

**Supporting Information for**  
**Palladium-catalyzed asymmetric allylic amination of**  
**vinylethylene carbonate with *N*-heteroaromatics**

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## 1. General information

$^1\text{H}$  NMR and  $^{13}\text{C}$  NMR spectra were recorded on Bruker Avance III HD 600 or Avance 400 MHz spectrometer. Chemical shifts are recorded in ppm relative to tetramethylsilane with the solvent resonance as the internal standard. Data are represented as follows: chemical shift, multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, dd = doublet of doublets, m = multiplet), coupling constants ( $J$ ) are in Hertz (Hz), and integration. Enantiomer excesses were determined by chiral HPLC analysis on Chiralcel IA/AS-H/ID/OD-H/IE/IG in comparison with the authentic racemates. Chiral HPLC analysis was recorded on Thermo Scientific Dionex Ultimate 3000 and Agilent Technologies 1260 Infinity. Optical rotations were recorded on Autopol Automatic Polarimeter, and were reported as follows:  $[\alpha]_{\text{D}}^{\text{T}}$  (c: g/100 mL, in  $\text{CH}_2\text{Cl}_2$ ). High resolution mass spectra (HRMS) was recorded on an ABI/Sciex QStar Mass Spectrometer (ESI). Single crystal X-ray crystallography data were obtained on Supernova Atlas S2 CCD detector. Melting point (m.p.) data were obtained on X-5 micro melting point apparatus. For column chromatography, silica gel (200-300 mesh) was used as the stationary phase. Unless stated otherwise, all the solvent and reagents were purchased from commercial suppliers and used without further purification.

## 2. The Optimization of Reaction Conditions

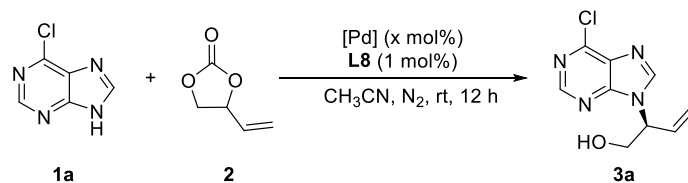
Table S1 The optimization of reaction conditions for selecting substrate **2**<sup>a</sup>

Reaction scheme: **1a** + **2a** or **2b**  $\xrightarrow[\text{DCM, N}_2, \text{rt, 6 h}]{\text{Pd}_2(\text{dba})_3 (5 \text{ mmol}\%), \text{L} (10 \text{ mmol}\%)}$  **3a**

L1, L2, L3, L4, L5, L6, L7, L8

| entry | 2         | L         | yield <sup>b</sup> (%) | ee <sup>c</sup> (%) |
|-------|-----------|-----------|------------------------|---------------------|
| 1     | <b>2a</b> | <b>L1</b> | 37                     | 43                  |
| 2     | <b>2b</b> | <b>L1</b> | NR                     | --                  |
| 3     | <b>2a</b> | <b>L2</b> | 50                     | 25                  |
| 4     | <b>2b</b> | <b>L2</b> | 48                     | 25                  |
| 5     | <b>2a</b> | <b>L3</b> | 28                     | 23                  |
| 6     | <b>2b</b> | <b>L3</b> | 35                     | 23                  |
| 7     | <b>2a</b> | <b>L4</b> | trace                  | --                  |
| 8     | <b>2b</b> | <b>L4</b> | NR                     | --                  |
| 9     | <b>2a</b> | <b>L5</b> | 42                     | 20                  |
| 10    | <b>2b</b> | <b>L5</b> | 45                     | 17                  |
| 11    | <b>2a</b> | <b>L6</b> | 88                     | 83                  |
| 12    | <b>2b</b> | <b>L6</b> | 88                     | 77                  |
| 13    | <b>2a</b> | <b>L7</b> | 85                     | 85                  |
| 14    | <b>2b</b> | <b>L7</b> | 80                     | 83                  |
| 15    | <b>2a</b> | <b>L8</b> | 90                     | 95                  |
| 16    | <b>2b</b> | <b>L8</b> | 86                     | 90                  |

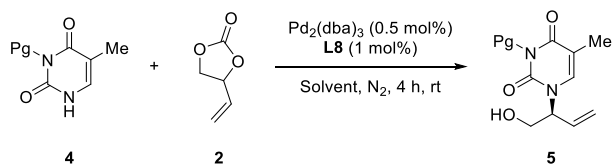
<sup>a</sup> Reaction conditions: **1a** (0.2 mmol), **2** (0.22 mmol), and solvent (2.0 mL). <sup>b</sup> Isolated yields. <sup>c</sup> Determined by chiral HPLC analysis.

**Table S2 The Screening of Palladium<sup>a</sup>**

| entry | [Pd] (x mol%)   | yield <sup>b</sup> (%) | ee <sup>c</sup> (%) |
|-------|---|------------------------|---------------------|
| 1     | Pd <sub>2</sub> (dba) <sub>3</sub> ·CHCl <sub>3</sub> (0.5) | 86                     | 96                  |
| 2     | Pd(dba) <sub>2</sub> (1)                                    | 88                     | 96                  |
| 3     | [Pd(C <sub>3</sub> H <sub>5</sub> Cl) <sub>2</sub> ] (0.5)  | 20                     | 73                  |
| 4     | Pd(PPh <sub>3</sub> ) <sub>4</sub> (1)                      | 47                     | 20                  |
| 5     | Pd(OAc) <sub>2</sub> (1)                                    | NR                     | --                  |

<sup>a</sup> Reaction conditions: **1a** (0.4 mmol), **2** (0.44 mmol), and solvent (4.0 mL). <sup>b</sup> Isolated yields. <sup>c</sup> Determined by chiral HPLC analysis.

**Table S3 The optimization of reaction conditions for pyrimidine **4**<sup>a</sup>**



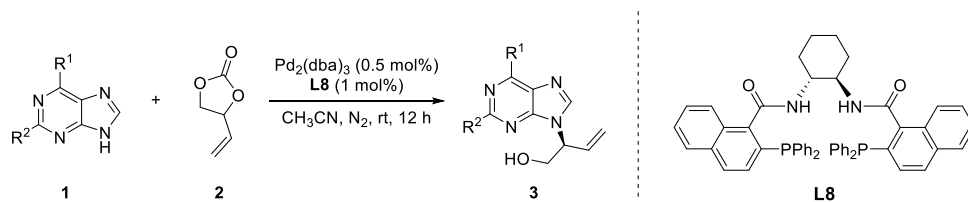
| entry           | <b>4</b>  | Pg  | Solvent (x mL)          | yield <sup>b</sup> (%) | ee <sup>c</sup> (%) |
|-----------------|-----------|-----|-------------------------|------------------------|---------------------|
| 1               | <b>4a</b> | Bz  | CH <sub>3</sub> CN (2)  | 97                     | 82                  |
| 2               | <b>4b</b> | Boc | CH <sub>3</sub> CN (2)  | 93                     | 82                  |
| 3               | <b>4a</b> | Bz  | DCM (2)                 | 85                     | 66                  |
| 4               | <b>4a</b> | Bz  | DCE (2)                 | 83                     | 69                  |
| 5               | <b>4a</b> | Bz  | CHCl <sub>3</sub> (2)   | 89                     | 50                  |
| 6               | <b>4a</b> | Bz  | EA (2)                  | 90                     | 76                  |
| 7               | <b>4a</b> | Bz  | THF (2)                 | NR                     | --                  |
| 8               | <b>4a</b> | Bz  | toluene (2)             | 92                     | 74                  |
| 9               | <b>4a</b> | Bz  | CH <sub>3</sub> CN (4)  | 97                     | 84                  |
| 10              | <b>4a</b> | Bz  | CH <sub>3</sub> CN (6)  | 80                     | 84                  |
| 11              | <b>4a</b> | Bz  | CH <sub>3</sub> CN (8)  | 53                     | 90                  |
| 12              | <b>4a</b> | Bz  | CH <sub>3</sub> CN (10) | 35                     | 92                  |
| 13 <sup>d</sup> | <b>4a</b> | Bz  | CH <sub>3</sub> CN (10) | 35                     | 92                  |
| 14 <sup>e</sup> | <b>4a</b> | Bz  | CH <sub>3</sub> CN (10) | 95                     | 92                  |

<sup>a</sup> Reaction conditions: **4** (0.2 mmol), **2** (0.22 mmol). <sup>b</sup> Isolated yields. <sup>c</sup>

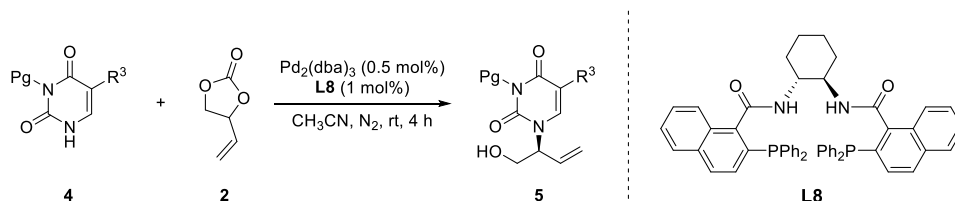
Determined by chiral HPLC analysis. <sup>d</sup> The reaction was carried out at 0 °C.

<sup>e</sup> 3 equivalent **2** was used.

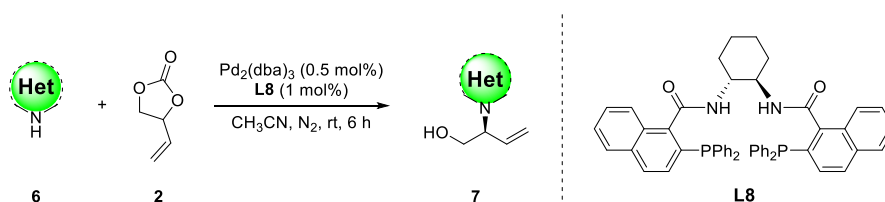
### 3. General procedure for the asymmetric allylic amination reactions



A reaction tube was charged with **1** (0.4 mmol), Pd<sub>2</sub>(dba)<sub>3</sub> (1.8 mg, 0.002 mmol, 0.5 mol%) and **L8** (3.2 mg, 0.004 mmol, 1 mol%). The reaction tube was placed under vacuum and backfilled with argon three times. CH<sub>3</sub>CN (4.0 mL) followed by **2** (0.44 mmol, 1.1 equiv) were added via syringe under argon. The resulting mixture was stirred at rt for 12 h, and the solvent was removed under vacuum. The residue was purified by flash column chromatography on silica gel (PE:EA = 2:1 to 1:1) to give the corresponding products **3**.

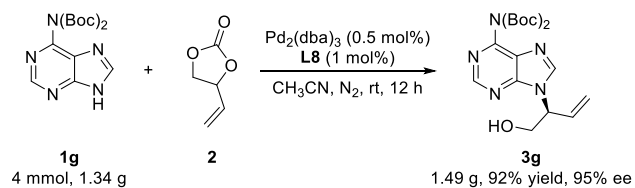


A reaction tube was charged with **4** (0.2 mmol), Pd<sub>2</sub>(dba)<sub>3</sub> (0.9 mg, 0.001 mmol, 0.5 mol%) and **L8** (1.6 mg, 0.002 mmol, 1 mol%). The reaction tube was placed under vacuum and backfilled with argon three times. CH<sub>3</sub>CN (10.0 mL) followed by **2** (0.6 mmol, 3 equiv) were added via syringe under argon. The resulting mixture was stirred at rt for 4 h, and the solvent was removed under vacuum. The residue was purified by flash column chromatography on silica gel (PE:EA = 2:1 to 1:1) to give the corresponding annulation **5**.



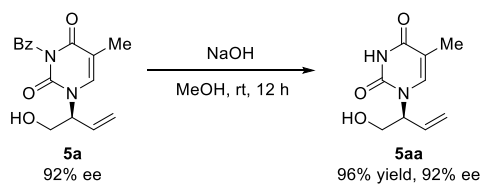
A reaction tube was charged with **6** (0.4 mmol), Pd<sub>2</sub>(dba)<sub>3</sub> (1.8 mg, 0.002 mmol, 0.5 mol%) and **L8** (3.2 mg, 0.004 mmol, 1 mol%). The reaction tube was placed under vacuum and backfilled with argon three times. CH<sub>3</sub>CN (4.0 mL) followed by **2** (0.44 mmol, 1.1 equiv) were added via syringe under argon. The resulting mixture was stirred at rt for 6 h, and the solvent was removed under vacuum. The residue was purified by flash column chromatography on silica gel (PE:EA = 4:1 to 2:1) to give the corresponding products **5**.

#### 4. Scale-up synthesis of product **3g**

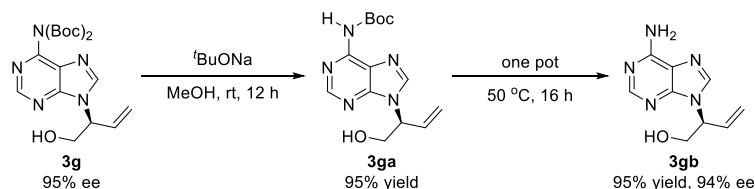


In a 50 mL reaction flask,  $\text{Pd}_2(\text{dba})_3$  (18 mg, 0.02 mmol, 0.5 mol%), **L8** (32 mg, 0.04 mmol, 1 mol%) and  $\text{CH}_3\text{CN}$  (40 mL) were introduced under an argon atmosphere. The resulting solution was stirred for 30 minutes. Then, **1g** (1.34g, 4 mmol) and **2** (502 mg, 4.4 mmol) were added in one portion. The resulting mixture was stirred at rt for 12 h, and the solvent was removed under vacuum. The residue was purified by flash column chromatography on silica gel (PE:EA = 2:1 to 1:1) to give product **3g** as white solid (1.49 g, 92% yield, 95% ee).

## 5. Transformation



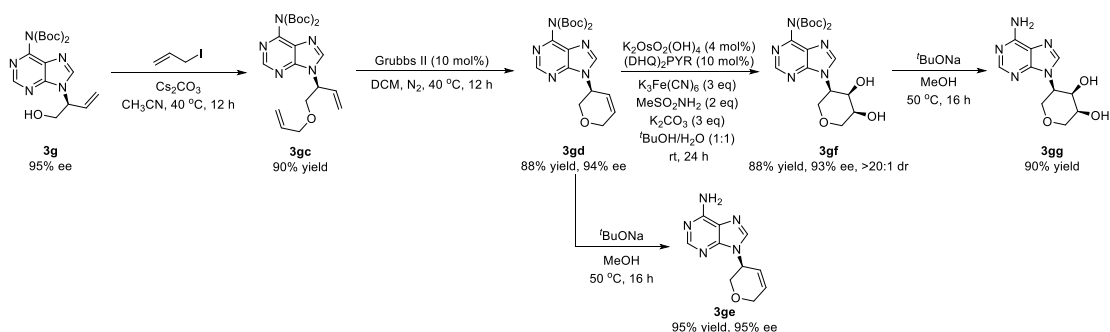
To a solution of **5a** (60 mg, 0.2 mmol) in MeOH (2.0 mL), NaOH (16 mg, 0.4 mmol) was added. The reaction was stirred at the room temperature for 12 h. After the reaction was consumed (determined by TLC), the solvent was removed under vacuum. The residue was purified by flash column chromatography on silica gel (PE:EA = 1:1 to 1:2) to give product **5aa** as white solid (37.7 mg, 96% yield, 92% ee).



**STEP 1:** To a solution of **3g** (81 mg, 0.2 mmol) in MeOH (2.0 mL), <sup>t</sup>BuONa (38.4 mg, 0.4 mmol) was added. The reaction was stirred at the room temperature for 12 h. After the reaction was consumed (determined by TLC), the solvent was removed under vacuum. The residue was purified by flash column chromatography on silica gel (PE:EA = 1:1 to 1:2) to give product **3ga** as white solid (58 mg, 95% yield).

**STEP 2:** Heated the temperature of the reaction solution that had been completed in **STEP 1** to 50 °C and stirred the reaction for other 16 h. After the reaction was consumed (determined by TLC), the solvent was removed under vacuum. The residue was purified by flash column chromatography on silica gel (DCM:MeOH = 10:1) to give product **3gb** as white solid (39.1 mg, 95% yield, 94% ee).





**STEP 1:** To a solution of **3g** (81 mg, 0.2 mmol) and  $\text{Cs}_2\text{CO}_3$  (130 mg, 0.4 mmol) in  $\text{CH}_3\text{CN}$  (2.0 mL), allyl iodide (51 mg, 0.3 mmol) was added. The reaction was stirred at 40 °C for 12 h. After the reaction was consumed (determined by TLC), the solvent was removed under vacuum. The residue was purified by flash column chromatography on silica gel (PE:EA = 4:1 to 2:1) to give product **3gc** as colorless oil (80.2 mg, 90% yield).

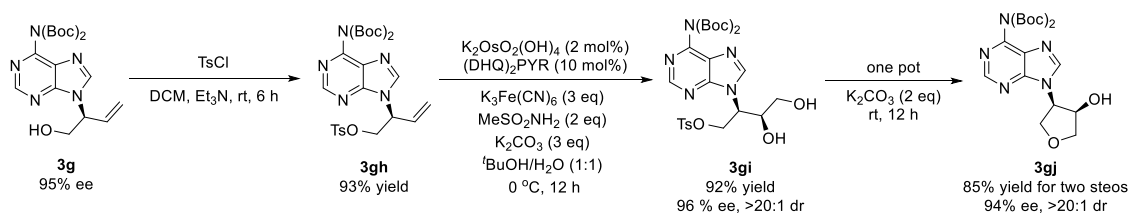
**STEP 2:** To a solution of **3gc** (89 mg, 0.2 mmol) in DCM (2.0 mL), Grubbs II catalyst (10 mol%) was added. The reaction was stirred under  $\text{N}_2$  at 40 °C for 12 h. After the reaction was consumed (determined by TLC), the solvent was removed under vacuum. The residue was purified by flash column chromatography on silica gel (PE:EA = 3:1 to 3:2) to give product **3gd** as colorless oil (73.4 mg, 88% yield, 94% ee).

**STEP 3:** To a solution of **3gd** (83.5 mg, 0.2 mmol) in MeOH (2.0 mL),  $t\text{BuONa}$  (38.4 mg, 0.4 mmol) was added. The reaction was stirred at 50 °C for 16 h. After the reaction was consumed (determined by TLC), the solvent was removed under vacuum. The residue was purified by flash column chromatography on silica gel (DCM:MeOH = 10:1) to give product **3ge** as white solid (41.2 mg, 95% yield, 95% ee).

**STEP 4:**  $\text{K}_2\text{OsO}_2(\text{OH})_4$  (2.4 mg, 0.008 mmol, 4 mol %),  $(\text{DHQ})_2\text{PYPYR}$  (17.6 mg, 0.02 mmol, 10 mol %),  $\text{K}_3\text{Fe}(\text{CN})_6$  (196 mg, 0.6 mmol, 3 equiv), methanesulfonamide (38 mg, 0.4 mmol, 2 equiv) and  $\text{K}_2\text{CO}_3$  (84 mg, 0.6 mmol, 3 equiv) were suspended in a mixture of water and *tert*-butyl alcohol (1:1, 8 mL). The mixture was stirred at room temperature for 1 h and then added **3gd** (83.5 mg, 0.2 mmol). The reaction was stirred at the room temperature for 24 h and monitored by TLC until the reaction was completed. The reaction was quenched at 0 °C by addition of  $\text{Na}_2\text{S}_2\text{O}_3$  and the mixture stirred at room temperature for 2 h. The reaction mixture was then partitioned between ethyl acetate and water. The combined organic phases were dried ( $\text{Na}_2\text{SO}_4$ ), filtered and concentrated in vacuo to afford a crude oil. Purification by flash column chromatography (PE:EA =

1:1 to 1:3) to furnished **3gf** (79.3 mg, 88% yield, 93% ee and >20:1 dr) as white solid.

**STEP 5:** To a solution of **3gd** (90.2 mg, 0.2 mmol) in MeOH (2.0 mL), *t*BuONa (38.4 mg, 0.4 mmol) was added. The reaction was stirred at 50 °C for 16 h. After the reaction was consumed (determined by TLC), the solvent was removed under vacuum. The residue was purified by flash column chromatography on silica gel (DCM:MeOH = 10:1 to 3:1) to give product **3gg** as white solid (45.2 mg, 90% yield).



**STEP 1:** To a solution of **3g** (81 mg, 0.2 mmol) and TsCl (53 mg, 0.3 mmol) in DCM (2.0 mL), Et<sub>3</sub>N (40 mg, 0.4 mmol) was added. The reaction was stirred at the room temperature for 6 h. After the reaction was consumed (determined by TLC), the solvent was removed under vacuum. The residue was purified by flash column chromatography on silica gel (PE:EA = 4:1 to 2:1) to give product **3gh** as white solid (104 mg, 93% yield).

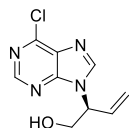
**STEP 2:** K<sub>2</sub>OsO<sub>2</sub>(OH)<sub>4</sub> (1.2 mg, 0.004 mmol, 2 mol %), (DHQ)<sub>2</sub>PYR (17.6 mg, 0.02 mmol, 10 mol %), K<sub>3</sub>Fe(CN)<sub>6</sub> (196 mg, 0.6 mmol, 3 equiv), methanesulfonamide (38 mg, 0.4 mmol, 2 equiv) and K<sub>2</sub>CO<sub>3</sub> (84 mg, 0.6 mmol, 3 equiv) were suspended in a mixture of water and *tert*-butyl alcohol (1:1, 8 mL). The mixture was stirred at room temperature for 1 h and then added **3gh** (112 mg, 0.2 mmol). The reaction was stirred at 0 °C for 12 h and monitored by TLC until the reaction was completed. The reaction was quenched at 0 °C by addition of Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> and the mixture stirred at room temperature for 2 h. The reaction mixture was then partitioned between ethyl acetate and water. The combined organic phases were dried (Na<sub>2</sub>SO<sub>4</sub>), filtered and concentrated in vacuo to afford a crude oil. Purification by flash column chromatography (PE:EA = 1:1 to 1:3) to furnished **3gi** (109.2 mg, 92% yield, 96% ee and >20:1 dr) as white solid.

**STEP 3:** Warmed the temperature of the reaction solution that had been completed in **STEP 2** up to room temperature and K<sub>2</sub>CO<sub>3</sub> (56 mg, 0.4 mmol, 2 equiv) was added. The reaction was stirred at the room temperature for other 12 h. The reaction was quenched at 0 °C by addition of Na<sub>2</sub>S<sub>2</sub>O<sub>3</sub> and the mixture stirred at room temperature for 2 h. The reaction mixture was then partitioned

between ethyl acetate and water. The combined organic phases were dried ( $\text{Na}_2\text{SO}_4$ ), filtered and concentrated in vacuo to afford a crude oil. Purification by flash column chromatography (PE:EA = 1:1 to 1:2) to furnished **3gj** (69.6 mg, 85% yield, 94% ee and >20:1 dr) as colorless oil.

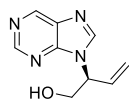
## 6.Characterization Data of Products

### (*S*)-2-(6-chloro-9*H*-purin-9-yl)but-3-en-1-ol (3a)



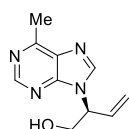
White solid; m.p. 104.8-106.3 °C; 81.6 mg, 91% yield, 97% ee;  $[\alpha]_D^{23} = -73.67$  ( $c = 0.600$ ,  $\text{CHCl}_3$ ); **HPLC** CHIRALCEL IE, *n*-hexane/2-propanol = 85/15, flow rate = 0.8 mL/min,  $\lambda = 256$  nm, retention time: 16.395 min (major), 17.837 min (minor); **<sup>1</sup>H NMR** (600 MHz,  $\text{CDCl}_3$ )  $\delta$  8.66 (s, 1H), 8.22 (s, 1H), 6.21 (ddd,  $J = 17.4, 10.8, 6.6$  Hz, 1H), 5.41 (dd,  $J = 10.8, 1.2$  Hz, 1H), 5.27 (ddd,  $J = 6.6, 4.8, 3.6, 1.2$  Hz, 1H), 5.24 (dd,  $J = 17.4, 1.8$  Hz, 1H), 4.25 (dd,  $J = 12.0, 6.0$  Hz, 1H), 4.15 (dd,  $J = 12.0, 3.6$  Hz, 1H), 4.01 (brs, 1H); **<sup>13</sup>C NMR** (150 MHz,  $\text{CDCl}_3$ )  $\delta$  151.8, 151.4, 150.9, 145.5, 132.1, 131.4, 120.4, 63.4, 60.8; **HRMS** (ESI-TOF): exact mass calcd. for  $\text{C}_9\text{H}_{10}\text{ClN}_4\text{O}$   $[\text{M}+\text{H}]^+$  requires  $m/z$  225.0538, found  $m/z$  225.0538.

### (*S*)-2-(9*H*-purin-9-yl)but-3-en-1-ol (3b)



White solid; m.p. 70.4-71.6 °C; 54.8 mg, 72% yield, 95% ee;  $[\alpha]_D^{23} = -84.21$  ( $c = 0.585$ ,  $\text{CHCl}_3$ ); **HPLC** CHIRALCEL IE, *n*-hexane/2-propanol = 70/30, flow rate = 1.0 mL/min,  $\lambda = 256$  nm, retention time: 13.320 min (minor), 17.232 min (major); **<sup>1</sup>H NMR** (400 MHz,  $\text{CDCl}_3$ )  $\delta$  8.88 (s, 1H), 8.79 (s, 1H), 8.19 (s, 1H), 6.21 (ddd,  $J = 17.6, 10.4, 6.4$  Hz, 1H), 5.37 (d,  $J = 10.4$  Hz, 1H), 5.28 – 5.23 (m, 1H), 5.20 (d,  $J = 17.2$  Hz, 1H), 4.96 (brs, 1H), 4.23 (dd,  $J = 12.0, 6.0$  Hz, 1H), 4.10 (dd,  $J = 12.0, 3.6$  Hz, 1H); **<sup>13</sup>C NMR** (100 MHz,  $\text{CDCl}_3$ )  $\delta$  152.1, 151.0, 148.3, 145.5, 133.8, 132.5, 120.0, 63.3, 60.4; **HRMS** (ESI-TOF): exact mass calcd. for  $\text{C}_9\text{H}_{11}\text{N}_4\text{O}$   $[\text{M}+\text{H}]^+$  requires  $m/z$  191.0927, found  $m/z$  191.0924.

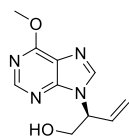
### (*S*)-2-(6-methyl-9*H*-purin-9-yl)but-3-en-1-ol (3c)



White solid; m.p. 108.6-110.2 °C; 63.6 mg, 78% yield, 96% ee;  $[\alpha]_D^{23} = -100.55$  ( $c = 0.610$ ,  $\text{CHCl}_3$ );

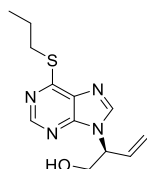
**HPLC** CHIRALCEL IE, *n*-hexane/2-propanol = 85/15, flow rate = 1.0 mL/min,  $\lambda$  = 256 nm, retention time: 21.165 min (major), 23.288 min (minor); **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$  8.64 (s, 1H), 8.09 (s, 1H), 6.20 (ddd,  $J$  = 17.0, 10.4, 6.4 Hz, 1H), 5.35 (d,  $J$  = 10.4 Hz, 1H), 5.22 – 5.09 (m, 3H), 4.28 – 4.20 (m, 1H), 4.10 (d,  $J$  = 12.4 Hz, 1H), 2.68 (s, 3H); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$  159.4, 151.7, 150.1, 144.1, 132.9, 132.6, 119.7, 63.4, 61.0, 19.3; **HRMS** (ESI-TOF): exact mass calcd for C<sub>10</sub>H<sub>13</sub>N<sub>4</sub>O [M+H]<sup>+</sup> requires  $m/z$  205.1084, found  $m/z$  205.1083.

**(S)-2-(6-methoxy-9H-purin-9-yl)but-3-en-1-ol (3d)**



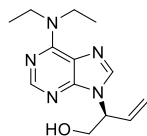
White solid; m.p. 116.2-117.4 °C; 81.0 mg, 76% yield, 92% ee;  $[\alpha]_D^{23}$  = -93.33 ( $c$  = 0.660, CHCl<sub>3</sub>); **HPLC** CHIRALCEL IG, *n*-hexane/2-propanol = 80/20, flow rate = 0.8 mL/min,  $\lambda$  = 256 nm, retention time: 13.873 min (major), 15.707 min (minor); **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$  8.43 (s, 1H), 7.92 (s, 1H), 6.23 (ddd,  $J$  = 17.2, 10.4, 6.4 Hz, 1H), 5.37 (d,  $J$  = 10.4 Hz, 1H), 5.28 – 5.22 (m, 1H), 5.19 (d,  $J$  = 17.2 Hz, 1H), 5.16 – 5.11 (m, 1H), 4.25 – 4.14 (m, 2H), 4.10 (s, 3H); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$  160.8, 151.6, 151.2, 142.5, 132.8, 121.2, 119.7, 63.6, 61.4, 54.3; **HRMS** (ESI-TOF): exact mass calcd for C<sub>10</sub>H<sub>13</sub>N<sub>4</sub>O<sub>2</sub> [M+H]<sup>+</sup> requires  $m/z$  221.1033, found  $m/z$  221.1032.

**(S)-2-(6-(propylthio)-9H-purin-9-yl)but-3-en-1-ol (3e)**



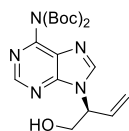
Colorless oil; 87.7 mg, 83% yield, 94% ee;  $[\alpha]_D^{23}$  = -81.97 ( $c$  = 0.610, CHCl<sub>3</sub>); **HPLC** CHIRALCEL IE, *n*-hexane/2-propanol = 80/20, flow rate = 1.0 mL/min,  $\lambda$  = 256 nm, retention time: 10.732 min (major), 11.790 min (minor); **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$  8.58 (s, 1H), 7.98 (s, 1H), 6.16 (ddd,  $J$  = 17.2, 10.4, 6.4 Hz, 1H), 5.33 (d,  $J$  = 10.4 Hz, 1H), 5.20 – 5.05 (m, 3H), 4.15 (s, 2H), 3.26 (t,  $J$  = 7.2 Hz, 2H), 1.75 (h,  $J$  = 7.2 Hz, 2H), 1.03 (t,  $J$  = 7.2 Hz, 3H); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$  161.7, 151.5, 147.7, 142.7, 132.7, 131.0, 119.6, 63.6, 60.6, 30.7, 22.9, 13.5; **HRMS** (ESI-TOF): exact mass calcd for C<sub>12</sub>H<sub>17</sub>N<sub>4</sub>OS [M+H]<sup>+</sup> requires  $m/z$  265.1118, found  $m/z$  265.1119.

**(S)-2-(6-(diethylamino)-9H-purin-9-yl)but-3-en-1-ol (3f)**



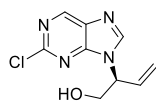
Colorless oil; 74.2 mg, 71% yield, 94% ee;  $[\alpha]_{\text{D}}^{23} = -87.87$  ( $c = 0.500$ ,  $\text{CHCl}_3$ ); **HPLC** CHIRALCEL IE, *n*-hexane/2-propanol = 85/15, flow rate = 1.0 mL/min,  $\lambda = 256$  nm, retention time: 11.492 min (major), 12.808 min (minor);  **$^1\text{H NMR}$**  (400 MHz,  $\text{CDCl}_3$ )  $\delta$  8.23 (s, 1H), 7.73 (s, 1H), 6.15 (ddd,  $J = 16.8, 10.4, 6.0$  Hz, 1H), 5.30 (d,  $J = 10.4$  Hz, 1H), 5.03 (d,  $J = 17.2$  Hz, 2H), 4.14 – 4.05 (m, 2H), 3.96 (brs, 4H), 1.27 (t,  $J = 7.2$  Hz, 6H);  **$^{13}\text{C NMR}$**  (100 MHz,  $\text{CDCl}_3$ )  $\delta$  154.0, 151.9, 149.7, 138.6, 133.5, 119.9, 118.6, 64.2, 61.5, 43.3, 13.6; **HRMS** (ESI-TOF): exact mass calcd for  $\text{C}_{13}\text{H}_{20}\text{N}_5\text{O}$   $[\text{M}+\text{H}]^+$  requires  $m/z$  262.1662, found  $m/z$  262.1663.

**(S)-2-(6-(diBocamino)-9H-purin-9-yl)but-3-en-1-ol (3g)**



White solid; m.p. 59.5-61.2 °C; 142.6 mg, 88% yield, 94% ee;  $[\alpha]_{\text{D}}^{23} = -44.95$  ( $c = 0.525$ ,  $\text{CHCl}_3$ ); **HPLC** CHIRALCEL OD, *n*-hexane/2-propanol = 90/10, flow rate = 0.7 mL/min,  $\lambda = 256$  nm, retention time: 11.008 min (minor), 12.845 min (major);  **$^1\text{H NMR}$**  (400 MHz,  $\text{CDCl}_3$ )  $\delta$  8.75 (s, 1H), 8.18 (s, 1H), 6.15 (ddd,  $J = 17.2, 10.4, 6.4$  Hz, 1H), 5.29 (d,  $J = 10.4$  Hz, 1H), 5.23 (q,  $J = 5.6$  Hz, 1H), 5.07 (d,  $J = 17.2$  Hz, 1H), 4.36 (brs, 1H), 4.12 (dd,  $J = 12.0, 6.2$  Hz, 1H), 4.01 (dd,  $J = 12.0, 3.6$  Hz, 1H), 1.39 (s, 18H);  **$^{13}\text{C NMR}$**  (100 MHz,  $\text{CDCl}_3$ )  $\delta$  153.1, 151.6, 150.5, 150.2, 145.2, 132.7, 128.8, 119.4, 84.0, 63.2, 60.3, 27.8; **HRMS** (ESI-TOF): exact mass calcd for  $\text{C}_{19}\text{H}_{28}\text{N}_5\text{O}_5$   $[\text{M}+\text{H}]^+$  requires  $m/z$  406.2085, found  $m/z$  406.2080.

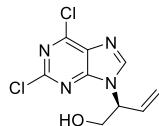
**(S)-2-(2-chloro-9H-purin-9-yl)but-3-en-1-ol (3h)**



White solid; m.p. 89.0-90.6 °C; 68.2 mg, 76% yield, 96% ee;  $[\alpha]_{\text{D}}^{23} = -53.55$  ( $c = 0.620$ ,  $\text{CHCl}_3$ ); **HPLC** CHIRALCEL OD, *n*-hexane/2-propanol = 90/10, flow rate = 0.8 mL/min,  $\lambda = 256$  nm, retention time: 23.547 min (minor), 25.702 min (major);  **$^1\text{H NMR}$**  (400 MHz,  $\text{CDCl}_3$ )  $\delta$  8.85 (s, 1H), 8.23 (s, 1H), 6.19 (ddd,  $J = 17.2, 10.4, 6.4$  Hz, 1H), 5.42 (d,  $J = 10.4$  Hz, 1H), 5.31 – 5.22 (m, 2H), 4.21 (dd,  $J = 12.0, 6.2$  Hz, 1H), 4.09 (dd,  $J = 12.0, 3.7$  Hz, 1H), 3.60 (brs, 1H);  **$^{13}\text{C NMR}$**  (150

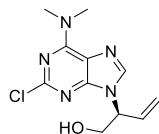
MHz, CDCl<sub>3</sub>) δ 154.2, 153.0, 150.0, 146.1, 133.0, 132.0, 120.5, 63.4, 59.8; **HRMS** (ESI-TOF): exact mass calcd for C<sub>9</sub>H<sub>10</sub>ClN<sub>4</sub>O [M+H]<sup>+</sup> requires m/z 225.0538, found m/z 225.0537.

**(S)-2-(2,6-dichloro-9H-purin-9-yl)but-3-en-1-ol (3i)**



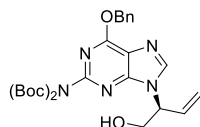
White solid; m.p. 144.6-146.2 °C; 53.8 mg, 52% yield, 97% ee; [α]<sub>D</sub><sup>23</sup> = -49.25 (c = 0.555, CHCl<sub>3</sub>); **HPLC** CHIRALCEL ID, *n*-hexane/2-propanol = 90/10, flow rate = 0.8 mL/min, λ = 256 nm, retention time: 14.182 min (major), 16.353 min (minor); **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>) δ 8.27 (s, 1H), 6.20 (ddd, *J* = 17.2, 10.4, 6.4 Hz, 1H), 5.45 (d, *J* = 10.4 Hz, 1H), 5.32 – 5.26 (m, 2H), 4.20 (dd, *J* = 12.0, 6.0 Hz, 1H), 4.12 (dd, *J* = 12.0, 3.6 Hz, 1H), 3.20 (brs, 1H); **<sup>13</sup>C NMR** (150 MHz, CDCl<sub>3</sub>) δ 153.0, 152.9, 151.7, 146.0, 131.7, 130.6, 120.9, 63.4, 60.1; **HRMS** (ESI-TOF): exact mass calcd for C<sub>9</sub>H<sub>9</sub>Cl<sub>2</sub>N<sub>4</sub>O [M+H]<sup>+</sup> requires m/z 259.0148, found m/z 259.0148.

**(S)-2-(2-chloro-6-(dimethylamino)-9H-purin-9-yl)but-3-en-1-ol (3j)**



White solid; m.p. 119.5-121.1 °C; 77.0 mg, 72% yield, 94% ee; [α]<sub>D</sub><sup>23</sup> = -73.53 (c = 0.835, CHCl<sub>3</sub>); **HPLC** CHIRALCEL IE, *n*-hexane/2-propanol = 70/30, flow rate = 1.0 mL/min, λ = 256 nm, retention time: 6.885 min (major), 8.505 min (minor); **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>) δ 7.70 (s, 1H), 6.13 (ddd, *J* = 17.2, 10.4, 6.2 Hz, 1H), 5.34 (d, *J* = 10.4 Hz, 1H), 5.14 (d, *J* = 17.2 Hz, 1H), 5.11 – 5.05 (m, 1H), 4.28 (s, 1H), 4.15 – 4.02 (m, 2H), 3.62 (s, 3H), 3.29 (s, 3H); **<sup>13</sup>C NMR** (150 MHz, CDCl<sub>3</sub>) δ 155.0, 153.5, 151.3, 138.5, 132.9, 119.4, 118.9, 64.0, 60.3, 39.2, 38.2; **HRMS** (ESI-TOF): exact mass calcd for C<sub>11</sub>H<sub>15</sub>ClN<sub>5</sub>O [M+H]<sup>+</sup> requires m/z 268.0960, found m/z 268.0957.

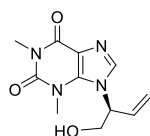
**(S)-2-(2-(diBocamino)-6-(benzyloxy)-9H-purin-9-yl)but-3-en-1-ol (3k)**



White solid; m.p. 61.0-62.2 °C; 184.0 mg, 90% yield, 95% ee; [α]<sub>D</sub><sup>23</sup> = -30.00 (c = 0.600, CHCl<sub>3</sub>); **HPLC** CHIRALCEL IG, *n*-hexane/2-propanol = 80/20, flow rate = 0.8 mL/min, λ = 256 nm, retention time: 12.292 min (minor), 14.260 min (major); **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>) δ 7.99 (s,

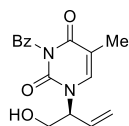
1H), 7.48 (d,  $J = 7.6$  Hz, 2H), 7.35 – 7.25 (m, 3H), 6.10 (ddd,  $J = 16.8, 10.4, 6.0$  Hz, 1H), 5.59 (s, 2H), 5.27 (d,  $J = 10.4$  Hz, 1H), 5.10 (q,  $J = 5.6, 4.4$  Hz, 1H), 5.03 (d,  $J = 17.2$  Hz, 1H), 4.44 (t,  $J = 6.0$  Hz, 1H), 4.10 (dt,  $J = 12.0, 6.0$  Hz, 1H), 4.01 (dt,  $J = 12.0, 4.0$  Hz, 1H), 1.40 (s, 18H);  $^{13}\text{C NMR}$  (100 MHz,  $\text{CDCl}_3$ )  $\delta$  160.9, 152.6, 151.4, 150.8, 143.2, 135.8, 133.1, 128.6, 128.5, 128.3, 119.7, 119.0, 83.4, 68.8, 63.4, 60.7, 27.9; **HRMS** (ESI-TOF): exact mass calcd for  $\text{C}_{26}\text{H}_{34}\text{N}_5\text{O}_6$   $[\text{M}+\text{H}]^+$  requires  $m/z$  512.2504, found  $m/z$  512.2503.

**(S)-9-(1-hydroxybut-3-en-2-yl)-1,3-dimethyl-3,9-dihydro-1H-purine-2,6-dione (3l)**



White solid; m.p. 140.9-142.6 °C; 76.1 mg, 76% yield, 97% ee;  $[\alpha]_{\text{D}}^{23} = -65.11$  ( $c = 0.600$ ,  $\text{CHCl}_3$ ); **HPLC** CHIRALCEL OD,  $n$ -hexane/2-propanol = 60/40, flow rate = 0.4 mL/min,  $\lambda = 256$  nm, retention time: 18.970 min (major), 25.622 min (minor);  $^1\text{H NMR}$  (400 MHz,  $\text{CDCl}_3$ )  $\delta$  7.75 (s, 1H), 6.16 (ddd,  $J = 17.2, 10.4, 6.8$  Hz, 1H), 5.41 (t,  $J = 9.2$  Hz, 2H), 5.31 (d,  $J = 17.2$  Hz, 1H), 4.06 (qd,  $J = 12.0, 5.2$  Hz, 2H), 3.50 (s, 3H), 3.33 (s, 3H);  $^{13}\text{C NMR}$  (150 MHz,  $\text{CDCl}_3$ )  $\delta$  155.4, 151.5, 149.0, 141.0, 132.6, 120.5, 106.9, 64.2, 61.8, 29.9, 28.2; **HRMS** (ESI-TOF): exact mass calcd for  $\text{C}_{11}\text{H}_{15}\text{N}_4\text{O}_3$   $[\text{M}+\text{H}]^+$  requires  $m/z$  251.1139, found  $m/z$  251.1138.

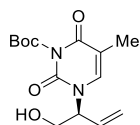
**(S)-3-benzoyl-1-(1-hydroxybut-3-en-2-yl)-5-methylpyrimidine-2,4(1H,3H)-dione (5a)**



White solid; m.p. 49.5-50.8 °C; 57.0 mg, 95% yield, 92% ee;  $[\alpha]_{\text{D}}^{23} = -1.85$  ( $c = 0.505$ ,  $\text{CHCl}_3$ ); **HPLC** CHIRALCEL IE,  $n$ -hexane/2-propanol = 70/30, flow rate = 1.0 mL/min,  $\lambda = 256$  nm, retention time: 13.050 min (minor), 14.757 min (major);  $^1\text{H NMR}$  (400 MHz,  $\text{CDCl}_3$ )  $\delta$  7.95 – 7.86 (m, 2H), 7.66 – 7.60 (m, 1H), 7.50 – 7.45 (m, 2H), 7.22 (q,  $J = 1.2$  Hz, 1H), 5.88 (ddd,  $J = 17.2, 10.8, 5.6$  Hz, 1H), 5.41 (dd,  $J = 10.8, 1.2$  Hz, 1H), 5.33 (dd,  $J = 17.2, 1.2$  Hz, 1H), 5.14 – 5.08 (m, 1H), 3.91 – 3.78 (m, 2H), 2.75 (brs, 1H), 1.92 (d,  $J = 1.2$  Hz, 3H);  $^{13}\text{C NMR}$  (150 MHz,  $\text{CDCl}_3$ )  $\delta$  169.3, 163.0, 150.6, 138.4, 135.2, 132.0, 131.6, 130.5, 129.3, 120.6, 110.7, 62.7, 59.0, 12.6; **HRMS** (ESI-TOF): exact mass calcd for  $\text{C}_{16}\text{H}_{16}\text{N}_2\text{NaO}_4$   $[\text{M}+\text{Na}]^+$  requires  $m/z$  323.1002, found  $m/z$  323.0998.

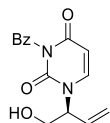


**tert-butyl (S)-3-(1-hydroxybut-3-en-2-yl)-5-methyl-2,6-dioxo-3,6-dihydropyrimidine-1(2H)-carboxylate (5b)**



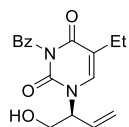
Colorless oil; 53.2 mg, 90% yield, 90% ee;  $[\alpha]_D^{23} = -12.02$  ( $c = 0.560$ ,  $\text{CHCl}_3$ ); **HPLC** CHIRALCEL IE, *n*-hexane/2-propanol = 80/20, flow rate = 1.0 mL/min,  $\lambda = 256$  nm, retention time: 11.653 min (minor), 13.247 min (major); **<sup>1</sup>H NMR** (400 MHz,  $\text{CDCl}_3$ )  $\delta$  7.14 (d,  $J = 1.2$  Hz, 1H), 5.91 (ddd,  $J = 17.2, 10.8, 5.6$  Hz, 1H), 5.42 (ddd,  $J = 10.8, 1.6, 0.8$  Hz, 1H), 5.35 (ddd,  $J = 17.2, 1.6, 0.8$  Hz, 1H), 5.15 – 5.10 (m, 1H), 3.91 (h,  $J = 6.8, 6.0$  Hz, 2H), 2.80 (s, 1H), 1.89 (d,  $J = 1.2$  Hz, 3H), 1.59 (s, 9H); **<sup>13</sup>C NMR** (150 MHz,  $\text{CDCl}_3$ )  $\delta$  161.6, 149.7, 148.3, 138.2, 132.1, 120.7, 110.2, 87.0, 62.7, 59.2, 27.5, 12.6; **HRMS** (ESI-TOF): exact mass calcd for  $\text{C}_{14}\text{H}_{20}\text{N}_2\text{NaO}_5$   $[\text{M}+\text{Na}]^+$  requires  $m/z$  319.1264, found  $m/z$  319.1258.

**(S)-3-benzoyl-1-(1-hydroxybut-3-en-2-yl)pyrimidine-2,4(1H,3H)-dione (5c)**



Colorless oil; 54.9 mg, 96% yield, 89% ee;  $[\alpha]_D^{23} = -6.27$  ( $c = 0.765$ ,  $\text{CHCl}_3$ ); **HPLC** CHIRALCEL IE, *n*-hexane/2-propanol = 60/40, flow rate = 1.0 mL/min,  $\lambda = 256$  nm, retention time: 11.888 min (minor), 14.988 min (major); **<sup>1</sup>H NMR** (400 MHz,  $\text{CDCl}_3$ )  $\delta$  8.00 – 7.87 (m, 2H), 7.67 – 7.62 (m, 1H), 7.52 – 7.46 (m, 2H), 7.43 (d,  $J = 8.0$  Hz, 1H), 5.91 (ddd,  $J = 17.2, 10.7, 5.5$  Hz, 1H), 5.78 (d,  $J = 8.0$  Hz, 1H), 5.47 – 5.42 (m, 1H), 5.40 – 5.34 (m, 1H), 5.18 – 5.11 (m, 1H), 3.88 (qd,  $J = 10.8, 10.4, 6.8$  Hz, 2H), 2.68 (s, 1H); **<sup>13</sup>C NMR** (150 MHz,  $\text{CDCl}_3$ )  $\delta$  169.0, 162.4, 150.5, 142.9, 135.3, 131.8, 131.5, 130.6, 129.4, 121.0, 101.9, 62.7, 59.2; **HRMS** (ESI-TOF): exact mass calcd for  $\text{C}_{15}\text{H}_{14}\text{N}_2\text{NaO}_4$   $[\text{M}+\text{Na}]^+$  requires  $m/z$  309.0846, found  $m/z$  309.0842.

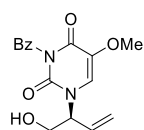
**(S)-3-benzoyl-5-ethyl-1-(1-hydroxybut-3-en-2-yl)pyrimidine-2,4(1H,3H)-dione (5d)**



Colorless oil; 59.6 mg, 95% yield, 93% ee;  $[\alpha]_D^{23} = -1.04$  ( $c = 0.575$ ,  $\text{CHCl}_3$ ); **HPLC** CHIRALCEL IE, *n*-hexane/2-propanol = 80/20, flow rate = 1.0 mL/min,  $\lambda = 256$  nm, retention time: 19.610 min

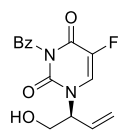
(minor), 21.112 min (major); **<sup>1</sup>H NMR** (600 MHz, CDCl<sub>3</sub>) δ 7.91 (d, *J* = 7.8 Hz, 2H), 7.63 (t, *J* = 7.2 Hz, 1H), 7.48 (t, *J* = 7.8 Hz, 2H), 7.18 (s, 1H), 5.90 (ddd, *J* = 16.8, 10.8, 5.4 Hz, 1H), 5.42 (d, *J* = 10.8 Hz, 1H), 5.34 (d, *J* = 17.4 Hz, 1H), 5.12 (q, *J* = 5.4 Hz, 1H), 3.89 (dd, *J* = 11.4, 3.6 Hz, 1H), 3.87 – 3.81 (m, 1H), 2.63 (s, 1H), 2.36 (qd, *J* = 7.8, 3.0 Hz, 2H), 1.12 (t, *J* = 7.2 Hz, 3H); **<sup>13</sup>C NMR** (150 MHz, CDCl<sub>3</sub>) δ 169.4, 162.6, 150.6, 137.7, 135.2, 132.0, 131.7, 130.5, 129.3, 120.6, 116.5, 62.8, 59.1, 20.3, 12.8; **HRMS** (ESI-TOF): exact mass calcd for C<sub>17</sub>H<sub>19</sub>N<sub>2</sub>O<sub>4</sub> [M+H]<sup>+</sup> requires *m/z* 315.1339, found *m/z* 315.1334.

**(S)-3-benzoyl-1-(1-hydroxybut-3-en-2-yl)-5-methoxypyrimidine-2,4(1*H*,3*H*)-dione (5e)**



Colorless oil; 58.8 mg, 93% yield, 94% ee; [α]<sub>D</sub><sup>23</sup> = -4.31 (c = 0.650, CHCl<sub>3</sub>); **HPLC** CHIRALCEL AS, *n*-hexane/2-propanol = 70/30, flow rate = 1.0 mL/min, λ = 256 nm, retention time: 11.307 min (major), 14.690 min (minor); **<sup>1</sup>H NMR** (600 MHz, CDCl<sub>3</sub>) δ 7.91 (d, *J* = 7.8 Hz, 2H), 7.64 (t, *J* = 7.8 Hz, 1H), 7.48 (t, *J* = 7.8 Hz, 2H), 7.02 (s, 1H), 5.89 (ddd, *J* = 16.8, 10.8, 5.4 Hz, 1H), 5.43 (d, *J* = 10.8 Hz, 1H), 5.35 (d, *J* = 17.8 Hz, 1H), 5.17 – 5.12 (m, 1H), 3.90 (dd, *J* = 12.0, 4.2 Hz, 1H), 3.85 (dd, *J* = 12.0, 7.2 Hz, 1H), 3.72 (s, 3H), 2.83 (s, 1H); **<sup>13</sup>C NMR** (150 MHz, CDCl<sub>3</sub>) δ 168.4, 158.7, 149.2, 136.1, 135.4, 131.9, 131.4, 130.6, 129.3, 123.0, 120.7, 62.7, 59.1, 58.1; **HRMS** (ESI-TOF): exact mass calcd for C<sub>16</sub>H<sub>16</sub>N<sub>2</sub>NaO<sub>5</sub> [M+Na]<sup>+</sup> requires *m/z* 339.0951, found *m/z* 339.0946.

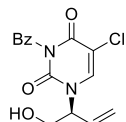
**(S)-3-benzoyl-5-fluoro-1-(1-hydroxybut-3-en-2-yl)pyrimidine-2,4(1*H*,3*H*)-dione (5f)**



Colorless oil; 57.6 mg, 95% yield, 90% ee; [α]<sub>D</sub><sup>23</sup> = -2.35 (c = 0.510, CHCl<sub>3</sub>); **HPLC** CHIRALCEL IE, *n*-hexane/2-propanol = 80/20, flow rate = 1.0 mL/min, λ = 256 nm, retention time: 21.060 min (minor), 22.550 min (major); **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>) δ 8.00 – 7.84 (m, 2H), 7.70 – 7.64 (m, 1H), 7.57 (d, *J* = 6.0 Hz, 1H), 7.54 – 7.47 (m, 2H), 5.91 (ddd, *J* = 17.6, 10.8, 5.6 Hz, 1H), 5.49 (dd, *J* = 10.8, 1.6 Hz, 1H), 5.41 (dd, *J* = 17.2, 1.6 Hz, 1H), 5.18 (dt, *J* = 5.6, 4.0, 1.6 Hz, 1H), 3.96 (dd, *J* = 12.0, 4.0 Hz, 1H), 3.88 (dd, *J* = 12.0, 6.4 Hz, 1H), 2.45 (s, 1H); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>) δ 167.5, 156.3 (*J*<sub>C-F</sub> = 27.0 Hz), 149.1, 139.9 (*J*<sub>C-F</sub> = 238.0 Hz), 135.7, 131.3, 131.1, 130.7, 129.5, 127.2

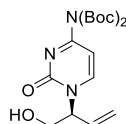
( $J_{C-F}$  = 33.0 Hz), 121.5, 62.7, 59.0;  $^{19}\text{F}$  NMR (376 MHz,  $\text{CDCl}_3$ )  $\delta$  -164.58 (s); HRMS (ESI-TOF): exact mass calcd for  $\text{C}_{15}\text{H}_{13}\text{FN}_2\text{NaO}_4$   $[\text{M}+\text{Na}]^+$  requires  $m/z$  327.0752, found  $m/z$  327.0750.

**(S)-3-benzoyl-5-chloro-1-(1-hydroxybut-3-en-2-yl)pyrimidine-2,4(1H,3H)-dione (5g)**



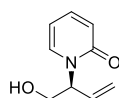
White waxy solid; m.p. 65.0-70.0 °C; 59.0 mg, 92% yield, 88% ee;  $[\alpha]_{\text{D}}^{23}$  = -6.38 ( $c$  = 0.690,  $\text{CHCl}_3$ ); HPLC CHIRALCEL ID,  $n$ -hexane/2-propanol = 70/30, flow rate = 1.0 mL/min,  $\lambda$  = 256 nm, retention time: 9.748 min (minor), 10.738 min (major);  $^1\text{H}$  NMR (600 MHz,  $\text{CDCl}_3$ )  $\delta$  7.92 (d,  $J$  = 7.8 Hz, 2H), 7.71 – 7.63 (m, 2H), 7.50 (t,  $J$  = 7.8 Hz, 2H), 5.93 (ddd,  $J$  = 16.8, 10.8, 5.4 Hz, 1H), 5.51 (d,  $J$  = 10.8 Hz, 1H), 5.43 (d,  $J$  = 17.4 Hz, 1H), 5.19 (q,  $J$  = 6.0 Hz, 1H), 3.97 (dt,  $J$  = 12.0, 3.6 Hz, 1H), 3.92 (dt,  $J$  = 11.4, 4.8 Hz, 1H), 2.29 (s, 1H);  $^{13}\text{C}$  NMR (150 MHz,  $\text{CDCl}_3$ )  $\delta$  167.8, 158.3, 149.6, 139.8, 135.6, 131.4, 131.1, 130.7, 129.4, 121.7, 108.6, 62.7, 59.4; HRMS (ESI-TOF): exact mass calcd for  $\text{C}_{15}\text{H}_{13}\text{ClN}_2\text{NaO}_4$   $[\text{M}+\text{Na}]^+$  requires  $m/z$  343.0456, found  $m/z$  343.0452.

**(S)-4-(diBocamino)-1-(1-hydroxybut-3-en-2-yl)pyrimidin-2(1H)-one (5h)**



White solid; m.p. 118.2-119.5 °C; 72.2 mg, 95% yield, 84% ee;  $[\alpha]_{\text{D}}^{23}$  = -41.10 ( $c$  = 0.725,  $\text{CHCl}_3$ ); HPLC CHIRALCEL ID,  $n$ -hexane/2-propanol = 60/40, flow rate = 0.5 mL/min,  $\lambda$  = 256 nm, retention time: 12.065 min (minor), 13.032 min (major);  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ )  $\delta$  7.69 (d,  $J$  = 7.2 Hz, 1H), 7.04 (d,  $J$  = 7.2 Hz, 1H), 5.98 (ddd,  $J$  = 17.2, 10.8, 5.6 Hz, 1H), 5.37 (d,  $J$  = 10.8 Hz, 1H), 5.31 (d,  $J$  = 17.2 Hz, 1H), 5.27 – 5.20 (m, 1H), 4.01 – 3.86 (m, 2H), 3.67 (s, 1H), 1.54 (s, 18H);  $^{13}\text{C}$  NMR (150 MHz,  $\text{CDCl}_3$ )  $\delta$  161.9, 155.9, 149.7, 147.2, 132.8, 120.3, 96.3, 85.1, 62.5, 61.1, 27.8; HRMS (ESI-TOF): exact mass calcd for  $\text{C}_{18}\text{H}_{27}\text{N}_3\text{NaO}_6$   $[\text{M}+\text{Na}]^+$  requires  $m/z$  404.1792, found  $m/z$  404.1789.

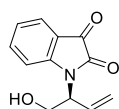
**(S)-1-(1-hydroxybut-3-en-2-yl)pyridin-2(1H)-one (7a)**



White solid; m.p. 88.2-90.1 °C; 55.4 mg, 84% yield, 75% ee;  $[\alpha]_{\text{D}}^{23}$  = -86.90 ( $c$  = 0.290,  $\text{CHCl}_3$ );

**HPLC** CHIRALCEL IG, *n*-hexane/2-propanol = 80/20, flow rate = 0.4 mL/min,  $\lambda$  = 240 nm, retention time: 22.160 min (minor), 23.753 min (major); **<sup>1</sup>H NMR** (600 MHz, CDCl<sub>3</sub>)  $\delta$  7.37 (d,  $J$  = 6.6 Hz, 1H), 7.30 (t,  $J$  = 7.2 Hz, 1H), 6.53 (d,  $J$  = 9.0 Hz, 1H), 6.21 (t,  $J$  = 6.6 Hz, 1H), 5.97 (ddd,  $J$  = 16.8, 10.8, 5.4 Hz, 1H), 5.54 (q,  $J$  = 5.4 Hz, 1H), 5.35 (d,  $J$  = 10.8 Hz, 1H), 5.25 (d,  $J$  = 17.4 Hz, 1H), 4.10 (t,  $J$  = 6.0 Hz, 1H), 3.96 (dt,  $J$  = 12.0, 4.2 Hz, 1H), 3.89 (dt,  $J$  = 12.0, 6.0 Hz, 1H); **<sup>13</sup>C NMR** (150 MHz, CDCl<sub>3</sub>)  $\delta$  163.3, 139.6, 135.8, 133.3, 120.6, 119.6, 106.6, 63.3, 59.4; **HRMS** (ESI-TOF): exact mass calcd for C<sub>9</sub>H<sub>11</sub>NNaO<sub>2</sub> [M+Na]<sup>+</sup> requires *m/z* 188.0682, found *m/z* 188.0677.

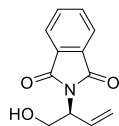
**(S)-1-(1-hydroxybut-3-en-2-yl)indoline-2,3-dione (7b)**



Red solid; m.p. 102.7-104.5 °C; 57.2 mg, 66% yield, 96% ee;  $[\alpha]_D^{23}$  = 58.00 (*c* = 0.500, CHCl<sub>3</sub>);

**HPLC** CHIRALCEL OD, *n*-hexane/2-propanol = 90/10, flow rate = 1.0 mL/min,  $\lambda$  = 256 nm, retention time: 17.402 min (major), 20.738 min (minor); **<sup>1</sup>H NMR** (600 MHz, CDCl<sub>3</sub>)  $\delta$  7.61 (d,  $J$  = 7.2 Hz, 1H), 7.55 (t,  $J$  = 7.8 Hz, 1H), 7.12 (t,  $J$  = 7.8 Hz, 1H), 6.99 (d,  $J$  = 7.8 Hz, 1H), 6.02 (ddd,  $J$  = 16.6, 10.8, 5.8 Hz, 1H), 5.37 (d,  $J$  = 10.8 Hz, 1H), 5.33 (d,  $J$  = 17.4 Hz, 1H), 4.79 (q,  $J$  = 6.0 Hz, 1H), 4.21 (t,  $J$  = 10.2 Hz, 1H), 4.05 (dd,  $J$  = 12.0, 4.2 Hz, 1H), 2.85 (s, 1H); **<sup>13</sup>C NMR** (150 MHz, CDCl<sub>3</sub>)  $\delta$  183.0, 158.9, 150.8, 138.3, 131.1, 125.7, 124.0, 119.5, 118.1, 112.1, 61.9, 58.2; **HRMS** (ESI-TOF): exact mass calcd for C<sub>12</sub>H<sub>11</sub>NNaO<sub>3</sub> [M+Na]<sup>+</sup> requires *m/z* 240.0631, found *m/z* 240.0628.

**(S)-2-(1-hydroxybut-3-en-2-yl)isoindoline-1,3-dione (7c)**

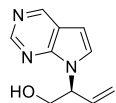


White solid; m.p. 64.9-66.6 °C; 70.3 mg, 81% yield, 96% ee;  $[\alpha]_D^{23}$  = -62.22 (*c* = 0.585, CHCl<sub>3</sub>);

**HPLC** CHIRALCEL OD, *n*-hexane/2-propanol = 70/30, flow rate = 1.0 mL/min,  $\lambda$  = 256 nm, retention time: 5.817 min (minor), 6.797 min (major); **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$  7.78 (dd,  $J$  = 5.6, 2.8 Hz, 2H), 7.70 – 7.65 (m, 2H), 6.11 (ddd,  $J$  = 17.2, 10.4, 6.8 Hz, 1H), 5.26 (dt,  $J$  = 4.8, 1.2 Hz, 1H), 5.22 (p,  $J$  = 1.2 Hz, 1H), 4.88 (dddt,  $J$  = 8.4, 7.2, 4.8, 1.2 Hz, 1H), 4.12 (dt,  $J$  = 11.6, 8.0 Hz, 1H), 3.91 (dt,  $J$  = 11.6, 4.0 Hz, 1H), 3.06 (dd,  $J$  = 8.0, 4.0 Hz, 1H); **<sup>13</sup>C NMR** (150 MHz, CDCl<sub>3</sub>)  $\delta$  168.6, 134.2, 132.1, 131.8, 123.4, 118.9, 62.7, 56.0; **HRMS** (ESI-TOF): exact mass calcd for

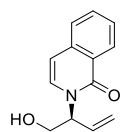
C<sub>12</sub>H<sub>11</sub>NNaO<sub>3</sub> [M+Na]<sup>+</sup> requires m/z 240.0631, found m/z 240.0629.

**(S)-2-(7H-pyrrolo[2,3-d]pyrimidin-7-yl)but-3-en-1-ol (7d)**



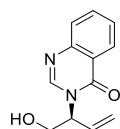
Colorless oil; 59.7 mg, 79% yield, 92% ee;  $[\alpha]_D^{23} = -59.48$  (c = 0.575, CHCl<sub>3</sub>); **HPLC** CHIRALCEL IG, *n*-hexane/2-propanol = 80/20, flow rate = 0.7 mL/min,  $\lambda = 256$  nm, retention time: 16.857 min (minor), 18.233 min (major); **<sup>1</sup>H NMR** (600 MHz, CDCl<sub>3</sub>)  $\delta$  8.79 (s, 1H), 8.68 (s, 1H), 7.32 (d, *J* = 3.6 Hz, 1H), 6.54 (d, *J* = 3.6 Hz, 1H), 6.14 (ddd, *J* = 16.8, 10.8, 6.0 Hz, 1H), 5.31 (p, *J* = 4.2 Hz, 1H), 5.27 (d, *J* = 10.8 Hz, 1H), 5.02 (d, *J* = 17.4 Hz, 2H), 4.15 (dd, *J* = 12.0, 6.6 Hz, 1H), 4.10 (dd, *J* = 12.0, 3.6 Hz, 1H); **<sup>13</sup>C NMR** (150 MHz, CDCl<sub>3</sub>)  $\delta$  150.7, 150.1, 149.3, 133.8, 129.0, 119.3, 118.5, 100.0, 64.0, 60.8; **HRMS** (ESI-TOF): exact mass calcd for C<sub>10</sub>H<sub>12</sub>N<sub>3</sub>O [M+H]<sup>+</sup> requires m/z 190.0975, found m/z 190.0975.

**(S)-2-(1-hydroxybut-3-en-2-yl)isoquinolin-1(2H)-one (7e)**



Colorless oil; 55.0 mg, 64% yield, 79% ee;  $[\alpha]_D^{23} = -69.70$  (c = 0.505, CHCl<sub>3</sub>); **HPLC** CHIRALCEL IG, *n*-hexane/2-propanol = 70/30, flow rate = 1.0 mL/min,  $\lambda = 256$  nm, retention time: 8.133 min (minor), 9.602 min (major); **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$  8.36 (d, *J* = 7.6 Hz, 1H), 7.60 (ddd, *J* = 8.0, 6.8, 1.2 Hz, 1H), 7.50 – 7.40 (m, 2H), 7.15 (d, *J* = 7.6 Hz, 1H), 6.52 (d, *J* = 7.6 Hz, 1H), 6.00 (ddd, *J* = 17.2, 10.8, 5.2 Hz, 1H), 5.67 (dt, *J* = 6.8, 5.2, 2.0 Hz, 1H), 5.35 (ddd, *J* = 10.8, 2.0, 0.8 Hz, 1H), 5.26 (ddd, *J* = 17.2, 2.0, 0.8 Hz, 1H), 4.04 (dd, *J* = 11.6, 4.8 Hz, 1H), 3.96 (t, *J* = 9.6 Hz, 1H), 3.62 (s, 1H); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$  163.0, 136.8, 133.5, 132.5, 129.1, 128.1, 127.0, 126.0, 125.9, 119.3, 106.7, 63.6, 59.1; **HRMS** (ESI-TOF): exact mass calcd for C<sub>13</sub>H<sub>14</sub>NO<sub>2</sub> [M+H]<sup>+</sup> requires m/z 216.1019, found m/z 216.1021.

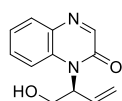
**(S)-3-(1-hydroxybut-3-en-2-yl)quinazolin-4(3H)-one (7f)**



White solid; m.p. 79.9-81.5 °C; 71.7 mg, 83% yield, 88% ee;  $[\alpha]_D^{23} = -75.96$  (c = 0.545, CHCl<sub>3</sub>);

**HPLC** CHIRALCEL IG, *n*-hexane/2-propanol = 70/30, flow rate = 1.0 mL/min,  $\lambda$  = 256 nm, retention time: 8.798 min (major), 10.423 min (minor); **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$  8.11 (s, 1H), 8.07 (dd,  $J$  = 8.0, 1.6 Hz, 1H), 7.63 (ddd,  $J$  = 8.4, 7.2, 1.6 Hz, 1H), 7.51 (d,  $J$  = 7.8 Hz, 1H), 7.35 (ddd,  $J$  = 8.0, 7.2, 1.2 Hz, 1H), 6.08 (ddd,  $J$  = 17.2, 10.8, 6.0 Hz, 1H), 5.47 – 5.39 (m, 2H), 5.36 (ddd,  $J$  = 17.2, 1.6, 0.8 Hz, 1H), 4.30 (s, 1H), 4.09 (qd,  $J$  = 12.0, 5.2 Hz, 2H); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$  161.2, 147.0, 145.9, 134.5, 132.7, 127.4, 126.9, 126.8, 121.6, 120.4, 62.7, 58.6; **HRMS** (ESI-TOF): exact mass calcd for C<sub>12</sub>H<sub>13</sub>N<sub>2</sub>O<sub>2</sub> [M+H]<sup>+</sup> requires *m/z* 217.0972, found *m/z* 217.0971.

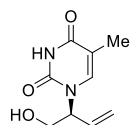
**(S)-1-(1-hydroxybut-3-en-2-yl)quinoxalin-2(1H)-one (7g)**



White solid; m.p. 112.5-114.4 °C; 82.0 mg, 95% yield, 99% ee;  $[\alpha]_D^{23}$  = -77.04 (*c* = 0.540, CHCl<sub>3</sub>);

**HPLC** CHIRALCEL AS, *n*-hexane/2-propanol = 80/20, flow rate = 1.0 mL/min,  $\lambda$  = 256 nm, retention time: 7.980 min (minor), 9.965 min (major); **<sup>1</sup>H NMR** (600 MHz, CDCl<sub>3</sub>)  $\delta$  8.20 (s, 1H), 7.85 (d,  $J$  = 7.8 Hz, 1H), 7.53 – 7.49 (m, 2H), 7.33 (ddd,  $J$  = 8.4, 5.4, 2.4 Hz, 1H), 6.20 (ddd,  $J$  = 17.4, 10.8, 4.8 Hz, 1H), 5.71 (s, 1H), 5.35 – 5.32 (m, 1H), 5.23 – 5.19 (m, 1H), 4.31 (dt,  $J$  = 12.0, 6.6 Hz, 1H), 4.17 (d,  $J$  = 9.4 Hz, 1H), 3.51 (s, 1H); **<sup>13</sup>C NMR** (150 MHz, CDCl<sub>3</sub>)  $\delta$  155.9, 150.5, 134.2, 132.4, 132.2, 131.0, 130.8, 124.1, 118.6, 115.2, 62.4, 59.7; **HRMS** (ESI-TOF): exact mass calcd for C<sub>12</sub>H<sub>12</sub>N<sub>2</sub>NaO<sub>2</sub> [M+Na]<sup>+</sup> requires *m/z* 239.0791, found *m/z* 239.0789.

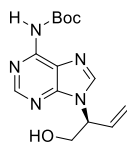
**(S)-1-(1-hydroxybut-3-en-2-yl)-5-methylpyrimidine-2,4(1H,3H)-dione (5aa)**



White solid; m.p. 139.5-141.2 °C; 37.7 mg, 96% yield, 92% ee;  $[\alpha]_D^{23}$  = -2.95 (*c* = 0.745, CHCl<sub>3</sub>);

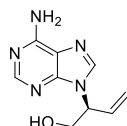
**HPLC** CHIRALCEL ID, *n*-hexane/2-propanol = 70/30, flow rate = 1.0 mL/min,  $\lambda$  = 256 nm, retention time: 11.372 min (minor), 12.470 min (major); **<sup>1</sup>H NMR** (600 MHz, CDCl<sub>3</sub>)  $\delta$  9.99 (s, 1H), 7.10 (d,  $J$  = 1.2 Hz, 1H), 5.91 (ddd,  $J$  = 17.4, 10.8, 5.4 Hz, 1H), 5.43 – 5.39 (m, 1H), 5.35 (dd,  $J$  = 17.4, 1.2 Hz, 1H), 5.21 – 5.17 (m, 1H), 4.00 (dt,  $J$  = 12.0, 4.8 Hz, 1H), 3.89 (dt,  $J$  = 12.0, 6.6 Hz, 1H), 3.71 (t,  $J$  = 6.0 Hz, 1H), 1.86 (d,  $J$  = 1.2 Hz, 3H); **<sup>13</sup>C NMR** (150 MHz, CDCl<sub>3</sub>)  $\delta$  164.4, 152.1, 138.7, 132.4, 120.4, 110.6, 62.6, 59.2, 12.6; **HRMS** (ESI-TOF): exact mass calcd for C<sub>9</sub>H<sub>12</sub>N<sub>2</sub>NaO<sub>3</sub> [M+Na]<sup>+</sup> requires *m/z* 219.0740, found *m/z* 219.0739.

***tert*-butyl (*S*)-(9-(1-hydroxybut-3-en-2-yl)-9*H*-purin-6-yl)carbamate (3ga)**



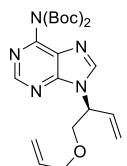
White solid; m.p. 118.2-119.6 °C; 58.0 mg, 95% yield; <sup>1</sup>H NMR (600 MHz, CDCl<sub>3</sub>) δ 8.65 (s, 1H), 8.28 (s, 1H), 7.99 (s, 1H), 6.19 (ddd, *J* = 16.8, 10.8, 6.6 Hz, 1H), 5.38 (d, *J* = 10.8 Hz, 1H), 5.19 – 5.13 (m, 2H), 4.60 (s, 1H), 4.24 (dd, *J* = 12.0, 6.0 Hz, 1H), 4.15 (dd, *J* = 12.6, 3.0 Hz, 1H), 1.55 (s, 9H); <sup>13</sup>C NMR (150 MHz, CDCl<sub>3</sub>) δ 152.5, 150.7, 150.1, 149.9, 142.7, 132.8, 121.8, 119.7, 82.5, 63.8, 61.4, 28.3; HRMS (ESI-TOF): exact mass calcd for C<sub>14</sub>H<sub>20</sub>N<sub>5</sub>O<sub>3</sub> [M+H]<sup>+</sup> requires *m/z* 306.1561, found *m/z* 306.1557.

**(*S*)-2-(6-amino-9*H*-purin-9-yl)but-3-en-1-ol (3gb)**



White solid; m.p. 163.2-164.7 °C; 39.1 mg, 95% yield, 94% ee; [α]<sub>D</sub><sup>20</sup> = -55.28 (c = 0.615, CH<sub>3</sub>OH); HPLC CHIRALCEL IG, *n*-hexane/2-propanol = 70/30, flow rate = 1.0 mL/min, λ = 256 nm, retention time: 17.220 min (minor), 19.225 min (major); <sup>1</sup>H NMR (600 MHz, Methanol-*d*<sub>4</sub>) δ 8.22 (s, 1H), 8.19 (s, 1H), 6.26 (ddd, *J* = 17.4, 10.2, 6.6 Hz, 1H), 5.33 (dt, *J* = 10.8, 1.2 Hz, 1H), 5.23 – 5.20 (m, 1H), 5.17 (dt, *J* = 17.4, 1.2 Hz, 1H), 4.13 (dd, *J* = 12.0, 7.2 Hz, 1H), 3.98 (dd, *J* = 12.0, 4.2 Hz, 1H); <sup>13</sup>C NMR (150 MHz, Methanol-*d*<sub>4</sub>) δ 157.3, 153.5, 150.7, 142.0, 134.7, 120.0, 119.3, 64.0, 61.2; HRMS (ESI-TOF): exact mass calcd for C<sub>9</sub>H<sub>12</sub>N<sub>5</sub>O [M+H]<sup>+</sup> requires *m/z* 206.1036, found *m/z* 206.1035.

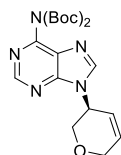
**(*S*)-9-(1-(allyloxy)but-3-en-2-yl)-9*H*-purin-6-diBocamine (3gc)**



Colorless oil; 80.2 mg, 90% yield; <sup>1</sup>H NMR (600 MHz, CDCl<sub>3</sub>) δ 8.82 (s, 1H), 8.24 (s, 1H), 6.21 (ddd, *J* = 16.8, 10.8, 6.0 Hz, 1H), 5.79 – 5.70 (m, 1H), 5.43 – 5.40 (m, 1H), 5.35 (dd, *J* = 10.8, 1.2 Hz, 1H), 5.19 (dd, *J* = 16.8, 1.2 Hz, 1H), 5.16 (dd, *J* = 17.4, 1.8 Hz, 1H), 5.12 (dd, *J* = 10.2, 1.2 Hz, 1H), 3.98 (dd, *J* = 10.2, 6.0 Hz, 1H), 3.96 – 3.91 (m, 2H), 3.82 (dd, *J* = 10.2, 4.2 Hz, 1H), 1.43 (s,

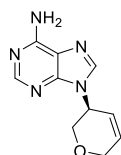
18H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ )  $\delta$  153.3, 151.9, 150.6, 150.3, 144.7, 133.7, 132.8, 128.8, 119.5, 117.9, 83.7, 72.4, 70.6, 57.2, 27.9; **HRMS** (ESI-TOF): exact mass calcd for  $\text{C}_{22}\text{H}_{31}\text{N}_5\text{NaO}_5$   $[\text{M}+\text{Na}]^+$  requires  $m/z$  468.2217, found  $m/z$  468.2221.

**(S)-9-(3,6-dihydro-2H-pyran-3-yl)-9H-purin-6-diBocamine (3gd)**



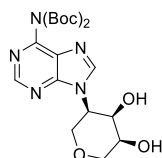
Colorless oil; 73.4 mg, 88% yield, 94% ee;  $[\alpha]_{\text{D}}^{23} = 53.55$  ( $c = 0.600$ ,  $\text{CHCl}_3$ ); **HPLC** CHIRALCEL IE, *n*-hexane/2-propanol = 70/30, flow rate = 1.0 mL/min,  $\lambda = 256$  nm, retention time: 22.153 min (minor), 23.503 min (major);  $^1\text{H}$  NMR (600 MHz,  $\text{CDCl}_3$ )  $\delta$  8.84 (s, 1H), 8.26 (s, 1H), 6.31 (ddt,  $J = 10.2, 3.6, 1.8$  Hz, 1H), 6.05 – 6.02 (m, 1H), 5.21 – 5.18 (m, 1H), 4.38 (dddd,  $J = 17.2, 3.6, 2.4, 1.2$  Hz, 1H), 4.27 (dq,  $J = 17.2, 2.4$  Hz, 1H), 4.04 (dt,  $J = 12.0, 1.8$  Hz, 1H), 4.01 (dd,  $J = 12.0, 3.0$  Hz, 1H), 1.45 (s, 18H);  $^{13}\text{C}$  NMR (150 MHz,  $\text{CDCl}_3$ )  $\delta$  153.0, 152.0, 150.7, 150.4, 144.4, 133.5, 129.1, 121.4, 83.8, 68.5, 65.4, 47.4, 27.9; **HRMS** (ESI-TOF): exact mass calcd for  $\text{C}_{20}\text{H}_{28}\text{N}_5\text{O}_5$   $[\text{M}+\text{H}]^+$  requires  $m/z$  418.2085, found  $m/z$  418.2081.

**(S)-9-(3,6-dihydro-2H-pyran-3-yl)-9H-purin-6-amine (3ge)**



White solid; m.p. 192.6-194.4 °C; 41.2 mg, 95% yield, 95% ee;  $[\alpha]_{\text{D}}^{20} = 92.36$  ( $c = 0.550$ ,  $\text{CH}_3\text{OH}$ ); **HPLC** CHIRALCEL IF, *n*-hexane/2-propanol = 50/50, flow rate = 1.0 mL/min,  $\lambda = 256$  nm, retention time: 24.745 min (minor), 32.330 min (major);  $^1\text{H}$  NMR (400 MHz, Methanol- $d_4$ )  $\delta$  8.22 (s, 1H), 8.14 (s, 1H), 6.34 (ddt,  $J = 10.0, 3.2, 1.6$  Hz, 1H), 6.06 (ddt,  $J = 10.0, 4.8, 2.0$  Hz, 1H), 5.09 (s, 1H), 4.39 – 4.33 (m, 1H), 4.28 – 4.22 (m, 1H), 4.00 (t,  $J = 3.2$  Hz, 2H);  $^{13}\text{C}$  NMR (150 MHz,  $\text{CDCl}_3$ )  $\delta$  157.3, 153.7, 150.1, 141.7, 134.6, 122.1, 120.1, 69.2, 66.4, 48.9; **HRMS** (ESI-TOF): exact mass calcd for  $\text{C}_{10}\text{H}_{12}\text{N}_5\text{O}$   $[\text{M}+\text{H}]^+$  requires  $m/z$  218.1036, found  $m/z$  218.1039.

**(3S,4R,5R)-5-(6-diBocamino-9H-purin-9-yl)tetrahydro-2H-pyran-3,4-diol (3gf)**

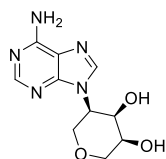


White solid; m.p. 124.6-126.3 °C; 79.3 mg, 88% yield, 93% ee, >20:1 dr;  $[\alpha]_{\text{D}}^{20} = 37.62$  ( $c = 0.505$ ,



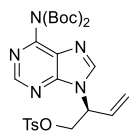
CHCl<sub>3</sub>); **HPLC** CHIRALCEL OD, *n*-hexane/2-propanol = 70/30, flow rate = 1.0 mL/min, λ = 256 nm, retention time: 5.005 min (minor), 8.857 min (major); **<sup>1</sup>H NMR** (600 MHz, CDCl<sub>3</sub>) δ 8.77 (s, 1H), 8.05 (s, 1H), 4.78 (td, *J* = 9.6, 4.8 Hz, 1H), 4.46 (dt, *J* = 9.6, 4.2 Hz, 1H), 4.11 (dd, *J* = 11.4, 4.8 Hz, 1H), 4.08 – 3.99 (m, 3H), 3.97 (s, 1H), 3.71 (dd, *J* = 12.6, 1.8 Hz, 1H), 3.52 (s, 1H), 1.46 (s, 18H); **<sup>13</sup>C NMR** (150 MHz, CDCl<sub>3</sub>) δ 153.6, 151.9, 150.9, 150.4, 145.2, 129.2, 84.5, 70.5, 69.4, 68.4, 67.4, 56.2, 28.0; **HRMS** (ESI-TOF): exact mass calcd for C<sub>20</sub>H<sub>30</sub>N<sub>5</sub>O<sub>7</sub> [M+H]<sup>+</sup> requires *m/z* 452.2140, found *m/z* 452.2137.

**(3*S*,4*R*,5*R*)-5-(6-amino-9*H*-purin-9-yl)tetrahydro-2*H*-pyran-3,4-diol (3gg)**



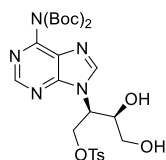
White solid; m.p. 265.5-267.2 °C; 46.0 mg, 92% yield; **<sup>1</sup>H NMR** (600 MHz, Methanol-*d*<sub>4</sub>) δ 8.18 (s, 2H), 4.78 (td, *J* = 10.2, 4.8 Hz, 1H), 4.46 (dd, *J* = 10.2, 3.0 Hz, 1H), 4.06 (dd, *J* = 11.4, 4.8 Hz, 1H), 4.02 – 3.92 (m, 3H), 3.74 (dd, *J* = 12.0, 1.2 Hz, 1H); **<sup>13</sup>C NMR** (150 MHz, CDCl<sub>3</sub>) δ 157.3, 153.5, 151.2, 142.4, 120.4, 72.0, 70.8, 70.1, 68.8, 56.4; **HRMS** (ESI-TOF): exact mass calcd for C<sub>10</sub>H<sub>14</sub>N<sub>5</sub>O<sub>3</sub> [M+H]<sup>+</sup> requires *m/z* 252.1091, found *m/z* 252.1093.

**(*S*)-2-(6-diBocamino-9*H*-purin-9-yl)but-3-en-1-yl 4-methylbenzenesulfonate (3gh)**



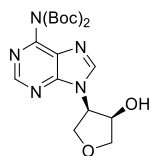
White solid; m.p. 52.2-54.7 °C; 104.0 mg, 93% yield; **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>) δ 8.62 (s, 1H), 8.03 (s, 1H), 7.51 (d, *J* = 8.0 Hz, 2H), 7.22 (d, *J* = 8.0 Hz, 2H), 6.18 (ddd, *J* = 17.2, 10.4, 6.4 Hz, 1H), 5.44 (d, *J* = 10.4 Hz, 1H), 5.37 (q, *J* = 6.4 Hz, 1H), 5.31 (d, *J* = 17.2 Hz, 1H), 4.66 (dd, *J* = 10.8, 7.2 Hz, 1H), 4.43 (dd, *J* = 10.8, 4.0 Hz, 1H), 2.40 (s, 3H), 1.47 (s, 18H); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>) δ 152.8, 151.8, 150.7, 150.5, 145.7, 144.0, 131.6, 130.1, 128.9, 127.8, 121.8, 84.0, 68.3, 57.4, 27.9, 21.7; **HRMS** (ESI-TOF): exact mass calcd for C<sub>26</sub>H<sub>34</sub>N<sub>5</sub>O<sub>7</sub>S [M+H]<sup>+</sup> requires *m/z* 560.2173, found *m/z* 560.2172.

**(2*R*,3*R*)-2-(6-diBocamino-9*H*-purin-9-yl)-3,4-dihydroxybutyl 4-methylbenzenesulfonate (3gi)**



White solid; m.p. 128.4-129.9 °C; 109.2 mg, 92% yield, 96% ee, >20:1 dr;  $[\alpha]_D^{23} = 2.17$  (c = 0.400, CHCl<sub>3</sub>); **HPLC** CHIRALCEL ID, *n*-hexane/2-propanol = 70/30, flow rate = 1.0 mL/min,  $\lambda = 256$  nm, retention time: 9.662 min (major), 15.002 min (minor); **<sup>1</sup>H NMR** (600 MHz, CDCl<sub>3</sub>)  $\delta$  8.65 (s, 1H), 8.10 (s, 1H), 7.54 (d, *J* = 8.4 Hz, 2H), 7.24 (d, *J* = 7.8 Hz, 2H), 5.06 (dt, *J* = 9.0, 4.2 Hz, 1H), 4.58 (dd, *J* = 11.4, 9.0 Hz, 1H), 4.52 (dd, *J* = 10.8, 4.8 Hz, 1H), 4.20 (td, *J* = 6.0, 4.2 Hz, 1H), 3.41 (dd, *J* = 11.2, 6.0 Hz, 1H), 3.20 (dd, *J* = 11.2, 6.6 Hz, 1H), 2.40 (s, 3H), 1.47 (s, 18H); **<sup>13</sup>C NMR** (150 MHz, CDCl<sub>3</sub>)  $\delta$  153.1, 151.6, 150.6, 145.7, 145.7, 131.7, 130.2, 128.5, 127.8, 84.4, 70.1, 67.7, 62.9, 57.0, 27.9, 21.7; **HRMS** (ESI-TOF): exact mass calcd for C<sub>26</sub>H<sub>36</sub>N<sub>5</sub>O<sub>9</sub>S [M+H]<sup>+</sup> requires *m/z* 594.2228, found *m/z* 594.2226.

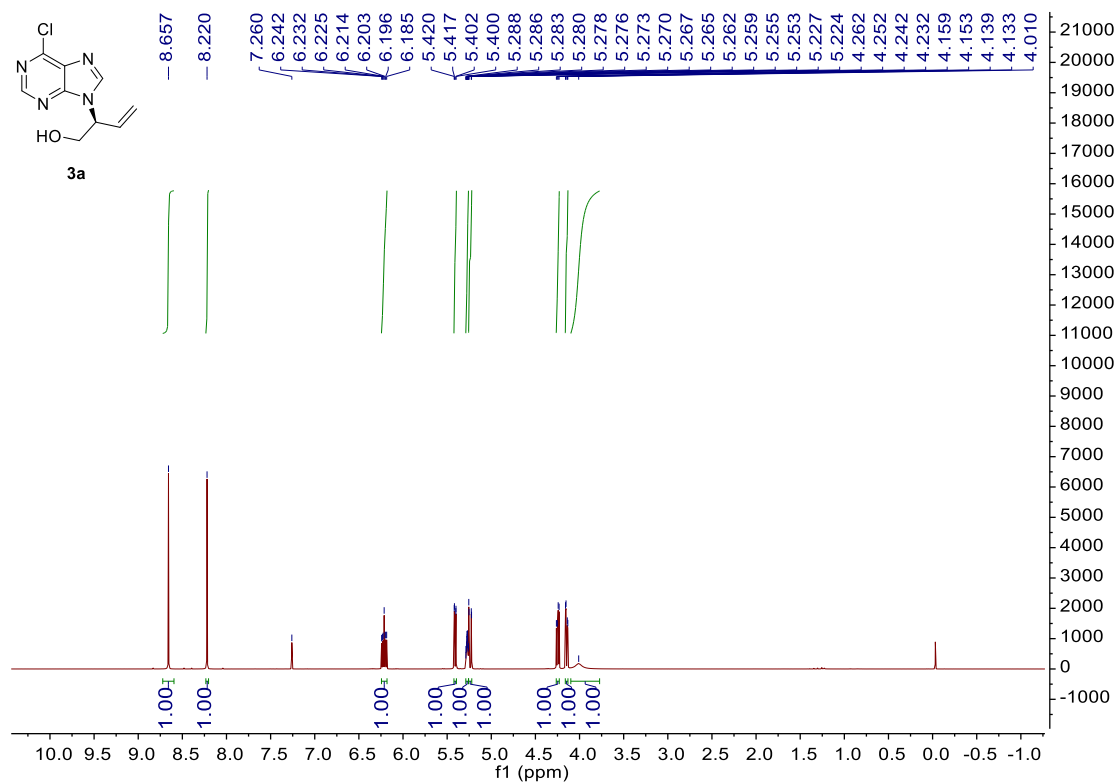
**(3*R*,4*R*)-4-(6-diBocamino-9*H*-purin-9-yl)tetrahydrofuran-3-ol (3gj)**



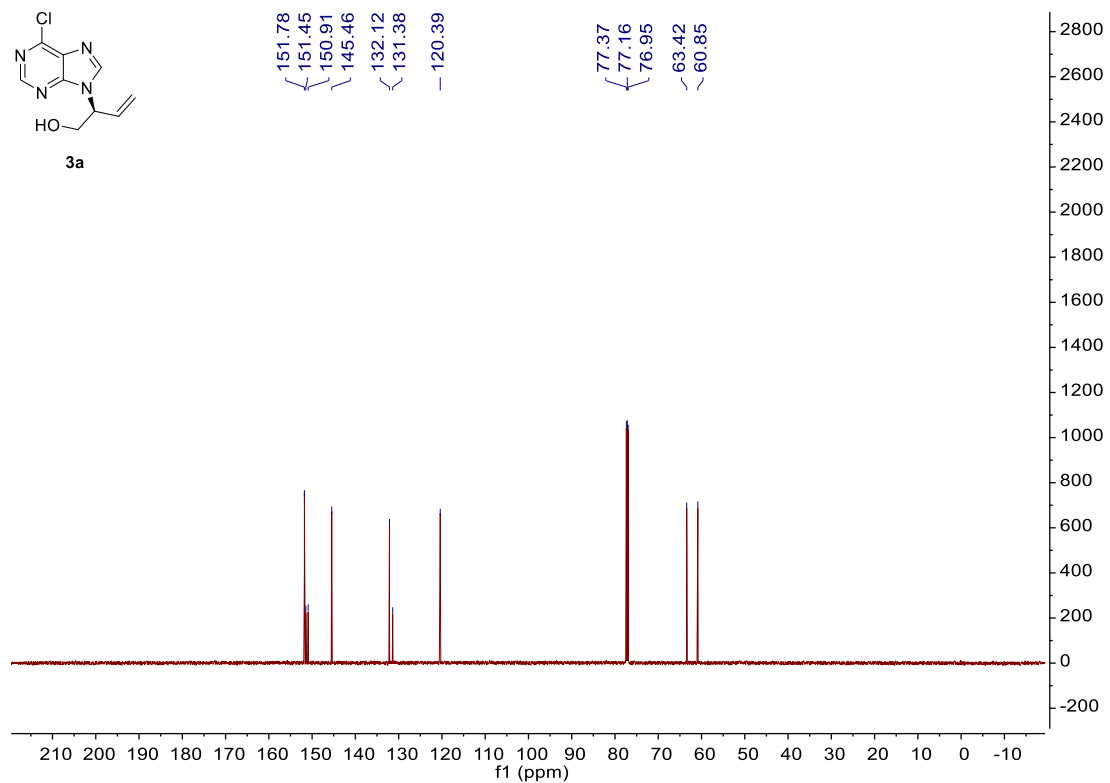
Colorless oil; 69.6 mg, 85% yield, 94% ee, 20:1 dr;  $[\alpha]_D^{23} = -5.50$  (c = 0.800, CHCl<sub>3</sub>); **HPLC** CHIRALCEL ID, *n*-hexane/2-propanol = 70/30, flow rate = 0.8 mL/min,  $\lambda = 256$  nm, retention time: 12.100 min (major), 16.352 min (minor); **<sup>1</sup>H NMR** (600 MHz, CDCl<sub>3</sub>)  $\delta$  8.87 (s, 1H), 8.12 (s, 1H), 5.02 (dt, *J* = 5.4, 3.0 Hz, 1H), 4.61 (dt, *J* = 6.0, 3.0 Hz, 1H), 4.44 (dd, *J* = 10.2, 5.4 Hz, 1H), 4.32 – 4.28 (m, 2H), 3.89 (dd, *J* = 10.2, 3.6 Hz, 2H), 1.47 (s, 18H); **<sup>13</sup>C NMR** (150 MHz, CDCl<sub>3</sub>)  $\delta$  153.3, 152.2, 150.8, 150.7, 142.8, 128.9, 84.2, 76.6, 74.1, 70.0, 63.0, 28.0; **HRMS** (ESI-TOF): exact mass calcd for C<sub>19</sub>H<sub>27</sub>N<sub>5</sub>NaO<sub>6</sub> [M+Na]<sup>+</sup> requires *m/z* 444.1854, found *m/z* 444.1857.

## 7. Copies of NMR spectra for the products

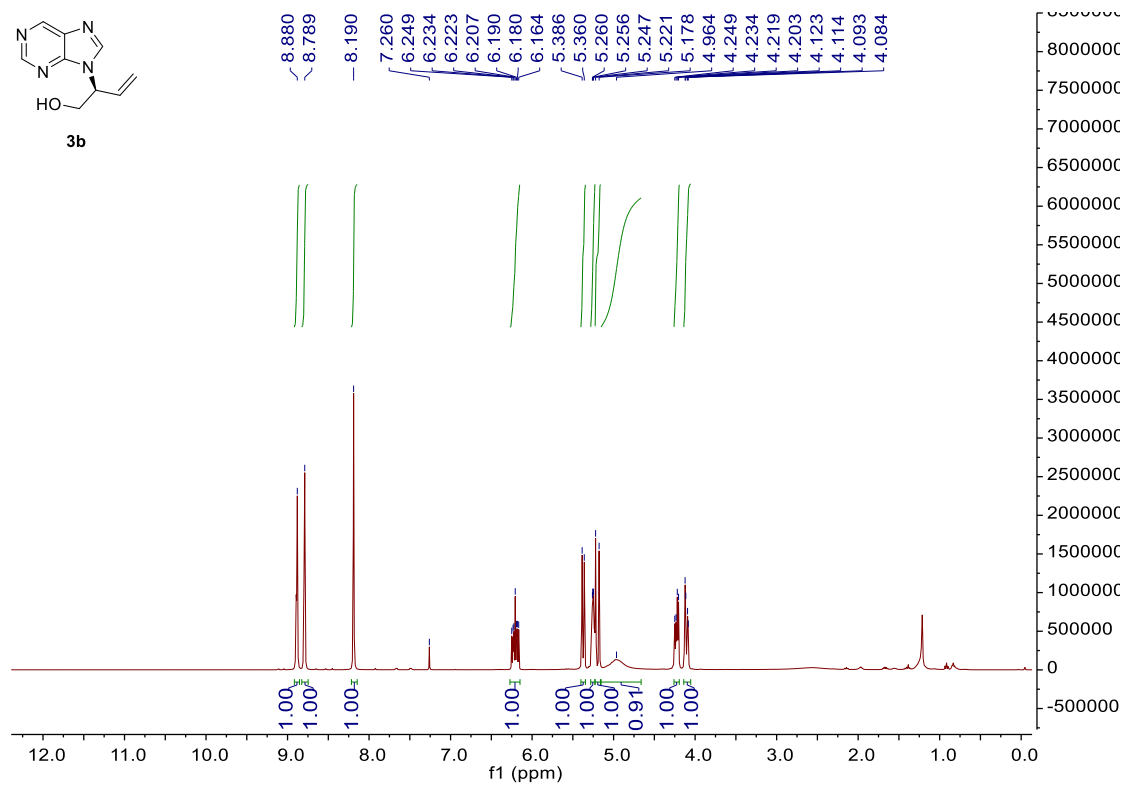
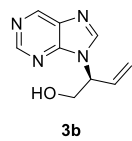
### <sup>1</sup>H NMR for 3a



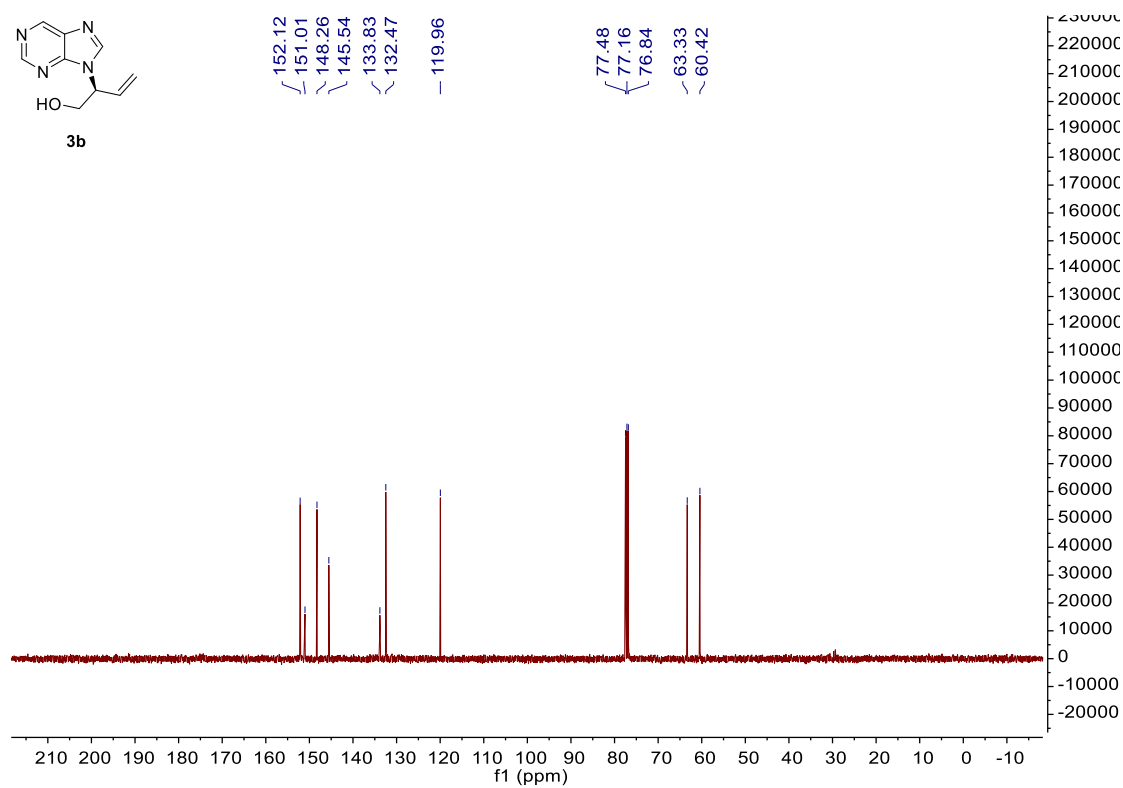
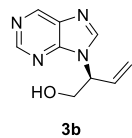
### <sup>13</sup>C NMR for 3a



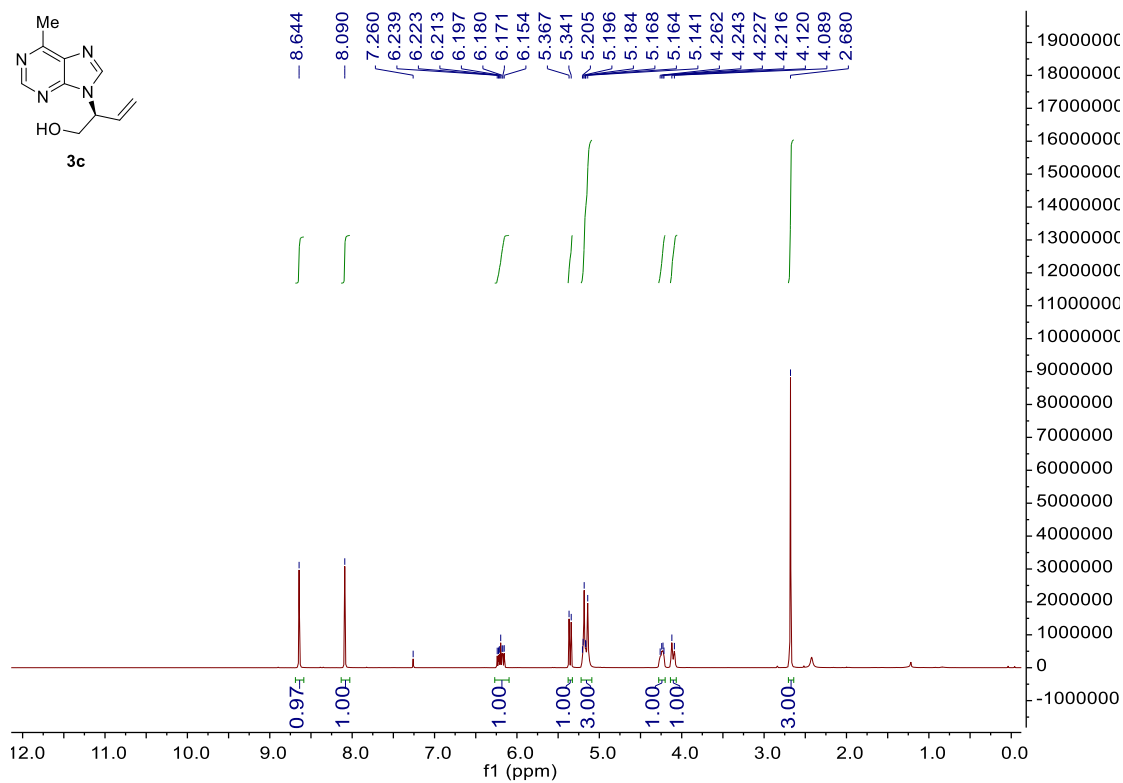
### <sup>1</sup>H NMR for 3b



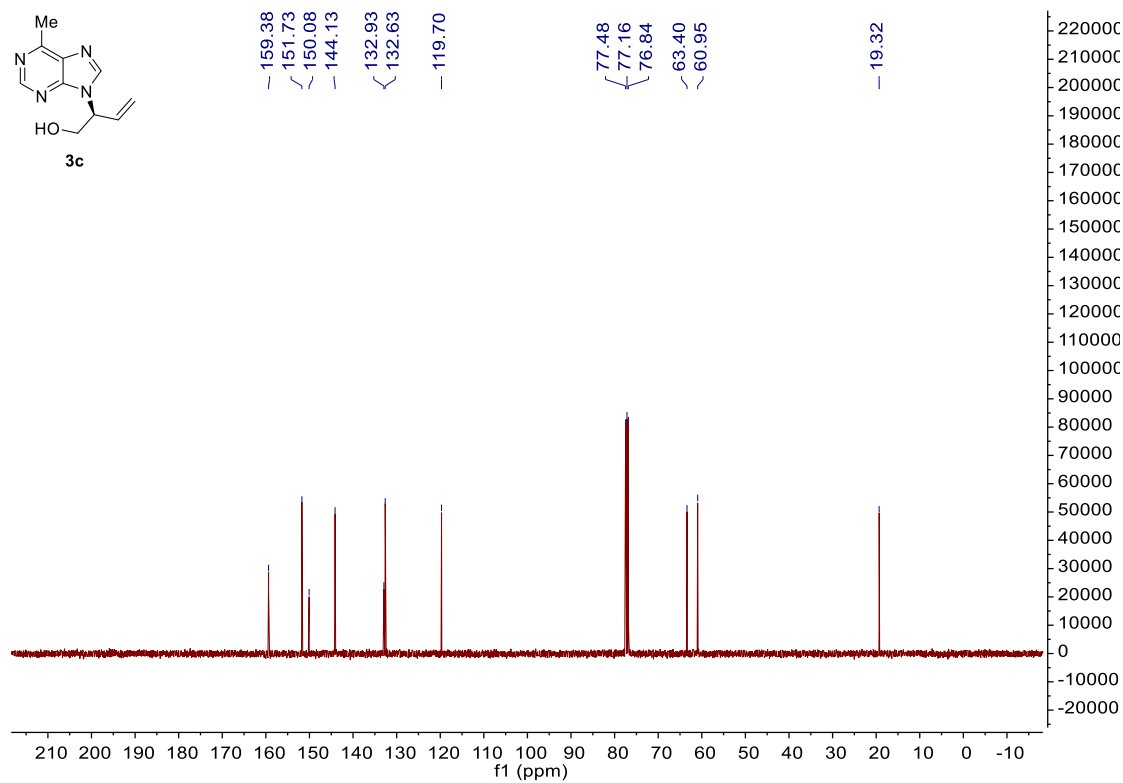
### <sup>13</sup>C NMR for 3b



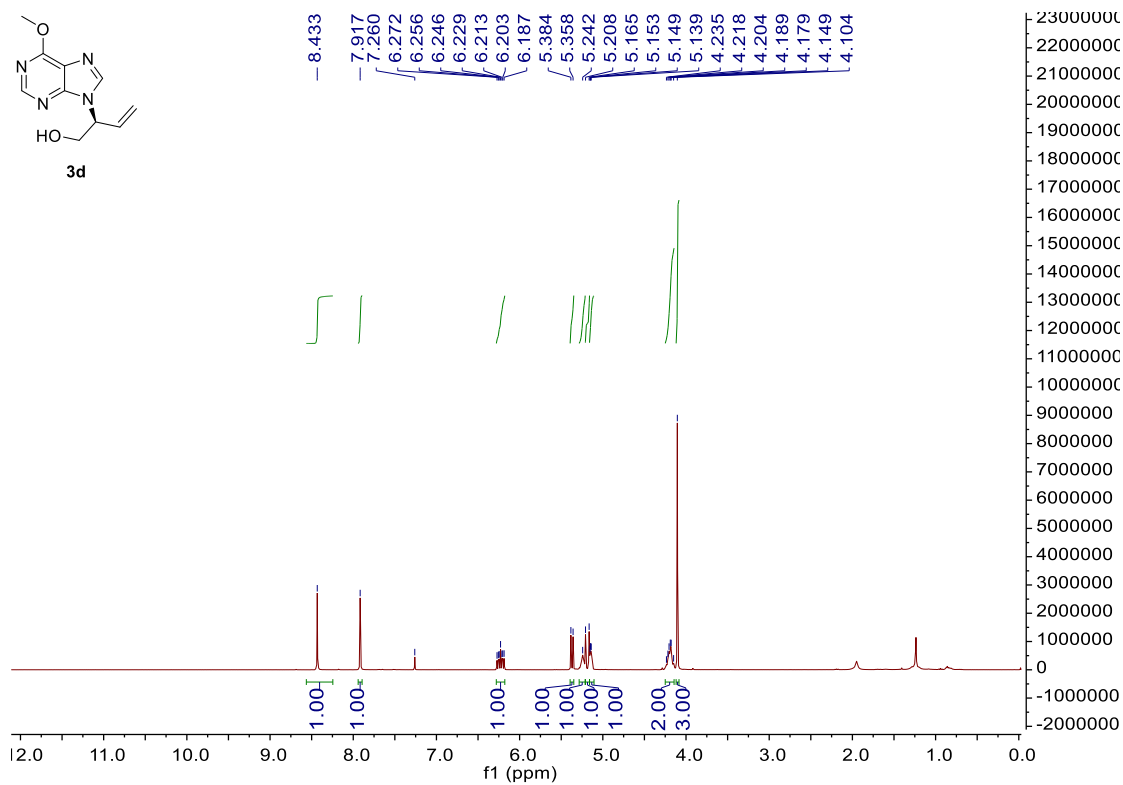
<sup>1</sup>H NMR for 3c



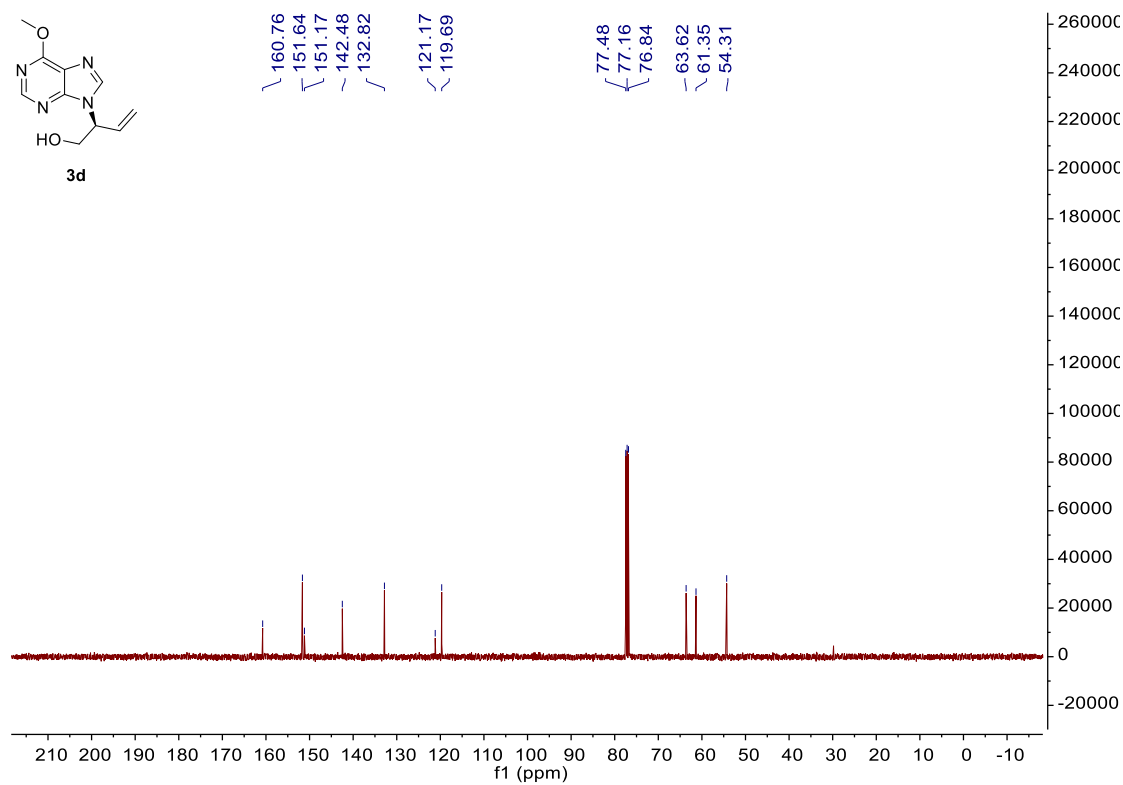
<sup>13</sup>C NMR for 3c



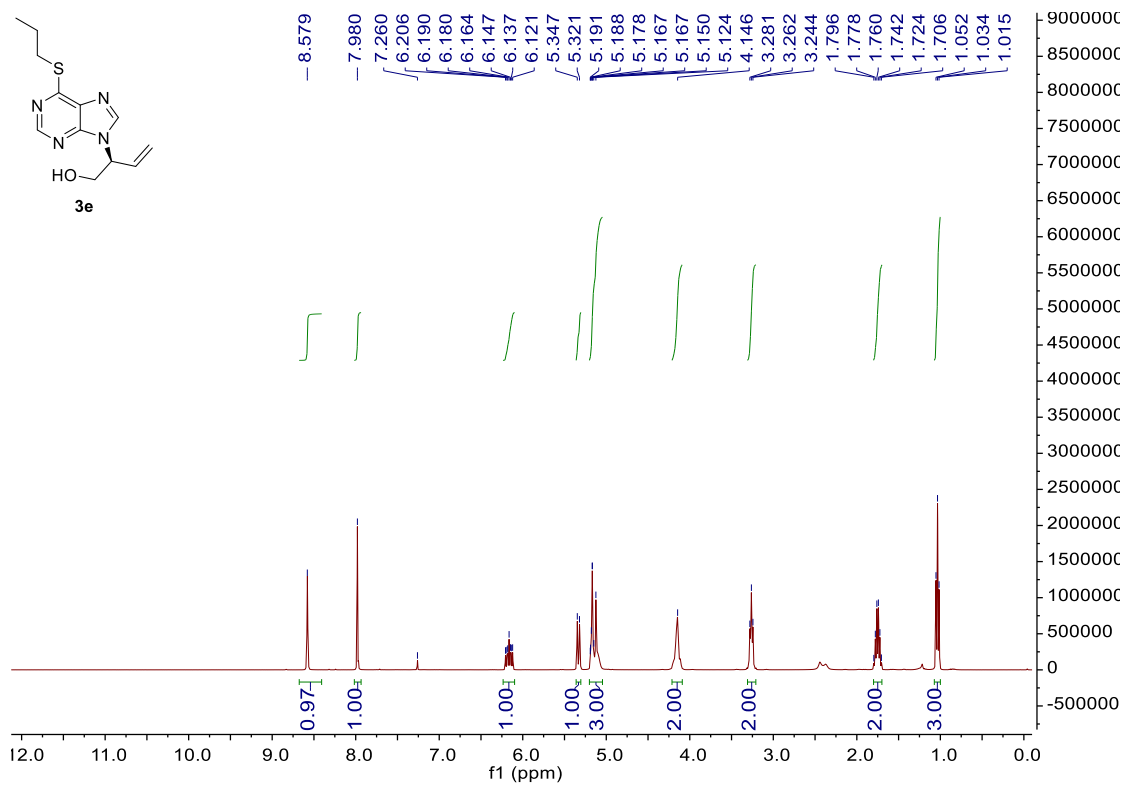
<sup>1</sup>H NMR for **3d**



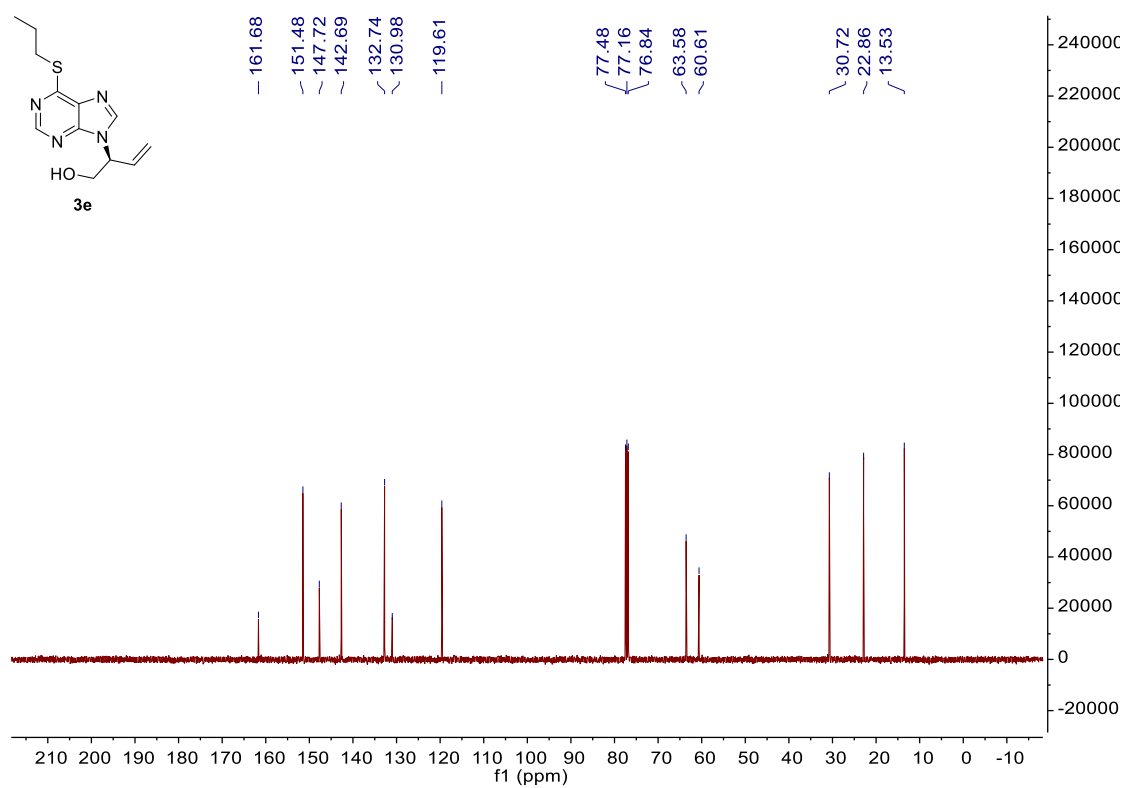
<sup>13</sup>C NMR for **3d**



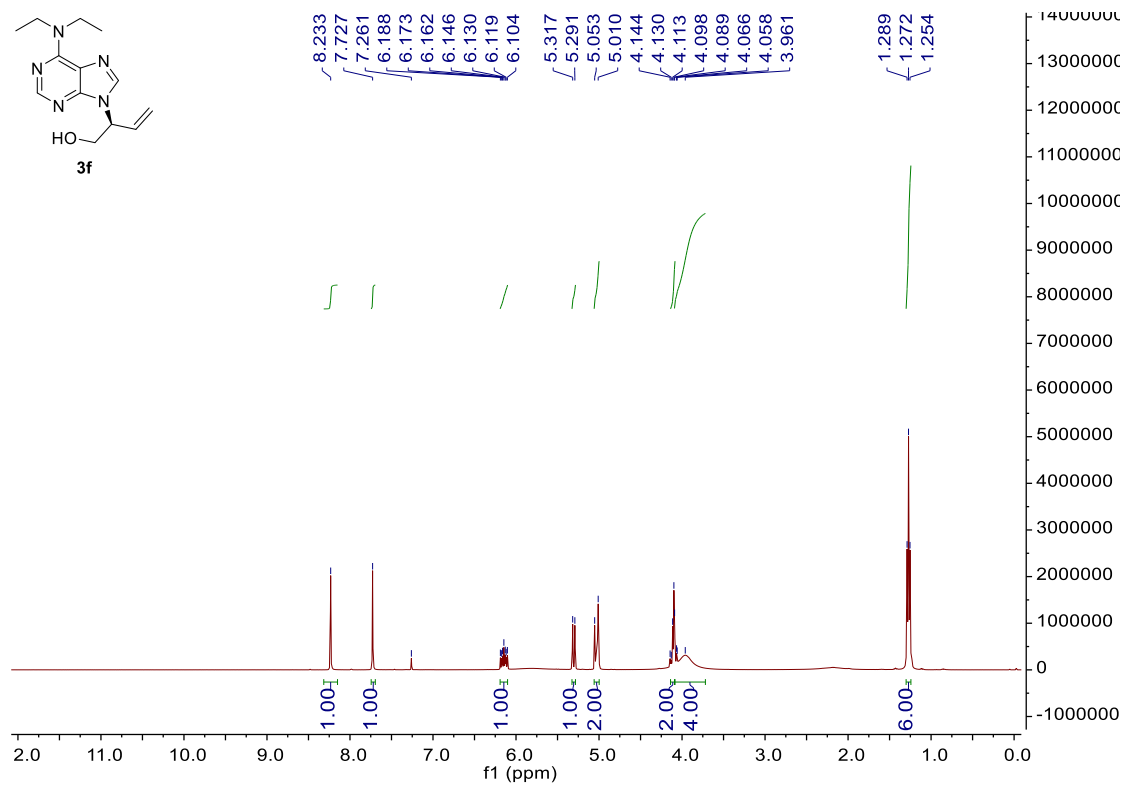
### <sup>1</sup>H NMR for 3e



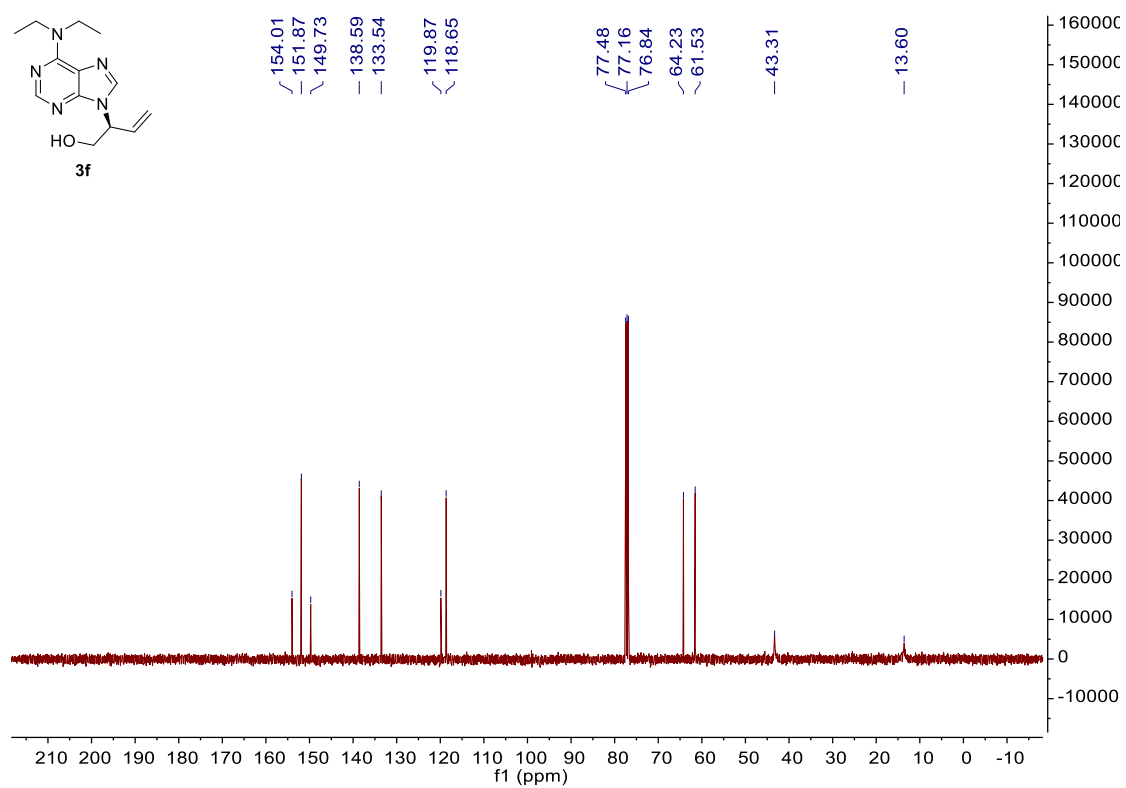
### <sup>13</sup>C NMR for 3e



### <sup>1</sup>H NMR for 3f

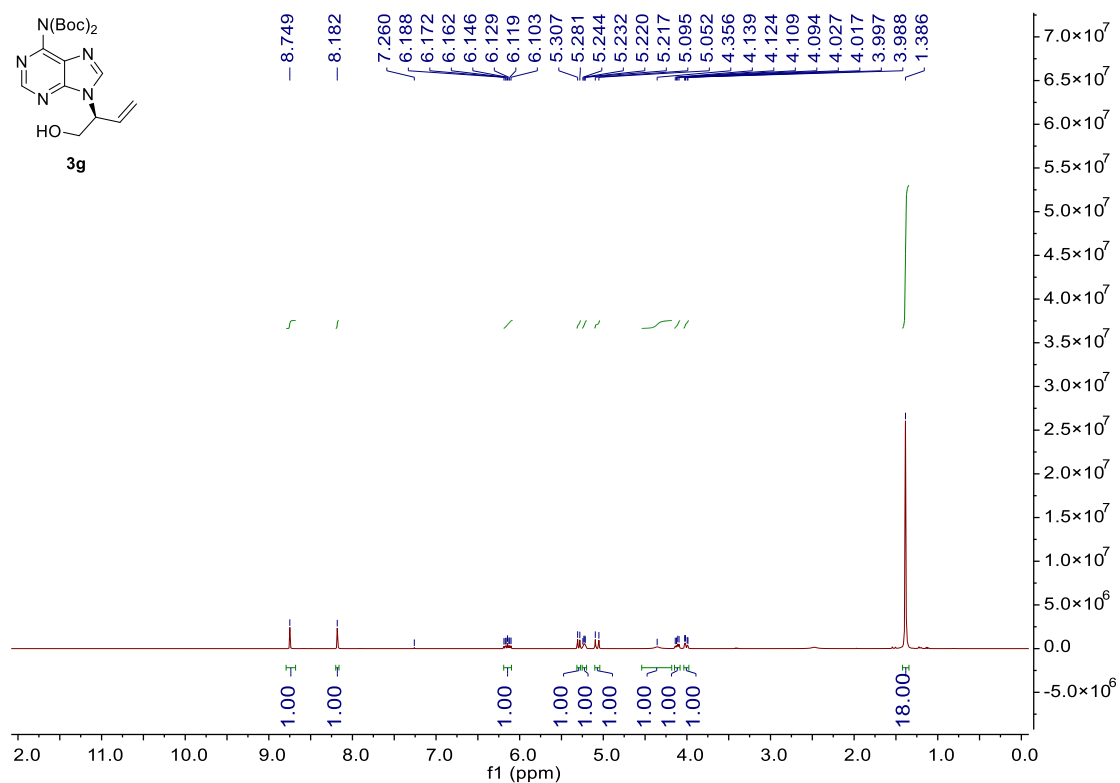


### <sup>13</sup>C NMR for 3f

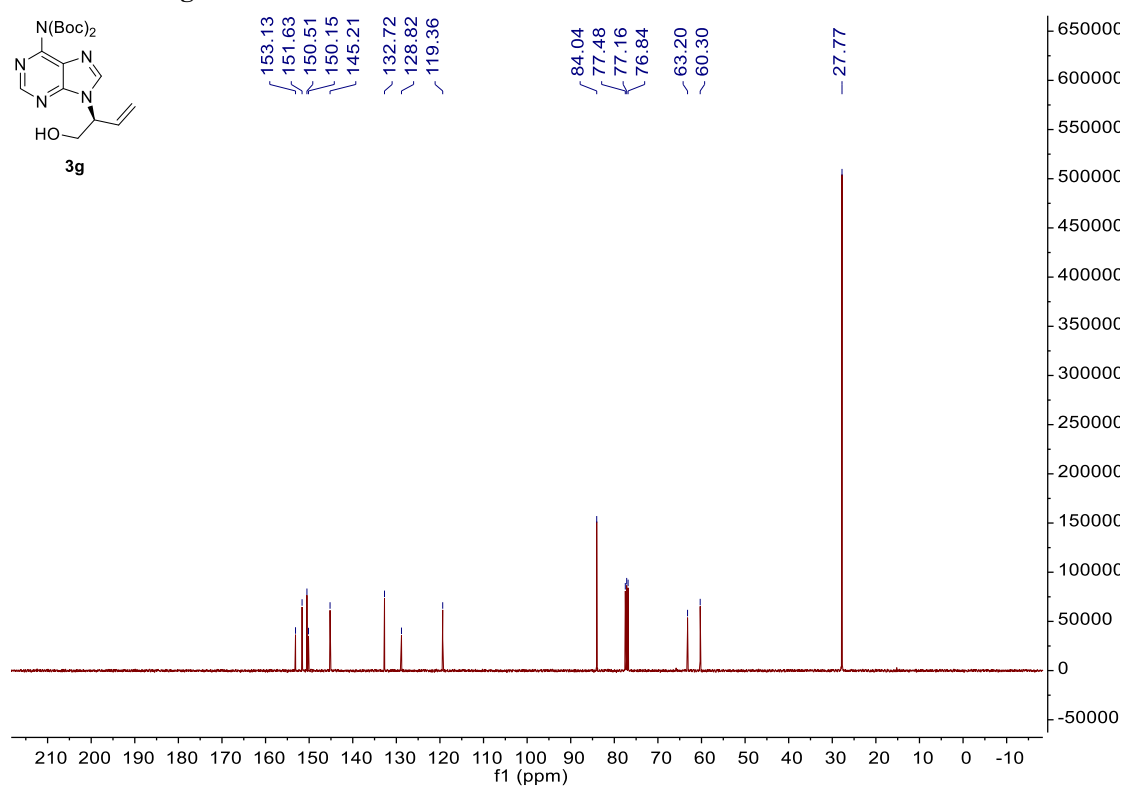




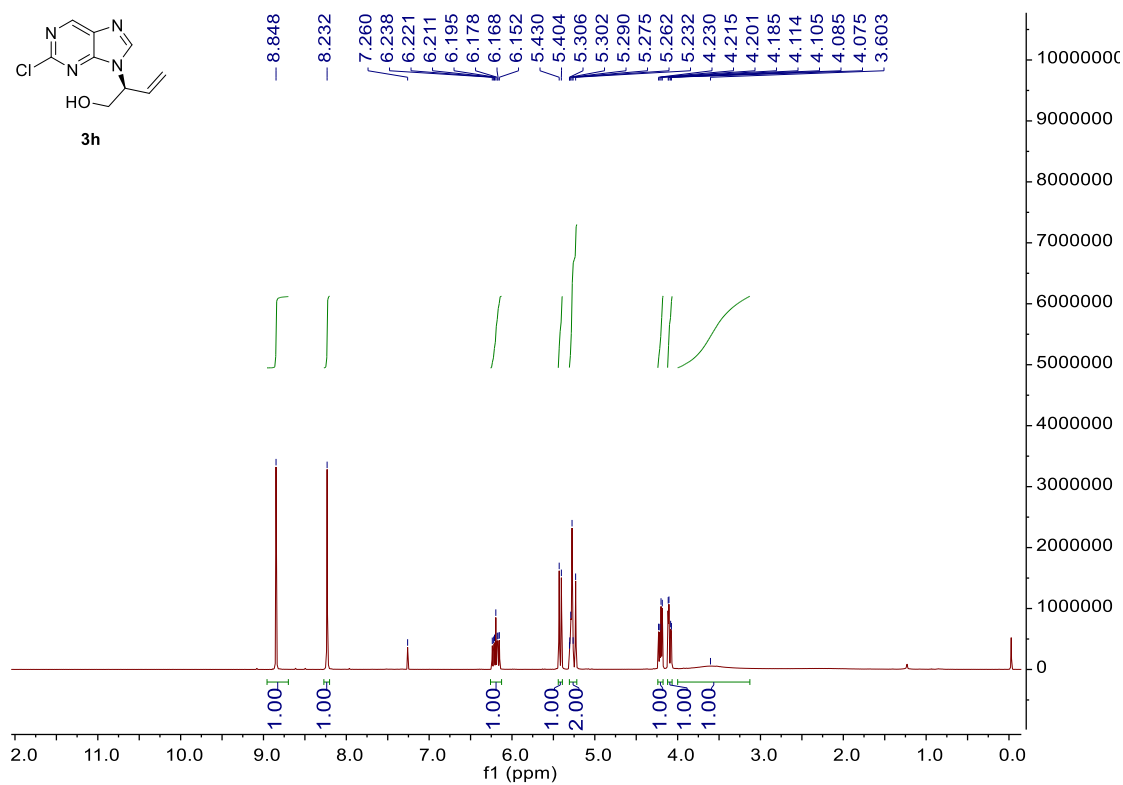
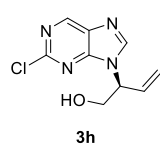
<sup>1</sup>H NMR for **3g**



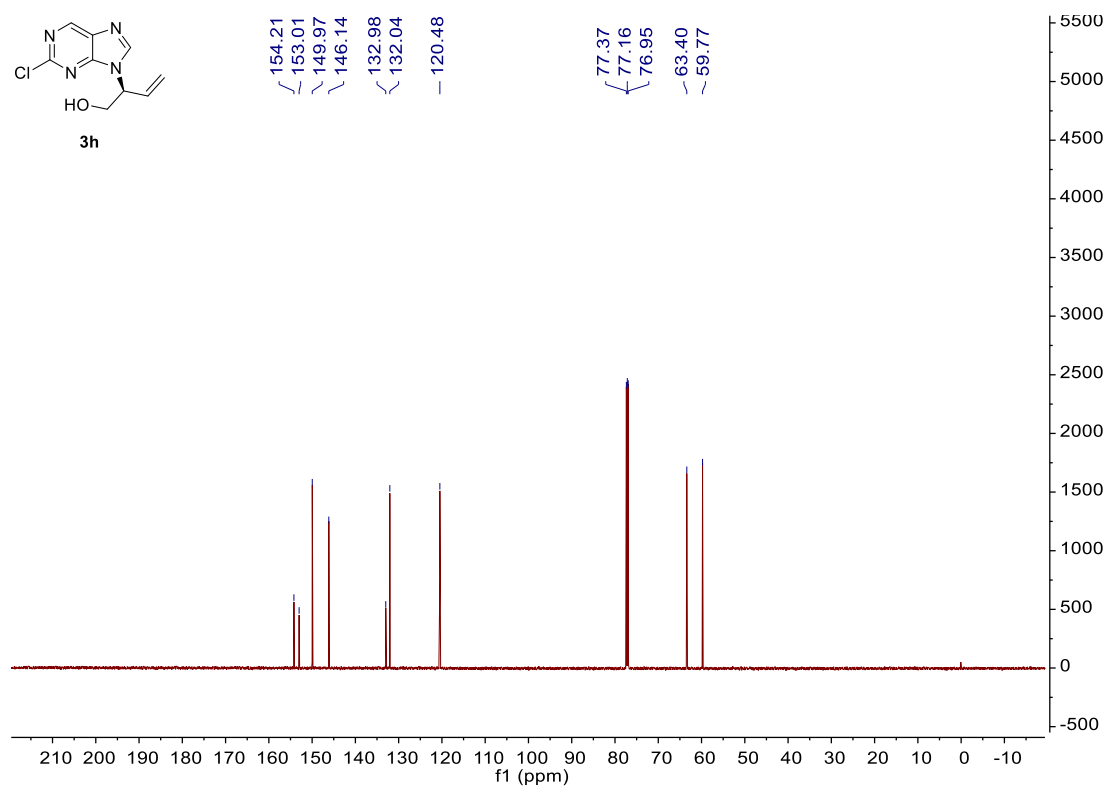
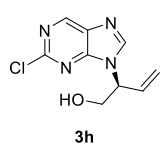
<sup>13</sup>C NMR for **3g**



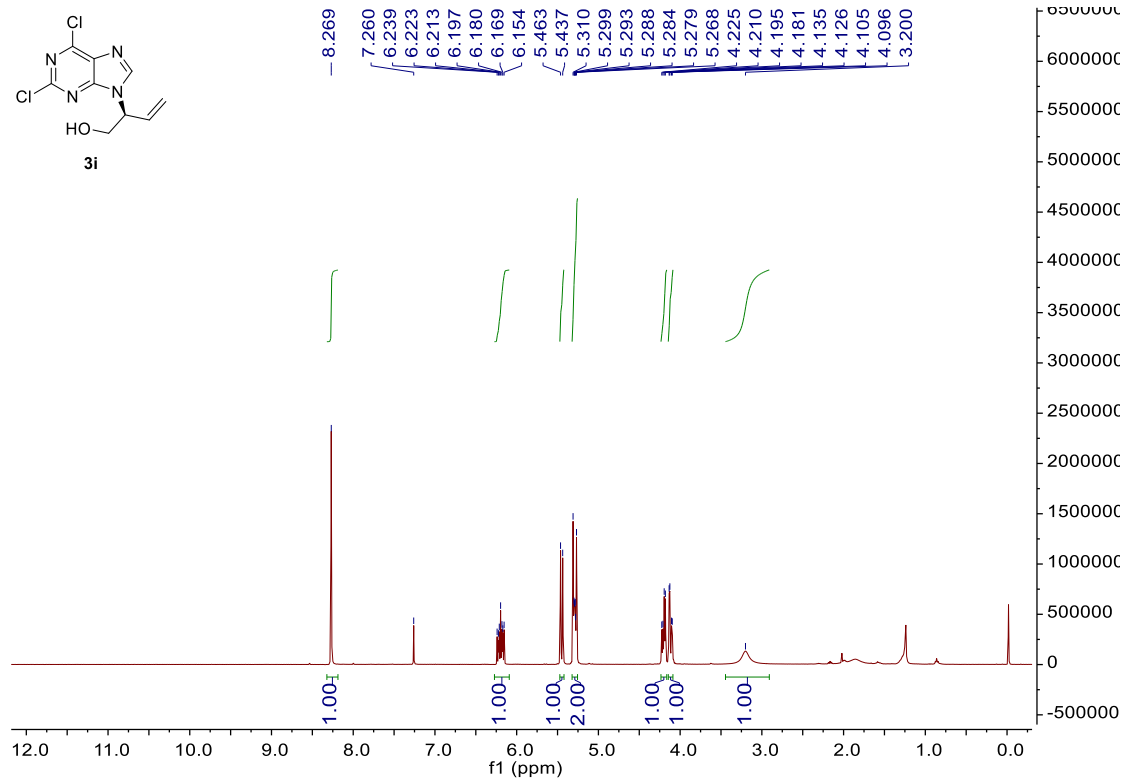
<sup>1</sup>H NMR for 3h



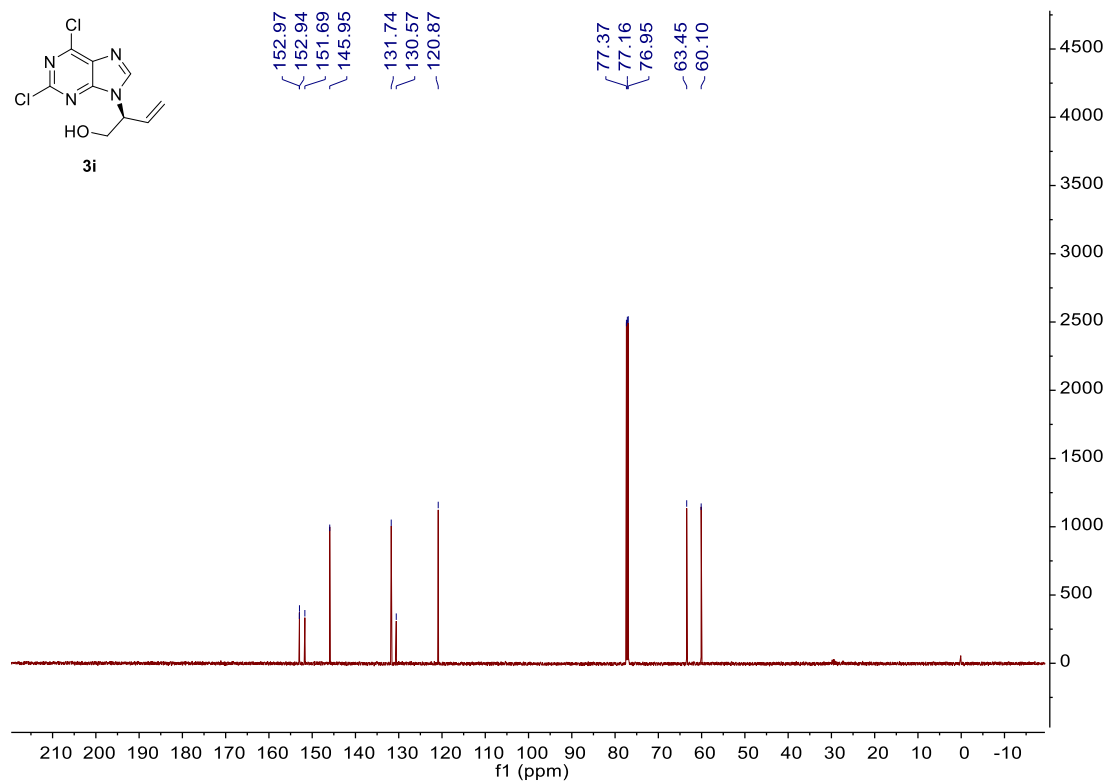
<sup>13</sup>C NMR for 3h



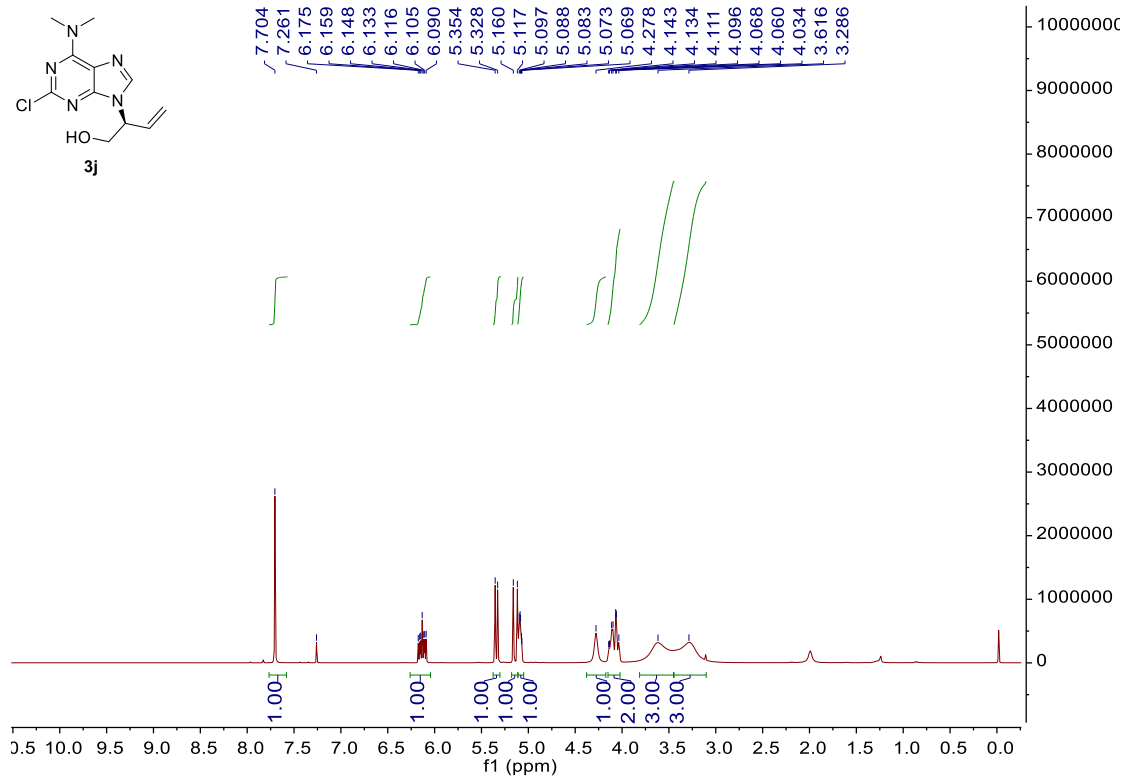
<sup>1</sup>H NMR for **3i**



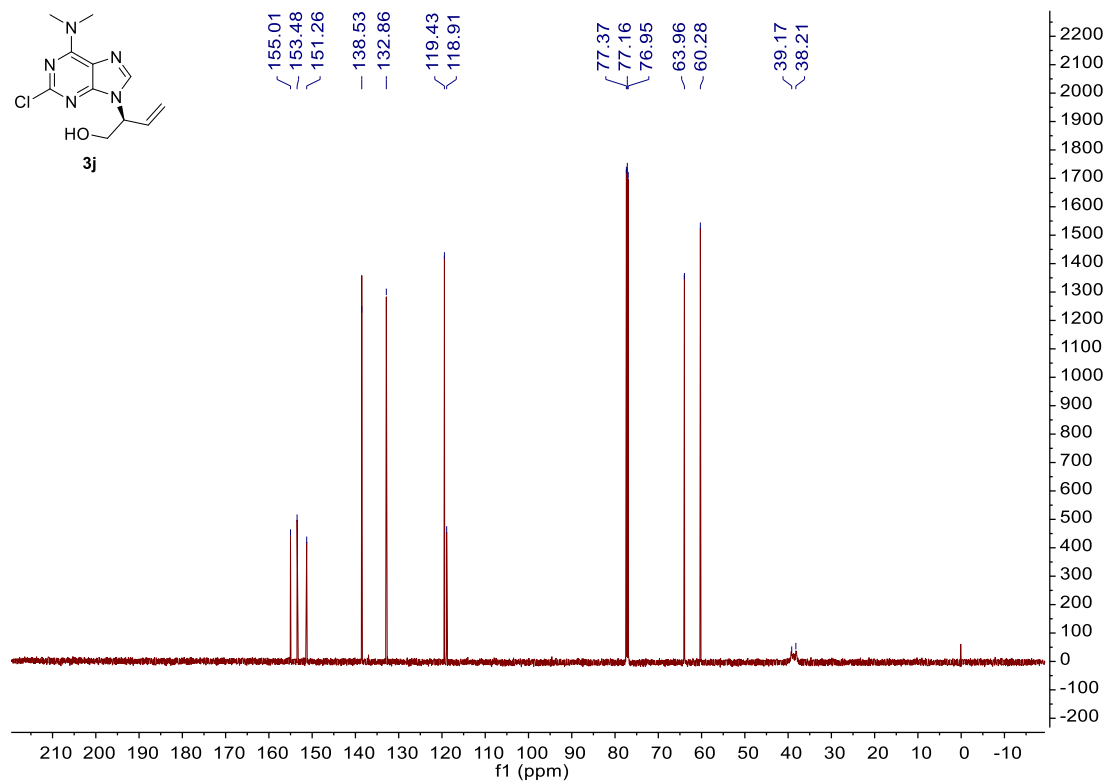
<sup>13</sup>C NMR for **3i**



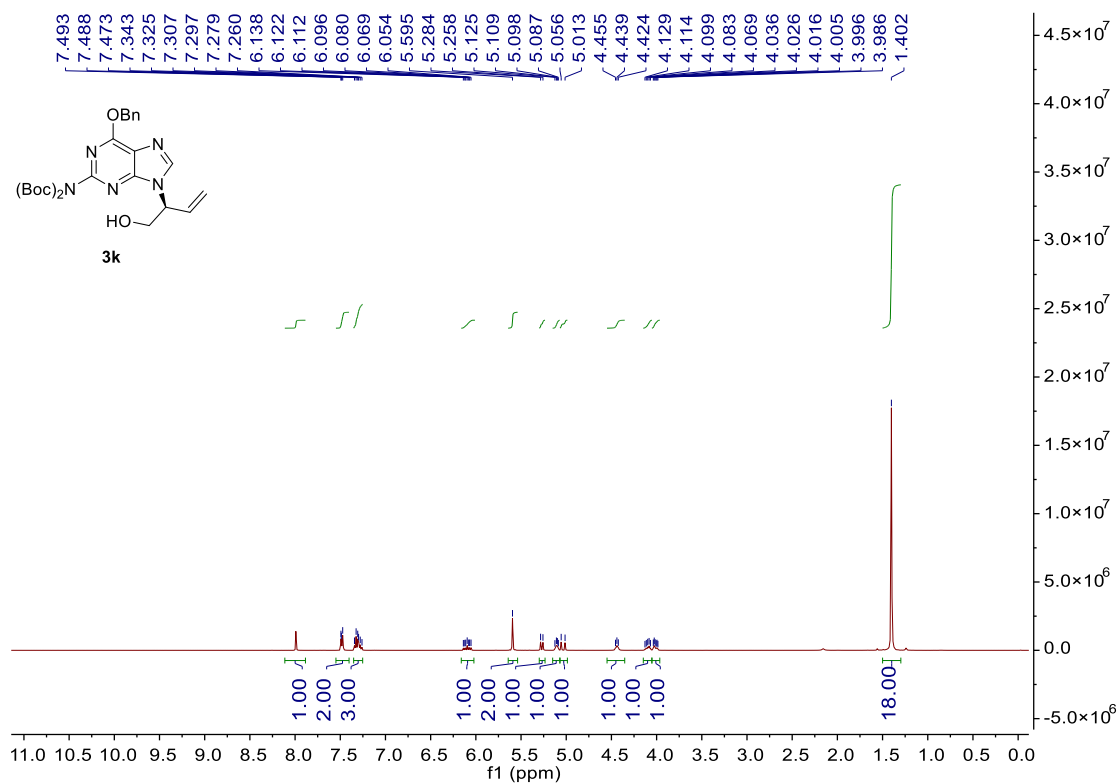
### <sup>1</sup>H NMR for 3j



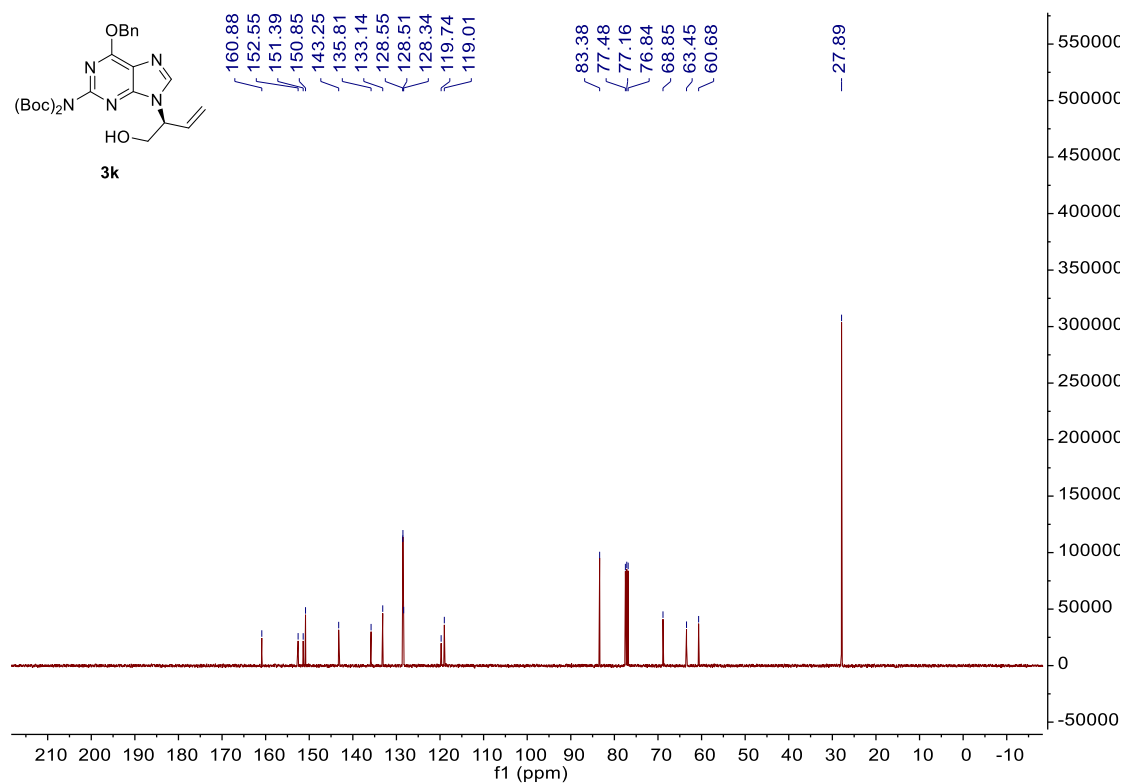
### <sup>13</sup>C NMR for 3j



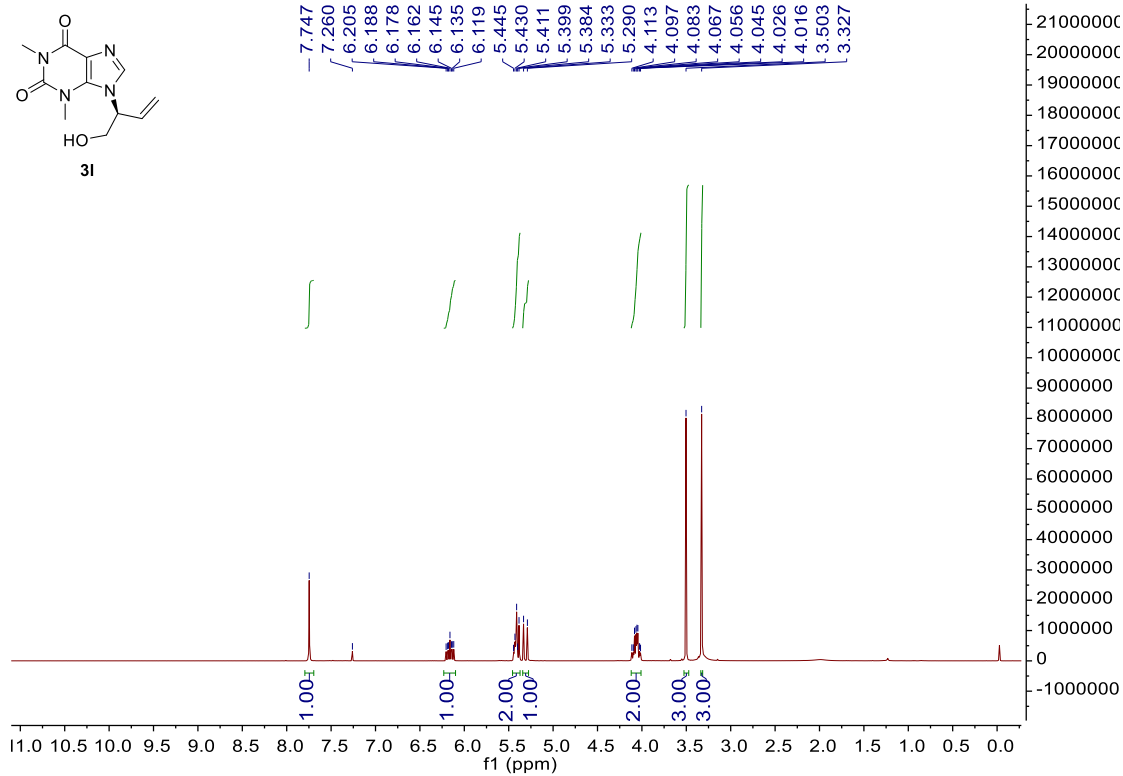
<sup>1</sup>H NMR for **3k**



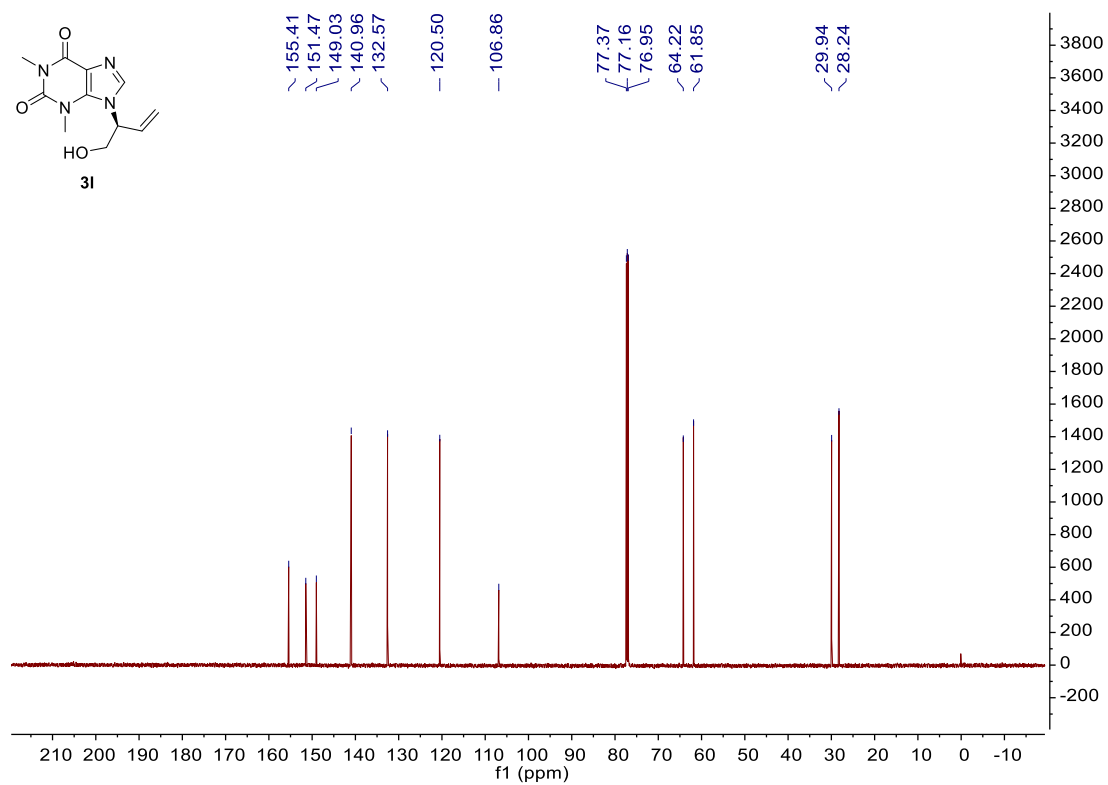
<sup>13</sup>C NMR for **3k**



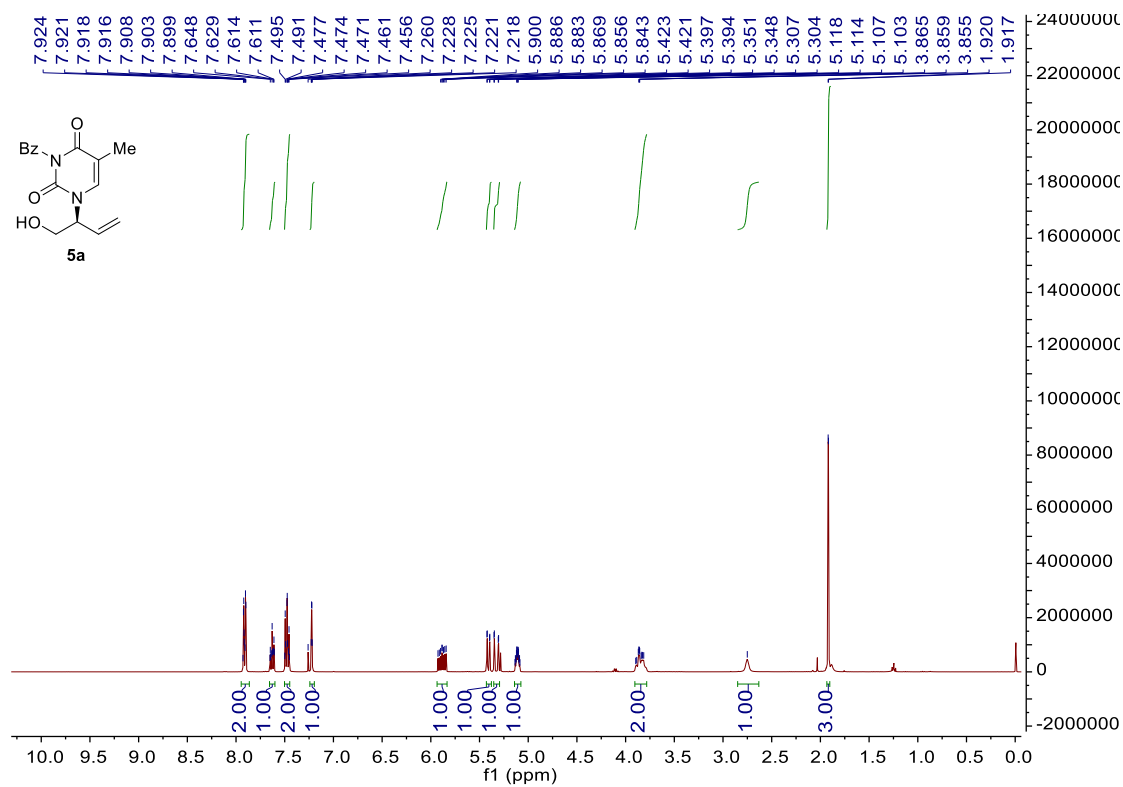
### <sup>1</sup>H NMR for **31**



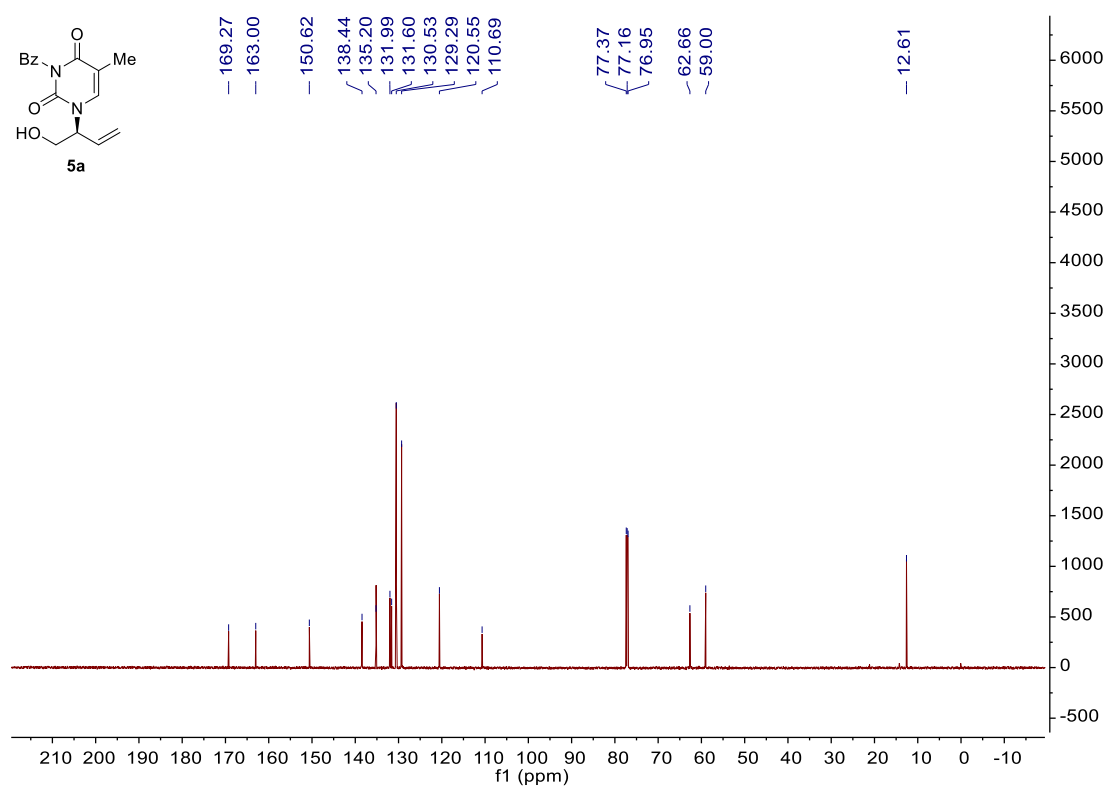
### <sup>13</sup>C NMR for **31**



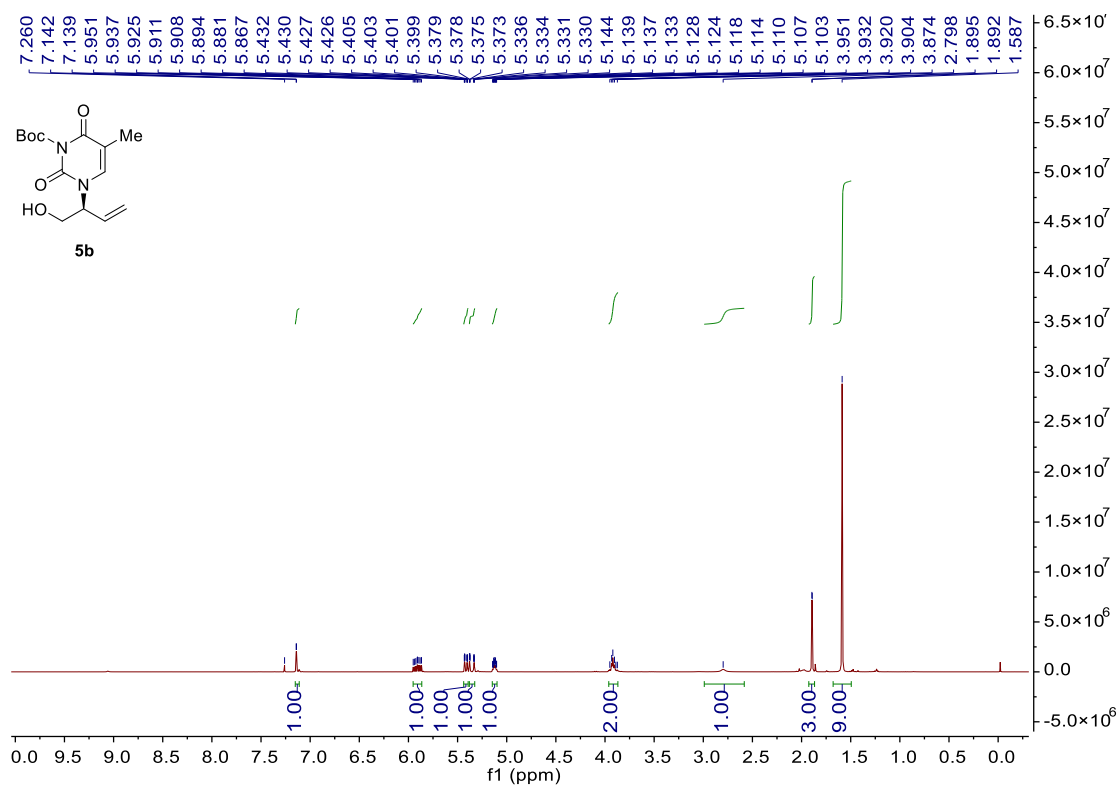
<sup>1</sup>H NMR for **5a**



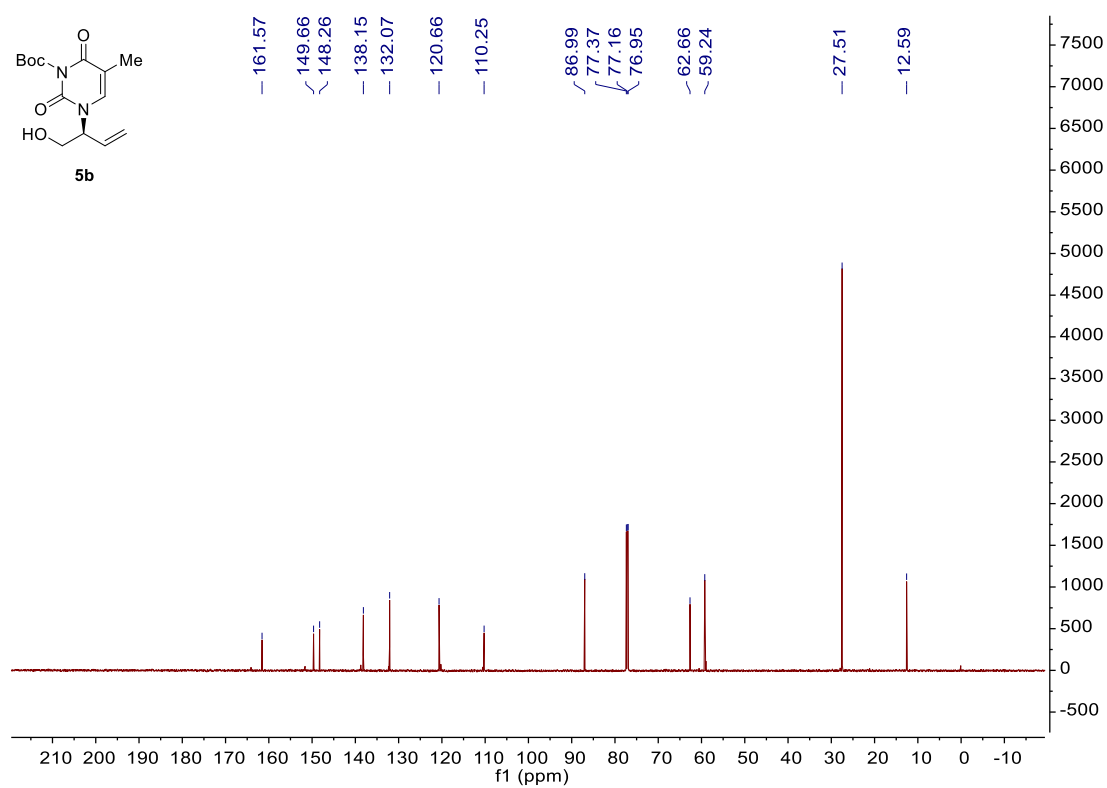
<sup>13</sup>C NMR for **5a**



<sup>1</sup>H NMR for **5b**

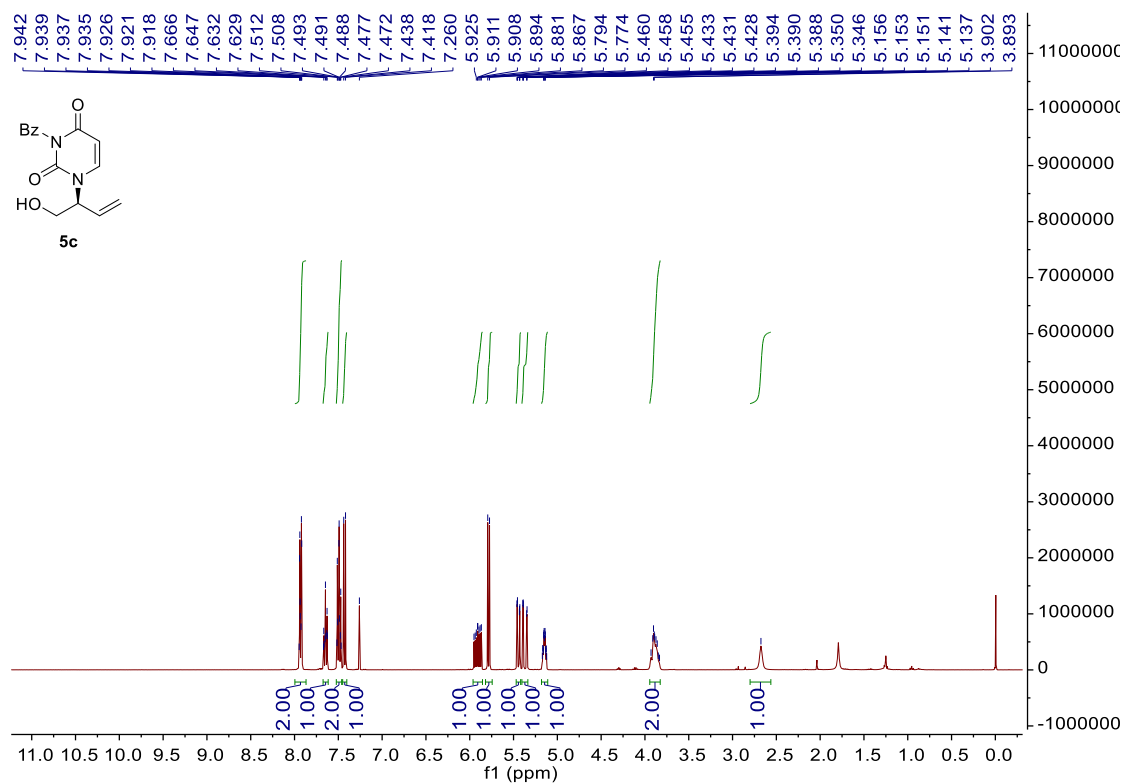


<sup>13</sup>C NMR for **5b**

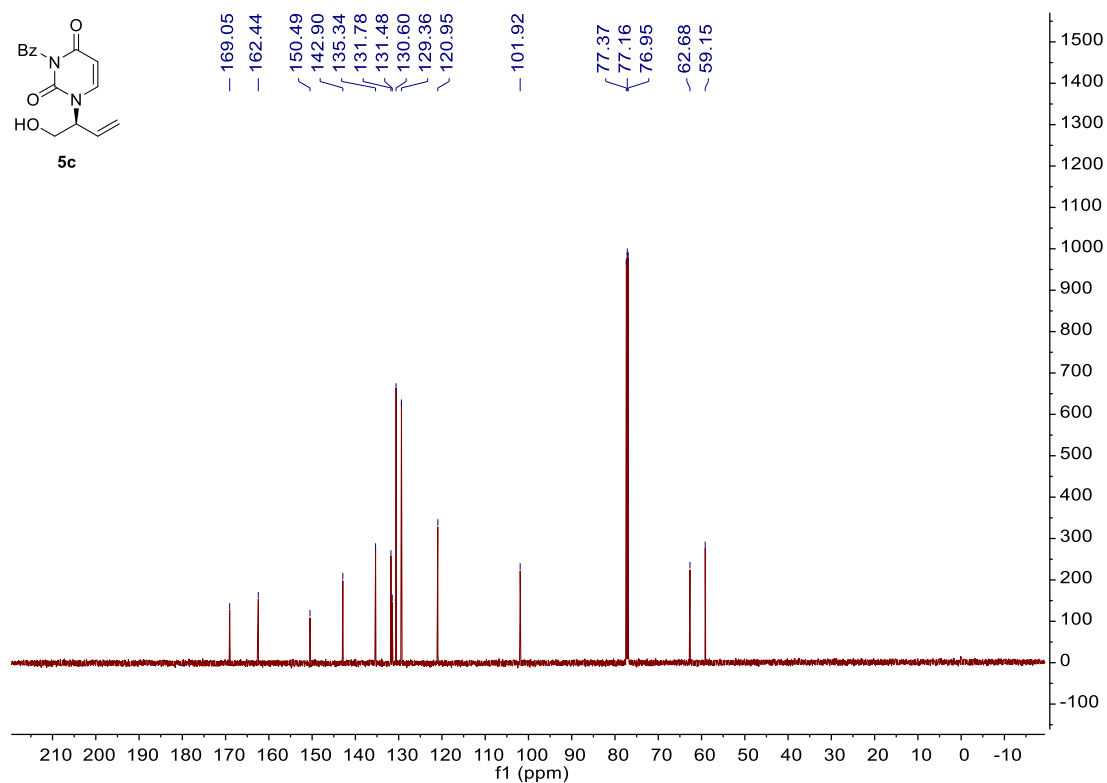




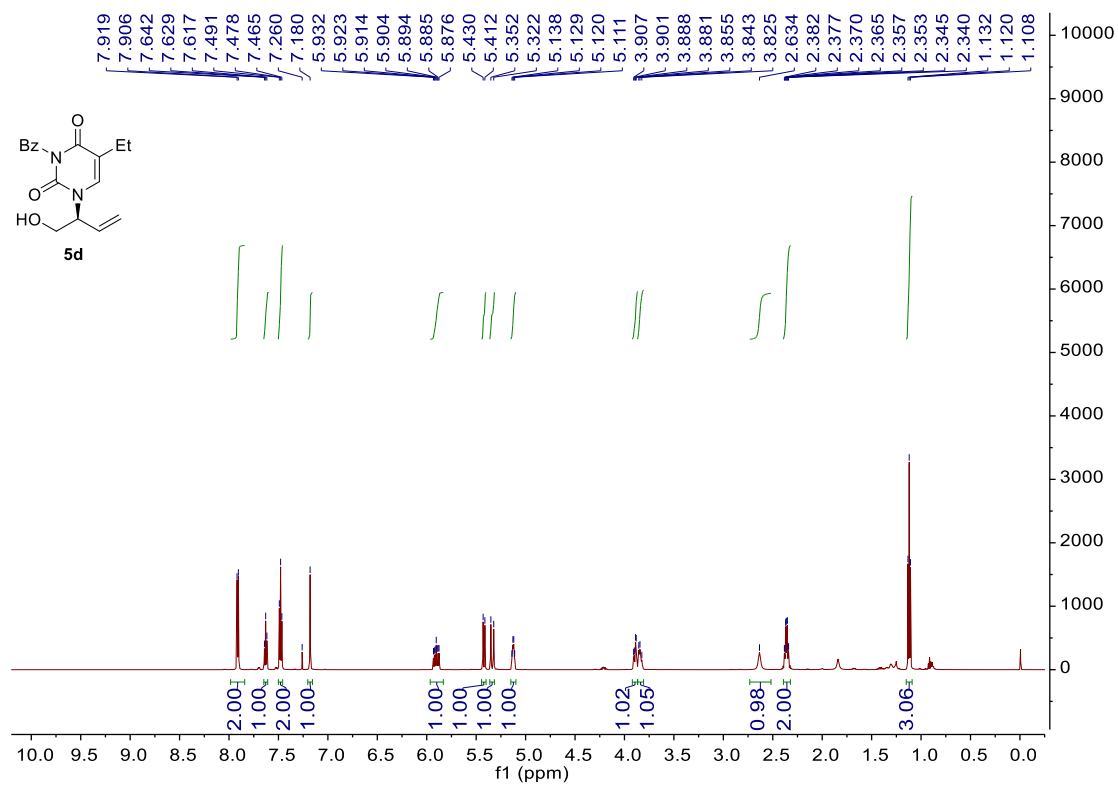
<sup>1</sup>H NMR for 5c



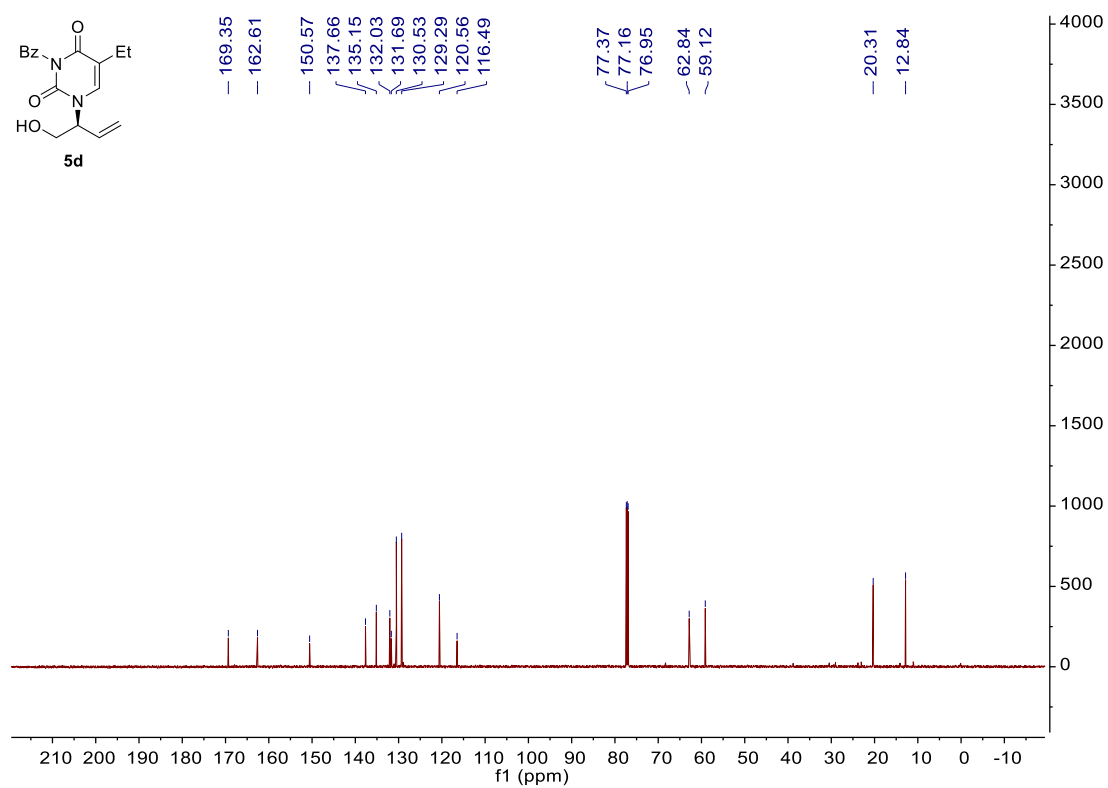
<sup>13</sup>C NMR for 5c



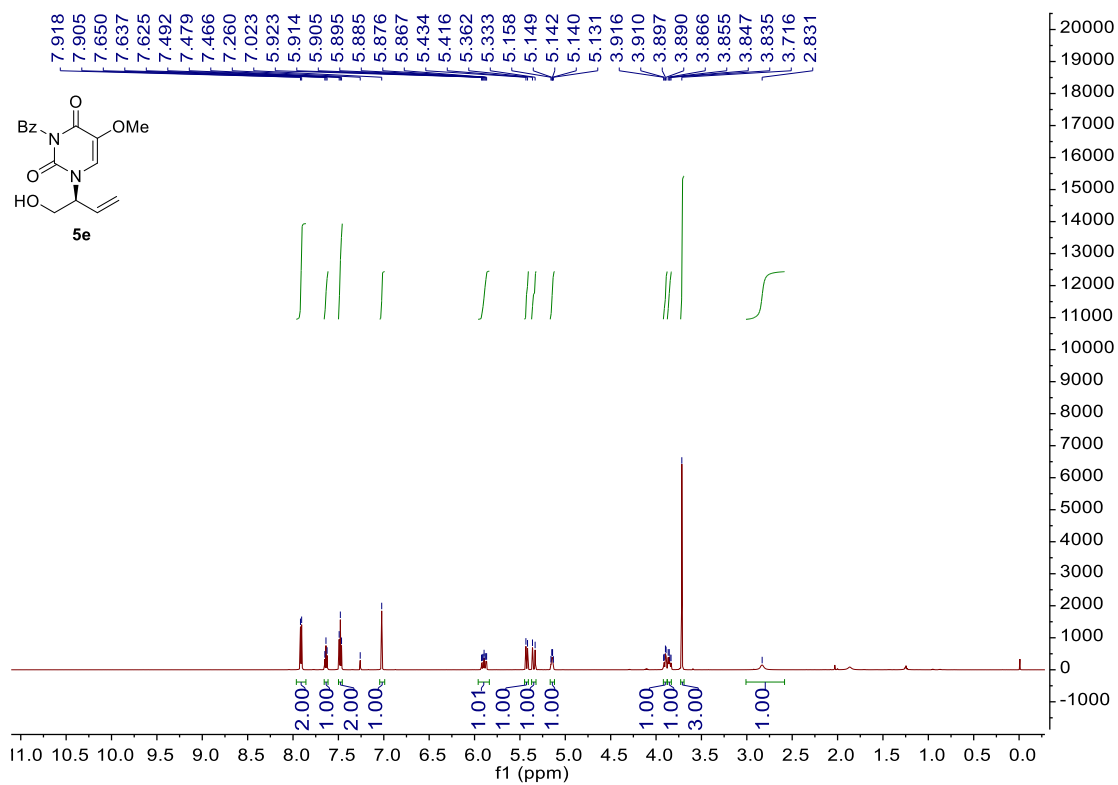
<sup>1</sup>H NMR for **5d**



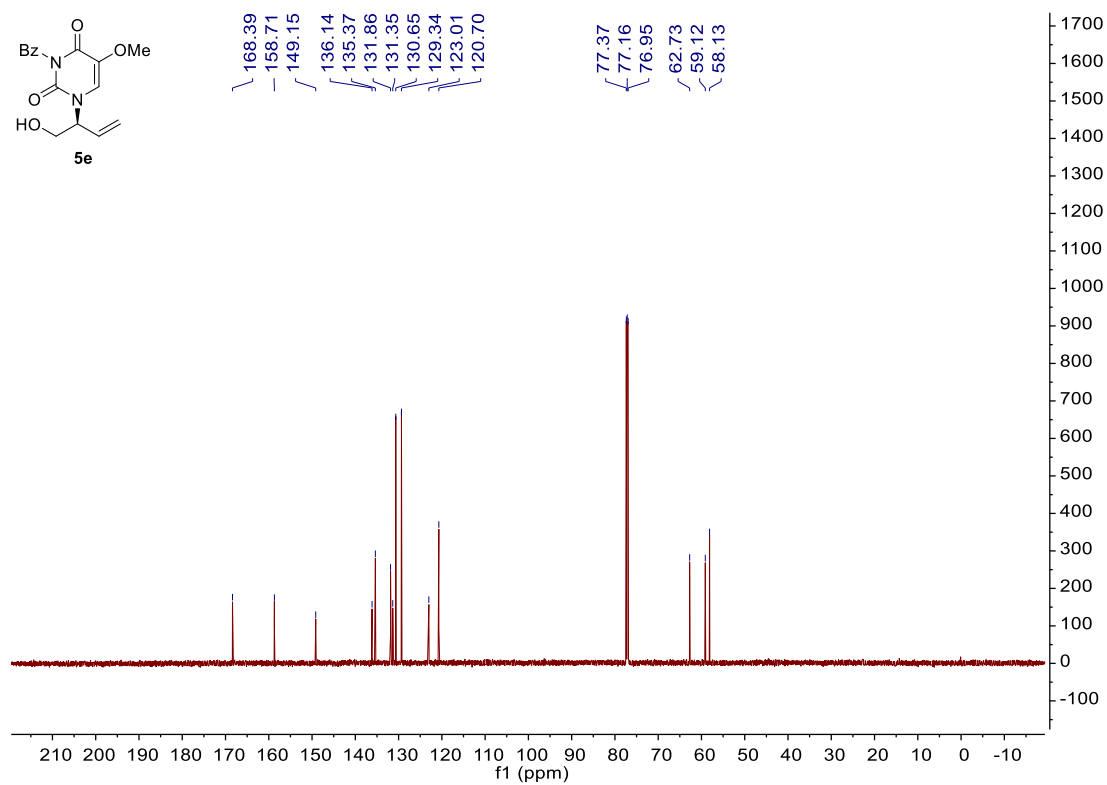
<sup>13</sup>C NMR for **5d**



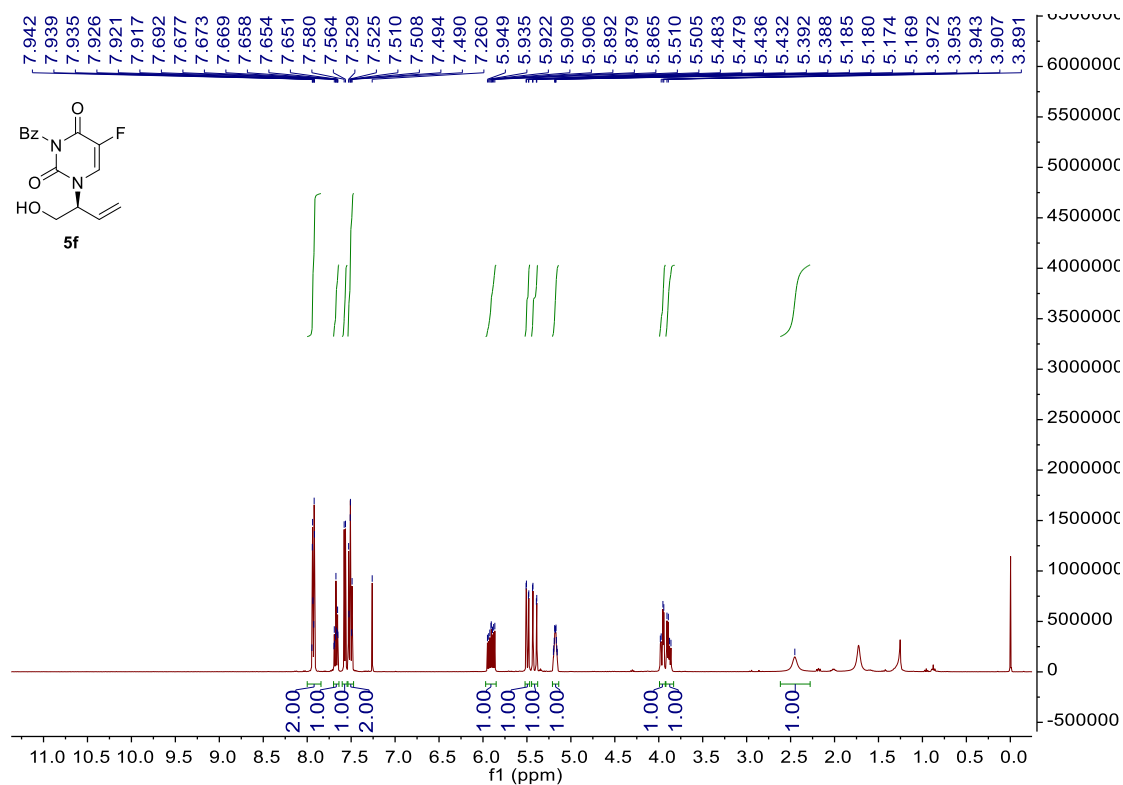
### <sup>1</sup>H NMR for 5e



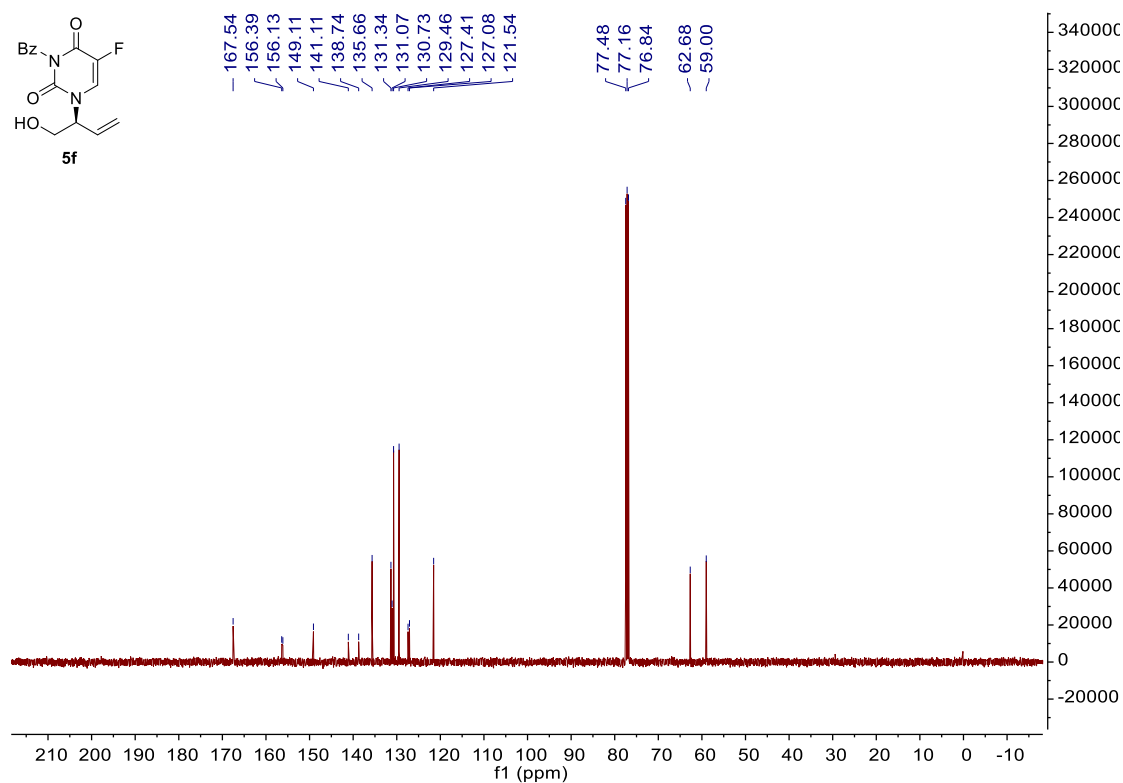
### <sup>13</sup>C NMR for 5e



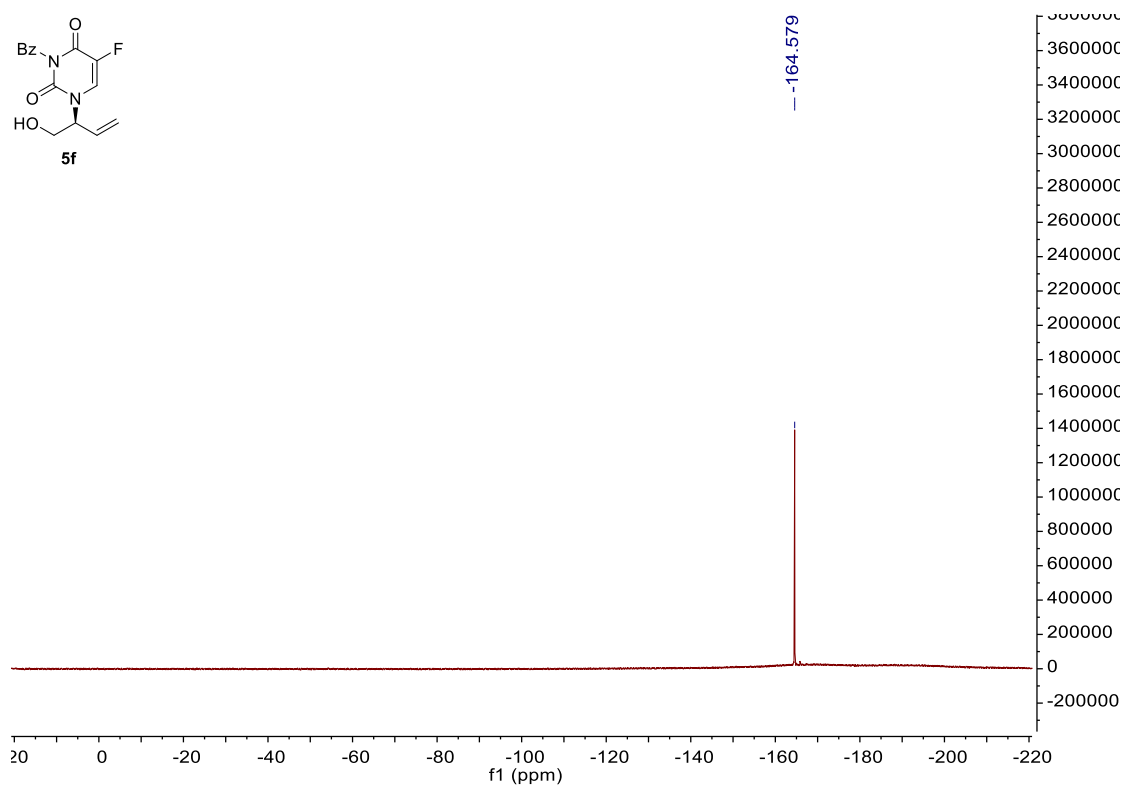
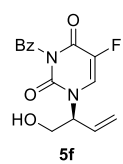
### <sup>1</sup>H NMR for **5f**



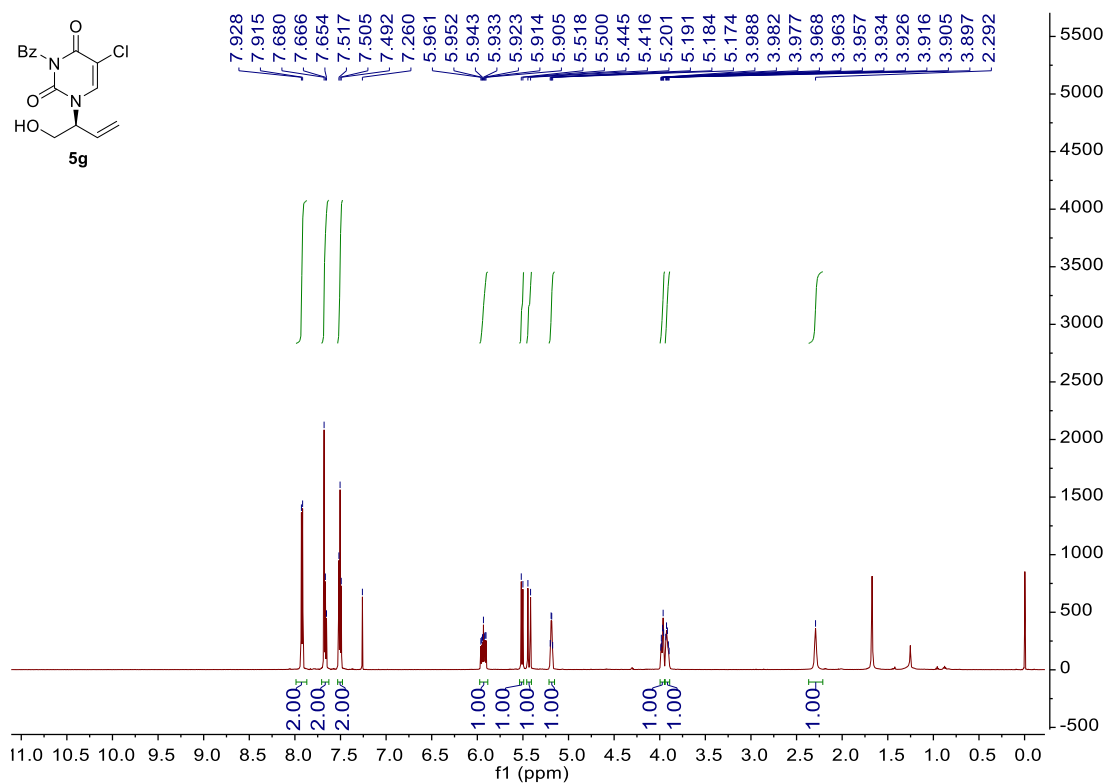
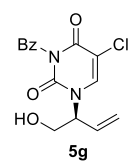
### <sup>13</sup>C NMR for **5f**



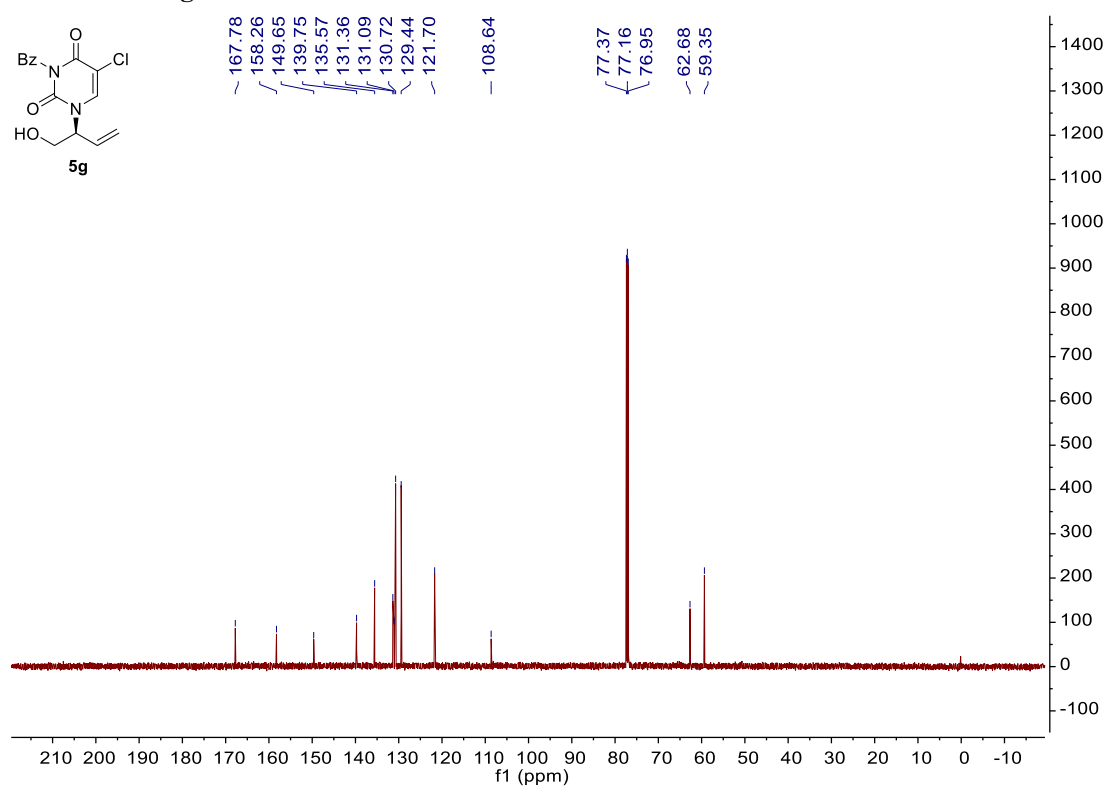
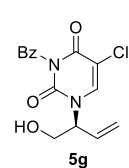
<sup>19</sup>F NMR for **5f**



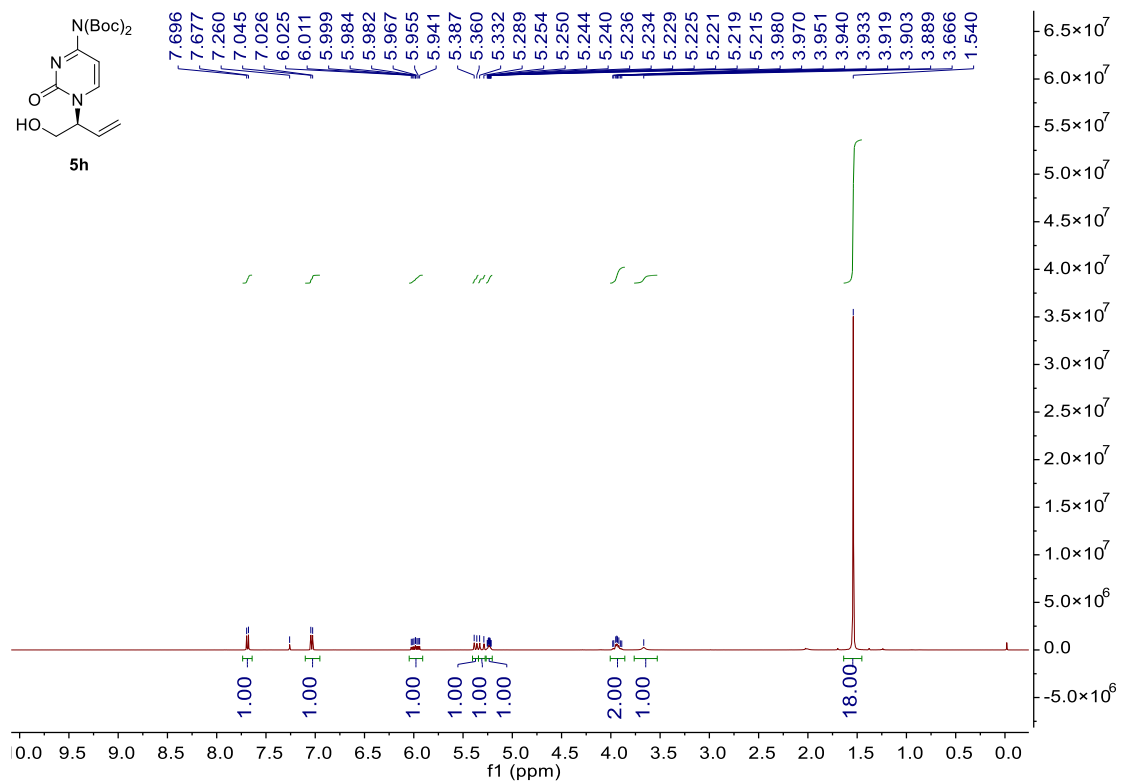
### <sup>1</sup>H NMR for 5g



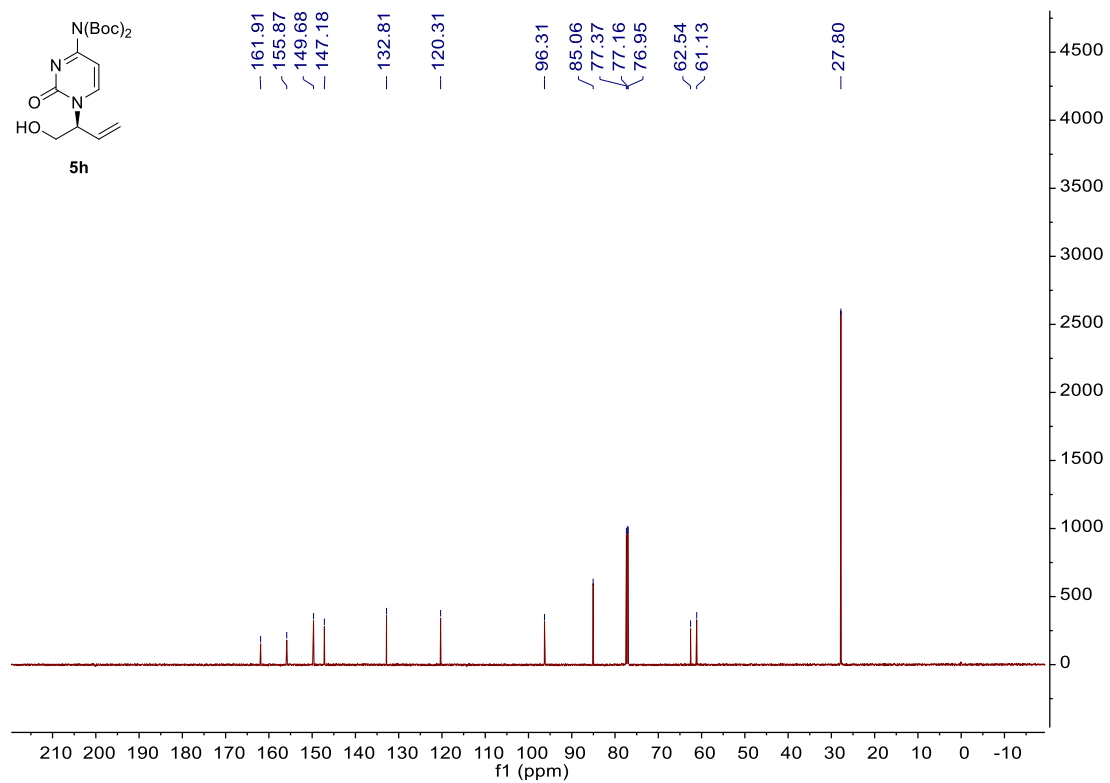
### <sup>13</sup>C NMR for 5g



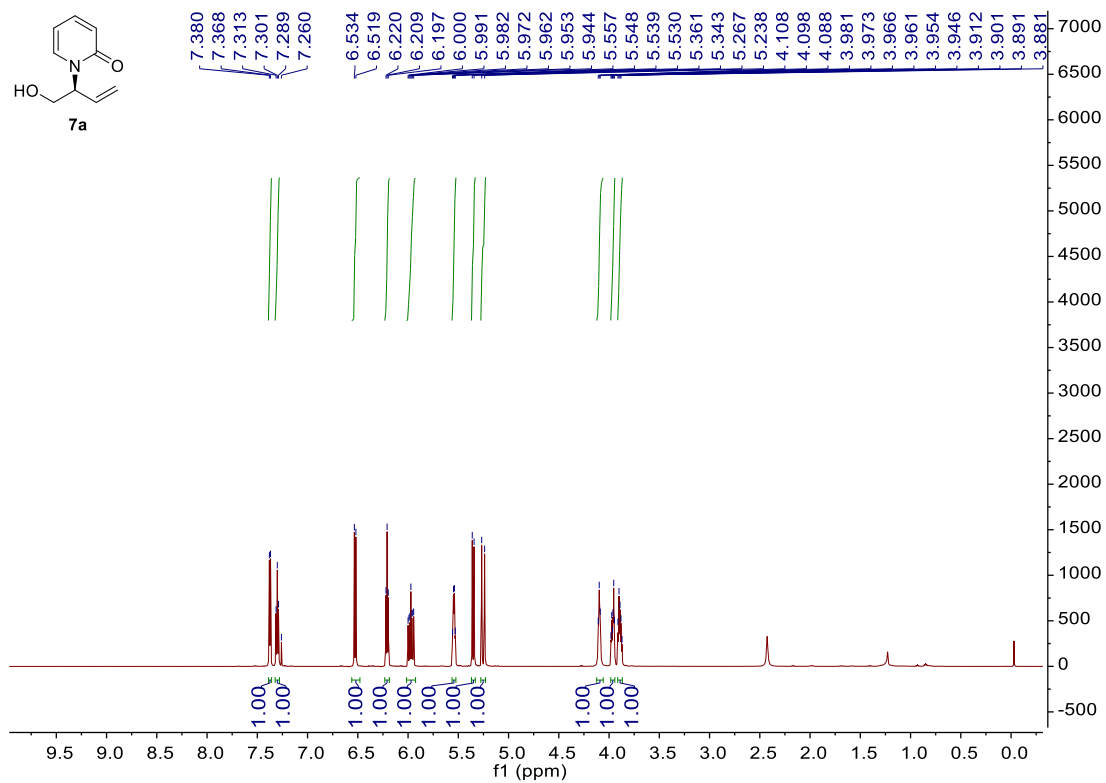
<sup>1</sup>H NMR for **5h**



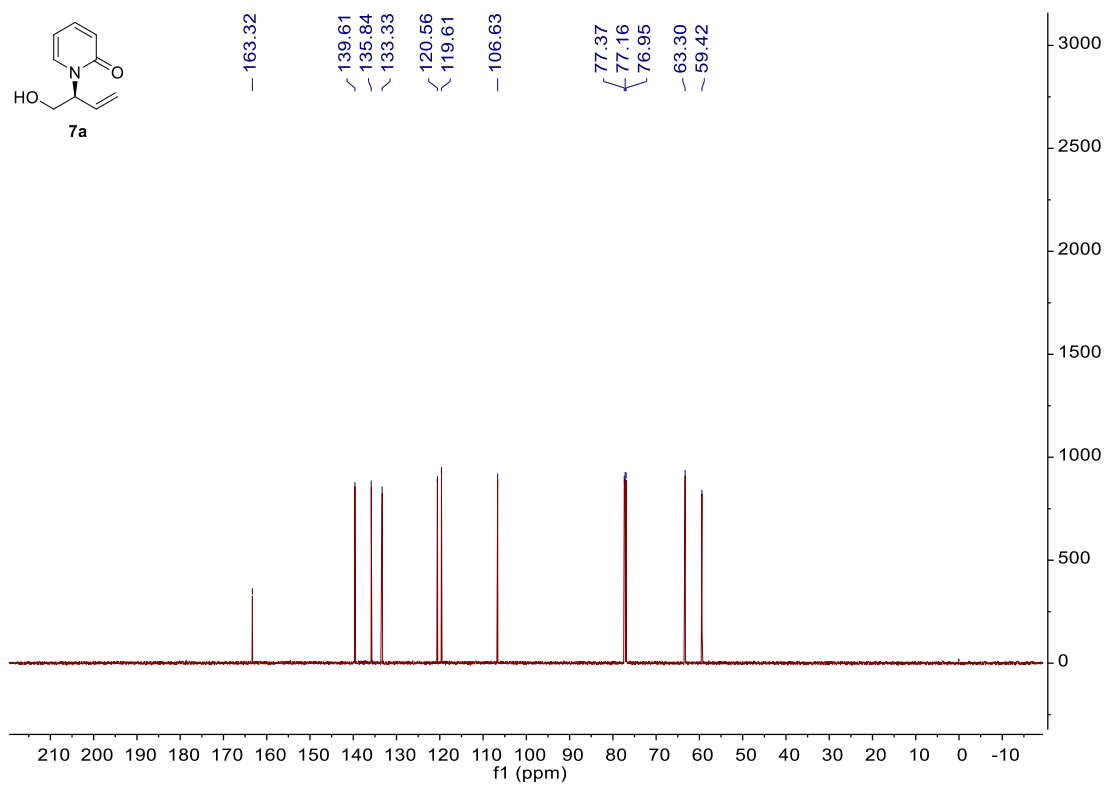
<sup>13</sup>C NMR for **5h**



### <sup>1</sup>H NMR for 7a

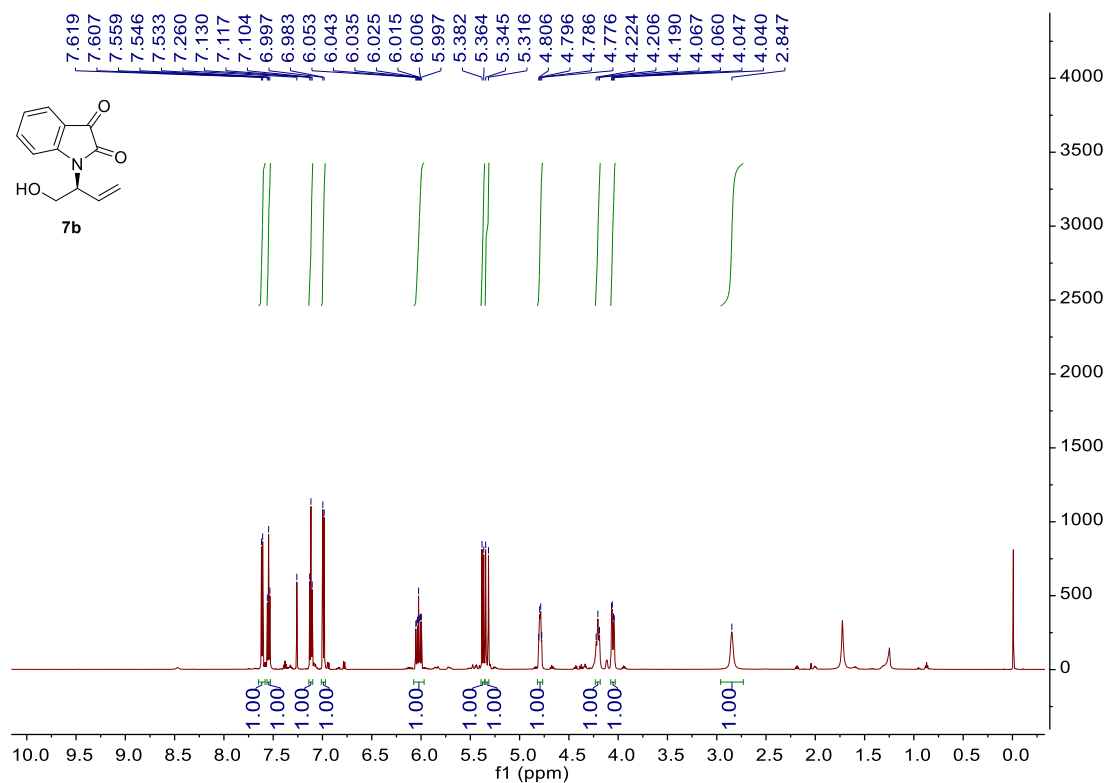


### <sup>13</sup>C NMR for 7a

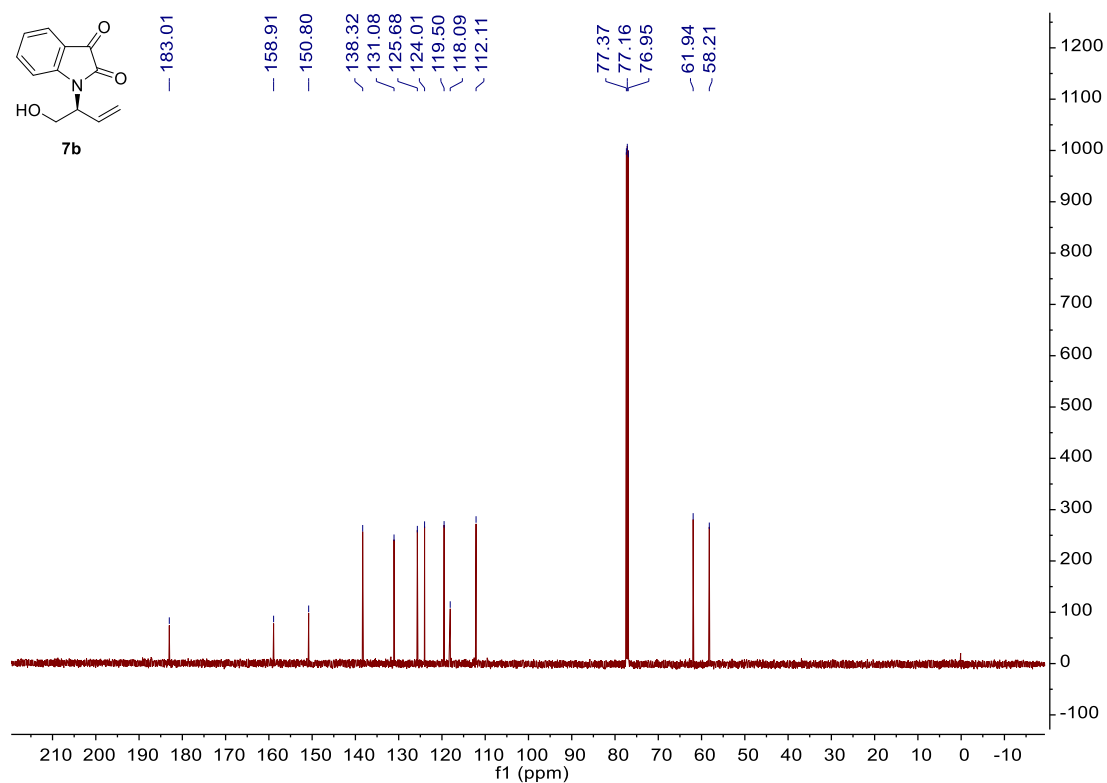




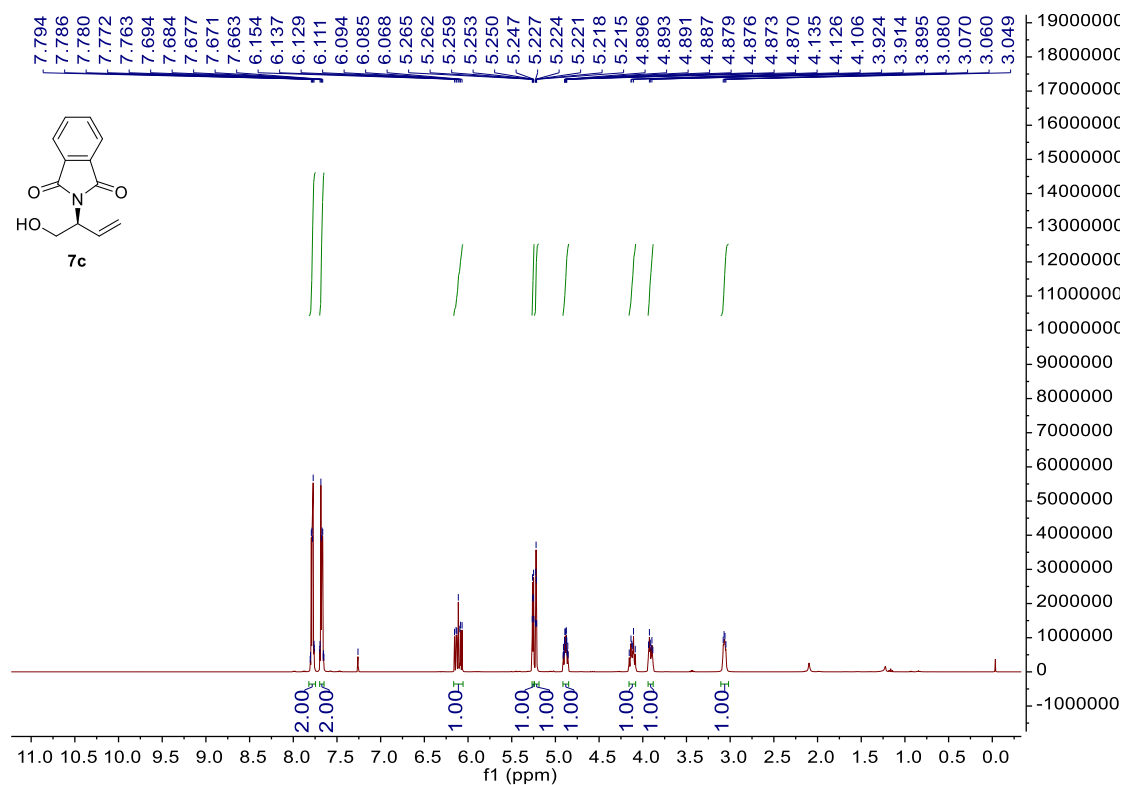
<sup>1</sup>H NMR for **7b**



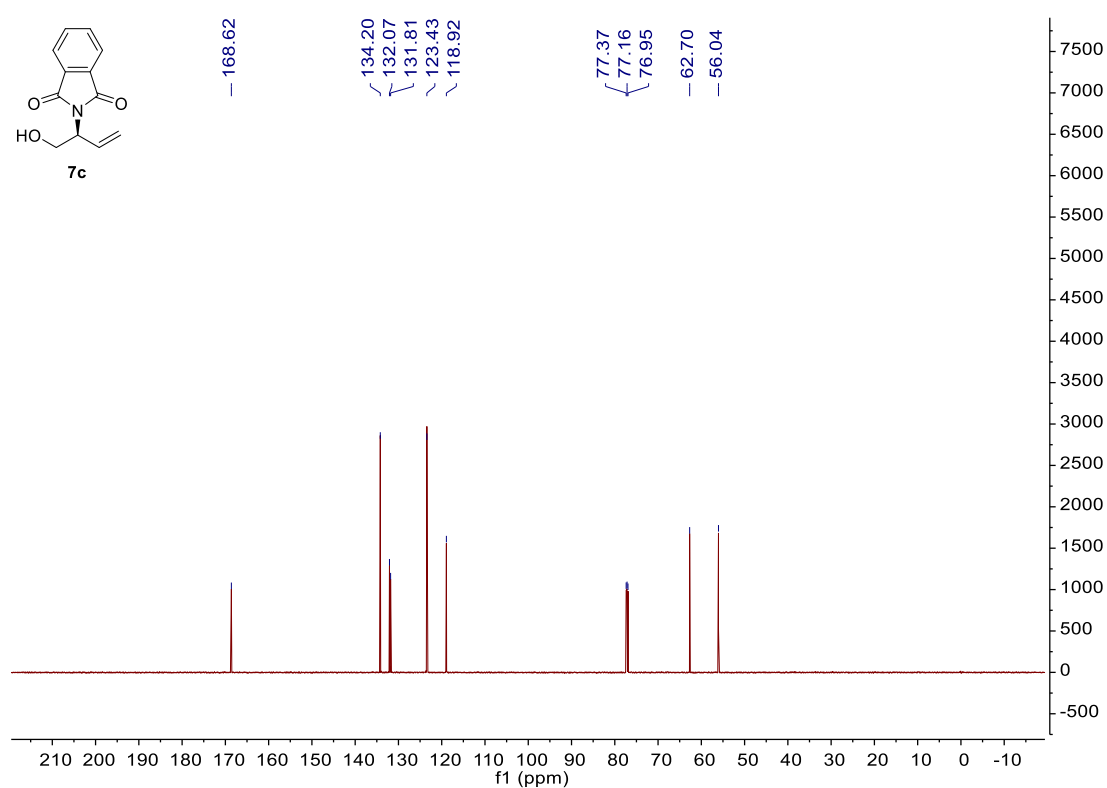
<sup>13</sup>C NMR for **7b**



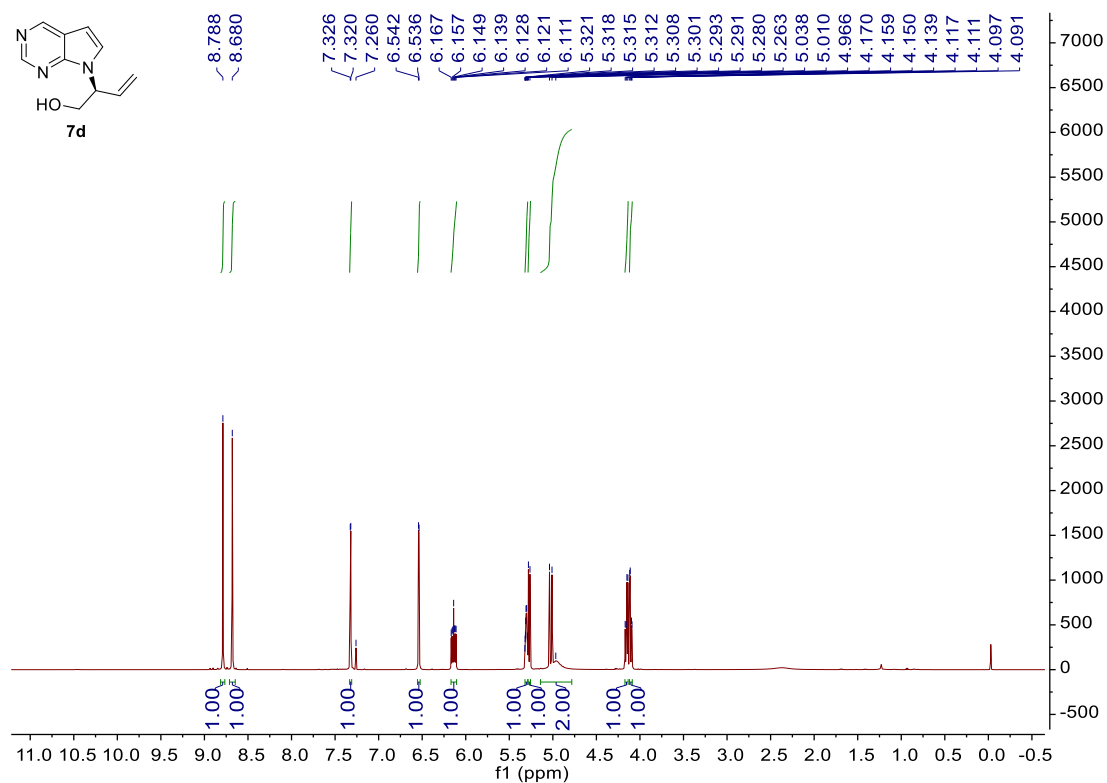
### <sup>1</sup>H NMR for 7c



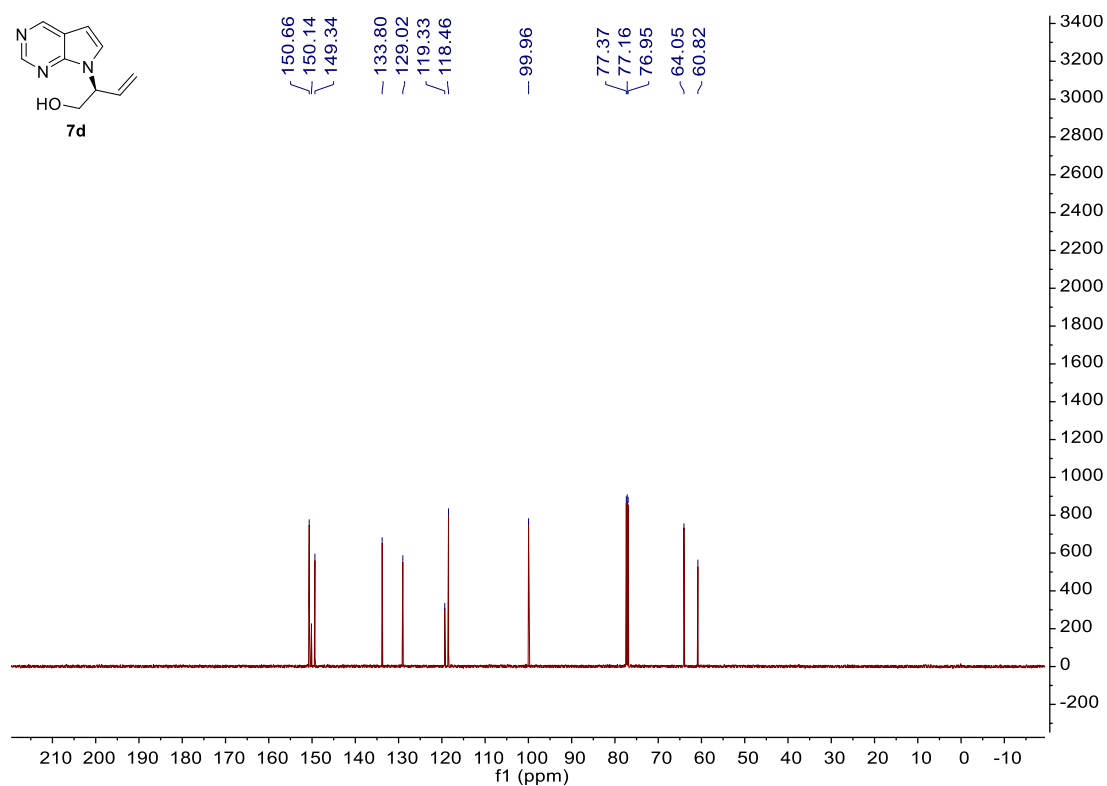
### <sup>13</sup>C NMR for 7c



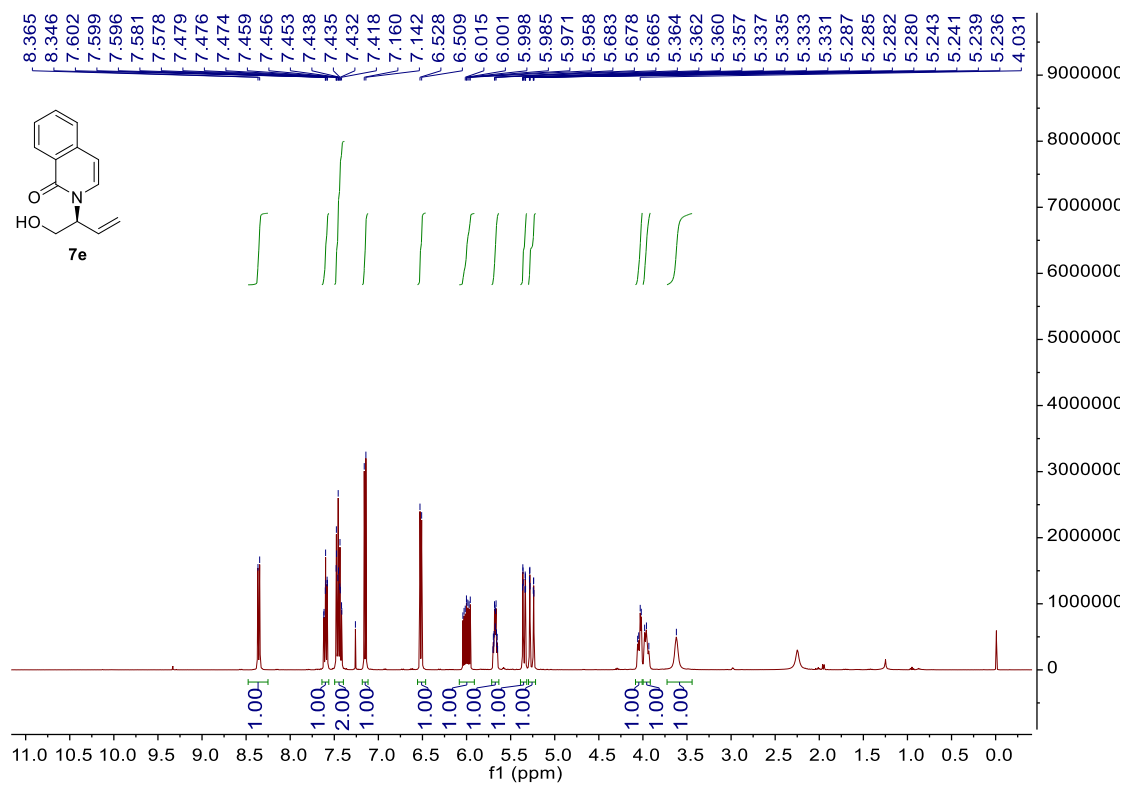
<sup>1</sup>H NMR for 7d



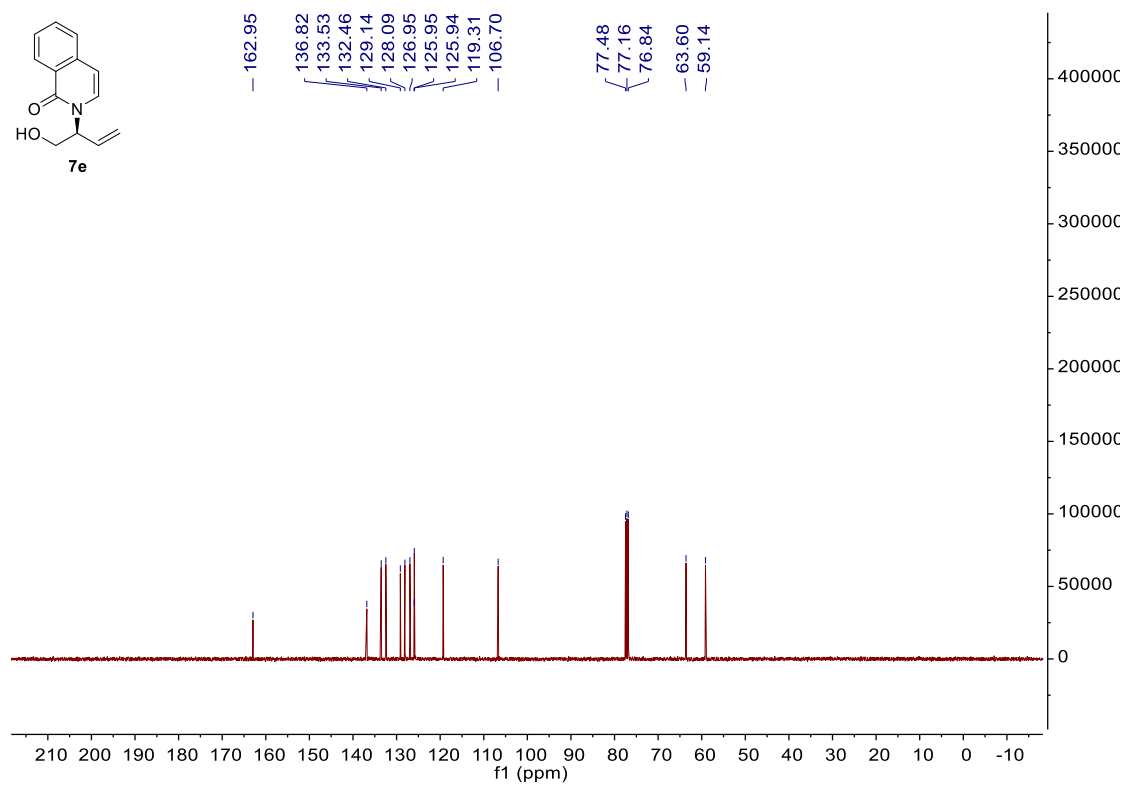
<sup>13</sup>C NMR for 7d



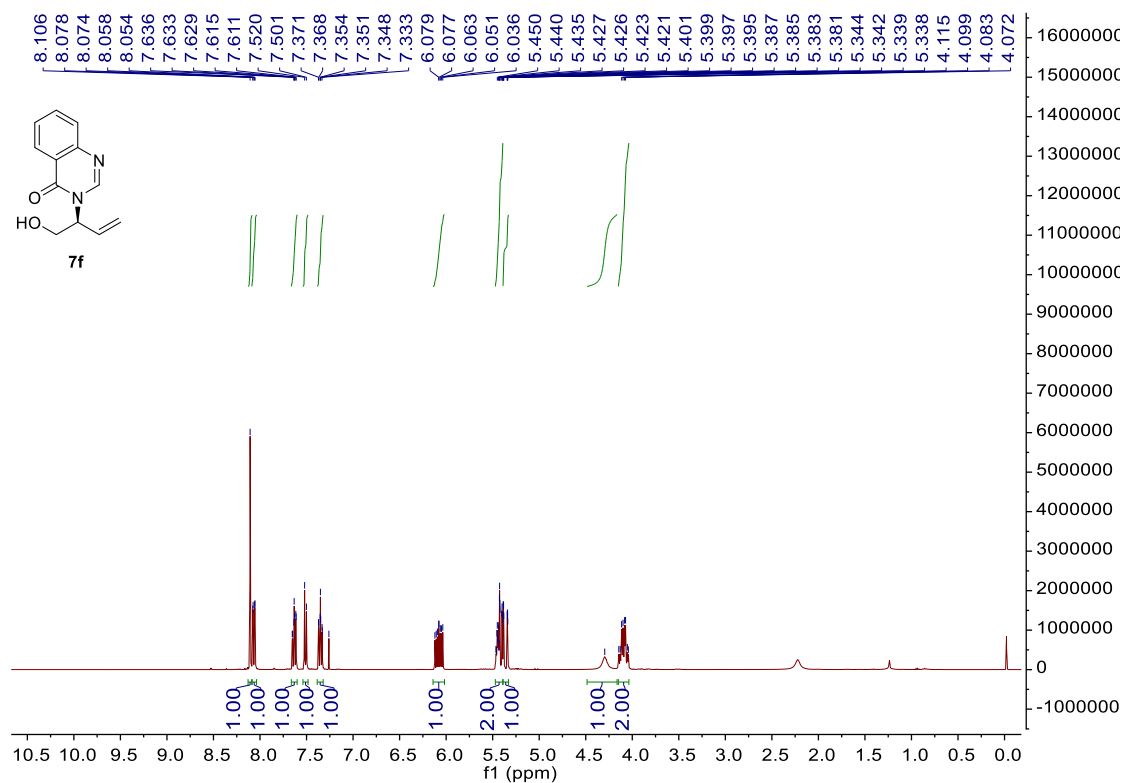
### <sup>1</sup>H NMR for 7e



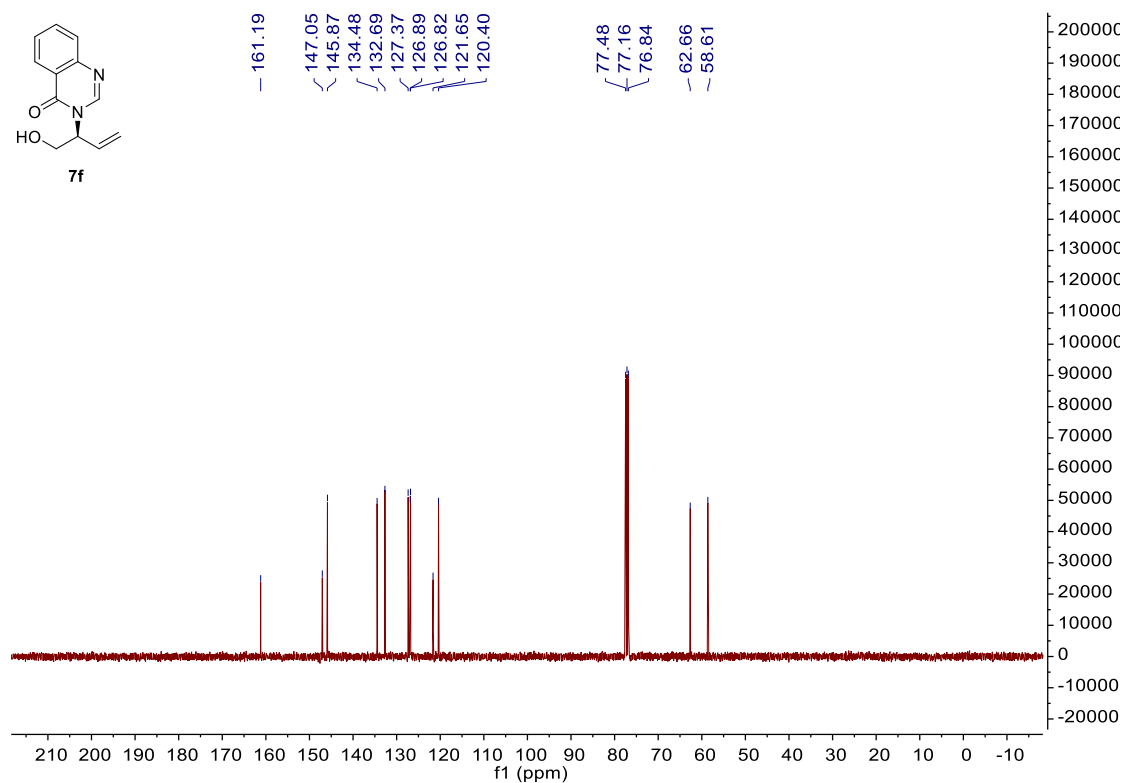
### <sup>13</sup>C NMR for 7e



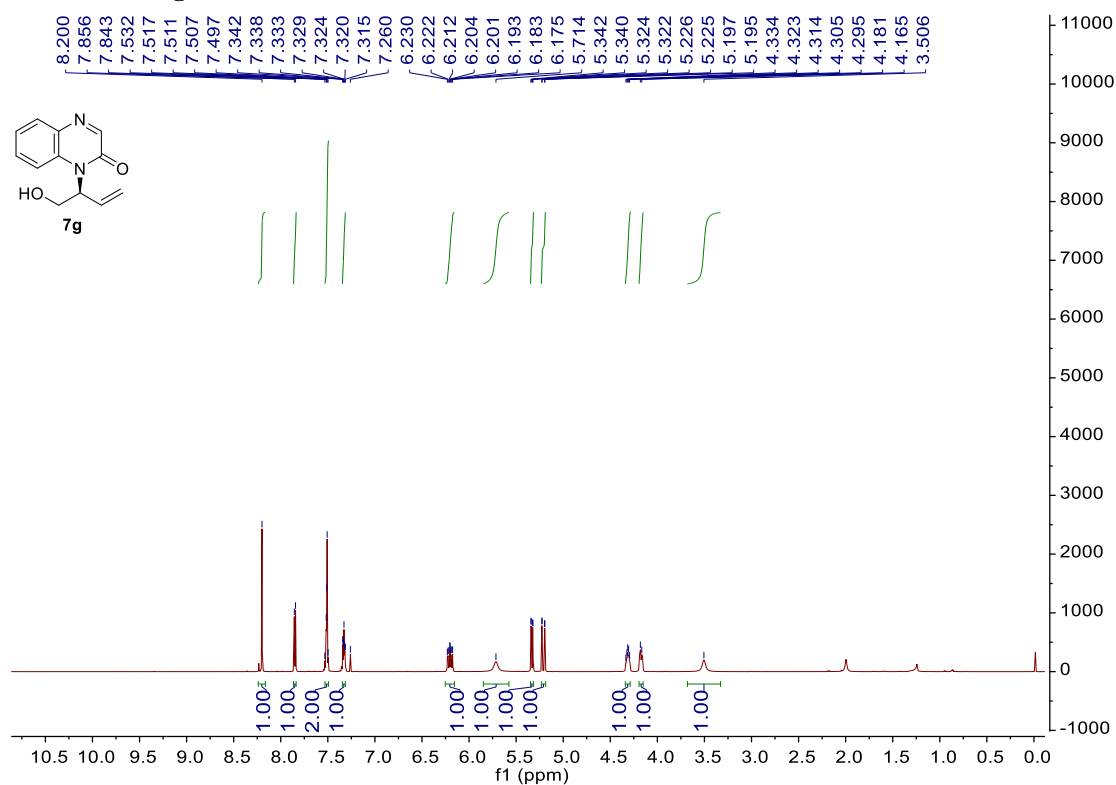
### <sup>1</sup>H NMR for 7f



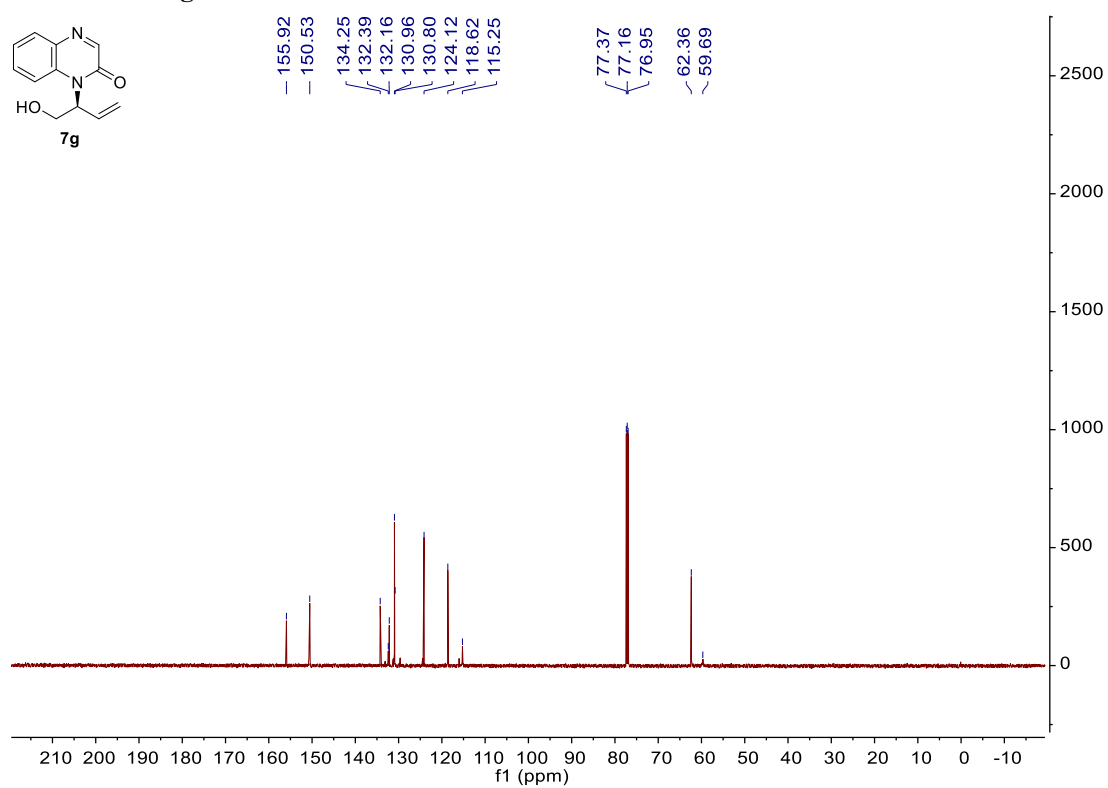
### <sup>13</sup>C NMR for 7f



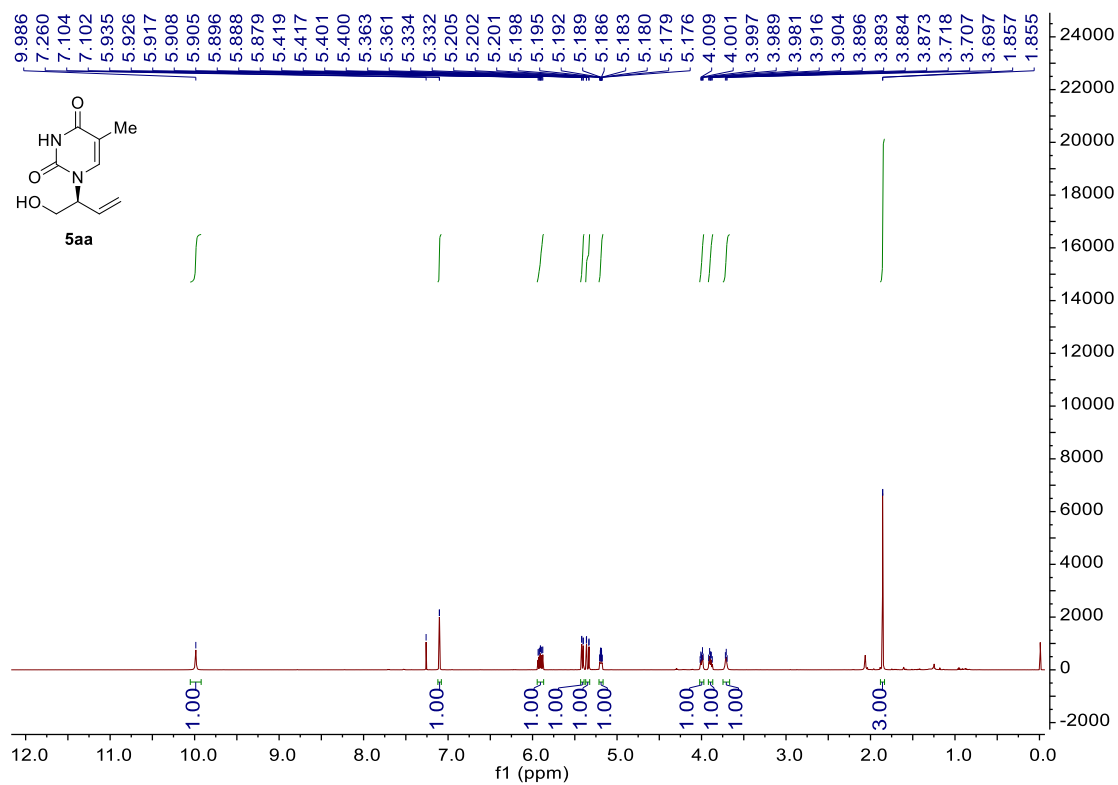
### <sup>1</sup>H NMR for 7g



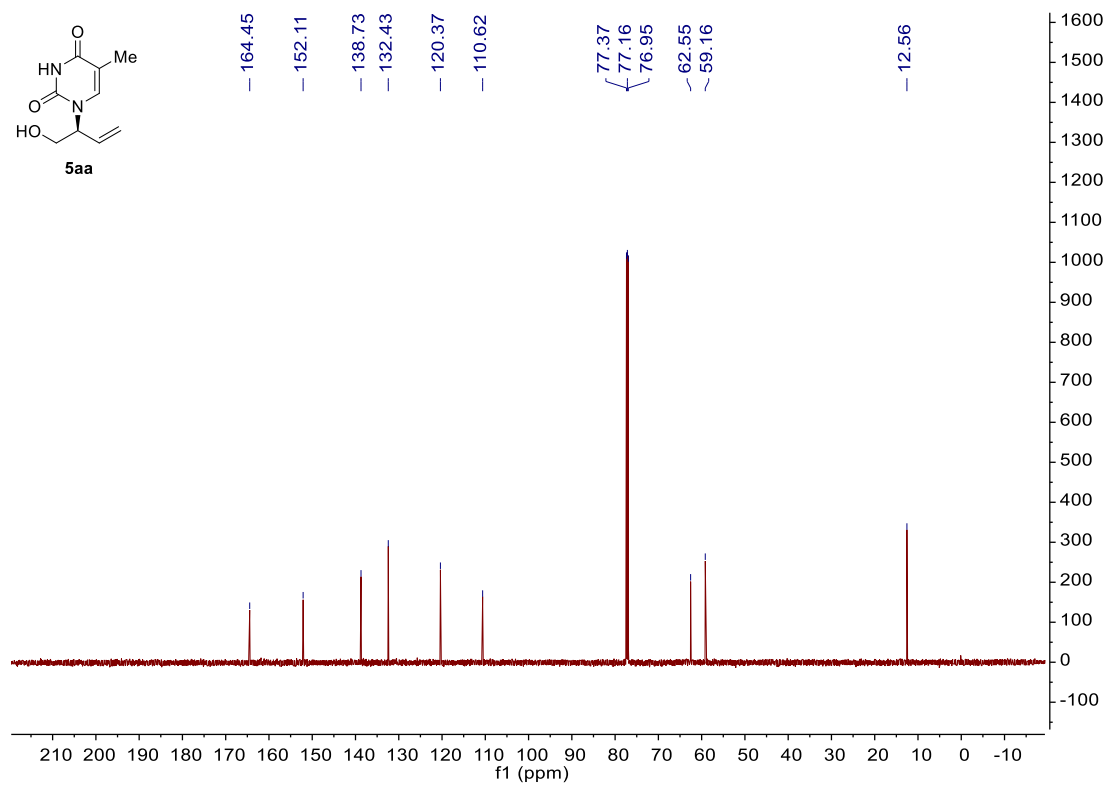
### <sup>13</sup>C NMR for 7g



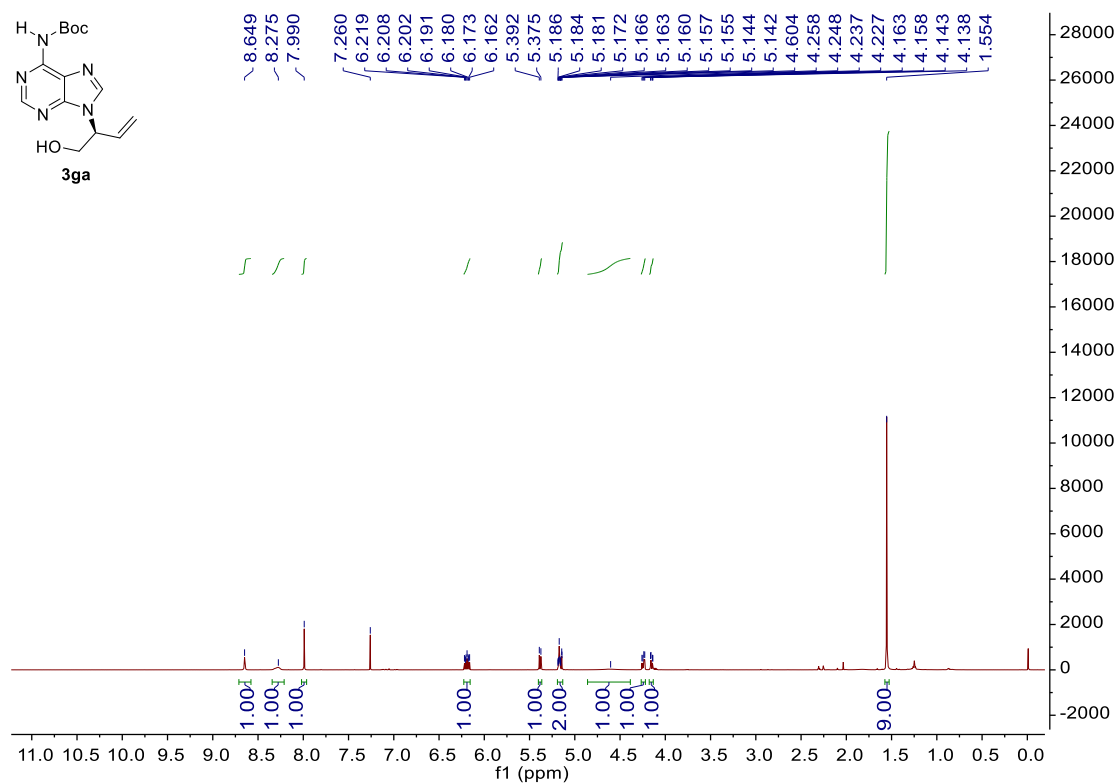
### <sup>1</sup>H NMR for 5aa



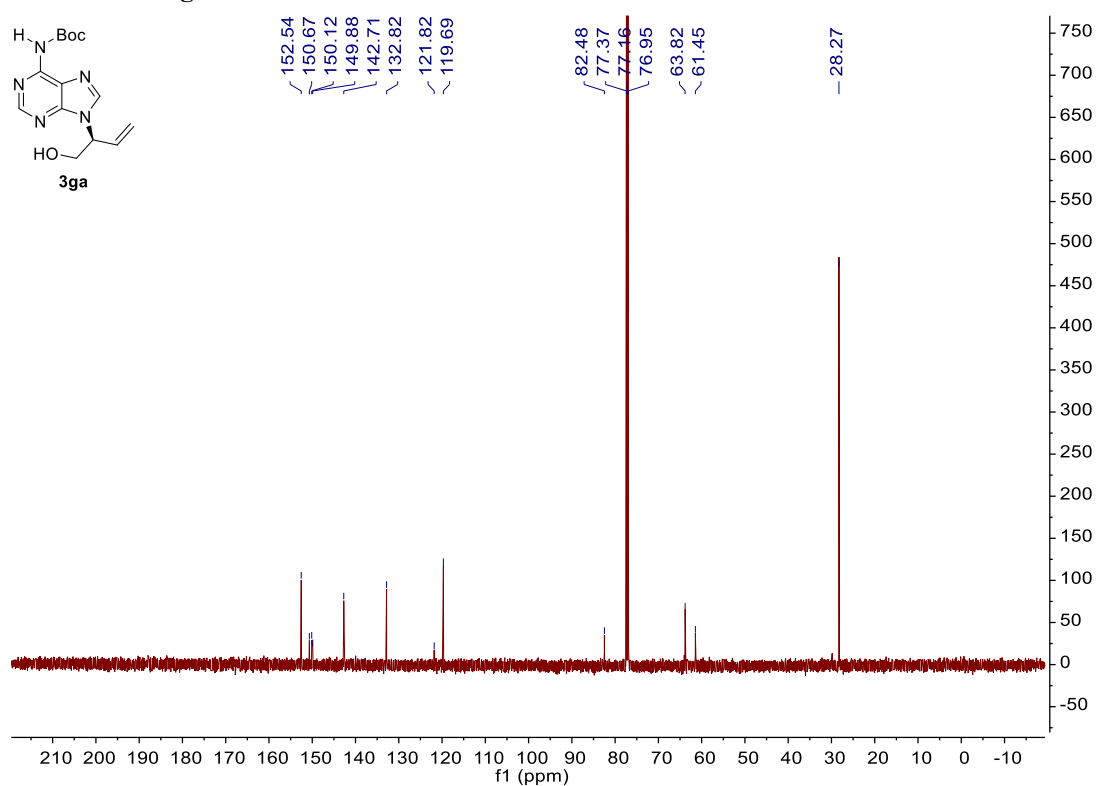
### <sup>13</sup>C NMR for 5aa



### <sup>1</sup>H NMR for 3ga

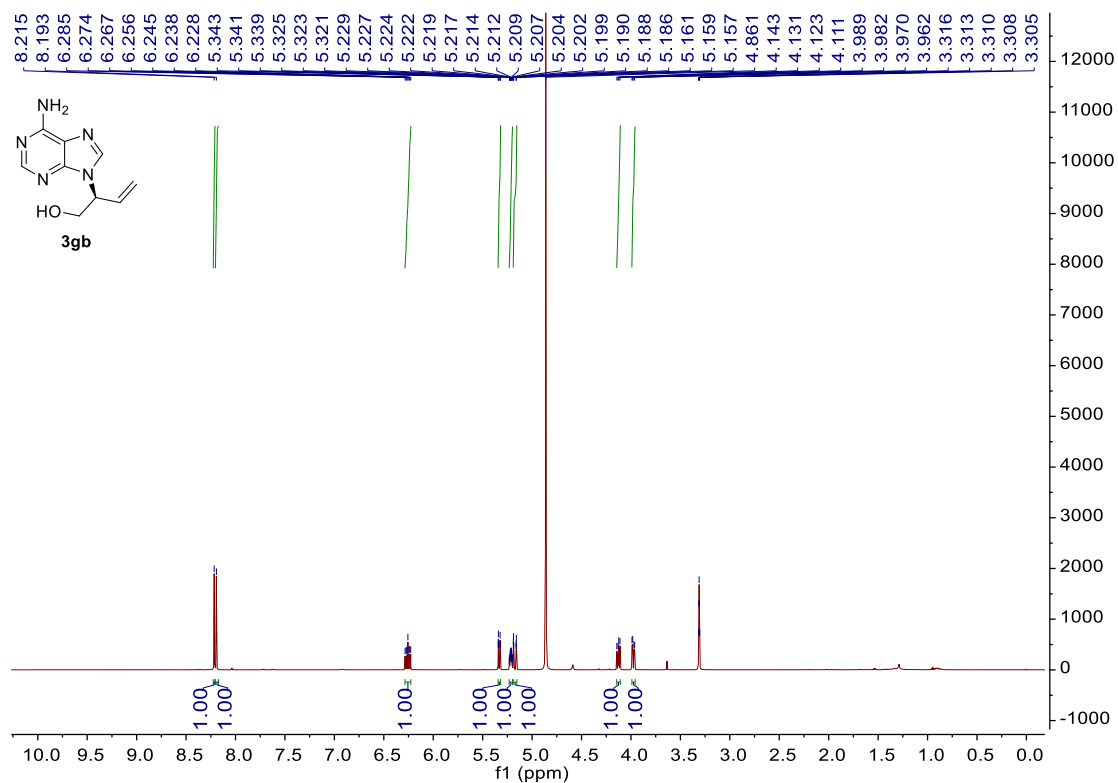


### <sup>13</sup>C NMR for 3ga

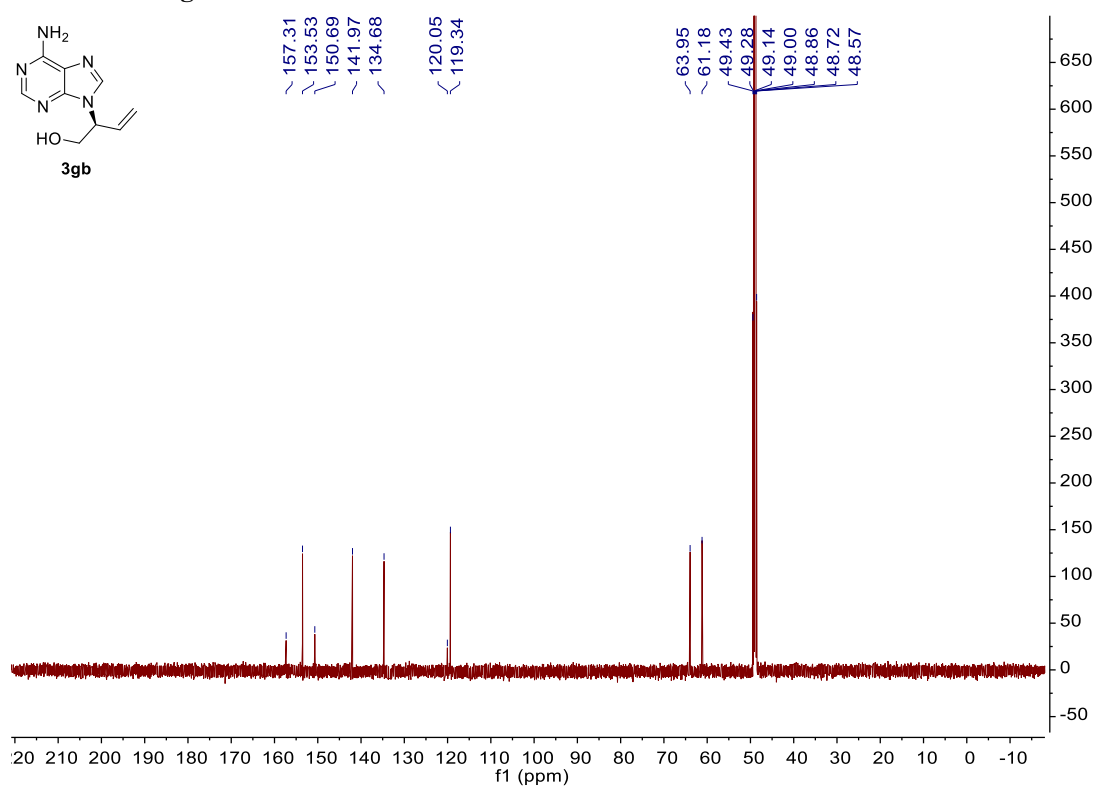




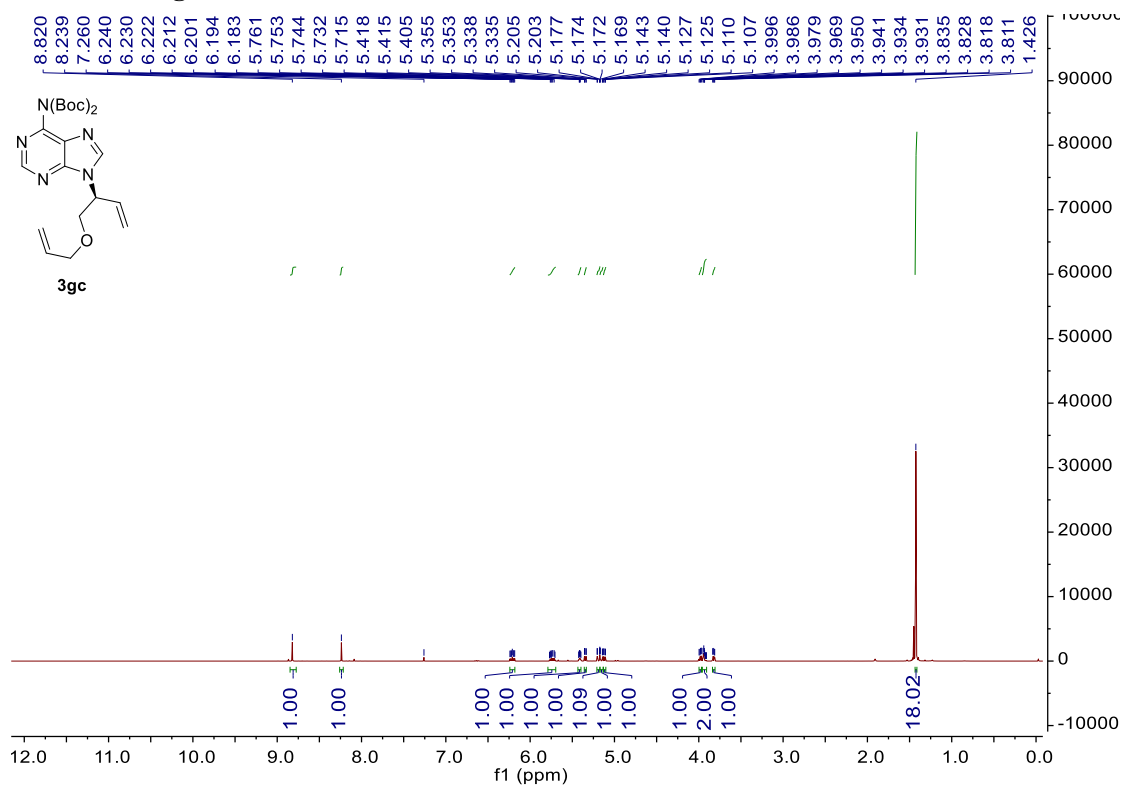
### <sup>1</sup>H NMR for 3gb



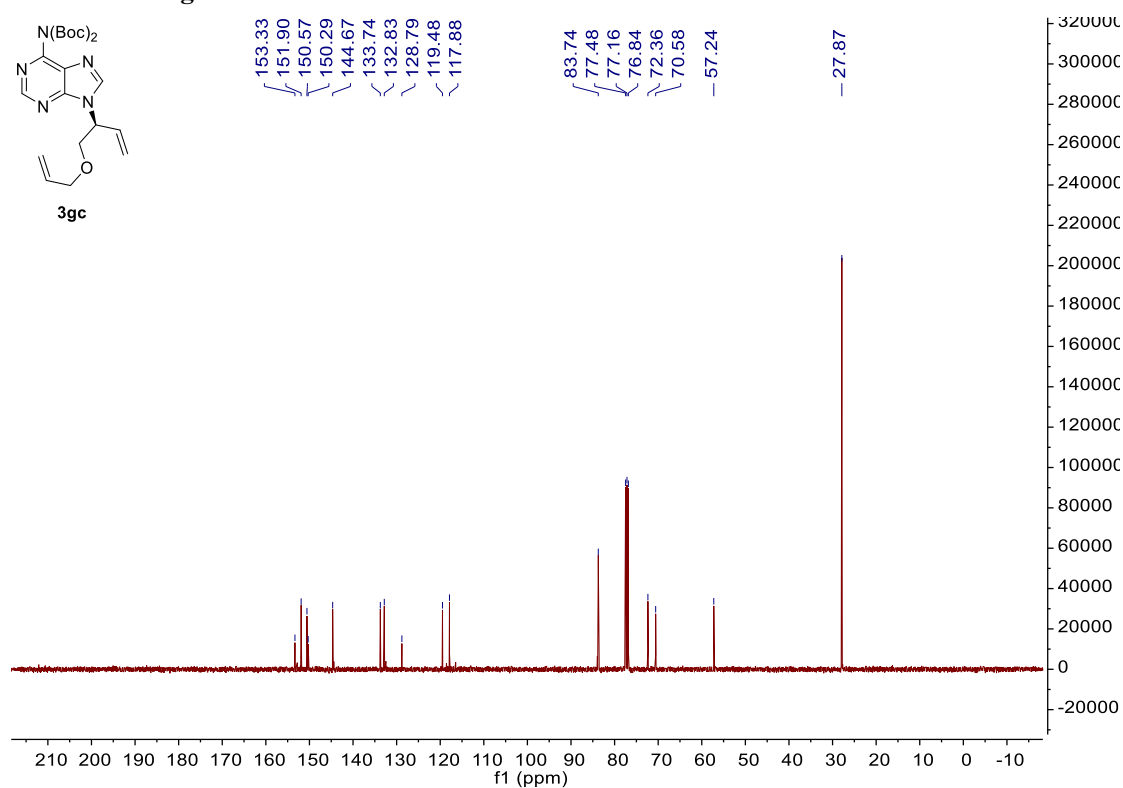
### <sup>13</sup>C NMR for 3gb



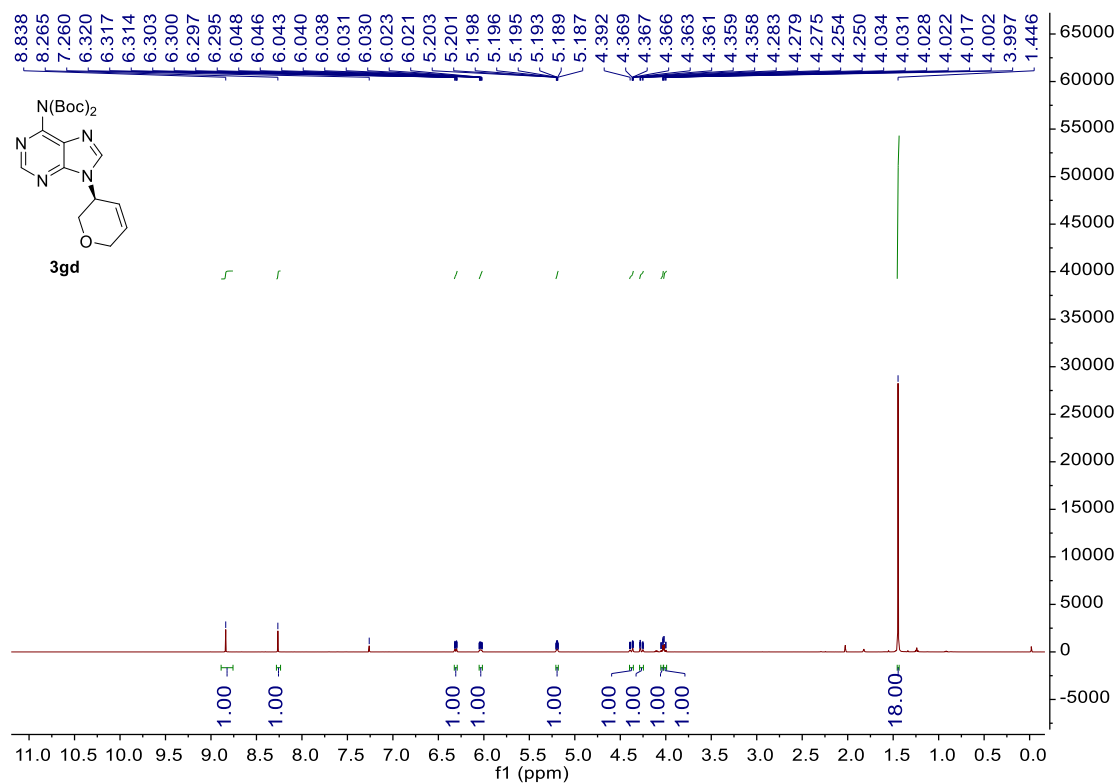
### <sup>1</sup>H NMR for 3gc



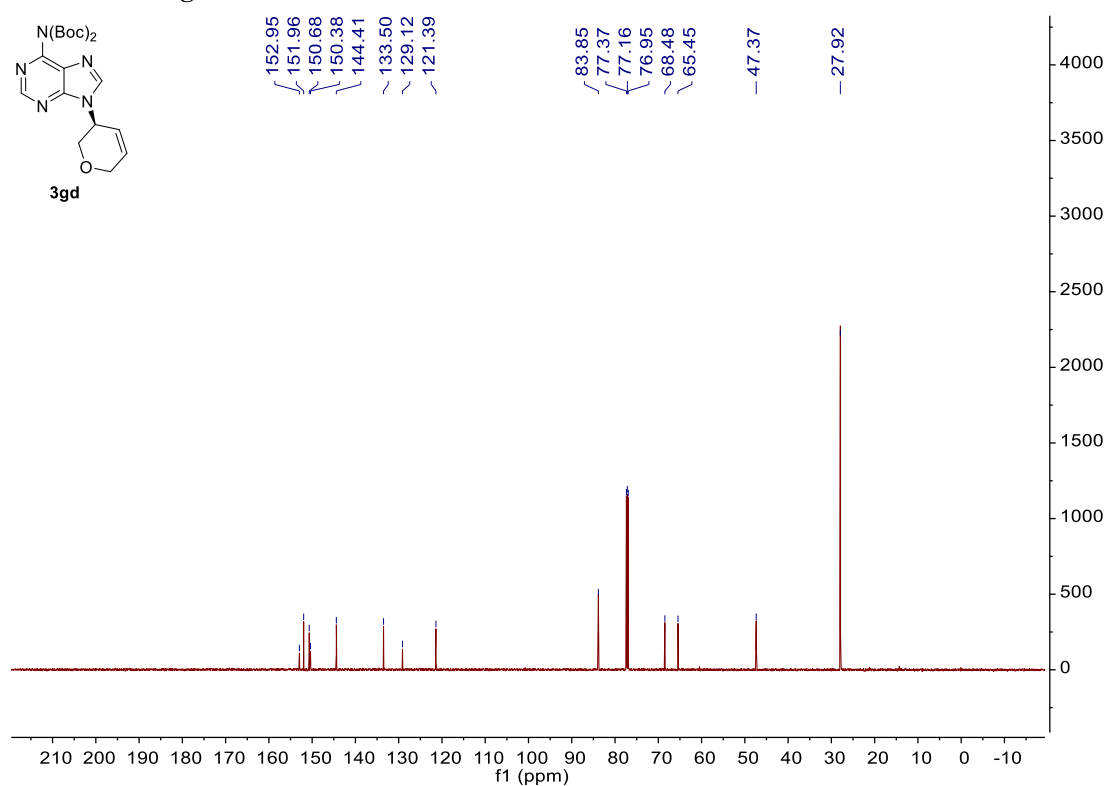
### <sup>13</sup>C NMR for 3gc



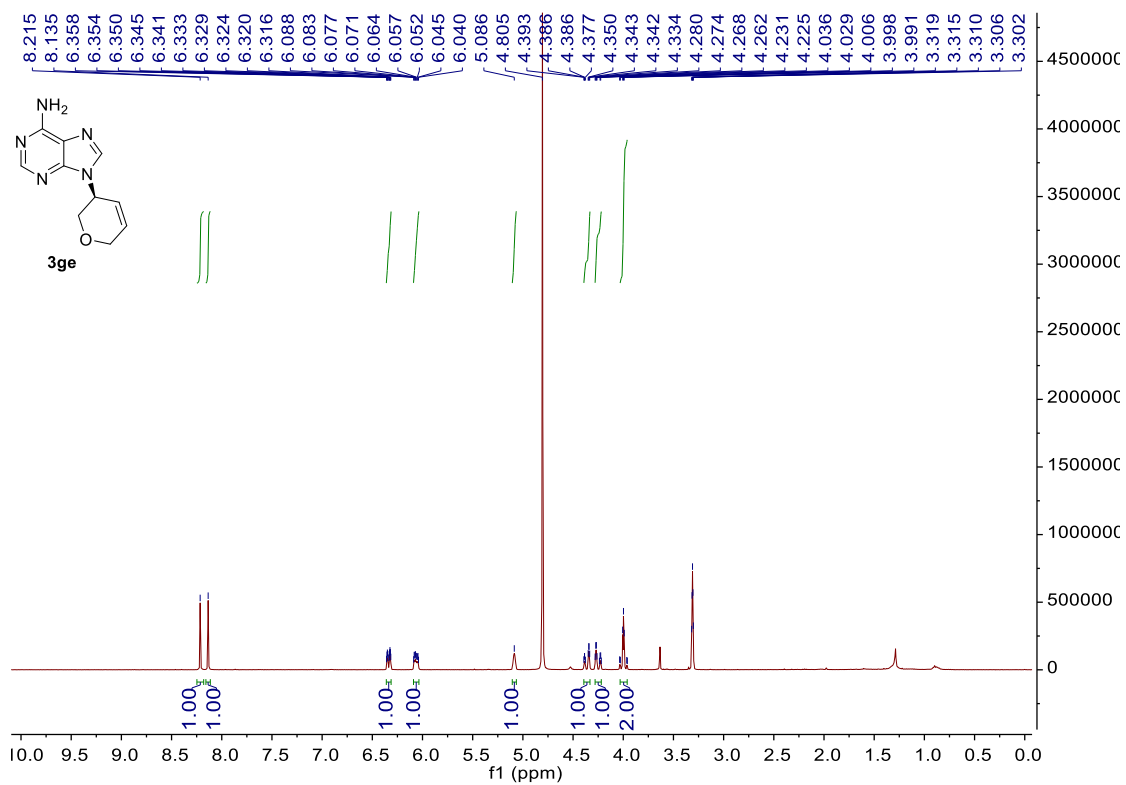
<sup>1</sup>H NMR for **3gd**



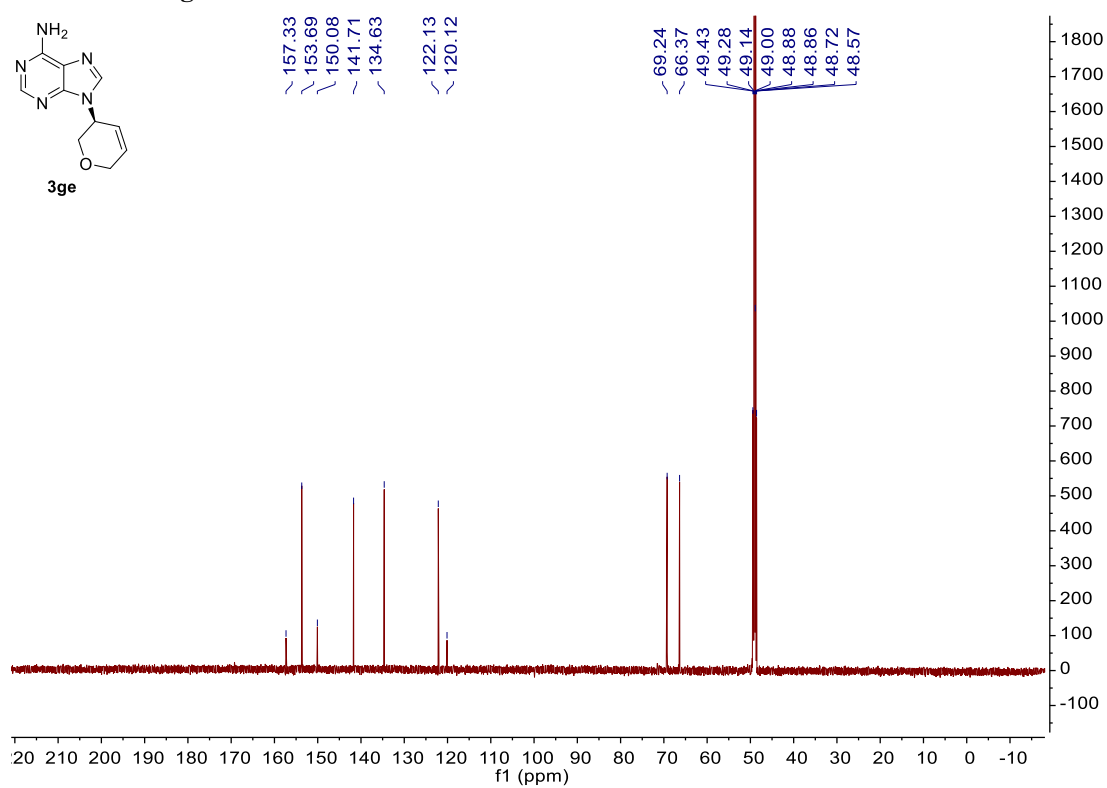
<sup>13</sup>C NMR for **3gd**



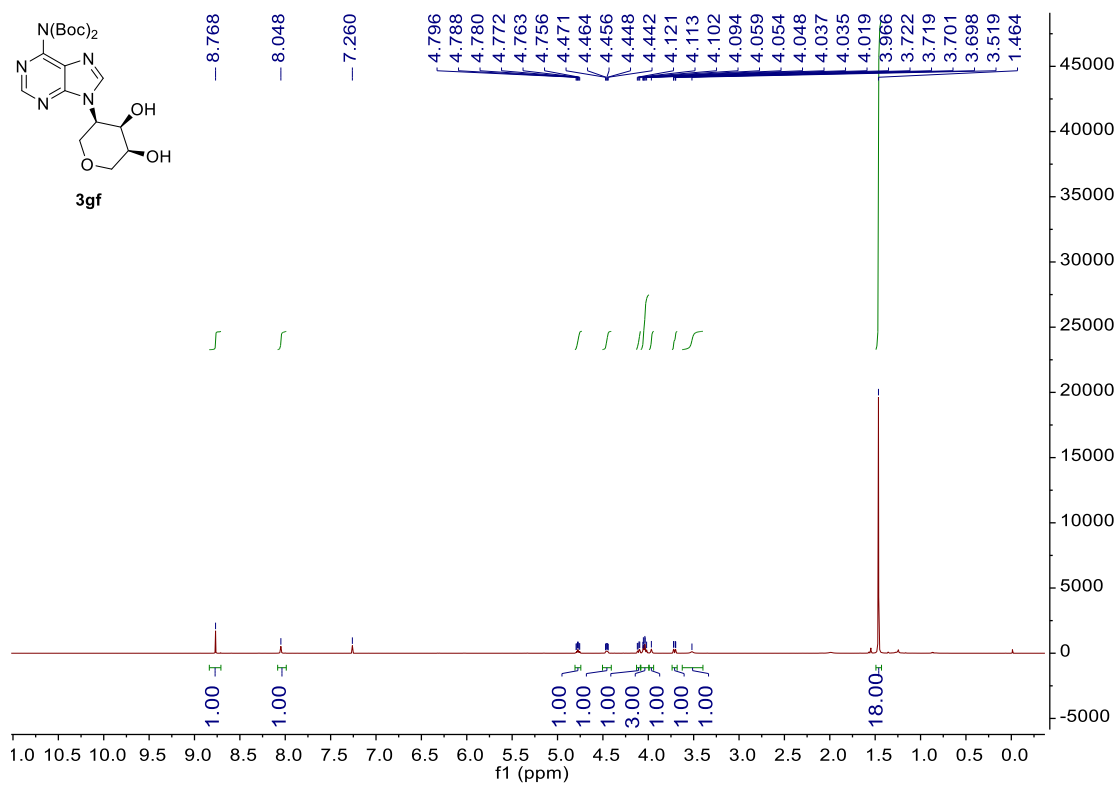
### <sup>1</sup>H NMR for 3ge



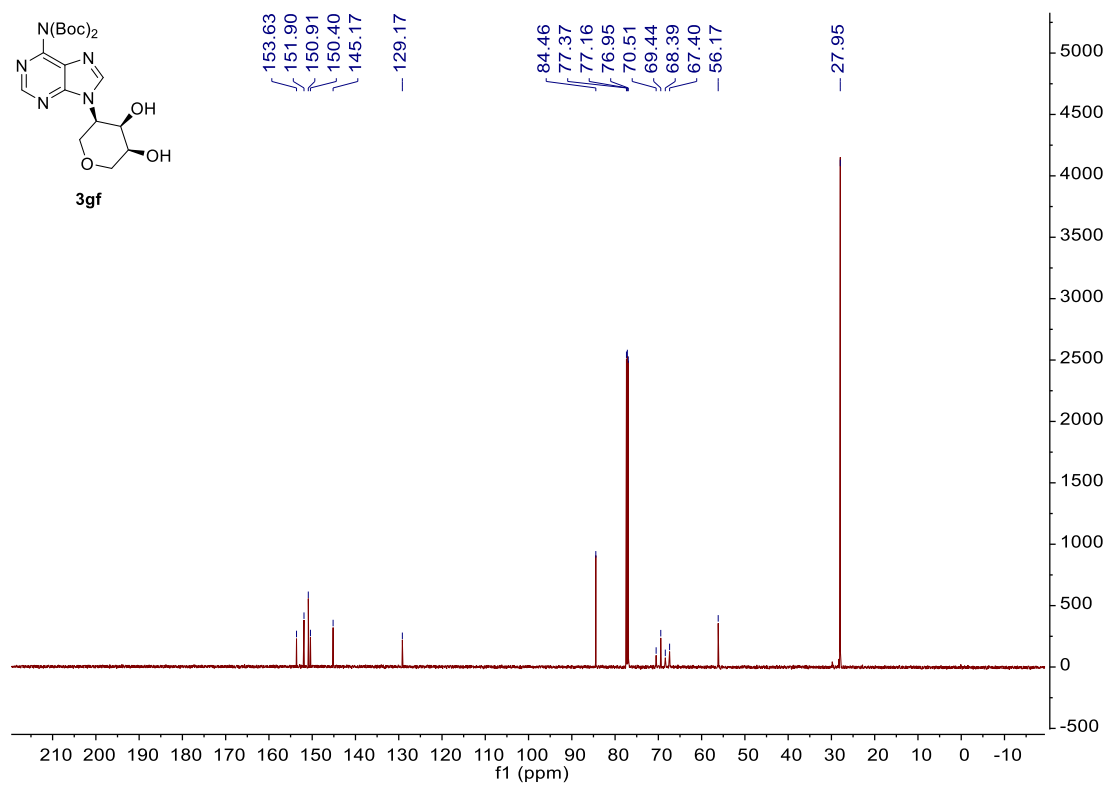
### <sup>13</sup>C NMR for 3ge



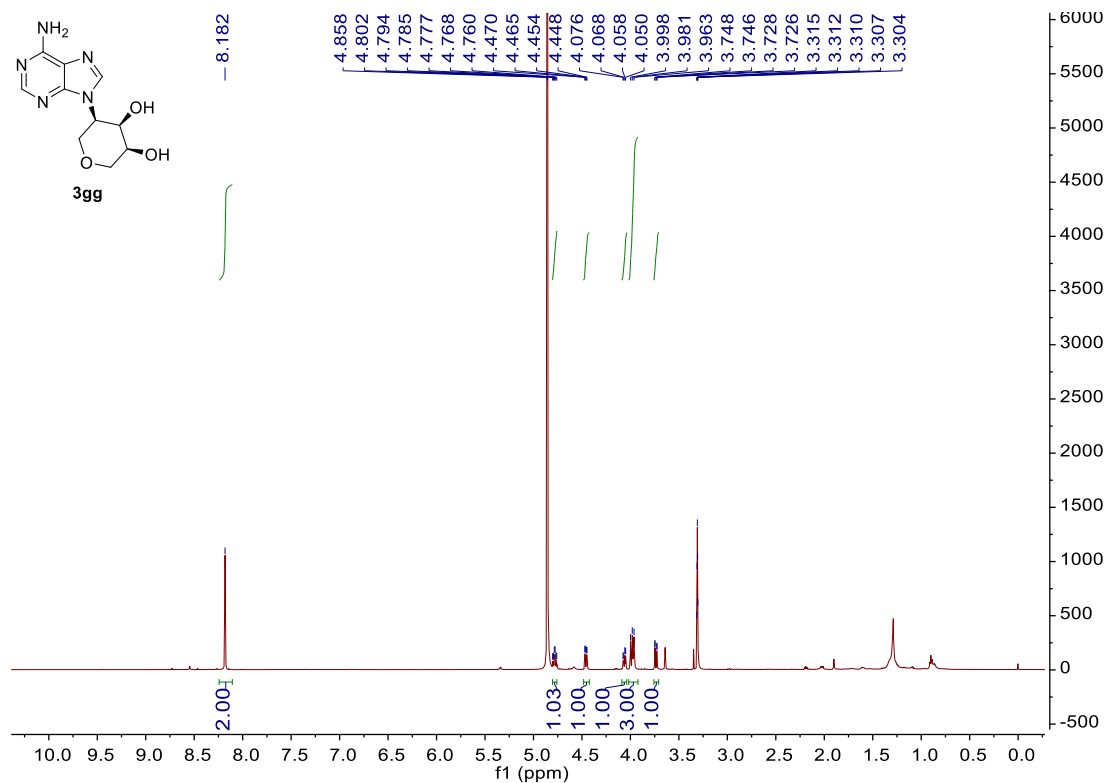
### <sup>1</sup>H NMR for 3gf



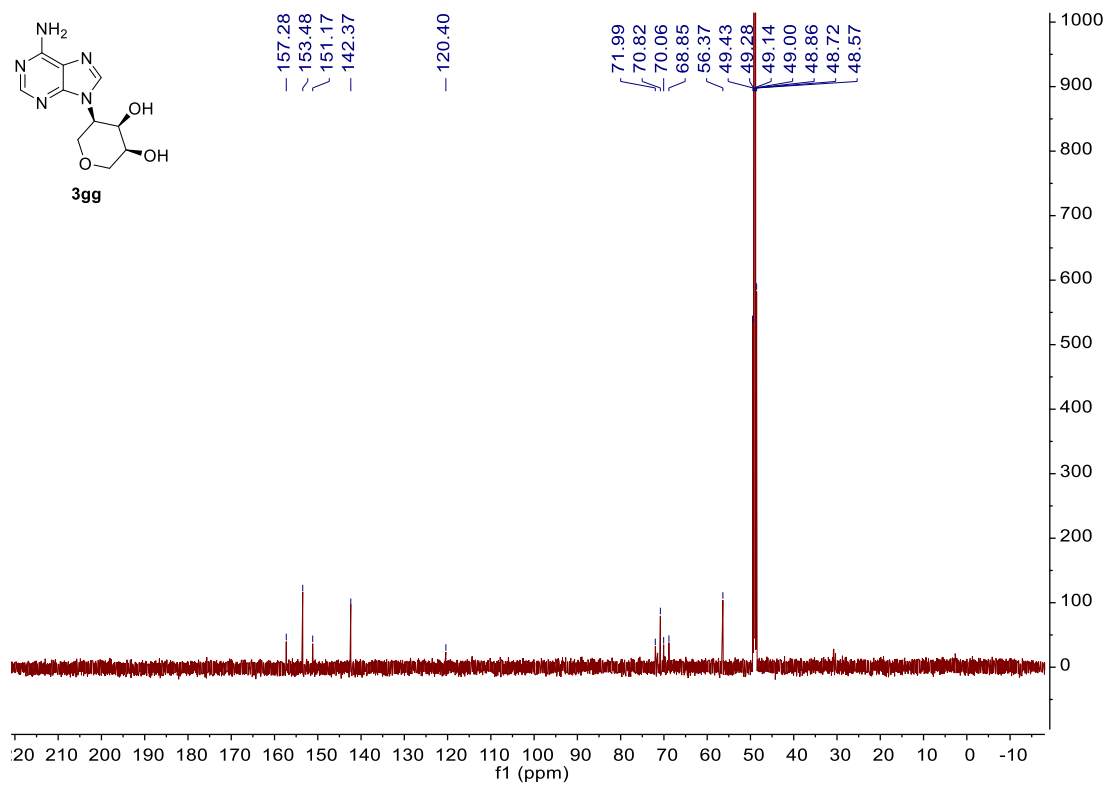
### <sup>13</sup>C NMR for 3gf



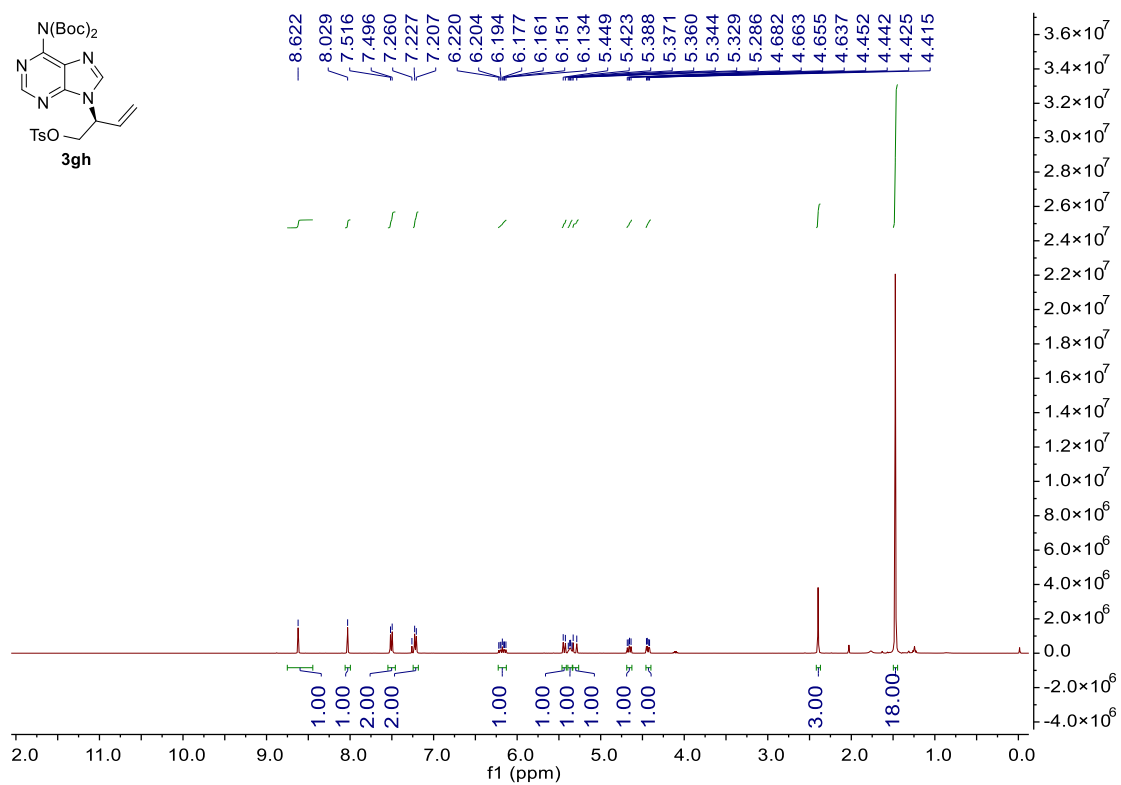
<sup>1</sup>H NMR for **3gg**



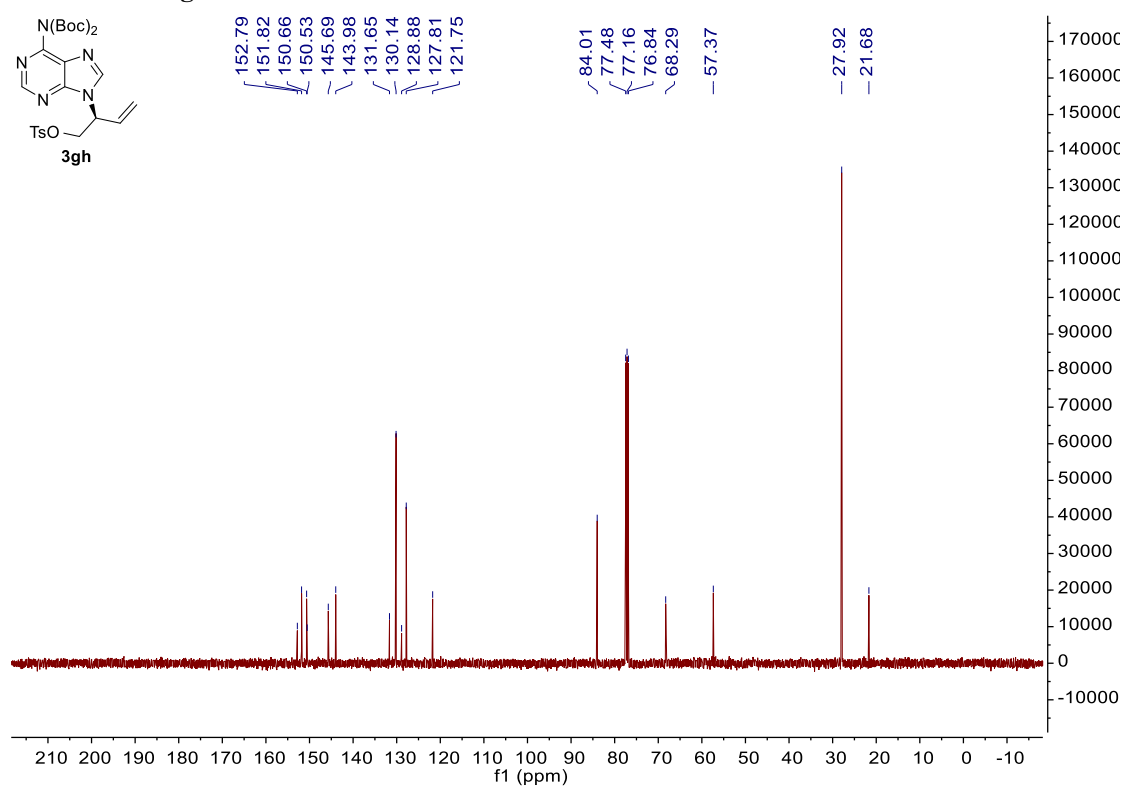
<sup>13</sup>C NMR for **3gg**



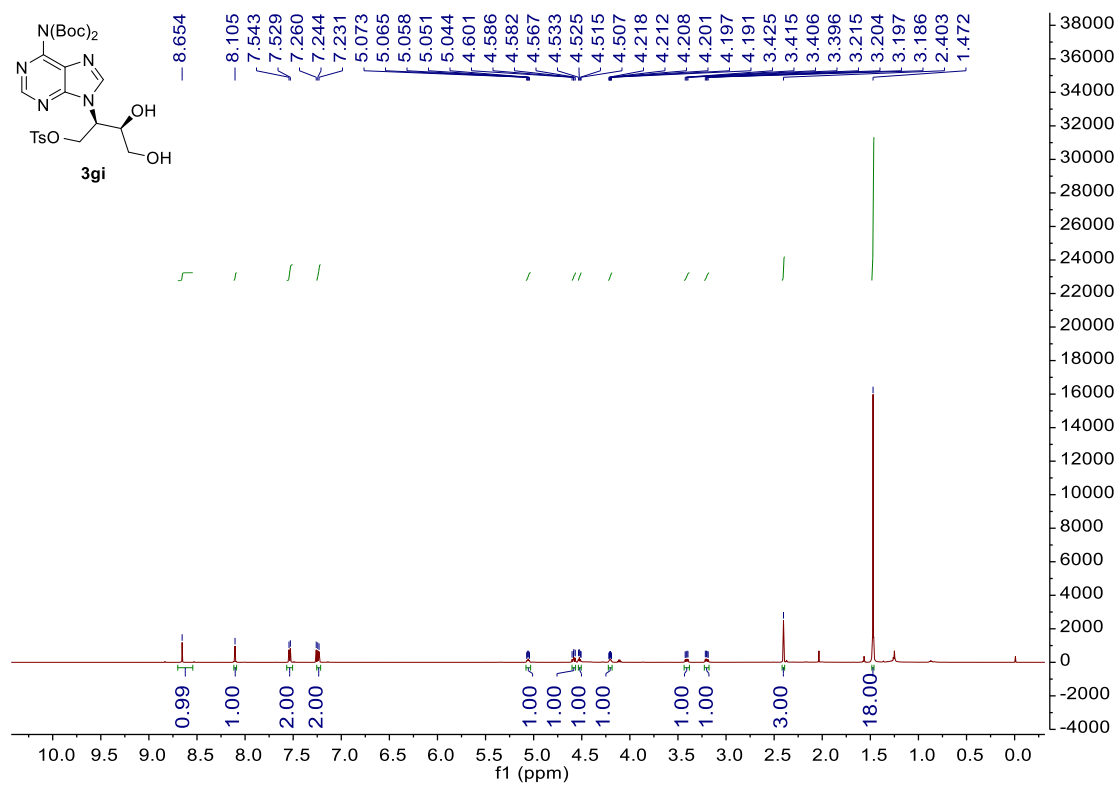
### <sup>1</sup>H NMR for 3gh



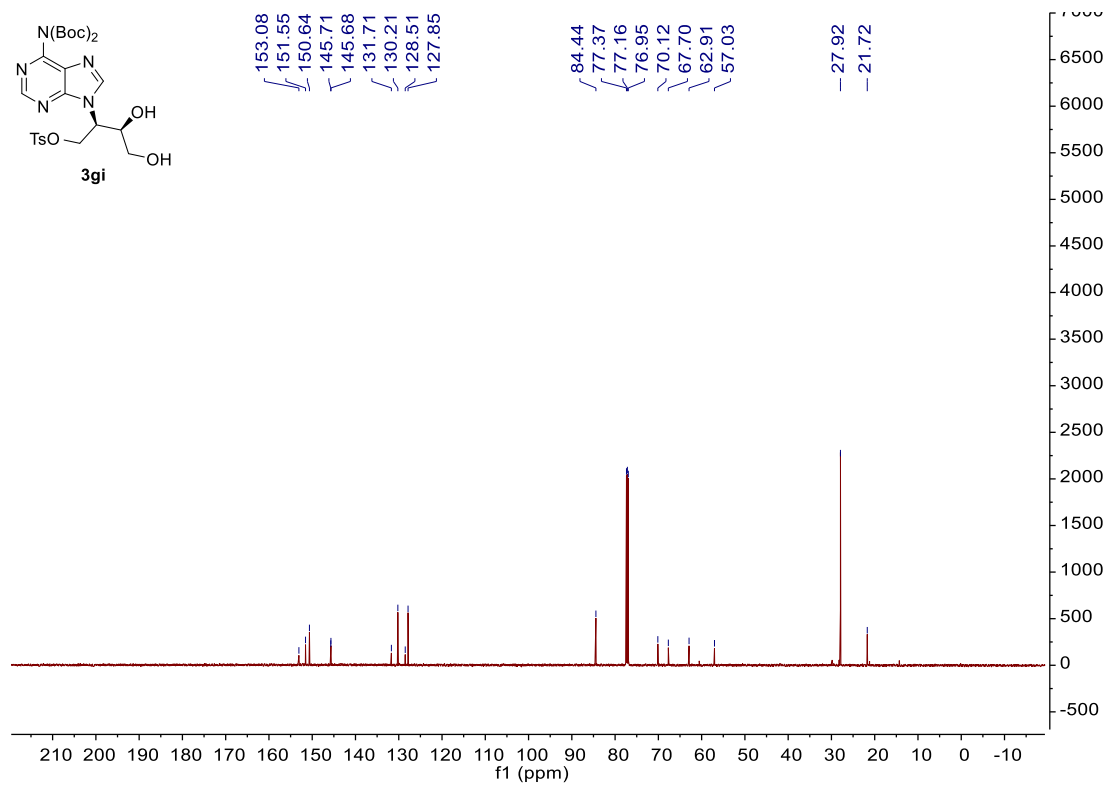
### <sup>13</sup>C NMR for 3gh



<sup>1</sup>H NMR for **3gi**

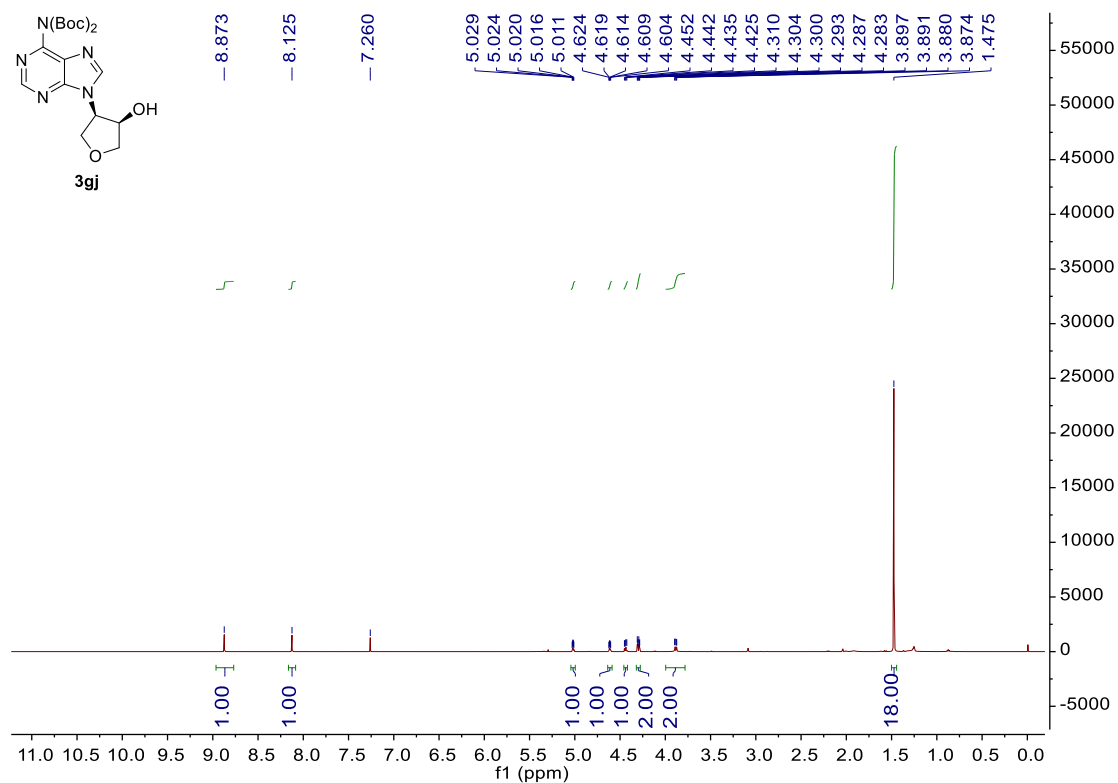


<sup>13</sup>C NMR for **3gi**

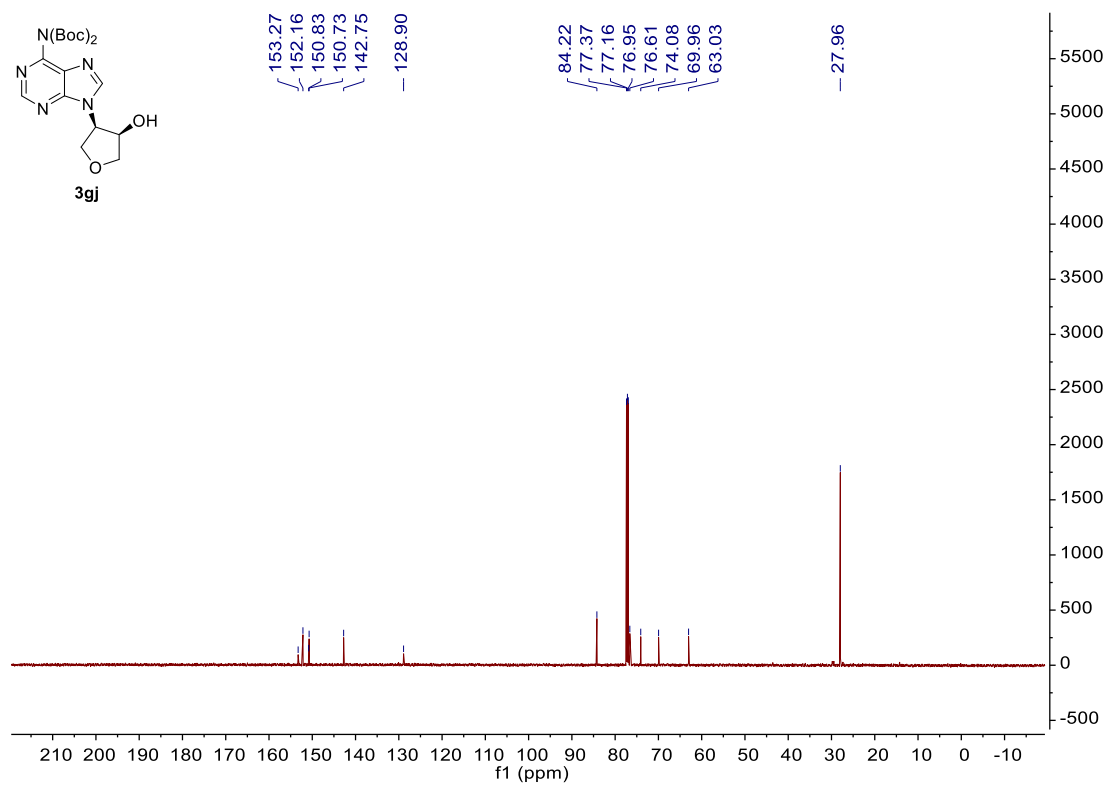




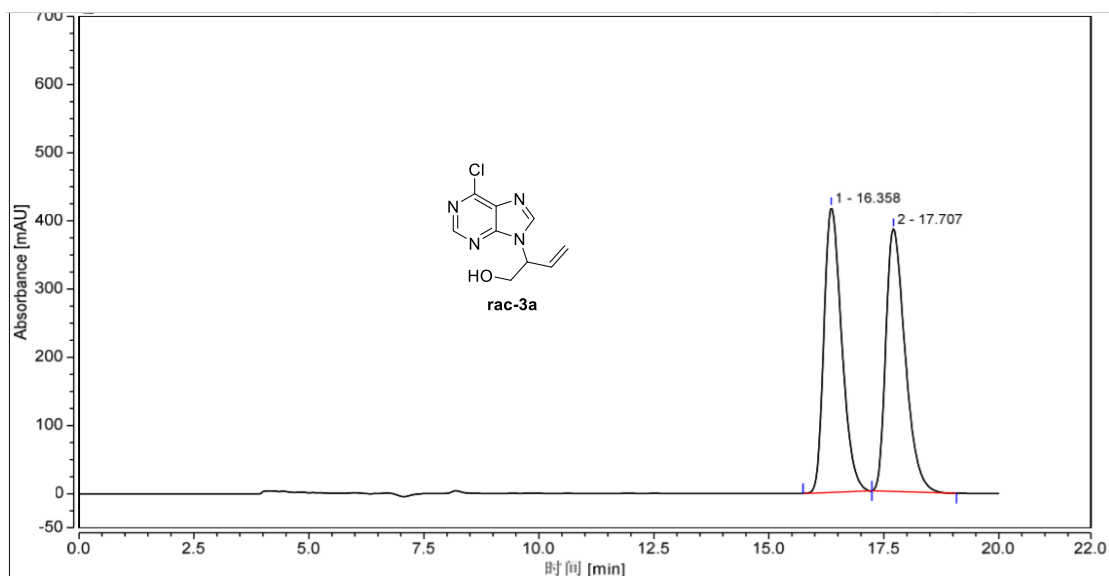
### <sup>1</sup>H NMR for 3gj



### <sup>13</sup>C NMR for 3gj

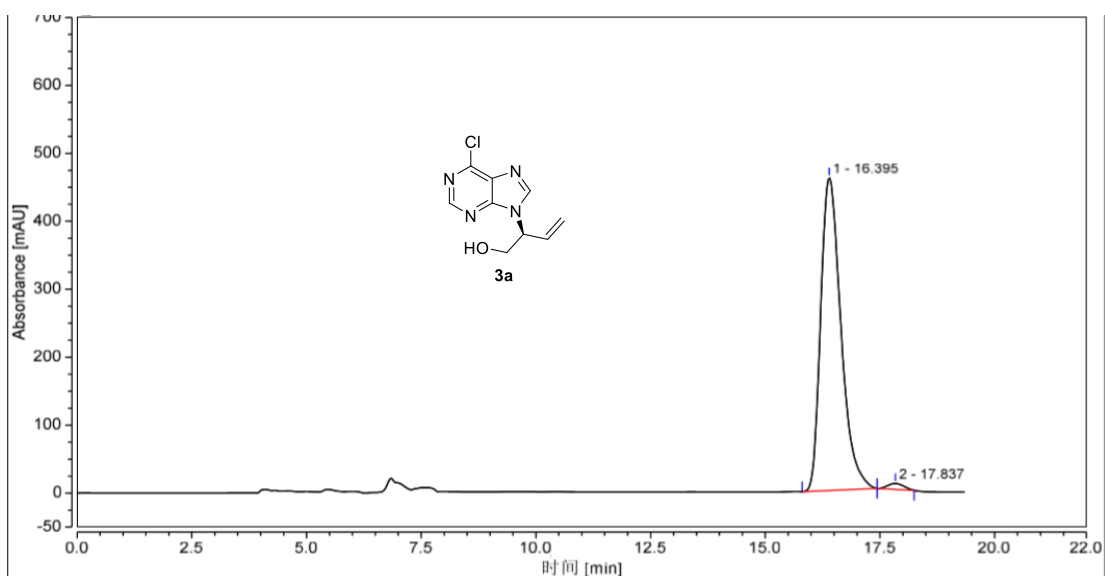


## 8. Copies of HPLC spectra for racemic and chiral products



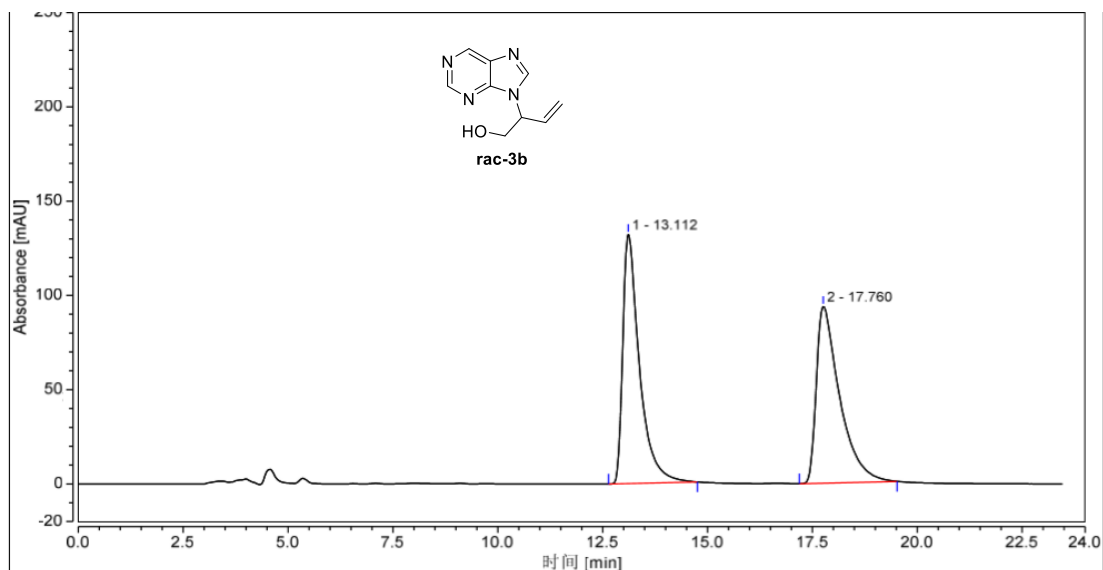
### 积分结果

| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU  | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|----------------|---------------|---------------|
| 1             | 16.358                | 187.001         | 417.805        | 49.90         | 52.01         |
| 2             | 17.707                | 187.732         | 385.500        | 50.10         | 47.99         |
| <b>Total:</b> |                       | <b>374.733</b>  | <b>803.306</b> | <b>100.00</b> | <b>100.00</b> |



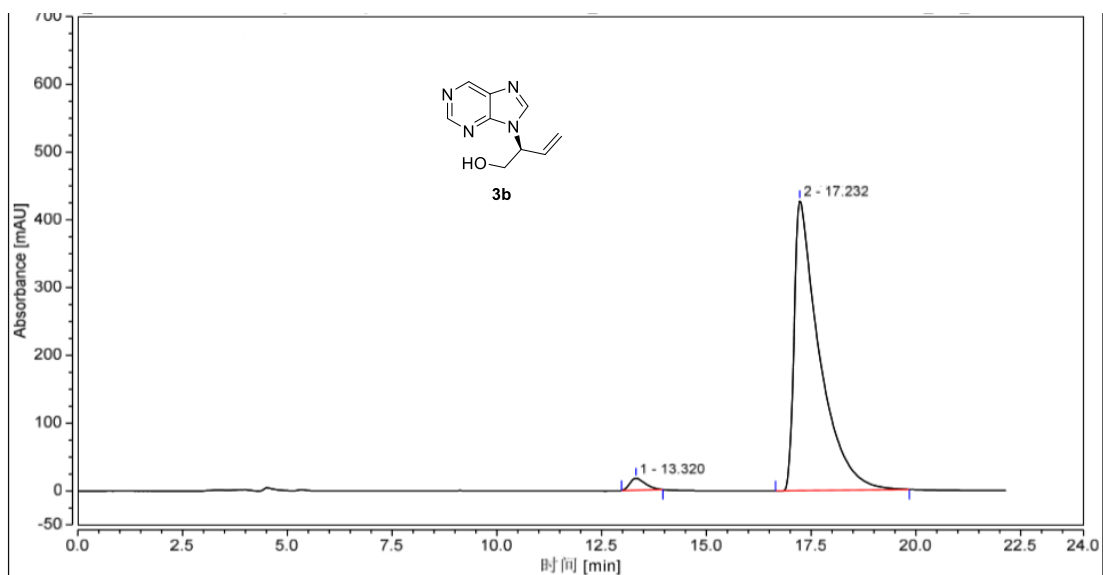
### 积分结果

| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU  | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|----------------|---------------|---------------|
| 1             | 16.395                | 234.905         | 460.178        | 98.54         | 98.19         |
| 2             | 17.837                | 3.480           | 8.492          | 1.46          | 1.81          |
| <b>Total:</b> |                       | <b>238.385</b>  | <b>468.670</b> | <b>100.00</b> | <b>100.00</b> |



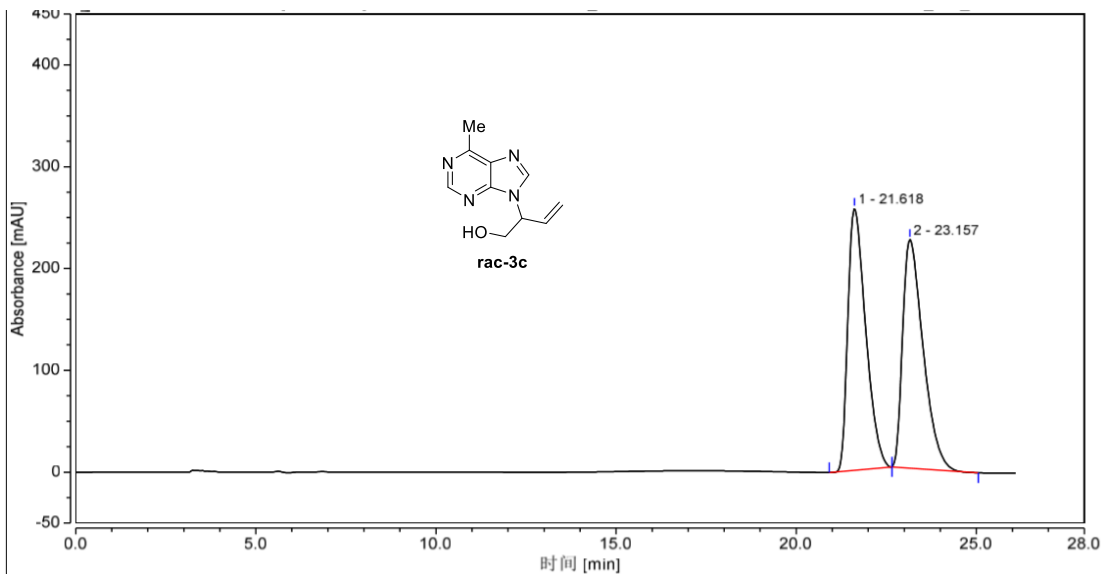
### 积分结果

| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU  | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|----------------|---------------|---------------|
| 1             | 13.112                | 60.805          | 132.222        | 50.20         | 58.49         |
| 2             | 17.760                | 60.323          | 93.827         | 49.80         | 41.51         |
| <b>Total:</b> |                       | <b>121.128</b>  | <b>226.050</b> | <b>100.00</b> | <b>100.00</b> |



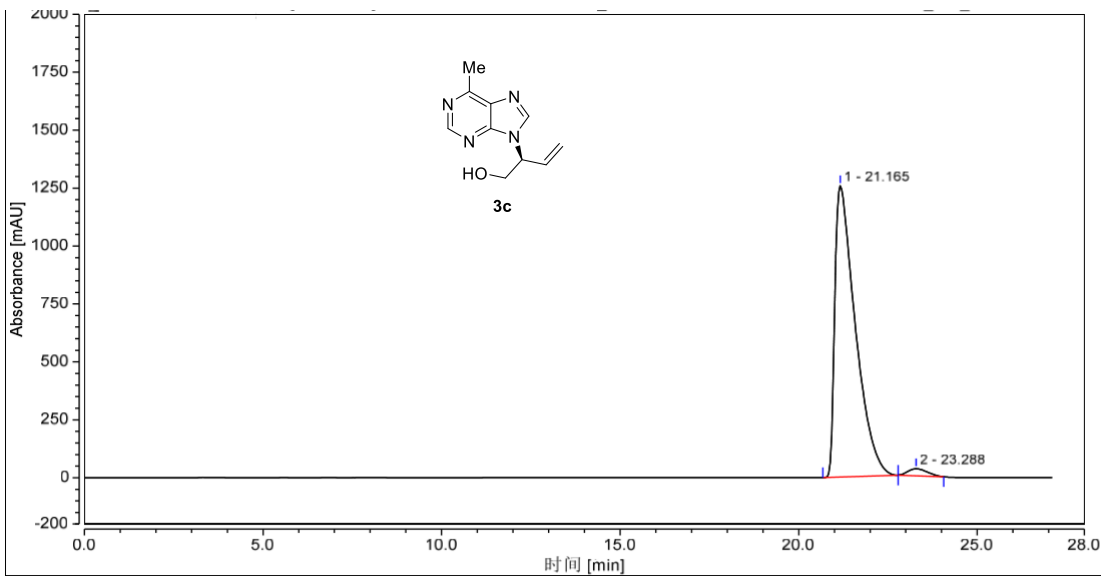
### 积分结果

| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU  | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|----------------|---------------|---------------|
| 1             | 13.320                | 7.561           | 17.654         | 2.48          | 3.96          |
| 2             | 17.232                | 297.434         | 427.810        | 97.52         | 96.04         |
| <b>Total:</b> |                       | <b>304.995</b>  | <b>445.464</b> | <b>100.00</b> | <b>100.00</b> |



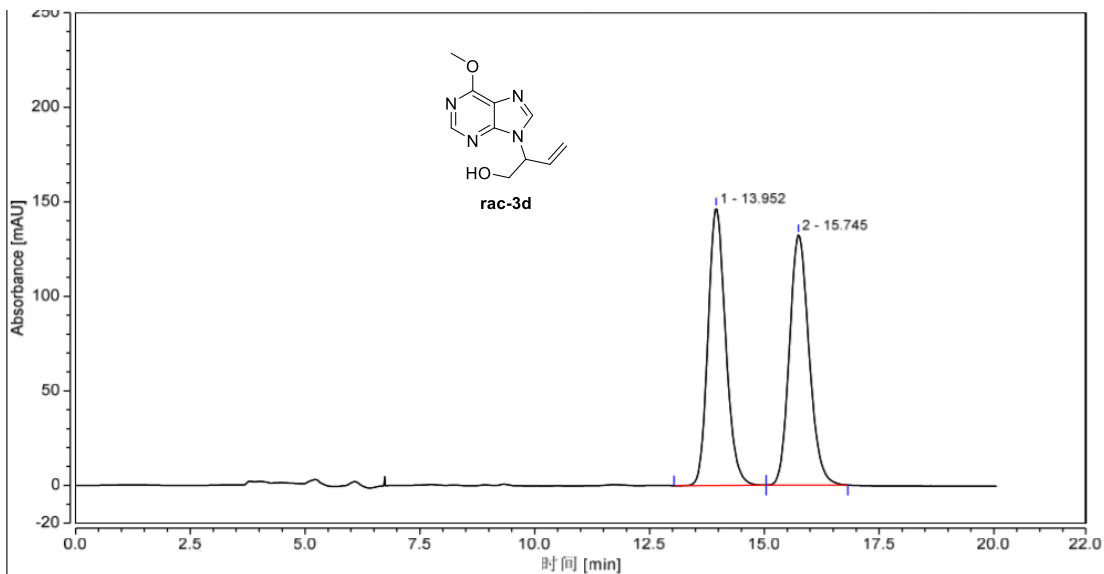
积分结果

| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU  | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|----------------|---------------|---------------|
| 1             | 21.618                | 147.655         | 257.366        | 49.99         | 53.40         |
| 2             | 23.157                | 147.711         | 224.571        | 50.01         | 46.60         |
| <b>Total:</b> |                       | <b>295.365</b>  | <b>481.937</b> | <b>100.00</b> | <b>100.00</b> |



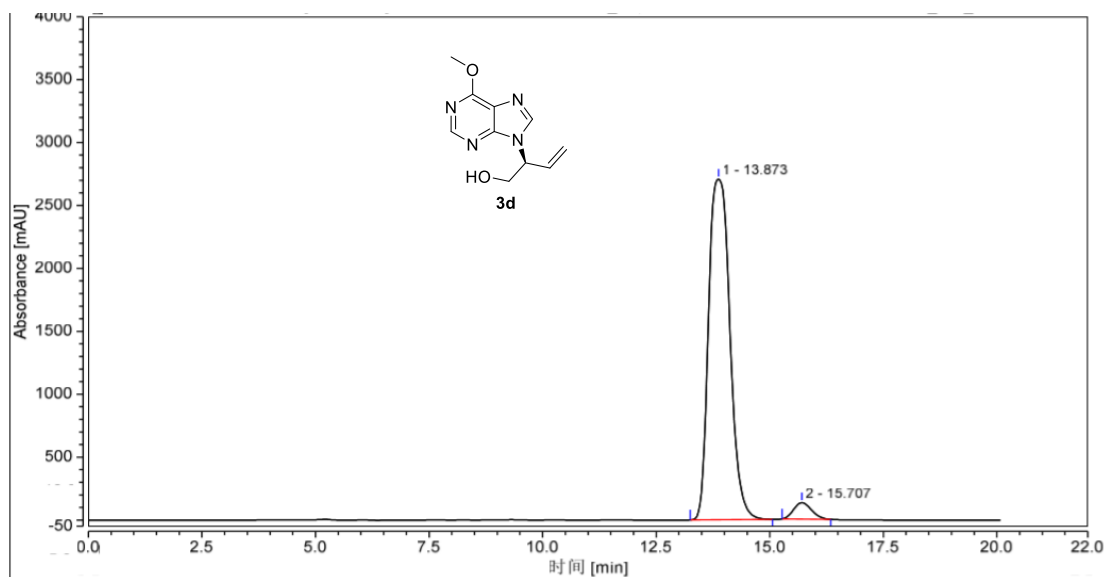
积分结果

| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU   | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|-----------------|---------------|---------------|
| 1             | 21.165                | 835.005         | 1257.164        | 97.77         | 97.64         |
| 2             | 23.288                | 19.036          | 30.342          | 2.23          | 2.36          |
| <b>Total:</b> |                       | <b>854.042</b>  | <b>1287.507</b> | <b>100.00</b> | <b>100.00</b> |



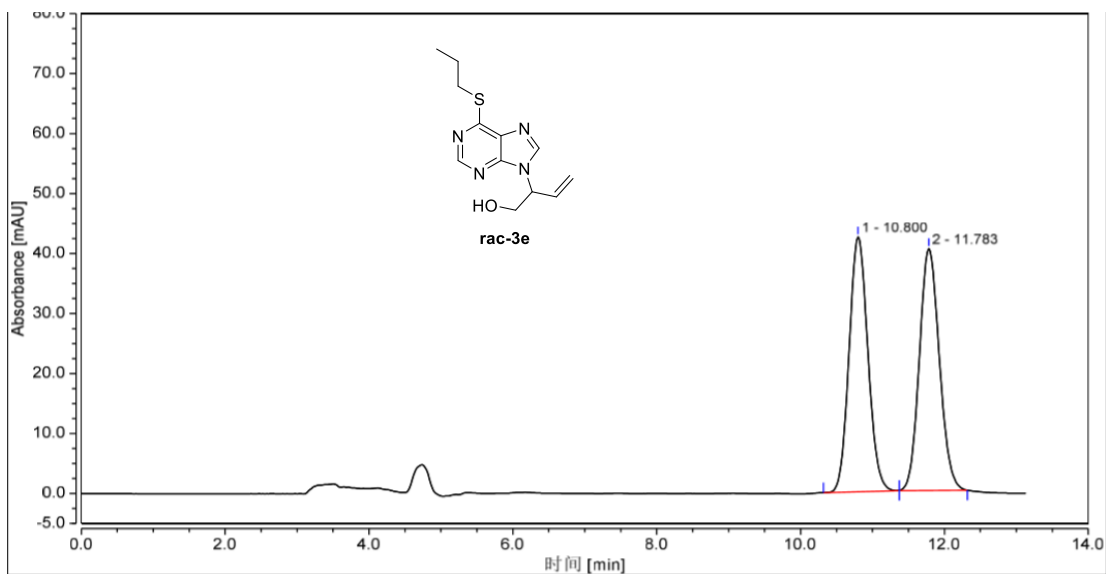
**积分结果**

| Peak          | Retention Time min | Area mAU*min   | Height mAU     | Area %        | Height %      |
|---------------|--------------------|----------------|----------------|---------------|---------------|
| 1             | 13.952             | 65.324         | 146.815        | 49.81         | 52.56         |
| 2             | 15.745             | 65.823         | 132.537        | 50.19         | 47.44         |
| <b>Total:</b> |                    | <b>131.147</b> | <b>279.352</b> | <b>100.00</b> | <b>100.00</b> |



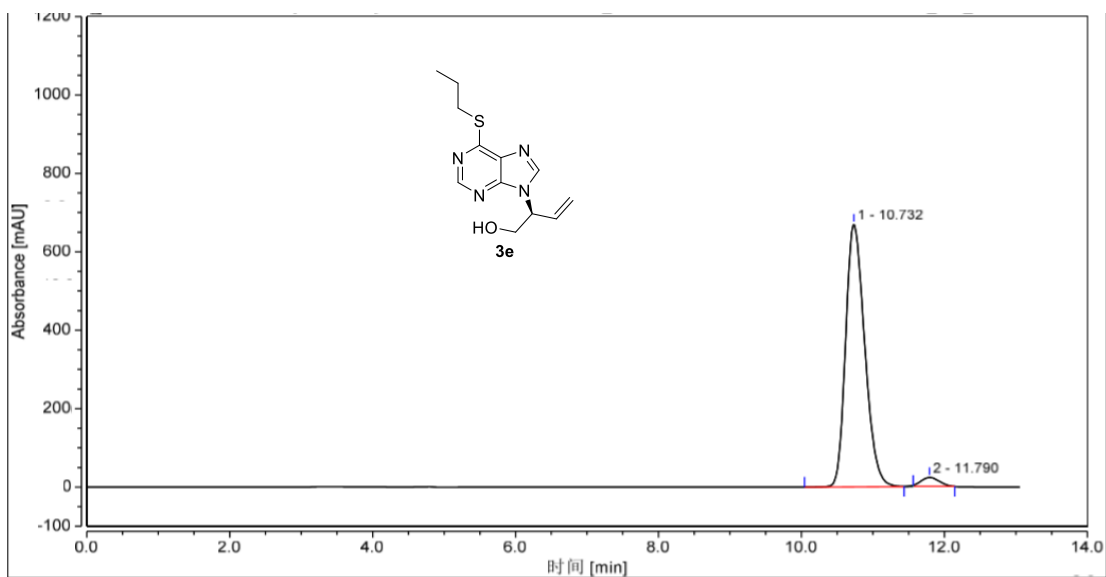
**积分结果**

| Peak          | Retention Time min | Area mAU*min    | Height mAU      | Area %        | Height %      |
|---------------|--------------------|-----------------|-----------------|---------------|---------------|
| 1             | 13.873             | 1471.461        | 2707.963        | 96.07         | 95.37         |
| 2             | 15.707             | 60.210          | 131.486         | 3.93          | 4.63          |
| <b>Total:</b> |                    | <b>1531.671</b> | <b>2839.449</b> | <b>100.00</b> | <b>100.00</b> |



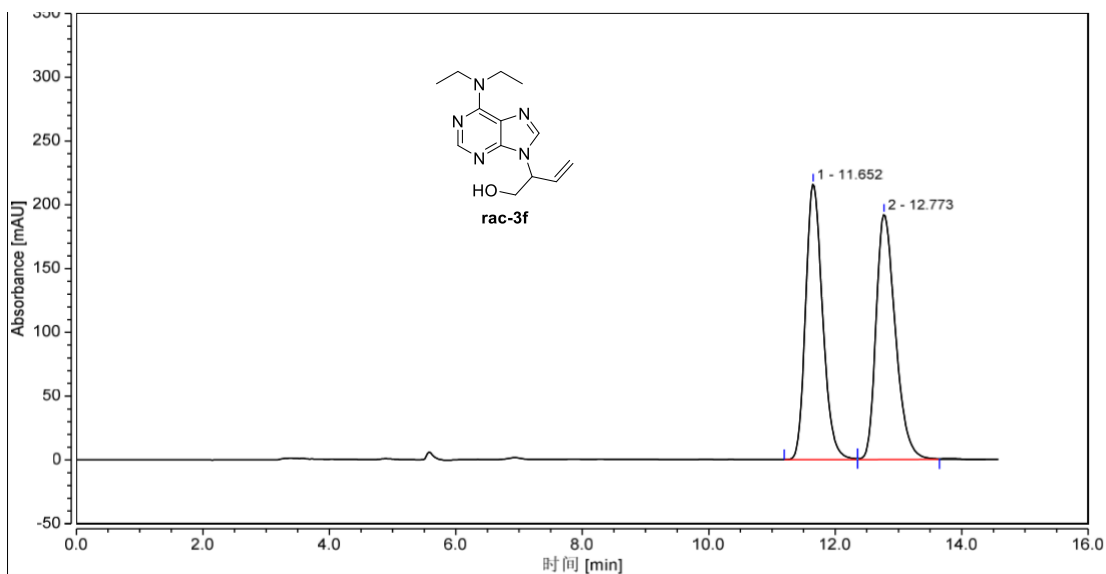
### 积分结果

| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|---------------|---------------|---------------|
| 1             | 10.800                | 12.853          | 42.513        | 49.76         | 51.32         |
| 2             | 11.783                | 12.976          | 40.328        | 50.24         | 48.68         |
| <b>Total:</b> |                       | <b>25.829</b>   | <b>82.841</b> | <b>100.00</b> | <b>100.00</b> |



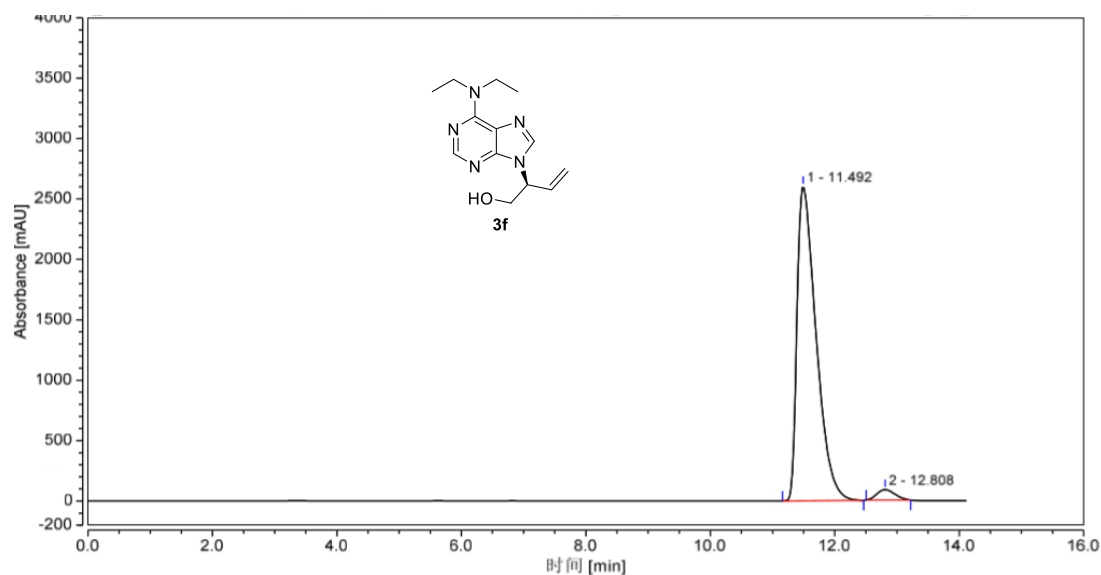
### 积分结果

| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU  | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|----------------|---------------|---------------|
| 1             | 10.732                | 207.273         | 669.861        | 96.79         | 96.68         |
| 2             | 11.790                | 6.884           | 22.991         | 3.21          | 3.32          |
| <b>Total:</b> |                       | <b>214.157</b>  | <b>692.852</b> | <b>100.00</b> | <b>100.00</b> |



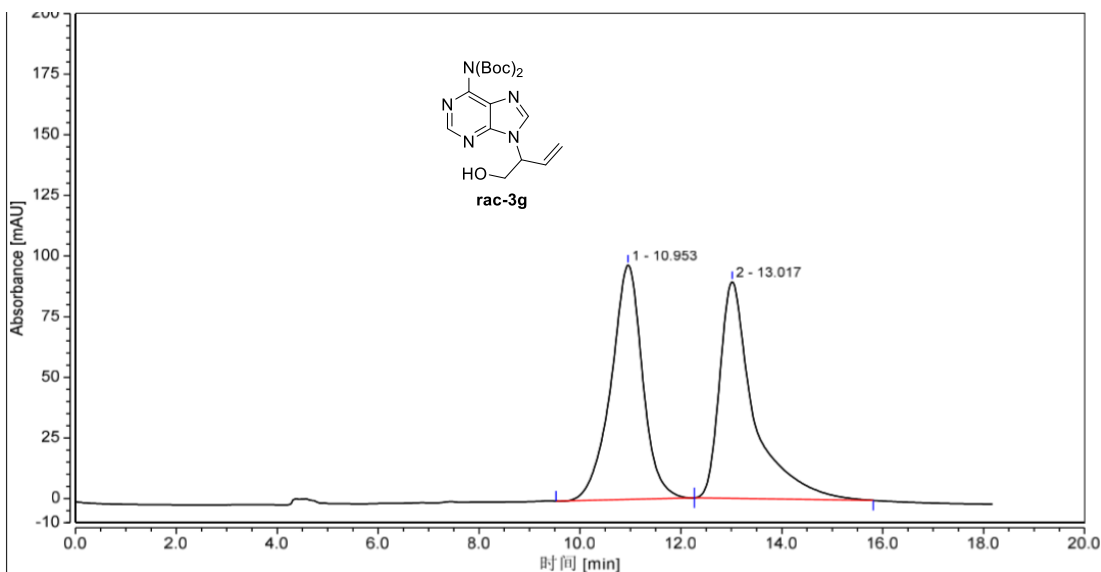
**积分结果**

| Peak          | Retention Time min | Area mAU*min   | Height mAU     | Area %        | Height %      |
|---------------|--------------------|----------------|----------------|---------------|---------------|
| 1             | 11.652             | 67.289         | 216.181        | 49.67         | 52.91         |
| 2             | 12.773             | 68.170         | 192.383        | 50.33         | 47.09         |
| <b>Total:</b> |                    | <b>135.459</b> | <b>408.564</b> | <b>100.00</b> | <b>100.00</b> |



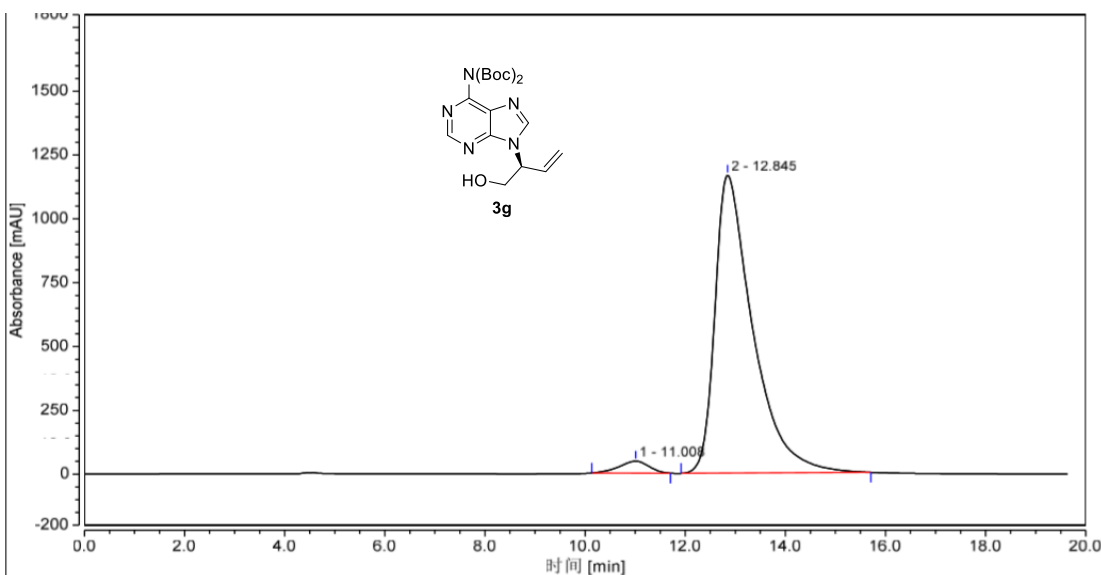
**积分结果**

| Peak          | Retention Time min | Area mAU*min   | Height mAU      | Area %        | Height %      |
|---------------|--------------------|----------------|-----------------|---------------|---------------|
| 1             | 11.492             | 921.928        | 2602.760        | 96.97         | 96.82         |
| 2             | 12.808             | 28.784         | 85.352          | 3.03          | 3.18          |
| <b>Total:</b> |                    | <b>950.711</b> | <b>2688.111</b> | <b>100.00</b> | <b>100.00</b> |



### 积分结果

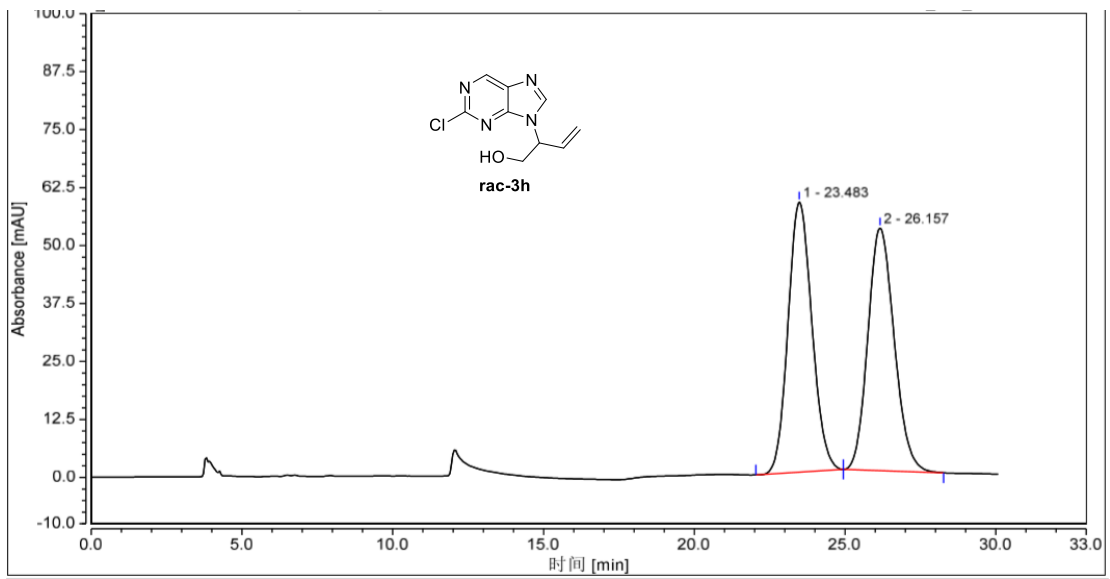
| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU  | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|----------------|---------------|---------------|
| 1             | 10.953                | 69.934          | 96.693         | 50.03         | 51.96         |
| 2             | 13.017                | 69.849          | 89.405         | 49.97         | 48.04         |
| <b>Total:</b> |                       | <b>139.783</b>  | <b>186.099</b> | <b>100.00</b> | <b>100.00</b> |



### 积分结果

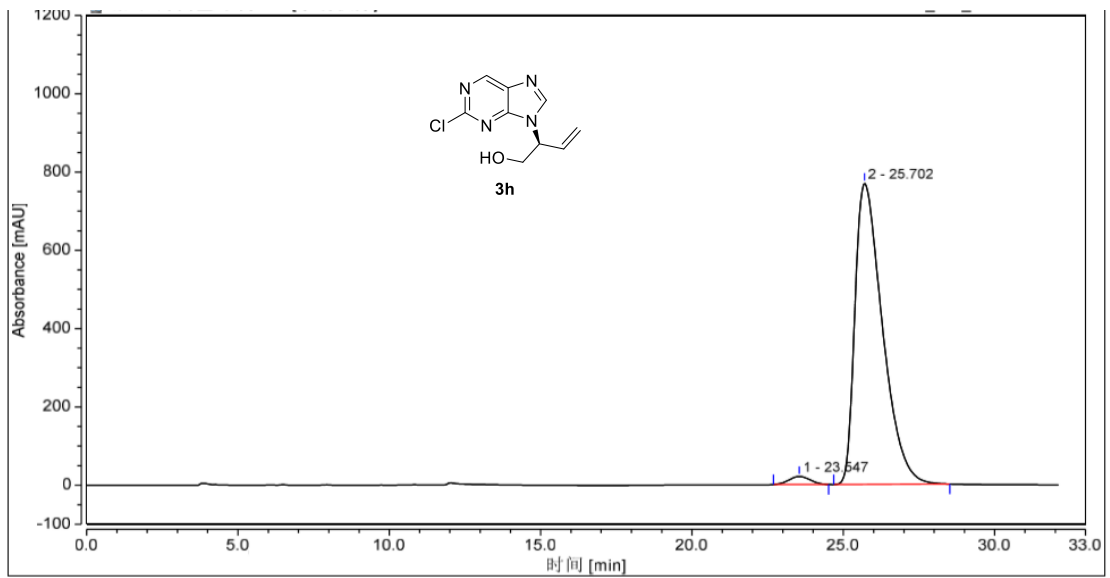
| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU   | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|-----------------|---------------|---------------|
| 1             | 11.008                | 32.086          | 46.581          | 3.04          | 3.84          |
| 2             | 12.845                | 1022.821        | 1167.253        | 96.96         | 96.16         |
| <b>Total:</b> |                       | <b>1054.907</b> | <b>1213.834</b> | <b>100.00</b> | <b>100.00</b> |





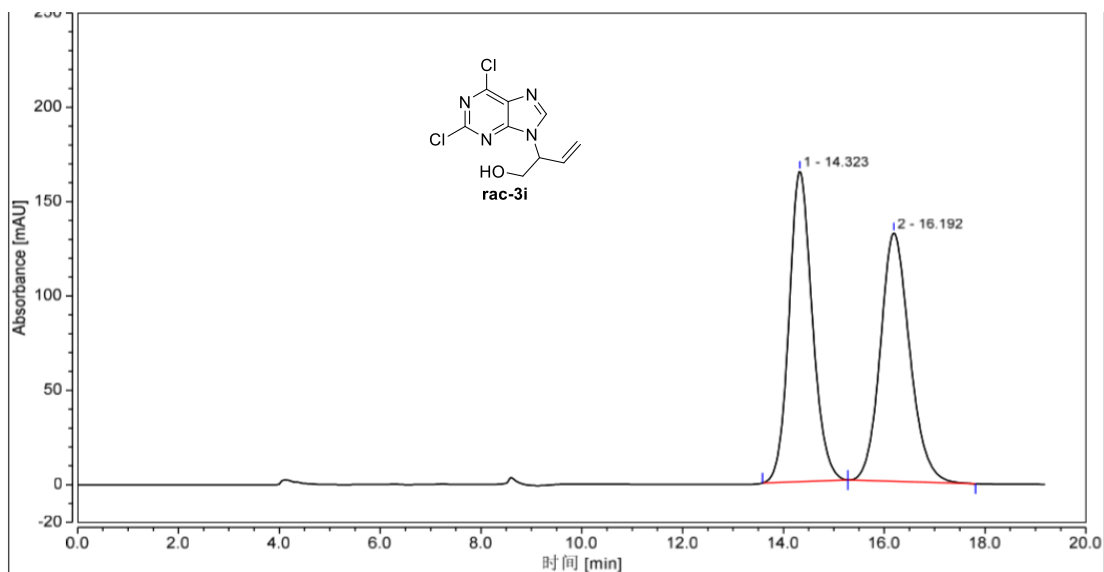
### 积分结果

| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU  | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|----------------|---------------|---------------|
| 1             | 23.483                | 53.528          | 58.301         | 50.21         | 52.68         |
| 2             | 26.157                | 53.083          | 52.364         | 49.79         | 47.32         |
| <b>Total:</b> |                       | <b>106.611</b>  | <b>110.665</b> | <b>100.00</b> | <b>100.00</b> |



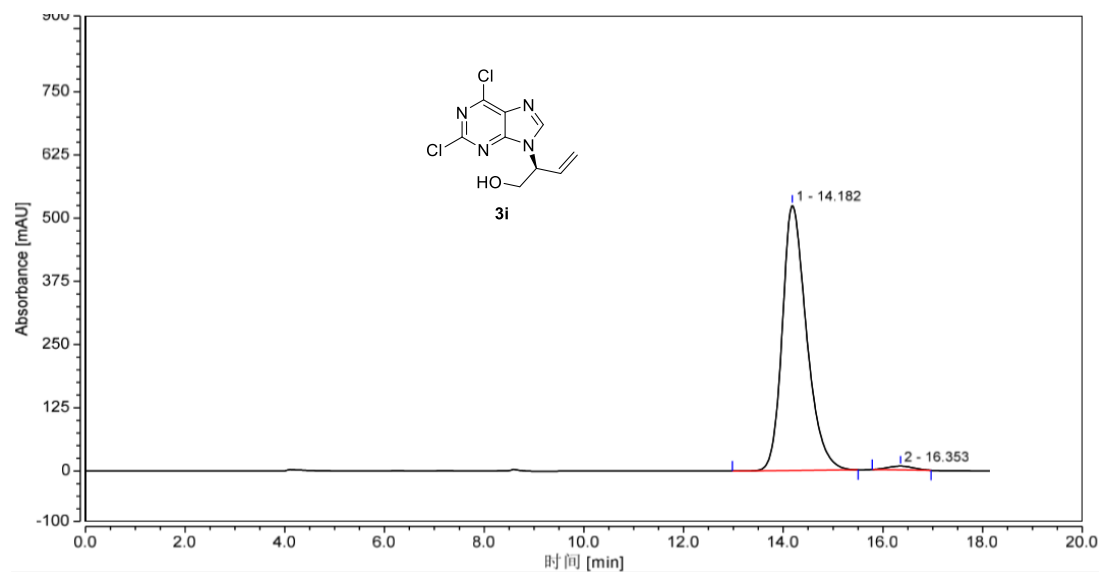
### 积分结果

| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU  | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|----------------|---------------|---------------|
| 1             | 23.547                | 16.879          | 20.581         | 2.04          | 2.61          |
| 2             | 25.702                | 810.764         | 769.282        | 97.96         | 97.39         |
| <b>Total:</b> |                       | <b>827.644</b>  | <b>789.863</b> | <b>100.00</b> | <b>100.00</b> |



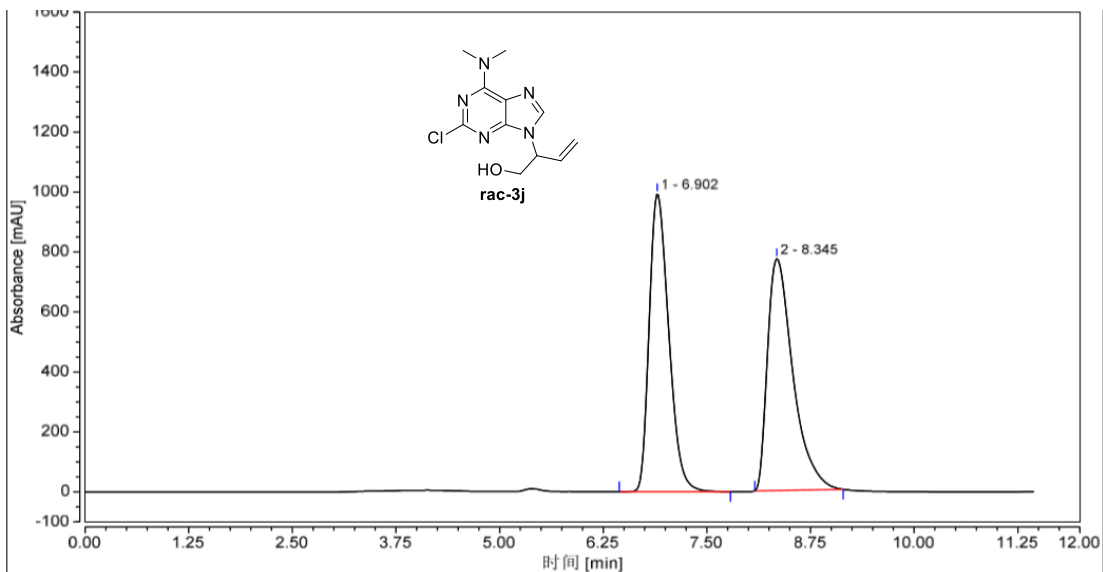
### 积分结果

| Peak          | Retention Time min | Area mAU*min   | Height mAU     | Area %        | Height %      |
|---------------|--------------------|----------------|----------------|---------------|---------------|
| 1             | 14.323             | 87.924         | 164.606        | 49.71         | 55.56         |
| 2             | 16.192             | 88.963         | 131.657        | 50.29         | 44.44         |
| <b>Total:</b> |                    | <b>176.887</b> | <b>296.263</b> | <b>100.00</b> | <b>100.00</b> |



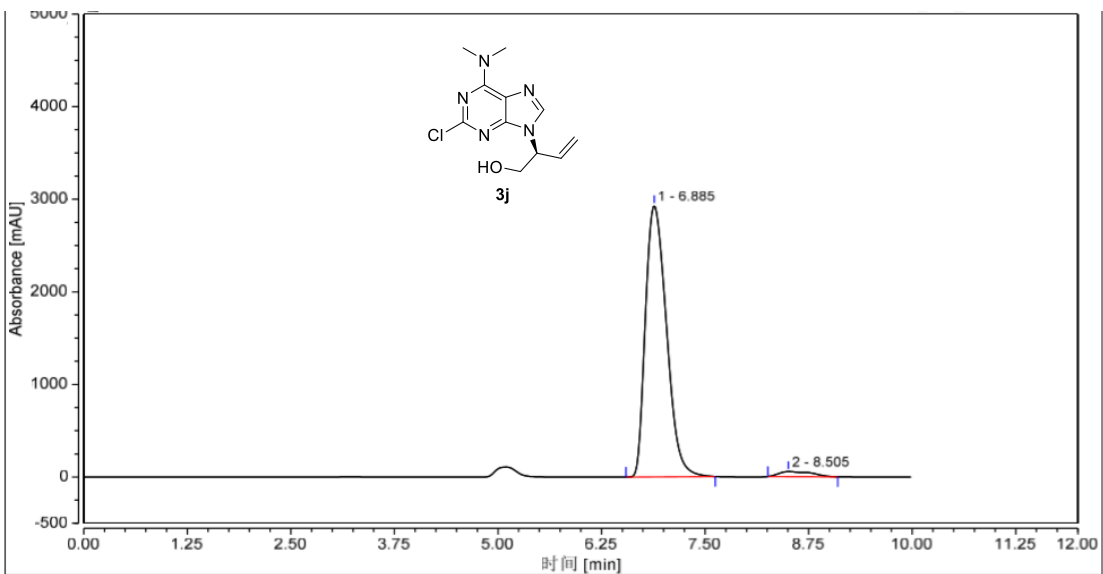
### 积分结果

| Peak          | Retention Time min | Area mAU*min   | Height mAU     | Area %        | Height %      |
|---------------|--------------------|----------------|----------------|---------------|---------------|
| 1             | 14.182             | 295.911        | 524.439        | 98.49         | 98.56         |
| 2             | 16.353             | 4.530          | 7.653          | 1.51          | 1.44          |
| <b>Total:</b> |                    | <b>300.441</b> | <b>532.092</b> | <b>100.00</b> | <b>100.00</b> |



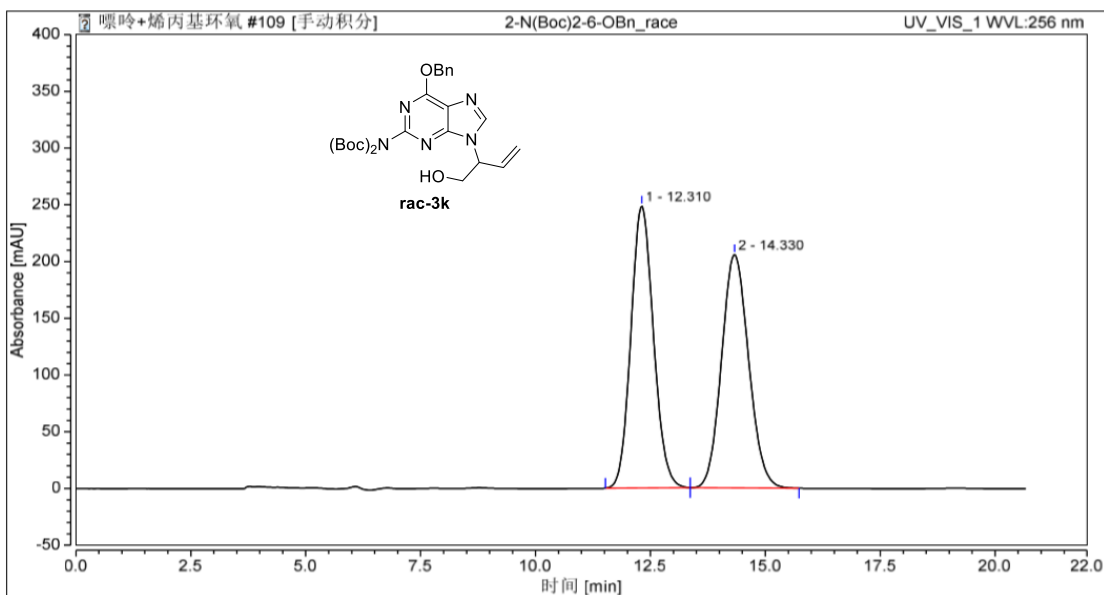
**积分结果**

| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU   | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|-----------------|---------------|---------------|
| 1             | 6.902                 | 270.838         | 993.512         | 49.63         | 56.25         |
| 2             | 8.345                 | 274.899         | 772.874         | 50.37         | 43.75         |
| <b>Total:</b> |                       | <b>545.737</b>  | <b>1766.386</b> | <b>100.00</b> | <b>100.00</b> |



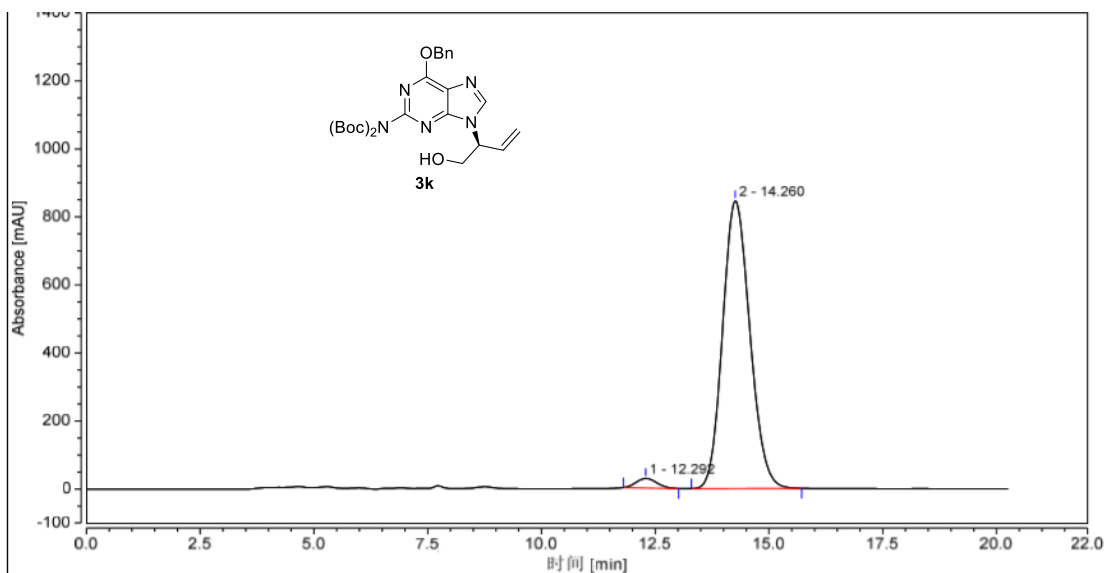
**积分结果**

| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU   | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|-----------------|---------------|---------------|
| 1             | 6.885                 | 863.523         | 2931.162        | 97.17         | 98.16         |
| 2             | 8.505                 | 25.136          | 55.071          | 2.83          | 1.84          |
| <b>Total:</b> |                       | <b>888.659</b>  | <b>2986.233</b> | <b>100.00</b> | <b>100.00</b> |



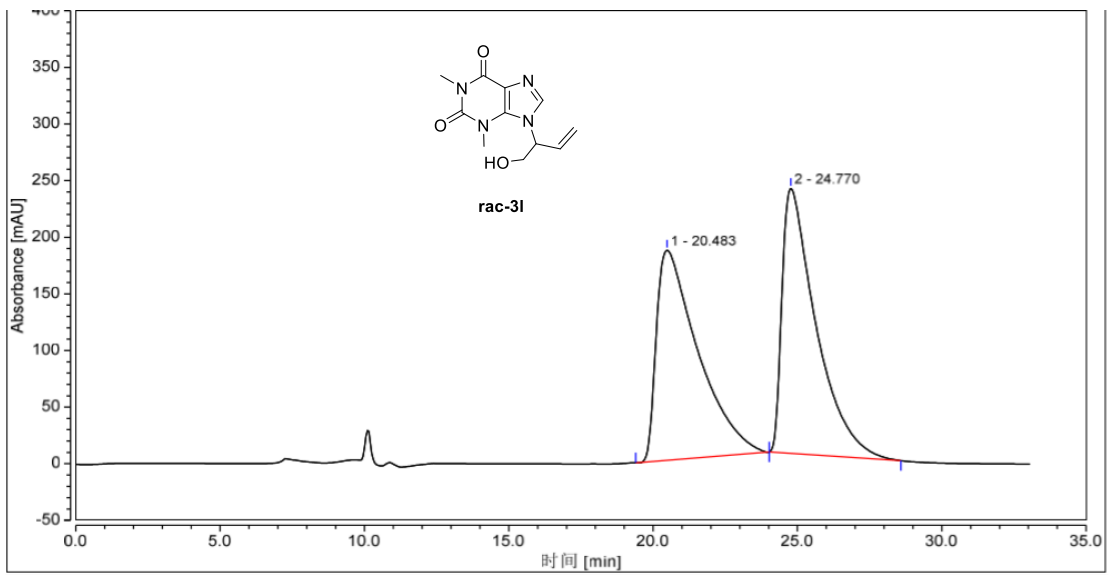
### 积分结果

| Peak          | Retention Time min | Area mAU*min   | Height mAU     | Area %        | Height %      |
|---------------|--------------------|----------------|----------------|---------------|---------------|
| 1             | 12.310             | 141.474        | 248.413        | 50.11         | 54.71         |
| 2             | 14.330             | 140.836        | 205.656        | 49.89         | 45.29         |
| <b>Total:</b> |                    | <b>282.310</b> | <b>454.069</b> | <b>100.00</b> | <b>100.00</b> |



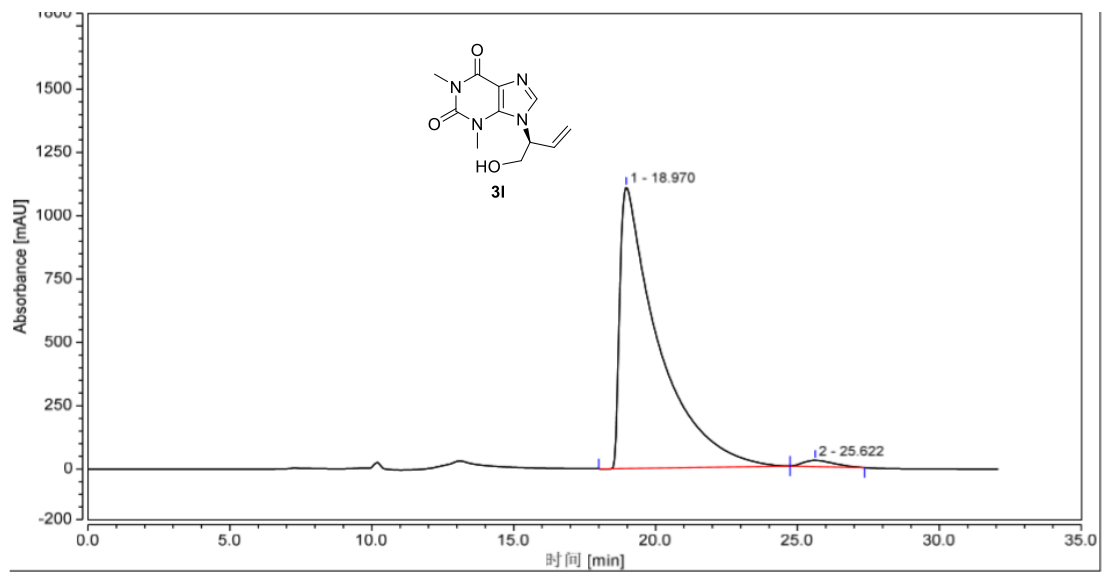
### 积分结果

| Peak          | Retention Time min | Area mAU*min   | Height mAU     | Area %        | Height %      |
|---------------|--------------------|----------------|----------------|---------------|---------------|
| 1             | 12.292             | 14.956         | 28.214         | 2.48          | 3.23          |
| 2             | 14.260             | 587.604        | 846.342        | 97.52         | 96.77         |
| <b>Total:</b> |                    | <b>602.560</b> | <b>874.556</b> | <b>100.00</b> | <b>100.00</b> |



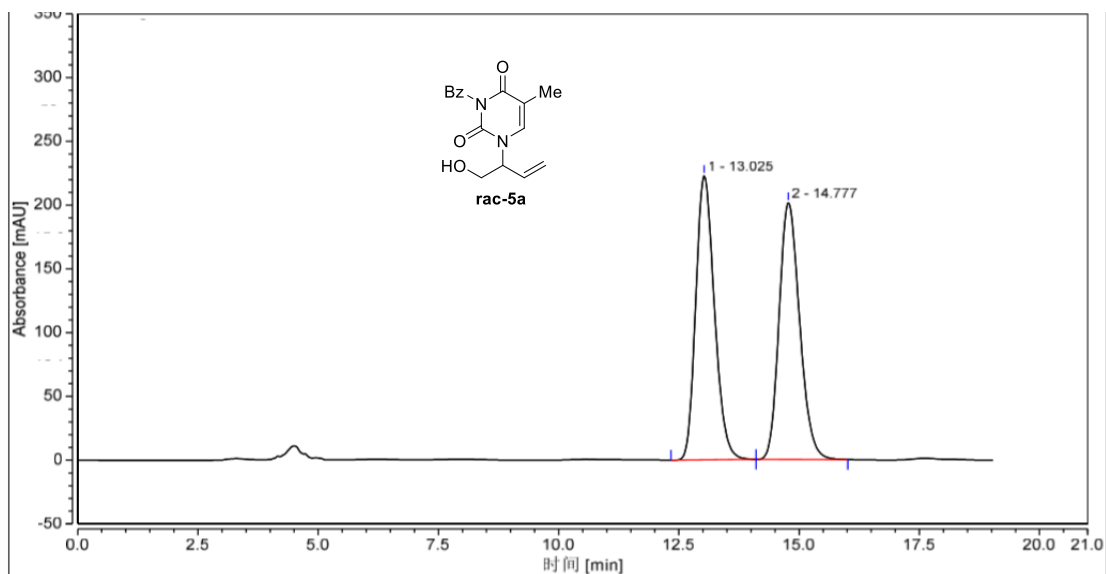
### 积分结果

| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU  | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|----------------|---------------|---------------|
| 1             | 20.483                | 309.501         | 185.687        | 49.26         | 44.24         |
| 2             | 24.770                | 318.784         | 234.034        | 50.74         | 55.76         |
| <b>Total:</b> |                       | <b>628.285</b>  | <b>419.722</b> | <b>100.00</b> | <b>100.00</b> |



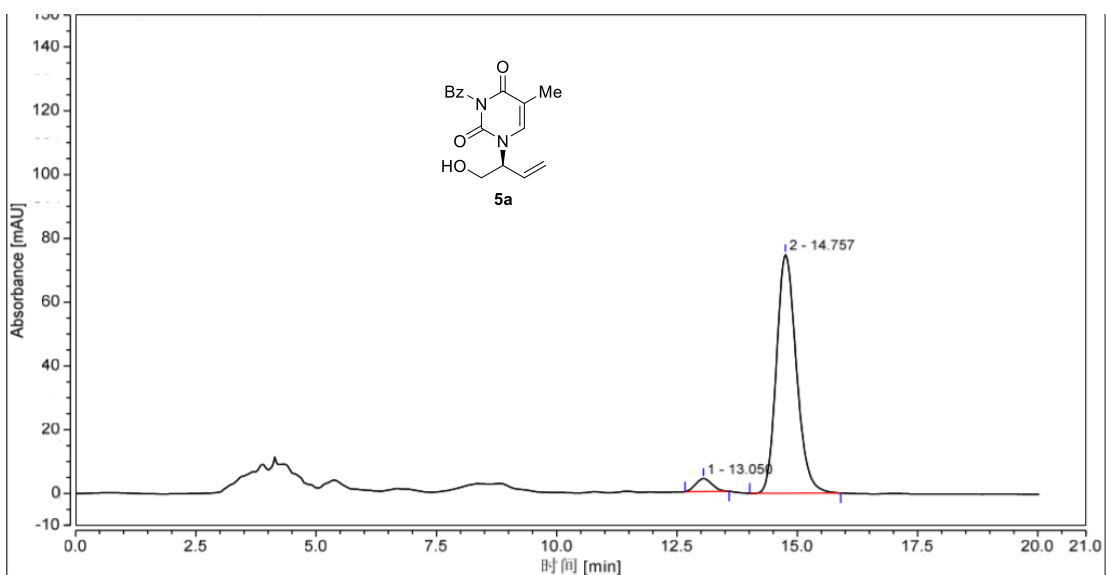
### 积分结果

| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU   | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|-----------------|---------------|---------------|
| 1             | 18.970                | 1739.579        | 1110.341        | 98.25         | 97.84         |
| 2             | 25.622                | 30.905          | 24.504          | 1.75          | 2.16          |
| <b>Total:</b> |                       | <b>1770.484</b> | <b>1134.844</b> | <b>100.00</b> | <b>100.00</b> |



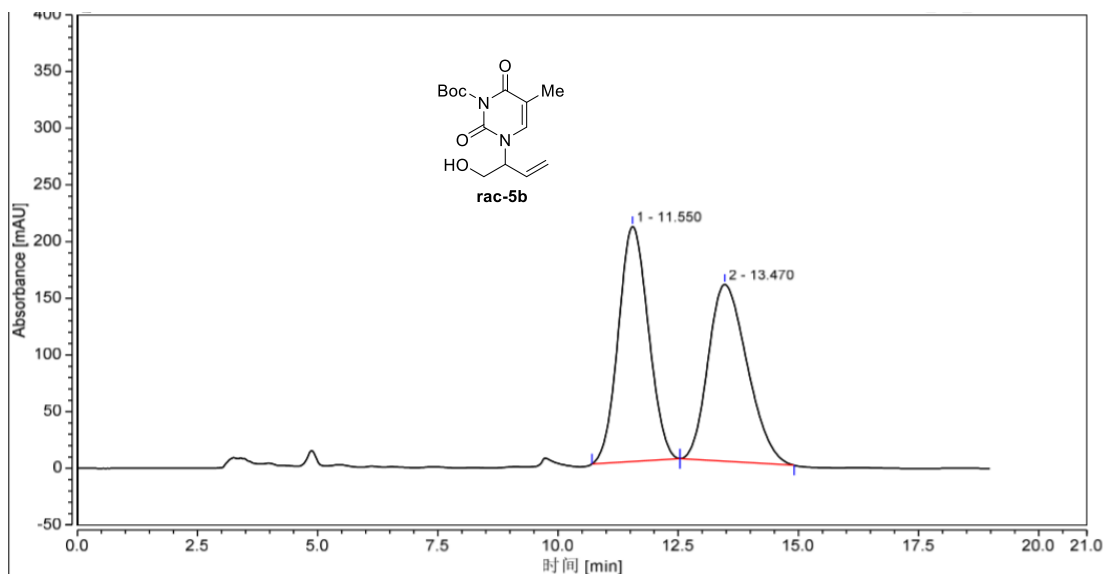
### 积分结果

| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU  | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|----------------|---------------|---------------|
| 1             | 13.025                | 100.164         | 222.981        | 50.09         | 52.53         |
| 2             | 14.777                | 99.812          | 201.482        | 49.91         | 47.47         |
| <b>Total:</b> |                       | <b>199.976</b>  | <b>424.463</b> | <b>100.00</b> | <b>100.00</b> |



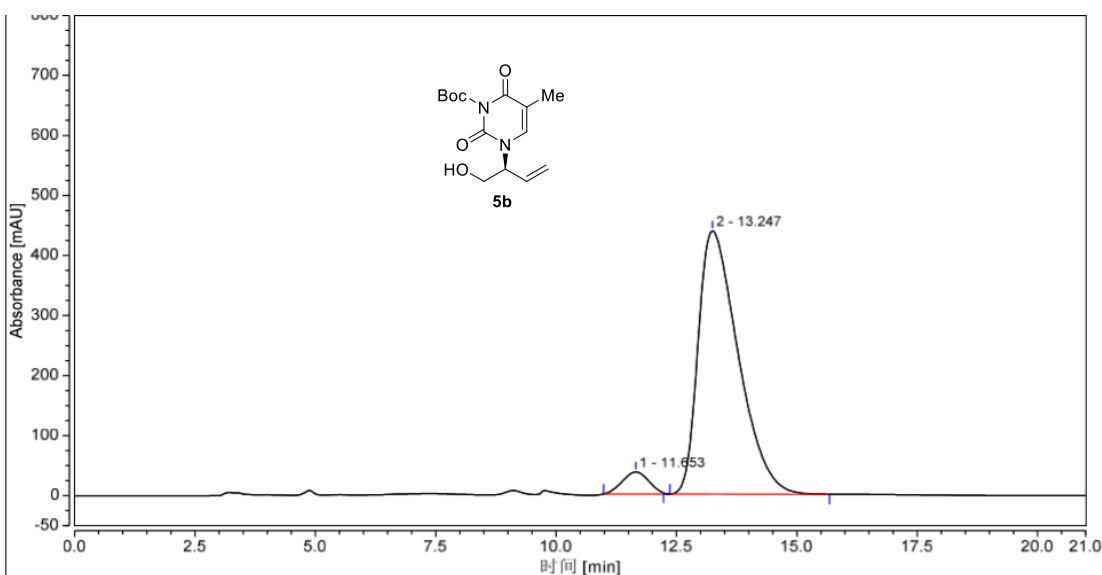
### 积分结果

| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|---------------|---------------|---------------|
| 1             | 13.050                | 1.595           | 4.038         | 4.25          | 5.12          |
| 2             | 14.757                | 35.927          | 74.819        | 95.75         | 94.88         |
| <b>Total:</b> |                       | <b>37.523</b>   | <b>78.857</b> | <b>100.00</b> | <b>100.00</b> |



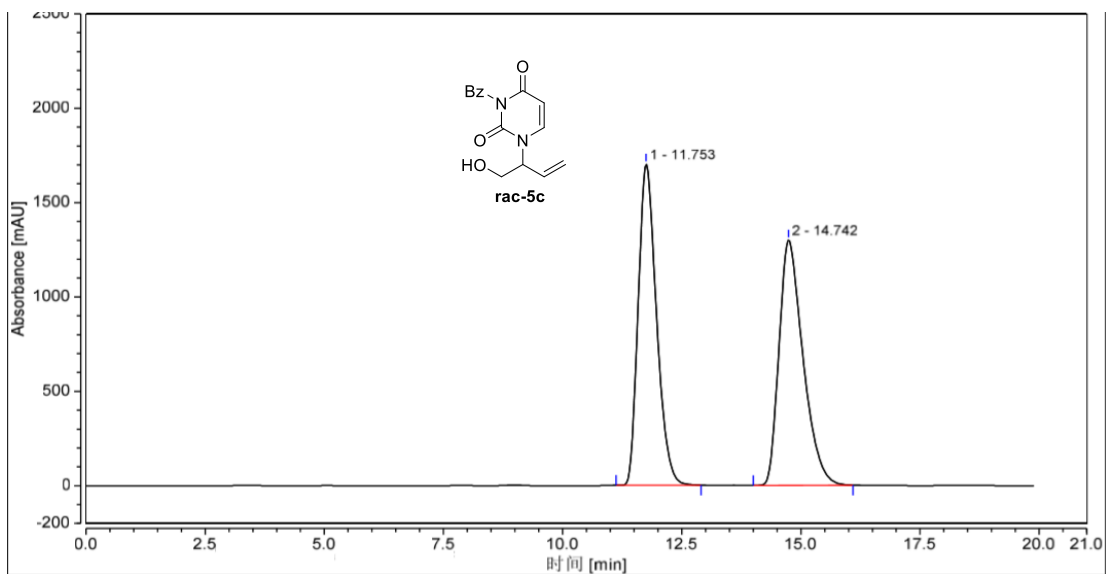
**积分结果**

| Peak          | Retention Time min | Area mAU*min   | Height mAU     | Area %        | Height %      |
|---------------|--------------------|----------------|----------------|---------------|---------------|
| 1             | 11.550             | 150.275        | 207.446        | 50.53         | 57.07         |
| 2             | 13.470             | 147.137        | 156.064        | 49.47         | 42.93         |
| <b>Total:</b> |                    | <b>297.411</b> | <b>363.510</b> | <b>100.00</b> | <b>100.00</b> |



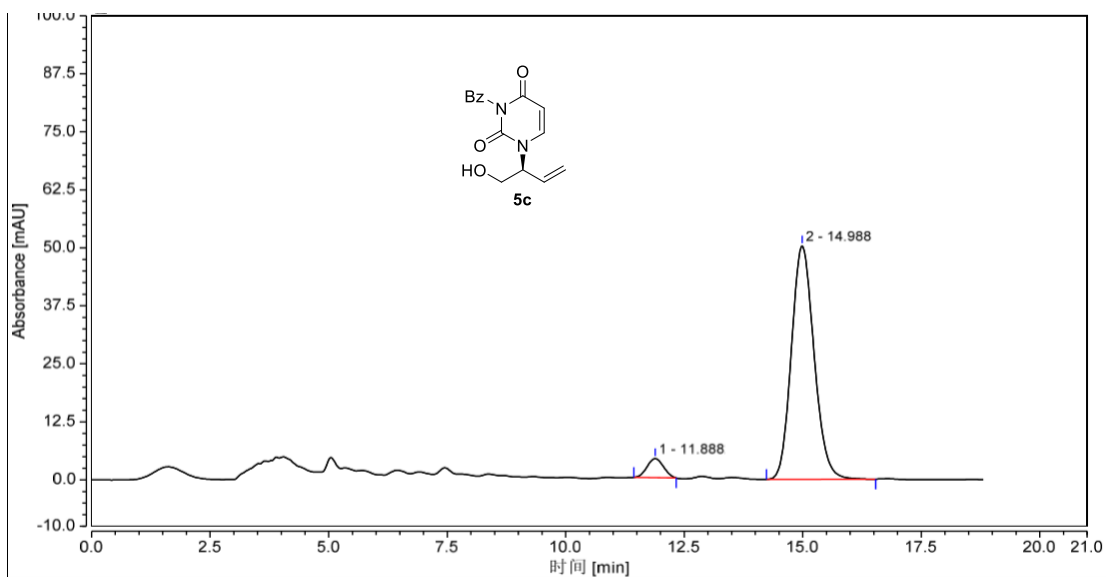
**积分结果**

| Peak          | Retention Time min | Area mAU*min   | Height mAU     | Area %        | Height %      |
|---------------|--------------------|----------------|----------------|---------------|---------------|
| 1             | 11.653             | 23.414         | 36.713         | 5.25          | 7.72          |
| 2             | 13.247             | 422.238        | 438.630        | 94.75         | 92.28         |
| <b>Total:</b> |                    | <b>445.653</b> | <b>475.343</b> | <b>100.00</b> | <b>100.00</b> |



### 积分结果

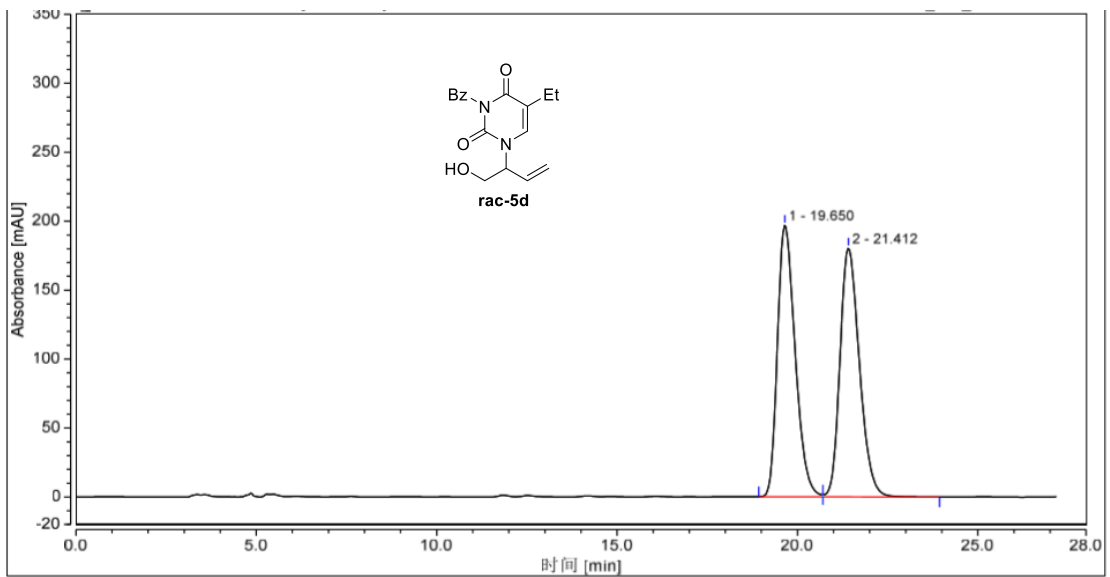
| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU   | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|-----------------|---------------|---------------|
| 1             | 11.753                | 757.588         | 1703.052        | 49.98         | 56.69         |
| 2             | 14.742                | 758.208         | 1301.088        | 50.02         | 43.31         |
| <b>Total:</b> |                       | <b>1515.795</b> | <b>3004.140</b> | <b>100.00</b> | <b>100.00</b> |



### 积分结果

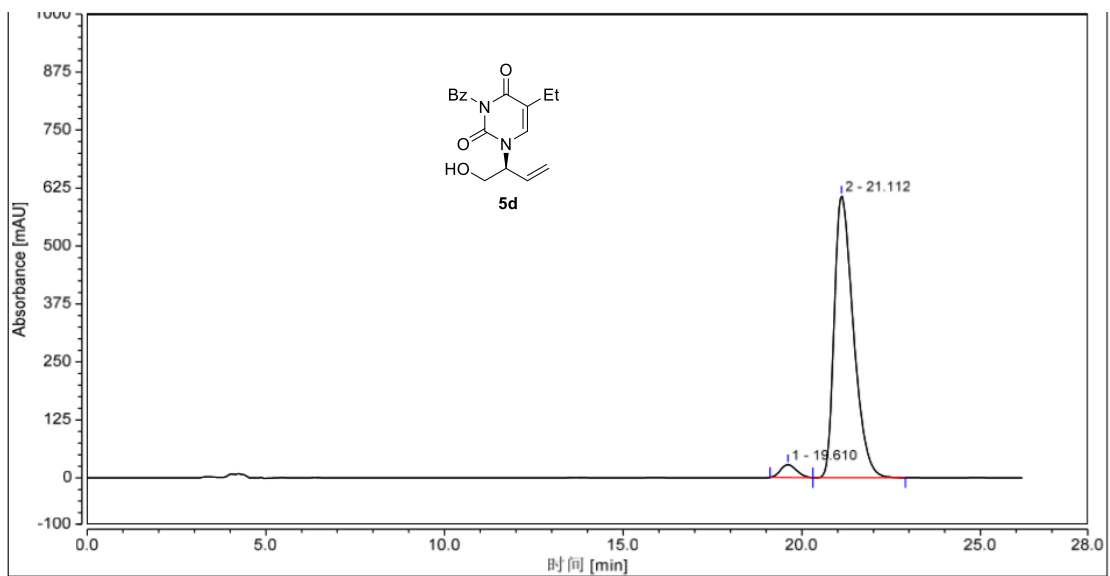
| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|---------------|---------------|---------------|
| 1             | 11.888                | 1.652           | 4.125         | 5.60          | 7.58          |
| 2             | 14.988                | 27.865          | 50.296        | 94.40         | 92.42         |
| <b>Total:</b> |                       | <b>29.517</b>   | <b>54.421</b> | <b>100.00</b> | <b>100.00</b> |





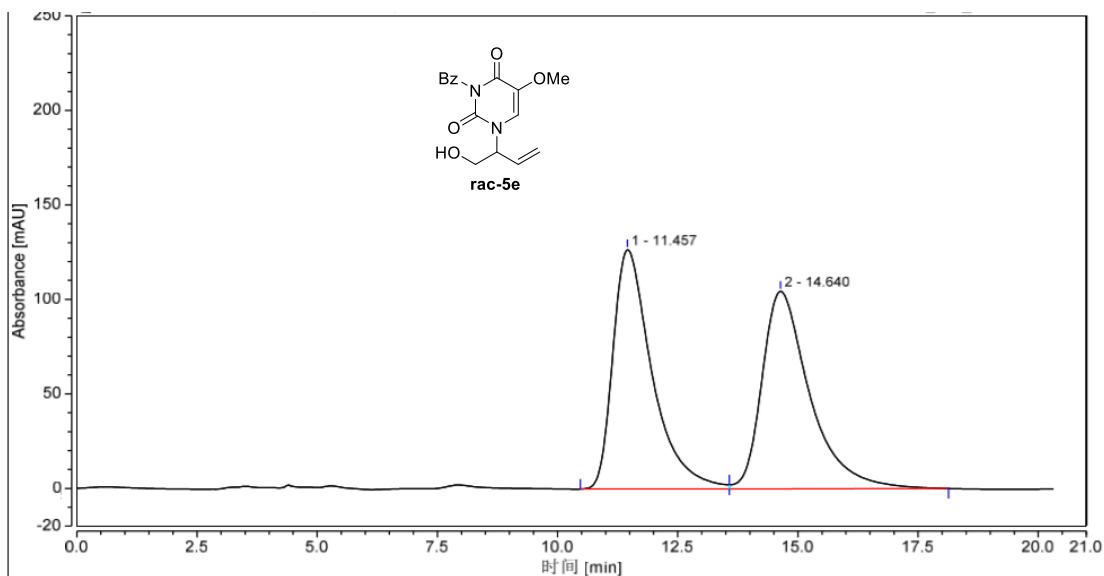
### 积分结果

| Peak          | Retention Time min | Area mAU*min   | Height mAU     | Area %        | Height %      |
|---------------|--------------------|----------------|----------------|---------------|---------------|
| 1             | 19.650             | 112.080        | 196.999        | 49.88         | 52.21         |
| 2             | 21.412             | 112.609        | 180.331        | 50.12         | 47.79         |
| <b>Total:</b> |                    | <b>224.689</b> | <b>377.330</b> | <b>100.00</b> | <b>100.00</b> |

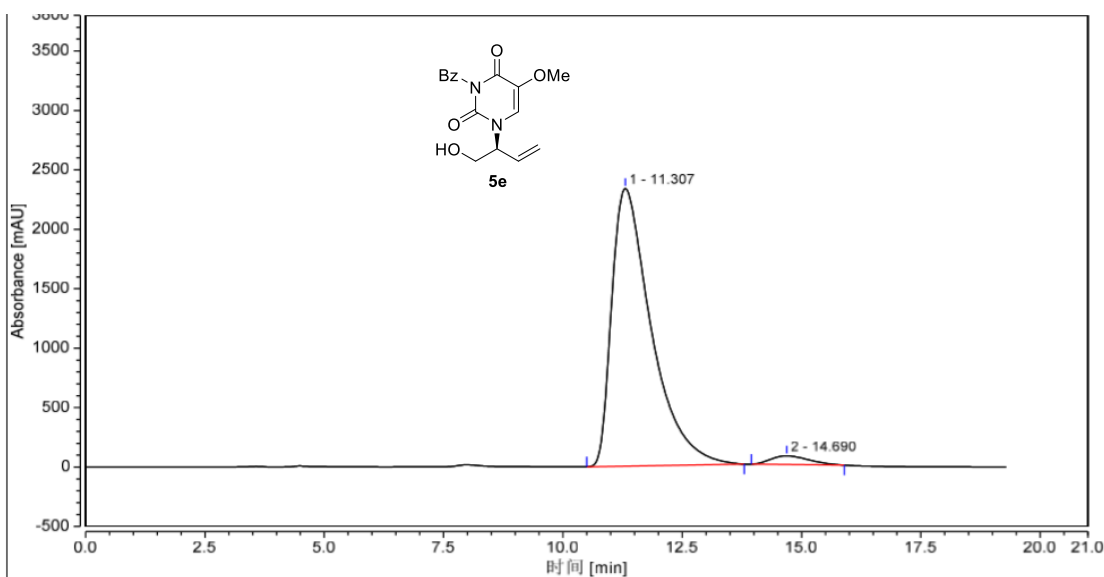


### 积分结果

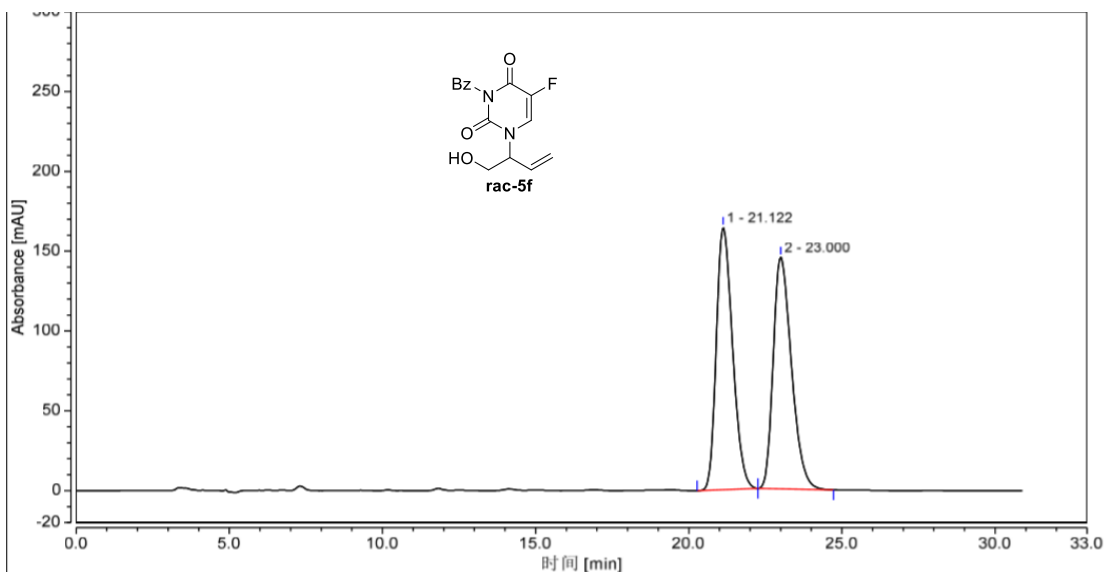
| Peak          | Retention Time min | Area mAU*min   | Height mAU     | Area %        | Height %      |
|---------------|--------------------|----------------|----------------|---------------|---------------|
| 1             | 19.610             | 14.455         | 27.845         | 3.69          | 4.38          |
| 2             | 21.112             | 377.396        | 607.486        | 96.31         | 95.62         |
| <b>Total:</b> |                    | <b>391.851</b> | <b>635.331</b> | <b>100.00</b> | <b>100.00</b> |



| 积分结果          |                       |                 |                |               |               |
|---------------|-----------------------|-----------------|----------------|---------------|---------------|
| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU  | Area<br>%     | Height<br>%   |
| 1             | 11.457                | 119.610         | 126.604        | 49.87         | 54.78         |
| 2             | 14.640                | 120.246         | 104.513        | 50.13         | 45.22         |
| <b>Total:</b> |                       | <b>239.857</b>  | <b>231.116</b> | <b>100.00</b> | <b>100.00</b> |

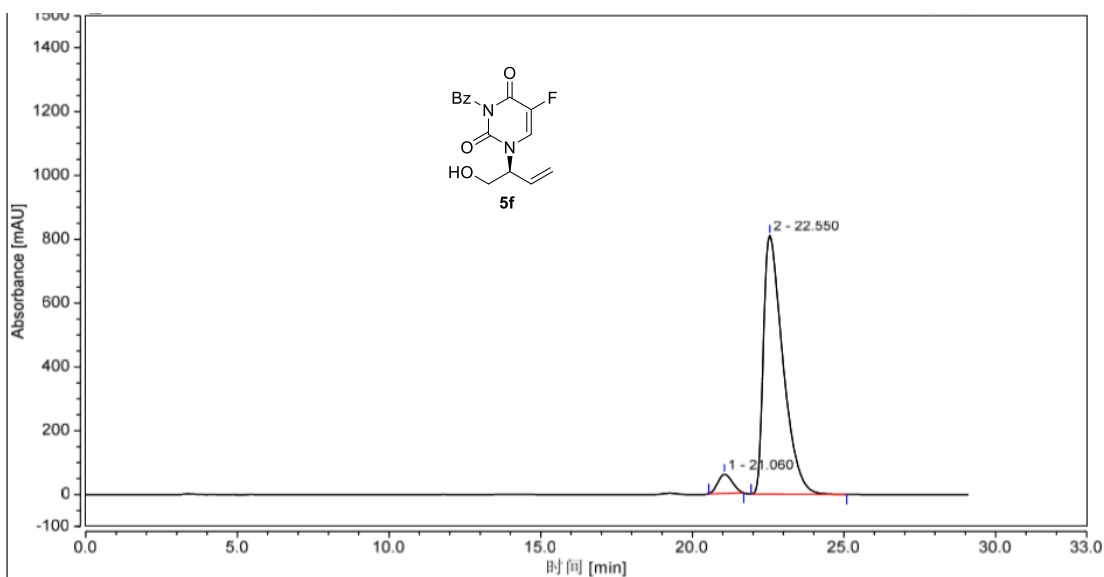


| 积分结果          |                       |                 |                 |               |               |
|---------------|-----------------------|-----------------|-----------------|---------------|---------------|
| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU   | Area<br>%     | Height<br>%   |
| 1             | 11.307                | 2243.472        | 2336.370        | 97.06         | 96.95         |
| 2             | 14.690                | 67.921          | 73.500          | 2.94          | 3.05          |
| <b>Total:</b> |                       | <b>2311.393</b> | <b>2409.871</b> | <b>100.00</b> | <b>100.00</b> |



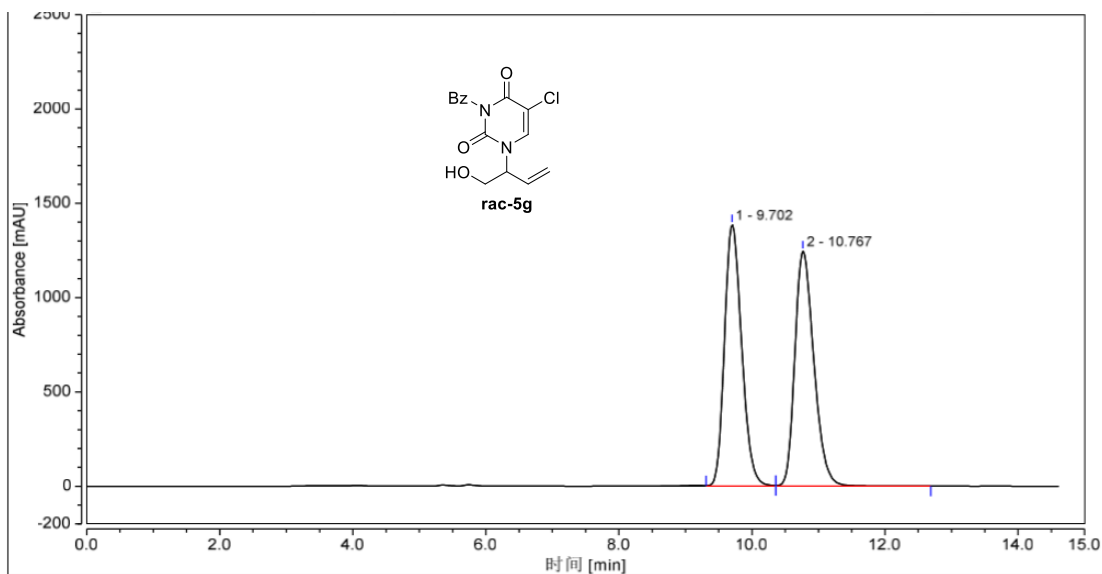
### 积分结果

| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU  | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|----------------|---------------|---------------|
| 1             | 21.122                | 101.388         | 164.460        | 50.24         | 53.09         |
| 2             | 23.000                | 100.428         | 145.289        | 49.76         | 46.91         |
| <b>Total:</b> |                       | <b>201.816</b>  | <b>309.749</b> | <b>100.00</b> | <b>100.00</b> |



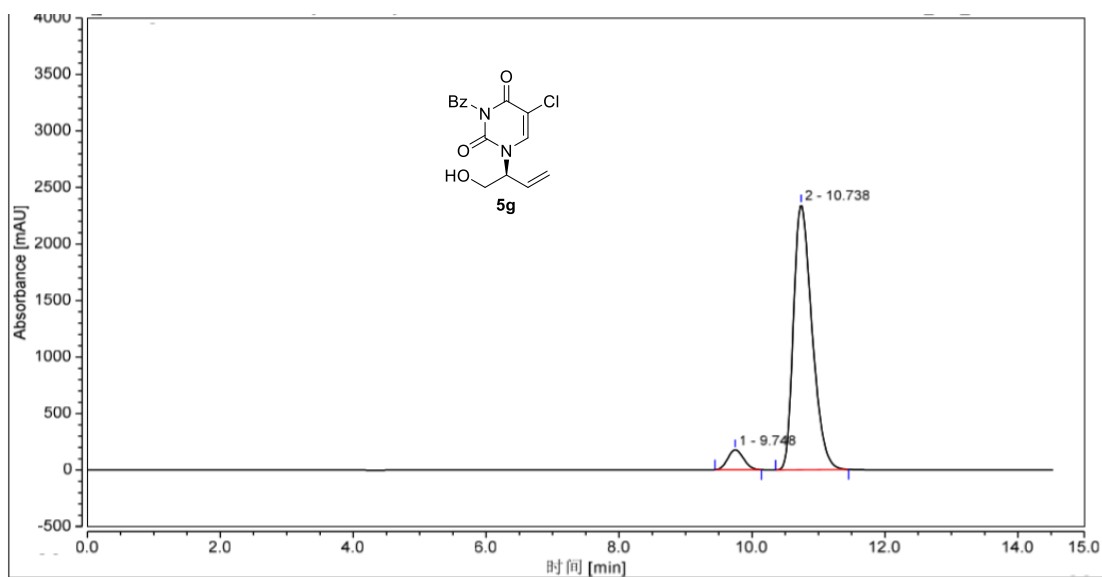
### 积分结果

| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU  | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|----------------|---------------|---------------|
| 1             | 21.060                | 33.257          | 59.903         | 5.24          | 6.88          |
| 2             | 22.550                | 601.410         | 811.266        | 94.76         | 93.12         |
| <b>Total:</b> |                       | <b>634.667</b>  | <b>871.169</b> | <b>100.00</b> | <b>100.00</b> |



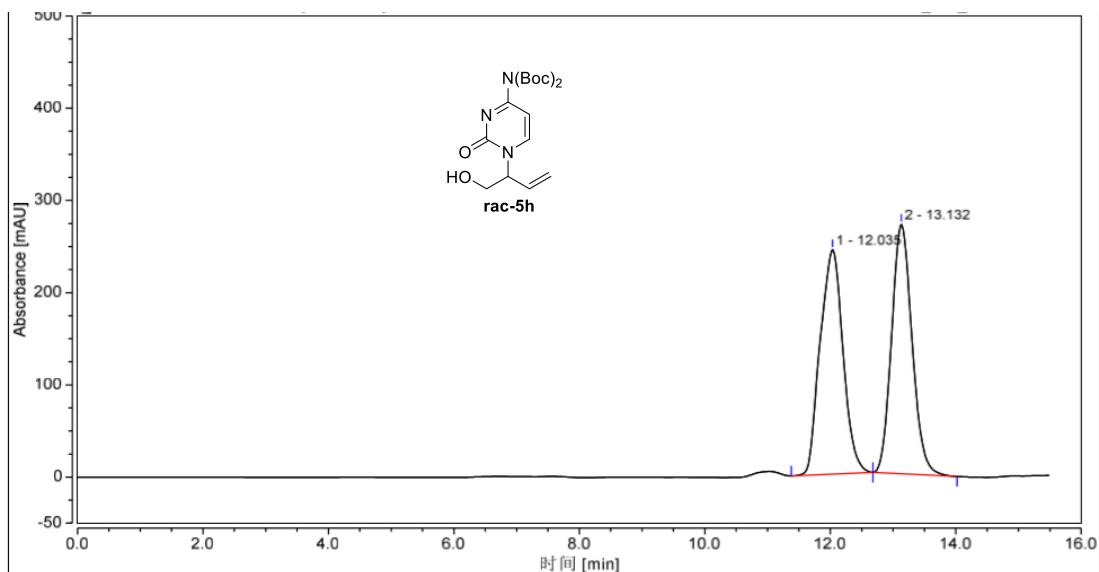
### 积分结果

| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU   | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|-----------------|---------------|---------------|
| 1             | 9.702                 | 415.150         | 1386.466        | 50.10         | 52.65         |
| 2             | 10.767                | 413.562         | 1246.943        | 49.90         | 47.35         |
| <b>Total:</b> |                       | <b>828.713</b>  | <b>2633.409</b> | <b>100.00</b> | <b>100.00</b> |

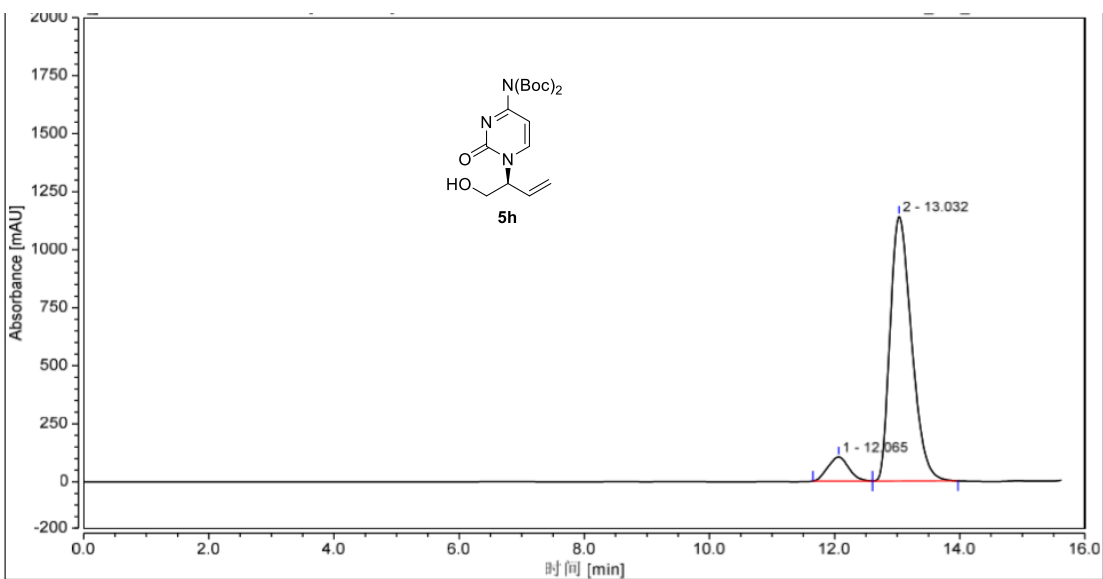


### 积分结果

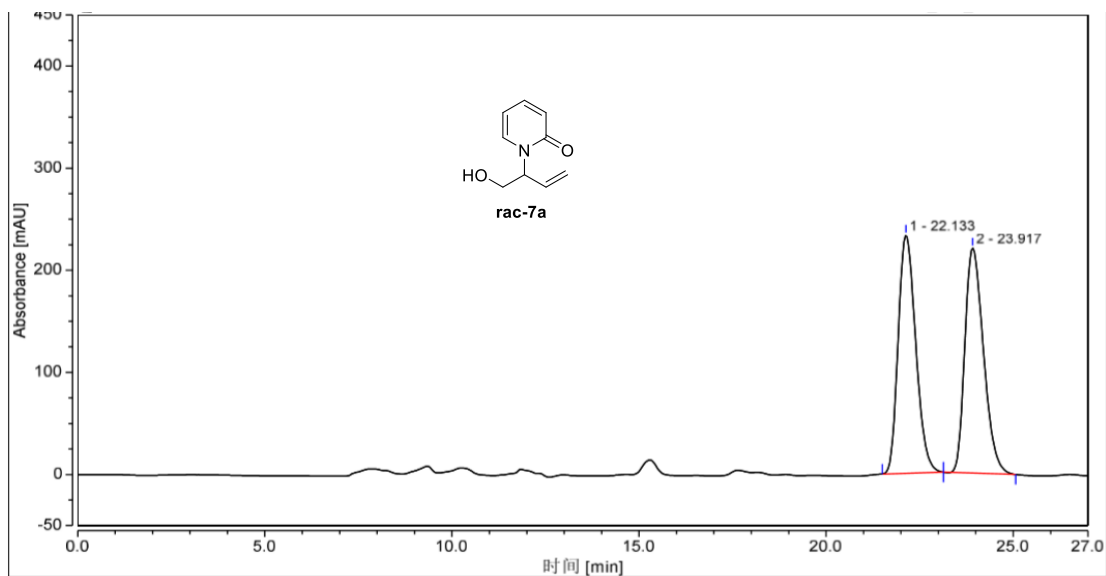
| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU   | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|-----------------|---------------|---------------|
| 1             | 9.748                 | 49.121          | 177.300         | 6.09          | 7.03          |
| 2             | 10.738                | 757.358         | 2345.581        | 93.91         | 92.97         |
| <b>Total:</b> |                       | <b>806.478</b>  | <b>2522.881</b> | <b>100.00</b> | <b>100.00</b> |



| 积分结果          |                       |                 |                |               |               |
|---------------|-----------------------|-----------------|----------------|---------------|---------------|
| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU  | Area<br>%     | Height<br>%   |
| 1             | 12.035                | 102.756         | 243.631        | 50.13         | 47.37         |
| 2             | 13.132                | 102.208         | 270.734        | 49.87         | 52.63         |
| <b>Total:</b> |                       | <b>204.964</b>  | <b>514.366</b> | <b>100.00</b> | <b>100.00</b> |

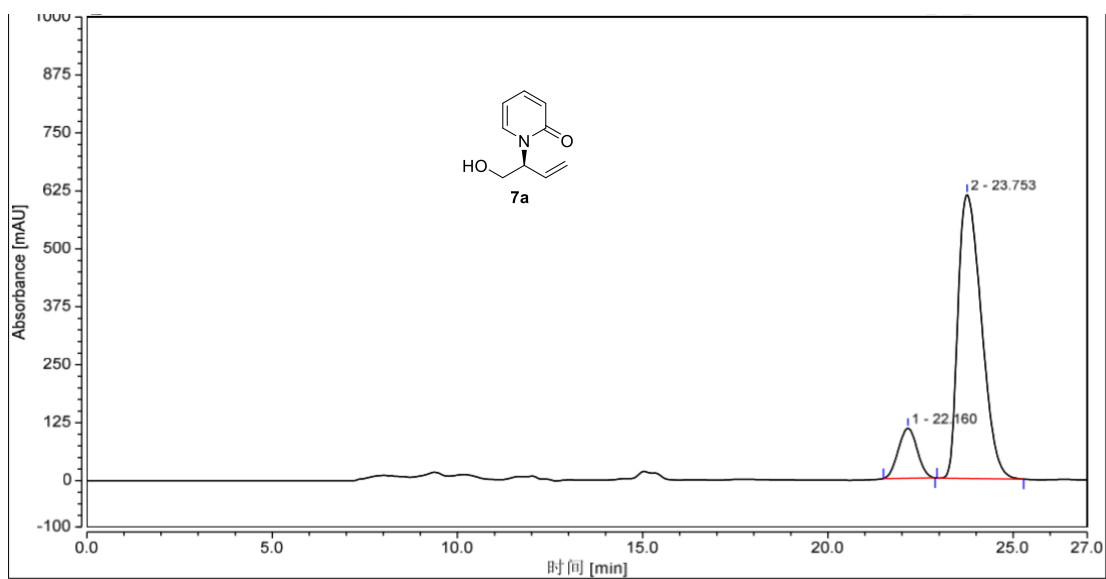


| 积分结果          |                       |                 |                 |               |               |
|---------------|-----------------------|-----------------|-----------------|---------------|---------------|
| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU   | Area<br>%     | Height<br>%   |
| 1             | 12.065                | 40.407          | 104.673         | 8.21          | 8.40          |
| 2             | 13.032                | 452.012         | 1141.062        | 91.79         | 91.60         |
| <b>Total:</b> |                       | <b>492.419</b>  | <b>1245.735</b> | <b>100.00</b> | <b>100.00</b> |



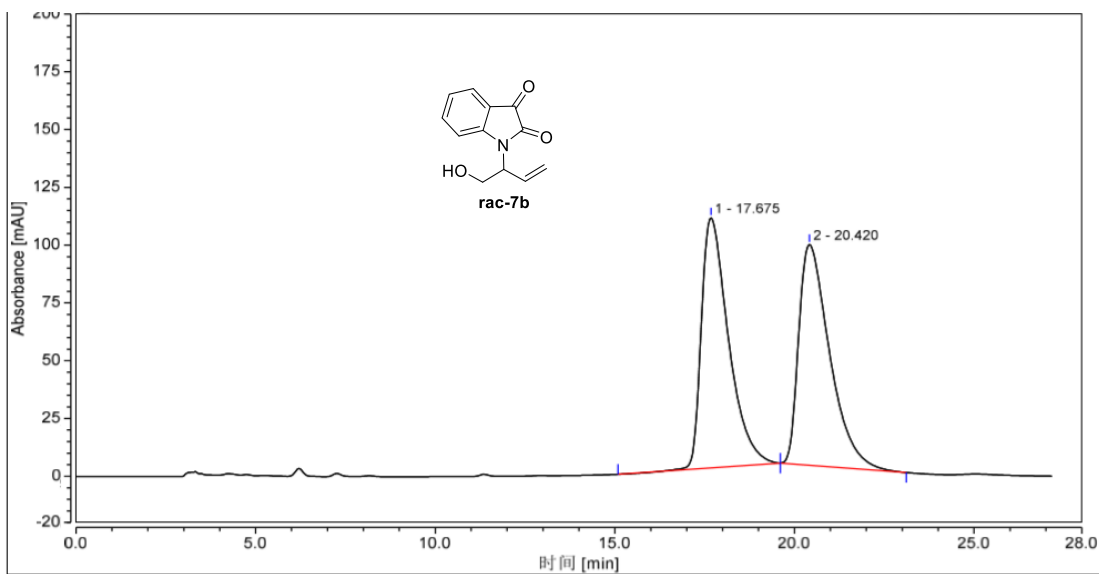
### 积分结果

| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU  | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|----------------|---------------|---------------|
| 1             | 22.133                | 126.618         | 233.100        | 49.82         | 51.41         |
| 2             | 23.917                | 127.517         | 220.284        | 50.18         | 48.59         |
| <b>Total:</b> |                       | <b>254.135</b>  | <b>453.384</b> | <b>100.00</b> | <b>100.00</b> |



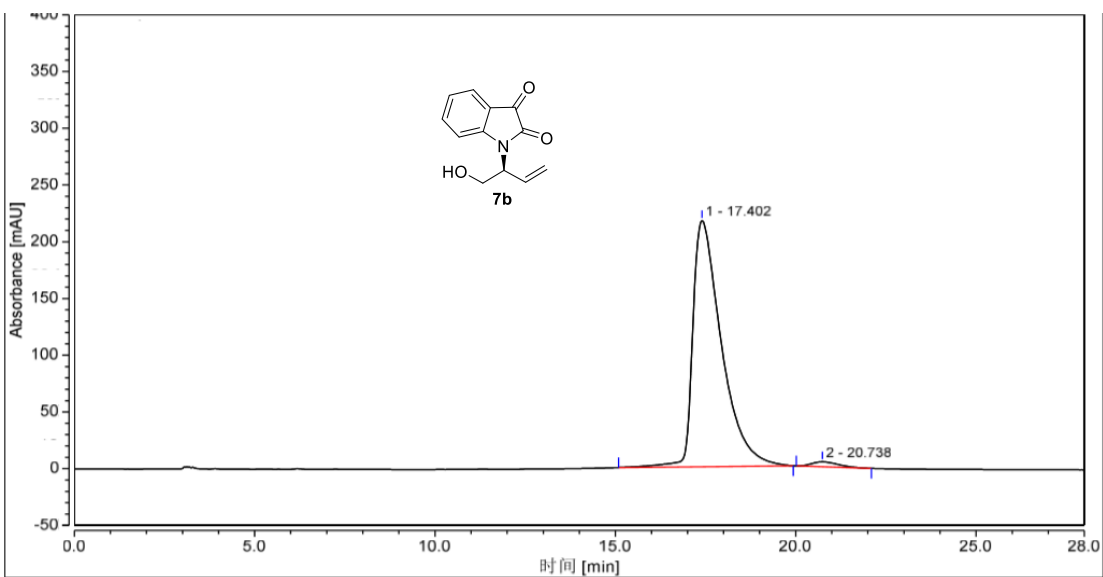
### 积分结果

| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU  | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|----------------|---------------|---------------|
| 1             | 22.160                | 63.600          | 107.763        | 12.43         | 14.96         |
| 2             | 23.753                | 448.263         | 612.519        | 87.57         | 85.04         |
| <b>Total:</b> |                       | <b>511.864</b>  | <b>720.282</b> | <b>100.00</b> | <b>100.00</b> |



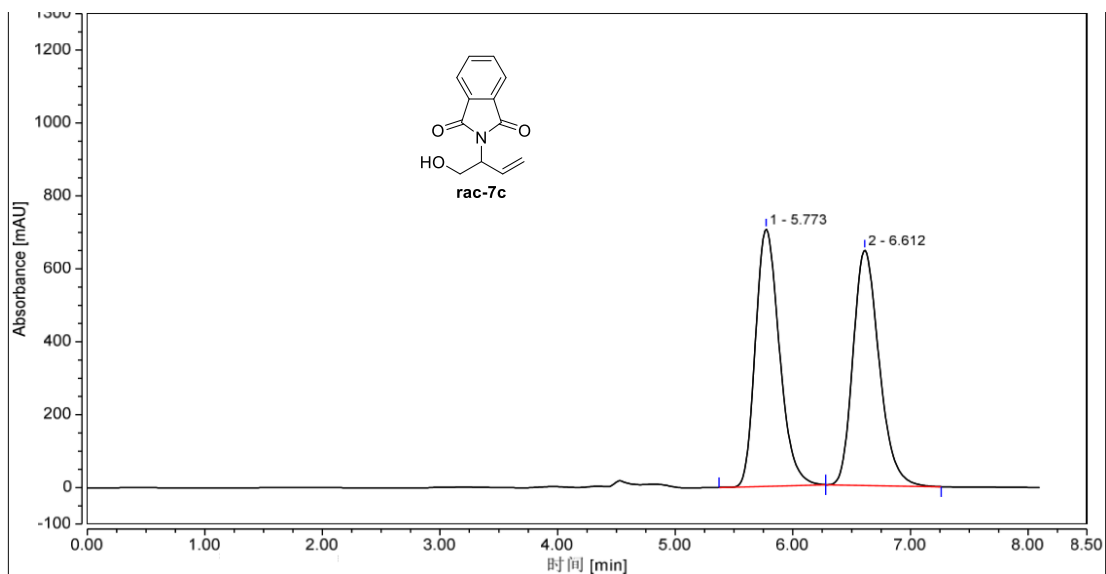
**积分结果**

| Peak          | Retention Time min | Area mAU*min   | Height mAU     | Area %        | Height %      |
|---------------|--------------------|----------------|----------------|---------------|---------------|
| 1             | 17.675             | 94.791         | 108.259        | 49.84         | 53.12         |
| 2             | 20.420             | 95.391         | 95.544         | 50.16         | 46.88         |
| <b>Total:</b> |                    | <b>190.182</b> | <b>203.803</b> | <b>100.00</b> | <b>100.00</b> |



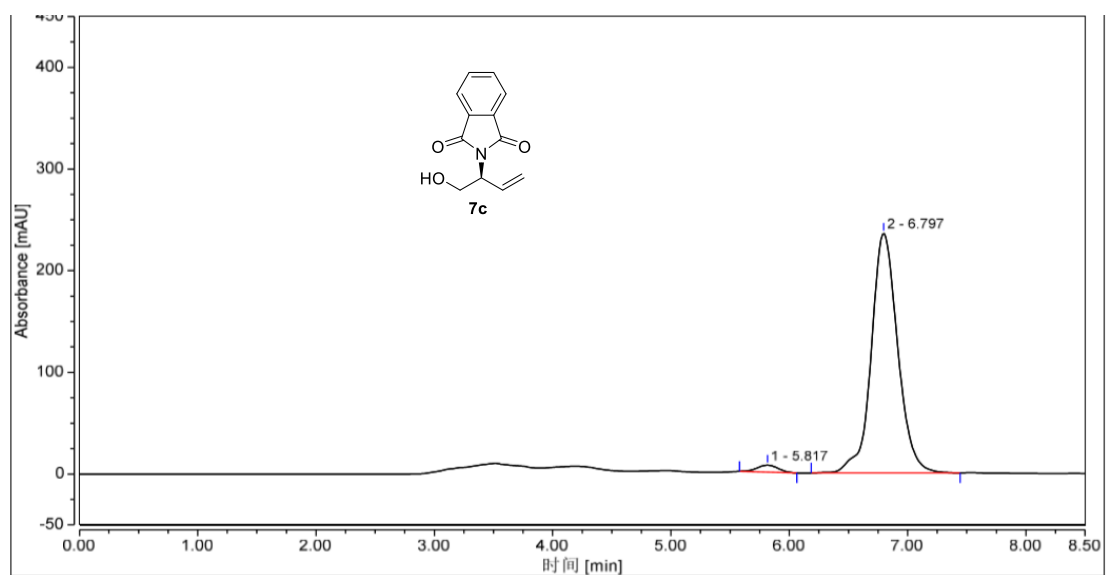
**积分结果**

| Peak          | Retention Time min | Area mAU*min   | Height mAU     | Area %        | Height %      |
|---------------|--------------------|----------------|----------------|---------------|---------------|
| 1             | 17.402             | 199.742        | 216.948        | 98.19         | 98.06         |
| 2             | 20.738             | 3.687          | 4.283          | 1.81          | 1.94          |
| <b>Total:</b> |                    | <b>203.429</b> | <b>221.231</b> | <b>100.00</b> | <b>100.00</b> |



### 积分结果

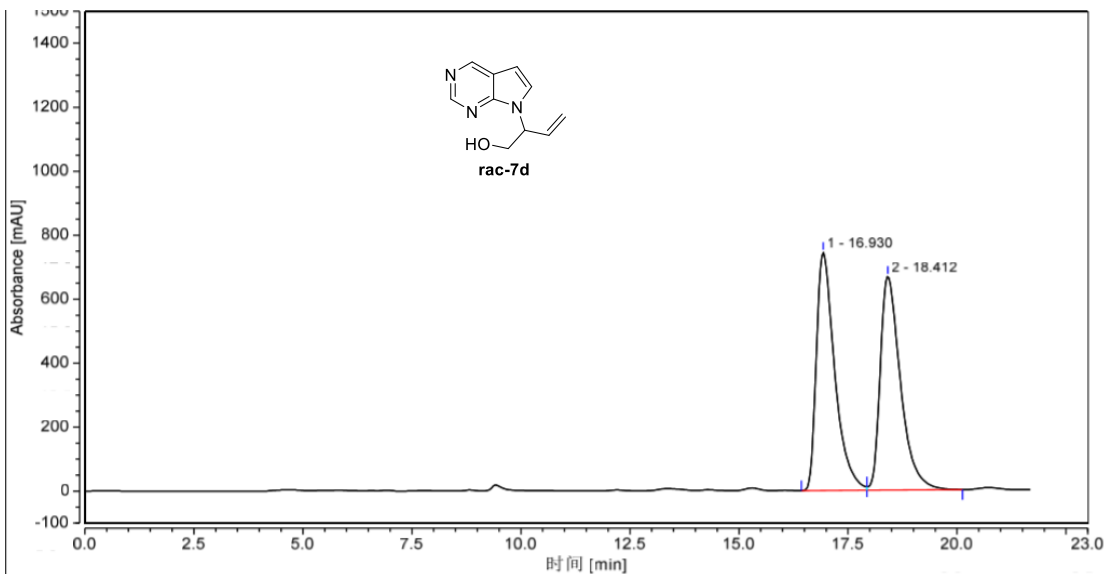
| Peak          | Retention Time min | Area mAU*min   | Height mAU      | Area %        | Height %      |
|---------------|--------------------|----------------|-----------------|---------------|---------------|
| 1             | 5.773              | 166.552        | 705.659         | 50.09         | 52.22         |
| 2             | 6.612              | 165.939        | 645.688         | 49.91         | 47.78         |
| <b>Total:</b> |                    | <b>332.491</b> | <b>1351.346</b> | <b>100.00</b> | <b>100.00</b> |



### 积分结果

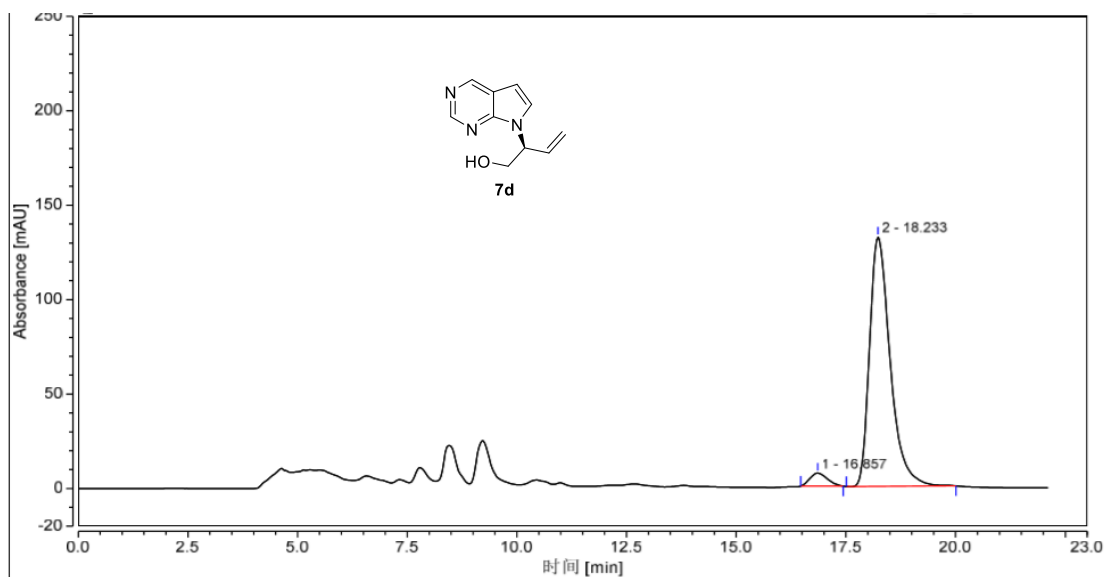
| Peak          | Retention Time min | Area mAU*min  | Height mAU     | Area %        | Height %      |
|---------------|--------------------|---------------|----------------|---------------|---------------|
| 1             | 5.817              | 1.401         | 6.913          | 2.24          | 2.85          |
| 2             | 6.797              | 61.103        | 235.760        | 97.76         | 97.15         |
| <b>Total:</b> |                    | <b>62.505</b> | <b>242.673</b> | <b>100.00</b> | <b>100.00</b> |





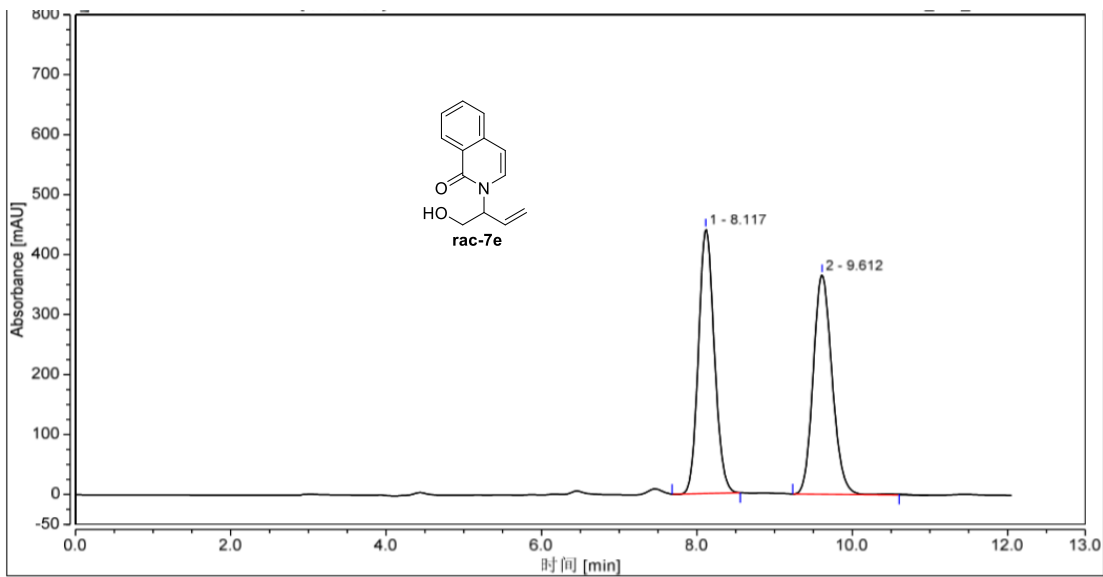
积分结果

| Peak          | Retention Time min | Area mAU*min   | Height mAU      | Area %        | Height %      |
|---------------|--------------------|----------------|-----------------|---------------|---------------|
| 1             | 16.930             | 363.538        | 744.348         | 50.21         | 52.70         |
| 2             | 18.412             | 360.507        | 667.987         | 49.79         | 47.30         |
| <b>Total:</b> |                    | <b>724.045</b> | <b>1412.335</b> | <b>100.00</b> | <b>100.00</b> |



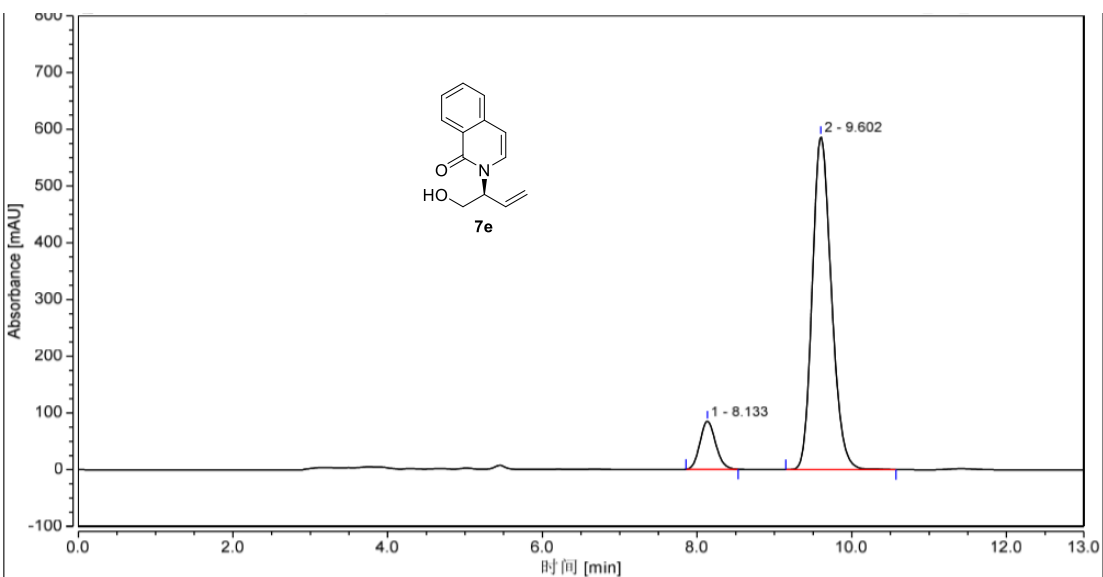
积分结果

| Peak          | Retention Time min | Area mAU*min  | Height mAU     | Area %        | Height %      |
|---------------|--------------------|---------------|----------------|---------------|---------------|
| 1             | 16.857             | 3.138         | 6.826          | 4.18          | 4.91          |
| 2             | 18.233             | 71.924        | 132.077        | 95.82         | 95.09         |
| <b>Total:</b> |                    | <b>75.063</b> | <b>138.903</b> | <b>100.00</b> | <b>100.00</b> |



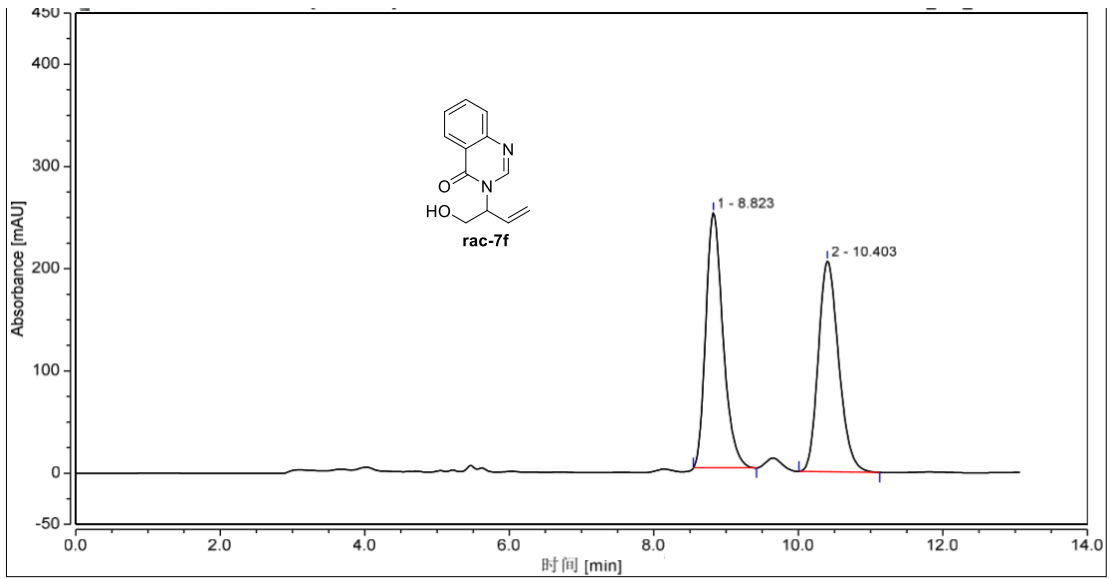
### 积分结果

| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU  | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|----------------|---------------|---------------|
| 1             | 8.117                 | 104.133         | 441.028        | 50.17         | 54.65         |
| 2             | 9.612                 | 103.413         | 366.023        | 49.83         | 45.35         |
| <b>Total:</b> |                       | <b>207.545</b>  | <b>807.051</b> | <b>100.00</b> | <b>100.00</b> |



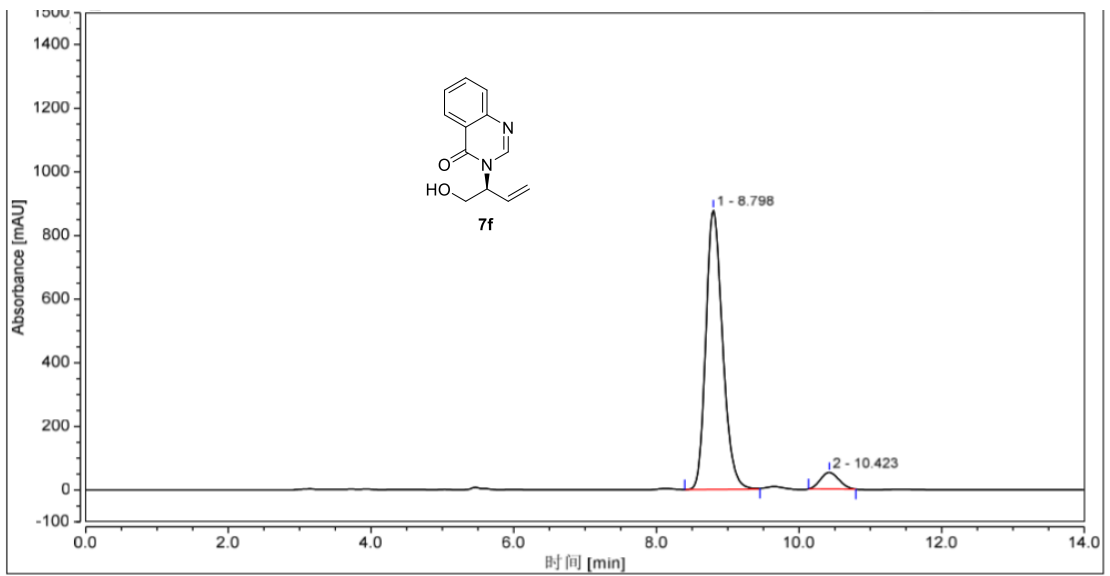
### 积分结果

| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU  | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|----------------|---------------|---------------|
| 1             | 8.133                 | 20.010          | 85.060         | 10.63         | 12.65         |
| 2             | 9.602                 | 168.248         | 587.338        | 89.37         | 87.35         |
| <b>Total:</b> |                       | <b>188.257</b>  | <b>672.398</b> | <b>100.00</b> | <b>100.00</b> |



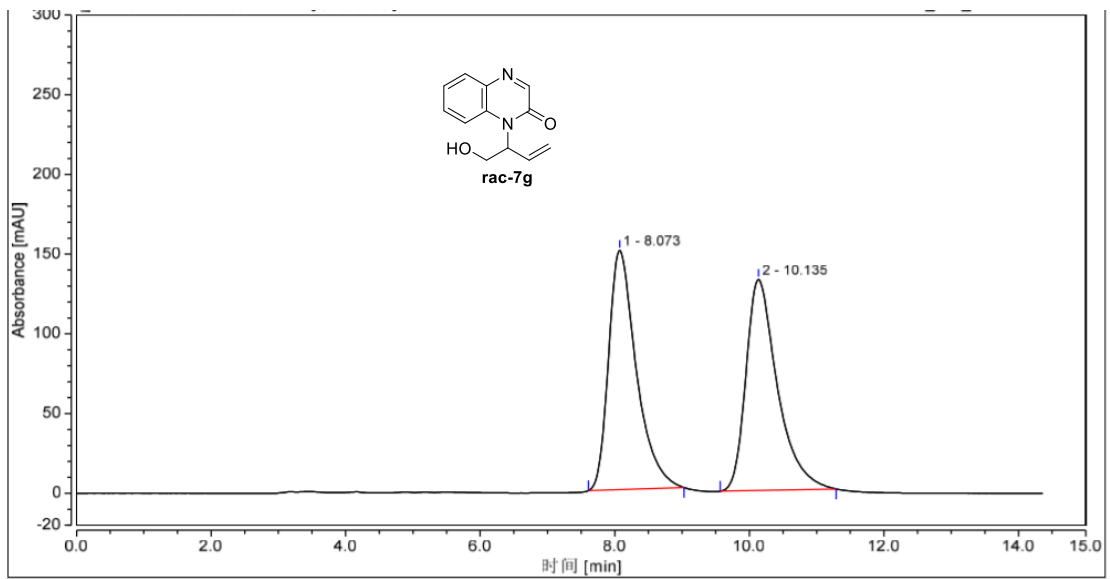
**积分结果**

| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU  | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|----------------|---------------|---------------|
| 1             | 8.823                 | 68.987          | 249.589        | 50.61         | 54.77         |
| 2             | 10.403                | 67.329          | 206.089        | 49.39         | 45.23         |
| <b>Total:</b> |                       | <b>136.317</b>  | <b>455.678</b> | <b>100.00</b> | <b>100.00</b> |



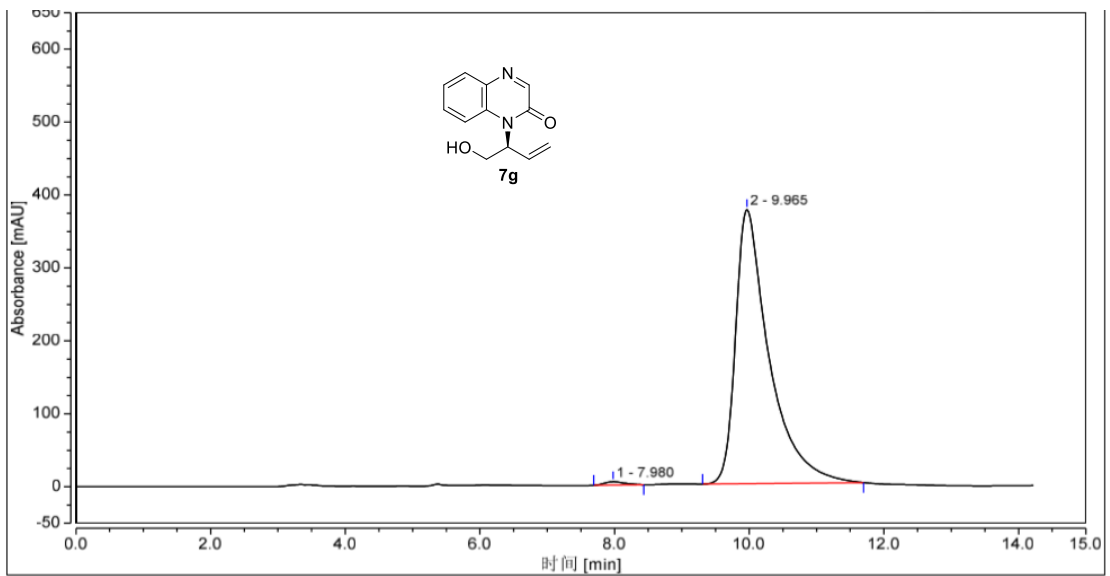
**积分结果**

| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU  | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|----------------|---------------|---------------|
| 1             | 8.798                 | 239.091         | 877.729        | 93.85         | 94.40         |
| 2             | 10.423                | 15.679          | 52.025         | 6.15          | 5.60          |
| <b>Total:</b> |                       | <b>254.770</b>  | <b>929.754</b> | <b>100.00</b> | <b>100.00</b> |



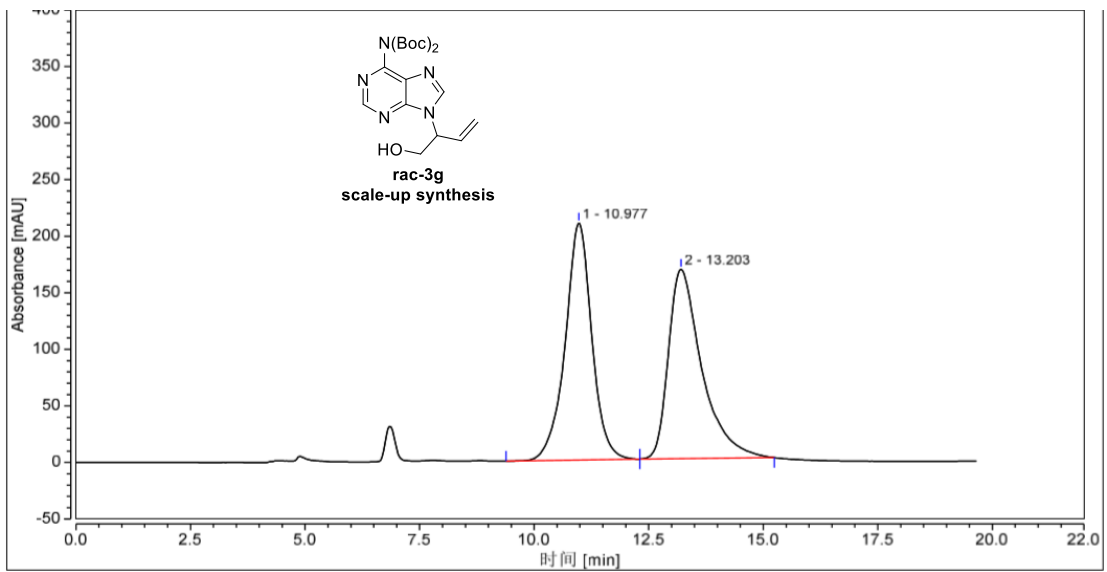
**积分结果**

| Peak          | Retention Time min | Area mAU*min   | Height mAU     | Area %        | Height %      |
|---------------|--------------------|----------------|----------------|---------------|---------------|
| 1             | 8.073              | 71.583         | 150.117        | 50.01         | 53.13         |
| 2             | 10.135             | 71.550         | 132.427        | 49.99         | 46.87         |
| <b>Total:</b> |                    | <b>143.133</b> | <b>282.544</b> | <b>100.00</b> | <b>100.00</b> |



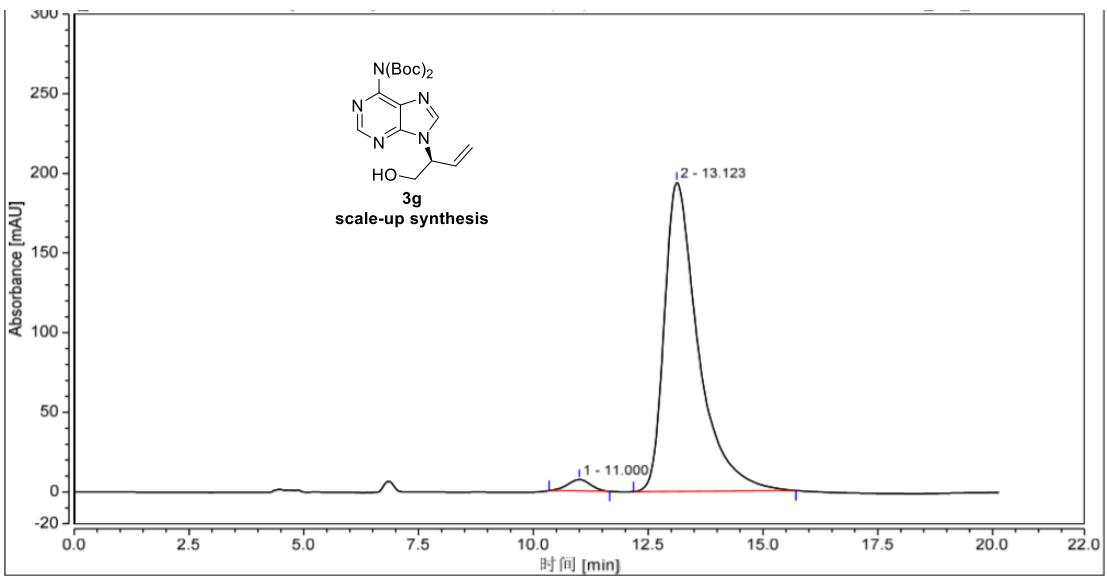
**积分结果**

| Peak          | Retention Time min | Area mAU*min   | Height mAU     | Area %        | Height %      |
|---------------|--------------------|----------------|----------------|---------------|---------------|
| 1             | 7.980              | 1.604          | 4.534          | 0.73          | 1.19          |
| 2             | 9.965              | 216.949        | 376.140        | 99.27         | 98.81         |
| <b>Total:</b> |                    | <b>218.553</b> | <b>380.674</b> | <b>100.00</b> | <b>100.00</b> |



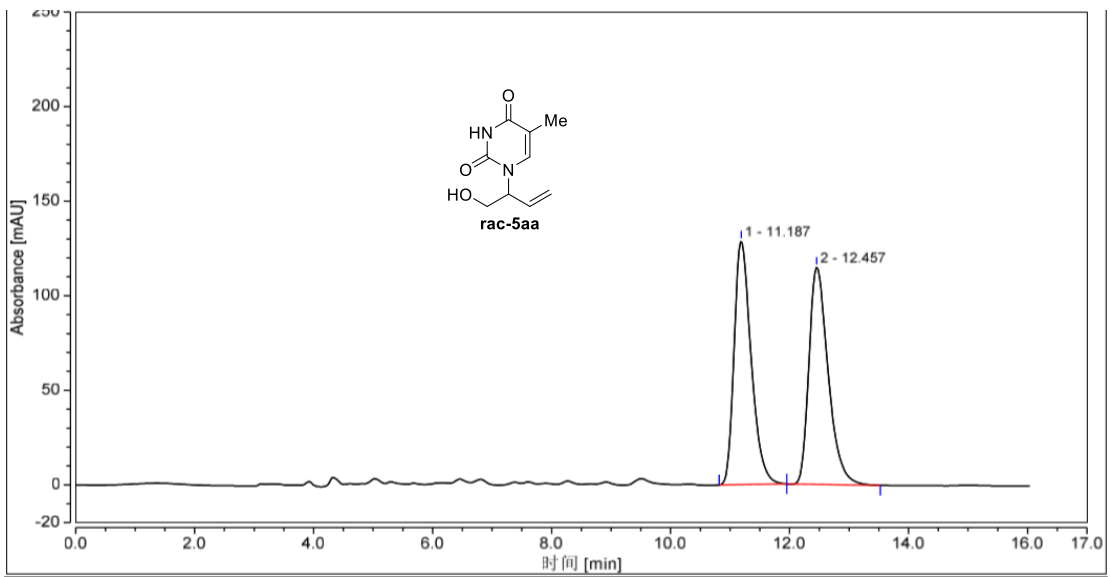
**积分结果**

| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU  | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|----------------|---------------|---------------|
| 1             | 10.977                | 140.576         | 209.451        | 49.93         | 55.59         |
| 2             | 13.203                | 140.986         | 167.341        | 50.07         | 44.41         |
| <b>Total:</b> |                       | <b>281.562</b>  | <b>376.792</b> | <b>100.00</b> | <b>100.00</b> |



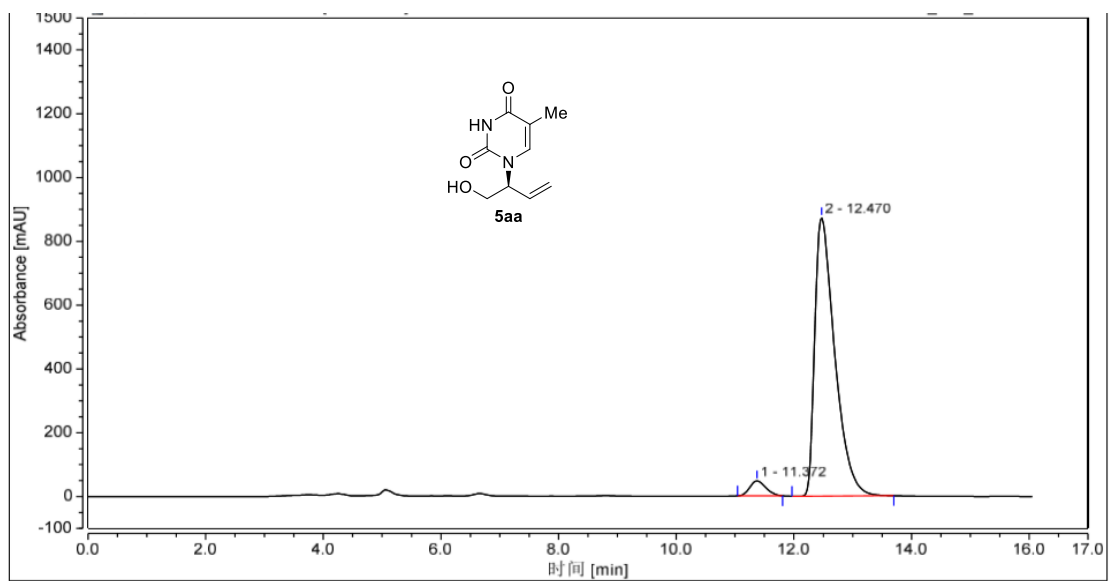
**积分结果**

| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU  | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|----------------|---------------|---------------|
| 1             | 11.000                | 4.210           | 7.193          | 2.47          | 3.58          |
| 2             | 13.123                | 166.365         | 193.951        | 97.53         | 96.42         |
| <b>Total:</b> |                       | <b>170.575</b>  | <b>201.145</b> | <b>100.00</b> | <b>100.00</b> |



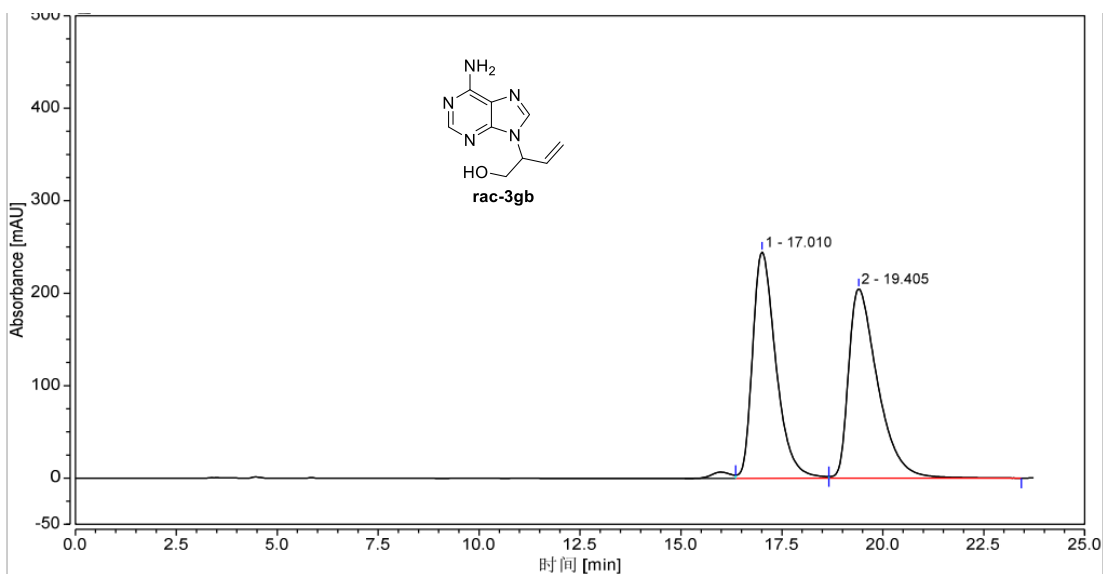
### 积分结果

| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU  | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|----------------|---------------|---------------|
| 1             | 11.187                | 42.734          | 128.863        | 49.86         | 52.87         |
| 2             | 12.457                | 42.977          | 114.857        | 50.14         | 47.13         |
| <b>Total:</b> |                       | <b>85.711</b>   | <b>243.720</b> | <b>100.00</b> | <b>100.00</b> |



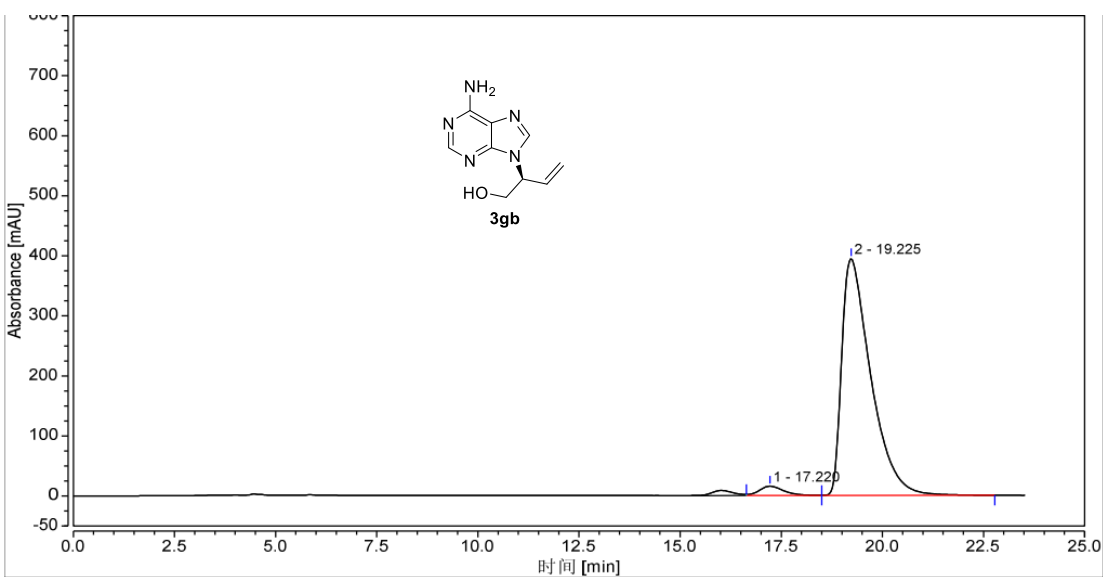
### 积分结果

| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU  | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|----------------|---------------|---------------|
| 1             | 11.372                | 14.796          | 46.683         | 4.13          | 5.08          |
| 2             | 12.470                | 343.328         | 872.736        | 95.87         | 94.92         |
| <b>Total:</b> |                       | <b>358.124</b>  | <b>919.419</b> | <b>100.00</b> | <b>100.00</b> |



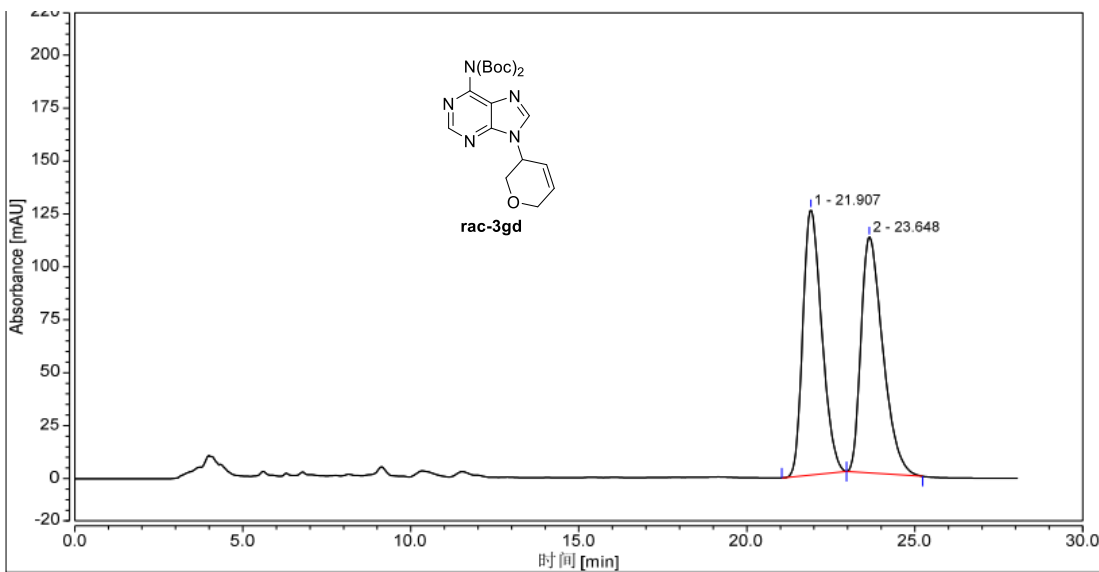
### 积分结果

| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU  | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|----------------|---------------|---------------|
| 1             | 17.010                | 164.110         | 244.684        | 48.98         | 54.43         |
| 2             | 19.405                | 170.958         | 204.879        | 51.02         | 45.57         |
| <b>Total:</b> |                       | <b>335.069</b>  | <b>449.562</b> | <b>100.00</b> | <b>100.00</b> |

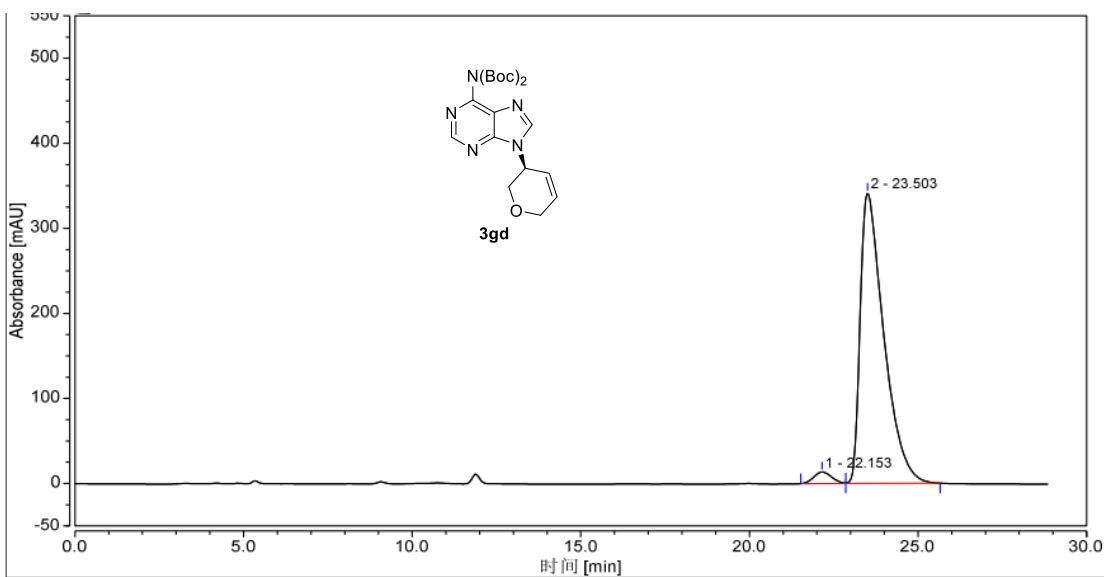


### 积分结果

| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU  | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|----------------|---------------|---------------|
| 1             | 17.220                | 10.882          | 15.626         | 3.21          | 3.81          |
| 2             | 19.225                | 328.255         | 394.209        | 96.79         | 96.19         |
| <b>Total:</b> |                       | <b>339.137</b>  | <b>409.836</b> | <b>100.00</b> | <b>100.00</b> |

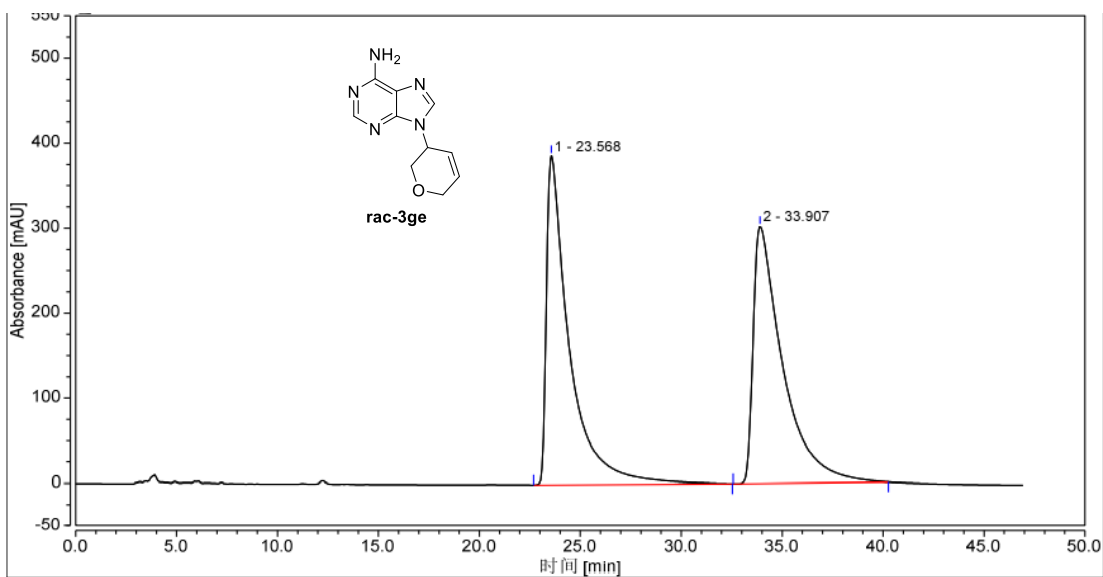


| 积分结果          |                       |                 |                |               |               |
|---------------|-----------------------|-----------------|----------------|---------------|---------------|
| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU  | Area<br>%     | Height<br>%   |
| 1             | 21.907                | 81.845          | 125.358        | 49.25         | 52.92         |
| 2             | 23.648                | 84.331          | 111.540        | 50.75         | 47.08         |
| <b>Total:</b> |                       | <b>166.176</b>  | <b>236.897</b> | <b>100.00</b> | <b>100.00</b> |

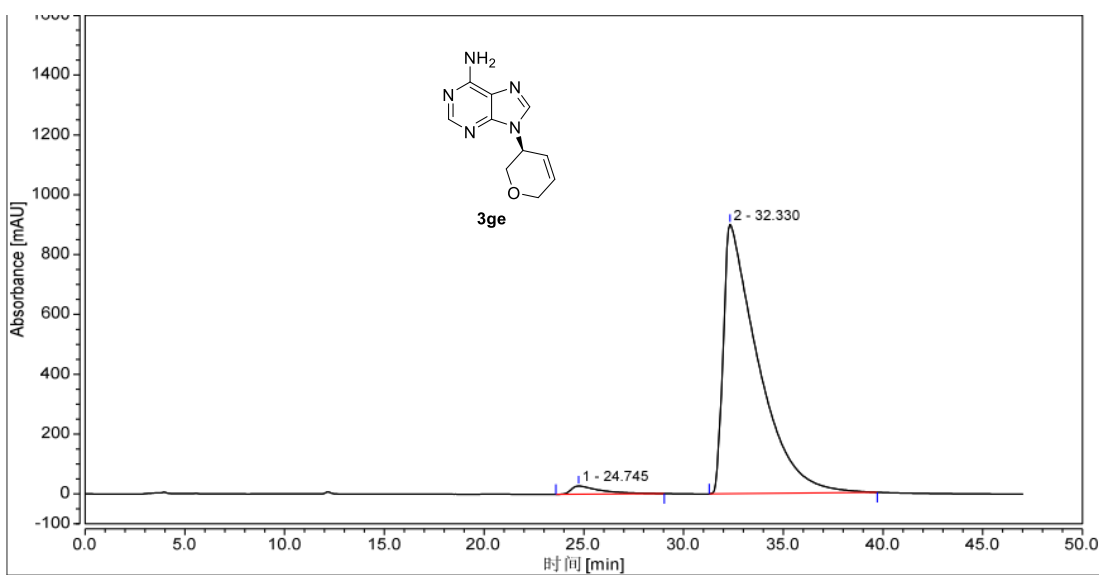


| 积分结果          |                       |                 |                |               |               |
|---------------|-----------------------|-----------------|----------------|---------------|---------------|
| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU  | Area<br>%     | Height<br>%   |
| 1             | 22.153                | 8.345           | 13.556         | 2.92          | 3.82          |
| 2             | 23.503                | 277.015         | 341.377        | 97.08         | 96.18         |
| <b>Total:</b> |                       | <b>285.360</b>  | <b>354.934</b> | <b>100.00</b> | <b>100.00</b> |

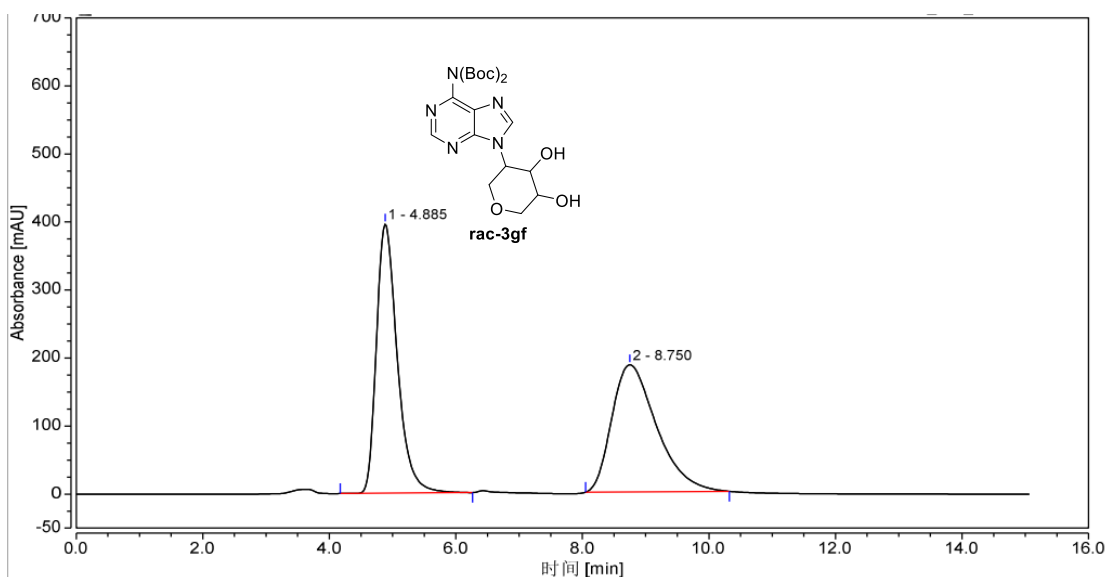




| 积分结果          |                       |                 |                |               |               |
|---------------|-----------------------|-----------------|----------------|---------------|---------------|
| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU  | Area<br>%     | Height<br>%   |
| 1             | 23.568                | 507.288         | 387.086        | 49.89         | 56.15         |
| 2             | 33.907                | 509.546         | 302.303        | 50.11         | 43.85         |
| <b>Total:</b> |                       | <b>1016.834</b> | <b>689.389</b> | <b>100.00</b> | <b>100.00</b> |

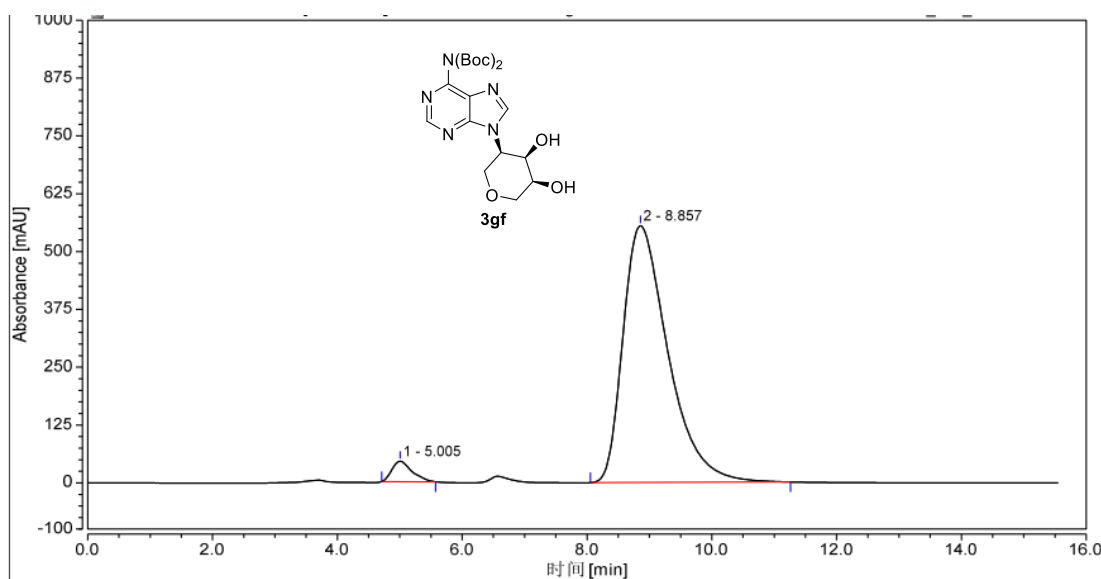


| 积分结果          |                       |                 |                |               |               |
|---------------|-----------------------|-----------------|----------------|---------------|---------------|
| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU  | Area<br>%     | Height<br>%   |
| 1             | 24.745                | 46.606          | 27.319         | 2.50          | 2.95          |
| 2             | 32.330                | 1816.801        | 899.994        | 97.50         | 97.05         |
| <b>Total:</b> |                       | <b>1863.407</b> | <b>927.314</b> | <b>100.00</b> | <b>100.00</b> |



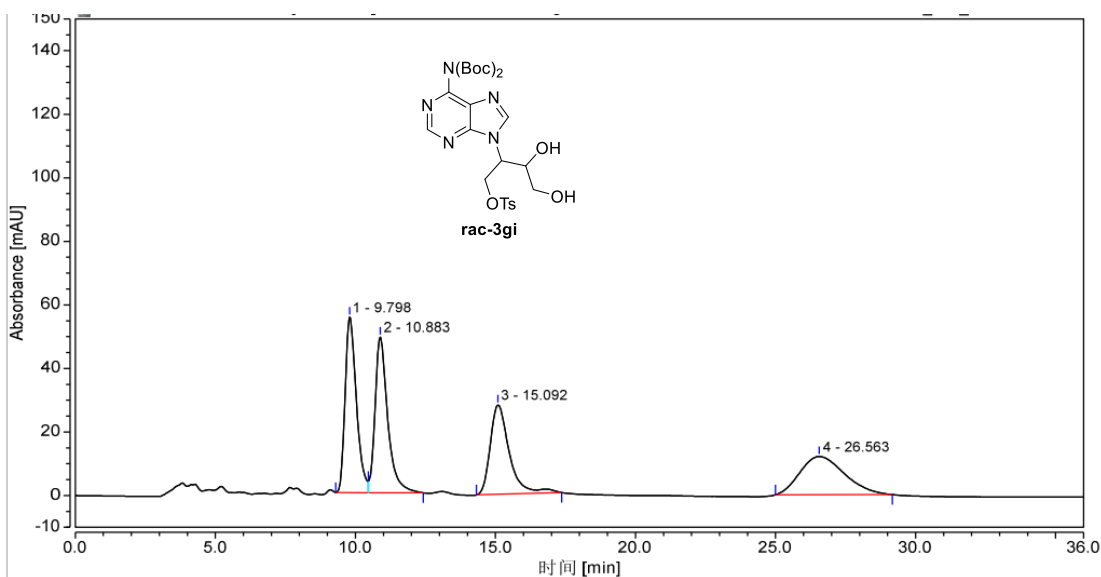
### 积分结果

| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU  | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|----------------|---------------|---------------|
| 1             | 4.885                 | 150.833         | 395.726        | 49.60         | 67.90         |
| 2             | 8.750                 | 153.260         | 187.059        | 50.40         | 32.10         |
| <b>Total:</b> |                       | <b>304.093</b>  | <b>582.784</b> | <b>100.00</b> | <b>100.00</b> |



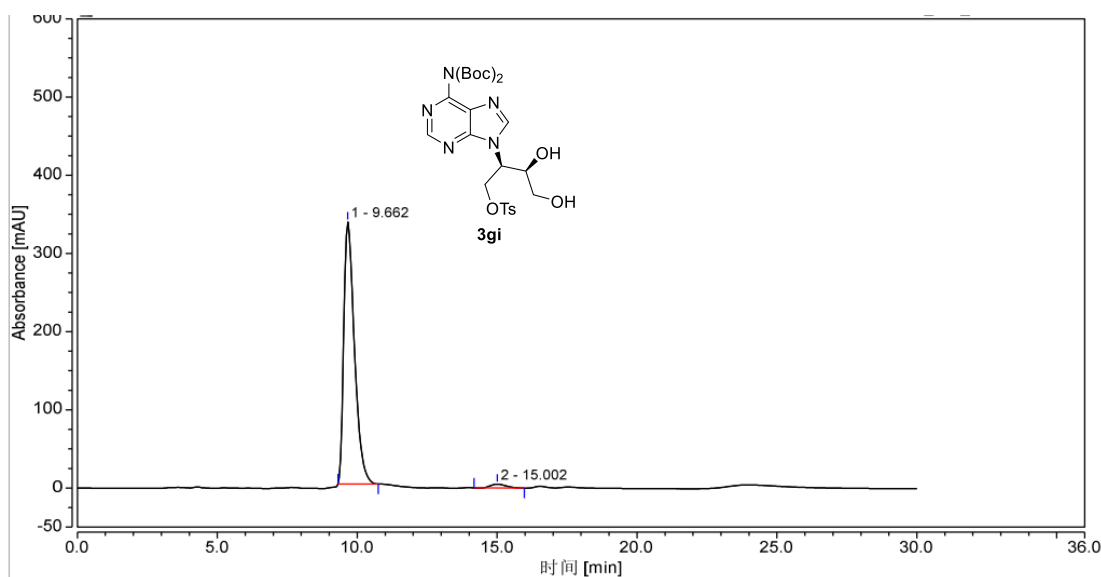
### 积分结果

| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU  | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|----------------|---------------|---------------|
| 1             | 5.005                 | 16.426          | 44.164         | 3.42          | 7.37          |
| 2             | 8.857                 | 463.372         | 555.129        | 96.58         | 92.63         |
| <b>Total:</b> |                       | <b>479.798</b>  | <b>599.293</b> | <b>100.00</b> | <b>100.00</b> |



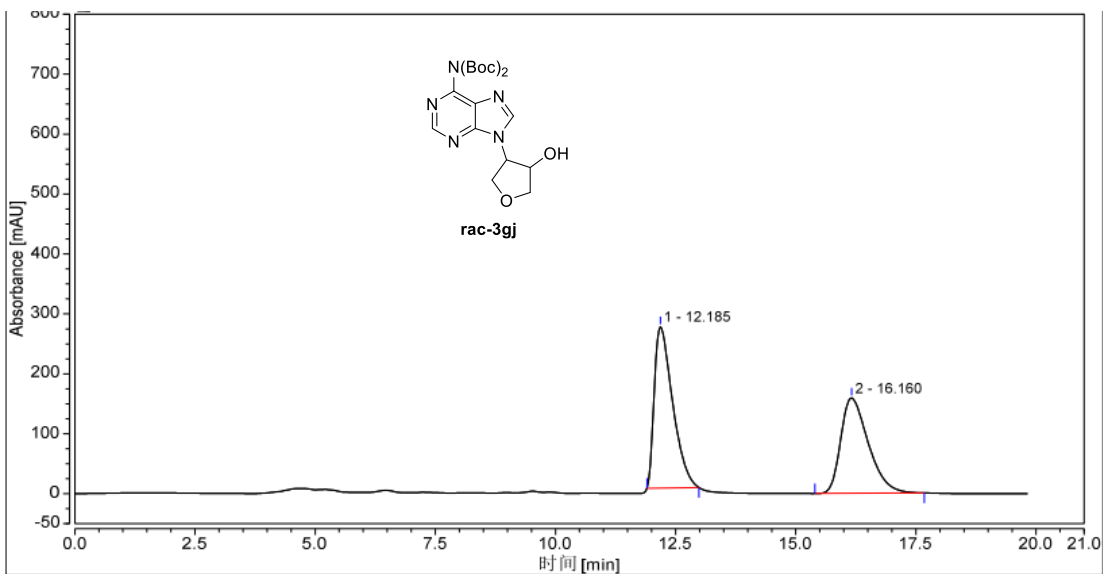
### 积分结果

| Peak          | Retention Time min | Area mAU*min  | Height mAU     | Area %        | Height %      |
|---------------|--------------------|---------------|----------------|---------------|---------------|
| 1             | 9.798              | 25.753        | 55.234         | 26.87         | 38.25         |
| 2             | 10.883             | 25.653        | 48.983         | 26.77         | 33.92         |
| 3             | 15.092             | 22.223        | 28.155         | 23.19         | 19.50         |
| 4             | 26.563             | 22.210        | 12.036         | 23.17         | 8.33          |
| <b>Total:</b> |                    | <b>95.839</b> | <b>144.408</b> | <b>100.00</b> | <b>100.00</b> |



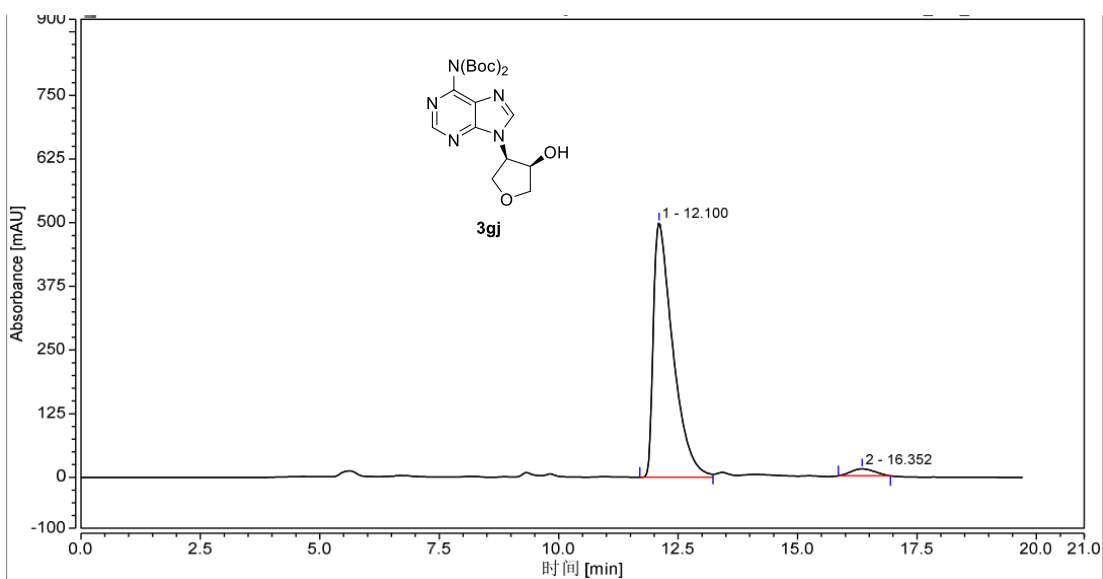
### 积分结果

| Peak          | Retention Time min | Area mAU*min   | Height mAU     | Area %        | Height %      |
|---------------|--------------------|----------------|----------------|---------------|---------------|
| 1             | 9.662              | 148.706        | 334.856        | 97.89         | 98.55         |
| 2             | 15.002             | 3.211          | 4.930          | 2.11          | 1.45          |
| <b>Total:</b> |                    | <b>151.917</b> | <b>339.786</b> | <b>100.00</b> | <b>100.00</b> |



### 积分结果

| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU  | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|----------------|---------------|---------------|
| 1             | 12.185                | 119.459         | 269.271        | 53.00         | 62.87         |
| 2             | 16.160                | 105.945         | 159.019        | 47.00         | 37.13         |
| <b>Total:</b> |                       | <b>225.403</b>  | <b>428.290</b> | <b>100.00</b> | <b>100.00</b> |



### 积分结果

| Peak          | Retention Time<br>min | Area<br>mAU*min | Height<br>mAU  | Area<br>%     | Height<br>%   |
|---------------|-----------------------|-----------------|----------------|---------------|---------------|
| 1             | 12.100                | 237.663         | 499.750        | 96.80         | 97.34         |
| 2             | 16.352                | 7.853           | 13.670         | 3.20          | 2.66          |
| <b>Total:</b> |                       | <b>245.516</b>  | <b>513.420</b> | <b>100.00</b> | <b>100.00</b> |