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Supporting Information

Visible-light-mediated regioselective ring-opening hydrogenolysis of donor-acceptor cyclopropanes with DIPEA and H_2O

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1. General remarks

^{1}H, ^{13}C and ^{19}F NMR spectra were recorded at 400 MHz, 100 MHz and 376 MHz, respectively. HRMS spectra were recorded by EI, ESI, FI method. Infrared spectra were recorded on a Perkin-Elmer PE-983 spectrometer with absorption in cm^{-1}. Mass spectra were recorded by EI, ESI, and HRMS was measured on an Agilent Technologies 6224 TOF LC/MS instrument and a Waters Micromass GCT Permier. Melting points were determined on a digital melting point apparatus and temperatures were uncorrected. The employed solvents were dried up by standard methods when necessary. Commercially obtained reagents were used without further purification. All reactions were monitored by TLC plate analysis with silica gel coated plates (Huanghai GF254). Flash column chromatography was performed by using 300-400 mesh silica gel eluting with ethyl acetate and petroleum ether at increased pressure.

Reaction setup

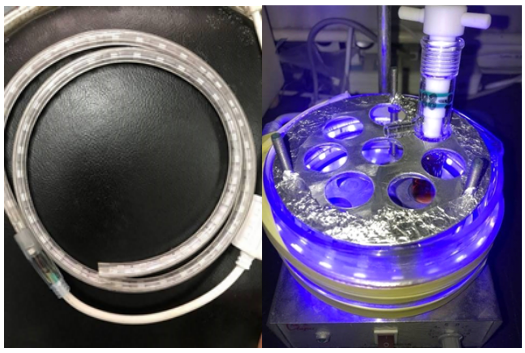
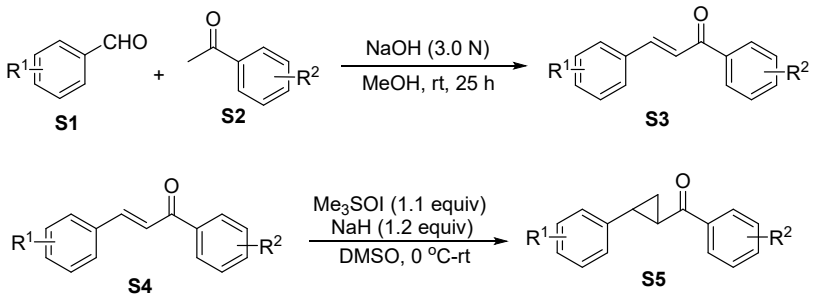


Figure S1. 8 W LEDs strip and reaction setup

As depicted in the picture, reactions were carried out in oven-dried sealed tubes. The reaction temperature was maintained at room temperature by a water bath and a fan.

2. General procedures for the synthesis of substrates 1

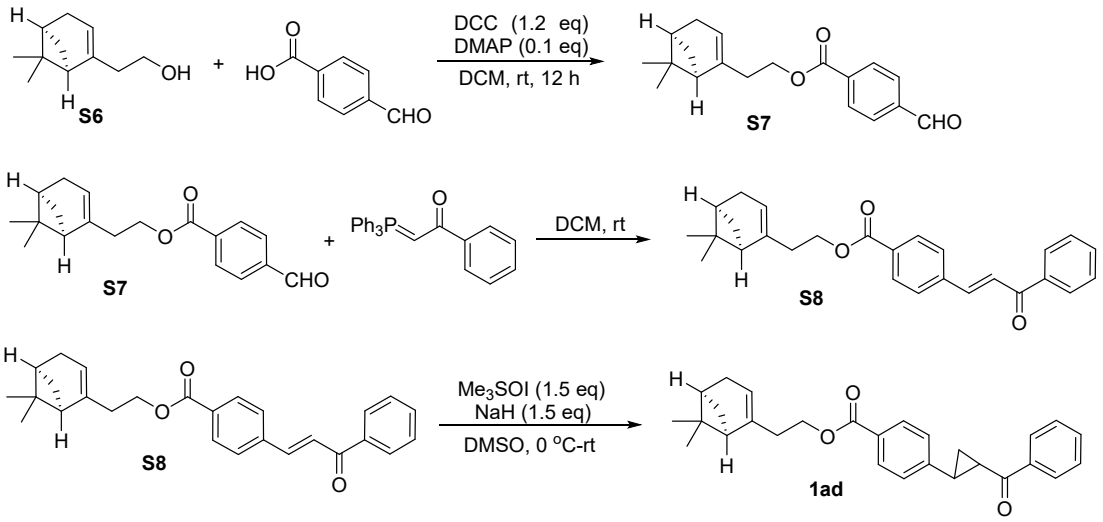
Synthesis of substrates **1a-1ac**



A sodium hydroxide solution (3.0 N, 2.0 equiv) was added to a solution of **S1** (1.0 equiv) in MeOH (20 mL per gram) at room temperature. Then acetophenone **S2** (1.1 equiv) was added to the reaction mixture. After stirring at room temperature for 25 h, the resulting mixture was concentrated to yield the residue. The residue was dissolved in ethyl acetate and washed with brine, dried over anhydrous Na_2SO_4.After evaporation of the solvents, the residue was further purified by a flash column chromatography on silica gel (petroleum ether: ethyl acetate : dichloromethane = 25 : 1 : 1) to afford **S3** as a yellow solid in 40 – 65% yields.

S5 were synthesized according to the previous literature.[1] To a two-necked round flask, sodium hydride (1.2 equiv) was added in dry DMSO, trimethylsulfoxonium iodide (1.1 equiv) was added to the flask under argon atmosphere. The flask was immersed in an ice bath and a solution of **S4** (5 mmol, 1.0 equiv) in dry DMSO was added to the reaction mixture. After that, the reaction was quenched with addition of water and the aqueous layer was extracted with ethyl acetate. The crude product was purified by a column chromatography with eluent (petroleum ether : ethyl acetate = 20 : 1) to afford products **S5** (**1a-1ac**) in 80 – 90% yields.

Synthesis of substrates **1ad** and **1ae**.[2]



Dicyclohexylcarbodiimide (1.2 equiv) and 4-dimethylaminopyridine (0.1 equiv) were added to a solution of 4-formylbenzoic acid (1.0 equiv) in dichloromethane (DCM) (0.3 M). Dimethylbicycloheptenеethanol (**S6**) (1.0 equiv) was added after stirring for five minutes. After the reaction mixture was stirred for 12 h, petroleum ether was added and the resulting mixture was filtered through a thin pad of silica gel. The solvent was removed in vacuo and the residue was purified by a flash column chromatography on silica gel to afford **S7**.

To a suspension of aldehyde **S7** (1.0 equiv) in DCM (0.3 M) was added the triphenylphosphoranylidene (2.2 equiv), and the reaction mixture was stirred at room temperature for 24 h. Then, the mixture was concentrated directly in vacuum and the residue was purified by a silica gel chromatography with petroleum ether : EtOAc (10 : 1) to give **S8**.

To a two-necked round flask, sodium hydride (1.2 equiv) was added in dry DMSO, trimethylsulfoxonium iodide (1.1 equiv) was added to the flask under argon atmosphere. The flask was immersed in an ice bath and a solution of **S8** (5.0 mmol, 1.0 equiv) in dry DMSO was added to the reaction mixture. After that, the reaction was quenched with water and the aqueous layer was extracted with ethyl acetate. The crude product was purified by a column chromatography with eluent (petroleum ether : ethyl acetate = 20 : 1) to afford product **1ad** in 75% yields.

The experimental procedure for the synthesis of **1ae** is the same as that of **1ad**.

3. Optimization of reaction conditions

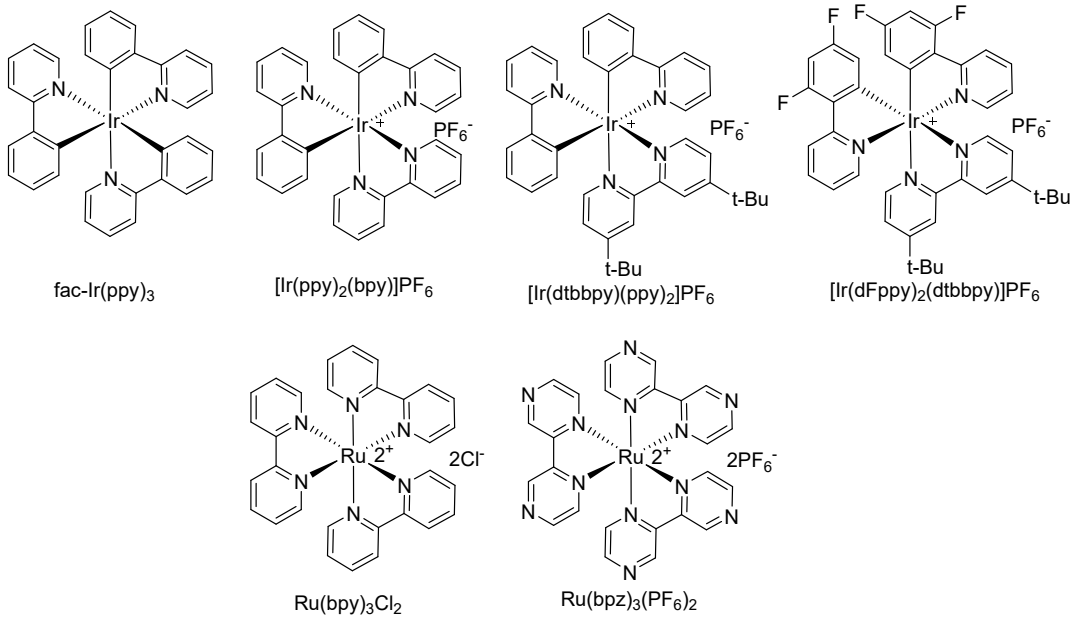
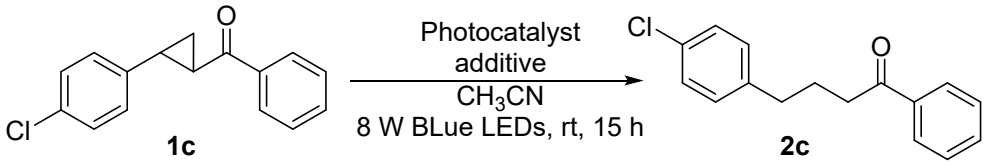


Figure S2. Structure of photocatalysts

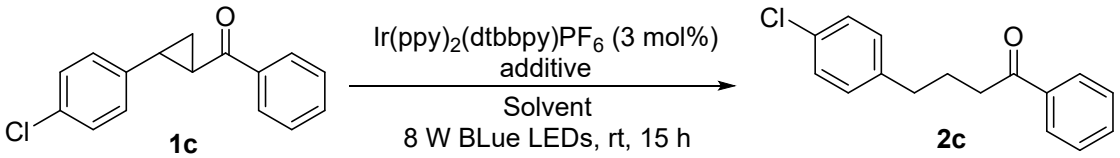
Table S1. Optimization of the reaction conditions using **1c** as a template substrate (photocatalyst and Lewis or Brønsted acid).



entry	photocatalyst	additive	yield (%)[b]
1[a]	$Ir(ppy)_2(dtbbpy)PF_6$ (3 mol%)	$^iPr_2NEt$ (1.5 eq)	75
2	$Ir(ppy)_3$ (3 mol%)	$^iPr_2NEt$ (1.5 eq)	32
3	$Ir(dF\text{-}CF_3\text{-}ppy)_2(dtbpy)PF_6$ (3 mol%)	$^iPr_2NEt$ (1.5 eq)	18
4	$Ir(dF\text{-}ppy)_3PF_6$ (3 mol%)	$^iPr_2NEt$ (1.5 eq)	trace
5	$Ru(bpy)_3(PF_6)_2$ (3 mol%)	$^iPr_2NEt$ (1.5 eq)	trace
6	$Ru(bpz)_3(PF_6)_2$ (3 mol%)	$^iPr_2NEt$ (1.5 eq)	trace
7	$Ir(ppy)_2(dtbbpy)PF_6$ (3 mol%)	$^iPr_2NEt$ (1.5 eq) $Sc(OTf)_3$ (20 mol%)	50
8	$Ir(ppy)_2(dtbbpy)PF_6$ (3 mol%)	$^iPr_2NEt$ (1.5 eq) $Gd(OTf)_3$ (20 mol%)	65
8	$Ir(ppy)_2(dtbbpy)PF_6$ (3 mol%)	$^iPr_2NEt$ (1.5 eq) PhCOOH (1.0 eq)	63

[a] Reaction condition: 0.2 mmol of substrate **1c**, 2 mL of CH_3CN, Ar, 8 W Blue LEDs, 15 h. [b] Yields were determined by ^1H NMR analysis of the crude mixture using CH_2Br_2 as an internal standard.

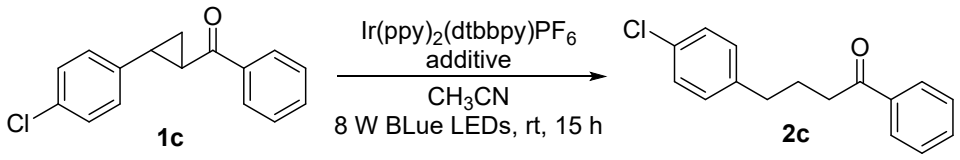
Table S2. Optimization of the reaction conditions using **1c** as a template substrate (additive and solvent).



entry	additive	solvent	yield (%)[b]
1	TEA (1.5 eq)	CH_3CN	55
2	TMEDA (1.5 eq)	CH_3CN	21
3	TEEDA (1.5 eq)	CH_3CN	70
4	HE (1.5 eq)	CH_3CN	N.R
5	$^{i}Pr_2NEt$ (1.0 eq)	CH_3CN	81
6	$^{i}Pr_2NEt$ (2.0 eq)	CH_3CN	59
7	$^{i}Pr_2NEt$ (1.0 eq)	DCM	trace
8	$^{i}Pr_2NEt$ (1.0 eq)	Toluene	65
9	$^{i}Pr_2NEt$ (1.0 eq)	THF	41

[a] Reaction condition: 0.2 mmol of substrate **1c**, 2 mL of CH_3CN, Ar, 8 W Blue LEDs, 15 h. [b] Yields were determined by ^1H NMR analysis of the crude mixture using CH_2Br_2 as an internal standard.

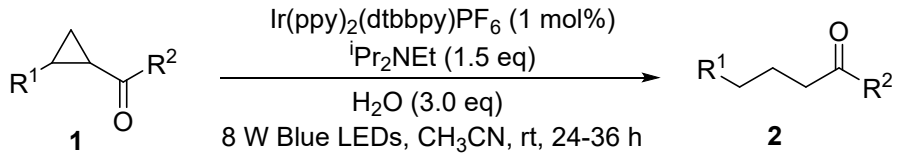
Table S3. Optimization of the reaction conditions using **1c** as a template substrate (equivalent of photocatalyst**,** equivalent of H_2O and control experiments).



entry	photocatalyst	additive	yield (%)[d]
1	$Ir(ppy)_2(dtbbpy)PF_6$ (3 mol%)	$^{i}Pr_2NEt$ (1.0 eq) 4 A molecular sieves	60
2	$Ir(ppy)_2(dtbbpy)PF_6$ (3 mol%)	$^{i}Pr_2NEt$ (1.0 eq) H_2O (1.2 eq)	90
3[b]	$Ir(ppy)_2(dtbbpy)PF_6$ (2 mol%)	$^{i}Pr_2NEt$ (1.0 eq) H_2O (1.2 eq)	92
4[b]	$Ir(ppy)_2(dtbbpy)PF_6$ (2 mol%)	$^{i}Pr_2NEt$ (1.5 eq) H_2O (3.0 eq)	99
5[b]	**$Ir(ppy)_2(dtbbpy)PF_6$ (1 mol%)**	**$^{i}Pr_2NEt$ (1.5 eq) H_2O (3.0 eq)**	**99 (97)**
6	$Ir(ppy)_2(dtbbpy)PF_6$ (2 mol%)	—	N.R
7	—	$^{i}Pr_2NEt$ (1.5 eq) H_2O (3.0 eq)	N.R
8[c]	$Ir(ppy)_2(dtbbpy)PF_6$ (1 mol%)	$^{i}Pr_2NEt$ (1.5 eq) H_2O (3.0 eq)	N.R

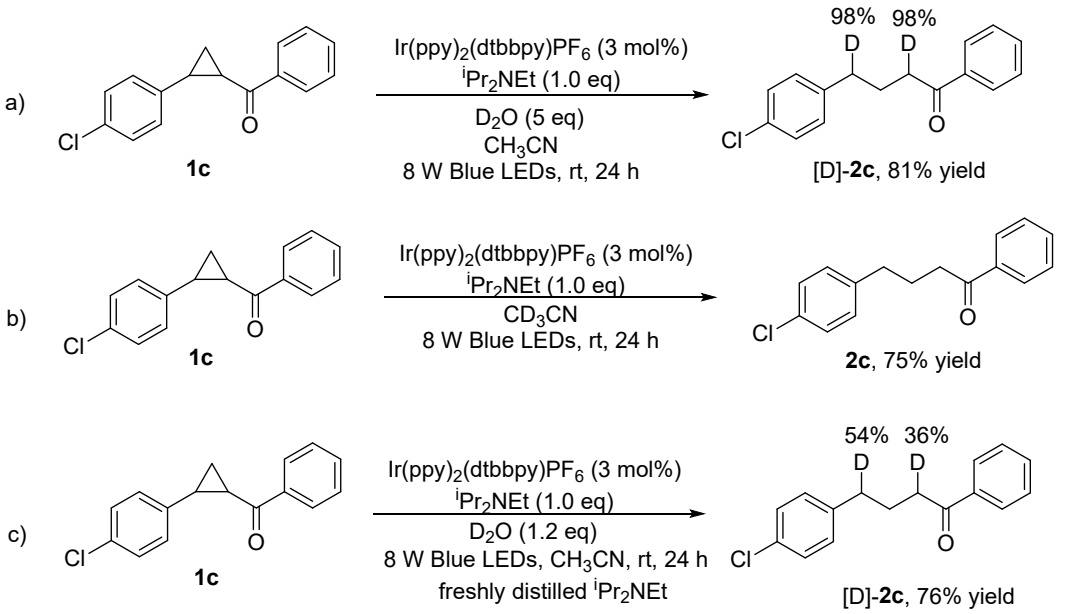
[a] Reaction condition: 0.2 mmol of substrate **1c**, 2 mL of CH_3CN, Ar, 8 W Blue LEDs, 15 h. [b] Reaction time: 24 h. [c] No light. [d] Yields were determined by ^1H NMR analysis of the crude mixture using CH_2Br_2 as an internal standard.

4. General procedure for the synthesis of 2



To a 10.0 mL oven-dried tube were added substrate **1** (0.20 mmol, 1.0 equiv), $Ir(ppy)_3$ (0.002 mmol, 0.01 equiv), and the flask was equipped with Argon for three times. Then the anhydrous degassed CH_3CN (4.0 mL), *N*,*N*-diisopropylethylamine (0.3 mmol, 1.5 equiv) and H_2O (0.6 mmol, 3.0 equiv) were added to this flask via a syringe. The resulting mixture was stirred upon irradiation of 8 W blue LEDs at room temperature for 24-36 hours. Then, the solvent was removed under vacuum and the residue was purified by a silica gel column chromatography (petroleum ether: ethyl acetate = 30 : 1) to give the desired products **2** in 38 - 99% yields.

5. Deuterium labeling experiment



Experimental procedure:

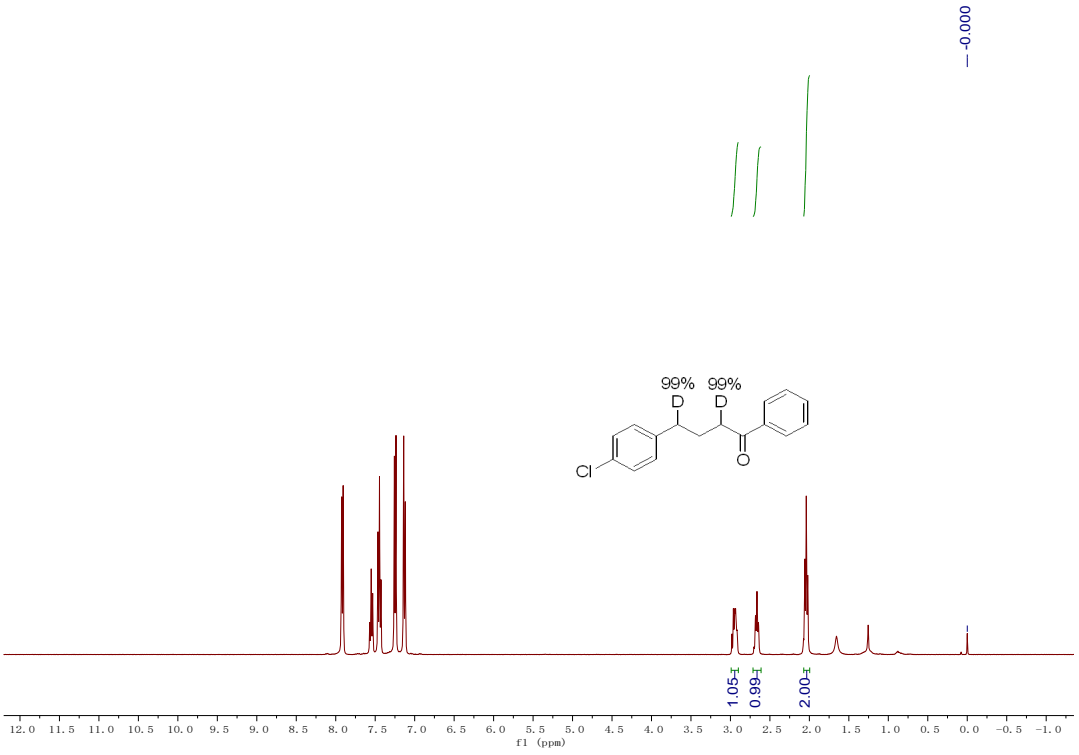
a) To a 10.0 mL oven-dried tube were added substrate **1c** (0.20 mmol, 1.0 equiv), $Ir(ppy)_3$ (0.002 mmol, 0.01 equiv), and the flask was equipped with Argon for three times. Then the anhydrous degassed CH_3CN (4.0 mL), *N*,*N*-diisopropylethylamine (0.2 mmol, 1.0 equiv) and D_2O (1.0 mmol, 5.0 equiv) were added to this flask via a syringe. The resulting mixture was stirred upon irradiation of 8 W blue LEDs at room temperature for 24 hours. Then, the solvent was removed under vacuum and the residue was dissolved in $CDCl_3$ to afford the crude ^1H NMR spectrum using CH_2Br_2 as the internal standard.

b) To a 10.0 mL oven-dried tube were added substrate **1c** (0.20 mmol, 1.0 equiv), $Ir(ppy)_3$ (0.002 mmol, 0.01 equiv), and the flask was equipped with Argon for three times. Then the anhydrous degassed CD_3CN (4.0 mL) and *N*,*N*-diisopropylethylamine (0.2 mmol, 1.0 equiv) were added to this flask via a syringe. The resulting mixture was stirred upon irradiation of 8 W blue LEDs at room temperature for 24 hours. Then, the solvent was removed under vacuum and the residue was dissolved in $CDCl_3$ to afford the crude ^1H NMR spectrum using CH_2Br_2 as the internal standard.

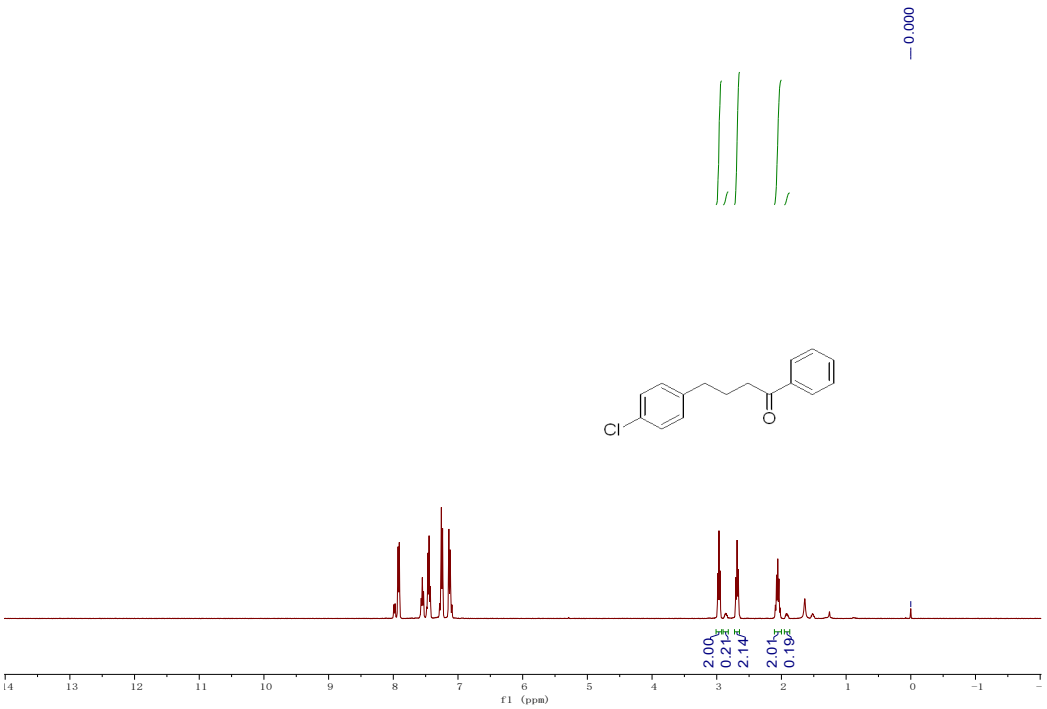
c) To a 10.0 mL oven-dried tube were added substrate **1c** (0.20 mmol, 1.0 equiv), $Ir(ppy)_3$ (0.002 mmol, 0.01 equiv), and the flask was equipped with Argon for three times. Then the anhydrous degassed CH_3CN (4.0 mL), *N*,*N*-diisopropylethylamine (newly distilled) (0.2 mmol, 1.0 equiv) and

D_2O (0.24 mmol, 1.2 equiv) were added to this flask via a syringe. The resulting mixture was stirred upon irradiation of 8 W blue LEDs at room temperature for 24 hours. Then, the solvent was removed under vacuum and the residue was dissolved in $CDCl_3$ to afford the crude ^1H NMR spectrum using CH_2Br_2 as the internal standard.

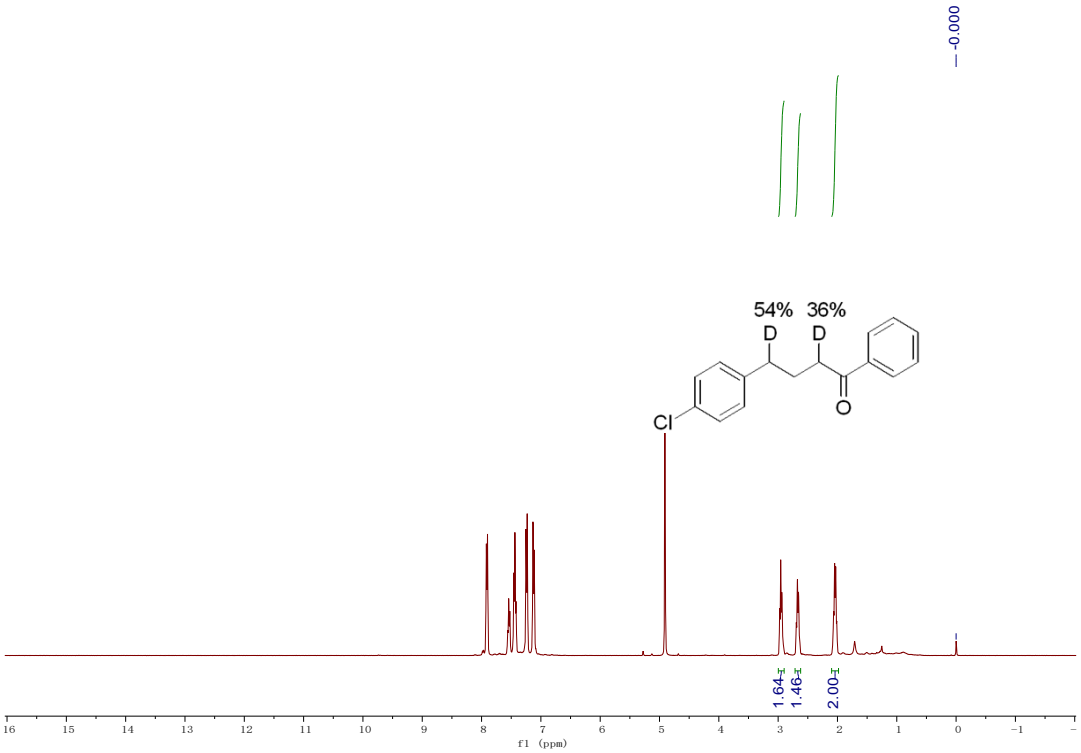
a)



b)



c)


-0.000
54%
36%
D
D
Cl
O
1.64
1.46
2.00
16
15
14
13
12
11
10
9
8
7
6
5
4
3
2
1
0
−1
f1 (ppm)

6. The monitoring of ^{1}H NMR spectra of the reaction residues.

Experimental procedure:

To a 10.0 mL oven-dried tube were added substrate **1c** (0.20 mmol, 1.0 equiv), $Ir(ppy)_3$ (0.006mmol, 0.03 equiv), and the flask was equipped with Argon for three times. Then the anhydrous degassed CD_3CN (4.0 mL), *N*,*N*-diisopropylethylamine (0.2 mmol, 1.0 equiv) and H_2O (1.0 mmol, 5.0 equiv) were added to this flask via a syringe. The resulting mixture was stirred upon irradiation of 8 W blue LEDs at room temperature for 24 hours. Then, the mixture was monitored by ^{1}H NMR spectra. By comparing the spectroscopic data with those in the previous reference,[3] we successfully detected the presence of acetaldehyde.

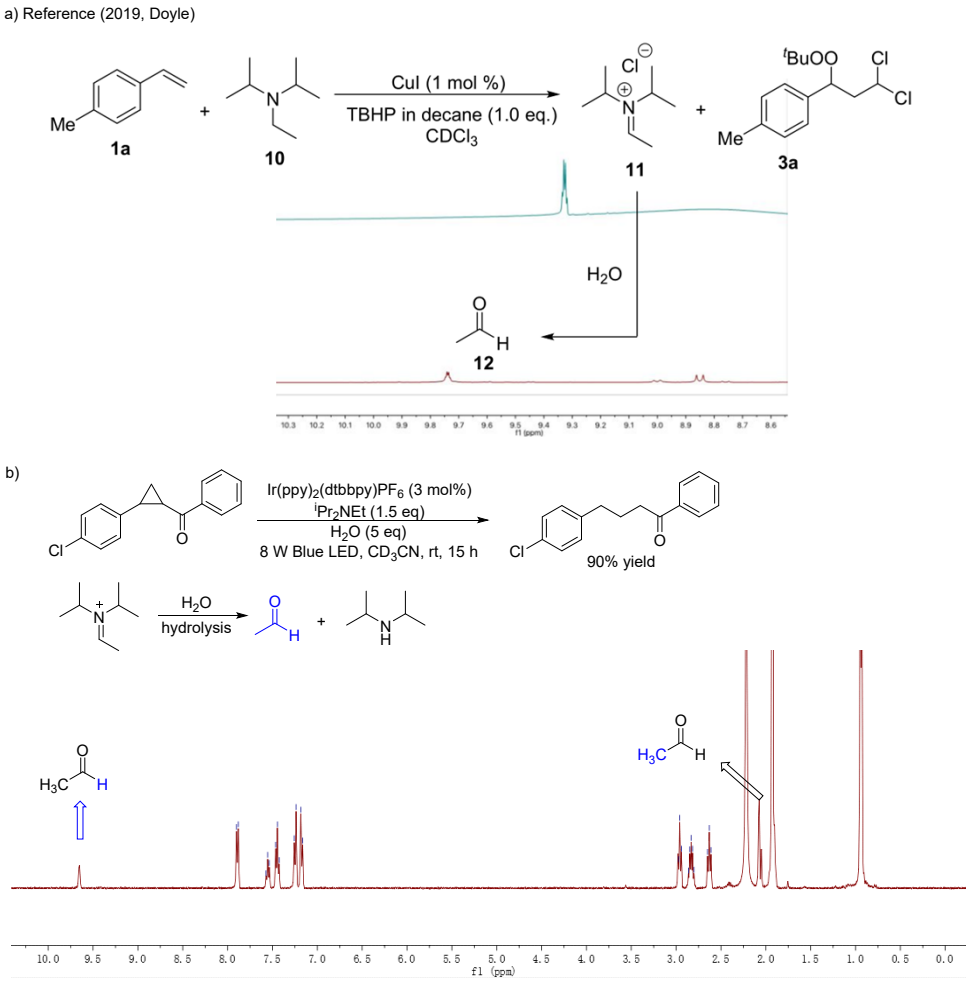
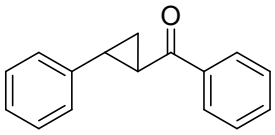


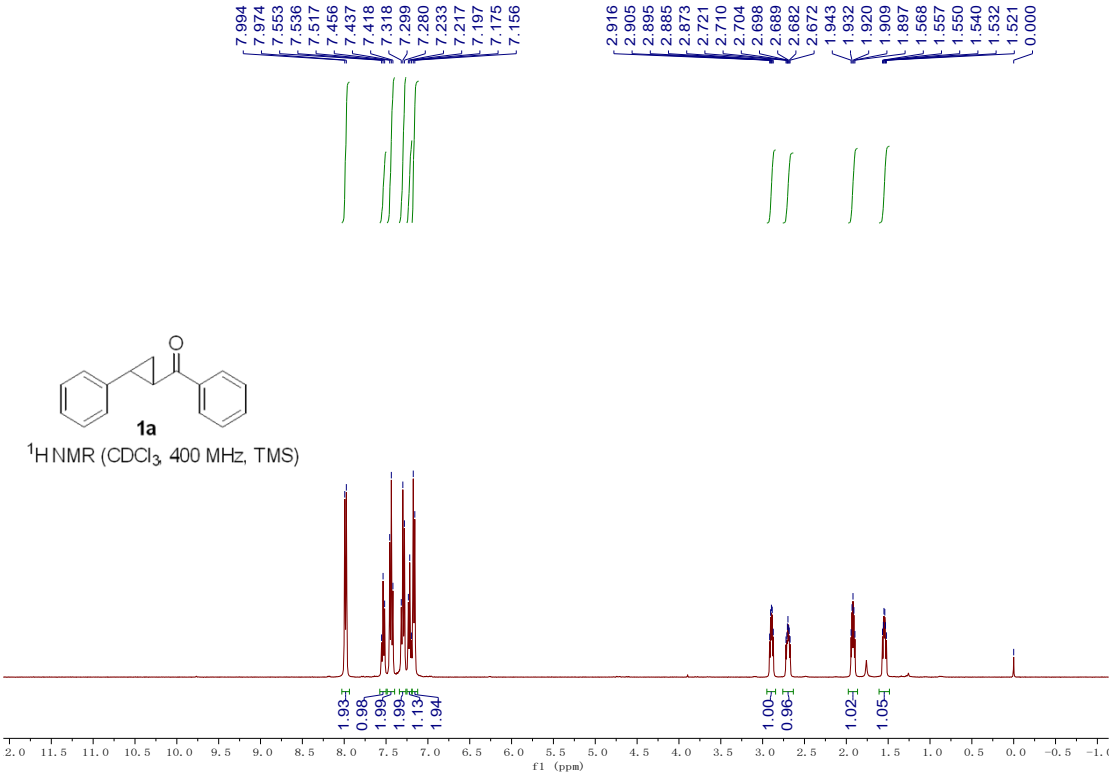
Figure S3. ^{1}H NMR spectra of the reaction residues.

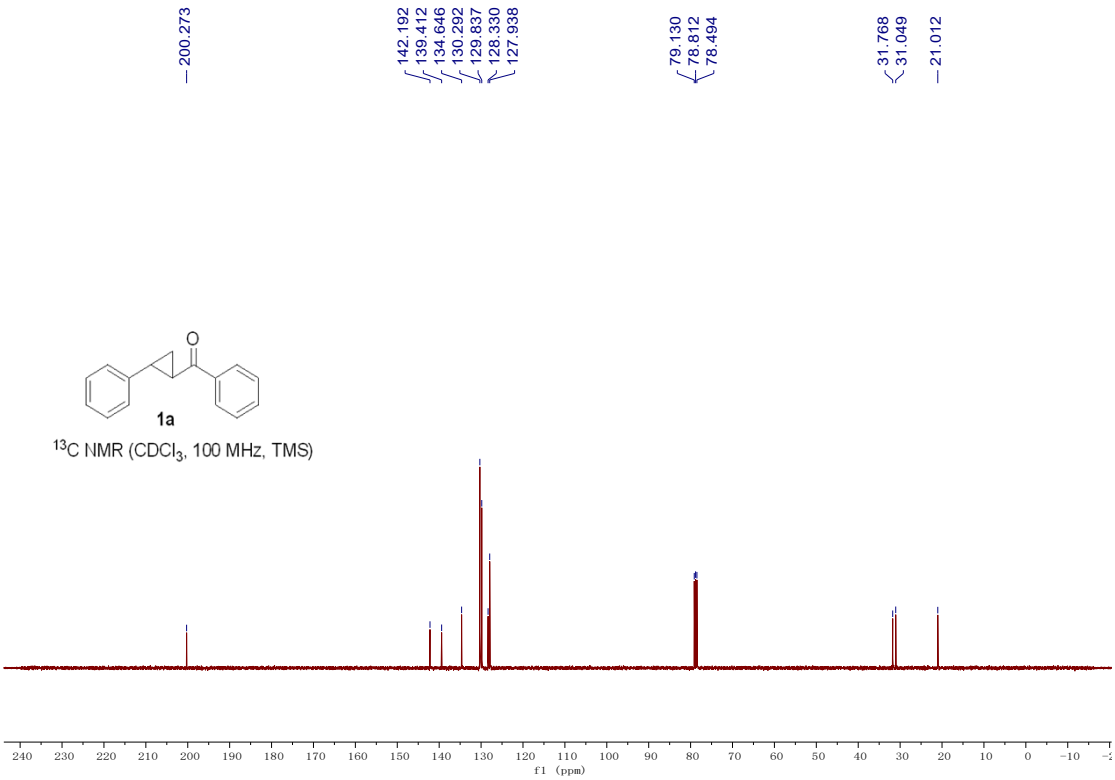
7. Spectroscopic data of substrates 1

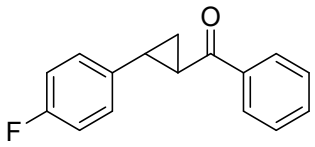


Phenyl(2-phenylcyclopropyl)methanone (1a)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[4] A colorless oil. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 1.52-1.57 (m, 1H), 1.90-1.94 (m, 1H), 2.67-2.72 (m, 1H), 2.87-2.92 (m, 1H), 7.17 (d, *J* = 7.2 Hz, 2H), 7.22 (t, *J* = 7.2 Hz, 1H), 7.30 (t, *J* = 7.4 Hz, 2H), 7.44 (t, *J* = 7.6 Hz, 2H), 7.54 (t, *J* = 7.2 Hz, 1H), 7.98 (d, *J* = 7.6 Hz, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 21.0, 31.0, 31.8, 127.9, 128.3, 129.8, 130.3, 134.6, 139.4, 142.2, 200.3.

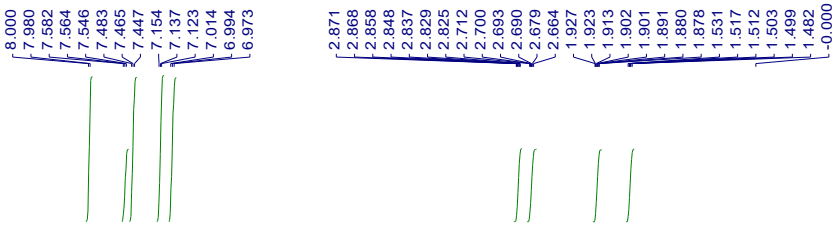


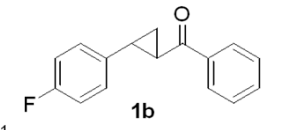




(2-(4-fluorophenyl)cyclopropyl)(phenyl)methanone (1b)

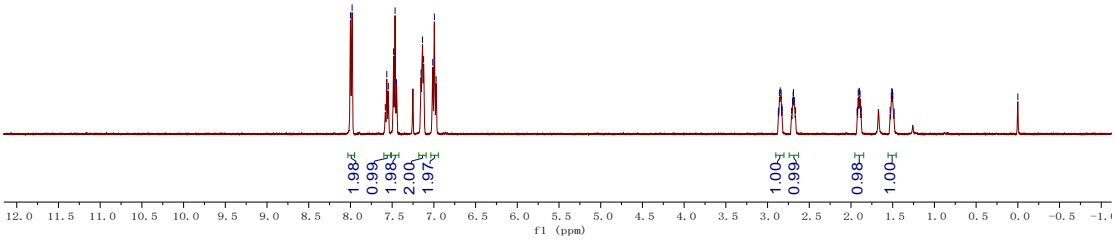
This is a known compound and its spectroscopic data are consistent with those in the previous literature.[4] A white solid. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 1.48-1.53 (m, 1H), 1.88-1.93 (m, 1H), 2.66-2.71 (m, 1H), 2.83-2.87 (m, 1H), 6.49 (t, *J* = 8.2 Hz, 2H), 7.14 (t, *J* = 6.8 Hz, 2H), 7.47 (t, *J* = 7.2 Hz, 2H), 7.56 (t, *J* = 7.2 Hz, 1H), 7.99 (d, *J* = 7.8 Hz, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 20.9, 30.8, 30.9, 117.1 (d, *J* = 21.5 Hz), 129.5 (d, *J* = 8.0 Hz), 129.8, 130.3, 134.7, 137.8 (d, *J* = 3.0 Hz), 139.3, 163.4 (d, *J* = 244.7 Hz), 200.1. ^{19}F NMR ($CDCl_3$, $CFCl_3$, 376 MHz) δ -116.1.

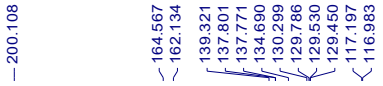


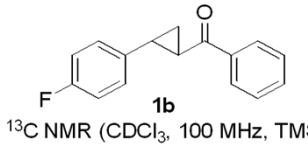


1b

^{1}H NMR ($CDCl_3$, 400 MHz, TMS)

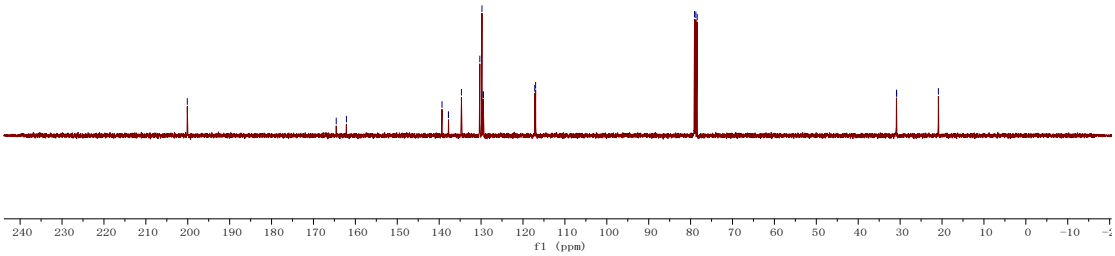


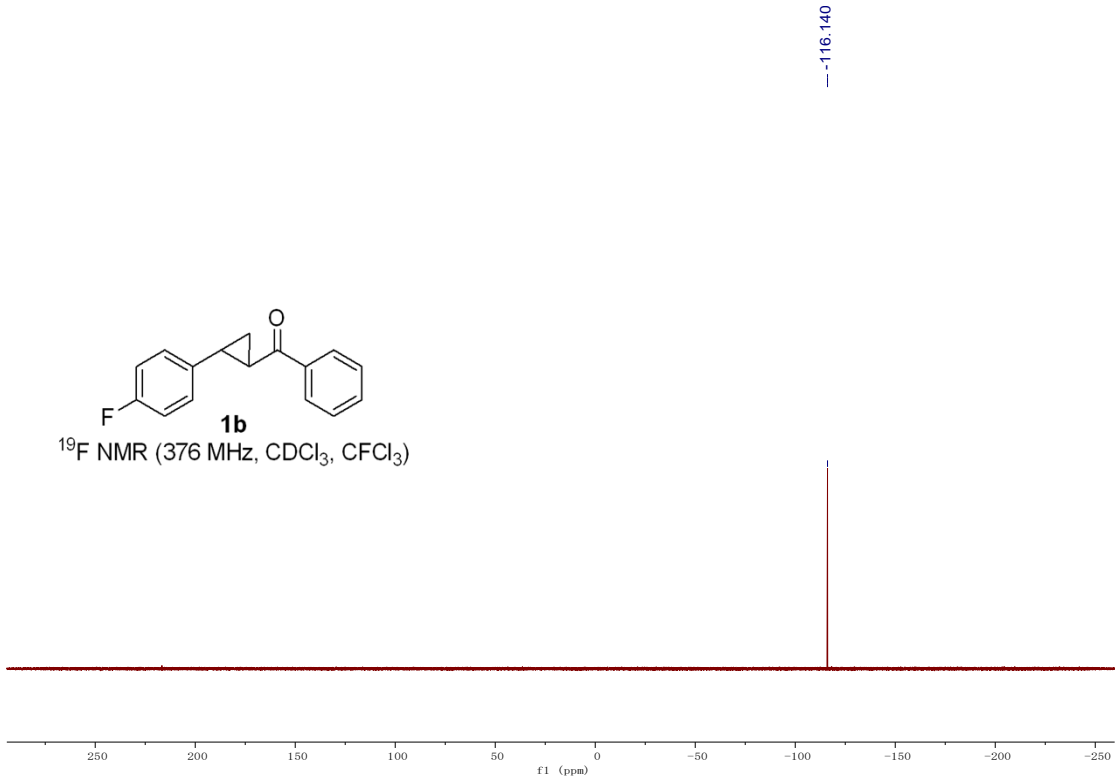


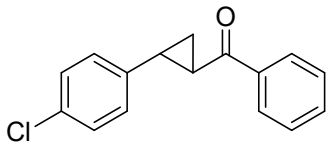


1b

^{13}C NMR ($CDCl_3$, 100 MHz, TMS)

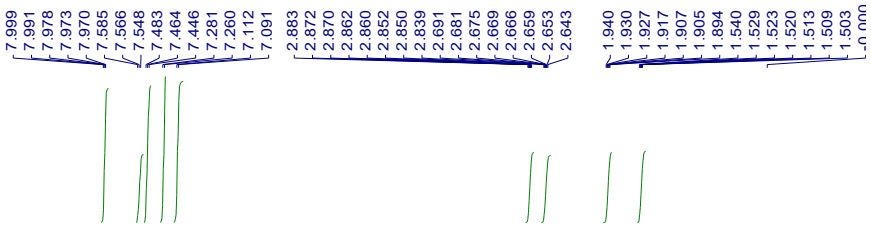


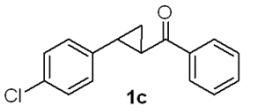




(2-(4-chlorophenyl)cyclopropyl)(phenyl)methanone (1c)

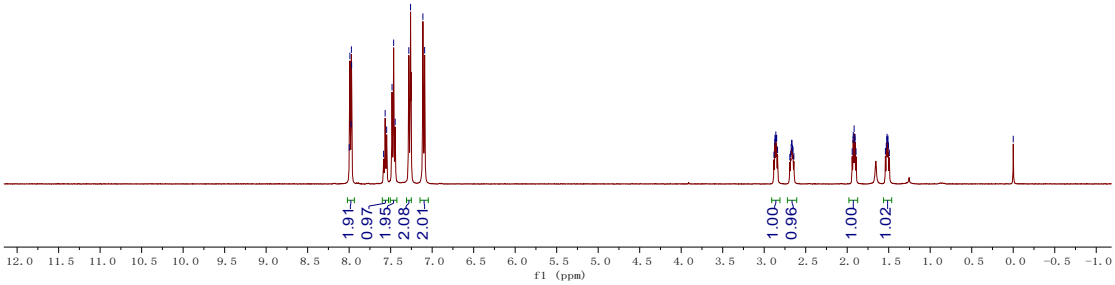
This is a known compound and its spectroscopic data are consistent with those in the previous literature.[4] A white solid. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 1.49-1.54 (m, 1H), 1.89-1.94 (m, 1H), 2.64-2.69 (m, 1H), 2.84-2.88 (m, 1H), 7.10 (d, *J* = 8.4 Hz, 2H), 7.27 (d, *J* = 8.4 Hz, 2H), 7.46 (t, *J* = 7.6 Hz, 2H), 7.57 (t, *J* = 7.4 Hz, 1H), 7.97-8.00 (m, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 20.9, 30.9, 31.0, 129.3, 129.8, 130.3, 130.4, 134.0, 134.7, 139.2, 140.7, 199.9.

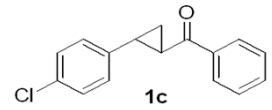




1c

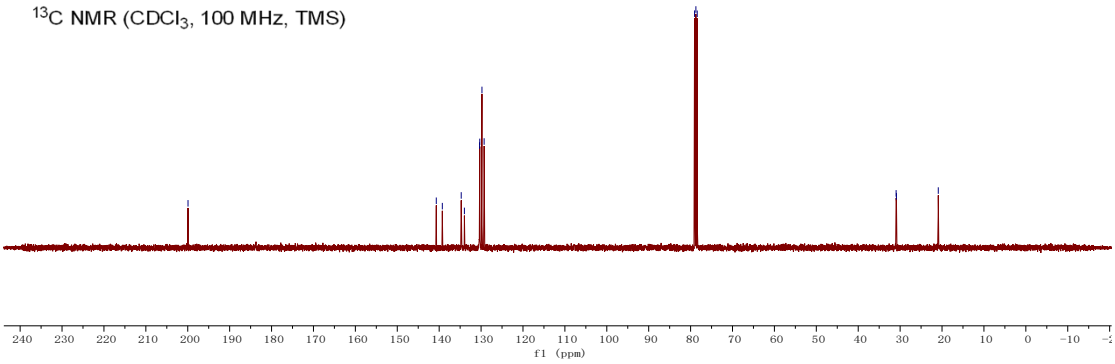
^{1}H NMR ($CDCl_3$, 400 MHz, TMS)

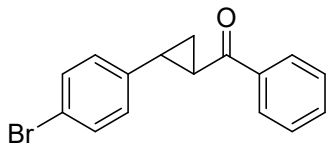




1c

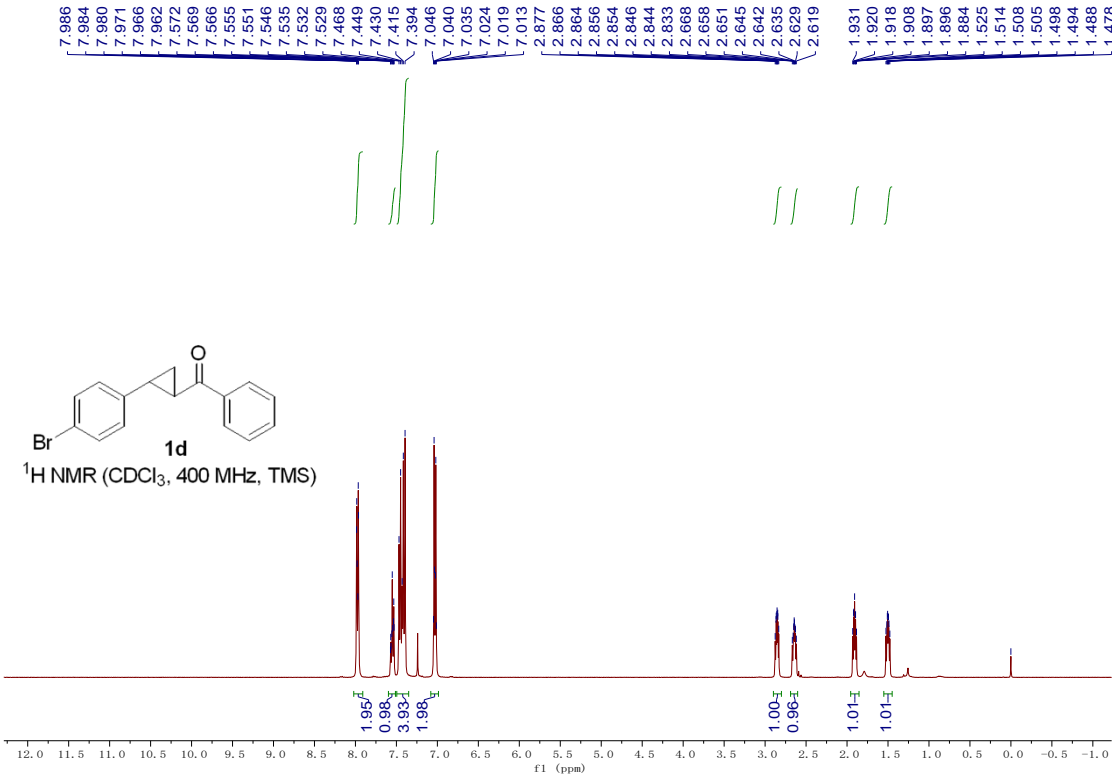
^{13}C NMR ($CDCl_3$, 100 MHz, TMS)

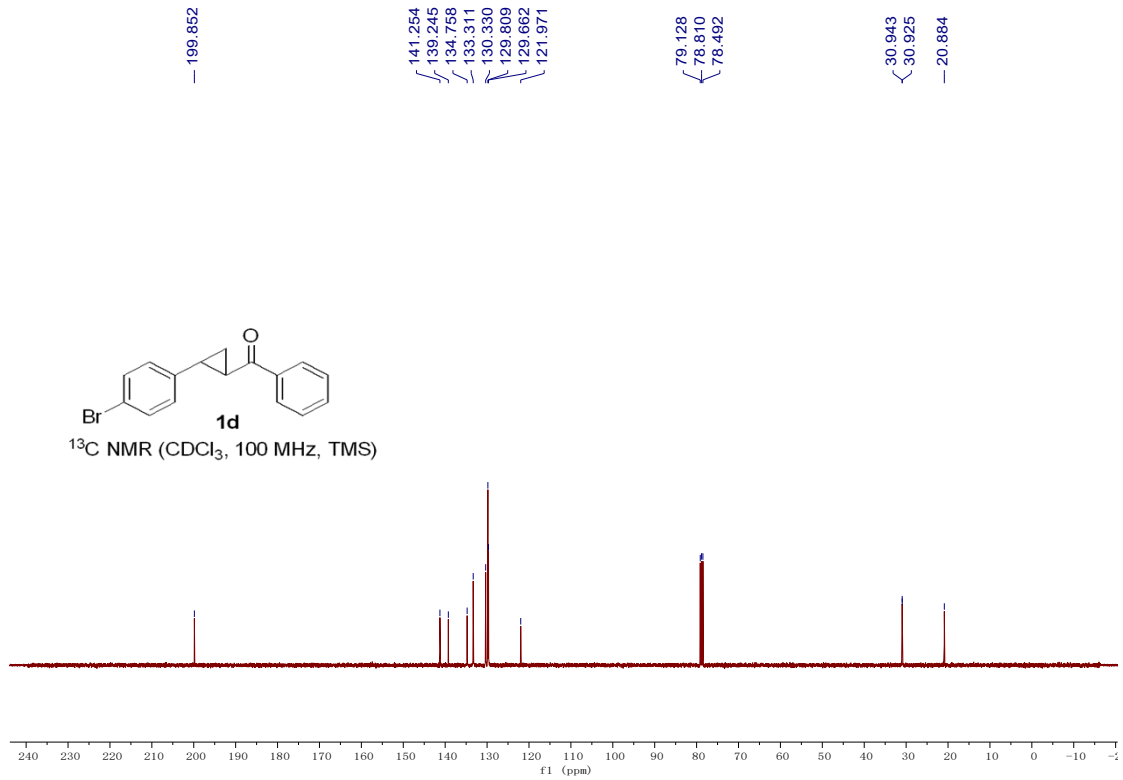


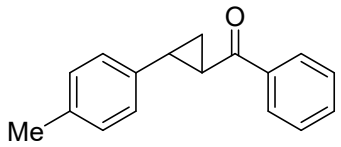


(2-(4-bromophenyl)cyclopropyl)(phenyl)methanone (1d)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[7] A white solid. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 1.48-1.53 (m, 1H), 1.88-1.93 (m, 1H), 2.62-2.67 (m, 1H), 2.83-2.88 (m, 1H), 7.03 (dt, J_1 = 8.4 Hz, J_2 = 2.4 Hz, 2H), 7.39-7.47 (m, 4H), 7.55 (tt, J_1 = 7.2 Hz, J_2 = 1.2 Hz, 1H), 7.96-7.99 (m, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 20.9, 30.9, 30.9, 122.0, 129.7, 129.8, 130.3, 133.3, 134.8, 139.2, 141.3, 199.9.

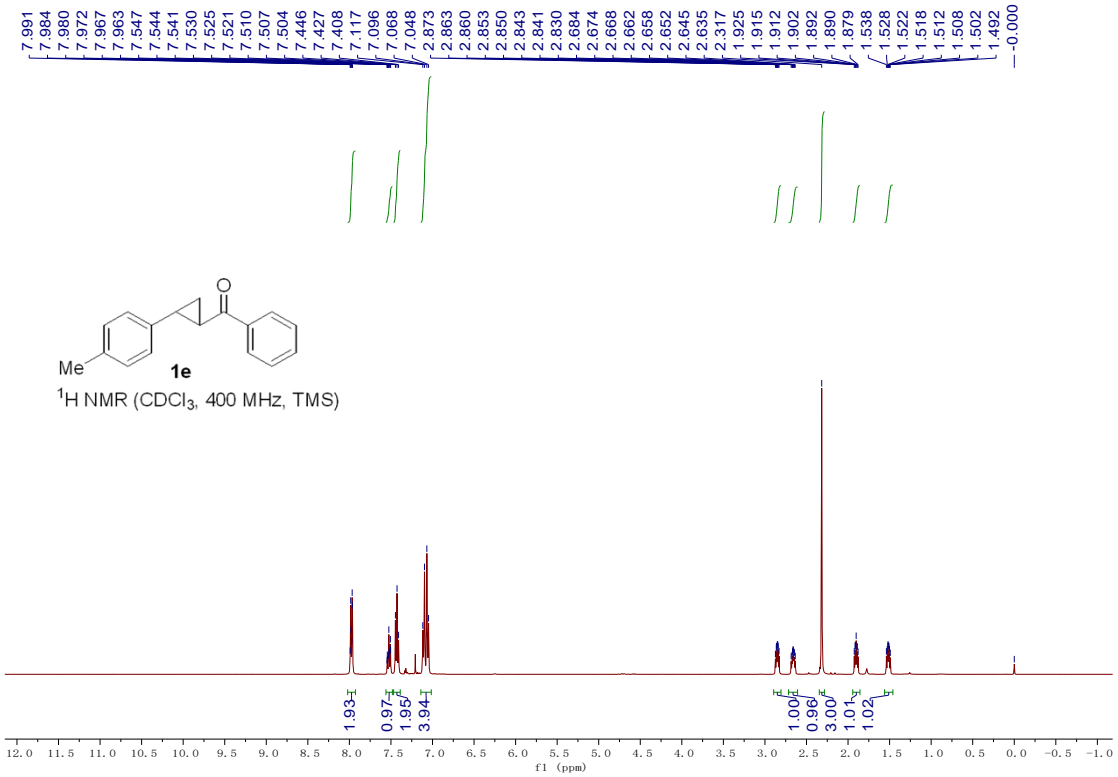


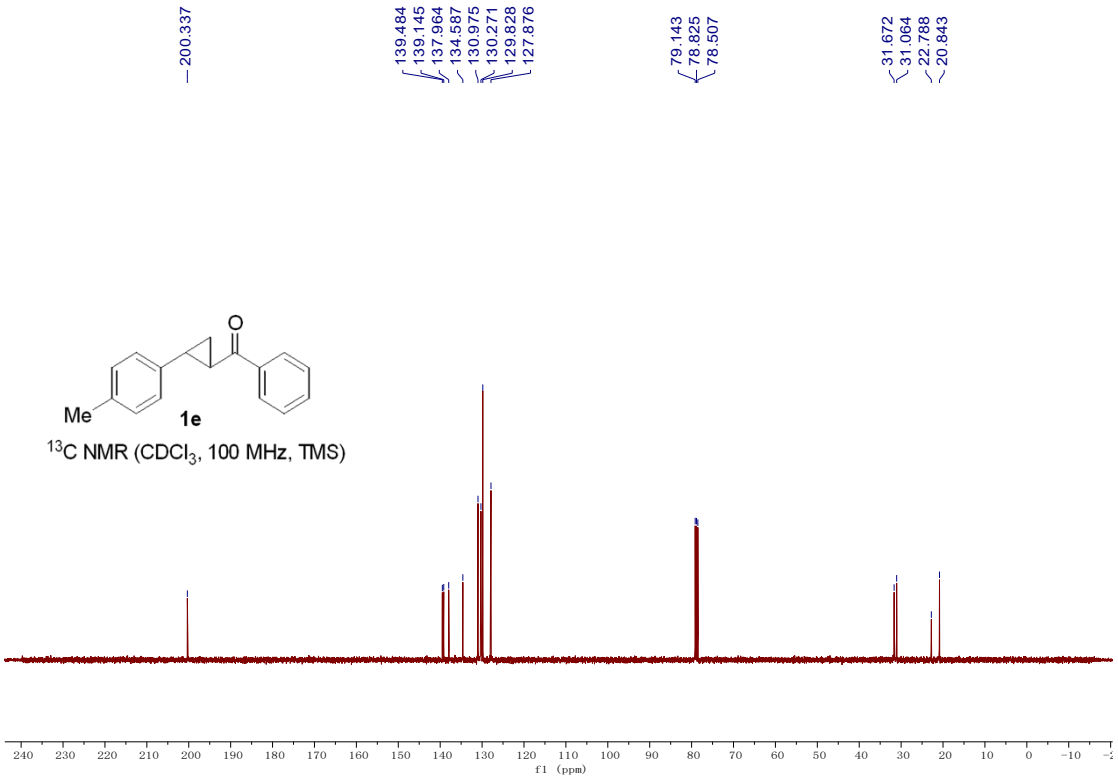


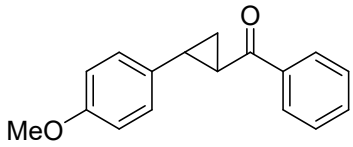


Phenyl(2-(p-tolyl)cyclopropyl)methanone (1e)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[7] A white solid. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 1.49-1.54 (m, 1H), 1.88-1.93 (m, 1H), 2.32 (s, 3H), 2.64-2.68 (m, 1H), 2.83-2.87 (m, 1H), 7.05-7.12 (m, 4H), 7.43 (t, J = 7.6 Hz, 2H), 7.53 (tt, J_1 = 6.8 Hz, J_2 = 1.2Hz, 1H), 7.96-7.99 (m, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 20.8, 22.8, 31.1, 31.7, 127.9, 129.8, 130.3, 131.0, 134.6, 138.0, 139.1, 139.5, 200.3.

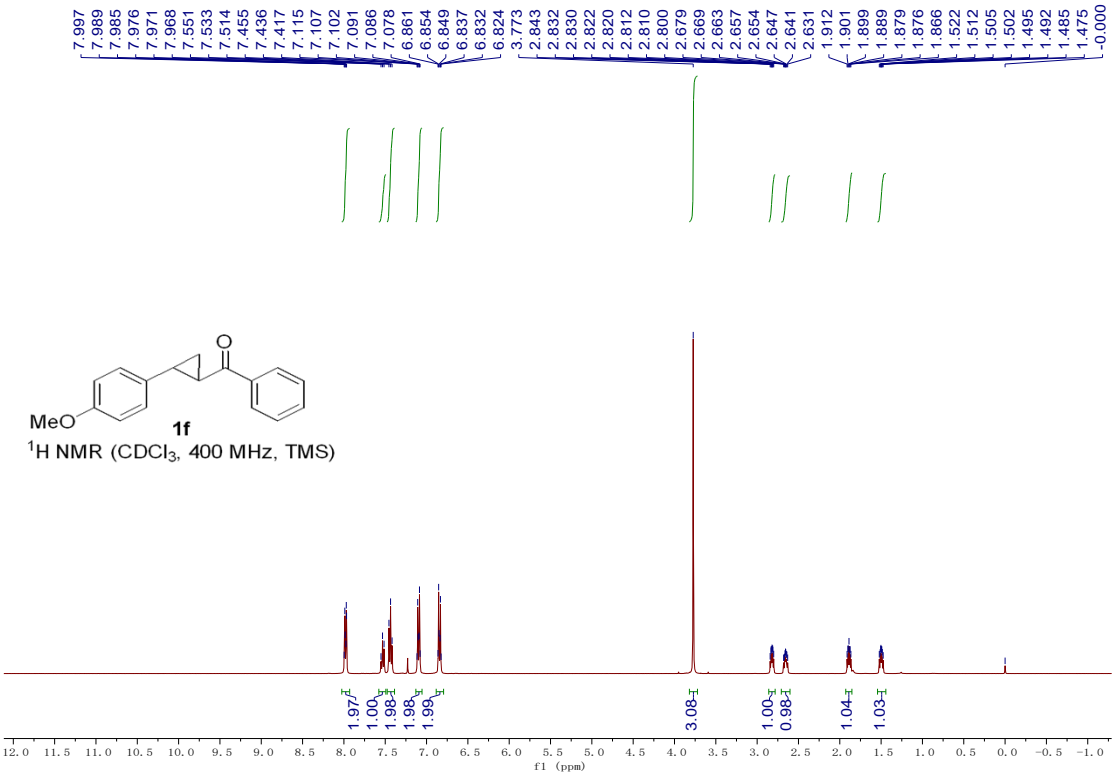

7.991
7.984
7.980
7.972
7.967
7.963
7.547
7.544
7.541
7.530
7.525
7.521
7.510
7.507
7.504
7.446
7.427
7.408
7.117
7.096
7.068
7.048
2.873
2.863
2.860
2.853
2.850
2.843
2.841
2.830
2.684
2.674
2.668
2.662
2.658
2.652
2.645
2.635
2.317
1.925
1.915
1.912
1.902
1.892
1.890
1.879
1.538
1.528
1.522
1.518
1.512
1.508
1.502
1.492
-0.000
O
Me
1e
1H NMR (CDCl3, 400 MHz, TMS)
1.93
0.97
1.95
3.94
1.00
0.96
3.00
1.01
1.02
f1 (ppm)

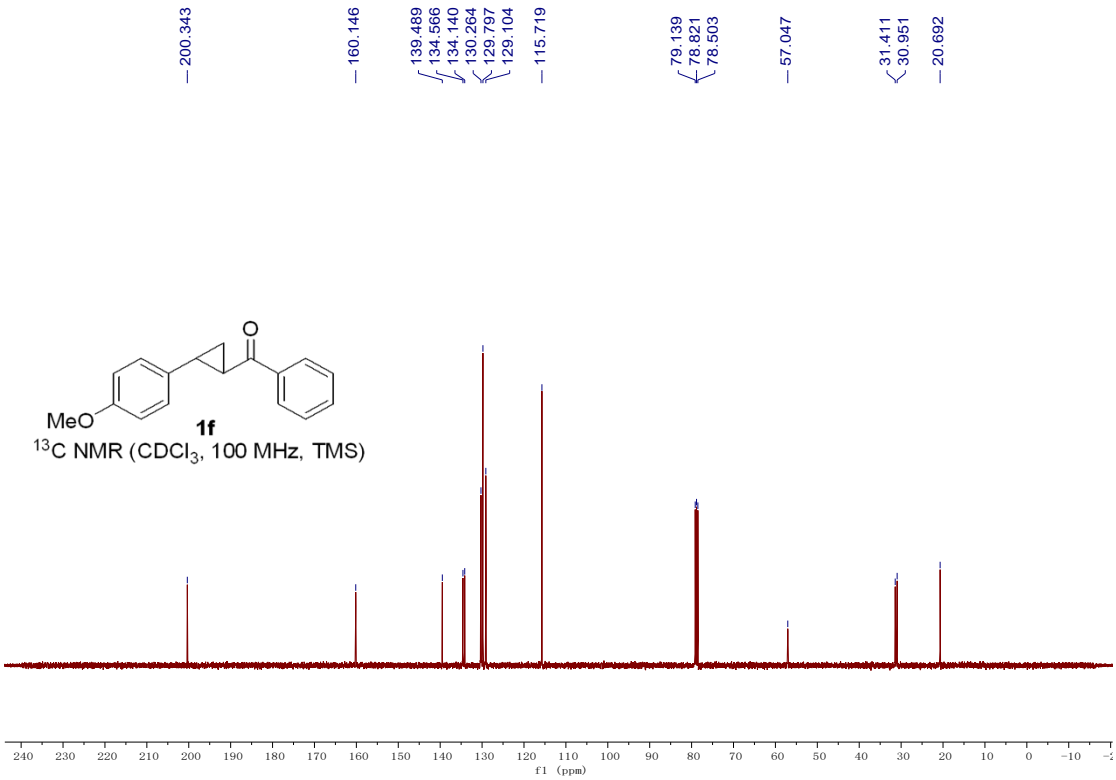

200.337
139.484
139.145
137.964
134.587
130.975
130.271
129.828
127.876
79.143
78.825
78.507
31.672
31.064
22.788
20.843
O
Me
1e
13C NMR (CDCl3, 100 MHz, TMS)
f1 (ppm)

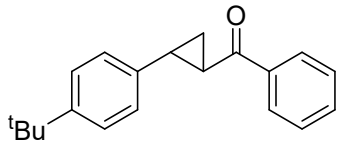


(2-(4-methoxyphenyl)cyclopropyl)(phenyl)methanone (1f)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[7] A white solid. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 1.48-1.52 (m, 1H), 1.87-1.91 (m, 1H), 2.63-2.68 (m, 1H), 2.80-2.84 (m, 1H), 3.77 (s, 3H), 6.84 (dt, J_1 = 8.8 Hz, J_2 = 3.2 Hz, 2H), 7.10 (dt, J_1 = 8.4 Hz, J_2 = 3.2 Hz, 2H), 7.44 (t, J = 7.6Hz, 2H), 7.53 (t, J = 7.4Hz, 1H), 7.97-8.00 (m, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 20.7, 31.0, 31.4, 57.0, 115.7, 129.1, 129.8, 130.3, 134.1, 134.6, 139.5, 160.1, 200.3.

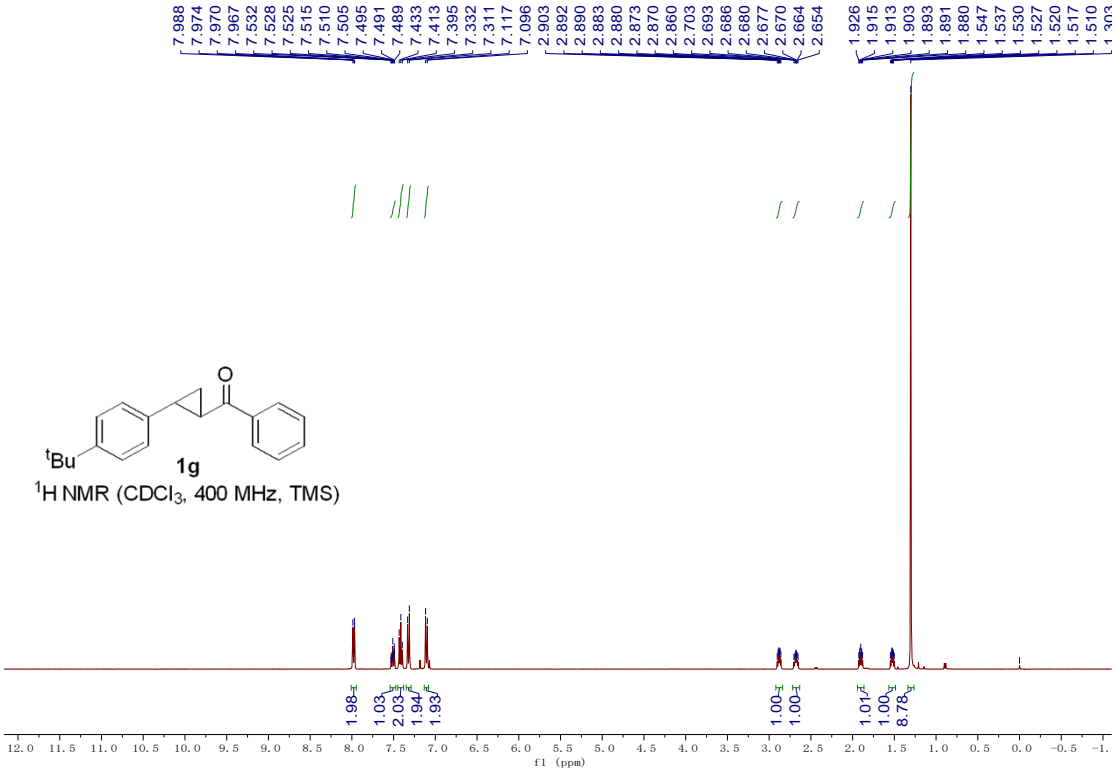


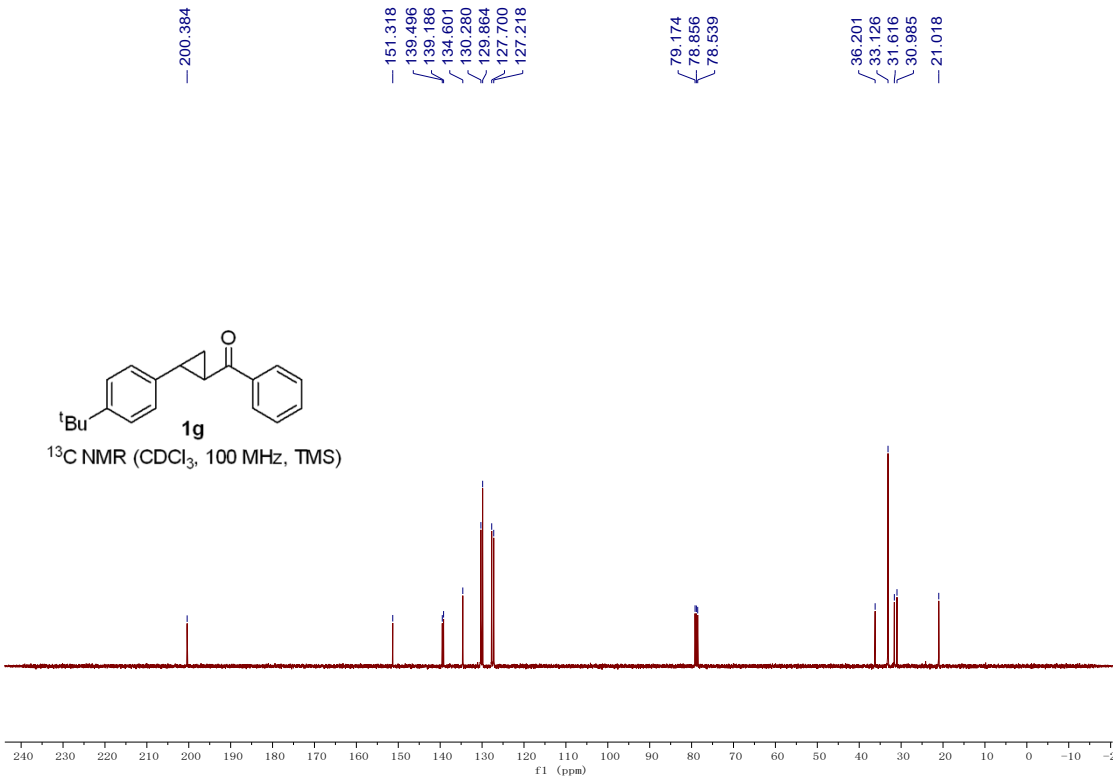

200.343
160.146
139.489
134.566
134.140
130.264
129.797
129.104
115.719
79.139
78.821
78.503
57.047
31.411
30.951
20.692
O
MeO
1f
13C NMR (CDCl3, 100 MHz, TMS)
f1 (ppm)

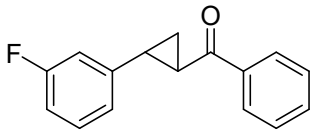


(2-(4-(tert-butyl)phenyl)cyclopropyl)(phenyl)methanone (1g)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[6] A white solid. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 1.30 (s, 9H), 1.50-1.55 (m, 1H), 1.88-1.93 (m, 1H), 2.65-2.70 (m, 1H), 2.86-2.90 (m, 1H), 7.11 (d, J = 8.4 Hz, 2H), 7.32 (d, J = 8.2 Hz, 2H), 7.41 (t, J = 7.6 Hz, 2H), 7.51 (tt, J_1 = 7.2 Hz, J_2 = 2.0 Hz, 1H), 7.97-7.99 (m, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 21.0, 31.0, 31.6, 33.1, 36.2, 127.2, 127.7, 129.9, 130.3, 134.6, 139.2, 139.5, 151.3, 200.4.

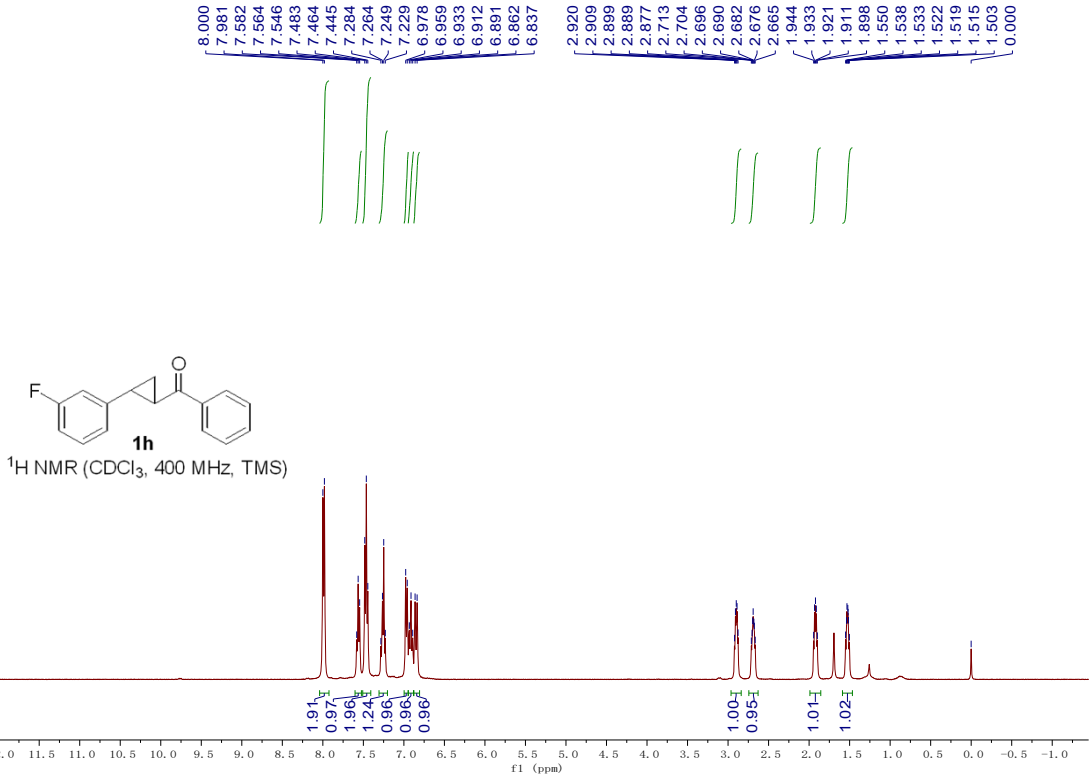


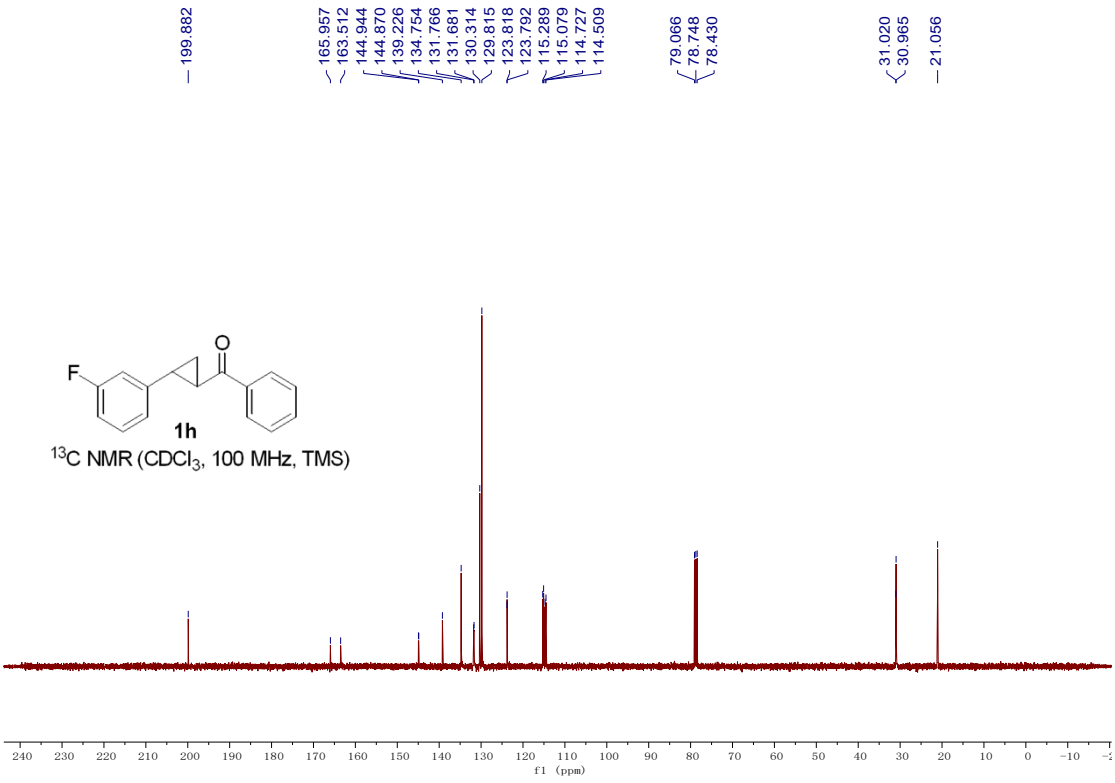

200.384
151.318
139.496
139.186
134.601
130.280
129.864
127.700
127.218
79.174
78.856
78.539
36.201
33.126
31.616
30.985
21.018
tBu
1g
13C NMR (CDCl3, 100 MHz, TMS)
f1 (ppm)

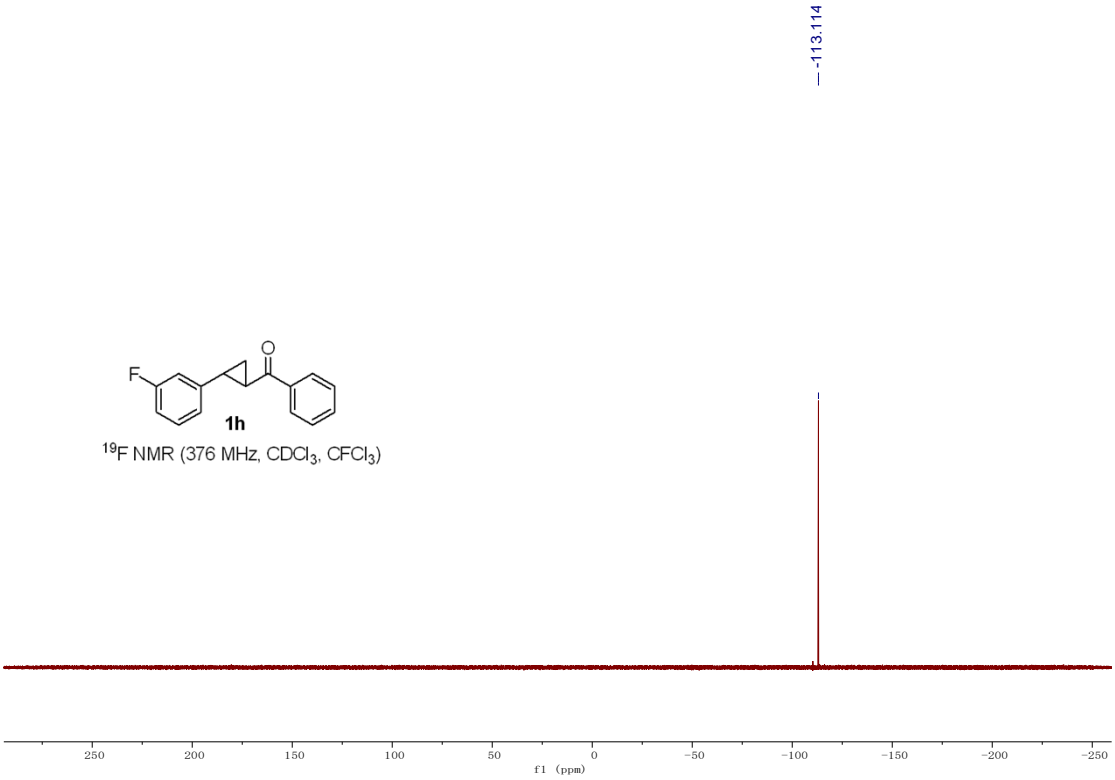


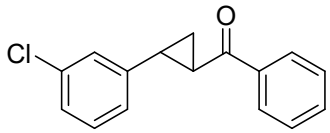
(2-(3-fluorophenyl)cyclopropyl)(phenyl)methanone (1h)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[7] A white solid. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 1.50-1.55 (m, 1H), 1.90-1.94 (m, 1H), 2.67-2.71 (m, 1H), 2.88-2.92 (m, 1H), 6.85 (d, *J* = 10.0 Hz, 1H), 6.91 (t, *J* = 8.2 Hz, 1H), 6.97 (d, *J* = 7.6 Hz, 1H), 7.26 (q, *J* = 7.8 Hz, 1H), 7.46 (t, *J* = 7.6 Hz, 2H), 7.56 (t, *J* = 7.2 Hz, 1H), 7.99 (d, *J* = 7.6 Hz, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 21.1, 30.97, 31.0, 114.6 (d, *J* = 21.9 Hz), 115.2 (d, *J* = 21.1 Hz), 123.8 (d, *J* = 2.6 Hz), 129.8, 130.3, 131.7 (d, *J* = 8.5 Hz), 134.8, 139.2, 144.9 (d, *J* = 7.5 Hz), 164.7 (d, *J* = 245.9 Hz), 199.9. ^{19}F NMR ($CDCl_3$, $CFCl_3$, 376 MHz) δ -113.1.



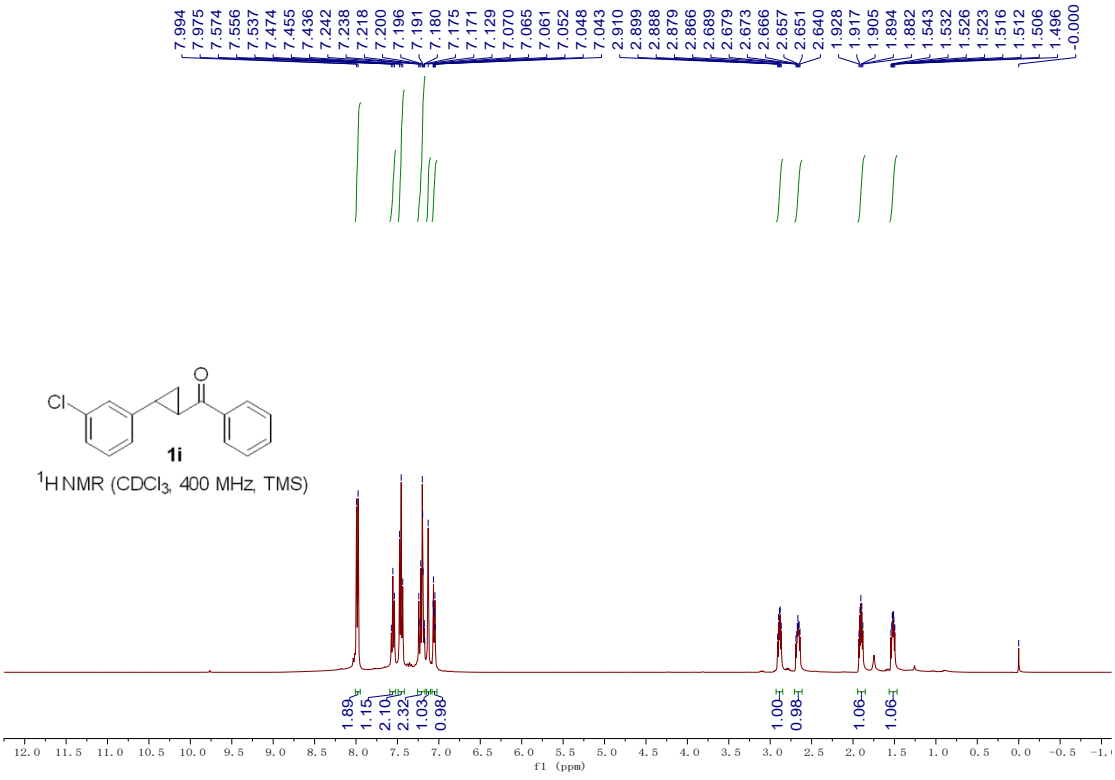

199.882
165.957
163.512
144.944
144.870
139.226
134.754
131.766
131.681
130.314
129.815
123.818
123.792
115.289
115.079
114.727
114.509
79.066
78.748
78.430
31.020
30.965
21.056
F
O
1h
13C NMR (CDCl3, 100 MHz, TMS)
240 230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

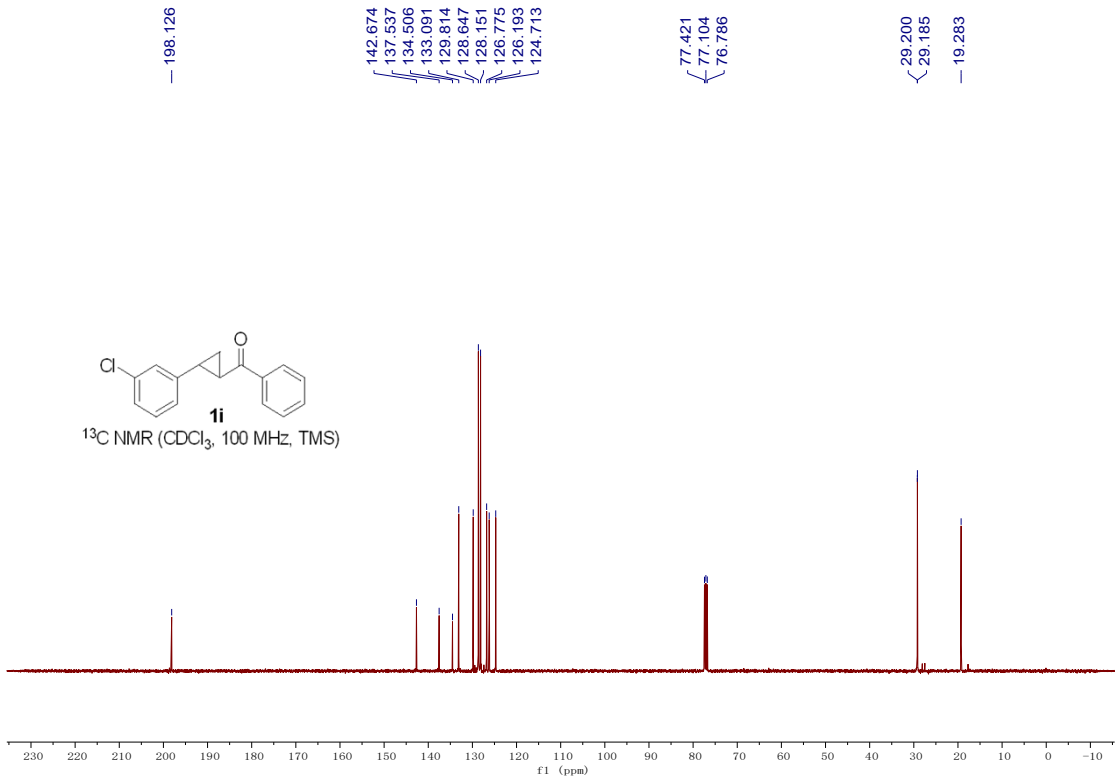

-113.114
F
O
1h
19F NMR (376 MHz, CDCl3, CFCl3)
250 200 150 100 50 0 −50 −100 −150 −200 −250
f1 (ppm)

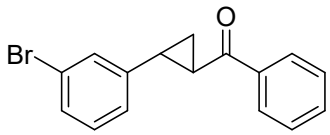


(2-(3-chlorophenyl)cyclopropyl)(phenyl)methanone (1i)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[7] A white solid. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 1.50-1.54 (m, 1H), 1.88-1.93 (m, 1H), 2.64-2.69 (m, 1H), 2.87-2.91 (m, 1H), 7.06 (dt, J_1 = 7.2 Hz, J_2 = 1.8Hz, 1H), 7.13 (s, 1H), 7.17-7.24 (m, 2H), 7.46 (t, J = 7.6 Hz, 2H), 7.56 (t, J = 7.2 Hz, 1H), 7.98 (d, J = 7.4 Hz, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 19.3, 29.18, 29.2, 124.7, 126.2, 126.8, 128.2, 128.6, 129.8, 13.1, 134.5, 137.5, 142.7, 198.1.

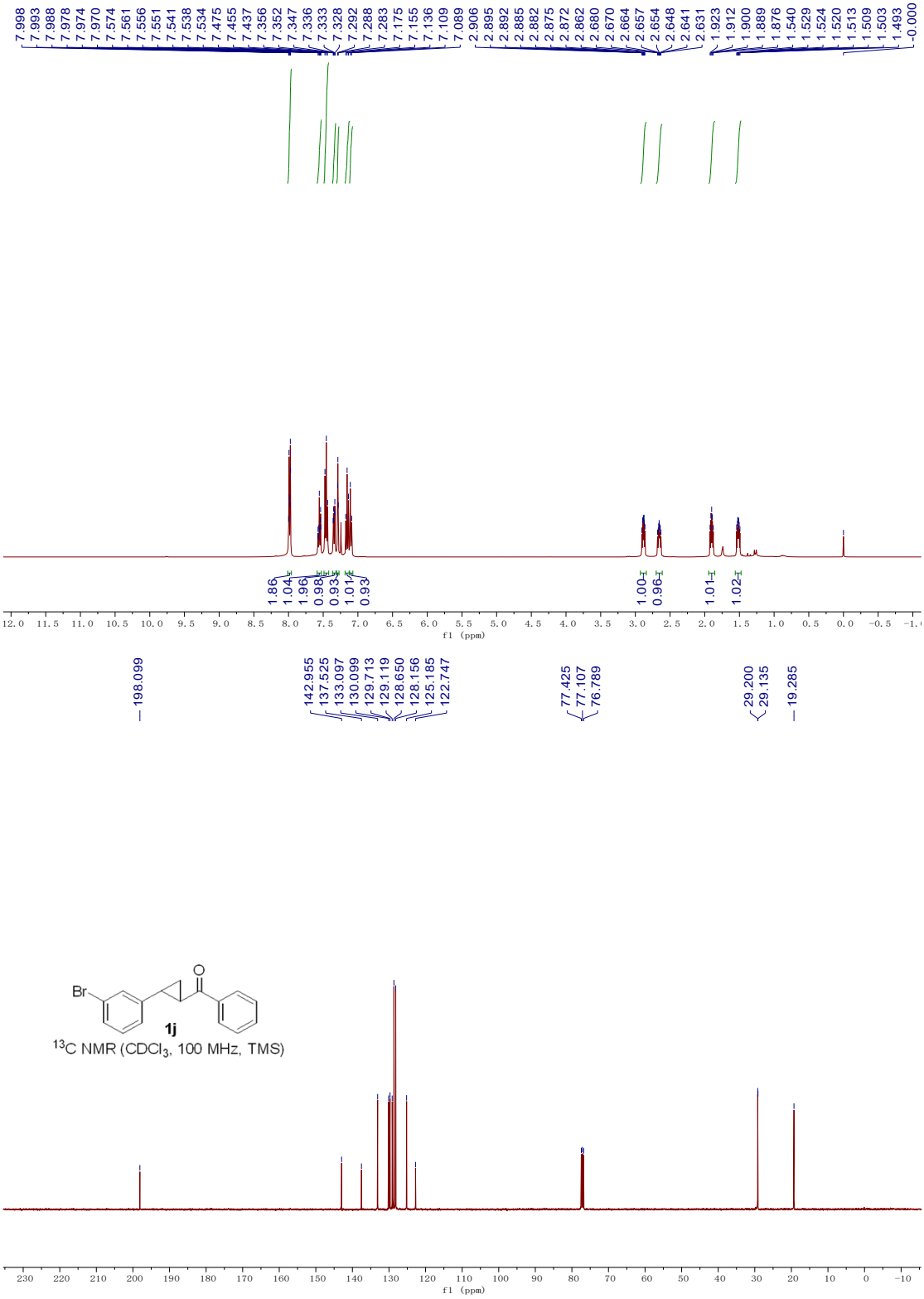


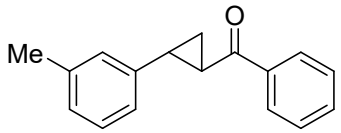




(2-(3-bromophenyl)cyclopropyl)(phenyl)methanone (1j)

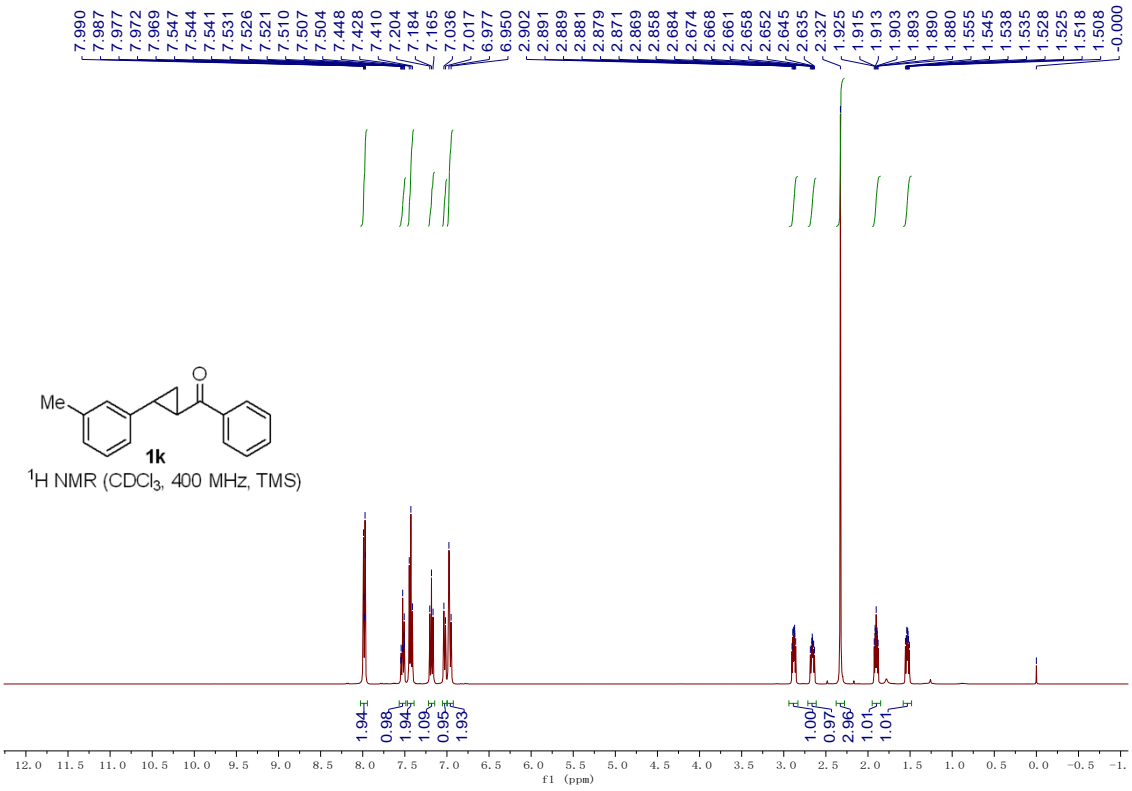
This is a known compound and its spectroscopic data are consistent with those in the previous literature.[8] A white solid. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 1.49-1.54 (m, 1H), 1.88-1.92 (m, 1H), 2.63-2.68 (m, 1H), 2.86-2.91 (m, 1H), 7.10 (d, J = 7.8Hz, 1H), 7.16 (t, J = 7.8 Hz, 1H), 7.29 (t, J = 1.8 Hz, 1H), 7.34 (dt, J_1 = 7.8 Hz, J_2 = 1.6Hz, 1H), 7.46 (t, J = 7.6 Hz, 2H), 7.55 (tt, J_1 = 7.2 Hz, J_2 = 1.6 Hz, 1H), 7.98 (dt, J_1 = 7.2 Hz, J_2 = 1.6 Hz, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 19.3, 29.1, 29.2, 122.7, 125.2, 128.2, 128.6, 129.1, 129.7, 130.1, 133.1, 137.5, 143.0, 198.1.

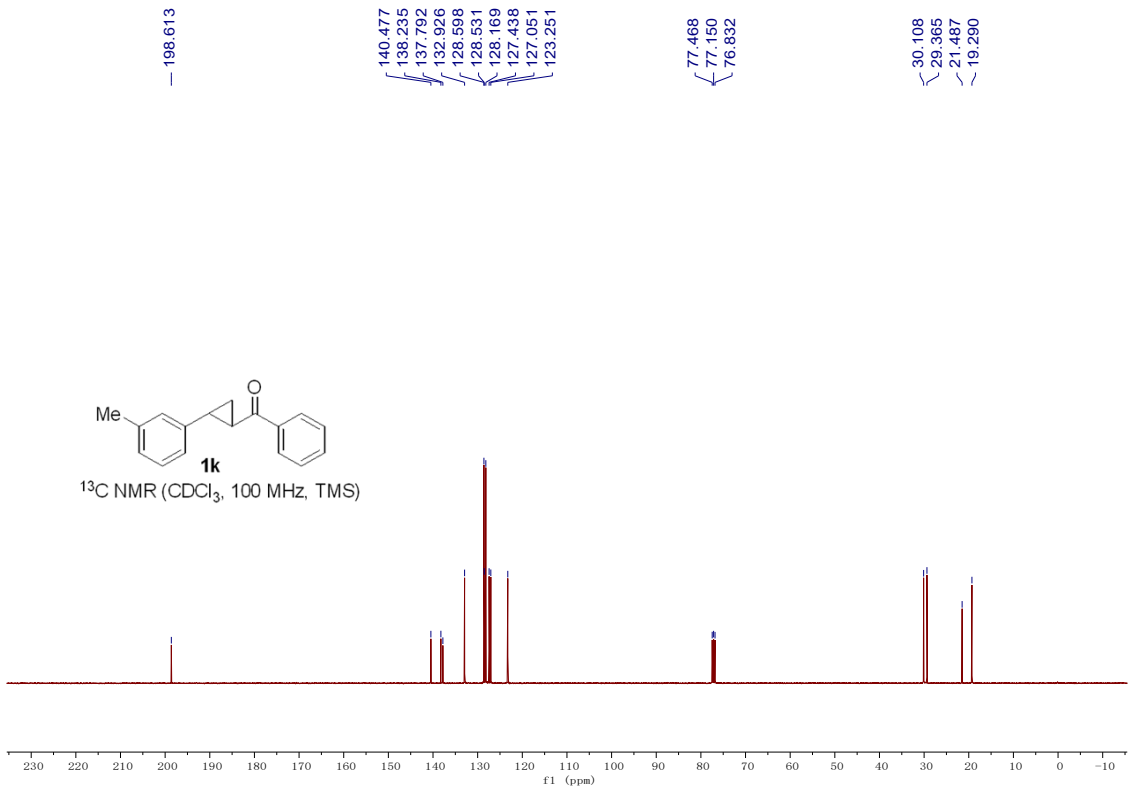

7.998
7.993
7.988
7.978
7.974
7.970
7.574
7.561
7.556
7.551
7.541
7.538
7.534
7.475
7.455
7.437
7.356
7.352
7.347
7.336
7.333
7.328
7.292
7.288
7.283
7.175
7.155
7.136
7.109
7.089
2.906
2.895
2.892
2.885
2.882
2.875
2.872
2.862
2.680
2.670
2.664
2.657
2.654
2.648
2.641
2.631
1.923
1.912
1.900
1.889
1.876
1.540
1.529
1.524
1.520
1.513
1.509
1.503
1.493
-0.000
1.86
1.04
1.96
0.98
0.93
1.01
0.93
1.00
0.96
1.01
1.02
f1 (ppm)
198.099
142.955
137.525
133.097
130.099
129.713
129.119
128.650
128.156
125.185
122.747
77.425
77.107
76.789
29.200
29.135
19.285
Br
O
1j
13C NMR (CDCl3, 100 MHz, TMS)
f1 (ppm)

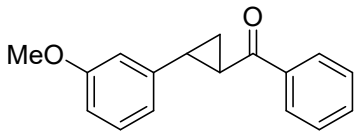


phenyl(2-(m-tolyl)cyclopropyl)methanone (1k)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[8] A white solid. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 1.51-1.56 (m, 1H), 1.88-1.93 (m, 1H), 2.33 (s, 3H), 2.64-2.68 (m, 1H), 2.86-2.90 (m, 1H), 6.96 (d, J = 10.4 Hz, 2H), 7.03 (d, J = 7.6 Hz, 1H), 7.18 (t, J = 7.8 Hz, 1H), 7.43 (t, J = 7.6 Hz, 2H), 7.53 (tt, J_1 = 7.4 Hz, J_2 = 1.2 Hz, 1H), 7.97-7.99 (m, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 19.3, 21.5, 29.4, 30.1, 123.3, 127.1, 127.4, 128.2, 128.5, 128.6, 132.9, 137.8, 138.2, 140.5, 198.6.

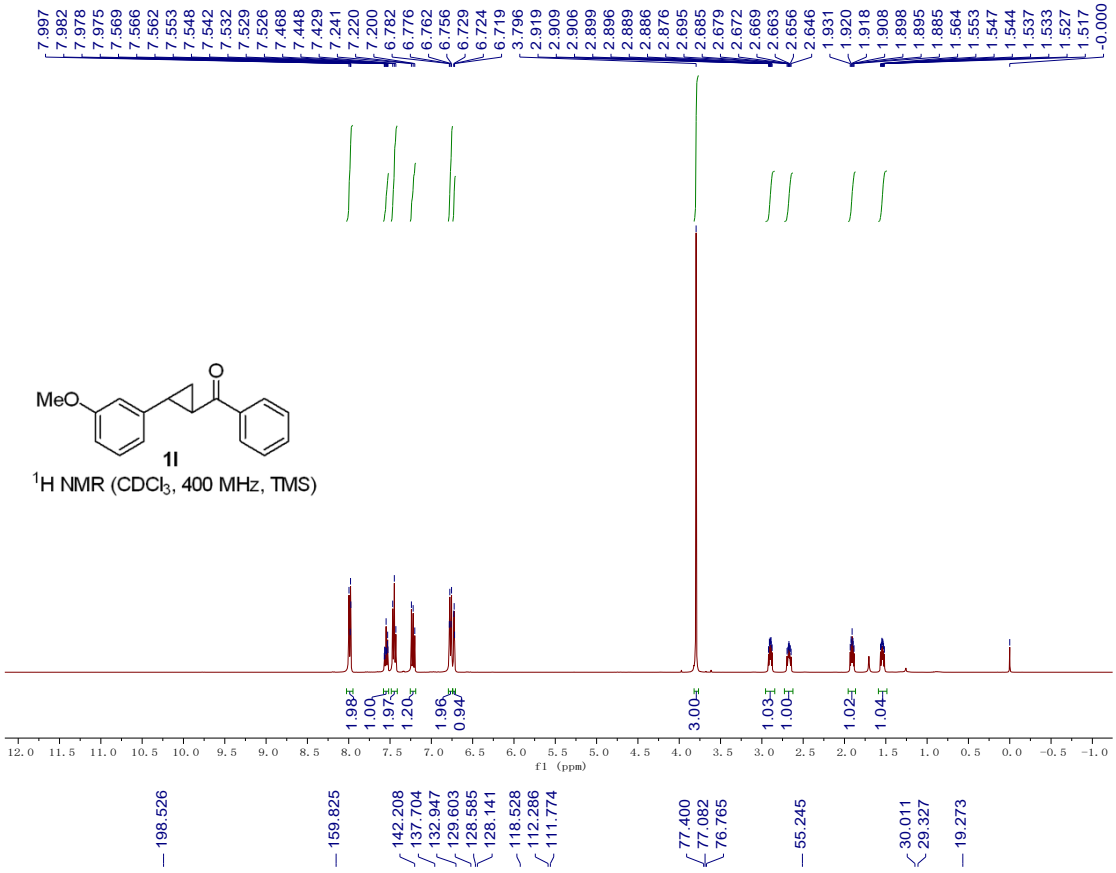


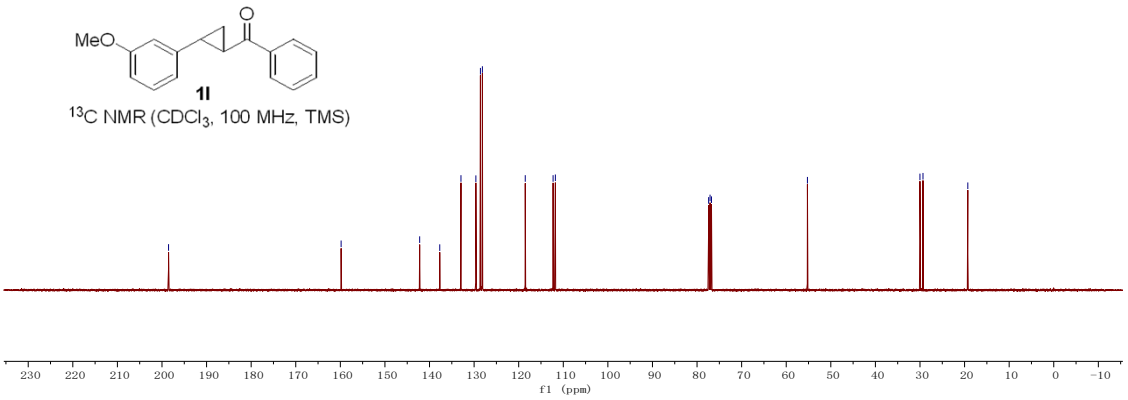


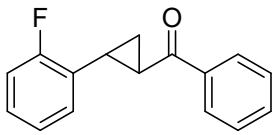


(2-(3-methoxyphenyl)cyclopropyl)(phenyl)methanone (1l)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[7] A white solid. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 1.52-1.56 (m, 1H), 1.89-1.93 (m, 1H), 2.65-2.70 (m, 1H), 2.88-2.92 (m, 1H), 3.80 (s, 3H), 6.72 (t, J = 2.0 Hz, 1H), 6.76-6.78 (m, 2H), 7.22 (t, J = 8.4 Hz, 1H), 7.45 (t, J = 8.0 Hz, 2H), 7.55 (tt, J_1 = 7.2 Hz, J_2 = 1.2 Hz, 1H), 7.98-8.00 (m, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 19.3, 29.3, 30.0, 55.2, 111.8, 112.3, 118.5, 128.1, 128.6, 129.6, 132.9, 137.7, 142.2, 159.8, 198.5.

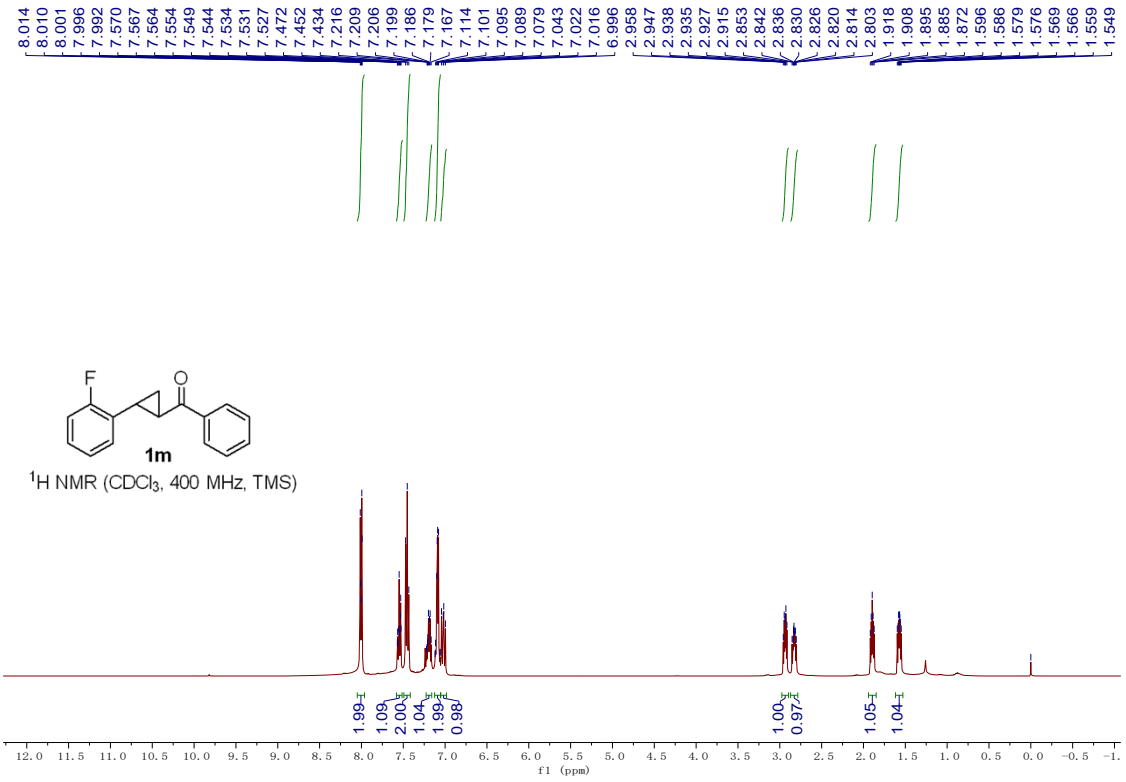

MeO
O
1l
^{1}H NMR (CDCl$_3$, 400 MHz, TMS)


MeO
O
1l
^{13}C NMR (CDCl$_3$, 100 MHz, TMS)

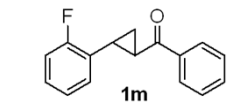


(2-(2-fluorophenyl)cyclopropyl)(phenyl)methanone (1m)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[4] A white solid. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 1.55-1.60 (m, 1H), 1.87-1.92 (m, 1H), 2.80-2.85 (m, 1H), 2.92-2.96 (m, 1H), 6.99-7.04 (m, 1H), 7.06-7.12 (m, 2H), 7.17-7.22 (m, 1H), 7.45 (t, J = 8.0 Hz, 2H), 7.55 (tt, J_1 = 7.2 Hz, J_2 = 1.2 Hz, 1H), 7.99-8.01 (m, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 17.7, 23.7 (d, J = 4.4 Hz), 27.4, 115.5 (d, J = 21.8 Hz), 124.1 (d, J = 3.6 Hz), 127.3 (d, J = 3.9 Hz), 127.5 (d, J = 14.0 Hz), 128.1 (d, J = 8.4 Hz), 128.14, 128.6, 133.0, 137.7, 161.8 (d, J = 246.7 Hz), 198.6. ^{19}F NMR ($CDCl_3$, $CFCl_3$, 376 MHz) δ -118.3.

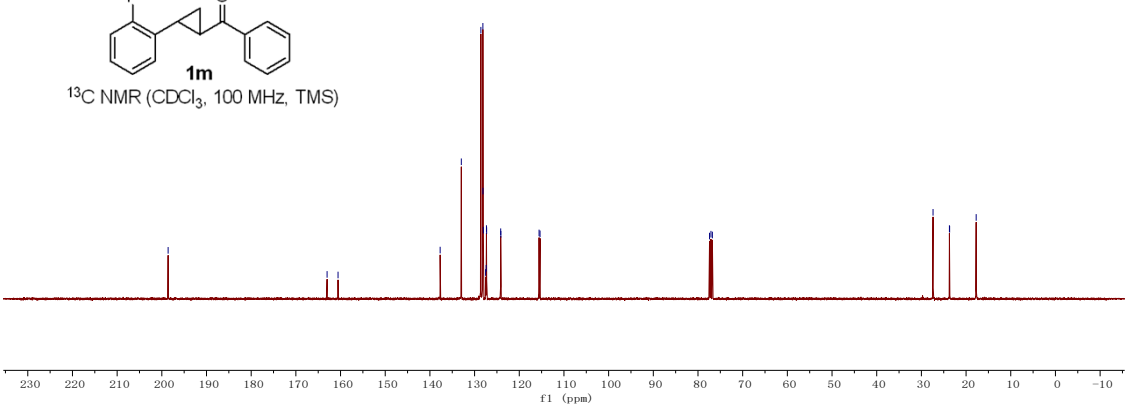


198.590
163.012
160.560
137.709
132.970
128.591
128.144
128.127
128.044
127.539
127.401
127.343
127.304
124.156
124.120
115.568
115.352
77.415
77.097
76.779
27.393
23.726
23.682
17.739

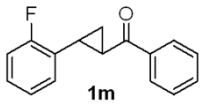


1m

^{13}C NMR ($CDCl_3$, 100 MHz, TMS)

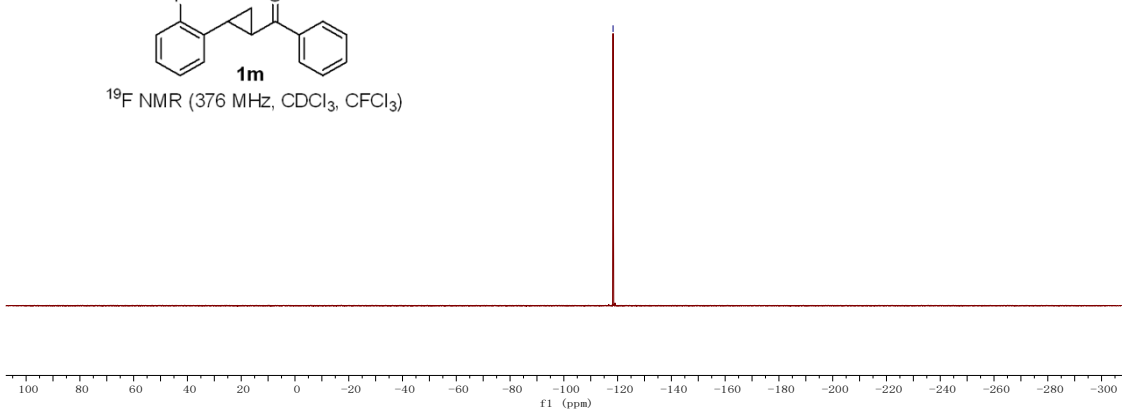


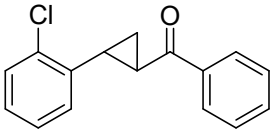
-118.307



1m

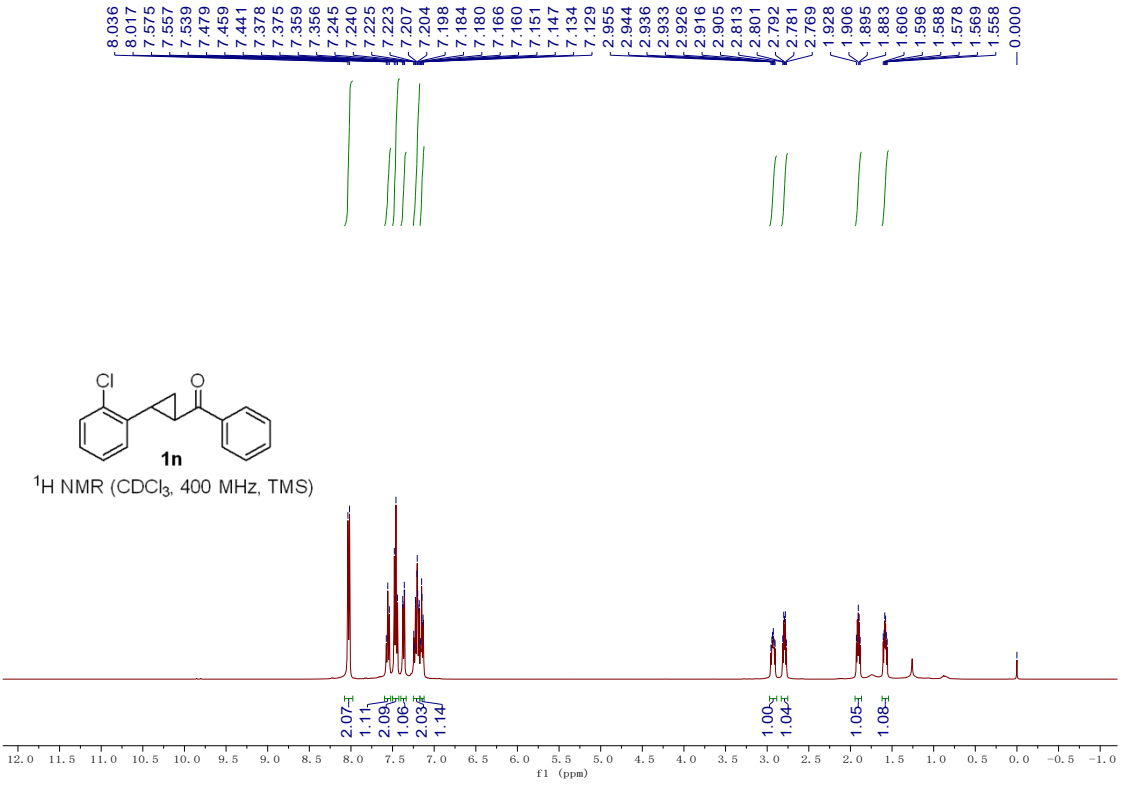
^{19}F NMR (376 MHz, $CDCl_3$, $CFCl_3$)

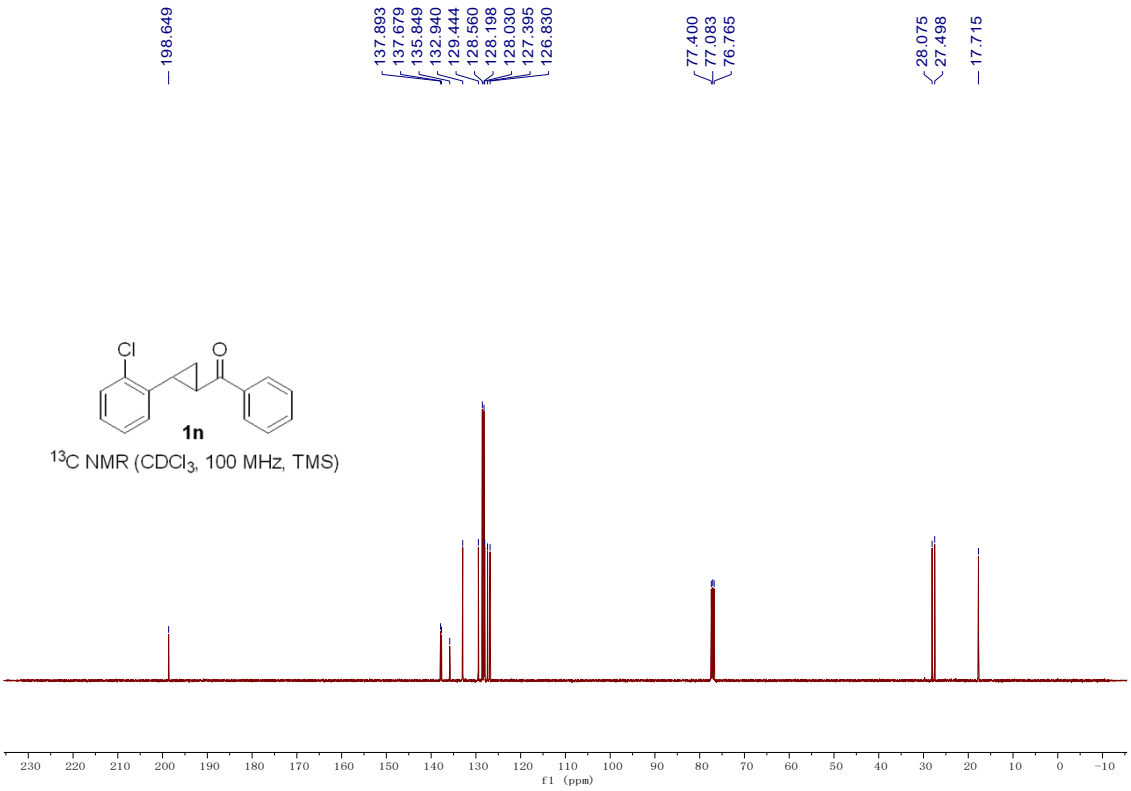


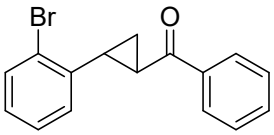


(2-(2-chlorophenyl)cyclopropyl)(phenyl)methanone (1n)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[9] A white solid. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 1.56-1.61 (m, 1H), 1.88-1.93 (m, 1H), 2.77-2.81 (m, 1H), 2.91-2.96 (m, 1H), 7.15 (td, J_1 = 6.0 Hz, J_2 = 2.4 Hz, 1H), 7.18-7.25 (m, 2H), 7.36 (dd, J_1 = 7.6 Hz, J_2 = 1.2 Hz, 1H), 7.46 (t, J = 7.6 Hz, 2H), 7.56 (t, J = 7.4 Hz, 1H), 8.03 (d, J = 7.8 Hz, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 17.7, 27.5, 28.1, 126.8, 127.4, 128.0, 128.2, 128.6, 129.4, 132.9, 135.8, 137.7, 137.9, 198.6.

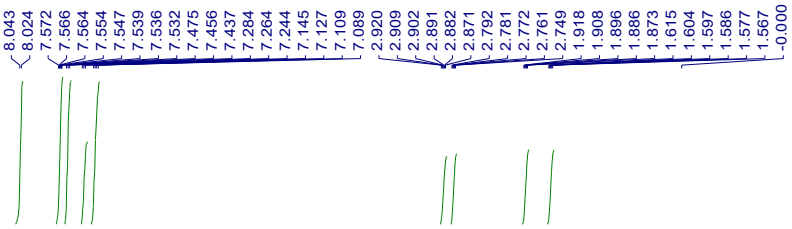


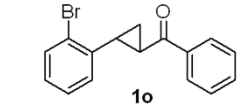




(2-(2-bromophenyl)cyclopropyl)(phenyl)methanone (1o)

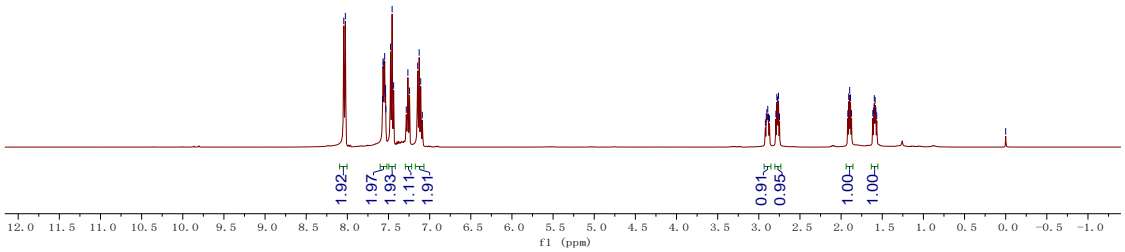
This is a known compound and its spectroscopic data are consistent with those in the previous literature.[9] A white solid. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 1.57-1.62 (m, 1H), 1.87-1.92 (m, 1H), 2.75-2.79 (m, 1H), 2.87-2.92 (m, 1H), 7.09-7.15 (m, 2H), 7.26 (t, J = 7.8 Hz, 1H), 7.46 (t, J = 7.6 Hz, 2H), 7.53-7.57 (m, 2H), 8.03 (d, J = 7.6 Hz, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 18.1, 27.6, 30.8, 126.5, 127.4, 127.8, 128.2, 128.4, 128.6, 132.7, 132.9, 137.7, 139.5, 198.7.

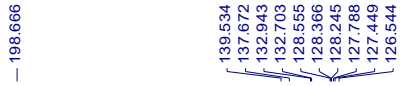


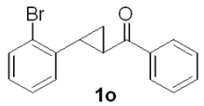


1o

^{1}H NMR ($CDCl_3$, 400 MHz, TMS)

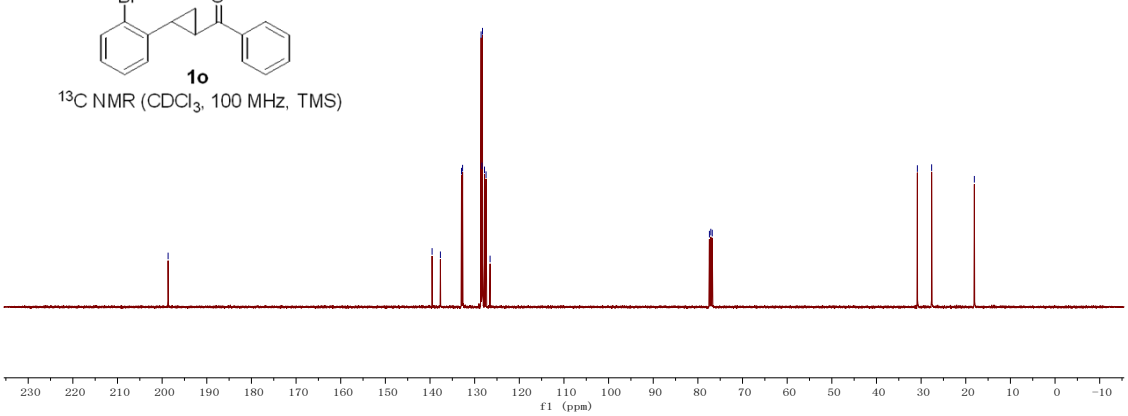


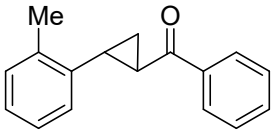




1o

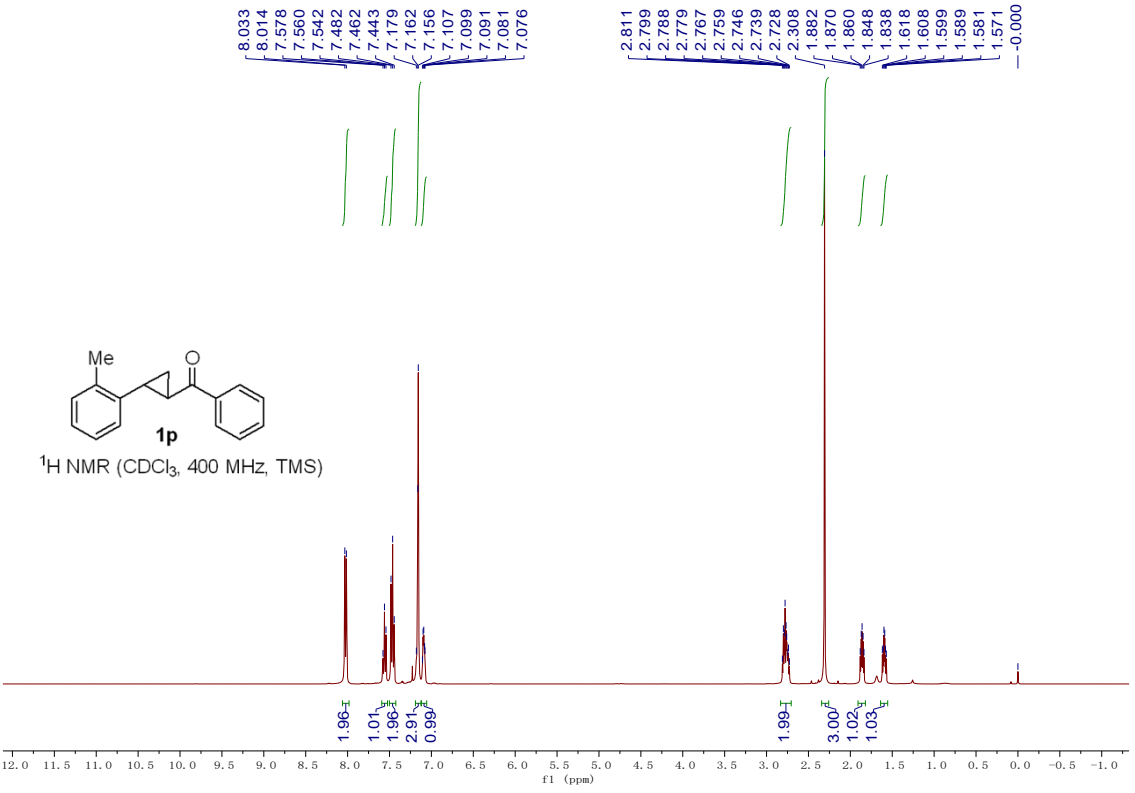
^{13}C NMR ($CDCl_3$, 100 MHz, TMS)

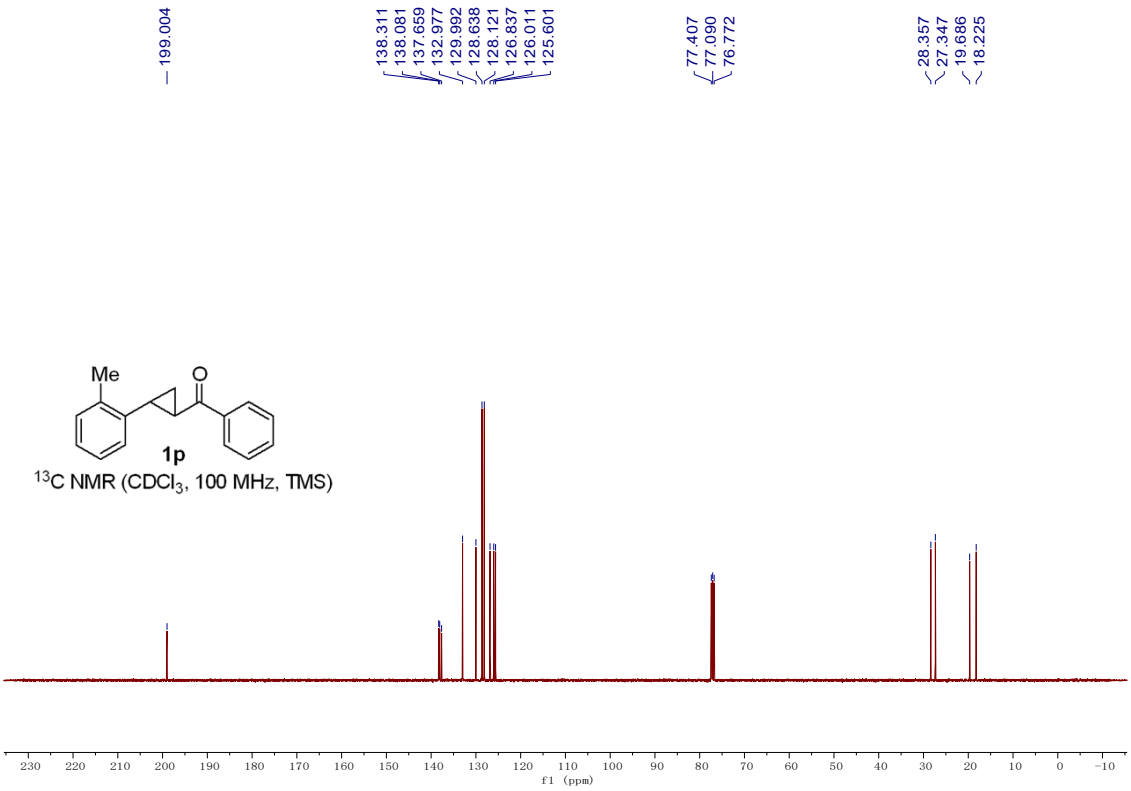


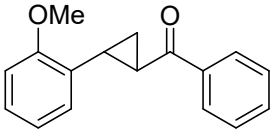


Phenyl(2-(o-tolyl)cyclopropyl)methanone (1p)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[9] A colorless oil. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 1.57-1.62 (m, 1H), 1.84-1.88 (m, 1H), 2.31 (s, 3H), 2.73-2.81 (m, 2H), 7.08-7.11 (m, 1H), 7.16-7.18 (m, 3H), 7.46 (t, *J* = 7.6 Hz, 2H), 7.56 (t, *J* = 7.2 Hz, 1H), 8.02 (d, *J* = 7.6 Hz, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 18.2, 19.7, 27.3, 28.4, 125.6, 126.0, 126.8, 128.1, 128.6, 130.0, 133.0, 137.7, 138.1, 138.3, 199.0.

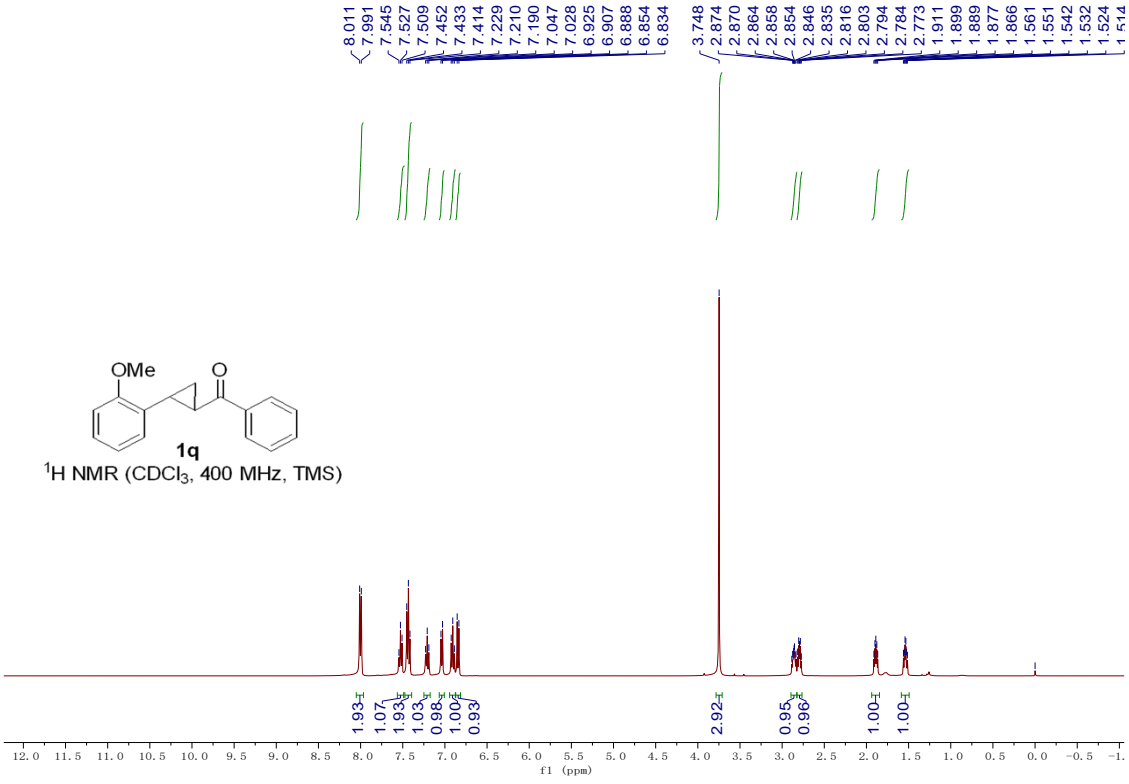


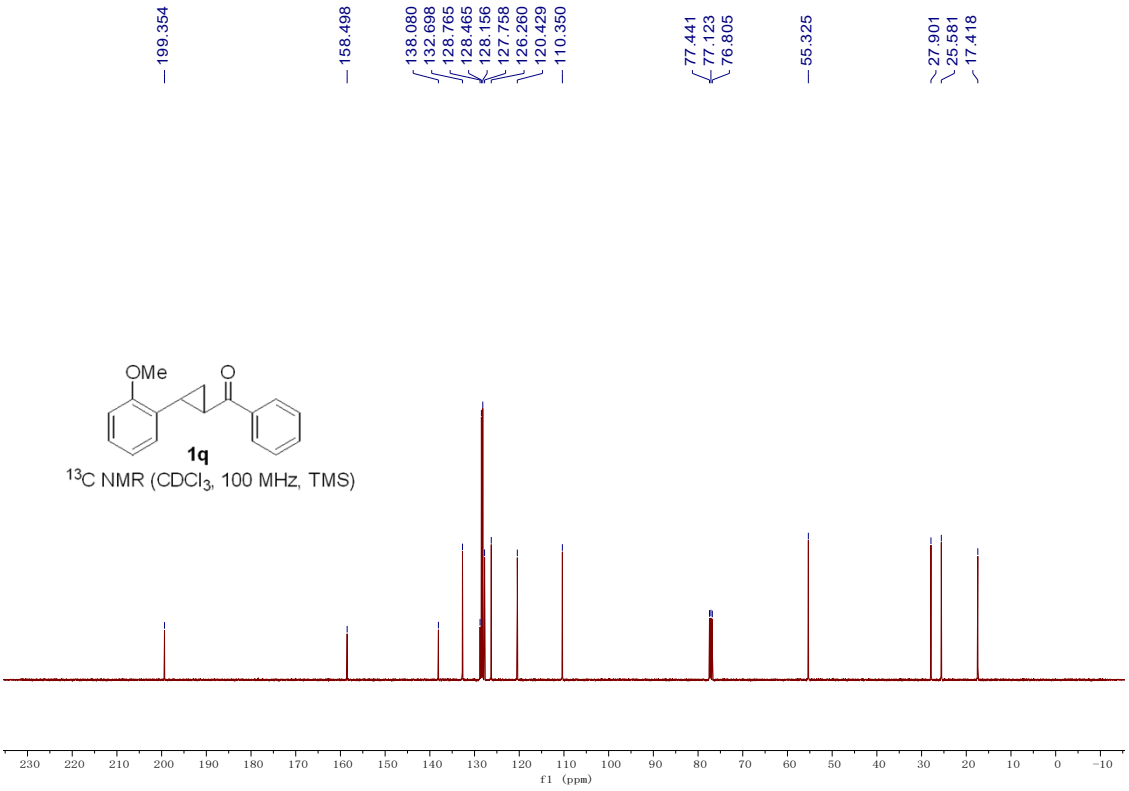

199.004
138.311
138.081
137.659
132.977
129.992
128.638
128.121
126.837
126.011
125.601
77.407
77.090
76.772
28.357
27.347
19.686
18.225
Me
O
1p
13C NMR (CDCl3, 100 MHz, TMS)
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

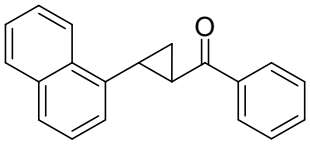


(2-(2-methoxyphenyl)cyclopropyl)(phenyl)methanone (1q)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[4] A colorless oil. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 1.51-1.56 (m, 1H), 1.87-1.91 (m, 1H), 2.77-2.82 (m, 1H), 2.84-2.89 (m, 1H), 3.75 (s, 3H), 6.84 (d, *J* = 8.2 Hz, 1H), 6.91 (t, *J* = 7.6 Hz, 1H), 7.04 (d, *J* = 7.2 Hz, 1H), 7.21 (t, *J* = 7.6 Hz, 1H), 7.43 (t, *J* = 7.6 Hz, 2H), 7.53 (t, *J* = 7.2 Hz, 1H), 8.00 (d, *J* = 7.8 Hz, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 17.4, 25.6, 27.9, 55.3, 110.4, 120.4, 126.3, 127.8, 128.2, 128.5, 128.8, 132.7, 138.1, 158.5, 199.4.

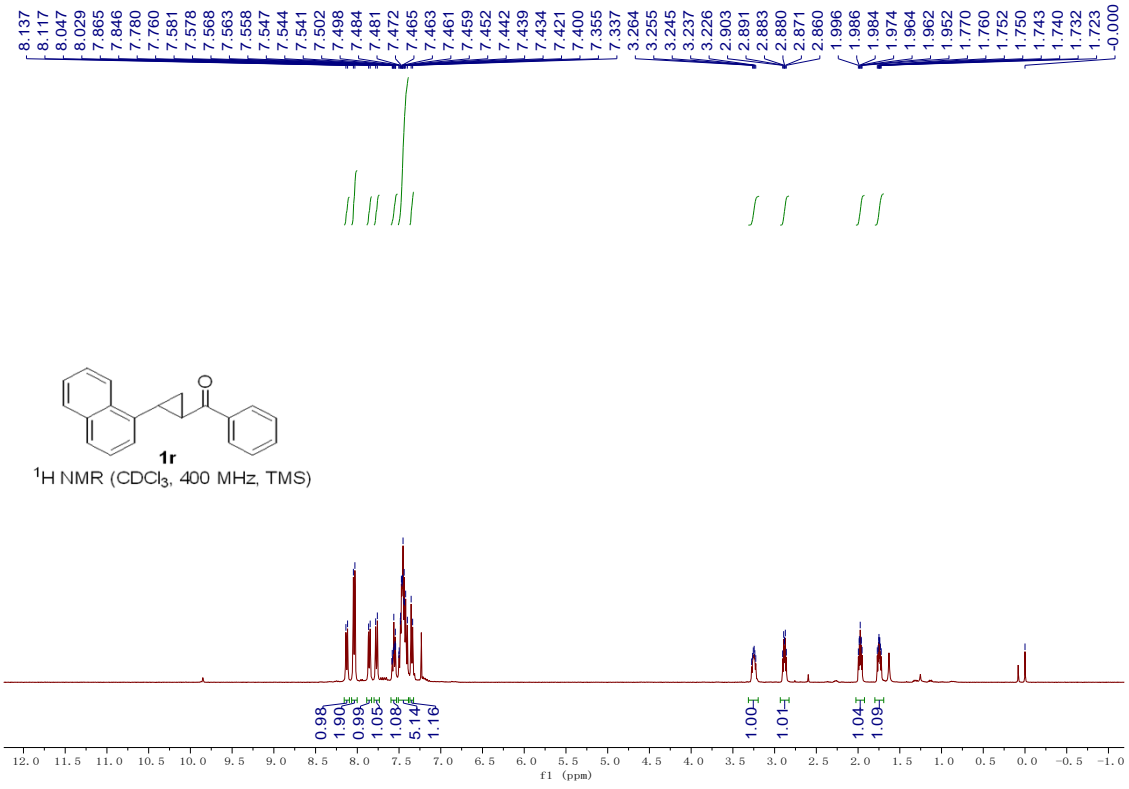


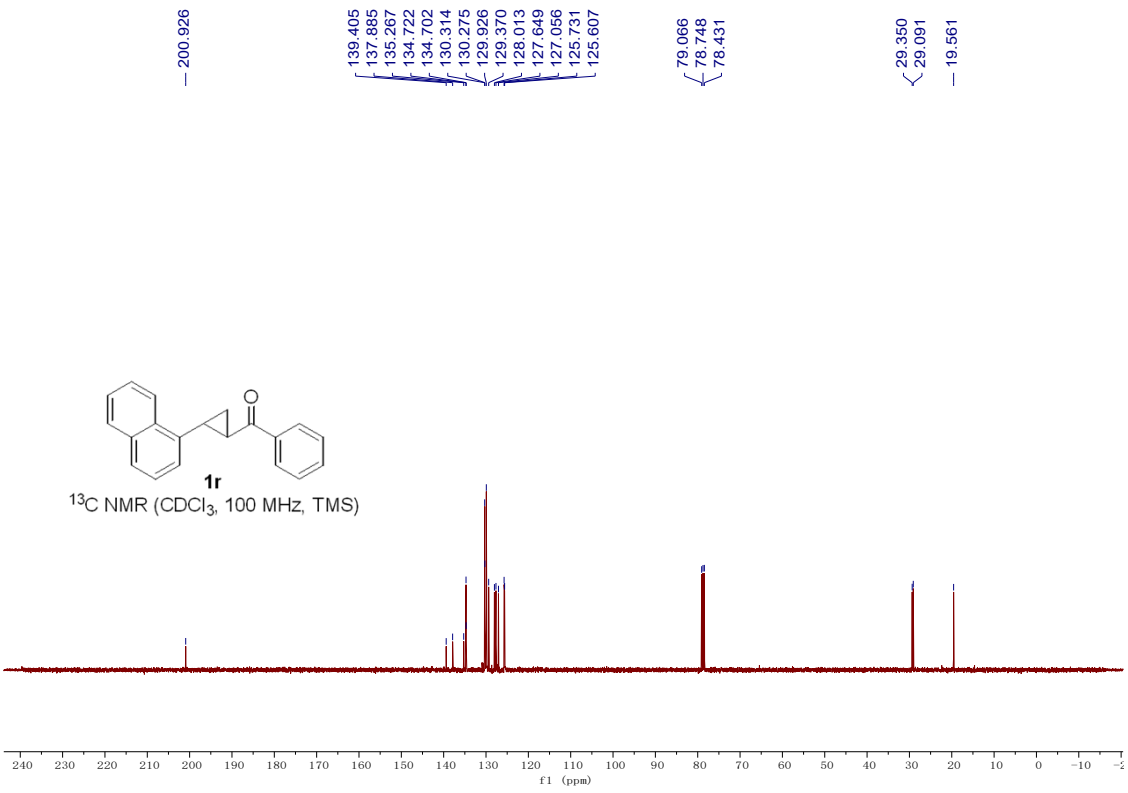

199.354
158.498
138.080
132.698
128.765
128.465
128.156
127.758
126.260
120.429
110.350
77.441
77.123
76.805
55.325
27.901
25.581
17.418
OMe
O
1q
13C NMR (CDCl3, 100 MHz, TMS)
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

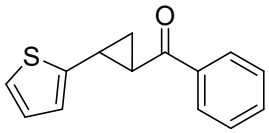


(2-(naphthalen-1-yl)cyclopropyl)(phenyl)methanone (1r)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[4] A white solid. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 1.72-1.77 (m, 1H), 1.95-2.00 (m, 1H), 2.86-2.90 (m, 1H), 3.23-3.28 (m, 1H), 7.35 (d, J = 7.2 Hz, 1H), 7.40-7.50 (m, 5H), 7.56 (tt, J_1 = 7.4 Hz, J_2 = 1.2 Hz, 1H), 7.77 (d, J = 8.2 Hz, 1H), 7.86 (d, J = 7.6 Hz, 1H), 8.04 (d, J = 7.2 Hz, 2H), 8.13 (d, J = 8.0 Hz, 1H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 19.6, 29.1, 29.3, 125.6, 125.7, 127.1, 127.6, 128.0, 129.4, 129.9, 130.27, 130.31, 134.70, 134.72, 135.3, 137.9, 139.4, 200.9.

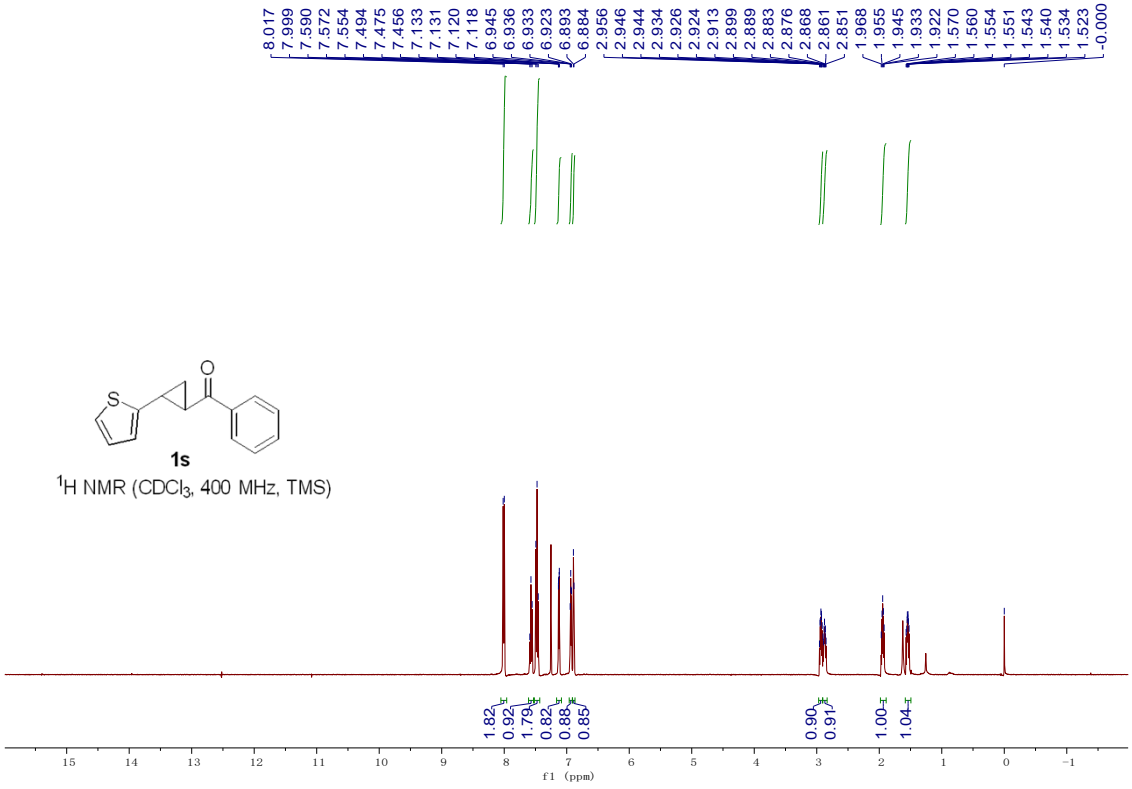


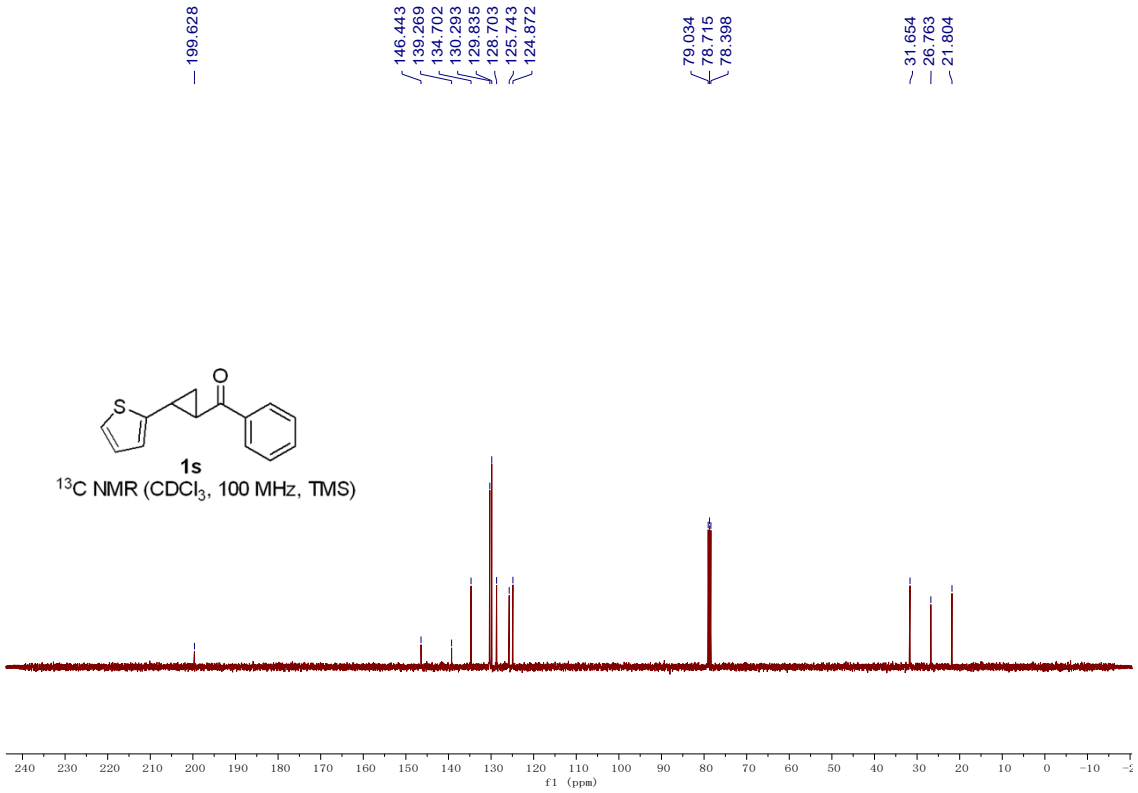

200.926
139.405
137.885
135.267
134.722
134.702
130.314
130.275
129.926
129.370
128.013
127.649
127.056
125.731
125.607
79.066
78.748
78.431
29.350
29.091
19.561
1r
13C NMR (CDCl3, 100 MHz, TMS)
f1 (ppm)

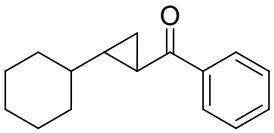


Phenyl(2-(thiophen-2-yl)cyclopropyl)methanone (1s)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[4] A white solid. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 1.52-1.57 (m, 1H), 1.92-1.97 (m, 1H), 2.85-2.90 (m, 1H), 2.91-2.96 (m, 1H), 6.89 (d, J = 3.6 Hz, 1H), 6.92-6.95 (m, 1H), 7.13 (dd, J_1 = 5.2 Hz, J_2 = 0.8 Hz, 1H), 7.47 (t, J = 7.6 Hz, 2H), 7.57 (t, J = 7.2 Hz, 1H), 8.01 (d, J = 7.4 Hz, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 21.8, 26.8, 31.7, 124.9, 125.7, 128.7, 129.8, 130.3, 134.7, 139.3, 146.4, 199.6.

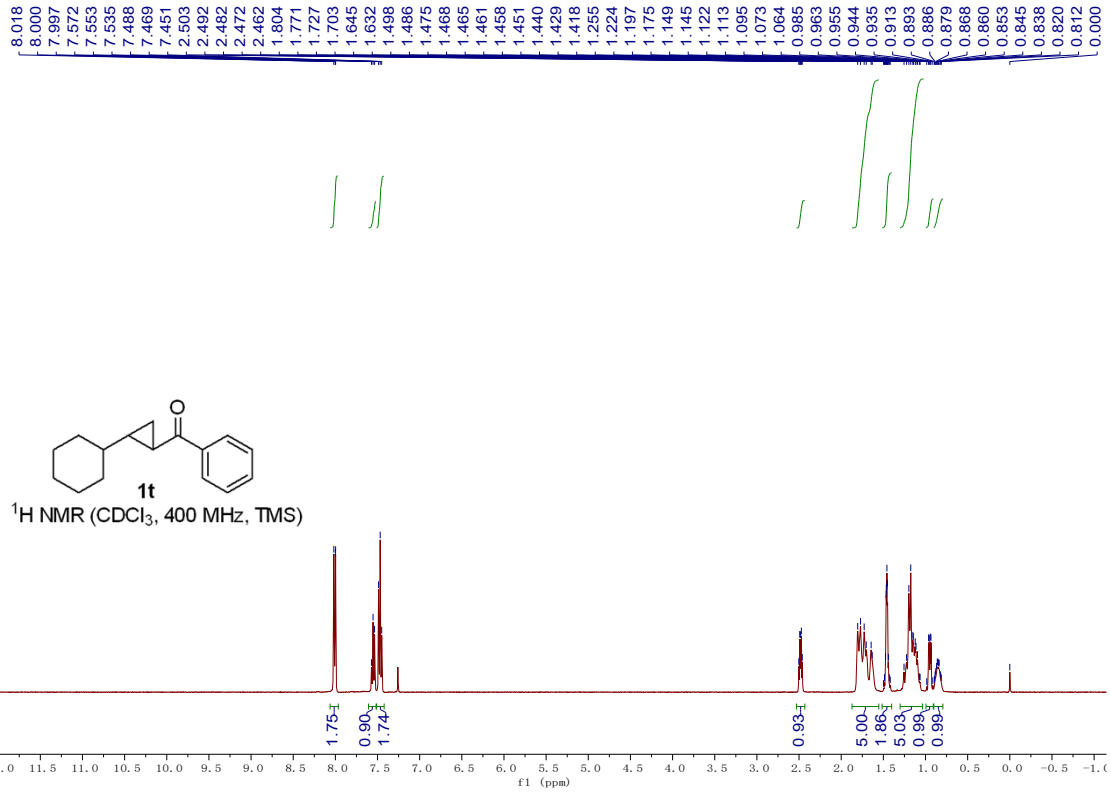


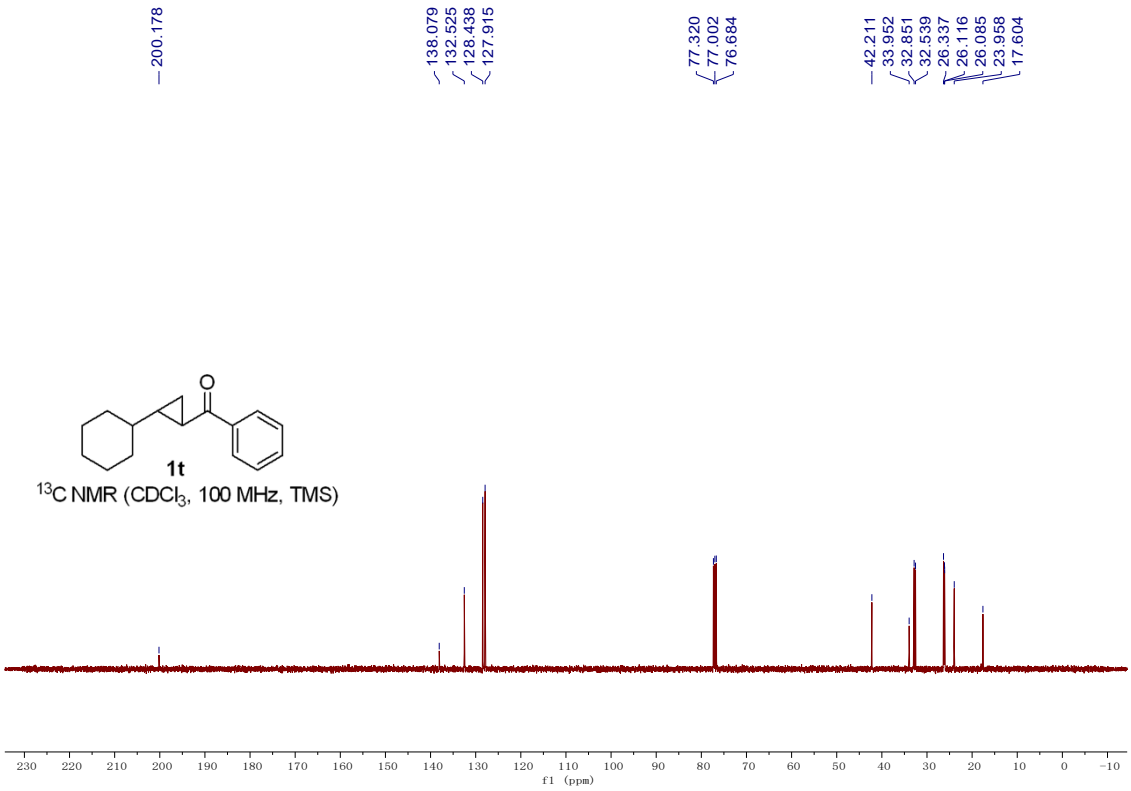

199.628
146.443
139.269
134.702
130.293
129.835
128.703
125.743
124.872
79.034
78.715
78.398
31.654
26.763
21.804
O
S
1s
13C NMR (CDCl3, 100 MHz, TMS)
240 230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

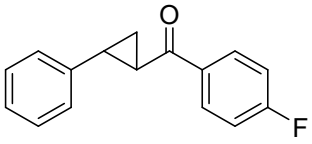


(2-cyclohexylcyclopropyl)(phenyl)methanone (1t)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[7] A colorless oil. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 0.81-0.89 (m, 1H), 0.91-0.99 (m, 1H), 1.06-1.26 (m, 5H), 1.42-1.50 (m, 2H), 1.63-1.80 (m, 5H), 2.46-2.50 (m, 1H), 7.47 (t, *J* = 7.4 Hz, 2H), 7.55 (t, *J* = 7.2 Hz, 1H), 7.99-8.02 (m, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 17.6, 24.0, 26.1, 26.1, 26.3, 32.5, 32.9, 34.0, 42.2, 127.9, 128.4, 132.5, 138.1, 200.2.

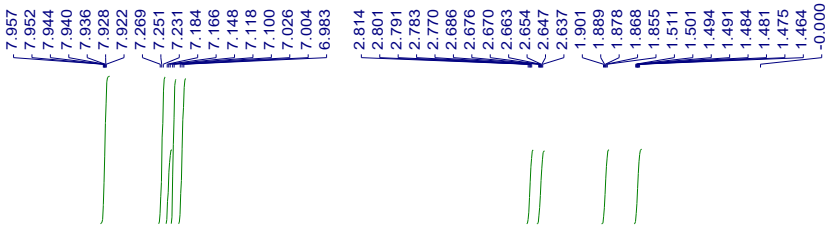


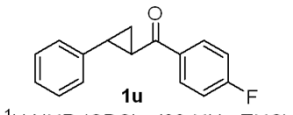




(4-fluorophenyl)(2-phenylcyclopropyl)methanone (1u)

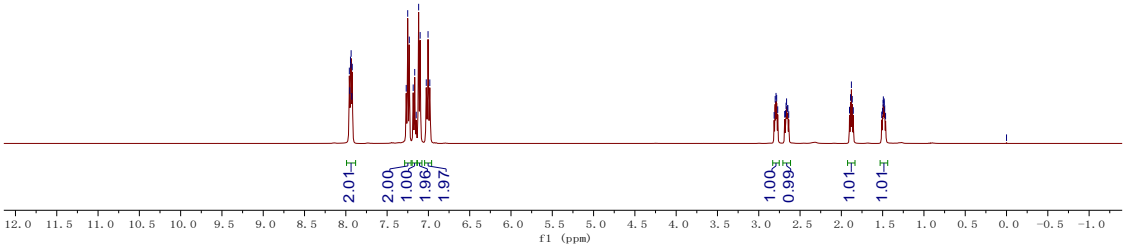
This is a known compound and its spectroscopic data are consistent with those in the previous literature.[4] A white solid. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 1.46-1.51 (m, 1H), 1.86-1.90 (m, 1H), 2.64-2.69 (m, 1H), 2.77-2.81 (m, 1H), 7.00 (t, *J* = 8.6 Hz, 2H), 7.11 (d, *J* = 7.2 Hz, 2H), 7.17 (t, *J* = 7.2 Hz, 1H), 7.25 (t, *J* = 7.4 Hz, 2H), 7.92-7.96 (m, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 19.3, 29.2, 30.0, 115.7 (d, *J* = 21.8 Hz), 126.3, 126.8, 128.7, 130.8 (d, *J* = 9.3 Hz), 134.2 (d, *J* = 2.9 Hz), 140.5, 165.7 (d, *J* = 254.2 Hz), 196.6. ^{19}F NMR ($CDCl_3$, $CFCl_3$, 376 MHz) δ -105.3.

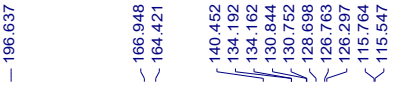




1u

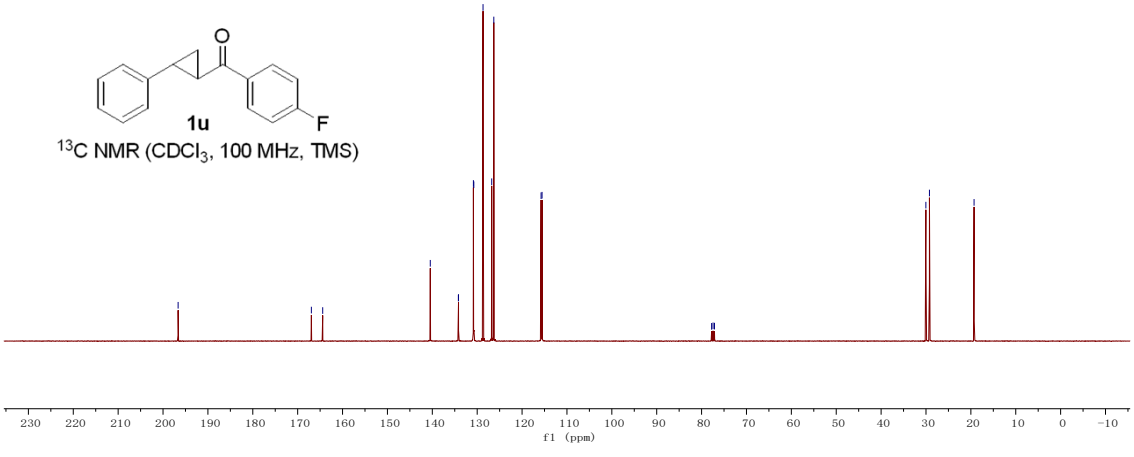
^{1}H NMR ($CDCl_3$, 400 MHz, TMS)

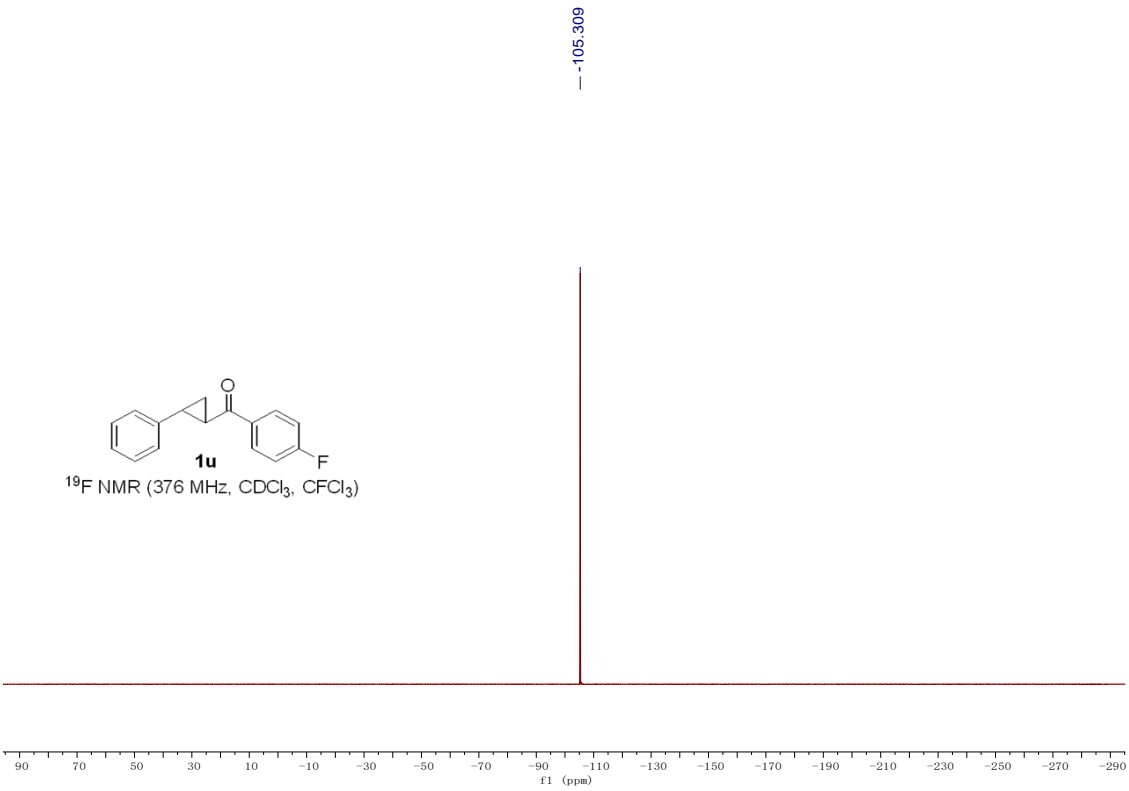




1u

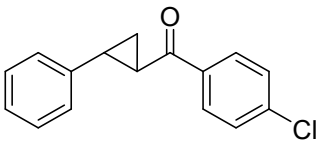
^{13}C NMR ($CDCl_3$, 100 MHz, TMS)





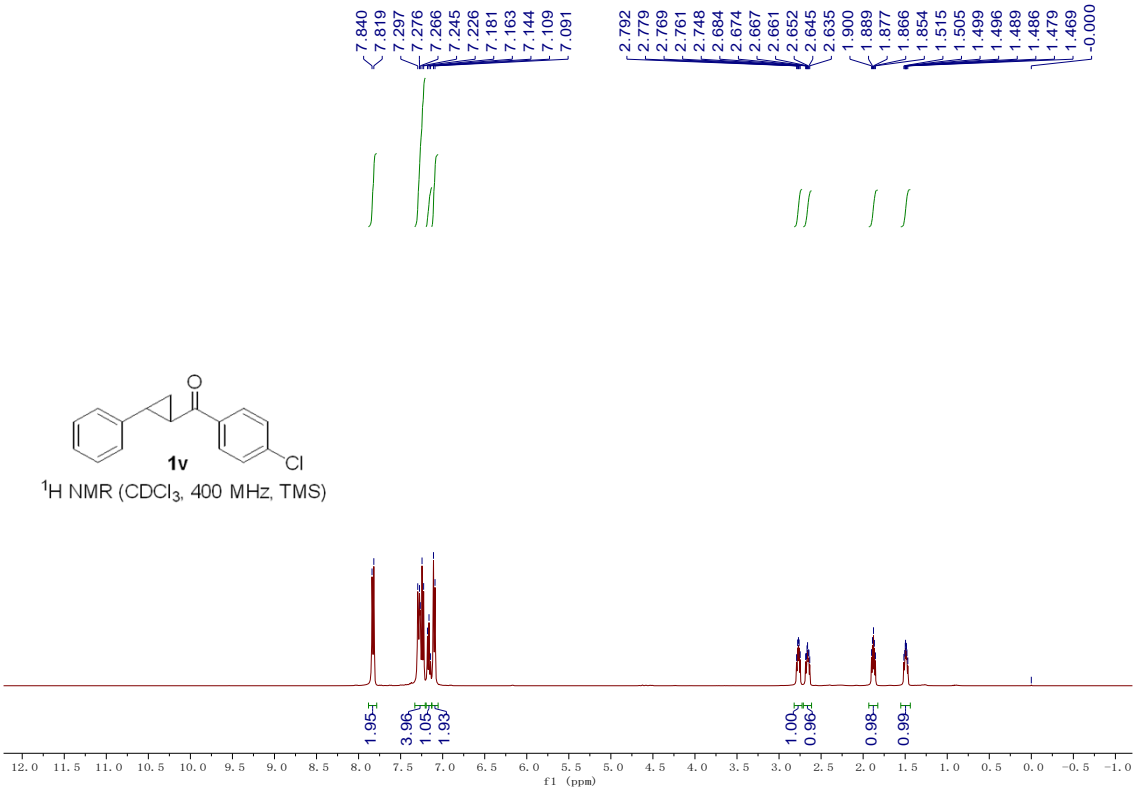
1u

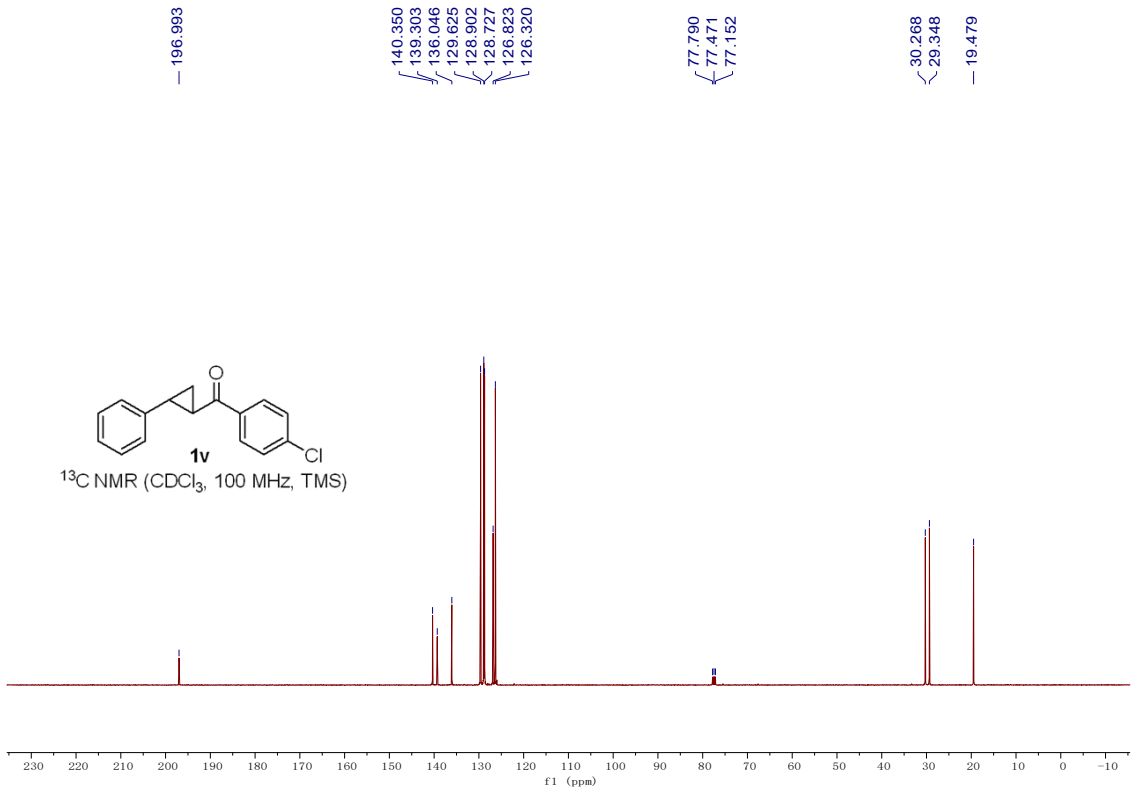
^{19}F NMR (376 MHz, $CDCl_3$, $CFCl_3$)

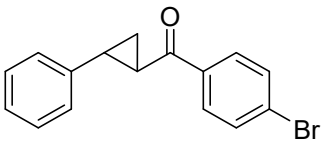


(4-chlorophenyl)(2-phenylcyclopropyl)methanone (1v)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[4] A white solid. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 1.47-1.52 (m, 1H), 1.85-1.90 (m, 1H), 2.64-2.68 (m, 1H), 2.75-2.79 (m, 1H), 7.10 (d, *J* = 7.2 Hz, 2H), 7.16 (t, *J* = 7.2 Hz, 1H), 7.23-7.30 (m, 4H), 7.83 (d, *J* = 8.6 Hz, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 19.5, 29.3, 30.3, 126.3, 126.8, 128.7, 128.9, 129.6, 136.0, 139.3, 140.3, 197.0.

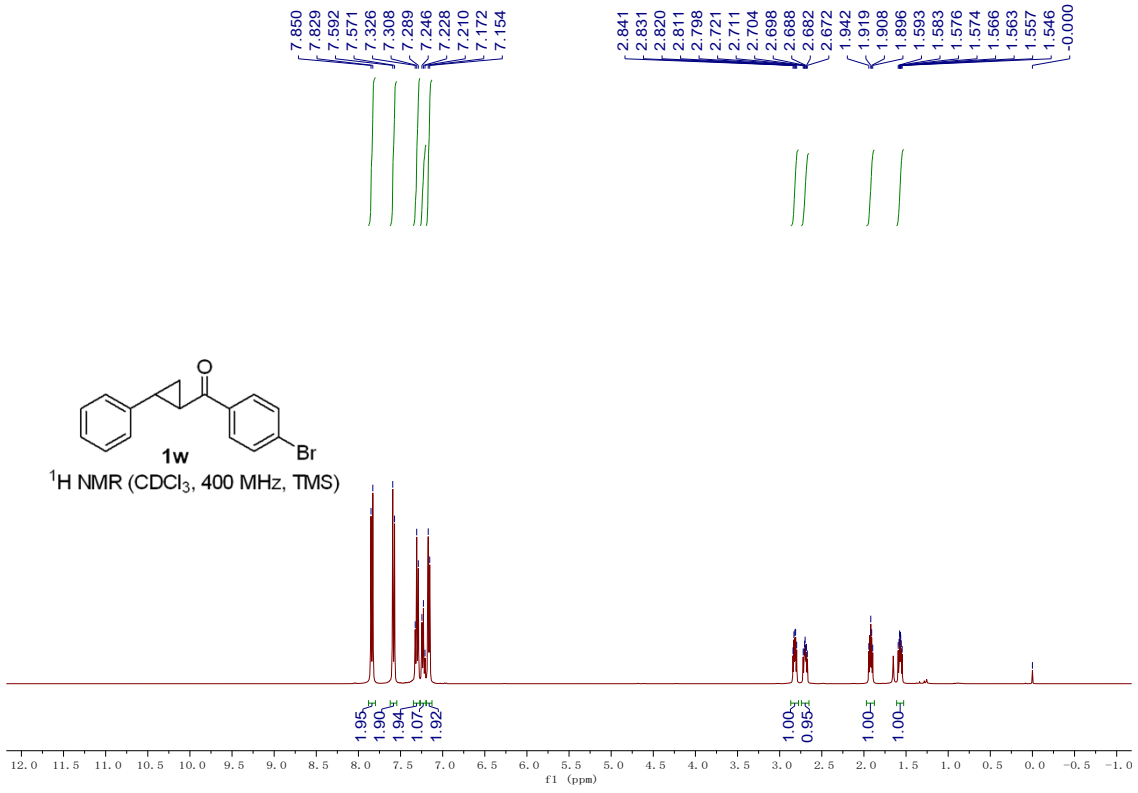


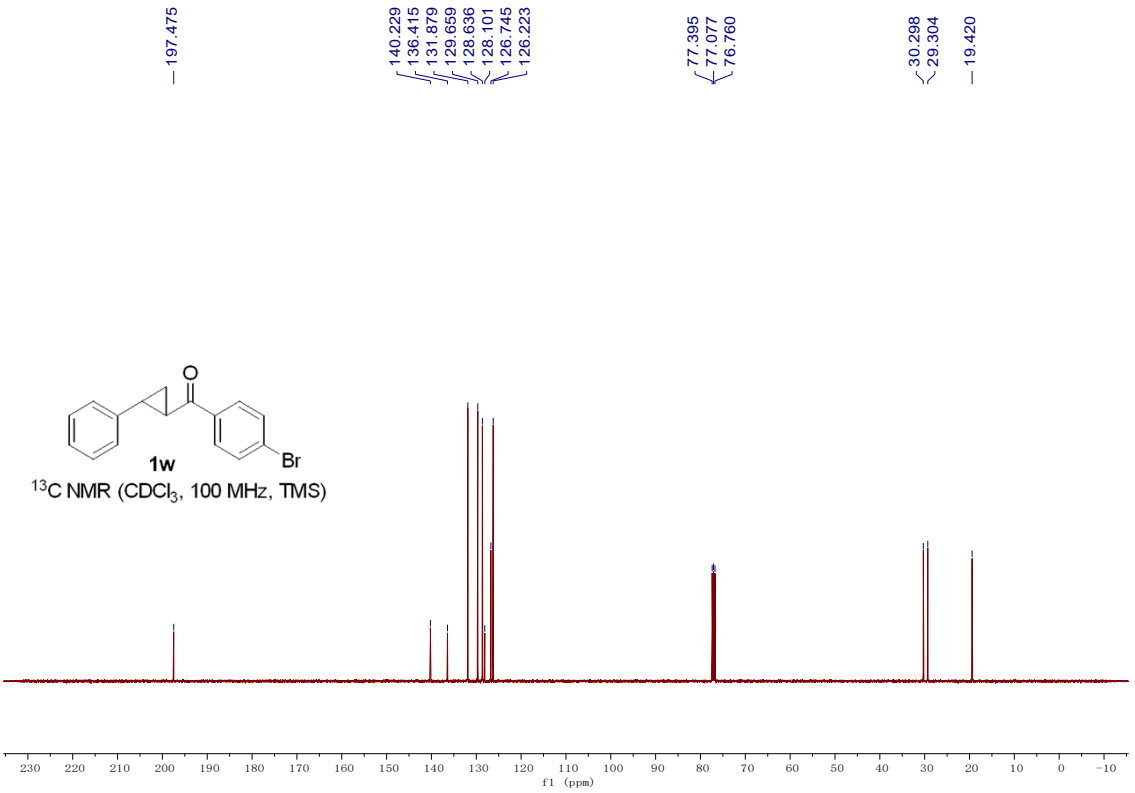

196.993
140.350
139.303
136.046
129.625
128.902
128.727
126.823
126.320
77.790
77.471
77.152
30.268
29.348
19.479
O
Cl
1v
13C NMR (CDCl3, 100 MHz, TMS)
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

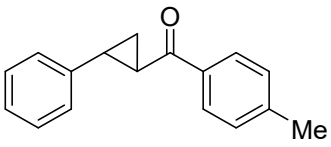


(4-bromophenyl)(2-phenylcyclopropyl)methanone (1w)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[4] A white solid. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 1.55-1.59 (m, 1H), 1.90-1.94 (m, 1H), 2.67-2.72 (m, 1H), 2.80-2.84 (m, 1H), 7.16 (d, *J* = 7.2 Hz, 2H), 7.23 (t, *J* = 7.2 Hz, 1H), 7.31 (t, *J* = 7.4 Hz, 2H), 7.58 (d, *J* = 8.4 Hz, 2H), 7.84 (d, *J* = 8.4 Hz, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 19.4, 29.3, 30.3, 126.2, 126.7, 128.1, 128.6, 129.7, 131.9, 136.4, 140.2, 197.5.

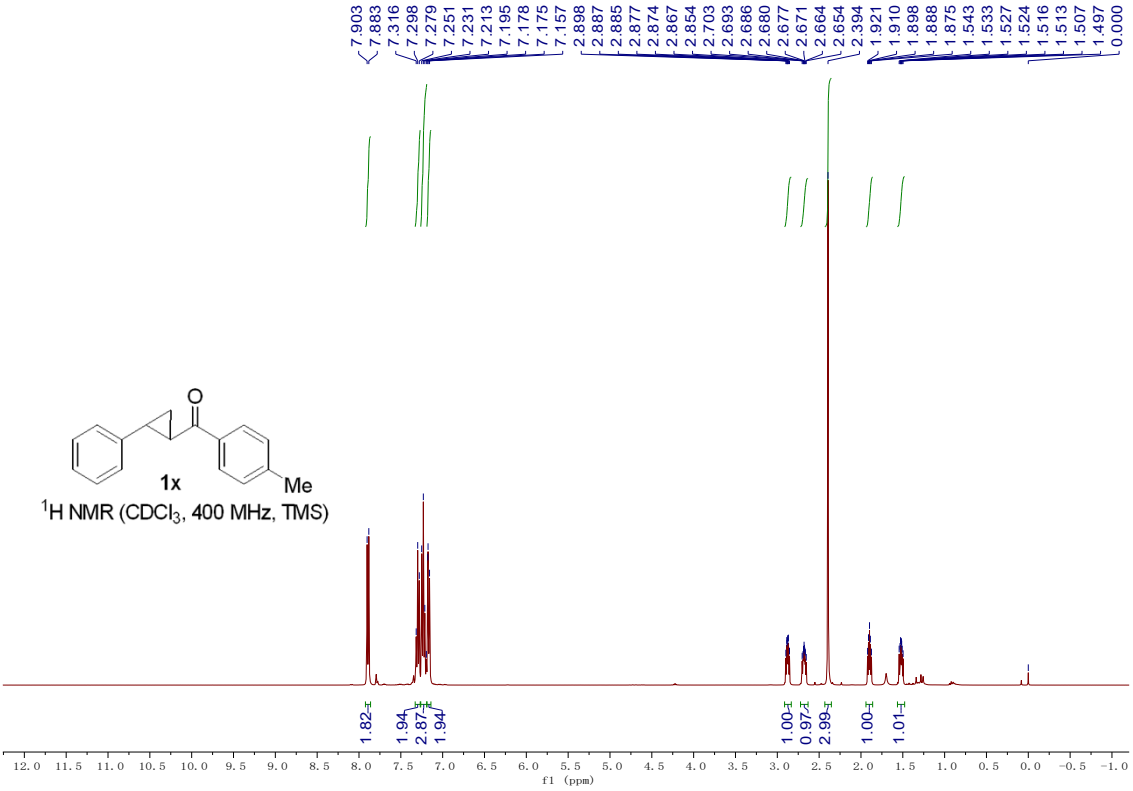


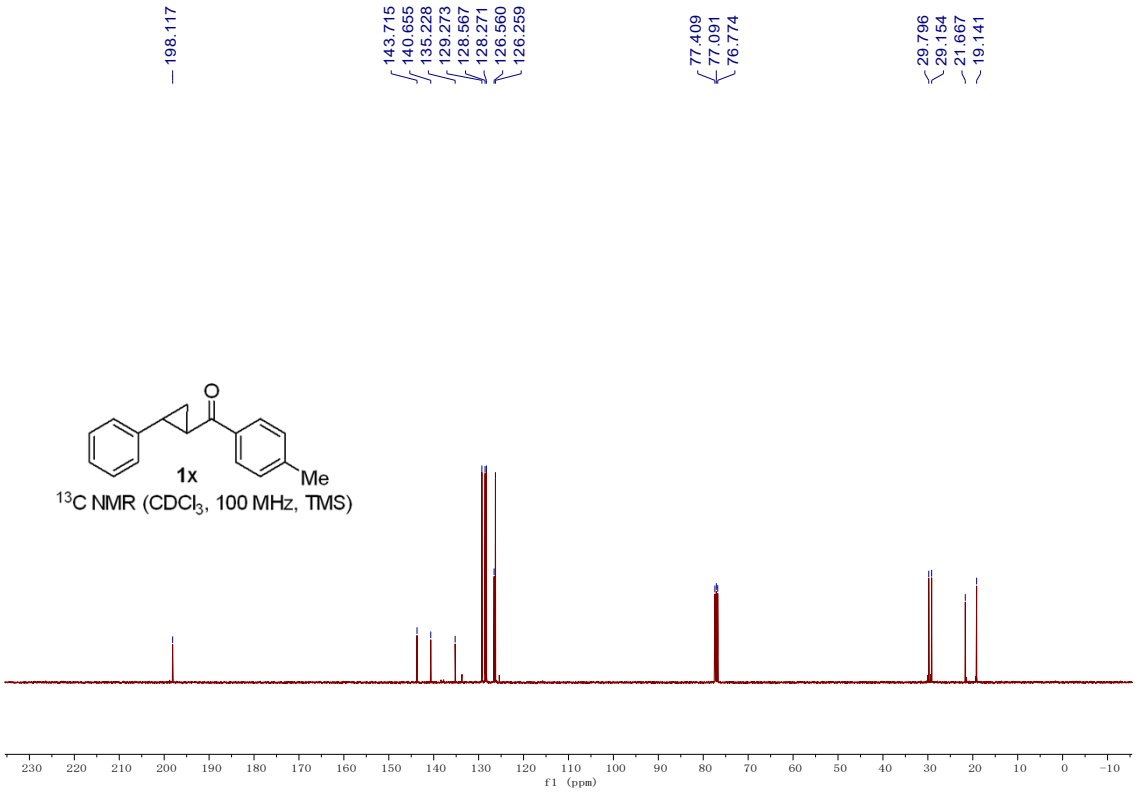

197.475
140.229
136.415
131.879
129.659
128.636
128.101
126.745
126.223
77.395
77.077
76.760
30.298
29.304
19.420
O
Br
1w
13C NMR (CDCl3, 100 MHz, TMS)
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

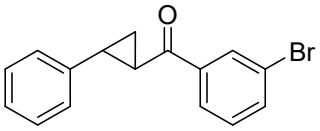


(2-phenylcyclopropyl)(p-tolyl)methanone (1x)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[4] A colorless oil. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 1.50-1.54 (m, 1H), 1.88-1.92 (m, 1H), 2.39 (s, 3H), 2.65-2.70 (m, 1H), 2.85-2.90 (m, 1H), 7.16-7.18 (m, 2H), 7.20-7.25 (m, 3H), 7.30 (t, J = 7.4 Hz, 2H), 7.89 (d, J = 8.2 Hz, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 19.1, 21.7, 29.2, 29.8, 126.3, 126.6, 128.3, 128.6, 129.3, 135.2, 140.7, 143.7, 198.1.

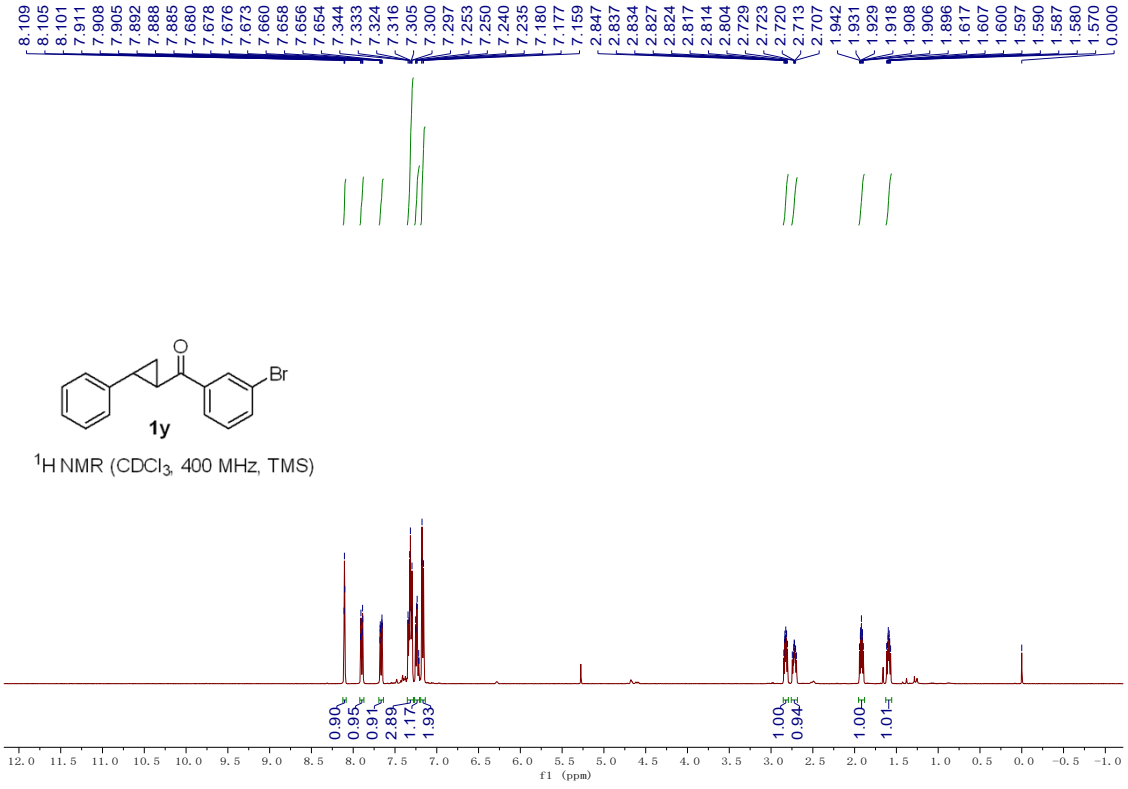


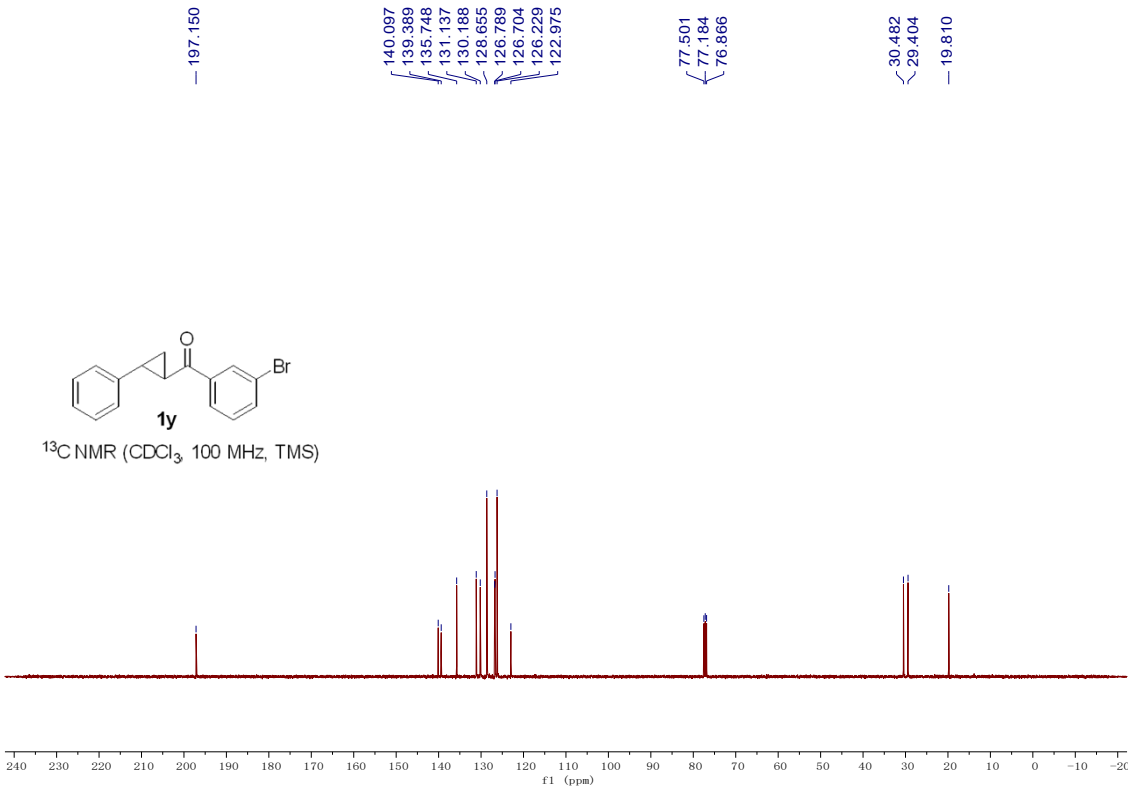

198.117
143.715
140.655
135.228
129.273
128.567
128.271
126.560
126.259
77.409
77.091
76.774
29.796
29.154
21.667
19.141
O
1x
Me
13C NMR (CDCl3, 100 MHz, TMS)
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

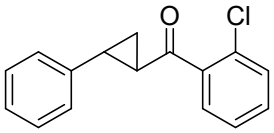


(3-bromophenyl)(2-phenylcyclopropyl)methanone (1y)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[4] A colorless oil. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 1.57-1.62 (m, 1H), 1.90-1.94 (m, 1H), 2.70-2.75 (m, 1H), 2.80-2.85 (m, 1H), 7.16-7.18 (m, 2H), 7.21-7.25 (m, 1H), 7.30-7.34 (m, 3H), 7.65-7.68 (m, 1H), 7.90 (dt, J_1 = 8.0 Hz, J_2 = 1.2 Hz, 1H), 8.11 (t, J = 1.6 Hz, 1H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 19.8, 29.4, 30.5, 123.0, 126.2, 126.7, 126.8, 128.7, 130.2, 131.1, 135.7, 139.4, 140.1, 197.1.

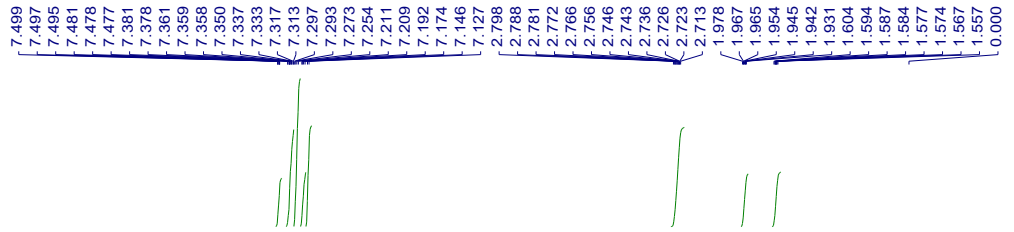


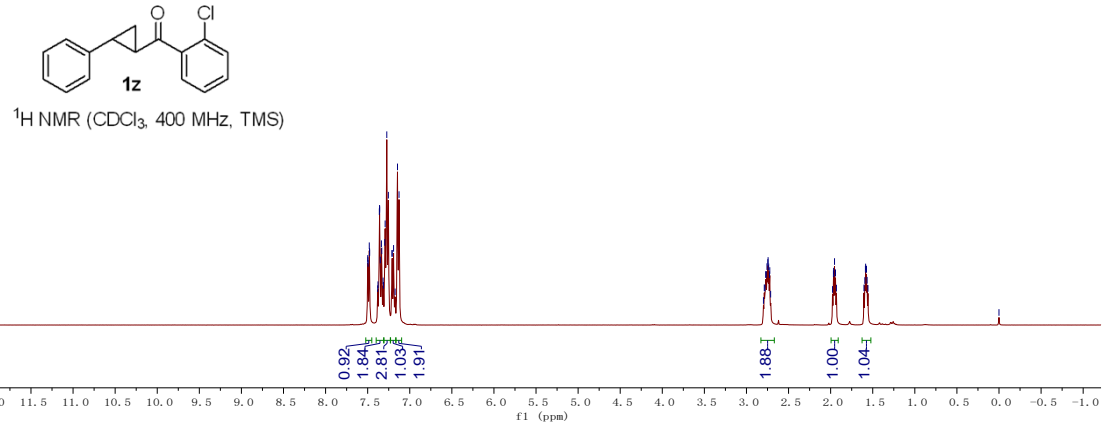

197.150
140.097
139.389
135.748
131.137
130.188
128.655
126.789
126.704
126.229
122.975
77.501
77.184
76.866
30.482
29.404
19.810
O
Br
1y
13C NMR (CDCl3, 100 MHz, TMS)
240 230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10 −20
f1 (ppm)

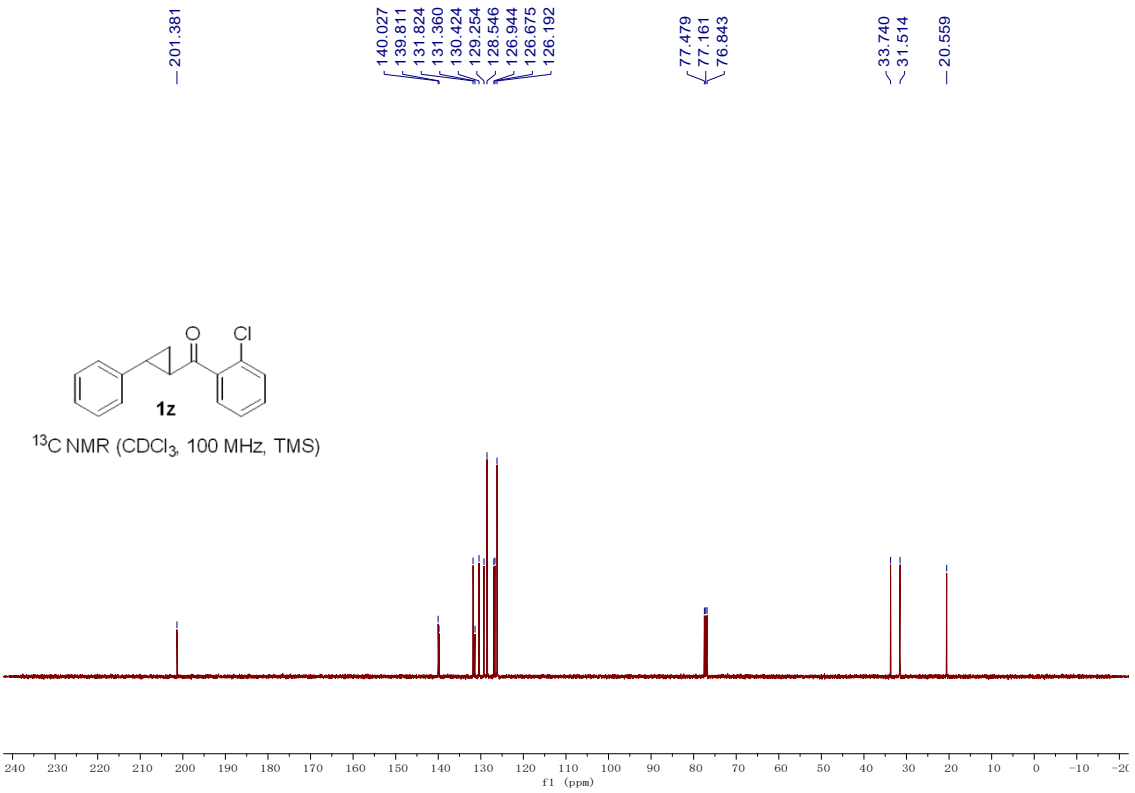


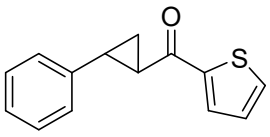
(2-chlorophenyl)(2-phenylcyclopropyl)methanone (1z)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[6] A colorless oil. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 1.56-1.60 (m, 1H), 1.93-1.98 (m, 1H), 2.71-2.80 (m, 2H), 7.14 (d, *J* = 7.6 Hz, 2H), 7.17-7.21 (m, 1H), 7.25-7.29 (m, 3H), 7.31-7.38 (m, 2H), 7.48-7.50 (m, 1H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 20.6, 31.5, 33.7, 126.2, 126.7, 126.9, 128.5, 129.3, 130.4, 131.4, 131.8, 139.8, 140.0, 201.4.



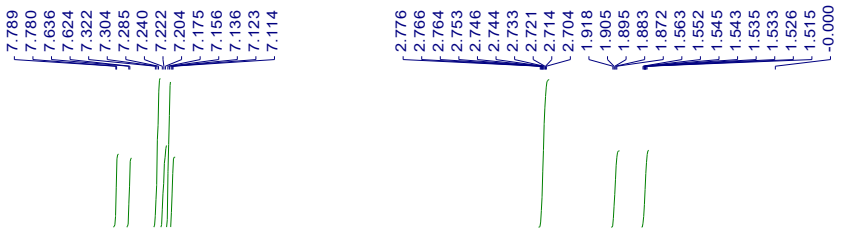


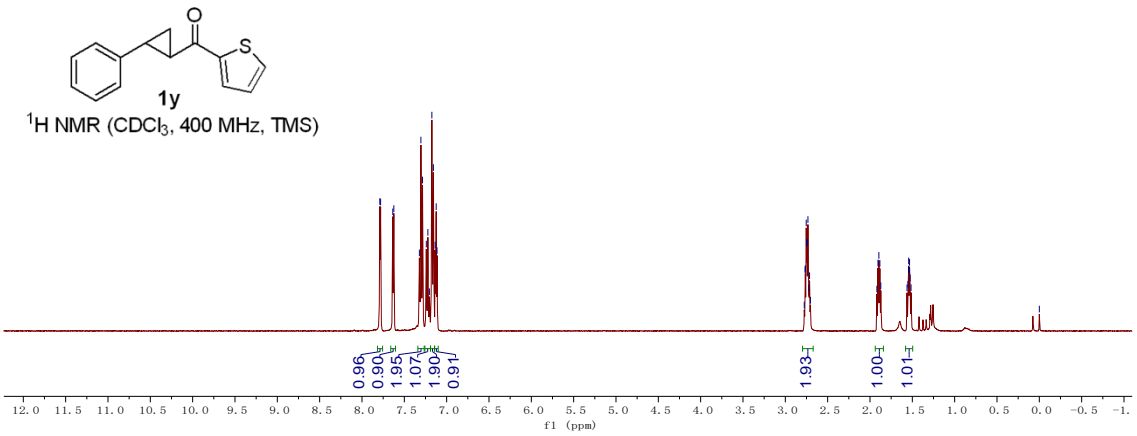

201.381
140.027
139.811
131.824
131.360
130.424
129.254
128.546
126.944
126.675
126.192
77.479
77.161
76.843
33.740
31.514
20.559
O
Cl
1z
13C NMR (CDCl3, 100 MHz, TMS)
f1 (ppm)

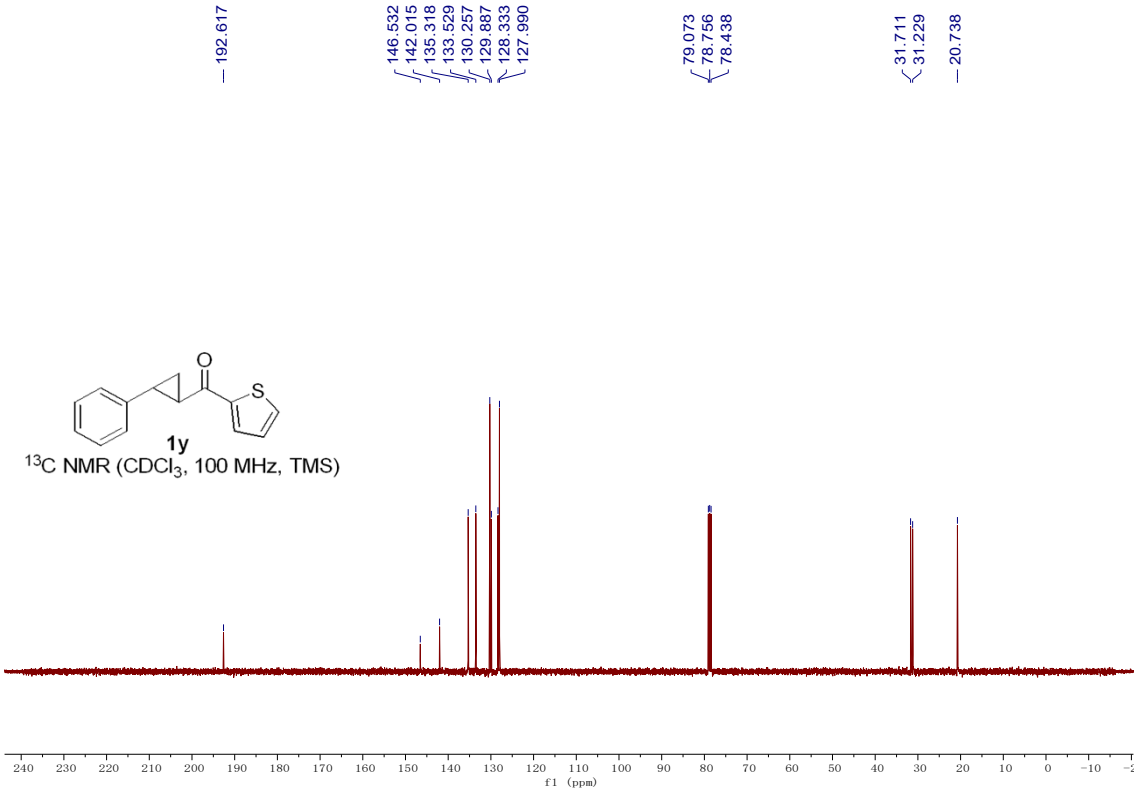


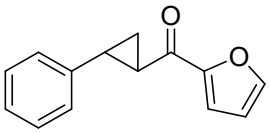
(2-phenylcyclopropyl)(thiophen-2-yl)methanone (1aa)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[5] A white solid. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 1.52-1.56 (m, 1H), 1.87-1.92 (m, 1H), 2.70-2.78 (m, 2H), 7.12 (t, *J* = 4.4 Hz, 1H), 7.17 (d, *J* = 7.2 Hz, 2H), 7.22 (t, *J* = 7.2 Hz, 1H), 7.30 (t, *J* = 7.4 Hz, 2H), 7.63 (d, *J* = 5.0 Hz, 1H), 7.78 (d, *J* = 3.8 Hz, 1H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 20.7, 31.2, 31.7, 128.0, 128.3, 129.9, 130.3, 133.5, 135.3, 142.0, 146.5, 192.6.



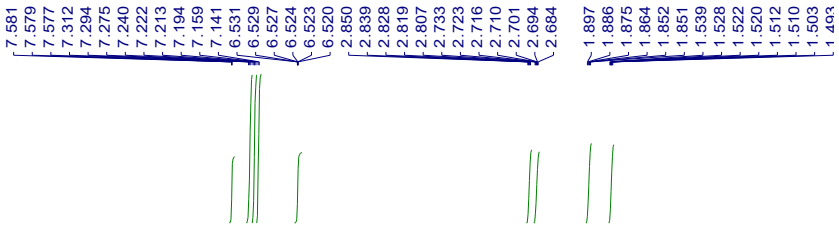


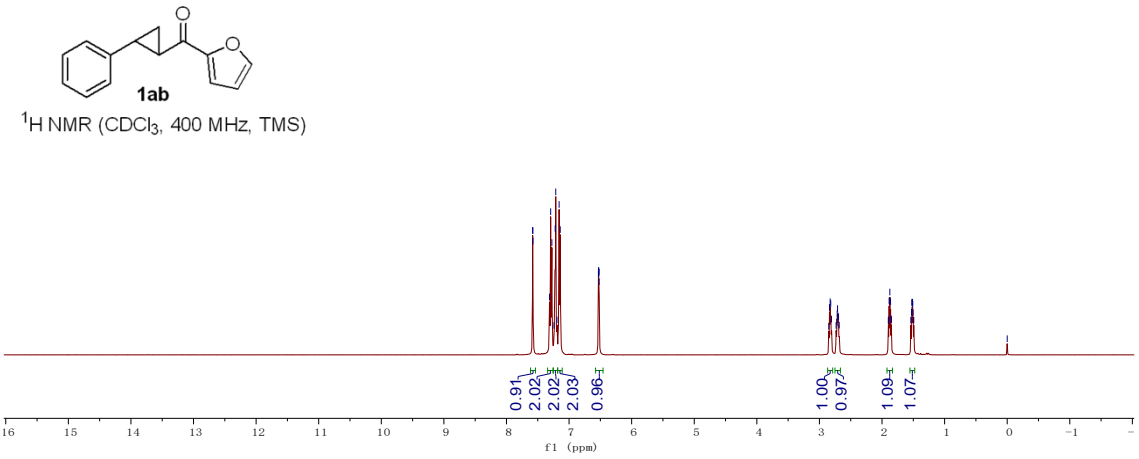

192.617
146.532
142.015
135.318
133.529
130.257
129.887
128.333
127.990
79.073
78.756
78.438
31.711
31.229
20.738
O
S
1y
13C NMR (CDCl3, 100 MHz, TMS)
f1 (ppm)

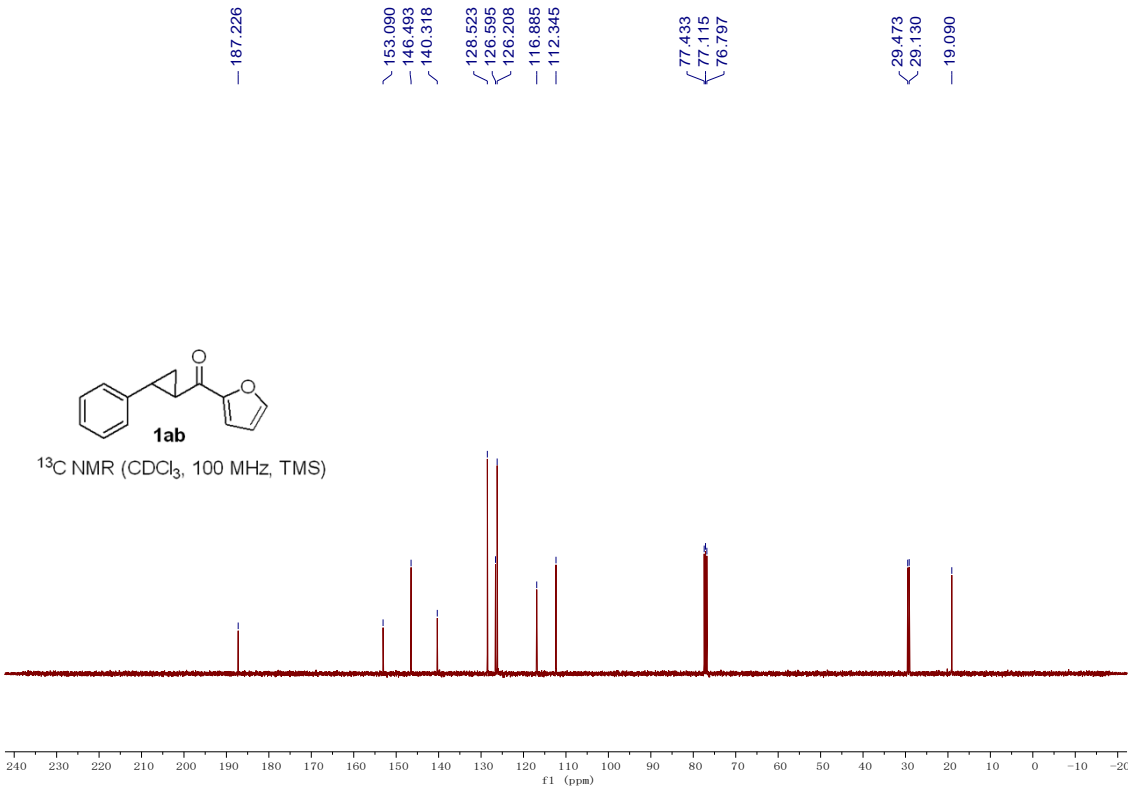


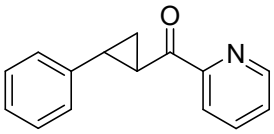
furan-2-yl(2-phenylcyclopropyl)methanone (1ab)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[19] A white solid. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 1.49-1.54 (m, 1H), 1.85-1.90 (m, 1H), 2.68-2.73 (m, 1H), 2.81-2.85 (m, 1H), 6.52-6.53 (m, 1H), 7.15 (d, *J* = 7.2 Hz, 2H), 7.19-7.24 (m, 2H), 7.29 (t, *J* = 7.2 Hz, 2H), 7.57-7.58 (m, 1H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 19.1, 29.1, 29.5, 112.3, 116.9, 126.2, 126.6, 128.5, 140.3, 146.5, 153.1, 187.2.



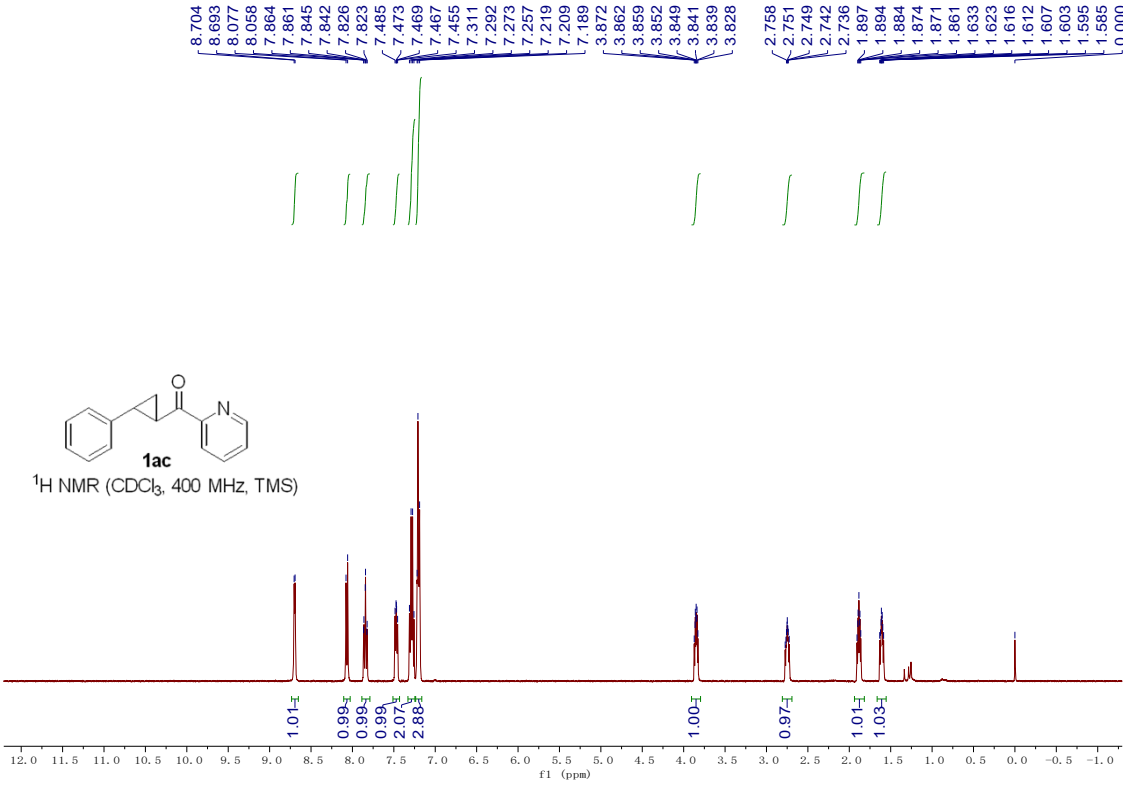


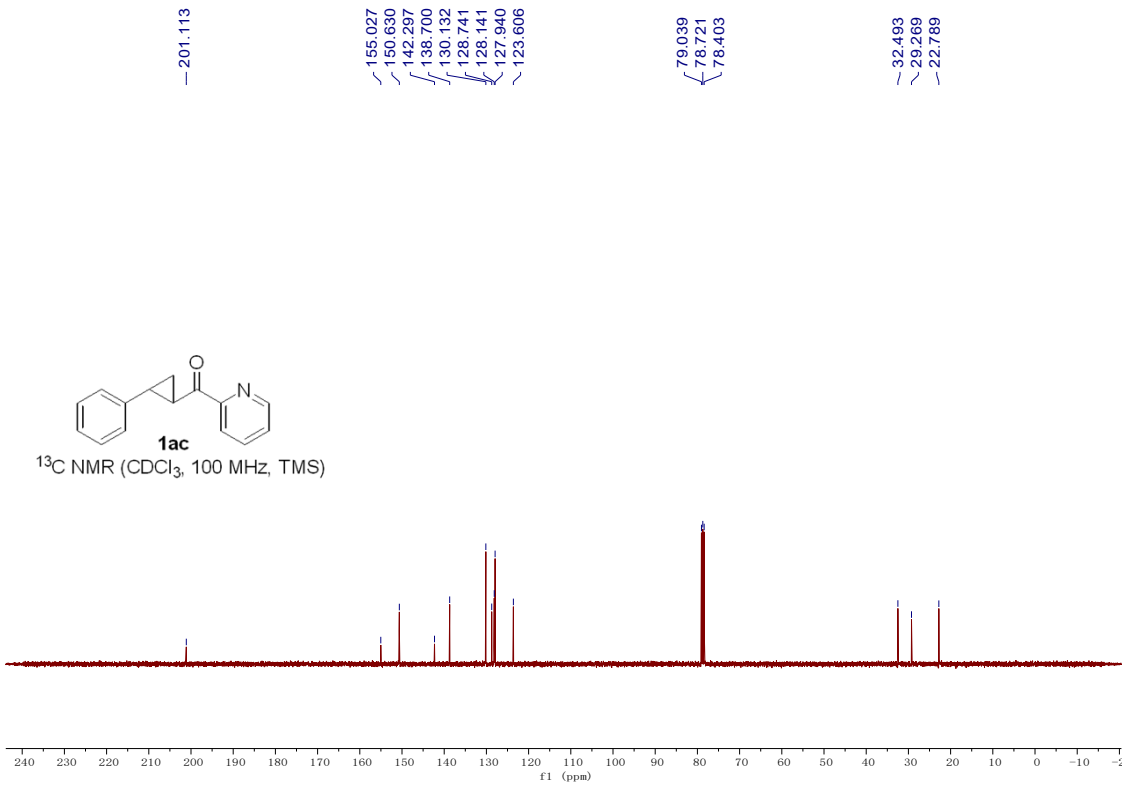

187.226
153.090
146.493
140.318
128.523
126.595
126.208
116.885
112.345
77.433
77.115
76.797
29.473
29.130
19.090
1ab
13C NMR (CDCl3, 100 MHz, TMS)
f1 (ppm)

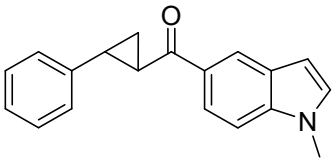


(2-phenylcyclopropyl)(pyridin-2-yl)methanone (1ac)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[4] A white solid. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 1.59-1.63 (m, 1H), 1.86-1.91 (m, 1H), 2.73-2.77 (m, 1H), 3.83-3.87 (m, 1H), 7.19-7.22 (m, 3H), 7.26-7.31 (m, 2H), 7.46-7.49 (m, 1H), 7.82-7.86 (m, 1H), 8.07 (d, *J* = 7.6 Hz, 1H), 8.70 (d, *J* = 4.6 Hz, 1H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 22.8, 29.3, 32.5, 123.6, 127.9, 128.1, 128.7, 130.1, 138.7, 142.3, 150.6, 155.0, 201.1.

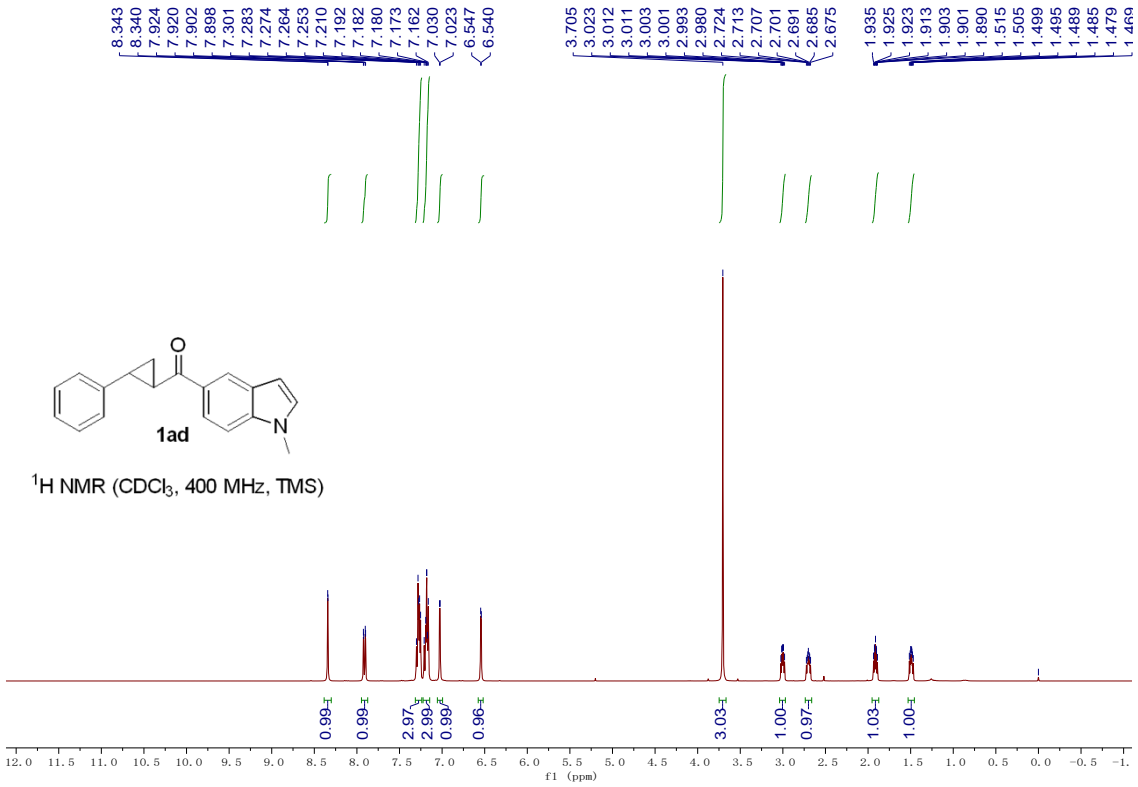


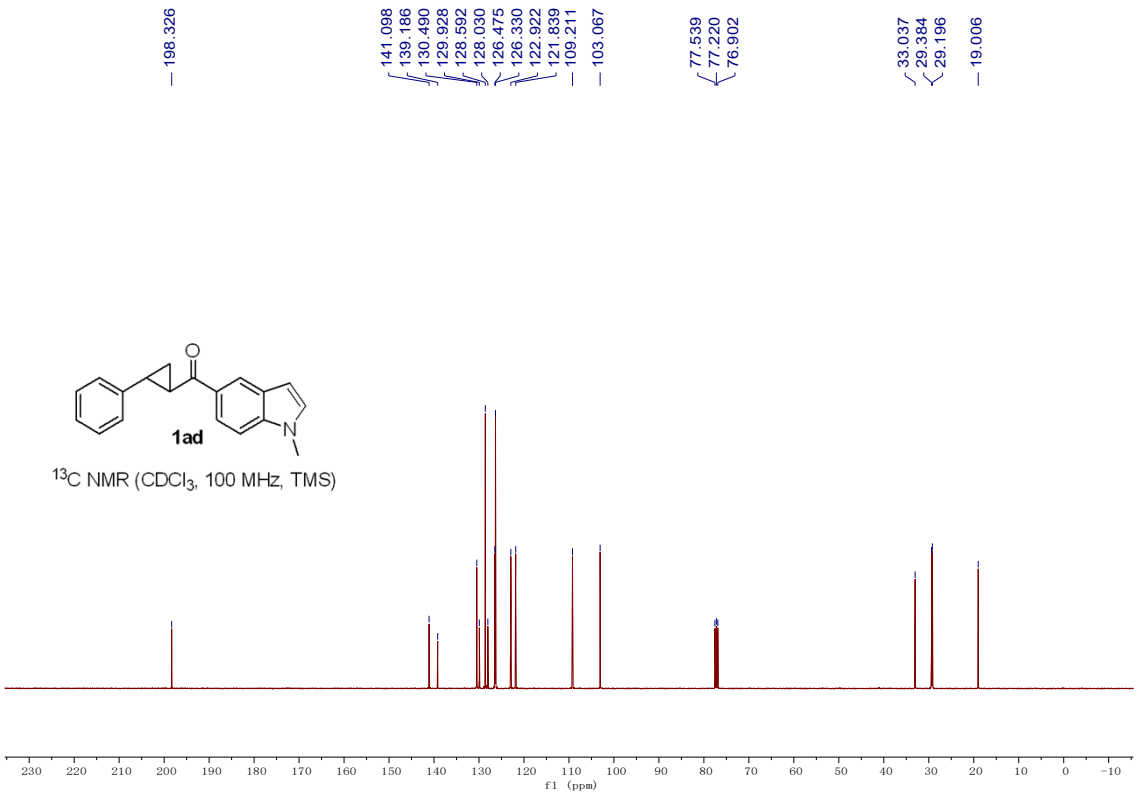

201.113
155.027
150.630
142.297
138.700
130.132
128.741
128.141
127.940
123.606
79.039
78.721
78.403
32.493
29.269
22.789
O
N
1ac
13C NMR (CDCl3, 100 MHz, TMS)
f1 (ppm)

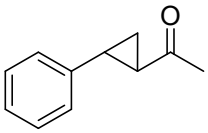


(1-methyl-1H-indol-5-yl)(2-phenylcyclopropyl)methanone (1ad)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[19] A white solid. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 1.47-1.52 (m, 1H), 1.89-1.52 (m, 1H), 2.68-2.72 (m, 1H), 2.98-3.02 (m, 1H), 3.71 (s, 3H), 6.54 (d, J = 2.8 Hz, 1H), 7.03 (d, J = 2.8 Hz, 1H), 7.16-7.21 (m, 3H), 7.25-7.30 (m, 3H), 7.91 (dd, J_1 = 8.8 Hz, J_2 = 1.6 Hz, 1H), 8.34 (d, J = 1.2 Hz, 1H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 19.0, 29.2, 29.4, 33.0, 103.1, 109.2, 121.8, 122.9, 126.3, 126.5, 128.0, 128.6, 129.9, 130.5, 139.2, 141.1, 198.3.

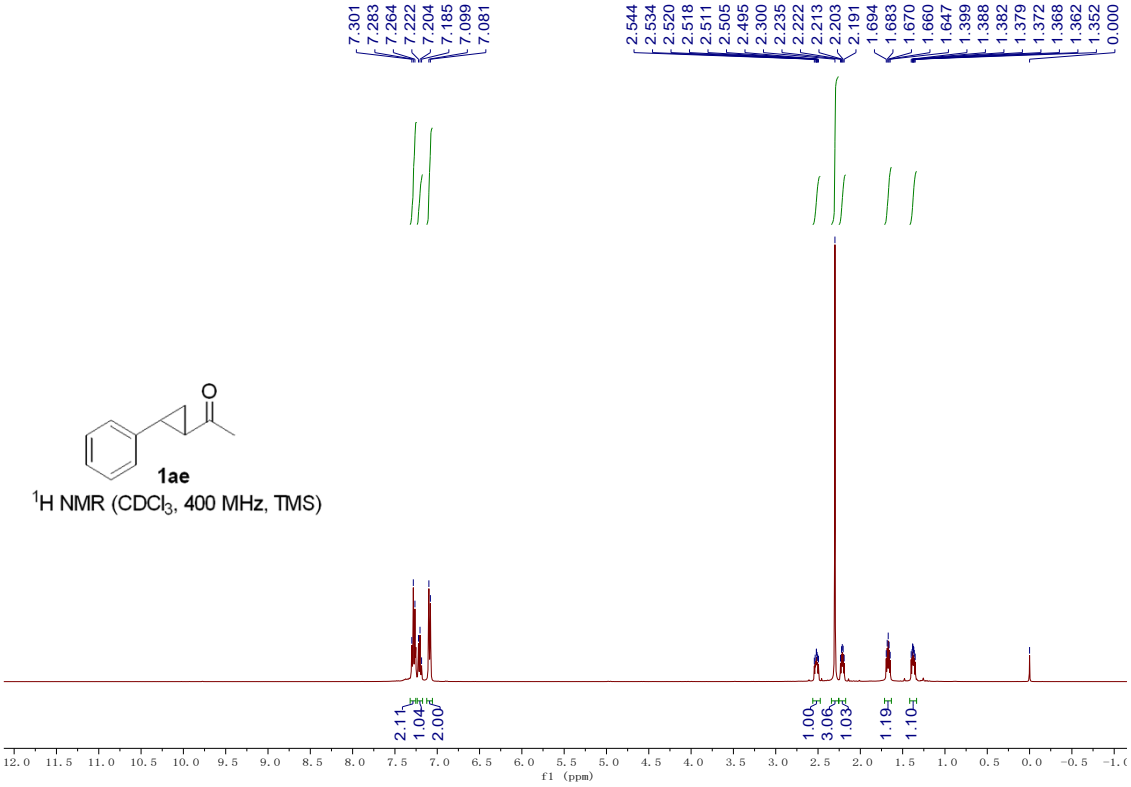


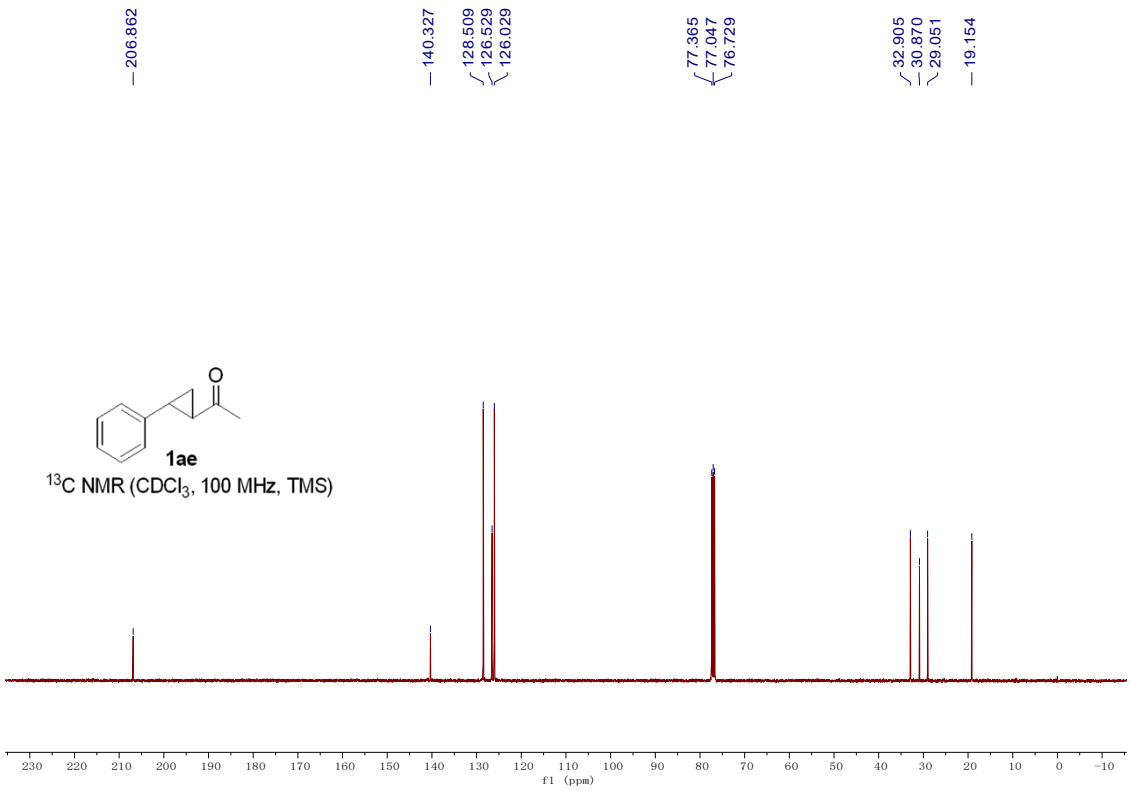

198.326
141.098
139.186
130.490
129.928
128.592
128.030
126.475
126.330
122.922
121.839
109.211
103.067
77.539
77.220
76.902
33.037
29.384
29.196
19.006
1ad
13C NMR (CDCl3, 100 MHz, TMS)
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

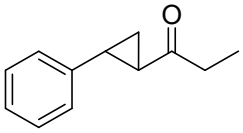


1-(2-phenylcyclopropyl)ethan-1-one (1ae)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[10] A colorless oil. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 1.35-1.40 (m, 1H), 1.65-1.69 (m, 1H), 2.19-2.24 (m, 1H), 2.30 (s, 3H), 2.50-2.54 (m, 1H), 7.09 (d, *J* = 7.2 Hz, 2H), 7.20 (t, *J* = 7.4 Hz, 1H), 7.28 (t, *J* = 7.4 Hz, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 19.2, 29.1, 30.9, 32.9, 126.0, 126.5, 128.5, 140.3, 206.9.

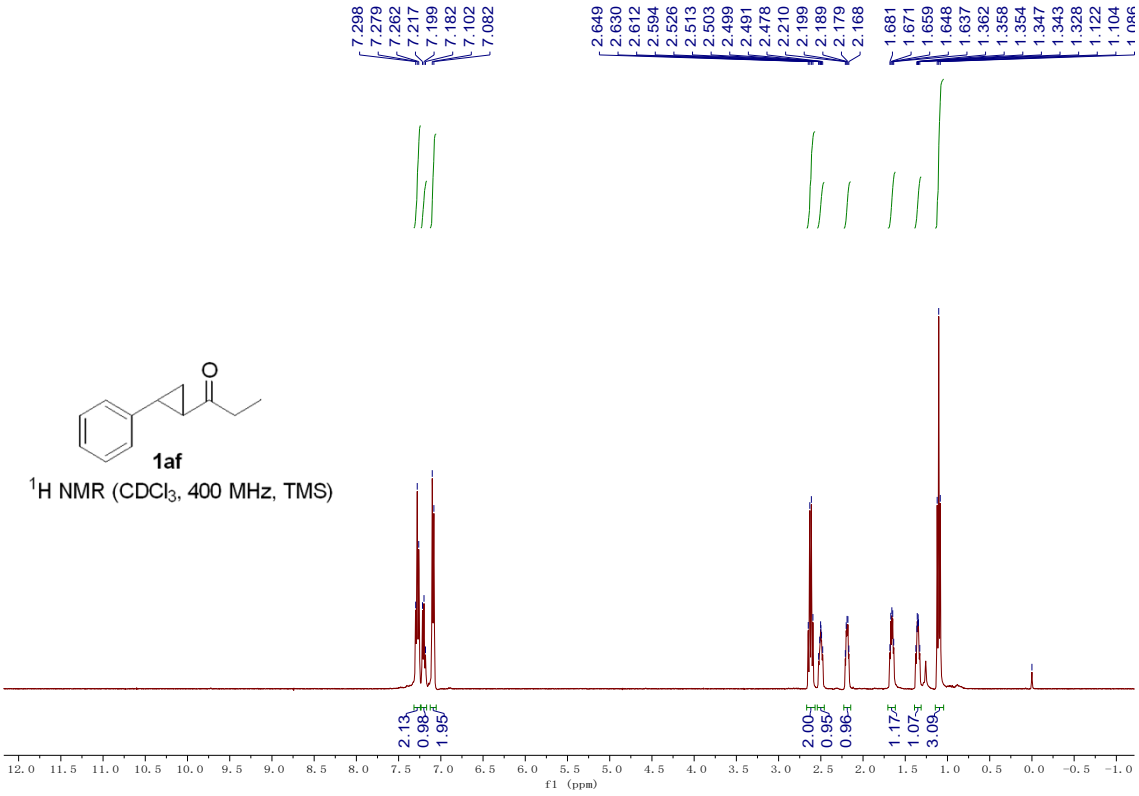


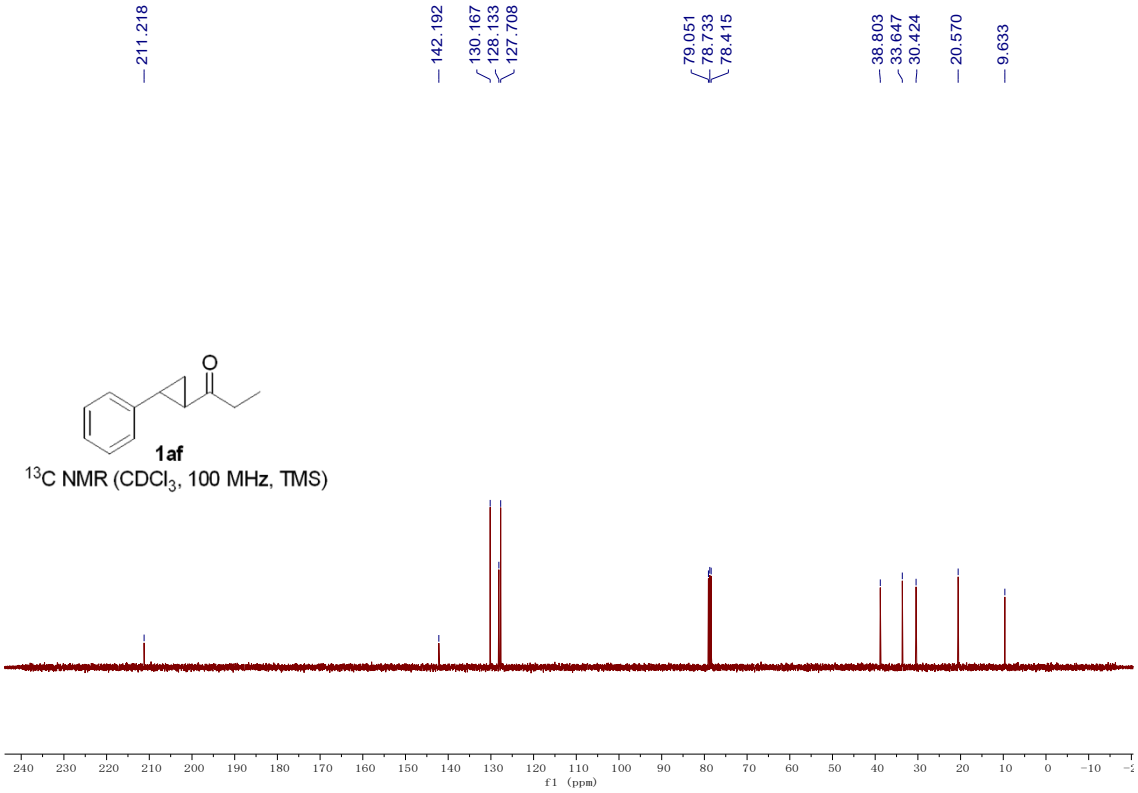

206.862
140.327
128.509
126.529
126.029
77.365
77.047
76.729
32.905
30.870
29.051
19.154
O
1ae
13C NMR (CDCl3, 100 MHz, TMS)
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

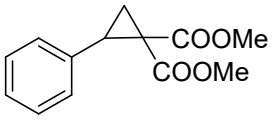


1-(2-phenylcyclopropyl)propan-1-one (1af)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[11] A colorless oil. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 1.10 (t, *J* = 7.2Hz, 3H), 1.33-1.37 (m, 1H), 1.64-1.68 (m, 1H), 2.17-2.21 (m, 1H), 2.48-2.53 (m, 1H), 2.62 (q, *J* = 7.2 Hz, 2H), 7.09 (d, *J* = 8.0 Hz, 2H), 7.20 (t, *J* = 7.2 Hz, 1H), 7.28 (t, *J* = 7.2 Hz, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 9.6, 20.6, 30.4, 33.6, 38.8, 127.7, 128.1, 130.2, 142.2, 211.2.

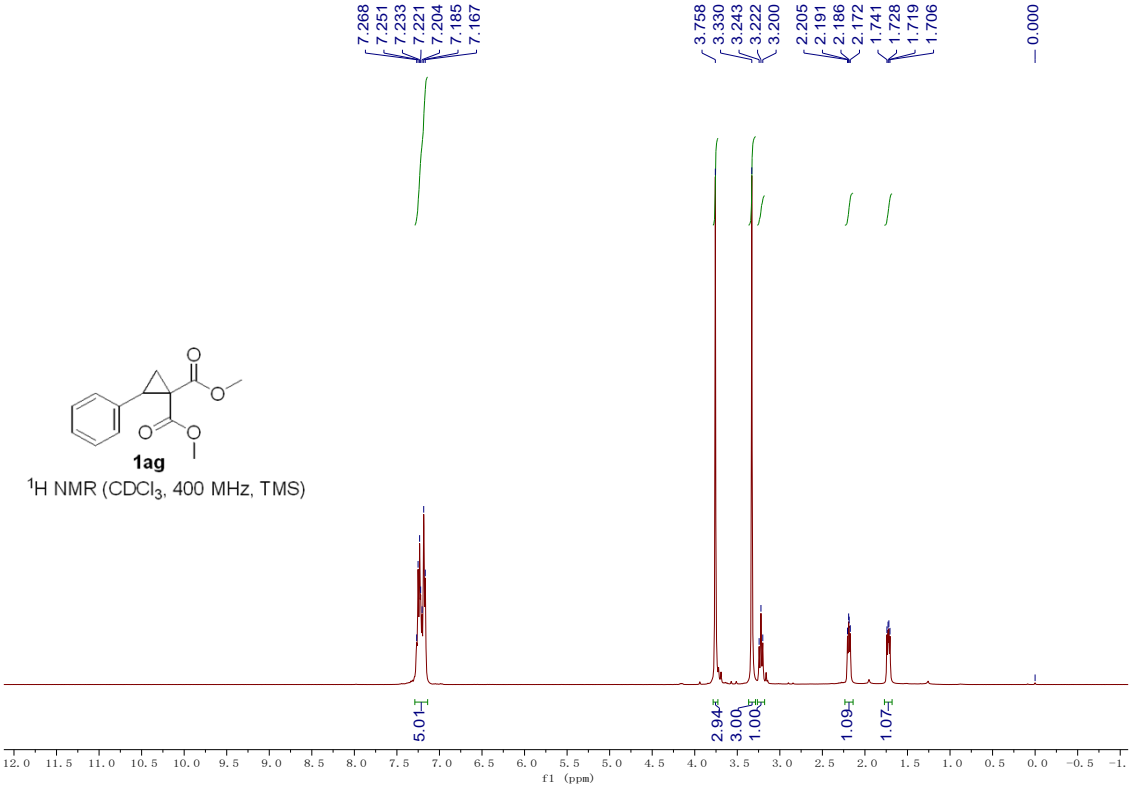


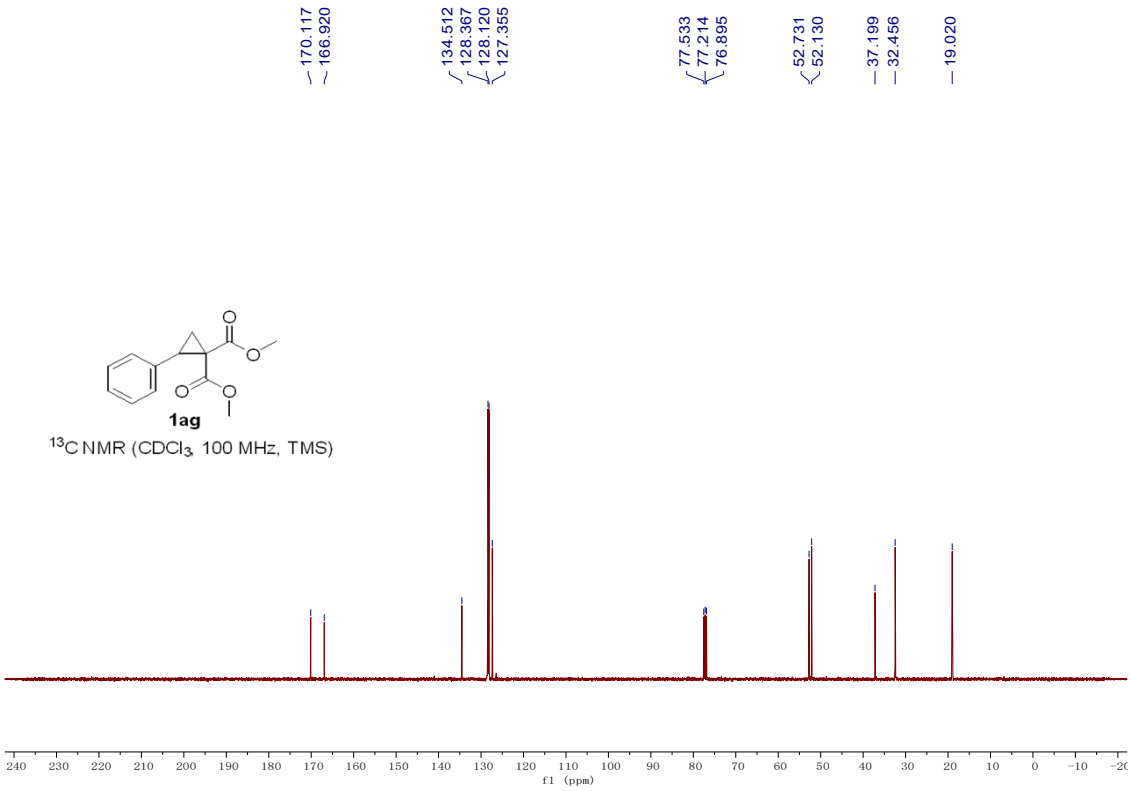

211.218
142.192
130.167
128.133
127.708
79.051
78.733
78.415
38.803
33.647
30.424
20.570
9.633
O
1af
13C NMR (CDCl3, 100 MHz, TMS)
f1 (ppm)

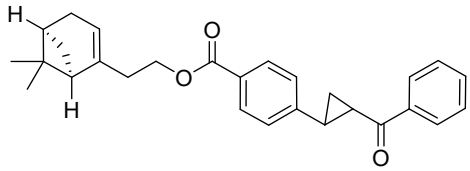


dimethyl 2-phenylcyclopropane-1,1-dicarboxylate (1ag)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[22] A colorless oil. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 1.72 (dd, J_1 = 8.8 Hz, J_2 = 5.2 Hz, 1H), 2.19 (dd, J_1 = 7.6 Hz, J_2 = 5.6 Hz, 1H), 3.22 (t, J = 8.4 Hz, 1H), 3.33 (s, 3H), 3.76 (s, 3H), 7.17-7.27 (m, 5H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 19.0, 32.5, 37.2, 52.1, 52.7, 127.4, 128.1, 128.4, 134.5, 166.9, 170.1.

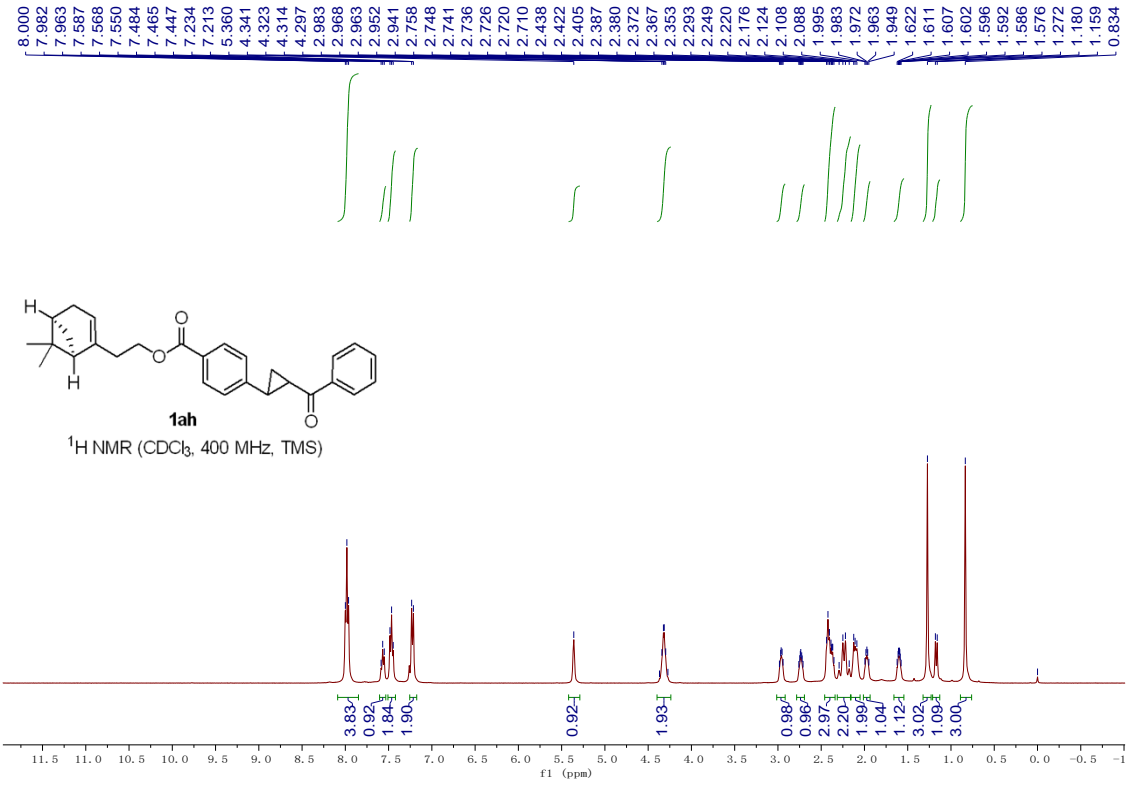



170.117
166.920
134.512
128.367
128.120
127.355
77.533
77.214
76.895
52.731
52.130
37.199
32.456
19.020
1ag
13C NMR (CDCl3, 100 MHz, TMS)
f1 (ppm)

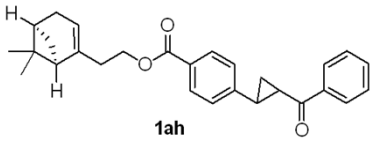


2-((1R,5S)-6,6-dimethylbicyclo[3.1.1]hept-2-en-2-yl)ethyl4-(2-benzoylcyclopropyl)benzoate (1ah)

A white solid. M.P.: 98-100 °C. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 0.83 (s, 3H), 1.17 (d, *J* = 8.4 Hz, 1H), 1.27 (s, 3H), 1.58-1.62 (m, 1H), 1.95-2.00 (m, 1H), 2.09-2.12 (m, 2H), 2.18-2.29 (m, 2H), 2.35-2.44 (m, 3H), 2.71-2.76 (m, 1H), 2.94-2.98 (m, 1H), 4.27-4.37 (m, 2H), 5.36 (s, 1H), 7.22 (d, *J* = 8.4 Hz, 2H), 7.47 (t, *J* = 7.6 Hz, 2H), 7.57 (t, *J* = 7.6 Hz, 1H), 7.98 (t, *J* = 7.2 Hz, 4H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 19.7, 21.2, 26.2, 29.6, 29.6, 31.4, 31.7, 36.0, 38.0, 40.7, 45.6, 63.2, 118.9, 126.0, 128.1, 128.6, 128.7, 129.8, 133.1, 137.4, 144.2, 145.9, 166.3, 198.0. IR (EtOH) $\tilde{\nu}$ 2973, 2928, 2883, 1700, 1650, 1449, 1379, 1330, 1277, 1088, 1045, 880, 802, 631, 432 cm^{-1}. HRMS (ESI) calcd. for $C_{28}H_{30}O_3Na$ (M+Na): 437.2087, Found: 437.2096.

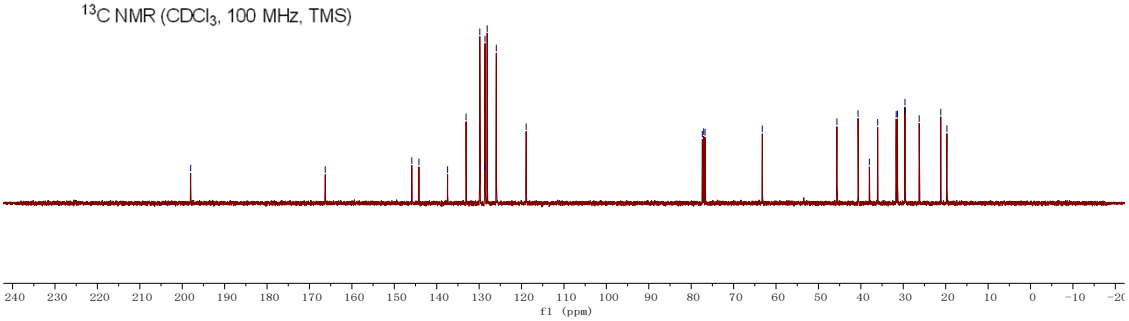


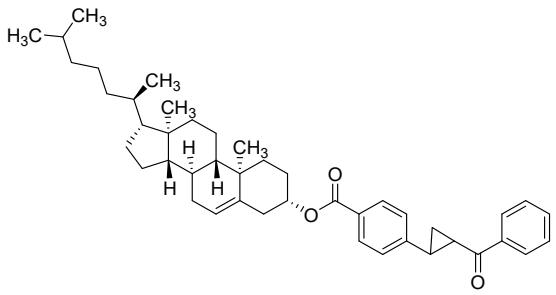
198.010
166.275
145.871
144.193
137.432
133.082
129.835
128.682
128.606
128.103
125.952
118.905
77.372
77.054
76.736
63.233
45.643
40.655
37.994
36.033
31.671
31.360
29.628
29.598
26.246
21.156
19.706



1ah

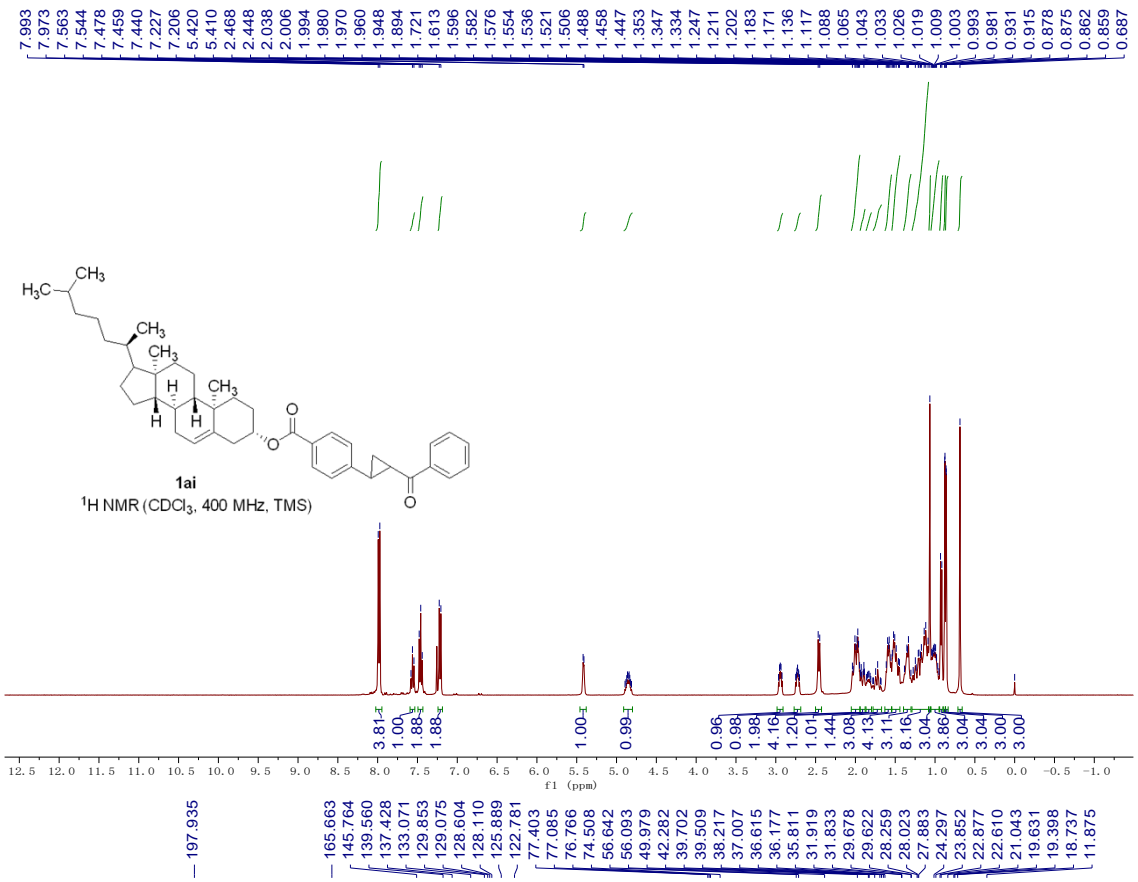
^{13}C NMR ($CDCl_3$, 100 MHz, TMS)

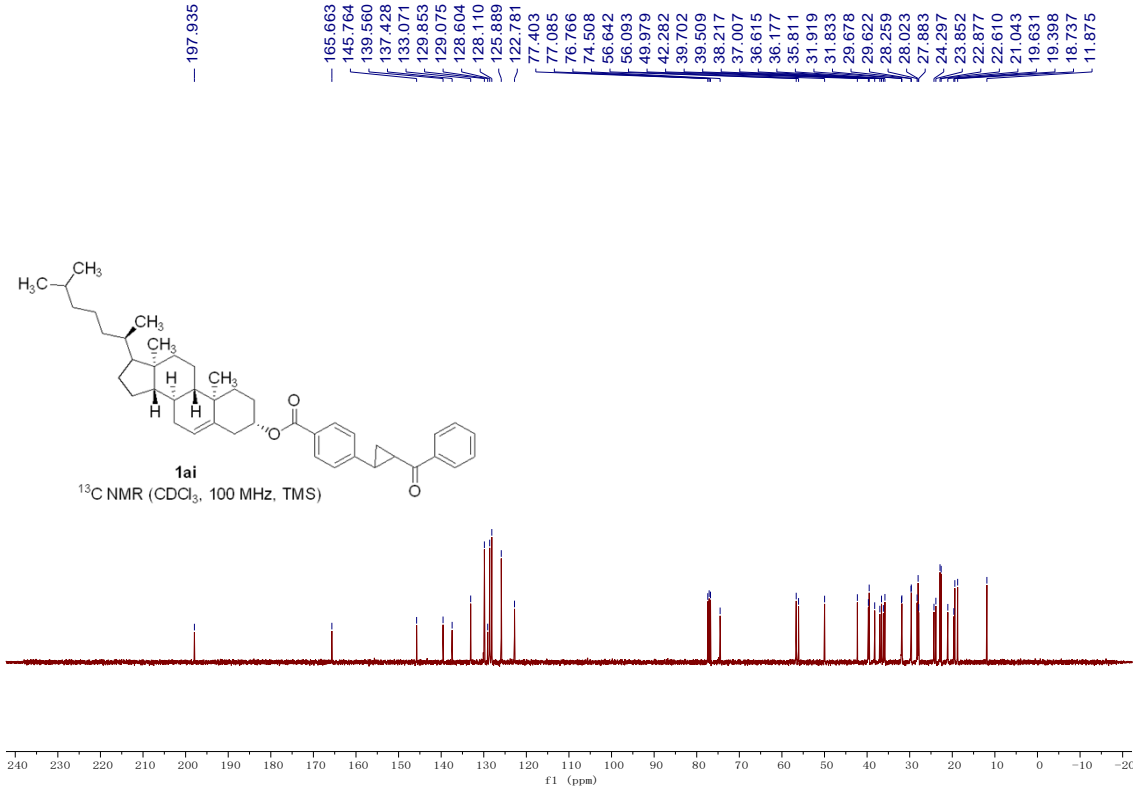




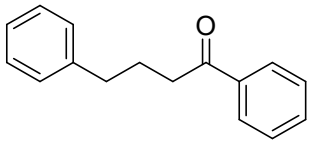
(3S,8S,9S,10R,13R,14S,17R)-10,13-dimethyl-17-((R)-6-methylheptan-2-yl)-2,3,4,7,8,9,10,11,12,13,14,15,16,17-tetradecahydro-1H-cyclopenta[a]phenanthren-3-yl4-(2-benzoylcyclopropyl)benzoate (1ai)

A white solid. M.P.: 130-132 ^{o}C. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 0.69 (s, 3H), 0.86 (d, *J* = 1.2 Hz, 3H), 0.87 (d, *J* = 1.2 Hz, 3H), 0.92 (d, *J* = 6.4 Hz, 3H), 0.95-1.04 (m, 4H), 1.07 (s, 3H), 1.09-1.27 (m, 8H), 1.30-1.38 (m, 3H), 1.45-1.54 (m, 4H), 1.55-1.61 (m, 3H), 1.68-1.78 (m, 1H), 1.81-1.86 (m, 1H), 1.89-1.94 (m, 1H), 1.92-2.04 (m, 4H), 2.46 (d, *J* = 8.0 Hz, 2H), 2.70-2.75 (m, 1H), 2.92-2.97 (m, 1H), 4.81-4.89 (m, 1H), 5.41 (d, *J* = 4.0 Hz, 1H), 7.22 (d, *J* = 8.4 Hz, 2H), 7.46 (t, *J* = 7.6 Hz, 2H), 7.56 (t, *J* = 7.2 Hz, 1H), 7.98 (d, *J* = 8.0 Hz, 4H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 11.9, 18.7, 19.4, 19.6, 21.0, 22.6, 22.9, 23.9, 24.3, 27.9, 28.0, 28.3, 29.6, 29.7, 31.8, 31.9, 35.8, 36.2, 36.6, 37.0, 38.2, 39.5, 39.7, 42.3, 50.0, 56.1, 56.6, 74.5, 122.8, 125.9, 128.1, 128.6, 129.1, 129.9, 133.1, 137.4, 139.6, 145.8, 165.7, 197.9. IR (EtOH) $\tilde{\nu}$ 2972, 2917, 1713, 1668, 1611, 1598, 1450, 1396, 1272, 1181, 1047, 989, 880, 753, 702 cm^{-1}. HRMS (ESI) calcd. for $C_{44}H_{58}O_3Na$ (M+Na): 657.4278, Found: 657.4287.


1ai
1H NMR (CDCl3, 400 MHz, TMS)

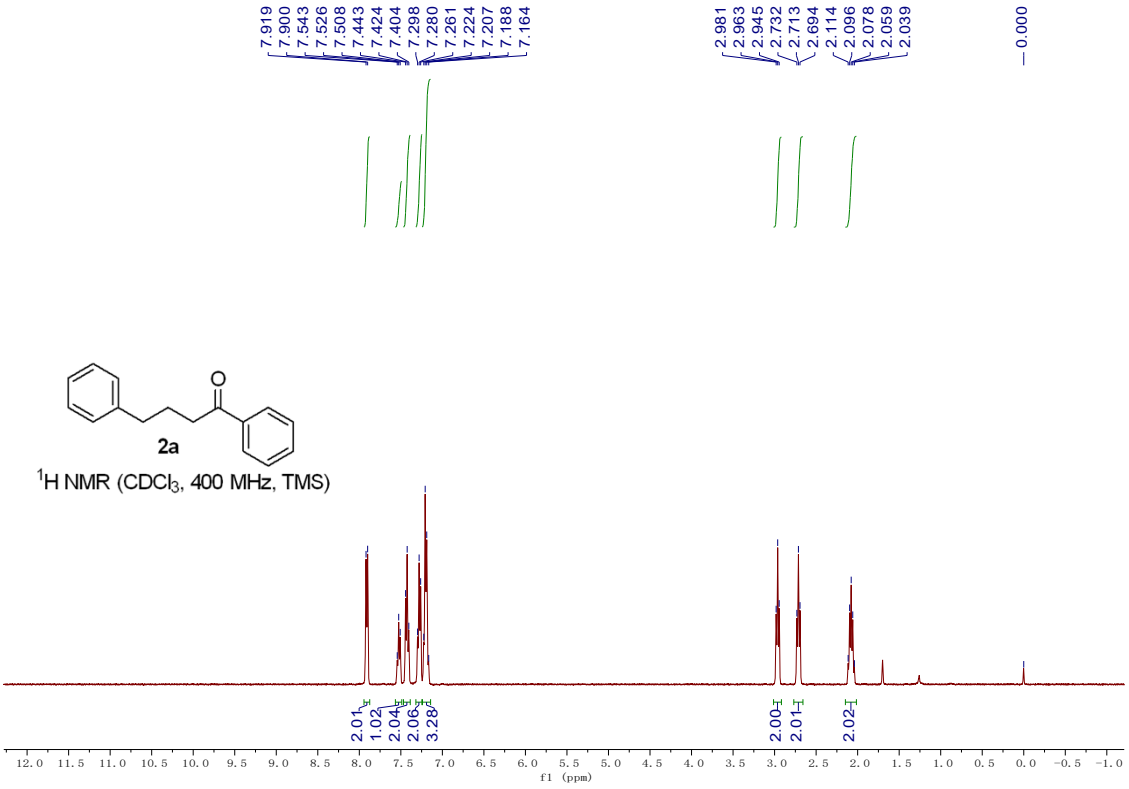

1ai
13C NMR (CDCl3, 100 MHz, TMS)

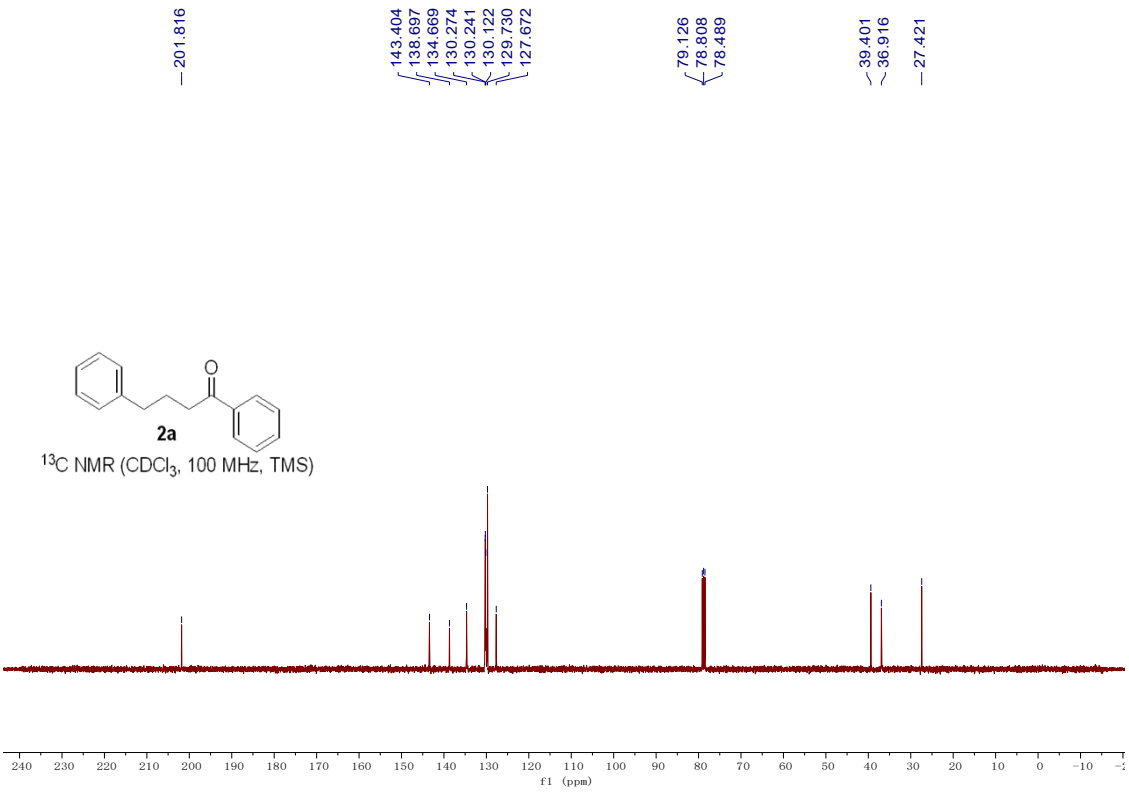
8. Spectroscopic data of products 2.

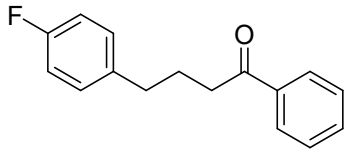


1,4-diphenylbutan-1-one (2a)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[12] A colorless oil. 43.5 mg, 97% yield. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 2.04-2.11 (m, 2H), 2.71 (t, *J* = 7.6 Hz, 2H), 2.96 (t, *J* = 7.2 Hz, 2H), 7.16-7.22 (m, 3H), 7.28 (t, *J* = 7.4 Hz, 2H), 7.42 (t, *J* = 7.6 Hz, 2H), 7.53 (t, *J* = 7.2 Hz, 1H), 7.91 (d, *J* = 7.6 Hz, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 27.4, 36.9, 39.4, 127.7, 129.7, 130.1, 130.2, 130.3, 134.7, 138.7, 143.4, 201.8.

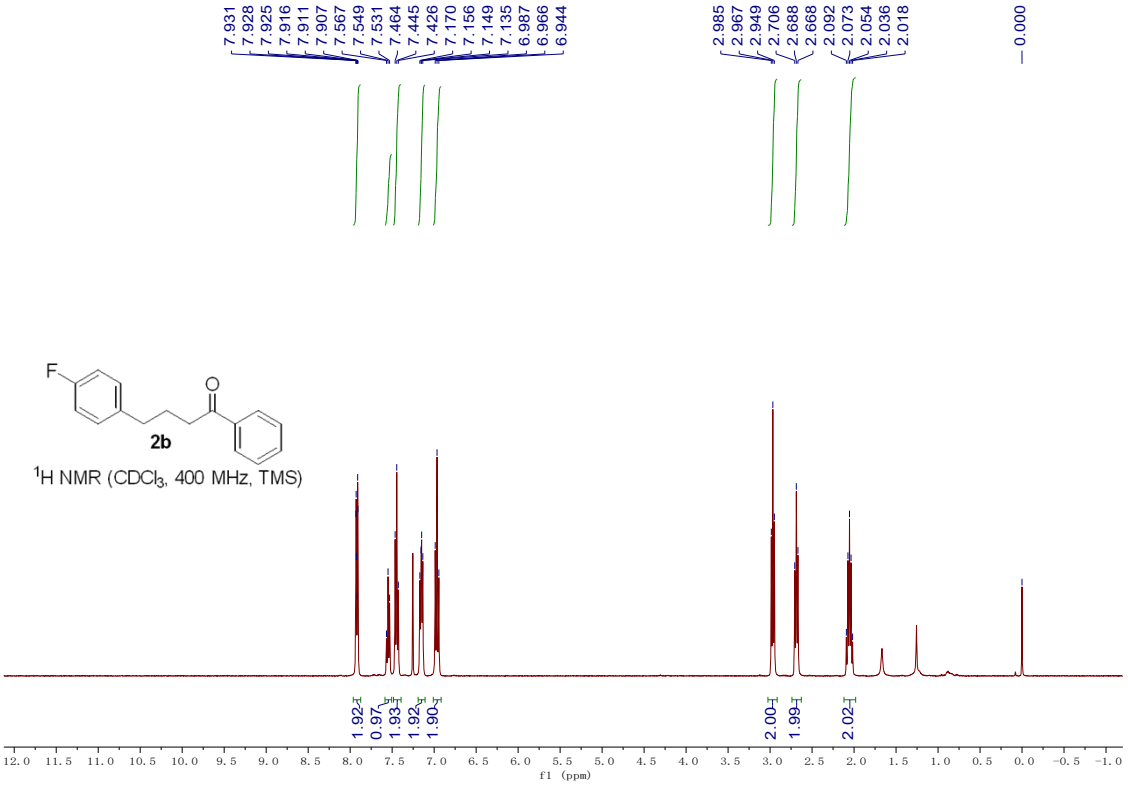


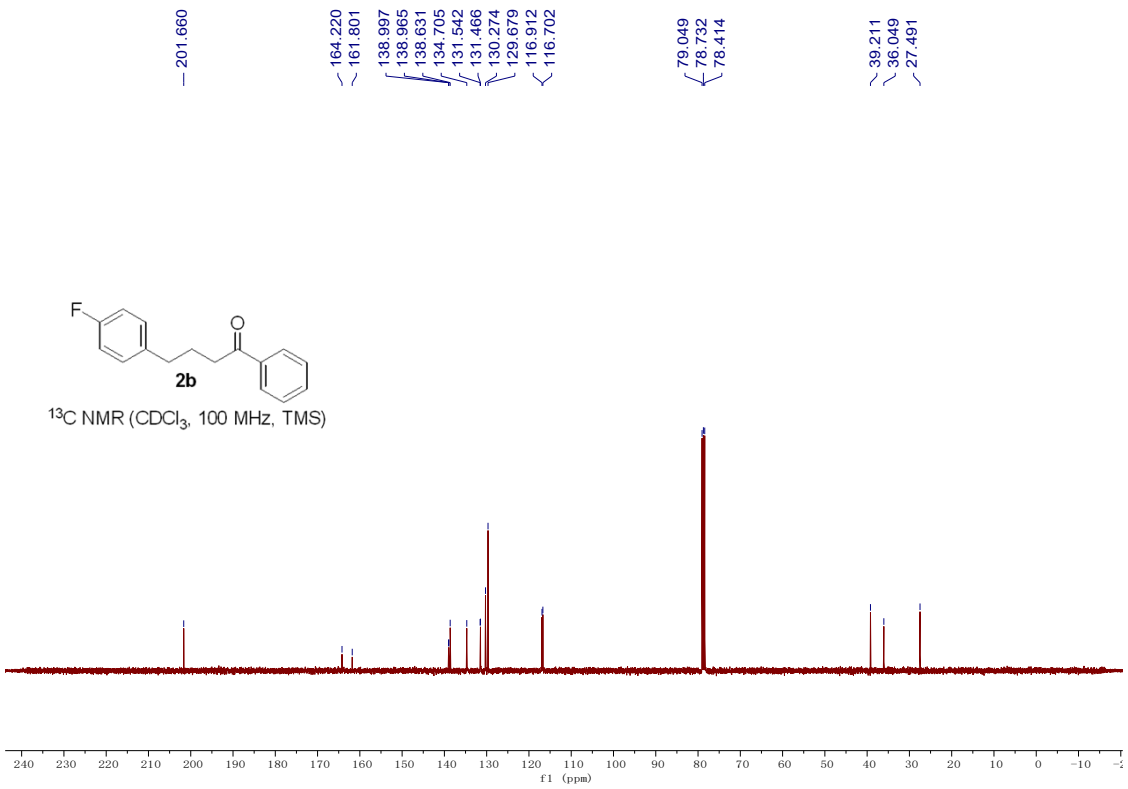

201.816
143.404
138.697
134.669
130.274
130.241
130.122
129.730
127.672
79.126
78.808
78.489
39.401
36.916
27.421
O
2a
13C NMR (CDCl3, 100 MHz, TMS)
240 230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)



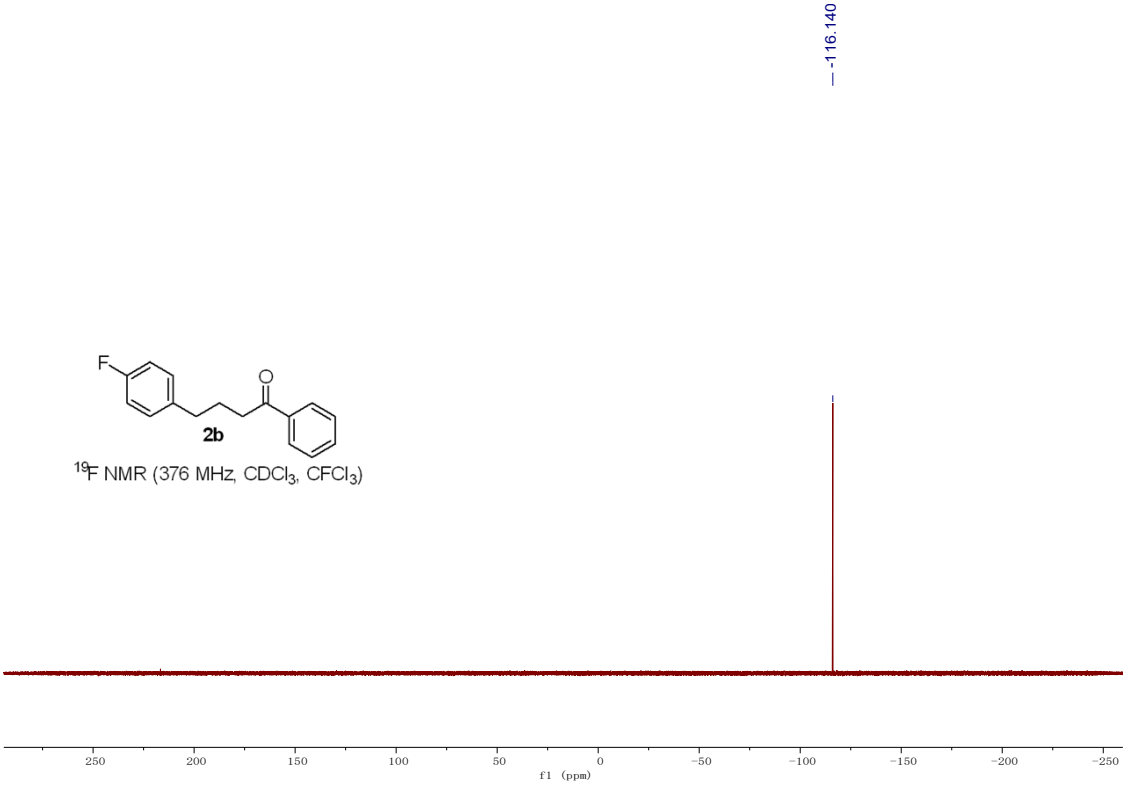
4-(4-fluorophenyl)-1-phenylbutan-1-one (2b)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[13] A colorless oil. 47.5 mg, 98% yield. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 2.02-2.09 (m, 2H), 2.69 (t, *J* = 7.2 Hz, 2H), 2.97 (t, *J* = 7.2 Hz, 2H), 6.97 (t, *J* = 8.4 Hz, 2H), 7.14-7.17 (m, 2H), 7.45 (t, *J* = 7.6 Hz, 2H), 7.55 (t, *J* = 7.2 Hz, 1H), 7.91-7.93 (m, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 27.5, 36.0, 39.2, 116.8 (d, *J* = 21.0 Hz), 129.7, 130.3, 131.5 (d, *J* = 7.6 Hz), 134.7, 138.6, 139.0 (d, *J* = 3.2 Hz), 163.0 (d, *J* = 243.4 Hz), 201.7. ^{19}F NMR ($CDCl_3$, $CFCl_3$, 376 MHz) δ -116.1.

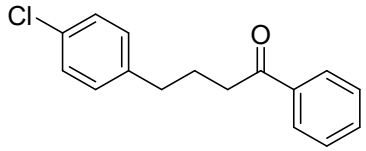




^{13}C NMR ($CDCl_3$, 100 MHz, TMS)

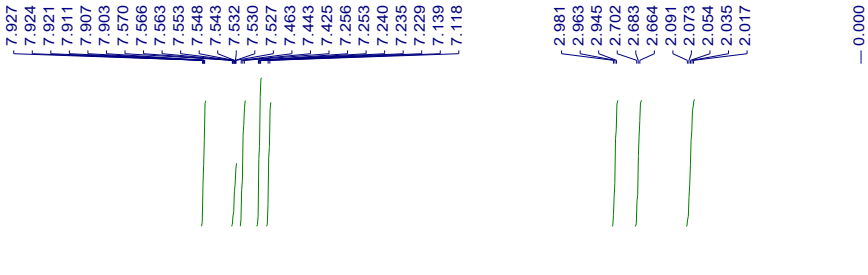


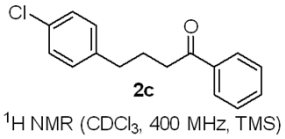
^{19}F NMR (376 MHz, $CDCl_3$, $CFCl_3$)



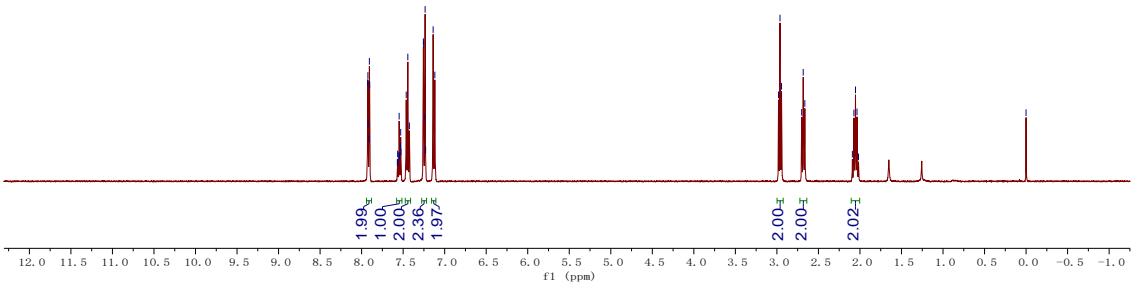
4-(4-chlorophenyl)-1-phenylbutan-1-one (2c)

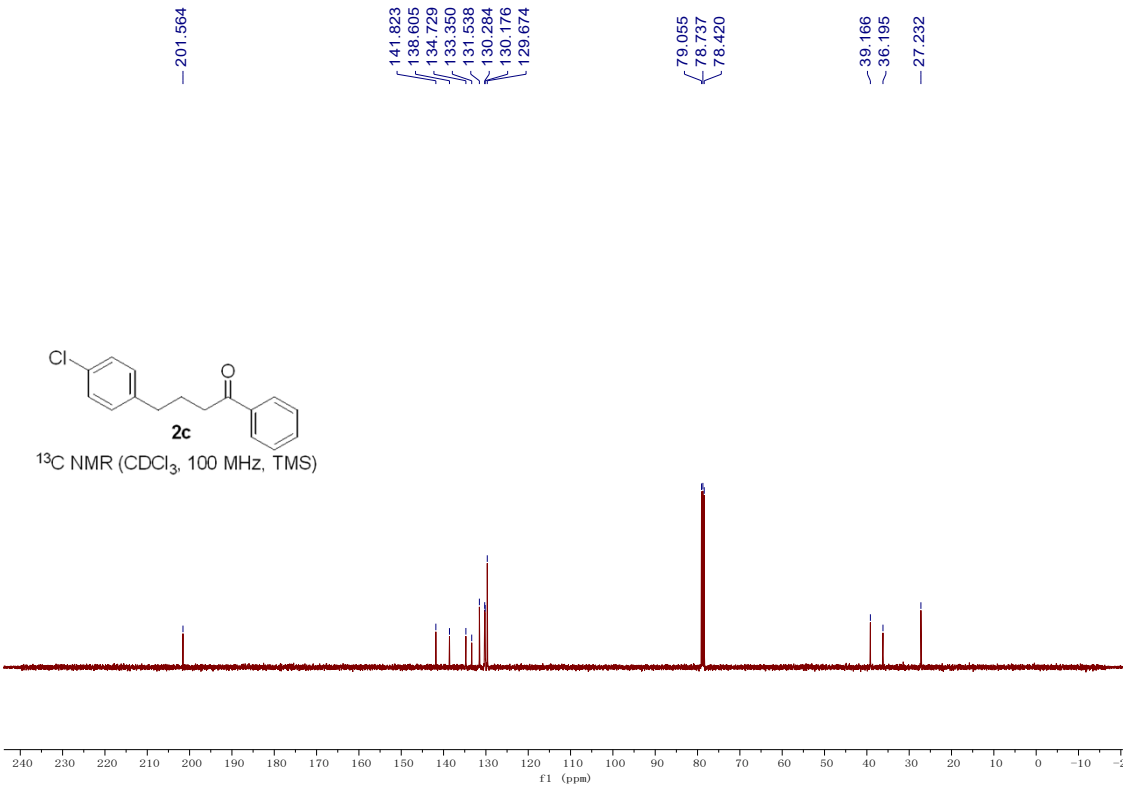
This is a known compound and its spectroscopic data are consistent with those in the previous literature.[14] A colorless oil. 50.2 mg, 97% yield. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 2.02-2.09 (m, 2H), 2.68 (t, J = 7.6 Hz, 2H), 2.96 (t, J = 7.2 Hz, 2H), 7.13 (t, J = 8.2 Hz, 2H), 7.23-7.26 (m, 2H), 7.44 (t, J = 7.6 Hz, 2H), 7.55 (tt, J_1 = 7.2 Hz, J_2 = 1.6 Hz, 1H), 7.90-7.93 (m, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 27.2, 36.2, 39.2, 129.7, 130.2, 130.3, 131.5, 133.4, 134.7, 138.6, 141.8, 201.6.

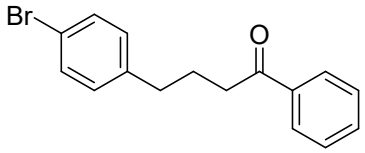




^{1}H NMR ($CDCl_3$, 400 MHz, TMS)

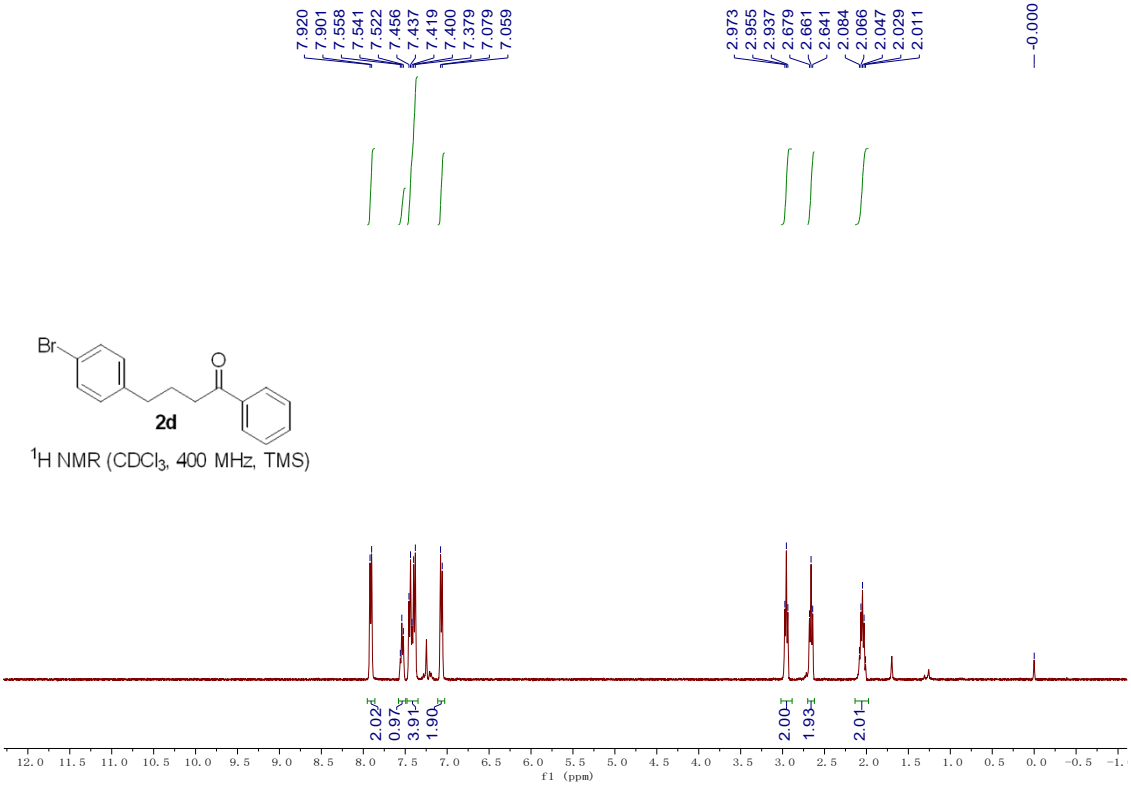


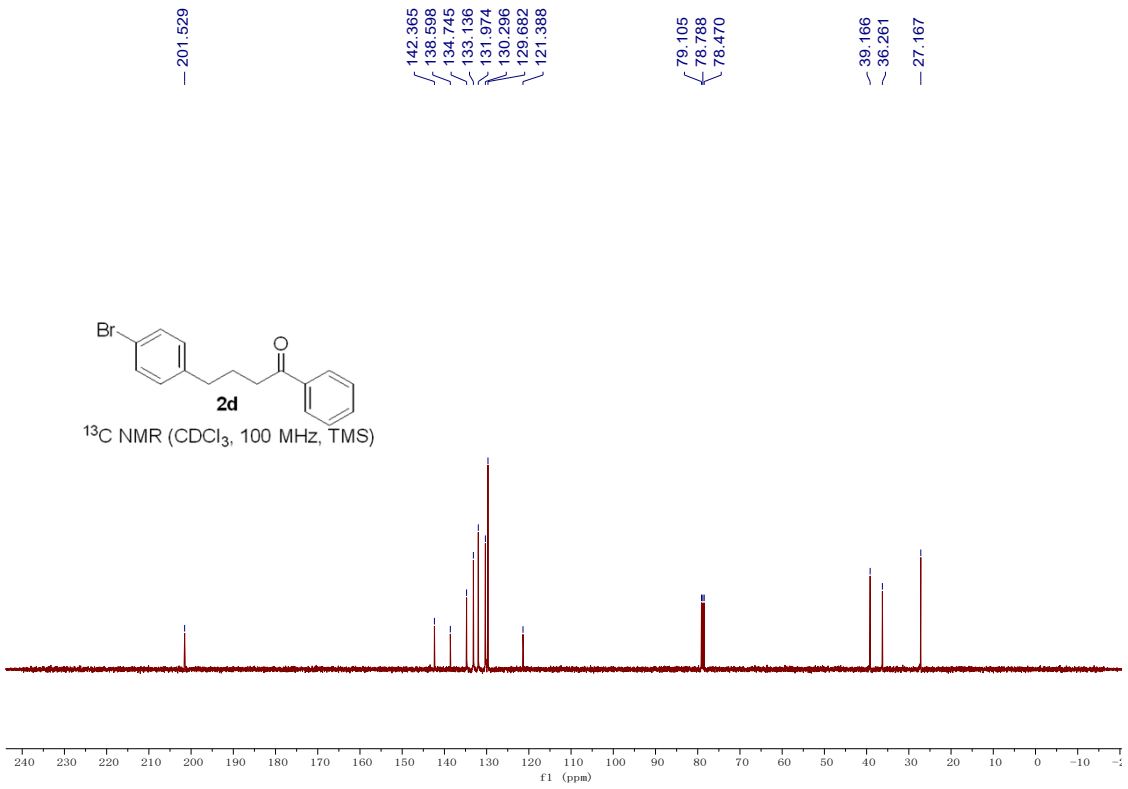

201.564
141.823
138.605
134.729
133.350
131.538
130.284
130.176
129.674
79.055
78.737
78.420
39.166
36.195
27.232
Cl
O
2c
13C NMR (CDCl3, 100 MHz, TMS)
240 230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

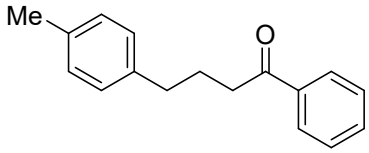


4-(4-bromophenyl)-1-phenylbutan-1-one (2d)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[15] A colorless oil. 58.2 mg, 96% yield. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 2.01-2.08 (m, 2H), 2.66 (t, *J* = 7.6 Hz, 2H), 2.96 (t, *J* = 7.2 Hz, 2H), 7.07 (d, *J* = 8.0 Hz, 2H), 7.38-7.46 (m, 4H), 7.54 (t, *J* = 7.2 Hz, 1H), 7.91 (t, *J* = 7.6 Hz, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 27.2, 36.3, 39.2, 121.4, 129.7, 130.3, 132.0, 133.1, 134.7, 138.6, 142.4, 201.5.

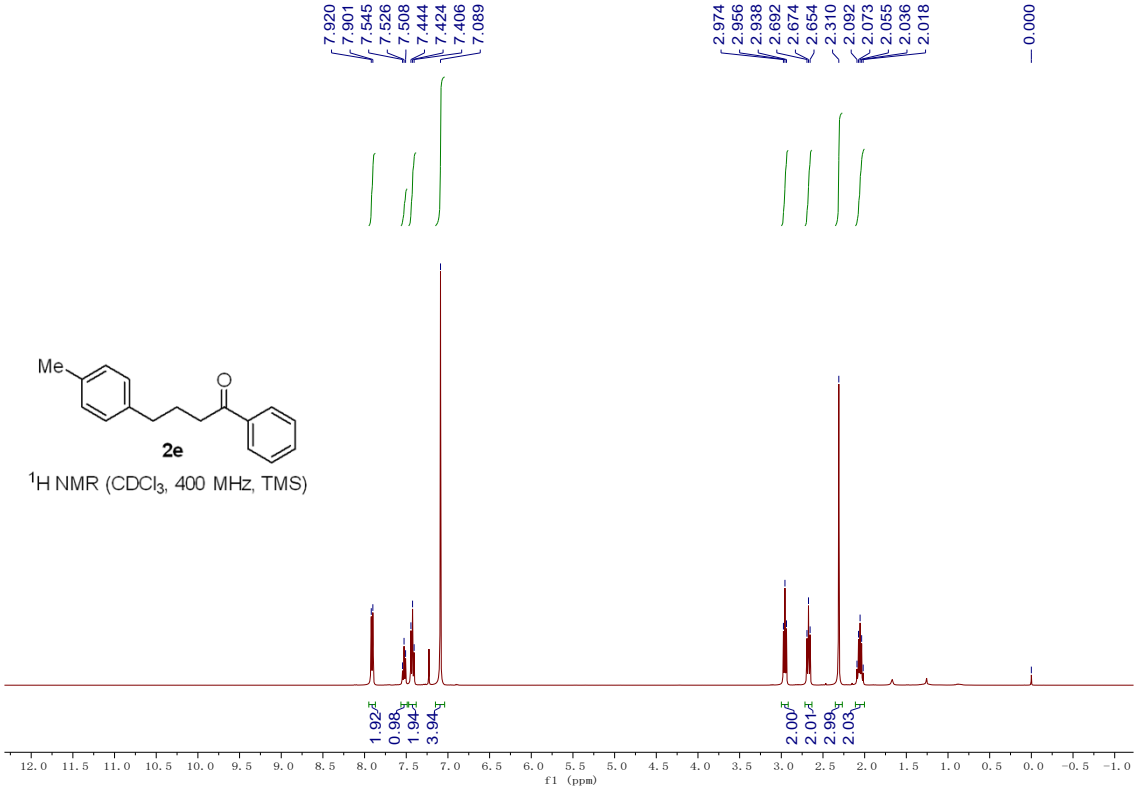


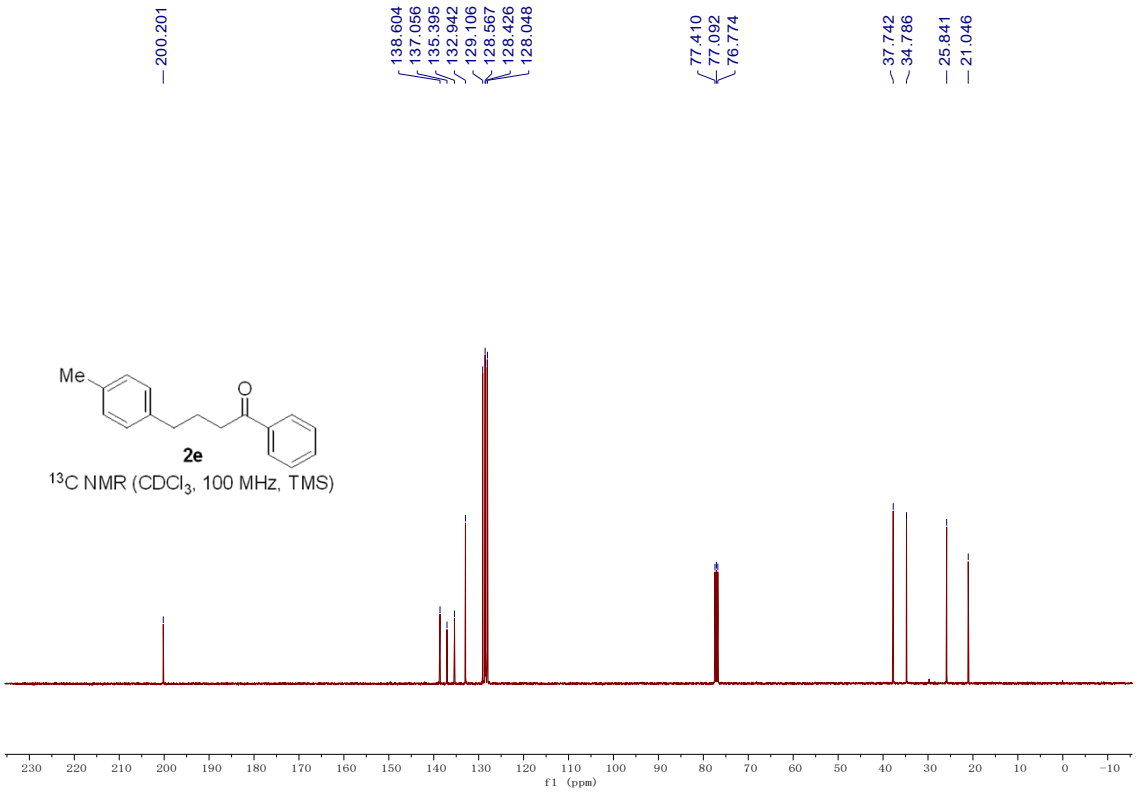

201.529
142.365
138.598
134.745
133.136
131.974
130.296
129.682
121.388
79.105
78.788
78.470
39.166
36.261
27.167
Br
O
2d
13C NMR (CDCl3, 100 MHz, TMS)
f1 (ppm)

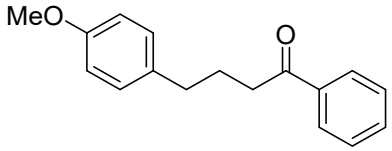


1-phenyl-4-(p-tolyl)butan-1-one (2e)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[14] A colorless oil. 42.9 mg, 90% yield. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 2.02-2.09 (m, 2H), 2.31 (s, 3H), 2.67 (t, *J* = 7.6 Hz, 2H), 2.96 (t, *J* = 7.2 Hz, 2H), 7.09 (s, 4H), 7.42 (t, *J* = 7.6 Hz, 2H), 7.53 (t, *J* = 7.2 Hz, 1H), 7.91 (t, *J* = 7.6 Hz, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 21.0, 25.8, 34.8, 37.7, 128.0, 128.4, 128.6, 129.1, 132.9, 135.4, 137.1, 138.6, 200.2.

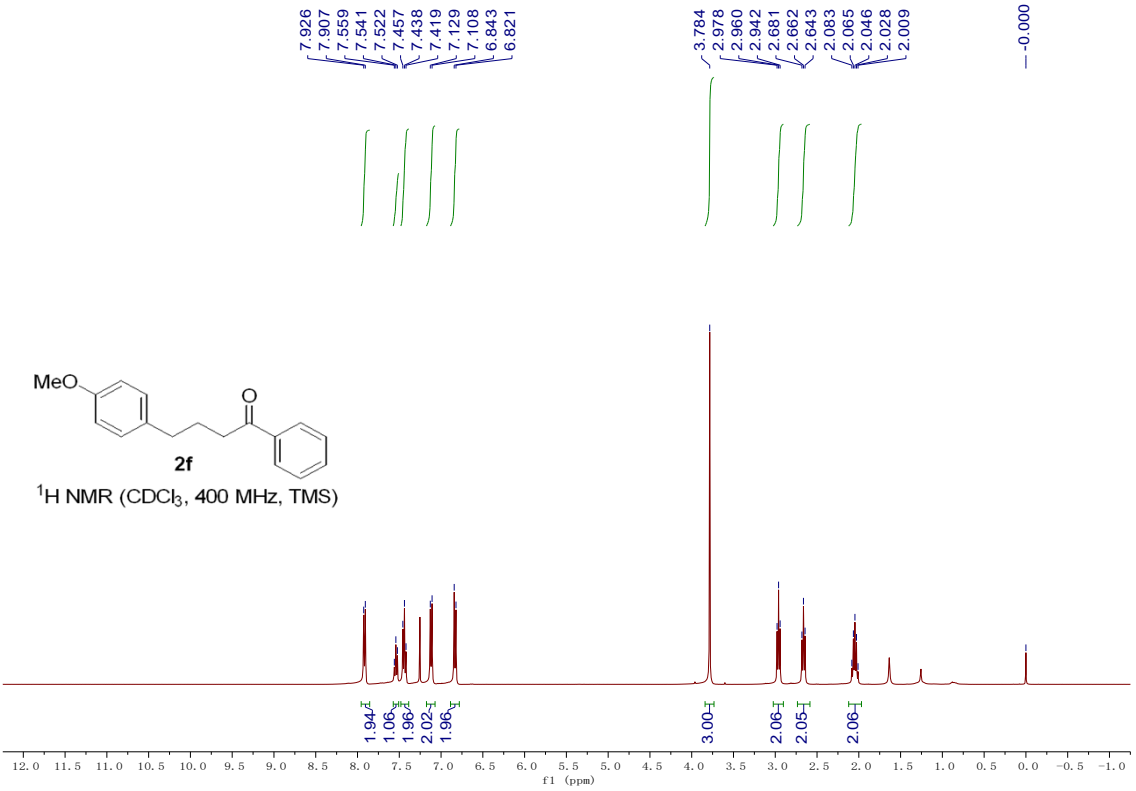


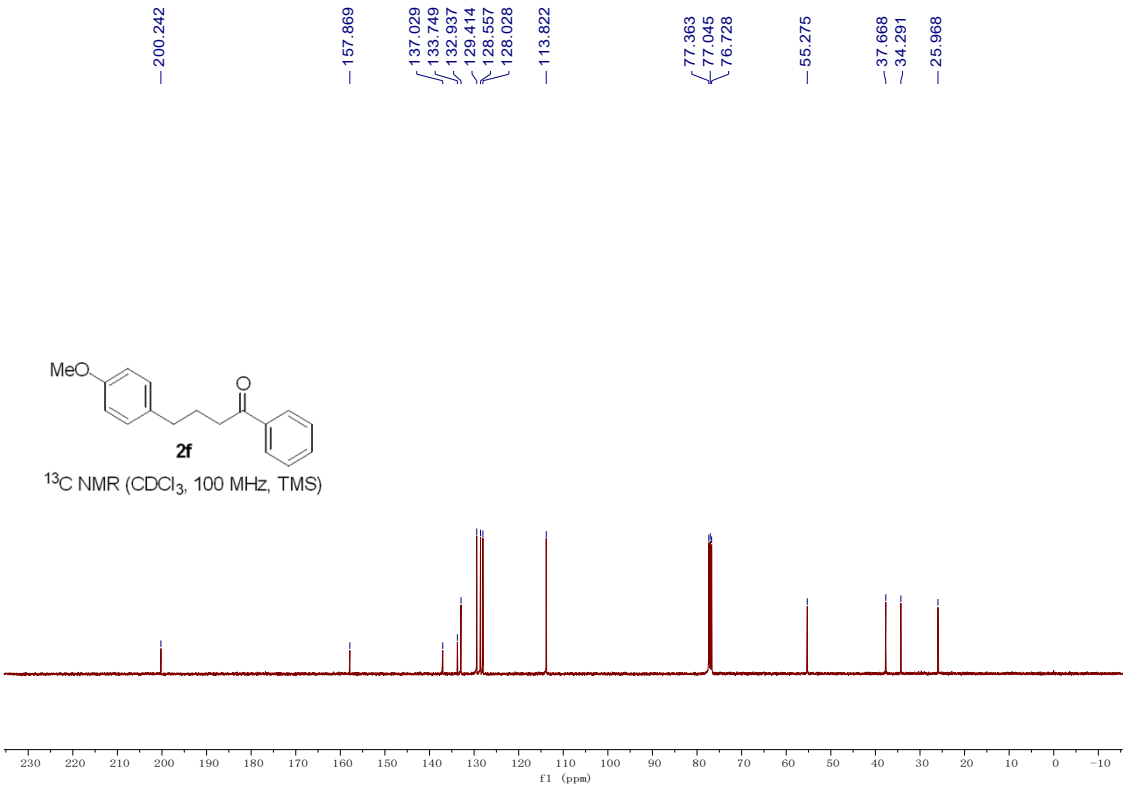

200.201
138.604
137.056
135.395
132.942
129.106
128.567
128.426
128.048
77.410
77.092
76.774
37.742
34.786
25.841
21.046
Me
O
2e
13C NMR (CDCl3, 100 MHz, TMS)
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

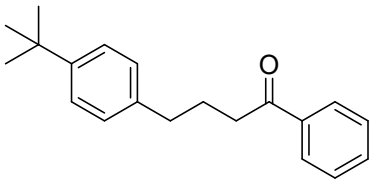


4-(4-methoxyphenyl)-1-phenylbutan-1-one (2f)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[14] A colorless oil. 38.1 mg, 75% yield. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 2.01-2.08 (m, 2H), 2.66 (t, J = 7.6 Hz, 2H), 2.96 (t, J = 7.2 Hz, 2H), 3.78 (s, 3H), 6.83 (d, J = 8.6 Hz, 2H), 7.12 (d, J = 8.4 Hz, 2H), 7.44 (t, J = 7.6 Hz, 2H), 7.54 (t, J = 7.4 Hz, 1H), 7.92 (t, J = 7.6 Hz, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 26.0, 34.3, 37.7, 55.3, 113.8, 128.0, 128.6, 129.4, 132.9, 133.7, 137.0, 157.9, 200.2.

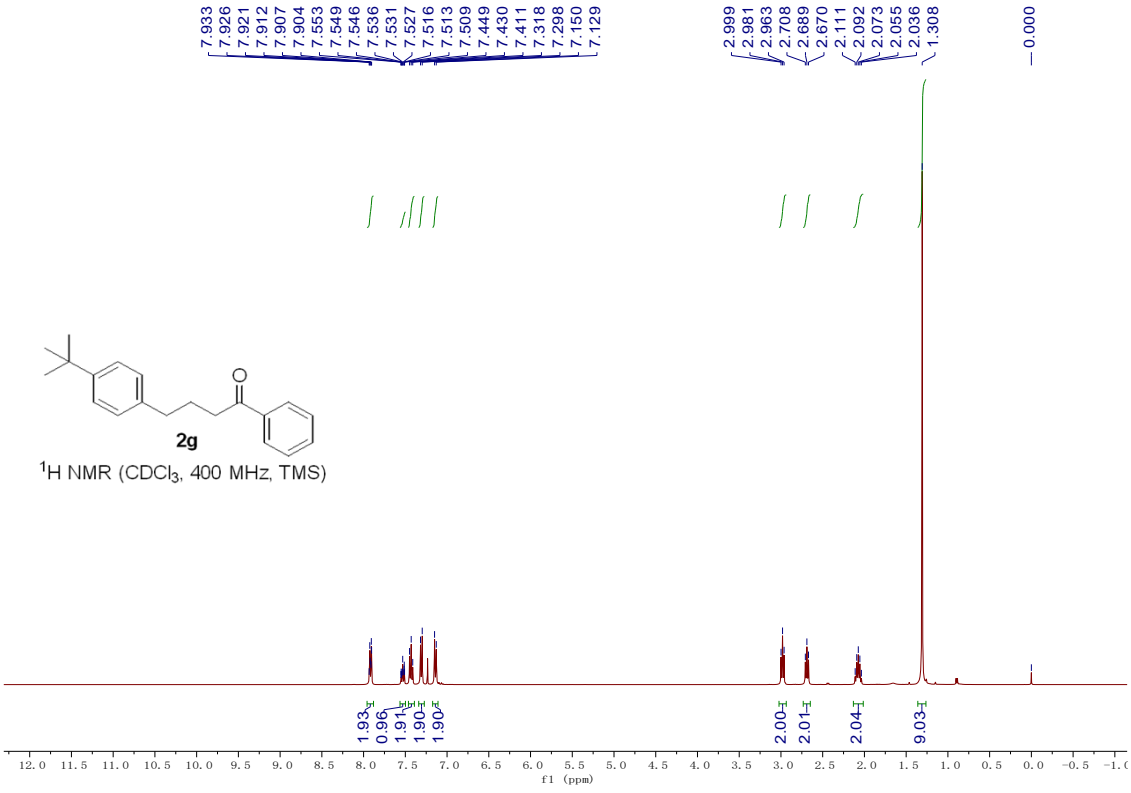


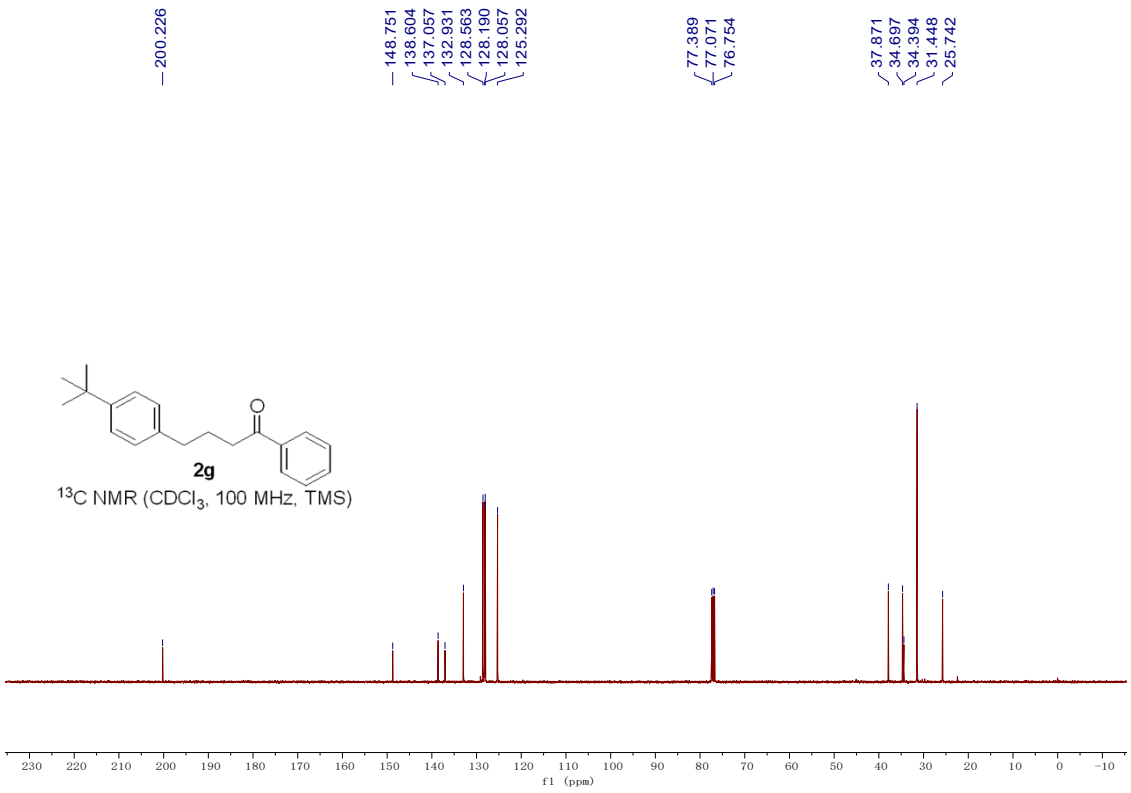

200.242
157.869
137.029
133.749
132.937
129.414
128.557
128.028
113.822
77.363
77.045
76.728
55.275
37.668
34.291
25.968
MeO
O
2f
13C NMR (CDCl3, 100 MHz, TMS)
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

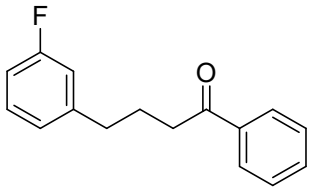


4-(4-(tert-butyl)phenyl)-1-phenylbutan-1-one (2g)

A colorless oil. 44.9 mg, 80% yield. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 1.31 (s, 9H), 2.04-2.11 (m, 2H), 2.69 (t, J = 7.6 Hz, 2H), 2.98 (t, J = 7.2 Hz, 2H), 7.14 (d, J = 8.2 Hz, 2H), 7.31 (d, J = 8.2 Hz, 2H), 7.43 (t, J = 7.6 Hz, 2H), 7.53 (tt, J_1 = 7.4 Hz, J_2 = 1.6 Hz,1H), 7.90-7.93 (m, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 25.7, 31.4, 34.4, 34.7, 37.9, 125.3, 128.1, 128.2, 128.6, 132.9, 137.1, 138.6, 148.8, 200.2. IR (EtOH) $\tilde{\nu}$ 2959, 2866, 1683, 1448, 1363, 1266, 1225, 1199, 1001, 833, 745, 689 cm^{-1}. HRMS (EI) calcd. for $C_{16}H_{15}ClO$ (M^+): 280.1827, Found: 280.1824.

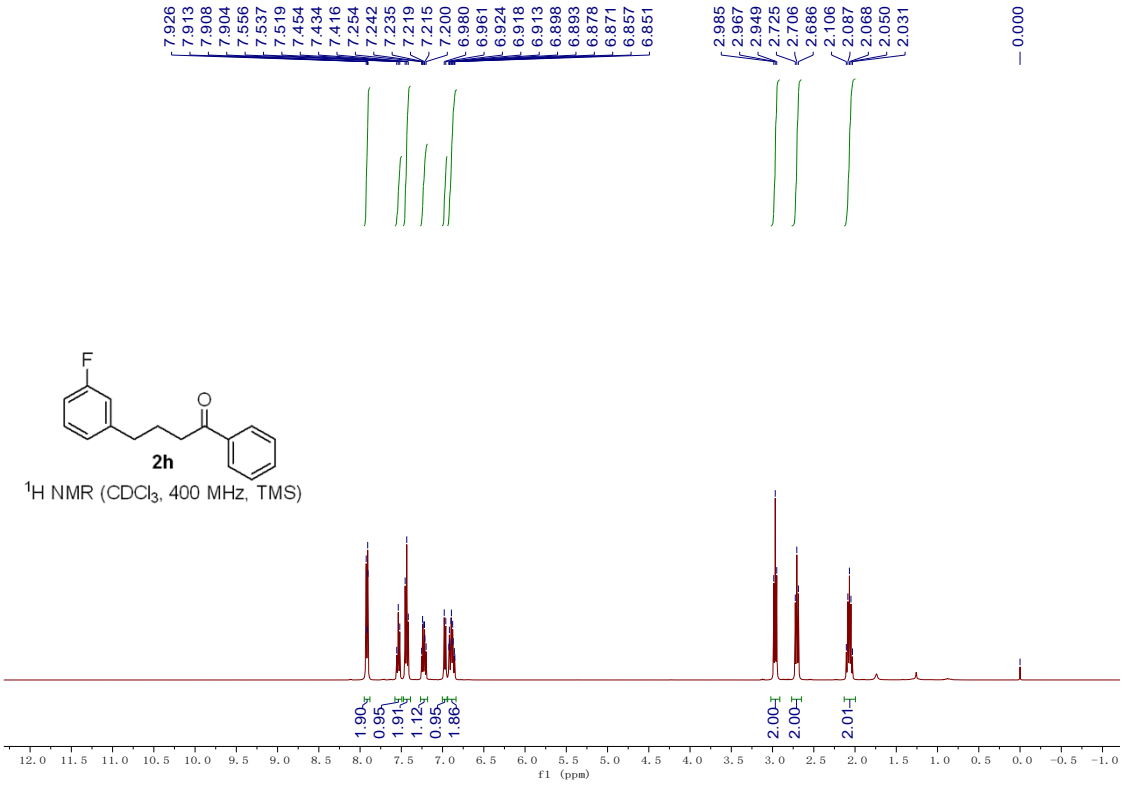


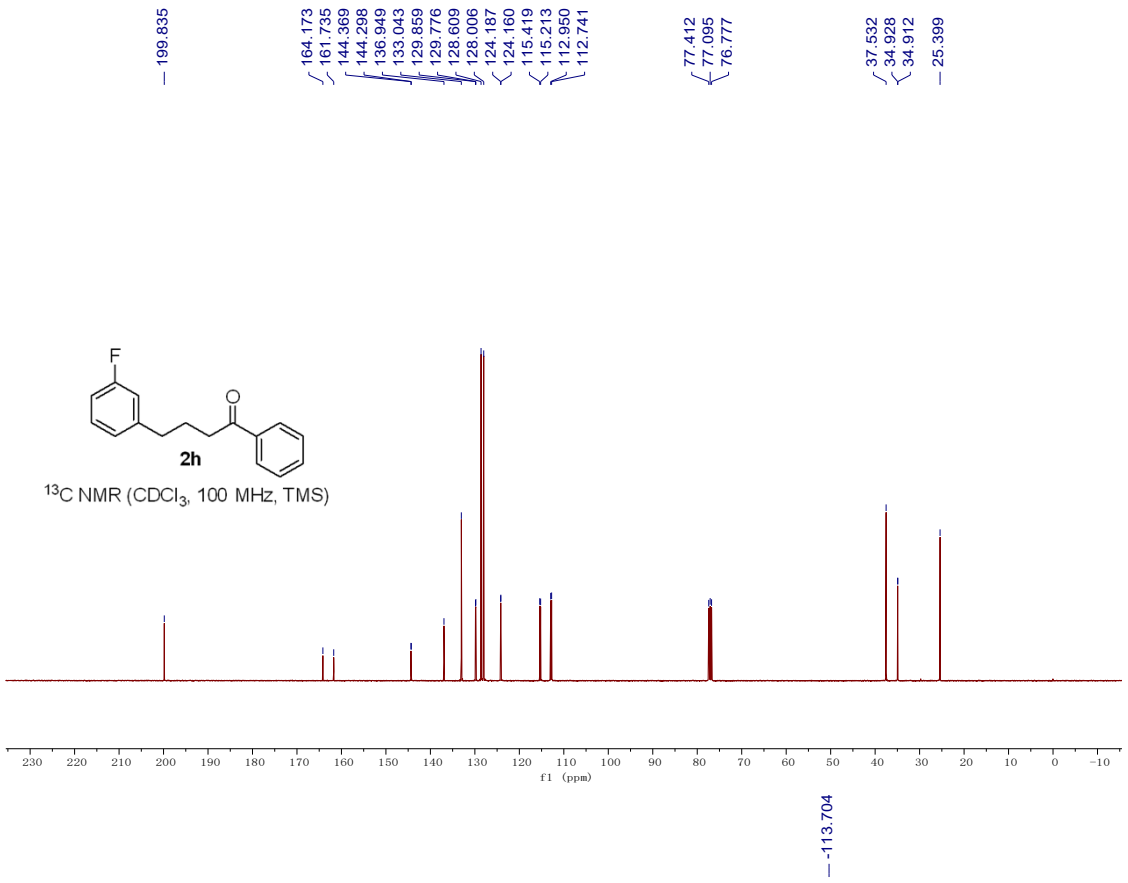

200.226
148.751
138.604
137.057
132.931
128.563
128.190
128.057
125.292
77.389
77.071
76.754
37.871
34.697
34.394
31.448
25.742
2g
13C NMR (CDCl3, 100 MHz, TMS)
f1 (ppm)



4-(3-fluorophenyl)-1-phenylbutan-1-one (2h)

A colorless oil. 45.6 mg, 94% yield. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 2.03-2.11 (m, 2H), 2.71 (t, *J* = 7.6 Hz, 2H), 2.97 (t, *J* = 7.2 Hz, 2H), 6.85-6.92 (m, 2H), 6.97 (d, *J* = 7.6 Hz, 1H), 7.20-7.25 (m, 1H), 7.43 (d, *J* = 7.6 Hz, 2H), 7.54 (t, *J* = 7.4 Hz, 1H), 7.90-7.93 (m,2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 25.4, 34.9 (d, *J* = 1.6 Hz), 37.5, 112.9 (d, *J* = 21.0 Hz), 115.3 (d, *J* = 20.8 Hz), 124.2 (d, *J* = 2.7 Hz), 128.0, 128.6, 129.8 (d, *J* = 8.3 Hz), 133.0, 136.9, 144.3 (d, *J* = 7.1 Hz), 162.9 (d, *J* = 245.3 Hz), 199.8. ^{19}F NMR ($CDCl_3$, $CFCl_3$, 376 MHz) δ -113.7. IR (EtOH) $\tilde{\nu}$ 2935, 1682, 1587, 1486, 1448, 1264, 1225, 1138, 782, 733, 689 cm^{-1}. HRMS (EI) calcd. for $C_{16}H_{15}FO$ (M^+): 242.1107, Found: 242.1102.




199.835
164.173
161.735
144.369
144.298
136.949
133.043
129.859
129.776
128.609
128.006
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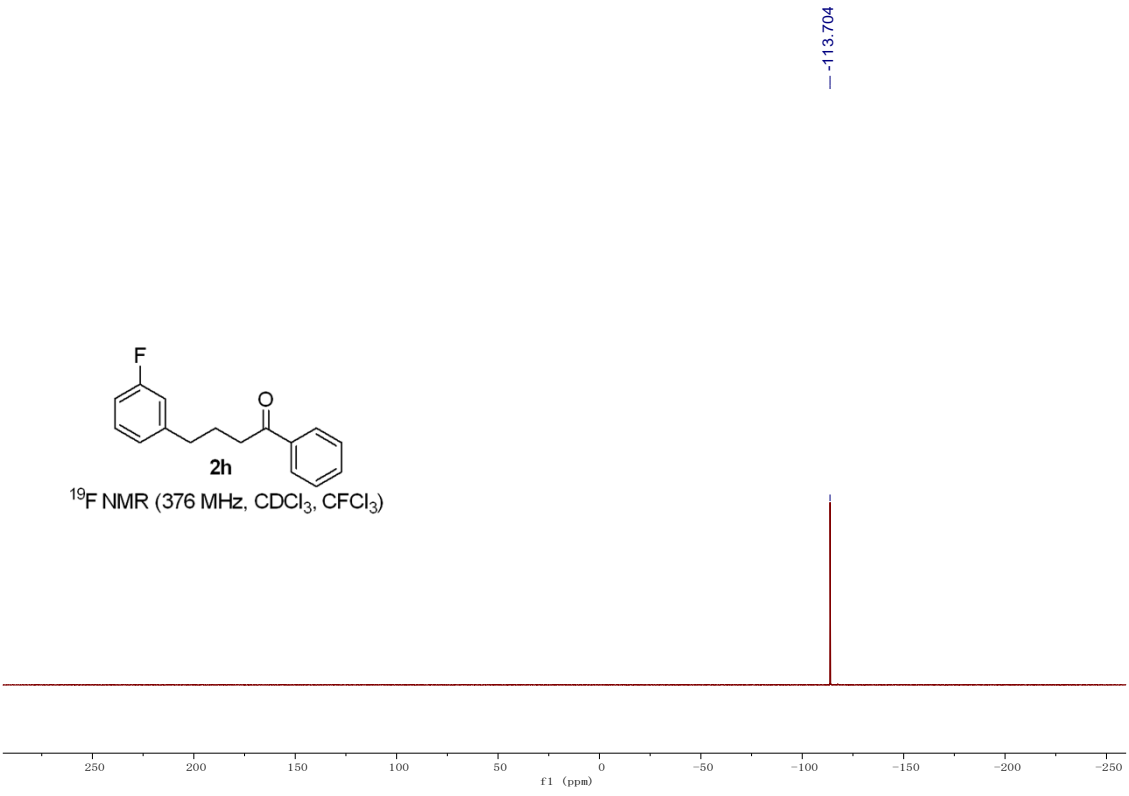
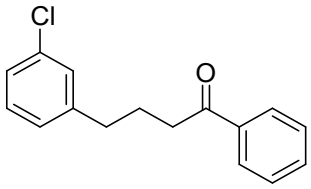
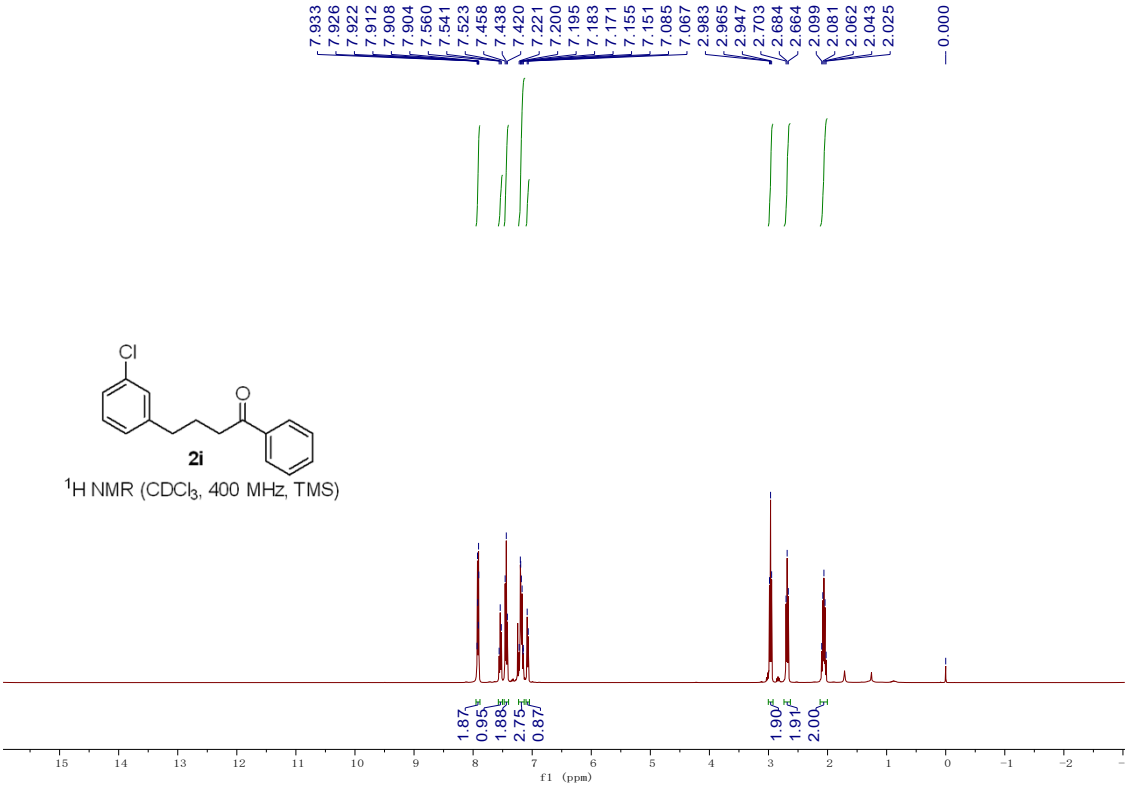
124.160
115.419
115.213
112.950
112.741
77.412
77.095
76.777
37.532
34.928
34.912
25.399
F
O
2h
13C NMR (CDCl3, 100 MHz, TMS)
f1 (ppm)

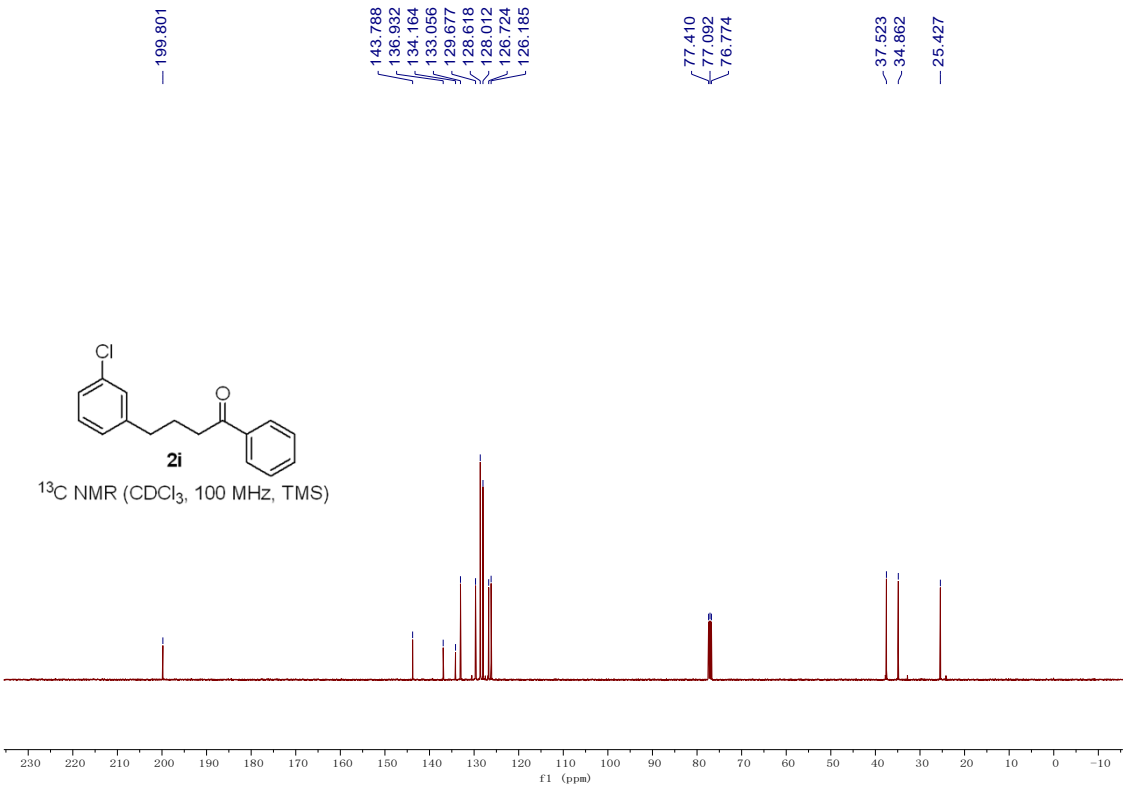

-113.704
F
O
2h
19F NMR (376 MHz, CDCl3, CFCl3)
f1 (ppm)

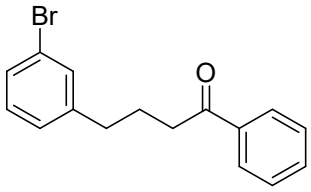


4-(3-chlorophenyl)-1-phenylbutan-1-one (2i)

A colorless oil. 46.1 mg, 89% yield.^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 2.03-2.10 (m, 2H), 2.68 (t, J = 7.6 Hz, 2H), 2.96 (t, J = 7.2 Hz, 2H), 7.08 (d, J = 7.2 Hz, 1H), 7.15-7.22 (m, 3H), 7.44 (t, J = 7.6 Hz, 2H), 7.54 (t, J = 7.4 Hz, 1H), 7.90-7.93 (m, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 25.4, 34.9, 37.5, 126.2, 126.7, 128.0, 128.6, 129.7, 133.1, 134.2, 136.9, 143.8, 199.8. IR (EtOH) $\tilde{\nu}$ 3059, 2928, 2860, 1683, 1597, 1573, 1475, 1447, 1367, 1225, 1201, 1000, 780, 752, 689 cm^{-1}. HRMS (EI) calcd. for $C_{16}H_{15}ClO$ (M^+): 258.0811, Found: 258.0808.

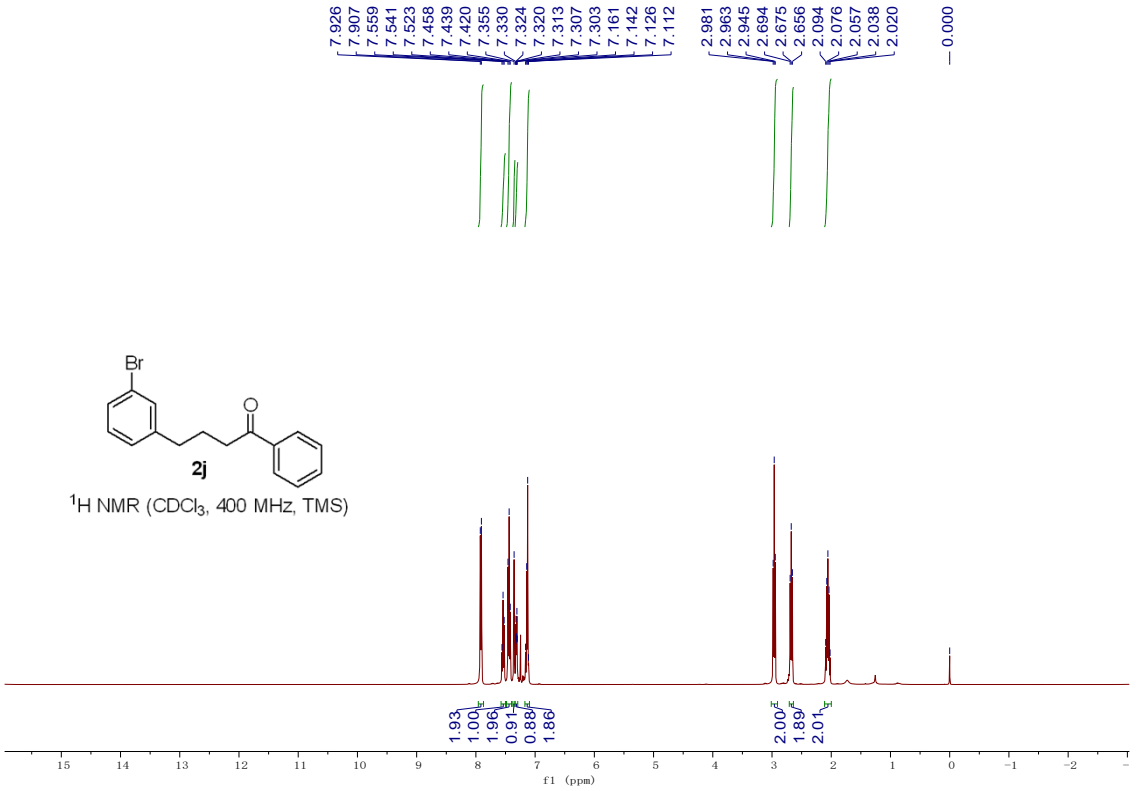


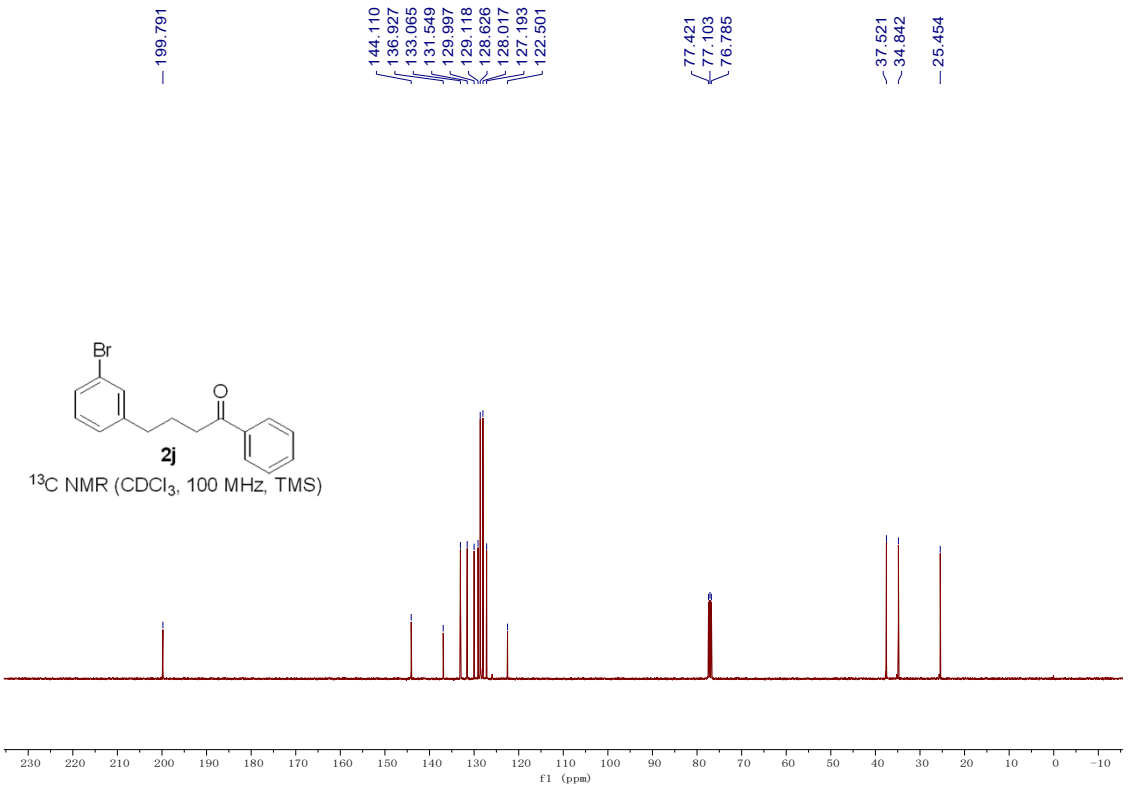

199.801
143.788
136.932
134.164
133.056
129.677
128.618
128.012
126.724
126.185
77.410
77.092
76.774
37.523
34.862
25.427
Cl
O
2i
13C NMR (CDCl3, 100 MHz, TMS)
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

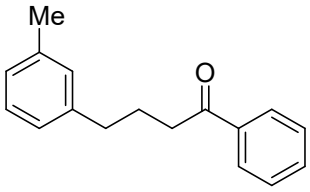


4-(3-bromophenyl)-1-phenylbutan-1-one (2j)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[16] A colorless oil. 55.8 mg, 92% yield. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 2.02-2.09 (m, 2H), 2.68 (t, J = 7.6 Hz, 2H), 2.96 (t, J = 7.2 Hz, 2H), 7.11-7.16 (m, 2H), 7.32 (dt, J_1 = 6.8 Hz, J_2 = 2.0 Hz, 1H), 7.35 (s, 1H), 7.44 (t, J = 7.6 Hz, 2H), 7.54 (t, J = 7.2 Hz, 1H), 7.92 (d, J = 7.4 Hz, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 25.5, 34.8, 37.5, 122.5, 127.2, 128.0, 128.6, 129.1, 130.0, 131.5, 133.1, 136.9, 144.1, 199.8.

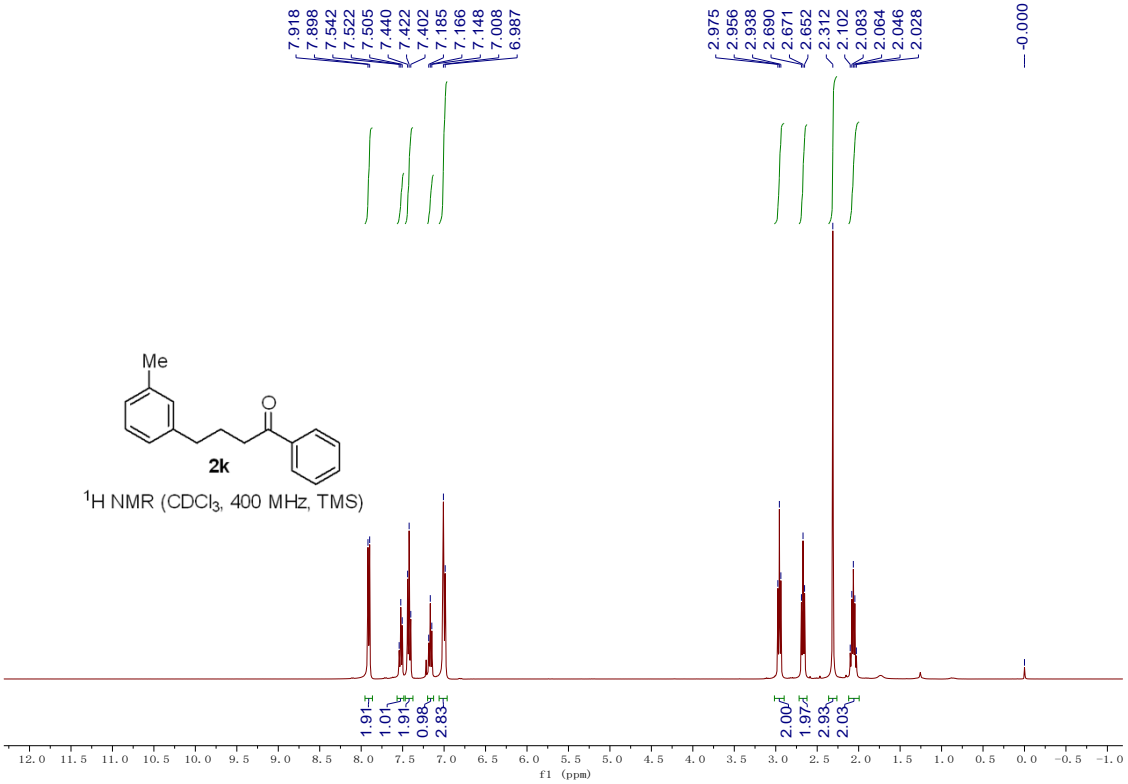


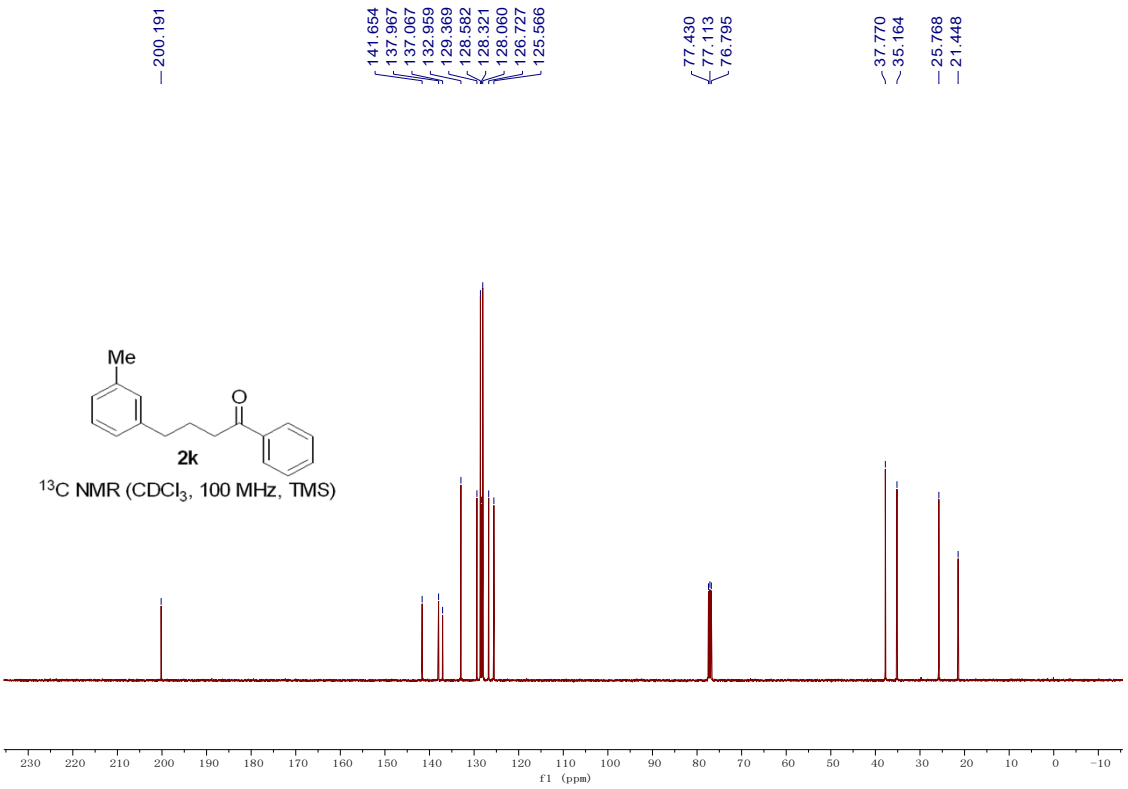

199.791
144.110
136.927
133.065
131.549
129.997
129.118
128.626
128.017
127.193
122.501
77.421
77.103
76.785
37.521
34.842
25.454
Br
O
2j
13C NMR (CDCl3, 100 MHz, TMS)
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

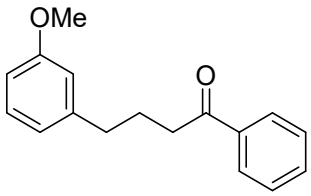


Phenyl-4-(m-tolyl)butan-1-one (2k)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[13] A colorless oil. 46.7 mg, 98% yield. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 2.03-2.10 (m, 2H), 2.31 (s, 3H), 2.67 (t, *J* = 7.6 Hz, 2H), 2.96 (t, *J* = 7.2 Hz, 2H), 7.00 (d, *J* = 8.6 Hz, 3H), 7.17 (t, *J* = 7.4 Hz, 1H), 7.42 (t, *J* = 7.6 Hz, 2H), 7.52 (t, *J* = 7.2 Hz, 1H), 7.91 (d, *J* = 8.2 Hz, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 21.4, 25.8, 35.2, 37.8, 125.6, 126.7, 128.1, 128.3, 128.6, 129.4, 133.0, 137.1, 138.0, 141.7, 200.2.

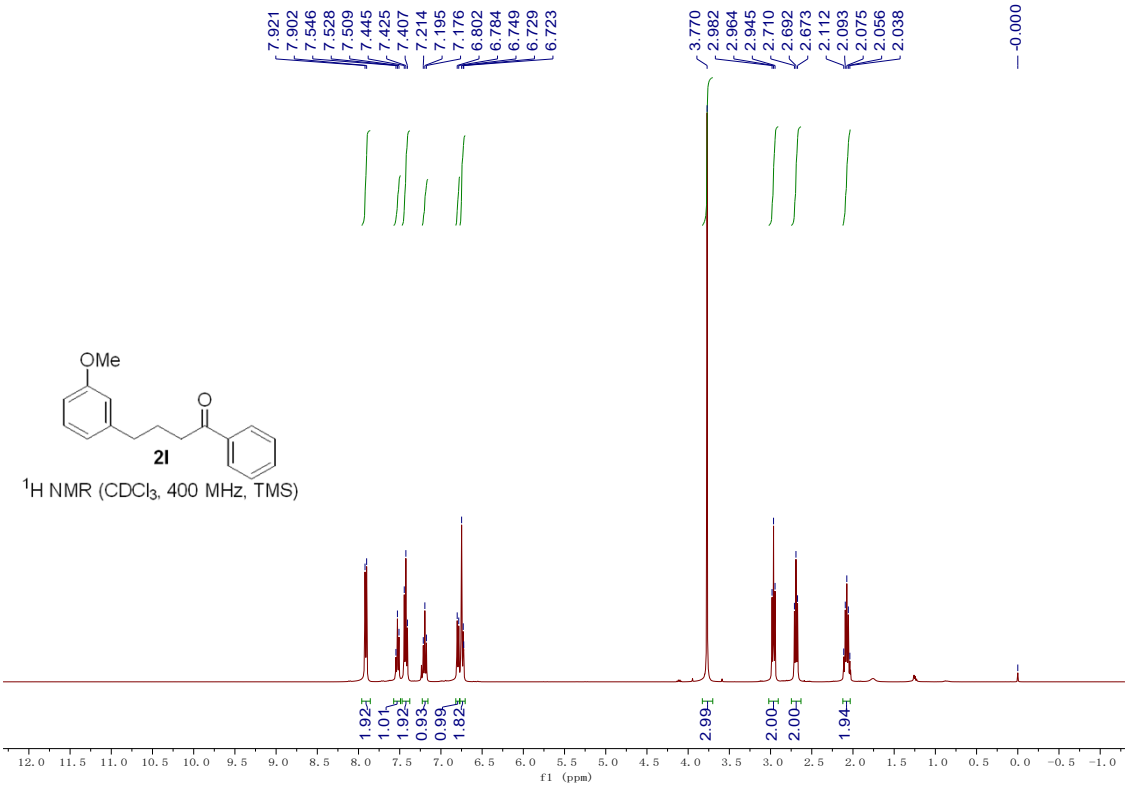


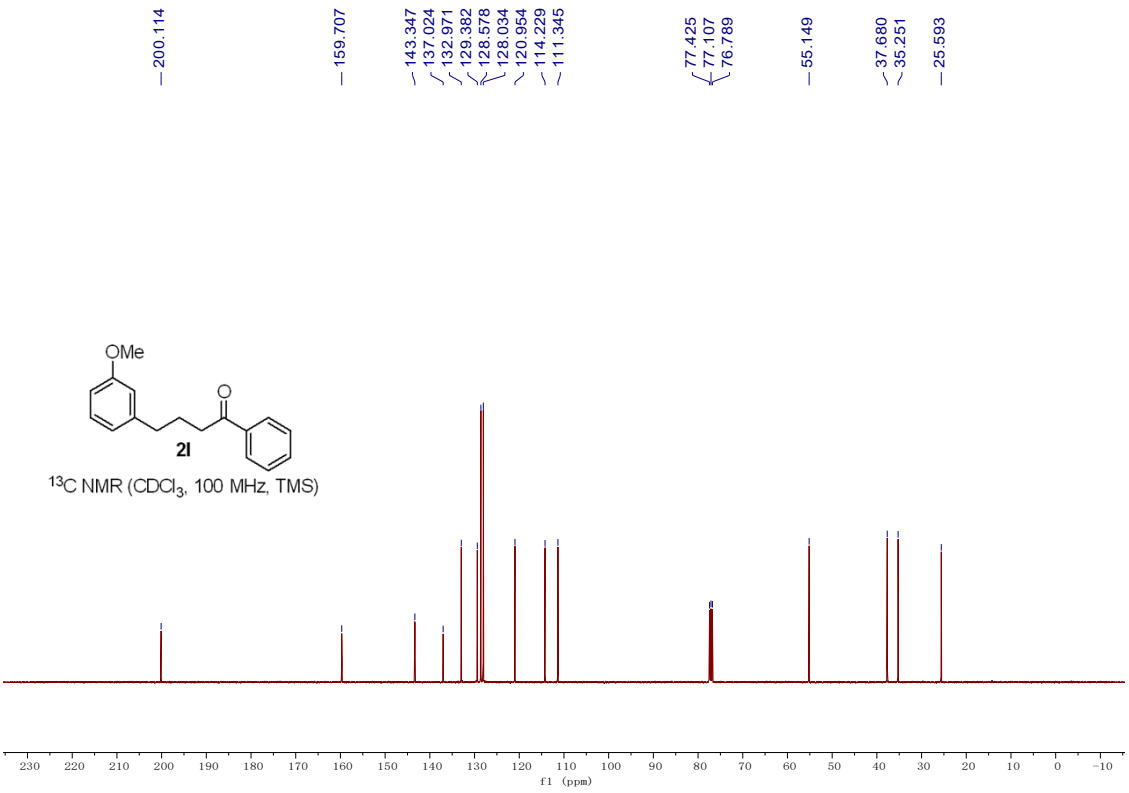

200.191
141.654
137.967
137.067
132.959
129.369
128.582
128.321
128.060
126.727
125.566
77.430
77.113
76.795
37.770
35.164
25.768
21.448
Me
O
2k
13C NMR (CDCl3, 100 MHz, TMS)
f1 (ppm)

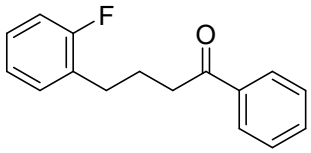


4-(3-methoxyphenyl)-1-phenylbutan-1-one (2l)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[2] A colorless oil. 48.3 mg, 95% yield. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 2.04-2.11 (m, 2H), 2.69 (t, *J* = 7.6 Hz, 2H), 2.96 (t, *J* = 7.2 Hz, 2H), 3.77 (s, 3H), 6.72-6.75 (m, 2H), 6.79 (d, *J* = 7.2 Hz, 1H), 7.19 (t, *J* = 7.6 Hz, 1H), 7.43 (t, *J* = 7.8 Hz, 2H), 7.53 (t, *J* = 7.4 Hz, 1H), 7.91 (d, *J* = 7.8 Hz, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 25.6, 35.3, 37.7, 55.1, 111.3, 114.2, 121.0, 128.0, 128.6, 129.4, 133.0, 137.0, 143.3, 159.7, 200.1.

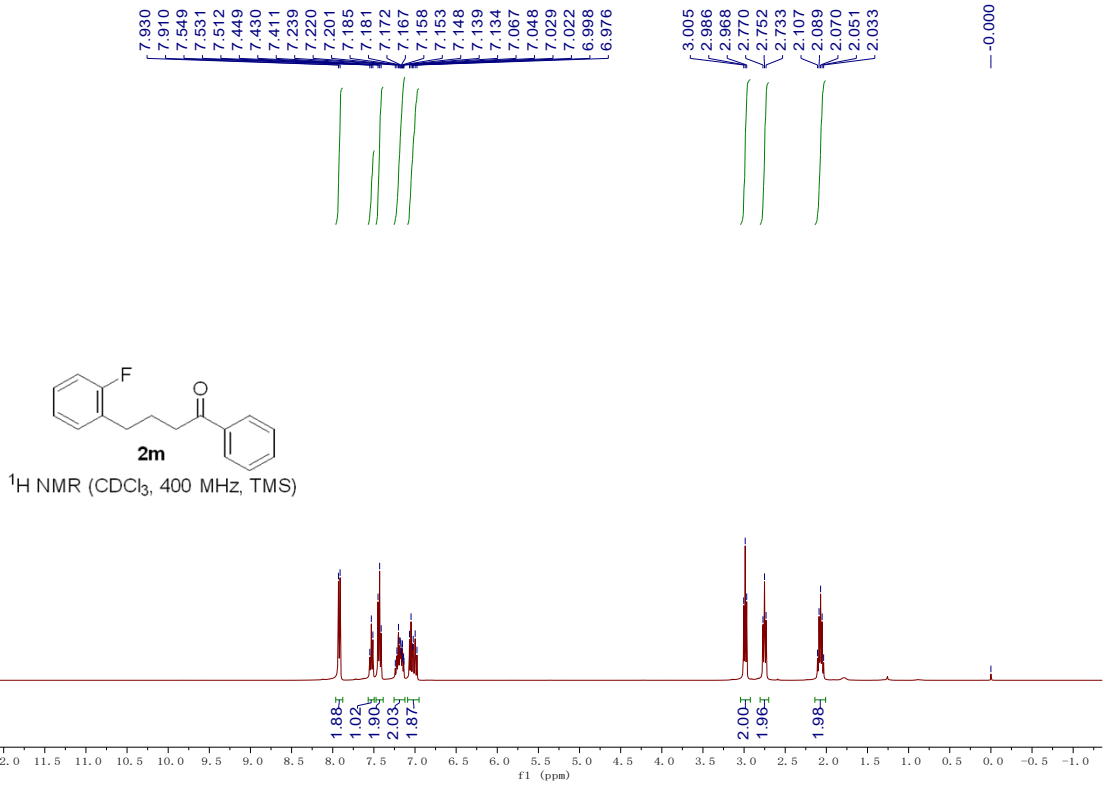


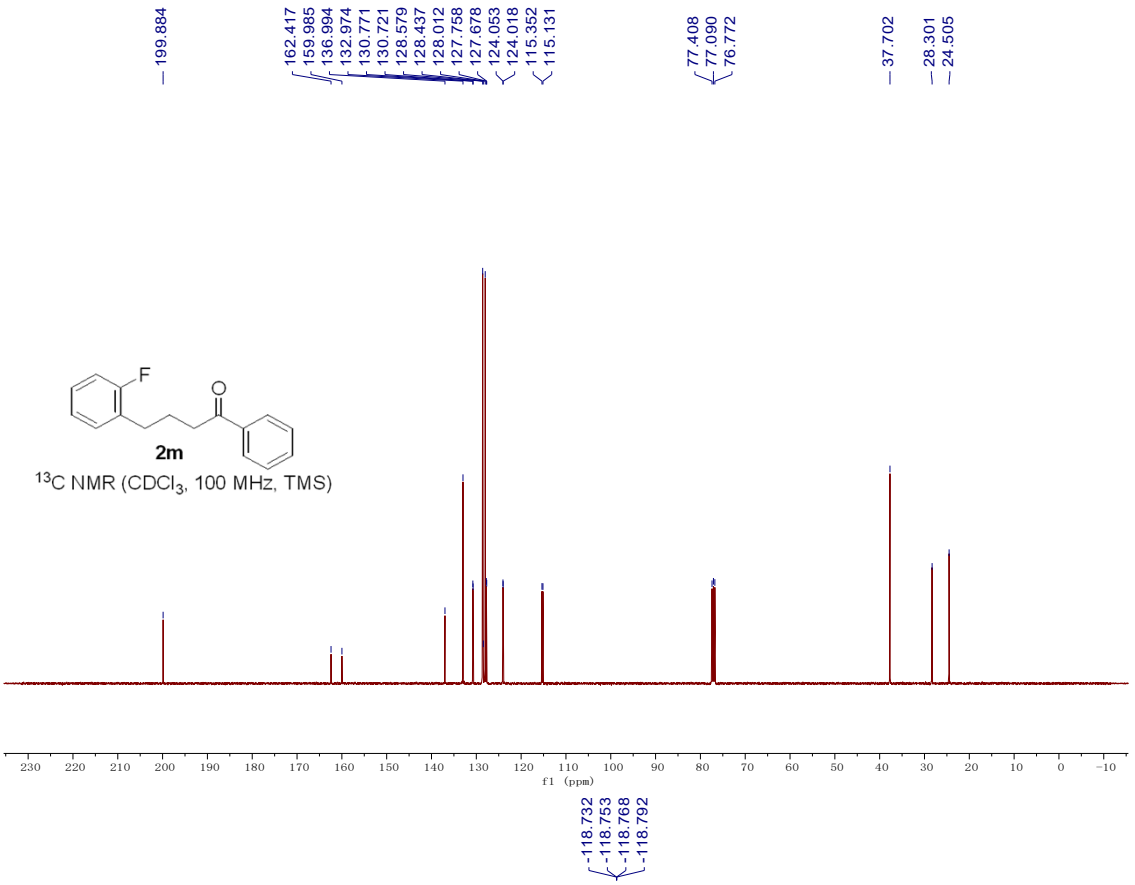

200.114
159.707
143.347
137.024
132.971
129.382
128.578
128.034
120.954
114.229
111.345
77.425
77.107
76.789
55.149
37.680
35.251
25.593
OMe
O
2l
13C NMR (CDCl3, 100 MHz, TMS)
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

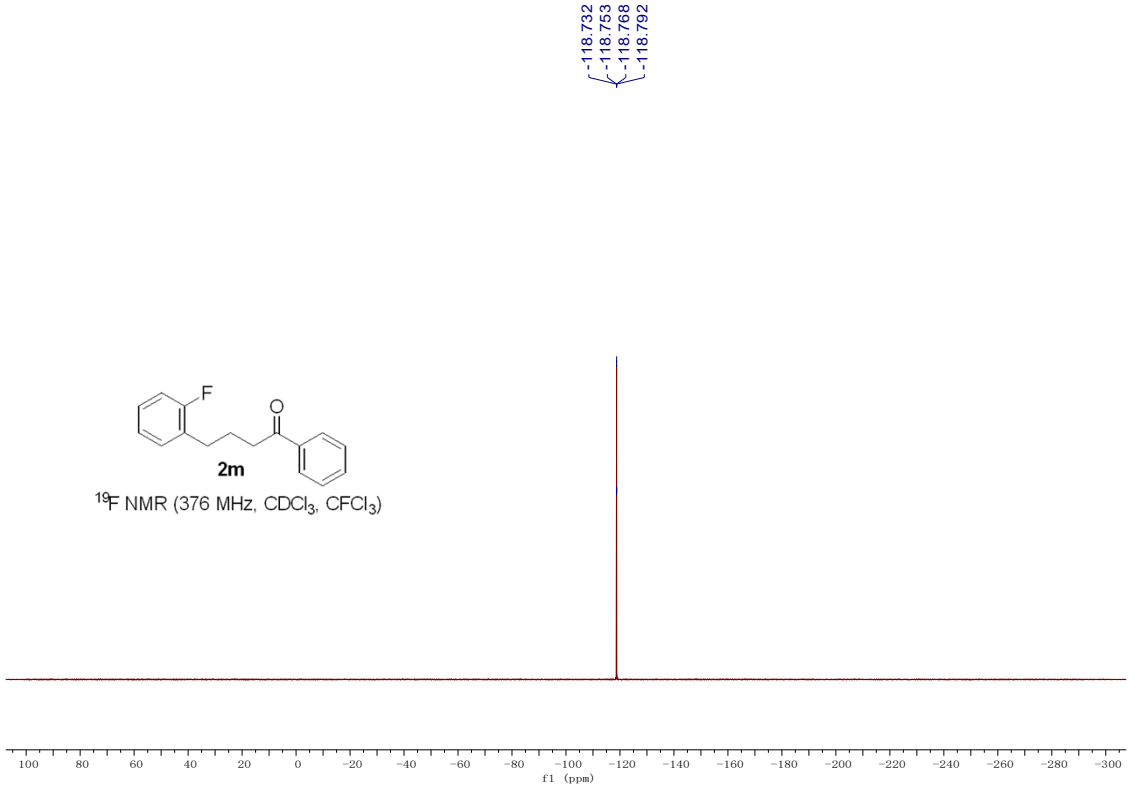


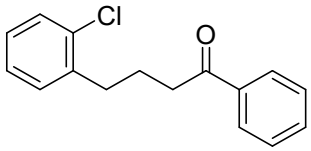
4-(2-fluorophenyl)-1-phenylbutan-1-one (2m)

A colorless oil. 47.5 mg, 98% yield.^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 2.03-2.11 (m, 2H), 2.75 (t, *J* = 7.6 Hz, 2H), 2.99 (t, *J* = 7.2 Hz, 2H), 6.98-7.07 (m, 2H), 7.13-7.24 (m, 2H), 7.43 (t, *J* = 7.6 Hz, 2H), 7.53 (t, *J* = 7.4 Hz, 1H), 7.92 (d, *J* = 7.8 Hz, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 24.5, 28.3, 37.7, 115.2 (d, *J* = 22.2 Hz), 124.0 (d, *J* = 3.5 Hz), 127.7 (d, *J* = 8.1 Hz), 128.0, 128.5 (d, *J* = 14.2 Hz), 128.6, 130.8 (d, *J* = 5.1 Hz), 133.0, 137.0, 161.2 (d, *J* = 244.6 Hz), 199.9. ^{19}F NMR ($CDCl_3$, $CFCl_3$, 376 MHz) δ -118.8. IR (Acetone) $\tilde{\nu}$ 3028, 2932, 2910, 1690, 1587, 1482, 1448, 1164, 1125, 1038, 772, 723, 679 cm^{-1}. HRMS (EI) calcd. for $C_{16}H_{15}FO$ (M^+): 242.1107, Found: 242.1101.



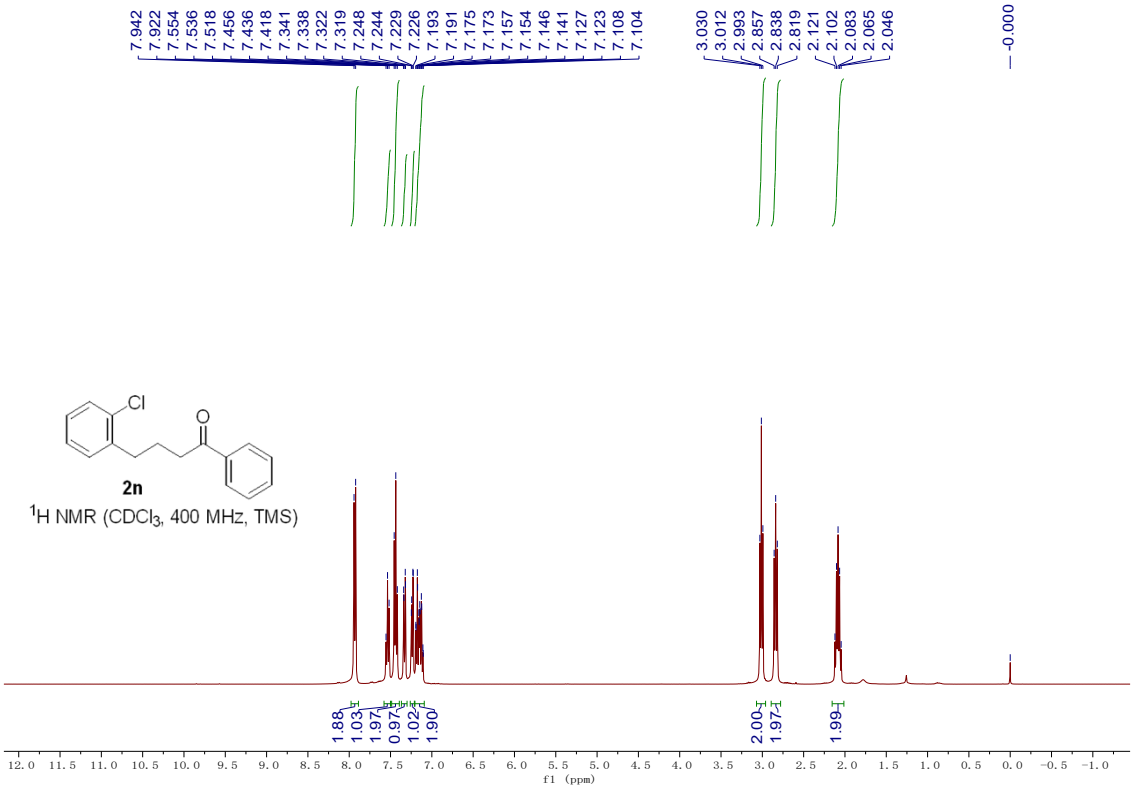

199.884
162.417
159.985
136.994
132.974
130.771
130.721
128.579
128.437
128.012
127.758
127.678
124.053
124.018
115.352
115.131
77.408
77.090
76.772
37.702
28.301
24.505
F
O
2m
13C NMR (CDCl3, 100 MHz, TMS)
f1 (ppm)

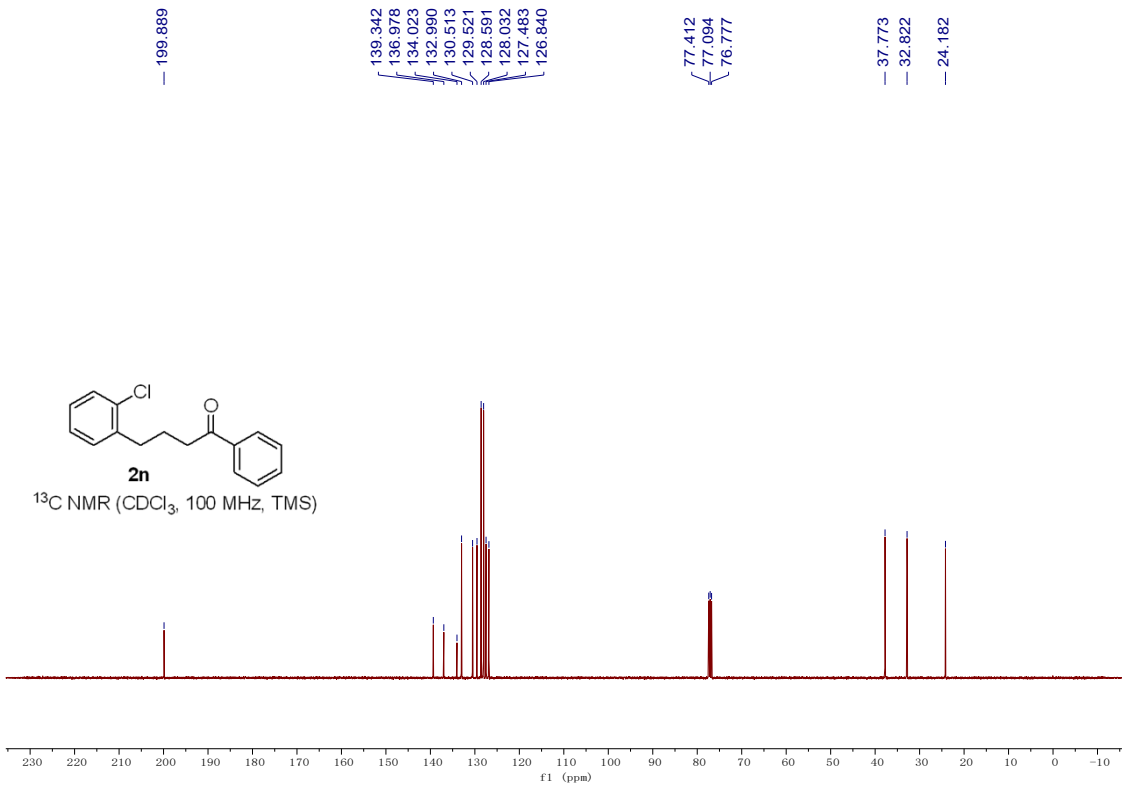

-118.732
-118.753
-118.768
-118.792
F
O
2m
19F NMR (376 MHz, CDCl3, CFCl3)
f1 (ppm)

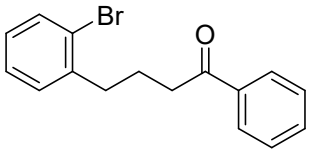


4-(2-chlorophenyl)-1-phenylbutan-1-one (2n)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[17] A colorless oil. 50.7 mg, 98% yield. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 2.05-2.12 (m, 2H), 2.84 (t, J = 7.6 Hz, 2H), 3.01 (t, J = 7.2 Hz, 2H), 7.10-7.19 (m, 2H), 7.24 (dd, J_1 = 7.4 Hz, J_2 = 1.6 Hz, 1H), 7.33 (dd, J_1 = 7.6 Hz, J_2 = 1.2 Hz, 1H), 7.44 (t, J = 7.6 Hz, 2H), 7.54 (t, J = 7.4 Hz, 1H), 7.93 (d, J = 7.8 Hz, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 24.2, 32.8, 37.8, 126.8, 127.5, 128.0, 128.6, 129.5, 130.5, 133.0, 134.0, 137.0, 139.3, 199.9.

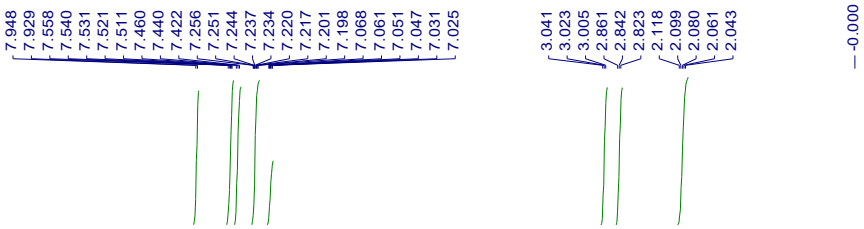


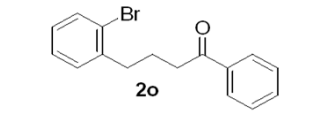

199.889
139.342
136.978
134.023
132.990
130.513
129.521
128.591
128.032
127.483
126.840
77.412
77.094
76.777
37.773
32.822
24.182
Cl
O
2n
13C NMR (CDCl3, 100 MHz, TMS)
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)



4-(2-bromophenyl)-1-phenylbutan-1-one (2o)

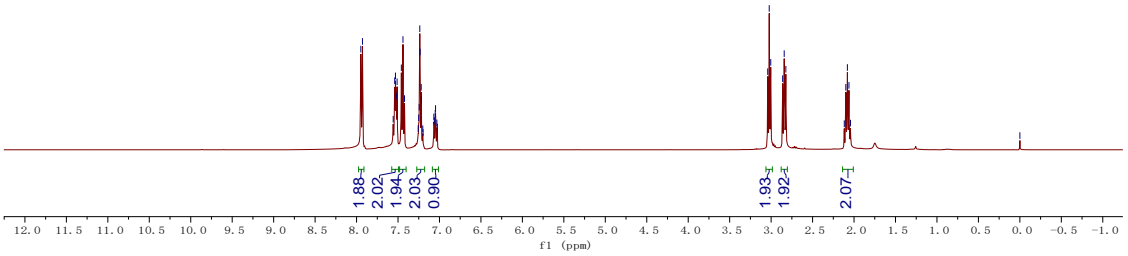
This is a known compound and its spectroscopic data are consistent with those in the previous literature.[16] A colorless oil. 57.0 mg, 94% yield. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 2.04-2.12 (m, 2H), 2.84 (t, *J* = 7.6 Hz, 2H), 3.02 (t, *J* = 7.2 Hz, 2H), 7.03-7.07 (m, 1H), 7.20-7.26 (m, 2H), 7.44 (t, *J* = 8.0 Hz, 2H), 7.51-7.56 (m, 2H), 7.94 (d, *J* = 7.6 Hz, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 24.3, 35.4, 37.8, 124.6, 127.5, 127.7, 128.0, 128.6, 130.5, 132.8, 133.0, 137.0, 141.1, 199.9.

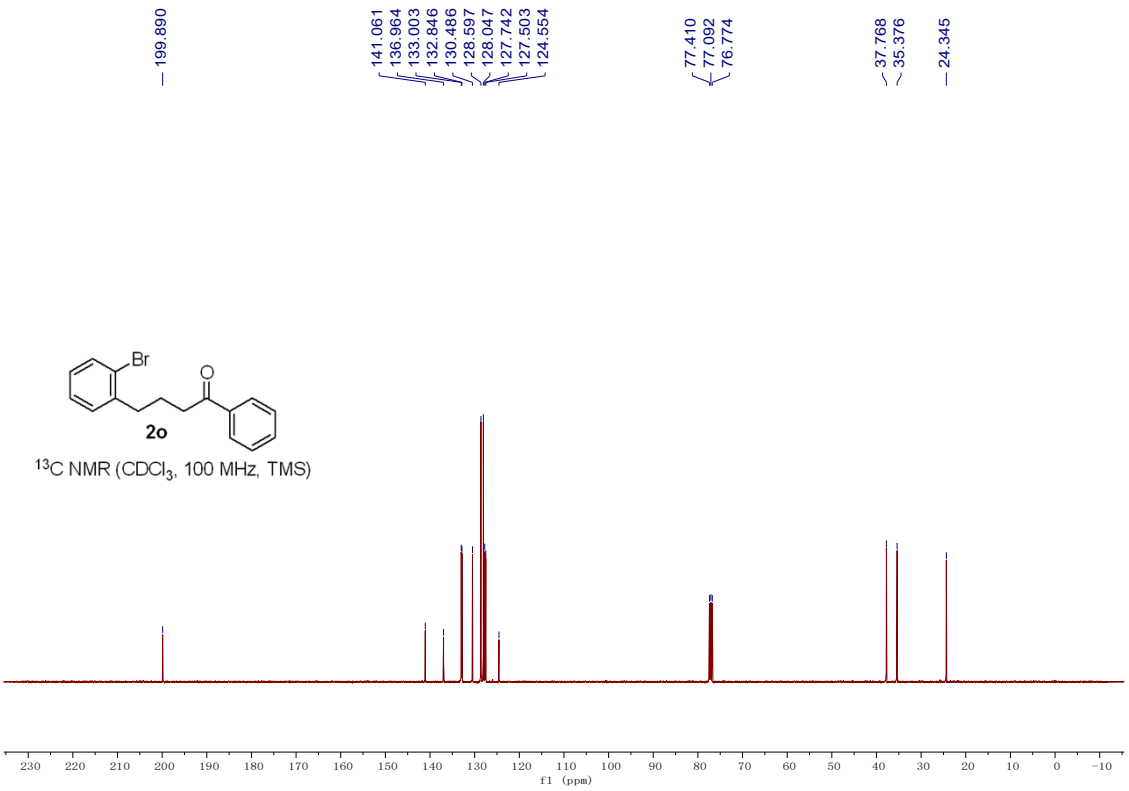


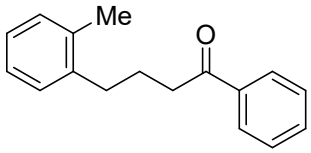


2o

^{1}H NMR ($CDCl_3$, 400 MHz, TMS)

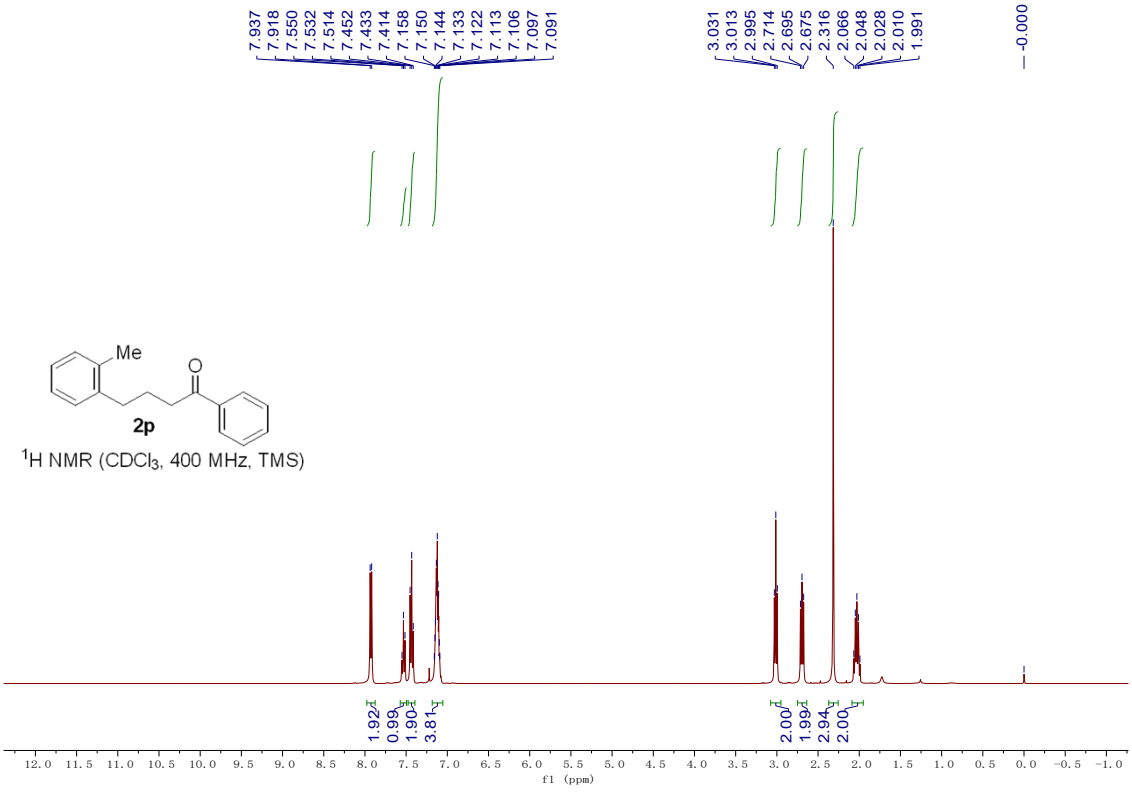


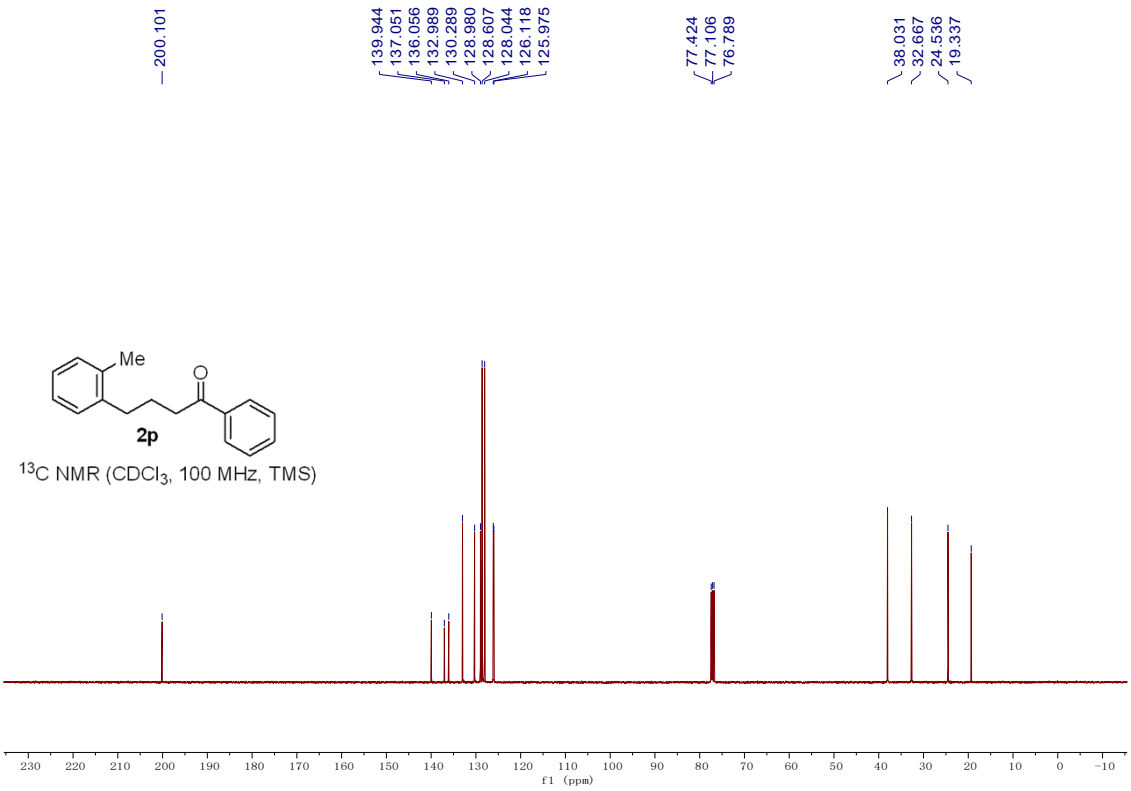

199.890
141.061
136.964
133.003
132.846
130.486
128.597
128.047
127.742
127.503
124.554
77.410
77.092
76.774
37.768
35.376
24.345
Br
O
2o
13C NMR (CDCl3, 100 MHz, TMS)
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

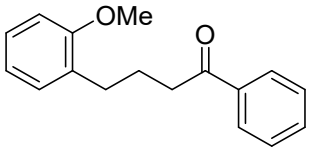


1-phenyl-4-(o-tolyl)butan-1-one (2p)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[18] A colorless oil. 45.8 mg, 96% yield. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 1.99-2.07 (m, 2H), 2.32 (s, 3H), 2.70 (t, *J* = 7.6 Hz, 2H), 3.01 (t, *J* = 7.2 Hz, 2H), 7.09-7.16 (m, 4H), 7.43 (t, *J* = 7.6 Hz, 2H), 7.53 (t, *J* = 7.2 Hz, 1H), 7.93 (d, *J* = 7.6 Hz, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 19.3, 24.5, 32.7, 38.0, 126.0, 126.1, 128.0, 128.6, 129.0, 130.3, 133.0, 136.1, 137.1, 139.9, 200.1.

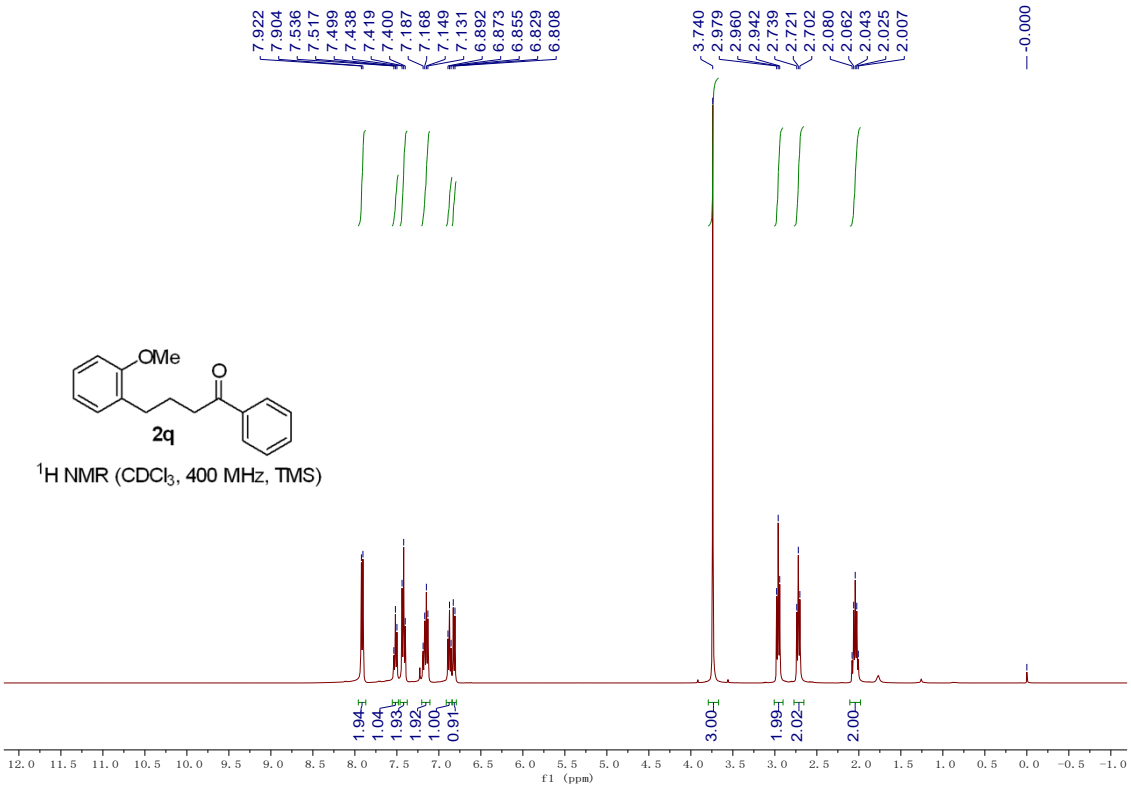


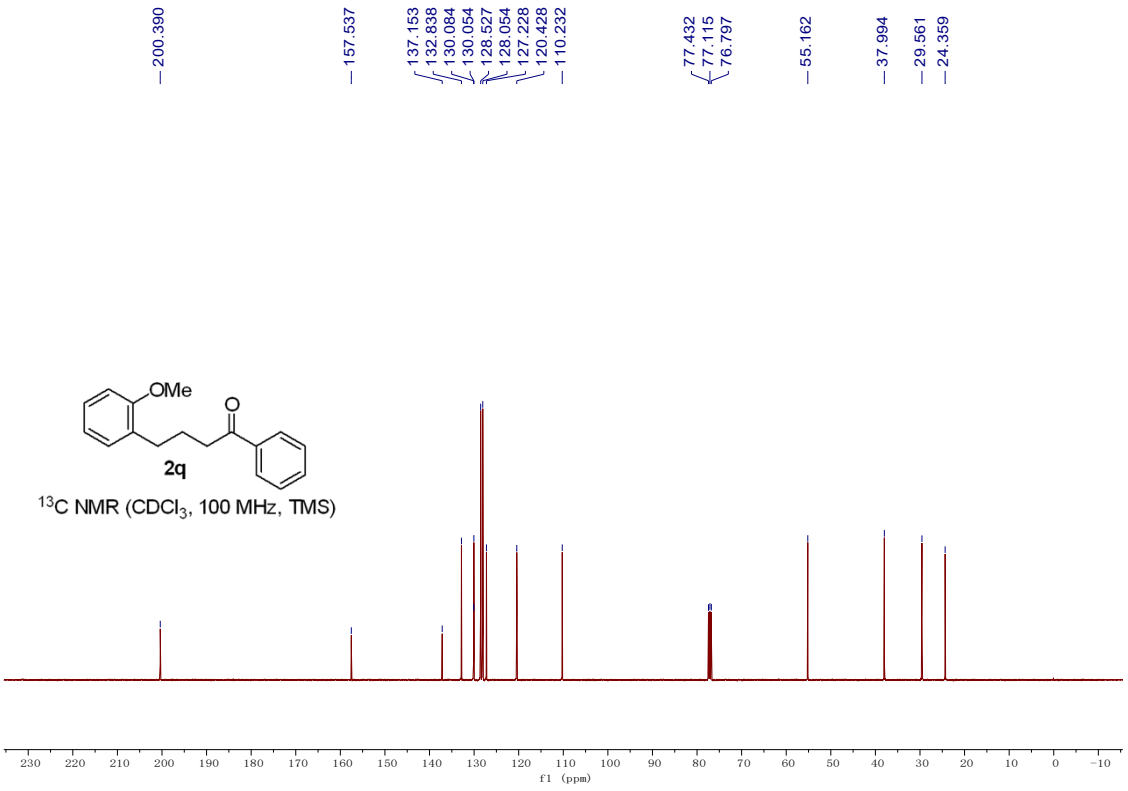

200.101
139.944
137.051
136.056
132.989
130.289
128.980
128.607
128.044
126.118
125.975
77.424
77.106
76.789
38.031
32.667
24.536
19.337
Me
O
2p
13C NMR (CDCl3, 100 MHz, TMS)
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

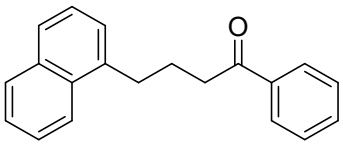


4-(2-methoxyphenyl)-1-phenylbutan-1-one (2q)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[2] A colorless oil. 46.3 mg, 91% yield. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 2.01-2.08 (m, 2H), 2.72 (t, *J* = 7.6 Hz, 2H), 2.96 (t, *J* = 7.2 Hz, 2H), 3.74 (s, 3H), 6.82 (d, *J* = 8.2 Hz, 1H), 6.87 (t, *J* = 7.4 Hz, 1H), 7.13-7.19 (m, 2H), 7.42 (t, *J* = 7.6 Hz, 2H), 7.52 (t, *J* = 7.2 Hz, 1H), 7.91 (d, *J* = 7.2 Hz, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 24.4, 29.6, 38.0, 55.2, 110.2, 120.4, 127.2, 128.1, 128.5, 130.1, 130.1, 132.8, 137.2, 157.5, 200.4.

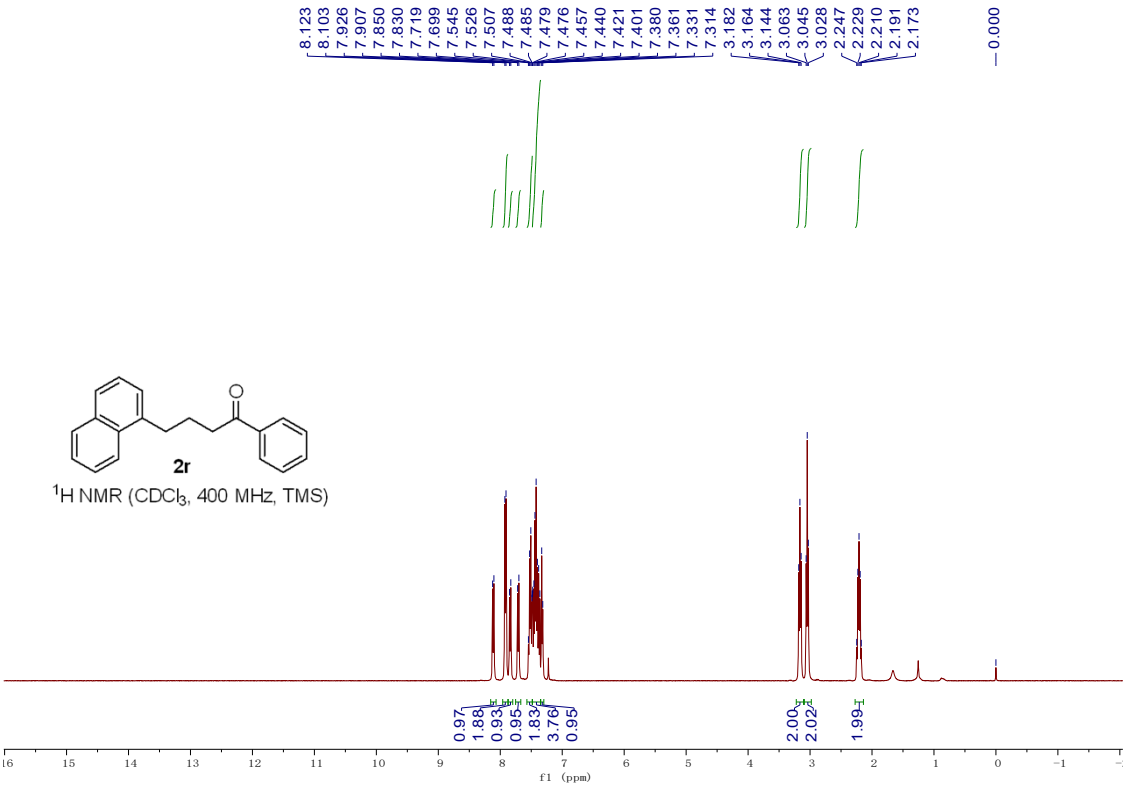


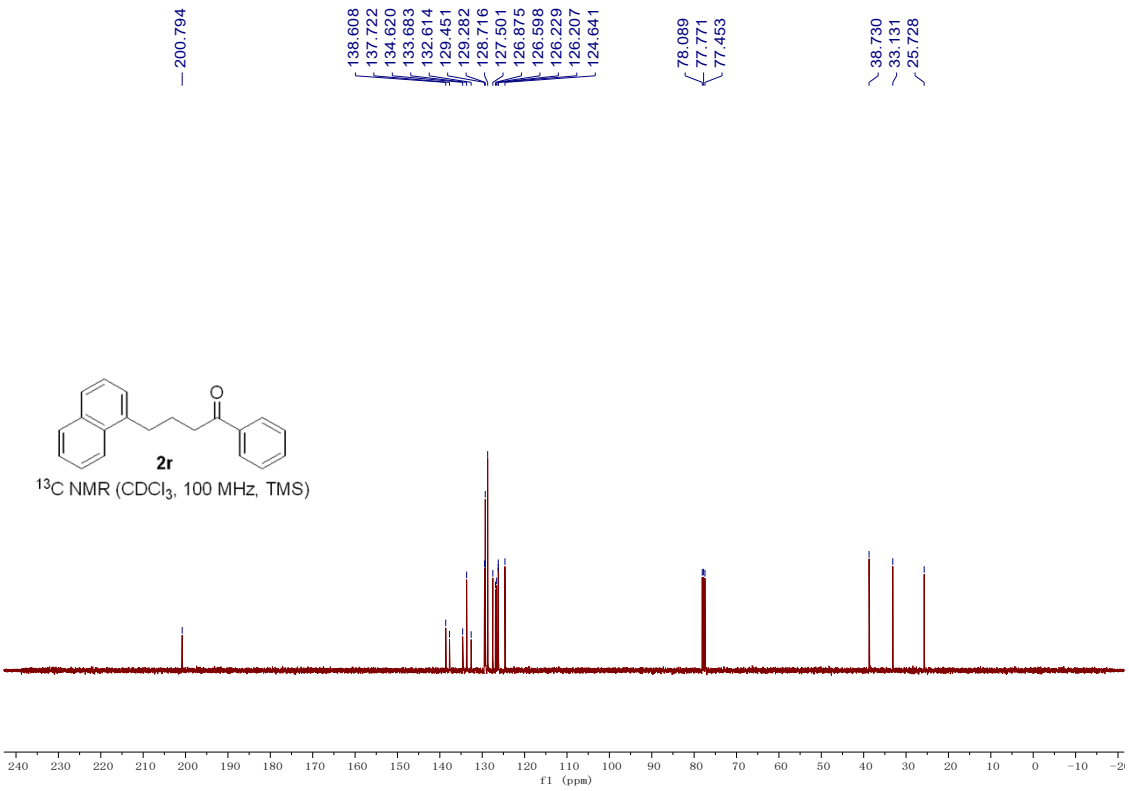

200.390
157.537
137.153
132.838
130.084
130.054
128.527
128.054
127.228
120.428
110.232
77.432
77.115
76.797
55.162
37.994
29.561
24.359
OMe
O
2q
13C NMR (CDCl3, 100 MHz, TMS)
f1 (ppm)

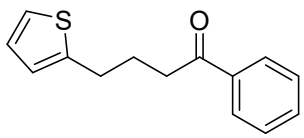


4-(naphthalen-1-yl)-1-phenylbutan-1-one (2r)

A colorless oil. 34.0 mg, 62% yield. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 2.17-2.25 (m, 2H), 3.05 (t, *J* = 7.0 Hz, 2H), 3.16 (t, *J* = 7.6 Hz, 2H), 7.32 (d, *J* = 6.8 Hz, 1H), 7.36-7.48 (m, 4H), 7.49-7.55 (m, 2H), 7.71 (d, *J* = 8.0 Hz, 1H), 7.84 (d, *J* = 8.0 Hz, 1H), 7.92 (d, *J* = 7.6 Hz, 2H), 8.11 (d, *J* = 8.0 Hz, 1H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 25.7, 33.1, 38.7, 124.6, 126.21, 126.23, 126.6, 126.9, 127.5, 128.7, 129.3, 129.5, 132.6, 133.7, 134.6, 137.7, 138.6, 200.8. IR (EtOH) $\tilde{\nu}$ 3057, 2927, 2870, 1681, 1596, 1509, 1447, 1365, 1226, 965, 776, 753, 688 cm^{-1}. HRMS (ESI) calcd. for $C_{20}H_{18}O$ (M^+): 274.1358, Found: 274.1360.

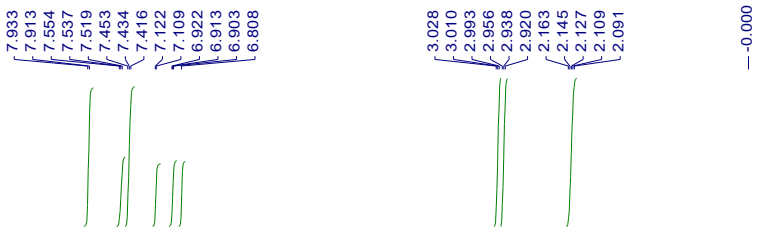


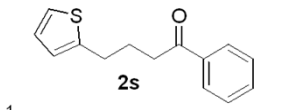

200.794
138.608
137.722
134.620
133.683
132.614
129.451
129.282
128.716
127.501
126.875
126.598
126.229
126.207
124.641
78.089
77.771
77.453
38.730
33.131
25.728
2r
13C NMR (CDCl3, 100 MHz, TMS)
f1 (ppm)



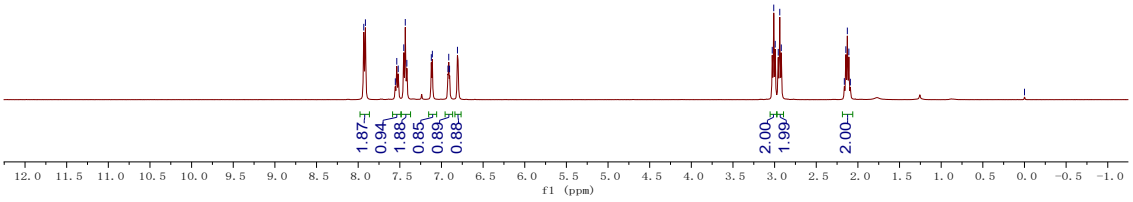
1-phenyl-4-(thiophen-2-yl)butan-1-one (2s)

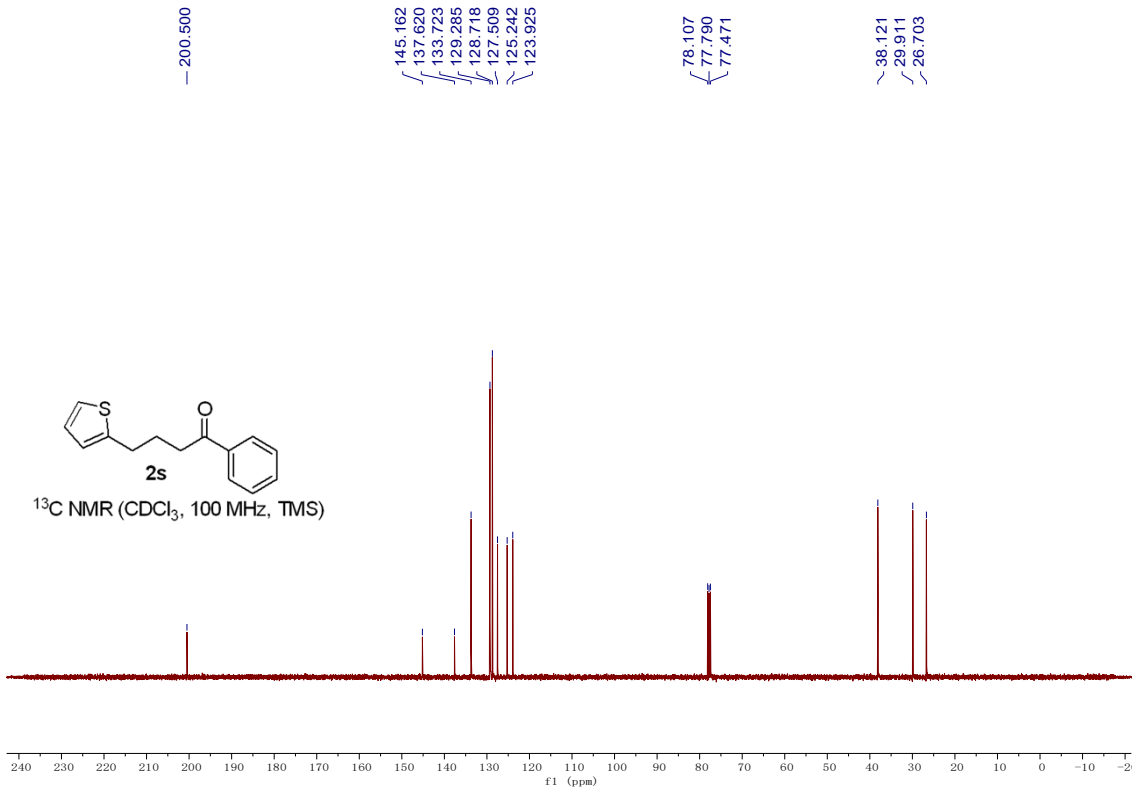
This is a known compound and its spectroscopic data are consistent with those in the previous literature.[15] A colorless oil. 45.1 mg, 98% yield. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 2.09-2.16 (m, 2H), 2.94 (t, *J* = 7.2 Hz, 2H), 3.01 (t, *J* = 7.0 Hz, 2H), 6.81 (s, 1H), 6.91 (t, *J* = 3.6 Hz, 1H), 7.12 (d, *J* = 5.2 Hz, 1H), 7.43 (t, *J* = 7.4 Hz, 2H), 7.54 (t, *J* = 7.0 Hz, 1H), 7.92 (d, *J* = 8.0 Hz, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 26.7, 29.9, 38.1, 123.9, 125.2, 127.5, 128.7, 129.3, 133.7, 137.6, 145.2, 200.5.

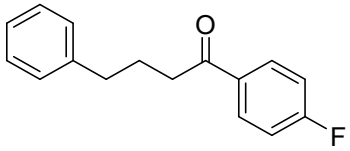




^{1}H NMR ($CDCl_3$, 400 MHz, TMS)

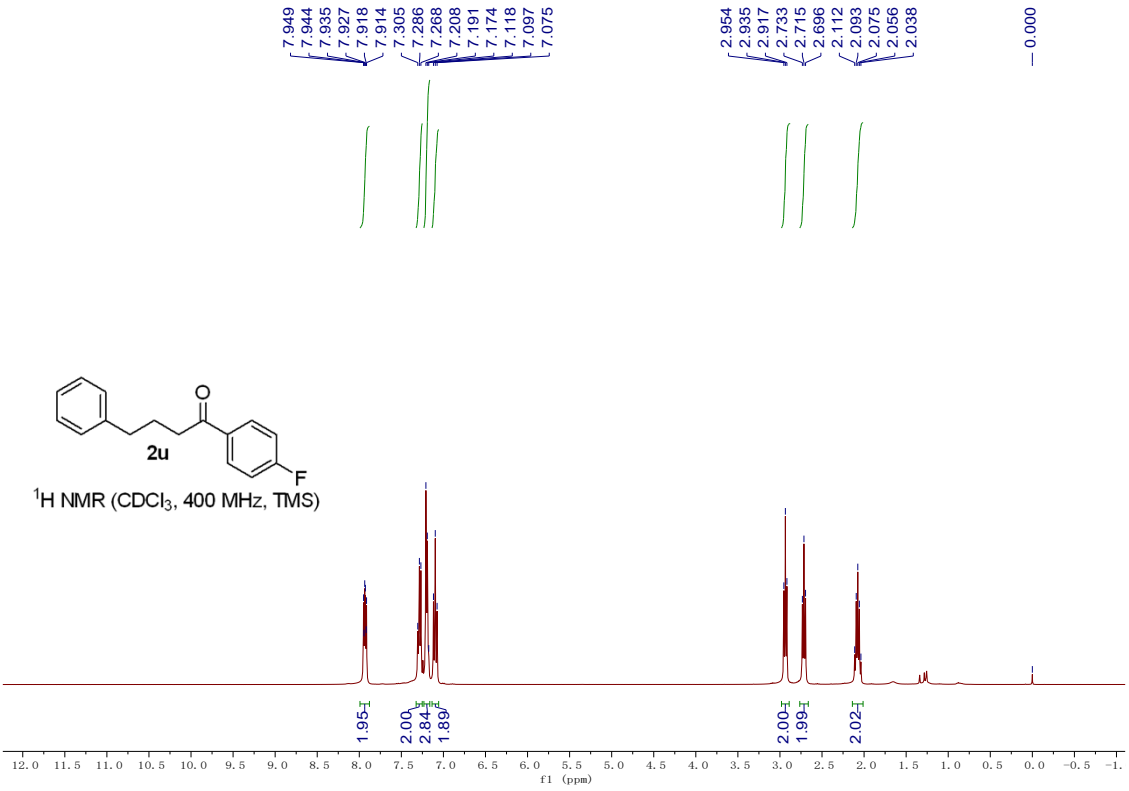


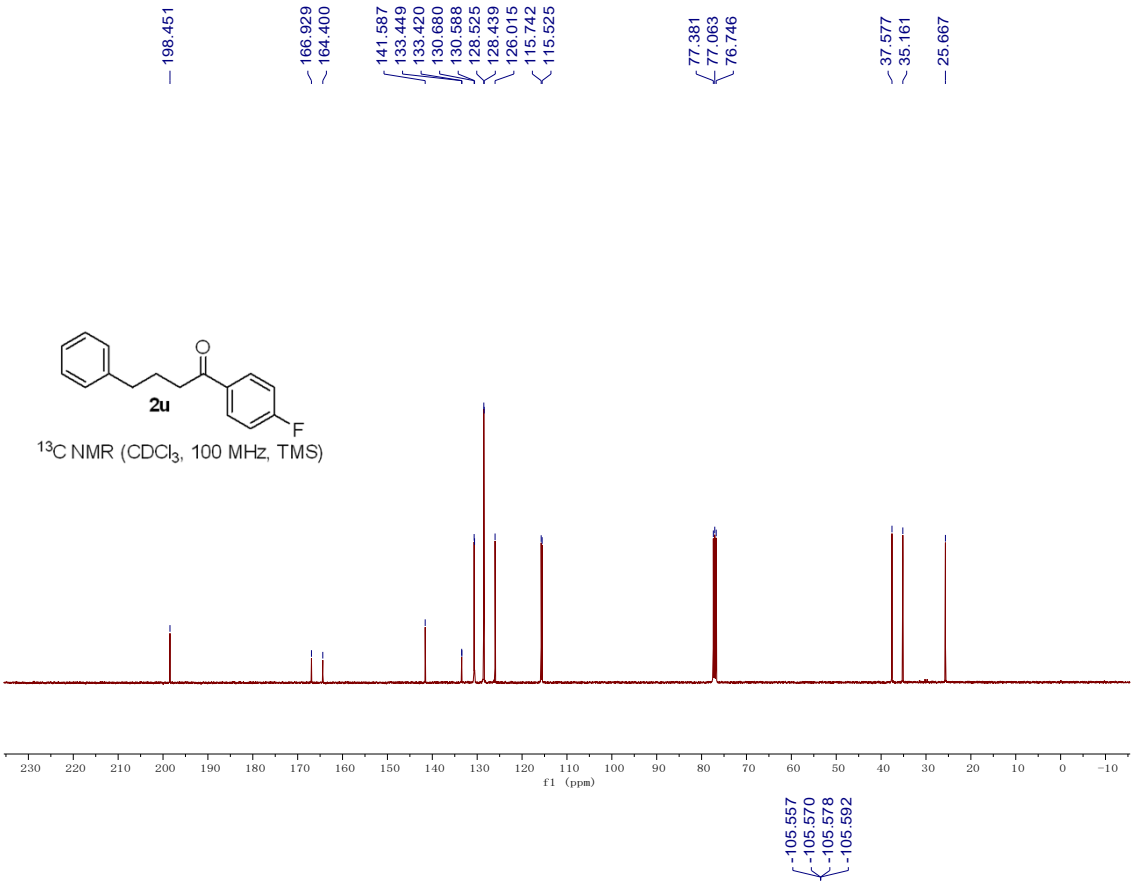

200.500
145.162
137.620
133.723
129.285
128.718
127.509
125.242
123.925
78.107
77.790
77.471
38.121
29.911
26.703
S
O
2s
13C NMR (CDCl3, 100 MHz, TMS)
f1 (ppm)

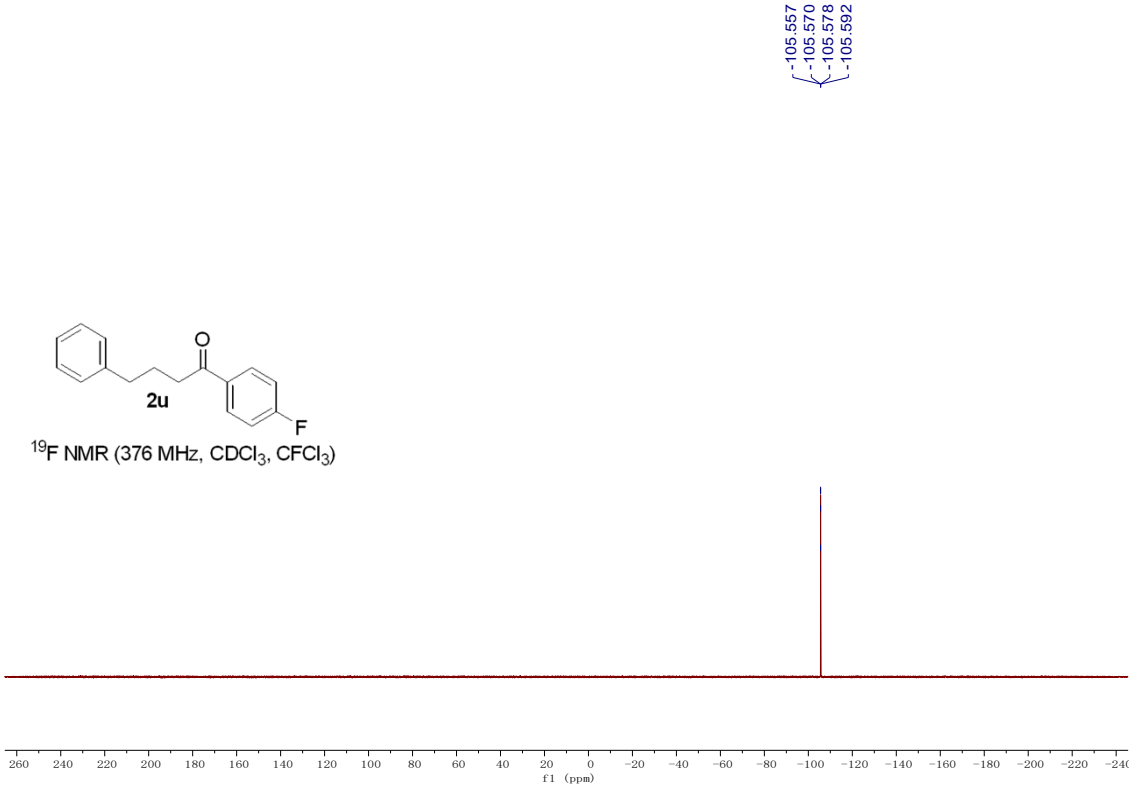


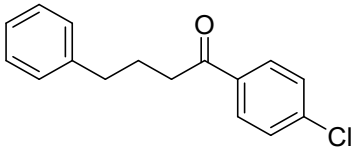
1-(4-fluorophenyl)-4-phenylbutan-1-one (2u)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[12] A colorless oil. 47.5 mg, 98% yield. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 2.04-2.11 (m, 2H), 2.71 (t, *J* = 7.4 Hz, 2H), 2.94 (t, *J* = 7.4 Hz, 2H), 7.10 (t, *J* = 8.4 Hz, 2H), 7.17-7.21 (m, 3H), 7.27-7.31 (m, 2H), 7.91-7.95 (m, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 25.7, 35.2, 37.6, 115.6 (d, *J* = 21.8 Hz), 126.0, 128.4, 128.5, 130.6 (d, *J* = 9.3 Hz), 133.4 (d, *J* = 3.0 Hz), 141.6, 165.7 (d, *J* = 254.4 Hz), 198.5. ^{19}F NMR ($CDCl_3$, $CFCl_3$, 376 MHz) δ -105.6.



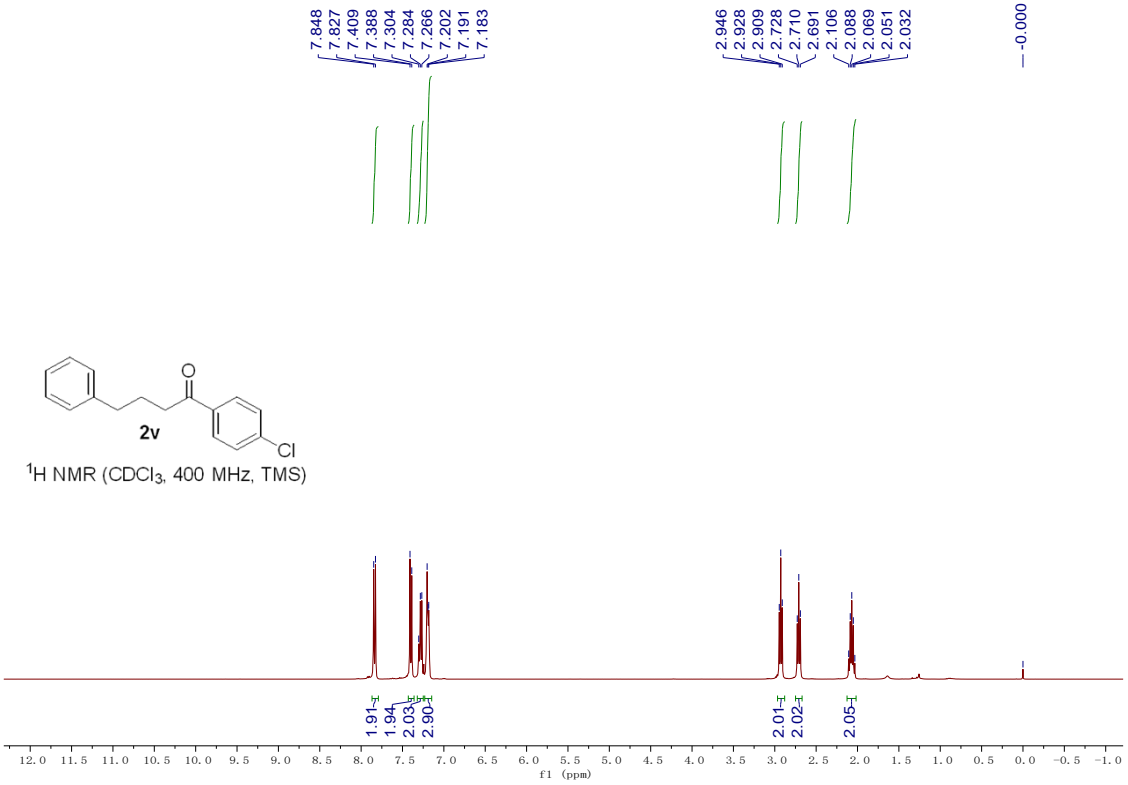

198.451
166.929
164.400
141.587
133.449
133.420
130.680
130.588
128.525
128.439
126.015
115.742
115.525
77.381
77.063
76.746
37.577
35.161
25.667
2u
F
13C NMR (CDCl3, 100 MHz, TMS)
f1 (ppm)

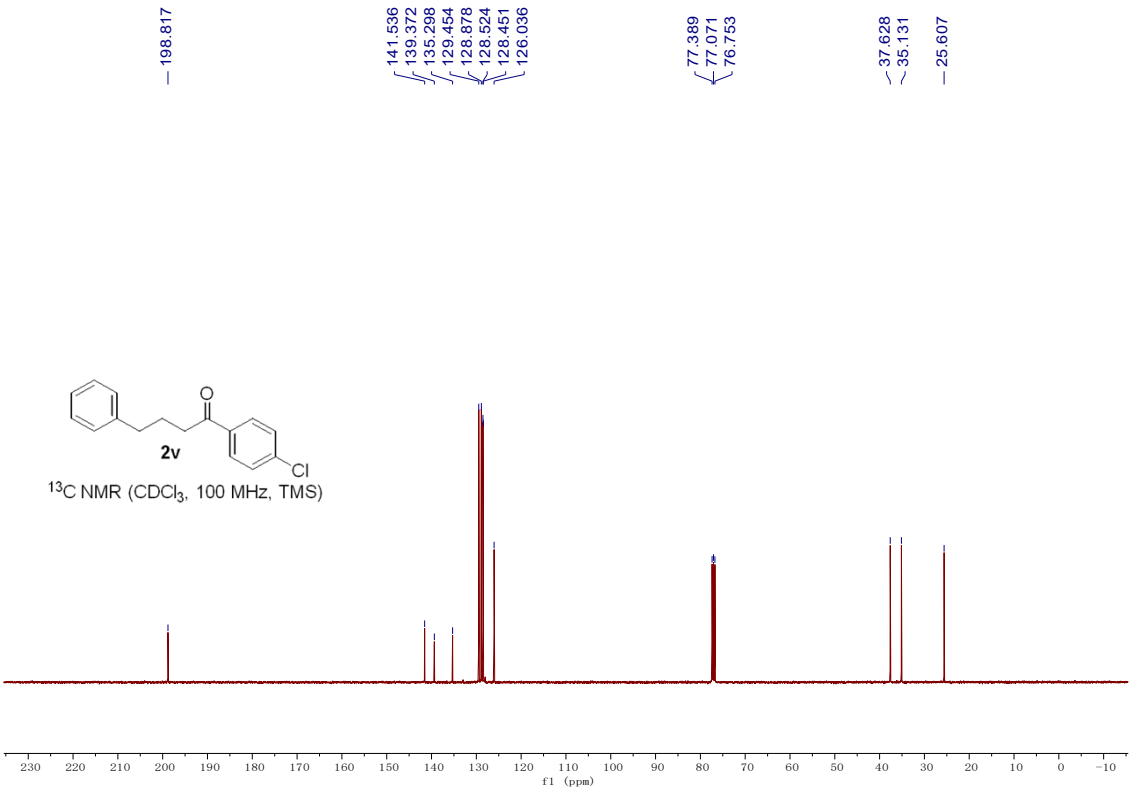

-105.557
-105.570
-105.578
-105.592
2u
F
19F NMR (376 MHz, CDCl3, CFCl3)
f1 (ppm)

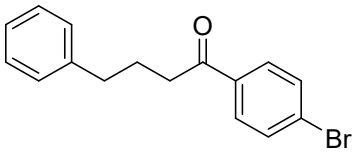


1-(4-chlorophenyl)-4-phenylbutan-1-one (2v)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[12] A colorless oil. 46.6 mg, 90% yield. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 2.04-2.11 (m, 2H), 2.71 (t, *J* = 7.4 Hz, 2H), 2.93 (t, *J* = 7.0 Hz, 2H), 7.18-7.20 (m, 3H), 7.27-7.30 (m, 2H), 7.40 (d, *J* = 8.4 Hz, 2H), 7.84 (d, *J* = 8.4 Hz, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 25.6, 35.1, 37.6, 126.0, 128.45, 128.5, 128.9, 129.5, 135.3, 139.4, 141.5, 198.8.

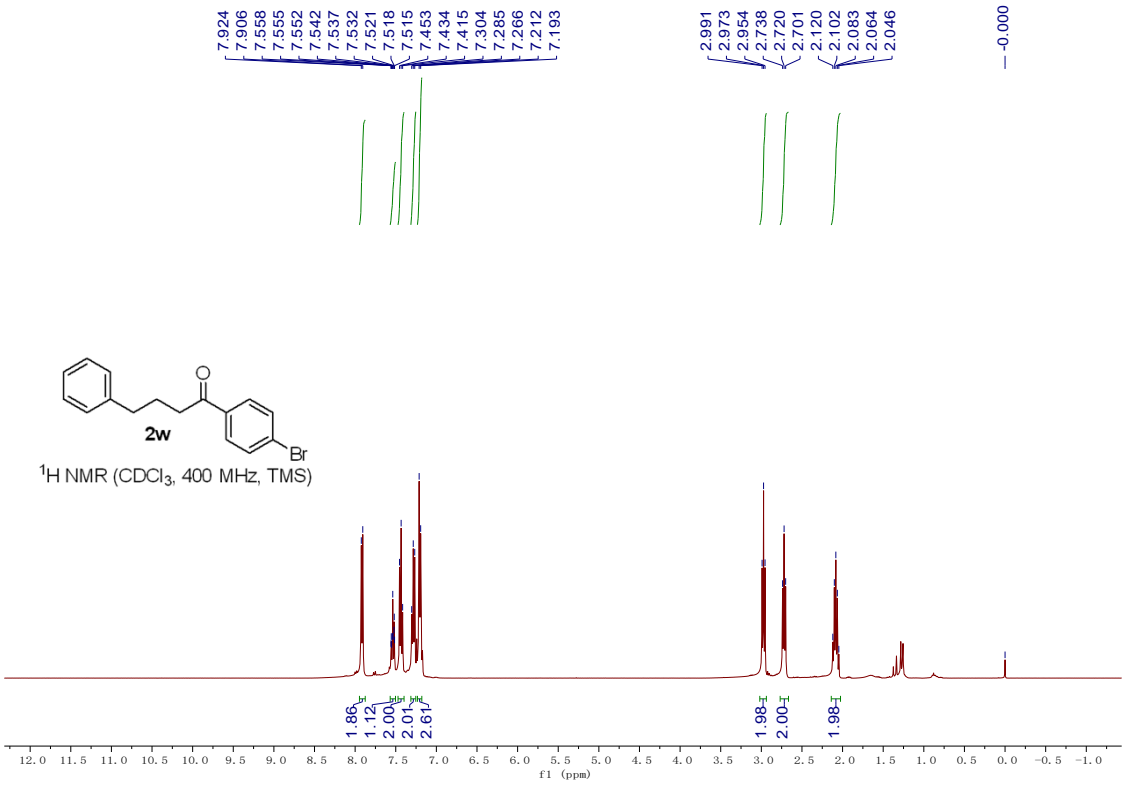


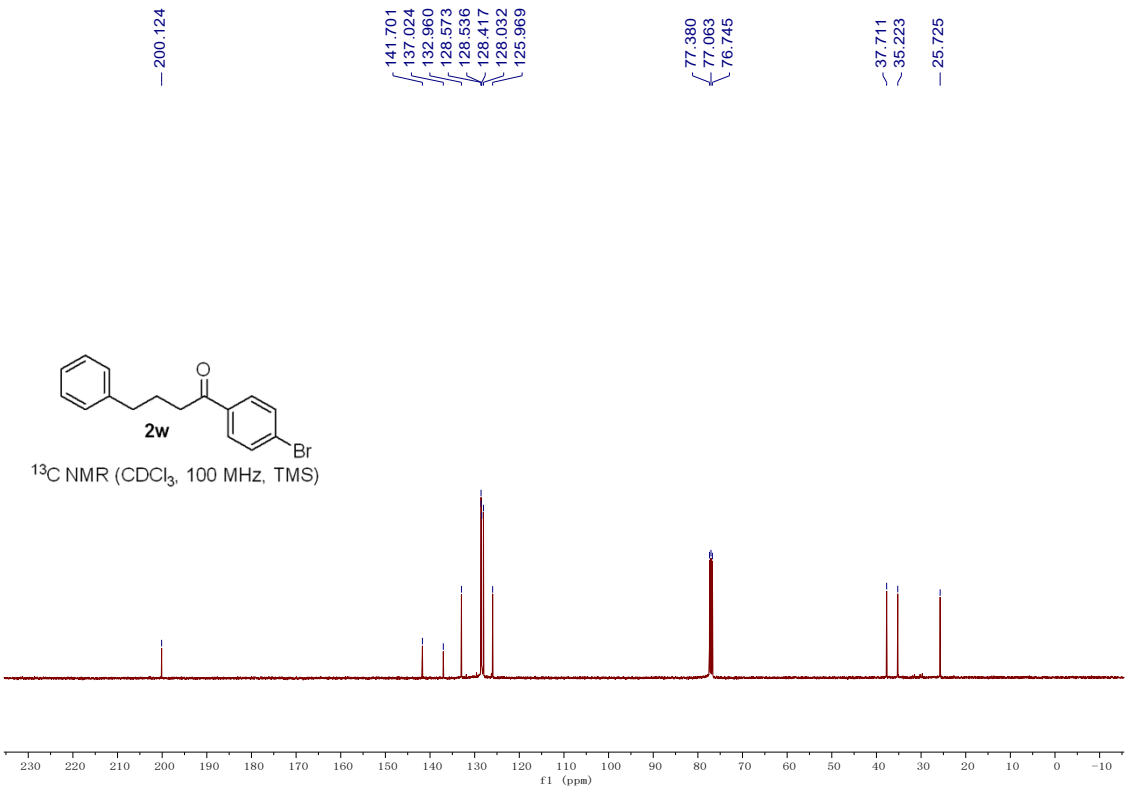

198.817
141.536
139.372
135.298
129.454
128.878
128.524
128.451
126.036
77.389
77.071
76.753
37.628
35.131
25.607
2v
Cl
13C NMR (CDCl3, 100 MHz, TMS)
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

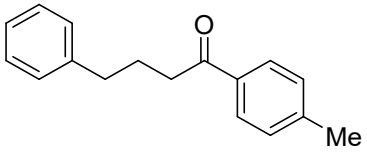


1-(4-bromophenyl)-4-phenylbutan-1-one (2w)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[12] A colorless oil. 57.6 mg, 95% yield. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 2.05-2.12 (m, 2H), 2.72 (t, J = 7.4 Hz, 2H), 2.97 (t, J = 7.4 Hz, 2H), 7.20 (d, J = 7.6 Hz, 2H), 7.27-7.30 (m, 2H), 7.43 (t, J = 7.6 Hz, 2H), 7.54 (tt, J_1 = 7.4 Hz, J_2 = 1.2 Hz, 1H), 7.91 (d, J = 7.2 Hz, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 25.7, 35.2, 37.7, 126.0, 128.0, 128.4, 128.5, 128.6, 133.0, 137.0, 141.7, 200.1.

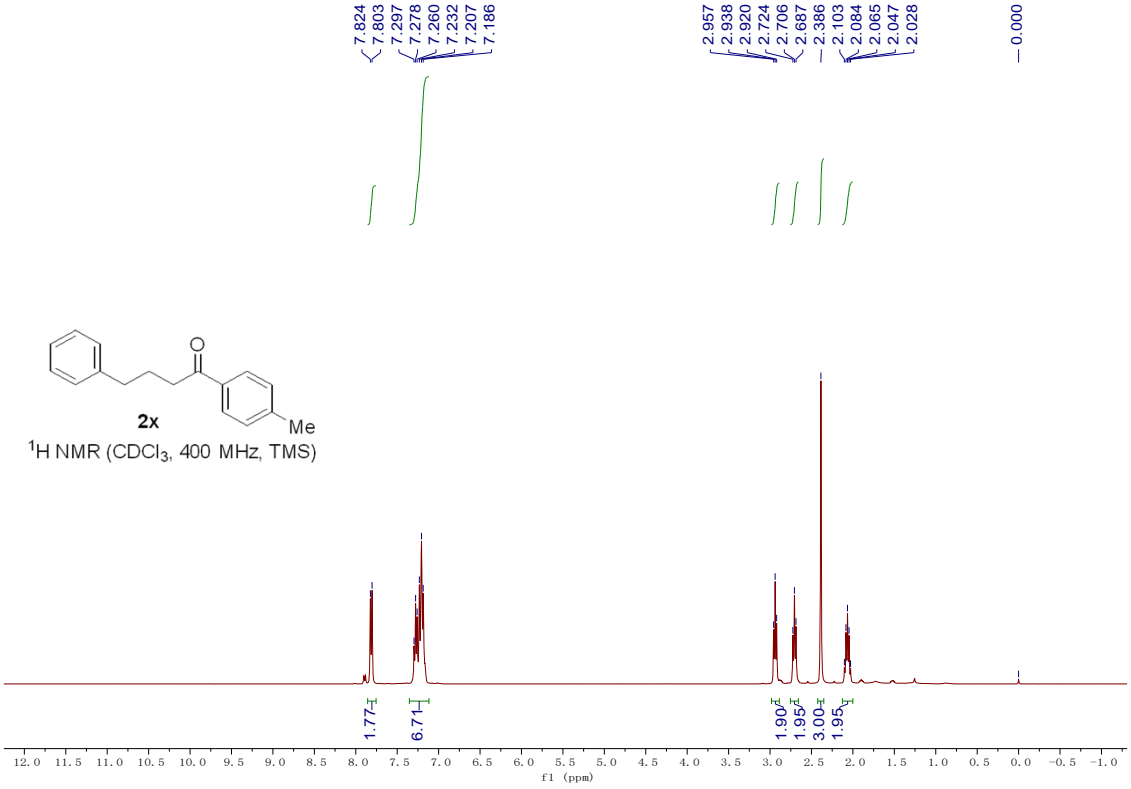


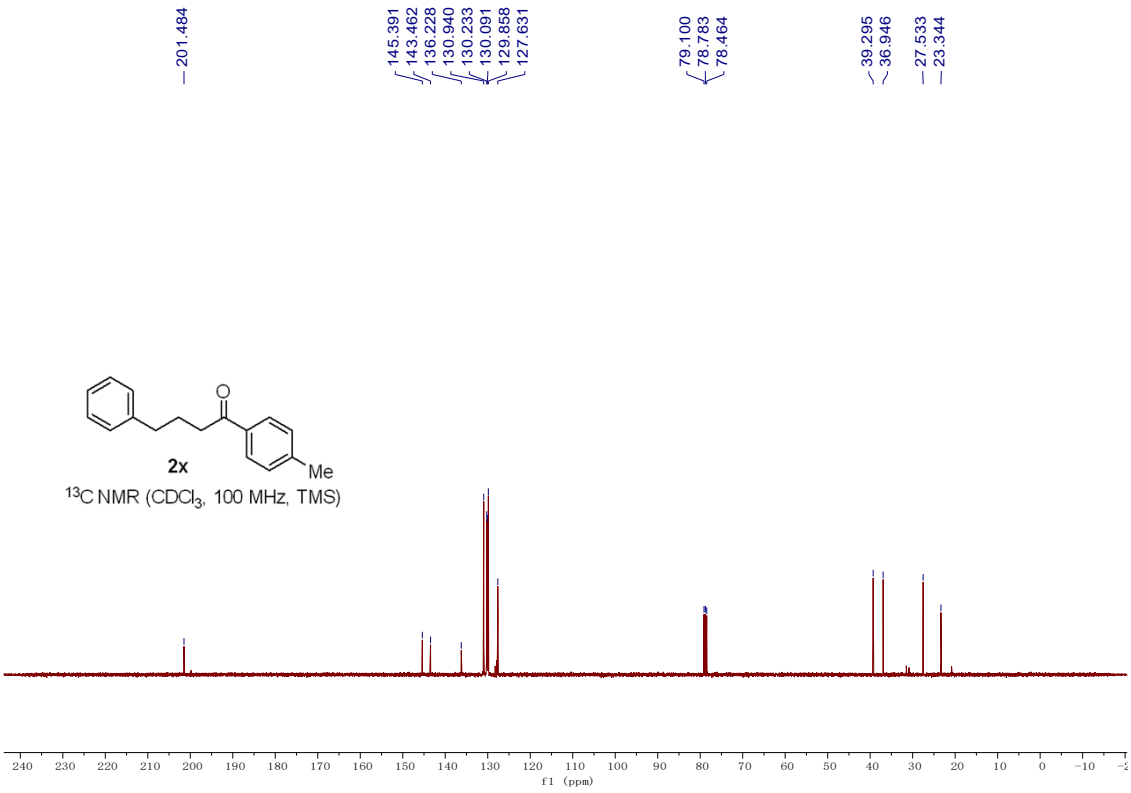

200.124
141.701
137.024
132.960
128.573
128.536
128.417
128.032
125.969
77.380
77.063
76.745
37.711
35.223
25.725
O
2w
Br
13C NMR (CDCl3, 100 MHz, TMS)
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

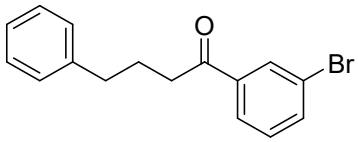


4-phenyl-1-(p-tolyl)butan-1-one (2x)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[12] A colorless oil. 46.7 mg, 98% yield. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 2.03-2.10 (m, 2H), 2.39 (s, 3H), 2.71 (t, *J* = 7.4 Hz, 2H), 2.94 (t, *J* = 7.4 Hz, 2H), 7.19-7.30 (m, 7H), 7.81 (d, *J* = 8.4 Hz, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 23.3, 27.5, 36.9, 39.3, 127.6, 129.9, 130.1, 130.2, 130.9, 136.2, 143.5, 145.4, 201.5.

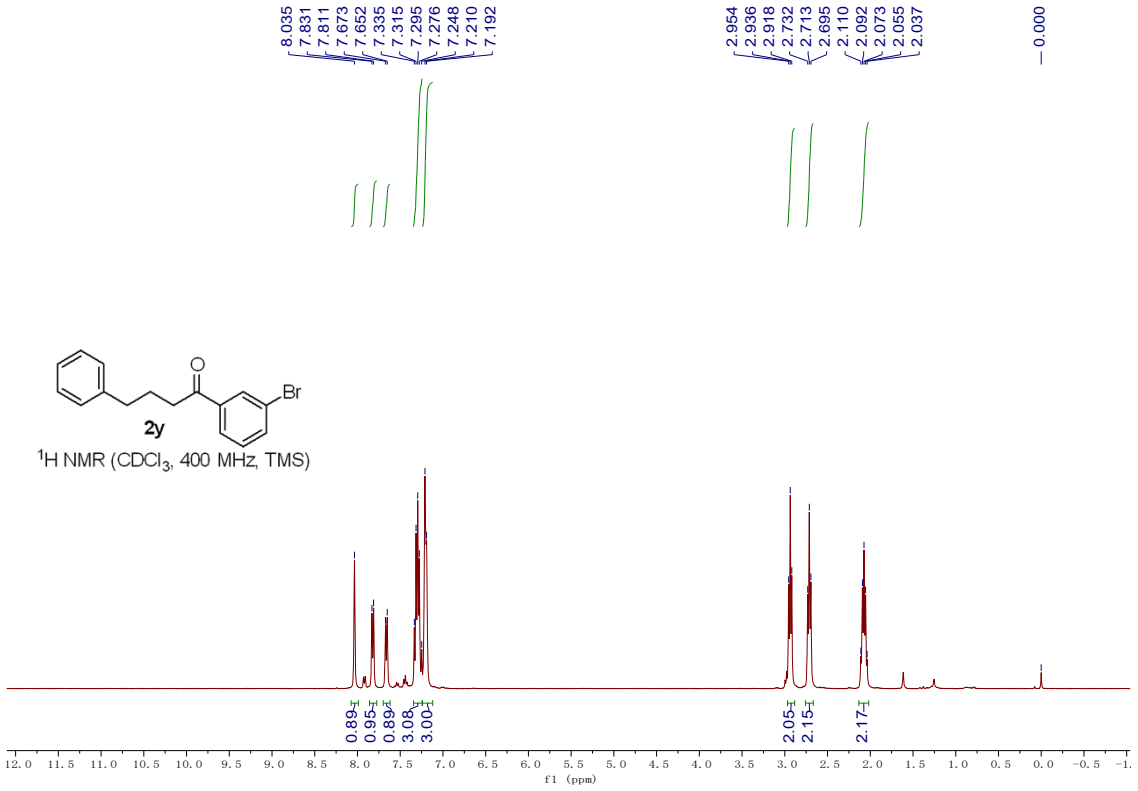



201.484
145.391
143.462
136.228
130.940
130.233
130.091
129.858
127.631
79.100
78.783
78.464
39.295
36.946
27.533
23.344
2x
Me
13C NMR (CDCl3, 100 MHz, TMS)
f1 (ppm)

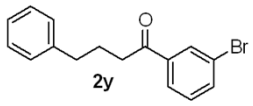


1-(3-bromophenyl)-4-phenylbutan-1-one (2y)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[12] A colorless oil. 54.6 mg, 90% yield. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 2.04-2.11 (m, 2H), 2.71 (t, *J* = 7.4 Hz, 2H), 2.94 (t, *J* = 7.2 Hz, 2H), 7.19-7.21 (m, 3H), 7.25-7.34 (m, 3H), 7.66 (d, *J* = 8.4 Hz, 1H), 7.82 (d, *J* = 8.0 Hz, 1H), 8.04 (s, 1H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 25.5, 35.0, 37.7, 122.9, 126.0, 126.5, 128.4, 128.5, 130.2, 131.1, 135.8, 138.6, 141.4, 198.6.

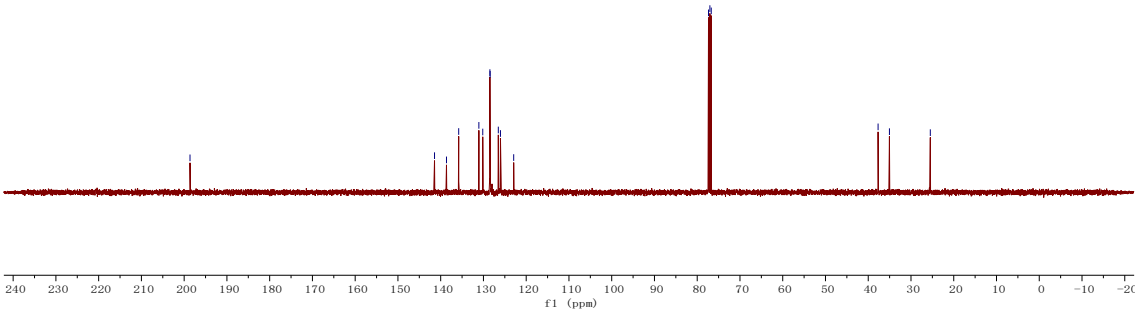


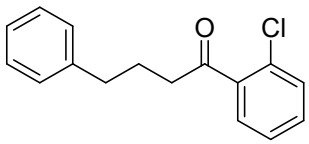
198.632
141.443
138.643
135.789
131.070
130.161
128.490
128.436
126.521
126.021
122.925
77.354
77.036
76.719
37.696
35.042
25.481



2y

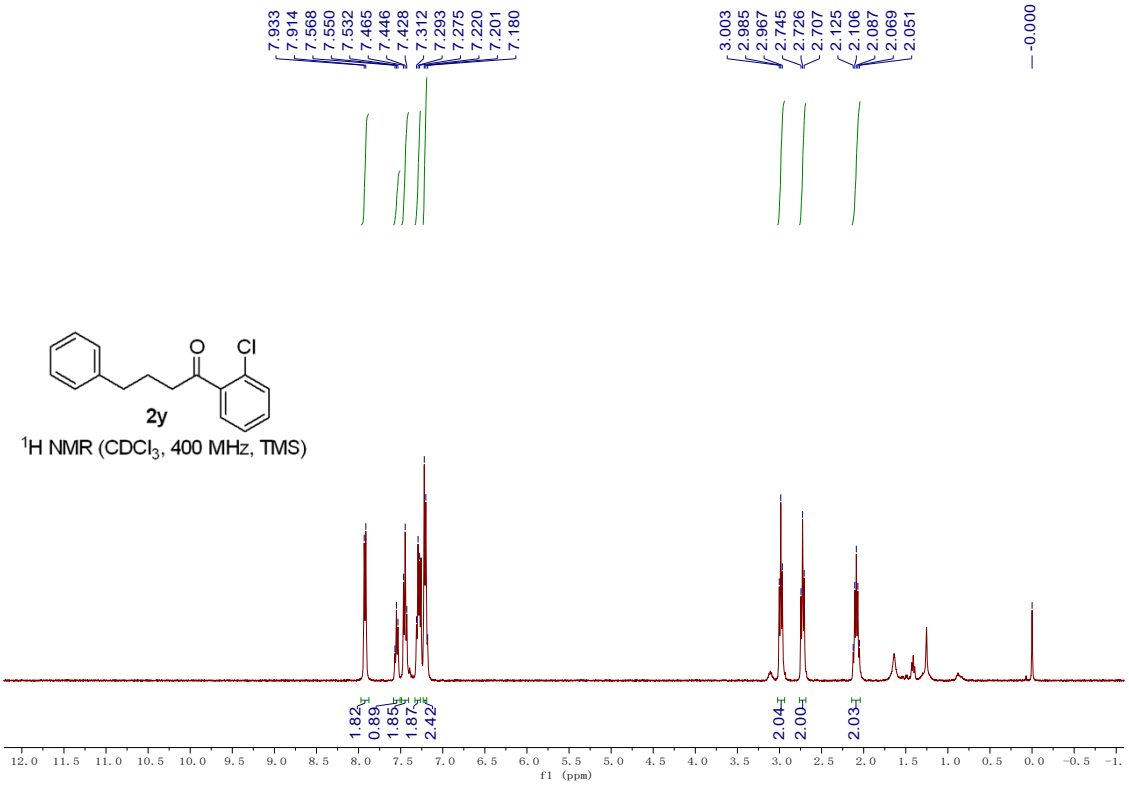
^{13}C NMR ($CDCl_3$, 100 MHz, TMS)

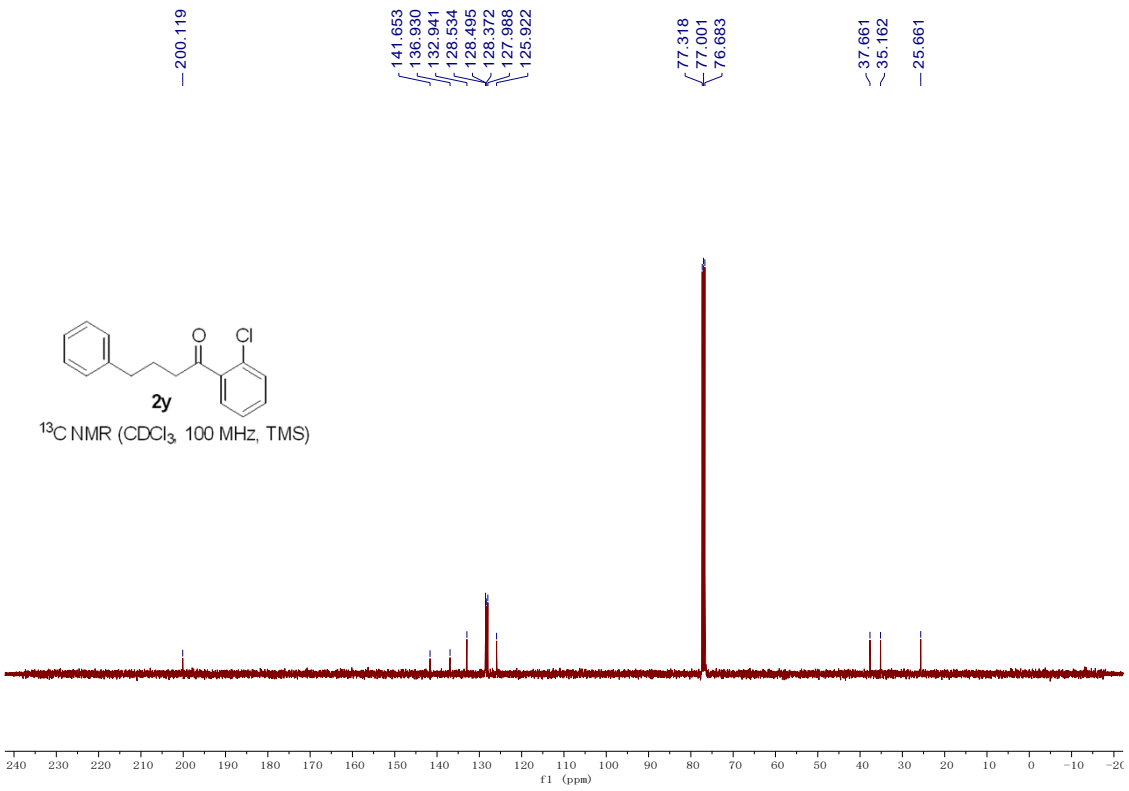


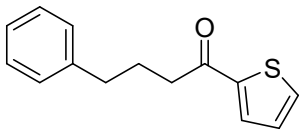


1-(2-chlorophenyl)-4-phenylbutan-1-one (2z)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[15] A colorless oil. 44.5 mg, 86% yield. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 2.05-2.13 (m, 2H), 2.73 (t, *J* = 7.6 Hz, 2H), 2.99 (t, *J* = 7.2 Hz, 2H), 7.21 (m, d, *J* = 7.6 Hz, 2H), 7.29 (t, d, *J* = 7.6 Hz, 2H), 7.45 (t, d, *J* = 7.4 Hz, 2H), 7.55 (t, d, *J* = 7.6 Hz, 2H), 7.92 (d, *J* = 7.6 Hz, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 25.7, 35.2, 37.7, 125.9, 128.0, 128.4, 128.5, 128.5, 132.9, 136.9, 141.7, 200.1.

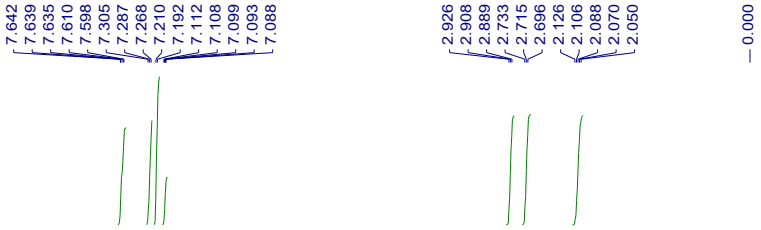


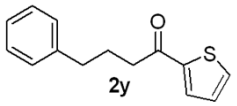

200.119
141.653
136.930
132.941
128.534
128.495
128.372
127.988
125.922
77.318
77.001
76.683
37.661
35.162
25.661
O
Cl
2y
13C NMR (CDCl3, 100 MHz, TMS)
f1 (ppm)



4-phenyl-1-(thiophen-2-yl)butan-1-one (2aa)

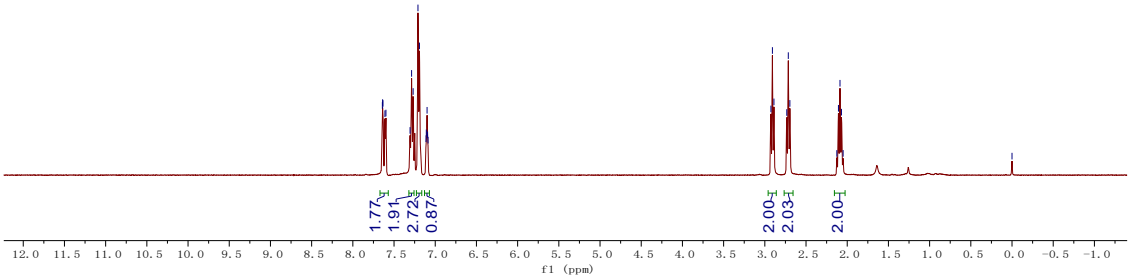
This is a known compound and its spectroscopic data are consistent with those in the previous literature.[15] A colorless oil. 35.9 mg, 78% yield. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 2.05-2.13 (m, 2H), 2.71 (t, *J* = 7.2 Hz, 2H), 2.91 (t, *J* = 7.4 Hz, 2H), 7.09-7.11 (m, 1H), 7.20 (d, *J* = 7.2 Hz, 3H), 7.29 (t, *J* = 7.4 Hz, 2H), 7.60-7.64 (m, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 26.8, 35.9, 39.1, 126.7, 128.7, 129.1, 129.2, 132.4, 134.1, 142.2, 145.1, 193.8.

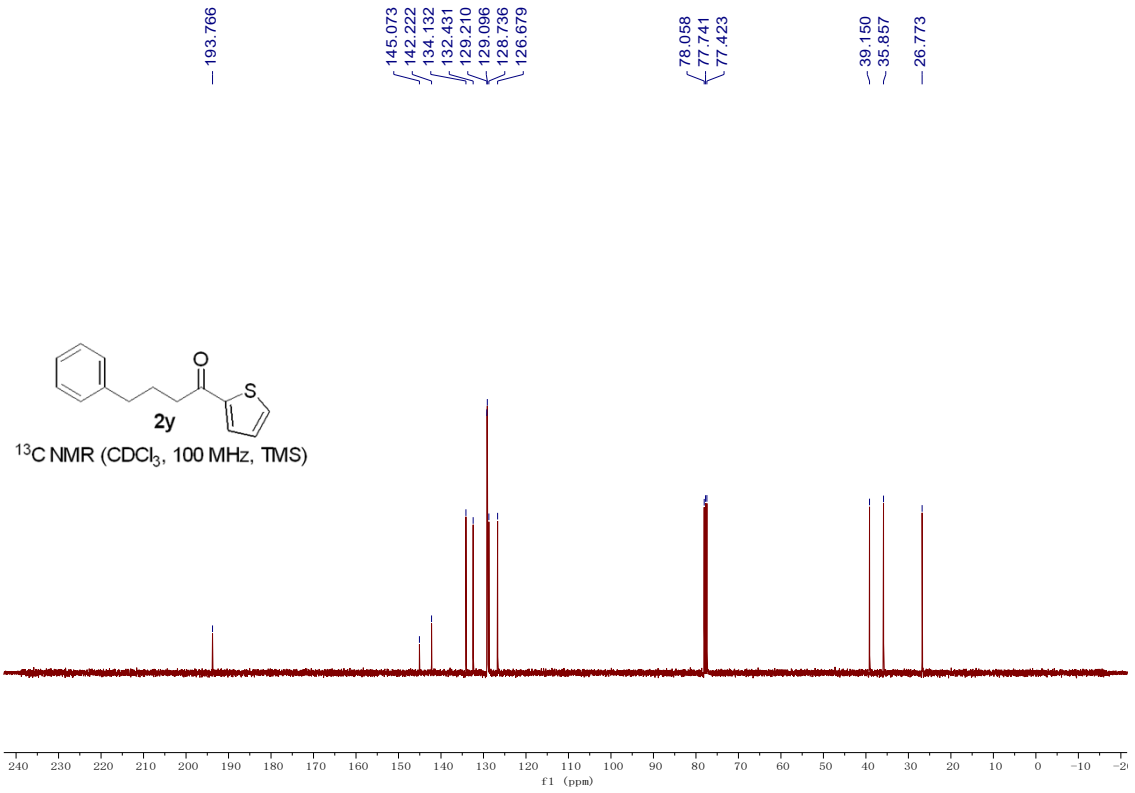


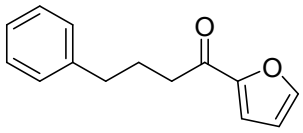


2y

^{1}H NMR ($CDCl_3$, 400 MHz, TMS)

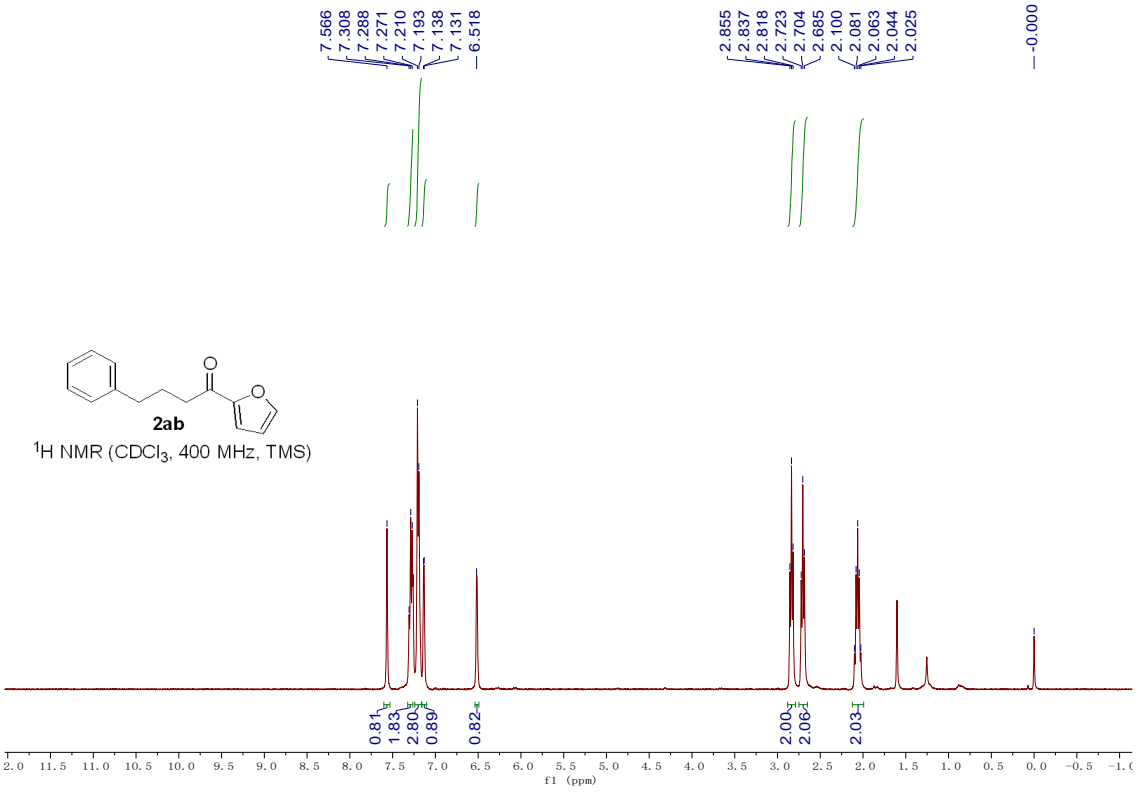


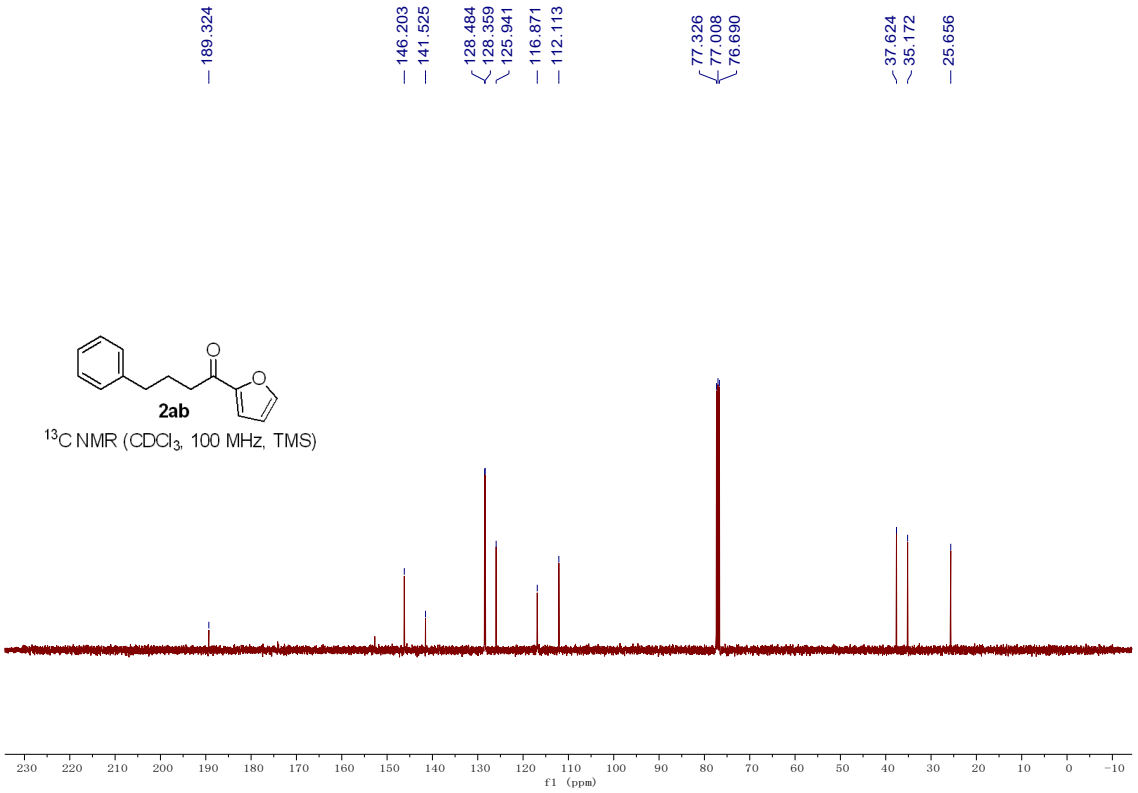

193.766
145.073
142.222
134.132
132.431
129.210
129.096
128.736
126.679
78.058
77.741
77.423
39.150
35.857
26.773
O
S
2y
13C NMR (CDCl3, 100 MHz, TMS)
f1 (ppm)

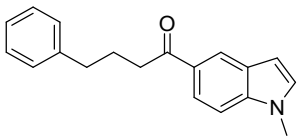


1-(furan-2-yl)-4-phenylbutan-1-one (2ab)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[21] A colorless oil. 30.9 mg, 72% yield. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 2.03-2.10 (m, 2H), 2.70 (t, *J* = 7.6 Hz, 2H), 2.84 (t, *J* = 7.4 Hz, 2H), 6.52 (s, 1H), 7.13 (d, *J* = 2.8 Hz, 1H), 7.20 (t, *J* = 6.8 Hz, 3H), 7.29 (t, *J* = 7.4 Hz, 2H), 7.57 (s, 1H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 25.7, 35.2, 37.6, 112.1, 116.9, 125.9, 128.4, 128.5, 141.5, 146.2, 189.3.

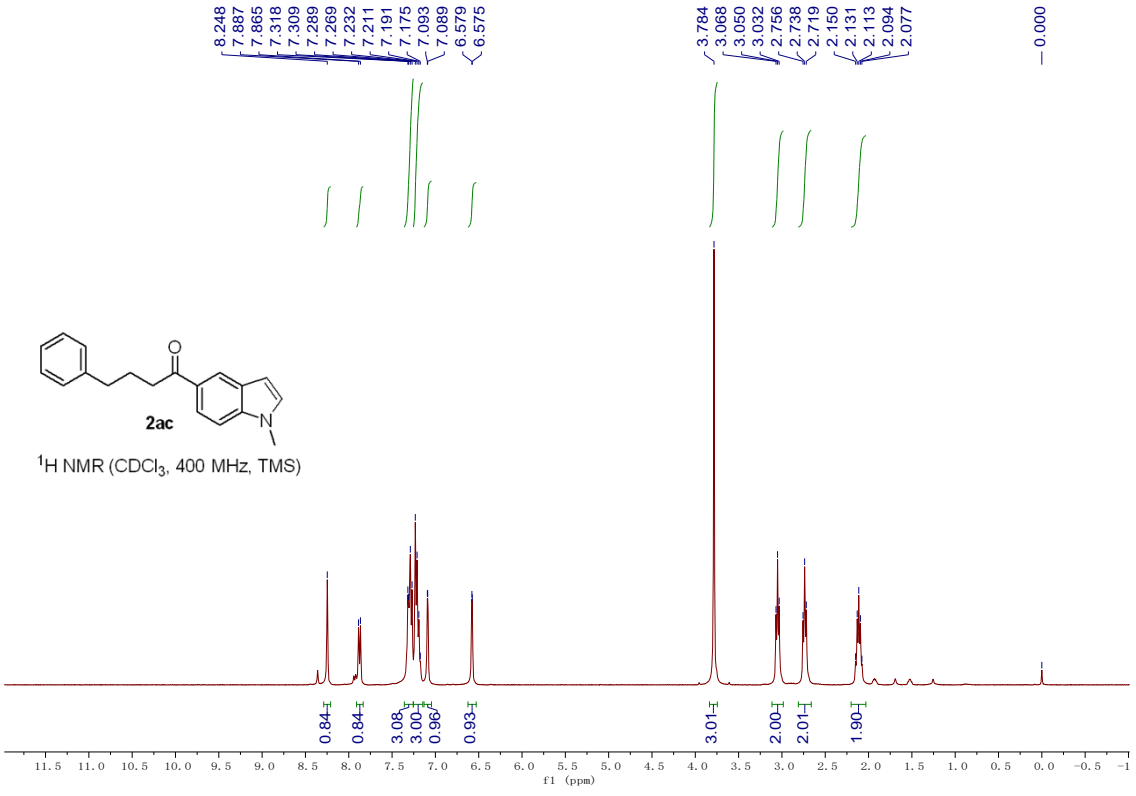


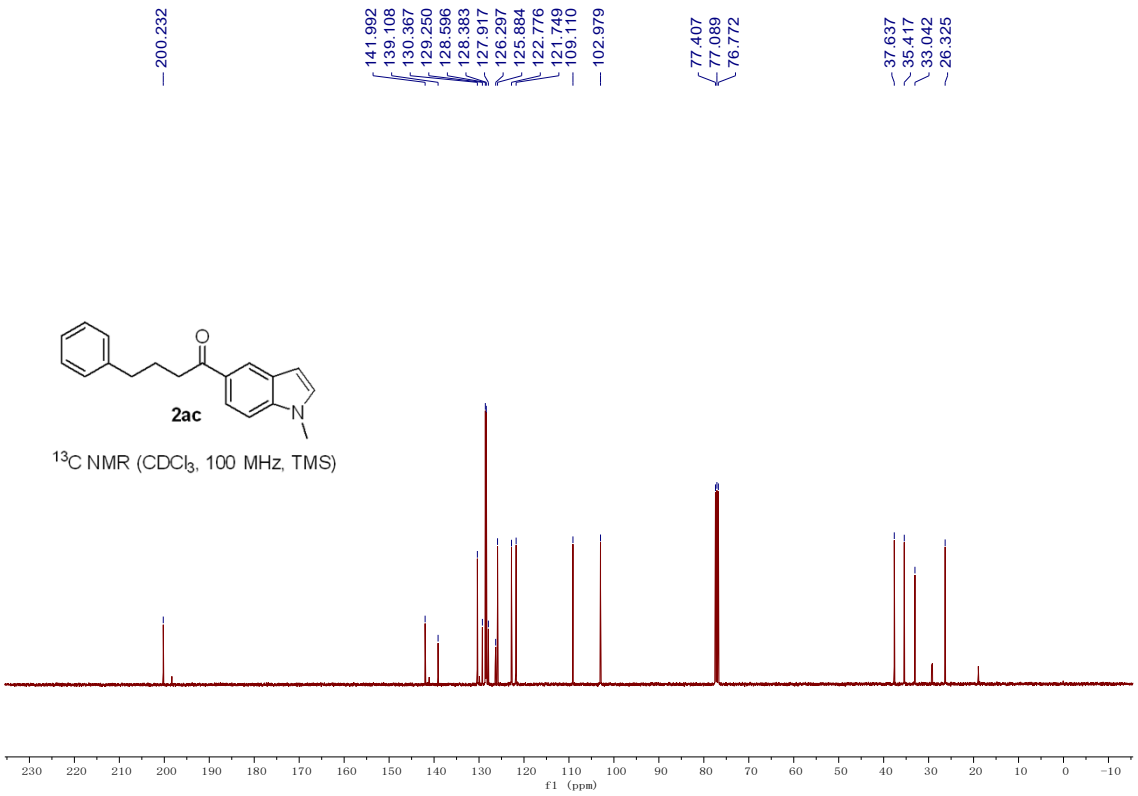

189.324
146.203
141.525
128.484
128.359
125.941
116.871
112.113
77.326
77.008
76.690
37.624
35.172
25.656
2ab
13C NMR (CDCl3, 100 MHz, TMS)
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

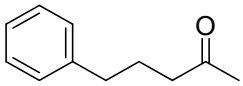


1-(1-methyl-1H-indol-5-yl)-4-phenylbutan-1-one (2ac)

A colorless oil. 44.9 mg, 81% yield. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 2.08-2.15 (m, 2H),2.74 (t, *J* = 7.4 Hz, 2H), 3.05 (t, *J* = 7.2 Hz, 2H), 3.78 (s, 3H), 6.58 (d, *J* = 1.6 Hz, 1H), 6.09 (d, *J* = 1.6 Hz, 1H), 7.18-7.23 (m, 3H), 7.27-7.32 (m, 3H), 7.88 (d, *J* = 8.8 Hz, 1H), 8.25 (s, 1H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 26.3, 33.0, 35.4, 37.6, 103.0, 109.1, 121.7, 122.8, 125.9, 126.3, 127.9, 128.4, 128.6, 129.3, 130.4, 139.1, 142.0, 200.2. IR (EtOH) $\tilde{\nu}$ 2973, 2881, 1702, 1379, 1329, 1088, 1056, 880, 803, 634 cm^{-1}. HRMS (ESI) calcd. for $C_{19}H_{19}NONa$ (M+Na): 300.13589, Found: 300.13585.

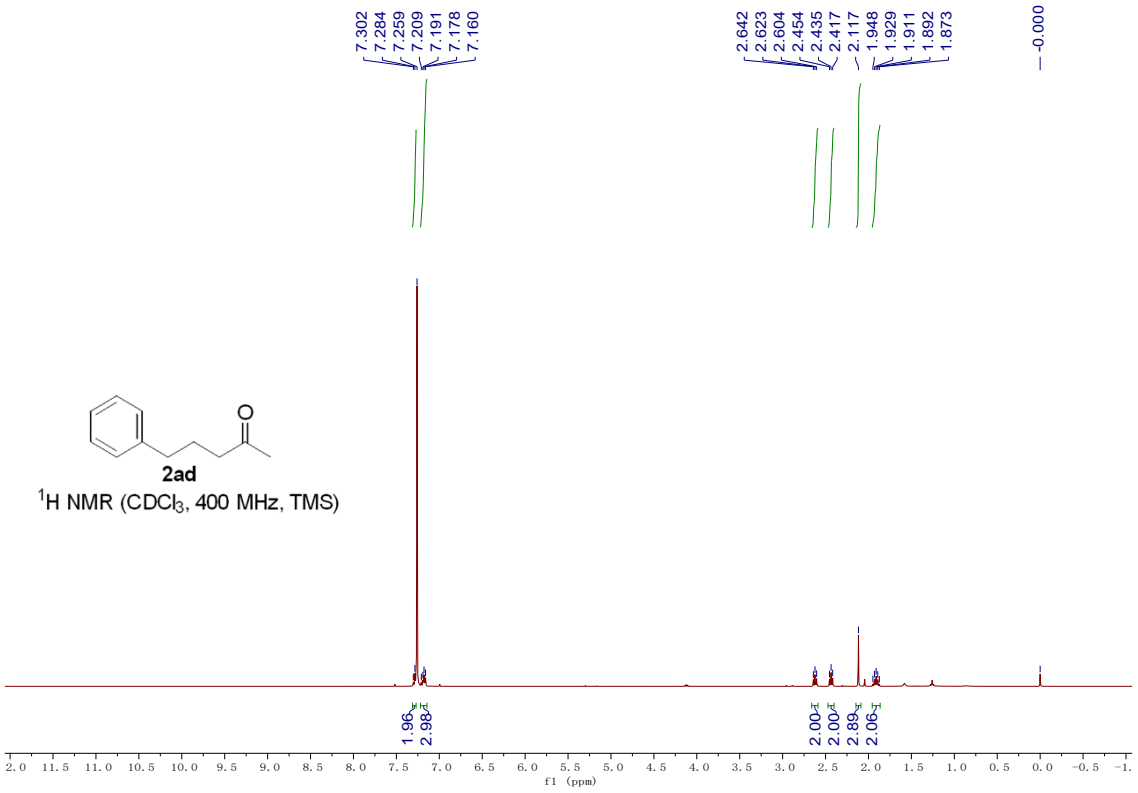


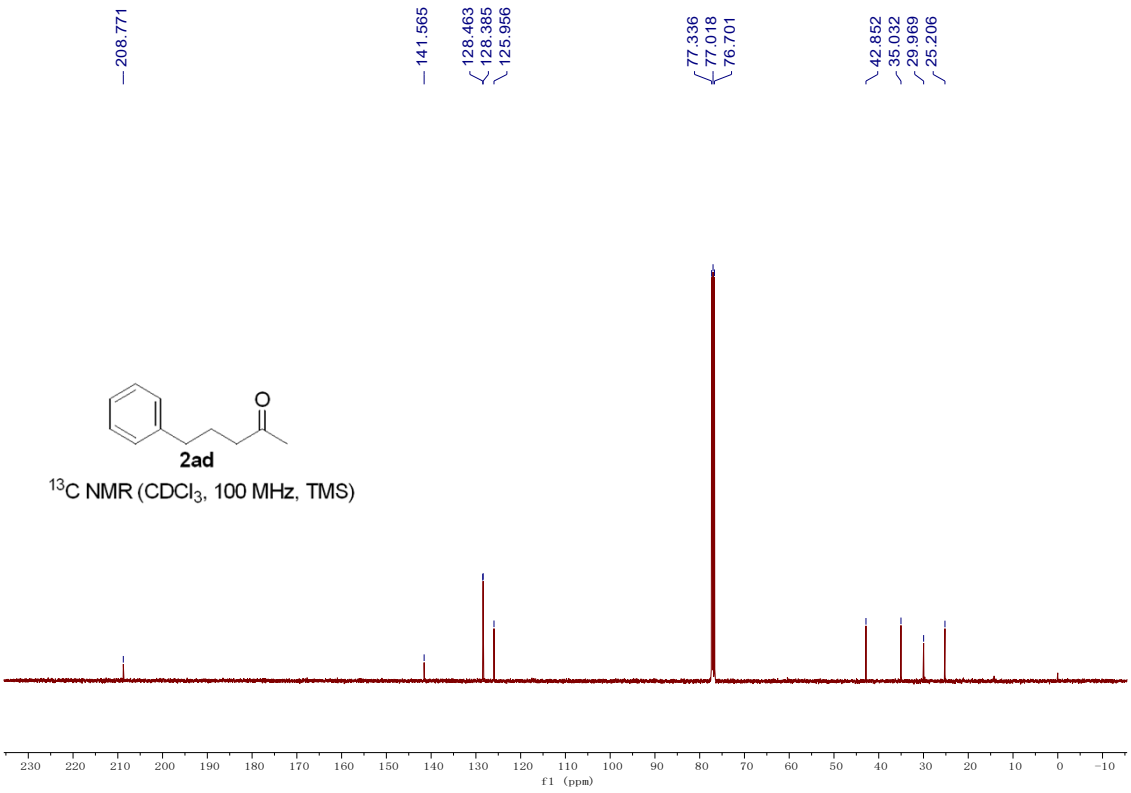

200.232
141.992
139.108
130.367
129.250
128.596
128.383
127.917
126.297
125.884
122.776
121.749
109.110
102.979
77.407
77.089
76.772
37.637
35.417
33.042
26.325
O
N
2ac
13C NMR (CDCl3, 100 MHz, TMS)
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

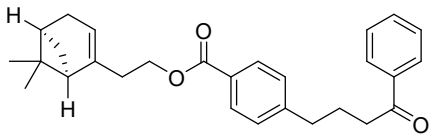


5-phenylpentan-2-one (2ad)

This is a known compound and its spectroscopic data are consistent with those in the previous literature.[20] A colorless oil. 12.7 mg, 48% yield. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 1.87-1.95(m, 2H), 2.12 (s, 3H), 2.44 (t, J = 7.4 Hz, 2H), 2.62 (t, J = 7.6 Hz, 2H), 7.16-7.21 (m, 3H), 7.26-7.30 (m, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 25.2, 30.0, 35.0, 42.9, 125.9, 128.4, 128.5, 141.6, 208.8.

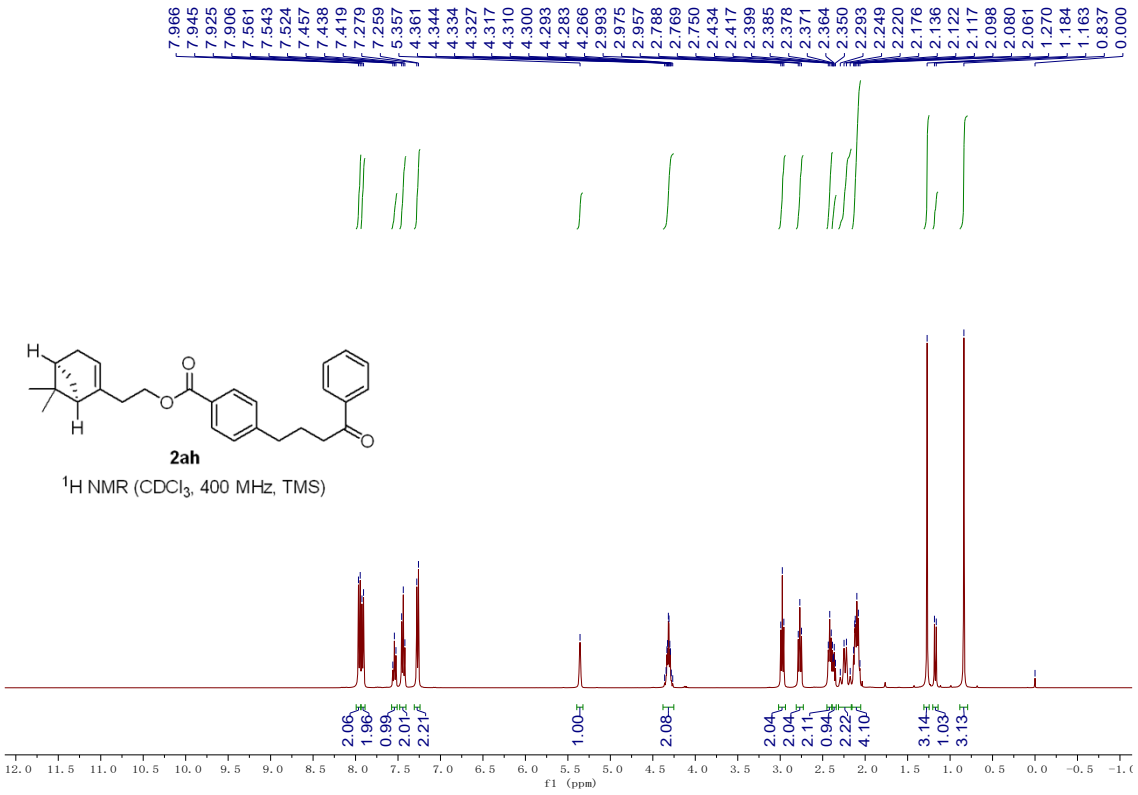


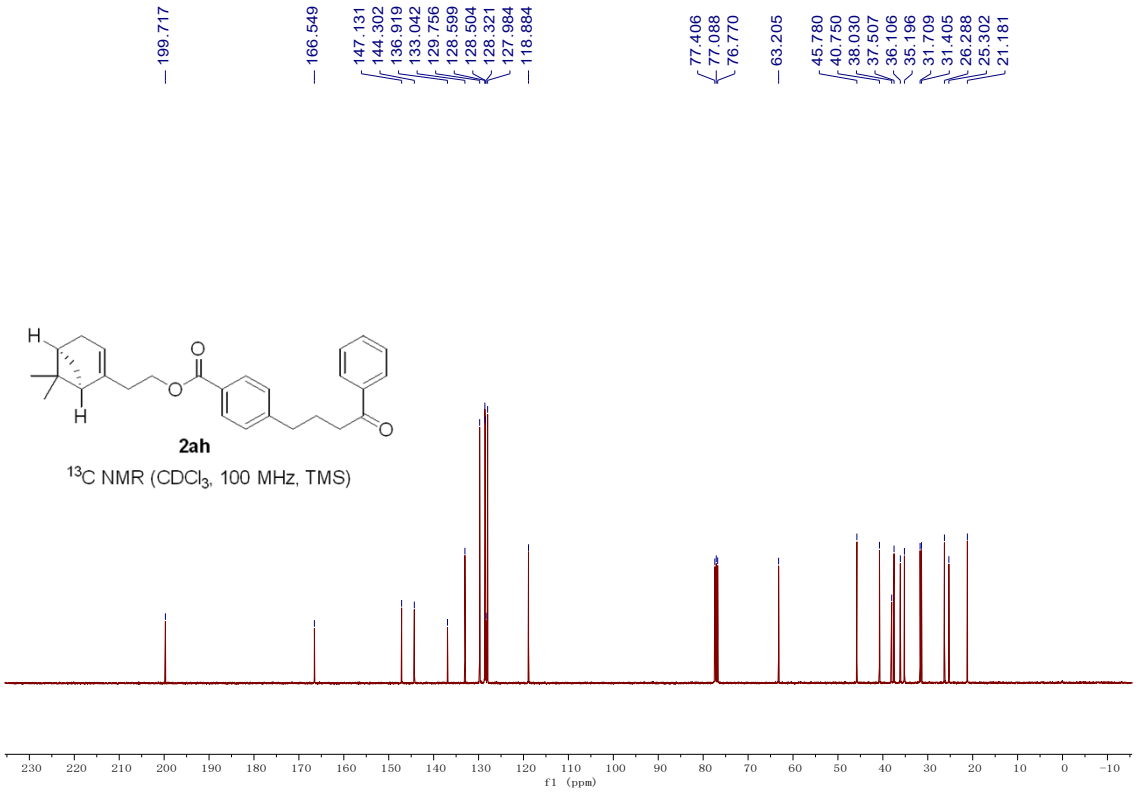

208.771
141.565
128.463
128.385
125.956
77.336
77.018
76.701
42.852
35.032
29.969
25.206
O
2ad
13C NMR (CDCl3, 100 MHz, TMS)
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)

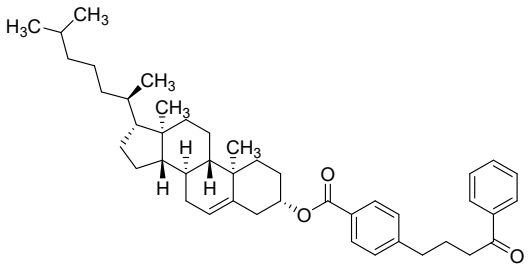


2-((1R,5S)-6,6-dimethylbicyclo[3.1.1]hept-2-en-2-yl)ethyl 4-(4-oxo-4-phenylbutyl)benzoate (2ah)

A white solid. 79.1 mg, 95% yield. M.P.: 106-108 °C. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 0.84 (s, 3H), 1.17 (d, *J* = 8.4 Hz, 1H), 1.27 (s, 3H), 2.06-2.14 (m, 4H), 2.18-2.29 (m, 2H), 2.35-2.39 (m, 1H), 2.42 (t, *J* = 6.8 Hz, 2H), 2.77 (t, *J* = 7.6 Hz, 2H), 2.98 (t, *J* = 7.2 Hz, 2H), 4.27-4.36 (m, 2H), 5.36 (s, 1H), 7.27 (d, *J* = 8.0 Hz, 2H), 7.44 (t, *J* = 7.6 Hz, 2H), 7.54 (t, *J* = 7.4 Hz, 1H), 7.92 (d, *J* = 7.6 Hz, 2H), 7.96 (d, *J* = 8.4 Hz, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 21.2, 25.3, 26.3, 31.4, 31.7, 35.2, 36.1, 37.5, 38.0, 40.8, 45.8, 63.2, 118.9, 128.0, 128.3, 128.5, 128.6, 129.8, 133.0, 136.9, 144.3, 147.1, 166.5, 199.7. IR (EtOH) $\tilde{\nu}$ 2972, 2880, 1742, 1414, 1379, 1329, 1273, 1088, 1046, 880, 803, 756, 637 cm^{-1}. HRMS (ESI) calcd. for $C_{28}H_{32}O_3Na$ (M+Na): 439.2244, Found: 439.2250.

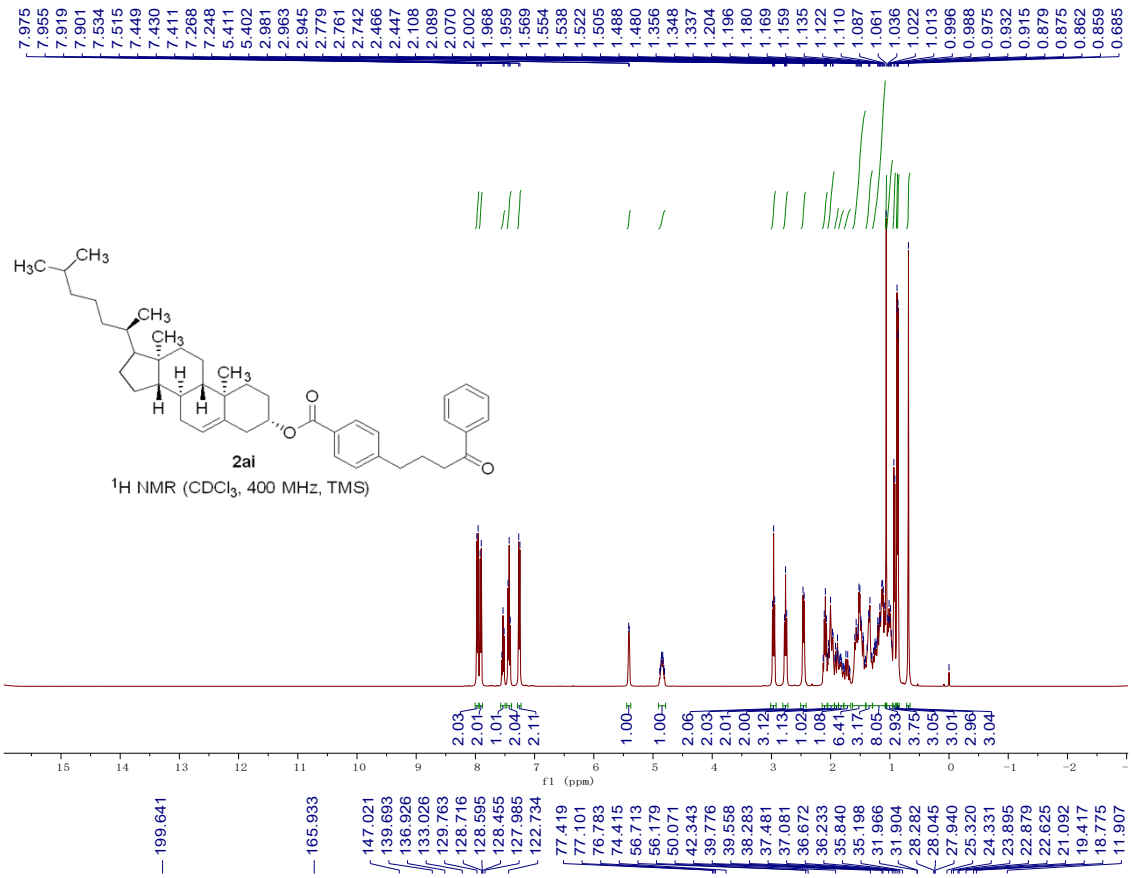


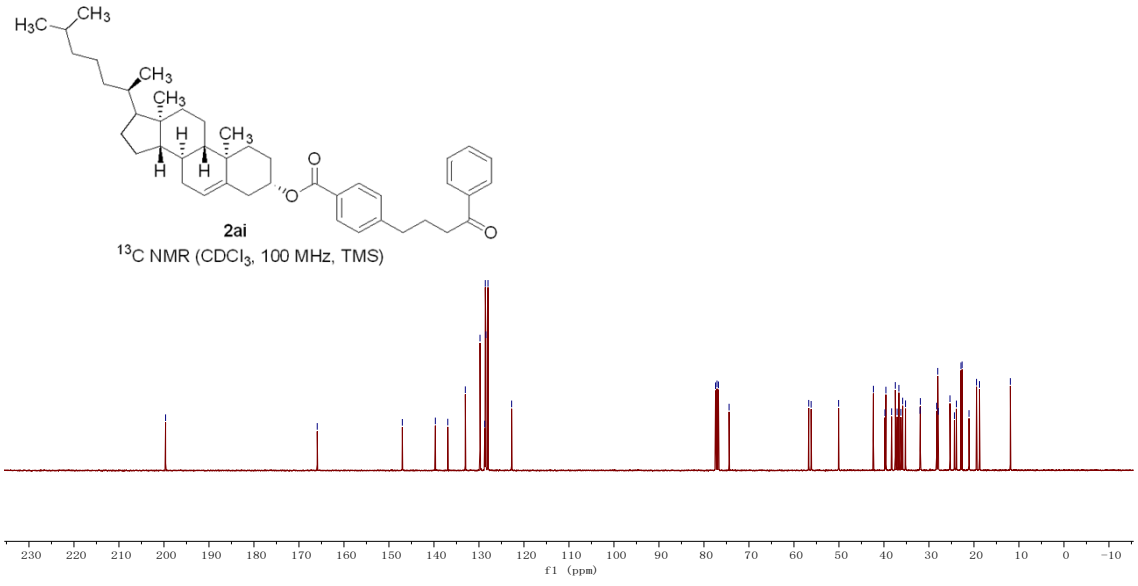

199.717
166.549
147.131
144.302
136.919
133.042
129.756
128.599
128.504
128.321
127.984
118.884
77.406
77.088
76.770
63.205
45.780
40.750
38.030
37.507
36.106
35.196
31.709
31.405
26.288
25.302
21.181
H
O
O
H
O
2ah
13C NMR (CDCl3, 100 MHz, TMS)
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 −10
f1 (ppm)



(3S,8S,9S,10R,13R,14S,17R)-10,13-dimethyl-17-((R)-6-methylheptan-2-yl)-2,3,4,7,8,9,10,11,12,13,14,15,16,17-tetradecahydro-1H-cyclopenta[a]phenanthren-3-yl4-(4-oxo-4-phenylbutyl) Benzoate (2ai)

A white solid. 117.2 mg, 92% yield. M.P.: 121-123 ^{o}C. ^{1}H NMR ($CDCl_3$, TMS, 400 MHz) δ 0.69 (s, 3H), 0.86 (d, *J* = 1.2 Hz, 3H), 0.88 (d, *J* = 1.6 Hz, 3H), 0.92 (d, *J* = 6.8 Hz, 3H), 0.97-1.04 (m, 4H), 1.06 (s, 3H), 1.09-1.28 (m, 8H),1.30-1.41 (m, 3H), 1.43-1.59 (m, 6H), 1.67-1.77 (m, 1H), 1.78-1.86 (m, 1H), 1.88-1.93 (m, 1H), 1.96-2.03 (m, 3H), 2.05-2.13 (m, 2H), 2.46 (d, *J* = 7.6 Hz, 2H), 2.76 (t, *J* = 7.2 Hz, 2H), 2.96 (t, *J* = 7.2 Hz, 2H), 4.81-4.89 (m, 1H), 5.40 (d, *J* = 3.6 Hz, 1H), 7.26 (d, *J* = 8.0 Hz, 2H), 7.43 (t, *J* = 7.6 Hz, 2H), 7.53 (t, *J* = 7.4 Hz, 1H), 7.91 (d, *J* = 7.2 Hz, 2H), 7.96 (d, *J* = 8.0 Hz, 2H). ^{13}C NMR ($CDCl_3$, TMS, 100 MHz) δ 11.9, 18.8, 19.4, 21.1, 22.6, 22.9, 23.9, 24.3, 25.3, 27.9, 28.0, 28.3, 31.9, 32.0, 35.2, 35.8, 36.2, 36.7, 37.1, 37.5, 38.3, 39.6, 39.8, 42.3, 50.1, 56.2, 56.7, 74.4, 122.7, 128.0, 128.5, 128.6, 128.7, 129.8, 133.0, 136.9, 139.7, 147.0, 165.9, 199.6. IR (EtOH) $\tilde{\nu}$ 2902, 2864, 2848, 1703, 1675, 1457, 1369, 1273, 1260, 1195, 1116, 1037, 1022, 872, 799, 742, 686, 563 cm^{-1}. HRMS (ESI) calcd. for $C_{44}H_{60}O_3Na$ (M+Na): 659.4435, Found: 659.4432.


2ai
^{1}H NMR ($CDCl_3$, 400 MHz, TMS)
f1 (ppm)


2ai
^{13}C NMR ($CDCl_3$, 100 MHz, TMS)
f1 (ppm)

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