

# Iron-Catalyzed Intramolecular C–H Amination of $\alpha$ -Azidyl Amides

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## General methods

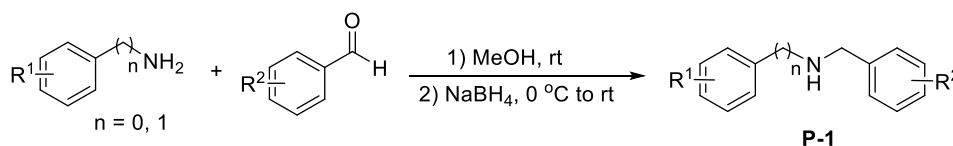
The  $^1\text{H}$  and  $^{13}\text{C}$  NMR spectra were recorded on a Bruker 300 MHz spectrometer, a Bruker 400 MHz spectrometer or a Bruker 600 MHz spectrometer with  $\text{CDCl}_3$  as the solvent. The chemical shifts in  $^1\text{H}$  NMR spectra were determined with  $\text{Si}(\text{CH}_3)_4$  as the internal standard ( $\delta = 0.00$  ppm); the chemical shifts in  $^{13}\text{C}$  NMR spectra were determined based on the chemical shift of  $\text{CDCl}_3$  ( $\delta = 77.0$  ppm). The high resolution mass spectra (HRMS) were measured on a Bruker micrOTOF QII by ESI. The Fourier transformation infrared spectra (FT-IR) were measured on a NEXUS 670 spectrometer. Melting points (m.p.) were measured on an XT-4 melting point apparatus and are uncorrected. Flash column chromatography was carried out on aluminum oxide (200-300 mesh) or silica gel (200-300 mesh).

$\text{FeCl}_2$  (99.5%)  $\text{FeBr}_2$  (98.5%) and  $\text{FeI}_2$  (97%) were purchased from Alfa Aesar; Anhydrous acetonitrile (MeCN) and dimethyl sulfoxide (DMSO) were purchased from Energy Chemical and used without further processing. Other solvents were treated before use following the standard procedures.

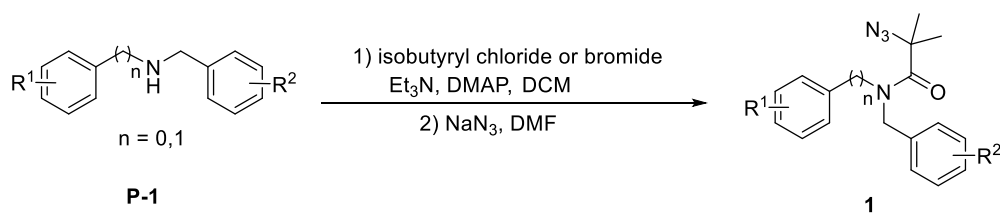
$\beta$ -Diketiminates L1 was prepared following the reported procedure.<sup>1</sup> L2 and L3 were prepared according to literature methods.<sup>2</sup> Ligand L4 (4,4'-di-tert-butyl-2,2'-dipyridyl) was purchased from Sigma-Aldrich. Ligand L5 (1,10-phenanthroline) was purchased from Acros Organics.

## General experimental procedures

### General procedure for the preparation of compounds 1a-1l:



(a) To a flask charged with amine (6.0 mmol, 1.2 equiv.) dissolved in MeOH (0.5 M), was added dropwise benzaldehydes (5.0 mmol, 1.0 equiv.) The resulting mixture was stirred at room temperature overnight.  $\text{NaBH}_4$  (0.38 g, 10 mmol, 2.0 equiv.) was then added into the mixture in several portions at  $0^\circ\text{C}$  (immersed in an ice-bath), and the mixture was stirred at this temperature for 6 h. Cold water was then added into the mixture till no bubbles produced, and the mixture was extracted with ethyl acetate ( $3 \times 10$  mL). The combined organic phases were dried over anhydrous  $\text{Na}_2\text{SO}_4$ . The solvent was then evaporated under reduced pressure on a rotary evaporator, and the crude secondary amine product (**P-1**) was directly used for the next step without further purification.

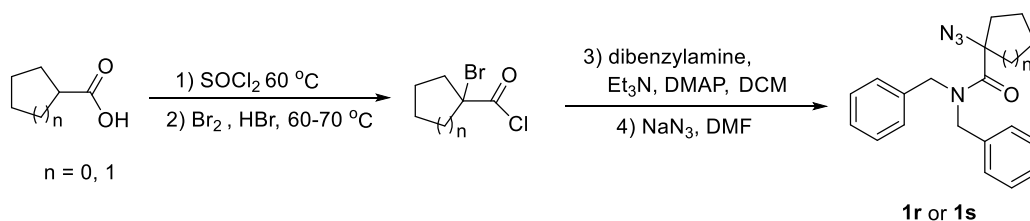


(b) The crude **P-1** (5.0 mmol, 1.0 equiv.) and triethylamine ( $\text{Et}_3\text{N}$ ) (2.1 mL, 15 mmol, 3.0 equiv.) was dissolved in dry dichloromethane (DCM) (0.5 M) in a 50 mL round bottom flask. After stirring at 0 °C for 5 min, 4-dimethylaminopyridine (DMAP) (30.5 mg, 0.25 mmol, 0.05 equiv.) was added into the mixture, followed by dropwise addition of the corresponding 2-bromoisobutyryl bromide (0.74 mL, 6 mmol, 1.2 equiv.) at 0 °C. The stirring was continued until the reaction was complete as indicated by TLC. The reaction mixture was then quenched with water (10 mL). The aqueous phase was extracted with DCM (3×10 mL). The combined organic phases was treated with 0.5 M HCl solution (10 mL), washed with brine (3×15 mL), and dried over anhydrous  $\text{NaSO}_4$ . The solution was concentrated under reduced pressure on a rotary evaporator, and the residual was treated with silica gel column chromatography (eluent: petroleum ether (PE) and ethyl acetate (EA)) to afford the pure amide products.

(c) The thus obtained amide (5.0 mmol, 1.0 equiv.) was dissolved in DMF (0.3 M), and the solution was stirred at 0 °C (ice-water bath) for 5 min.  $\text{NaN}_3$  (0.98 g, 15 mmol, 3.0 equiv.) was then added in a few portions, and the reaction mixture was stirred overnight at room temperature. After that, the reaction mixture was poured into water (15 mL), and the product was extracted with ethyl acetate (3×10 mL). The combined organic phases were washed with  $\text{H}_2\text{O}$  (3×10 mL) and brine (3×15 mL), dried over anhydrous  $\text{Na}_2\text{SO}_4$ , filtered and concentrated under reduced pressure on a rotary evaporator. Purification of the crude product by silica gel column chromatography (with PE and EA) afforded the azidation product.

Compounds **1m**, **1n**, **1p** and **1q** were prepared from the corresponding amines following the same procedure.

#### Preparation of compounds **1r** and **1s**:

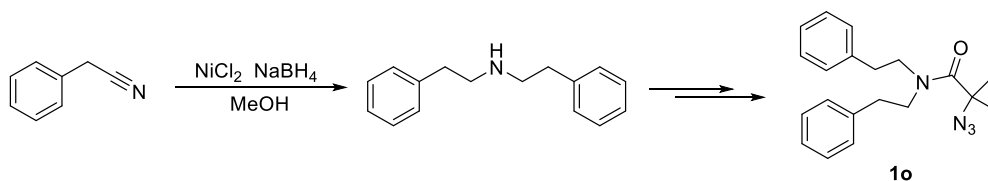


(a) Cyclopentanecarboxylic acid (0.48 mL, 5.0 mmol, 1.0 equiv.) or cyclobutanecarboxylic acid (0.54 mL, 5.0 mmol, 1.0 equiv.) was dissolved in a 25 mL round bottom flask charged with  $\text{SOCl}_2$  (10 mL), and the mixture was stirred for 1 h

at 60 °C. After cooling down to room temperature, Br<sub>2</sub> (0.34 mL, 5.5 mmol, 1.1 equiv.) and a few drops of HBr (48% in H<sub>2</sub>O) (or PBr<sub>3</sub>) were added to the solution, and the stirring was continued at 60–70 °C until the red colour in the flask lightened. The volatile components were then removed by distillation, and the residual was diluted with DCM (5 mL).

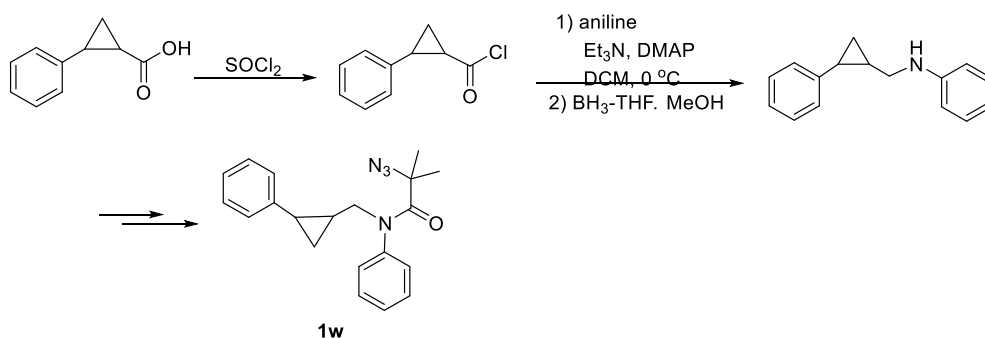
(b) The diluted chloride was added dropwise to a 50 mL round bottom flask charged with a DCM solution (10 mL) of dibenzylamine (0.96 mL, 5.0 mmol, 1.0 equiv.), Et<sub>3</sub>N (2.1 mL, 15 mmol, 3 equiv.) and DMAP (30.5 mg, 0.25 mmol, 0.05 equiv.) at 0 °C, and the mixture was stirred till the reaction was complete as indicated by TLC. The mixture was then added into water (10 mL), and the separated aqueous phase was extracted with DCM (3×10 mL). The combined organic phases were treated with 0.5 M HCl solution (10 mL), washed with brine (3×15 mL), and dried over anhydrous NaSO<sub>4</sub>. The solution was concentrated under reduced pressure on a rotary evaporator, and the residual was treated with silica gel column chromatography to afford the pure amide products (with PE and EA). The azidation procedure was the same as described above. Compounds **1t** and **1u** were prepared from 2-phenylacetic acid following the same procedure.

#### Preparation of compound 1o:



Diphenethylamine was prepared according to a literature method.<sup>4</sup> **1o** was prepared from diphenethylamine following the procedures described above.

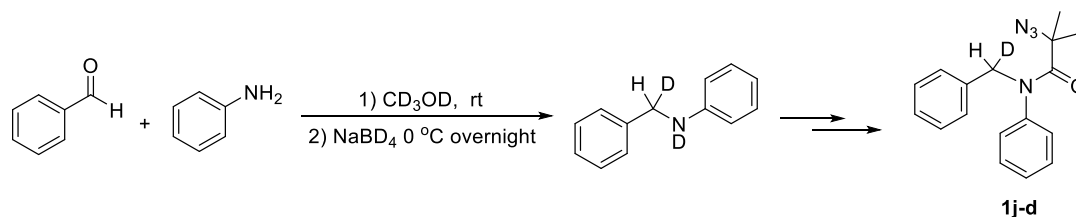
#### Preparation of compound 1w:



*N*-((2-Phenylcyclopropyl) methyl) aniline was synthesized based on a literature method.<sup>5</sup> **1w** was prepared from *N*-((2-phenylcyclopropyl) methyl) aniline following the procedures described above.

#### Preparation of compound 1j-d:





To a flask charged with amine (0.55 mL, 6.0 mmol, 1.2 equiv.) dissolved in CD<sub>3</sub>OD (0.5 M), was added dropwise benzaldehyde (0.51 mL, 5.0 mmol, 1.0 equiv.) The resulting mixture was stirred at room temperature till the condensation was complete as indicated by TLC. NaBD<sub>4</sub> (0.63 g, 15 mmol, 3.0 equiv.) was then added into the mixture in several portions at 0 °C (immersed in an ice-bath), and the mixture was stirred at this temperature for 8 h. Cold water then was added to the mixture till no bubbles produced, and the mixture was extracted with dichloromethane (3×10 mL). The combined organic phases were dried over anhydrous NaSO<sub>4</sub>. The solvent was then evaporated under reduced pressure on a rotary evaporator, and the crude secondary amine product was directly used for the next step without further purification. Acylation and azidation procedures were the same as described above.

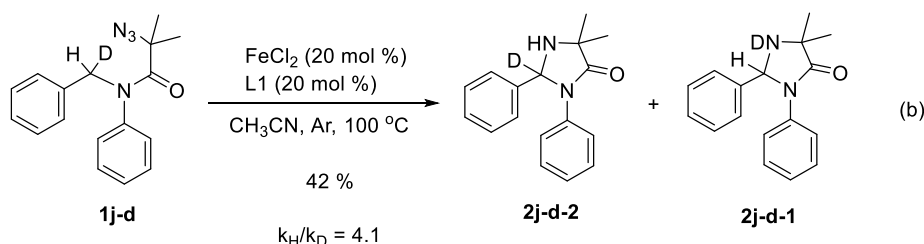
#### General procedure for the iron-catalyzed C–H amination reactions of compounds **1**:

Into an oven dried reaction tube equipped with a magnetic stirring bar and a rubber stopper were added FeCl<sub>2</sub> (5.1 mg, 0.04 mmol, 20 mol %) and L1 (13.4 mg, 0.04 mmol, 20 mol %). The tube was evacuated and backfilled with argon for three times. Then 1 mL of anhydrous acetonitrile was added into the tube with a syringe under argon atmosphere (argon balloon), the mixture was stirred for 30 min at room temperature. Another 1 mL of acetonitrile containing 0.2 mmol of **1** (1.0 equiv.) was then added into the reaction tube with a syringe. The mixture was stirred at 100 °C (oil bath temperature) for 12 h. After the reaction completed, the mixture was cooled to room temperature, and was allowed to pass through a short pad of aluminum oxide, which was washed with ethyl acetate (20 mL). The solution was concentrated under reduced pressure on a rotary evaporator, and the residual was treated with flash column chromatography (with PE and EA) on aluminum oxide to afford the pure product (s). For the reactions of compounds **1p**, **1q**, **3** and **4** in the presence of Boc<sub>2</sub>O, 92 uL of Boc<sub>2</sub>O (2.4 mmol, 2.0 equiv.) was added into the reaction mixture before heating.

#### Gram scale experiment of **1a**:

1.23 g of **1a** (4.0 mmol, 1.0 equiv.), 114 mg of FeCl<sub>2</sub> (0.9 mmol 22 mol %), 267 mg of L1 (0.8 mmol, 20 mol %) and 40 mL of anhydrous acetonitrile were used following the procedure described above.

#### Kinetic isotope experiment with **1j-d**:



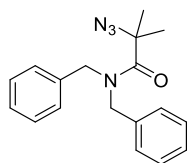
The value of  $k_{\text{H}}/k_{\text{D}}$  was calculated based on the integrals of methine hydrogen ( $\delta = 5.98$  and the hydrogen ( $\delta = 1.98$ ) of amino group in  $^1\text{H}$  NMR spectra.

### Cautions:

Organic azides are potentially *explosive* compounds. While we haven't encountered any problems handling them in our experiments, proper precautions must be taken. All the azidation reactions and subsequent workups should be performed in a hood behind a blast shield. After they were prepared, all the organic azides were stored at  $-18\text{ }^\circ\text{C}$  in a refrigerator.

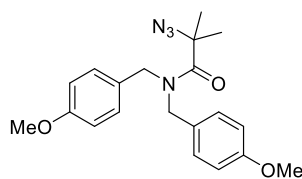
## Characterization data

### Characterization data for the substrates



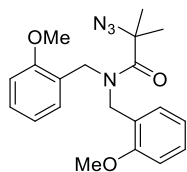
#### 2-Azido-*N,N*-dibenzyl-2-methylpropanamide (1a)

White solid (1.01 g, 61%\*), m.p. =  $54\text{--}55\text{ }^\circ\text{C}$ ;  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm) 7.42–7.24 (m, 6H), 7.21–7.09 (m, 4H), 4.86 (s, 2H), 4.52 (s, 2H), 1.62 (s, 6H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm) 171.9, 136.9, 136.5, 128.7, 128.6, 127.9, 127.4, 126.8, 64.1, 50.6, 48.6, 25.5; FT-IR (KBr,  $\text{cm}^{-1}$ ): 2107, 1643; HRMS (ESI-TOF)  $m/z$ :  $[\text{M}+\text{H}]^+$  calcd for  $[\text{C}_{18}\text{H}_{21}\text{N}_4\text{O}]^+$ : 309.1710, found: 309.1700.



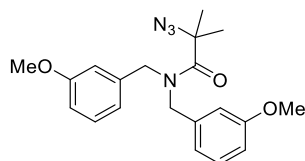
#### 2-Azido-*N,N*-bis(4-methoxybenzyl)-2-methylpropanamide (1b)

Colorless oil (1.51 g, 82%),  $R_f = 0.56$  (PE:EA = 5:1);  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 7.15–7.03 (m, 4H), 6.95–6.79 (m, 4H), 4.76 (s, 2H), 4.43 (s, 2H), 3.80 (s, 6H), 1.61 (s, 6H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 171.7, 159.0, 129.4, 129.0, 128.3, 128.2, 114.2, 114.0, 64.2, 55.2, 49.7, 47.6, 25.5; FT-IR (KBr,  $\text{cm}^{-1}$ ): 2107, 1641; HRMS (ESI-TOF)  $m/z$ :  $[\text{M}+\text{H}]^+$  calcd for  $[\text{C}_{20}\text{H}_{25}\text{N}_4\text{O}_3]^+$ : 369.1921, found: 369.1914.



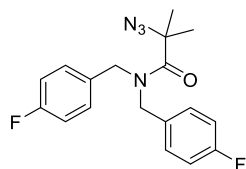
**2-Azido-*N,N*-bis(2-methoxybenzyl)-2-methylpropanamide (1c)**

Light yellow solid (1.01 g, 55%), m.p. = 93–95 °C;  $^1\text{H}$  NMR (600 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 7.25–7.19 (m, 2H), 7.12–7.10 (m, 2H), 6.98–6.96 (m, 1H), 6.91–6.88 (m, 1H), 6.85–6.79 (m, 2H), 4.93 (s, 2H), 4.58 (s, 2H), 3.75 (s, 3H), 3.69 (s, 3H), 1.56 (s, 6H).  $^{13}\text{C}$  NMR (150 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 172.2, 157.4, 156.8, 128.0, 127.9, 126.6, 125.4, 124.9, 120.4, 101.0, 64.1, 55.0, 46.9, 45.3, 25.5. FT-IR (KBr,  $\text{cm}^{-1}$ ): 2108, 1642; HRMS (ESI-TOF)  $m/z$ :  $[\text{M}+\text{H}]^+$  calcd for  $[\text{C}_{20}\text{H}_{25}\text{N}_4\text{O}_3]^+$ : 369.1921, found: 369.1923.



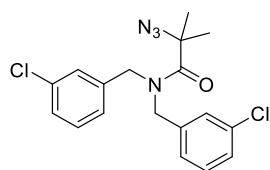
**2-Azido-*N,N*-bis(3-methoxybenzyl)-2-methylpropanamide (1d)**

Colorless oil (1.24 g, 67%),  $R_f$  = 0.41 (PE:EA = 10:1);  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 7.28–7.21 (m, 2H), 6.85–6.82 (m, 2H), 6.76–6.72 (m, 4H), 4.85 (s, 2H), 4.51 (s, 2H), 3.78 (s, 6H), 1.62 (s, 6H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 171.9, 160.1, 159.9, 138.5, 138.2, 129.8, 129.6, 120.2, 119.1, 113.2, 113.0, 112.4, 64.1, 55.1, 50.6, 48.7, 25.5; FT-IR (KBr,  $\text{cm}^{-1}$ ): 2108, 1643; HRMS (ESI-TOF)  $m/z$ :  $[\text{M}+\text{H}]^+$  calcd for  $[\text{C}_{20}\text{H}_{25}\text{N}_4\text{O}_3]^+$ : 369.1921, found: 369.1924.



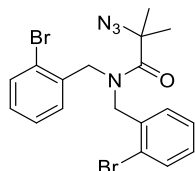
**2-Azido-*N,N*-bis(4-fluorobenzyl)-2-methylpropanamide (1e)**

White solid (1.37 g, 80%), m.p. = 73–74 °C;  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 7.21–6.93 (m, 8H), 4.81 (s, 2H), 4.45 (s, 2H), 1.62 (s, 6H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 171.3, 162.15 (d,  $J$  = 246.0 Hz), 132.5, 132.0, 129.7, 128.6, 115.6, 64.1, 49.9, 47.9, 25.4; FT-IR (KBr,  $\text{cm}^{-1}$ ): 2109, 1644; HRMS (ESI-TOF)  $m/z$ :  $[\text{M}+\text{H}]^+$  calcd for  $[\text{C}_{18}\text{H}_{19}\text{F}_2\text{N}_4\text{O}]^+$ : 345.1521, found: 345.1524.



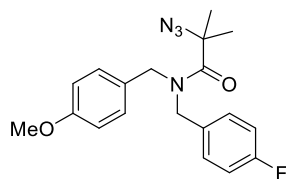
**2-Azido-*N,N*-bis(3-chlorobenzyl)-2-methylpropanamide (1f)**

Light yellow solid (1.79 g, 95%), m.p. = 55–57 °C;  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 7.36–7.21 (m, 4H), 7.20–6.94 (m, 4H), 4.85 (s, 2H), 4.48 (s, 2H), 1.62 (s, 6H).  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 172.0, 138.7, 134.6, 130.09, 127.8, 127.0, 126.0, 124.9, 64.0, 50.5, 48.6, 25.5; FT-IR (KBr,  $\text{cm}^{-1}$ ): 2107, 1640; HRMS (ESI-TOF)  $m/z$ :  $[\text{M}+\text{H}]^+$  calcd for  $[\text{C}_{18}\text{H}_{19}\text{Cl}_2\text{N}_4\text{O}]^+$ : 377.0930, found: 377.0928.



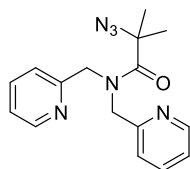
**2-Azido-*N,N*-bis(2-bromobenzyl)-2-methylpropanamide (1g)**

White solid (1.72 g, 76%), m.p. = 107–109 °C;  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 7.61–7.50 (m, 2H), 7.42–7.34 (m, 1H), 7.33–7.24 (m, 1H), 7.23–7.10 (m, 4H), 4.92 (s, 2H), 4.67 (s, 2H), 1.59 (s, 6H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 172.5, 135.8, 135.5, 133.1, 128.9, 128.4, 127.8, 127.1, 64.0, 52.1, 50.4, 25.5. FT-IR (KBr,  $\text{cm}^{-1}$ ): 2108, 1649; HRMS (ESI-TOF)  $m/z$ :  $[\text{M}+\text{H}]^+$  calcd for  $[\text{C}_{18}\text{H}_{19}\text{Br}_2\text{N}_4\text{O}]^+$ : 466.9900, found: 466.9899.



**2-Azido-*N*-(4-fluorobenzyl)-2-methyl-*N*-(4-methylbenzyl)propanamide (1h)**

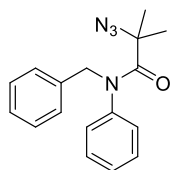
Yellow oil (1.35 g, 76%),  $R_f$  = 0.35 (PE:EA = 5:1);  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 7.19–7.04 (m, 5H), 7.04–6.94 (m, 1H), 6.93–6.79 (m, 2H), 4.78 (s, 2H), 4.43 (s, 2H), 3.81 (s, 3H), 1.61 (s, 6H).  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 171.7, 162.07 (d,  $J$  = 245.9 Hz) 159.0, 132.7, 129.7, 129.4, 128.5, 128.2, 115.8, 115.5, 114.2, 114.0, 64.1, 55.2, 50.0, 47.6, 25.5. FT-IR (KBr,  $\text{cm}^{-1}$ ): 2108, 1642; HRMS (ESI-TOF)  $m/z$ :  $[\text{M}+\text{H}]^+$  calcd for  $[\text{C}_{19}\text{H}_{22}\text{FN}_4\text{O}_2]^+$ : 357.1721, found: 357.1717.



**2-Azido-2-methyl-*N,N*-bis(pyridin-2-ylmethyl)propanamide (1i)**

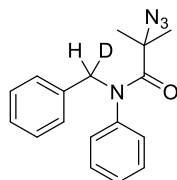
Yellow solid (1.13 g, 73%),  $R_f$  = 0.33 (PE:EA = 1:2);  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 8.54 (d,  $J$  = 21.4 Hz, 2H), 7.74–7.57 (m, 2H), 7.21 (d,  $J$  = 21.4 Hz, 4H), 5.17 (s, 2H), 4.69 (s, 2H), 1.61 (s, 6H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 172.2, 156.9, 149.6, 149.2, 136.6, 122.2, 121.7, 120.9, 63.9, 53.9, 52.2, 25.4; FT-IR (KBr,  $\text{cm}^{-1}$ ): 2109, 1643;

HRMS (ESI-TOF)  $m/z$ :  $[M+H]^+$  calcd for  $[C_{16}H_{19}N_6O]^+$ : 311.1615, found: 311.1616.



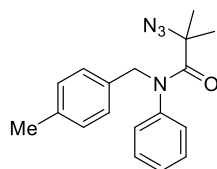
**2-Azido-*N*-benzyl-2-methyl-*N*-phenylpropanamide (1j)**

Colorless oil (1.07 g, 73%),  $R_f$  = 0.38 (PE:EA = 10:1);  $^1H$  NMR (400 MHz,  $CDCl_3$ ,  $\delta$  ppm): 7.34–7.29 (m, 3H), 7.28–7.23 (m, 3H), 7.18–7.14 (m, 2H), 7.05–7.01 (m, 2H), 4.85 (s, 2H), 1.45 (s, 6H);  $^{13}C$  NMR (100 MHz,  $CDCl_3$ ,  $\delta$  ppm): 171.9, 142.2, 137.0, 129.0, 128.9, 128.3, 128.2, 128.0, 127.5, 64.8, 56.5, 26.6; FT-IR (KBr,  $cm^{-1}$ ): 2108, 1647; HRMS (ESI-TOF)  $m/z$ :  $[M+H]^+$  calcd for  $[C_{17}H_{19}N_4O]^+$ : 295.1553, found: 295.1560.



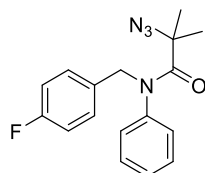
**2-Azido-2-methyl-*N*-phenyl-*N*-(phenylmethyl-*d*) propanamide (1j-d)**

Light yellow or colorless liquid (1.34 g, 90%),  $R_f$  = 0.58 (PE:EA = 5:1);  $^1H$  NMR (600 MHz,  $CDCl_3$ ,  $\delta$  ppm): 7.33–7.29 (m, 3H), 7.28–7.24 (m, 3H), 7.18–7.15 (m, 2H), 7.05–7.02 (m, 2H), **4.85 (s, 1H)** [Ph-CHD], 1.46 (s, 6H).  $^{13}C$  NMR (150 MHz,  $CDCl_3$ ,  $\delta$  ppm): 171.9, 142.2, 137.0, 129.0, 129.0, 129.0, 128.4, 128.3, 128.0, 127.5, 64.8, 56.1, 26.6. The data was corresponding to the reactant **1j**.



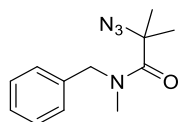
**2-Azido-2-methyl-*N*-(4-methylbenzyl)-*N*-phenylpropanamide (1k)**

Light yellow solid (1.02 g, 66%), m.p. = 40–41 °C,  $^1H$  NMR (400 MHz,  $CDCl_3$ ,  $\delta$  ppm): 7.35–7.27 (m, 3H), 7.09–6.98 (m, 6H), 4.81 (s, 2H), 2.31 (s, 3H), 1.44 (s, 6H);  $^{13}C$  NMR (100 MHz,  $CDCl_3$ ,  $\delta$  ppm): 171.7, 142.2, 137.1, 133.9, 129.0, 128.9, 128.9, 128.2, 127.9, 64.8, 56.1, 26.5, 21.1; FT-IR (KBr,  $cm^{-1}$ ): 2108, 1647; HRMS (ESI-TOF)  $m/z$ :  $[M+H]^+$  calcd for  $[C_{18}H_{21}N_4O]^+$ : 309.1710, found: 309.1716.

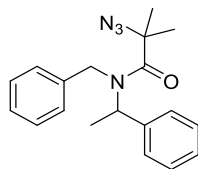


**2-Azido-*N*-(4-fluorobenzyl)-2-methyl-*N*-phenylpropanamide (1l)**

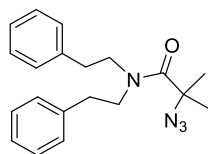
Yellow oil (1.18 g, 76%),  $R_f = 0.56$  (PE:EA = 5:1);  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 7.36–7.28 (m, 3H), 7.17–7.08 (m, 2H), 7.03–6.97 (m, 2H), 6.97–6.89 (m, 2H), 4.81 (s, 2H), 1.44 (s, 6H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 171.9, 162.18 (d,  $J = 245.9$  Hz), 141.9, 132.8, 132.8, 130.8, 130.7, 129.0, 128.2, 128.1, 115.3, 115.0, 64.7, 55.6, 26.5; FT-IR (KBr,  $\text{cm}^{-1}$ ): 2109, 1647; HRMS (ESI-TOF)  $m/z$ :  $[\text{M}+\text{H}]^+$  calcd for  $[\text{C}_{17}\text{H}_{18}\text{FN}_4\text{O}]^+$ : 313.1460, found: 313.1466.

**2-Azido-*N*-benzyl-*N*-2-dimethylpropanamide (1m)**

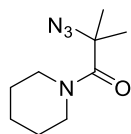
Light yellow oil (0.72 g, 62%),  $R_f = 0.72$  (PE:EA = 1:1),  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 7.39–7.30 (m, 2H), 7.30–7.26 (m, 1H), 7.25–7.18 (m, 2H), 4.67 (s, 2H), 3.12 (s, 3H), 1.58 (s, 6H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 171.4, 136.9, 128.6, 127.4, 64.1, 53.1, 35.6, 25.2; FT-IR (KBr,  $\text{cm}^{-1}$ ): 2107, 1642; HRMS (ESI-TOF)  $m/z$ :  $[\text{M}+\text{H}]^+$  calcd for  $[\text{C}_{12}\text{H}_{17}\text{N}_4\text{O}]^+$ : 233.1397, found: 233.1396.

**2-Azido-*N*-benzyl-2-methyl-*N*-(1-phenylethyl) propanamide (1n)**

Colorless or light yellow oil (1.37 g, 84%),  $R_f = 0.45$  (PE:EA = 10:1);  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 7.42–7.33 (m, 2H), 7.32–7.27 (m, 4H), 7.24–7.14 (m, 2H), 7.14–7.05 (m, 2H), 6.03 (s, 1H), 4.84 (d,  $J = 15.5$  Hz, 1H), 3.80 (d,  $J = 15.7$  Hz, 1H), 1.69 (s, 3H), 1.60 (s, 6H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 172.2, 140.7, 138.7, 128.7, 128.3, 127.4, 126.7, 64.5, 55.9, 47.9, 26.0, 25.7; FT-IR (KBr,  $\text{cm}^{-1}$ ): 2105, 1641; HRMS (ESI-TOF)  $m/z$ :  $[\text{M}+\text{H}]^+$  calcd for  $[\text{C}_{19}\text{H}_{23}\text{N}_4\text{O}]^+$ : 323.1866, found: 323.1859.

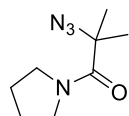
**2-Azido-2-methyl-*N,N*-diphenethylpropanamide (1o)**

Colorless oil (0.15 g, 9%),  $R_f = 0.31$  (PE:EA = 10:1);  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 7.36–7.13 (m, 10H), 3.61 (s, 4H), 2.91 (s, 4H), 1.54 (s, 6H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 170.9, 139.1, 138.1, 128.8, 128.7, 128.6, 128.5, 126.6, 126.4, 64.0, 50.8, 49.4, 35.5, 33.6, 25.4. FT-IR (KBr,  $\text{cm}^{-1}$ ): 2107, 1632; HRMS (ESI-TOF)  $m/z$ :  $[\text{M}+\text{H}]^+$  calcd for  $[\text{C}_{20}\text{H}_{25}\text{N}_4\text{O}]^+$ : 337.2023, found: 337.2029.



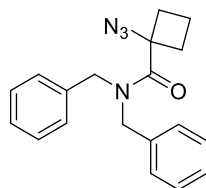
### 2-Azido-2-methyl-1-(piperidin-1-yl) propan-1-one (1p)

Colorless liquid (0.50 g, 51%),  $R_f = 0.25$  (PE:EA = 5:1);  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 3.79–3.57 (m, 4H), 1.71–1.55 (m, 6H), 1.51 (s, 6H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 169.4, 64.1, 46.4, 26.3, 25.2, 24.5; FT-IR (KBr,  $\text{cm}^{-1}$ ): 2105, 1641; HRMS (ESI-TOF)  $m/z$ :  $[\text{M}+\text{H}]^+$  calcd for  $[\text{C}_9\text{H}_{17}\text{N}_4\text{O}]$ : 197.1396; found: 197.1396.



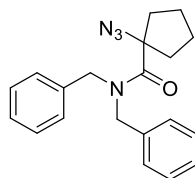
### 2-Azido-2-methyl-1-(pyrrolidin-1-yl) propan-1-one (1q)

Colorless liquid (0.36 g, 37%),  $R_f = 0.19$  (PE:EA = 5:1),  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 3.73 (t,  $J = 6.9$  Hz, 2H), 3.51 (t,  $J = 6.9$  Hz, 2H), 1.99–1.89 (m, 2H), 1.89–1.78 (m, 2H), 1.52 (s, 6H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 169.8, 64.2, 47.8, 47.5, 27.0, 24.5, 23.1; FT-IR (KBr,  $\text{cm}^{-1}$ ): 2106, 1634; HRMS (ESI-TOF)  $m/z$ :  $[\text{M}+\text{H}]^+$  calcd for  $[\text{C}_8\text{H}_{15}\text{N}_4\text{O}]^+$ : 183.1240, found: 183.1240.



### 1-Azido-*N,N*-dibenzylcyclobutane-1-carboxamide (1r)

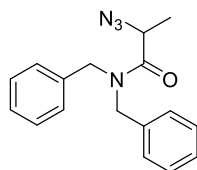
Colorless oil (1.07 g, 67%),  $R_f = 0.40$  (PE:EA = 10:1),  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 7.40–7.34 (m, 2H), 7.33–7.23 (m, 4H), 7.20–7.11 (m, 4H), 4.52 (s, 2H), 4.40 (s, 2H), 2.80 (dddd,  $J = 12.1, 9.6, 6.2, 2.8$  Hz, 2H), 2.28 (dddd,  $J = 12.0, 8.7, 5.8, 3.0$  Hz, 2H), 2.04 (dt,  $J = 11.4, 9.4, 6.9$  Hz, 1H), 1.86 (dt,  $J = 11.7, 9.2, 6.0$  Hz, 1H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 170.3, 136.8, 136.1, 128.8, 128.6, 128.1, 127.6, 127.4, 127.0, 66.2, 49.8, 47.6, 31.1, 29.5, 14.3; FT-IR (KBr,  $\text{cm}^{-1}$ ): 2105, 1724; HRMS (ESI-TOF)  $m/z$ :  $[\text{M}+\text{H}]^+$  calcd for  $[\text{C}_{19}\text{H}_{21}\text{N}_4\text{O}]^+$ : 321.1710, found: 321.1715.



### 1-Azido-*N,N*-dibenzylcyclopentane-1-carboxamide (1s)

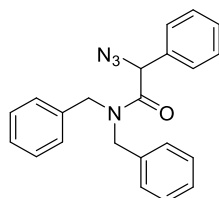
Yellow solid (0.86 g, 51%), m.p. = 67–68 °C;  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 7.41–7.34 (m, 2H), 7.34–7.25 (m, 4H), 7.19–7.12 (m, 4H), 4.75 (s, 2H), 4.55 (s, 2H), 2.41–2.29 (m, 2H), 2.06–1.92 (m, 2H), 1.86–1.72 (m, 4H);  $^{13}\text{C}$  NMR (100 MHz,

CDCl<sub>3</sub>,  $\delta$  ppm): 171.5, 136.9, 136.5, 128.8, 128.6, 128.0, 127.4, 126.7, 74.4, 50.3, 48.3, 36.2, 23.9; FT-IR (KBr, cm<sup>-1</sup>): 2102, 1643; HRMS (ESI-TOF) m/z: [M+H]<sup>+</sup> calcd for [C<sub>20</sub>H<sub>23</sub>N<sub>4</sub>O]<sup>+</sup>: 335.1866, found: 335.1873.



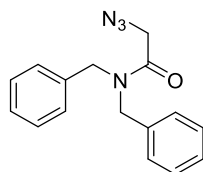
### 2-Azido-*N,N*-dibenzylpropanamide (1t)

Light yellow oil (0.85 g, 58%), R<sub>f</sub> = 0.31 (PE:EA = 10:1), <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>,  $\delta$  ppm): 7.40–7.27 (m, 6H), 7.23–7.20 (m, 2H), 7.16–7.11 (m, 2H), 4.72–4.35 (m, 4H), 3.98 (q, *J* = 6.7 Hz, 1H), 1.53 (d, *J* = 6.7 Hz, 3H); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>,  $\delta$  ppm): 170.9, 136.6, 135.8, 129.0, 128.7, 128.2, 127.8, 127.6, 126.2, 54.0, 49.6, 48.6, 16.2; FT-IR (KBr, cm<sup>-1</sup>): 2118, 1656; HRMS (ESI-TOF) m/z: [M+H]<sup>+</sup> calcd for [C<sub>17</sub>H<sub>19</sub>N<sub>4</sub>O]<sup>+</sup>: 295.1553; found: 295.1557.



### 2-Azido-*N,N*-dibenzyl-2-phenylacetamide (1u)

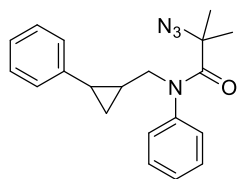
Yellow oil (0.75 g, 42%), R<sub>f</sub> = 0.49 (PE:EA = 10:1); <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>,  $\delta$  ppm): 7.47–7.37 (m, 5H), 7.35–7.22 (m, 6H), 7.22–7.12 (m, 2H), 7.04–6.96 (m, 2H), 5.08 (d, *J* = 14.7 Hz, 1H), 4.91 (s, 1H), 4.35–4.10 (m, 3H); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>,  $\delta$  ppm): 169.5, 136.5, 135.3, 133.7, 129.4, 129.4, 129.0, 128.6, 128.3, 128.0, 127.9, 127.6, 126.2, 63.6, 49.4, 48.8; FT-IR (KBr, cm<sup>-1</sup>): 2098, 1658; HRMS (ESI-TOF) m/z: [M+H]<sup>+</sup> calcd for [C<sub>22</sub>H<sub>21</sub>N<sub>4</sub>O]<sup>+</sup>: 357.1710, found: 357.1719.



### 2-Azido-*N,N*-dibenzylacetamide (1v)

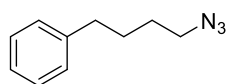
Yellow oil (0.87 g, 62%), R<sub>f</sub> = 0.16 (PE:EA = 10:1), <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>,  $\delta$  ppm):  $\delta$  7.39–7.18 (m, 8H), 7.15–7.09 (m, 2H), 4.64 (s, 2H), 4.36 (s, 2H), 3.96 (s, 2H); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>,  $\delta$  ppm): 167.9, 136.4, 135.4, 129.2, 129.1, 128.7, 128.4, 128.2, 128.0, 127.7, 126.2, 50.6, 49.4, 48.9; FT-IR (KBr, cm<sup>-1</sup>): 2117, 1648; HRMS (ESI-TOF) m/z: [M+H]<sup>+</sup> calcd for [C<sub>16</sub>H<sub>17</sub>N<sub>4</sub>O]<sup>+</sup>: 281.1397, found: 281.1400.





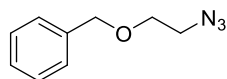
**2-Azido-2-methyl-N-phenyl-N-(2-phenylcyclopropyl) propanamide (1w)**

Light yellow oil (0.41 g, 25%),  $R_f = 0.49$  (PE:EA = 5:1);  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 7.37–7.29 (m, 3H), 7.26–7.17 (m, 4H), 7.16–7.07 (m, 1H), 6.97–6.89 (m, 2H), 3.92 (dd,  $J = 13.8, 6.3$  Hz, 1H), 3.52 (dd,  $J = 13.7, 7.8$  Hz, 1H), 1.69–1.60 (m, 1H), 1.42 (d,  $J = 4.8$  Hz, 6H), 1.37–1.26 (m, 1H), 0.86 (ddt,  $J = 23.4, 8.7, 5.2$  Hz, 2H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 171.7, 142.5, 142.4, 129.0, 128.4, 128.2, 127.9, 125.6, 125.5, 64.8, 56.4, 26.5, 22.5, 21.7, 14.4; FT-IR (KBr,  $\text{cm}^{-1}$ ): 2109, 1647; HRMS (ESI-TOF)  $m/z$ :  $[\text{M}+\text{H}]^+$  calcd for  $[\text{C}_{20}\text{H}_{23}\text{N}_4\text{O}]^+$ : 335.1866, found: 335.1870.



**(4-Azidobutyl) benzene (3)<sup>6</sup>**

Light yellow or colorless liquid;  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 7.32–7.24 (m, 2H), 7.22–7.13 (m, 3H), 3.26 (t,  $J = 6.5$  Hz, 2H), 2.63 (t,  $J = 7.3$  Hz, 2H), 1.76–1.55 (m, 4H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 141.8, 128.3, 125.8, 51.3, 35.3, 28.4; FT-IR (KBr,  $\text{cm}^{-1}$ ): 2094.

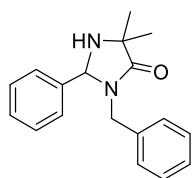


**(3-Azidopropoxy) benzene (4)<sup>6</sup>**

Light yellow or colorless liquid;  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 7.36–7.33 (m, 4H), 7.32–7.26 (m, 1H), 4.57 (s, 2H), 3.64 (t,  $J = 5.0$  Hz, 2H), 3.39 (t,  $J = 5.0$  Hz, 2H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 137.7, 128.4, 127.7, 127.6, 73.2, 68.8, 50.8. FT-IR (KBr,  $\text{cm}^{-1}$ ): 2102.

\*The yield given is for the last azidation step.

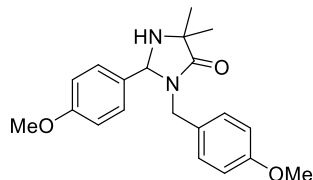
**Characterization data for the products**



**3-Benzyl-5,5-dimethyl-2-phenylimidazolidin-4-one (2a)**

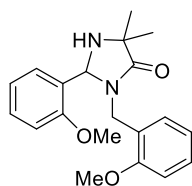
White solid (55.5 mg, 99%), m.p. = 86–88 °C;  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm):  $\delta$  7.43–7.38 (m, 3H), 7.28–7.22 (m, 5H), 7.05–6.99 (m, 2H), 5.04 (s, 1H), 5.01 (d,  $J =$

14.6 Hz, 1H), 3.52 (d,  $J = 14.5$  Hz, 1H), 1.86 (s, 1H), 1.46 (s, 3H), 1.28 (s, 3H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 178.1, 137.9, 135.8, 129.4, 129.1, 128.5, 128.2, 127.6, 127.2, 73.0, 59.4, 44.3, 25.5, 24.4; HRMS (ESI-TOF)  $m/z$ :  $[\text{M}+\text{H}]^+$  calcd for  $[\text{C}_{18}\text{H}_{21}\text{N}_2\text{O}]^+$ : 281.1648, found: 281.1647.



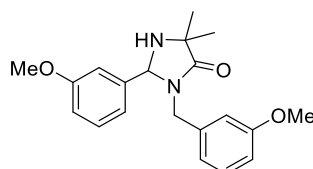
### 3-(4-Methoxybenzyl)-2-(4-methoxyphenyl)-5,5-dimethylimidazolidin-4-one (2b)

Colorless or light yellow oil (55.8 mg, 84%),  $R_f = 0.21$  (PE:EA = 1:1);  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 7.17 (d,  $J = 8.2$  Hz, 2H), 6.93 (t,  $J = 8.4$  Hz, 4H), 6.78 (d,  $J = 8.1$  Hz, 2H), 4.99 (s, 1H), 4.92 (d,  $J = 14.4$  Hz, 1H), 3.83 (s, 3H), 3.78 (s, 3H), 3.46 (d,  $J = 14.4$  Hz, 1H), 1.85 (s, 1H), 1.44 (s, 3H), 1.25 (s, 3H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 178.0, 160.3, 159.0, 123.0, 129.6, 128.6, 128.1, 114.4, 113.8, 72.5, 59.3, 55.2, 55.1, 43.6, 25.5, 24.2. HRMS (ESI-TOF)  $m/z$ :  $[\text{M}+\text{H}]^+$  calcd for  $[\text{C}_{20}\text{H}_{25}\text{N}_2\text{O}_3]^+$ : 341.1860, found: 341.1859.



### 3-(2-Methoxybenzyl)-2-(2-methoxyphenyl)-5,5-dimethylimidazolidin-4-one (2c)

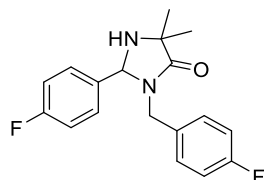
Light yellow oil (67.4 mg, 99%),  $R_f = 0.16$  (PE:EA = 1:1);  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm):  $\delta$  7.32 (td,  $J = 7.8, 1.8$  Hz, 1H), 7.20 (td,  $J = 7.8, 1.8$  Hz, 1H), 7.12 (dd,  $J = 7.6, 1.8$  Hz, 1H), 6.95 (td,  $J = 7.5, 1.0$  Hz, 1H), 6.91 (dd,  $J = 7.5, 1.8$  Hz, 1H), 6.84 (dd,  $J = 8.3, 1.0$  Hz, 1H), 6.79 (td,  $J = 7.4, 1.1$  Hz, 1H), 6.75 (dd,  $J = 8.2, 1.0$  Hz, 1H),  $\delta$  5.42 (s, 1H), 4.88 (d,  $J = 14.5$  Hz, 1H), 3.79 (d,  $J = 14.5$  Hz, 1H), 3.69 (s, 3H), 3.63 (s, 3H), 2.23 (s, 1H), 1.42 (s, 3H), 1.29 (s, 3H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 178.0, 157.8, 157.3, 130.4, 130.1, 128.7, 128.4, 125.5, 123.6, 120.6, 120.1, 110.7, 109.7, 69.3, 59.4, 55.2, 54.8, 39.8, 25.2, 24.3; HRMS (ESI-TOF)  $m/z$ :  $[\text{M}+\text{H}]^+$  calcd for  $[\text{C}_{20}\text{H}_{25}\text{N}_2\text{O}_3]^+$ : 341.1860, found: 341.1861.



### 3-(3-Methoxybenzyl)-2-(3-methoxyphenyl)-5,5-dimethylimidazolidin-4-one (2d)

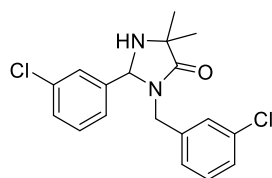
Colorless oil (59.9 mg, 88%),  $R_f = 0.36$  (PE:EA = 1:1);  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ,  $\delta$

ppm): 7.32 (t,  $J = 7.9$  Hz, 1H), 7.17 (t,  $J = 7.9$  Hz, 1H), 6.93 (dd,  $J = 8.3, 2.5$  Hz, 1H), 6.85 (d,  $J = 7.6$  Hz, 1H), 6.79 (dd,  $J = 8.5, 2.6$  Hz, 1H), 6.77 (s, 1H), 6.62 (d,  $J = 7.6$  Hz, 1H), 6.58 (s, 1H), 5.04 (s, 1H), 4.97 (d,  $J = 14.5$  Hz, 1H), 3.78 (s, 3H), 3.73 (s, 3H), 3.54 (d,  $J = 14.4$  Hz, 1H), 1.98 (s, 1H), 1.46 (s, 3H), 1.29 (s, 3H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 178.1, 160.1, 159.7, 139.7, 137.4, 130.1, 129.5, 120.5, 119.4, 115.0, 113.5, 113.3, 112.5, 73.0, 59.3, 55.2, 55.0, 44.4, 25.6, 24.4; HRMS (ESI-TOF)  $m/z$ :  $[\text{M}+\text{H}]^+$  calcd for  $[\text{C}_{20}\text{H}_{25}\text{N}_2\text{O}_3]^+$ : 341.1860; found: 341.1860.



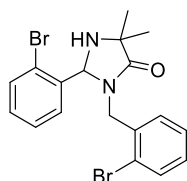
### 3-(4-Fluorobenzyl)-2-(4-fluorophenyl)-5,5-dimethylimidazolidin-4-one (2e)

Colorless or light yellow oil (62.6 mg, 99%),  $R_f = 0.44$  (PE:EA = 1:1);  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 7.26–7.18 (m, 2H), 7.13–7.04 (m, 2H), 7.02–6.91 (m, 4H), 5.04 (s, 1H), 4.89 (d,  $J = 14.6$  Hz, 1H), 3.55 (d,  $J = 14.6$  Hz, 1H), 1.86 (s, 1H), 1.45 (s, 3H), 1.27 (s, 3H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 178.0, 163.2 (d,  $J = 248.0$  Hz), 162.2 (d,  $J = 245.0$  Hz), 133.8 (d,  $J = 3.2$  Hz), 131.7 (d,  $J = 3.3$  Hz), 123.0 (d,  $J = 8.1$  Hz), 129.2 (d,  $J = 8.4$  Hz), 116.1 (d,  $J = 21.7$  Hz), 115.5 (d,  $J = 21.4$  Hz), 72.5, 59.3, 43.7, 25.7, 24.3; HRMS (ESI-TOF)  $m/z$ :  $[\text{M}+\text{H}]^+$  calcd for  $[\text{C}_{18}\text{H}_{19}\text{F}_2\text{N}_2\text{O}]^+$ : 317.1460, found: 317.1459.



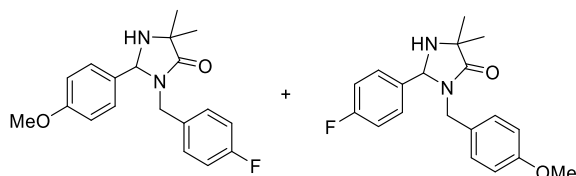
### 3-(3-Chlorobenzyl)-2-(3-chlorophenyl)-5,5-dimethylimidazolidin-4-one (2f)

Colorless oil (64.3 mg, 92%),  $R_f = 0.26$  (PE:EA = 1:1);  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 7.40–7.29 (m, 2H), 7.26–7.17 (m, 3H), 7.12 (d,  $J = 7.3$  Hz, 1H), 6.98 (s, 1H), 6.92 (d,  $J = 7.2$  Hz, 1H), 5.07 (s, 1H), 4.85 (d,  $J = 14.8$  Hz, 1H), 3.62 (d,  $J = 14.7$  Hz, 1H), 1.91 (s, 1H), 1.46 (s, 3H), 1.30 (s, 3H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 177.9, 140.2, 137.8, 135.1, 134.4, 130.3, 129.9, 129.8, 128.3, 128.0, 127.4, 126.3, 125.6, 72.7, 59.2, 43.9, 25.9, 24.6; HRMS (ESI-TOF)  $m/z$ :  $[\text{M}+\text{H}]^+$  calcd for  $[\text{C}_{18}\text{H}_{19}\text{Cl}_2\text{N}_2\text{O}]^+$ : 349.0869, found: 349.0872.

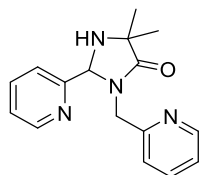


**3-(2-Bromobenzyl)-2-(2-bromophenyl)-5,5-dimethylimidazolidin-4-one (2g)**

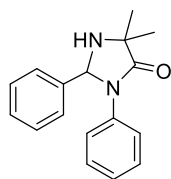
Colorless oil (85.9 mg, 98%),  $R_f = 0.49$  (PE:EA = 5:1);  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 7.58–7.44 (m, 2H), 7.40–7.30 (m, 1H), 7.26–7.06 (m, 4H), 7.01–6.92 (m, 1H), 5.56 (s, 1H), 5.03 (d,  $J = 14.8$  Hz, 1H), 3.95 (d,  $J = 14.8$  Hz, 1H), 2.00 (s, 1H), 1.42 (s, 3H), 1.38 (s, 3H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 177.8, 134.4, 133.6, 132.9, 130.6, 130.4, 129.3, 128.1, 127.5, 123.9, 72.2, 59.3, 44.7, 25.2; HRMS (ESI-TOF)  $m/z$ :  $[\text{M}+\text{H}]^+$  calcd for  $[\text{C}_{18}\text{H}_{19}\text{Br}_2\text{N}_2\text{O}]^+$ : 438.9838, found: 438.9839.

**3-(4-Fluorobenzyl)-2-(4-methoxyphenyl)-5,5-dimethylimidazolidin-4-one (2h-1)****2-(4-fluorophenyl)-3-(4-methoxybenzyl)-5,5-dimethylimidazolidin-4-one (2h-2)**

Colorless or light yellow oil (64.4 mg, 98%),  $R_f = 0.22$  (PE:EA = 1:1),  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 7.25–7.20 (m, 2H), 7.18–7.04 (m, 4H), 7.02–6.88 (m, 8H), 6.82–6.75 (m, 2H), 5.03 (s, 1H), 5.00 (s, 1H), 4.93 (d,  $J = 14.7$  Hz, 1H), 4.88 (d,  $J = 14.7$  Hz, 1H), 3.83 (s, 3H), 3.78 (s, 3H), 3.55 (d,  $J = 14.5$  Hz, 1H), 3.46 (d,  $J = 14.4$  Hz, 1H), 1.92 (s, 2H), 1.45 (d,  $J = 1.6$  Hz, 6H), 1.26 (d,  $J = 2.0$  Hz, 6H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 178.1, 178.0, 163.2 (d,  $J = 247.0$  Hz), 162.2 (d,  $J = 245.0$  Hz), 160.4, 159.0, 134.0, 134.0, 131.9, 131.9, 130.0, 130.0, 129.7, 129.5, 129.2, 129.2, 128.6, 127.8, 116.1, 115.9, 115.5, 115.3, 114.4, 113.9, 72.7, 72.3, 59.4, 59.3, 55.3, 55.2, 43.8, 43.6, 25.6, 25.5, 24.3, 24.2; HRMS (ESI-TOF)  $m/z$ :  $[\text{M}+\text{H}]^+$  calcd for  $[\text{C}_{19}\text{H}_{22}\text{FN}_2\text{O}_2]^+$ : 329.1660, found: 329.1660.

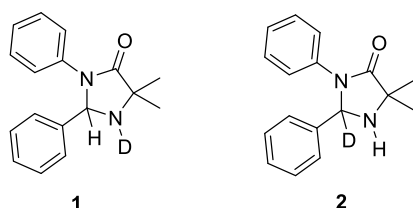
**5, 5-Dimethyl-2-(pyridin-2-yl)-3-(pyridin-2-ylmethyl) imidazolidin-4-one (2i)**

Yellow oil (40.1 mg, 71%),  $R_f = 0.31$  (DCM: MeOH = 20:1);  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 8.58 (d,  $J = 4.8$  Hz, 1H), 8.44 (d,  $J = 4.8$  Hz, 1H), 7.66 (t,  $J = 7.5$  Hz, 1H), 7.58 (t,  $J = 7.7$  Hz, 1H), 7.33–7.22 (m, 2H), 7.12 (d,  $J = 5.8$  Hz, 2H), 5.48 (s, 1H), 4.80 (d,  $J = 15.7$  Hz, 1H), 3.97 (d,  $J = 15.7$  Hz, 1H), 2.95 (s, 1H), 1.53 (d,  $J = 1.8$  Hz, 3H), 1.36 (d,  $J = 1.8$  Hz, 3H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 178.4, 156.0, 155.0, 149.9, 148.9, 136.7, 136.5, 124.1, 124.1, 122.1, 122.0, 73.8, 59.3, 46.0, 24.8, 24.3; HRMS (ESI-TOF)  $m/z$ :  $[\text{M}+\text{H}]^+$  calcd for  $[\text{C}_{16}\text{H}_{19}\text{N}_4\text{O}]^+$ : 283.1553, found: 283.1554.



**5, 5-Dimethyl-2,3-diphenylimidazolidin-4-one (2j)**

Light yellow oil (27.7 mg, 52%),  $R_f = 0.32$  (PE:EA = 1:1);  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 7.38–7.28 (m, 7H), 7.27–7.19 (m, 2H), 7.10–7.02 (m, 1H), 5.98 (s, 1H), 1.98 (s, 1H), 1.49 (s, 3H), 1.40 (s, 3H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 177.8, 138.4, 137.2, 129.1, 129.0, 128.6, 126.8, 125.0, 121.8, 74.8, 60.2, 25.5, 24.2; HRMS (ESI-TOF)  $m/z$ :  $[\text{M}+\text{H}]^+$  calcd for  $[\text{C}_{17}\text{H}_{19}\text{N}_2\text{O}]^+$ : 267.1492, found: 267.1497.

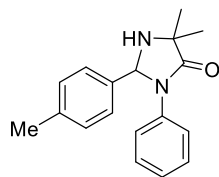


0.20 : 0.82

**5, 5-Dimethyl-2,3-diphenylimidazolidin-4-one-1-d (2j-d-1)**

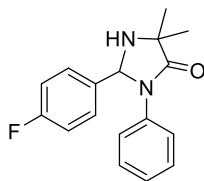
**5, 5-Dimethyl-2,3-diphenylimidazolidin-4-one-2-d (2j-d-2)**

Light yellow oil (22.5 mg, 42%),  $R_f = 0.36$  (PE:EA = 1:1);  $^1\text{H}$  NMR (600 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 7.37–7.28 (m, 7H), 7.26–7.22 (m, 2H), 7.08–7.04 (m, 1H), 5.98 (s, 0.20H) [C-H], 1.98 (s, 0.82H) [B N-H], 1.49 (s, 3H), 1.40 (s, 3H);  $^{13}\text{C}$  NMR (150 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 177.9, 138.5, 137.3, 129.1, 129.1, 128.7, 126.8, 125.0, 121.9, 75.0, 60.2, 25.6, 24.3.



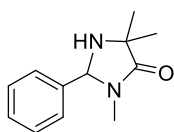
**5, 5-Dimethyl-3-phenyl-2-(p-tolyl)imidazolidin-4-one (2k)**

Light yellow oil (28.0 mg, 50%),  $R_f = 0.35$  (PE:EA = 1:1);  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 7.33 (d,  $J = 8.5$  Hz, 2H), 7.26–7.19 (m, 4H), 7.11 (d,  $J = 7.9$  Hz, 2H), 7.04 (t,  $J = 7.4$  Hz, 1H), 5.94 (s, 1H), 2.28 (s, 3H), 1.94 (s, 1H), 1.48 (s, 3H), 1.39 (s, 3H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 177.8, 138.9, 137.3, 135.5, 129.7, 128.6, 126.6, 124.9, 121.9, 74.7, 60.1, 25.6, 24.2, 21.1; HRMS (ESI-TOF)  $m/z$ :  $[\text{M}+\text{H}]^+$  calcd for  $[\text{C}_{18}\text{H}_{21}\text{N}_2\text{O}]^+$ : 281.1648, found: 281.1652.



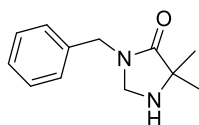
### 2-(4-Fluorophenyl)-5,5-dimethyl-3-phenylimidazolidin-4-one (2l)

Colorless oil (27.3 mg, 48%),  $R_f = 0.34$  (PE:EA = 1:1);  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 7.35–7.28 (m, 4H), 7.27–7.22 (m, 2H), 7.10–7.04 (m, 1H), 7.00 (t,  $J = 8.6$  Hz, 2H), 5.97 (s, 1H), 1.95 (d,  $J = 9.1$  Hz, 1H), 1.48 (s, 3H), 1.39 (s, 3H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 177.6, 162.9 (d,  $J = 248.3$  Hz), 137.1, 134.4, 134.4, 128.7, 128.7, 128.6, 125.2, 122.0, 116.2, 116.0, 74.2, 60.2, 25.6, 24.2; HRMS (ESI-TOF)  $m/z$ :  $[\text{M}+\text{H}]^+$  calcd for  $[\text{C}_{17}\text{H}_{18}\text{FN}_2\text{O}]^+$ : 285.1398, found: 285.1403.



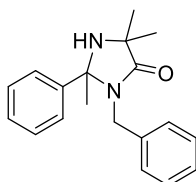
### 3,5,5-Trimethyl-2-phenylimidazolidin-4-one (2m-1)

Light yellow oil (8.2 mg, 20%),  $R_f = 0.18$  (PE:EA = 1:1);  $^1\text{H}$  NMR (600 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 7.46–7.39 (m, 3H), 7.36–7.32 (m, 2H), 5.23 (s, 1H), 2.65 (s, 3H), 1.87 (s, 1H), 1.42 (s, 3H), 1.32 (s, 3H);  $^{13}\text{C}$  NMR (150 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 178.4, 138.5, 129.5, 129.2, 126.9, 77.2, 77.0, 76.8, 75.9, 59.5, 27.6, 26.0, 24.6; HRMS (ESI-TOF)  $m/z$ :  $[\text{M}+\text{H}]^+$  calcd for  $[\text{C}_{12}\text{H}_{17}\text{N}_2\text{O}]^+$ : 205.1335, found: 205.1335.



### 3-Benzyl-5,5-dimethylimidazolidin-4-one (2m-2)

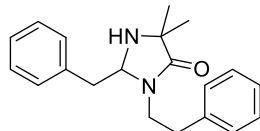
Light yellow oil (16.3 mg, 40%),  $R_f = 0.08$  (PE:EA = 1:1);  $^1\text{H}$  NMR (600 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 7.35–7.31 (m, 2H), 7.30–7.26 (m, 1H), 7.24–7.21 (m, 2H), 4.14 (s, 2H), 2.27 (s, 2H), 2.11 (s, 1H), 1.30 (s, 6H);  $^{13}\text{C}$  NMR (150 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 177.6, 136.0, 128.6, 127.8, 127.6, 60.4, 59.3, 45.4, 23.8; HRMS (ESI-TOF)  $m/z$ :  $[\text{M}+\text{H}]^+$  calcd for  $[\text{C}_{12}\text{H}_{17}\text{N}_2\text{O}]^+$ : 205.1335, found: 205.1335.



### 3-Benzyl-2,5,5-trimethyl-2-phenylimidazolidin-4-one (2n)

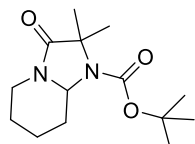
Colorless or light yellow oil (52.4 mg, 89%),  $R_f = 0.41$  (PE:EA = 1:1),  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 7.41–7.30 (m, 5H), 7.27–7.20 (m, 3H), 7.20–7.14 (m, 2H), 4.96

(d,  $J = 15.3$  Hz, 1H), 3.78 (d,  $J = 15.3$  Hz, 1H), 2.24 (s, 1H), 1.58 (s, 3H), 1.47 (s, 3H), 1.32 (s, 3H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 177.8, 143.7, 138.1, 128.8, 128.4, 128.2, 127.8, 127.2, 125.8, 78.5, 58.8, 44.8, 28.5, 28.1, 26.5; HRMS (ESI-TOF)  $m/z$ :  $[\text{M}+\text{H}]^+$  calcd for  $[\text{C}_{19}\text{H}_{23}\text{N}_2\text{O}]^+$ : 295.1805, found: 295.1805.



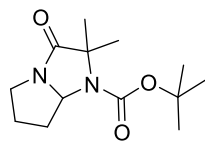
**2-Benzyl-5,5-dimethyl-3-phenethylimidazolidin-4-one (2o)**

Yellow oil (41.3 mg, 67%),  $R_f = 0.33$  (PE:EA = 1:1);  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 7.34–7.15 (m, 8H), 7.14–7.08 (m, 2H), 4.47 (dd,  $J = 6.4, 4.0$  Hz, 1H), 4.00 (ddd,  $J = 13.9, 8.0, 6.2$  Hz, 1H), 3.27 (ddd,  $J = 14.0, 7.9, 6.2$  Hz, 1H), 3.03–2.68 (m, 4H), 1.72 (s, 1H), 1.14 (s, 3H), 1.04 (s, 3H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 177.9, 138.3, 135.1, 129.4, 128.7, 128.6, 128.5, 127.0, 126.5, 71.0, 58.6, 41.7, 39.9, 33.5, 25.6, 24.7; HRMS (ESI-TOF)  $m/z$ :  $[\text{M}+\text{H}]^+$  calcd for  $[\text{C}_{20}\text{H}_{25}\text{N}_2\text{O}]^+$ : 309.1961, found: 309.1962.



**tert-Butyl 2,2-dimethyl-3-oxohexahydroimidazo[1,2-a]pyridine-1(5H)-carboxylate (2p')**

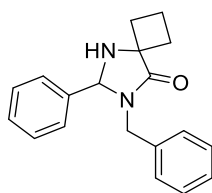
Colorless or light yellow oil (45.1 mg, 84%),  $R_f = 0.33$  (PE:EA = 3:1);  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 4.85–4.69 (m, 1H), 4.32–4.20 (m, 1H), 2.85–2.69 (m, 1H), 2.68–2.39 (m, 1H), 1.96–1.85 (m, 1H), 1.74–1.63 (m, 1H), 1.62–1.45 (m, 16H), 1.43–1.29 (m, 1H), 1.18–0.93 (m, 1H);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 171.4, 153.0, 80.6, 70.3, 60.6, 39.8, 32.9, 28.4, 25.0, 24.4, 24.1, 22.2; HRMS (ESI-TOF)  $m/z$ :  $[\text{M}+\text{H}]^+$  calcd for  $[\text{C}_{14}\text{H}_{25}\text{N}_2\text{O}_3]^+$ : 269.1860, found: 269.1867.



**tert-Butyl-2,2-dimethyl-3-oxohexahydro-1H-pyrrolo[1,2-a]imidazole-1-carboxylate (2q')**

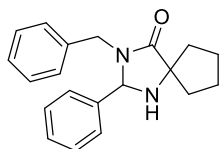
Colorless or light yellow oil (16.8 mg, 33%),  $R_f = 0.28$  (PE:EA = 3:1);  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 5.11–4.97 (m, 1H), 3.77–3.66 (m, 1H), 3.17–3.09 (m, 1H), 2.51–2.27 (m, 1H), 2.17–2.06 (m, 1H), 2.06–1.92 (m, 1H), 1.58–1.45 (m, 15H), 1.42–1.24 (m, 1H);  $^{13}\text{C}$  NMR (150 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 176.1, 153.5, 74.4, 41.4, 33.3, 32.6, 28.4, 25.0, 24.0, 23.8, 22.6; HRMS (ESI-TOF)  $m/z$ :  $[\text{M}+\text{H}]^+$  calcd for

$[\text{C}_{13}\text{H}_{23}\text{N}_2\text{O}_3]^+$ : 255.1703, found: 255.1710.



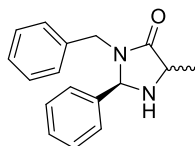
**7-Benzyl-6-phenyl-5,7-diazaspiro[3.4]octan-8-one (2r)**

Yellow oil (46.2 %, 79%),  $R_f = 0.56$  (PE:EA = 1:1);  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 7.40–7.34 (m, 3H), 7.29–7.22 (m, 3H), 7.21–7.15 (m, 2H), 7.09–7.02 (m, 2H), 5.10 (s, 1H), 4.99 (d,  $J = 14.7$  Hz, 1H), 3.50 (d,  $J = 14.7$  Hz, 1H), 2.78–2.66 (m, 1H), 2.62–2.50 (m, 1H), 2.21 (s, 1H), 2.17–2.05 (m, 3H), 1.93–1.76 (m, 1H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 176.5, 139.0, 136.0, 129.2, 129.0, 128.5, 128.2, 127.5, 127.0, 73.8, 62.6, 43.9, 34.6, 34.1, 13.8; HRMS (ESI-TOF)  $m/z$ :  $[\text{M}+\text{H}]^+$  calcd for  $[\text{C}_{19}\text{H}_{21}\text{N}_2\text{O}]^+$ : 293.1648, found: 293.1650.



**3-Benzyl-2-phenyl-1,3-diazaspiro[4.4]nonan-4-one (2s)**

Colorless oil (57.6 mg, 94%),  $R_f = 0.67$  (PE:EA = 1:1);  $^1\text{H}$  NMR (300 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 7.41–7.35 (m, 3H), 7.28–7.20 (m, 5H), 7.05–6.98 (m, 2H), 5.01 (d,  $J = 14.3$  Hz, 2H), 3.56 (d,  $J = 14.6$  Hz, 1H), 2.48–2.33 (m, 1H), 1.93–1.67 (m, 7H), 1.63–1.50 (m, 1H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 178.48, 138.13, 136.01, 129.4, 129.0, 128.5, 128.2, 127.5, 127.3, 73.8, 69.5, 44.5, 37.8, 37.2, 25.2, 25.1; HRMS (ESI-TOF)  $m/z$ :  $[\text{M}+\text{H}]^+$  calcd for  $[\text{C}_{20}\text{H}_{23}\text{N}_2\text{O}]^+$ : 307.1805, found: 307.1807.



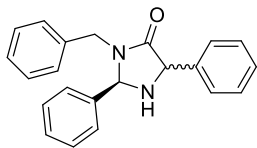
**(2R\*,5R\*)-3-Benzyl-5-methyl-2-phenylimidazolidin-4-one and**

**(2R\*,5S\*)-3-benzyl-5-methyl-2-phenylimidazolidin-4-one (2t)**

Colorless oil (38.4 mg, 72%),  $R_f = 0.67$  (PE:EA = 1:1); dr = 1:1;  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): (**A**): 7.45–7.38 (m, 3H), 7.33–7.22 (m, 5H), 7.12–7.07 (m, 1H), 7.07–7.01 (m, 1H), 5.21 (s, 1H), 5.07 (d,  $J = 14.7$  Hz, 1H), 3.93 (q,  $J = 6.9$  Hz, 1H), 3.57 (t,  $J = 14.7$  Hz, 2H), 2.82 (s, 1H), 1.49 (d,  $J = 6.8$  Hz, 3H); (**B**): 7.45–7.38 (m, 3H), 7.33–7.22 (m, 5H), 7.12–7.07 (m, 1H), 7.07–7.01 (m, 1H), 5.15 (s, 1H), 4.98 (d,  $J = 14.6$  Hz, 1H), 3.67 (q,  $J = 6.8$  Hz, 1H), 2.82 (s, 1H), 1.40 (d,  $J = 6.9$  Hz, 3H);  $^{13}\text{C}$  NMR (75 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 175.6, 175.2, 138.4, 138.0, 135.8, 135.7, 129.6, 129.4, 129.1, 129.0, 128.6, 128.5, 128.4, 128.2, 127.7, 127.6, 127.5, 126.9, 74.8, 74.3, 55.3, 54.2,

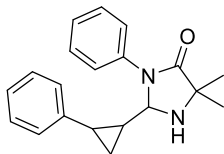


44.4, 44.1, 18.0, 17.9; HRMS (ESI-TOF)  $m/z$ :  $[M+H]^+$  calcd for  $[C_{17}H_{19}N_2O]^+$ : 267.1492, found: 267.1495.



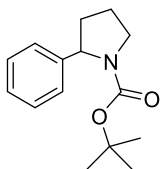
**(2R\*, 5R\*)-3-benzyl-2,5-diphenylimidazolidin-4-one and  
(2S\*, 5R\*)-3-Benzyl-2, 5-diphenylimidazolidin-4-one (2u)**

Yellow oil (51.9 mg, 79%),  $R_f$  = 0.67 (PE:EA = 1:1); dr = 1: 0.7;  $^1H$  NMR (300 MHz,  $CDCl_3$ ,  $\delta$  ppm): (**A**) 7.56–7.52 (m, 2H), 7.43–7.20 (m, 11H), 7.11–7.04 (m, 2H), 5.28 (d,  $J$  = 1.9, 1H), 4.98 (d,  $J$  = 14.6 Hz, 1H), 4.72 (d,  $J$  = 1.9 Hz, 1H), 3.60 (d,  $J$  = 14.7 Hz, 1H), 2.41 (s, 1H); (**B**) 7.49–7.44 (m, 2H), 7.43–7.20 (m, 11H), 7.04–6.98 (m, 2H), 5.36 (d,  $J$  = 1.8 Hz, 1H), 5.05 (d,  $J$  = 14.7 Hz, 1H), 4.93 (s, 1H), 3.55 (d,  $J$  = 14.7 Hz, 1H), 2.41 (s, 1H);  $^{13}C$  NMR (75 MHz,  $CDCl_3$ ,  $\delta$  ppm): 172.9, 172.8, 139.2, 139.0, 138.4, 138.1, 135.9, 135.7, 129.5, 129.4, 129.1, 128.9, 128.6, 128.6, 128.6, 128.5, 128.2, 128.0, 127.8, 127.6, 127.0, 126.9, 75.3, 74.4, 63.1, 62.2, 44.5, 44.2; HRMS (ESI-TOF)  $m/z$ :  $[M+H]^+$  calcd for  $[C_{22}H_{21}N_2O]^+$ : 329.1648, found: 329.1650.



**5, 5-Dimethyl-3-phenyl-2-(2-phenylcyclopropyl) imidazolidin-4-one (2w)**

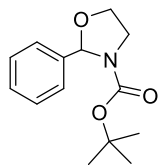
Colorless oil (27.0 mg, 44%),  $R_f$  = 0.21 (PE:EA = 1:1);  $^1H$  NMR (300 MHz,  $CDCl_3$ ,  $\delta$  ppm): 7.46–7.38 (m, 2H), 7.35–7.27 (m, 3H), 7.25–7.19 (m, 2H), 7.18–7.12 (m, 1H), 7.03–6.98 (m, 2H), 4.53 (d,  $J$  = 7.6 Hz, 1H), 2.08–1.98 (m, 2H (NH and CH)), 1.45 (s, 3H), 1.34 (s, 3H), 1.21–1.10 (m, 1H), 1.00–0.83 (m, 2H);  $^{13}C$  NMR 100 MHz,  $CDCl_3$ ,  $\delta$  ppm): 177.3, 140.5, 136.9, 129.2, 128.0, 126.8, 126.0, 125.9, 125.8, 76.9, 59.4, 27.3, 26.1, 24.7, 22.5, 10.0; HRMS (ESI-TOF)  $m/z$ :  $[M+H]^+$  calcd for  $[C_{20}H_{23}N_2O]^+$ : 307.1806, found: 307.1805.



**tert-Butyl 2-phenylpyrrolidine-1-carboxylate (5)<sup>6</sup>**

Yellow liquid (**A** & **B**, 44.0 mg, 89%);  $R_f$  = 0.21 (PE:EA = 20:1); **A**:**B** = 2:1; (**A**):  $^1H$  NMR (400 MHz,  $CDCl_3$ ,  $\delta$  ppm): 7.35–7.27 (m, 2H), 7.26–7.14 (m, 3H), 4.78 (s, 1H), 3.72–3.46 (m, 2H), 2.41–2.20 (m, 1H), 2.00–1.78 (m, 3H), 1.20 (s, 9H);  $^{13}C$  NMR 100 MHz,  $CDCl_3$ ,  $\delta$  ppm): 154.5, 145.1, 128.3, 128.0, 126.4, 125.4, 79.1, 61.2, 47.0, 36.0,

28.4, 28.1, 23.1. (**B**):  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 7.35–7.27 (m, 2H), 7.26–7.14 (m, 3H), 4.98 (s, 1H), 3.72–3.46 (m, 2H), 2.41–2.20 (m, 1H), 2.00–1.78 (m, 3H), 1.47 (s, 9H).  $^{13}\text{C}$  NMR 100 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 154.5, 145.1, 128.2, 126.4, 125.2, 79.1, 60.6, 47.2, 34.8, 28.3, 23.3. HRMS (ESI-TOF)  $m/z$ :  $[\text{M}+\text{H}]^+$  calcd for  $[\text{C}_{15}\text{H}_{22}\text{NO}_2]^+$ : 248.1645, found: 248.1648.



***tert*-Butyl 2-phenyloxazolidine-3-carboxylate (**6**)<sup>7</sup>**

Yellow liquid (38.9 mg, 78%);  $R_f$  = 0.33 (PE: EA = 10:1);  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 7.48–7.30 (m, 5H), 5.98 (s, 1H), 4.18–4.08 (m, 1H), 4.07–3.99 (m, 1H), 3.85 (s, 1H), 3.58 (s, 1H), 1.30 (s, 9H).  $^{13}\text{C}$  NMR 100 MHz,  $\text{CDCl}_3$ ,  $\delta$  ppm): 153.1, 139.6, 128.3, 128.2, 126.5, 89.1, 80.4, 65.7, 44.9, 28.2. HRMS (ESI-TOF)  $m/z$ :  $[\text{M}+\text{H}]^+$  calcd for  $[\text{C}_{14}\text{H}_{20}\text{NO}_3]^+$ : 250.1440, found: 250.1438.

## Crystallographic data for compound **2a**

The single crystal of **2a** was collected through mixed solvent recrystallization with dichloromethane and petroleum Ether, and the collected crystal **2a** was colorless and transparent. A suitable crystal was selected and the measurement was carried on a SuperNova, Eos diffractometer. The data for compound **2a** were collected on Brookhaven BI-200SM. The crystal was kept at 295.62(10) K during data collection. Using Olex2,<sup>8</sup> the structure was solved with the ShelXS<sup>9</sup> structure solution program using Direct Methods and refined with the ShelXL<sup>10</sup> refinement package using Least Squares minimization.

### Molecular Structure of **2a**

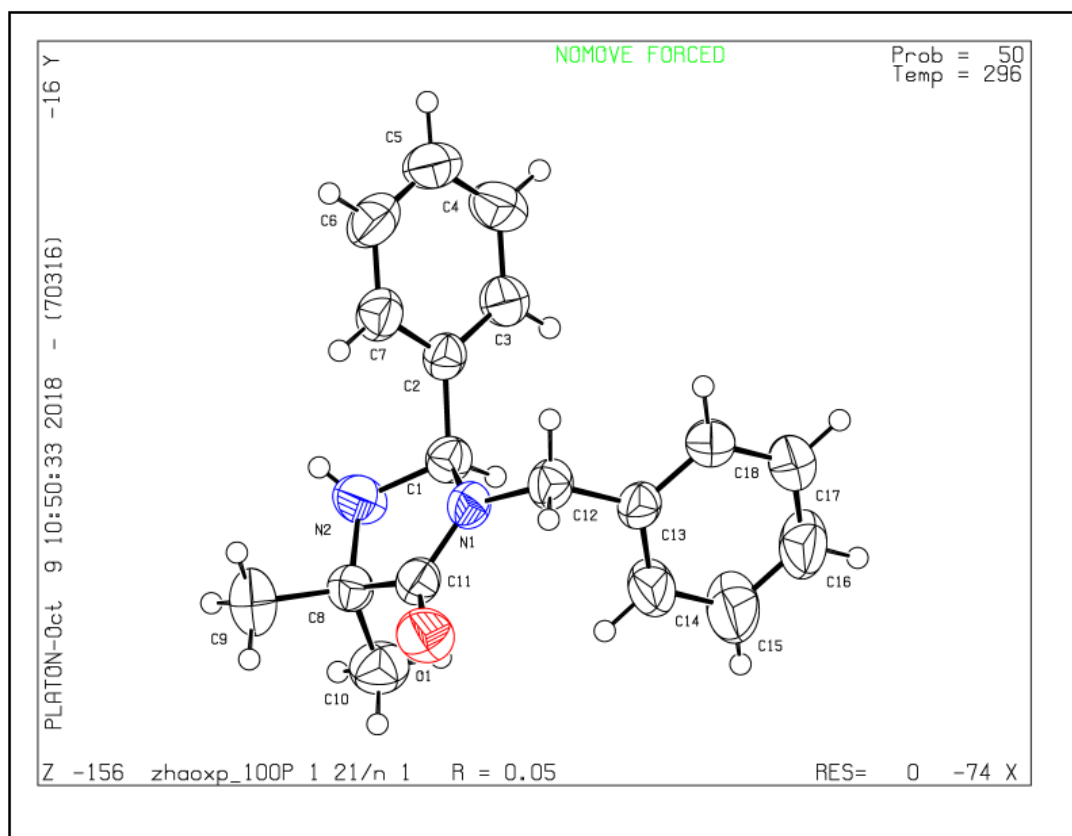
Crystal Data for C<sub>18</sub>H<sub>20</sub>N<sub>2</sub>O (*M* = 280.36 g/mol): monoclinic, space group P2<sub>1</sub>/n (no. 14), *a* = 17.1267(9) Å, *b* = 5.5794(3) Å, *c* = 17.3458(8) Å,  $\beta$  = 110.422(6)°, *V* = 1553.33(13) Å<sup>3</sup>, *Z* = 4, *T* = 295.62(10) K,  $\mu(\text{CuK}\alpha)$  = 0.587 mm<sup>-1</sup>, *D*<sub>calc</sub> = 1.199 g/cm<sup>3</sup>, 5180 reflections measured (11.02° ≤ 2 $\Theta$  ≤ 133.02°), 2668 unique (*R*<sub>int</sub> = 0.0183, *R*<sub>sigma</sub> = 0.0235) which were used in all calculations. The final *R*<sub>I</sub> was 0.0495 (> 2 $\sigma$ (*I*)) and *wR*<sub>2</sub> was 0.1419 (all data). CCDC-1872309 contains the supplementary crystallographic data for this paper. These data can be obtained free from [www.ccdc.cam.ac.uk](http://www.ccdc.cam.ac.uk). (CCDC No. 1872309).

**Table S1. Crystal data and structure refinement of 2a**

Empirical formula	C <sub>18</sub> H <sub>20</sub> N <sub>2</sub> O
Formula weight	280.36
Temperature/K	295.62(10)
Crystal system	monoclinic
Space group	P2 <sub>1</sub> /n
a/Å	17.1267(9)
b/Å	5.5794(3)
c/Å	17.3458(8)
$\alpha$ /°	90.00
$\beta$ /°	110.422(6)
$\gamma$ /°	90.00
Volume/Å <sup>3</sup>	1553.33(13)
Z	4
$\rho_{\text{calc}}$ /g/cm <sup>3</sup>	1.199
$\mu$ /mm <sup>-1</sup>	0.587
F(000)	600.0
Crystal size/mm <sup>3</sup>	0.17 × 0.14 × 0.12
Radiation	CuK $\alpha$ ( $\lambda$ = 1.54184)
2 $\Theta$ range for data collection/°	11.02 to 133.02
Index ranges	-15 ≤ h ≤ 20, -5 ≤ k ≤ 6, -20 ≤ l ≤ 14
Reflections collected	5180
Independent reflections	2668 [R <sub>int</sub> = 0.0183, R <sub>sigma</sub> = 0.0235]
Data/restraints/parameters	2668/0/196
Goodness-of-fit on F <sup>2</sup>	1.053
Final R indexes [I ≥ 2 $\sigma$ (I)]	R <sub>1</sub> = 0.0495, wR <sub>2</sub> = 0.1321
Final R indexes [all data]	R <sub>1</sub> = 0.0583, wR <sub>2</sub> = 0.1419
Largest diff. peak/hole / e Å <sup>-3</sup>	0.17/-0.15

**Table S2. Fractional atomic coordinates ( $\times 10^4$ ) and equivalent isotropic displacement parameters ( $\text{\AA}^2 \times 10^3$ ) for 2a.  $U_{\text{eq}}$  is defined as 1/3 of the trace of the orthogonalised  $U_L$  tensor.**

Atom	x	y	z	$U(\text{eq})$
N1	8030.1(8)	2111(2)	5399.8(8)	47.2(3)
O1	7389.9(8)	4831(2)	4390.0(8)	67.8(4)
C2	9228.6(9)	-108(3)	6360.9(10)	45.1(4)
C12	7547.3(10)	2585(3)	5927.1(11)	52.5(4)
C7	9819.7(11)	1679(3)	6644.4(12)	58.0(5)
C8	8389.2(10)	1903(3)	4229.8(10)	49.7(4)
N2	8949.2(11)	360(3)	4872.4(10)	64.2(5)
C13	6923.0(9)	640(3)	5892.4(10)	48.4(4)
C11	7871.4(10)	3163(3)	4663.0(10)	47.9(4)
C1	8579.7(10)	23(3)	5511.2(10)	47.7(4)
C6	10431.3(11)	1516(4)	7407.3(13)	69.1(6)
C3	9259.7(12)	-2027(3)	6870.7(11)	57.5(5)
C17	6272.0(13)	-2050(4)	6565.1(13)	74.9(6)
C4	9873.1(14)	-2178(4)	7636.8(12)	69.9(5)
C18	6852.5(12)	-294(4)	6597.5(11)	66.4(5)
C5	10467.2(12)	-432(4)	7905.4(12)	68.9(6)
C9	8877.4(14)	3687(4)	3920.3(15)	77.2(6)
C10	7810.5(13)	430(4)	3520.8(12)	70.1(5)
C16	5766.7(16)	-2884(5)	5833.3(15)	89.6(8)
C14	6403.6(15)	-211(5)	5156.9(12)	96.2(9)
C15	5828(2)	-1947(7)	5126.2(16)	131.2(14)



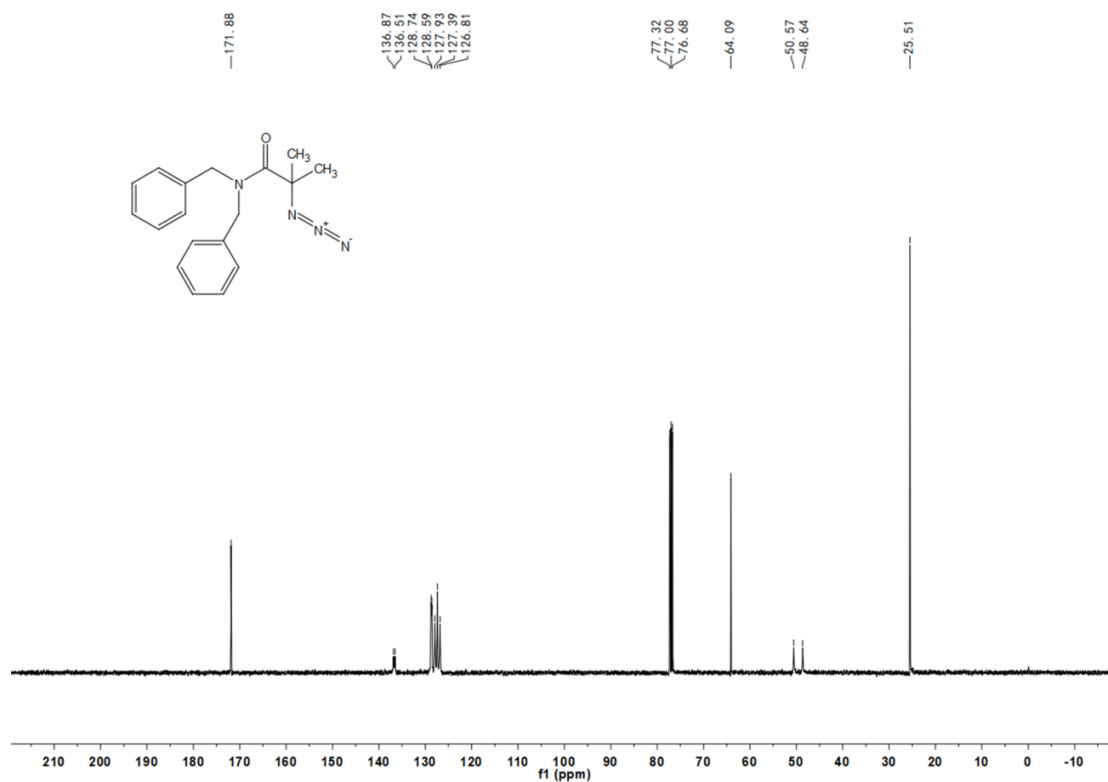
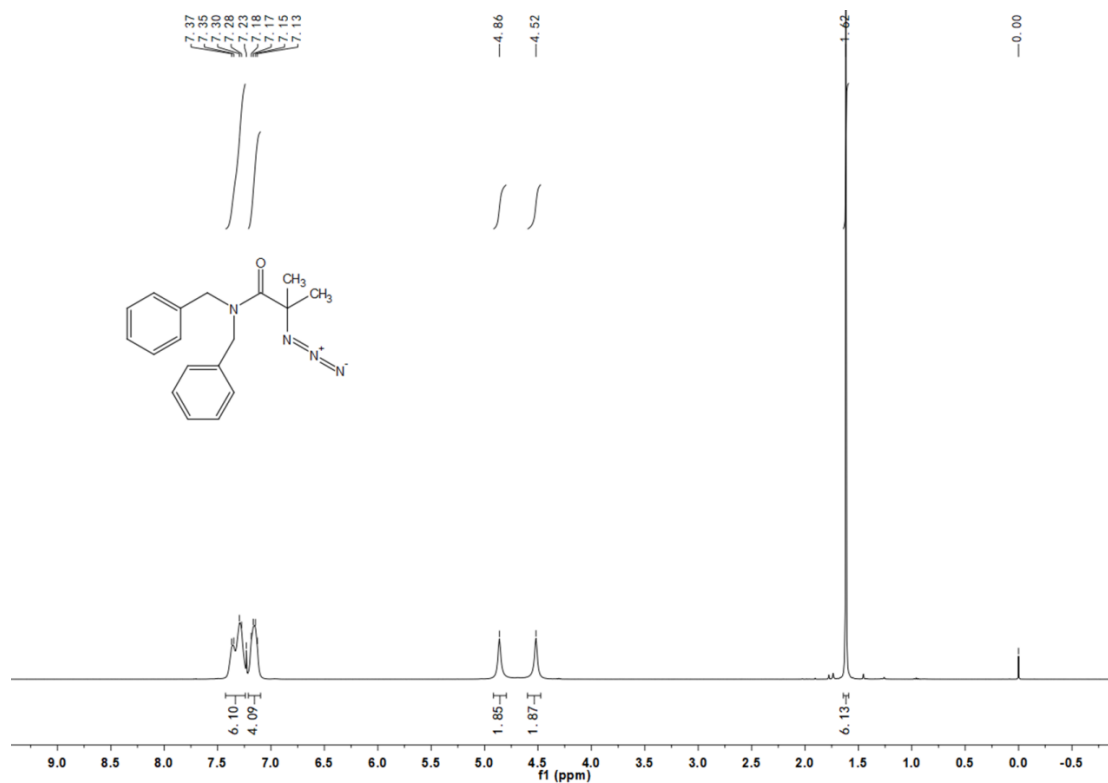
**Figure S1** Molecular structure of **2a**. Hydrogen and solvent molecules are omitted for clarity. Thermal ellipsoids are drawn with 50% probability.

## References

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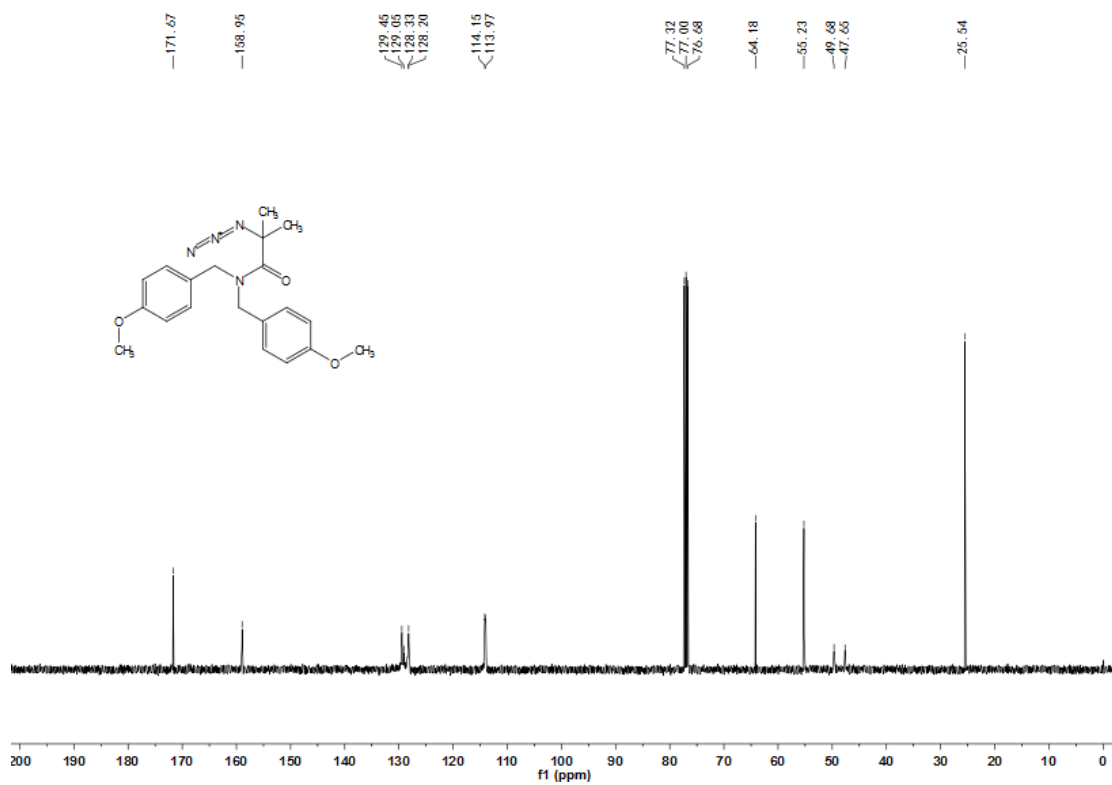
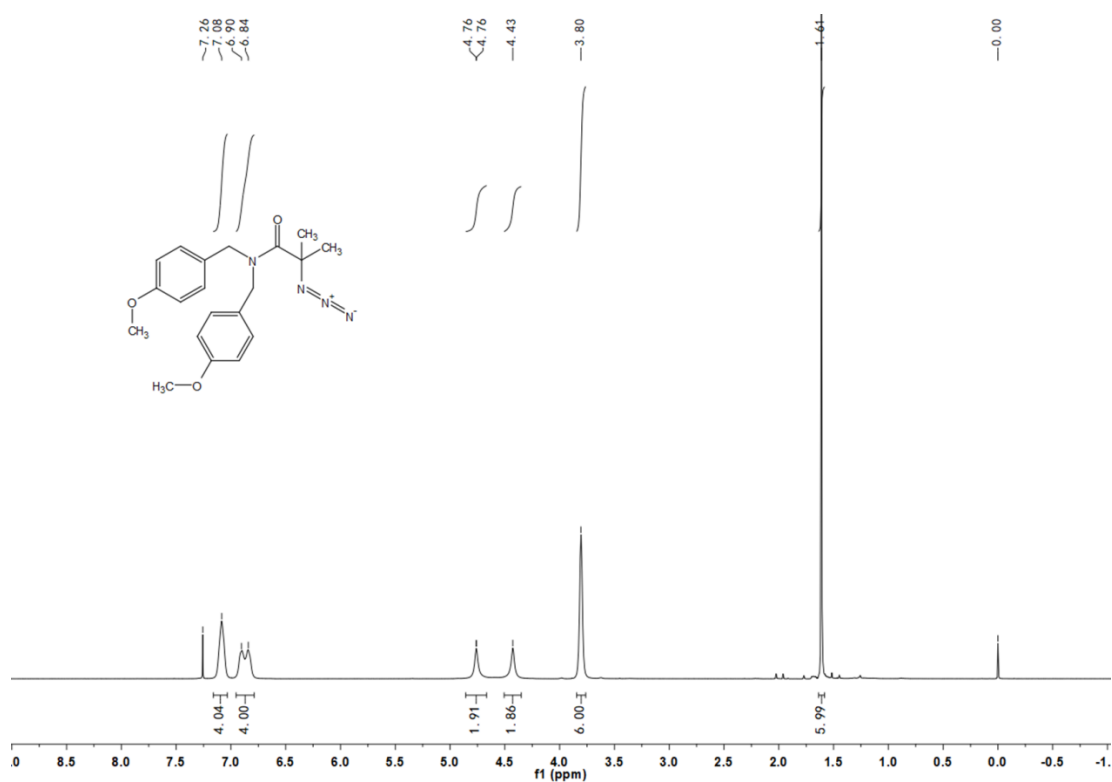
# Copies of $^1\text{H}$ NMR and $^{13}\text{C}$ NMR spectra

**1a**

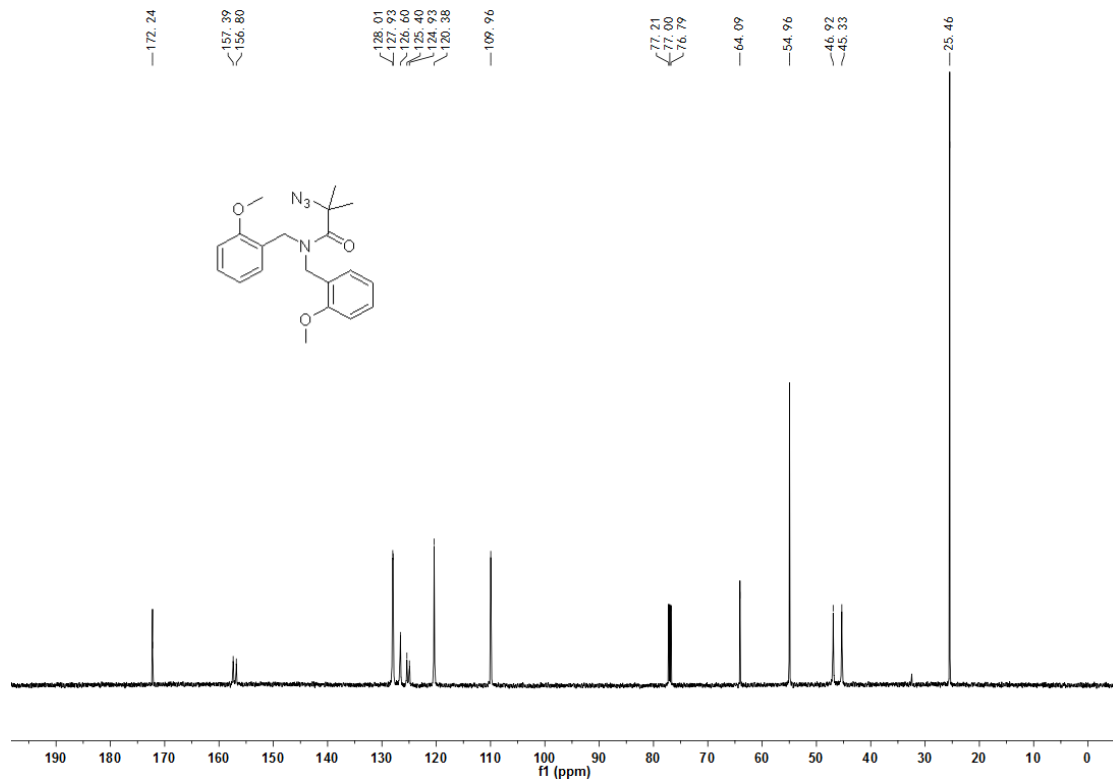
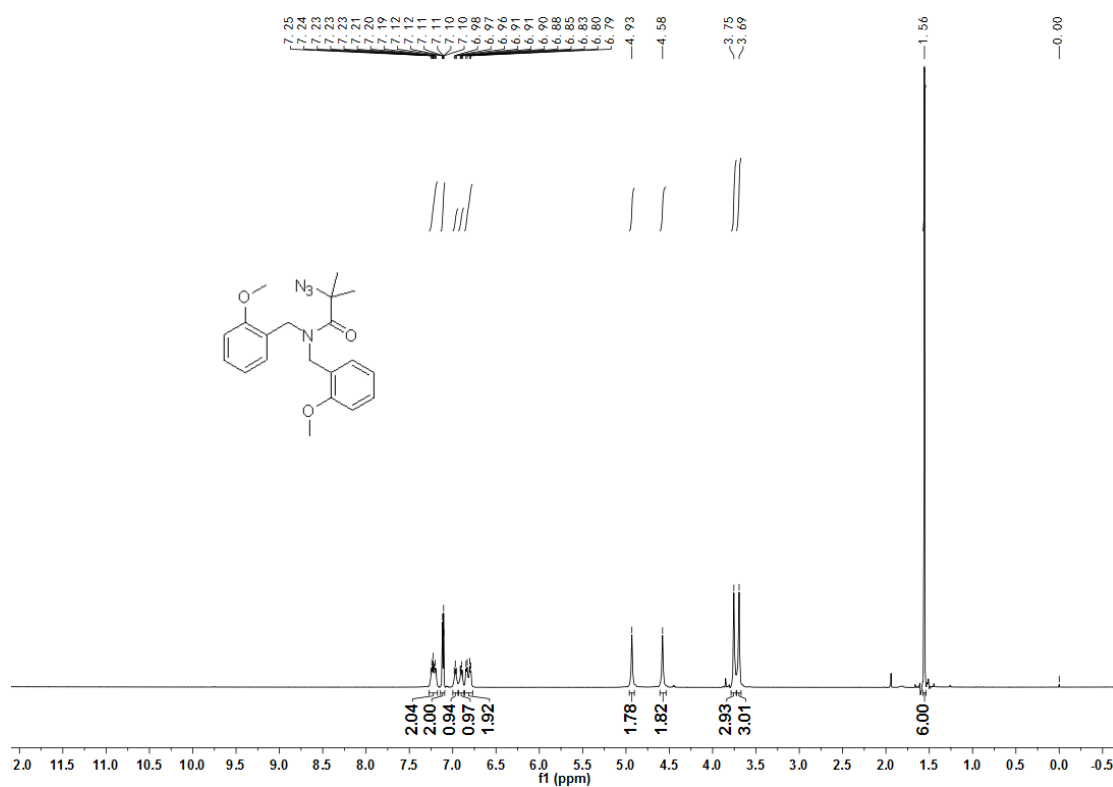




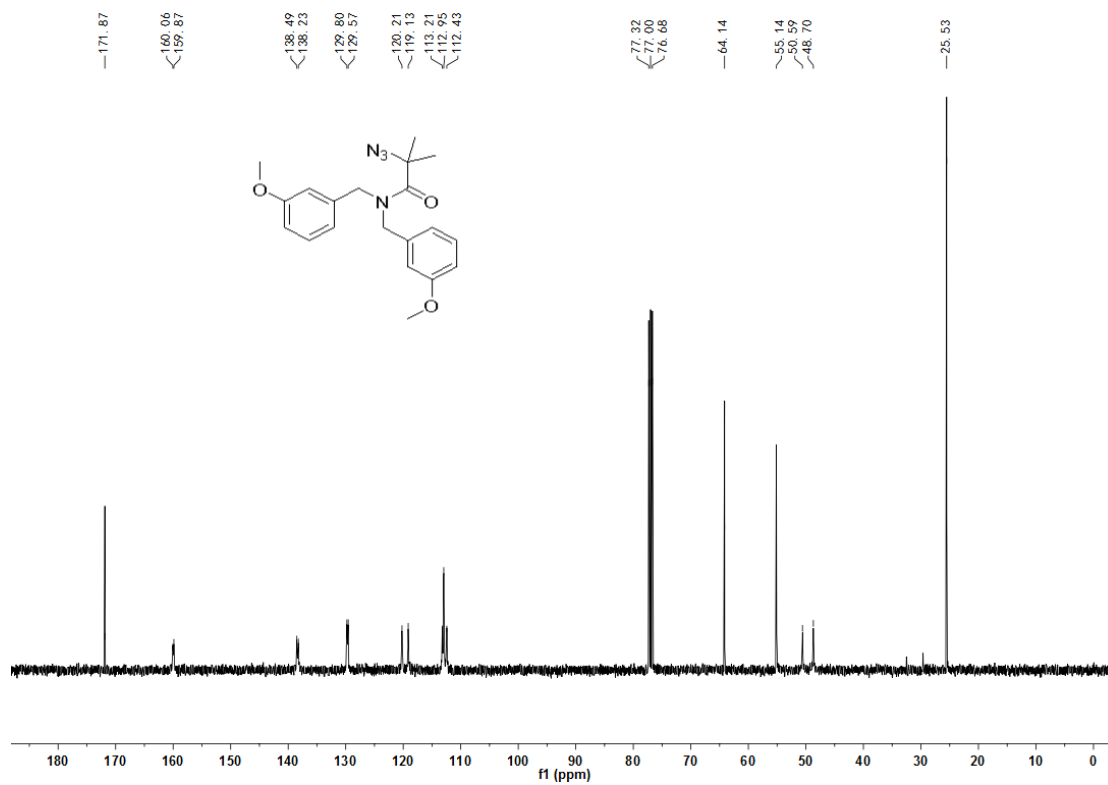
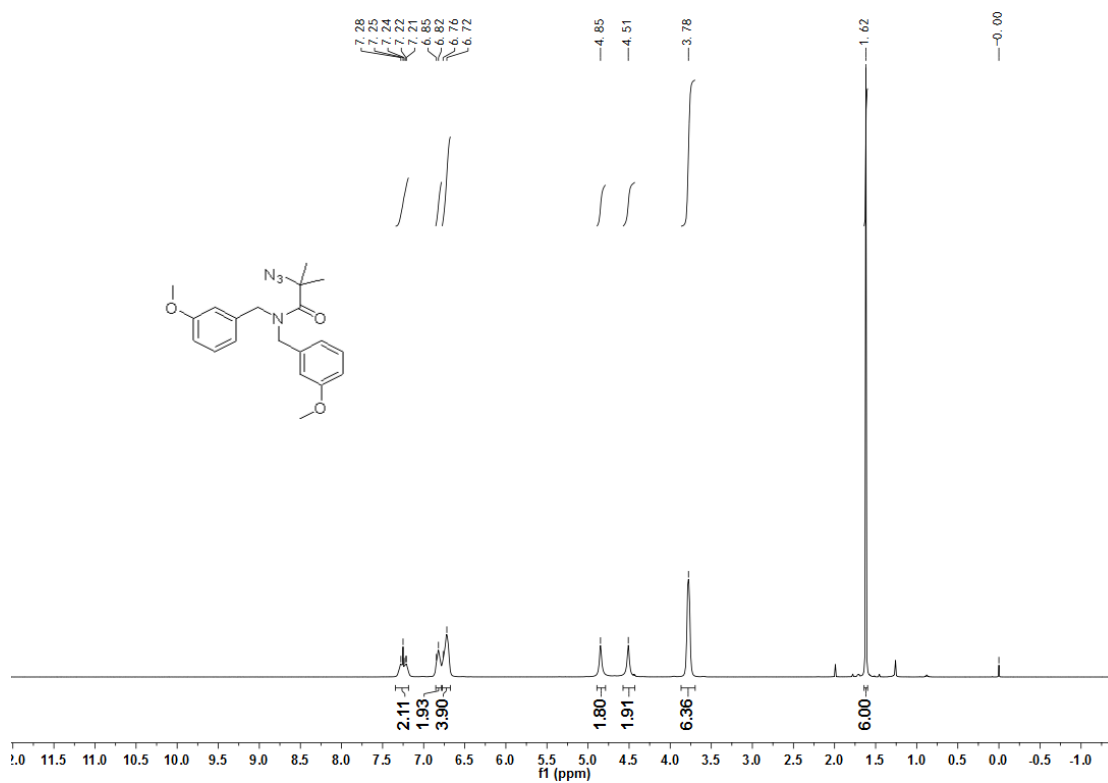
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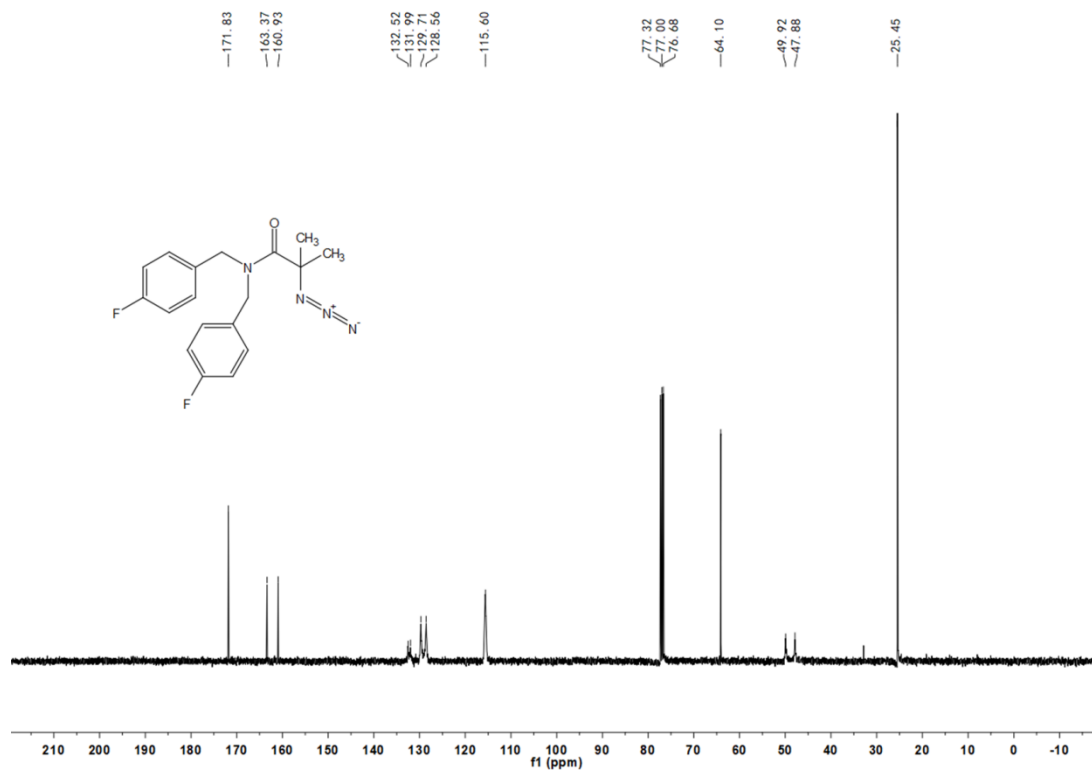
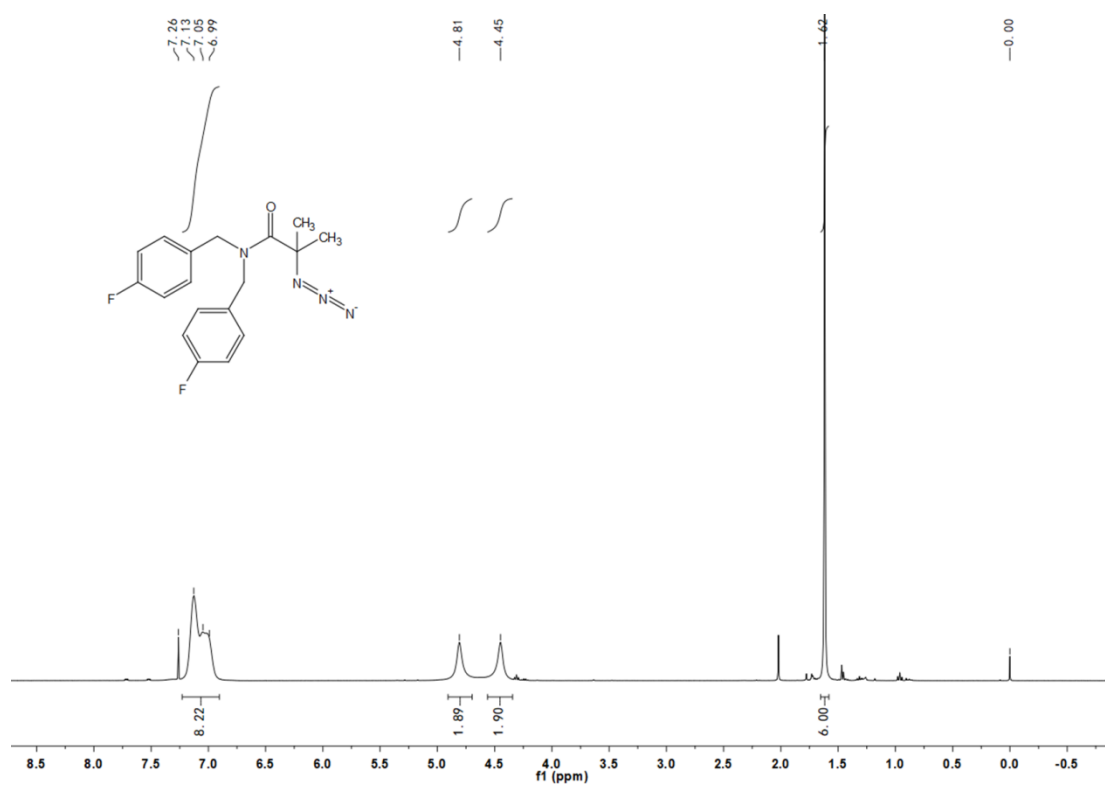
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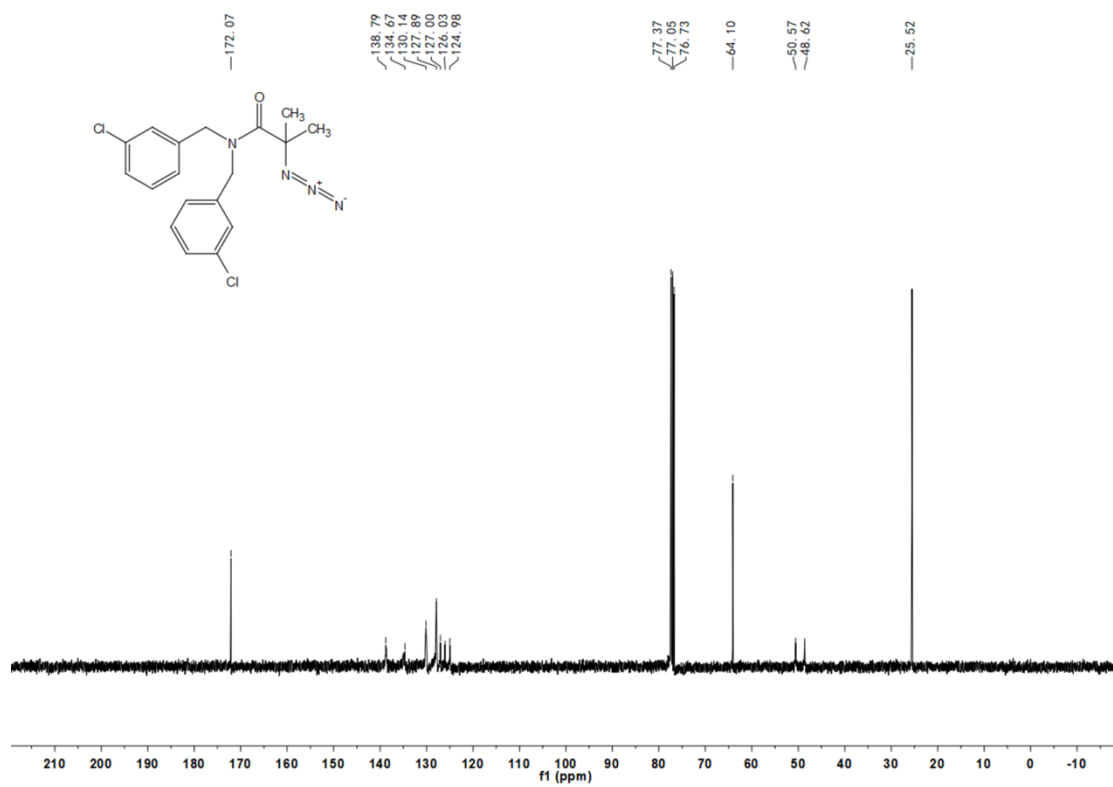
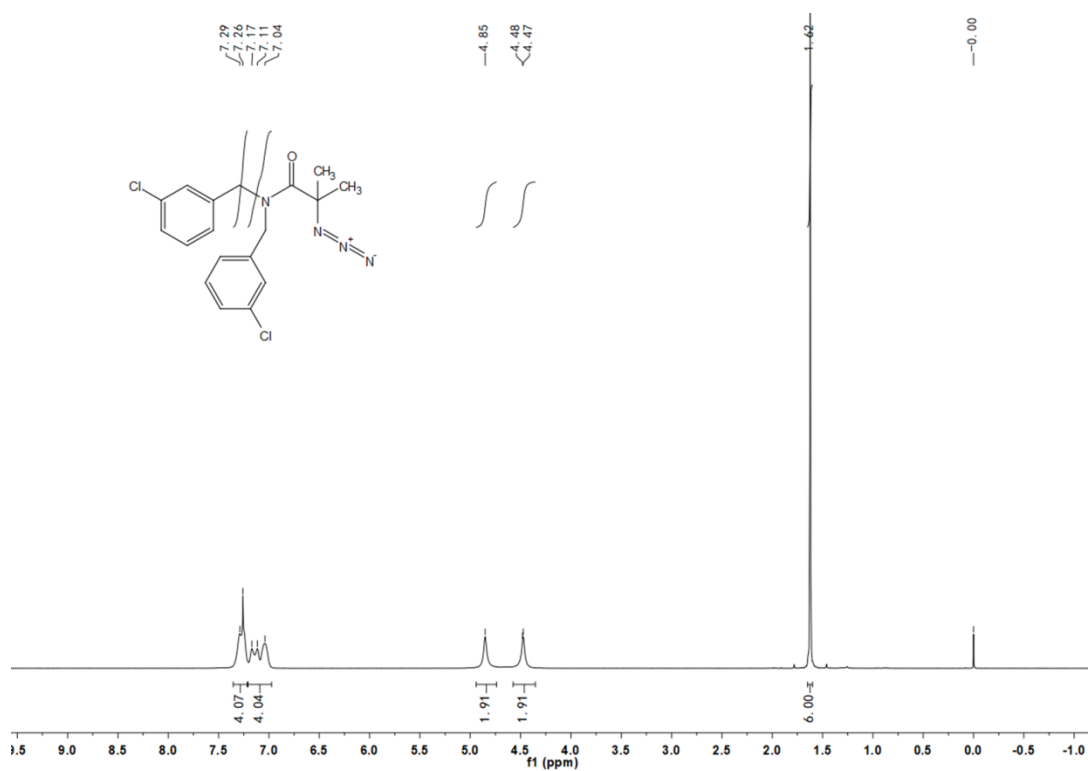
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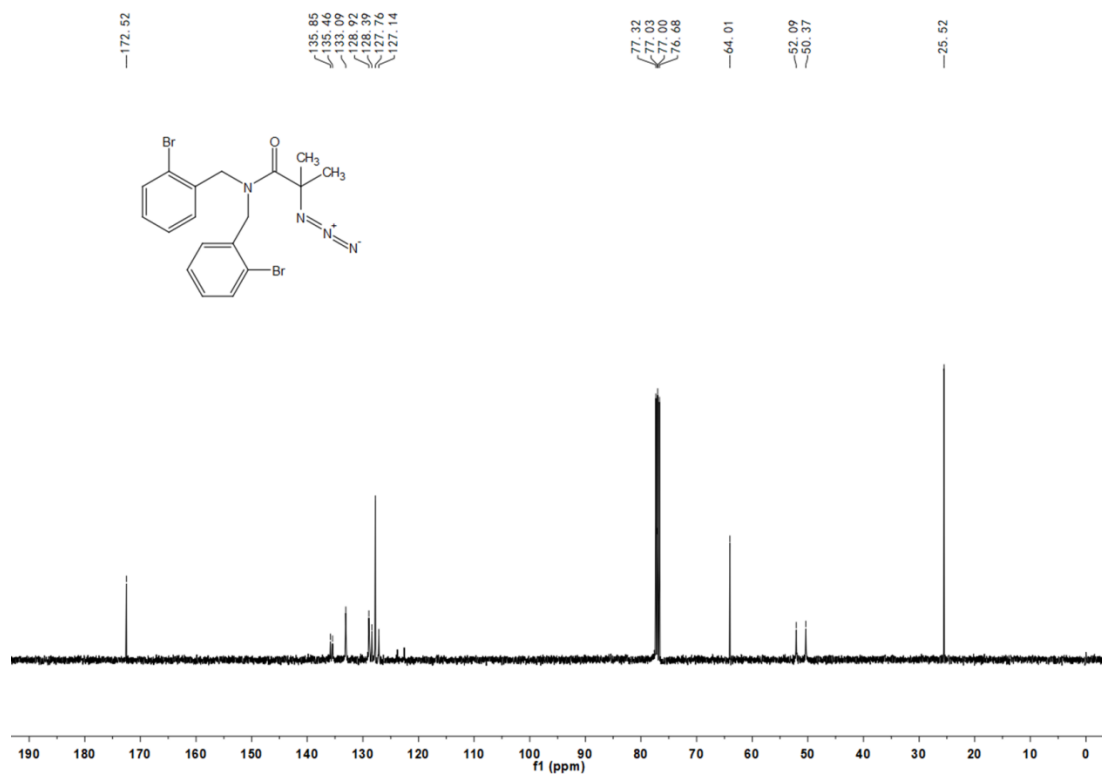
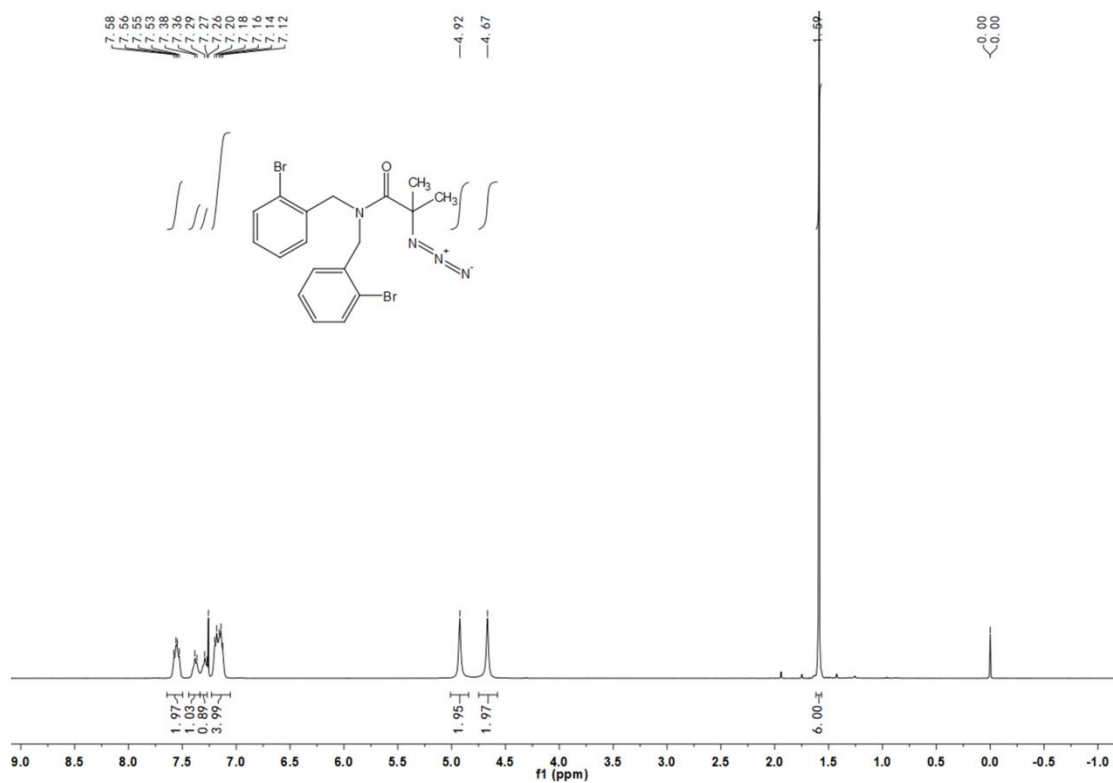
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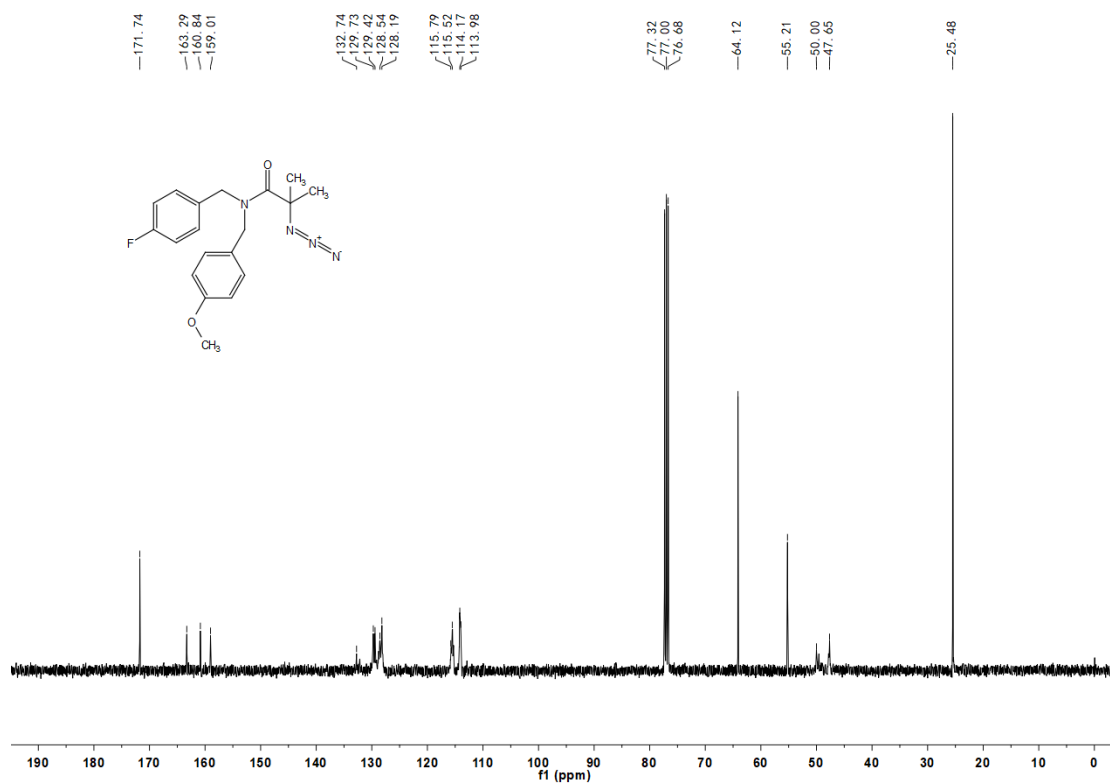
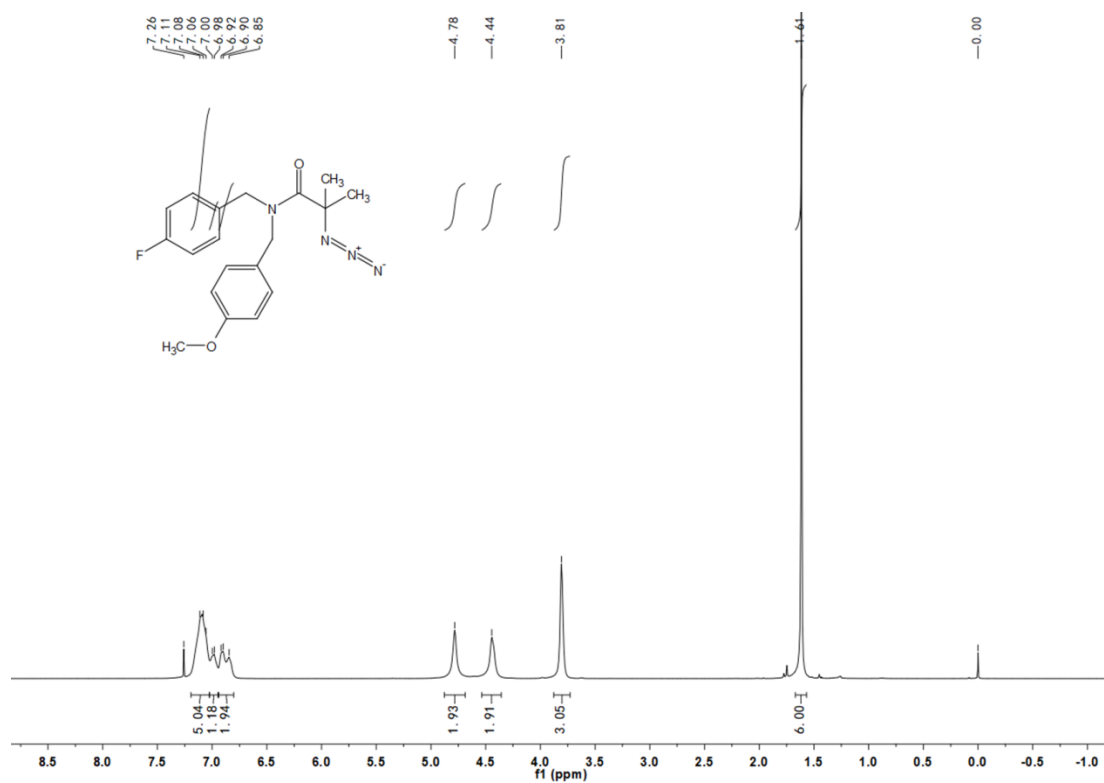
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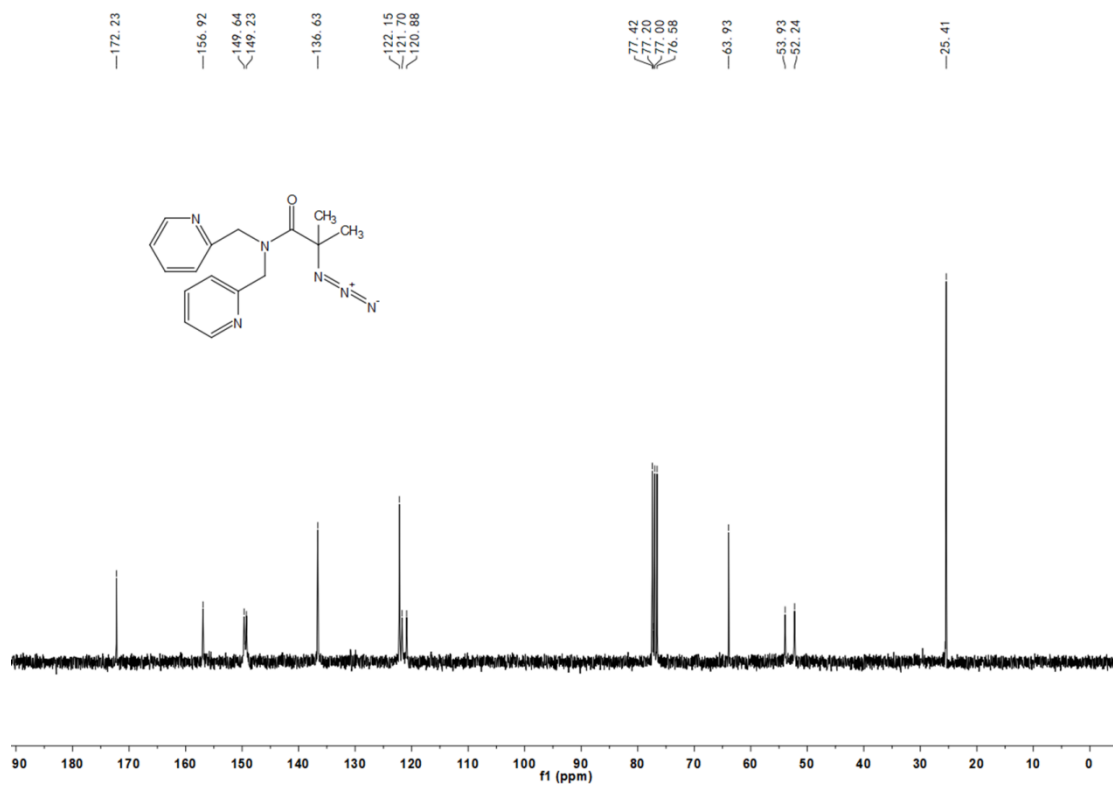
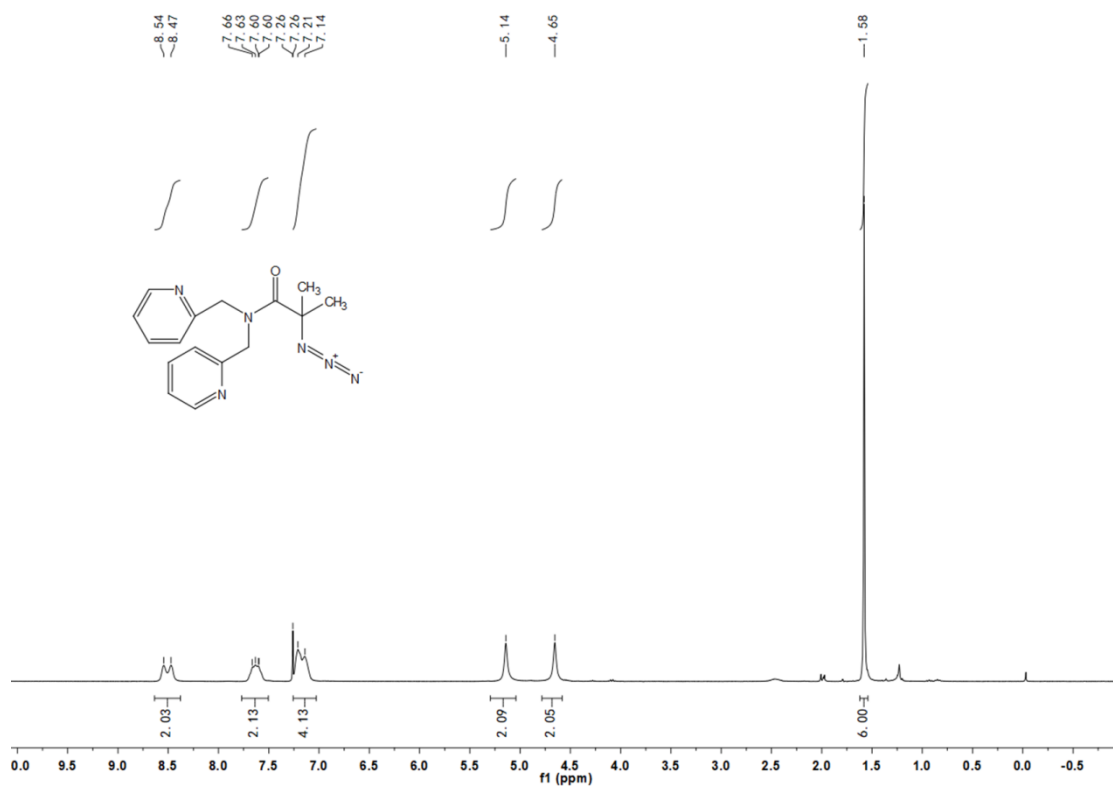
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1h

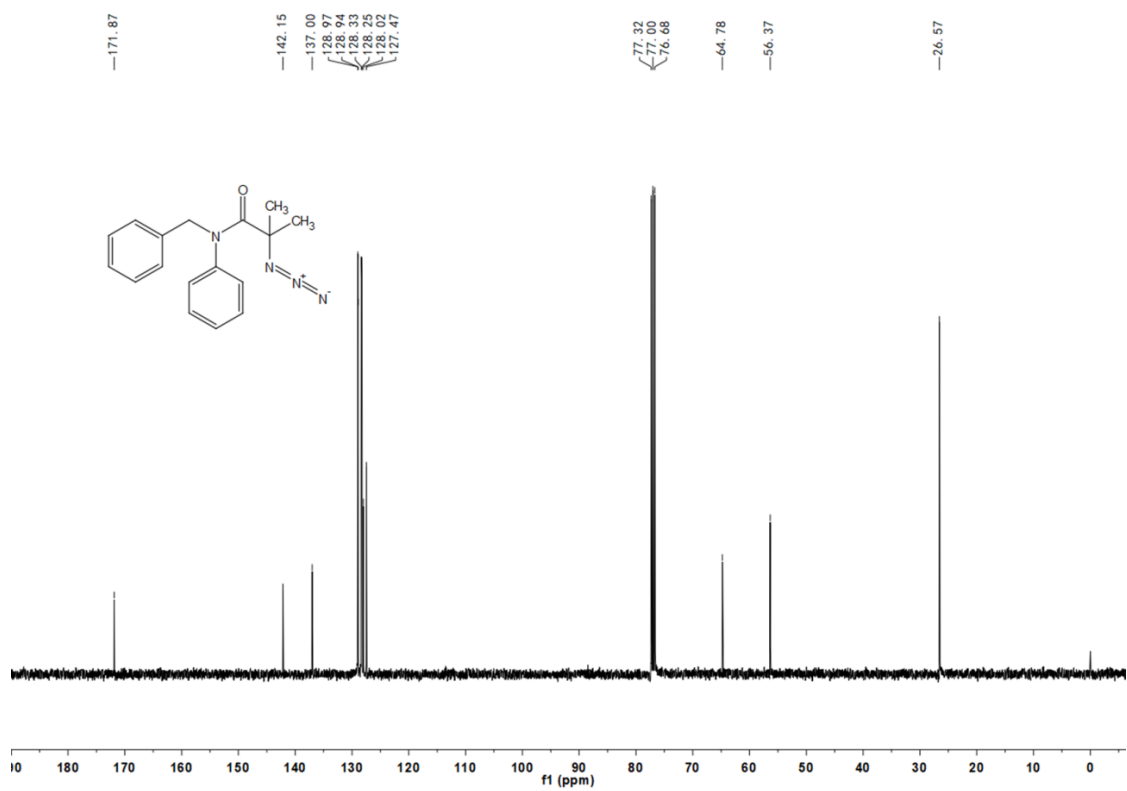
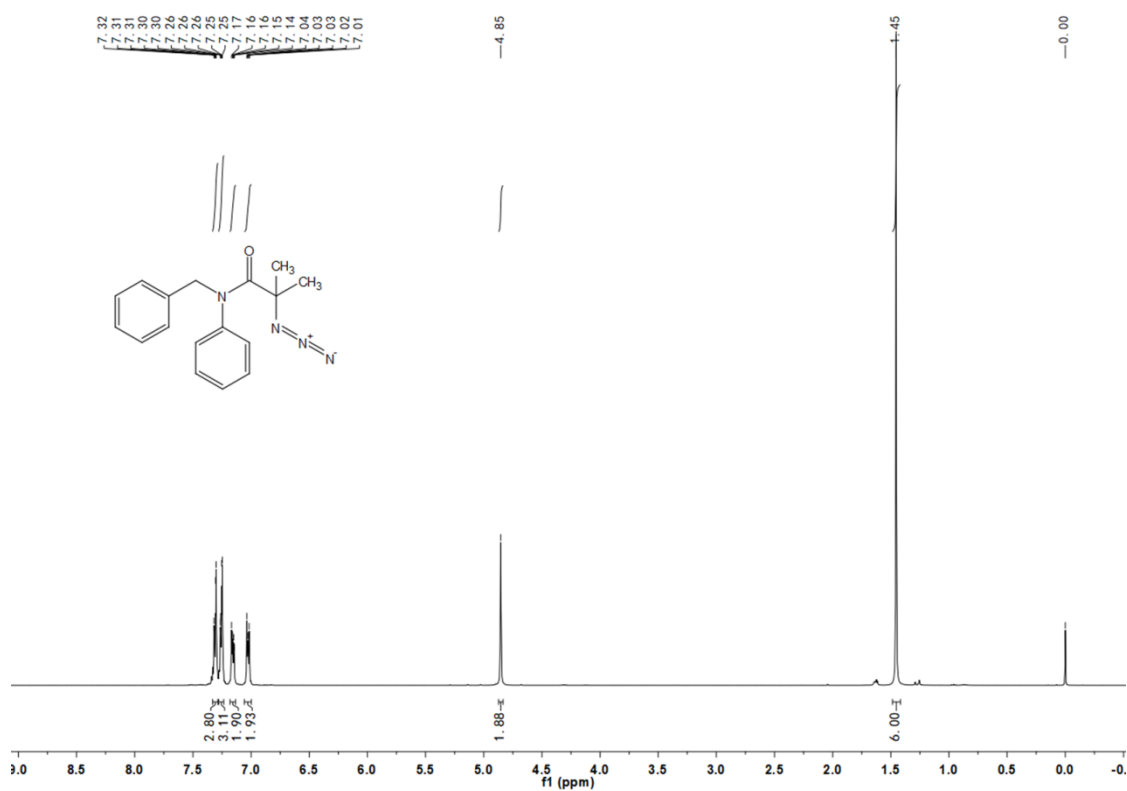


1i

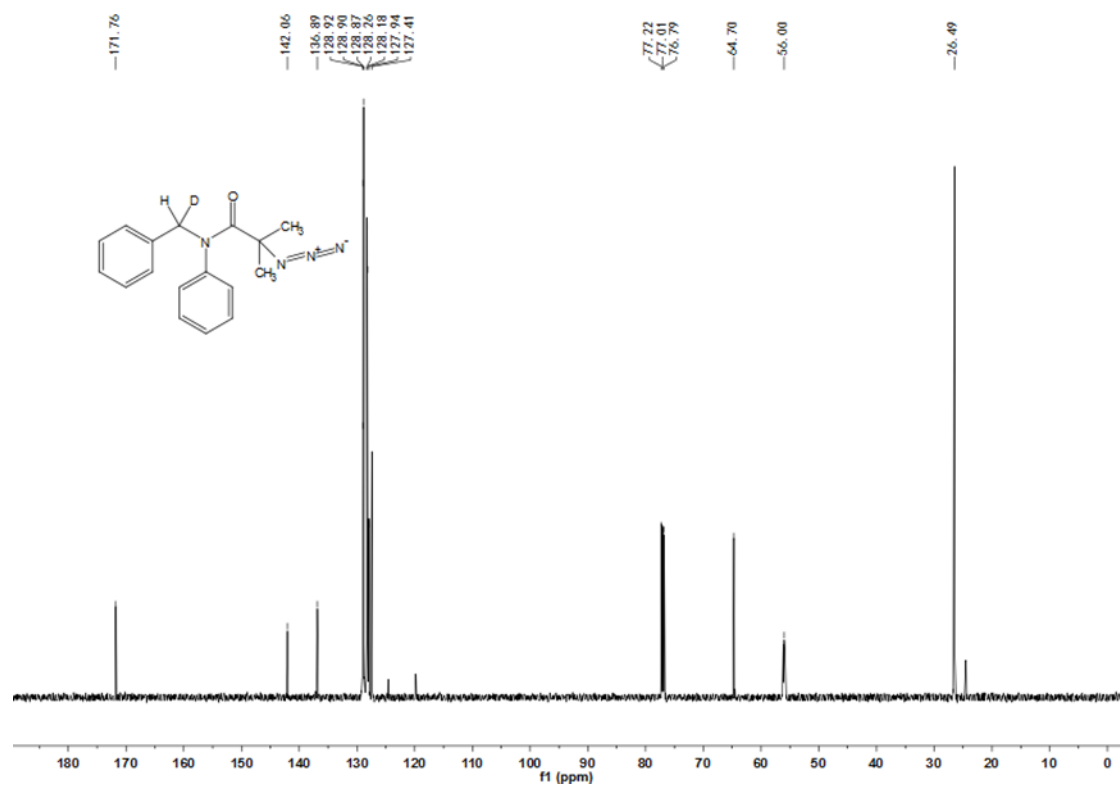
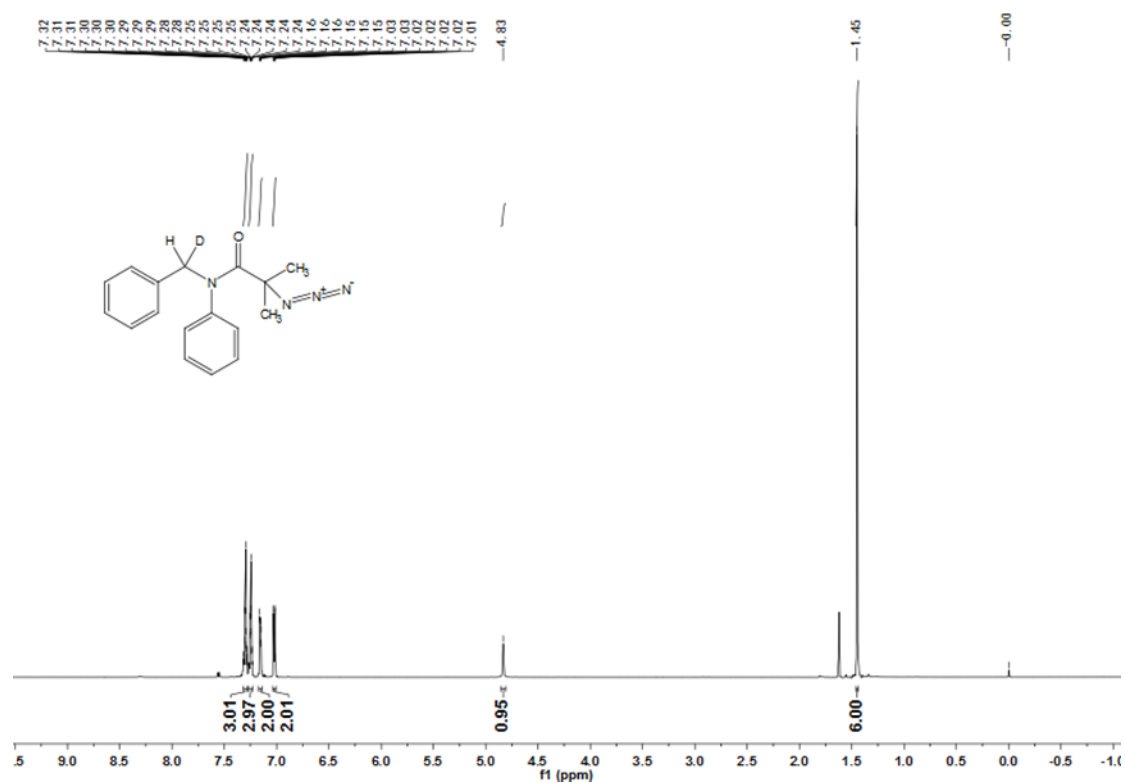




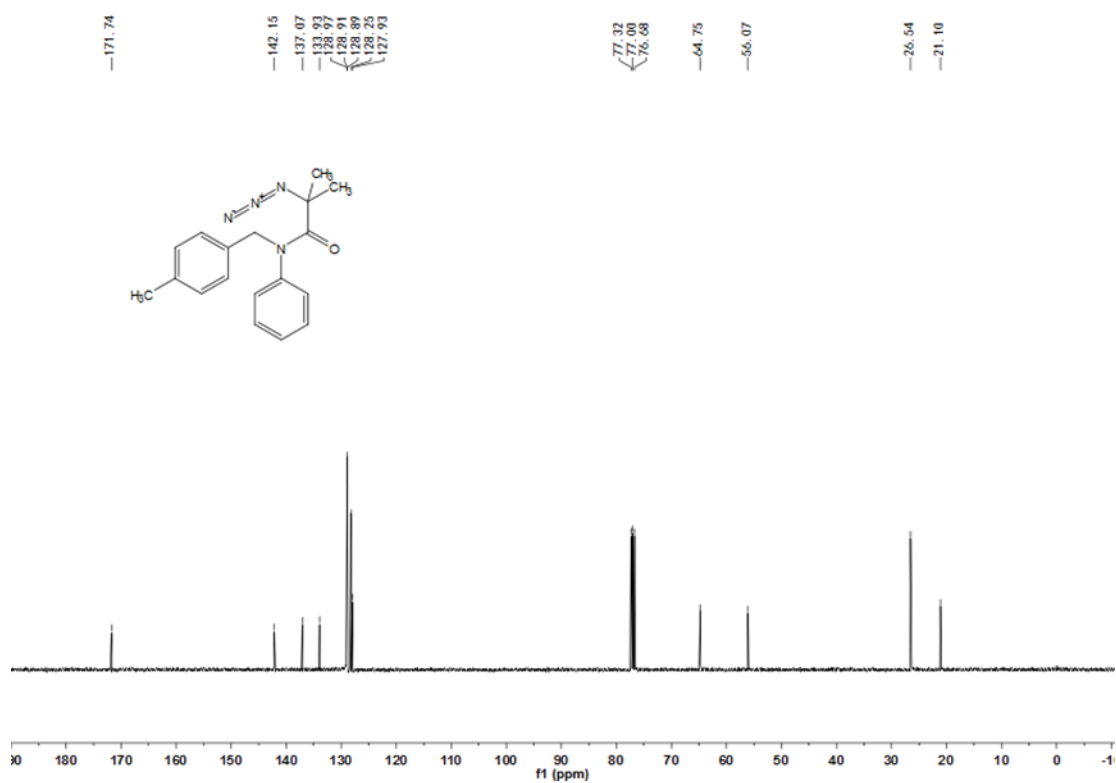
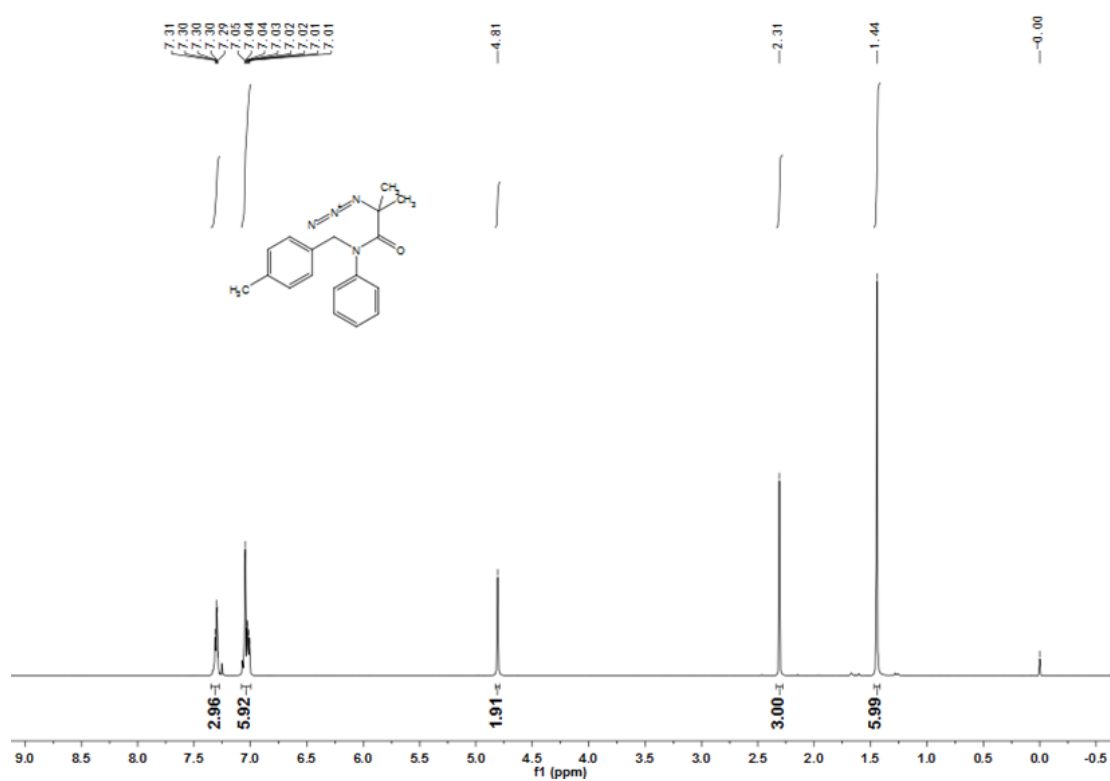
1j



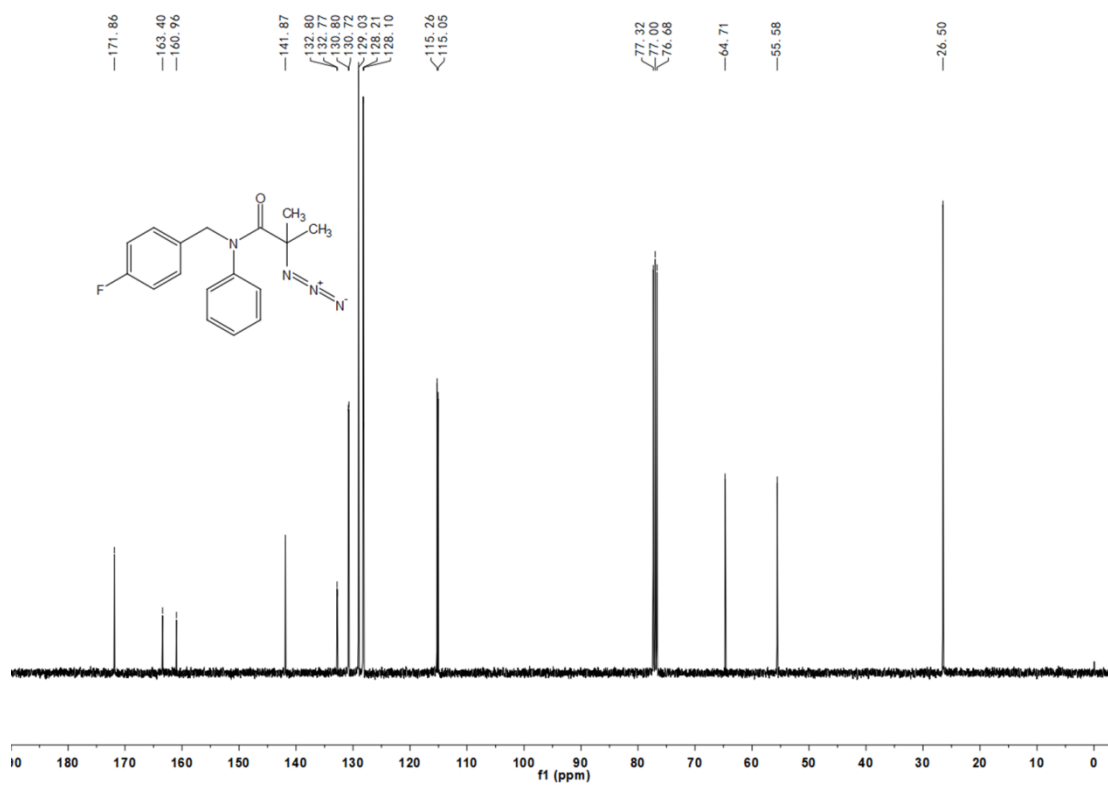
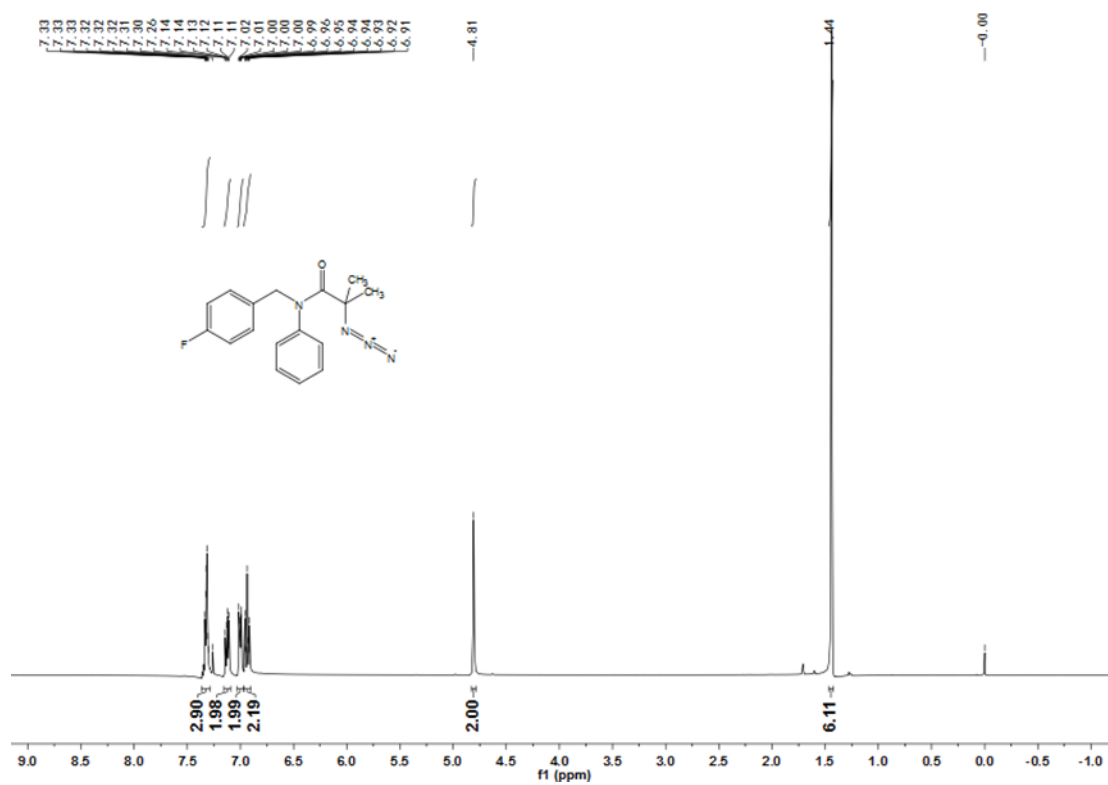
1j-d



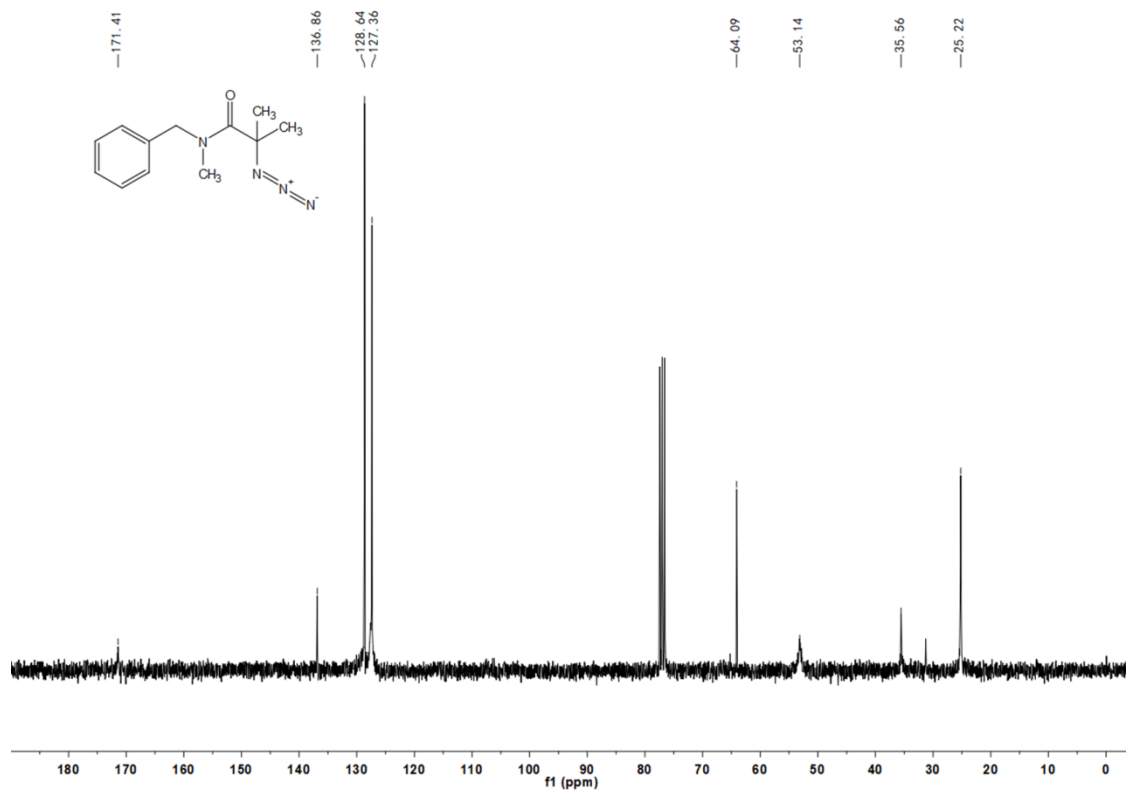
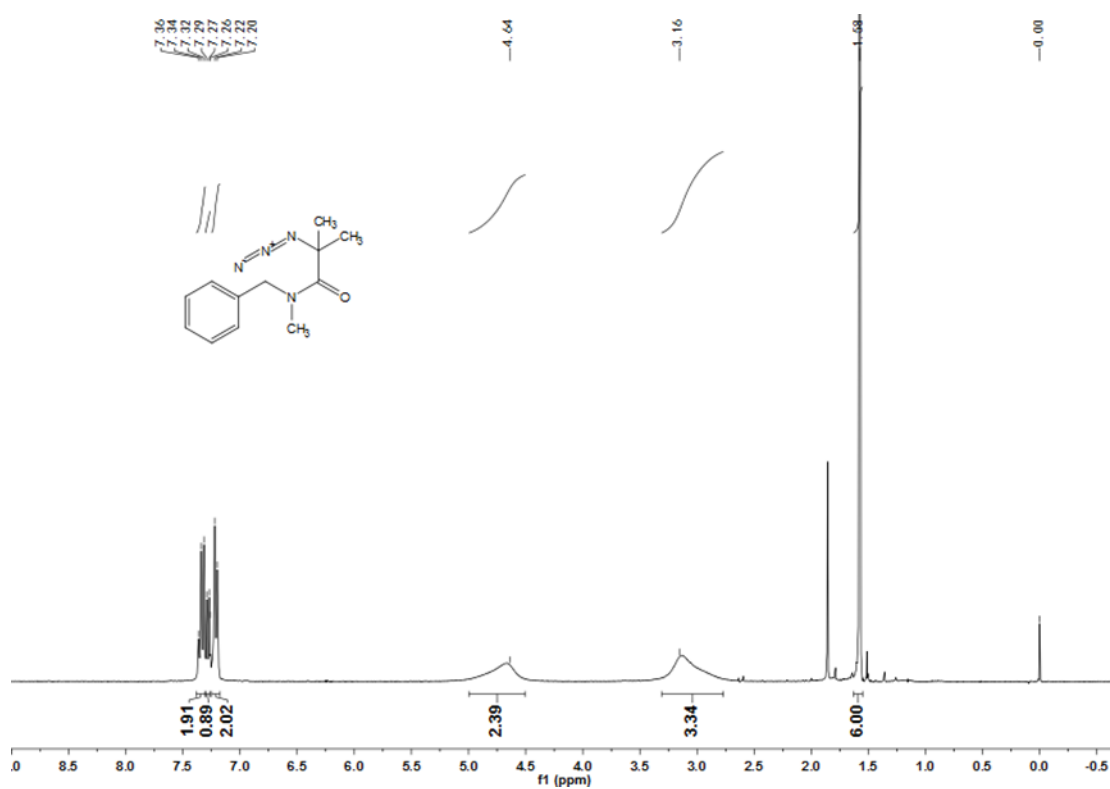
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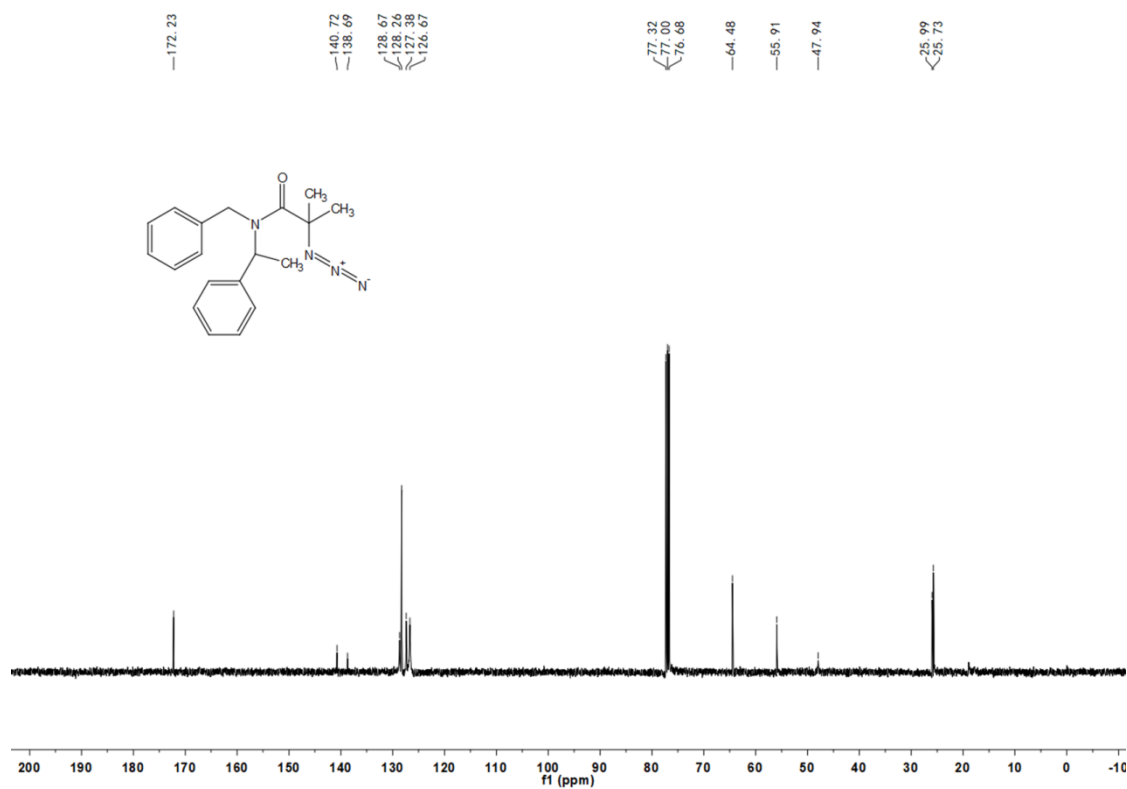
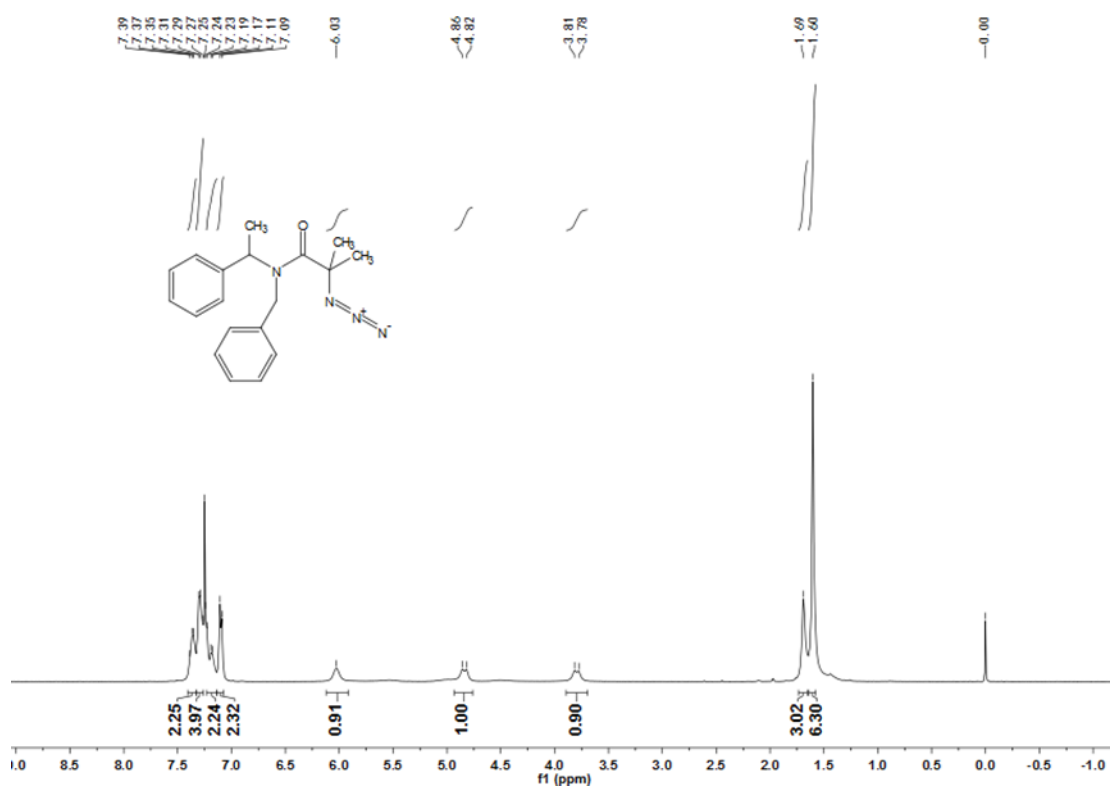
11



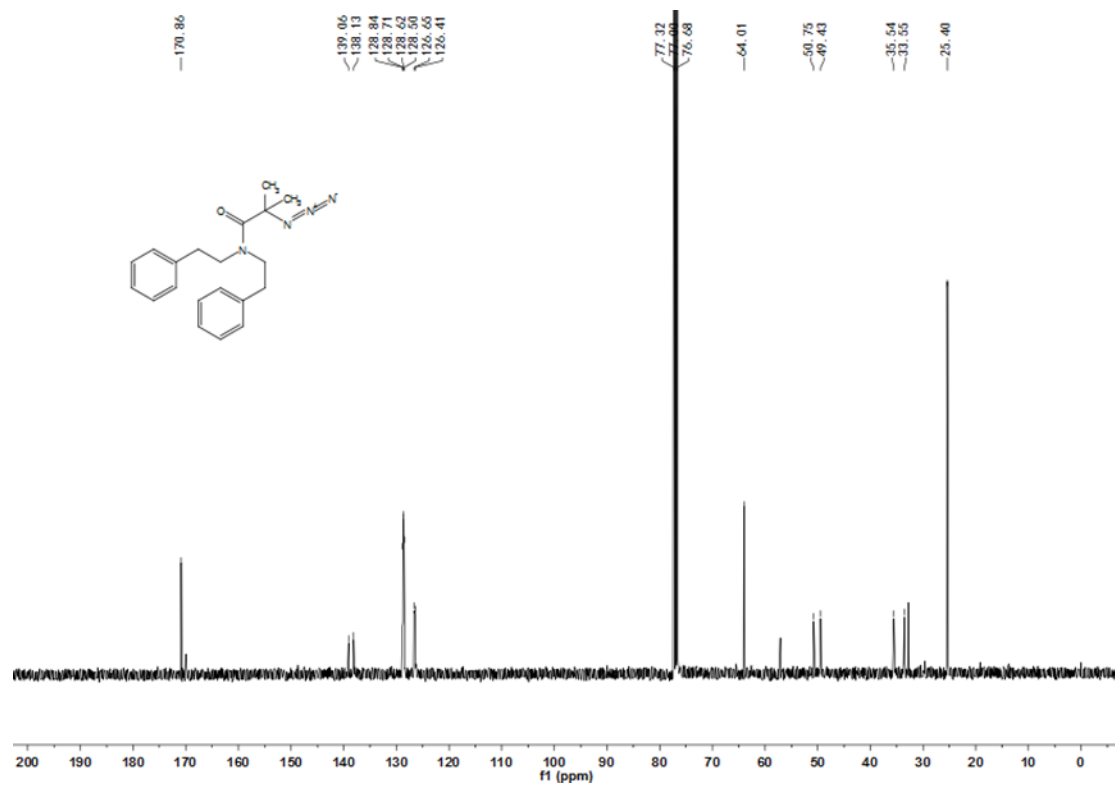
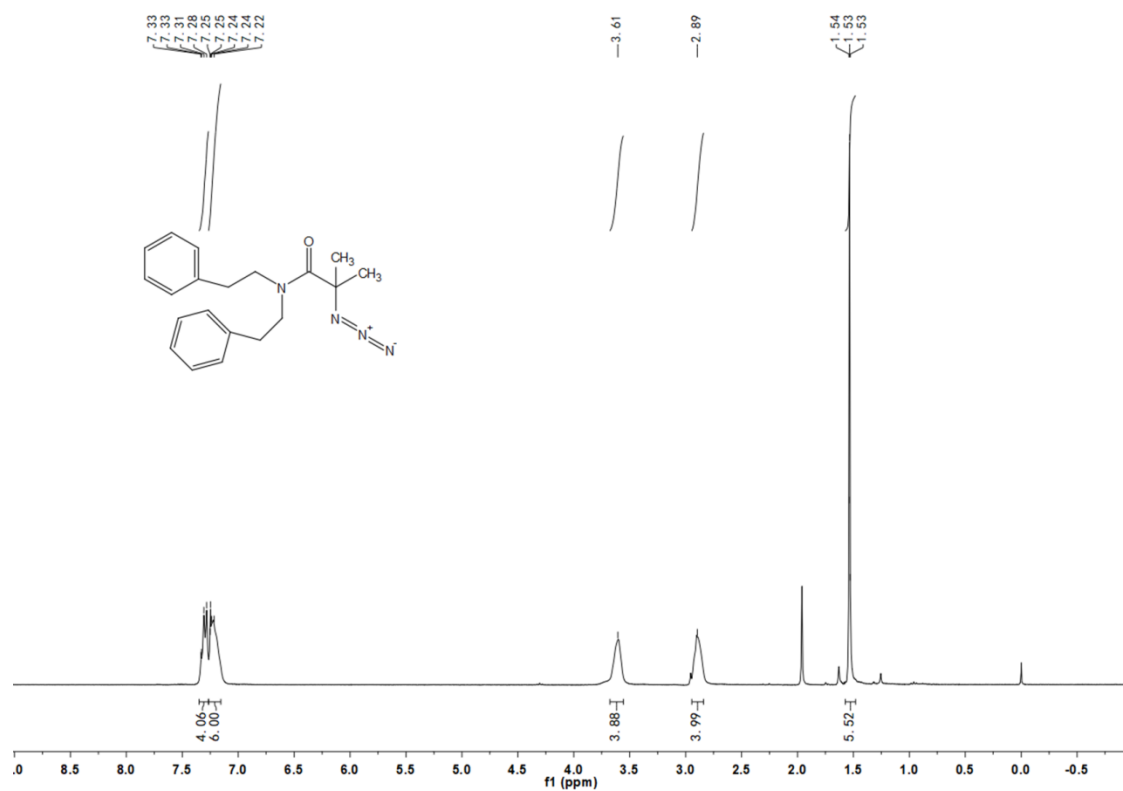
1m



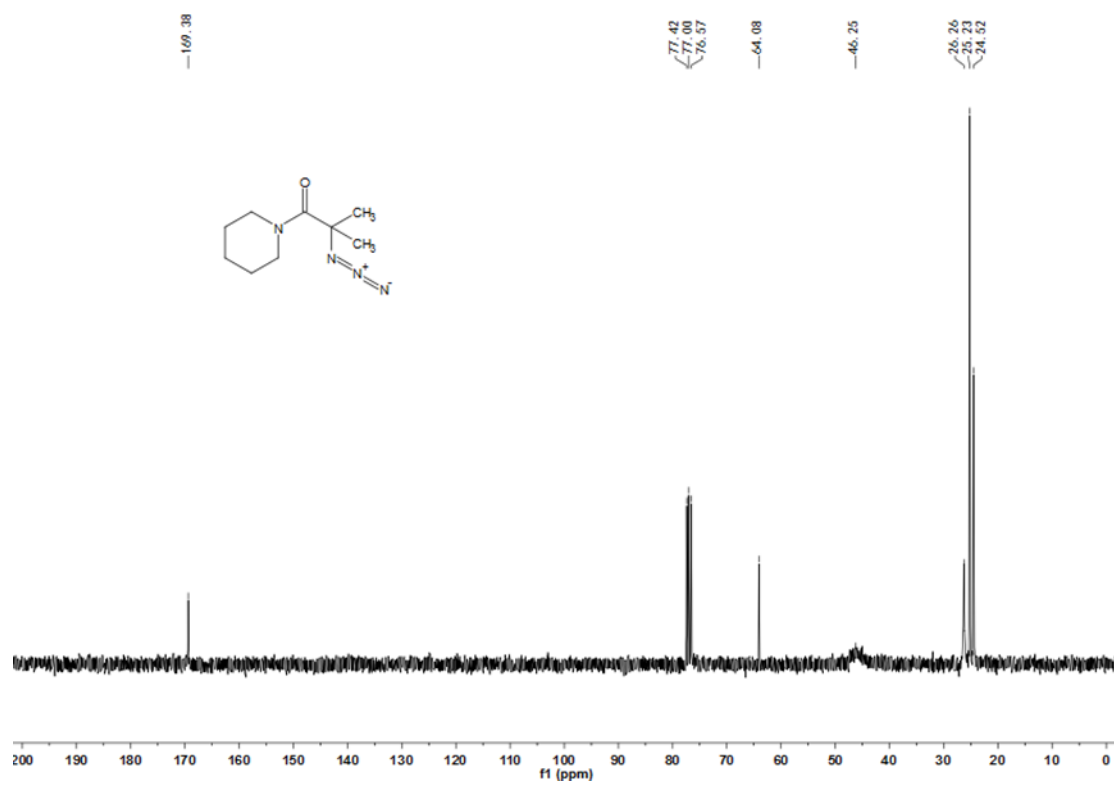
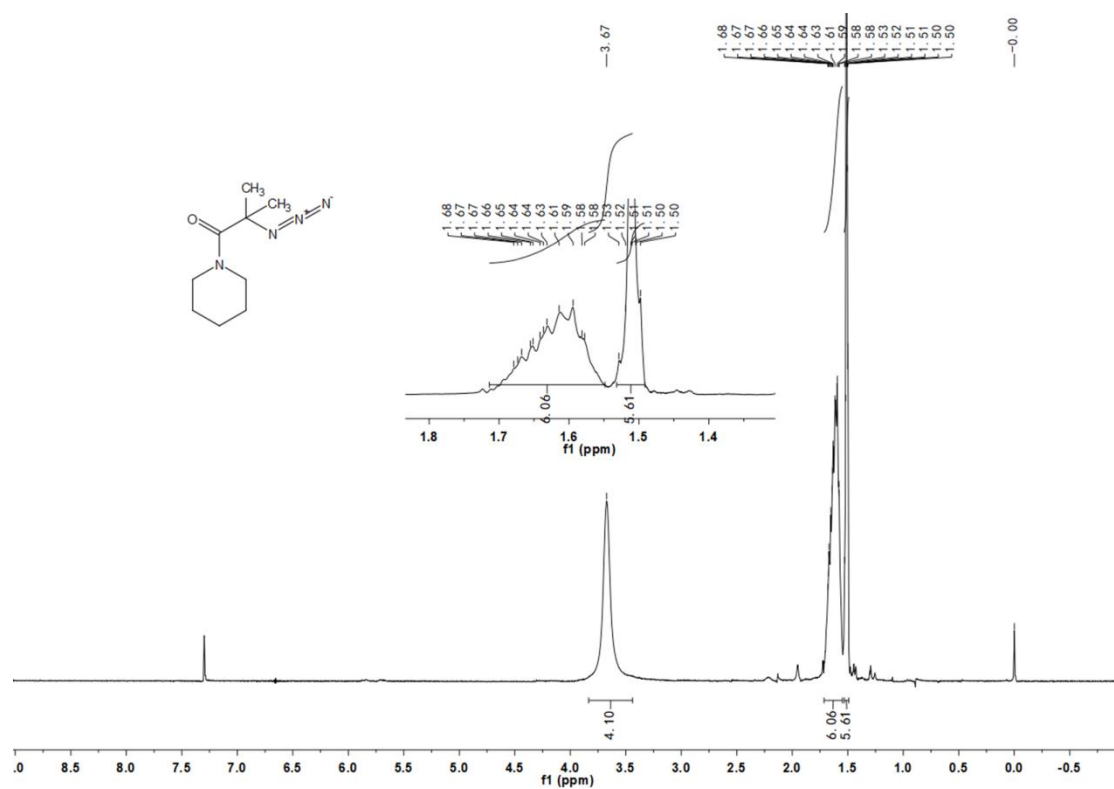
1n



1o

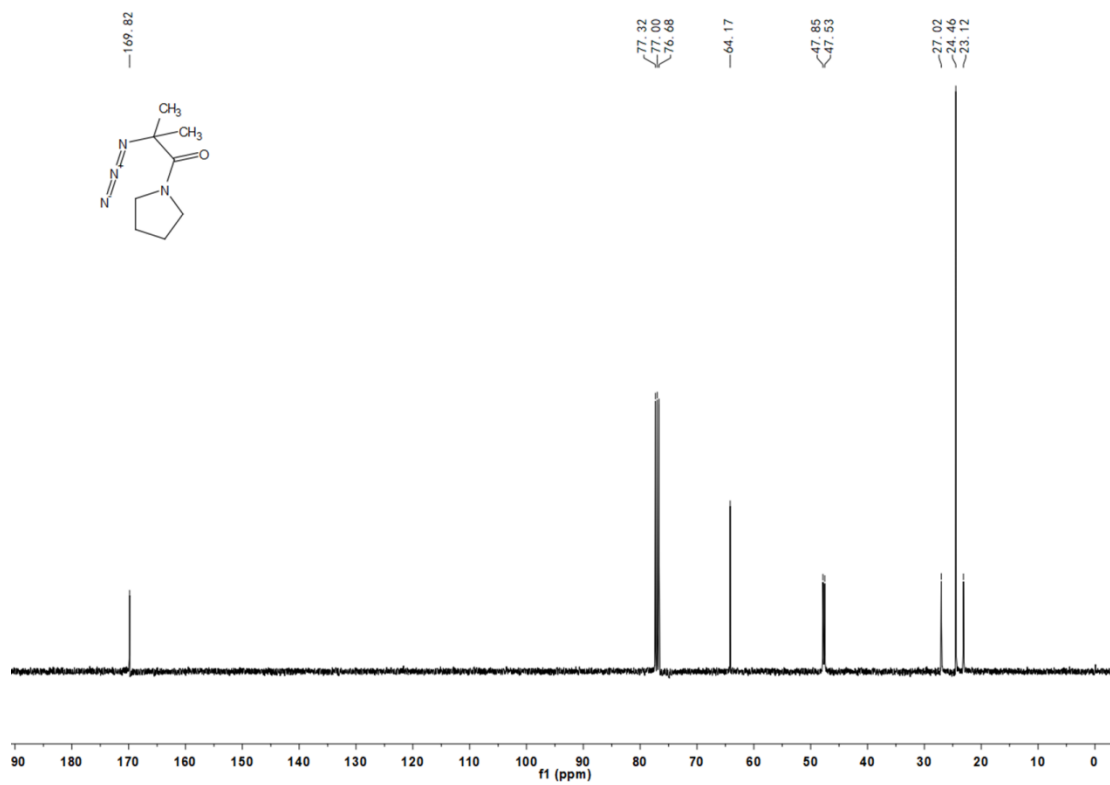
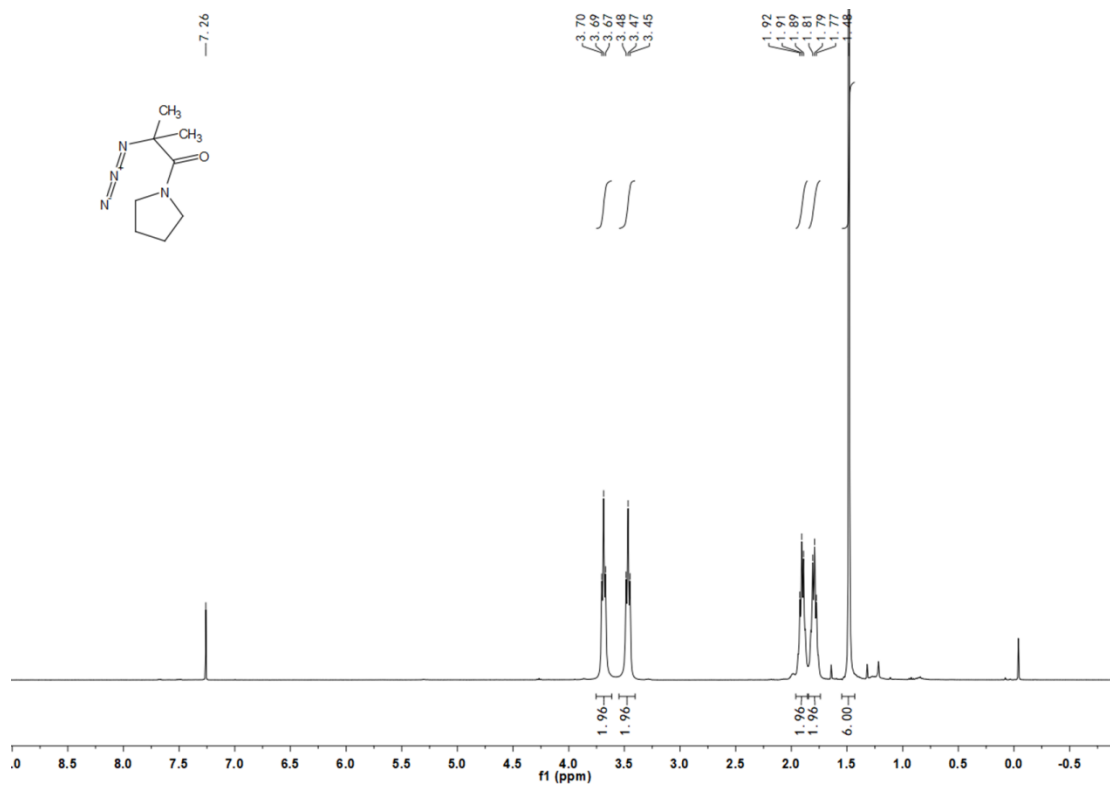


1p

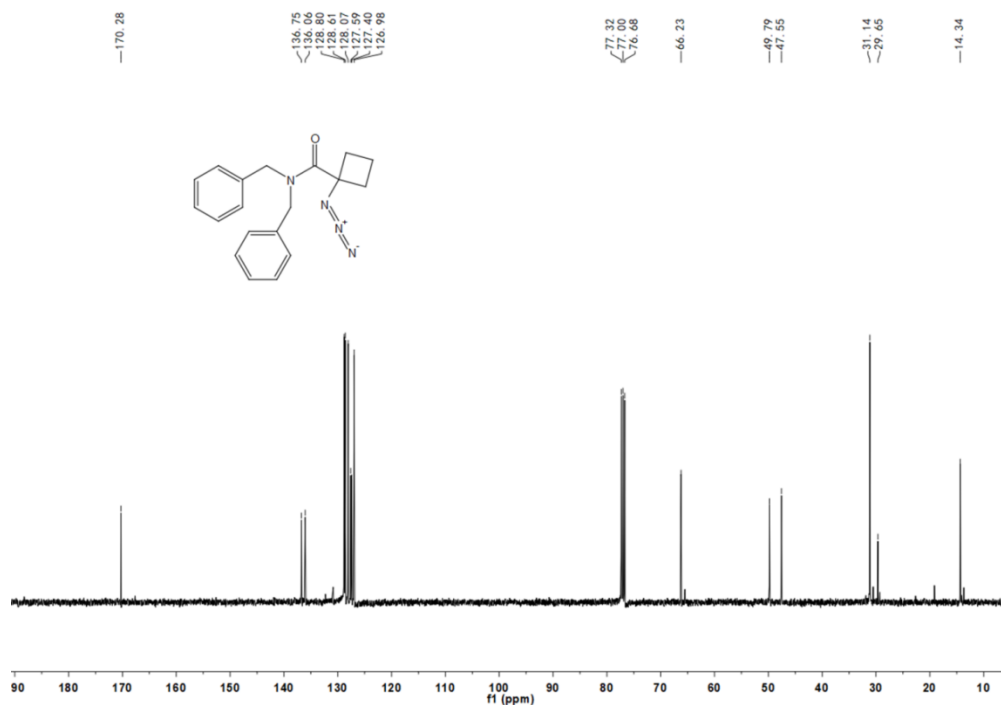
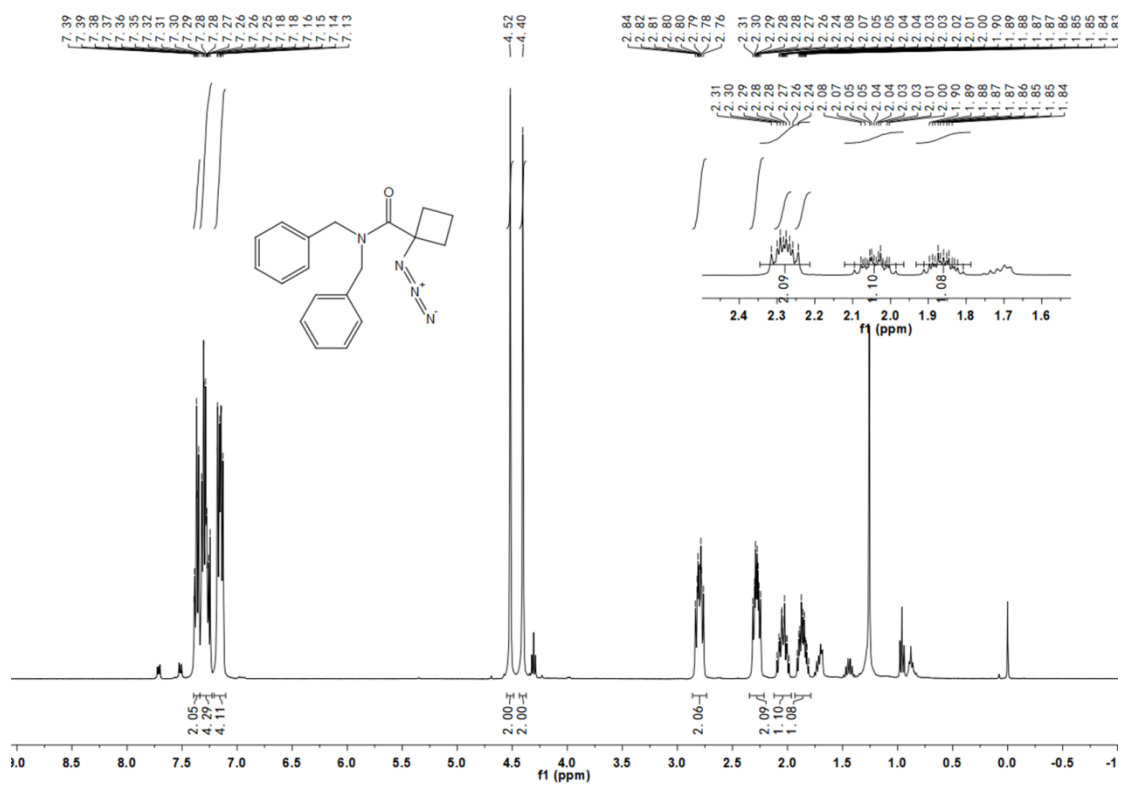




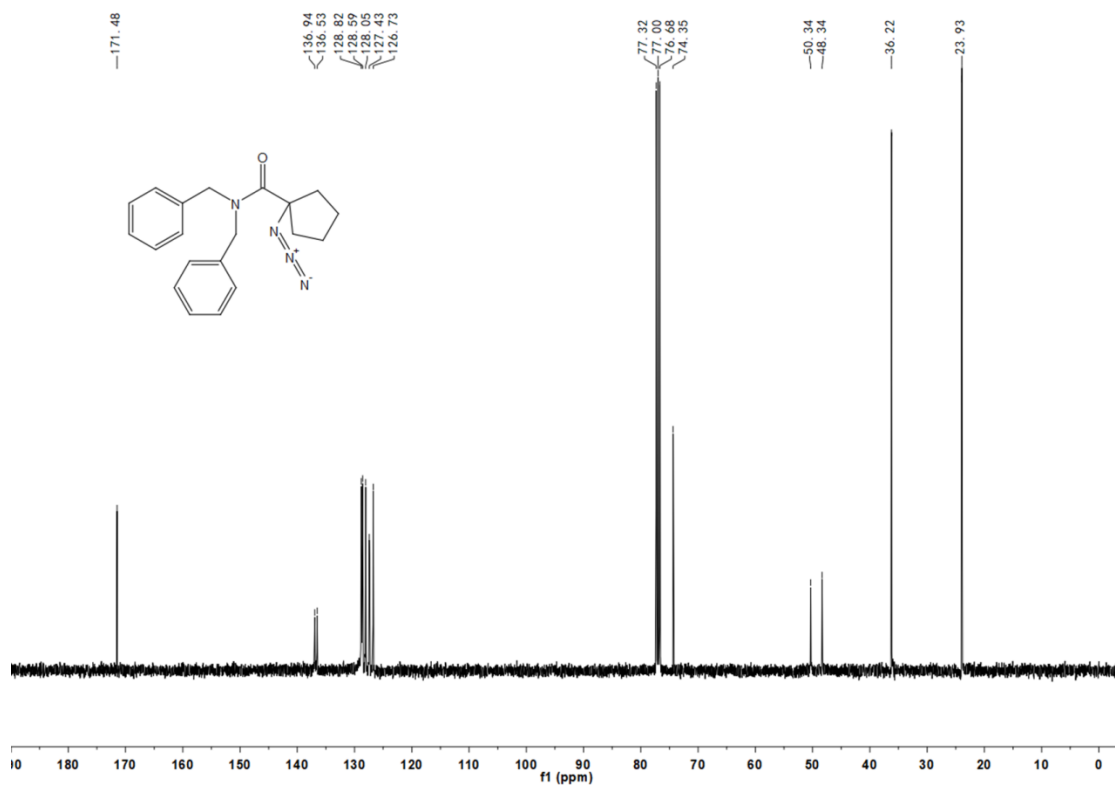
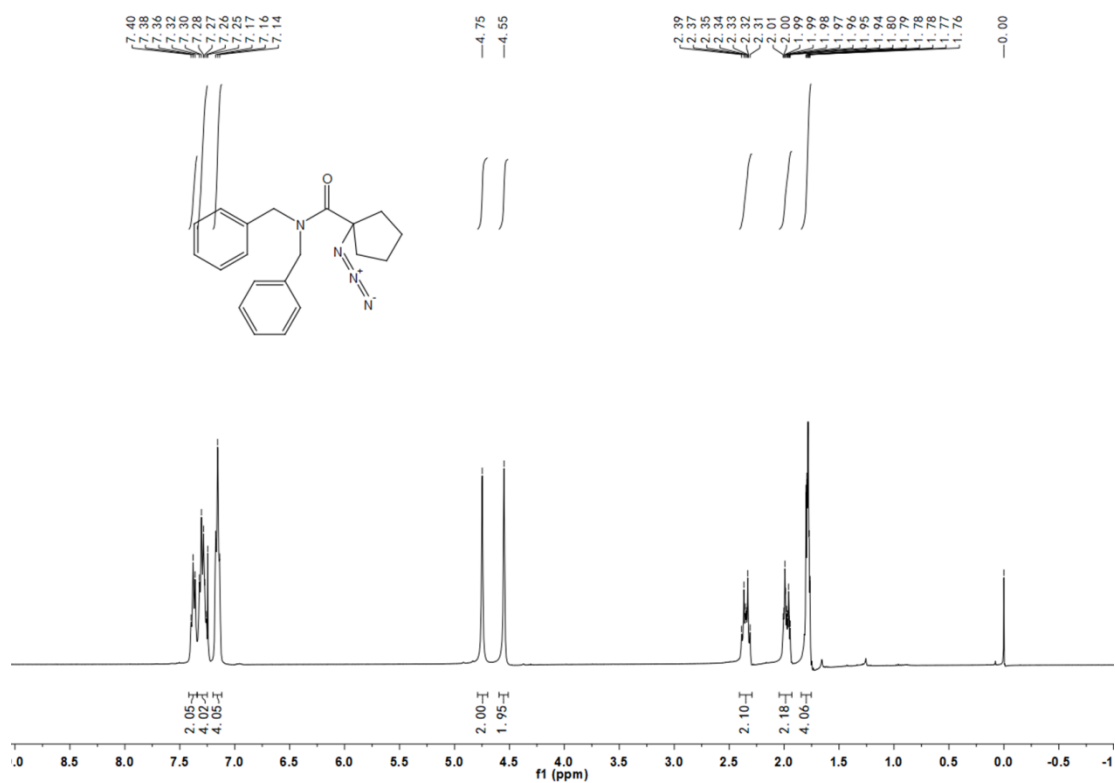
1q



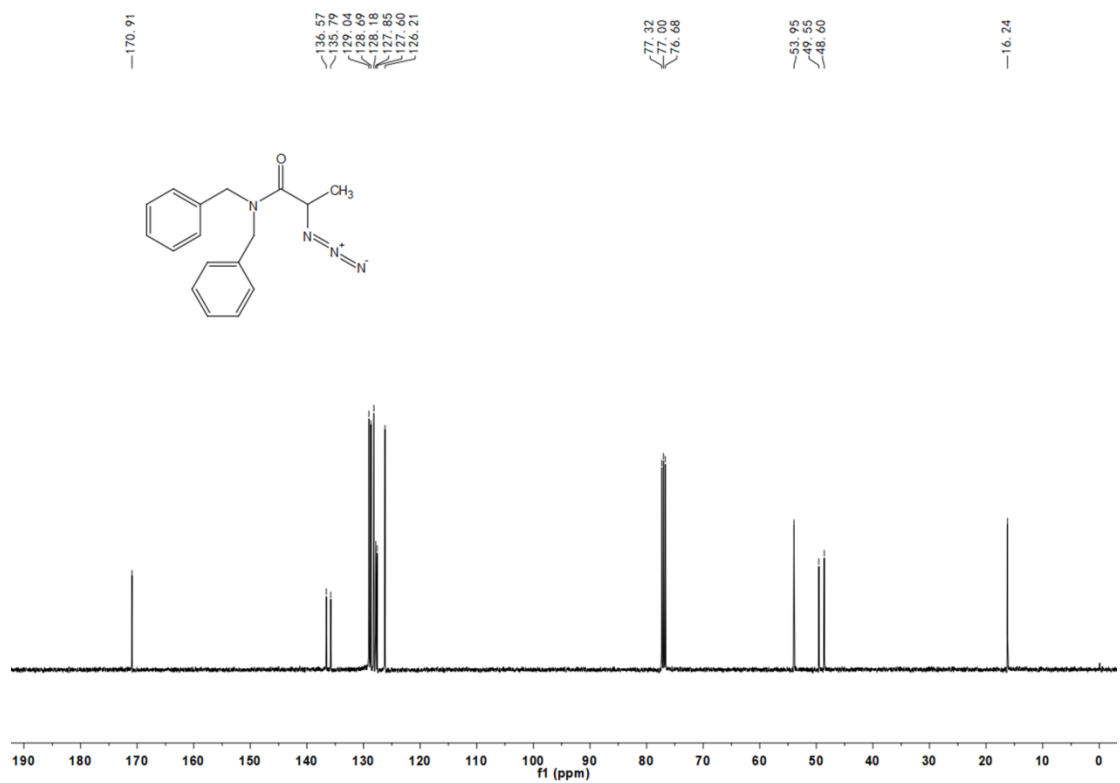
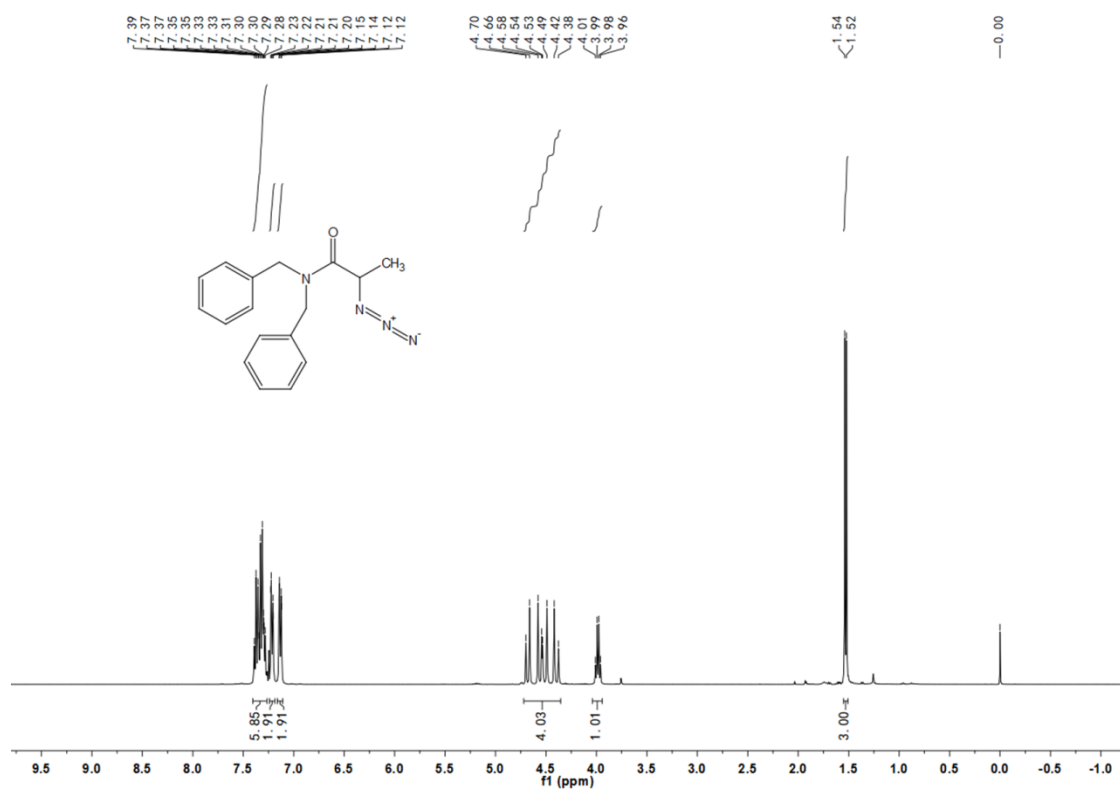
1r



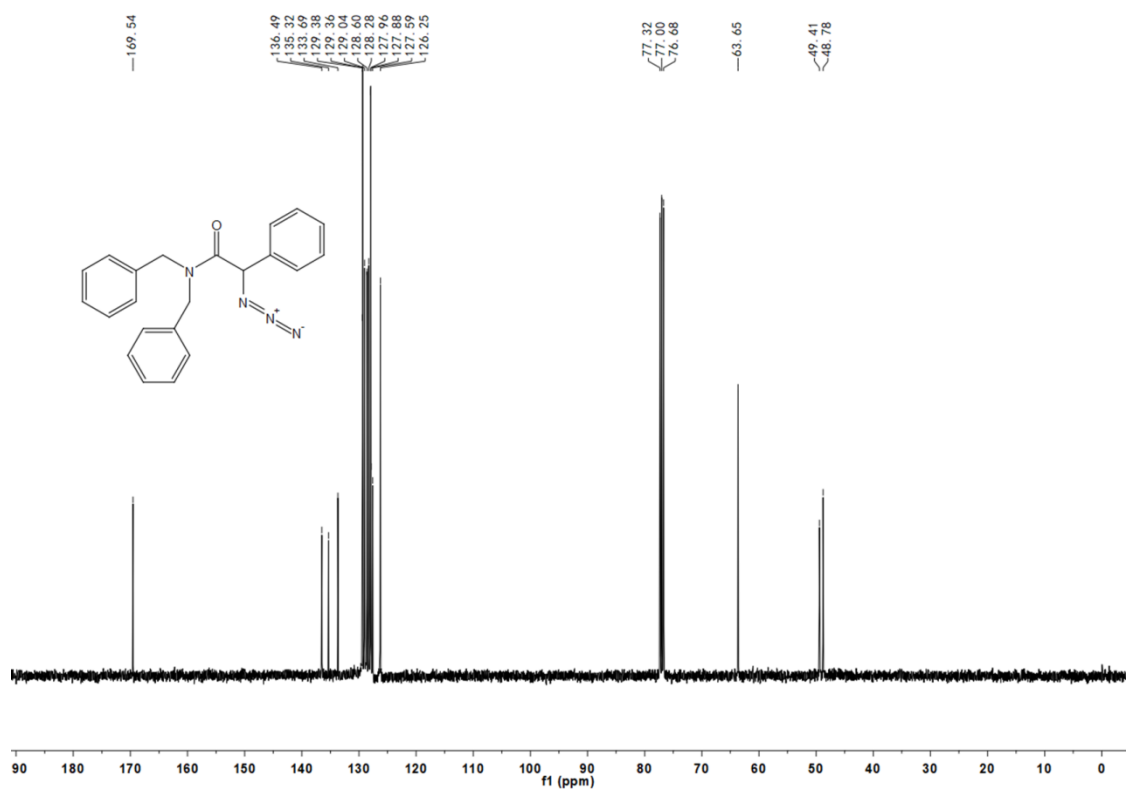
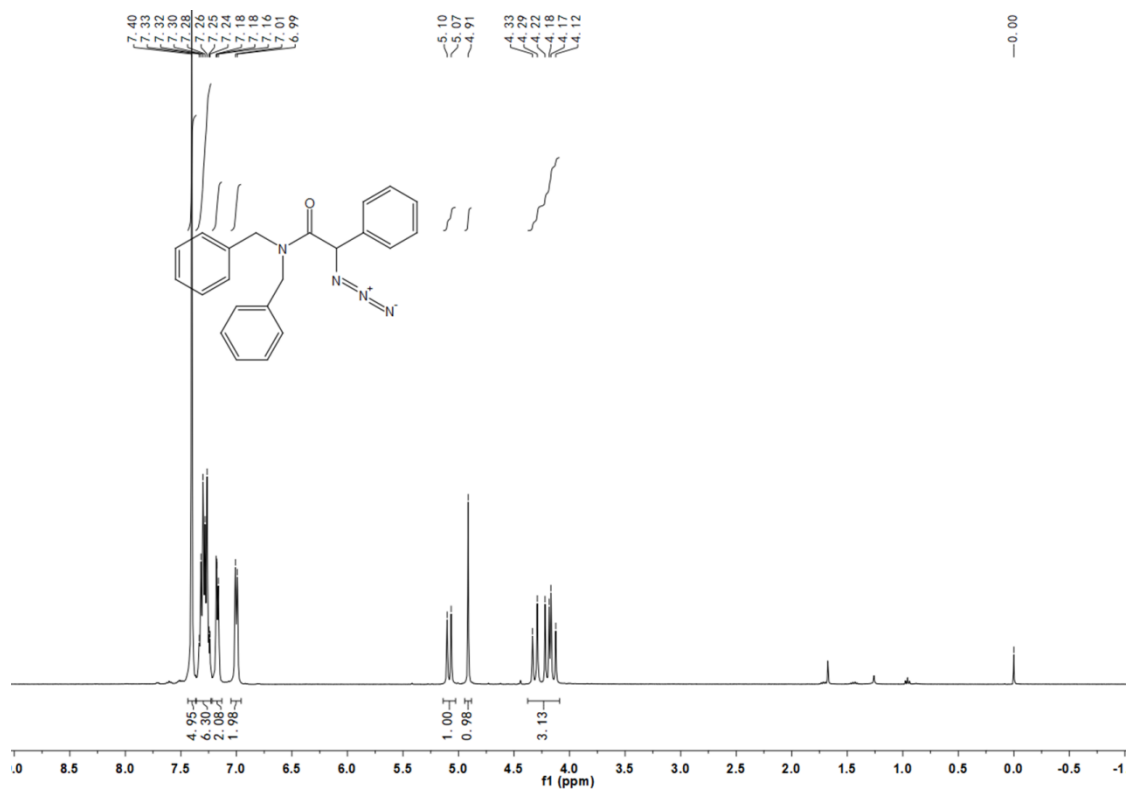
1s



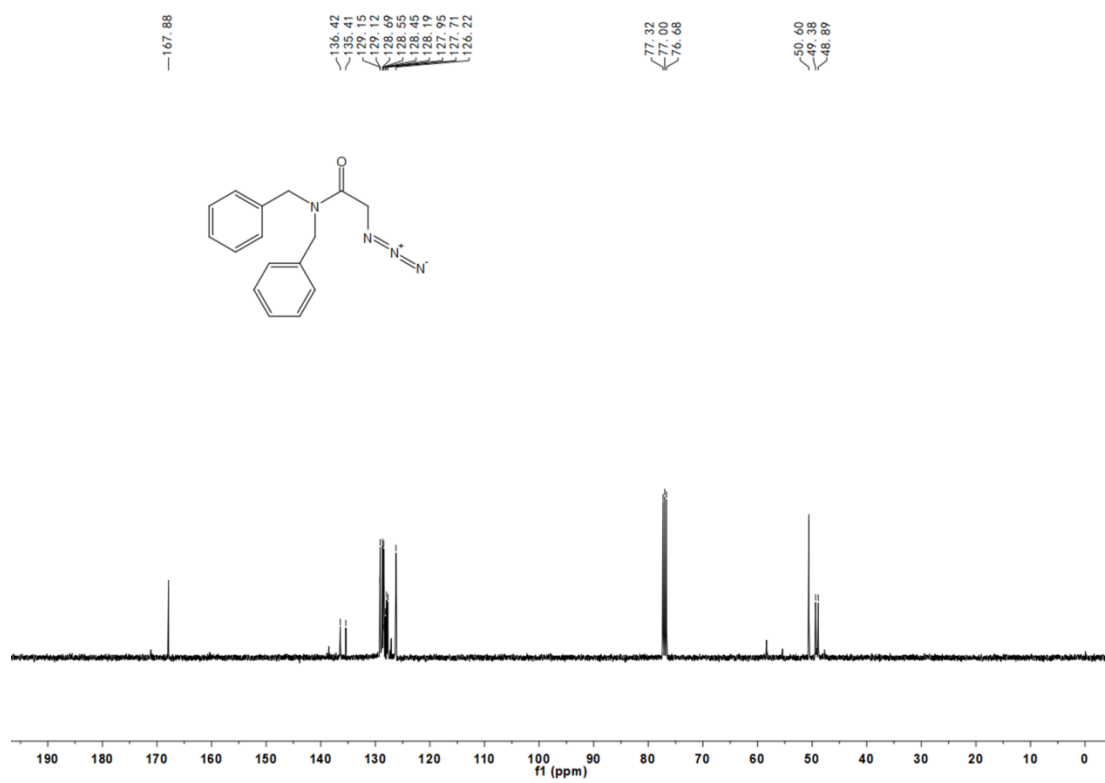
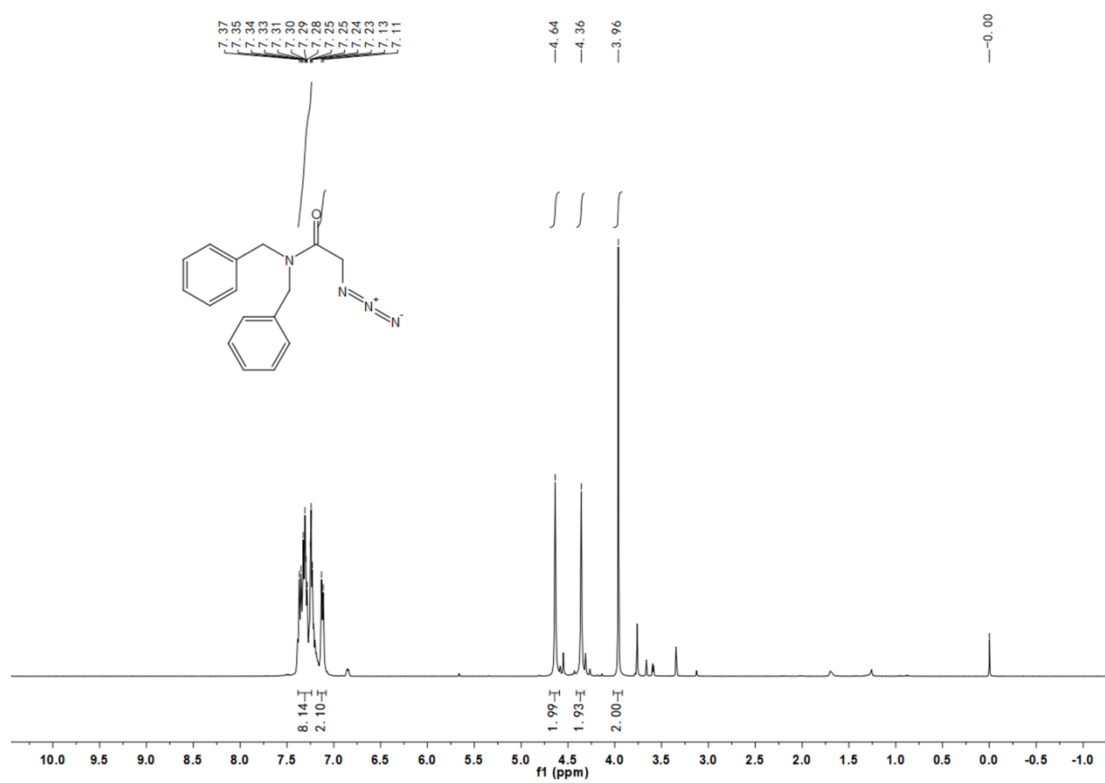
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1u

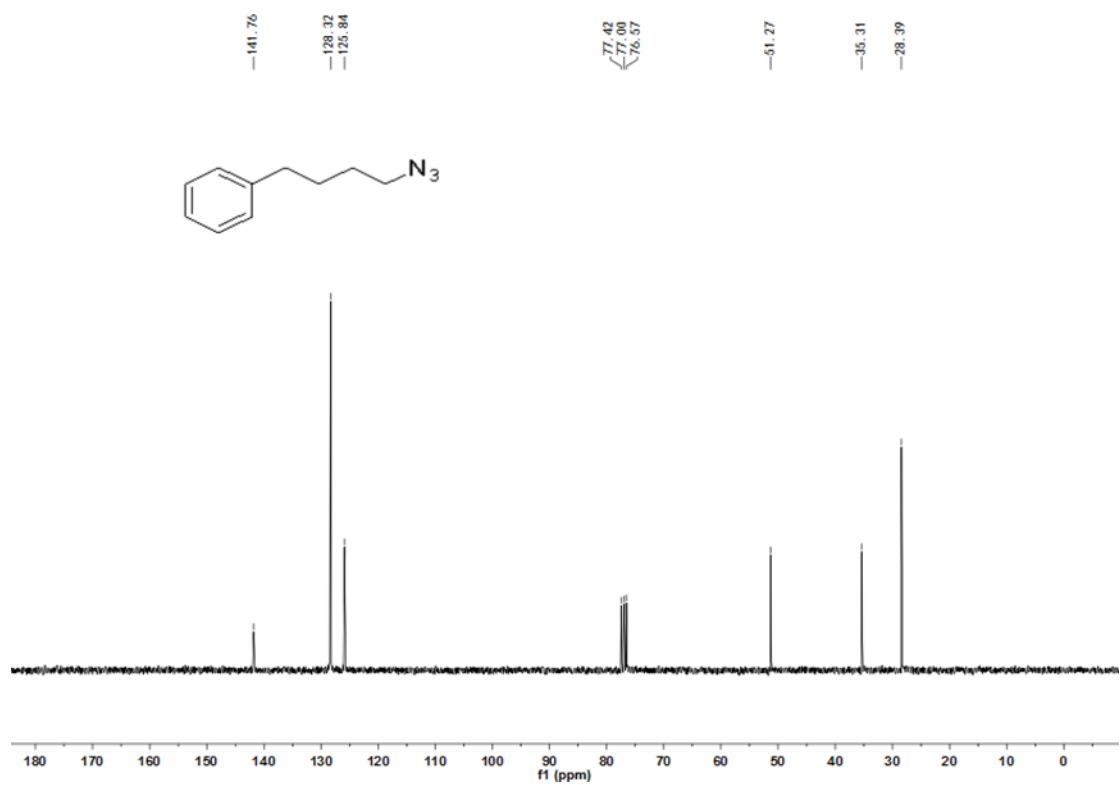
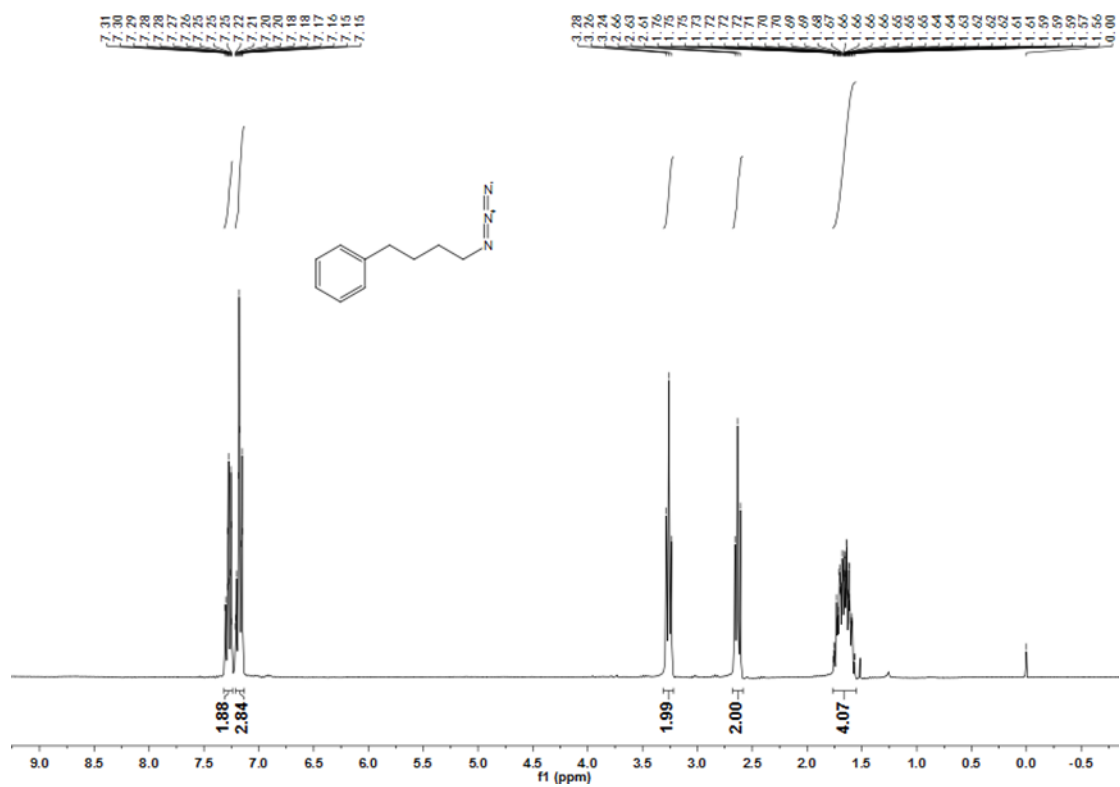


1v



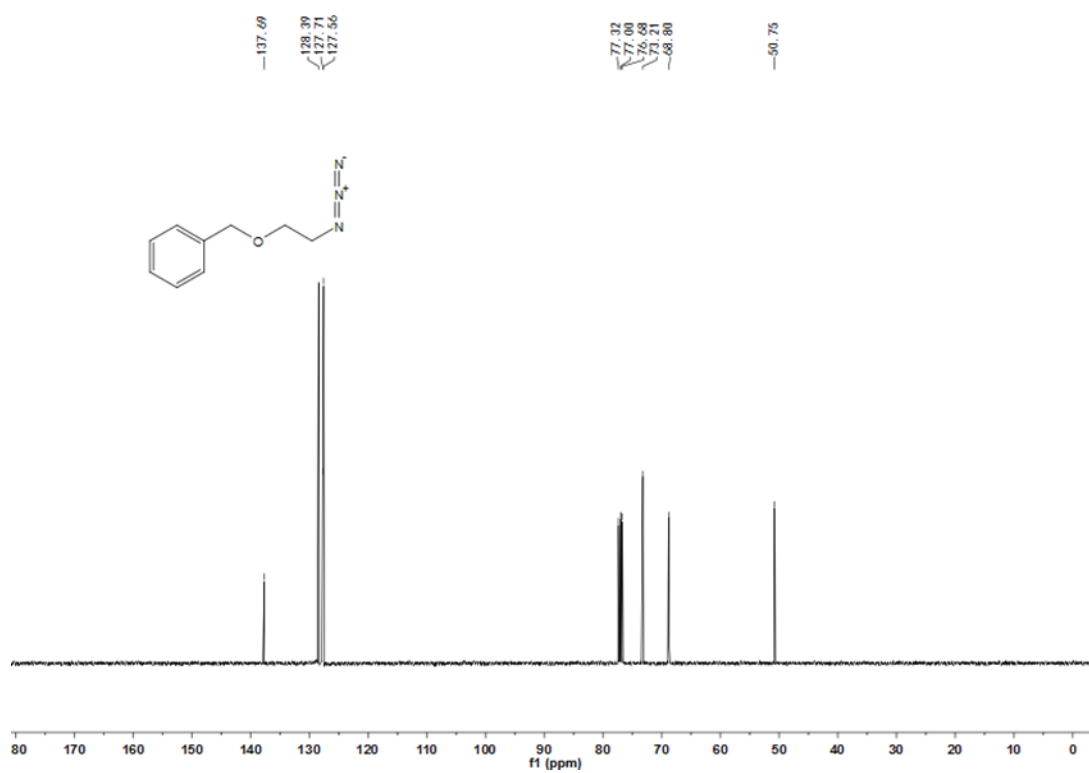
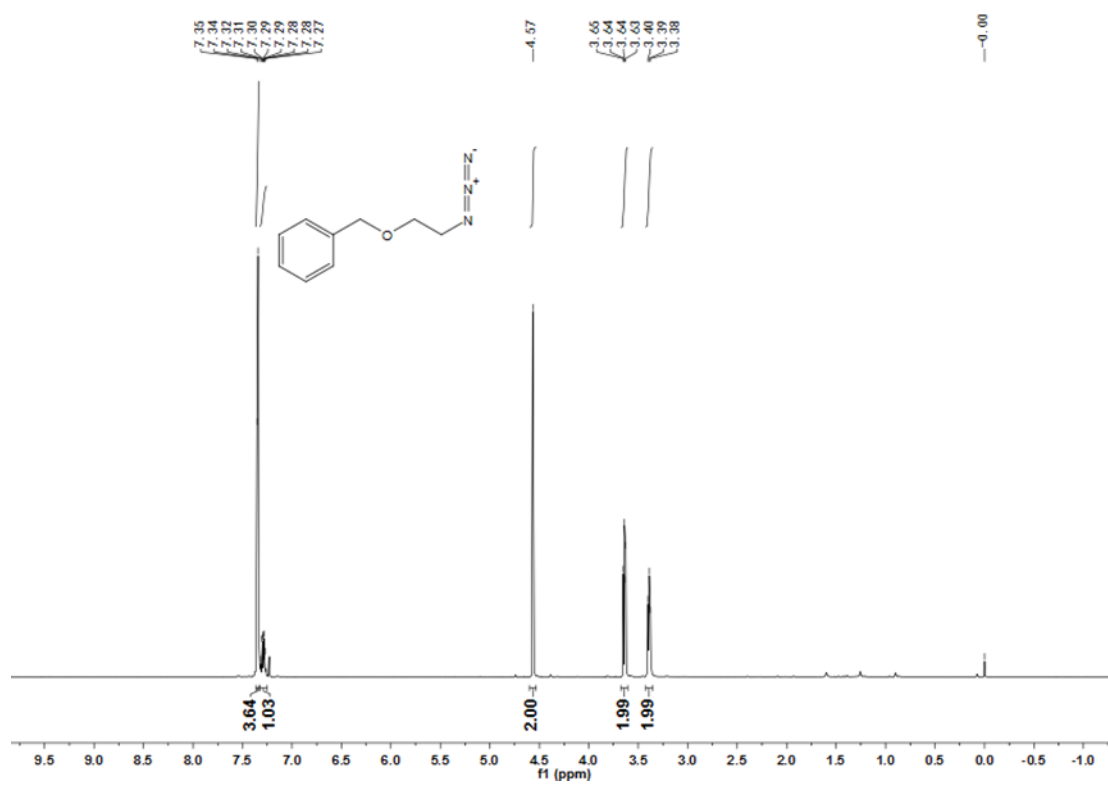


3



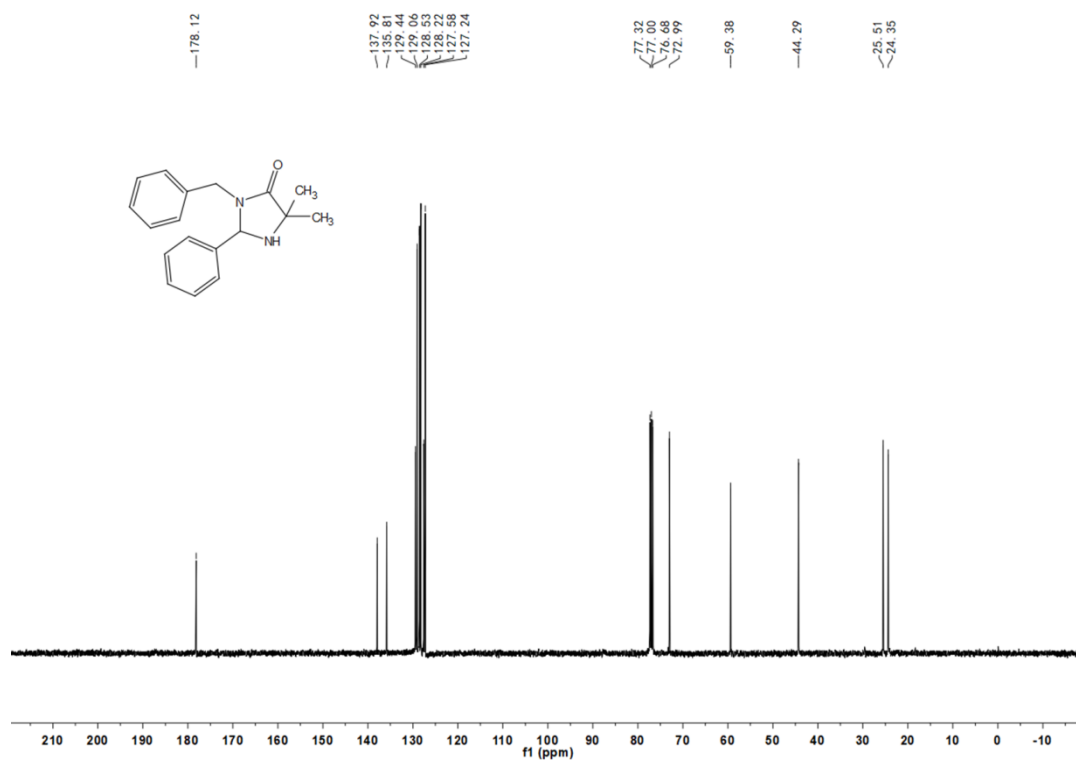
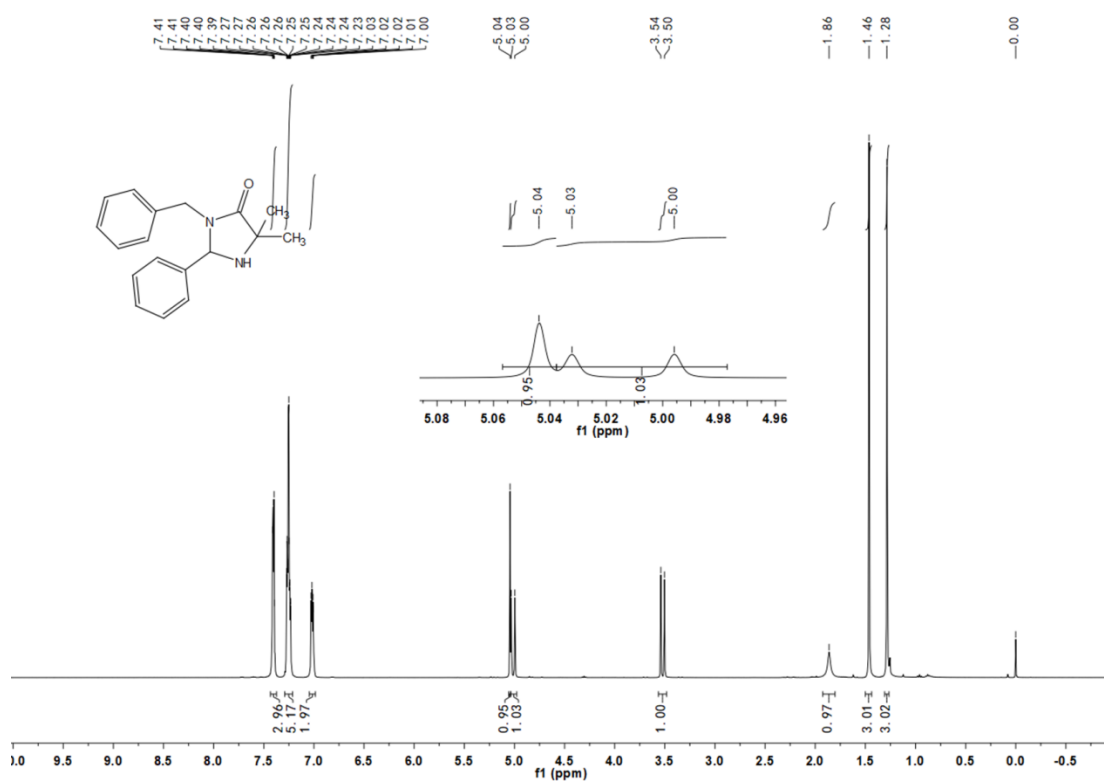


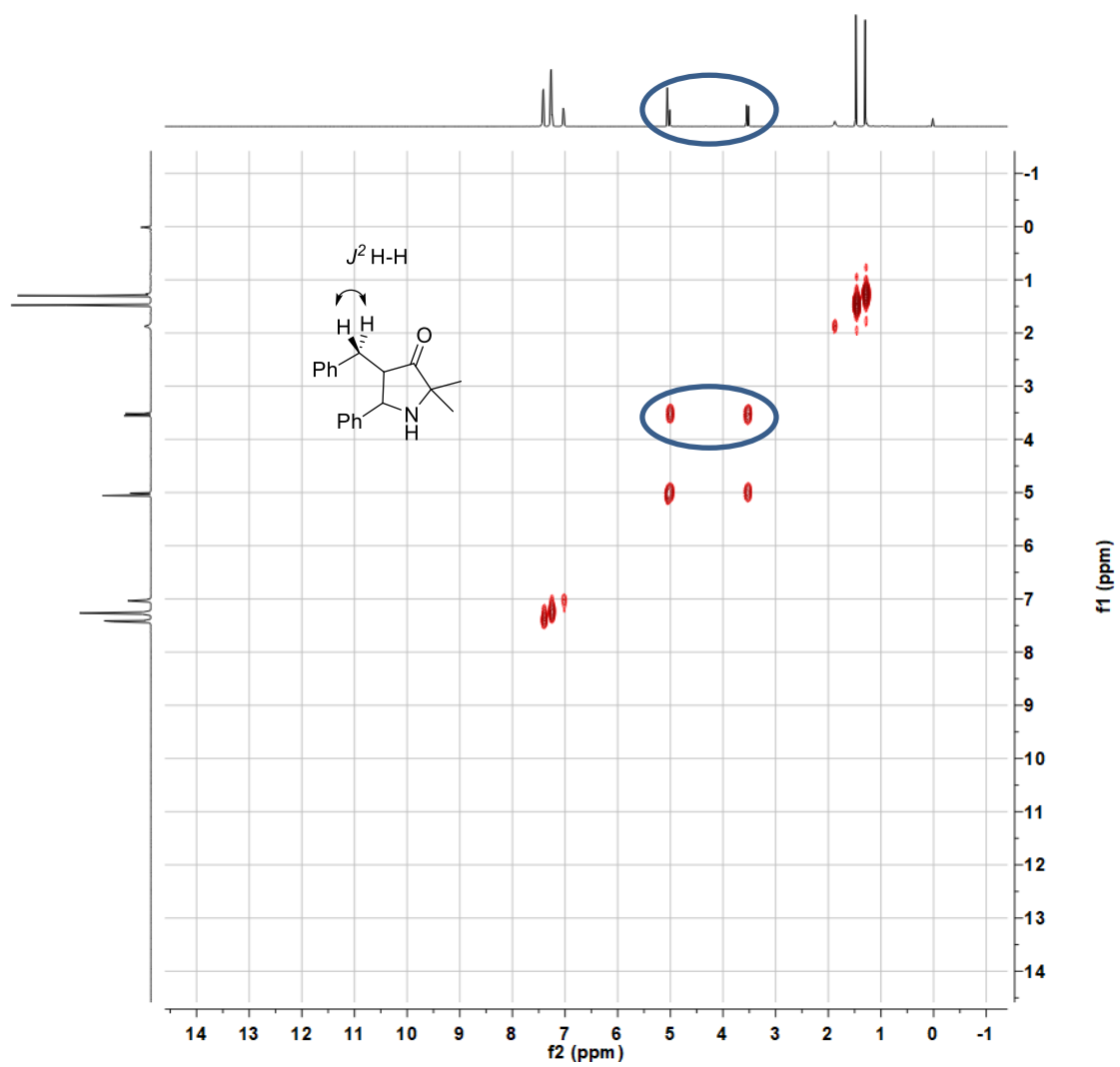
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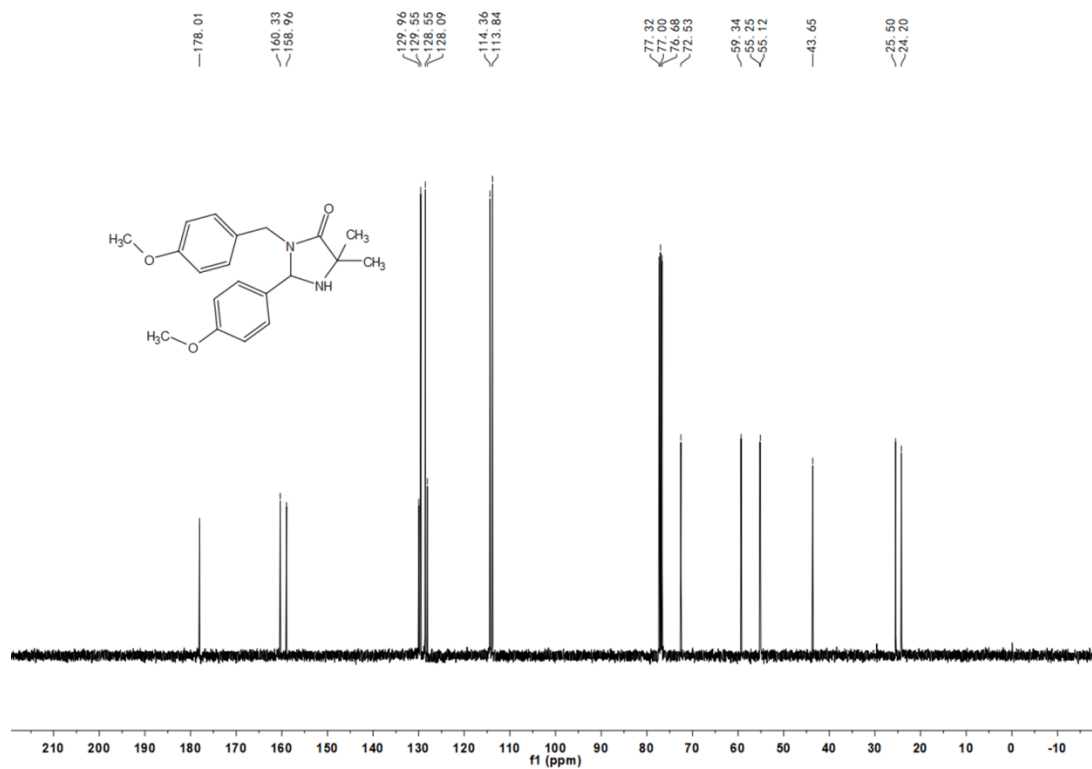
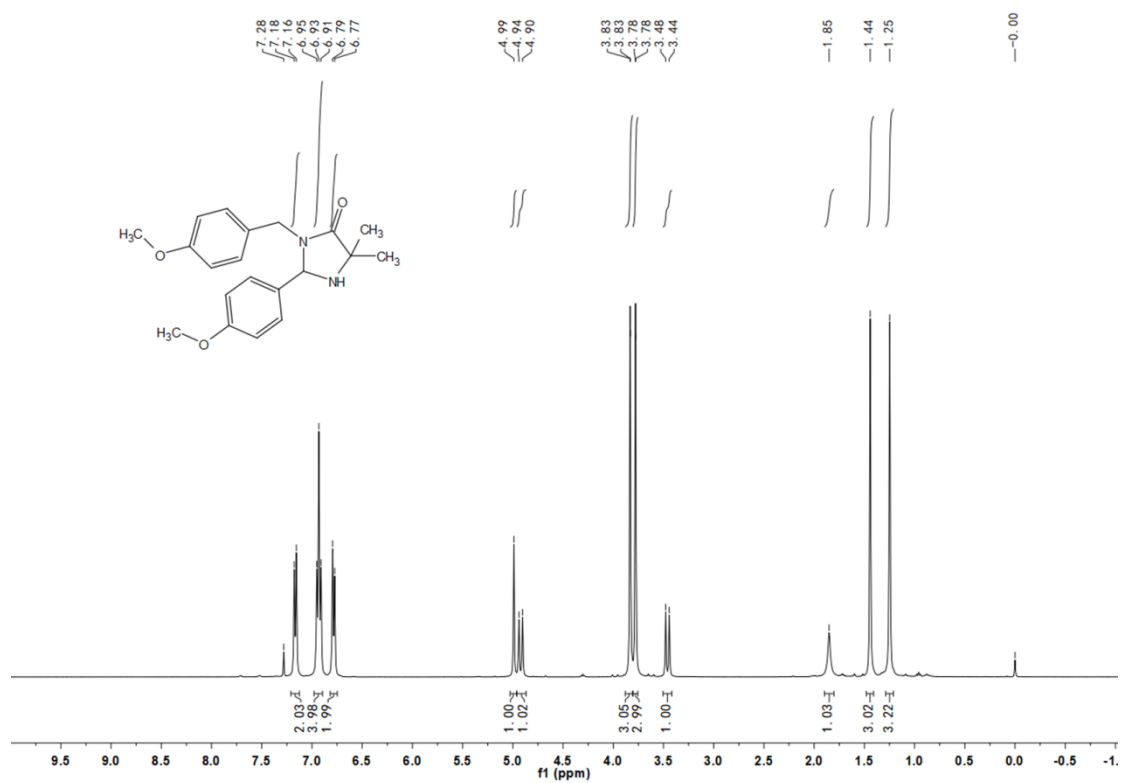
S53

2a

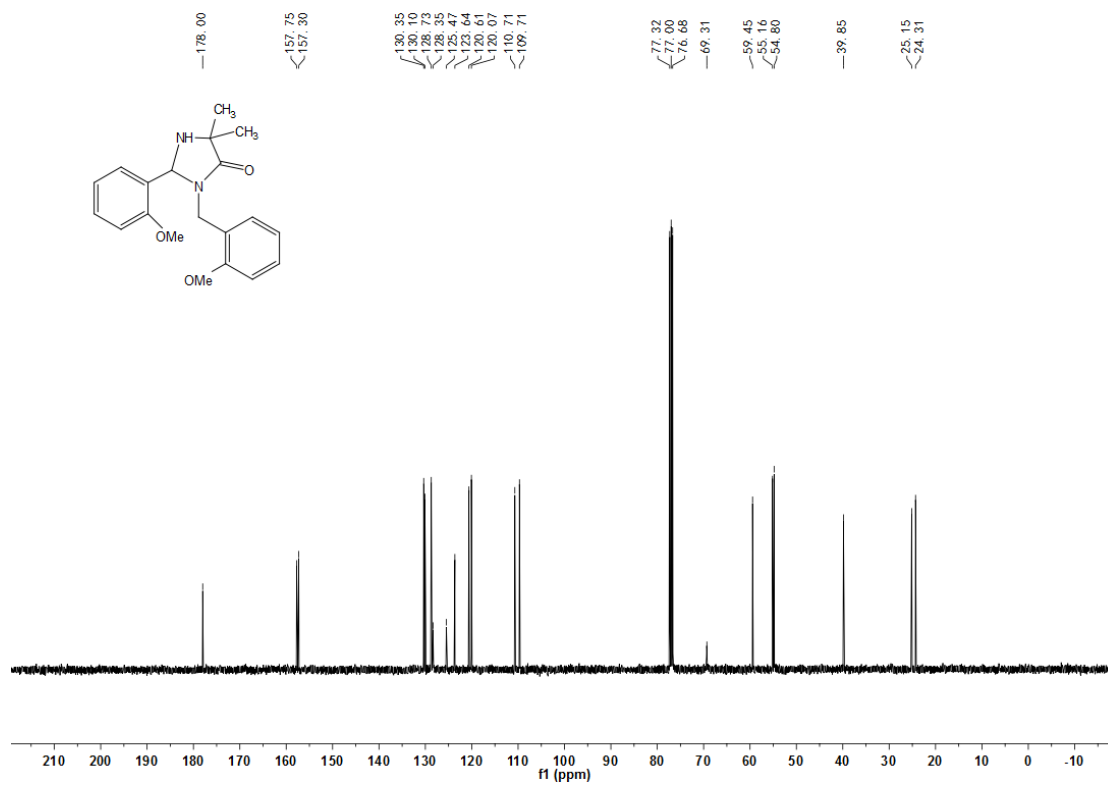
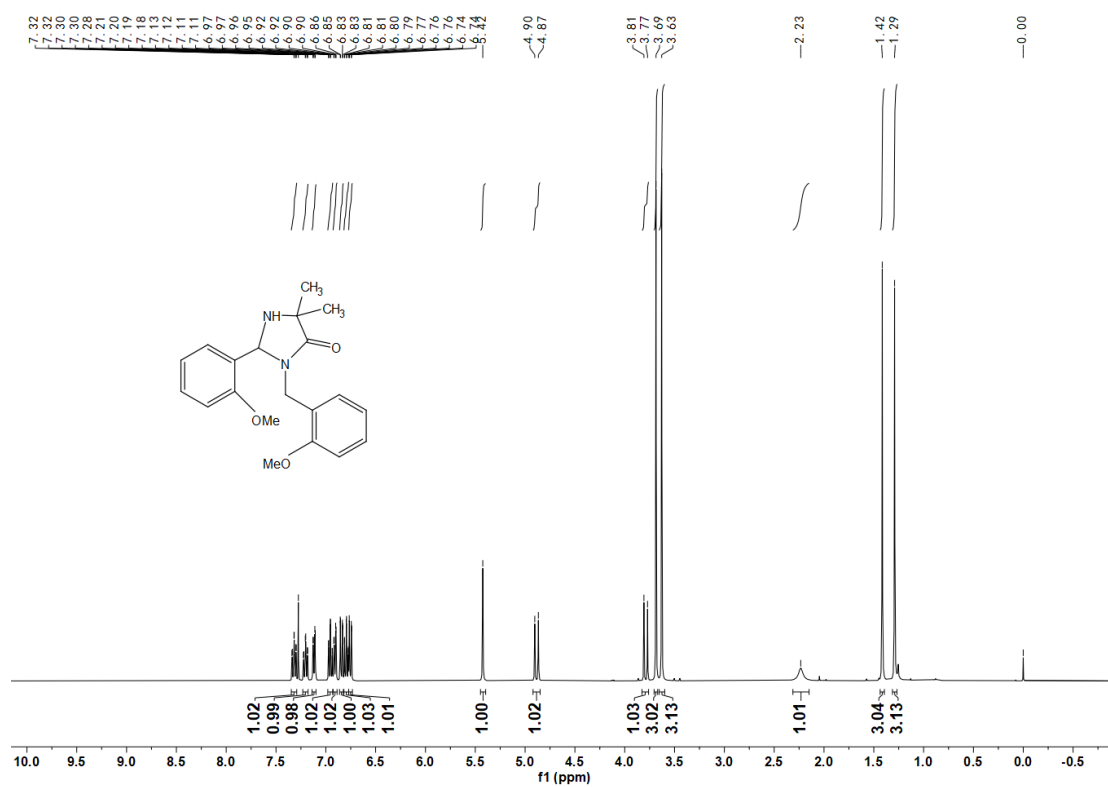




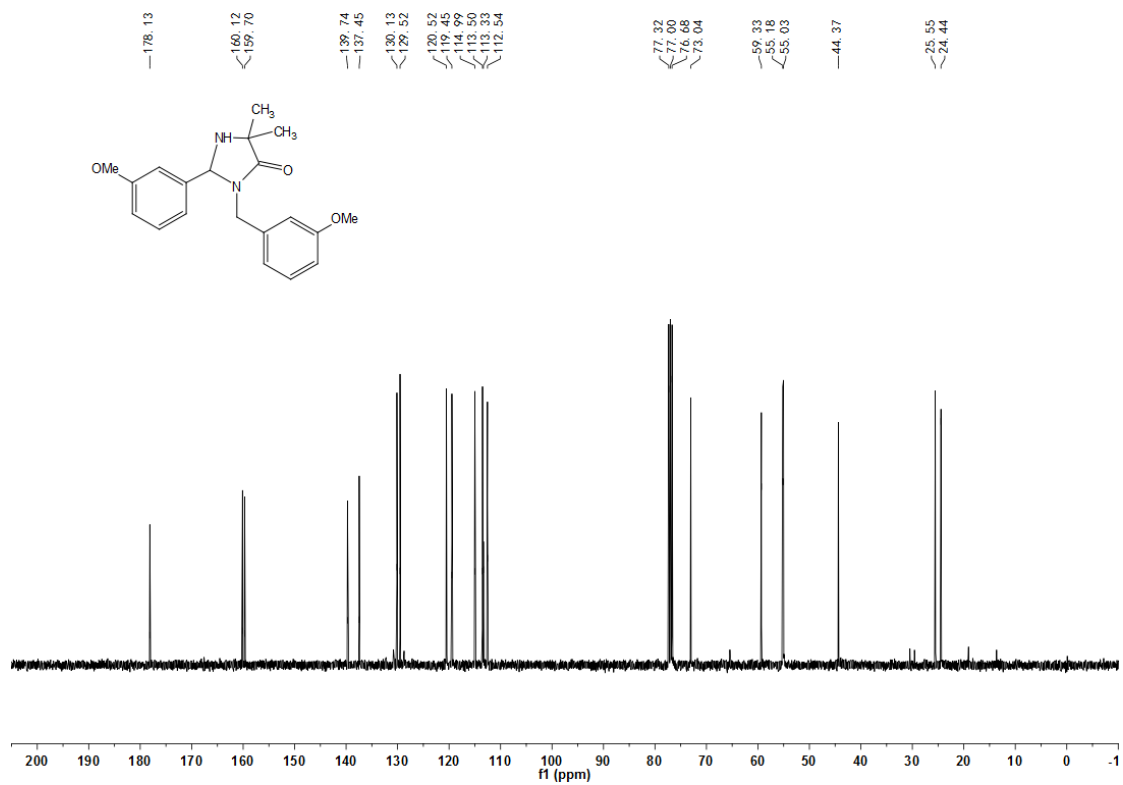
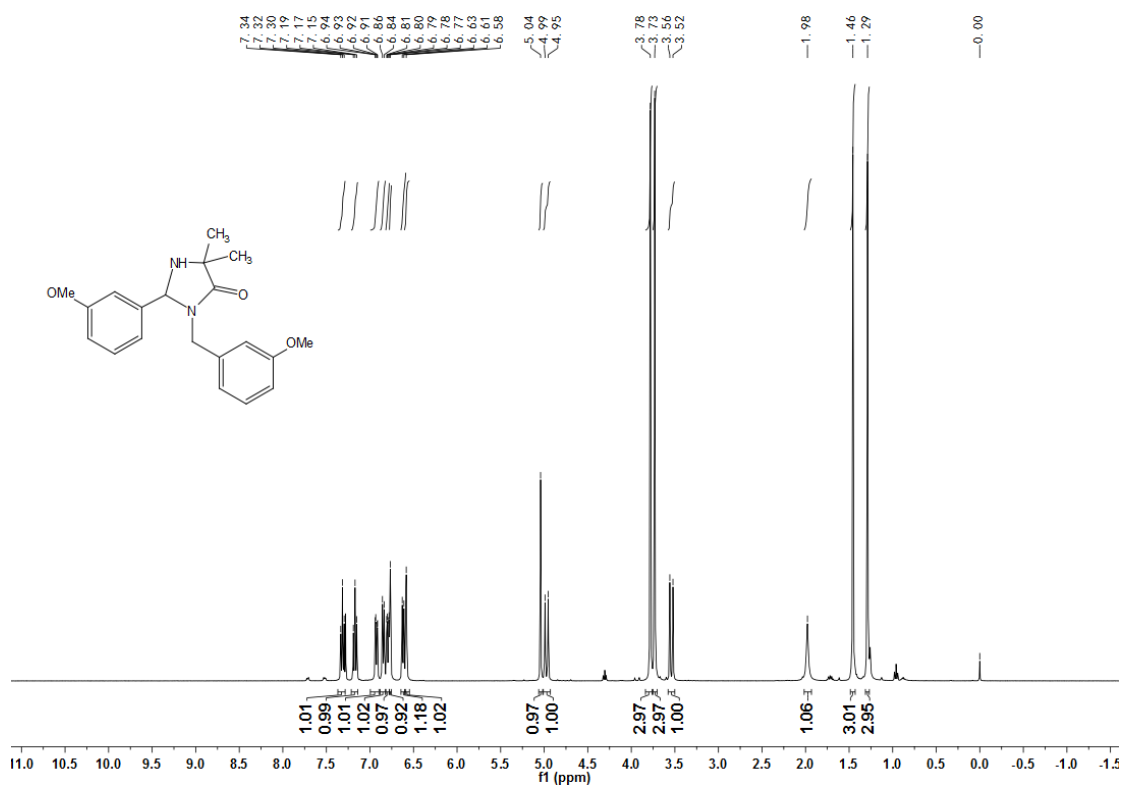
2b



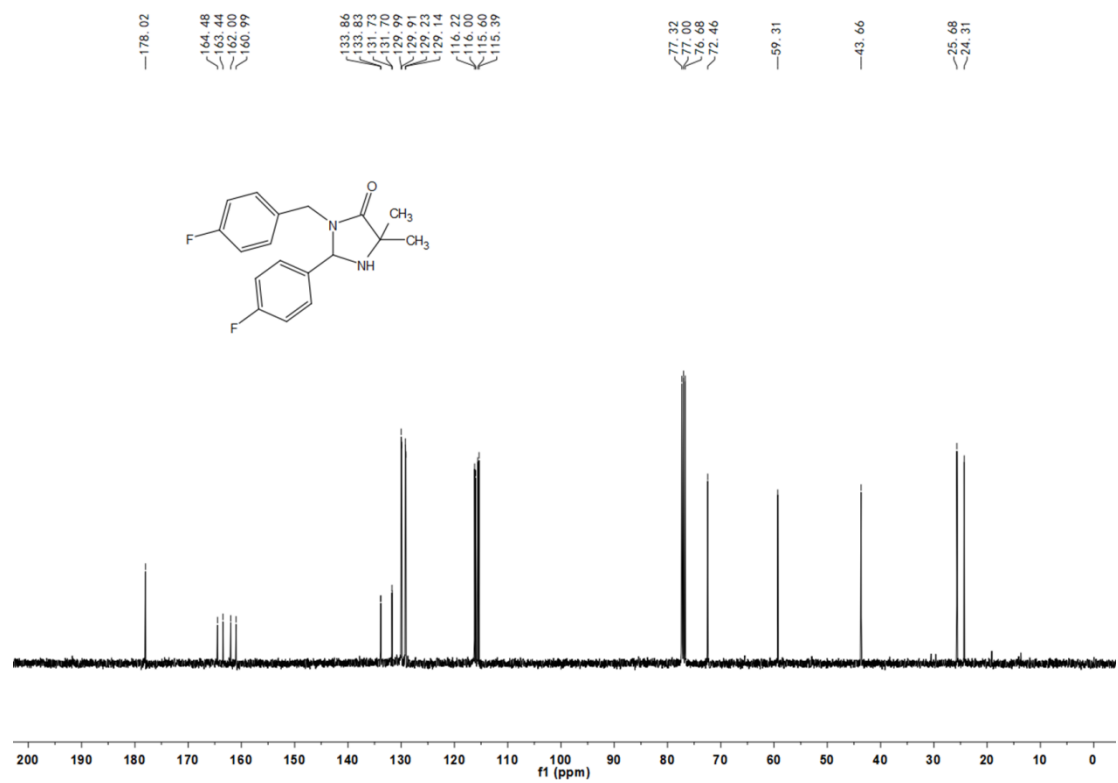
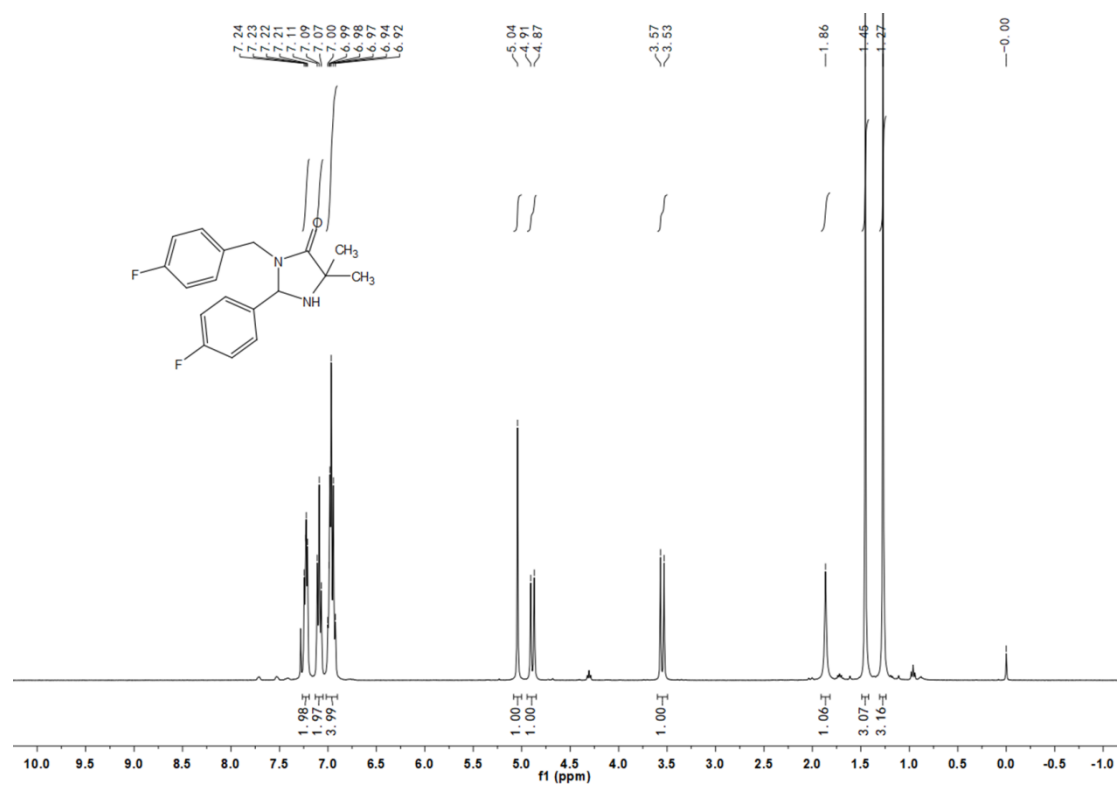
2c



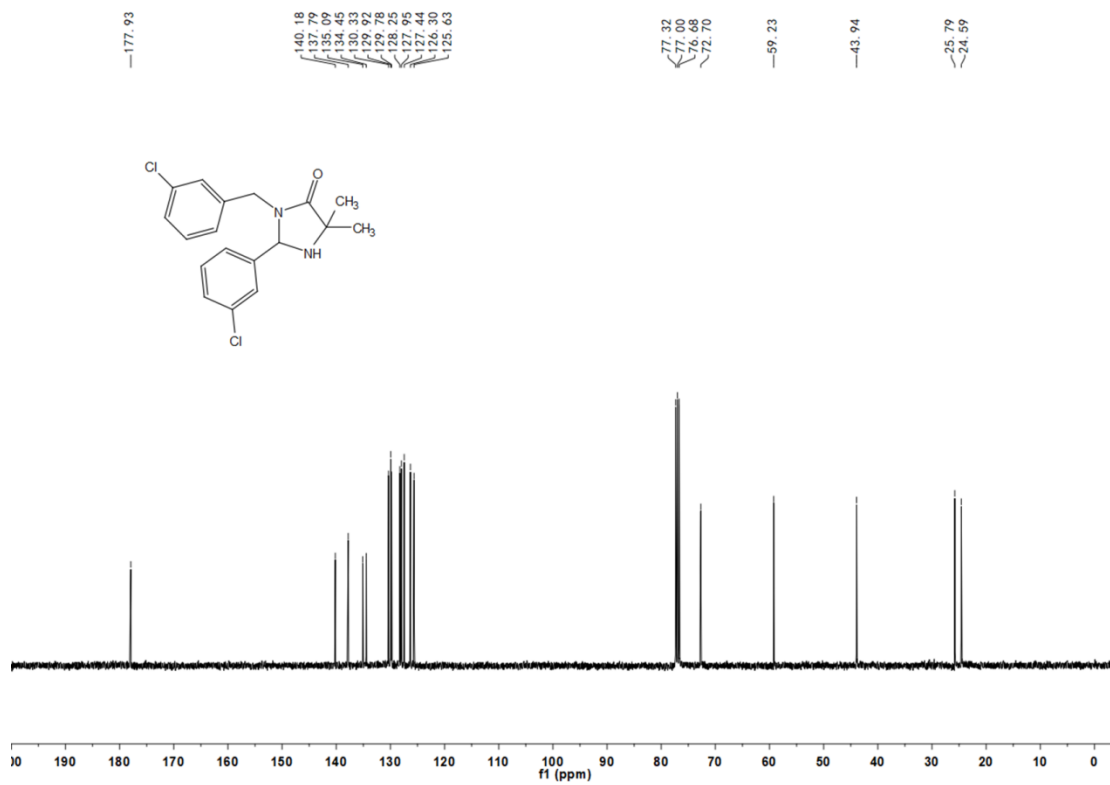
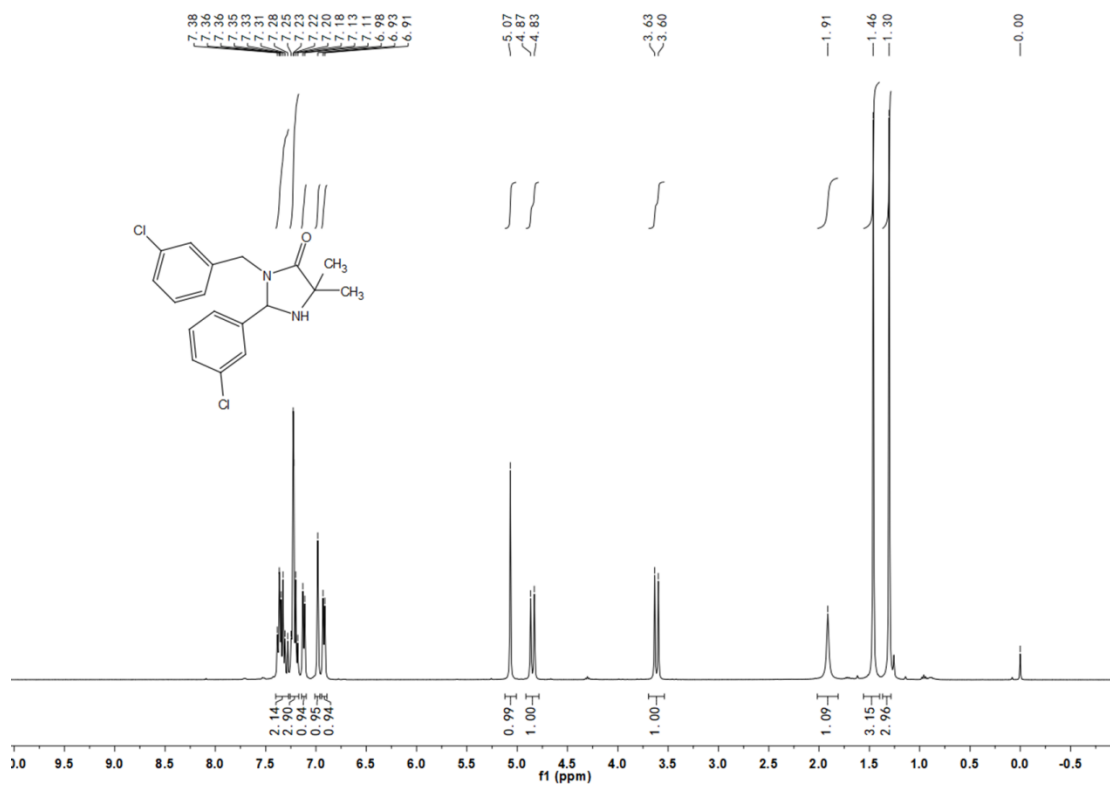
2d



2e

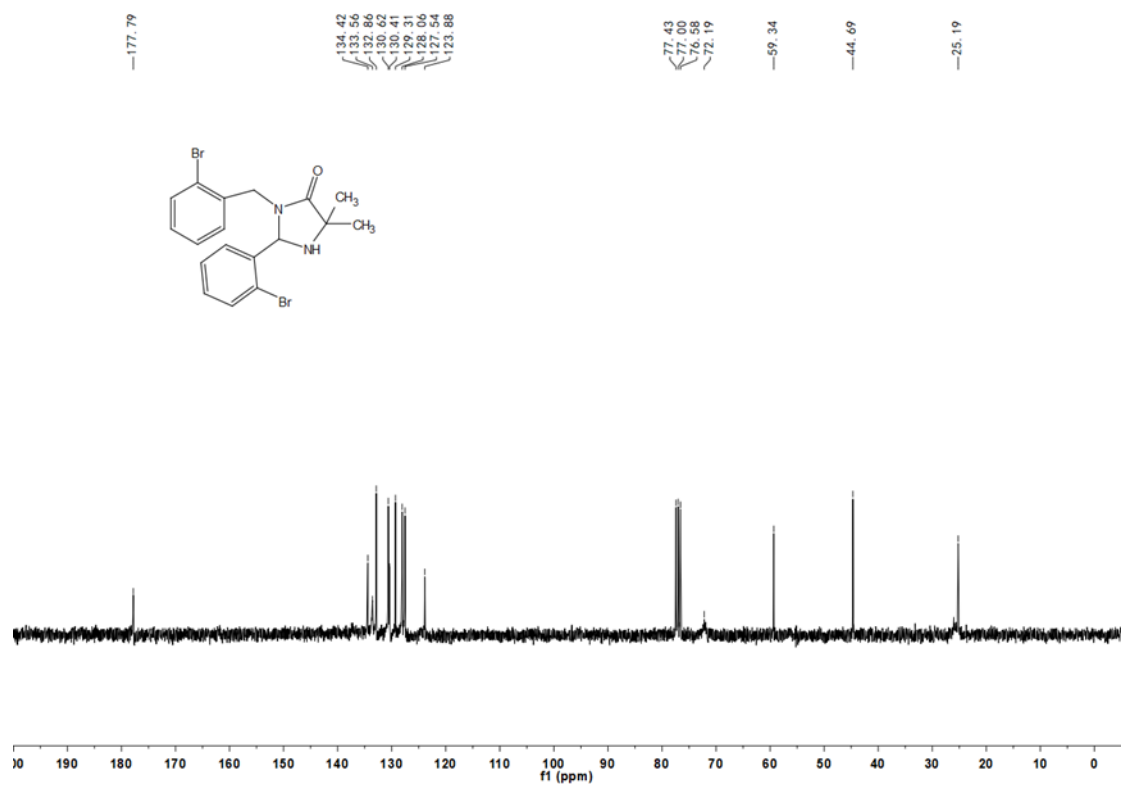
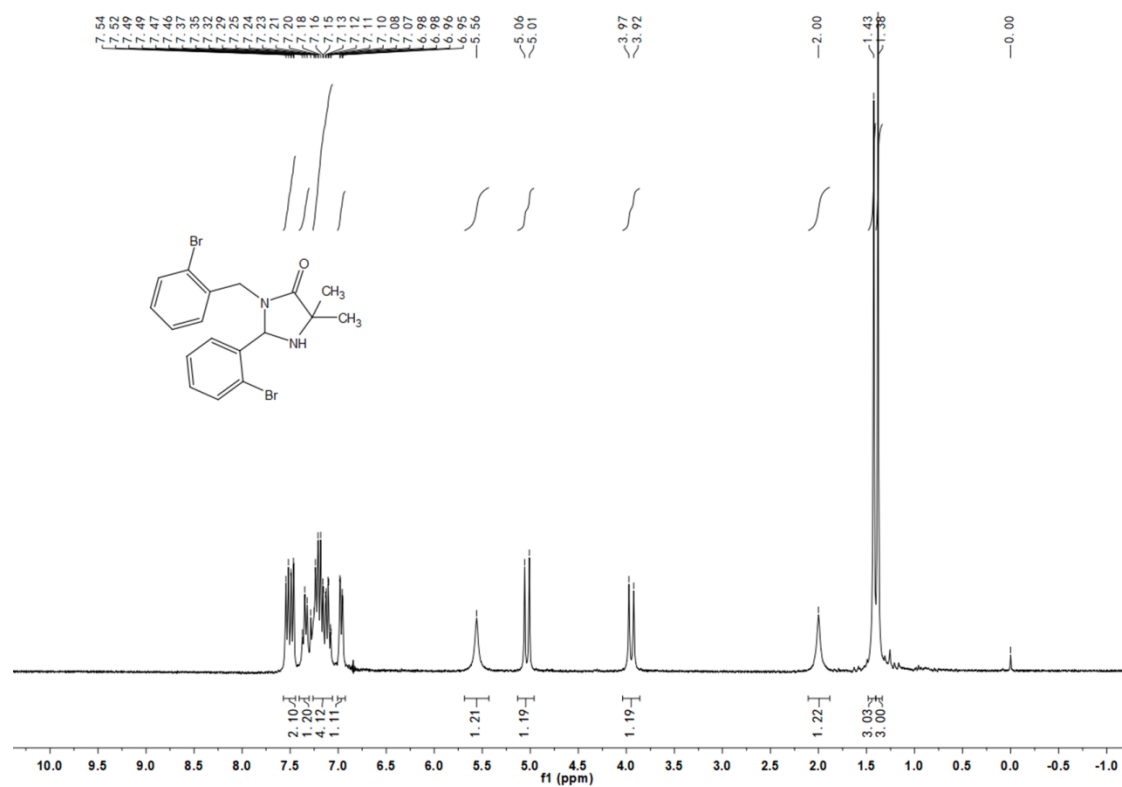


2f

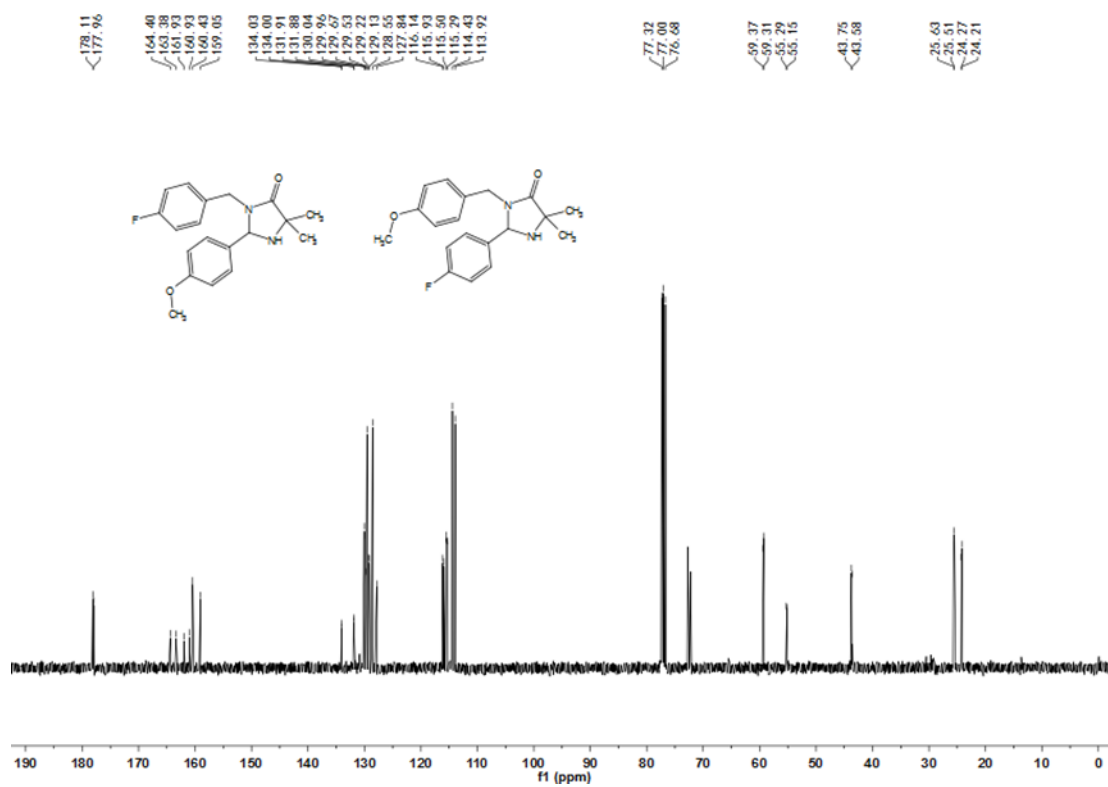
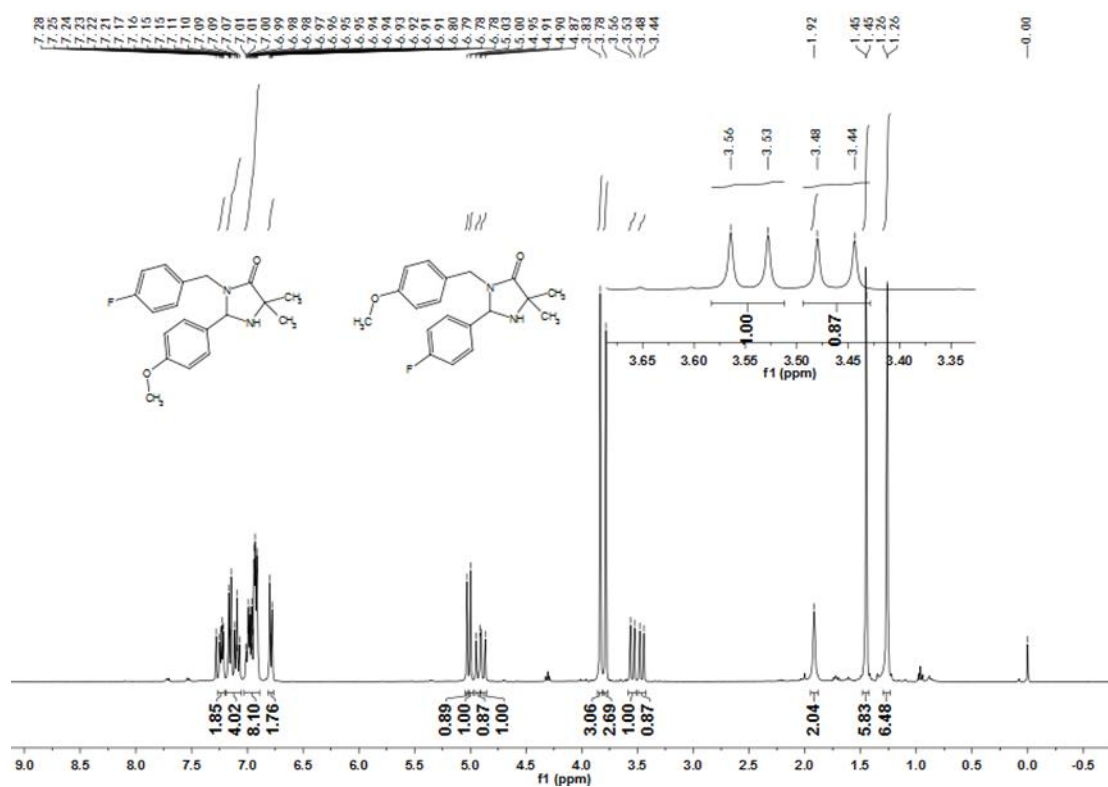




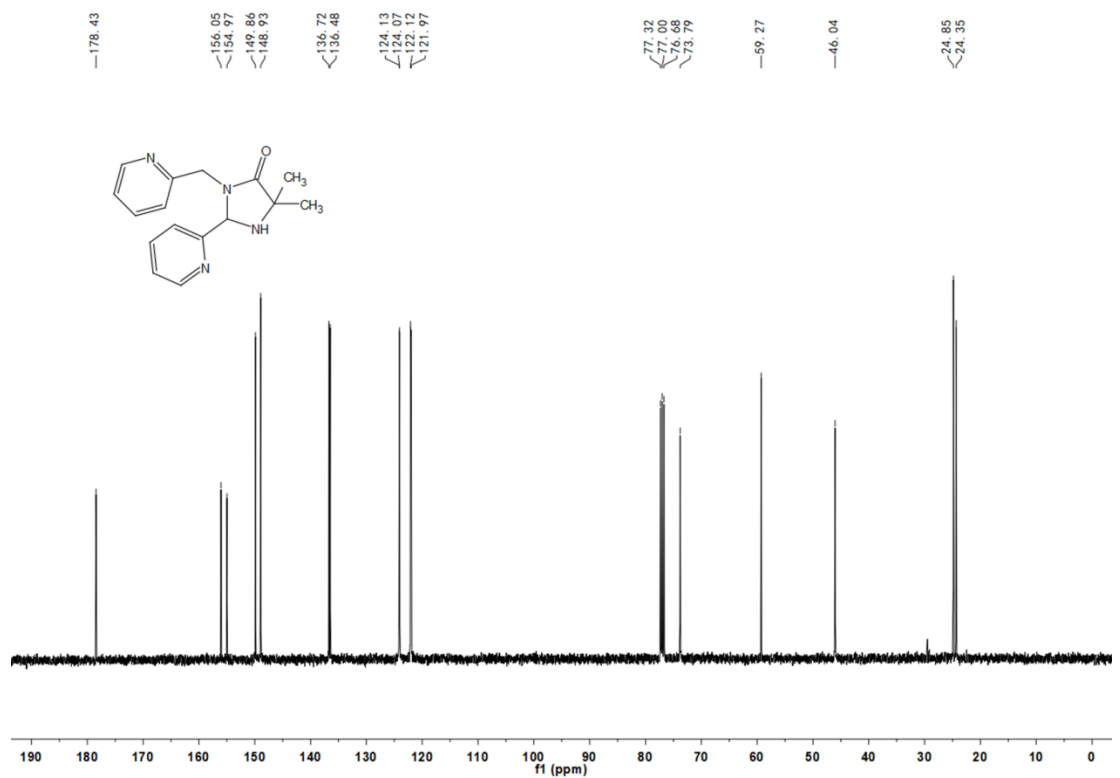
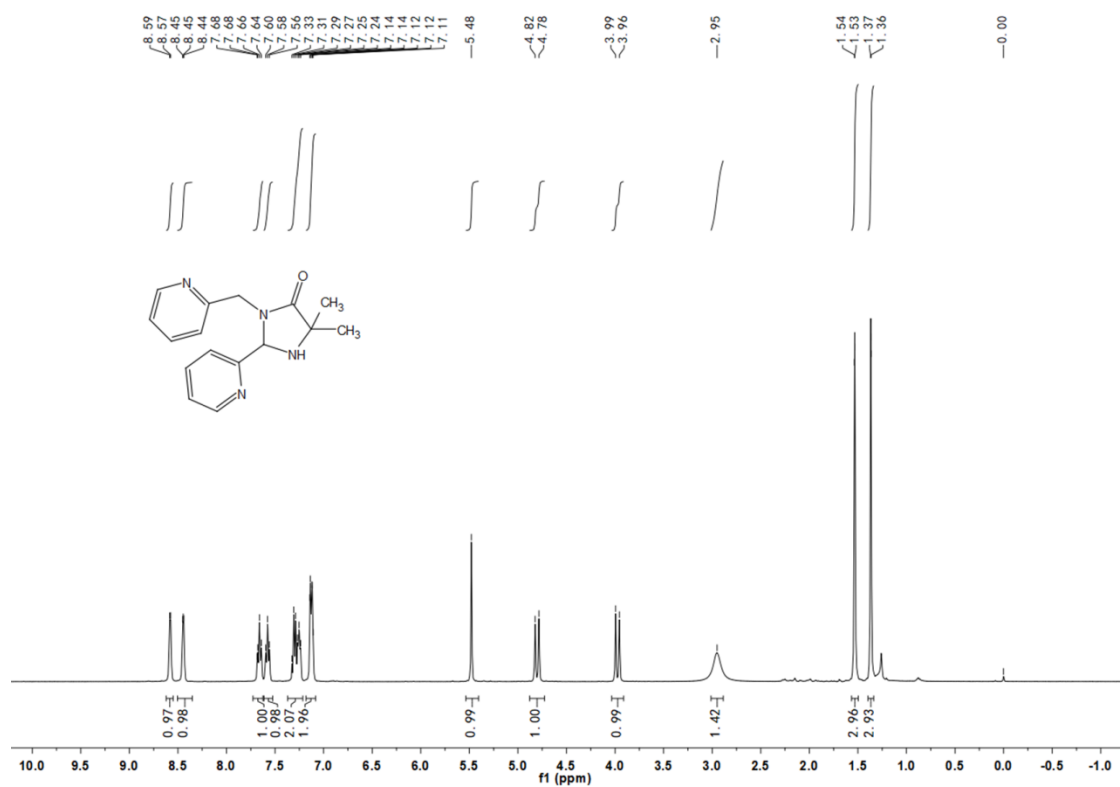
2g



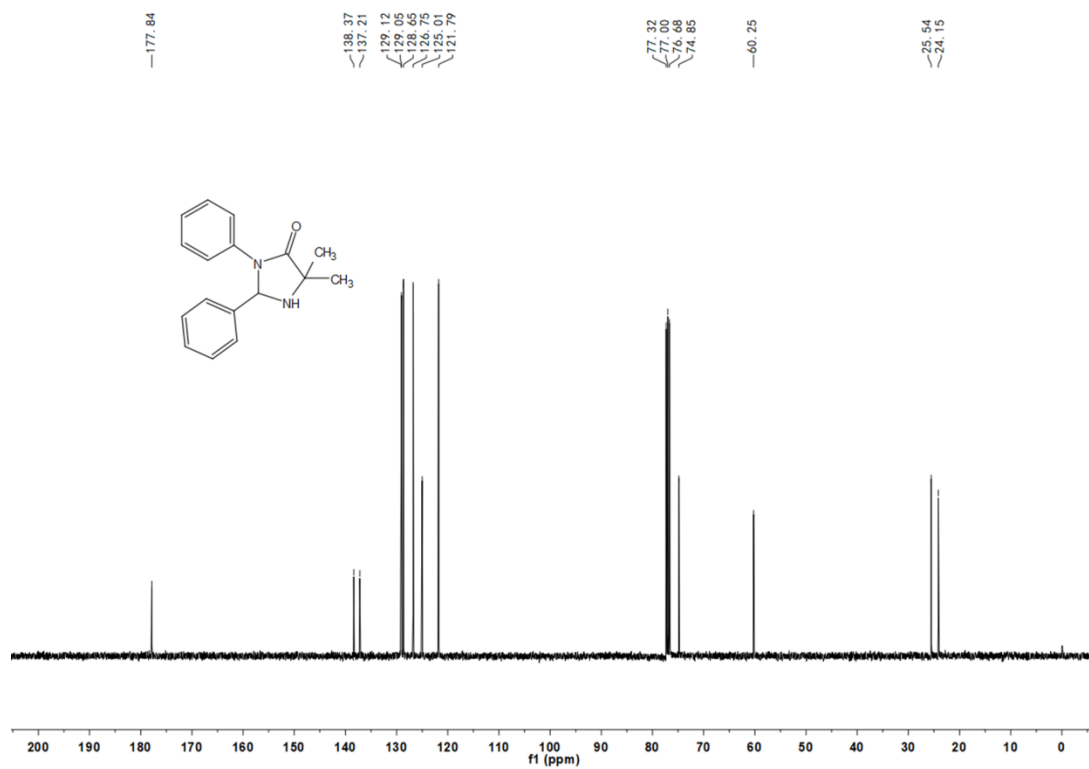
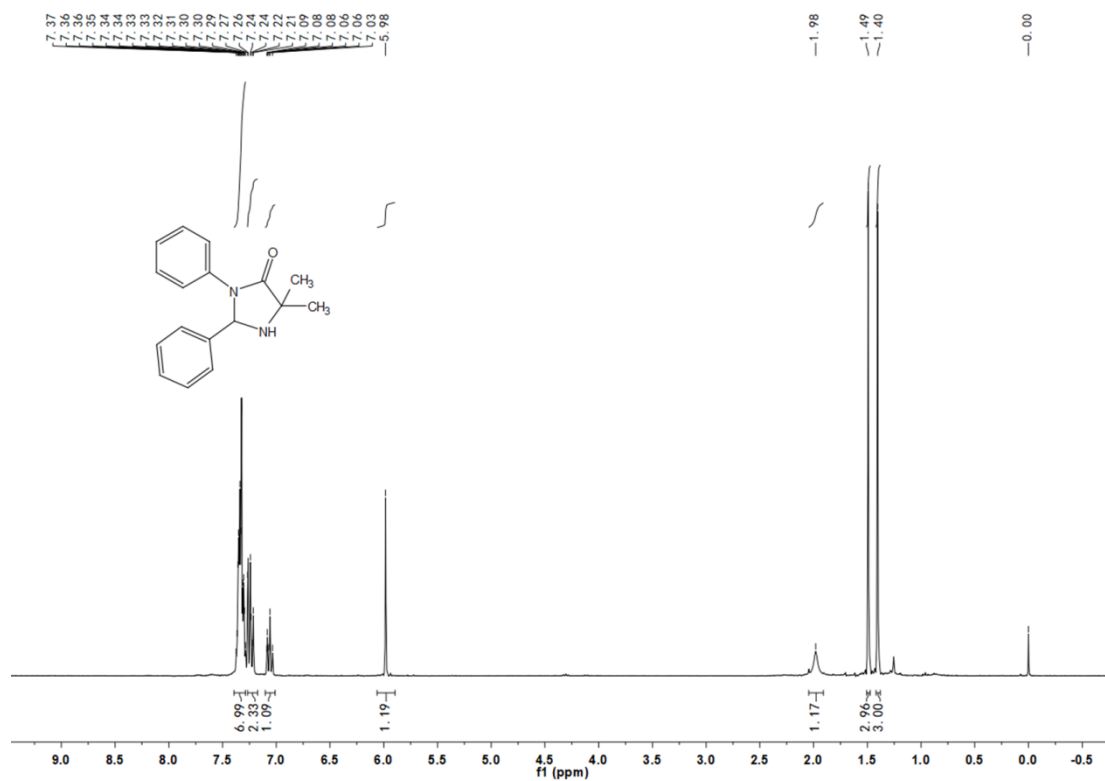
# 2h-1&2h-2



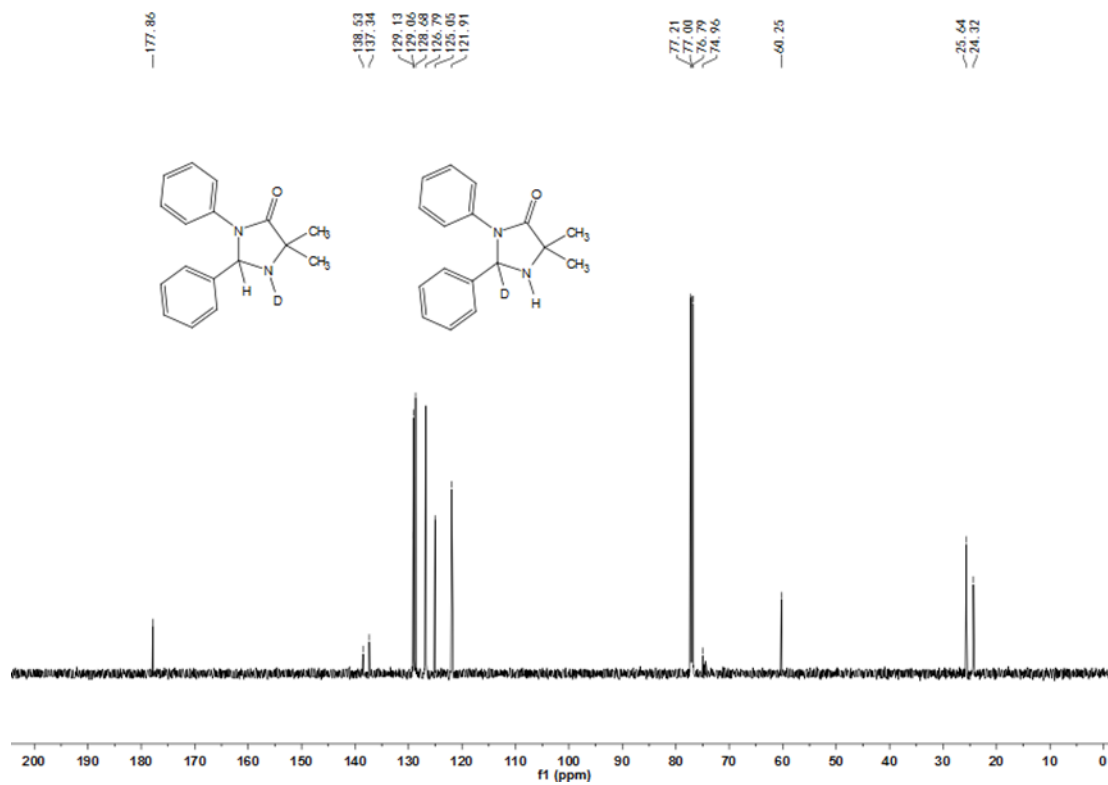
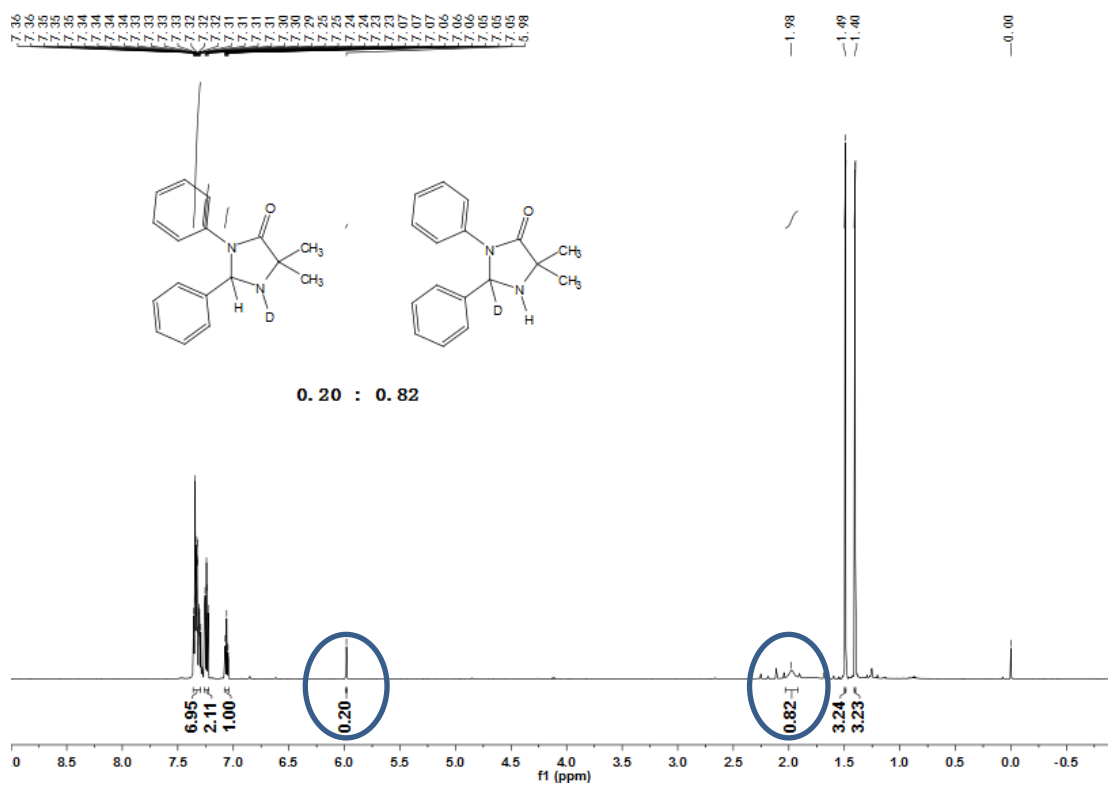
2i



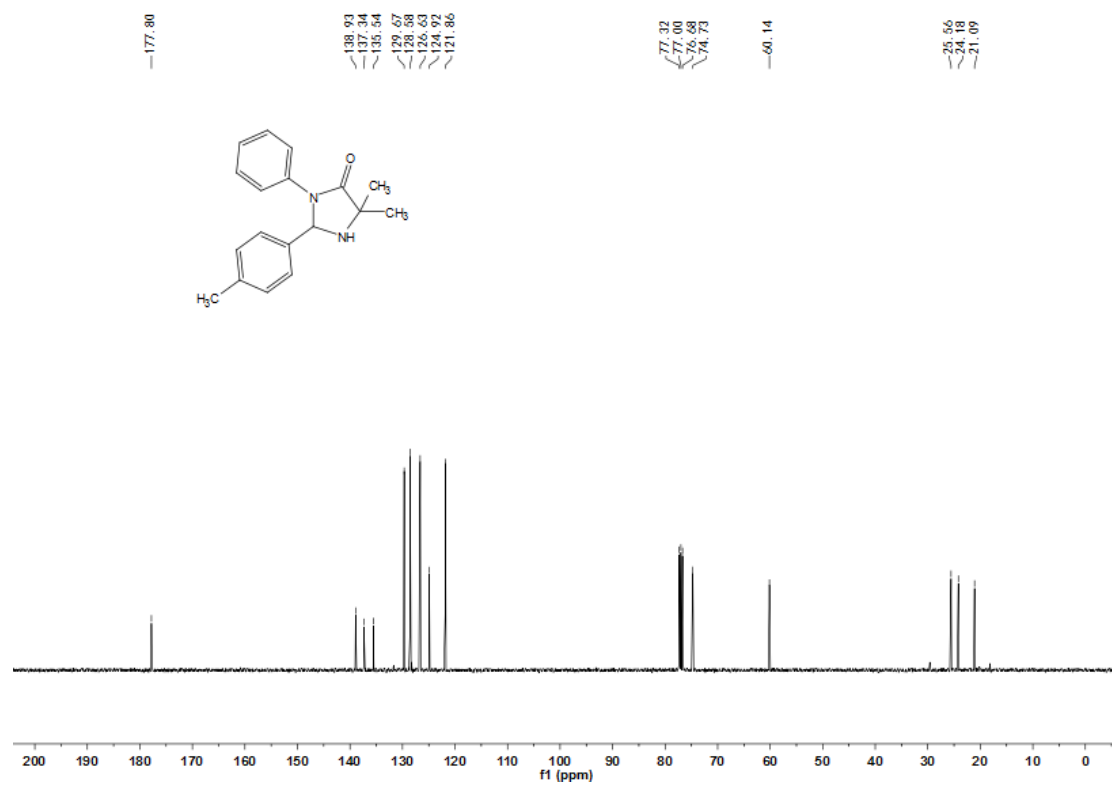
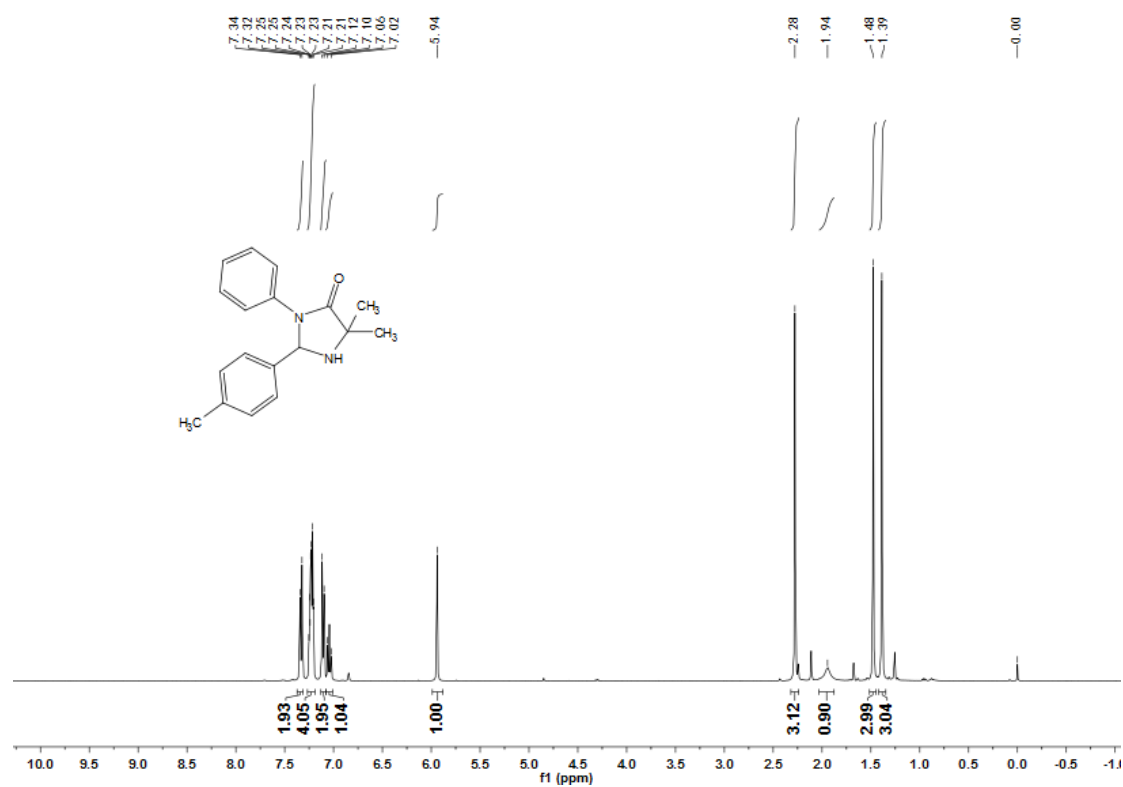
2j



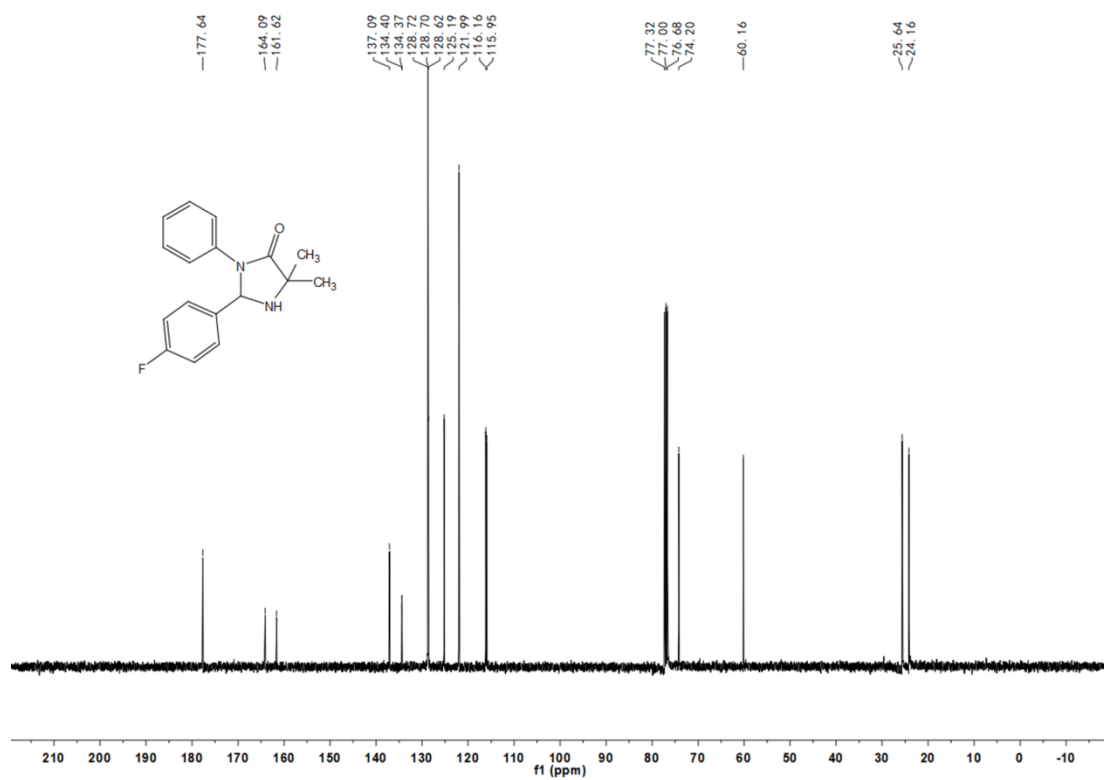
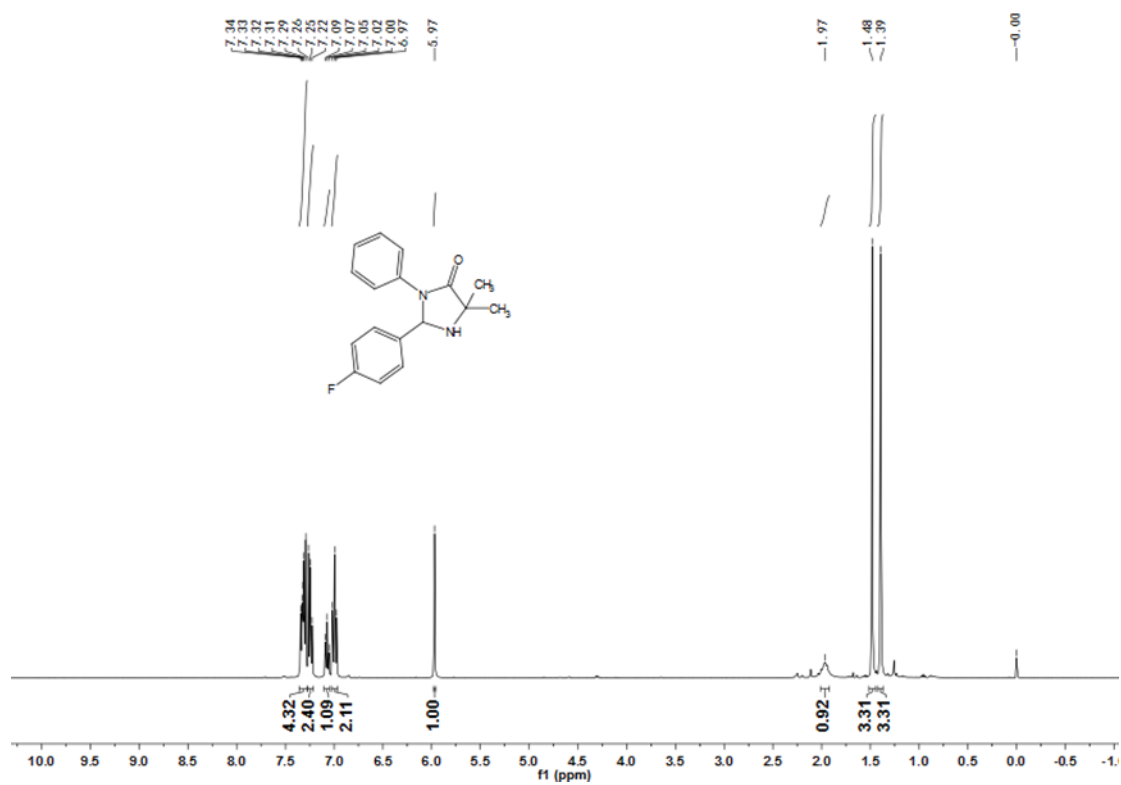
7.36  
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7.05  
5.98



2k

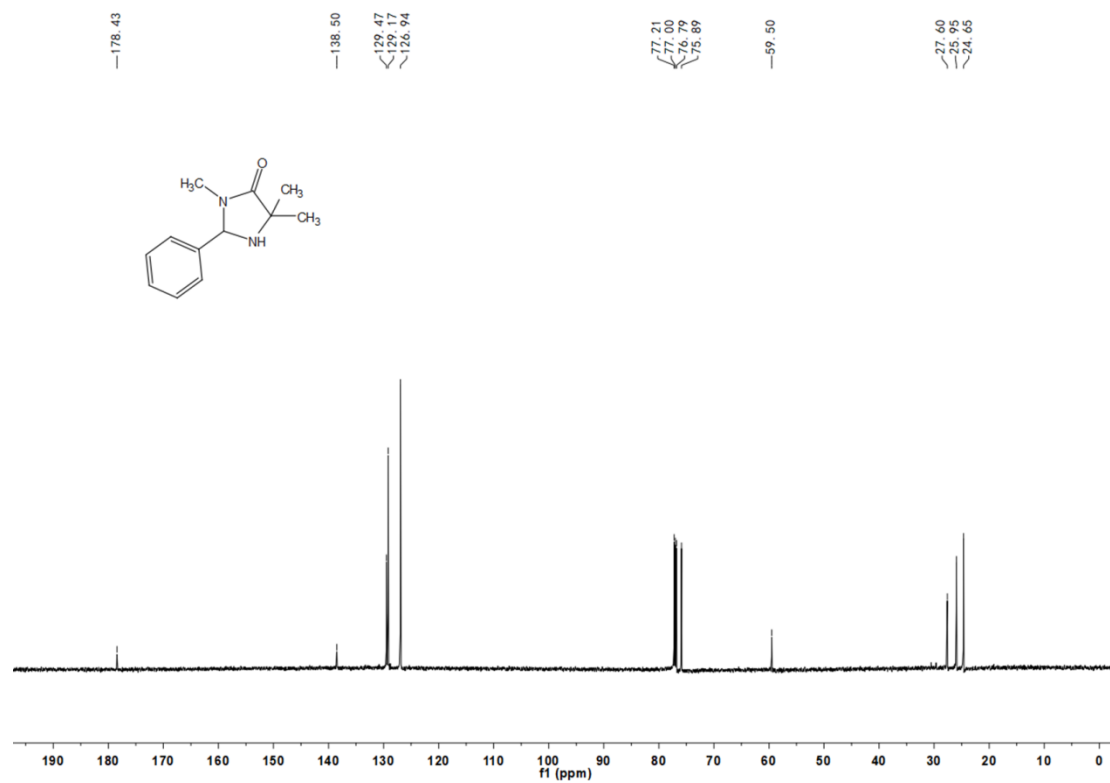
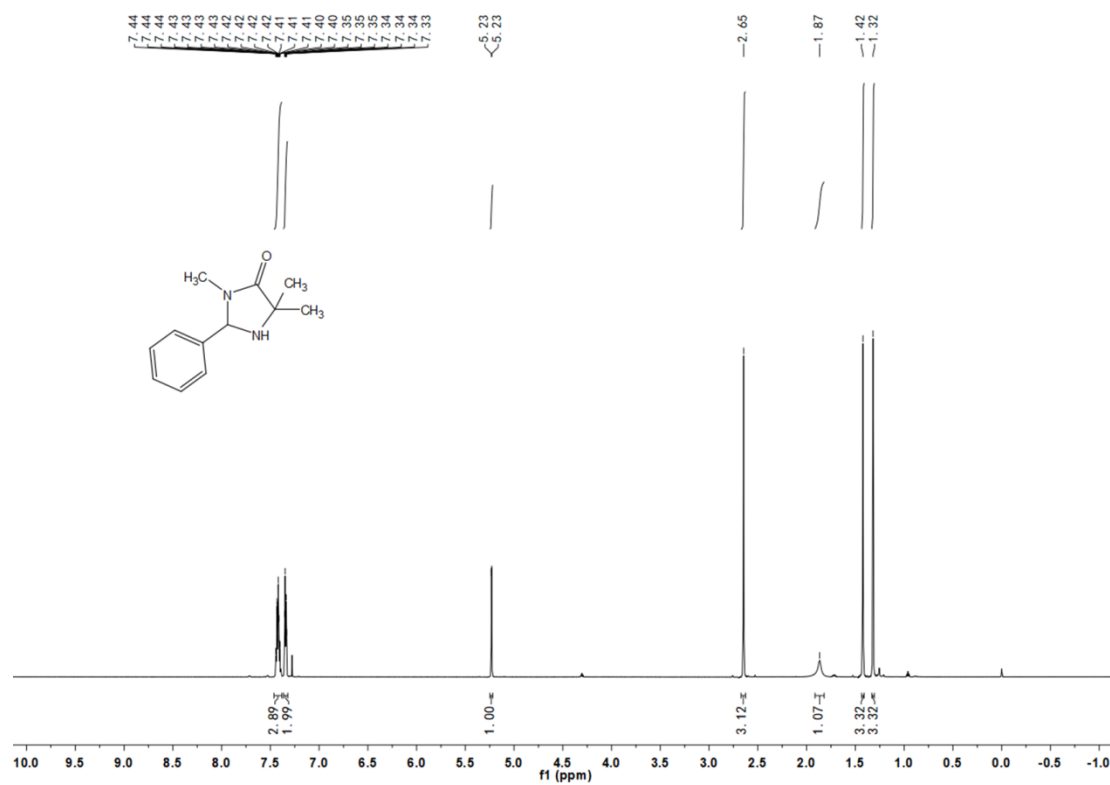


21



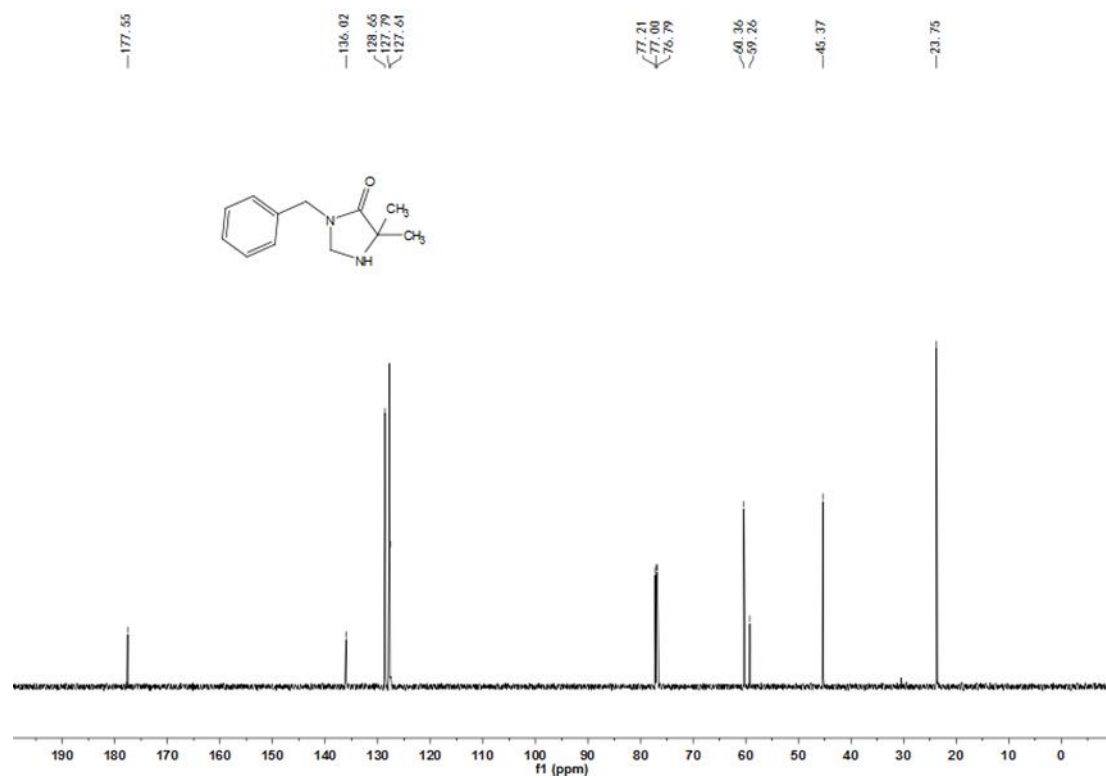
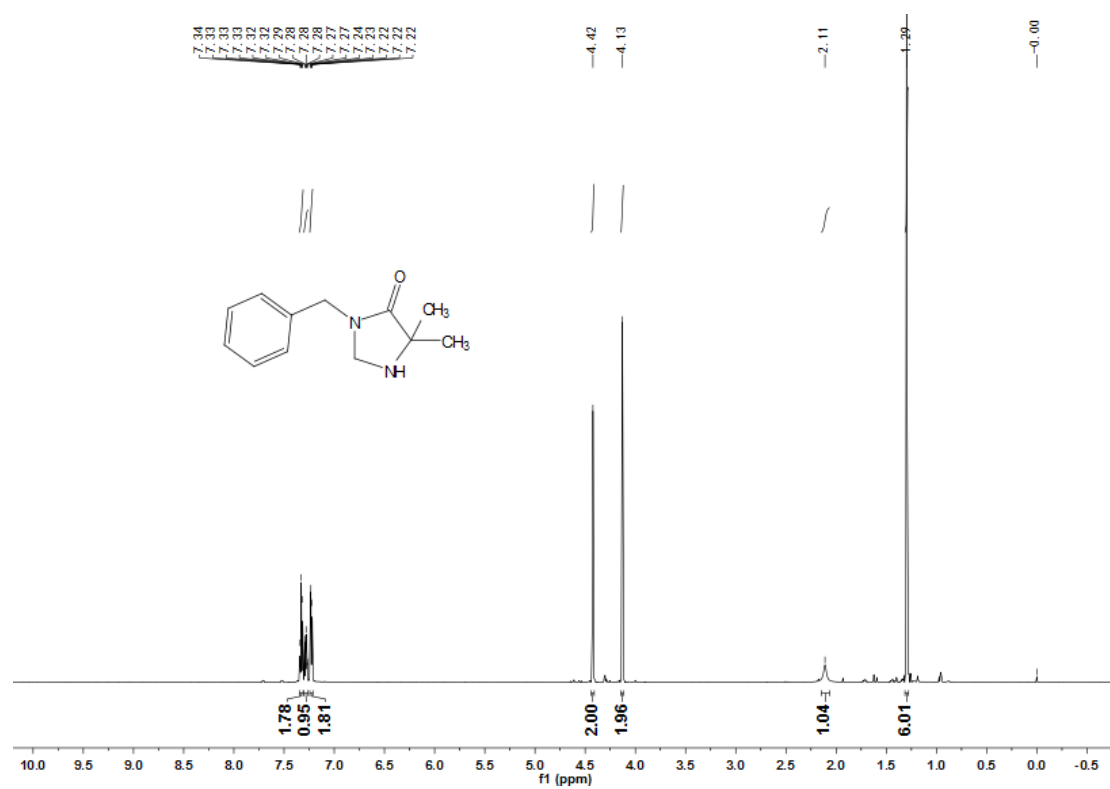
S67

2m-1

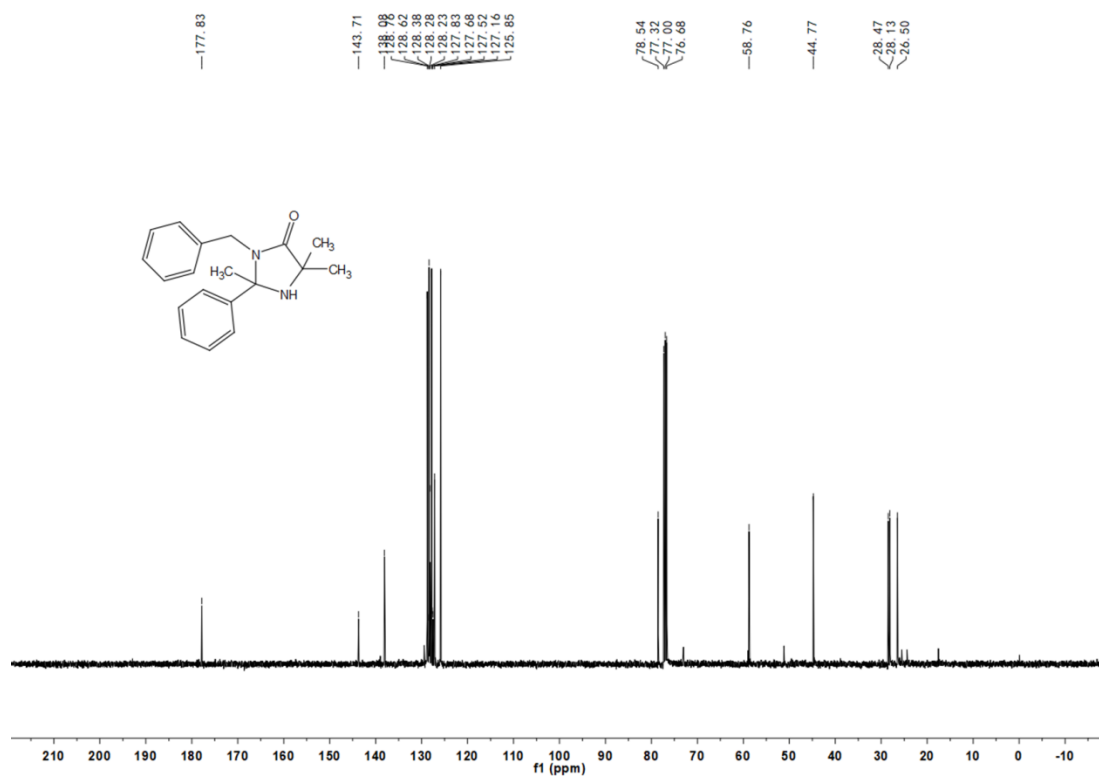
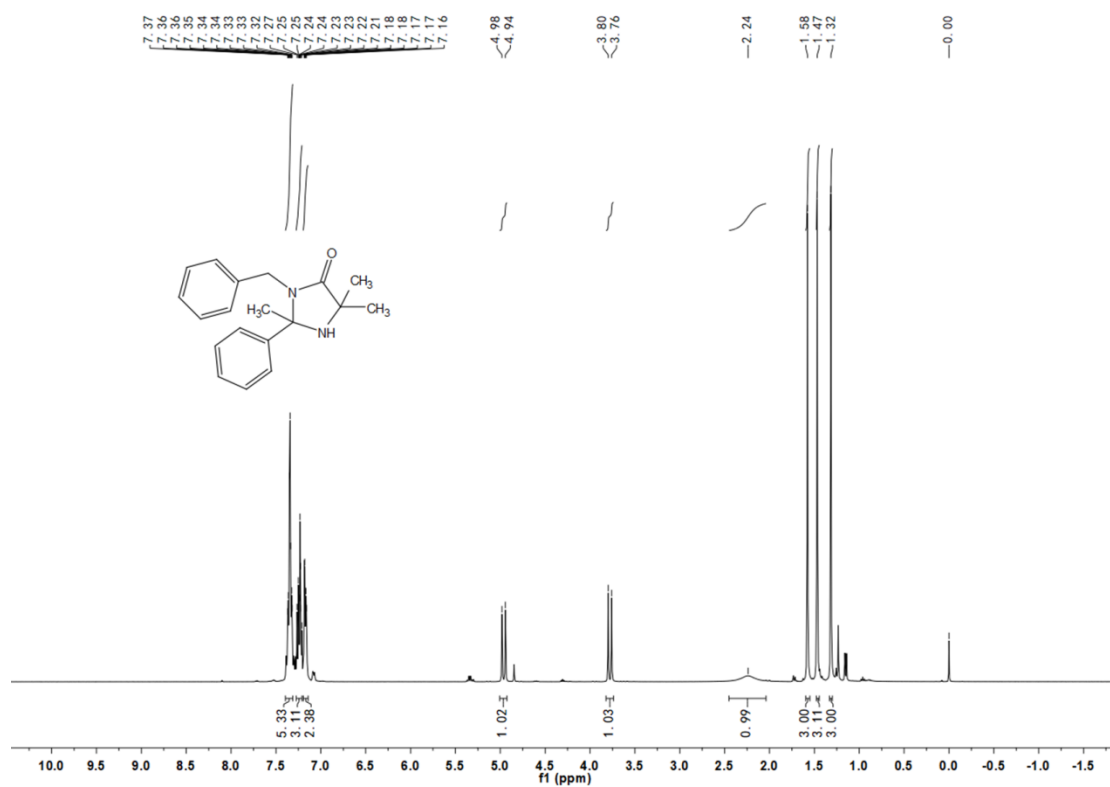




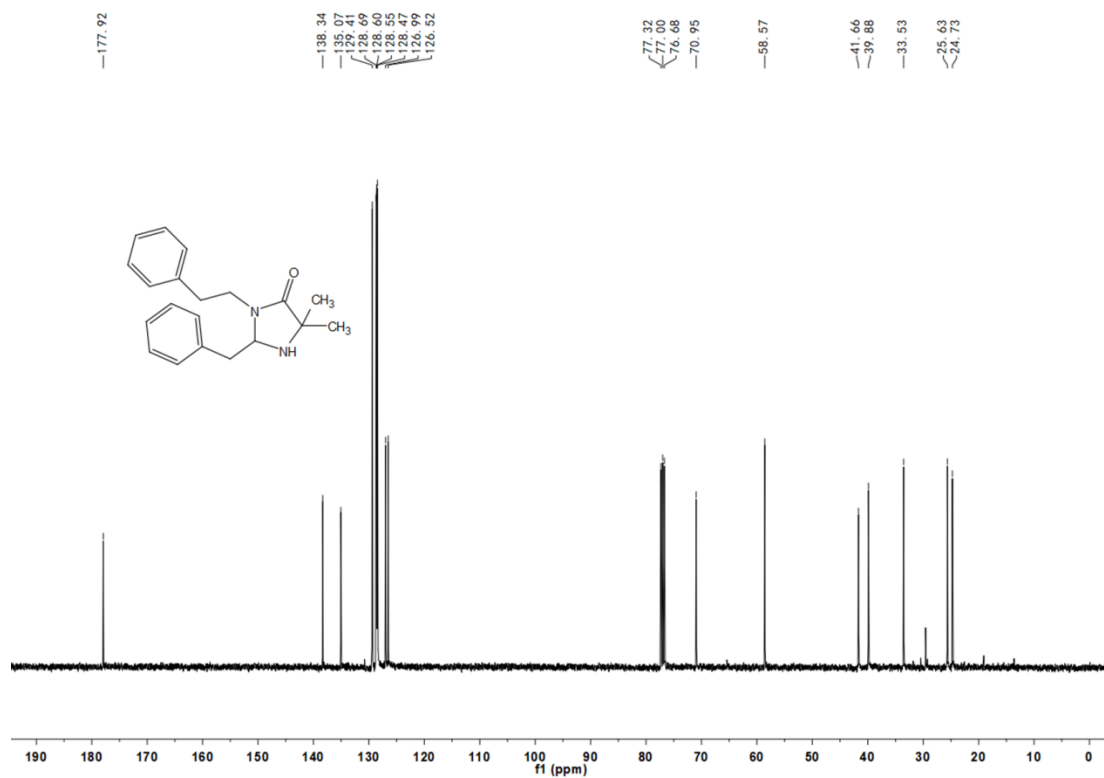
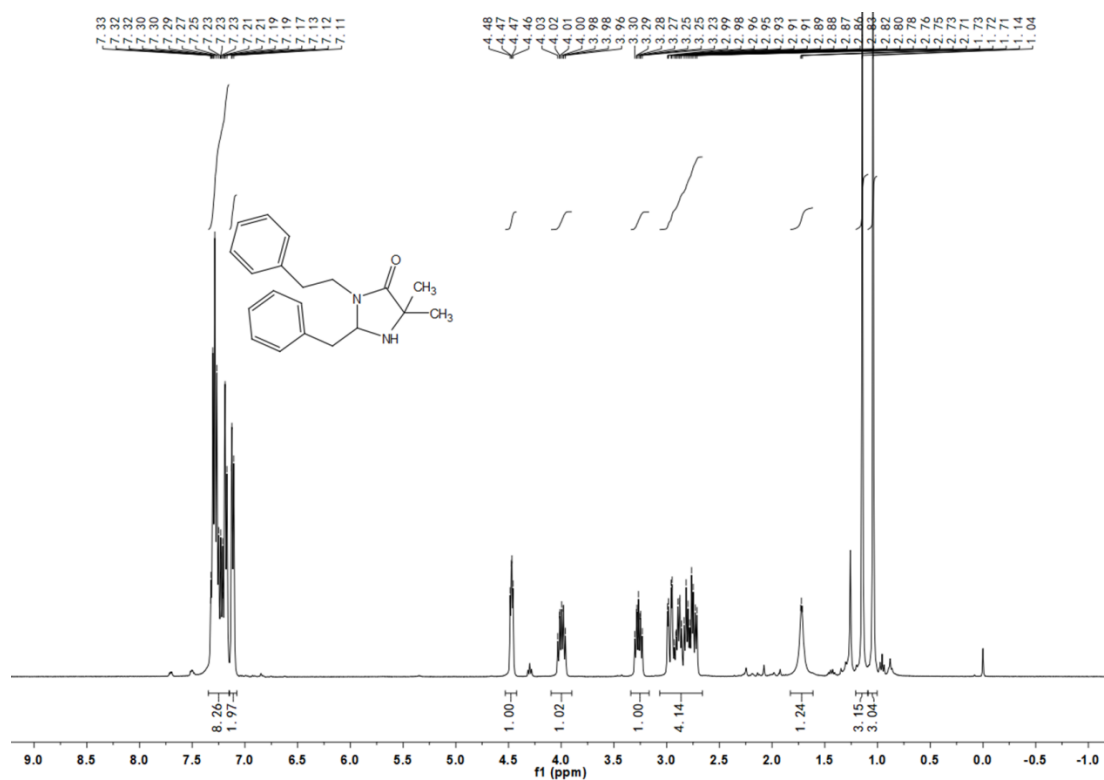
2m-2



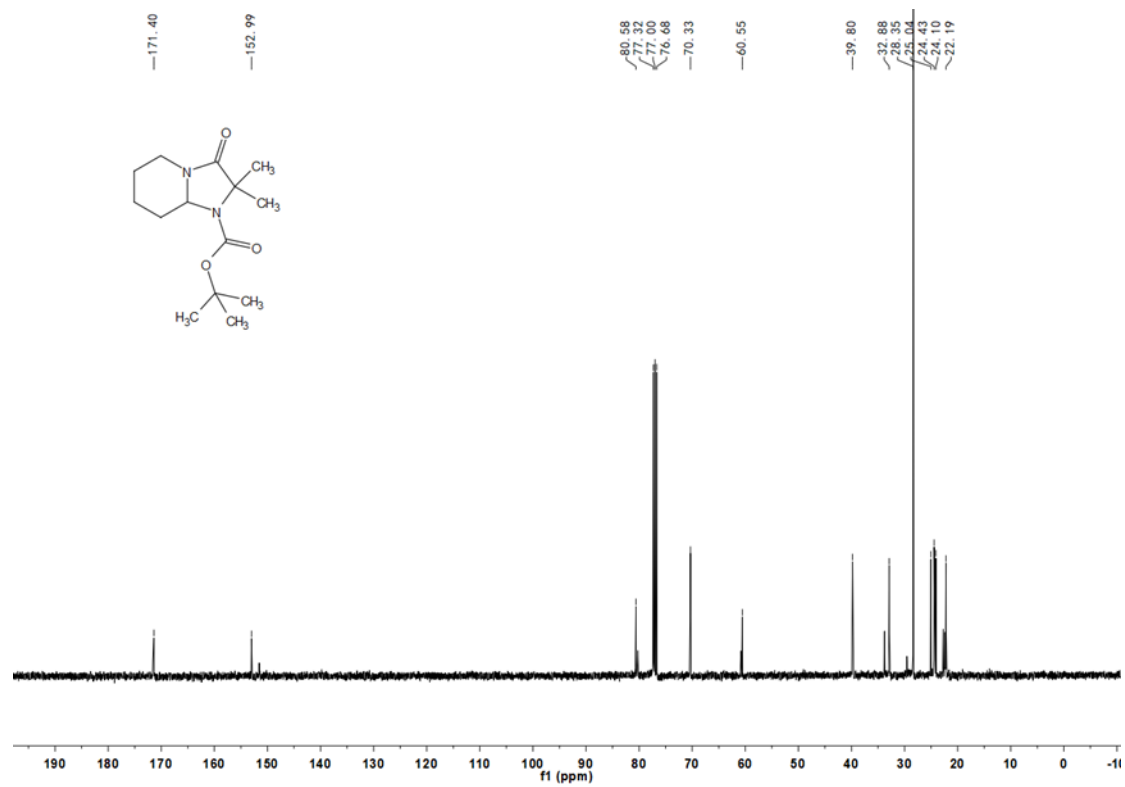
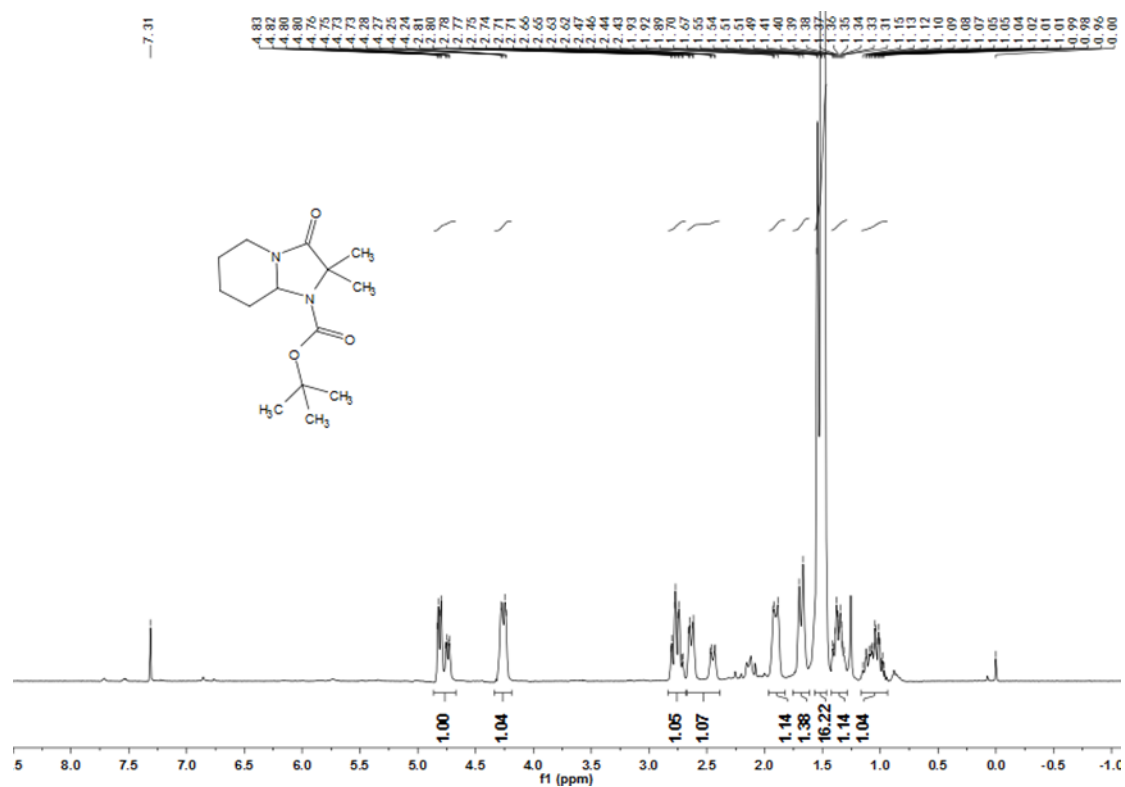
2n



2o



2p'

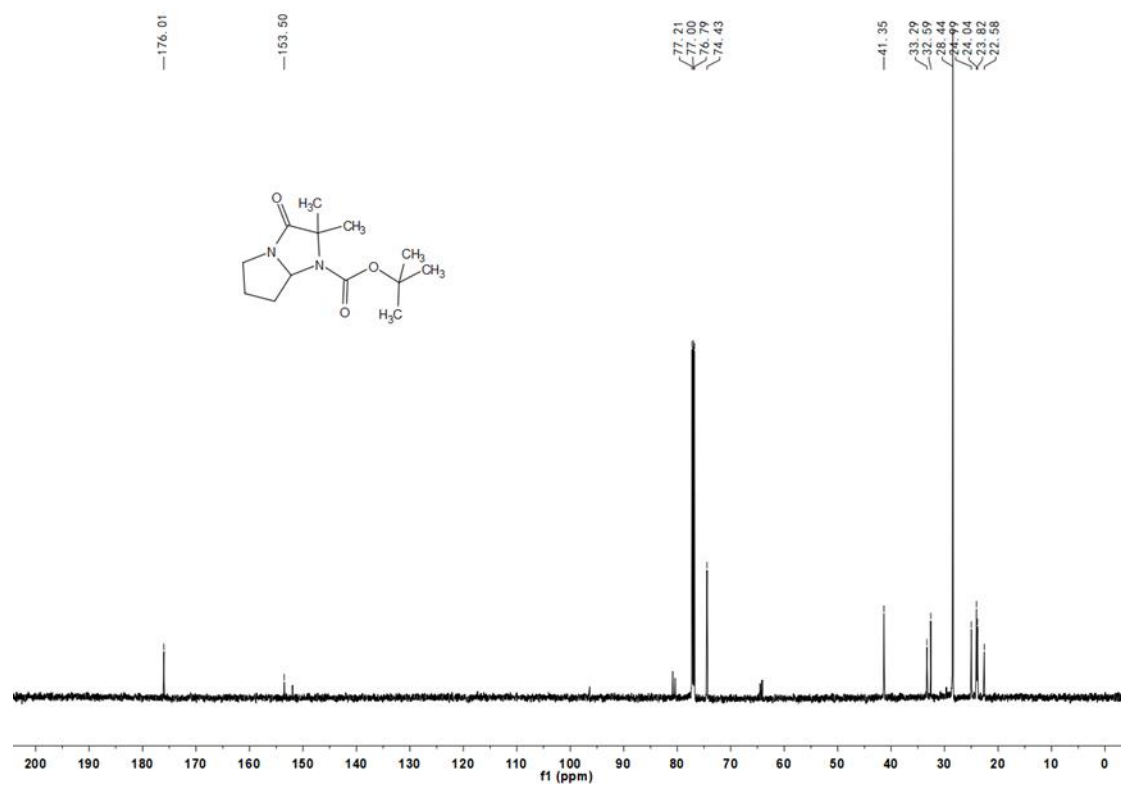


Chemical structure of 1-(2,2-dimethyl-1-oxo-1,2,3,4,5-pyrrolidin-5-yl)propan-1-one:

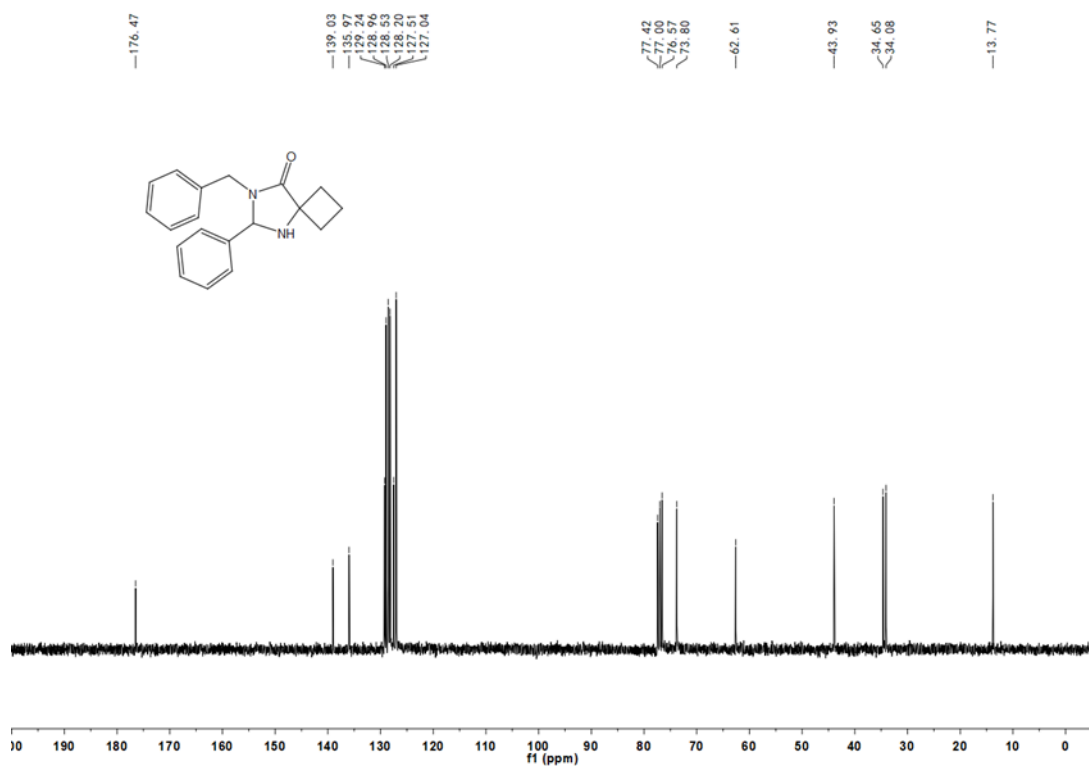
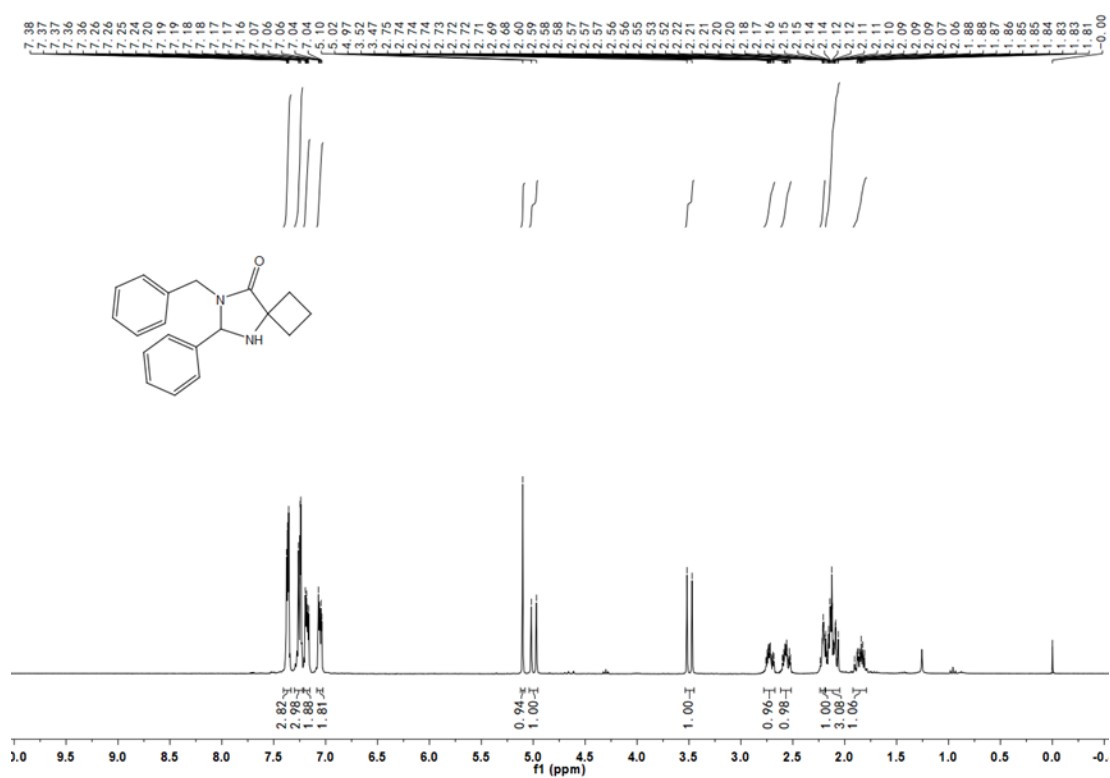
CC(C)OC(=O)N1CCCC1=O

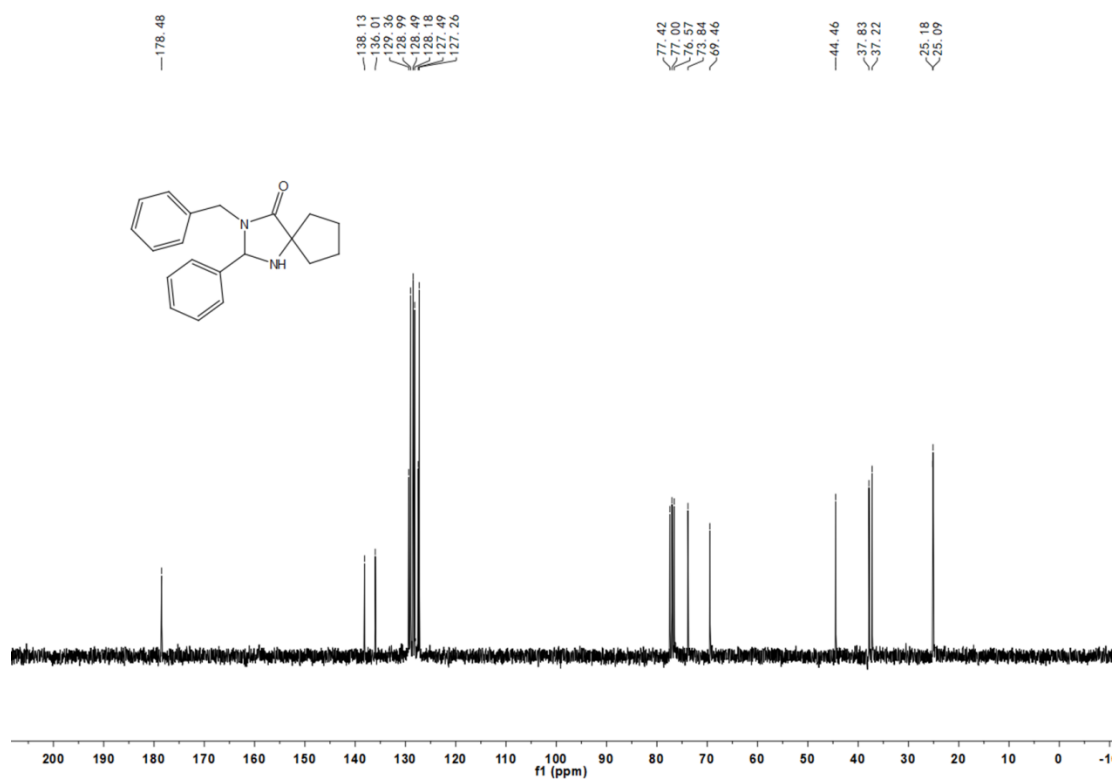
<sup>1</sup>H NMR spectrum (CDCl<sub>3</sub>) showing peaks from 0 to 7.28 ppm. Integration values are provided below the baseline.

Chemical Shift (ppm)	Integration
7.28	1.00
5.0	1.05
3.76	1.03
2.0-2.5	1.10, 1.11, 1.04
1.55	15.30, 1.22

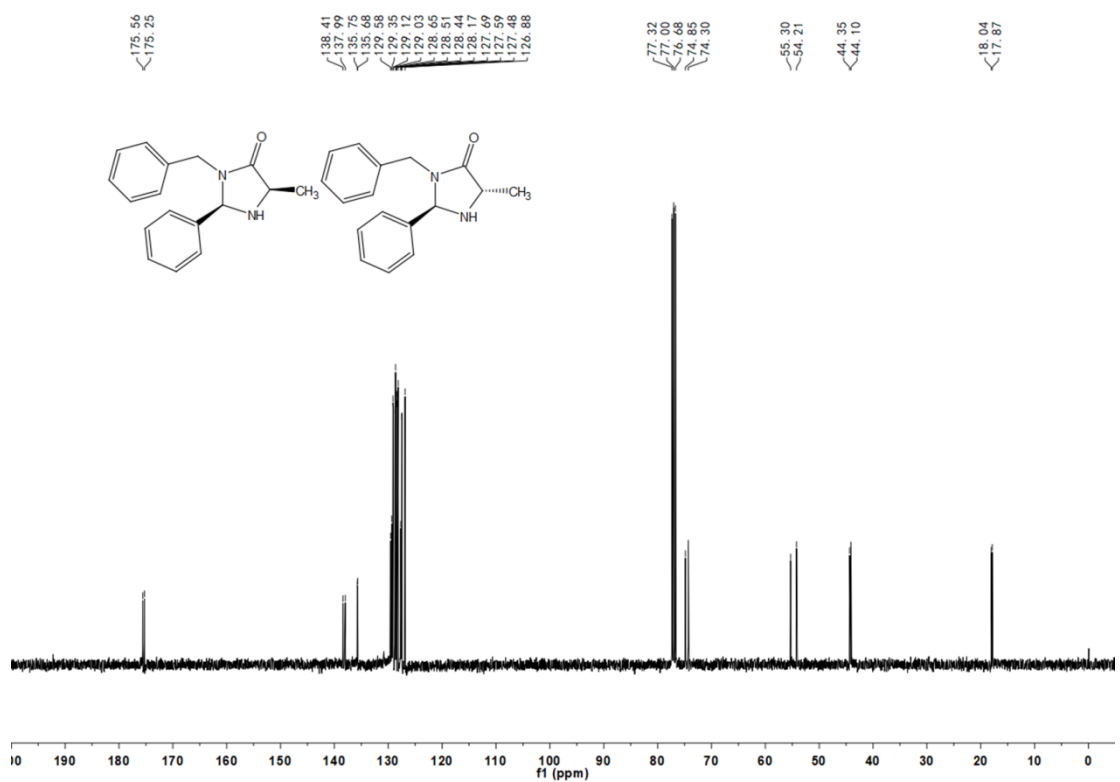
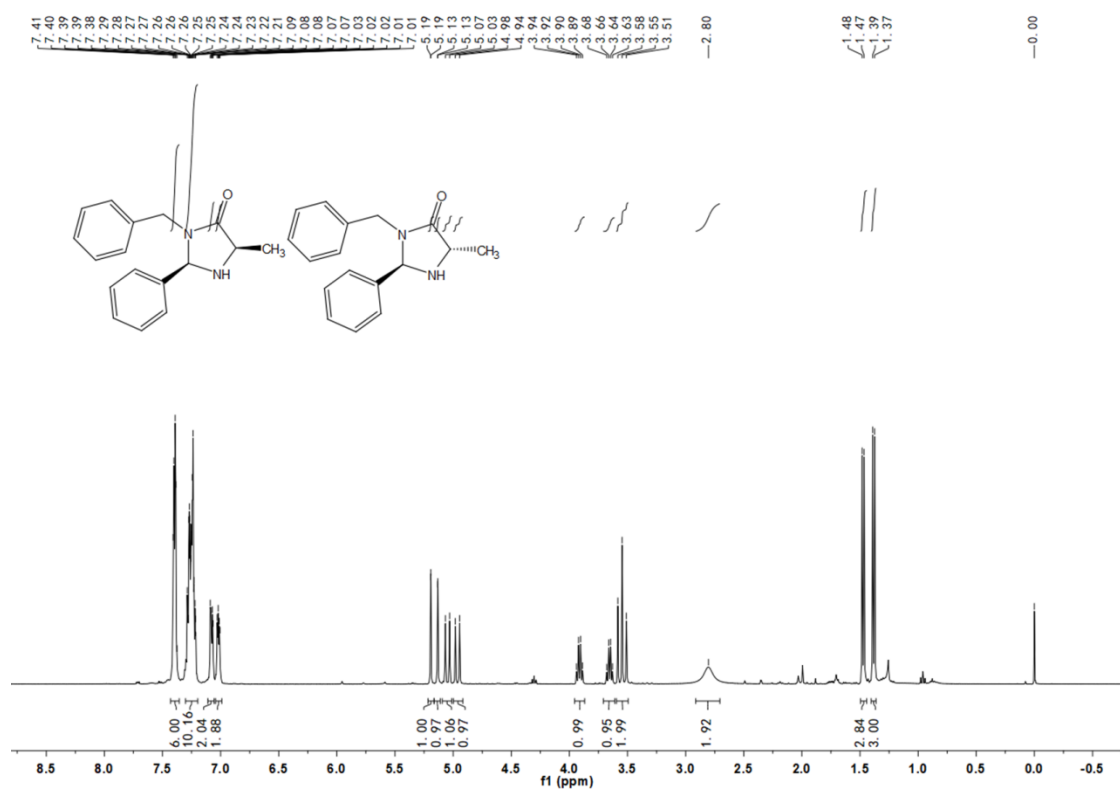


2r



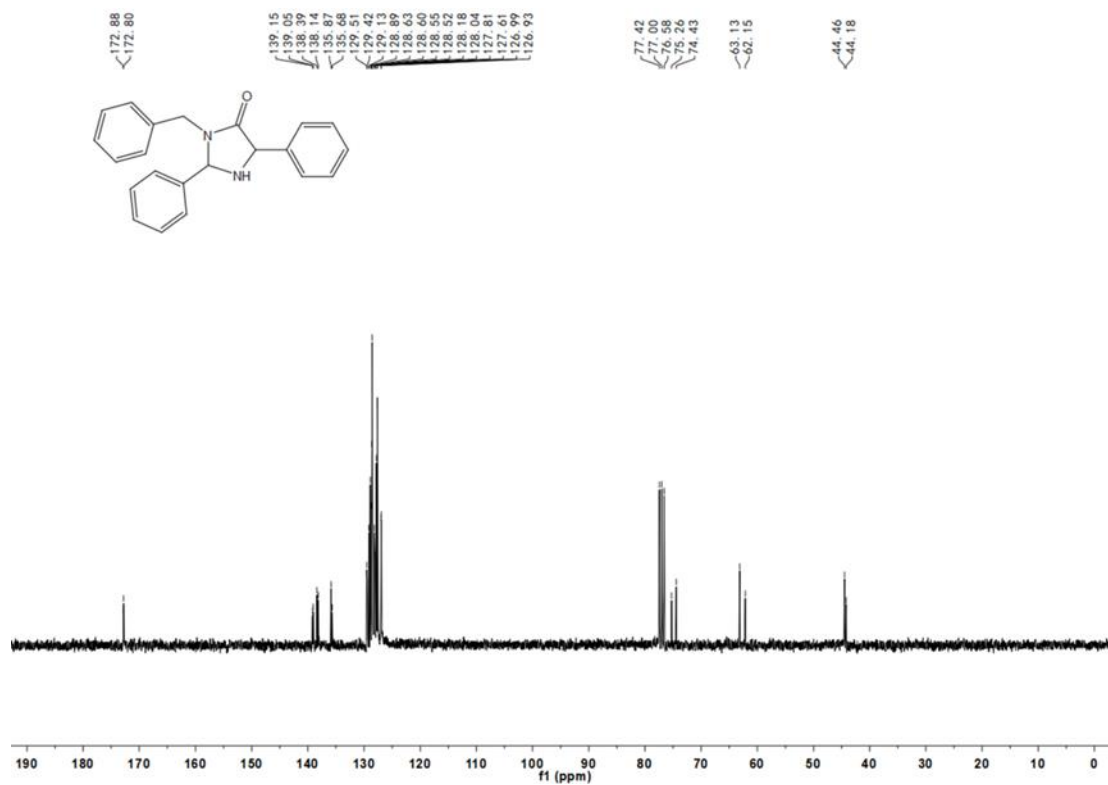
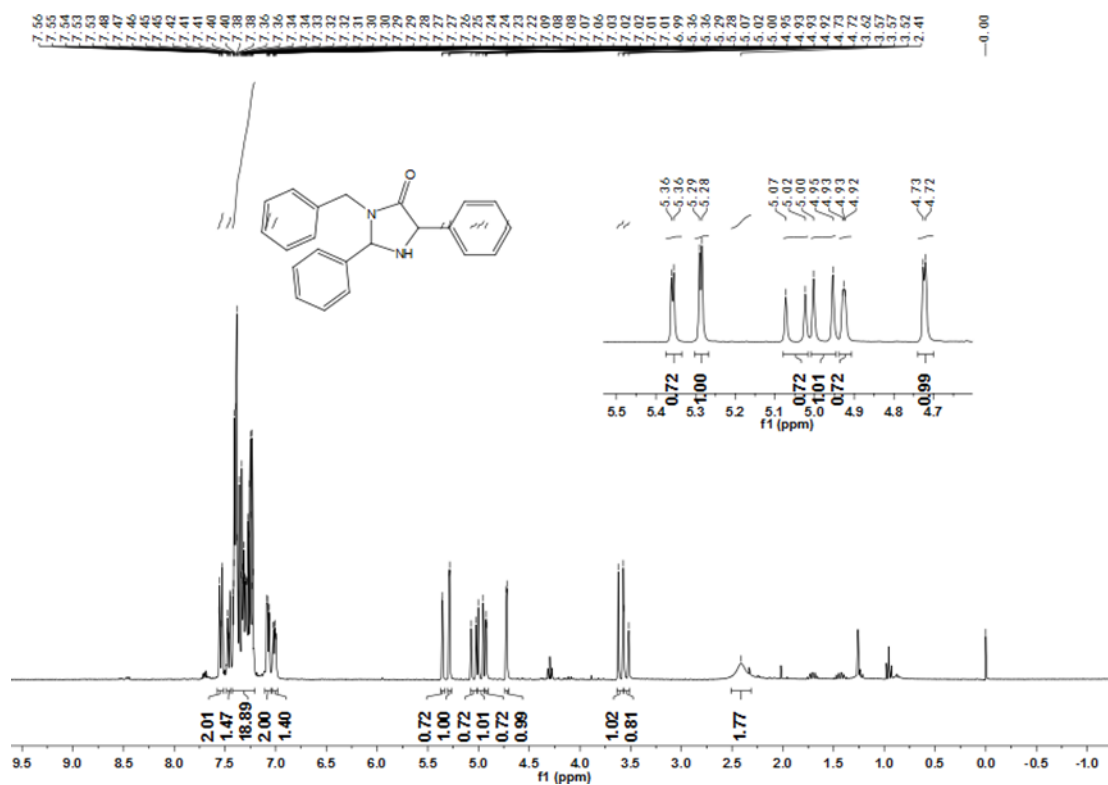


2t

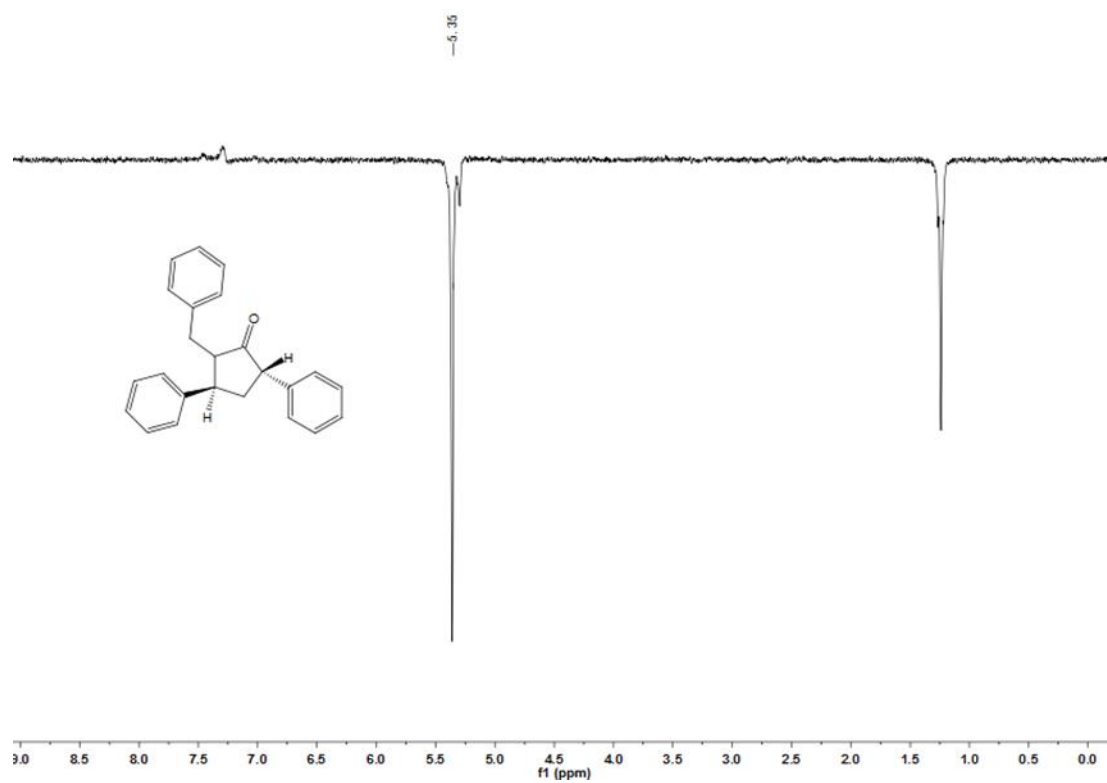
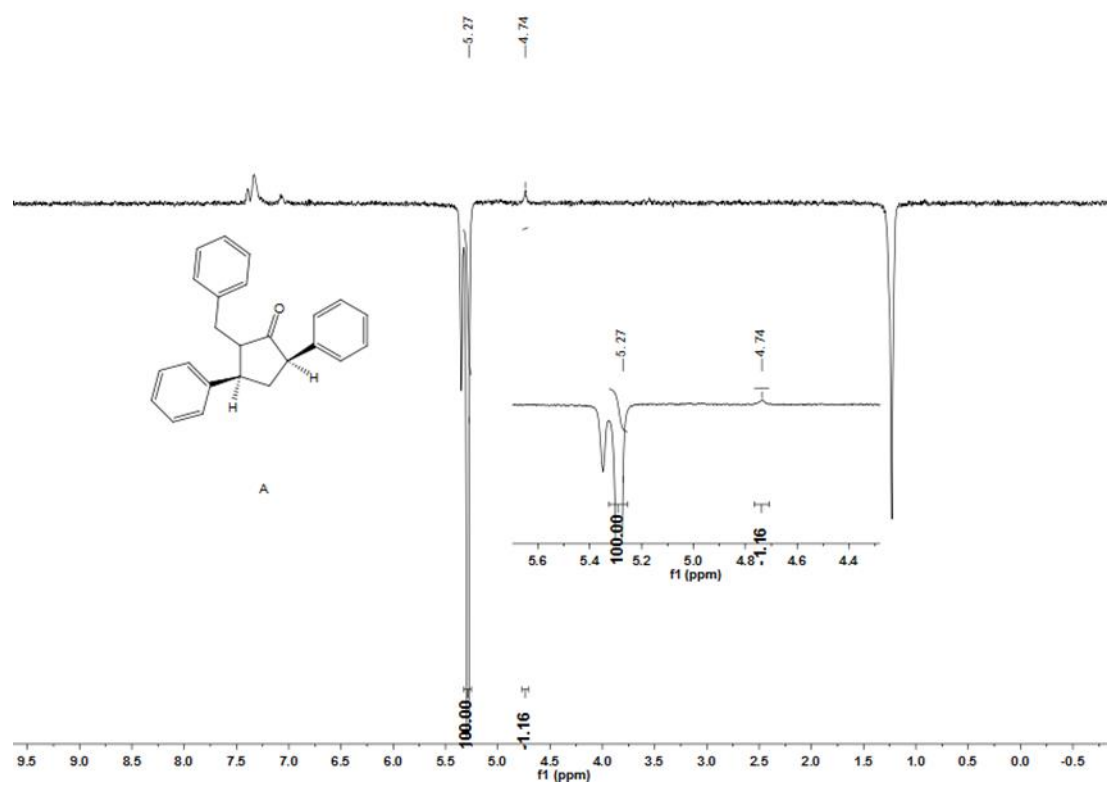




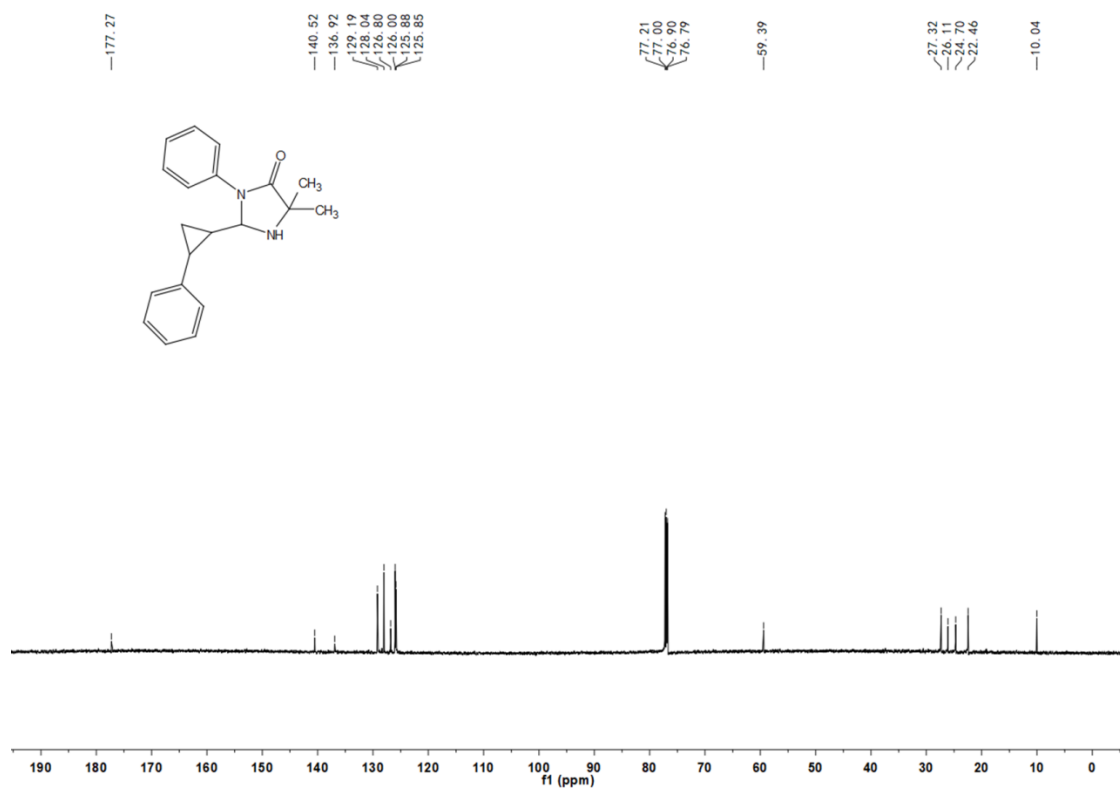
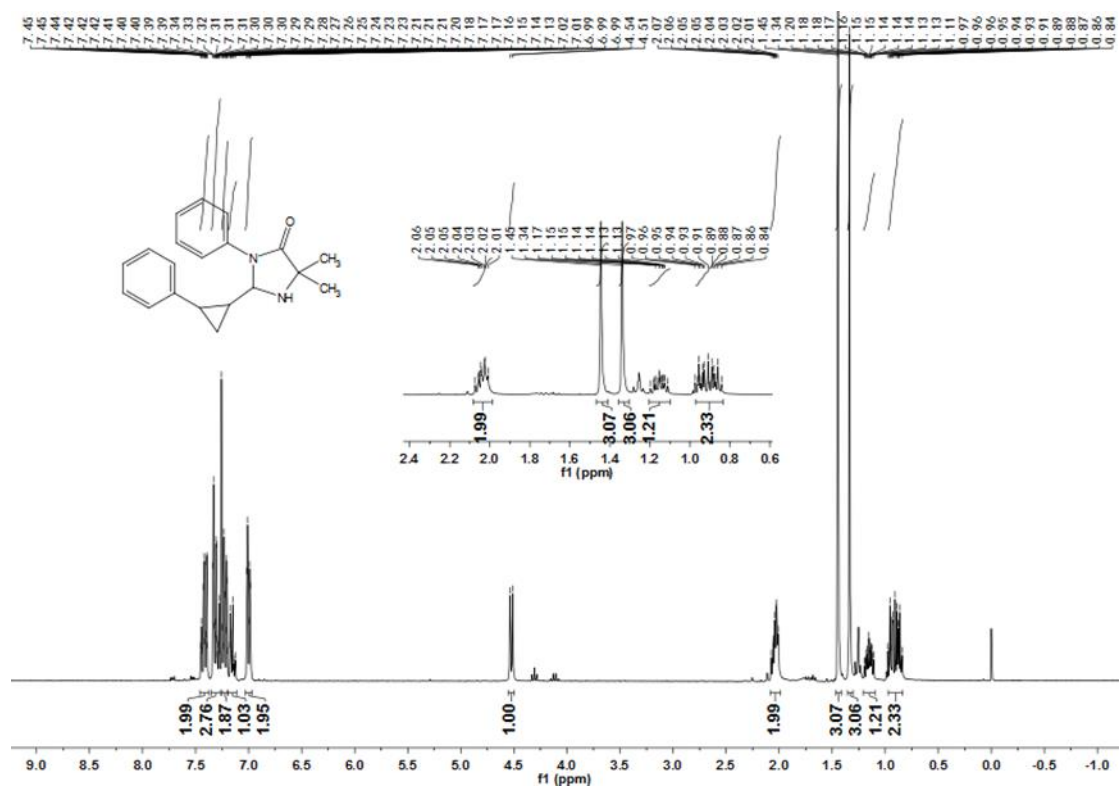
2u



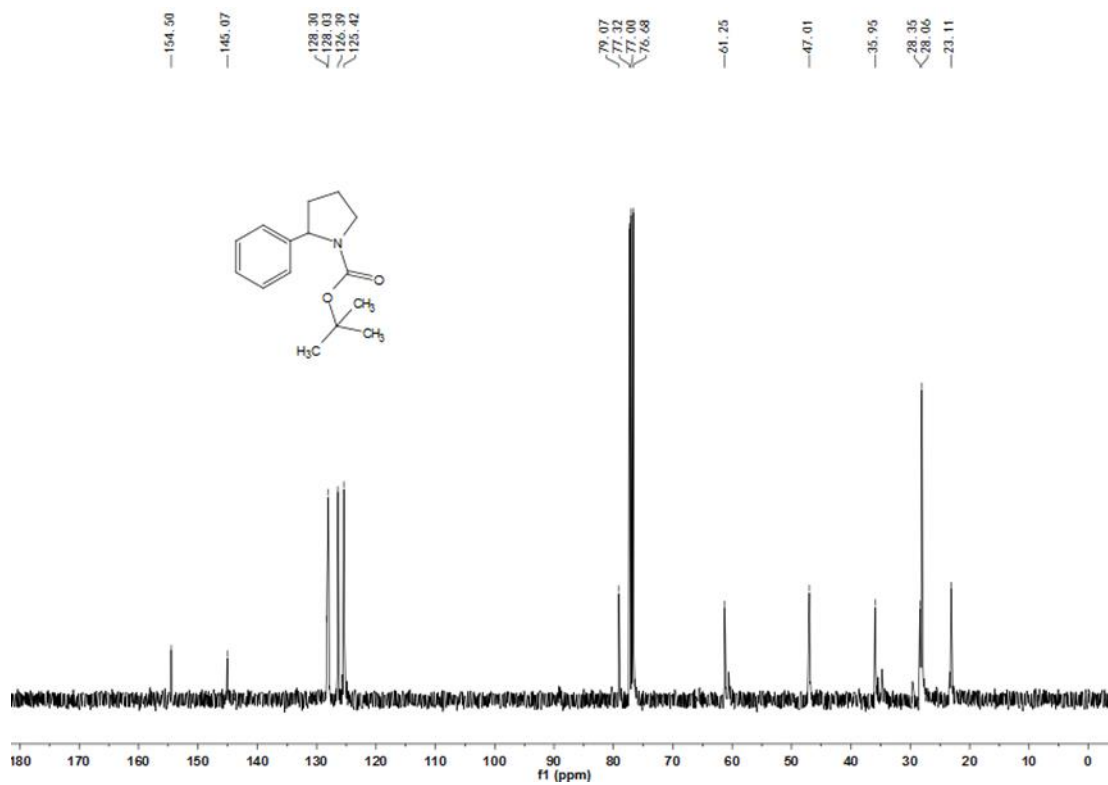
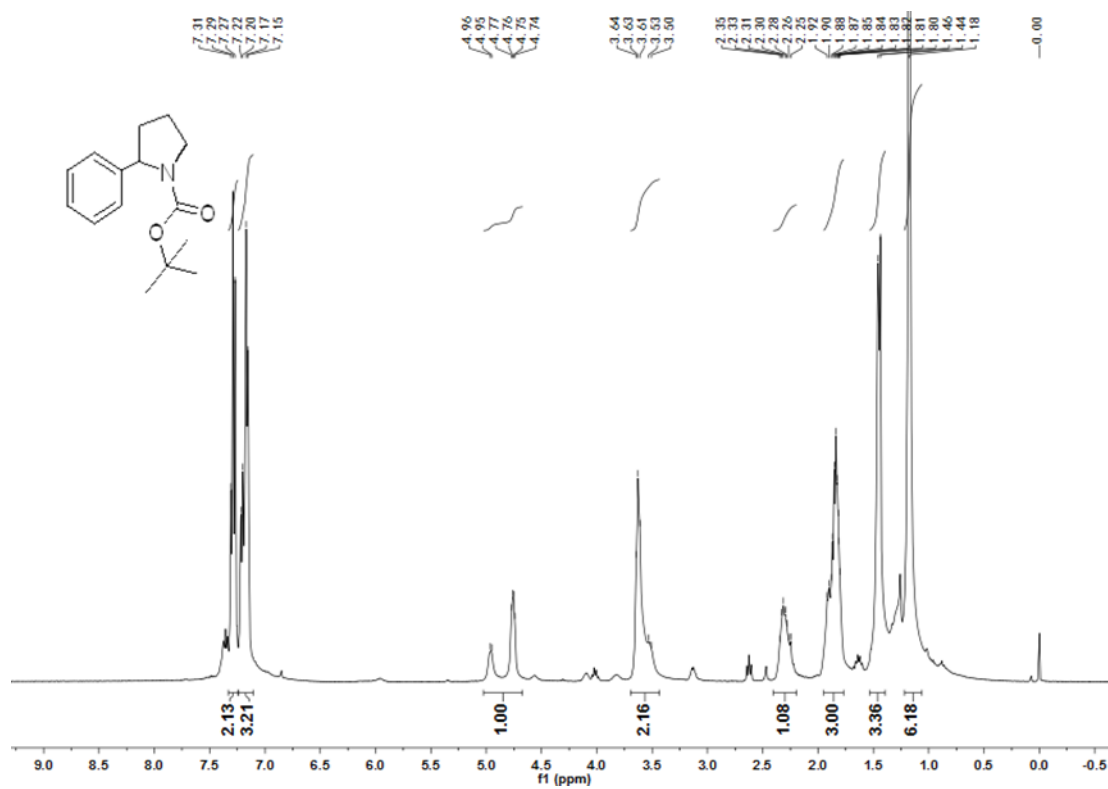
# NOE Data of 2u:



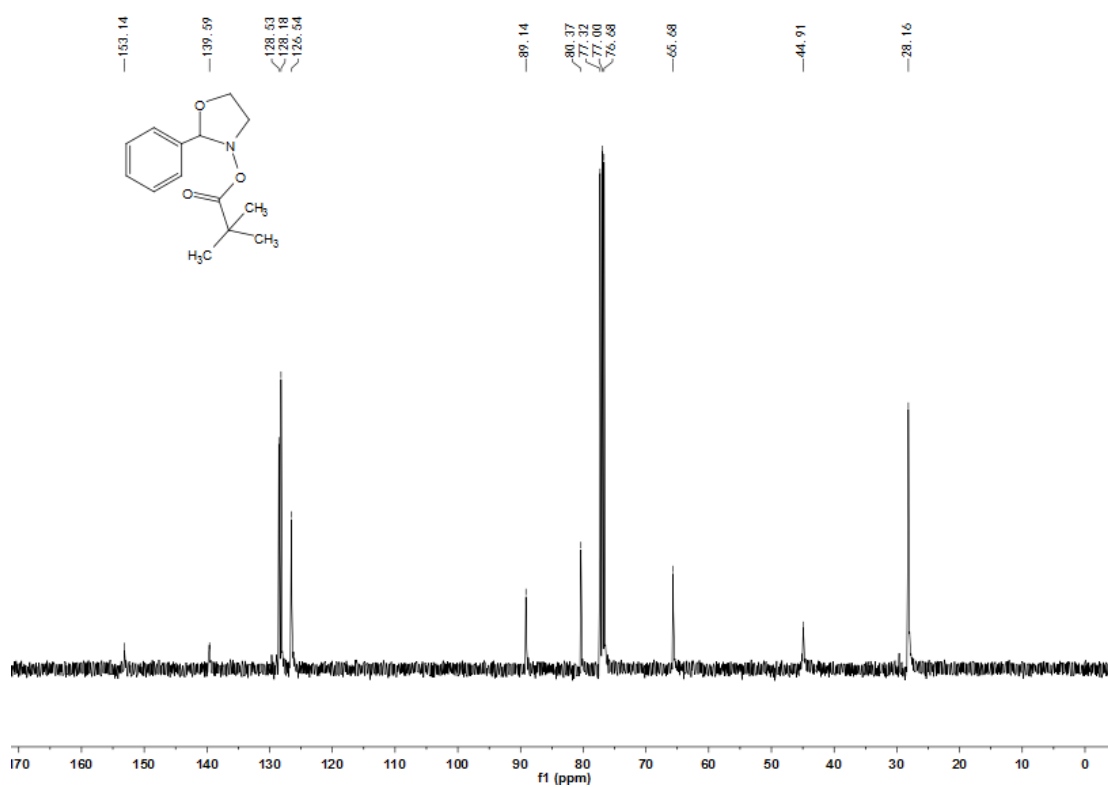
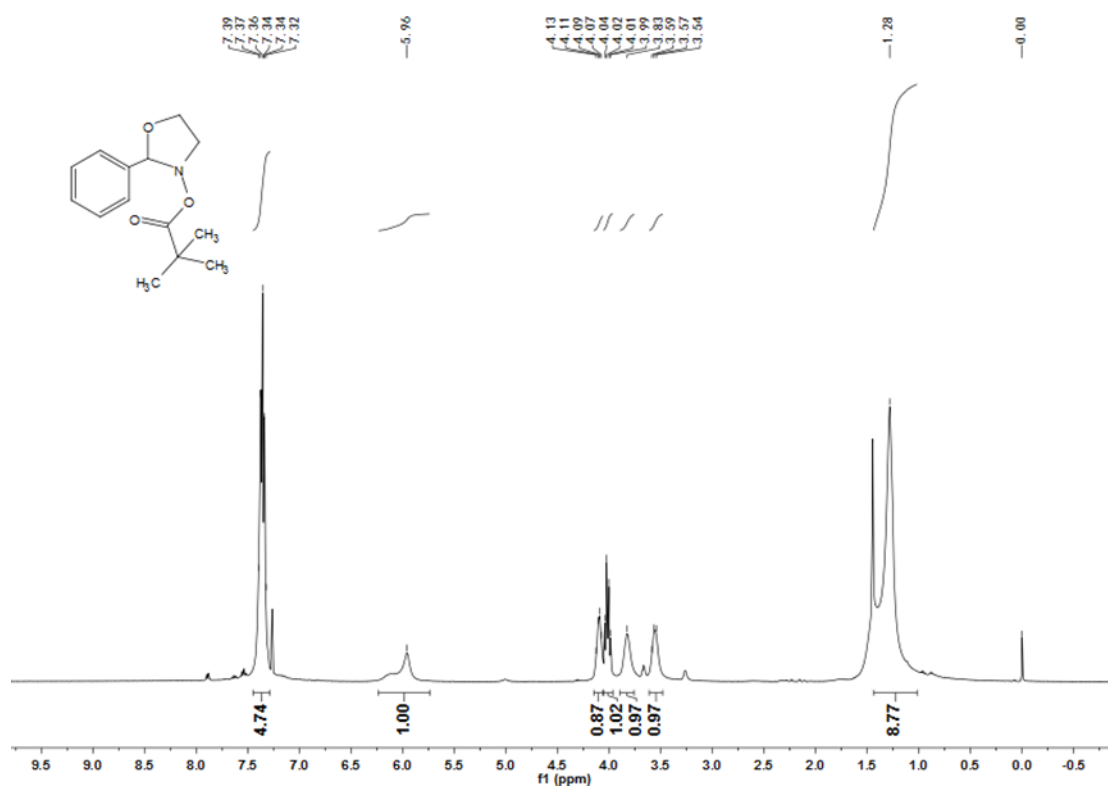
2w



5



6



S81