Supporting Information

Nickel-Catalyzed Reductive Coupling of 2-Pyridyl Esters with Unreactivated Alkyl Chlorides: A Universal Synthesis of Aryl-Alkyl and Dialkyl Ketones *via* Dynamic Halide Exchange

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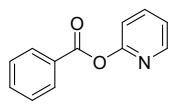
1. General Information

Unless otherwise noted, all reagents and solvents were obtained from commercial suppliers and used without further purification. Reactions involving air or moisture-sensitive reagents or intermediates were performed under an inert atmosphere of nitrogen or argon in oven-dried glassware and a glove box. The products were purified by flash column chromatography on silica gel (300-400 meshes). GC and GC-MS monitored the reactions, GC-MS results were recorded on GC-MS 7890B/7000D, and All GC analyses were performed on GC 2014C. *n*-tridecane was used as an internal standard to calculate GC yields. ^{1}H, ^{13}C, and ^{19}F NMR spectra were recorded on Bruker ADVANCE III 500, and chemical shifts in parts per million (ppm) were reported. ^{1}H NMR spectra were recorded on a 500 MHz spectrometer at ambient temperature. Data were reported as follows: (1) chemical shift in parts per million (δ, ppm) from $CDCl_3$ (7.26 ppm); (2) multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, and br for broad.); (3) coupling constants (Hz). ^{13}C NMR spectra were recorded on a 125 MHz spectrometer at ambient temperature. Chemical shifts were reported in ppm from $CDCl_3$ (77.00 ppm), and ^{19}F NMR spectra were recorded on a 470 MHz spectrometer at ambient temperature. The melting points (MP) were determined using the SGW® X-4 melting point apparatus. High-resolution mass spectra (HRMS) were obtained on a Waters XEVO G2-XS QTOF mass spectrometer with ESI resource.

2. Preparation of 2-Pyridyl Esters:



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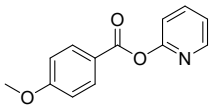

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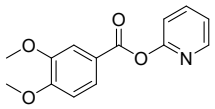

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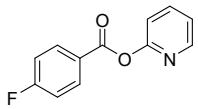

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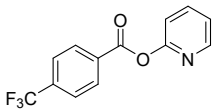

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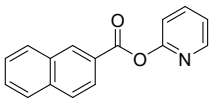

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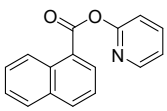

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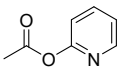

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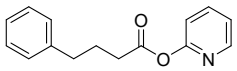

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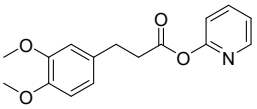

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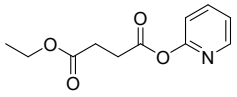

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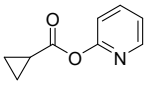

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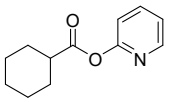

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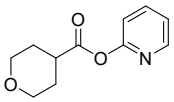

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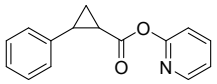

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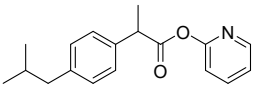

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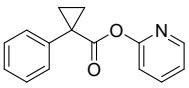

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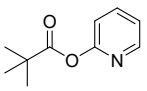

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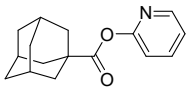

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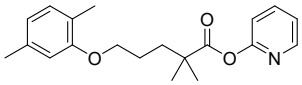
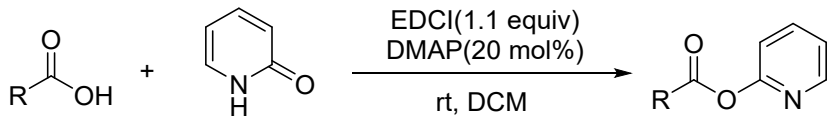


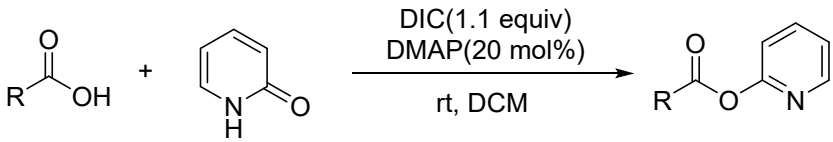
1t

General procedure A for substituted 2-pyridyl esters synthesis (GP-A) [1]

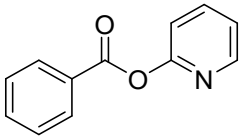


In a round-bottomed flask, carboxylic acid (1.0 equiv) was combined with pyridine-2-ol (1.0 equiv), DMAP (0.20 equiv), EDCI (1.1 equiv), and DCM (0.30 M). The reaction progress was monitored by GC/TLC. Once the starting material was completely consumed, the reaction was quenched with saturated aqueous $NaHCO_3$ and extracted three times with DCM. The combined organic layers were washed with brine, dried over Na_2SO_4, and filtered. After concentration in vacuo, the residue was purified by flash column chromatography to obtain the corresponding 2-pyridyl ester.

General procedure B for substituted 2-pyridyl esters synthesis (GP-B) [1]



Carboxylic acid (1.0 equiv) was added to a round-bottomed flask along with pyridine-2-ol (1.0 equiv), DMAP (0.20 equiv), DIC (1.1 equiv), and DCM (0.30 M). The progress of the reaction was monitored by GC/TLC. Upon complete consumption of the starting material, the mixture was filtered through Celite and rinsed with additional DCM. The filtrate was then concentrated in vacuo, and the resulting residue was purified by flash column chromatography to obtain the corresponding 2-pyridyl ester.

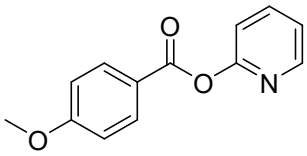


Pyridin-2-yl benzoate [1]

Following **GP-A**, the title compound **1a** was isolated as a white solid.

^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.47 (d, *J* = 4.8 Hz, 1H), 8.26 – 8.20 (m, 2H), 7.87 – 7.81 (m, 1H), 7.67 – 7.62 (m, 1H), 7.54 – 7.49 (m, 2H), 7.30 – 7.25 (m, 1H), 7.22 (d, *J* = 8.1 Hz, 1H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 164.8, 158.3, 148.7, 139.6, 133.9, 130.4, 129.1, 128.6, 122.1, 116.7.

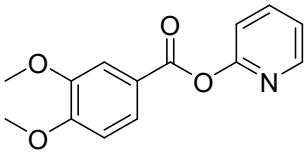


Pyridin-2-yl 4-methoxybenzoate [1]

Following **GP-A**, the title compound **1b** was isolated as a white solid.

^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.47 – 8.43 (m, 1H), 8.21 – 8.16 (m, 2H), 7.85 – 7.79 (m, 1H), 7.28 – 7.22 (m, 1H), 7.20 (d, *J* = 8.1 Hz, 1H), 7.01 – 6.95 (m, 2H), 3.88 (s, 3H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 164.5, 164.1, 158.4, 148.6, 139.5, 132.6, 122.0, 121.4, 116.8, 113.9, 55.5.

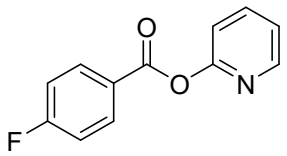


Pyridin-2-yl 3,4-dimethoxybenzoate [1]

Following **GP-A**, the title compound **1c** was isolated as a white solid.

^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.49 – 8.44 (m, 1H), 7.90 (dd, *J* = 8.5, 2.0 Hz, 1H), 7.87 – 7.81 (m, 1H), 7.70 (d, *J* = 2.0 Hz, 1H), 7.29 – 7.26 (m, 1H), 7.22 (d, *J* = 8.1 Hz, 1H), 6.96 (d, *J* = 8.4 Hz, 1H), 3.97 (d, *J* = 9.0 Hz, 6H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 164.6, 158.4, 153.8, 148.8, 148.7, 139.5, 124.8, 122.0, 121.5, 116.8, 112.5, 110.4, 56.1.

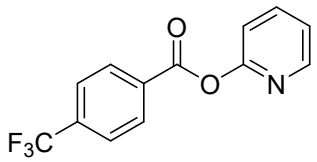


Pyridin-2-yl 4-fluorobenzoate [1]

Following **GP-A**, the title compound **1d** was isolated as a white solid.

^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.41 – 8.36 (m, 1H), 8.21 – 8.14 (m, 2H), 7.81 – 7.73 (m, 1H), 7.23 – 7.20 (m, 1H), 7.15 – 7.07 (m, 3H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 166.3 (d, *J* = 255.6 Hz), 163.9, 158.1, 148.7, 139.6, 133.0 (d, *J* = 9.6 Hz), 125.4 (d, *J* = 3.1 Hz), , 122.2, 116.6, 115.8 (d, *J* = 22.1 Hz).

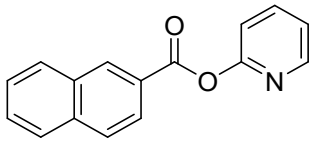


Pyridin-2-yl 4-(trifluoromethyl)benzoate [1]

Following **GP-A**, the title compound **1e** was isolated as a white solid.

^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.41 – 8.35 (m, 1H), 8.26 (t, *J* = 7.0 Hz, 2H), 7.81 – 7.73 (m, 1H), 7.69 (t, *J* = 7.0 Hz, 2H), 7.25 – 7.19 (m, 1H), 7.16 – 7.11 (m, 1H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 163.6, 157.9, 148.8, 139.7, 135.2 (q, *J* = 32.9 Hz), 132.4, 130.7, 125.7 (q, *J* = 3.8 Hz), 122.5 (q, *J* = 271.2 Hz), 122.5, 116.5..



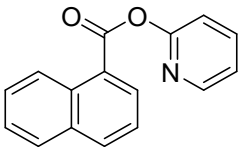
Pyridin-2-yl 2-naphthoate [1]

Following **GP-A**, the title compound **1f** was isolated as a white solid.

^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.84 (s, 1H), 8.51 – 8.47 (m, 1H), 8.22 (dd, *J* =

8.6, 1.8 Hz, 1H), 8.00 (d, *J* = 8.1 Hz, 1H), 7.94 (dd, *J* = 15.6, 8.4 Hz, 2H), 7.87 (td, *J* = 7.8, 2.0 Hz, 1H), 7.66 – 7.61 (m, 1H), 7.61 – 7.56 (m, 1H), 7.32 – 7.27 (m, 2H).

^{13}C NMR (126 MHz, Chloroform-*d*) δ 165.0, 158.3, 148.8, 139.6, 136.0, 132.5, 132.4, 129.6, 128.8, 128.5, 127.9, 126.9, 126.3, 125.5, 122.2, 116.7.

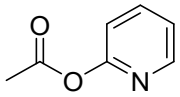


Pyridin-2-yl 1-naphthoate [1]

Following **GP-A**, the title compound **1g** was isolated as a white solid.

^{1}H NMR (500 MHz, Chloroform-*d*) δ 9.07 (d, *J* = 8.7 Hz, 1H), 8.56 (d, *J* = 7.2 Hz, 1H), 8.51 (dd, *J* = 4.9, 2.0 Hz, 1H), 8.12 (d, *J* = 8.2 Hz, 1H), 7.93 (d, *J* = 8.1 Hz, 1H), 7.88 (td, *J* = 7.7, 2.0 Hz, 1H), 7.68 – 7.62 (m, 1H), 7.57 (td, *J* = 7.5, 3.6 Hz, 2H), 7.32 – 7.26 (m, 2H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 165.3, 158.4, 148.8, 139.6, 134.7, 133.9, 131.8, 131.8, 128.7, 128.3, 126.5, 125.8, 125.2, 124.5, 122.1, 116.9.

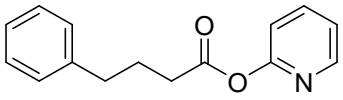


Pyridin-2-yl acetate [1]

Following **GP-A**, the title compound **1h** was isolated as a clear oil.

^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.43 – 8.40 (m, 1H), 7.82 – 7.77 (m, 1H), 7.25 – 7.21 (m, 1H), 7.09 (d, *J* = 8.1 Hz, 1H), 2.35 (s, 3H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 169.1, 157.8, 148.6, 139.6, 122.1, 116.5, 21.2.



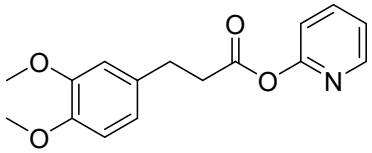
Pyridin-2-yl 4-phenylbutanoate [1]

Following **GP-A**, the title compound **1i** was isolated as a white solid.

^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.40 (dd, *J* = 4.8, 2.0 Hz, 1H), 7.78 (td, *J* = 7.8, 2.0 Hz, 1H), 7.30 (t, *J* = 7.6 Hz, 2H), 7.21 (dd, *J* = 8.6, 3.2 Hz, 4H), 7.05 (d, *J* = 8.1 Hz, 1H), 2.75 (t, *J* = 7.6 Hz, 2H), 2.63 (t, *J* = 7.4 Hz, 2H), 2.10 (p, *J* = 7.5 Hz, 2H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 171.6, 158.0, 148.6, 141.2, 139.5, 128.6, 128.5,

126.1, 122.0, 116.4, 35.0, 33.7, 26.3.

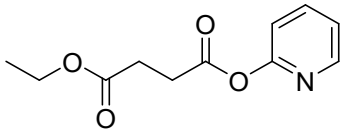


Pyridin-2-yl 3-(3,4-dimethoxyphenyl)propanoate [1]

Following **GP-A**, the title compound **1j** was isolated as a white solid.

^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.31 (dd, *J* = 5.0, 2.0 Hz, 1H), 7.68 (td, *J* = 7.7, 2.1 Hz, 1H), 7.17 – 7.09 (m, 1H), 6.92 (d, *J* = 8.1 Hz, 1H), 6.76 – 6.70 (m, 3H), 3.78 (d, *J* = 7.8 Hz, 6H), 2.96 (t, *J* = 7.7 Hz, 2H), 2.84 (t, *J* = 7.5 Hz, 2H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 171.0, 157.9, 149.0, 148.6, 147.7, 139.5, 132.7, 122.1, 120.2, 116.4, 111.8, 111.4, 55.9, 55.8, 36.4, 30.4.

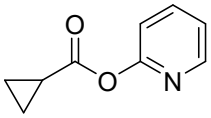


Ethyl pyridin-2-yl succinate [1]

Following **GP-B**, the title compound **1k** was isolated as a clear oil.

^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.40 (d, *J* = 4.7 Hz, 1H), 7.82 – 7.75 (m, 1H), 7.25 – 7.19 (m, 1H), 7.10 (d, *J* = 8.1 Hz, 1H), 4.18 (q, *J* = 7.1 Hz, 2H), 2.94 (t, *J* = 6.8 Hz, 2H), 2.75 (t, *J* = 6.8 Hz, 2H), 1.30 – 1.25 (m, 3H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 172.0, 170.6, 157.8, 148.6, 139.5, 122.1, 116.4, 60.8, 29.4, 29.0, 14.2.

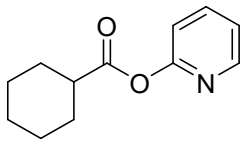


Pyridin-2-yl cyclopropanecarboxylate [1]

Following **GP-A**, the title compound **1l** was isolated as a clear oil.

^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.40 (d, *J* = 4.7 Hz, 1H), 7.80 – 7.74 (m, 1H), 7.23 – 7.18 (m, 1H), 7.09 (d, *J* = 8.1 Hz, 1H), 1.92 – 1.84 (m, 1H), 1.24 – 1.18 (m, 2H), 1.07 – 1.01 (m, 2H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 173.1, 158.0, 148.6, 139.4, 121.9, 116.5, 13.1, 9.6.

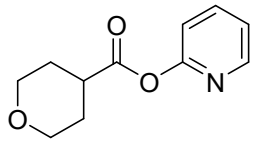


Pyridin-2-yl cyclohexanecarboxylate [1]

Following **GP-B**, the title compound **1m** was isolated as a yellow oil.

^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.40 (d, *J* = 4.0 Hz, 1H), 7.24 – 7.17 (m, 1H), 7.05 (d, *J* = 8.1 Hz, 1H), 2.65 – 2.55 (m, 1H), 2.10 (d, *J* = 10.8 Hz, 2H), 1.87 – 1.79 (m, 2H), 1.73 – 1.55 (m, 3H), 1.42 – 1.24 (m, 3H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 174.1, 158.2, 148.6, 139.4, 121.9, 116.4, 43.2, 28.8, 25.7, 25.3.

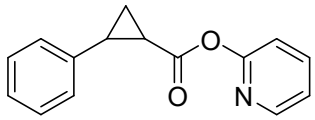


Pyridin-2-yl tetrahydro-2H-pyran-4-carboxylate [1]

Following **GP-B**, the title compound **1n** was isolated as a white solid.

^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.42 (d, *J* = 4.7 Hz, 1H), 7.83 – 7.76 (m, 1H), 7.24 (dd, *J* = 7.2, 5.0 Hz, 1H), 7.07 (d, *J* = 8.1 Hz, 1H), 4.04 (dt, *J* = 11.6, 3.5 Hz, 3H), 3.58 – 3.43 (m, 2H), 2.91 – 2.81 (m, 1H), 2.08 – 2.00 (m, 2H), 2.00 – 1.93 (m, 2H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 172.6, 158.0, 148.6, 139.5, 122.1, 116.3, 67.0, 40.2, 28.5.

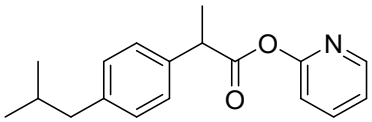


Pyridin-2-yl 2-phenylcyclopropane-1-carboxylate [1]

Following **GP-A**, the title compound **1o** was isolated as a white solid.

^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.43 – 8.39 (m, 1H), 7.81 – 7.77 (m, 1H), 7.25 – 7.21 (m, 2H), 7.17 – 7.14 (m, 2H), 7.11 (d, *J* = 8.1 Hz, 1H), 2.78 – 2.71 (m, 1H), 2.21 – 2.14 (m, 1H), 1.80 (dt, *J* = 9.7, 5.0 Hz, 1H), 1.54 – 1.48 (m, 1H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 171.6, 157.9, 148.6, 139.5, 139.4, 128.6, 126.8, 126.3, 122.1, 116.5, 27.4, 24.2, 18.0.

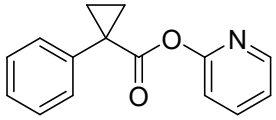


Pyridin-2-yl 2-(4-isobutylphenyl)propanoate [1]

Following **GP-A**, the title compound **1p** was isolated as a white solid.

^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.38 (dd, *J* = 4.9, 1.5 Hz, 1H), 7.75 – 7.69 (m, 1H), 7.32 (d, *J* = 8.1 Hz, 2H), 7.20 – 7.16 (m, 1H), 7.14 (d, *J* = 8.0 Hz, 2H), 6.95 (d, *J* = 8.1 Hz, 1H), 3.99 (q, *J* = 7.1 Hz, 1H), 2.46 (d, *J* = 7.2 Hz, 2H), 1.90 – 1.81 (m, 1H), 1.62 (d, *J* = 7.2 Hz, 3H), 0.91 (d, *J* = 6.6 Hz, 6H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 172.8, 158.1, 148.5, 140.9, 139.4, 136.9, 129.6, 127.3, 122.0, 116.3, 45.3, 45.1, 30.2, 22.4, 18.5.

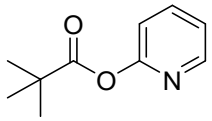


Pyridin-2-yl 1-phenylcyclopropane-1-carboxylate [1]

Following **GP-A**, the title compound **1q** was isolated as a white solid.

^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.37 (dd, *J* = 4.9, 1.5 Hz, 1H), 7.73 (td, *J* = 8.2, 1.9 Hz, 1H), 7.49 (dt, *J* = 8.2, 1.8 Hz, 2H), 7.37 – 7.32 (m, 2H), 7.30 – 7.26 (m, 1H), 7.18 (dd, *J* = 6.6, 5.1 Hz, 1H), 7.00 (d, *J* = 8.1 Hz, 1H), 1.85 (q, *J* = 4.1 Hz, 2H), 1.39 (q, *J* = 4.1 Hz, 2H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 173.1, 158.2, 148.5, 139.4, 138.7, 130.7, 128.3, 127.5, 121.9, 116.5, 29.2, 17.6.

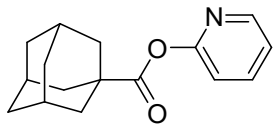


Pyridin-2-yl pivalate [1]

Following **GP-A**, the title compound **1k** was isolated as a clear oil.

^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.41 (d, *J* = 4.2 Hz, 1H), 7.81 – 7.71 (m, 1H), 7.23 – 7.16 (m, 1H), 7.04 (d, *J* = 8.1 Hz, 1H), 1.39 (s, 9H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 176.77, 158.43, 148.62, 139.40, 121.86, 116.41, 39.18, 27.05.

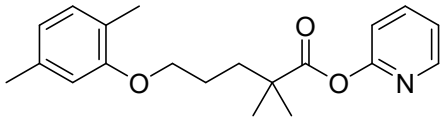


Pyridin-2-yl adamantane-1-carboxylate [1]

Following **GP-A**, the title compound **1s** was isolated as a white solid.

^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.41 (dd, *J* = 4.9, 2.0 Hz, 1H), 7.77 (td, *J* = 7.7, 2.0 Hz, 1H), 7.23 – 7.18 (m, 1H), 7.03 (d, *J* = 8.1 Hz, 1H), 2.09 (s, 9H), 1.77 (s, 6H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 175.8, 158.5, 148.6, 139.3, 121.8, 116.5, 41.1, 38.6, 36.4, 27.9.



Pyridin-2-yl 5-(2,5-dimethylphenoxy)-2,2-dimethylpentanoate [1]

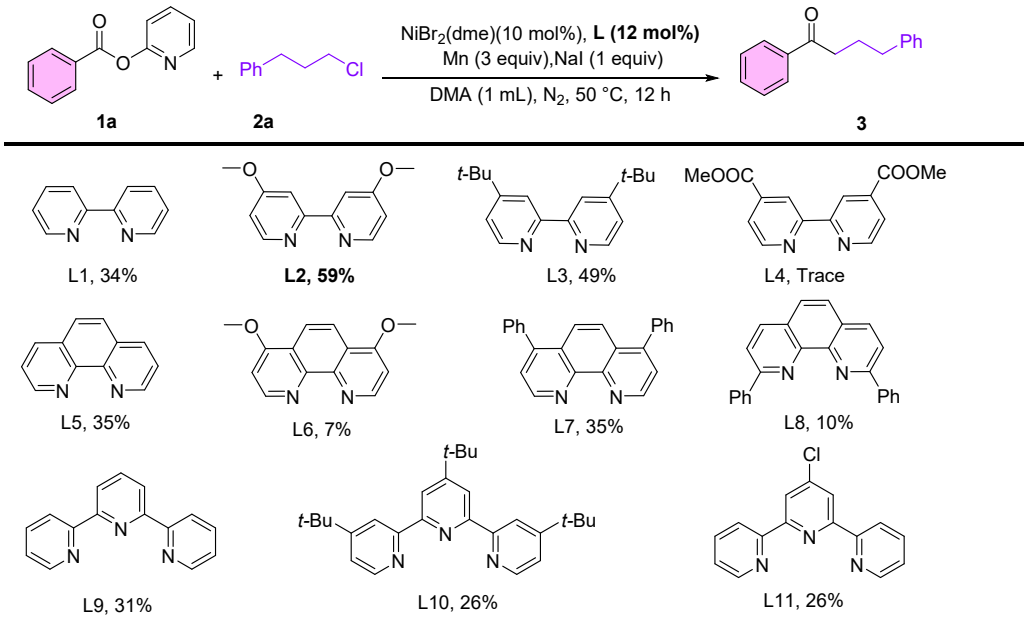
Following **GP-A**, the title compound **1t** was isolated as a white solid.

^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.34 (dd, *J* = 4.9, 1.4 Hz, 1H), 7.74 – 7.66 (m, 1H), 7.16 – 7.09 (m, 1H), 6.92 (d, *J* = 7.4 Hz, 2H), 6.59 (d, *J* = 7.4 Hz, 1H), 6.55 (s, 1H), 3.92 (s, 2H), 2.23 (s, 3H), 2.10 (s, 3H), 1.84 (s, 3H), 1.33 (s, 6H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 176.1, 158.4, 156.9, 148.7, 139.4, 136.5, 130.32, 123.6, 121.9, 120.7, 116.4, 112.0, 67.8, 42.5, 37.1, 25.2, 25.1, 21.4, 15.8.

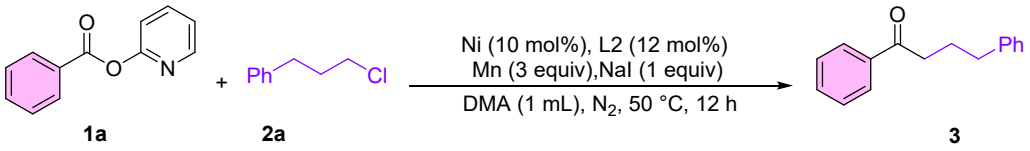
3. Optimization of the Reaction Conditions

Table S1. Optimization of the Ligands [a]



Reaction conditions: **1a** (0.2 mmol), **2a** (0.3 mmol), $NiBr_2$(dme) (10 mol%), ligand (12 mol%), NaI (1.0 equiv), and Mn (3.0 equiv) in DMA (1 mL) at 50 °C for 12 h. [a] Yields were detected by GC yields vs *n*-tridecane internal standard. N.D. = not detected.

Table S2. Optimization of the Catalysts

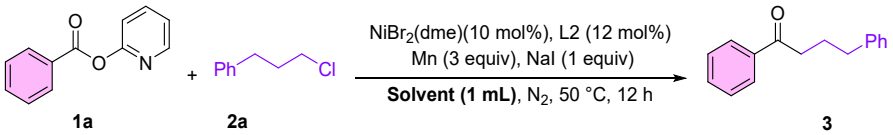


1a **2a** **3**

Entry	Catalyst	3[a]
1	$Ni(COD)_2$	11
2	NiF_2	N.D.
3	$NiCl_2$	34
4	$NiBr_2$	30
5	$NiCl_2$·dme	18
6	$NiCl_2$·dppf	Trace
7	$NiCl_2$·dppe	11
8	$NiCl_2$·$(PCy_3)_2$	Trace
9	(1,3-dppp) $NiCl_2$	12
10	Ni $(OAc)_2$·$4H_2O$	21
11	$NiClO_4$·$6H_2O$	9
12	$NiCl_2$·$6H_2O$	24
13	$NiBr_2$·$3H_2O$	35
14	Ni $(OTf)_2$	Trace
15	$Ni(acac)_2$	29
16	**$NiBr_2$·dme**	**59**

Reaction conditions: **1a** (0.2 mmol), **2a** (0.3 mmol), [Ni] (10 mol%), L2 (12 mol%), NaI (1.0 equiv), and Mn (3.0 equiv) in DMA (1.0 mL) at 50 °C for 12 h. [a] Yields were detected by GC yields vs *n*-tridecane internal standard. N.D. = not detected.

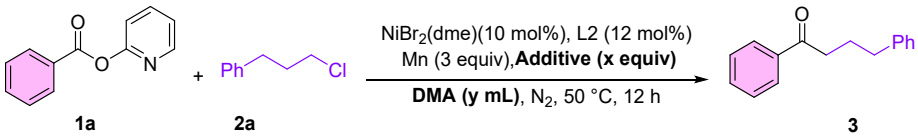
Table S3. Optimization of the Solvents



Entry	Solvent	3[a]
1	**DMA**	**59**
2	DMF	19
3	DMSO	20
4	NMP	9
5	CH_3CN	5
6	1,4-dioxane	N.D.
7	THF	N.D.

Reaction conditions: **1a** (0.2 mmol), **2a** (0.3 mmol), $NiBr_2$(dme) (10 mol%), L2 (12 mol%), NaI (1.0 equiv), and Mn (3.0 equiv) in solvent (1 mL) at 50 °C for 12 h. [a] Yields were detected by GC yields vs *n*-tridecane internal standard. N.D. = not detected.

Table S4. Optimization of the Additives

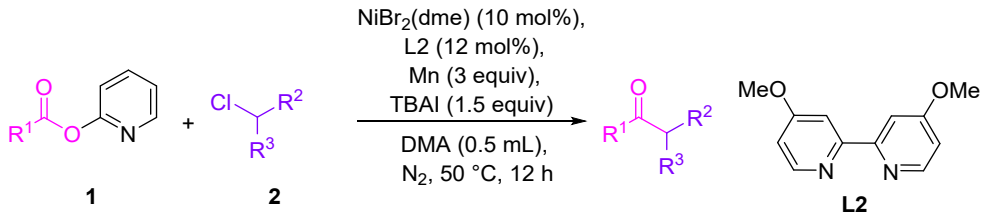


1a 2a 3

Entry	Additive (x equiv)	DMA (y mL)	3[a]
1	NaI (1.0 equiv)	1.0	58
2	KI (1.0 equiv)	1.0	56
3	LiI (1.0 equiv)	1.0	47
4	TBAI (1.0 equiv)	1.0	59
5	TMAI (1.0 equiv)	1.0	11
6	TBAI (1.5 equiv)	1.0	60
7	**TBAI (1.5 equiv)**	**0.5**	**83**
8	TBAI (1.0 equiv)	0.5	67
9	TBAI (1.0 equiv)	2.0	33

Reaction conditions: **1a** (0.2 mmol), **2a** (0.3 mmol), $NiBr_2$(dme) (10 mol%), L2 (12 mol%), additive (x equiv), and Mn (3.0 equiv) in DMA (y mL) at 50 °C for 12 h. [a] Yields were detected by GC yields vs *n*-tridecane internal standard. N.D. = not detected.

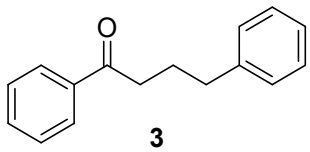
4. Nickel-Catalyzed Reductive Coupling of 2-Pyridyl Ester with Alkyl Chlorides



To a Schlenk tube (10 mL) equipped with a stir bar was added $NiBr_2$(dme) (6.2 mg, 0.02 mmol, 10 mol%), **L2** (5.2 mg, 0.024 mmol, 12 mol%) under an argon atmosphere. Next, 0.5 mL of dry DMA was added. To this solution, TBAI (110.8 mg, 0.3 mmol, 1.5 equiv), Mn powder (33.0 mg, 0.6 mmol, 3.0 equiv), 2-pyridyl esters **1** (0.2 mmol), alkyl chloride **2** (0.3 mmol, 1.5 equiv.) was added successively under nitrogen atmosphere. The reaction mixture was stirred at 50 °C for 12 hours. The resulting black solution was cooled to room temperature and then passed through a plug of silica gel (200–300 mesh). The silica gel was subsequently rinsed with 5 mL of ethyl acetate to ensure complete transfer of the product. The combined filtrates were concentrated using a rotary evaporator to remove the solvent and volatile materials. The resulting residue was then purified by silica gel chromatography to afford the desired products.

5. Analytical Data of Products

1,4-Diphenylbutan-1-one (3) [2]



3

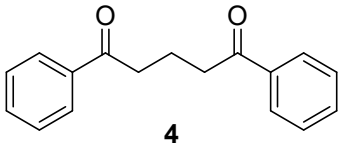
The title compound **3** was isolated as a white solid (32.3 mg, 72% yield).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.94 – 7.90 (m, 2H), 7.57 – 7.52 (m, 1H), 7.44 (t, *J* = 7.5 Hz, 2H), 7.31 – 7.26 (m, 2H), 7.23 – 7.17 (m, 3H), 2.98 (t, *J* = 7.5 Hz, 2H), 2.72 (t, *J* = 7.6 Hz, 2H), 2.09 (p, *J* = 7.4 Hz, 2H).

^{13}C NMR (125MHz, Chloroform-*d*) δ 200.2, 141.7, 137.0, 133.0, 128.6, 128.5, 128.4, 128.0, 126.0, 37.7, 35.2, 25.7.

HRMS (ESI-TOF) m/z: $[M + K]^+$ Calcd for $C_{16}H_{16}O$ K 263.0838; Found 263.0835.

1,5-Diphenylpentane-1,5-dione (4) [3]



4

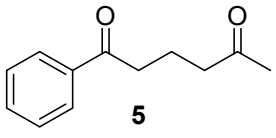
The title compound **4** was isolated as a white solid (37.8 mg, 75% yield).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.98 (d, *J* = 7.7 Hz, 4H), 7.55 (t, *J* = 7.4 Hz, 2H), 7.46 (t, *J* = 7.6 Hz, 4H), 3.12 (t, *J* = 7.0 Hz, 4H), 2.20 (p, *J* = 7.0 Hz, 2H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 199.9, 136.9, 133.1, 128.6, 128.1, 37.6, 18.7.

HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{17}H_{16}O_2$ Na 275.1048; Found 275.1057.

1-Phenylhexane-1,5-dione (5) [4]



5

The title compound **5** was isolated as a white solid (20.9 mg, 55% yield).

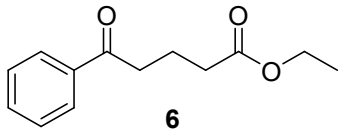
^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.96 (d, *J* = 7.5 Hz, 2H), 7.56 (t, *J* = 7.3 Hz, 1H), 7.46 (t, *J* = 7.5 Hz, 2H), 3.02 (t, *J* = 7.0 Hz, 2H), 2.57 (t, *J* = 7.0 Hz, 2H), 2.15 (s, 3H),

2.02 (p, *J* = 7.1 Hz, 2H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 208.5, 199.8, 136.8, 133.1, 128.6, 128.1, 42.6, 37.4, 30.0, 18.2.

HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{12}H_{14}O_2$ H 191.1072; Found 191.1080.

Ethyl 5-oxo-5-phenylpentanoate (6) [5]



6

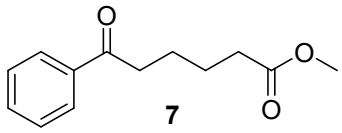
The title compound **6** was isolated as a clear oil (26.4 mg, 60% yield).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.98 – 7.94 (m, 2H), 7.56 (t, *J* = 7.3 Hz, 1H), 7.46 (t, *J* = 7.8 Hz, 2H), 4.14 (q, *J* = 7.3 Hz, 2H), 3.06 (t, *J* = 7.3 Hz, 2H), 2.43 (t, *J* = 7.3 Hz, 2H), 2.08 (p, *J* = 7.1 Hz, 2H), 1.26 (t, *J* = 7.0 Hz, 3H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 199.5, 173.3, 136.9, 133.1, 128.6, 128.0, 60.4, 37.5, 33.4, 19.4, 14.2.

HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{13}H_{16}O_3$ H 221.1177; Found 221.1177.

Methyl 6-oxo-6-phenylhexanoate (7) [6]



7

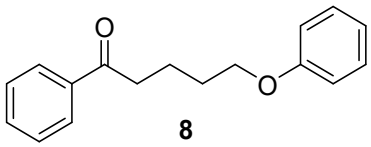
The title compound **7** was isolated as a clear oil (30.2 mg, 68% yield).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.95 (d, *J* = 7.0 Hz, 2H), 7.56 (t, *J* = 7.5 Hz, 1H), 7.46 (t, *J* = 7.8 Hz, 2H), 3.67 (s, 3H), 3.00 (t, *J* = 7.0 Hz, 2H), 2.38 (t, *J* = 7.0 Hz, 2H), 1.81 – 1.71 (m, 4H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 199.8, 173.9, 137.0, 133.0, 128.6, 128.0, 51.5, 38.1, 33.9, 24.6, 23.7.

HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{13}H_{16}O_3$ H 221.1177; Found 221.1184.

5-Phenoxy-1-phenylpentan-1-one (8) [7]



8

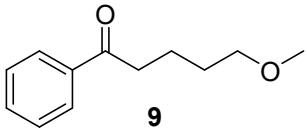
The title compound **8** was isolated as a white solid (46.3 mg, 91% yield).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.96 (d, *J* = 7.5 Hz, 2H), 7.56 (t, *J* = 7.3 Hz, 1H), 7.46 (t, *J* = 7.8 Hz, 2H), 7.30 – 7.24 (m, 2H), 6.93 (t, *J* = 7.3 Hz, 1H), 6.89 (d, *J* = 8.0 Hz, 2H), 4.01 (t, *J* = 6.0 Hz, 2H), 3.06 (t, *J* = 7.0 Hz, 2H), 1.98 – 1.86 (m, 4H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 200.0, 159.0, 137.0, 133.0, 129.4, 128.6, 128.1, 120.6, 114.5, 67.5, 38.1, 28.9, 21.0.

HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{17}H_{18}O_2$ H 255.1385; Found 255.1389.

5-Methoxy-1-phenylpentan-1-one (9)



9

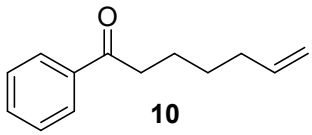
The title compound **9** was isolated as a clear oil (18.1 mg, 47% yield).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.98 – 7.93 (m, 2H), 7.58 – 7.51 (m, 1H), 7.49 – 7.42 (m, 2H), 3.42 (t, *J* = 6.5 Hz, 2H), 3.33 (s, 3H), 3.00 (t, *J* = 7.5 Hz, 2H), 1.82 (p, *J* = 7.5 Hz, 2H), 1.72 – 1.62 (m, 2H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 200.2, 137.1, 132.9, 128.6, 128.0, 72.5, 58.6, 38.3, 29.2, 21.0.

HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{13}H_{16}O_3$ H 193.1228; Found 193.1237.

1-Phenylhept-6-en-1-one (10) [2]



10

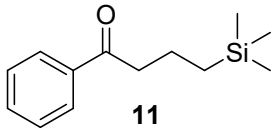
The title compound **10** was isolated as a yellow oil (12.8 mg, 34% yield).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.91 – 7.87 (m, 2H), 7.51 – 7.46 (m, 1H), 7.42 – 7.37 (m, 2H), 5.80 – 5.70 (m, 1H), 4.98 – 4.92 (m, 1H), 4.91 – 4.86 (m, 1H), 2.94 – 2.88 (m, 2H), 2.08 – 2.01 (m, 2H), 1.73 – 1.65 (m, 2H), 1.46 – 1.38 (m, 2H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 200.4, 138.6, 137.0, 133.0, 128.6, 128.1, 114.7, 38.4, 33.6, 28.6, 23.8.

HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{13}H_{16}O$ H 189.1279; Found 189.1276.

1-Phenyl-4-(trimethylsilyl)butan-1-one (11) [8]



11

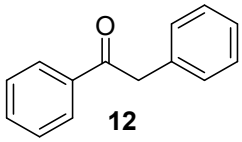
The title compound **11** was isolated as a yellow oil (14.1 mg, 32% yield).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.95 (d, *J* = 7.5 Hz, 2H), 7.54 (t, *J* = 7.3 Hz, 1H), 7.45 (t, *J* = 7.8 Hz, 2H), 2.98 (t, *J* = 7.3 Hz, 2H), 1.80 – 1.71 (m, 2H), 0.61-0.54 (m, 2H), -0.001 (s, 9H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 202.4, 138.9, 134.6, 130.3, 129.8, 44.1, 20.9, 18.4, 0.001.

HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{13}H_{20}OSi$ H 221.1361; Found 221.1364.

1,2-Diphenylethan-1-one (12) [9]



12

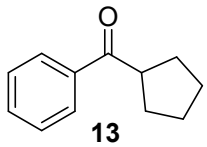
The title compound **12** was isolated as a white solid (18.0 mg, 46% yield).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.01 (d, *J* = 7.5 Hz, 2H), 7.55 (t, *J* = 7.3 Hz, 1H), 7.45 (t, *J* = 7.5 Hz, 2H), 7.32 (t, *J* = 7.3 Hz, 2H), 7.29 – 7.24 (m, 3H), 4.28 (s, 2H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 197.7, 136.6, 134.6, 133.2, 129.5, 128.7, 128.7, 128.6, 126.9, 45.5.

HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{14}H_{12}O$ H 197.0966; Found 197.0974.

Cyclopentyl(phenyl)methanone (13) [2]



13

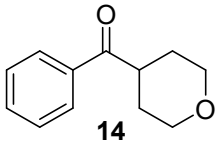
The title compound **13** was isolated as a white solid (16.7 mg, 48% yield).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.01 – 7.95 (m, 2H), 7.58 – 7.51 (m, 1H), 7.46 (t, *J* = 7.5 Hz, 2H), 3.72 (p, *J* = 7.9 Hz, 1H), 1.97 – 1.88 (m, 4H), 1.78 – 1.62 (m, 4H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 202.8, 137.0, 132.7, 128.50, 128.46, 46.4, 30.0, 26.3.

HRMS (ESI-TOF) m/z: $[M + K]^+$ Calcd for $C_{12}H_{14}O$ K 213.0682; Found 213.0675.

Phenyl(tetrahydro-2H-pyran-4-yl)methanone (14) [10]



14

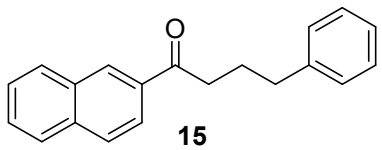
The title compound **14** was isolated as a white solid (6.5 mg, 17% yield).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.97 – 7.93 (m, 2H), 7.60 – 7.55 (m, 1H), 7.48 (t, *J* = 7.7 Hz, 2H), 4.10 – 4.03 (m, 2H), 3.57 (td, *J* = 11.6, 2.2 Hz, 2H), 3.54 – 3.47 (m, 1H), 1.94 – 1.84 (m, 2H), 1.83 – 1.76 (m, 2H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 201.9, 135.8, 133.1, 128.8, 128.23, 67.3, 42.6, 29.1.

HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{14}H_{12}O_2$ H 191.1072; Found 191.1073.

1-(Naphthalen-2-yl)-4-phenylbutan-1-one (15) [11]



15

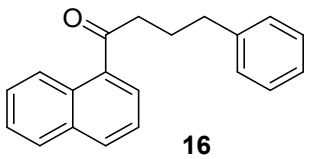
The title compound **15** was isolated as a white solid (41.2 mg, 75% yield).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.40 (s, 1H), 8.00 (d, *J* = 8.5 Hz, 1H), 7.93 (d, *J* = 8.5 Hz, 1H), 7.90 – 7.84 (m, 2H), 7.59 (t, *J* = 7.5 Hz, 1H), 7.54 (t, *J* = 7.5 Hz, 1H), 7.30 (t, *J* = 7.5 Hz, 2H), 7.22 (dd, *J* = 15.7, 7.6 Hz, 3H), 3.11 (t, *J* = 7.3 Hz, 2H), 2.77 (t, *J* = 7.5 Hz, 2H), 2.15 (p, *J* = 7.4 Hz, 2H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 200.1, 141.7, 135.6, 134.4, 132.6, 129.6, 129.6, 128.6, 128.4, 128.4, 128.4, 127.8, 126.7, 126.0, 123.9, 37.7, 35.2, 25.9.

HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{20}H_{18}O$ Na 297.1256; Found 297.1261.

1-(Naphthalen-1-yl)-4-phenylbutan-1-one (16) [11]



16

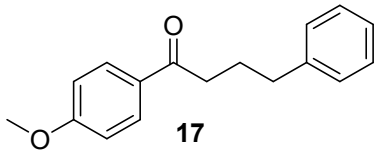
The title compound **16** was isolated as a white solid (27.4 mg, 50% yield).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.97 – 7.93 (m, 1H), 7.86 – 7.82 (m, 1H), 7.70 (d, *J* = 8.1 Hz, 1H), 7.50 – 7.43 (m, 2H), 7.38 (t, *J* = 7.6 Hz, 1H), 7.34 – 7.26 (m, 3H), 7.24 – 7.16 (m, 3H), 3.10 (t, *J* = 7.8 Hz, 2H), 2.75 (t, *J* = 7.7 Hz, 2H), 2.13 – 2.06 (m, 2H).

^{13}C NMR (125 MHz, Chloroform-*d*) *δ* 142.2, 138.4, 133.9, 131.9, 128.8, 128.5, 128.4, 126.6, 126.0, 125.8, 125.7, 125.5, 125.4, 123.8, 35.9, 32.6, 32.3.

HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{20}H_{18}O$ H 275.1436; Found 275.1443.

1-(4-Methoxyphenyl)-4-phenylbutan-1-one (17) [2]



17

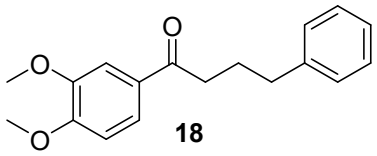
The title compound **17** was isolated as a white solid (43.8 mg, 86% yield).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.90 (d, *J* = 8.2 Hz, 2H), 7.28 (t, *J* = 7.5 Hz, 2H), 7.20 (d, *J* = 6.9 Hz, 3H), 6.91 (d, *J* = 8.8 Hz, 2H), 3.85 (s, 3H), 2.92 (t, *J* = 7.3 Hz, 2H), 2.71 (t, *J* = 7.6 Hz, 2H), 2.11 – 2.03 (m, 2H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 198.7, 163.4, 141.8, 130.3, 130.2, 128.5, 128.4, 125.9, 113.7, 55.5, 37.4, 35.3, 26.0.

HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{17}H_{18}O_2$ H 255.1385; Found 255.1394.

1-(3,4-Dimethoxyphenyl)-4-phenylbutan-1-one (18) [9]



18

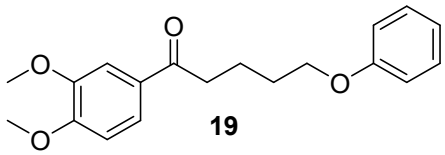
The title compound **18** was isolated as a white solid (31.3 mg, 55% yield).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.54 – 7.49 (m, 2H), 7.29 (t, *J* = 7.5 Hz, 2H), 7.23 – 7.17 (m, 3H), 6.86 (d, *J* = 8.5 Hz, 1H), 3.93 (s, 3H), 3.92 (s, 3H), 2.93 (t, *J* = 7.5 Hz, 2H), 2.72 (t, *J* = 7.5 Hz, 2H), 2.08 (p, *J* = 7.4 Hz, 2H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 198.8, 153.2, 149.0, 141.8, 130.3, 128.5, 128.4, 125.9, 122.7, 110.2, 110.0, 56.1, 56.0, 37.2, 35.3, 26.1.

HRMS (ESI-TOF) m/z: $[M + K]^+$ Calcd for $C_{18}H_{20}O_3$ K 323.1049; Found 323.1049.

1-(3,4-Dimethoxyphenyl)-5-phenoxypentan-1-one (19)



19

The title compound **19** was isolated as a white solid (44.0 mg, 70% yield).

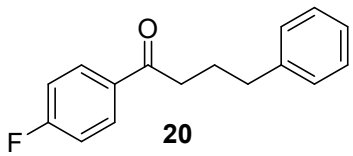
^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.59 (dd, *J* = 2.0, 2.0 Hz, 1H), 7.53 (d, *J* = 2.0 Hz, 1H), 7.30 – 7.25 (m, 2H), 6.93 (t, *J* = 7.3 Hz, 1H), 6.91 – 6.86 (m, 3H), 4.01 (t, *J* = 6.0 Hz, 2H), 3.94 (d, *J* = 8.0 Hz, 6H), 3.02 (t, *J* = 7.0 Hz, 2H), 1.98 – 1.85 (m, 4H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 198.7, 159.0, 153.2, 149.0, 130.3, 129.4, 122.7, 120.6, 114.5, 110.1, 110.0, 67.5, 56.1, 56.0, 37.6, 28.9, 21.3.

HRMS (ESI-TOF) m/z: $[M + K]^+$ Calcd for $C_{19}H_{22}O_4$ K 353.1155; Found 353.1161.

Melting point: 82–84 °C;

1-(4-Fluorophenyl)-4-phenylbutan-1-one (20) [2]



20

The title compound **20** was isolated as a white solid (24.2 mg, 50% yield).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.97 – 7.92 (m, 2H), 7.32 – 7.27 (m, 2H), 7.22 – 7.18 (m, 3H), 7.14 – 7.08 (m, 2H), 2.95 (t, *J* = 7.5 Hz, 2H), 2.72 (t, *J* = 7.8 Hz, 2H),

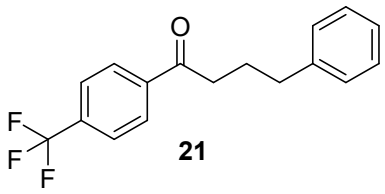
2.08 (p, *J* = 7.5 Hz, 2H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 198.5, 165.7 (d, *J* = 254.5 Hz), 141.6, 133.4 (d, *J* = 2.9 Hz), 130.6 (d, *J* = 9.3 Hz), 128.5, 128.4, 126.0, 115.6 (d, *J* = 21.9 Hz), 37.6, 35.2, 25.7.

^{19}F NMR (470 MHz, Chloroform-*d*) δ -105.57.

HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{16}H_{15}FO$ H 243.1185; Found 243.1182.

4-Phenyl-1-(4-(trifluoromethyl)phenyl)butan-1-one (21) [2]



21

The title compound **21** was isolated as a white solid (25.7 mg, 44% yield).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.00 (d, *J* = 8.1 Hz, 2H), 7.71 (d, *J* = 8.2 Hz, 2H), 7.33 – 7.27 (m, 2H), 7.23 – 7.18 (m, 3H), 2.99 (t, *J* = 7.3 Hz, 2H), 2.73 (t, *J* = 7.5 Hz, 2H), 2.10 (p, *J* = 7.4 Hz, 2H).

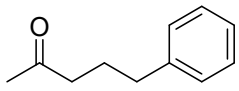
^{13}C NMR (125 MHz, Chloroform-*d*) δ 199.1, 141.4, 139.6, 134.3 (q, *J* = 32.7 Hz), 128.53, 128.49, 128.4, 126.1, 125.7 (q, *J* = 3.7 Hz), 123.6 (q, *J* = 272.7 Hz), 37.9, 35.1, 25.5.

^{19}F NMR (470 MHz, Chloroform-*d*) δ -63.07.

HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{17}H_{15}F_3O$ H 293.1153; Found 293.1147.

Melting point: 48 – 50 °C;

5-Phenylpentan-2-one (22) [10]



22

The title compound **22** was isolated as a yellow oil (7.1 mg, 22% yield).

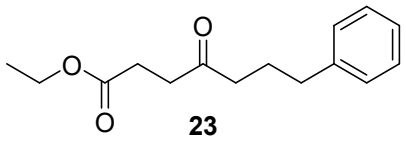
^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.31 – 7.26 (m, 2H), 7.21 – 7.15 (m, 3H), 2.62 (t, *J* = 7. Hz, 2H), 2.43 (t, *J* = 7.4 Hz, 2H), 2.11 (s, 3H), 1.91 (p, *J* = 7.5 Hz, 2H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 208.8, 141.6, 128.5, 128.4, 126.0, 42.9, 35.1,

30.0, 25.2.

HRMS (ESI-TOF) m/z: $[M + K]^+$ Calcd for $C_{11}H_{14}O$ K 201.0682; Found 201.0679.

Ethyl 4-oxo-7-phenylheptanoate (23) [12]



23

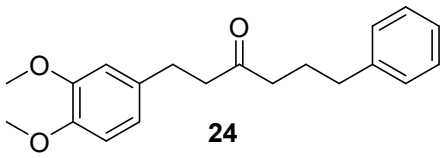
The title compound **23** was isolated as a clear oil (18.9 mg, 38% yield).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.28 (t, *J* = 7.4 Hz, 2H), 7.18 (dd, *J* = 12.3, 7.1 Hz, 3H), 4.12 (q, *J* = 7.2 Hz, 2H), 2.68 (t, *J* = 6.5 Hz, 2H), 2.62 (t, *J* = 7.6 Hz, 2H), 2.56 (t, *J* = 6.5 Hz, 2H), 2.46 (t, *J* = 7.4 Hz, 2H), 1.93 (p, *J* = 7.5 Hz, 2H), 1.24 (t, *J* = 7.1 Hz, 3H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 208.7, 172.8, 141.6, 128.5, 128.4, 126.0, 60.6, 41.9, 37.1, 35.1, 28.0, 25.2, 14.2.

HRMS (ESI-TOF) m/z: $[M + K]^+$ Calcd for $C_{15}H_{20}O_3$ K 287.1049; Found 287.1057.

1-(3,4-Dimethoxyphenyl)-6-phenylhexan-3-one (24) [13]



24

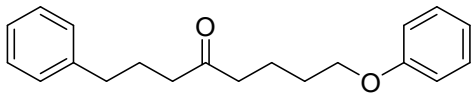
The title compound **24** was isolated as a clear oil (14.4 mg, 23% yield).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.29 – 7.24 (m, 2H), 7.21 – 7.11 (m, 3H), 6.77 (d, *J* = 8.6 Hz, 1H), 6.69 (dd, *J* = 4.3, 2.4 Hz, 2H), 3.85 (s, 3H), 3.84 (s, 3H), 2.82 (t, *J* = 7.6 Hz, 2H), 2.67 (t, *J* = 7.5 Hz, 2H), 2.59 (t, *J* = 7.6 Hz, 2H), 2.38 (t, *J* = 7.4 Hz, 2H), 1.89 (p, *J* = 7.4 Hz, 2H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 210.0, 148.9, 147.4, 141.6, 133.8, 128.5, 128.4, 126.0, 120.1, 111.8, 111.4, 56.0, 55.9, 44.6, 42.2, 35.1, 29.4, 25.2.

HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{20}H_{24}O_3$ H 313.1803; Found 313.1808.

8-Phenoxy-1-phenyloctan-4-one (25)



25

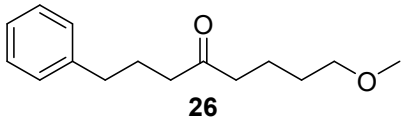
The title compound **25** was isolated as a clear oil (28.5 mg, 48% yield).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.30 – 7.25 (m, 4H), 7.21 – 7.15 (m, 3H), 6.95 – 6.91 (m, 1H), 6.90 – 6.85 (m, 2H), 3.94 (t, *J* = 5.5 Hz, 2H), 2.61 (t, *J* = 7.6 Hz, 2H), 2.45 (t, *J* = 6.7 Hz, 2H), 2.41 (t, *J* = 7.4 Hz, 2H), 1.91 (p, *J* = 8.0, 7.6 Hz, 2H), 1.80 – 1.71 (m, 4H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 210.6, 159.0, 141.6, 129.5, 128.5, 128.4, 126.0, 120.6, 114.5, 67.4, 42.4, 42.0, 35.1, 28.8, 25.2, 20.5.

HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{20}H_{24}O_2$ H 297.1854; Found 297.1863.

8-Methoxy-1-phenyloctan-4-one (26)



26

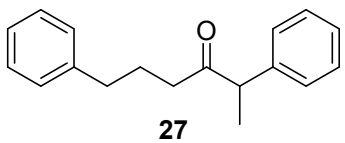
The title compound **26** was isolated as a clear oil (23.9 mg, 51% yield).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.27 (t, *J* = 7.5 Hz, 2H), 7.20 – 7.14 (m, 3H), 3.35 (t, *J* = 6.3 Hz, 2H), 3.30 (s, 3H), 2.61 (t, *J* = 7.6 Hz, 2H), 2.40 (td, *J* = 7.3, 2.5 Hz, 4H), 1.90 (p, *J* = 7.5 Hz, 2H), 1.67 – 1.51 (m, 4H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 210.7, 141.7, 128.5, 128.4, 125.9, 72.5, 58.5, 42.5, 41.9, 35.1, 29.1, 25.2, 20.5.

HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{15}H_{22}O_2$ H 235.1698; Found 235.1696.

2,6-Diphenylhexan-3-one (27) [14]



27

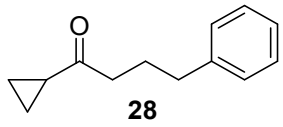
The title compound **27** was isolated as a clear oil (12.1 mg, 24% yield).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.32 (t, *J* = 7.4 Hz, 2H), 7.28 – 7.17 (m, 5H), 7.15 (t, *J* = 7.3 Hz, 1H), 7.04 (d, *J* = 7.0 Hz, 2H), 3.72 (q, *J* = 6.9 Hz, 1H), 2.56 – 2.41 (m, 2H), 2.41 – 2.30 (m, 2H), 1.82 (p, *J* = 7.3 Hz, 2H), 1.38 (d, *J* = 7.0 Hz, 3H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 210.6, 141.7, 140.6, 128.9, 128.4, 128.3, 127.9, 127.1, 125.8, 53.0, 40.2, 34.9, 25.3, 17.4.

HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{18}H_{20}O$ H 253.1592; Found 253.1600.

1-Cyclopropyl-4-phenylbutan-1-one (28) [10]



28

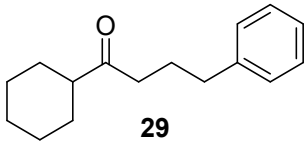
The title compound **28** was isolated as a clear oil (22.6 mg, 60% yield).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.28 (dd, *J* = 8.5, 6.6 Hz, 2H), 7.21 – 7.16 (m, 3H), 2.63 (t, *J* = 7.6 Hz, 2H), 2.56 (t, *J* = 7.4 Hz, 2H), 1.95 (q, *J* = 7.5 Hz, 2H), 1.92 – 1.87 (m, 1H), 1.03 – 0.98 (m, 2H), 0.87 – 0.81 (m, 2H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 210.8, 141.7, 128.5, 128.4, 125.9, 42.7, 35.2, 25.5, 20.4, 10.6.

HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{13}H_{16}O$ H 189.1279; Found 189.1275.

1-Cyclohexyl-4-phenylbutan-1-one (29) [10]



29

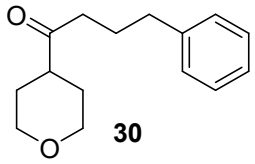
The title compound **29** was isolated as a yellow oil (25.6 mg, 55% yield).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.28 (t, *J* = 7.6 Hz, 2H), 7.22 – 7.15 (m, 3H), 2.63 (t, *J* = 7.6 Hz, 2H), 2.56 (t, *J* = 7.4 Hz, 2H), 1.99 – 1.90 (m, 2H), 1.93 – 1.85 (m, 2H), 1.03 – 0.97 (m, 2H), 0.88 – 0.80 (m, 2H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 214.0, 141.8, 128.5, 128.4, 125.9, 50.9, 39.8, 35.2, 28.5, 25.9, 25.7, 25.1.

HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{16}H_{22}O$ H 231.1749; Found 231.1751.

4-Phenyl-1-(tetrahydro-2*H*-pyran-4-yl)butan-1-one (30) [10]



30

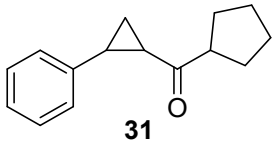
The title compound **30** was isolated as a white solid (28.8 mg, 62% yield).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.28 (t, *J* = 7.5 Hz, 2H), 7.21 – 7.14 (m, 3H), 3.98 (dt, *J* = 11.5, 3.6 Hz, 2H), 3.39 (td, *J* = 11.2, 3.3 Hz, 2H), 2.62 (t, *J* = 7.5 Hz, 2H), 2.54 – 2.47 (m, 1H), 2.45 (t, *J* = 7.2 Hz, 2H), 1.92 (p, *J* = 7.4 Hz, 2H), 1.71 – 1.64 (m, 4H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 211.7, 141.6, 128.5, 128.4, 126.0, 67.3, 47.6, 39.3, 35.1, 28.2, 24.9.

HRMS (ESI-TOF) m/z: $[M + K]^+$ Calcd for $C_{15}H_{20}O_2$ K 277.1100; Found 277.1104.

Cyclopentyl(2-phenylcyclopropyl)methanone (31)



31

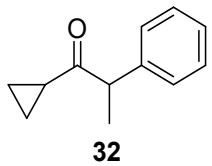
The title compound **31** was isolated as a yellow oil (15.8 mg, 37% yield).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.31 – 7.26 (m, 2H), 7.23 – 7.17 (m, 1H), 7.12 – 7.07 (m, 2H), 3.04 (p, *J* = 8.0 Hz, 1H), 2.51 – 2.45 (m, 1H), 2.23 – 2.17 (m, 1H), 1.90 – 1.80 (m, 4H), 1.71 – 1.62 (m, 3H), 1.62 – 1.54 (m, 2H), 1.38 – 1.33 (m, 1H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 211.2, 140.6, 128.5, 126.4, 126.1, 52.4, 31.5, 28.9, 28.6, 26.1, 26.0, 18.7.

HRMS (ESI-TOF) m/z: $[M + K]^+$ Calcd for $C_{15}H_{18}O$ K 253.0995; Found 253.0993.

1-Cyclopropyl-2-phenylpropan-1-one (32) [15]



32

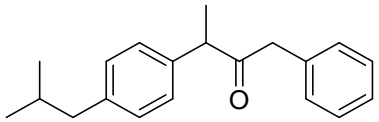
The title compound **32** was isolated as a yellow oil (17.4 mg, 50% yield).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.34 (t, *J* = 7.5 Hz, 2H), 7.28 – 7.21 (m, 3H), 3.90 (q, *J* = 7.0 Hz, 1H), 1.85 (td, *J* = 7.9, 3.9 Hz, 1H), 1.41 (d, *J* = 7.0 Hz, 3H), 1.04 – 0.92 (m, 2H), 0.84 – 0.66 (m, 2H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 210.9, 140.9, 128.9, 128.1, 127.0, 53.8, 19.7, 17.6, 11.3, 11.3.

HRMS (ESI-TOF) m/z: $[M + Na]^+$ Calcd for $C_{12}H_{14}O$ Na 197.0943; Found 197.0949.

3-(4-Isobutylphenyl)-1-phenylbutan-2-one (33)



33

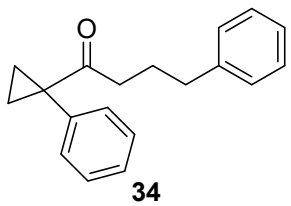
The title compound **33** was isolated as a clear oil (21.9 mg, 39% yield).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.30 – 7.18 (m, 3H), 7.13 – 7.07 (m, 4H), 7.05 – 7.00 (m, 2H), 3.82 (q, *J* = 6.9 Hz, 1H), 3.62 (d, *J* = 3.6 Hz, 2H), 2.46 (d, *J* = 7.2 Hz, 2H), 1.92 – 1.80 (m, 1H), 1.35 (d, *J* = 6.9 Hz, 3H), 0.91 (d, *J* = 6.7 Hz, 6H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 208.3, 140.8, 137.5, 134.5, 129.7, 129.5, 128.5, 127.8, 126.8, 51.9, 47.9, 45.1, 30.2, 22.4, 17.6.

HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{20}H_{24}O$ H 281.1905; Found 281.1908.

4-Phenyl-1-(1-phenylcyclopropyl)butan-1-one (34) [10]



34

The title compound **34** was isolated as a clear oil (40.0 mg, 76% yield).

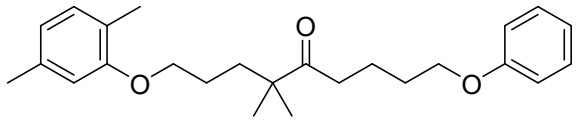
^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.33 (d, *J* = 4.3 Hz, 4H), 7.31 – 7.27 (m, 1H), 7.25 – 7.21 (m, 2H), 7.15 (dd, *J* = 8.1, 6.4 Hz, 1H), 7.07 (d, *J* = 7.2 Hz, 2H), 2.50 – 2.44 (m, 2H), 2.30 (t, *J* = 7.1 Hz, 2H), 1.77 (p, *J* = 7.1 Hz, 2H), 1.58 (q, *J* = 3.4 Hz, 3H), 1.14 (q, *J* = 3.6 Hz, 2H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 210.4, 141.9, 140.9, 130.9, 128.6, 128.4, 128.3,

127.4, 125.8, 40.8, 37.4, 35.0, 25.5, 18.6.

HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{19}H_{20}O$ H 265.1592; Found 265.1592.

1-(2,5-Dimethylphenoxy)-4,4-dimethyl-9-phenoxynonan-5-one (35) [2]



35

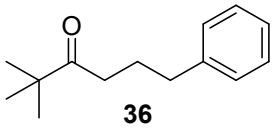
The title compound **35** was isolated as a yellow oil (48.2 mg, 63% yield).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.21 – 7.16 (m, 2H), 6.92 (d, *J* = 7.5 Hz, 1H), 6.87 – 6.83 (m, 1H), 6.82 – 6.78 (m, 2H), 6.58 (d, *J* = 7.5 Hz, 1H), 6.52 (s, 1H), 3.88 (t, *J* = 5.9 Hz, 2H), 3.82 (t, *J* = 5.9 Hz, 2H), 2.50 (t, *J* = 6.8 Hz, 2H), 2.23 (s, 3H), 2.10 (s, 3H), 1.73 – 1.62 (m, 6H), 1.62 – 1.54 (m, 2H), 1.09 (s, 6H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 215.3, 159.0, 156.9, 136.5, 130.4, 129.5, 123.5, 120.8, 120.6, 114.5, 111.9, 67.8, 67.6, 47.3, 36.4, 36.3, 28.9, 25.0, 24.5, 21.5, 20.5, 15.9.

HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{25}H_{34}O_3$ H 383.2586; Found 383.2581.

2,2-Dimethyl-6-phenylhexan-3-one (36) [10]



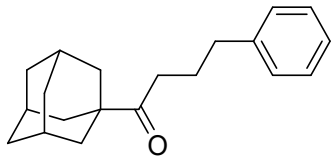
36

The title compound **36** was isolated as a clear oil (25.0 mg, 61% yield).

^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.28 (t, *J* = 7.6 Hz, 2H), 7.18 (t, *J* = 6.8 Hz, 3H), 2.61 (t, 2H), 2.50 (t, *J* = 7.2 Hz, 2H), 1.89 (p, *J* = 7.3 Hz, 2H), 1.12 (s, 9H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 215.8, 141.9, 128.5, 128.3, 125.9, 44.1, 35.6, 35.2, 26.4, 25.4.

HRMS (ESI-TOF) m/z: $[M + H]^+$ Calcd for $C_{14}H_{20}O$ H 205.1592; Found 205.1593.



37

1-((3r,5r,7r)-Adamantan-1-yl)-4-phenylbutan-1-one (37) [10]

The title compound **37** was isolated as a clear oil (24.3 mg, 43% yield).

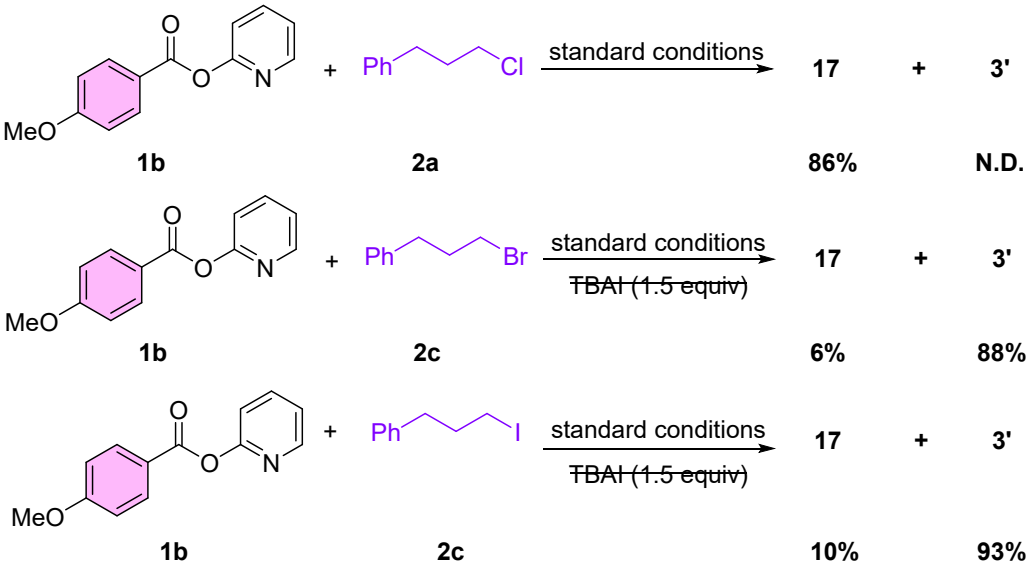
^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.30 – 7.25 (m, 2H), 7.21 – 7.14 (m, 3H), 2.59 (t, *J* = 7.7 Hz, 2H), 2.45 (t, *J* = 7.2 Hz, 2H), 2.05 – 2.00 (m, 3H), 1.87 (p, *J* = 7.2 Hz, 2H), 1.81 – 1.64 (m, 12H).

^{13}C NMR (125 MHz, Chloroform-*d*) δ 215.4, 142.0, 128.5, 128.3, 125.8, 46.3, 38.3, 36.6, 35.2, 35.2, 28.0, 25.2.

HRMS (ESI-TOF) m/z: $[M + K]^+$ Calcd for $C_{20}H_{26}O$ K 321.1621; Found 321.1624.

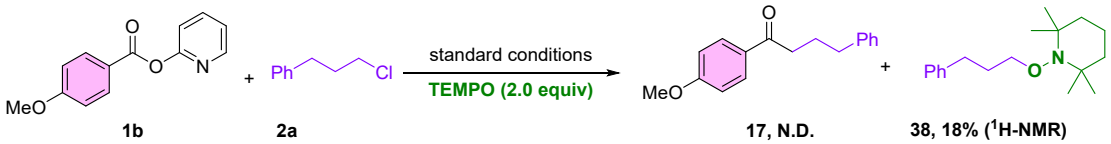
6. Control Experiments.

A)



A dry test tube equipped with a stirring bar was charged with $NiBr_2$(dme) (6.2 mg, 0.02 mmol, 10 mol %), **L2** (5.2 mg, 0.024 mmol, 12 mol%) under an argon atmosphere. Next, 0.5 mL of dry DMA was added. To this solution, TBAI (110.8 mg, 0.3 mmol, 1.5 equiv), Mn powder (33.0 mg, 0.6 mmol, 3.0 equiv), pyridin-2-yl 4-methoxybenzoate (**1b**) (45.8 mg, 0.2 mmol, 1.0 equiv) and (3-chloropropyl)benzene (**2a**), alkyl bromide (**2b**) or alkyl iodide (**2c**) (0.3 mmol, 1.5 equiv) was added successively under nitrogen atmosphere. The reaction mixture was stirred at 50 °C for 12 hours. The reaction was subjected to GC analysis.

B)



A dry test tube equipped with a stirring bar was charged with $NiBr_2$(dme) (6.2 mg, 0.02 mmol, 10 mol %), **L2** (5.2 mg, 0.024 mmol, 12 mol%) under an argon atmosphere. Next, 0.5 mL of dry DMA was added. To this solution, TBAI (110.8 mg, 0.3 mmol, 1.5 equiv), Mn powder (33.0 mg, 0.6 mmol, 3.0 equiv), TEMPO (62.5 mg, 0.4 mmol, 2.0 equiv), pyridin-2-yl 4-methoxybenzoate (**1b**) (45.8 mg, 0.2 mmol, 1.0 equiv) and (3-chloropropyl)benzene (**2a**) (46.2 mg, 0.3 mmol, 1.5 equiv) was added successively

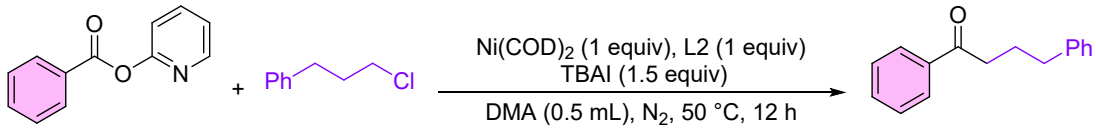
under nitrogen atmosphere. The reaction mixture was stirred at 50 °C for 12 hours. After removing the solvent, the residue was analyzed by ^{1}H NMR spectroscopy to calculate the yield using dibromomethane as an internal standard.

C)

1b **39** **40, 56% (^{1}H-NMR)** **41, trace**

A dry test tube equipped with a stirring bar was charged with $NiBr_2$(dme) (6.2 mg, 0.02 mmol, 10 mol %), **L2** (5.2 mg, 0.024 mmol, 12 mol%) under an argon atmosphere. Next, 0.5 mL of dry DMA was added. To this solution, TBAI (110.8 mg, 0.3 mmol, 1.5 equiv), Mn powder (33.0 mg, 0.6 mmol, 3.0 equiv), pyridin-2-yl 4-methoxybenzoate (**1b**) (45.8 mg, 0.2 mmol, 1.0 equiv) and (chloromethyl)cyclopropane (**39**) (27.0 mg, 0.3 mmol, 1.5 equiv) was added successively under nitrogen atmosphere. The reaction mixture was stirred at 50 °C for 24 hours. After removing the solvent, the residue was analyzed by ^{1}H NMR spectroscopy to calculate the yield using dibromomethane as an internal standard.

D)



1a **2a** **3**

A dry test tube equipped with a stirring bar was charged with $Ni(COD)_2$ (55.0 mg, 0.2 mmol, 1.0 equiv), **L2** (43.2 mg, 0.2 mmol, 1.0 equiv) under an argon atmosphere inside a glove box. Next, 0.5 mL of dry DMA was added via syringe. Subsequently, removed from the glove box, the Schlenk tube was evacuated and filled with nitrogen (three cycles). To this solution, TBAI (110.8 mg, 0.3 mmol, 1.5 equiv), cyclopropyl(phenyl)methanone (**1a**) (39.8 mg, 0.2 mmol, 1.0 equiv) and (3-chloropropyl)benzene (**2a**) (46.2 mg, 0.3 mmol, 1.5 equiv) was added successively under nitrogen atmosphere. The reaction mixture was stirred at 50 °C for 12 hours. The reaction was subjected to GC analysis.

7. References

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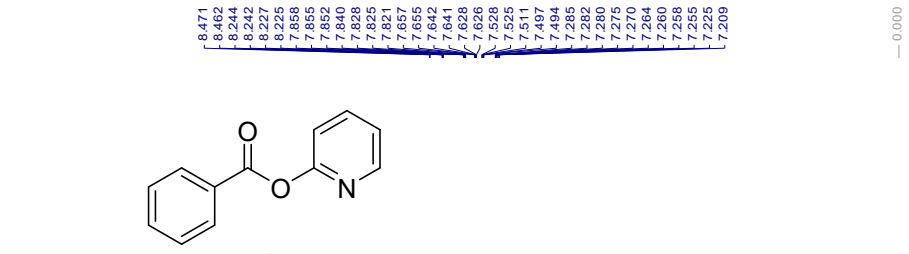
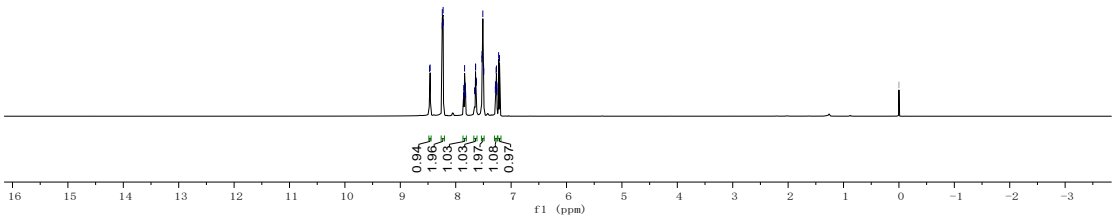
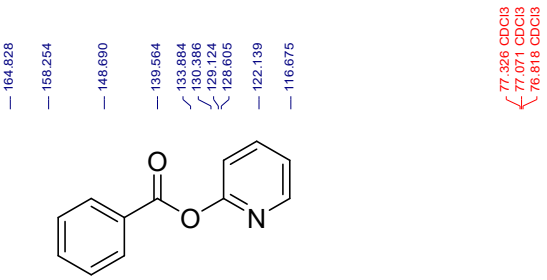
8. NMR Spectra



1a

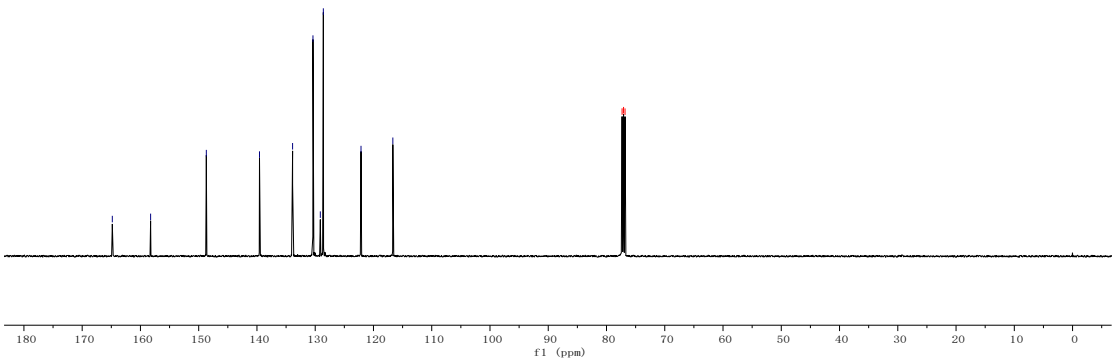
500 MHZ,^{1}H-NMR

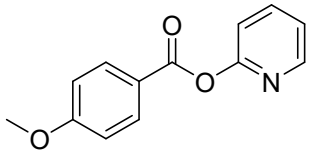




1a

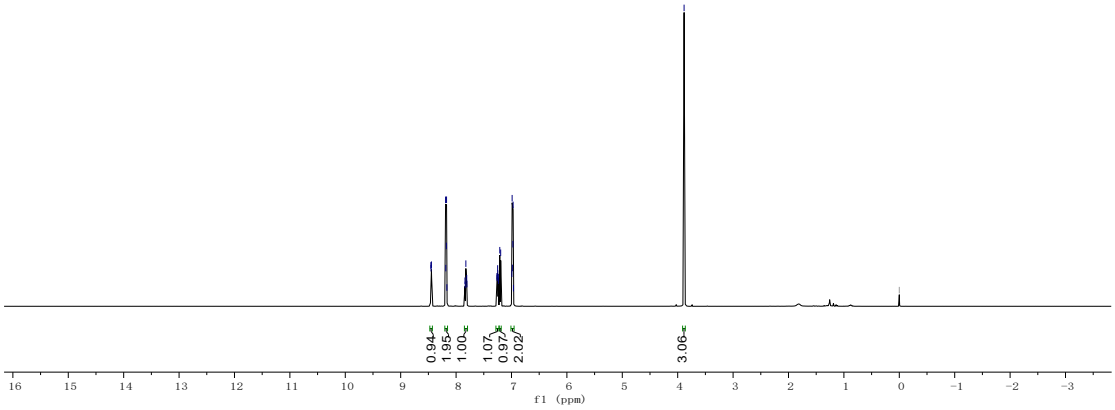
125 MHZ,^{13}C-NMR

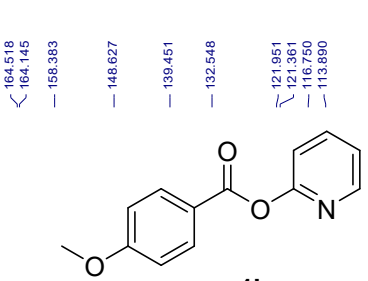




1b

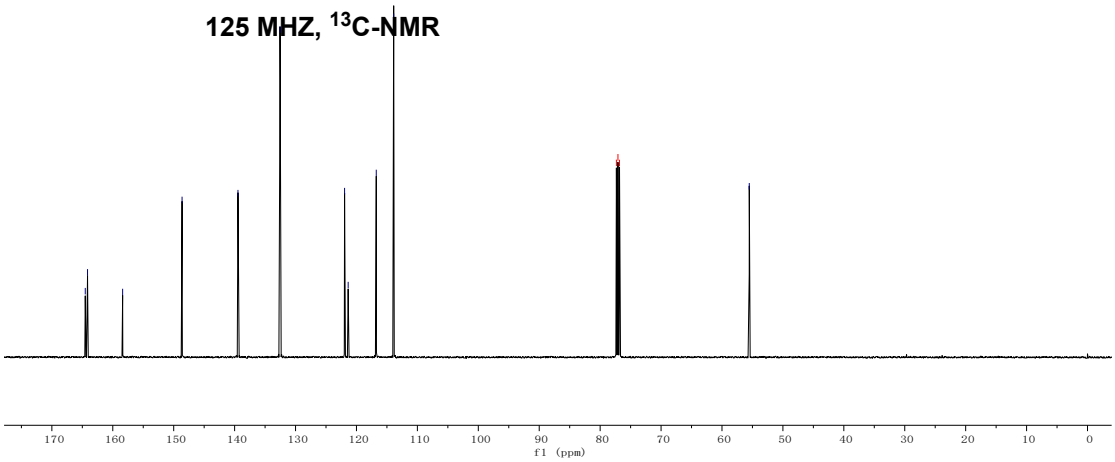
500 MHZ, ^{1}H-NMR

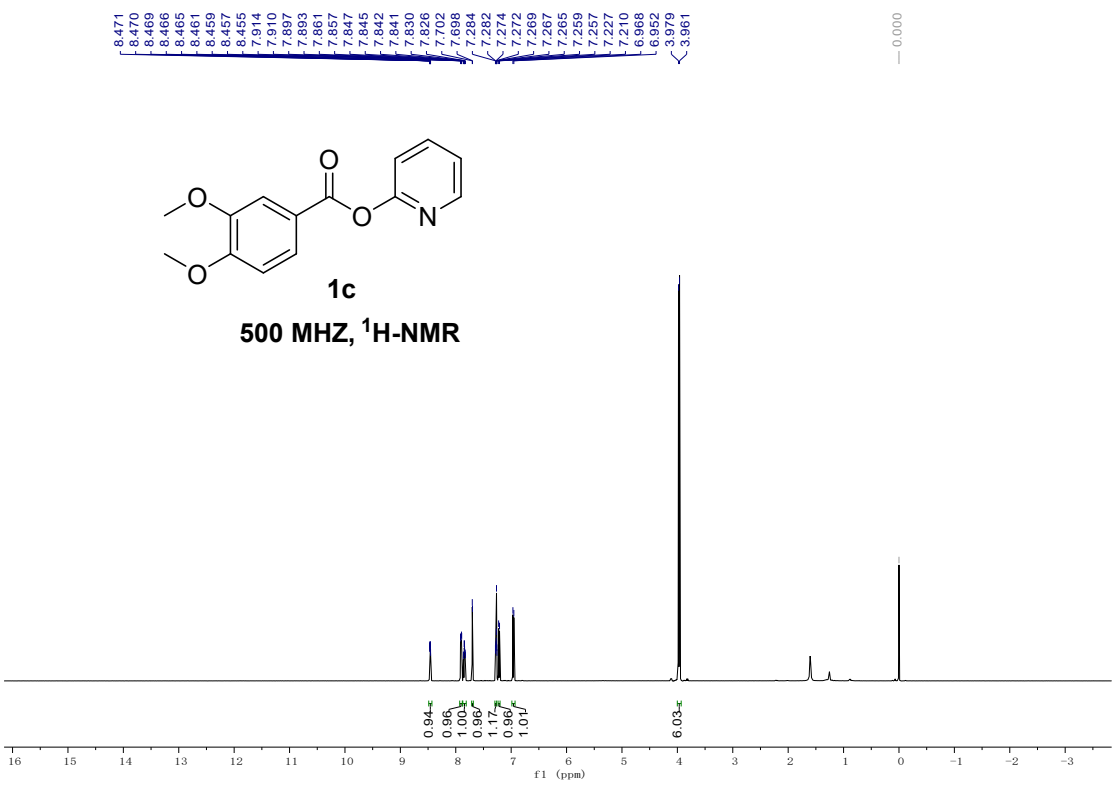


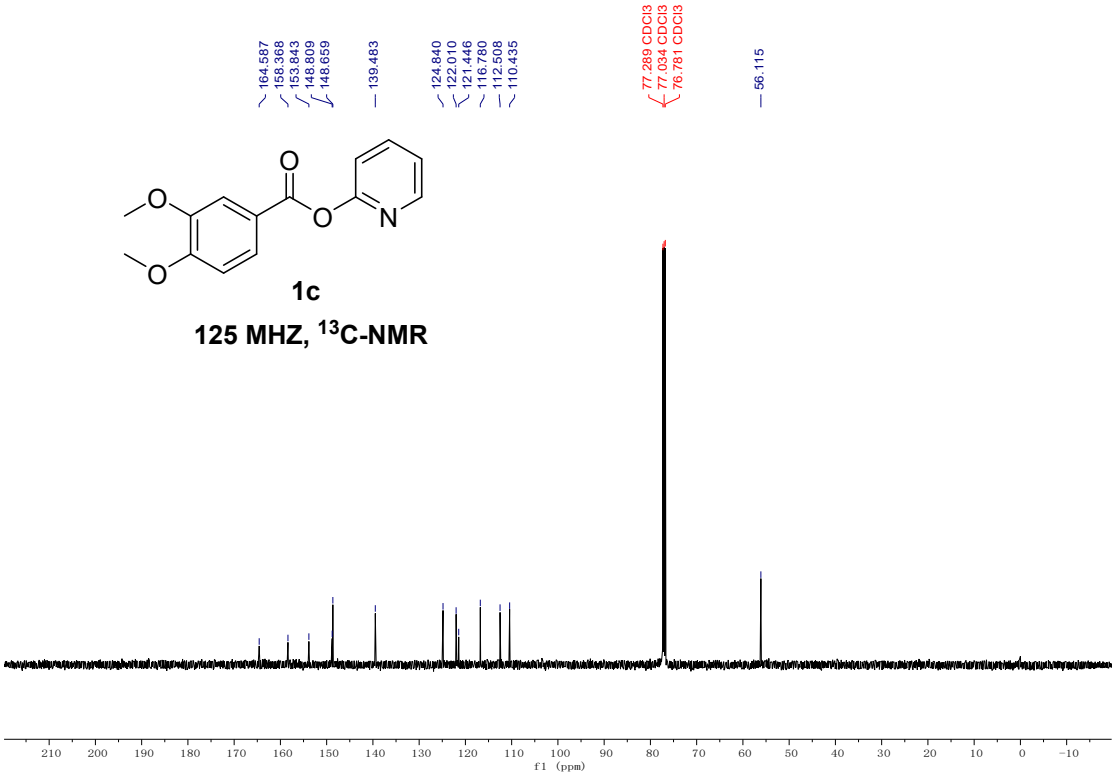


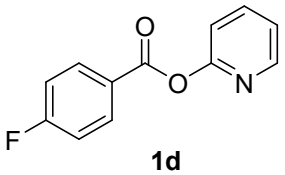
1b

125 MHZ, ^{13}C-NMR



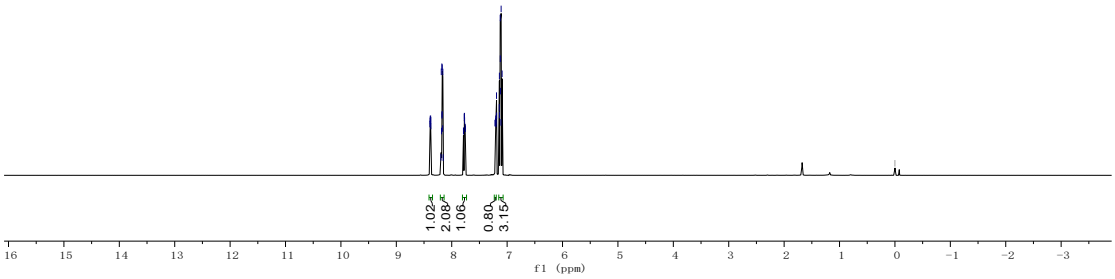

8.471
8.470
8.469
8.466
8.465
8.461
8.459
8.457
8.455
7.914
7.910
7.897
7.893
7.861
7.857
7.847
7.845
7.842
7.841
7.830
7.826
7.702
7.698
7.284
7.282
7.274
7.272
7.269
7.267
7.265
7.259
7.257
7.227
7.210
6.968
6.952
3.979
3.961
0.000
O
O
O
O
N
1c
500 MHZ, 1H-NMR
0.94
0.96
1.00
0.96
1.17
0.96
1.01
6.03
f1 (ppm)

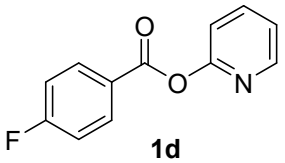

164.587
158.368
153.843
148.809
148.659
139.483
124.840
122.010
121.446
116.780
112.508
110.435
77.289 CDCl3
77.034 CDCl3
76.781 CDCl3
56.115
O
O
O
O
N
1c
125 MHZ, 13C-NMR
f1 (ppm)



1d

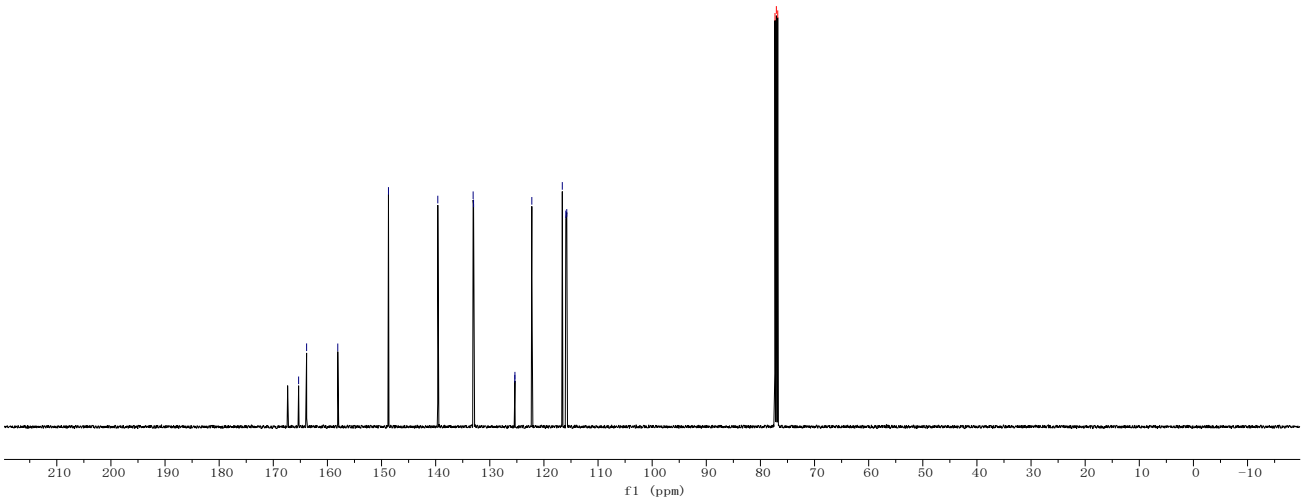
500 MHZ, ^{1}H-NMR

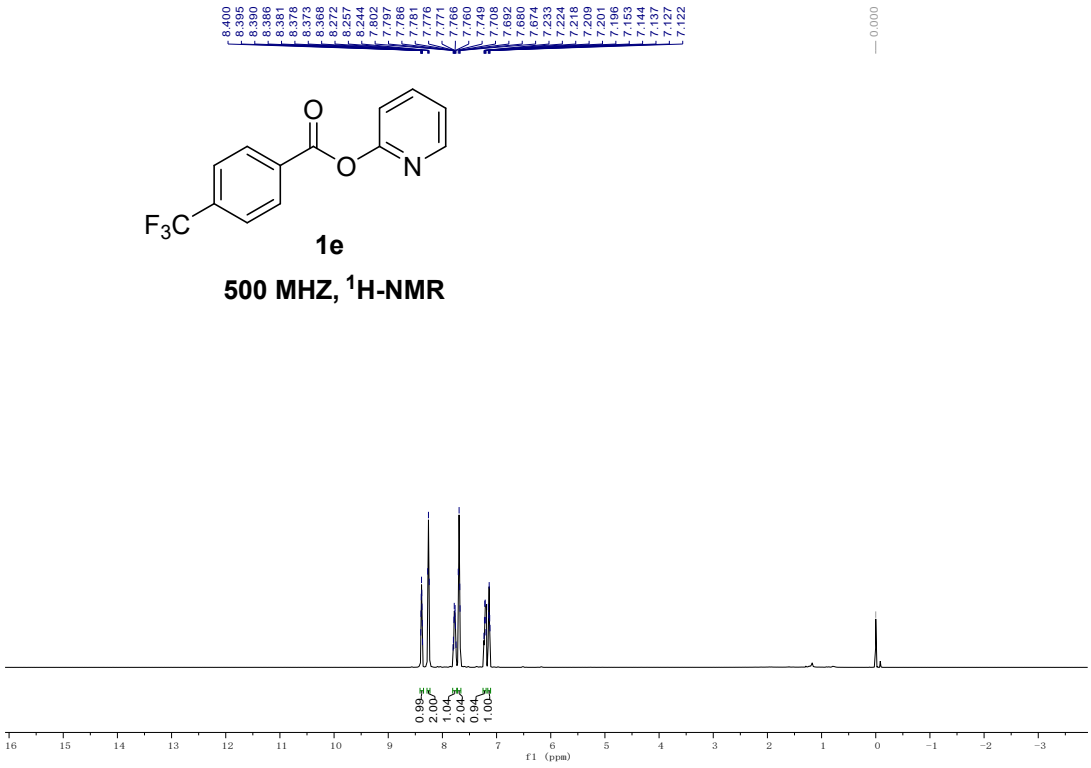


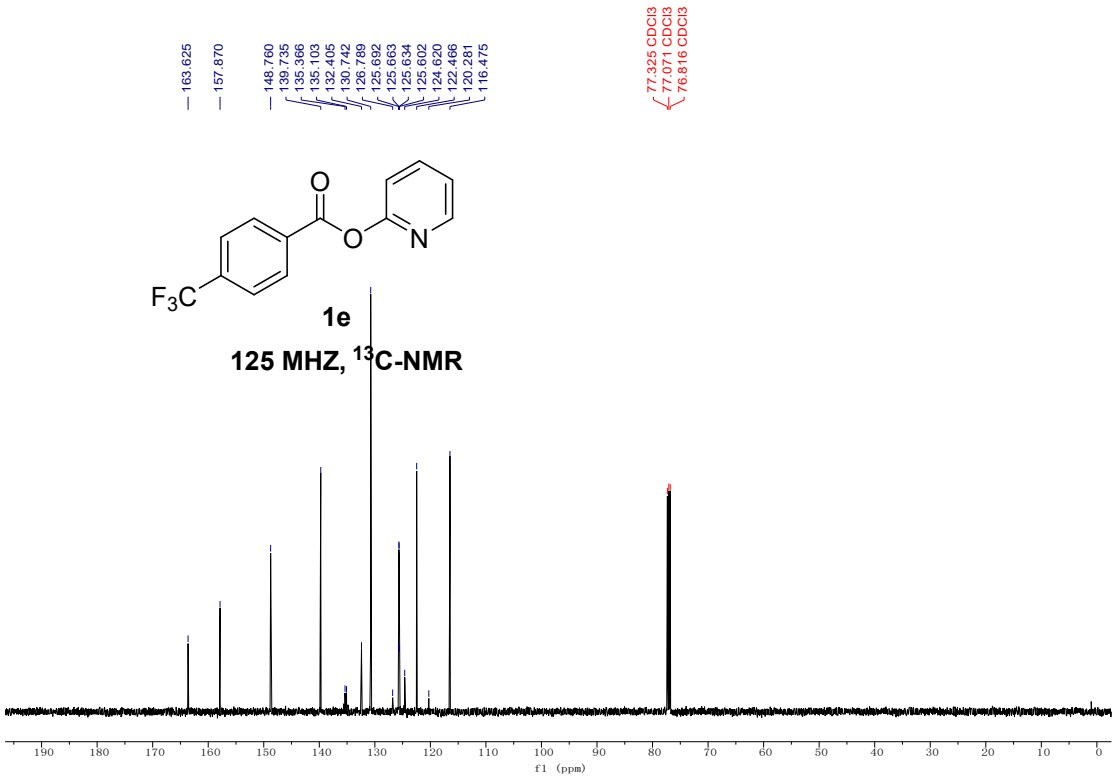


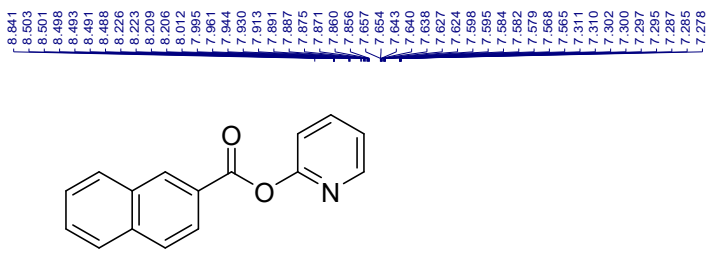
1d

125 MHZ, ^{13}C-NMR



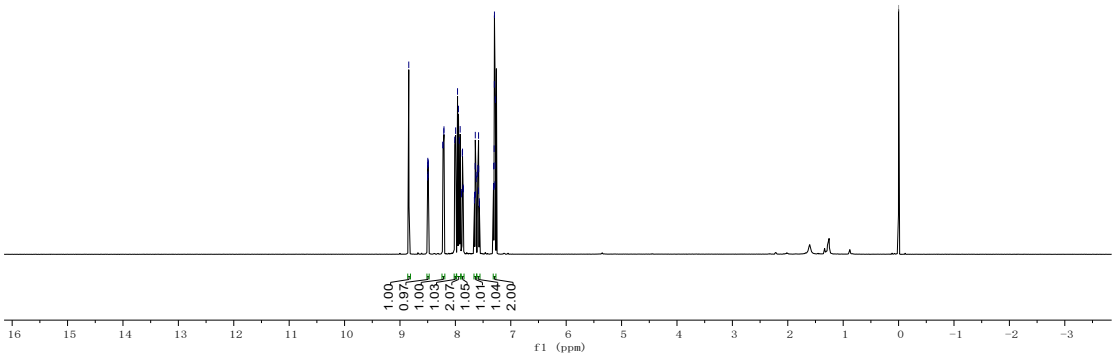

8.400
8.395
8.390
8.386
8.381
8.378
8.373
8.368
8.272
8.257
8.244
7.802
7.797
7.786
7.781
7.776
7.771
7.766
7.760
7.749
7.708
7.692
7.680
7.674
7.233
7.224
7.218
7.209
7.201
7.196
7.153
7.144
7.137
7.127
7.122
0.000
O
O
N
F3C
1e
500 MHZ, 1H-NMR
0.99
2.00
1.04
2.04
0.94
1.00
f1 (ppm)

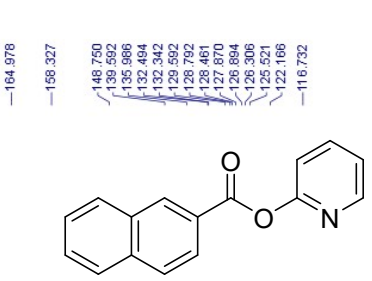

163.625
157.870
148.760
139.735
135.366
135.103
132.405
130.742
126.789
125.692
125.663
125.634
125.602
124.620
122.466
120.281
116.475
77.325 CDCl3
77.071 CDCl3
76.816 CDCl3
O
O
N
F3C
1e
125 MHZ, 13C-NMR
f1 (ppm)



1f

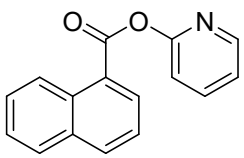
500 MHZ,^{1}H-NMR





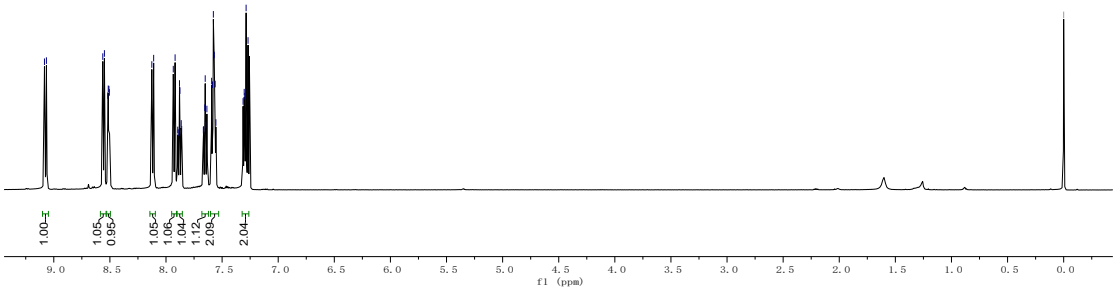
1f

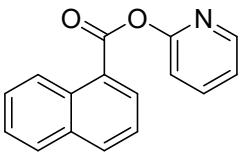
125 MHZ,^{13}C-NMR



1g

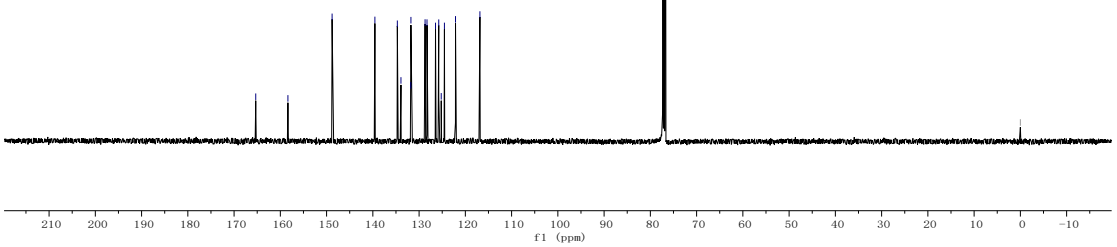
500 MHZ, ^{1}H-NMR

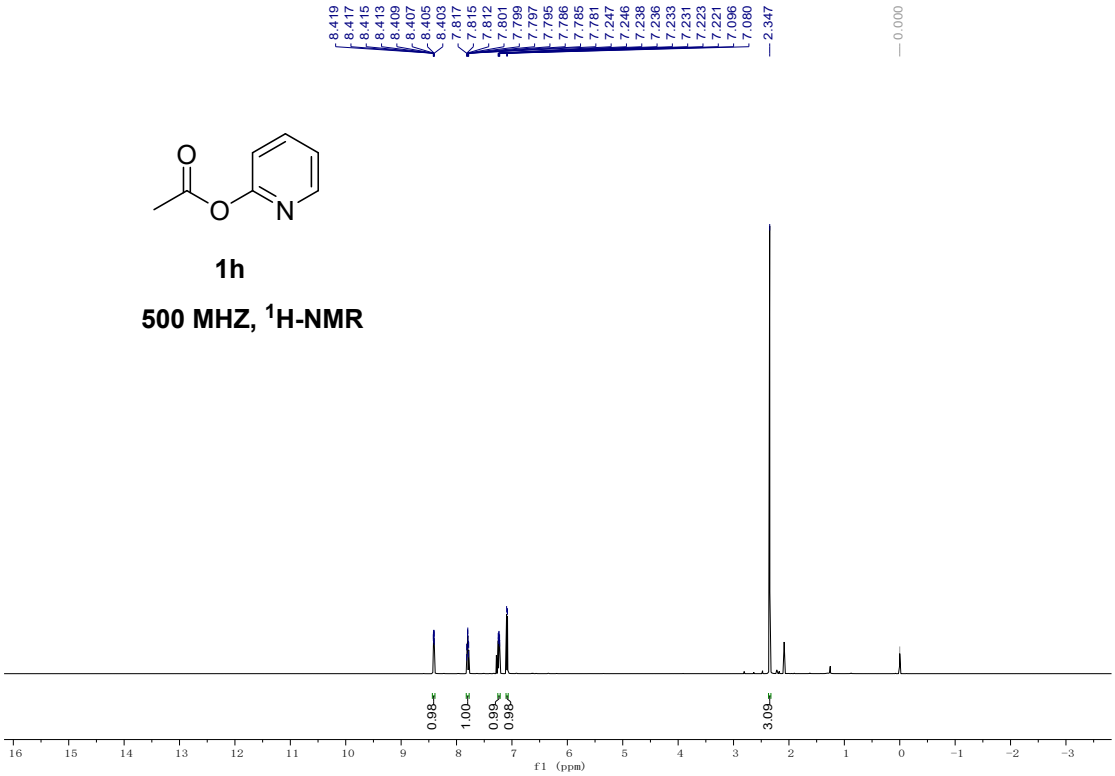




1g

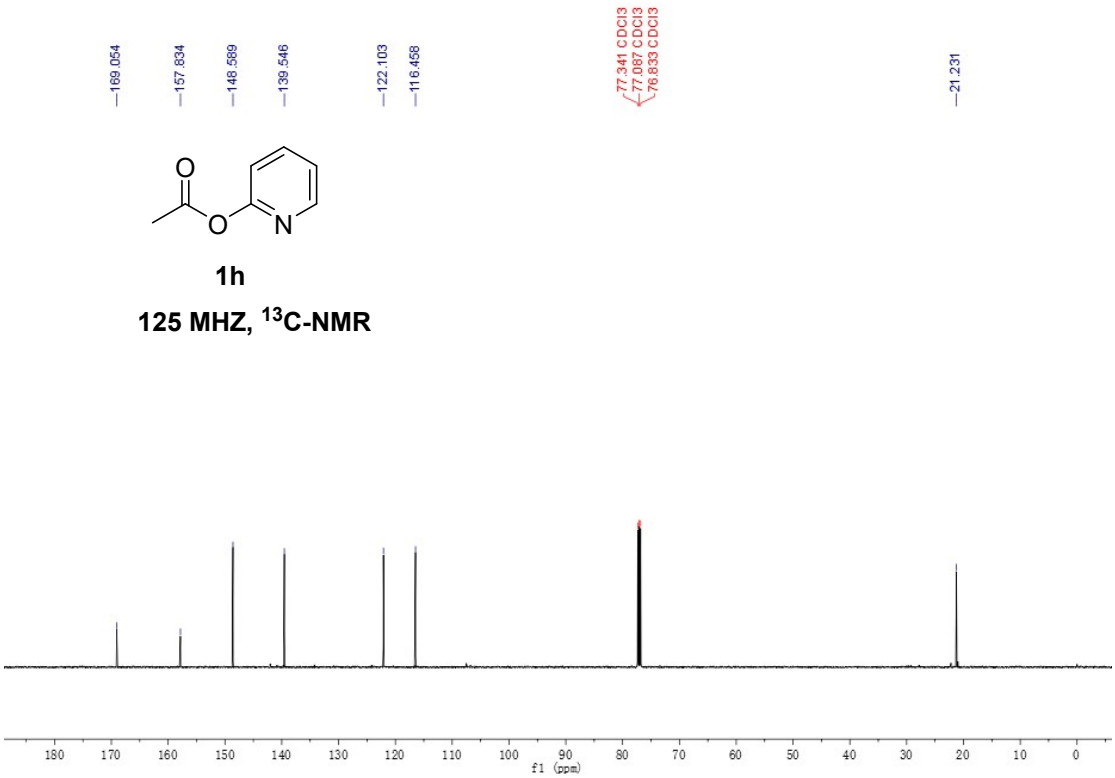
125 MHZ, ^{13}C-NMR





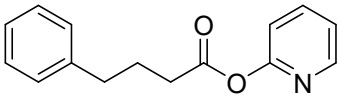
1h

500 MHZ, ^{1}H-NMR



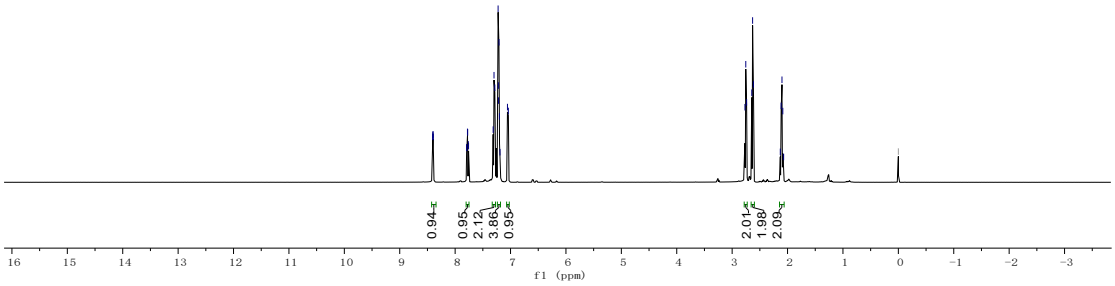
1h

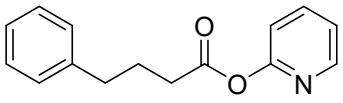
125 MHZ, ^{13}C-NMR



1i

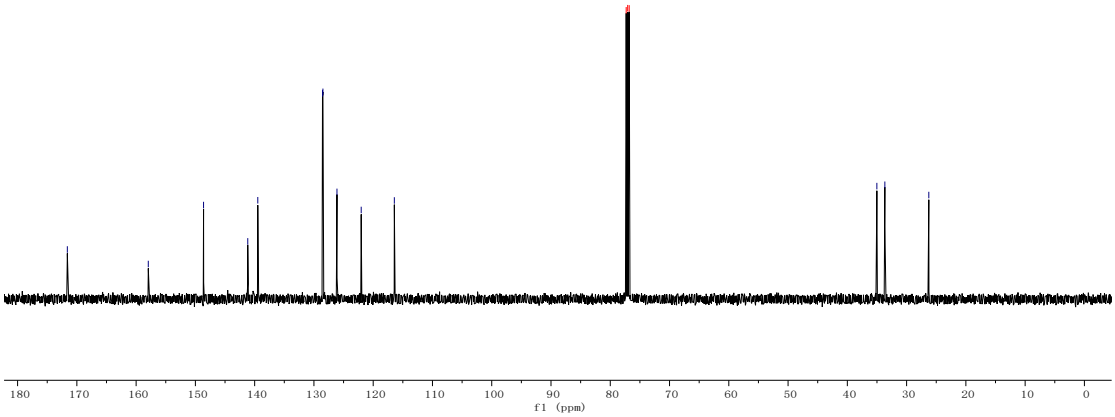
500 MHZ, ^{1}H-NMR

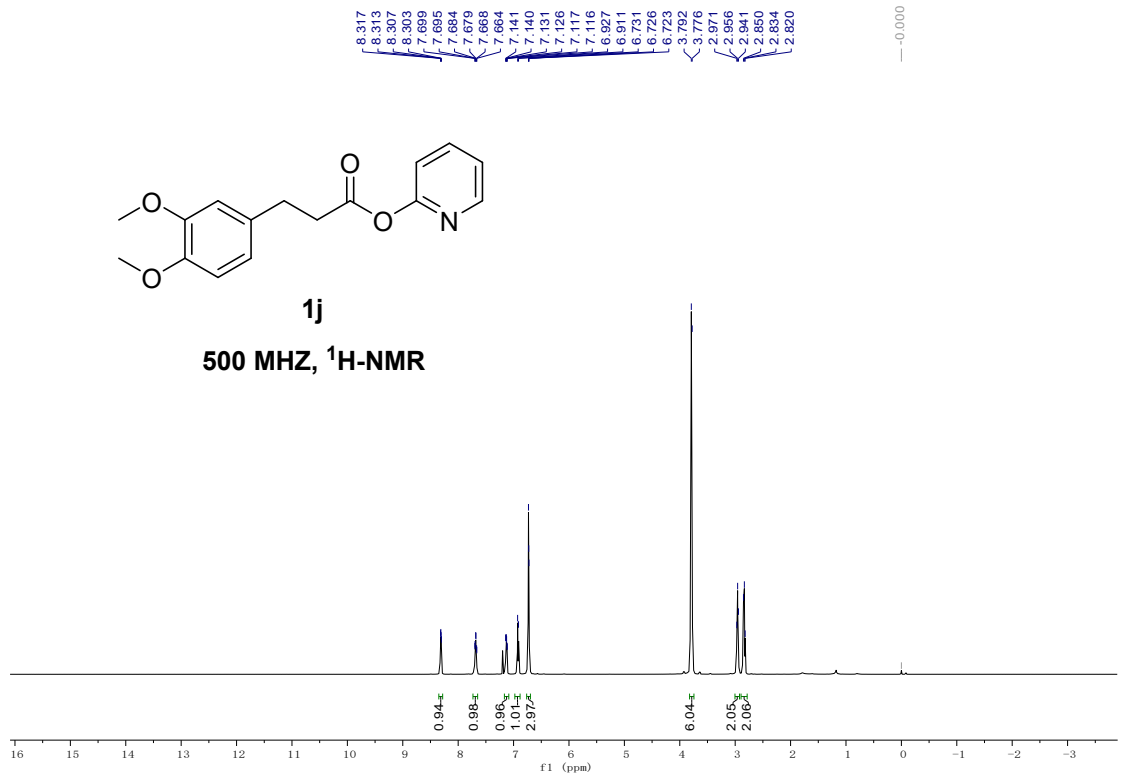




1i

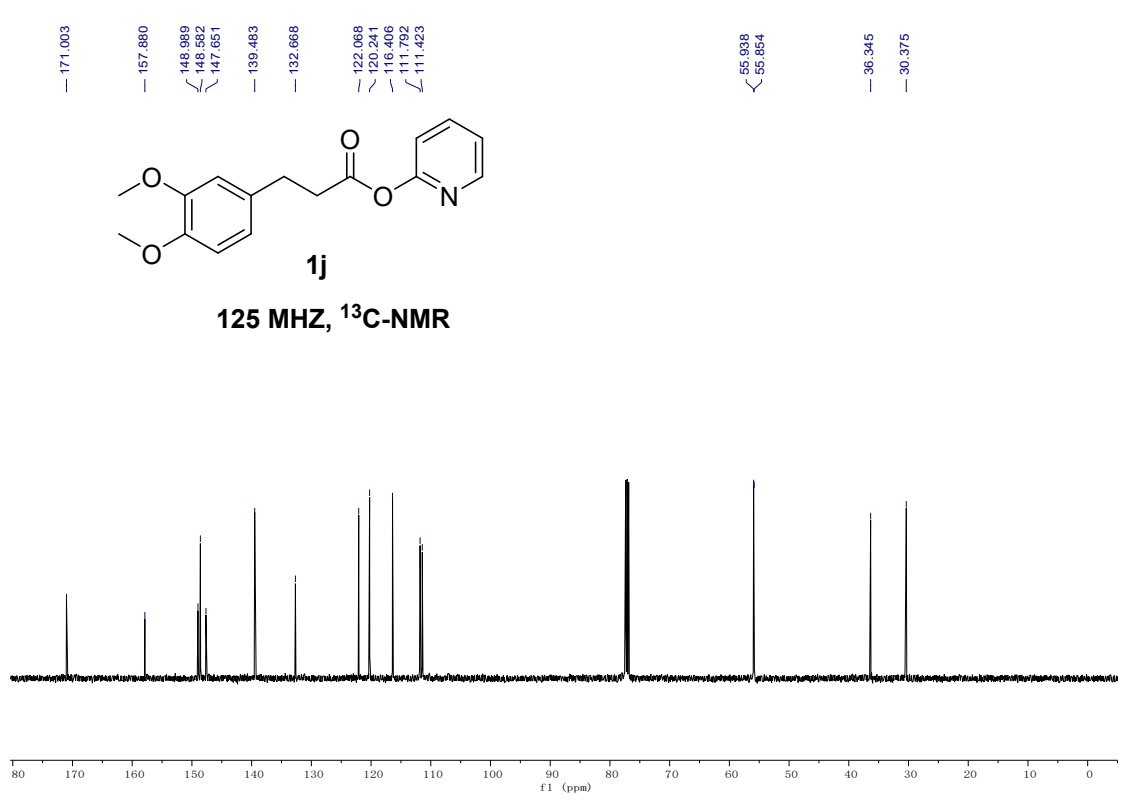
125 MHZ, ^{13}C-NMR





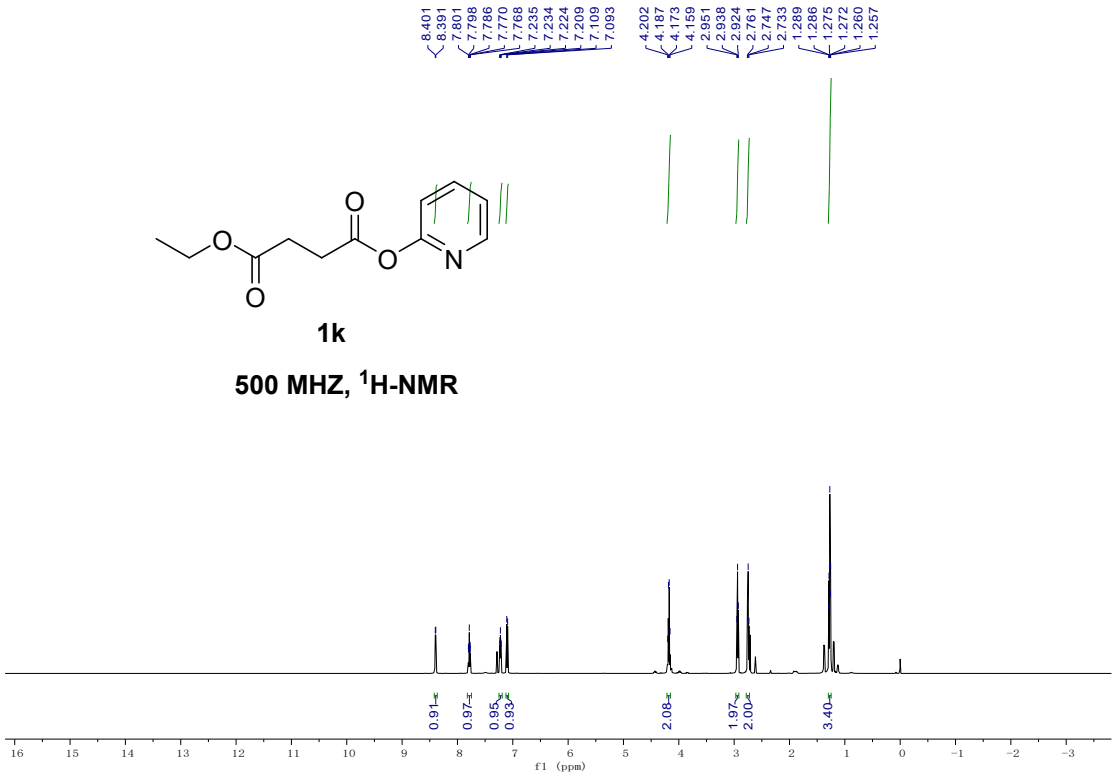
1j

500 MHZ, ^{1}H-NMR



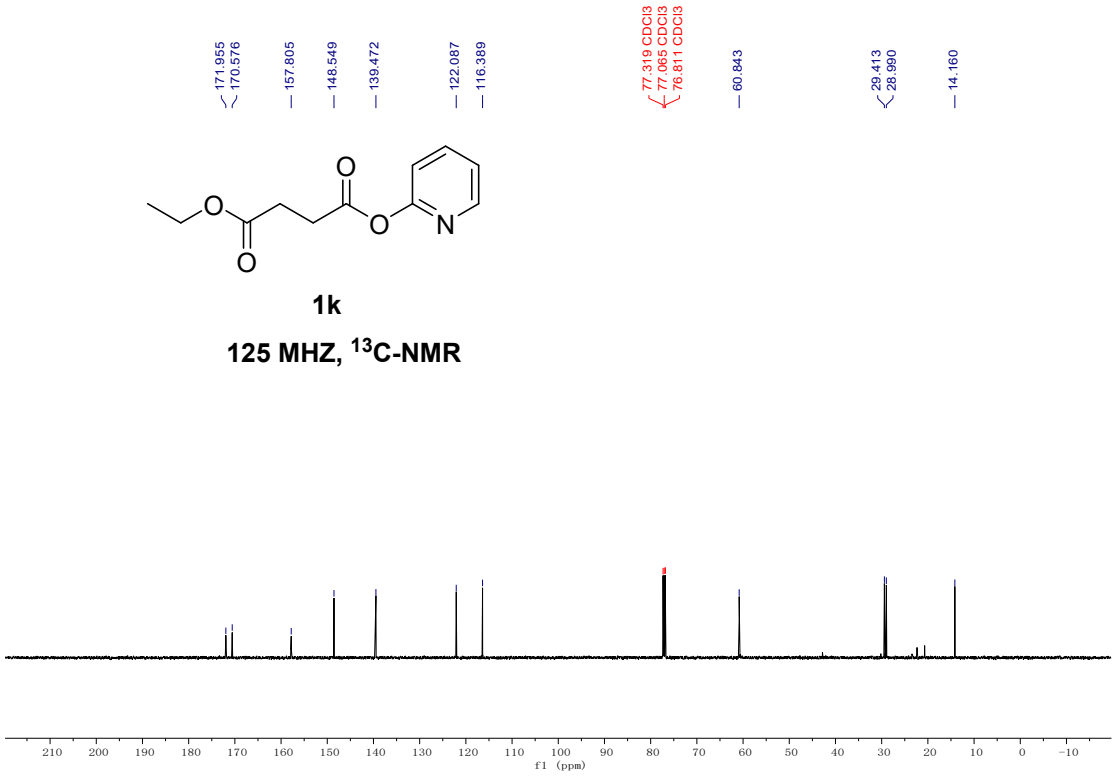
1j

125 MHZ, ^{13}C-NMR



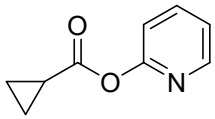
1k

500 MHZ, ^{1}H-NMR



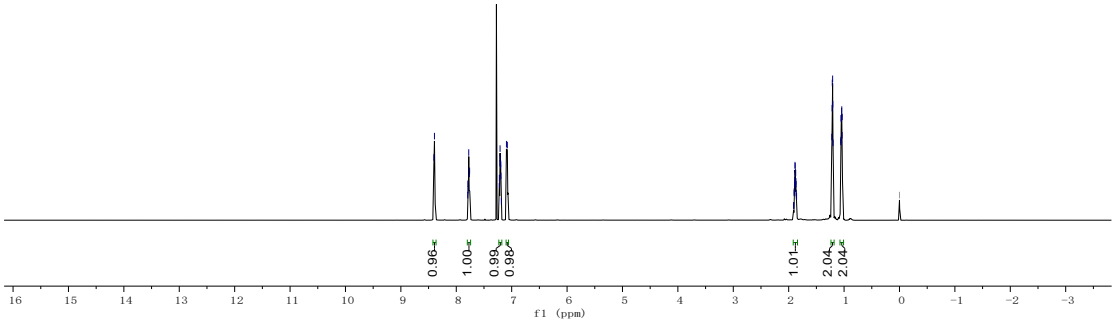
1k

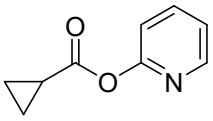
125 MHZ, ^{13}C-NMR



1l

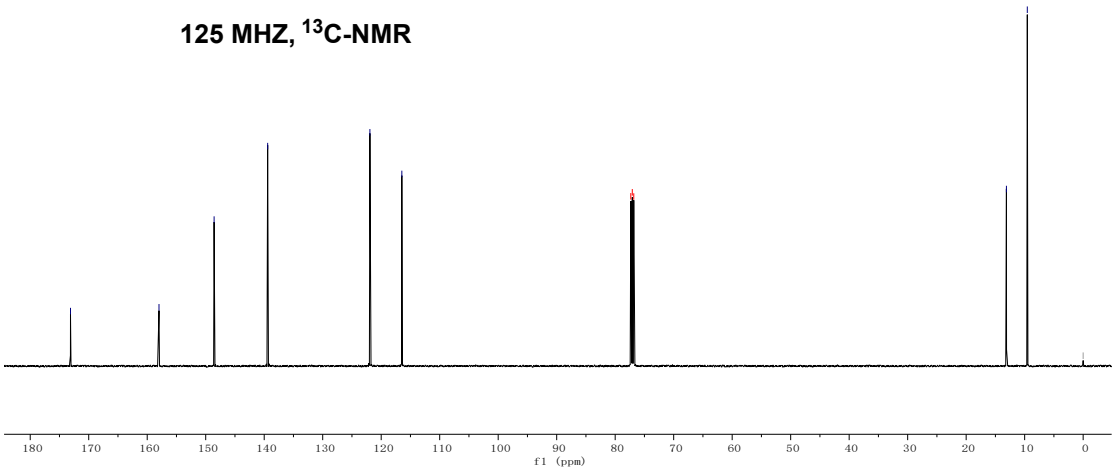
500 MHZ, ^{1}H-NMR

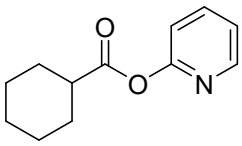




1l

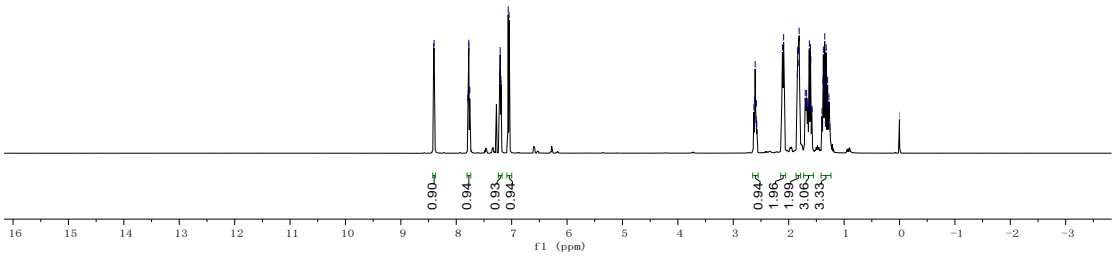
125 MHZ, ^{13}C-NMR

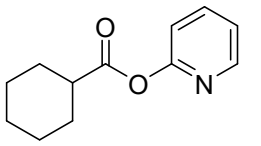




1m

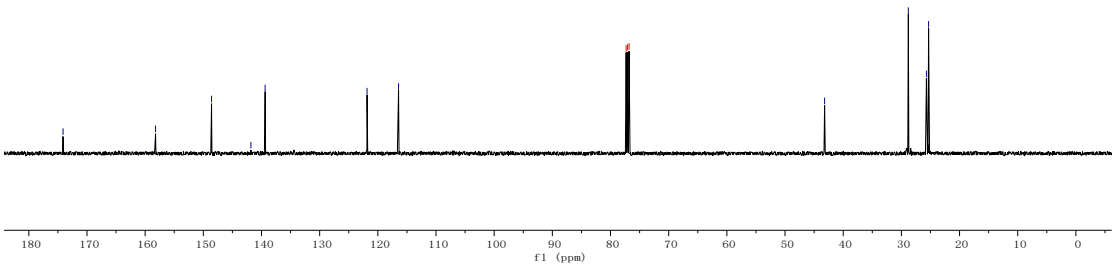
500 MHZ, ^{1}H-NMR

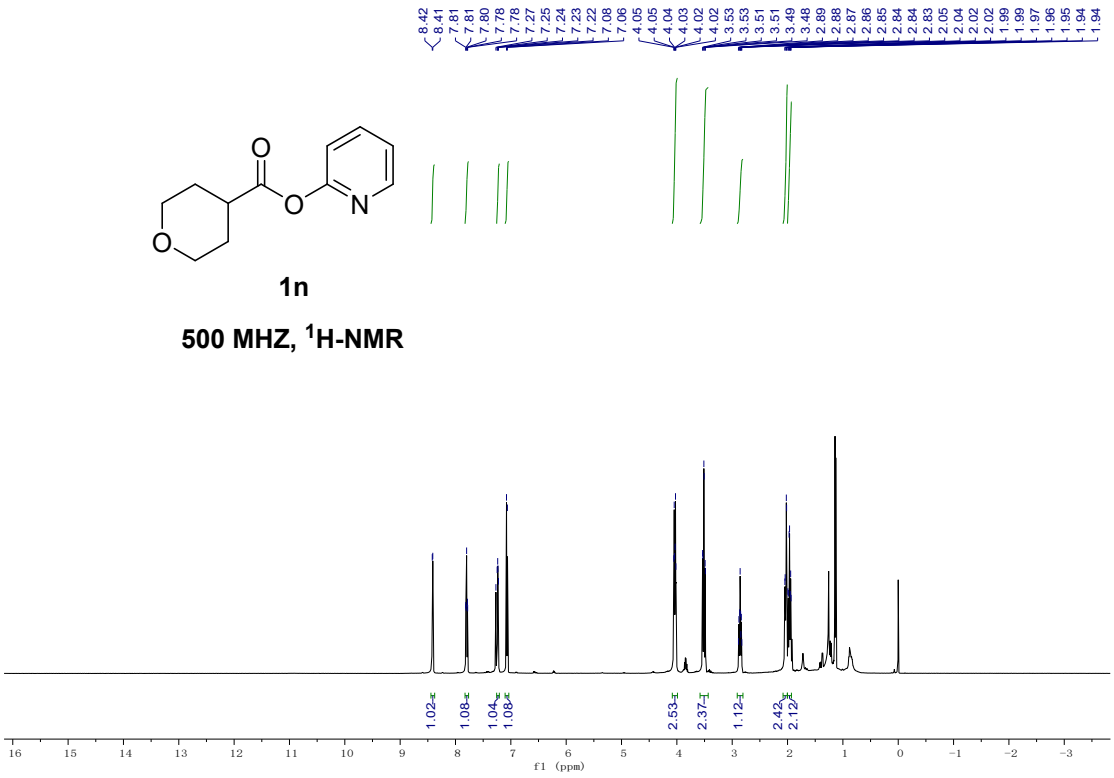




1m

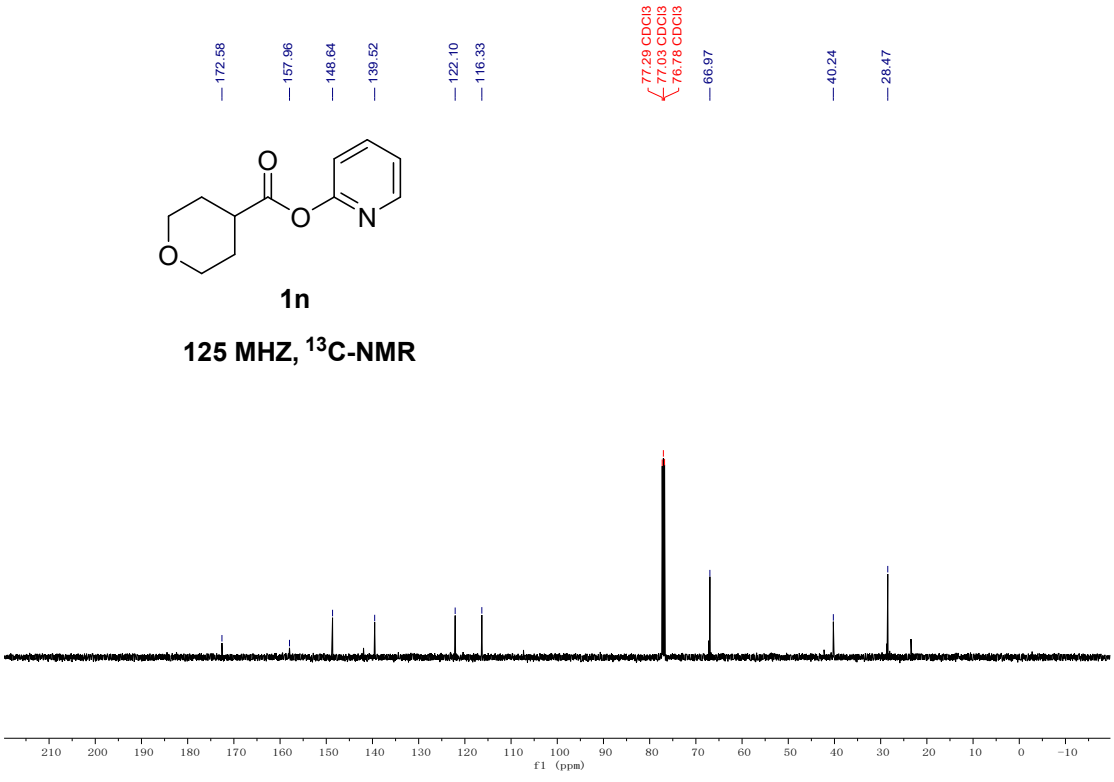
125 MHZ, ^{13}C-NMR





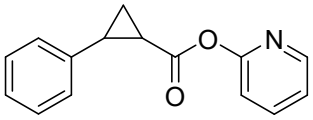
1n

500 MHZ, ^{1}H-NMR



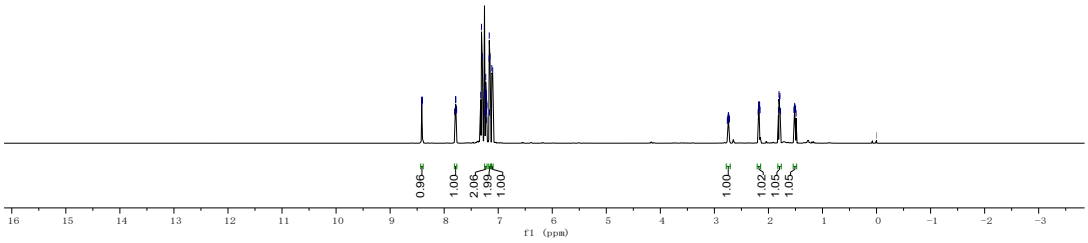
1n

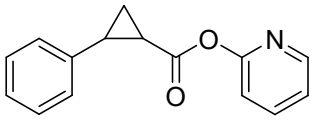
125 MHZ, ^{13}C-NMR



1o

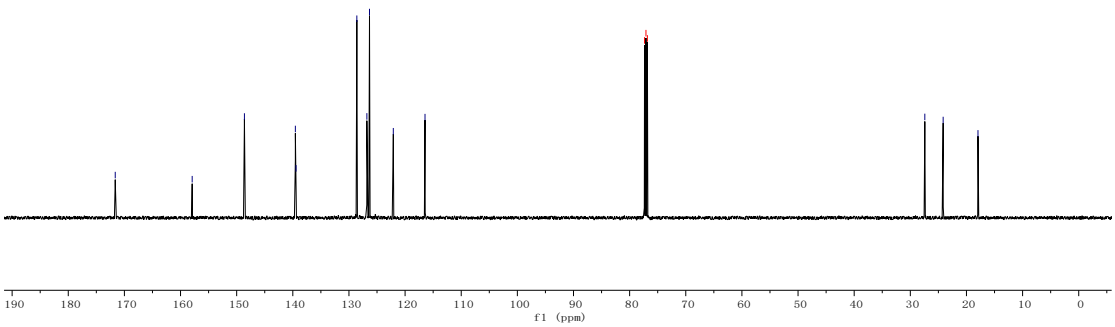
500 MHZ, ^{1}H-NMR

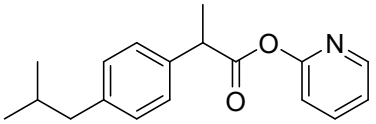




1o

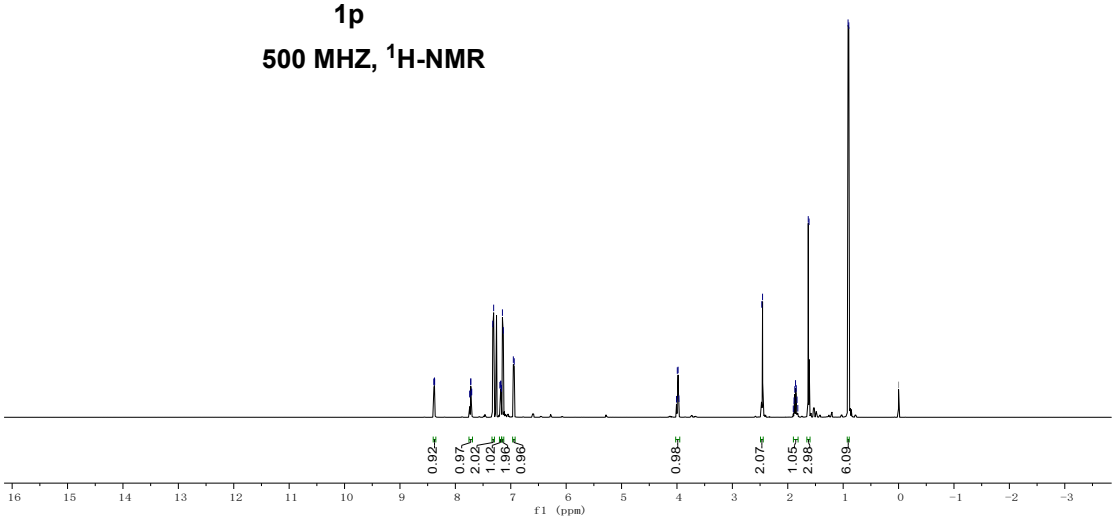
125 MHZ, ^{13}C-NMR

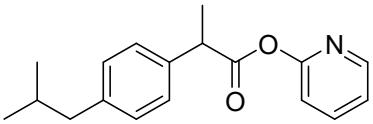




1p

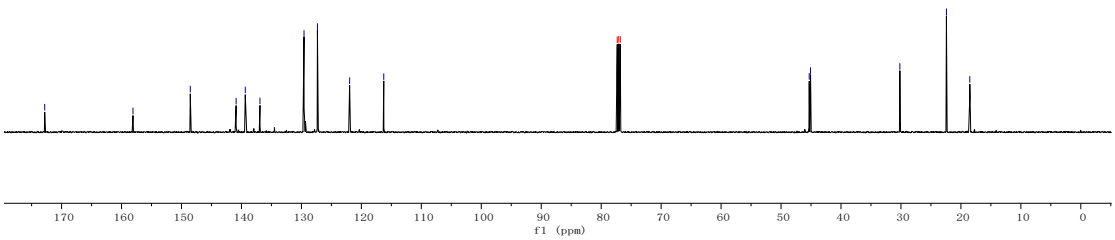
500 MHZ, ^{1}H-NMR

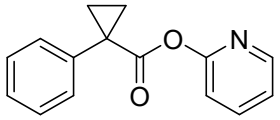




1p

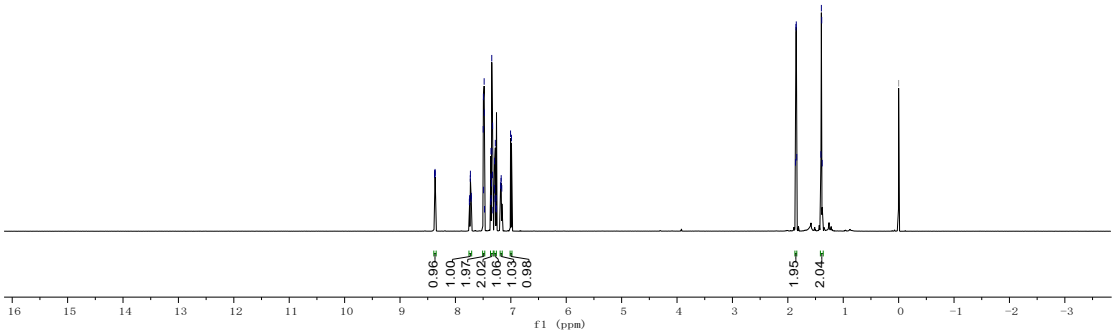
125 MHZ, ^{13}C-NMR

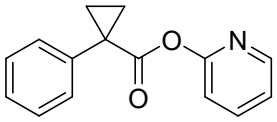




1q

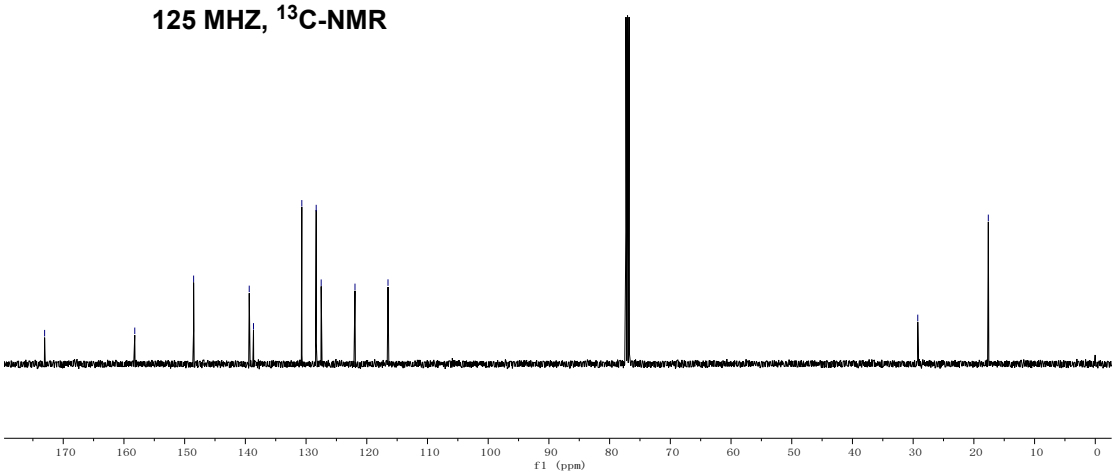
500 MHZ, ^{1}H-NMR

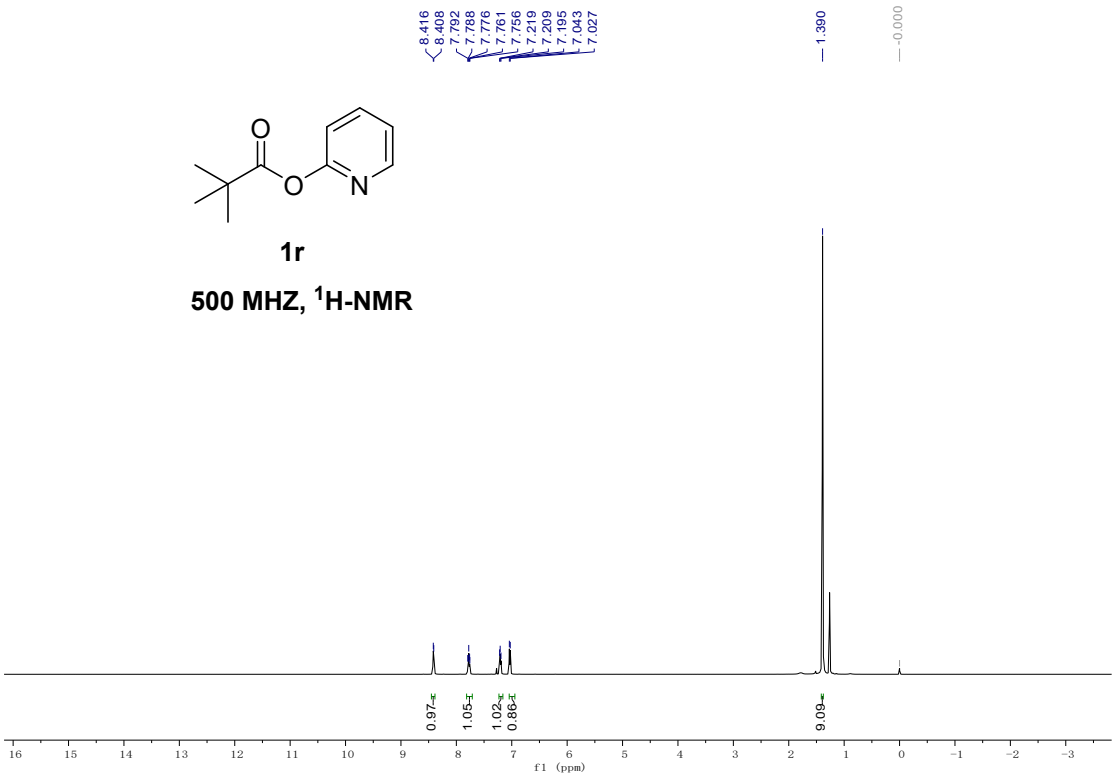




1q

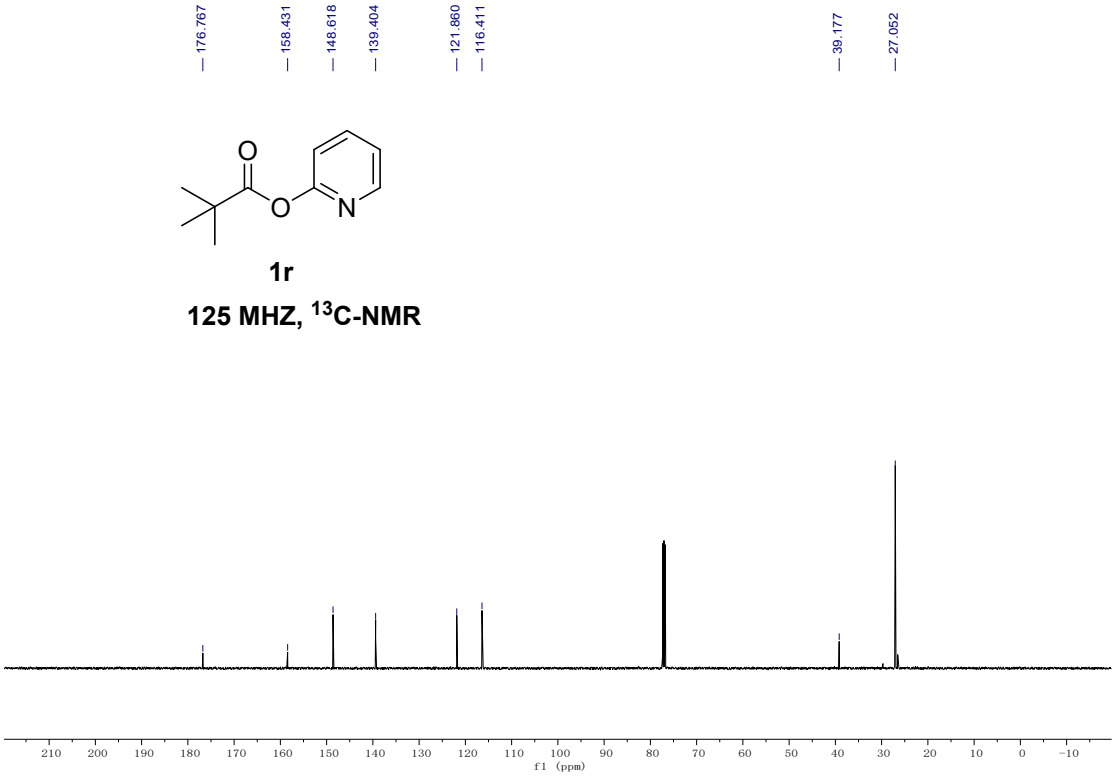
125 MHZ, ^{13}C-NMR





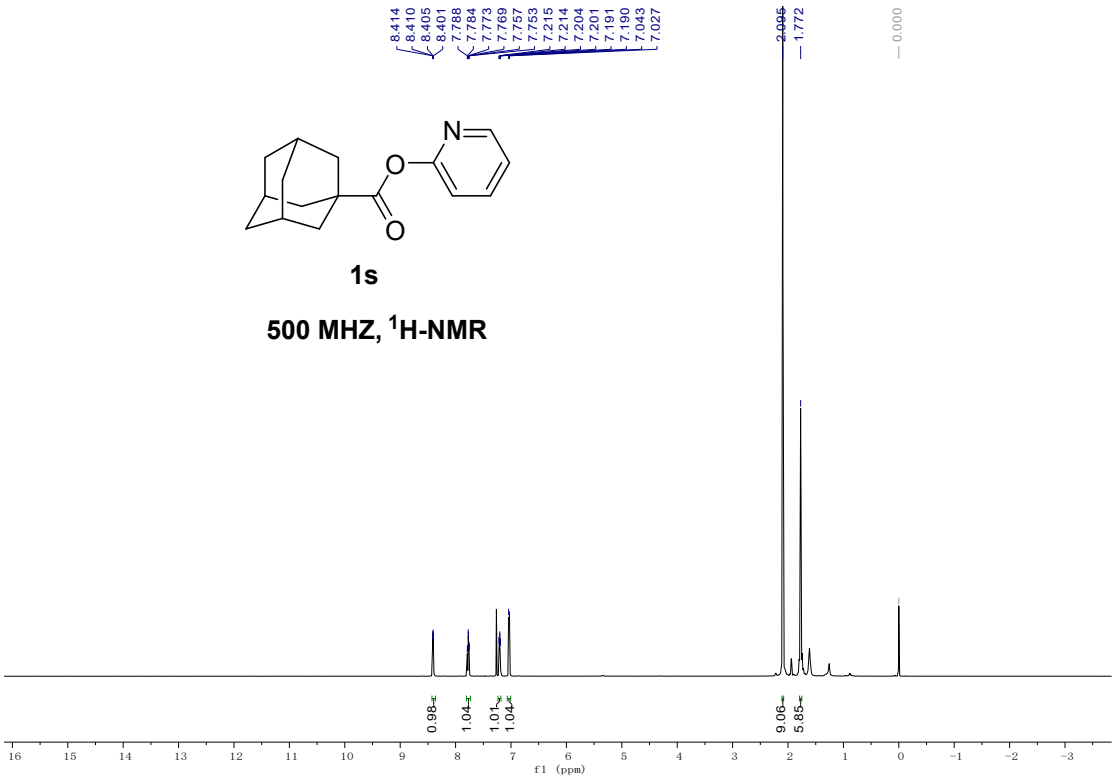
1r

500 MHZ, ^{1}H-NMR



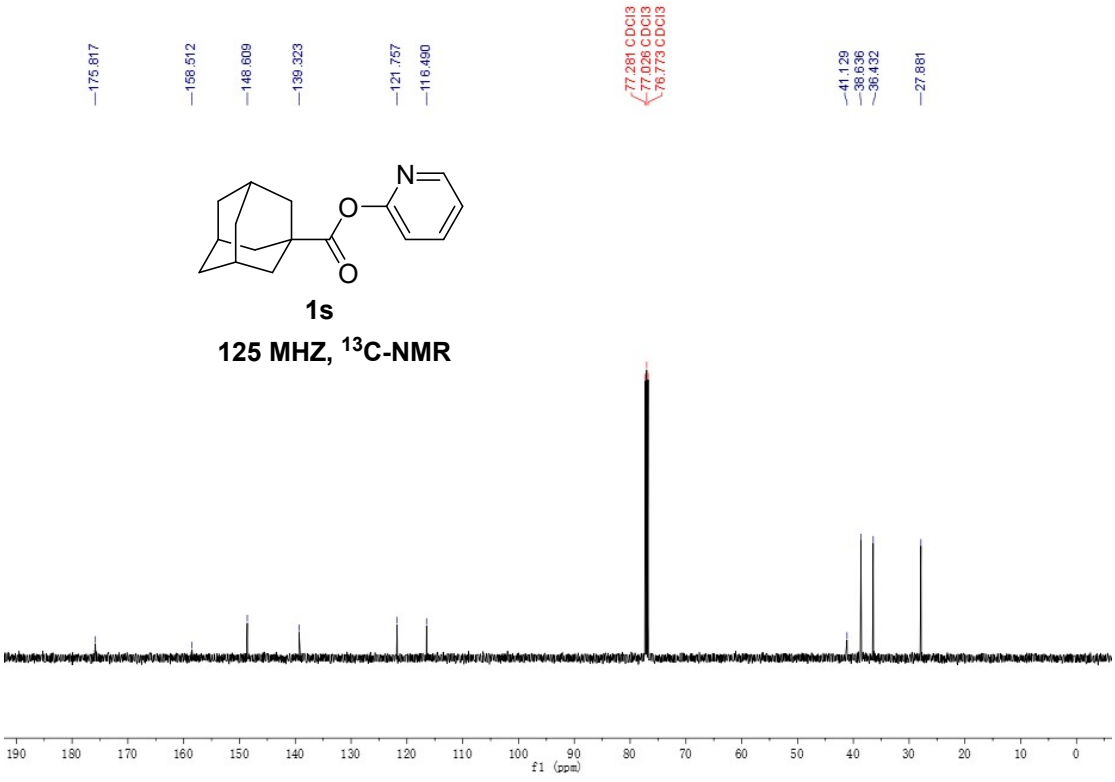
1r

125 MHZ, ^{13}C-NMR



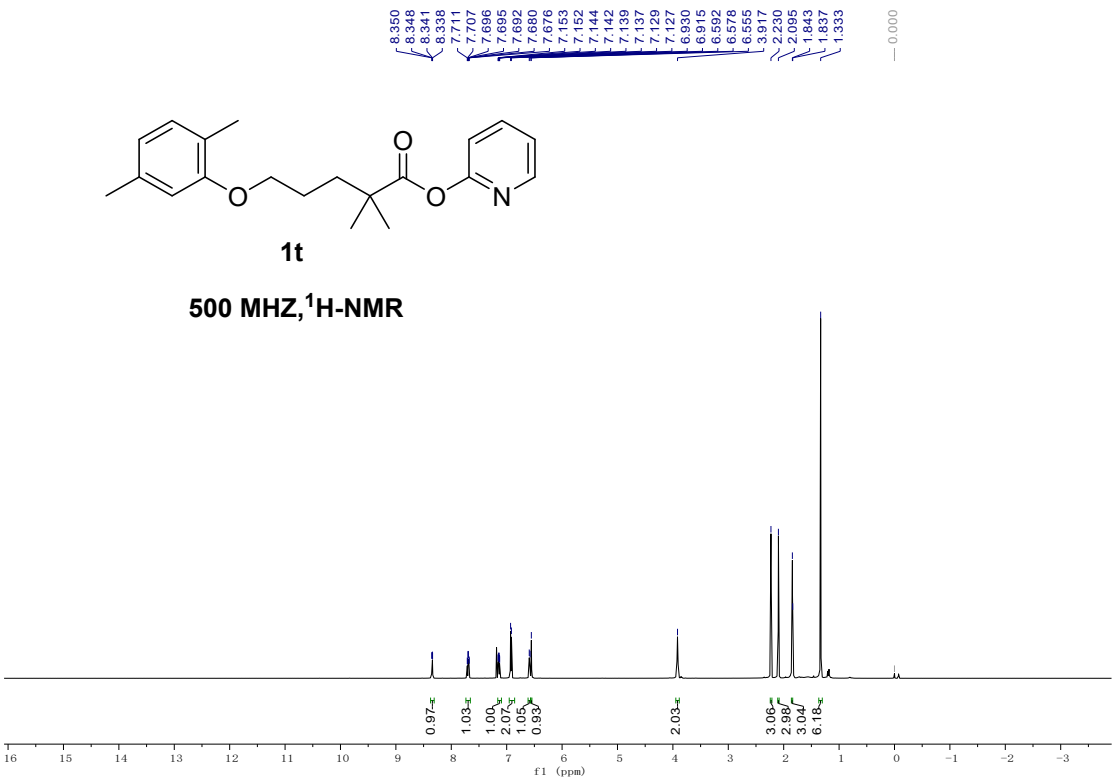
1s

500 MHZ, ^{1}H-NMR



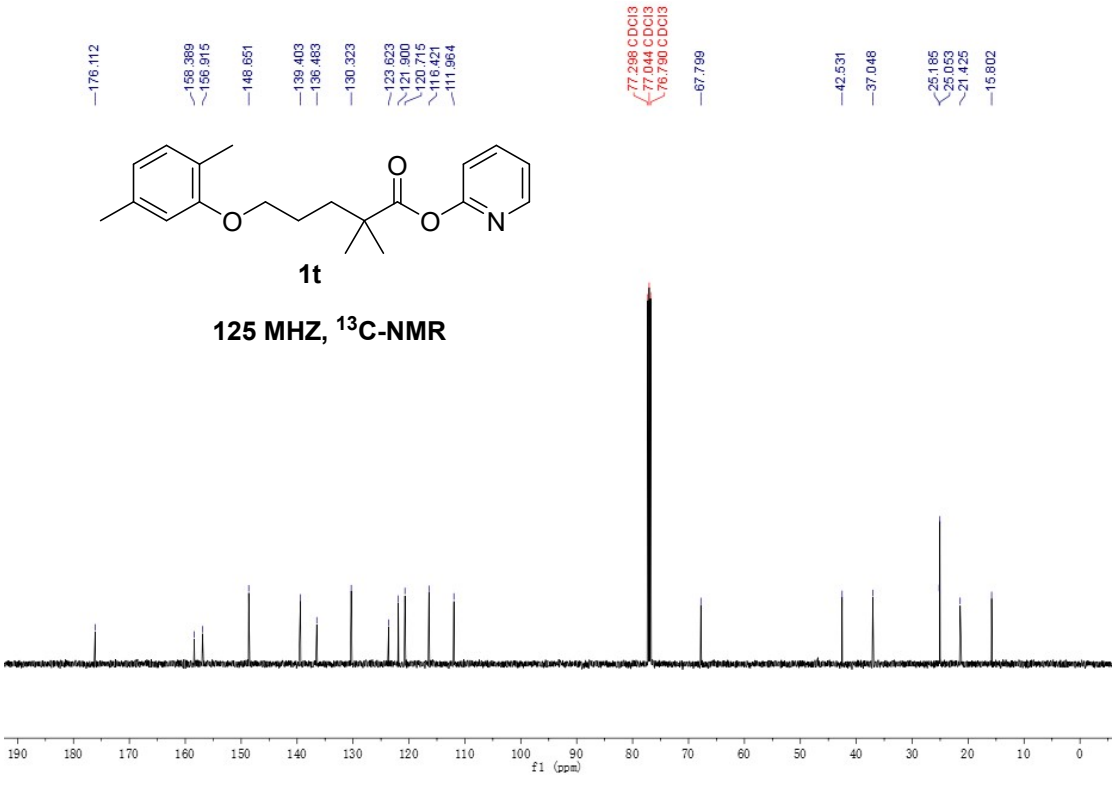
1s

125 MHZ, ^{13}C-NMR



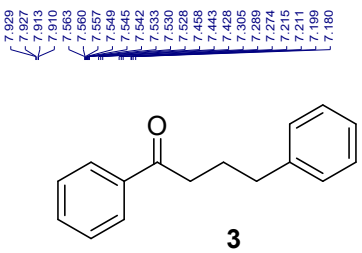
1t

500 MHZ,^{1}H-NMR



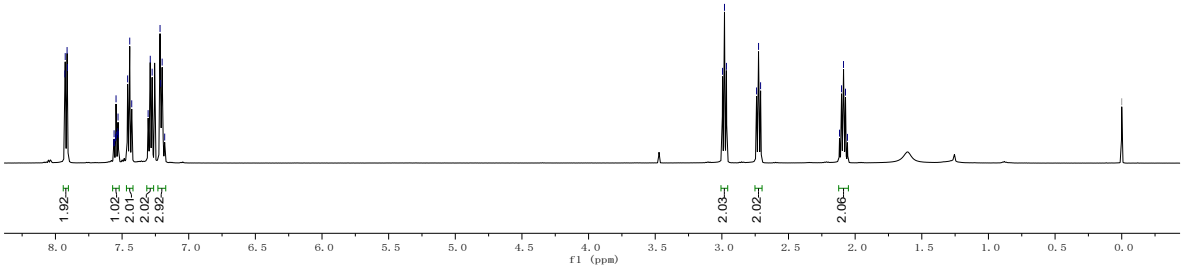
1t

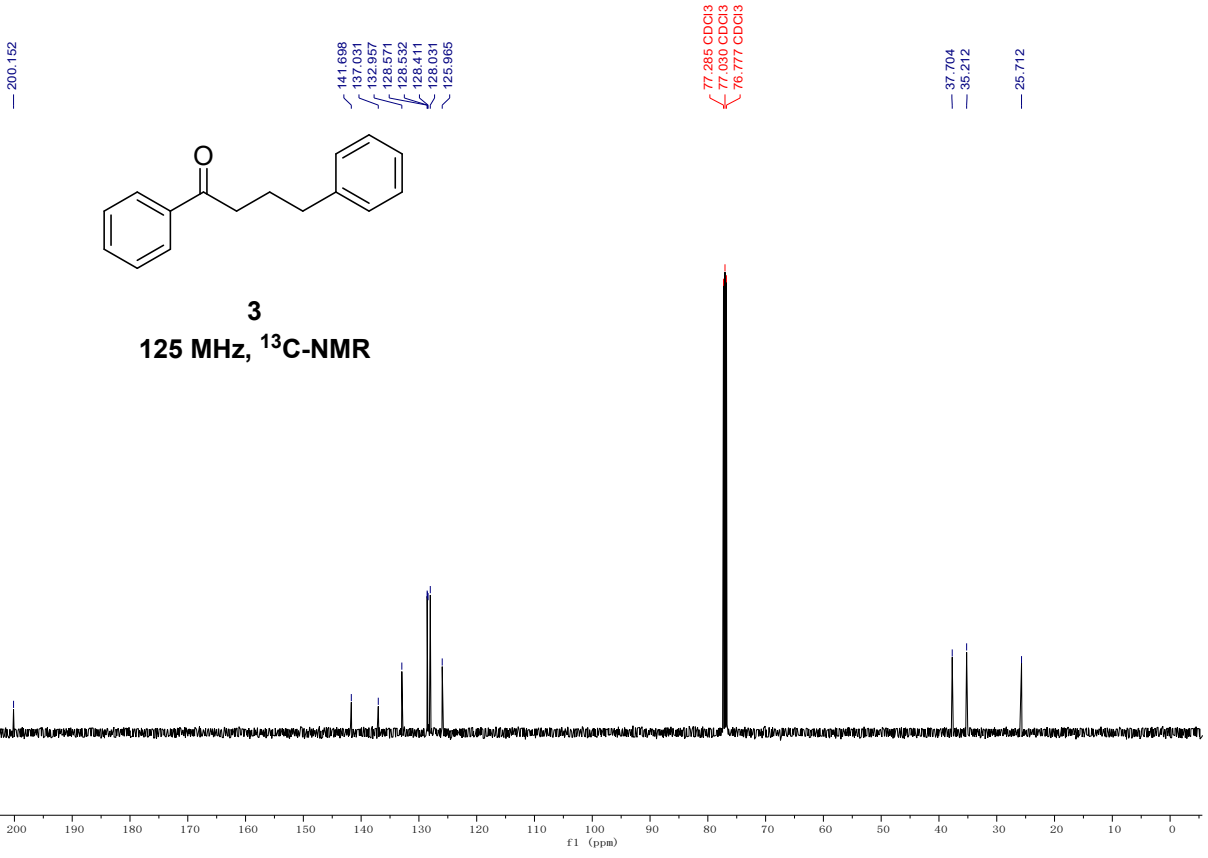
125 MHZ, ^{13}C-NMR



3

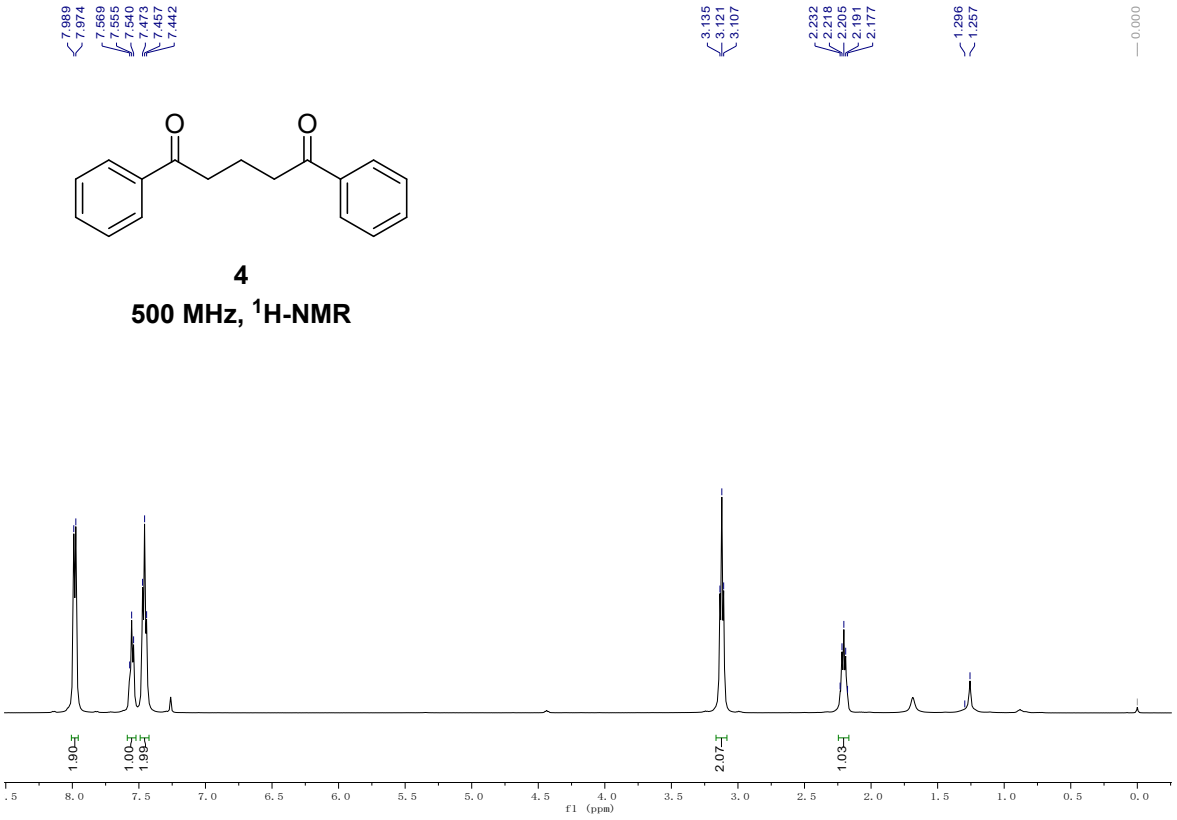
500 MHz, ^{1}H-NMR





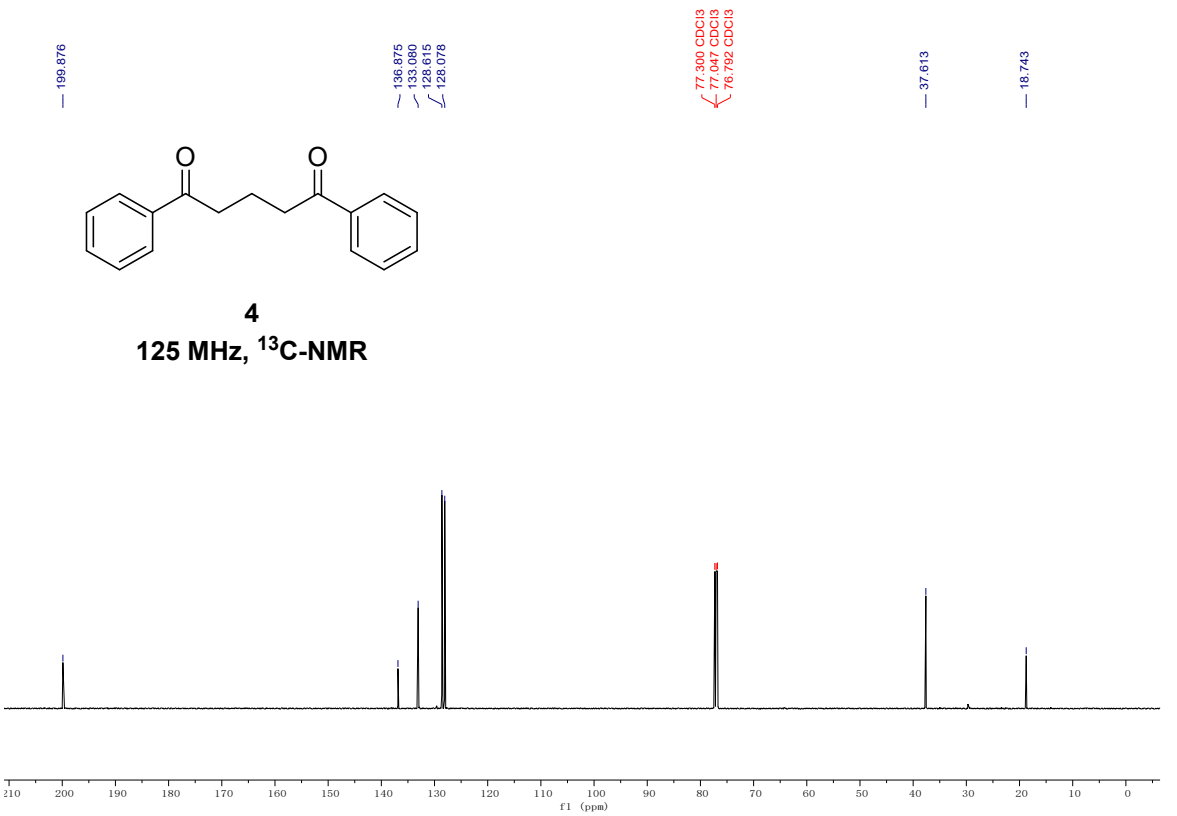
3

125 MHz, ^{13}C-NMR



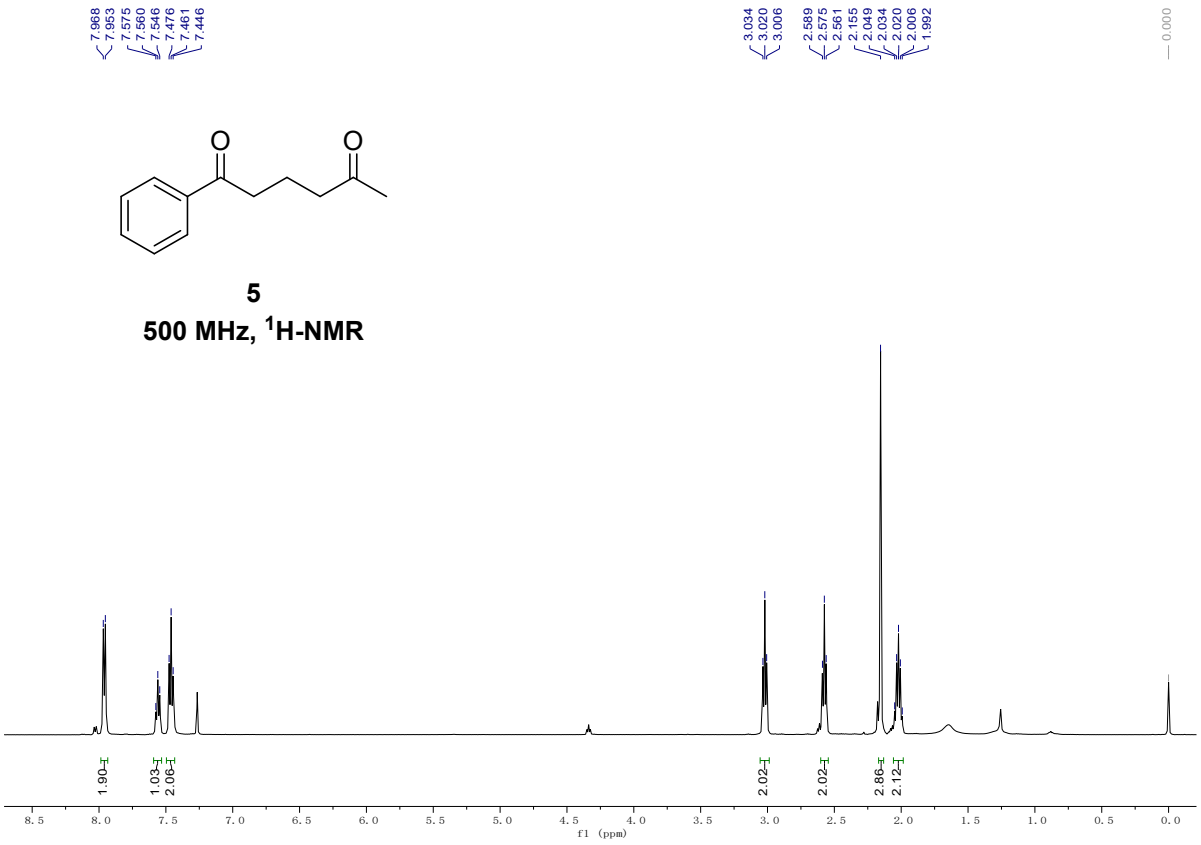
4

500 MHz, ^{1}H-NMR



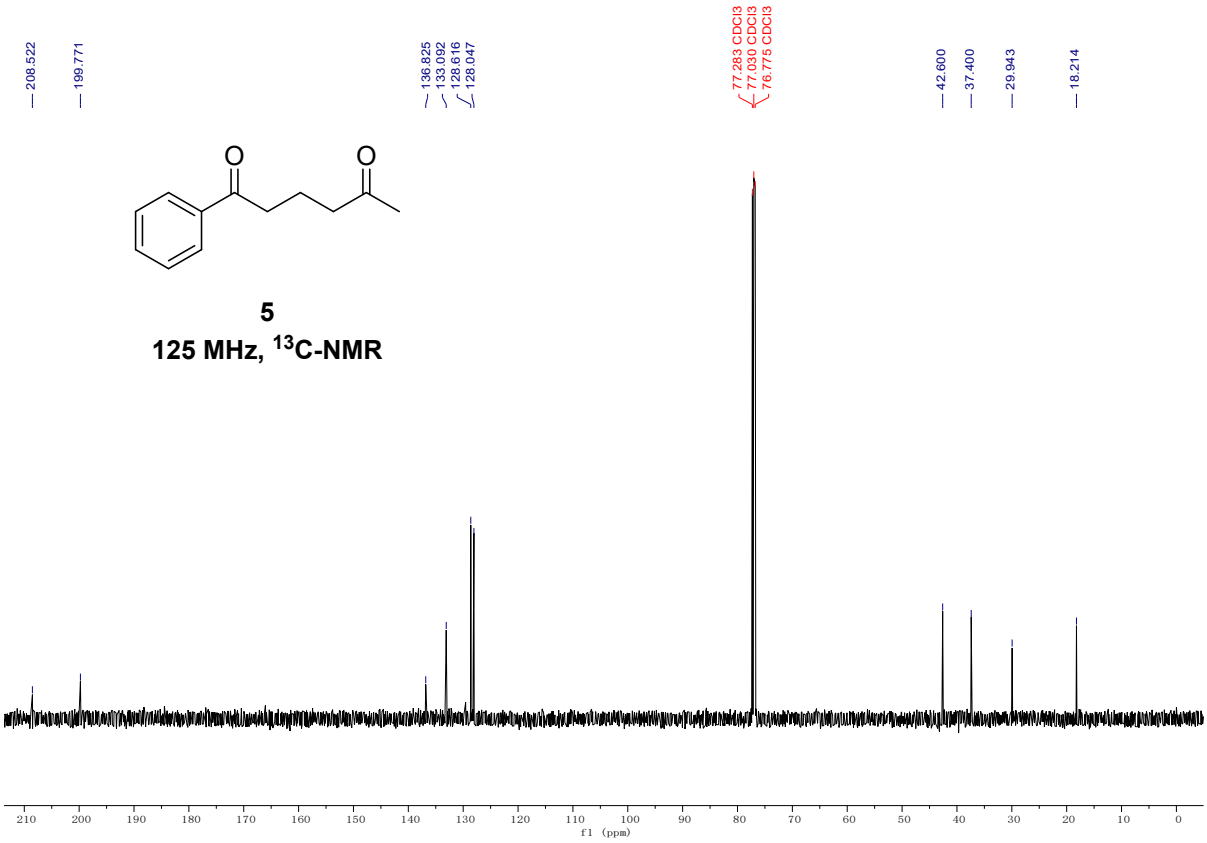
4

125 MHz, ^{13}C-NMR



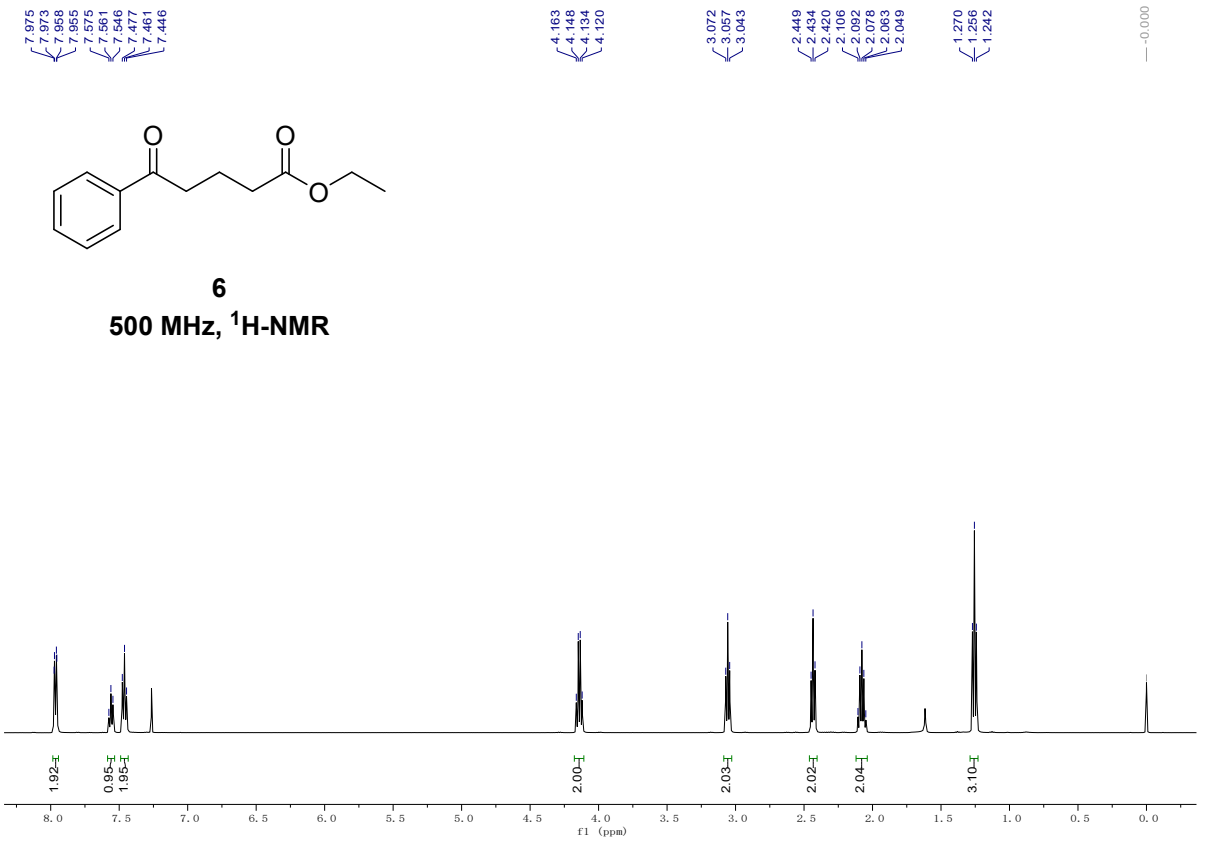
5

500 MHz, ^{1}H-NMR



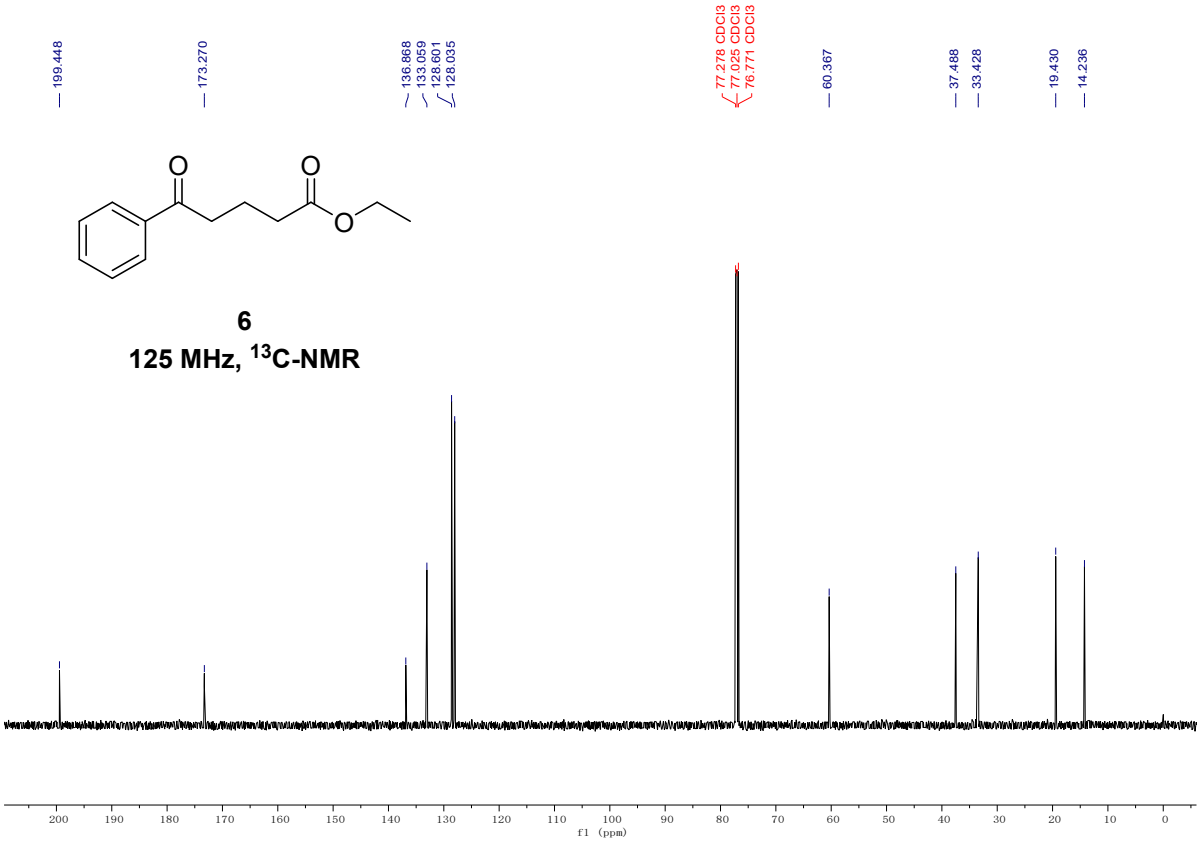
5

125 MHz, ^{13}C-NMR



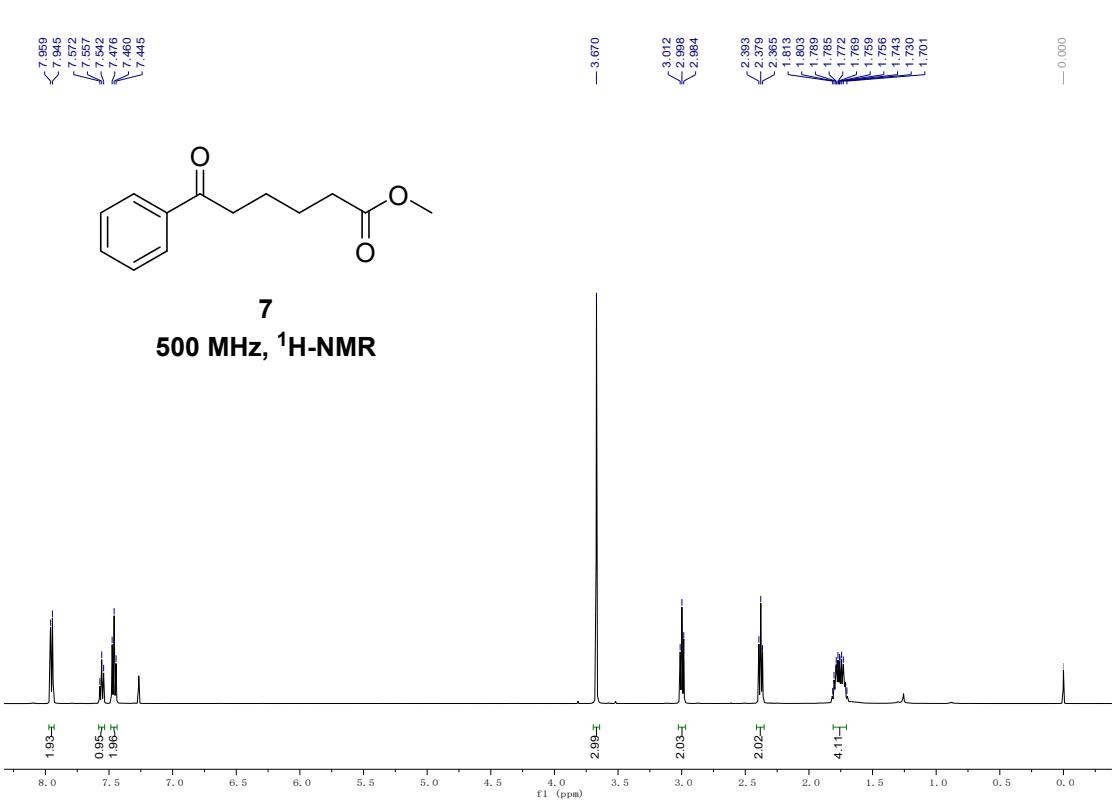
6

500 MHz, ^{1}H-NMR



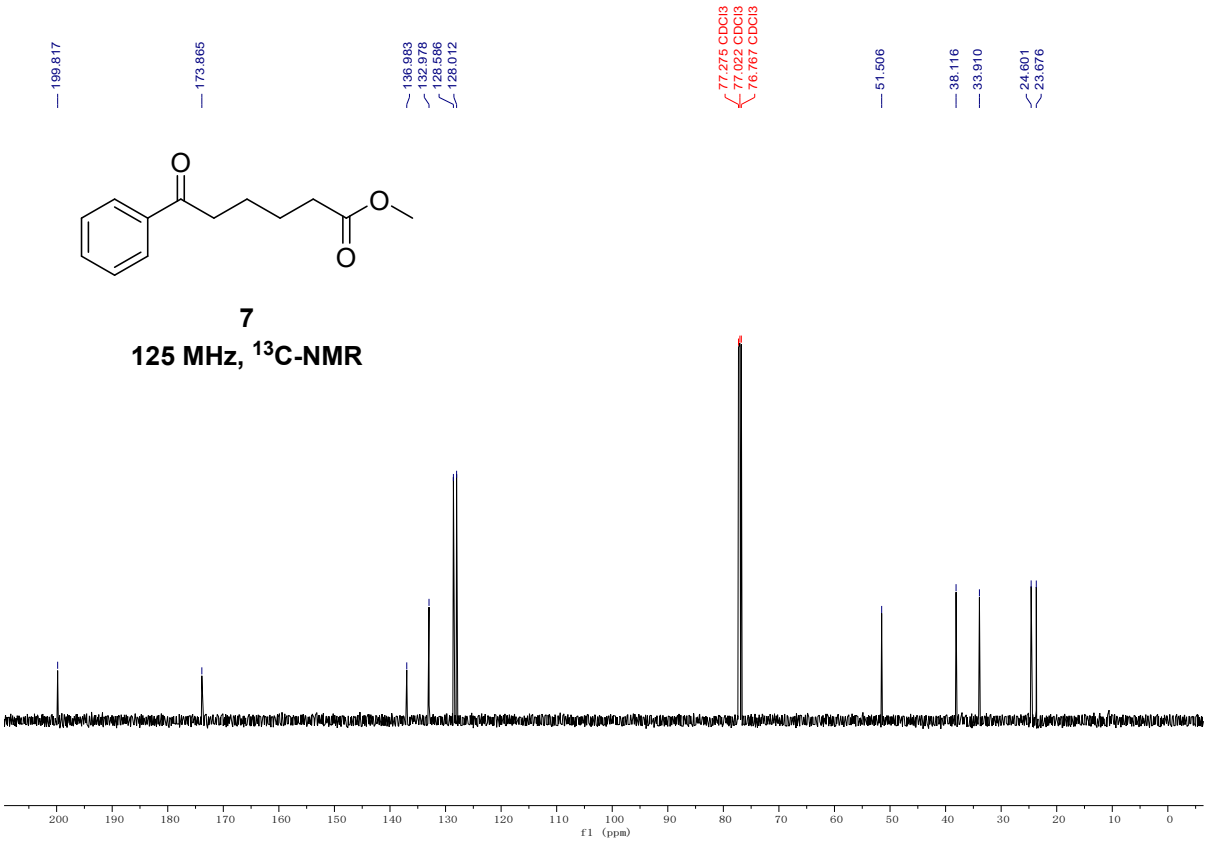
6

125 MHz, ^{13}C-NMR



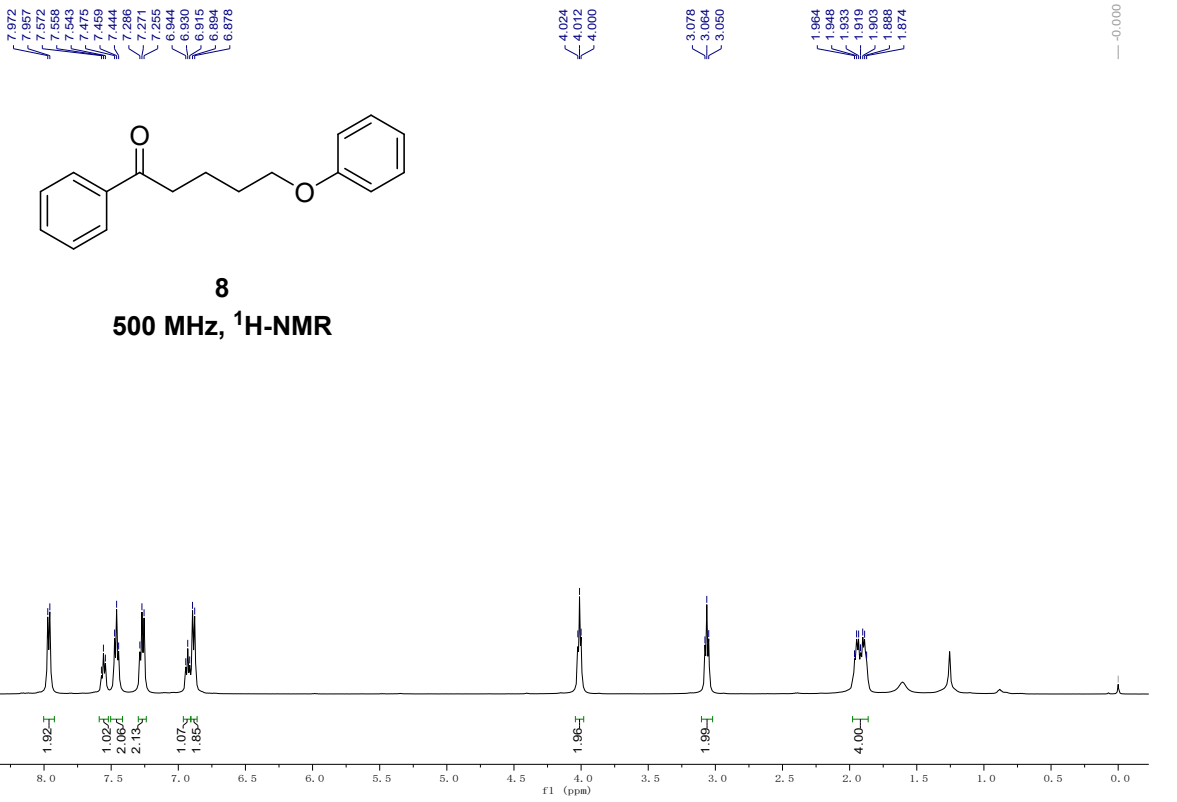
7

500 MHz, ^{1}H-NMR



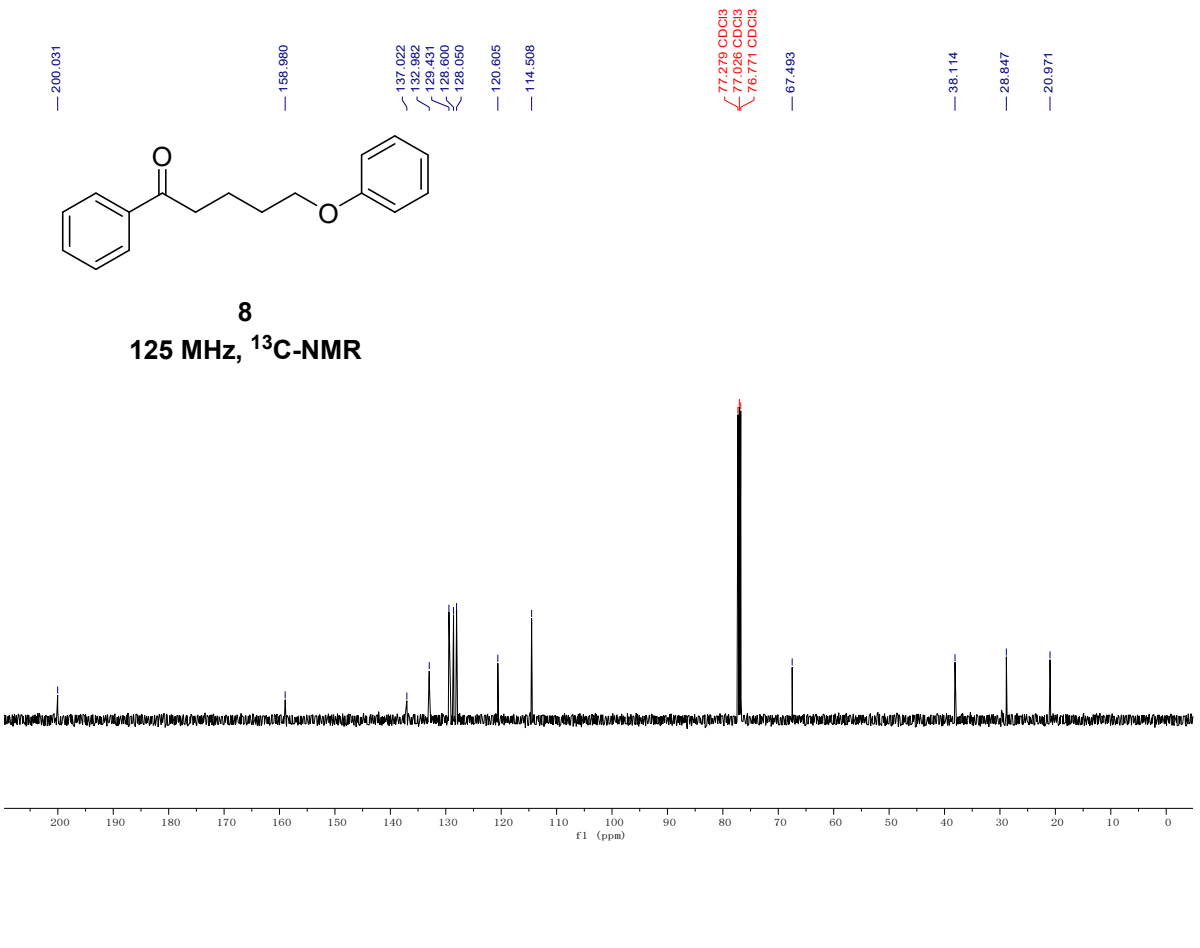
7

125 MHz, ^{13}C-NMR



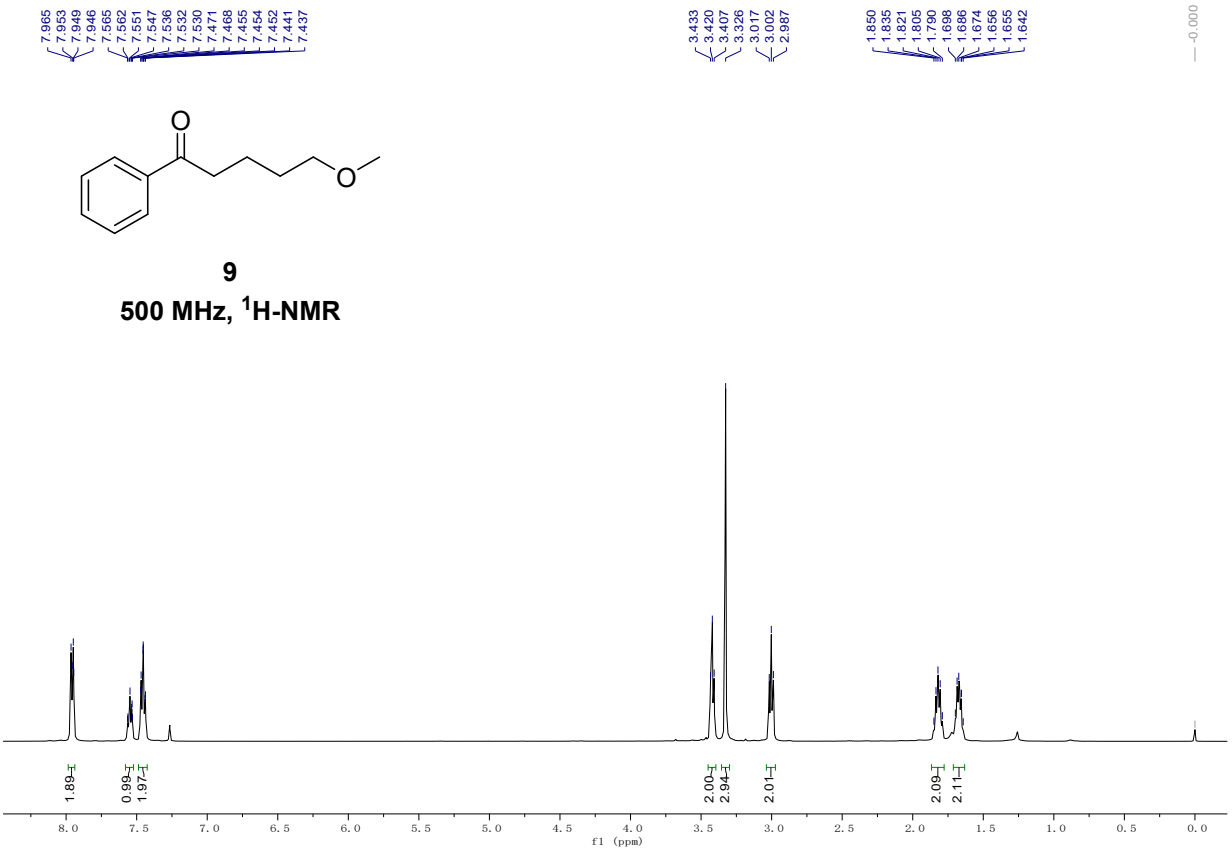
8

500 MHz, ^{1}H-NMR



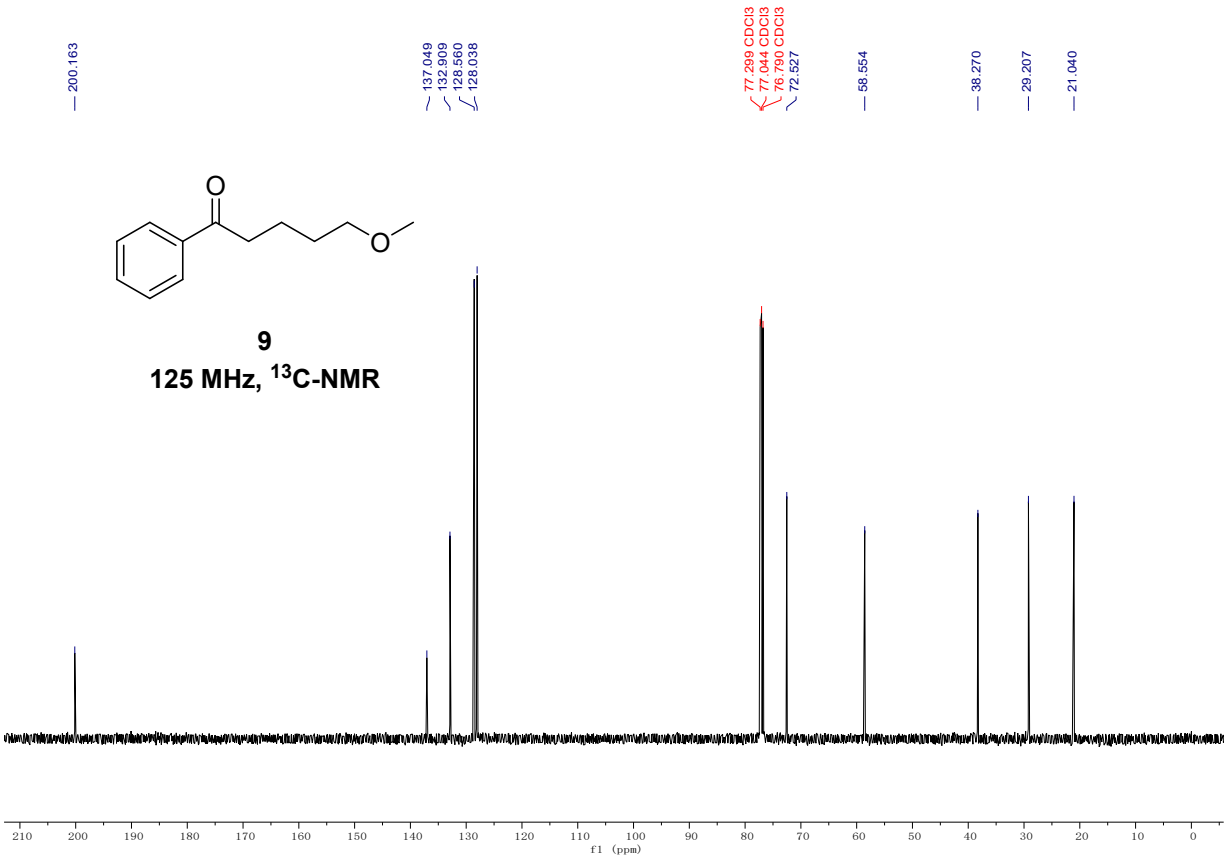
8

125 MHz, ^{13}C-NMR



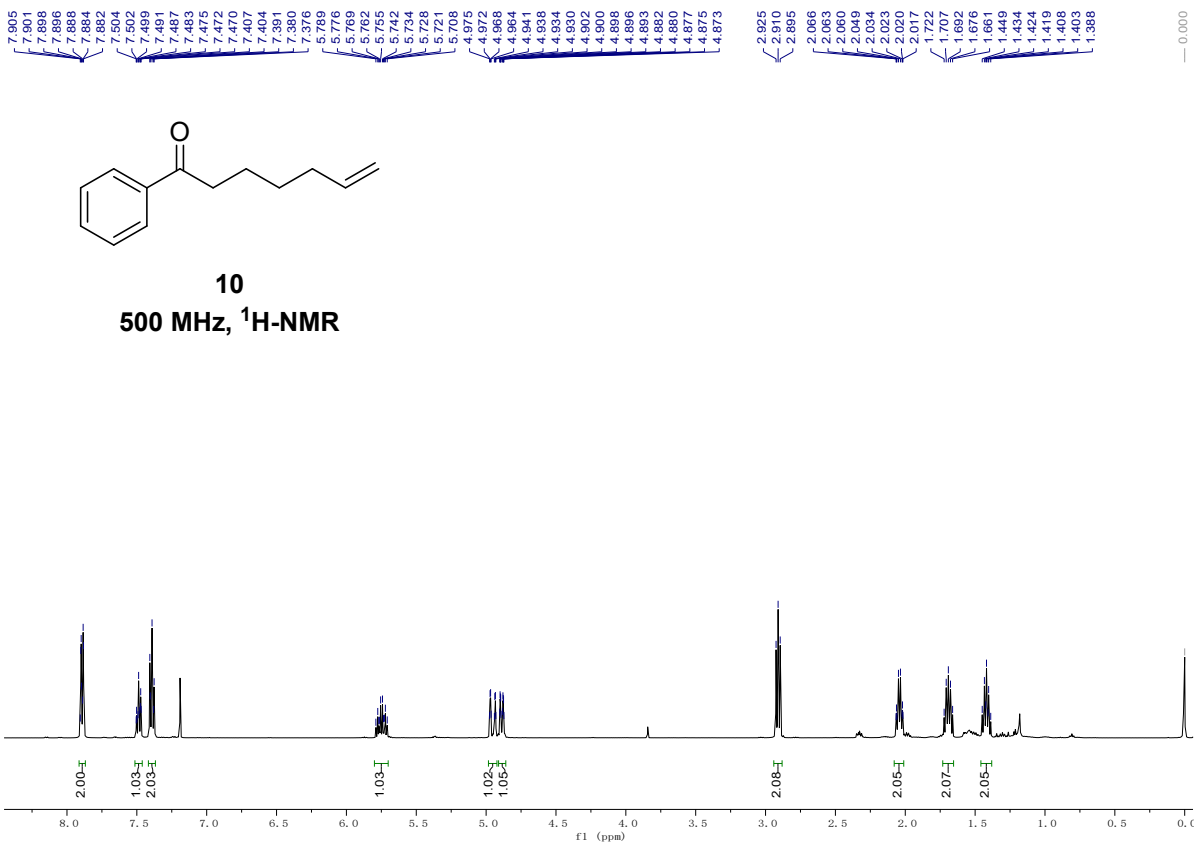
9

500 MHz, ^{1}H-NMR



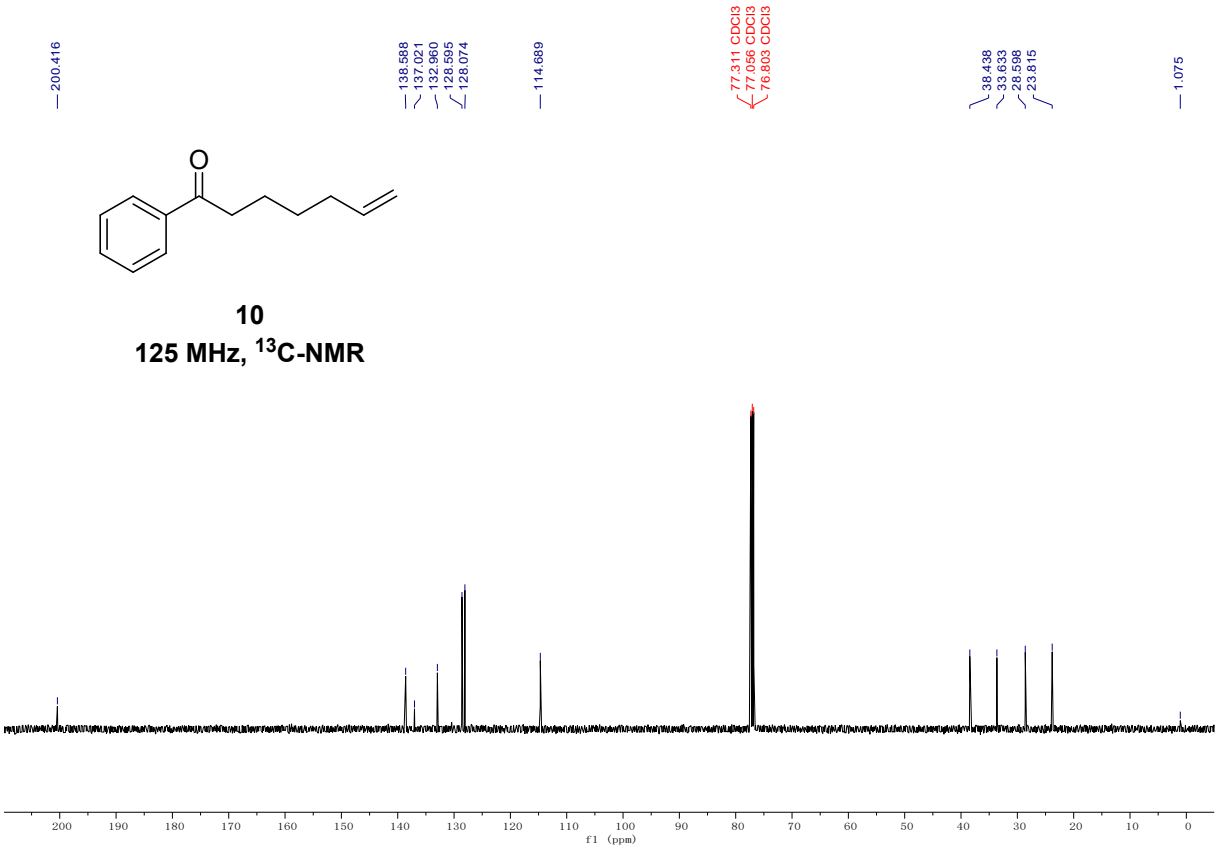
9

125 MHz, ^{13}C-NMR



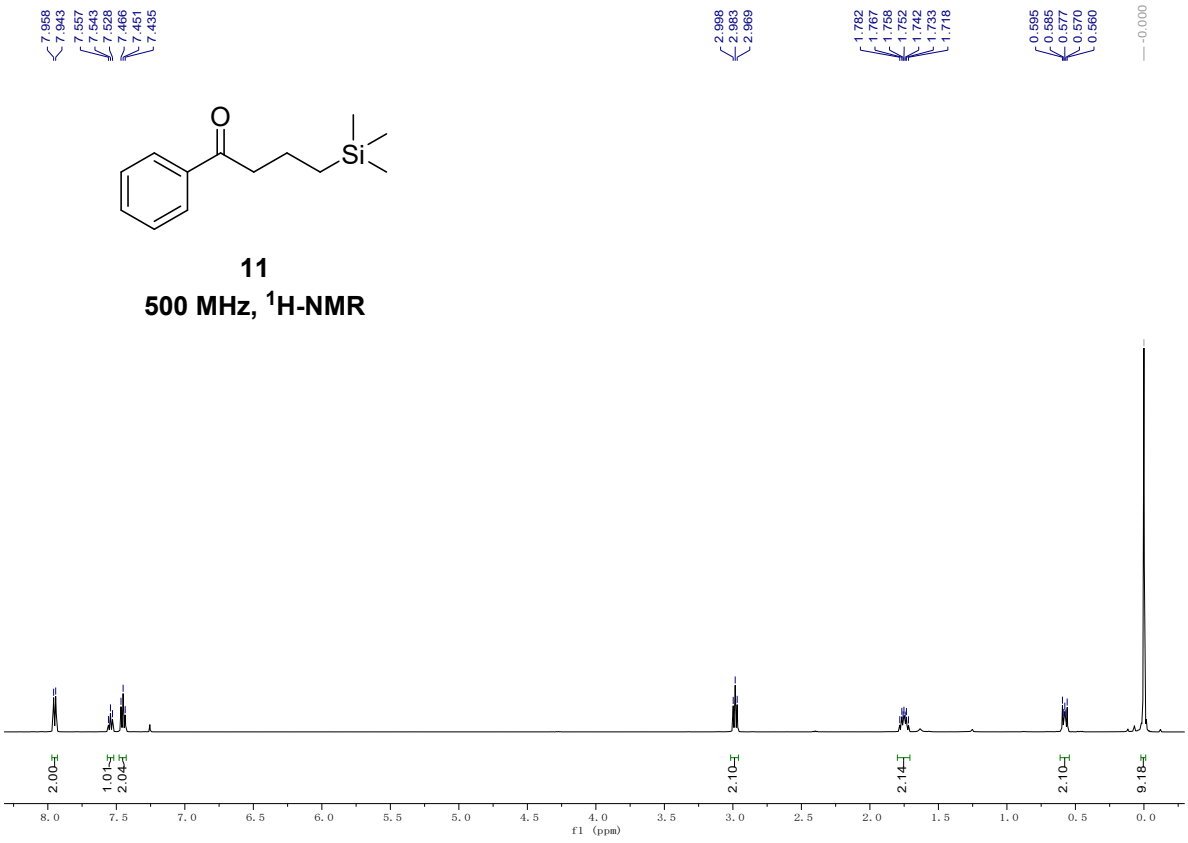
10

500 MHz, ^{1}H-NMR



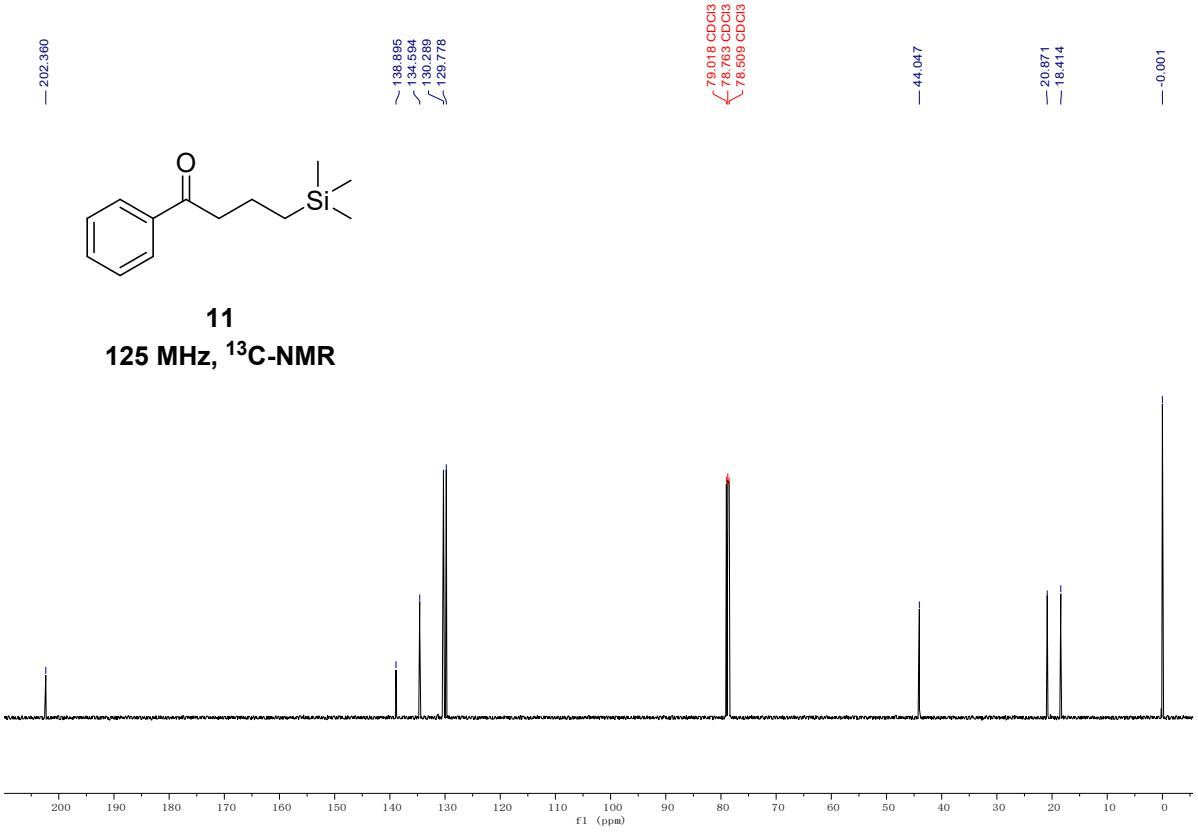
10

125 MHz, ^{13}C-NMR



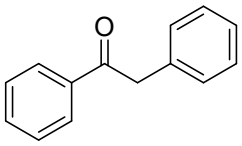
11

500 MHz, ^{1}H-NMR



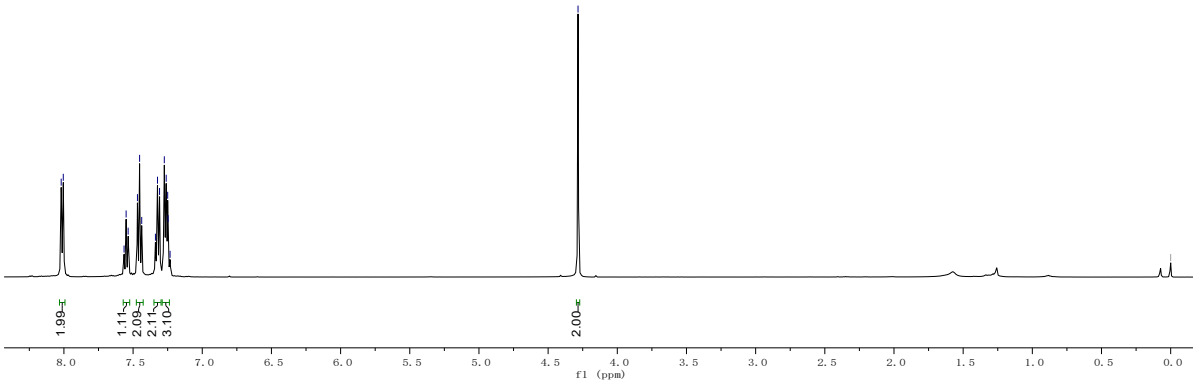
11

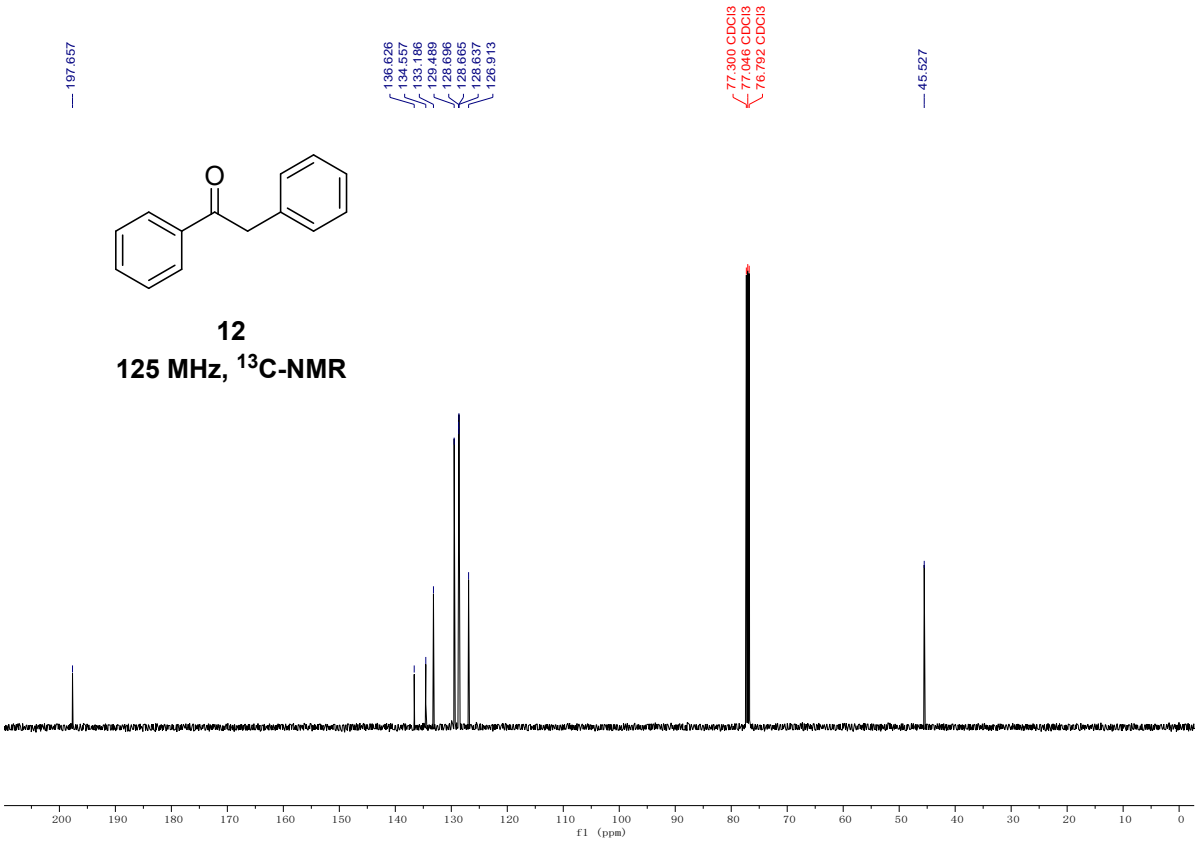
125 MHz, ^{13}C-NMR



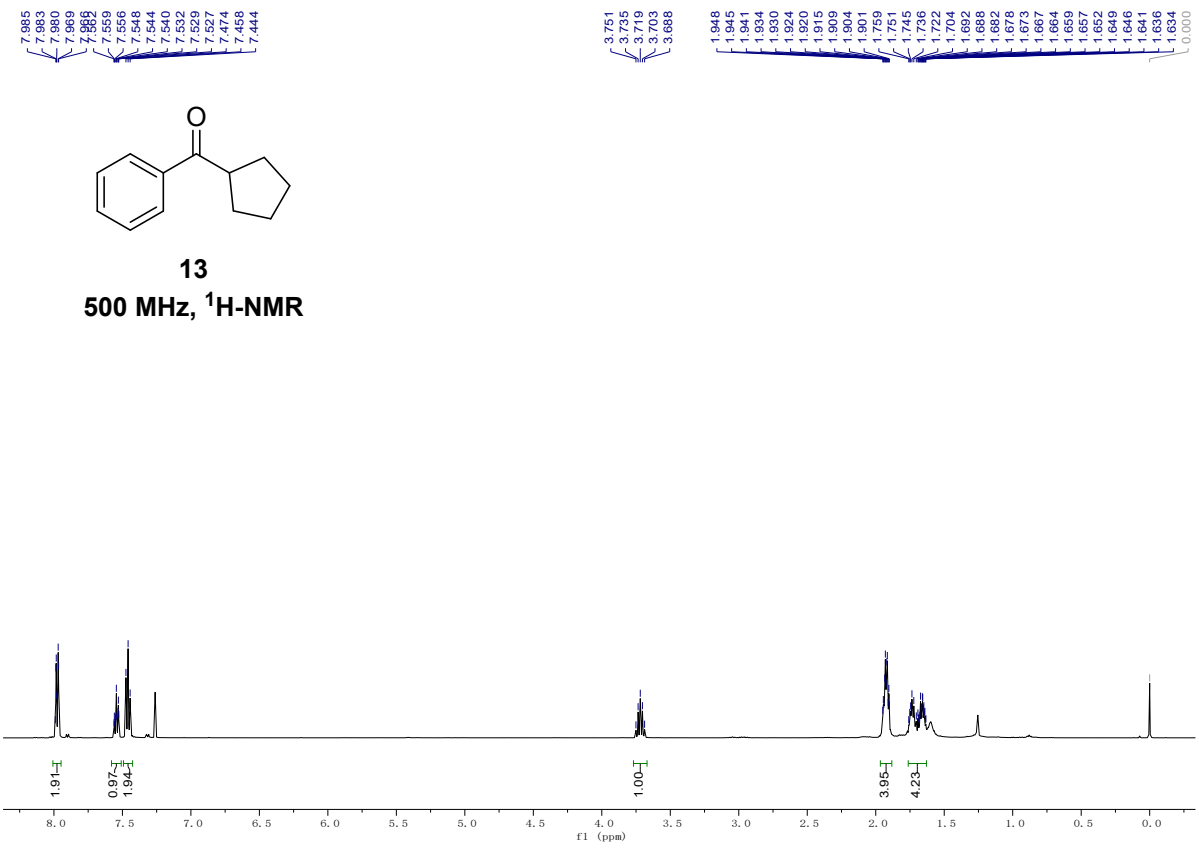
12

500 MHz, ^{1}H-NMR

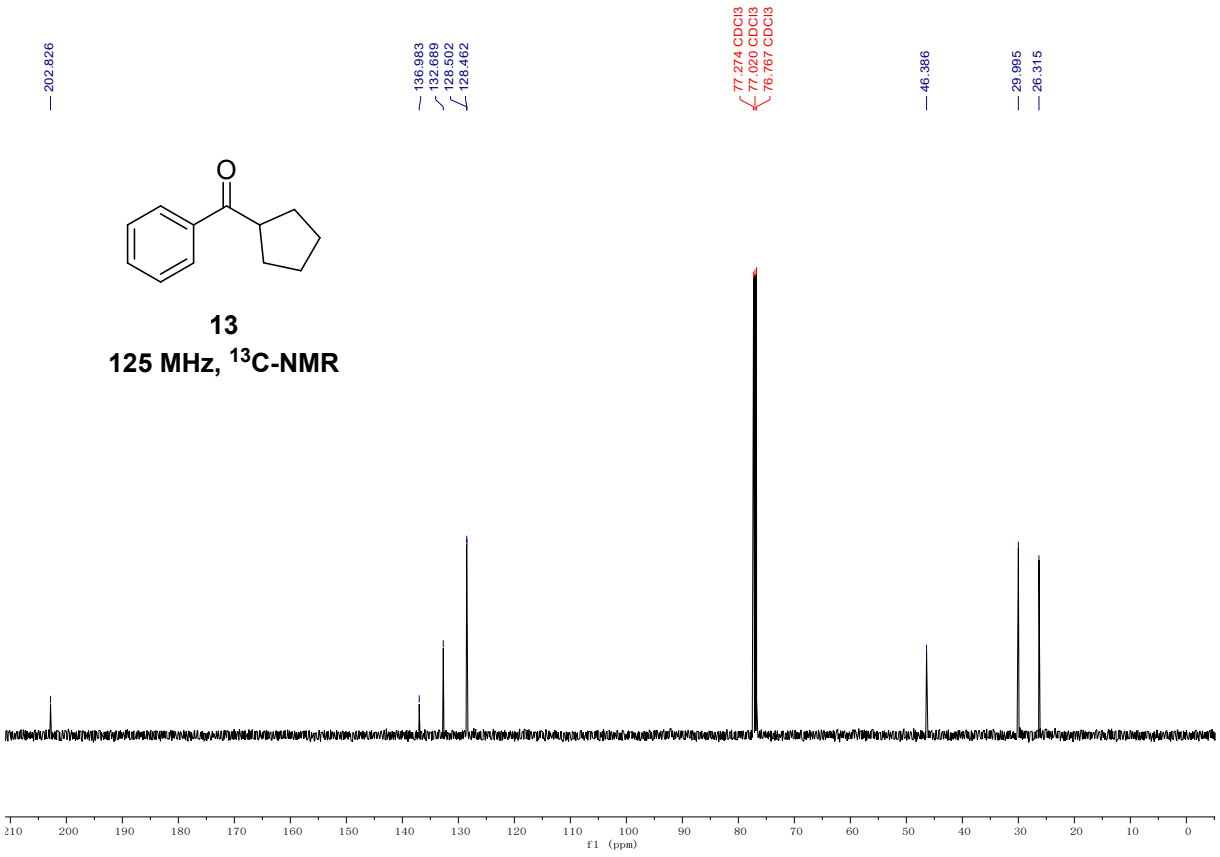


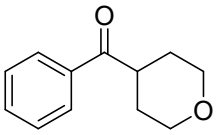


12
125 MHz, ^{13}C-NMR

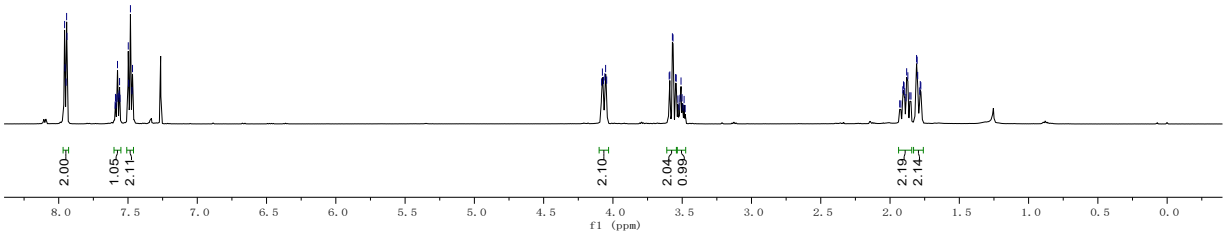


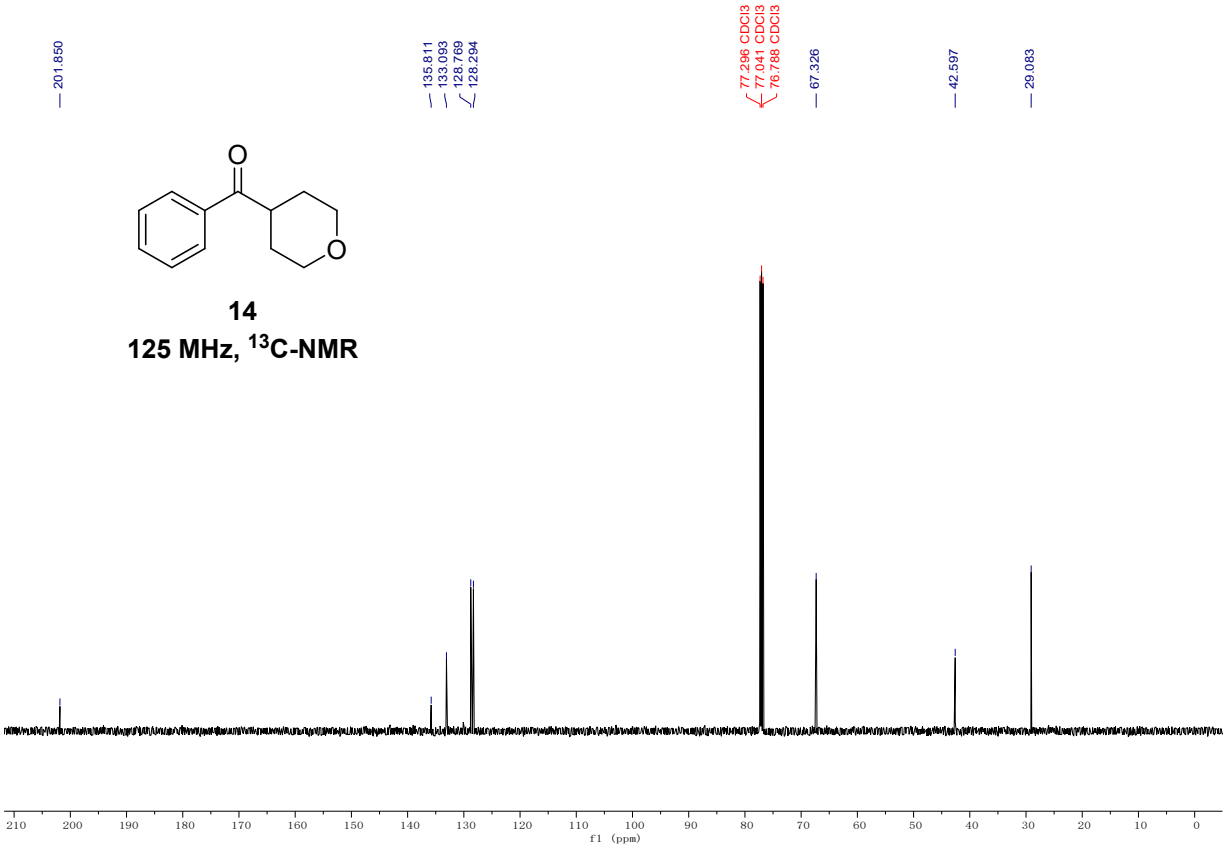
13
500 MHz, ^{1}H-NMR


202.826
136.983
132.689
128.502
128.462
77.274 CDCl3
77.020 CDCl3
76.767 CDCl3
46.386
29.995
26.315
O
13
125 MHz, 13C-NMR
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

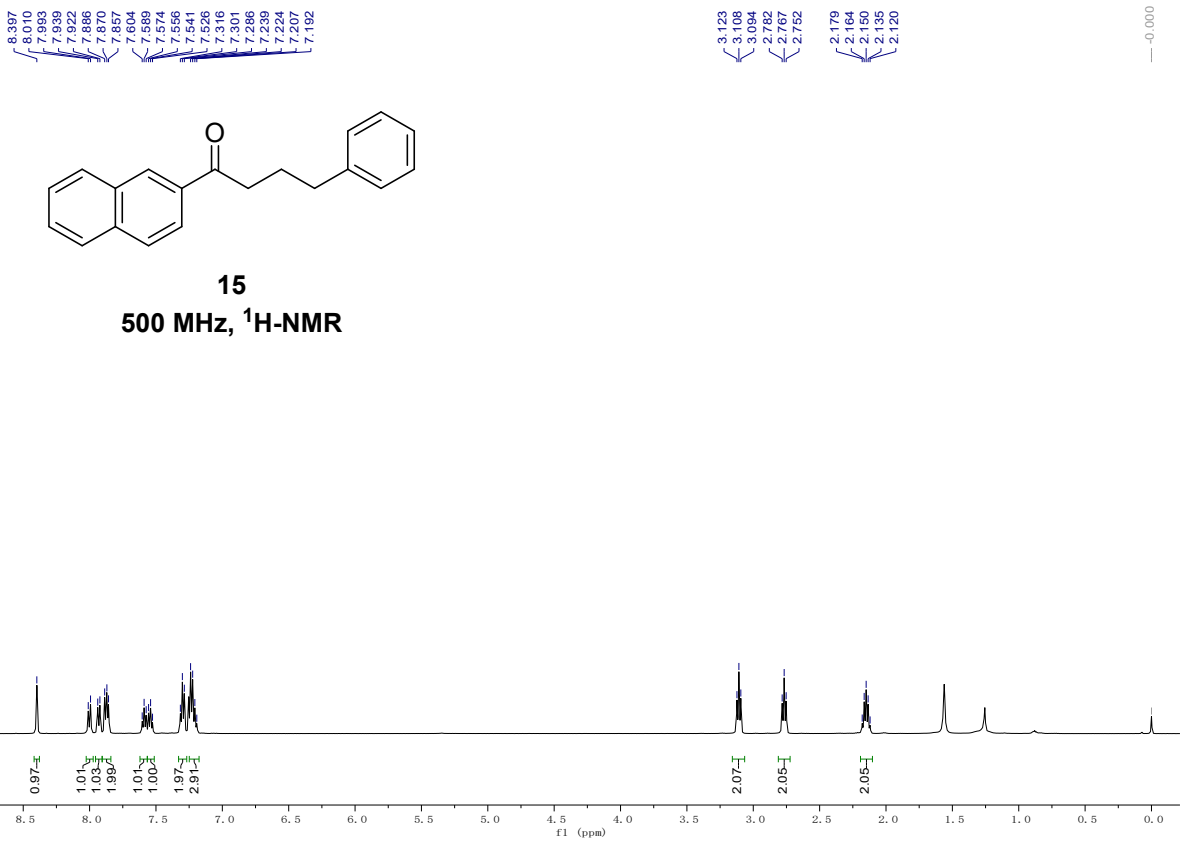


14
500 MHz, ^{1}H-NMR



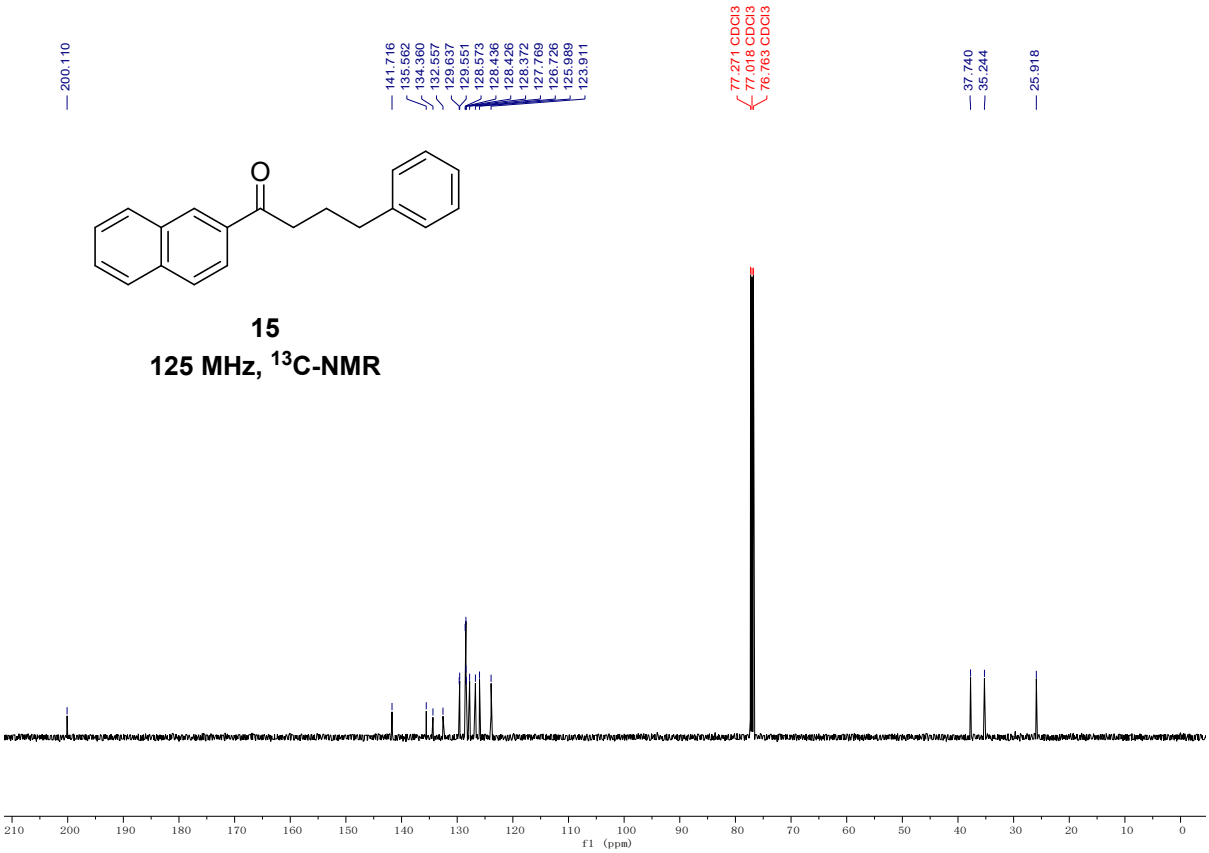


14
125 MHz, ^{13}C-NMR



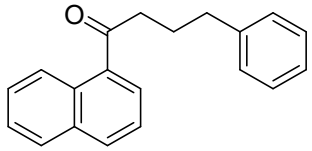
15

500 MHz, ^{1}H-NMR



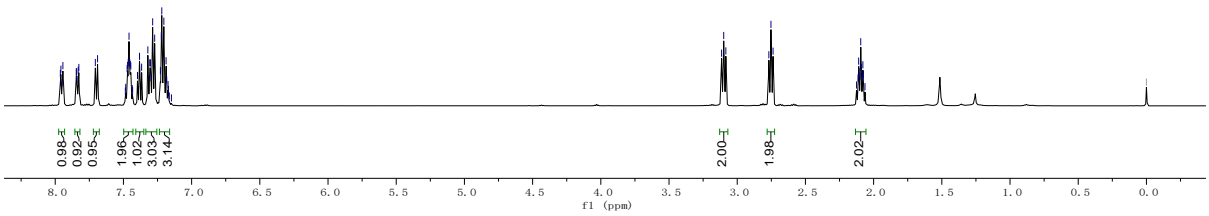
15

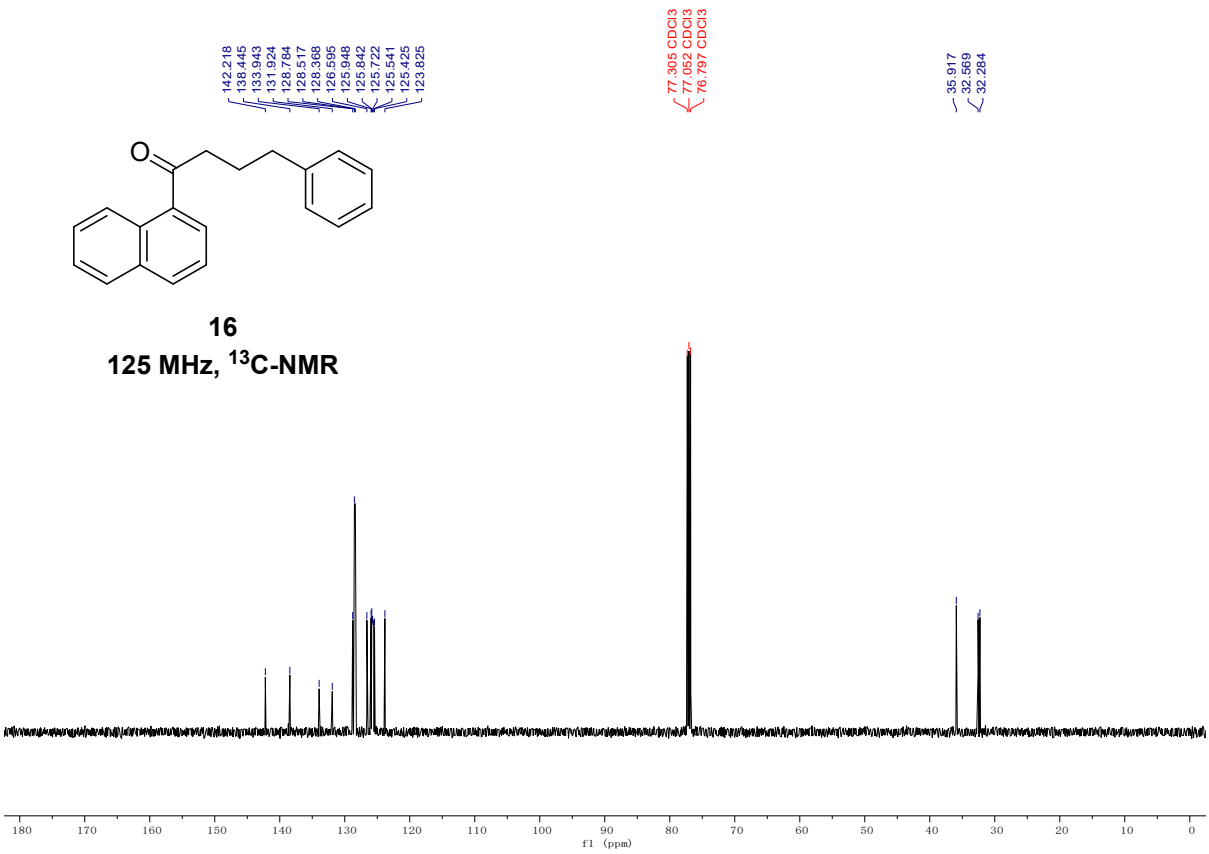
125 MHz, ^{13}C-NMR



16

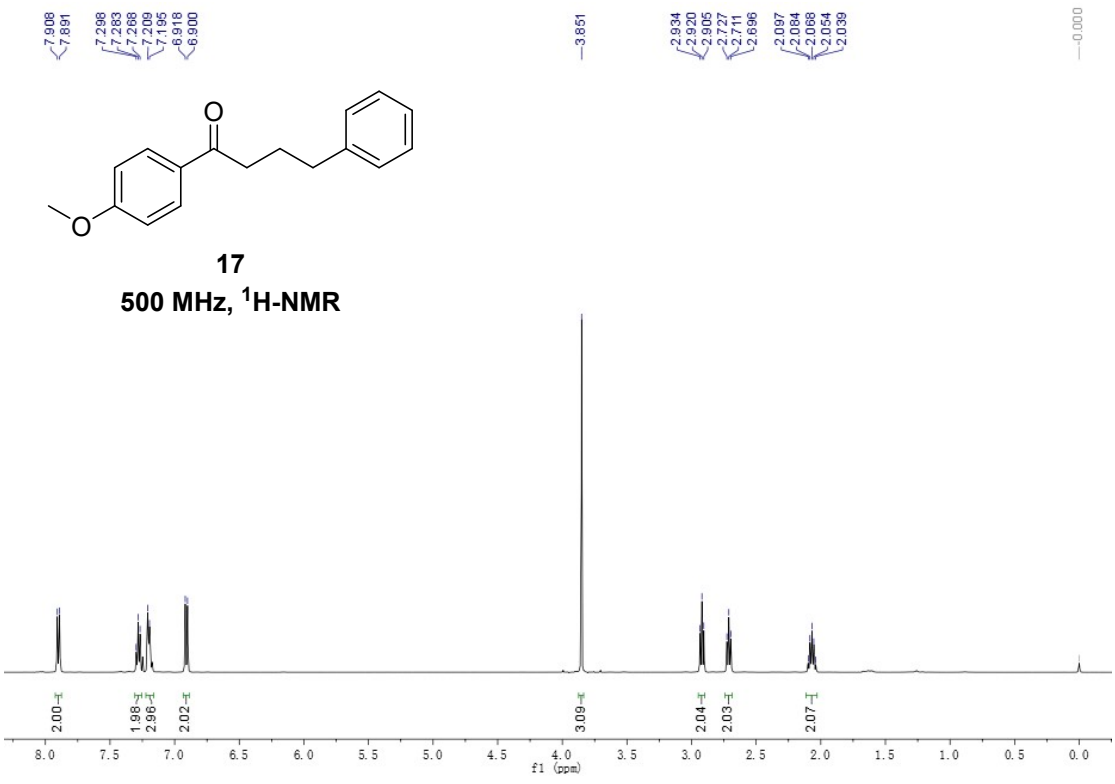
500 MHz, ^{1}H-NMR





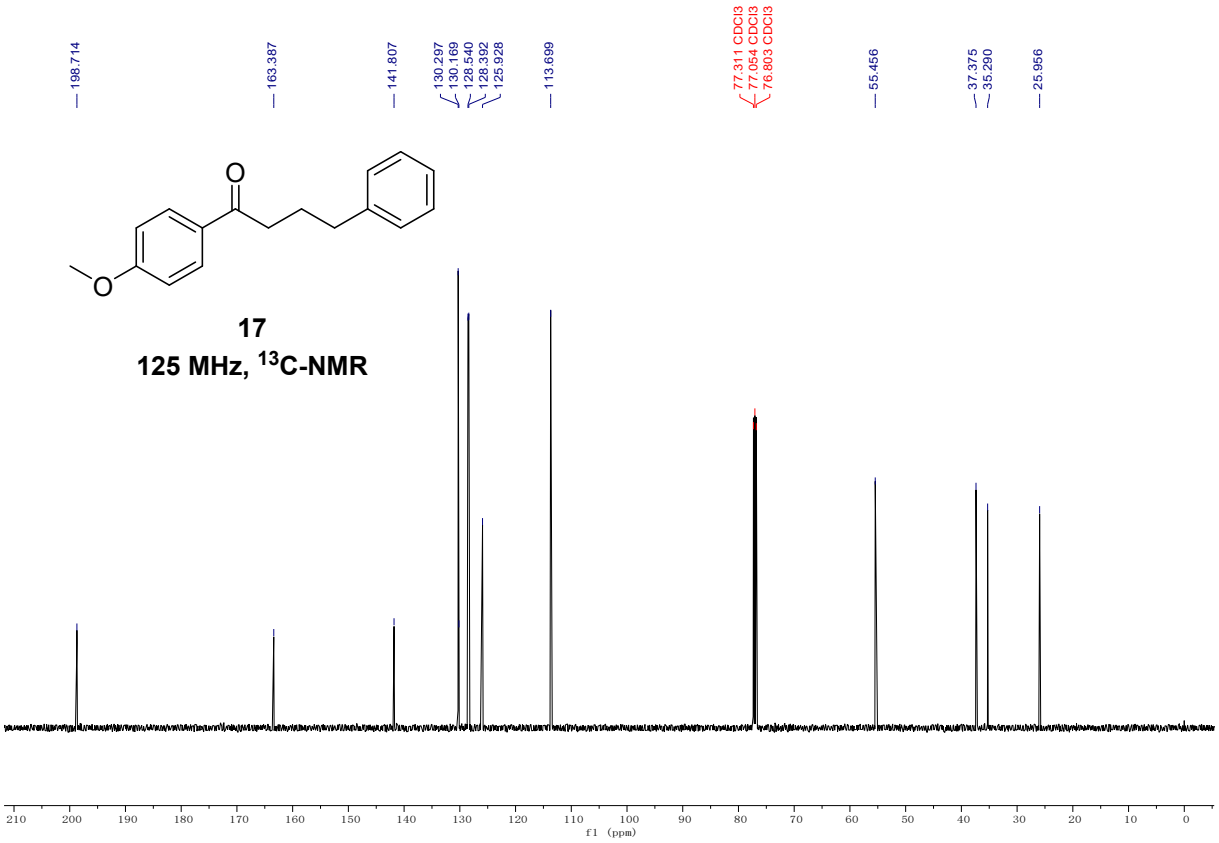
16

125 MHz, ^{13}C-NMR



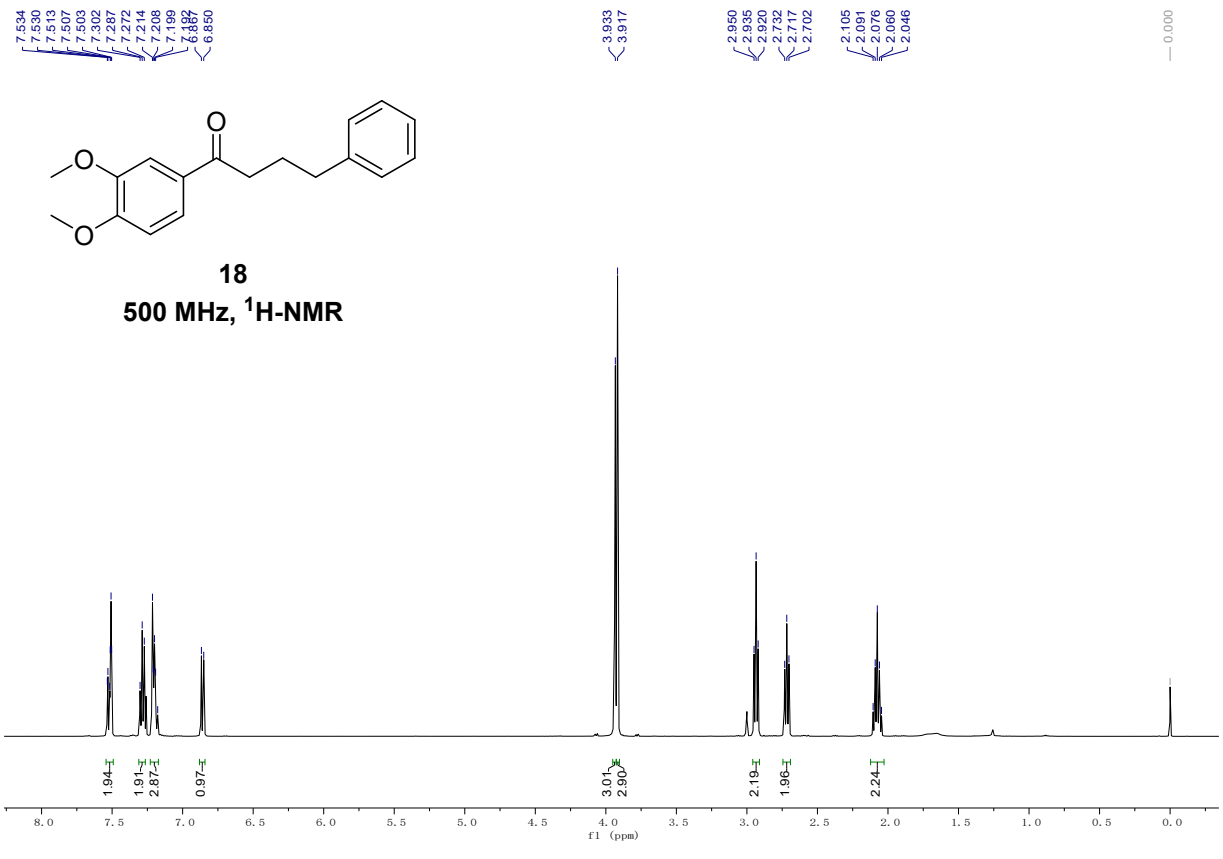
17

500 MHz, ^{1}H-NMR



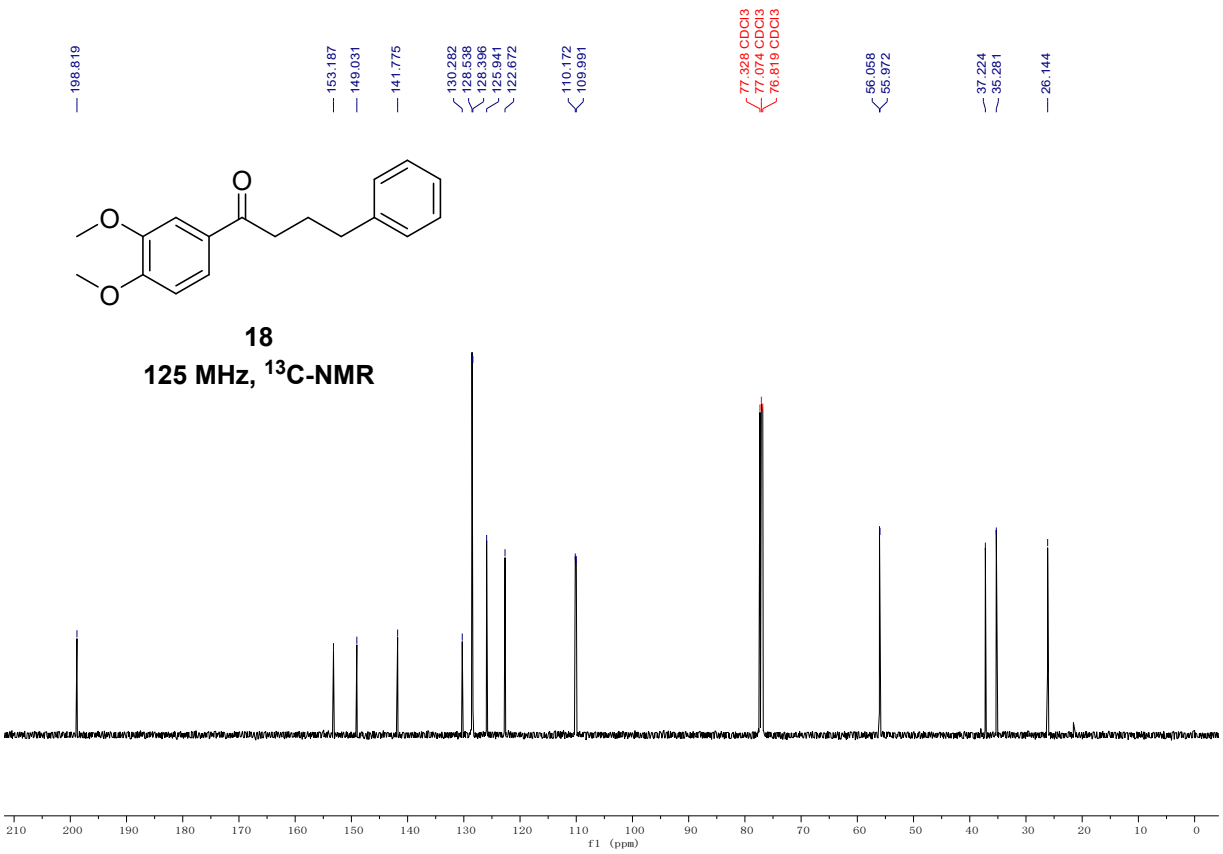
17

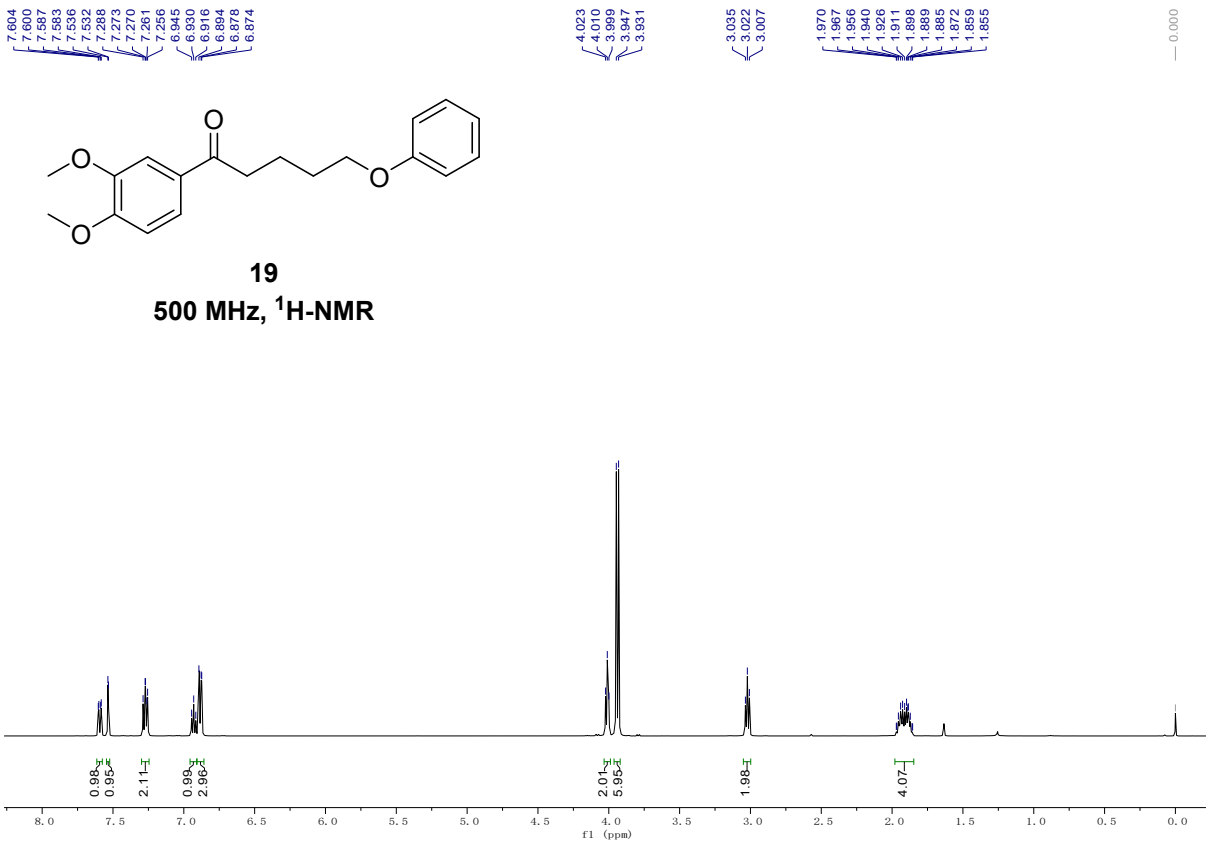
125 MHz, ^{13}C-NMR



18

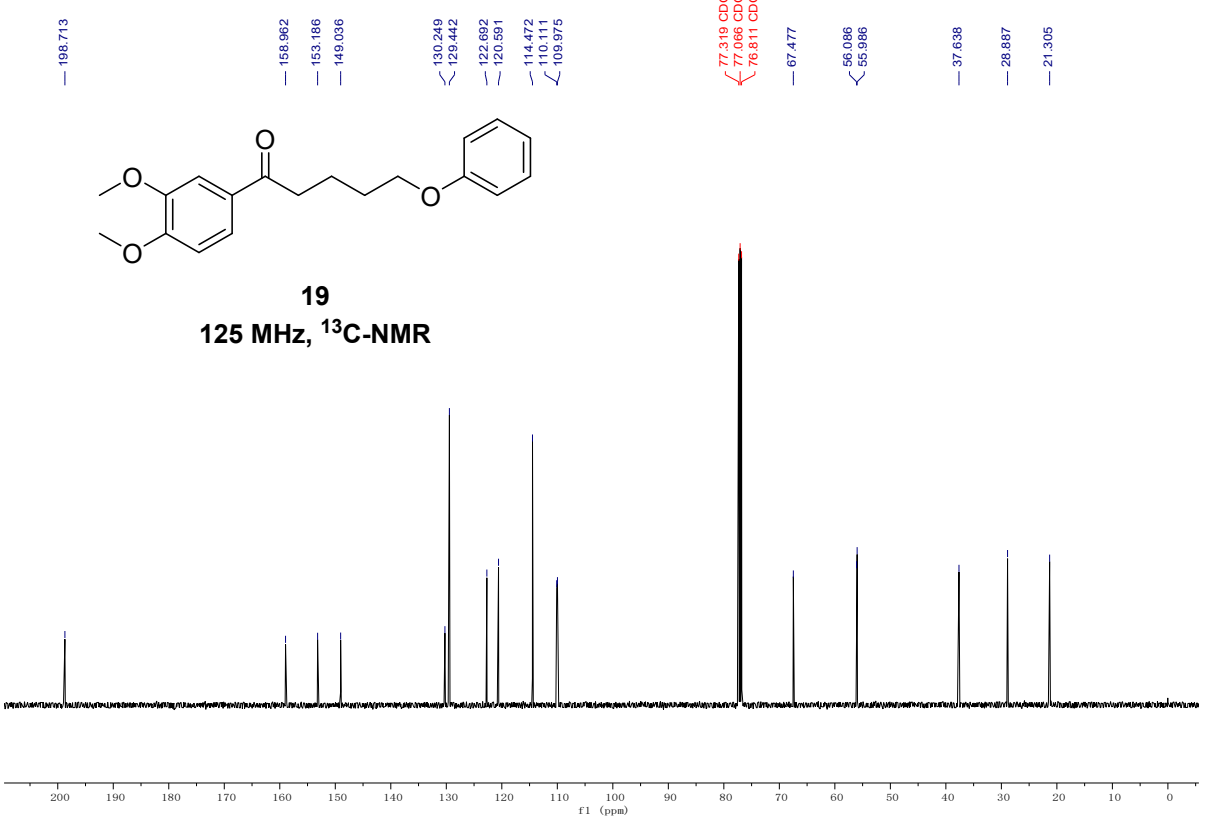
500 MHz, ^{1}H-NMR


198.819
153.187
149.031
141.775
130.282
128.538
128.396
125.941
122.672
110.172
109.991
77.328 CDCl3
77.074 CDCl3
76.819 CDCl3
56.058
55.972
37.224
35.281
26.144
O
O
O
18
125 MHz, 13C-NMR
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)



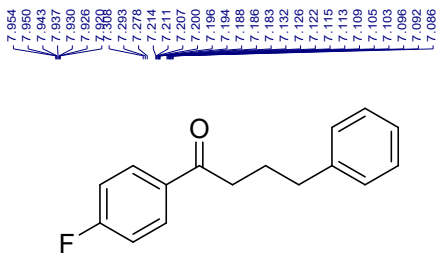
19

500 MHz, ^{1}H-NMR



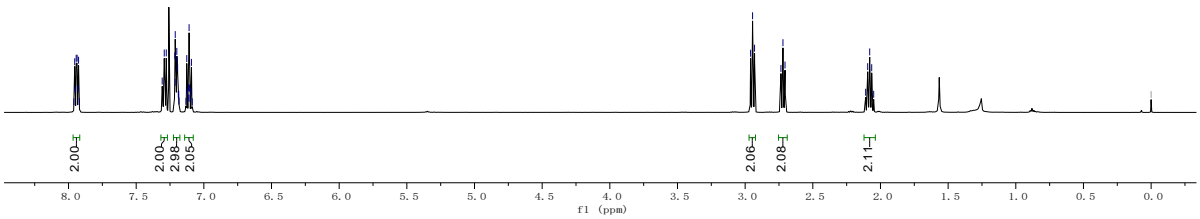
19

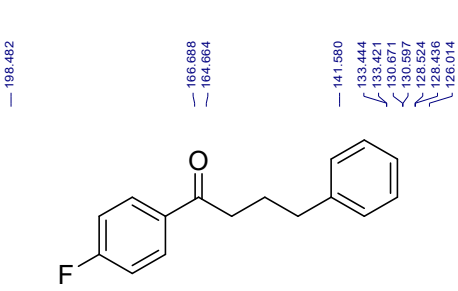
125 MHz, ^{13}C-NMR



20

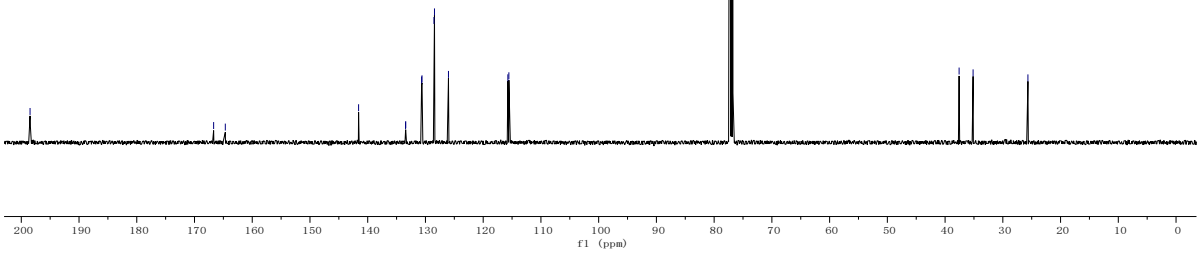
500 MHz, ^{1}H-NMR

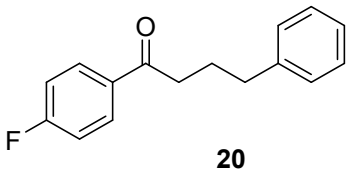




20

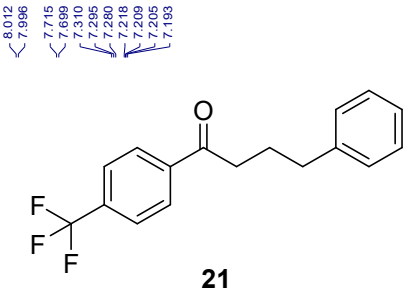
125 MHz, ^{13}C-NMR





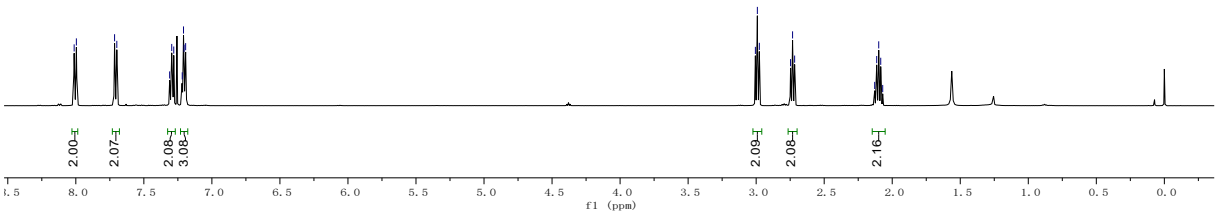
20

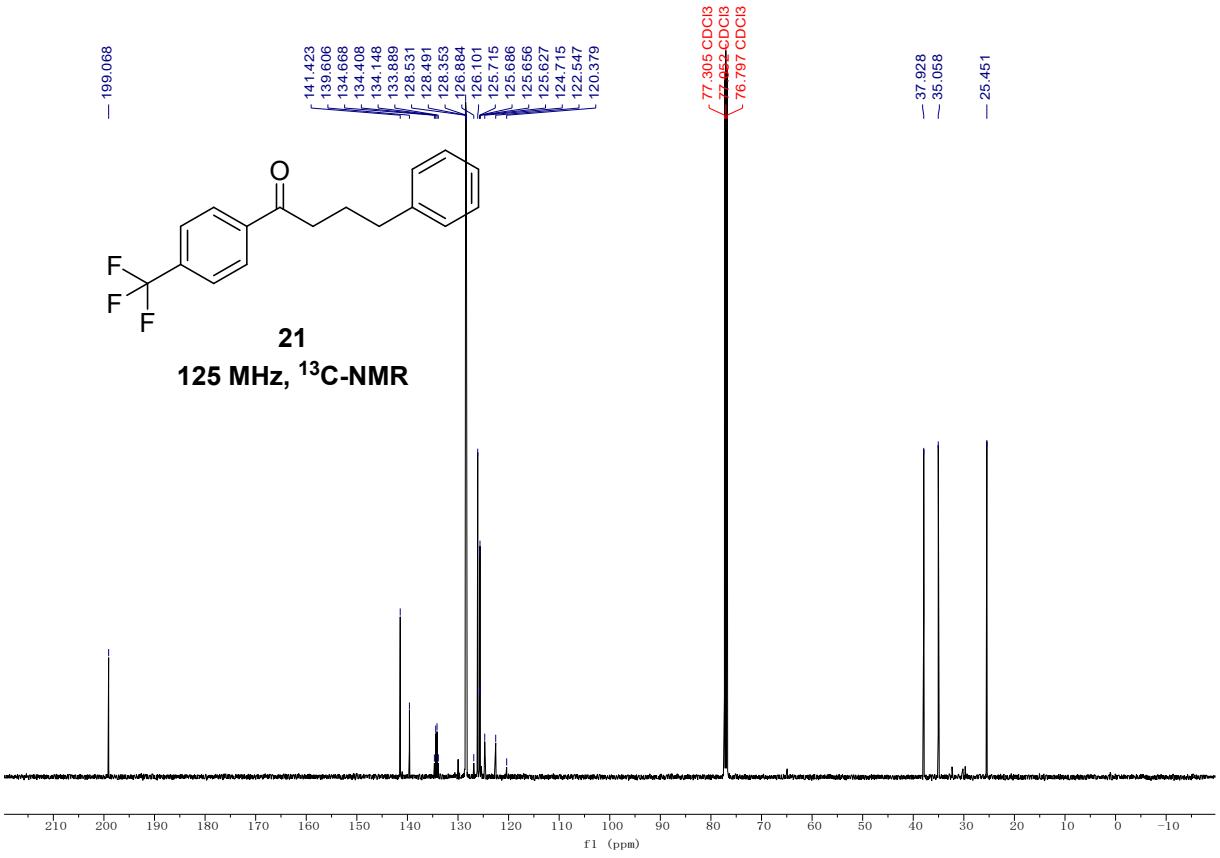
470 MHZ, ^{19}F-NMR



21

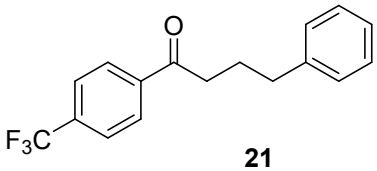
500 MHz, ^{1}H-NMR





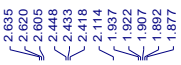
21

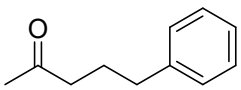
125 MHz, ^{13}C-NMR



21

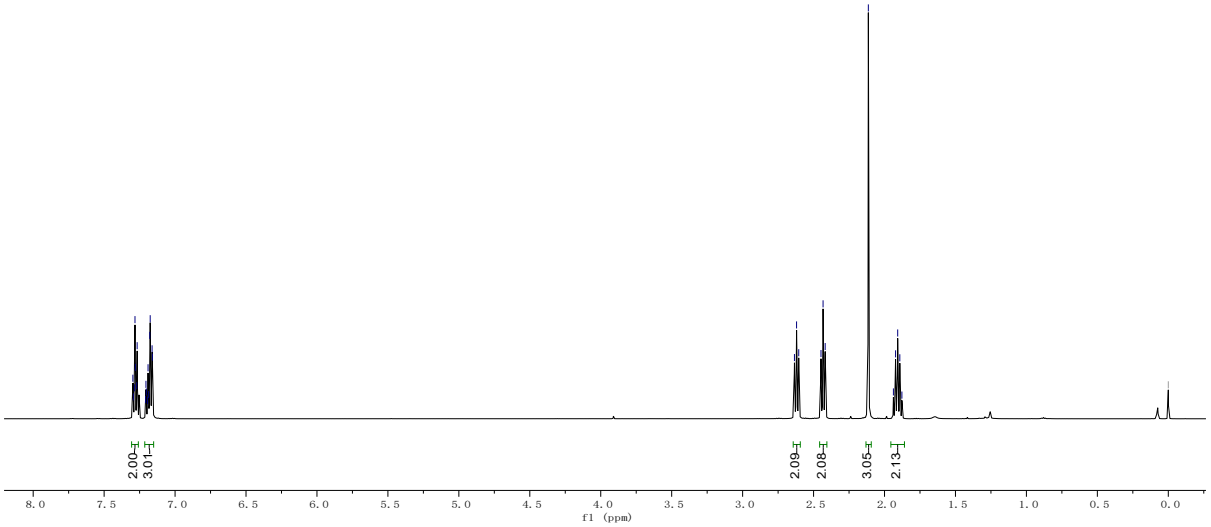
470 MHZ, ^{19}F-NMR

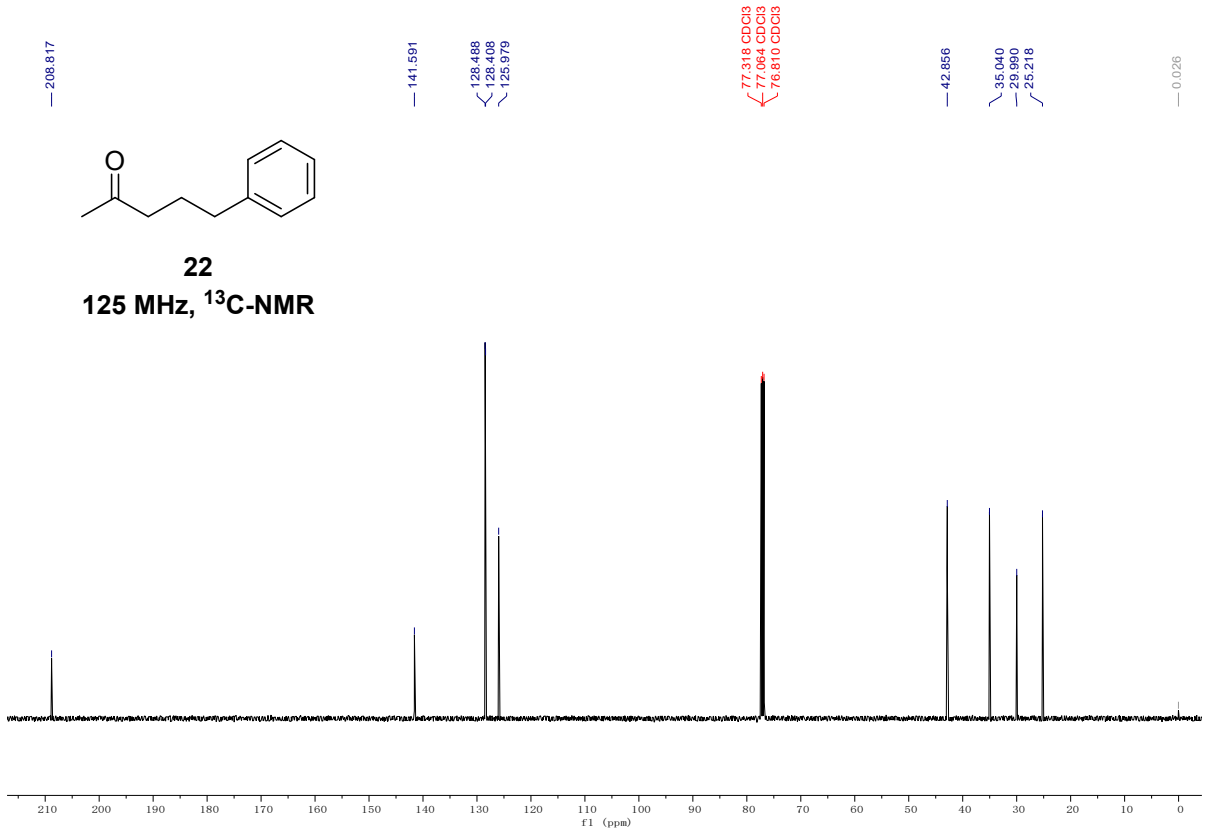


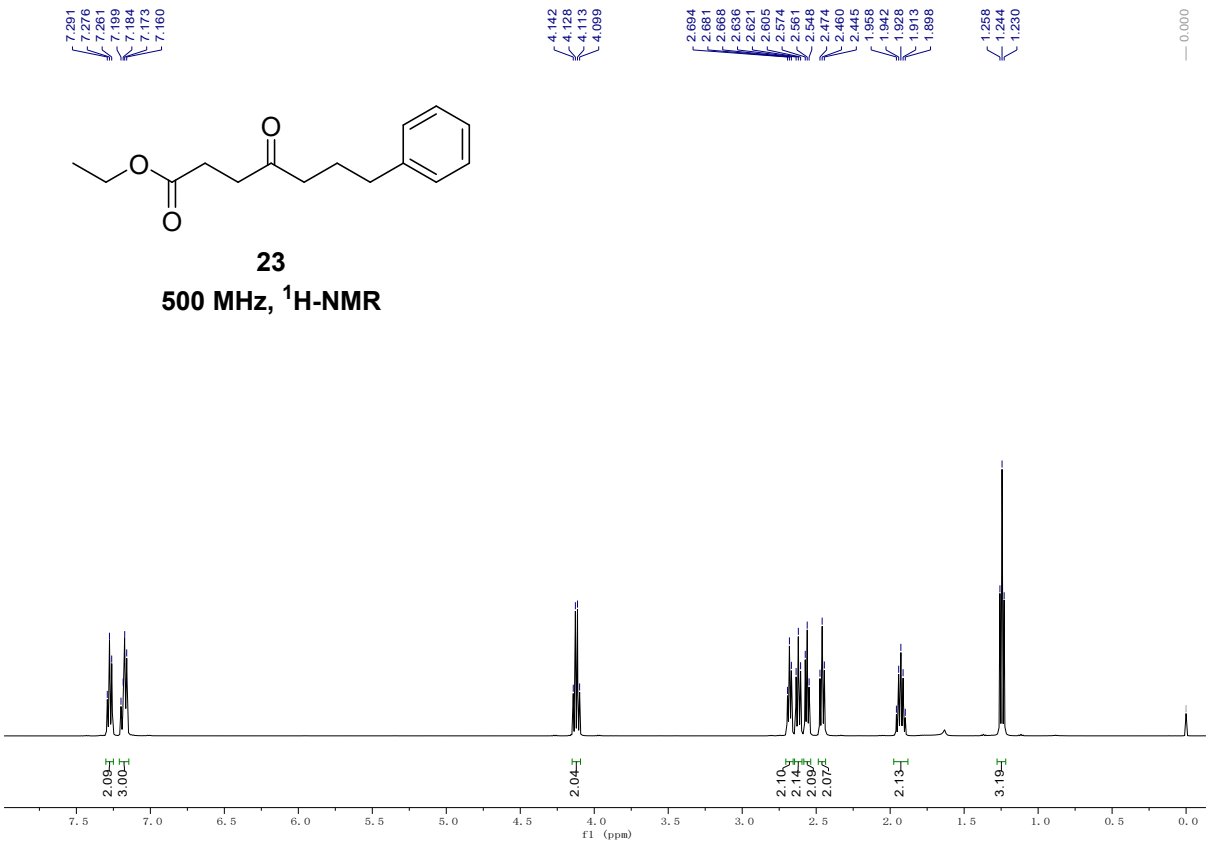


22

500 MHz, ^{1}H-NMR

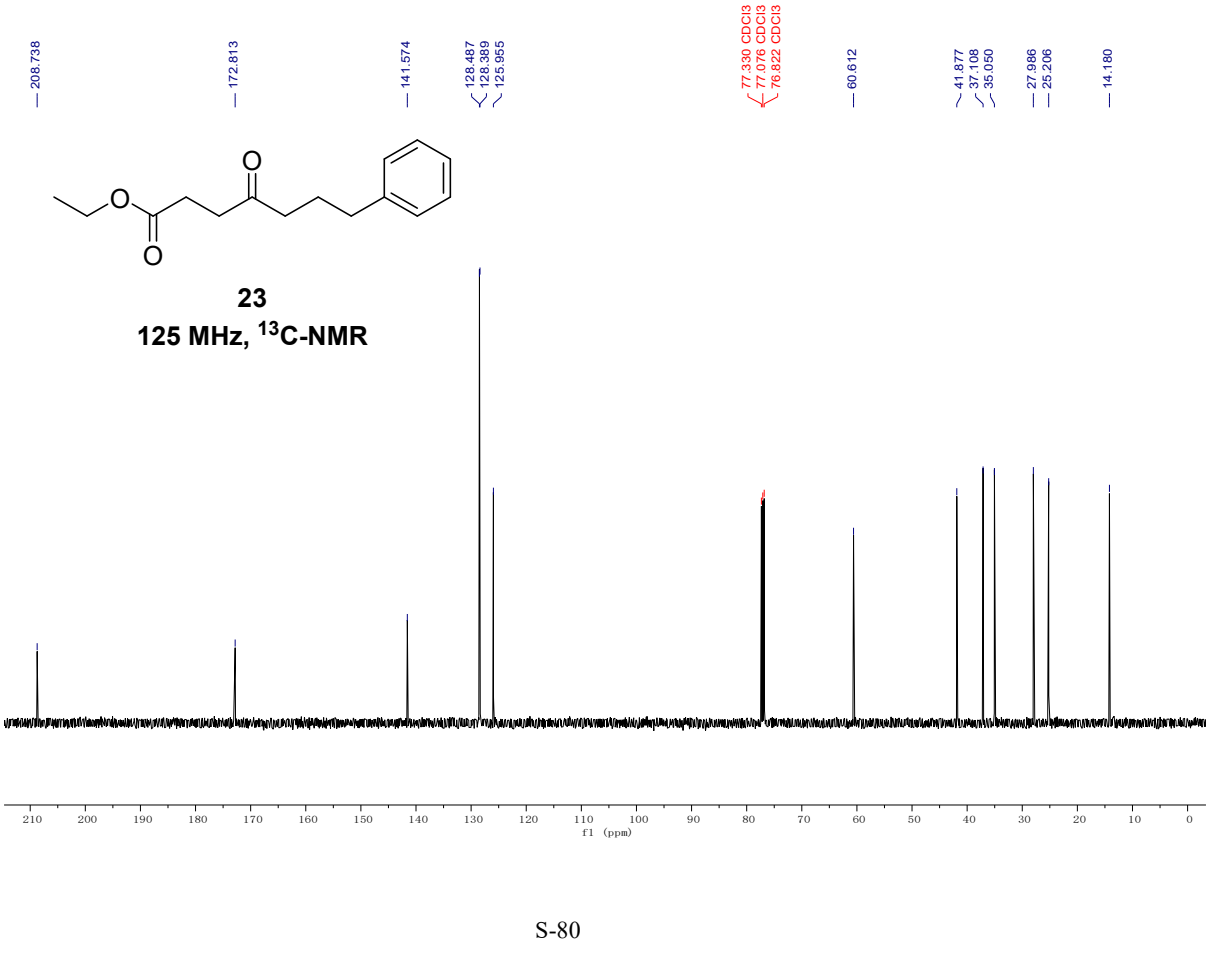



208.817
141.591
128.488
128.408
125.979
77.318 CDCl3
77.064 CDCl3
76.810 CDCl3
42.856
35.040
29.990
25.218
0.026
O
22
125 MHz, 13C-NMR
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)



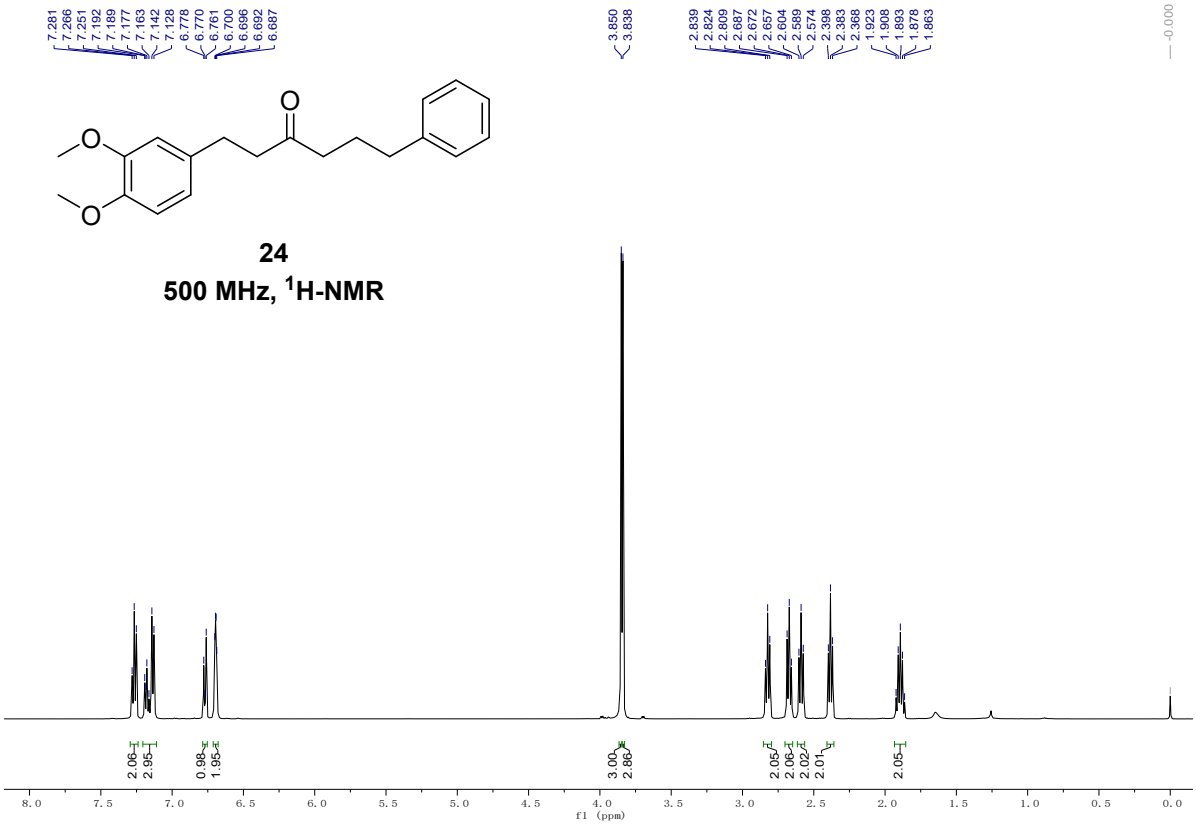
23

500 MHz, ^{1}H-NMR



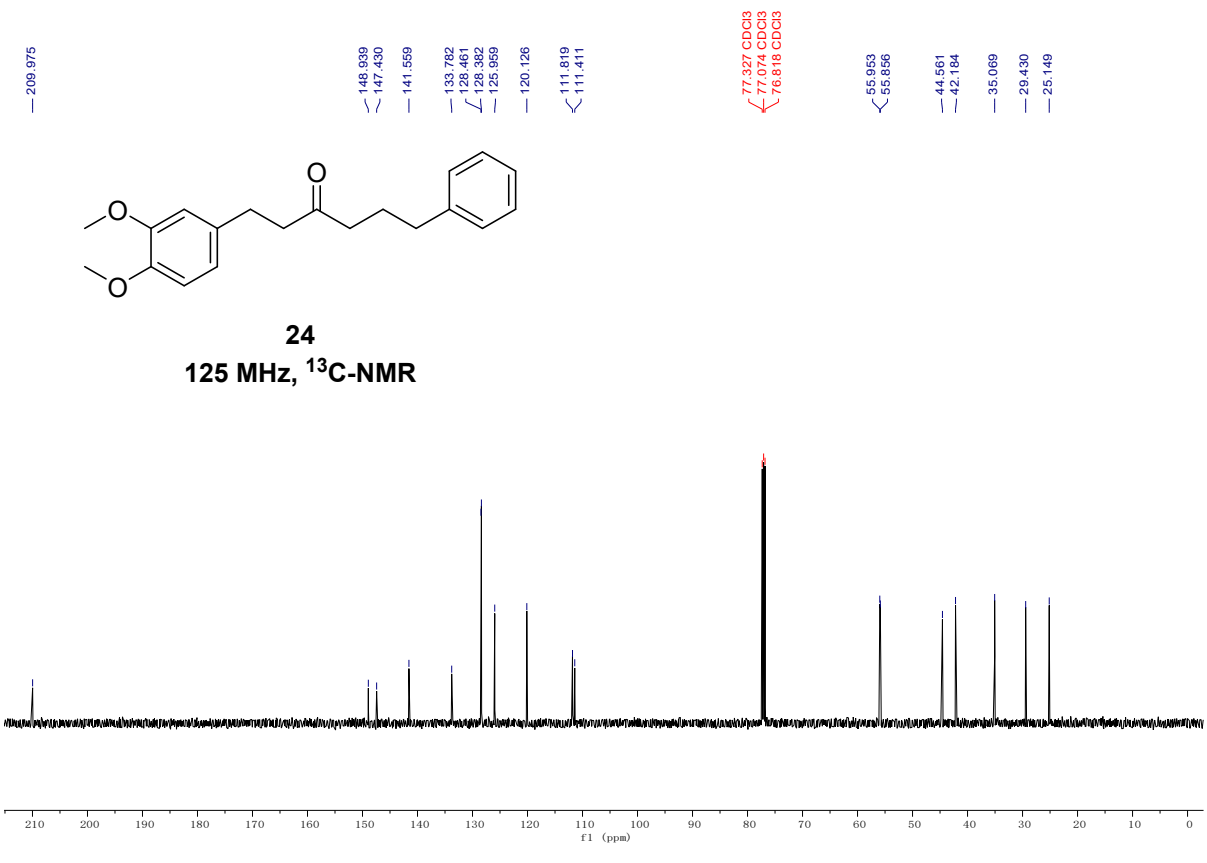
23

125 MHz, ^{13}C-NMR



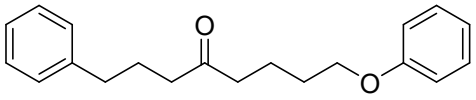
24

500 MHz, ^{1}H-NMR



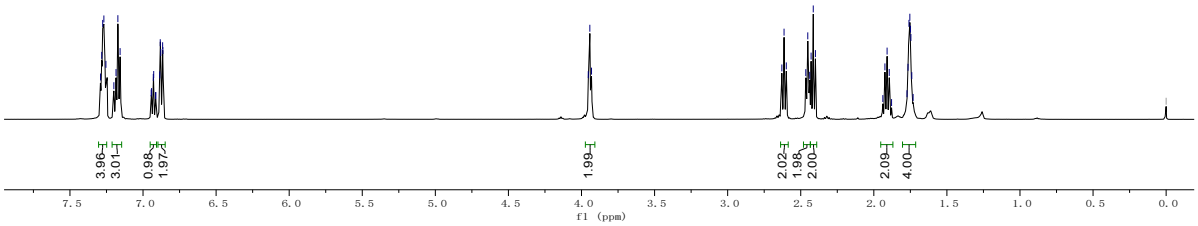
24

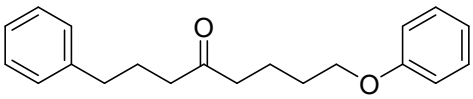
125 MHz, ^{13}C-NMR



25

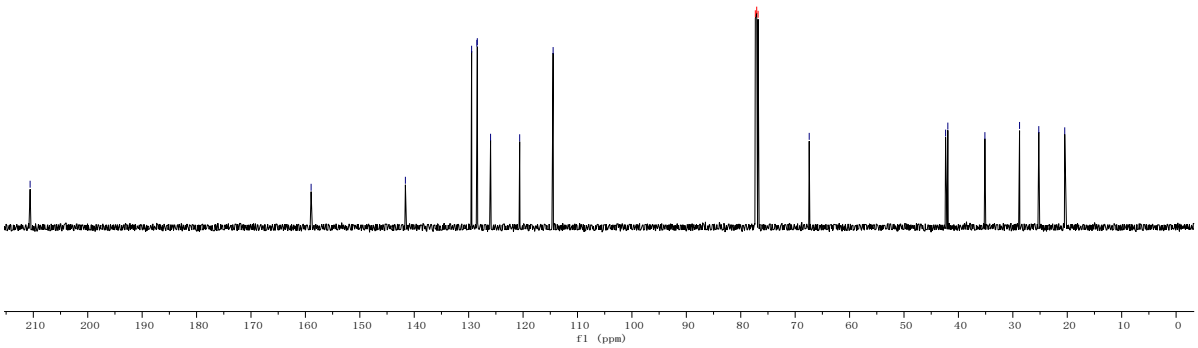
500 MHz, ^{1}H-NMR

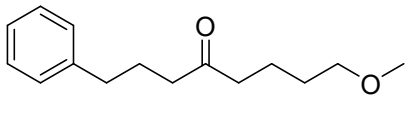




25

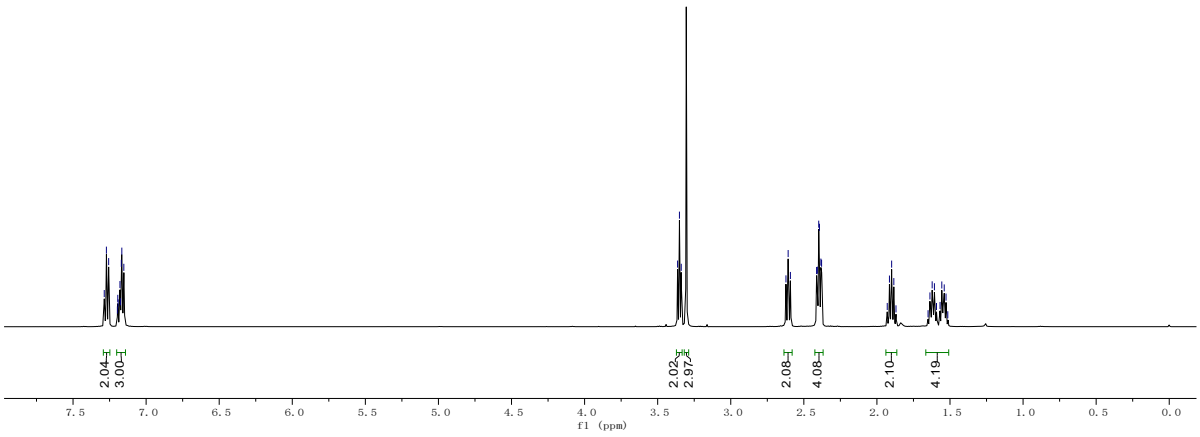
125 MHz, ^{13}C-NMR

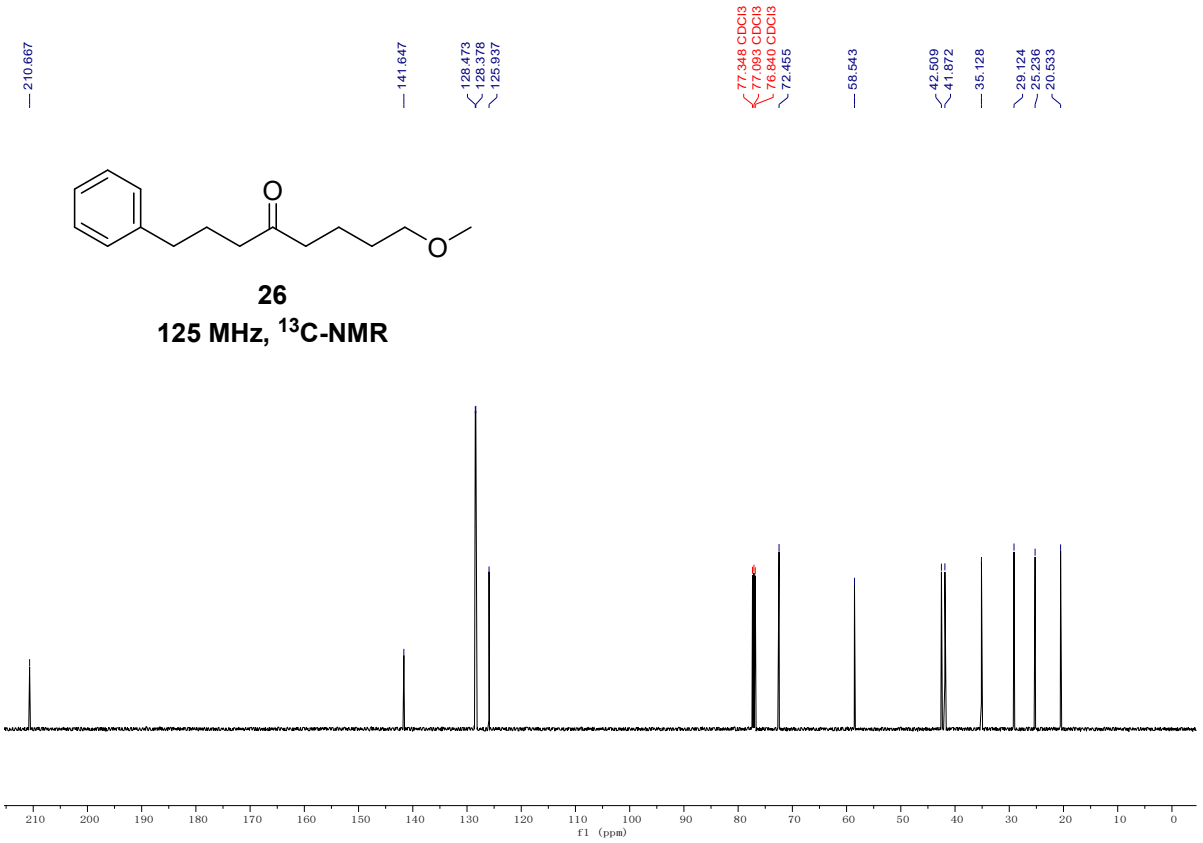




26

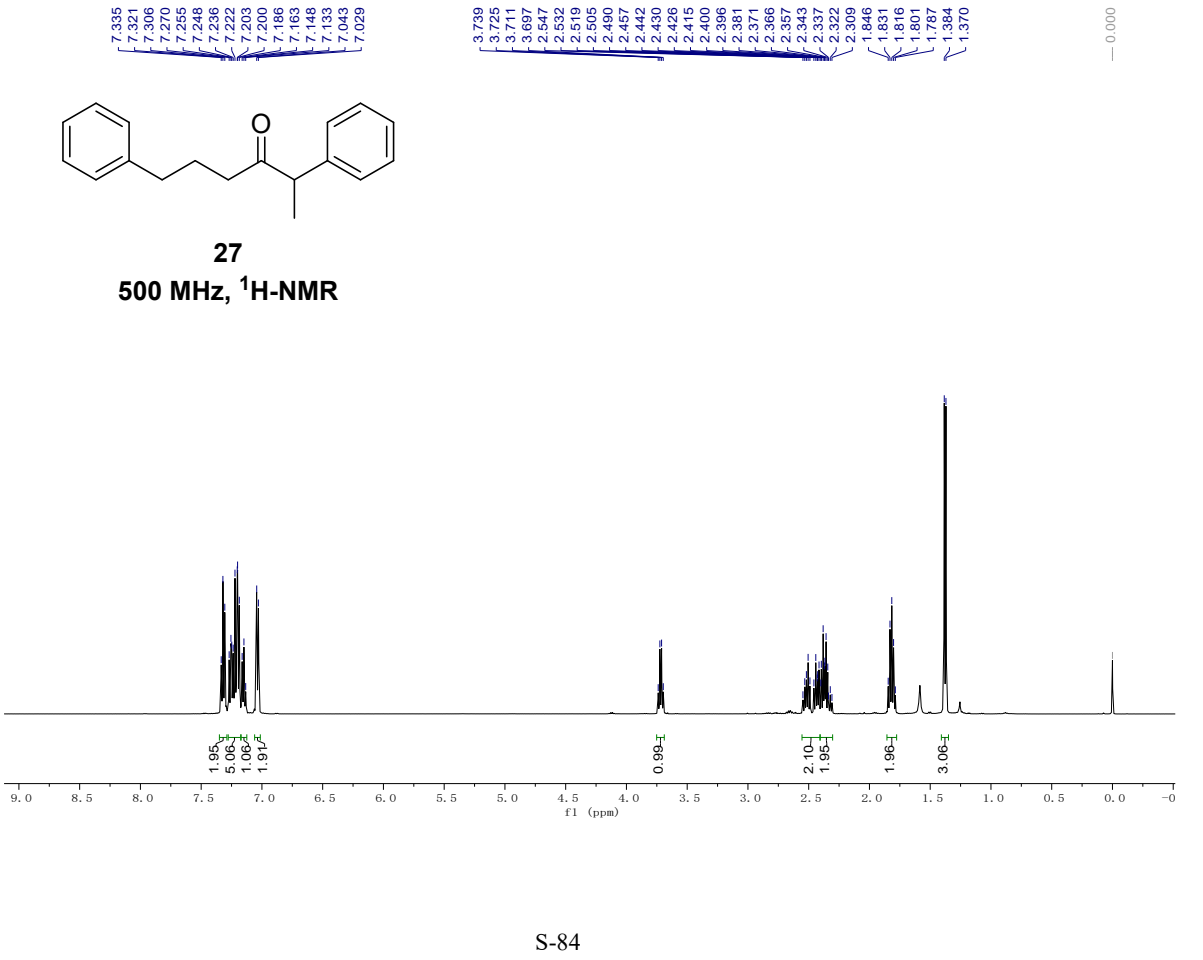
500 MHz, ^{1}H-NMR





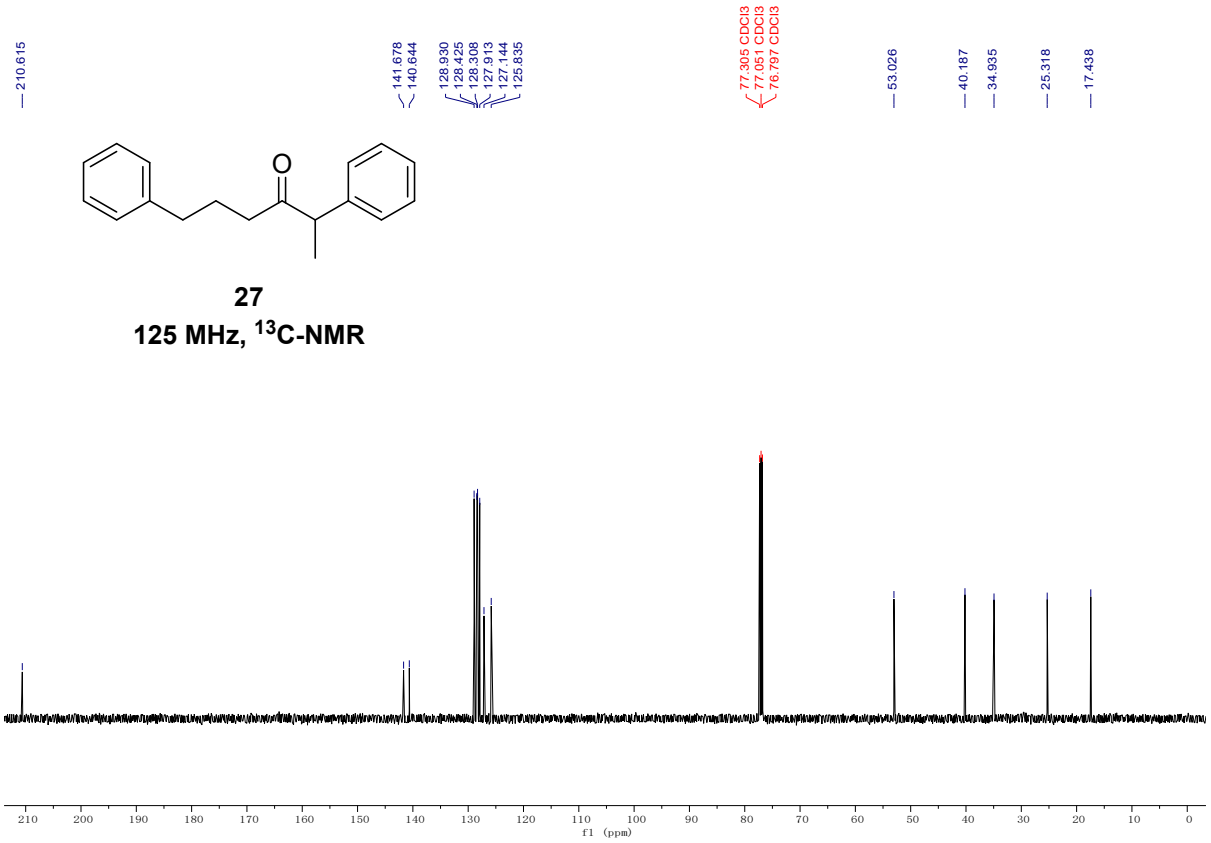
26

125 MHz, ^{13}C-NMR

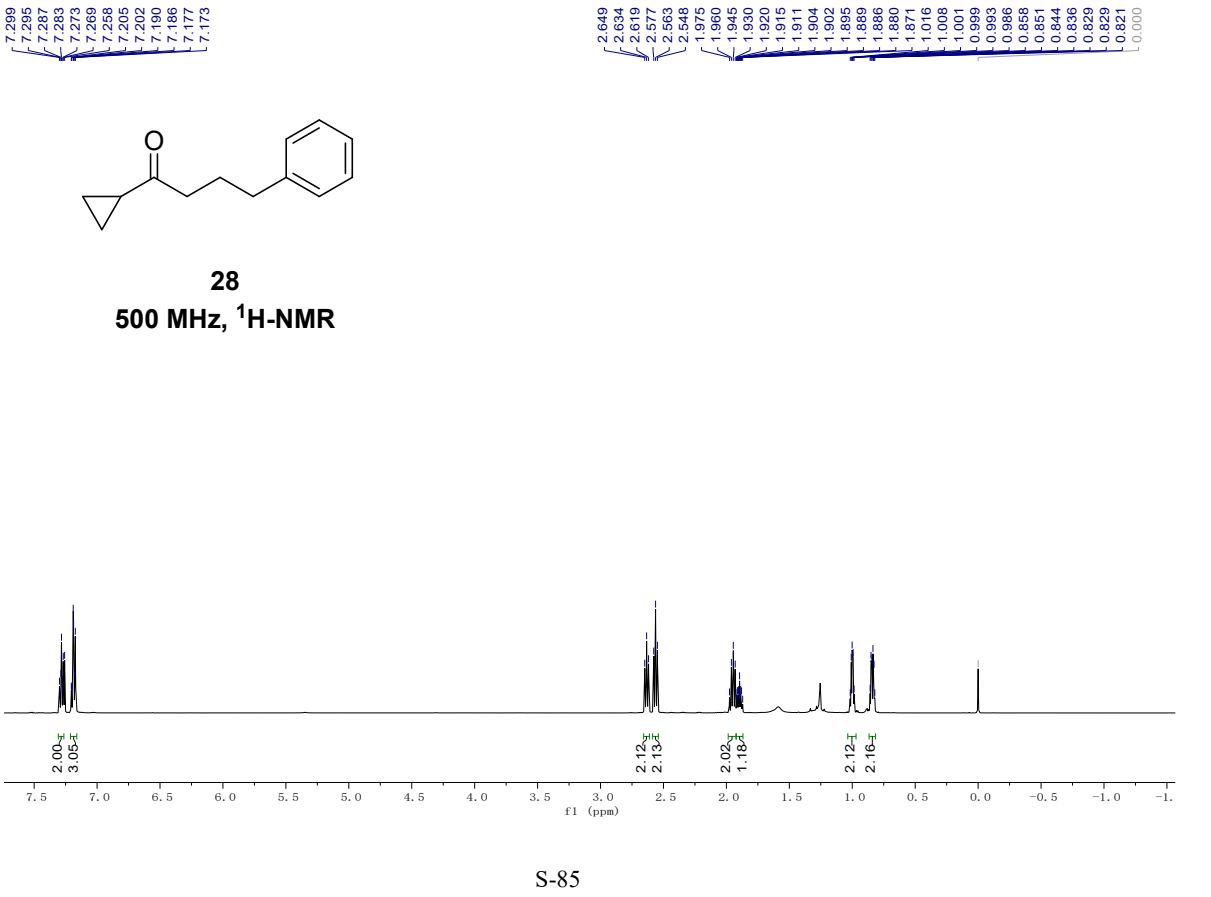


27

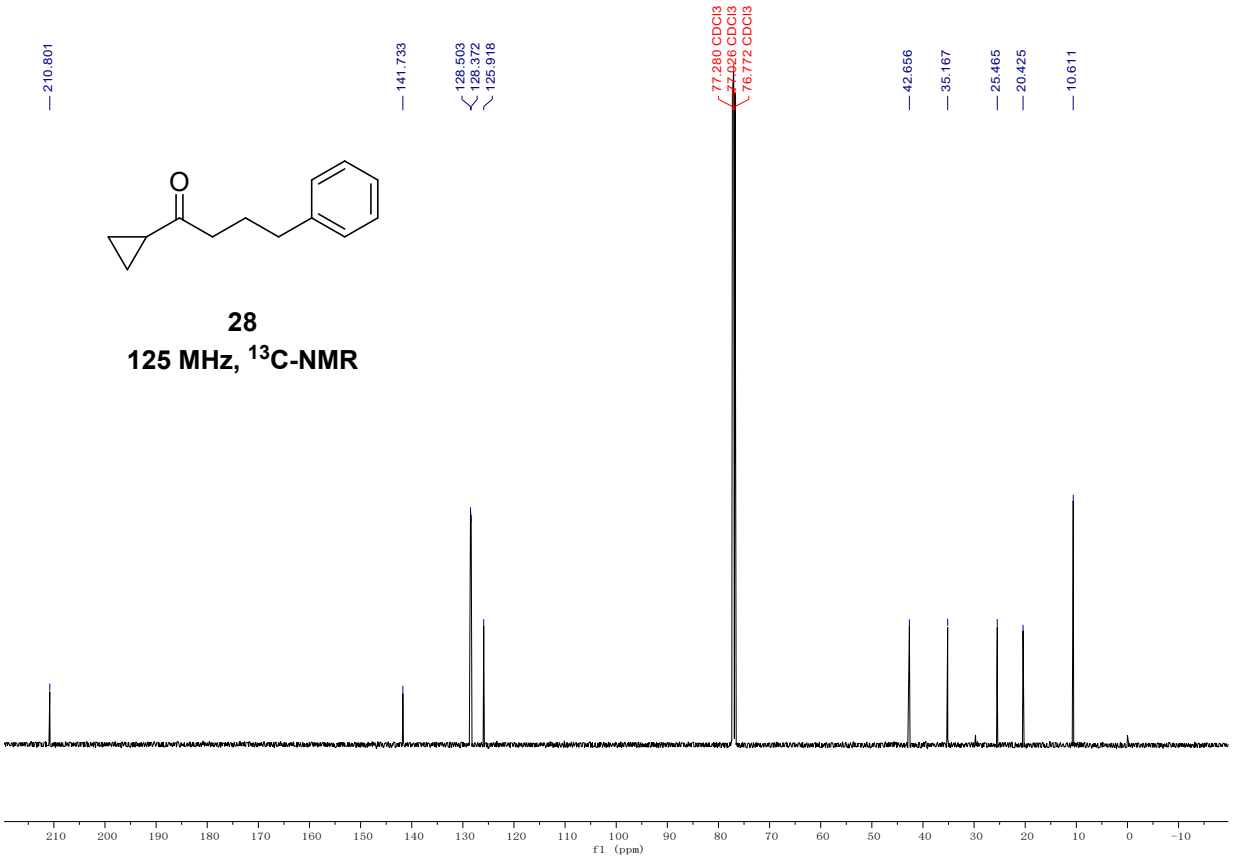
500 MHz, ^{1}H-NMR

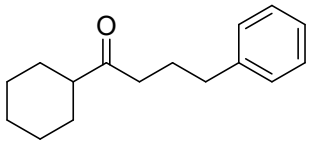


27
125 MHz, ^{13}C-NMR



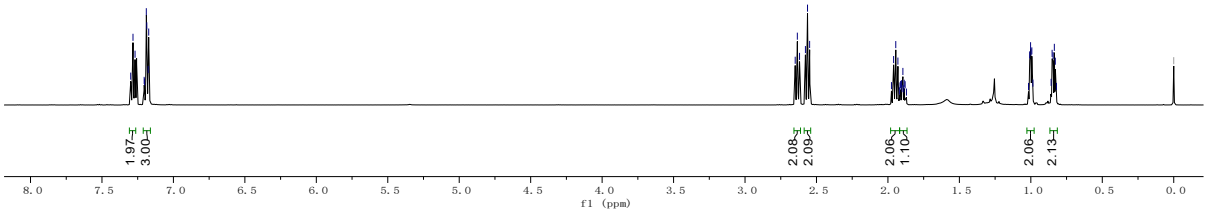
28
500 MHz, ^{1}H-NMR

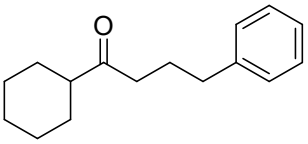

210.801
141.733
128.503
128.372
125.918
77.280 CDCl3
77.026 CDCl3
76.772 CDCl3
42.656
35.167
25.465
20.425
10.611
O
28
125 MHz, 13C-NMR
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)



29

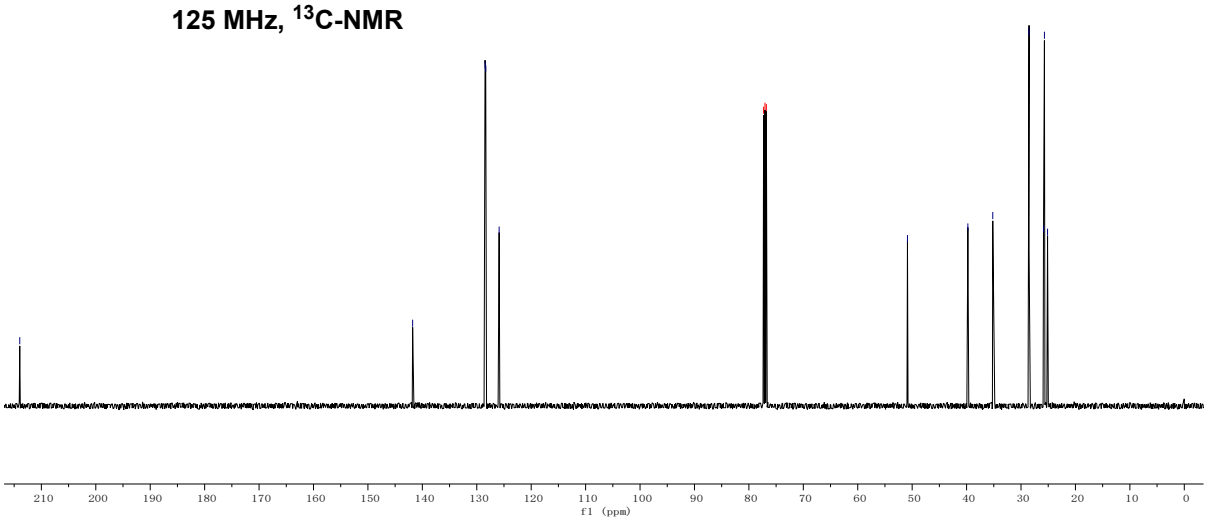
500 MHz, ^{1}H-NMR

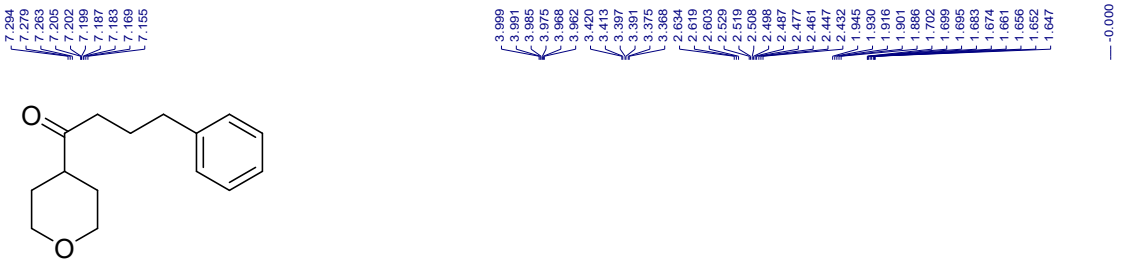




29

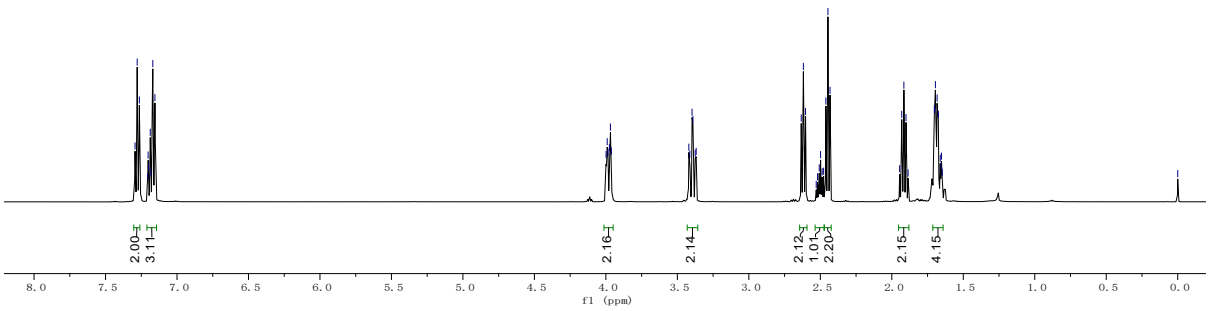
125 MHz, ^{13}C-NMR

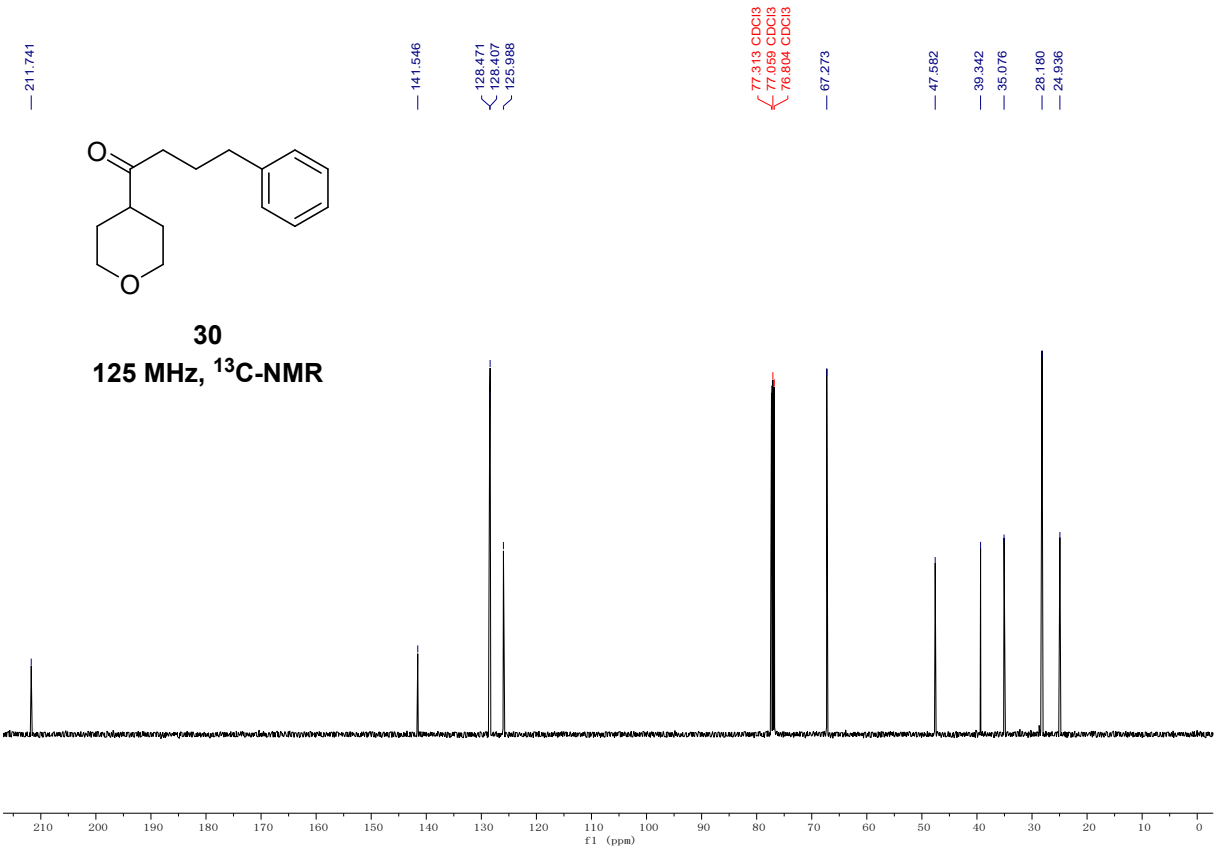




30

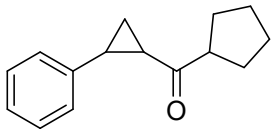
500 MHz, ^{1}H-NMR





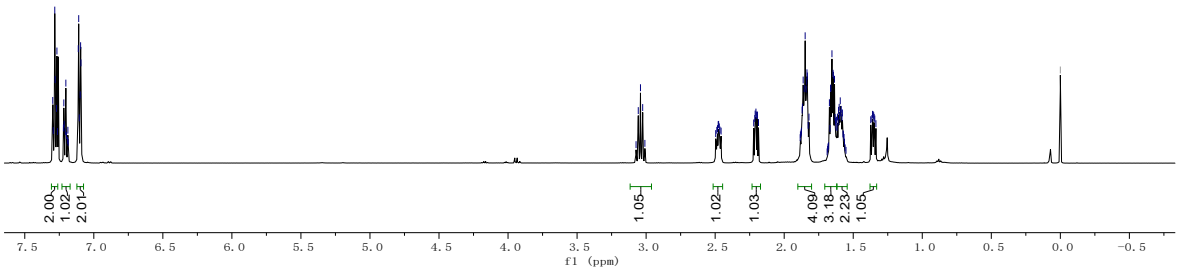
30

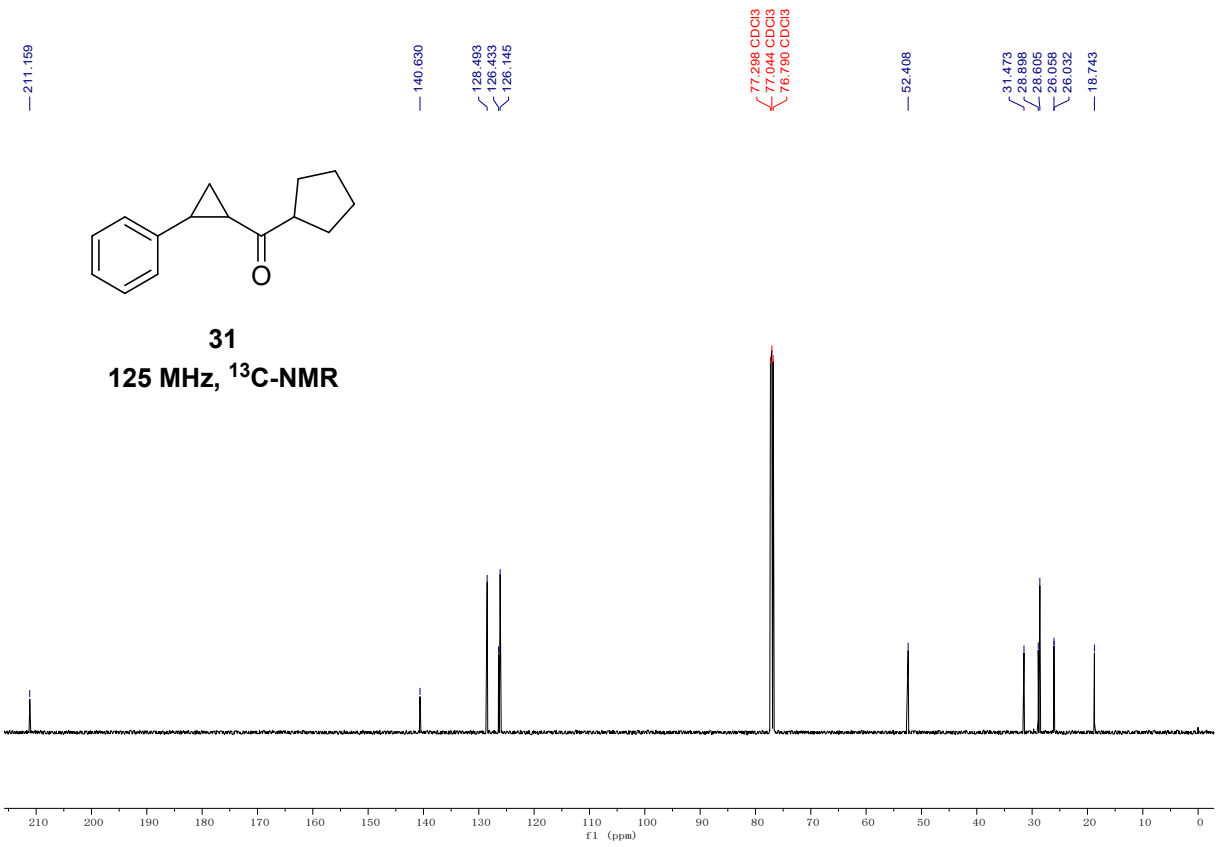
125 MHz, ^{13}C-NMR



31

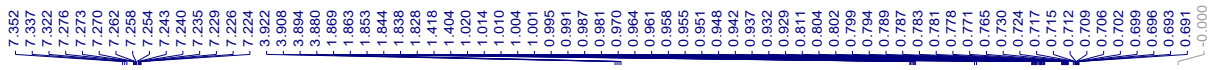
500 MHz, ^{1}H-NMR

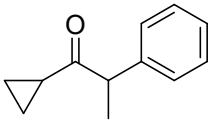




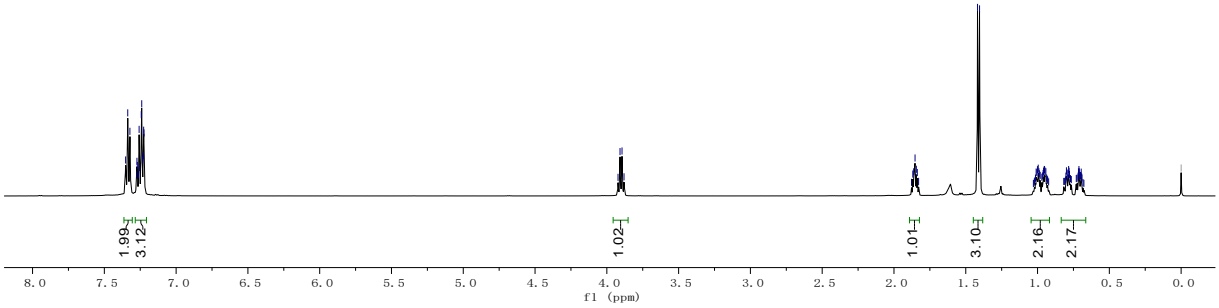
31

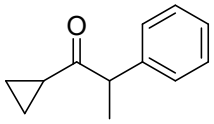
125 MHz, ^{13}C-NMR



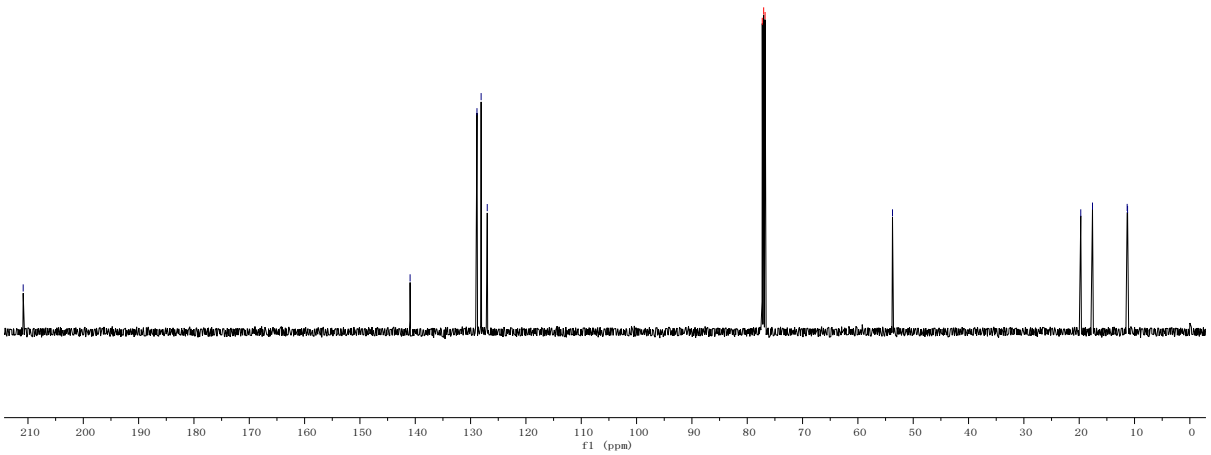


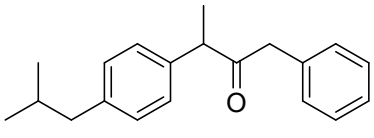
32
500 MHz, ^{1}H-NMR





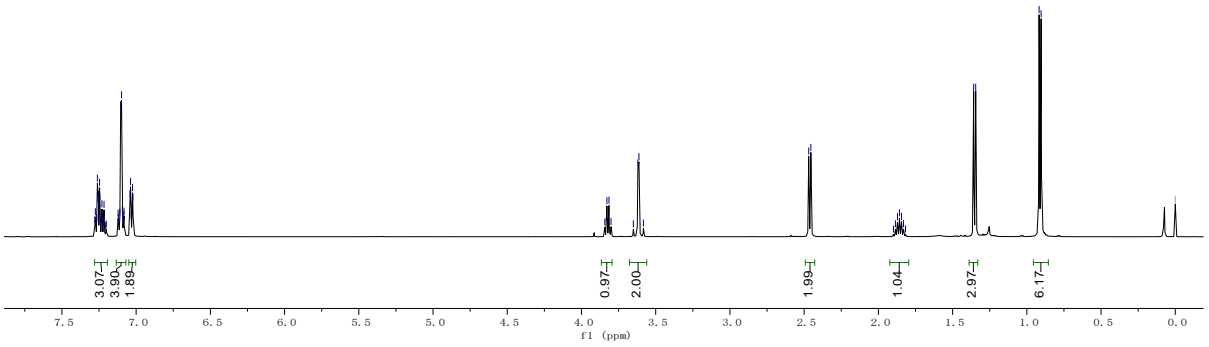
32
125 MHz, ^{13}C-NMR

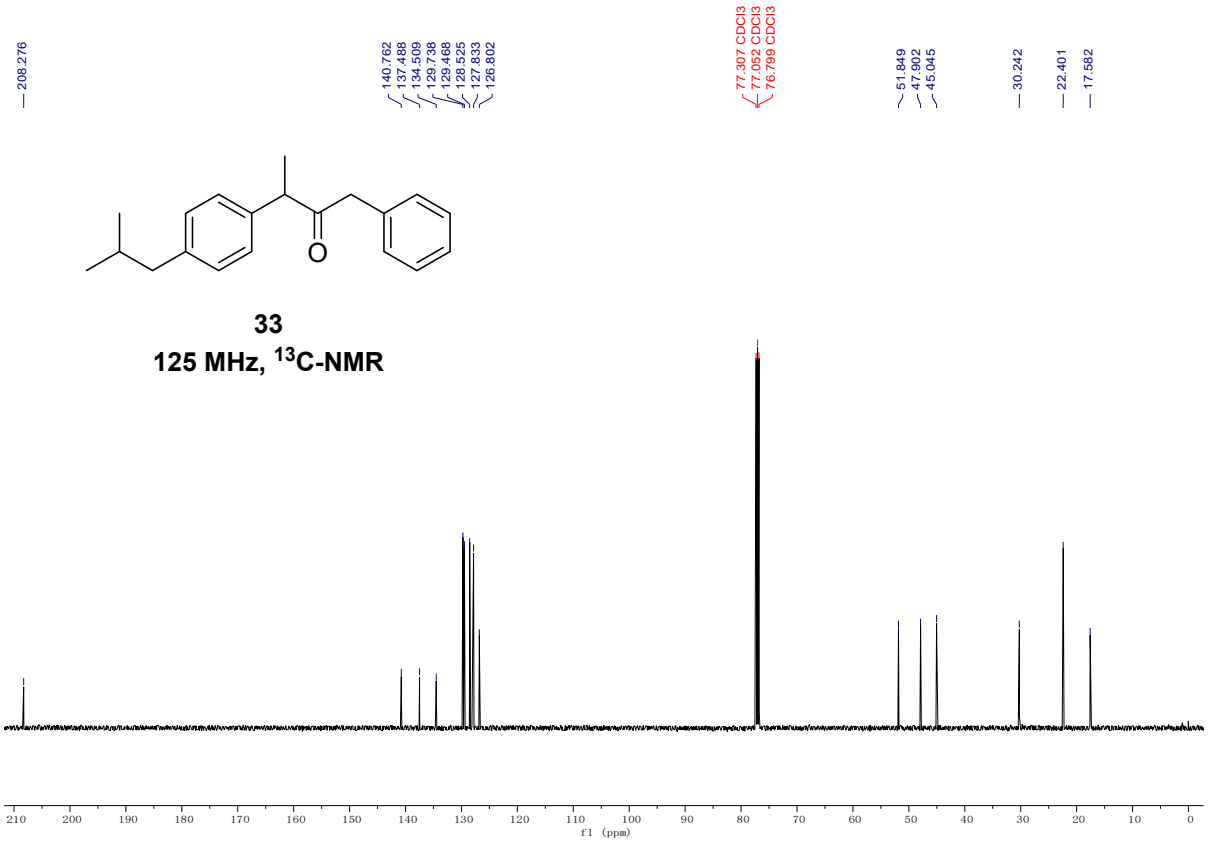




33

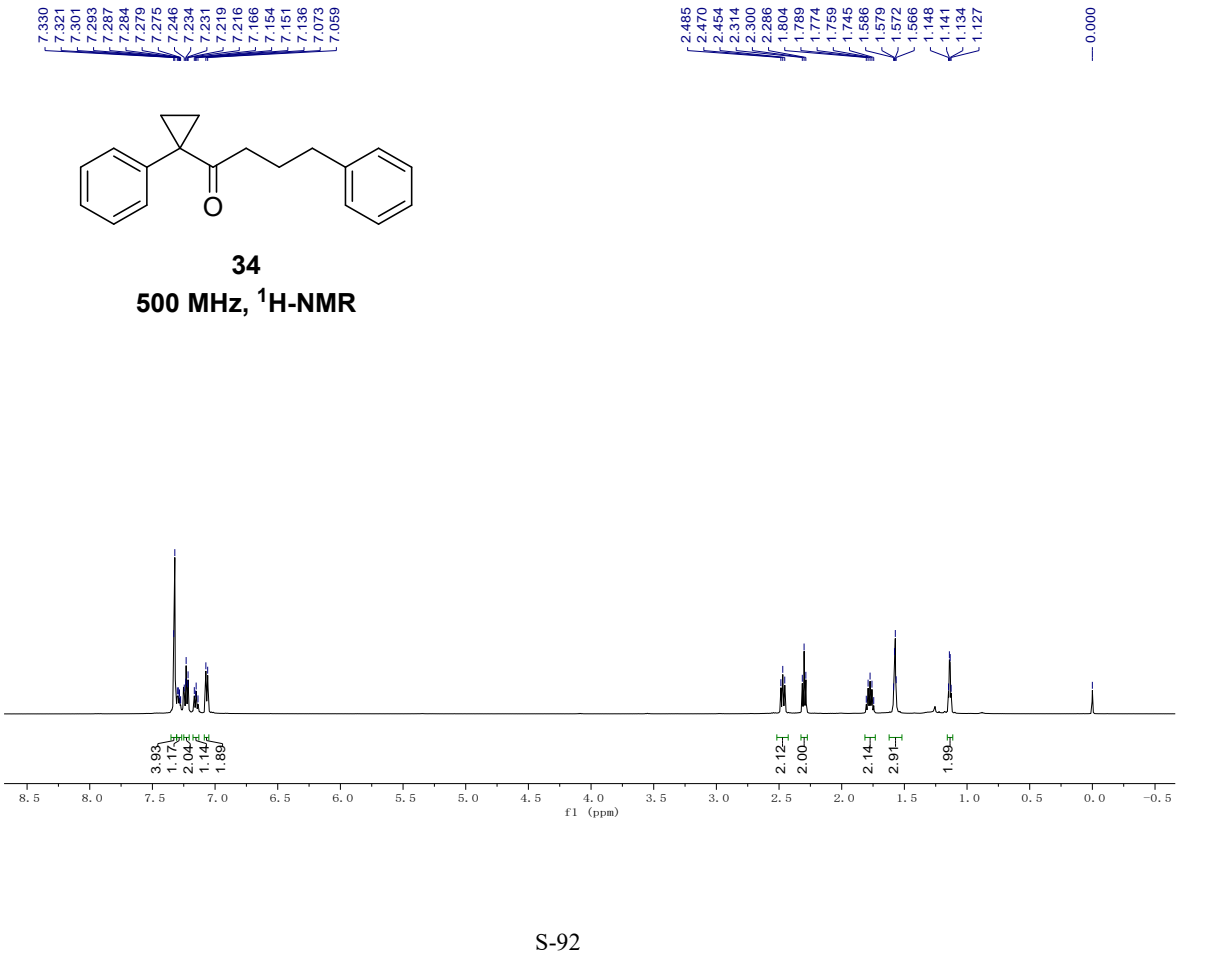
500 MHz, ^{1}H-NMR





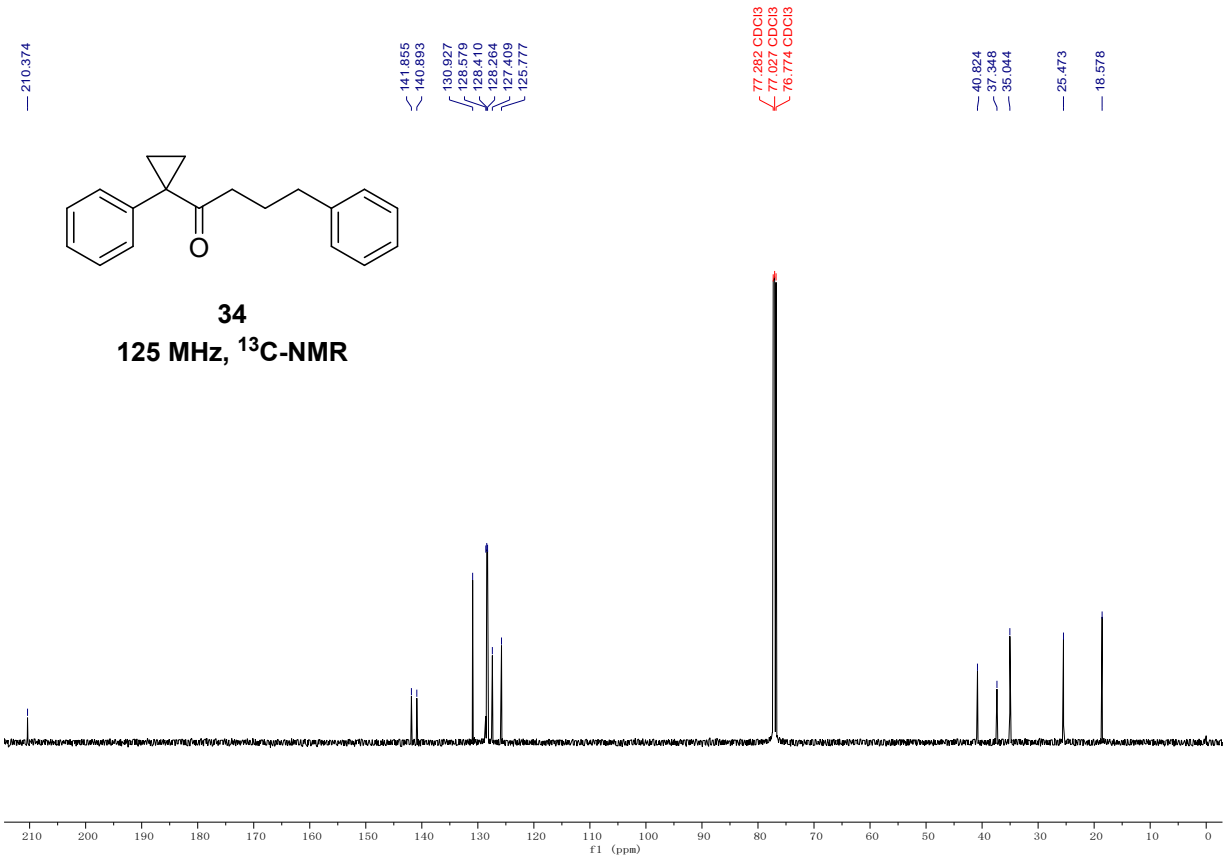
33

125 MHz, ^{13}C-NMR

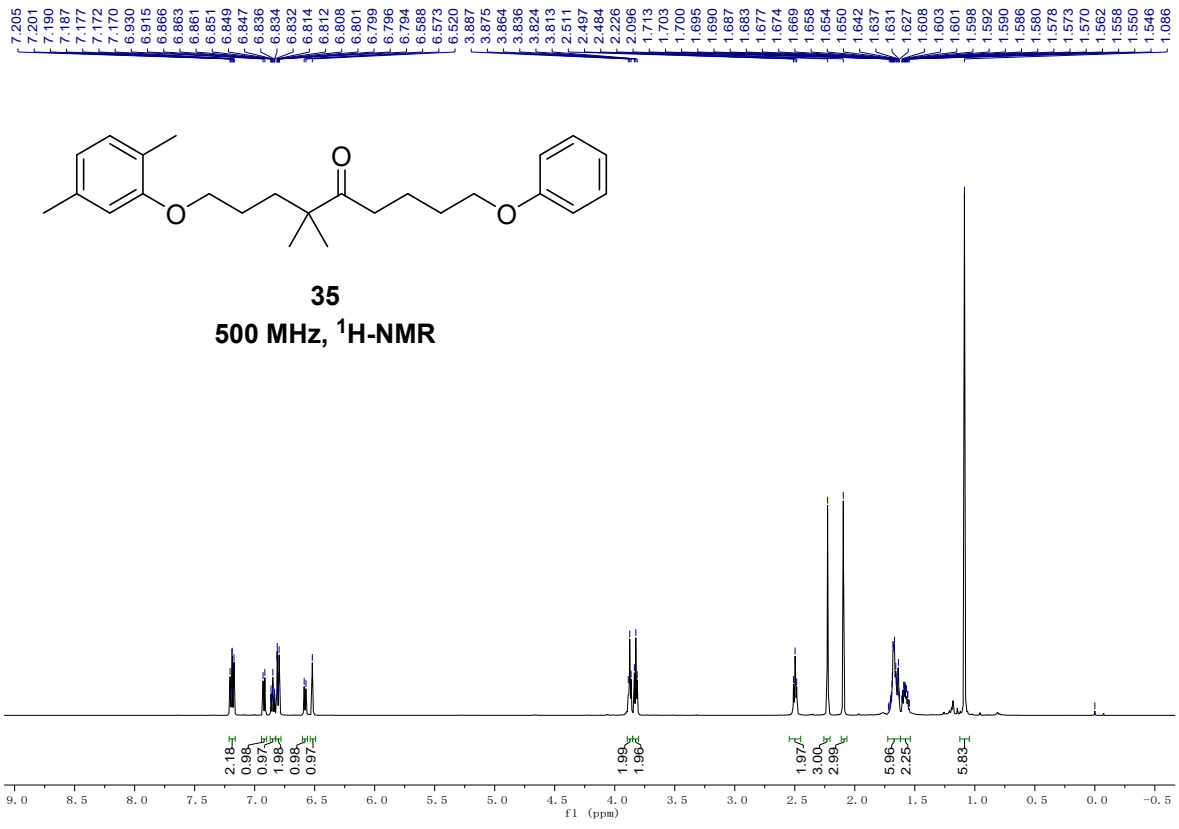


34

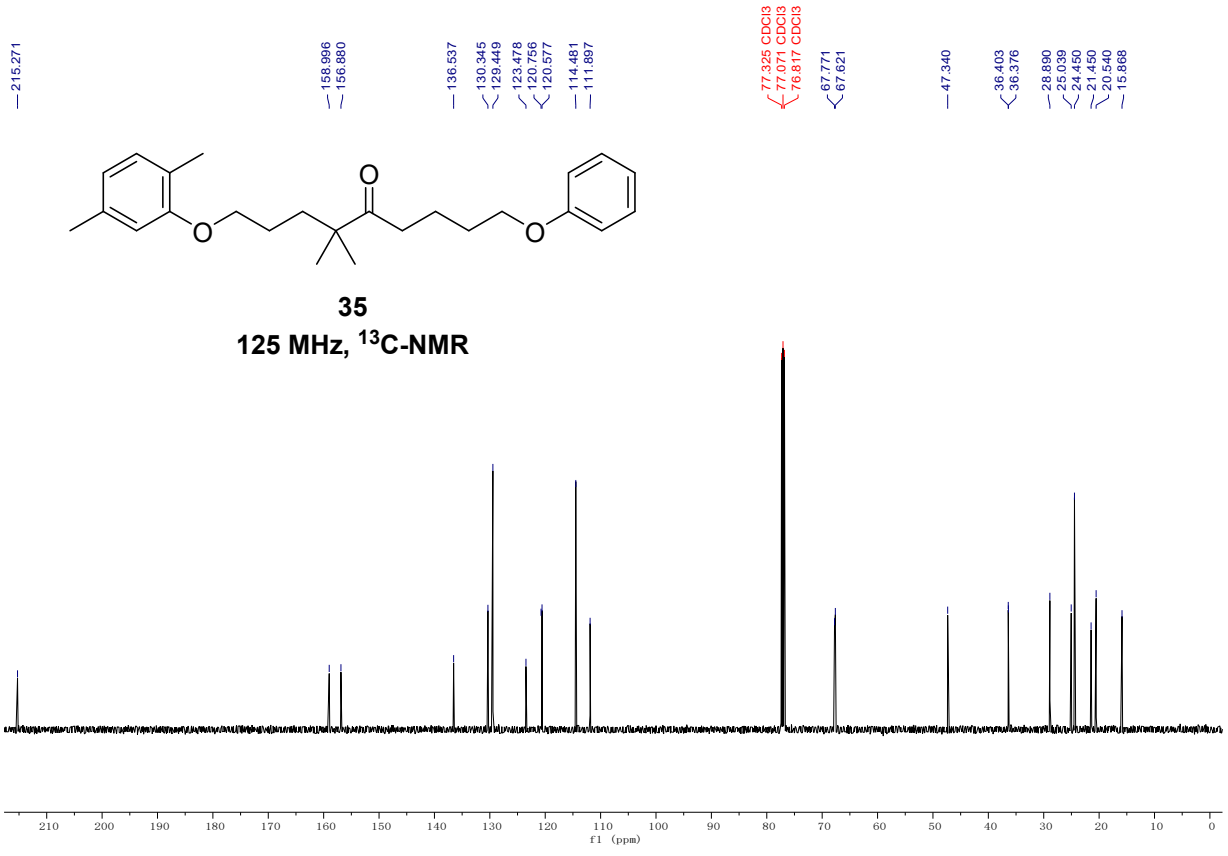
500 MHz, ^{1}H-NMR

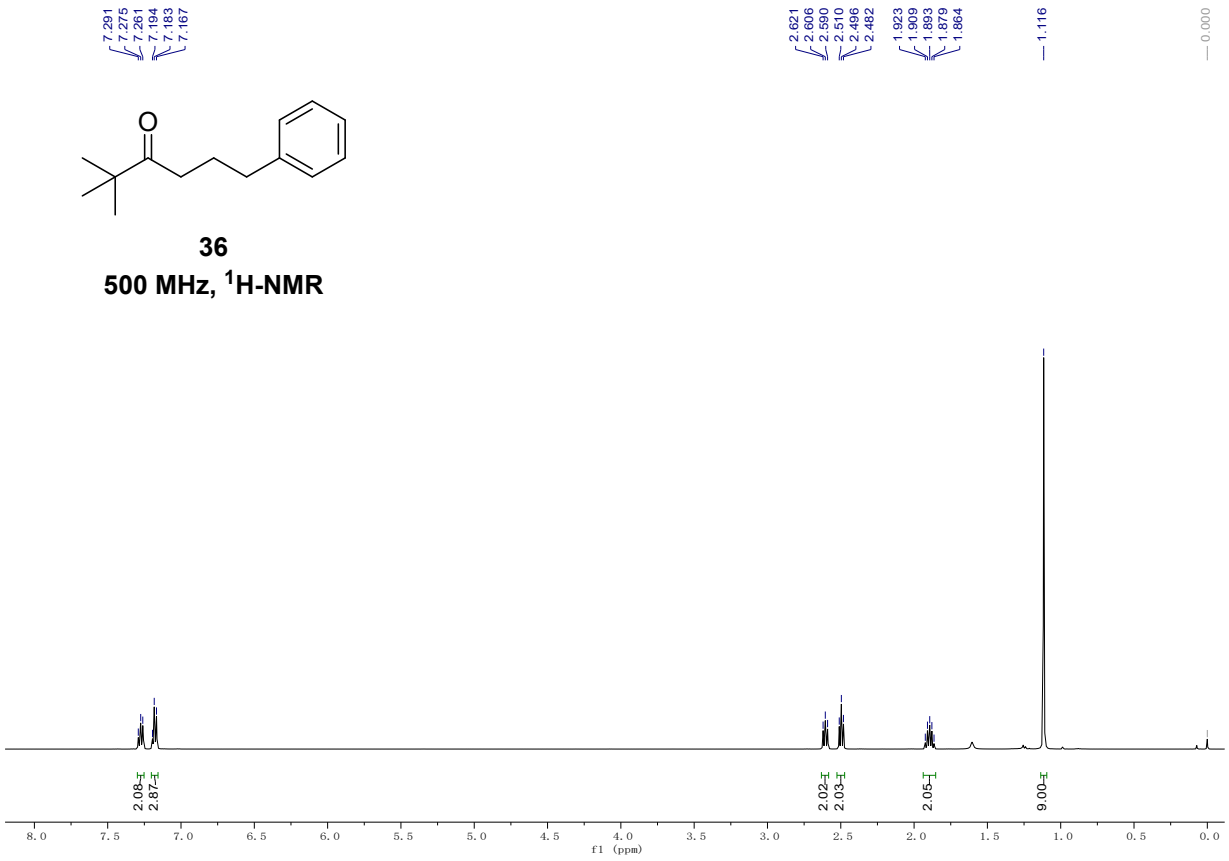


34
125 MHz, ^{13}C-NMR

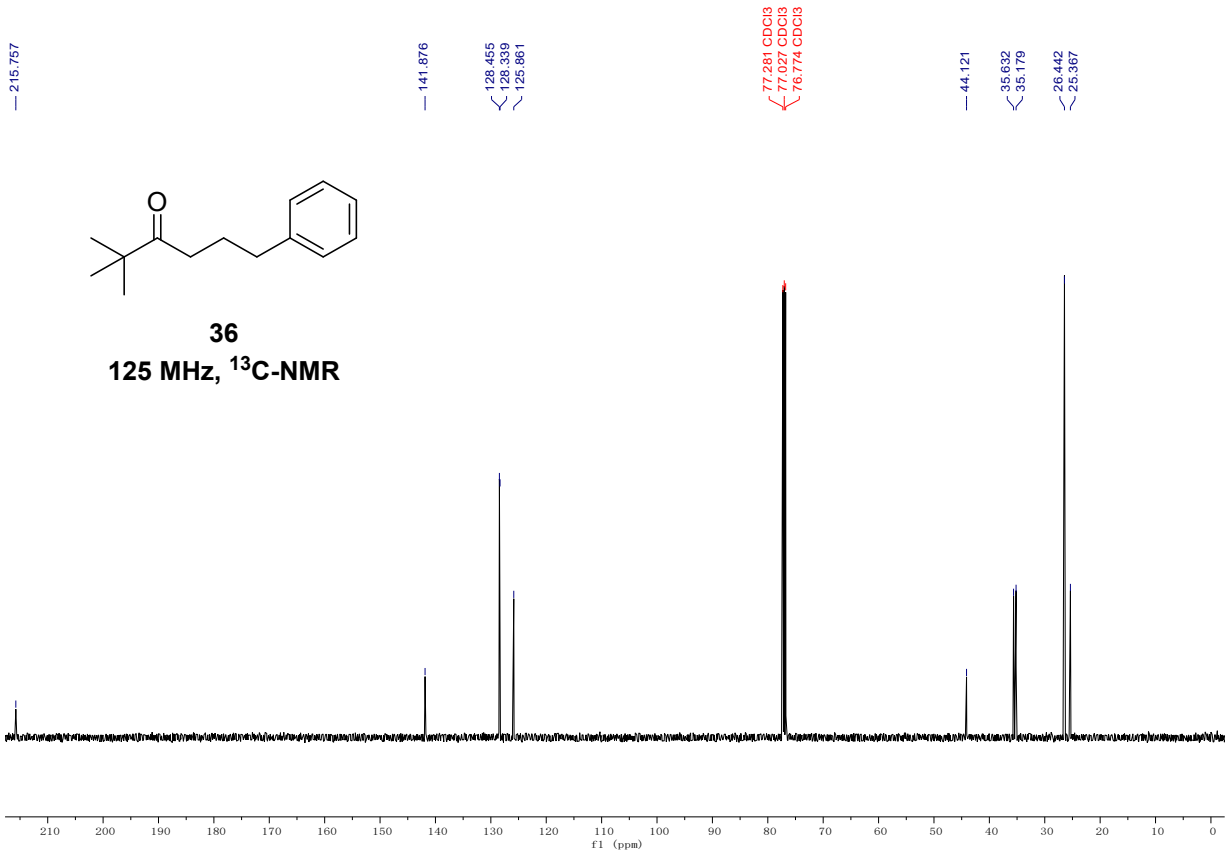


35
500 MHz, ^{1}H-NMR


215.271
158.996
156.880
136.537
130.345
129.449
123.478
120.756
120.577
114.481
111.897
77.325 CDCl3
77.071 CDCl3
76.817 CDCl3
67.771
67.621
47.340
36.403
36.376
28.890
25.039
24.450
21.450
20.540
15.868
O
O
O
35
125 MHz, 13C-NMR
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)



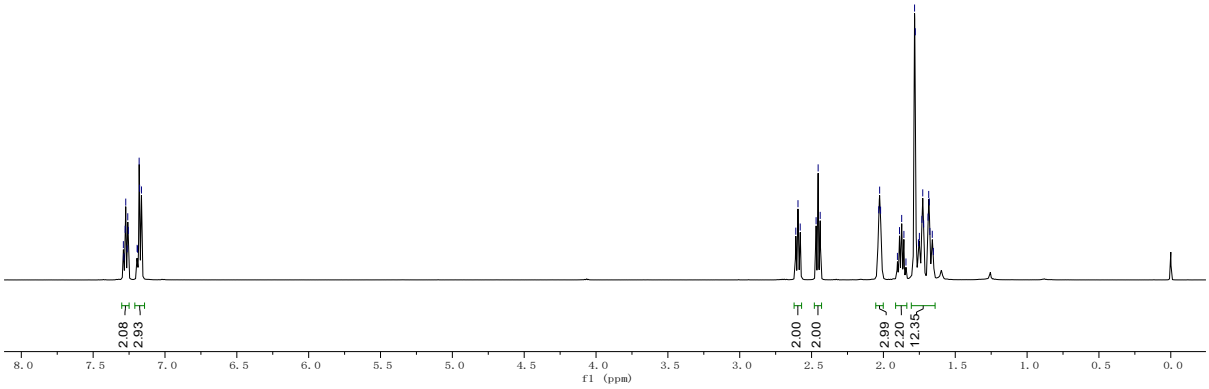
36
500 MHz, ^{1}H-NMR

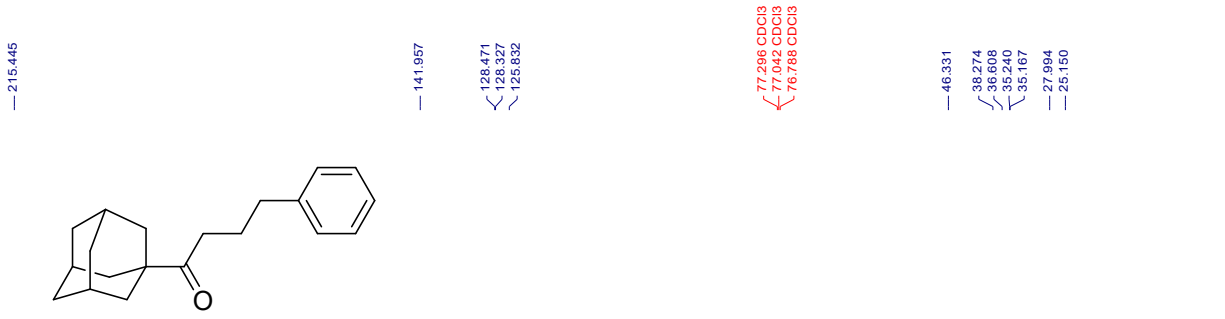


36
125 MHz, ^{13}C-NMR

37

500 MHz, ^{1}H-NMR





37

125 MHz, ^{13}C-NMR