Electronic Supplementary Material (ESI) for ChemComm.

Supporting Information for

Photoredox Catalyzed Iminyl Radical-Triggered C-C Bond Cleavage/Addition/Kornblum Oxidation Cascade of Oxime Esters and Styrenes: Synthesis of Ketonitriles

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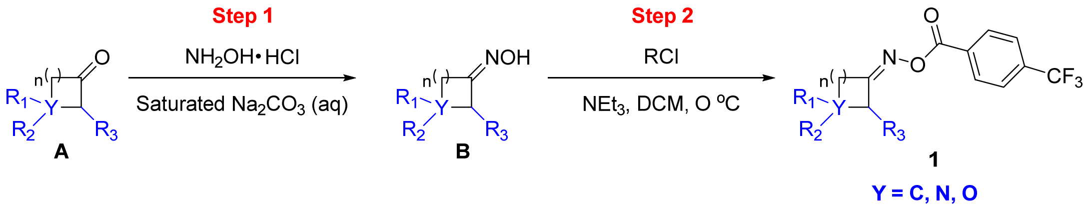
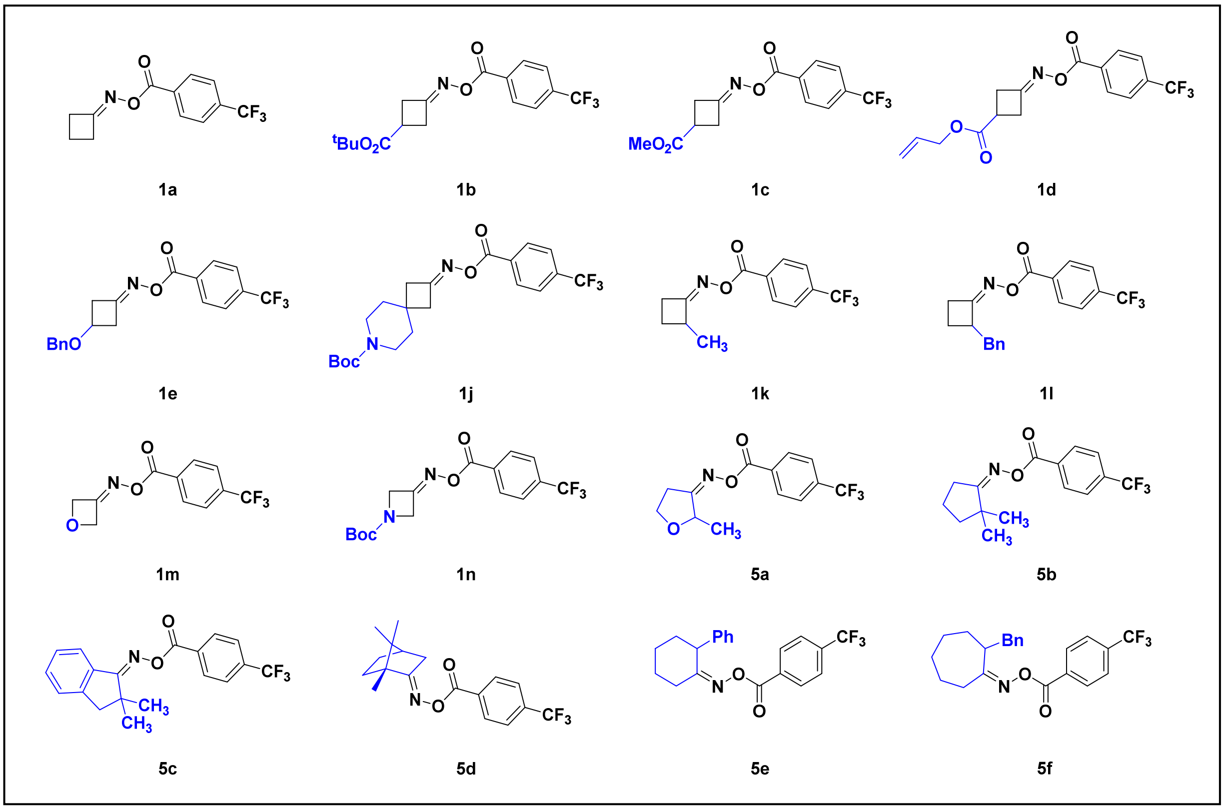
1. General Information

Unless otherwise noted, materials were purchased from commercial suppliers and used without further purification. All the solvents were treated according to general methods. Flash column chromatography was performed using 200-300 mesh silica gel. ^{1}H NMR spectra were recorded on 400 or 600 MHz spectrophotometers. Chemical shifts (δ) are reported in ppm from the resonance of tetramethyl silane as the internal standard (TMS: 0.00 ppm). Data are reported as follows: chemical shift, multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet), coupling constants (Hz) and integration. ^{13}C NMR spectra were recorded on 100 or 150 MHz with complete proton decoupling spectrophotometers. The high resolution mass spectra (HRMS) were measured on a Shimadzu LCMS-IT-TOF mass spectrometer or DIONEX UltiMate 3000 & Bruker Compact TOF or DIONEX UltiMate 3000 & Bruker Compact TOF mass spectrometer by ESI. Unless otherwise noted, materials obtained from commercial suppliers were used without further purification.

2. Preparation of Substrates

2.1 General Procedure for Preparation of Cyclobutanone Oxime Esters 1a-1e, 1j-1n, and 5a-5f.

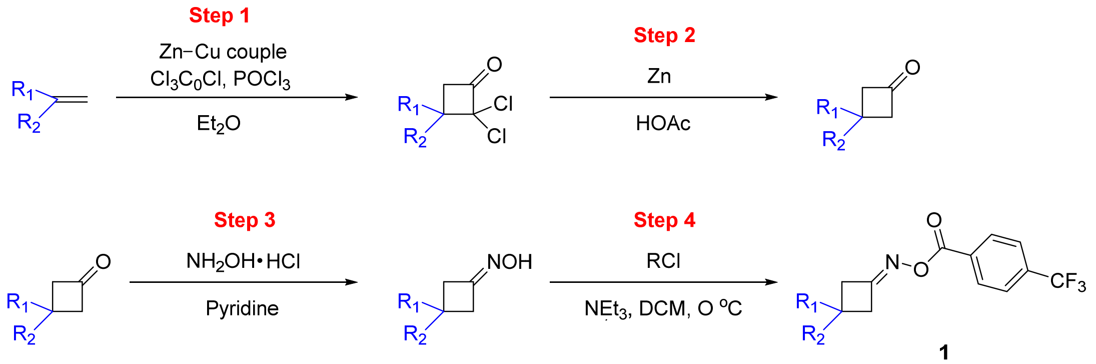




To a stirred solution of cyclobutanone **A** (30 mmol, 1.0 equiv) in saturated Na_2CO_3 (30 mL), hydroxylamine hydrochloride **B** (36 mmol, 1.2 equiv) was added. Then, the pH value of the mixture was held at 7~8 by adding H_2O to the system, The mixture was stirred at room temperature until the reaction was completed, as monitored by TLC. Then, after the extration with ether, the solution was dried over Na_2SO_4 and evaporated to provide crude product which was used in the next step without any further purifications.

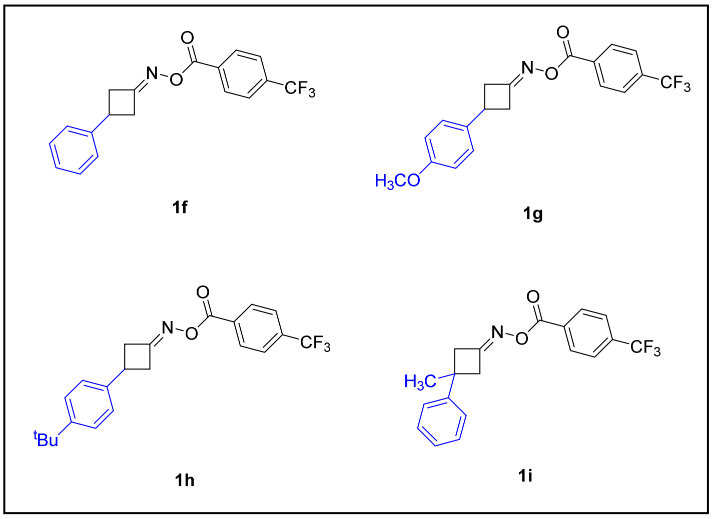
To a mixture of cyclobutanone oxime (1.0 equiv.), triethylamine (2.0 equiv.) and DCM (0.5 M) in a 30-mL two-necked flask was added *p*-CF_3benzoyl chloride (1.5 equiv.) at 0 °C. After 6 h, water was added to the above solution, and the mixture was diluted with diethyl ether. The organic layer was washed with water and dried over Na_2SO_4. The solvent was removed under vacuum and the residue was subjected to column chromatography on SiO_2 with PE/EtOAc as an eluent to give cyclobutanone oxime esters.[1]

2.2 General Procedure for Preparation of Cyclobutanone Oxime Esters 1f-1i.



1

R = *p*-$CF_3C_6H_4CO$



1f **1g** **1h** **1i**

To a 50 mL three-necked flask under argon were added alkene derivative (5.0 mmol, 1.0 equiv.), zinc-copper couple (15 mmol, 3.0 equiv.), and anhydrous ether (0.5 M). To this mixture was added a solution of trichloroacetyl chloride (10 mmol, 2.0 equiv.) and phosphorus oxychloride (5.5 mmol, 1.1 equiv.) in ether (0.5 M) over 1 h through an addition funnel. The suspension was stirred overnight at reflux. The resulting mixture was filtered through a pad of celite and was washed with ether (20 mL). The organic layer was successively washed with water (30 mL), a saturated aqueous solution of $NaHCO_3$ (30 mL) and brine (30 mL) before it was dried over Na_2SO_4. Then, the solution was filtered, concentrated and used in the next step without further purification.

A mixture of 2, 2-dichlorocyclobutanones (1.0 equiv.) and zinc dust (4.0 equiv.) in acetic acid (10 mL) was stirred at room temperature for 2 h and then heated at 80 °C for 5 h. The resulting mixture was allowed to cool to room temperature. Then, the solution was diluted with water (30 mL) and extracted with ether (3*20 mL). The organic phase was washed successively with a saturated solution of aqueous $NaHCO_3$ (3*30 mL), water (30 mL) and brine (30 mL), then dried over Na_2SO_4 and concentrated in vacuum. The crude material was then purified by flash chromatography with a mixture of petroleum ether and ethyl acetate to afford various cyclobutanones.

To a stirred solution of cyclobutanones (1.0 equiv.) in pyridine (0.5 M) was added hydroxylamine hydrochloride (2.0 equiv.) at rt. After stirring for 2 h, pyridine was removed under reduced pressure. The residue was diluted with water and extracted with EtOAc. The aqueous layer was extracted with EtOAc and the combined organic extracts were washed with brine, dried over Na_2SO_4, and evaporated under reduced pressure to give the crude material, which were used in the next step without further purification.

To a mixture of cyclobutanone oxime (1.0 equiv.), triethylamine (2.0 equiv.) and DCM (0.5 M) in a 30-mL two-necked flask was added *p*-CF_3 benzoyl chloride (1.5 equiv.) at 0 °C. After 6 h, water was added to the above solution, and the mixture was diluted with diethyl ether. The organic layer was washed with water and dried over Na_2SO_4. The solvent was removed under vacuum and the residue was subjected to column chromatography on SiO_2 with PE-EtOAc as an eluent to give cyclobutanone oxime esters.[2]

Reference:

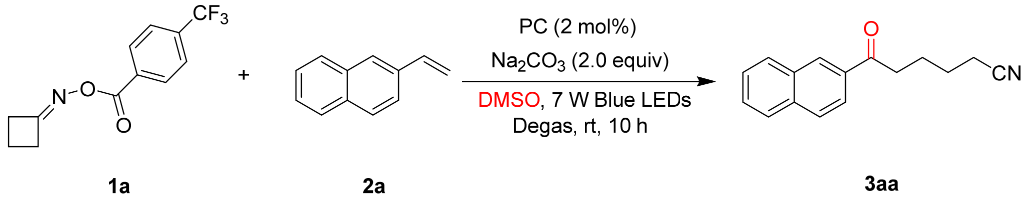
[1] a) J. Ramnauth, E. Lee-Ruff, *Can.J.Chem*. **2001**, ***79***, 114–120. b) Š. M. Vesna, M. Zlatko, V. Hrvoj, *Chem. Soc. Perkin Trans. 2*, **2002**, 2154–2158. c) B.-L. Zhao, Z.-Z. Shi, *Angew. Chem. Int. Ed.* **2017**, *56*, 12727-12731. d) H.-B. Yang, N. Selander, *Chem. Eur. J.* **2017**, *23*, 1779 – 1783. e) L.–Y. Li, H.-G. Chen, M.-J. Mei, L. Zhou, *Chem.Commun*. **2017**, *53*, 11544-11547. f) Y.-R. Gu, X.-H. Duan, L. Yang, L.-N. Guo, *Org. Lett*. **2017**, *19*, 5908–5911.

[2] a) T. Nishimura, Y. Nishiguchi, Y. Maeda, S. Uemura, *J. Org. Chem*. **2004**, **69**, 5342 − 5347. b) K. S. Petersen, B.M. Stoltz, *Tetrahedron* **2011**, *67*, 4352-4357. c) H.-J. Xu, F.-F. Zhu, Y.-Y. Shen, X. Wan, Y.-S. Feng, *Tetrahedron* **2012**, *68*, 4145-4151. d) H. Cho, Y. Iwama, K. J. Sugimoto, S. Mori, H. Tokuyama, *J. Org. Chem*. **2010**, 75, 627-636. e) T. Nishimura, T. Yoshinaka, Y. Nishiguchi, Y. Maeda, S. Uemura, *Org. Lett.* **2005**, *7*, 2425-2427.

3. Detailed Optimization of Reaction Conditions

3.1 Optimization of Reaction Conditions

Table S1. Screen of photocatalysts[a]

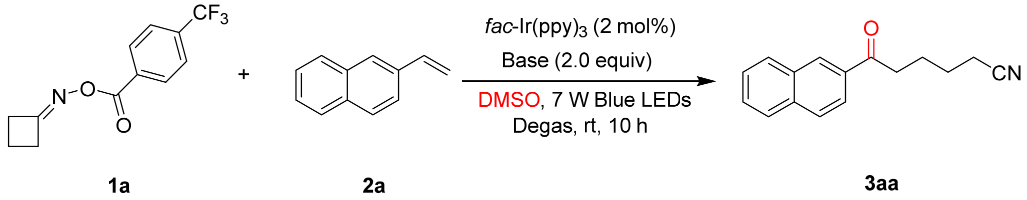


Entry	[Photocatalyst] (2 mol%)	Yield[b] (%)
1	*fac*-Ir(ppy)$_3$	47
2	Ru(bpy)$_3$Cl$_2$·6H$_2$O	N. R.
3	Eosin Y	N. R.
4	Ir(4-Fppy)$_2$(dtbbpy)PF$_6$	N. R.
5	Ir(2,4-dFppy)$_3$	N. R.
6	Ir(4-Fppy)$_3$	N. R.

[a]Unless otherwise noted, reactions were carried out with **1a** (0.20 mmol), **2a** (0.30 mmol), Photocatalyst (2 mol %), Na$_2$CO$_3$ (0.40 mmol) in **DMSO** (2.0 mL) at rt. [b]Isolated yields. N.R. = no reaction.

As shown in *Table S1*, among all the photocatalysts tested, only *fac*-Ir(ppy)$_3$ gave the desired product (47% yield), and was thus selected for further optimization studies.

Table S2. Screen of bases[a]

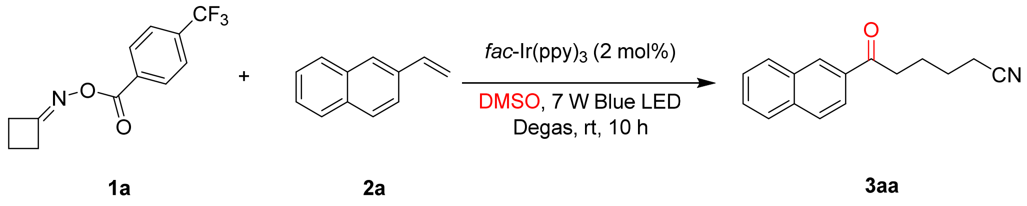


Entry	Base	Yield[b] (%)
1	None	75
2	K$_2$CO$_3$	68
3	Cs$_2$CO$_3$	Trace
4	NaHCO$_3$	49
5	Li$_2$CO$_3$	27
7	NaOAc	42

[a]Unless otherwise noted, reactions were carried out with **1a** (0.20 mmol), **2a** (0.30 mmol), *fac*-Ir(ppy)$_3$ (2 mol %), Base (0.40 mmol) in **DMSO** (2.0 mL) at rt. [b]Isolated yield.

As shown in *Table S2,* among all the bases tested, the reaction without any base gave the best result in terms of yield (75% yield), and was thus selected for further studies.

Table S3. Screen of concentration of substrates[a]



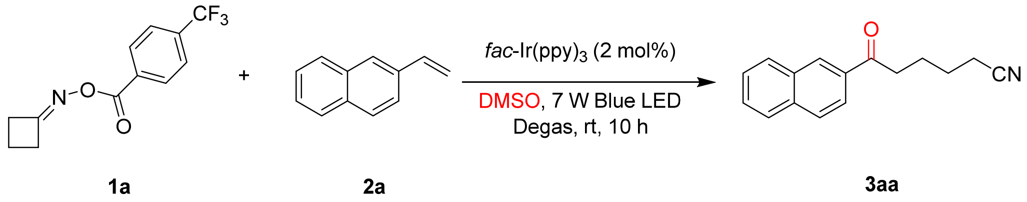
Entry	Concentration of **1a** (M)	Yield[b] (%)
1	0.40	34
2	0.20	67
3	0.10	75
4	0.05	Trace

[a]Unless otherwise noted, reactions were carried out with **1a** (0.20 mmol), **2a** (0.30 mmol), *fac*-Ir(ppy)$_3$ (2 mol %) in **DMSO** at rt. [b]Isolated yield.

As shown in *Table S3*, When 2.0 mL of DMSO was added into the system, the concentration of **1a** was 0.10 M. The reaction gave the best result in terms of yield (75%), and was thus selected as the optimal condition.

3.2 Control Experiments for Synthesis of 3aa

Table S4. Control experiments[a]



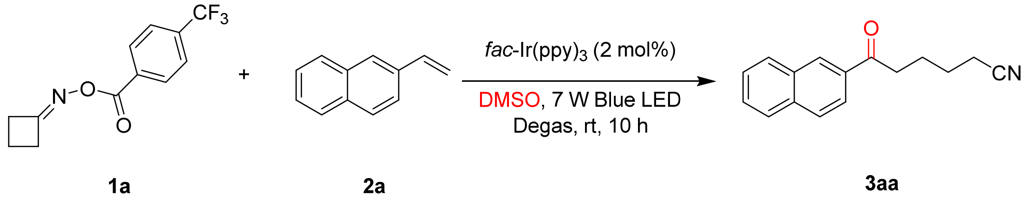
Entry	Light	Photocatalyst	Yield[b] (%)
1	-	+	N. R.
2	+	-	N. R.

[a]Unless otherwise noted, reactions were carried out with **1a** (0.20 mmol), **2a** (0.30 mmol), *fac*-Ir(ppy)$_3$ (2 mol %) in **DMSO** (2.0 mL) at rt. [b]Isolated yield. N.R. = no reaction.

The results of *Table S4* reveal that both of photocatalyst and light are necessary for the synthesis of **3aa**.

4. General Procedure and Spectral Data of Products

4.1 General Procedure for Synthesis of 3aa

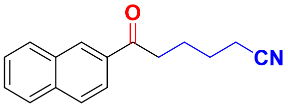


To a 10 mL flame-dried round Schlenk tube equipped with a magnetic stirbar was added **1a** (51.4 mg, 0.2 mmol), **2a** (46.3 mg, 0.3 mmol), *fac*-Ir(ppy)$_3$ (2.62 mg, 0.004 mmol), and DMSO (2.0 mL) under argon atmosphere. Then, the resulting mixture was degassed through the "freeze-pump-thaw" procedure (3 times). Subsequently, the solution was stirred at a distance of ~5 cm from a 7 W blue LEDs (450-460 nm) at room tempeature for about 10 h until the reaction was completed as monitored by TLC analysis. The crude product was then quenched by water and extracted with EtOAc. Then, the combined mixture was washed by an saturated aqueous solution of NaCl before purified by flash chromatography on silica gel (petroleum ether/ethyl acetate 20:1~10:1) to give the the corresponding product **3aa** in 75% yield as a white solid.

The reactions of all of the other products **3** were carried out according to the above procedure.

4.2 Spectral Data of Products

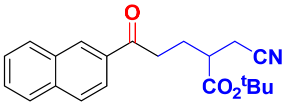
Product 3aa. 6-(naphthalen-2-yl)-6-oxohexanenitrile



3aa

Yield of **3aa** (10 h): 35.5 mg, 75% as a white solid. ^{1}H NMR (400 MHz, CDCl$_3$) δ (ppm) = 8.46 (s, 1H), 8.02 – 7.95 (m, 2H), 7.89 (t, J = 8.2 Hz, 2H), 7.62 – 7.54 (m, 2H), 3.16 (t, J = 6.9 Hz, 2H), 2.45 – 2.39 (m, 2H), 2.00 –1.92 (m, 2H), 1.83 – 1.76 (m, 2H). ^{13}C NMR (100 MHz, CDCl$_3$) δ (ppm)= 199.0, 135.6, 133.9, 132.4, 130.5, 129.6, 129.5, 128.5, 127.8, 126.8, 123.7, 119.5, 37.4, 25.0, 23.2, 17.0. M.P.: 93.5 - 94.8 °C. HRMS (EI): m/z [M+Na]$^+$ calcd for $C_{16}H_{15}NNaO$: 260.1046; found: 260.1045.

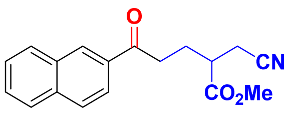
Product 3ba. Tert-butyl-2-(cyanomethyl)-5-(naphthalen-2-yl)-5-oxopentanoate



3ba

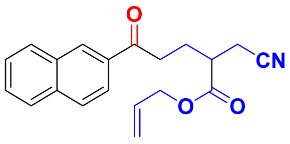
Yield of **3ba** (10 h): 64.7 mg, 64% as a white solid. ^{1}H NMR (400 MHz, CDCl$_3$) δ (ppm) = 8.47 (s, 1H), 7.99 (d, J = 26.2 Hz, 2H), 7.92 – 7.86 (m, 2H), 7.63 – 7.55 (m, 2H), 3.24 (t, J = 7.2 Hz, 2H), 2.82 (d, J = 6.9 Hz, 1H), 2.69 (t, J = 8.4 Hz, 2H), 2.18 (q, J = 7.2 Hz, 2H), 1.48 (s, 9H). ^{13}C NMR (100 MHz, CDCl$_3$) δ (ppm) = 198.2, 171.5, 135.6, 133.8, 132.5, 129.7, 129.6, 128.6, 127.8, 127.6, 126.9, 123.6, 117.7, 82.4, 41.6, 35.3, 28.0, 25.9, 20.0. M.P.: 69.9 – 70.0 °C. HRMS (EI): m/z [M+Na]$^+$ calcd for $C_{21}H_{23}NNaO_3$: 360.1570; found: 360.1568.

Product 3ca. Methyl-2-(cyanomethyl)-5-(naphthalen-2-yl)-5-oxopentanoate


3ca

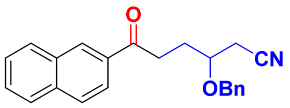
Yield of **3ca** (10 h)**:** 56.1 mg, 63% as a yellow solid. ^{1}H NMR (400 MHz, CDCl$_3$) δ (ppm) = 8.46 (s, 1H), 8.02 – 7.96 (m, 2H), 7.91 – 7.87 (m, 2H), 7.63 – 7.55 (m, 2H), 3.75 (s, 3H), 3.24 (t, J = 7.1 Hz, 2H), 2.98 – 2.90 (m, 1H), 2.78 – 2.64 (m, 2H), 2.28 – 2.21 (m, 2H). ^{13}C NMR (100 MHz, CDCl$_3$) δ (ppm) = 198.2, 172.7, 135.6, 133.7, 132.4, 129.7, 129.5, 128.6, 128.6, 127.8, 126.9, 123.6, 117.6, 52.5, 40.7, 35.2, 25.6, 19.8. M.P.: 56.6 - 57.2 °C. HRMS (EI): m/z [M+Na]$^+$ calcd for C$_{18}$H$_{17}$NNaO$_3$: 318.1101; found: 318.1103.

Product 3da. Allyl-2-(cyanomethyl)-5-(naphthalen-2-yl)-5-oxopentanoate


3da

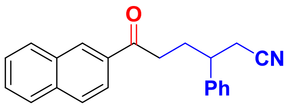
Yield of **3da** (10 h)**:** 67.5 mg, 70% as a yellow solid. ^{1}H NMR (400 MHz, CDCl$_3$) δ (ppm) = 8.46 (s, 1H), 8.03 – 7.88 (m, 2H), 7.94 – 7.87 (m, 2H), 7.64 – 7.55 (m, 2H), 5.96 – 5.82 (m, 1H), 5.37 – 5.22 (m, 2H), 4.65 (d, J = 5.8 Hz, 2H), 3.26 (t, J = 7.1 Hz, 2H), 3.03 – 2.94 (m, 1H), 2.81 – 2.67 (m, 2H), 2.26 (q, J = 7.1 Hz, 2H). ^{13}C NMR (100 MHz, CDCl$_3$) δ (ppm) = 198.2, 171.9, 135.6, 133.7, 132.4, 131.3, 129.7, 129.5, 128.6, 128.5, 127.7, 126.8, 123.6, 119.2, 117.5, 66.1, 40.8, 35.2, 25.7, 19.8. M.P.: 38.0 – 38.5 °C. HRMS (EI): m/z [M+H]$^+$ calcd for C$_{20}$H$_{20}$NO$_3$: 322.1438; found: 322.1436.

Product 3ea. 3-(benzyloxy)-6-(naphthalen-2-yl)-6-oxohexanenitrile


3ea

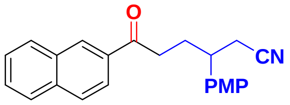
Yield of **3ea** (10 h): 74.8 mg, 73% as a white solid. ^{1}H NMR (400 MHz, CDCl$_3$) δ (ppm) = 8.41 (s, 1H), 8.00 – 7.89 (m, 4H), 7.65 – 7.55 (m, 2H), 7.36 – 7.26 (m, 5H), 4.71 (d, J = 7.9 Hz, 1H), 4.53 (d, J = 11.4 Hz, 1H), 3.92– 3.89 (m, 1H), 3.27 – 3.14 (m, 2H), 2.71 – 2.59 (m, 2H), 2.24 – 2.07 (m, 2H). ^{13}C NMR (100 MHz, CDCl$_3$) δ (ppm) = 199.0, 137.3, 135.6, 133.9, 132.5, 129.7, 129.5, 128.5, 128.5, 128.1, 127.8, 126.8, 123.7, 117.4, 73.4, 72.1, 33.5, 28.7, 23.2. M.P.: 81.5 – 81.8 °C. HRMS (EI): m/z [M+Na]$^+$ calcd for C$_{23}$H$_{21}$NNaO$_2$: 366.1464; found: 366.1456.

Product 3fa. 6-(naphthalen-2-yl)-6-oxo-3-phenylhexanenitrile


3fa

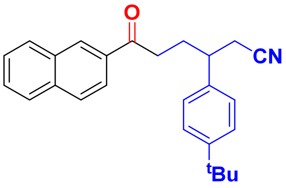
Yield of **3fa** (10 h): 62.2 mg, 66% as a white solid. ^{1}H NMR (400 MHz, CDCl$_3$) δ (ppm) = 8.28 (s, 1H), 7.93 – 7.83 (m, 4H), 7.59 – 7.50 (m, 2H), 7.36 (t, J = 7.3 Hz, 2H), 7.30 (d, J = 7.0 Hz, 1H), 7.25 (s, 1H), 3.08 – 3.15 (m, 1H), 3.05 – 2.89 (m, 2H), 2.68 (d, J = 6.9 Hz, 2H), 2.42 – 2.33 (m, 1H), 2.23 – 2.17 (m, 1H). ^{13}C NMR (100 MHz, CDCl$_3$) δ (ppm) = 199.0, 140.8, 135.5, 133.9, 132.4, 129.6, 129.5, 129.1, 128.5, 128.4, 127.7, 127.7, 127.3, 126.7, 123.6, 118.3, 41.5, 35.8, 29.3, 25.4. M.P.:136.7 – 137.2 °C. HRMS (EI): m/z [M+Na]$^+$ calcd for C$_{22}$H$_{19}$NNaO: 336.1359; found: 336.1359.

Product 3ga. 3-(4-methoxyphenyl)-6-(naphthalen-2-yl)-6-oxohexanenitrile


3ga

Yield of **3ga** (10 h): 52.4 mg, 51% as a white solid. ^{1}H NMR (400 MHz, CDCl$_3$) δ (ppm) = 8.29 (s, 1H), 7.95 – 7.84 (m, 4H), 7.61 – 7.52 (m, 2H), 7.18 (d, J = 7.2 Hz, 2H), 6.90 (d, J = 7.1 Hz, 2H), 3.79 (s, 3H), 3.09 – 2.95 (m, 3H), 2.66 (d, J = 7.5 Hz, 3H), 2.38 – 2.32 (m, 1H), 2.20 – 2.14 (m, J = 9.8, 6.9 Hz, 1H). ^{13}C NMR (100 MHz, CDCl$_3$) δ (ppm) = 199.1, 159.0, 135.5, 133.9, 132.6, 132.4, 129.6, 129.5, 128.5, 128.4, 128.3, 127.7, 126.8, 123.6, 118.4, 114.4, 55.2, 40.8, 35.9, 29.4, 25.7. M.P.: 100.5 – 101.0 °C. HRMS (EI): m/z $[M+H]^+$ calcd for $C_{23}H_{22}NO_2$: 344.1645; found: 344.1643.

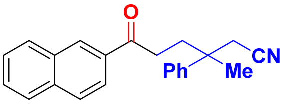
Product 3hb. 3-(4-(tert-butyl)phenyl)-6-(naphthalen-2-yl)-6-oxohexanenitrile



3ha

Yield of **3ha** (10 h): 69.1 mg, 62% as a white solid.. ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm) = 8.30 (s, 1H), 7.95 – 7.85 (m, 4H), 7.61 – 7.51 (m, 2H), 7.37 (d, J = 8.1 Hz, 2H), 7.19 (d, J = 8.1 Hz, 2H), 3.15 – 2.95 (m, 3H), 2.68 (d, J = 6.8 Hz, 2H), 2.40 – 2.33 (m, 1H), 2.28 – 2.17 (m, 1H), 1.31 (s, 9H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm) = 199.3, 150.6, 137.6, 135.6, 134.0, 132.4, 129.7, 129.5, 128.5, 128.4, 127.7, 127.0, 126.8, 126.0, 123.7, 118.5, 41.1, 36.0, 34.5, 31.3, 29.4, 25.5. M.P.: 146.5 – 147.0 °C. HRMS (EI): m/z $[M+Na]^+$ calcd for $C_{26}H_{27}NNaO$: 392.1985; found: 392.1985.

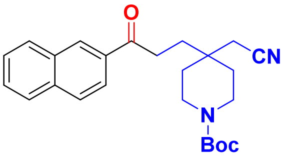
Product 3ia. 3-methyl-6-(naphthalen-2-yl)-6-oxo-3-phenylhexanenitrile



3ia

Yield of **3ia** (10 h)**:** 58.7 mg, 57% as a white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm) = 8.25 (s, 1H), 7.91 – 7.83 (m, 4H), 7.60 – 7.51 (m, 2H), 7.41 (d, J = 6.2 Hz, 4H), 7.31 (t, J = 6.2 Hz, 1H), 2.98 – 2.90 (m, 1H), 2.83 – 2.71 (m, 3H), 2.47 – 2.40 (m, 1H), 2.27 – 2.19 (m, 1H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm) = 199.1, 143.1, 135.5, 133.8, 132.4, 129.6, 129.5, 129.0, 128.5, 128.4, 127.7, 127.2, 126.8, 125.8, 123.7, 117.8, 40.0, 35.8, 33.7, 32.2, 24.7. M.P.: 110.1. – 110.3 °C. HRMS (EI): m/z $[M+H]^+$ calcd for $C_{23}H_{22}NO$: 328.1696; found: 328.1699.

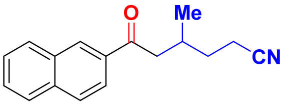
Product 3ja. Tert-butyl-4-(cyanomethyl)-4-(3-(naphthalen-2-yl)-3-oxopropyl)piperidine-1-carboxylate



3ja

Yield of **3ja** (10 h)**:** 81.8 mg, 67 % as a white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm) = 8.49 (s, 1H), 8.03 – 7.98 (m, 2H), 7.93 – 7.87 (m, 2H), 7.64 – 7.57 (m, 2H), 3.55 – 3.47 (m, 2H), 3.45 – 3.37 (m, 2H), 3.15 – 3.09 (m, 2H), 2.48 (s, 2H), 2.06 (d, J = 9.1 Hz, 2H), 1.61 (s, 4H), 1.46 (s, 9H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm) = 198.8, 154.7, 135.7, 133.8, 132.5, 129.8, 129.6, 128.6, 127.8, 126.9, 123.7, 117.4, 79.9, 42.6, 40.9, 34.2, 34.1, 32.3, 31.2, 28.4, 26.2. M.P.: 111.5 – 112.0 °C. HRMS (EI): m/z $[M+K]^+$ calcd for $C_{25}H_{30}KN_2O_3$: 445.1888; found: 445.1890.

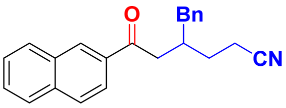
Product 3ka. 4-methyl-6-(naphthalen-2-yl)-6-oxohexanenitrile



3ka

Yield of **3ka** (10 h)**:** 48.1 mg, 64% as a white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm) = 8.47 (s, 1H), 8.03– 7.97 (m, 2H), 7.93 – 7.87 (m, 2H), 7.64 – 7.55 (m, 2H), 3.15 – 3.00 (m, 2H), 2.50 – 2.37 (m, 3H), 1.94 – 1.85 (m, 1H), 1.69 – 1.64 (m, 1H), 1.08 (d, J = 6.7 Hz, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm) = 198.9, 135.6, 134.3, 132.5, 129.7, 129.6, 128.6, 128.6, 127.8, 126.9, 123.7, 119.7, 45.0, 32.3, 29.0, 19.4, 15.1. M.P.: 25.0 – 26.2 °C. HRMS (EI): m/z $[M+H]^+$ calcd for $C_{17}H_{18}NO$: 252.1383; found: 252.1380.

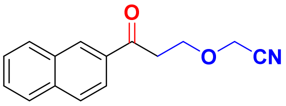
Product 3la. 4-benzyl-6-(naphthalen-2-yl)-6-oxohexanenitrile



3la

Yield of **3la** (10 h)**:** 85.0 mg, 87% as a white solid. ^{1}H NMR (400 MHz, CDCl$_3$) δ (ppm) = 8.30 (s, 1H), 7.97 – 7.86 (m, 4H), 7.63 – 7.53 (m, 2H), 7.32 (t, J = 7.2 Hz, 2H), 7.23 (t, J = 6.9 Hz, 3H), 3.19 – 3.13 (m, 1H), 3.02 – 2.96 (m, 1H), 2.82 – 2.68 (m, 2H), 2.63 – 2.56 (m, 1H), 2.41 (t, J = 7.6 Hz, 2H), 1.89 – 1.81 (m, 2H). ^{13}C NMR (100 MHz, CDCl$_3$) δ (ppm) = 199.0, 139.2, 135.6, 134.1, 132.4, 129.8, 129.6, 129.2, 128.6, 128.6, 128.5, 127.8, 126.8, 126.6, 123.7, 119.6, 41.8, 40.2, 35.8, 29.7, 15.2. M.P.: 81.0 – 81.8 °C. HRMS (EI): m/z [M+Na]$^+$ calcd for $C_{23}H_{21}NNaO$: 350.1515; found: 350.1517.

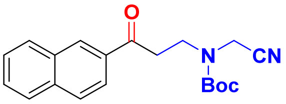
Product 3ma. 2-(3-(naphthalen-2-yl)-3-oxopropoxy)acetonitrile



3ma

Yield of **3ma** (10 h)**:** 54.7 mg, 72% as a white solid. ^{1}H NMR (400 MHz, CDCl$_3$) δ (ppm) = 8.48 (s, 1H), 8.04 – 7.97 (m, 2H), 7.93 – 7.87 (m, 2H), 7.64 – 7.55 (m, 2H), 4.33 (s, 2H), 4.11 (t, J = 6.0 Hz, 2H), 3.44 (t, J = 6.0 Hz, 2H). ^{13}C NMR (100 MHz, CDCl$_3$) δ (ppm) = 197.1, 135.7, 133.9, 132.4, 130.0, 129.6, 128.7, 128.6, 127.8, 126.9, 123.6, 115.9, 66.9, 56.7, 38.2. M.P.: 63.0 – 63.3 °C. HRMS (EI): m/z [M + H]$^+$ calcd for $C_{15}H_{14}NO_2$: 240.1019; found: 240.1020.

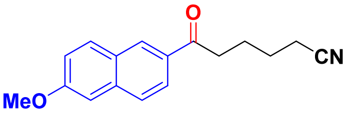
Product 3na. Tert-butyl(cyanomethyl)(3-(naphthalen-2-yl)-3-oxopropyl)carbamate



3na

Yield of **3na** (10 h)**:** 67.5 mg, 69% as a white solid. ^{1}H NMR (400 MHz, CDCl$_3$) δ (ppm) = 8.53 (s, 1H), 8.08 – 8.01 (m, 2H), 7.97 – 7.91 (m, 2H), 7.69 – 7.62 (m, 2H), 4.40 (s, 2H), 3.83 (d, J = 5.5 Hz, 2H), 3.55 (s, 2H), 1.54 (s, 9H). ^{13}C NMR (100 MHz, CDCl$_3$) δ (ppm) = 198.6, 154.1, 135.7, 133.6, 132.4, 130.3, 130.0, 129.5, 128.6, 127.7, 126.9, 123.5, 116.5, 81.9, 43.8, 37.8, 36.2, 28.2. M.P.: 126.5 – 126.8 °C. HRMS (EI): m/z [M+Na]$^+$ calcd for $C_{20}H_{22}N_2NaO_3$: 361.1523; found: 361.1520.

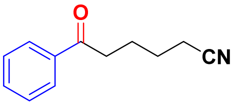
Product 3ab. 6-(6-methoxynaphthalen-2-yl)-6-oxohexanenitrile



3ab

Yield of **3ab** (10 h)**:** 50.1 mg, 62% as a white solid. ^{1}H NMR (400 MHz, CDCl$_3$) δ (ppm) = 8.38 (s, 1H), 7.98 (d, J = 7.2 Hz, 1H), 7.84 (d, J = 9.0 Hz, 1H), 7.77 (d, J = 8.6 Hz, 1H), 7.23 – 7.14 (m, 2H), 3.94 (s, 3H), 3.13 (t, J = 7.0 Hz, 2H), 2.42 (t, J = 7.1 Hz, 2H), 1.99 – 1.92 (m, 2H), 1.83 – 1.74 (m, 2H). ^{13}C NMR (100 MHz, CDCl$_3$) δ (ppm) = 198.7, 159.8, 137.3, 132.0, 131.1, 129.5, 127.7, 127.2, 124.4, 119.8, 119.5, 105.7, 55.4, 37.2, 25.0, 23.3, 17.1. M.P.: 104.6 – 104.9 °C. HRMS (EI): m/z [M+Na]$^+$ calcd for $C_{17}H_{17}NNaO_2$: 290.1151; found: 290.1152.

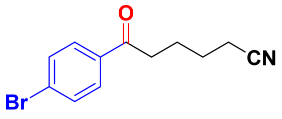
Product 3ac. 6-oxo-6-phenylhexanenitrile



3ac

Yield of **3ac** (10 h)**:** 46.0 mg, 82% as a white solid. ^{1}H NMR (400 MHz, CDCl$_3$) δ (ppm) = 7.95 (d, J = 7.7 Hz, 2H), 7.65 – 7.54 (m, 1H), 7.47 (t, J = 7.6 Hz, 2H), 3.04 (t, J = 6.9 Hz, 2H), 2.41 (t, J = 7.0 Hz, 2H), 1.95 – 1.88 (m, 2H), 1.80 – 1.73 (m, 2H). ^{13}C NMR (100 MHz, CDCl$_3$) δ (ppm) = 199.0, 136.7, 133.2, 128.6, 127.9, 119.4, 37.3, 25.0, 23.1, 17.1. M.P.: 65.9 – 66.0 °C. HRMS (EI): m/z [M+Na]$^+$ calcd for $C_{12}H_{13}NNaO$: 210.0889; found: 210.0888.

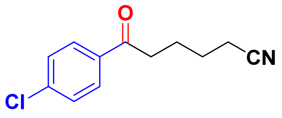
Product 3ad. 6-(4-bromophenyl)-6-oxohexanenitrile



3ad

Yield of **7ad** (10 h): 70.9 mg, 89% as a white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm) = 7.82 (d, J = 8.5 Hz, 2H), 7.62 (d, J = 8.5 Hz, 2H), 3.01 (t, J = 6.9 Hz, 2H), 2.41 (t, J = 7.1 Hz, 2H), 1.90 (q, J = 7.2 Hz, 2H), 1.80 – 1.74 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm) = 197.9, 135.4, 132.0, 129.5, 128.4, 119.4, 37.3, 24.9, 23.0, 17.2 M.P.: 136 – 137 °C. HRMS (EI): m/z $[M+Na]^+$ calcd for $C_{12}H_{12}BrNNaO$: 287.9994; found: 287.9991.

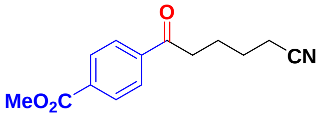
Product 3ae. 6-(4-chlorophenyl)-6-oxohexanenitrile



3ae

Yield of **3ae** (10 h): 49.3 mg, 74% as a white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm) = 7.89 (d, J = 8.5 Hz, 2H), 7.45 (d, J = 8.5 Hz, 2H), 3.02 (t, J = 6.9 Hz, 2H), 2.41 (t, J = 7.0 Hz, 2H), 1.95-1.87 (m, 2H), 1.80-1.73 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm) = 197.8, 139.7, 135.0, 129.4, 129.0, 119.4, 37.3, 24.9, 23.0, 17.2. M.P.: 170 – 171 °C. HRMS (EI): m/z $[M+Na]^+$ calcd for $C_{12}H_{12}ClNNaO$: 244.0500; found: 244.0496.

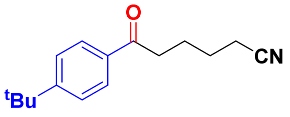
Product 3af. Methyl-4-(5-cyanopentanoyl)benzoate



3af

Yield of **3af** (10 h): 36.9 mg, 50% as a white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm) = 8.13 (d, J = 8.2 Hz, 2H), 8.00 (d, J = 8.1 Hz, 2H), 3.96 (s, 3H), 3.08 (t, J = 6.9 Hz, 2H), 2.43 (t, J = 7.0 Hz, 2H), 1.92 (t, J = 11.3 Hz, 2H), 1.82 – 1.74 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm) = 198.5, 166.2, 139.8, 134.0, 129.9, 127.9, 119.4, 52.5, 37.7, 24.9, 22.9, 17.2. M.P.: 86– 87°C HRMS (EI): m/z $[M+Na]^+$ calcd for $C_{14}H_{15}NNaO_3$: 268.0944; found: 268.0945.

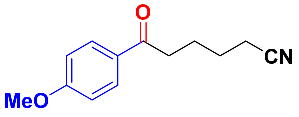
Product 3ag. 6-(4-(tert-butyl)phenyl)-6-oxohexanenitrile



3ag

Yield of **3ag** (10 h): 73.7 mg, 90% as a white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm) = 7.90 (d, J = 8.0 Hz, 2H), 7.48 (d, J = 7.9 Hz, 2H), 3.02 (t, J = 6.7 Hz, 2H), 2.41 (t, J = 6.9 Hz, 2H), 1.90 (q, J = 6.9 Hz, 2H), 1.77 (q, J = 7.0 Hz, 2H), 1.34 (s, 9H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm) = 198.7, 156.9, 134.1, 127.9, 125.5, 119.5, 37.2, 35.0, 31.0, 25.0, 23.1, 17.1. M.P.: 140 – 141 °C. HRMS (EI): m/z $[M+Na]^+$ calcd for $C_{16}H_{21}NNaO$: 266.1515; found: 266.1514.

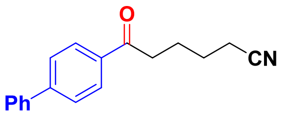
Product 3ah. 6-(4-methoxyphenyl)-6-oxohexanenitrile



3ah

Yield of **3ah** (10 h): 34.1 mg, 52% as a white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm) = 7.94 (d, J = 8.8 Hz, 2H), 6.94 (d, J = 8.8 Hz, 2H), 3.88 (s, 3H), 2.99 (t, J = 6.9 Hz, 2H), 2.41 (t, J = 7.1 Hz, 2H), 1.94 – 1.86 (m, 2H), 1.80 – 1.73 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm) = 197.7, 163.6, 130.2, 129.8, 119.5, 113.8, 55.5, 37.0, 25.1, 23.3, 17.2. M.P.: 59 – 60 °C. HRMS (EI) for $C_{13}H_{15}NnaO_2$ $[M+Na]^+$: calcd 240.0995; found 240.0995.

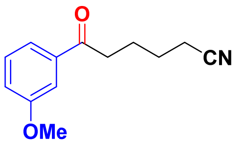
Product 3ai. 6-([1,1'-biphenyl]-4-yl)-6-oxohexanenitrile



3ai

Yield of **3ai** (10 h): 70.6 mg, 89% as a white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm) = 8.03 (d, J = 8.3 Hz, 2H), 7.71 – 7.62 (m, 4H), 7.50 – 7.39 (m, 3H), 3.08 (t, J = 6.9 Hz, 2H), 2.43 (t, J = 7.1 Hz, 2H), 1.98– 1.90 (m, 2H), 1.83 – 1.75 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm) = 198.7, 145.9, 139.8, 135.4, 129.0, 128.6, 128.3, 127.3, 127.2, 119.5, 37.4, 25.0, 23.2, 17.2. M.P.: 134 – 135 °C. HRMS (EI) for $C_{18}H_{17}NNaO$ [M+Na]$^+$: calcd 286.1202, found 286.1202.

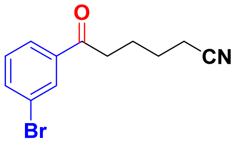
Product 3aj. 6-(3-methoxyphenyl)-6-oxohexanenitrile



3aj

Yield of **3aj** (10 h): 47.6 mg, 73% as a yellow solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm) = 7.54 (d, J = 7.7 Hz, 1H), 7.49 (s, 1H), 7.39 (t, J = 7.9 Hz, 1H), 7.15 – 1.72 (m, 1H), 3.87 (s, 3H), 3.04 (t, J = 6.9 Hz, 2H), 2.42 (t, J = 7.1 Hz, 2H), 1.96 – 1.88 (m, 2H), 1.82 – 1.74 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm) = 198.9, 159.8, 138.0, 129.6, 120.5, 119.5, 119.4, 112.3, 55.4, 37.4, 24.9, 23.1, 17.1. M.P.: 141 – 142 °C. HRMS (EI) for $C_{13}H_{15}NNaO_2$ [M+Na]$^+$: calcd 240.0995; found 240.0995.

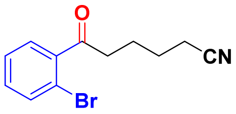
Product 3ak. 6-(3-bromophenyl)-6-oxohexanenitrile



3ak

Yield of **3ak** (10 h): 42.7 mg, 53% as a white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm) = 8.07 (s, 1H), 7.87 (d, J = 7.8 Hz, 1H), 7.70 (d, J = 8.0 Hz, 1H), 7.36 (t, J = 7.9 Hz, 1H), 3.02 (t, J = 6.9 Hz, 2H), 2.42 (t, J = 7.0 Hz, 2H), 1.95 – 1.87 (m, 2H), 1.77 (q, J = 7.4 Hz, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm) = 197.6, 138.4, 136.0, 131.0, 130.3, 126.5, 123.0, 119.4, 37.4, 24.9, 22.9, 17.2. M.P.: 110 – 111 °C. HRMS (EI) for $C_{12}H_{12}BrNNaO$ [M+Na]$^+$: calcd 287.9994; found 287.9994.

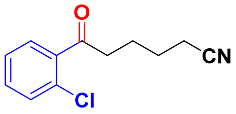
Product 3al. 6-(2-bromophenyl)-6-oxohexanenitrile



3al

Yield of **3al** (10 h): 44.2 mg, 55% as a white solid.. ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm) = 7.61 (d, J = 7.8 Hz, 1H), 7.41 – 7.29 (m, 3H), 2.99 (t, J = 6.9 Hz, 2H), 2.41 (t, J = 7.0 Hz, 2H), 1.94 – 1.85 (m, 2H), 1.82 – 1.75 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm) = 203.2, 141.5, 133.7, 131.6, 128.2, 127.5, 119.4, 118.5, 41.5, 24.8, 23.0, 17.2. M.P.: 163 – 164 °C HRMS (EI): m/z [M+Na]$^+$ calcd for $C_{12}H_{12}BrNNaO$: 287.9994; found: 287.9996.

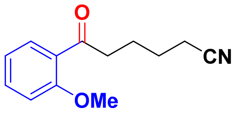
Product 3am. 6-(2-chlorophenyl)-6-oxohexanenitrile



3am

Yield of **3am** (10 h): 29.2 mg, 44% as a white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm) = 7.49 – 7.30 (m, 4H), 3.01 (t, J = 6.9 Hz, 2H), 2.40 (t, J = 7.0 Hz, 2H), 1.96 – 1.85 (m, 2H), 1.80 – 1.73 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm) = 202.4, 139.2, 131.8, 130.7, 130.5, 128.7, 127.0, 119.4, 41.8, 24.8, 23.1, 17.1. M.P.: 155 – 156 °C. HRMS (EI): m/z [M+Na]$^+$ calcd for $C_{12}H_{12}ClNNaO$: 244.0500; found: 244.0503.

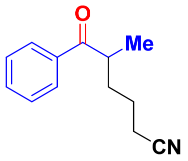
Product 3an. 6-(2-methoxyphenyl)-6-oxohexanenitrile



3an

Yield of **3an** (10 h): 43.0 mg, 70% as a yellow solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm) = 7.68 (d, J = 7.7 Hz, 1H), 7.47 (t, J = 8.6 Hz, 1H), 7.03 – 6.95 (m, 2H), 3.91 (s, 3H), 3.03 (t, J = 6.9 Hz, 2H), 2.38 (t, J = 7.0 Hz, 2H), 1.88 – 1.81 (m, 2H), 1.78 – 1.70 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm) = 201.6, 158.5, 133.5, 130.2, 128.0, 120.7, 119.6, 111.5, 55.5, 42.5, 25.0, 23.3, 17.1. M.P.: 26 – 27 °C. HRMS (EI) for $C_{13}H_{15}NNaO_2$ [M+Na]$^+$: calcd 240.0995; found 240.0993.

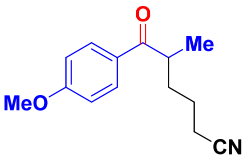
Product 3ao. 5-methyl-6-oxo-6-phenylhexanenitrile



3ao

Yield of **3ao** (10 h): 36.3 mg, 60% as a white solid. ^{1}H NMR (400 MHz, CDCl$_3$) δ (ppm) = 7.98 (d, J = 7.5 Hz, 2H), 7.61 (t, J = 7.3 Hz, 1H), 7.52 (t, J = 7.6 Hz, 2H), 3.60 – 3.46 (m, 1H), 2.38 (t, J = 6.6 Hz, 2H), 2.05 – 1.93 (m, 1H), 1.73 – 1.65 (m, 3H), 1.27 (d, J = 7.0 Hz, 3H). ^{13}C NMR (100 MHz, CDCl$_3$) δ (ppm) = 203.3, 136.2, 133.2, 128.8, 128.2, 119.4, 40.0, 32.2, 23.3, 17.8, 17.3. M.P.: 117 – 118 °C. HRMS (EI) for $C_{13}H_{15}NNaO$ [M+Na]$^+$: calcd 224.1046; found 224.1042.

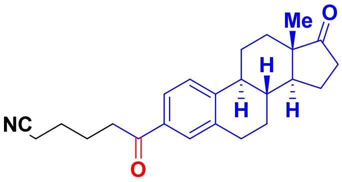
Product 3ap. 6-(4-methoxyphenyl)-5-methyl-6-oxohexanenitrile



3ap

Yield of **3ap** (10 h): 57.6 mg, 78% as a white solid. ^{1}H NMR (400 MHz, CDCl$_3$) δ (ppm) = 7.95 (d, J = 8.8 Hz, 2H), 6.96 (d, J = 8.8 Hz, 2H), 3.88 (s, 3H), 3.48 (q, J = 6.9, 6.3 Hz, 1H), 2.32 (s, 2H), 2.03 – 1.90 (m, 1H), 1.67 – 1.61 (m, 3H), 1.22 (d, J = 7.0 Hz, 3H). ^{13}C NMR (100 MHz, CDCl$_3$) δ (ppm) = 201.8, 163.6, 130.5, 129.2, 119.5, 113.9, 55.5, 39.6, 32.4, 23.3, 18.0, 17.3. M.P.: 116 – 117 °C. HRMS (EI) for $C_{14}H_{17}NNaO_2$ [M+Na]$^+$: calcd 254.1151; found 254.1155.

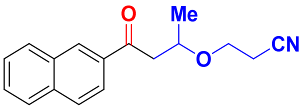
Product 1aq. (8R,9S,13S,14S)-3-(5-isocyanopentanoyl)-13-methyl-6,7,8,9,11,12,13,14,15,16-decahydro-17H-cyclopenta[a]phenanthren-17-one



3aq

Yield of **3aq** (20 h): 69.4 mg, 64% as a white solid, ^{1}H NMR (400 MHz, CDCl$_3$) δ (ppm) = 7.76 – 7.68 (m, 2H), 7.39 (d, J = 8.1 Hz, 1H), 3.14 – 2.87 (m, 4H), 2.53 – 1.43 (m, 19H), 0.92 (s, 3H). ^{13}C NMR (100 MHz, CDCl$_3$) δ (ppm) = 220.5, 199.0, 145.6, 137.0, 134.4, 128.6, 125.6, 125.4, 119.5, 50.5, 47.8, 44.7, 37.8, 37.2, 35.7, 31.5, 29.3, 26.2, 25.5, 25.0, 23.2, 21.5, 17.1, 13.8. M.P.: 129 – 130 °C HRMS (EI) for $C_{24}H_{30}NO_2$ [M+H]$^+$: calcd 364.2271; found 364.2271.

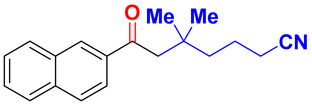
Product 6aa. 3-((4-(naphthalen-2-yl)-4-oxobutan-2-yl)oxy)propanenitrile



6aa

Yield of **6aa** (10 h)**:** 59.2 mg, 74% as a white solid. ^{1}H NMR (400 MHz, CDCl$_3$) δ (ppm) = 8.48 (s, 1H), 8.05 – 7.83 (m, 4H), 7.63 – 7.54 (m, 2H), 4.35 – 4.10 (m, 1H), 3.85 – 3.73 (m, 1H), 3.66 (s, 1H), 3.54 – 3.48 (m, 1H), 3.09 – 3.03 (m, 1H), 2.55 (t, J = 6.3 Hz, 2H), 1.34 (d, J = 6.2 Hz, 3H). ^{13}C NMR (100 MHz, CDCl$_3$) δ (ppm) = 198.2, 135.6, 134.4, 132.5, 130.0, 129.6, 128.6, 128.5, 127.8, 126.8, 123.8, 117.9, 72.8, 63.6, 45.6, 20.0, 19.1. M.P.: 30.0 – 31.0 °C.HRMS (EI): m/z [M+H]$^+$ calcd for $C_{17}H_{18}NO_2$: 268.1332; found: 268.1329.

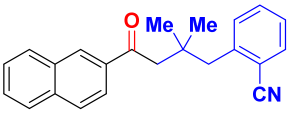
Product 6ba. 5,5-dimethyl-7-(naphthalen-2-yl)-7-oxoheptanenitrile



6ba

Yield of **6ba** (10 h)**:** 52.8 mg, 63% as a yellow solid. ^{1}H NMR (400 MHz, CDCl$_3$) δ (ppm) = 8.45 (s, 1H), 8.01 (t, J = 10.2 Hz, 2H), 7.93 – 7.88 (m, 2H), 7.65 – 7.56 (m, 2H), 3.02 (s, 2H), 2.36 (t, J = 6.9 Hz, 2H), 1.77 – 1.62 (m, 5H), 1.11 (s, 6H). ^{13}C NMR (100 MHz, CDCl$_3$) δ (ppm) = 199.9, 135.7, 135.4, 132.5, 129.7, 129.6, 128.5, 128.4, 127.7, 126.8, 123.9, 119.7, 47.7, 41.1, 33.9, 27.7, 20.7, 17.8. M.P.: 26.0 – 27.0 °C. HRMS (EI): m/z [M + Na]$^+$ calcd for $C_{19}H_{21}NNaO$: 302.1515; found: 302.1515.

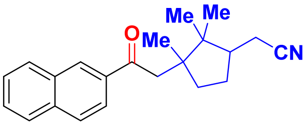
Product 6ca. 2-(2,2-dimethyl-4-(naphthalen-2-yl)-4-oxobutyl)benzonitrile



6ca

Yield of **6ca** (20 h)**:** 38.1 mg, 39% as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm) = 8.47 – 8.45 (m, 1H), 8.05 – 8.01 (m, 1H), 7.98 (d, J = 8.0 Hz, 1H), 7.92 – 7.87 (m, 2H), 7.66 – 7.49 (m, 4H), 7.41 – 7.38 (m, 1H), 7.34 – 7.30 (m, 1H), 3.12 (s, 2H), 3.09 (s, 2H), 1.17 (s, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm) = 199.8, 142.9, 135.6, 135.5, 132.9, 132.5, 132.1, 131.7, 129.9, 129.8, 129.7, 128.5, 128.5, 127.7, 126.8, 123.9, 119.1, 114.2, 47.8, 45.7, 36.2, 27.4. HRMS (EI): m/z [M + Na]$^+$ calcd for $C_{23}H_{21}NNaO$: 350.1515; found: 350.1515.

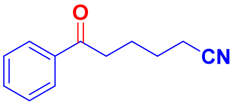
Product 6da. 2-(2,2,3-trimethyl-3-(2-(naphthalen-2-yl)-2-oxoethyl)cyclopentyl)acetonitrile



6da

Yield of **6da** (24 h)**:** 30.9 mg, 32% (d.r. = 10:1) as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm) = 8.41 (s, 1H), 8.02 – 7.95 (m, 2H), 7.93 – 7.86 (m, 2H), 7.65 – 7.54 (m, 2H), 3.05 – 2.95 (m, 2H), 2.44 – 2.39 (m, 1H), 2.35 – 2.23 (m, 2H), 2.14 – 2.00 (m, 2H), 1.46 – 1.19 (m, 2H), 1.06 (s, 6H), 0.81 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm) = 200.8, 136.2, 135.4, 132.5, 129.6, 129.5, 128.5, 128.5, 127.7, 126.8, 123.9, 119.8, 47.9, 46.3, 44.4, 42.7, 33.0, 27.9, 22.3, 20.9, 19.1, 18.7. HRMS (EI): m/z [M + H]$^+$ calcd for $C_{22}H_{26}NO$: 320.2009; found: 320.2007.

Product 6e. 6-oxo-6-phenylhexanenitrile

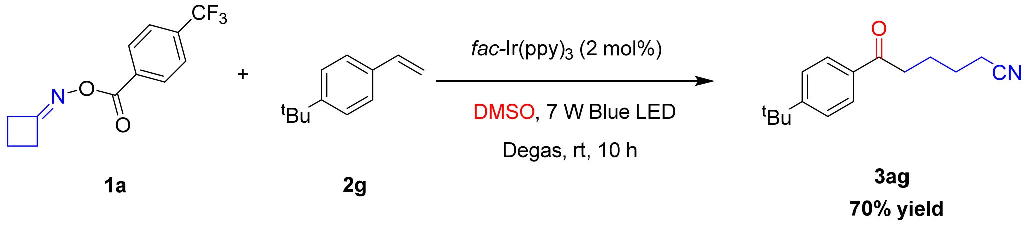


6e

Yield of **6e** (10 h)**:** 33.7 mg, 60% as a white solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm) = 7.95 (d, J = 7.7 Hz, 2H), 7.65 – 7.54 (m, 1H), 7.47 (t, J = 7.6 Hz, 2H), 3.04 (t, J = 6.9 Hz, 2H), 2.41 (t, J = 7.0 Hz, 2H), 1.95 – 1.88 (m, 2H), 1.80 – 1.73 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm) = 199.0, 136.7, 133.2, 128.6, 127.9, 119.4, 37.3, 25.0, 23.1, 17.1. M.P.: 65.9 – 66.0 °C. HRMS (EI): m/z [M + Na]$^+$ calcd for $C_{12}H_{13}NNaO$: 210.0889; found: 210.0889.

5. Preparative Utility of the Methodology

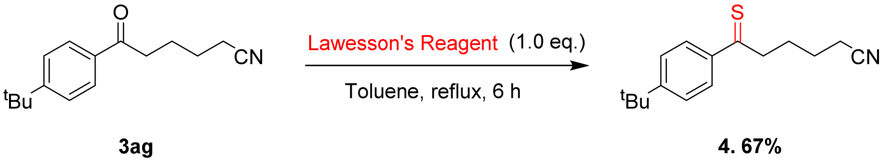
5.1 1.0 mmol Reaction of 1a



To a 10 mL flame-dried round Schlenk tube equipped with a magnetic stirbar was added **1a** (257.2 mg, 1.0 mmol), **2g** (0.275 mL, 1.5 mmol), *fac*-Ir(ppy)$_3$ (13.1 mg, 0.02 mmol), DMSO (5.0 mL) under argon atmosphere. then the resulting mixture was degassed through the "freeze-pump-thaw" procedure (3 times). Then the solution was stirred at a distance of ~5 cm from a 7 W blue LED (450-460 nm) at room tempeature for about 10 h untill the reaction was completed as monitored by TLC analysis Then the resulting mixture was quenched by water and extracted with EtOAc, and dried over Na_2SO_4. The prude product was then purified by flash chromatography on silica gel (petroleum ether/ethyl acetate 20:1~10:1) directly to give the the corresponding product **3ag** with 169.6 mg, 70% yield as a white solid.

6. Synthetic Transformation of the product

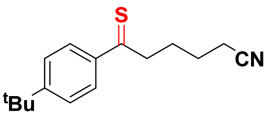
6.1 Thiolation of Product 3ag



To a 10 mL flame-dried round Schlenk tube equipped with a magnetic stirbar was added **3ag** (73.0 mg, 0.30 mmol), Lawesson's reagent (121.3 mg, 0.30 mmol), toluene (5.0 mL) under argon atmosphere. Then the solution was stirred at 110°C to reflux for about 6 h untill the reaction was completed as monitored by TLC analysis Then, the resulting mixture was cooled to room temperature, and extracted with DCM, washed by saturated $NaHCO_3$ solution, then dried over Na_2SO_4. The prude product was then purified by flash chromatography on silica gel (petroleum ether/ethyl acetate 20:1~10:1) directly to give the the corresponding product **4** with 51.9 mg, 67% yield as a brown solid

6.2 The Spectra Data of 4

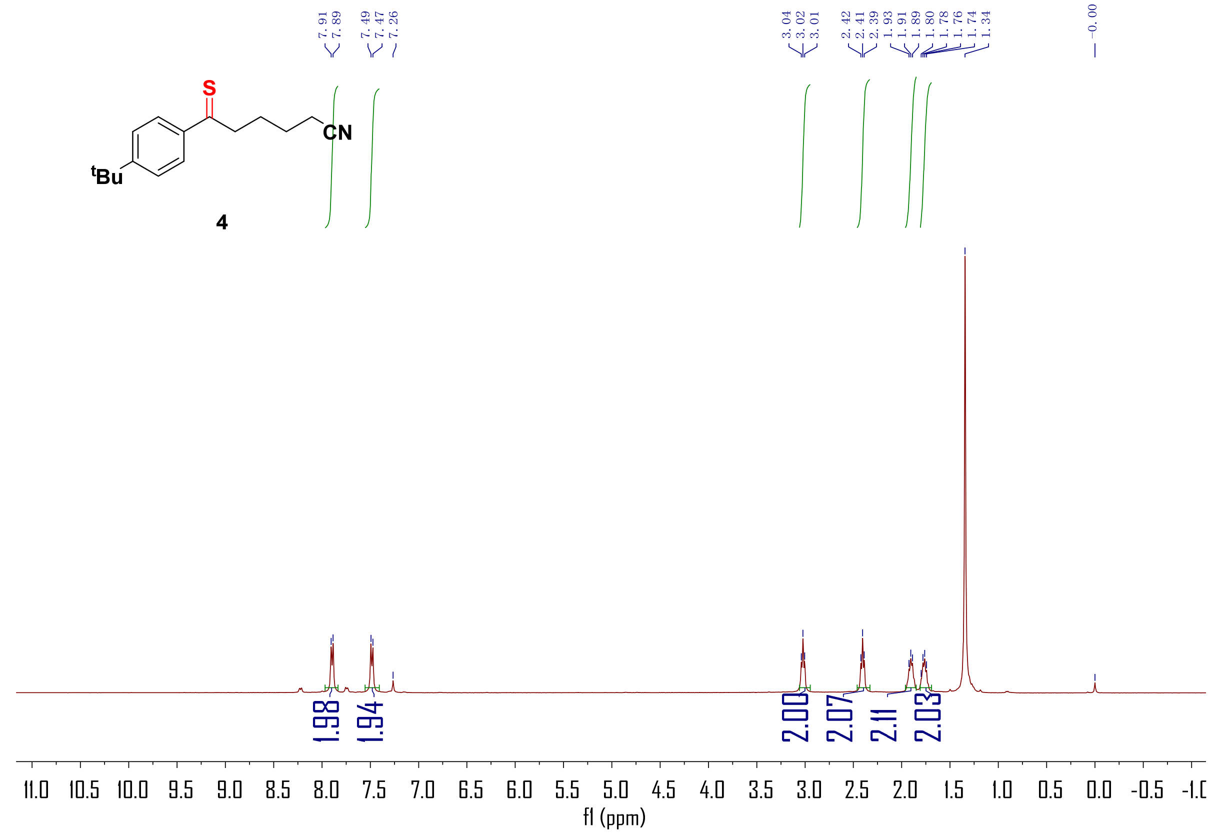
The Spectra Data of Product 4. 6-(4-(tert-butyl)phenyl)-6-thioxohexanenitrile

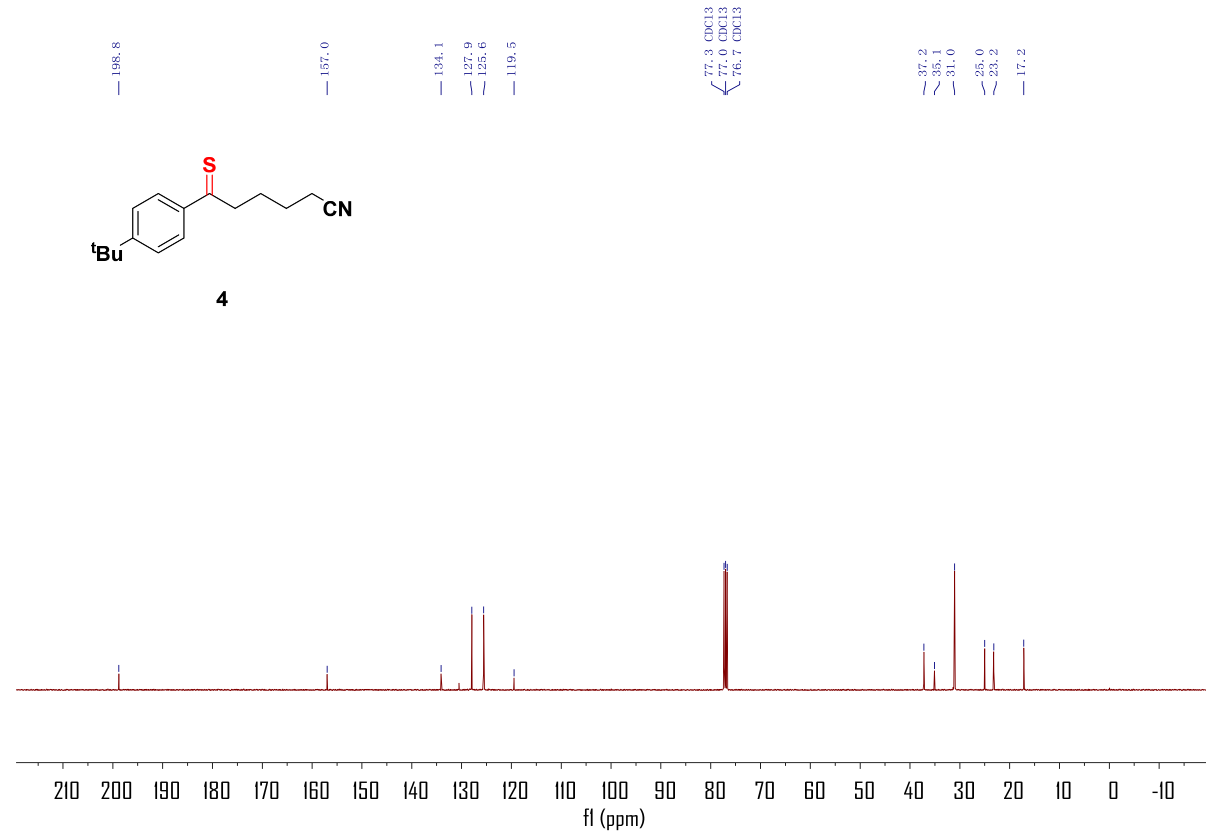


4

Yield of **4** (6 h): 51.9 mg, 67% as a brown solid. ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm) = 7.90 (d, J = 8.0 Hz, 2H), 7.48 (d, J = 7.9 Hz, 2H), 3.02 (t, J = 6.7 Hz, 2H), 2.41 (t, J = 6.9 Hz, 2H), 1.96 – 1.85 (m, 2H), 1.77 (q, J = 7.0 Hz, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm) = 198.8, 157.0, 134.1, 127.9, 125.6, 119.5, 37.2, 35.1, 31.0, 25.0, 23.2, 17.2. HRMS (EI) for $C_{16}H_{21}NNaS^+$ $[M+Na]^+$: calcd 282.1287; found 282.1281

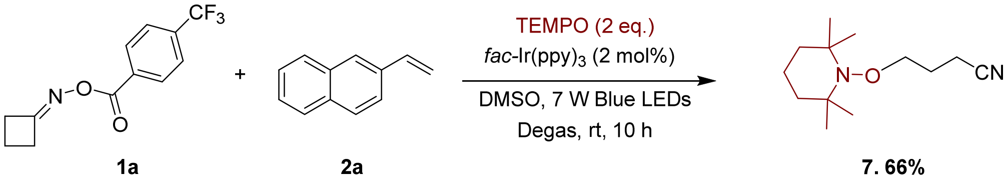
^{1}H NMR (400 MHz, CDCl$_3$), ^{13}C NMR (100 MHz, CDCl$_3$) spectra of product 4





7. Mechanistic Studies

7.1 TEMPO Traping Experiment

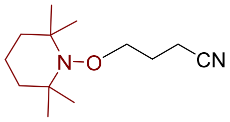


To a 10 mL flame-dried round Schlenk tube equipped with a magnetic stirbar was added **1a** (77.2 mg, 0.30 mmol), **2a** (69.4 mg, 0.45 mmol), *fac*-Ir(ppy)$_3$ (3.93mg, 2 mol%) and DMSO (3.0 mL). Then TEMPO (93.7 mg, 2.0 eq.) was added into system. The resulting mixture was degassed via 'freeze-pump-thaw' procedure (3 times). After that, the solution was stirred at a distance of ~5 cm from a 7 W blue LED (450-460 nm) at room temperature about 10 h until the reaction was completed as monitored by TLC analysis. The crude product was quenched by water and then extracted with EtOAc, after it was dried over Na_2SO_4, the remaining mixture was purified by flash chromatography on silica gel (petroleum ether/ethylacetate 20:1~15:1) directly to give the desired product **7** with 44.5 mg, 66% yield as a brown oil.

This result suggests the ring opening of the cyclobutanone oxime esters and the formation the cyanoalkyl radical intermediate.

7.2 The Spectra and Spectra Data of 7

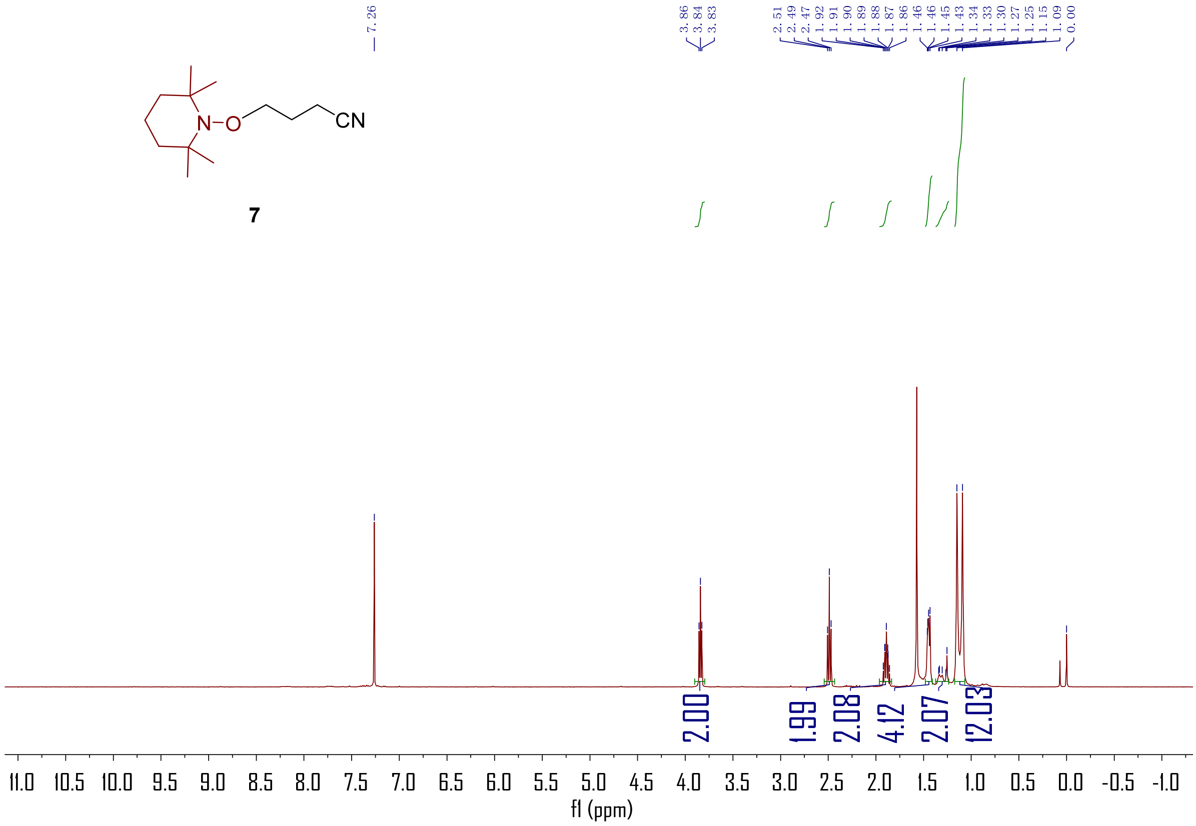
The Spectra Data of Product 7. 4-((2,2,6,6-tetramethylpiperidin-1-yl)oxy)butanenitrile

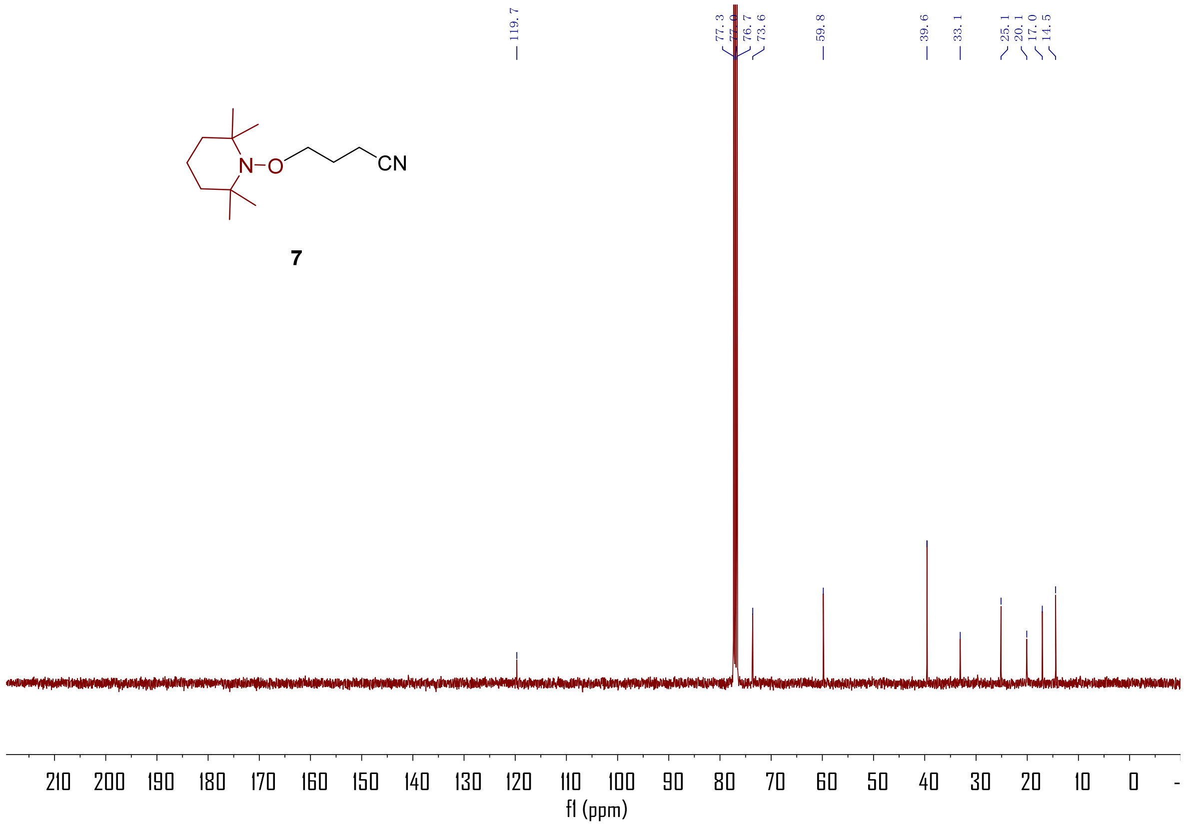


7

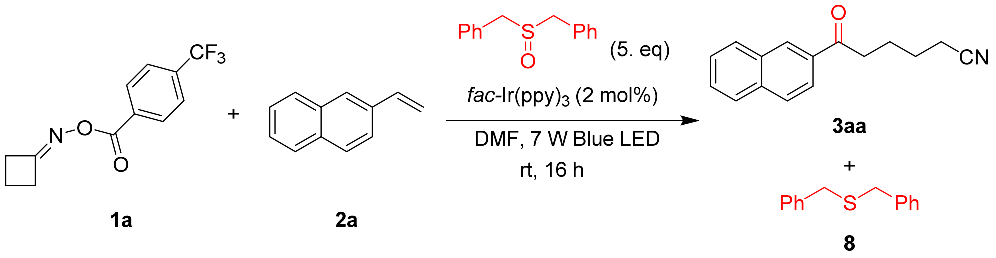
Yield of **7** (10 h): 44.5 mg, 66% as a brown oil. ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm) = 3.84 (t, J = 5.8 Hz, 2H), 2.49 (t, J = 7.2 Hz, 2H), 1.92 – 1.86 (m, 2H), 1.46 – 1.46 (m, 4H), 1.37 – 1.24 (m, 2H), 1.12 (d, J = 23.3 Hz, 12H). ^{13}C NMR (100 MHz, $CDCl_3$) δ (ppm) = 119.7, 73.6, 59.8, 39.6, 33.1, 25.1, 20.1, 17.0, 14.5. HRMS (EI) for $C_{12}H_{25}N_2O^+$ $[M+H]^+$: calcd 225.1961; found 225.1961.

^{1}H NMR (400 MHz, $CDCl_3$), ^{13}C NMR (100 MHz, $CDCl_3$) spectra of product 7





7.3 Reaction with Dibenzyl Sulfoxide Instead of DMSO

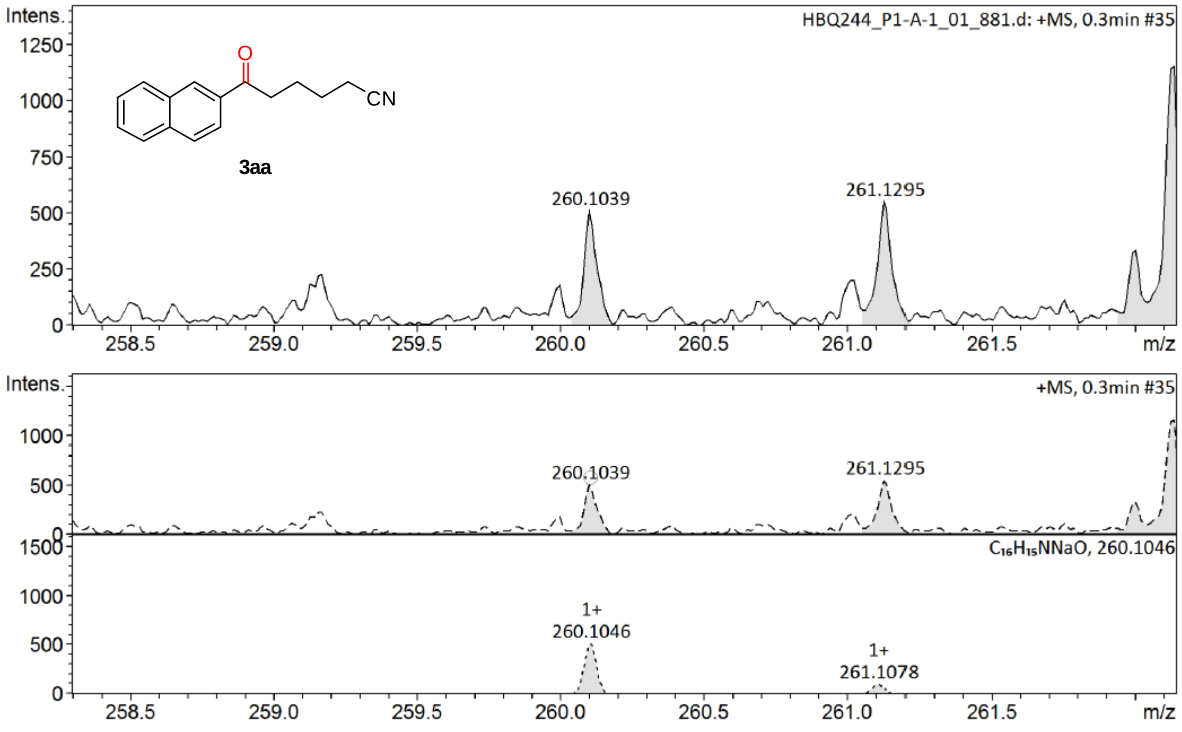


To a 10 mL flame-dried round Schlenk tube equipped with a magnetic stirbar was added **1a** (77.2 mg, 0.30 mmol), **2a** (69.4 mg, 0.45 mmol), *fac*-Ir(ppy)$_3$ (3.93 mg, 2 mol%) and DMF (3.0 mL). Then dibenzyl sulfoxide (345.5 mg, 5.0 eq.) was added into system. The resulting mixture was degassed via 'freeze-pump-thaw'procedure (3 times). After that, the solution was stirred at a distance of ~5 cm from a 7 W blue LEDs (450-460 nm) at room temperature about 16 h until the reaction was completed as monitored by TLC analysis. The crude product was quenched by water and then extracted with EtOAc, after it was dried over Na_2SO_4, the organic layer was subjected to HRMS analysis, both **3aa** and **8** were detected.

This result suggests that DMSO acts both as the solvent and the oxidant during the chemical transformation.

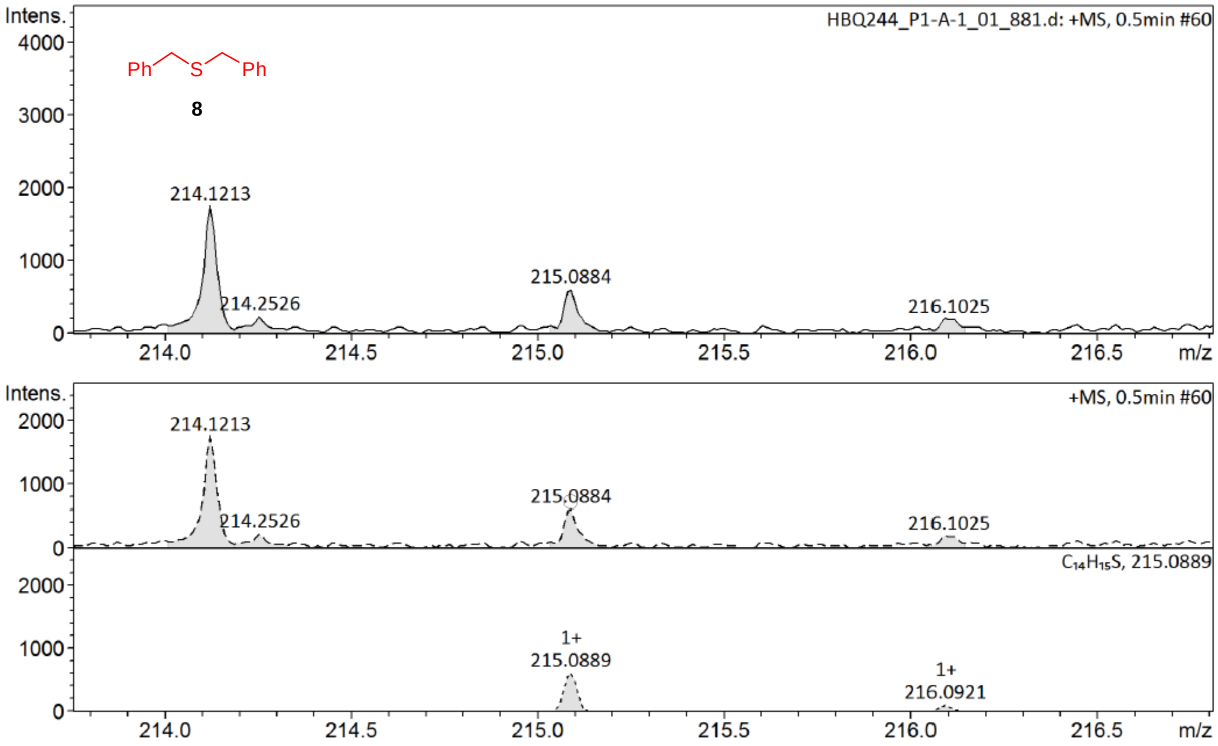
The HRMS Data of Product 3aa and 8

3aa. HRMS (EI): m/z $[M+Na]^+$ calcd for $C_{16}H_{15}NNaO$: 260.1046; found: 260.1039



Meas. m/z	#	Ion Formula	m/z	err [ppm]	mSigma	# mSigma	Score	rdb	e⁻ Conf	N-Rule
260.1039	1	C16H15NNaO	260.1046	2.5	n.a.	1	100.00	9.5	even	ok

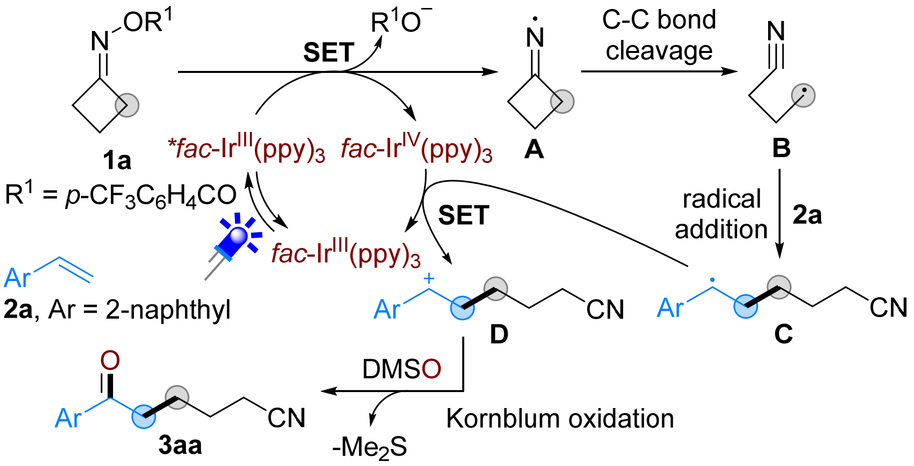
8. HRMS (EI): m/z $[M+H]^+$ calcd for $C_{14}H_{15}S^+$: 215.0889; found: 215.0884



Meas. m/z	#	Ion Formula	m/z	err [ppm]	mSigma	# mSigma	Score	rdb	e¯ Conf	N-Rule
215.0884	1	C14H15S	215.0889	2.5	689.4	2	21.59	7.5	even	ok

7.4 Plausible Mechanism

According to the previous lectures[1] and all the control experiments, a plausible mechanism is depicted as the following.

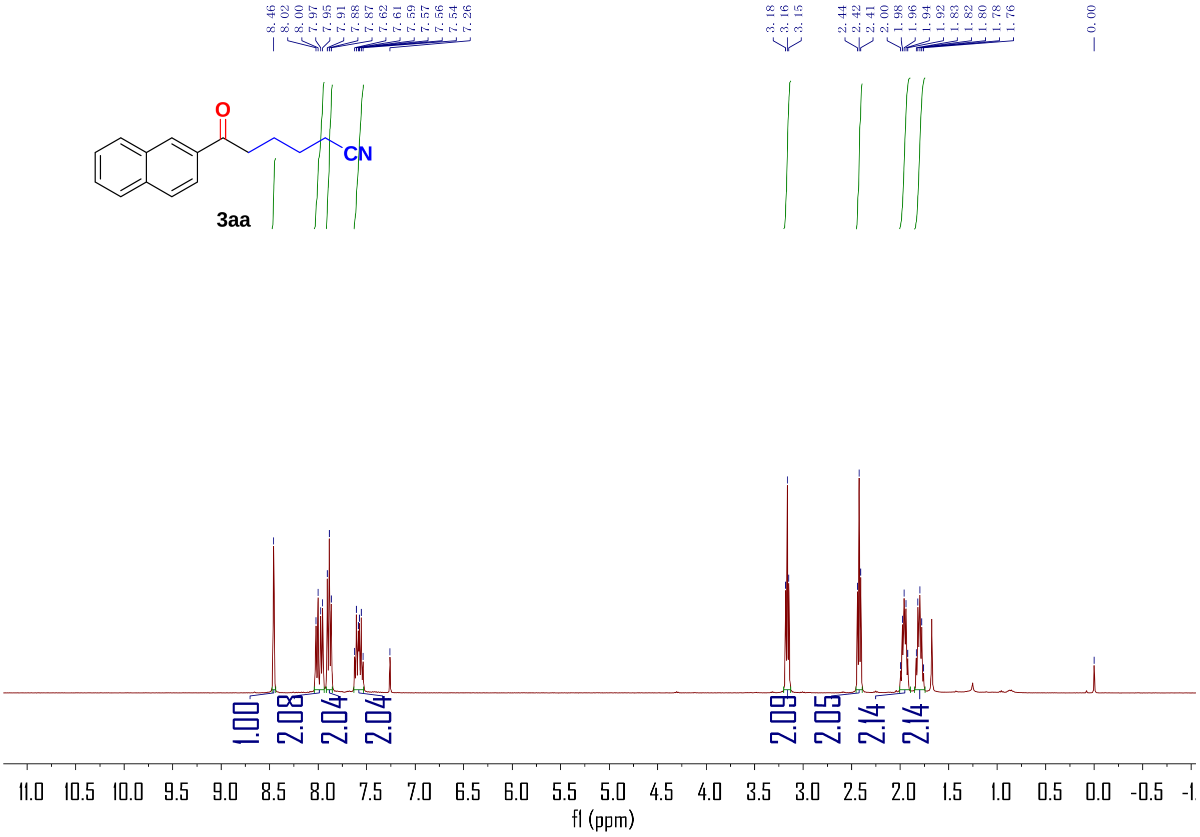


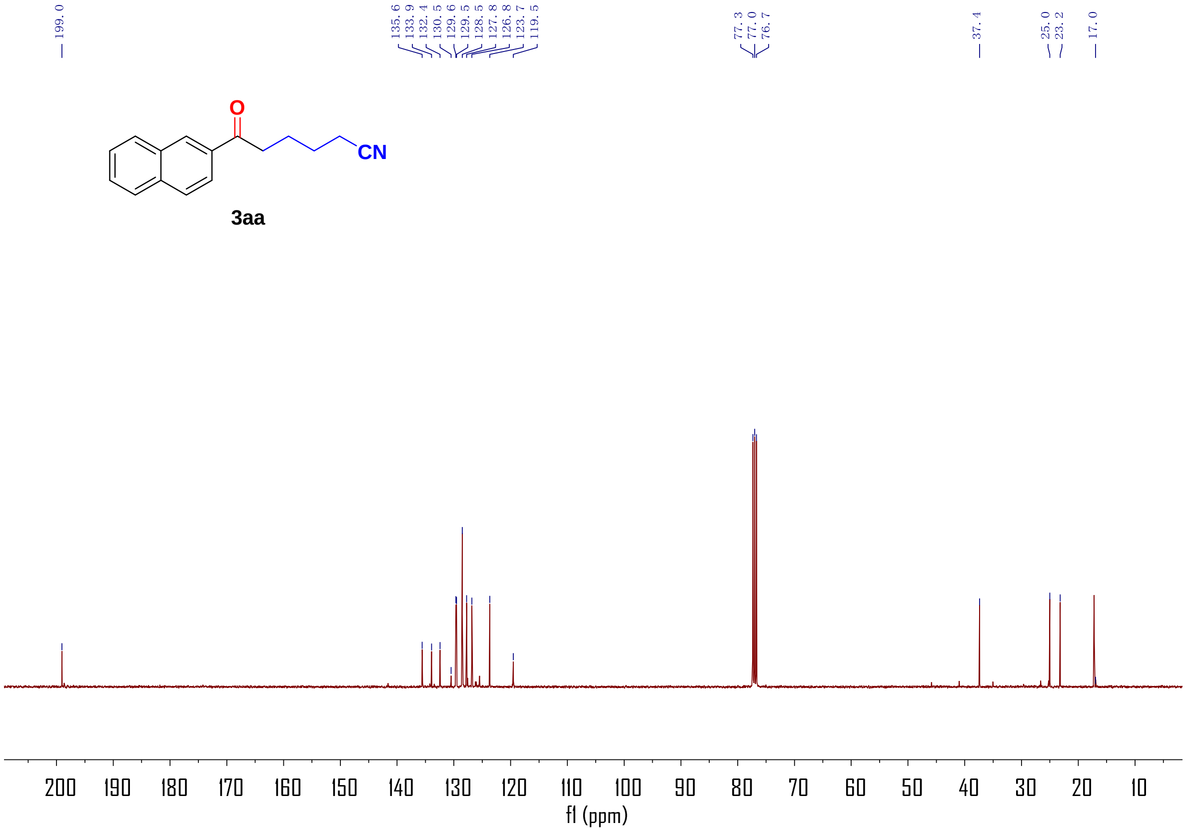
Reference:

[1] (a) Adrian Tlahuext-Aca, R. Aleyda Garza-Sanchez, Michael Schäfer, Frank GloriusA. Tlahuext-Aca, R. A. Garza-Sanchez, M. Schafer, F. Glorius, *Org. Lett.* **2018,** *20*, 1546–1549. (b) Z.-H. Xia, C.-L. Zhang, Z.-H. Gao, S. Ye, *Org. Lett.* **2018**, 20, 3496-3499.

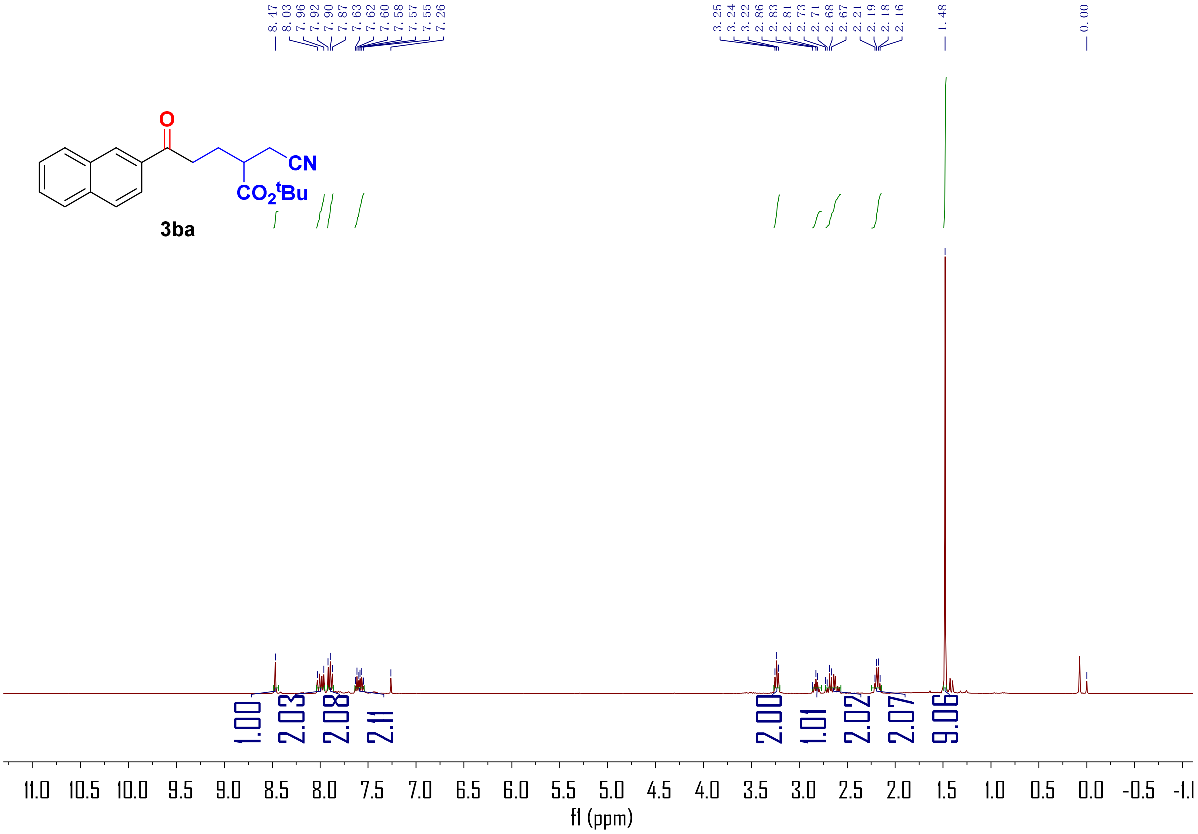
8. The Spectra of Products

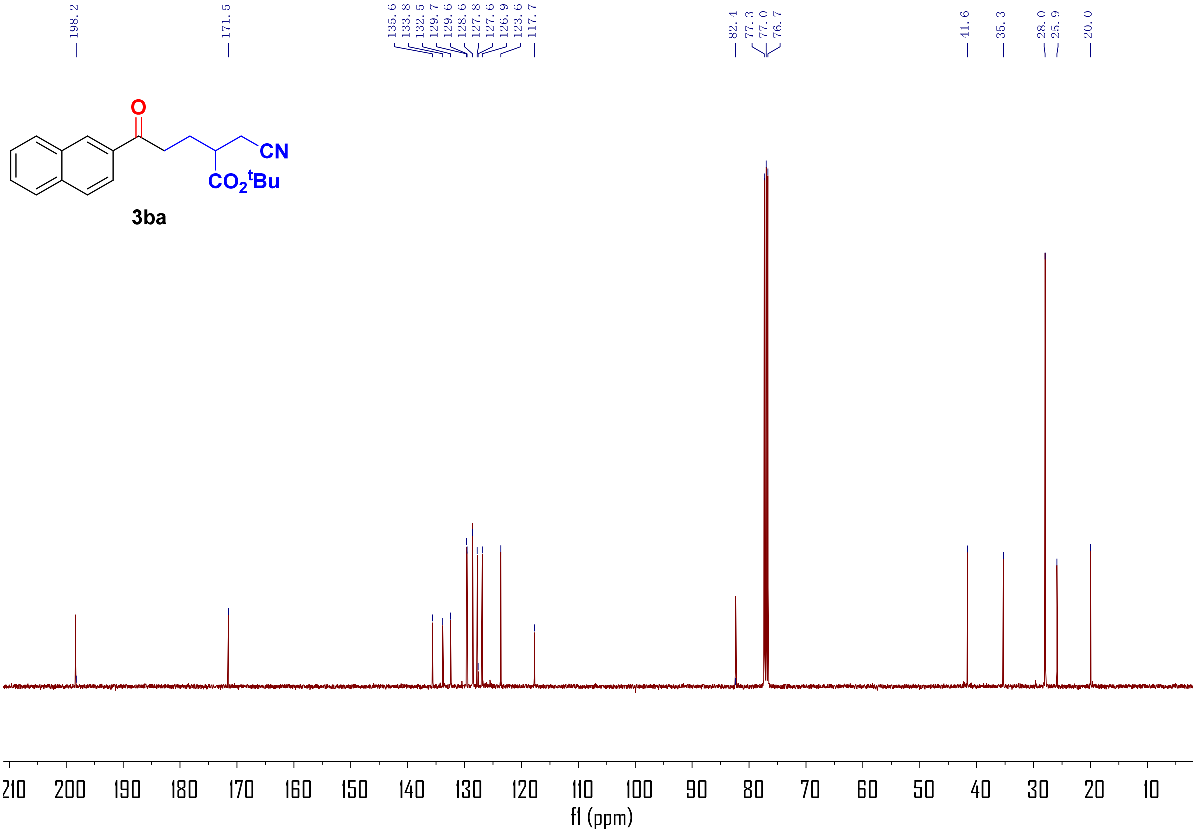
^{1}H NMR (400 MHz, CDCl$_3$), ^{13}C NMR (100 MHz, CDCl$_3$) spectra of product 3aa



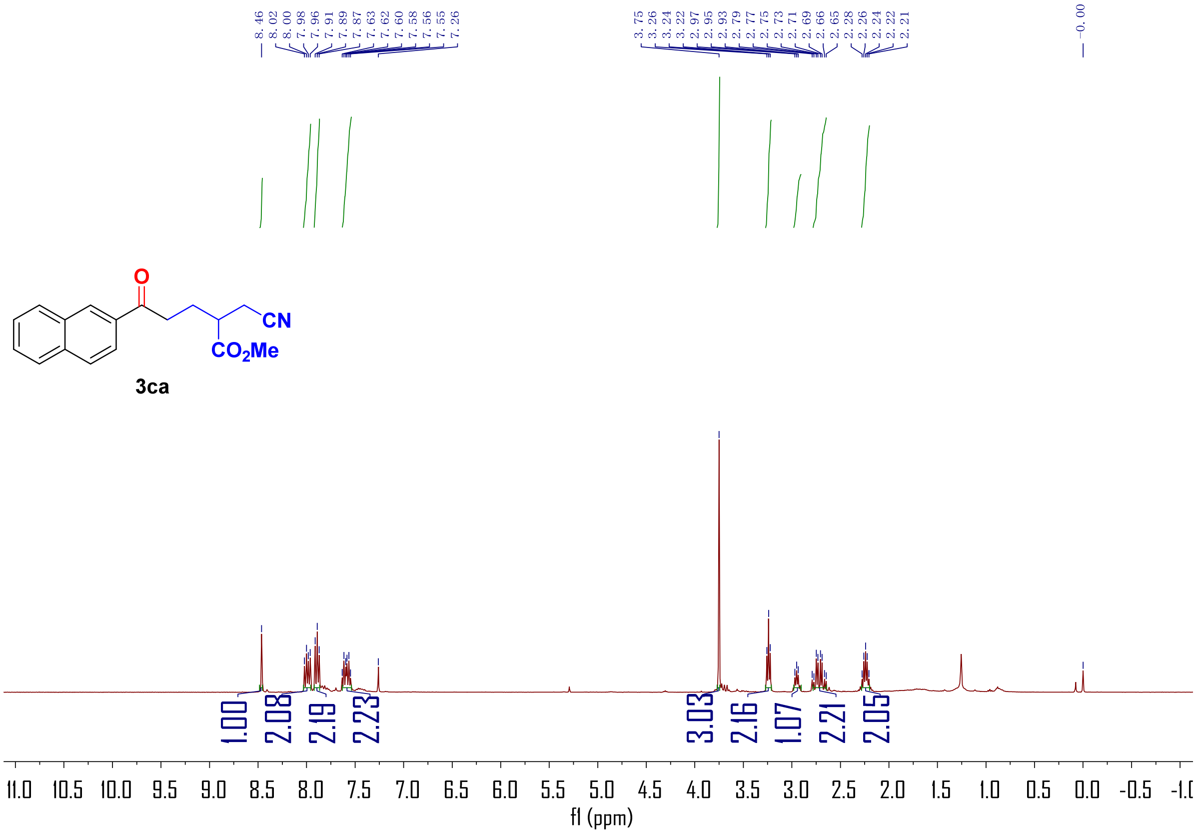


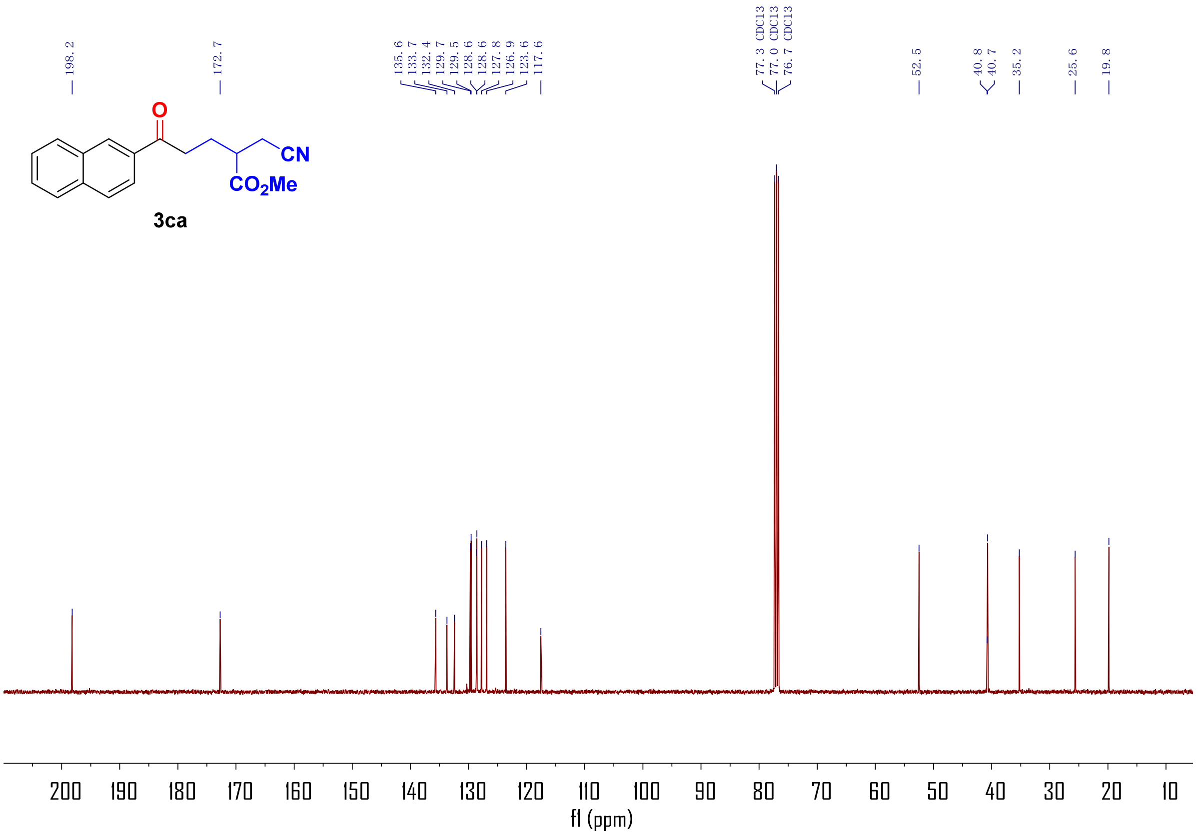
^{1}H NMR (400 MHz, CDCl$_3$), ^{13}C NMR (100 MHz, CDCl$_3$) spectra of product 3ba



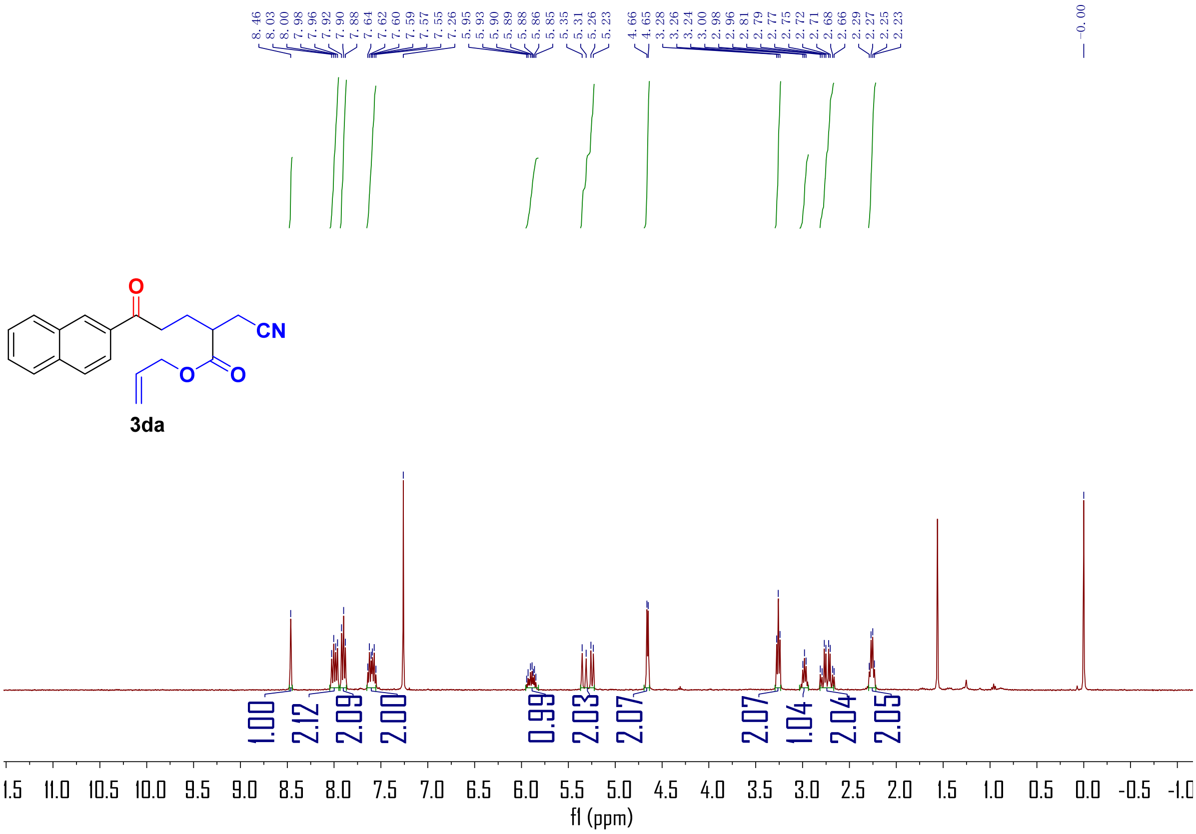


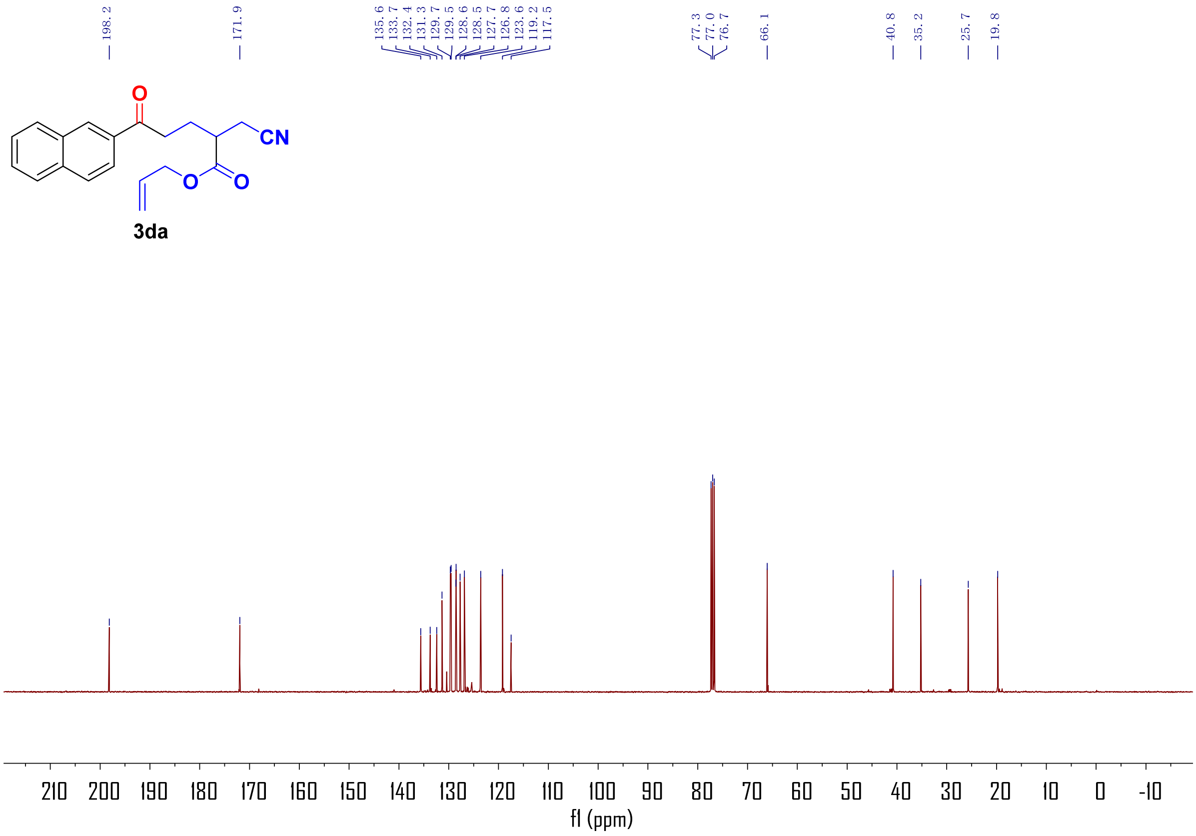
^{1}H NMR (400 MHz, CDCl$_3$), ^{13}C NMR (100 MHz, CDCl$_3$) spectra of product 3ca



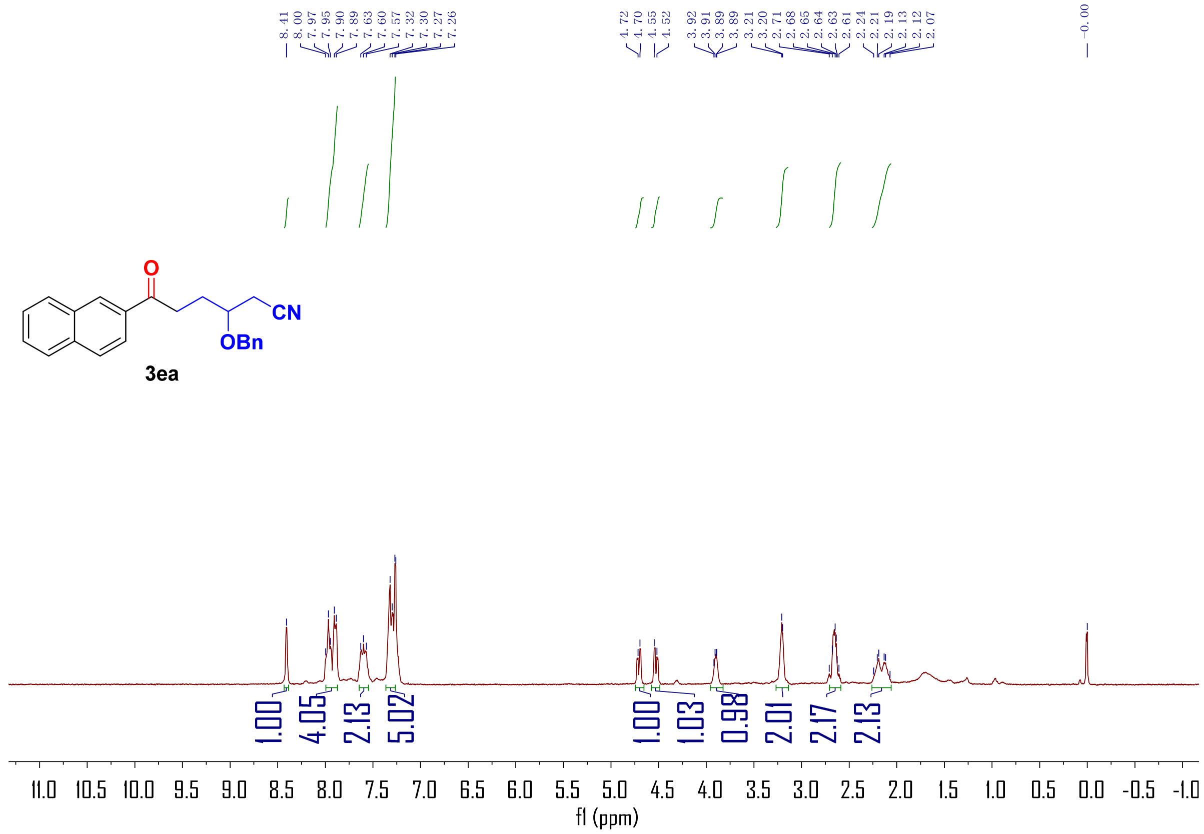


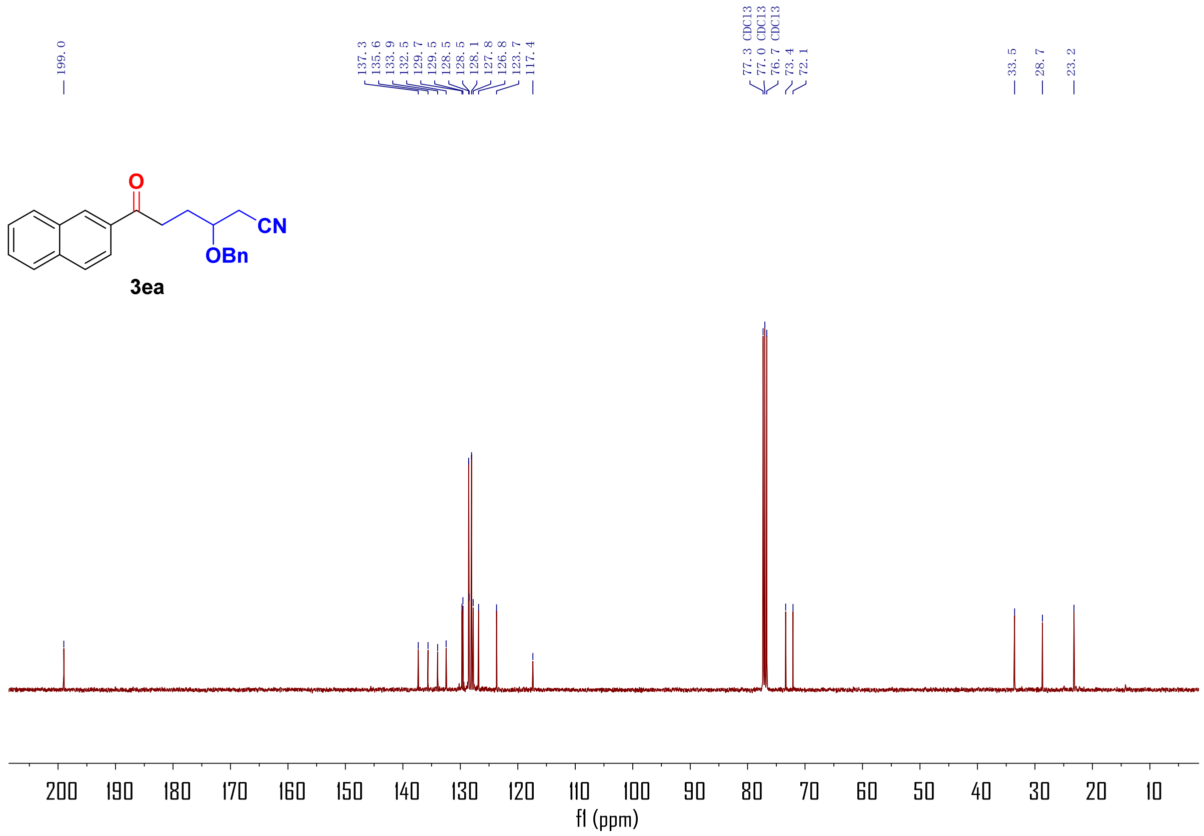
^{1}H NMR (400 MHz, CDCl$_3$), ^{13}C NMR (100 MHz, CDCl$_3$) spectra of product 3da



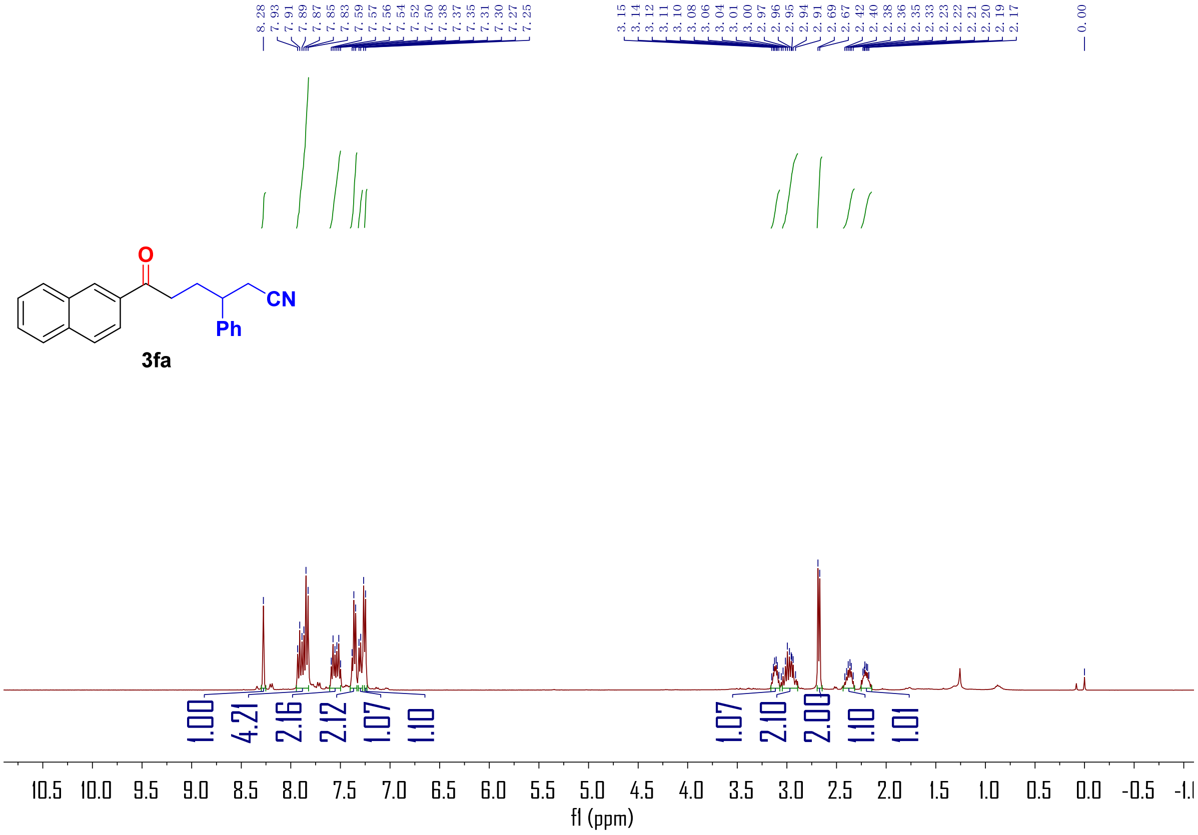


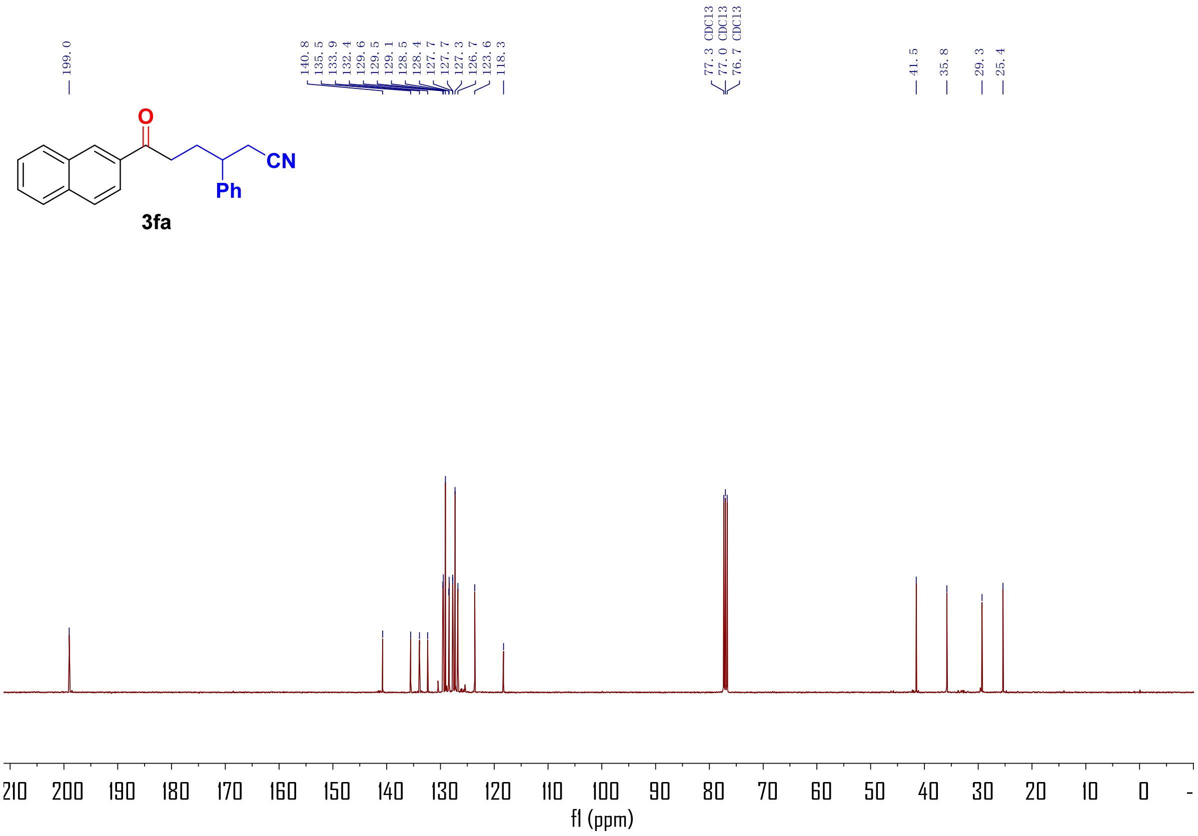
^{1}H NMR (400 MHz, CDCl$_3$), ^{13}C NMR (100 MHz, CDCl$_3$) spectra of product 3ea



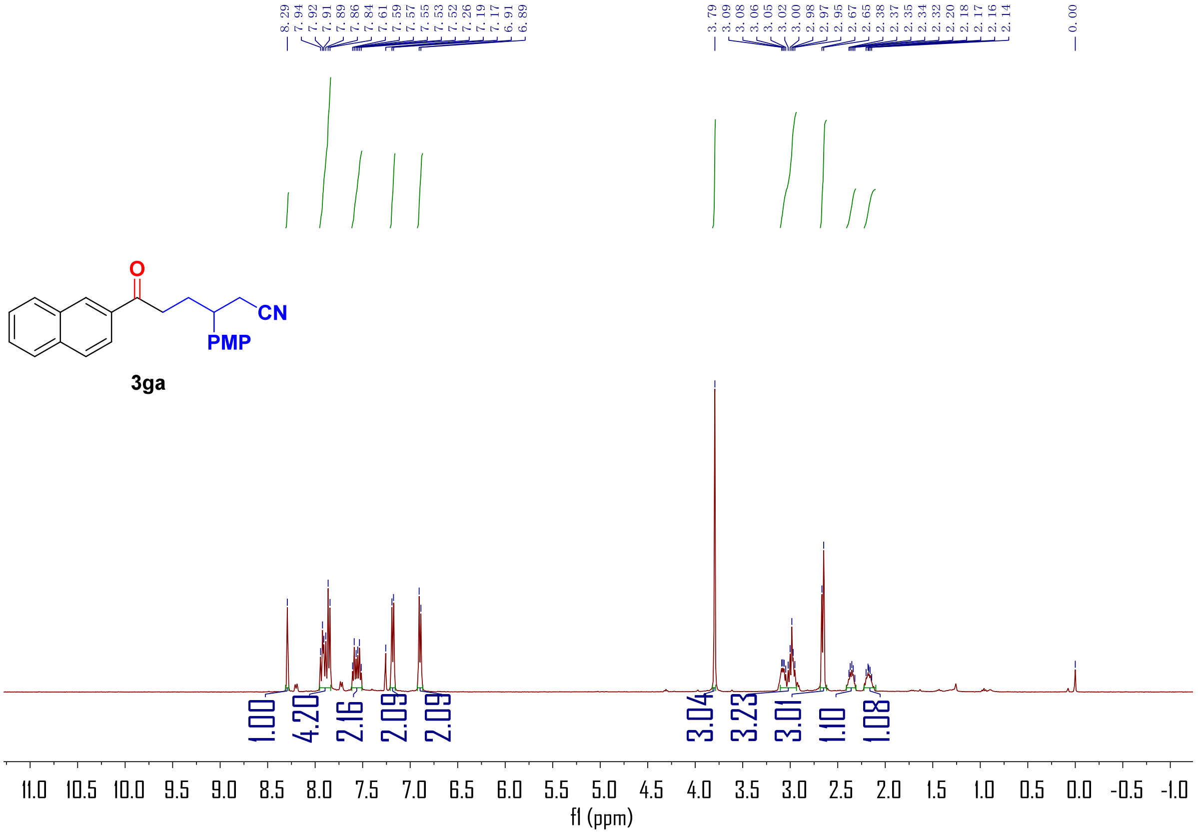


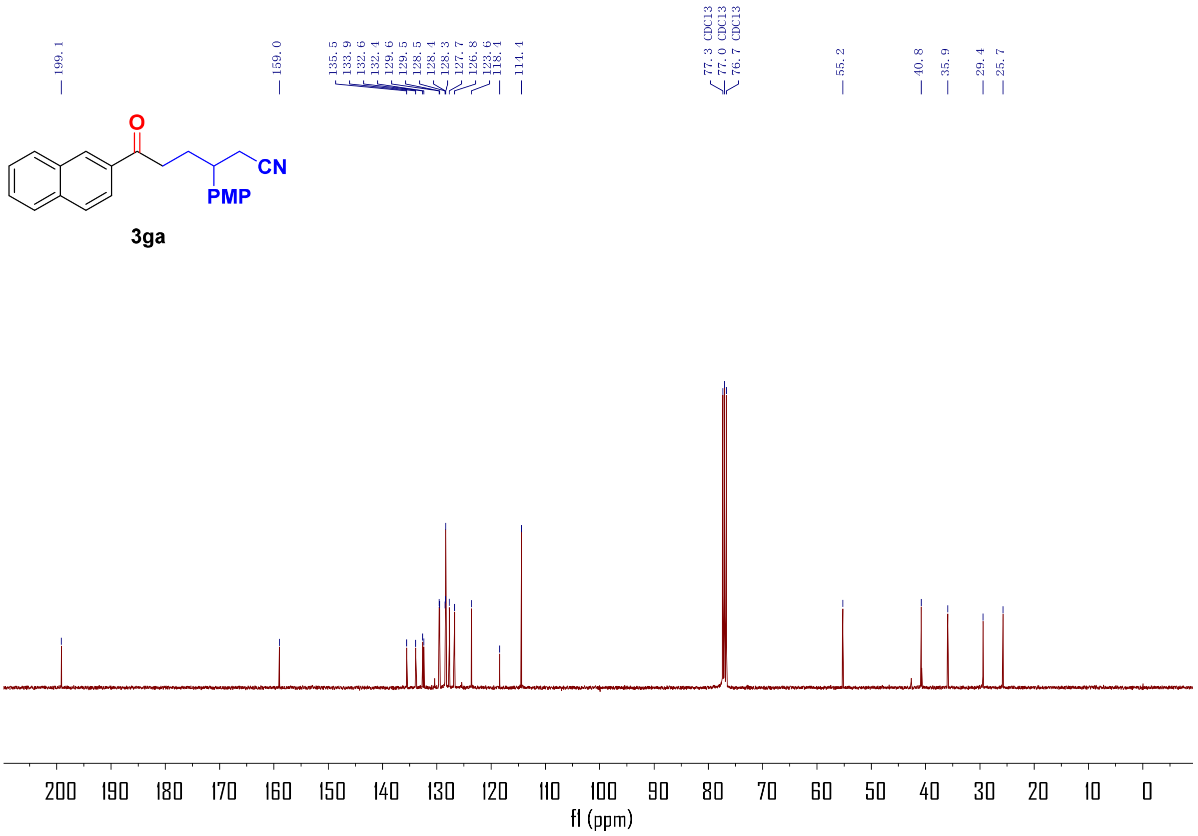
^{1}H NMR (400 MHz, $CDCl_3$), ^{13}C NMR (100 MHz, $CDCl_3$) spectra of product 3fa



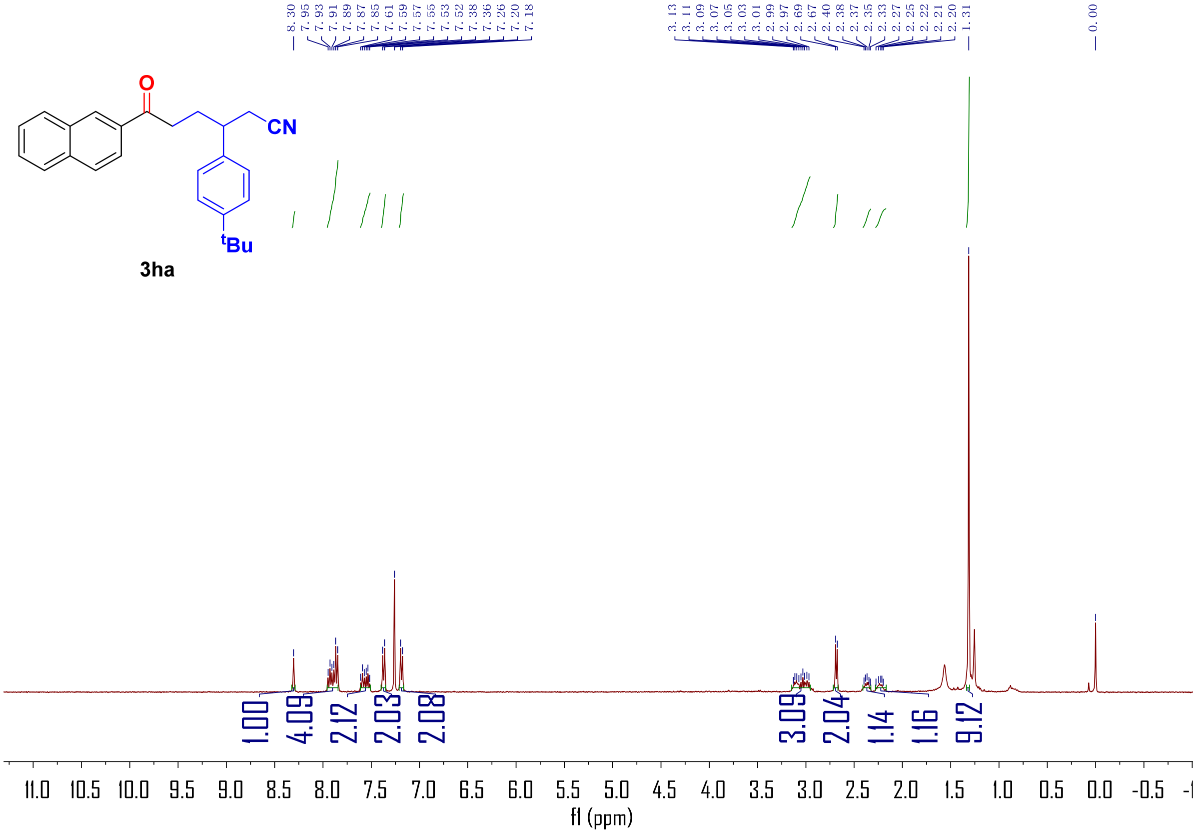


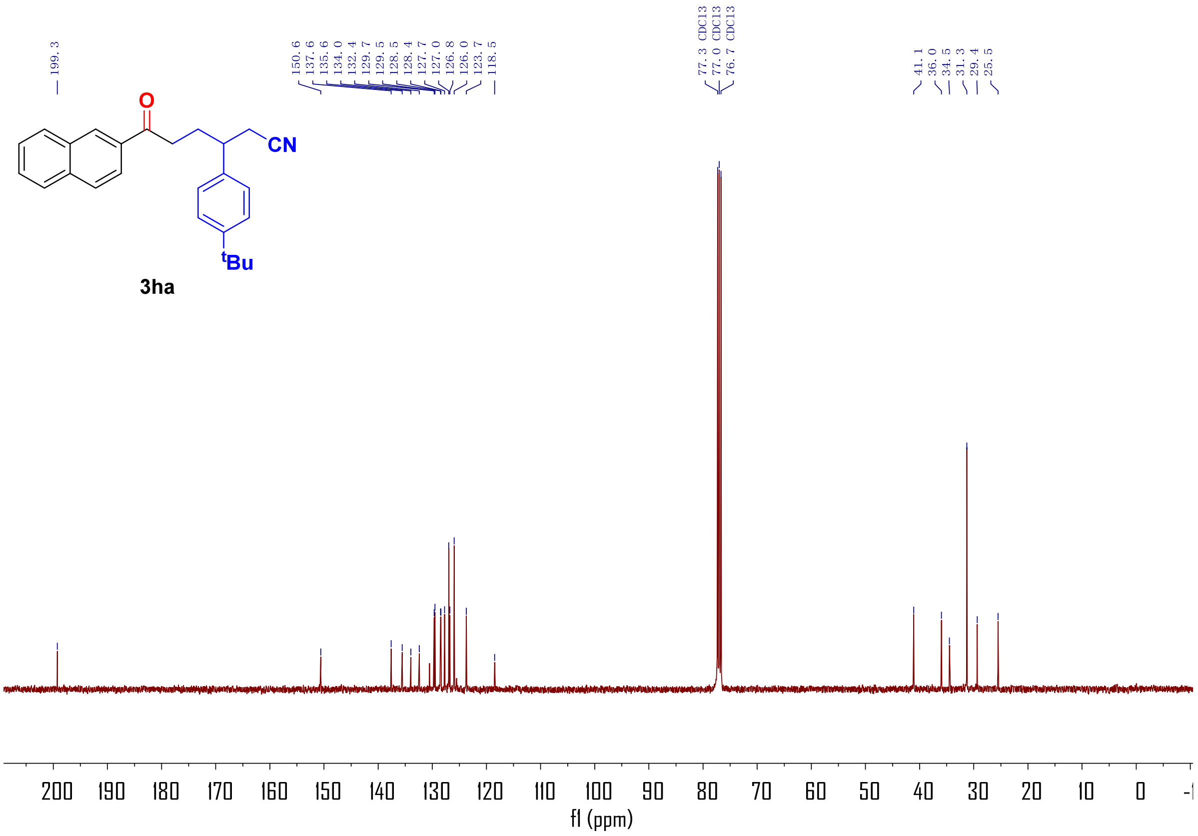
^{1}H NMR (400 MHz, CDCl$_3$), ^{13}C NMR (100 MHz, CDCl$_3$) spectra of product 3ga



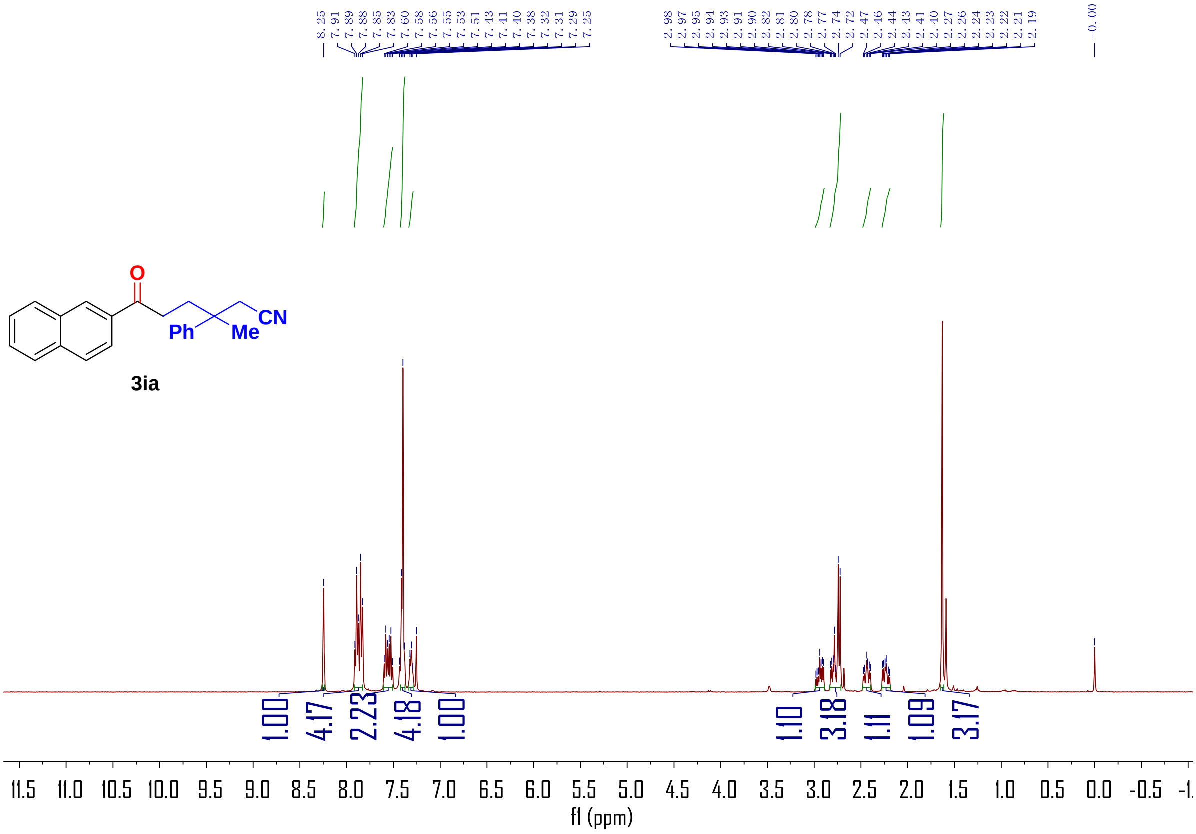


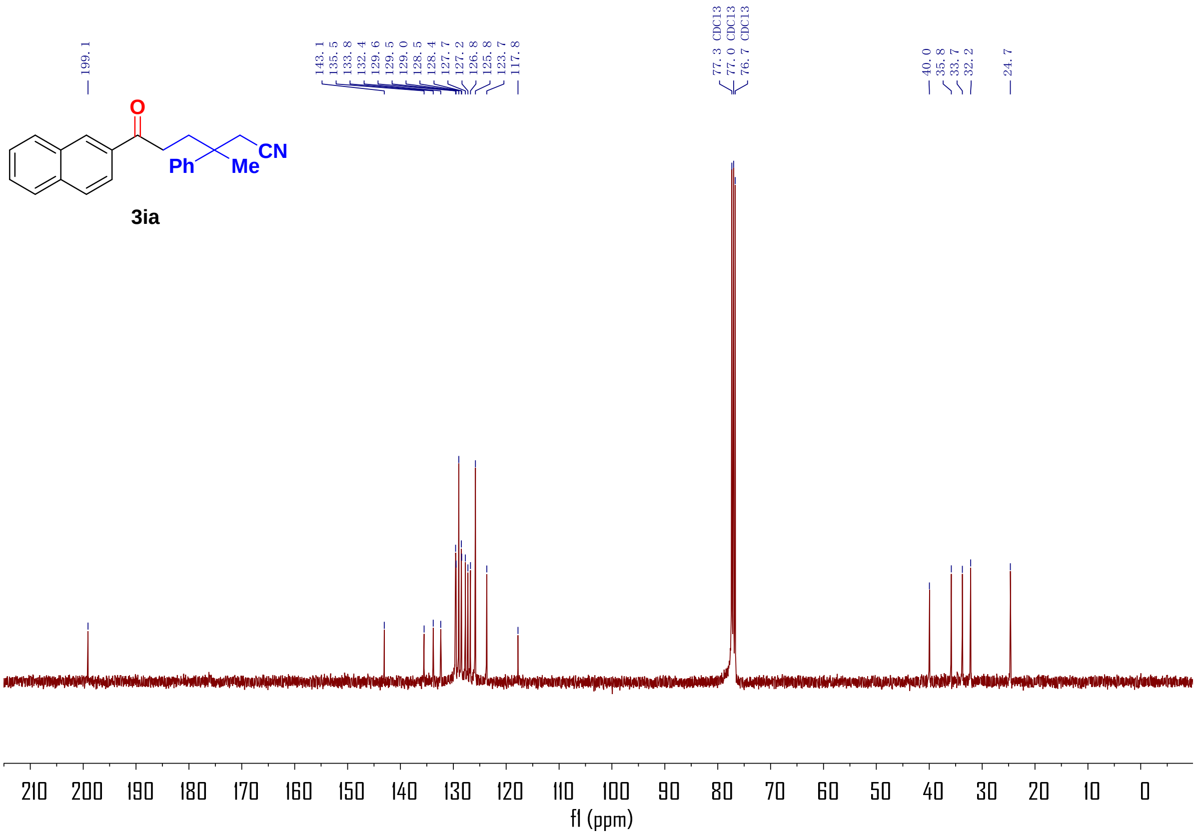
^{1}H NMR (400 MHz, CDCl$_3$), ^{13}C NMR (100 MHz, CDCl$_3$) spectra of product 3ha



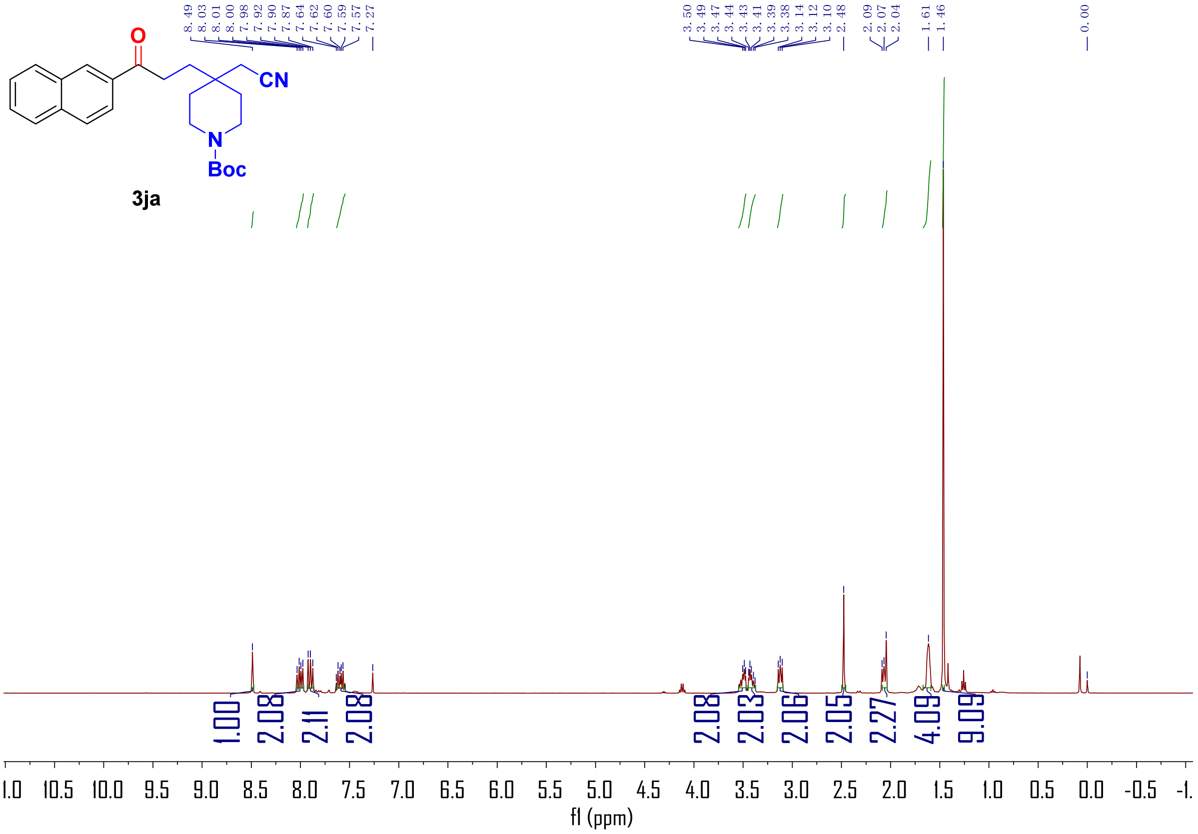


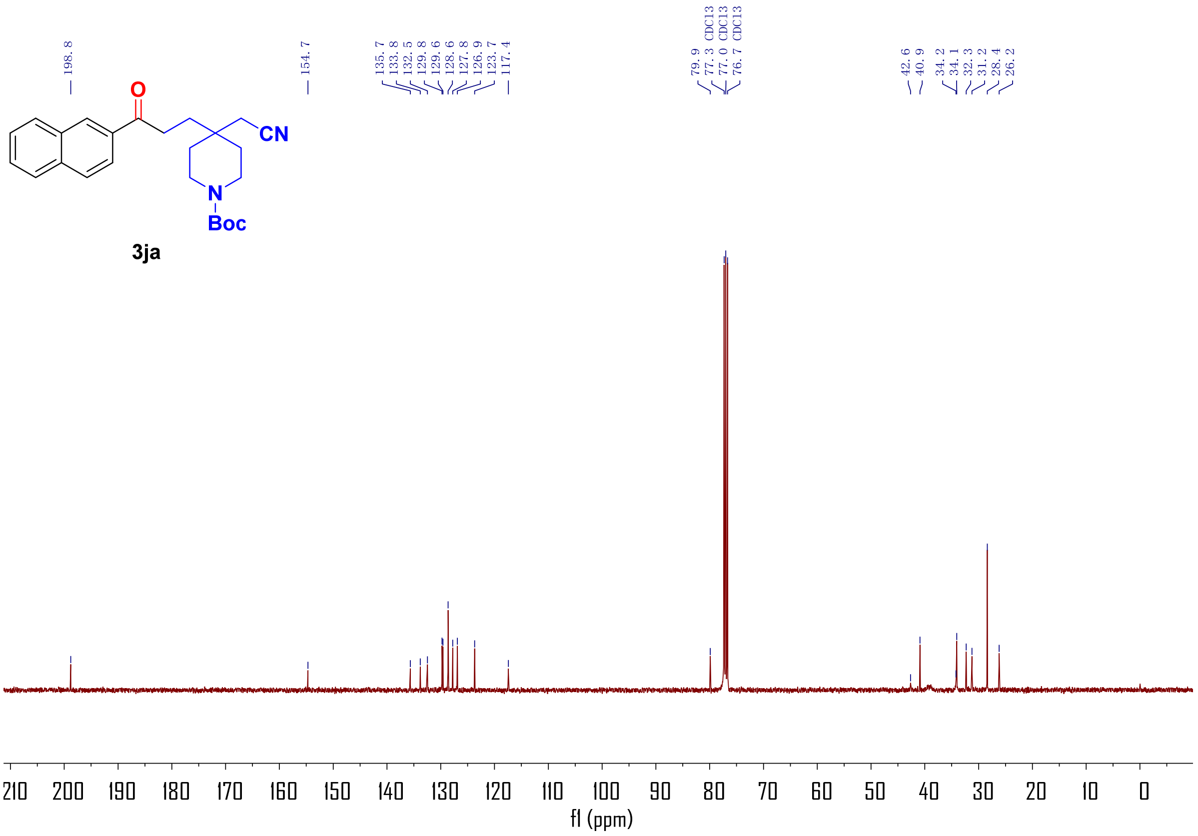
^{1}H NMR (400 MHz, CDCl$_3$), ^{13}C NMR (100 MHz, CDCl$_3$) spectra of product 3ia



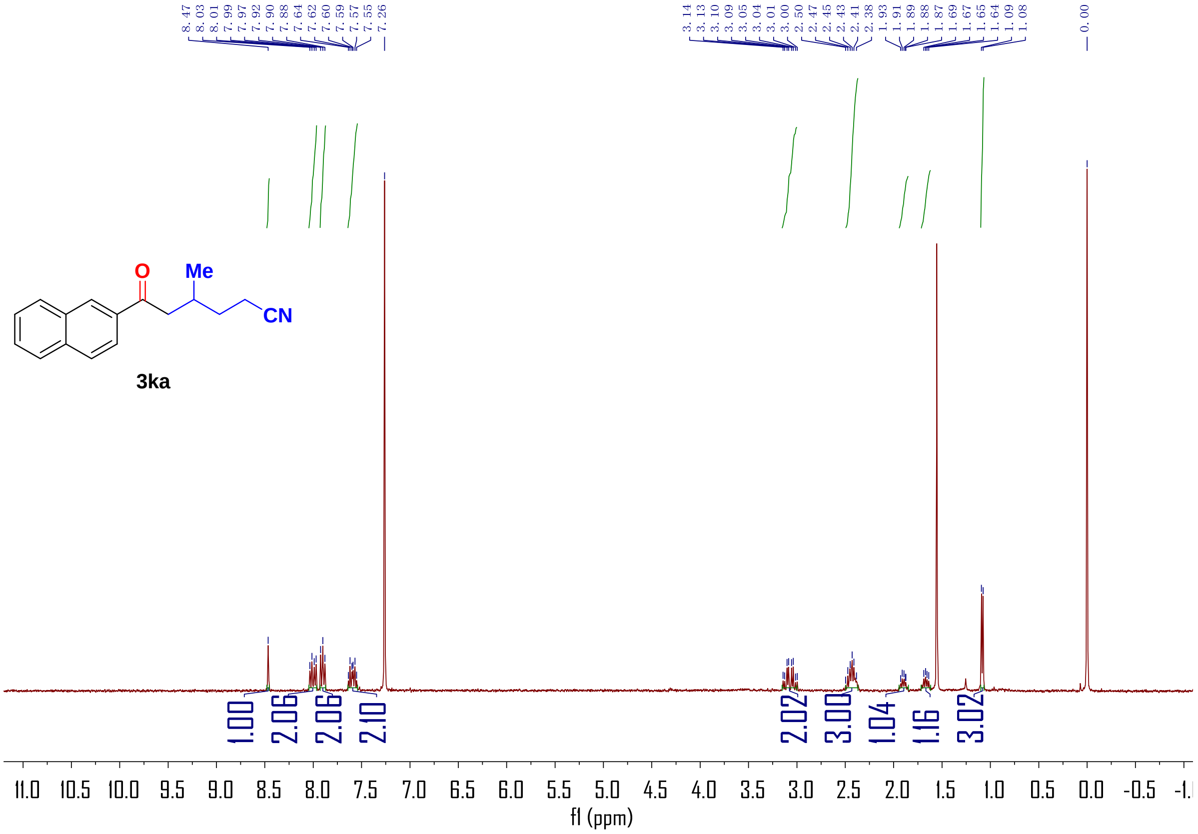


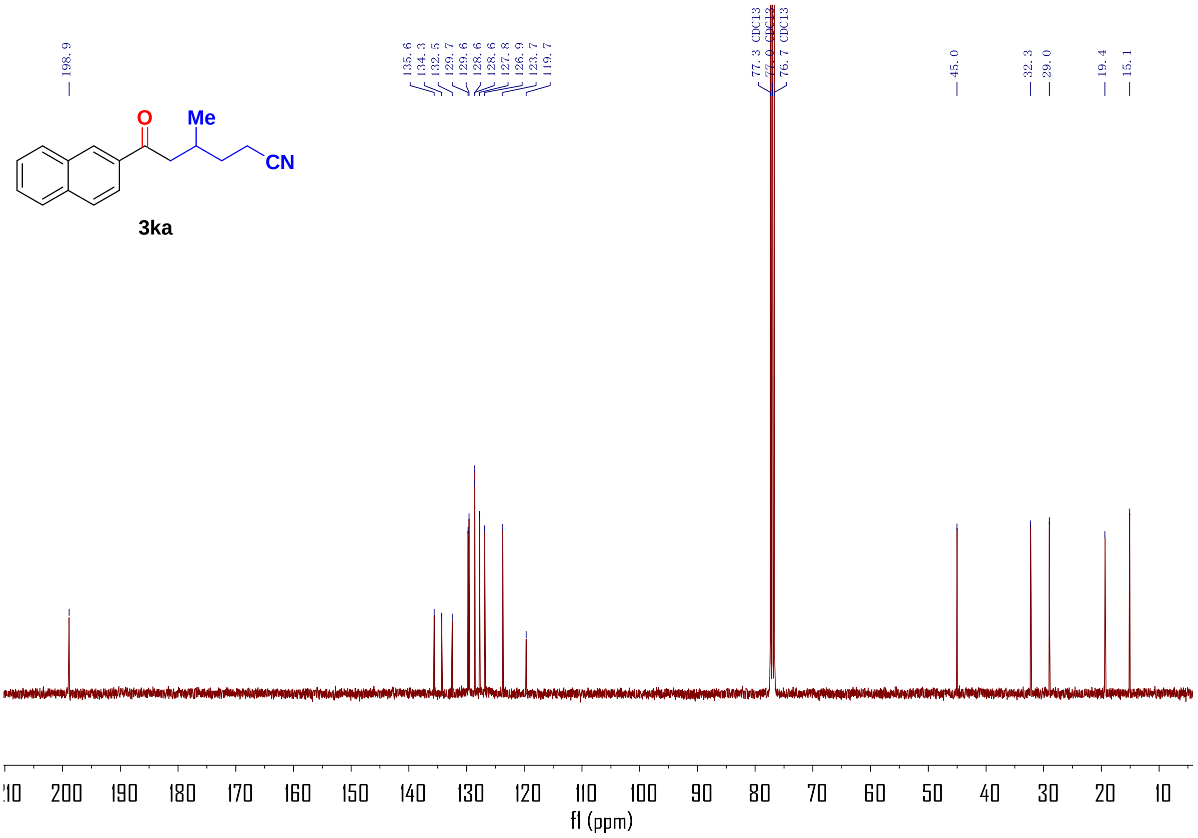
^{1}H NMR (400 MHz, CDCl$_3$), ^{13}C NMR (100 MHz, CDCl$_3$) spectra of product 3ja



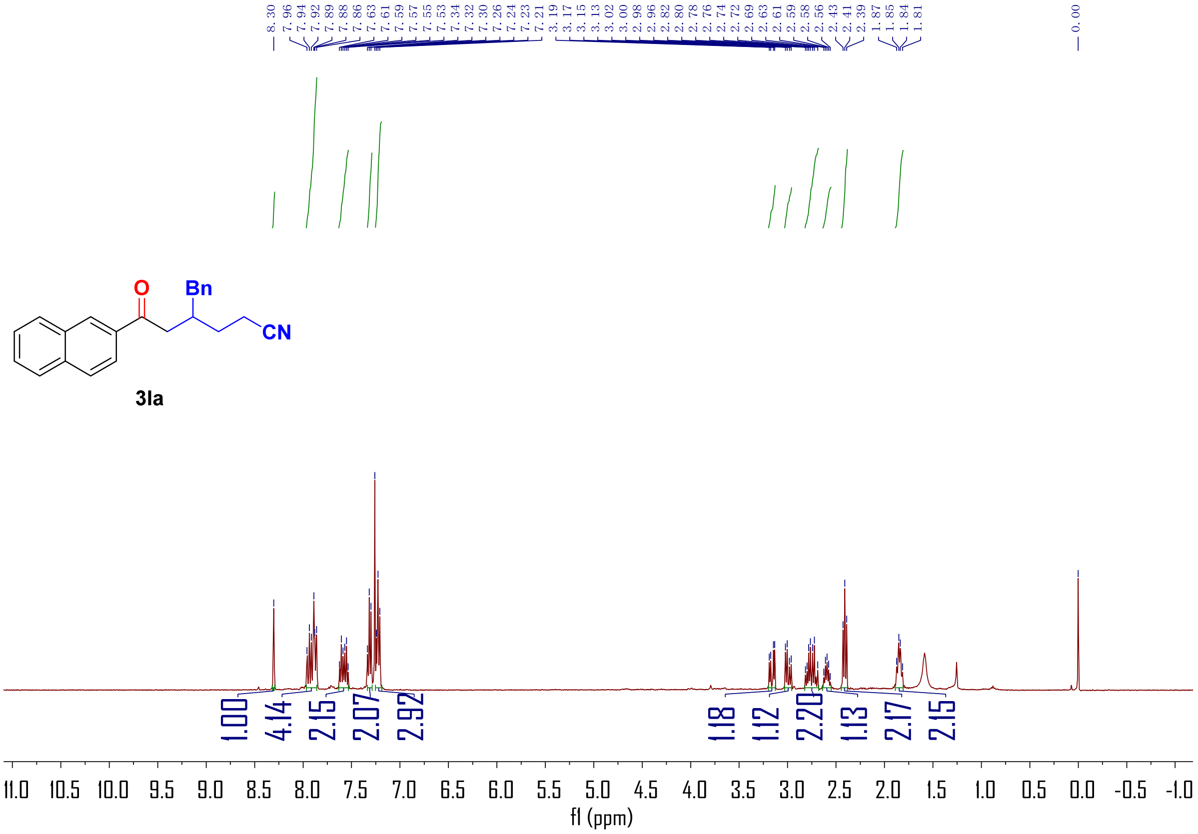


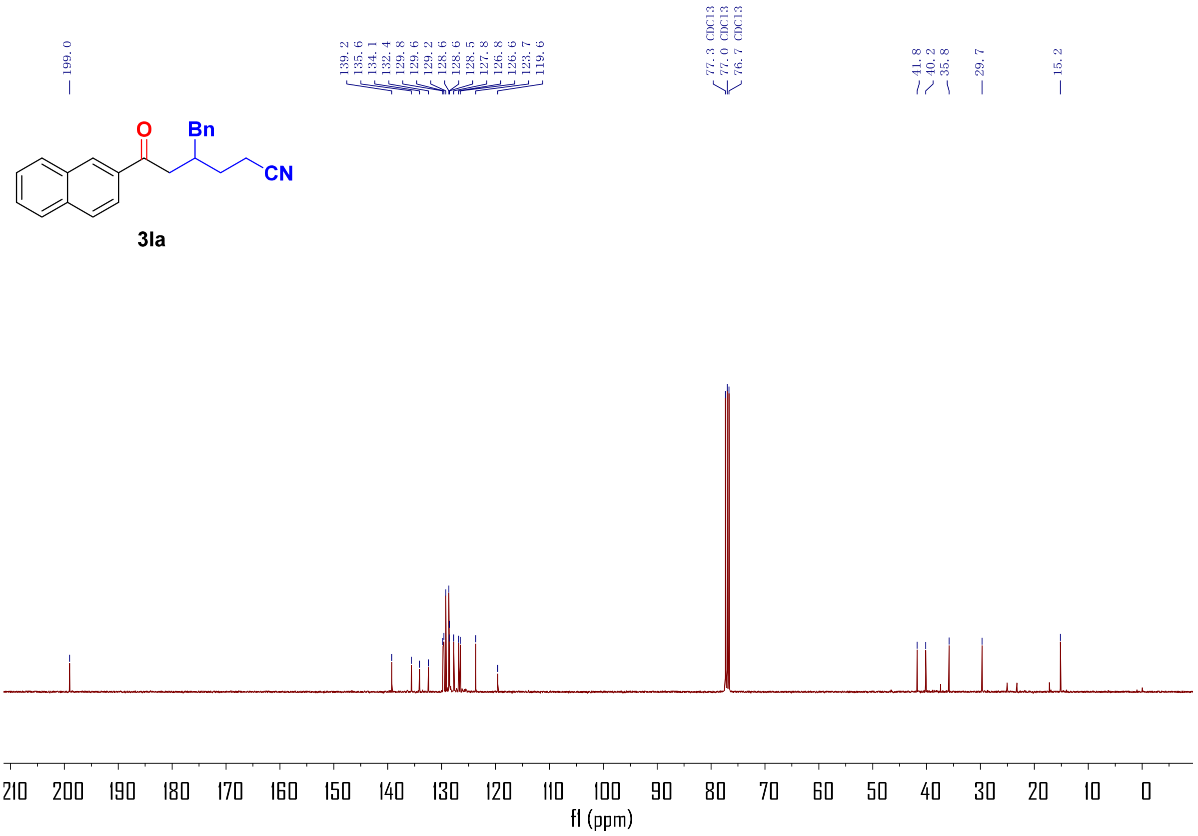
^{1}H NMR (400 MHz, CDCl$_3$), ^{13}C NMR (100 MHz, CDCl$_3$) spectra of product 3ka



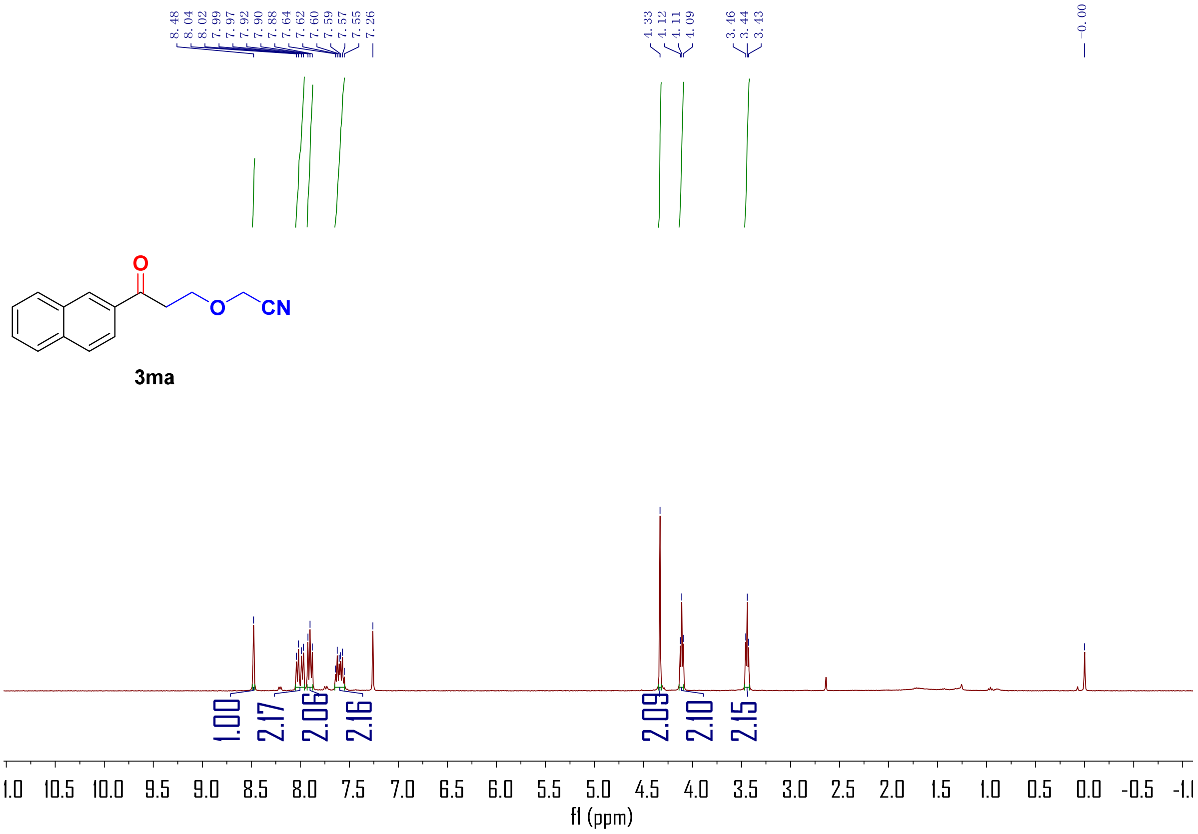


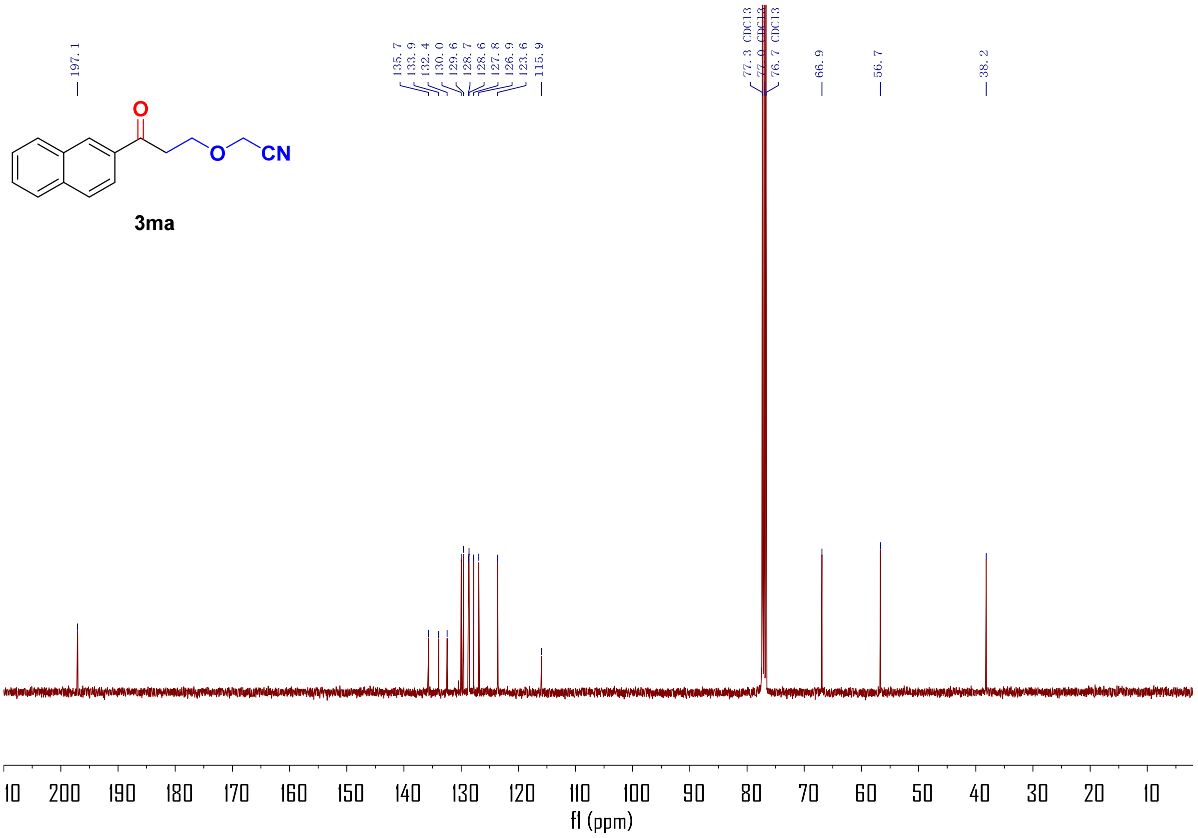
^{1}H NMR (400 MHz, CDCl$_3$), ^{13}C NMR (100 MHz, CDCl$_3$) spectra of product 3la



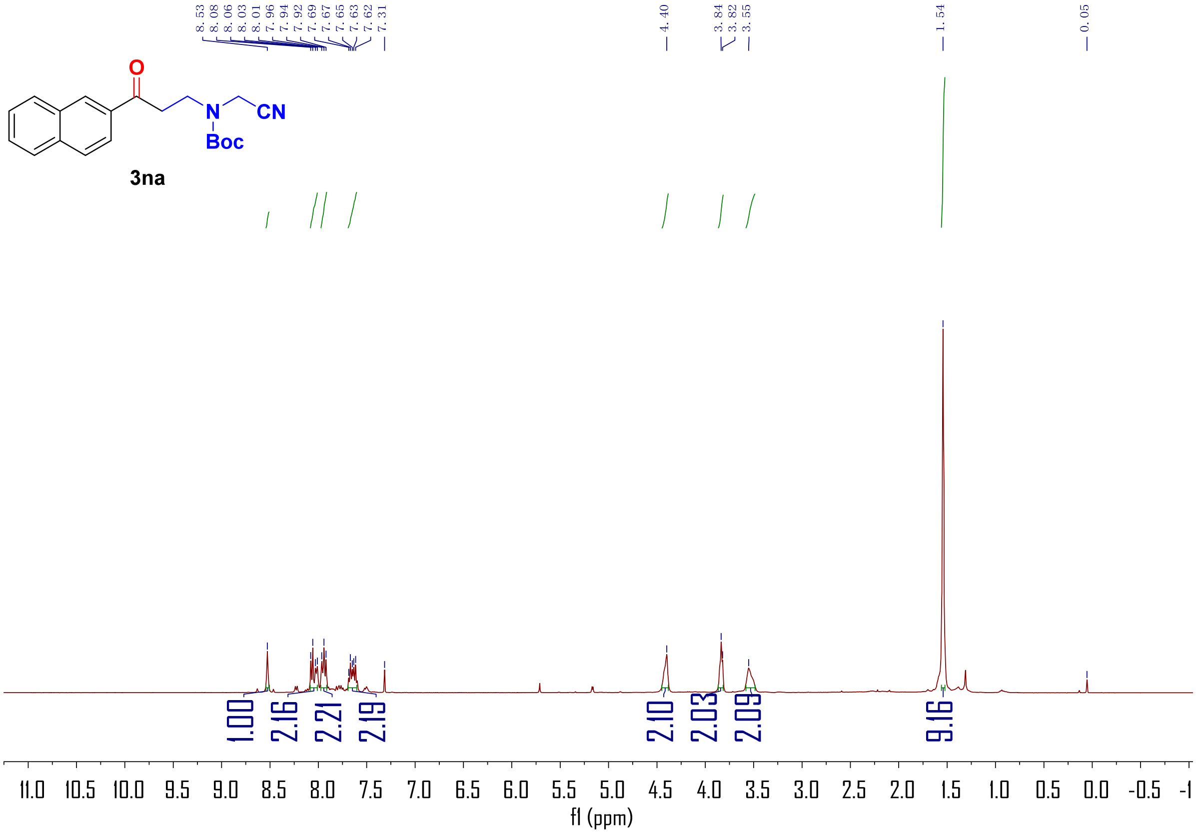


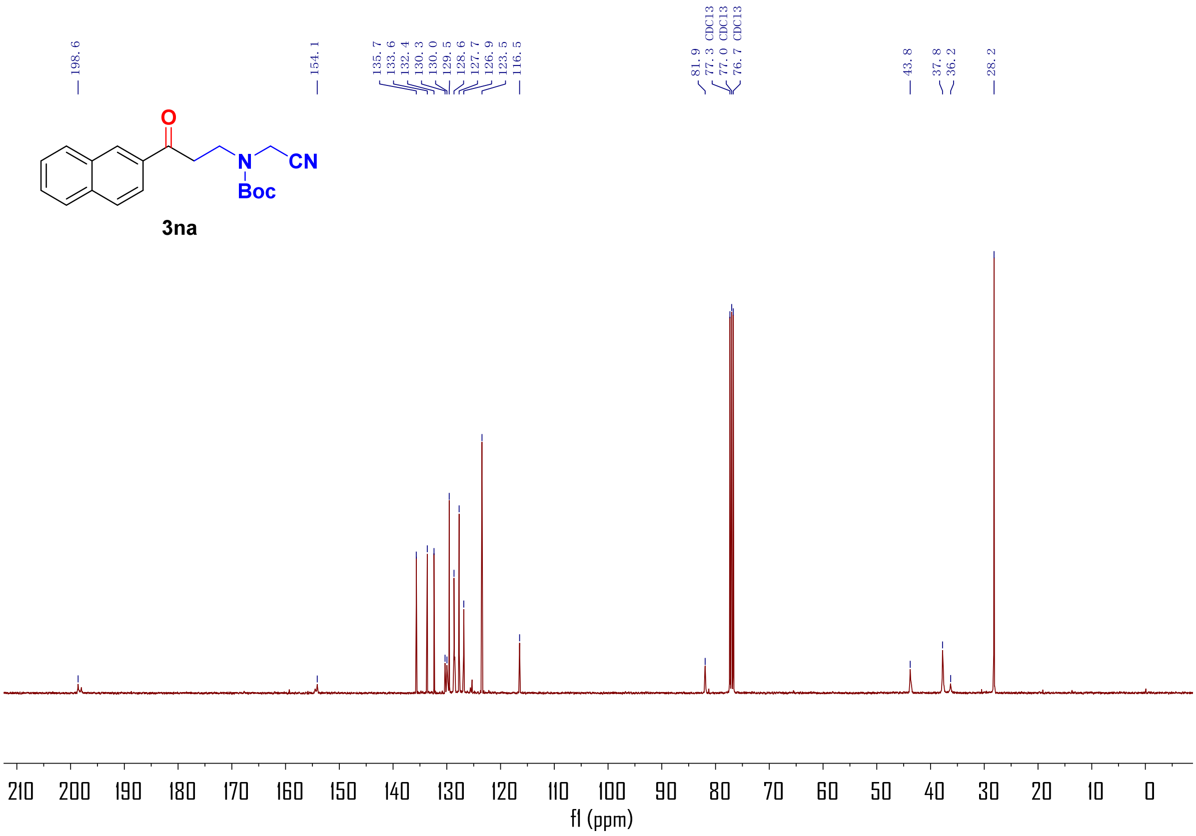
^{1}H NMR (400 MHz, CDCl$_3$), ^{13}C NMR (100 MHz, CDCl$_3$) spectra of product 3ma



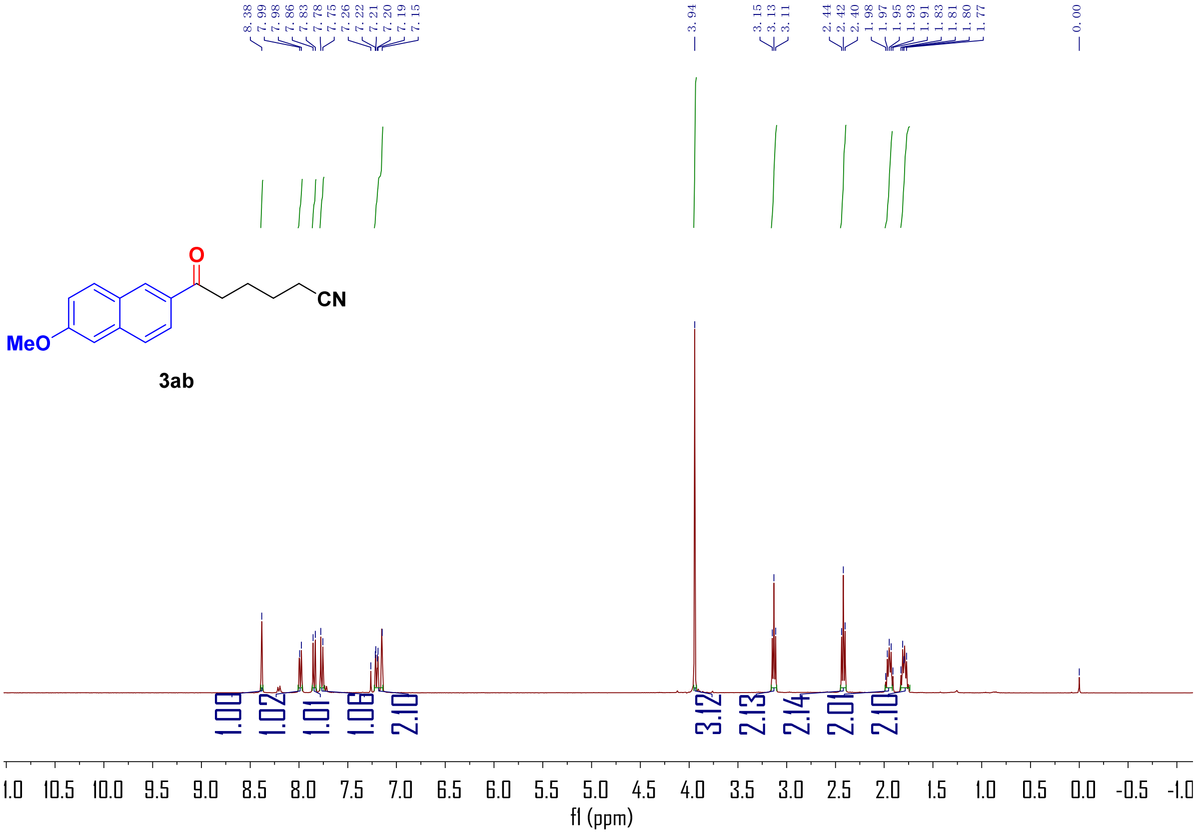


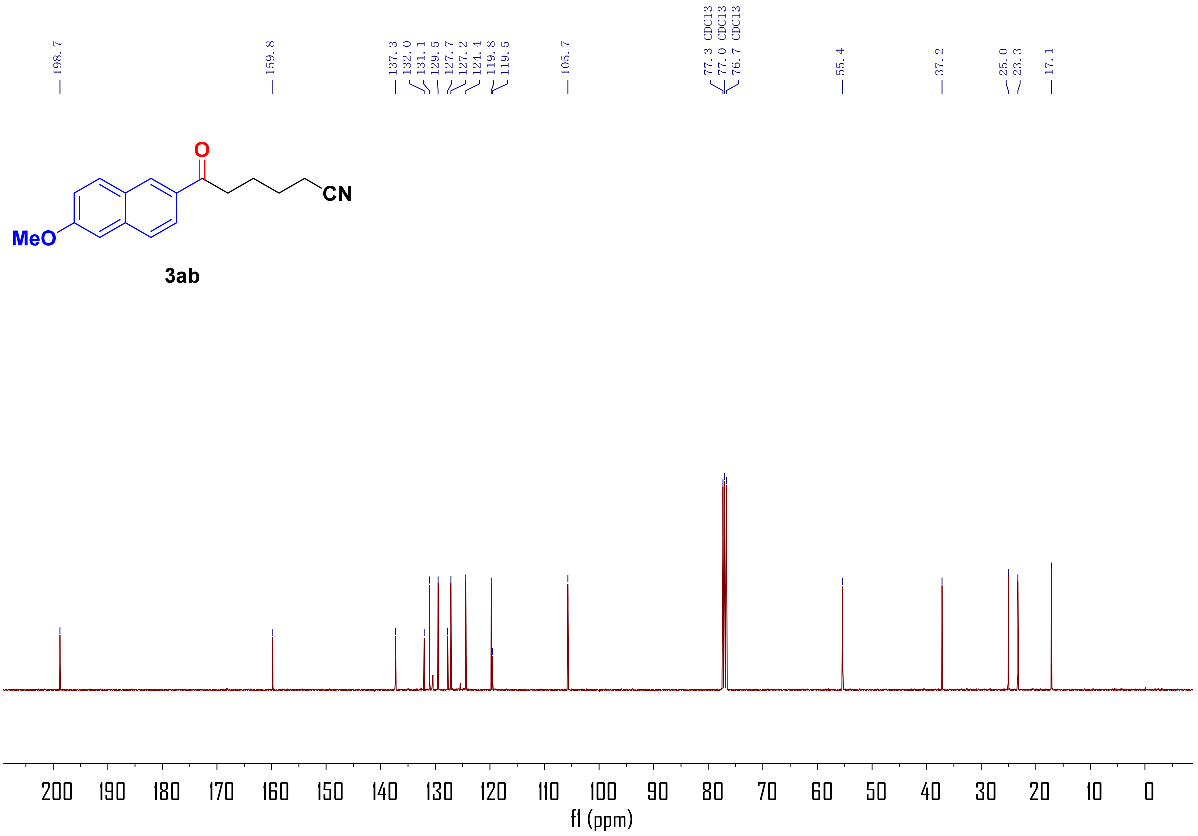
^{1}H NMR (400 MHz, CDCl$_3$), ^{13}C NMR (100 MHz, CDCl$_3$) spectra of product 3na



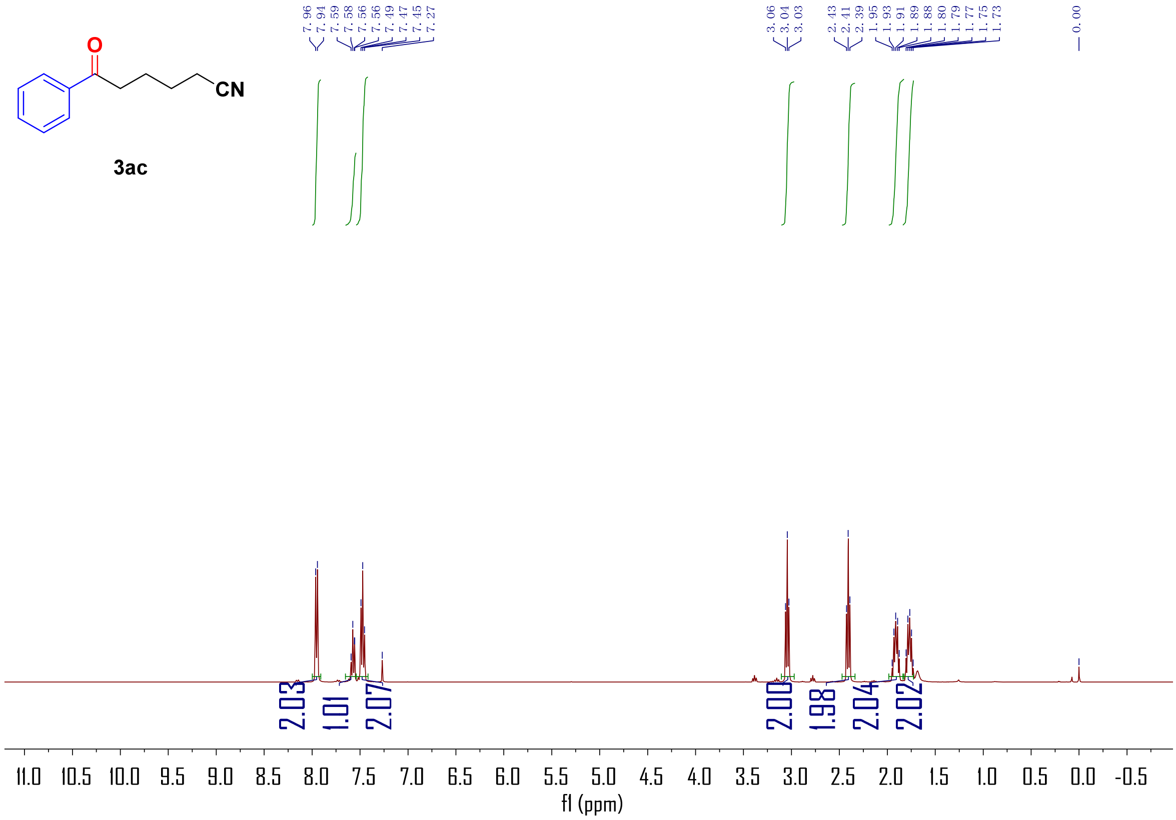


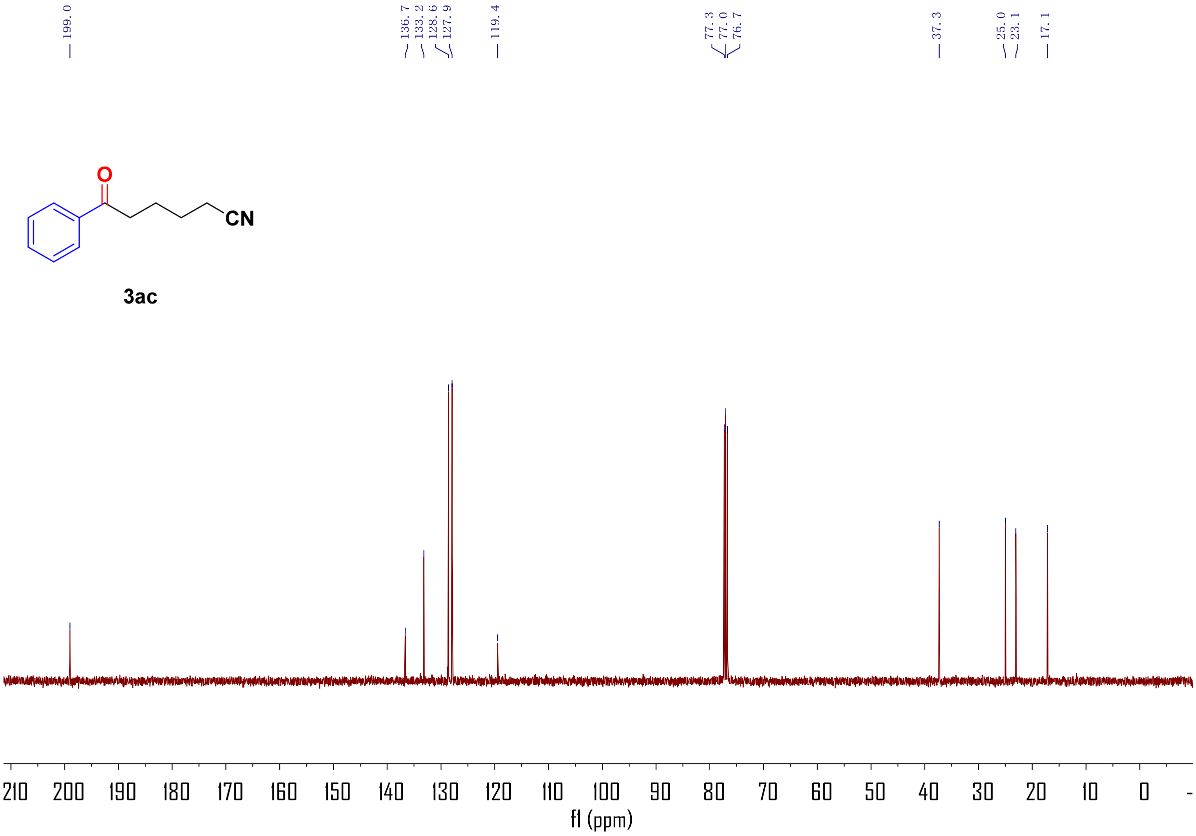
^{1}H NMR (400 MHz, CDCl$_3$), ^{13}C NMR (100 MHz, CDCl$_3$) spectra of product 3ab



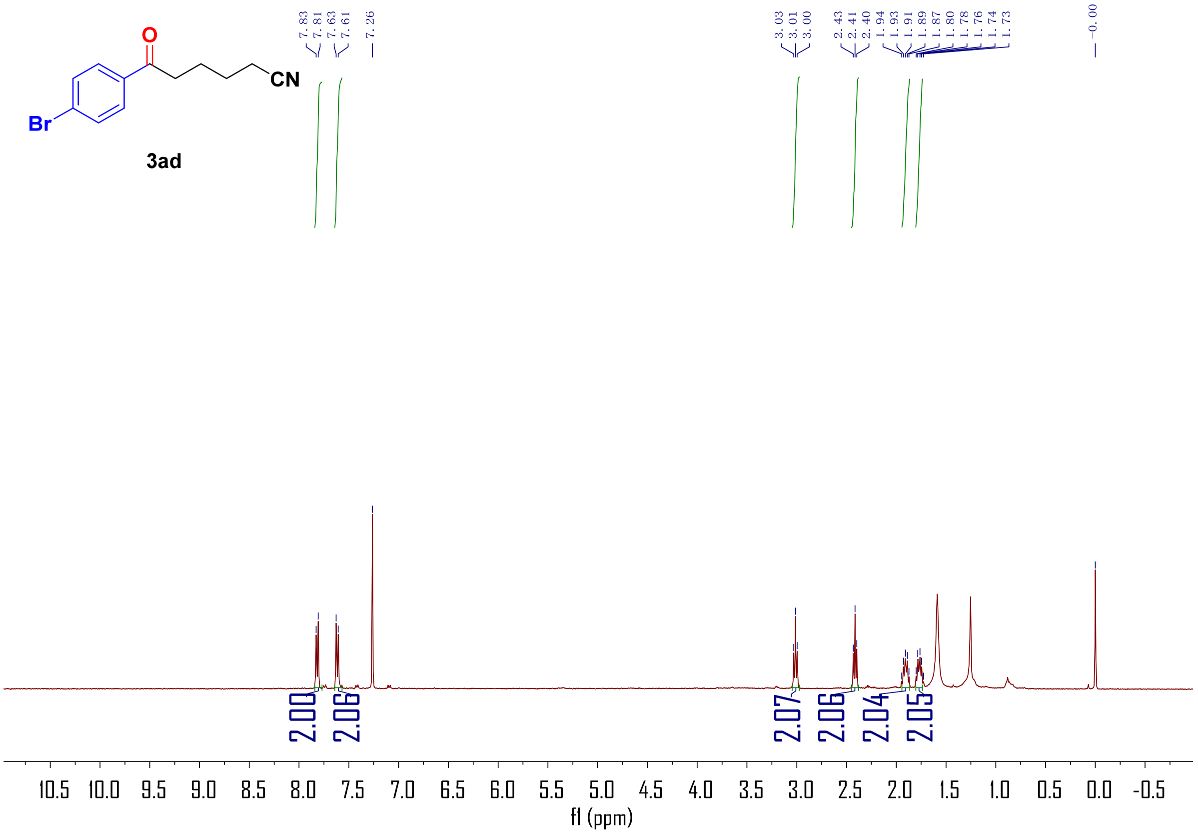


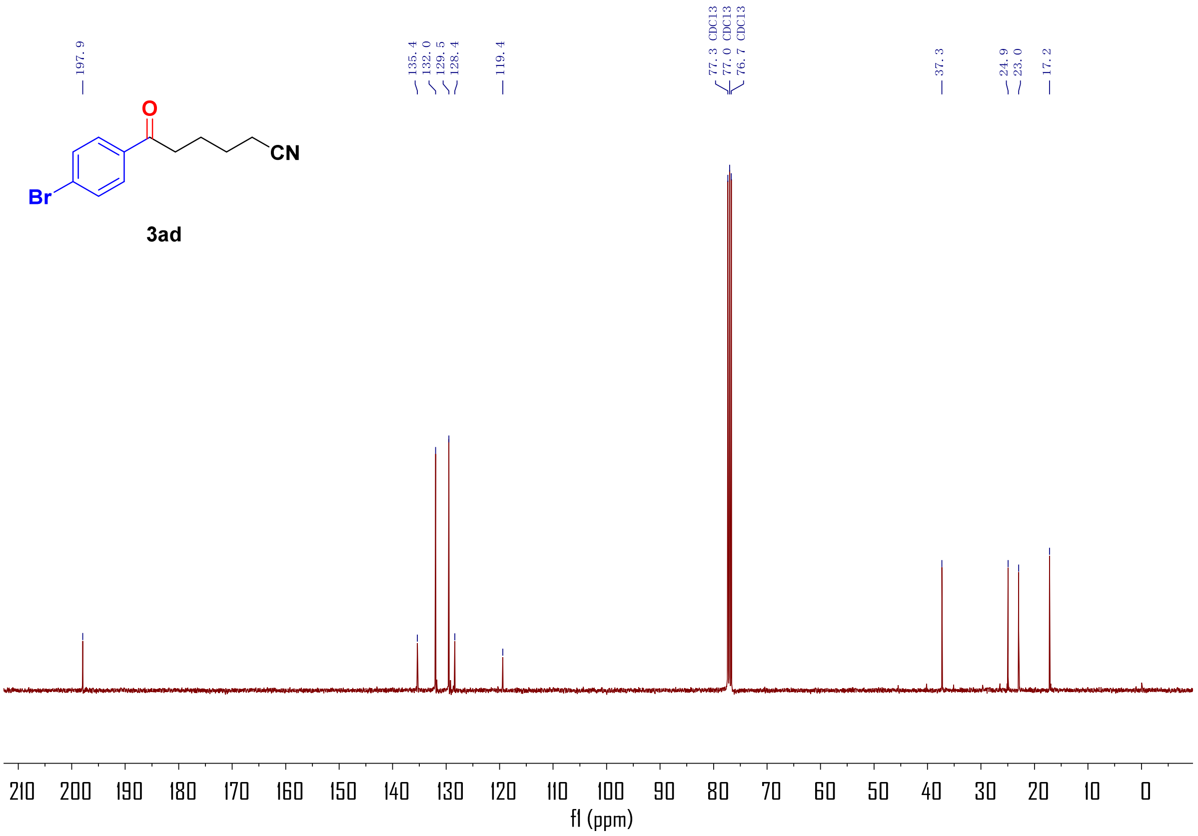
^{1}H NMR (400 MHz, CDCl$_3$), ^{13}C NMR (100 MHz, CDCl$_3$) spectra of product 3ac



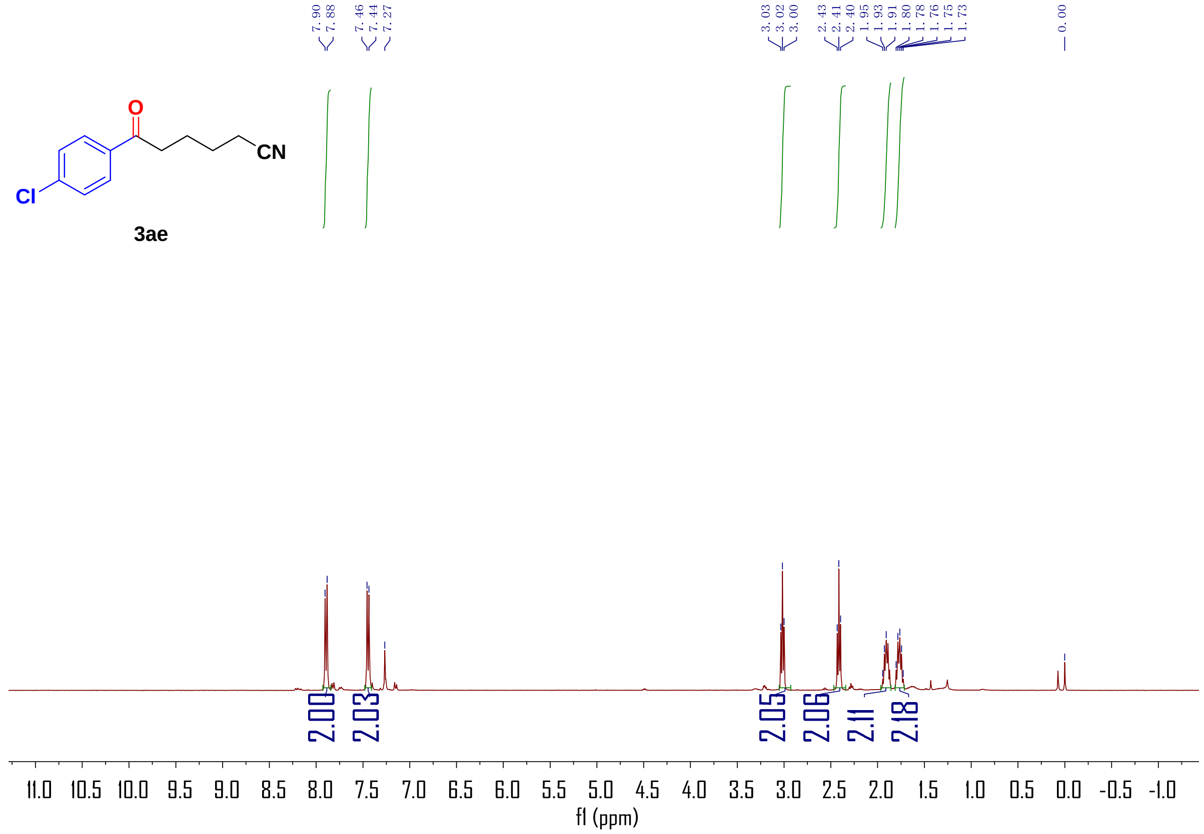


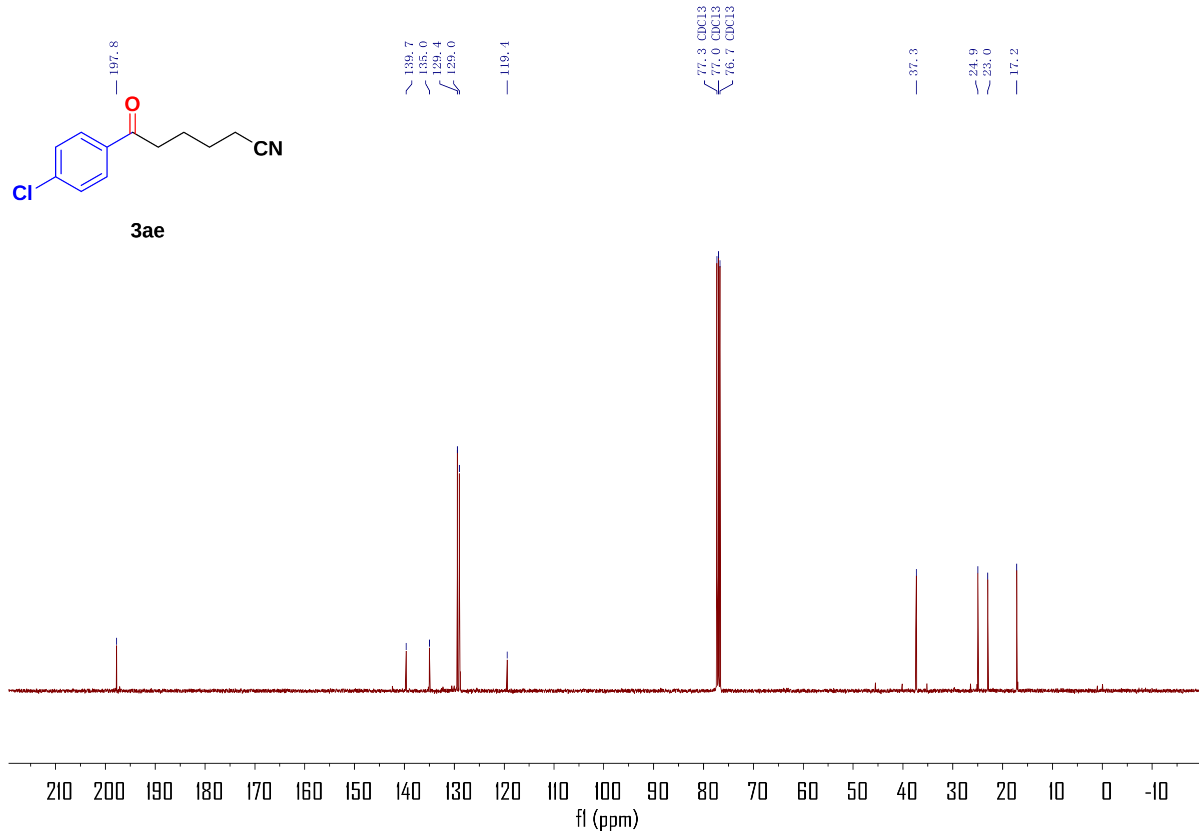
^{1}H NMR (400 MHz, CDCl$_3$), ^{13}C NMR (100 MHz, CDCl$_3$) spectra of product 3ad



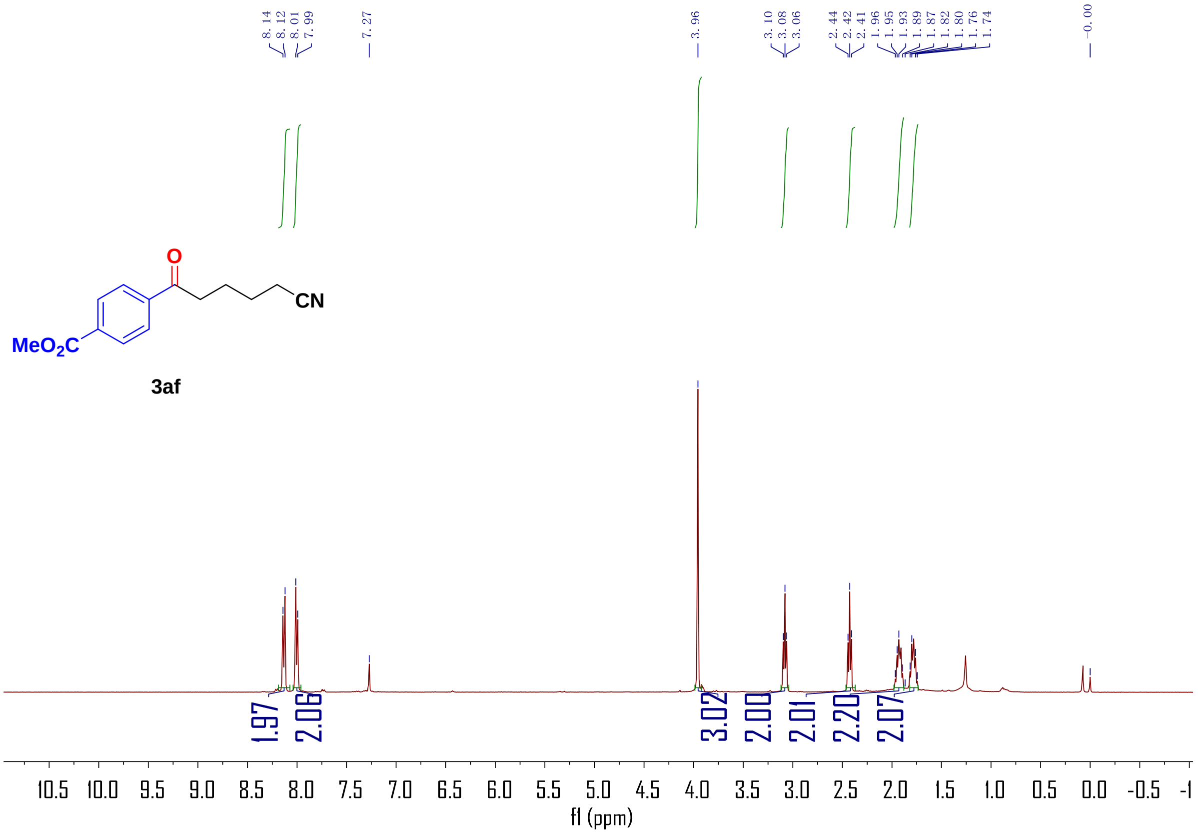


^{1}H NMR (400 MHz, CDCl$_3$), ^{13}C NMR (100 MHz, CDCl$_3$) spectra of product 3ae

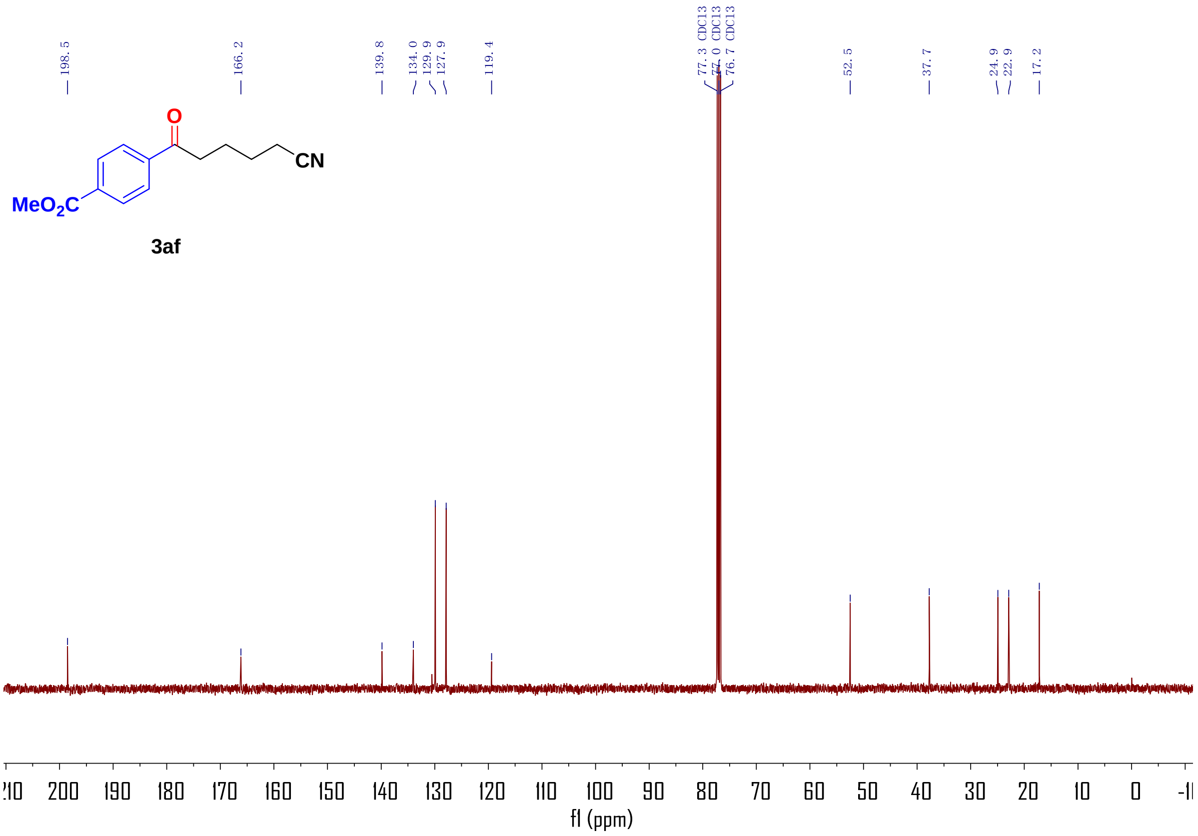




^{1}H NMR (400 MHz, CDCl$_3$), ^{13}C NMR (100 MHz, CDCl$_3$) spectra of product 3af



3af



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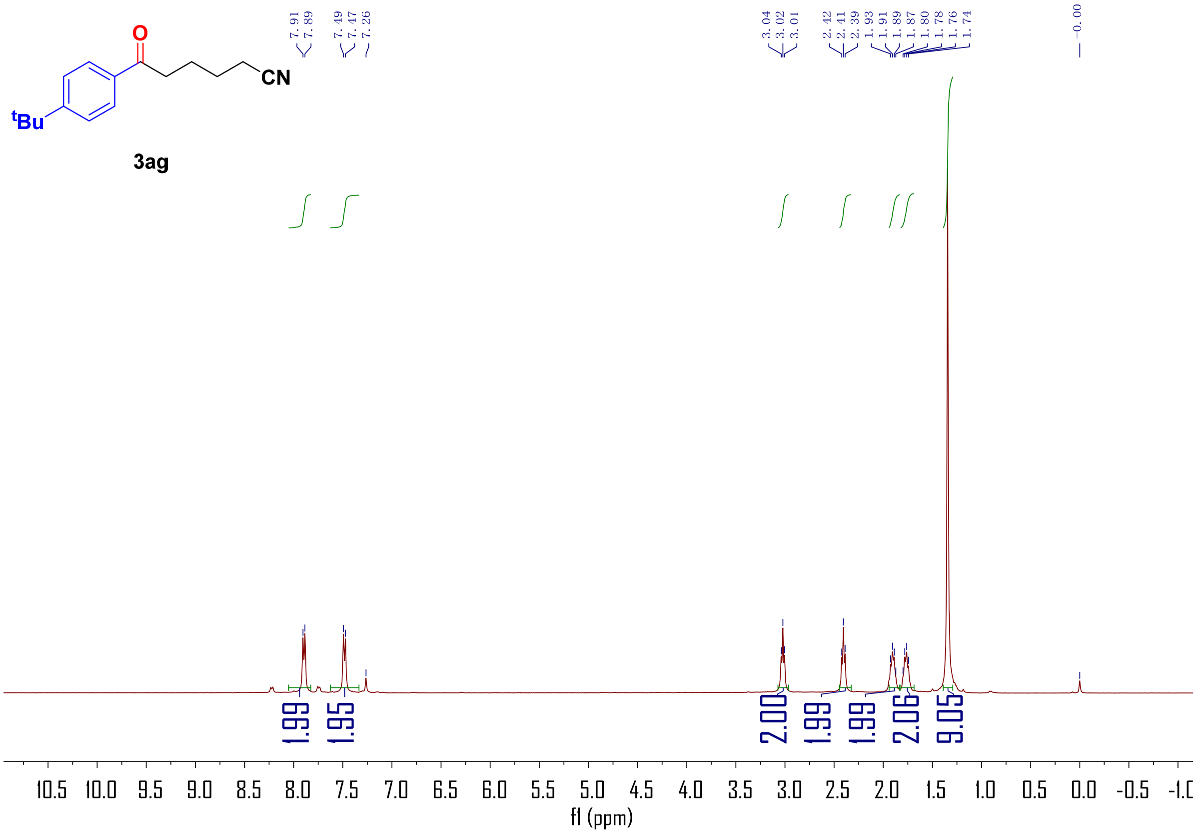
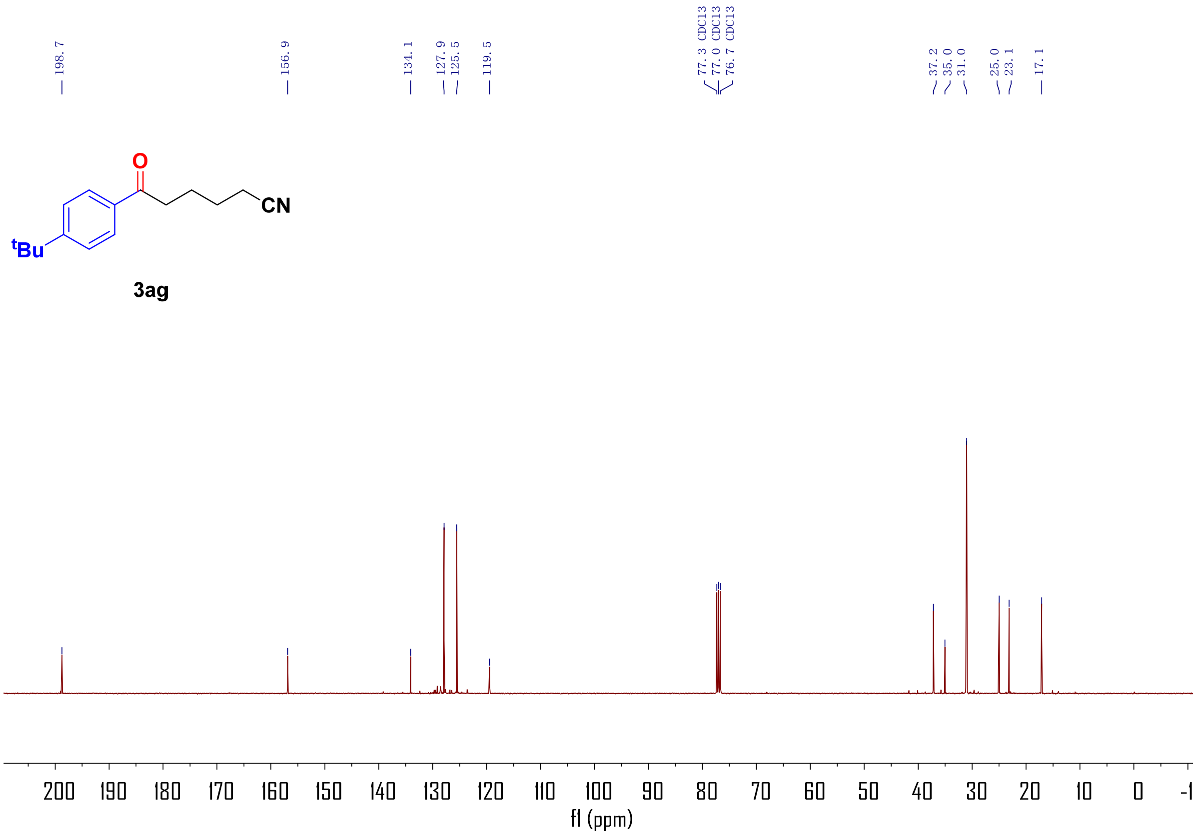
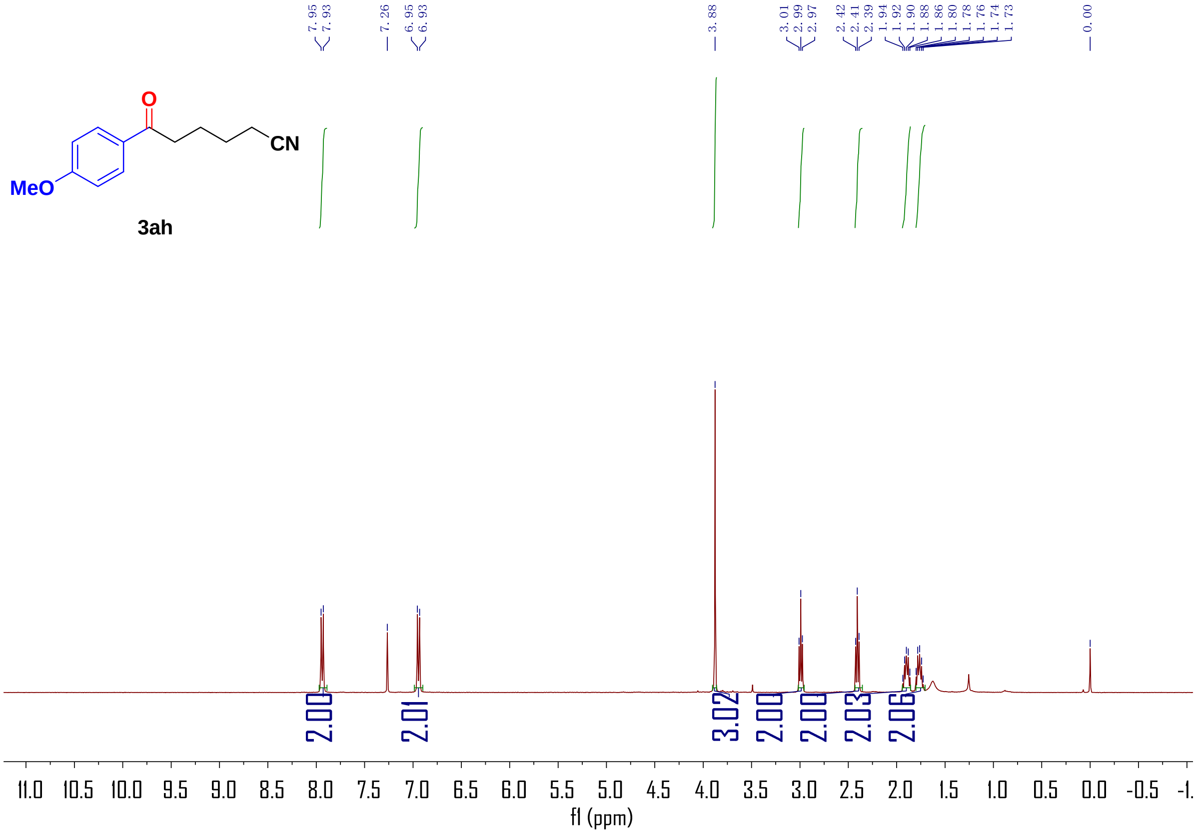
^{1}H NMR (400 MHz, CDCl$_3$), ^{13}C NMR (100 MHz, CDCl$_3$) spectra of product 3ag

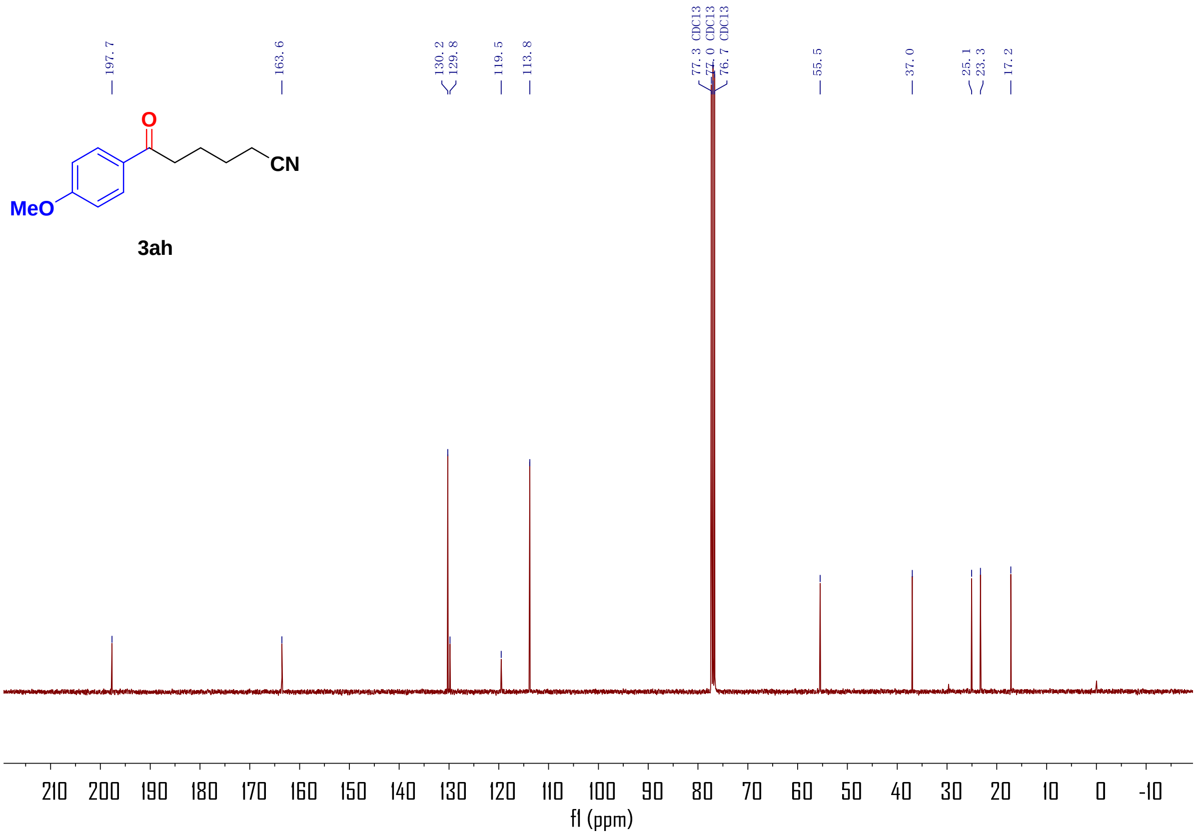




^{1}H NMR (400 MHz, CDCl$_3$), ^{13}C NMR (100 MHz, CDCl$_3$) spectra of product 3ah

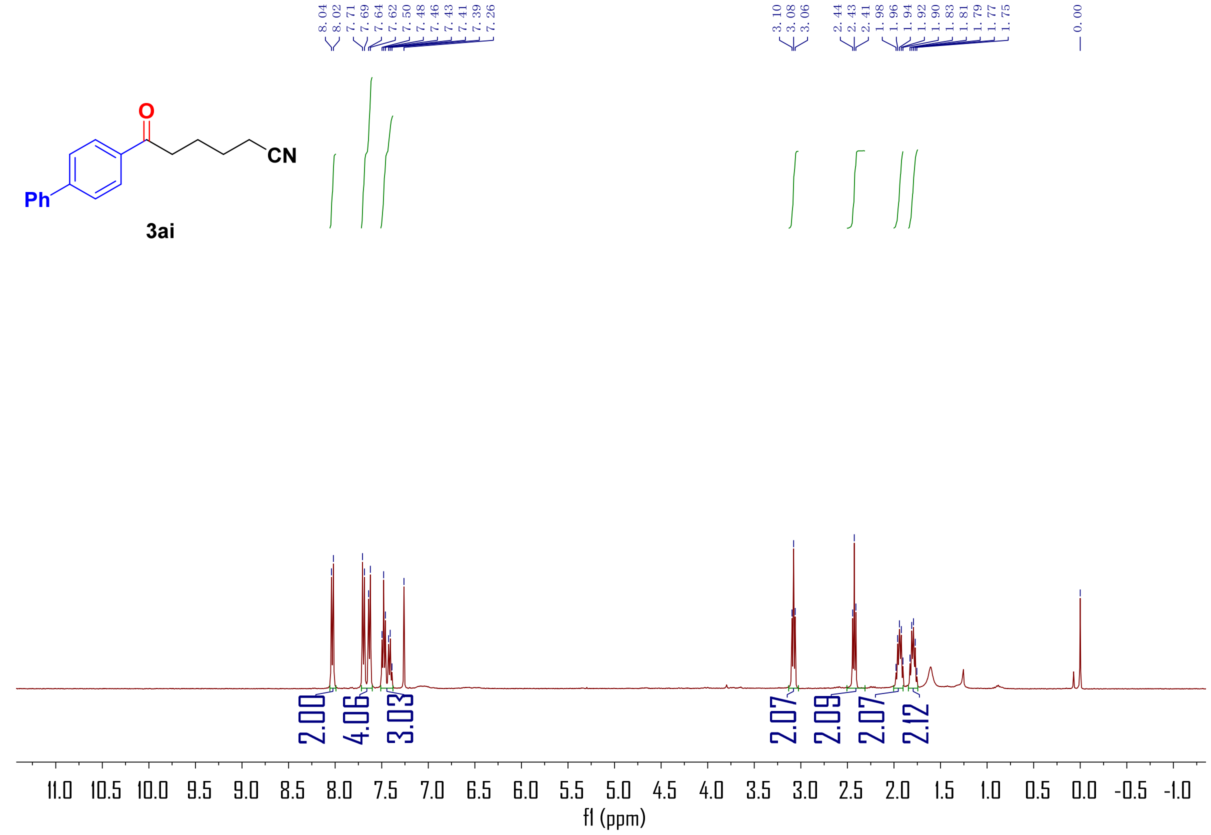


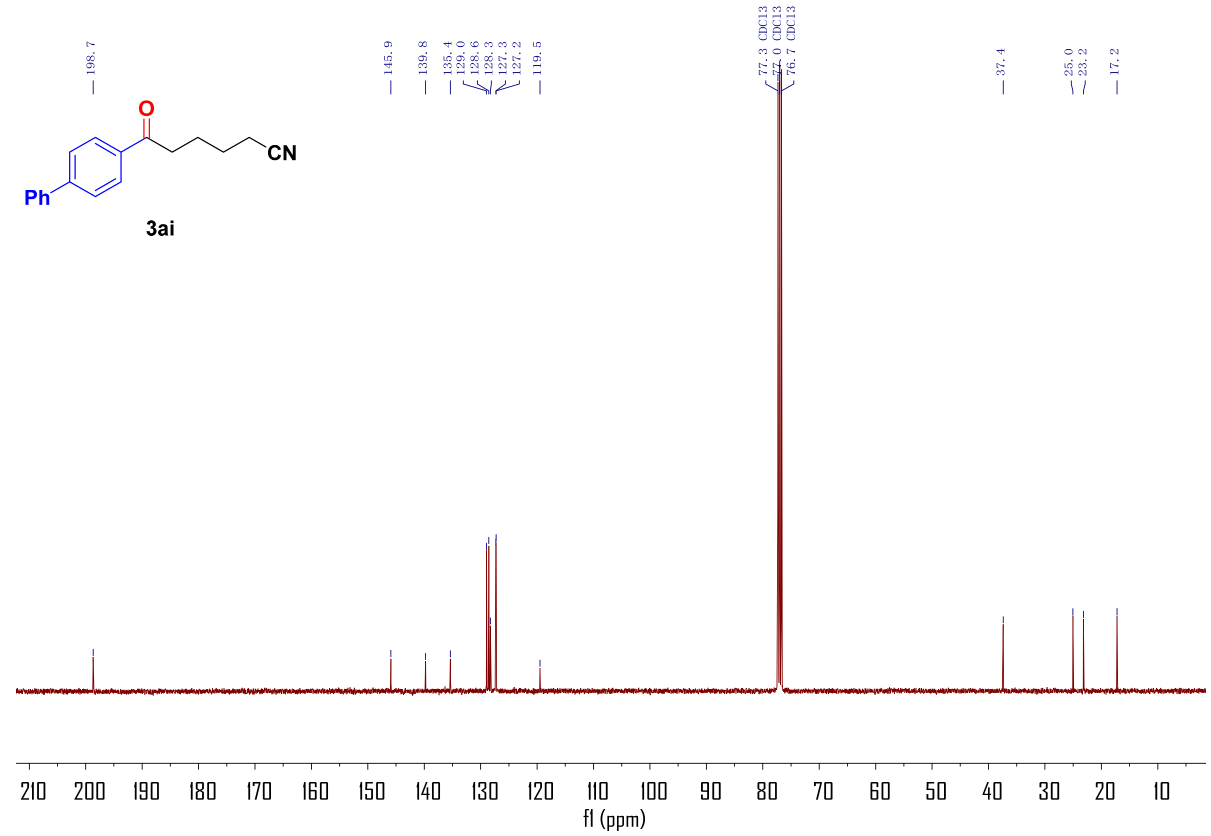
3ah



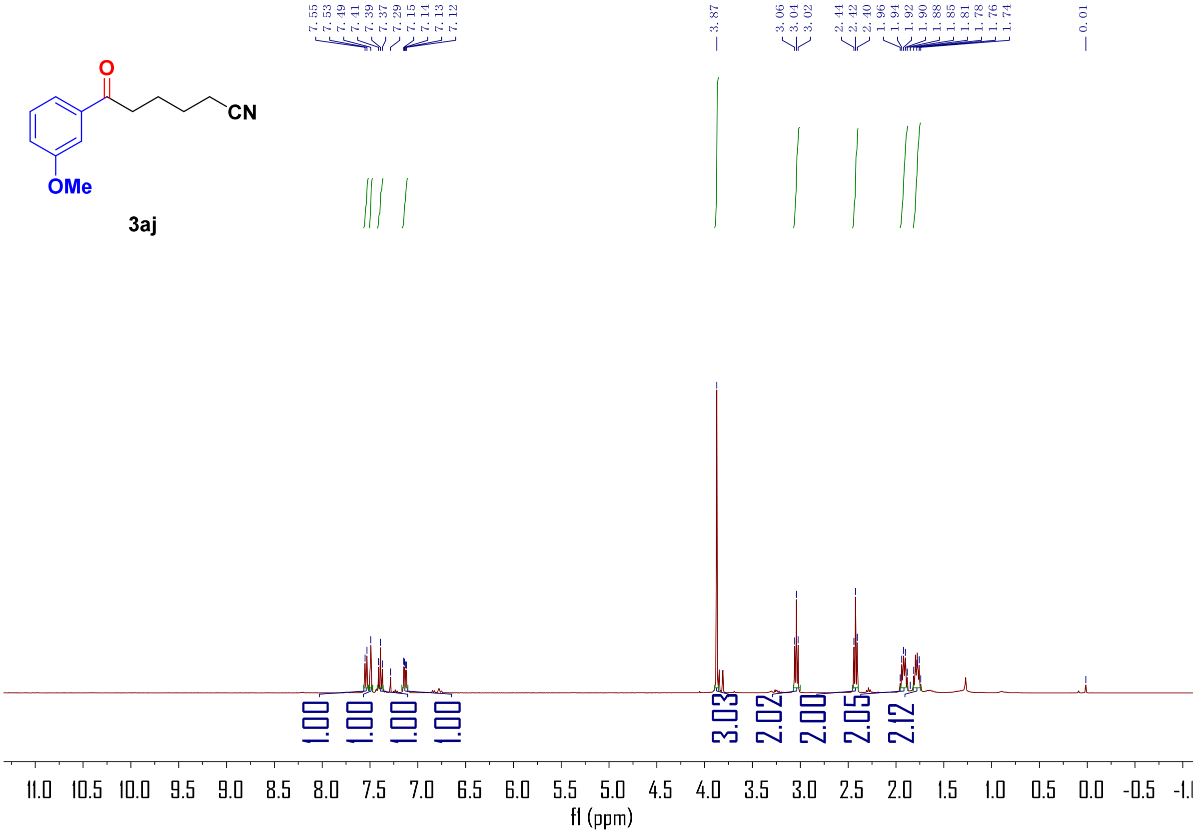
3ah

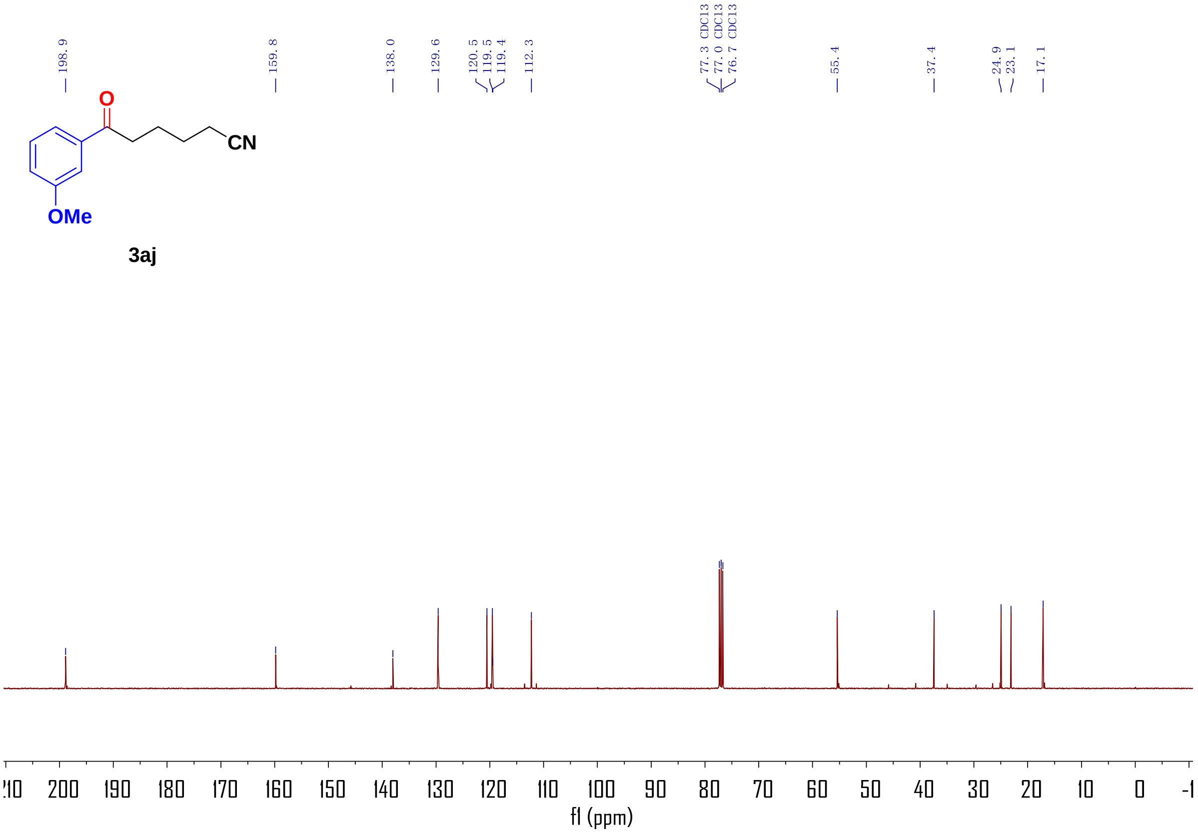
^{1}H NMR (400 MHz, CDCl$_3$), ^{13}C NMR (100 MHz, CDCl$_3$) spectra of product 3ai



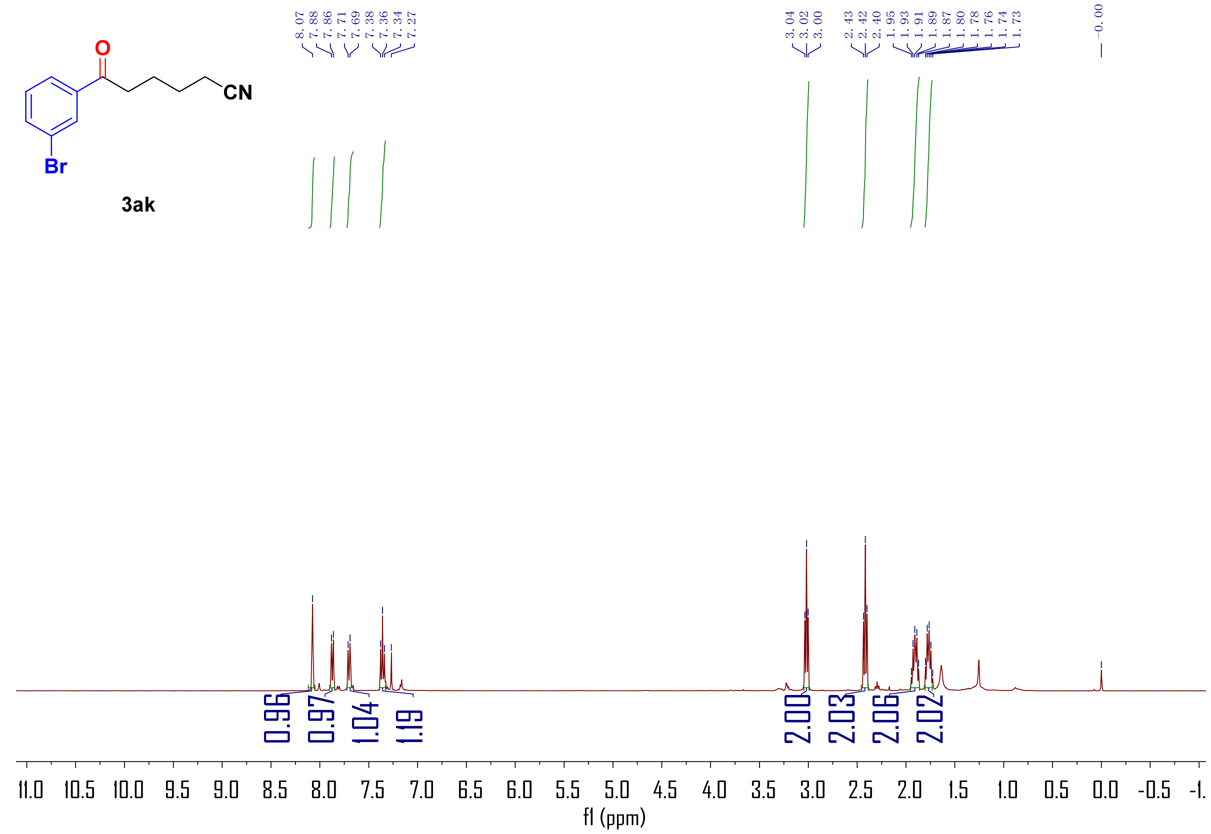


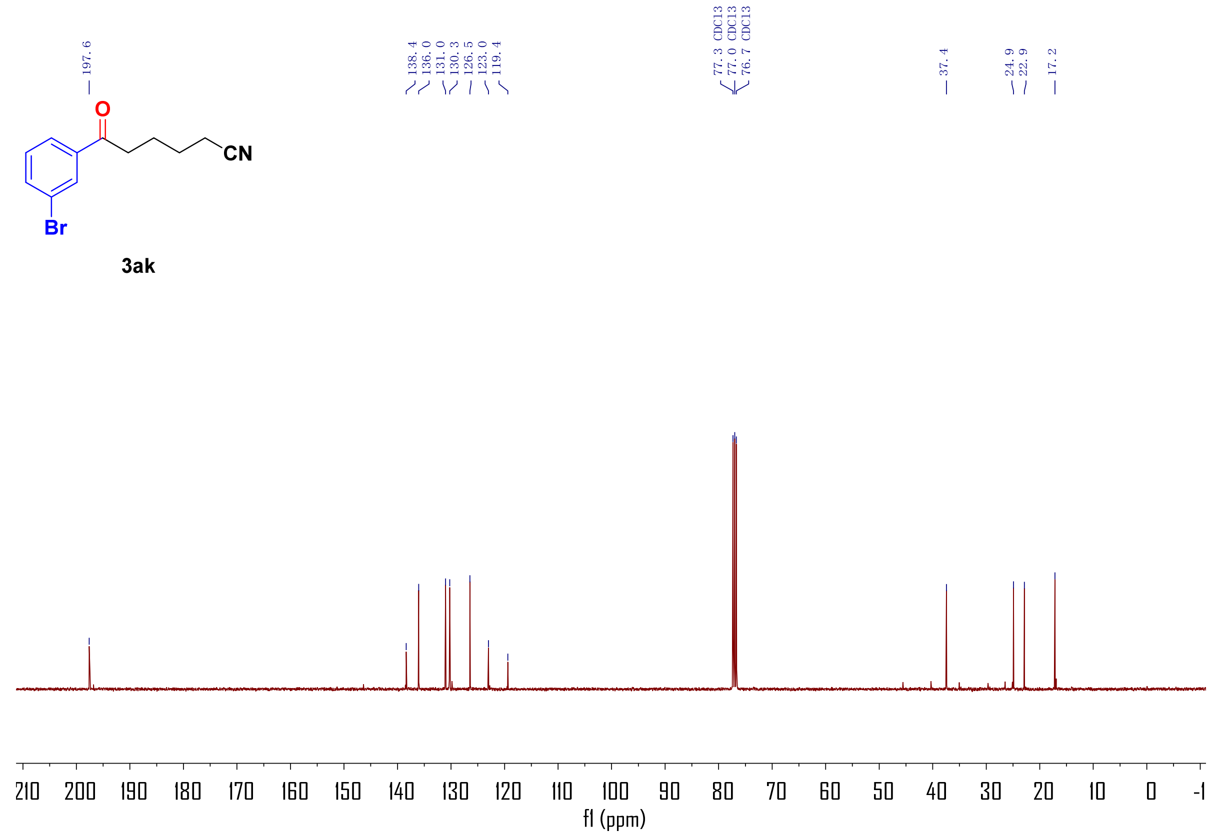
^{1}H NMR (400 MHz, CDCl$_3$), ^{13}C NMR (100 MHz, CDCl$_3$) spectra of product 3aj



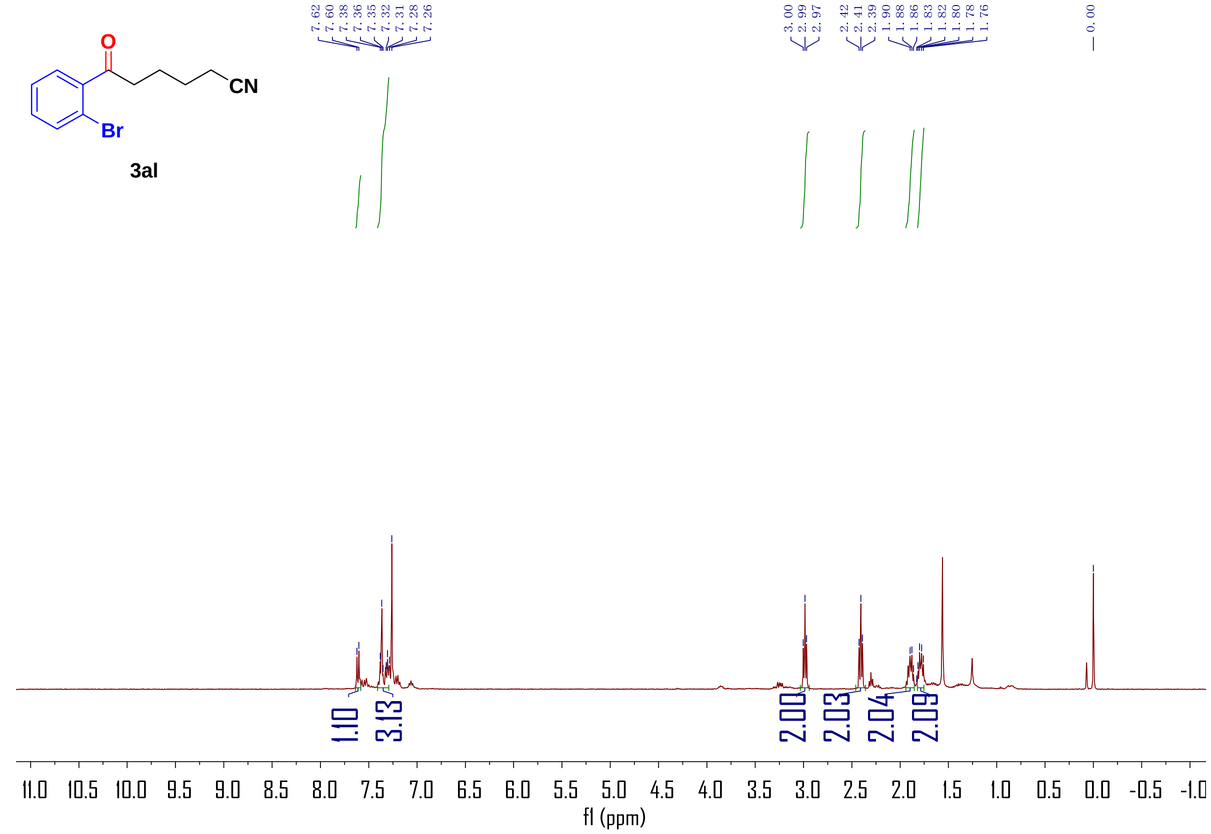


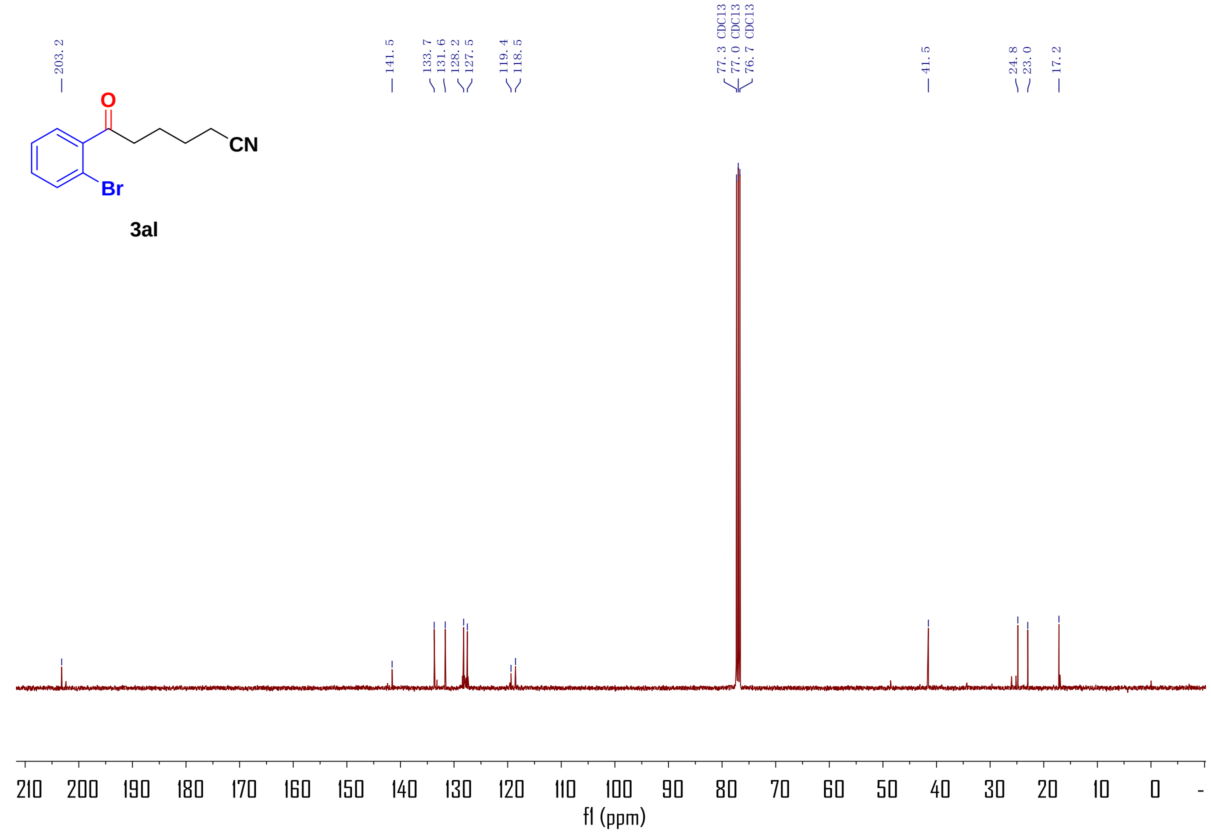
^{1}H NMR (400 MHz, CDCl$_3$), ^{13}C NMR (100 MHz, CDCl$_3$) spectra of product 3ak



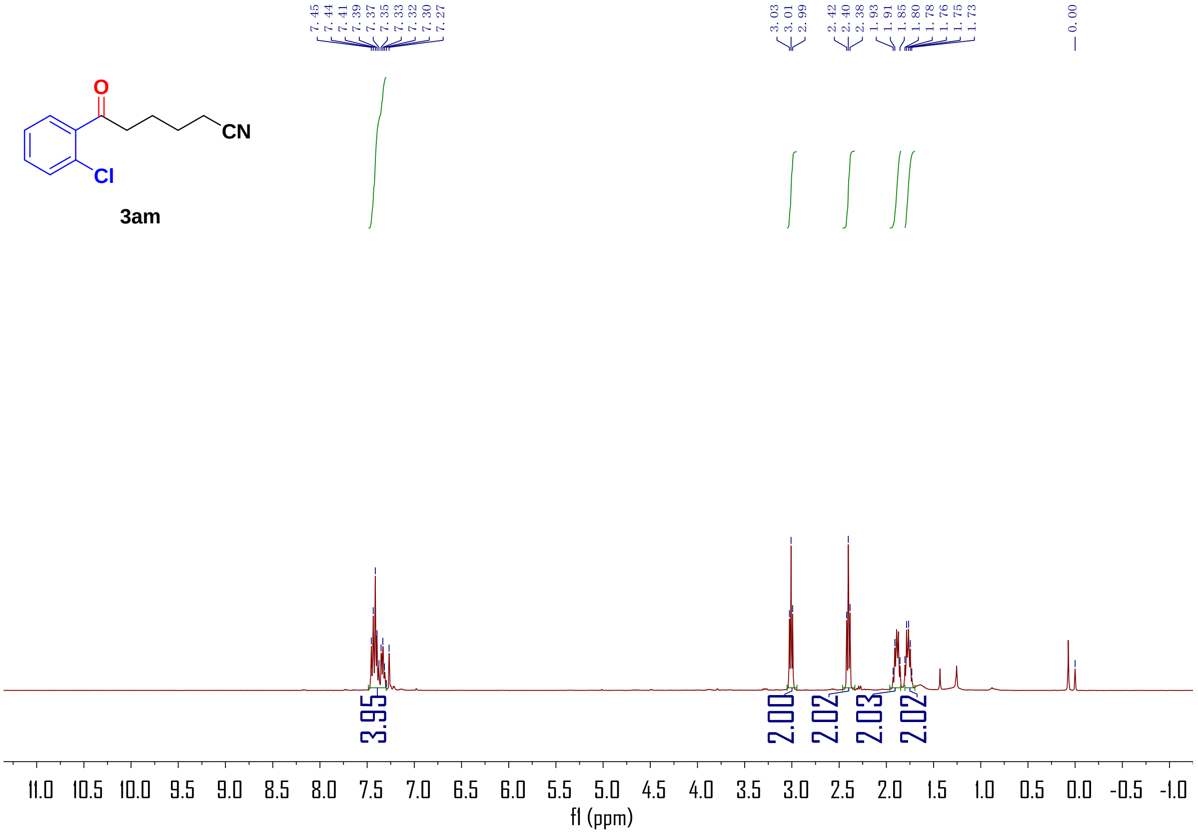


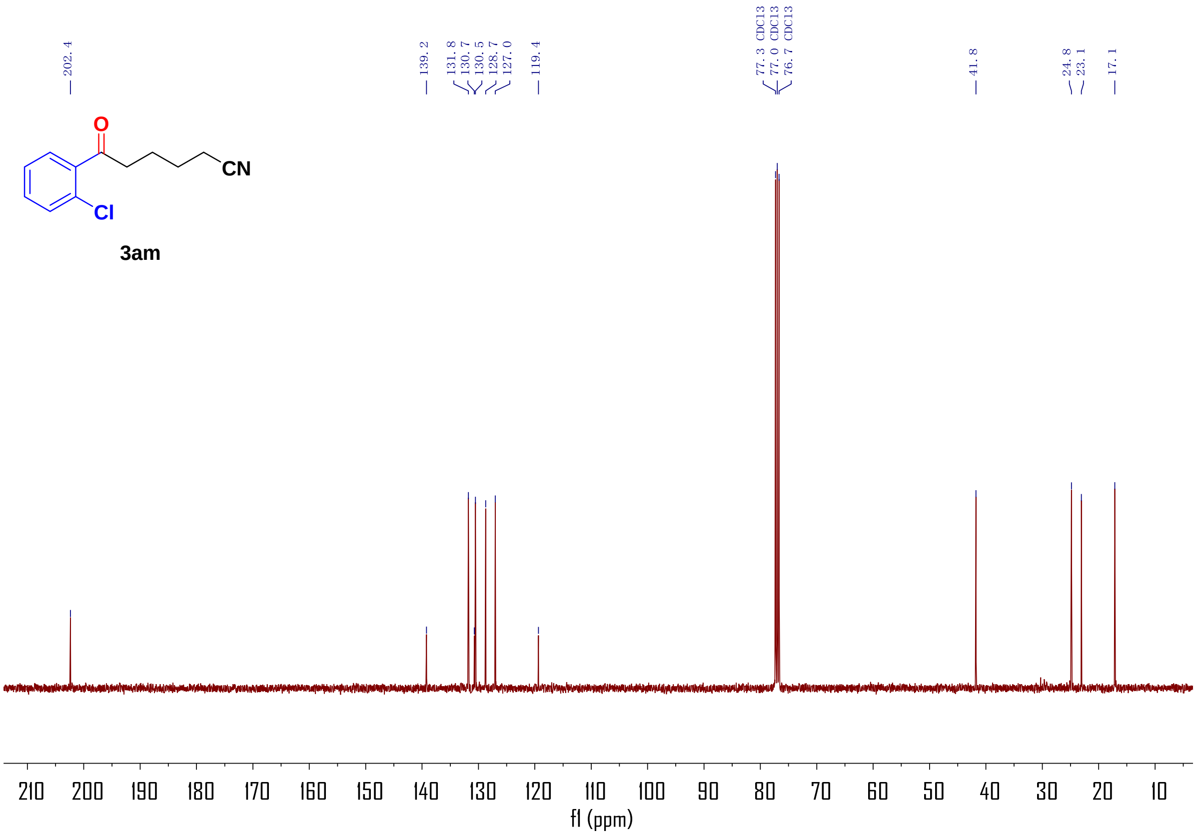
^{1}H NMR (400 MHz, CDCl$_3$), ^{13}C NMR (100 MHz, CDCl$_3$) spectra of product 3al



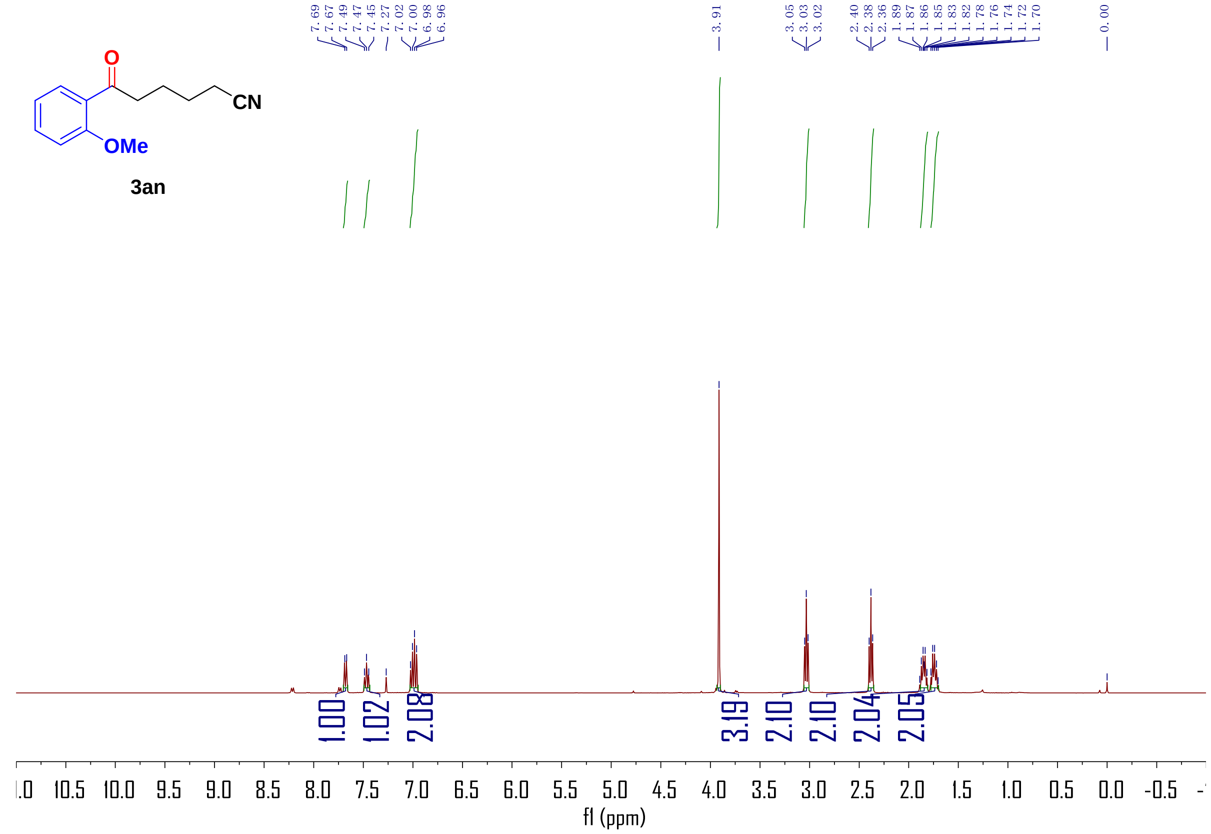


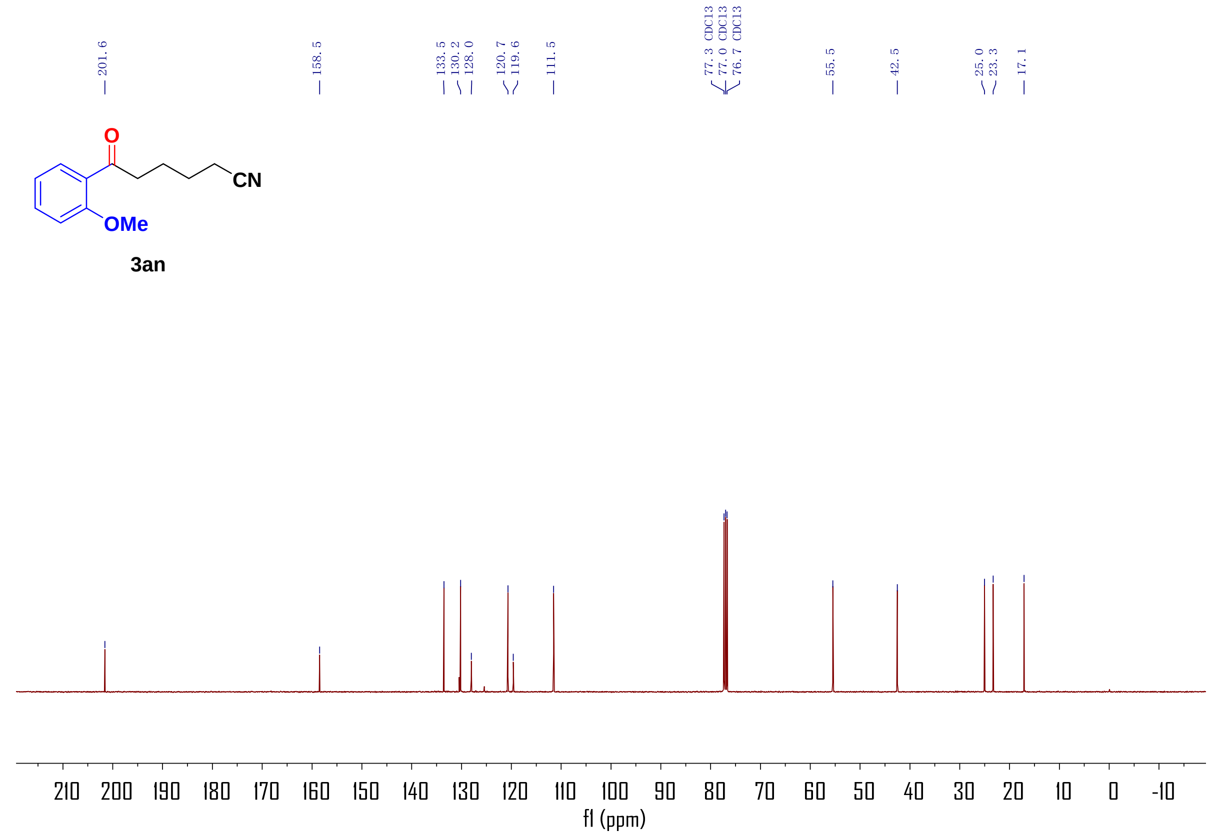
^{1}H NMR (400 MHz, CDCl$_3$), ^{13}C NMR (100 MHz, CDCl$_3$) spectra of product 3am



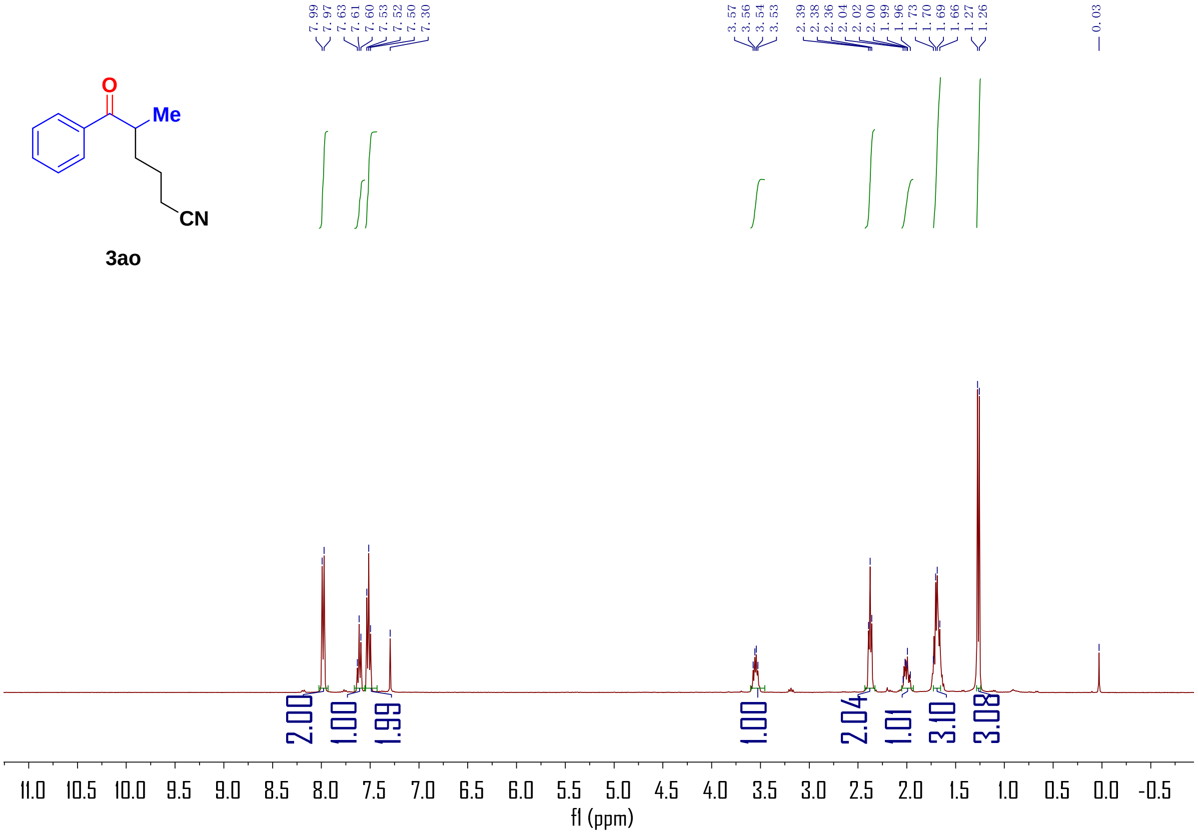


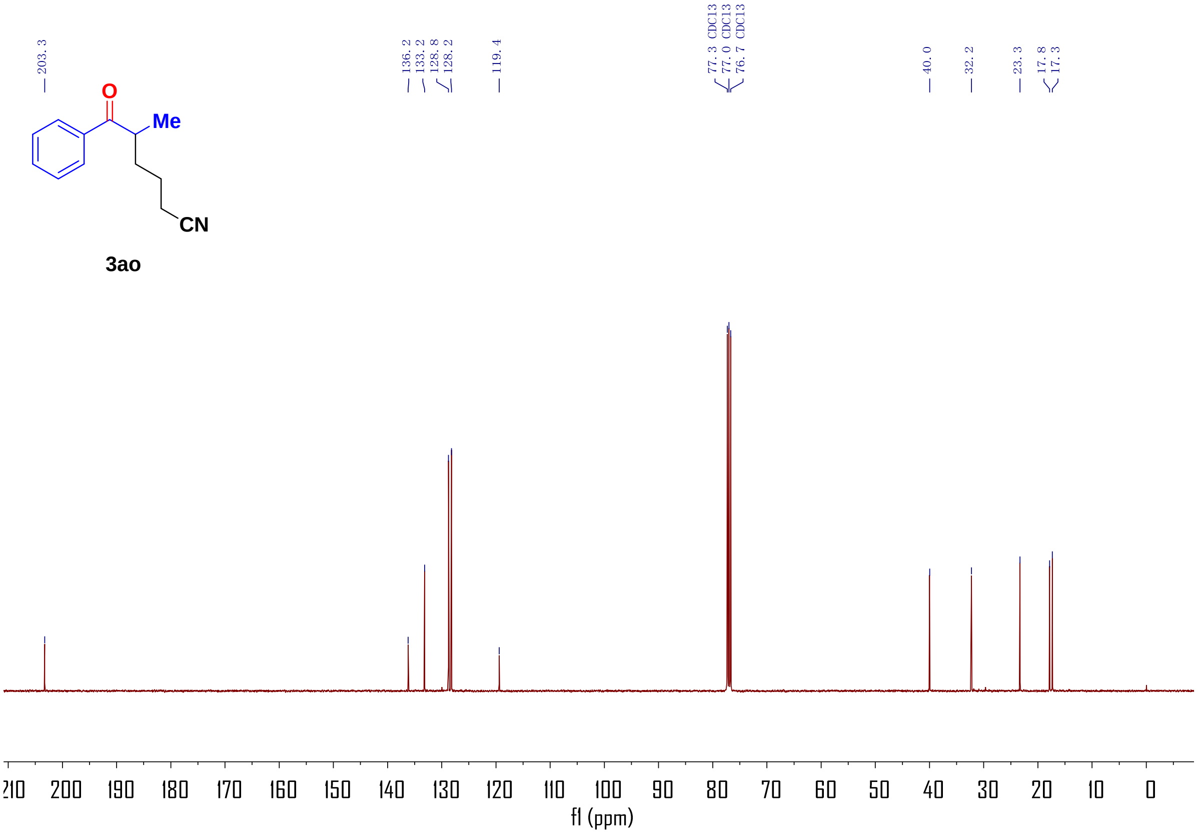
^{1}H NMR (400 MHz, CDCl$_3$), ^{13}C NMR (100 MHz, CDCl$_3$) spectra of product 3an



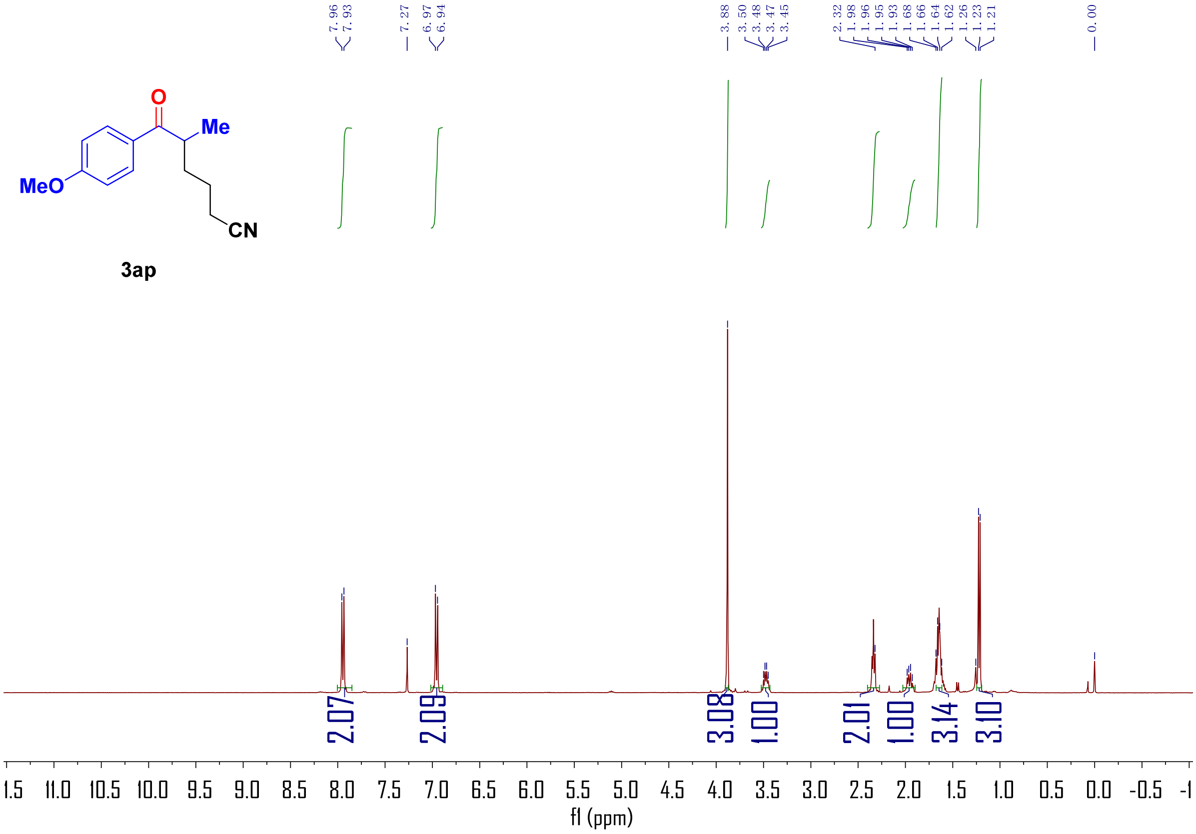


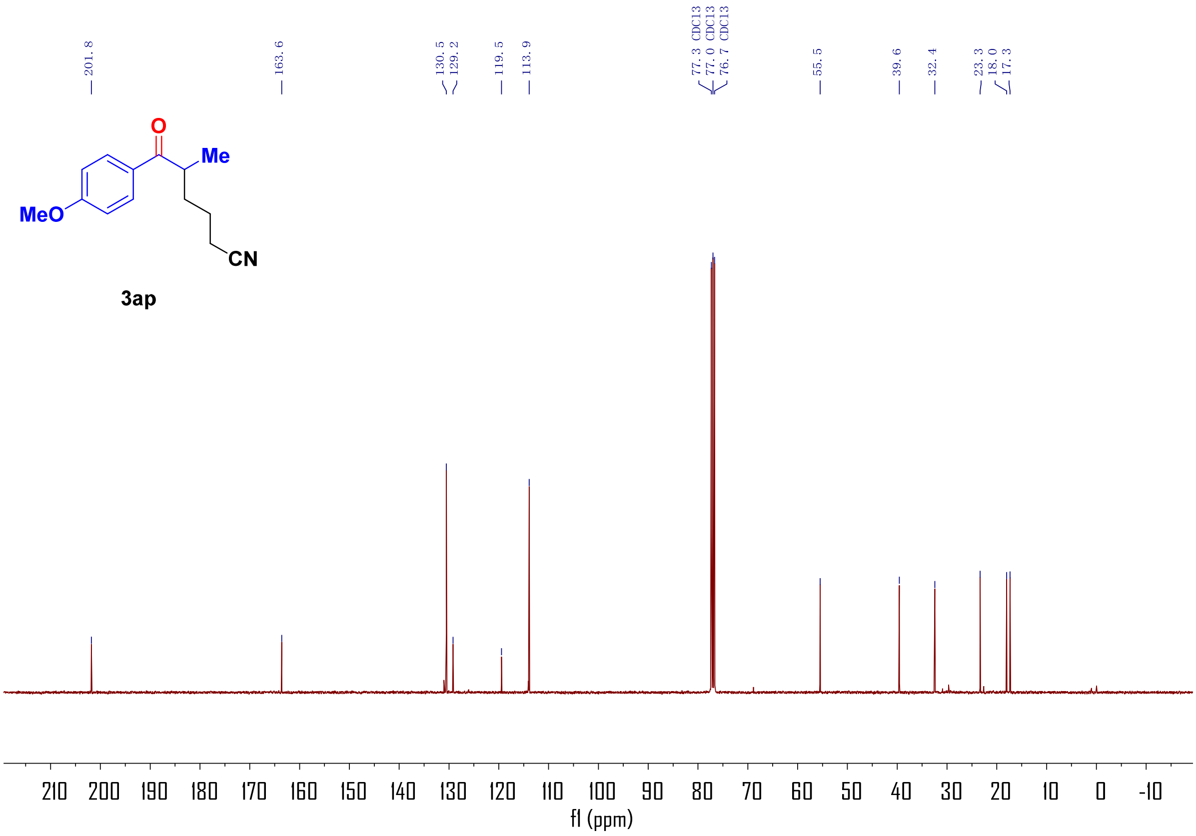
^{1}H NMR (400 MHz, CDCl$_3$), ^{13}C NMR (100 MHz, CDCl$_3$) spectra of product 3ao



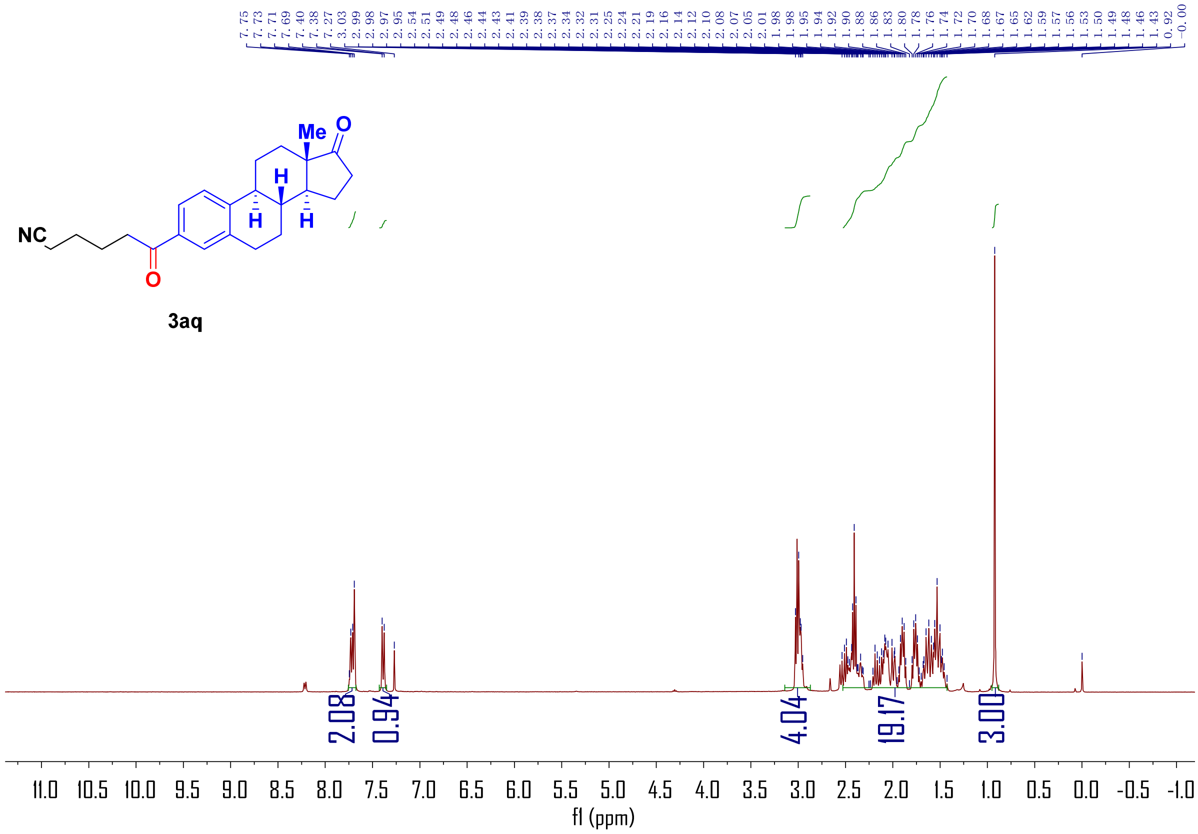


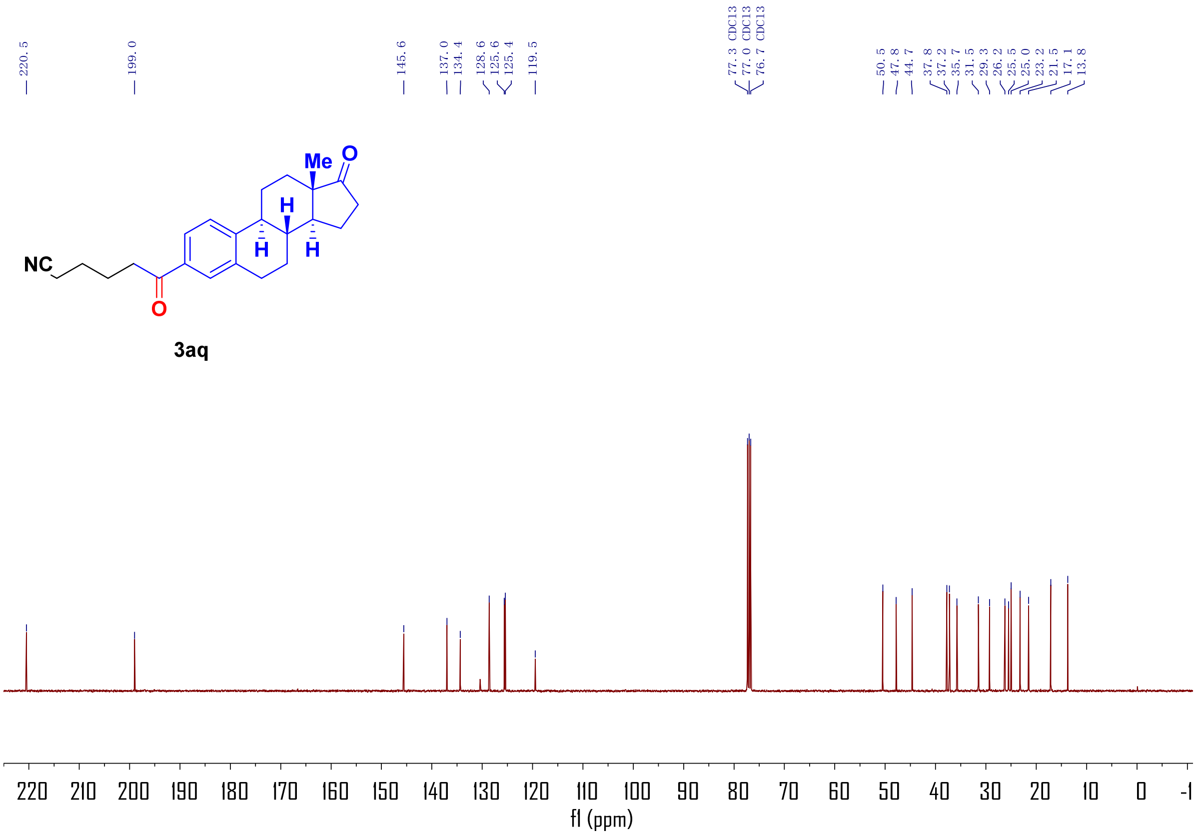
^{1}H NMR (400 MHz, CDCl$_3$), ^{13}C NMR (100 MHz, CDCl$_3$) spectra of product 3ap



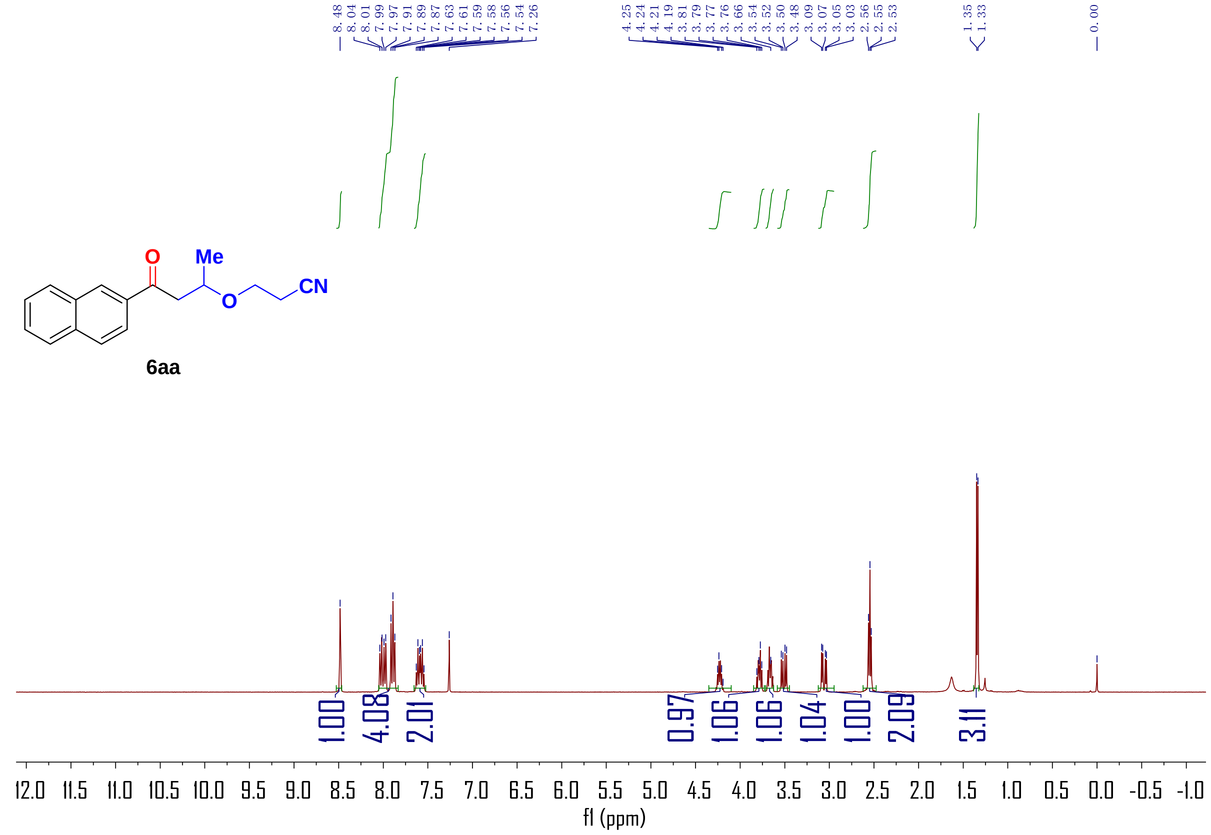


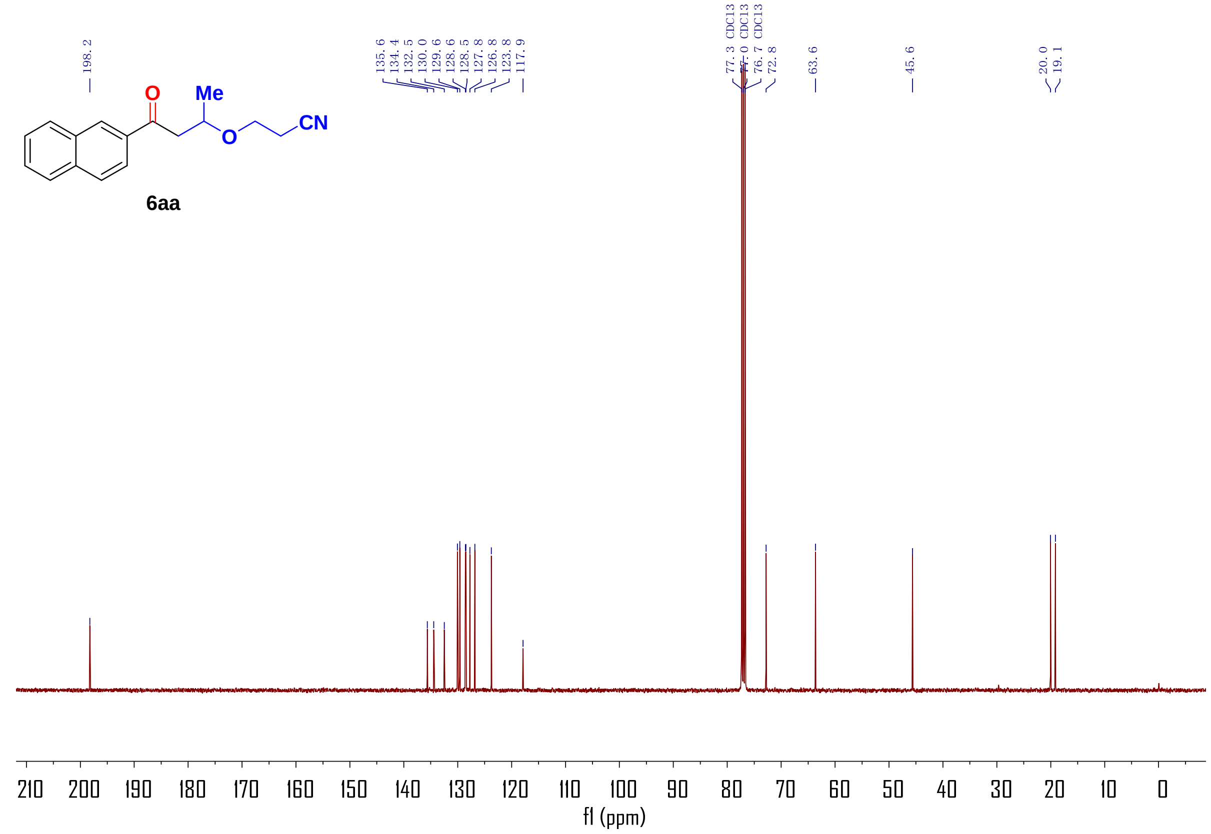
^{1}H NMR (400 MHz, CDCl$_3$), ^{13}C NMR (100 MHz, CDCl$_3$) spectra of product 3aq



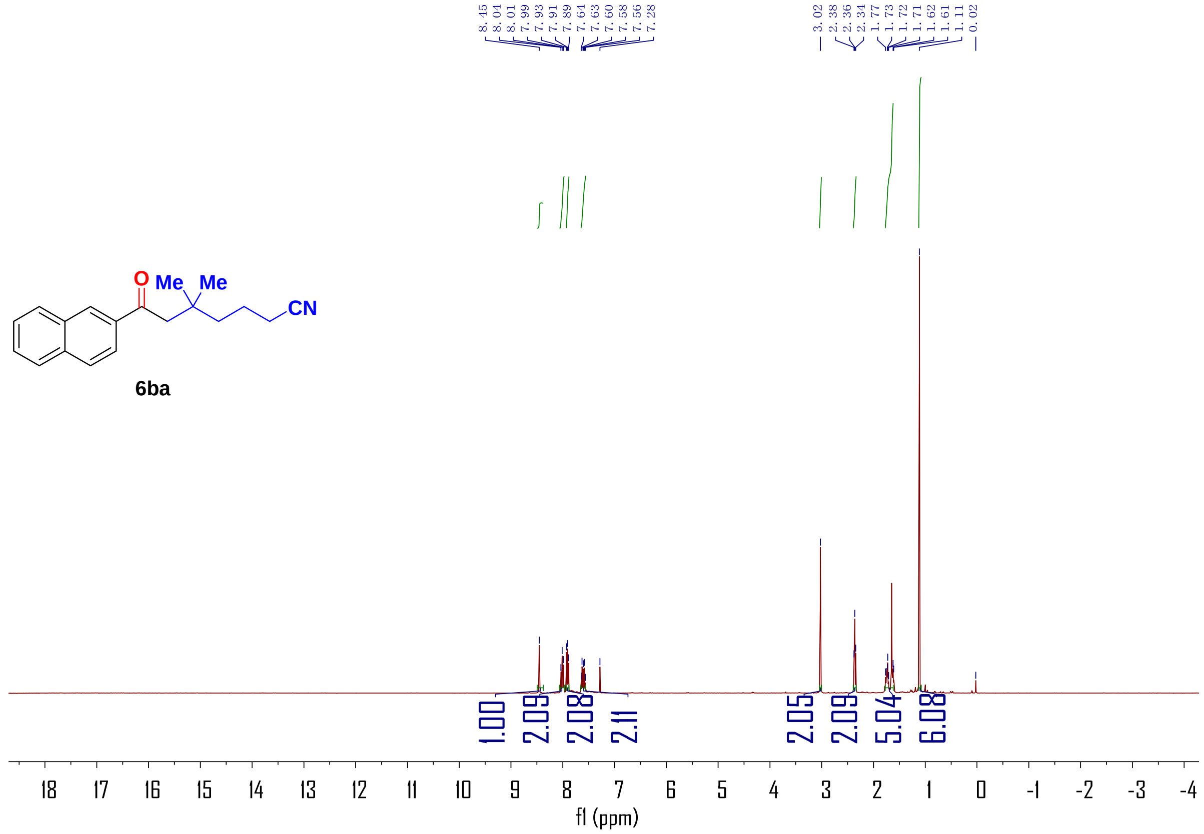


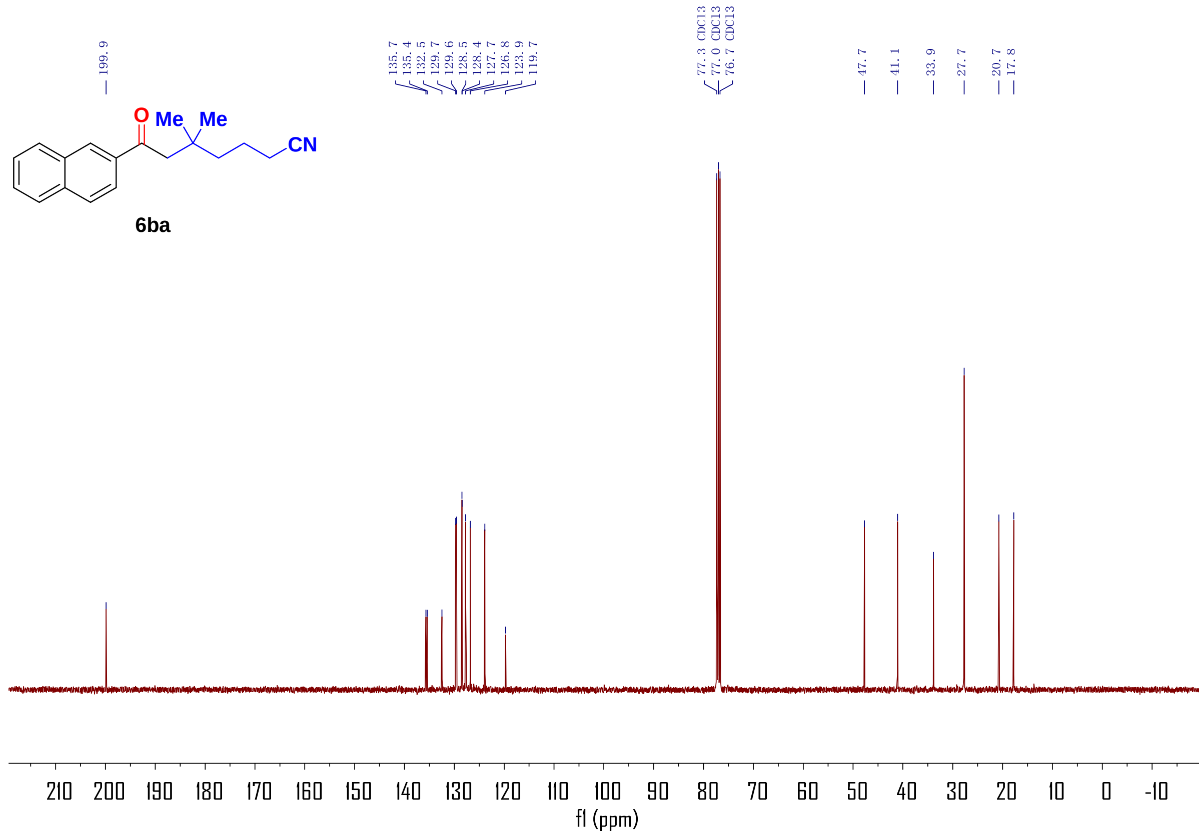
^{1}H NMR (400 MHz, CDCl$_3$), ^{13}C NMR (100 MHz, CDCl$_3$) spectra of product 6aa



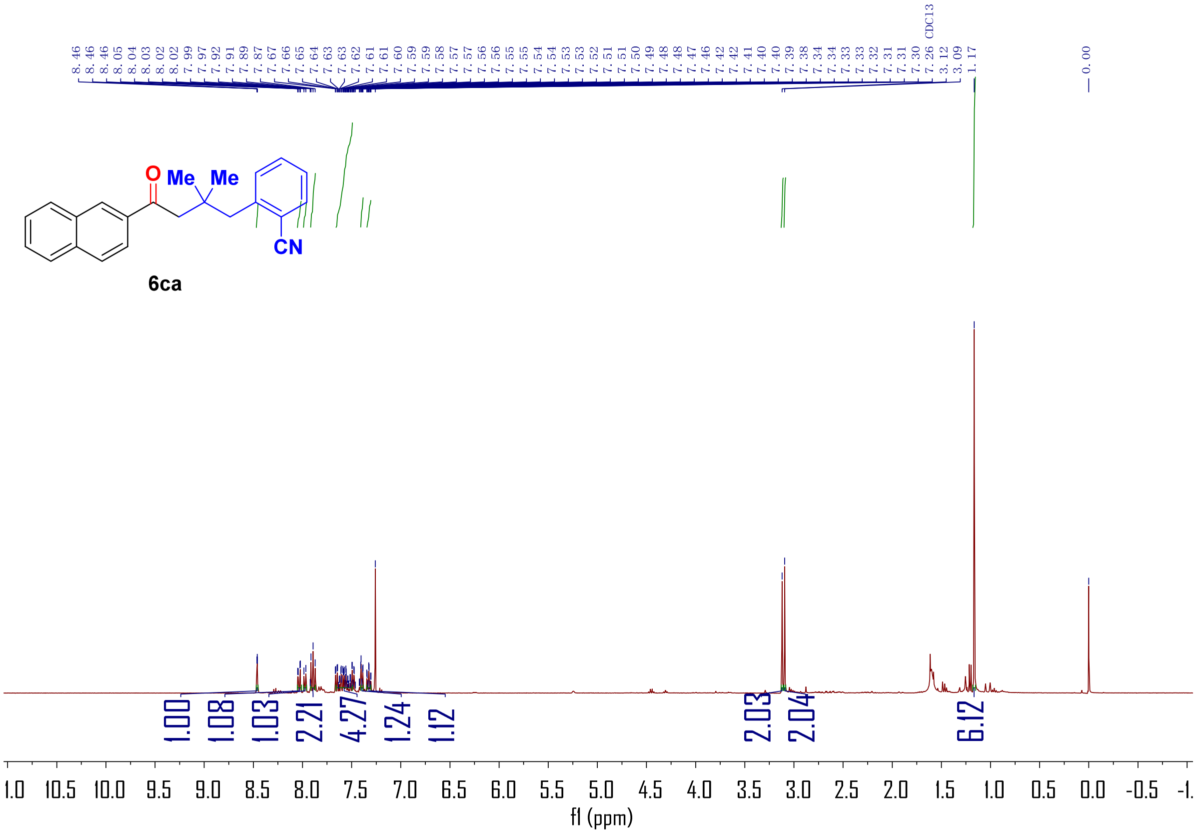


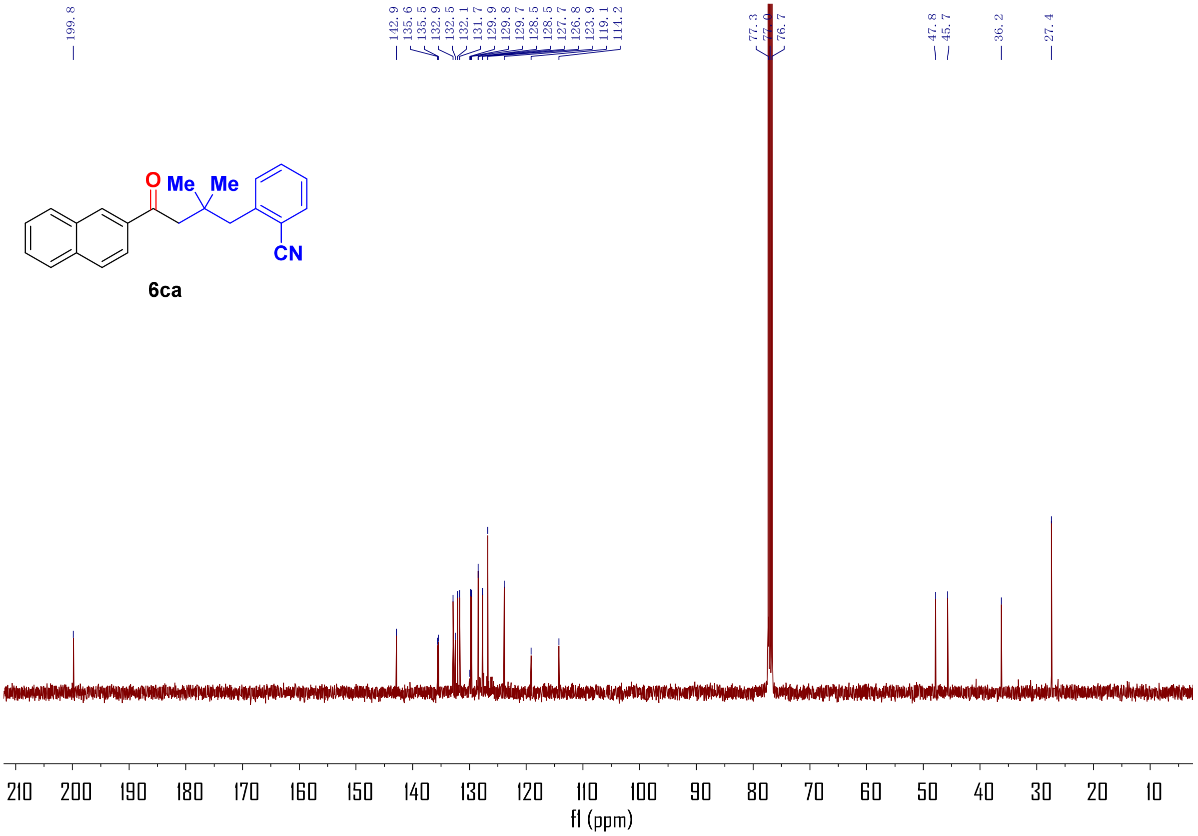
^{1}H NMR (400 MHz, CDCl$_3$), ^{13}C NMR (100 MHz, CDCl$_3$) spectra of product 6ba



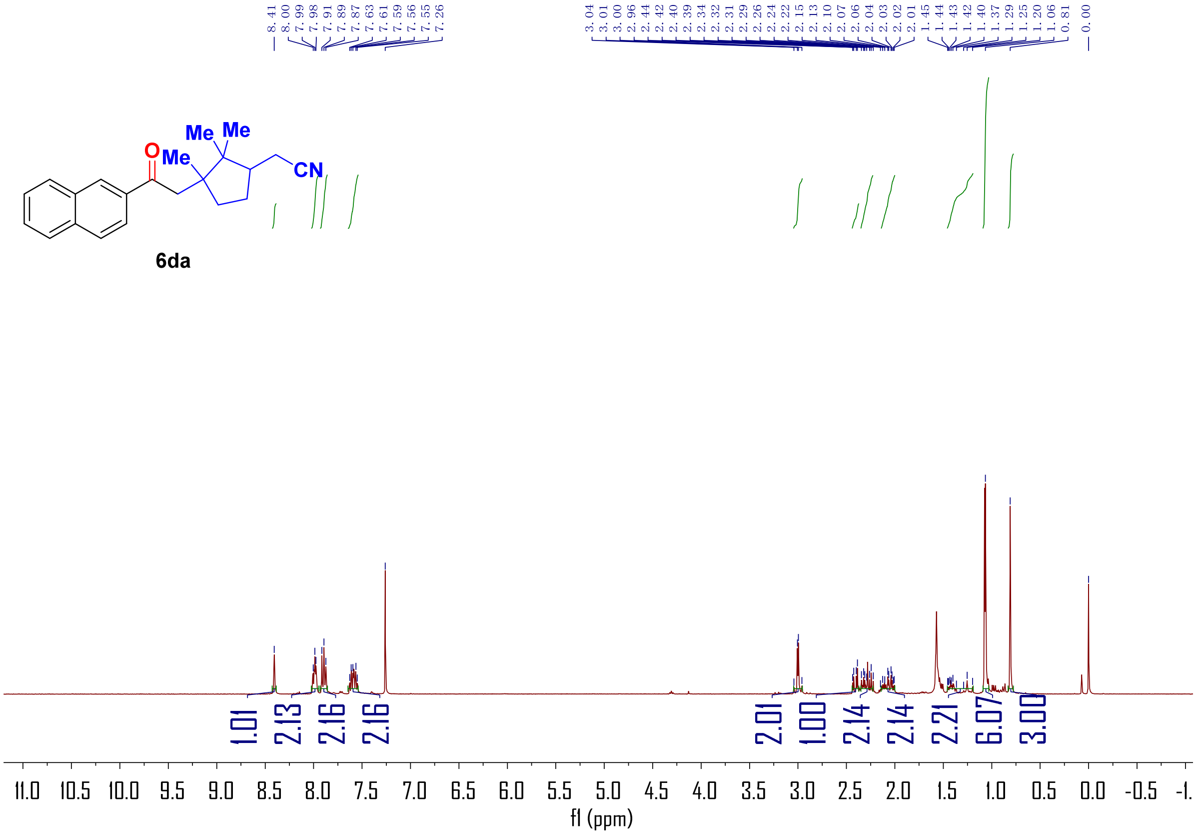


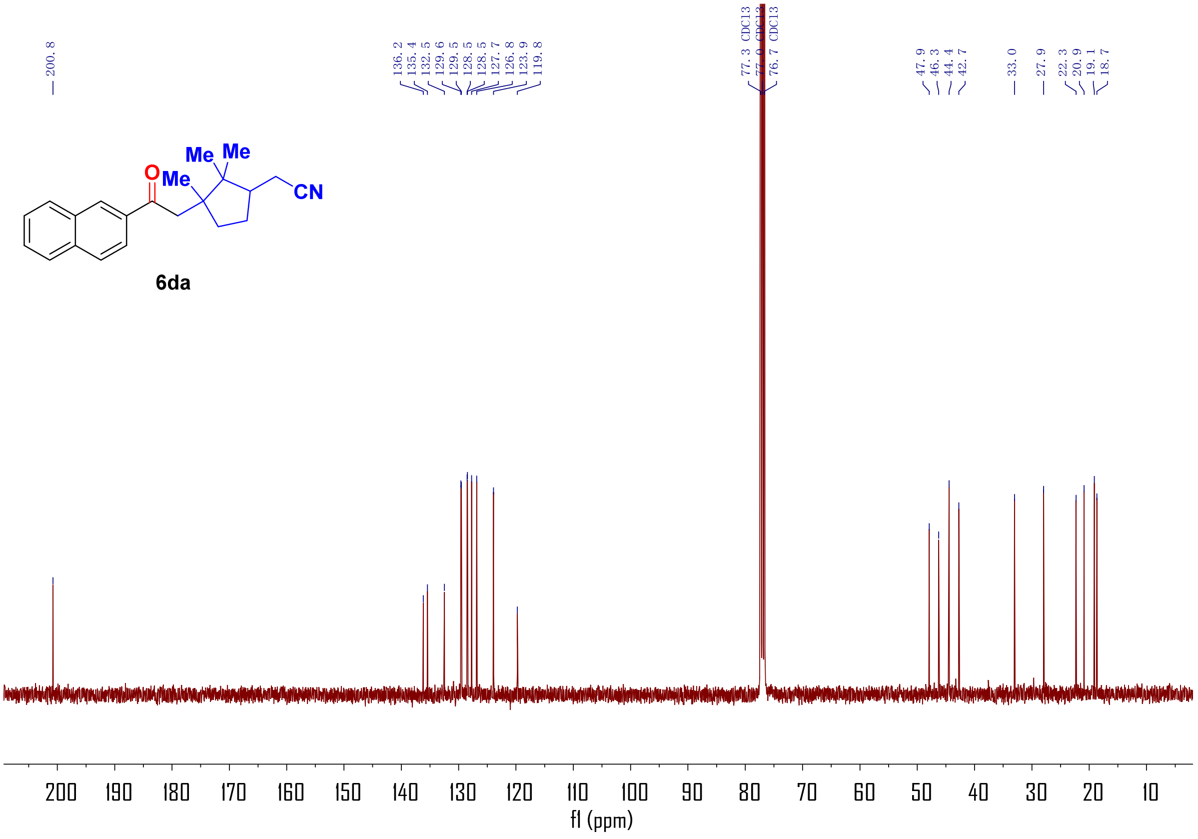
^{1}H NMR (400 MHz, CDCl$_3$), ^{13}C NMR (100 MHz, CDCl$_3$) spectra of product 6ca





^{1}H NMR (400 MHz, CDCl$_3$), ^{13}C NMR (100 MHz, CDCl$_3$) spectra of product 6da





^{1}H NMR (400 MHz, CDCl$_3$), ^{13}C NMR (100 MHz, CDCl$_3$) spectra of product **6e**