*Supporting Information*

# Where Does Au Coordinate to a N-(2-Pyridiyl)benzotriazole: Gold-catalyzed Chemoselective Dehydrogenation and Borrowing Hydrogen Reaction

Ronghui Huang,[a] Yongchun Yang,[a] Duo-Sheng Wang,[c] Liang Zhang*[b] and Dawei Wang*[a]

[a] *Key Laboratory of Synthetic and Biological Colloids, Ministry of Education, School of Chemical and Material Engineering, Jiangnan University, Wuxi 214122, Jiangsu Province, China.* [b] *National Engineering Laboratory for Cereal Fermentation Technology, Jiangnan University, Wuxi 214122, China.* [c]*Department of Chemistry, University of Chicago, 5735 S. Ellis Avenue, Chicago, IL 60637, USA.*

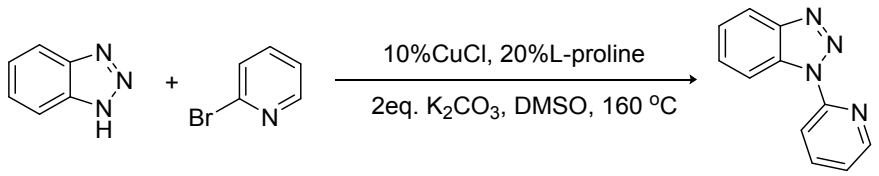
## Table of Contants

## Ⅰ. General Methods and materials:

All of the reactions dealing with air and/or moisture-sensitive reactions were carried out under an atmosphere of nitrogen using oven/flame-dried glassware and standard syringe/septa techniques. Unless otherwise noted, all commercial reagents and solvents were obtained from the commercial provider and used without further purification. $^{1}H$ NMR and $^{13}C$ NMR spectra were recorded on Varian 400 or 600 MHz spectrometers. Chemical shifts were reported relative to internal tetramethylsilane (δ 0.00 ppm) or $CDCl_3$ (δ 7.26 ppm) for $^{1}H$ NMR and $CDCl_3$ (δ 77.0 ppm) for $^{13}C$ NMR. Flash column chromatography was performed on 230-430 mesh silica gel. Analytical thin layer chromatography was performed with precoated glass baked plates (250μ) and visualized by fluorescence and by charring after treatment with potassium permanganate stain. HRMS were recorded on LTQ-FTUHRA spectrometer.
Substrates **8** and **11** were synthesized according to the literature as below:
(1). Yu, M.; Zhang, G.; Zhang, L. *Org. Lett*. **2007**, *9*, 2147-2150.
(2). Marion, N.; Carlqvist, P.; Gealageas, R.; Fremont, P.; Maseras, F.; Nolan, S. P. *Chem. Eur. J*. **2007**, *13*, 6437-6451.
(3). Nonoshita, K.; Banno, H.; Maruoka, K.; Yamamoto, H. *J. Am. Chem. Soc.* **1990**, *112*, 316-322.
(4). (a) Sherry, B. D.; Toste, F. D. *J. Am. Chem. Soc.* **2004**, *126*, 15978-15979. (b) Sherry, B. D.; Maus, L.; Laforteza, B. N.; Toste, F. D. *J. Am. Chem. Soc.* **2006**, *128*, 8132-8133. (c) Mauleon, P.; Krinsky, J. L.; Toste, F. D. *J. Am. Chem. Soc.* **2009**, *131*, 4513-4520.

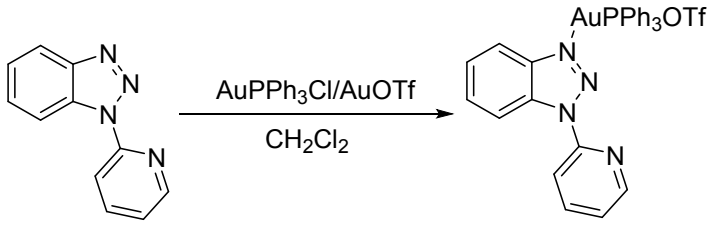
### 1.1 Synthesis of Pyridyltriazole Gold Complexe

### 1.1.1 Procedure for synthesis of 1-(pyridin-2-yl)-1H-benzo[d][1,2,3]triazole




To 100 mL round-bottom flask was successively added N-H triazole (2.983 g, 25 mmol), bromopyridine (3.160 g, 20 mmol), copper (I) iodide (381 mg, 2 mmol), L-proline (0.461 mg, 4 mmol) and potassium carbonate (2.403 g, 40 mmol) under $N_2$, and then dimethylsulfoxide (30 mL) was added by syringes. The reaction mixture was stirred overnight at 160 °C and monitored by TLC until complete disappearance of the bromopyridine was confirmed. Then the reaction mixture was added water and extracted with ethyl acetate. The combined organic phases were washed with dried over anhydrous $MgSO_4$. The solvent was removed under reduced pressure and flash silica gel chromatography gave the product (58% yield).

### 1.1.2 Preparation of Gold Complexe




To a solution of $PPh_3AuCl$ (2.0 mmol) in 10 mL $CH_2Cl_2$ was added 1.1 equiv of AgOTf (2.2 mmol) at room temperature. The mixture was stirred for 5 min and was added the ligand (2.1 mmol). The resulting mixture was stirred for 4 h at room temperature. After this, the cloudy solution was filtered through a short pad of celite and washed with DCM (5 mL). Then petroleum ether was added very slowly on the top of the $CH_2Cl_2$ layer. The resultant white solid was collected and washed with petroleum ether and dried by vacuum pump, the pyridyltriazole Gold complexe (**1a**) was synthesized in 91% yield; CCDC number: 1490192.

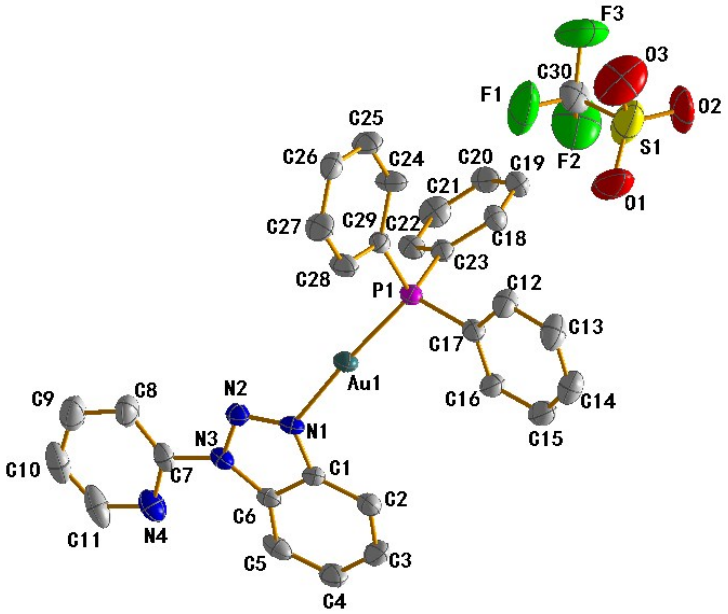



**Figure S1.** Crystal structure of Pyridyltriazole Gold(I) Complexe

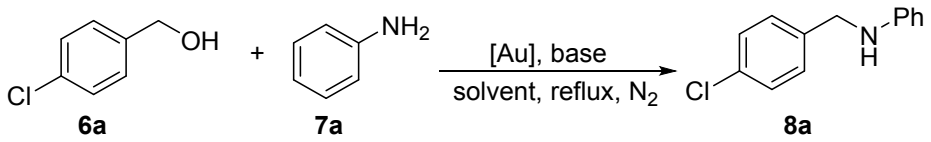
**Table. S1** Crystallographic data for pyridyltriazole gold(I) complexe

| | | |
|---|---|---|
| Empirical formula | $C_{30}H_{23}AuF_3N_4O_3PS$ | |
| Formula weight | 804.52 | |
| Temperature | 296(2) K | |
| Wavelength | 0.71073 A | |
| Crystal system, space group | Triclinic *P-1* | |
| Unit cell dimensions | a = 11.706(5) A | alpha = 90 deg. |
| | b = 16.717(7) A | beta = 96.390(7) deg. |

| | |
|---|---|
| | c = 15.157(7) A gamma = 90 deg. |
| Volume Å | 2948(2) |
| Z, Calculated density Mg/ $m^{-3}$ | 4, 1.813 |
| Absorption coefficient $mm^{-1}$ | 5.174 |
| F(000) | 1568 |
| Crystal size mm | 0.26 x 0.22 x 0.19 |
| Limiting indices | -13<=h<=13, -19<=k<=17, -18<=l<=14 |
| Reflections collected / unique | 13065 / 5179 [R(int) = 0.0389] |
| Completeness to theta = 25.01 | 99.8 % |
| Max. and min. transmission | 0.4397 and 0.3464 |
| Refinement method | Full-matrix least-squares on $F^2$ |
| Data / restraints / parameters | 5179 / 18 / 364 |
| Goodness-of-fit on $F^2$ | 1.027 |
| Final R indices [I>2σ(I)] | R1 = 0.0460, wR2 = 0.1132 |
| CCDC number | 1490192 |

## 1.2. Optimization of reaction conditions

Table S2. Optimization of reaction conditions[a]

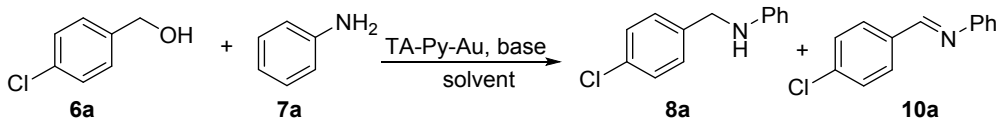



| Entry | Catalyst | Base | Solvent | Yield[%][b] |
|---|---|---|---|---|
| 1 | TA-Py-Au(**1a**) (1%) | KOH | toluene | 67 |
| 2 | TA-Py-Au(**1a**) (1%) | KOH | MeOH | 26 |
| 3 | TA-Py-Au(**1a**) (1%) | KOH | DCM | 18 |
| **4** | **TA-Py-Au(1a)** (1%) | **KOH** | **THF** | **91** |
| 5 | TA-Py-Au(**1a**) (1%) | *t*BuOK | THF | 83 |
| 6 | TA-Py-Au(**1a**) (1%) | $Cs_2CO_3$ | THF | 59 |
| 7 | TA-Py-Au(**1a**) (1%) | NaOH | THF | 44 |
| 8 | TA-Py-Au(**1a**) (1%) | $Et_3N$ | THF | 23 |
| 9 | $Ph_3PAuCl$ (1%) | KOH | THF | 9 |

| | | | | |
|---|---|---|---|---|
| 10 | $Ph_3PAuCl$ (10%) | KOH | THF | 17 |
| 11 | $Ph_3PAuCl/AgOTf$ (1%) | KOH | THF | 35, 64[c] |
| 12 | $KAuCl_4$ (1%) | KOH | THF | 16 |
| 13 | $KAuCl_4$ (10%) | KOH | THF | 21 |
| 14 | AgOTf | KOH | THF | nr |
| 15 | - | KOH | THF | nr |

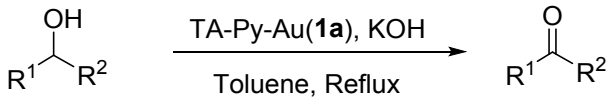
[a] Reagents and conditions: **6a** (0.6 mmol), **7a** (0.5 mmol), **1a** (1 mol%), KOH (0.75 mmol), solvent (3 mL), 24 h, $N_2$, reflux. [b] Yields of isolated product, nr = no reaction. [c] $Ph_3PAuCl/AgOTf$ (10%), in dioxane, with *t*BuOK as the base, ref 14 in main text.

## 1.3 Representative procedure for N-alkylation of aromatic amines with primary alcohols.



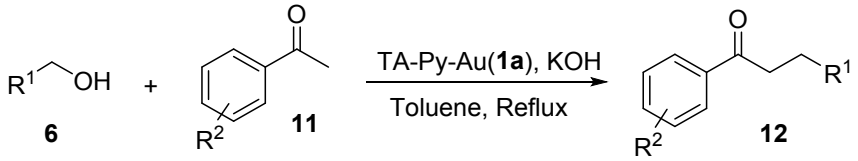

To 25 mL round-bottom flask was successively added aromatic amine (0.5 mmol), primary alcohol (0.6 mmol), potassium hydroxide (0.75 mmol), **1a** (1 mol%,) and THF (3 mL) at room temperature. The reaction mixture was stirred at reflux and monitored by TLC. After the reaction was completed (24 h), the mixture was cooled to room temperature. The resulting solution was directly purified by column chromatography with petroleum ether/ethyl acetate (20:1) as eluent to give the desired product.

## 1.4 Representative procedure for the preparation of acetophenone




To 25 mL Schlenk tube was added **1a** (1 mol%), toluene (3 mL), and alcohol (1 mmol) was added. Then the mixture was stirred at 110 °C for 10 h. Then the mixture was added water and extracted with ethyl acetate. The combined organic phases were washed with dried over anhydrous $MgSO_4$. The solvent was removed under reduced pressure carefully and purification of the crude product by column chromatography on silica-gel (petroleum ether/ethyl acetate = 50:1) afforded the compound **9a** as a colorless oil.

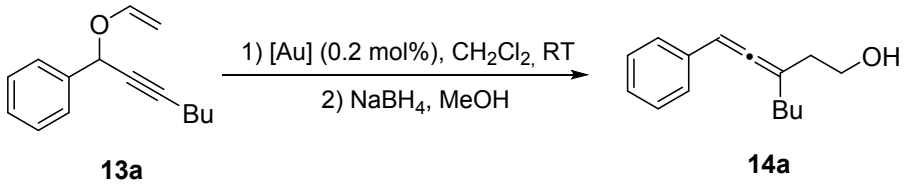
## 1.5 Representative procedure for the preparation of ketones




To 25 mL round-bottom flask was successively added **11** (0.5 mmol), primary alcohol (0.6 mmol), potassium hydroxide (0.75 mmol), **1a** (1 mol%) and toluene (3 mL) at room temperature. The reaction mixture was stirred at reflux and monitored by TLC. After the reaction was completed (24 h), the mixture was cooled to room temperature. The resulting

solution was directly purified by column chromatography with petroleum ether/ethyl acetate (20:1) as eluent to give the desired product.

### 1.6 Representative procedure for the preparation of Allene 14a




To a solution of **13a** (1 mmol) in wet $CH_2Cl_2$ (3.0 mL), was added Au(I) catalyst (0.2 mol%) at RT. The reaction mixture was kept at room temperature and monitored by TLC. After the reaction was completed (6-12 h), $NaBH_4$ (1.5 mmol) and MeOH (0.5 mL) was added to the mixture. After the reaction was finished (monitored by TLC), the solvent was removed under reduced pressure and purification of the crude product by column chromatography on silica-gel (petroleum ether/ethyl acetate = 80:1) afforded the title compound **14a** as colorless oil.

### 1.7 Heat-stabilization experiments for gold complexes: **1a** for TA-Py-Au (**1a**); **5** for pyridine gold. 7 for $AuPPh_3OTf$

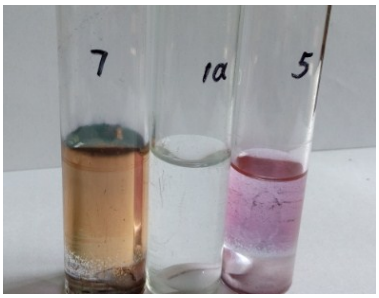
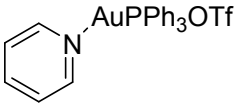
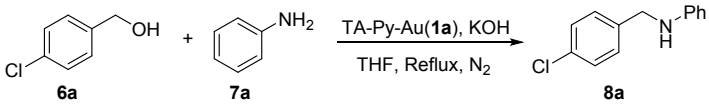



**Figure S2**. Heat stabilization test in toluene under reflux condition for 0.5 hour.

pyridine gold (**5**): 


### 1.8 Run kinetics



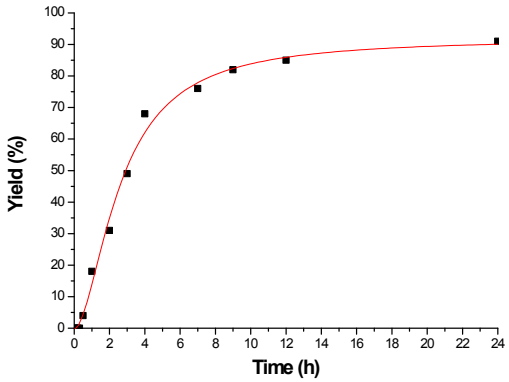



**Figure S3**. The kinetics curve.

## II. Compounds Characterization

**1-(pyridin-2-yl)-1H-benzo[d][1,2,3]triazole** $^{1}$H NMR (400 MHz, $CDCl_3$) δ 8.66 (d, *J* = 8.4 Hz, 1H), 8.61 (d, *J* = 4.0 Hz, 1H), 8.31 (d, *J* = 8.3 Hz, 1H), 8.13 (d, *J* = 8.3 Hz, 1H), 7.94 (td, *J* = 8.3, 1.8 Hz, 1H), 7.65 – 7.57 (m, 1H), 7.50 – 7.43 (m, 1H), 7.32 (dt, *J* = 12.1, 6.0 Hz, 1H). $^{13}$C NMR (101 MHz, $CDCl_3$) δ 151.72, 148.33, 146.77, 138.81, 131.53, 128.76, 124.89, 122.27, 119.75, 114.83, 114.44. HRMS (ESI) Calculated for $C_{11}H_9N_4$ $(M+H)^+$ 198.0827, found 198.0825.

**(1a)** $^{1}$H NMR (400 MHz, $CDCl_3$) δ 8.85 – 8.81 (m, 1H), 8.74 (dd, *J* = 4.8, 1.2 Hz, 1H), 8.37 (d, *J* = 8.4 Hz, 1H), 8.28 – 8.24 (m, 1H), 8.18 (td, *J* = 7.8, 1.6 Hz, 1H), 7.85-7.81 (m, 2H), 7.68 – 7.56 (m, 16H); $^{13}$C NMR (101 MHz, $CDCl_3$): δ 149.9, 149.1, 144.1, 140.5, 140.4, 134.3, 134.1, 132.9, 132.8, 132.2, 131.4, 129.9, 129.8, 129.3, 127.0, 126.4, 125.3, 117.1, 116.3, 116.2, 116.1, 116.0, 115.9. $^{31}$P NMR (162 MHz, $CDCl_3$) δ 29.4; Anal. Calcd for $C_{30}H_{23}AuF_3N_4O_3PS$: C, 44.79, H, 2.88, N, 6.96; Found: C, 44.63, H, 2.80, N,6.89. CCDC number: 1490192. $[M+H]^+$ 805.0846

**(1b)** $^{1}$H NMR (400 MHz, $CDCl_3$) δ 8.83 (d, *J* = 8.0 Hz, 1H), 8.74 (dd, *J* = 4.8, 1.2 Hz, 1H), 8.37 (d, *J* = 8.0 Hz, 1H), 8.30 (d, *J* = 8.0 Hz, 1H), 8.20 (td, *J* = 7.6, 1.6 Hz, 1H), 7.91 – 7.80 (m, 2H), 7.70 – 7.55 (m, 16H); $^{13}$C NMR (101 MHz, $CDCl_3$): δ 150.0, 149.0, 144.2, 140.5, 134.3, 134.1, 132.9, 132.8, 132.1, 131.4, 130.2, 130.1, 130.0, 129.9, 129.8, 129.4, 127.1, 126.5, 125.3, 117.2, 116.2, 116.1. $^{31}$P NMR (162 MHz, $CDCl_3$) δ 29.6; Anal. Calcd for $C_{29}H_{23}AuBF_4N_4P$: C, 46.93, H, 3.12, N, 7.55; Found: C, 47.04, H, 3.16, N, 7.48. $[M+H]^+$ 743.1355

**(1c)** $^{1}$H NMR (400 MHz, DMSO) δ 8.74 (dd, *J* = 4.8, 0.8 Hz, 1H), 8.61 (d, *J* = 8.8 Hz, 1H), 8.28 (dd, *J* = 8.4, 3.2 Hz, 2H), 8.19 (td, *J* = 7.2, 1.6 Hz, 1H), 7.76 (td, *J* = 6.8, 0.8 Hz, 1H), 7.72 – 7.57 (m, 17H); $^{13}$C NMR (101 MHz, $CDCl_3$): δ 151.0, 149.3, 146.2, 140.6, 134.7, 134.6, 135.5, 134.4, 134.3, 133.1, 133.0, 132.9, 131.5, 130.2, 130.1, 130.0, 128.1, 127.4, 126.3, 124.0, 119.8, 115.2, 115.0. $^{31}$P NMR (162 MHz, DMSO) δ 27.0; Anal. Calcd for $C_{29}H_{23}AuF_6N_4PSb$: C, 39.08, H, 2.60, N, 6.29; Found: C, 38.91, H, 2.52, N, 6.17. $[M+H]^+$ 891.0268

**N-(4-chlorobenzyl)aniline (8a)** (Known compound, ref: F. Huang, Z. Liu, Z. Yu, *Angew. Chem. Int. Ed.* **2016**, *55*, 862) $^{1}$H NMR (400 MHz, $CDCl_3$) δ 7.22 (s, 4H), 7.09 (t, *J* = 7.6 Hz, 2H), 6.65 (t, *J* = 7.2 Hz, 1H), 6.53 (d, *J* = 8.0 Hz, 2H), 4.23 (s, 2H), 4.04 – 3.91 (m, 1H); $^{13}$C NMR (101 MHz, $CDCl_3$) δ 146.8, 137.0, 131.9, 128.3, 127.7, 127.6, 116.8, 111.9, 46.6.

**N-(4-methylbenzyl)aniline (8b)** (Known compound, ref: F. Huang, Z. Liu, Z. Yu, *Angew. Chem. Int. Ed.* **2016**, *55*, 862) $^{1}$H NMR (400 MHz, $CDCl_3$) δ 7.41 (d, *J* = 7.6 Hz, 2H), 7.33 (dd, *J* = 12.4, 7.6 Hz, 4H), 6.88 (t, *J* = 7.2 Hz, 1H), 6.78 (d, *J* = 8.0 Hz, 2H), 4.41 (s, 2H), 4.08 (s, 1H), 2.51 (s, 3H); $^{13}$C NMR (101 MHz, $CDCl_3$) δ 148.4, 137.0, 136.6, 129.5, 129.4, 127.7, 117.6, 113.0, 48.2, 21.3.

**N-(4-methoxybenzyl)aniline (8c)** (Known compound, ref: F. Huang, Z. Liu, Z. Yu, *Angew. Chem. Int. Ed.* **2016**, *55*, 862) $^{1}$H NMR (400 MHz, $CDCl_3$) δ 7.41 (t, *J* = 7.2 Hz, 2H), 7.33 (t, *J* = 7.6 Hz, 2H), 7.02 (d, *J* = 8.2 Hz, 2H), 6.87 (t, *J* = 7.2 Hz, 1H), 6.77 (d, *J* = 8.0 Hz, 2H), 4.36 (s, 2H), 4.17 – 3.96 (m, 1H), 3.91 (s, 3H); $^{13}$C NMR (101 MHz, $CDCl_3$) δ 159.0, 148.4, 131.6, 129.4, 128.9, 117.6, 114.2, 113.0, 55.4, 47.9.

**N-benzylaniline (8d)** (Known compound, ref: F. Huang, Z. Liu, Z. Yu, *Angew. Chem. Int. Ed.* **2016**, *55*, 862) $^{1}$H NMR (400 MHz, $CDCl_3$) δ 7.31-7.21 (m, 4H), 7.20-7.14 (m, 1H), 7.08 (t, J = 7.6 Hz, 2H), 6.62 (t, J = 7.2 Hz, 1H), 6.54 (d, J = 7.6 Hz, 2H), 4.23 (s, 2H), 4.05-3.80 (m, 1H); $^{13}$C NMR (101 MHz, $CDCl_3$) δ 148.2, 139.4, 129.3, 128.6, 127.5, 127.2, 117.6, 112.8, 48.3.

**N-pentylaniline (8e)** (Known compound, ref: F. Huang, Z. Liu, Z. Yu, *Angew. Chem. Int. Ed.* **2016**, *55*, 862) $^{1}$H NMR (400 MHz, $CDCl_3$) δ 7.09 (t, *J* = 7.2 Hz, 2H), 6.60 (t, *J* = 7.2 Hz, 1H), 6.52 (d, *J* = 8.0 Hz, 2H), 3.72-3.43 (m, 1H), 3.02 (t, *J* = 7.2 Hz, 2H), 1.58-1.50 (m, 2H), 1.29 (d, *J* = 3.2 Hz, 4H), 0.84 (t, *J* = 6.4 Hz, 3H); $^{13}$C NMR (101 MHz, $CDCl_3$) δ 148.58, 129.25, 117.09, 112.71, 44.01, 29.36, 22.56, 14.09.

**N-(2-ethylhexyl)aniline (8f)** (Known compound, ref: F. Huang, Z. Liu, Z. Yu, *Angew. Chem. Int. Ed.* **2016**, *55*, 862) $^{1}$H NMR (400 MHz, $CDCl_3$) δ 7.08 (t, *J* = 7.6 Hz, 2H), 6.58 (t, *J* = 7.2 Hz, 1H), 6.51 (d, *J* = 7.6 Hz, 2H), 3.50 (s, 1H), 3.01-2.78 (m, 2H), 1.63-1.28 (m, 1H), 1.37-1.29 (m, 2H), 1.24 (d, *J* = 8.0 Hz, 6H), 0.83 (t, *J* = 7.2 Hz, 6H); $^{13}$C NMR (101 MHz, $CDCl_3$) δ 148.82, 129.28, 116.95, 112.66, 47.09, 39.17, 31.40, 29.07, 24.57, 23.20, 14.19, 11.01.

**N-benzyl-3-chloroaniline (8g)** (Known compound, ref: F. Huang, Z. Liu, Z. Yu, *Angew. Chem. Int. Ed.* **2016**, *55*, 862) $^{1}$H NMR (400 MHz, $CDCl_3$) δ 7.28-7.23 (m, 4H), 7.20 – 7.14 (m, 1H), 6.96 (t, *J* = 8.0 Hz, 1H), 6.60 – 6.53 (m, 1H), 6.50 (t, *J* = 2.0 Hz, 1H), 6.39 (dd, *J* = 8.0, 2.0 Hz, 1H), 4.22 (s, 2H), 4.01 (s, 1H); $^{13}$C NMR (101 MHz, $CDCl_3$) δ 149.4, 139.0, 135.2, 130.4, 128.9, 127.6, 127.5, 117.5, 112.7, 111.3, 48.2.

**N-benzyl-4-chloroaniline (8h)** (Known compound, ref: F. Huang, Z. Liu, Z. Yu, *Angew. Chem. Int. Ed.* **2016**, *55*, 862) $^{1}$H NMR (400 MHz, $CDCl_3$) δ 7.27 (d, *J* = 4.4 Hz, 4H), 7.21 – 7.14 (m, 1H), 7.06 – 7.00 (m, 2H), 6.50 – 6.44 (m, 2H), 4.20 (s, 2H), 4.05 (s, 1H); $^{13}$C NMR (101 MHz, $CDCl_3$) δ 146.6, 138.9, 129.1, 128.7, 127.5, 122.1, 113.9, 48.4.

**N-benzyl-2-chloroaniline (8i)** (Known compound, ref: F. Huang, Z. Liu, Z. Yu, *Angew. Chem. Int. Ed.* **2016**, *55*, 862) $^{1}$H NMR (400 MHz, $CDCl_3$) δ 7.25 (dd, *J* = 6.0, 4.0 Hz, 4H), 7.18 (t, *J* = 6.8 Hz, 2H), 6.99 (t, *J* = 7.6 Hz, 1H), 6.54 (t, *J* = 7.2 Hz, 2H), 4.64 (s, 1H), 4.30 (d, *J* = 5.6 Hz, 2H); $^{13}$C NMR (101 MHz, $CDCl_3$) δ 143.9, 138.8, 129.2, 128.8, 127.9, 127.4, 127.3, 119.2, 117.5, 111.6, 47.9.

**N-benzyl-4-fluoroaniline (8j)** (Known compound, ref: F. Huang, Z. Liu, Z. Yu, *Angew. Chem. Int. Ed.* **2016**, *55*, 862) $^{1}$H NMR (400 MHz, $CDCl_3$) δ 7.28-7.20 (m, 4H), 7.20 -7.12 (m, 1H), 6.83-6.70 (m, 2H), 6.44 (dt, *J* = 6.4, 4.0 Hz, 2H), 4.18 (s, 2H), 4.11-3.59 (m, 1H); $^{13}$C NMR (101 MHz, $CDCl_3$) δ 157.1, 154.7, 144.5, 139.3, 128.7, 127.5, 115.7, 113.7, 48.9.

**N-benzyl-4-methoxyaniline (8k)** (Known compound, ref: F. Huang, Z. Liu, Z. Yu, *Angew. Chem. Int. Ed.* **2016**, *55*, 862) $^1$H NMR (400 MHz, $CDCl_3$) δ 7.28 (q, *J* = 7.6 Hz, 4H), 7.23 – 7.16 (m, 1H), 6.70 (d, *J* = 8.4 Hz, 2H), 6.53 (d, *J* = 8.4 Hz, 2H), 4.21 (s, 2H), 3.79 – 3.58 (m, 4H); $^{13}$C NMR (101 MHz, $CDCl_3$) δ 152.2, 142.5, 139.7, 128.6, 127.6, 127.2, 114.9, 114.1, 55.8, 49.3.

**3-chloro-N-(furan-2-ylmethyl)aniline (8l)** (Known compound, ref: F. Huang, Z. Liu, Z. Yu, *Angew. Chem. Int. Ed.* **2016**, *55*, 862) $^1$H NMR (400 MHz, $CDCl_3$) δ 7.23 – 7.18 (m, 2H), 7.16 (d, *J* = 8.4 Hz, 2H), 6.96 (t, *J* = 8.0 Hz, 1H), 6.58 (dd, *J* = 7.6, 1.2 Hz, 1H), 6.47 (t, *J* = 2.0 Hz, 1H), 6.35 (dd, *J* = 8.4, 1.6 Hz, 1H), 4.16 (s, 2H), 4.01 (s, 1H); $^{13}$C NMR (101 MHz, $CDCl_3$) δ 148.8, 142.2, 135.1, 130.3, 127.0, 125.3, 124.8, 118.0, 112.9, 111.5, 43.3.

**4-chloro-N-(furan-2-ylmethyl)aniline (8m)** (Known compound, ref: F. Huang, Z. Liu, Z. Yu, *Angew. Chem. Int. Ed.* **2016**, *55*, 862) $^1$H NMR (400 MHz, $CDCl_3$) δ 7.29 (d, *J* = 1.2 Hz, 1H), 7.10 – 6.99 (m, 2H), 6.56 – 6.44 (m, 2H), 6.25 (dd, *J* = 3.2, 2.0 Hz, 1H), 6.15 (dd, *J* = 3.2, 0.4 Hz, 1H), 4.21 (s, 2H), 3.99 (s, 1H); $^{13}$C NMR (101 MHz, $CDCl_3$) δ 152.3, 146.2, 142.1, 129.1, 122.7, 114.3, 110.4, 107.2, 41.5.

**N-(furan-2-ylmethyl)aniline (8n)** (Known compound, ref: F. Huang, Z. Liu, Z. Yu, *Angew. Chem. Int. Ed.* **2016**, *55*, 862) $^1$H NMR (400 MHz, $CDCl_3$) δ 7.29 (t, *J* = 5.6 Hz, 1H), 7.11 (t, *J* = 8.0 Hz, 2H), 6.66 (t, *J* = 7.2 Hz, 1H), 6.60 (d, *J* = 8.0 Hz, 2H), 6.29 – 6.20 (m, 1H), 6.16 (t, *J* = 5.2 Hz, 1H), 4.24 (s, 2H), 4.00 – 3.85 (m, 1H); $^{13}$C NMR (101 MHz, $CDCl_3$) δ 151.7, 146.6, 140.9, 128.2, 117.0, 112.1, 109.3, 105.9, 40.4.

**4-chloro-N-(4-chlorobenzyl)aniline (8o)** (Known compound, ref: F. Huang, Z. Liu, Z. Yu, *Angew. Chem. Int. Ed.* **2016**, *55*, 862) $^1$H NMR (400 MHz, $CDCl_3$) δ 7.34 – 7.24 (m, 4H), 7.19 – 7.00 (m, 2H), 6.51 (d, *J* = 8.8 Hz, 2H), 4.28 (s, 2H), 4.12 (s, 1H); $^{13}$C NMR (101 MHz, $CDCl_3$) δ 146.4, 137.5, 133.1, 129.1, 128.9, 128.6, 122.4, 114.0, 47.7.

**4-chloro-N-(4-methylbenzyl)aniline (8p)** (Known compound, ref: F. Huang, Z. Liu, Z. Yu, *Angew. Chem. Int. Ed.* **2016**, *55*, 862) $^1$H NMR (400 MHz, $CDCl_3$) δ 7.14 (d, *J* = 7.6 Hz, 2H), 7.06 (d, *J* = 7.6 Hz, 2H), 7.01 (d, *J* = 8.0 Hz, 2H), 6.44 (d, *J* = 8.0 Hz, 2H), 4.15 (s, 2H), 3.91 (s, 1H), 2.26 (s, 3H); $^{13}$C NMR (101 MHz, $CDCl_3$) δ 146.7, 137.1, 135.9, 129.4, 129.1, 127.5, 122.0, 113.9, 4.1, 21.1.

**4-chloro-N-(4-methoxybenzyl)aniline (8q)** (Known compound, ref: F. Huang, Z. Liu, Z. Yu, *Angew. Chem. Int. Ed.* **2016**, *55*, 862) $^1$H NMR (400 MHz, $CDCl_3$) δ 7.16 (d, *J* = 8.4 Hz, 2H), 7.00 (d, *J* = 8.4 Hz, 2H), 6.78 (d, *J* = 8.4 Hz, 2H), 6.43 (d, *J* = 8.4 Hz, 2H), 4.11 (s, 2H), 3.86 (s, 1H), 3.70 (s, 3H); $^{13}$C NMR (101 MHz, $CDCl_3$) δ 159.0, 146.8, 131.0, 129.1, 128.8, 122.0, 114.1, 114.0, 55.3, 47.9.

**3-chloro-N-(4-chlorobenzyl)aniline (8r)** (Known compound, ref: F. Huang, Z. Liu, Z. Yu, *Angew. Chem. Int. Ed.* **2016**, *55*, 862) $^1$H NMR (400 MHz, $CDCl_3$) δ 7.21 (d, *J* = 8.4 Hz, 2H), 7.16 (d, *J* = 8.4 Hz, 2H), 6.96 (t, *J* = 8.0 Hz, 1H), 6.58 (dd, *J* = 8.0, 1.2 Hz, 1H), 6.47 (t, *J* = 2.0 Hz,

1H), 6.35 (dd, $J$ = 8.4, 1.6 Hz, 1H), 4.16 (s, 2H), 4.01 (s, 1H); $^{13}$C NMR (101 MHz, $CDCl_3$) δ 149.0, 137.4, 135.1, 133.1, 130.3, 128.9,128.7, 117.7, 112.7, 111.3, 47.4.

**N-(4-methoxybenzyl)naphthalen-1-amine (8s)** (Known compound, ref: F. Huang, Z. Liu, Z. Yu, *Angew. Chem. Int. Ed.* **2016**, *55*, 862) $^1$H NMR (400 MHz, $CDCl_3$) δ 7.70 – 7.61 (m, 2H), 7.35 – 7.26 (m, 2H), 7.25 – 7.17 (m, 3H), 7.13 (d, $J$ = 8.4 Hz, 1H), 6.77 (d, $J$ = 8.4 Hz, 2H), 6.51 (d, $J$ = 7.6 Hz, 1H), 4.49 (s, 1H), 4.26 (s, 2H), 3.66 (s, 3H); $^{13}$C NMR (101 MHz, $CDCl_3$) δ 159.1, 143.3, 134.4, 131.1, 1292. 128.8, 126.7, 125.8, 124.8, 123.5, 120.0, 117.8, 114.2, 104.9, 55.4, 48.2.

**N-(4-methoxybenzyl)pyridin-2-amine (8t)** (Known compound, ref: F. Huang, Z. Liu, Z. Yu, *Angew. Chem. Int. Ed.* **2016**, *55*, 862) $^1$H NMR (400 MHz, $CDCl_3$) δ 8.00 (d, $J$ = 4.8 Hz, 1H), 7.30 (t, $J$ = 7.6 Hz, 1H), 7.19 (d, $J$ = 8.0 Hz, 2H), 6.78 (d, $J$ = 8.0 Hz, 2H), 6.48 (t, $J$ = 6.0 Hz, 1H), 6.27 (d, $J$ = 8.4 Hz, 1H), 4.87 (s, 1H), 4.33 (d, $J$ = 5.6 Hz, 2H), 3.70 (s, 3H); $^{13}$C NMR (101 MHz, $CDCl_3$) δ 158.9, 158.7, 148.2, 137.4, 131.2, 128.7, 114.0, 113.7, 106.8, 55.3, 45.8.

**1-(2-fluorophenyl)ethanone (9a)** (Known compound, ref: Y. Yang, A. Qin, K. Zhao, D. Wang, X. Shi, *Adv. Synth. Catal.* **2016**, *358*, 1433.) $^1$H NMR (400 MHz, $CDCl_3$) δ 7.88 (td, $J$ = 7.6, 2.0 Hz, 1H), 7.52 (dddd, $J$ = 8.4, 7.2, 5.2, 2.0 Hz, 1H), 7.25 – 7.20 (m, 1H), 7.14 (ddd, $J$ = 11.2, 8.4, 0.8 Hz, 1H), 2.65 (d, $J$ = 4.8 Hz, 3H); $^{13}$C NMR (101 MHz, $CDCl_3$) δ 195.9, 163.5 (d, $J$ = 255.8 Hz), 134.7 (d, $J$ = 9.1 Hz), 130.6 (d, $J$ = 2.4 Hz), 125.8 (d, $J$ = 12.7 Hz), 124.4 (d, $J$ = 3.4 Hz), 116.8 (d, $J$ = 23.8 Hz), 31.4.

**1-(o-tolyl)ethanone (9b)** (Known compound, ref: Y. Yang, A. Qin, K. Zhao, D. Wang, X. Shi, *Adv. Synth. Catal.* **2016**, *358*, 1433.) $^1$H NMR (400 MHz, $CDCl_3$) δ 7.73 (d, $J$ = 7.2 Hz, 1H), 7.41 (t, $J$ = 7.2 Hz, 1H), 7.30 (dd, $J$ = 11.8, 7.6 Hz, 2H), 2.62 (s, 3H), 2.57 (s, 3H); $^{13}$C NMR (101 MHz, $CDCl_3$) δ 201.6, 138.5, 137.8, 132.1, 131.4, 129.2, 125.6, 29.4, 21.6.

**1-(3-nitrophenyl)ethanone (9c)** (Known compound, ref: Y. Yang, A. Qin, K. Zhao, D. Wang, X. Shi, *Adv. Synth. Catal.* **2016**, *358*, 1433.) $^1$H NMR (400 MHz, $CDCl_3$) δ 8.76 (s, 1H), 8.42 (d, $J$ = 7.2 Hz, 1H), 8.29 (d, $J$ = 7.6 Hz, 1H), 7.70 (t, $J$ = 8.0 Hz, 1H), 2.70 (s, 3H); $^{13}$C NMR (101 MHz, $CDCl_3$) δ 195.7, 148.5, 138.3, 138.8, 129.9, 127.4, 123.2, 26.7.

**1-(3-methoxyphenyl)ethanone (9d)** (Known compound, ref: Y. Yang, A. Qin, K. Zhao, D. Wang, X. Shi, *Adv. Synth. Catal.* **2016**, *358*, 1433.) $^1$H NMR (400 MHz, $CDCl_3$) δ 7.54 (d, $J$ = 7.2 Hz, 1H), 7.52 (s, 1H), 7.36 (t, $J$ = 8.4 Hz, 1H), 7.10 (d, $J$ = 8.4 Hz, 1H), 3.85 (s, 3H), 2.63 (s, 3H); $^{13}$C NMR (101 MHz, $CDCl_3$) δ 197.8, 159.6, 138.4, 129.7, 121.3, 119.5, 112.3, 55.6, 26.8.

**1-(4-bromophenyl)ethanone (9e)** (Known compound, ref: Y. Yang, A. Qin, K. Zhao, D. Wang, X. Shi, *Adv. Synth. Catal.* **2016**, *358*, 1433.) $^1$H NMR (400 MHz, $CDCl_3$) δ 7.85 – 7.81 (m, 2H), 7.65 – 7.59 (m, 2H), 2.60 (s, 3H); $^{13}$C NMR (101 MHz, $CDCl_3$) δ 197.0, 135.8, 131.9, 129.9, 128.3, 26.5.

**1-(4-nitrophenyl)ethanone (9f)** (Known compound, ref: Y. Yang, A. Qin, K. Zhao, D. Wang, X. Shi, *Adv. Synth. Catal.* **2016**, *358*, 1433.) $^1$H NMR (400 MHz, $CDCl_3$) δ 8.34 – 8.30 (m, 2H),

8.15 – 8.10 (m, 2H), 2.70 (s, 3H); $^{13}$C NMR (101 MHz, $CDCl_3$) δ 196.3, 150.4, 141.4, 129.3, 123.9, 27.0.

**1-(4-chlorophenyl)ethanone (9g)** (Known compound, ref: Y. Yang, A. Qin, K. Zhao, D. Wang, X. Shi, *Adv. Synth. Catal.* **2016**, *358*, 1433.) $^1$H NMR (400 MHz, $CDCl_3$) δ 7.92 – 7.88 (m, 2H), 7.46 – 7.42 (m, 2H), 2.59 (s, 3H); $^{13}$C NMR (101 MHz, $CDCl_3$) δ 196.8, 139.5, 135.4, 129.7, 128.9, 26.5.

**1-(4-fluorophenyl)ethanone (9h)** (Known compound, ref: Y. Yang, A. Qin, K. Zhao, D. Wang, X. Shi, *Adv. Synth. Catal.* **2016**, *358*, 1433.) $^1$H NMR (400 MHz, $CDCl_3$) δ 8.02 – 7.95 (m, 2H), 7.17 – 7.09 (m, 2H), 2.59 (s, 3H); $^{13}$C NMR (101 MHz, $CDCl_3$) δ 196.4, 167.0 (d, $J$ = 255.5 Hz), 133.6(d, $J$ = 3.0 Hz), 131.0(d, $J$ = 9.4 Hz), 115.7(d, $J$ = 21.9 Hz), 26.5.

**Acetophenone (9i)** (Known compound, ref: Y. Yang, A. Qin, K. Zhao, D. Wang, X. Shi, *Adv. Synth. Catal.* **2016**, *358*, 1433.) $^1$H NMR (400 MHz, $CDCl_3$) δ 7.95 (d, $J$ = 7.2 Hz, 2H), 7.56 (t, $J$ = 7.2 Hz, 1H), 7.49 (t, $J$ = 7.2 Hz, 2H), 2.60 (s, 3H); $^{13}$C NMR (101 MHz, $CDCl_3$) δ 198.1, 137.2, 133.1, 128.6, 128.3, 26.6.

**heptan-2-one (9j)** (Known compound, ref: Y. Yang, A. Qin, K. Zhao, D. Wang, X. Shi, *Adv. Synth. Catal.* **2016**, *358*, 1433.) $^1$H NMR (400 MHz, $CDCl_3$) δ 2.41 (t, $J$ = 7.6 Hz, 2H), 2.12 (s, 3H), 1.61 – 1.51 (m, 2H), 1.35 – 1.21 (m, 4H), 0.88 (t, $J$ = 7.2 Hz, 3H); $^{13}$C NMR (101 MHz, $CDCl_3$) δ 209.4, 43.8, 31.4, 29.8, 23.6, 22.5, 13.9.

**1-(p-tolyl)ethanone (9k)** (Known compound, ref: Y. Yang, A. Qin, K. Zhao, D. Wang, X. Shi, *Adv. Synth. Catal.* **2016**, *358*, 1433.) $^1$H NMR (400 MHz, $CDCl_3$) δ 7.85 (d, $J$ = 7.2 Hz, 2H), 7.25 (d, $J$ = 7.2 Hz, 2H), 2.57 (s, 3H), 2.40 (s, 3H); $^{13}$C NMR (101 MHz, $CDCl_3$) δ 197.6, 143.7, 134.7, 129.1, 128.3, 26.4, 21.5.

**1-(2-methoxyphenyl)ethanone (9l)** (Known compound, ref: Y. Yang, A. Qin, K. Zhao, D. Wang, X. Shi, *Adv. Synth. Catal.* **2016**, *358*, 1433.) $^1$H NMR (400 MHz, $CDCl_3$) δ 7.73 (dd, $J$ = 7.6, 1.6 Hz, 1H), 7.46 (td, $J$ = 8.4, 2.0 Hz, 1H), 7.92 – 6.05 (m, 2H), 3.91 (s, 3H), 2.61 (s, 3H); $^{13}$C NMR (101 MHz, $CDCl_3$) δ 199.9, 158.9, 133.6, 130.3, 128.3, 120.5, 111.6, 55.5, 31.8.

**1-(2-chlorophenyl)ethanone(9m)** (Known compound, ref: Y. Yang, A. Qin, K. Zhao, D. Wang, X. Shi, *Adv. Synth. Catal.* **2016**, *358*, 1433.) $^1$H NMR (400 MHz, $CDCl_3$) δ 7.54 (d, $J$ = 7.2 Hz, 1H), 7.40 (q, $J$ = 8.0 Hz, 2H), 7.32 (t, $J$ = 7.2 Hz, 1H), 2.64 (s, 3H); $^{13}$C NMR (101 MHz, $CDCl_3$): δ 200.3, 139.1, 132.1, 131.2, 130.5, 129.3, 126.7, 30.5.

**1-(2-nitrophenyl)ethanone(9n)** (Known compound, ref: Y. Yang, A. Qin, K. Zhao, D. Wang, X. Shi, *Adv. Synth. Catal.* **2016**, *358*, 1433.) $^1$H NMR (400 MHz, $CDCl_3$) δ 8.07 (d, $J$ = 8.0 Hz, 1H), 7.76 (t, $J$ = 7.6 Hz, 1H), 7.60 (t, $J$ = 7.6 Hz, 1H), 7.43 (d, $J$ = 7.6 Hz, 1H), 2.55 (s, 3H); $^{13}$C NMR (101 MHz, $CDCl_3$): δ 199.5, 145.6, 137.7, 134.1, 130.5, 127.2, 124.1, 30.3.

**1-(m-tolyl)ethanone(9o)** (Known compound, ref: Y. Yang, A. Qin, K. Zhao, D. Wang, X. Shi, *Adv. Synth. Catal.* **2016**, *358*, 1433.) $^{1}$H NMR (400 MHz, $CDCl_3$) δ 7.75 (d, *J* = 10.4 Hz, 2H), 7.43-7.32 (m, 2H), 2.63 (s, 3H), 2.42 (s, 3H); $^{13}$C NMR (101 MHz, $CDCl_3$): δ 198.2, 138.1, 137.3, 133.7, 128.7, 128.5, 125.6, 26.7, 21.2.

**1,3-diphenylpropan-1-one (12a)** (Known compound, ref: Cho, C. S.; Kim, B. T.; Kim, T.-J.; Shim, S. C. *Tetrahedron Lett.* **2002,** *43*, 7987) $^{1}$H NMR (400 MHz, $CDCl_3$) δ 7.89 (d, *J* = 7.6 Hz, 2H), 7.48 (t, *J* = 6.8, 1H), 7.38 (t, *J* = 7.6 Hz, 2H), 7.26 – 7.16 (m, 4H), 7.13 (t, *J* = 7.2 Hz, 1H), 3.23 (t, *J* = 7.2 Hz, 2H), 3.00 (t, *J* = 7.6 Hz, 2H); $^{13}$C NMR (101 MHz, $CDCl_3$): δ 199.5, 141.5, 137.1, 133.2, 128.8, 128.7, 128.6, 128.2, 126.3, 40.6, 30.3.

**1-(4-fluorophenyl)-3-phenylpropan-1-one (12b)** (Known compound, ref: Yan, F.-X.; Zhang, M.; Wang, X.-T.; Xie, F.; Chen, M.-M.; Jiang, H. *Tetrahedron* **2014,** *70*, 1193. and Cho, C. S.; Kim, B. T.; Kim, T.-J.; Shim, S. C. *Tetrahedron Lett.* **2002,** *43*, 7987.) $^{1}$H NMR (400 MHz, $CDCl_3$) δ 8.01 (dd, *J* = 8.0, 5.6 Hz, 2H), 7.37 – 7.20 (m, 5H), 7.14 (t, *J* = 8.4 Hz, 2H), 3.30 (t, *J* = 7.6 Hz, 2H), 3.09 (t, *J* = 7.6 Hz, 2H); $^{13}$C NMR (101 MHz, $CDCl_3$): δ 197.6, 167.0(d, *J* = 255.7 Hz), 141.1, 131.1(d, *J* = 9.2 Hz), 130.7(d, *J* = 9.3 Hz), 129.0, 128.6(d, *J* = 15.0 Hz), 126.2, 115.8(d, *J* = 21.9 Hz), 40.4, 30.1.

**3-(2-chlorophenyl)-1-phenylpropan-1-one (12c)** (Known compound, ref: Xu, Q.; Chen, J.; Tian, H.; Yuan, X.; Li, S.; Zhou, C.; Liu, J. *Angew. Chem. Int. Ed.* **2014**, *53*, 225.) $^{1}$H NMR (400 MHz, $CDCl_3$) δ 7.99 – 7.94 (m, 2H), 7.58 – 7.52 (m, 1H), 7.45 (t, *J* = 7.6 Hz, 2H), 7.35 (dd, *J* = 7.6, 1.6 Hz, 1H), 7.31 (dd, *J* = 7.2, 2.0 Hz, 1H), 7.17 (pd, *J* = 7.2, 1.6 Hz, 2H), 3.34 – 3.28 (m, 2H), 3.21 – 3.15 (m, 2H). $^{13}$C NMR (101 MHz, $CDCl_3$): δ 198.9, 140.6, 136.8, 133.2, 132.9, 130.9, 128.6, 128.2, 128.1, 127.7, 124.4, 38.6, 30.8.

**1,3-bis(4-chlorophenyl)propan-1-one (12d)** (Known compound, ref: Yan, F.-X.; Zhang, M.; Wang, X.-T.; Xie, F.; Chen, M.-M.; Jiang, H. *Tetrahedron* **2014,** *70*, 1193. and Cho, C. S.; Kim, B. T.; Kim, T.-J.; Shim, S. C. *Tetrahedron Lett.* **2002,** *43*, 7987.) $^{1}$H NMR (400 MHz, $CDCl_3$) δ 7.93 – 7.88 (m, 2H), 7.49 – 7.42 (m, 2H), 7.28 (dd, *J* = 6.8, 1.6 Hz, 2H), 7.19 (d, *J* = 8.4 Hz, 2H), 3.27 (t, *J* = 7.6 Hz, 2H), 3.06 (t, *J* = 7.6 Hz, 2H). $^{13}$C NMR (101 MHz, $CDCl_3$): δ 197.5, 140.8, 139.7, 137.6, 135.1, 130.5, 129.3, 128.9, 91.3, 40.1, 29. 5.

**3-(4-chlorophenyl)-1-(4-fluorophenyl)propan-1-one (12e)** (Known compound, ref: Yan, F.-X.; Zhang, M.; Wang, X.-T.; Xie, F.; Chen, M.-M.; Jiang, H. *Tetrahedron* **2014,** *70*, 1193. and Cho, C. S.; Kim, B. T.; Kim, T.-J.; Shim, S. C. *Tetrahedron Lett.* **2002,** *43*, 7987.) $^{1}$H NMR (400 MHz, $CDCl_3$) δ 8.03 – 7.96 (m, 2H), 7.31 – 7.26 (m, 2H), 7.20 (d, *J* = 8.4 Hz, 2H), 7.15 (t, *J* = 8.4 Hz, 2H), 3.27 (t, *J* = 7.6 Hz, 2H), 3.06 (t, *J* = 7.6 Hz, 2H). $^{13}$C NMR (101 MHz, $CDCl_3$): δ 197.2, 167.1(d, *J* = 255.8 Hz), 139.6, 133.3(d, *J* = 2.9 Hz), 132.0, 130.7(d, *J* = 9.3 Hz), 129.8, 128.6, 115.8(d, *J* = 22.0 Hz), 40.0, 29.4.

**1-(4-chlorophenyl)-3-phenylpropan-1-one (12f)** (Known compound, ref: Yan, F.-X.; Zhang, M.; Wang, X.-T.; Xie, F.; Chen, M.-M.; Jiang, H. *Tetrahedron* **2014,** *70*, 1193. and Cho, C. S.; Kim, B. T.; Kim, T.-J.; Shim, S. C. *Tetrahedron Lett.* **2002,** *43*, 7987.) $^{1}$H NMR (400 MHz, $CDCl_3$) δ 7.94 – 7.88

(m, 2H), 7.47 – 7.43 (m, 2H), 7.36 – 7.30 (m, 2H), 7.29 – 7.23 (m, 3H), 3.33 – 3.27 (m, 2H), 3.11 – 3.07 (m, 2H). $^{13}$C NMR (101 MHz, $CDCl_3$) δ 198.00, 141.07, 139.52, 135.20, 129.47, 128.94, 128.58, 128.42, 126.24, 40.43, 30.12.

**3-(4-methoxyphenyl)-1-phenylpropan-1-one (12g)** (Known compound, ref: Xu, Q.; Chen, J.; Tian, H.; Yuan, X.; Li, S.; Zhou, C.; Liu, J. *Angew. Chem. Int. Ed.* **2014**, *53*, 225.) $^{1}$H NMR (400 MHz, $CDCl_3$) δ 7.95 (d, *J* = 7.6 Hz, 2H), 7.55 (t, *J* = 7.6 Hz, 1H), 7.45 (t, *J* = 7.6 Hz, 2H), 7.17 (d, *J* = 8.4 Hz, 2H), 6.84 (d, *J* = 8.4 Hz, 2H), 3.78 (s, 3H), 3.26 (t, *J* = 7.6 Hz, 2H), 3.01 (t, *J* = 7.6 Hz, 2H). $^{13}$C NMR (101 MHz, $CDCl_3$) δ 199.33, 138.23, 136.96, 135.64, 133.03, 129.23, 128.61, 128.32, 128.07, 40.62, 29.76, 21.02.

**3-(furan-2-yl)-1-phenylpropan-1-one (12h)** (Known compound, ref: Xu, Q.; Chen, J.; Tian, H.; Yuan, X.; Li, S.; Zhou, C.; Liu, J. *Angew. Chem. Int. Ed.* **2014**, *53*, 225.) $^{1}$H NMR (400 MHz, $CDCl_3$) δ 8.00 (t, *J* = 7.2 Hz, 2H), 7.59 (t, *J* = 7.2 Hz, 1H), 7.50 (t, *J* = 7.6 Hz, 2H), 7.34 (d, *J* = 1.2 Hz, 1H), 6.31 (dd, *J* = 7.6, 3.6 Hz, 1H), 6.08 (d, *J* = 3.2 Hz, 1H), 3.36 (t, *J* = 7.2 Hz, 2H), 3.12 (t, *J* = 7.6 Hz, 2H). $^{13}$C NMR (101 MHz, $CDCl_3$): δ 198.5, 143.9, 136.7, 133.1, 128.7, 128.1, 126.8, 124.6, 123.4, 40.6, 24.2.

**1-(4-methoxyphenyl)-3-phenylpropan-1-one (12i).** (Known compound, ref: Babu S. A.; Yasuda M.; Baba A. *Org. Lett.* **2007**, *9*, 405-408). $^{1}$H NMR (400 MHz, $CDCl_3$) δ 7.95 – 7.90 (m, 2H), 7.31 – 7.15 (m, 5H), 6.94 – 6.87 (m, 2H), 3.83 (s, 3H), 3.23 (t, *J* = 7.2 Hz, 2H), 3.04 (t, *J* = 8.0 Hz, 2H); $^{13}$C NMR (101 MHz, $CDCl_3$) δ 197.8 163.4, 141.5, 130.4, 130.1, 128.5, 128.4, 126.1, 113.7, 55.5, 40.2, 30.4.

**1-(4-methoxyphenyl)-3-(o-tolyl)propan-1-one (12j)** (Known compound, ref: Vellakkaran M.; Andappan M.; Kommu N. *Eur. J. Org. Chem.* **2012**, *2012*, 4694-4698). $^{1}$H NMR (400 MHz, $CDCl_3$) δ 7.96 – 7.91 (m, 2H), 7.20 – 7.09 (m, 4H), 6.94 – 6.88 (m, 2H), 3.84 (s, 3H), 3.21 – 3.13 (m, 2H), 3.08 – 2.99 (m, 2H), 2.34 (s, 3H); $^{13}$C NMR (101 MHz, $CDCl_3$) δ 197.9, 163.7, 139.7, 136.02, 130.3, 130.3, 130.0, 128.8, 126.3, 126.2, 113.7, 55.5, 38.8, 27.7, 19.3.

**3-(2-bromophenyl)-1-(4-methoxyphenyl)propan-1-one (12k).** (Known compound, ref: Zhou X.; Li X.; Zhang W, *Tetrahedron Lett.* **2014**, *55*, 5137-5140). $^{1}$H NMR (400 MHz, $CDCl_3$) δ 7.99 – 7.93 (m, 2H), 7.54 (dd, *J* = 8.0, 1.2 Hz, 1H), 7.30 (td, *J* = 7.6, 1.6 Hz, 1H), 7.27 – 7.21 (m, 2H), 7.11 – 7.04 (m, 1H), 6.95 – 6.89 (m, 2H), 3.86 (s, 3H), 3.28 – 3.22 (m, 2H), 3.20 – 3.14 (m, 2H); $^{13}$C NMR (101 MHz, $CDCl_3$) δ 197.5, 163.4, 140.7, 132.8, 130.8, 130.4, 129.9, 127.9, 127.6, 124.4, 113.7, 55.4, 38.3, 31.1.

**1-phenyl-3-(o-tolyl)propan-1-one (12l).** (Known compound, ref: Buil M. L.; Esteruelas M. A.; Herrero J. *ACS Catal.* **2013**, *3*, 2072-2075). $^{1}$H NMR (400 MHz, $CDCl_3$) δ 7.98 – 7.94 (m, 2H), 7.58 – 7.52 (m, 1H), 7.48 – 7.42 (m, 2H), 7.20 – 7.11 (m, 4H), 3.27 – 3.21 (m, 2H), 3.08 – 3.02 (m, 2H), 2.34 (s, 3H); $^{13}$C NMR (101 MHz, $CDCl_3$) δ 199.4, 139.4, 136.9, 136.1, 133.1, 130.4, 128.7, 128.6, 128.1, 126.3, 126.2, 39.1, 27.6, 19.4.

**3-(2-Phenylvinylidene)heptan-1-ol (14a)** (Known compound, see: D., Wang; Gautam, L. N. S.; Bollinger, C.; Harris, A.; M. Li; X. Shi. *Org. Lett.* **2011**, *13*, 2618-2621) ($^{1}$H NMR (400 MHz, $CDCl_3$): δ 7.28-7.31 (m, 4H), 7.17-7.20 (m, 1H), 6.20 (m, 1H), 3.78 (t, *J* = 6.4 Hz, 2H), 2.32-3.39

(m, 2H), 2.10-2.14 (m, 2H), 1.63 (s, 1H), 1.46-1.50 (m, 2H), 1.34-1.40 (m, 2H), 0.90 (t, *J* = 7.6 Hz, 3H); $^{13}$C NMR (101MHz, $CDCl_3$): δ 201.9, 135.4, 128.6, 126.7, 126.4, 105.8, 96.1, 60.9, 35.9, 32.7, 29.7, 22.4, 13.9.

**3-(2-(2-fluorophenyl)vinylidene)heptan-1-ol (14b)**. $^1$H NMR (400 MHz, $CDCl_3$): δ 7.38 (td, *J* = 7.6, 1.6 Hz, 1H), 7.20-7.13 (m, 1H), 7.12-7.00 (m, 2H), 6.47-6.39 (m, 1H), 3.80 (t, *J* = 6.4 Hz, 2H), 2.43-2.35 (m, 2H), 2.18-2.07 (m, 2H), 1.65 (s, 1H), 1.55-1.33 (m, 4H), 0.92 (t, *J* = 7.2 Hz, 3H); $^{13}$C NMR (101 MHz, CDCl3): δ 202.8 (d, *J* = 2.0 Hz), 161.0 (d, *J* = 249.8 Hz), 128.0 (d, *J* = 8.2 Hz), 127.9 (d, *J* = 3.6 Hz), 124.2 (d, *J* = 3.5 Hz), 122.9 (d, *J* = 11.8 Hz), 115.8 (d, *J* = 21.6 Hz), 105.5, 88.5 (d, *J* = 6.4 Hz), 60.8, 35.9, 32.6, 29.7, 22.4, 13.9. HRMS (ESI) Calculated for $C_{15}H_{20}FO_2$ $[M+H]^+$ 235.1498, found 235.1495.

**3-(2-(o-tolyl)vinylidene)heptan-1-ol (14c)**. $^1$H NMR (400 MHz, $CDCl_3$): δ 7.39 (d, *J* = 7.6 Hz, 1H), 7.20-7.09 (m, 3H), 6.44-6.39 (m, 1H), 3.81 (dd, *J* = 11.2, 5.6 Hz, 2H), 2.47-2.31 (m, 5H), 2.21-2.08 (m, 2H), 1.67-1.33 (m, 5H), 0.93 (t, *J* = 7.2 Hz, 3H); $^{13}$C NMR (101 MHz, $CDCl_3$): δ 202.6, 134.8, 133.4, 130.6, 126.7, 126.6, 126.2, 104.7, 93.2, 61.0, 35.9, 32.8, 29.8, 22.5, 19.8, 13.9. HRMS (ESI) Calculated for $C_{16}H_{22}ONa$ $[M+Na]^+$ 253.1568, found 253.1564.

**3-(2-(2-methoxyphenyl)vinylidene)heptan-1-ol (14d)**. $^1$H NMR (400 MHz, $CDCl_3$): δ 7.35 (dd, *J* = 7.6, 1.6 Hz, 1H), 7.23-7.15 (m, 1H), 6.99-6.84 (m, 2H), 6.62-6.53 (m, 1H), 3.87 (s, 3H), 3.80 (s, 2H), 2.36 (td, *J* = 6.4, 3.2 Hz, 2H), 2.16-2.08 (m, 2H), 2.04 (s, 1H), 1.55-1.45 (m, 2H), 1.44-1.33 (m, 2H), 0.92 (t, *J* = 7.2 Hz, 3H); $^{13}$C NMR (101 MHz, $CDCl_3$): δ 202.4, 156.1, 127.8, 127.6, 123.7, 120.9, 111.1, 104.3, 90.3, 60.8, 55.6, 36.0, 32.8, 29.8, 22.5, 13.9. HRMS (ESI) Calculated for $C_{16}H_{23}O_2$ $[M+H]^+$ 247.1698, found 247.1696.

**3-(2-(2-chlorophenyl)vinylidene)heptan-1-ol (14e)**. $^1$H NMR (400 MHz, $CDCl_3$): δ 7.30-7.27 (m, 1H), 7.26-7.20 (m, 1H), 7.19-7.13 (m, 2H), 6.20-6.12 (m, 1H), 3.80 (t, *J* = 6.0 Hz, 2H), 2.45-2.31 (m, 2H), 2.18-2.10 (m, 2H), 1.60 (s, 1H), 1.53-1.43 (m, 2H), 1.43-1.33 (m, 2H), 0.92 (t, *J* = 7.2 Hz, 3H); $^{13}$C NMR (101 MHz, $CDCl_3$): δ 202.3, 137.6, 134.6, 129.8, 126.7, 126.3, 124.6, 106.4, 95.1, 60.9, 35.8, 32.6, 29.7, 22.4, 13.9. HRMS (ESI) Calculated for $C_{15}H_{20}OCl$ $[M+H]^+$ 251.1203, found 251.1200.

**3-(2-(3-Nitrophenyl)vinylidene)heptan-1-ol (14f)** $^1$H NMR (400 MHz, $CDCl_3$): δ 8.11-8.12 (m, 1H), 8.00-8.02 (m, 1H), 7.57-7.59 (m, 1H), 7.44 (t, *J* = 7.6 Hz, 1H), 6.24 (m, 1H), 3.79 (t, *J* = 6.4 Hz, 2H), 2.35-2.45 (m, 2H), 2.12-2.19 (m, 2H), 1.66 (s, 1H), 1.44-1.59 (m, 2H), 1.34-1.43 (m, 2H), 0.90 (t, *J* = 7.6 Hz, 3H). $^{13}$C NMR (101 MHz, $CDCl_3$): δ 203.1, 148.7, 137.8, 132.1, 129.4, 121.3, 121.0, 107.1, 94.5, 60.7, 35.7, 32.4, 29.6, 22.4, 13.9. HRMS (ESI) Calculated for $C_{15}H_{20}NO_3$ $[M+H]^+$ 262.1443, found 262.1441.

**3-(2-(3-chlorophenyl)vinylidene)heptan-1-ol (14g)**. $^1$H NMR (400 MHz, $CDCl_3$): δ 7.30-7.25 (m, 2H), 7.25-7.19 (m, 2H), 6.19-6.15 (m, 1H), 3.79 (t, *J* = 6.2 Hz, 2H), 2.45-2.30 (m, 2H), 2.13 (td, *J* = 7.2, 2.8 Hz, 2H), 1.61 (s, 1H), 1.53-1.43 (m, 2H), 1.43-1.32 (m, 2H), 0.91 (t, *J* = 7.2 Hz, 3H); $^{13}$C NMR (101 MHz, $CDCl_3$) δ 202.1, 134.0, 132.3, 128.8, 127.6, 106.2, 95.2, 60.9, 35.9, 32.7, 25.7, 22.4, 13.9. HRMS (ESI) Calculated for $C_{15}H_{20}OCl$ $[M+H]^+$ 251.1203, found 251.1202.

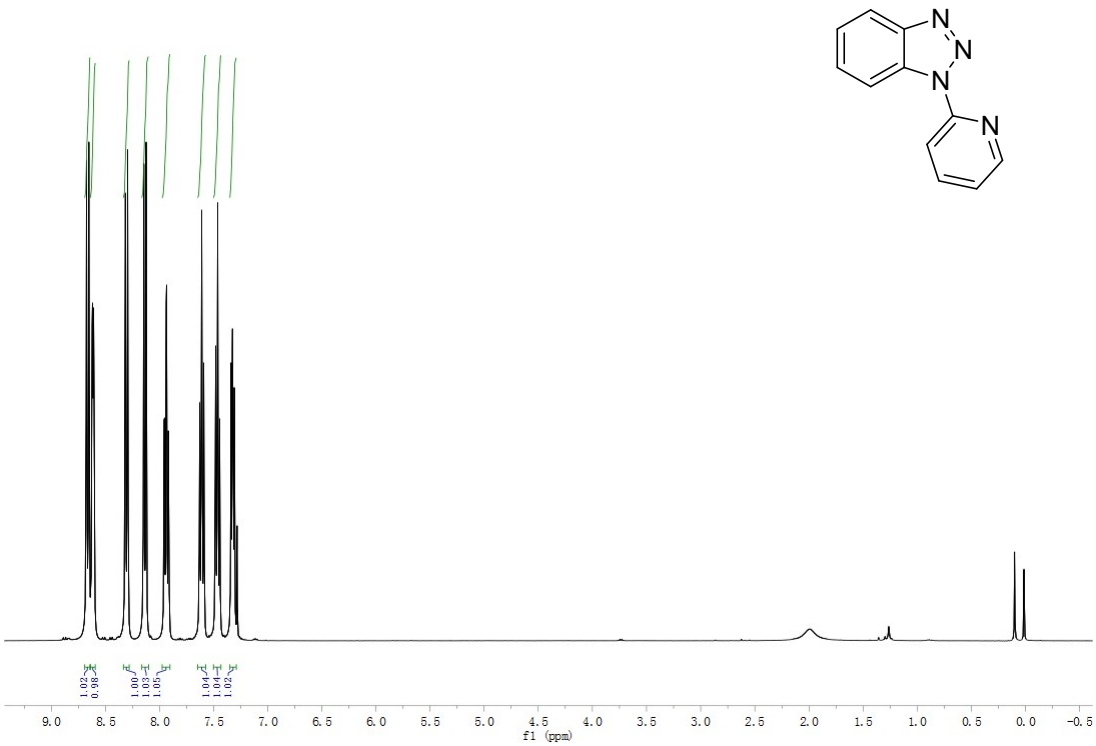
**3-(2-(4-Fluorophenyl)vinylidene)heptan-1-ol (14h)** (Known compound, see: D., Wang; Gautam, L. N. S.; Bollinger, C.; Harris, A.; M. Li; X. Shi. *Org. Lett.* **2011**, *13*, 2618-2621) $^{1}$H NMR (400 MHz, $CDCl_3$): δ 7.22-7.26 (m, 2H), 6.97-6.70 (m, 2H), 6.20 (quintet, *J* = 2.0 Hz, 1H), 3.76 (t, *J* = 6.0 Hz, 2H), 2.31-3.37 (m, 2H), 2.09-2.12 (m, 2H), 1.68 (s, 1H), 1.43-1.49 (m, 2H), 1.34-1.40 (m, 2H), 0.88 (t, *J* = 7.6 Hz, 3H). $^{13}$C NMR (101 MHz, $CDCl_3$): δ 201.7, 162.6 (d, *J* = 244.4 Hz), 131.3 (d, *J* = 3.3 Hz), 127.8 (q, *J* = 8.4 Hz), 115.5, 105.9, 95.08 (t, *J* = 8.5 Hz), 60.9, 35.9, 32.7, 29.7, 22.4, 23.8.

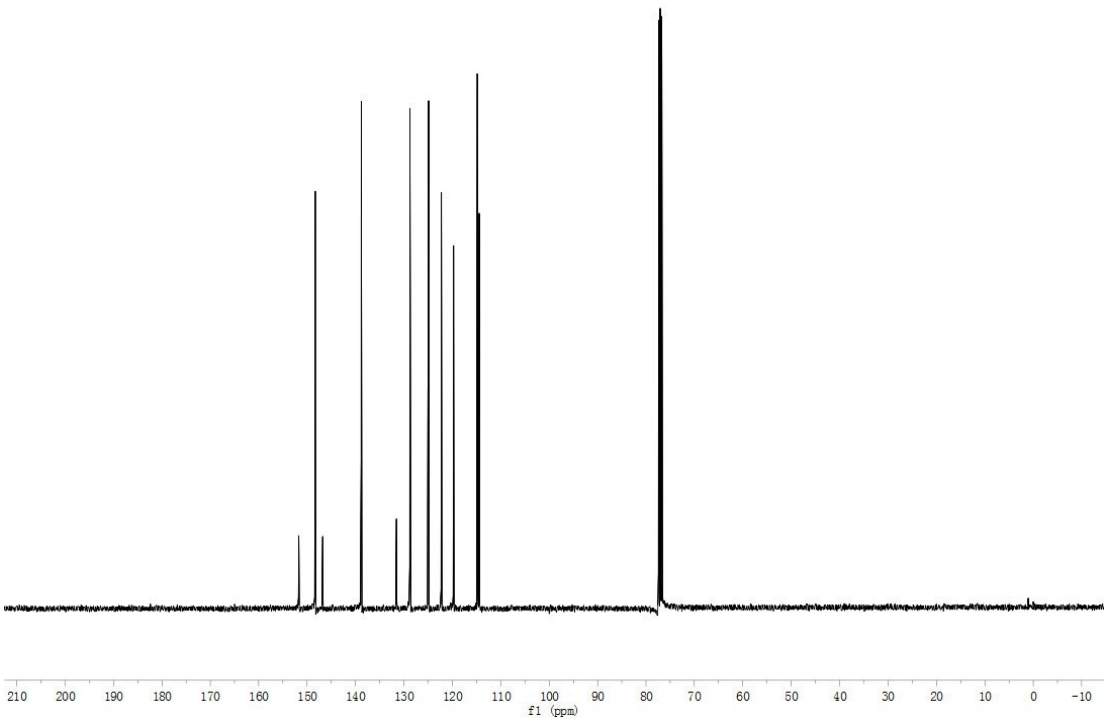
**Methyl 4-(3-(2-hydroxyethyl)hepta-1,2-dienyl)benzoate (14i)** (Known compound, see: D., Wang; Gautam, L. N. S.; Bollinger, C.; Harris, A.; M. Li; X. Shi. *Org. Lett.* **2011**, *13*, 2618-2621) $^{1}$H NMR (400 MHz, $CDCl_3$): δ 7.95-7.96 (m, 2H), 7.31-7.33 (m, 2H), 6.22 (quintet, *J* = 3.2 Hz, 1H), 3.90 (s, 3H), 3.77 (t, *J* = 6.4 Hz, 2H), 2.34-2.42 (m, 2H), 2.11-2.15 (m, 2H), 1.68 (s, 1H), 1.42-1.50 (m, 2H), 1.34-1.39 (m, 2H), 0.88 (t, *J* = 7.6 Hz, 3H). $^{13}$C NMR (101 MHz, $CDCl_3$): δ 203.3, 166.9, 140.5, 129.9, 128.2, 126.2, 106.2, 95.5, 60.8, 51.9, 35.7, 32.5, 29.7, 22.4, 13.9.

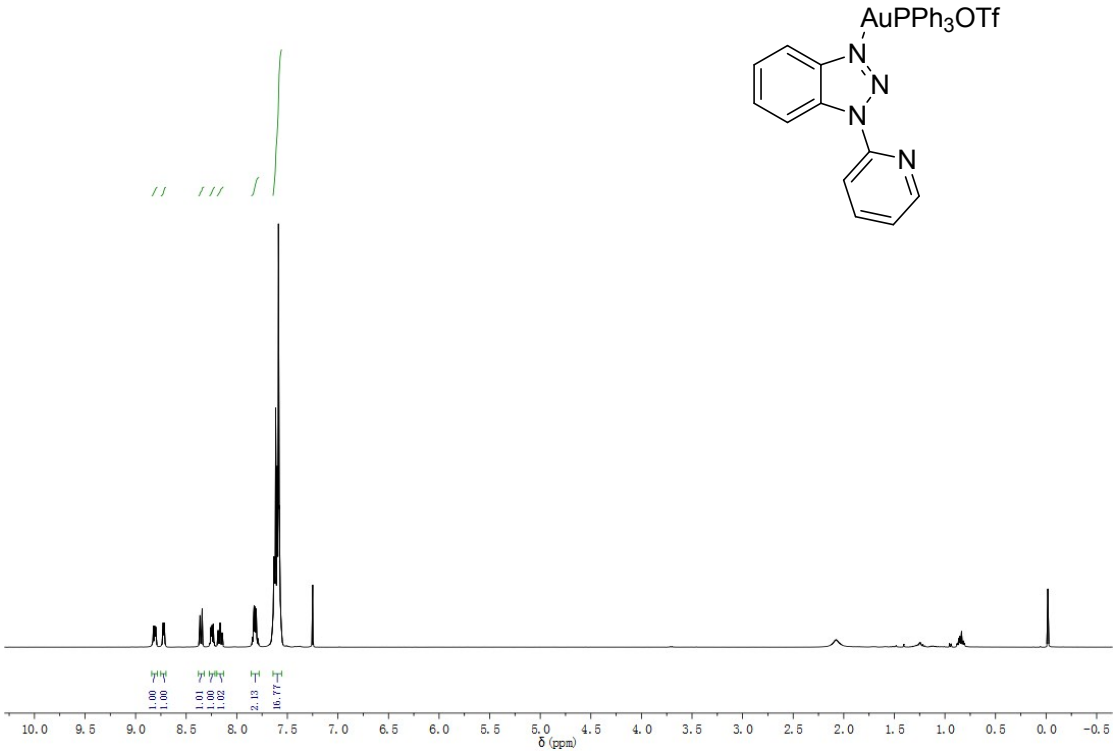
**3-(2-(2-Nitrophenyl)vinylidene)heptan-1-ol (14j)**. $^{1}$H NMR (400 MHz, $CDCl_3$): δ 7.90 (dd, *J* = 8.4, 1.2 Hz, 1H), 7.64 (dd, *J* = 8.0, 1.2 Hz, 1H), 7.52 (td, *J* = 7.6, 1.2 Hz, 1H), 7.35-7.27 (m, 1H), 6.87-6.81 (m, 1H), 3.81 (t, *J* = 6.2 Hz, 2H), 2.45-2.37 (m, 2H), 2.21-2.11 (m, 2H), 166 (s, 1H), 1.54-1.34 (m, 4H), 0.91 (t, *J* = 7.2 Hz, 3H); $^{13}$C NMR (101 MHz, $CDCl_3$): δ 204.5, 147.4, 132.7, 130.5, 129.1, 127.1, 124.8, 106.6, 91.0, 60.7, 35.6, 32.3, 29.6, 22.4, 13.9. HRMS (ESI) Calculated for $C_{15}H_{20}NO_3$ $[M+H]^+$ 262.1443, found 262.1442.

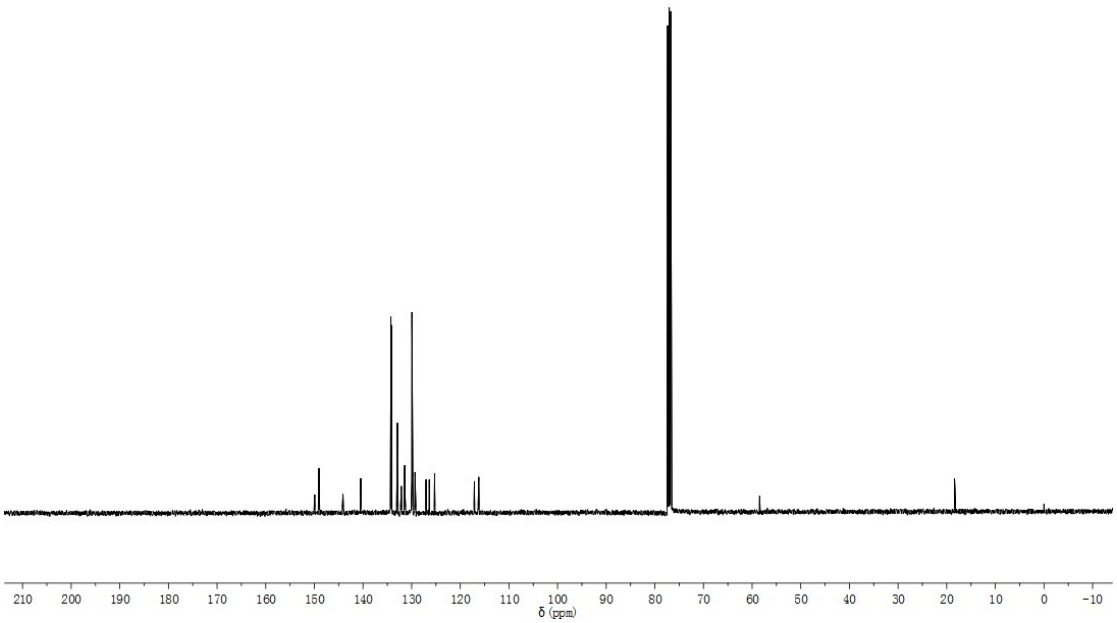
**1-methyl-2-(1-phenylhex-5-en-1-yn-3-yl)benzene (16)** $^{1}$H NMR (400 MHz, $CDCl_3$) δ 7.66 (d, *J* = 7.6 Hz, 1H), 7.54 – 7.49 (m, 2H), 7.39 – 7.33 (m, 3H), 7.33 – 7.27 (m, 1H), 7.24 (d, *J* = 4.0 Hz, 2H), 6.05 (m, 1H), 5.26 – 5.15 (m, 2H), 4.18 (t, *J* = 7.2 Hz, 1H), 2.63 (dd, *J* = 13.6, 7.2 Hz, 2H), 2.47 (s, 3H). $^{13}$C NMR (101 MHz, $CDCl_3$) δ 139.65, 135.73, 134.93, 131.70, 130.53, 128.31, 127.74, 126.84, 126.29, 123.84, 117.02, 91.42, 83.18 , 41.32, 35.08, 19.37.

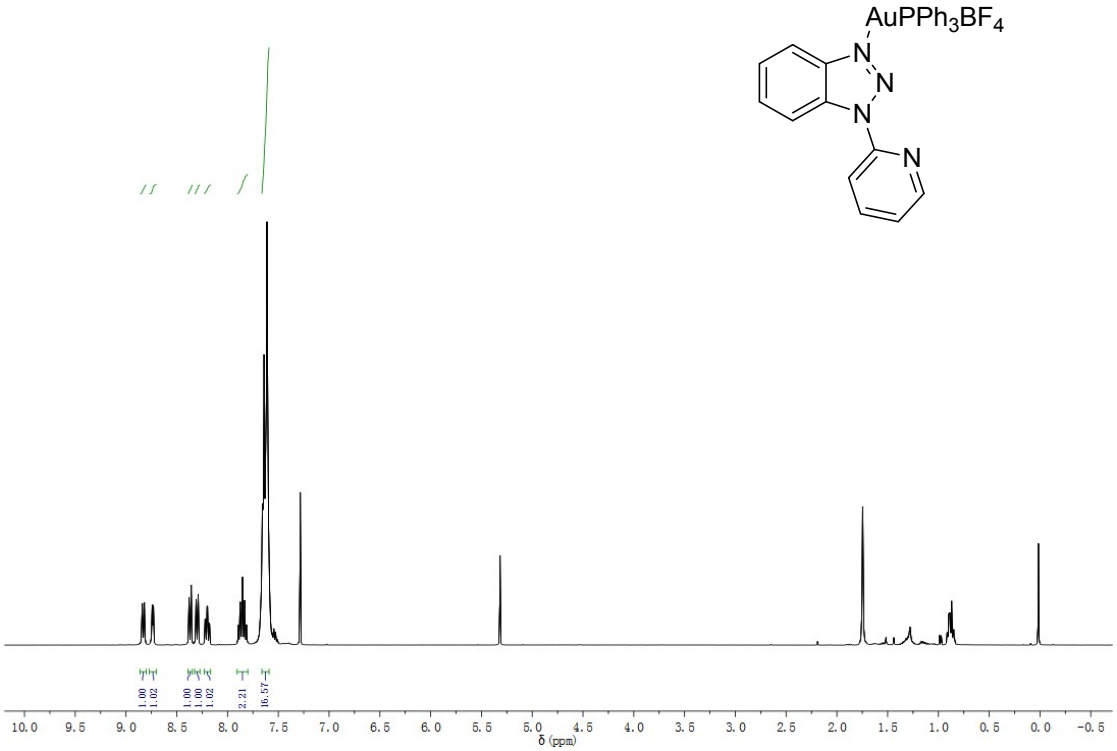
## Ⅲ. $^{1}$H NMR and $^{13}$C NMR Spectra

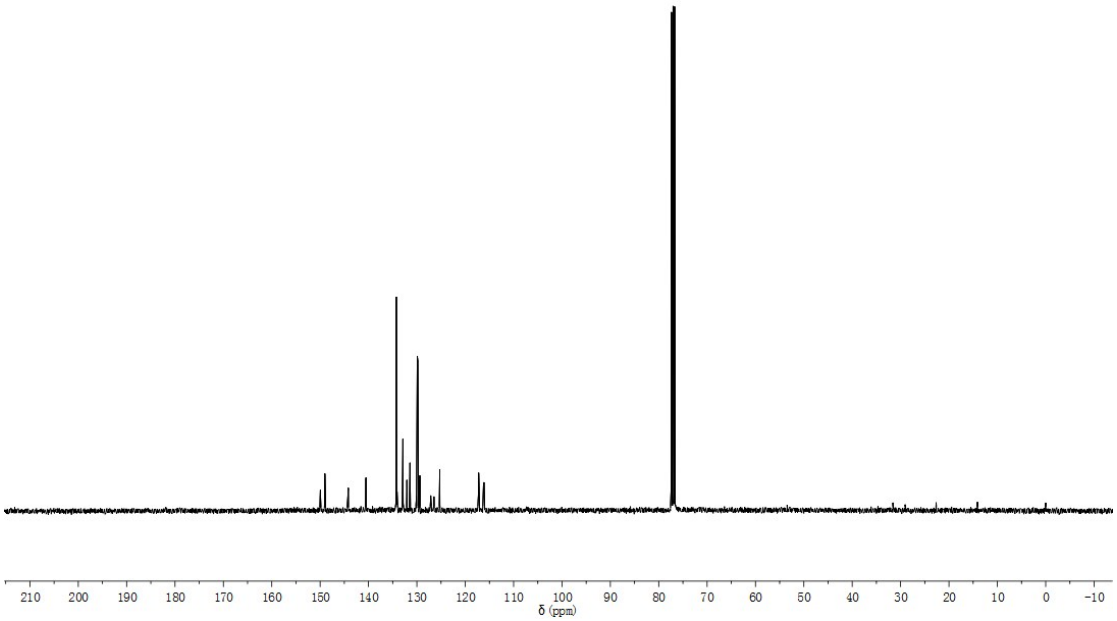


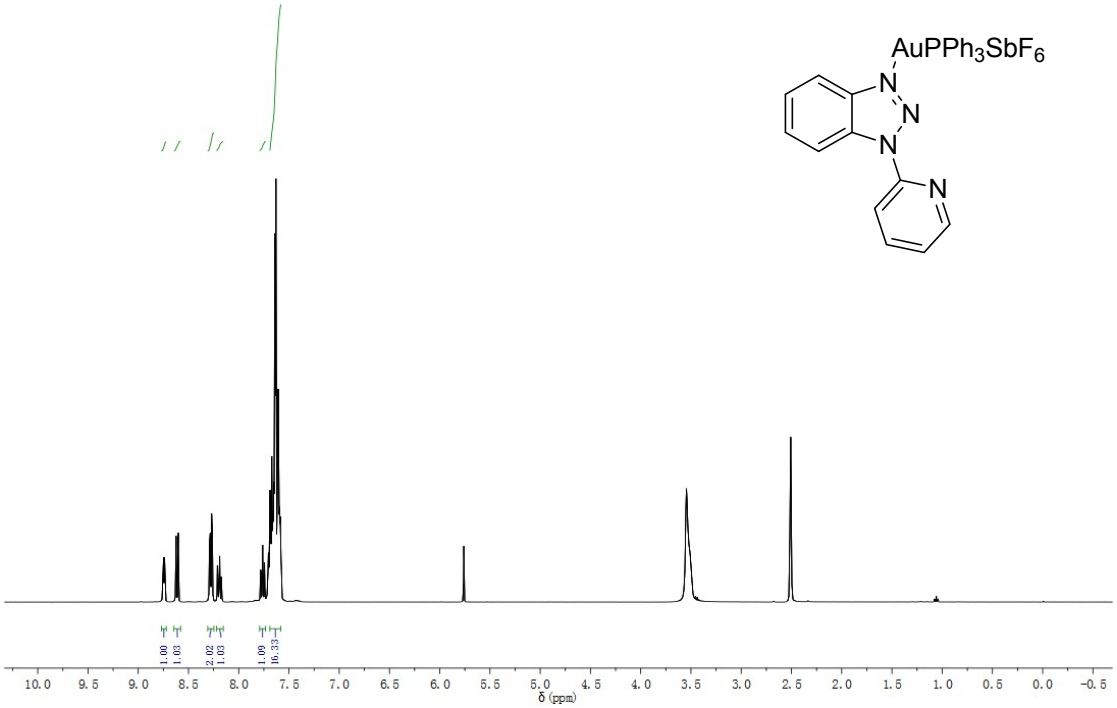



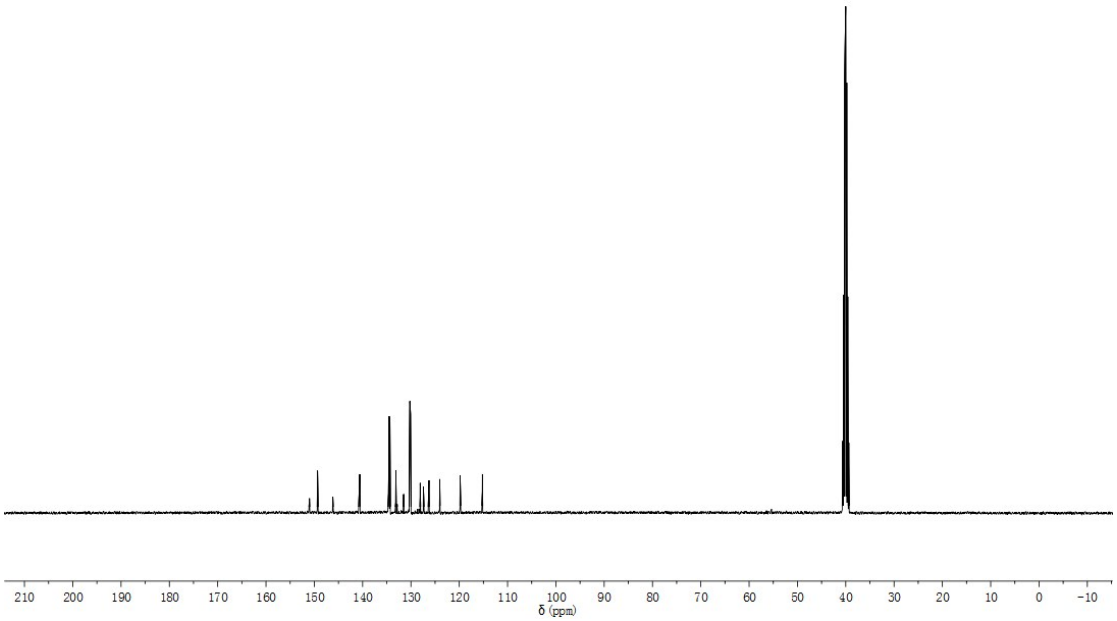

AuPPh3OTf
N
N
N
N
1.00
1.00
1.01
1.00
1.02
2.13
16.77
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
δ (ppm)

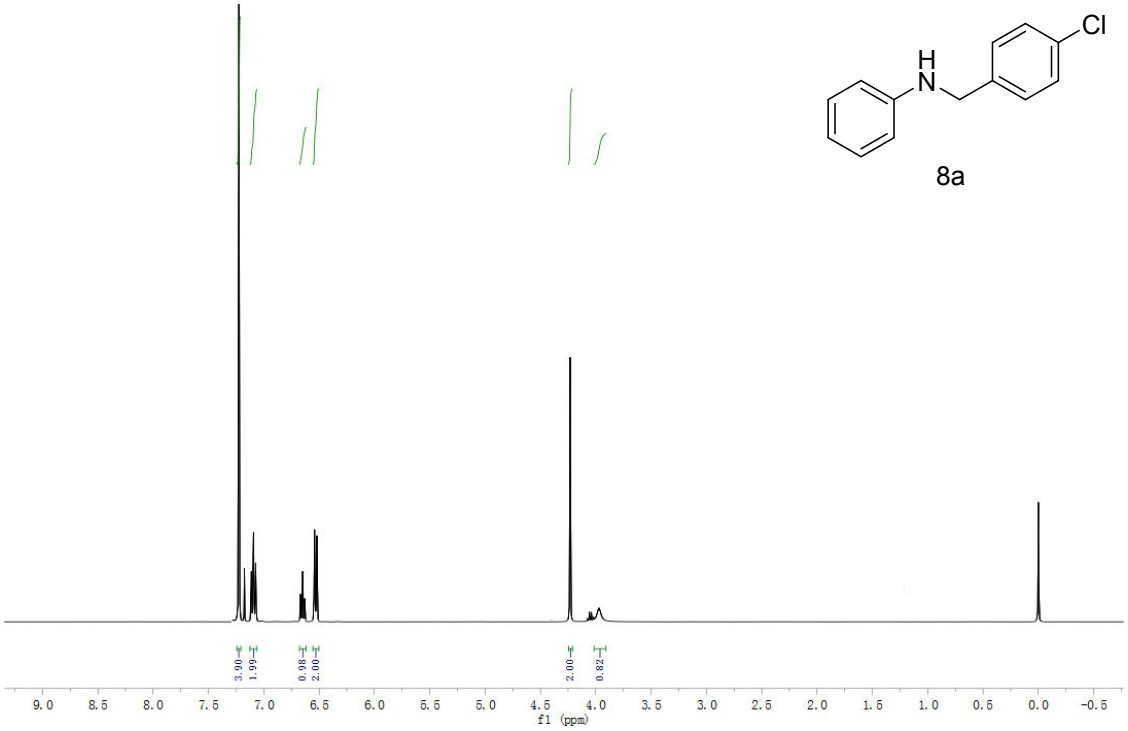

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)

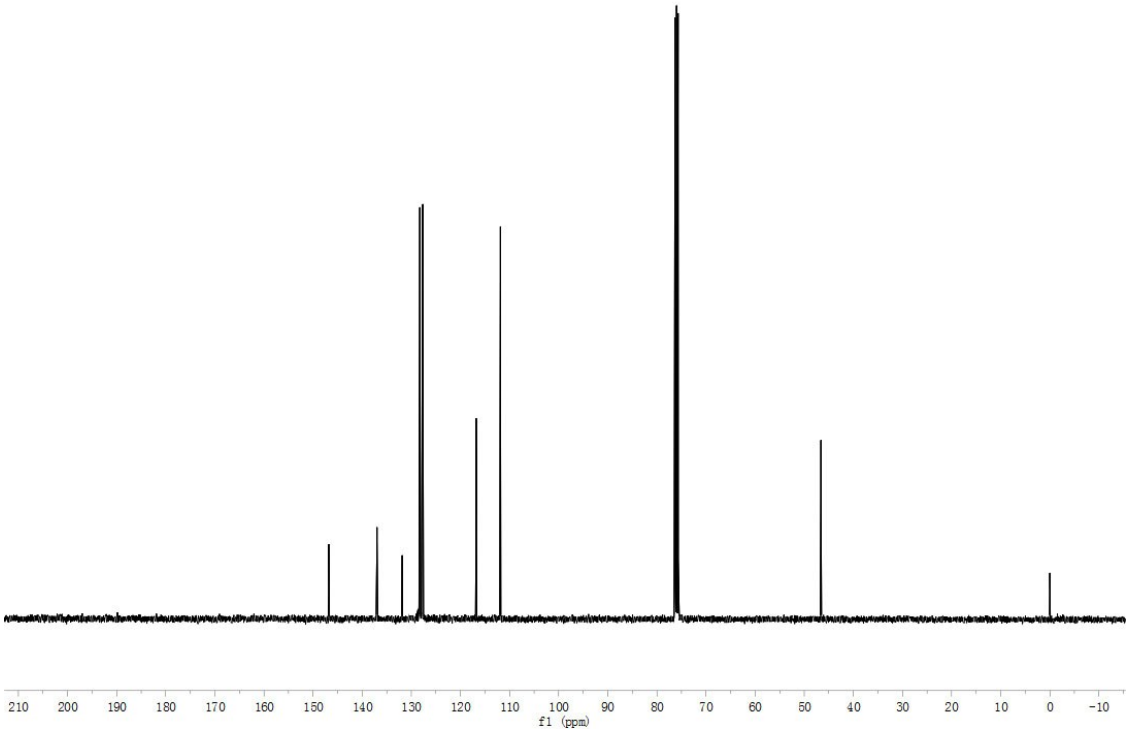

AuPPh3BF4
N
N
N
N
1.00
1.02
1.00
1.00
1.02
2.21
16.57
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
δ (ppm)

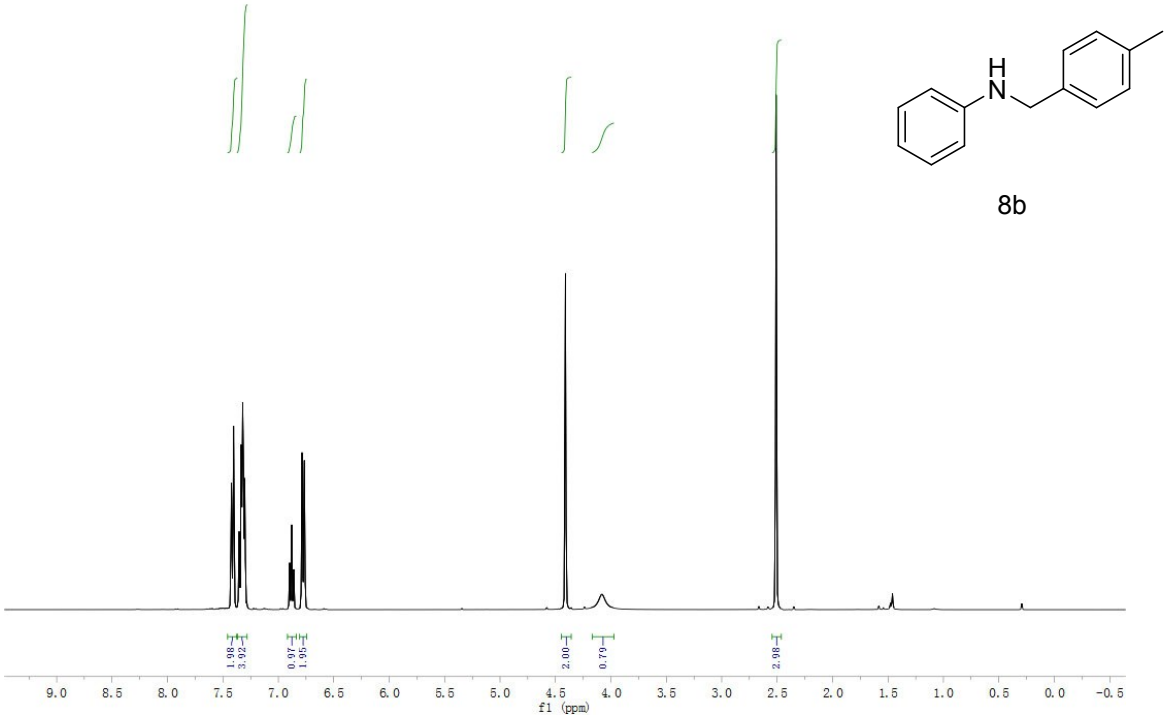

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)

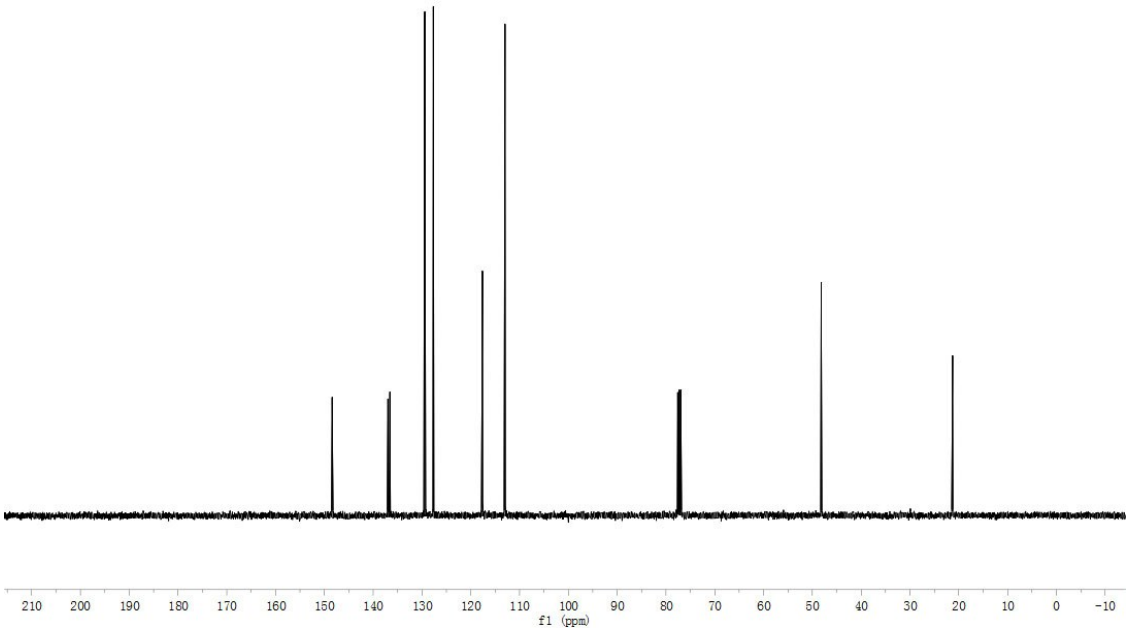

AuPPh3SbF6
N
N
N
N
1.00
1.03
2.02
1.03
1.09
16.33
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
δ (ppm)

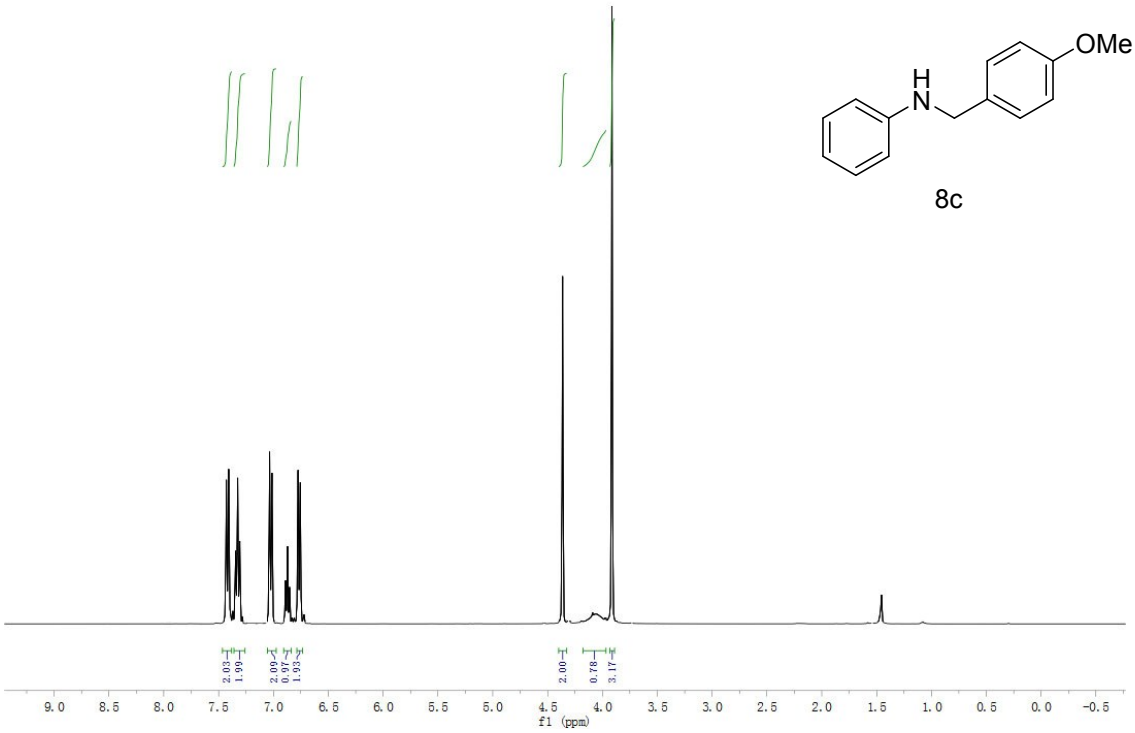

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)

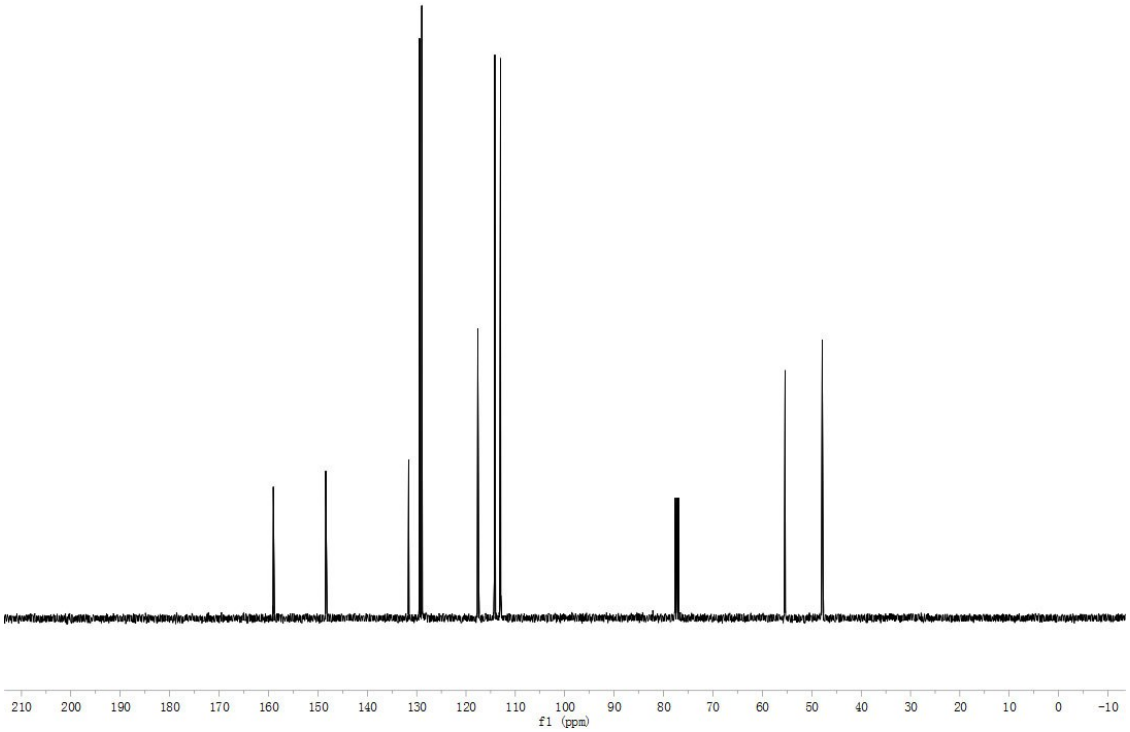

Cl
H
N
8a
3.90
1.99
0.98
2.00
2.00
0.82
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

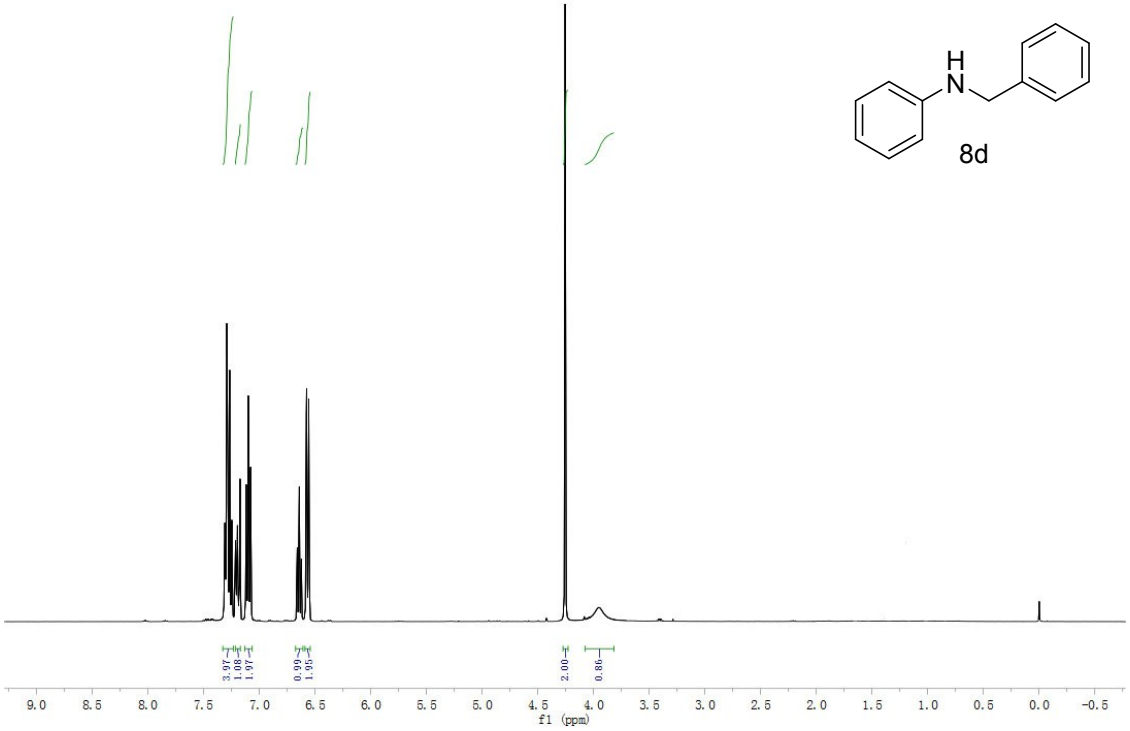

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

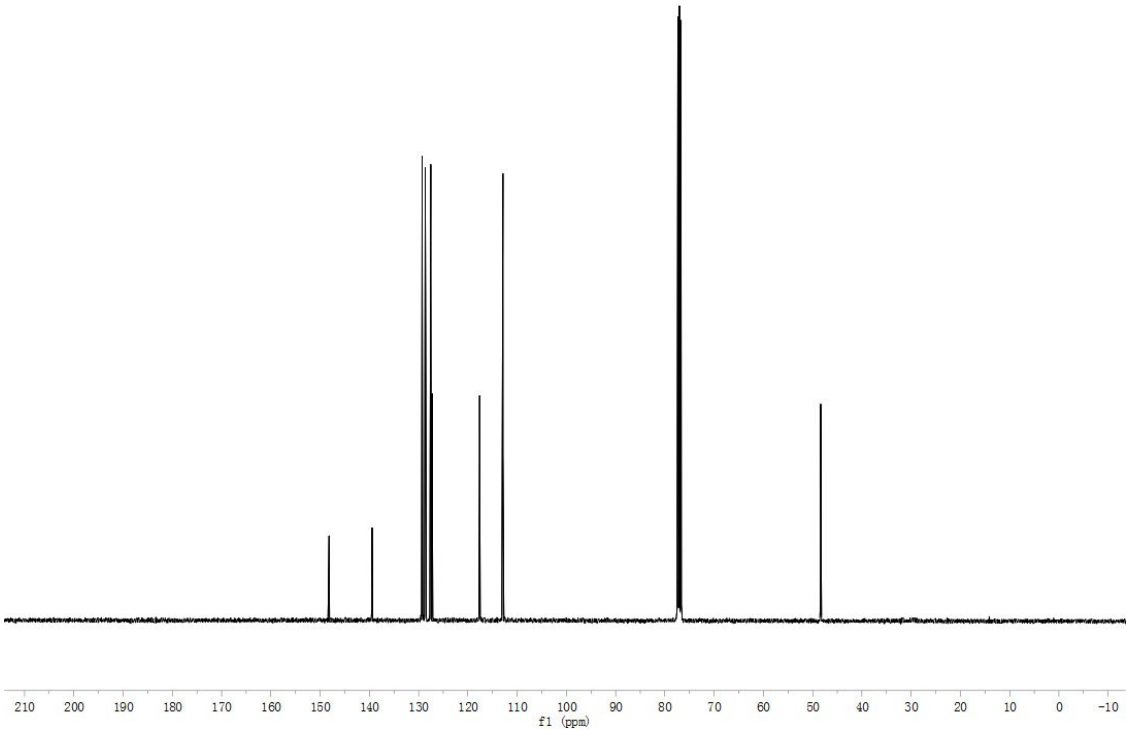

H
N
8b
1.98
3.92
0.97
1.95
2.00
0.79
2.98
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

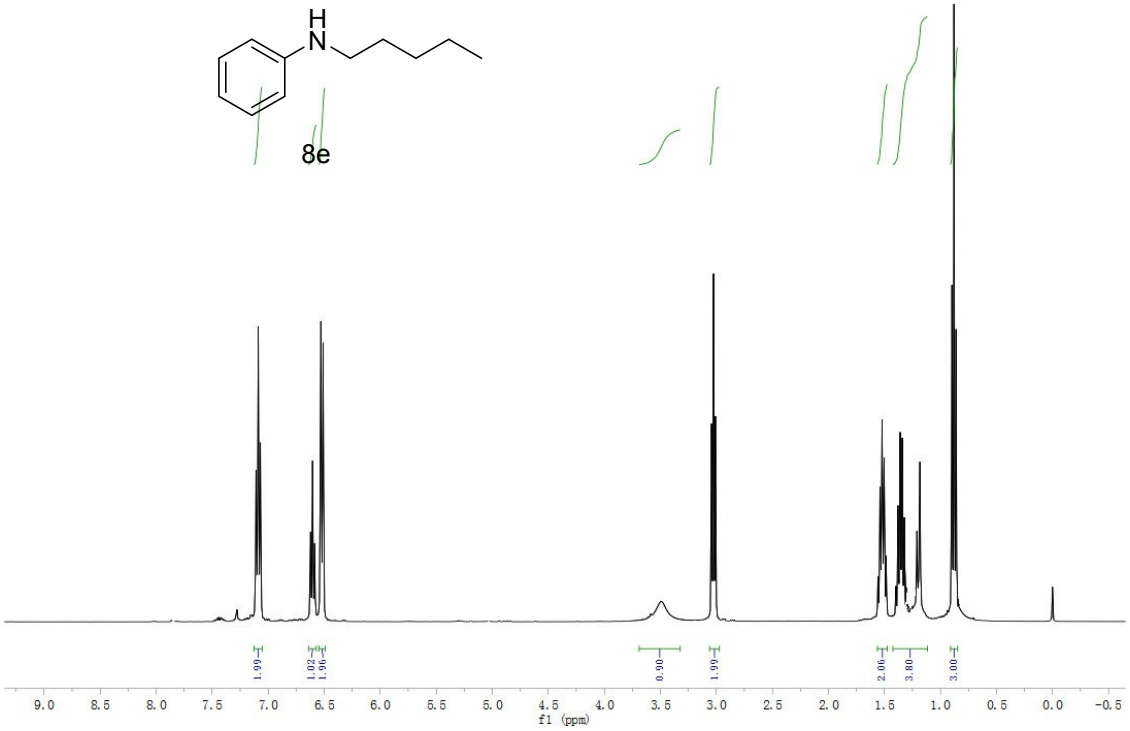

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

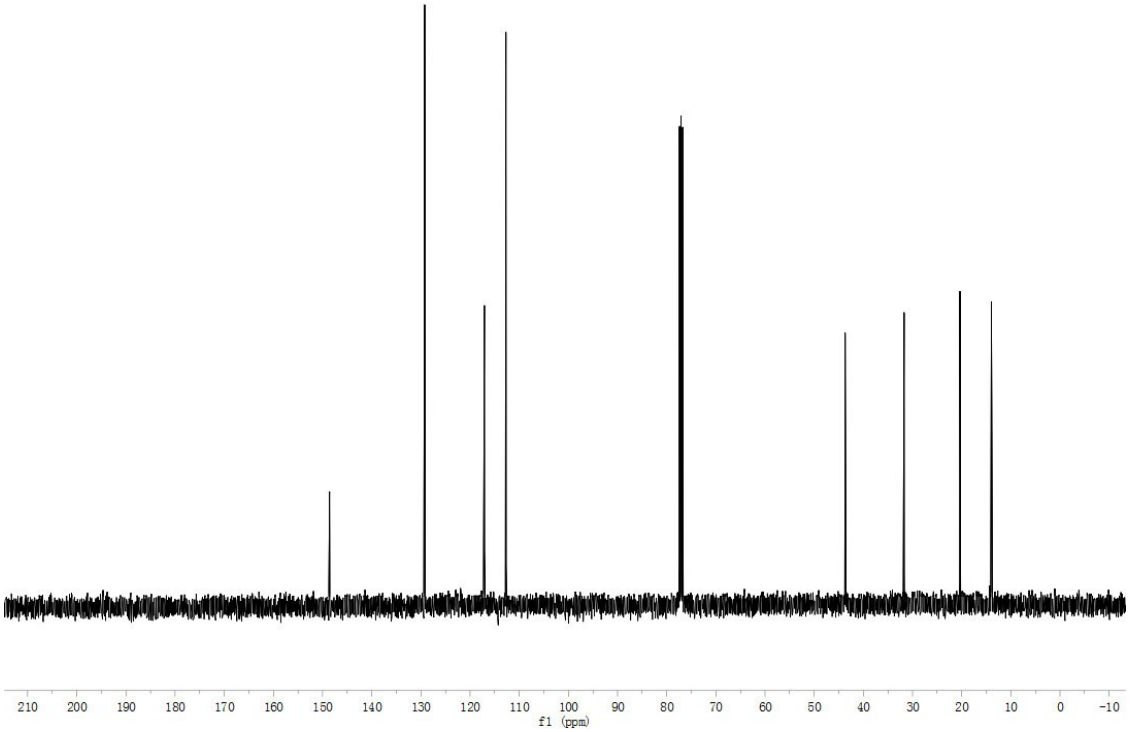

OMe
H
N
8c
2.03
1.99
2.09
0.97
1.93
2.00
0.78
3.17
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)


210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

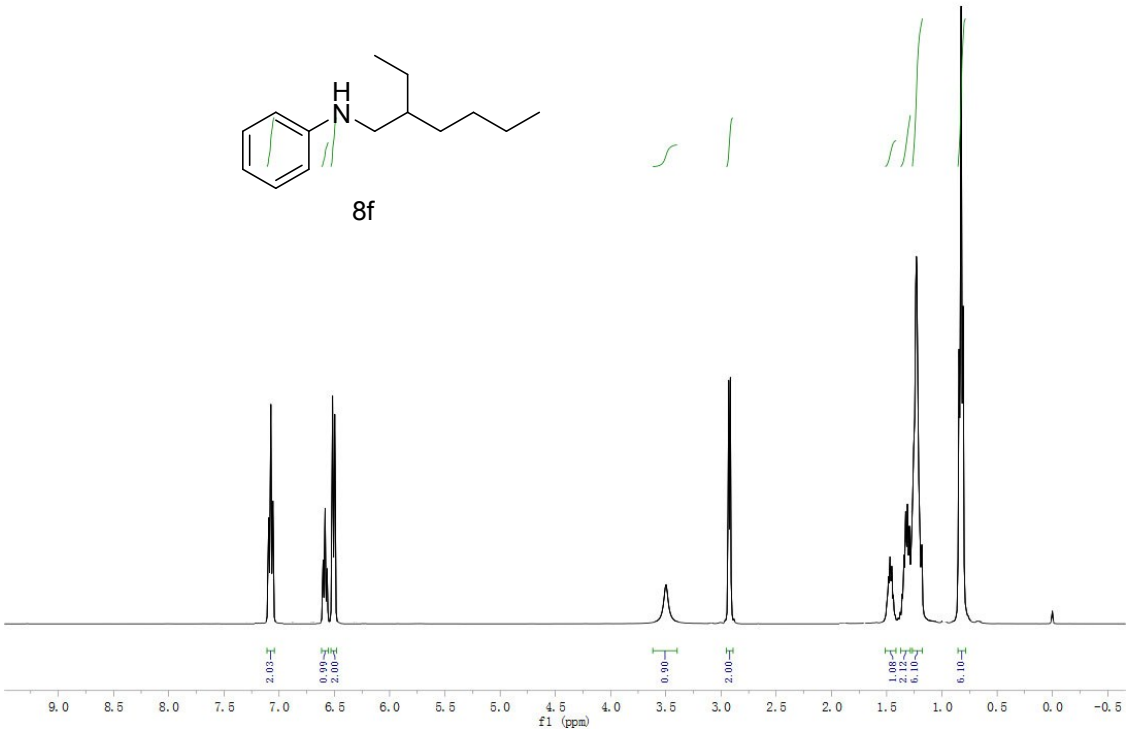

H
N
8d
3.97
1.08
1.07
0.99
1.95
2.00
0.86
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

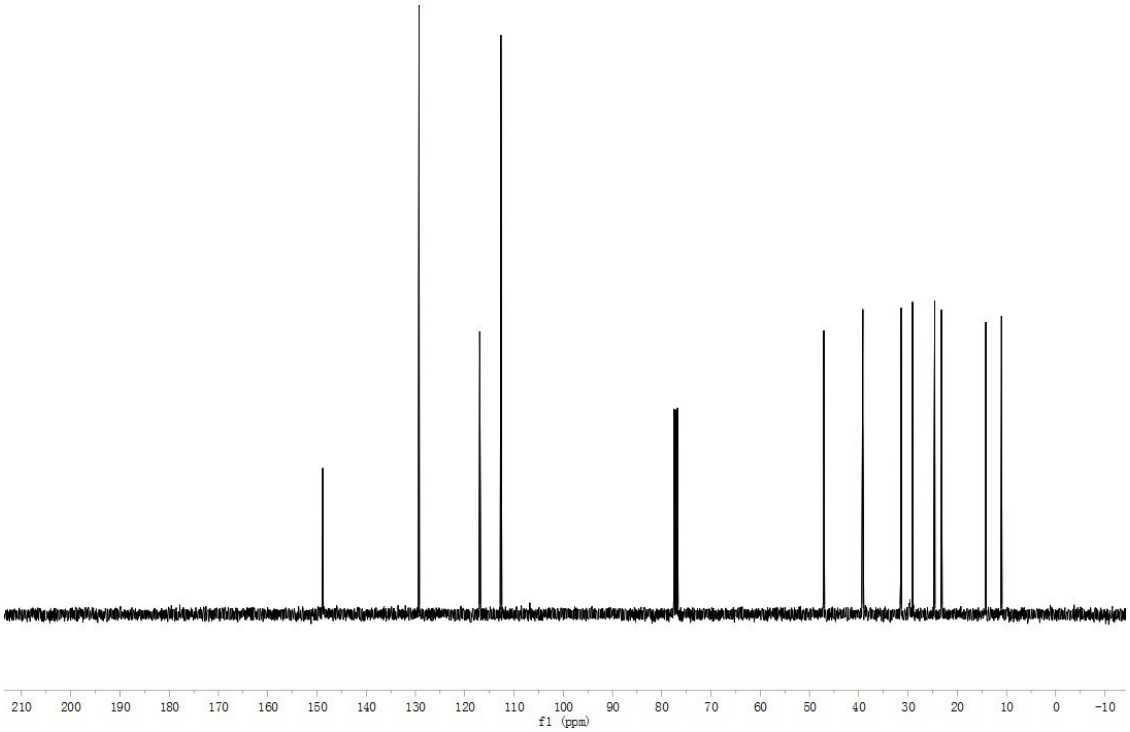

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

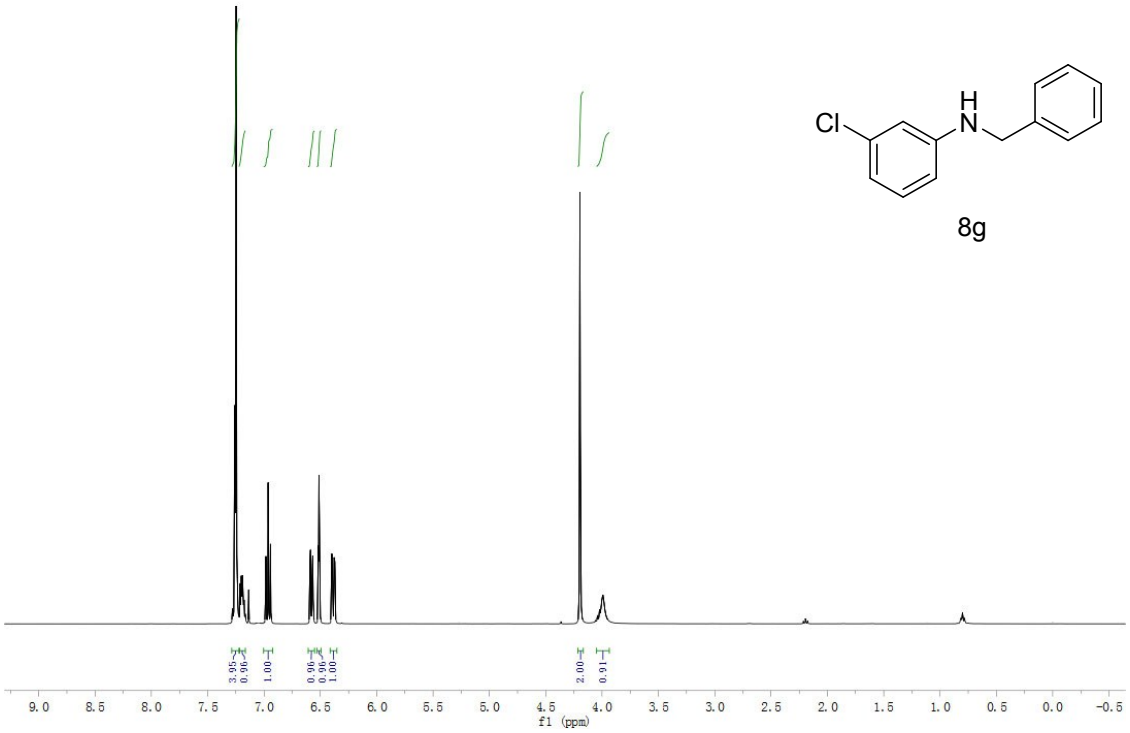

H
N
8e
1.99
1.02
1.96
0.90
1.99
2.06
3.80
3.00
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

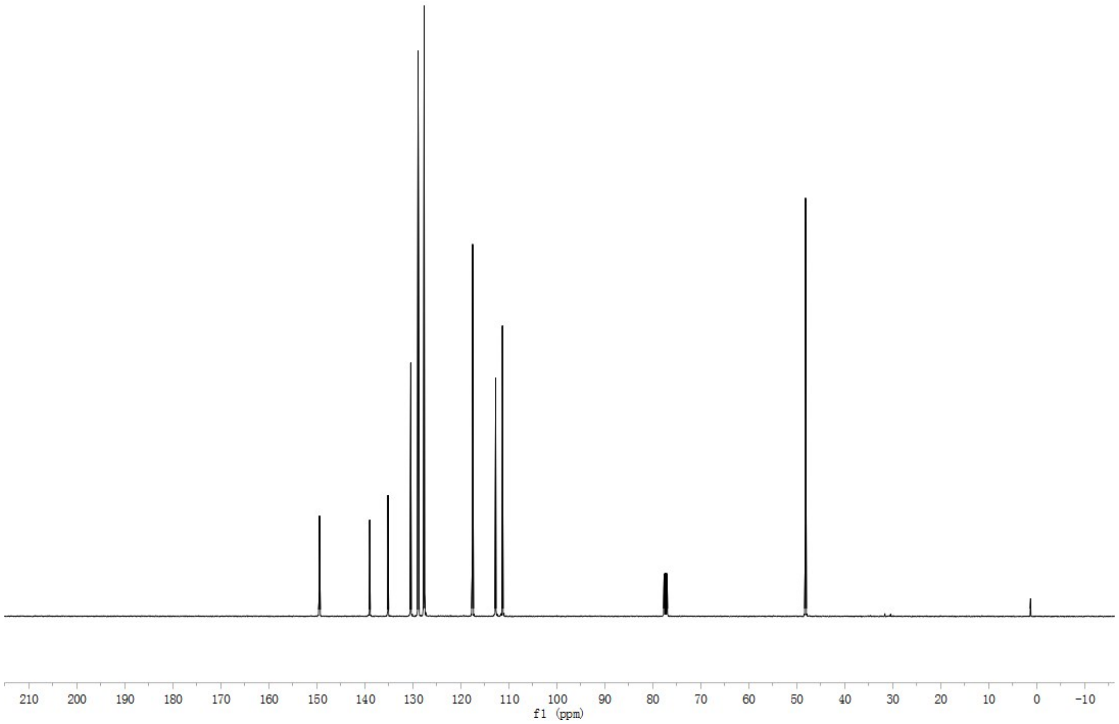

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

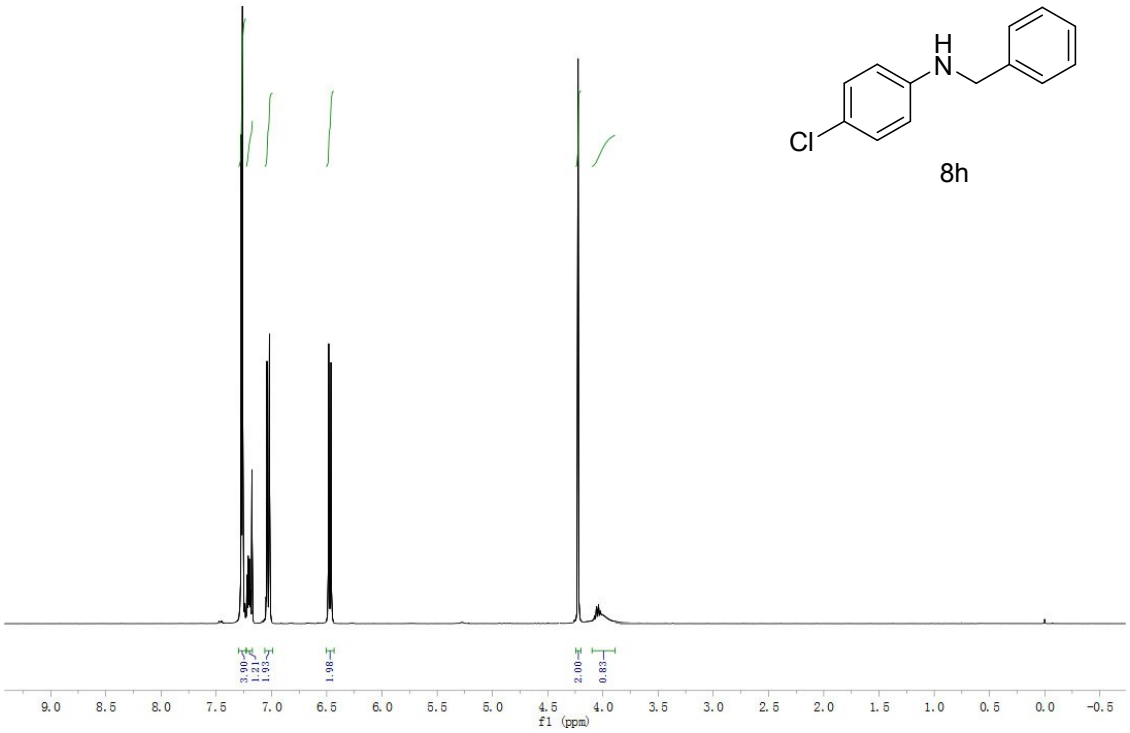
8f

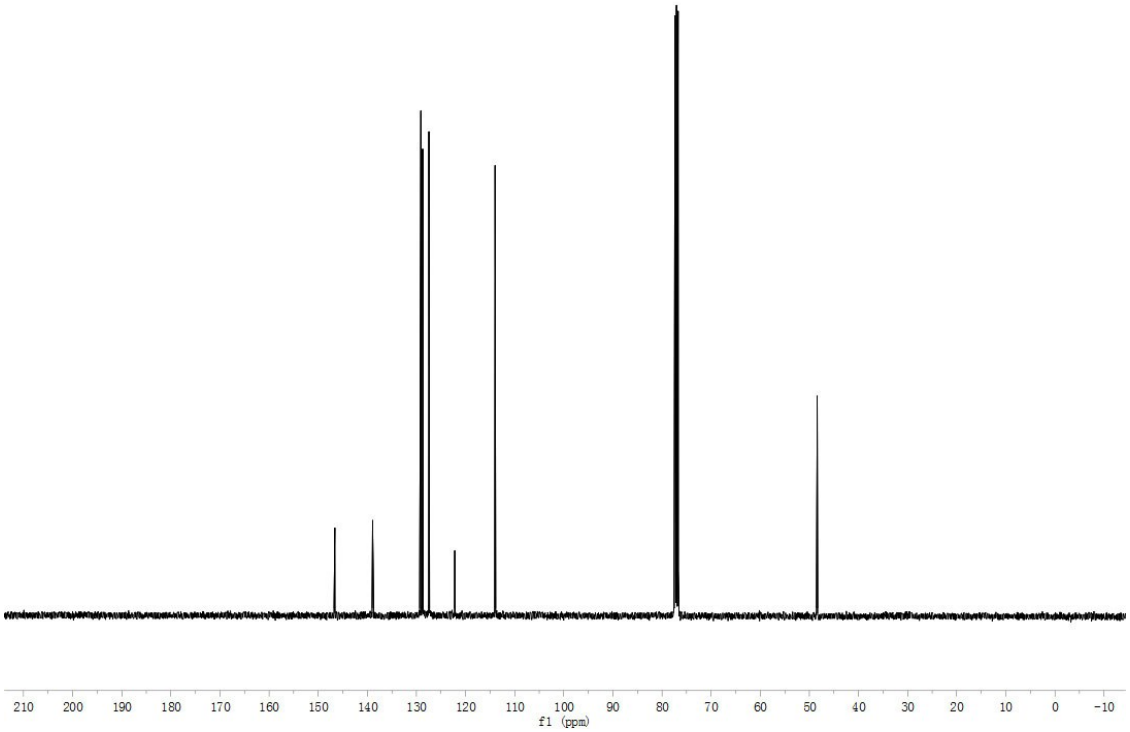

2.03
0.99
2.00
0.90
2.00
1.08
2.12
6.10
6.10
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

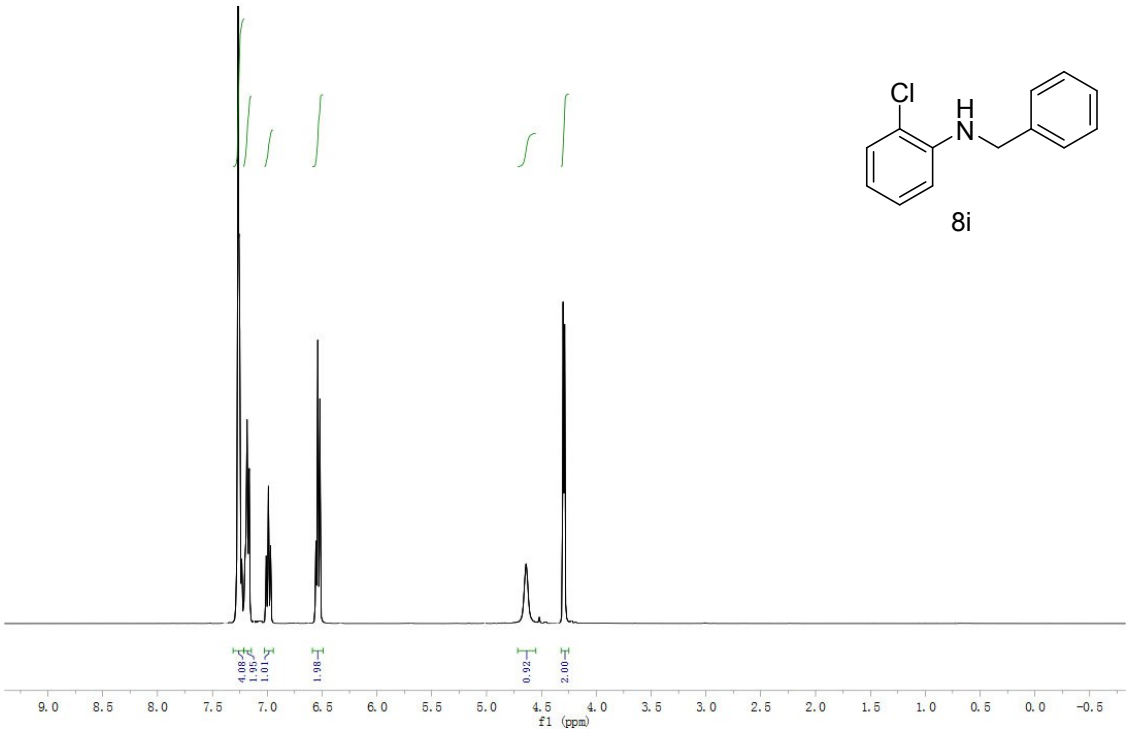

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

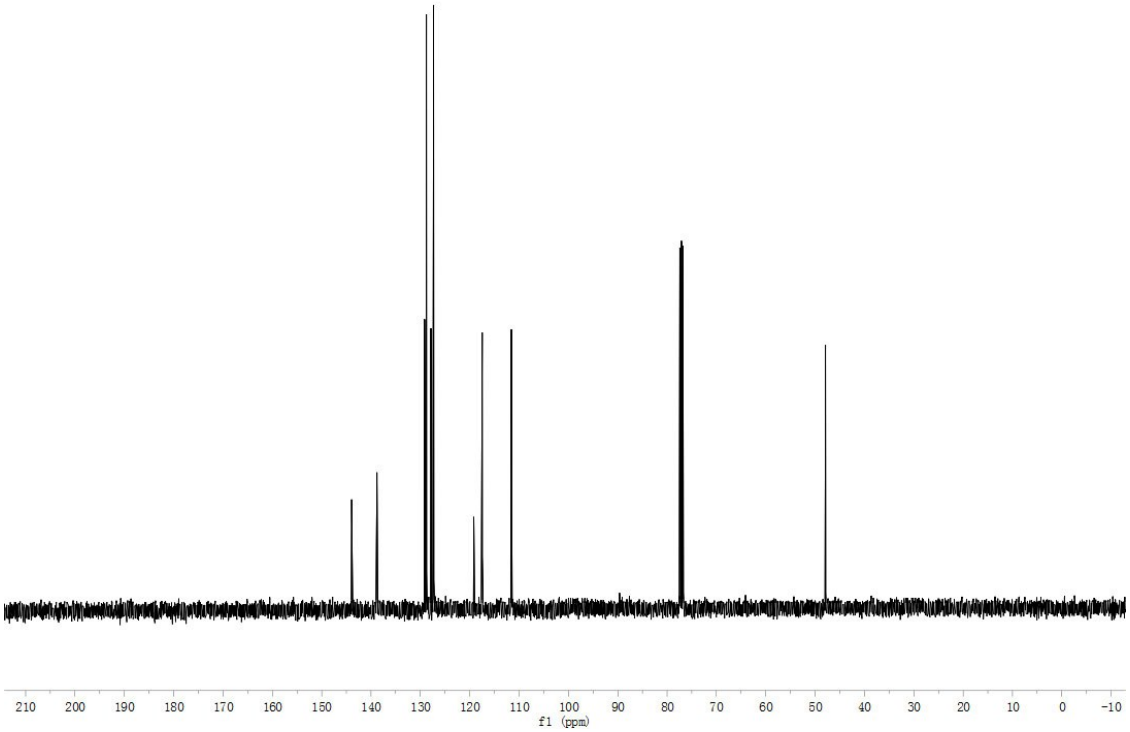

Cl
H
N
8g
3.95
0.96
1.00
0.96
0.96
1.00
2.00
0.91
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

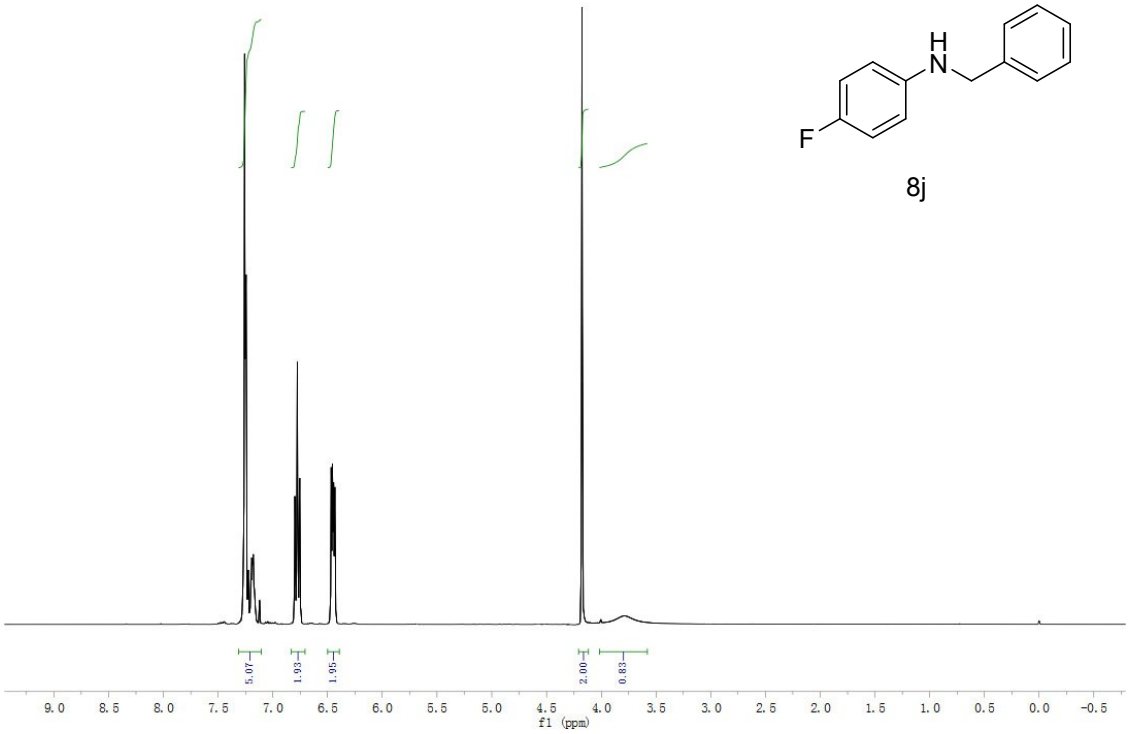

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

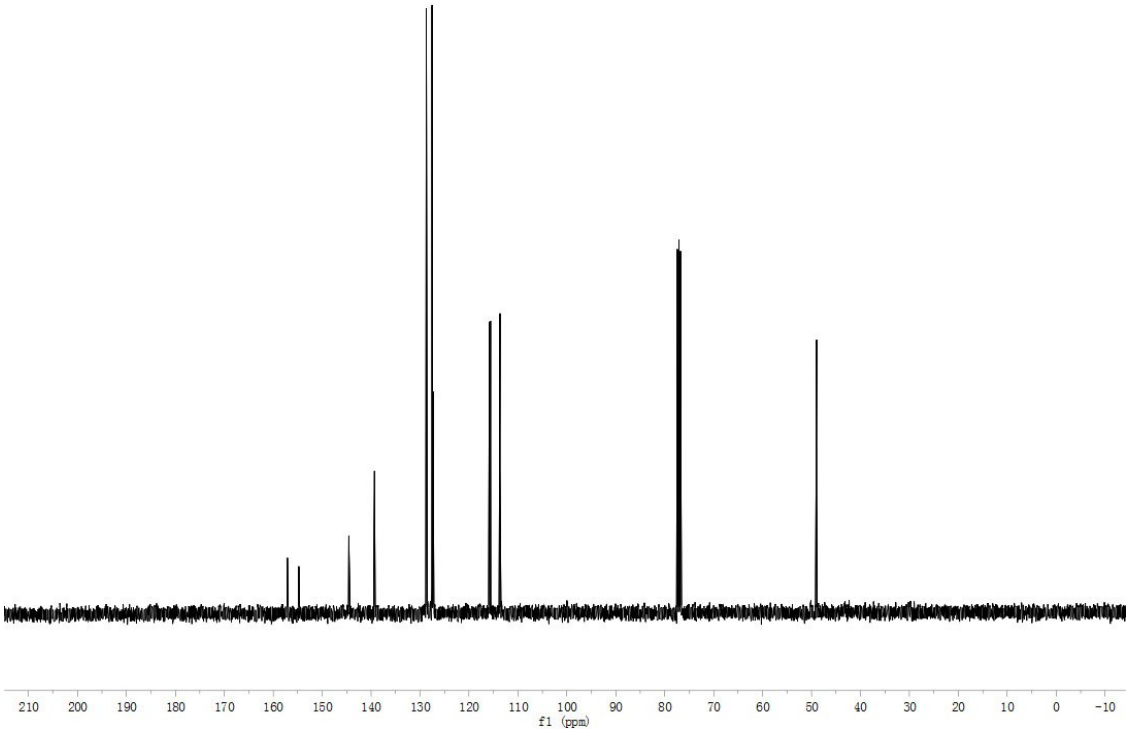

H
N
Cl
8h
3.90
1.93
1.95
1.98
2.00
0.83
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

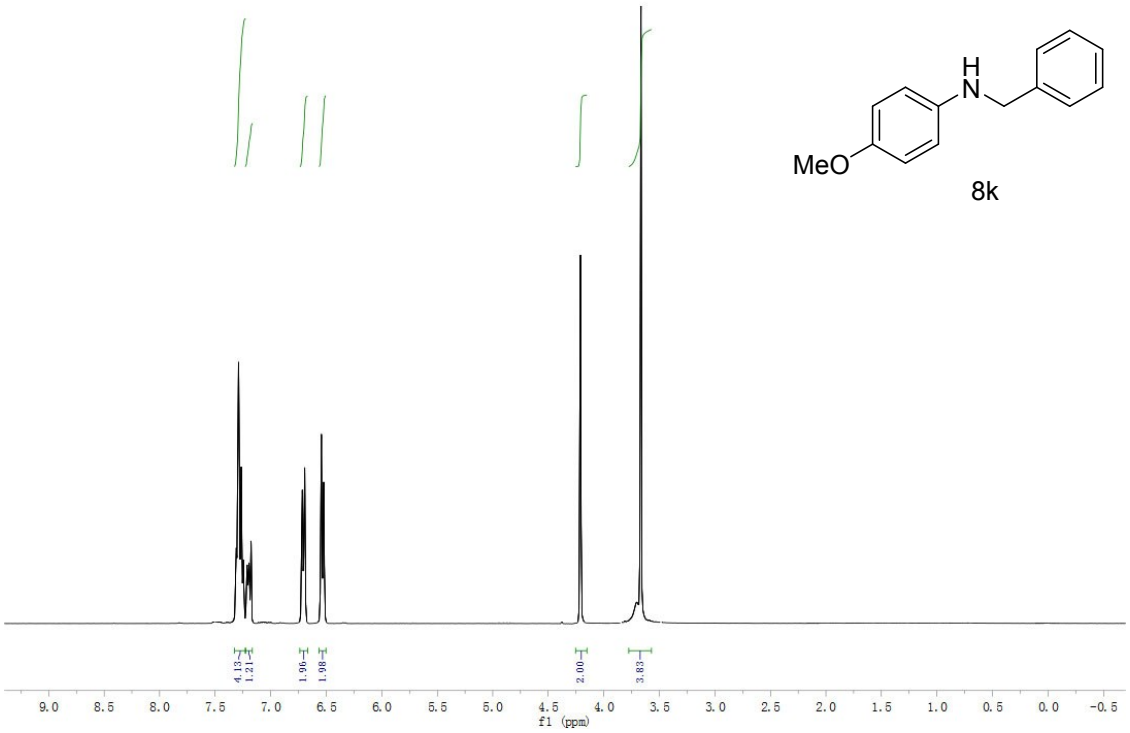

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

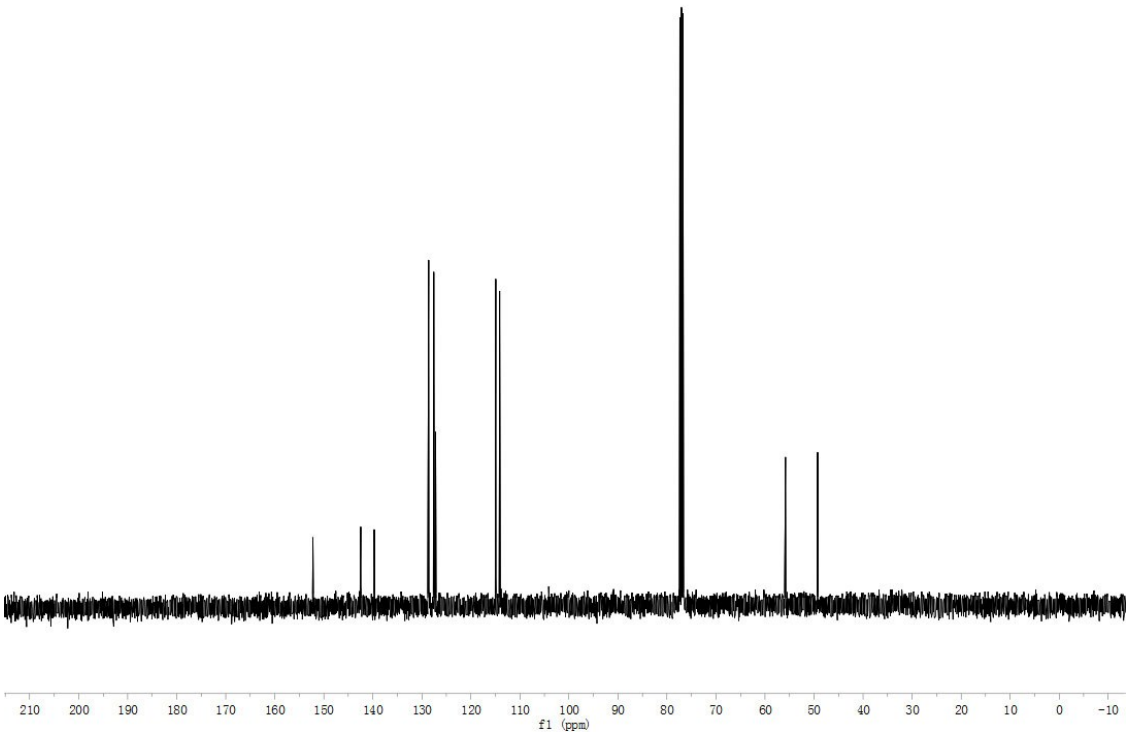

Cl
H
N
8i
4.08
1.05
1.01
1.98
0.92
2.00
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

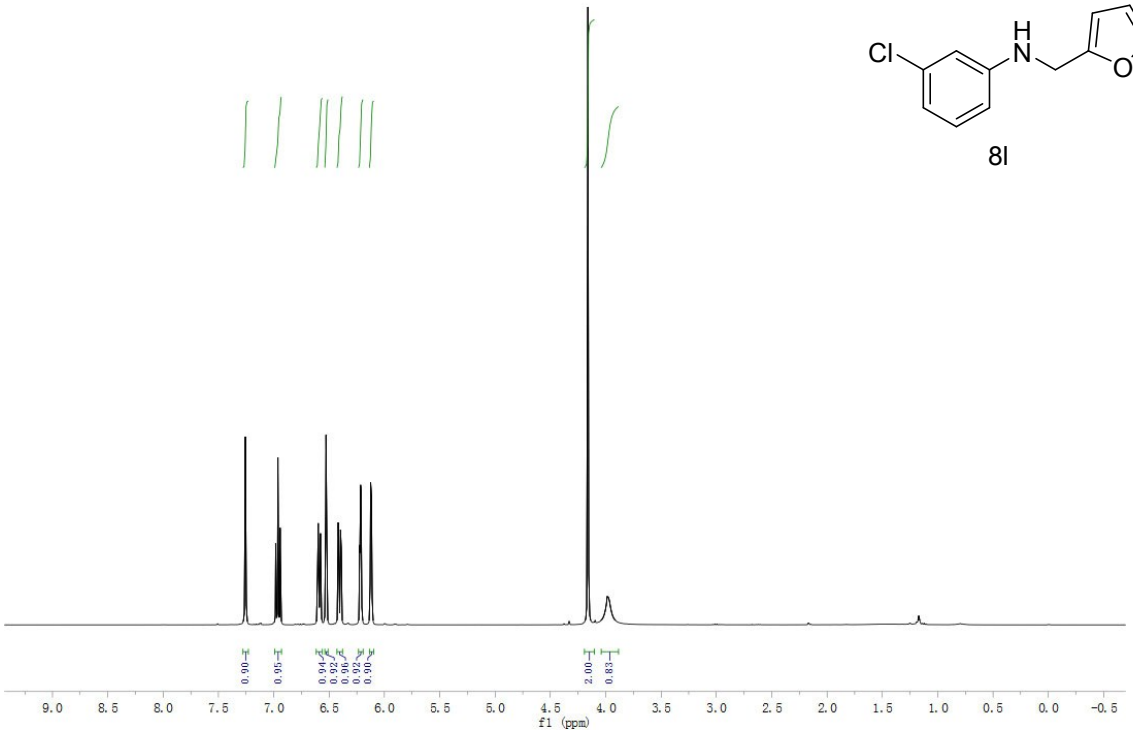

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

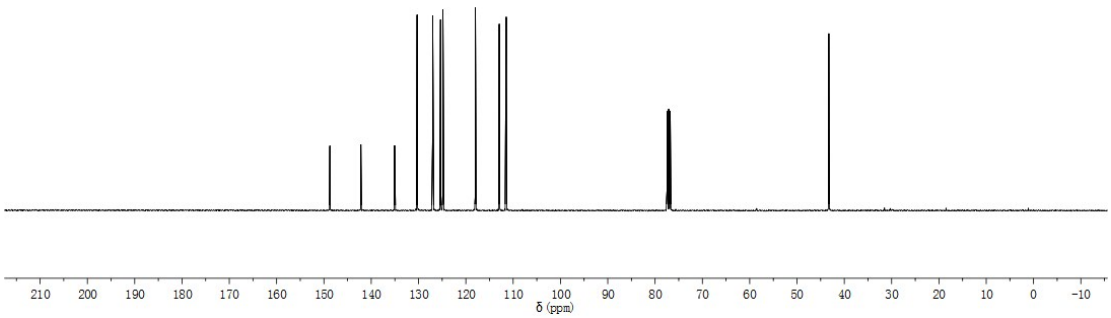

H
N
F
8j
5.07
1.93
1.95
2.00
0.83
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

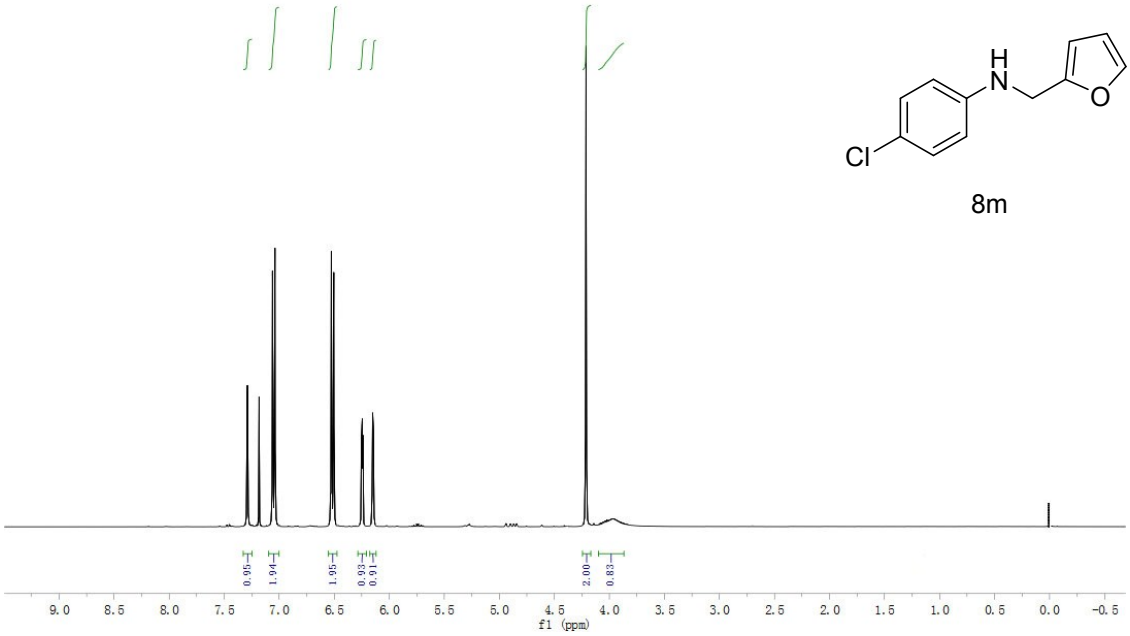

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

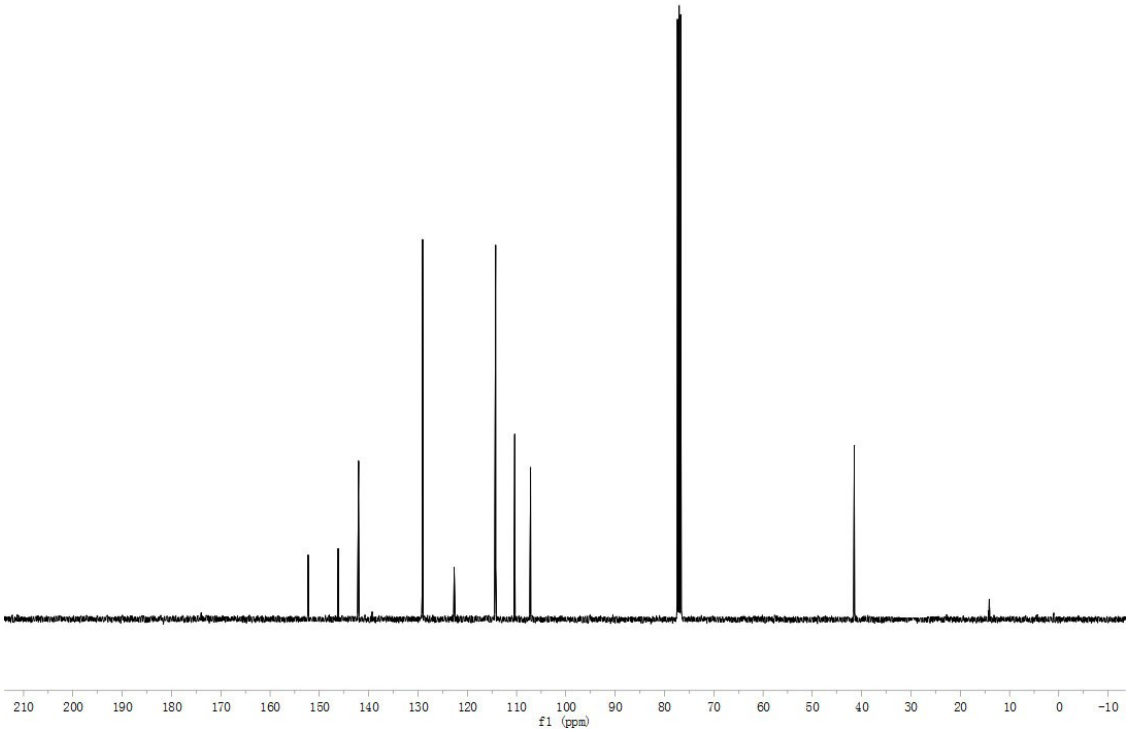

H
N
MeO
8k
4.13
1.21
1.96
1.98
2.00
3.83
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

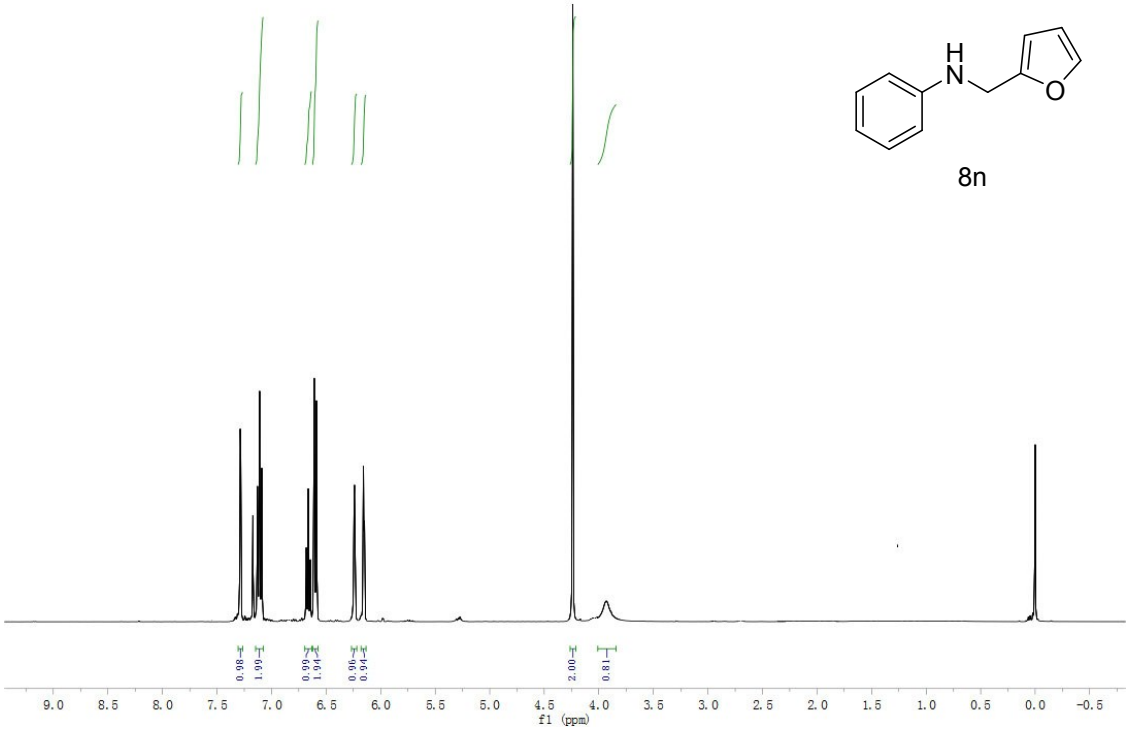

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

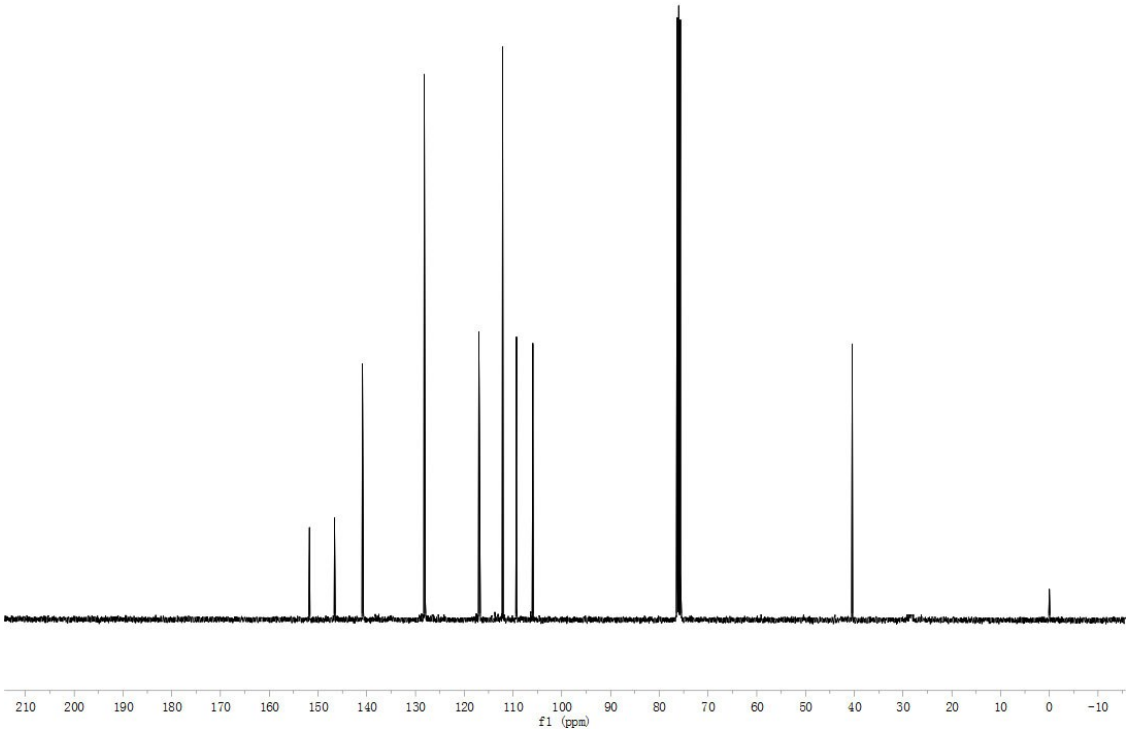

Cl
H
N
O
8l
0.90
0.95
0.94
0.92
0.96
0.92
0.90
2.00
0.83
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

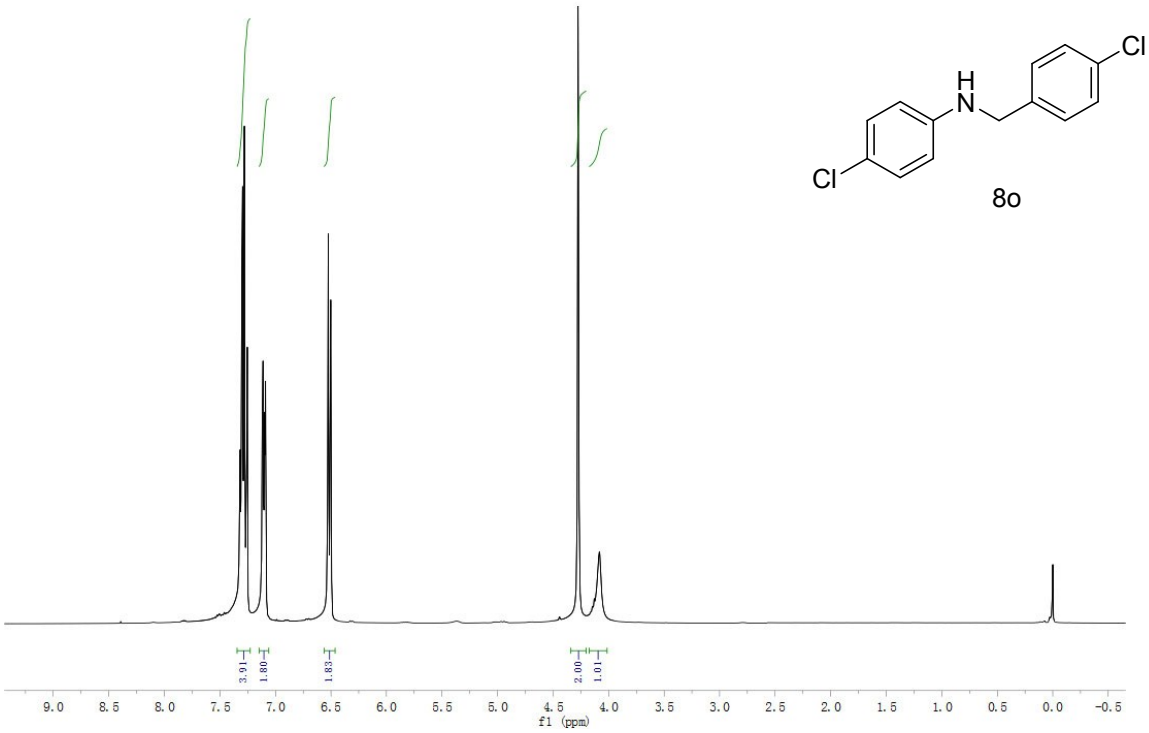

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)

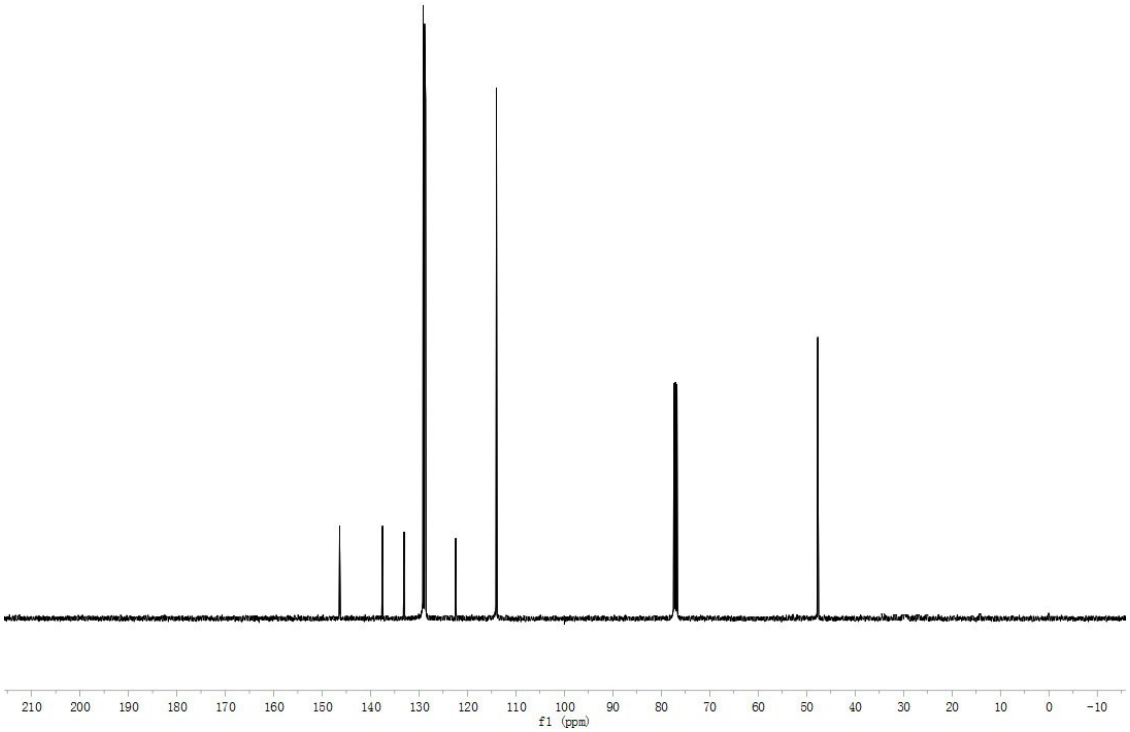

H
N
O
Cl
8m
0.95
1.94
1.95
0.93
0.91
2.00
0.83
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

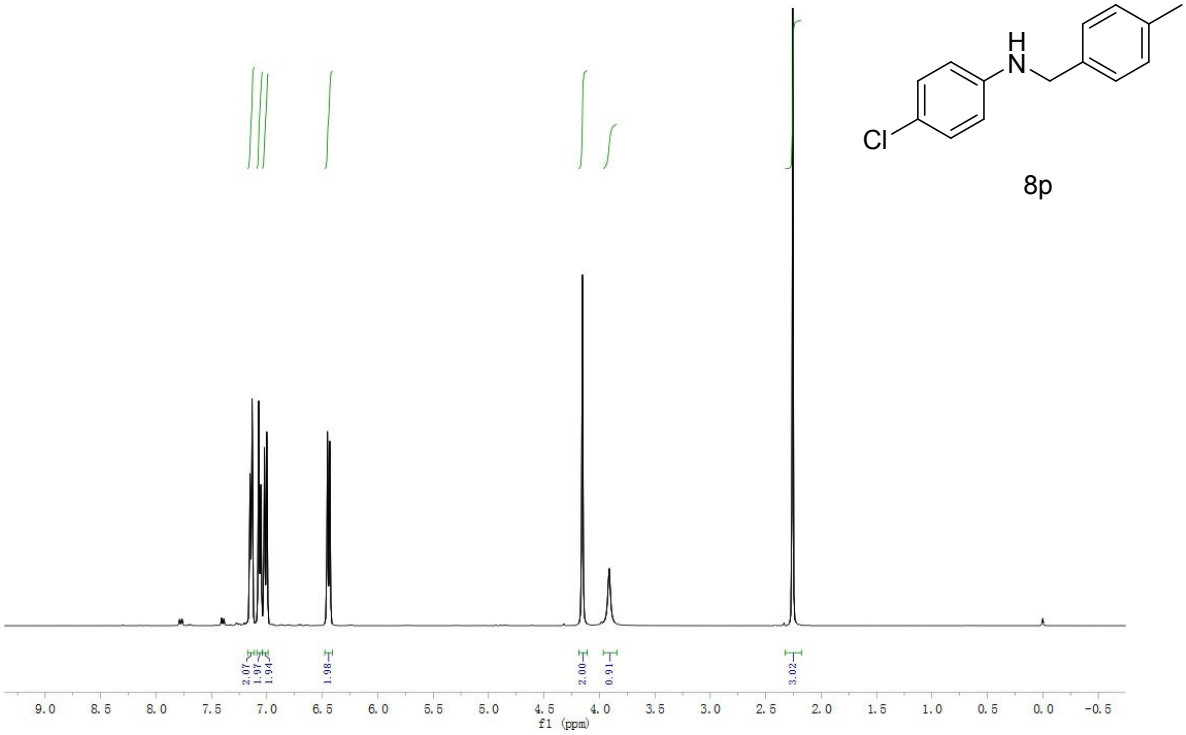

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

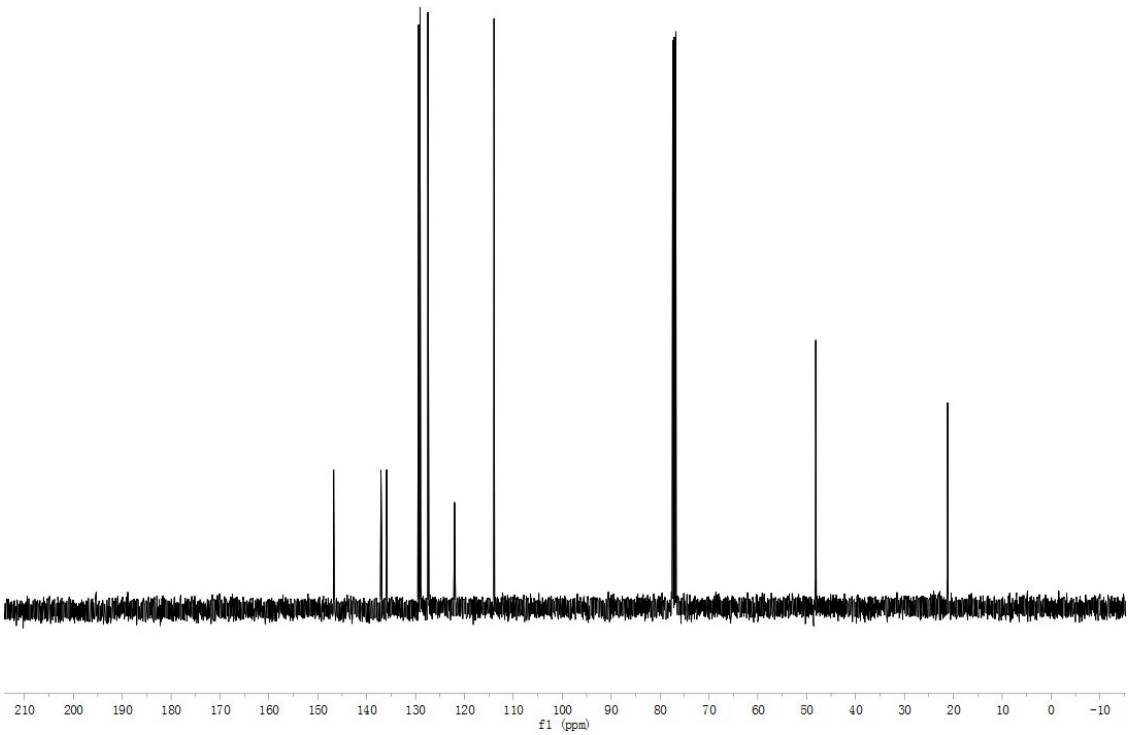

H
N
O
8n
0.98
1.99
0.99
1.94
0.96
0.94
2.00
0.81
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

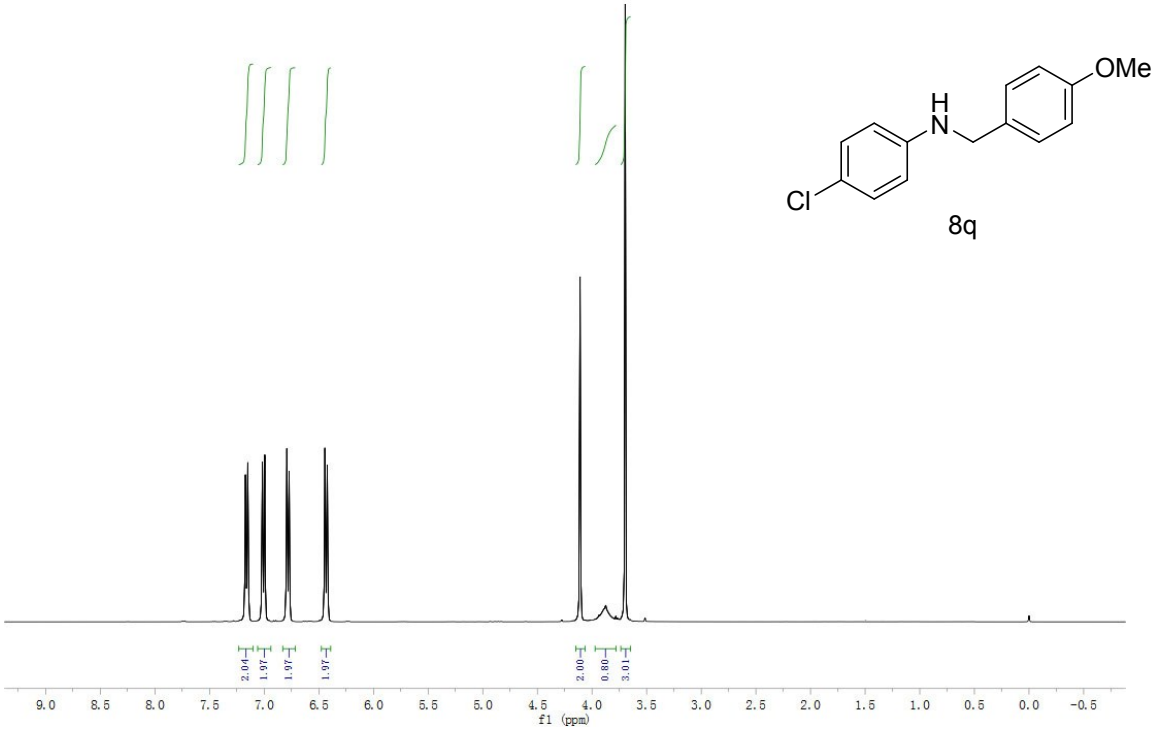

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

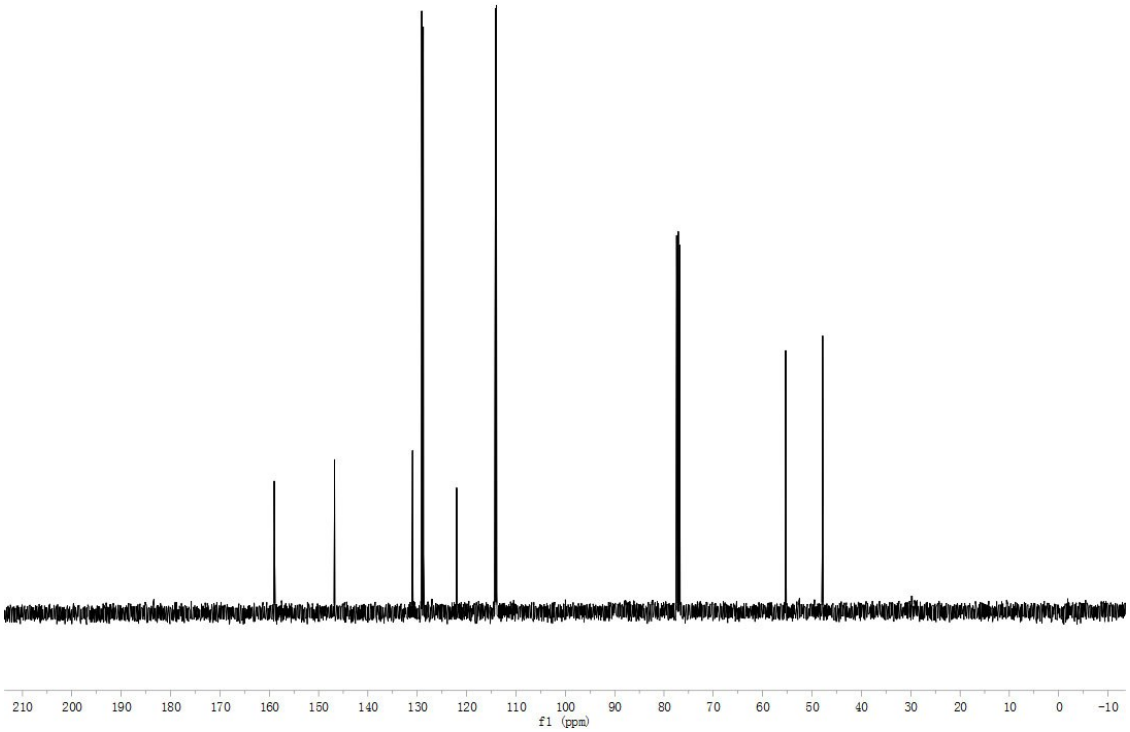

Cl
H
N
Cl
8o
3.91
1.80
1.83
2.00
1.01
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

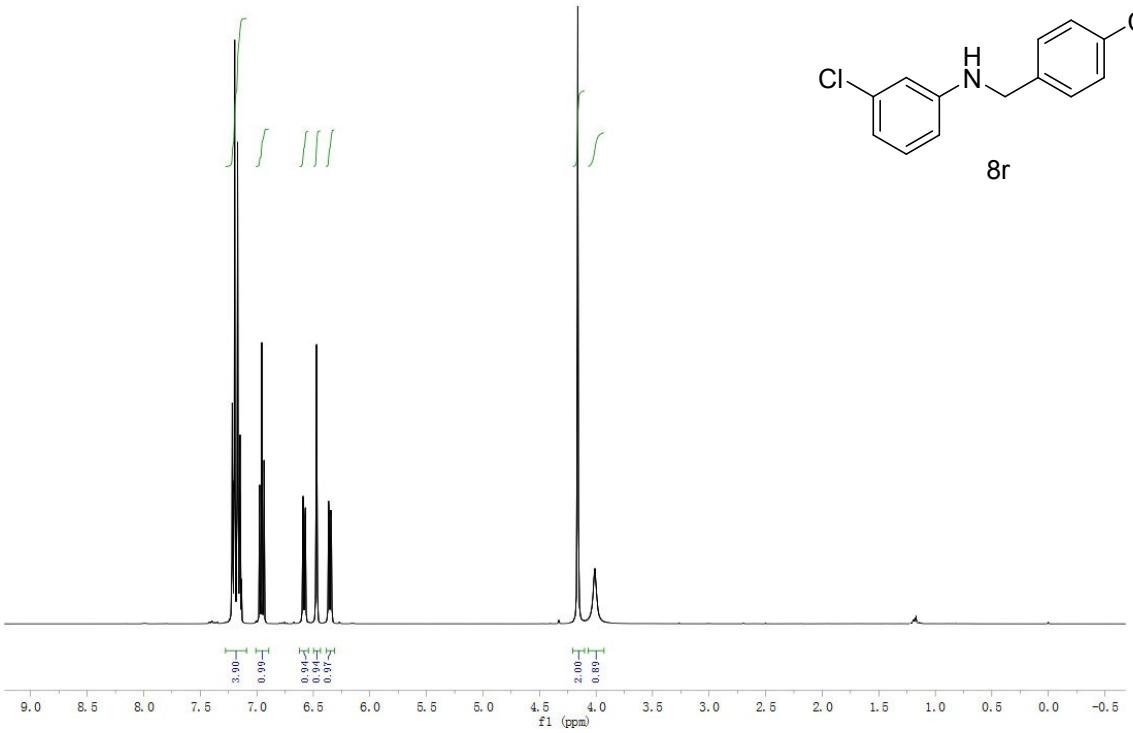

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

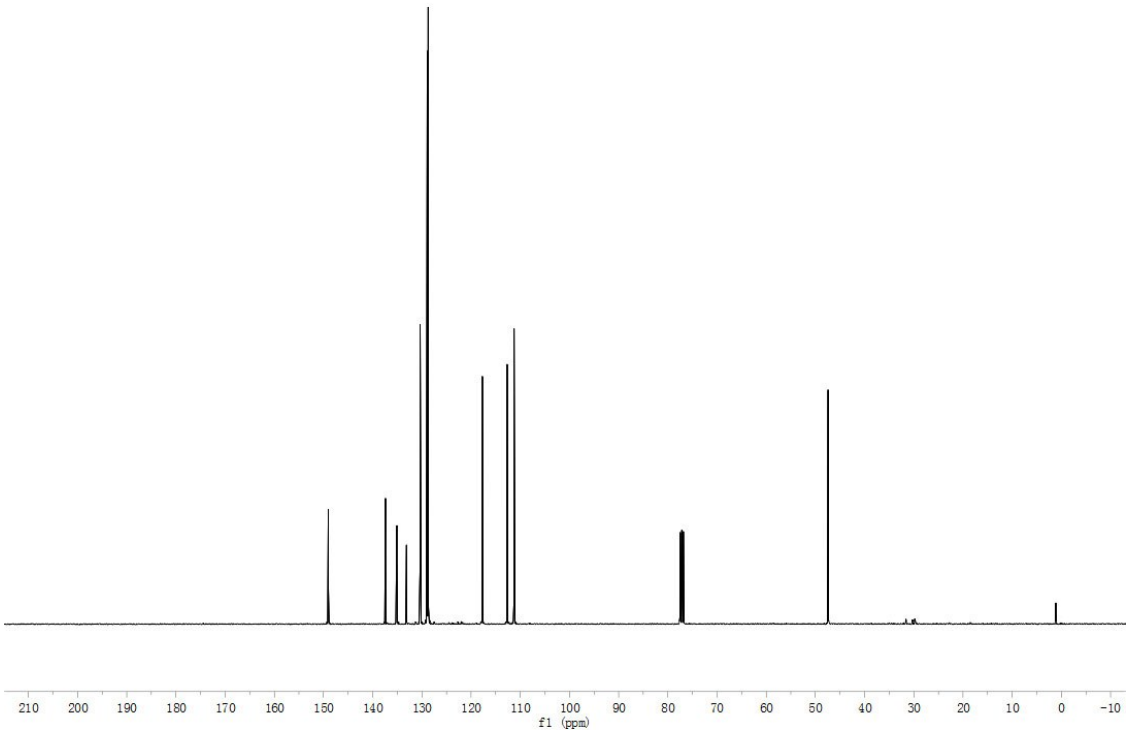

H
N
Cl
8p
2.07
1.97
1.94
1.98
2.00
0.91
3.02
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

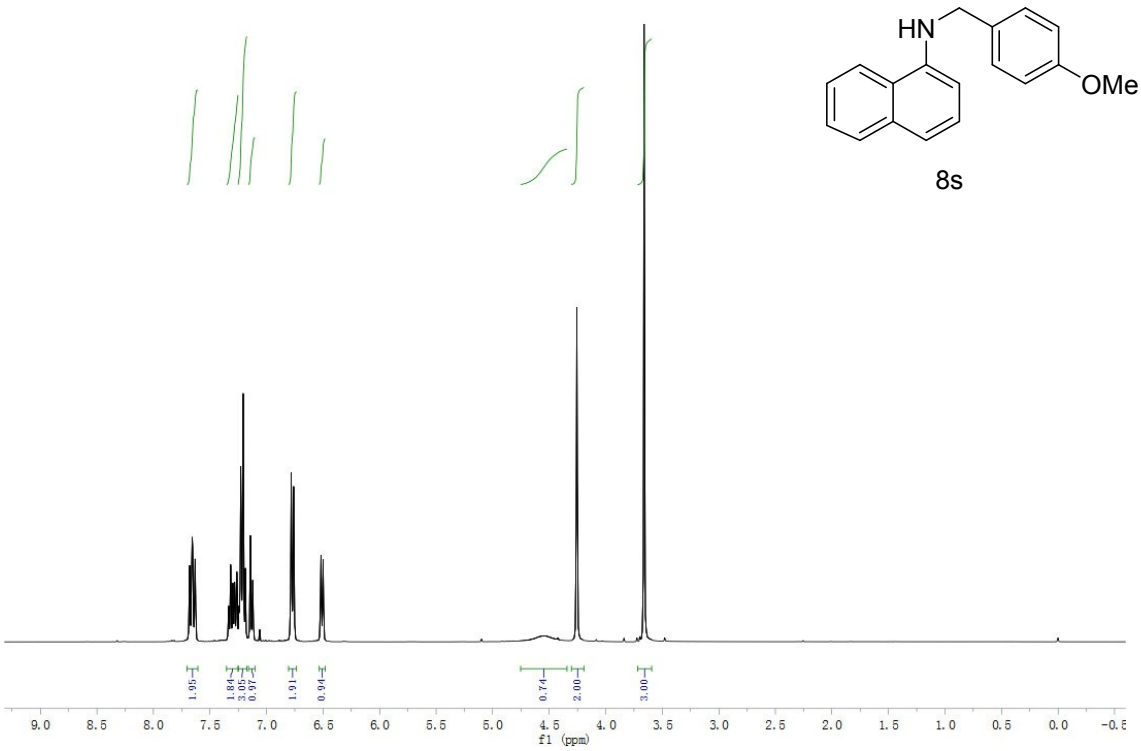

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

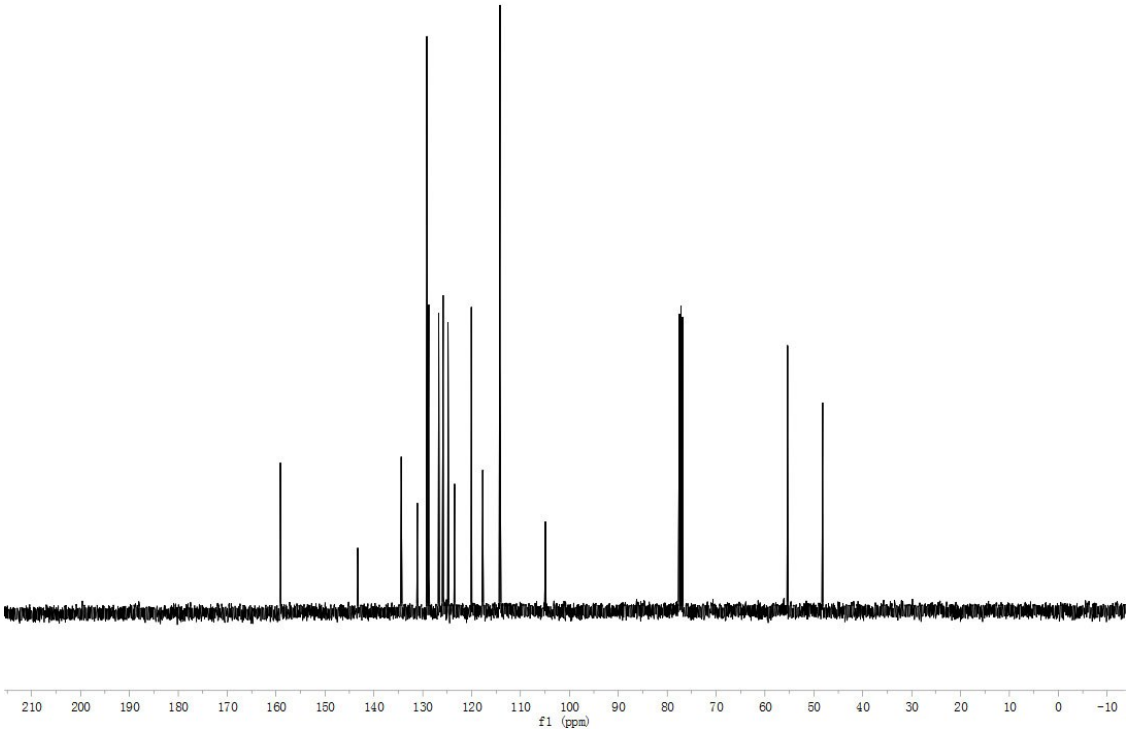

OMe
H
N
Cl
8q
2.04
1.97
1.97
1.97
2.00
0.80
3.01
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

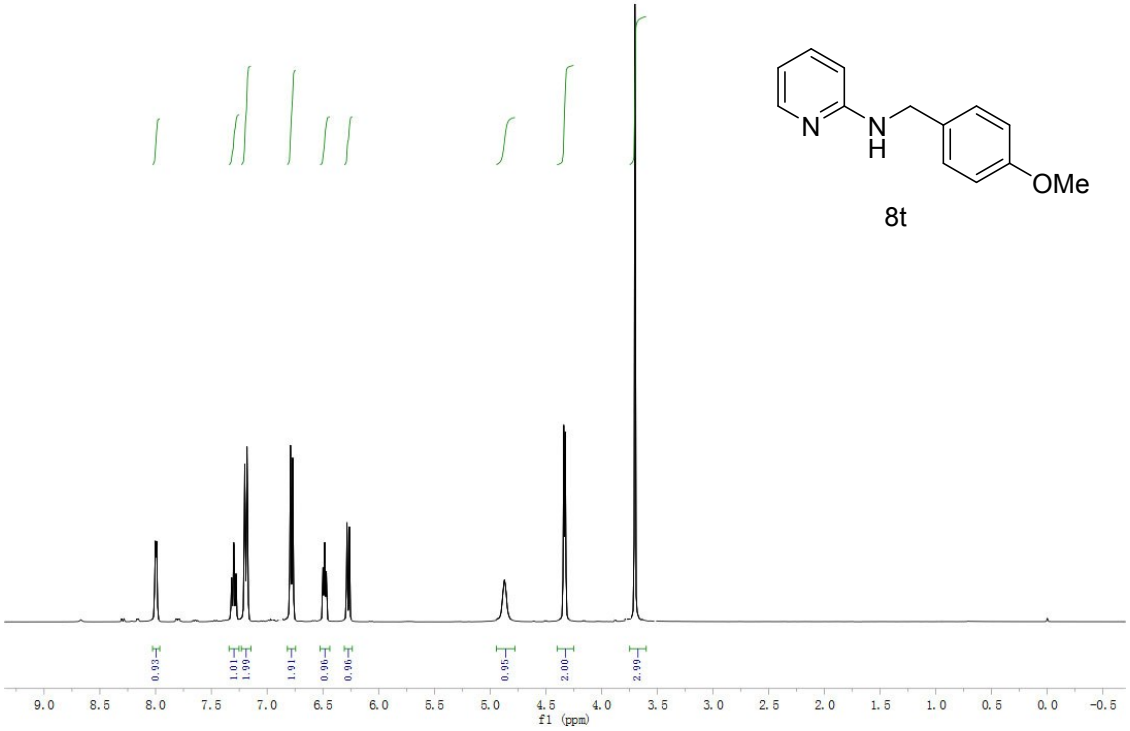

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

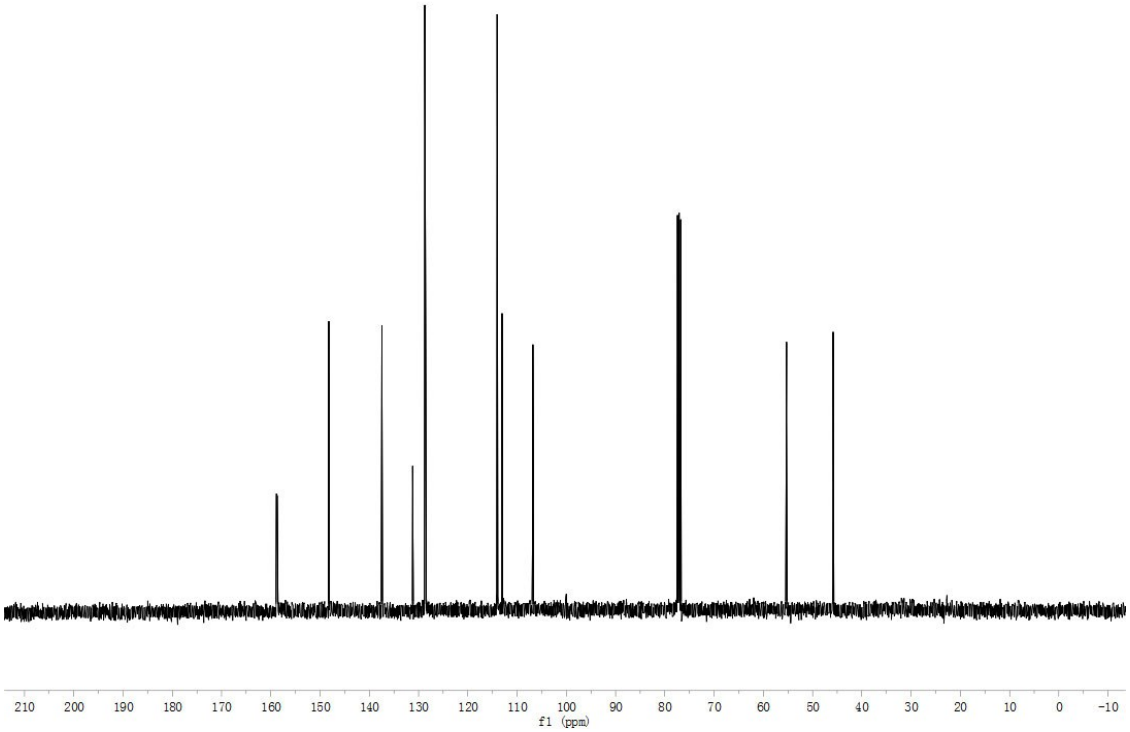

Cl
H
N
Cl
8r
3.90
0.99
0.94
0.94
0.97
2.00
0.89
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

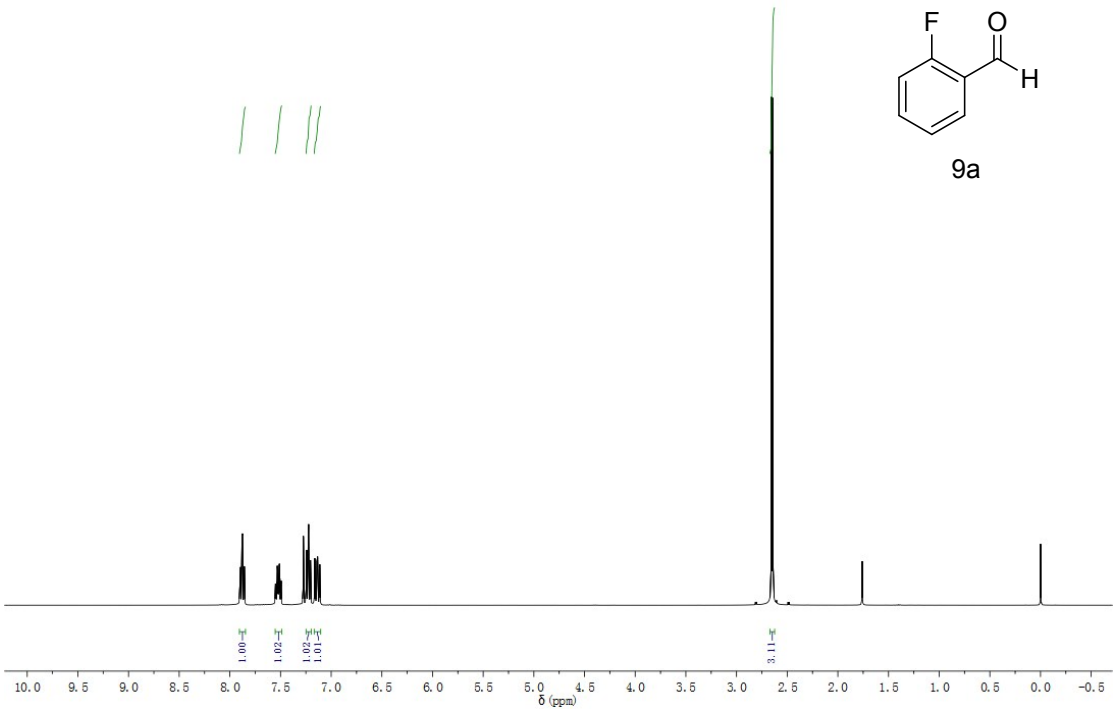

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

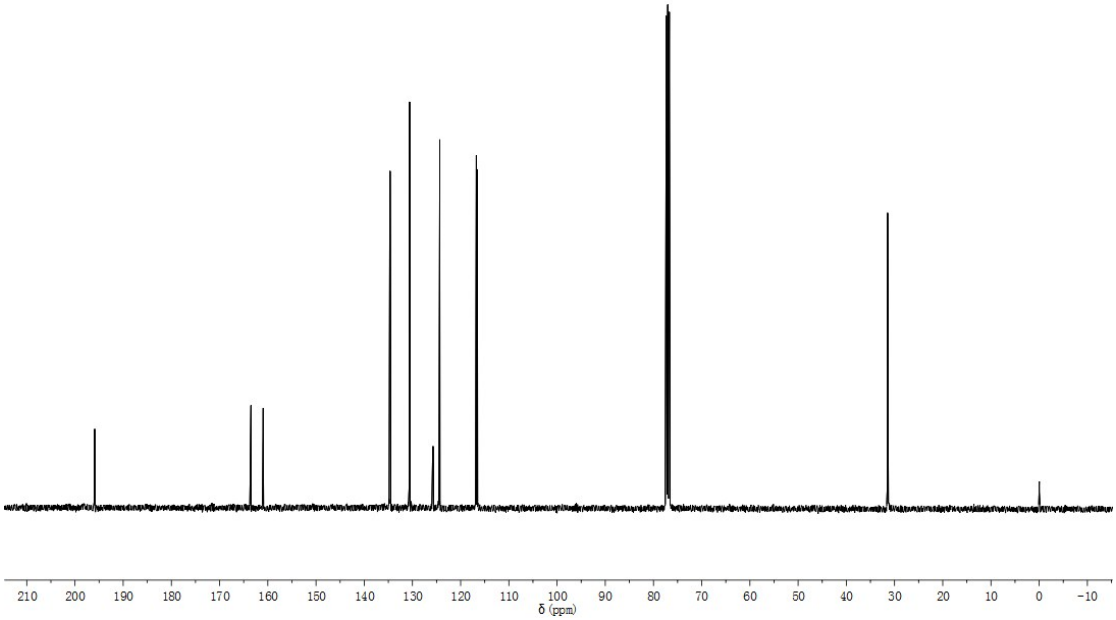

HN
OMe
8s
1.95
1.84
3.05
0.97
1.91
0.94
0.74
2.00
3.00
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

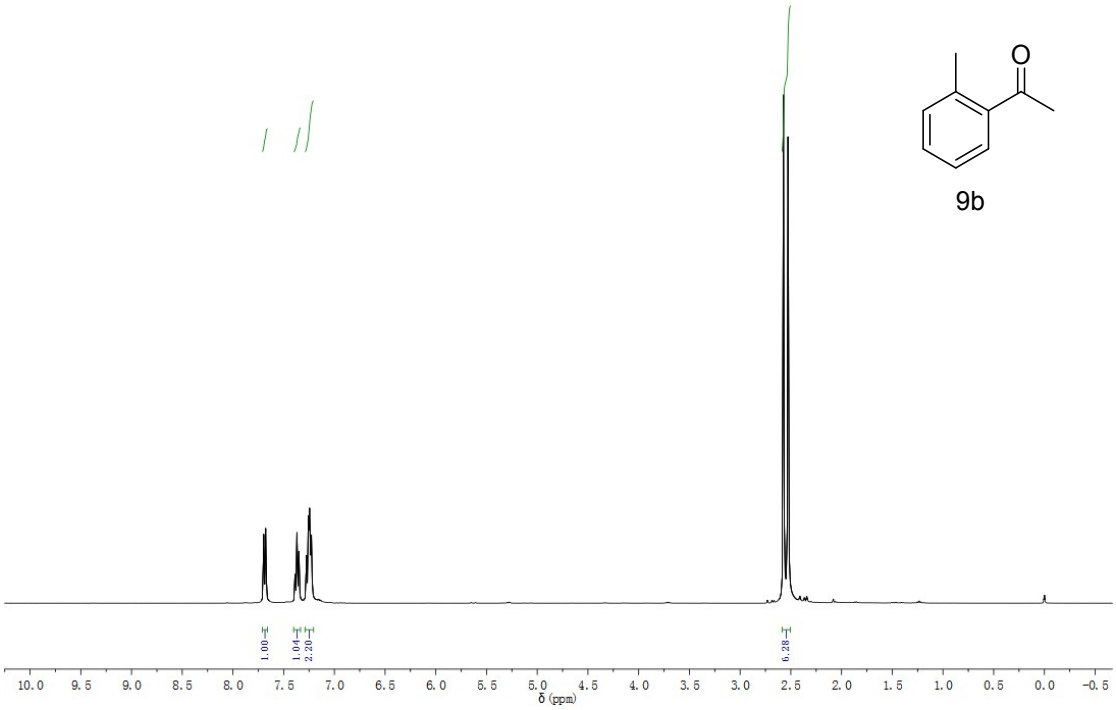

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

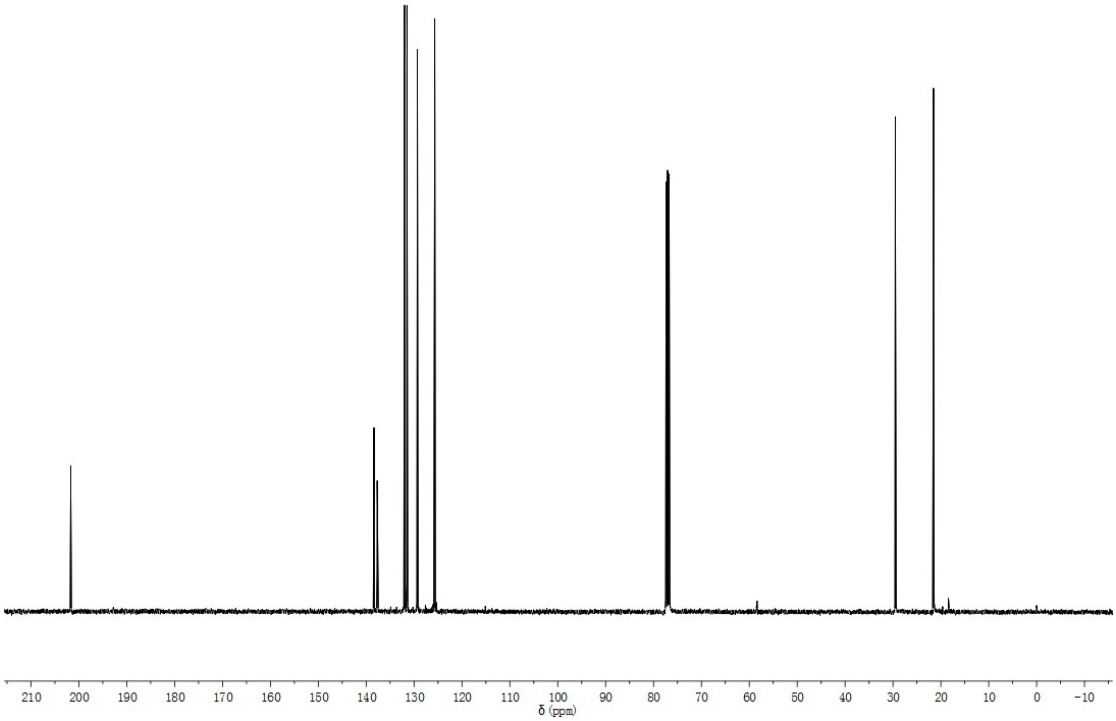

N
N
H
OMe
8t
0.93
1.01
1.99
1.91
0.96
0.96
0.95
2.00
2.99
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

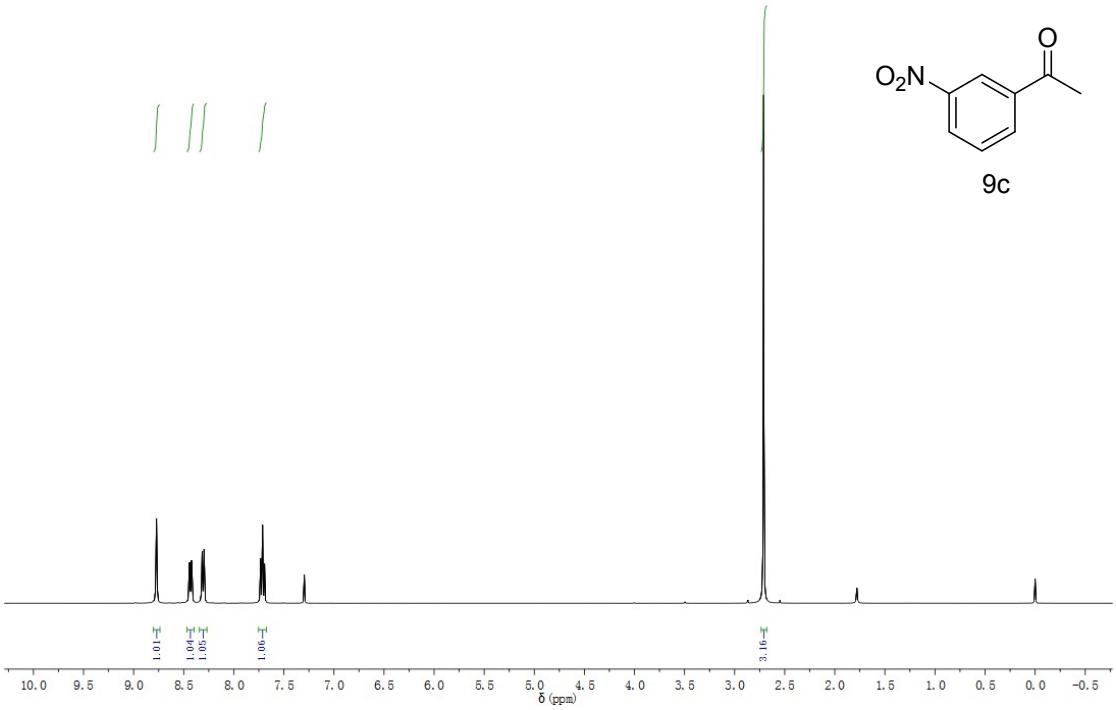

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

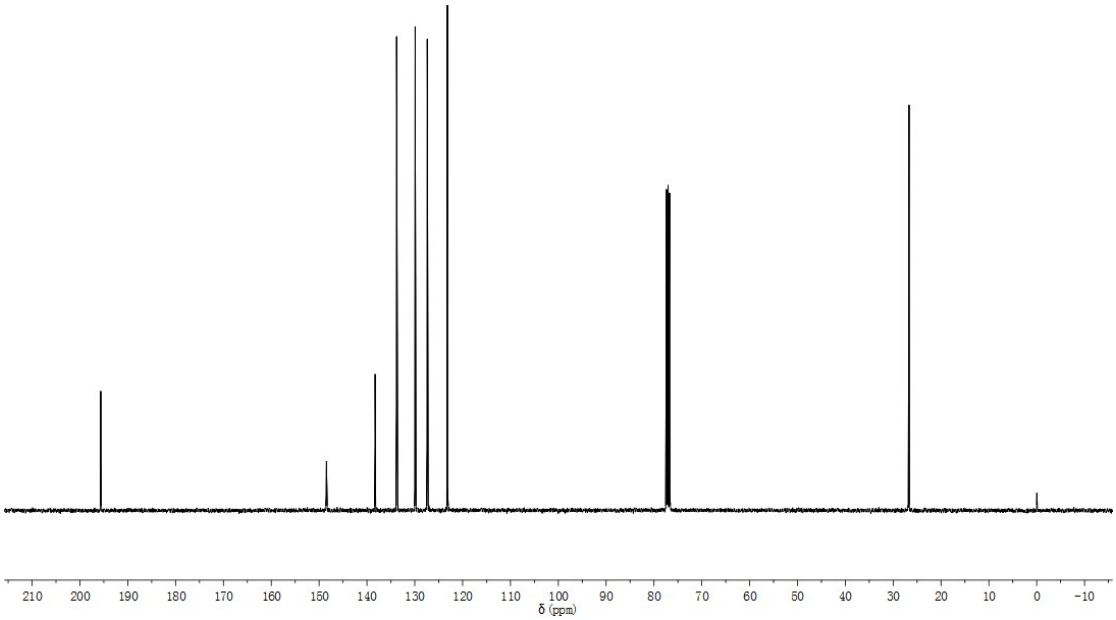

F
O
H
9a
1.00
1.02
1.02
1.01
3.11
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
δ (ppm)

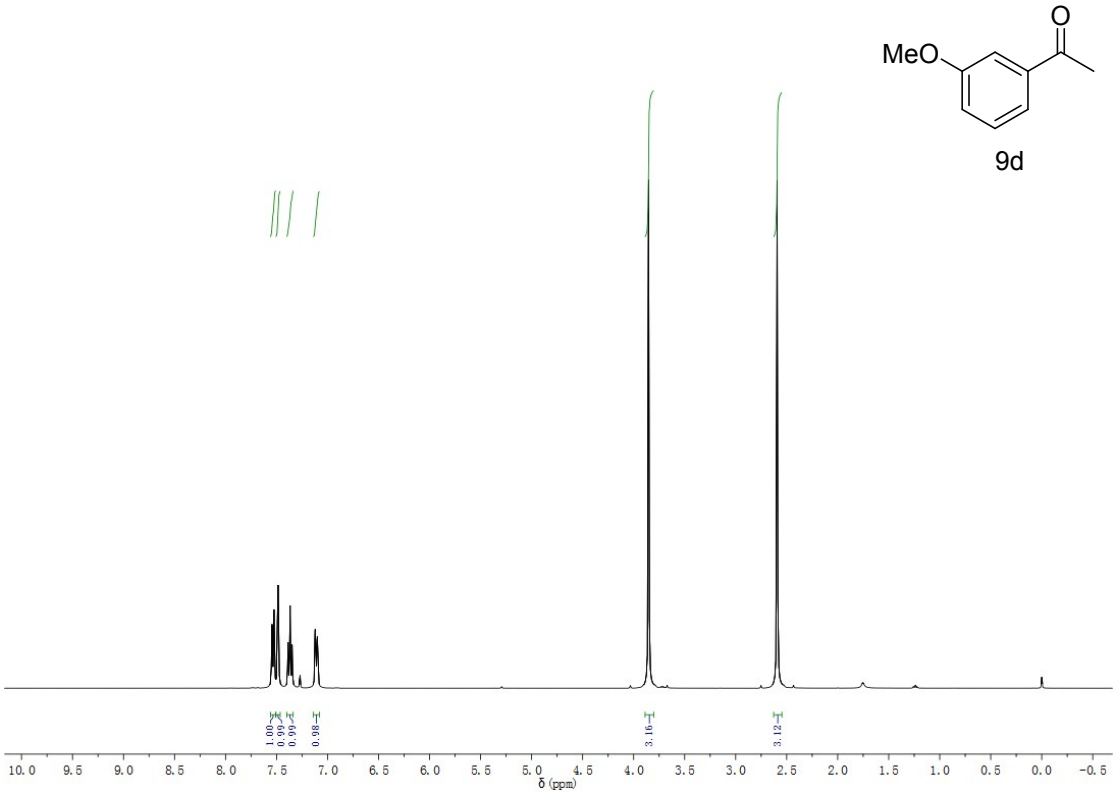

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)

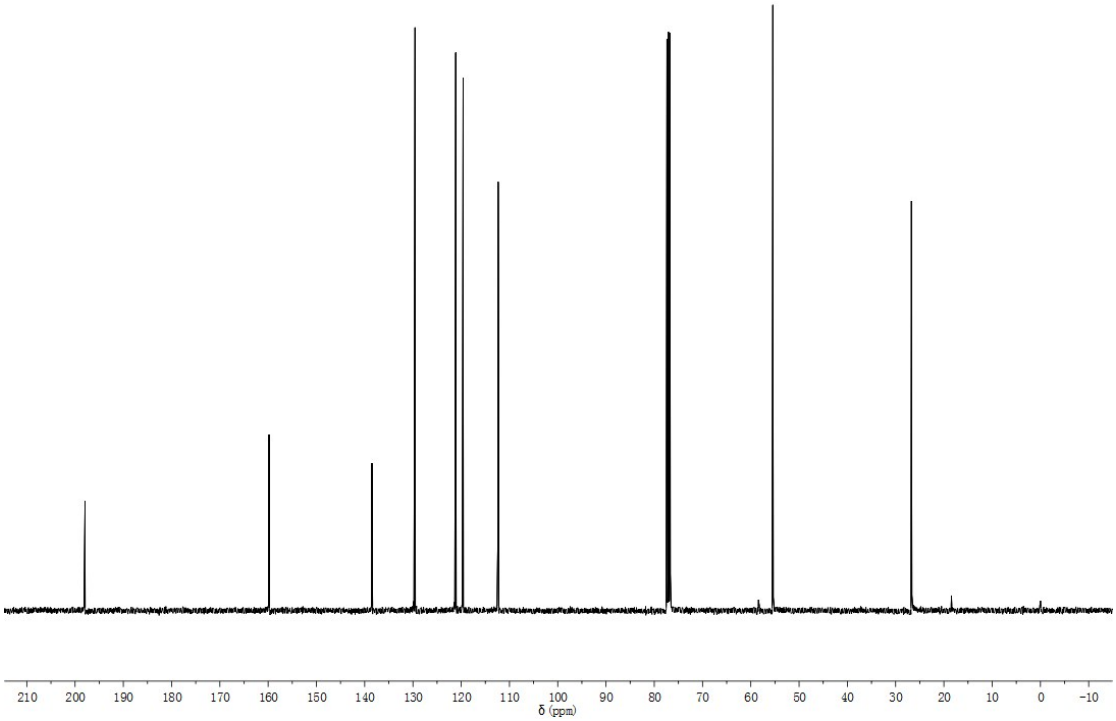

O
9b
1.00
1.04
2.20
6.28
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
δ (ppm)

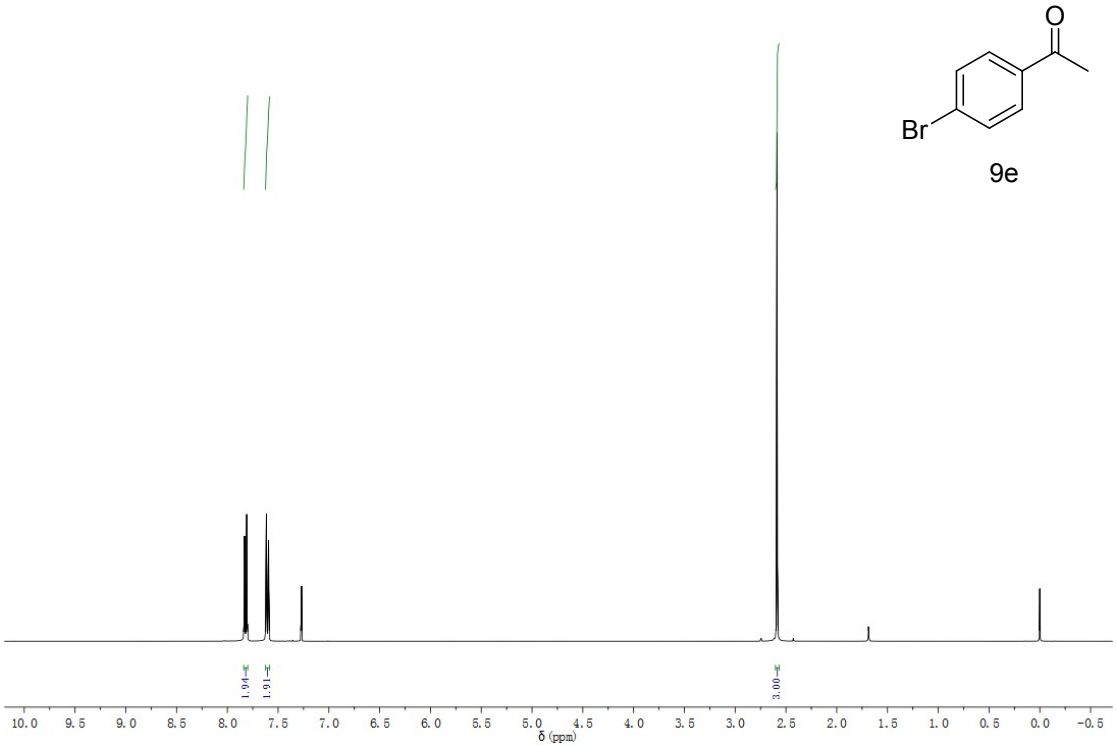

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)

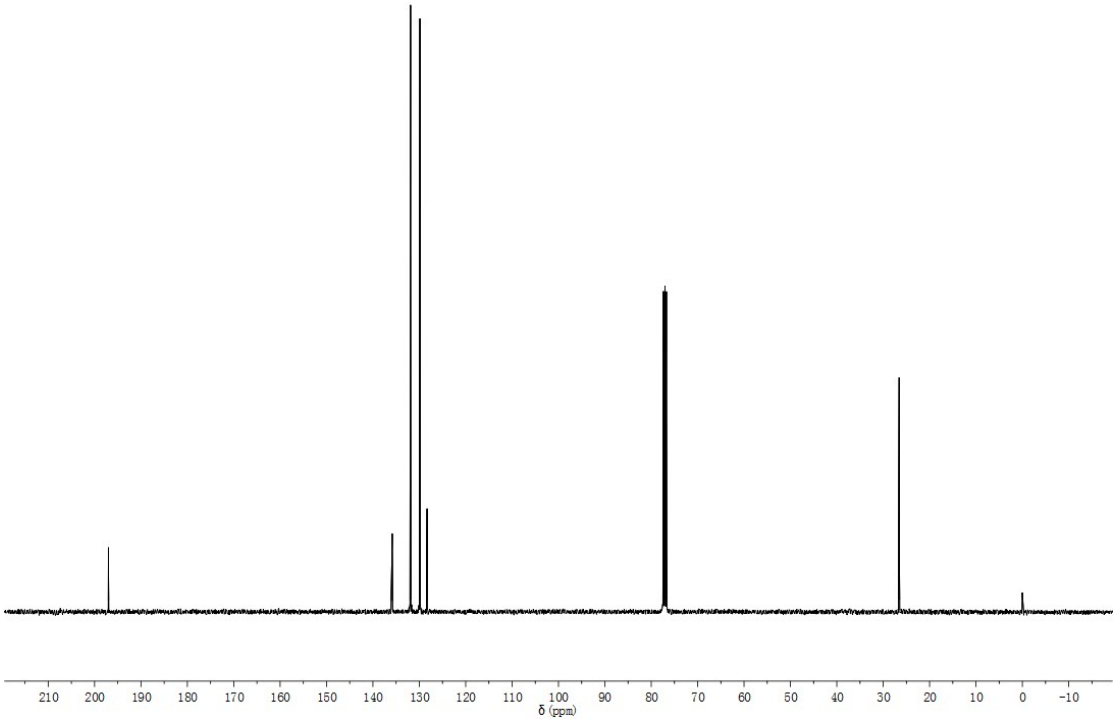

O
$O_2N$
9c
1.01
1.04
1.05
1.06
3.16
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
δ (ppm)

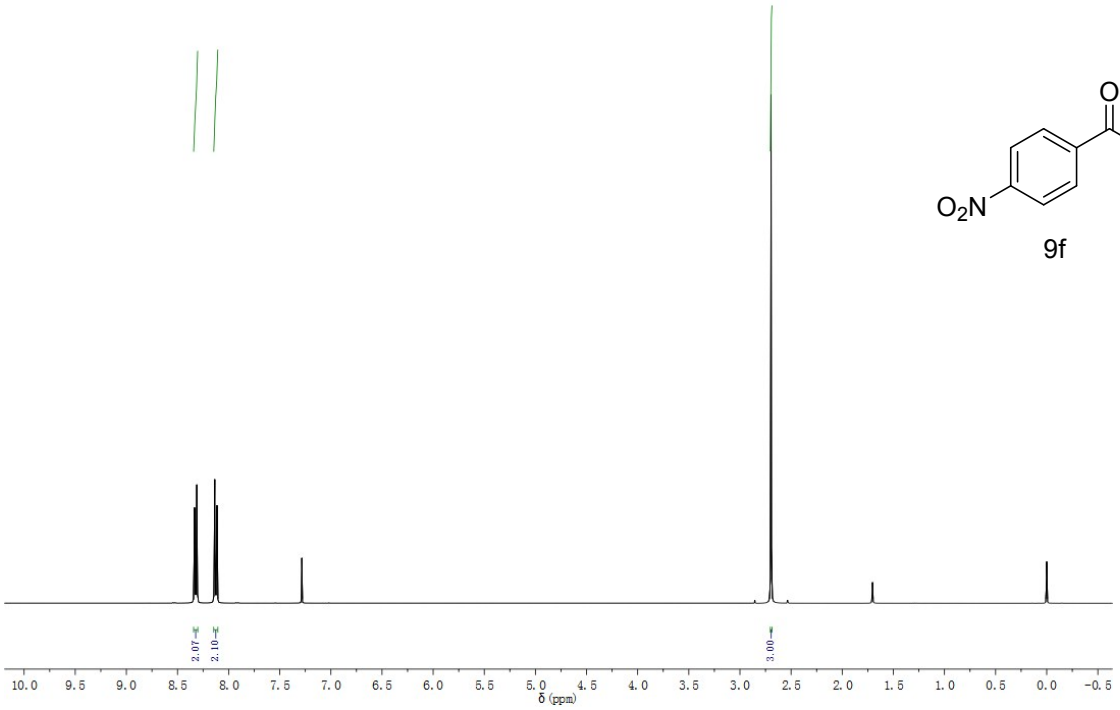

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)

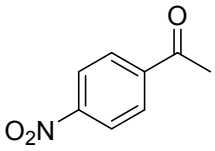

MeO
O
9d
1.00
0.99
0.99
0.98
3.16
3.12
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
δ (ppm)


δ (ppm)

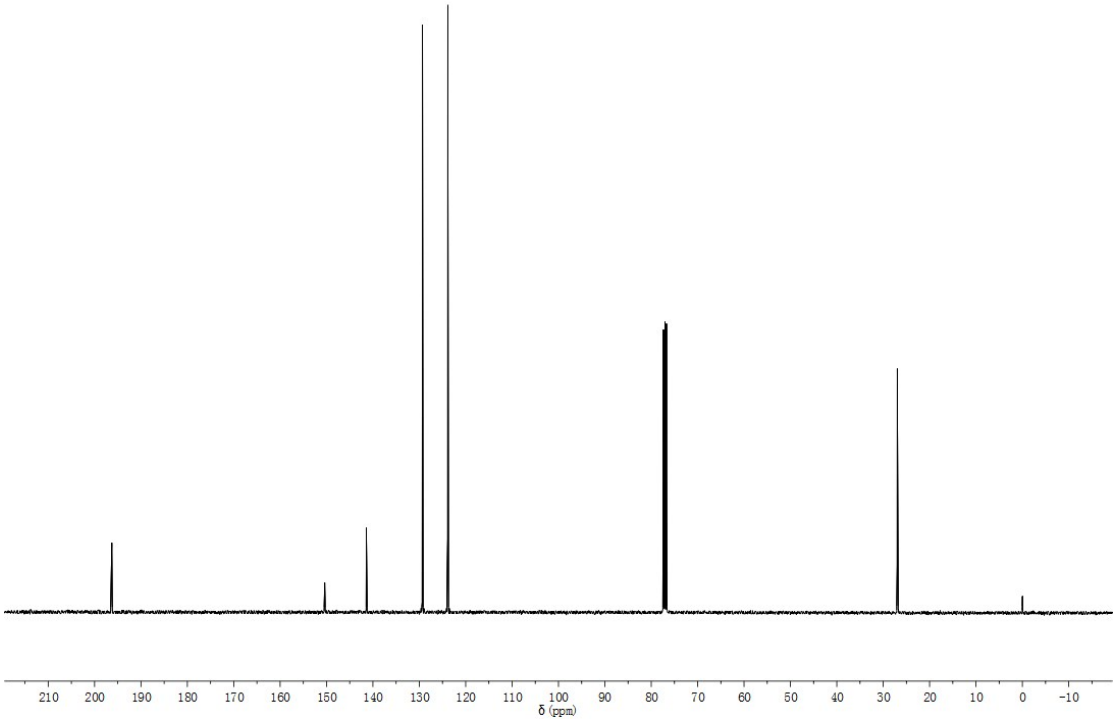

O
Br
9e
1.94
1.91
3.00
δ (ppm)

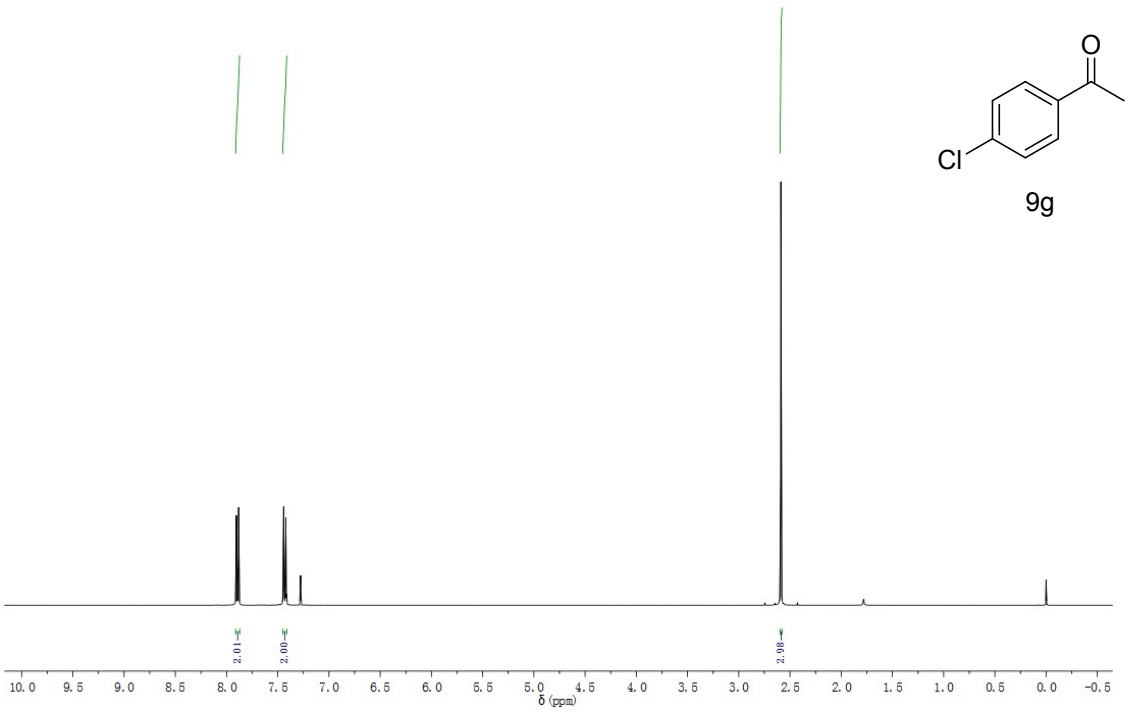

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)

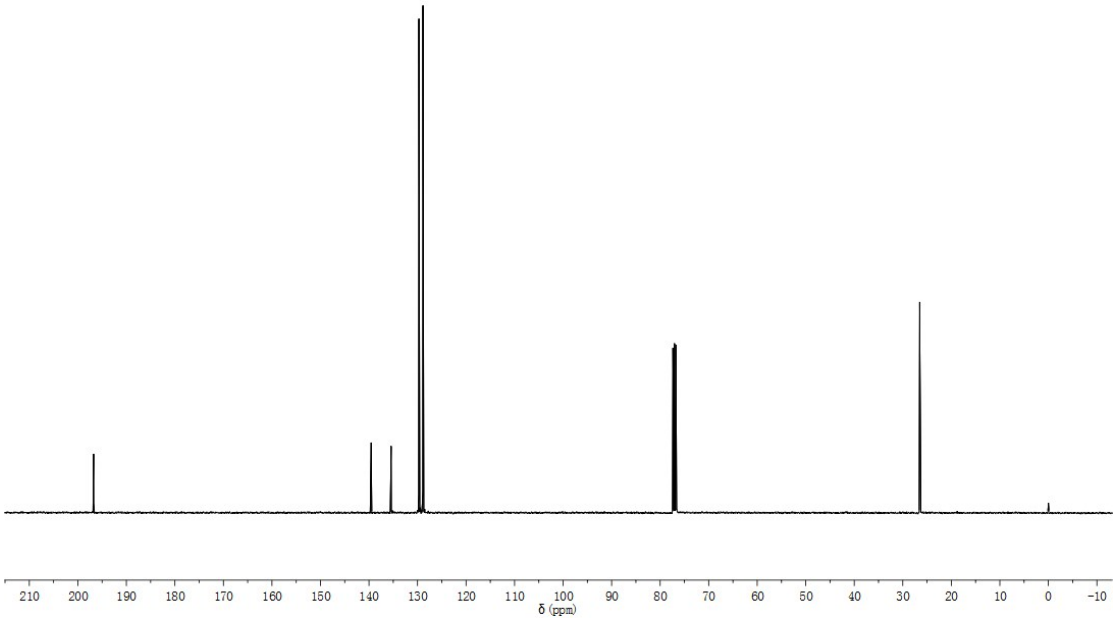

2.07
2.10
3.00
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
δ (ppm)

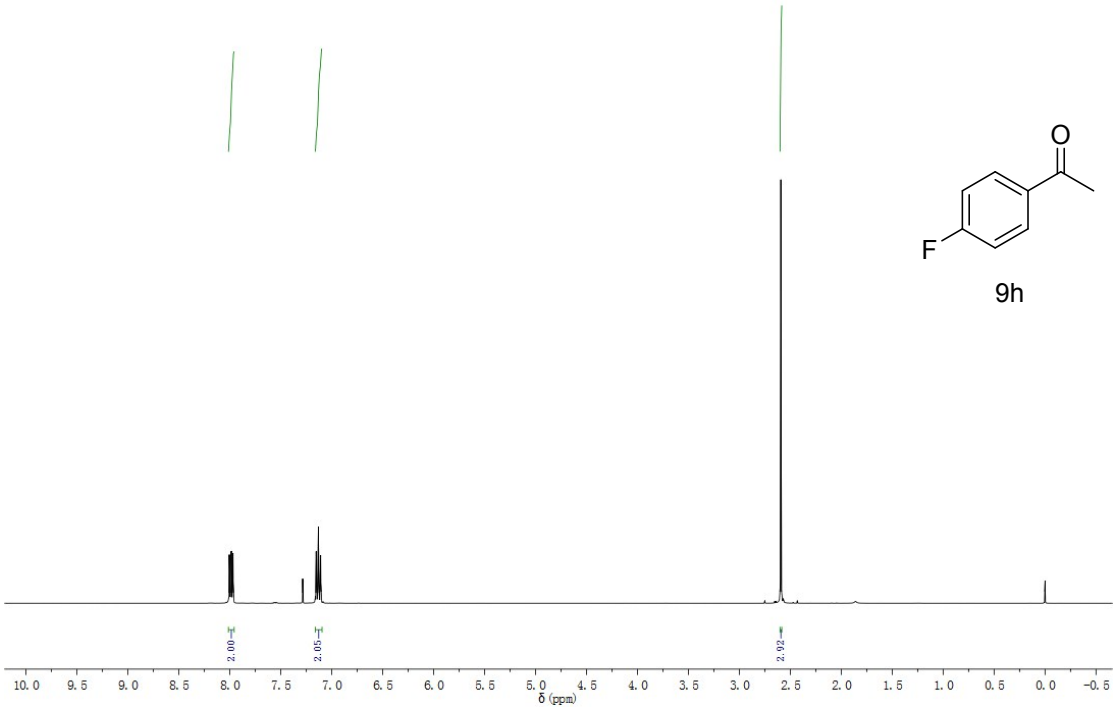

O
$O_2N$

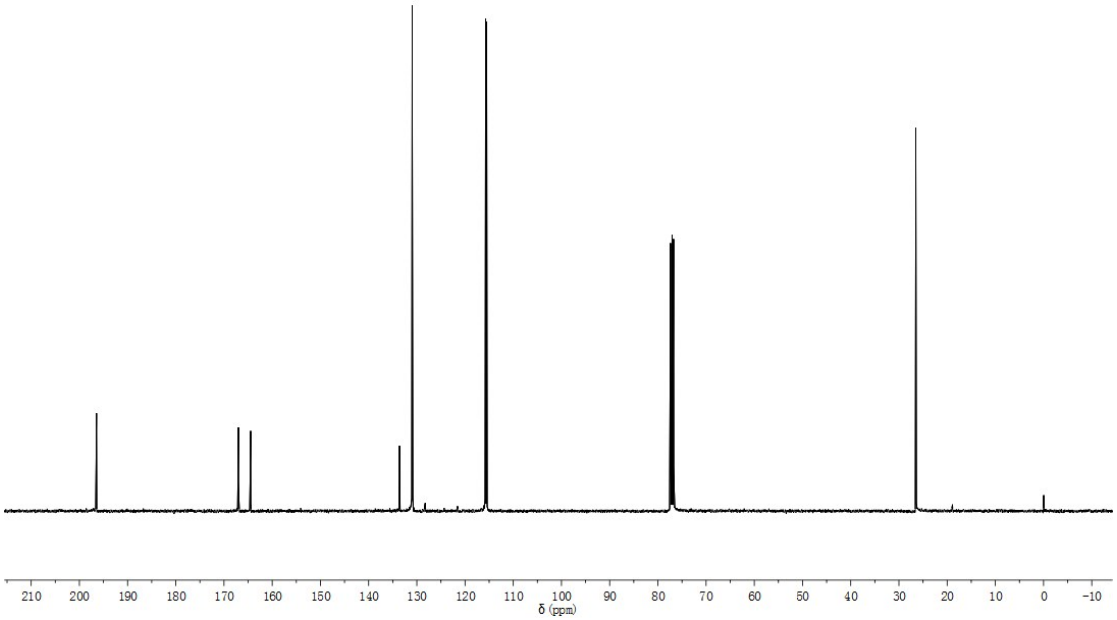
9f

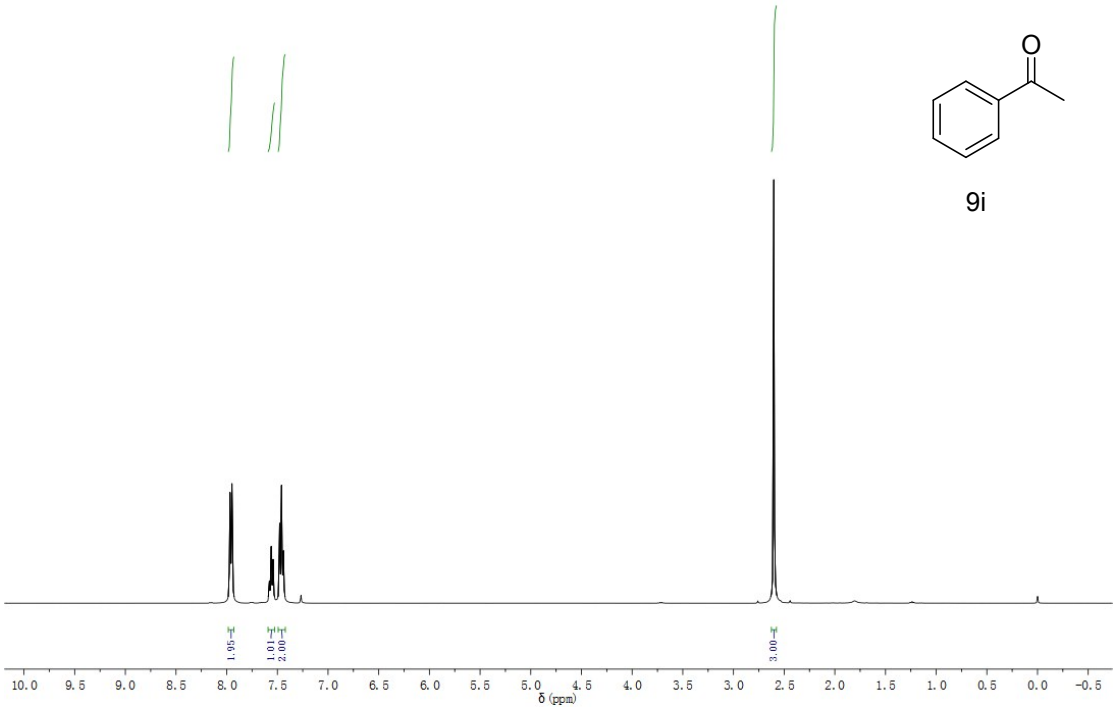

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)

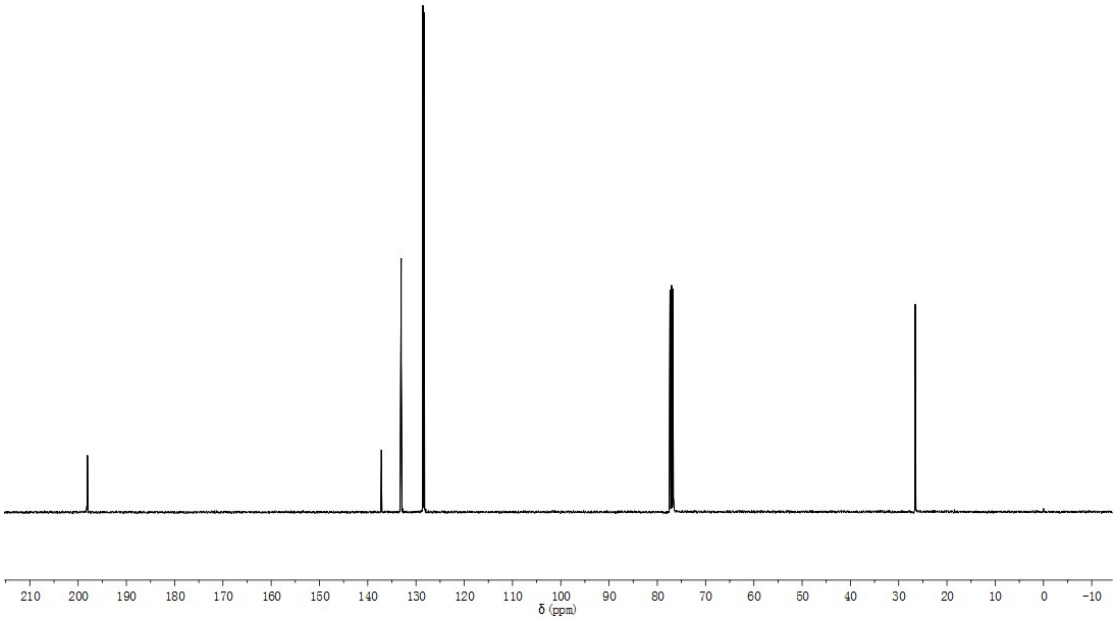

O
Cl
9g
2.01
2.00
2.98
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
δ (ppm)

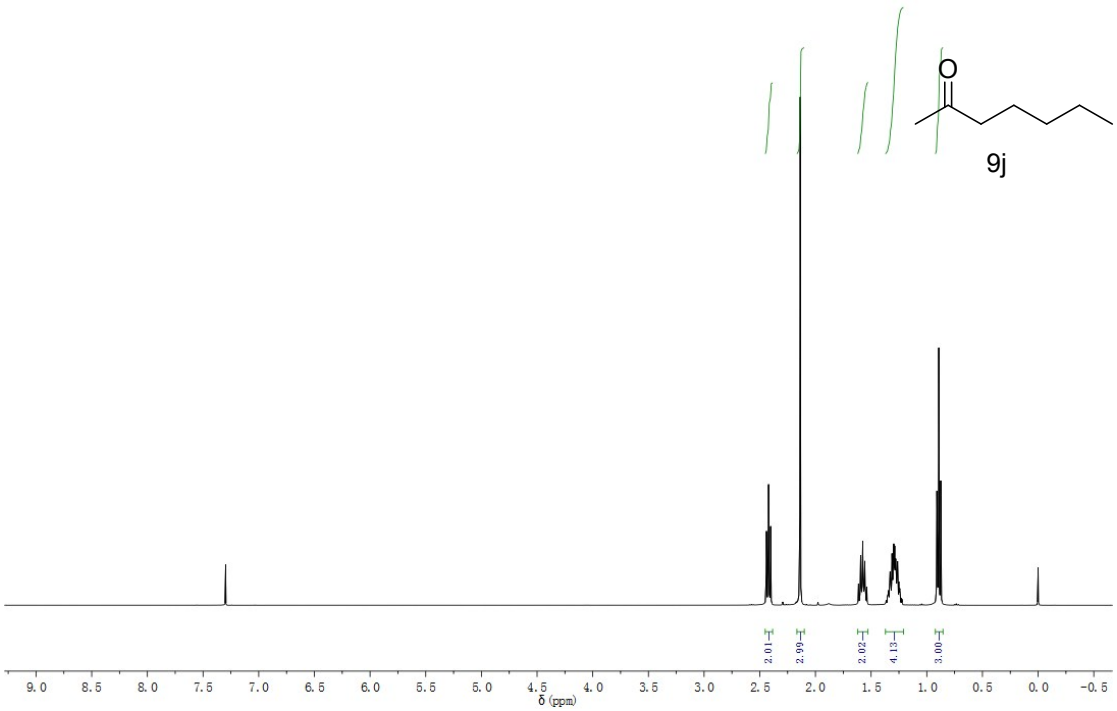

δ (ppm)

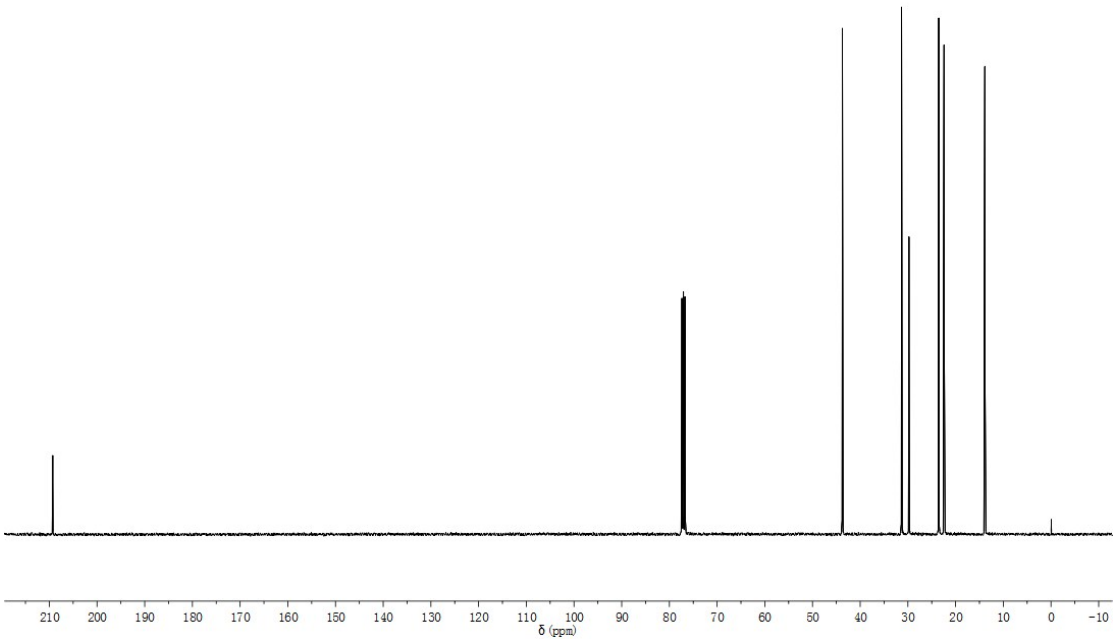

O
F
9h
2.00
2.05
2.92
δ (ppm)

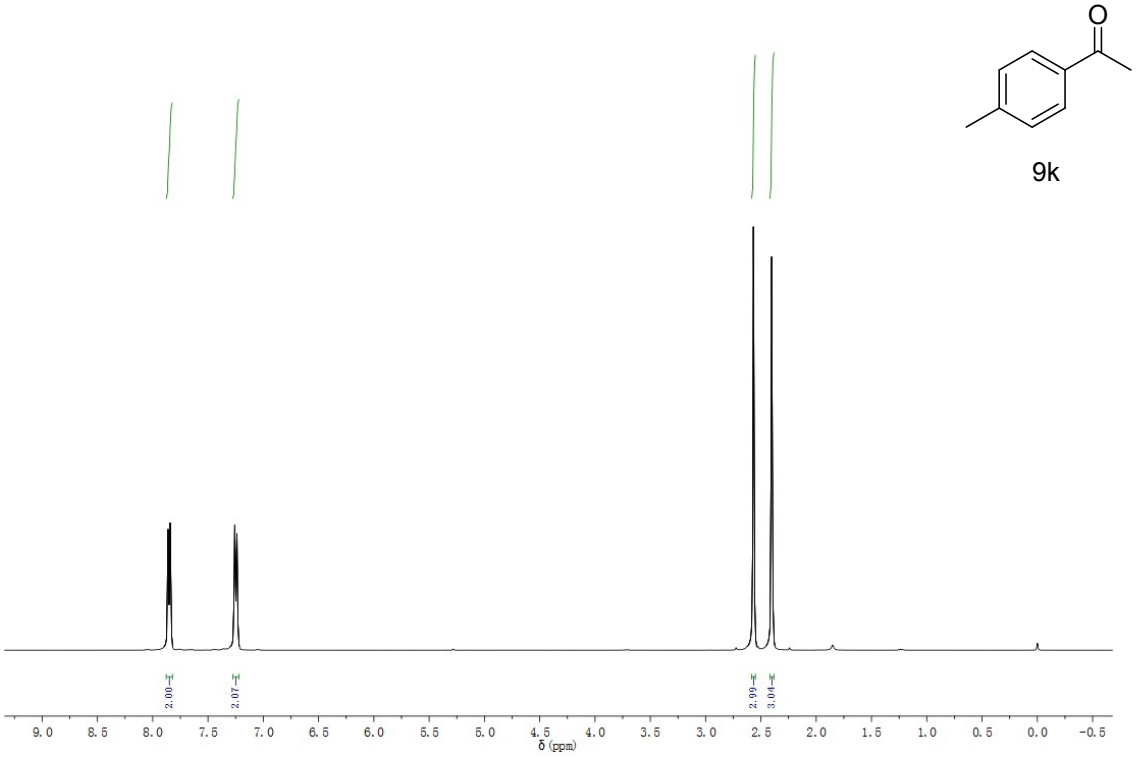

δ (ppm)

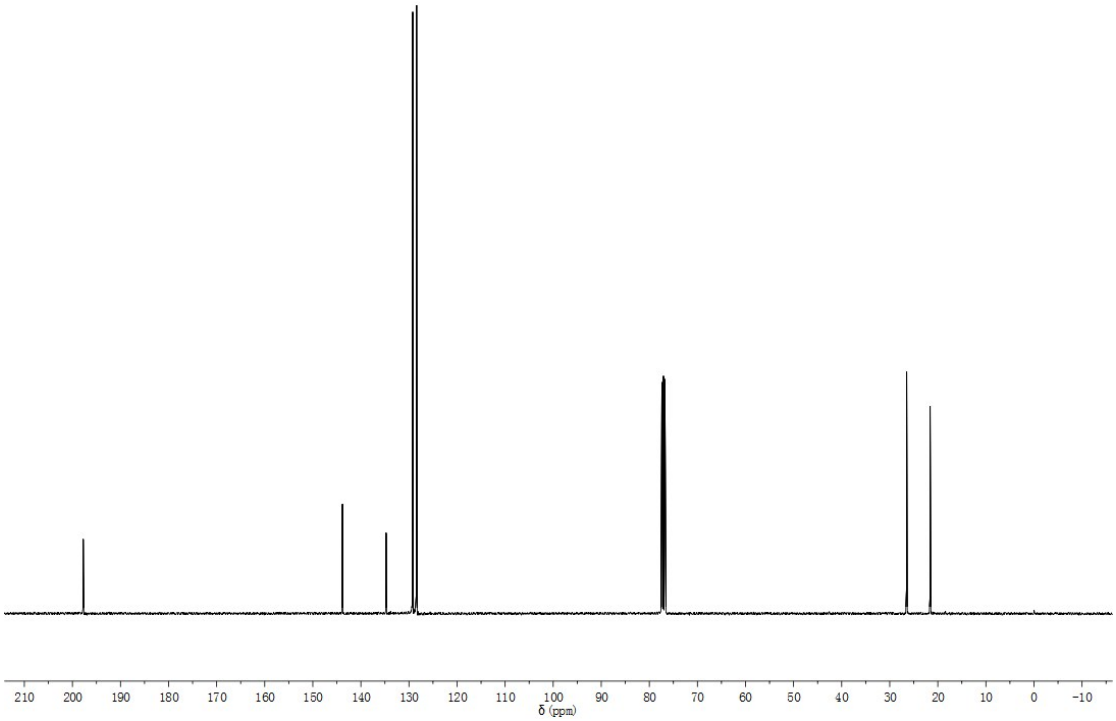

O
9i
1.95
1.01
2.00
3.00
δ (ppm)

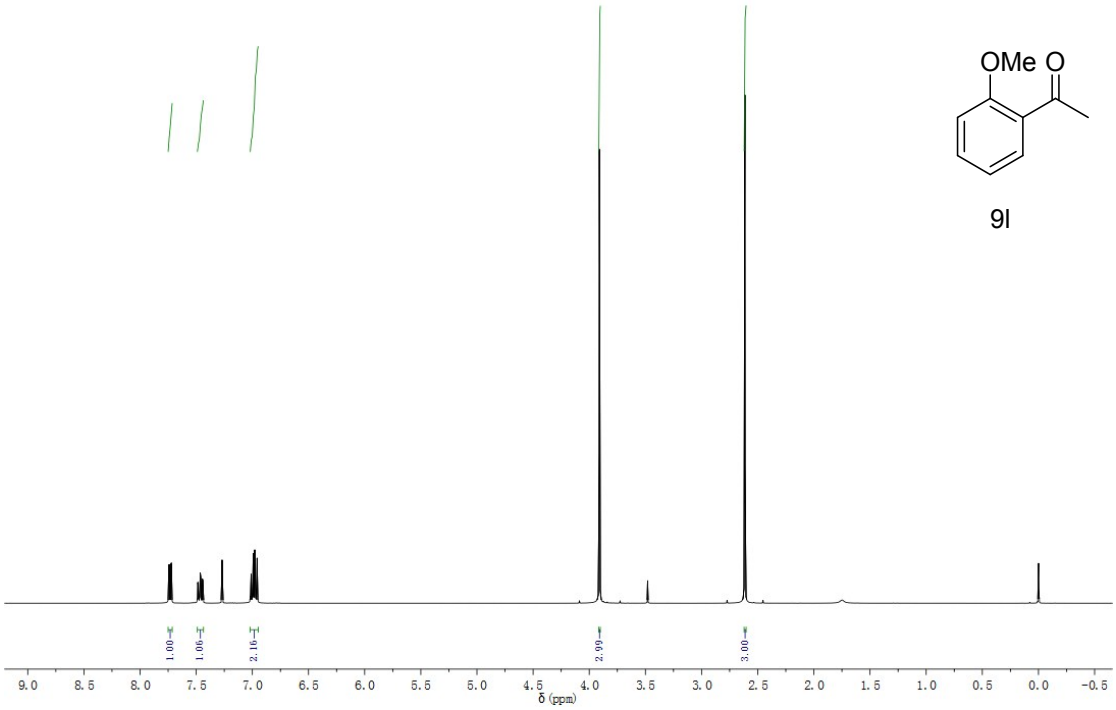

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)

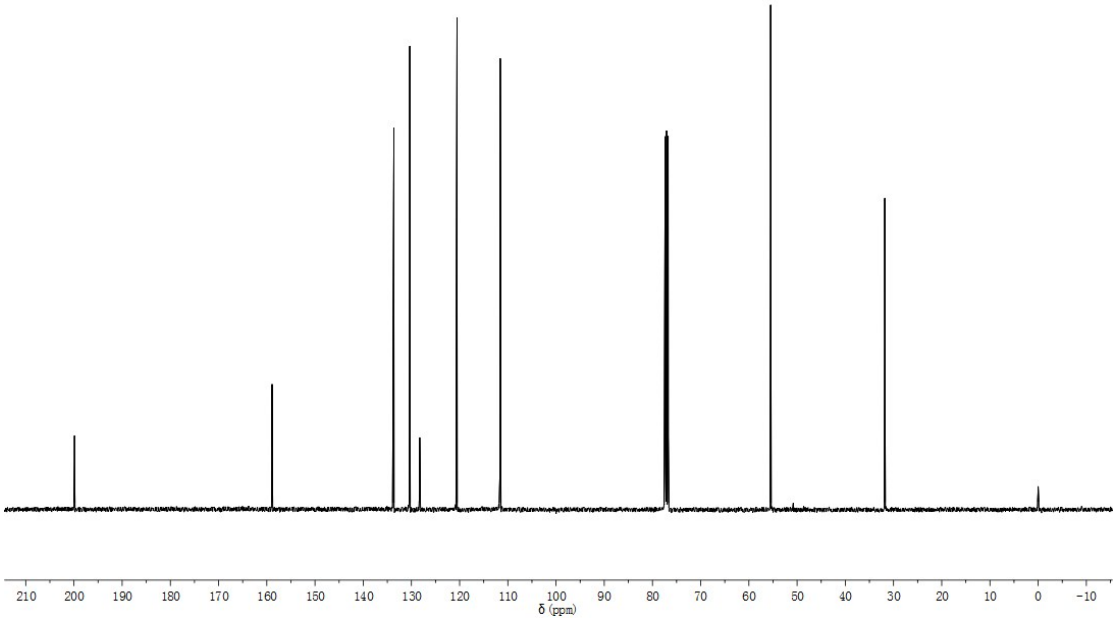

O
9j
2.01
2.99
2.02
4.13
3.00
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
δ (ppm)

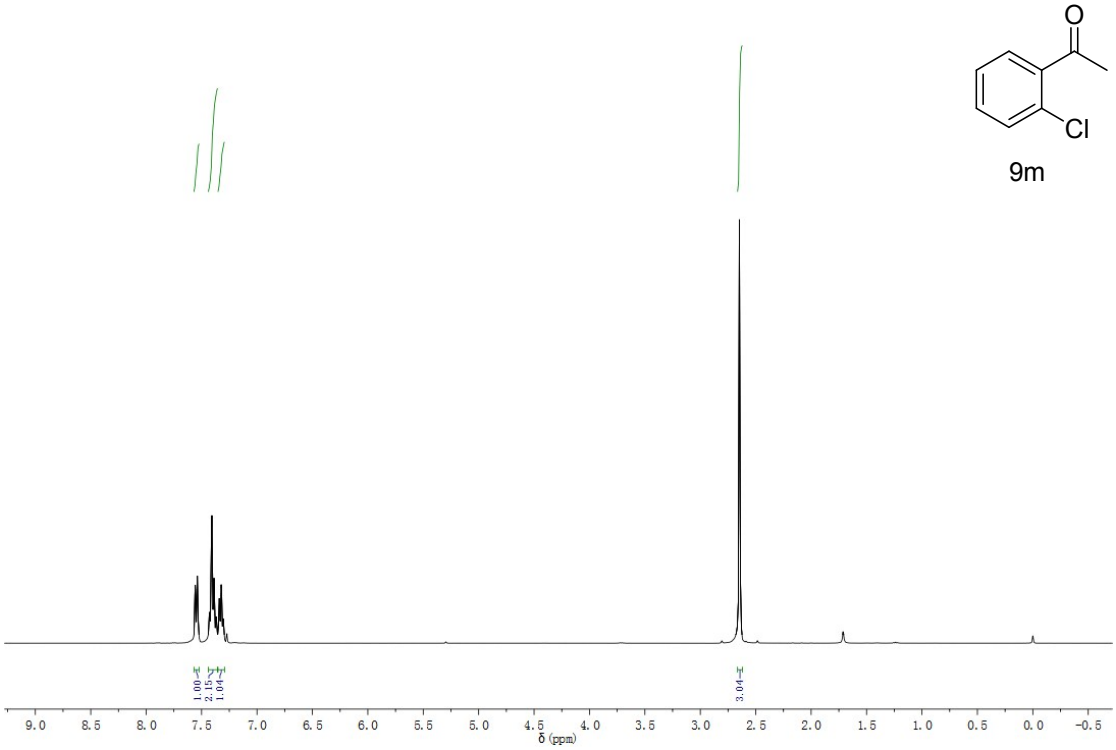

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)

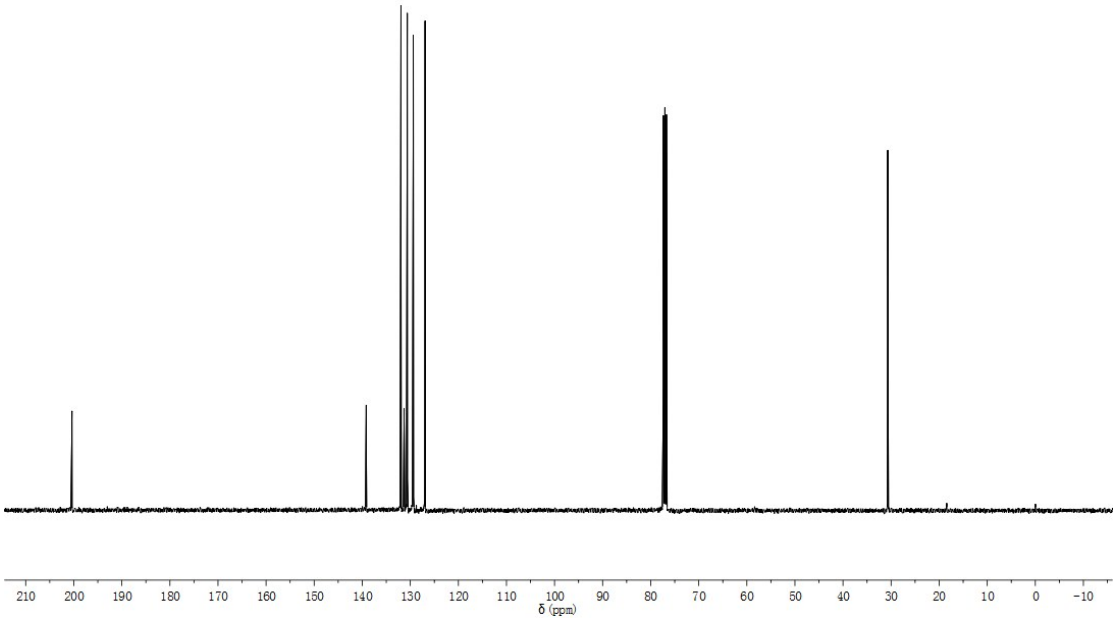

O
9k
2.00
2.07
2.99
3.04
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
δ (ppm)

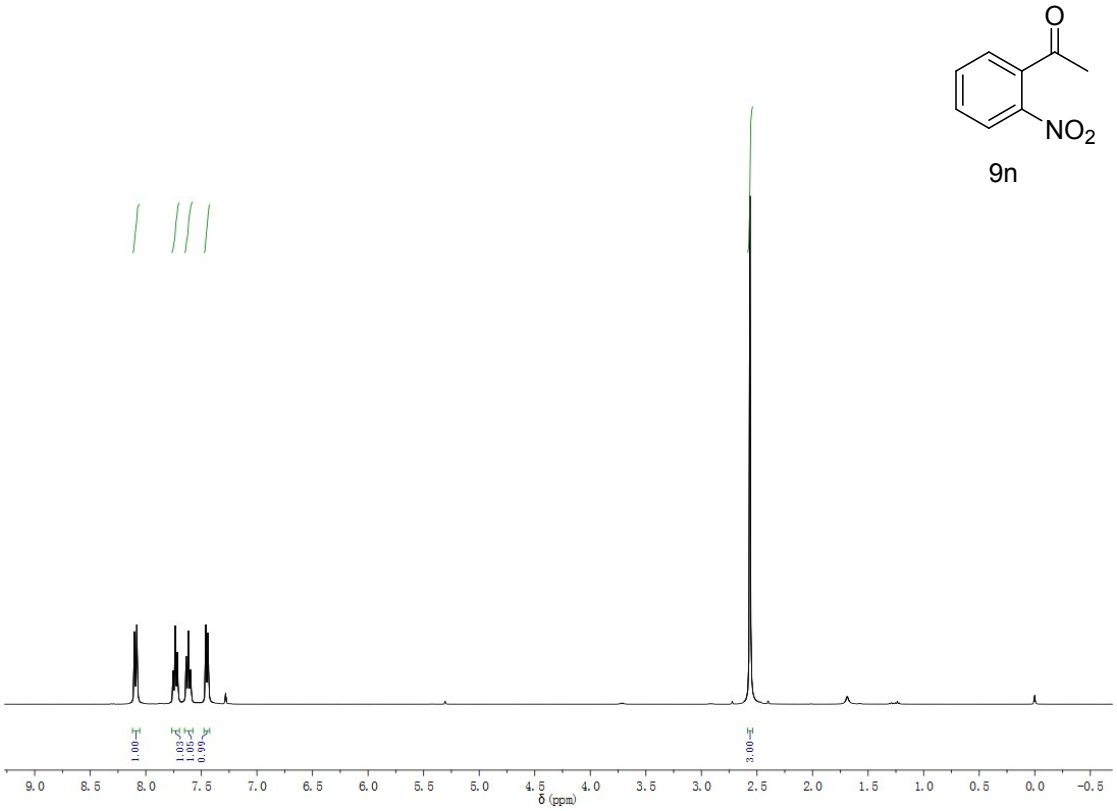

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)

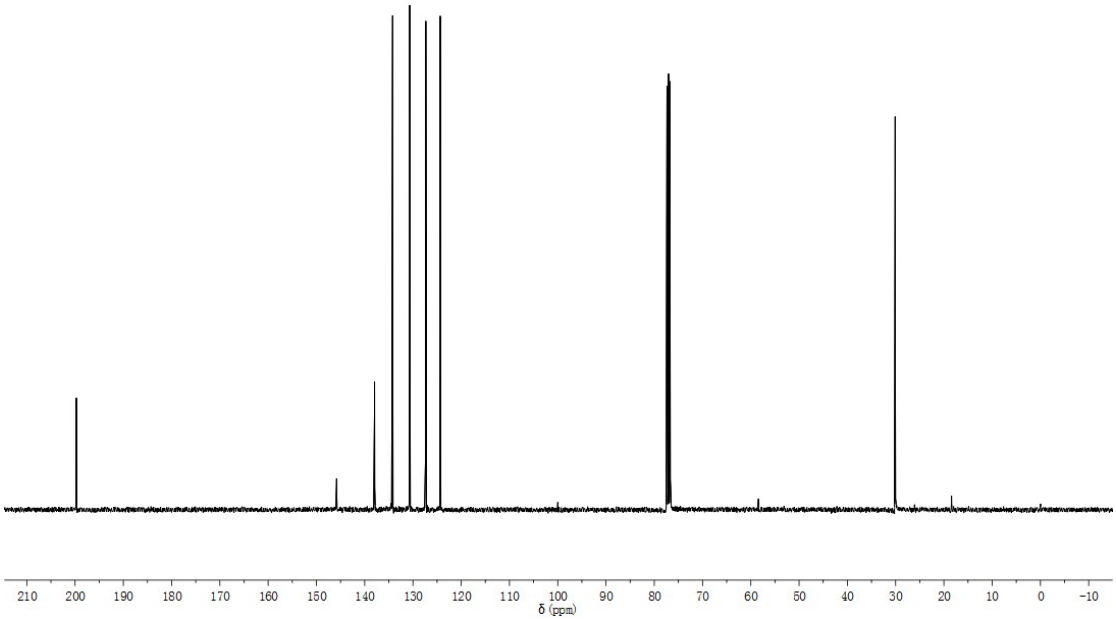

OMe O
9l
1.00
1.06
2.16
2.99
3.00
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
δ (ppm)

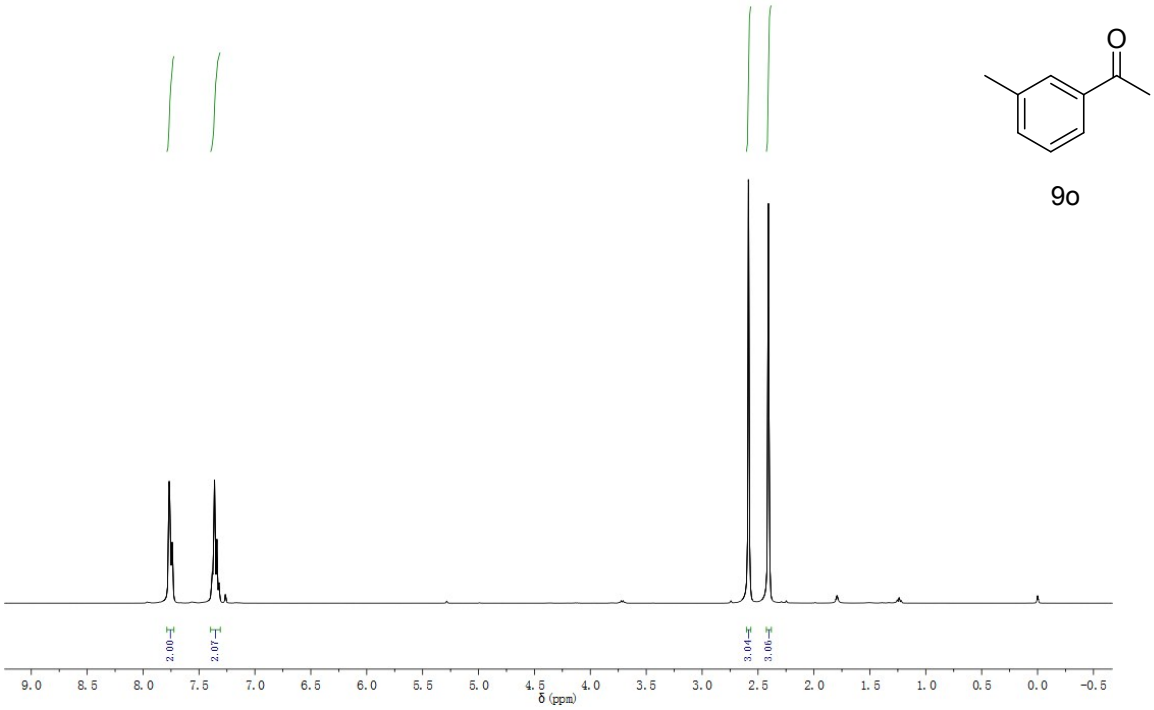

δ (ppm)

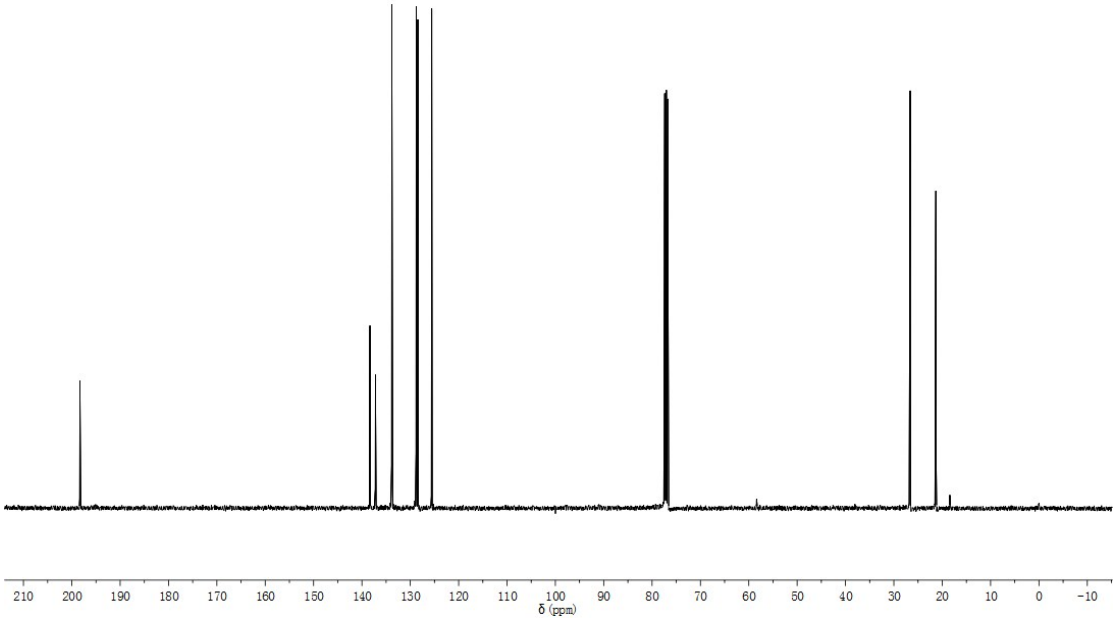

O
Cl
9m
1.00
2.15
1.04
3.04
δ (ppm)

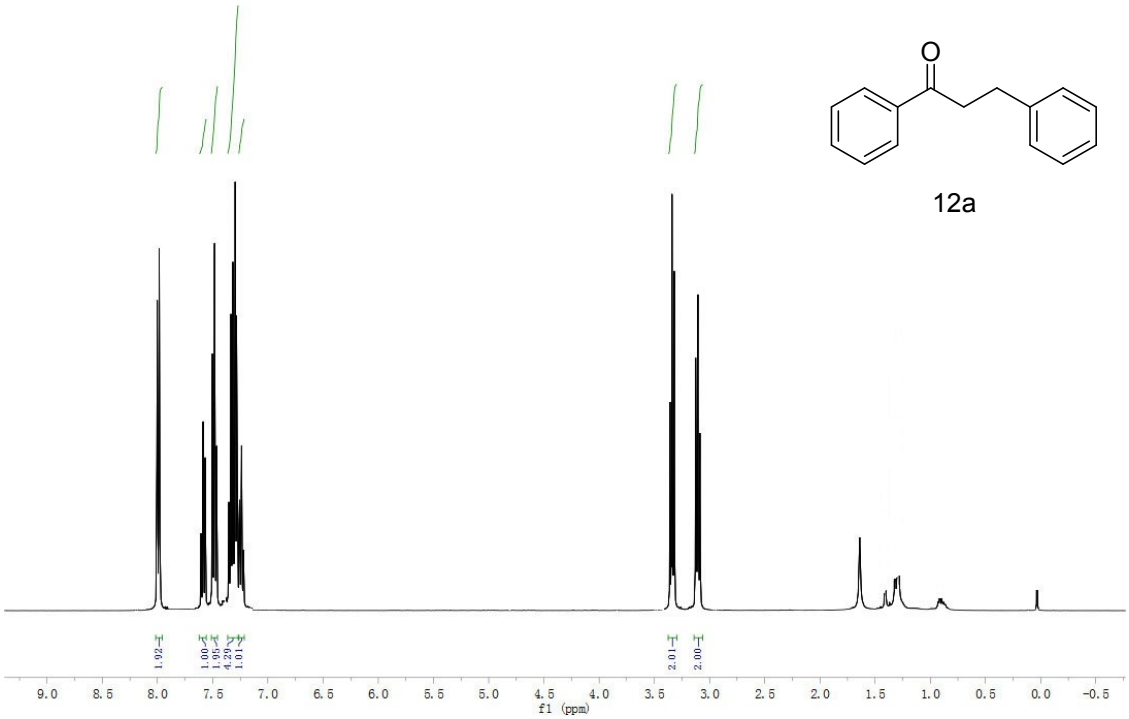

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)

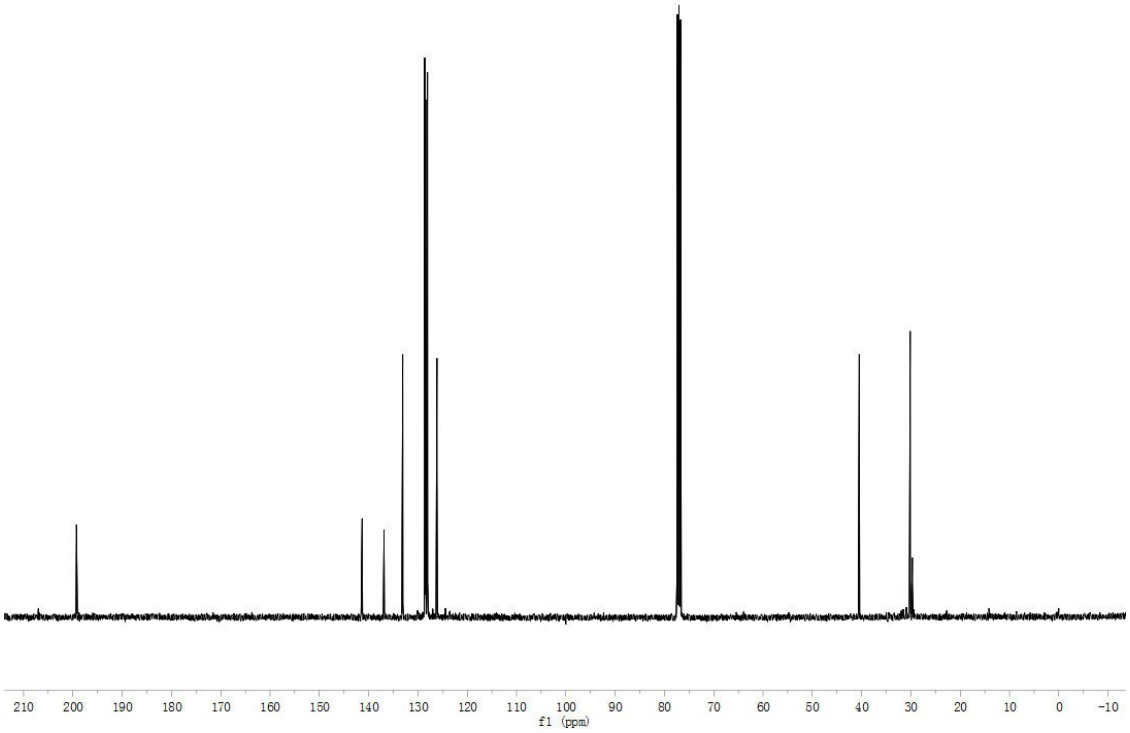

O
NO2
9n
1.00
1.03
1.05
0.99
3.00
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
δ (ppm)

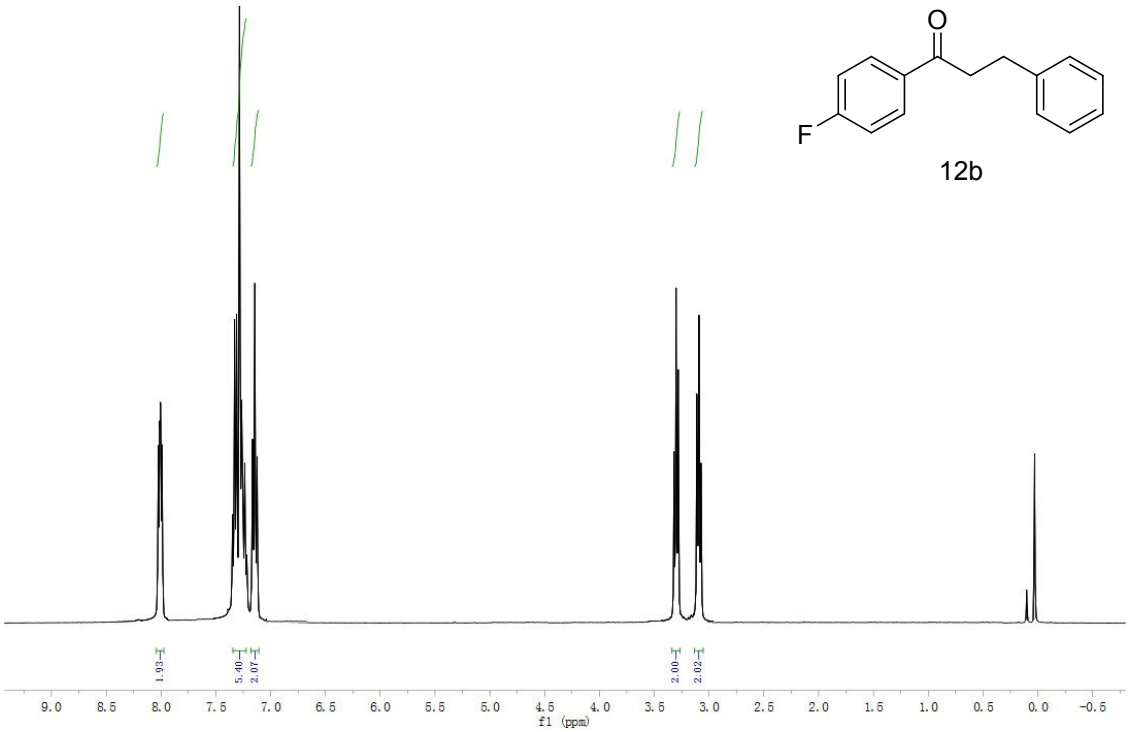

δ (ppm)

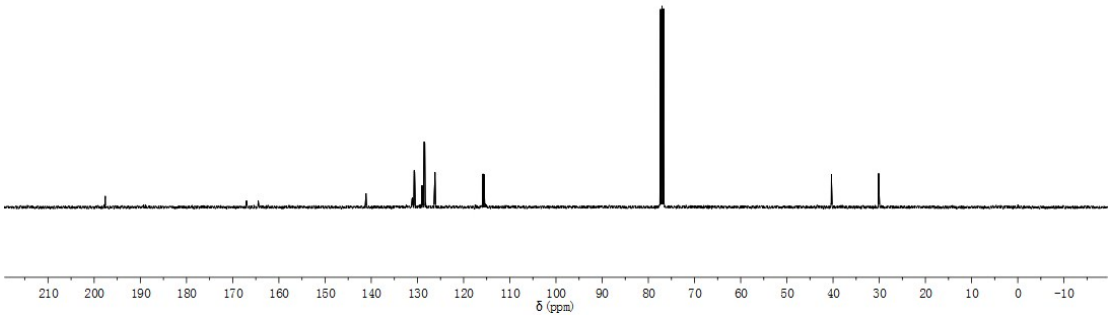

O
9o
2.00
2.07
3.04
3.06
δ (ppm)

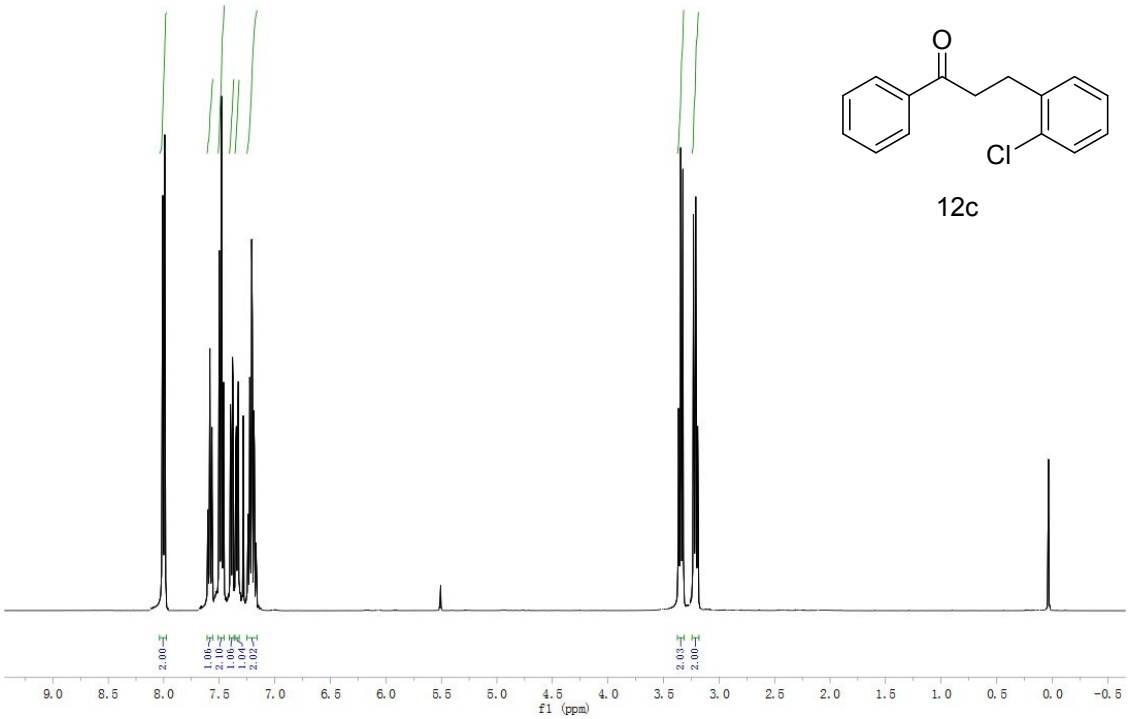

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)

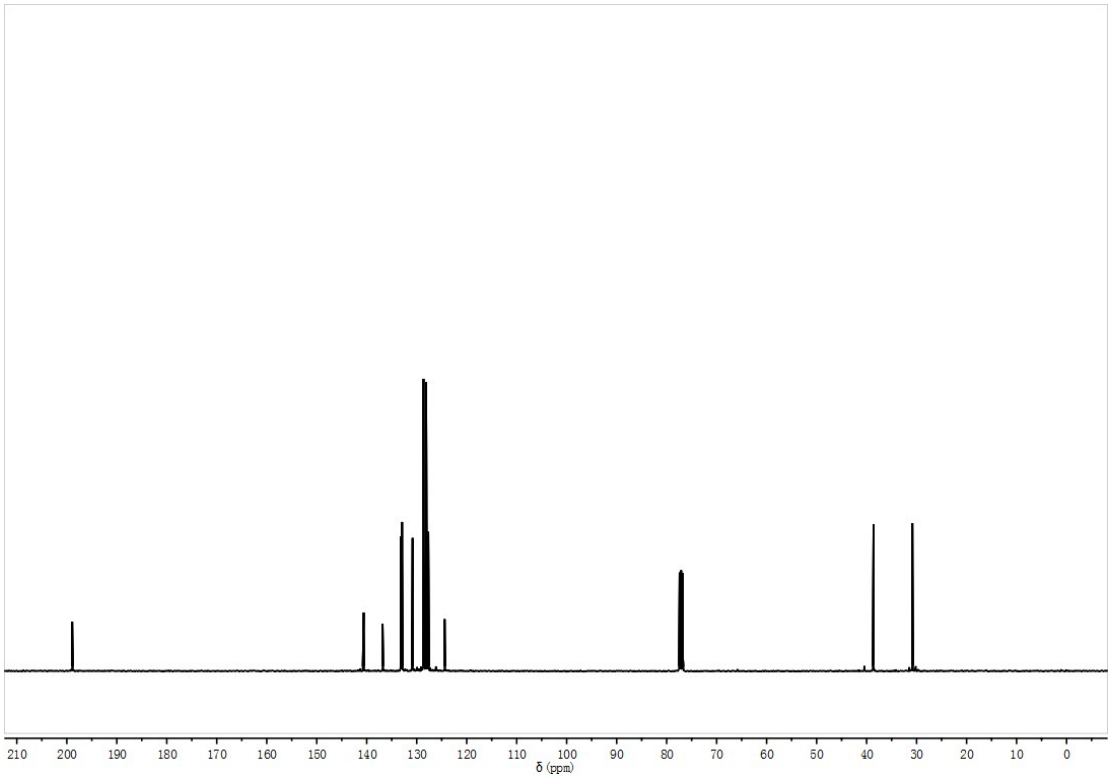

O
12a
1.92
1.00
1.95
4.29
1.01
2.01
2.00
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

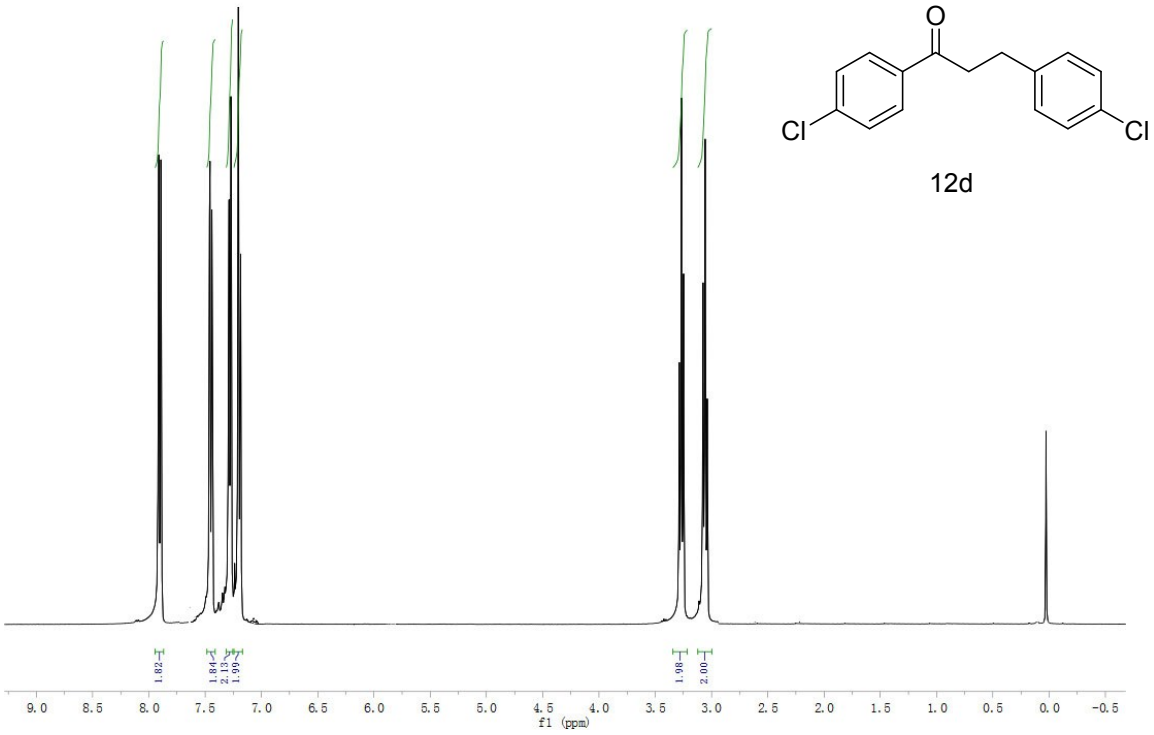

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

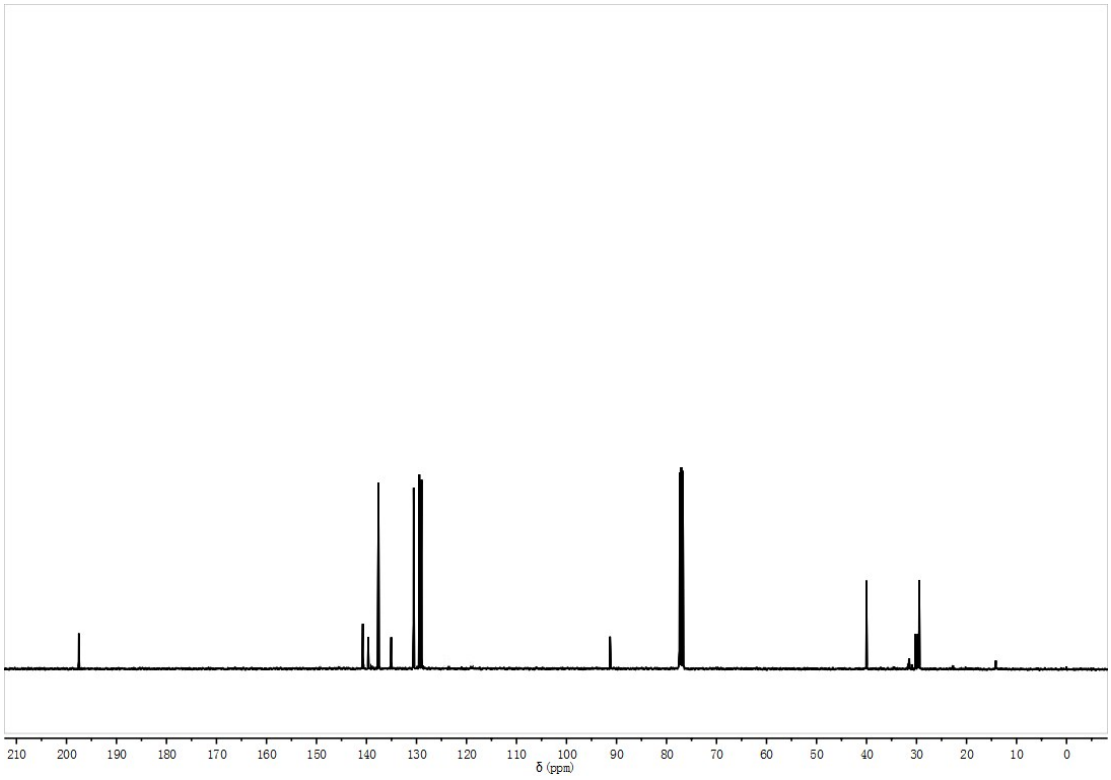

O
F
12b
1.93
5.40
2.07
2.00
2.02
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

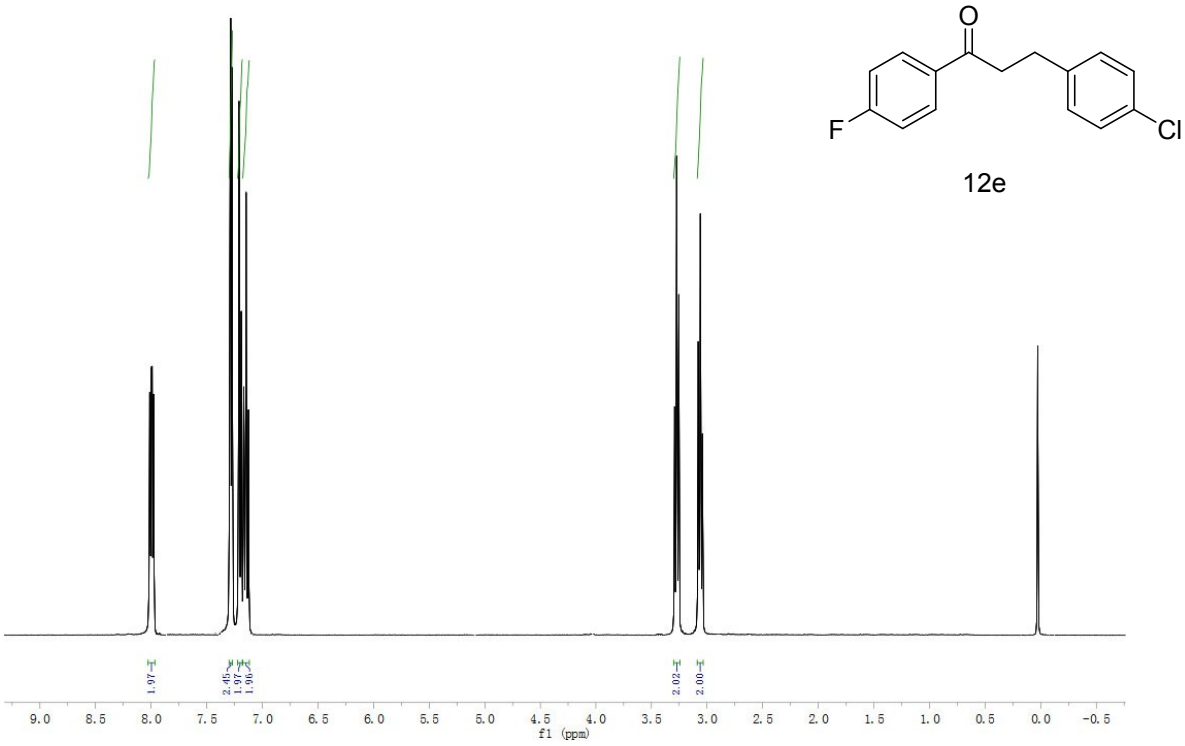

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)

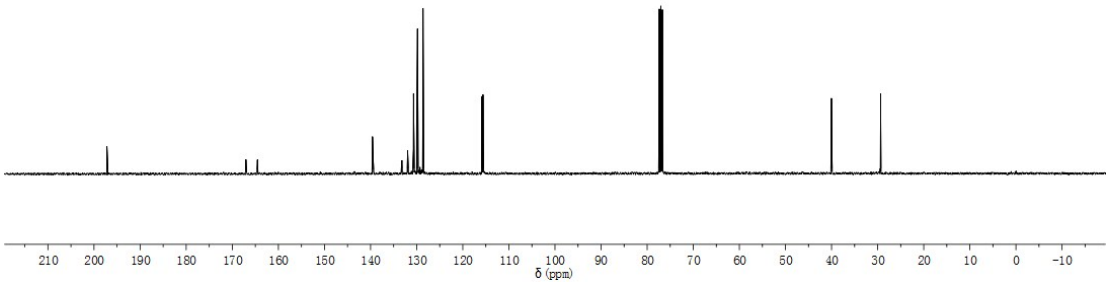

O
Cl
12c
2.00
1.06
2.10
1.06
1.04
2.02
2.03
2.00
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

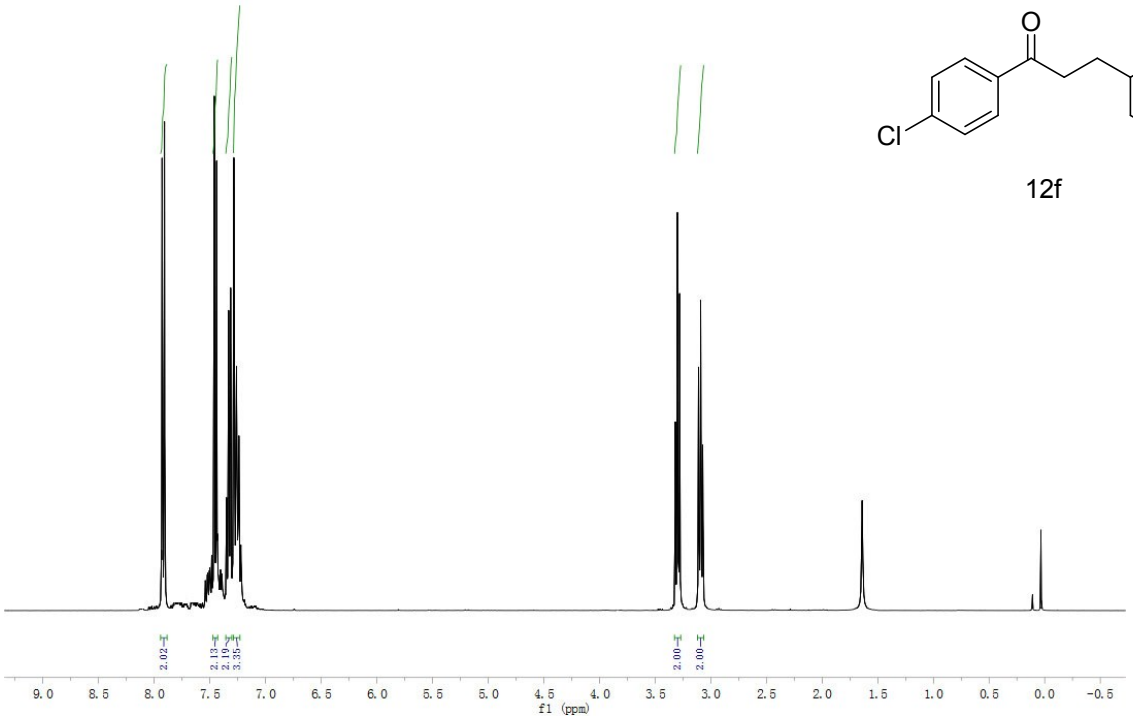

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
δ (ppm)

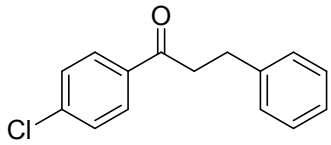

O
Cl
Cl
12d
1.82
1.84
2.13
1.99
1.98
2.00
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)


210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
δ (ppm)

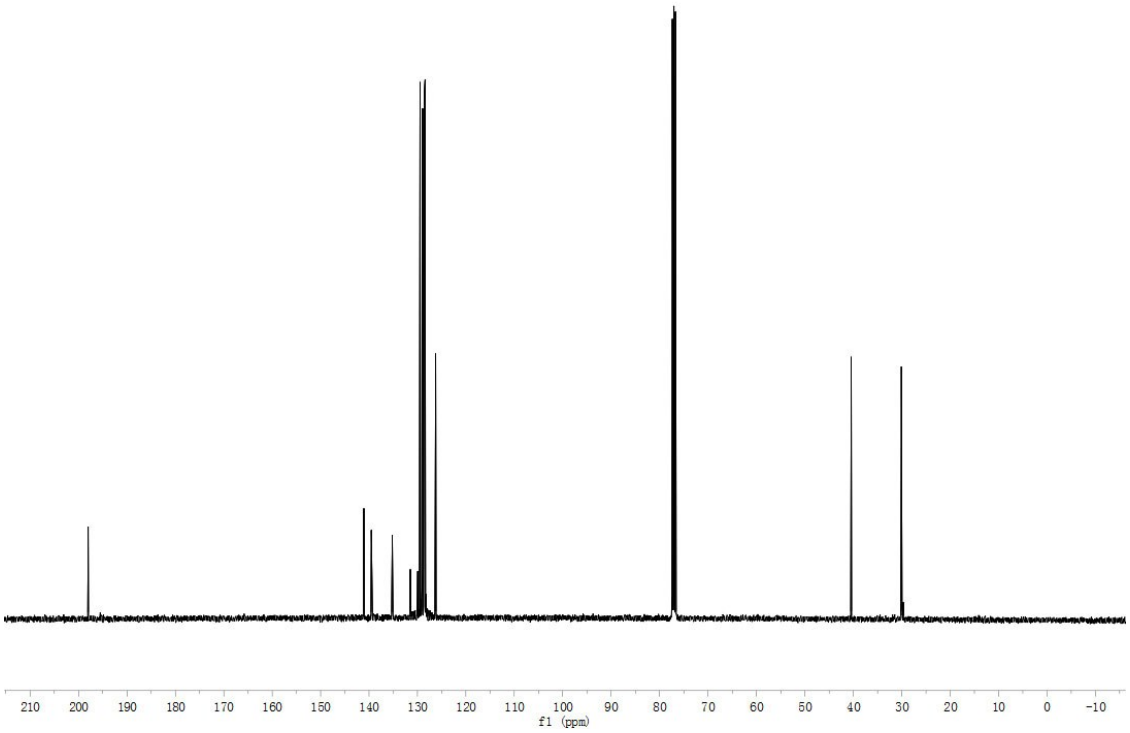

O
F
Cl
12e
1.97
2.45
1.97
1.96
2.02
2.00
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

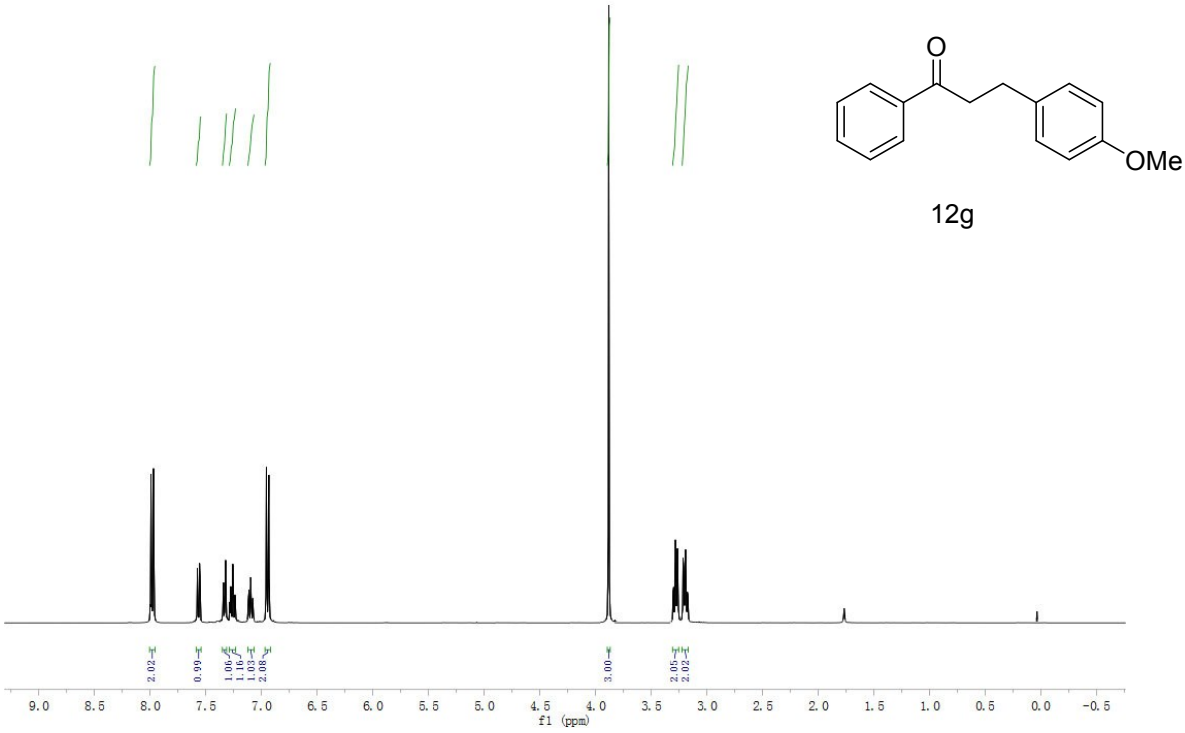

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
δ (ppm)

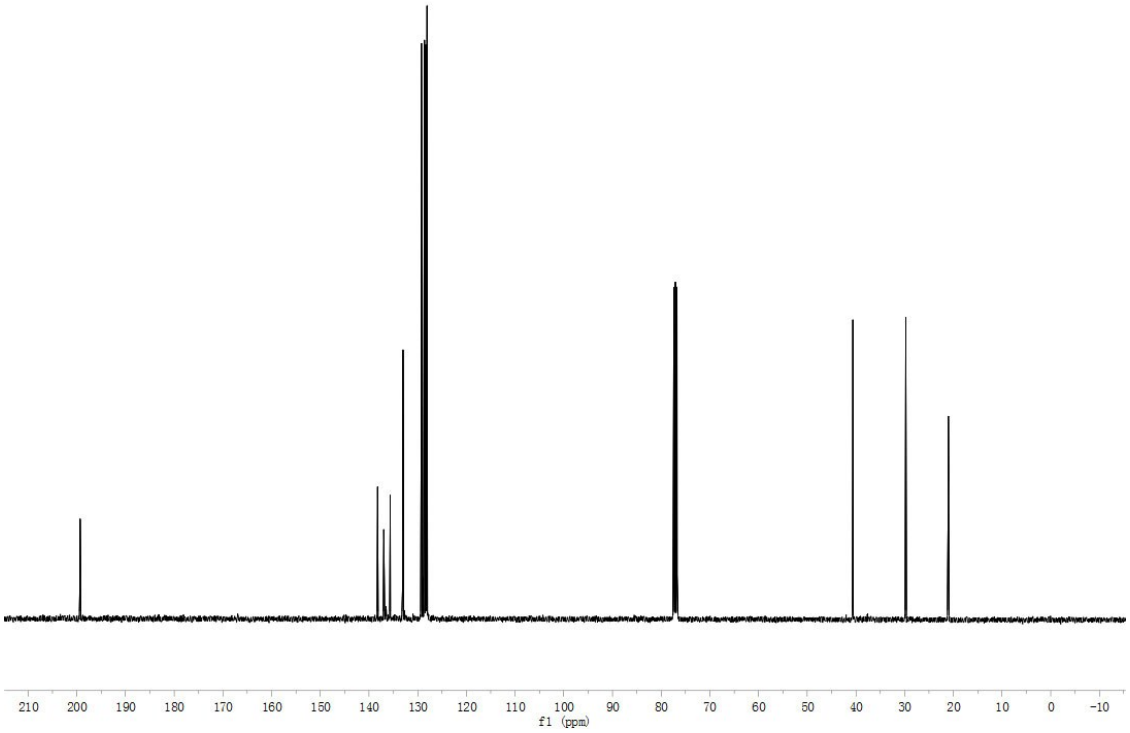

2.02
2.13
2.10
3.35
2.00
2.00
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

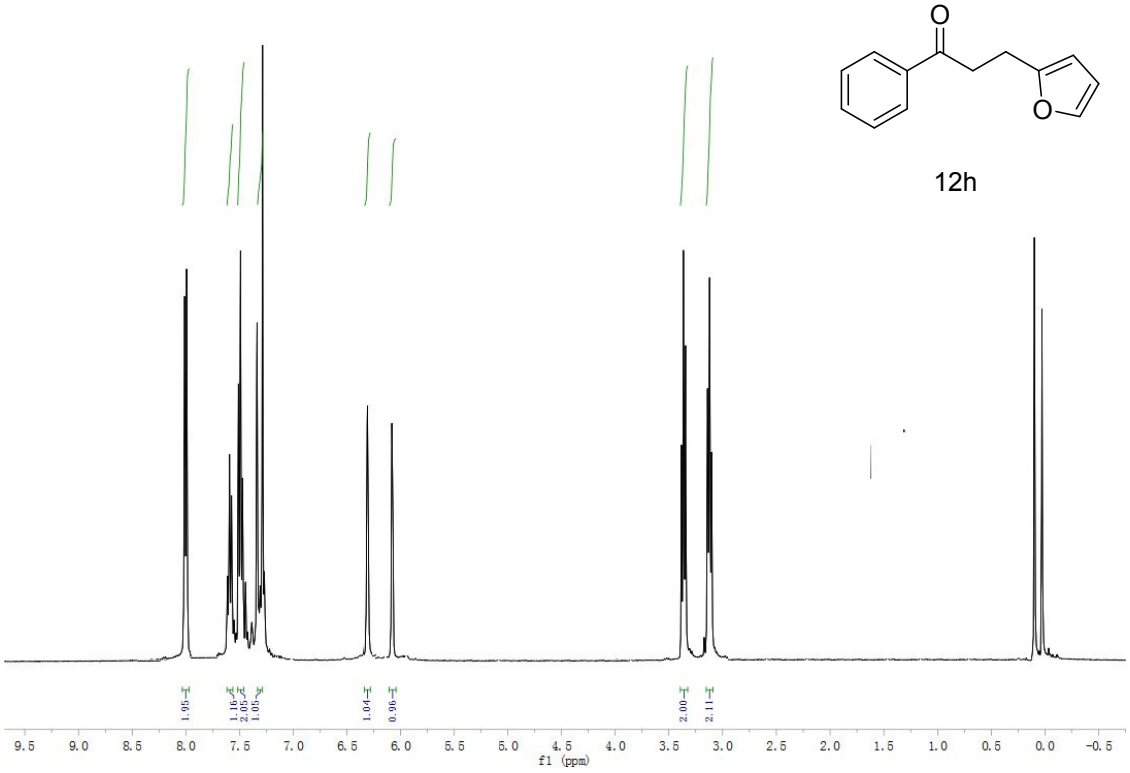

O
Cl

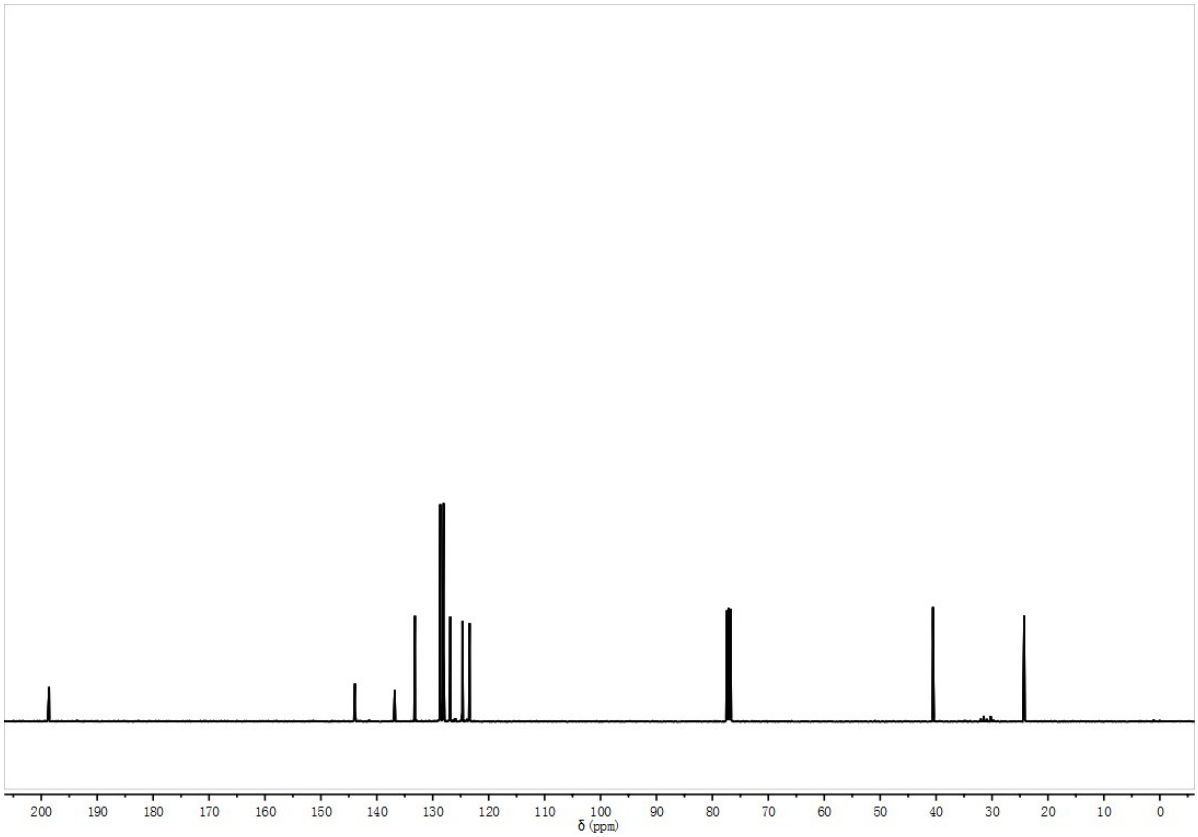
12f

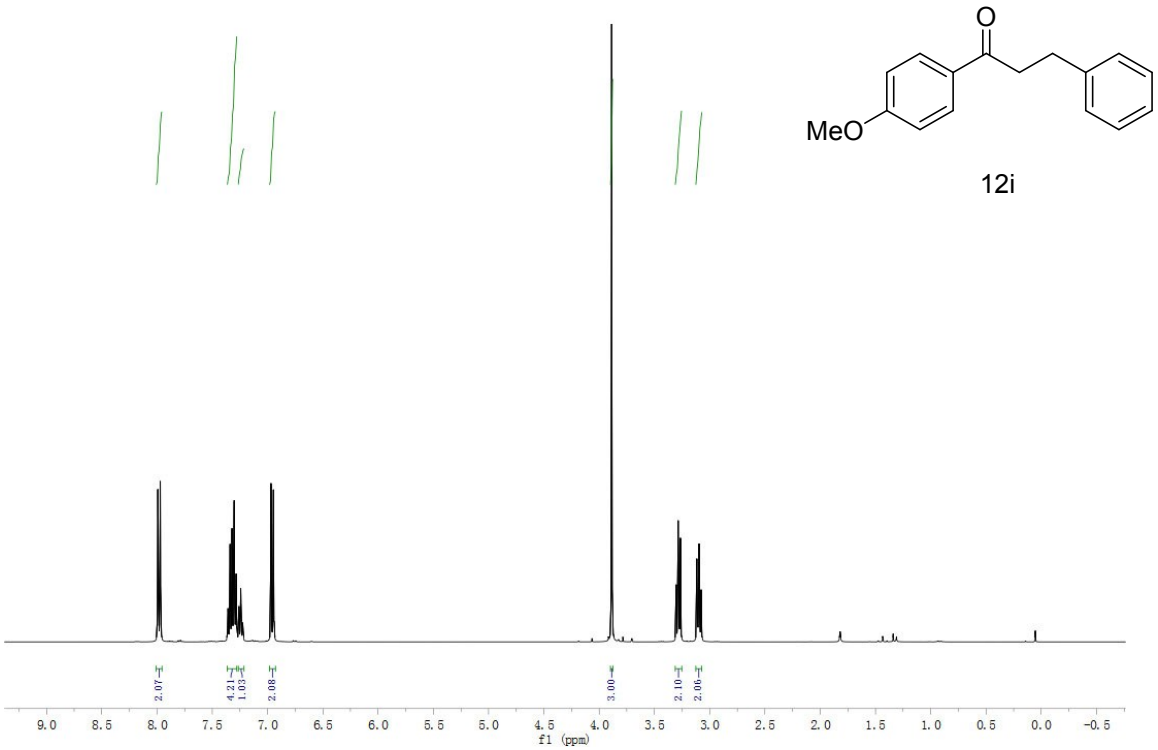

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

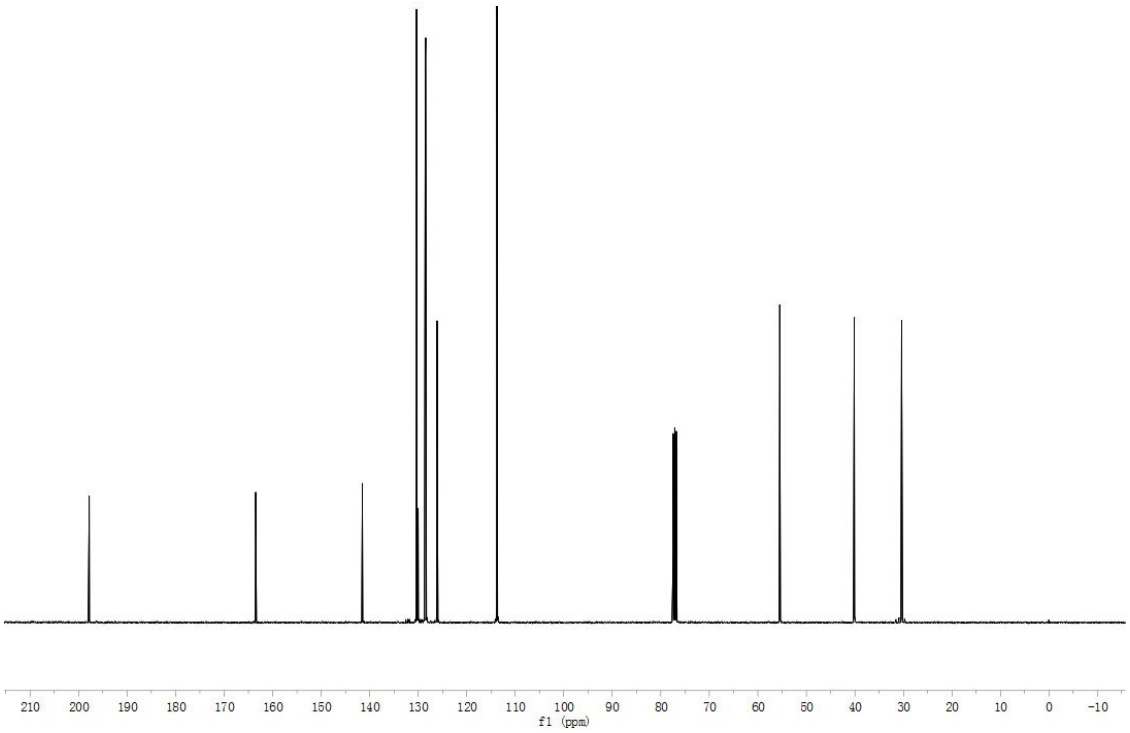

O
OMe
12g
2.02
0.99
1.06
1.02
1.03
2.08
3.00
2.05
2.02
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

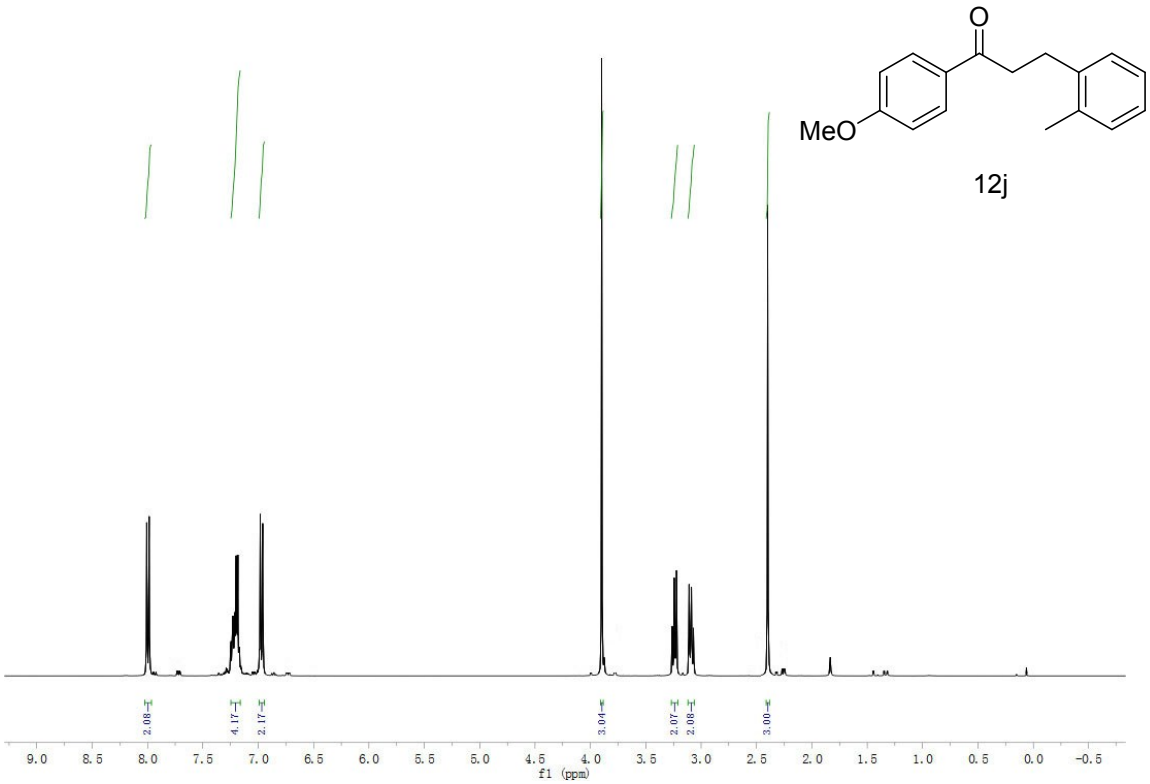

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

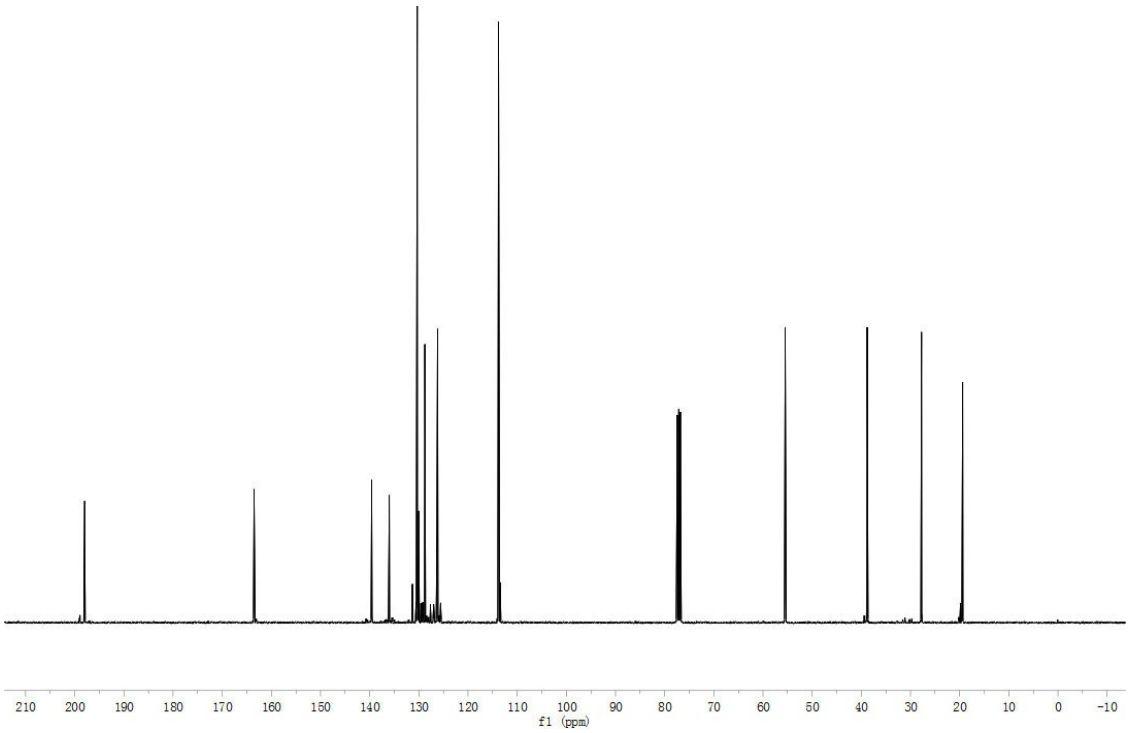

O
O
12h
1.95
1.16
2.05
1.05
1.04
0.96
2.00
2.11
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

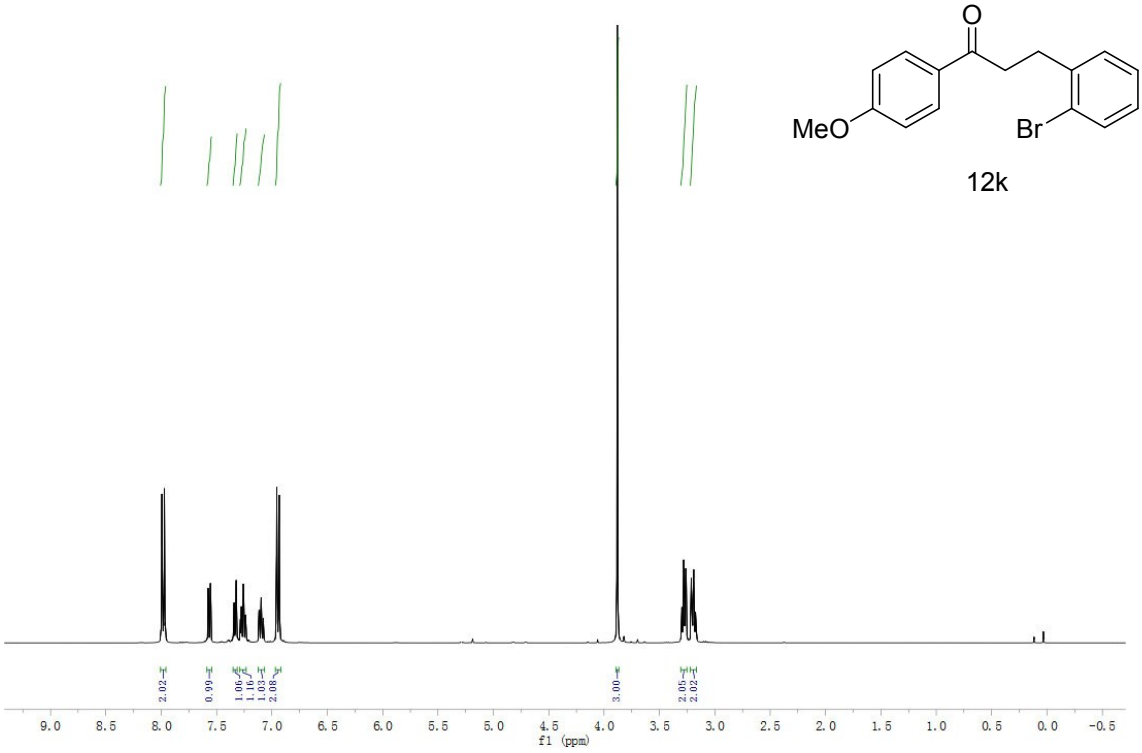

δ (ppm)

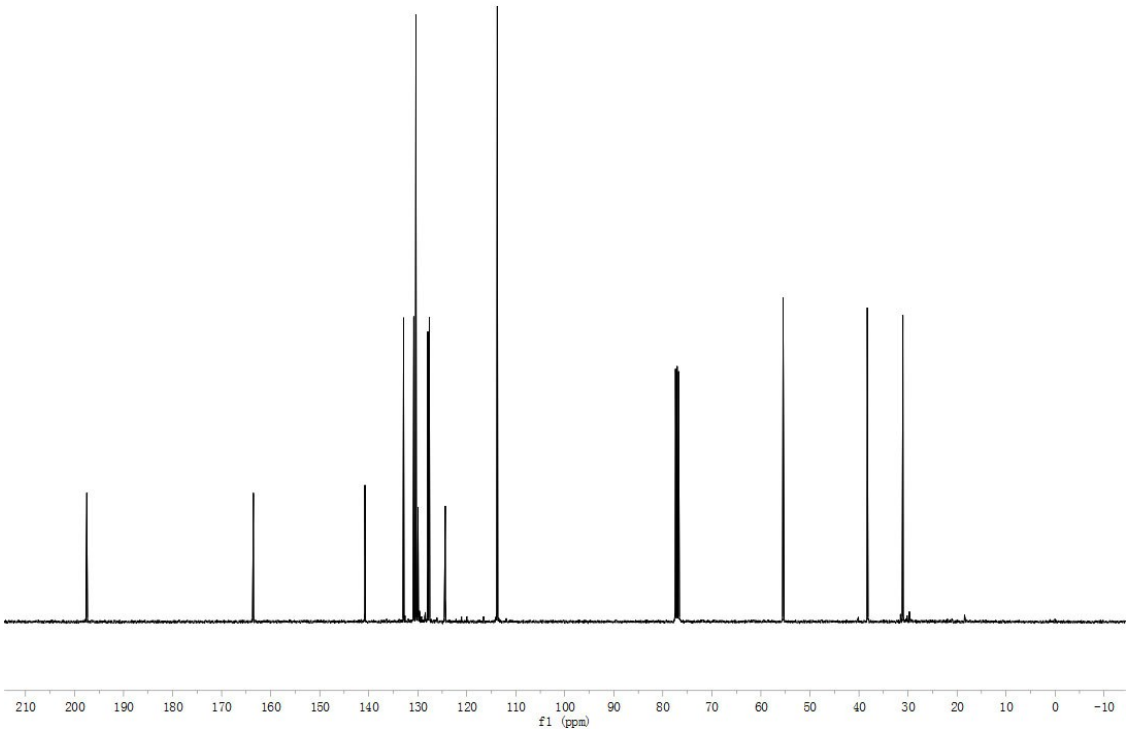

O
MeO
12i
2.07
4.21
1.03
2.08
3.00
2.10
2.06
f1 (ppm)

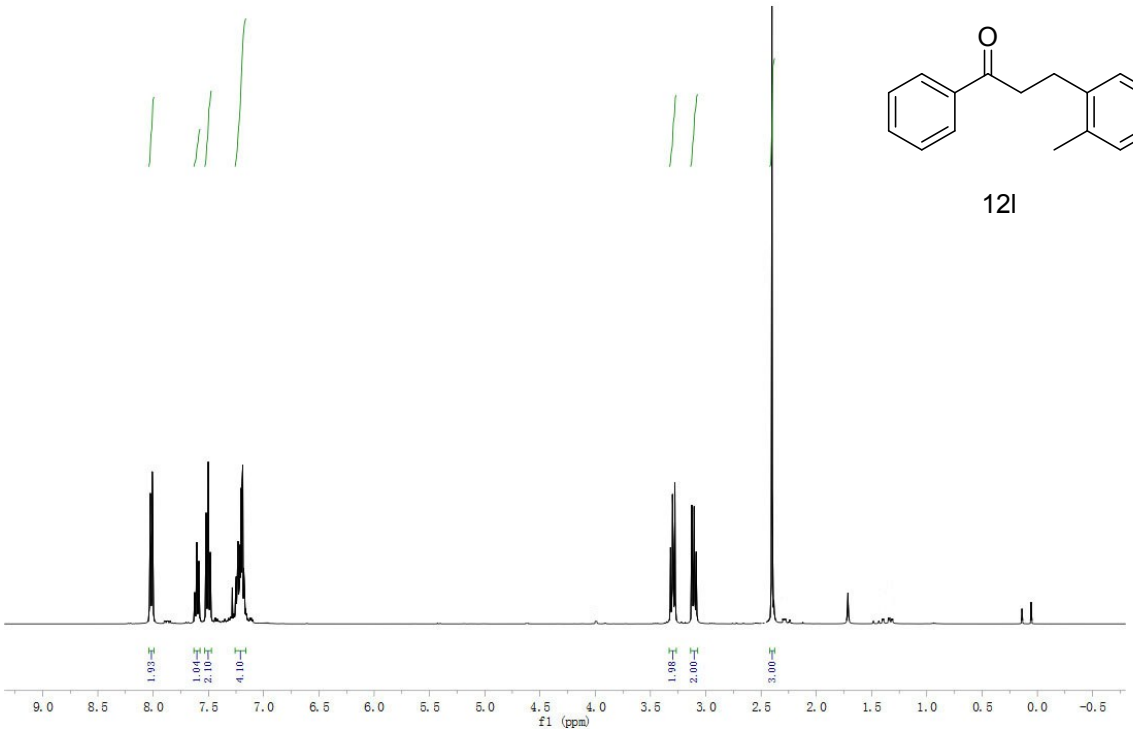

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

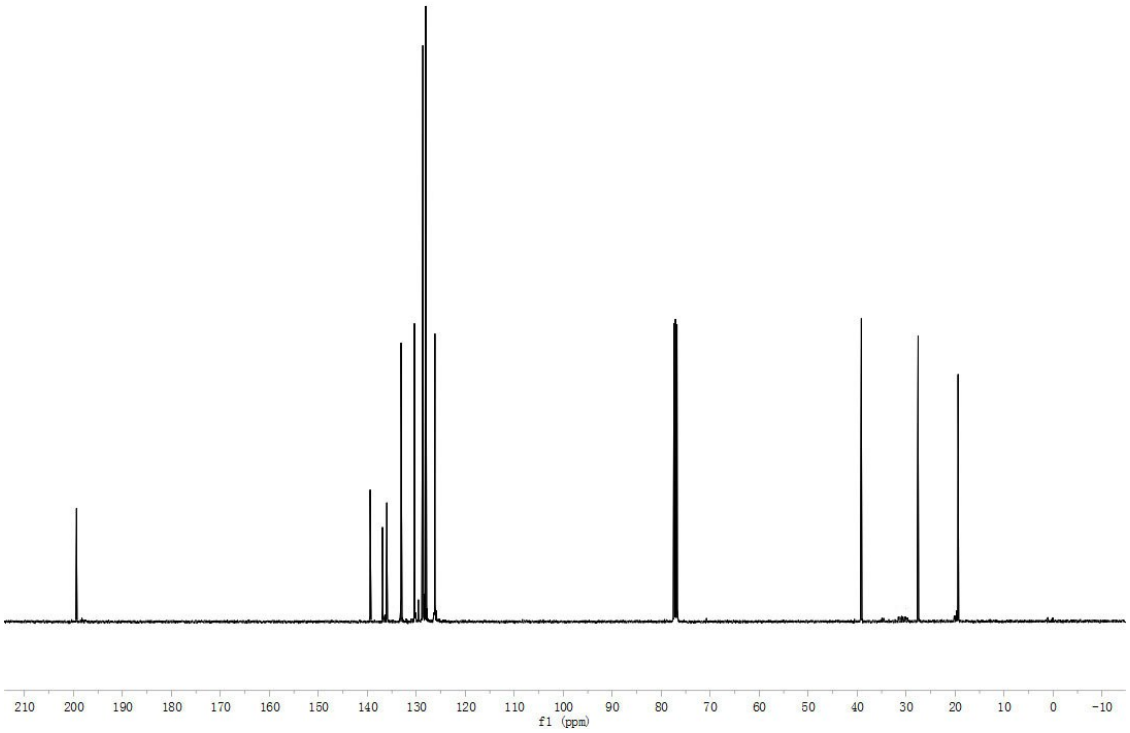

O
MeO
12j
2.08
4.17
2.17
3.04
2.07
2.08
3.00
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

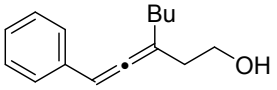

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


O
MeO
Br
12k
2.02
0.99
1.06
1.10
1.03
2.08
3.00
2.05
2.02
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

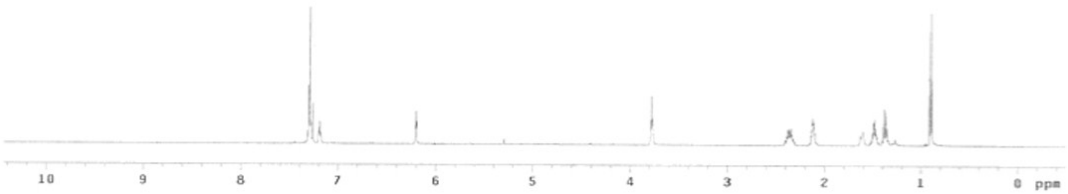

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

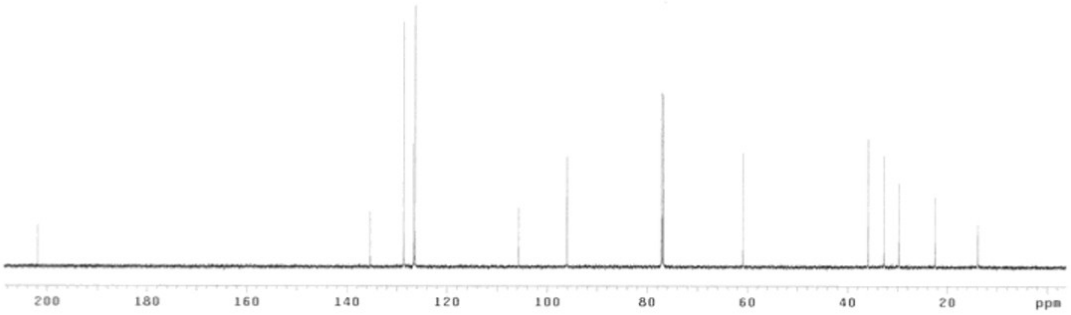

O
12l
1.93
1.04
2.10
4.10
1.98
2.00
3.00
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

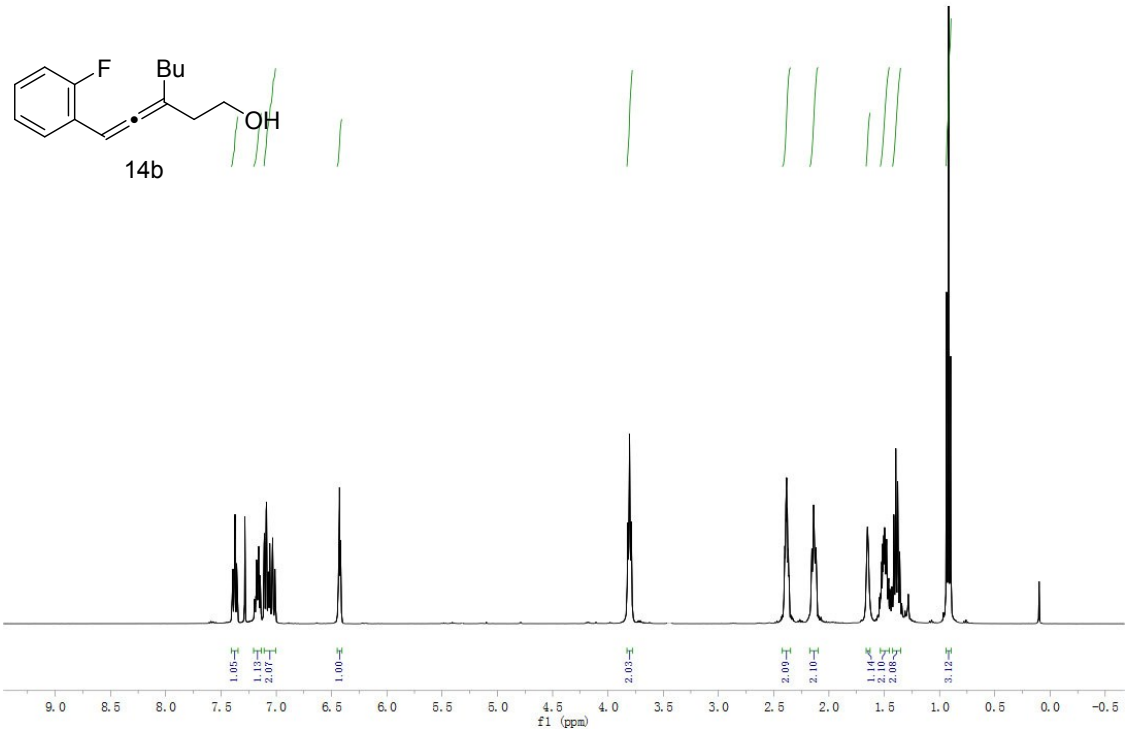

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

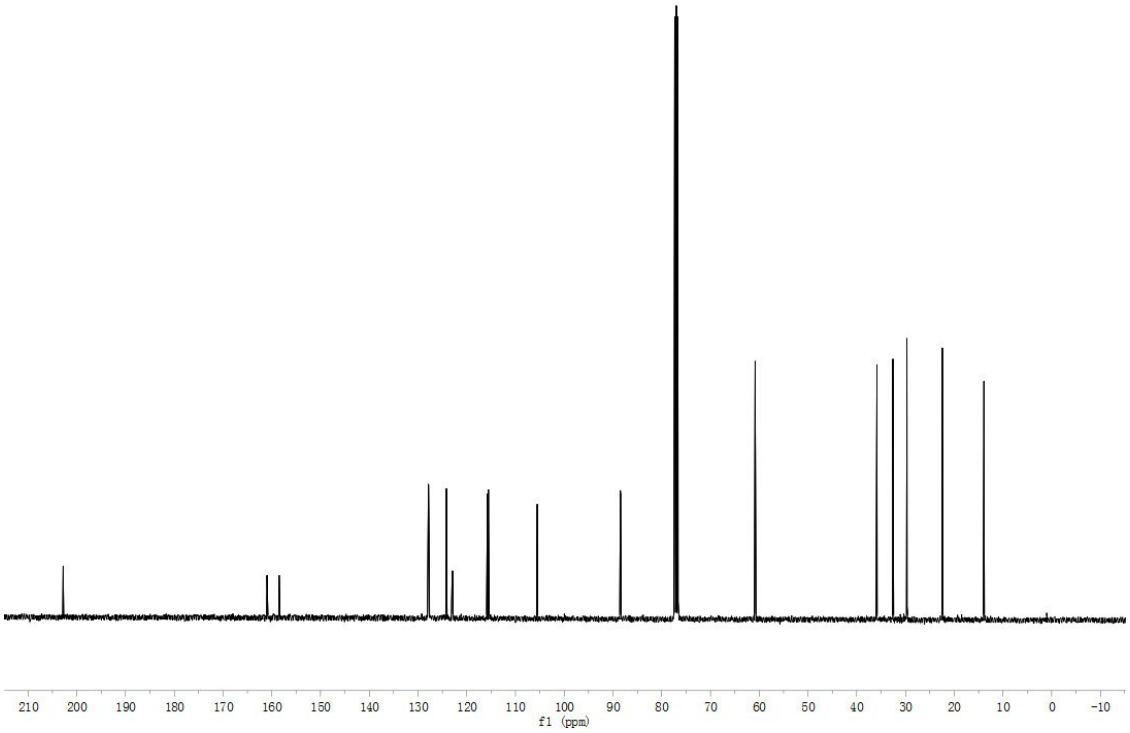

Bu
OH

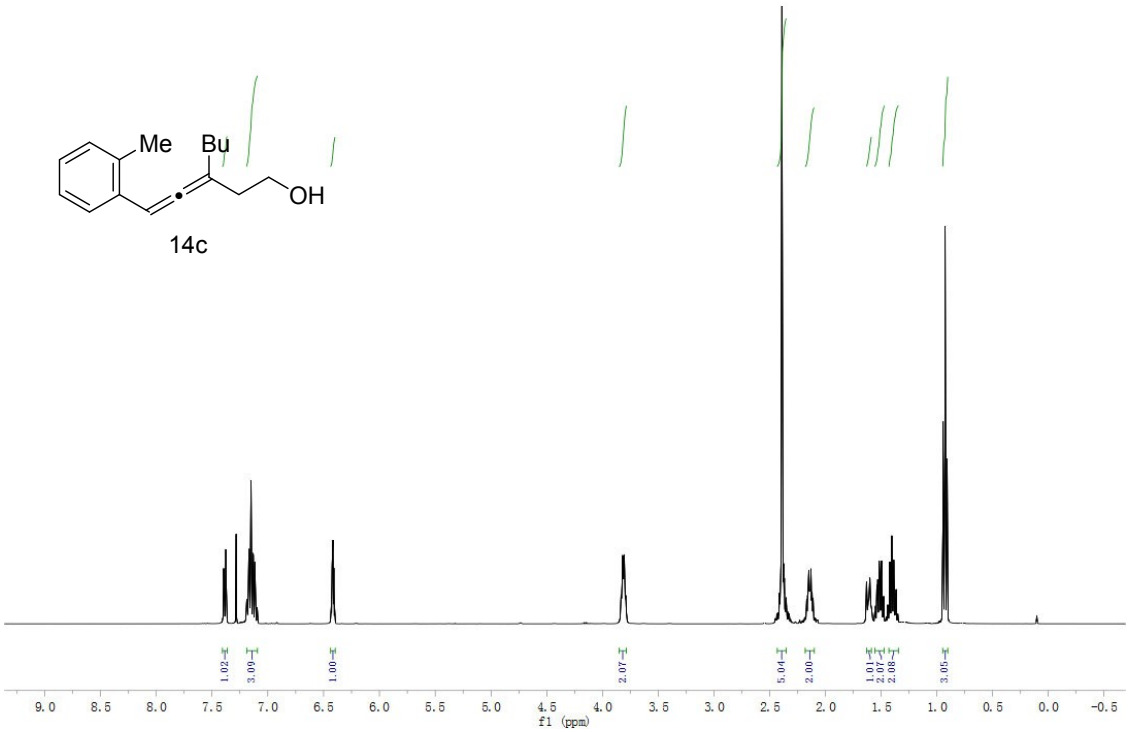
14a

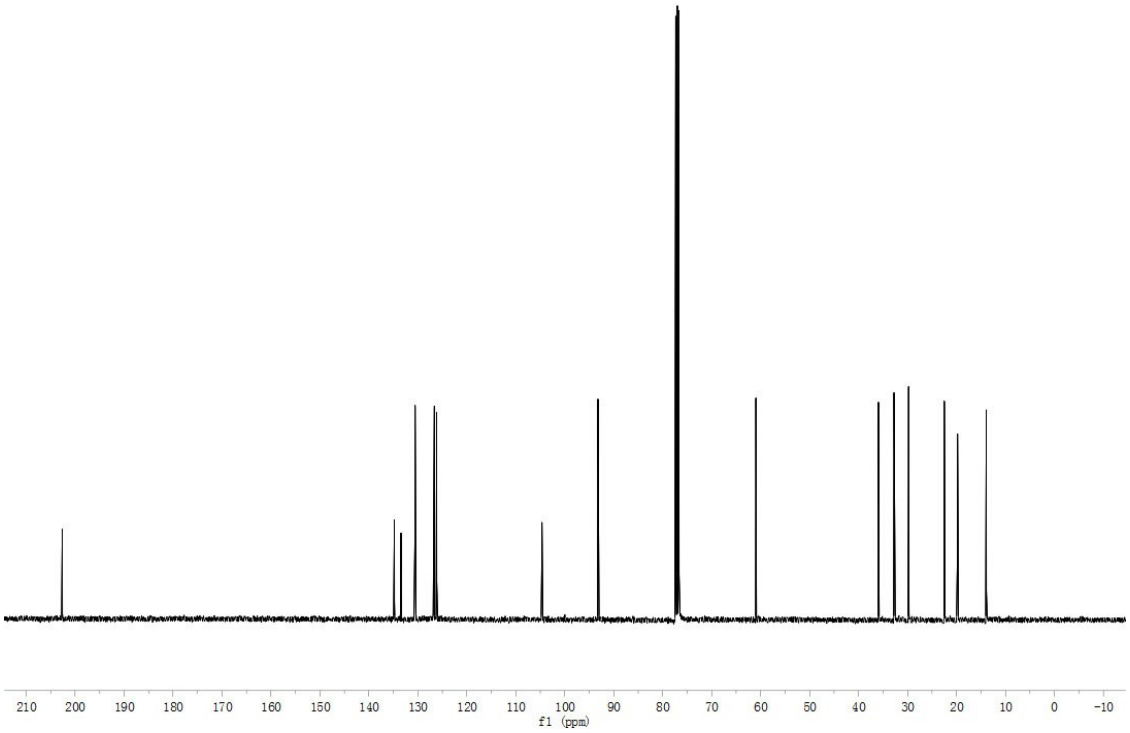

10 9 8 7 6 5 4 3 2 1 0 ppm

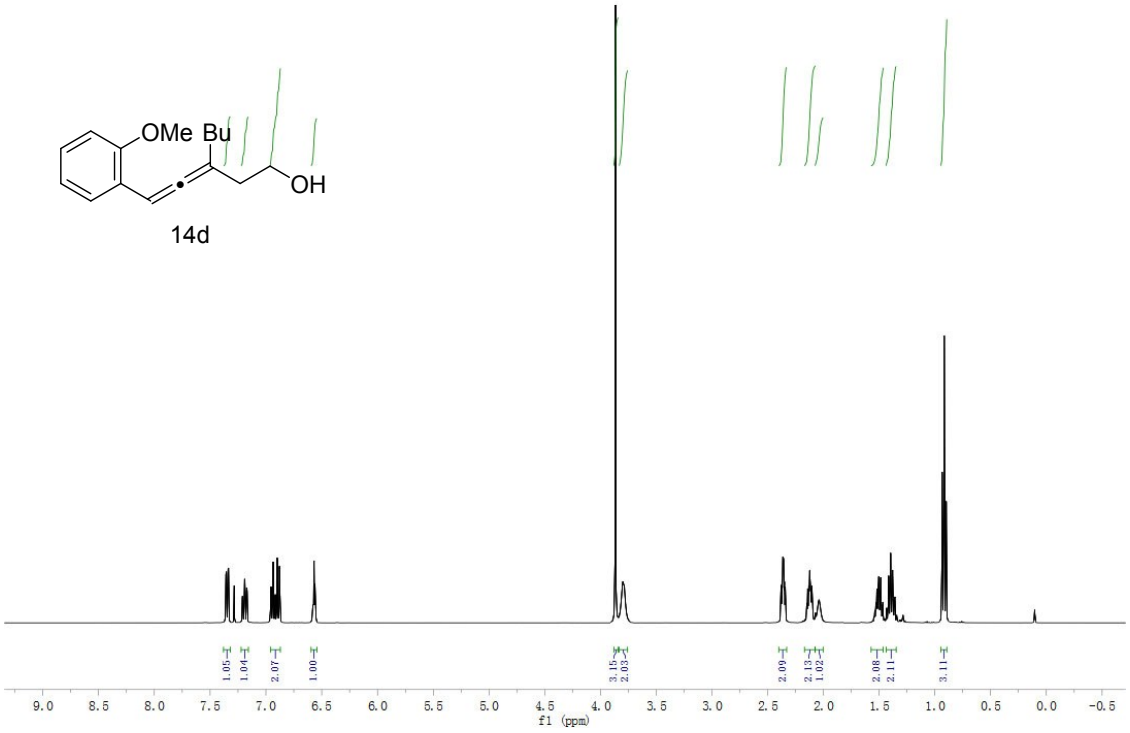

200
180
160
140
120
100
80
60
40
20
ppm

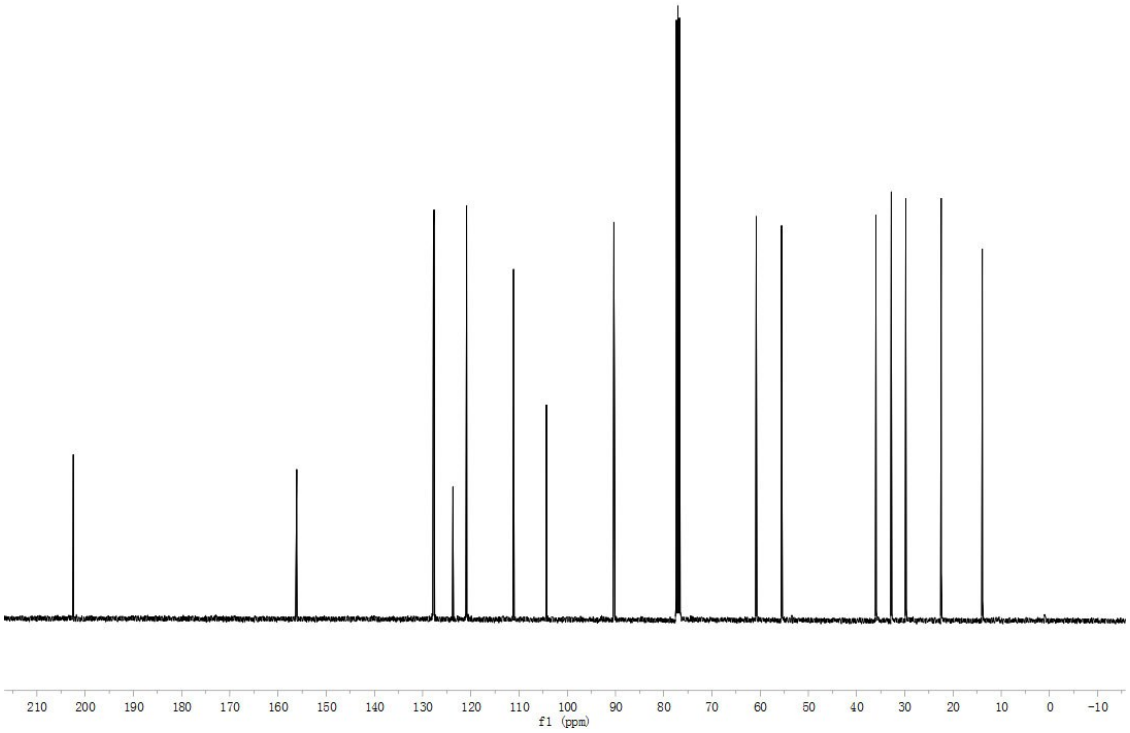

F
Bu
OH
14b
1.05
1.13
2.07
1.00
2.03
2.09
2.10
1.14
2.10
2.08
3.12
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

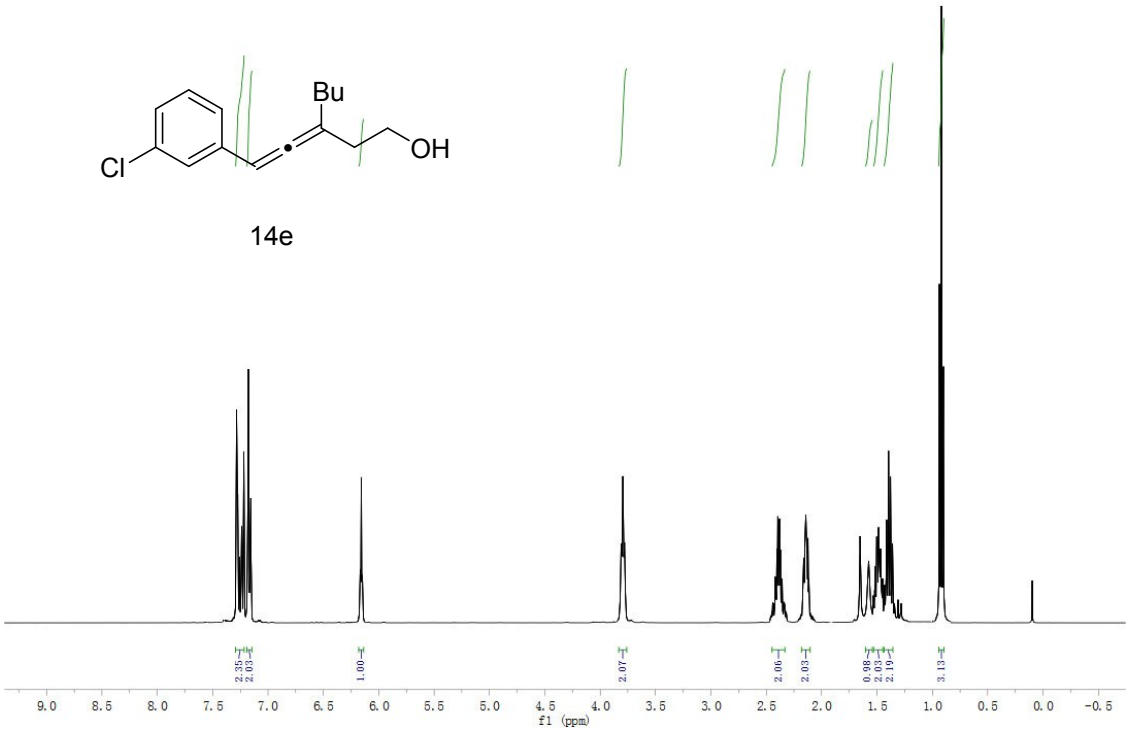

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

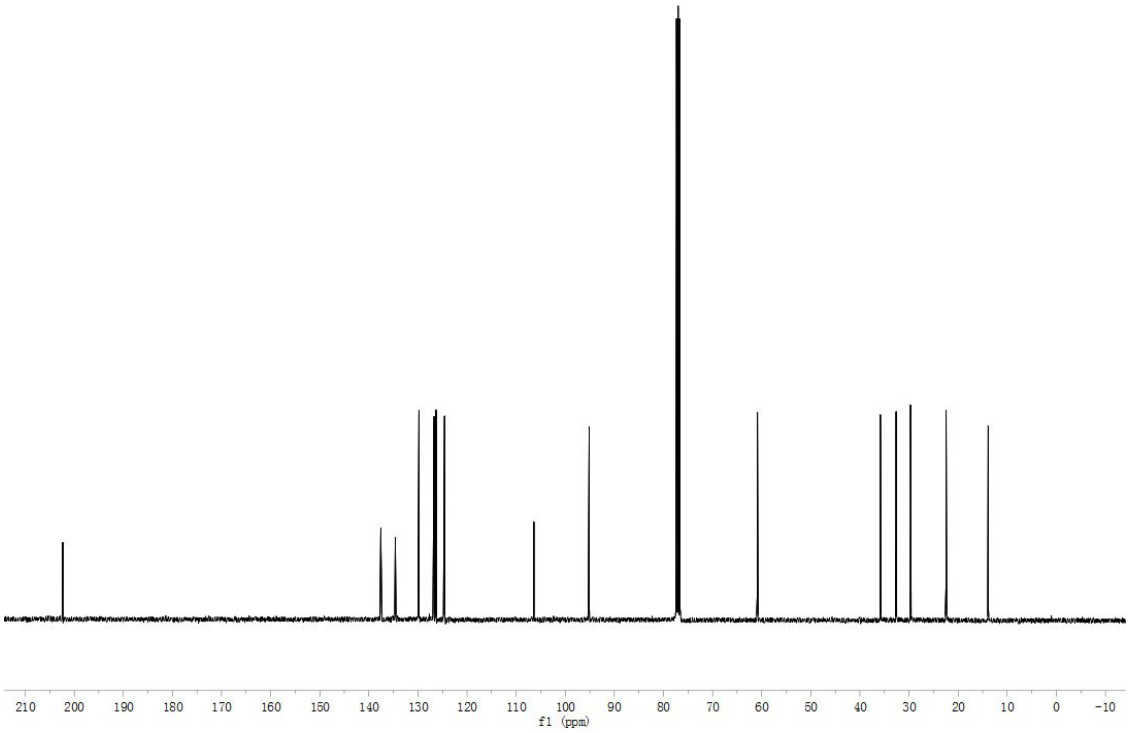

Me
Bu
OH
14c
1.02
3.09
1.00
2.07
5.04
2.00
1.01
2.07
2.08
3.05
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

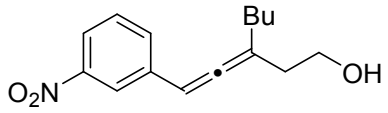

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


OMe
Bu
OH
14d
1.05
1.04
2.07
1.00
3.15
2.03
2.09
2.13
1.02
2.08
2.11
3.11
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

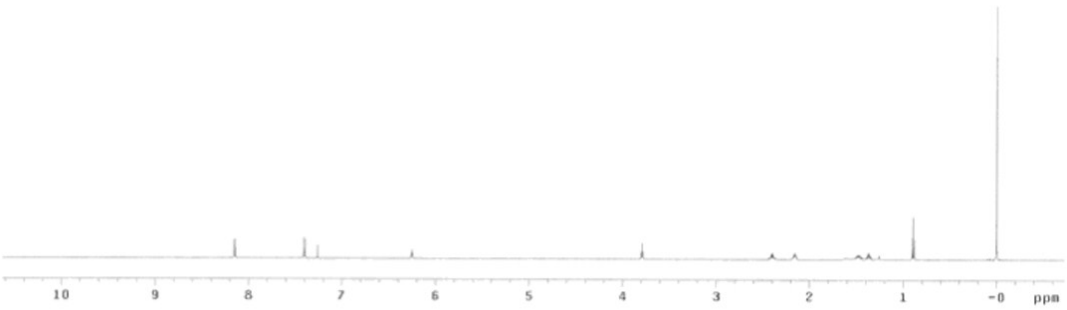

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

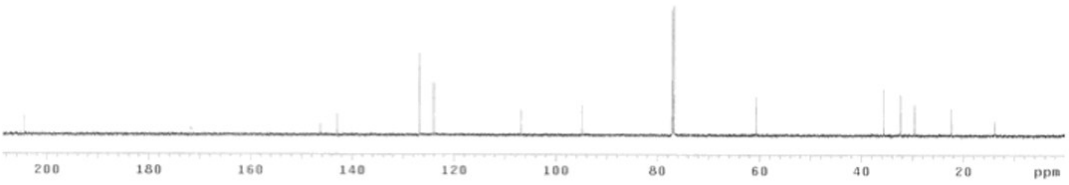

Bu
Cl
OH
14e
2.35
2.03
1.00
2.07
2.06
2.03
0.98
2.03
2.19
3.13
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

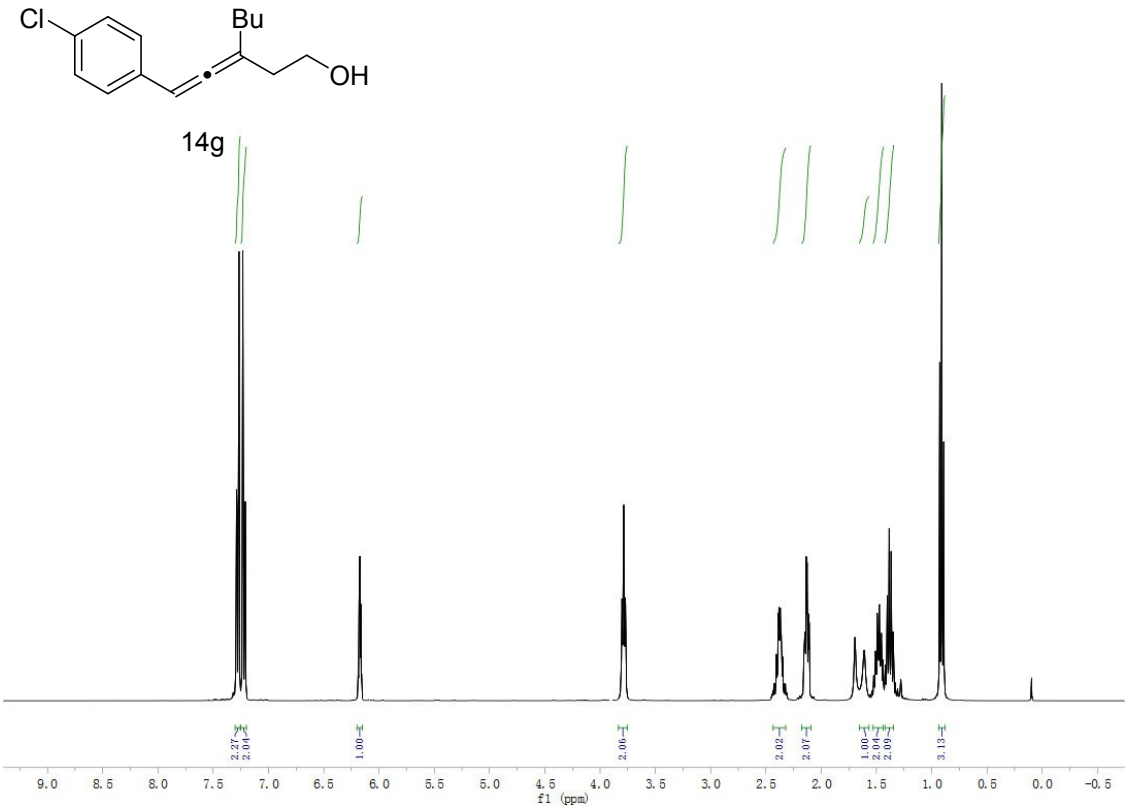

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

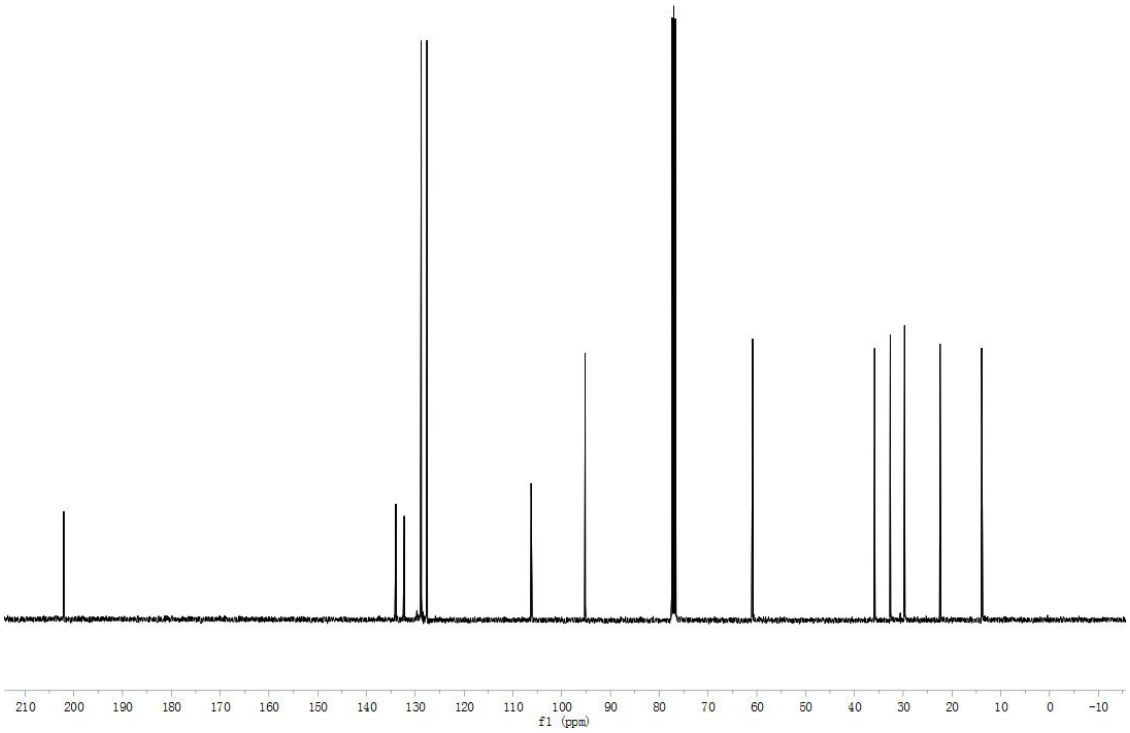

Bu
OH
$O_2N$

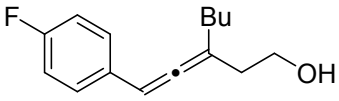
14f


10 9 8 7 6 5 4 3 2 1 -0 ppm

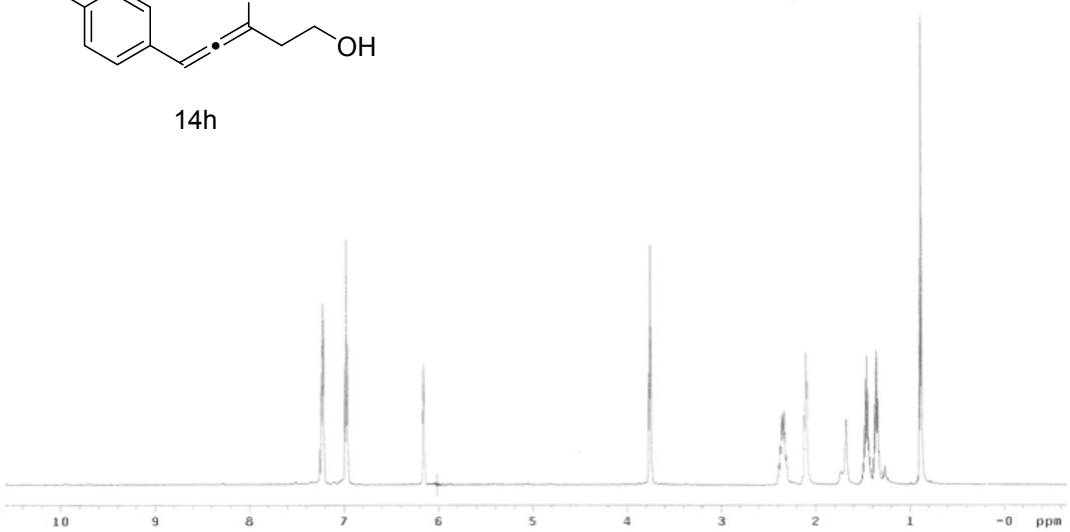

200
180
160
140
120
100
80
60
40
20
ppm

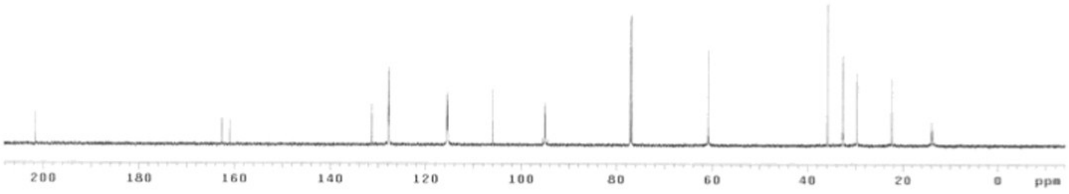

Cl
Bu
OH
14g
2.27
2.04
1.00
2.06
2.02
2.07
1.00
2.04
2.09
3.13
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

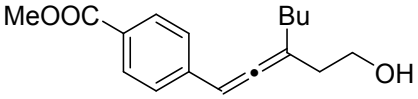

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


F
Bu
OH

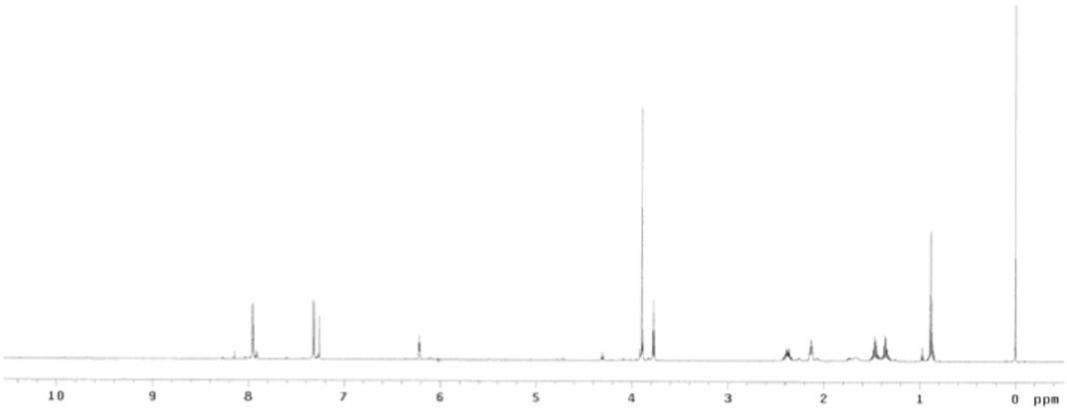
14h

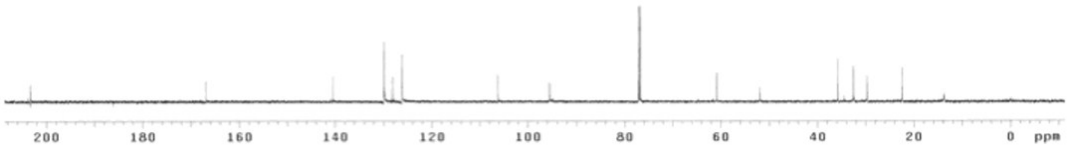

10 9 8 7 6 5 4 3 2 1 -0 ppm

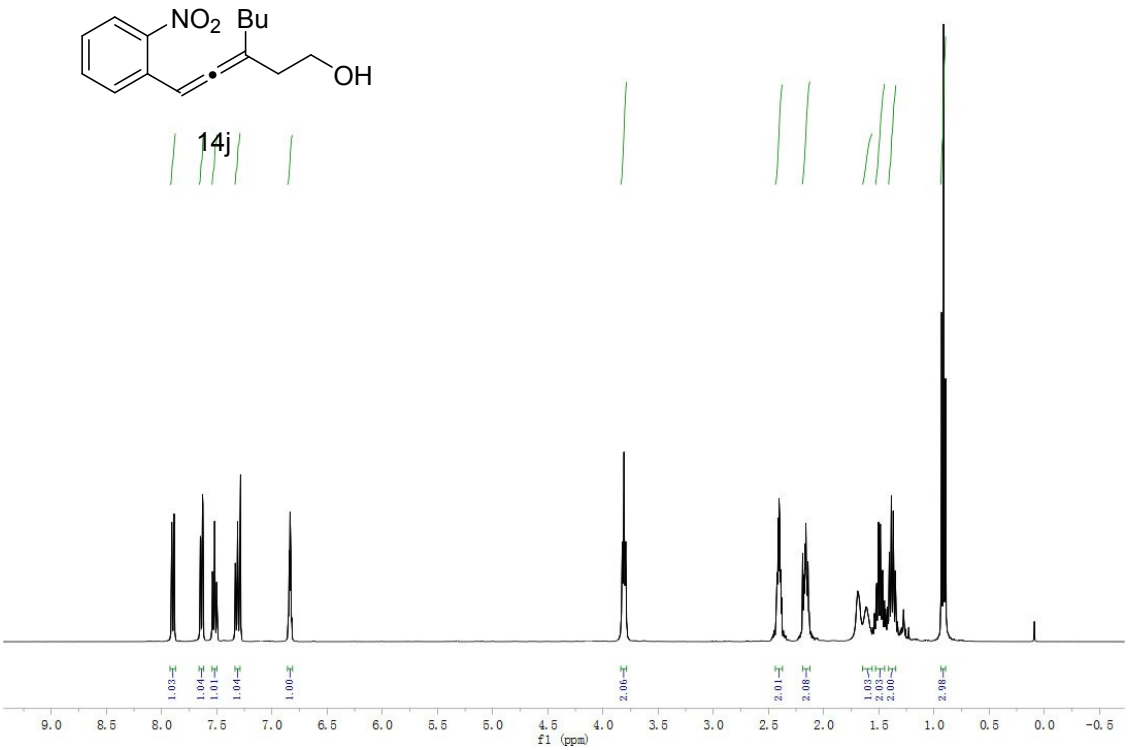

200
180
160
140
120
100
80
60
40
20
0
ppm

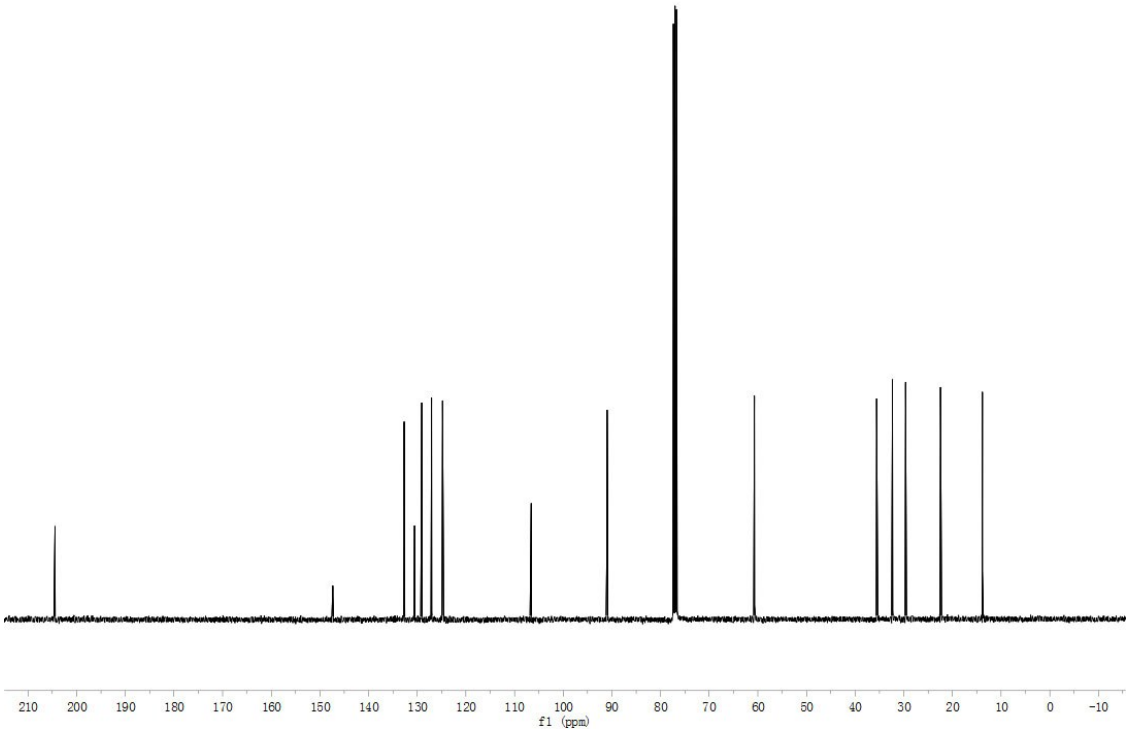

MeOOC
Bu
OH

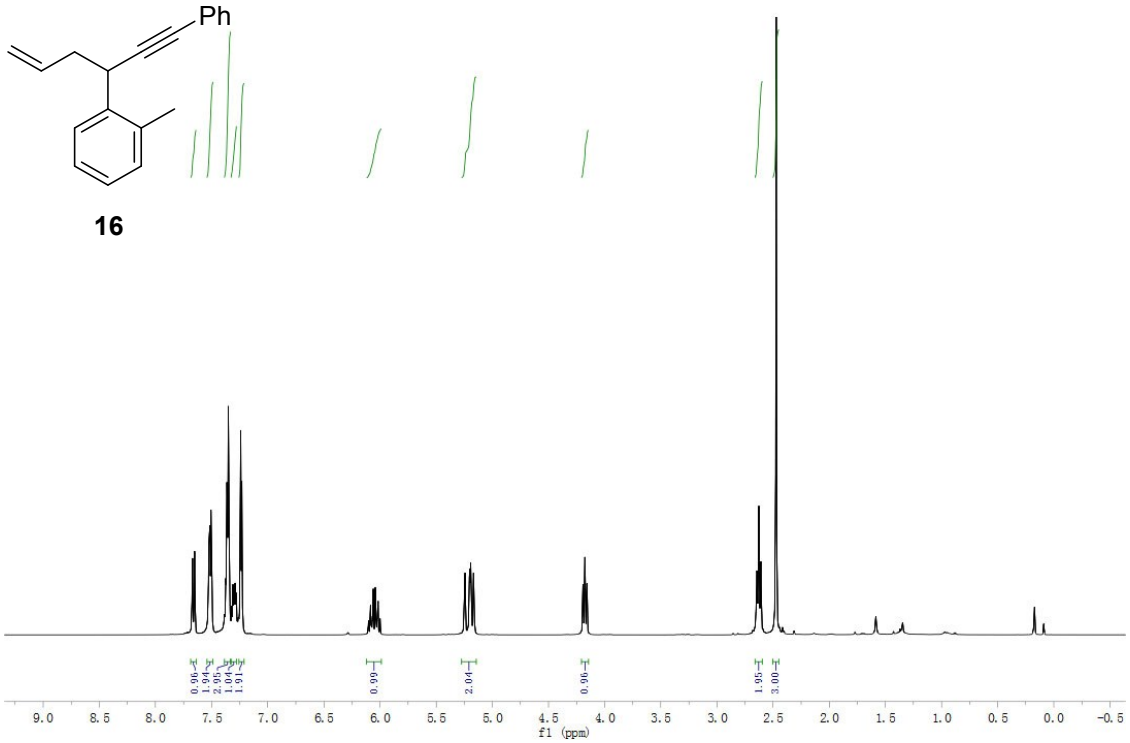
14i

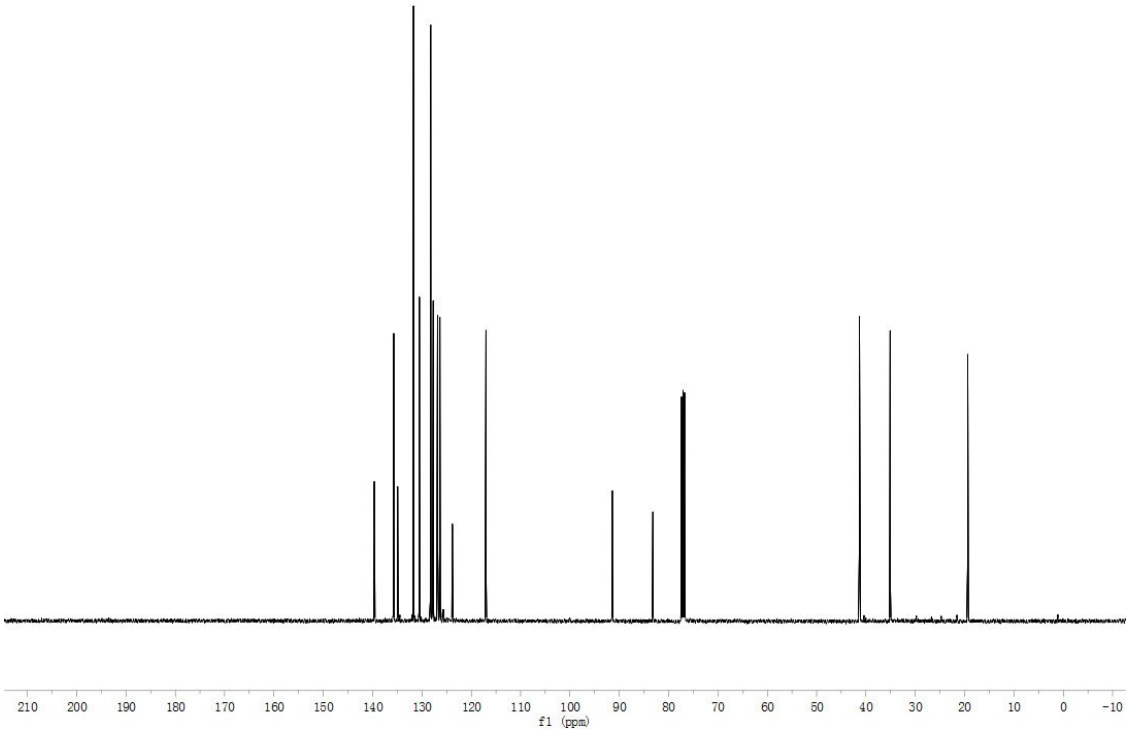

10
9
8
7
6
5
4
3
2
1
0
ppm


200
180
160
140
120
100
80
60
40
20
0 ppm


NO2
Bu
OH
14j
1.03
1.04
1.01
1.04
1.00
2.06
2.01
2.08
1.03
2.03
2.00
2.98
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)


210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


Ph
16
0.96
1.94
2.95
1.04
1.91
0.99
2.04
0.96
1.95
3.00
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)


210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)