

## Regio- and enantioselective formation of tetrazole-bearing quaternary stereocenters *via* palladium-catalyzed allylic amination

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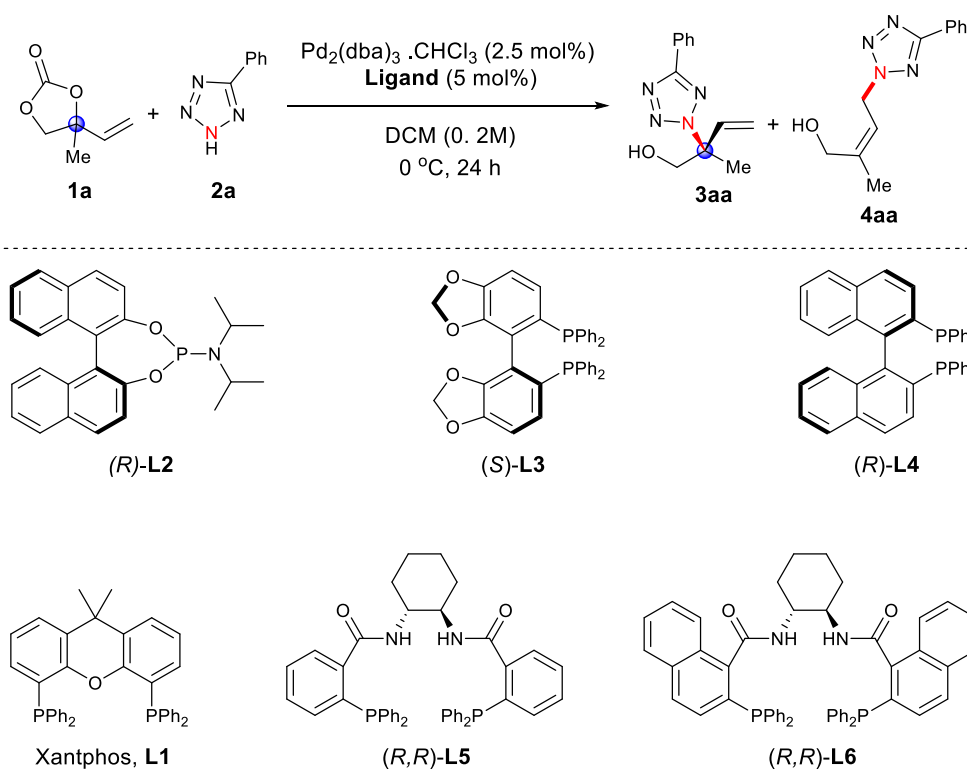
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## General experimental details

Analytical thin-layer chromatography (TLC) was carried out using 0.2 mm commercial silica gel plates (Yantai Jiangyou Silica Gel Development Co., Ltd., silica gel HSGF 254). Preparative column chromatography employing silica gel (Qingdao Shenghai Fine Silica Gel Chemical Co., Ltd., 200-300 mesh) was performed according to the method of Still. Solvents for the chromatography are listed as volume/volume ratios. High-resolution mass spectra (HRMS) were performed at Instrumental Analysis Center of Xi'an Jiao Tong University using ESI method. Proton nuclear magnetic resonance ( $^1\text{H}$  NMR) spectra were recorded with a Varian Mercuryplus 400 (400 MHz) spectrometer. Chemical shifts are reported in delta ( $\delta$ ) units, parts per million (ppm) downfield from tetramethylsilane or ppm relative to the center of the singlet at 7.26 ppm for deuteriochloroform. Coupling constants are reported in Hertz (Hz). Carbon-13 nuclear magnetic resonance ( $^{13}\text{C}$  NMR) spectra were recorded with a Varian Gemini 400 (100 MHz) spectrometer. Chemical shifts are reported in delta ( $\delta$ ) units, ppm relative to the center of the triplet at 77.0 ppm for deuteriochloroform.  $^{13}\text{C}$  NMR spectra were routinely run with broadband decoupling. High performance liquid chromatography (HPLC) was performed with FuLi (instruments) spectrometers using chiral column as noted for each compound. Optical rotations were measured on SGW<sup>®</sup>-1 polarimeter.  $\text{Pd}_2(\text{dba})_3 \cdot \text{CHCl}_3$ , Ligands and tetrazole compounds were purchased from Energy Chemicals and used as received. Substituted vinyl cyclic carbonates were synthesized according to the previously reported procedure.<sup>1</sup> All other chemicals were used as received from commercial resources.

## Details for the Optimization Conditions

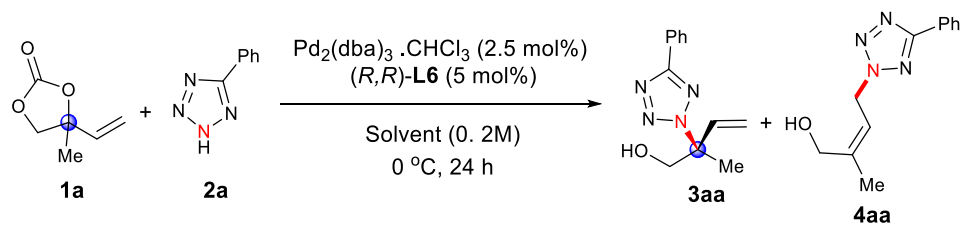
**Table S1.** Evaluation of ligand for asymmetric Pd-catalyzed amination of allylic cyclic carbonate **1a** with Phenyl tetrazole **2a**<sup>[a]</sup>



entry	ligand	yield (%) <sup>[b]</sup>	<i>b/l</i> <sup>[c]</sup>	ee (%) <sup>[d]</sup>
1	<b>L1</b>	76	1:1	--
2	<b>(S)-L2</b>	82	19:1	65
3	<b>(R)-L3</b>	24	2:1	28
4	<b>(R,R)-L4</b>	17	1:1	>10
5	<b>(R,R)-L5</b>	45	15:1	74
6	<b>(R,R)-L6</b>	77	15:1	82

[a] Reaction conditions:  $\text{Pd}_2(\text{dba})_3 \cdot \text{CHCl}_3$  (2.5 mol%), ligands in entry 2 (10 mol%), ligands in entry 1 and 3-6 (5 mol%), **1a** (0.2 mmol), **2a** (0.24 mmol, 1.2 equiv), DCM (1.0 mL, 0.2 M), 0 °C, 24 hours. [b] Isolated yields. [c] Determined by <sup>1</sup>H-NMR of the crude reaction mixture [d] Determined by HPLC using a Chiralcel IC Column.

**Table S2.** Evaluation of solvents for asymmetric Pd-catalyzed amination of allylic cyclic carbonate **1a** with Phenyl tetrazole **2a**<sup>[a]</sup>

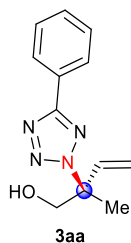


entry	solvent	yield (%) <sup>[b]</sup>	<i>b/l</i> <sup>[c]</sup>	ee (%) <sup>[d]</sup>
1	THF	54	15:1	85
2	toluene	89	>19:1	92
3	1,4-dioxane	40	10:1	72
4	CH <sub>3</sub> CN	63	10:1	65
5	Et <sub>2</sub> O	70	15:1	82
6	DCE	67	19:1	79
7	EtOH	80	19:1	45
8 <sup>e</sup>	toluene	38	10:1	87

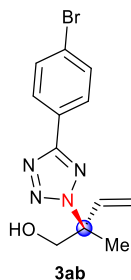
[a] Reaction conditions:  $\text{Pd}_2(\text{dba})_3 \cdot \text{CHCl}_3$  (2.5 mol%),  $(R,R)\text{-L6}$  (5 mol%), **1a** (0.2 mmol), **2a** (0.24 mmol, 1.2 equiv), solvent (1.0 mL, 0.2 M), 0 °C, 24 hours. [b] Isolated yields. [c] Determined by <sup>1</sup>H-NMR of the crude reaction mixture. [d] Determined by HPLC using a Chiralcel IC Column. [e] Reaction was performed at 20 °C temperature.

## General procedure for allylic substitution of vinyl cyclic carbonates **1** with tetrazole **2a**

To an oven dried screw-cap reaction tube equipped with a magnetic stir bar, Pd<sub>2</sub>(dba)<sub>3</sub>·CHCl<sub>3</sub> (5.2 mg, 2.5 mol%), Trost's ligand (*R,R*)-**L6** (7.8 mg, 5 mol%), vinyl cyclic carbonate **1a** (25.6 mg, 0.2 mmol), and phenyltetrazole **2a** (35.08 mg, 0.24 mmol) were added. The reaction tube was sealed with rubber-septum, then evacuated and backfilled with nitrogen. Anhydrous toluene (0.2 M, 1 mL) was added via syringe. The resulting mixture was stirred at 0 °C for 24 hours. The residue was purified by flash column chromatography on silica gel to afford the pure branched product **3aa**. The enantiomeric excesses of the products were determined by HPLC analysis using chiral stationary phases as indicated for each case.

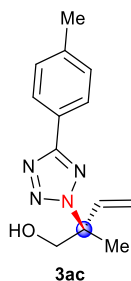


**(*R*)-2-methyl-2-(5-phenyl-2H-tetrazol-2-yl)but-3-en-1-ol (3aa)** was prepared according to the general procedure from **1a** and **2a**. The crude product was purified by flash column chromatography (Petroleum ether/EtOAc = 20:1) on silica gel to provide the title compound as a colorless oil in 89% yield (41.0 mg).  $[\alpha]_D^{25} = 20.5$  ( $c = 0.12$ , CHCl<sub>3</sub>); **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$  8.16–8.14 (m, 2H), 7.52–7.46 (m, 3H) 6.21 (dd,  $J = 10.8, 17.4$  Hz, 1H), 5.37 (d,  $J = 10.8$  Hz, 1H), 5.14 (d,  $J = 17.6$  Hz, 1H), 4.28 (dd,  $J = 7.1, 12.3$  Hz, 1H), 4.05 (dd,  $J = 7.0, 12.3$  Hz, 1H), 3.03 (brt, 1H), 1.91 (s, 3H); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$  164.6, 137.1, 130.4, 128.9, 127.1, 126.9, 117.3, 71.0, 68.4, 21.7; **HRMS (ESI-MS)**: Calcd. for C<sub>12</sub>H<sub>14</sub>N<sub>4</sub>O (M + Na): 253.1065, Found: 253.1057; **HPLC conditions**: Chiralcel IC column, 254 nm, flow rate: 1 ml/min, *i*-PrOH/hexanes = 1/19,  $t_{\text{major}} = 24.2$  min,  $t_{\text{minor}} = 29.1$  min; 92% ee.

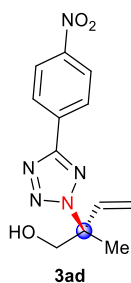


**(*R*)-2-(5-(4-bromophenyl)-2H-tetrazol-2-yl)-2-methylbut-3-en-1-ol (3ab)** was prepared according to the general procedure from **1a** and **2b**. The crude product was purified by flash column chromatography

(Petroleum ether/EtOAc = 20:1) on silica gel to provide the title compound as a colorless oil in 87% yield (53.8 mg).  $[\alpha]_{\text{D}}^{25} = -14.2$  ( $c = 1.03$ ,  $\text{CHCl}_3$ );  $^1\text{H NMR}$  (400 MHz,  $\text{CDCl}_3$ )  $\delta$  8.03–7.99 (m, 2H), 7.63–7.60 (m, 2H) 6.20 (dd,  $J = 10.8, 17.4$  Hz, 1H), 5.38 (d,  $J = 10.8$  Hz, 1H), 5.16 (d,  $J = 17.6$  Hz, 1H), 4.29 (d,  $J = 12.3$  Hz, 1H), 4.04 (dd,  $J = 12.8$  Hz, 1H), 2.97 (brs, 1H), 1.91 (s, 3H);  $^{13}\text{C NMR}$  (100 MHz,  $\text{CDCl}_3$ )  $\delta$  163.8, 137.0, 132.1, 128.4, 126.1, 124.8, 117.3, 71.2, 68.3, 21.5; **HRMS (ESI-MS)**: Calcd. for  $\text{C}_{12}\text{H}_{13}\text{BrN}_4\text{O}$  ( $M + \text{Na}$ ): 331.0170, Found: 331.0170; **HPLC conditions**: Chiralcel IC column, 254 nm, flow rate: 1 ml/min,  $i\text{-PrOH/hexanes} = 20/80$ ,  $t_{\text{major}} = 6.5$  min,  $t_{\text{minor}} = 7.5$  min; 96% ee.

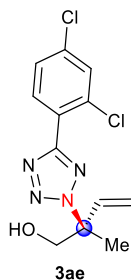


**(R)-2-methyl-2-(5-(p-tolyl)-2H-tetrazol-2-yl)but-3-en-1-ol (3ac)** was prepared according to the general procedure from **1a** and **2c**. The crude product was purified by flash column chromatography (Petroleum ether/EtOAc = 20:1) on silica gel to provide the title compound as a colorless oil in 93% yield (45.4 mg).  $[\alpha]_{\text{D}}^{25} = -6.5$  ( $c = 0.74$ ,  $\text{CHCl}_3$ );  $^1\text{H NMR}$  (400 MHz,  $\text{CDCl}_3$ )  $\delta$  8.03 (d,  $J = 8.2$  Hz, 2H), 7.28 (d,  $J = 8.0$  Hz, 2H), 6.20 (dd,  $J = 10.8, 17.4$  Hz, 1H), 5.35 (d,  $J = 10.8$  Hz, 1H), 5.13 (d,  $J = 17.6$  Hz, 1H), 4.26 (dd,  $J = 5.6, 12.1$  Hz, 1H), 4.03 (dd,  $J = 5.6, 12.1$  Hz, 1H), 3.12 (brt, 1H), 2.41 (s, 3H), 1.90 (s, 3H);  $^{13}\text{C NMR}$  (100 MHz,  $\text{CDCl}_3$ )  $\delta$  164.7, 140.6, 137.1, 129.5, 126.8, 124.4, 117.2, 70.9, 68.4, 29.7, 21.6; **HRMS (ESI-MS)**: Calcd. for  $\text{C}_{13}\text{H}_{16}\text{N}_4\text{O}$  ( $M + \text{Na}$ ): 267.1222, Found: 267.1213; **HPLC conditions**: Chiralcel IC column, 254 nm, flow rate: 1 ml/min,  $i\text{-PrOH/hexanes} = 20/80$ ,  $t_{\text{major}} = 8.2$  min,  $t_{\text{minor}} = 9.5$  min; 92% ee.

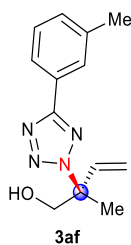


**(R)-2-methyl-2-(5-(4-nitrophenyl)-2H-tetrazol-2-yl)but-3-en-1-ol (3ad)** was prepared according to the general procedure from **1a** and **2d**. The crude product was purified by flash column chromatography (Petroleum ether/EtOAc = 20:1) on silica gel to provide the title compound as a white solid in 94% yield

(51.7 mg).  $[\alpha]_D^{25} = 27.5$  ( $c = 0.61$ ,  $\text{CHCl}_3$ );  $^1\text{H NMR}$  (400 MHz,  $\text{CDCl}_3$ )  $\delta$  8.35 (s, 4H), 6.23 (dd,  $J = 10.8$ , 17.4 Hz, 1H), 5.41 (d,  $J = 10.8$  Hz, 1H), 5.20 (d,  $J = 17.6$  Hz, 1H), 4.33 (d,  $J = 12.2$  Hz, 1H), 4.07 (d,  $J = 12.2$  Hz, 1H), 2.81 (brs, 1H), 1.95 (s, 3H);  $^{13}\text{C NMR}$  (100 MHz,  $\text{CDCl}_3$ )  $\delta$  162.8, 148.9, 136.7, 133.1, 127.7, 124.2, 117.6, 71.6, 68.2, 21.5; **HRMS (ESI-MS)**: Calcd. for  $\text{C}_{12}\text{H}_{13}\text{N}_5\text{O}_3$  ( $\text{M} + \text{Na}$ ): 298.0916, Found: 298.0938; **HPLC conditions**: Chiralcel IC column, 254 nm, flow rate: 1 ml/min, *i*-PrOH/hexanes = 10/90,  $t_{\text{major}} = 14.3$  min,  $t_{\text{minor}} = 17.1$  min; 90% ee.

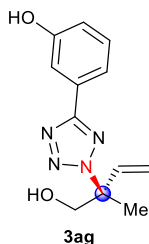


**(R)-2-(5-(2,4-dichlorophenyl)-2H-tetrazol-2-yl)-2-methylbut-3-en-1-ol (3ae)** was prepared according to the general procedure from **1a** and **2e**. The crude product was purified by flash column chromatography (Petroleum ether/EtOAc = 20:1) on silica gel to provide the title compound as a colorless oil in 87% yield (52.1 mg).  $[\alpha]_D^{25} = -13.4$  ( $c = 0.12$ ,  $\text{CHCl}_3$ );  $^1\text{H NMR}$  (400 MHz,  $\text{CDCl}_3$ )  $\delta$  7.99–7.95 (m, 1H), 7.58–7.55 (m, 1H), 7.41–7.37 (m, 1H), 6.22 (dd,  $J = 10.8$ , 17.4 Hz, 1H), 5.39 (d,  $J = 10.8$  Hz, 1H), 5.16 (d,  $J = 17.6$  Hz, 1H), 4.28 (d,  $J = 10.8$  Hz, 1H), 4.05 (d,  $J = 10.8$  Hz, 1H), 3.04 (brs, 1H), 1.93 (s, 3H);  $^{13}\text{C NMR}$  (100 MHz,  $\text{CDCl}_3$ )  $\delta$  162.0, 136.8, 136.7, 133.8, 132.0, 130.8, 127.4, 124.8, 117.5, 71.4, 86.4, 21.7; **HRMS (ESI-MS)**: Calcd. for  $\text{C}_{12}\text{H}_{12}\text{Cl}_2\text{N}_4\text{O}$  ( $\text{M} + \text{Na}$ ): 321.0286, Found: 321.0280; **HPLC conditions**: Chiralcel IC column, 254 nm, flow rate: 1 ml/min, *i*-PrOH/hexanes = 20/80,  $t_{\text{major}} = 6.7$  min,  $t_{\text{minor}} = 8.4$  min; 90% ee.

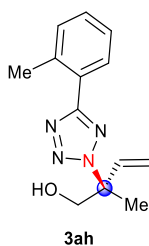


**(R)-2-methyl-2-(5-(m-tolyl)-2H-tetrazol-2-yl)but-3-en-1-ol (3af)** was prepared according to the general procedure from **1a** and **2f**. The crude product was purified by flash column chromatography (Petroleum ether/EtOAc = 20:1) on silica gel to provide the title compound as a colorless oil in 84% yield (41.1 mg).  $[\alpha]_D^{25} = -14.8$  ( $c = 1.10$ ,  $\text{CHCl}_3$ );  $^1\text{H NMR}$  (400 MHz,  $\text{CDCl}_3$ )  $\delta$  7.94 (s, 2H), 7.39–7.34 (m, 1H), 7.28 (s,

1H), 6.20 (dd,  $J = 10.8, 17.4$  Hz, 1H), 5.36 (d,  $J = 10.8$  Hz, 1H), 5.13 (d,  $J = 17.6$  Hz, 1H), 4.29 (d,  $J = 10.8$  Hz, 1H), 4.04 (d,  $J = 10.8$  Hz, 1H), 3.16 (brs, 1H), 2.42 (s, 3H), 1.91 (s, 3H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ )  $\delta$  164.8, 138.7, 137.1, 131.2, 128.8, 127.5, 127.0, 124.0, 117.3, 71.0, 68.4, 21.7, 21.4; **HRMS (ESI-MS)**: Calcd. for  $\text{C}_{13}\text{H}_{16}\text{N}_4\text{O}$  ( $\text{M} + \text{Na}$ ): 267.1222, Found: 267.1219; **HPLC conditions**: Chiralcel IC column, 254 nm, flow rate: 1 ml/min, *i*-PrOH/hexanes = 10/90,  $t_{\text{major}} = 14.7$  min,  $t_{\text{minor}} = 18.4$  min; 90% ee.



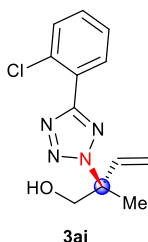
**(R)-3-(2-(1-hydroxy-2-methylbut-3-en-2-yl)-2H-tetrazol-5-yl)phenol (3ag)** was prepared according to the general procedure from **1a** and **2g**. The crude product was purified by flash column chromatography (Petroleum ether/EtOAc = 20:1) on silica gel to provide the title compound as a colorless oil in 83% yield (40.8 mg).  $[\alpha]_{\text{D}}^{25} = 6.2$  ( $c = 0.21$ ,  $\text{CHCl}_3$ );  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ )  $\delta$  7.67–7.64 (m, 2H), 7.35–7.31 (m, 1H), 6.98–6.95 (m, 1H), 6.20 (dd,  $J = 10.8, 17.4$  Hz, 1H), 5.36 (d,  $J = 10.8$  Hz, 1H), 5.14 (d,  $J = 17.4$  Hz, 1H), 4.32 (dd,  $J = 6.0, 11.7$  Hz, 1H), 4.05 (dd,  $J = 6.0, 11.7$  Hz, 1H), 3.41 (brt, 1H), 1.91 (s, 3H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ )  $\delta$  164.3, 156.3, 136.9, 130.3, 128.1, 119.1, 117.8, 117.4, 113.7, 71.2, 68.3, 21.5; **HRMS (ESI-MS)**: Calcd. for  $\text{C}_{12}\text{H}_{14}\text{N}_4\text{O}_2$  ( $\text{M} + \text{Na}$ ): 269.1014, Found: 269.1012; **HPLC conditions**: Chiralcel OD-H column, 254 nm, flow rate: 1 ml/min, *i*-PrOH/hexanes = 20/80,  $t_{\text{major}} = 7.4$  min,  $t_{\text{minor}} = 8.5$  min; 89% ee.



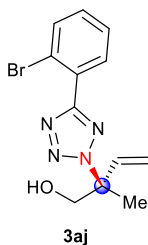
**(R)-2-methyl-2-(5-(o-tolyl)-2H-tetrazol-2-yl)but-3-en-1-ol (3ah)** was prepared according to the general procedure from **1a** and **2h**. The crude product was purified by flash column chromatography (Petroleum ether/EtOAc = 20:1) on silica gel to provide the title compound as a colorless oil in 97% yield (47.4 mg).  $[\alpha]_{\text{D}}^{25} = -21.4$  ( $c = 0.54$ ,  $\text{CHCl}_3$ );  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ )  $\delta$  8.02 (d,  $J = 7.3$  Hz, 1H), 7.39–7.29 (m, 3H), 6.21 (dd,  $J = 10.8, 17.4$  Hz, 1H), 5.37 (d,  $J = 10.8$  Hz, 1H), 5.13 (d,  $J = 17.6$  Hz, 1H), 4.27 (dd,  $J = 6.4, 12.0$  Hz, 1H), 4.05 (dd,  $J = 6.4, 12.0$  Hz, 1H), 3.03 (brt, 1H), 2.62 (s, 3H), 1.92 (s, 3H);  $^{13}\text{C}$  NMR



(100 MHz, CDCl<sub>3</sub>)  $\delta$  165.0, 137.4, 137.1, 131.4, 130.0, 129.5, 126.3, 126.0, 117.2, 70.9, 68.4, 29.7, 21.7; **HRMS (ESI-MS)**: Calcd. for C<sub>13</sub>H<sub>16</sub>N<sub>4</sub>O (M + Na): 267.1222, Found: 267.1216; **HPLC conditions**: Chiralcel IC column, 254 nm, flow rate: 1 ml/min, *i*-PrOH/hexanes = 20/80,  $t_{\text{major}} = 6.8$  min,  $t_{\text{minor}} = 8.3$  min; 90% ee.

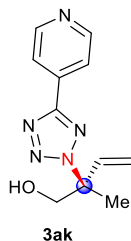


**(R)-2-(5-(2-chlorophenyl)-2H-tetrazol-2-yl)-2-methylbut-3-en-1-ol (3ai)** was prepared according to the general procedure from **1a** and **2i**. The crude product was purified by flash column chromatography (Petroleum ether/EtOAc = 20:1) on silica gel to provide the title compound as a colorless oil in 96% yield (50.8 mg).  $[\alpha]_{\text{D}}^{25} = -10.8$  ( $c = 0.70$ , CHCl<sub>3</sub>); **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$  8.00–7.96 (s, 1H), 7.55–7.52 (m, 1H), 7.44–7.36 (m, 2H), 6.22 (dd,  $J = 10.8, 17.6$  Hz, 1H), 5.38 (d,  $J = 10.8$  Hz, 1H), 5.15 (d,  $J = 17.6$  Hz, 1H), 4.28 (d,  $J = 12.3$  Hz, 1H), 4.06 (d,  $J = 12.3$  Hz, 1H), 3.18 (brs, 1H), 1.93 (s, 3H); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$  162.6, 136.9, 133.1, 131.2, 131.1, 130.8, 126.9, 126.2, 117.3, 71.2, 68.4, 21.6; **HRMS (ESI-MS)**: Calcd. for C<sub>12</sub>H<sub>13</sub>ClN<sub>4</sub>O (M + Na): 287.0676, Found: 287.0682; **HPLC conditions**: Chiralcel IC column, 254 nm, flow rate: 1 ml/min, *i*-PrOH/hexanes = 5/95,  $t_{\text{major}} = 27.3$  min,  $t_{\text{minor}} = 40.1$  min; 87% ee.

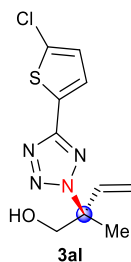


**(R)-2-(5-(2-bromophenyl)-2H-tetrazol-2-yl)-2-methylbut-3-en-1-ol (3aj)** was prepared according to the general procedure from **1a** and **2j**. The crude product was purified by flash column chromatography (Petroleum ether/EtOAc = 20:1) on silica gel to provide the title compound as a colorless oil in 83% yield (51.3 mg).  $[\alpha]_{\text{D}}^{25} = 12.1$  ( $c = 0.56$ , CHCl<sub>3</sub>); **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$  7.92 (dd,  $J = 1.7, 7.7$  Hz, 1H), 7.74 (dd,  $J = 1.0, 8.0$  Hz, 1H), 7.45 (ddd,  $J = 1.2, 7.5, 15.1$  Hz, 1H), 7.35 (dd,  $J = 1.8, 8.0$  Hz, 1H), 6.22 (dd,  $J = 10.8, 17.6$  Hz, 1H), 5.38 (d,  $J = 10.8$  Hz, 1H), 5.15 (d,  $J = 17.6$  Hz, 1H), 4.27 (d,  $J = 12.3$  Hz, 1H), 4.05 (d,  $J = 12.3$  Hz, 1H), 3.16 (brs, 1H), 1.93 (s, 3H); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$  163.4, 136.9,

134.1, 131.5, 131.3, 128.2, 127.5, 122.1, 117.3, 71.2, 68.4, 21.6; **HRMS (ESI-MS)**: Calcd. for  $C_{12}H_{13}BrN_4O$  (M + Na): 331.0170, Found: 331.0175; **HPLC conditions**: Chiralcel IC column, 254 nm, flow rate: 1 ml/min, *i*-PrOH/hexanes = 1/19,  $t_{major}$  = 28.4 min,  $t_{minor}$  = 40.5 min; 88% ee.

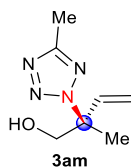


**(R)-2-(5-(2-bromophenyl)-2H-tetrazol-2-yl)-2-methylbut-3-en-1-ol (3ak)** was prepared according to the general procedure from **1a** and **2k**. The crude product was purified by flash column chromatography (Petroleum ether/EtOAc = 20:1) on silica gel to provide the title compound as a colorless oil in 82% yield (37.9 mg).  $[\alpha]_D^{25} = -21.3$  ( $c = 1.1$ ,  $CHCl_3$ );  **$^1H$  NMR** (400 MHz,  $CDCl_3$ )  $\delta$  8.70 (dd,  $J = 1.6, 4.6$  Hz, 2H), 8.00 (dd,  $J = 1.6, 4.5$  Hz, 2H), 6.24 (dd,  $J = 10.8, 17.6$  Hz, 1H), 5.40 (d,  $J = 10.8$  Hz, 1H), 5.19 (d,  $J = 17.6$  Hz, 1H), 4.33 (d,  $J = 12.2$  Hz, 1H), 4.06 (d,  $J = 12.2$  Hz, 1H), 1.95 (s, 3H);  **$^{13}C$  NMR** (100 MHz,  $CDCl_3$ )  $\delta$  162.5, 150.3, 136.8, 120.9, 119.1, 117.5, 71.7, 68.3, 21.5; **HRMS (ESI-MS)**: Calcd. for  $C_{11}H_{13}N_5O$  (M + Na): 254.1018, Found: 254.1025; **HPLC conditions**: Chiralcel IC column, 254 nm, flow rate: 1 ml/min, *i*-PrOH/hexanes = 1/19,  $t_{major}$  = 41.0 min,  $t_{minor}$  = 45.5 min; 98% ee.



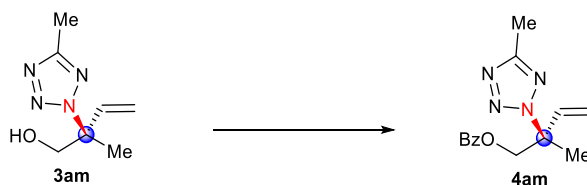
**(R)-2-(5-(5-chlorothiophen-2-yl)-2H-tetrazol-2-yl)-2-methylbut-3-en-1-ol (3al)** was prepared according to the general procedure from **1a** and **2l**. The crude product was purified by flash column chromatography (Petroleum ether/EtOAc = 20:1) on silica gel to provide the title compound as a colorless oil in 83% yield (44.9 mg).  $[\alpha]_D^{25} = -22.1$  ( $c = 1.02$ ,  $CHCl_3$ );  **$^1H$  NMR** (400 MHz,  $CDCl_3$ )  $\delta$  7.57 (d,  $J = 4.0$  Hz, 1H), 6.96 (d,  $J = 4.0$  Hz, 1H), 6.19 (dd,  $J = 10.8, 17.6$  Hz, 1H), 5.37 (d,  $J = 10.8$  Hz, 1H), 5.16 (d,  $J = 17.6$  Hz, 1H), 4.26 (dd,  $J = 4.0, 12.1$  Hz, 1H), 4.01 (dd,  $J = 4.0, 12.1$  Hz, 1H), 2.93 (brs, 1H), 1.89 (s, 3H);  **$^{13}C$  NMR** (100 MHz,  $CDCl_3$ )  $\delta$  159.9, 136.8, 133.0, 127.4, 127.2, 127.0, 117.4, 71.3, 68.2, 21.5; **HRMS (ESI-MS)**: Calcd. for  $C_{10}H_{11}ClN_4OS$  (M + Na): 293.0240, Found: 293.0235; **HPLC conditions**:

Chiralcel IC column, 254 nm, flow rate: 1 ml/min, *i*-PrOH/hexanes = 10/90,  $t_{\text{major}} = 10.7$  min,  $t_{\text{minor}} = 12.9$  min; 86% ee.

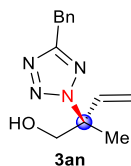


**(*R*)-2-methyl-2-(5-methyl-2H-tetrazol-2-yl)but-3-en-1-ol (3am)** was prepared according to the general procedure from **1a** and **2m**. The crude product was purified by flash column chromatography (Petroleum ether/EtOAc = 20:1) on silica gel to provide the title compound as a colorless oil in 78% yield (26.2 mg).  $[\alpha]_{\text{D}}^{25} = 38.3$  ( $c = 0.10$ ,  $\text{CHCl}_3$ );  $^1\text{H NMR}$  (400 MHz,  $\text{CDCl}_3$ )  $\delta$  6.15 (dd,  $J = 10.8, 17.6$  Hz, 1H), 5.35 (d,  $J = 10.8$  Hz, 1H), 5.13 (d,  $J = 17.6$  Hz, 1H), 4.20 (dd,  $J = 6.8, 12.1$  Hz, 1H), 3.98 (dd,  $J = 6.8, 12.1$  Hz, 1H), 3.05 (brt, 1H), 2.55 (s, 3H), 1.83 (s, 3H);  $^{13}\text{C NMR}$  (100 MHz,  $\text{CDCl}_3$ )  $\delta$  162.5, 137.1, 117.1, 70.5, 68.3, 21.5, 10.9;

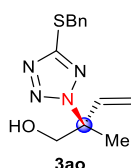
For the determination of enantiomeric excess of **3am**, compound **3am** was converted to corresponding benzoate **4am**. The ee value of **4am** was determined by chiral HPLC



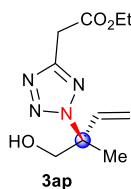
**(*R*)-2-methyl-2-(5-methyl-2H-tetrazol-2-yl)but-3-en-1-yl benzoate (4am)** was obtained as a white solid;  $^1\text{H NMR}$  (400 MHz,  $\text{CDCl}_3$ )  $\delta$  7.90–7.88 (m, 2H), 7.57–7.53 (m, 1H), 7.43–7.39 (m, 2H), 6.34 (dd,  $J = 10.8, 17.6$  Hz, 1H), 5.42 (d,  $J = 10.8$  Hz, 1H), 5.29 (d,  $J = 17.6$  Hz, 1H), 4.87 (d,  $J = 11.7$  Hz, 1H), 4.79 (d,  $J = 11.7$  Hz, 1H), 2.55 (s, 3H), 2.01 (s, 3H);  $^{13}\text{C NMR}$  (100 MHz,  $\text{CDCl}_3$ )  $\delta$  166.3, 161.3, 136.2, 133.4, 129.7, 129.4, 129.2, 117.9, 68.7, 58.5, 18.4, 13.7; **HRMS (ESI-MS)**: Calcd. for  $\text{C}_{14}\text{H}_{16}\text{N}_4\text{O}_2$  ( $\text{M} + \text{Na}$ ): 295.1171, Found: 295.1166; **HPLC conditions**: Chiralcel IC column, 254 nm, flow rate: 1 ml/min, *i*-PrOH/hexanes = 1/19,  $t_{\text{major}} = 22.6$  min,  $t_{\text{minor}} = 24.3$  min; 90% ee.



**(R)-2-(5-benzyl-2H-tetrazol-2-yl)-2-methylbut-3-en-1-ol (3an)** was prepared according to the general procedure from **1a** and **2n**. The crude product was purified by flash column chromatography (Petroleum ether/EtOAc = 20:1) on silica gel to provide the title compound as a colorless oil in 88% yield (42.9 mg).  $[\alpha]_D^{25} = 68.9$  ( $c = 0.07$ ,  $\text{CHCl}_3$ );  $^1\text{H NMR}$  (400 MHz,  $\text{CDCl}_3$ )  $\delta$  7.36–7.22 (m, 5H), 6.13 (dd,  $J = 10.8$ , 17.6 Hz, 1H), 5.34 (d,  $J = 10.8$  Hz, 1H), 5.07 (d,  $J = 17.6$  Hz, 1H), 4.26 (s, 2H), 4.19 (d,  $J = 12.3$  Hz, 1H), 3.96 (d,  $J = 12.3$  Hz, 1H), 2.85 (brs, 1H), 1.83 (s, 3H);  $^{13}\text{C NMR}$  (100 MHz,  $\text{CDCl}_3$ )  $\delta$  165.1, 137.1, 136.6, 128.8, 128.7, 126.9, 117.2, 70.8, 68.3, 31.8, 21.6; **HRMS (ESI-MS)**: Calcd. for  $\text{C}_{13}\text{H}_{16}\text{N}_4\text{O}$  ( $M + \text{Na}$ ): 267.1222, Found: 267.1217; **HPLC conditions**: Chiralcel IC column, 254 nm, flow rate: 1 ml/min,  $i$ -PrOH/hexanes = 10/90,  $t_{\text{major}} = 8.4$  min,  $t_{\text{minor}} = 9.5$  min; 90% ee.



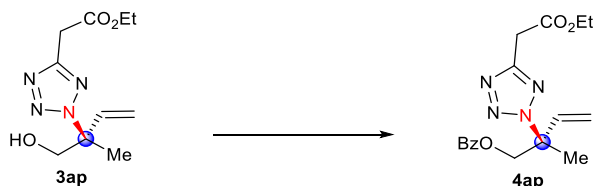
**(R)-2-(5-benzyl-2H-tetrazol-2-yl)-2-methylbut-3-en-1-ol (3ao)** was prepared according to the general procedure from **1a** and **2o**. The crude product was purified by flash column chromatography (Petroleum ether/EtOAc = 20:1) on silica gel to provide the title compound as a colorless oil in 87% yield (48.1 mg).  $[\alpha]_D^{25} = -16.4$  ( $c = 0.55$ ,  $\text{CHCl}_3$ );  $^1\text{H NMR}$  (400 MHz,  $\text{CDCl}_3$ )  $\delta$  7.39–7.36 (m, 2H), 7.31–7.22 (m, 3H), 6.10 (dd,  $J = 10.8$ , 17.6 Hz, 1H), 5.32 (d,  $J = 10.8$  Hz, 1H), 5.05 (d,  $J = 17.6$  Hz, 1H), 4.40 (s, 2H), 4.16 (dd,  $J = 5.4$ , 12.2 Hz, 1H), 3.92 (dd,  $J = 5.4$ , 12.2 Hz, 1H), 2.69 (brt, 1H), 1.81 (s, 3H);  $^{13}\text{C NMR}$  (100 MHz,  $\text{CDCl}_3$ )  $\delta$  163.2, 136.7, 136.5, 129.0, 128.5, 127.6, 117.3, 71.3, 68.1, 36.5, 21.4; **HRMS (ESI-MS)**: Calcd. for  $\text{C}_{13}\text{H}_{16}\text{N}_4\text{OS}$  ( $M + \text{Na}$ ): 299.0943, Found: 299.0939; **HPLC conditions**: Chiralcel IC column, 254 nm, flow rate: 1 ml/min,  $i$ -PrOH/hexanes = 10/90,  $t_{\text{major}} = 7.4$  min,  $t_{\text{minor}} = 8.5$  min; 81% ee.



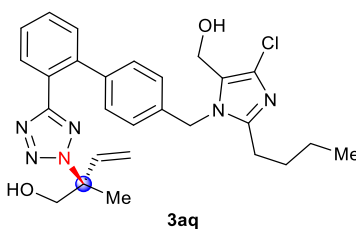
**ethyl (R)-2-(2-(1-hydroxy-2-methylbut-3-en-2-yl)-2H-tetrazol-5-yl)acetate (3ap)** was prepared according to the general procedure from **1a** and **2p**. The crude product was purified by flash column chromatography (Petroleum ether/EtOAc = 20:1) on silica gel to provide the title compound as a colorless oil in 72% yield (34.6 mg).  $[\alpha]_D^{25} = 42.7$  ( $c = 0.67$ ,  $\text{CHCl}_3$ );  $^1\text{H NMR}$  (400 MHz,  $\text{CDCl}_3$ )  $\delta$  6.17 (dd,  $J = 10.8$ , 17.6 Hz, 1H), 5.35 (d,  $J = 10.8$  Hz, 1H), 5.13 (d,  $J = 17.6$  Hz, 1H), 4.28–4.18 (m, 3H), 3.99 (s, 2H),

3.97 (dd,  $J = 4.0, 12.1$  Hz, 1H), 3.05 (brs, 1H), 1.86 (s, 3H), 1.26 (t,  $J = 7.2$  Hz, 3H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ )  $\delta$  168.4, 159.6, 137.0, 117.2, 71.1, 68.2, 61.6, 31.8, 21.4, 14.0;

For the determination of enantiomeric excess of **3ap**, compound **3ap** was converted to corresponding benzoate **4ap**. The ee value of **4ap** was determined by chiral HPLC

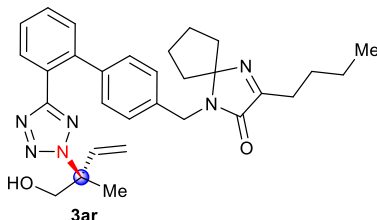


**(R)-2-(5-(2-ethoxy-2-oxoethyl)-2H-tetrazol-2-yl)-2-methylbut-3-en-1-yl benzoate (4ap)** was obtained as a white solid;  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ )  $\delta$  7.90–7.87 (m, 2H), 7.54–7.50 (m, 1H), 7.40–7.36 (m, 2H), 6.33 (dd,  $J = 10.8, 17.6$  Hz, 1H), 5.41 (d,  $J = 10.8$  Hz, 1H), 5.26 (d,  $J = 17.6$  Hz, 1H), 4.89 (d,  $J = 11.4$  Hz, 1H), 4.81 (d,  $J = 11.4$  Hz, 1H), 4.15 (dd,  $J = 7.1, 14.2$  Hz, 2H), 4.02 (s, 3H), 2.03 (s, 3H), 1.19 (t,  $J = 7.1$  Hz, 3H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ )  $\delta$  168.3, 165.7, 159.9, 136.1, 133.3, 129.6, 129.3, 117.8, 68.7, 68.3, 61.5, 31.9, 21.6, 13.9; **HRMS (ESI-MS)**: Calcd. for  $\text{C}_{17}\text{H}_{20}\text{N}_4\text{O}_4$  ( $M + \text{Na}$ ): 367.1382, Found: 367.1376; **HPLC conditions**: Chiralcel IC column, 254 nm, flow rate: 1 ml/min, *i*-PrOH/hexanes = 20/80,  $t_{\text{major}} = 7.7$  min,  $t_{\text{minor}} = 9.5$  min; 89% ee.

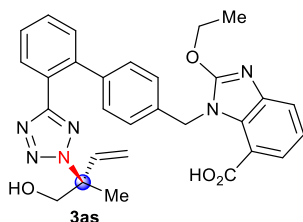


**(R)-2-(5-(4'-((2-butyl-4-chloro-5-(hydroxymethyl)-1H-imidazol-1-yl)methyl)-[1,1'-biphenyl]-2-yl)-2H-tetrazol-2-yl)-2-methylbut-3-en-1-ol (3aq)** was prepared according to the general procedure from **1a** and **2q**. The crude product was purified by flash column chromatography (Petroleum ether/EtOAc = 4:1) on silica gel to provide the title compound as a white solid in 67% yield (67.9 mg).  $[\alpha]_{\text{D}}^{25} = 35.3$  ( $c = 0.12$ ,  $\text{CHCl}_3$ );  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ )  $\delta$  8.06–8.04 (m, 1H), 7.57–7.50 (m, 2H), 7.42–7.40 (m, 1H), 7.17 (d,  $J = 8.0$  Hz, 1H), 6.97 (d,  $J = 8.0$  Hz, 1H), 6.01 (dd,  $J = 10.8, 17.6$  Hz, 1H), 5.26 (d,  $J = 10.8$  Hz, 1H), 5.26 (s, 2H), 4.94 (d,  $J = 17.6$  Hz, 1H), 4.52 (s, 2H), 3.85 (d,  $J = 12.4$  Hz, 1H), 3.69 (d,  $J = 12.4$  Hz, 1H), 2.61 (t,  $J = 7.6, 15.6$  Hz, 2H), 1.75 (s, 3H), 1.73–1.66 (m, 2H), 1.40–1.30 (m, 2H), 0.91 (t,  $J = 7.6, 15.6$  Hz, 3H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ )  $\delta$  164.0, 148.4, 141.0, 140.9, 136.8, 135.0, 130.8, 130.6, 130.1, 130.0, 129.6, 128.7, 127.9, 125.7, 125.4, 117.0, 70.6, 68.1, 47.2, 38.6, 28.8, 26.5, 23.7, 22.3, 13.7; **HRMS**

**(ESI-MS):** Calcd. for C<sub>27</sub>H<sub>13</sub>ClN<sub>6</sub>O<sub>2</sub> (M + Na): 529.2095, Found: 529.2086; **HPLC conditions:** Chiralcel IC column, 254 nm, flow rate: 1 ml/min, *i*-PrOH/hexanes = 10/90, *t*<sub>major</sub> = 48.87 min, *t*<sub>minor</sub> = 61.92 min; 97% ee.

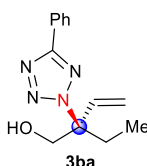


**(R)-2-(5-(4'-((2-butyl-4-chloro-5-(hydroxymethyl)-1H-imidazol-1-yl)methyl)-[1,1'-biphenyl]-2-yl)-2H-tetrazol-2-yl)-2-methylbut-3-en-1-ol (3ar)** was prepared according to the general procedure from **1a** and **2r**. The crude product was purified by flash column chromatography (Petroleum ether/EtOAc = 4:1) on silica gel to provide the title compound as a white solid in 74% yield (75.9 mg).  $[\alpha]_D^{25} = -19.4$  (*c* = 0.81, CHCl<sub>3</sub>); **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>) δ 8.00 (dd, *J* = 1.6, 6.8 Hz, 1H), 7.56–7.48 (m, 2H), 7.41 (dd, *J* = 1.4, 7.2 Hz, 1H), 7.15 (d, *J* = 8.0 Hz, 1H), 7.10 (d, *J* = 8.0 Hz, 1H), 6.00 (dd, *J* = 10.8, 17.6 Hz, 1H), 5.25 (d, *J* = 10.8 Hz, 1H), 4.93 (d, *J* = 17.6 Hz, 1H), 4.69 (s, 2H), 3.83 (d, *J* = 11.6 Hz, 1H), 3.67 (d, *J* = 11.6 Hz, 1H), 2.69 (brs, 1H), 2.37 (t, *J* = 7.6, 15.6 Hz, 2H), 2.02–1.93 (m, 6H), 1.86–1.77 (m, 2H), 1.71 (s, 3H), 1.66–1.59 (m, 2H), 1.39–1.34 (m, 2H), 0.90 (t, *J* = 7.6, 15.6 Hz, 3H); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>) δ 186.7, 164.1, 161.8, 141.2, 140.8, 136.9, 135.4, 130.5, 130.0, 129.9, 129.6, 127.8, 126.2, 126.0, 116.9, 76.5, 70.6, 68.0, 43.2, 37.3, 37.2, 28.7, 27.7, 26.0, 22.3, 21.3, 13.7; **HRMS (ESI-MS):** Calcd. for C<sub>30</sub>H<sub>36</sub>N<sub>6</sub>O<sub>2</sub> (M + Na): 535.2797, Found: 535.2802; **HPLC conditions:** Chiralcel IC column, 254 nm, flow rate: 1 ml/min, *i*-PrOH/hexanes = 20/80, *t*<sub>major</sub> = 10.5 min, *t*<sub>minor</sub> = 12.6 min; 95% ee.

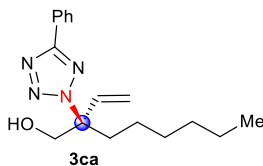


**(R)-2-(5-(4'-((2-butyl-4-chloro-5-(hydroxymethyl)-1H-imidazol-1-yl)methyl)-[1,1'-biphenyl]-2-yl)-2H-tetrazol-2-yl)-2-methylbut-3-en-1-ol (3as)** was prepared according to the general procedure from **1a** and **2s**. The crude product was purified by flash column chromatography (Petroleum ether/EtOAc = 4:1) on silica gel to provide the title compound as a white solid in 52% yield (54.6 mg).  $[\alpha]_D^{25} = -42.5$  (*c* = 0.70, CHCl<sub>3</sub>); **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>) δ 7.91 (dd, *J* = 1.6, 7.6 Hz, 1H), 7.71 (d, *J* = 7.6 Hz, 1H), 7.57

(d,  $J = 7.6$  Hz, 1H), 7.53–7.44 (m, 2H), 7.37 (dd,  $J = 1.4, 7.6$  Hz, 1H), 7.16 (t,  $J = 7.6, 15.6$  Hz, 1H), 7.04 (d,  $J = 8.0$  Hz, 2H), 6.96 (d,  $J = 8.0$  Hz, 2H), 5.88 (dd,  $J = 10.8, 17.6$  Hz, 1H), 5.64 (s, 2H), 5.10 (d,  $J = 10.8$  Hz, 1H), 4.83 (d,  $J = 17.6$  Hz, 1H), 4.65 (dd,  $J = 7.2, 14.4$  Hz, 2H), 3.81 (s, 3H), 3.78 (dd,  $J = 6.8, 12.0$  Hz, 1H), 3.60 (dd,  $J = 6.8, 12.0$  Hz, 1H), 2.48 (brt, 1H), 1.59 (s, 3H), 1.48 (t,  $J = 6.8, 14.0$  Hz, 3H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ )  $\delta$  166.8, 164.2, 158.7, 141.8, 141.5, 140.1, 136.8, 136.2, 131.4, 130.6, 130.0, 129.9, 129.2, 127.6, 126.3, 125.9, 123.7, 121.9, 120.8, 116.8, 115.6, 70.51, 68.0, 66.7, 52.2, 21.2, 14.6; **HRMS (ESI-MS)**: Calcd. for  $\text{C}_{29}\text{H}_{28}\text{N}_6\text{O}_2$  ( $\text{M} + \text{Na}$ ): 547.2070, Found: 547.2076; **HPLC conditions**: Chiralcel IC column, 254 nm, flow rate: 1 ml/min, *i*-PrOH/hexanes = 20/80,  $t_{\text{major}} = 18.5$  min,  $t_{\text{minor}} = 24.0$  min; 96% ee.

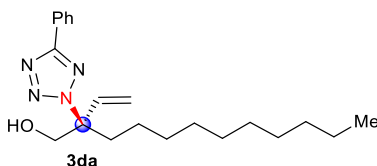


**(R)-2-ethyl-2-(5-phenyl-2H-tetrazol-2-yl)but-3-en-1-ol (3ba)** was prepared according to the general procedure from **1b** and **2a**. The crude product was purified by flash column chromatography (Petroleum ether/EtOAc = 20:1) on silica gel to provide the title compound as a colorless oil in 76% yield (37.1 mg).  $[\alpha]_{\text{D}}^{25} = 59.6$  ( $c = 0.24$ ,  $\text{CHCl}_3$ );  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ )  $\delta$  8.17–8.14 (m, 2H), 7.53–7.45 (m, 3H) 6.28 (dd,  $J = 10.8, 17.4$  Hz, 1H), 5.44 (d,  $J = 10.8$  Hz, 1H), 5.16 (d,  $J = 17.6$  Hz, 1H), 4.25 (t,  $J = 13.6$  Hz, 2H), 2.96 (brs, 1H), 2.39–2.26 (m, 2H), 0.93 (t,  $J = 7.4$  Hz, 3H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ )  $\delta$  164.5, 135.8, 130.4, 128.9, 127.2, 126.9, 117.6, 74.2, 66.1, 18.4, 8.0; **HRMS (ESI-MS)**: Calcd. for  $\text{C}_{13}\text{H}_{16}\text{N}_4\text{O}$  ( $\text{M} + \text{Na}$ ): 267.1222, Found: 267.1219; **HPLC conditions**: Chiralcel IC column, 254 nm, flow rate: 1 ml/min, *i*-PrOH/hexanes = 10/90,  $t_{\text{major}} = 12.2$  min,  $t_{\text{minor}} = 15.8$  min; 90% ee.

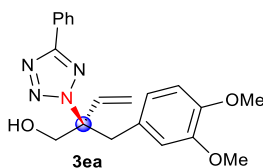


**(R)-2-(5-phenyl-2H-tetrazol-2-yl)-2-vinyloctan-1-ol (3ca)** was prepared according to the general procedure from **1c** and **2a**. The crude product was purified by flash column chromatography (Petroleum ether/EtOAc = 20:1) on silica gel to provide the title compound as a colorless oil in 84% yield (50.5 mg).  $[\alpha]_{\text{D}}^{25} = 52.4$  ( $c = 0.13$ ,  $\text{CHCl}_3$ );  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ )  $\delta$  8.17–8.14 (m, 2H), 7.52–7.47 (m, 3H) 6.29 (dd,  $J = 10.8, 17.4$  Hz, 1H), 5.42 (d,  $J = 10.8$  Hz, 1H), 5.11 (d,  $J = 17.6$  Hz, 1H), 4.28–4.19 (m, 2H), 3.00 (brt, 1H), 2.27–2.23 (m, 2H), 1.30–1.19 (m, 8H), 0.93 (t,  $J = 6.5$  Hz, 3H);  $^{13}\text{C}$  NMR (100 MHz,

CDCl<sub>3</sub>)  $\delta$  164.4, 136.2, 130.4, 128.9, 127.2, 126.9, 117.4, 73.9, 66.4, 36.0, 31.4, 29.3, 23.3, 22.5, 14.0; **HRMS (ESI-MS)**: Calcd. for C<sub>17</sub>H<sub>24</sub>N<sub>4</sub>O (M + Na): 323.1848, Found: 323.1842; **HPLC conditions**: Chiralcel IC column, 254 nm, flow rate: 1 ml/min, *i*-PrOH/hexanes = 10/90,  $t_{\text{major}}$  = 11.2 min,  $t_{\text{minor}}$  = 14.1 min; 90% ee.



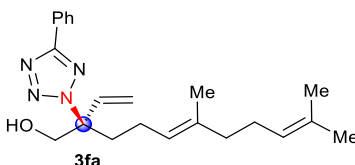
**(R)-2-(5-phenyl-2H-tetrazol-2-yl)-2-vinyloctan-1-ol (3da)** was prepared according to the general procedure from **1d** and **2a**. The crude product was purified by flash column chromatography (Petroleum ether/EtOAc = 20:1) on silica gel to provide the title compound as a colorless oil in 87% yield (62.0 mg).  $[\alpha]_{\text{D}}^{25}$  = 42.1 ( $c$  = 0.23, CHCl<sub>3</sub>); **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$  8.18–8.15 (m, 2H), 7.52–7.47 (m, 3H) 6.29 (dd,  $J$  = 10.8, 17.4 Hz, 1H), 5.42 (d,  $J$  = 10.8 Hz, 1H), 5.12 (d,  $J$  = 17.6 Hz, 1H), 4.28–4.19 (m, 2H), 2.91 (brt, 1H), 2.27–2.22 (m, 2H), 1.29–1.2 (m, 16H), 0.87 (t,  $J$  = 6.6 Hz, 3H); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$  164.5, 136.2, 130.4, 128.9, 127.3, 126.9, 117.4, 73.9, 66.4, 36.1, 31.9, 29.7, 29.5, 29.4, 29.3, 23.3, 22.6, 14.1; **HRMS (ESI-MS)**: Calcd. for C<sub>21</sub>H<sub>32</sub>N<sub>4</sub>O (M + Na): 379.2474, Found: 379.2469; **HPLC conditions**: Chiralcel IC column, 254 nm, flow rate: 1 ml/min, *i*-PrOH/hexanes = 10/90,  $t_{\text{major}}$  = 17.4 min,  $t_{\text{minor}}$  = 21.6 min; 96% ee.



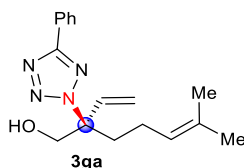
**(R)-2-(3,4-dimethoxybenzyl)-2-(5-phenyl-2H-tetrazol-2-yl)but-3-en-1-ol (3ea)** was prepared according to the general procedure from **1e** and **2a**. The crude product was purified by flash column chromatography (Petroleum ether/EtOAc = 20:1) on silica gel to provide the title compound as a colorless oil in 72% yield (52.8 mg).  $[\alpha]_{\text{D}}^{25}$  = 28.7 ( $c$  = 0.86, CHCl<sub>3</sub>); **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$  8.18–8.16 (m, 2H), 7.51–7.47 (m, 3H) 6.75 (d,  $J$  = 8.2 Hz, 1H), 6.70 (dd,  $J$  = 1.8, 8.2 Hz, 1H), 6.55 (d,  $J$  = 1.8 Hz, 1H), 6.22 (dd,  $J$  = 10.8, 17.4 Hz, 1H), 5.40 (d,  $J$  = 10.8 Hz, 1H), 5.02 (d,  $J$  = 17.6 Hz, 1H), 4.26–4.18 (m, 2H), 3.84 (s, 3H), 3.72 (s, 3H), 3.60 (d,  $J$  = 13.7 Hz, 1H), 3.50 (d,  $J$  = 13.7 Hz, 1H), 2.84 (brs, 1H); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$  164.5, 148.6, 148.2, 136.1, 132.4, 130.5, 128.9, 127.1, 126.5, 122.9, 117.6, 113.5, 110.9, 74.0, 64.7, 55.8, 55.7, 29.7; **HRMS (ESI-MS)**: Calcd. for C<sub>20</sub>H<sub>22</sub>N<sub>4</sub>O<sub>3</sub> (M + Na): 389.1590, Found:



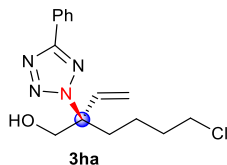
389.1584; **HPLC conditions:** Chiralcel IC column, 254 nm, flow rate: 1 ml/min, *i*-PrOH/hexanes = 10/90,  $t_{\text{major}} = 13.4$  min,  $t_{\text{minor}} = 15.0$  min; 90% ee.



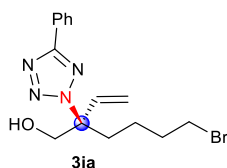
**(R,E)-6,10-dimethyl-2-(5-phenyl-2H-tetrazol-2-yl)-2-vinylundeca-5,9-dien-1-ol (3fa)** was prepared according to the general procedure from **1f** and **2a**. The crude product was purified by flash column chromatography (Petroleum ether/EtOAc = 20:1) on silica gel to provide the title compound as a colorless oil in 88% yield (64.5 mg).  $[\alpha]_{\text{D}}^{25} = 59.5$  ( $c = 0.84$ ,  $\text{CHCl}_3$ );  **$^1\text{H NMR}$**  (400 MHz,  $\text{CDCl}_3$ )  $\delta$  8.18–8.14 (m, 2H), 7.55–7.46 (m, 3H) 6.32 (dd,  $J = 10.8, 17.4$  Hz, 1H), 5.44 (d,  $J = 10.8$  Hz, 1H), 5.14 (d,  $J = 17.6$  Hz, 1H), 5.09–5.02 (m, 2H), 4.31–4.19 (m, 2H), 2.88 (brt, 1H), 2.31–2.24 (m, 2H), 2.06–1.92 (m, 6H), 1.65 (s, 3H), 1.62 (s, 3H), 1.55 (s, 3H);  **$^{13}\text{C NMR}$**  (100 MHz,  $\text{CDCl}_3$ )  $\delta$  164.5, 136.6, 136.1, 131.5, 130.4, 128.9, 127.2, 126.9, 124.1, 122.4, 117.5, 73.8, 66.5, 36.0, 31.9, 29.7, 26.5, 22.1, 17.7, 16.0; **HRMS (ESI-MS):** Calcd. for  $\text{C}_{22}\text{H}_{30}\text{N}_4\text{O}$  ( $\text{M} + \text{Na}$ ): 389.2317, Found: 389.2322; **HPLC conditions:** Chiralcel OD-H column, 254 nm, flow rate: 1 ml/min, *i*-PrOH/hexanes = 10/90,  $t_{\text{major}} = 10.5$  min,  $t_{\text{minor}} = 12.8$  min; 94% ee.



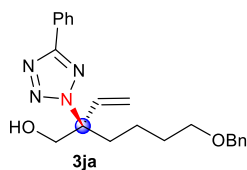
**(R)-6-methyl-2-(5-phenyl-2H-tetrazol-2-yl)-2-vinylhept-5-en-1-ol (3ga)** was prepared according to the general procedure from **1g** and **2a**. The crude product was purified by flash column chromatography (Petroleum ether/EtOAc = 20:1) on silica gel to provide the title compound as a colorless oil in 93% yield (55.5 mg).  $[\alpha]_{\text{D}}^{25} = 63.9$  ( $c = 0.14$ ,  $\text{CHCl}_3$ );  **$^1\text{H NMR}$**  (400 MHz,  $\text{CDCl}_3$ )  $\delta$  8.19–8.17 (m, 2H), 7.54–7.47 (m, 3H), 6.34 (dd,  $J = 10.8, 17.4$  Hz, 1H), 5.46 (d,  $J = 10.8$  Hz, 1H), 5.16 (d,  $J = 17.6$  Hz, 1H), 5.07 (t,  $J = 7.01$  Hz, 1H), 4.32–4.22 (m, 2H), 2.93 (brt, 1H), 2.32–2.28 (m, 2H), 2.04–1.98 (m, 2H), 1.66 (s, 3H), 1.57 (s, 3H);  **$^{13}\text{C NMR}$**  (100 MHz,  $\text{CDCl}_3$ )  $\delta$  164.5, 136.0, 132.9, 130.4, 128.9, 127.2, 126.9, 122.5, 117.5, 73.8, 66.5, 36.0, 25.6, 22.2, 17.6; **HRMS (ESI-MS):** Calcd. for  $\text{C}_{17}\text{H}_{22}\text{N}_4\text{O}$  ( $\text{M} + \text{Na}$ ): 321.1691, Found: 316.2190; **HPLC conditions:** Chiralcel IC column, 254 nm, flow rate: 1 ml/min, *i*-PrOH/hexanes = 10/90,  $t_{\text{minor}} = 13.8$  min,  $t_{\text{major}} = 15.0$  min; 94% ee.



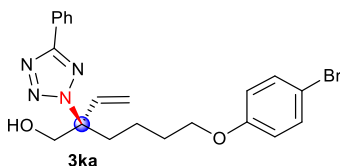
**(R)-6-chloro-2-(5-phenyl-2H-tetrazol-2-yl)-2-vinylhexan-1-ol (3ha)** was prepared according to the general procedure from **1h** and **2a**. The crude product was purified by flash column chromatography (Petroleum ether/EtOAc = 20:1) on silica gel to provide the title compound as a colorless oil in 85% yield (52.1 mg).  $[\alpha]_D^{25} = 32.2$  ( $c = 0.26$ ,  $\text{CHCl}_3$ );  $^1\text{H NMR}$  (400 MHz,  $\text{CDCl}_3$ )  $\delta$  8.17–8.13 (m, 2H), 7.52–7.48 (m, 3H), 6.28 (dd,  $J = 10.8, 17.4$  Hz, 1H), 5.44 (d,  $J = 10.8$  Hz, 1H), 5.12 (d,  $J = 17.6$  Hz, 1H), 4.30–4.20 (m, 2H), 3.55–3.51 (m, 2H), 2.98 (brs, 1H), 2.37–2.22 (m, 2H), 1.85–1.77 (m, 2H), 1.53–1.42 (m, 2H);  $^{13}\text{C NMR}$  (100 MHz,  $\text{CDCl}_3$ )  $\delta$  164.5, 135.8, 130.5, 128.9, 127.1, 126.7, 117.7, 73.7, 66.3, 44.3, 35.0, 32.4, 20.8; **HRMS (ESI-MS)**: Calcd. for  $\text{C}_{15}\text{H}_{19}\text{ClN}_4\text{O}$  ( $M + \text{Na}$ ): 329.1145, Found: 329.1144; **HPLC conditions**: Chiralcel IC column, 254 nm, flow rate: 1 ml/min,  $i$ -PrOH/hexanes = 10/90,  $t_{\text{major}} = 14.8$  min,  $t_{\text{minor}} = 18.6$  min; 87% ee.



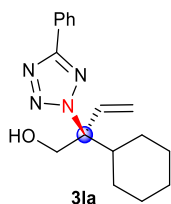
**(R)-6-bromo-2-(5-phenyl-2H-tetrazol-2-yl)-2-vinylhexan-1-ol (3ia)** was prepared according to the general procedure from **1i** and **2a**. The crude product was purified by flash column chromatography (Petroleum ether/EtOAc = 20:1) on silica gel to provide the title compound as a colorless oil in 83% yield (58.3 mg).  $[\alpha]_D^{25} = 42.9$  ( $c = 0.15$ ,  $\text{CHCl}_3$ );  $^1\text{H NMR}$  (400 MHz,  $\text{CDCl}_3$ )  $\delta$  8.16–8.13 (m, 2H), 7.51–7.47 (m, 3H), 6.28 (dd,  $J = 10.8, 17.4$  Hz, 1H), 5.43 (d,  $J = 10.8$  Hz, 1H), 5.12 (d,  $J = 17.6$  Hz, 1H), 4.28 (d,  $J = 12.2$  Hz, 1H), 4.22 (d,  $J = 12.2$  Hz, 1H), 3.54–3.37 (m, 2H), 3.05 (brs, 1H), 2.36–2.23 (m, 2H), 1.92–1.76 (m, 2H), 1.52–1.42 (m, 2H);  $^{13}\text{C NMR}$  (100 MHz,  $\text{CDCl}_3$ )  $\delta$  164.5, 135.8, 130.5, 128.9, 127.1, 126.7, 117.8, 73.6, 66.3, 34.8, 32.9, 32.5, 22.1; **HRMS (ESI-MS)**: Calcd. for  $\text{C}_{15}\text{H}_{19}\text{BrN}_4\text{O}$  ( $M + \text{Na}$ ): 373.0640, Found: 373.0645; **HPLC conditions**: Chiralcel IC column, 254 nm, flow rate: 1 ml/min,  $i$ -PrOH/hexanes = 15/85,  $t_{\text{major}} = 14.7$  min,  $t_{\text{minor}} = 19.0$  min; 90% ee.



**(R)-6-bromo-2-(5-phenyl-2H-tetrazol-2-yl)-2-vinylhexan-1-ol (3ja)** was prepared according to the general procedure from **1j** and **2a**. The crude product was purified by flash column chromatography (Petroleum ether/EtOAc = 20:1) on silica gel to provide the title compound as a colorless oil in 91% yield (68.9 mg).  $[\alpha]_D^{25} = 65.3$  ( $c = 0.11$ ,  $\text{CHCl}_3$ );  $^1\text{H NMR}$  (400 MHz,  $\text{CDCl}_3$ )  $\delta$  8.17–8.13 (m, 2H), 7.49–7.47 (m, 3H), 7.36–7.27 (m, 5H), 6.27 (dd,  $J = 10.8, 17.4$  Hz, 1H), 5.42 (d,  $J = 10.8$  Hz, 1H), 5.13 (d,  $J = 17.6$  Hz, 1H), 4.48 (s, 2H), 4.24 (s, 2H), 3.50–3.46 (m, 2H), 3.10 (brs, 1H), 2.41–2.37 (m, 2H), 1.67–1.60 (m, 2H), 1.30–1.26 (m, 2H);  $^{13}\text{C NMR}$  (100 MHz,  $\text{CDCl}_3$ )  $\delta$  164.5, 138.1, 136.0, 130.4, 128.8, 128.4, 127.6, 127.2, 126.9, 117.6, 73.7, 72.9, 69.8, 66.3, 32.4, 23.8; **HRMS (ESI-MS)**: Calcd. for  $\text{C}_{22}\text{H}_{26}\text{N}_4\text{O}_2$  ( $M + \text{Na}$ ): 401.1953, Found: 401.1959; **HPLC conditions**: Chiralcel IC column, 254 nm, flow rate: 1 ml/min,  $i\text{-PrOH/hexanes} = 1/9$ ,  $t_{\text{major}} = 15.9$  min,  $t_{\text{minor}} = 21.1$  min; 97% ee.



**(R)-6-(4-bromophenoxy)-2-(5-phenyl-2H-tetrazol-2-yl)-2-vinylhexan-1-ol (3ka)** was prepared according to the general procedure from **1k** and **2a**. The crude product was purified by flash column chromatography (Petroleum ether/EtOAc = 20:1) on silica gel to provide the title compound as a colorless oil in 89% yield (78.9 mg).  $[\alpha]_D^{25} = 67.3$  ( $c = 0.31$ ,  $\text{CHCl}_3$ );  $^1\text{H NMR}$  (400 MHz,  $\text{CDCl}_3$ )  $\delta$  8.15–8.13 (m, 2H), 7.52–7.47 (m, 3H), 7.35–7.31 (m, 2H), 6.75–6.70 (m, 2H), 6.29 (dd,  $J = 10.8, 17.4$  Hz, 1H), 5.43 (d,  $J = 10.8$  Hz, 1H), 5.12 (d,  $J = 17.6$  Hz, 1H), 4.26 (s, 2H), 3.93–3.88 (m, 2H), 2.96 (brt, 1H), 2.39–2.31 (m, 2H), 1.83–1.76 (m, 2H), 1.54–1.43 (m, 2H);  $^{13}\text{C NMR}$  (100 MHz,  $\text{CDCl}_3$ )  $\delta$  164.5, 157.9, 135.9, 132.2, 130.4, 128.9, 127.1, 126.9, 117.7, 116.2, 112.7, 73.8, 67.5, 66.4, 35.5, 29.1, 20.1; **HRMS (ESI-MS)**: Calcd. for  $\text{C}_{21}\text{H}_{23}\text{BrN}_4\text{O}_2$  ( $M + \text{Na}$ ): 465.0902, Found: 465.0907; **HPLC conditions**: Chiralcel IC column, 254 nm, flow rate: 1 ml/min,  $i\text{-PrOH/hexanes} = 10/90$ ,  $t_{\text{major}} = 16.2$  min,  $t_{\text{minor}} = 20.6$  min; 90% ee.



**(R)-2-cyclohexyl-2-(5-phenyl-2H-tetrazol-2-yl)but-3-en-1-ol (3la)** was prepared according to the general procedure from **1l** and **2a**. The crude product was purified by flash column chromatography (Petroleum ether/EtOAc = 20:1) on silica gel to provide the title compound as a colorless oil in 54% yield

(32.2 mg).  $[\alpha]_D^{25} = 20.7$  ( $c = 0.25$ ,  $\text{CHCl}_3$ );  **$^1\text{H NMR}$**  (400 MHz,  $\text{CDCl}_3$ )  $\delta$  8.19–8.14 (m, 2H), 7.53–7.48 (m, 3H), 6.46 (dd,  $J = 10.8, 17.4$  Hz, 1H), 5.50 (d,  $J = 10.8$  Hz, 1H), 5.21 (d,  $J = 17.6$  Hz, 1H), 4.44 (dd,  $J = 8.2, 12.4$  Hz, 1H), 4.19 (dd,  $J = 8.2, 12.4$  Hz, 1H), 2.97 (brt, 1H), 2.38 (t,  $J = 11.4$  Hz, 1H), 1.77–1.65 (m, 2H), 1.60–1.47 (m, 4H), 1.29–1.09 (m, 4H);  **$^{13}\text{C NMR}$**  (100 MHz,  $\text{CDCl}_3$ )  $\delta$  164.2, 134.4, 130.4, 128.9, 127.3, 126.9, 117.9, 64.2, 45.1, 27.4, 27.2, 26.4, 26.1; **HRMS (ESI-MS)**: Calcd. for  $\text{C}_{17}\text{H}_{22}\text{N}_4\text{O}$  ( $\text{M} + \text{Na}$ ): 321.1691, Found: 321.1690; **HPLC conditions**: Chiralcel IC column, 254 nm, flow rate: 1 ml/min,  $i$ -PrOH/hexanes = 15/85,  $t_{\text{major}} = 7.4$  min,  $t_{\text{minor}} = 8.5$  min; 89% ee.

### Scaled up procedure and X-ray crystallography of **3ad**

To an oven dried screw-cap reaction tube equipped with a magnetic stir bar,  $\text{Pd}_2(\text{dba})_3 \cdot \text{CHCl}_3$  (52.0 mg, 2.5 mol%), Trost's ligand (*R,R*)-**L6** (78.0 mg, 5 mol%), vinyl cyclic carbonate **1a** (256.25 mg, 2 mmol), and phenytetrazole **2a** (458.76 mg, 2.4 mmol) were added. The reaction tube was sealed with rubber-septum, then evacuated and backfilled with nitrogen. Anhydrous toluene (0.2 M, 10 mL) was added via syringe. The resulting mixture was stirred at 0 °C for 48 hours. The residue was purified by flash column chromatography on silica gel to afford the pure branched product **3ad** in 89% of isolated yield (0.45 g) and without any loss in enantioselectivity.

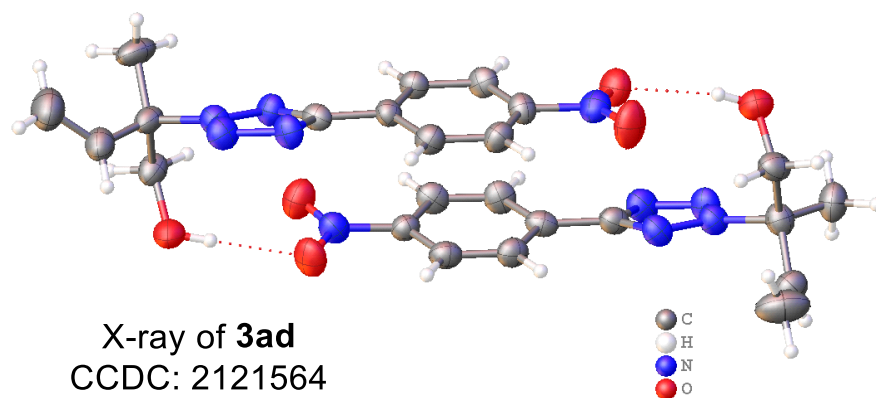
### X-ray crystallography of **3ad**

A single-crystal of **3ad** was obtained from dichloromethane/hexane solvent system at room temperature. Diffraction data were collected on a Bruker SMART Apex-II CCD-based X-ray diffractometer with  $\text{Cu-K}\alpha$  radiation. The empirical absorption correction was applied by using the SADABS program. The structure was solved using direct method, and refined by full-matrix least-squares on  $F^2$  (G.M. Sheldrick, SHELXTL2008, program of crystal structure refinement, University of Göttingen, Germany, 1997). H-atoms were refined isotopically, while all other atoms were refined anisotropically. The crystallographic data is summarized in Table F1 and the diagram is shown in Figure F1.

**Table F1.** Crystal data and structure refinement for **3ad**.

Identification code	A
Empirical formula	$\text{C}_{12}\text{H}_{13}\text{N}_5\text{O}_3$
Formula weight	275.27
Temperature/K	193.00

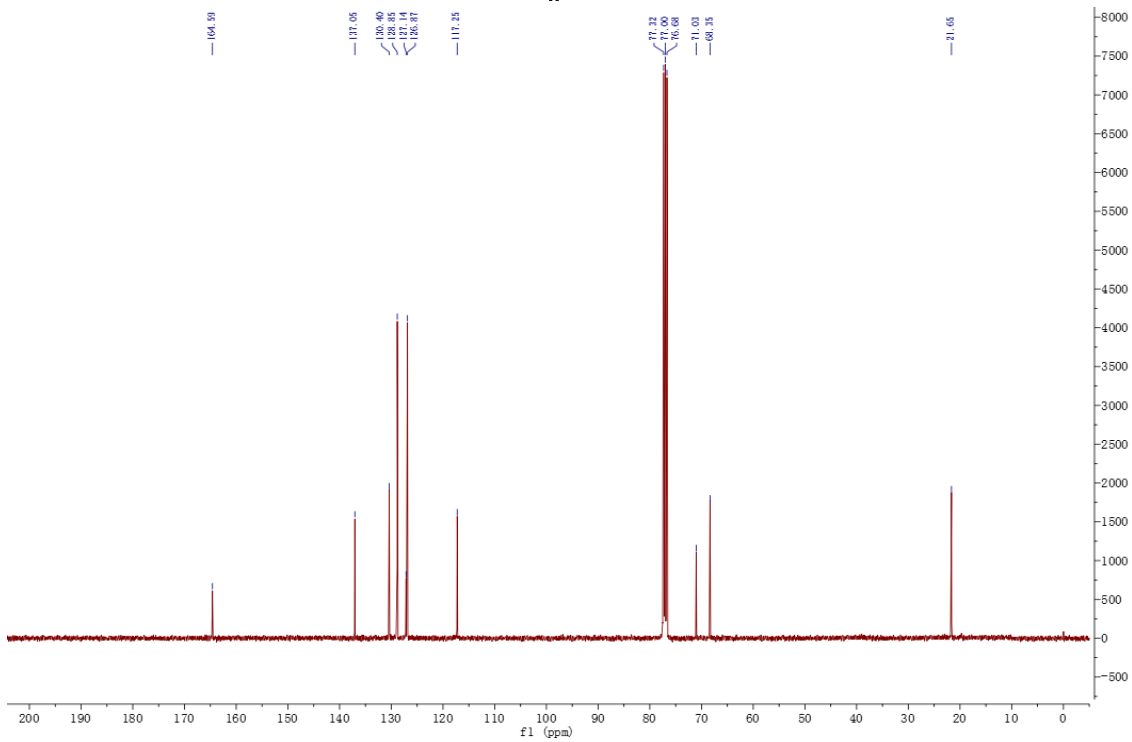
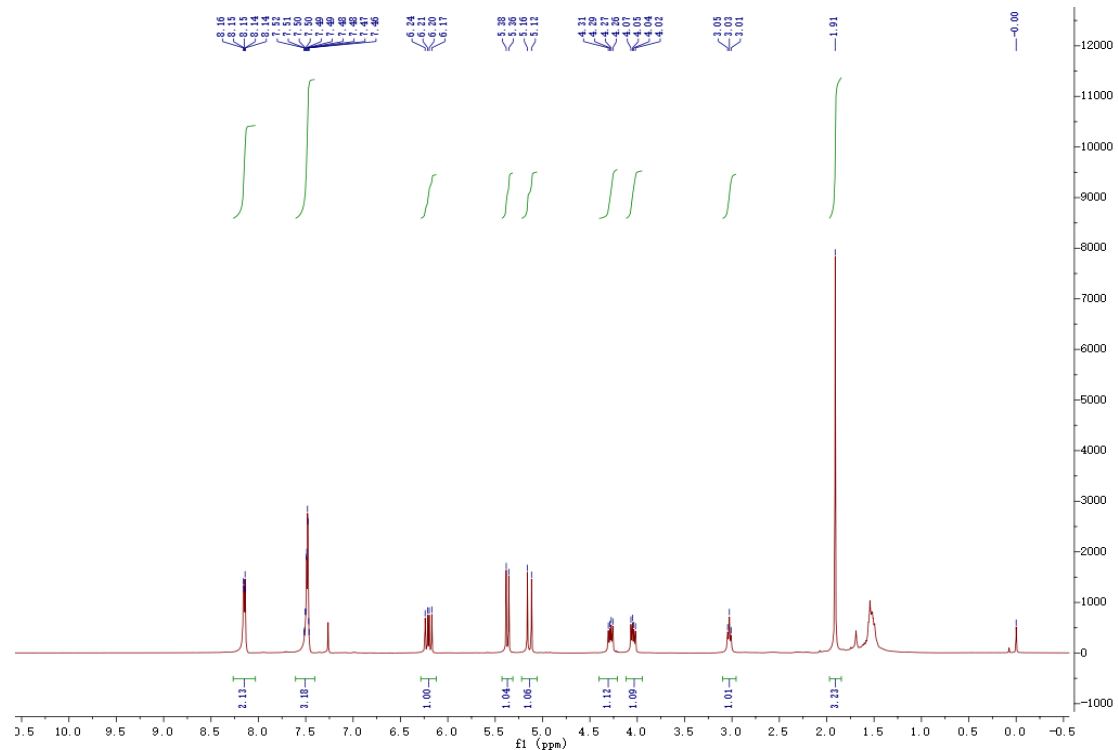
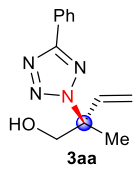
Wavelength	1.3414 Å
Crystal system	Triclinic
space group	P1
Unit cell dimensions	a = 7.1821(8) Å    alpha = 74 deg. b = 7.4470(8) Å    beta = 75 deg. c = 13.2850(15) Å    gamma = 83 deg.
Volume	659.82(13) Å <sup>3</sup>
Z	2
Calculated density	1.386 mg/m <sup>3</sup>
Absorption coefficient	0.552 mm <sup>-1</sup>
F(000)	288
Crystal size	0.12 x 0.1 x 0.1mm <sup>3</sup>
Theta range for data collection	10.766 to 120.664 deg.
Index range	-9 ≤ h ≤ 9, -9 ≤ k ≤ 9, -16 ≤ l ≤ 17
Reflections collected	8286
Independent reflections	4465 [R <sub>int</sub> = 0.0437, R <sub>sigma</sub> = 0.0569]
Completeness to theta	1.48/0.74
Theta (max)	60.332
Absorption correction	MULTI-SCAN
Radiation	GaKa (g = 1.34139)
Refinement method	Full-matrix least-squares on F <sup>2</sup>
Data / restraints / parameters	4465 / 3 / 365
Goodness-of-fit on F <sup>2</sup>	1.103
Final R indices [I > 2sigma(I)]	R <sub>1</sub> = 0.0650, wR <sub>2</sub> = 0.2021
R indices (all data)	R <sub>1</sub> = 0.0737, wR <sub>2</sub> = 0.2087
Absolute structure parameter	0.3(4)
Largest diff. peak and hole	0.33/-0.26 e.Å <sup>-3</sup>

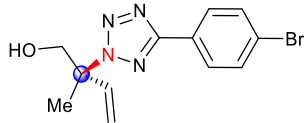


**Figure F1.** X-ray of **3ad**.

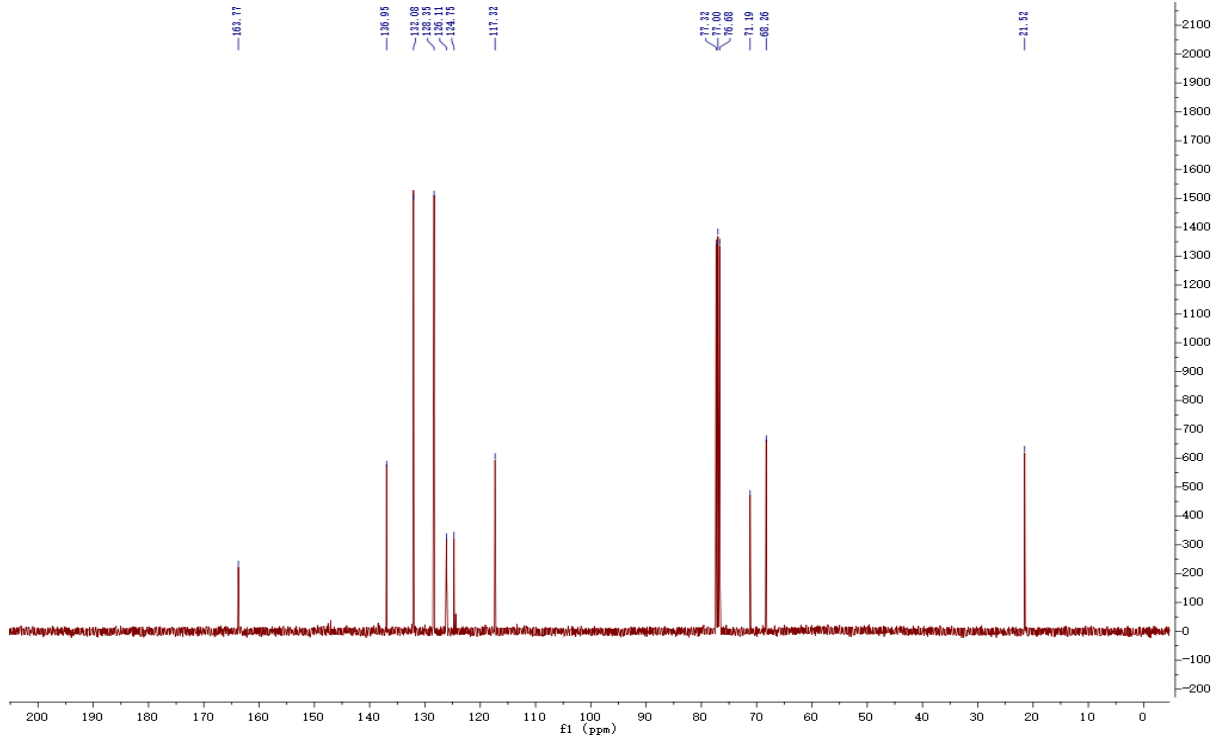
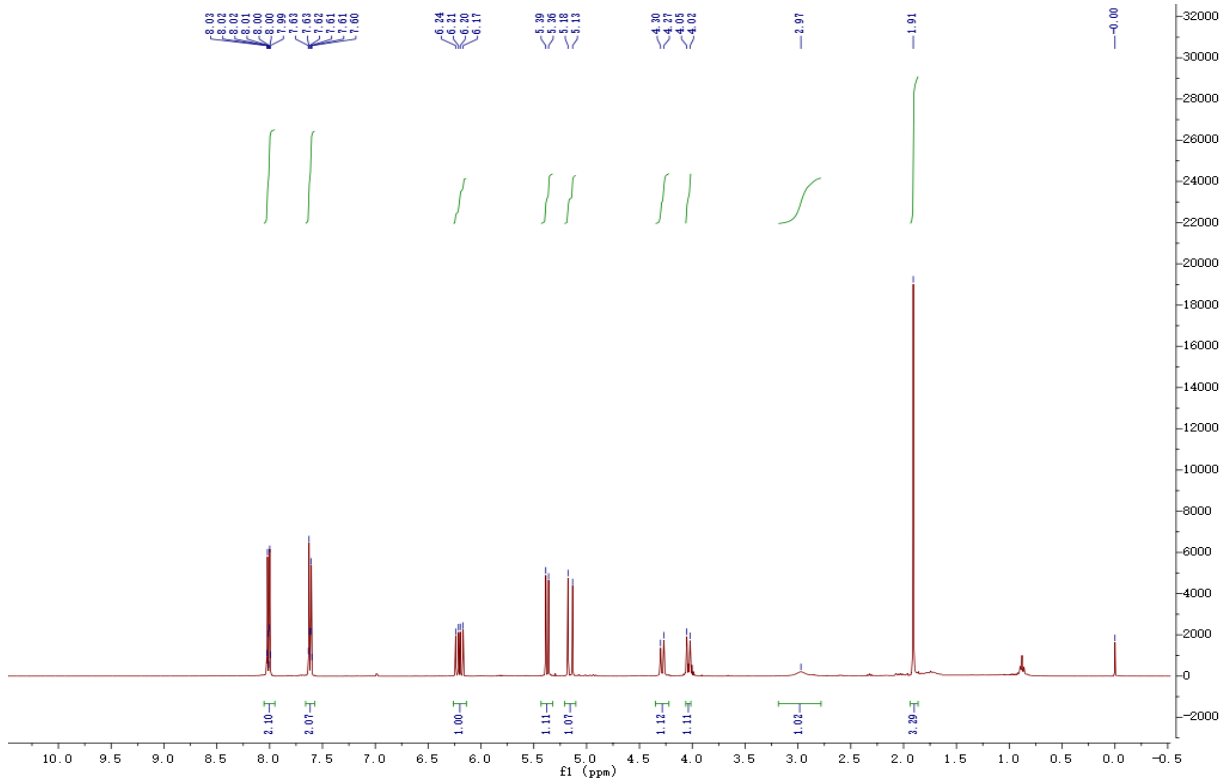
**References:**

1. A. Khan, H. Zhao, M. Zhang, S. Khan, D. Zhao, *Angew. Chem. Int. Ed.* **2020**, *59*, 1340-1345.

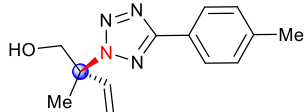




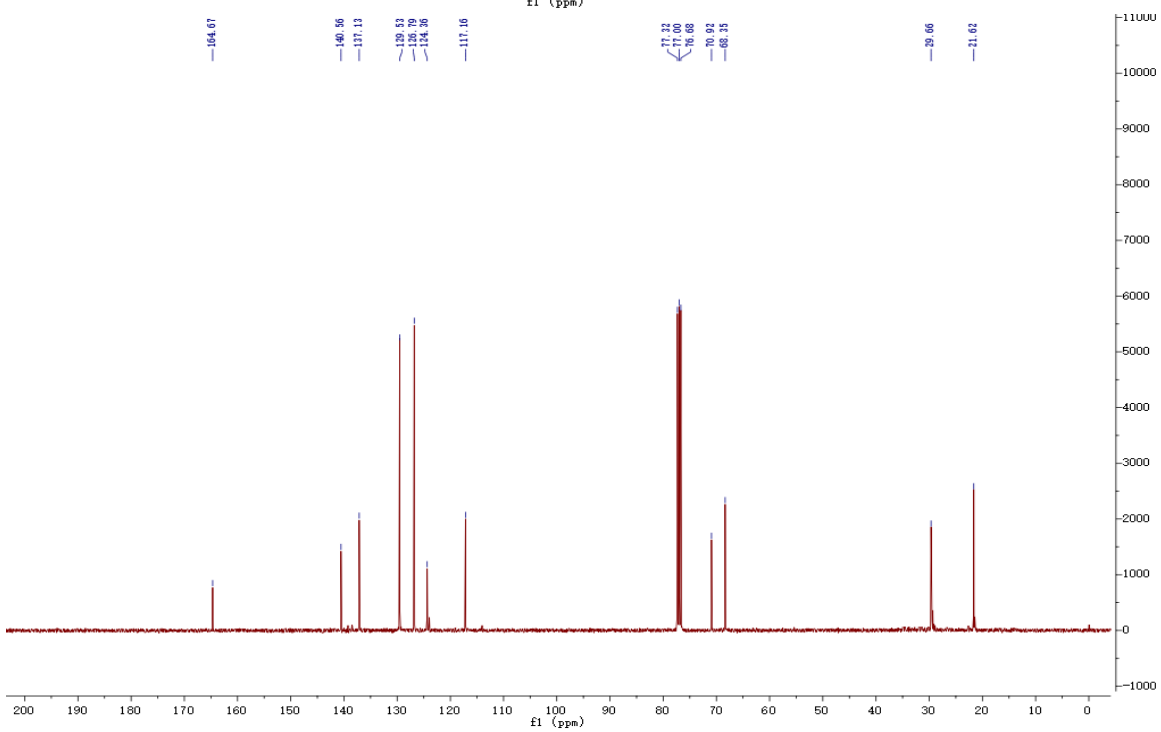
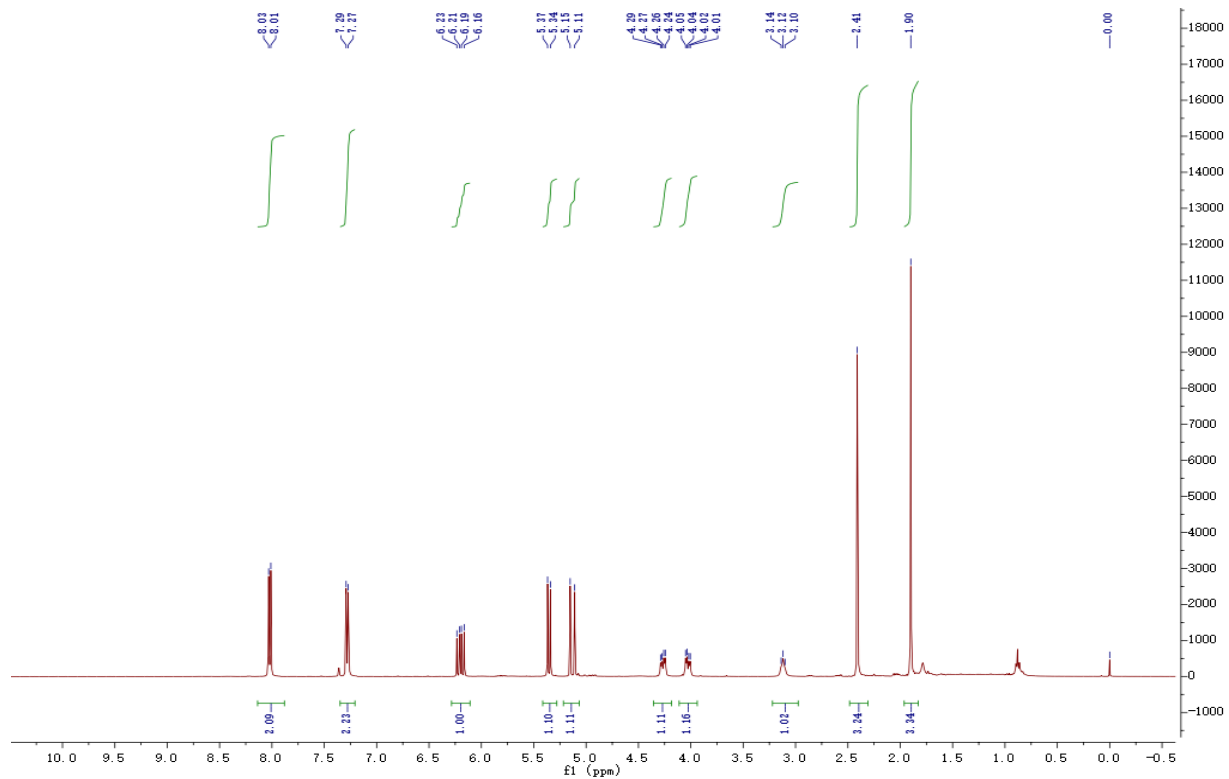
**3ab**

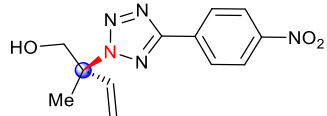




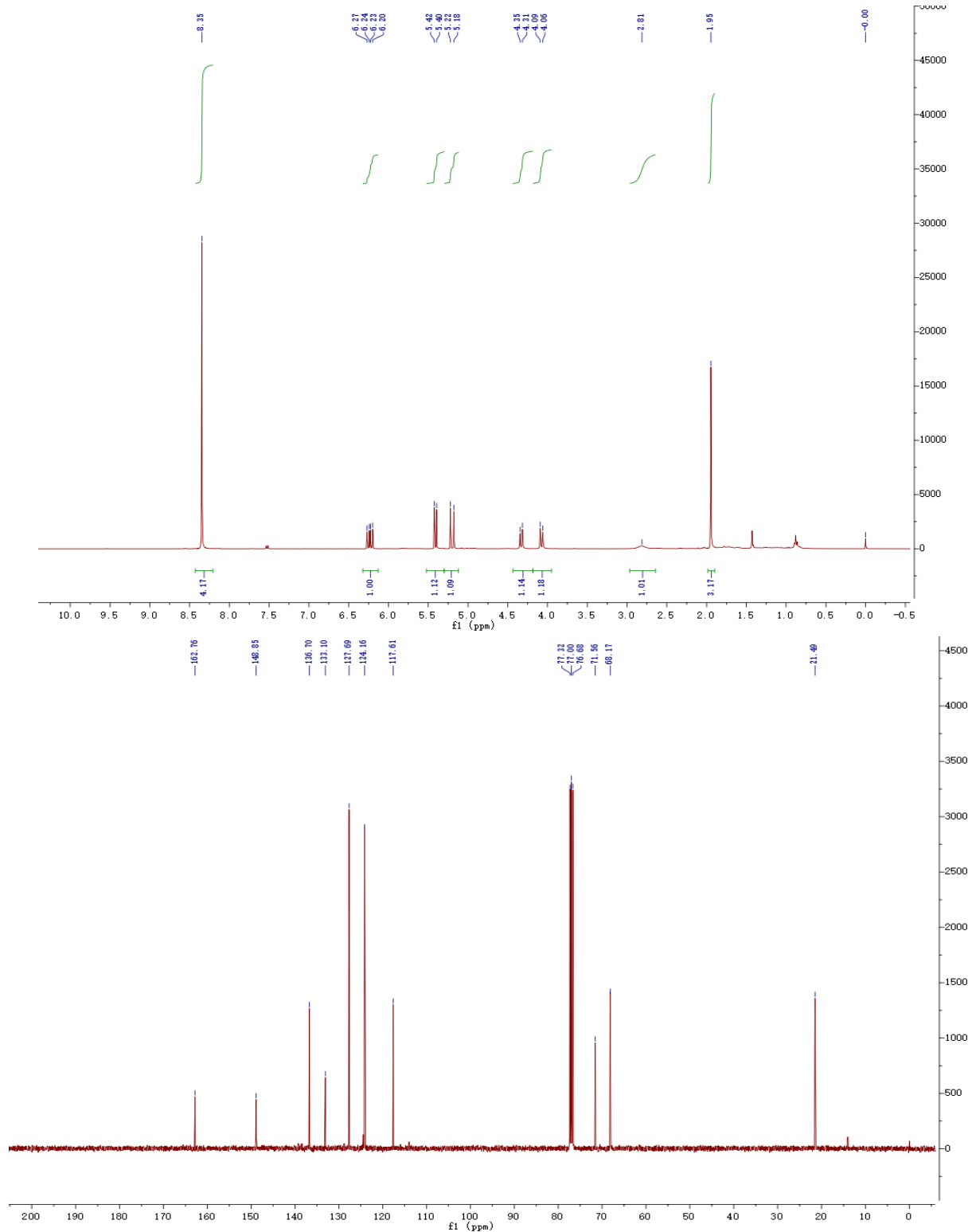


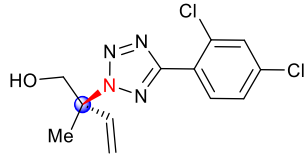
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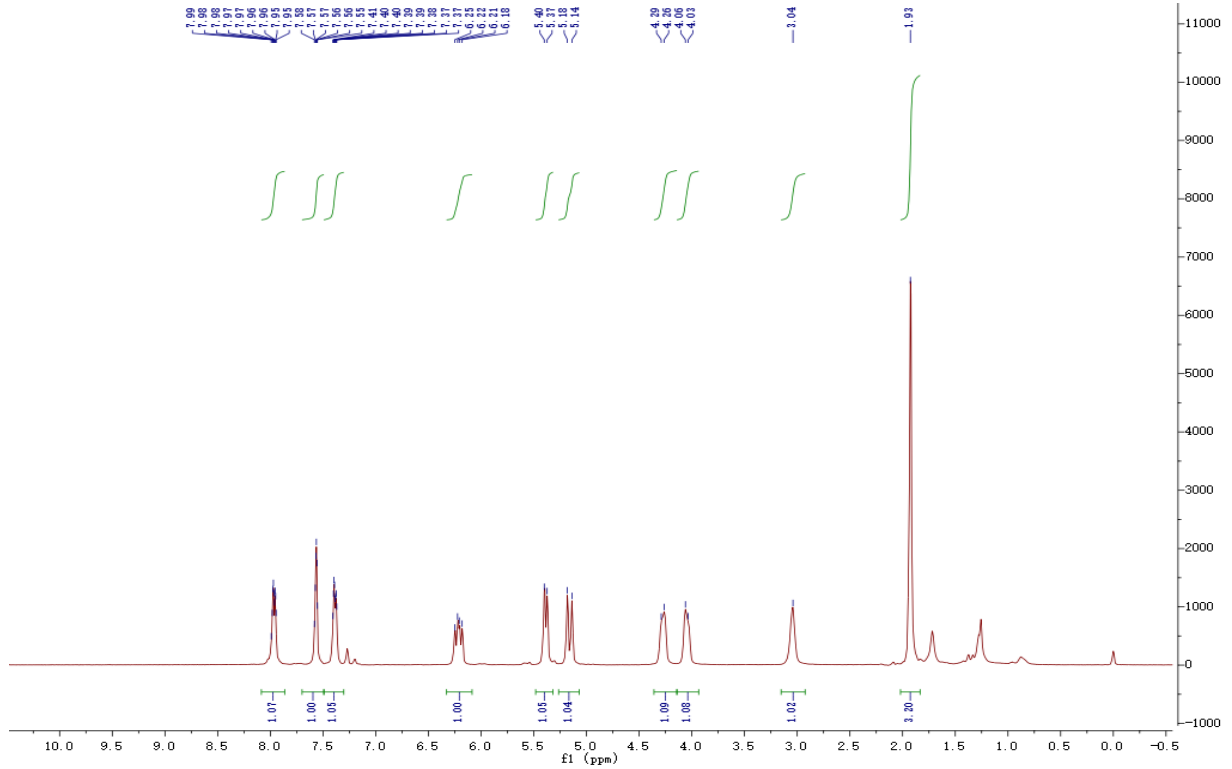


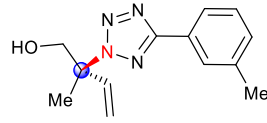
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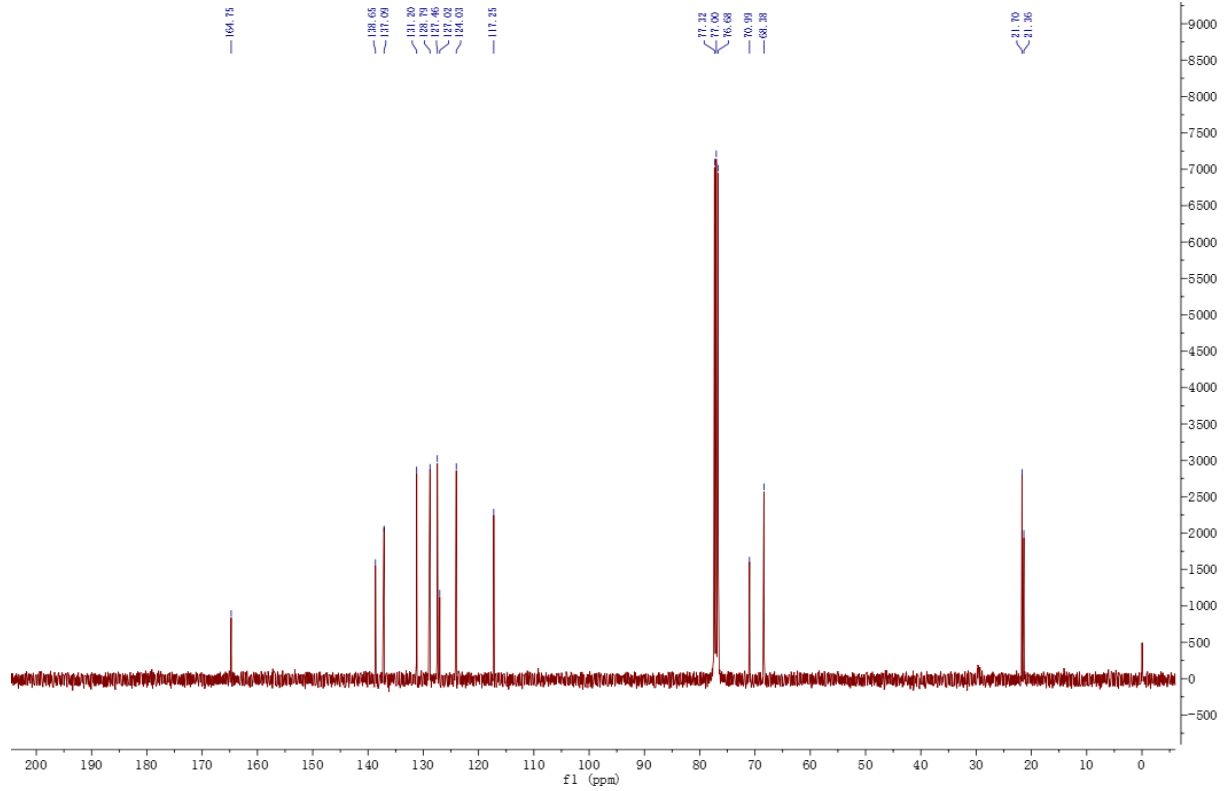
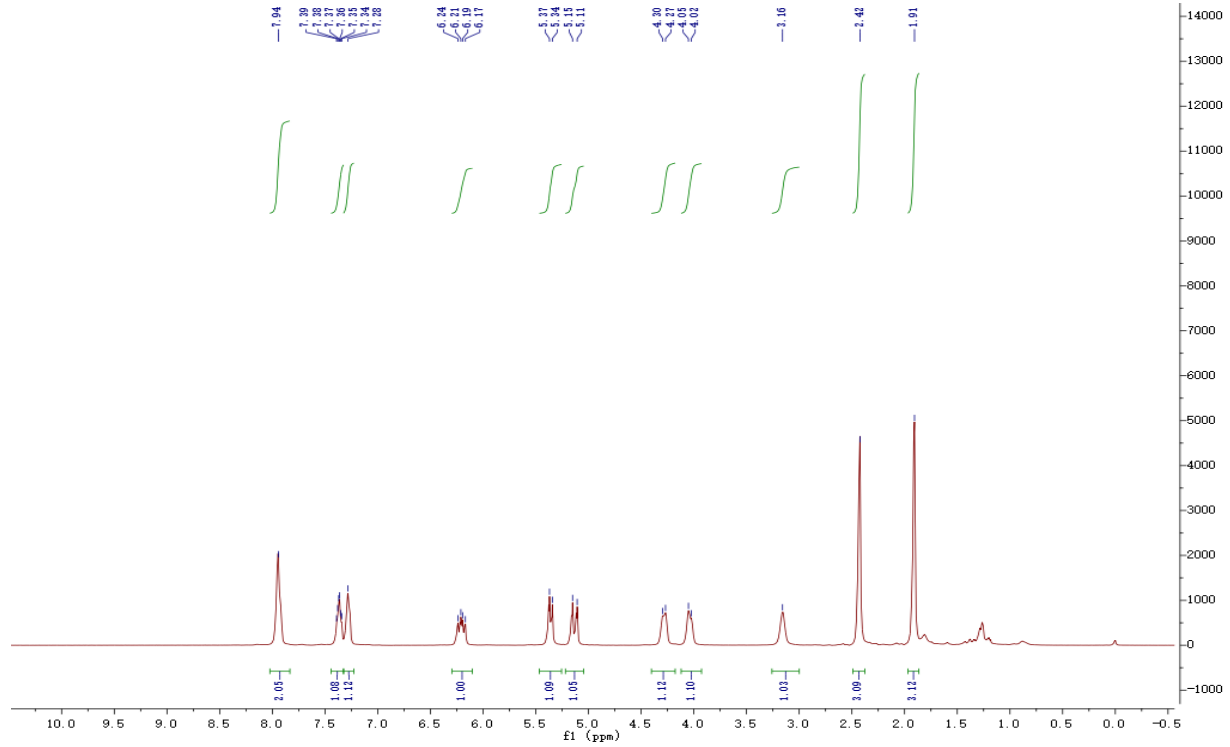


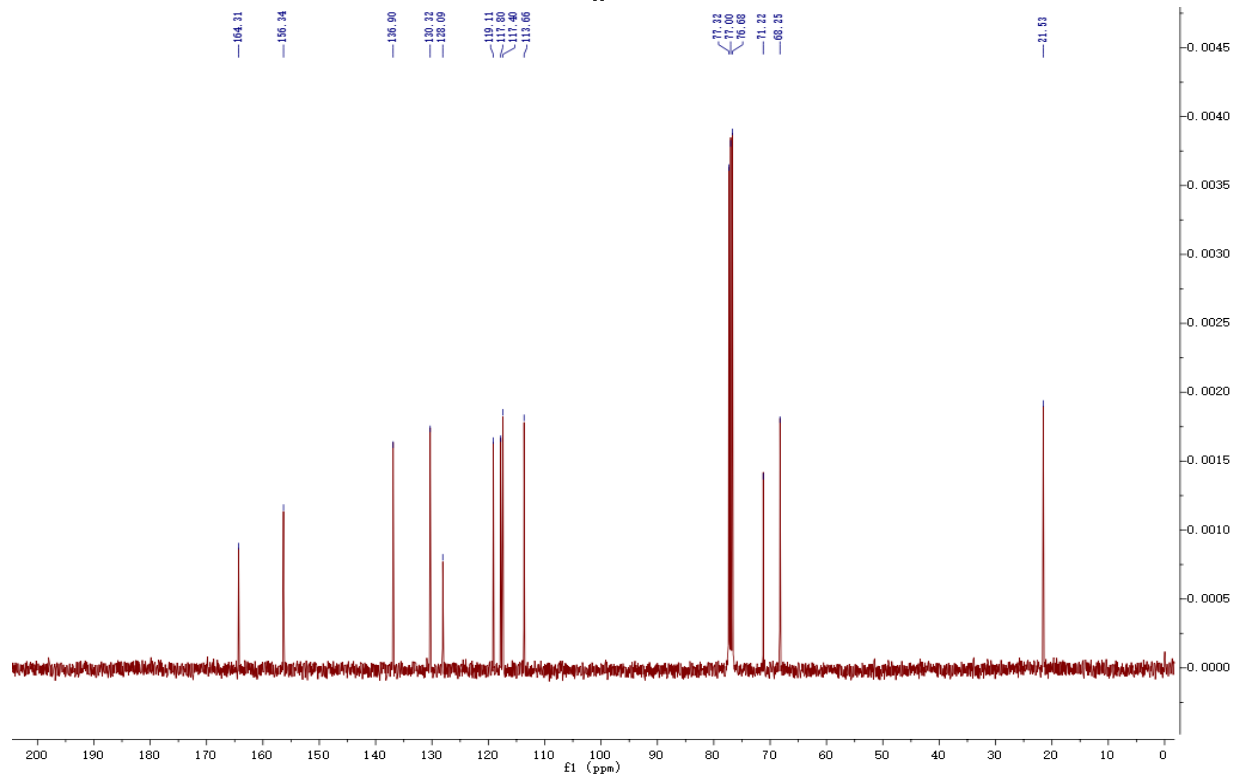
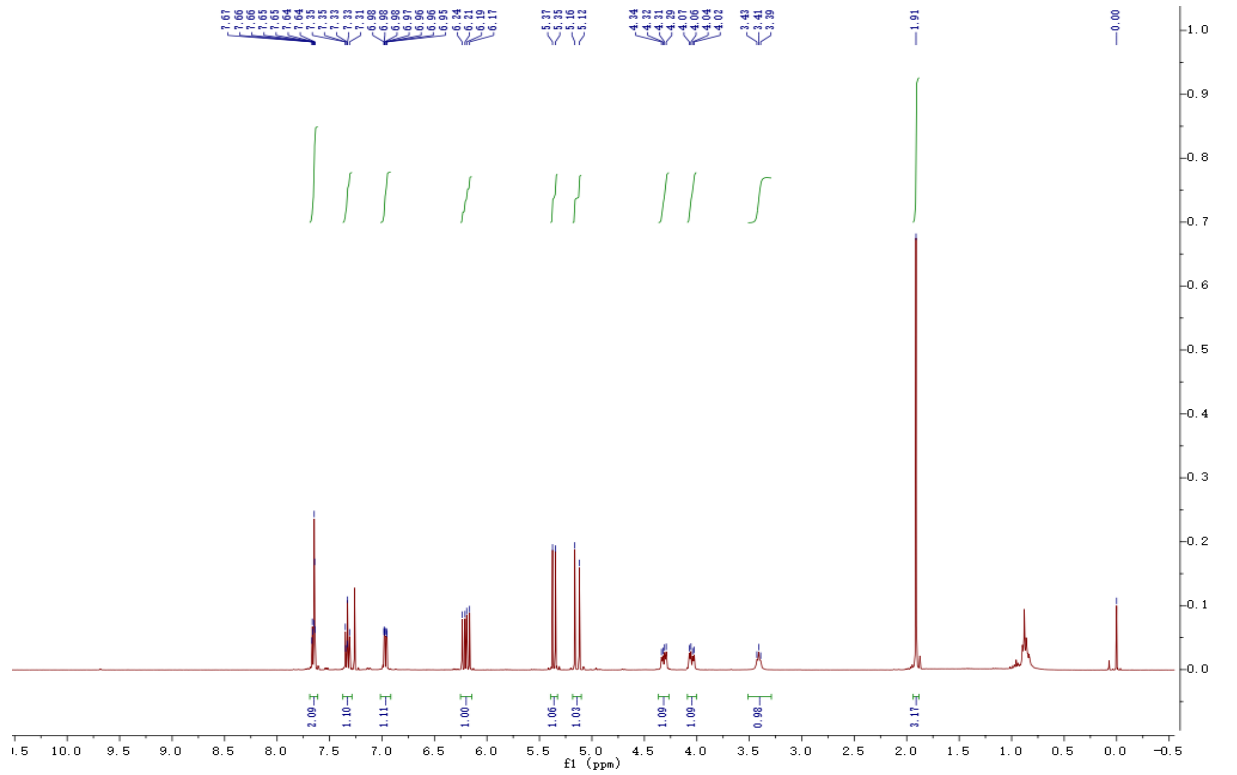
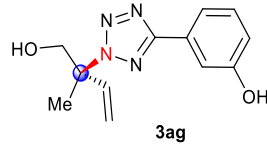
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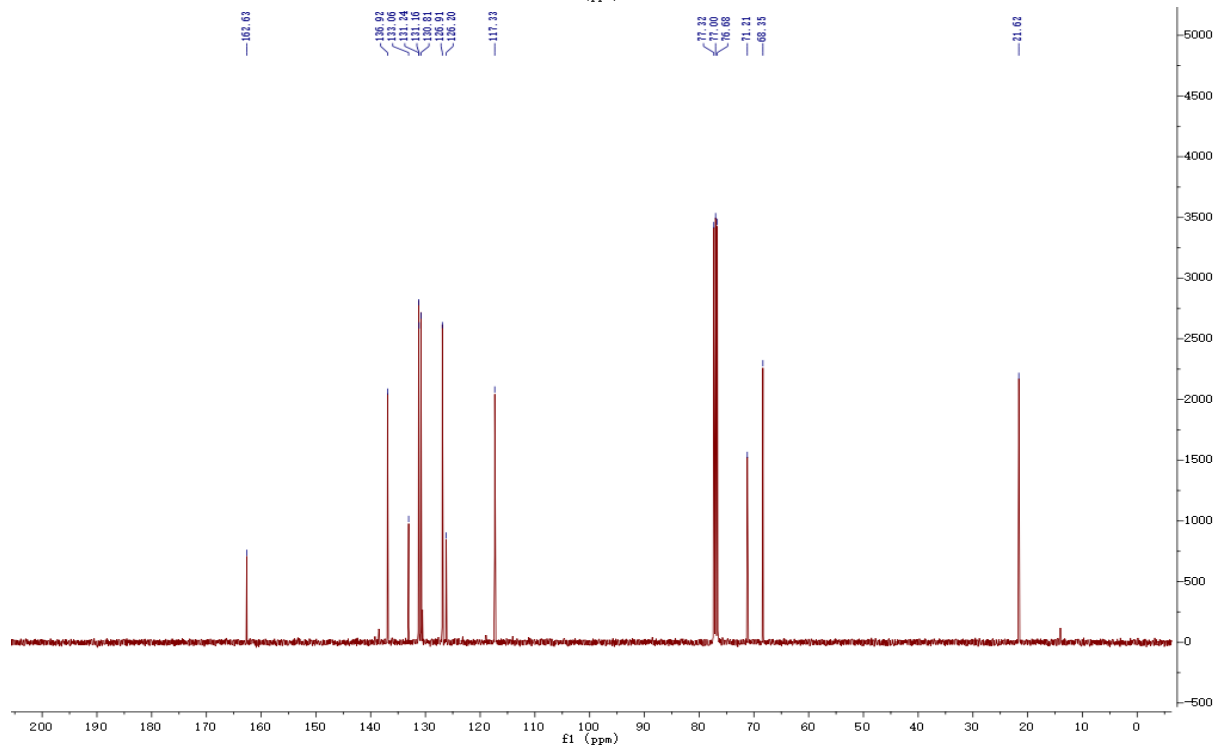
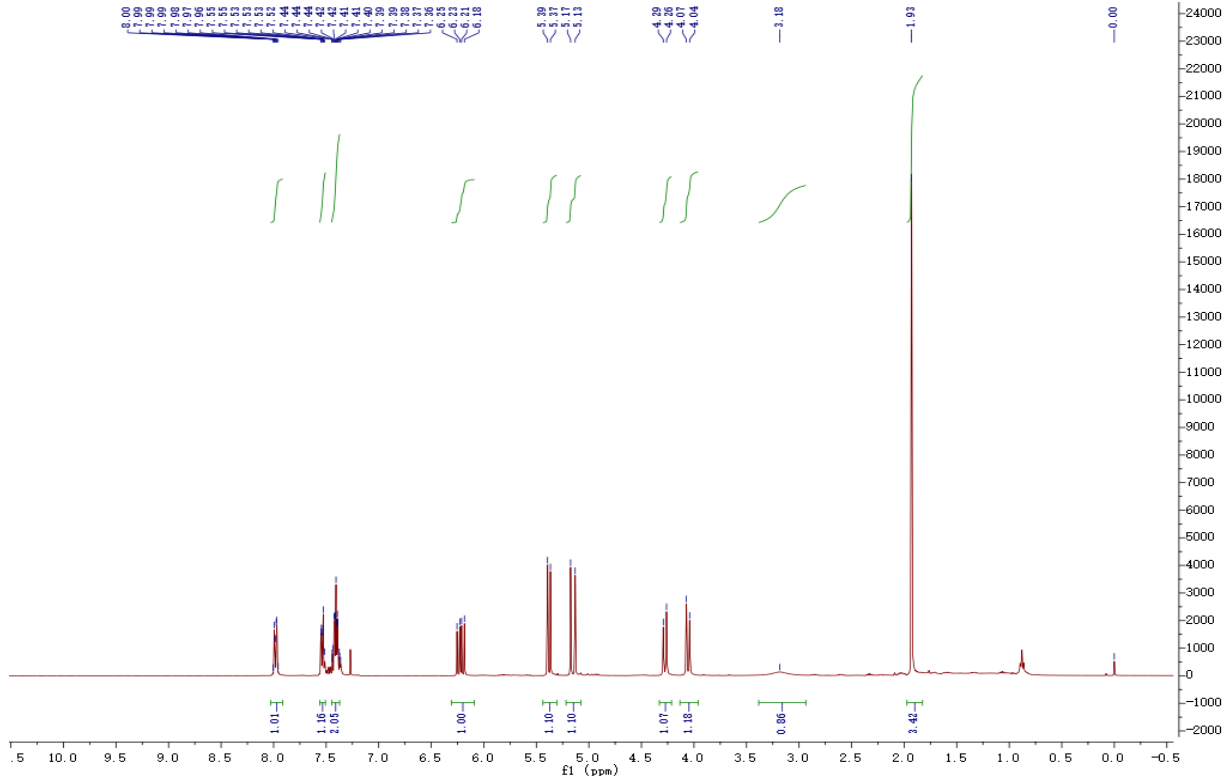
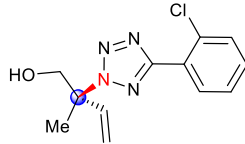


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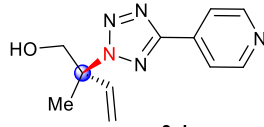




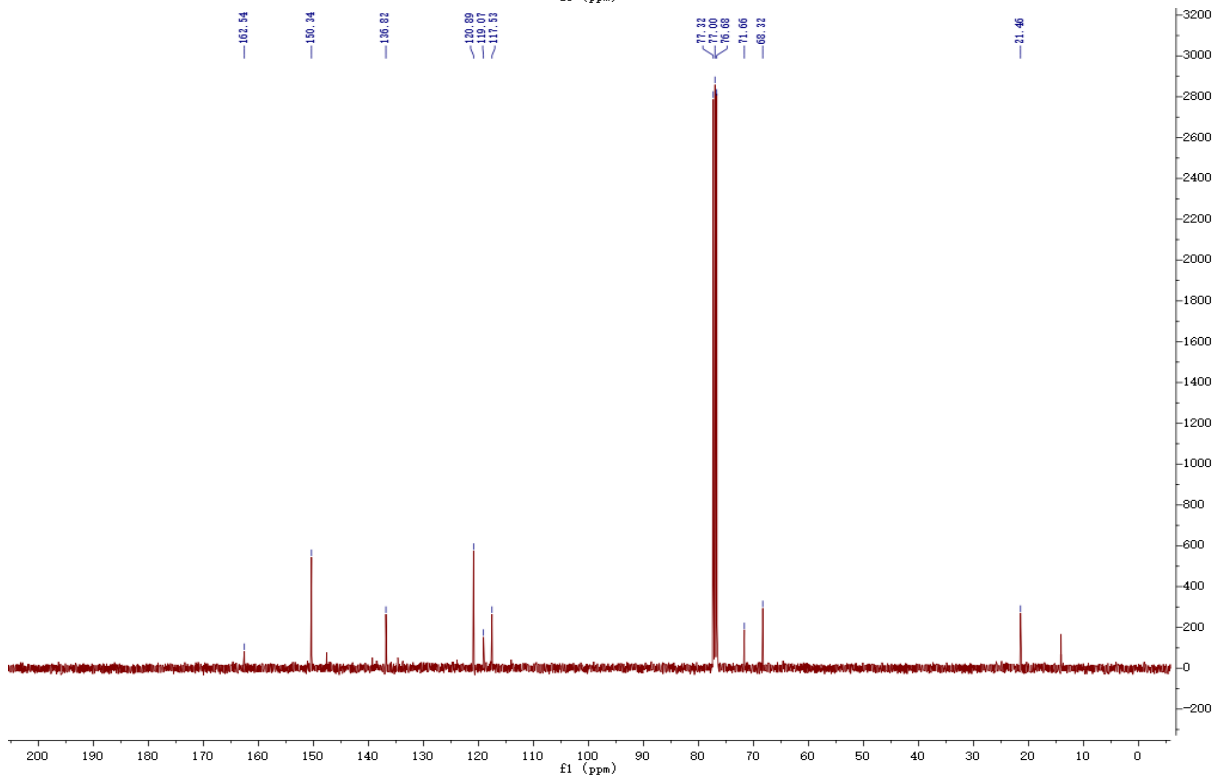
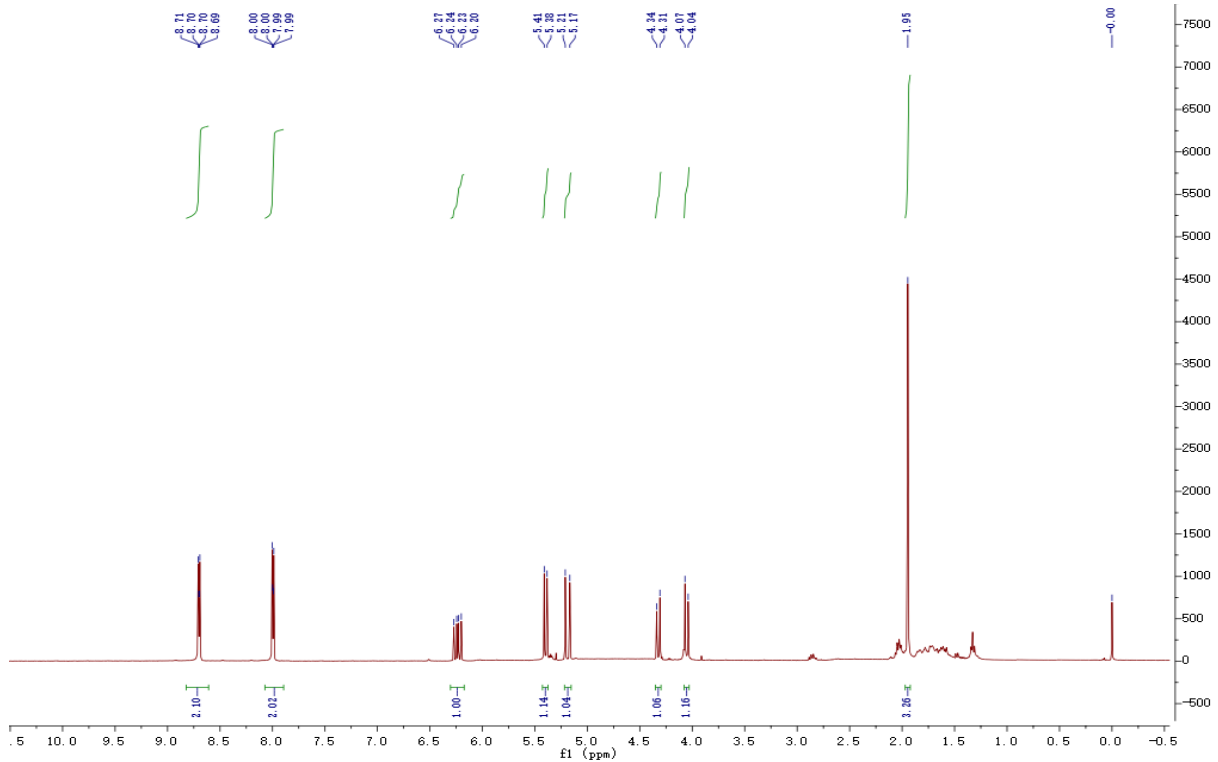


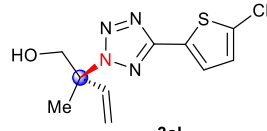




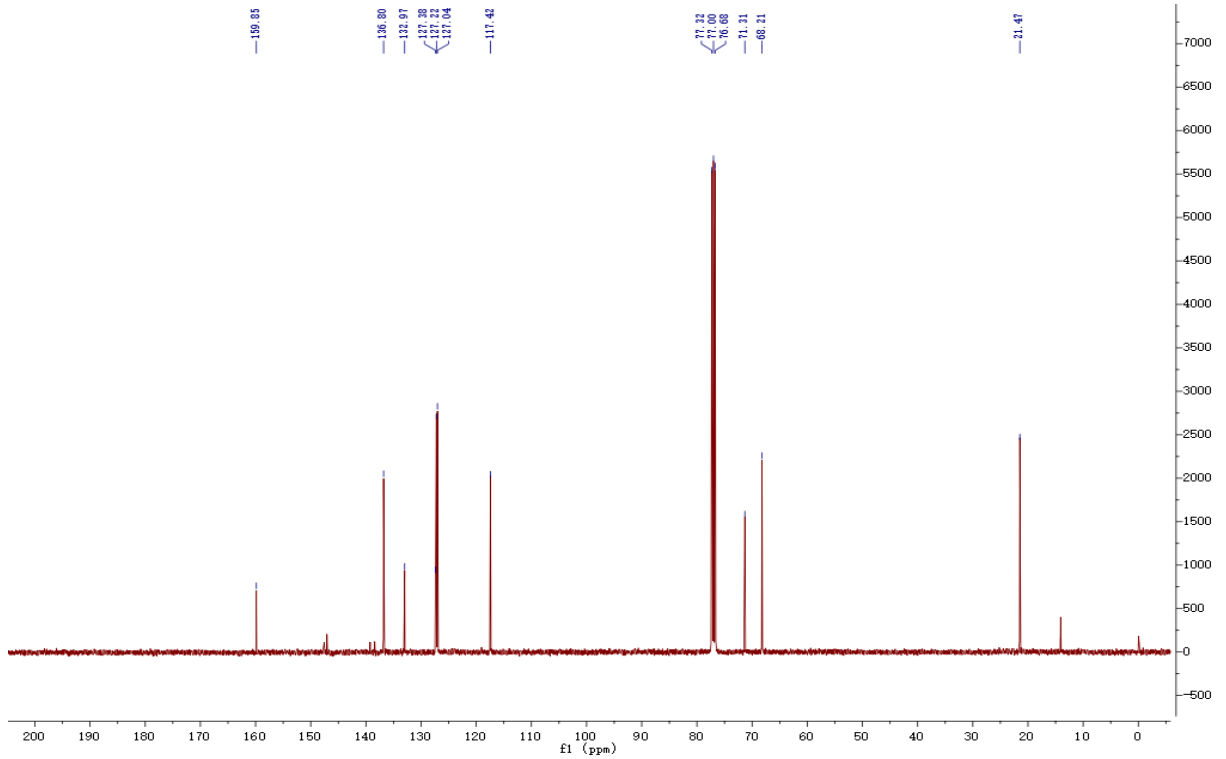
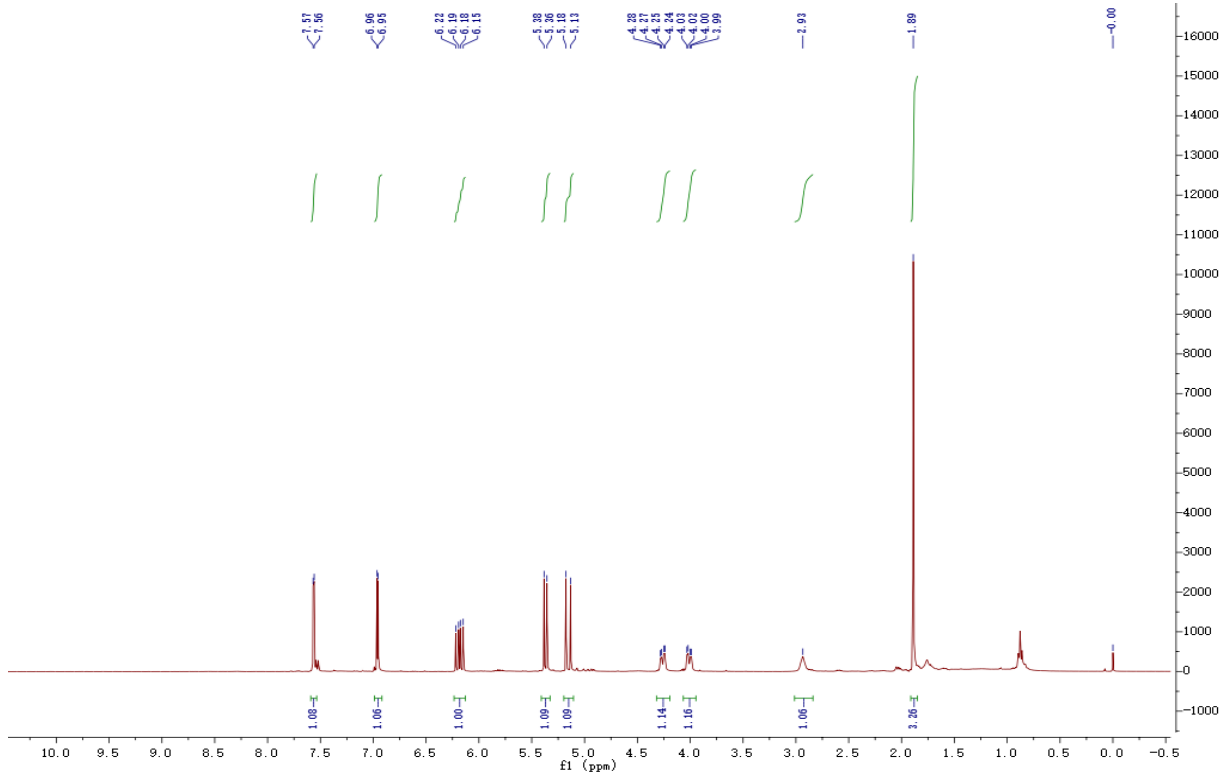


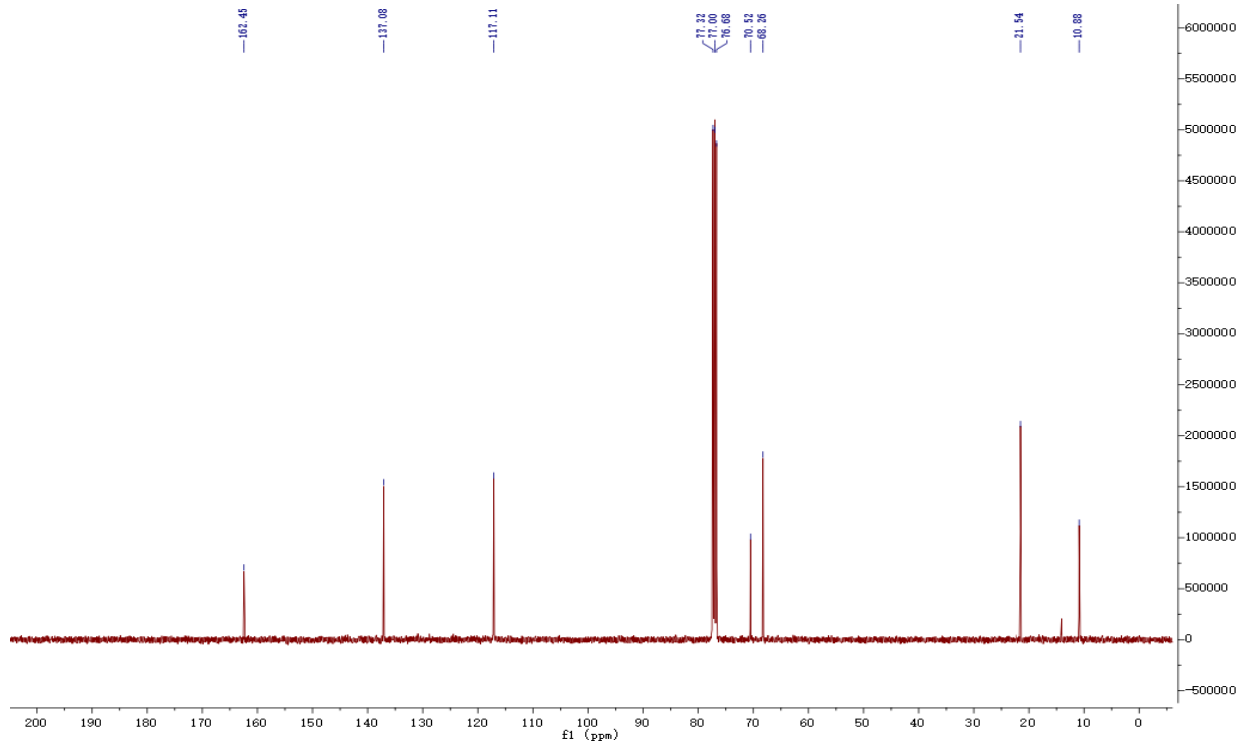
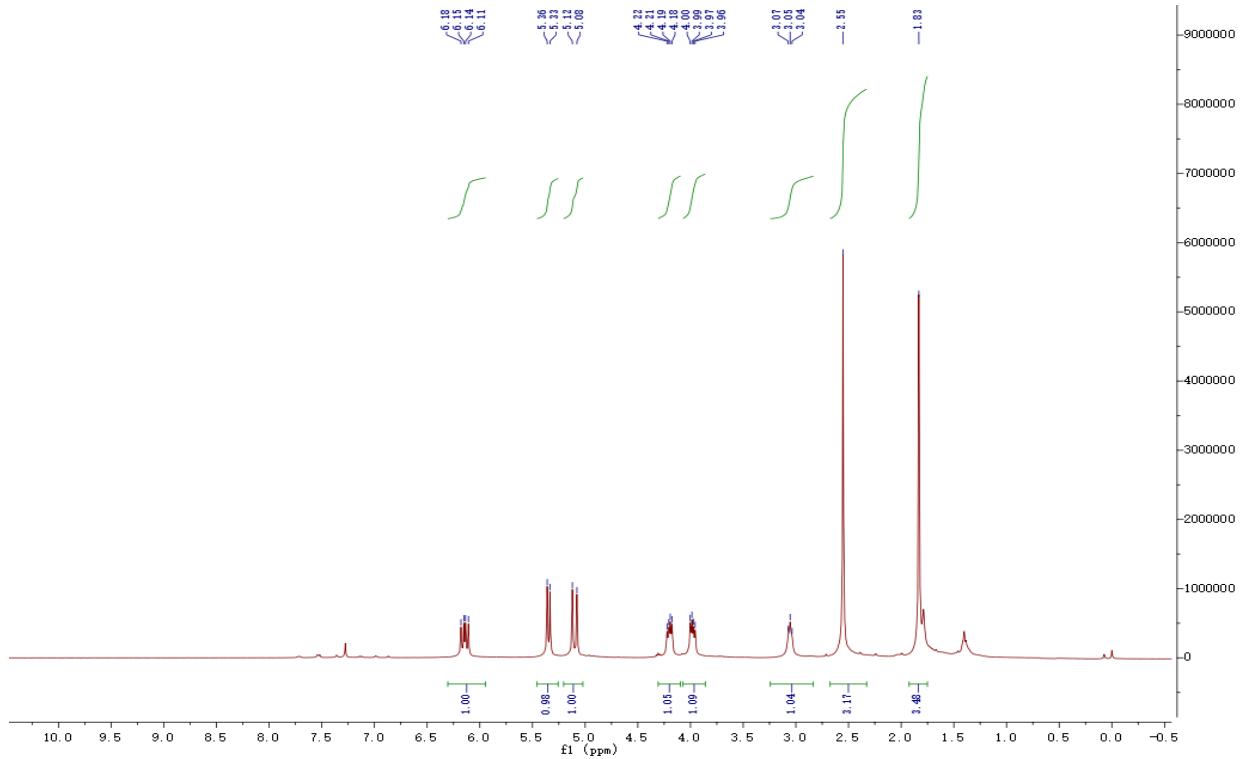
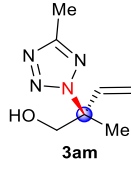
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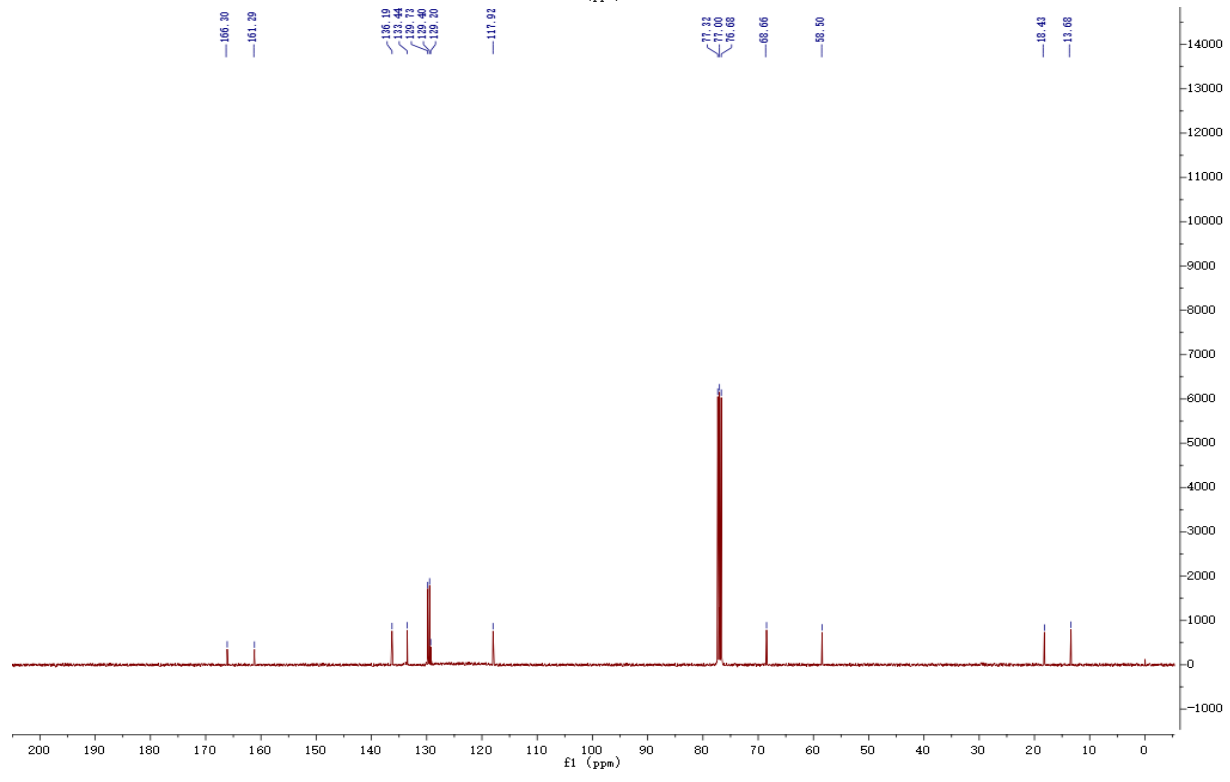
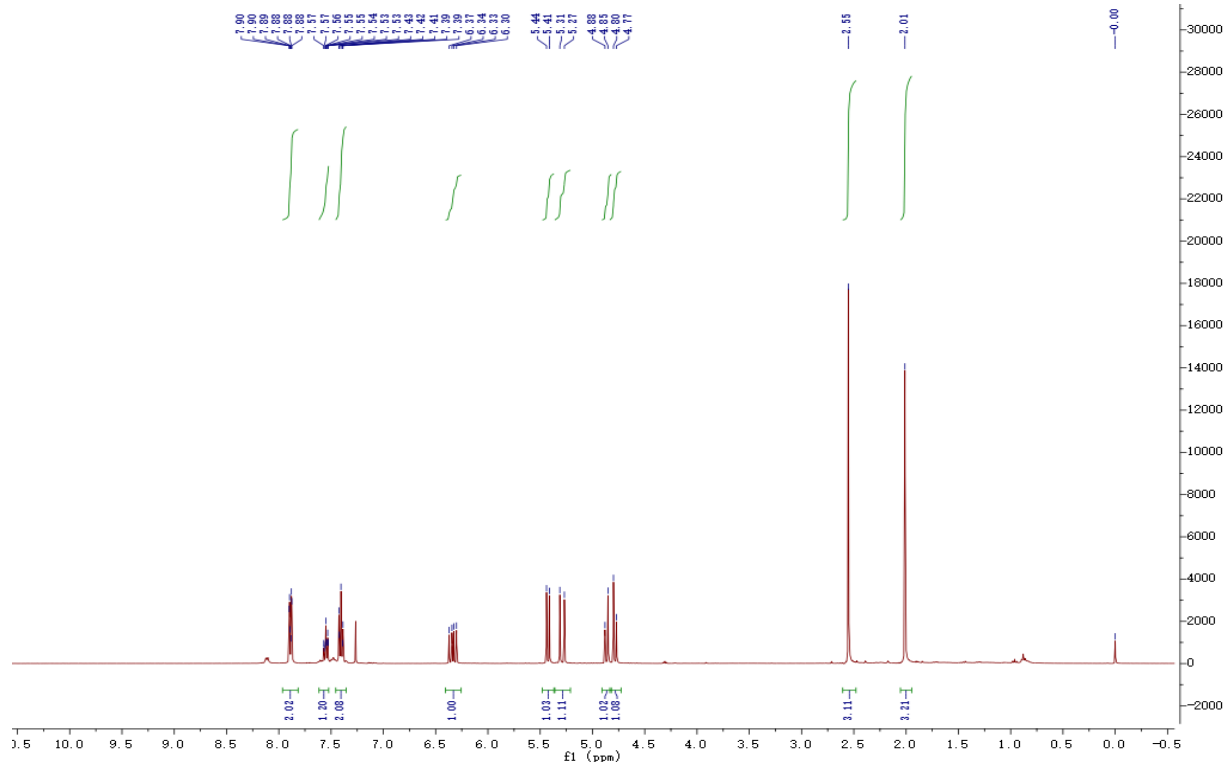
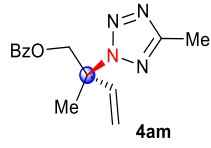


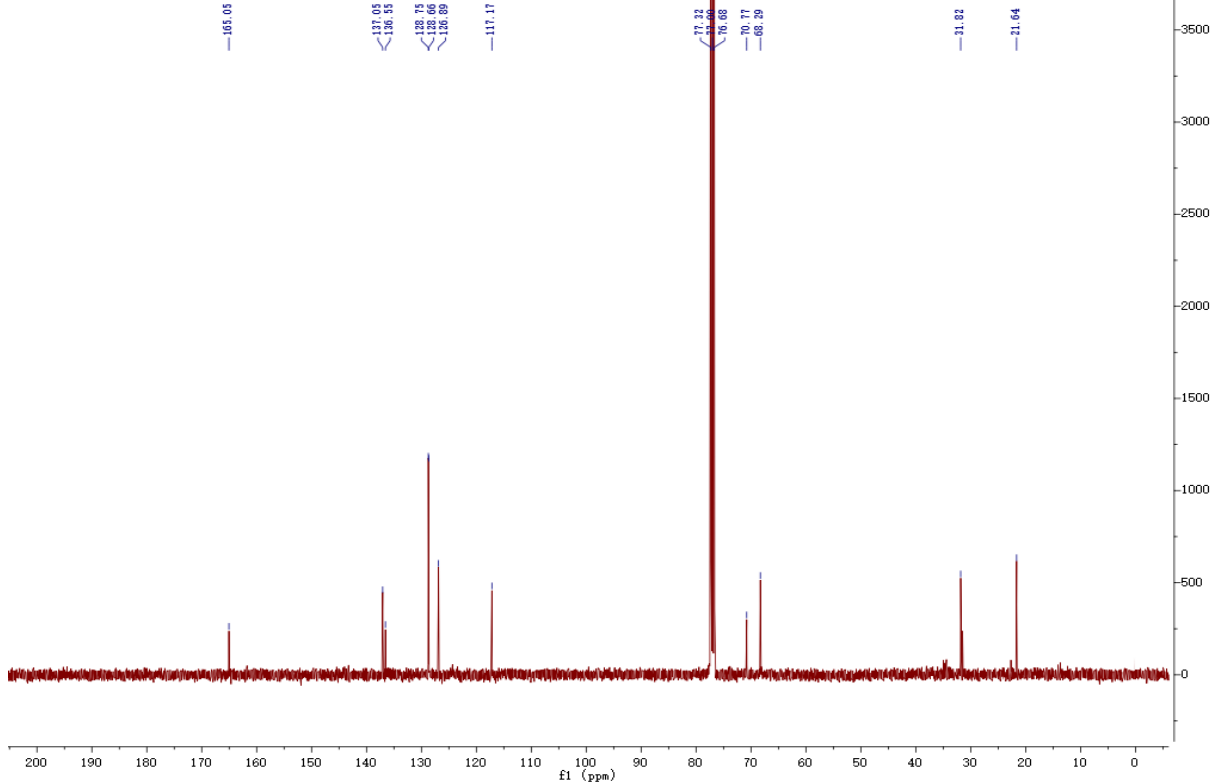
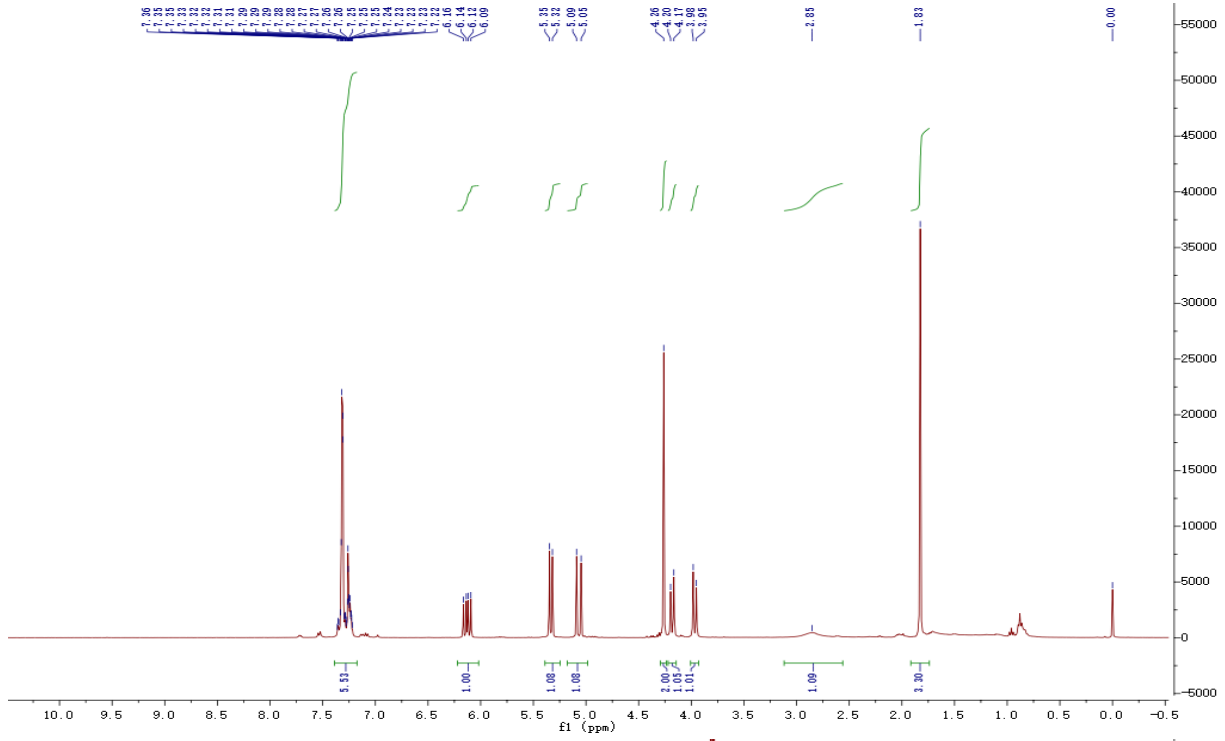
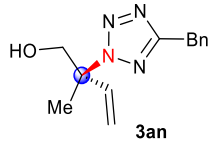


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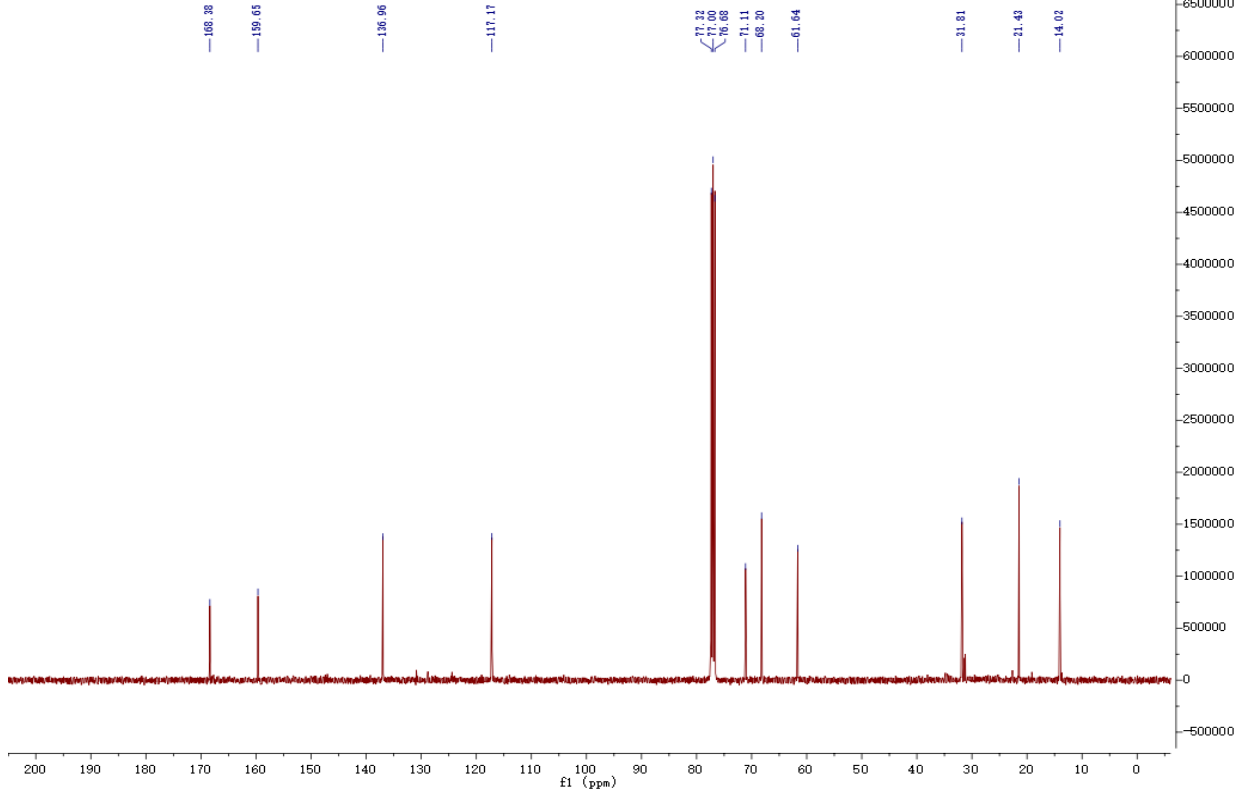
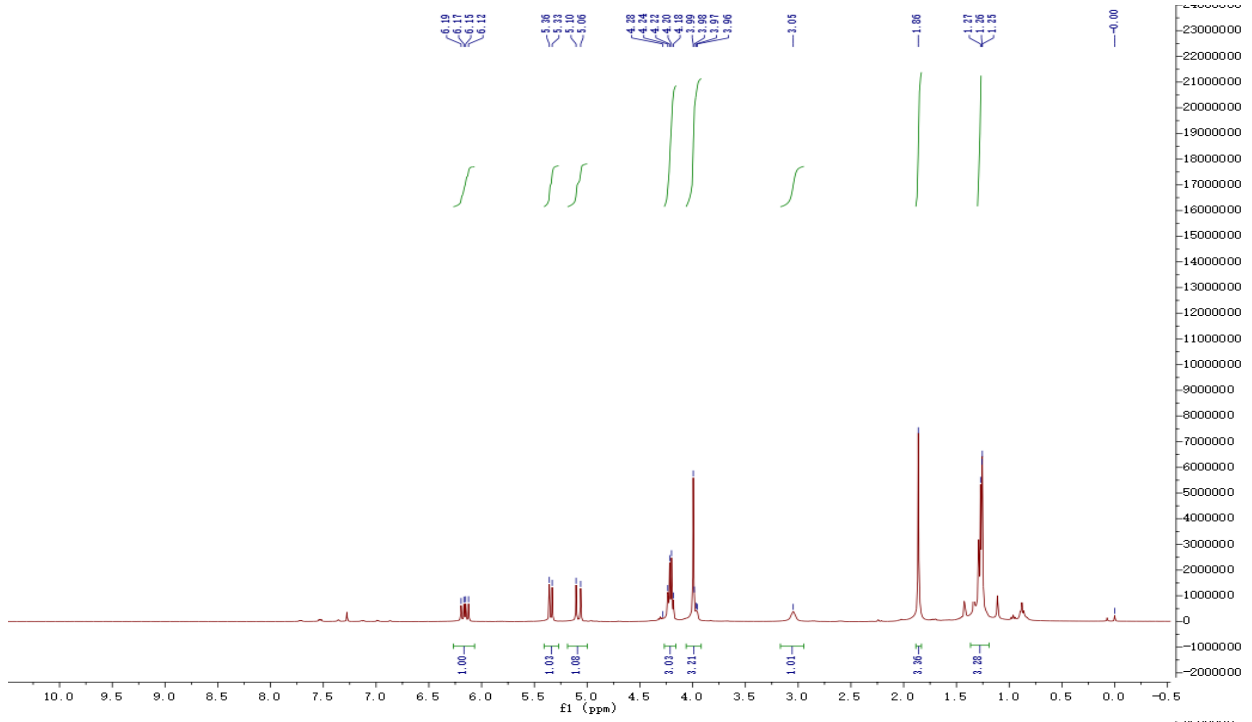
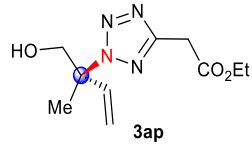


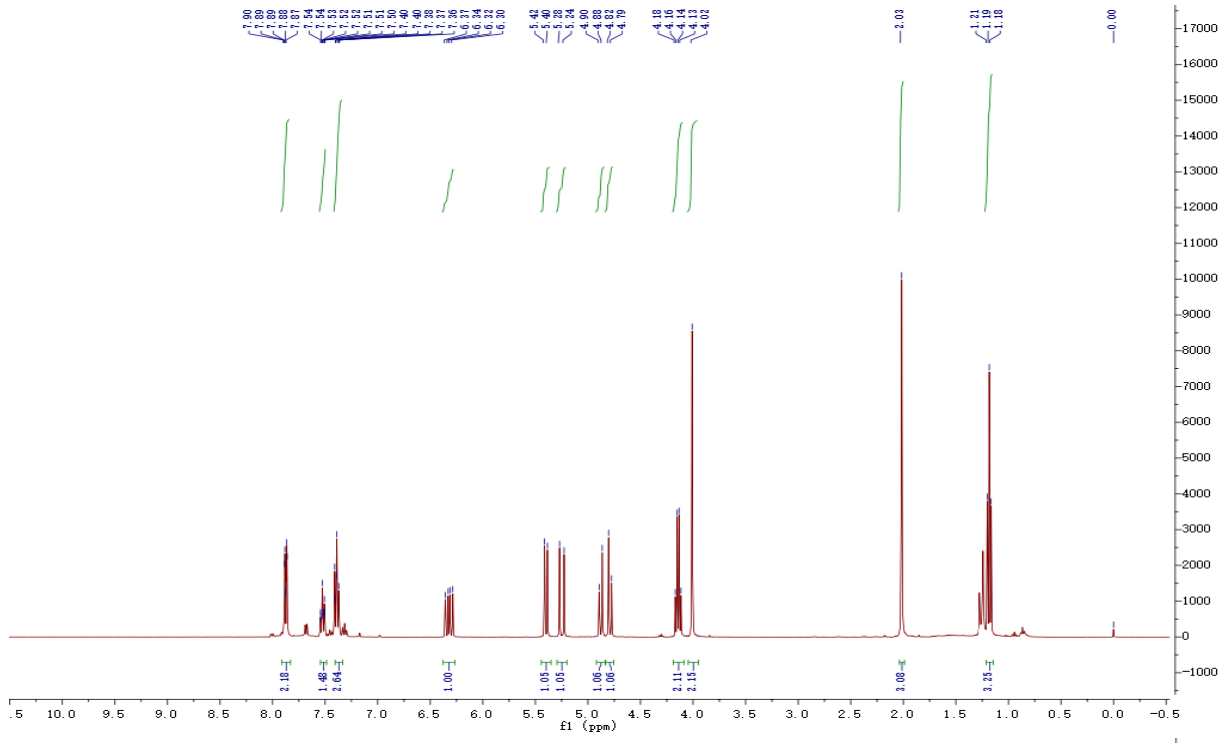
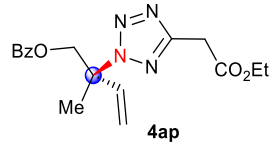




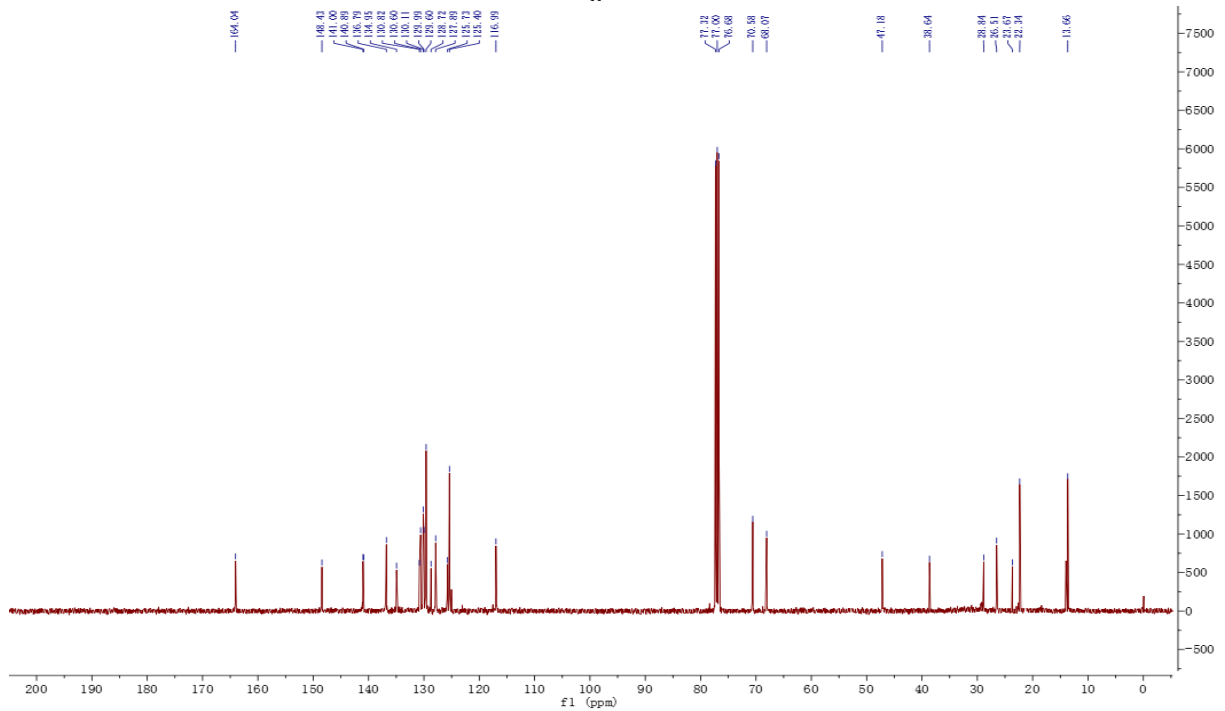
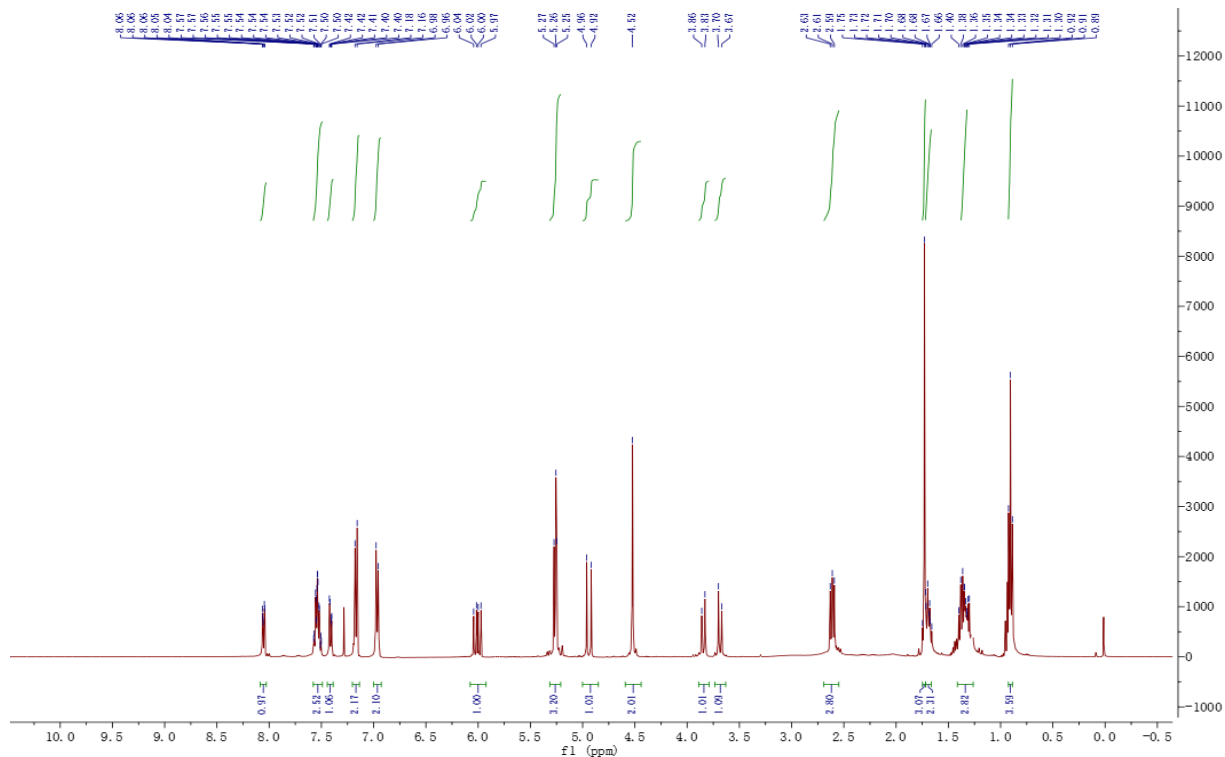
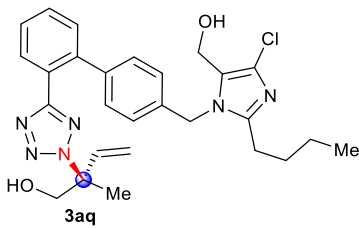




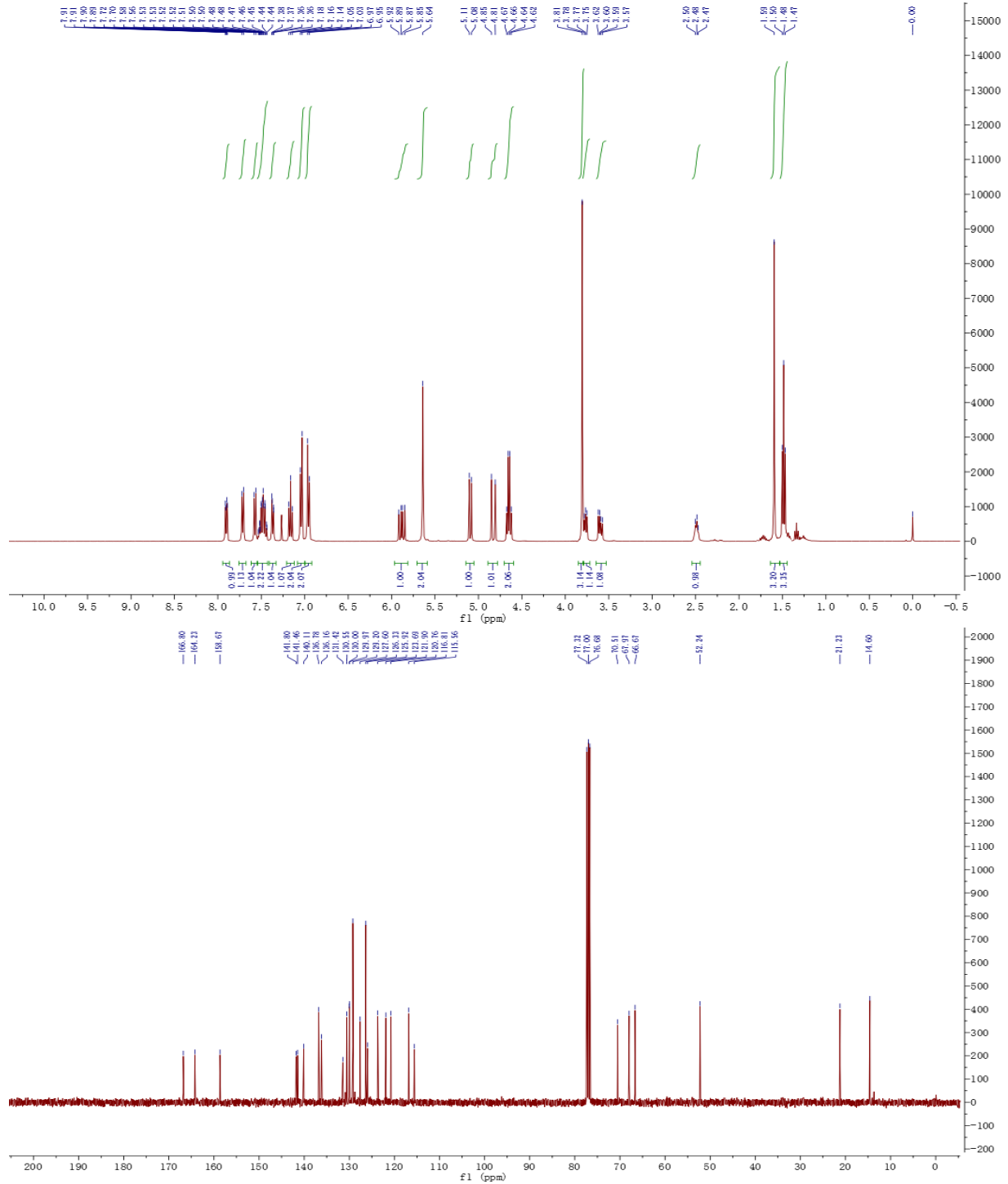
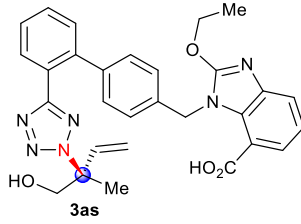


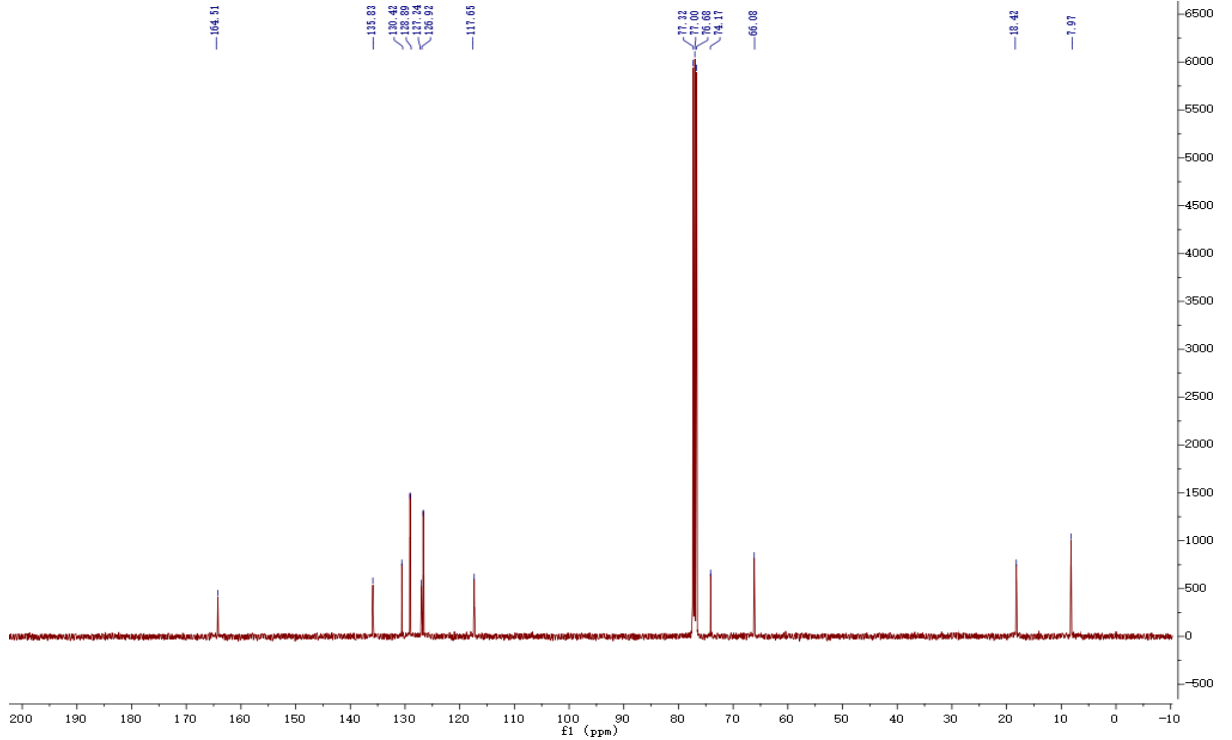
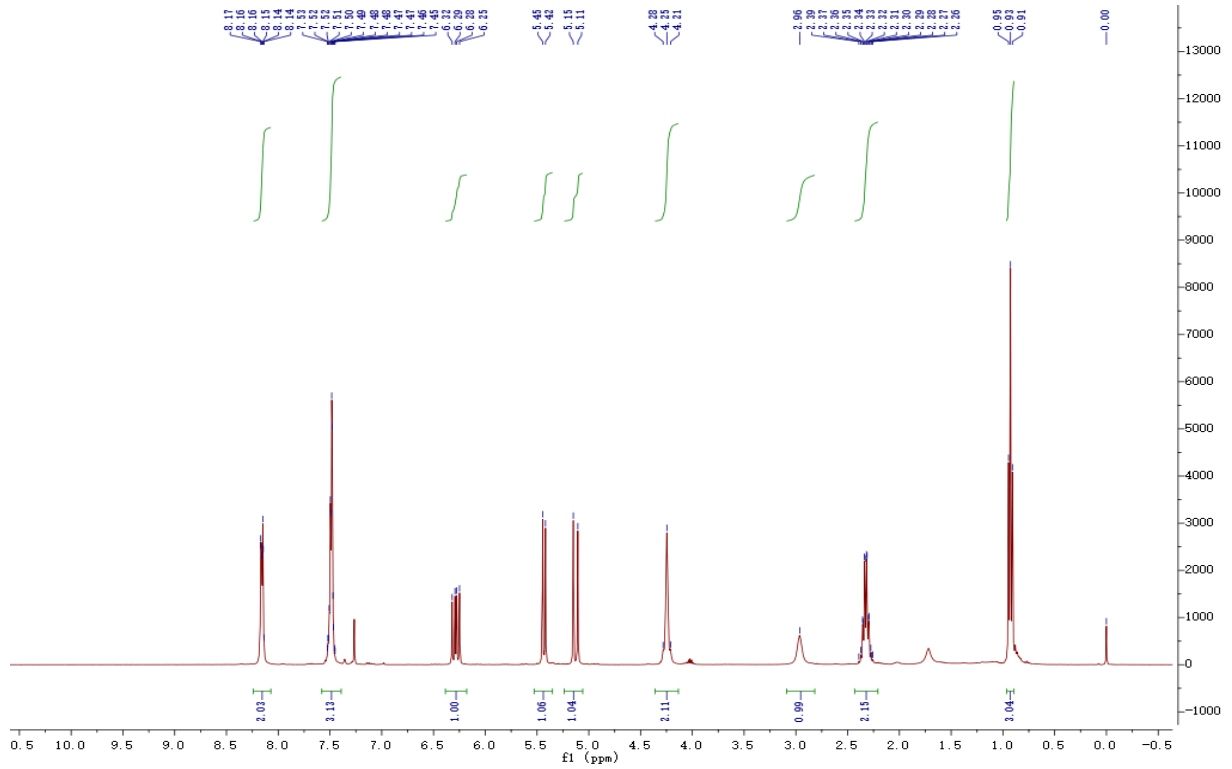
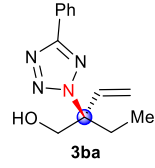


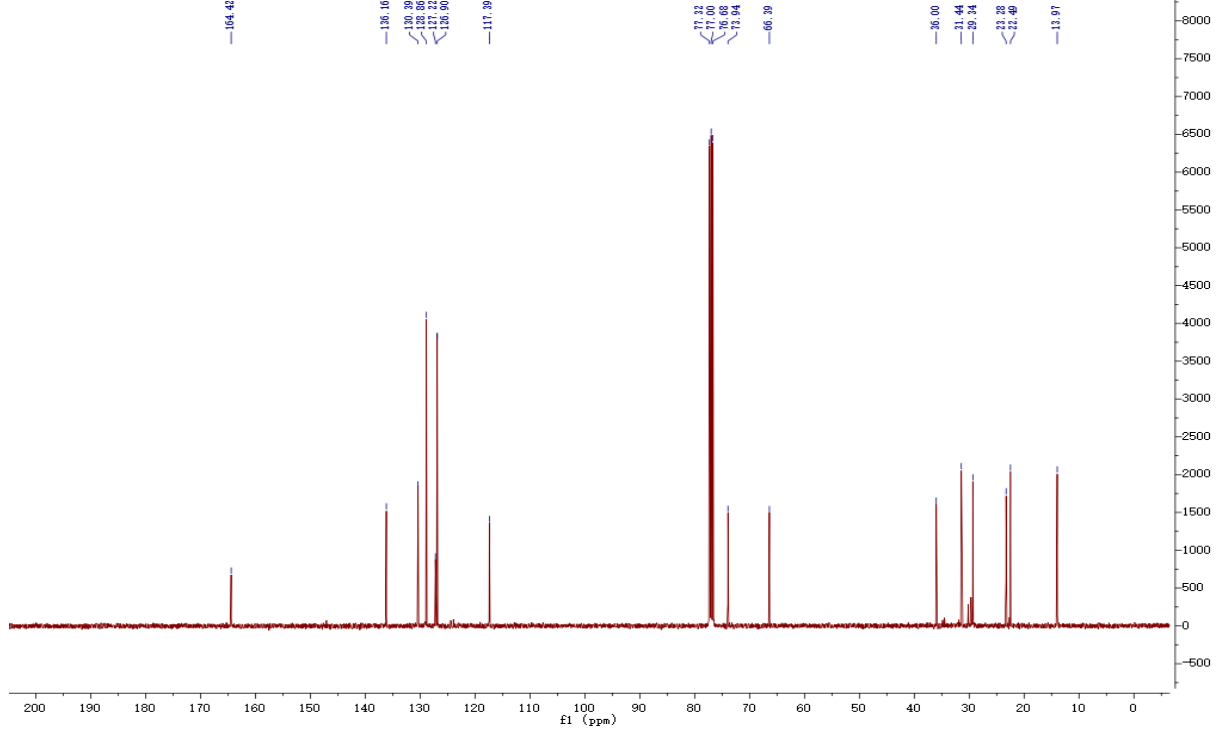
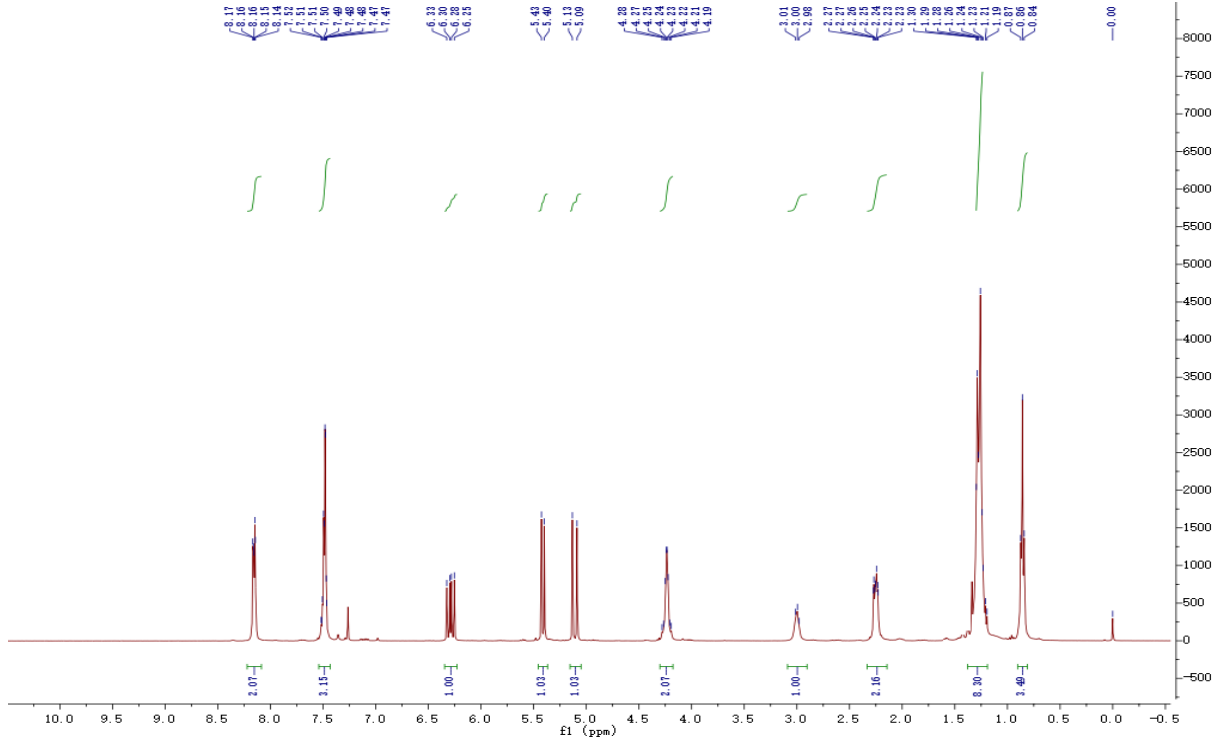
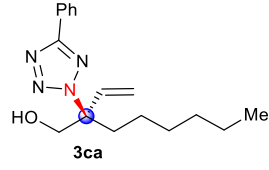


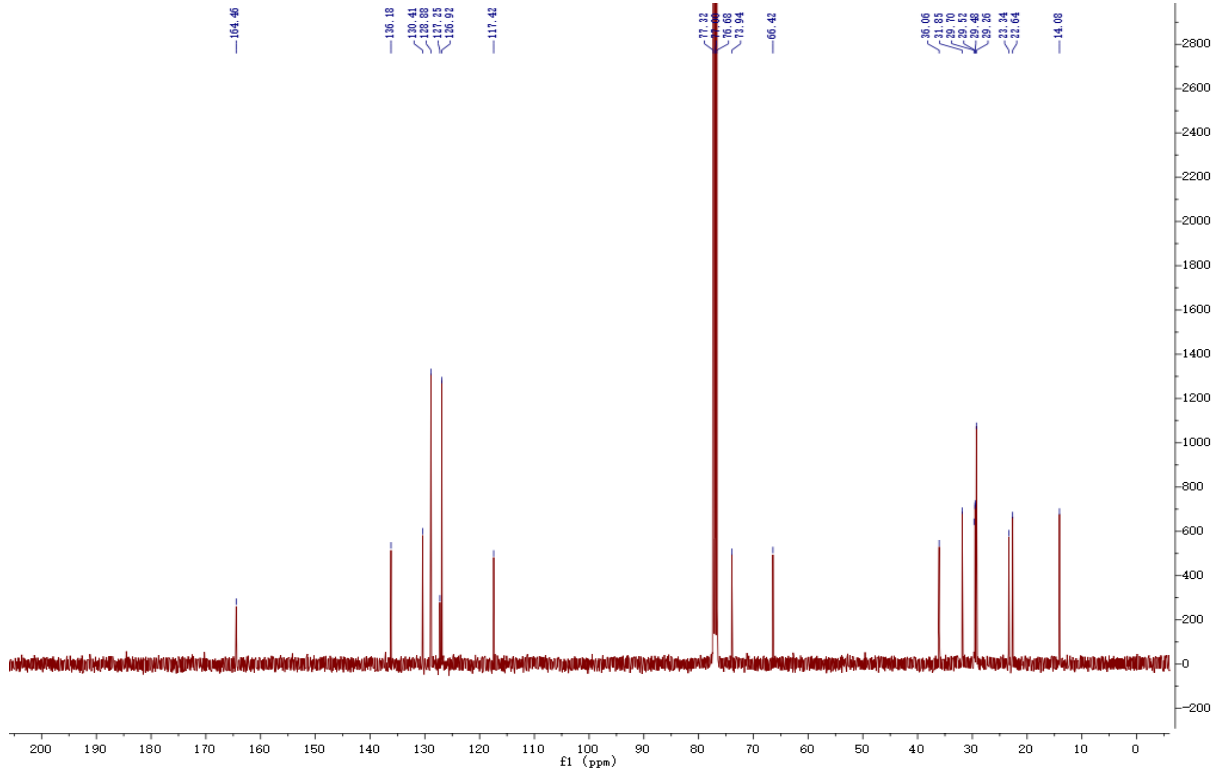
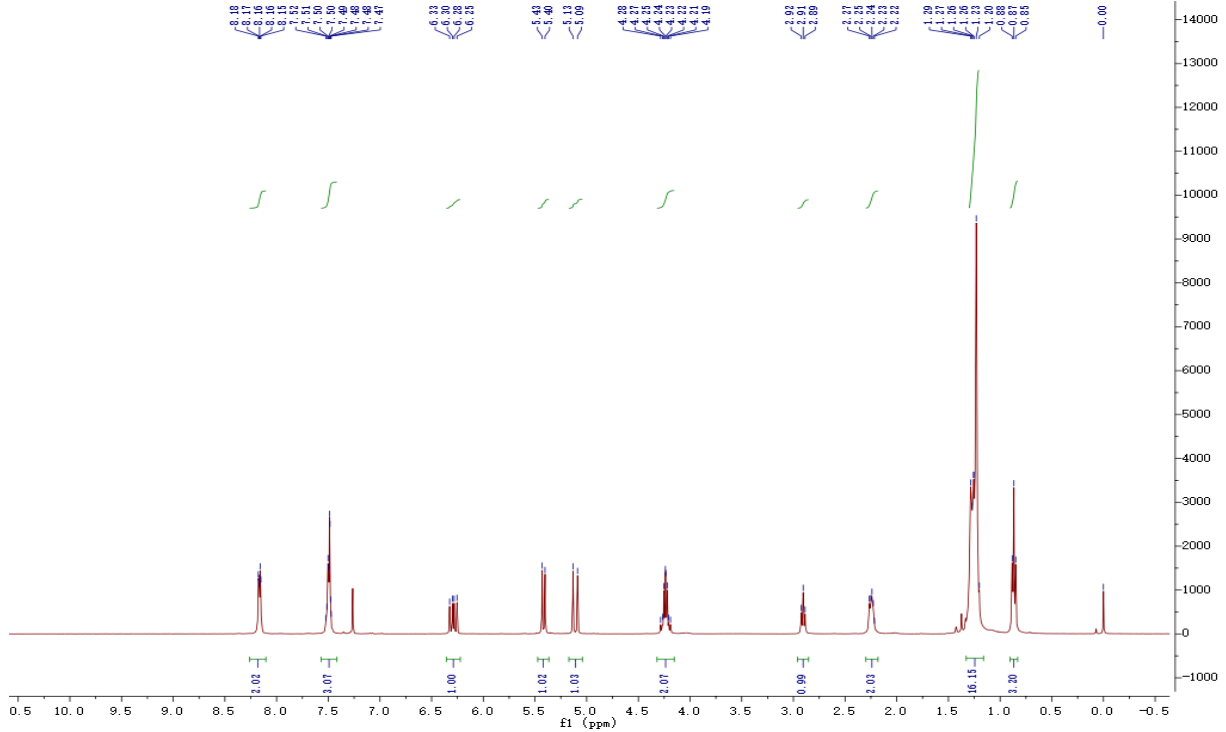
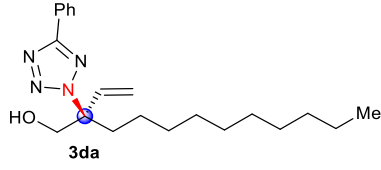




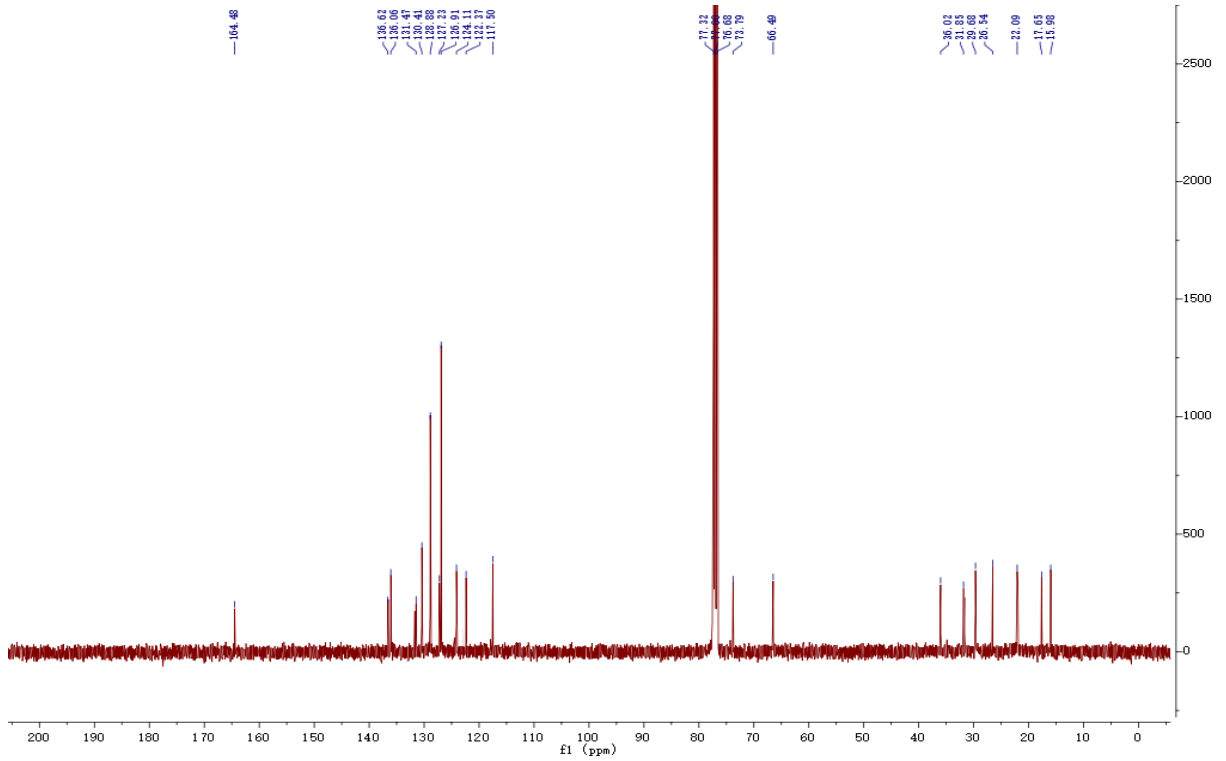
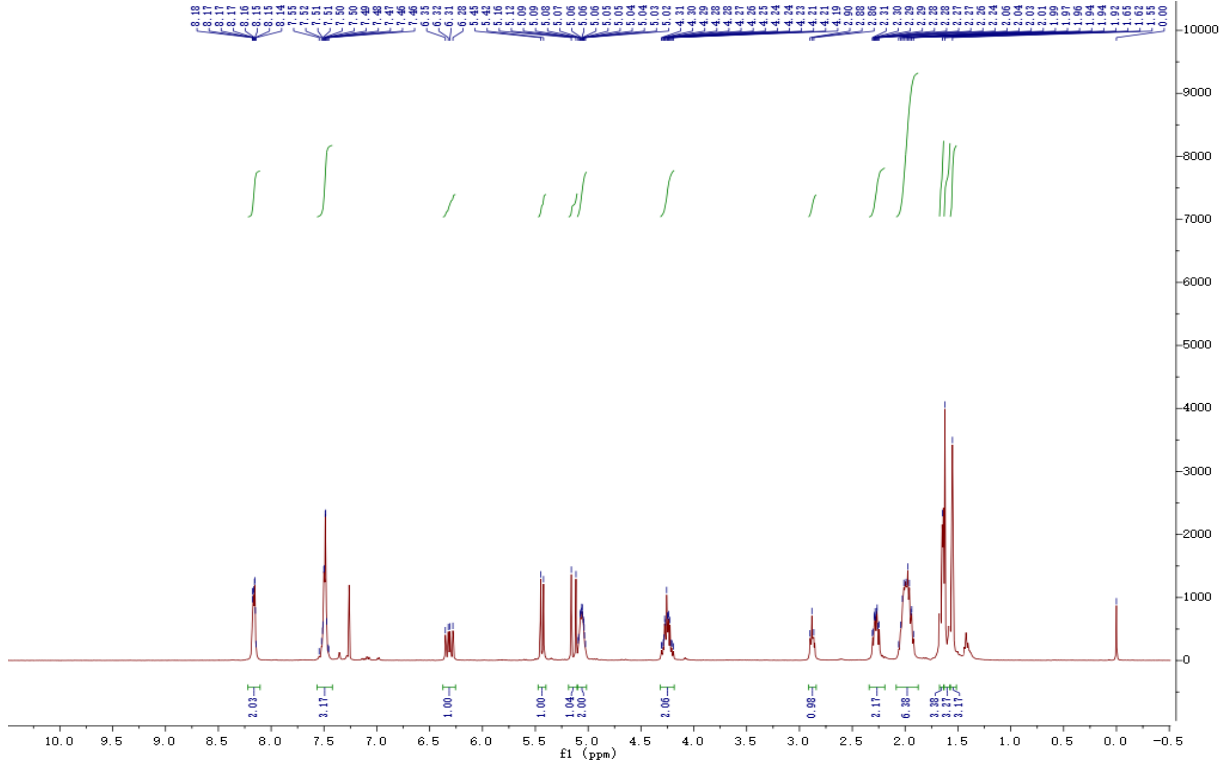
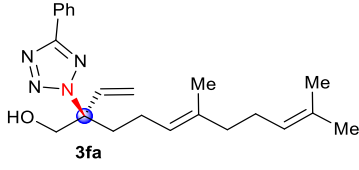








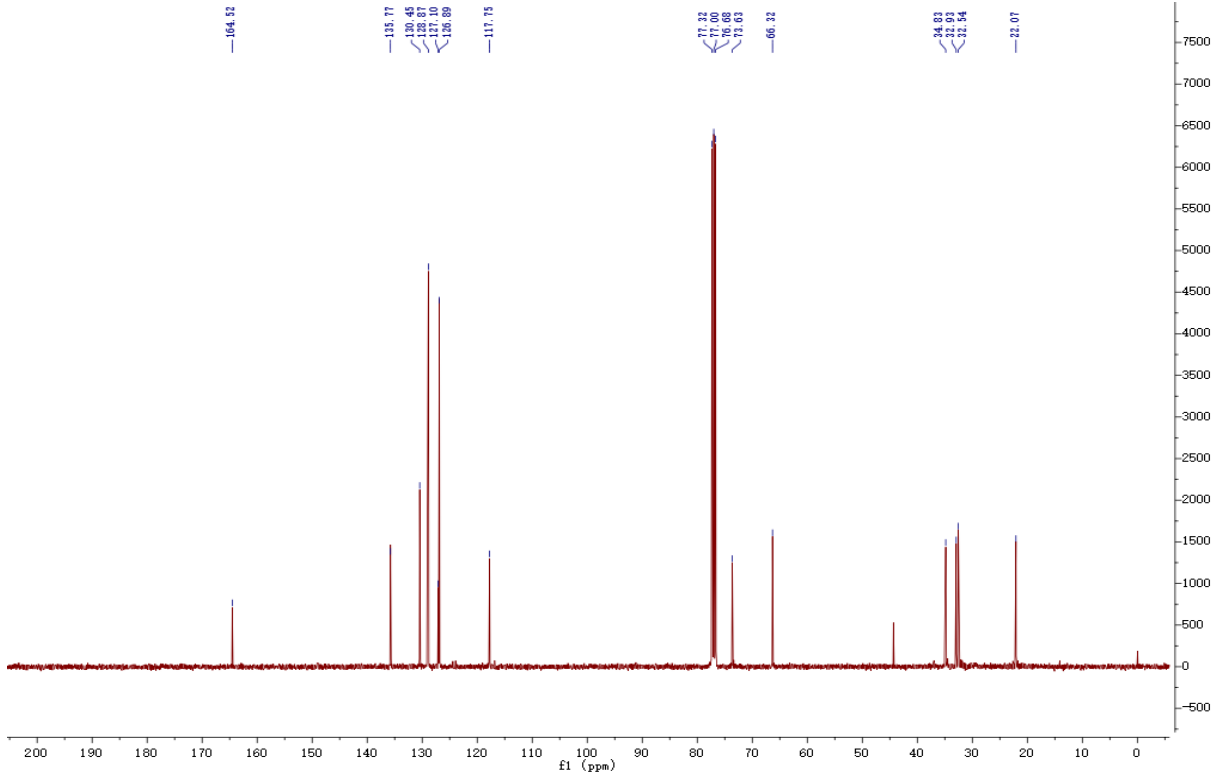
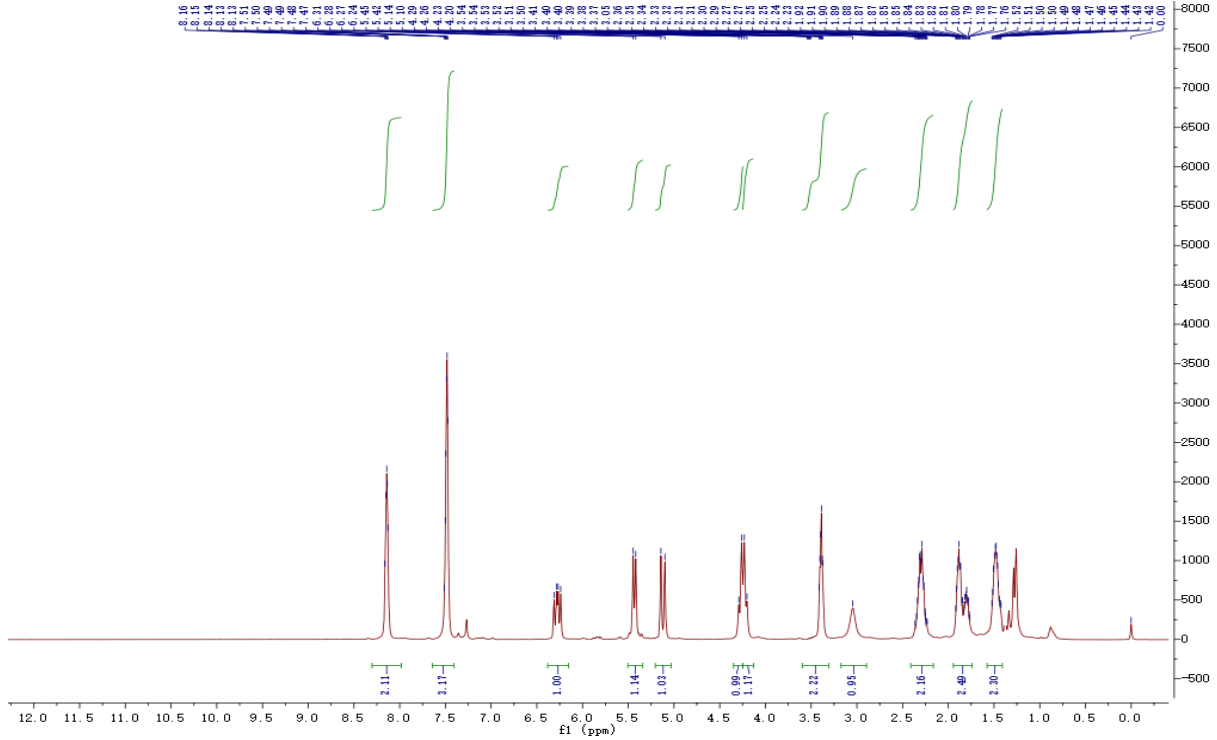
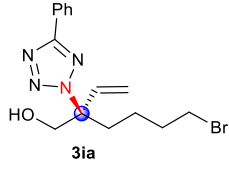




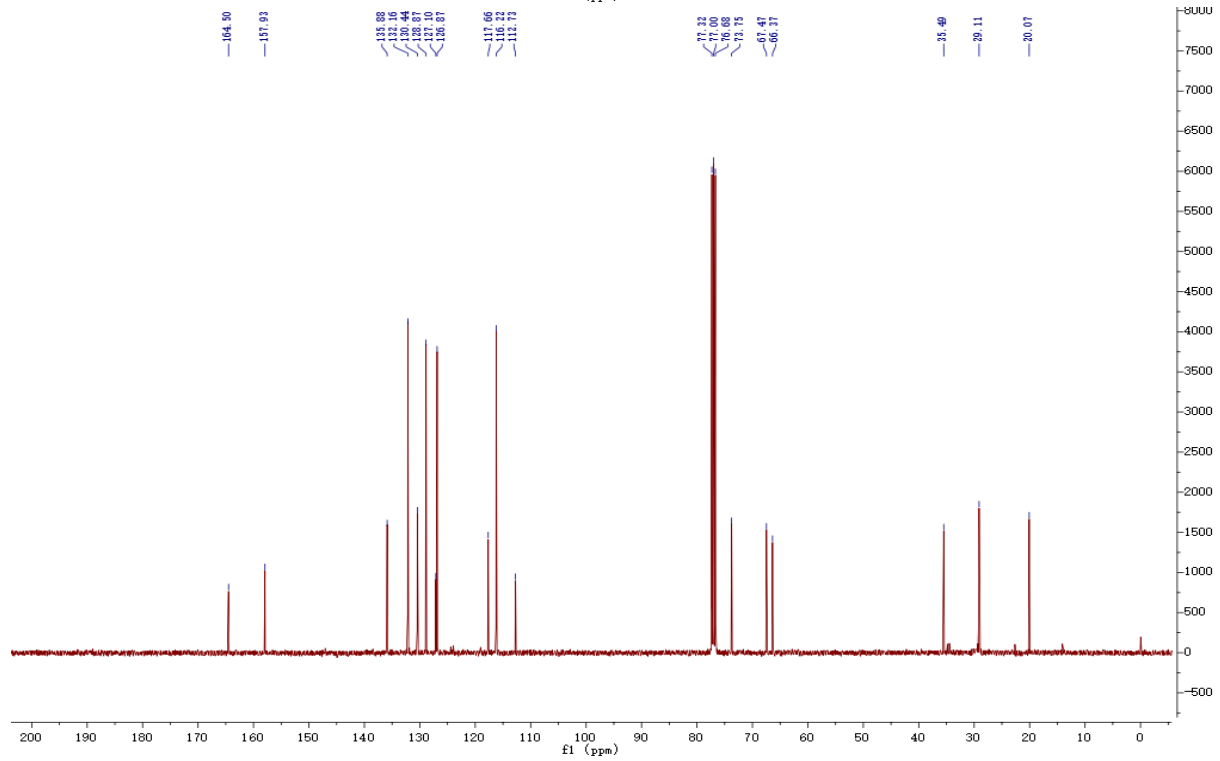
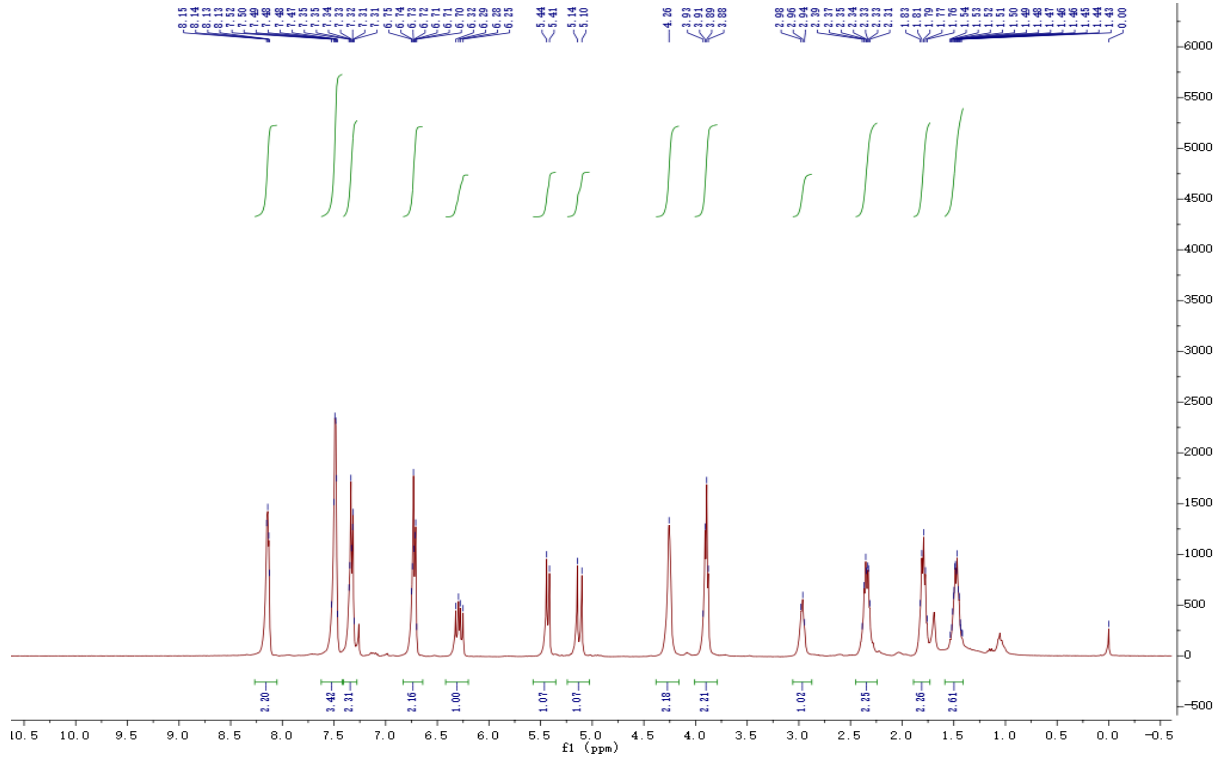
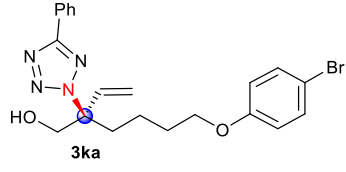


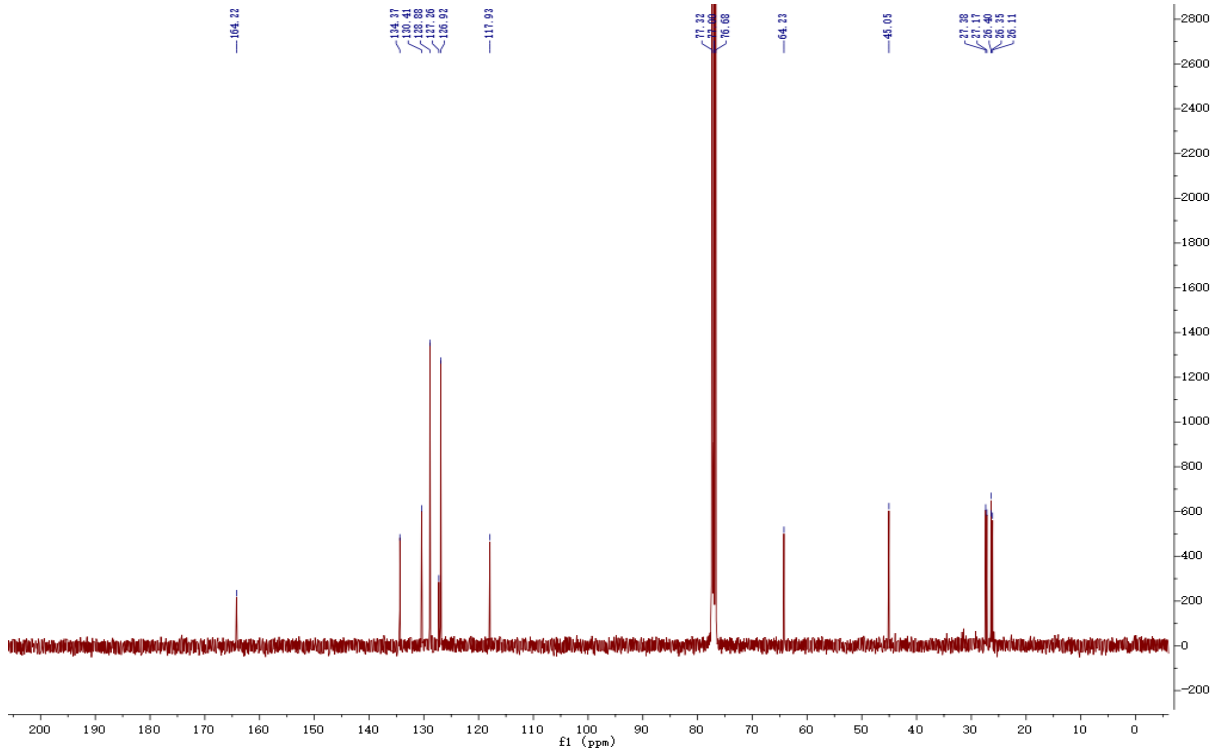
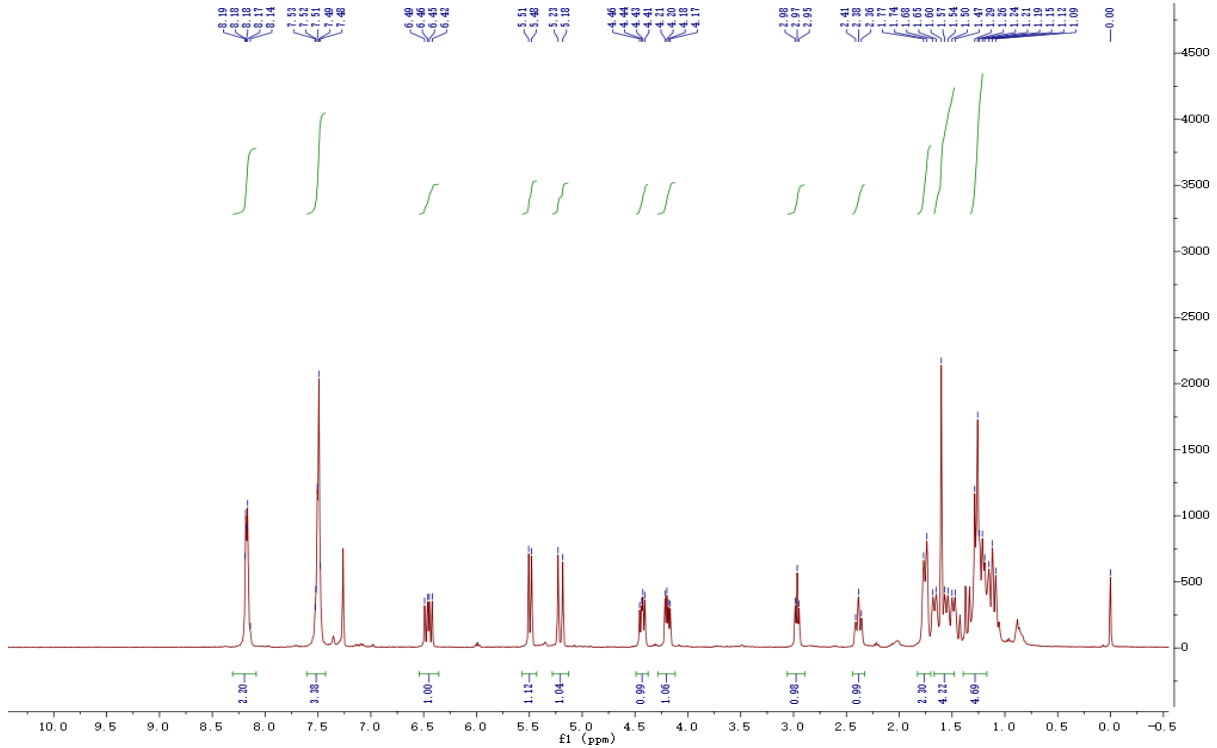
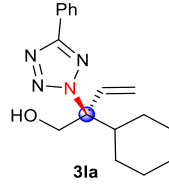


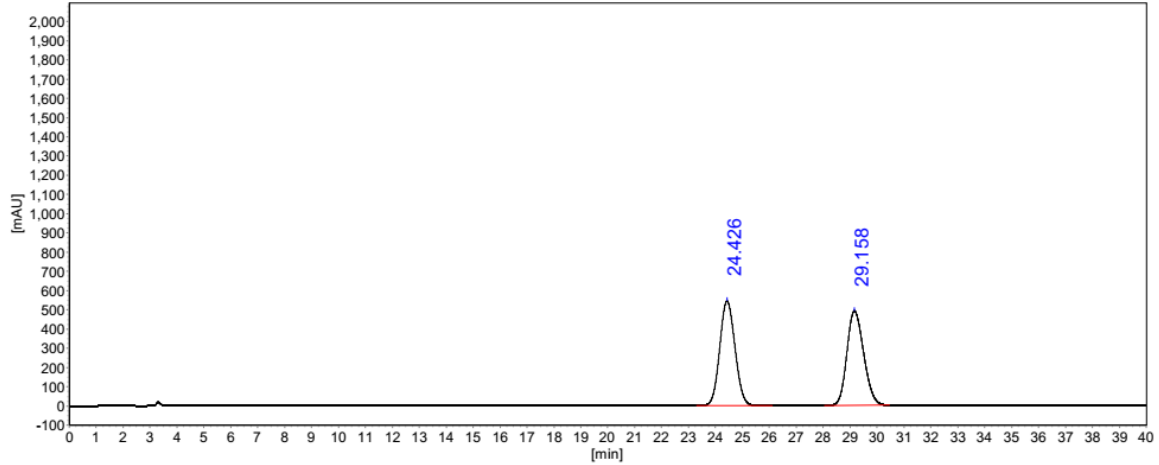
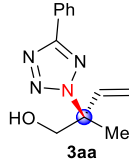






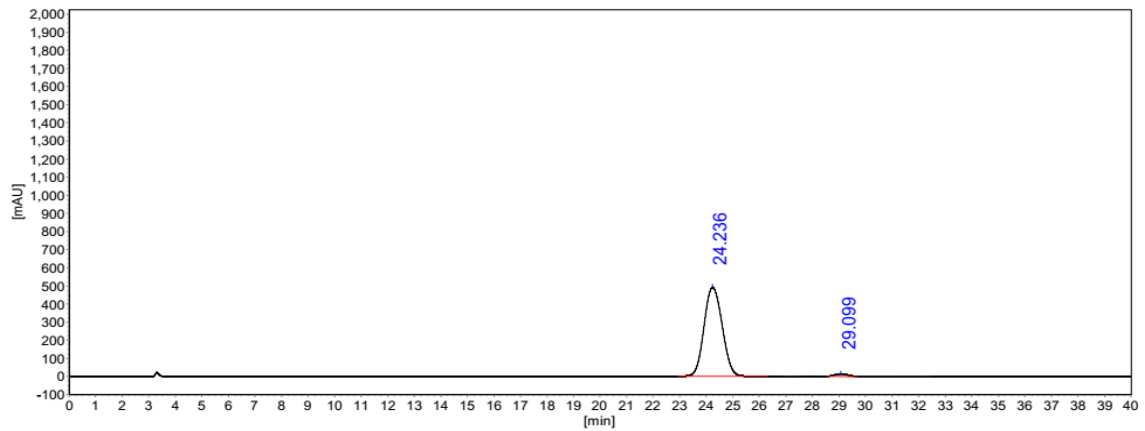






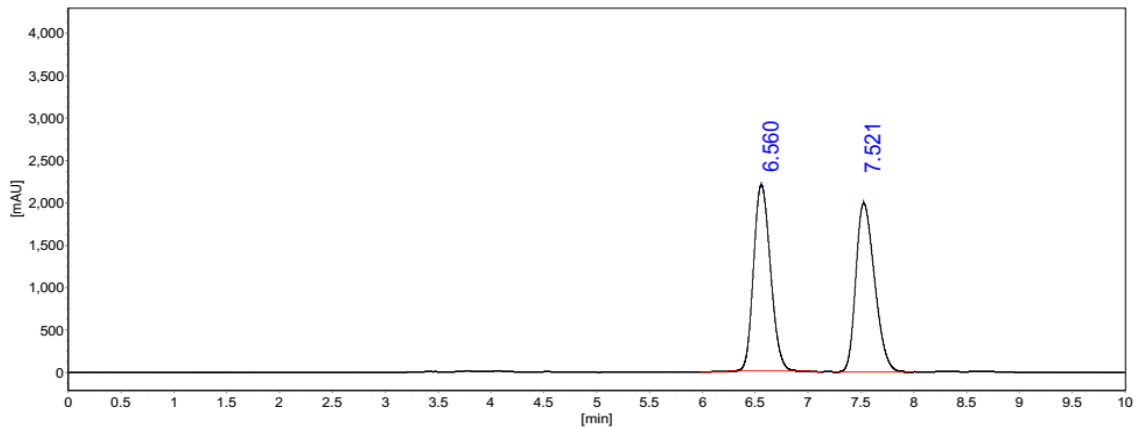
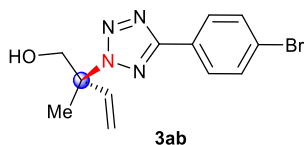
### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		24.426	543704.8	21366769.0	49.9749	49.9749	+ BB
2		29.158	491154.5	21388202.6	50.0251	50.0251	+ BB
<b>Total:</b>			<b>1034859.3</b>	<b>42754971.5</b>	<b>100.0000</b>	<b>100.0000</b>	



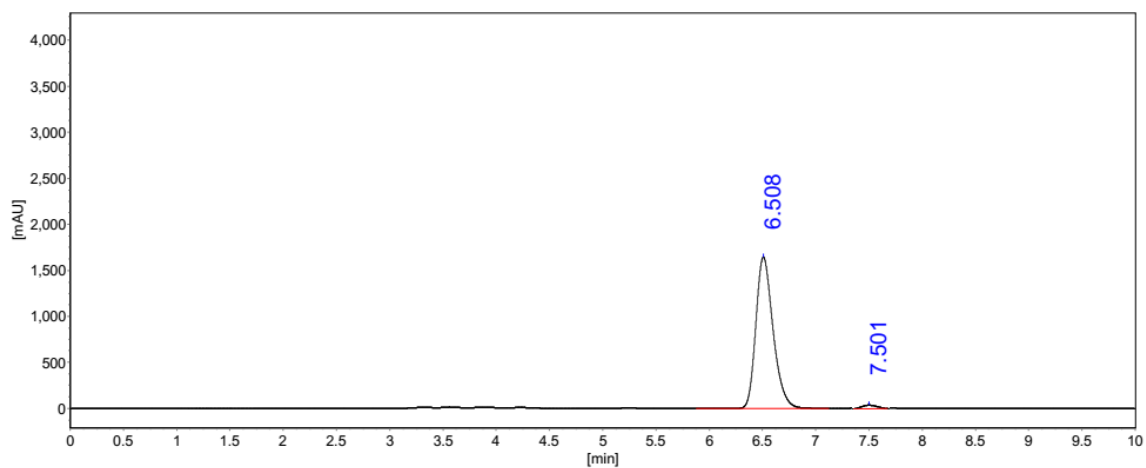
### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		24.236	489726.4	23159156.9	95.9793	95.9793	+ BB
2		29.099	27008.7	1201338.0	4.0207	4.0207	+ BB
<b>Total:</b>			<b>516735.1</b>	<b>24360494.9</b>	<b>100.0000</b>	<b>100.0000</b>	



### Analysis Results

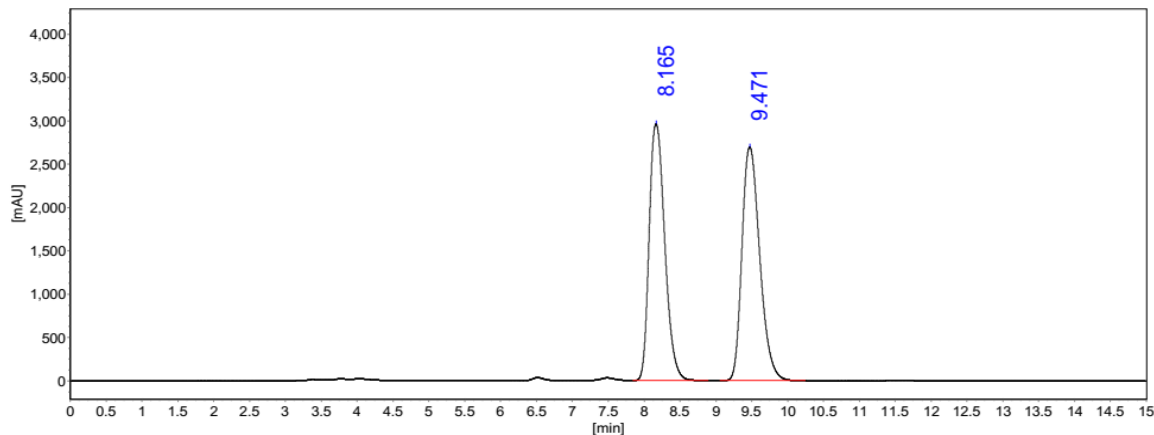
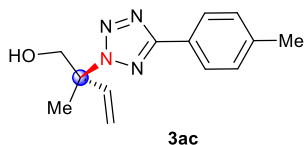
No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		6.560	3341483.0	53478455.3	49.1750	49.1750	+ BB
2		7.521	3244031.2	55272920.5	50.8250	50.8250	+ BB
<b>Total:</b>			<b>6585514.2</b>	<b>108751375.8</b>	<b>100.0000</b>	<b>100.0000</b>	



### Analysis Results

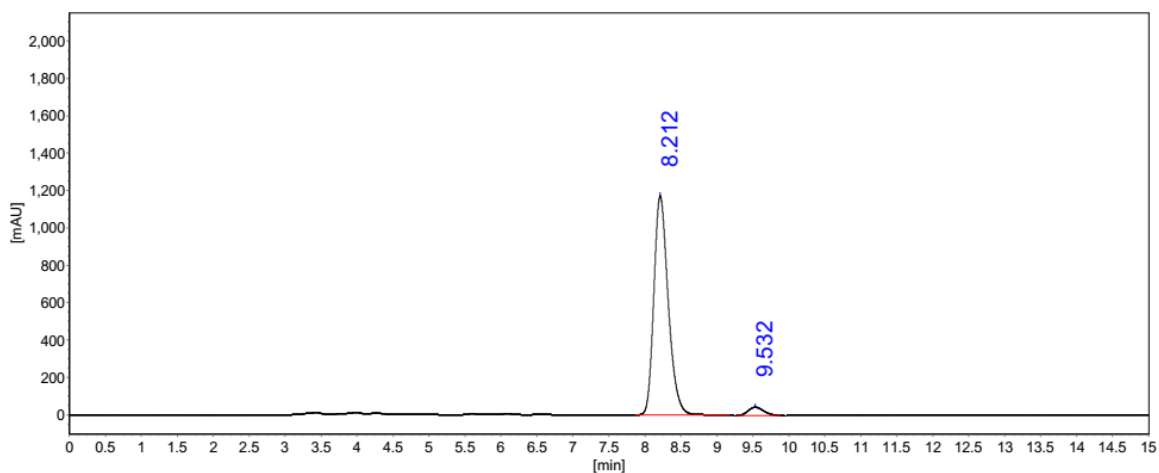
No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		6.508	1644741.6	18475437.8	97.7957	97.7957	+ BB
2		7.501	40172.4	416436.5	2.2043	2.2043	+ BB
<b>Total:</b>			<b>1684914.0</b>	<b>18891874.3</b>	<b>100.0000</b>	<b>100.0000</b>	





### Analysis Results

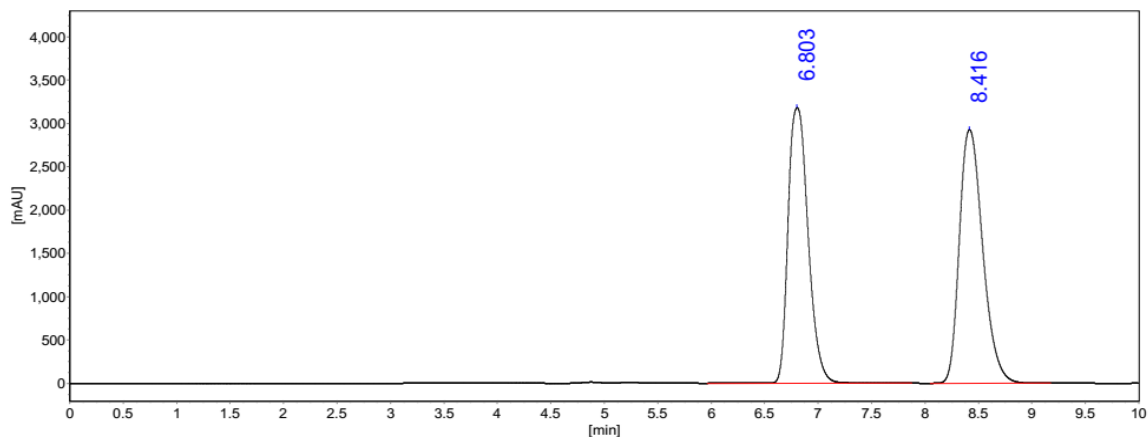
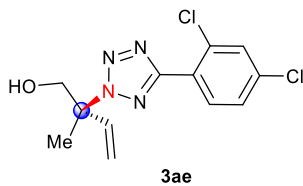
No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		8.165	2963080.6	44765225.5	49.0351	49.0351	+ BB
2		9.471	2700856.4	46526998.1	50.9649	50.9649	+ BB
<b>Total:</b>			<b>5663937.0</b>	<b>91292223.6</b>	<b>100.0000</b>	<b>100.0000</b>	



### Analysis Results

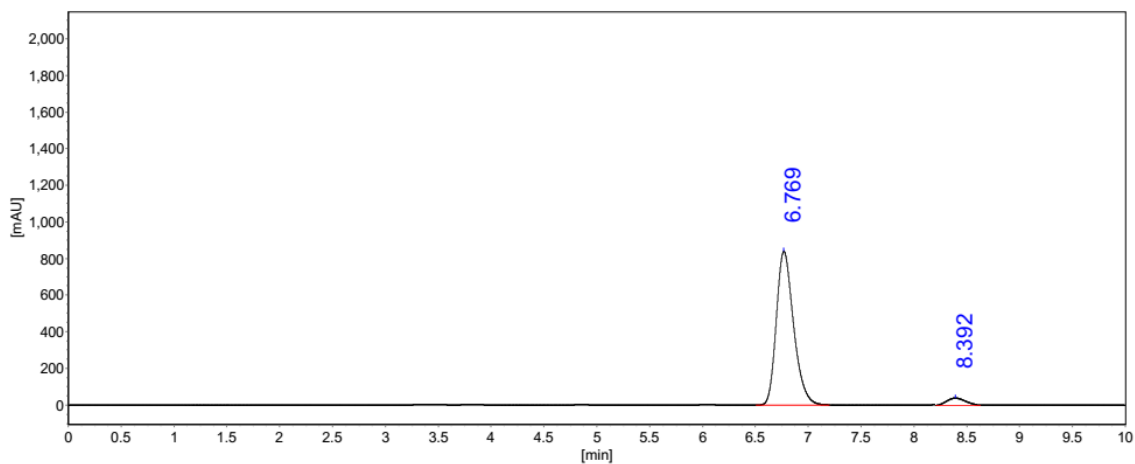
No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		8.212	1171927.1	16180336.9	95.8512	95.8512	+ BB
2		9.532	45652.3	700350.2	4.1488	4.1488	+ BB
<b>Total:</b>			<b>1217579.4</b>	<b>16880687.1</b>	<b>100.0000</b>	<b>100.0000</b>	





### Analysis Results

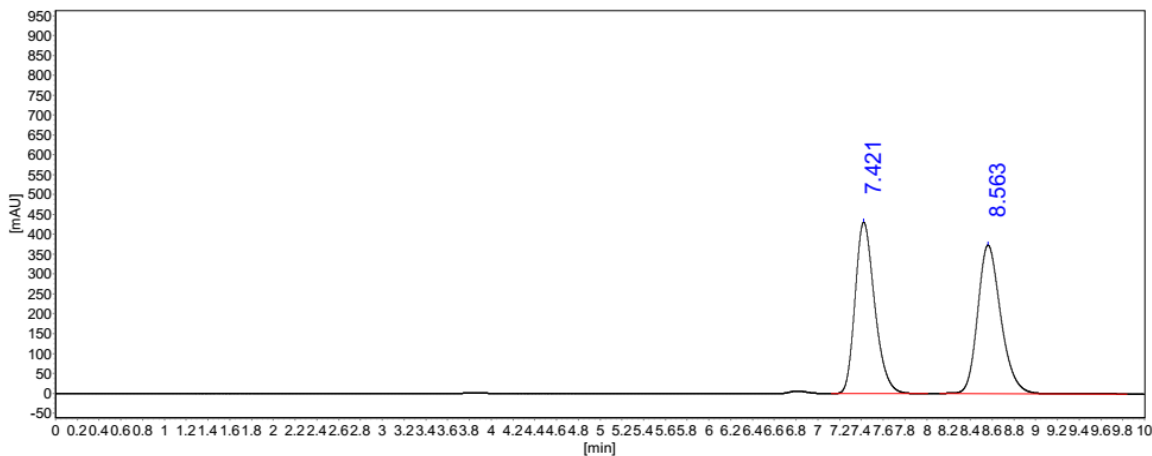
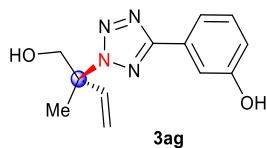
No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		6.803	3181454.8	41454359.7	48.2396	48.2396	+ BB
2		8.416	2928437.8	44479959.3	51.7604	51.7604	+ BB
<b>Total:</b>			<b>6109892.6</b>	<b>85934318.9</b>	<b>100.0000</b>	<b>100.0000</b>	



### Analysis Results

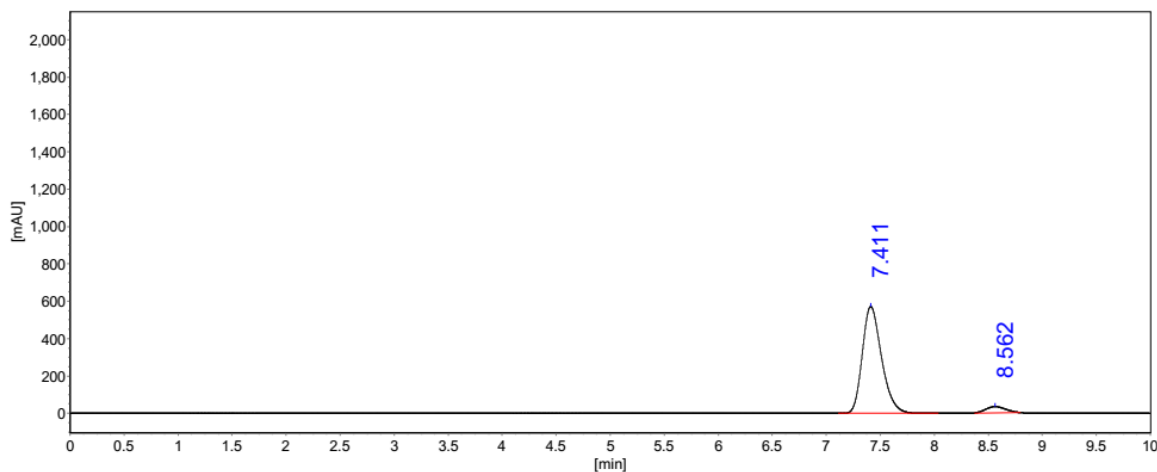
No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		6.769	839787.7	9497410.8	94.8005	94.8005	+ BB
2		8.392	40948.9	520906.7	5.1995	5.1995	+ BB
<b>Total:</b>			<b>880736.6</b>	<b>10018317.5</b>	<b>100.0000</b>	<b>100.0000</b>	





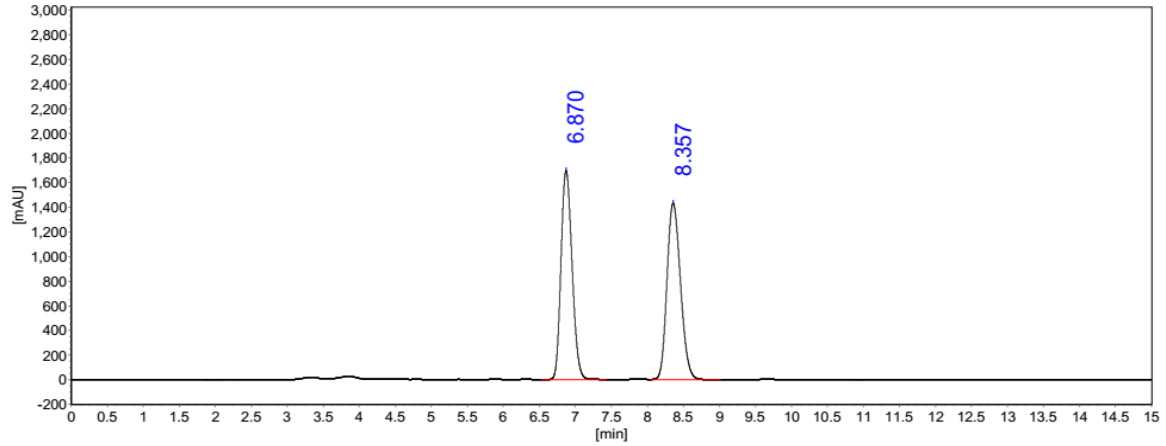
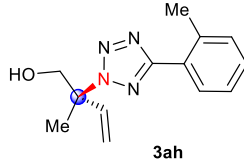
### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		7.421	431485.8	5410075.4	49.5250	49.5250	+ BB
2		8.563	373916.0	5513846.0	50.4750	50.4750	+ BB
<b>Total:</b>			<b>805401.8</b>	<b>10923921.4</b>	<b>100.0000</b>	<b>100.0000</b>	



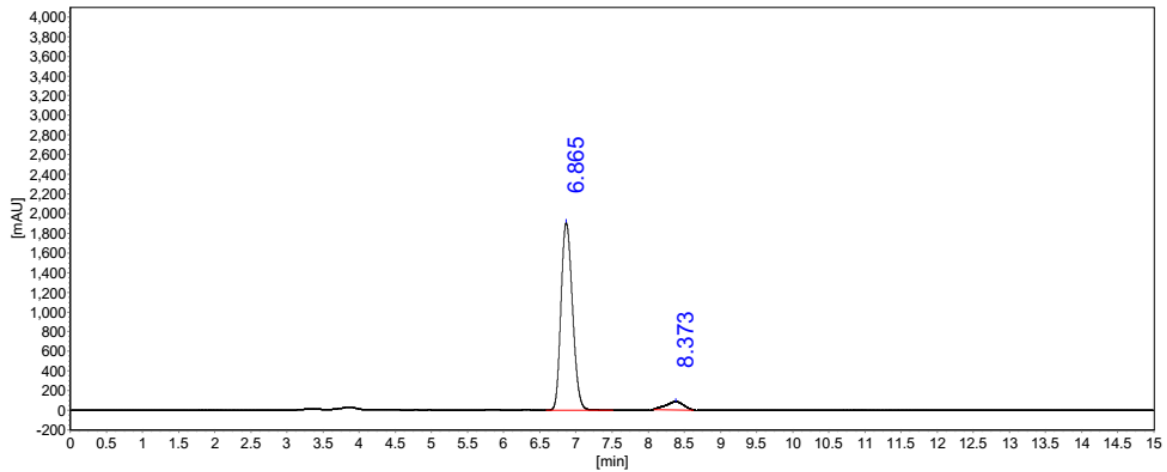
### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		7.411	572413.3	7117180.2	94.4491	94.4491	+ BB
2		8.562	33111.6	418290.1	5.5509	5.5509	+ BB
<b>Total:</b>			<b>605524.9</b>	<b>7535470.3</b>	<b>100.0000</b>	<b>100.0000</b>	



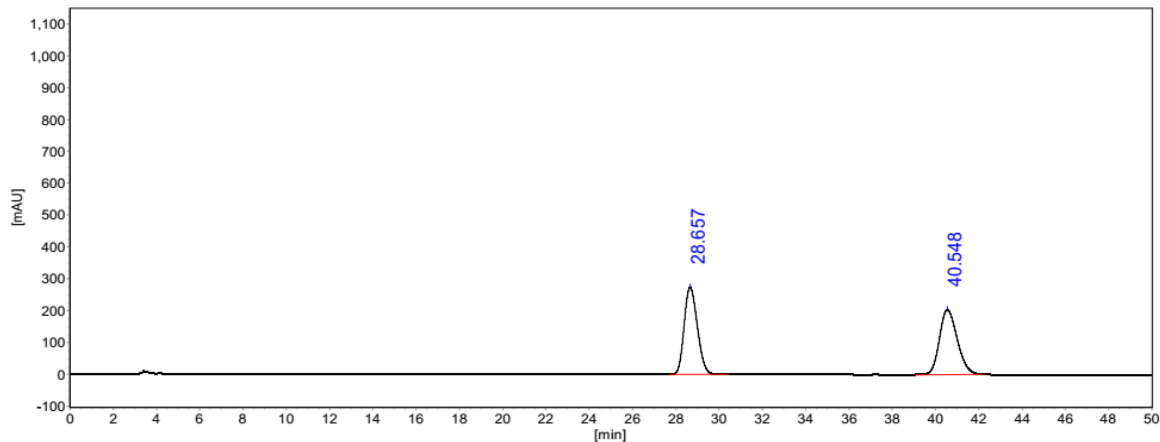
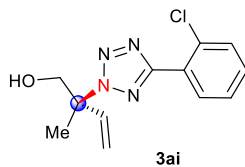
### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		6.870	1696874.0	18188586.2	49.3483	49.3483	+ BB
2		8.357	1432465.3	18668953.6	50.6517	50.6517	+ BB
<b>Total:</b>			<b>3129339.3</b>	<b>36857539.9</b>	<b>100.0000</b>	<b>100.0000</b>	



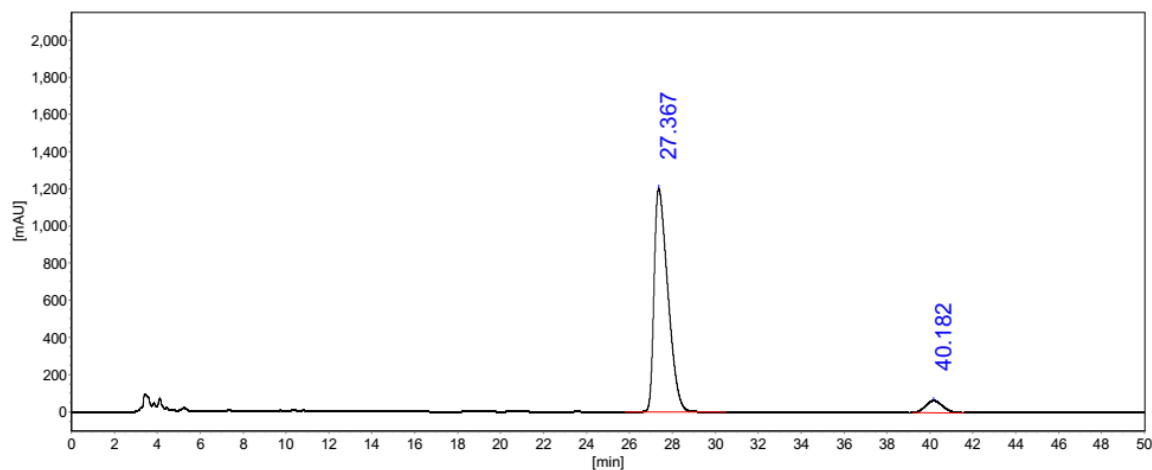
### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		6.865	1906000.4	21120700.0	94.8496	94.8496	+ BB
2		8.373	114515.2	1146864.6	5.1504	5.1504	+ BB
<b>Total:</b>			<b>2020515.6</b>	<b>22267564.6</b>	<b>100.0000</b>	<b>100.0000</b>	



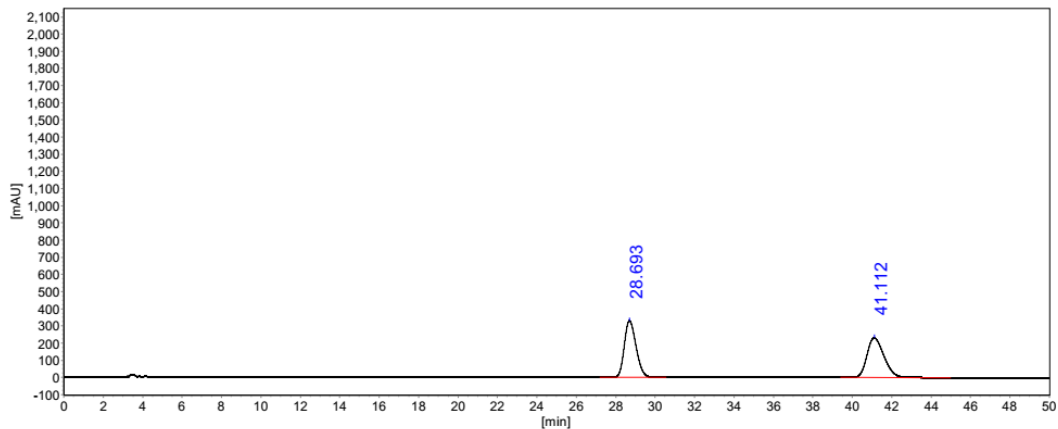
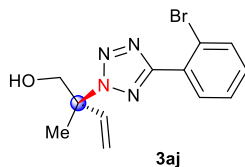
### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		28.657	273846.7	11600505.2	49.9166	49.9166	+ BB
2		40.548	203712.7	11639276.6	50.0834	50.0834	+ BB
<b>Total:</b>			<b>477559.4</b>	<b>23239781.9</b>	<b>100.0000</b>	<b>100.0000</b>	



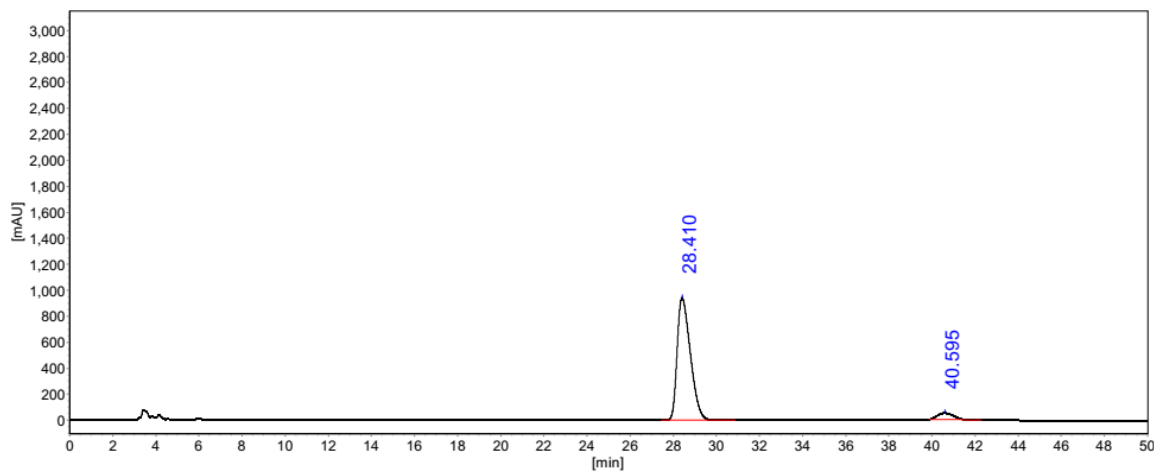
### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		27.367	1202503.8	53365624.3	93.5741	93.5741	+ BB
2		40.182	65298.9	3664741.8	6.4259	6.4259	+ BB
<b>Total:</b>			<b>1267802.7</b>	<b>57030366.2</b>	<b>100.0000</b>	<b>100.0000</b>	



### Analysis Results

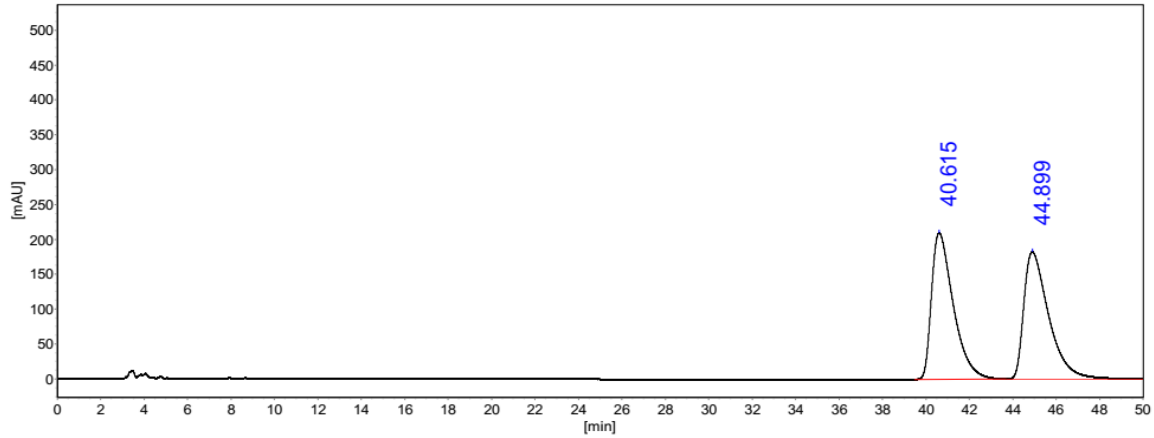
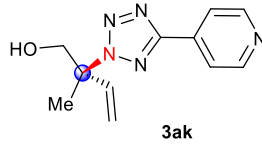
No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		28.693	330858.0	13754039.7	49.8698	49.8698	+ BB
2		41.112	231787.7	13825849.4	50.1302	50.1302	+ BB
<b>Total:</b>			<b>562645.7</b>	<b>27579889.2</b>	<b>100.0000</b>	<b>100.0000</b>	



### Analysis Results

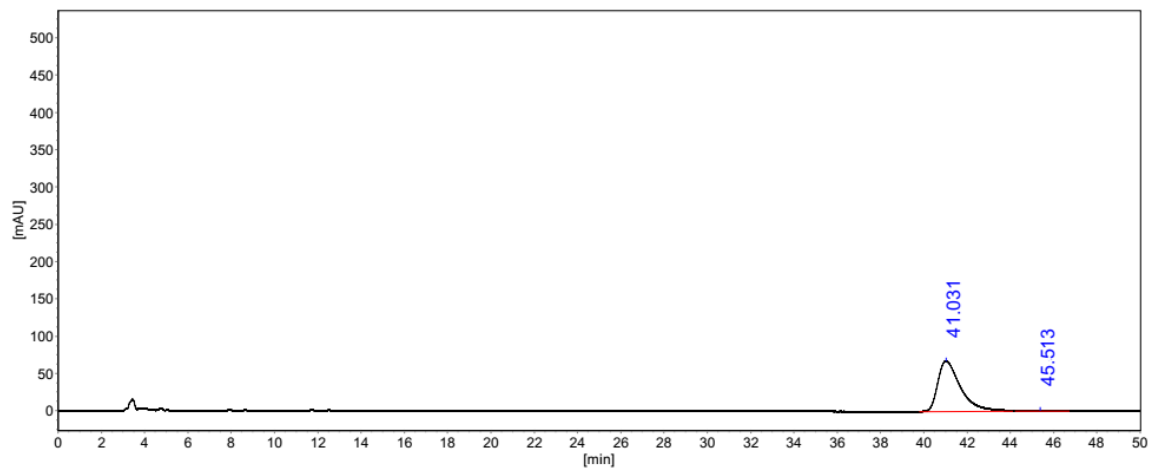
No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		28.410	942911.2	40130869.3	93.8842	93.8842	+ BB
2		40.595	50042.8	2614195.3	6.1158	6.1158	+ BB
<b>Total:</b>			<b>992954.0</b>	<b>42745064.6</b>	<b>100.0000</b>	<b>100.0000</b>	





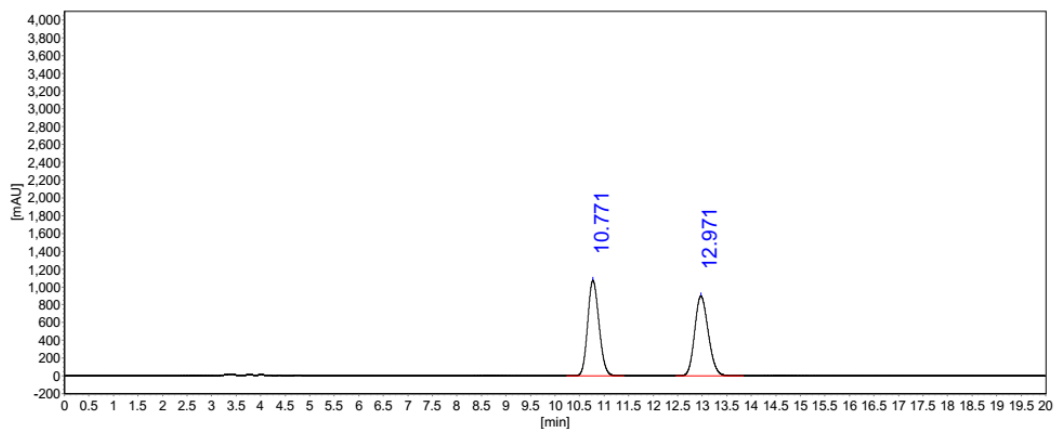
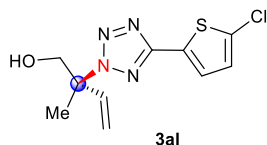
### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		40.615	210411.8	14670000.9	50.1140	50.1140	VV
2		44.899	182771.0	14603251.3	49.8860	49.8860	VB
<b>Total:</b>			<b>393182.8</b>	<b>29273252.2</b>	<b>100.0000</b>	<b>100.0000</b>	



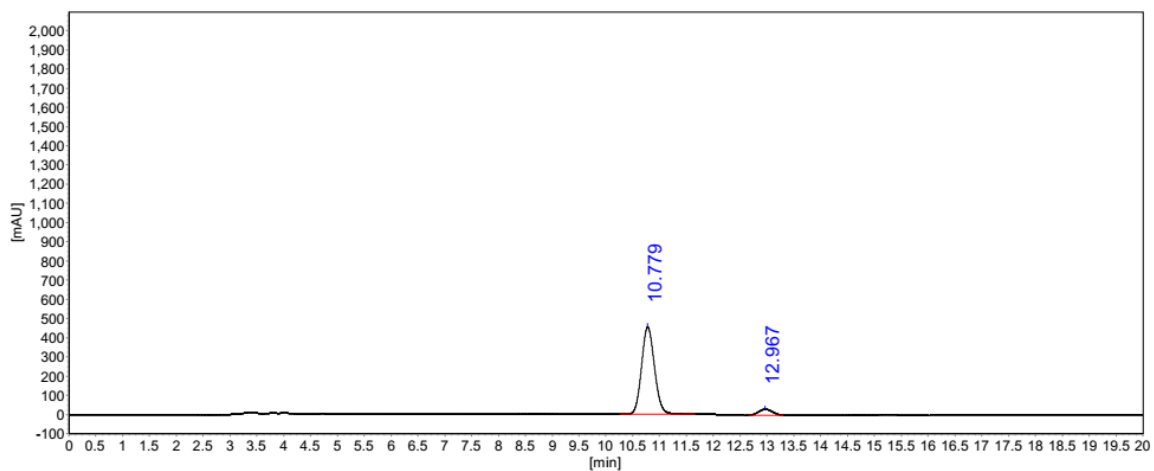
### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		41.031	67620.0	4932396.6	98.9238	98.9238	+ BB
2		45.513	639.5	53657.9	1.0762	1.0762	+ BB
<b>Total:</b>			<b>68259.5</b>	<b>4986054.5</b>	<b>100.0000</b>	<b>100.0000</b>	



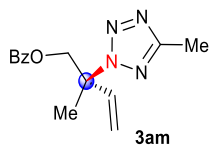
### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		10.771	1073529.5	17207728.1	49.9149	49.9149	+ BB
2		12.971	897082.1	17266371.8	50.0851	50.0851	+ BB
<b>Total:</b>			<b>1970611.6</b>	<b>34474099.9</b>	<b>100.0000</b>	<b>100.0000</b>	

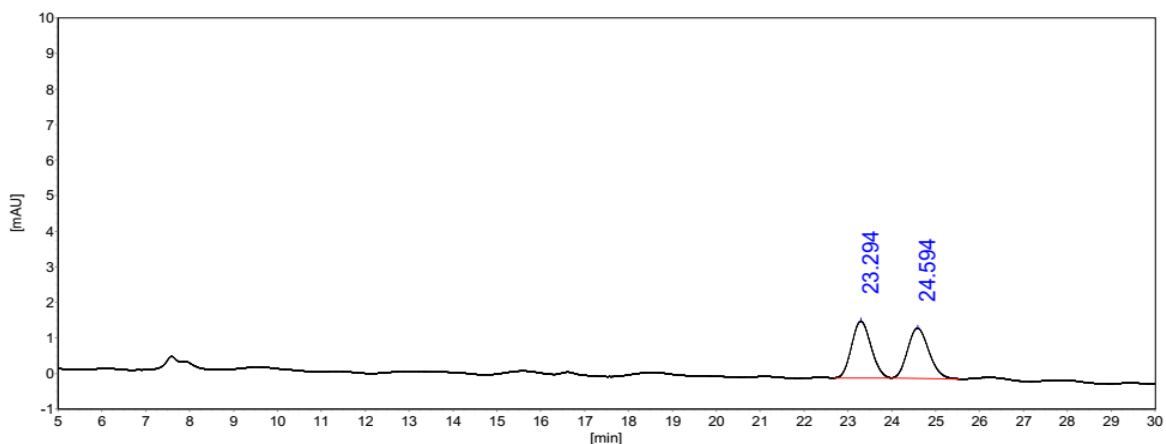


### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		10.779	455405.1	7652329.6	92.9545	92.9545	+ BB
2		12.967	31932.6	580009.2	7.0455	7.0455	+ BB
<b>Total:</b>			<b>487337.7</b>	<b>8232338.8</b>	<b>100.0000</b>	<b>100.0000</b>	

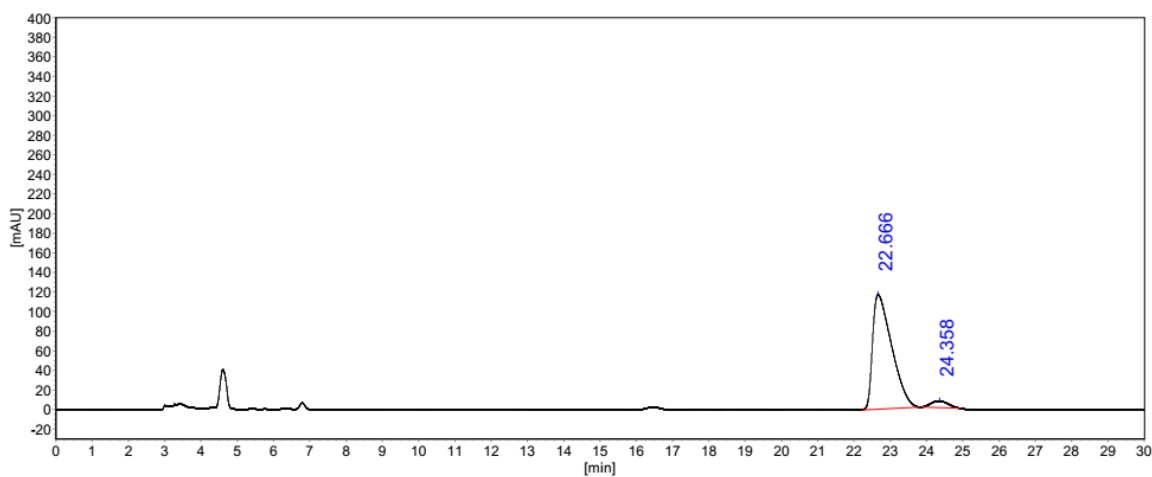


Comment:



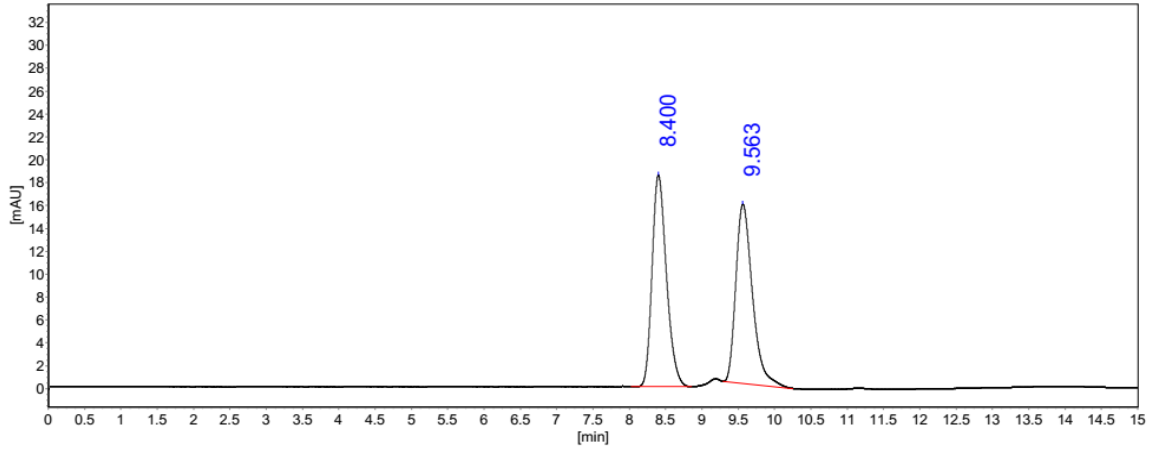
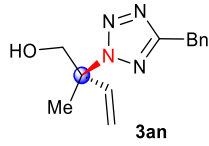
### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		23.294	1593.7	49168.0	50.9182	50.9182	+ BB
2		24.594	1412.5	47394.8	49.0818	49.0818	+ BB
<b>Total:</b>			<b>3006.2</b>	<b>96562.8</b>	<b>100.0000</b>	<b>100.0000</b>	



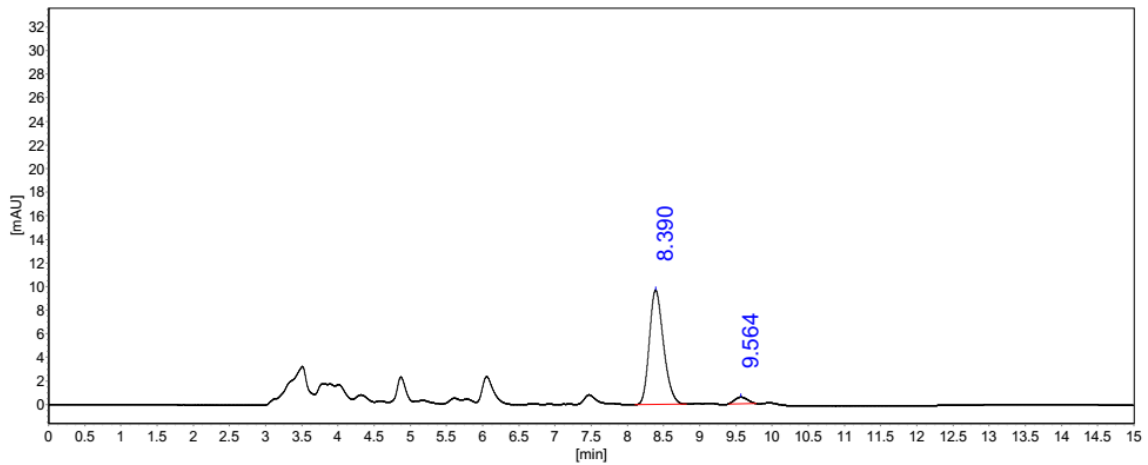
### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		22.666	116763.1	4276674.8	94.9100	94.9100	+ BB
2		24.358	6938.7	229358.5	5.0900	5.0900	+ BB
<b>Total:</b>			<b>123701.8</b>	<b>4506033.3</b>	<b>100.0000</b>	<b>100.0000</b>	



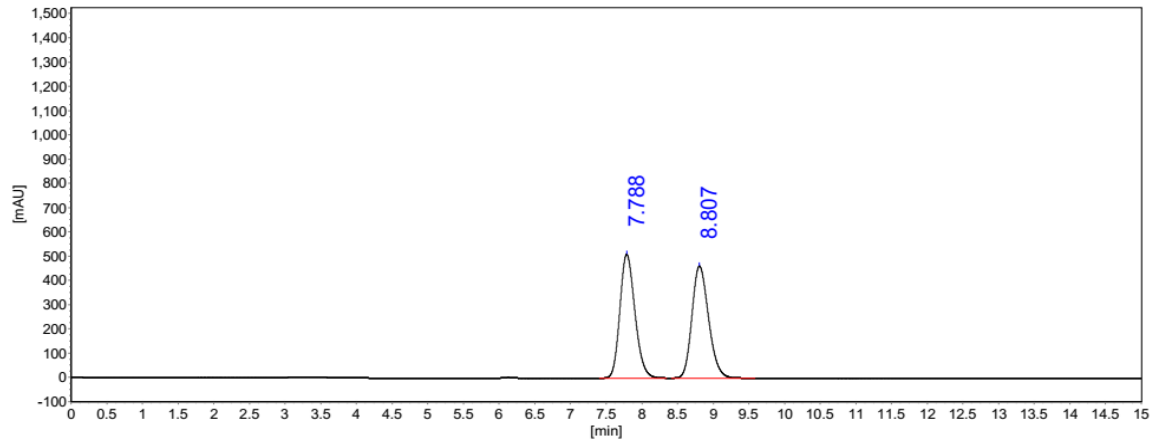
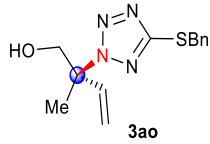
### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		8.400	18506.3	254981.4	50.5312	50.5312	+ BB
2		9.563	15670.9	249620.2	49.4688	49.4688	+ BB
<b>Total:</b>			<b>34177.2</b>	<b>504601.5</b>	<b>100.0000</b>	<b>100.0000</b>	



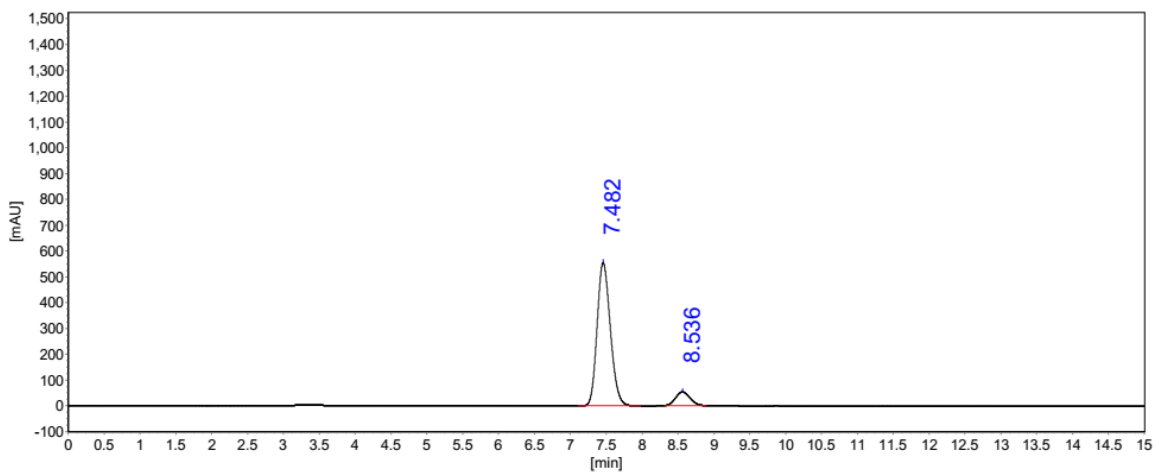
### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		8.390	9713.8	132533.4	95.0327	95.0327	+ BB
2		9.564	561.0	6927.4	4.9673	4.9673	+ BB
<b>Total:</b>			<b>10274.8</b>	<b>139460.8</b>	<b>100.0000</b>	<b>100.0000</b>	



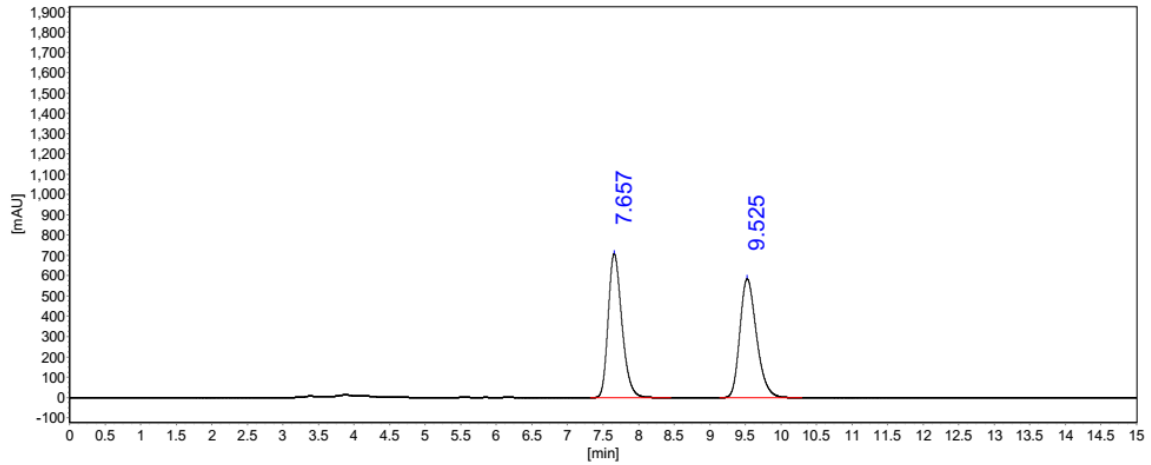
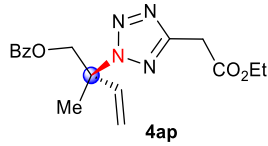
### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		7.788	510550.3	7480254.6	49.9955	49.9955	+ BB
2		8.807	462128.0	7481589.4	50.0045	50.0045	+ BB
<b>Total:</b>			<b>972678.3</b>	<b>14961843.9</b>	<b>100.0000</b>	<b>100.0000</b>	



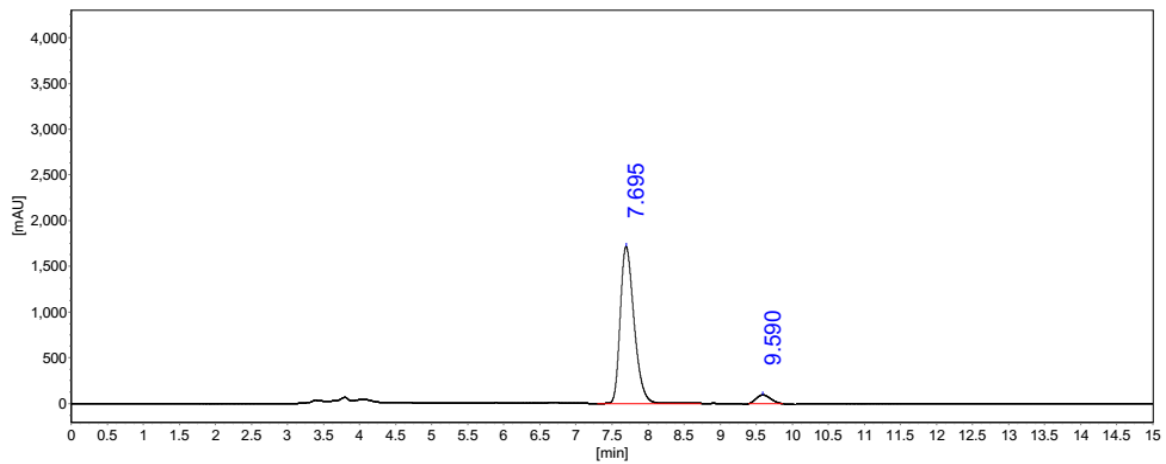
### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		7.482	554583.3	7119339.1	90.4468	90.4468	+ BB
2		8.536	53325.6	751962.7	9.5532	9.5532	+ BB
<b>Total:</b>			<b>607908.9</b>	<b>7871301.8</b>	<b>100.0000</b>	<b>100.0000</b>	



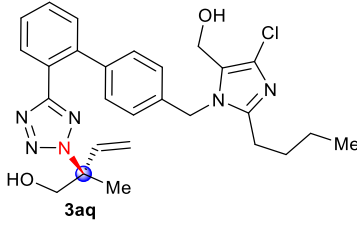
### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		7.657	709900.8	9500771.3	49.9121	49.9121	+ BB
2		9.525	586475.7	9534221.5	50.0879	50.0879	+ BB
<b>Total:</b>			<b>1296376.5</b>	<b>19034992.9</b>	<b>100.0000</b>	<b>100.0000</b>	

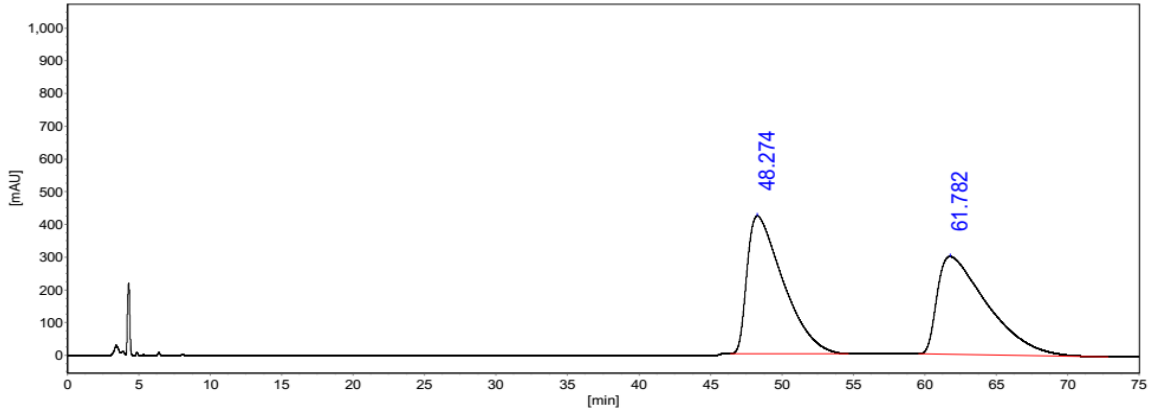


### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		7.695	1715841.2	22824736.0	94.4201	94.4201	+ BB
2		9.590	96398.9	1348871.6	5.5799	5.5799	+ BB
<b>Total:</b>			<b>1812240.1</b>	<b>24173607.6</b>	<b>100.0000</b>	<b>100.0000</b>	



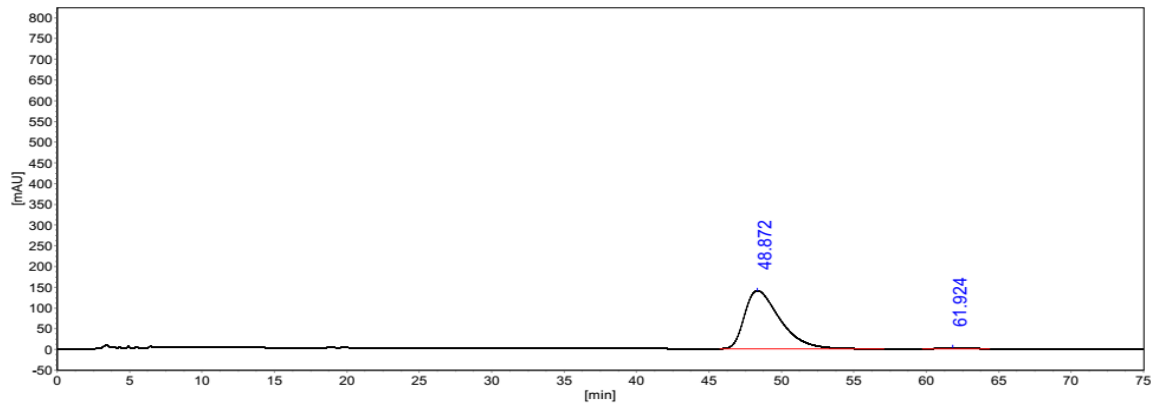
Comment:



### Analysis Results

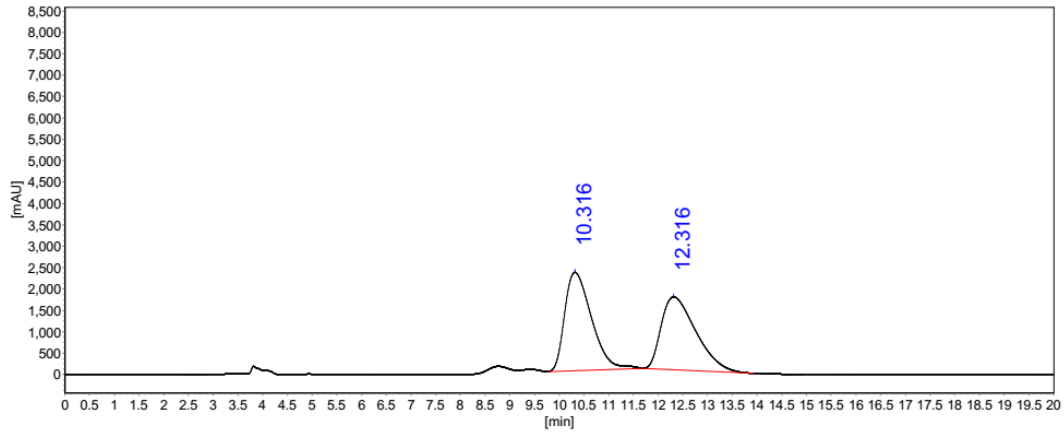
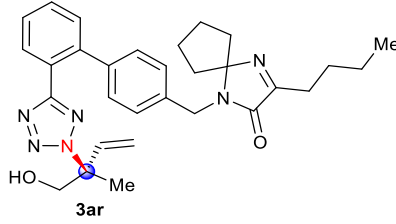
No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		48.274	421129.7	73767610.9	50.3857	50.3857	+ BB
2		61.782	298646.2	72638123.5	49.6143	49.6143	+ BB
<b>Total:</b>			<b>719775.9</b>	<b>146405734.4</b>	<b>100.0000</b>	<b>100.0000</b>	

Comment:



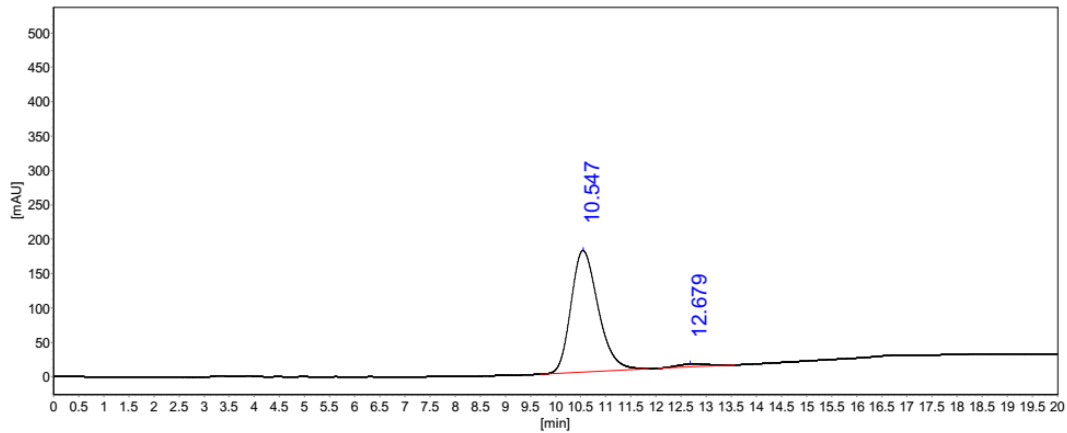
### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		48.872	139987.8	23789859.2	98.5715	98.5715	+ BB
2		61.924	2142.9	344770.2	1.4285	1.4285	+ BB
<b>Total:</b>			<b>142130.7</b>	<b>24134629.4</b>	<b>100.0000</b>	<b>100.0000</b>	



### Analysis Results

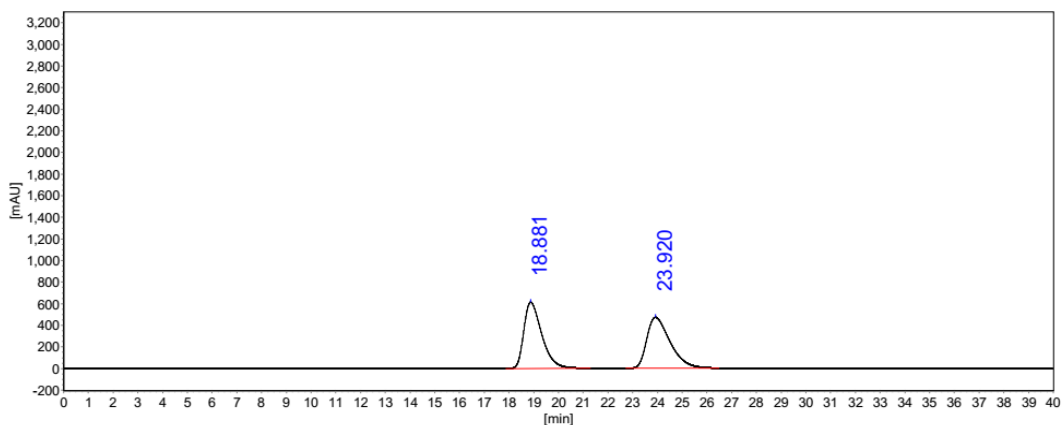
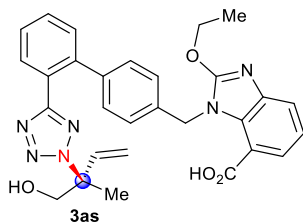
No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		10.316	2295601.6	86586051.0	51.0571	51.0571	+ BB
2		12.316	1701760.4	83000795.0	48.9429	48.9429	+ BB
<b>Total:</b>			<b>3997362.0</b>	<b>169586846.0</b>	<b>100.0000</b>	<b>100.0000</b>	



### Analysis Results

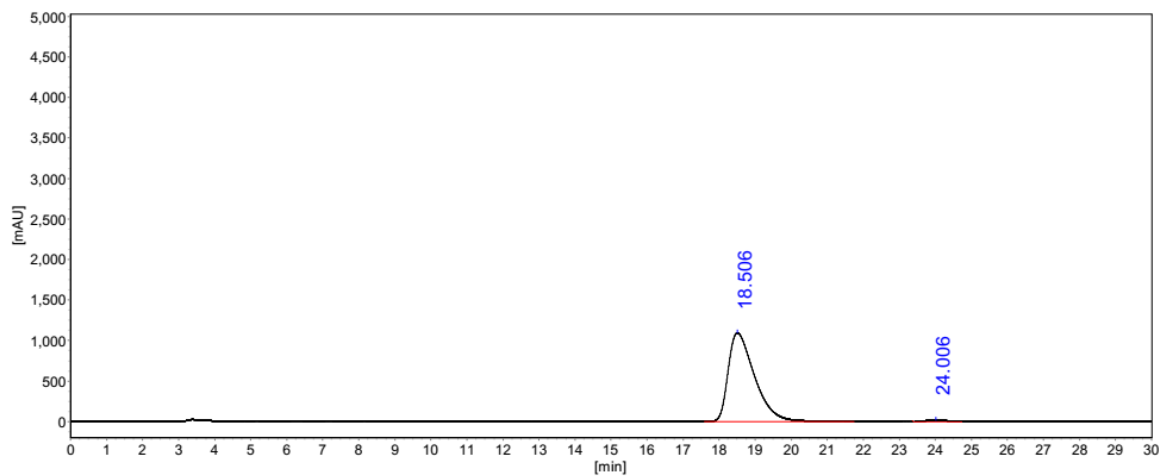
No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		10.547	176776.3	6635581.9	97.3876	97.3876	+ BB
2		12.679	4204.4	177998.4	2.6124	2.6124	+ BB
<b>Total:</b>			<b>180980.7</b>	<b>6813580.3</b>	<b>100.0000</b>	<b>100.0000</b>	





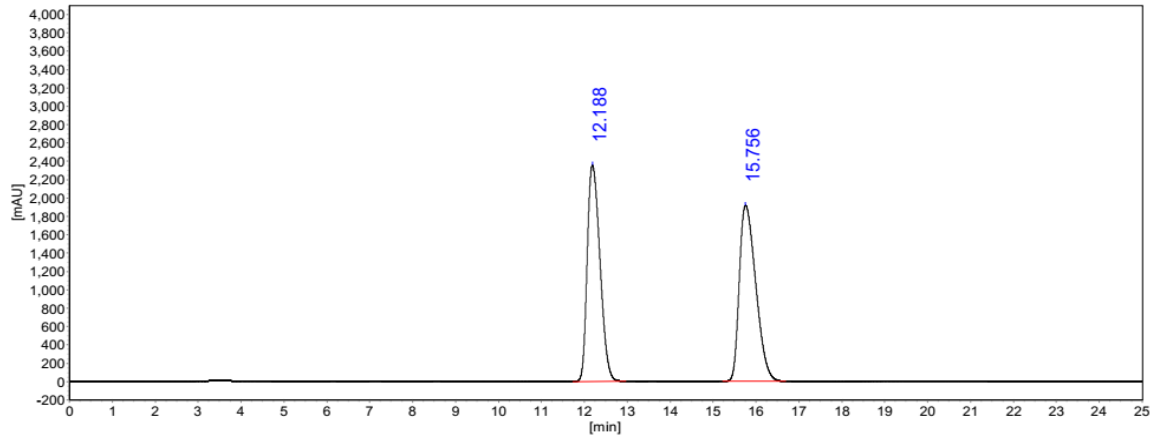
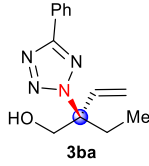
### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		18.881	612945.8	30999556.6	50.0782	50.0782	+ BB
2		23.920	471712.5	30902756.3	49.9218	49.9218	+ BB
<b>Total:</b>			<b>1084658.3</b>	<b>61902313.0</b>	<b>100.0000</b>	<b>100.0000</b>	



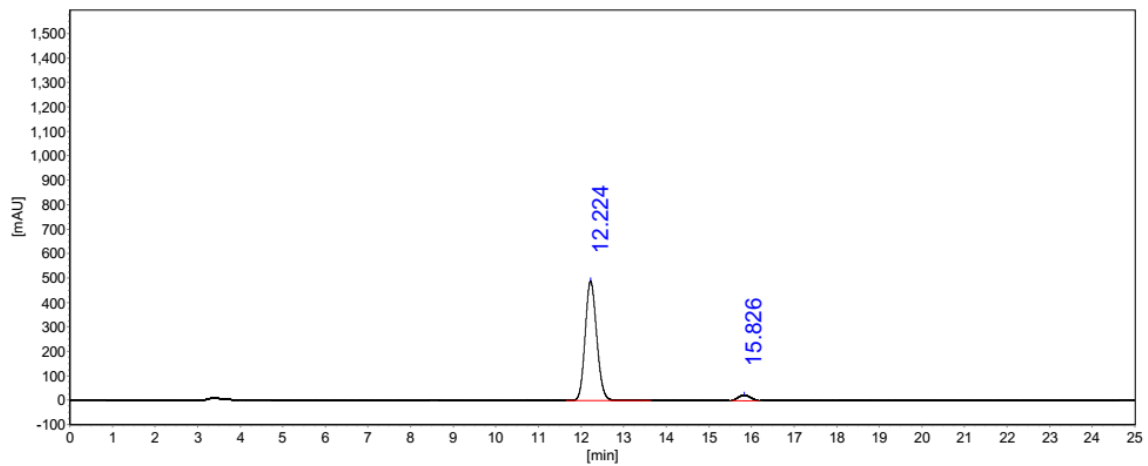
### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		18.506	1093737.6	55264062.7	98.0291	98.0291	+ BB
2		24.006	22608.3	1111121.5	1.9709	1.9709	+ BB
<b>Total:</b>			<b>1116345.9</b>	<b>56375184.1</b>	<b>100.0000</b>	<b>100.0000</b>	



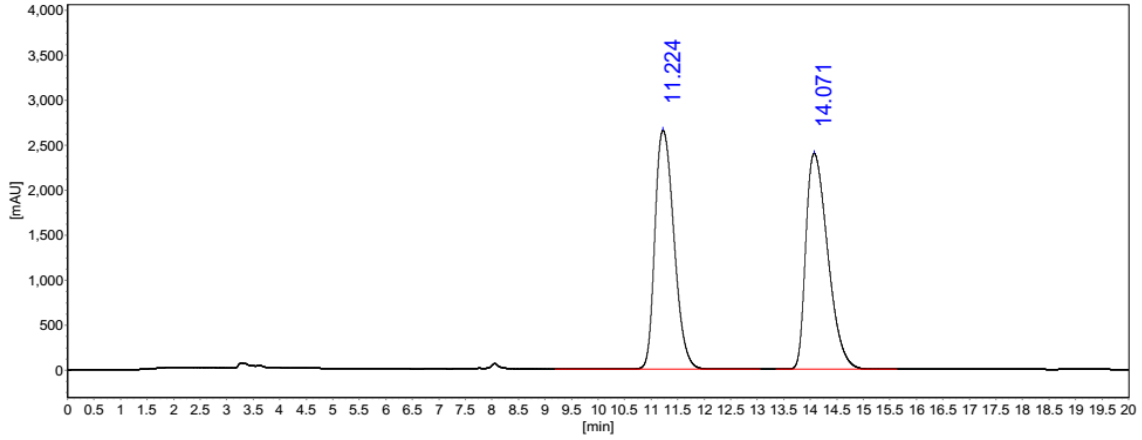
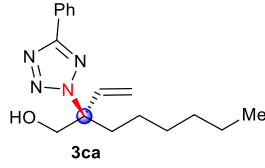
### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		12.188	2355267.6	48494692.8	48.6928	48.6928	+ BB
2		15.756	1919070.0	51098551.6	51.3072	51.3072	+ BB
<b>Total:</b>			<b>4274337.6</b>	<b>99593244.4</b>	<b>100.0000</b>	<b>100.0000</b>	



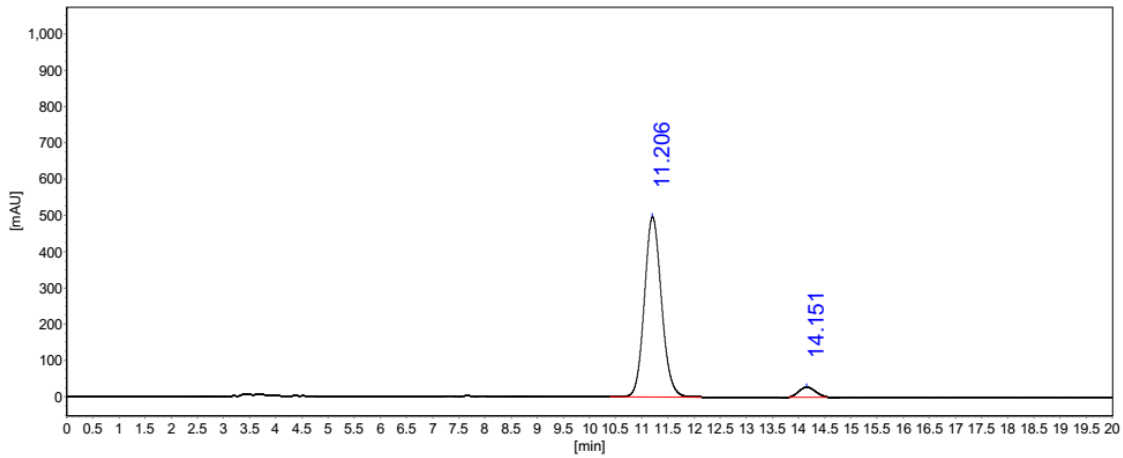
### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		12.224	488613.4	9187976.9	95.1228	95.1228	+ BB
2		15.826	23023.3	471097.0	4.8772	4.8772	+ BB
<b>Total:</b>			<b>511636.7</b>	<b>9659073.9</b>	<b>100.0000</b>	<b>100.0000</b>	



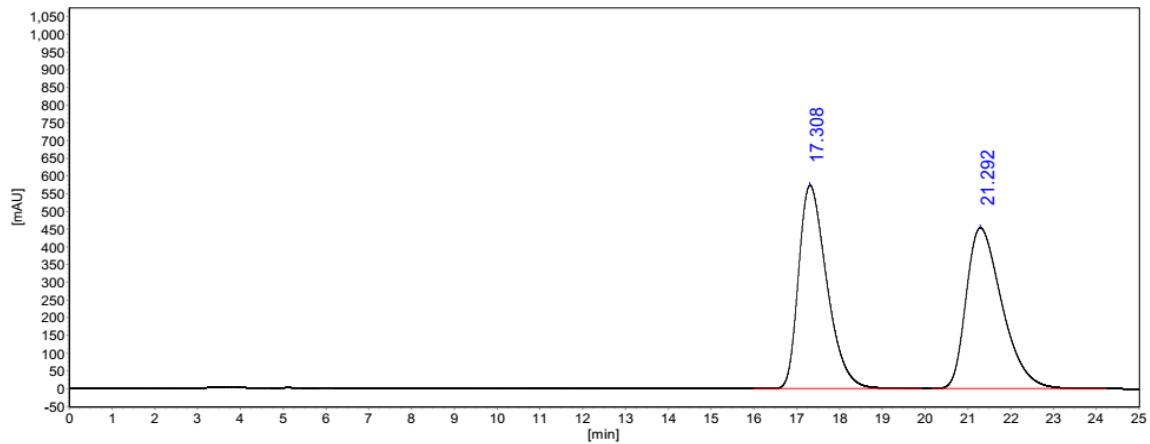
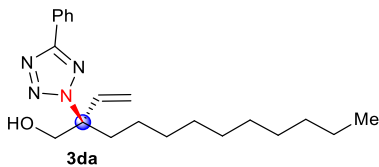
### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		11.224	2656740.4	66485128.1	49.1014	49.1014	+ BB
2		14.071	2399980.4	68918685.1	50.8986	50.8986	+ BB
<b>Total:</b>			<b>5056720.8</b>	<b>135403813.2</b>	<b>100.0000</b>	<b>100.0000</b>	



### Analysis Results

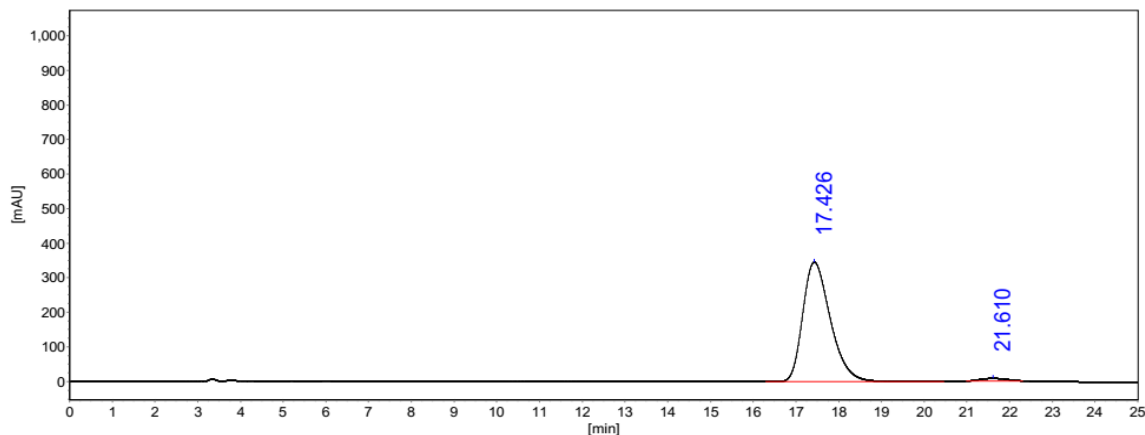
No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		11.206	497352.6	11300276.5	94.7954	94.7954	+ BB
2		14.151	27929.7	620427.9	5.2046	5.2046	+ BB
<b>Total:</b>			<b>525282.3</b>	<b>11920704.4</b>	<b>100.0000</b>	<b>100.0000</b>	



### Analysis Results

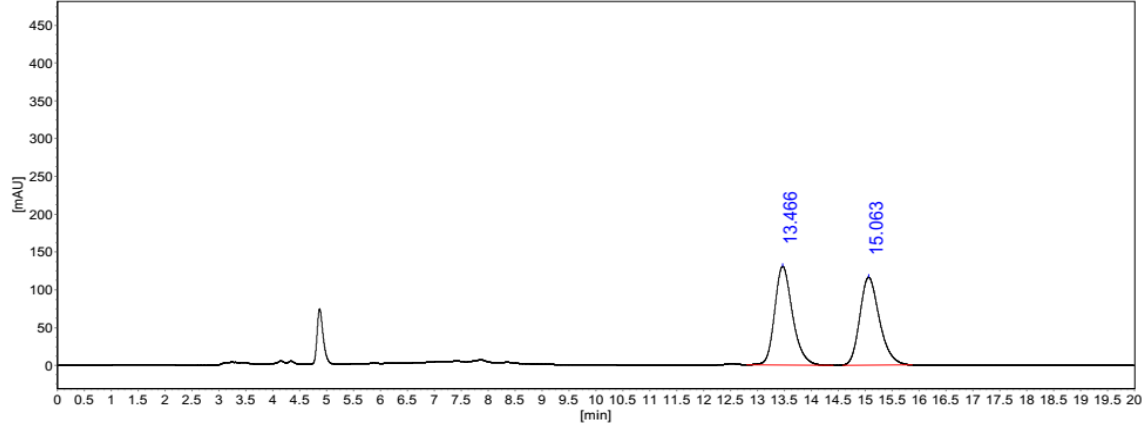
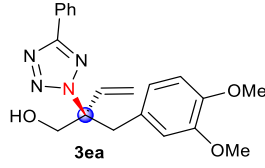
No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		17.308	573947.8	26343900.6	49.9351	49.9351	+ BB
2		21.292	453984.5	26412335.4	50.0649	50.0649	+ BB
<b>Total:</b>			<b>1027932.3</b>	<b>52756236.0</b>	<b>100.0000</b>	<b>100.0000</b>	

Comment:



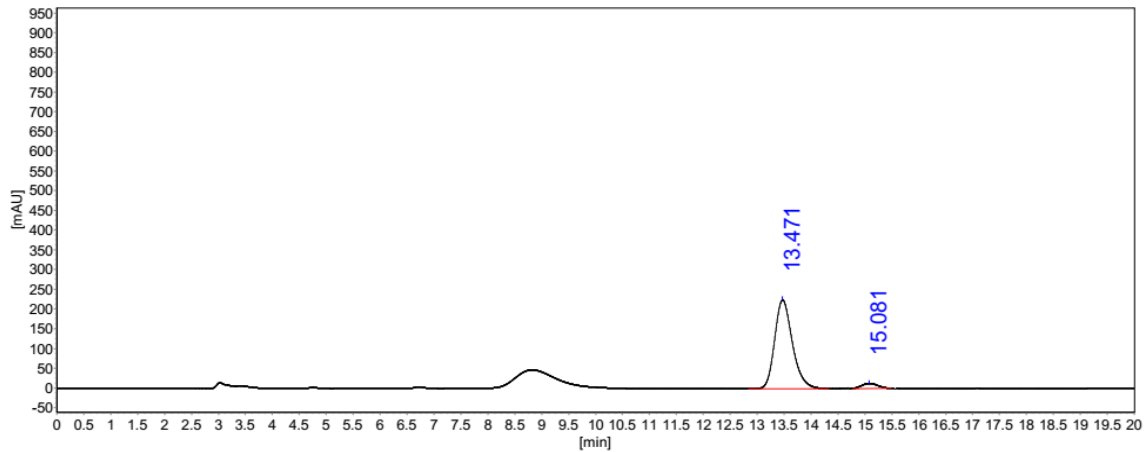
### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		17.426	346370.6	15615121.5	97.8218	97.8218	+ BB
2		21.610	7868.5	347708.4	2.1782	2.1782	+ BB
<b>Total:</b>			<b>354239.1</b>	<b>15962829.9</b>	<b>100.0000</b>	<b>100.0000</b>	



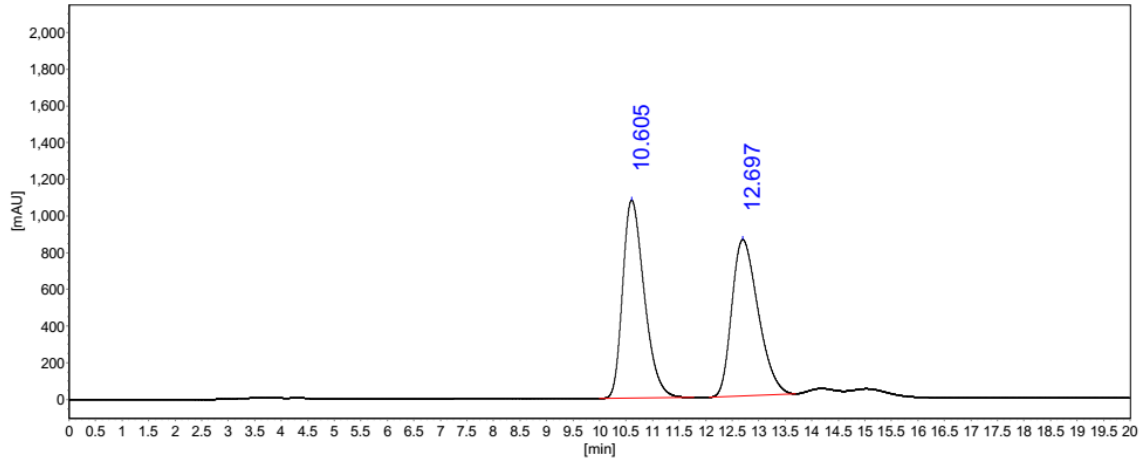
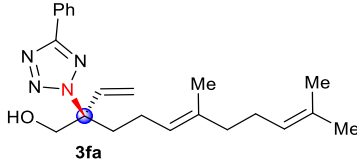
### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		13.466	130668.6	3013683.3	50.4412	50.4412	+ BB
2		15.063	116296.4	2960966.7	49.5588	49.5588	+ BB
<b>Total:</b>			<b>246965.0</b>	<b>5974649.9</b>	<b>100.0000</b>	<b>100.0000</b>	



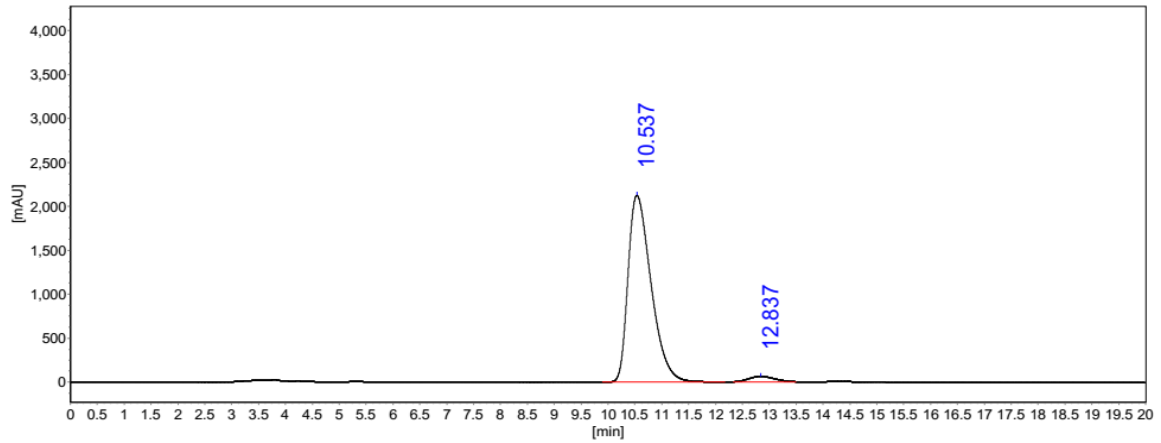
### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		13.471	224910.0	5128582.1	95.0924	95.0924	+ BB
2		15.081	12836.8	264678.5	4.9076	4.9076	+ BB
<b>Total:</b>			<b>237746.8</b>	<b>5393260.6</b>	<b>100.0000</b>	<b>100.0000</b>	



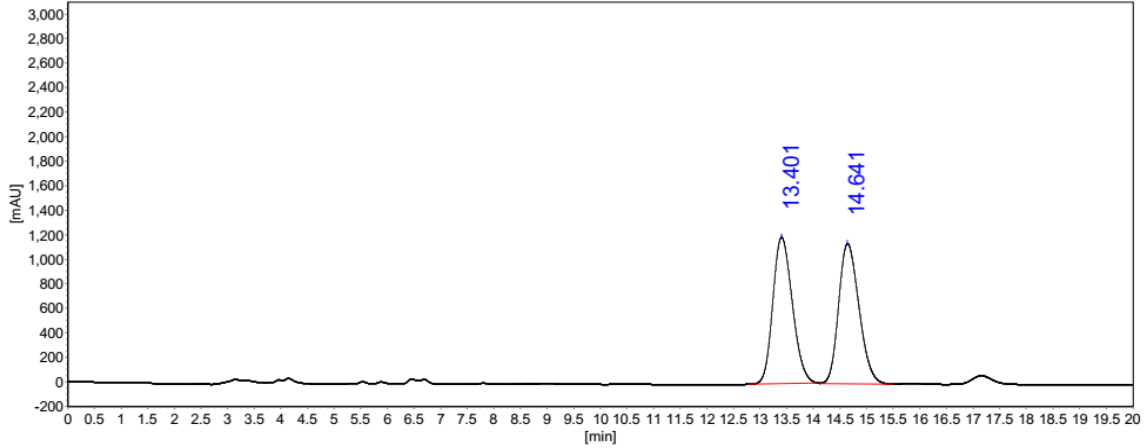
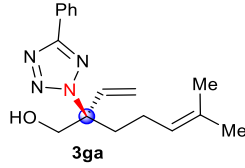
### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		10.605	1079952.0	30557871.2	50.9046	50.9046	+ BB
2		12.697	852109.3	29471773.3	49.0954	49.0954	+ BB
<b>Total:</b>			<b>1932061.3</b>	<b>60029644.5</b>	<b>100.0000</b>	<b>100.0000</b>	



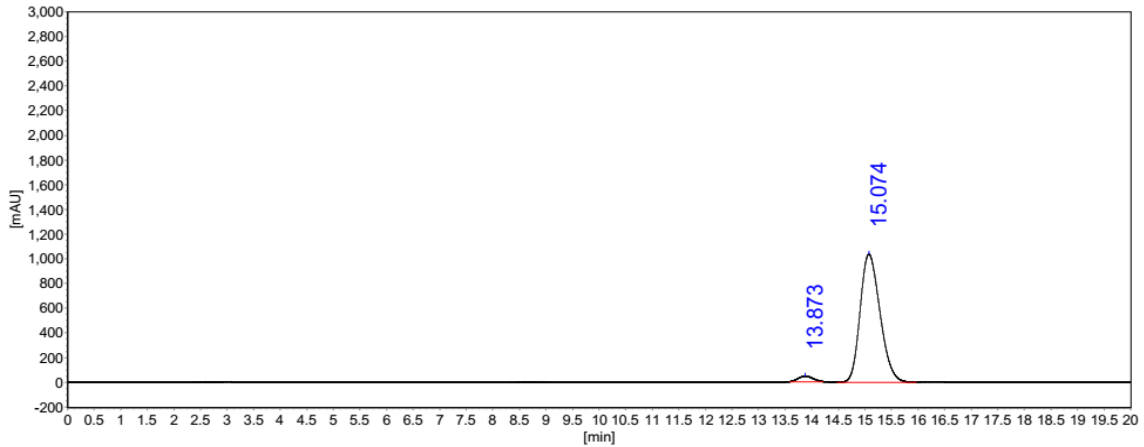
### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		10.537	2126494.0	63318989.2	96.9006	96.9006	+ BB
2		12.837	61528.9	2025303.2	3.0994	3.0994	+ BB
<b>Total:</b>			<b>2188022.9</b>	<b>65344292.4</b>	<b>100.0000</b>	<b>100.0000</b>	



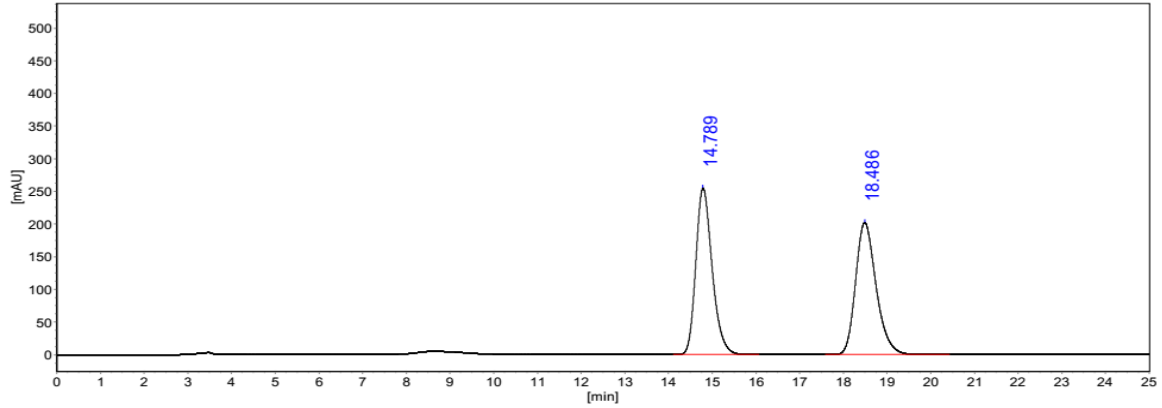
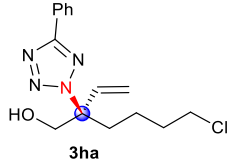
### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		13.401	1194812.0	30445304.4	50.0459	50.0459	+ BB
2		14.641	1141828.3	30389517.9	49.9541	49.9541	+ BB
<b>Total:</b>			<b>2336640.3</b>	<b>60834822.4</b>	<b>100.0000</b>	<b>100.0000</b>	



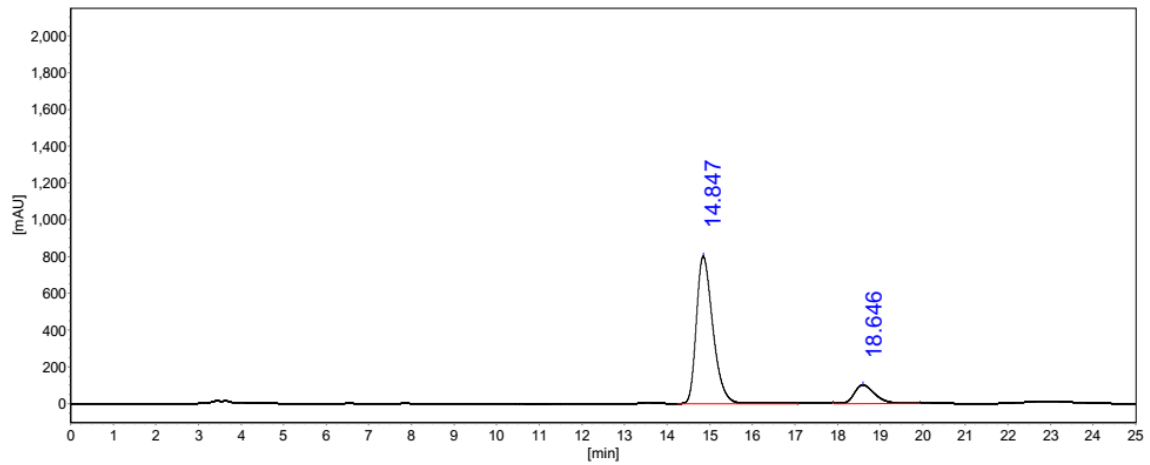
### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		13.873	45218.6	868814.2	3.1188	3.1188	+ BB
2		15.074	1037075.0	26988762.0	96.8812	96.8812	+ BB
<b>Total:</b>			<b>1082293.6</b>	<b>27857576.2</b>	<b>100.0000</b>	<b>100.0000</b>	



### Analysis Results

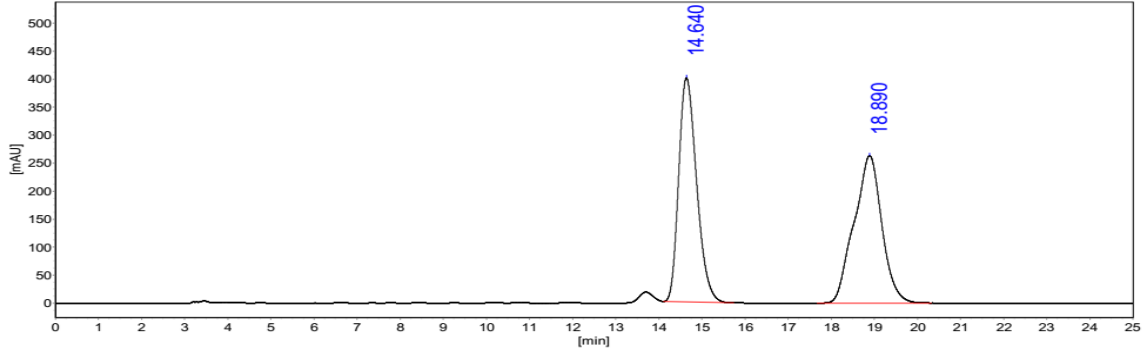
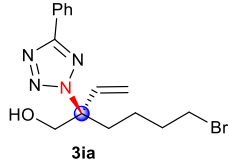
No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		14.789	255002.7	6612741.5	49.9554	49.9554	+ BB
2		18.486	202217.9	6624537.4	50.0446	50.0446	+ BB
<b>Total:</b>			<b>457220.6</b>	<b>13237278.9</b>	<b>100.0000</b>	<b>100.0000</b>	



### Analysis Results

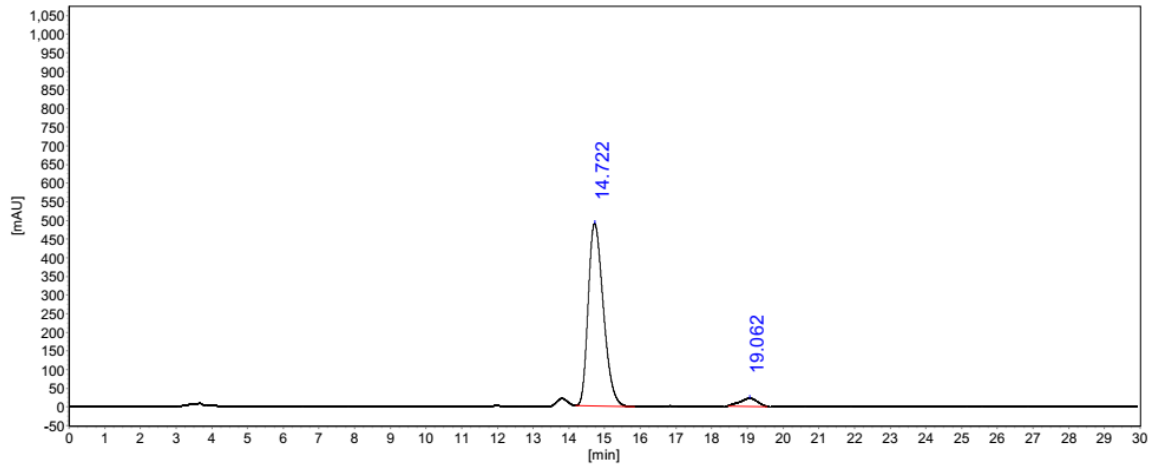
No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		14.847	801066.2	21432372.1	93.6985	93.6985	+ BB
2		18.646	61378.1	1441393.2	6.3015	6.3015	+ BB
<b>Total:</b>			<b>862444.3</b>	<b>22873765.2</b>	<b>100.0000</b>	<b>100.0000</b>	





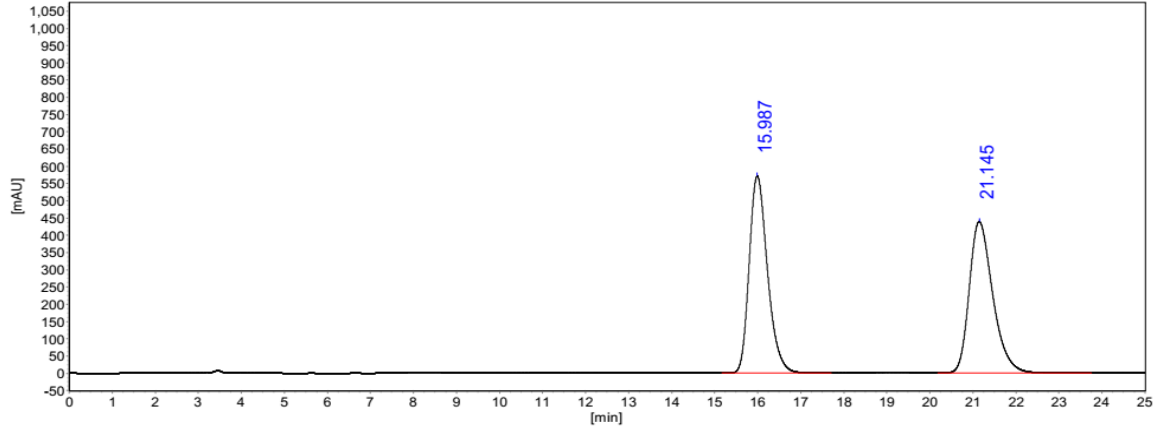
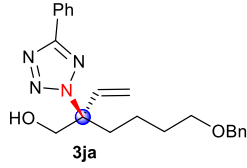
### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		14.640	400377.7	11558399.1	49.4578	49.4578	+ BB
2		18.890	263496.9	11811809.0	50.5422	50.5422	+ BB
<b>Total:</b>			<b>663874.6</b>	<b>23370208.1</b>	<b>100.0000</b>	<b>100.0000</b>	



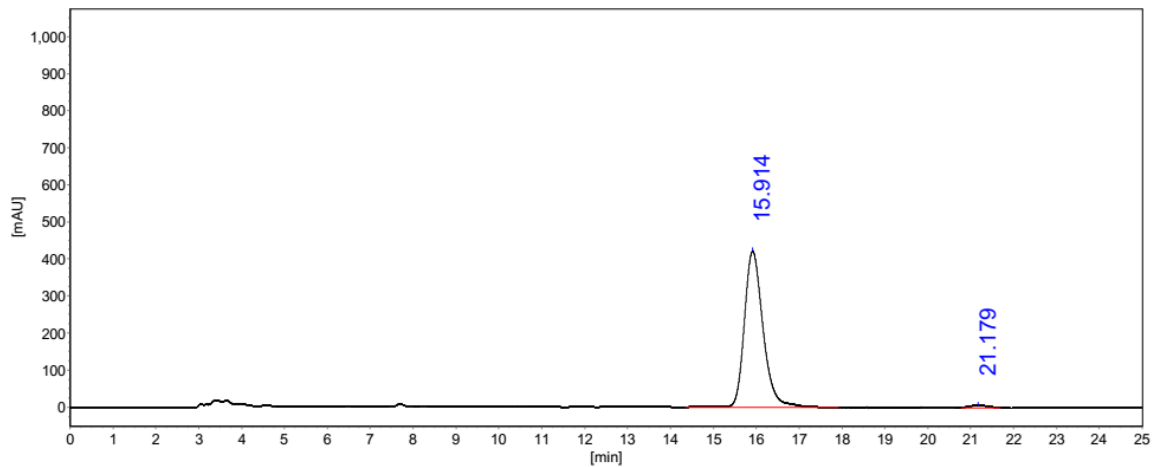
### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		14.722	490229.4	14479315.5	95.2335	95.2335	+ BB
2		19.062	21414.9	724694.4	4.7665	4.7665	+ BB
<b>Total:</b>			<b>511644.3</b>	<b>15204009.9</b>	<b>100.0000</b>	<b>100.0000</b>	



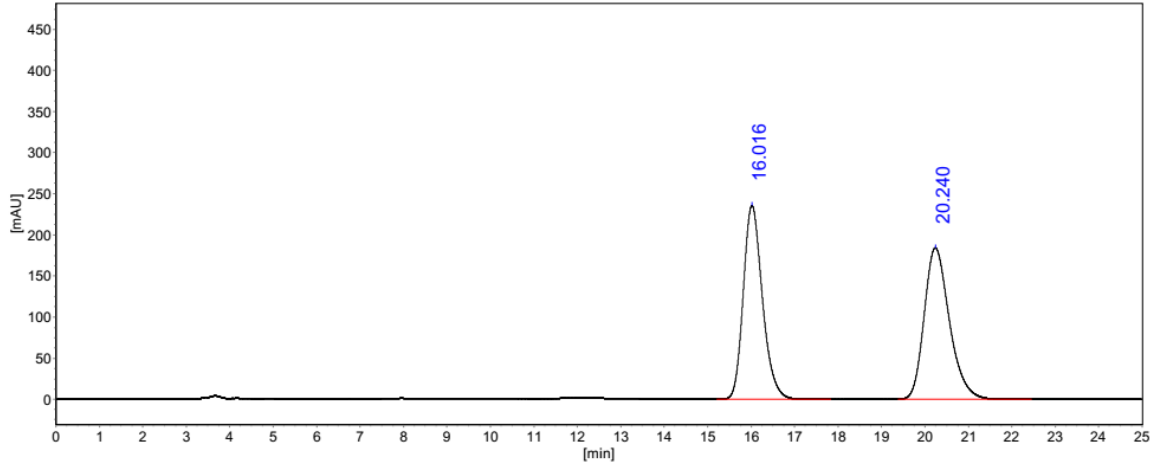
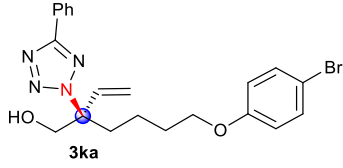
### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		15.987	571949.5	16895201.3	50.3900	50.3900	+ BB
2		21.145	439360.0	16633701.3	49.6100	49.6100	+ BB
<b>Total:</b>			<b>1011309.5</b>	<b>33528902.6</b>	<b>100.0000</b>	<b>100.0000</b>	



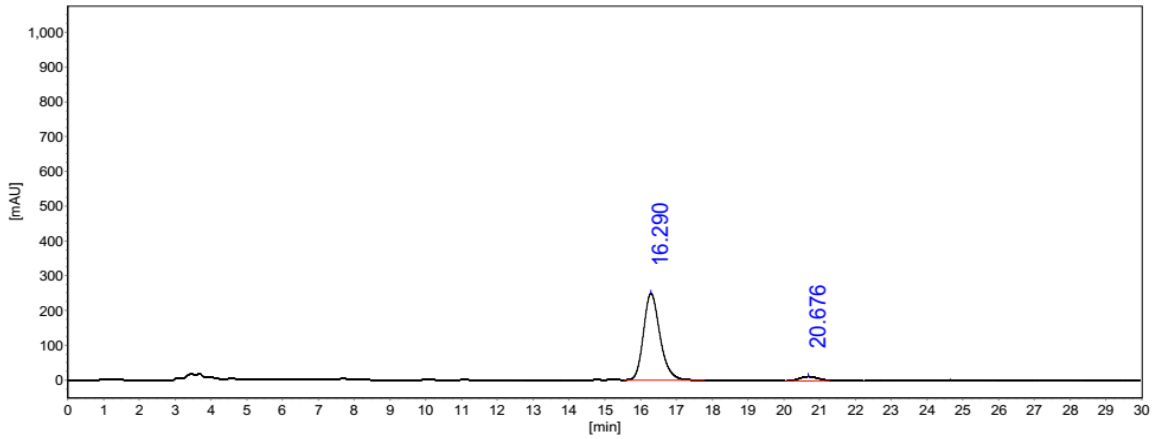
### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		15.914	421026.4	12677501.2	98.5038	98.5038	+ BB
2		21.179	6380.8	192559.8	1.4962	1.4962	+ BB
<b>Total:</b>			<b>427407.2</b>	<b>12870061.0</b>	<b>100.0000</b>	<b>100.0000</b>	



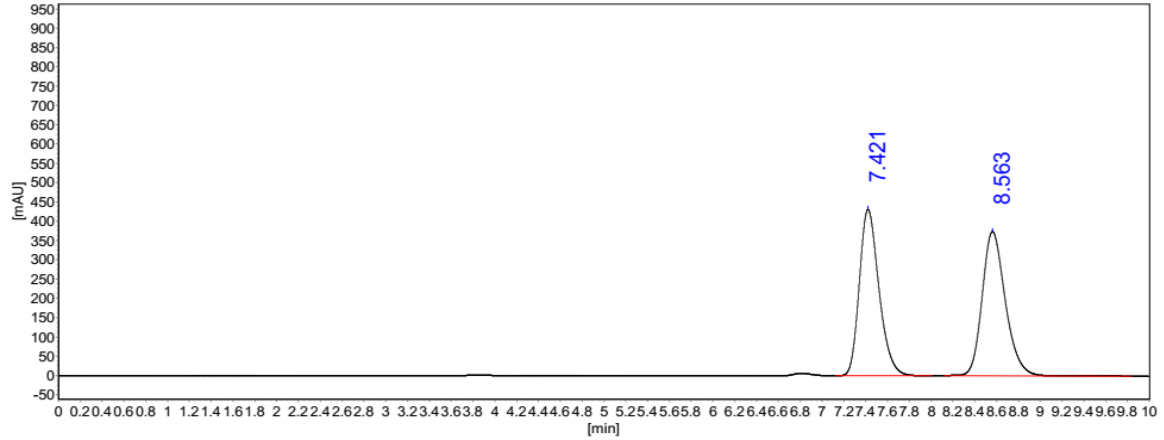
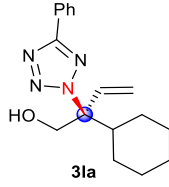
### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		16.016	235839.5	7205001.5	49.2171	49.2171	+ BB
2		20.240	184273.5	7434208.2	50.7829	50.7829	+ BB
<b>Total:</b>			<b>420113.0</b>	<b>14639209.6</b>	<b>100.0000</b>	<b>100.0000</b>	



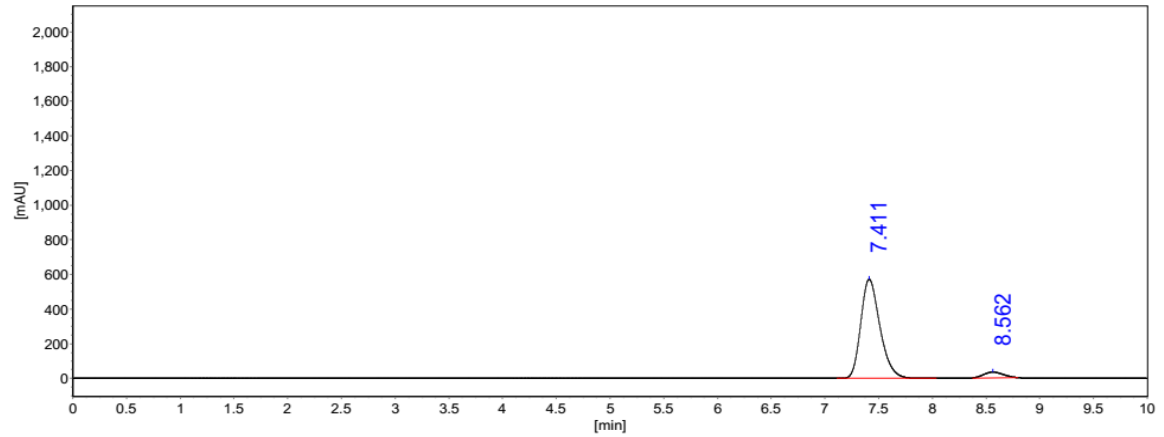
### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		16.290	249032.9	7929810.7	94.9761	94.9761	+ BB
2		20.676	12056.2	419457.1	5.0239	5.0239	+ BB
<b>Total:</b>			<b>261089.1</b>	<b>8349267.8</b>	<b>100.0000</b>	<b>100.0000</b>	



### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		7.421	431485.8	5410075.4	49.5250	49.5250	+ BB
2		8.563	373916.0	5513846.0	50.4750	50.4750	+ BB
<b>Total:</b>			<b>805401.8</b>	<b>10923921.4</b>	<b>100.0000</b>	<b>100.0000</b>	



### Analysis Results

No.	Compound	R.Time	Height	Area	Area%	Conc.	Type
1		7.411	572413.3	7117180.2	94.4491	94.4491	+ BB
2		8.562	33111.6	418290.1	5.5509	5.5509	+ BB
<b>Total:</b>			<b>605524.9</b>	<b>7535470.3</b>	<b>100.0000</b>	<b>100.0000</b>	