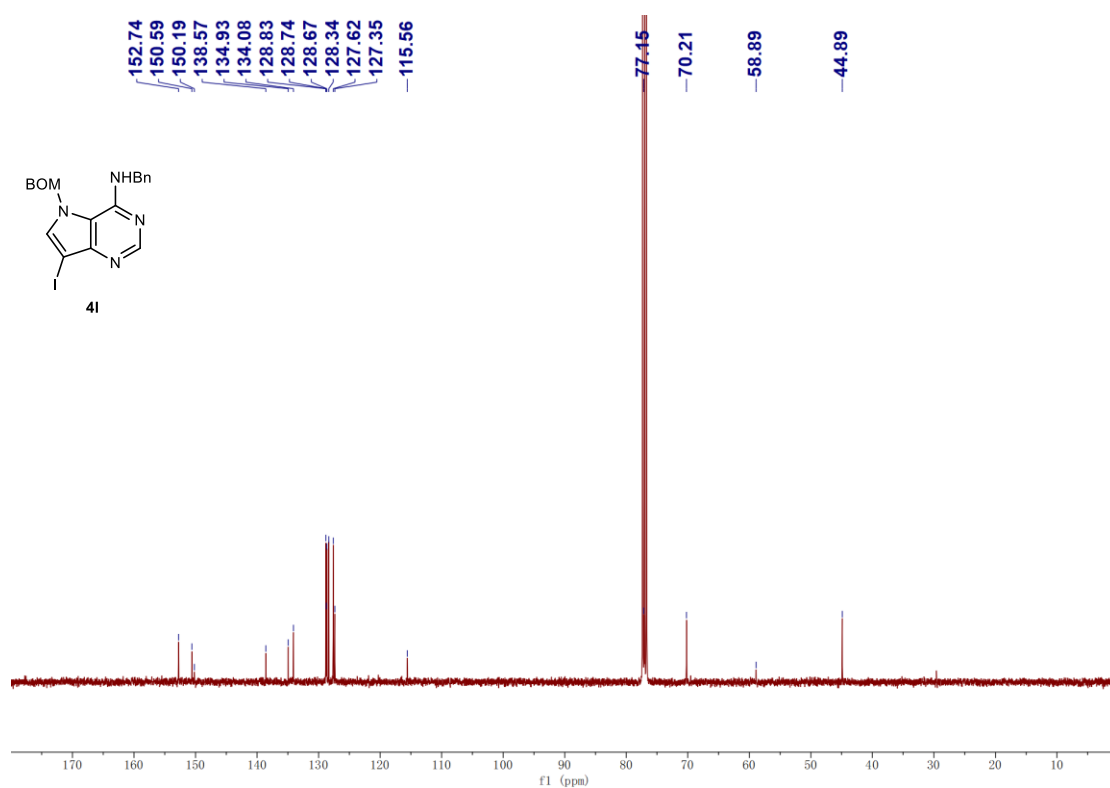
Supplementary Figure 30. ¹H NMR (400 MHz, CDCl₃) of compound **4k**.



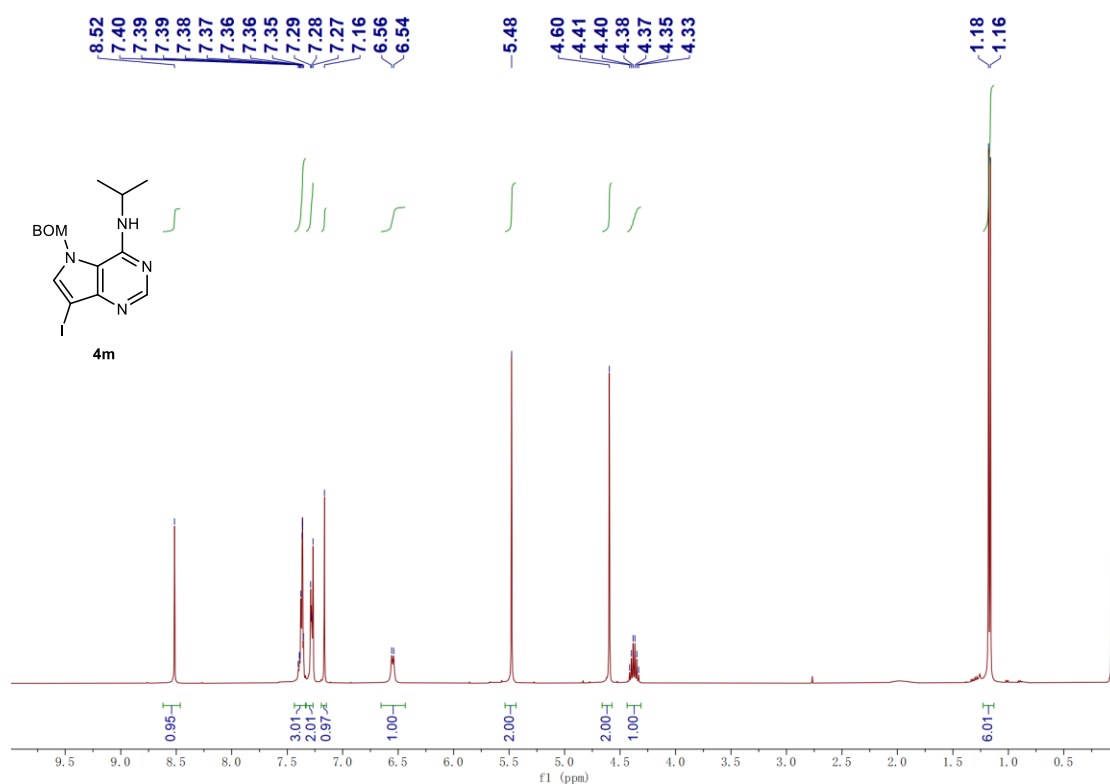
Supplementary Figure 31. ¹³C NMR (100 MHz, CDCl₃) of compound **4k**.



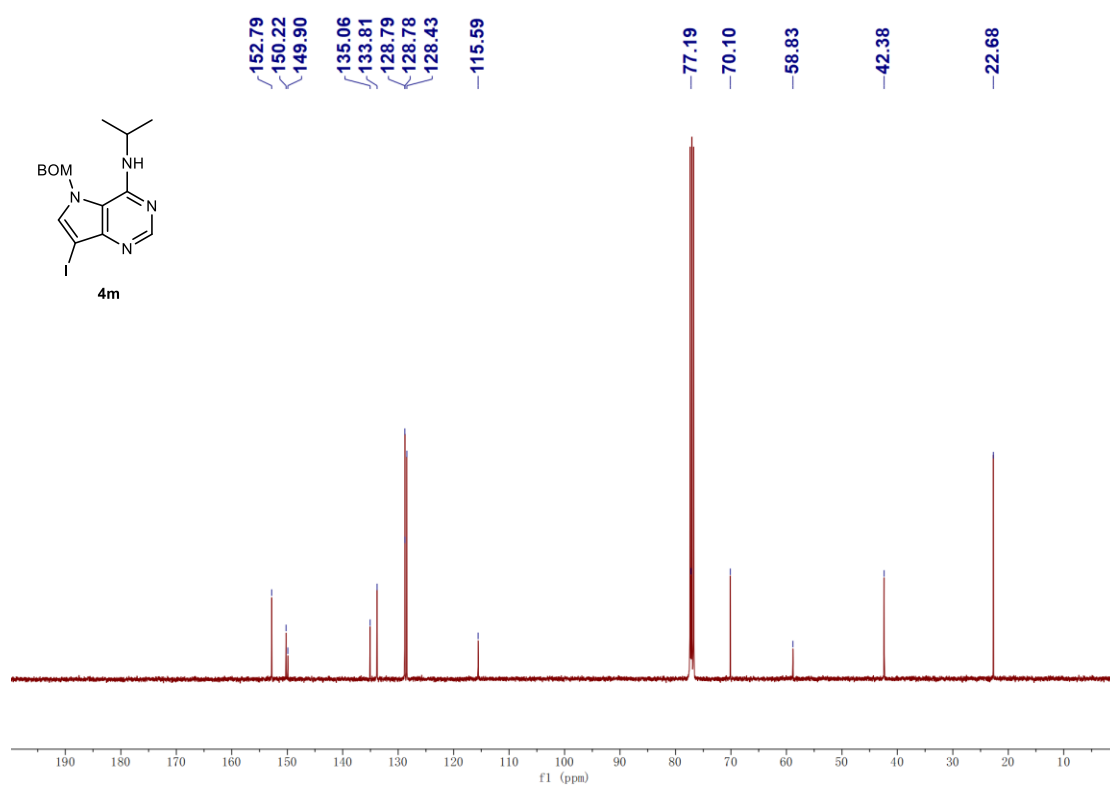
Supplementary Figure 32. ¹H NMR (400 MHz, CDCl₃) of compound **4I**.



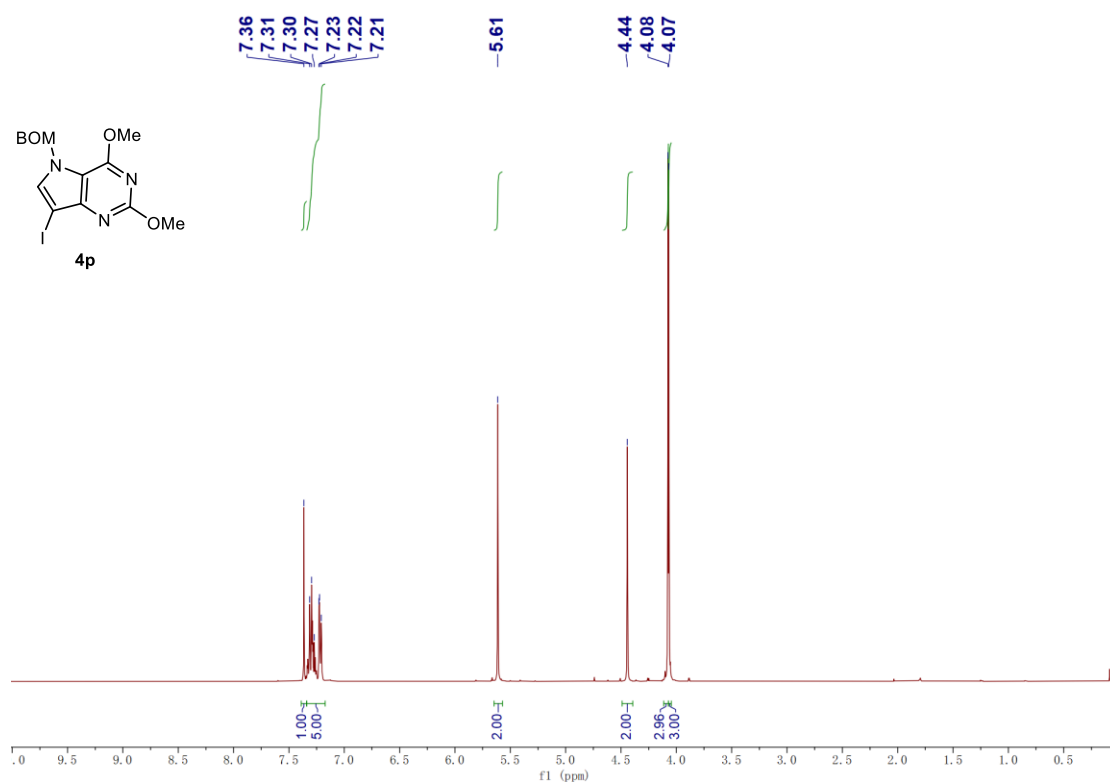
Supplementary Figure 33. ¹³C NMR (100 MHz, CDCl₃) of compound **4I**.



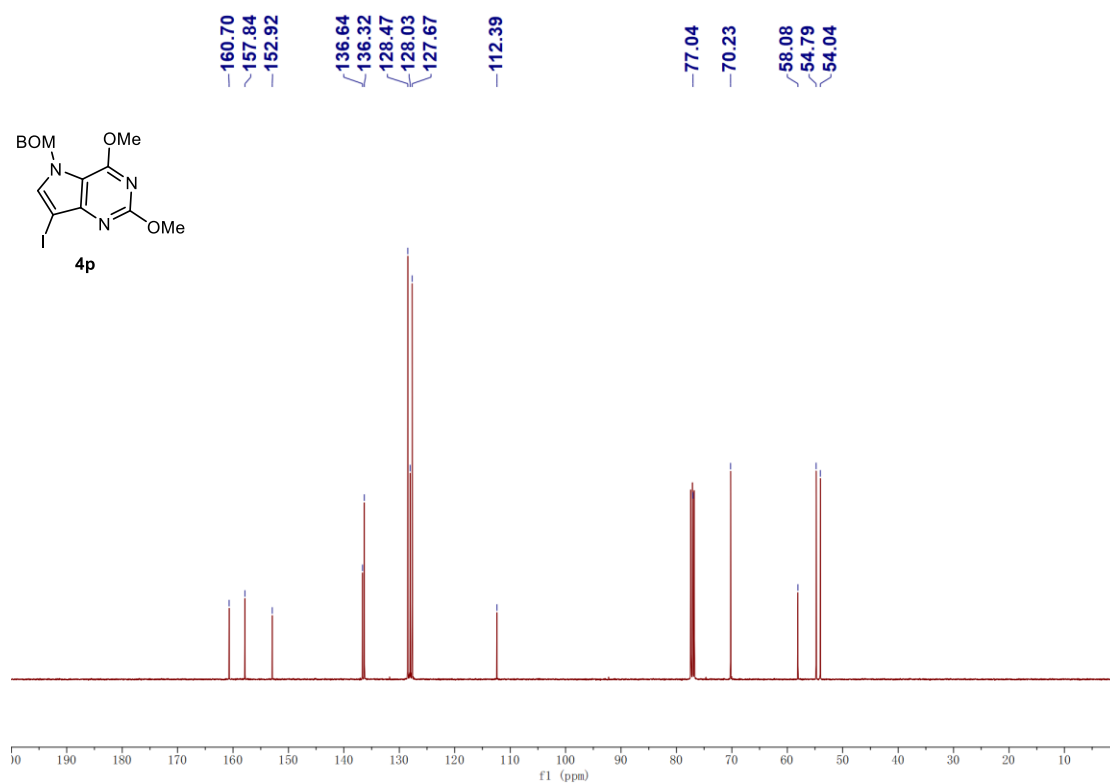
Supplementary Figure 34. ¹H NMR (400 MHz, CDCl₃) of compound **4m**.



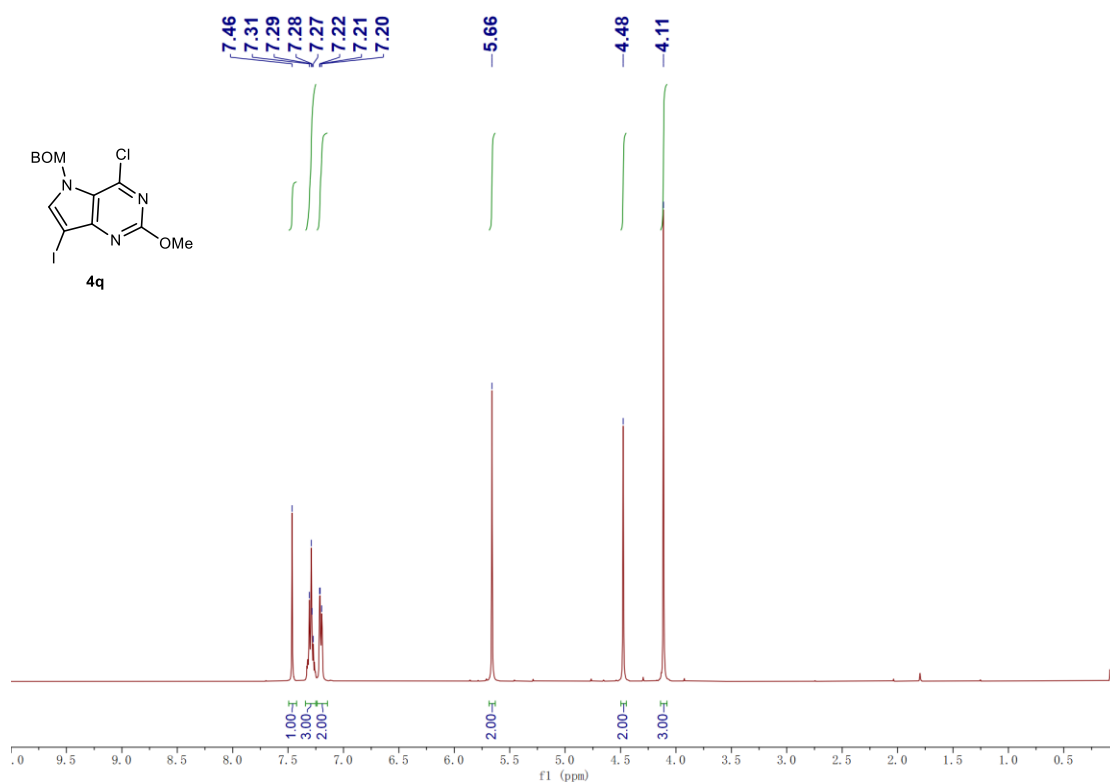
Supplementary Figure 35. ¹³C NMR (100 MHz, CDCl₃) of compound **4m**.



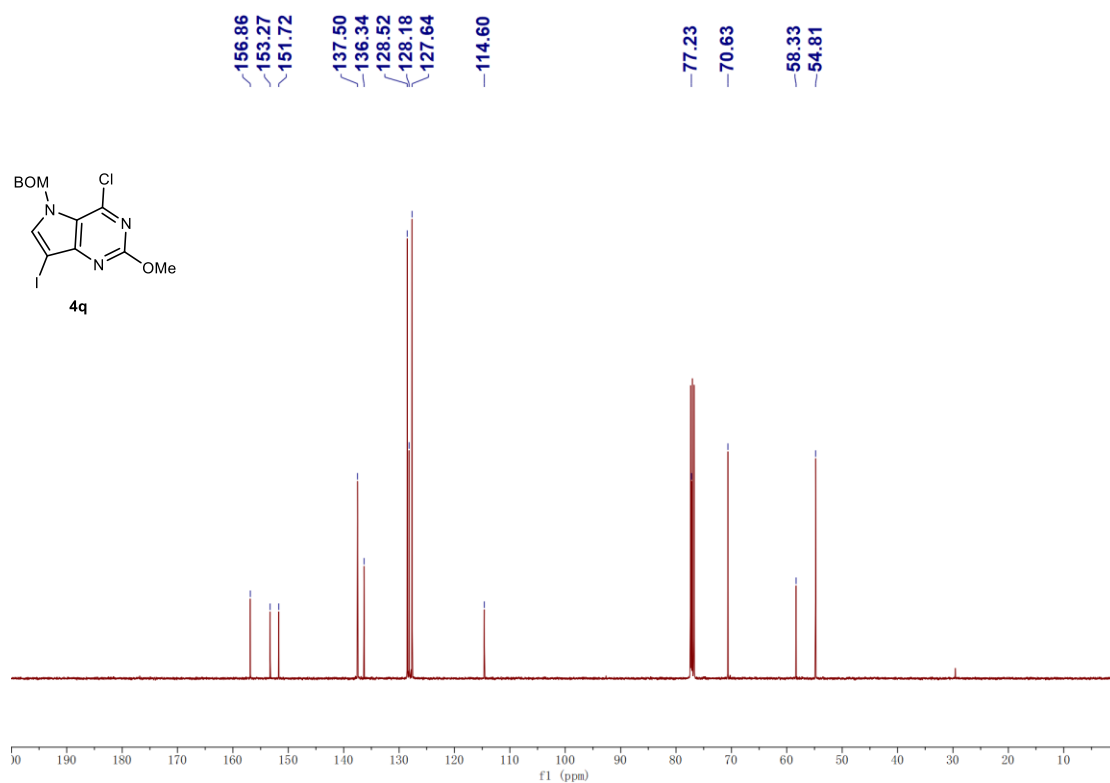
Supplementary Figure 36. ¹H NMR (400 MHz, CDCl₃) of compound **4p**.



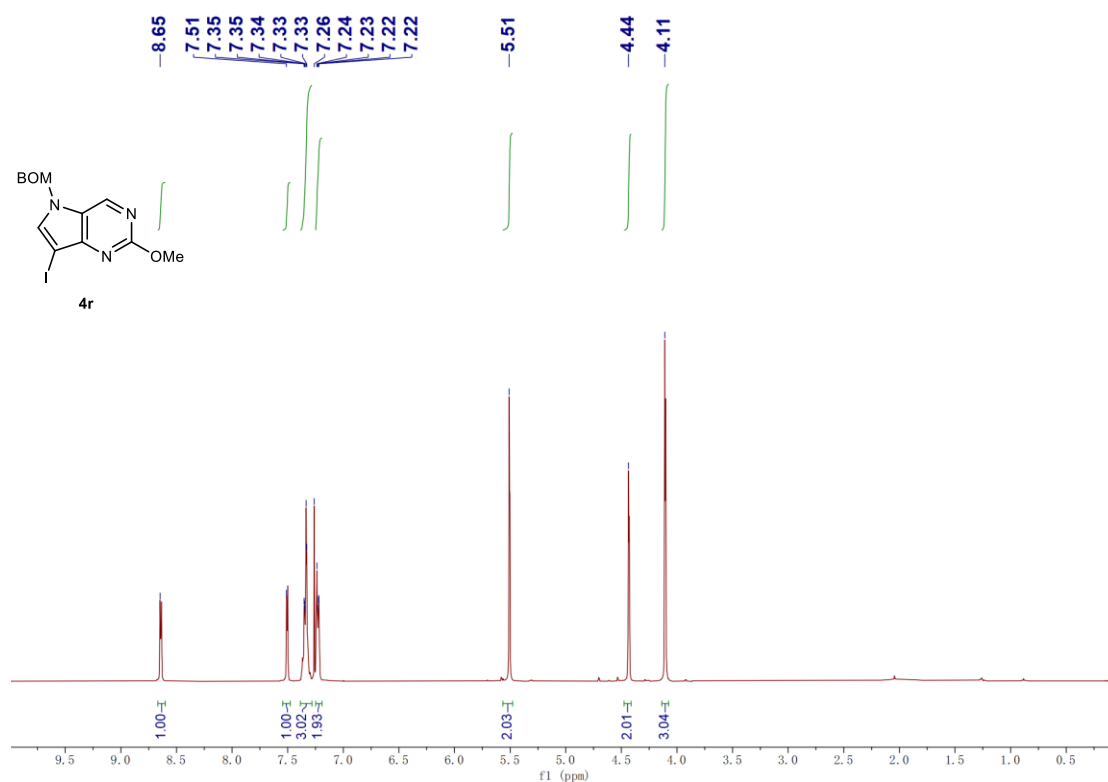
Supplementary Figure 37. ¹³C NMR (100 MHz, CDCl₃) of compound **4p**.



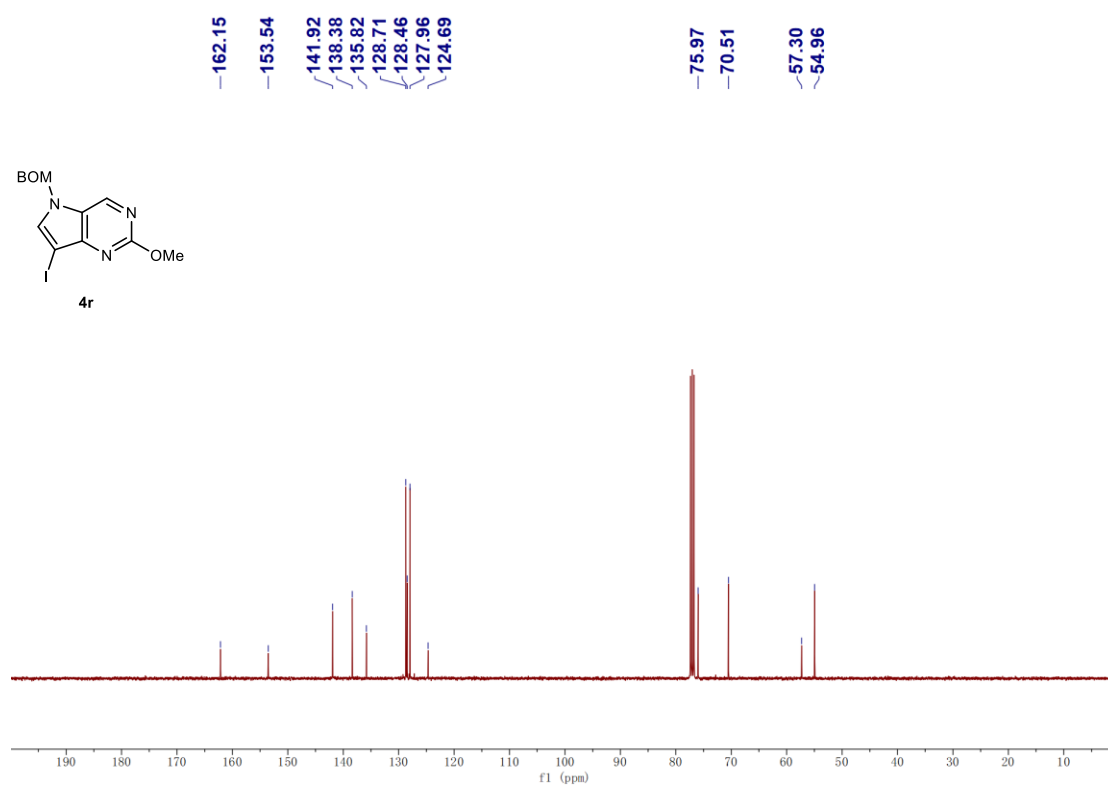
Supplementary Figure 38. ¹H NMR (400 MHz, CDCl₃) of compound **4q**.



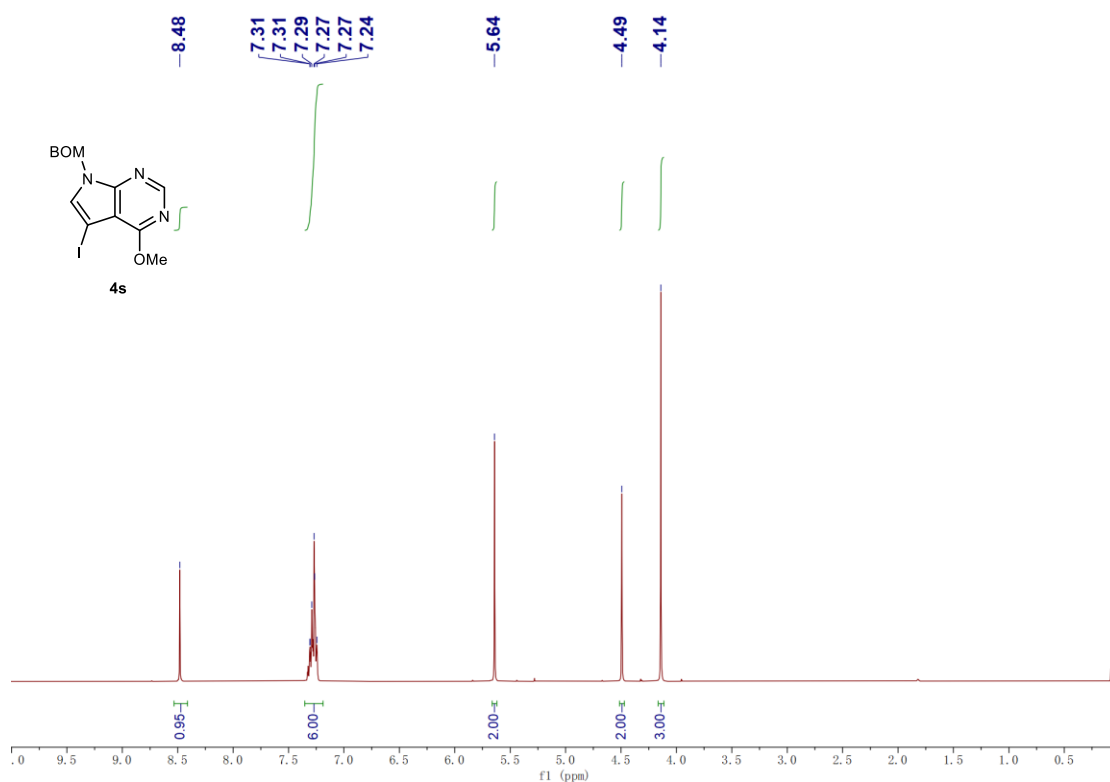
Supplementary Figure 39. ¹³C NMR (100 MHz, CDCl₃) of compound **4q**.



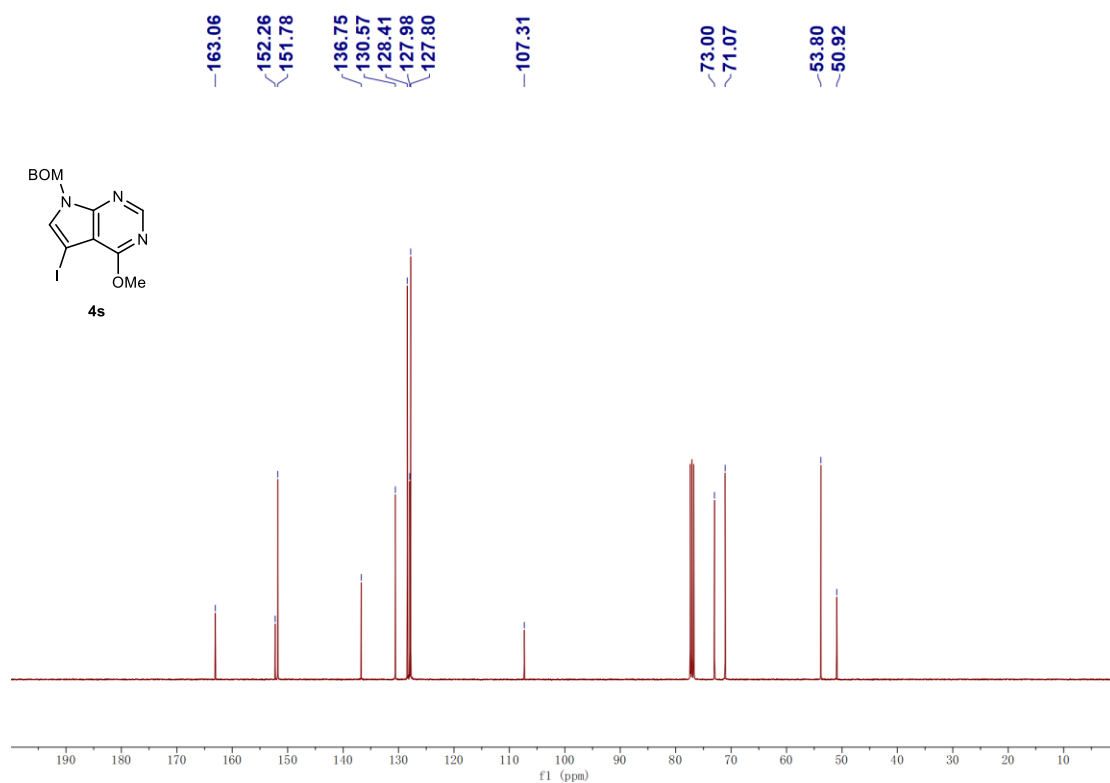
Supplementary Figure 40. ^1H NMR (400 MHz, CDCl_3) of compound **4r**.



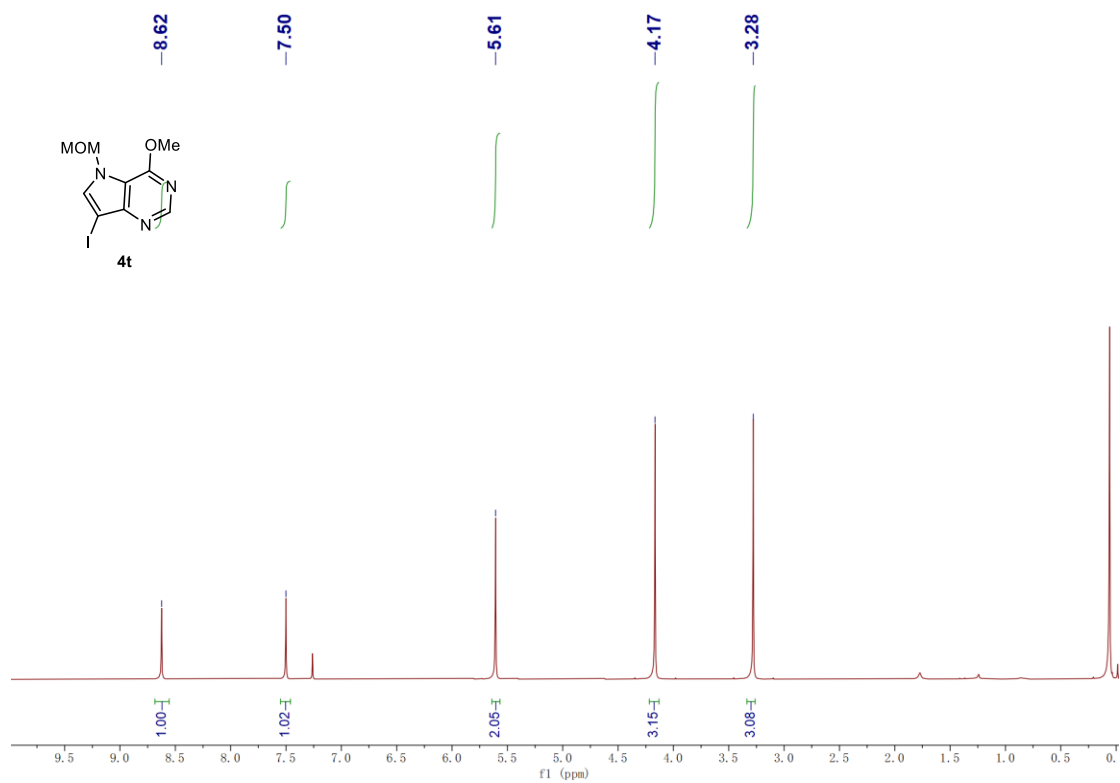
Supplementary Figure 41. ^{13}C NMR (100 MHz, CDCl_3) of compound **4r**.



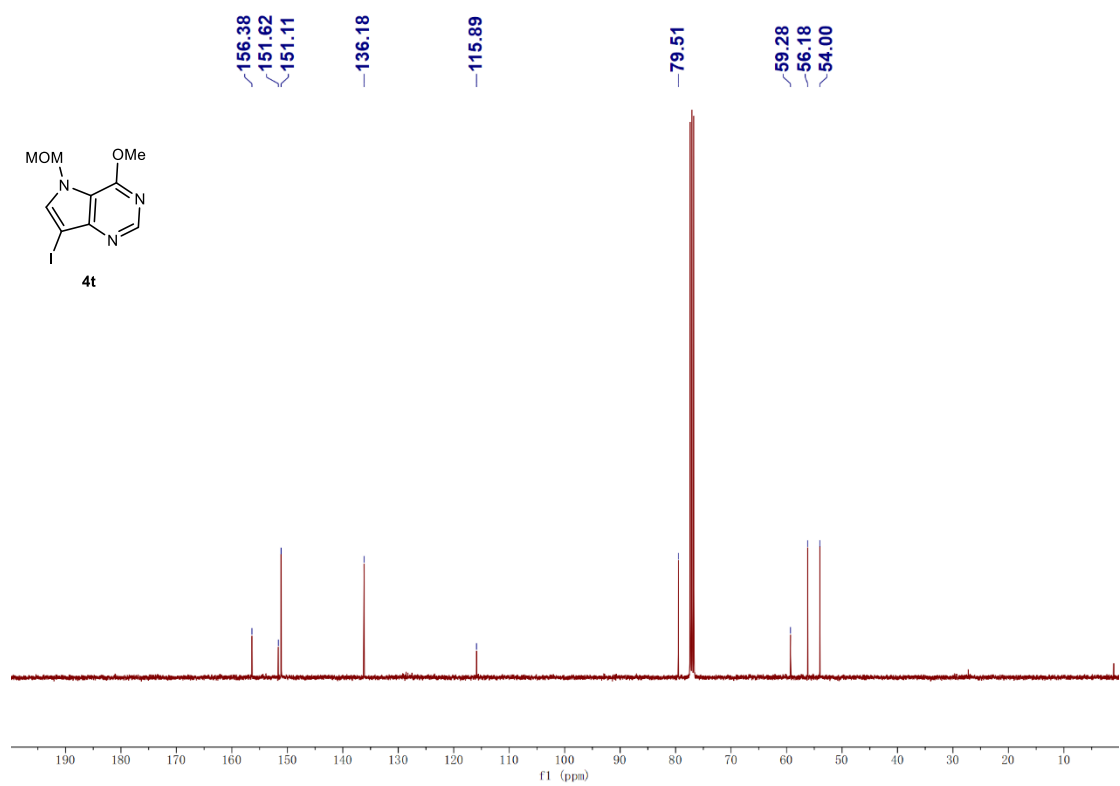
Supplementary Figure 42. ^1H NMR (400 MHz, CDCl_3) of compound **4s**.



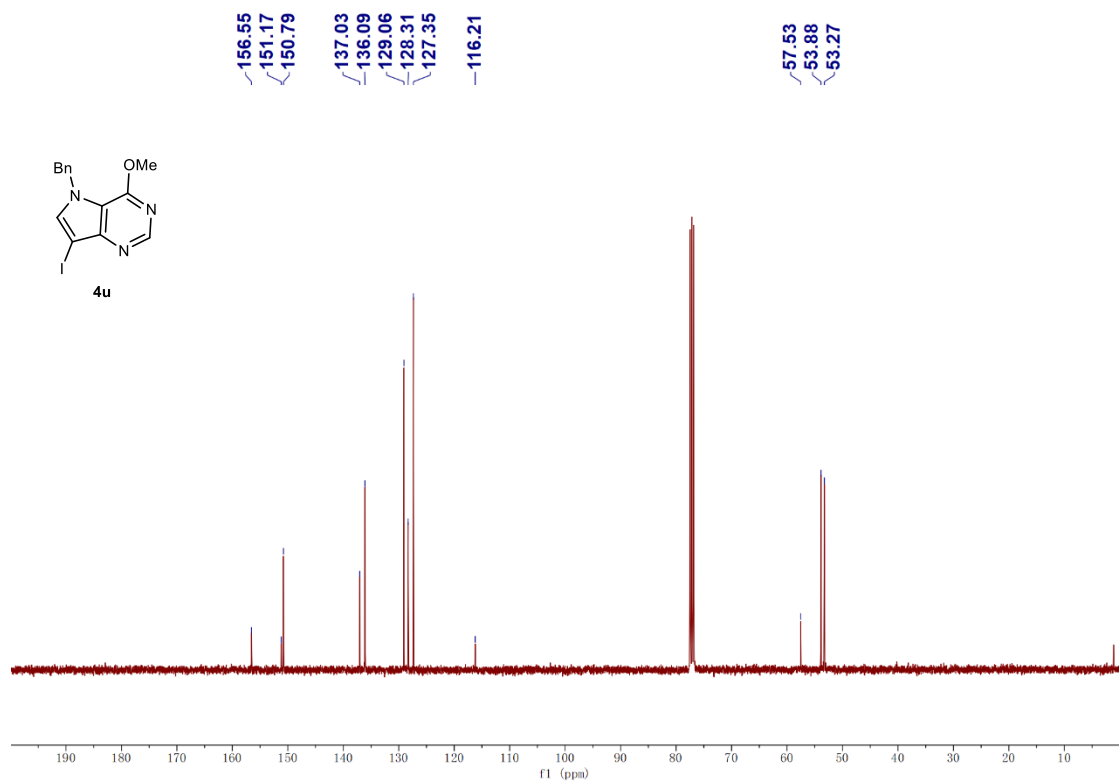
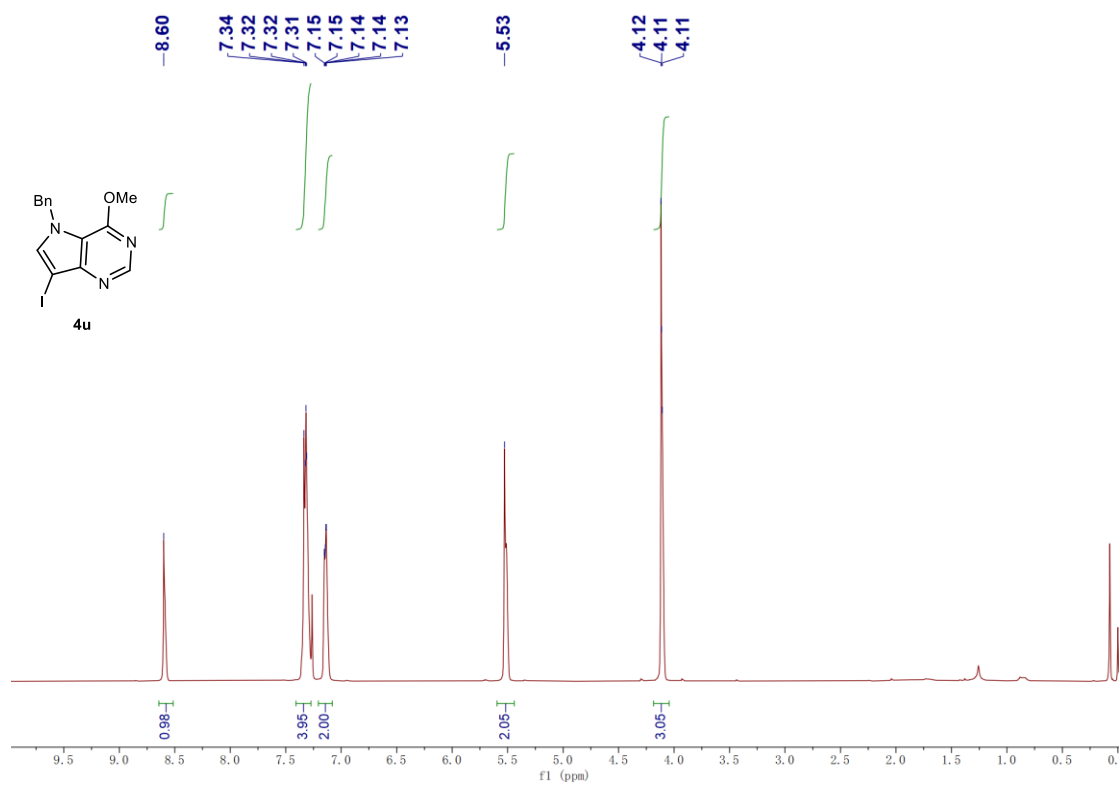
Supplementary Figure 43. ^{13}C NMR (100 MHz, CDCl_3) of compound **4s**.

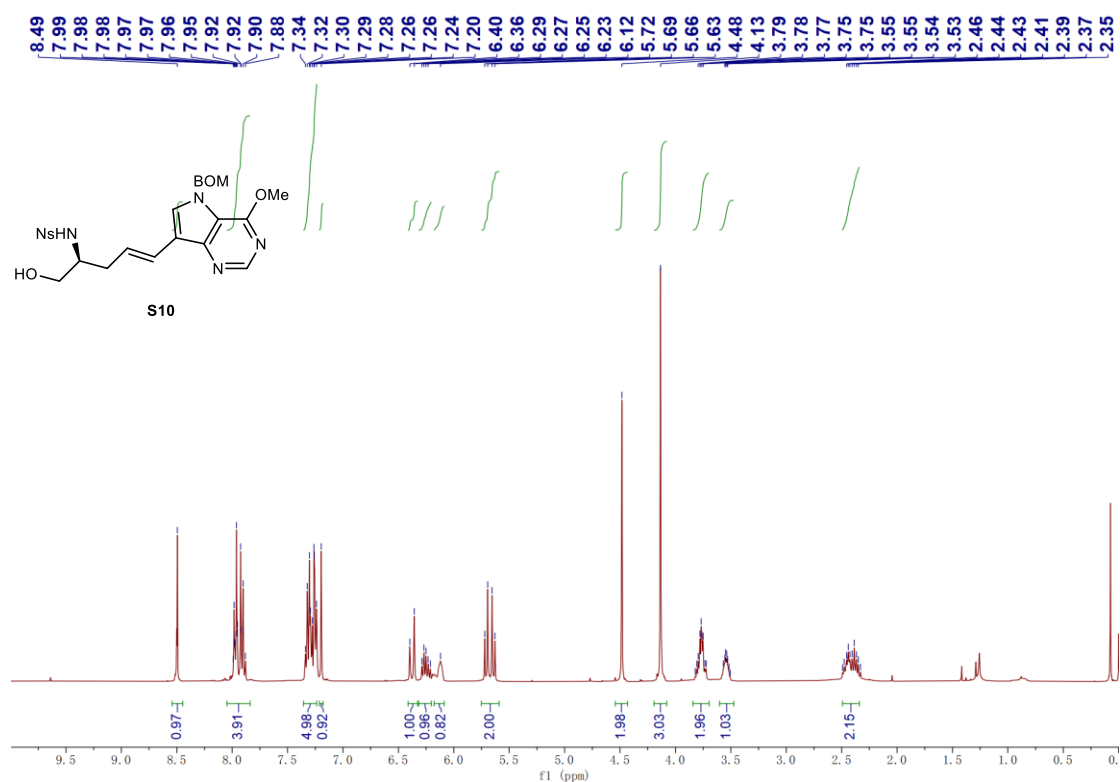


Supplementary Figure 44. ¹H NMR (400 MHz, CDCl₃) of compound **4t**.

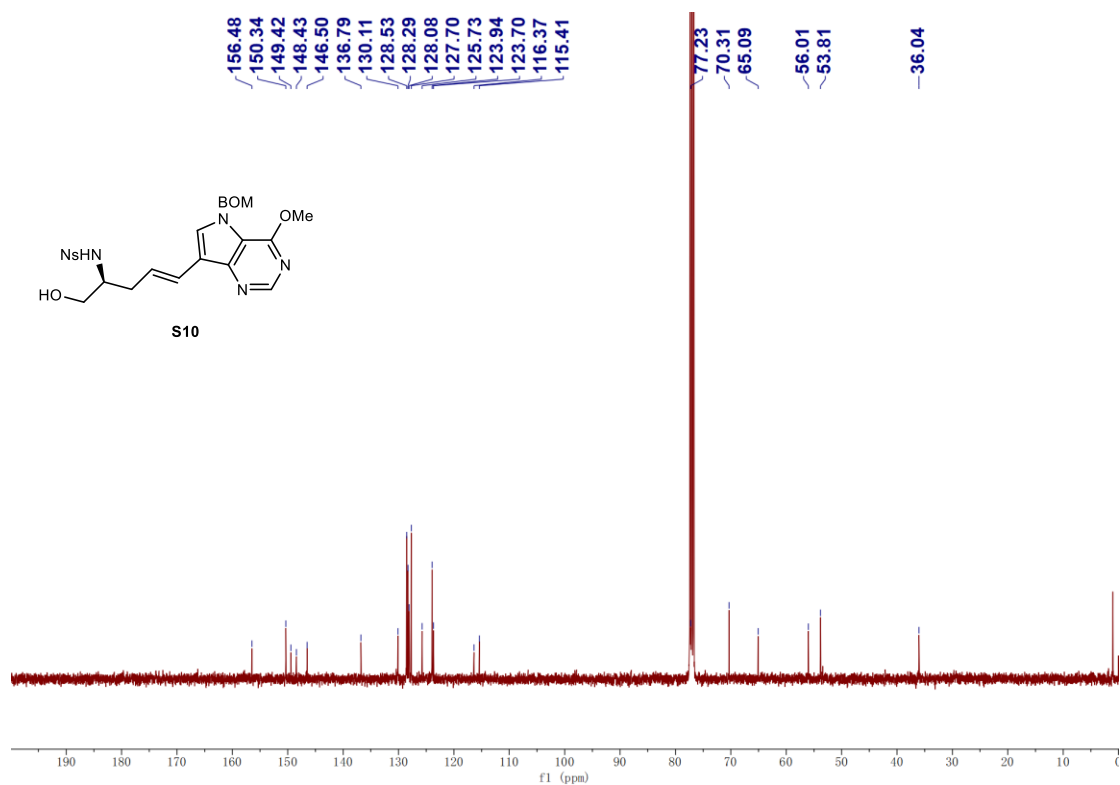


Supplementary Figure 45. ¹³C NMR (100 MHz, CDCl₃) of compound **4t**.

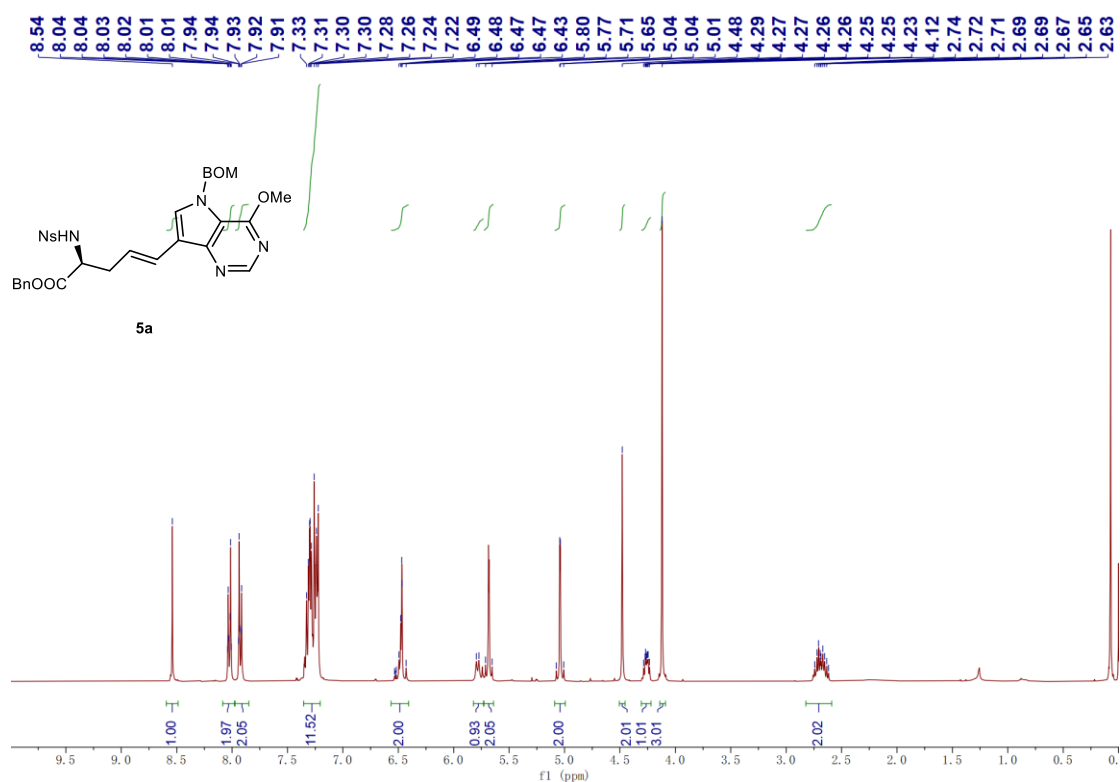




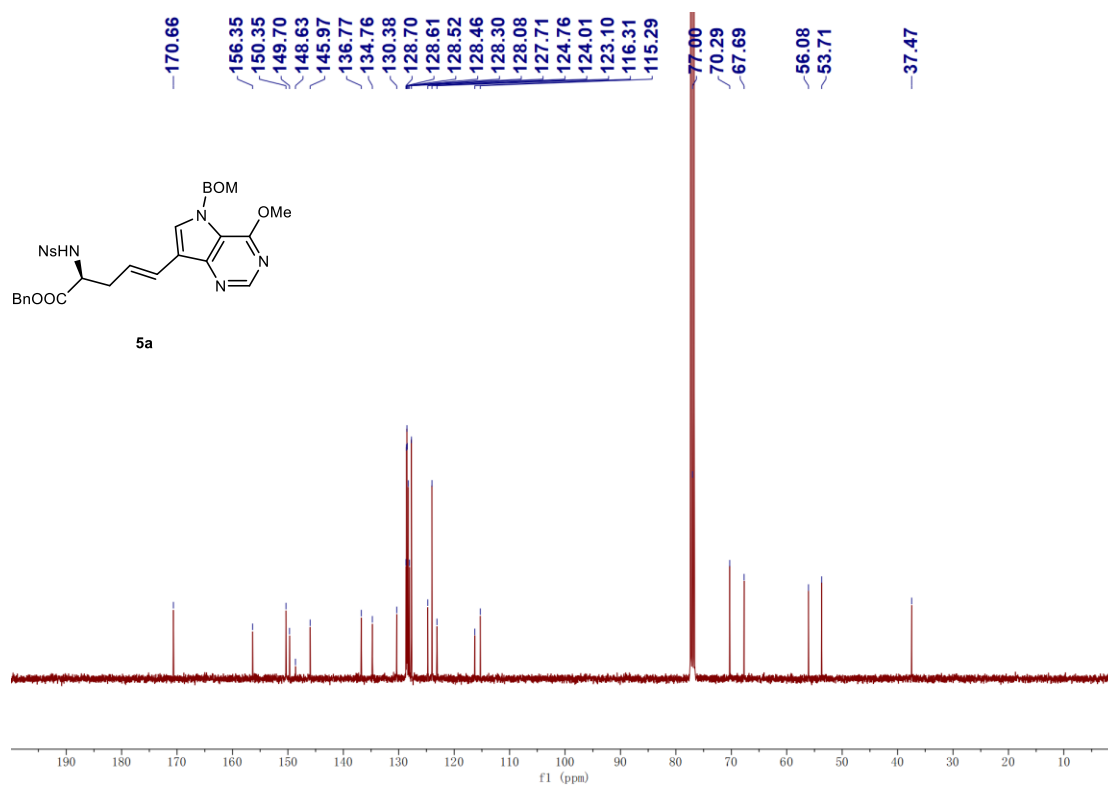
Supplementary Figure 48. ¹H NMR (400 MHz, CDCl₃) of compound S10.



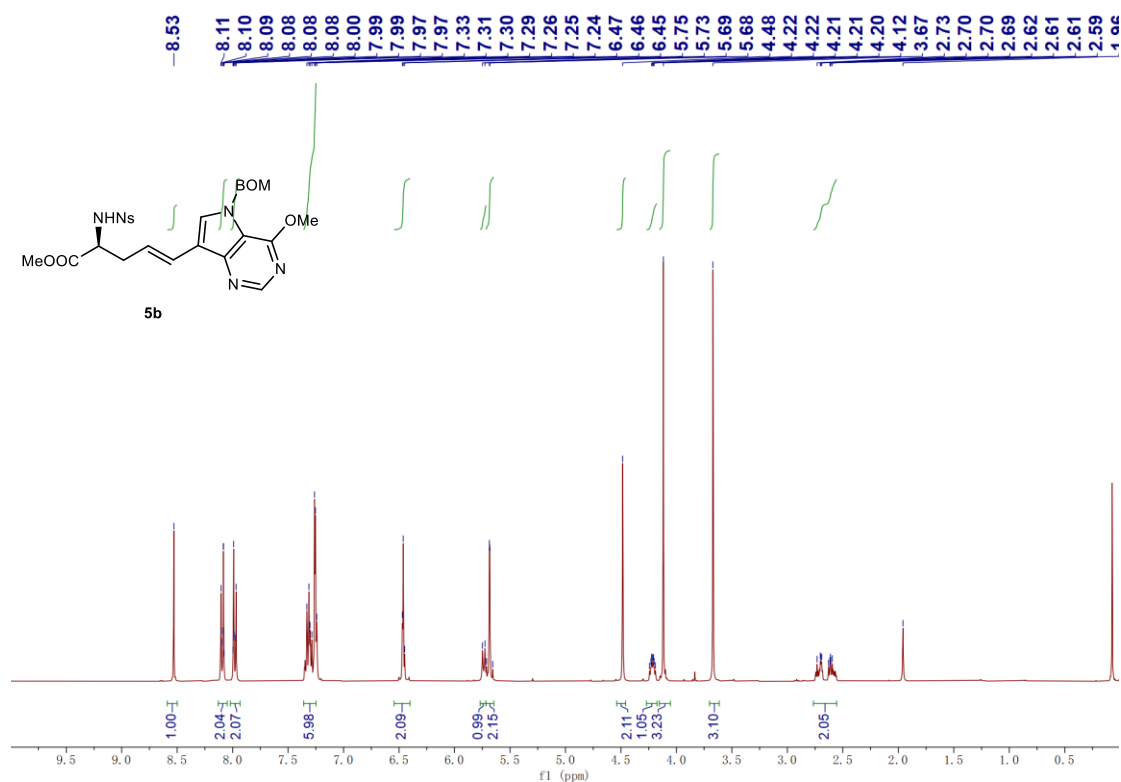
Supplementary Figure 49. ¹³C NMR (100 MHz, CDCl₃) of compound S10.



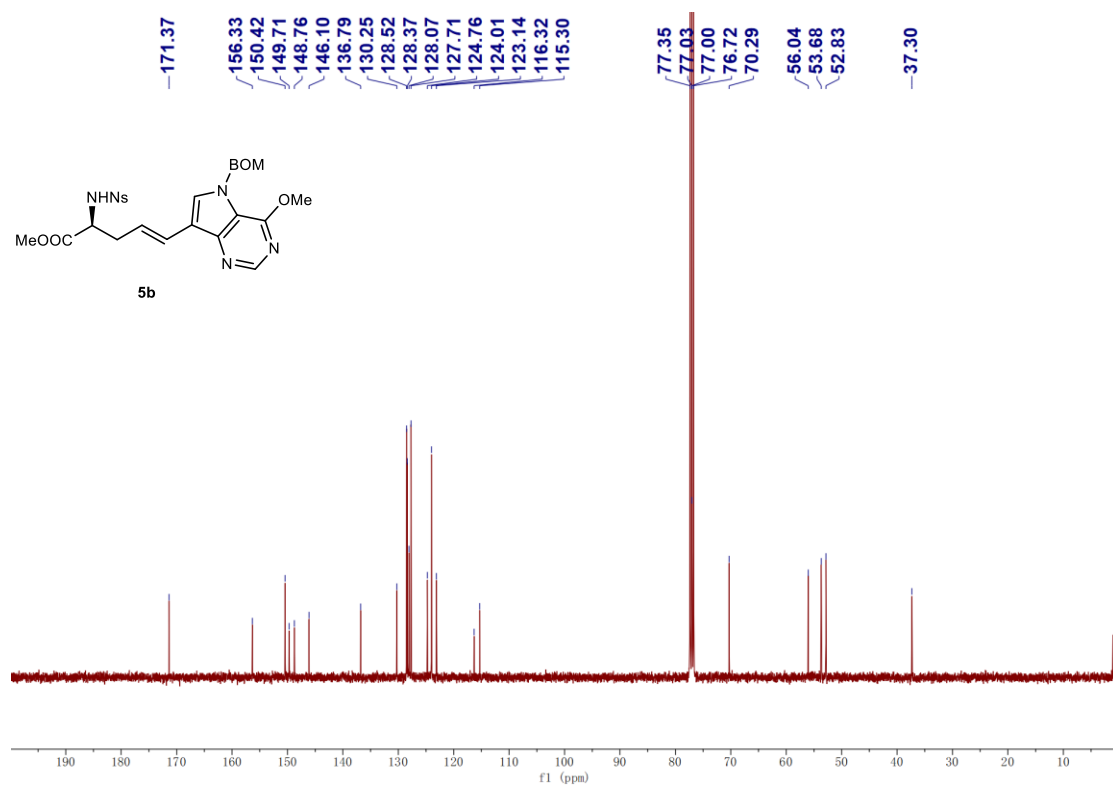
Supplementary Figure 50. ¹H NMR (400 MHz, CDCl₃) of compound **5a**.



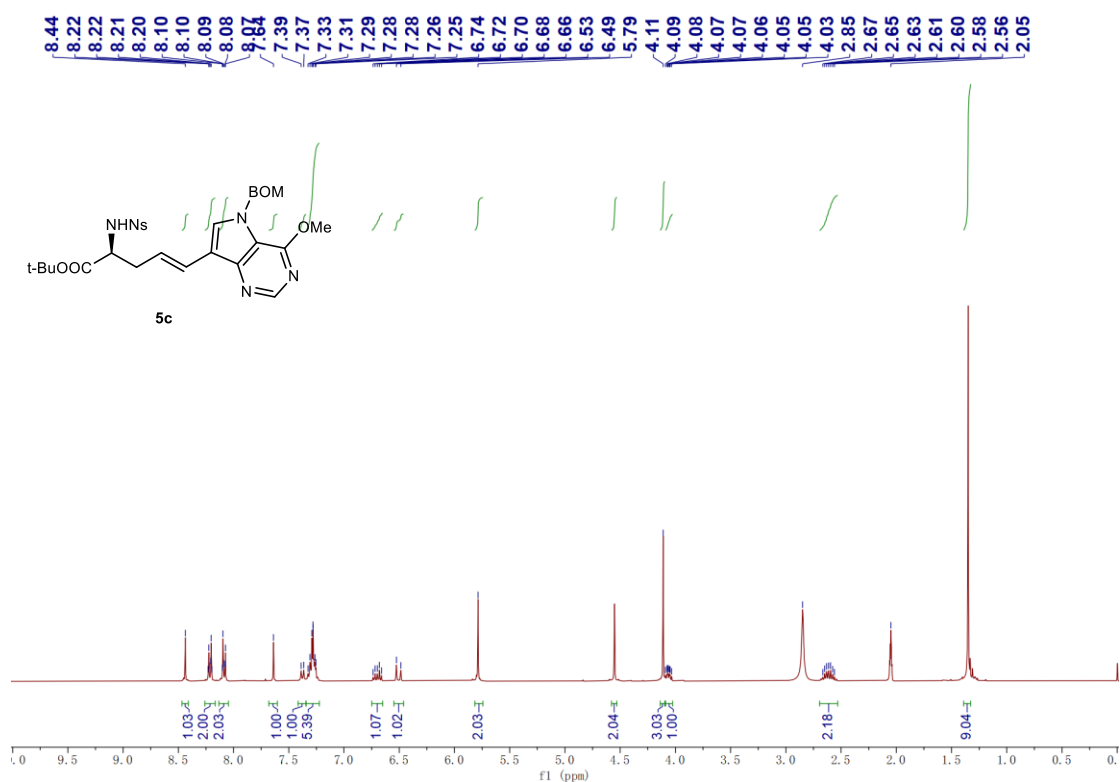
Supplementary Figure 51. ¹³C NMR (100 MHz, CDCl₃) of compound **5a**.



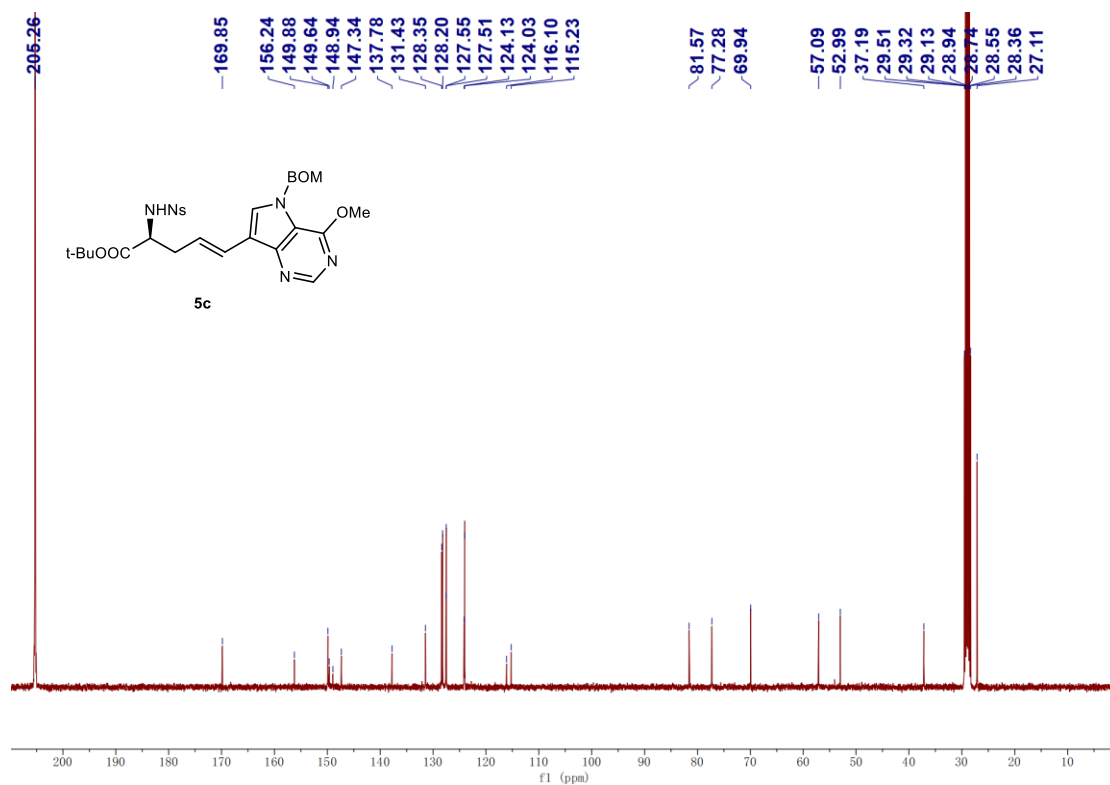
Supplementary Figure 52. ¹H NMR (400 MHz, CDCl₃) of compound **5b**.



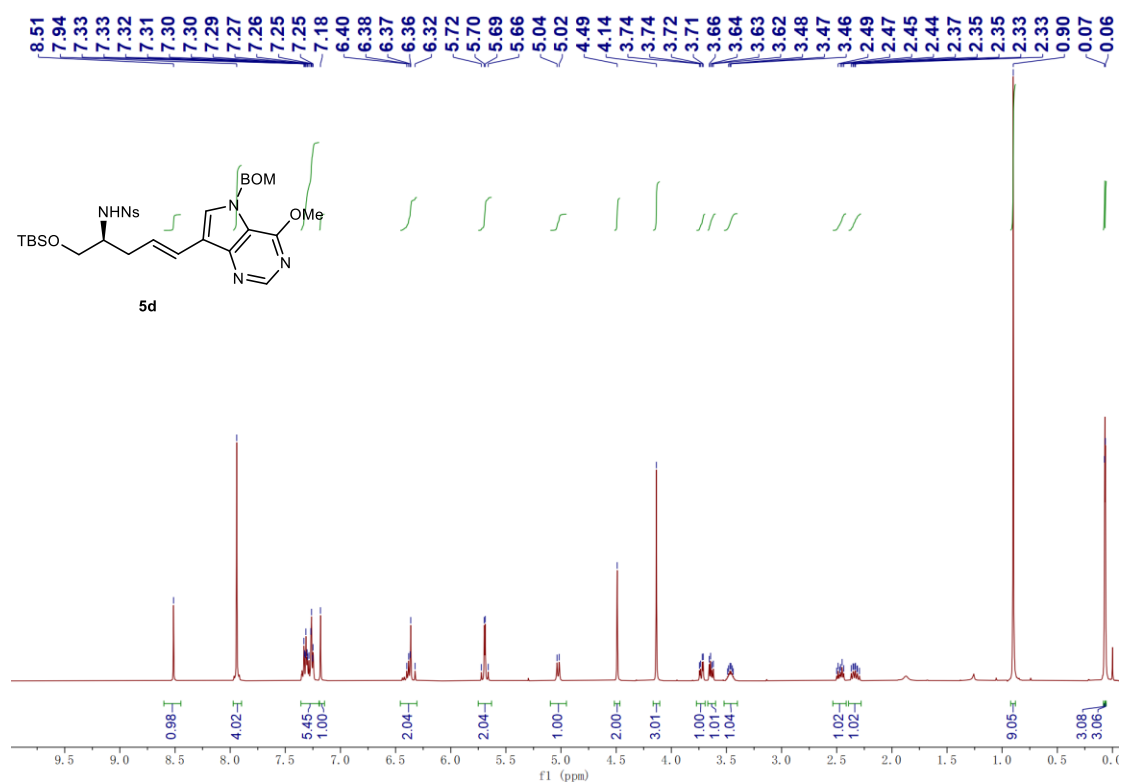
Supplementary Figure 53. ¹³C NMR (100 MHz, CDCl₃) of compound **5b**.



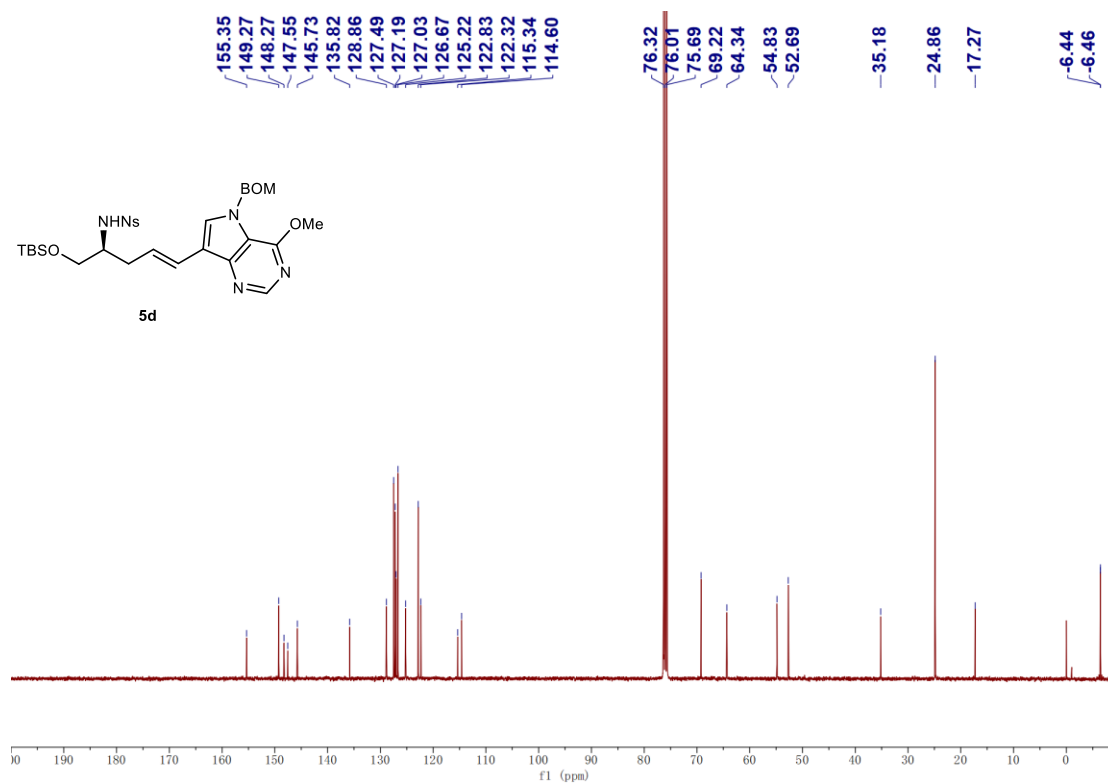
Supplementary Figure 54. ¹H NMR (400 MHz, Acetone) of compound **5c**.



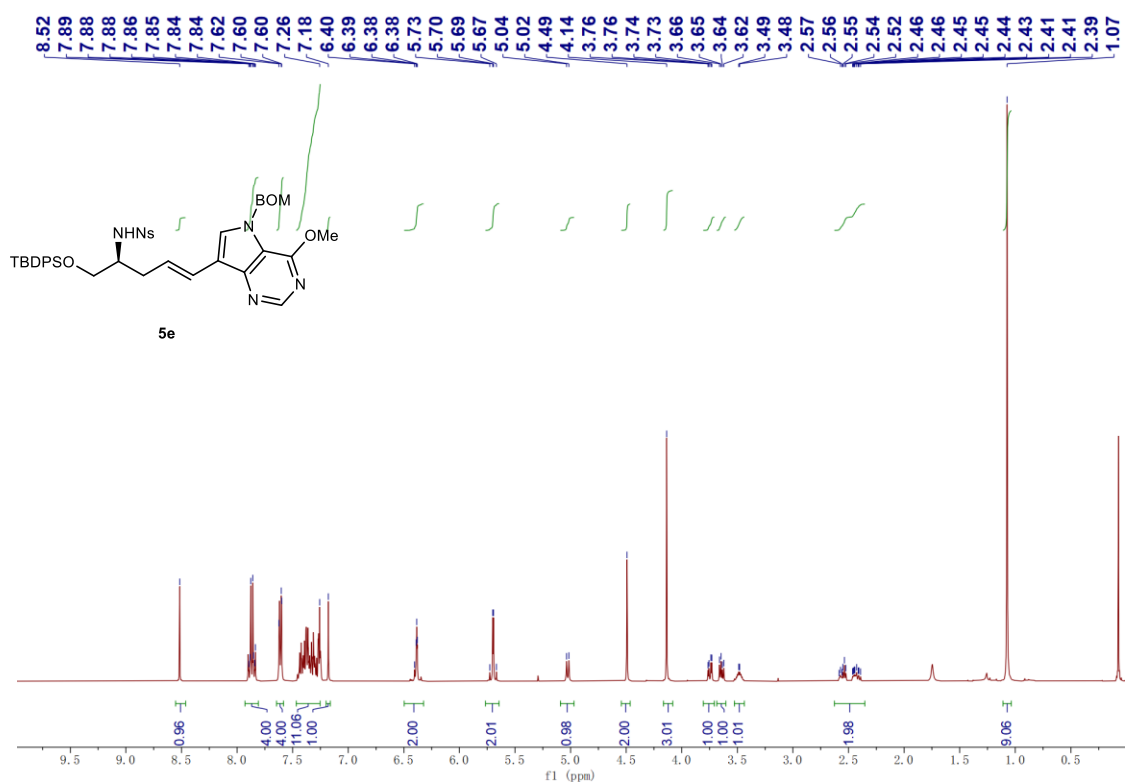
Supplementary Figure 55. ¹³C NMR (100 MHz, Acetone) of compound **5c**.



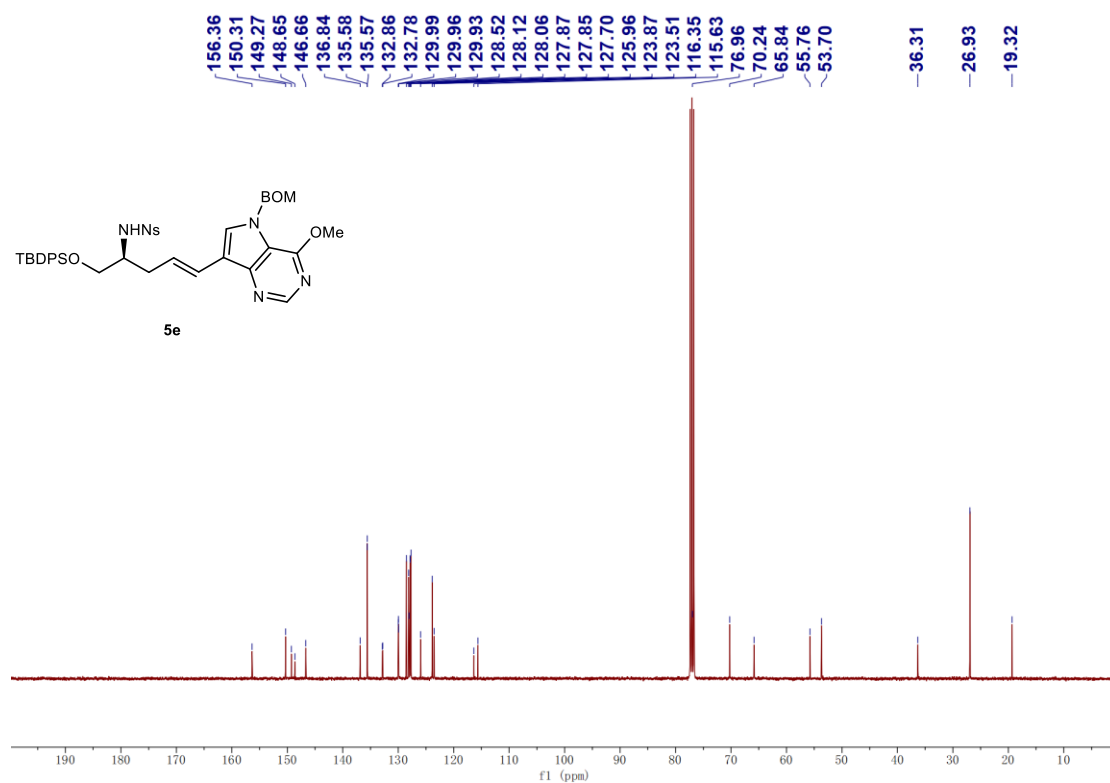
Supplementary Figure 56. ¹H NMR (400 MHz, CDCl₃) of compound **5d**.



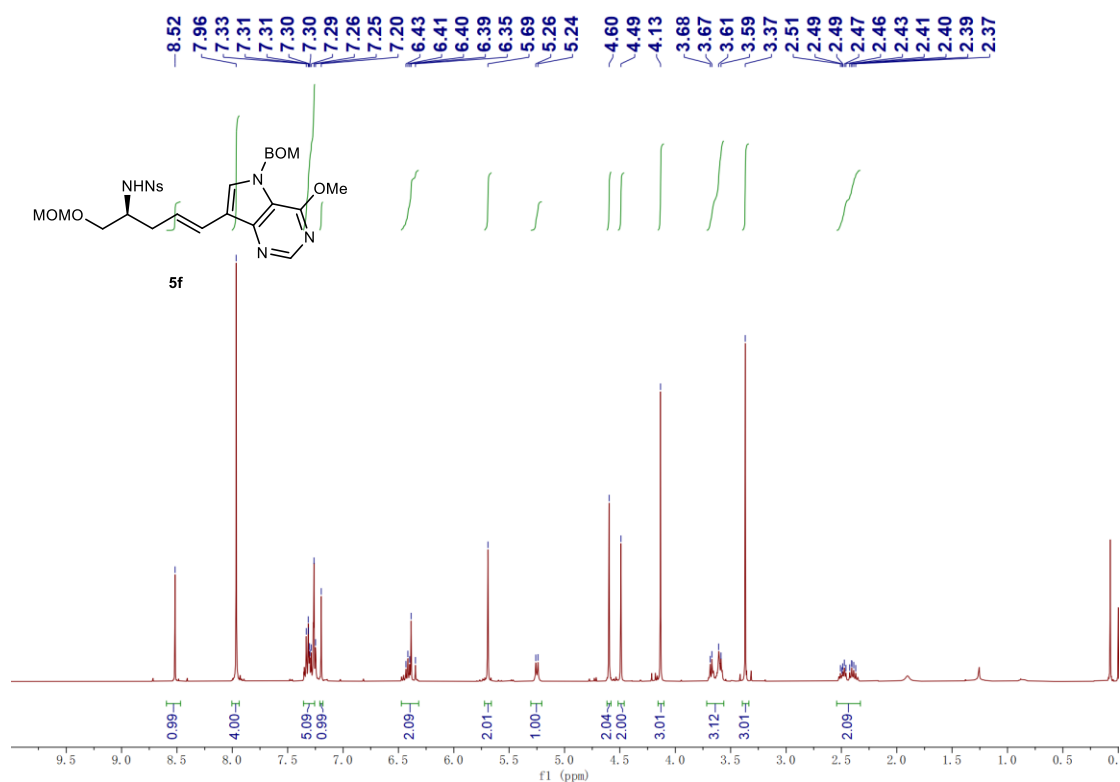
Supplementary Figure 57. ¹³C NMR (100 MHz, CDCl₃) of compound **5d**.



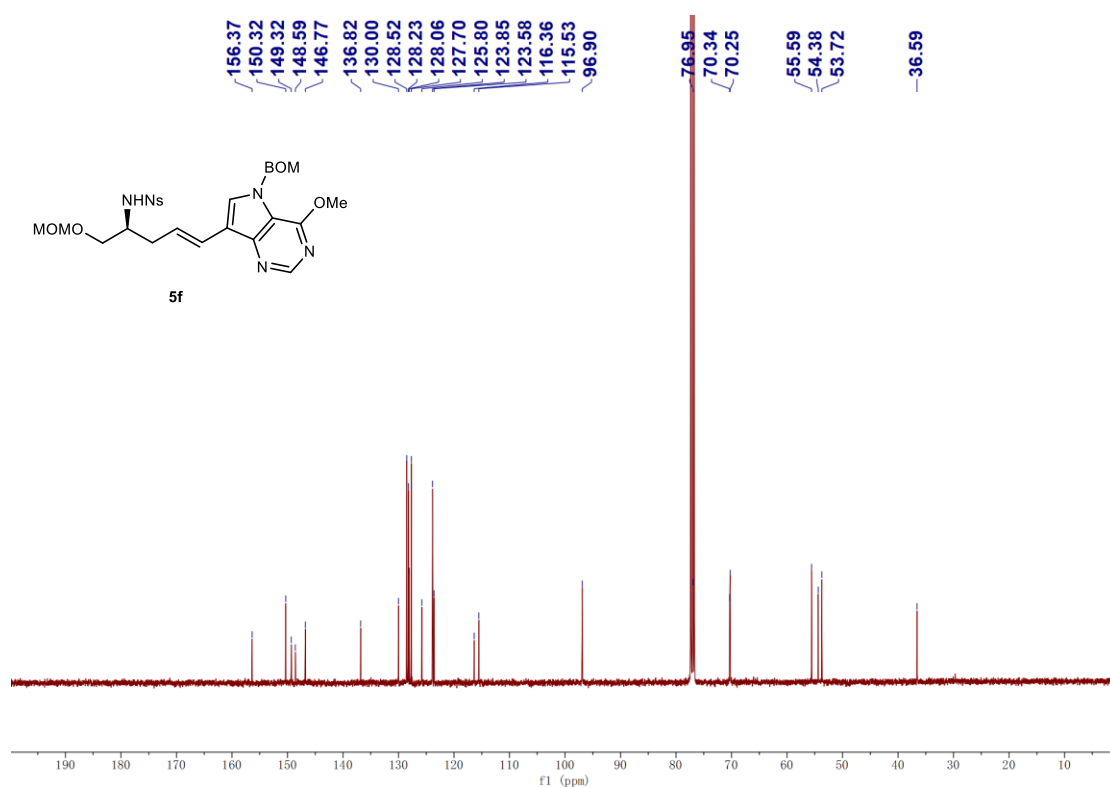
Supplementary Figure 58. ¹H NMR (400 MHz, CDCl₃) of compound **5e**.



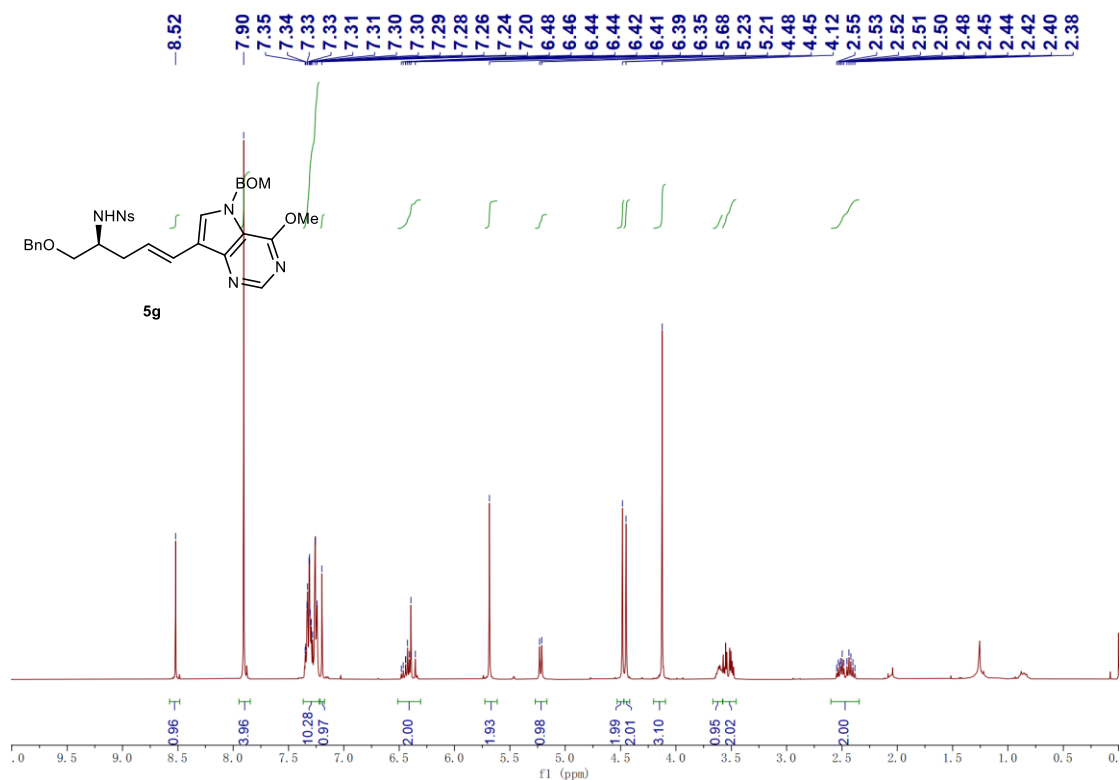
Supplementary Figure 59. ¹³C NMR (100 MHz, CDCl₃) of compound **5e**.



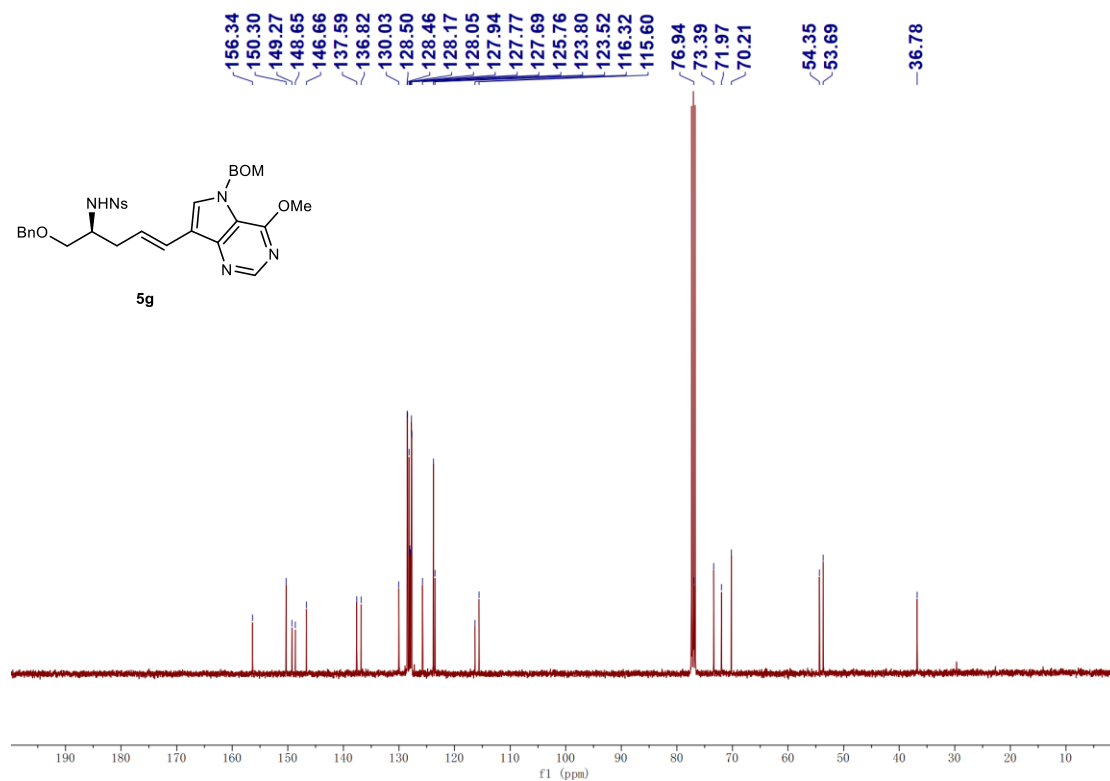
Supplementary Figure 60. ¹H NMR (400 MHz, CDCl₃) of compound **5f**.



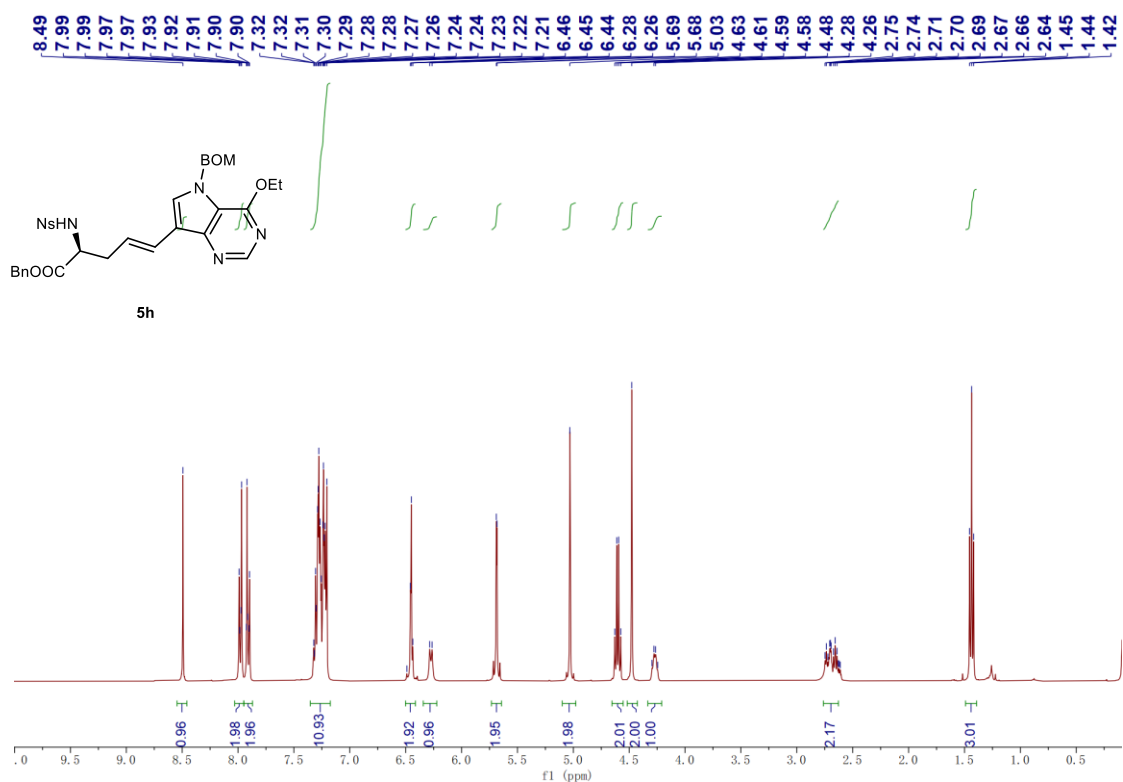
Supplementary Figure 61. ¹³C NMR (100 MHz, CDCl₃) of compound **5f**.



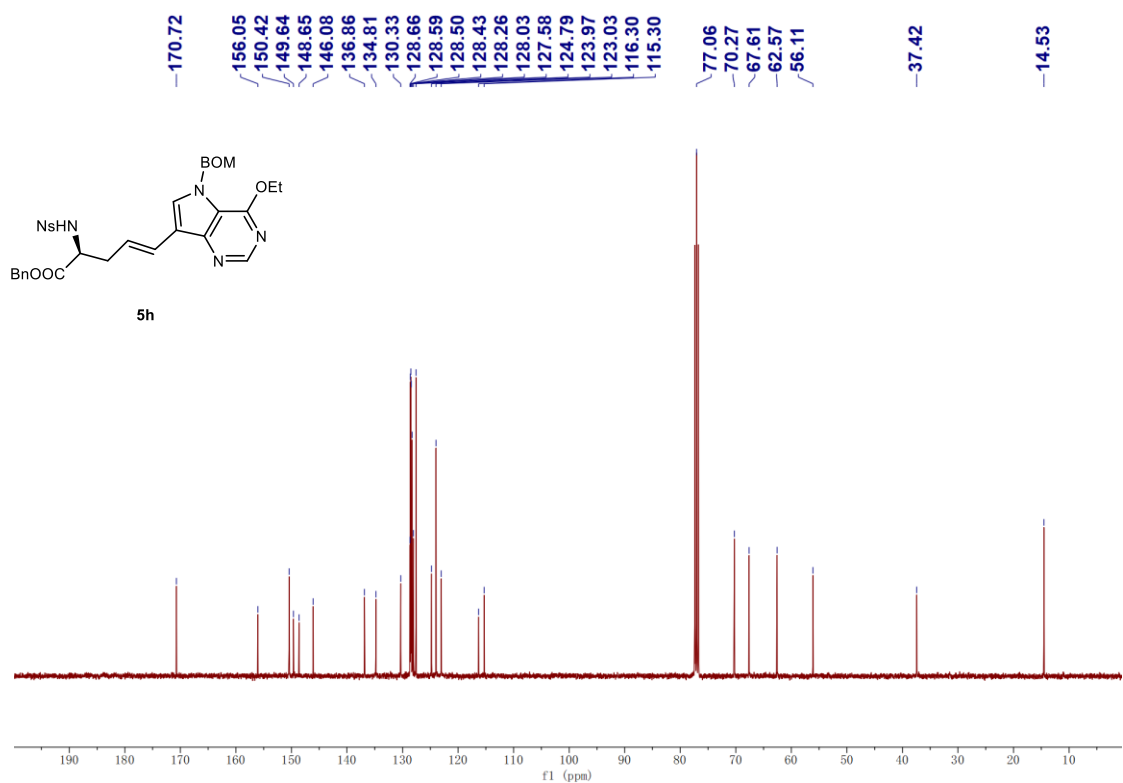
Supplementary Figure 62. ¹H NMR (400 MHz, CDCl₃) of compound **5g**.



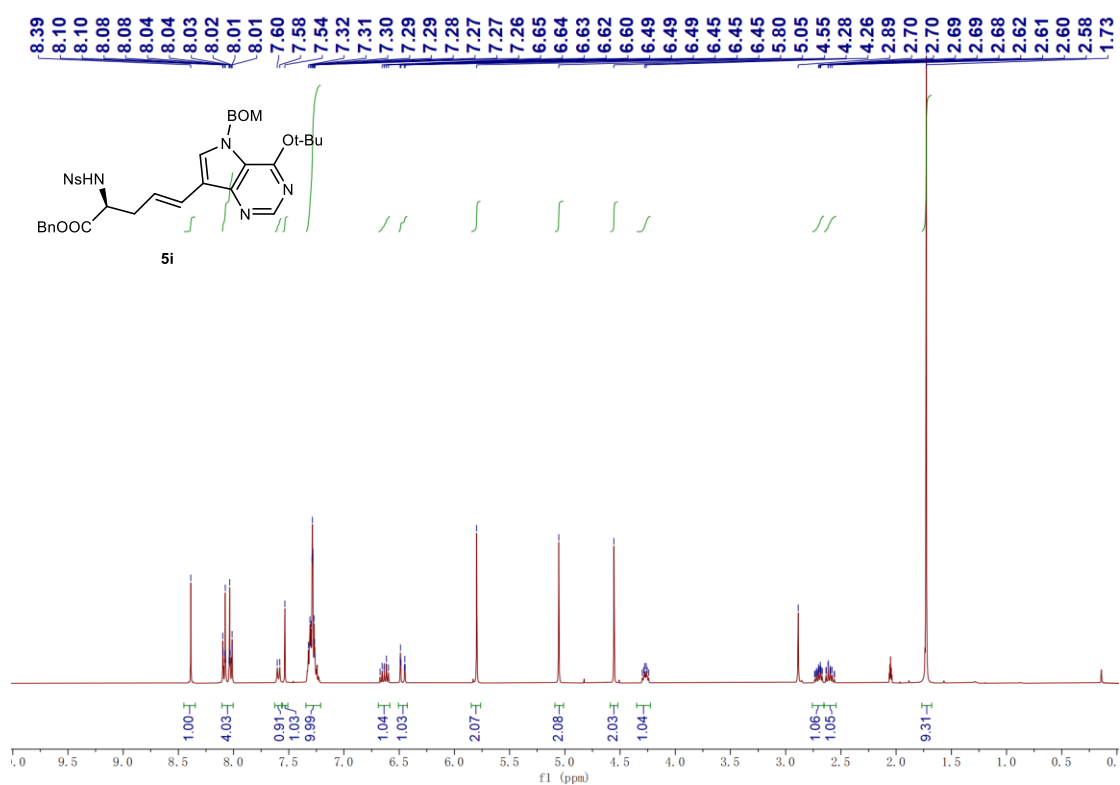
Supplementary Figure 63. ¹³C NMR (100 MHz, CDCl₃) of compound **5g**.



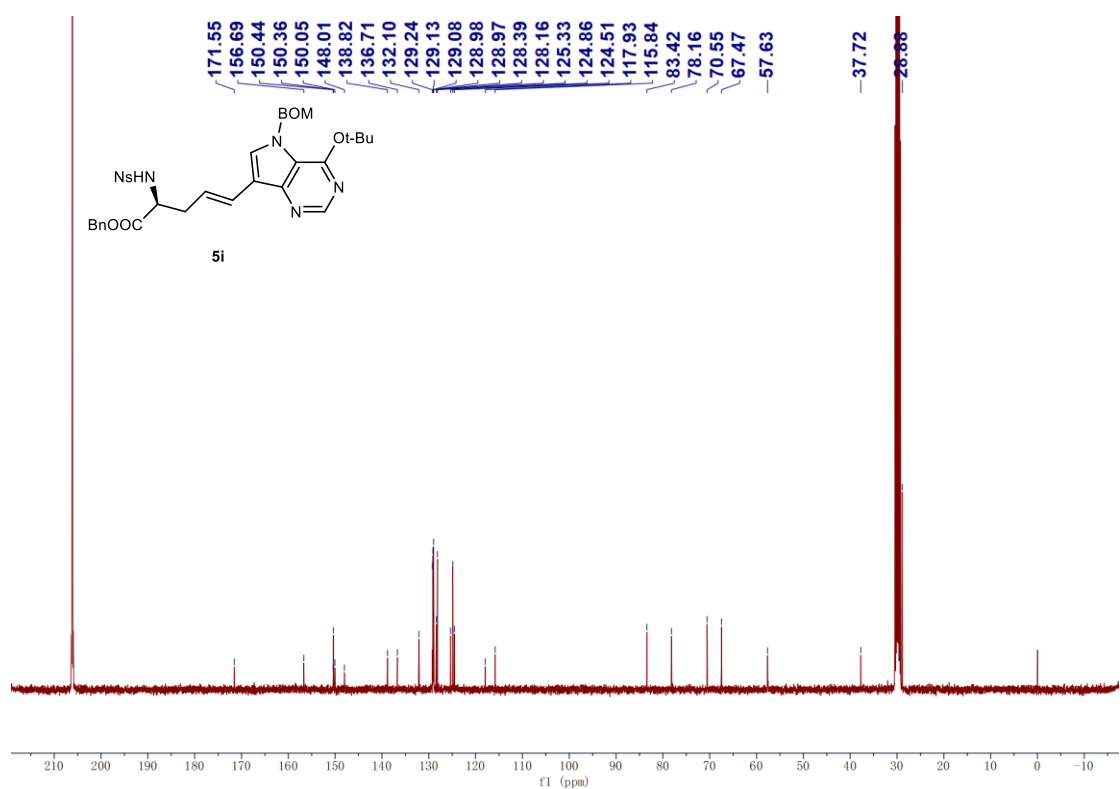
Supplementary Figure 64. ^1H NMR (400 MHz, CDCl_3) of compound **5h**.



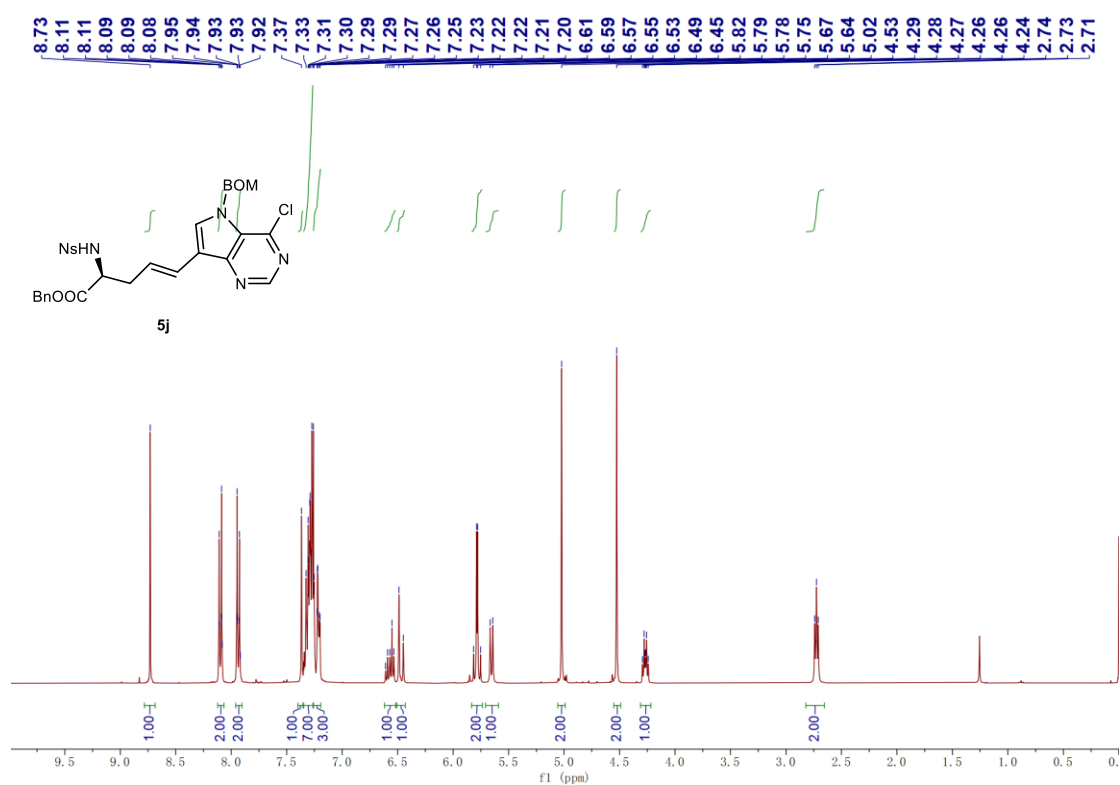
Supplementary Figure 65. ^{13}C NMR (100 MHz, CDCl_3) of compound **5h**.



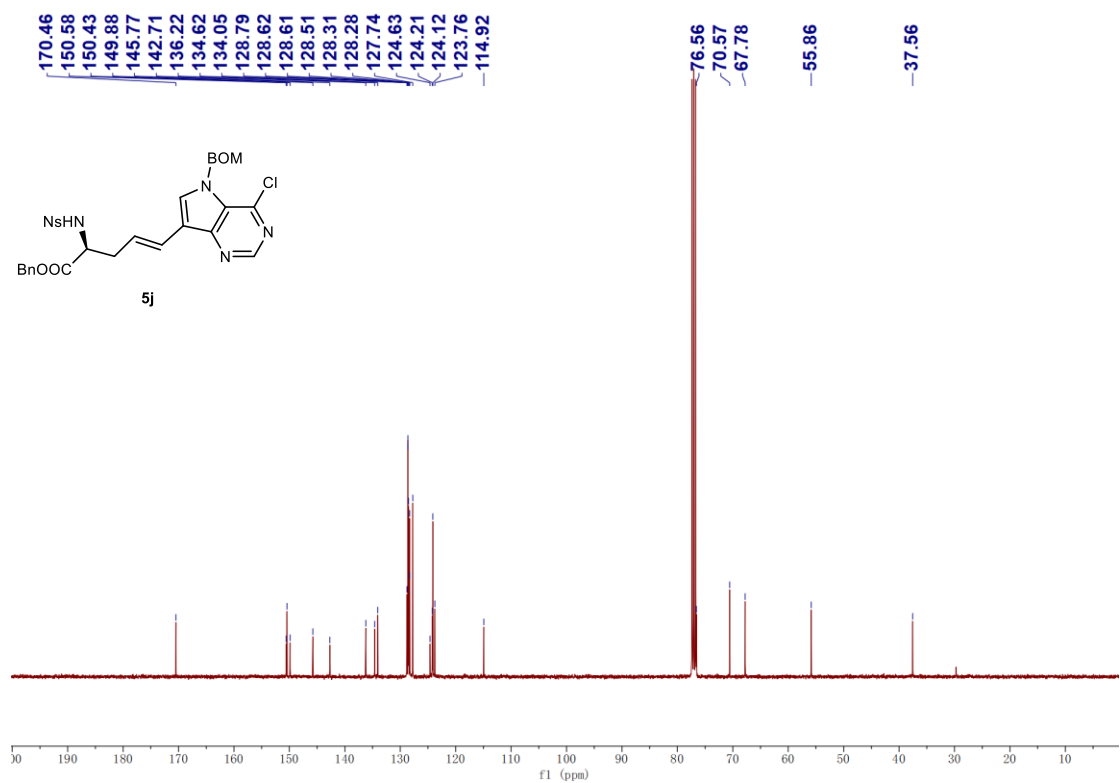
Supplementary Figure 66. ¹H NMR (400 MHz, Acetone) of compound **5i**.



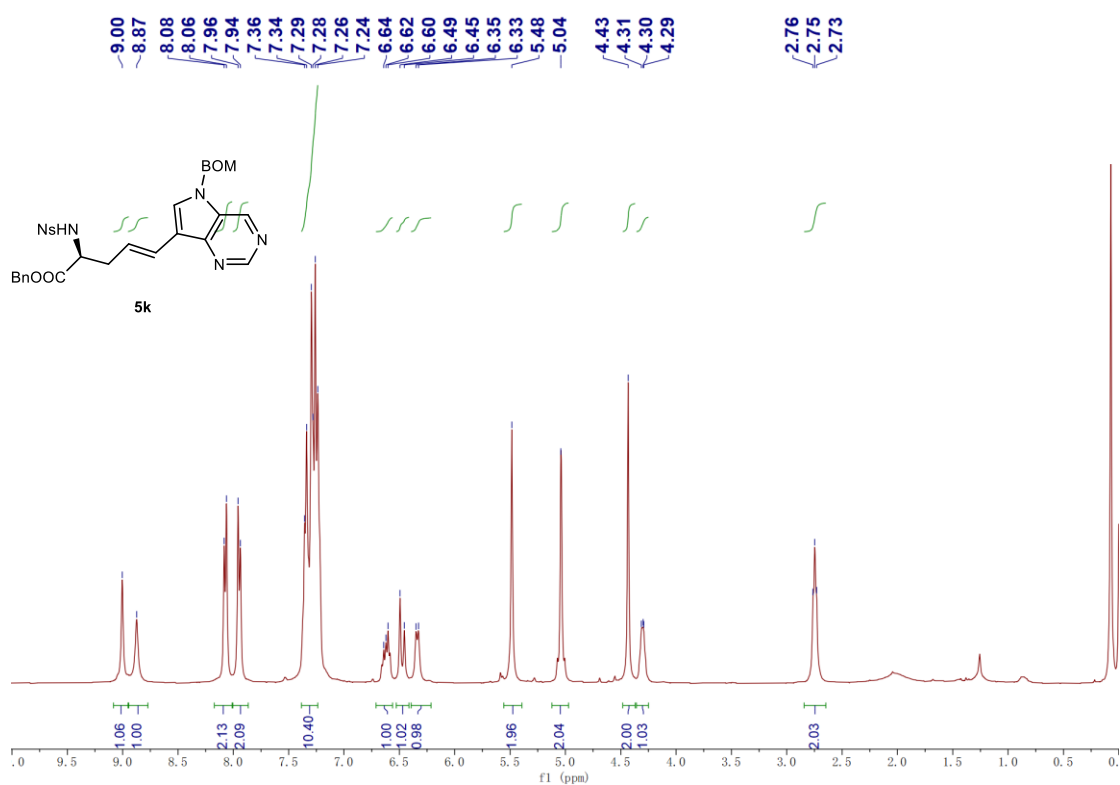
Supplementary Figure 67. ¹³C NMR (100 MHz, Acetone) of compound **5i**.



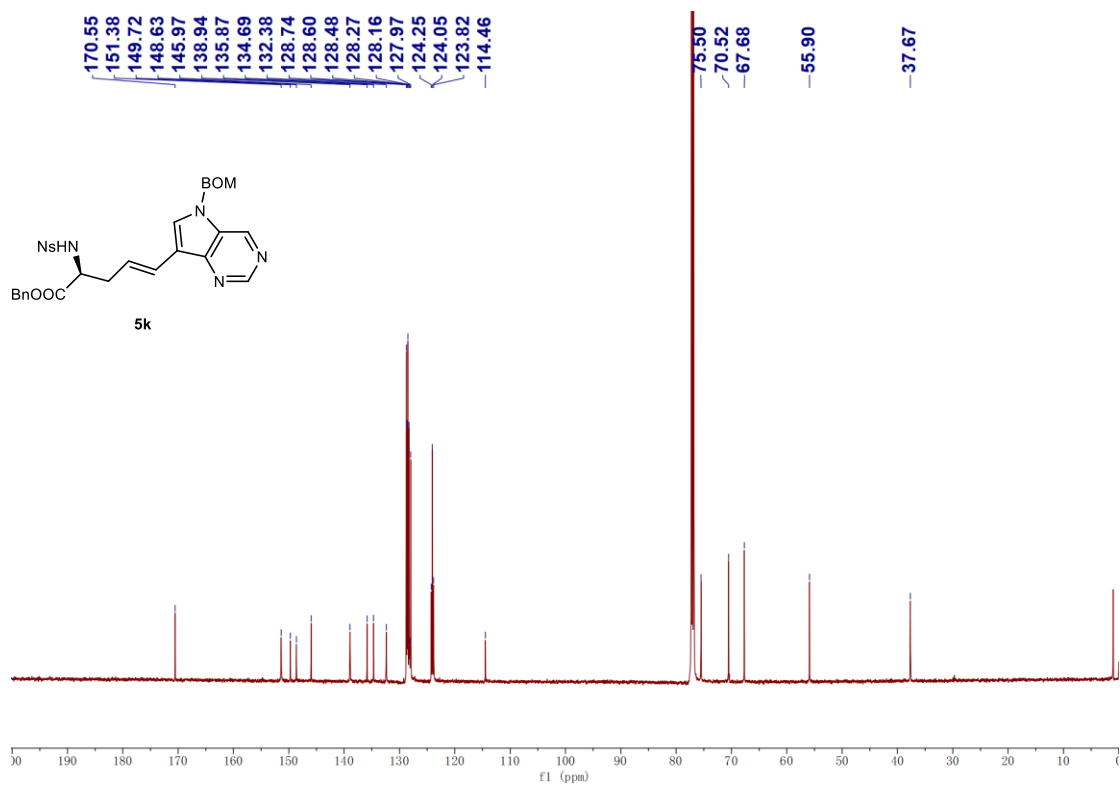
Supplementary Figure 68. ^1H NMR (400 MHz, CDCl_3) of compound **5j**.



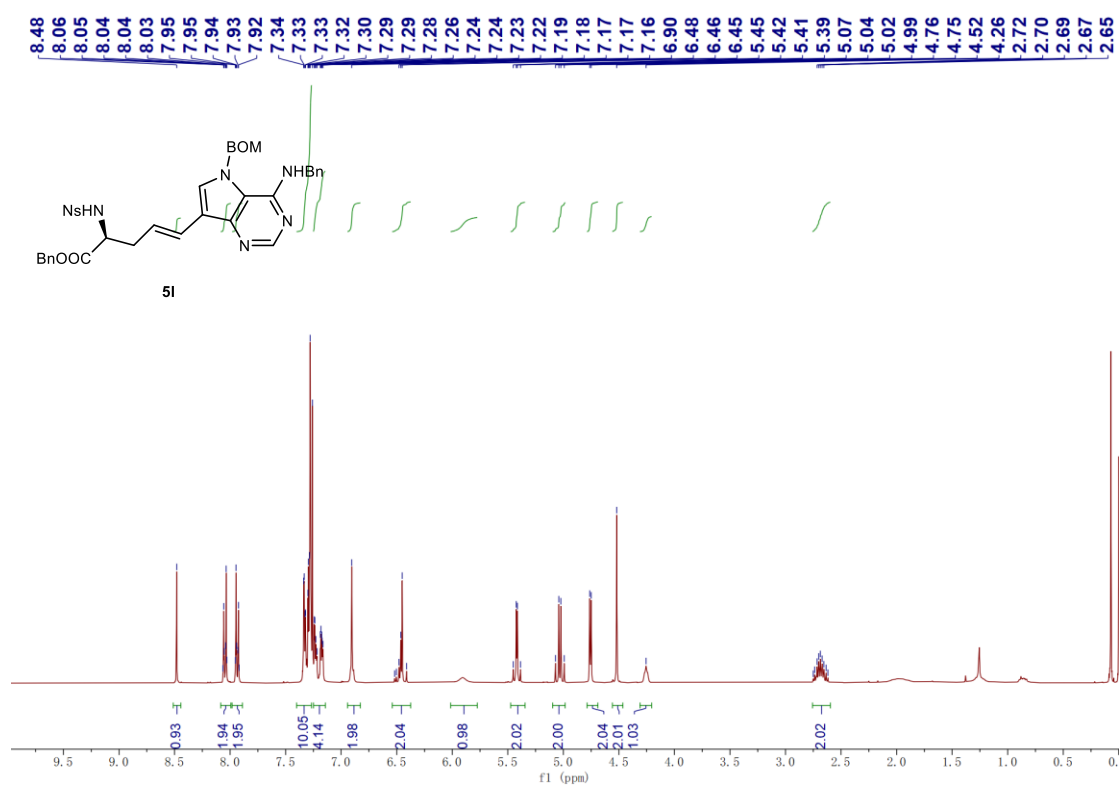
Supplementary Figure 69. ^{13}C NMR (100 MHz, CDCl_3) of compound **5j**.



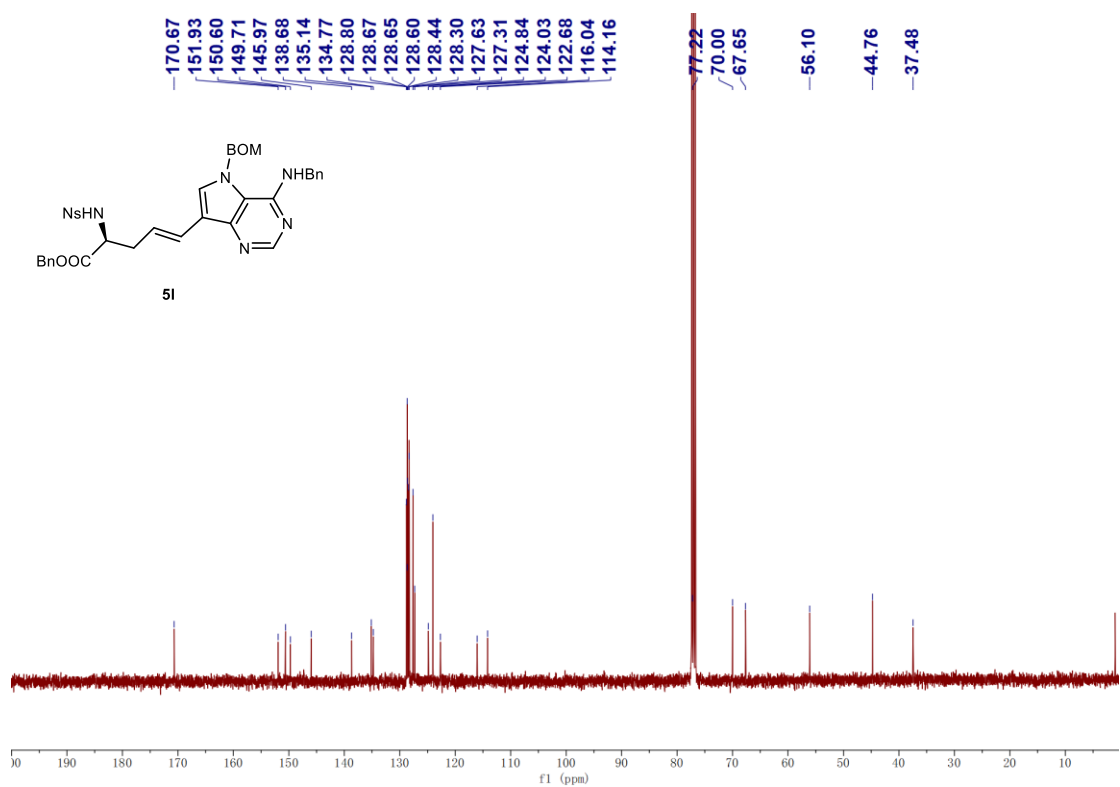
Supplementary Figure 70. ¹H NMR (400 MHz, CDCl₃) of compound **5k**.



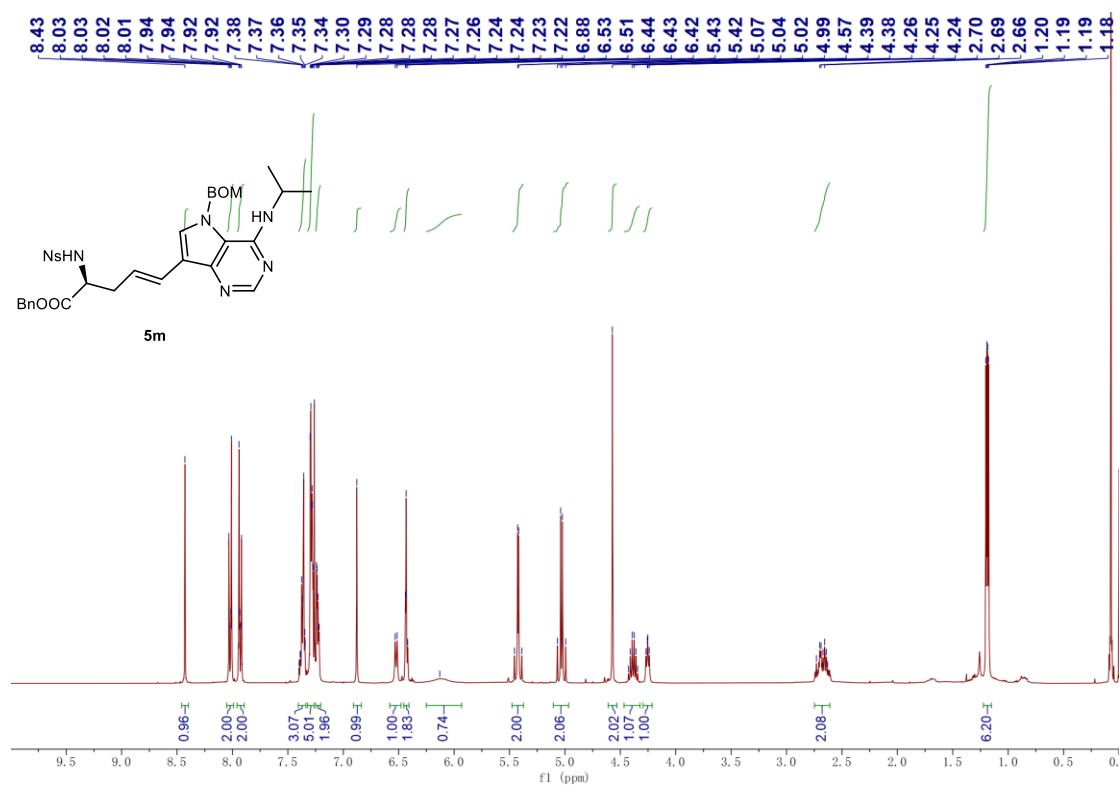
Supplementary Figure 71. ¹³C NMR (150M, CDCl₃) of compound **5k**.



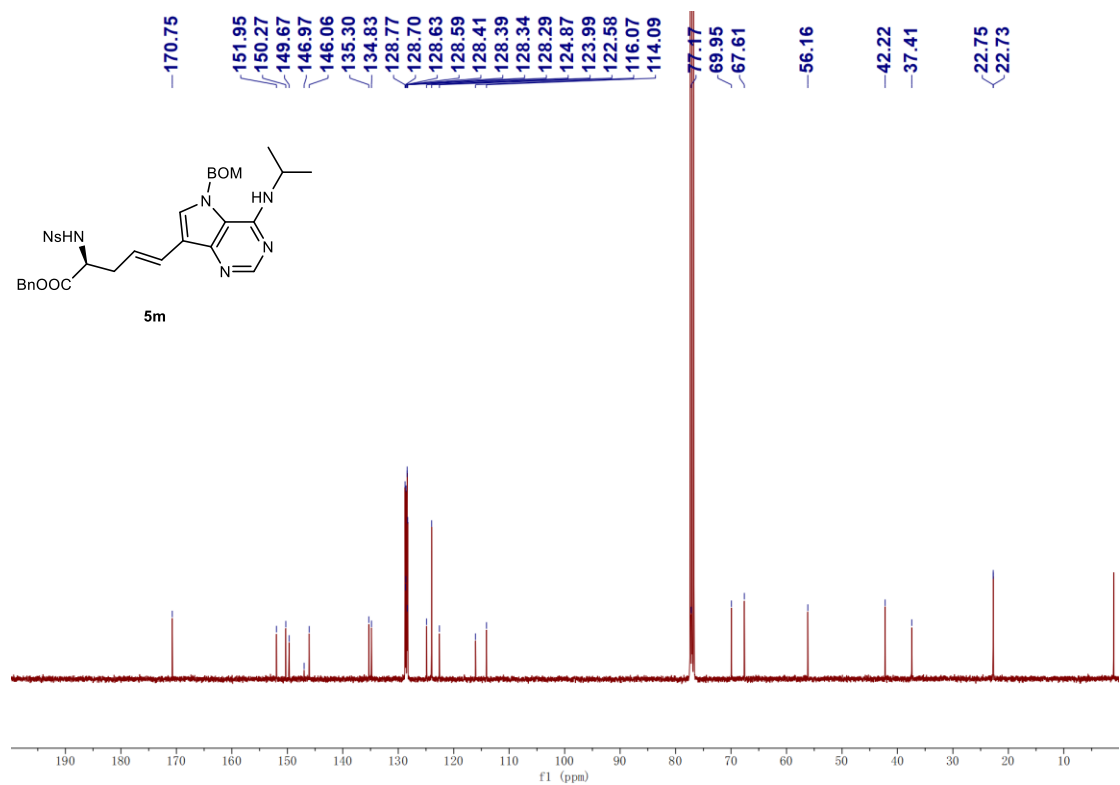
Supplementary Figure 72. ¹H NMR (400 MHz, CDCl₃) of compound **5I**.



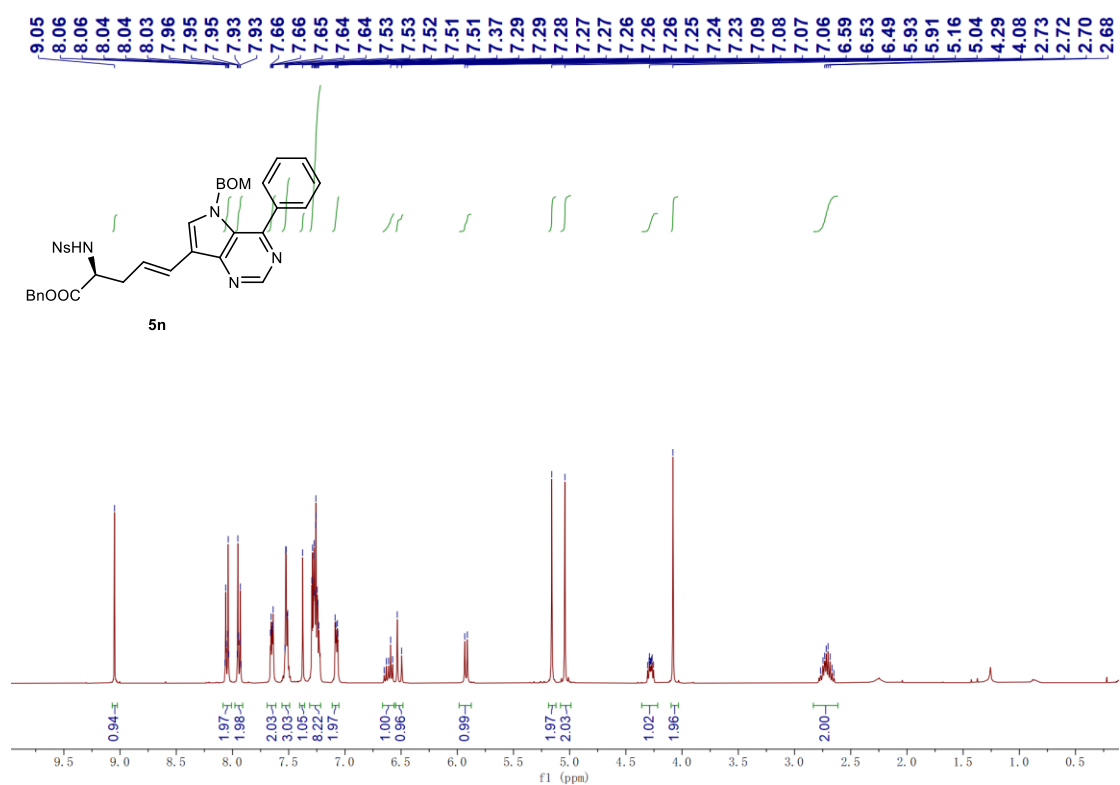
Supplementary Figure 73. ¹³C NMR (100 MHz, CDCl₃) of compound **5I**.



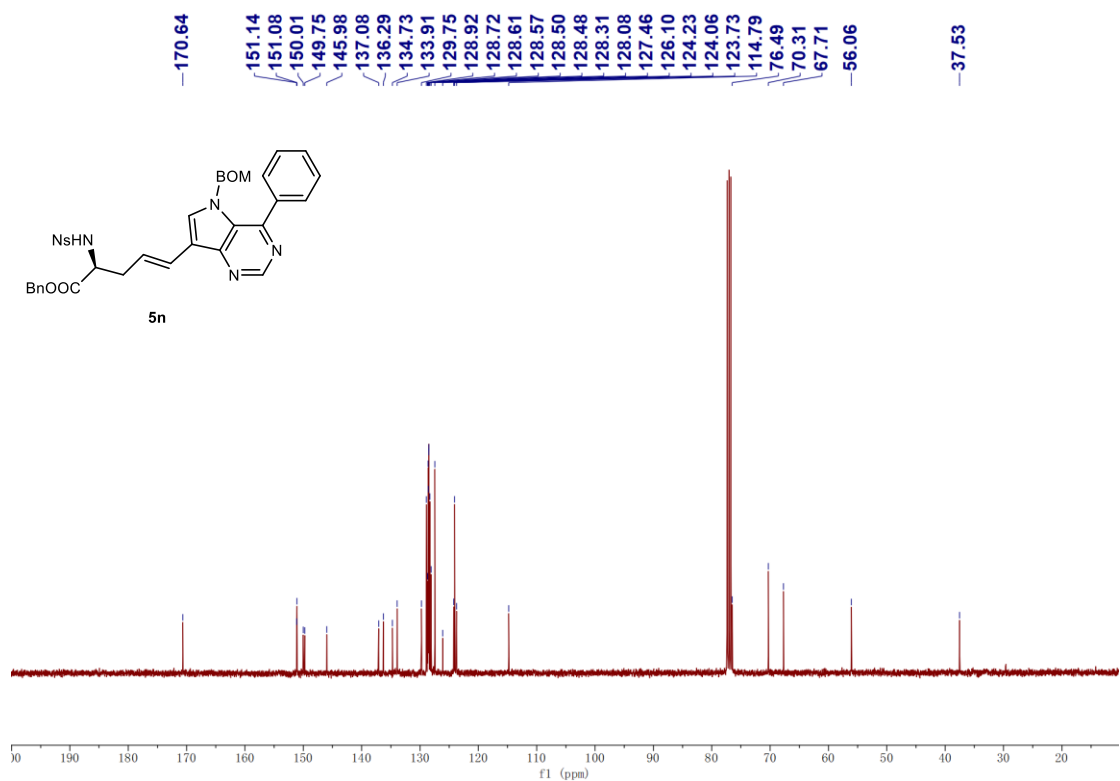
Supplementary Figure 74. ¹H NMR (400 MHz, CDCl₃) of compound **5m**.



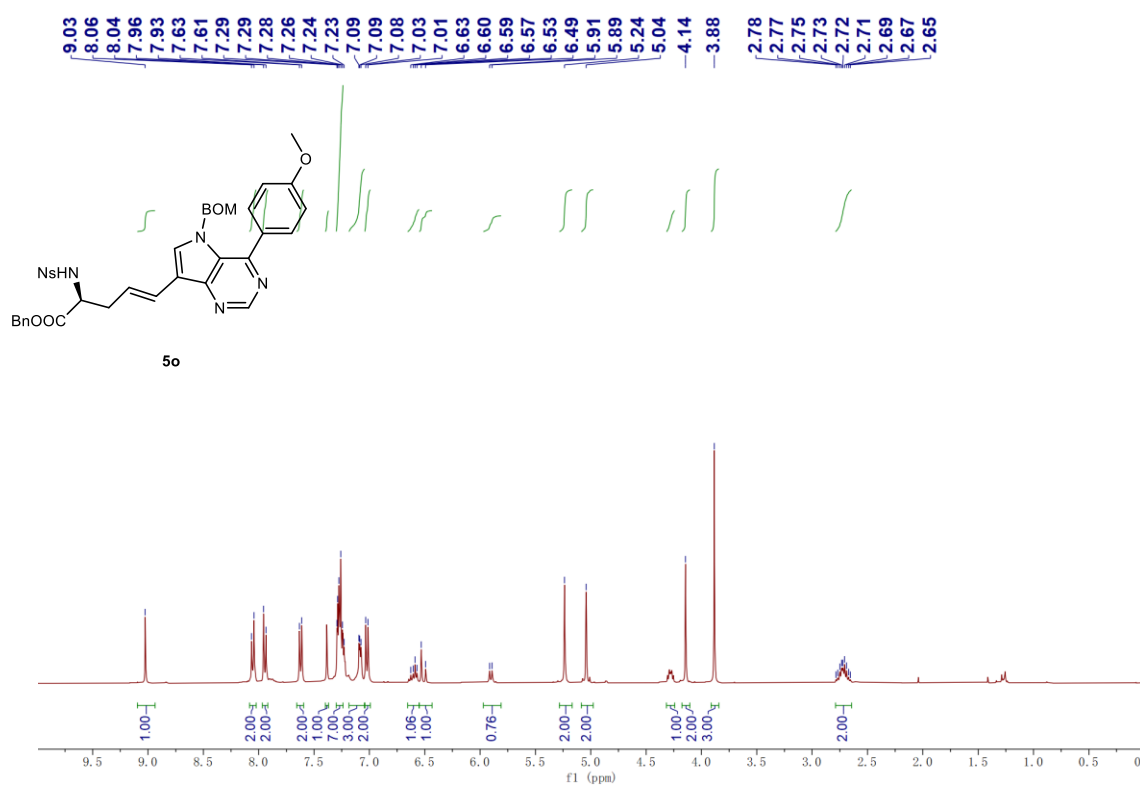
Supplementary Figure 75. ¹³C NMR (100 MHz, CDCl₃) of compound **5m**.



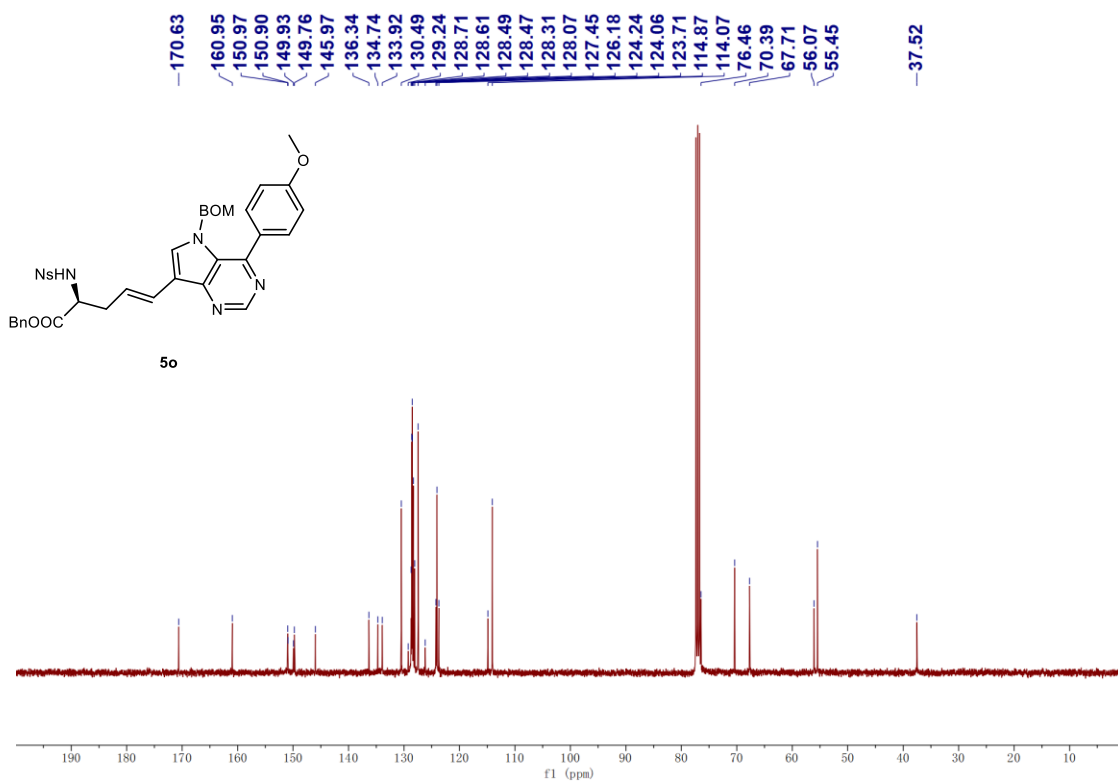
Supplementary Figure 76. ¹H NMR (400 MHz, CDCl₃) of compound **5n**.



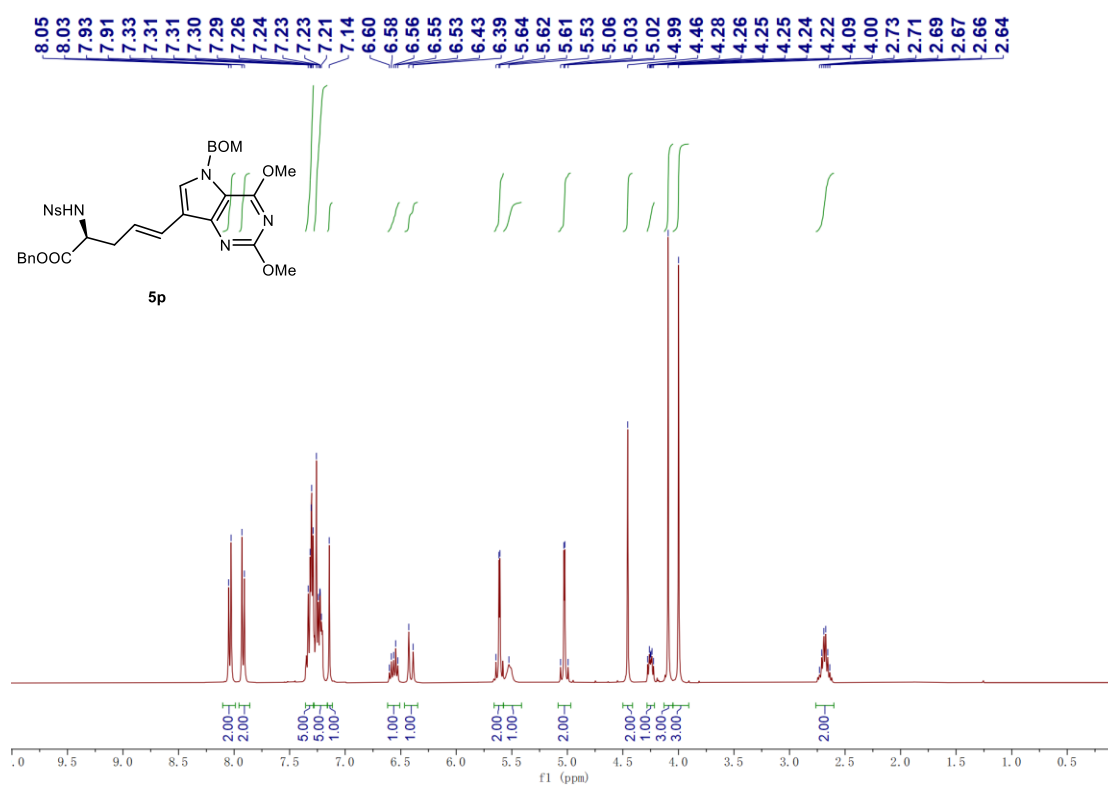
Supplementary Figure 77. ¹³C NMR (100 MHz, CDCl₃) of compound **5n**.



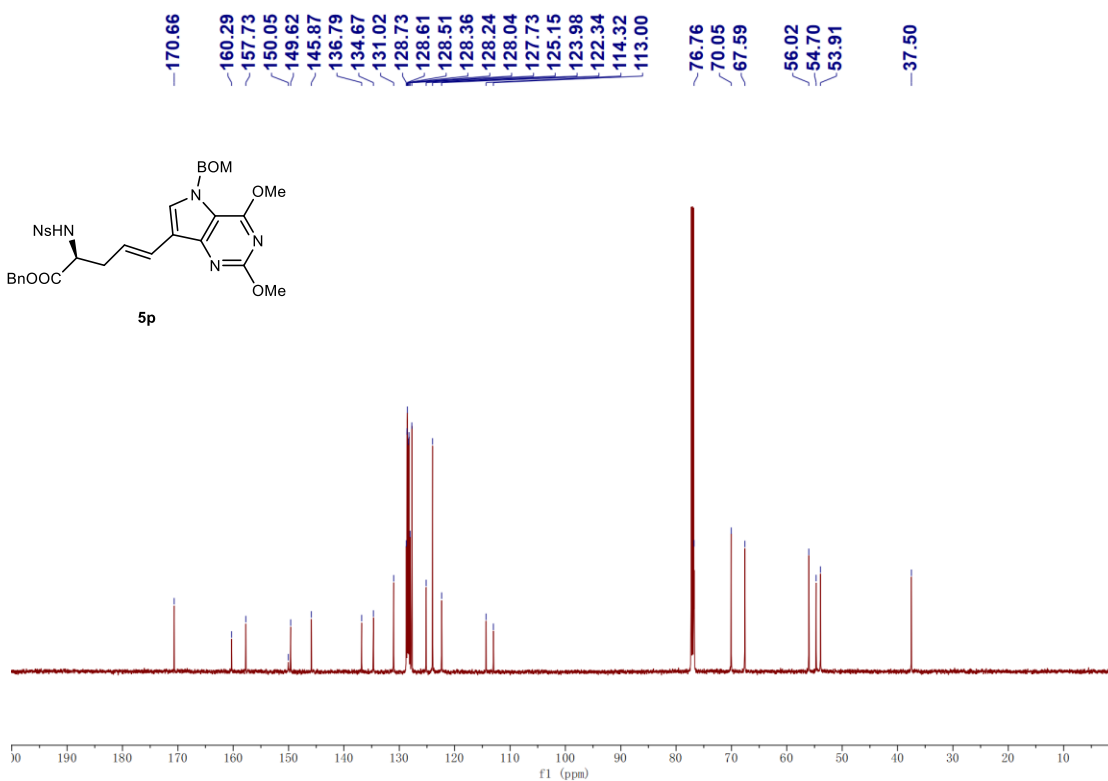
Supplementary Figure 78. ¹H NMR (400 MHz, CDCl₃) of compound **5o**.



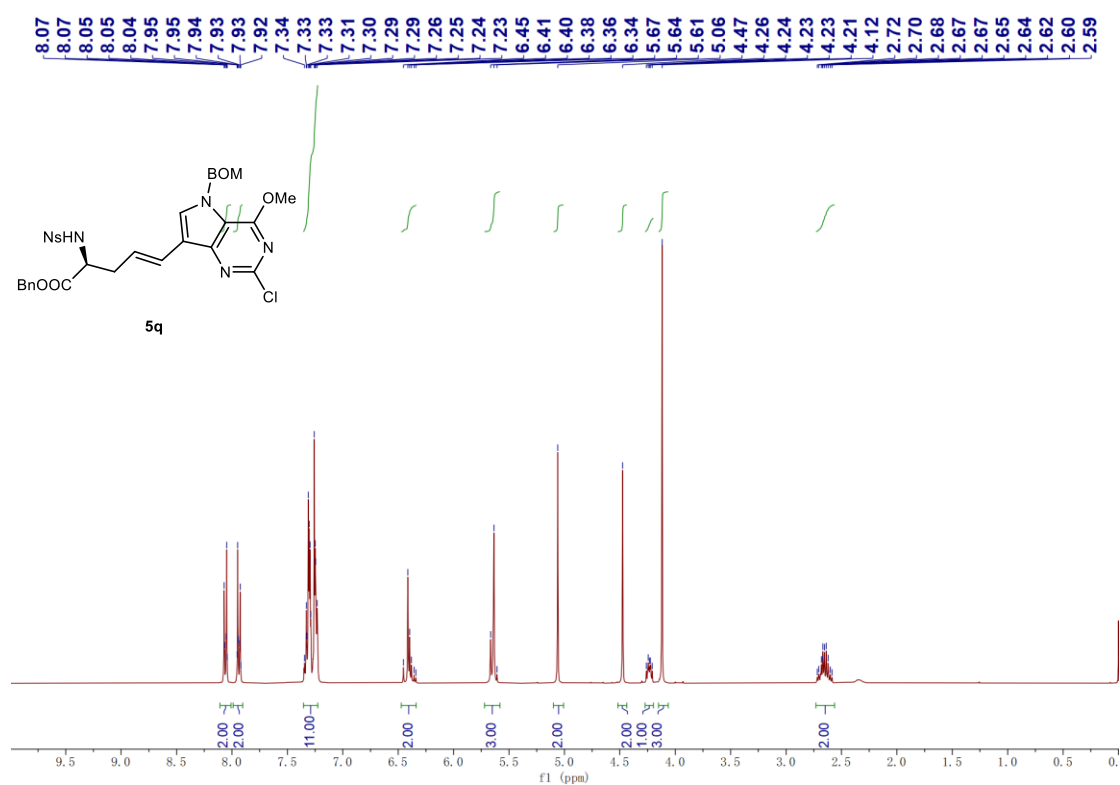
Supplementary Figure 79. ¹³C NMR (400 MHz, CDCl₃) of compound **5o**.



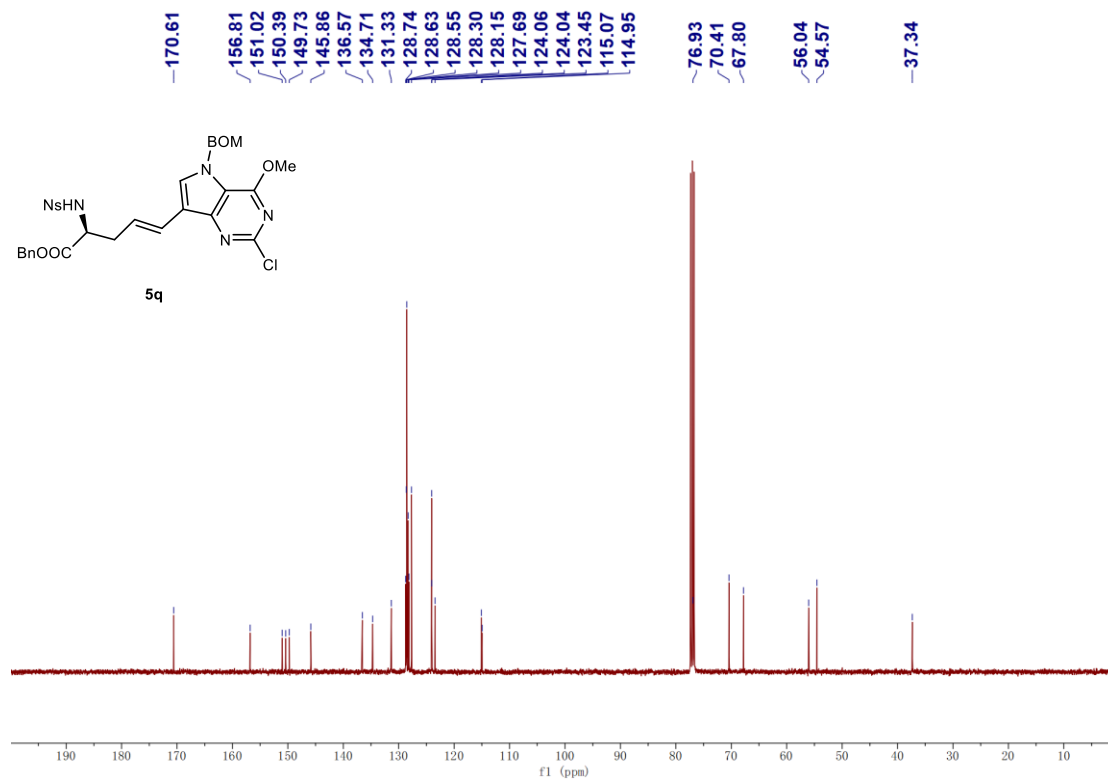
Supplementary Figure 80. ¹H NMR (400 MHz, CDCl₃) of compound **5p**.



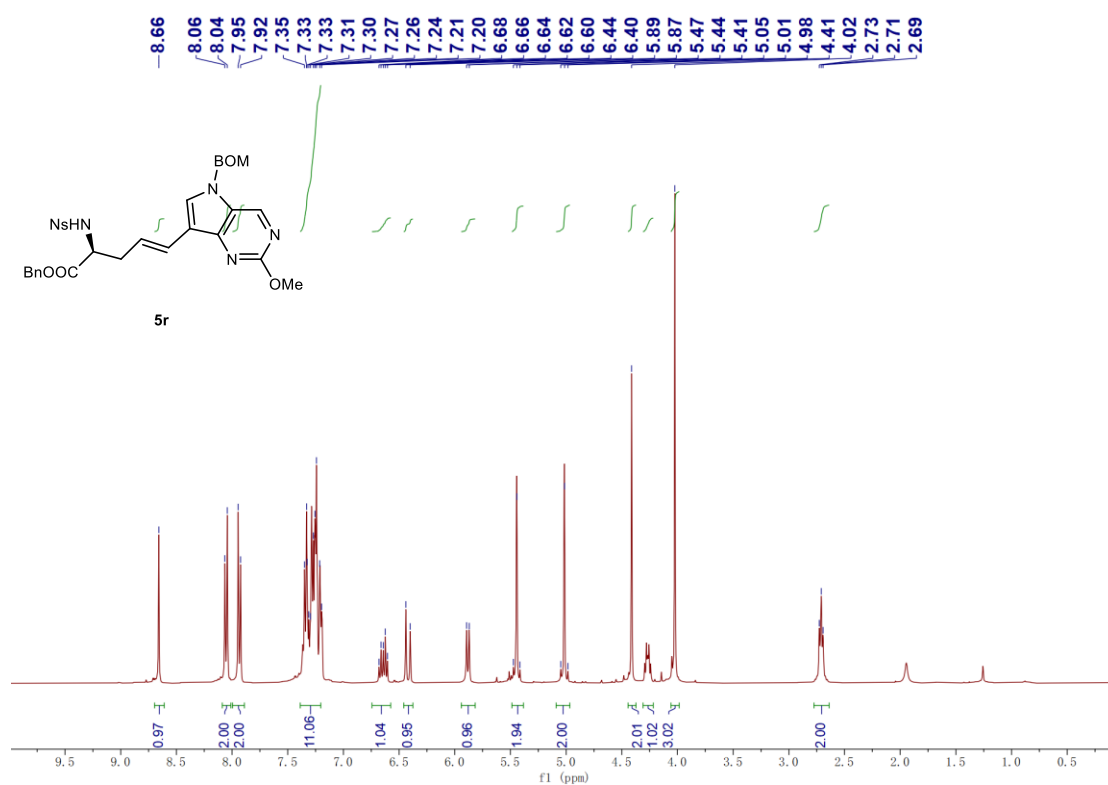
Supplementary Figure 81. ¹³C NMR (150M, CDCl₃) of compound **5p**.



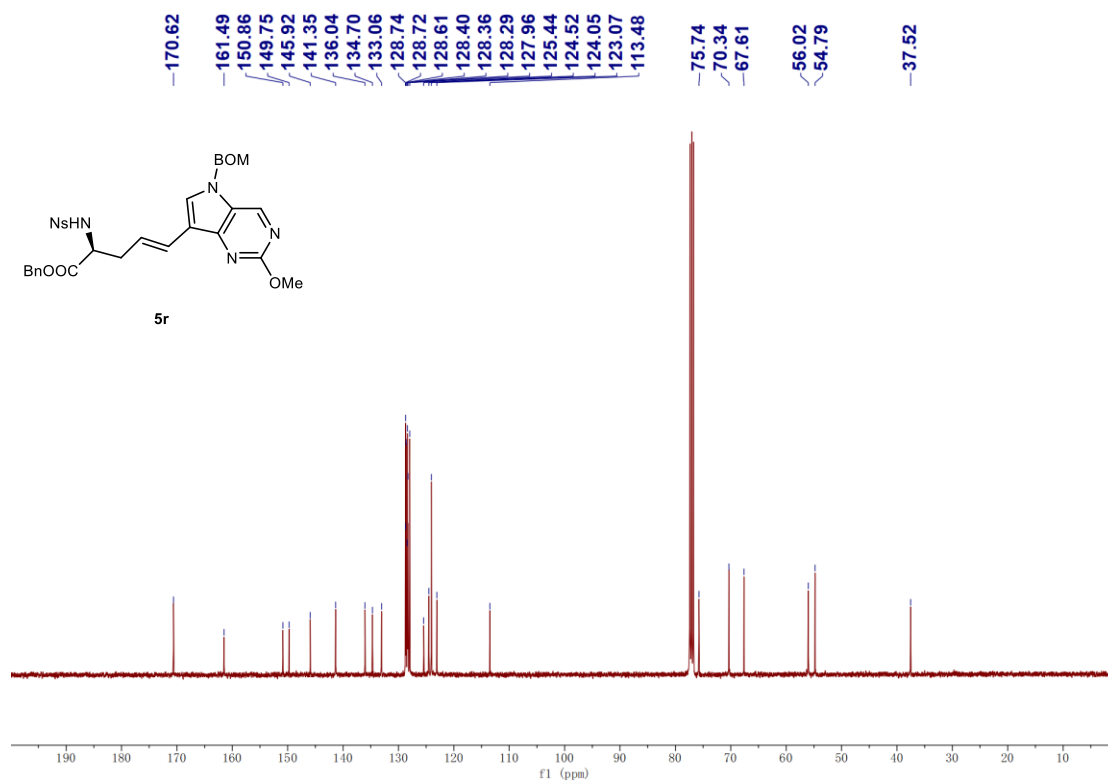
Supplementary Figure 82. ¹H NMR (400 MHz, CDCl₃) of compound **5q**.



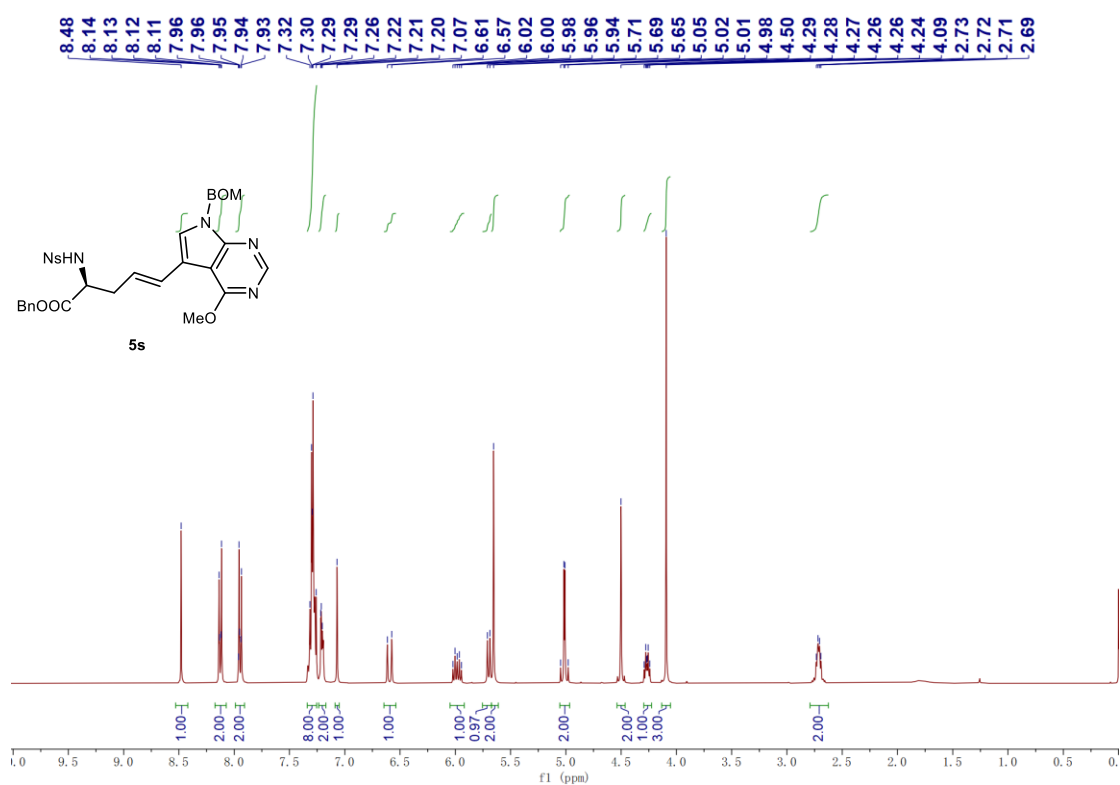
Supplementary Figure 83. ¹³C NMR (100 MHz, CDCl₃) of compound **5q**.



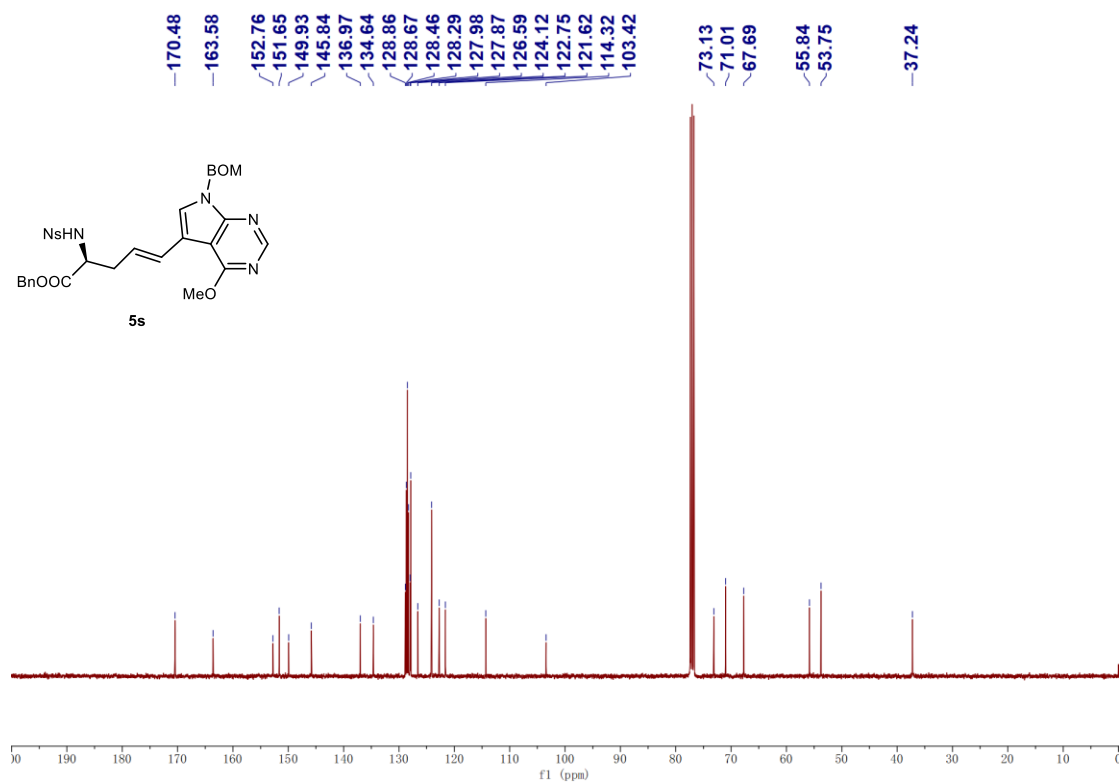
Supplementary Figure 84. ¹H NMR (400 MHz, CDCl₃) of compound **5r**.



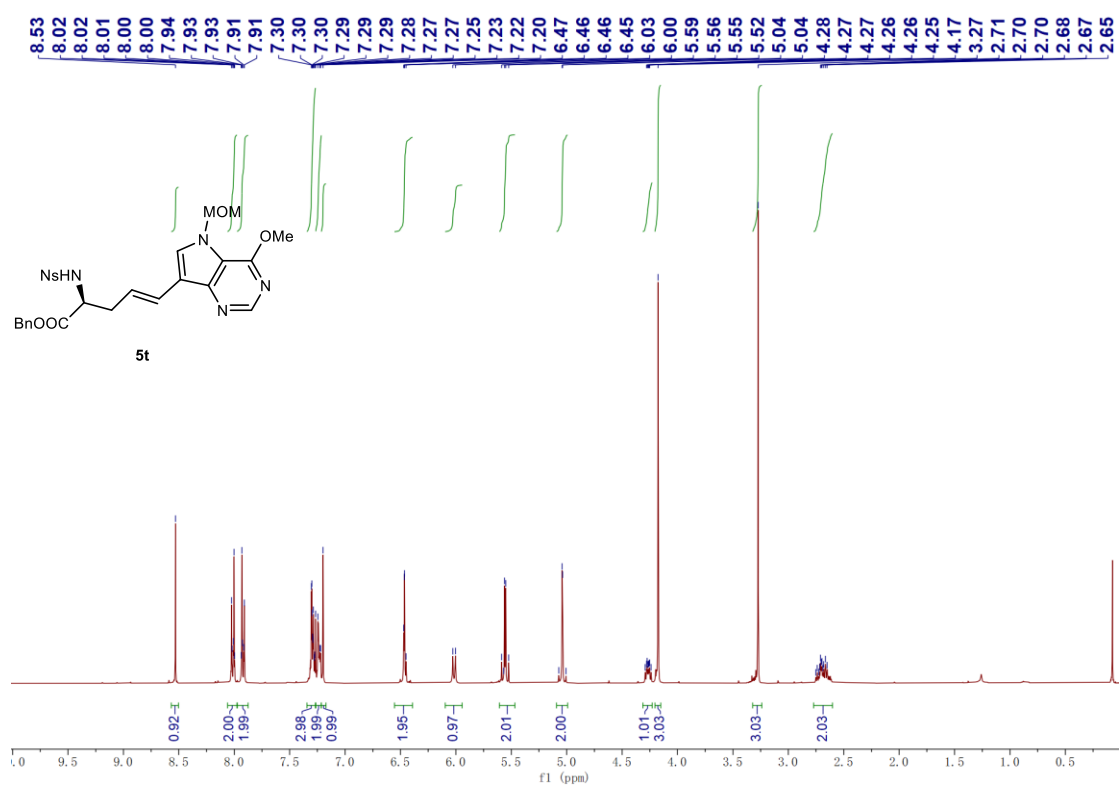
Supplementary Figure 85. ¹³C NMR (100 MHz, CDCl₃) of compound **5r**.



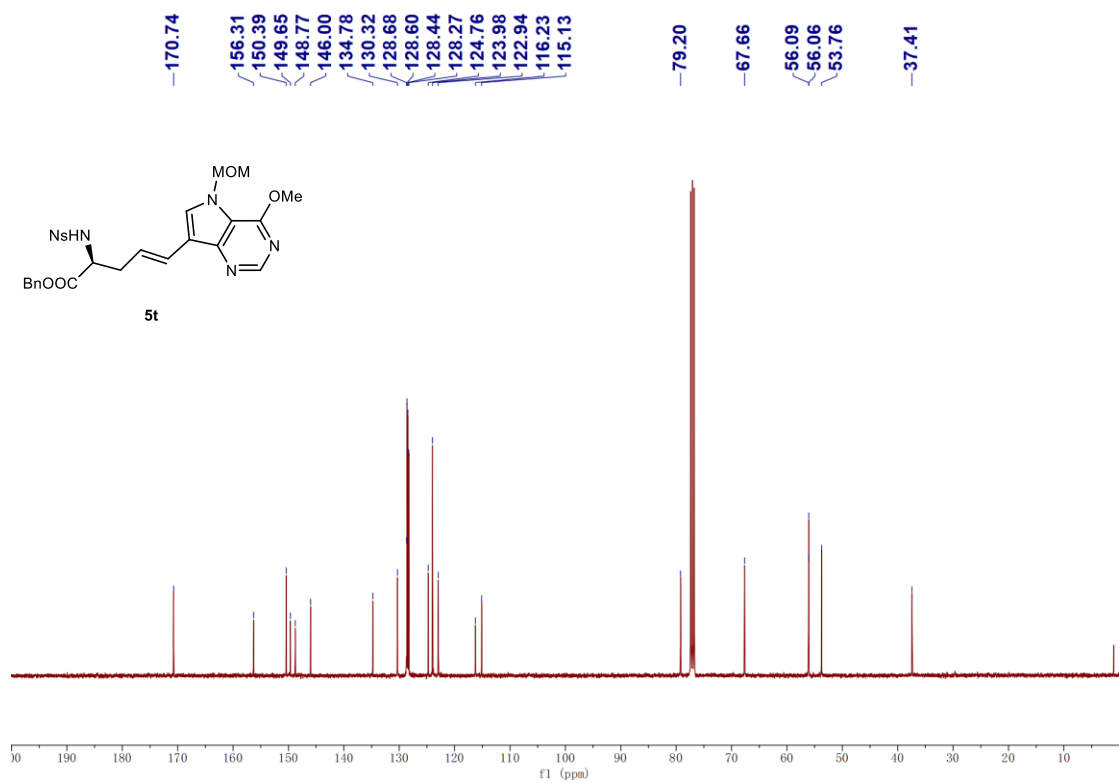
Supplementary Figure 86. ¹H NMR (400 MHz, CDCl₃) of compound **5s**.



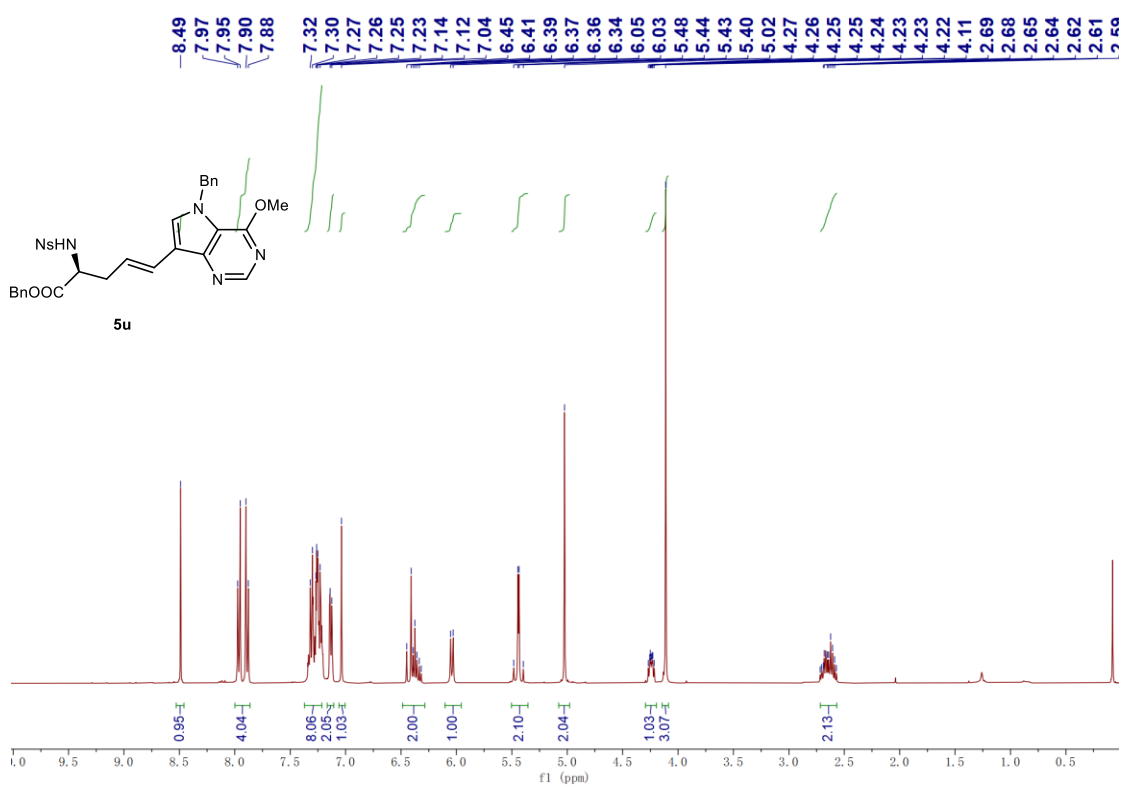
Supplementary Figure 87. ¹³C NMR (100 MHz, CDCl₃) of compound **5s**.



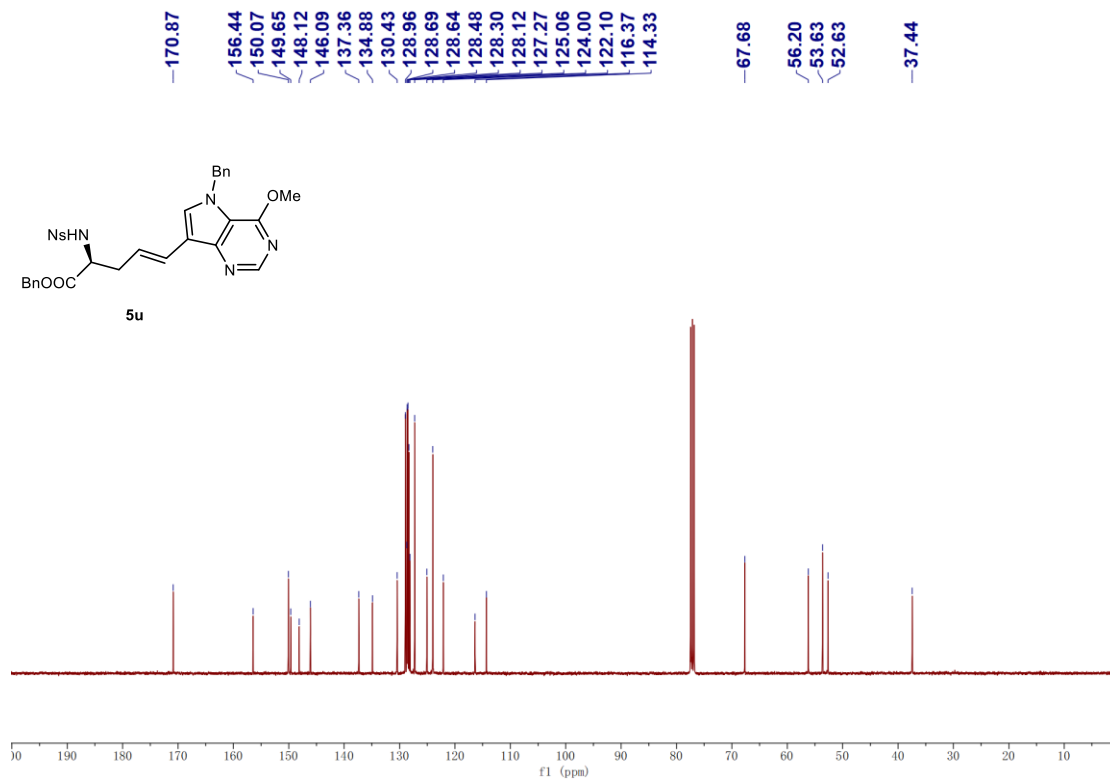
Supplementary Figure 88. ¹H NMR (400 MHz, CDCl₃) of compound **5t**.



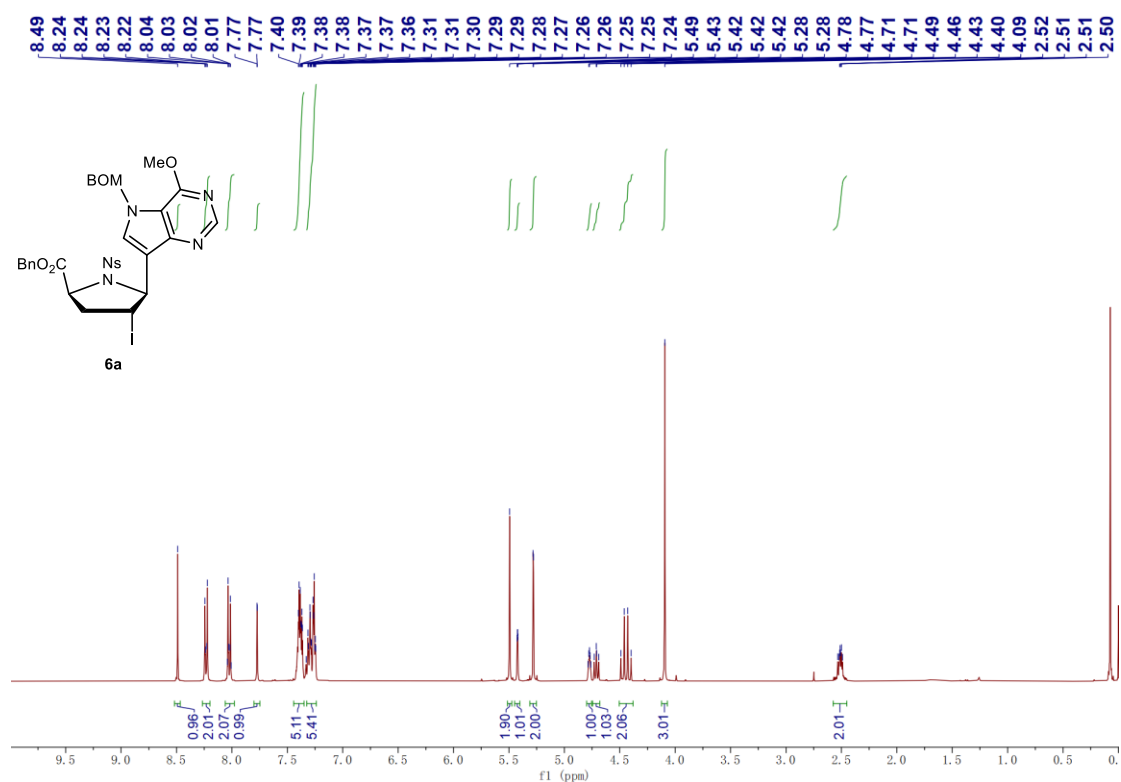
Supplementary Figure 89. ¹³C NMR (100 MHz, CDCl₃) of compound **5t**.



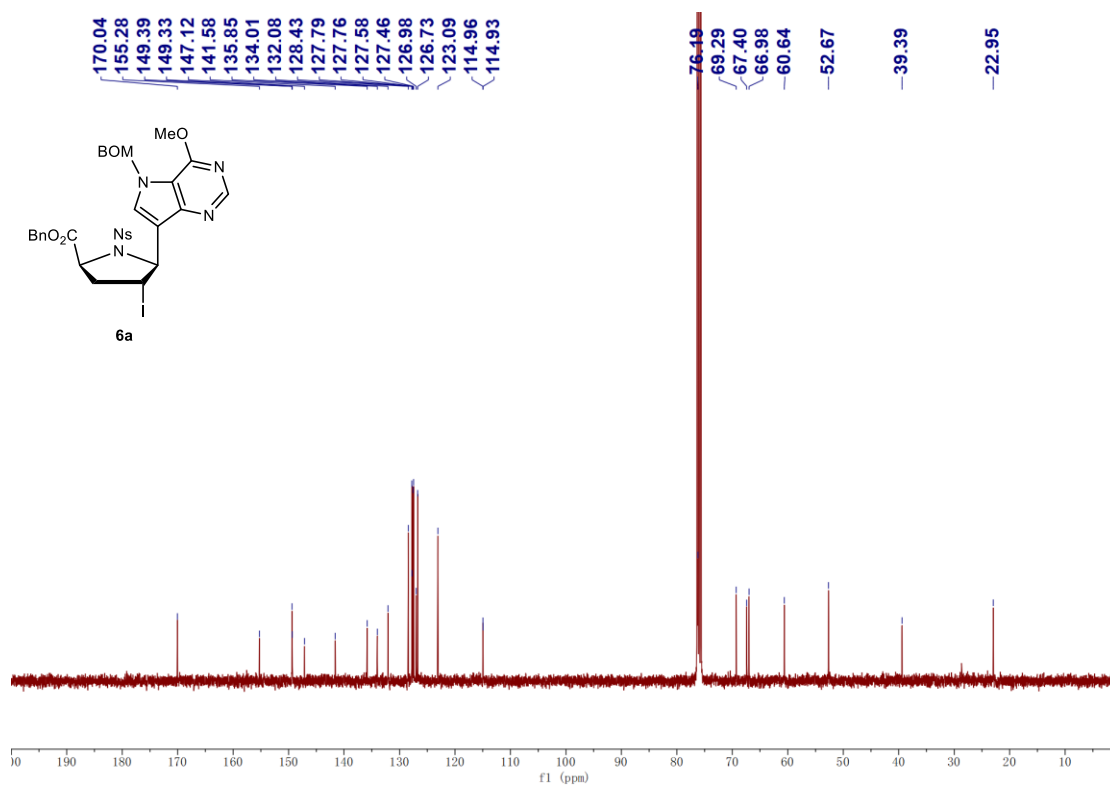
Supplementary Figure 90. ^1H NMR (400 MHz, CDCl_3) of compound **5u**.



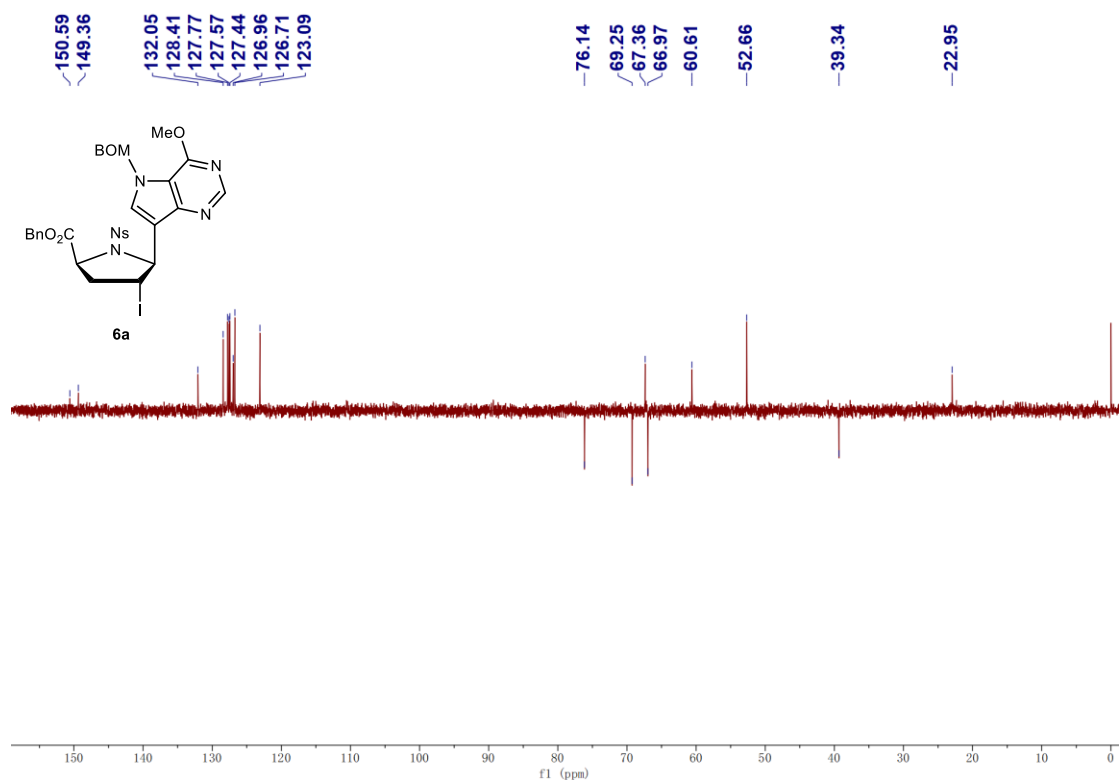
Supplementary Figure 91. ^{13}C NMR (100 MHz, CDCl_3) of compound **5u**.



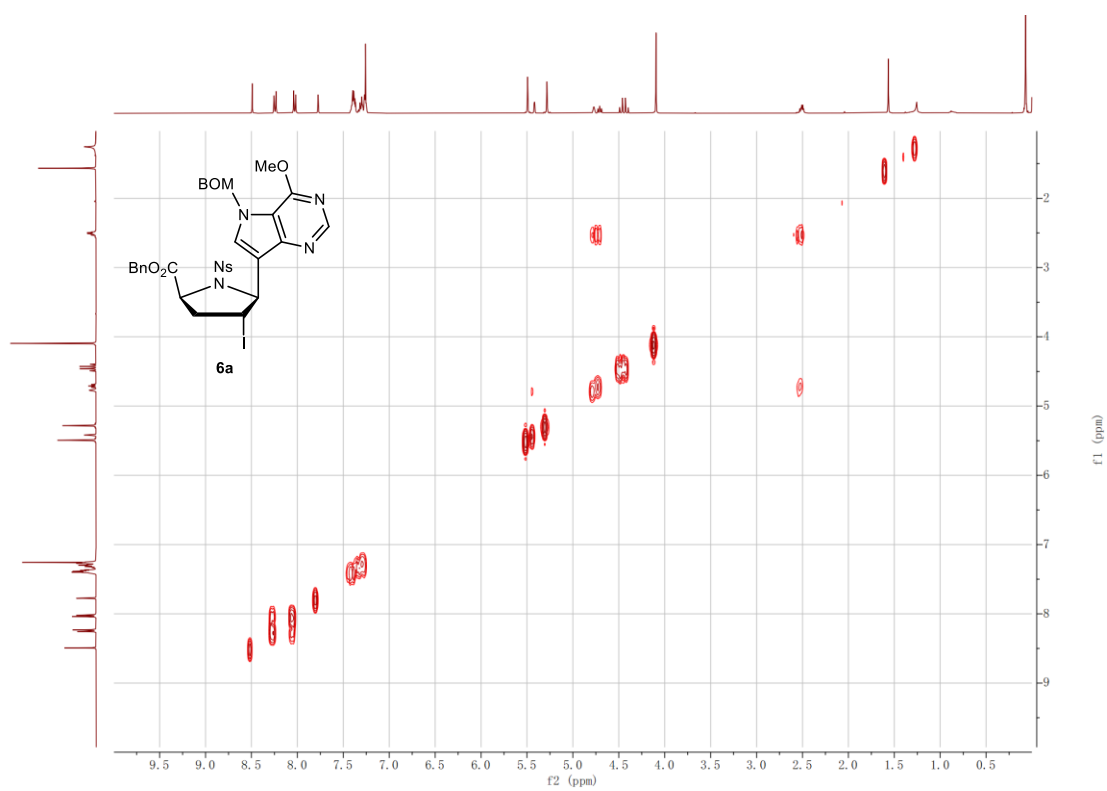
Supplementary Figure 92. ¹H NMR (400 MHz, CDCl₃) of compound 6a.



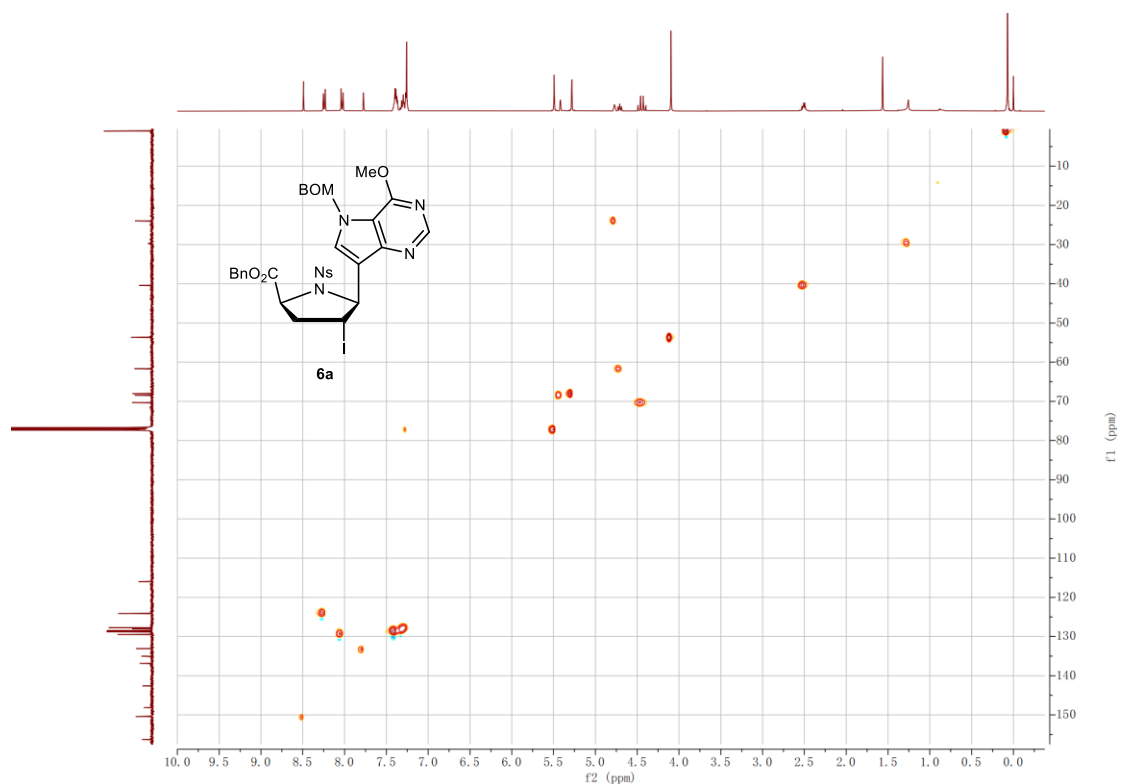
Supplementary Figure 93. ¹³C NMR (100 MHz, CDCl₃) of compound 6a.



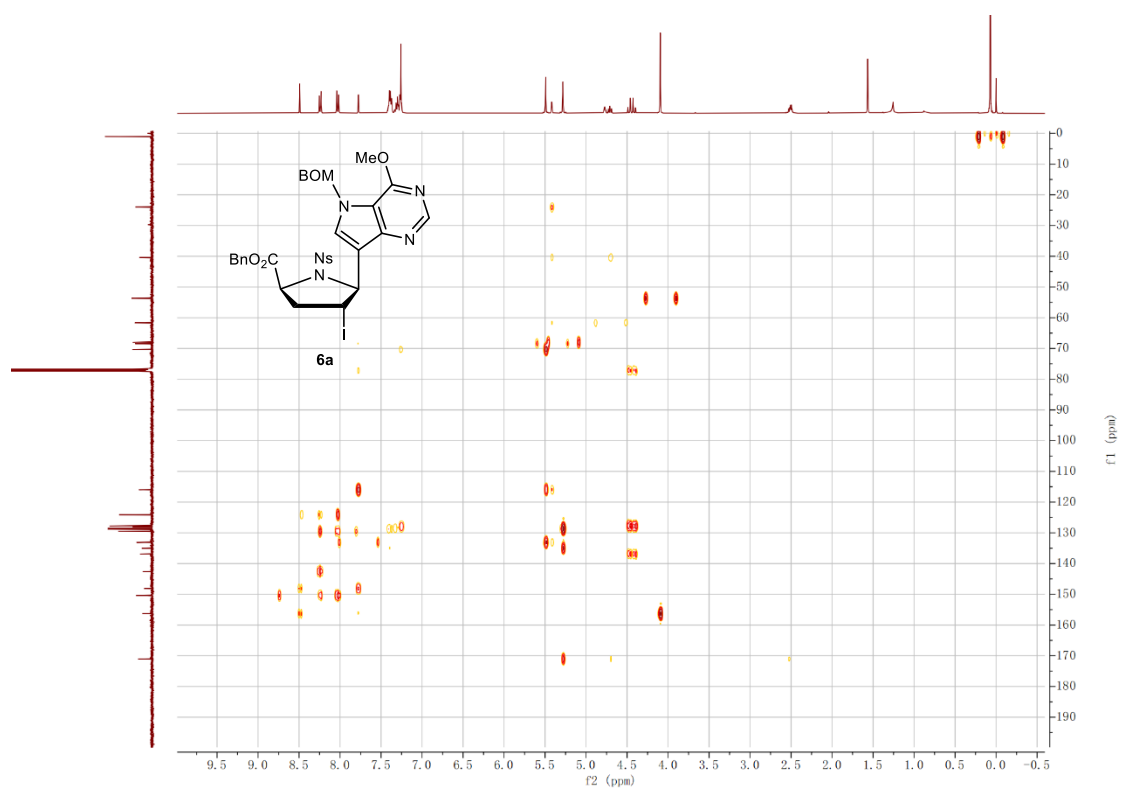
Supplementary Figure 94. DEPT 135^o (100 MHz, CDCl₃) of compound **6a**.



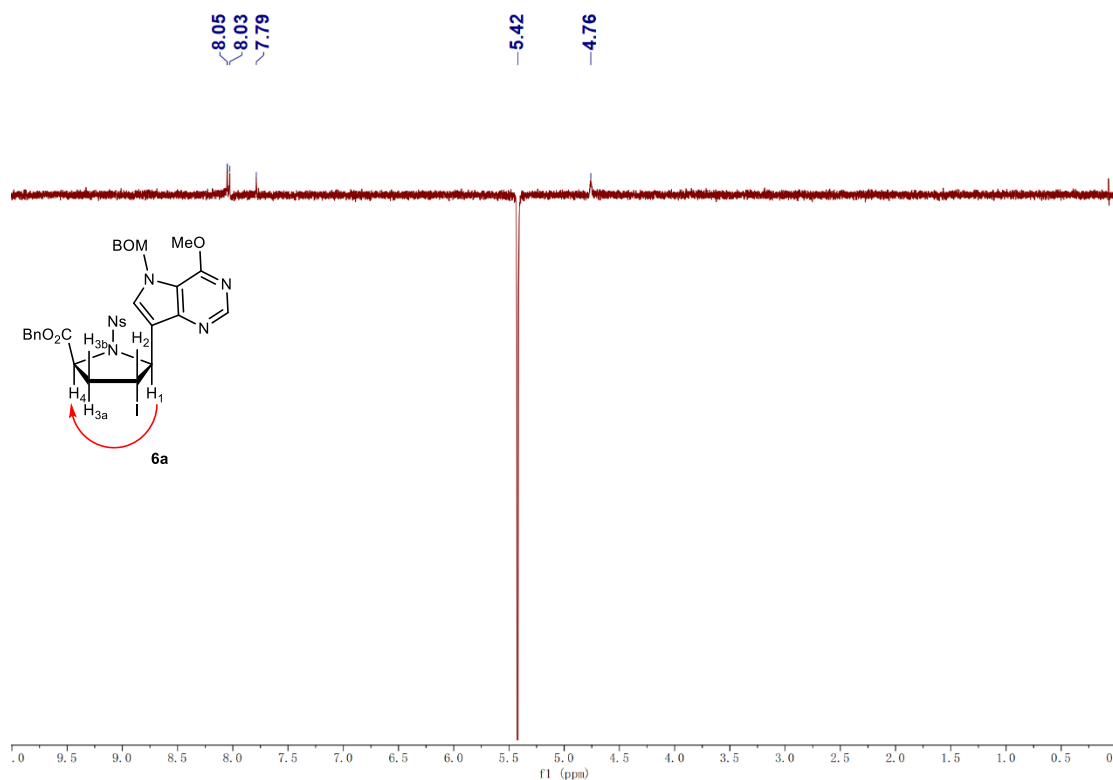
Supplementary Figure 95. ¹H-¹H COSY (400 MHz, CDCl₃) of compound **6a**.



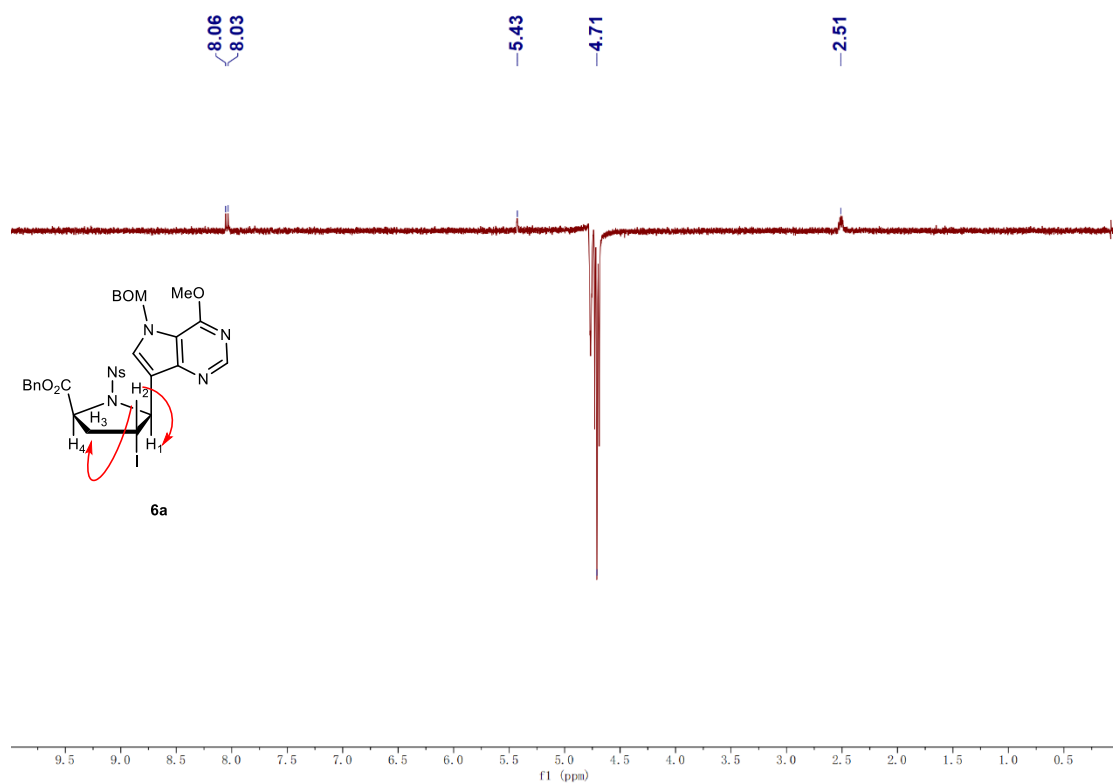
Supplementary Figure 96. ¹H-¹³C HSQC (400 MHz, CDCl₃) of compound **6a**.



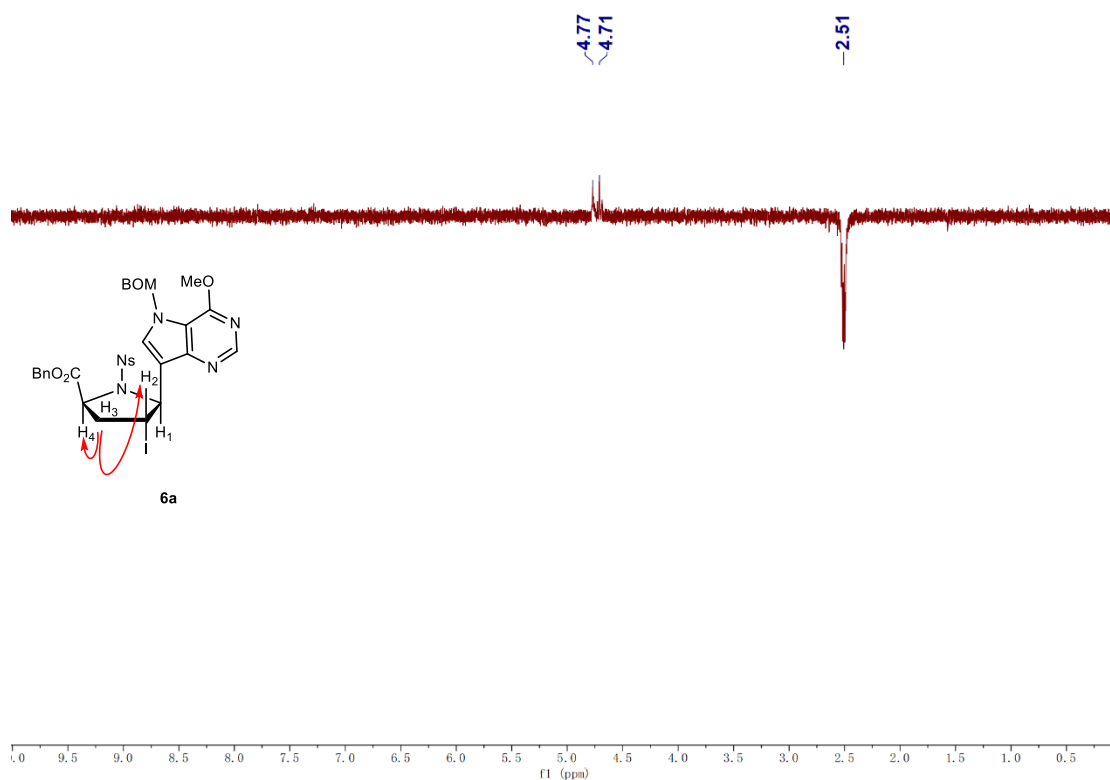
Supplementary Figure 97. ¹H-¹³C HMBC (400 MHz, CDCl₃) of compound **6a**.



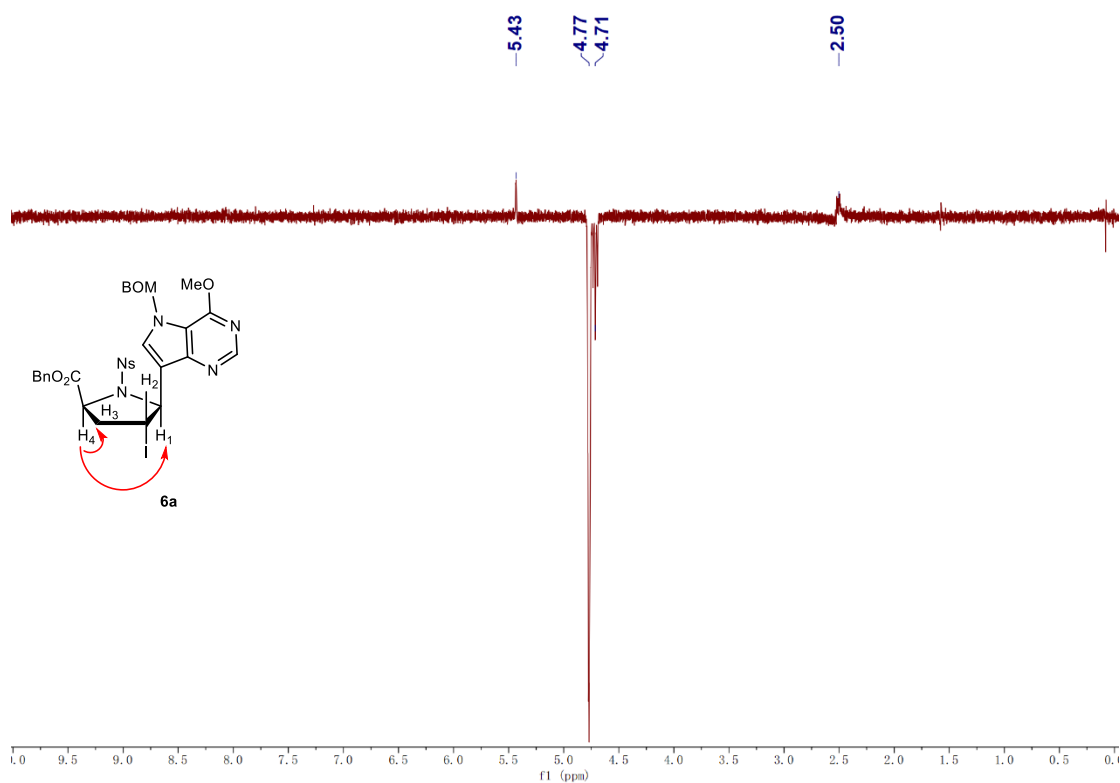
Supplementary Figure 98. H₁ NOEs (600 MHz, CDCl₃) of compound **6a**.



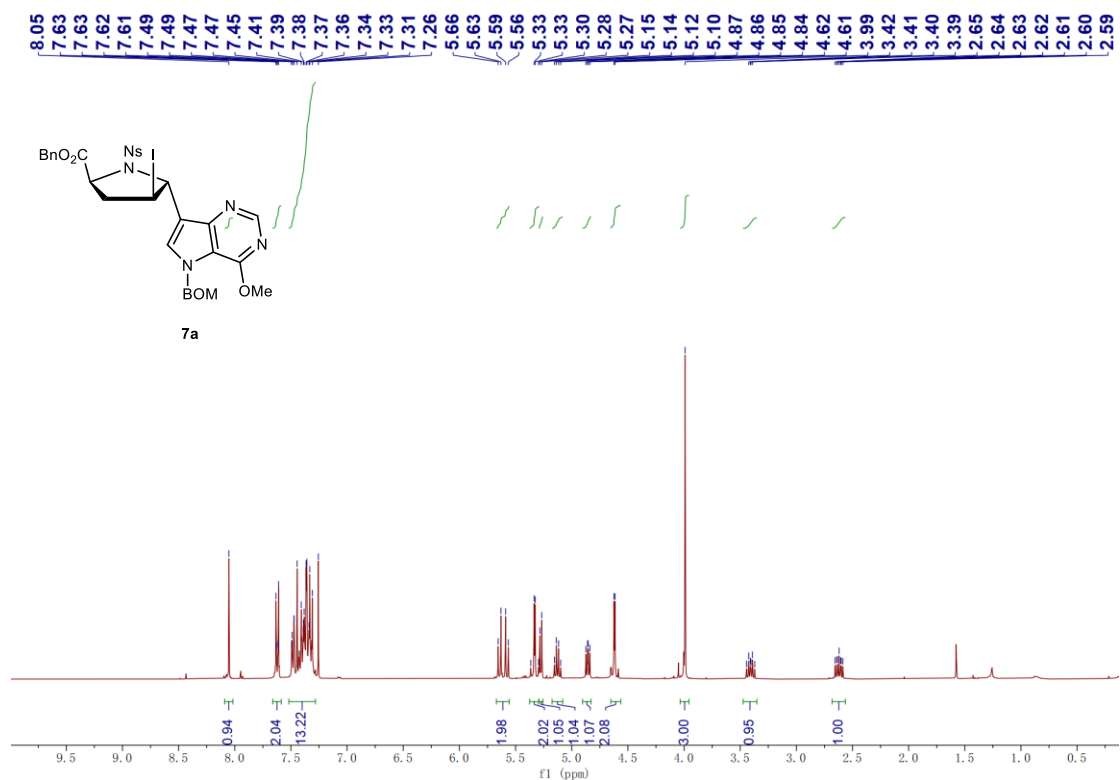
Supplementary Figure 99. H₂ NOEs (600 MHz, CDCl₃) of compound **6a**.



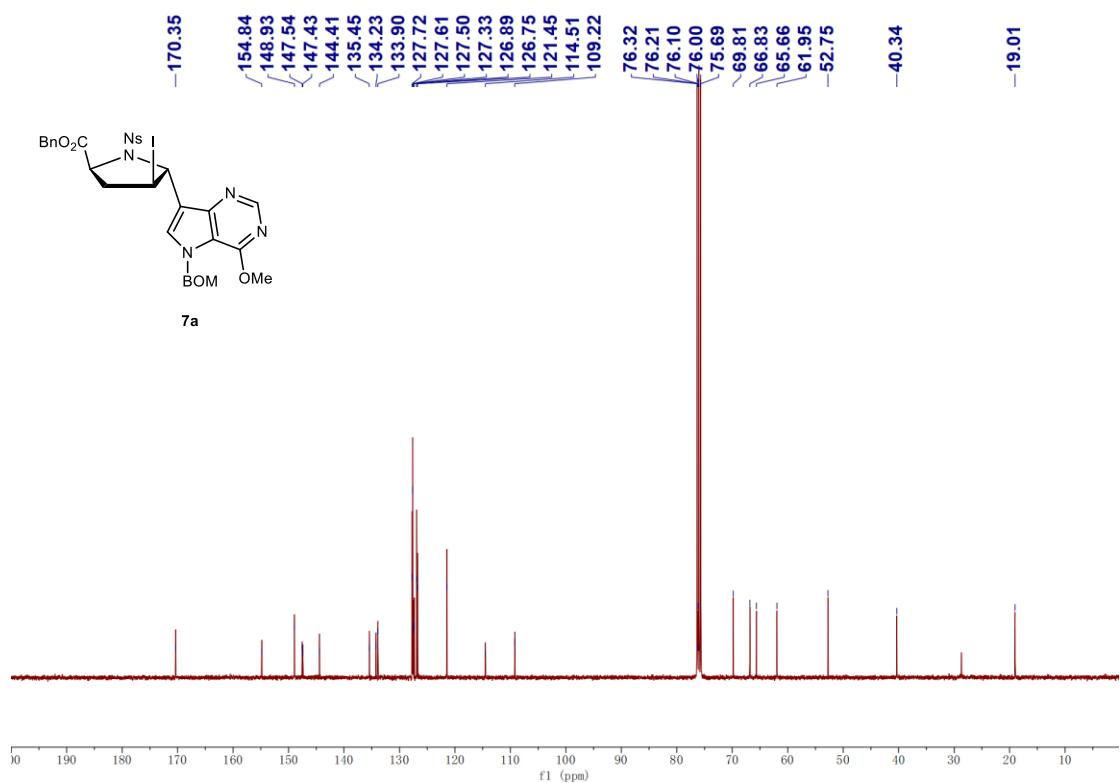
Supplementary Figure 100. H₃ NOEds (600 MHz, CDCl₃) of compound **6a**.



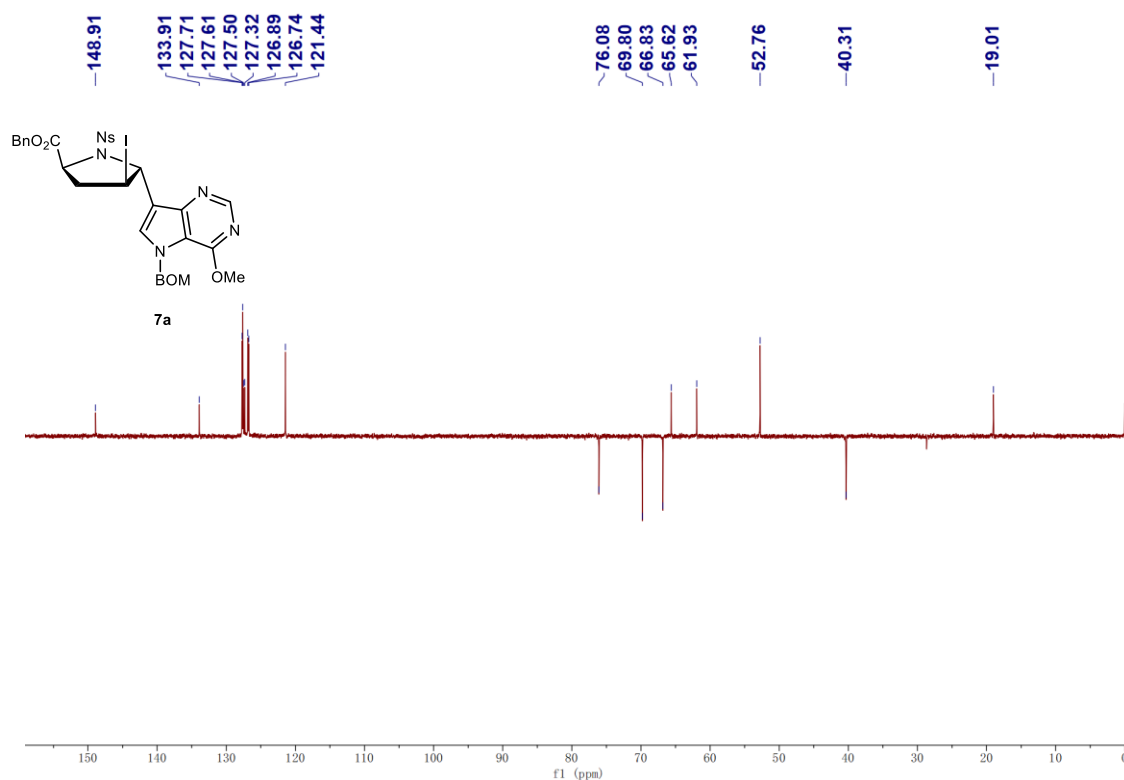
Supplementary Figure 101. H₄ NOEds (600 MHz, CDCl₃) of compound **6a**.



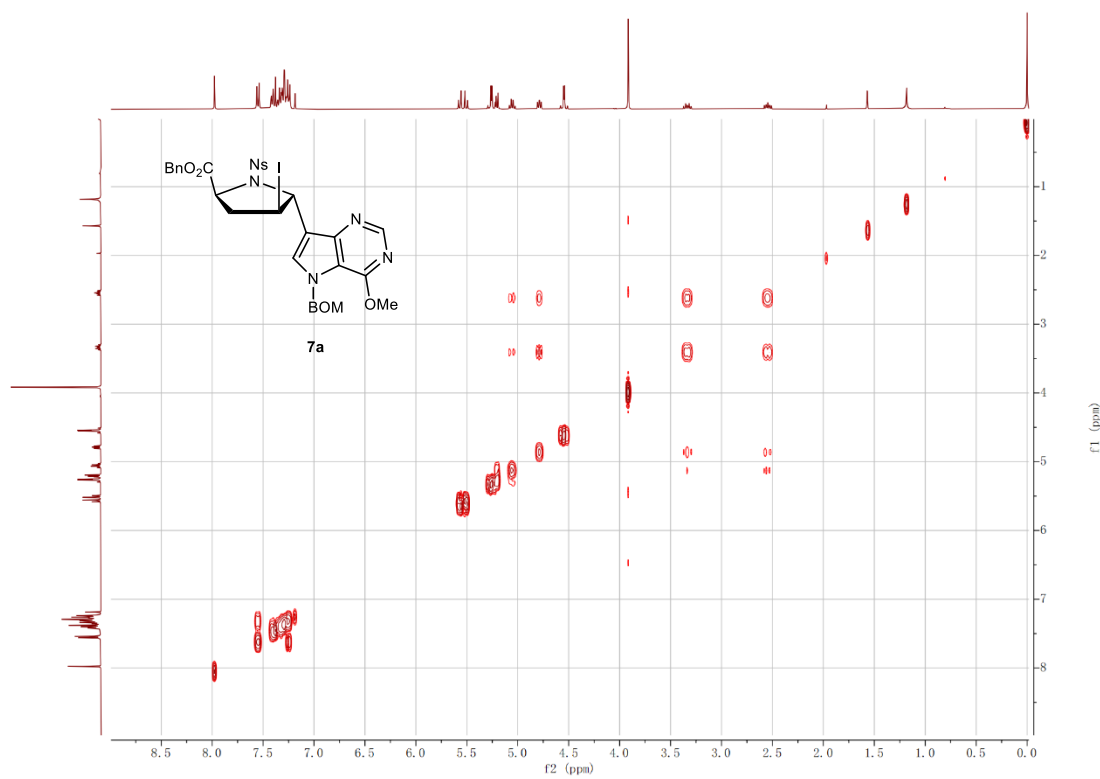
Supplementary Figure 102. ¹H NMR (400 MHz, CDCl₃) of compound **7a**.



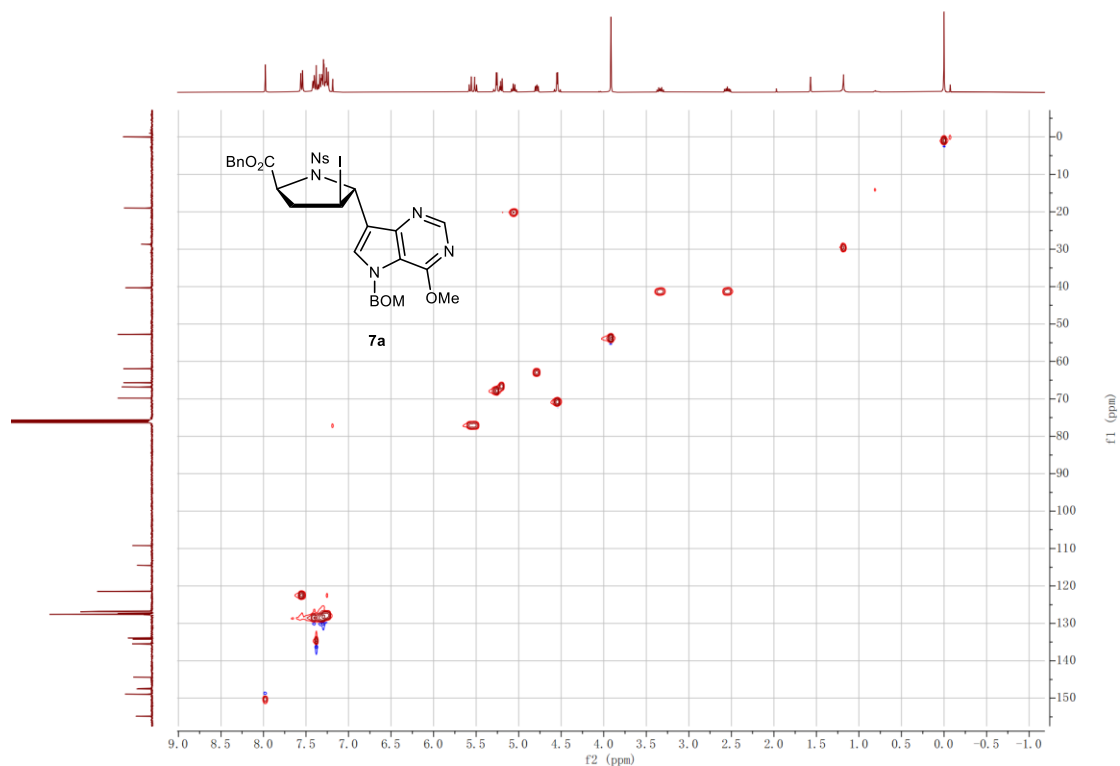
Supplementary Figure 103. ¹³C NMR (100 MHz, CDCl₃) of compound **7a**.



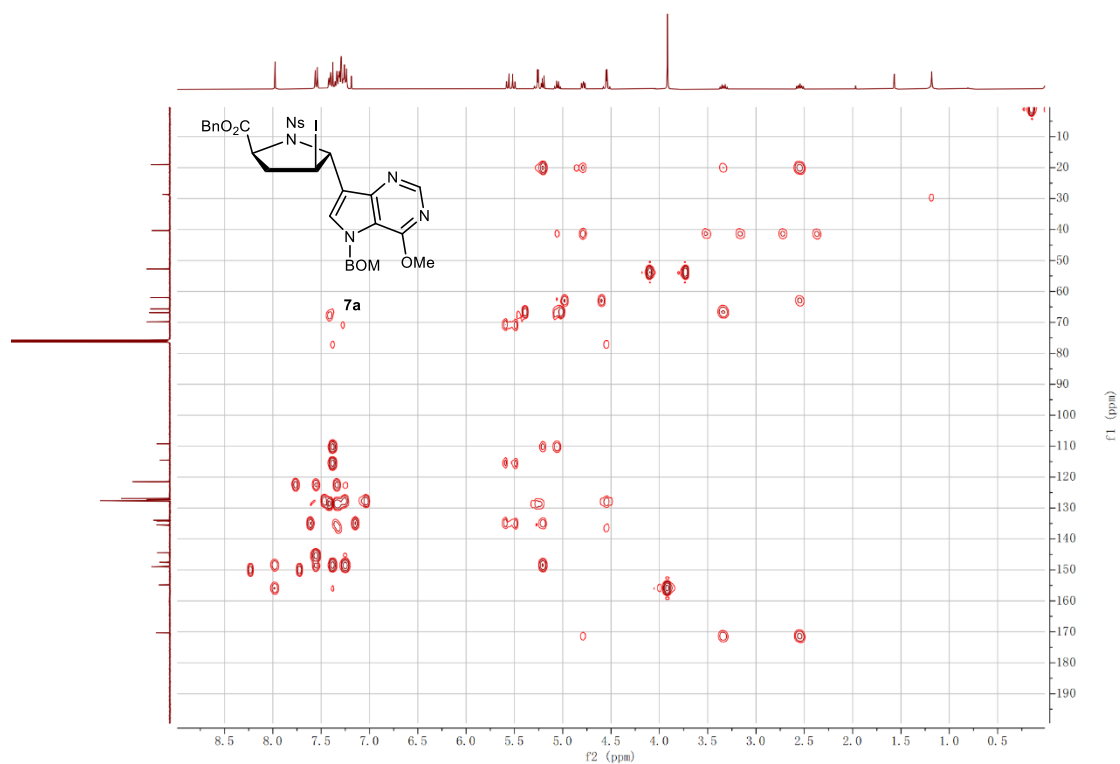
Supplementary Figure 104. DEPT 135° (100 MHz, CDCl₃) of compound **7a**.



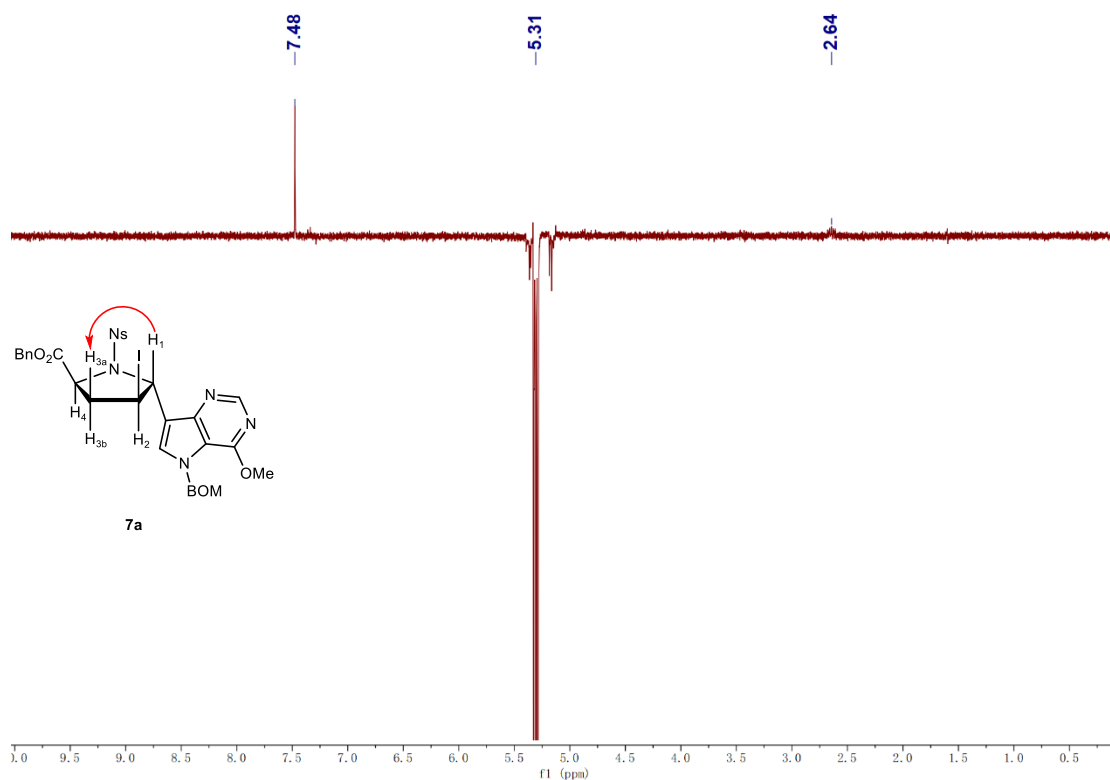
Supplementary Figure 105. ¹H-¹H COSY (400 MHz, CDCl₃) of compound **7a**.



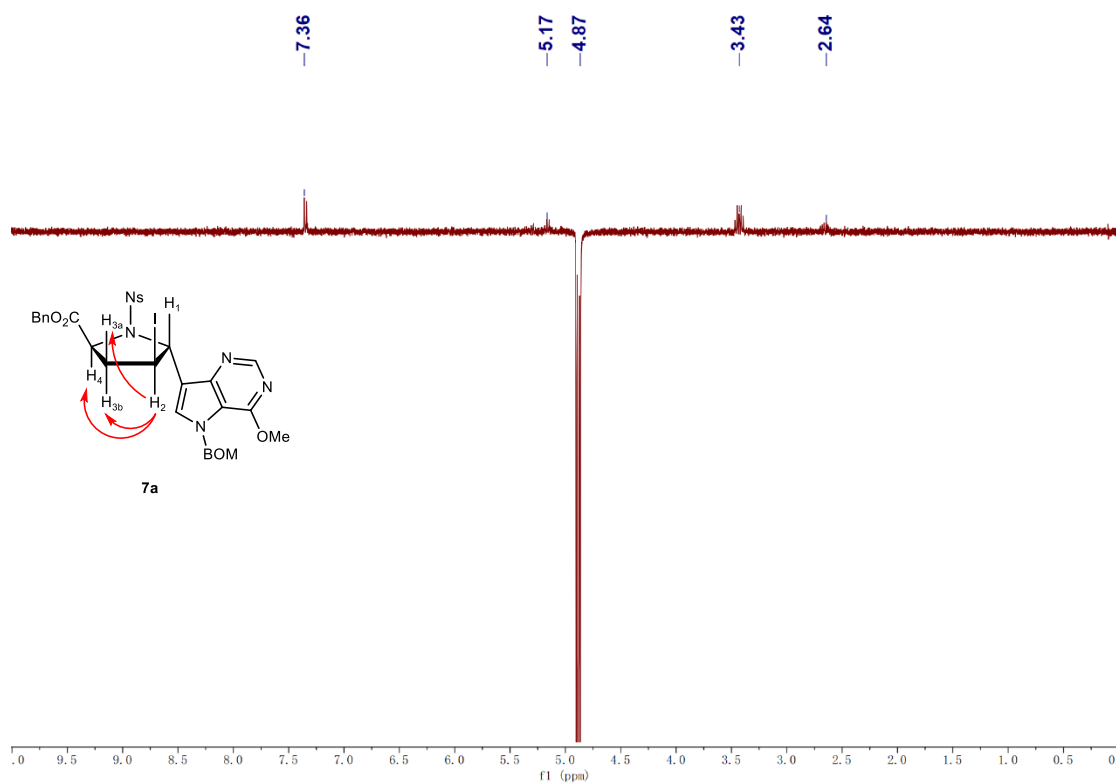
Supplementary Figure 106. ^1H - ^{13}C HSQC (400 MHz, CDCl_3) of compound **7a**.



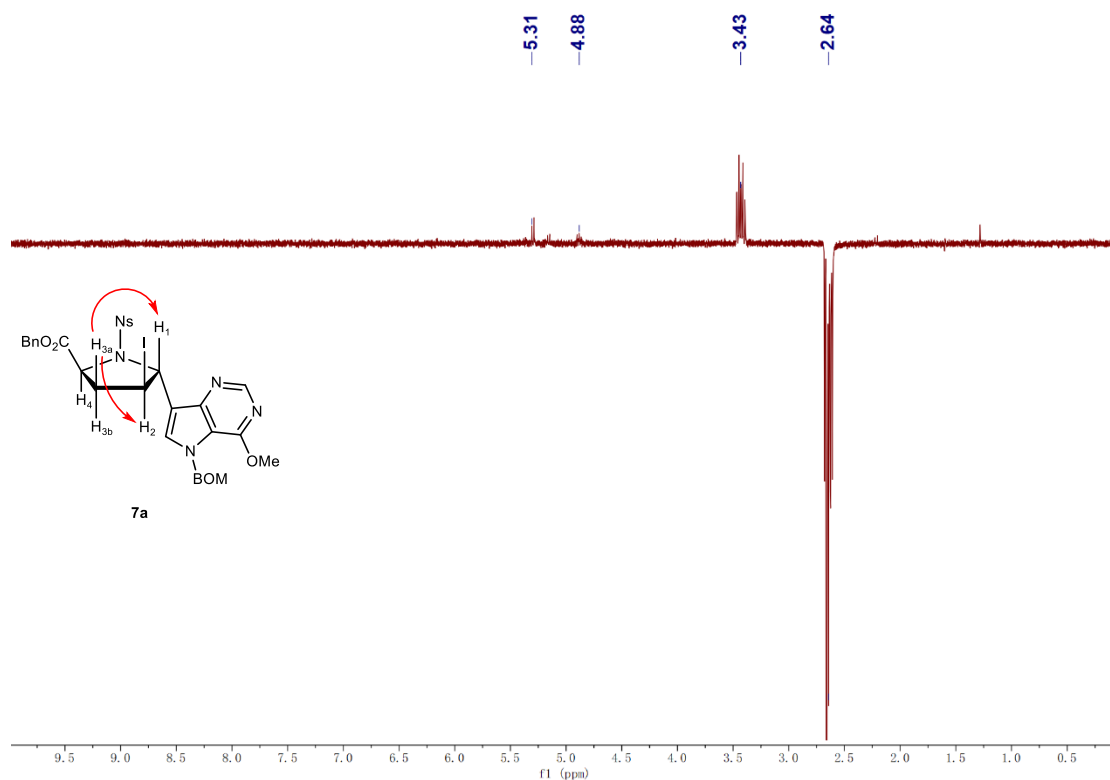
Supplementary Figure 107. ^1H - ^{13}C HMBC (400 MHz, CDCl_3) of compound **7a**.



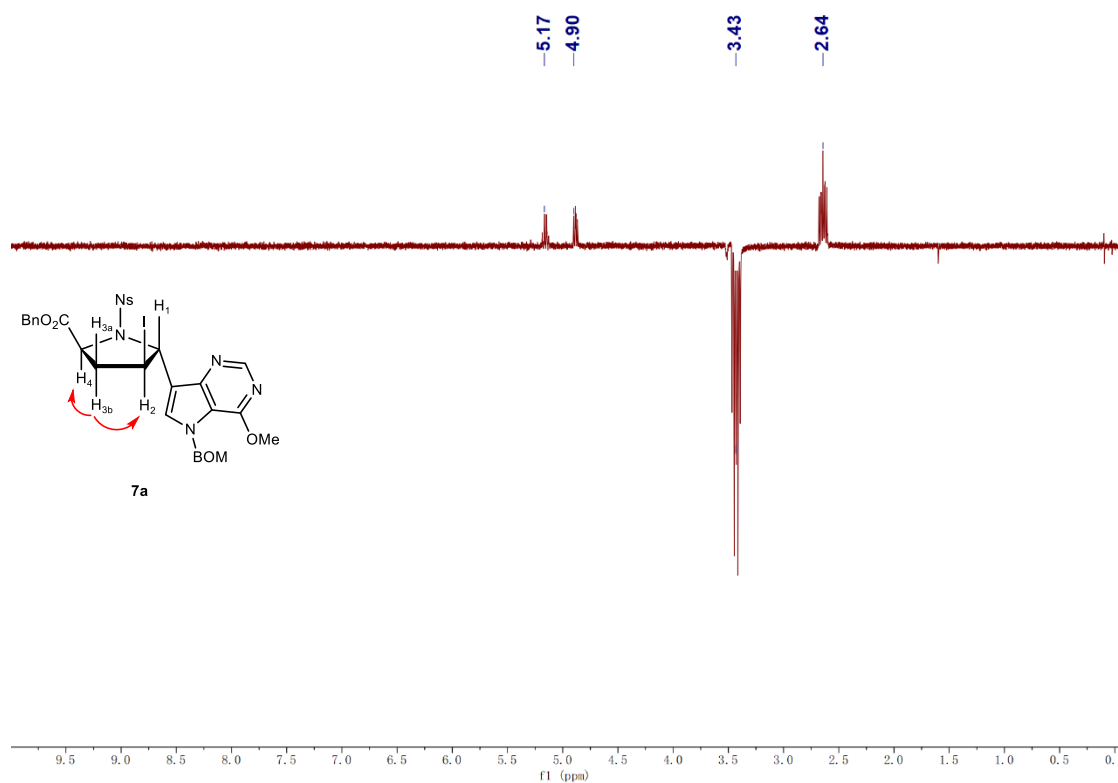
Supplementary Figure 108. H₁ NOEs (600 MHz, CDCl₃) of compound **7a**



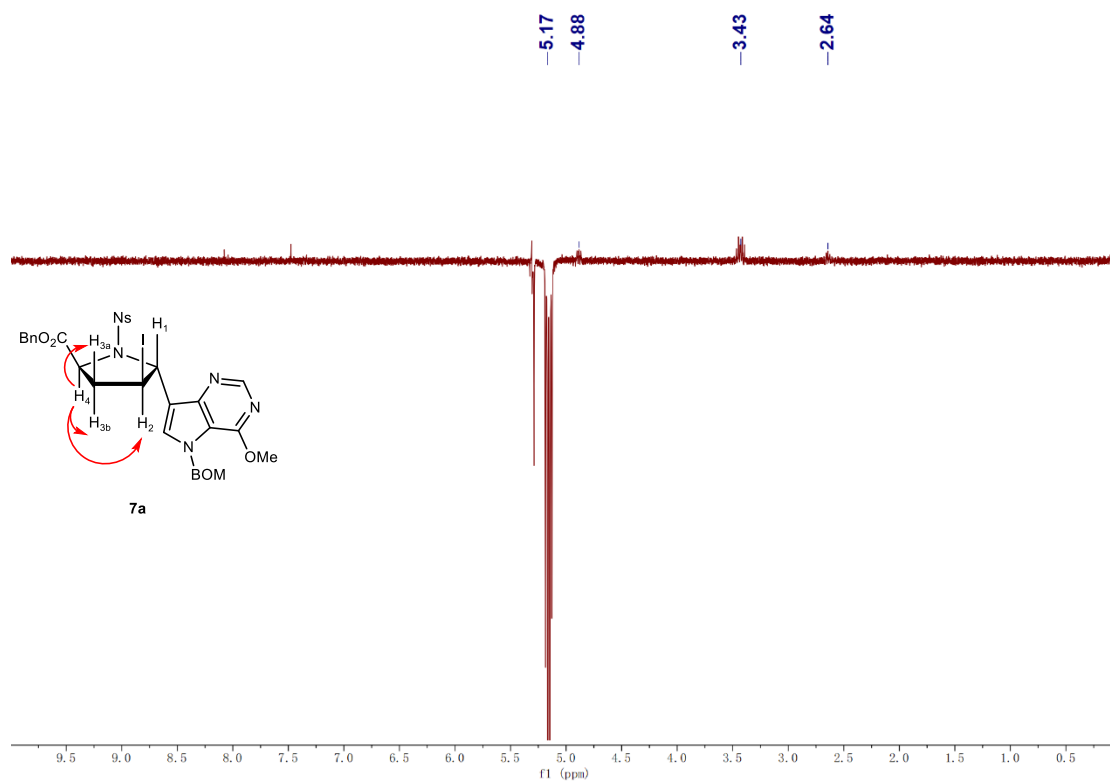
Supplementary Figure 109. H₂ NOEs (600 MHz, CDCl₃) of compound **7a**



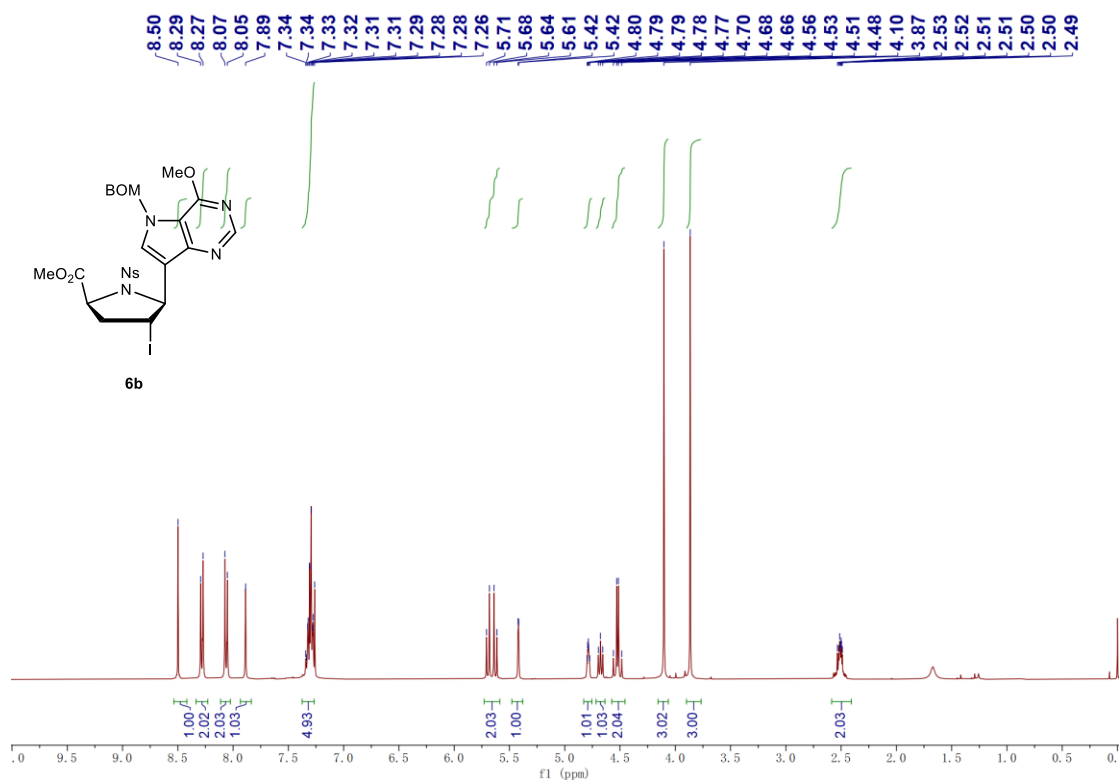
Supplementary Figure 110. H_{3a} NOEs (600 MHz, $CDCl_3$) of compound **7a**



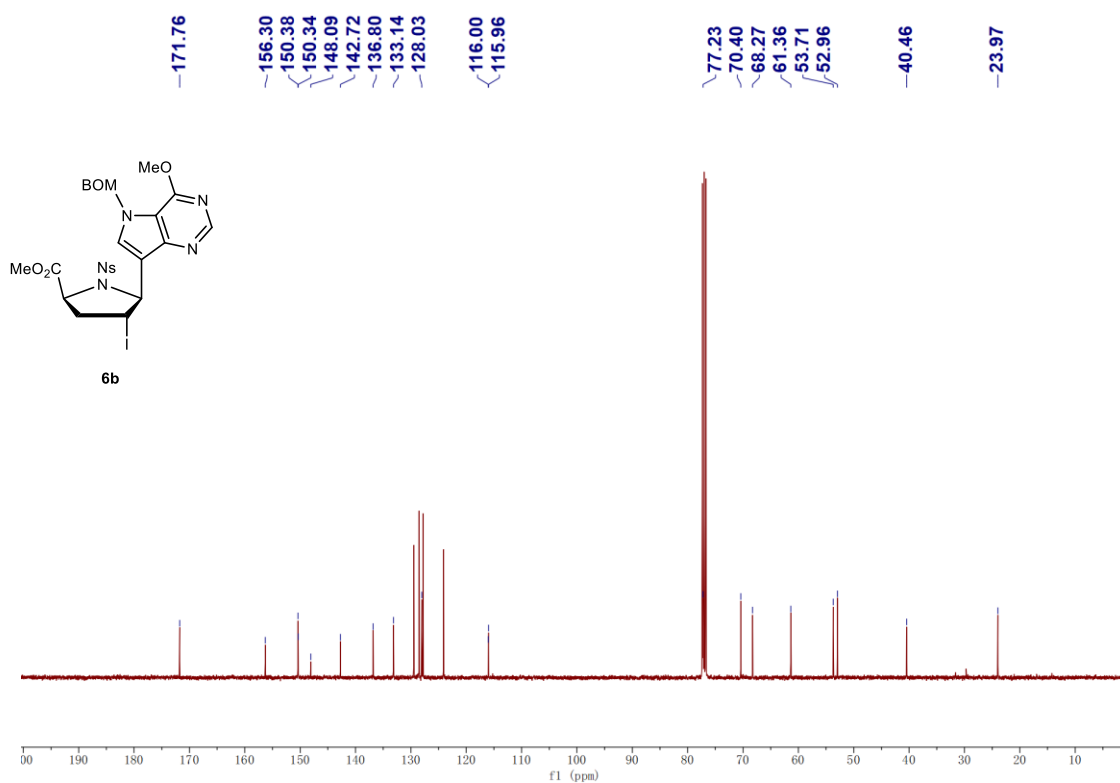
Supplementary Figure 111. H_{3b} NOEs (600 MHz, $CDCl_3$) of compound **7a**.



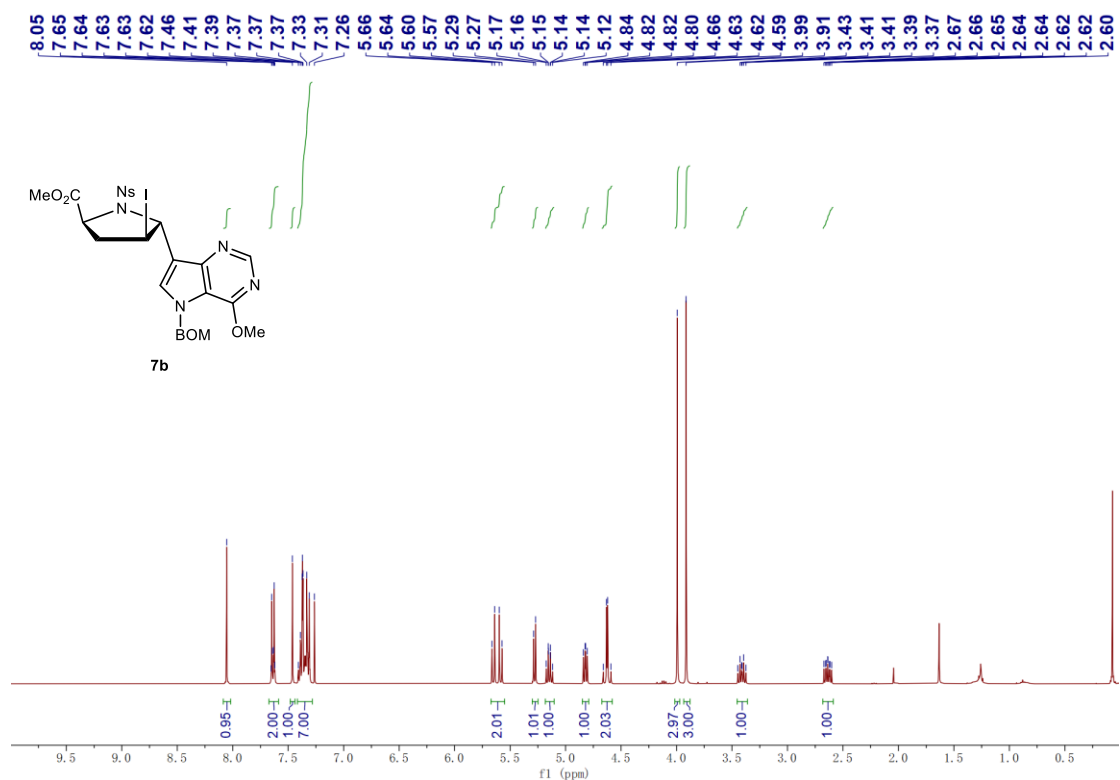
Supplementary Figure 112. H₄ NOEds (600 MHz, CDCl₃) of compound **7a**.



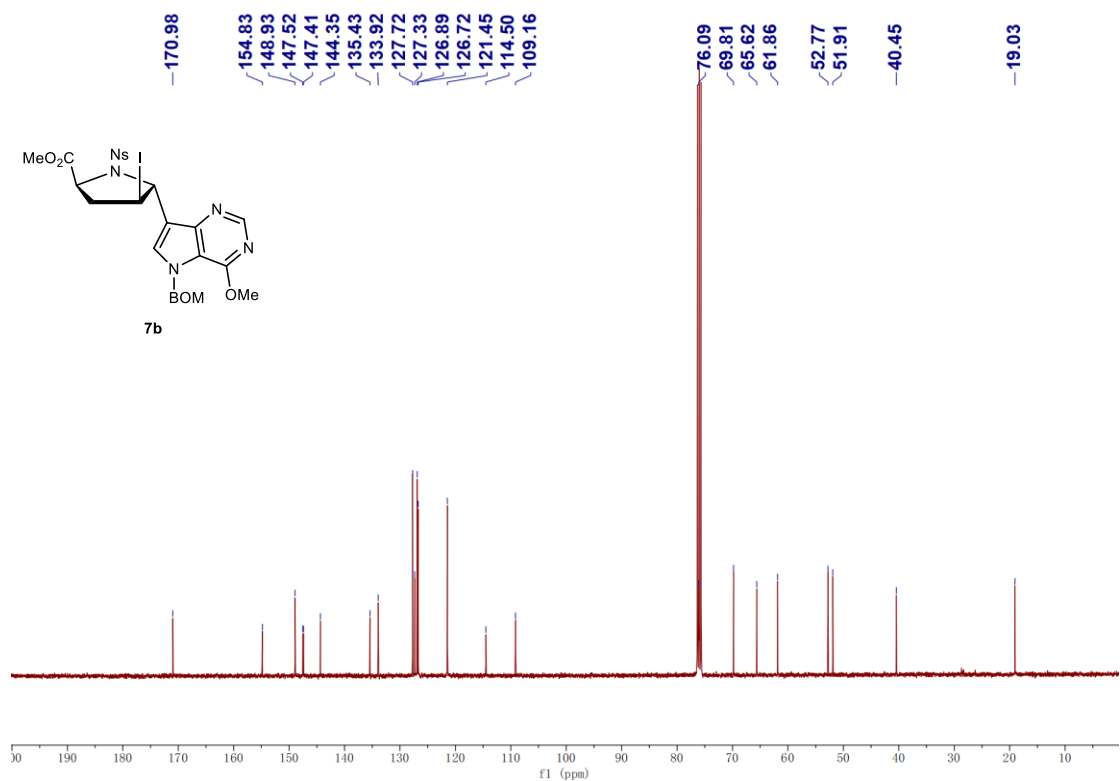
Supplementary Figure 113. ¹H NMR (400 MHz, CDCl₃) of compound **6b**.



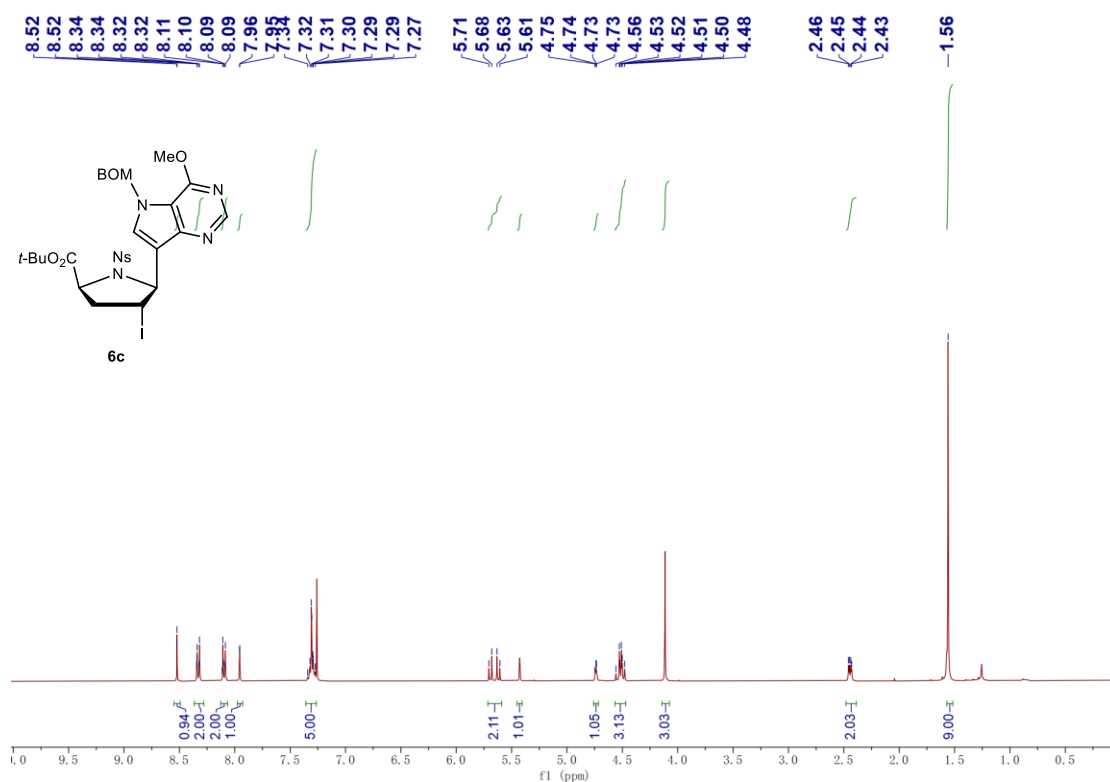
Supplementary Figure 114. ¹³C NMR (100 MHz, CDCl₃) of compound **6b**.



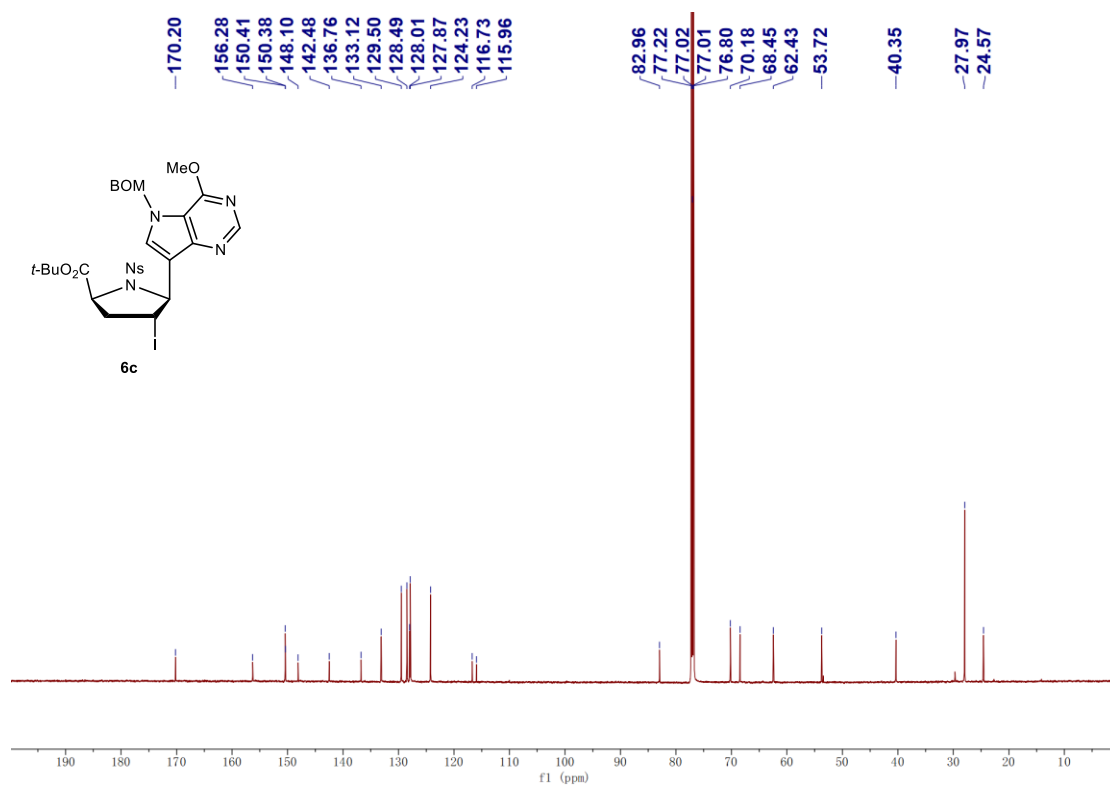
Supplementary Figure 115. ¹H NMR (400 MHz, CDCl₃) of compound **7b**.



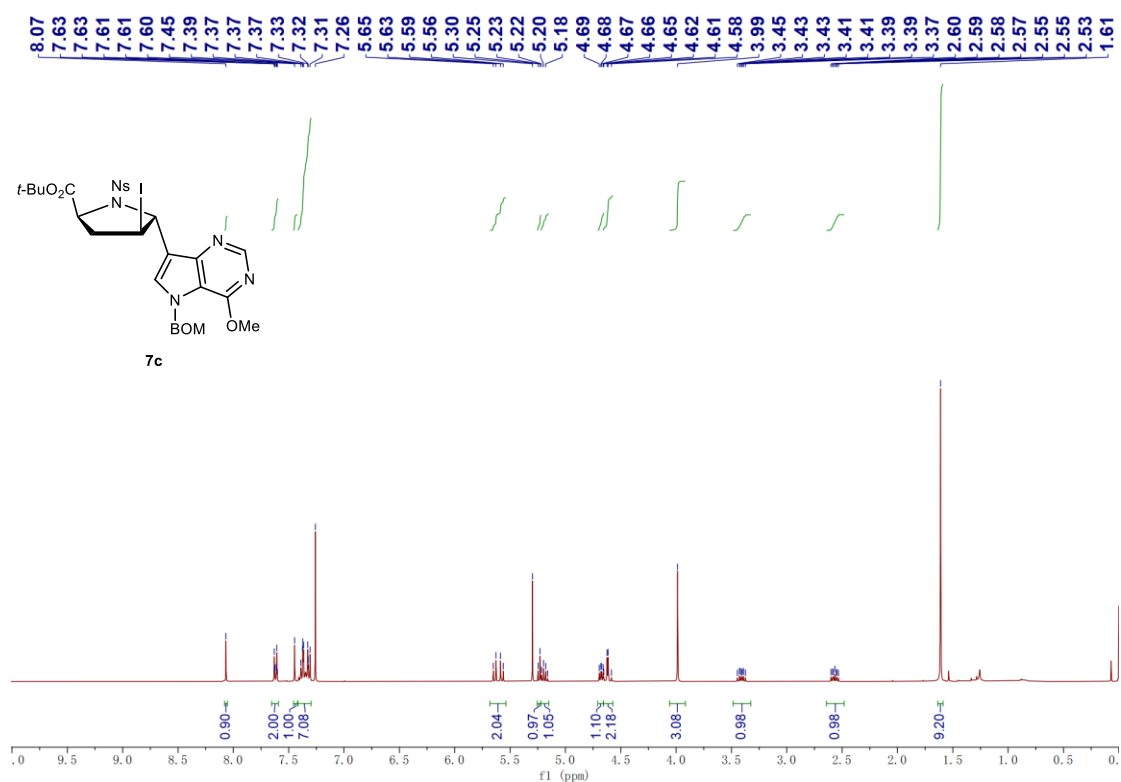
Supplementary Figure 116. ¹³C NMR (100 MHz, CDCl₃) of compound **7b**.



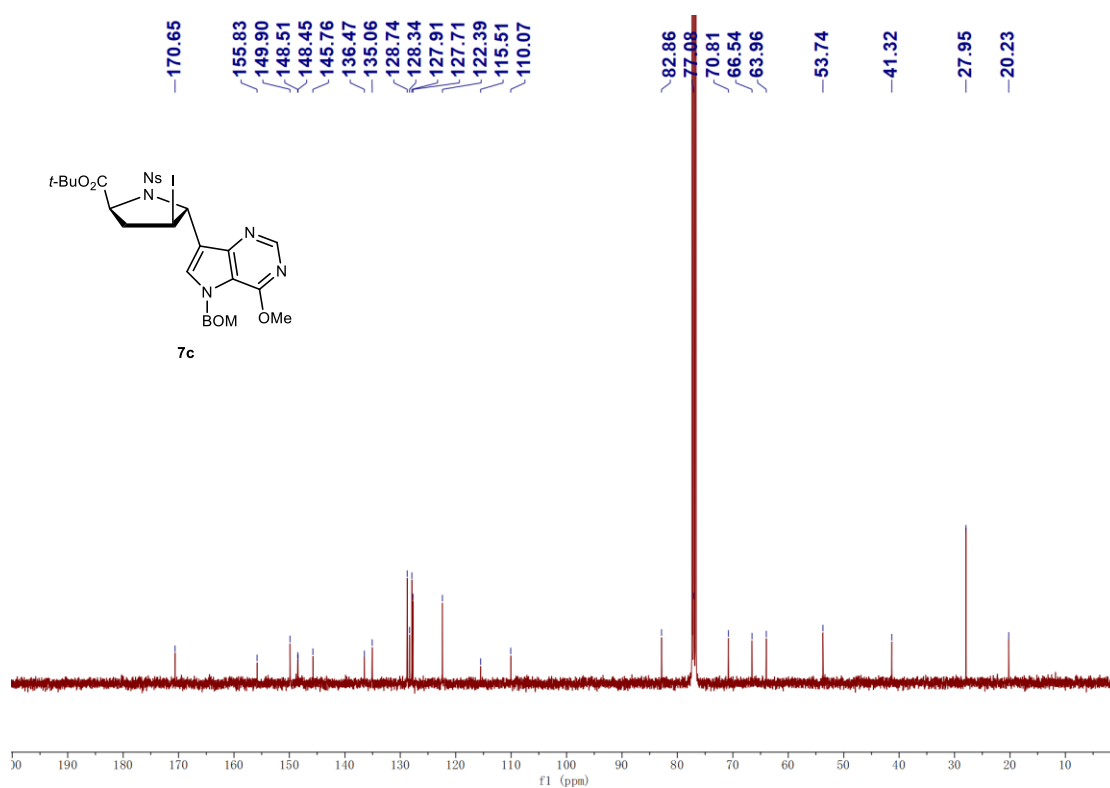
Supplementary Figure 117. ¹H NMR (400 MHz, CDCl₃) of compound **6c**.



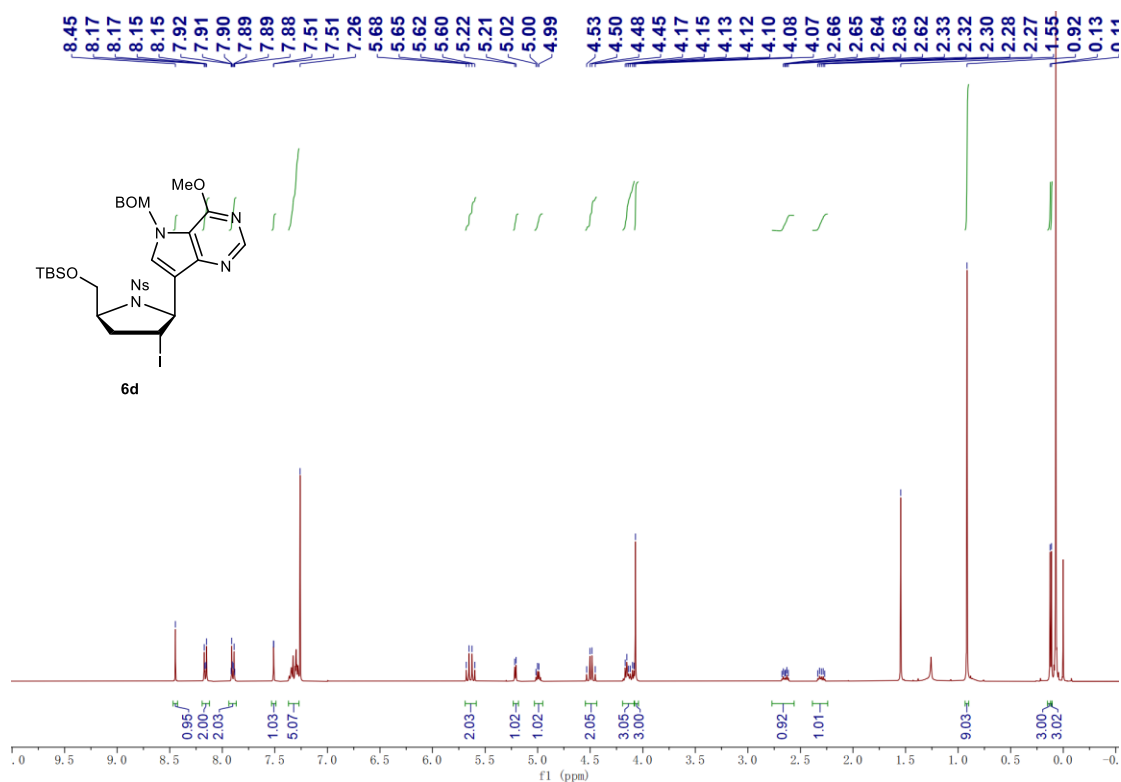
Supplementary Figure 118. ¹³C NMR (150 MHz, CDCl₃) of compound **6c**.



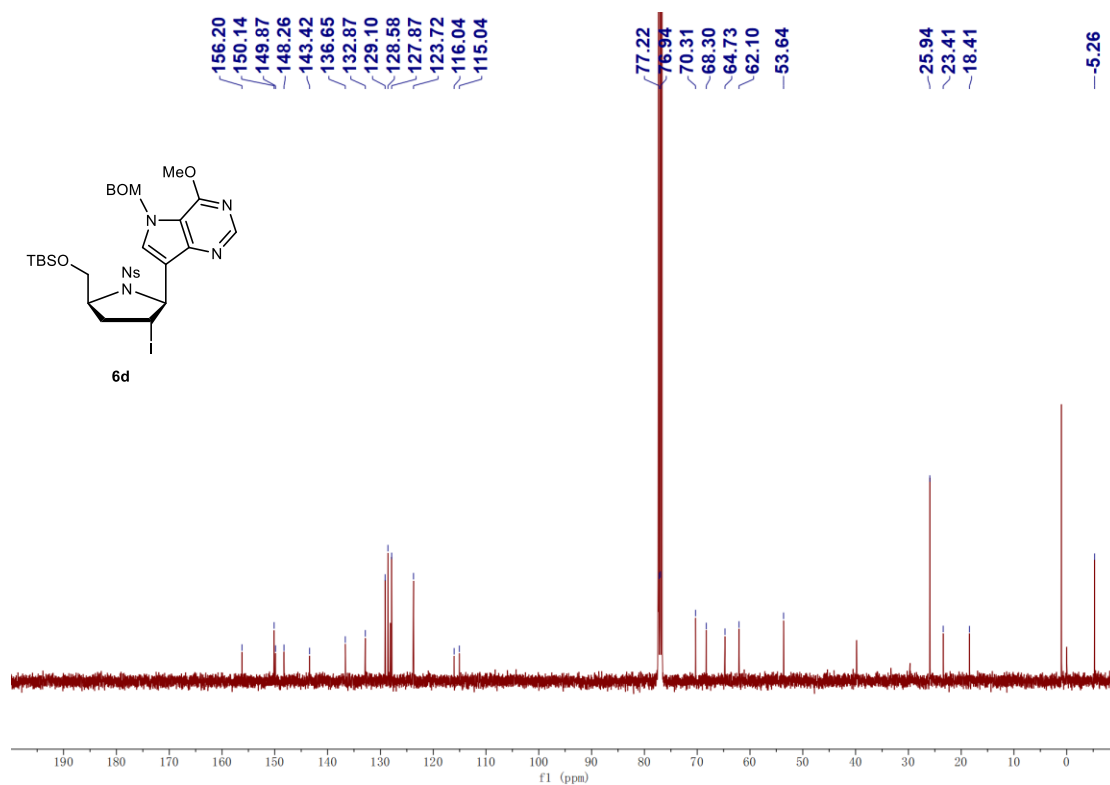
Supplementary Figure 119. ¹H NMR (400 MHz, CDCl₃) of compound **7c**.



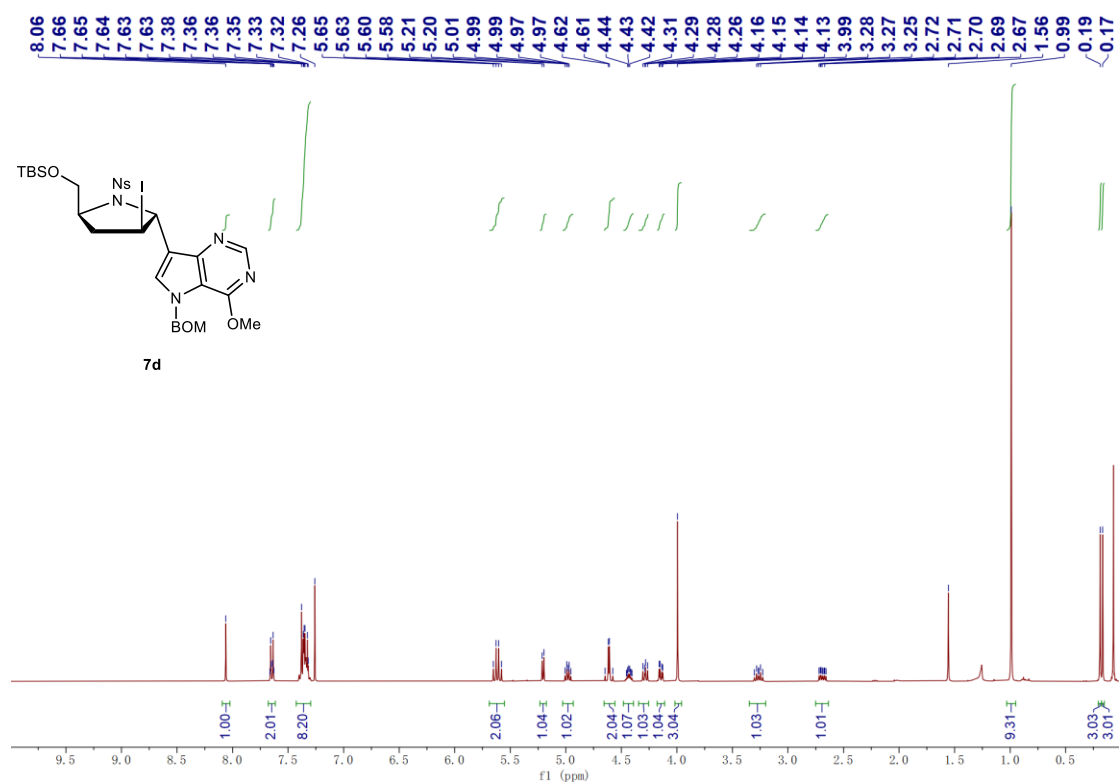
Supplementary Figure 120. ¹³C NMR (100 MHz, CDCl₃) of compound **7c**.



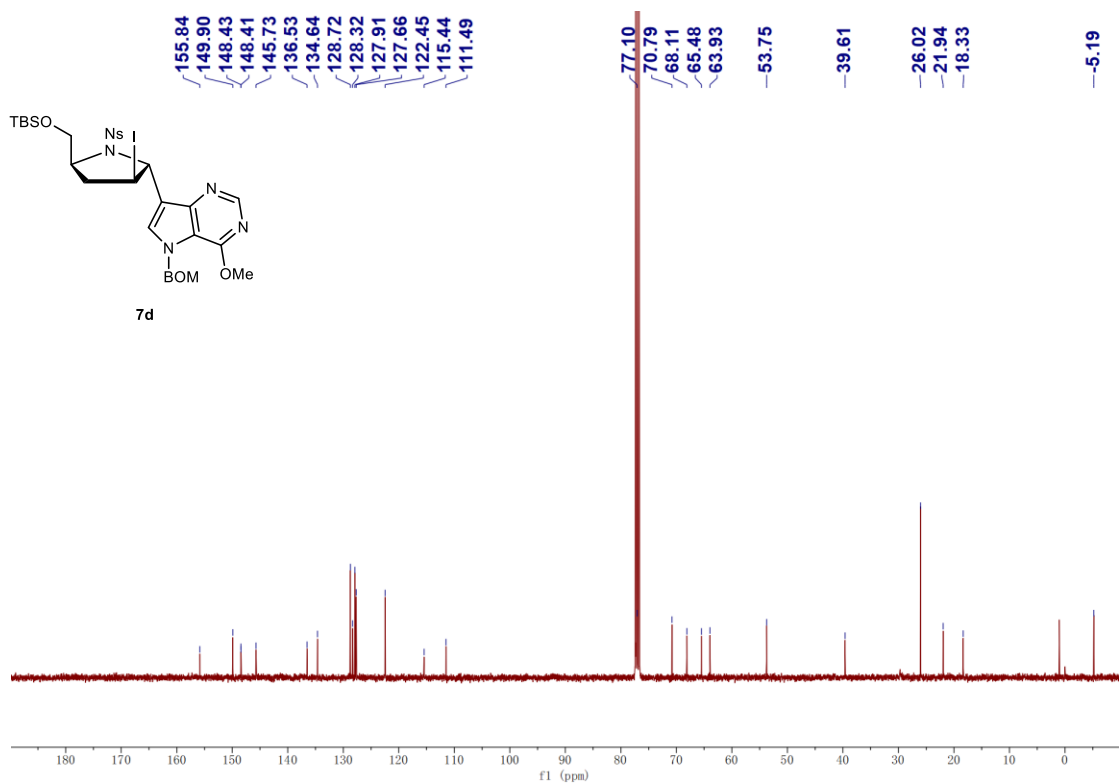
Supplementary Figure 121. ¹H NMR (400 MHz, CDCl₃) of compound **6d**.



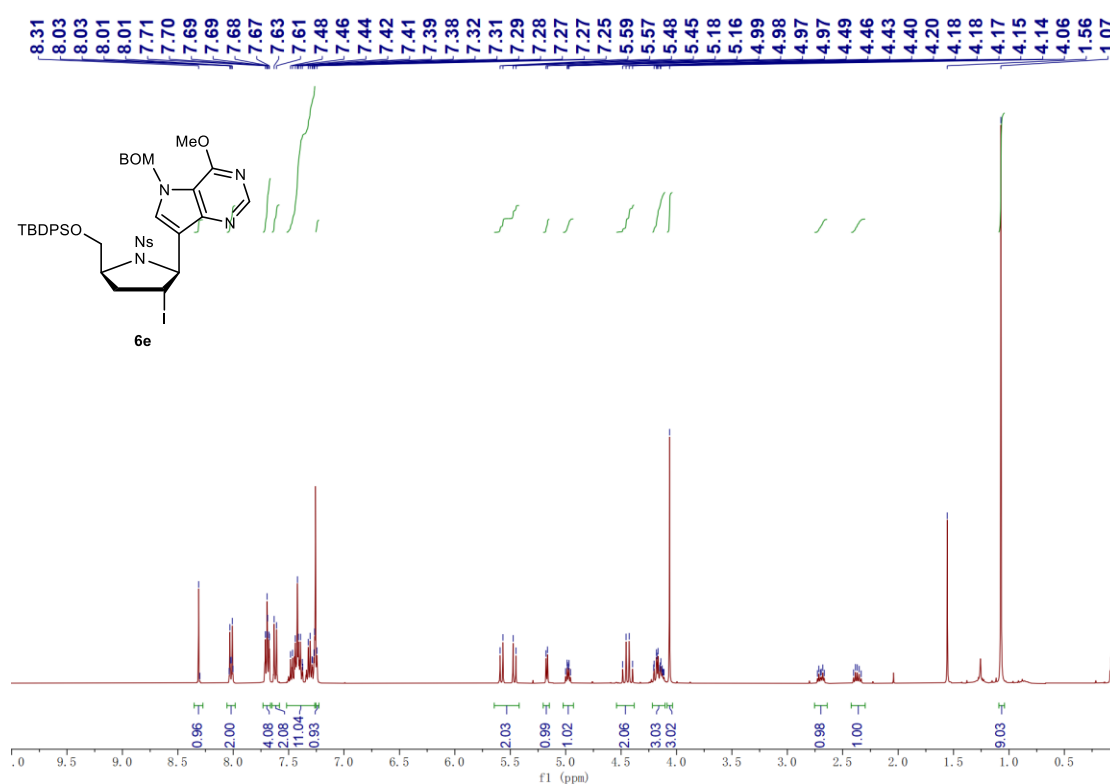
Supplementary Figure 122. ¹³C NMR (100 MHz, CDCl₃) of compound **6d**.



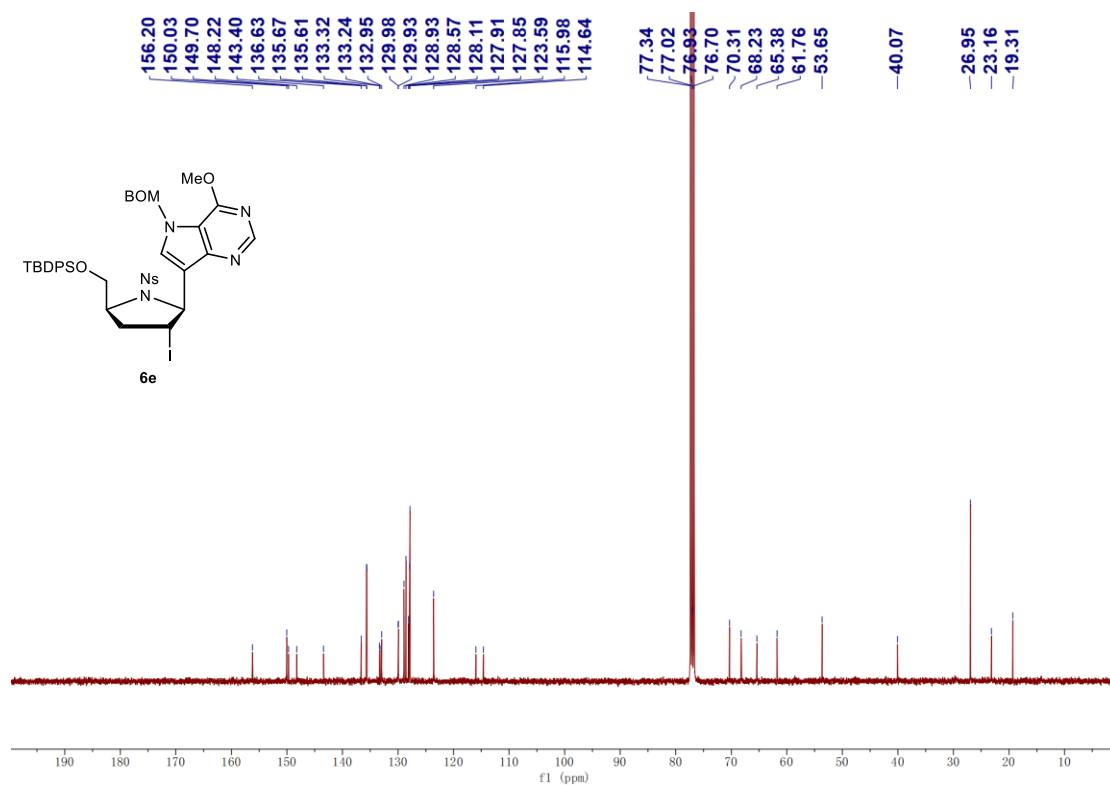
Supplementary Figure 123. ¹H NMR (400 MHz, CDCl₃) of compound **7d**.



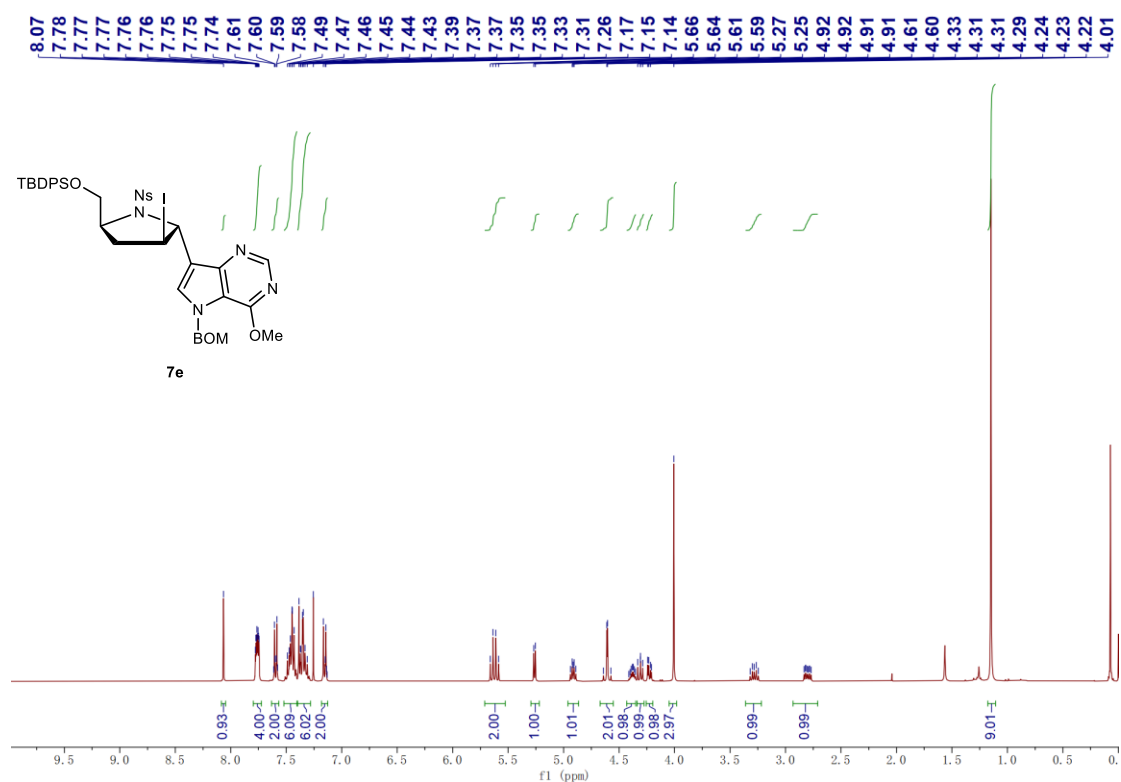
Supplementary Figure 124. ¹³C NMR (100 MHz, CDCl₃) of compound **7d**.



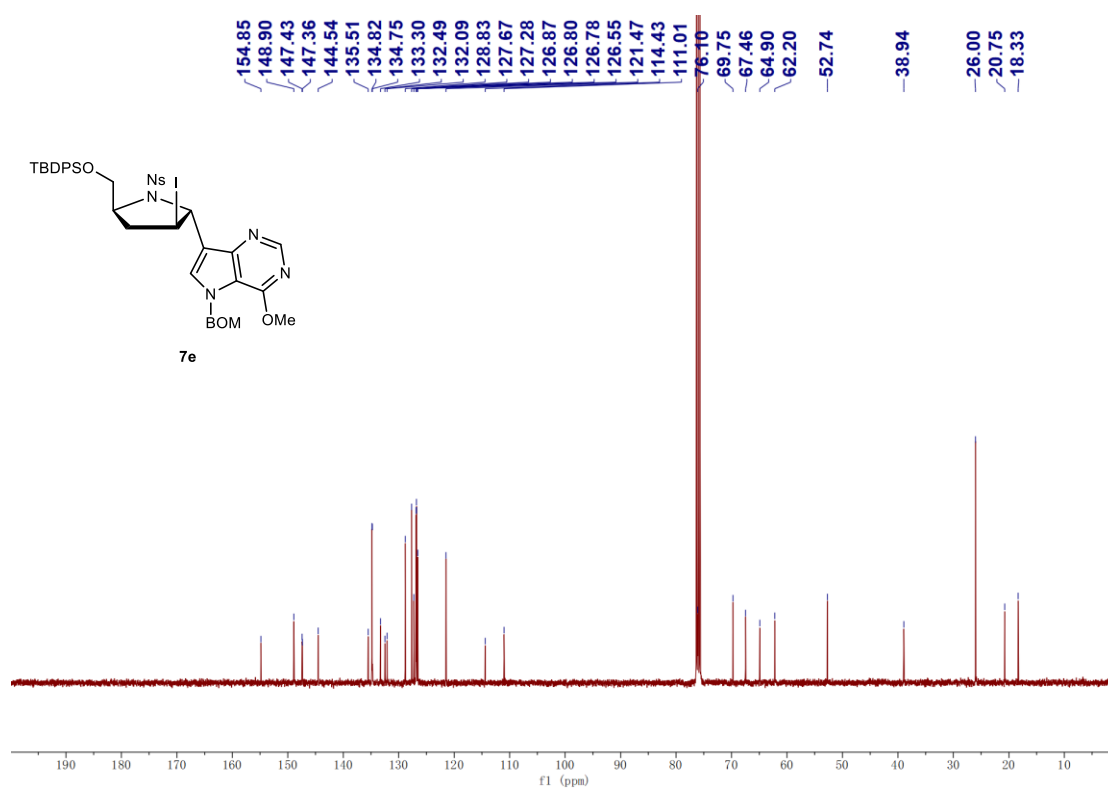
Supplementary Figure 125. ¹H NMR (400 MHz, CDCl₃) of compound **6e**.



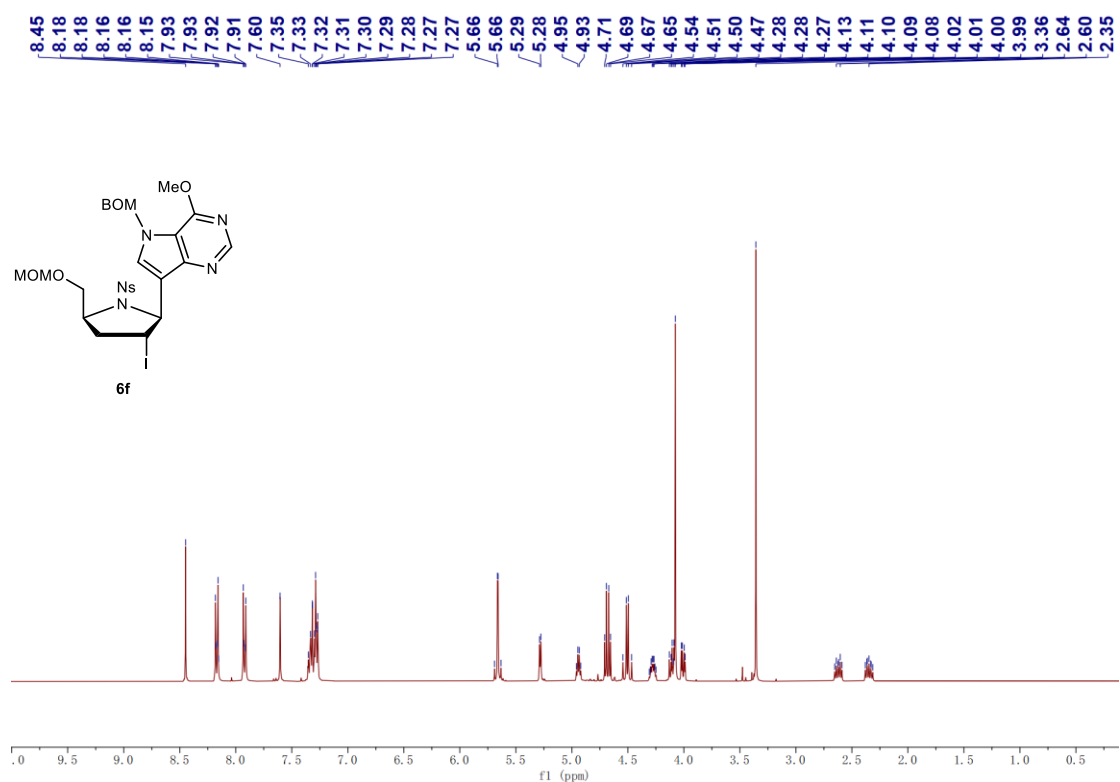
Supplementary Figure 126. ¹³C NMR (100 MHz, CDCl₃) of compound **6e**.



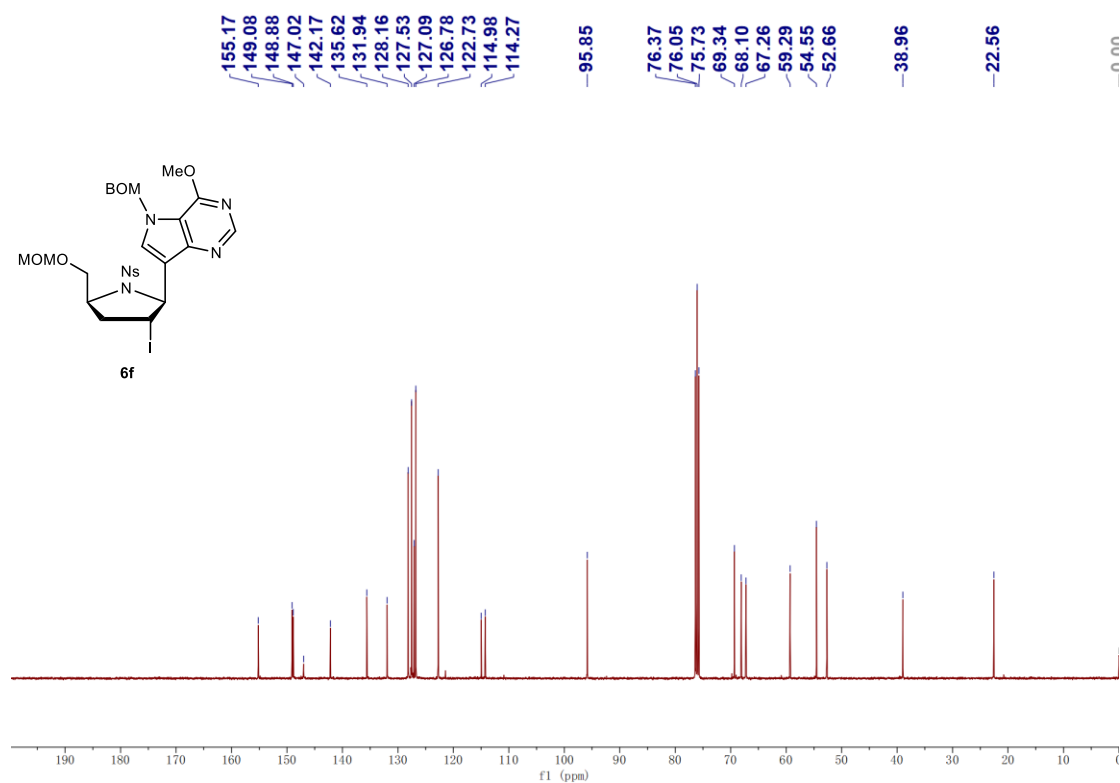
Supplementary Figure 127. ¹H NMR (400 MHz, CDCl₃) of compound **7e**.



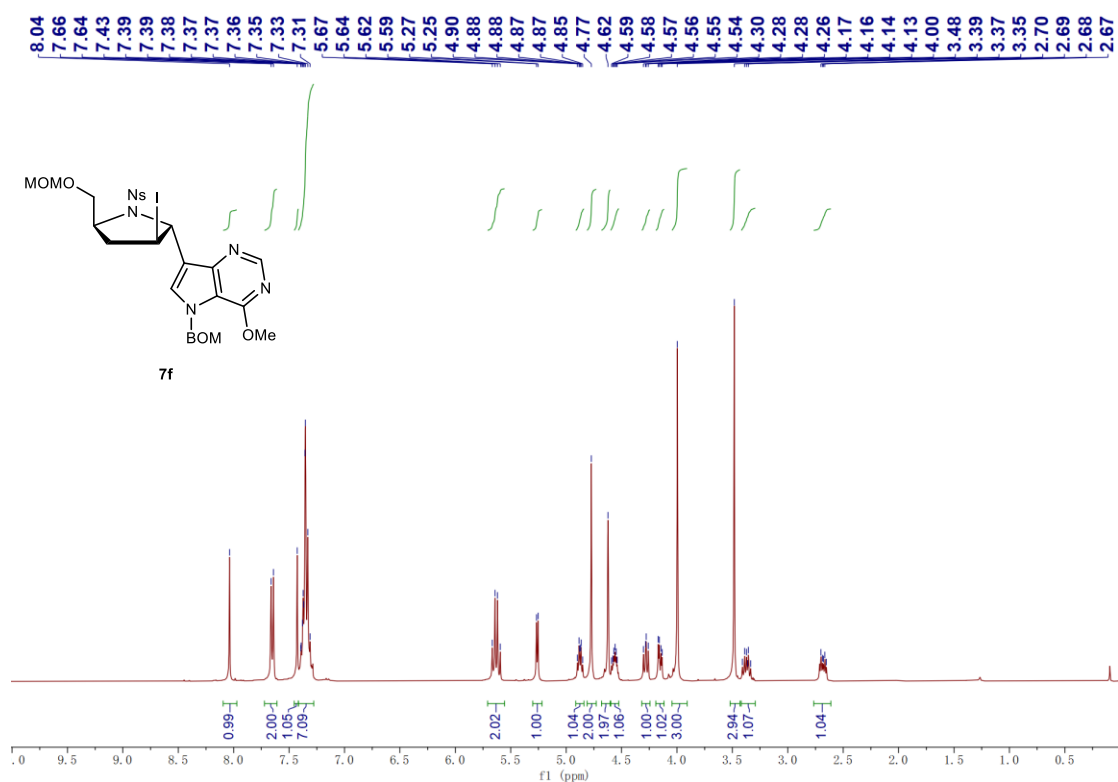
Supplementary Figure 128. ¹³C NMR (100 MHz, CDCl₃) of compound **7e**.



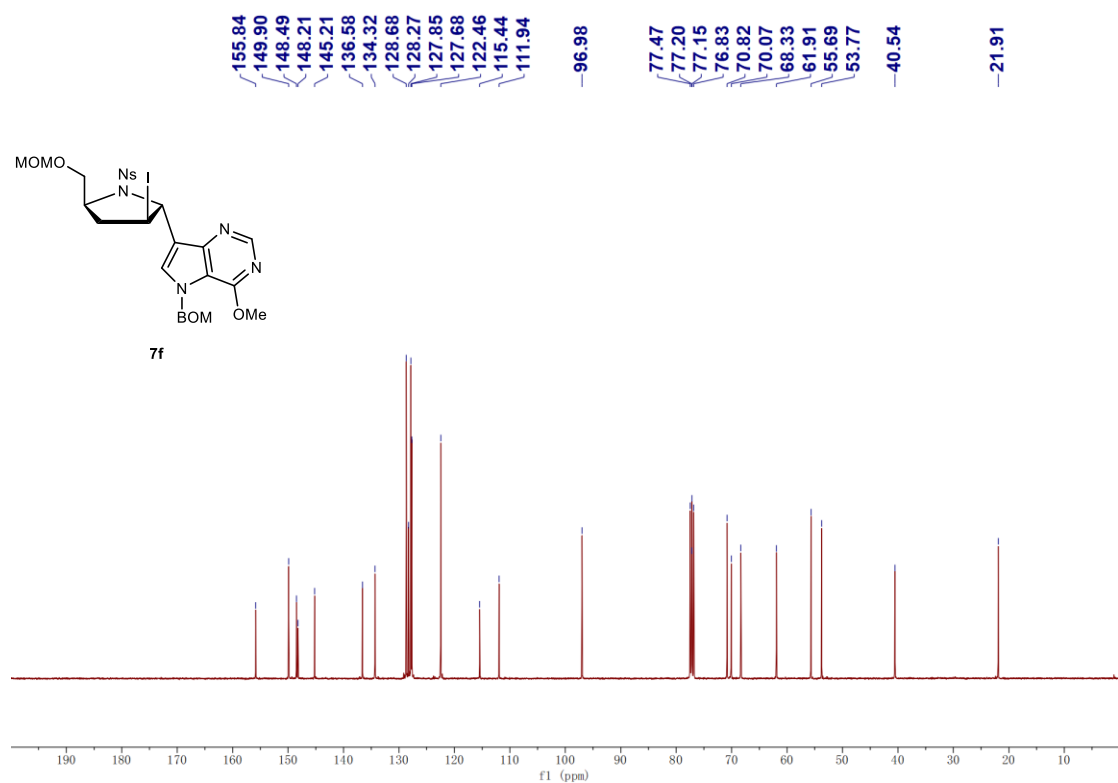
Supplementary Figure 129. ^1H NMR (400 MHz, CDCl_3) of compound **6f**.



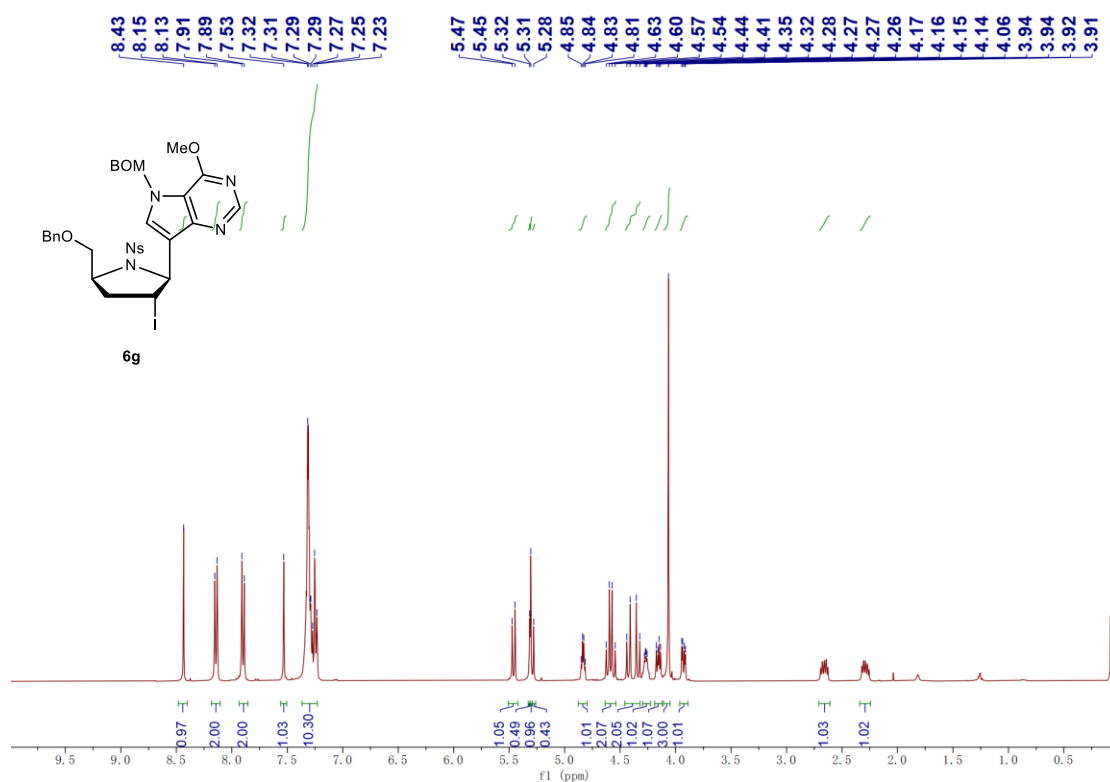
Supplementary Figure 130. ^{13}C NMR (100 MHz, CDCl_3) of compound **6f**.



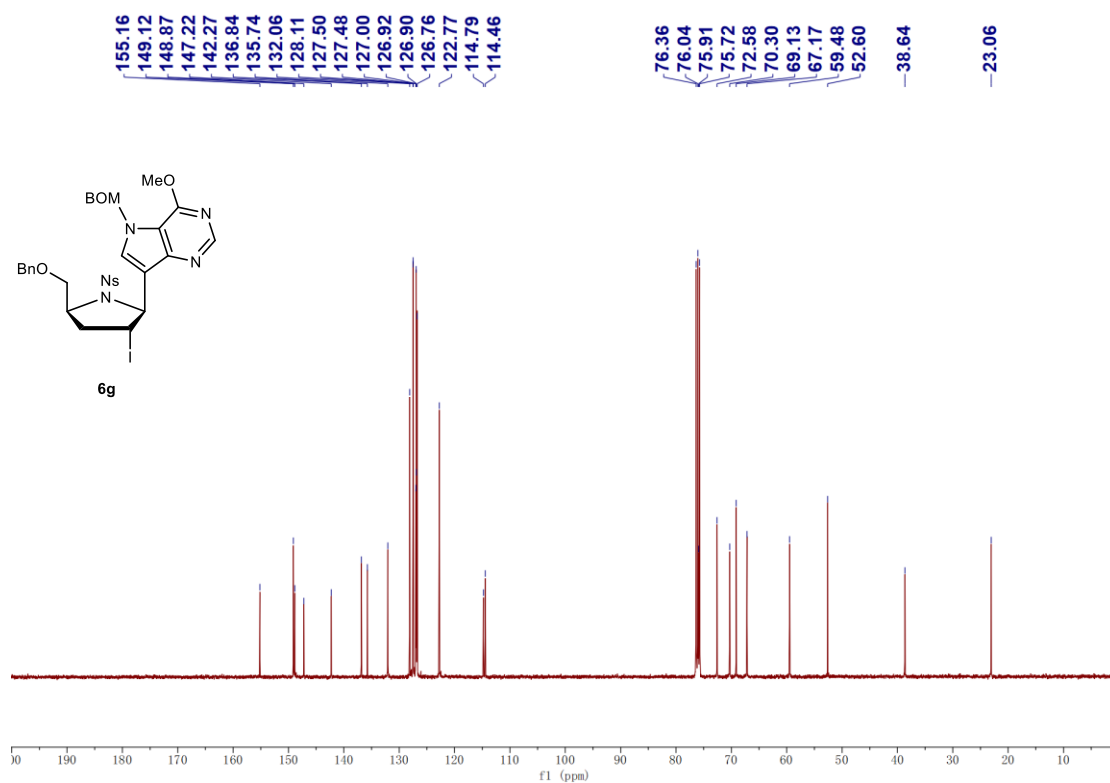
Supplementary Figure 131. ¹H NMR (400 MHz, CDCl₃) of compound **7f**.



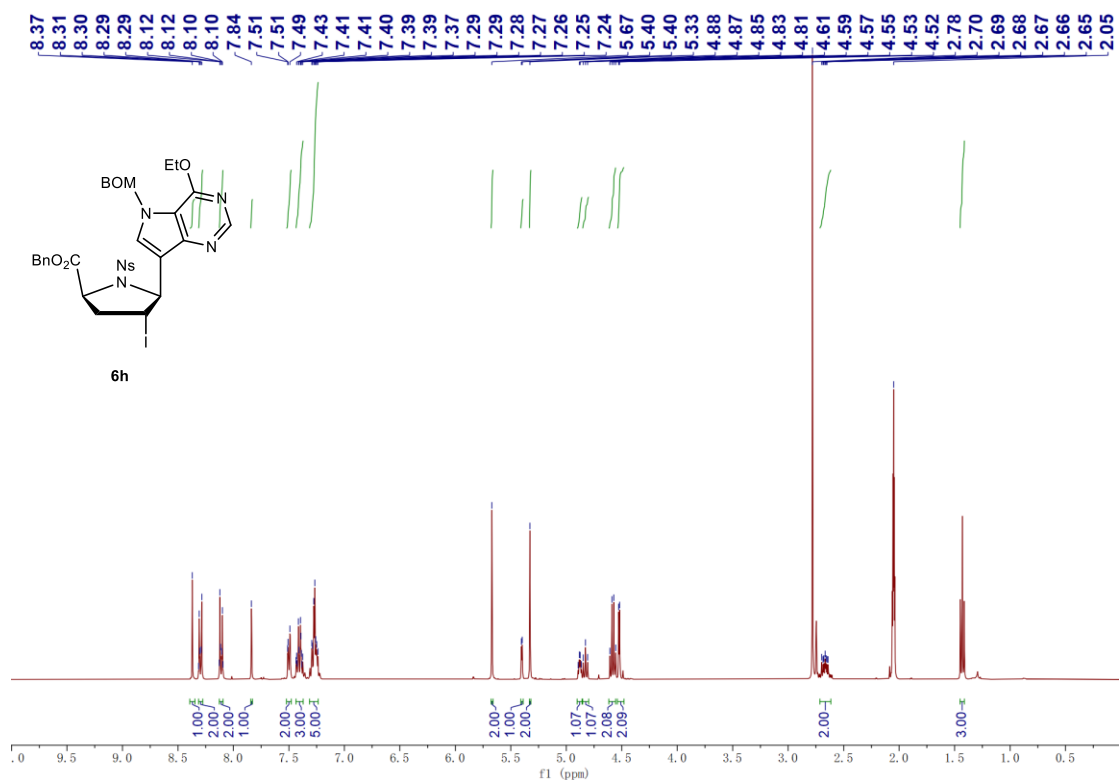
Supplementary Figure 132. ¹³C NMR (100 MHz, CDCl₃) of compound **7f**.



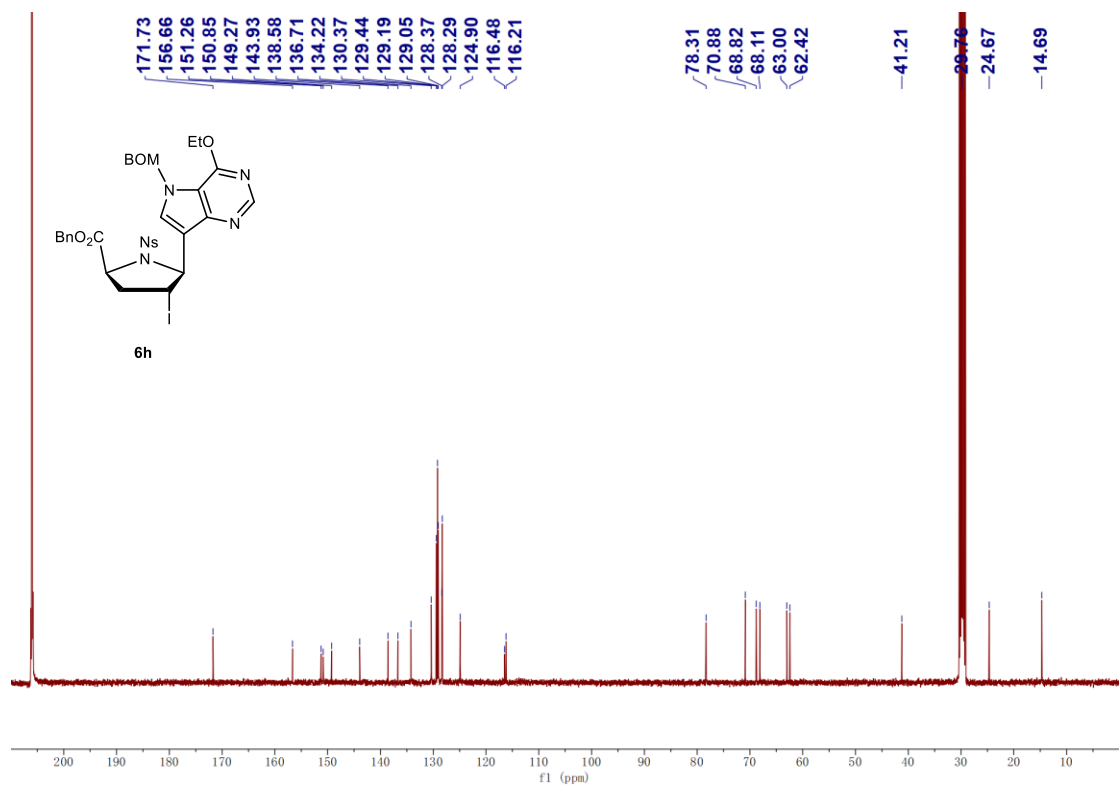
Supplementary Figure 133. ^1H NMR (400 MHz, CDCl_3) of compound **6g**.



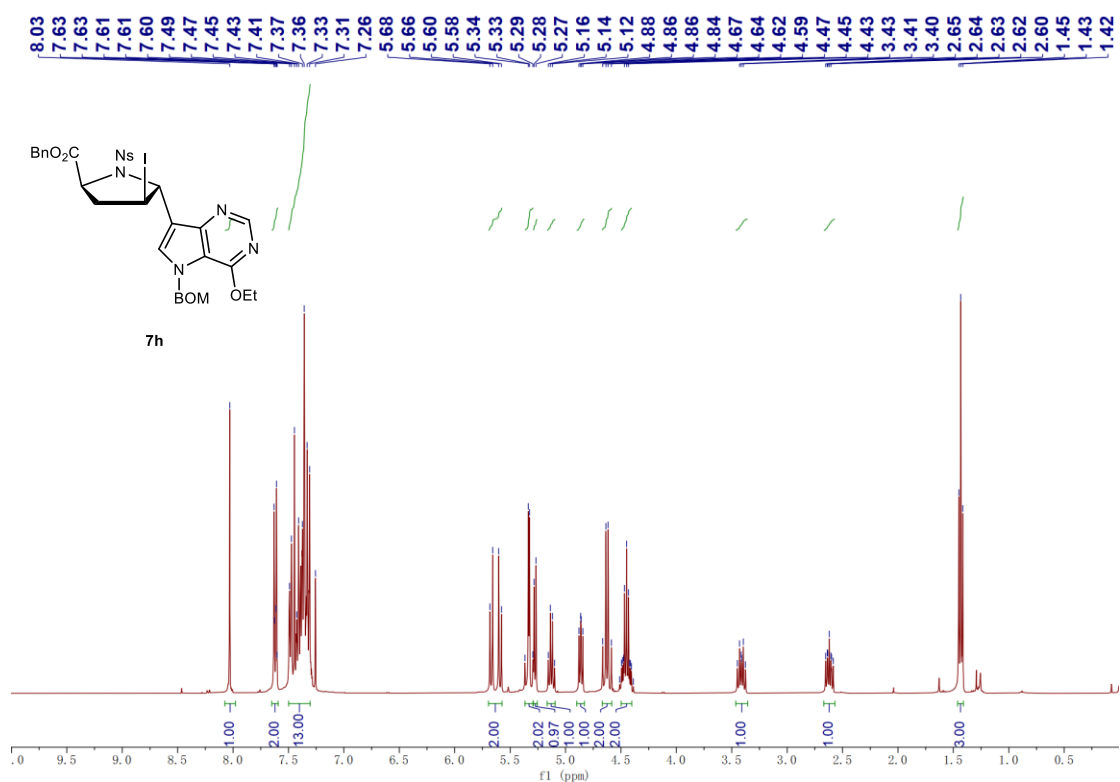
Supplementary Figure 134. ^{13}C NMR (100 MHz, CDCl_3) of compound **6g**.



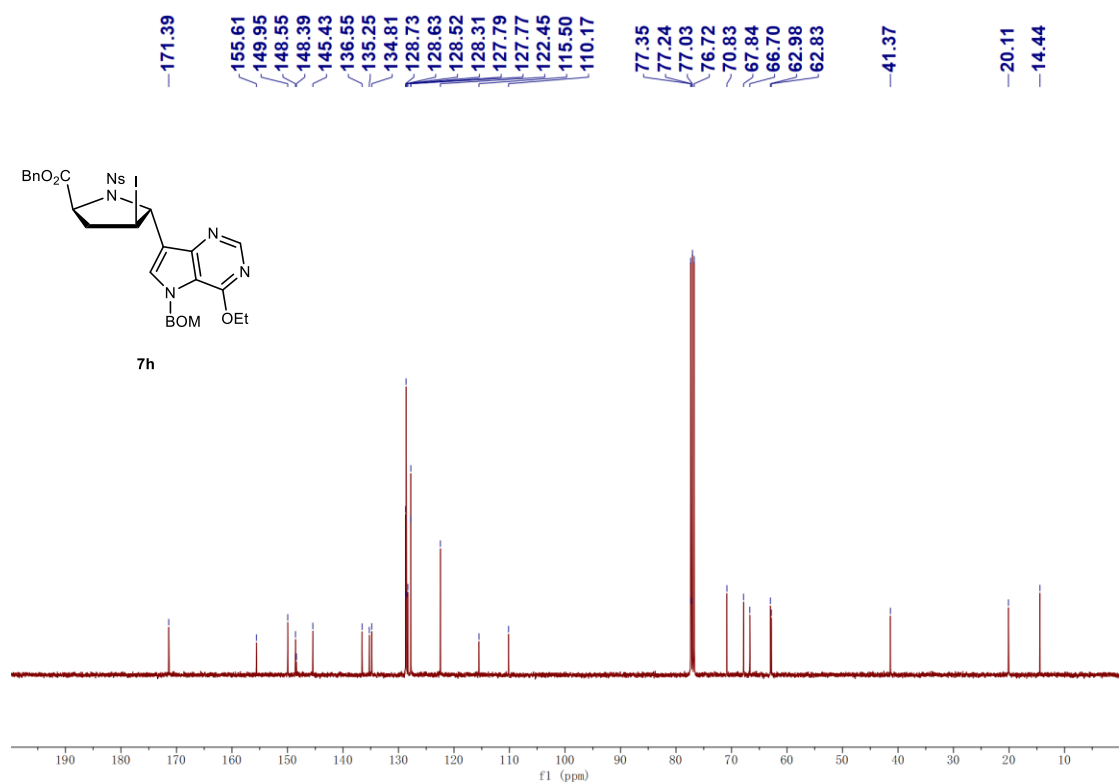
Supplementary Figure 137. ¹H NMR (400 MHz, Acetone) of compound **6h**.



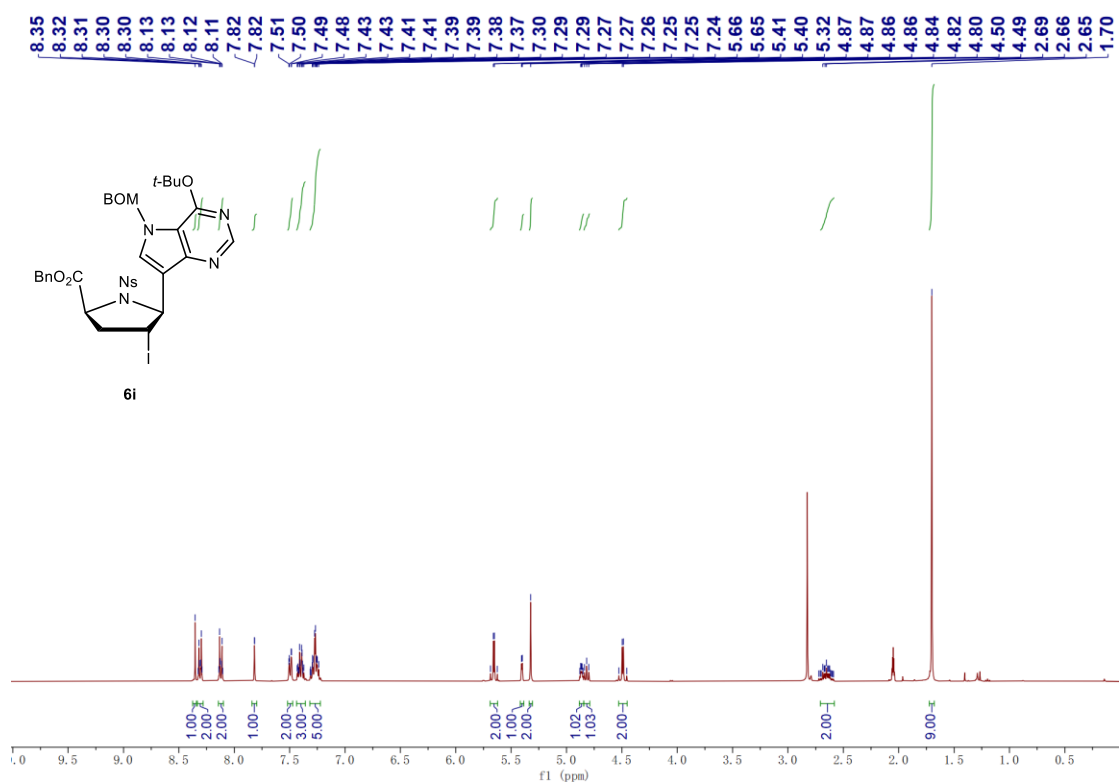
Supplementary Figure 138. ¹³C NMR (100 MHz, Acetone) of compound **6h**.



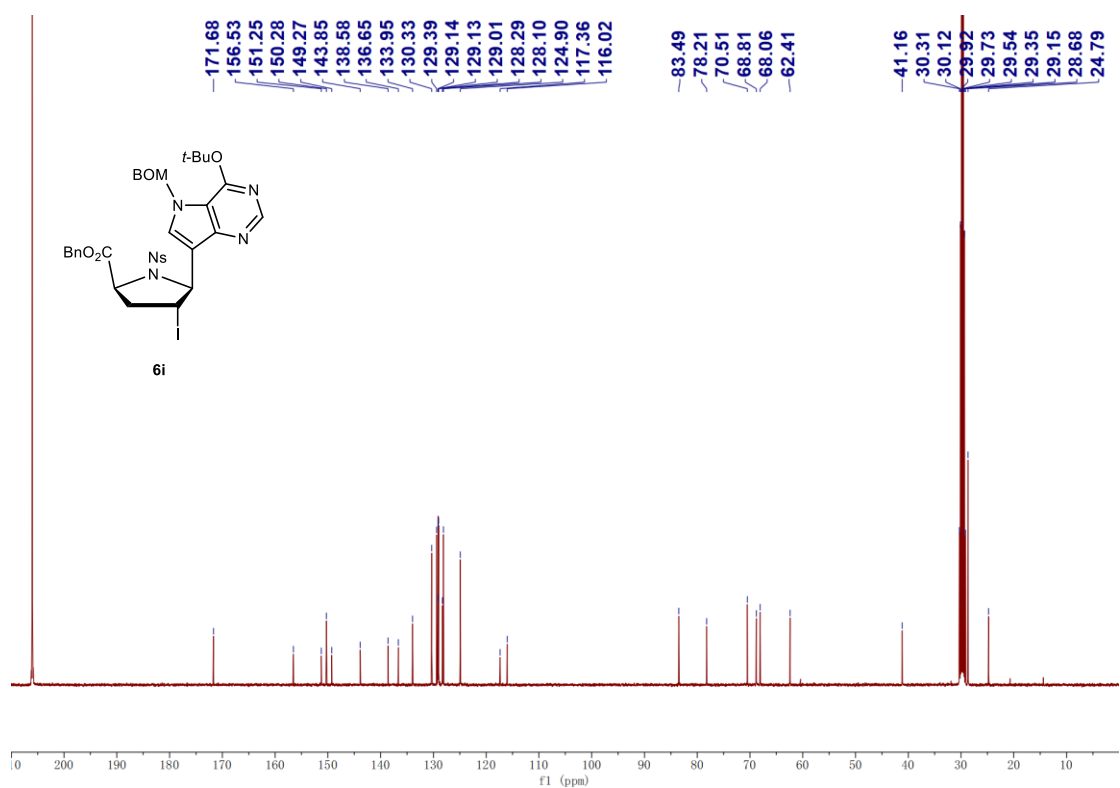
Supplementary Figure 139. ¹H NMR (400 MHz, CDCl₃) of compound 7h.



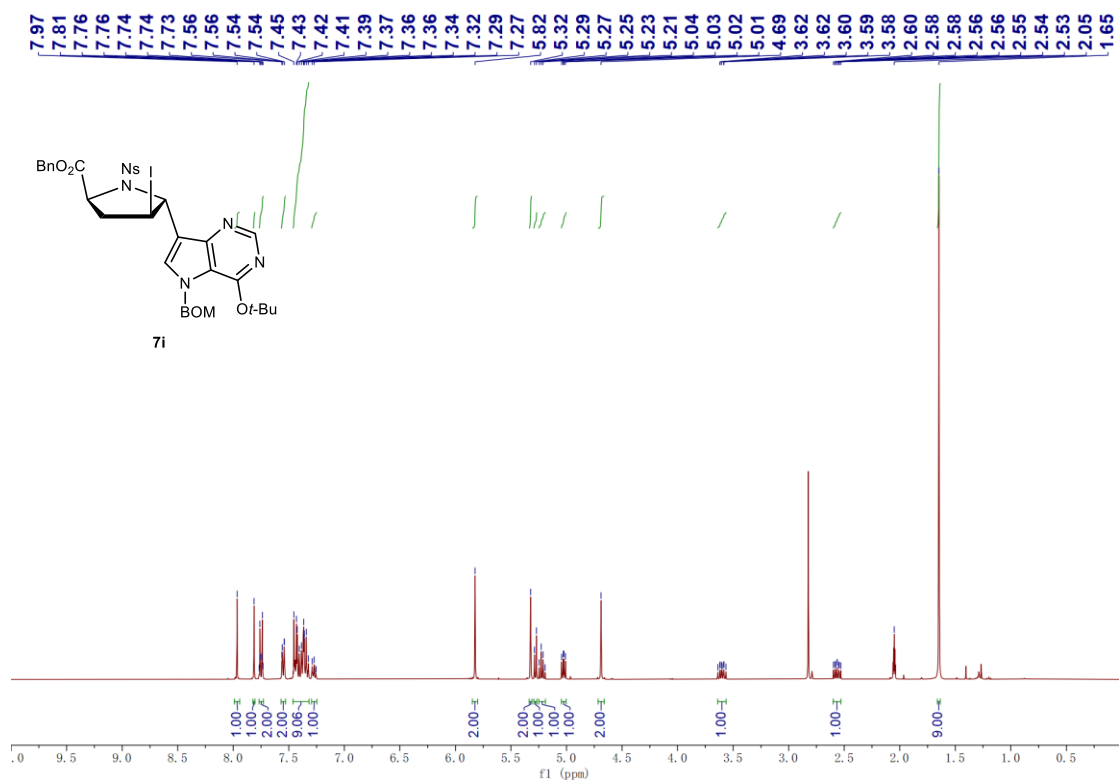
Supplementary Figure 140. ¹³C NMR (100 MHz, CDCl₃) of compound 7h.



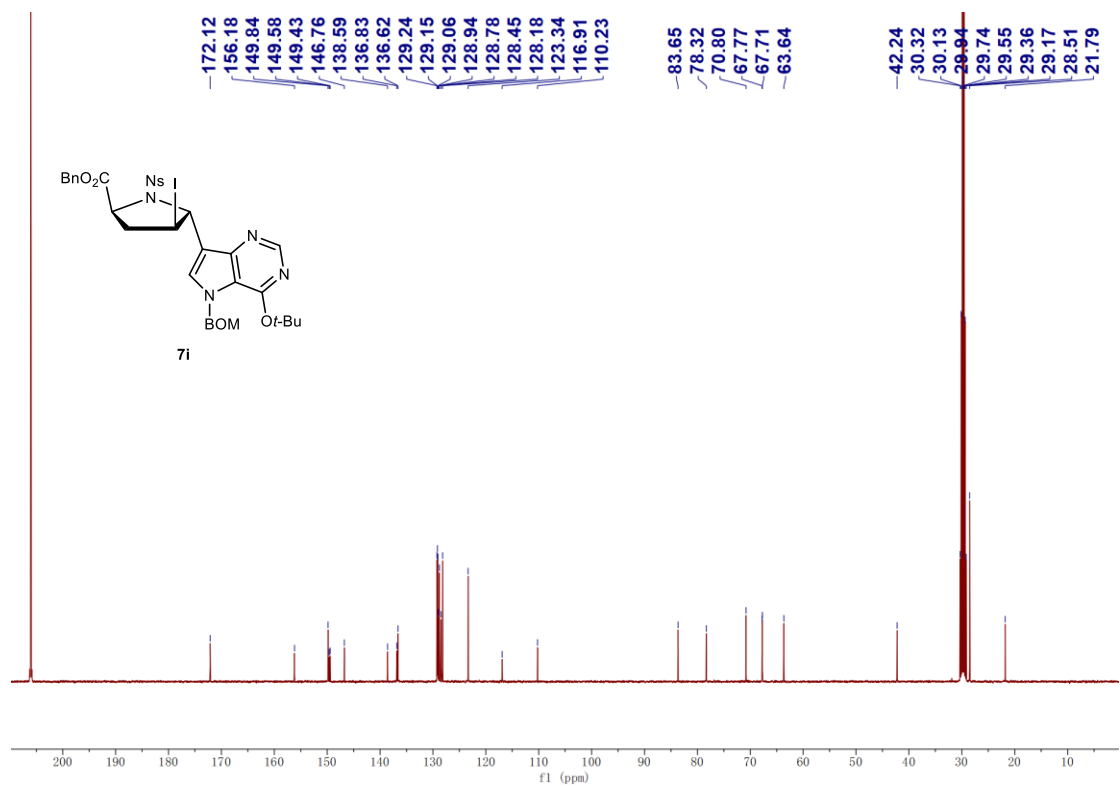
Supplementary Figure 141. ¹H NMR (400 MHz, Acetone) of compound **6i**.



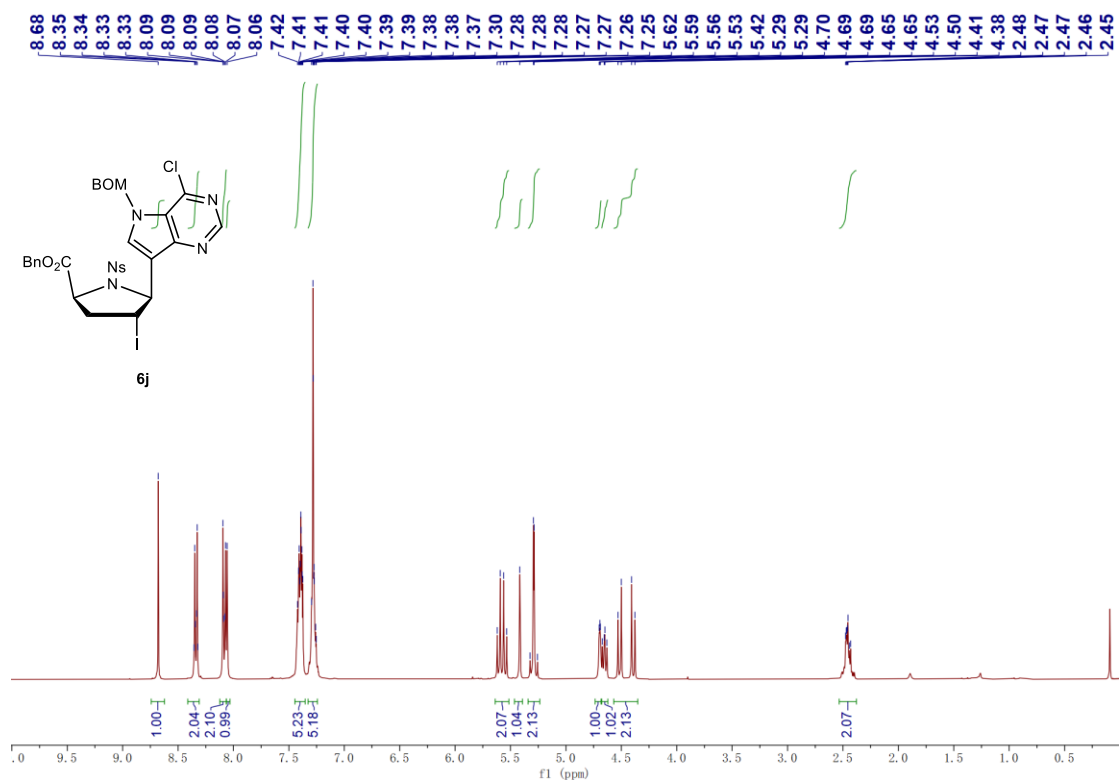
Supplementary Figure 142. ¹³C NMR (100 MHz, Acetone) of compound **6i**.



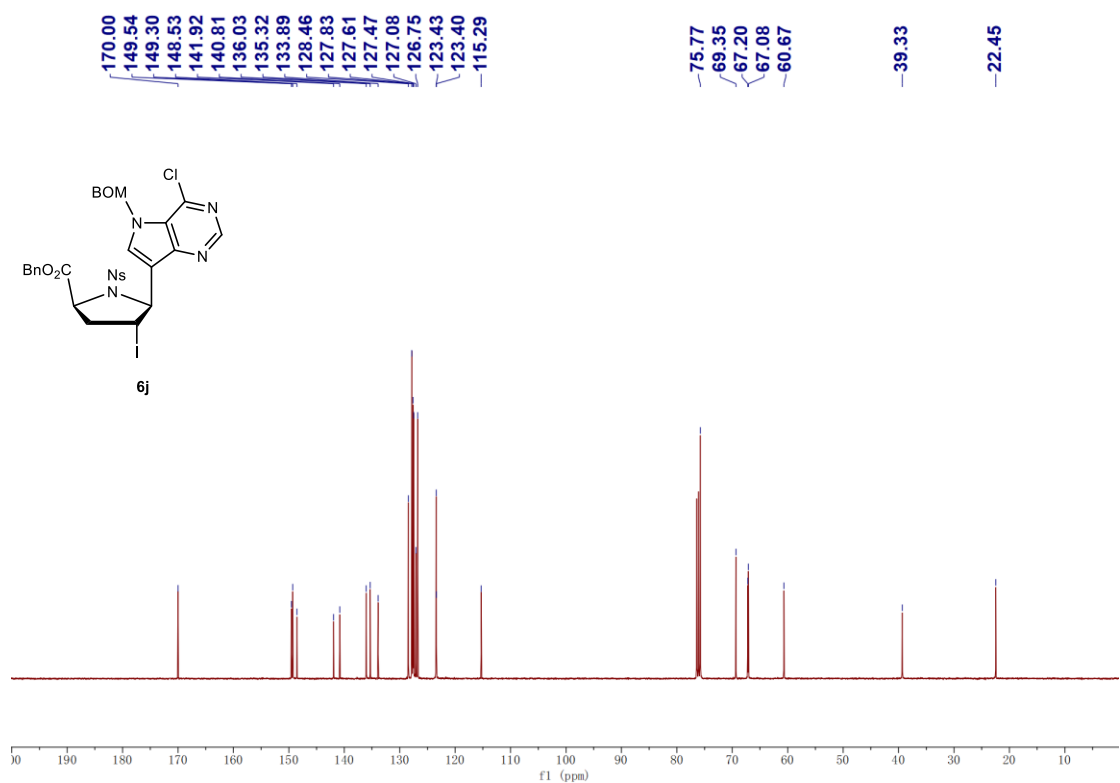
Supplementary Figure 143. ¹H NMR (400 MHz, Acetone) of compound **7i**.



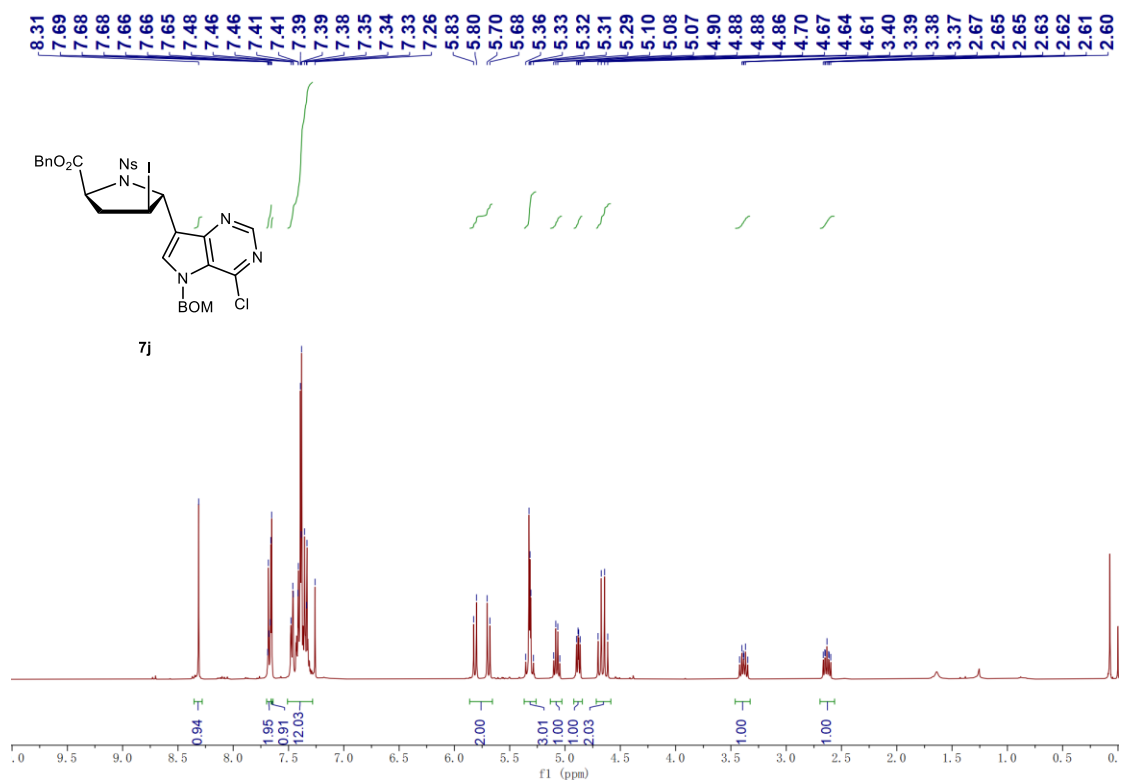
Supplementary Figure 144. ¹³C NMR (400 MHz, Acetone) of compound **7i**.



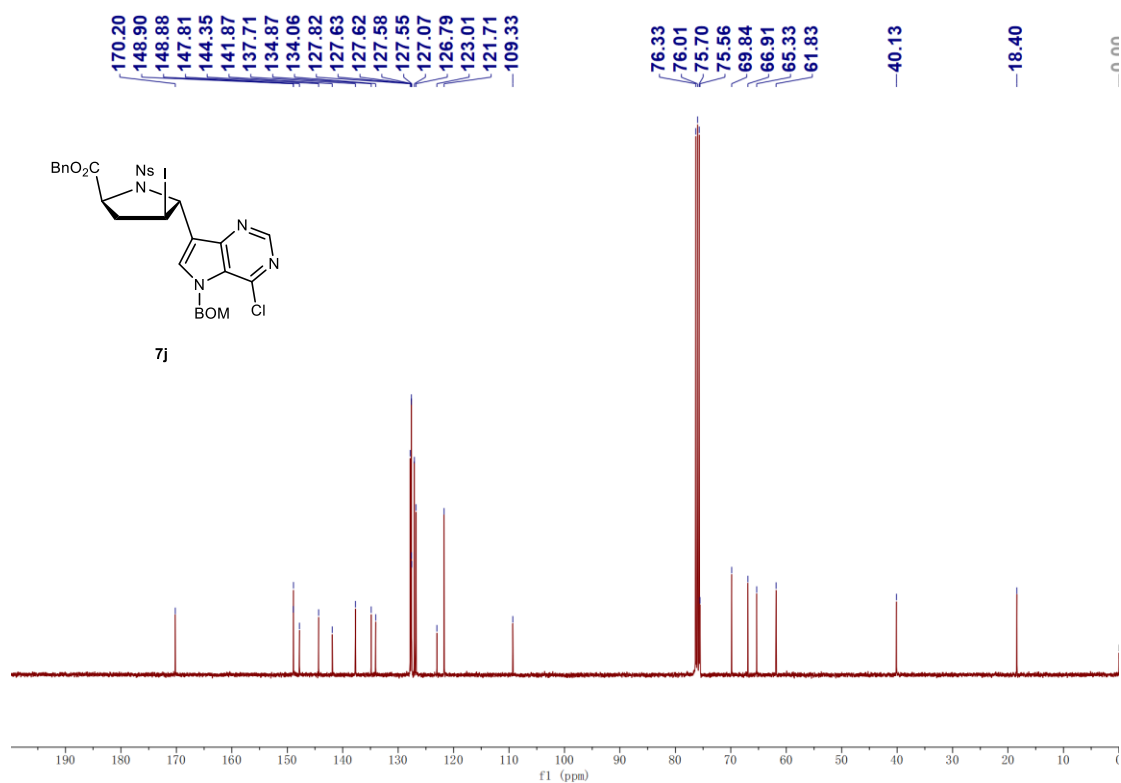
Supplementary Figure 145. ¹H NMR (400 MHz, CDCl₃) of compound **6j**.



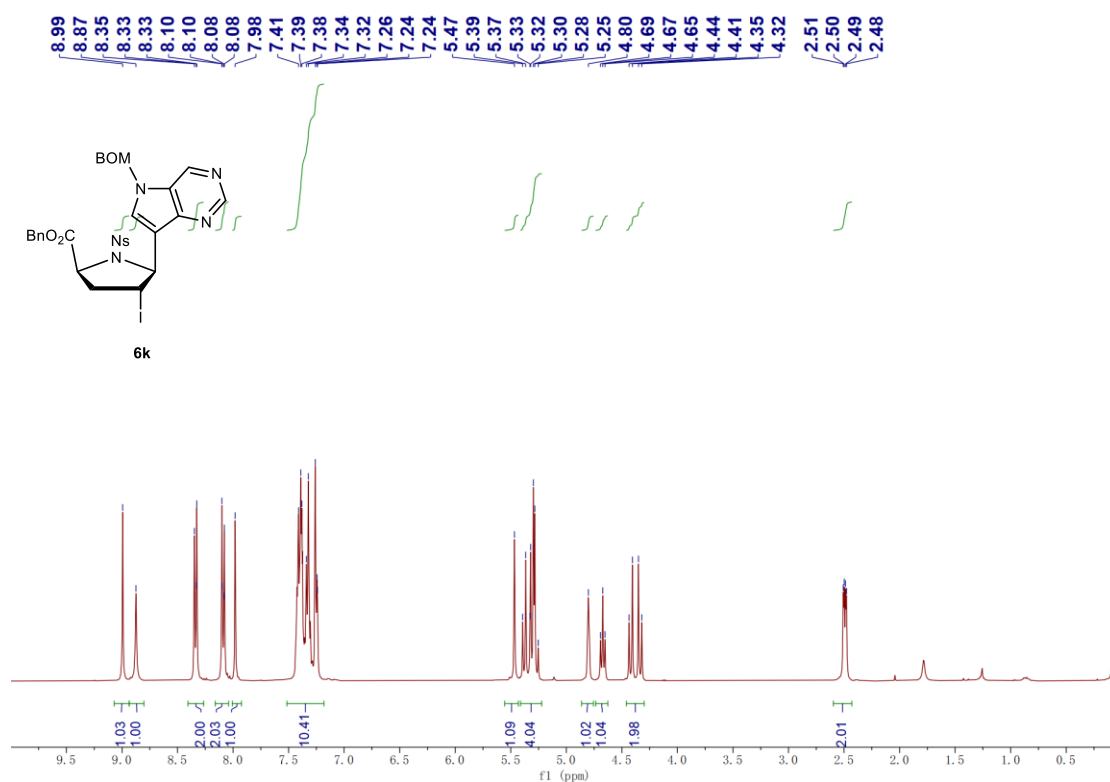
Supplementary Figure 146. ¹³C NMR (100 MHz, CDCl₃) of compound **6j**.



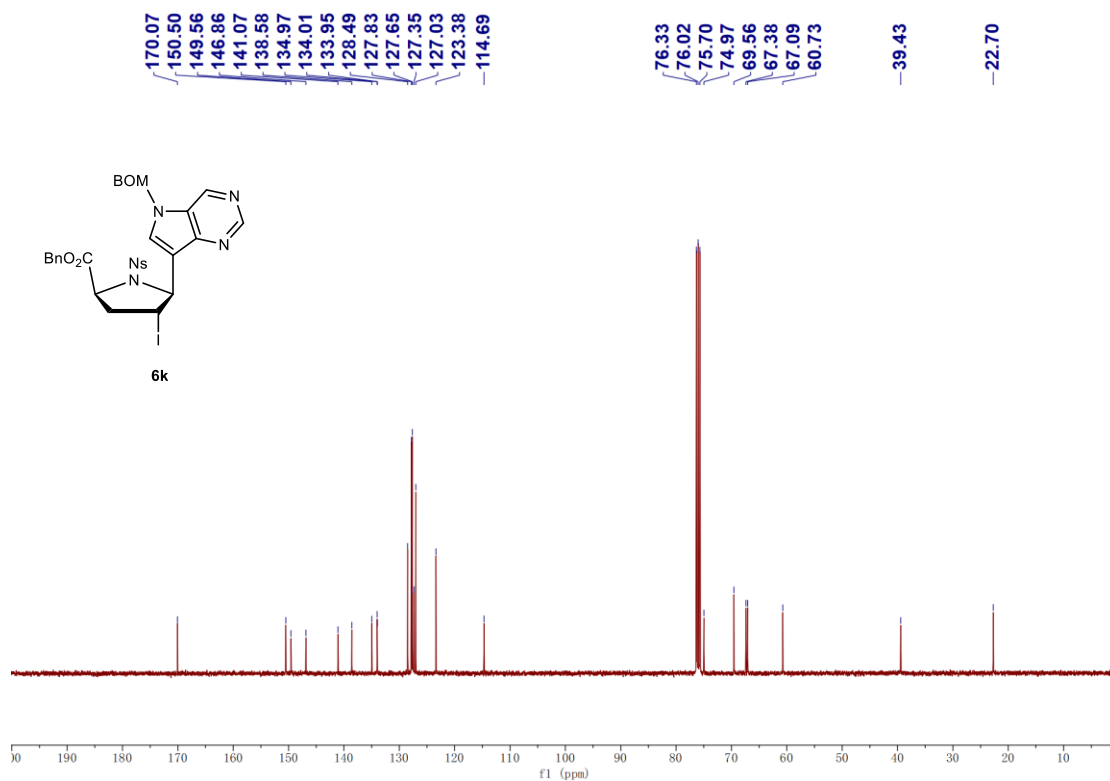
Supplementary Figure 147. ¹H NMR (400 MHz, CDCl₃) of compound **7j**.



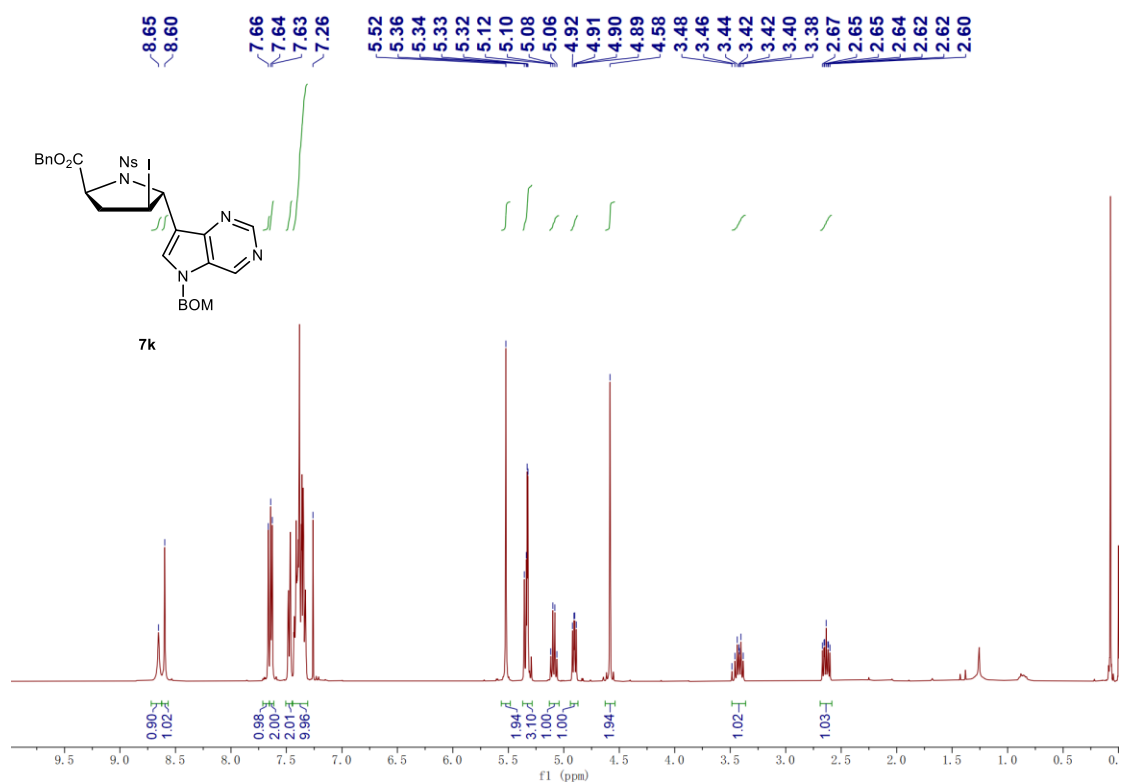
Supplementary Figure 148. ¹³C NMR (100 MHz, CDCl₃) of compound **7j**.



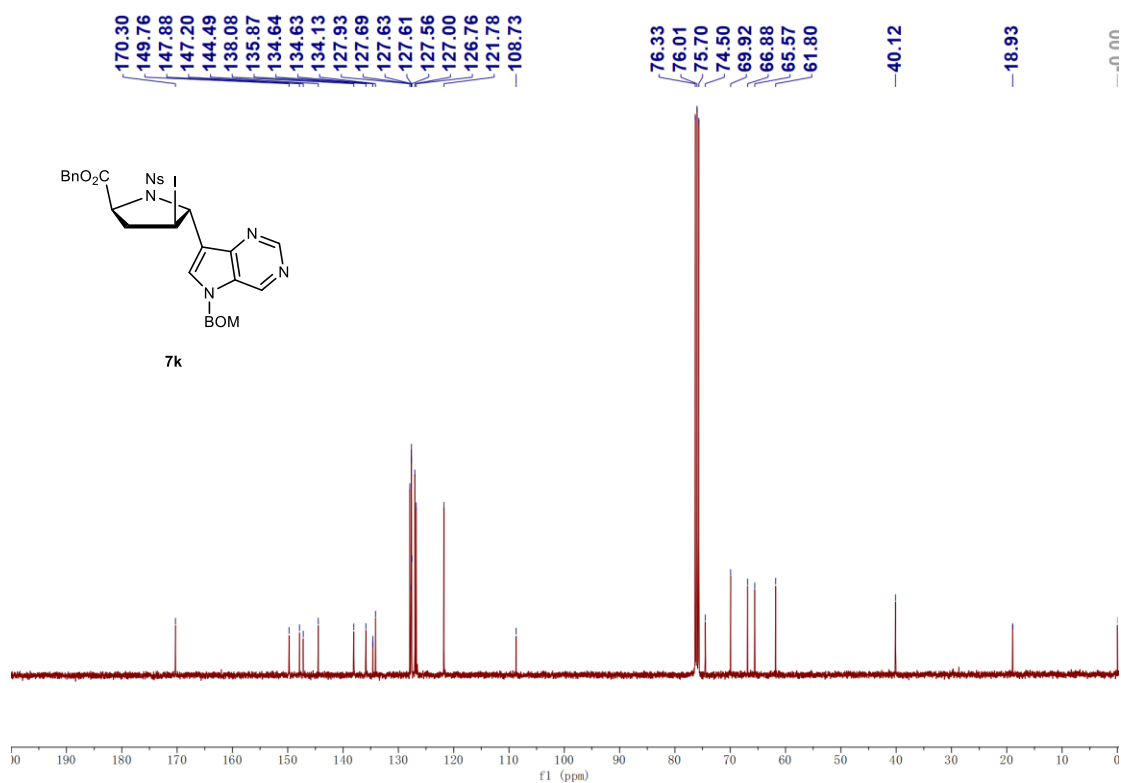
Supplementary Figure 149. ¹H NMR (400 MHz, CDCl₃) of compound **6k**.



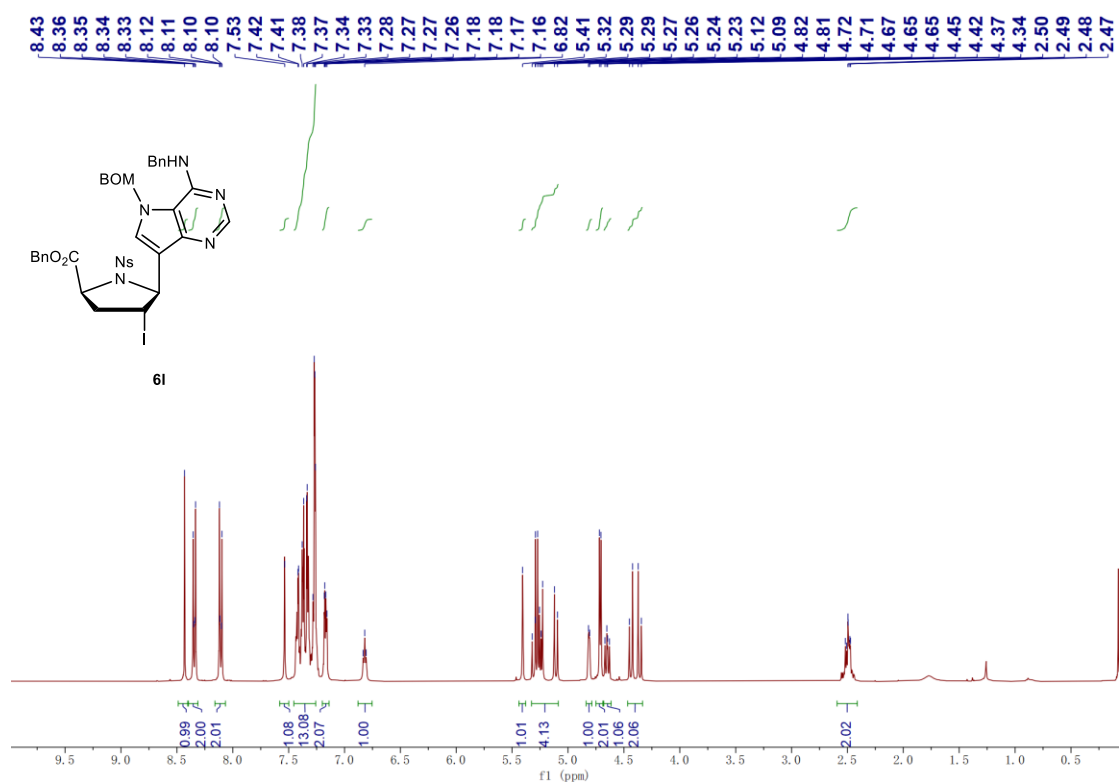
Supplementary Figure 150. ¹³C NMR (100 MHz, CDCl₃) of compound **6k**.



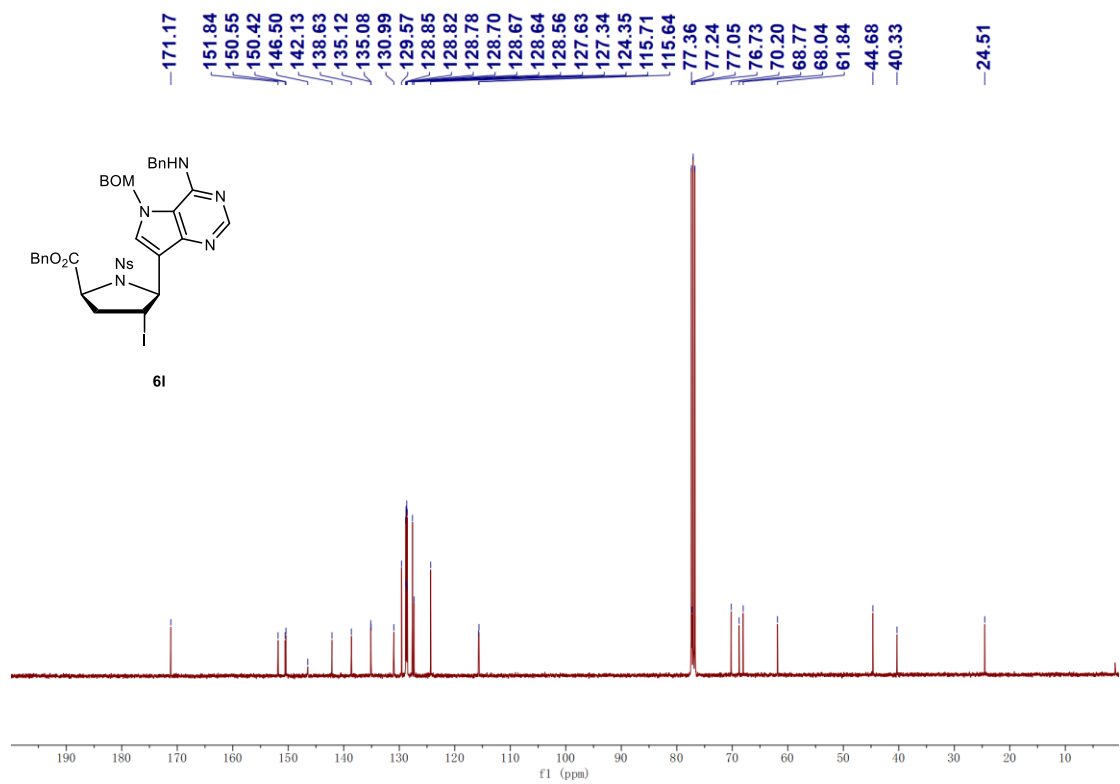
Supplementary Figure 151. ^1H NMR (400 MHz, CDCl_3) of compound **7k**.



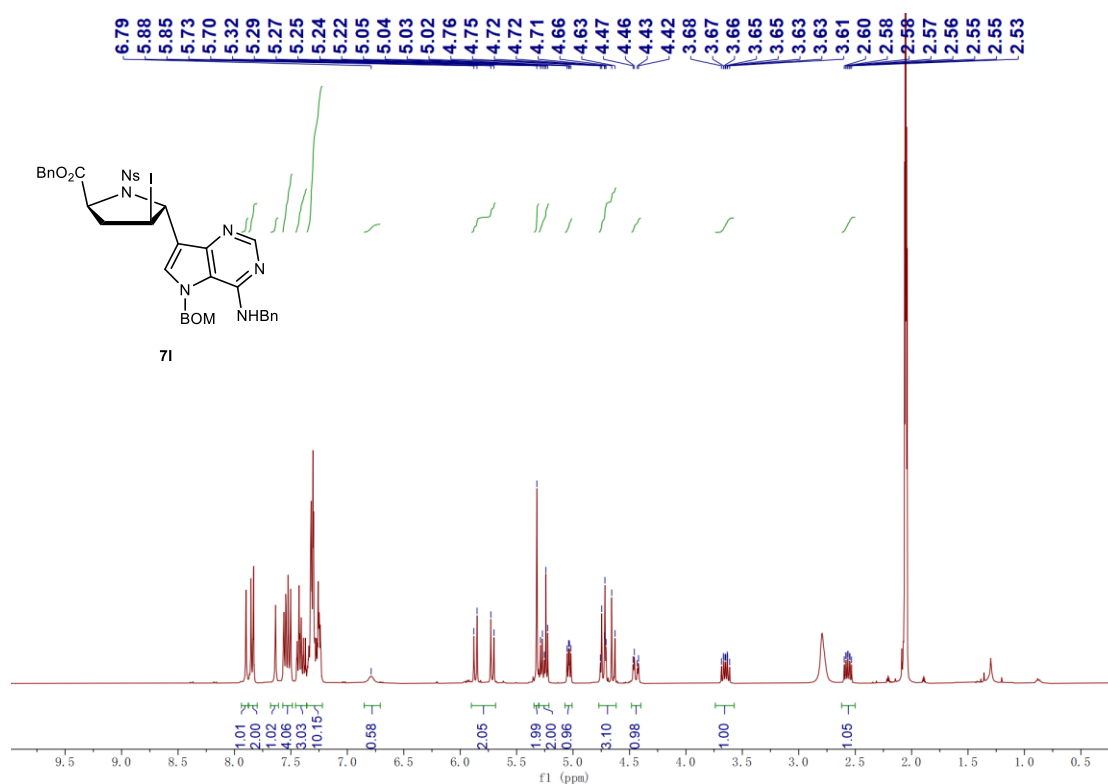
Supplementary Figure 152. ^{13}C NMR (100 MHz, CDCl_3) of compound **7k**.



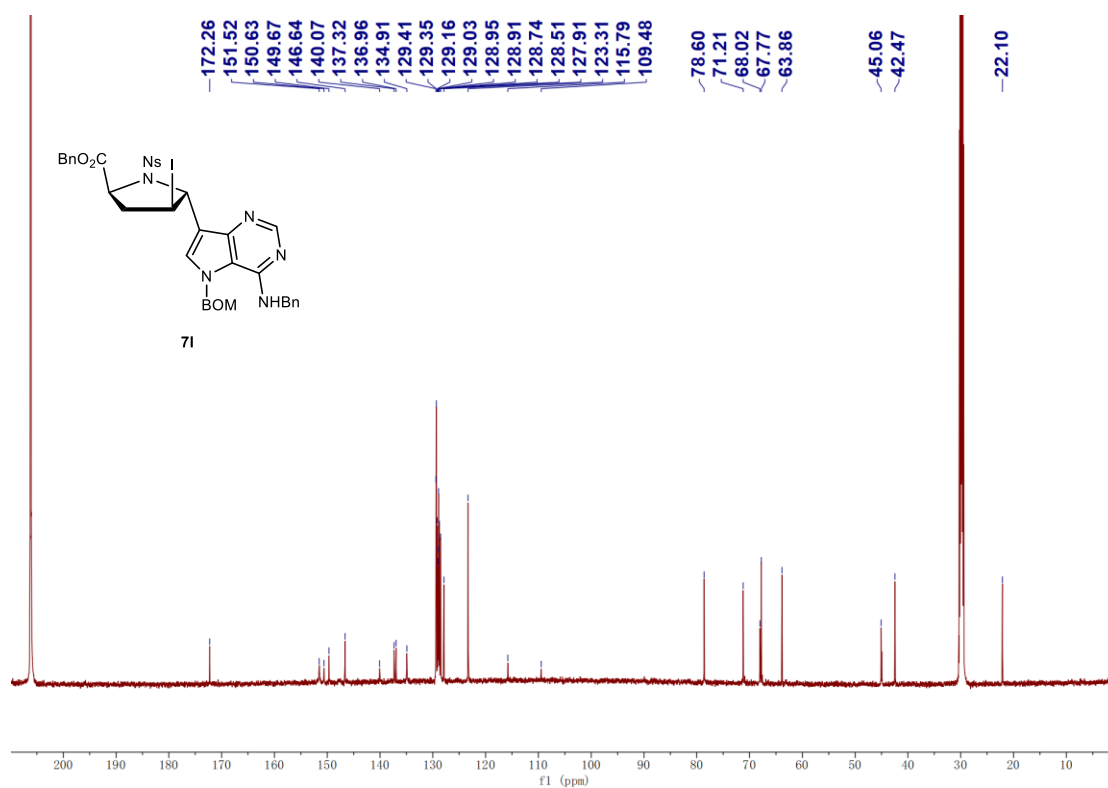
Supplementary Figure 153. ^1H NMR (400 MHz, CDCl_3) of compound **6l**.



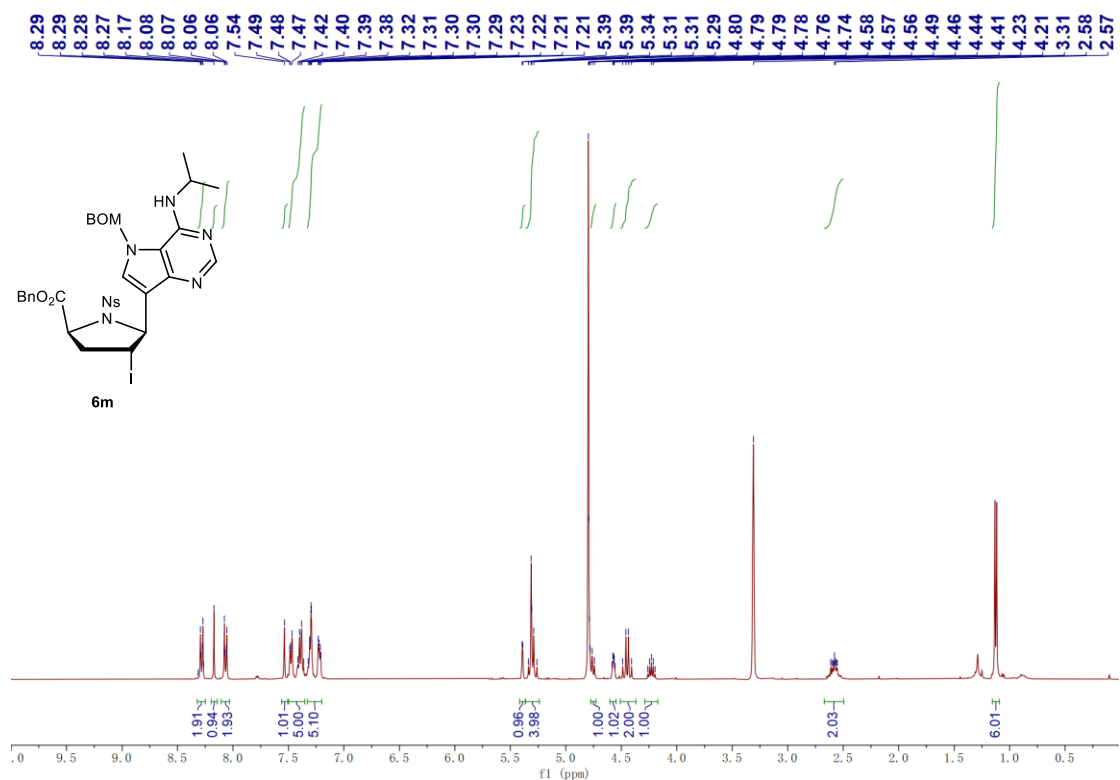
Supplementary Figure 154. ^{13}C NMR (100 MHz, CDCl_3) of compound **6l**.



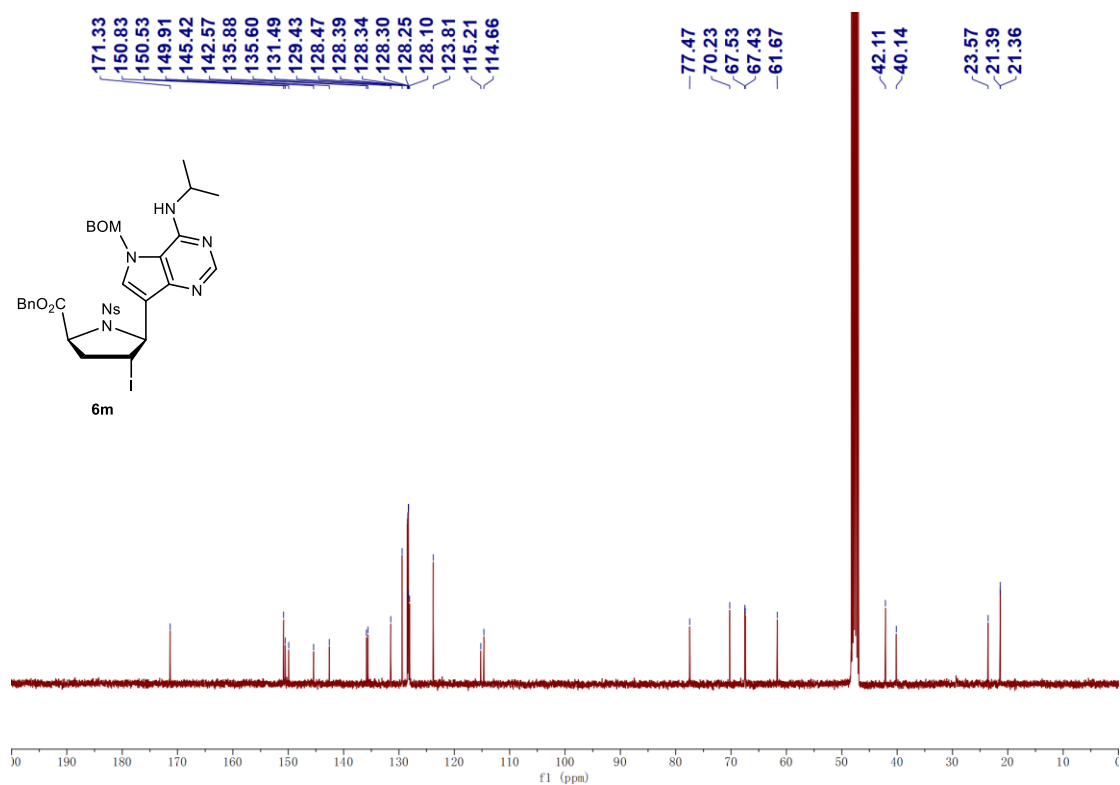
Supplementary Figure 155. ¹H NMR (400 MHz, Acetone) of compound 7l.



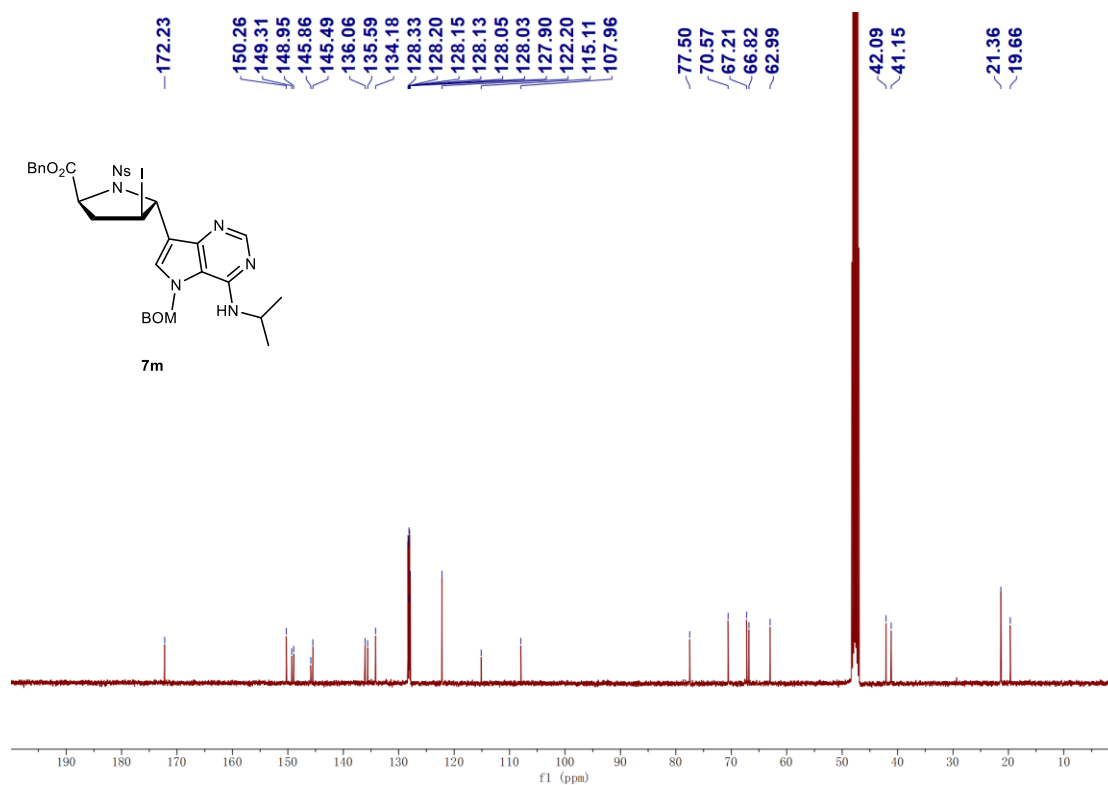
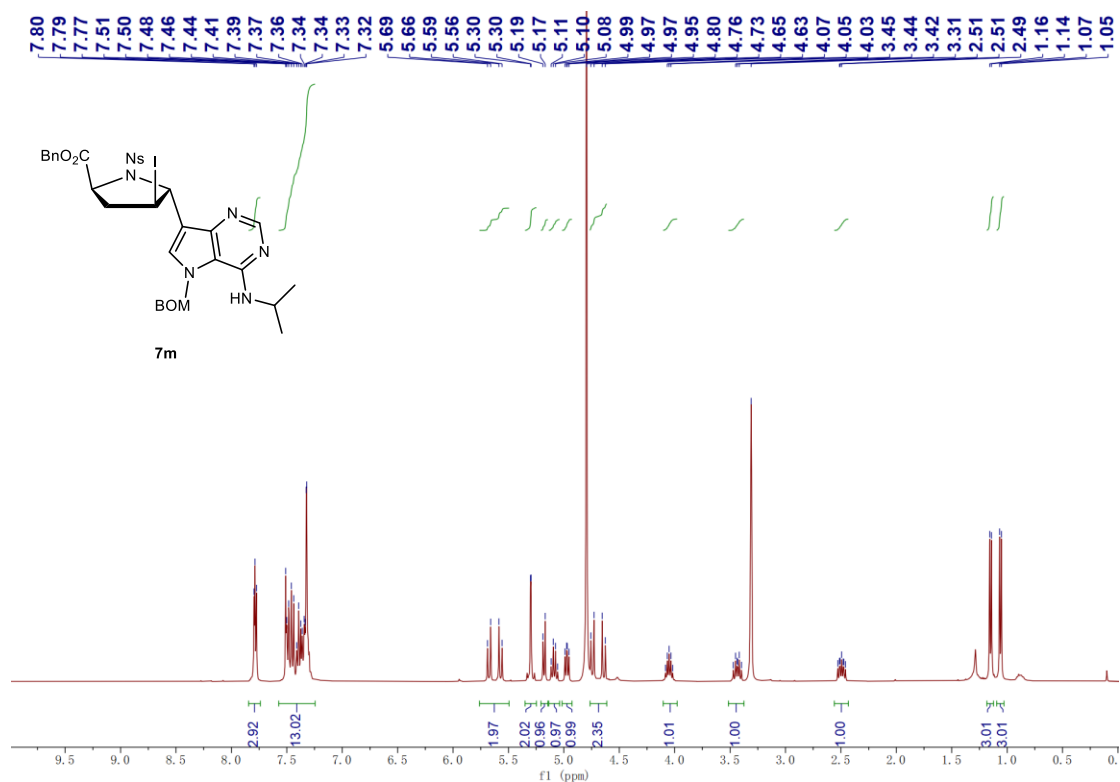
Supplementary Figure 156. ¹³C NMR (150 MHz, Acetone) of compound 7l.

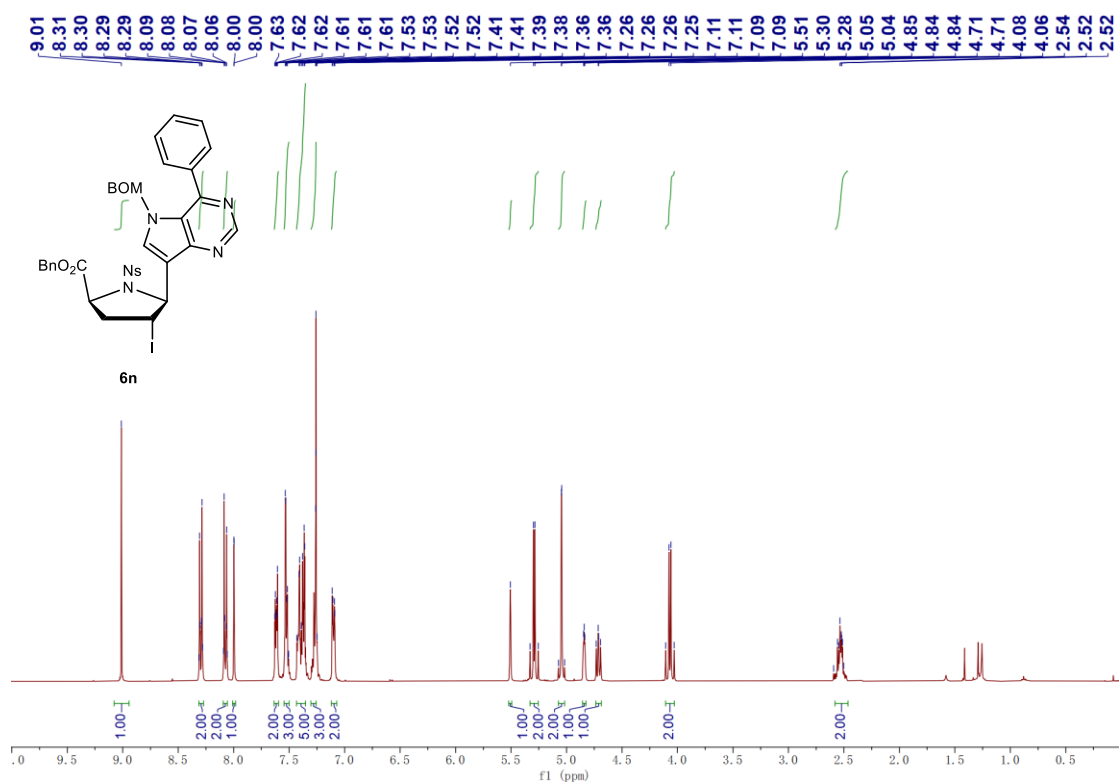


Supplementary Figure 157. ¹H NMR (400 MHz, MeOD) of compound **6m**.

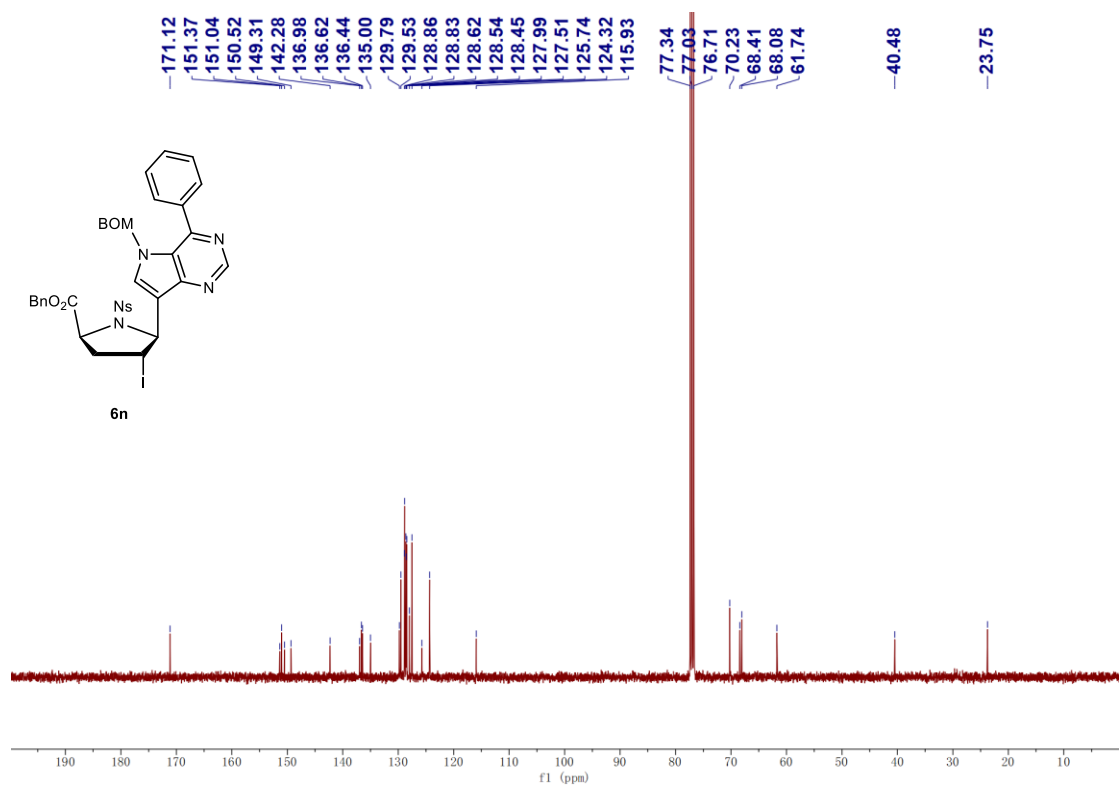


Supplementary Figure 158. ¹³C NMR (100 MHz, MeOD) of compound **6m**.

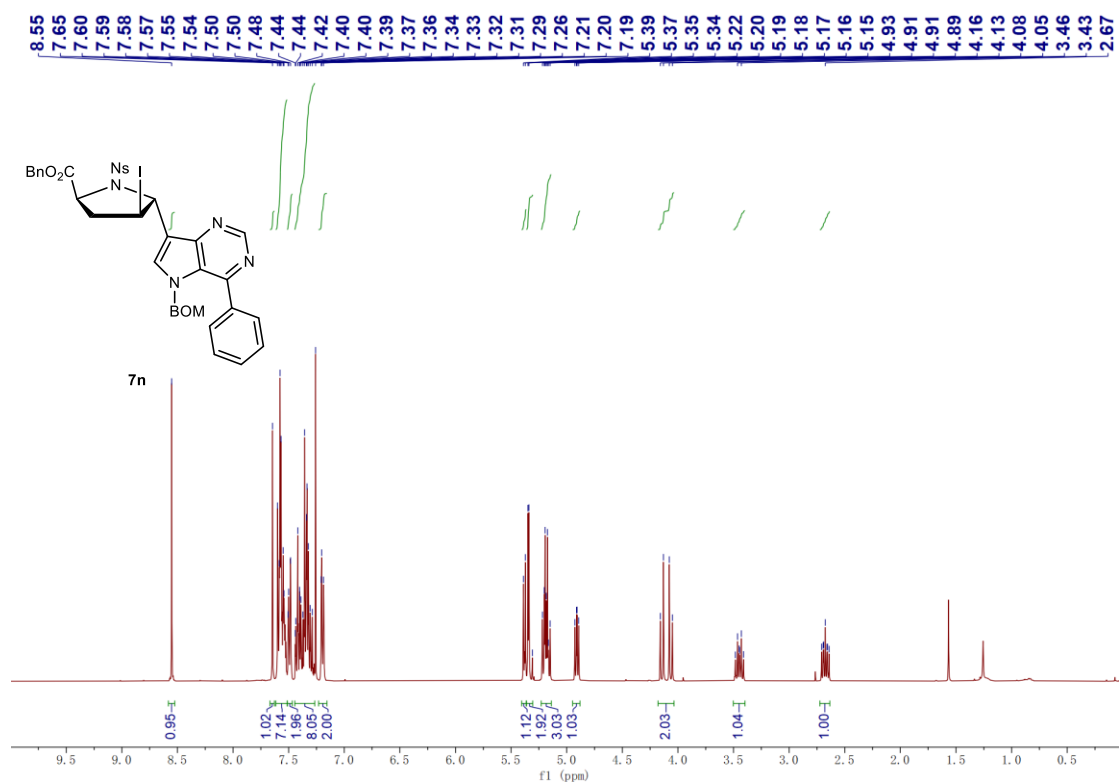




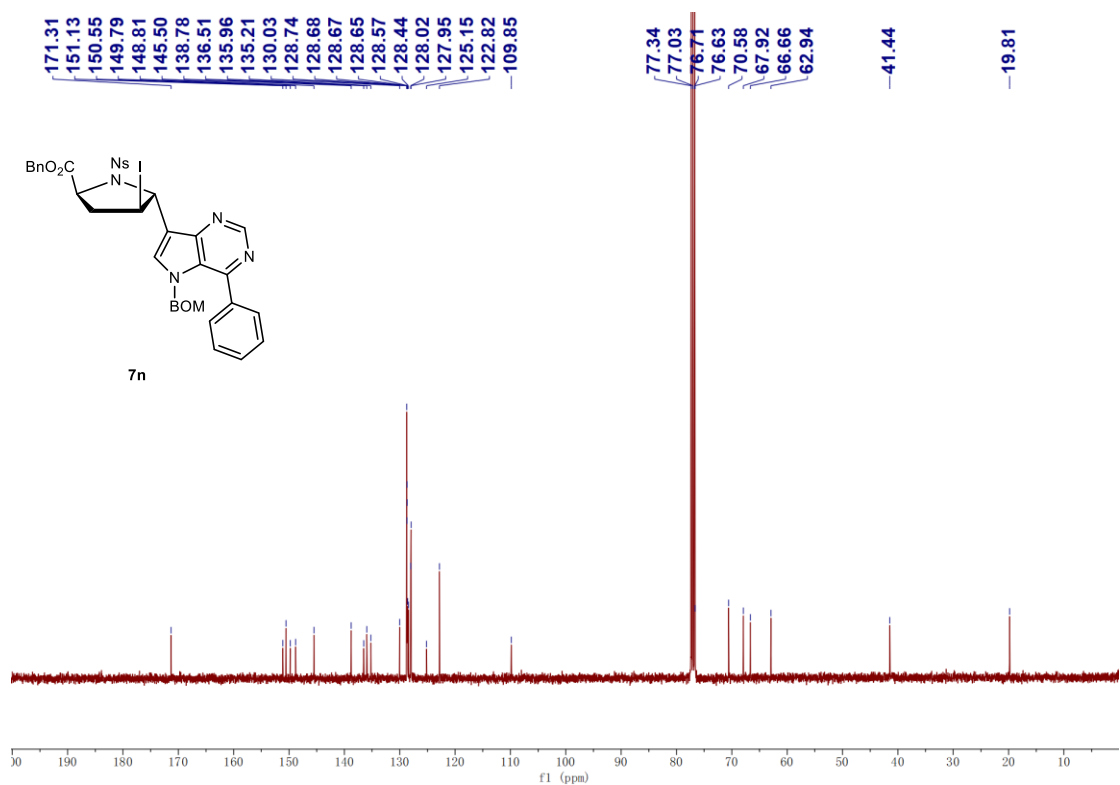
Supplementary Figure 161. ¹H NMR (400 MHz, CDCl₃) of compound **6n**.



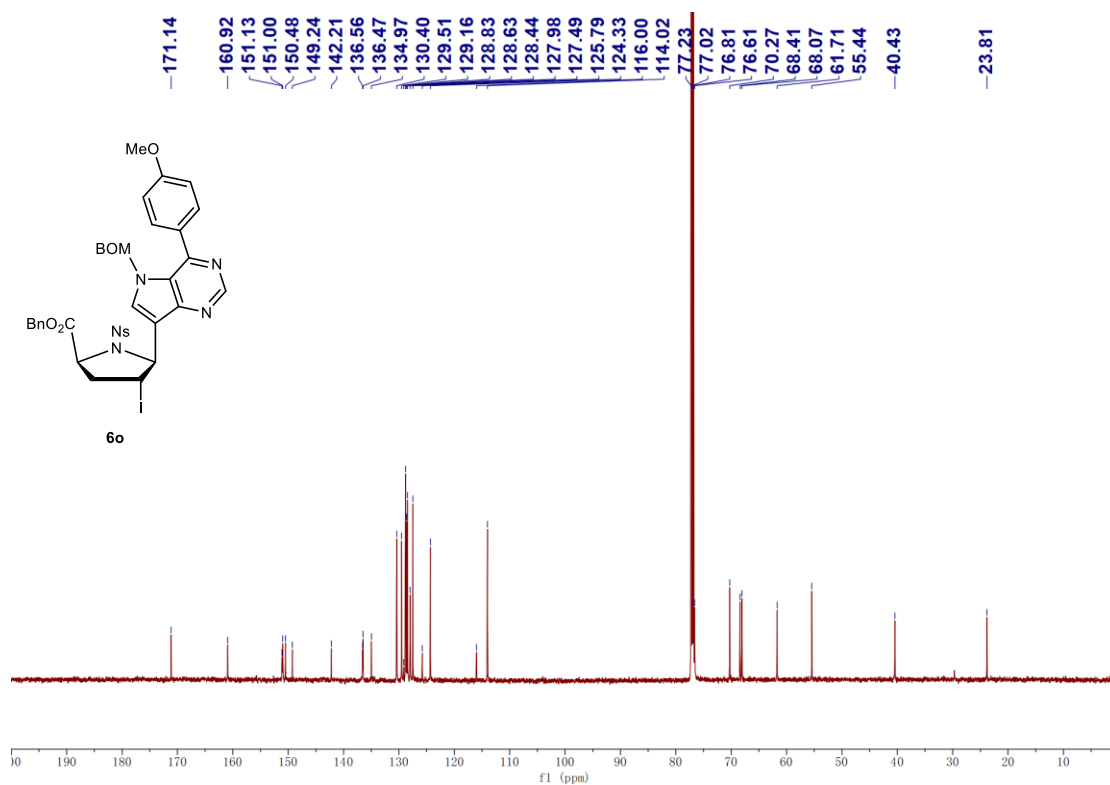
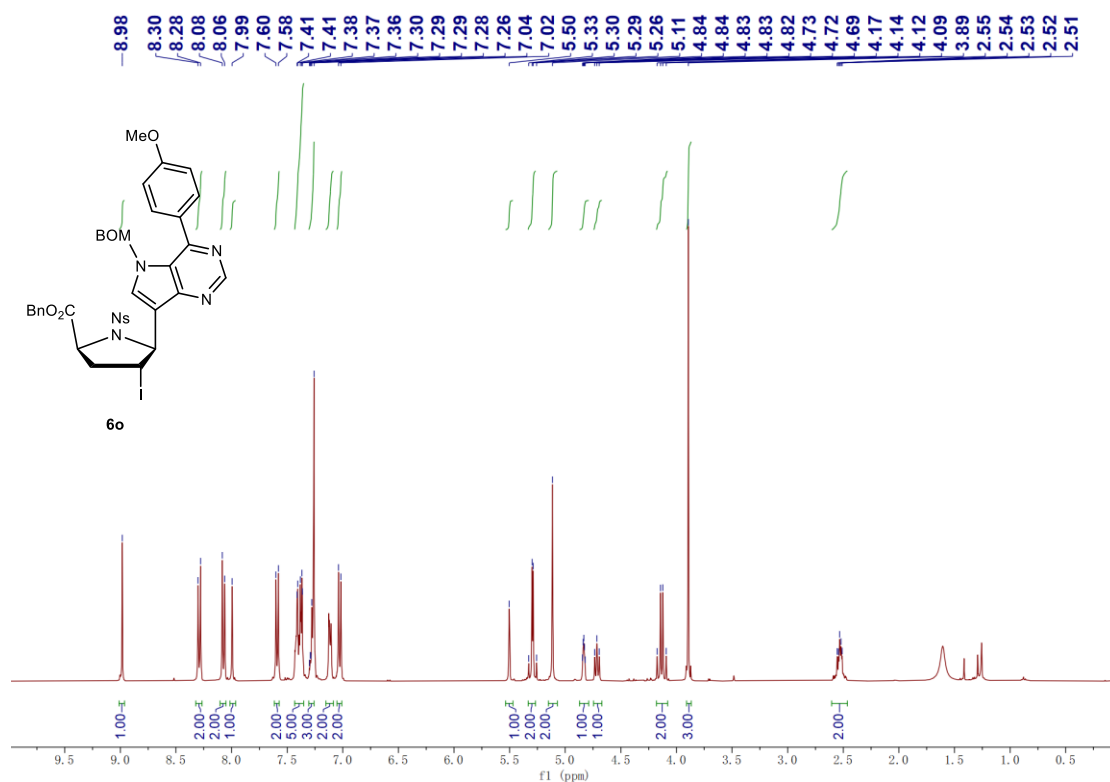
Supplementary Figure 162. ¹³C NMR (100 MHz, CDCl₃) of compound **6n**.

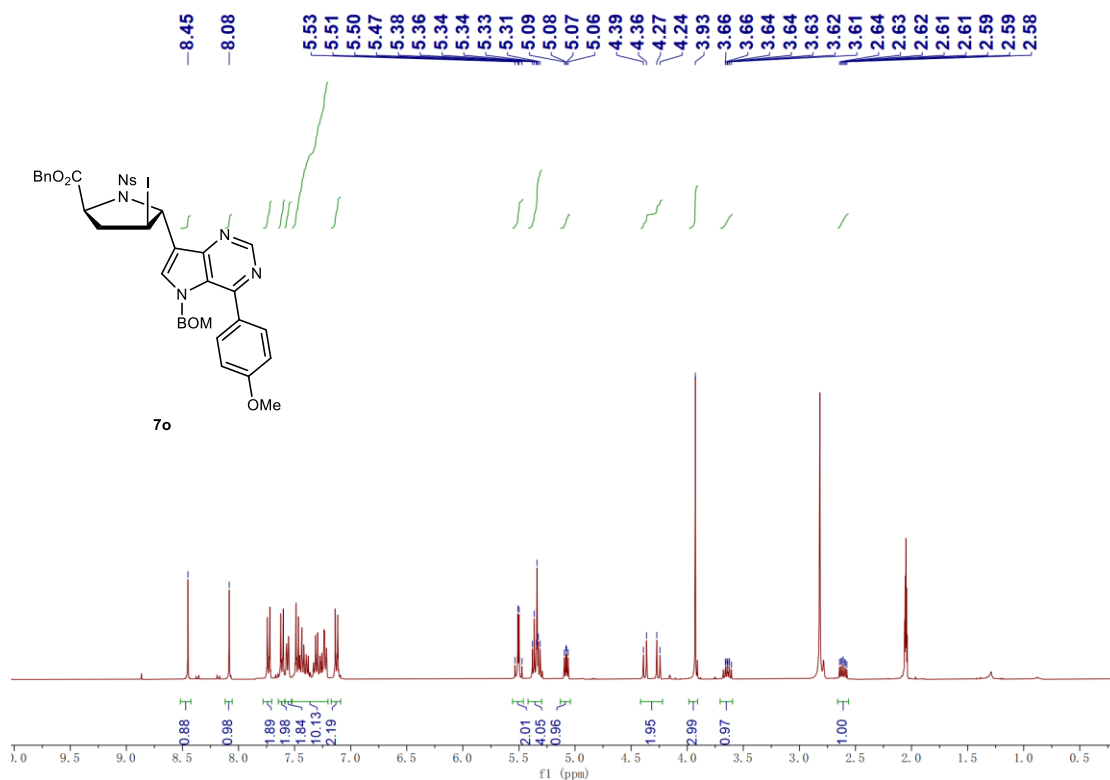


Supplementary Figure 163. ¹H NMR (400 MHz, CDCl₃) of compound **7n**.

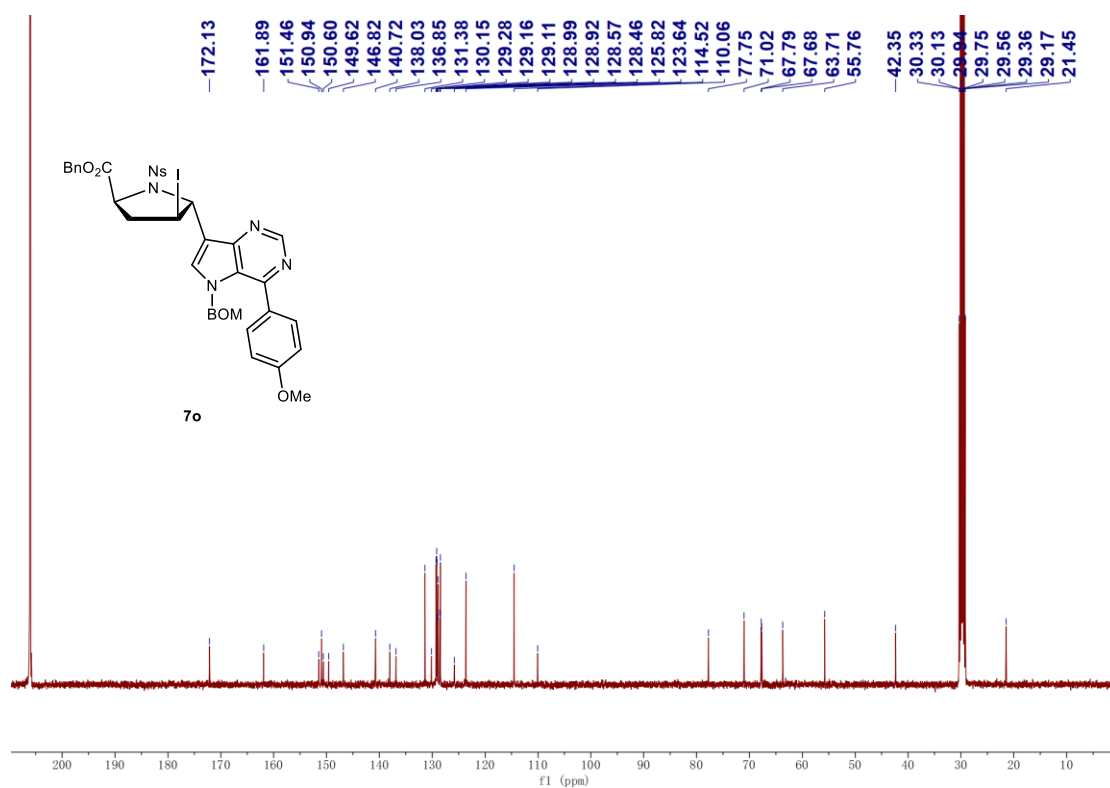


Supplementary Figure 164. ¹³C NMR (100 MHz, CDCl₃) of compound **7n**.

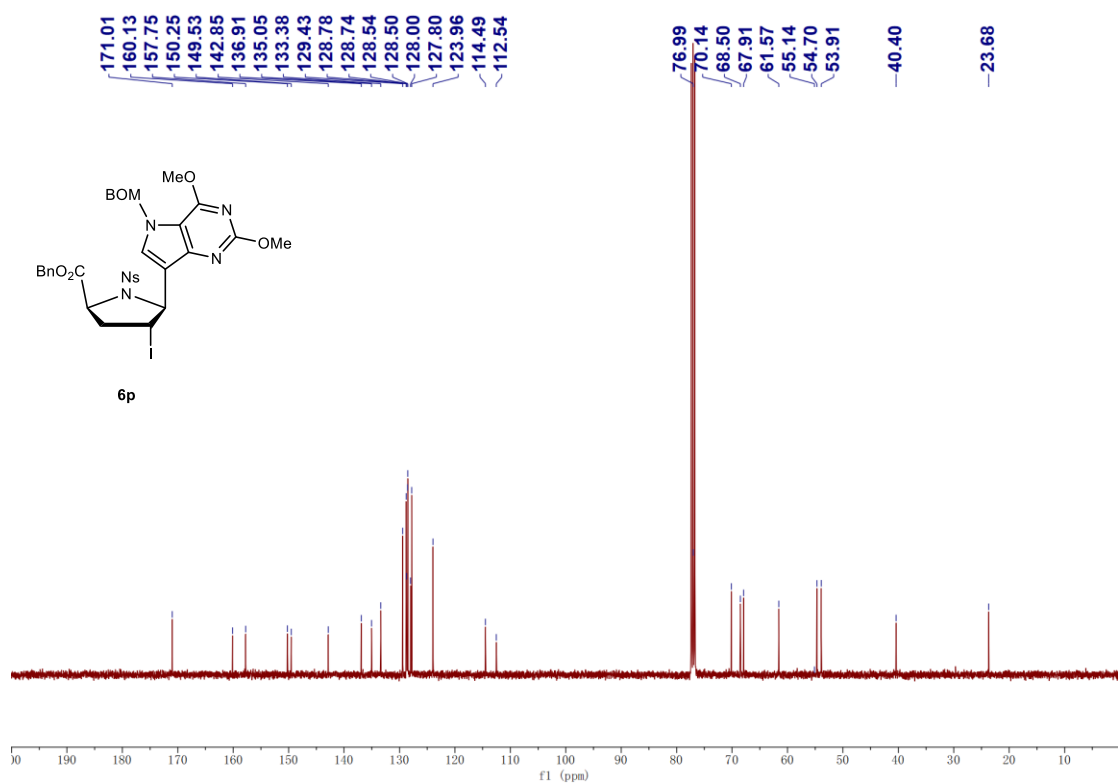
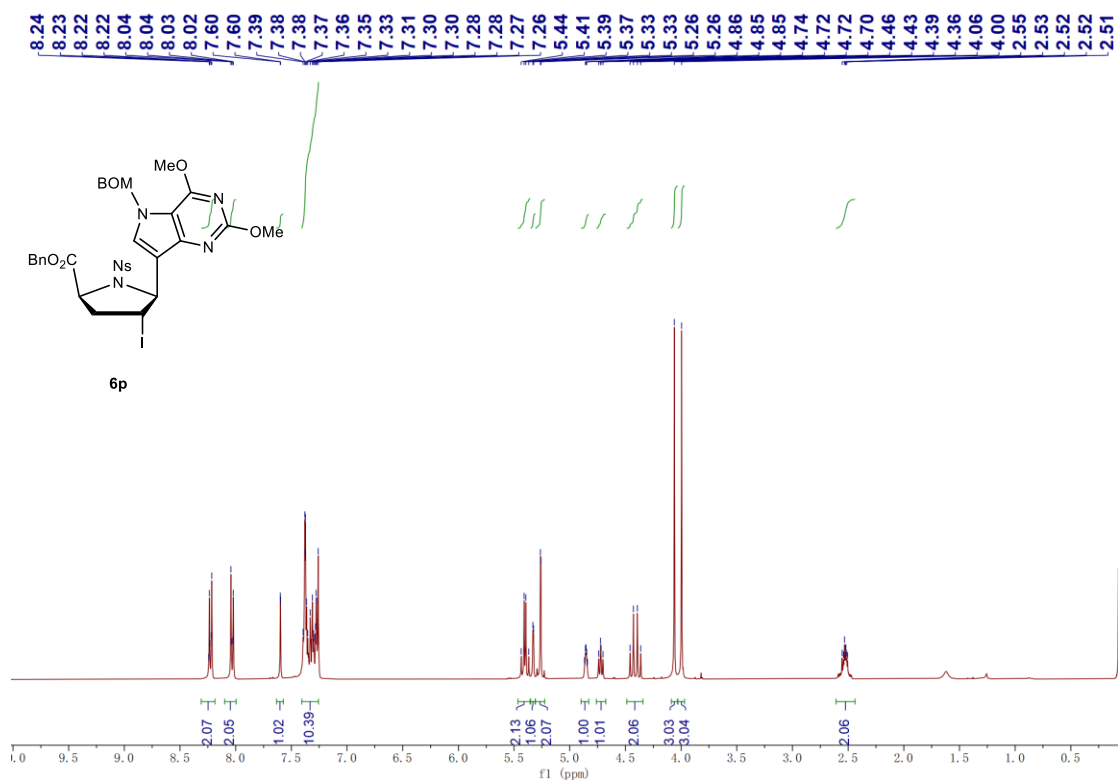


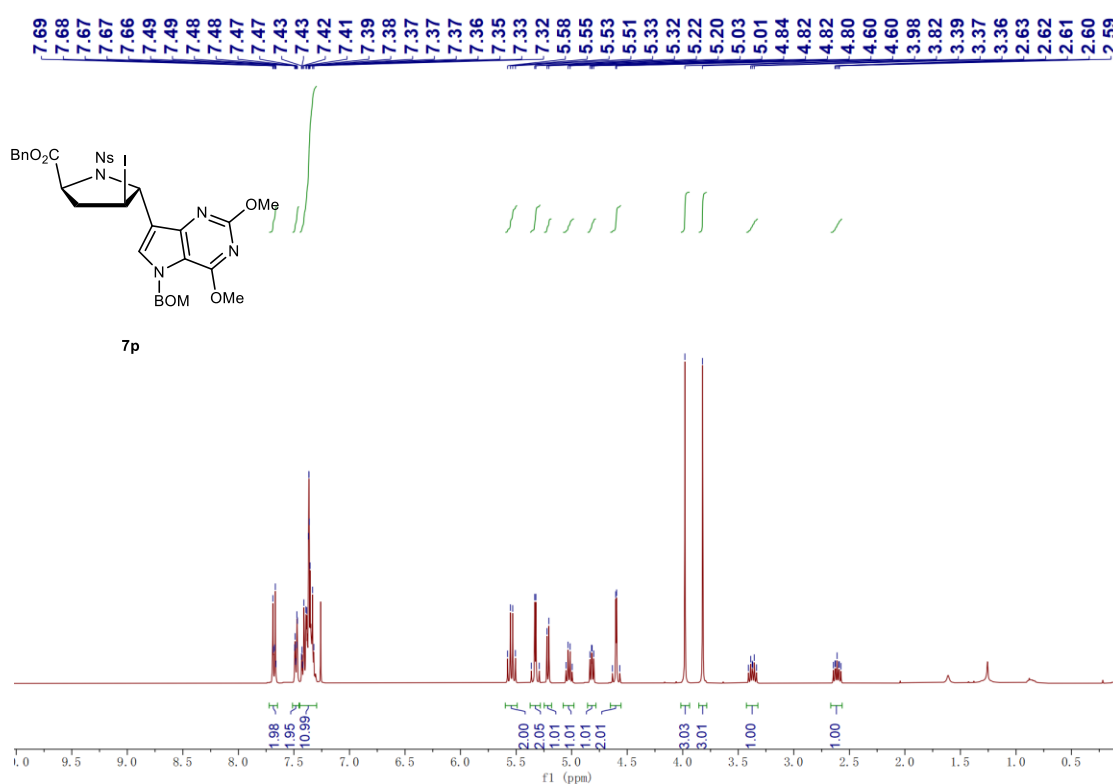


Supplementary Figure 167. ¹H NMR (400 MHz, Acetone) of compound **7o**.

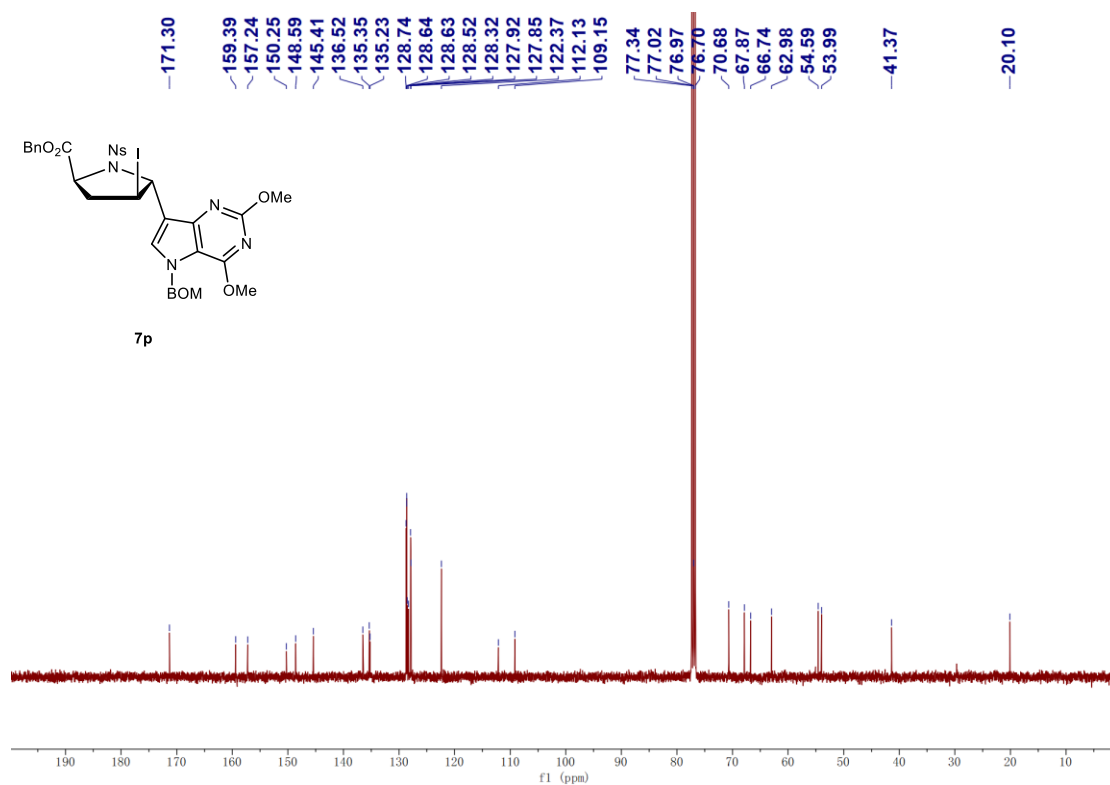


Supplementary Figure 168. ¹³C NMR (100 MHz, Acetone) of compound **7o**.

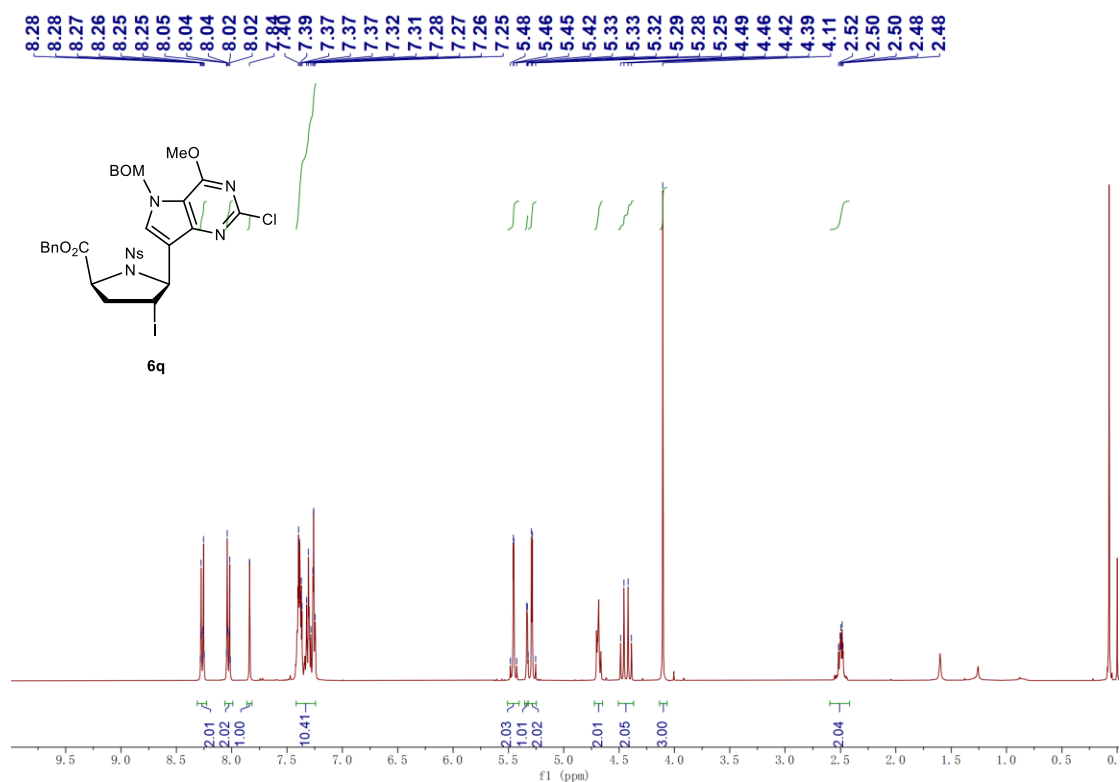




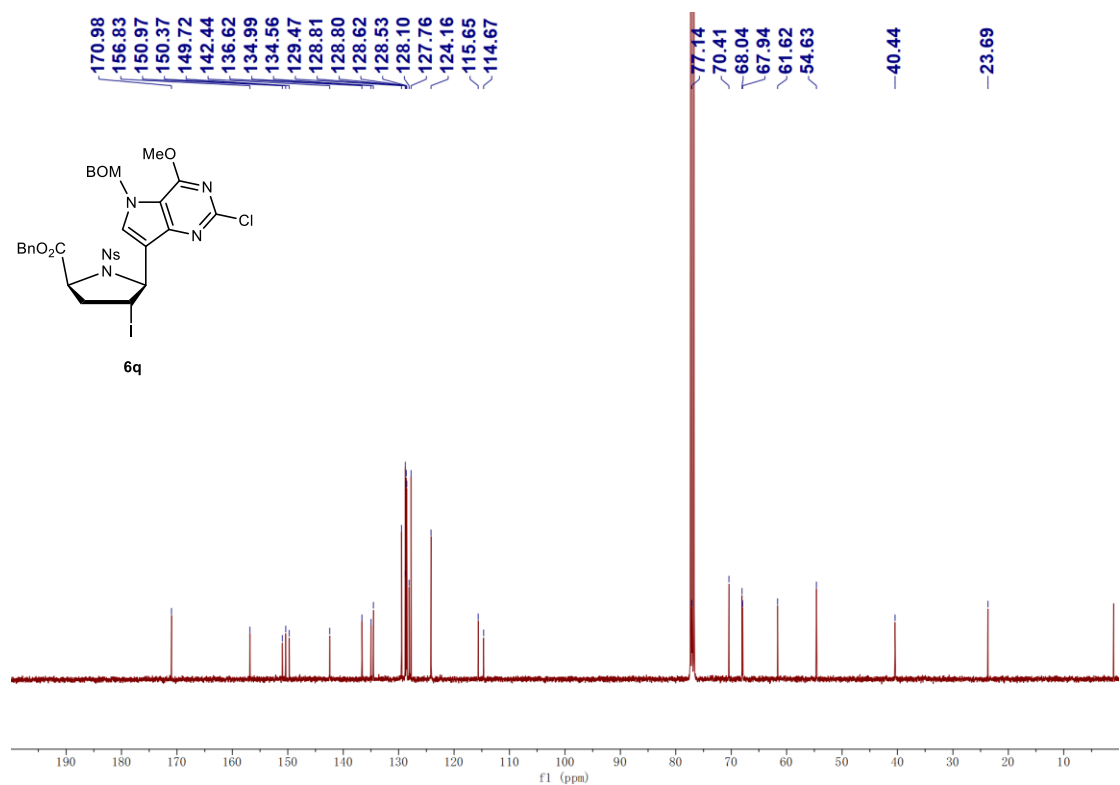
Supplementary Figure 171. ¹H NMR (400 MHz, CDCl₃) of compound **7p**.



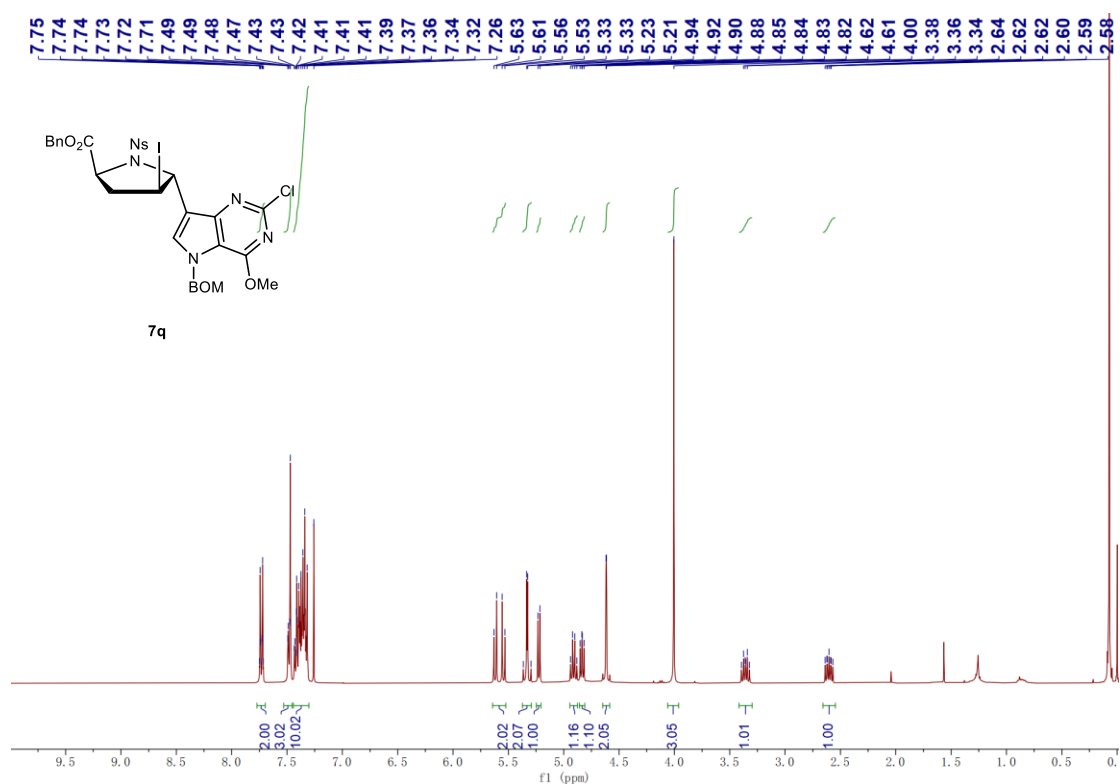
Supplementary Figure 172. ¹³C NMR (100 MHz, CDCl₃) of compound **7p**.



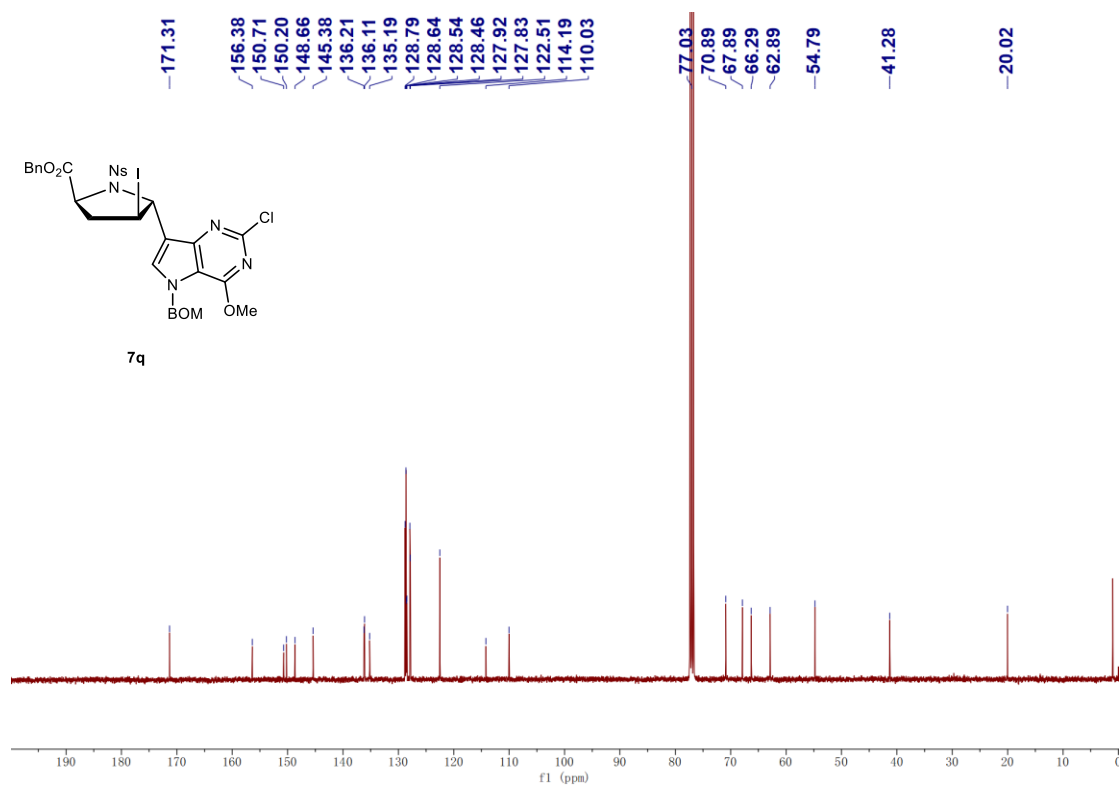
Supplementary Figure 173. ¹H NMR (400 MHz, CDCl₃) of compound **6q**.



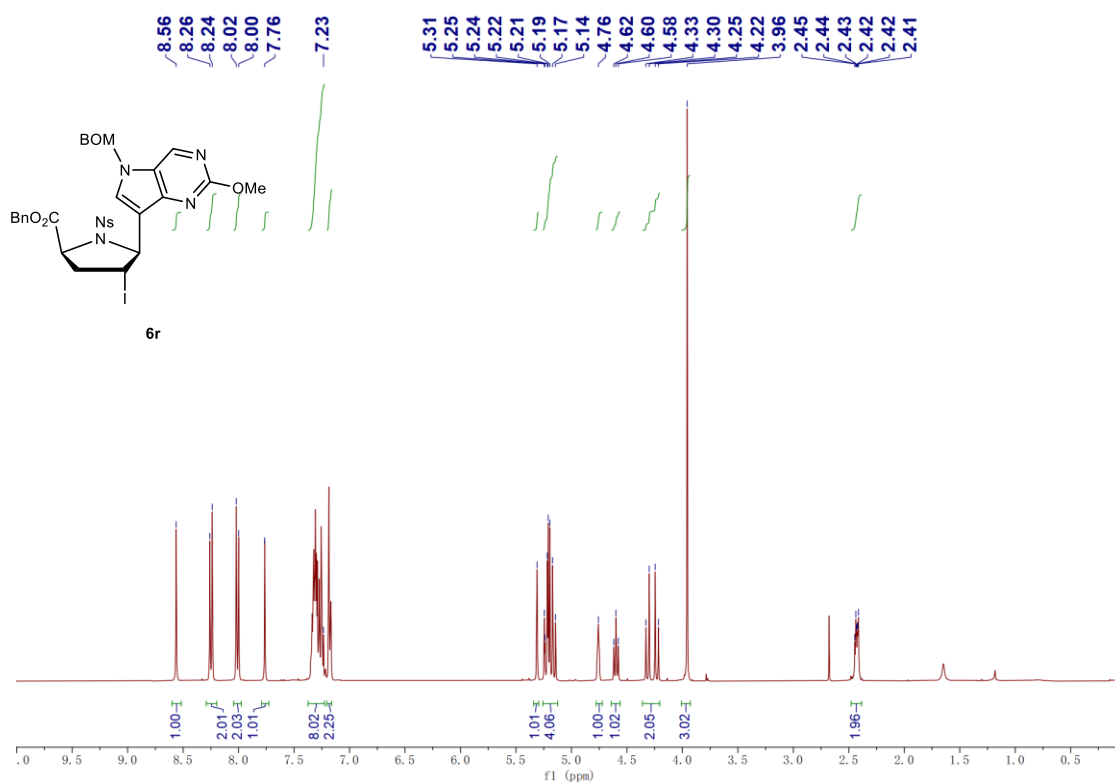
Supplementary Figure 174. ¹³C NMR (100 MHz, CDCl₃) of compound **6q**.



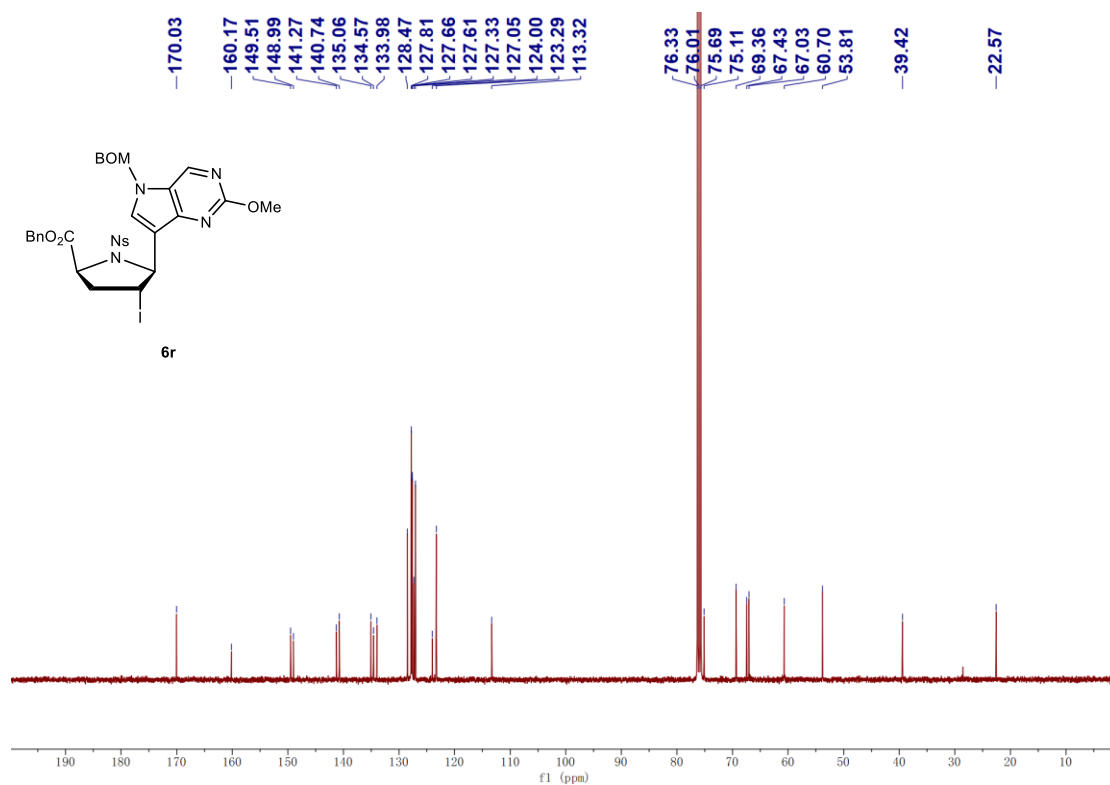
Supplementary Figure 175. ^1H NMR (400 MHz, CDCl_3) of compound **7q**.



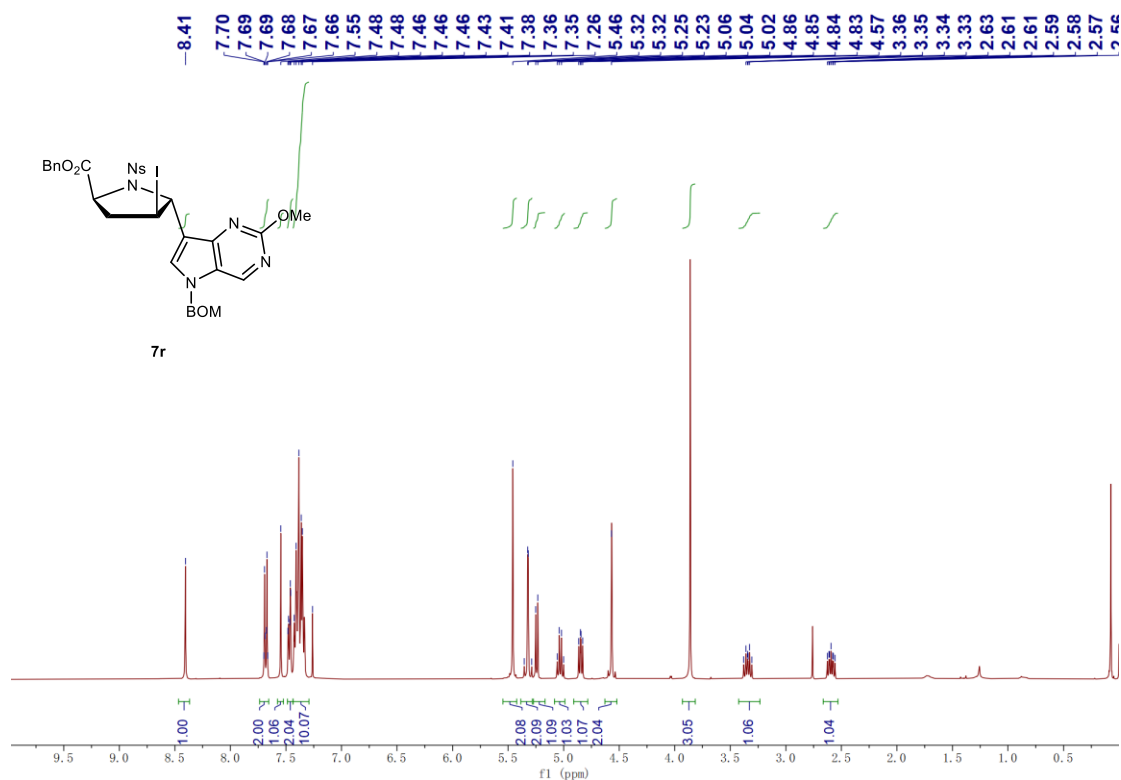
Supplementary Figure 176. ^{13}C NMR (100 MHz, CDCl_3) of compound **7q**.



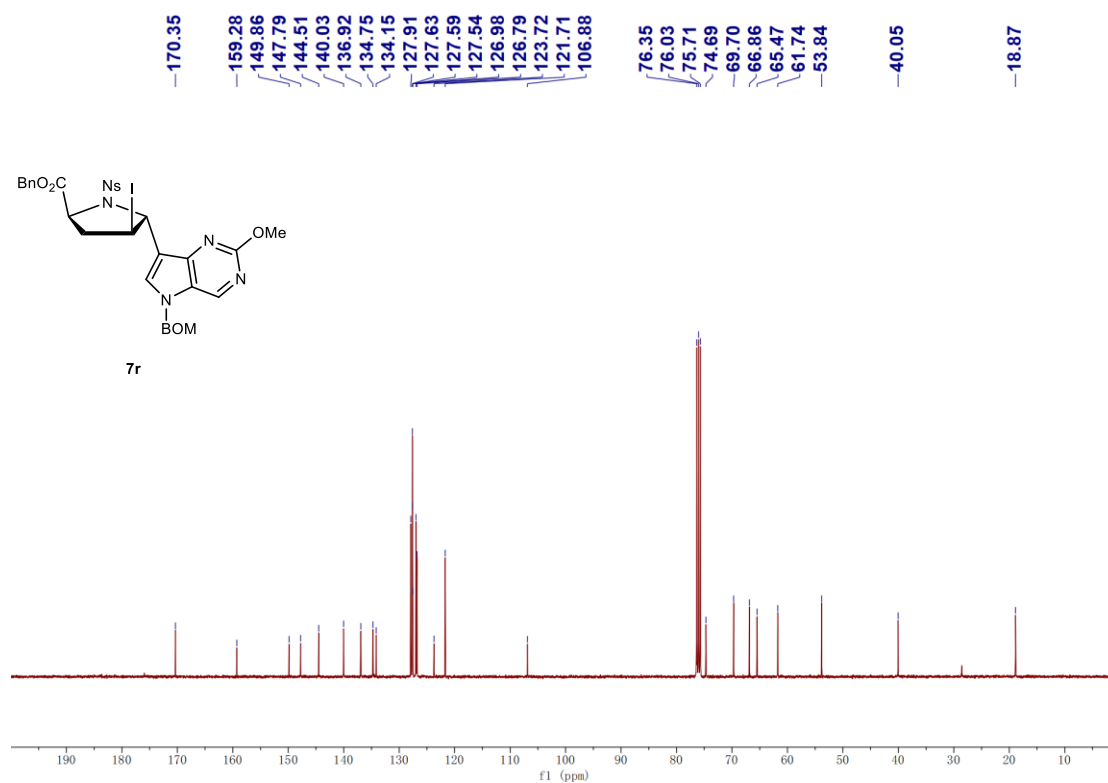
Supplementary Figure 177. ¹H NMR (400 MHz, CDCl₃) of compound **6r**.



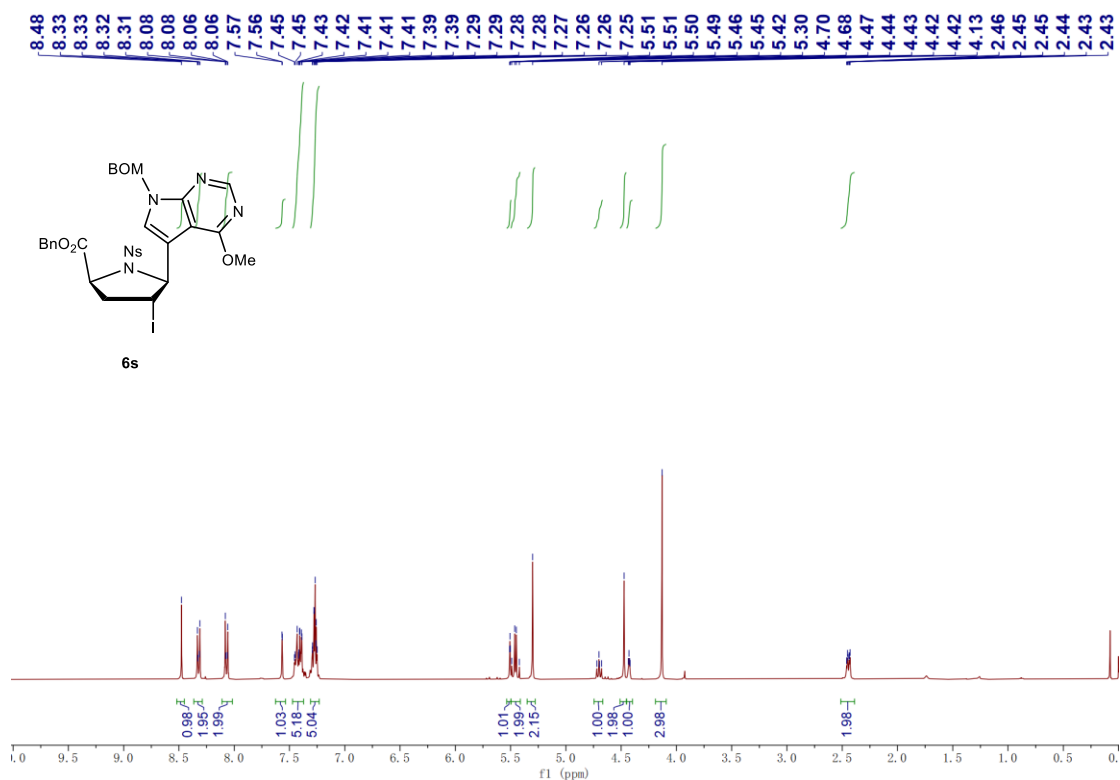
Supplementary Figure 178. ¹³C NMR (100 MHz, CDCl₃) of compound **6r**.



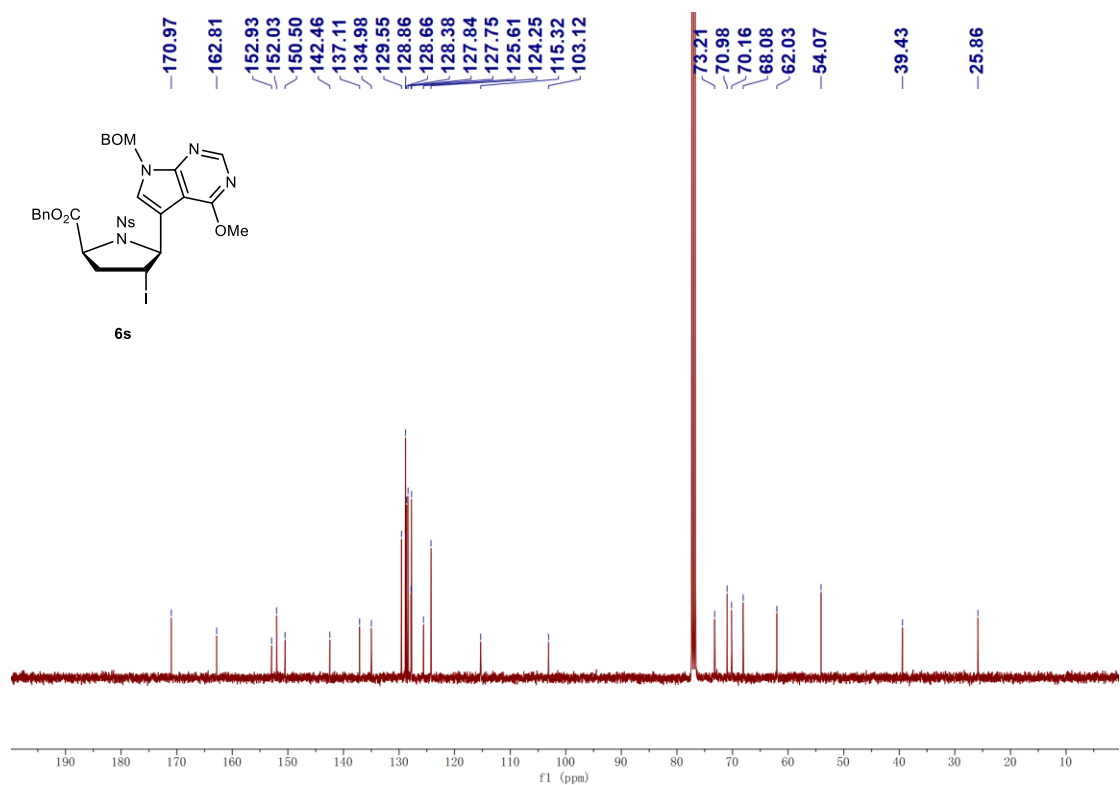
Supplementary Figure 179. ^1H NMR (400 MHz, CDCl_3) of compound **7r**.



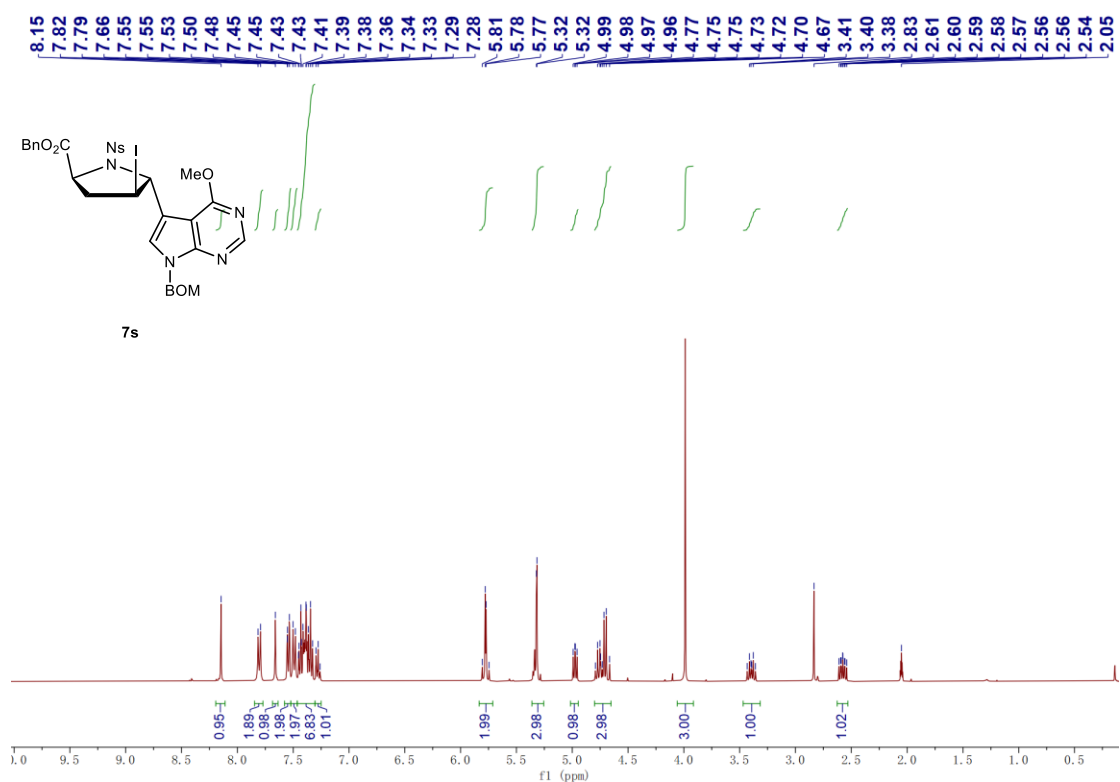
Supplementary Figure 180. ^{13}C NMR (100 MHz, CDCl_3) of compound **7r**.



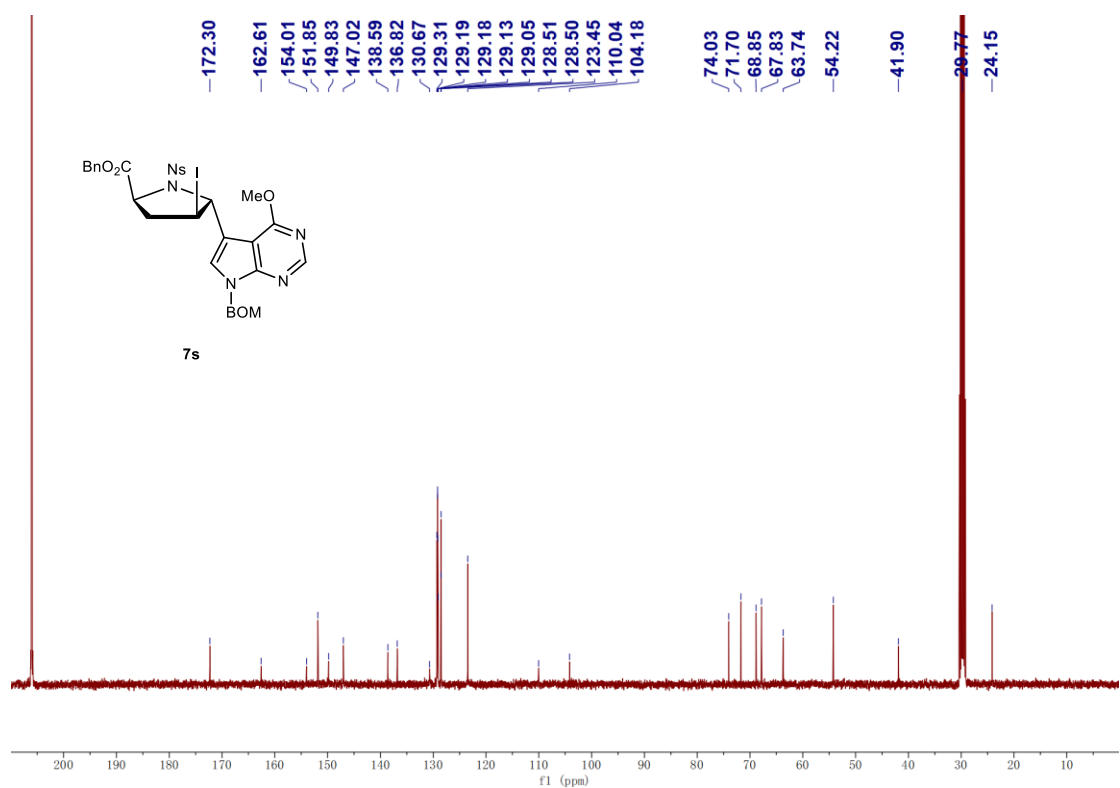
Supplementary Figure 181. ¹H NMR (400 MHz, CDCl₃) of compound **6s**.



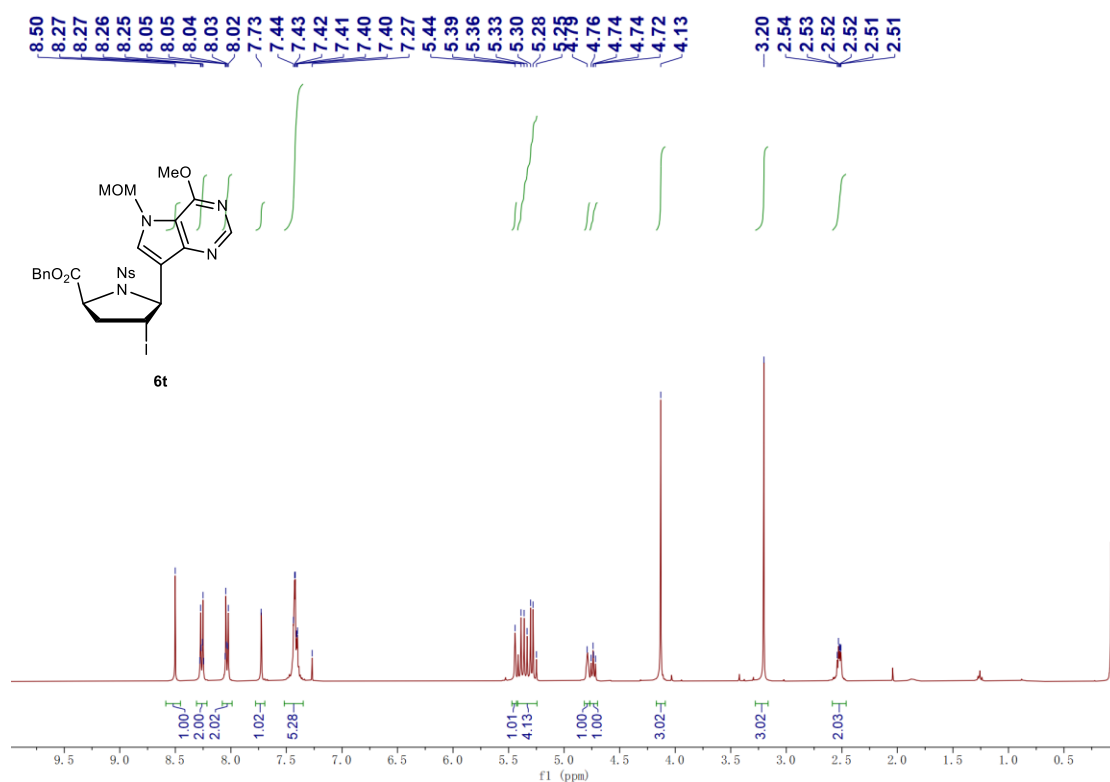
Supplementary Figure 182. ¹³C NMR (400 MHz, CDCl₃) of compound **6s**.



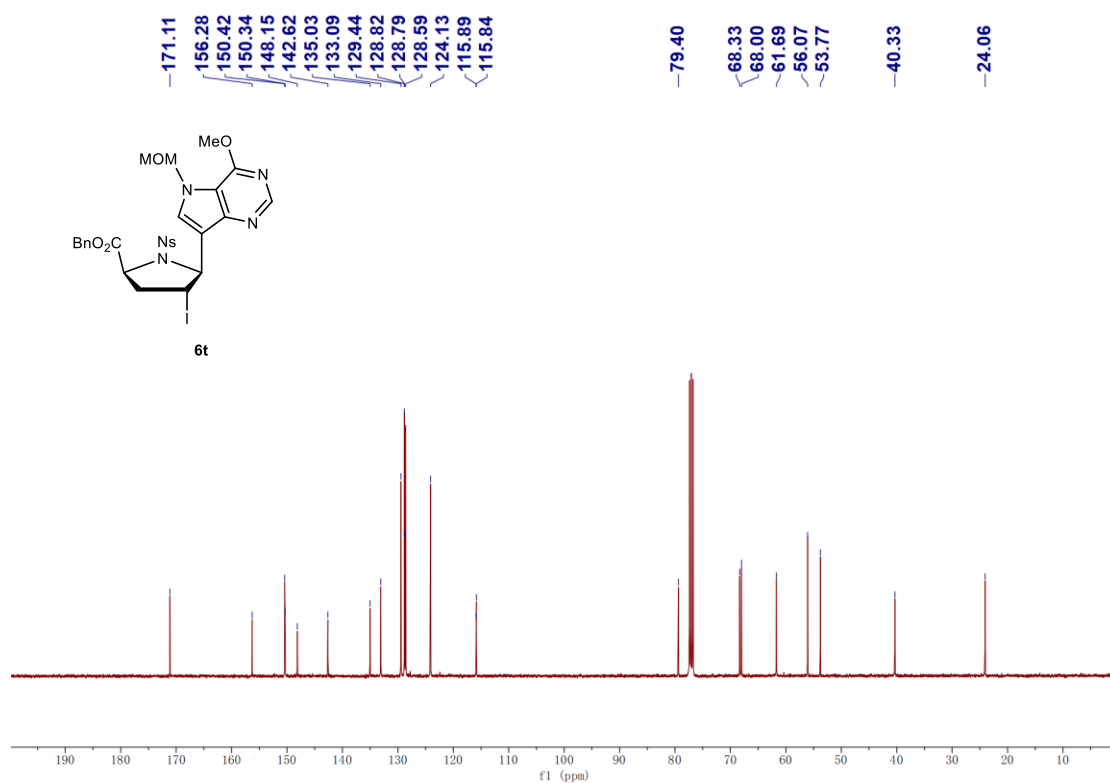
Supplementary Figure 183. ¹H NMR (400 MHz, Acetone) of compound 7s.



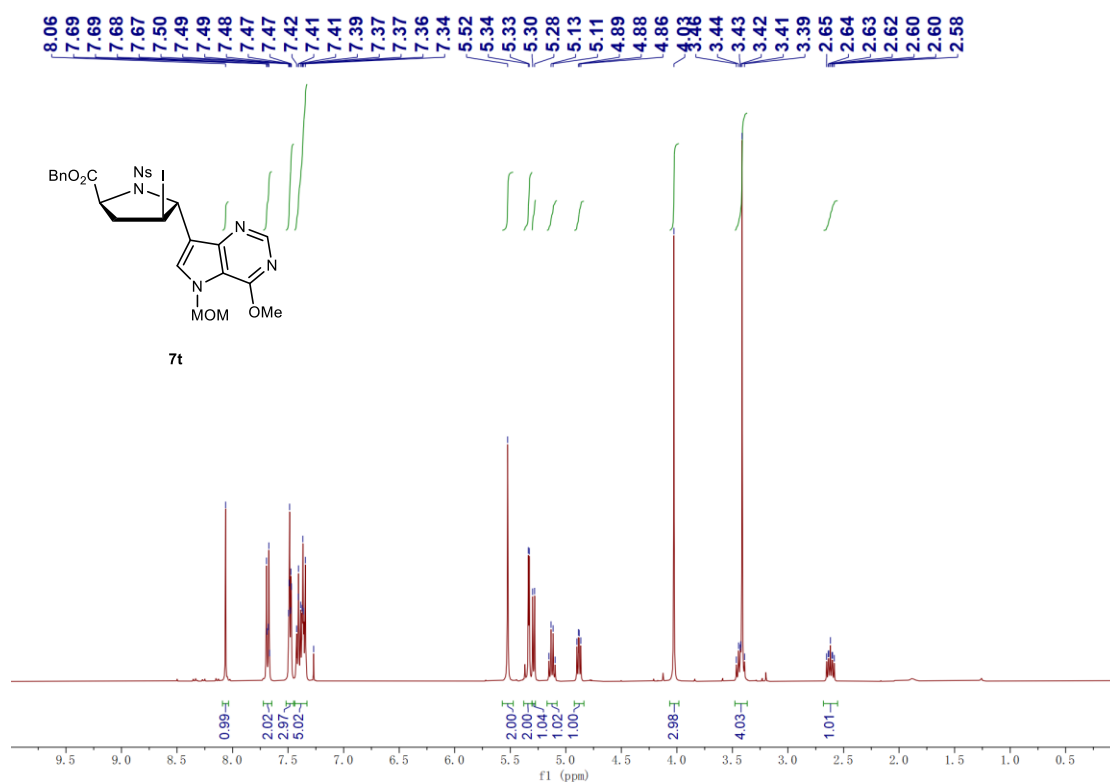
Supplementary Figure 184. ¹³C NMR (100 MHz, Acetone) of compound 7s.



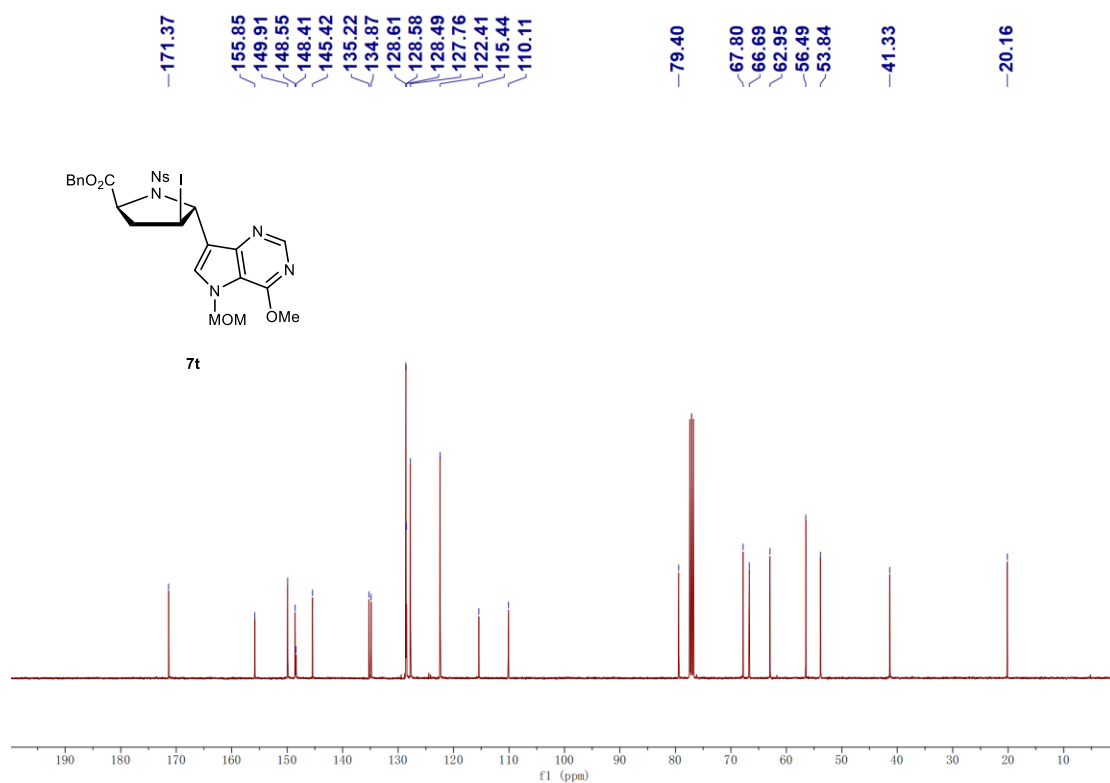
Supplementary Figure 185. ¹H NMR (400 MHz, CDCl₃) of compound **6t**.



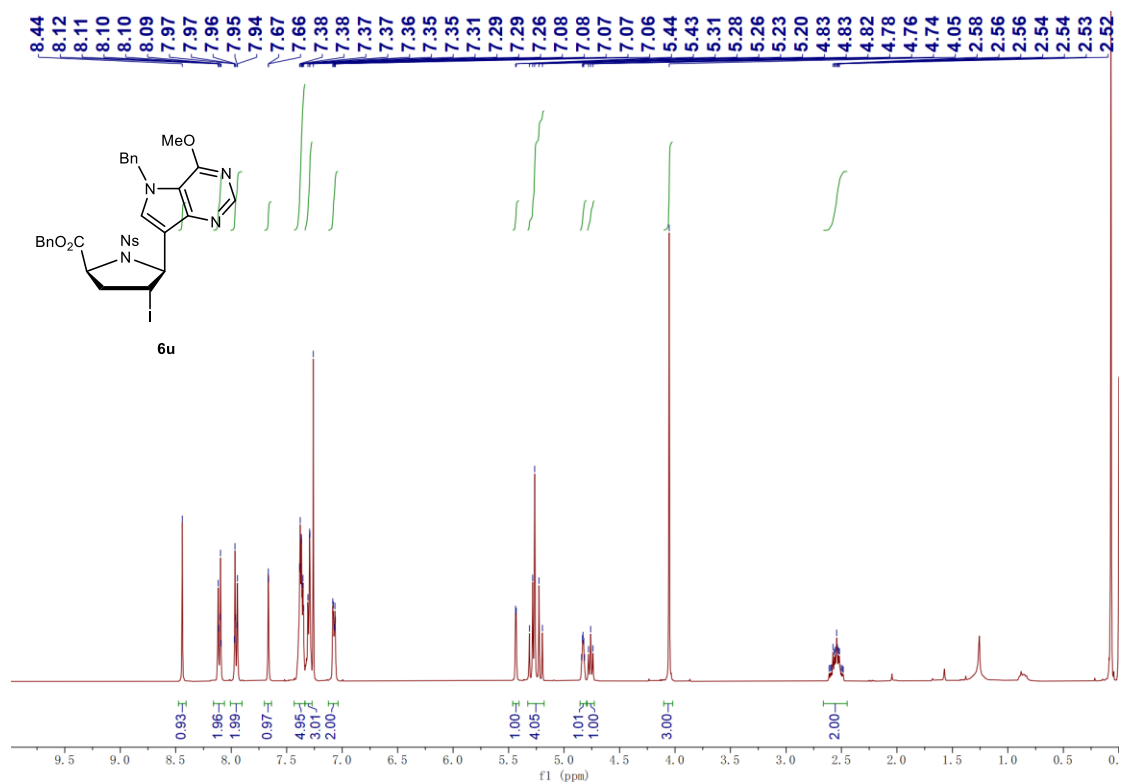
Supplementary Figure 186. ¹³C NMR (100 MHz, CDCl₃) of compound **6t**.



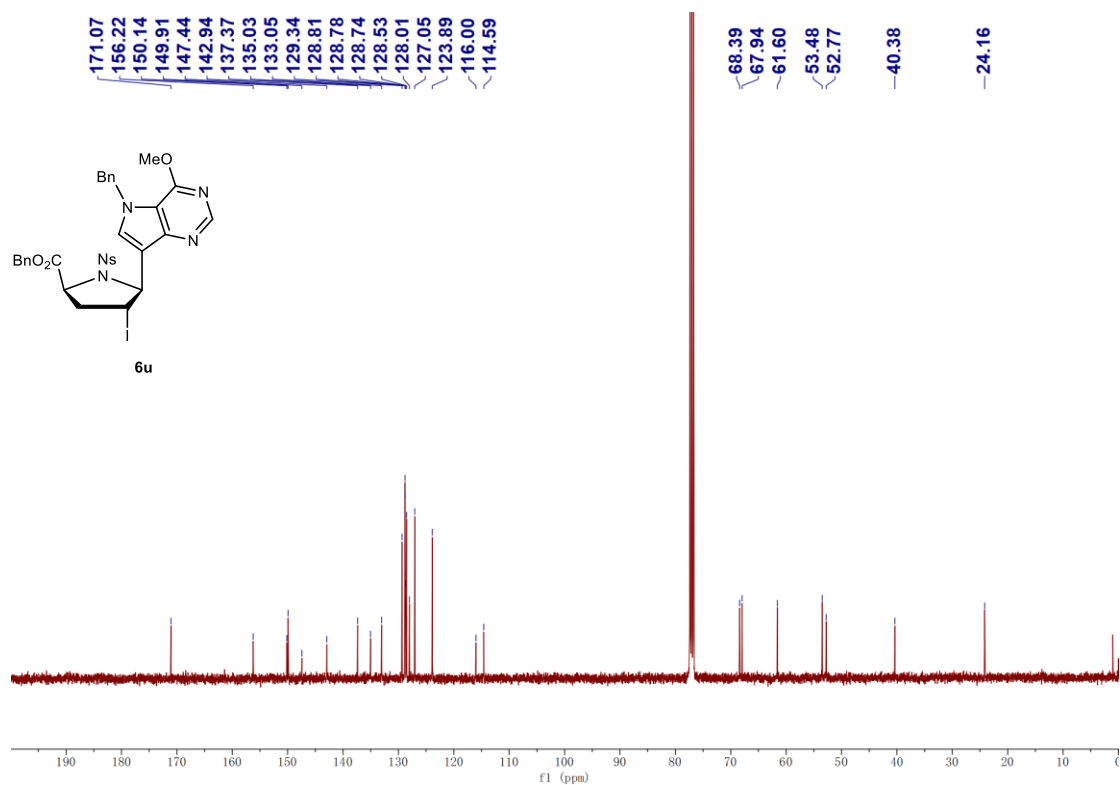
Supplementary Figure 187. ¹H NMR (400 MHz, CDCl₃) of compound **7t**.



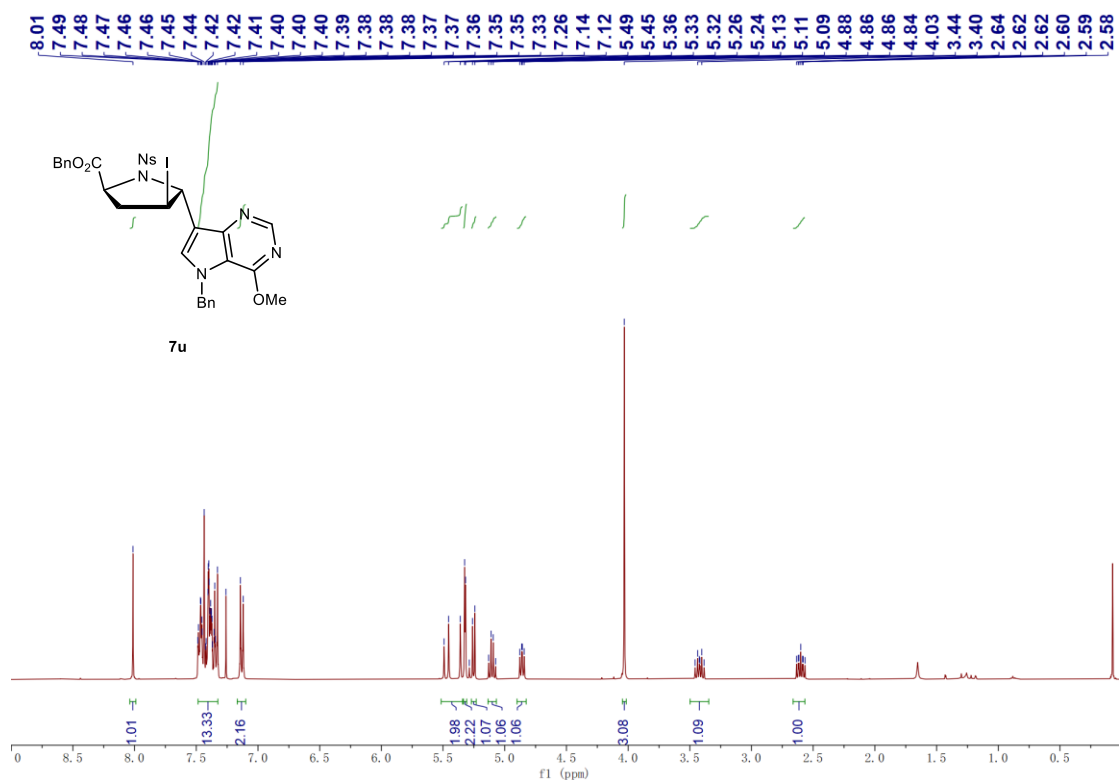
Supplementary Figure 188. ¹³C NMR (100 MHz, CDCl₃) of compound **7t**.



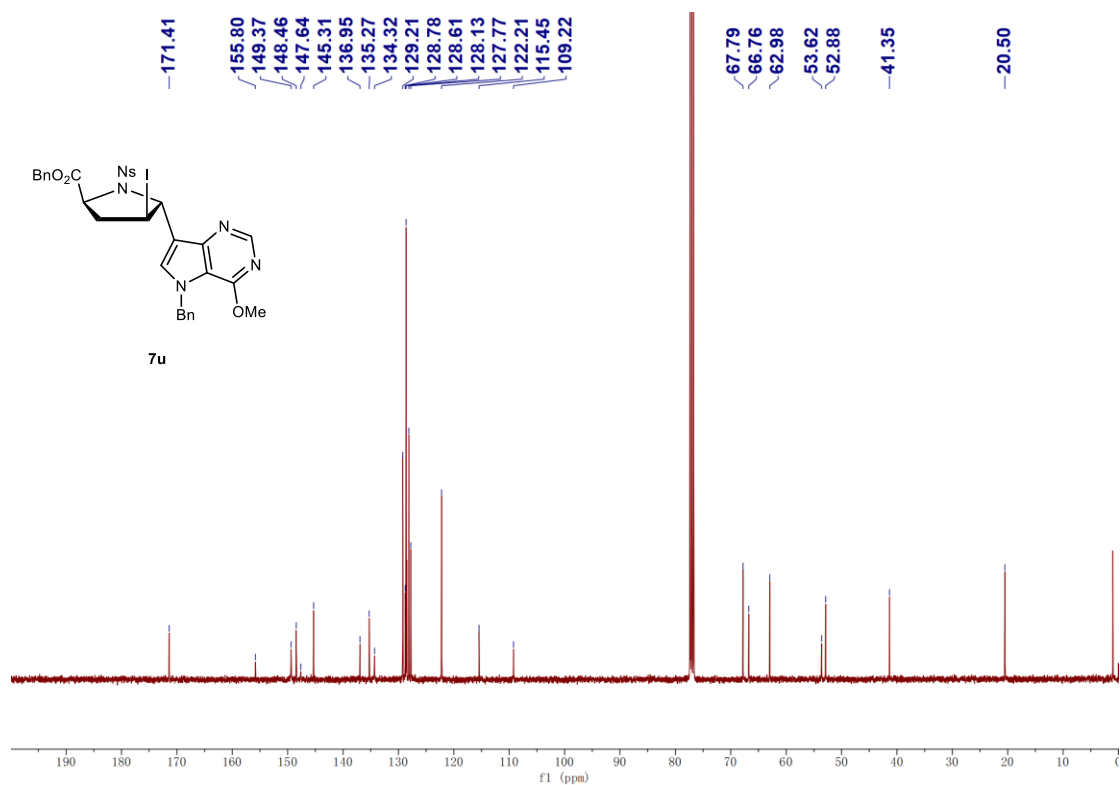
Supplementary Figure 189. ¹H NMR (400 MHz, CDCl₃) of compound **6u**.



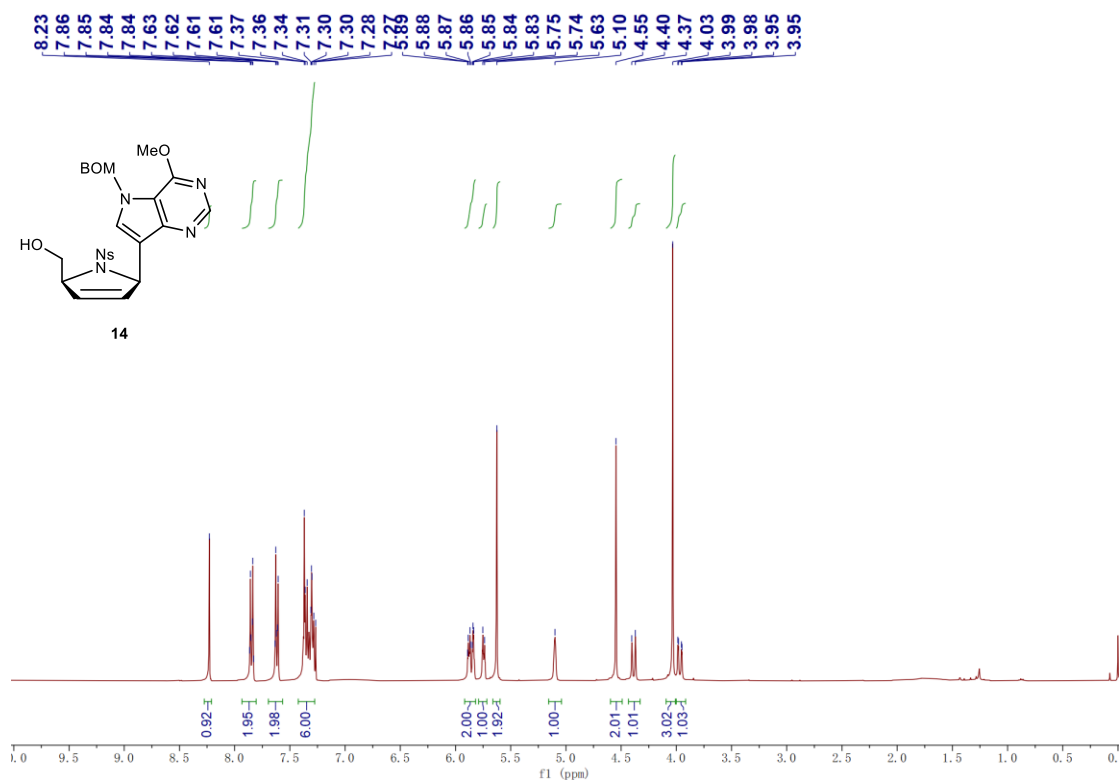
Supplementary Figure 190. ¹³C NMR (100 MHz, CDCl₃) of compound **6u**.



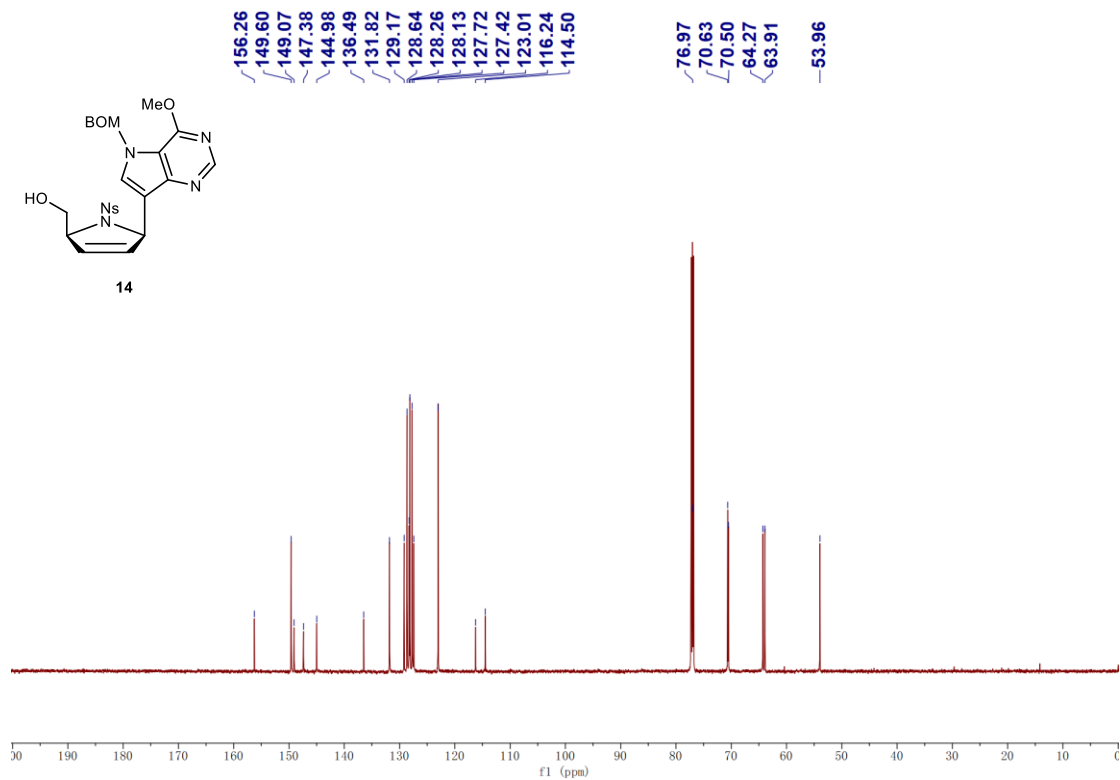
Supplementary Figure 191. ¹H NMR (400 MHz, CDCl₃) of compound **7u**.



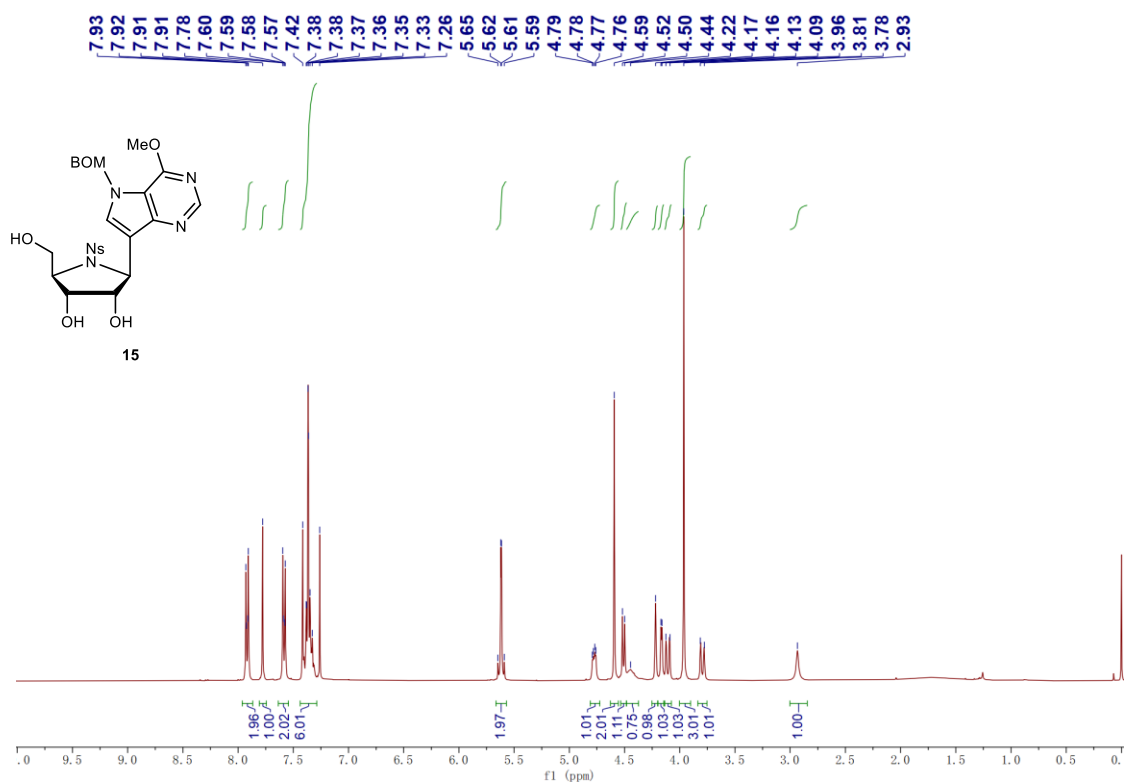
Supplementary Figure 192. ¹³C NMR (100 MHz, CDCl₃) of compound **7u**.



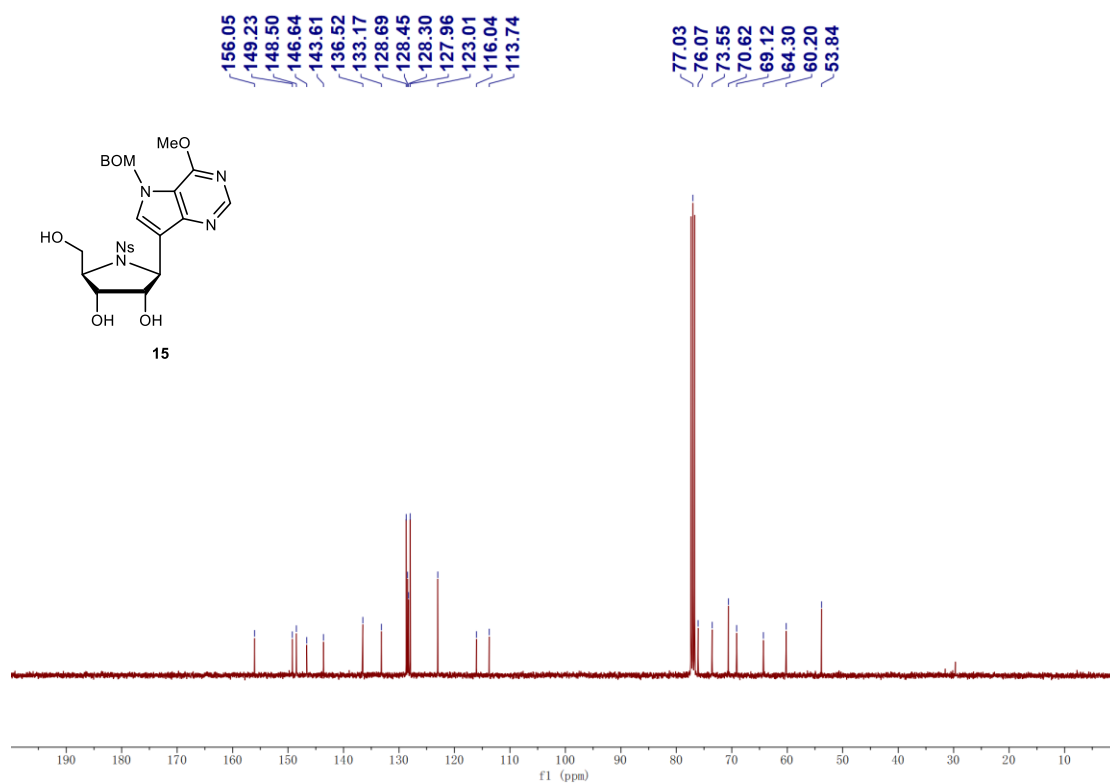
Supplementary Figure 193. ¹H NMR (400 MHz, CDCl₃) of compound 14.



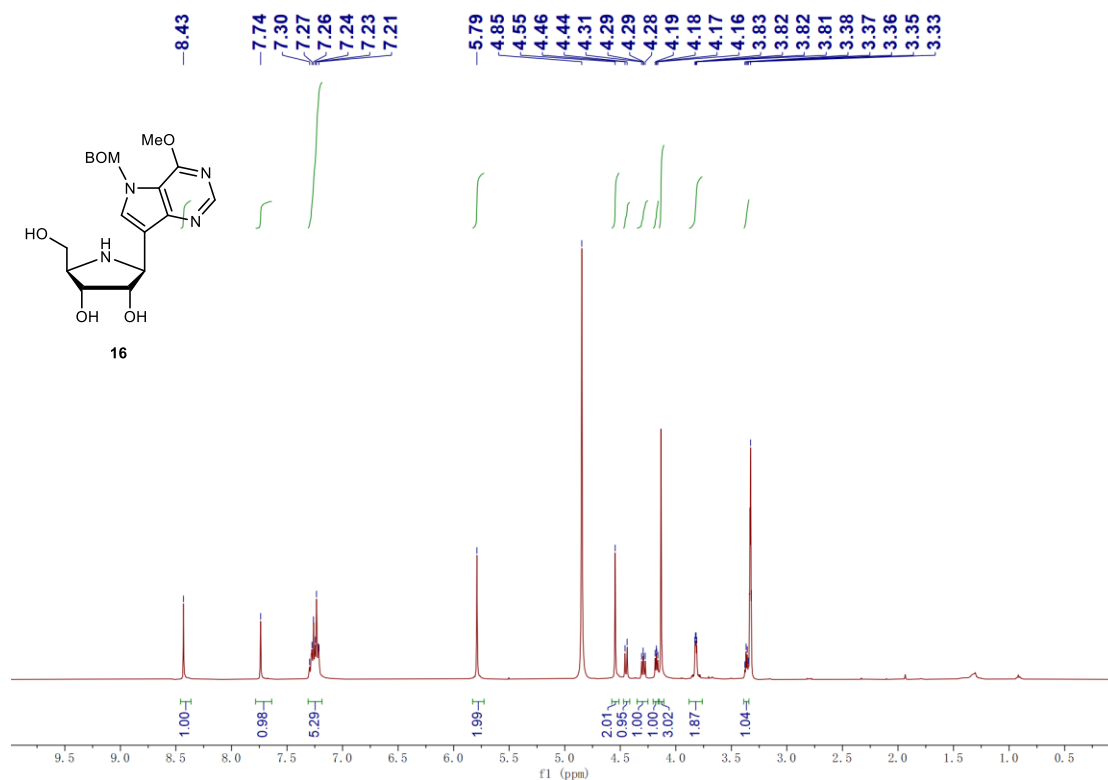
Supplementary Figure 194. ¹³C NMR (150 MHz, CDCl₃) of compound 14.



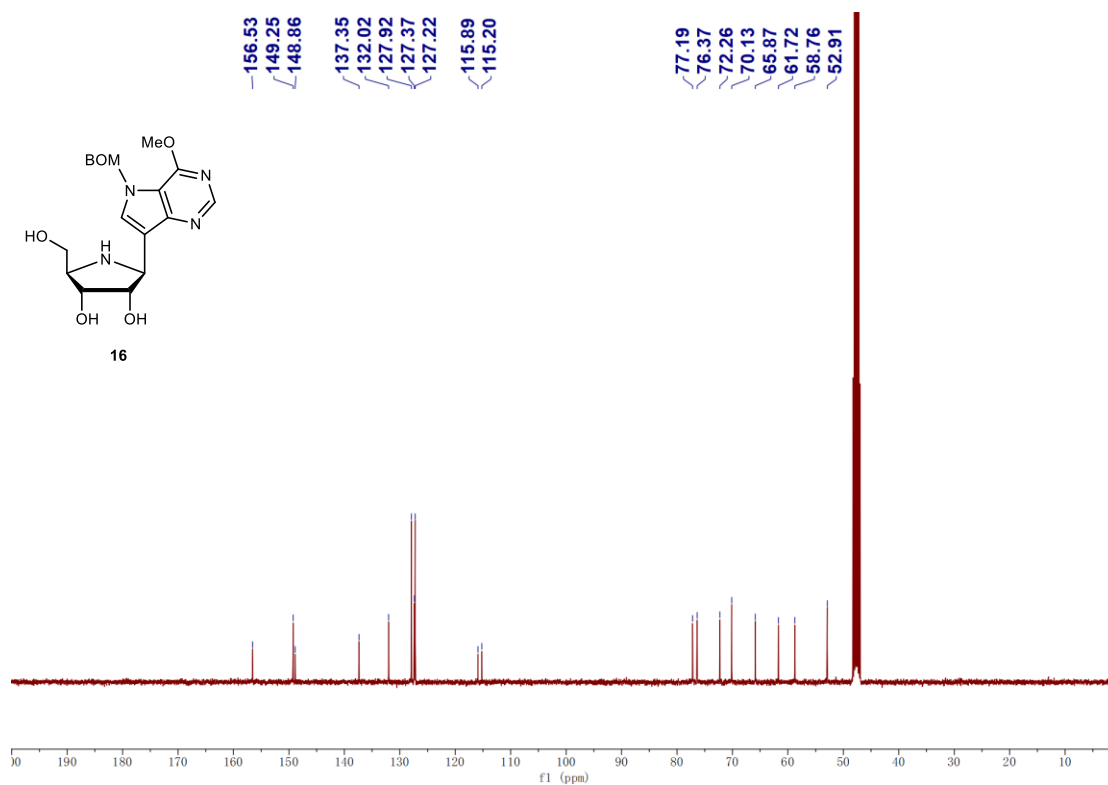
Supplementary Figure 195. ^1H NMR (400 MHz, CDCl_3) of compound 15.



Supplementary Figure 196. ^{13}C NMR (100 MHz, CDCl_3) of compound 15.

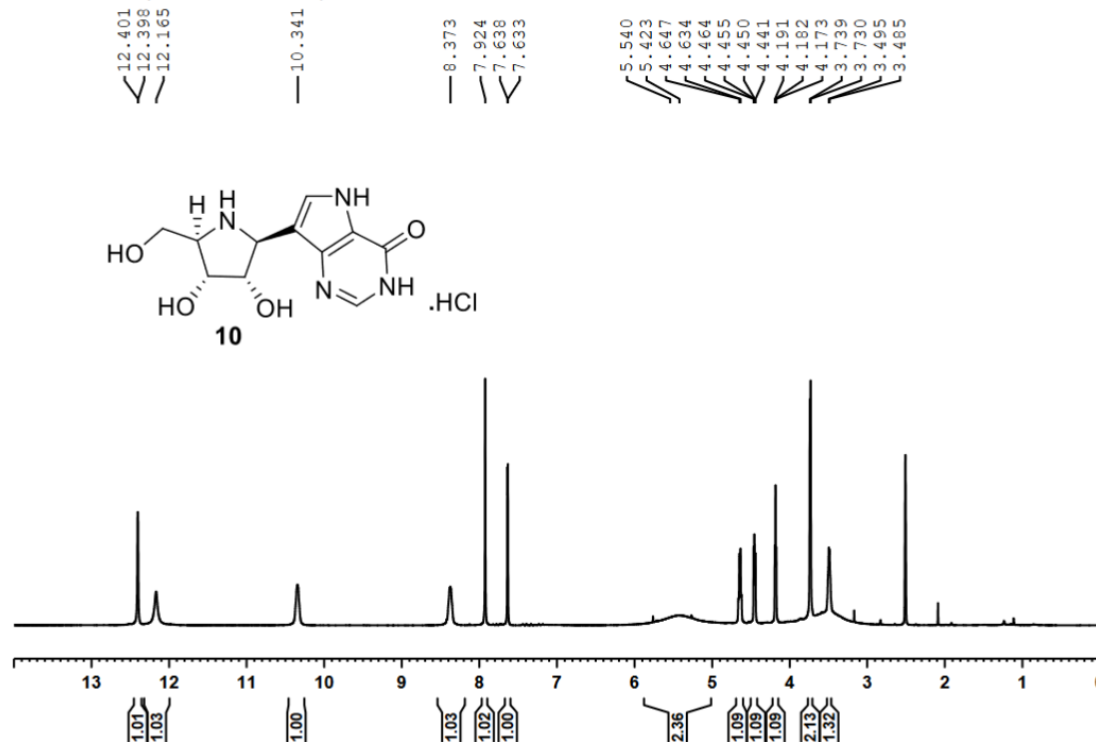


Supplementary Figure 197. ¹H NMR (400 MHz, MeOD) of compound **16**.

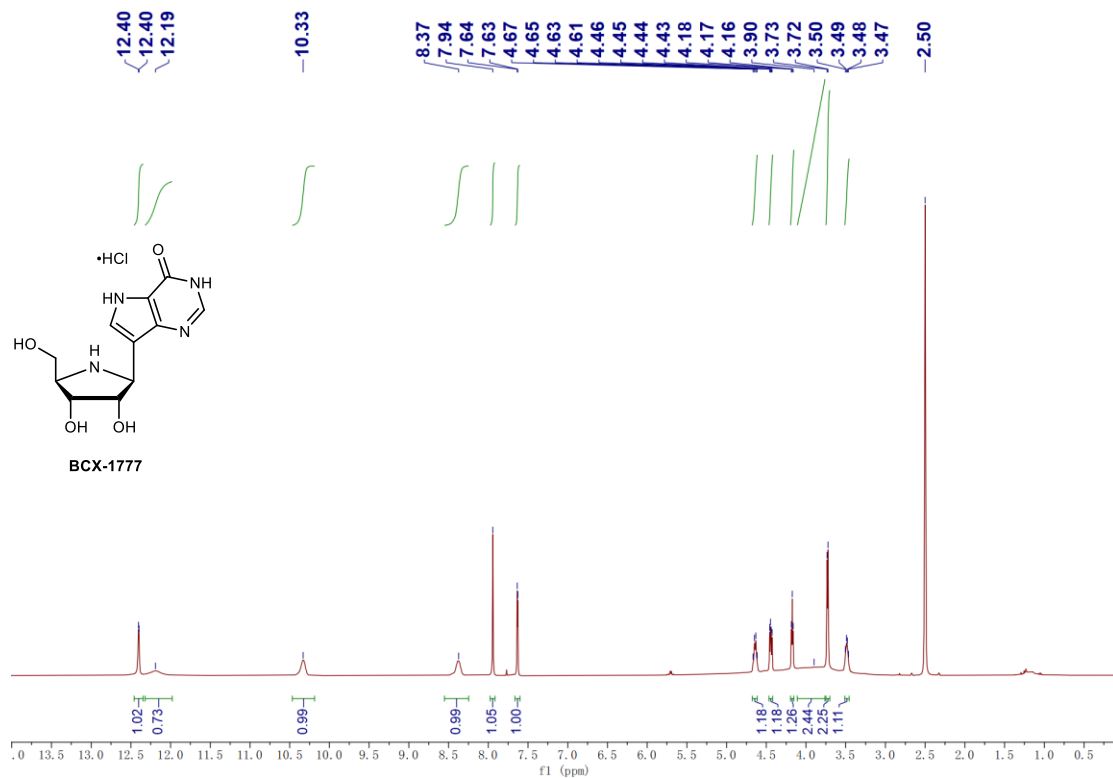


Supplementary Figure 198. ¹³C NMR (100 MHz, CDCl₃) of compound **16**.

KK-490
PROTON DMSO {E:\krishnakumar} niist 3

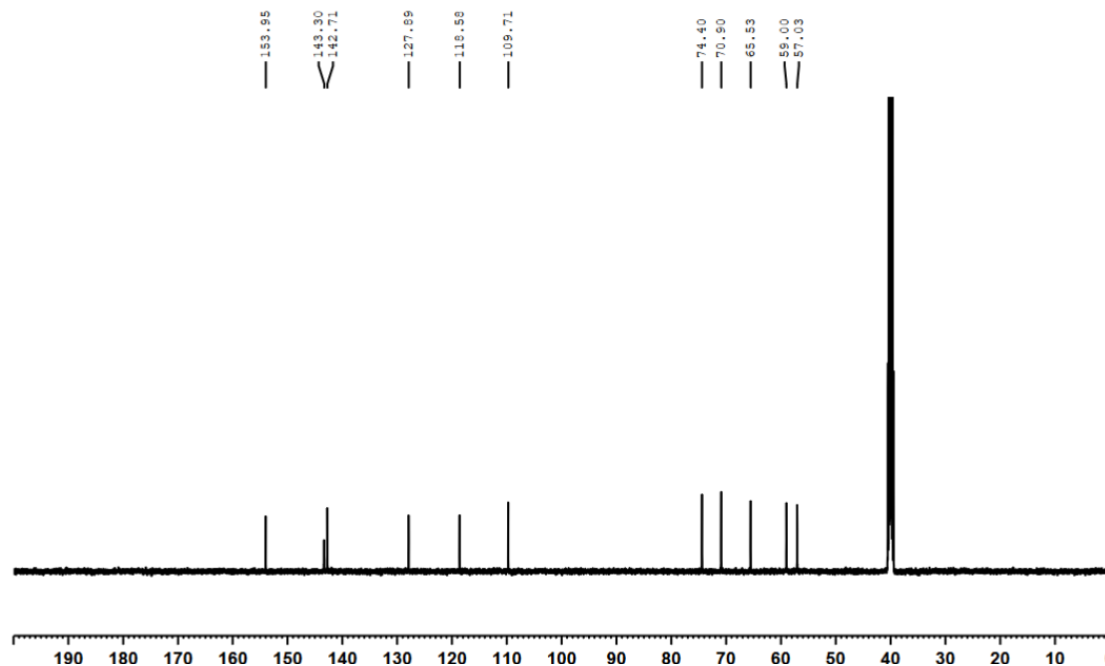


Supplementary Figure 199. Lit¹⁷. Data. ¹H NMR (400 MHz, (CD₃)₂SO) of compound **BCX-1777**.

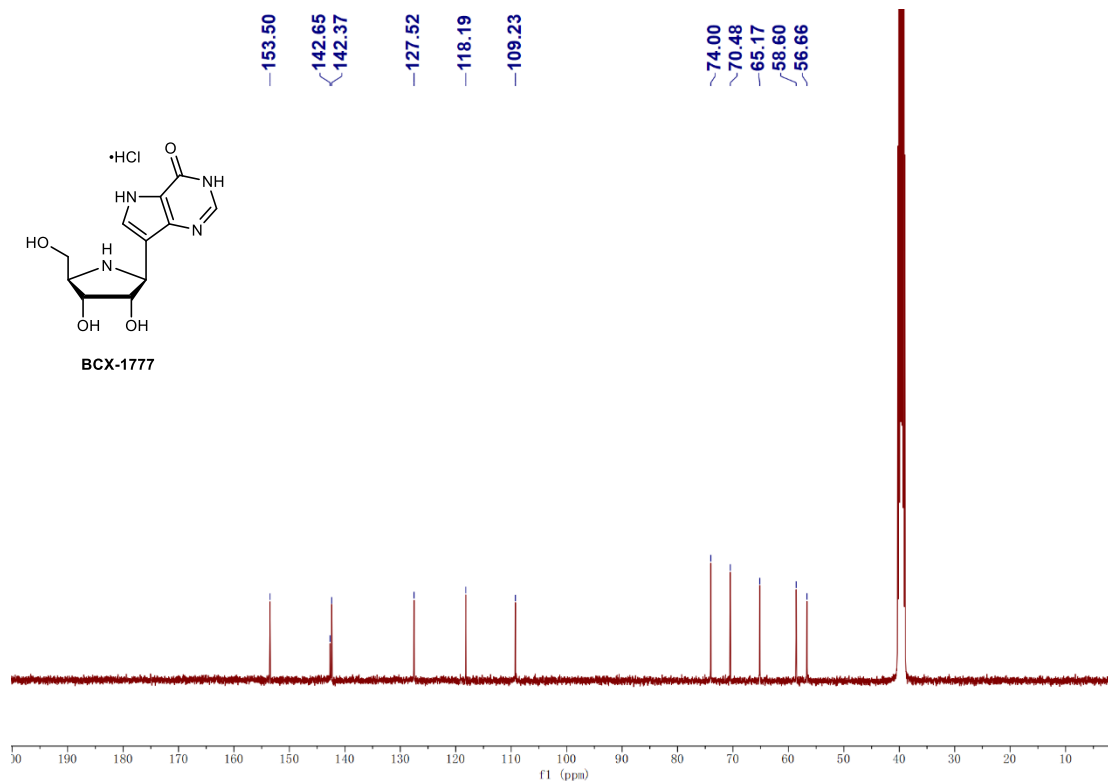


Supplementary Figure 200. ¹H NMR (400 MHz, (CD₃)₂SO) of compound **BCX-1777**.

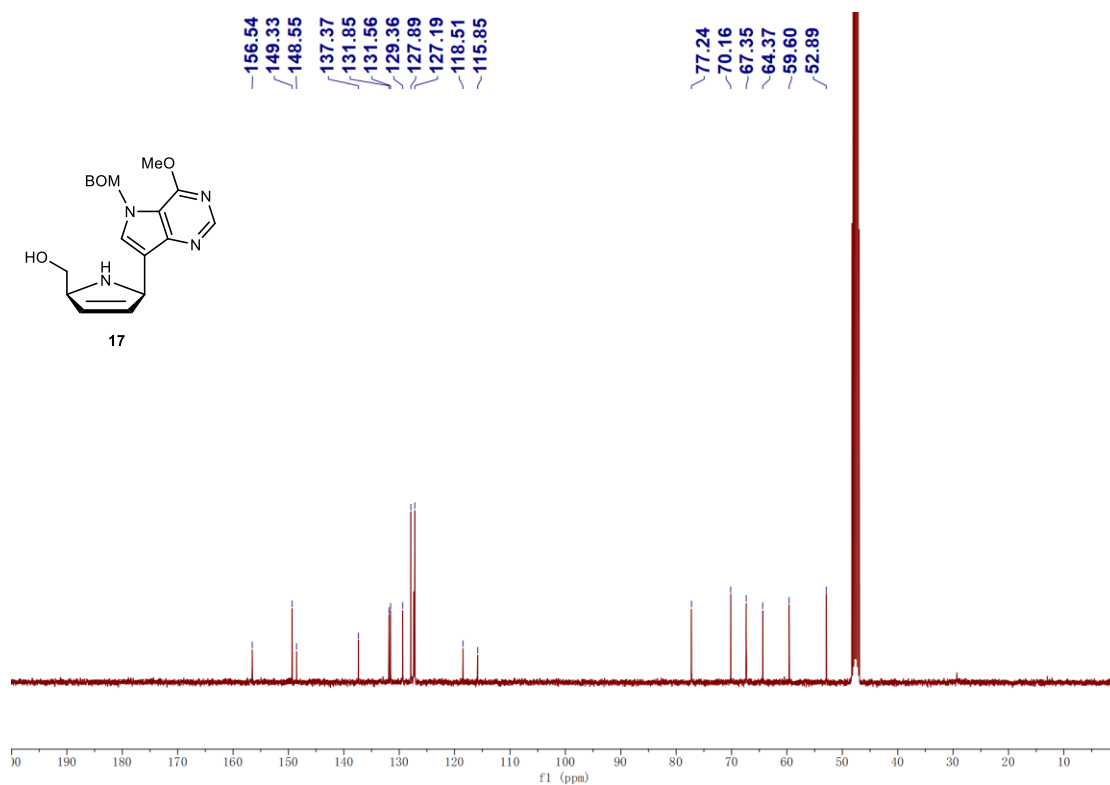
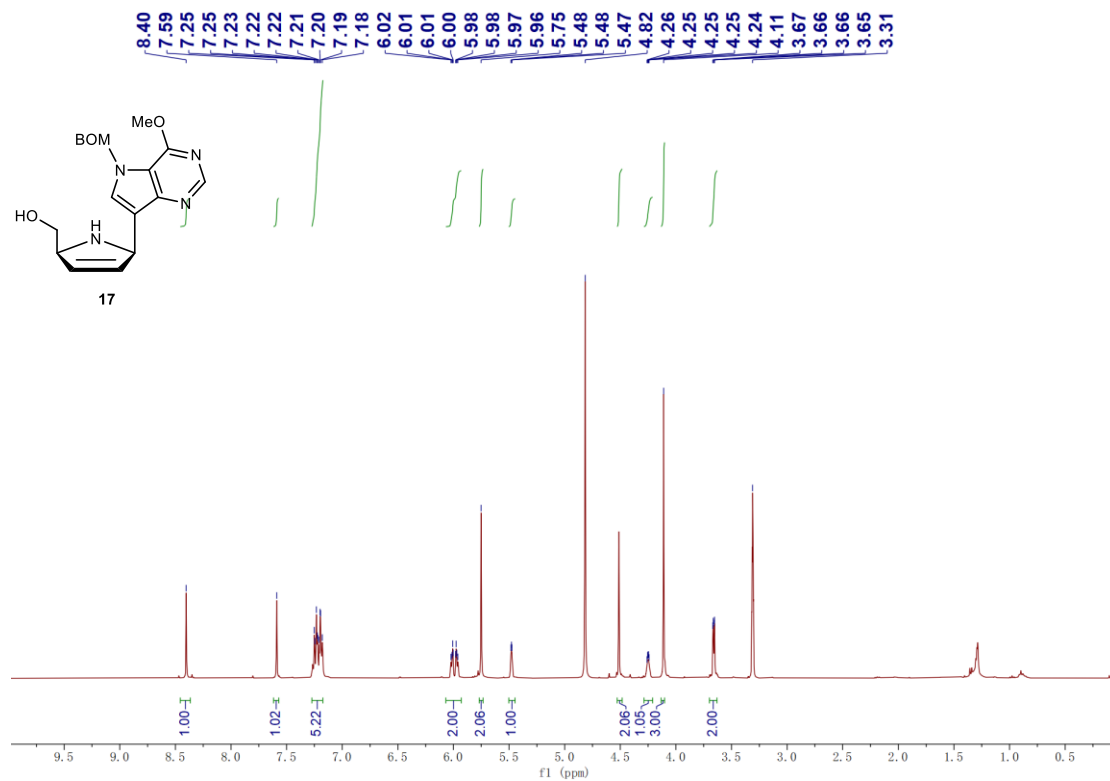
KK-490
C13CPD DMSO {E:\krishnakumar} niist 3

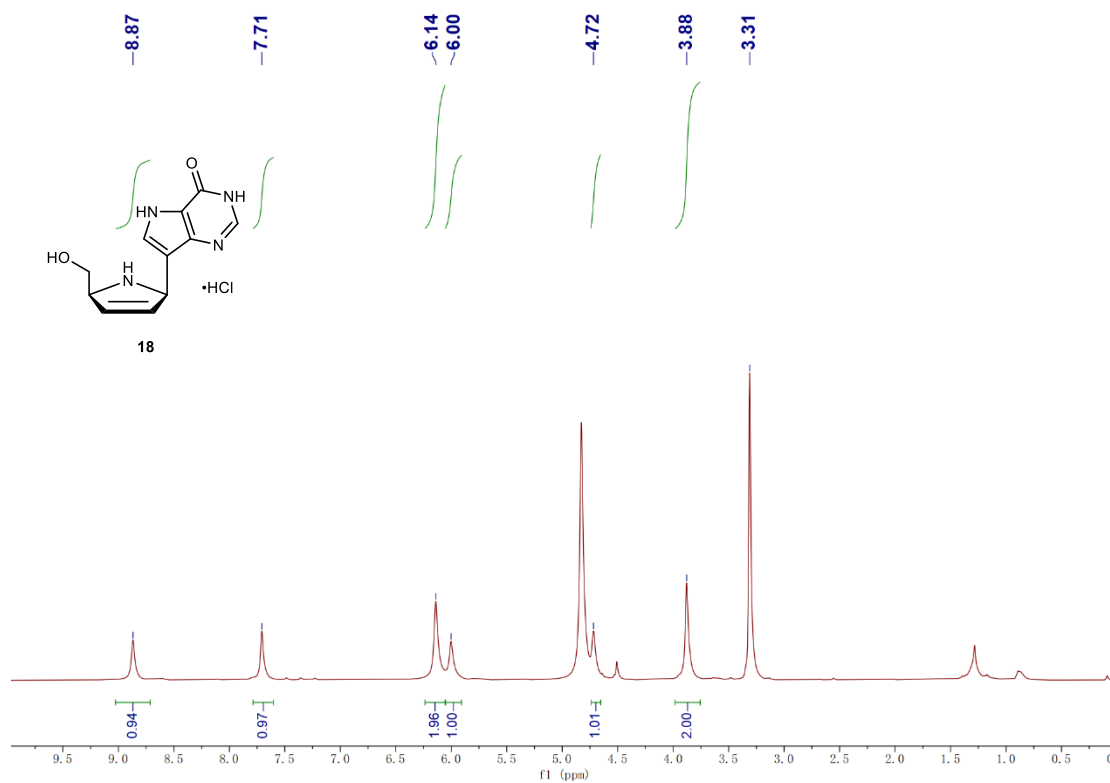


Supplementary Figure 201. Lit¹⁷. Data. ¹³C NMR (100 MHz, (CD₃)₂SO) of compound **BCX-1777**.

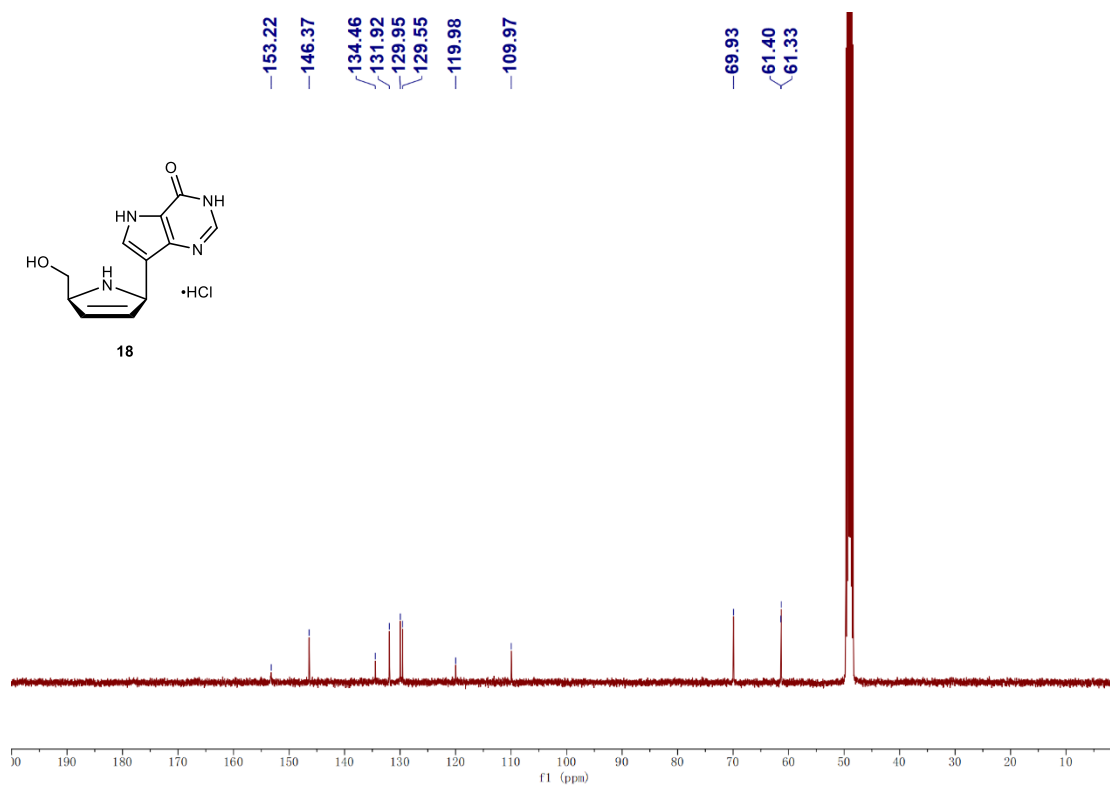


Supplementary Figure 202. ¹³C NMR (100 MHz, (CD₃)₂SO) of compound **BCX-1777**.

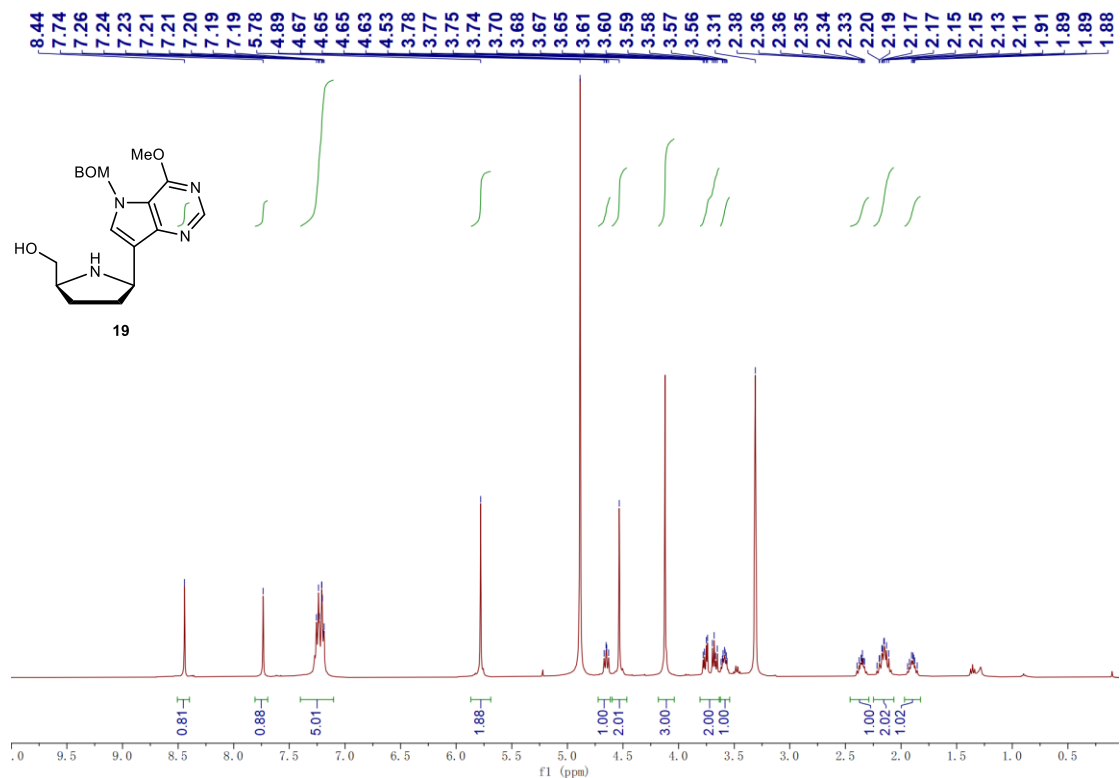




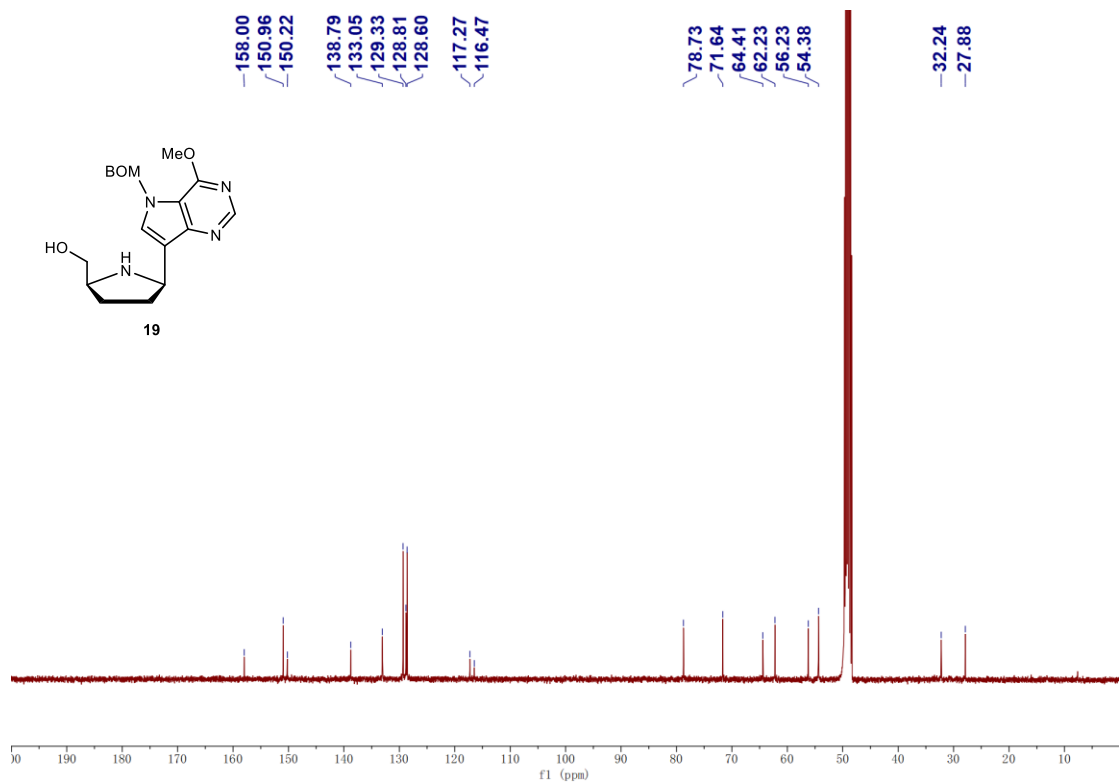
Supplementary Figure 205. ^1H NMR (400 MHz, MeOD) of compound **18**.



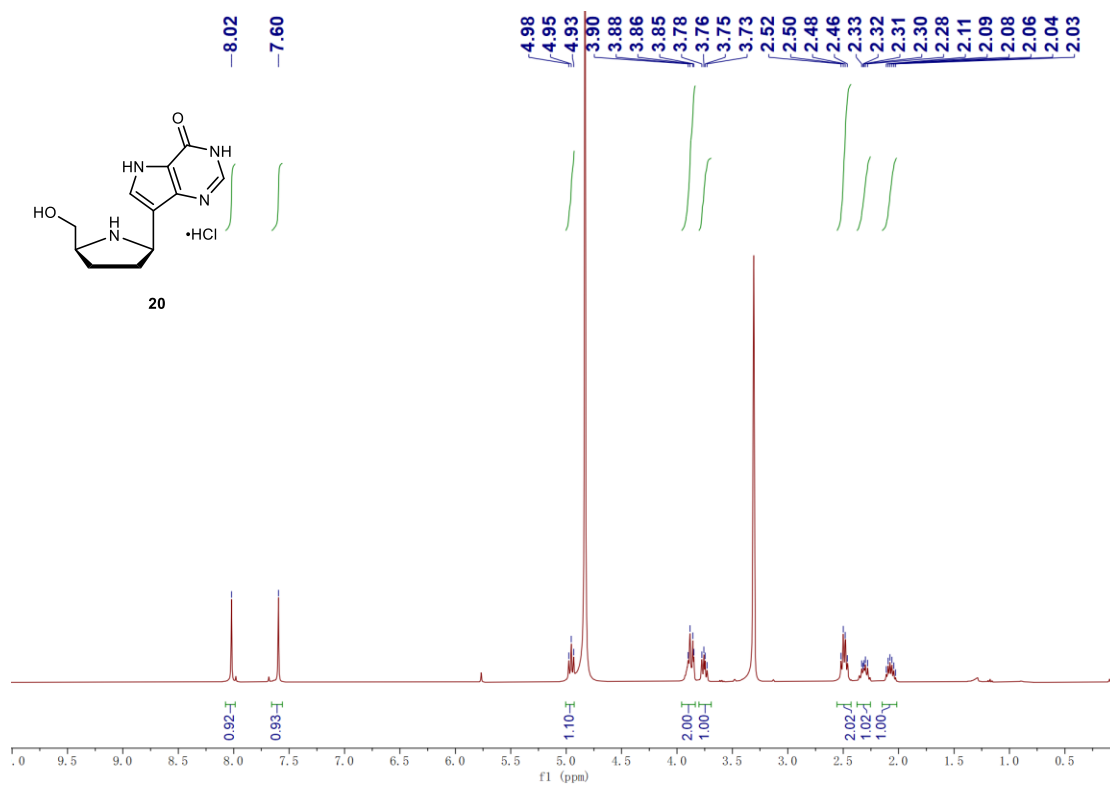
Supplementary Figure 206. ^{13}C NMR (100 MHz, MeOD) of compound **18**.



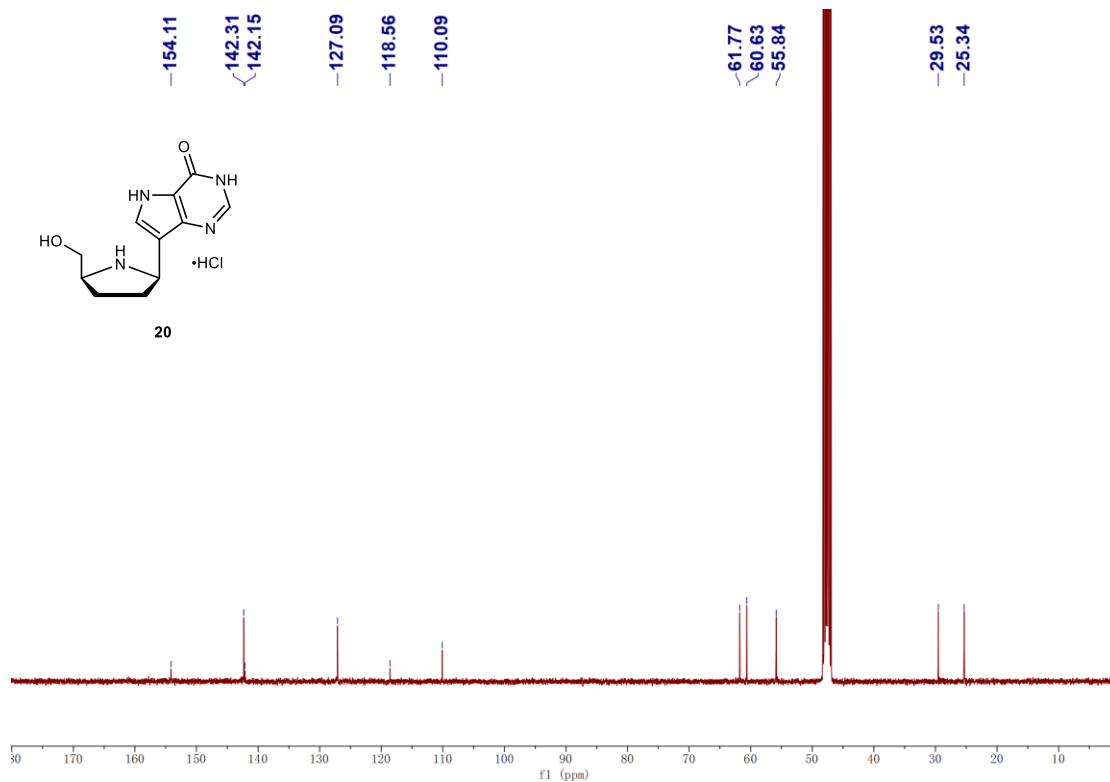
Supplementary Figure 207. ¹H NMR (400 MHz, MeOD) of compound 19.



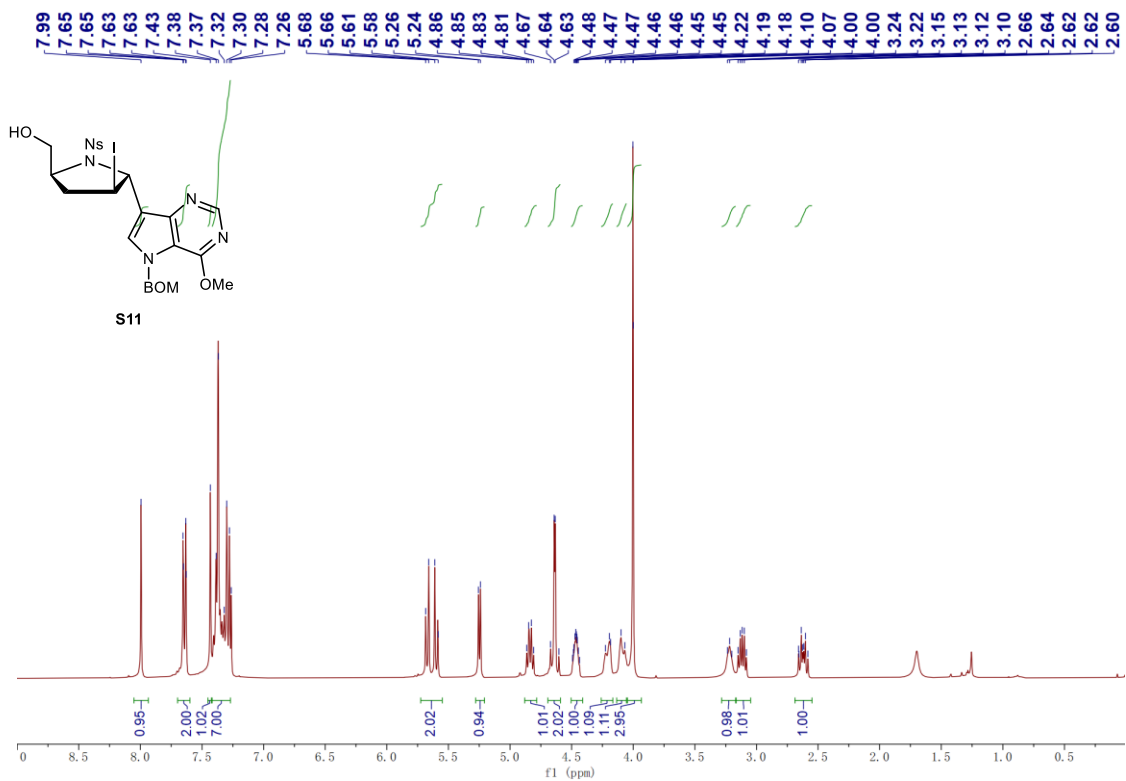
Supplementary Figure 208. ¹³C NMR (100 MHz, MeOD) of compound 19.



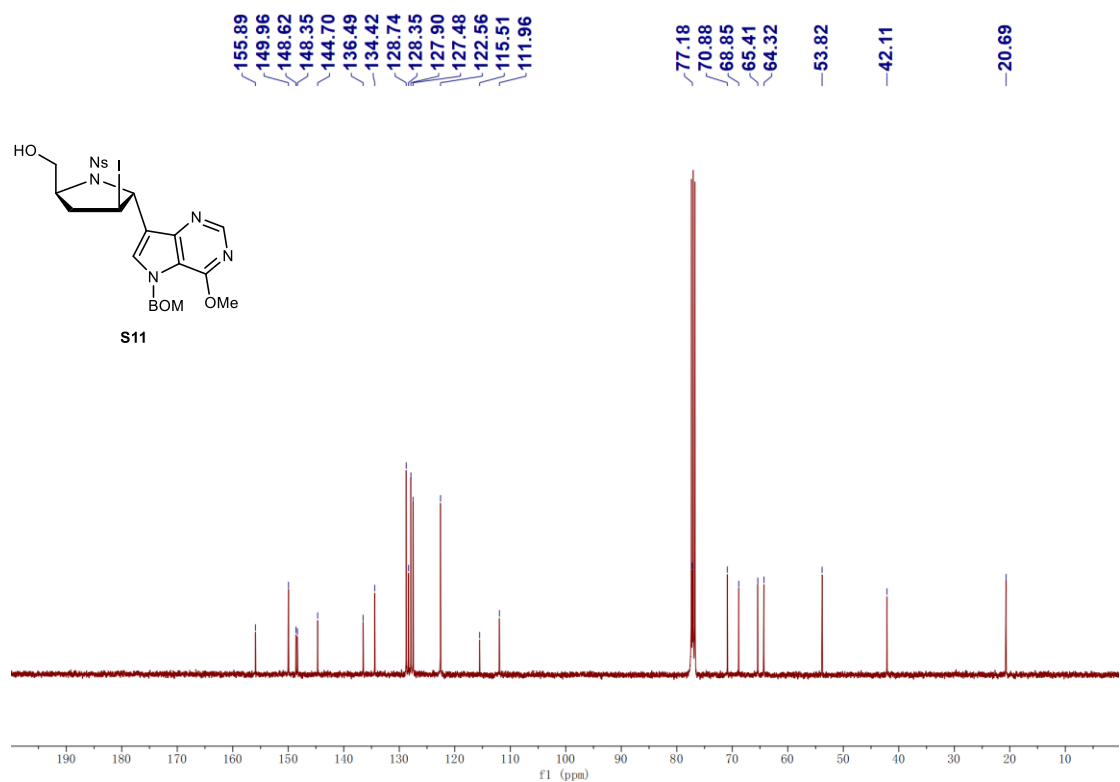
Supplementary Figure 209. ¹H NMR (400 MHz, MeOD) of compound **20**.



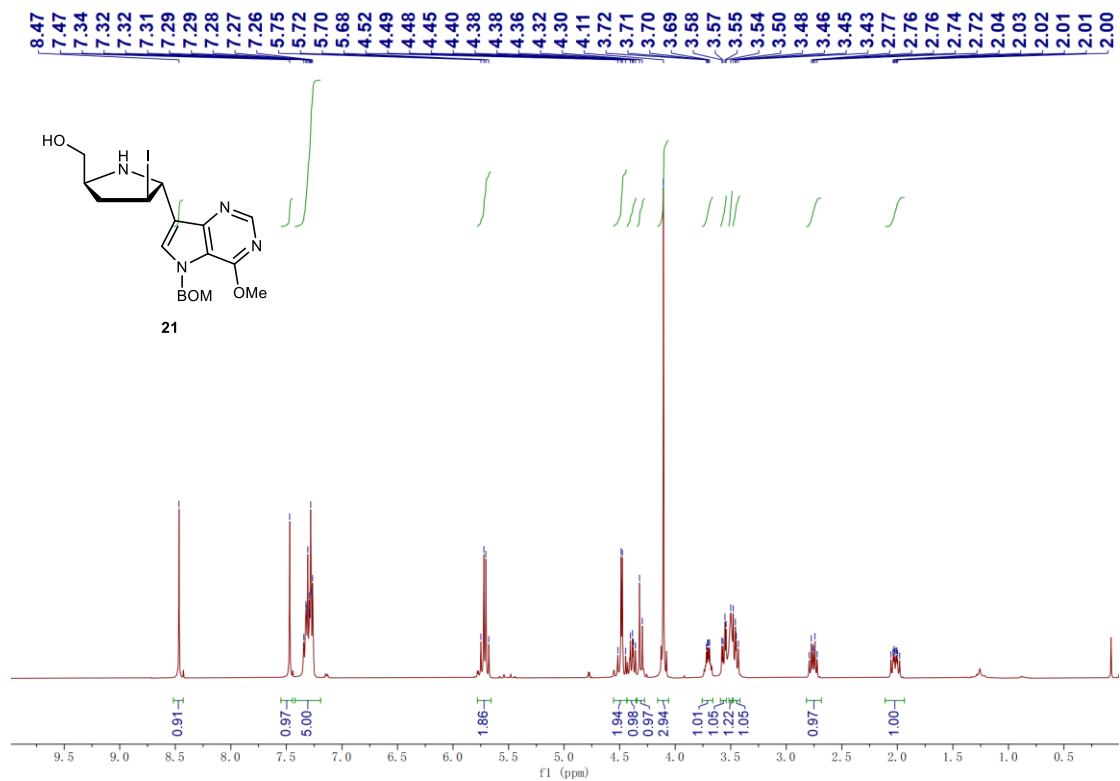
Supplementary Figure 210. ¹³C NMR (100 MHz, MeOD) of compound **20**.



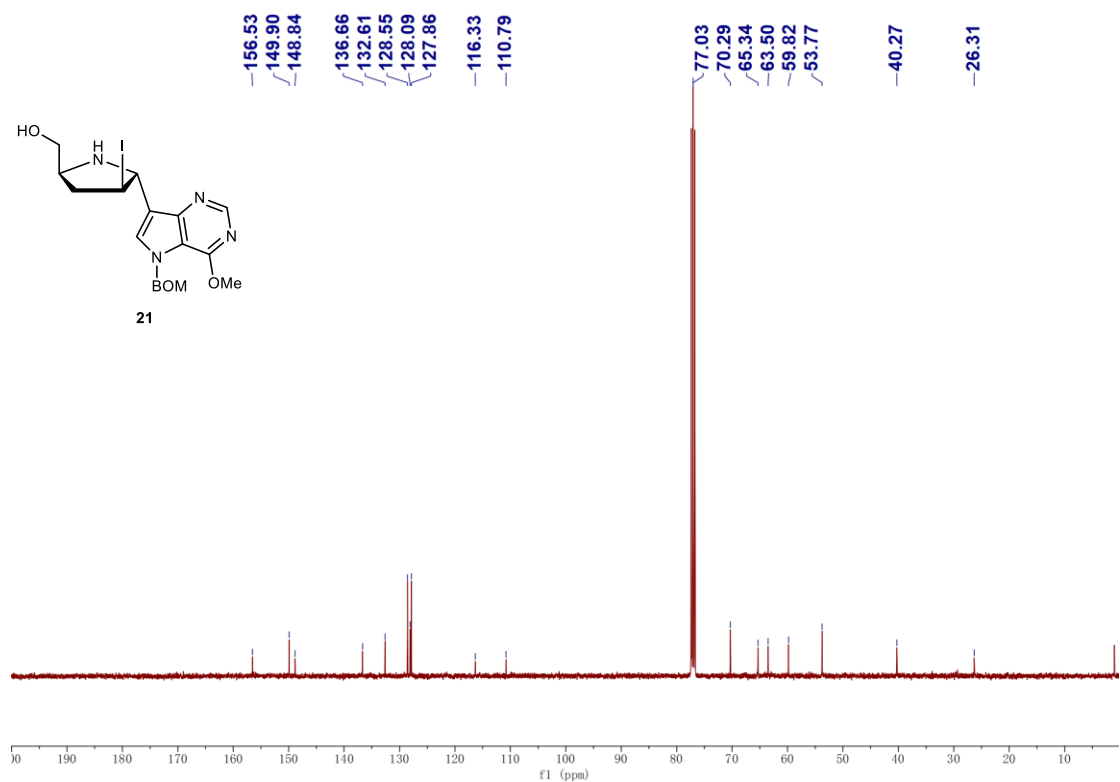
Supplementary Figure 211. ¹H NMR (400 MHz, CDCl₃) of compound S11.



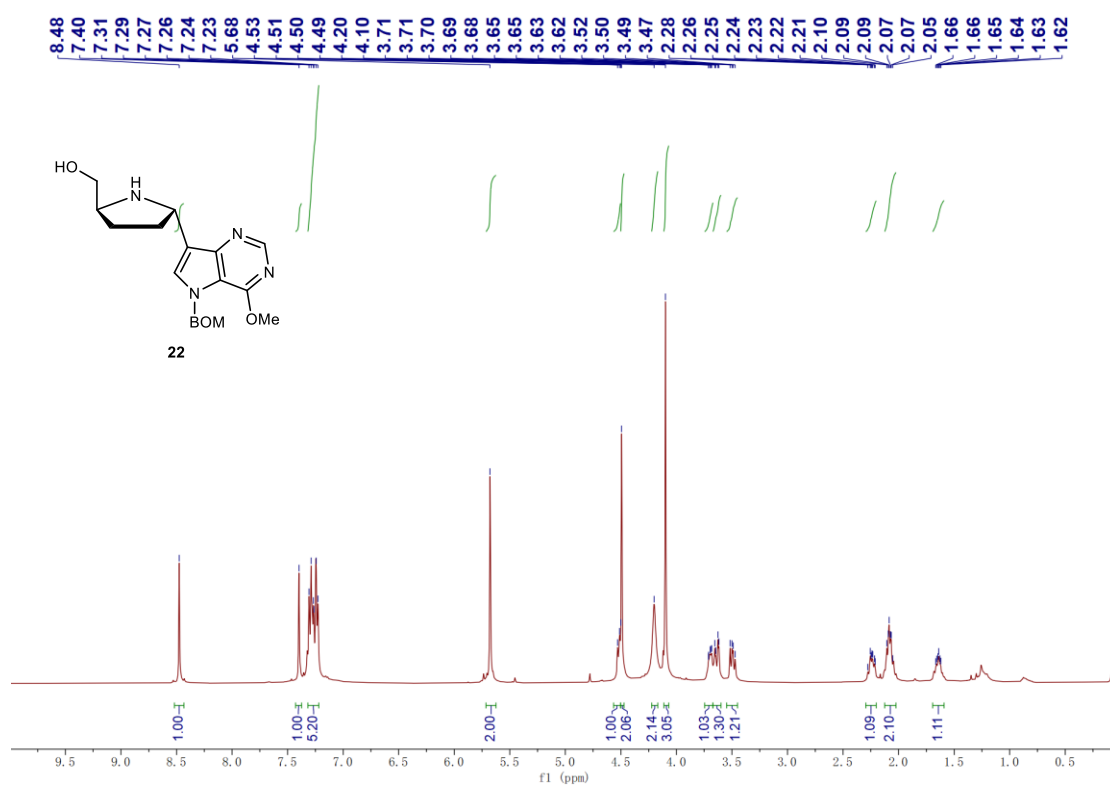
Supplementary Figure 212. ¹³C NMR (100 MHz, CDCl₃) of compound S11.



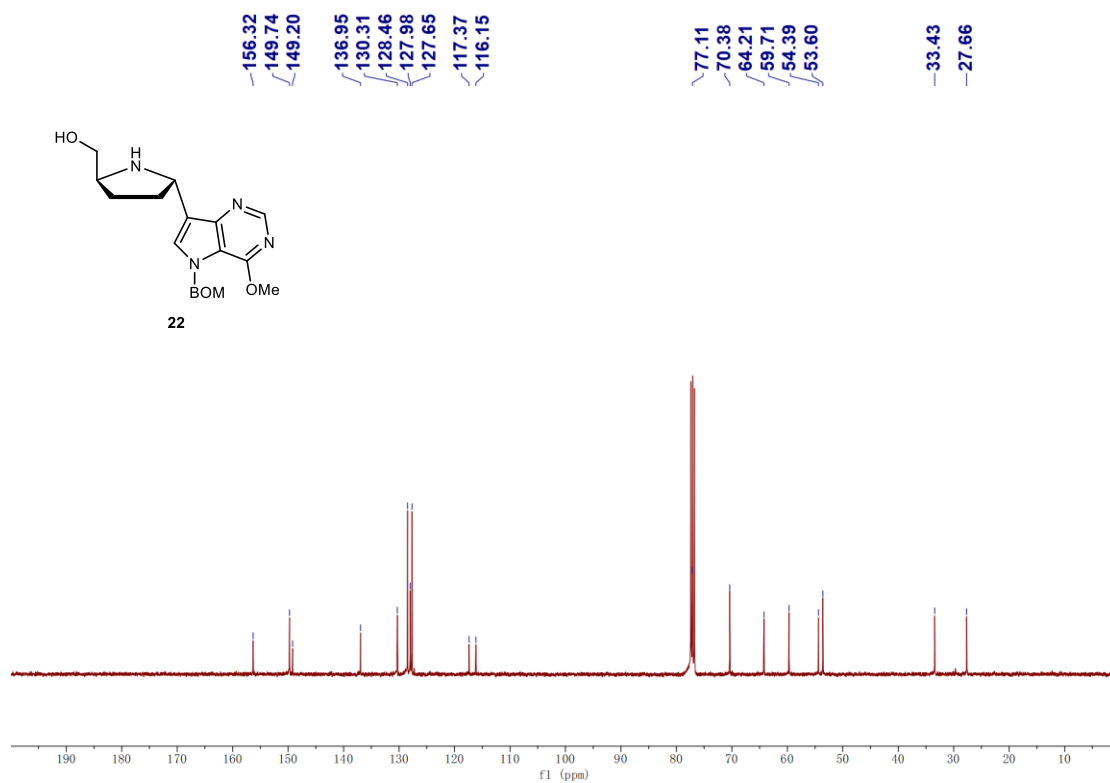
Supplementary Figure 213. ^1H NMR (400 MHz, CDCl_3) of compound 21.



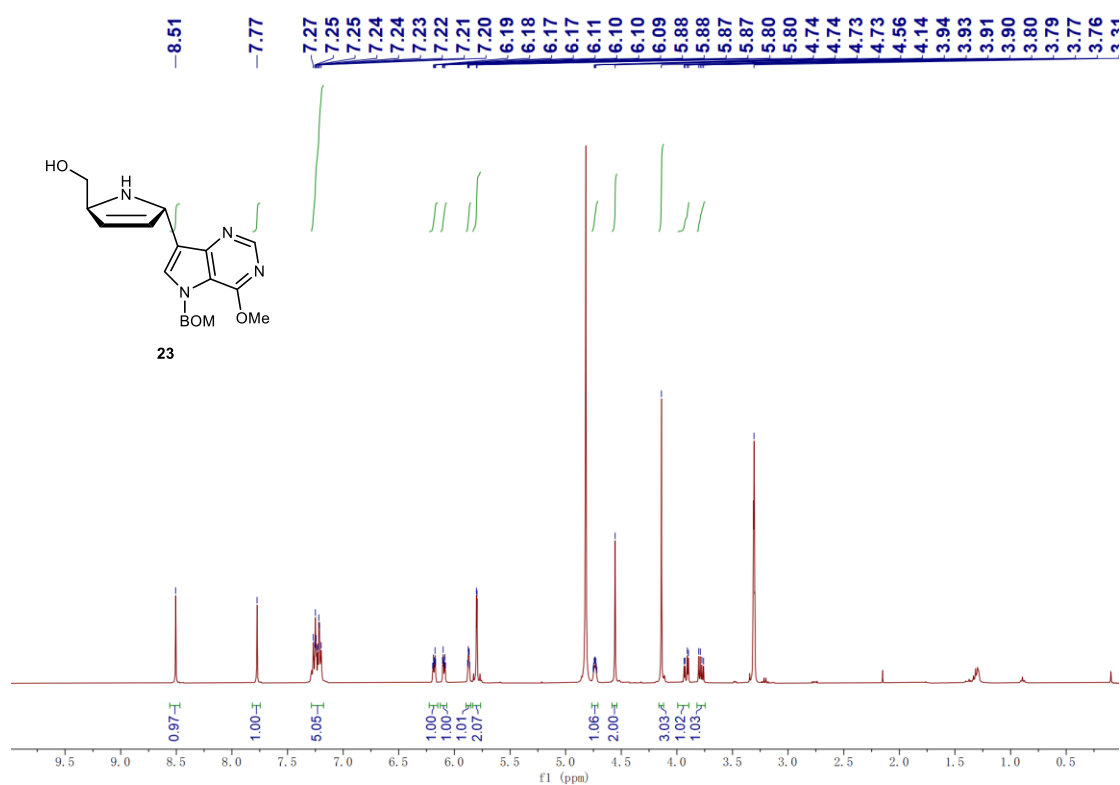
Supplementary Figure 214. ^{13}C NMR (100 MHz, CDCl_3) of compound 21.



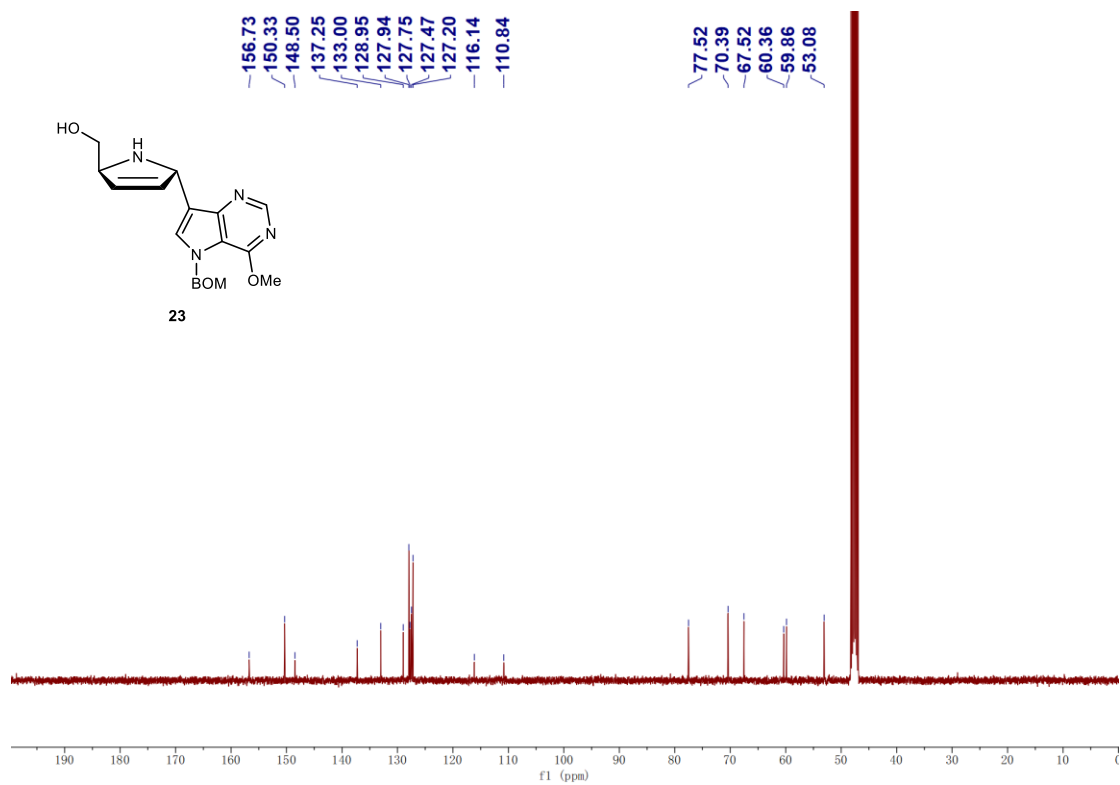
Supplementary Figure 215. ¹H NMR (400 MHz, CDCl₃) of compound **22**.



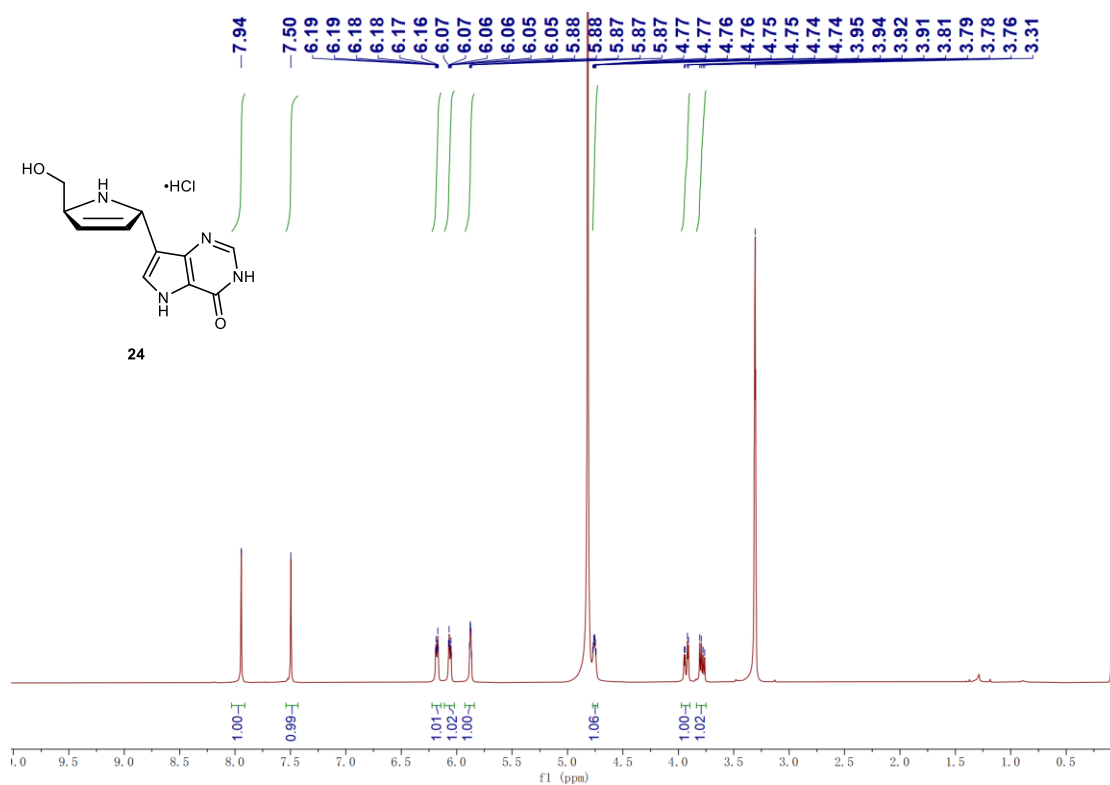
Supplementary Figure 216. ¹³C NMR (100 MHz, CDCl₃) of compound **22**.



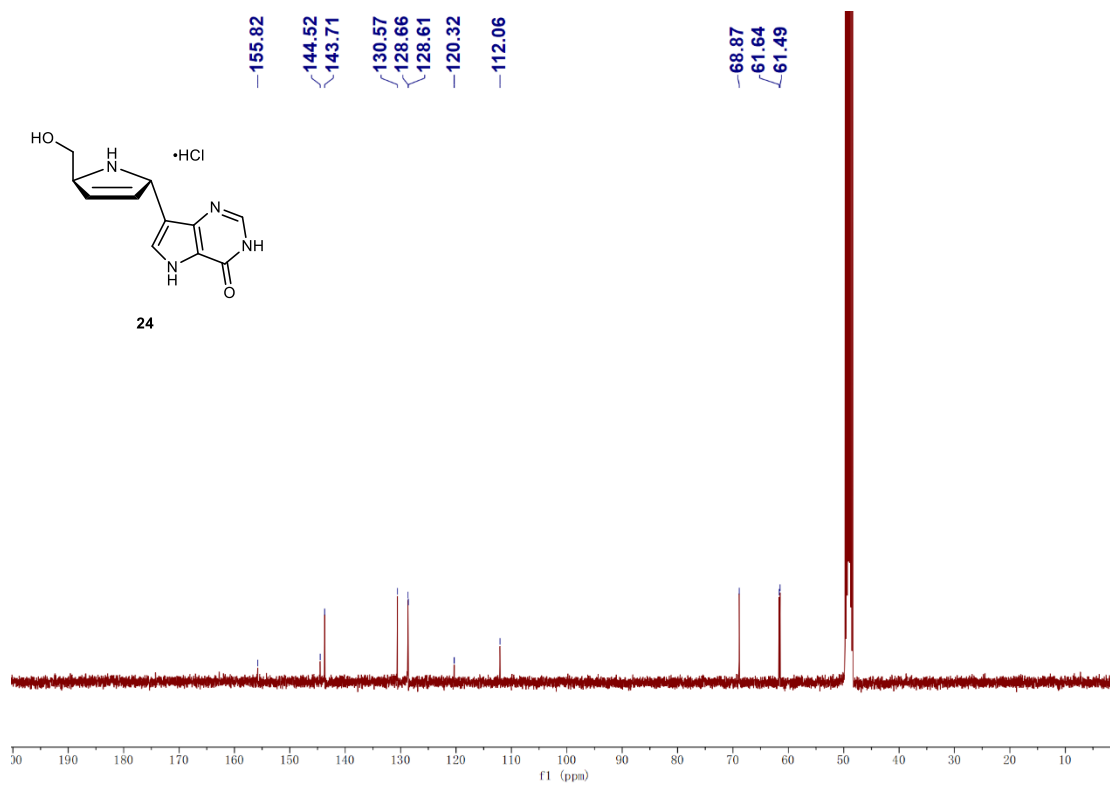
Supplementary Figure 217. ¹H NMR (400 MHz, MeOD) of compound 23.



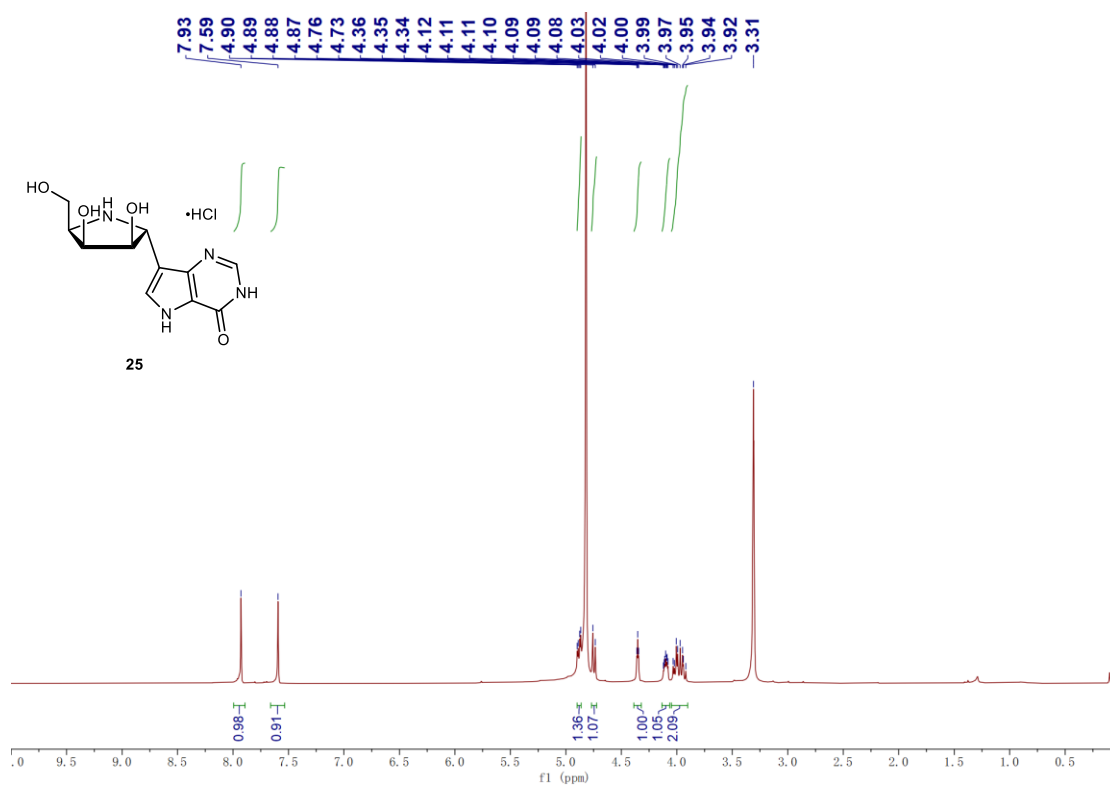
Supplementary Figure 218. ¹³C NMR (100 MHz, MeOD) of compound 23.



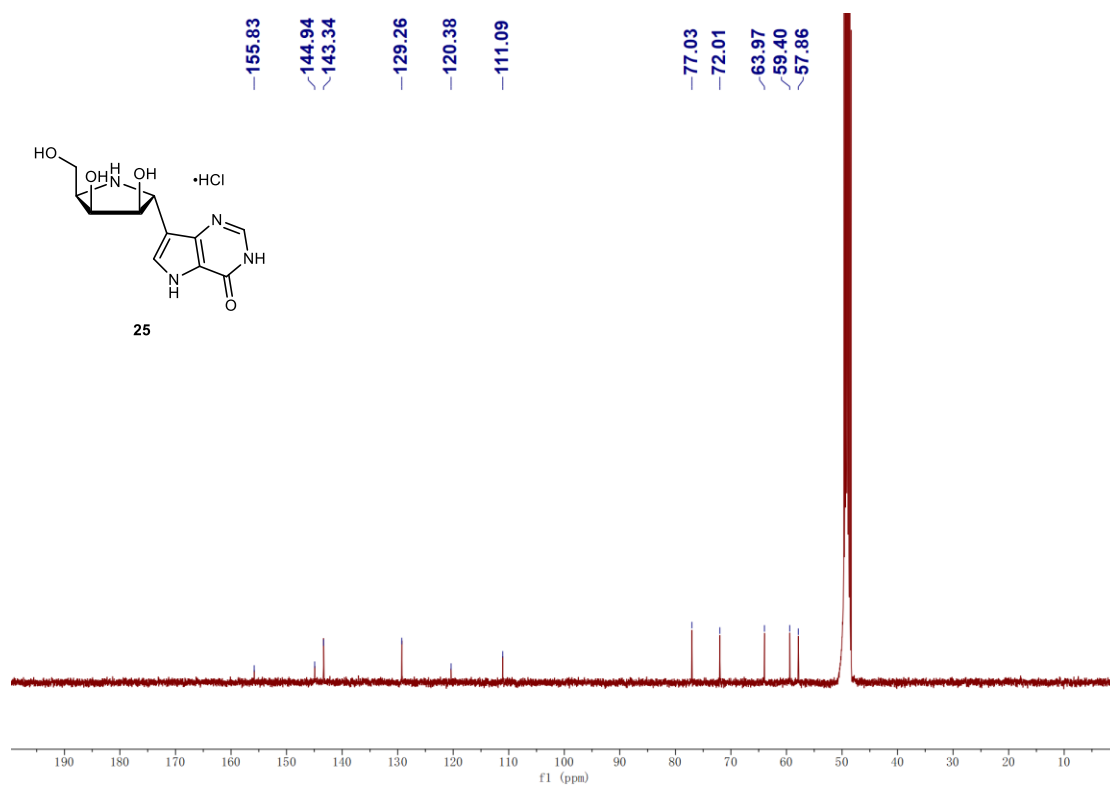
Supplementary Figure 219. ¹H NMR (400 MHz, MeOD) of compound 24.



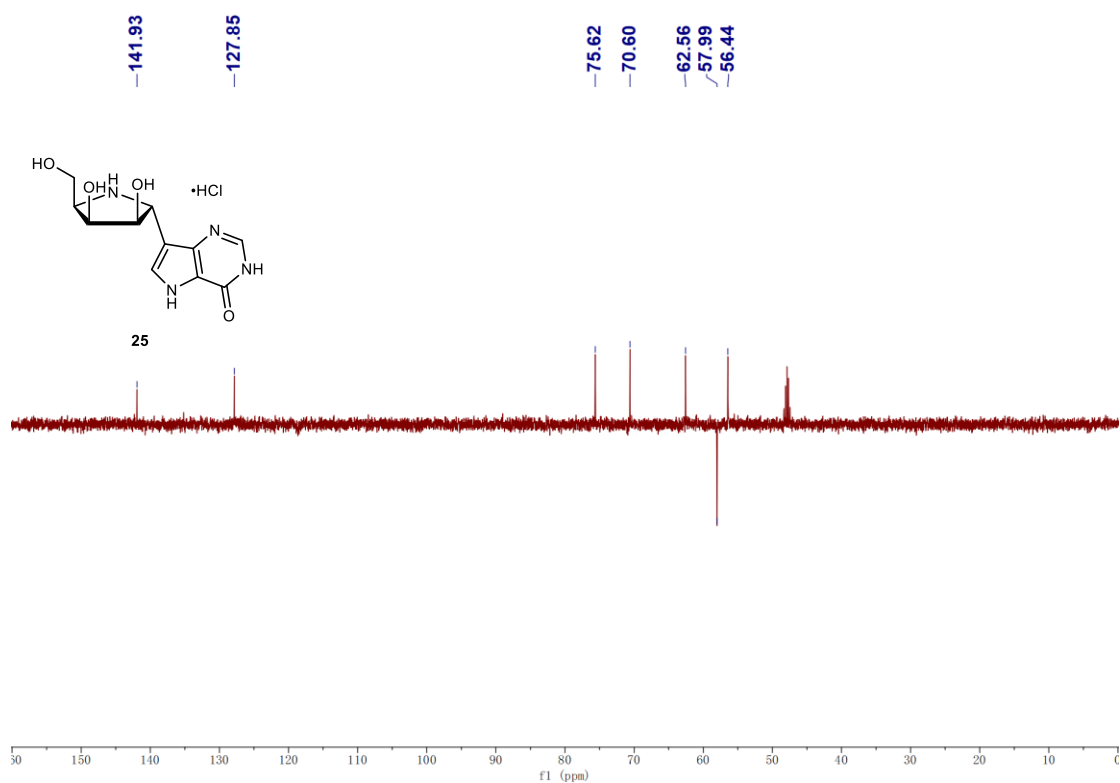
Supplementary Figure 220. ¹³C NMR (100 MHz, MeOD) of compound 24.



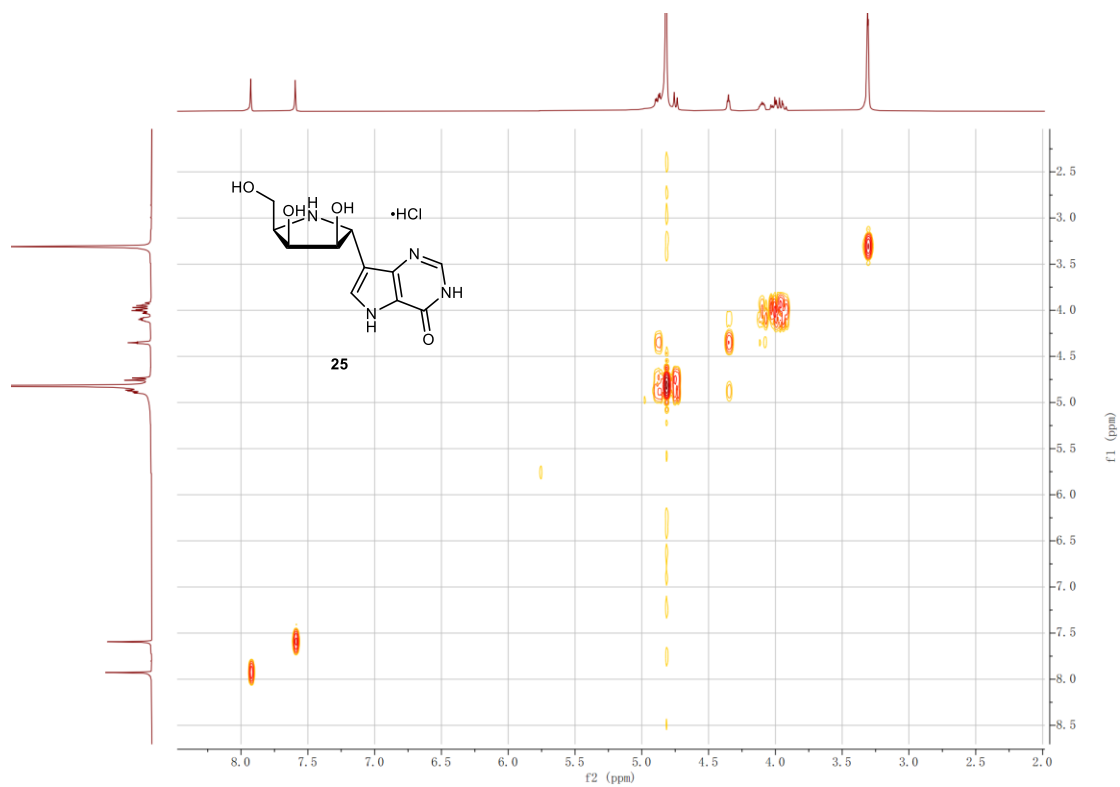
Supplementary Figure 221. ¹H NMR (400 MHz, MeOD) of compound 25.



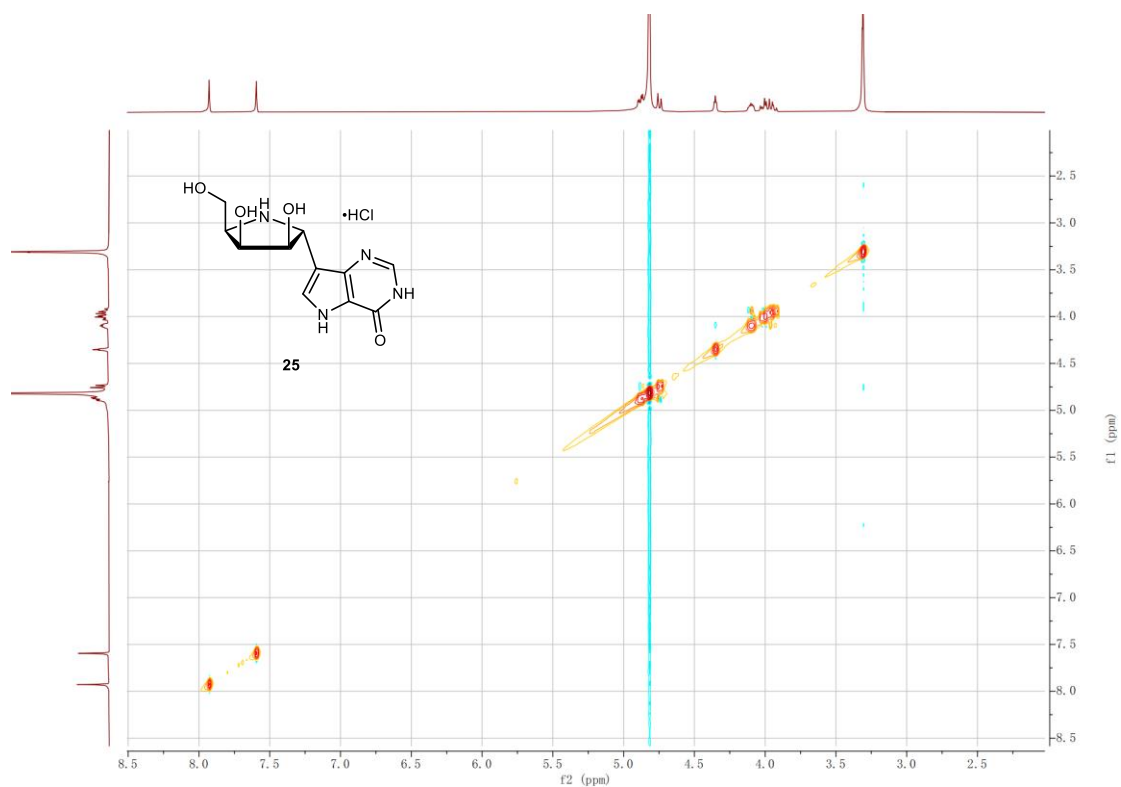
Supplementary Figure 222. ¹³C NMR (100 MHz, MeOD) of compound 25.



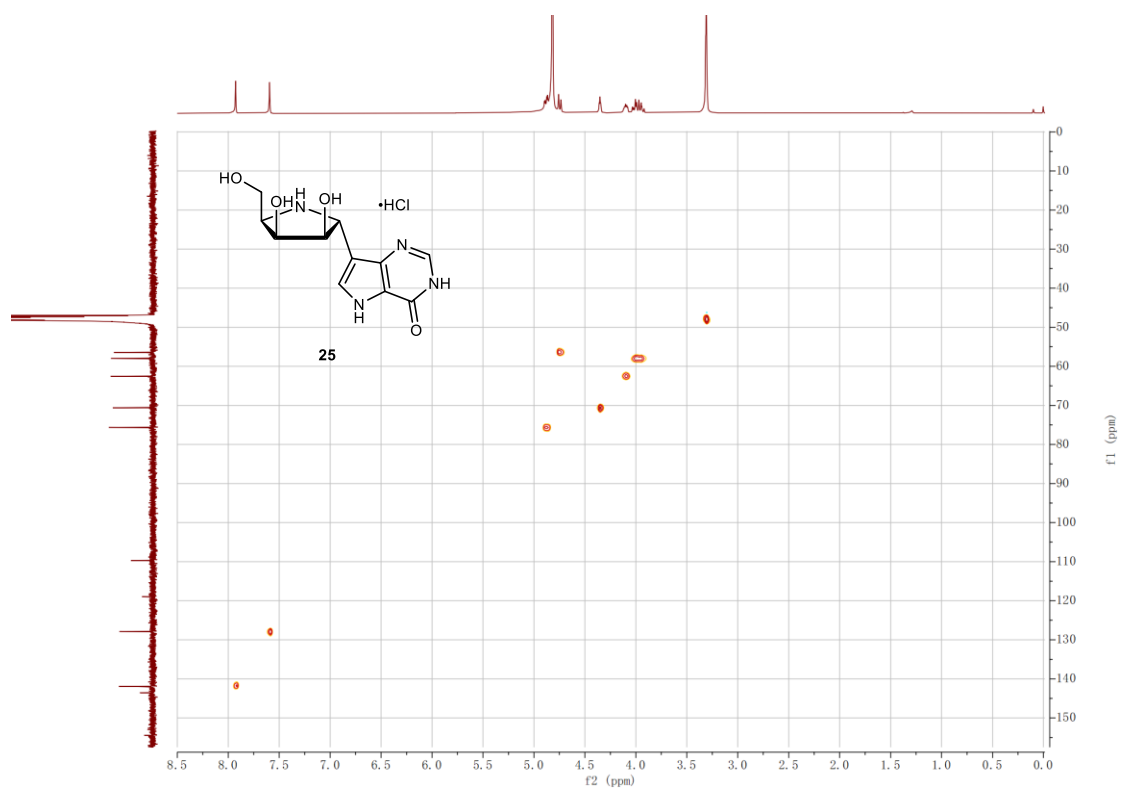
Supplementary Figure 223. DEPT 135° (100 MHz, MeOD) of compound **25**.



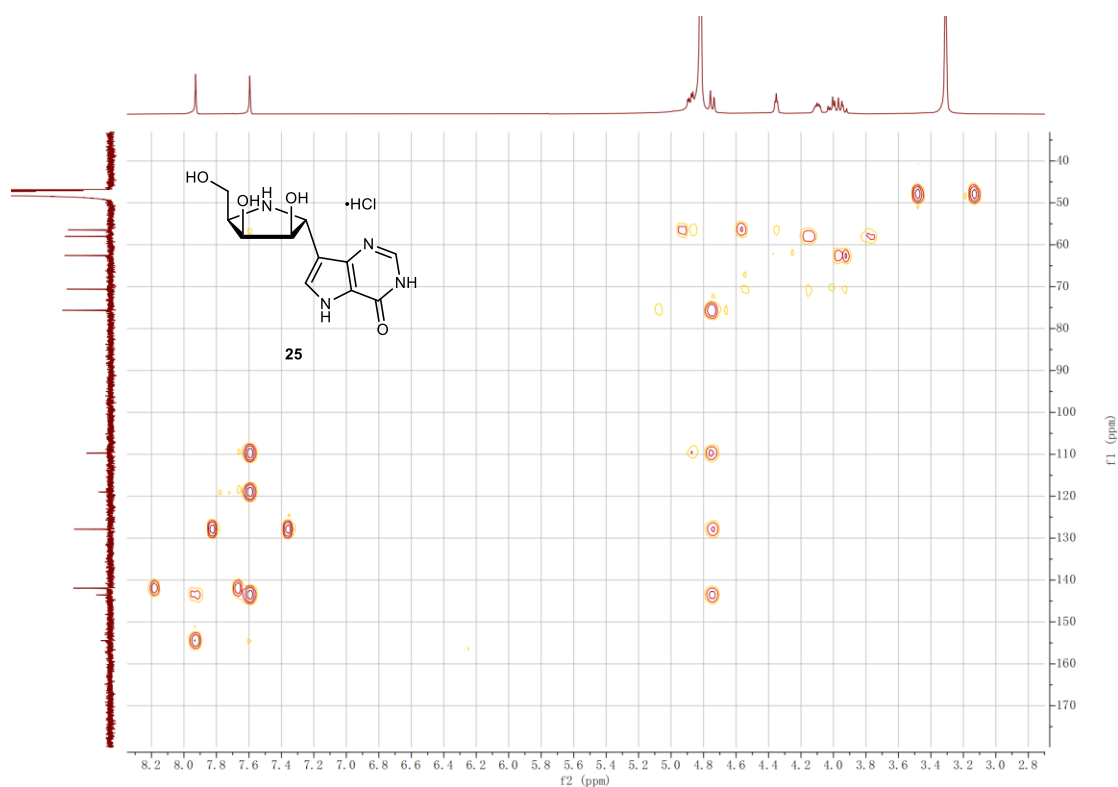
Supplementary Figure 224. ¹H-¹H COSY (100 MHz, MeOD) of compound **25**.



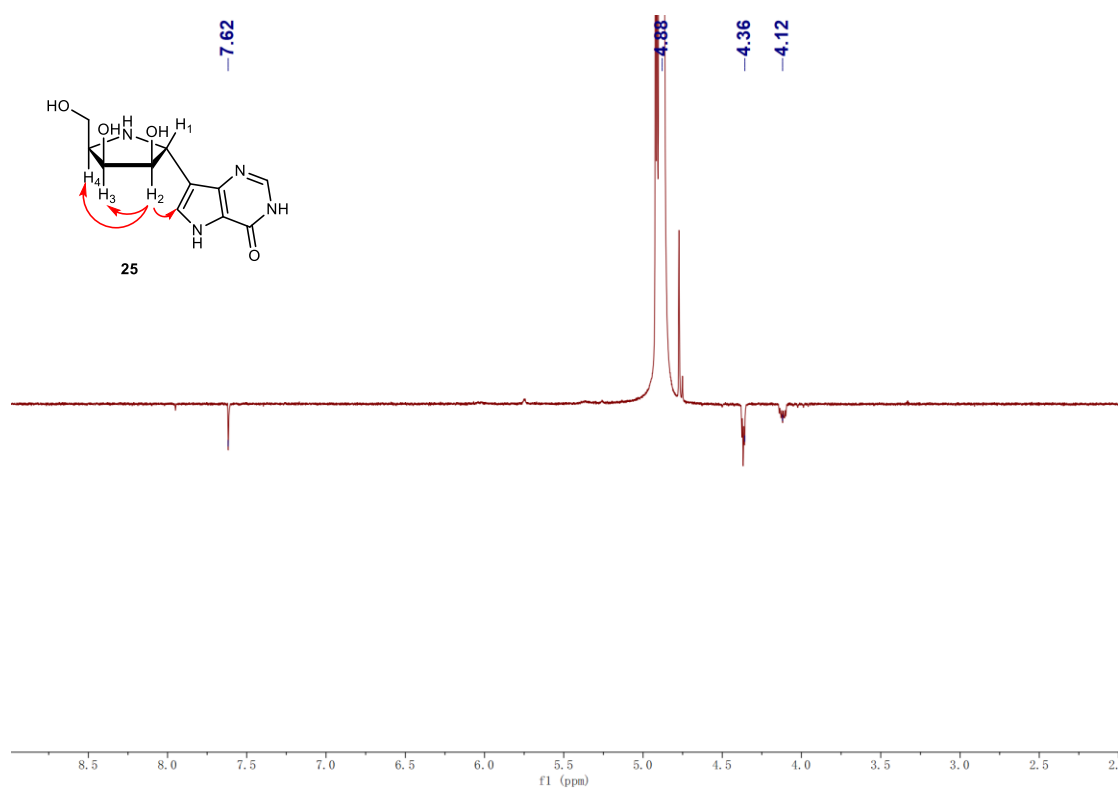
Supplementary Figure 225. NOESY (100 MHz, MeOD) of compound **25**.



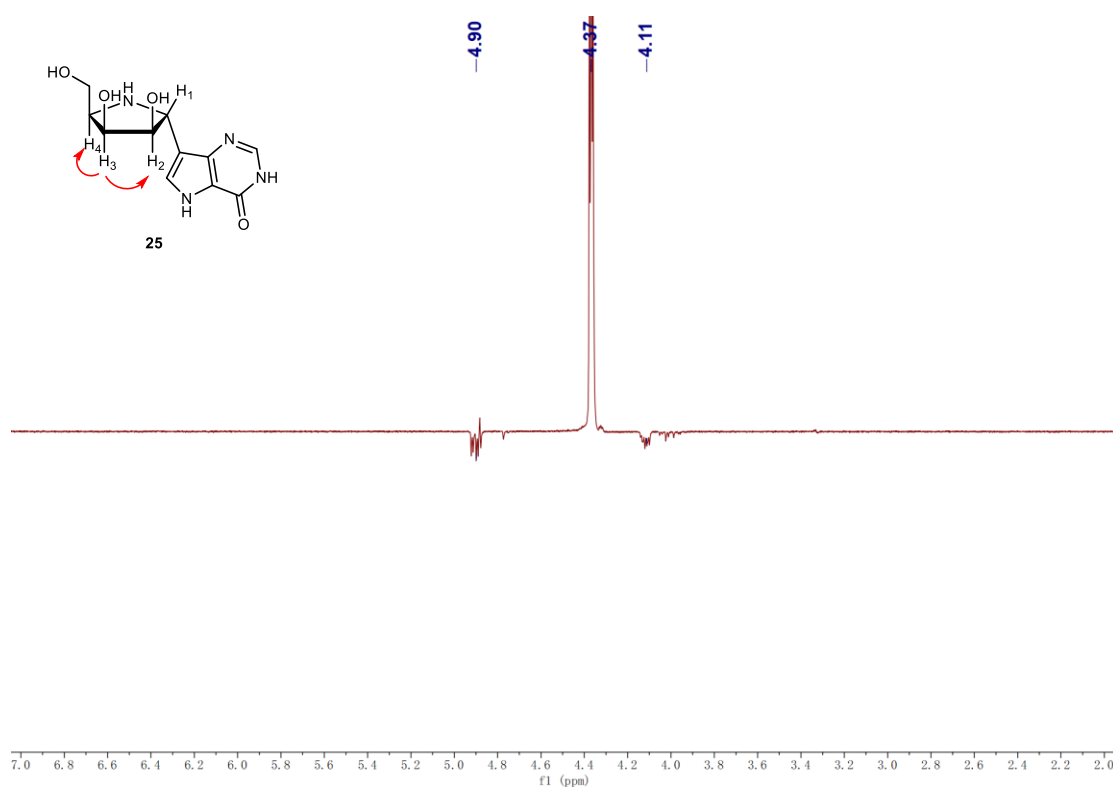
Supplementary Figure 226. ^1H - ^{13}C HSQC (100 MHz, MeOD) of compound **25**.



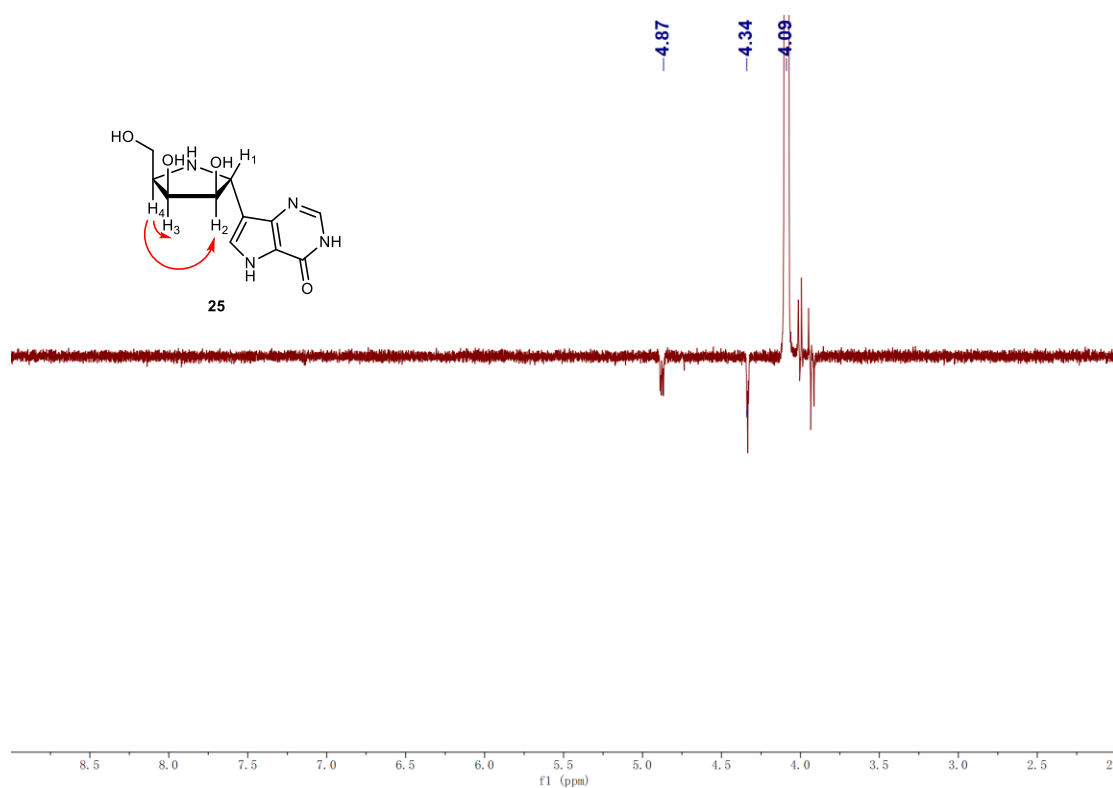
Supplementary Figure 227. ^1H - ^{13}C HMBC (100 MHz, MeOD) of compound **25**



Supplementary Figure 228. H_2 NOEs (600 MHz, MeOD) of compound **25**.



Supplementary Figure 229. H_3 NOEds (600 MHz, MeOD) of compound **25**.



Supplementary Figure 230. H_4 NOEds (600 MHz, MeOD) of compound **25**.

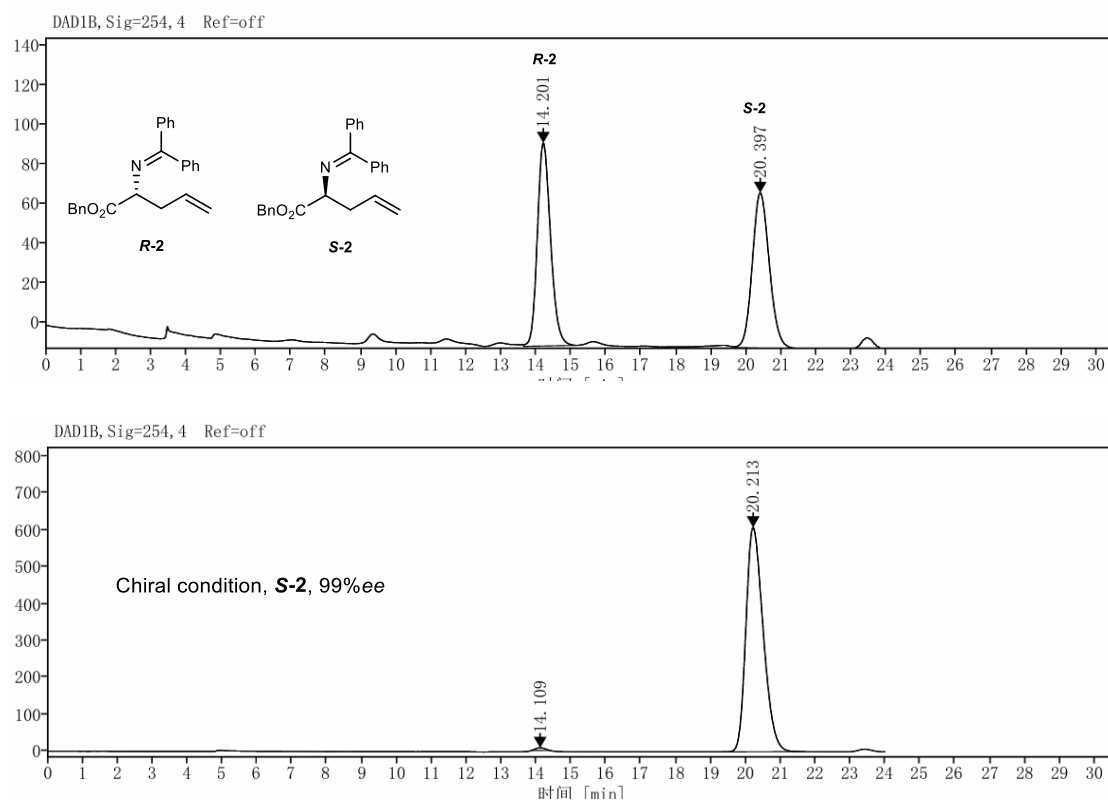
Supplementary Table 5. Comparison of ^1H NMR data of BCX-1777 with literature¹⁷.

H	Lit. data (500 MHz, $(\text{CD}_3)_2\text{SO}$) δ/ppm	Our data (400 MHz, $(\text{CD}_3)_2\text{SO}$) δ/ppm	Error $\Delta \delta/\text{ppm}$
NH-5	12.41 (s, 1H)	12.40 (d, $J = 3.2$ Hz, 1H)	-0.01
NH-3	12.16 (s, 1H)	12.19 (s, 1H)	0.03
NH-1'	10.30 (s, 1H)	10.33 (s, 1H)	0.03
NH-1'	8.35 (s, 1H)	8.37 (s, 1H)	0.02
H-2	7.93 (s, 1H)	7.94 (s, 1H)	0.01
H-6	7.63 (d, $J = 3.10$ Hz, 1H)	7.63 (d, $J = 3.00$ Hz, 1H)	0
OH	5.43 (brs, 3H)	3.90 (brs, 3H)	-
H-2'	4.64 (d, $J = 6.90$ Hz, 1H)	4.64 (q, $J = 6.8$ Hz, 1H)	0
H-3'	4.47 - 4.44 (m, 1H)	4.48 – 4.40 (m, 1H)	-
H-4'	4.18 (t, $J = 4.42$ Hz, 1H)	4.17 (t, $J = 4.6$ Hz, 1H)	-0.01
H-6'	3.73 (d, $J = 4.90$ Hz, 2H)	3.73 (d, $J = 4.8$ Hz, 2H)	0
H-5'	3.48 (q, $J = 4.92$ Hz, 1H)	3.48 (q, $J = 5.2$ Hz, 1H)	0

Supplementary Table 6. Comparison of ^{13}C NMR data of BCX-1777 with literature¹⁷.

C	Lit. data (125 MHz, $(\text{CD}_3)_2\text{SO}$) δ/ppm	Our data (100 MHz, $(\text{CD}_3)_2\text{SO}$) δ/ppm	Error $\Delta \delta/\text{ppm}$
C-2	153.5	153.5	0
C-4	142.8	142.7	-0.1
C-1	142.2	142.4,	0.2
C-8	127.3	127.5	0.2
C-6	118.1	118.2	0.1
C-7	109.2	109.2	0
C-2'	73.9	74.0	0.1
C-3'	70.4	70.5	0.1
C-4'	65.0	65.2	0.2
C-5'	58.5	58.6	0.1
C-1'	56.5	56.7	0.2

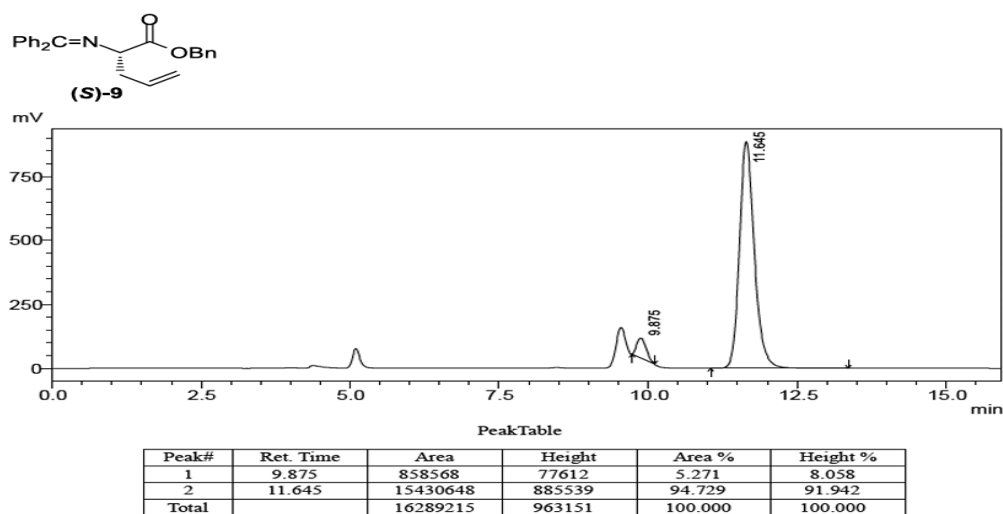
7. Supplementary HPLC Data



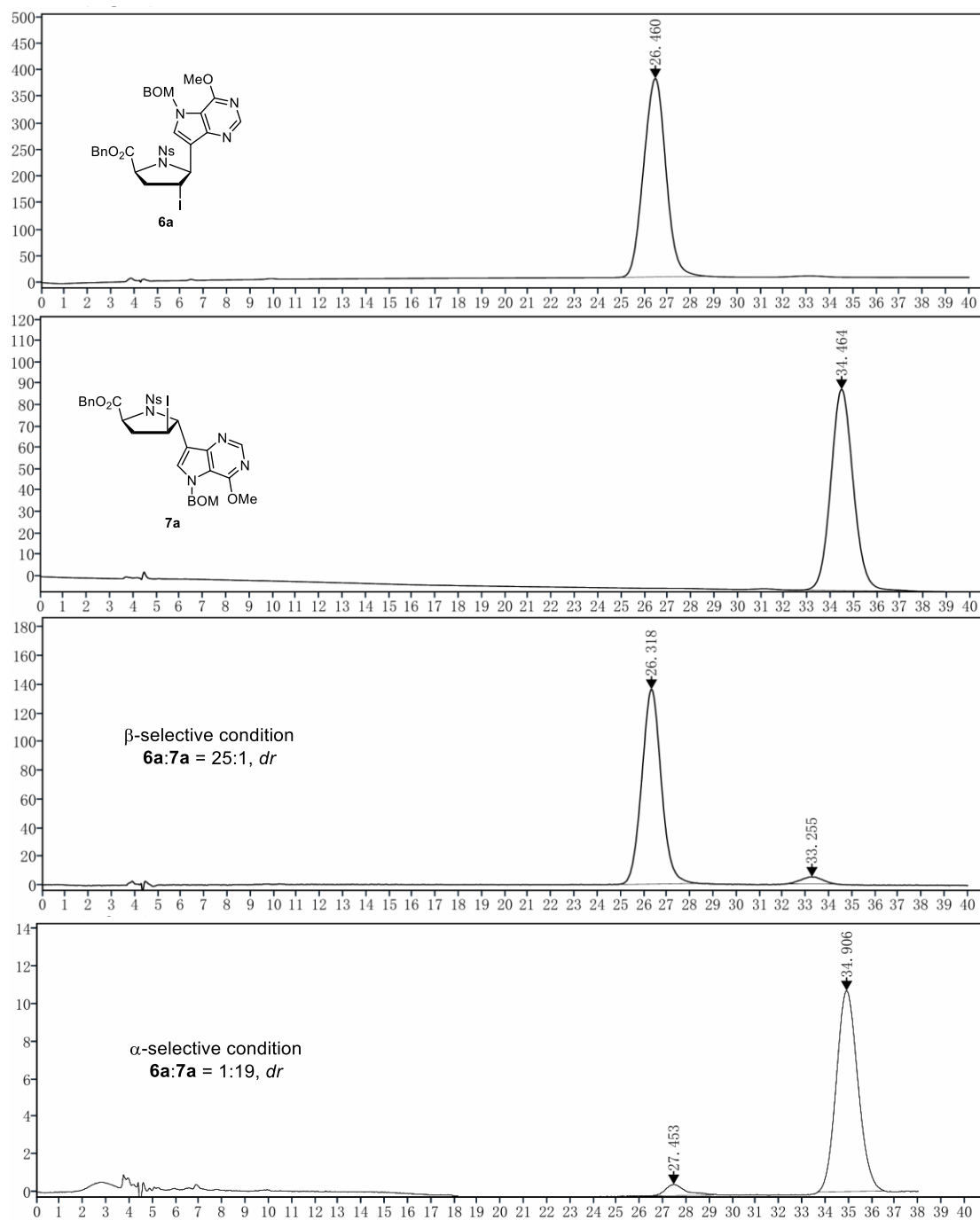
Supplementary Figure 231. HPLC Spectrum of **2**

Condition	Compound	Ret Time	Type	Width	Area	Height	Area%
Racemate	R-2	14.201	VM	0.41	2694.86	102.70	50.31
	S-2	20.397	VV	1.83	2661.33	78.60	49.69
Chirality	R-2	14.109	MM m	0.29	138.25	7.26	0.66
	S-2	20.213	MM m	0.54	20941.55	609.50	99.34

Chiral HPLC conditions: CHIRALCEL OD-H (4.6 x 250 mm), 100:1 *n*-hexane /*i*-PrOH, 0.50 mL/min, UV detector at 254 nm, injection volume: 10 μ L, T (column) = 20 $^{\circ}$ C.



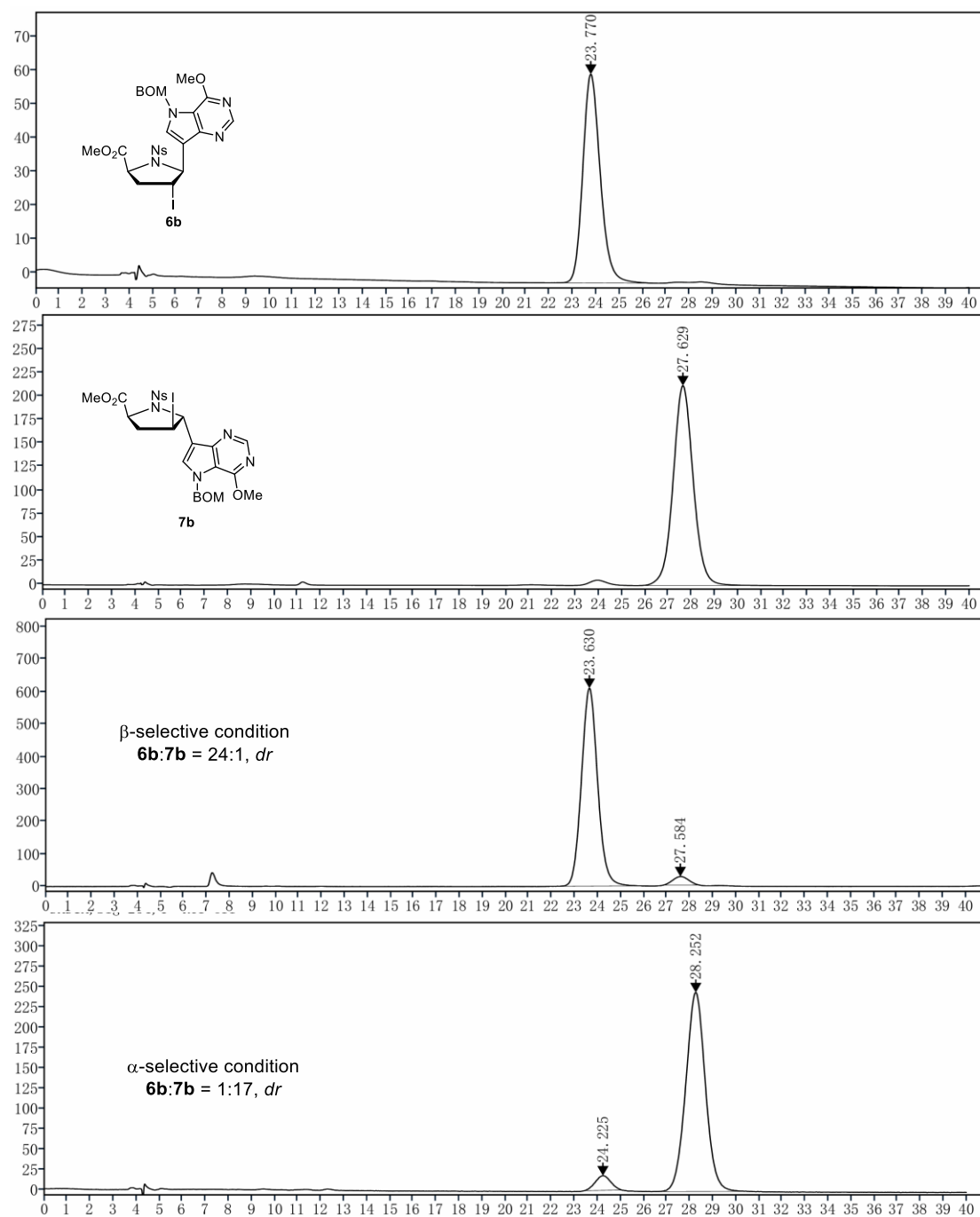
Supplementary Figure 232. Lit⁵. Data. HPLC Spectrum of **2**



Supplementary Figure 233. HPLC Spectrum of **6a (β -selective) and **7a** (α -selective)**

Condition	Compound	Ret Time	Type	Width	Area	Heigh	Area%
β -selective	6a	26.318	BM m	0.76	7979.89	135.98	96.21
	7a	33.255	MB m	0.75	314.03	4.97	3.79
α -selective	6a	27.453	MM m	0.72	36.66	0.60	5.03
	7a	34.906	MM m	0.80	691.67	10.70	94.97

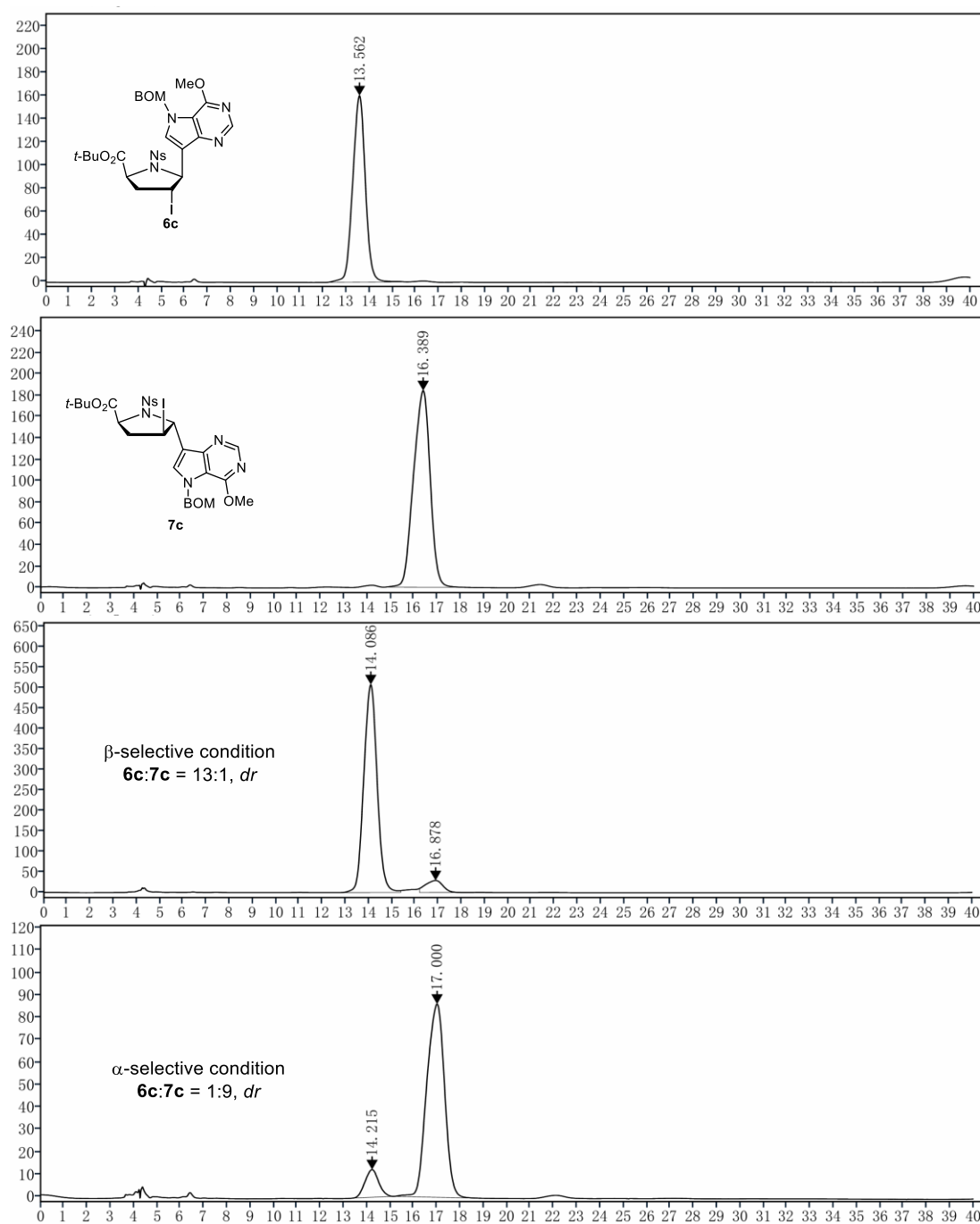
Chiral HPLC conditions: CHIRALCEL IA (4.6 x 250 mm), 80:20 *n*-hexane / *i*-PrOH, 0.80 mL/min, UV detector at 254 nm, injection volume: 5 μ L, T (column) = 20 $^{\circ}$ C.



Supplementary Figure 234. HPLC Spectrum of **6b** (β-selective) and **7b** (α-selective)

Condition	Compound	Ret Time	Type	Width	Area	Heigh	Area%
β-selective	6b	23.630	MM m	3.15	29800.15	610.11	95.98
	7b	27.584	MM m	0.57	1249.49	26.31	4.02
α-selective	6b	24.225	MM m	0.57	844.06	18.12	5.50
	7b	28.252	MM m	0.86	14504.77	245.41	94.50

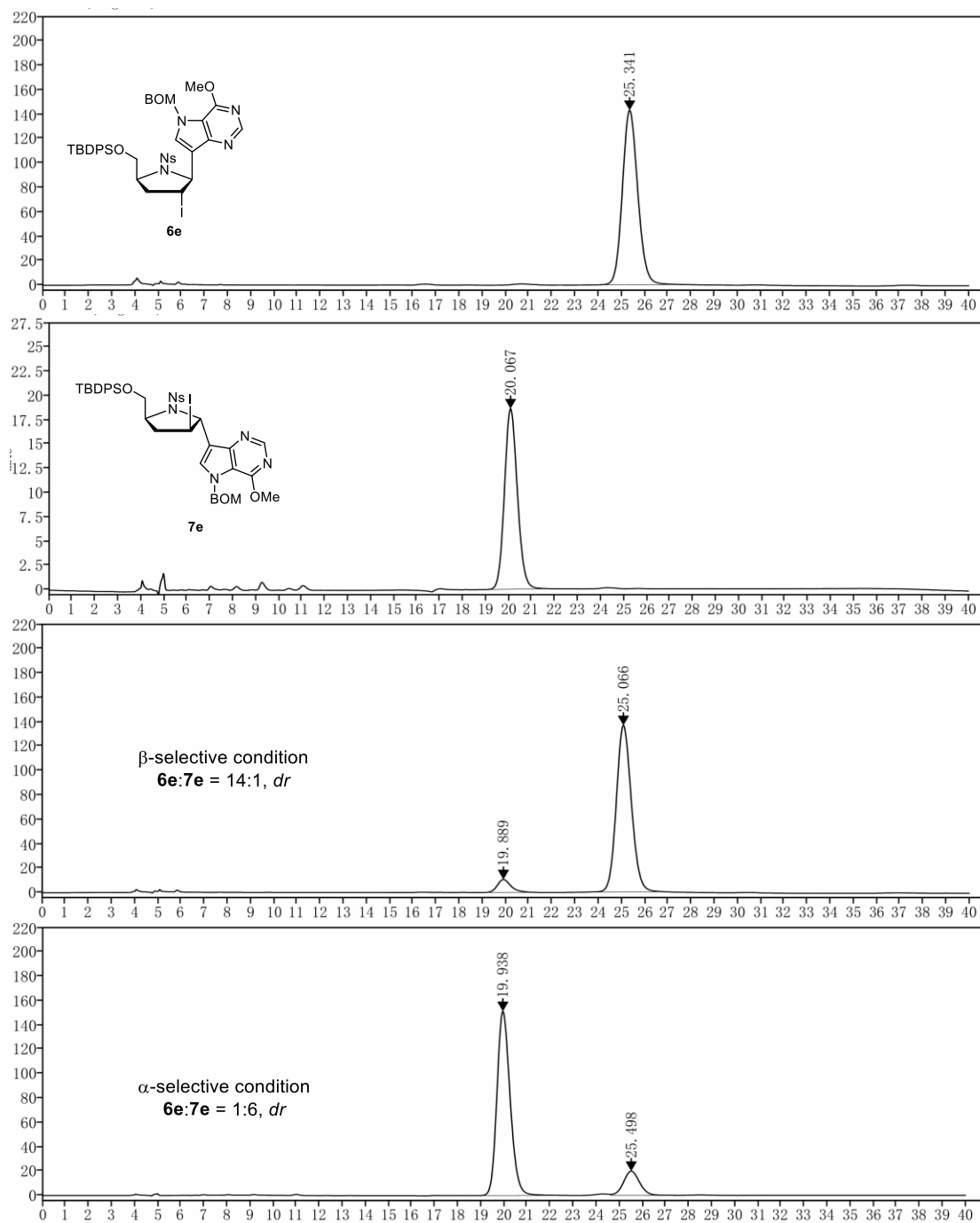
Chiral HPLC conditions: CHIRALCEL IA (4.6 x 250 mm), 85:15 *n*-hexane /*i*-PrOH, 0.80 mL/min, UV detector at 254 nm, injection volume: 5 μL, T (column) = 20 °C.



Supplementary Figure 235. HPLC Spectrum of 6c (β-selective) and 7c (α-selective)

Condition	Compound	Ret Time	Type	Width	Area	Heigh	Area%
β-selective	6c	14.086	BM m	0.64	20331.16	508.79	92.93
	7c	16.878	MB m	0.86	1546.89	29.48	7.07
α-selective	6c	14.215	MB m	0.63	505.24	12.36	9.96
	7c	17.000	BB	3.79	4566.69	86.22	90.04

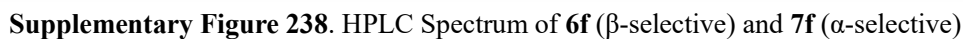
Chiral HPLC conditions: CHIRALCEL IA (4.6 x 250 mm), 85:15 *n*-hexane / *i*-PrOH, 0.80 mL/min, UV detector at 254 nm, injection volume: 5 μL, T (column) = 20 °C.



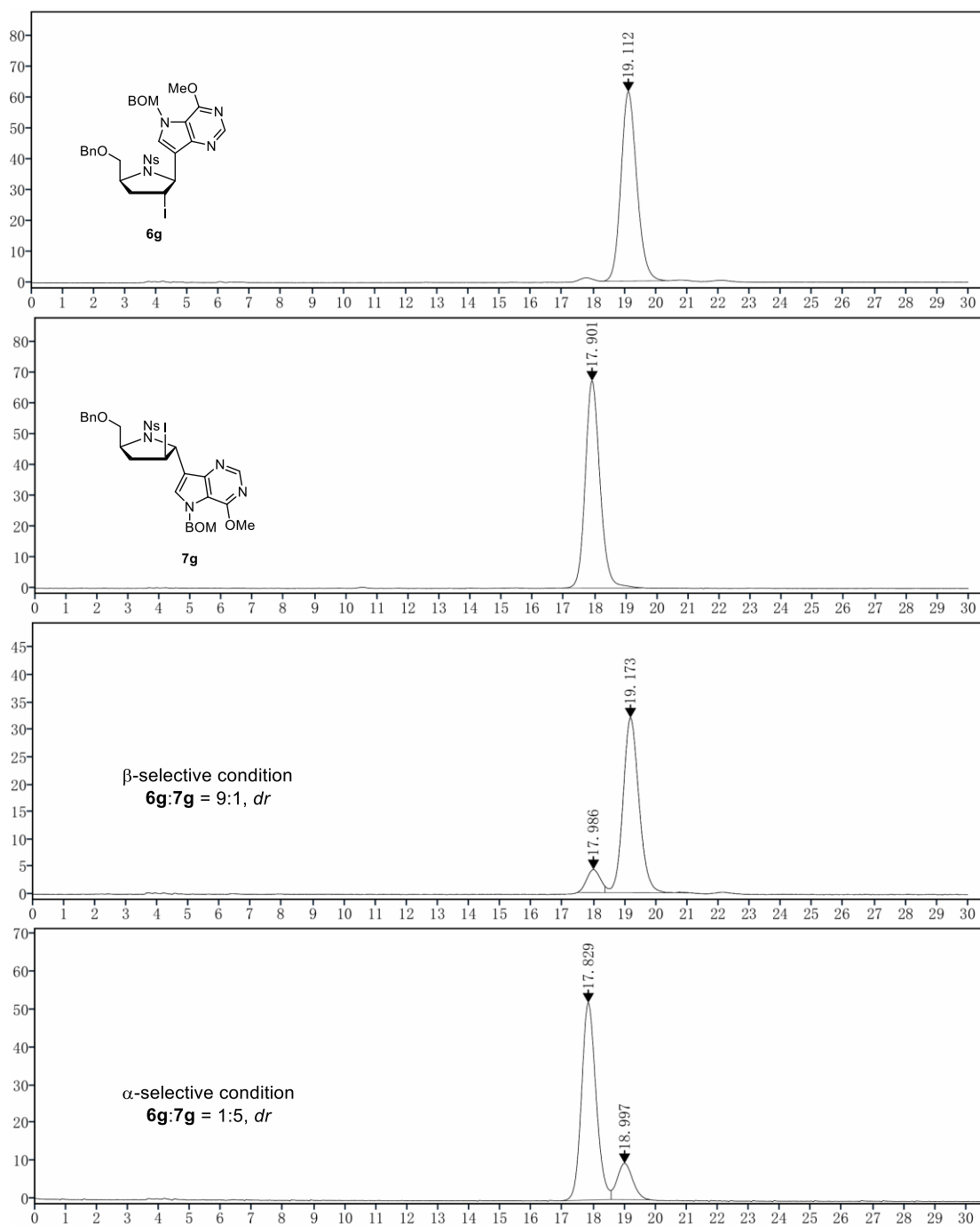
Supplementary Figure 237. HPLC Spectrum of **6e** (β -selective) and **7e** (α -selective)

Condition	Compound	Ret Time	Type	Width	Area	Heigh	Area%
β -selective	7e	19.889	BM m	0.60	438.15	10.63	6.62
	6e	25.066	MM m	0.70	6177.72	136.51	93.38
α -selective	7e	19.938	BB	4.06	6033.70	151.27	86.15
	6e	25.498	VB	3.02	970.23	19.91	13.85

Chiral HPLC conditions: CHIRALCEL IA (4.6 x 250 mm), 95:5 *n*-hexane / *i*-PrOH, 0.80 mL/min, UV detector at 254 nm, injection volume: 5 μ L, T (column) = 20 $^{\circ}$ C.



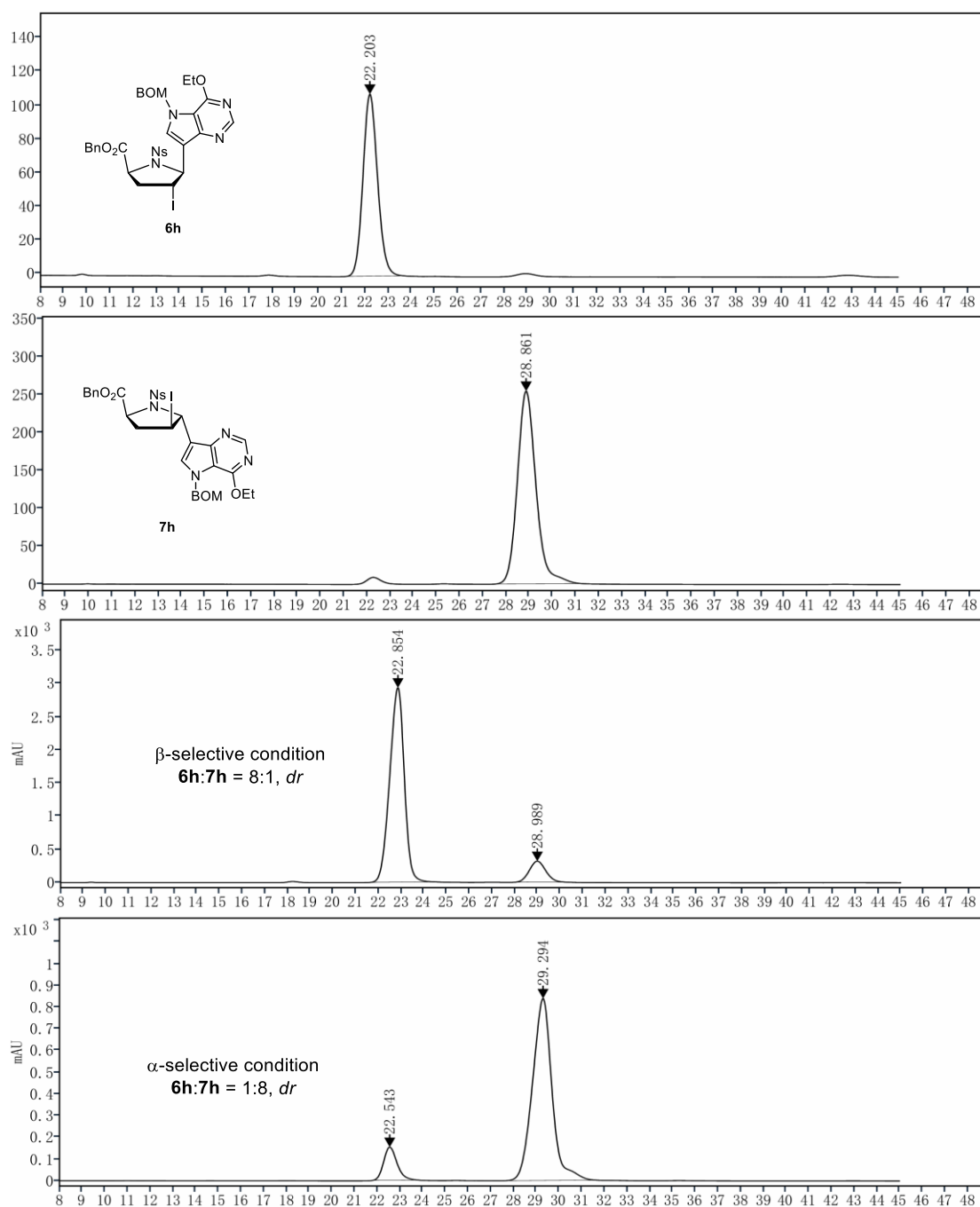
Chiral HPLC conditions: CHIRALCEL IA (4.6 x 250 mm), 80:20 *n*-hexane /*i*-PrOH, 0.80 mL/min, UV detector at 254 nm, injection volume: 5 μ L, T (column) = 20 $^{\circ}$ C.



Supplementary Figure 239. HPLC Spectrum of **6g** (β-selective) and **7g** (α-selective)

Condition	Compound	Ret Time	Type	Width	Area	Heigh	Area%
β-selective	7g	17.986	MM m	0.38	125.93	4.21	9.99
	6g	19.173	MM m	0.54	1134.83	31.88	90.01
α-selective	7g	17.829	BM m	0.50	1700.83	52.19	83.55
	6g	18.997	MM m	0.50	334.80	9.59	16.45

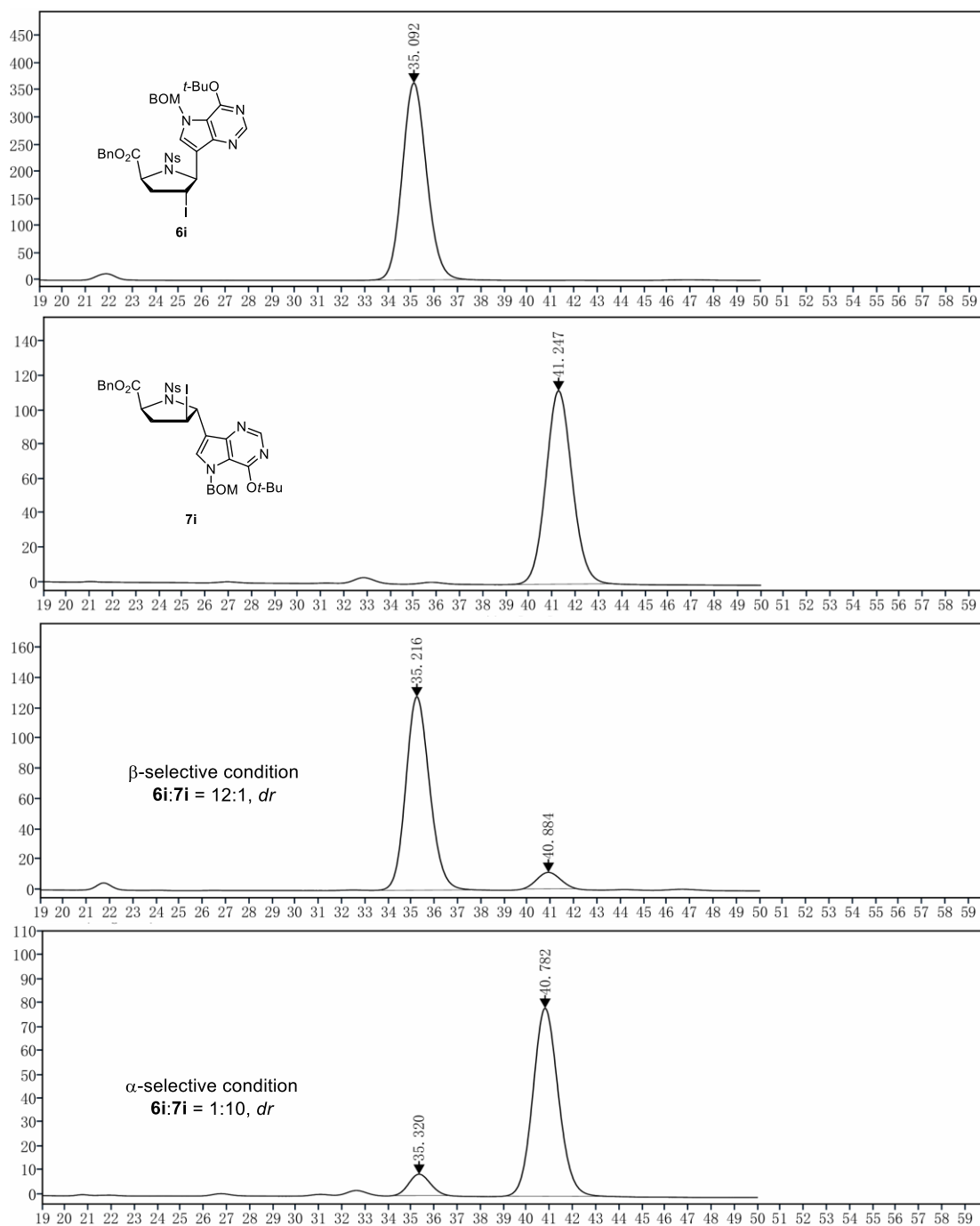
Chiral HPLC conditions: CHIRALCEL IA (4.6 x 250 mm), 80:20 *n*-hexane /*i*-PrOH, 0.80 mL/min, UV detector at 254 nm, injection volume: 5 μL, T (column) = 20 °C.



Supplementary Figure 240. HPLC Spectrum of **6h (β-selective) and **7h** (α-selective)**

Condition	Compound	Ret Time	Type	Width	Area	Heigh	Area%
β-selective	6h	22.854	MM m	0.69	130516.68	2927.99	89.23
	7h	28.989	MM m	0.78	15758.65	315.08	10.77
α-selective	6h	22.543	MM m	0.63	6234.52	152.27	11.06
	7h	29.294	MM m	0.90	50115.70	838.54	88.94

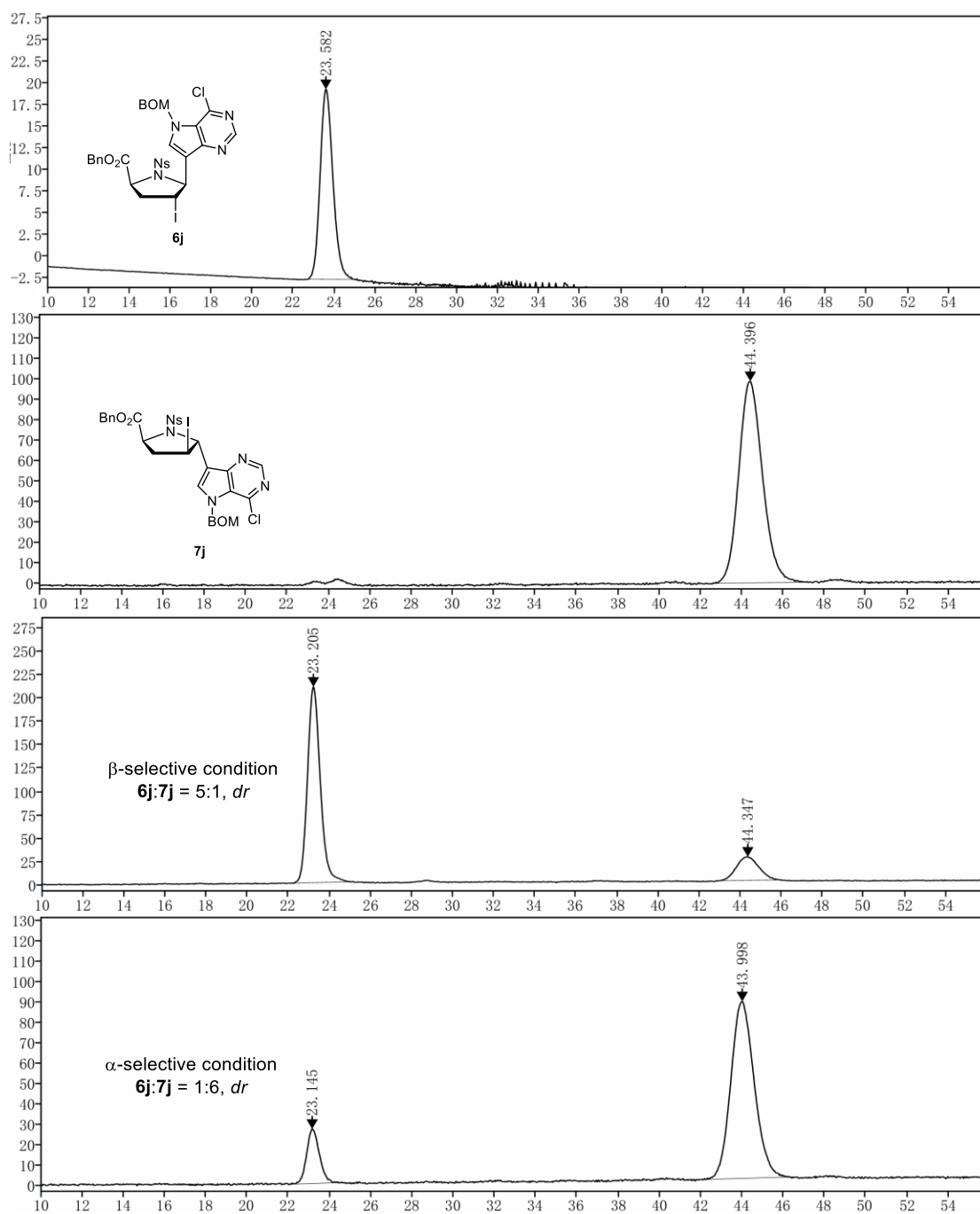
Chiral HPLC conditions: CHIRALCEL IA (4.6 x 250 mm), 85:15 *n*-hexane /*i*-PrOH, 0.80 mL/min, UV detector at 254 nm, injection volume: 5 μL, T (column) = 20 °C.



Supplementary Figure 241. HPLC Spectrum of **6i** (β-selective) and **7i** (α-selective)

Condition	Compound	Ret Time	Type	Width	Area	Heigh	Area%
β-selective	6i	35.216	MM m	1.10	9146.04	127.93	92.33
	7i	40.884	MM m	0.98	759.94	10.89	7.67
α-selective	6i	35.320	MM m	0.93	586.60	8.97	8.83
	7i	40.782	MM m	1.19	6055.54	78.63	91.17

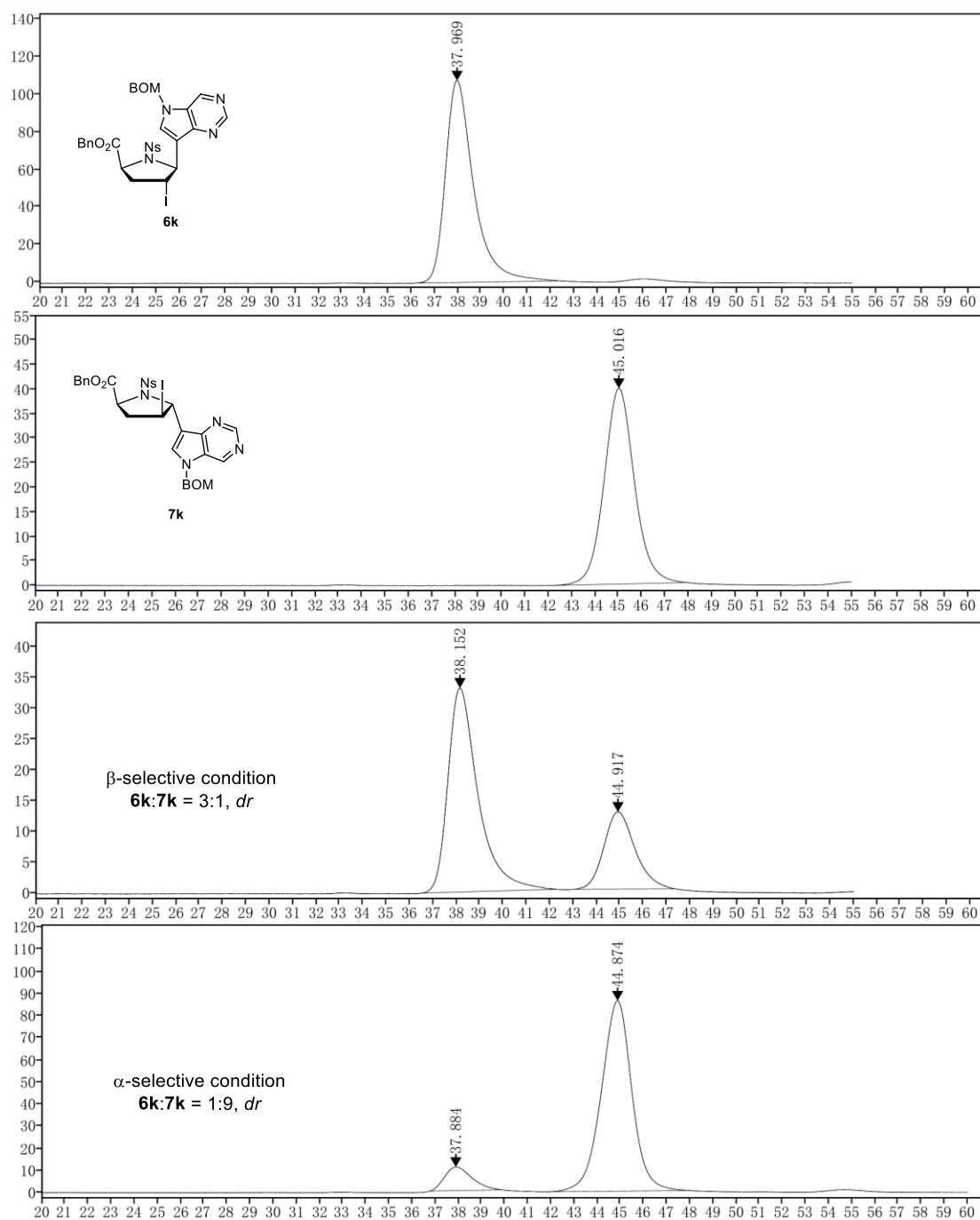
Chiral HPLC conditions: CHIRALCEL IA (4.6 x 250 mm), 90:10 *n*-hexane / *i*-PrOH, 0.80 mL/min, UV detector at 254 nm, injection volume: 5 μL, T (column) = 20 °C.



Supplementary Figure 242. HPLC Spectrum of **6j** (β-selective) and **7j** (α-selective)

Condition	Compound	Ret Time	Type	Width	Area	Heigh	Area%
β-selective	6j	23.205	MM m	0.60	9003.44	208.74	82.56
	7j	44.347	MM m	0.90	1902.00	25.08	17.44
α-selective	6j	23.145	MM m	0.52	1151.01	26.76	14.34
	7j	43.998	MM m	0.93	6873.63	86.88	85.66

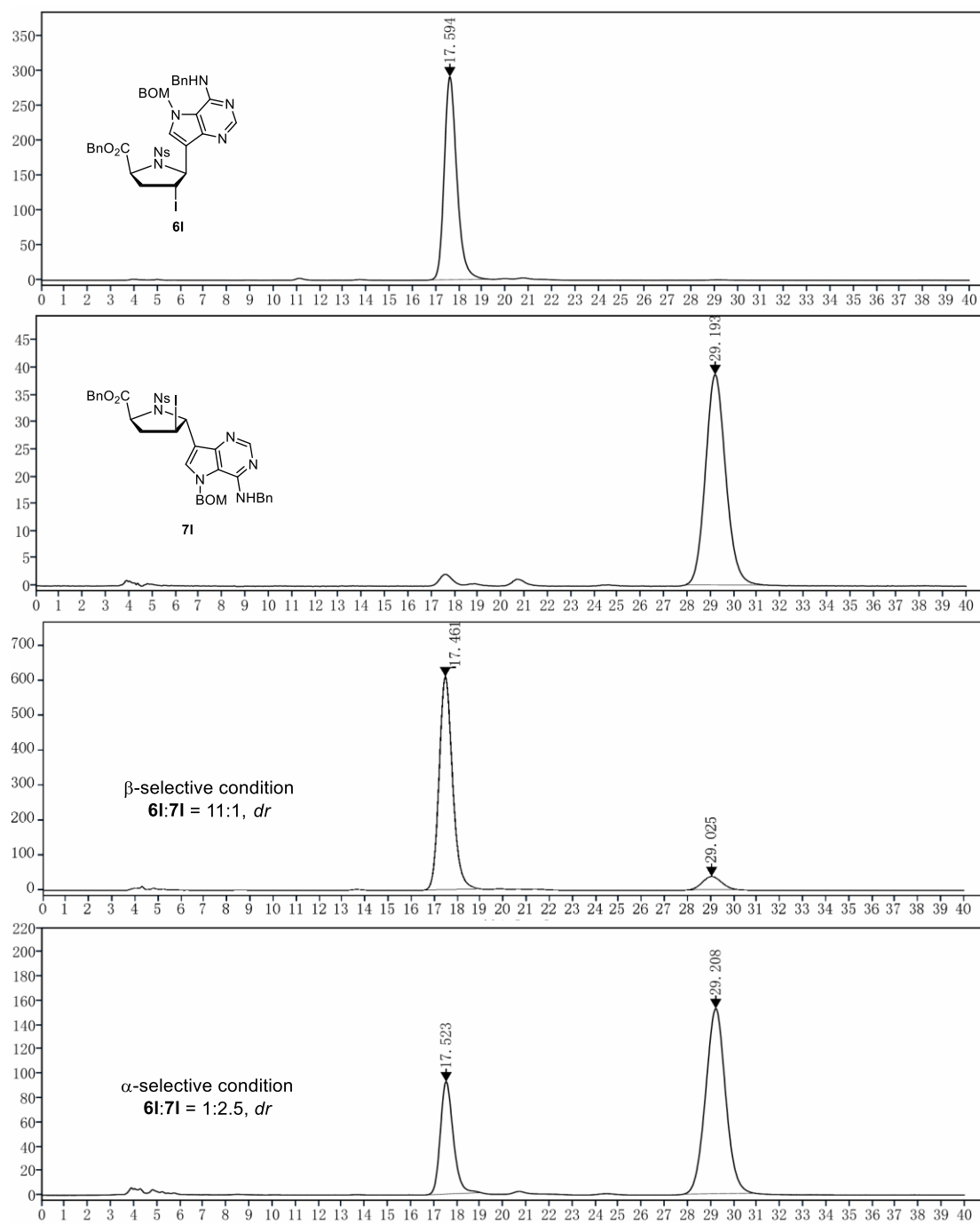
Chiral HPLC conditions: CHIRALCEL IA (4.6 x 250 mm), 80:20 *n*-hexane /*i*-PrOH, 0.80 mL/min, UV detector at 254 nm, injection volume: 5 µL, T (column) = 20 °C.



Supplementary Figure 243. HPLC Spectrum of **6k** (β -selective) and **7k** (α -selective)

Condition	Compound	Ret Time	Type	Width	Area	Heigh	Area%
β -selective	6k	38.152	BM m	1.13	2973.80	33.15	71.89
	7k	44.917	MM m	1.09	1162.57	12.54	28.11
α -selective	6k	37.884	MM m	0.97	879.78	10.71	10.01
	7k	44.874	MM m	1.33	7905.75	86.06	89.99

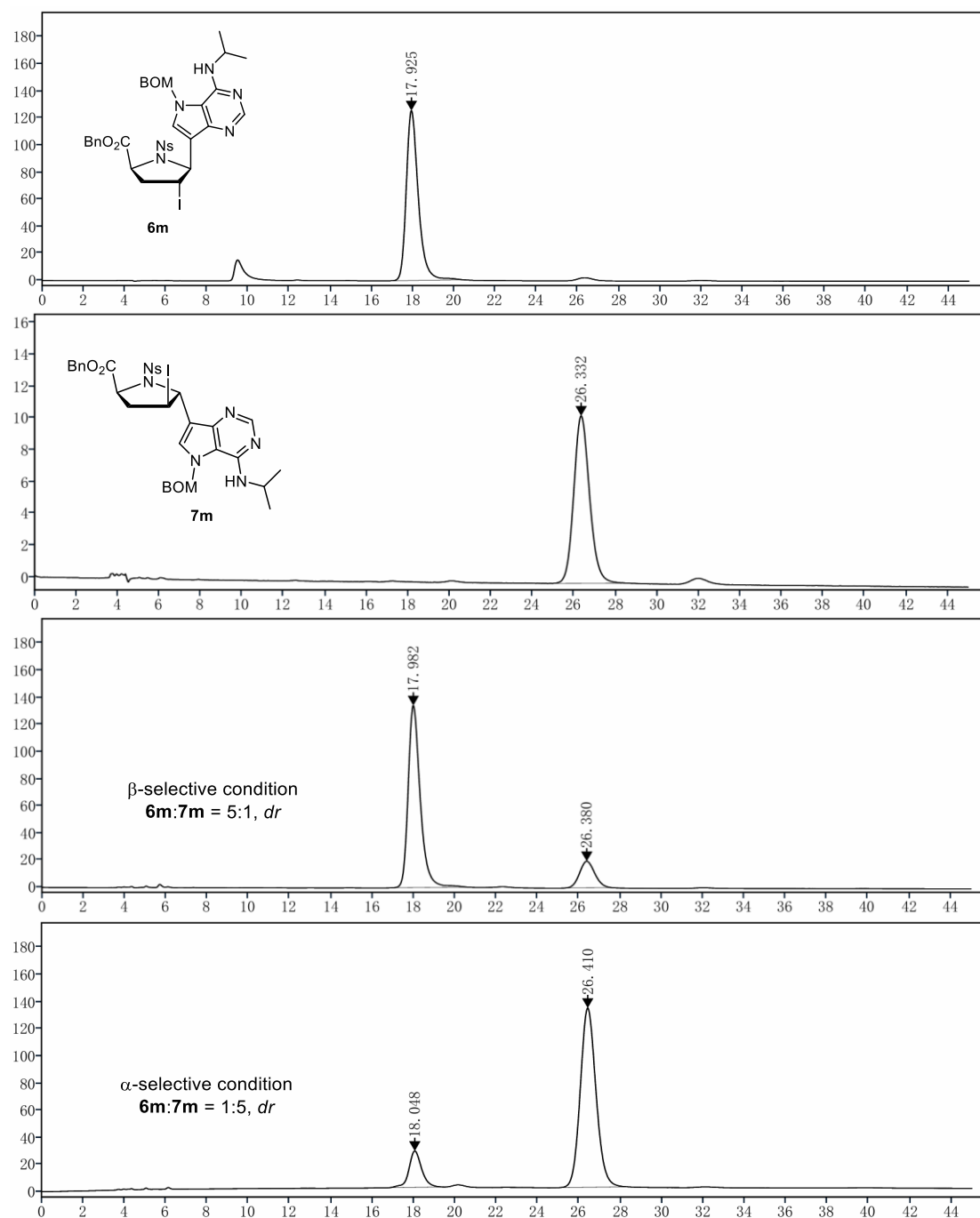
Chiral HPLC conditions: CHIRALCEL IA (4.6 x 250 mm), 80:20 *n*-hexane / *i*-PrOH, 0.80 mL/min, UV detector at 254 nm, injection volume: 5 μ L, T (column) = 20 $^{\circ}$ C.



Supplementary Figure 244. HPLC Spectrum of **6I** (β-selective) and **7I** (α-selective)

Condition	Compound	Ret Time	Type	Width	Area	Heigh	Area%
β-selective	6I	17.461	MM m	0.62	24641.76	610.84	91.93
	7I	29.025	MM m	0.81	2162.24	37.63	8.07
α-selective	6I	17.523	MM m	0.60	3600.16	92.38	28.12
	7I	29.208	MM m	0.92	9204.02	152.32	71.88

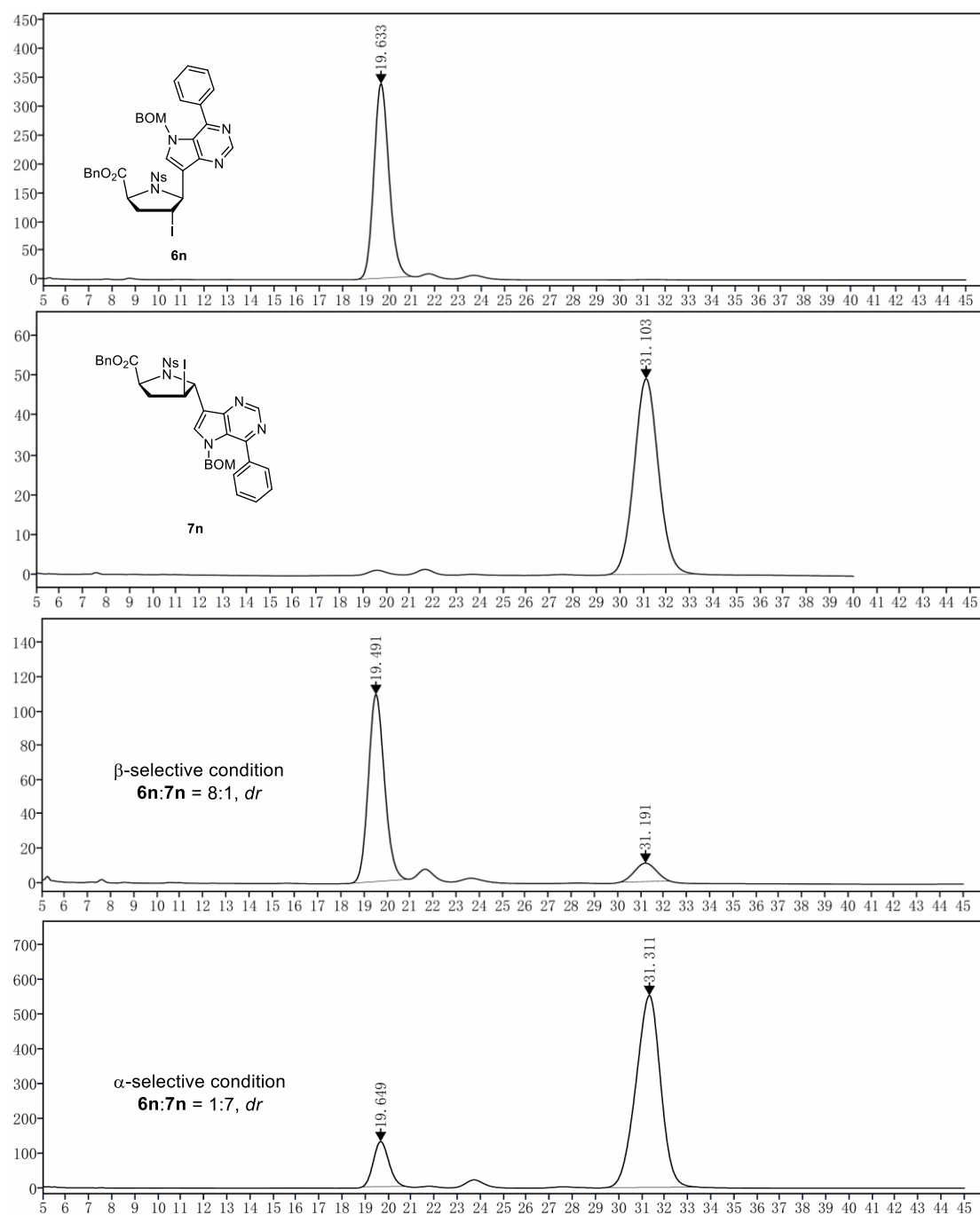
Chiral HPLC conditions: CHIRALCEL IA (4.6 x 250 mm), 70:30 *n*-hexane /*i*-PrOH, 0.80 mL/min, UV detector at 254 nm, injection volume: 5 μL, T (column) = 20 °C.



Supplementary Figure 245. HPLC Spectrum of **6m (β-selective) and **7m** (α-selective)**

Condition	Compound	Ret Time	Type	Width	Area	Heigh	Area%
β-selective	6m	17.982	MM m	0.62	5474.09	134.15	84.57
	7m	26.380	MM m	0.79	999.12	19.54	15.43
α-selective	6m	18.048	MM m	0.64	1149.84	26.77	14.12
	7m	26.410	MM m	0.82	6990.98	131.88	85.88

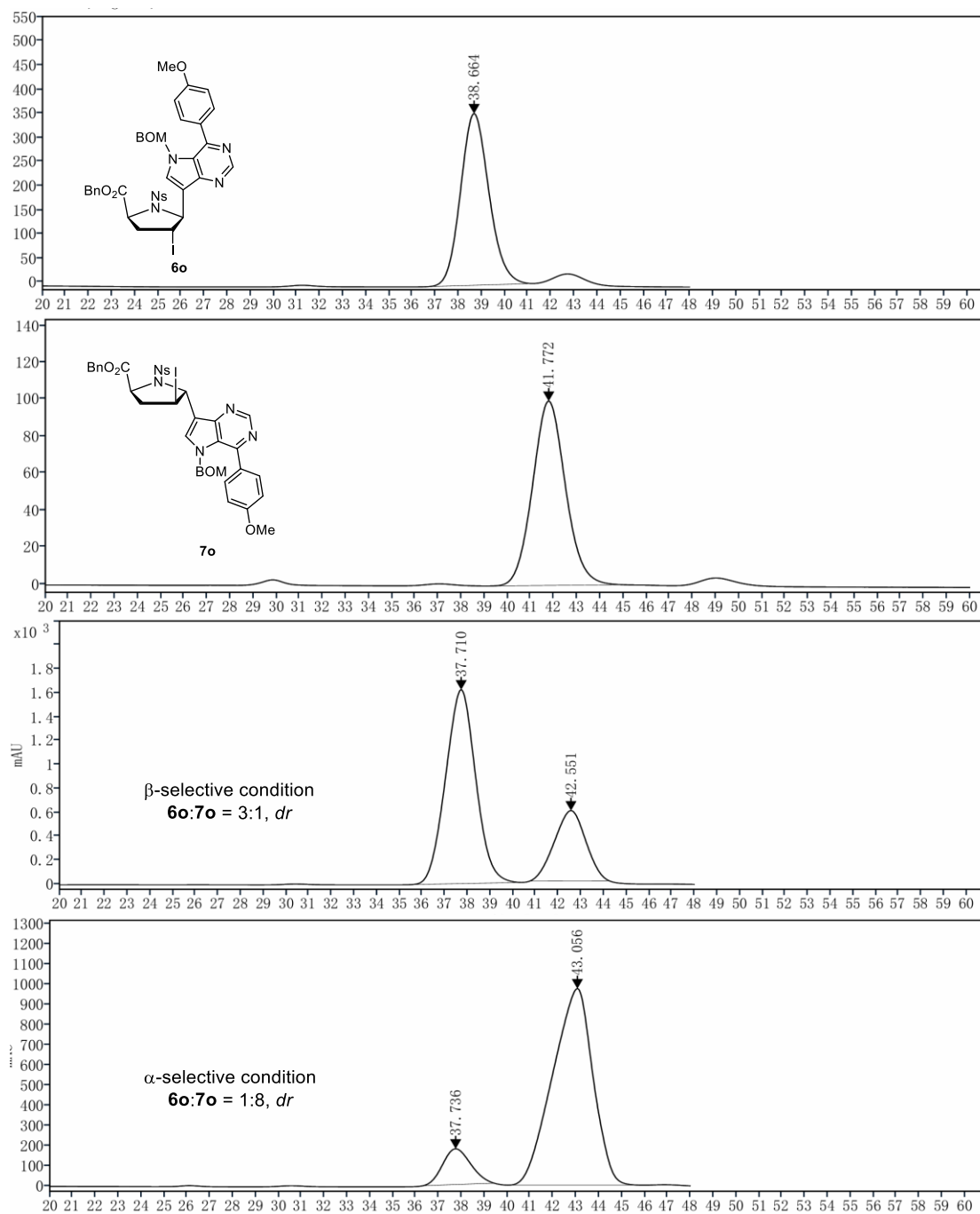
Chiral HPLC conditions: CHIRALCEL IA (4.6 x 250 mm), 80:20 *n*-hexane / *i*-PrOH, 0.80 mL/min, UV detector at 254 nm, injection volume: 5 μL, T (column) = 20 °C.



Supplementary Figure 246. HPLC Spectrum of **6n (β-selective) and **7n** (α-selective)**

Condition	Compound	Ret Time	Type	Width	Area	Heigh	Area%
β-selective	6n	19.491	MM m	0.75	5330.70	109.07	88.45
	7n	31.191	MM m	0.90	696.00	10.74	11.55
α-selective	6n	19.649	MM m	0.73	6099.30	130.43	12.86
	7n	31.311	MM m	1.15	41343.79	553.64	87.14

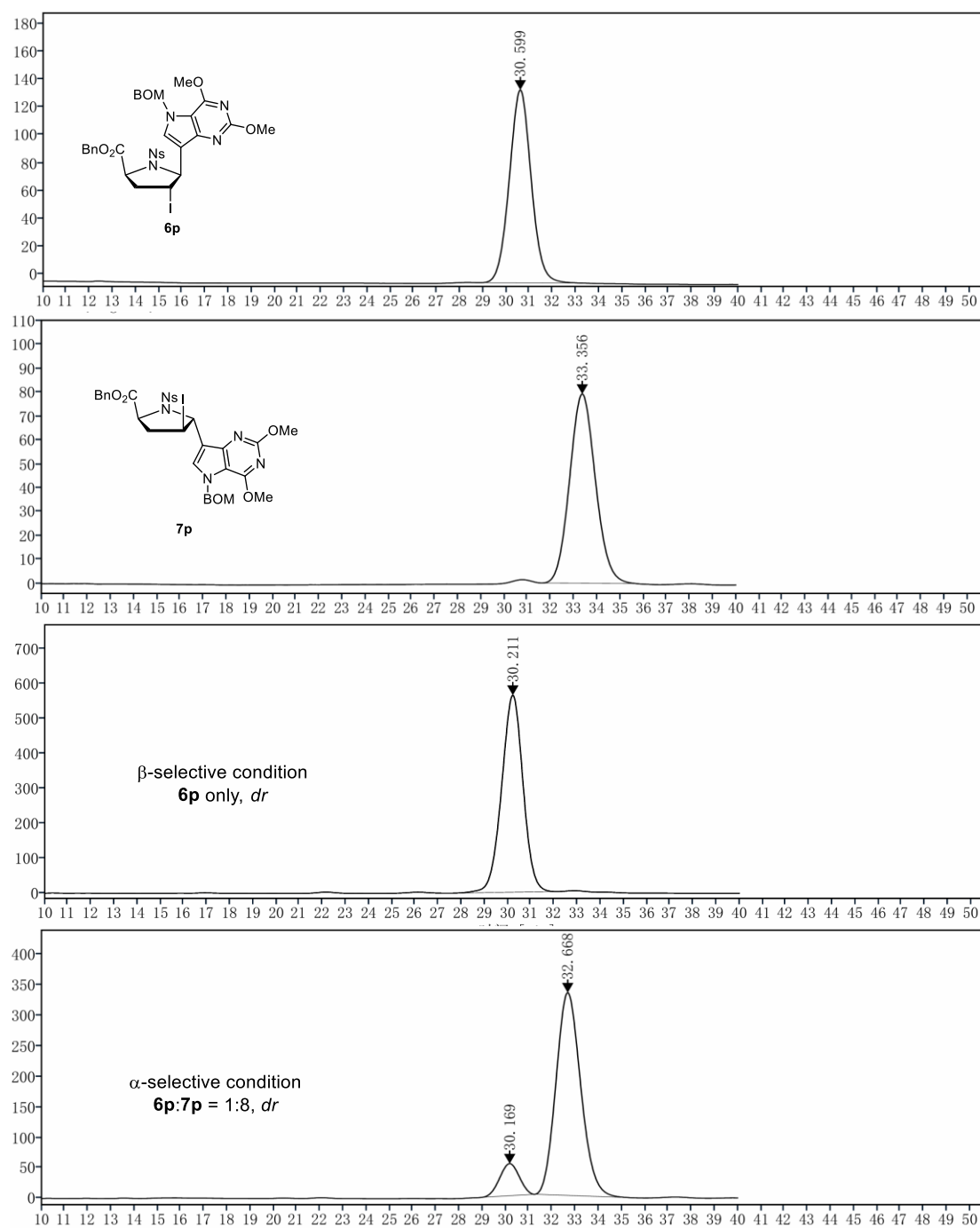
Chiral HPLC conditions: CHIRALCEL IA (4.6 x 250 mm), 70:30 *n*-hexane /*i*-PrOH, 0.80 mL/min, UV detector at 254 nm, injection volume: 5 μL, T (column) = 20 °C.



Supplementary Figure 247. HPLC Spectrum of **6o (β-selective) and **7o** (α-selective)**

Condition	Compound	Ret Time	Type	Width	Area	Heigh	Area%
β-selective	6o	37.710	MM m	1.42	149621.43	1620.16	72.63
	7o	42.551	MM m	1.48	56382.03	588.10	27.37
α-selective	6o	37.736	MM m	1.33	15068.76	177.19	11.20
	7o	43.056	MM m	1.88	119440.96	974.31	88.80

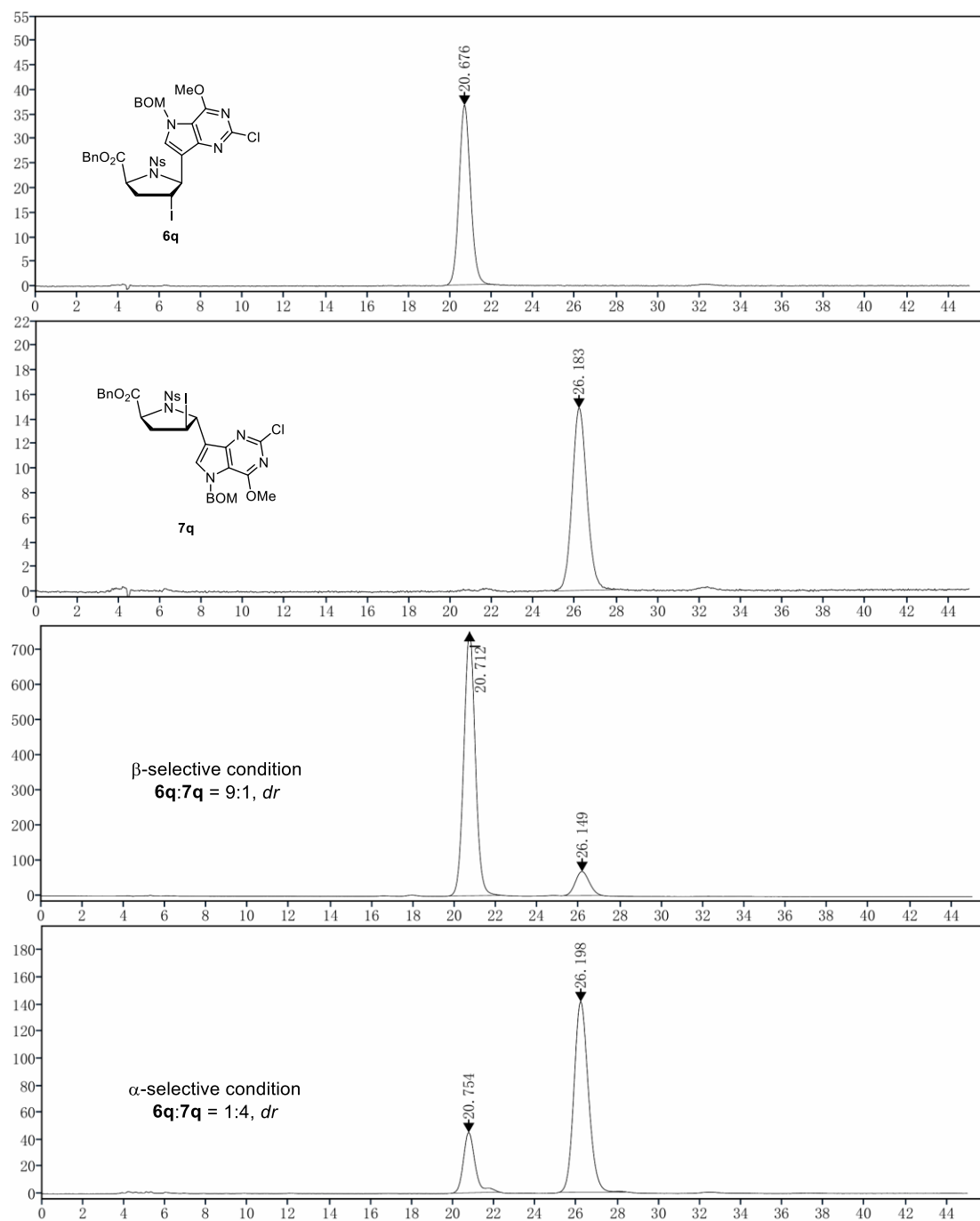
Chiral HPLC conditions: CHIRALCEL IA (4.6 x 250 mm), 70:30 *n*-hexane /*i*-PrOH, 0.80 mL/min, UV detector at 254 nm, injection volume: 5 μL, T (column) = 20 °C.



Supplementary Figure 248. HPLC Spectrum of **6p** (β -selective) and **7p** (α -selective)

Condition	Compound	Ret Time	Type	Width	Area	Heigh	Area%
β -selective	6p	30.211	MM m	1.00	36369.80	564.51	100.00
	7p						
α -selective	6p	30.169	MM m	0.92	3081.77	52.64	11.10
	7p	32.668	MM m	1.15	24687.42	332.55	88.90

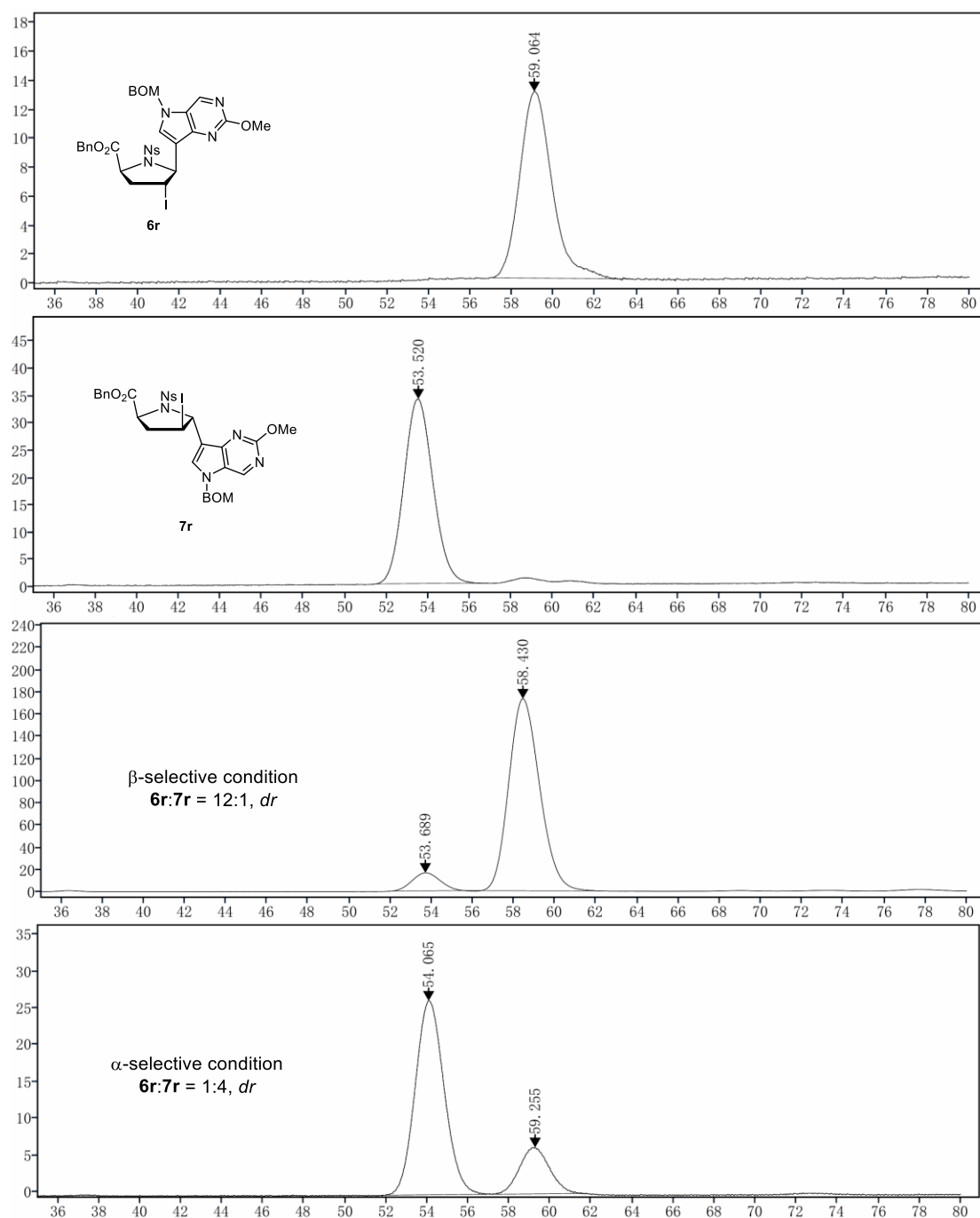
Chiral HPLC conditions: CHIRALCEL IA (4.6 x 250 mm), 85:15 *n*-hexane /*i*-PrOH, 0.80 mL/min, UV detector at 254 nm, injection volume: 5 μ L, T (column) = 20 $^{\circ}$ C.



Supplementary Figure 249. HPLC Spectrum of **6q (β-selective) and **7q** (α-selective)**

Condition	Compound	Ret Time	Type	Width	Area	Heigh	Area%
β-selective	6q	20.712	MM m	0.59	28975.68	752.37	90.06
	7q	26.149	MM m	0.71	3199.51	68.38	9.94
α-selective	6q	20.754	MM m	0.60	1772.46	44.56	20.56
	7q	26.198	MM m	0.72	6847.03	140.83	79.44

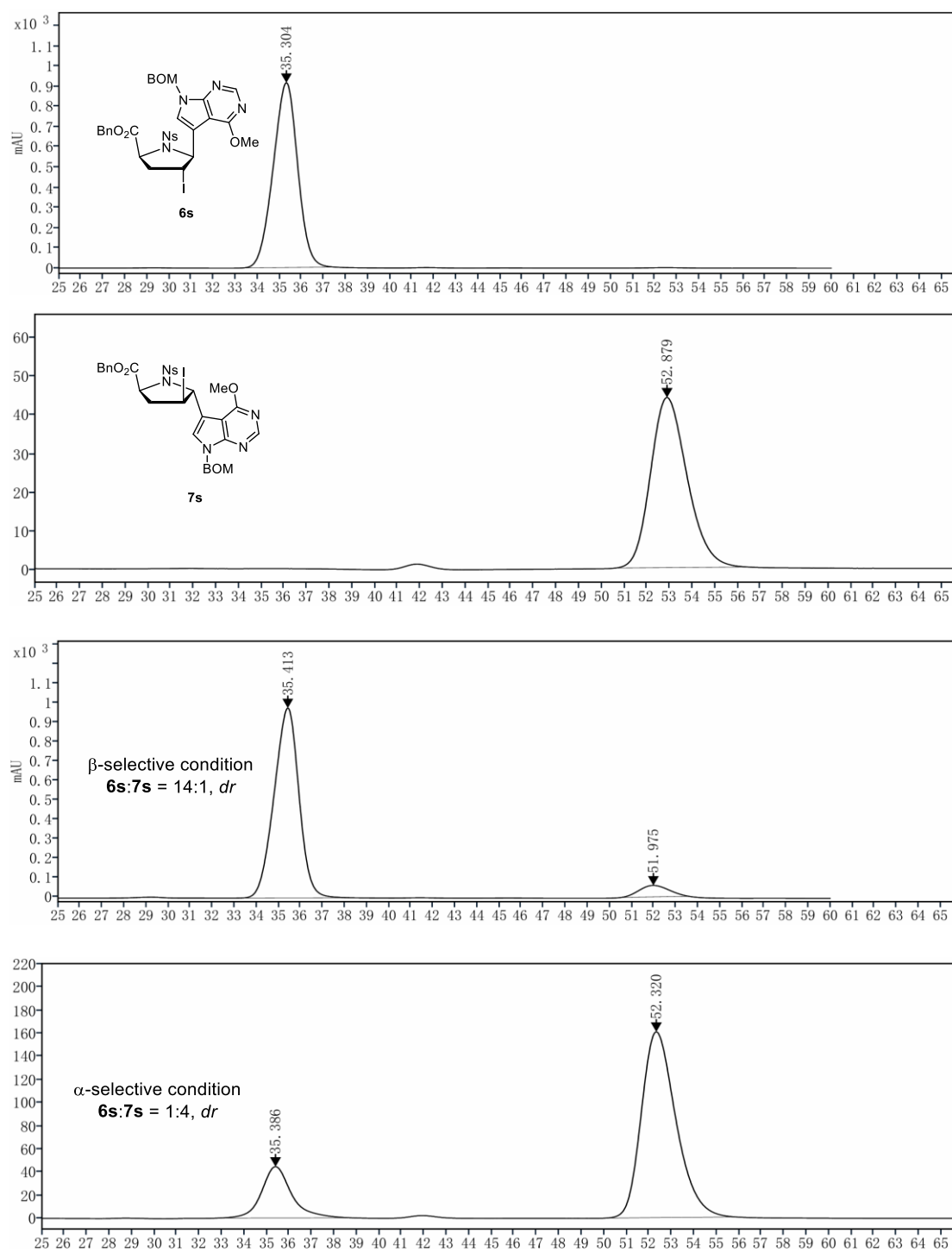
Chiral HPLC conditions: CHIRALCEL IA (4.6 x 250 mm), 80:20 *n*-hexane / *i*-PrOH, 0.80 mL/min, UV detector at 254 nm, injection volume: 5 μL, T (column) = 20 °C.



Supplementary Figure 250. HPLC Spectrum of 6r (β -selective) and 7r (α -selective)

Condition	Compound	Ret Time	Type	Width	Area	Heigh	Area%
β -selective	7r	53.689	MM m	1.10	1509.98	16.14	7.72
	6r	58.430	MM m	1.46	18039.86	172.82	92.28
α -selective	7r	54.065	MM m	1.17	2596.58	26.35	80.15
	6r	59.255	MM m	1.20	643.23	6.31	19.85

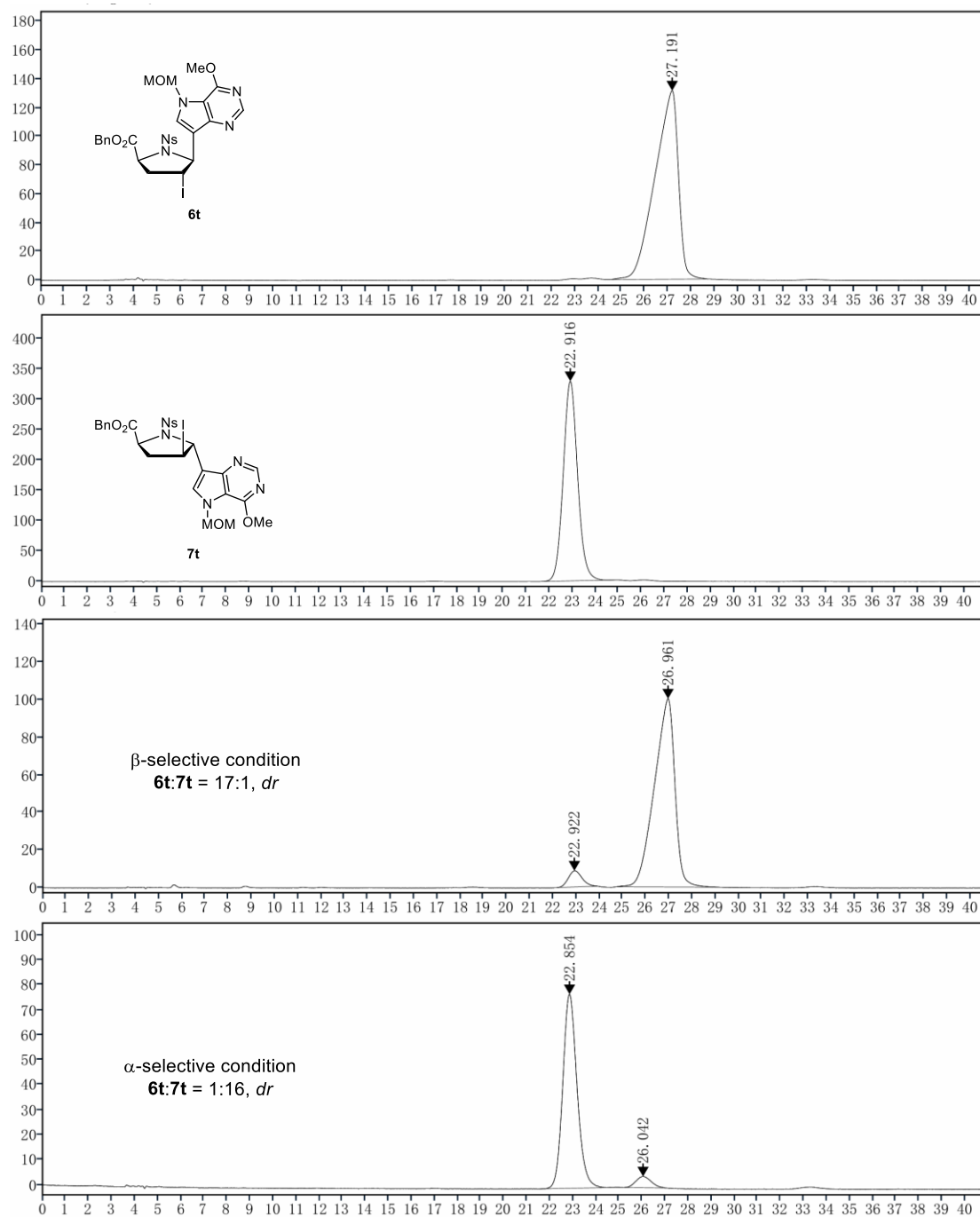
Chiral HPLC conditions: CHIRALCEL AD-H (4.6 x 250 mm), 80:20 *n*-hexane /*i*-PrOH, 0.80 mL/min, UV detector at 254 nm, injection volume: 5 μ L, T (column) = 20 $^{\circ}$ C.



Supplementary Figure 251. HPLC Spectrum of **6s (β -selective) and **7s** (α -selective)**

Condition	Compound	Ret Time	Type	Width	Area	Heigh	Area%
β -selective	6s	35.413	MM m	1.20	77054.69	981.59	93.28
	7s	51.975	MM m	1.44	5553.17	59.44	6.72
α -selective	6s	35.386	MM m	1.34	4088.60	44.36	19.21
	7s	52.320	MM m	1.63	17191.82	160.69	80.79

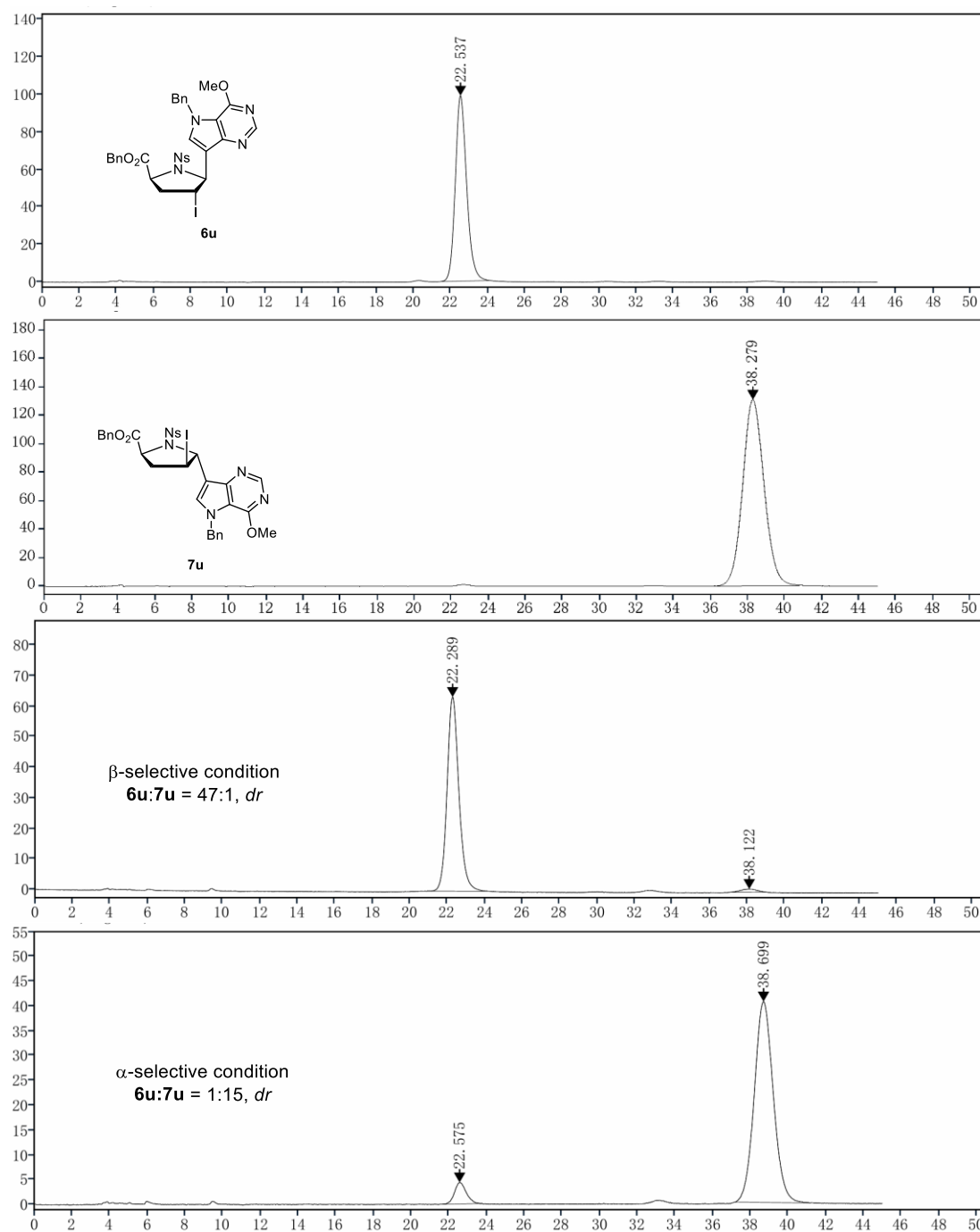
Chiral HPLC conditions: CHIRALCEL IA (4.6 x 250 mm), 85:15 *n*-hexane /*i*-PrOH, 0.80 mL/min, UV detector at 254 nm, injection volume: 5 μ L, T (column) = 20 $^{\circ}$ C.



Supplementary Figure 252. HPLC Spectrum of **6t** (β -selective) and **7t** (α -selective)

Condition	Compound	Ret Time	Type	Width	Area	Heigh	Area%
β -selective	7t	22.922	MM m	0.49	352.09	8.62	5.42
	6t	26.961	MM m	0.84	6147.59	100.21	94.58
α -selective	7t	22.854	MM m	0.65	3331.03	77.61	94.19
	6t	26.042	MM m	0.55	205.31	4.47	5.81

Chiral HPLC conditions: CHIRALCEL IA (4.6 x 250 mm), 80:20 *n*-hexane / *i*-PrOH, 0.80 mL/min, UV detector at 254 nm, injection volume: 5 μ L, T (column) = 20 $^{\circ}$ C.



Supplementary Figure 253. HPLC Spectrum of **6u** (β -selective) and **7u** (α -selective)

Condition	Compound	Ret Time	Type	Width	Area	Heigh	Area%
β -selective	6u	22.289	MM m	0.66	2783.58	63.61	97.90
	7u	38.122	MM m	0.68	59.79	1.04	2.10
α -selective	6u	22.575	MM m	0.51	185.82	4.32	6.14
	7u	38.699	MM m	0.89	2838.24	40.46	93.86

Chiral HPLC conditions: CHIRALCEL IA (4.6 x 250 mm), 80:20 *n*-hexane /*i*-PrOH, 0.80 mL/min, UV detector at 254 nm, injection volume: 5 μ L, T (column) = 20 $^{\circ}$ C.

8. Supplementary References

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