Electronic Supplementary Material (ESI) for ChemComm.

Supporting Information for

Palladium-Catalyzed Coupling of Amides and Cyclopropanols for the Synthesis of *γ*-Diketones

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Content

General Information 3
Optimization of the Reaction Conditions 3
Optimization of the Reaction Conditions for *N*-acyl phthalimides 3
Optimization of the Reaction Conditions for *N*-glutarimide benzamides 5
Optimization of the Reaction Conditions for certain *N*-glutarimide amides 6
Typical Procedure for the Synthesis of *γ*-Diketones 8
Characterization data of *N*-glutarimide amide 9
Characterization data of cyclopropanols 9
Characterization data of *γ*-diketones 10
Mechanistic Studies 21
Coupling of cyclopropanol and amide in the presence of BHT 21
Radical clock experiment 22
NMR spectrum evidence for the release of glutarimide. 22
Competition experiment 24
Control experiments 24
Proposed mechanism 26
Exploration for the cross-coupling reaction of acid chloride with cyclopropanol 26
Kinetic competition experiment 28
Reactivity order chemistry set 29
Reduction of *γ*-diketones to alkane 29
Reference 31
NMR spectra 32

General Information

All reactions were performed in a nitrogen-filled dry box unless otherwise stated. All solvents were obtained from commercial suppliers and were used as received. Toluene (PhMe) were purchased as HPLC-grade from Guoyao. Other commercially available reagents were used without further purification. Reaction temperature was reported corresponding to the oil bath temperature. Analytical thin-layer chromatography (TLC) was performed on Merck 60 F254 silica gel plates. Flash chromatography was performed using 40-63 μm silica gel (Si 60, Merck). ^{1}H and ^{13}C NMR spectra were recorded on Bruker 500 or 400 (stated espeacially) MHz NMR spectrometer in the solvents indicated. Chemical shifts (δ) are given in ppm relative to TMS. HRMS were obtained on a Thermo Fisher Scientific LTQ FT Ultra.

Tertiary cyclopropanols were prepared by Kulinkovich reaction or Simmons-Smith sequence according to the reported procedure.[1] The substrates of amide were prepared according to the reported literature procedures.[2] All the characteristic data are consistent with the data reported before.[3-10]

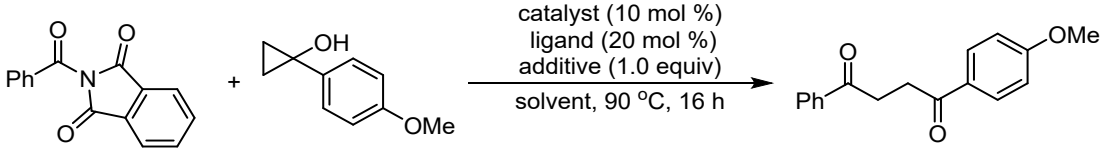
The amount of ligand PCy_3 is critical for the yield of γ-diketones, excessive ligand will reduce yields of γ-diketones. Otherwise, addition of 1.0 equiv amount of $B(OH)_3$ can promote the yield of γ-diketones derived from the reaction of **1a** and **2d**, but it seems ineffective for the other reactions sometime.

Additive distortion parameters ($\Sigma\tau + \chi_N$) refer to the literature reported before.[11]

Optimization of the Reaction Conditions

Optimization of the Reaction Conditions for *N*-acyl phthalimides

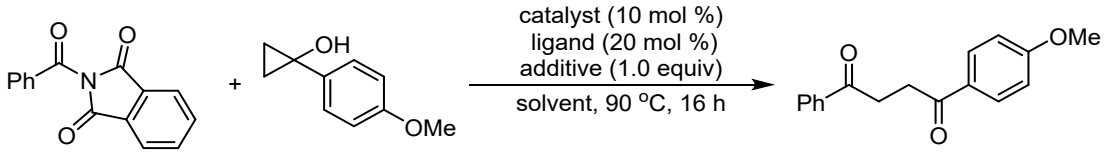
Table S1. Screening of solvent and ligand in the presence of $Pd(OAc)_2$



1aP **2d** **3ad**

Entry	catalyst	ligand	additive (1.0 equiv.)	solvent	Yield[a]
1	$Pd(OAc)_2$	PCy_3	K_2CO_3	1,4-Dioxane	Trace
2	$Pd(OAc)_2$	PCy_3	K_2CO_3	MeCN	Trace
3	$Pd(OAc)_2$	PCy_3	K_2CO_3	MeOH	ND
4	$Pd(OAc)_2$	PCy_3	K_2CO_3	THF	25%
5	$Pd(OAc)_2$	PCy_3	K_2CO_3	PhMe	30%
6	$Pd(OAc)_2$	PPh_3 (10 mol %)	K_2CO_3	PhMe	ND
7	$Pd(OAc)_2$	Dppf (10 mol %)	K_2CO_3	PhMe	ND
8	$Pd(OAc)_2$	IPr	K_2CO_3	PhMe	Trace
9	$Pd(OAc)_2$	PCy_3	Et_3N	PhMe	28%

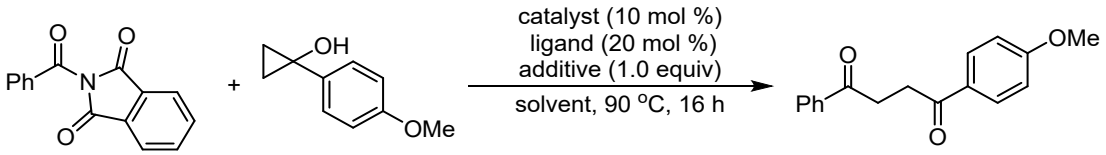
Table S2. Screening of ligand and additive in the presence of $Pd(OAc)_2$



1aP **2d** **3ad**

Entry	catalyst	ligand	additive	solvent	Yield[b]
1	$Pd(OAc)_2$	PCy_3	Et_3N	PhMe	29%
2	$Pd(OAc)_2$	P^tBu_3	Et_3N	PhMe	ND
3	$Pd(OAc)_2$	Dppm	Et_3N	PhMe	17%
4	$Pd(OAc)_2$	Dcype	Et_3N	PhMe	Trace
5	$Pd(OAc)_2$	X-phos	Et_3N	PhMe	messy
6	$Pd(OAc)_2$	Davephos	Et_3N	PhMe	ND
7	$Pd(OAc)_2$	2,2'-Bipyridine	Et_3N	PhMe	ND
8	$Pd(OAc)_2$	PCy_3	---	PhMe	20%
9	$Pd(OAc)_2$	PCy_3	KOAc	PhMe	23%
10	$Pd(OAc)_2$	PCy_3	K_3PO_4	PhMe	<20%
11	$Pd(OAc)_2$	PCy_3	KO^tBu	PhMe	ND
12	$Pd(OAc)_2$	PCy_3	DABCO	PhMe	40%
13	$Pd(OAc)_2$	PCy_3	HOAc	PhMe	<20%
14	$Pd(OAc)_2$	PCy_3	$B(OH)_3$	PhMe	ND
15	$Pd(OAc)_2$	PCy_3	PhCOOH	PhMe	ND

Table S3. Screening of catalyst

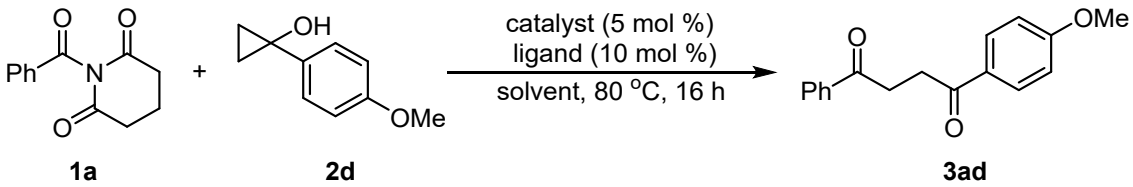


1aP **2d** **3ad**

Entry	catalyst	ligand	additive	solvent	yield[a]
1	$Pd(OAc)_2$	PCy_3	Et_3N	PhMe	29%
2	$Pd(OPiv)_2$	PCy_3	Et_3N	PhMe	40%
3	$Pd(CF_3COO)_2$	PCy_3	Et_3N	PhMe	ND
4	$Pd(acac)_2$	PCy_3	DABCO	PhMe	37%
5	$Pd_2(dba)_3$ (5 mol %)	PCy_3	Et_3N	PhMe	17%
6	$[Pd(allyl)Cl]_2$ (5 mol %)	PCy_3	Et_3N	PhMe	ND
7	$Pd(PPh_3)Cl_2$ (5 mol %)	PCy_3	Et_3N	PhMe	ND
8	$Pd(PPh_3)_4$ (5 mol %)	PCy_3	Et_3N	PhMe	ND
9	NiI_2	2,2'-Bipyridine	Zn (2.0 equiv)	DMF	ND
10	NiI_2	2,2'-Bipyridine	Zn (2.0 equiv)	PhMe	ND
11	$NiBr_2(dme)$	1,10-Phenanthroline	Zn (2.0 equiv)	MeOH	ND
12	$Ni(cod)_2$	IPr	---	PhMe	<30%
13	$Ru_3(CO)_{12}$	Dppp	---	PhMe	ND
14	$Ru_3(CO)_{12}$	PCy_3	---	PhMe	ND

15	$Pd(OPiv)_2$	PCy_3	DABCO	PhMe	41%
16	$Pd(OPiv)_2$	PCy_3	Et_3N	PhMe	62%[d]

Optimization of the Reaction Conditions for *N*-glutarimide benzamides



1a **2d** **3ad**

Table S4. Screening of solvent

Entry	catalyst	ligand	solvent	Yield[a]
1	$Pd(OAc)_2$	PCy_3	PhMe	56%
2	$Pd(OAc)_2$	PCy_3	1,4-dioxane	52%
3	$Pd(OAc)_2$	PCy_3	THF	55%
4	$Pd(OAc)_2$	PCy_3	MeCN	Trace
5	$Pd(OAc)_2$	PCy_3	DMF	ND
6	$Pd(OAc)_2$	PCy_3	DMSO	ND

Table S5. Screening of catalyst

Entry	catalyst	ligand	solvent	yield[a][b]
1	$Pd(OAc)_2$	PCy_3	PhMe	56%
2	$Pd(OPiv)_2$	PCy_3	PhMe	58%
3	$Pd(PPh_3)_4$	PCy_3	PhMe	43%
4	$Pd(acac)_2$	PCy_3	PhMe	60%
5	$Pd_2(dba)_3$	PCy_3	PhMe	60%
6	$PdCl_2$	PCy_3	PhMe	ND
7	$Pd(acac)_2$	PCy_3	PhMe	68%[c]

Table S6. Screening of ligand

Entry	catalyst	ligand	solvent	yield[a][d]
1	$Pd(acac)_2$	PPh_3	PhMe	16%
2	$Pd(acac)_2$	P^tBu_3	PhMe	ND
3	$Pd(acac)_2$	X-phos	PhMe	12%
4	$Pd(acac)_2$	Dcype	PhMe	Trace
5	$Pd(acac)_2$	Xantphos	PhMe	18%
6	$Pd(acac)_2$	Dppf	PhMe	10%
7	$Pd(acac)_2$	Dppm	PhMe	ND

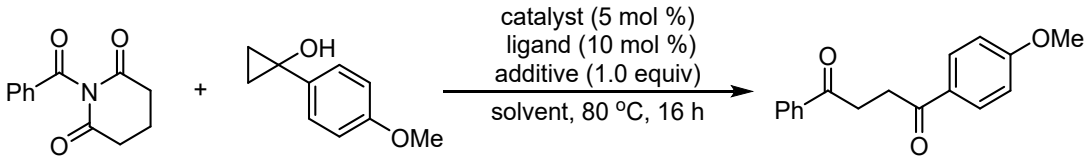
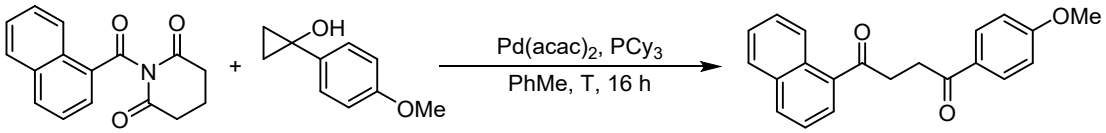


Table S7. Screening of Screening for additive

Entry	catalyst	ligand	additive (1.0 equiv)	solvent	Yield[b][d]
1	$Pd(acac)_2$	PCy_3	$B(OMe)_3$	PhMe	55%
2	$Pd(acac)_2$	PCy_3	PhCOOH	PhMe	61%
3	$Pd(acac)_2$	PCy_3	HOAc	PhMe	67%
4	$Pd(acac)_2$	PCy_3	$Zn(OTf)_2$	PhMe	ND
5	$Pd(acac)_2$	PCy_3	CuCl	PhMe	ND
6	$Pd(acac)_2$	PCy_3	H_3PO_4	PhMe	Trace
7	$Pd(acac)_2$	PCy_3	K_2CO_3	PhMe	17%
8	$Pd(acac)_2$	PCy_3	NaO^{t}Bu	PhMe	ND
9	$Pd(acac)_2$	PCy_3	Et_3N	PhMe	33%

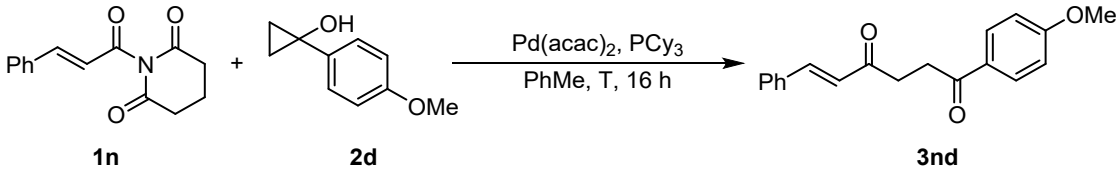
Optimization of the Reaction Conditions for certain *N*-glutarimide amides

Table S8. Optimization of the Reaction Conditions for the coupling of **1j** and **2d**



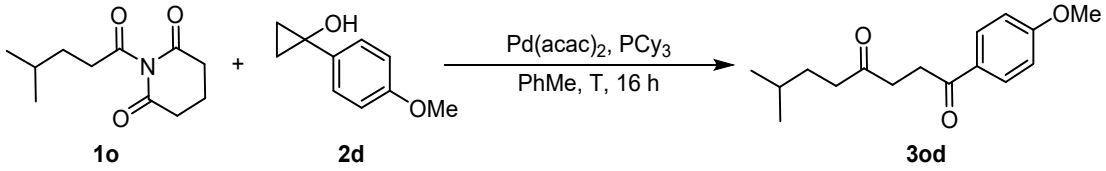
Entry	$Pd(acac)_2$	PCy_3	T	Yield[b]
1	5 mol %	10 mol %	80 °C	48%
2	10 mol %	20 mol %	80 °C	62%
3	5 mol %	10 mol %	100 °C	56%
4	10 mol %	20 mol %	100 °C	57%

Table S9. Optimization of the Reaction Conditions for the coupling of **1n** and **2d**



Entry	$Pd(acac)_2$	PCy_3	T	Yield[b]
1	5 mol %	10 mol %	80 °C	30%
2	5 mol %	10 mol %	100 °C	40%
3	10 mol %	20 mol %	100 °C	35%

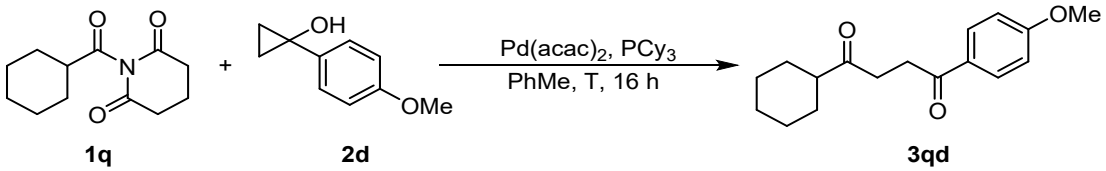
Table S10. Optimization of the Reaction Conditions for the coupling of **1o** and **2d**



1o **2d** **3od**

Entry	$Pd(acac)_2$	PCy_3	T	Yield[a]
1	10 mol %	20 mol %	100 °C	56%

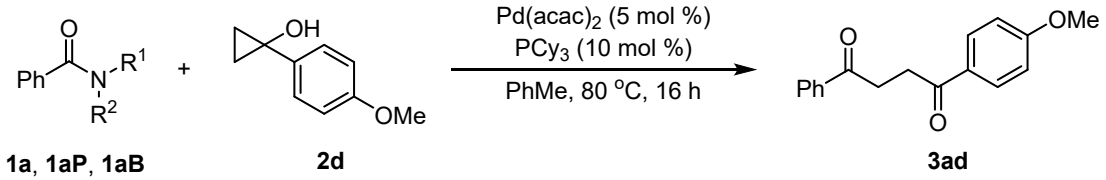
Table S11. Optimization of the Reaction Conditions for the coupling of **1q** and **2d**



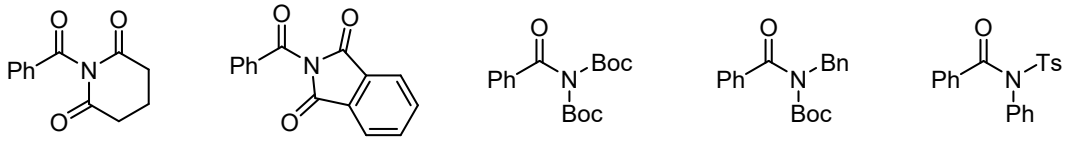
1q **2d** **3qd**

Entry	$Pd(acac)_2$	PCy_3	T	Yield[a]
1	5 mol %	10 mol %	80 °C	<30%
2	10 mol %	20 mol %	80 °C	53%
3	5 mol %	10 mol %	100 °C	39%
4	10 mol %	20 mol %	100 °C	66%

Scheme S1. *N*-substitutes evaluation of benzamides[a][c]



1a, **1aP**, **1aB** **2d** **3ad**



1a **1aP** **1aB**

68% 61%[d][e] Trace ND ND

All reactions were performed on 0.2 mmol scale benzamide with 1.0 equiv of the cyclopropanol under N_2 unless stated in 2 mL toluene;

[a]isolated yields;

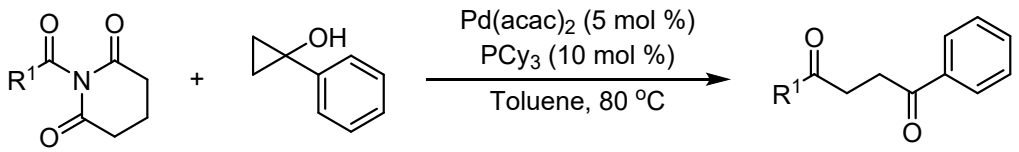
[b]yields determined by ^1H NMR with 1,3,5-trimethoxybenzene as the internal standard.

[c]1.25 equiv cyclopropanol was used;

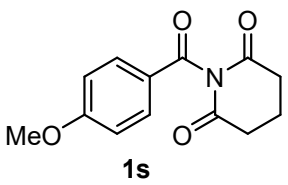
[d]1.5 equiv cyclopropanol was used;

[e]$Pd(OPiv)_2$ (10 mol %), PCy_3 (20 mol %), Et_3N (1.0 equiv) at 90 °C.

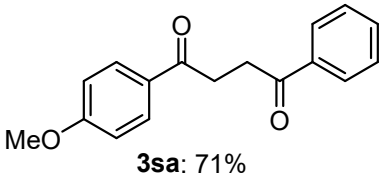
Scheme S2. Substrate scope of *N*-glutarimide amide with **2a** as coupling partner



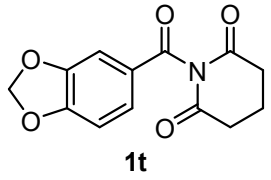
1s-1v **2a** **3sa-3va**



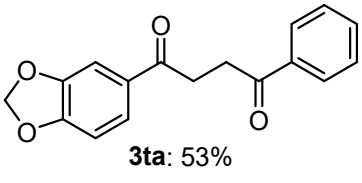
1s



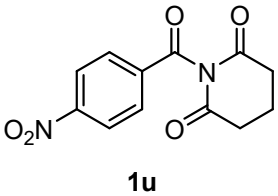
3sa: 71%



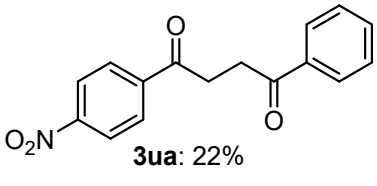
1t



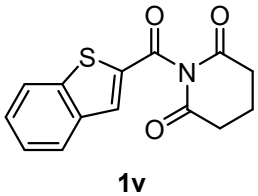
3ta: 53%



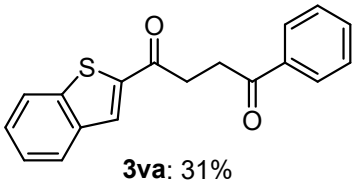
1u



3ua: 22%



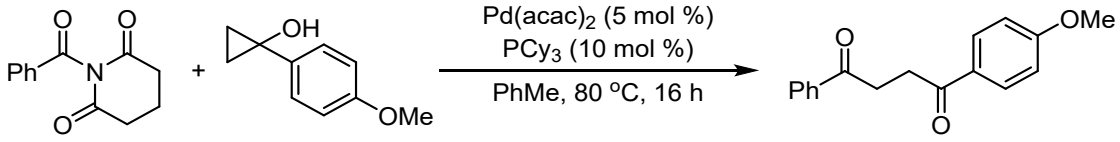
1v



3va: 31%

All reactions were performed on 0.2 mmol scale benzamide with 1.25 equiv of the cyclopropanol under N_2 unless stated in 2 mL toluene;

Typical Procedure for the Synthesis of *γ*-Diketones



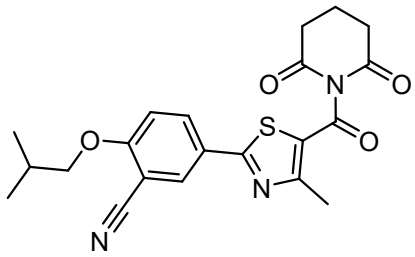
1a **2d** **3ad**

General procedure: A 10 mL oven-dried reaction vessel equipped with a magnetic stir bar was charged with **1a** (0.2 mmol, 1.0 equiv, 43.4 mg), **2d** (0.25 mmol, 1.25 equiv, 41mg), $Pd(acac)_2$ (0.01 mol, 0.05 equiv, 3.1 mg). The vessel was capped with a rubber septum and then transferred to the glove. PCy_3 (10 mol %, 0.02 mmol, 5.6 mg) then was added and removed from glove. The reaction

mixture was resolved in PhMe (2 mL) and allowed to stir at 80 °C for 16 h. The reaction was cooled to room temperature then mixture was filtered on celite and concentrated to yield the crude product, which was further purified by flash chromatography (Petroleum ether/EtOAc = 5:1 or Petroleum ether/ Dichloromethane = 1:2) to give the desired product **3ad**.

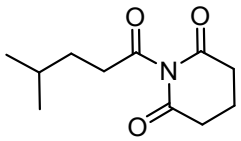
Characterization data of *N*-glutarimide amide

5-(5-(2,6-Dioxopiperidine-1-carbonyl)thiazol-2-yl)-2-isobutoxybenzonitrile (1m)



This compound was prepared according to the general procedure. Purification by column chromatography on silica gel (Petroleum ether/ Ethyl acetate = 1/1, v/v) afforded **3qd** as a yellow solid (29 mg). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.13 (d, *J* = 2.0 Hz, 1H), 8.11 (dd, *J* = 9.0, 2.5 Hz, 1H), 7.01 (d, *J* = 9.0 Hz, 1H), 3.90 (d, *J* = 6.5 Hz, 2H), 2.81 (s, 3H), 2.76 (t, *J* = 6.5 Hz, 4H), 2.20 (hept, *J* = 6.5 Hz, 1H), 2.13 (p, *J* = 6.5 Hz, 2H), 1.09 (d, *J* = 7.0 Hz, 6H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 171.39, 169.15, 164.90, 163.01, 162.65, 132.84, 132.45, 126.26, 125.26, 115.13, 112.70, 103.11, 75.77, 32.38, 28.12, 19.01, 18.21, 17.29.
HRMS (ESI) m/z calcd. for $C_{21}H_{21}N_3O_4S$ $[M-H]^-$ 410.1180, found 410.1176.

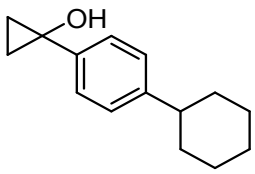
1-(4-Methylpentanoyl)piperidine-2,6-dione (1o)



White solid. ^{1}H NMR (500 MHz, Chloroform-*d*) δ 2.73 – 2.59 (m, 6H), 2.01 (h, *J* = 6.4 Hz, 2H), 1.60 (qd, *J* = 7.4, 6.4, 2.3 Hz, 3H), 0.90 (t, *J* = 5.8 Hz, 6H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 178.36, 171.56, 171.52, 39.09, 39.07, 32.24, 32.22, 32.03, 27.22, 22.20, 17.29.
HRMS (FI) m/z calcd. for $C_{11}H_{17}NO_3$ $[M]^+$ 211.1203, found 211.1197.

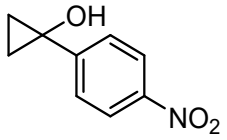
Characterization data of cyclopropanols

1-(4-cyclohexylphenyl)cyclopropan-1-ol (2c)



White solid. ^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.26 – 7.23 (m, 2H), 7.20 – 7.17 (m, 2H), 2.52 – 2.45 (m, 1H), 2.01 (br, 1H), 1.91 – 1.81 (m, 4H), 1.78 – 1.71(m, 1H), 1.47 – 1.33 (m, 4H), 1.31 – 1.25 (m, 1H), 1.24 – 1.22 (m, 2H), 1.04 – 1.00 (m, 2H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 146.47, 141.51, 126.83, 124.60, 56.70, 44.17, 34.49, 26.91, 26.16, 17.45.
HRMS (FI) m/z calcd. for $C_{15}H_{20}O$ $[M]^+$ 216.1509, found 216.1511.

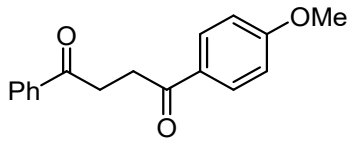
1-(4-Nitrophenyl)cyclopropan-1-ol (2i)



Yellow solid.[1]H NMR (500 MHz, Chloroform-*d*) δ 8.17 – 8.13 (m, 2H), 7.40 – 7.36 (m, 2H), 2.69 (br, 1H), 1.47 – 1.42 (m, 2H), 1.20 – 1.15 (m, 2H). [13]C NMR (126 MHz, Chloroform-*d*) δ 152.87, 146.16, 124.26, 123.55, 56.12, 20.28.
HRMS (FI) m/z calcd. for $C_9H_{10}O_3N$ $[M]^+$ 180.0654, found 180.0655.

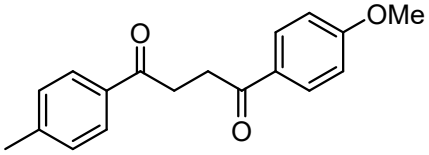
Characterization data of *γ*-diketones

1-(4-Methoxyphenyl)-4-phenylbutane-1,4-dione (3ad/3sa)



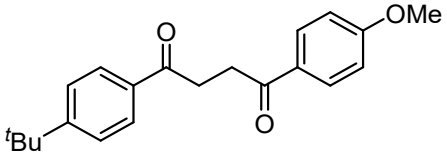
White solid (36.7 mg, 68%). [1]H NMR (500 MHz, Chloroform-d) *δ* 8.06 – 8.00 (m, 4H), 7.60 – 7.55 (m, 1H), 7.50 – 7.45 (m, 2H), 6.98 – 6.93 (m, 2H), 3.87 (s, 3H), 3.47 – 3.39 (m, 4H). [13]C NMR (126 MHz, Chloroform-*d*) δ 198.85, 197.15, 163.50, 136.81, 133.07, 130.35, 129.86, 128.55, 128.10, 113.70, 55.45, 32.65, 32.21.
The spectroscopic data matched literature values.[12]

1-(4-Methoxyphenyl)-4-(p-tolyl)butane-1,4-dione (3bd)



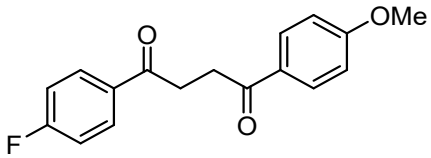
White solid (31.2 mg, 62%). [1]H NMR (500 MHz, Chloroform-*d*) δ 8.03 – 7.99 (m, 2H), 7.95 – 7.91 (m, 2H), 7.29 – 7.24 (m, 2H), 6.96 – 6.92 (m, 2H), 3.86 (s, 3H), 3.44 – 3.36 (m, 4H), 2.41 (s, 3H). [13]C NMR (126 MHz, Chloroform-*d*) δ 198.45, 197.25, 163.45, 143.80, 134.30, 130.32, 129.87, 129.22, 129.20, 128.18, 113.66, 55.41, 32.51, 32.21, 21.59.
The spectroscopic data matched literature values.[13]

1-(4-(*tert*-Butyl)phenyl)-4-(4-methoxyphenyl)butane-1,4-dione (3cd)



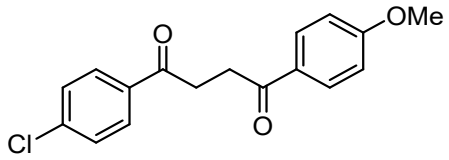
White solid (35.7 mg, 68%). [1]H NMR (500 MHz, Chloroform-*d*) δ 8.03 – 7.99 (m, 2H), 7.99 – 7.95 (m, 2H), 7.48 (dt, *J* = 8.0, 2.0 Hz, 2H), 6.96 – 6.92 (m, 2H), 3.86 (s, 3H), 3.44 - 3,38 (m, 4H), 1.34 (s, 9H). [13]C NMR (126 MHz, Chloroform-*d*) δ 198.47, 197.21, 163.43, 156.72, 134.21, 130.30, 129.86, 128.02, 125.45, 113.65, 55.39, 35.04, 32.50, 32.23, 31.03.
HRMS (FI) m/z calcd. for $C_{21}H_{24}O_3$ $[M]^+$ 324.1720, found 324.1712.

1-(4-Fluorophenyl)-4-(4-methoxyphenyl)butane-1,4-dione (3dd)



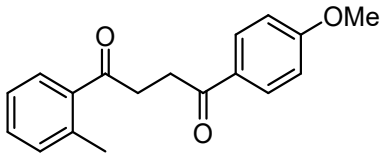
White solid (44.4 mg, 78%). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.07 – 8.02 (m, 2H), 8.02 – 7.97 (m, 2H), 7.15 – 7.10 (m, 2H), 6.95 – 6.91 (m, 2H), 3.85 (s, 3H), 3.40-3.37 (m, 4H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 197.22, 196.99, 166.70, 164.67, 163.50, 133.24, 133.21, 130.71, 130.64, 130.30, 129.73, 115.67, 115.49, 113.68, 55.40, 32.45, 32.14. ^{19}F NMR (471 MHz, Chloroform-*d*) δ -105.36.
The spectroscopic data matched literature values.[14]

1-(4-Chlorophenyl)-4-(4-methoxyphenyl)butane-1,4-dione (3ed)



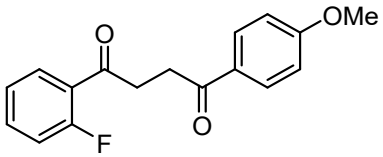
White solid (28.8 mg, 53%). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.04 – 7.95 (m, 4H), 7.48 – 7.43 (m, 2H), 6.98 – 6.93 (m, 2H), 3.88 (s, 3H), 3.44 – 3.37 (m, 4H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 197.69, 196.97, 163.58, 139.51, 135.16, 130.37, 129.76, 129.54, 128.89, 113.74, 55.47, 32.58, 32.19.
The spectroscopic data matched literature values.[14]

1-(4-Methoxyphenyl)-4-(*o*-tolyl)butane-1,4-dione (3fd)



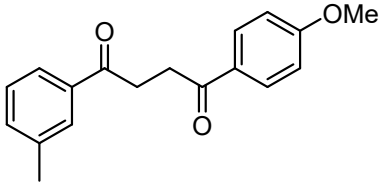
White solid (33.5 mg, 59%). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.02 – 7.98 (m, 2H), 7.80 (dd, *J* = 8.0, 1.5 Hz, 1H), 7.37 (td, *J* = 7.5, 1.5 Hz, 1H), 7.30 – 7.22 (m, 2H), 6.95 – 6.92 (m, 2H), 3.86 (s, 3H), 3.41 – 3.37 (m, 2H), 3.34 – 3.30 (m, 2H), 2.50 (s, 3H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 202.81, 197.05, 163.44, 137.95, 137.88, 131.79, 131.18, 130.28, 129.82, 128.53, 125.63, 113.65, 55.40, 35.34, 32.43, 21.19.
The spectroscopic data matched literature values.[15]

1-(2-Fluorophenyl)-4-(4-methoxyphenyl)butane-1,4-dione (3gd)



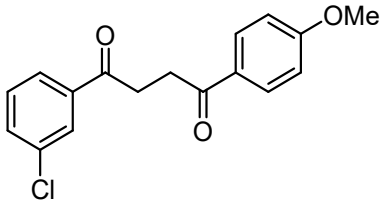
White solid (20.1 mg, 35%). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.03 – 7.98 (m, 2H), 7.89 (td, *J* = 7.5, 2.0 Hz, 1H), 7.54 -7.49 (m, 1H), 7.22 (td, *J* = 7.5, 1.0 Hz, 1H), 7.15 (ddd, *J* = 11.0, 8.0, 1.0 Hz, 1H), 6.96 – 6.92 (m, 2H), 3.87 (s, 3H), 3.45-3.37 (m, 4H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 197.16, 197.12, 196.94, 163.46, 163.06, 161.04, 134.51, 134.43, 130.65, 130.63, 130.32, 129.85, 124.37, 124.35, 116.74, 116.55, 113.67, 55.43, 37.47, 37.40, 32.19, 32.17. ^{19}F NMR (471 MHz, Chloroform-*d*) δ -109.01.
HRMS (FI) m/z calcd. for $C_{17}H_{15}O_3F$ $[M]^+$ 286.1000, found 286.0985.

1-(4-Methoxyphenyl)-4-(m-tolyl)butane-1,4-dione (3hd)



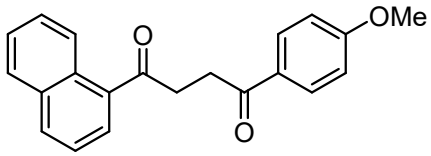
White solid (40.5 mg, 72%). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.03 – 7.99 (m, 2H), 7.85 – 7.80 (m, 2H), 7.39 – 7.32 (m, 2H), 6.96 – 6.91 (m, 2H), 3.86 (s, 3H), 3.44 – 3.37 (m, 4H), 2.40 (s, 3H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 199.00, 197.17, 163.44, 138.25, 136.79, 133.77, 130.30, 129.83, 128.58, 128.38, 125.25, 113.64, 55.39, 32.65, 32.20, 21.28.
The spectroscopic data matched literature values.[16]

1-(3-Chlorophenyl)-4-(4-methoxyphenyl)butane-1,4-dione (3id)



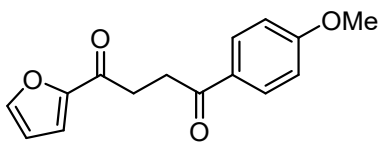
White solid (25.3 mg, 42%). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.03 – 7.98 (m, 3H), 7.91 (dt, *J* = 8.0, 1.5 Hz, 1H), 7.54 (ddd, *J* = 8.0, 2.5, 1.0 Hz, 1H), 7.42 (t, *J* = 8.0 Hz, 1H), 6.97 – 6.92 (m, 2H), 3.87 (s, 3H), 3.44 – 3.37 (m, 4H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 197.62, 196.83, 163.56, 134.89, 132.97, 130.34, 129.90, 129.71, 128.23, 126.19, 113.72, 55.45, 32.69, 32.16.
The spectroscopic data matched literature values.[14]

1-(4-Methoxyphenyl)-4-(naphthalen-1-yl)butane-1,4-dione (3jd)



White solid (39.2 mg, 62%). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.61 (dd, *J* = 8.5, 1.0 Hz, 1H), 8.07 – 8.02 (m, 3H), 7.99 (dt, *J* = 8.5, 1.0 Hz, 1H), 7.89 – 7.86 (m, 1H), 7.60 – 7.56 (m, 1H), 7.55 – 7.50 (m, 2H), 6.98 – 6.94 (m, 2H), 3.87 (s, 3H), 3.49 (s, 4H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 203.03, 197.05, 163.48, 136.02, 133.87, 132.45, 130.33, 130.07, 129.83, 128.29, 127.76, 127.55, 126.32, 125.81, 124.39, 113.69, 55.42, 36.02, 32.63.
The spectroscopic data matched literature values.[17]

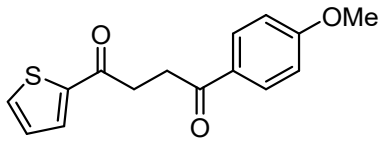
1-(Furan-2-yl)-4-(4-methoxyphenyl)butane-1,4-dione (3kd)



White solid (34.5 mg, 67%). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.00 – 7.96 (m, 2H), 7.58 (dd, *J* = 1.5, 0.5 Hz, 1H), 7.24 (dd, *J* = 3.5, 1.0 Hz, 1H), 6.94 – 6.90 (m, 2H), 6.53 (dd, *J* = 3.5, 2.0 Hz, 1H), 3.85 (s, 3H), 3.40 – 3.36 (m, 2H), 3.29 – 3.25 (m, 2H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 196.78, 187.98, 163.48, 152.50, 146.27, 130.29, 129.67, 117.04, 113.66, 112.13, 55.40, 32.26, 31.86.

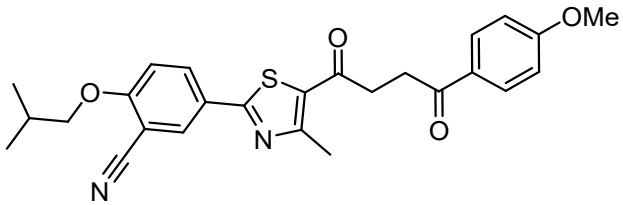
The spectroscopic data matched literature values.[14]

1-(4-Methoxyphenyl)-4-(thiophen-2-yl)butane-1,4-dione (3ld)



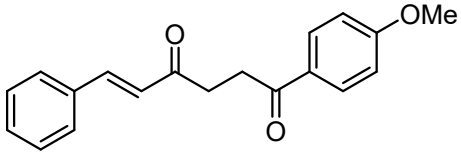
White solid (39 mg, 71%). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.02 – 7.97 (m, 2H), 7.82 (dd, *J* = 4.0, 1.0 Hz, 1H), 7.63 (dd, *J* = 5.0, 1.5 Hz, 1H), 7.14 (dd, *J* = 5.0, 3.5 Hz, 1H), 6.96 – 6.91 (m, 2H), 3.86 (s, 3H), 3.42 – 3.35 (m, 4H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 196.90, 191.78, 163.52, 143.91, 133.45, 131.98, 130.37, 130.33, 129.71, 128.07, 113.69, 55.43, 33.23, 32.22.
The spectroscopic data matched literature values.[18]

2-Isobutoxy-5-(5-(4-(4-methoxyphenyl)-4-oxobutanoyl)-4-methylthiazol-2-yl)benzonitrile (3md)



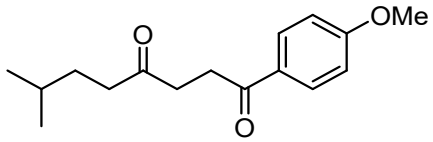
Light yellow solid (27 mg, 29%) ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.21 (d, *J* = 2.5 Hz, 1H), 8.11 (dd, *J* = 9.0, 2.5 Hz, 1H), 8.02 – 7.98 (m, 2H), 7.02 (d, *J* = 7.5 Hz, 1H), 6.97 – 6.93 (m, 2H), 3.90 (d, *J* = 6.5 Hz, 2H), 3.87 (s, 3H), 3.43 – 3,39 (m, 2H), 3.30 – 3.26 (m, 2H), 2.78 (s, 3H), 1.09 (d, *J* = 6.5 Hz, 6H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 196.61, 191.52, 166.53, 163.62, 162.56, 159.79, 132.66, 132.17, 130.64, 130.36, 129.58, 125.85, 115.34, 113.75, 112.62, 103.00, 55.46, 36.82, 32.31, 28.13, 19.02, 18.49.
HRMS (ESI) m/z calculated for $C_{26}H_{26}N_2O_4S$ $[M+H^+]^+$ 463.1687, found 463.1686.

(*E*)-1-(4-Methoxyphenyl)-6-phenylhex-5-ene-1,4-dione (3nd)



White solid. ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.03 – 7.98 (m, 2H), 7.64 (d, *J* = 16.5 Hz, 1H), 7.59 – 7.55 (m, 2H), 7.42 – 7.38 (m, 3H), 6.97 – 6.92 (m, 2H), 6.82 (d, *J* = 16.5 Hz, 1H), 3.87 (s, 3H), 3.35 (t, *J* = 6.5 Hz, 2H), 3.14 (t, *J* = 6.5 Hz, 2H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 198.84, 197.16, 163.51, 142.75, 134.51, 130.42, 130.35, 129.82, 128.91, 128.29, 126.19, 113.70, 55.45, 34.51, 32.23.
The spectroscopic data matched literature values.[17]

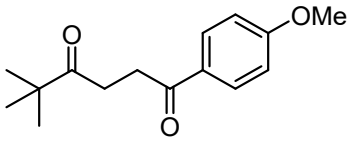
1-(4-Methoxyphenyl)-7-methyloctane-1,4-dione (3od)



Light green solid (29.1 mg, 56%). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.97 – 7.93 (m, 2H), 6.94 – 6.89 (m, 2H), 3.85 (s, 3H), 3.24 – 3.20 (m, 2H), 2.83 (t, *J* = 6.5 Hz, 2H), 2.54 – 2.49 (m, 2H), 1.59

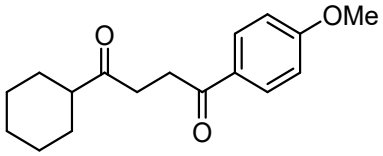
– 1.47 (m, 3H), 0.89 (d, *J* = 6.5 Hz, 6H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 210.05, 197.15, 163.44, 130.25, 129.76, 113.64, 55.40, 41.03, 36.20, 32.62, 31.98, 27.69, 22.31.
The spectroscopic data matched literature values.[19]

1-(4-Methoxyphenyl)-5,5-dimethylhexane-1,4-dione (3pd)



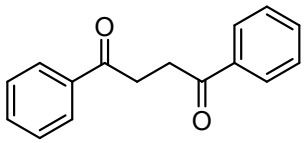
Colorless liquid (3mg, 6%). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.02 – 7.98 (m, 2H), 6.98 – 6.93 (m, 2H), 3.89 (s, 3H), 3.23 (t, *J* = 6.5 Hz, 2H), 2.97 (t, *J* = 6.5 Hz, 2H), 1.23 (s, 9H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 214.81, 197.44, 163.43, 130.28, 129.95, 113.66, 55.44, 44.07, 32.03, 30.82, 26.63.
The spectroscopic data matched literature values.[20]

1-Cyclohexyl-4-(4-methoxyphenyl)butane-1,4-dione (3qd)



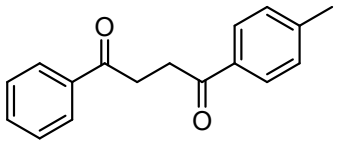
White solid (35.9 mg, 66%). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.98 – 7.94 (m, 2H), 6.94 – 6.90 (m, 2H), 3.86 (s, 3H), 3.24 – 3.19 (m, 2H), 2.87 (m, 2H), 2.46 (tt, *J* = 11.5, 3.5 Hz, 1H), 1.95 – 1.88 (m, 2H), 1.79 (dt, *J* = 12.5, 3.5 Hz, 2H), 1.70 – 1.64(m, 1H), 1.43 – 1.15 (m, 6H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 212.80, 197.28, 163.44, 130.27, 129.85, 113.65, 55.43, 50.92, 34.30, 31.94, 28.56, 25.87, 25.67.
HRMS (FI) m/z calcd. for $C_{17}H_{22}O_3$ $[M]^+$ 274.1564, found 274.1560.

1,4-Diphenylbutane-1,4-dione (3aa)



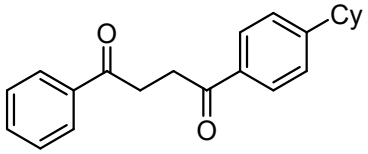
Colorless liquid (37.5 mg, 79%). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.06 – 8.02 (m, 4H), 7.60 – 7.55 (m, 2H), 7.50 – 7.45 (m, 4H), 3.46 (s, 4H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 198.62, 136.72, 133.10, 128.55, 128.07, 32.54.
The spectroscopic data matched literature values.[21]

1-Phenyl-4-(*p*-tolyl)butane-1,4-dione (3ab)



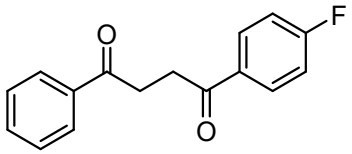
White solid (31.2 mg, 62%). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.06 – 8.02 (m, 2H), 7.96 – 7.92 (m, 2H), 7.59 – 7.55 (m, 1H), 7.50 – 7.45 (m, 2H), 7.29 – 7.25 (m, 2H), 3.46 -3.42 (m, 4H), 2.42 (s, 3H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 198.75, 198.26, 143.87, 136.77, 134.26, 133.07, 129.22, 128.54, 128.19, 128.08, 32.58, 32.44, 21.61.
The spectroscopic data matched literature values.[12]

1-(4-Cyclohexylphenyl)-4-phenylbutane-1,4-dione (3ac)



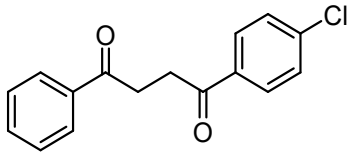
White solid (43.3 mg, 68%). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.06 – 8.02 (m, 2H), 7.99 – 7.95 (m, 2H), 7.59 – 7.54 (m, 1H), 7.50 – 7.44 (m, 2H), 7.33 – 7.29 (m, 2H), 3.48 – 3.41 (m, 4H), 2.57 (tt, *J* = 11.5, 3.5 Hz, 1H), 1.92 – 1.83 (m, 4H), 1.80 - 1.74 (m, 1H), 1.49 – 1.35 (m, 4H), 1.32 – 1.22 (m, 1H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 198.73, 198.28, 153.74, 136.76, 134.58, 133.04, 128.52, 128.29, 128.06, 127.02, 44.65, 34.06, 32.60, 32.43, 26.68, 25.99.
HRMS (FI) m/z calcd. for $C_{22}H_{24}O_2$ $[M]^+$ 320.1771, found 320.1766.

1-(4-Fluorophenyl)-4-phenylbutane-1,4-dione (3ae)



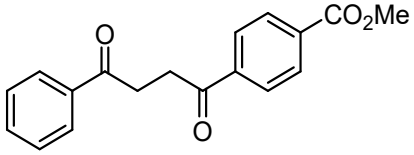
White solid (39.8 mg, 77%). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.09 – 8.01 (m, 4H), 7.60 – 7.55 (m, 1H), 7.51 – 7.45 (m, 2H), 7.17 – 7.12 (m, 2H), 3.48 – 3.44 (m, 2H), 3.44 – 3.40 (m, 2H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 198.53, 197.05, 166.77, 164.74, 136.66, 133.19, 133.17, 130.75, 130.68, 128.58, 128.07, 115.73, 115.56, 32.53, 32.41. ^{19}F NMR (471 MHz, Chloroform-*d*) δ -105.24.
The spectroscopic data matched literature values.[22]

1-(4-Chlorophenyl)-4-phenylbutane-1,4-dione (3af)



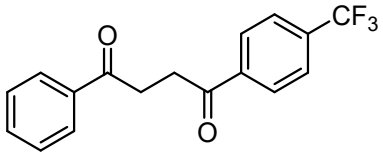
White solid (28.8 mg, 53%). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.05 – 8.01 (m, 2H), 7.99 – 7.95 (m, 2H), 7.60 – 7.55 (m, 1H), 7.50 – 7.42 (m, 4H), 3.48 – 3.44 (m, 2H), 3.43 – 3.39 (m, 2H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 198.43, 197.43, 139.51, 136.61, 135.06, 133.17, 129.50, 128.86, 128.57, 128.06, 32.50, 32.45.
The spectroscopic data matched literature values.[18]

Methyl 4-(4-oxo-4-phenylbutanoyl)benzoate (3ag)



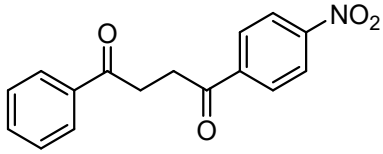
White solid (47.3 mg, 80%). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.16 – 8.12 (m, 2H), 8.10 – 8.07 (m, 2H), 8.05 – 8.02 (m, 2H), 7.61 – 7.56 (m, 1H), 7.51 – 7.46 (m, 2H), 3.95 (s, 3H), 3.49 – 3.45 (m, 4H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 198.28, 198.13, 166.12, 139.90, 136.54, 133.80, 133.14, 129.74, 128.53, 128.01, 127.94, 32.80, 32.44.
The spectroscopic data matched literature values.[23]

1-Phenyl-4-(4-(trifluoromethyl)phenyl)butane-1,4-dione (3ah)



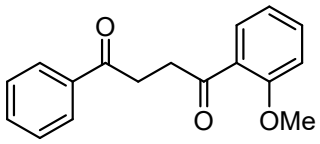
White solid (44.9 mg, 73%). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.15 (d, *J* = 7.5 Hz, 2H), 8.05 – 8.02 (m, 2H), 7.76 (d, *J* = 8.0 Hz, 2H), 7.61 – 7.57 (m, 1H), 7.51 – 7.47 (m, 2H), 3.52 – 3.44 (m, 4H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 198.30, 197.81, 139.46, 136.57, 133.30, 128.65, 128.45, 128.11, 125.74, 125.71, 125.68, 125.65, 32.79, 32.55. ^{19}F NMR (471 MHz, Chloroform-*d*) δ -63.10.
The spectroscopic data matched literature values.[24]

1-(4-Nitrophenyl)-4-phenylbutane-1,4-dione (3ai/3ua)



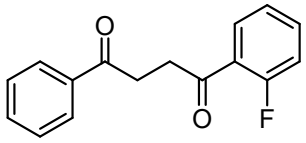
Yellow solid (42 mg, 74%). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.34 – 8.30 (m, 2H), 8.20 – 8.16 (m, 2H), 8.04 – 8.00 (m, 2H), 7.61 – 7.56 (m, 1H), 7.51 – 7.46 (m, 2H), 3.53 – 3.49 (m, 2H), 3.48 - 3.44 (m, 2H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 198.09, 197.30, 150.30, 141.24, 136.39, 133.35, 129.11, 128.63, 128.06, 123.81, 32.96, 32.56.
The spectroscopic data matched literature values.[25]

1-(2-Methoxyphenyl)-4-phenylbutane-1,4-dione (3aj)



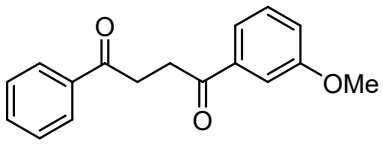
White solid (27.4 mg, 51%). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.05 – 8.01 (m, 2H), 7.77 (dd, *J* = 7.5, 2.0 Hz, 1H), 7.59 – 7.54 (m, 1H), 7.50 – 7.44 (m, 3H), 7.04 – 6.96 (m, 2H), 3.94 - 3.90 (m, 3H), 3.50 – 3.44 (m, 2H), 3.44 – 3.38 (m, 2H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 200.57, 199.03, 158.78, 136.91, 133.55, 132.95, 130.47, 128.55, 128.50, 128.08, 127.81, 120.61, 111.53, 55.50, 37.91, 32.97.
The spectroscopic data matched literature values.[16]

1-(2-Fluorophenyl)-4-phenylbutane-1,4-dione (3ak)



White solid (24.6 mg, 48%). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.05 – 8.01 (m, 2H), 7.90 (td, *J* = 7.5, 2.0 Hz, 1H), 7.59 – 7.54 (m, 1H), 7.54 – 7.49 (m, 1H), 7.49 – 7.44 (m, 2H), 7.22 (td, *J* = 7.5, 1.0 Hz, 1H), 7.15 (ddd, *J* = 11.0, 8.0, 1.0 Hz, 1H), 3.48 – 3.41 (m, 4H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 198.40, 196.89, 196.86, 163.07, 161.04, 136.70, 134.56, 134.49, 133.04, 130.63, 130.60, 128.51, 128.04, 125.44, 125.33, 124.37, 124.34, 116.73, 116.54, 37.36, 37.30, 32.51, 32.49. ^{19}F NMR (471 MHz, Chloroform-*d*) δ -108.95.
HRMS (FI) m/z calcd. for $C_{16}H_{13}O_2F$ $[M]^+$ 256.0894, found 256.0876.

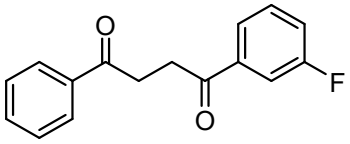
1-(3-Methoxyphenyl)-4-phenylbutane-1,4-dione (3al)



White solid (32 mg, 60%). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.05 – 8.01 (m, 2H), 7.65 – 7.62 (m, 1H), 7.59 – 7.55 (m, 1H), 7.54 (dd, *J* = 2.5, 1.5 Hz, 1H), 7.50 – 7.45 (m, 2H), 7.38 (t, *J* = 8.0 Hz, 1H), 7.12 (ddd, *J* = 8.5, 3.0, 1.0 Hz, 1H), 3.85 (s, 3H), 3.45 (s, 4H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 198.59, 198.43, 159.76, 138.06, 136.71, 133.08, 129.54, 128.53, 128.05, 120.74, 119.64, 112.22, 55.38, 32.67, 32.54.

The spectroscopic data matched literature values.[18]

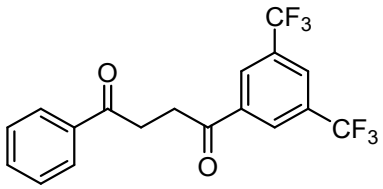
1-(3-Fluorophenyl)-4-phenylbutane-1,4-dione (3am)



White solid (37.2 mg, 73%). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.05 – 8.01 (m, 2H), 7.83 (dt, *J* = 8.0, 1.5 Hz, 1H), 7.71 (ddd, *J* = 9.5, 2.5, 1.5 Hz, 1H), 7.60 – 7.55 (m, 1H), 7.51 – 7.43 (m, 3H), 7.30 – 7.25 (m, 1H), 3.49 – 3.45 (m, 2H), 3.44 – 3.40 (m, 2H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 198.38, 197.43, 197.41, 163.81, 161.84, 138.85, 138.80, 136.61, 133.19, 130.27, 130.21, 128.59, 128.07, 123.87, 123.85, 120.19, 120.02, 114.90, 114.73, 32.66, 32.49. ^{19}F NMR (471 MHz, Chloroform-*d*) δ -111.89.

The spectroscopic data matched literature values.[26]

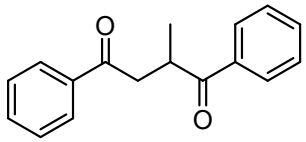
1-(3,5-Bis(trifluoromethyl)phenyl)-4-phenylbutane-1,4-dione (3an)



White solid (49.1 mg, 65%). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.47 (t, *J* = 1.0 Hz, 2H), 8.08 (t, *J* = 1.5 Hz, 1H), 8.05 – 8.01 (m, 2H), 7.61 – 7.57 (m, 1H), 7.51 – 7.46 (m, 2H), 3.56 – 3.51 (m, 2H), 3.49 – 3.45 (m, 2H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 197.99, 196.03, 138.26, 136.36, 133.41, 132.74, 132.47, 132.20, 131.93, 128.66, 128.49, 128.20, 128.17, 128.14, 128.09, 126.34, 126.31, 126.28, 126.25, 126.22, 126.16, 123.99, 121.82, 119.65, 32.63, 32.54. ^{19}F NMR (471 MHz, Chloroform-*d*) δ -62.92.

The spectroscopic data matched literature values.[27]

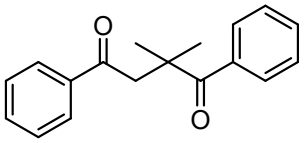
2-Methyl-1,4-diphenylbutane-1,4-dione (3ao)



White solid (22.1 mg, 44%). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.07 – 8.04 (m, 2H), 8.01 – 7.97 (m, 2H), 7.60 – 7.54 (m, 2H), 7.52 – 7.43 (m, 4H), 4.23 – 4.14 (m, 1H), 3.73 (dd, *J* = 18.0, 8.0 Hz, 1H), 3.12 (dd, *J* = 18.0, 5.0 Hz, 1H), 1.29 (d, *J* = 7.0 Hz, 3H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 203.38, 198.46, 136.64, 136.06, 133.16, 132.95, 128.64, 128.54, 128.49, 128.08, 42.32, 36.26, 17.94.

The spectroscopic data matched literature values.[22]

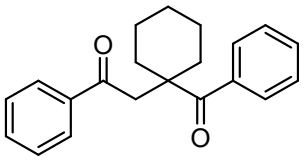
2,2-Dimethyl-1,4-diphenylbutane-1,4-dione (3ap)



White solid (37.5 mg, 70%). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.96 – 7.92 (m, 2H), 7.71 – 7.67 (m, 2H), 7.57 – 7.52 (m, 1H), 7.46 – 7.37 (m, 5H), 3.54 (s, 2H), 1.46 (s, 6H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 210.00, 197.67, 139.79, 136.85, 133.05, 130.14, 128.48, 127.96, 127.93, 127.90, 127.24, 50.41, 45.39, 26.82.

The spectroscopic data matched literature values.[28]

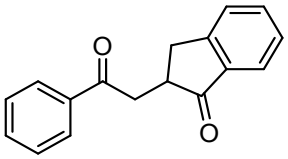
2-(1-Benzoylcyclohexyl)-1-phenylethan-1-one (3aq)



Colorless liquid (28.9 mg, 47%). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.00 – 7.94 (m, 2H), 7.70 – 7.65 (m, 2H), 7.58 – 7.53 (m, 1H), 7.49 – 7.43 (m, 2H), 7.42 – 7.36 (m, 3H), 3.68 (s, 2H), 1.97 – 1.85 (m, 4H), 1.64 – 1.55 (m, 3H), 1.51 – 1.41 (m, 2H), 1.31 – 1.22 (m, 2H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 211.20, 198.04, 140.59, 137.10, 133.08, 129.69, 128.52, 127.97, 127.83, 127.22, 49.54, 43.93, 33.86, 25.61, 22.20.

HRMS (ESI) m/z calcd. for $C_{21}H_{22}O_2$ $[M]^+$ 306.1614, found 306.1606.

2-(2-Oxo-2-phenylethyl)-2,3-dihydro-1*H*-inden-1-one (3ar)



This mixture compound was prepared according to the typical procedure. Purification by column chromatography on silica gel (Petroleum ether/ Ethyl acetate = 5/1, v/v) afforded **3ar** as a lightyellow liquid (37 mg, 74%). Then the mixture compound was purified by by column chromatography on silica gel (Petroleum ether / Ethyl acetate = 10/1, v/v then Petroleum ether / dichloromethane = 1/2).

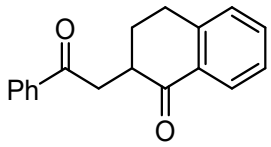
^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.01 – 7.97 (m, 2H), 7.81 (d, *J* = 7.5 Hz, 1H), 7.63 – 7.55 (m, 2H), 7.50 – 7.45 (m, 3H), 7.40 (t, *J* = 7.5 Hz, 1H), 3.77 (dd, *J* = 17.5, 2.5 Hz, 1H), 3.56 (dd, *J* = 17.0, 7.5 Hz, 1H), 3.26 (dd, *J* = 17.5, 9.5 Hz, 1H), 3.23 – 3.17 (m, 1H), 2.85 (dd, *J* = 17.0, 4.0 Hz, 1H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 207.89, 197.95, 153.58, 136.51, 136.44, 134.80, 133.33, 128.66, 128.08, 127.41, 126.54, 123.89, 43.19, 40.02, 33.57.

The spectroscopic data matched literature values.[29]

^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.08 (dd, *J* = 8.0, 1.5 Hz, 1H), 8.00 – 7.96 (m, 2H), 7.64 – 7.59 (m, 1H), 7.53 – 7.48 (m, 3H), 7.39 – 7.34 (m, 1H), 7.26 (d, *J* = 7.5 Hz, 1H), 4.25 – 4.18 (m, 1H), 3.34 – 3.26 (m, 1H), 3.20 (dd, *J* = 16.5, 4.5 Hz, 1H), 2.94 – 2.90 (m, 2H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 199.79, 196.45, 141.68, 135.14, 133.91, 133.62, 131.98, 128.95, 128.85, 128.44, 127.21, 127.19, 42.65, 41.25, 32.63.

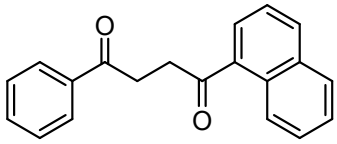
HRMS (ESI) m/z calcd. for $C_{17}H_{14}O_2$ $[M+H^+]^+$ 251.1067, found 251.1061.

2-(2-Oxo-2-phenylethyl)-3,4-dihydronaphthalen-1(2H)-one (3as)



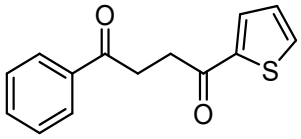
White solid (32.6 mg, 62%). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.04 (dt, *J* = 8.5, 1.5 Hz, 3H), 7.60 – 7.55 (m, 1H), 7.50 – 7.45 (m, 3H), 7.33 – 7.29 (m, 1H), 7.26 (d, *J* = 8.0 Hz, 1H), 3.86 (dd, *J* = 17.5, 5.0 Hz, 1H), 3.36 – 3.29 (m, 1H), 3.23 – 3.14 (m, 1H), 3.02 – 2.95 (m, 2H), 2.33 – 2.27 (m, 1H), 1.99 (qd, *J* = 13.0, 4.5 Hz, 1H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 198.98, 198.51, 144.11, 136.99, 133.33, 133.06, 132.26, 128.74, 128.56, 128.11, 127.44, 126.57, 44.21, 38.99, 29.54, 29.37.
The spectroscopic data matched literature values.[30]

1-(Naphthalen-1-yl)-4-phenylbutane-1,4-dione (3at)



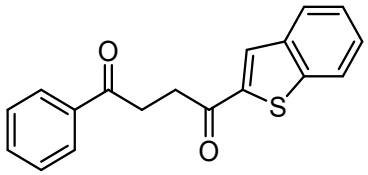
White Solid. (47.6 mg, 83%). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.63 (dd, *J* = 8.5, 1.0 Hz, 1H), 8.09 – 8.04 (m, 3H), 7.99 (dt, *J* = 8.5, 1.0 Hz, 1H), 7.88 (dd, *J* = 8.0, 1.5 Hz, 1H), 7.61 – 7.56 (m, 2H), 7.56 – 7.51 (m, 2H), 7.51 – 7.47 (m, 2H), 3.56 – 3.48 (m, 4H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 202.77, 198.54, 136.70, 135.89, 133.85, 133.08, 132.49, 130.05, 128.53, 128.29, 128.05, 127.78, 127.55, 126.33, 125.78, 124.37, 35.87, 32.96.
The spectroscopic data matched literature values.[18]

1-Phenyl-4-(thiophen-2-yl)butane-1,4-dione (3au)



Light yellow solid (15.8 mg. 32%). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.05 – 8.01 (m, 2H), 7.84 (dd, *J* = 4.0, 1.5 Hz, 1H), 7.64 (dd, *J* = 5.0, 1.0 Hz, 1H), 7.59 – 7.55 (m, 1H), 7.50 – 7.45 (m, 2H), 7.15 (dd, *J* = 5.0, 4.0 Hz, 1H), 3.48 – 3.44 (m, 2H), 3.43 – 3.38 (m, 2H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 198.41, 191.58, 143.87, 136.63, 133.53, 133.18, 132.01, 128.58, 128.09, 33.15, 32.59.
The spectroscopic data matched literature values.[18]

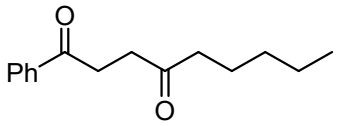
1-(Benzo[b]thiophen-2-yl)-4-phenylbutane-1,4-dione (3av/3va)



Yellow solid (35.4 mg, 60%). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.08 (d, *J* = 0.5 Hz, 1H), 8.05 – 8.01 (m, 2H), 7.89 (ddt, *J* = 18.0, 8.0, 1.0 Hz, 2H), 7.60 – 7.55 (m, 1H), 7.50 – 7.44 (m, 3H), 7.43 – 7.39

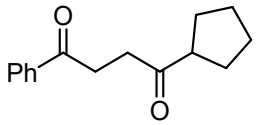
(m, 1H), 3.52 – 3.46 (m, 4H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 198.25, 193.12, 143.21, 142.41, 139.10, 136.55, 133.20, 129.20, 128.58, 128.07, 127.34, 125.93, 124.94, 122.92, 33.06, 32.62.
HRMS (FI) m/z calcd. for $C_{18}H_{14}O_2S$ $[M]^+$ 294.0709, found 294.0701.

1-Phenylnonane-1,4-dione (3aw)



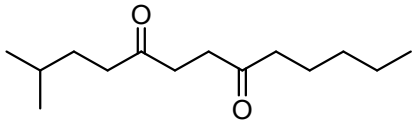
Colorless liquid (26 mg, 56%). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.99 – 7.95 (m, 2H), 7.57 – 7.52 (m, 1H), 7.47 -7.42 (m, 2H), 3.27 (dd, *J* = 7.0, 5.5 Hz, 2H), 2.85 (t, *J* = 6.5 Hz, 2H), 2.51 (t, *J* = 7.5 Hz, 2H), 1.61 (p, *J* = 7.5 Hz, 2H), 1.37 – 1.24 (m, 5H), 0.89 (t, *J* = 7.0 Hz, 3H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 209.73, 198.63, 136.65, 133.06, 128.51, 127.99, 42.93, 36.13, 32.32, 31.37, 23.52, 22.41, 13.88.
The spectroscopic data matched literature values.[31]

1-Cyclopentyl-4-phenylbutane-1,4-dione (3ax)



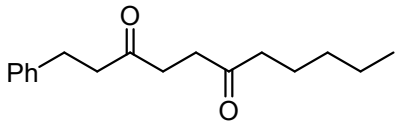
Colorless liquid (32.8 mg, 71%). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.00 – 7.96 (m, 2H), 7.57 – 7.52 (m, 1H), 7.47 – 7.42 (m, 2H), 3.29 – 3.25 (m, 2H), 2.98 (p, *J* = 8.0 Hz, 1H), 2.91 (dd, *J* = 6.5, 5.5 Hz, 2H), 1.91 – 1.77 (m, 4H), 1.69 – 1.54 (m, 4H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 211.70, 198.74, 136.71, 133.01, 128.49, 127.99, 51.44, 35.28, 32.33, 28.90, 25.97.
HRMS (ESI) m/z calcd. for $C_{15}H_{18}O_2$ $[M+H^+]^+$ 231.1380, found 231.1374.

2-Methyltridecane-5,8-dione (3ow)



Yellow liquid (19.9 mg, 44%). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 2.68 – 2.64 (m, 4H), 2.46 - 2.40 (m, 4H), 1.60 – 1.49 (m, 3H), 1.48 – 1.43 (m, 2H), 1.32 – 1.22 (m, 4H), 0.89 – 0.85 (m, 9H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 209.87, 209.77, 42.80, 40.86, 35.97, 35.94, 32.59, 31.34, 27.66, 23.49, 22.40, 22.29, 13.86.
HRMS (ESI) m/z calcd. for $C_{14}H_{26}O_2$ $[M+H^+]^+$ 227.2006, found 227.2002.

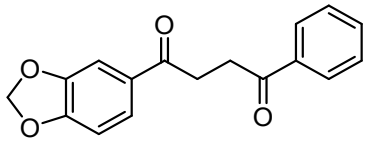
1-Phenylundecane-3,6-dione (3rw)



Yellow liquid. (24.1 mg, 44%) ^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.30 – 7.25 (m, 2H), 7.21 – 7.16 (m, 3H), 2.92 – 2.88 (m, 2H), 2.82 – 2.77 (m, 2H), 2.70 – 2.64 (m, 4H), 2.44 (t, *J* = 7.5 Hz, 2H), 1.58 (p, *J* = 7.5 Hz, 2H), 1.34 – 1.24 (m, 4H), 0.89 (t, *J* = 7.5 Hz, 3H). ^{13}C NMR (126 MHz,

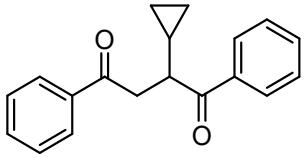
Chloroform-*d*) δ 209.68, 208.53, 140.98, 128.43, 128.24, 126.03, 44.28, 42.76, 36.14, 35.97, 31.34, 29.69, 23.49, 22.40, 13.88.
HRMS (ESI) m/z calcd. for $C_{17}H_{24}O_2$ $[M+H^+]^+$ 261.1849, found 261.1842.

1-(Benzo[d][1,3]dioxol-5-yl)-4-phenylbutane-1,4-dione (3ta)



White solid (30.3 mg, 53%). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.05 – 8.02 (m, 2H), 7.67 (dd, *J* = 8.0, 2.0 Hz, 1H), 7.60 – 7.55 (m, 1H), 7.50 – 7.45 (m, 3H), 6.87 (d, *J* = 8.0 Hz, 1H), 6.05 (s, 2H), 3.46 – 3.42 (m, 2H), 3.40 -3.36 (m, 2H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 198.74, 196.69, 151.77, 148.14, 136.76, 133.12, 131.64, 128.57, 128.10, 124.38, 107.93, 107.89, 101.80, 32.69, 32.31.
The spectroscopic data matched literature values.[18]

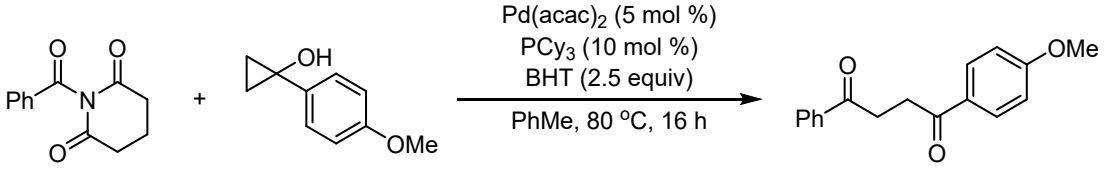
2-Clopropyl-1,4-diphenylbutane-1,4-dione (3ay)



Colorless liquid (27.3 mg, 50%). ^{1}H NMR (500 MHz, Chloroform-*d*) δ 8.06 – 8.02 (m, 2H), 8.01 – 7.97 (m, 2H), 7.60 – 7.53 (m, 2H), 7.51 – 7.43 (m, 4H), 3.92 (dd, *J* = 18.0, 9.5 Hz, 1H), 3.46 (td, *J* = 9.5, 3.5 Hz, 1H), 3.32 (dd, *J* = 18.0, 3.5 Hz, 1H), 1.31 (d, *J* = 25.5 Hz, 1H), 0.98 – 0.90 (m, 1H), 0.56 – 0.54 (m, 1H), 0.49 – 0.42 (m, 1H), 0.32 – 0.21 (m, 2H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 202.80, 198.75, 137.70, 136.51, 133.18, 132.79, 128.61, 128.53, 128.12, 45.25, 41.96, 13.85, 4.68, 4.14.
HRMS (FI) m/z calcd. for $C_{19}H_{18}O_2$ $[M]^+$ 278.1301, found 278.1293.

Mechanistic Studies

Coupling of cyclopropanol and amide in the presence of BHT



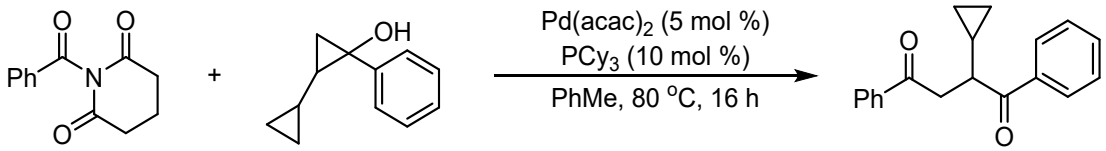
1a **2d** **3ad**

63%

A 10 mL oven-dried reaction vessel equipped with a magnetic stir bar was charged with **1a** (0.2 mmol, 1.0 equiv, 43.4 mg), **2d** (0.25 mmol, 1.25 equiv, 41mg), $Pd(acac)_2$ (0.01 mol, 0.05 equiv, 3.1 mg), and BHT (0.3 mmol, 2.5 equiv, 110.2 mg). The vessel was capped with a rubber septum and then transferred to the glove. PCy_3 (10 mol %, 0.02 mmol, 5.6 mg) then was added and removed from glove. The reaction mixture was resolved in PhMe (2 mL) and allowed to stir at 80 °C for 16 h. The reaction was cooled to room temperature then mixture was filtered on celite and concentrated to yield the crude product, which was further purified by flash chromatography (Petroleum ether / Ethyl acetate = 5/1) to give the desired product **3aa** in 63% of yield. No trapped

intermediate is detected.

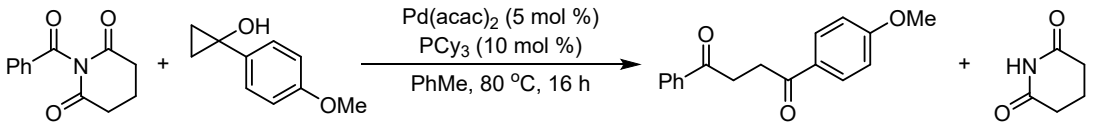
Radical clock experiment



1a **2y** **3ay**

A 10 mL oven-dried reaction vessel equipped with a magnetic stir bar was charged with 1a (0.2 mmol, 1.0 equiv, 43.4 mg), 2aa (1.25 equiv, 0.25 mmol, 41mg), $Pd(acac)_2$ (0.01 mol, 0.05 equiv, 3.1 mg). The vessel was capped with a rubber septum and then transferred to the glove. PCy_3 (10 mol %, 0.02 mmol, 5.6 mg) then was added and removed from glove. The reaction mixture was resolved in PhMe (2 mL) and allowed to stir at 80 °C for 16 h. The reaction was cooled to room temperature then mixture was filtered on celite and concentrated to yield the crude product, which was further purified by flash chromatography (Petroleum ether / ethyl acetate = 5/1) to give the desired product 3aaa in 50% yields, no cyclopropyl-opening product was observed.

NMR spectrum evidence for the release of glutarimide.



1a **2d** **3ad** 68% 73%

A 10 mL oven-dried reaction vessel equipped with a magnetic stir bar was charged with 1a (0.2 mmol, 1.0 equiv, 43.4 mg), 2d (0.25 mmol, 1.25 equiv, 41mg), $Pd(acac)_2$ (0.01 mol, 0.05 equiv, 3.1 mg). The vessel was capped with a rubber septum and then transferred to the glove. PCy_3 (10 mol %, 0.02 mmol, 5.6 mg) then was added and removed from glove. The reaction mixture was resolved in Toluene (2 mL) and allowed to stir at 80 °C for 16 h. After completion of reaction as monitored by TLC, solvent was removed under reduced pressure and the crude was subjected to perform an NMR test. From the NMR spectrum of the crude, we can clearly see the peak of glutarimide. Then the crude product was recovered, followed by glutarimides (0.2 mmol, 1.0 equiv, 22.6 mg) added, then was subjected to NMR test again. We can see the overlap of the peaks of glutarimide. Meanwhile, another same reaction mixture was filtered on celite and concentrated to yield crude product, which was further purified by flash chromatography (Petroleum ether / Ethyl acetate = 3/1 to Dichloromethane / Methanol = 10/1) to give the pure byproduct glutarimide in 73% (16.8 mg) yields. ^{1}H NMR (400 MHz, Chloroform-*d*) δ 7.97 (br, 1H), 2.62 – 2.56 (d, *J* = 2.0 Hz, 4H), 2.05 – 1.97 (m, 2H).

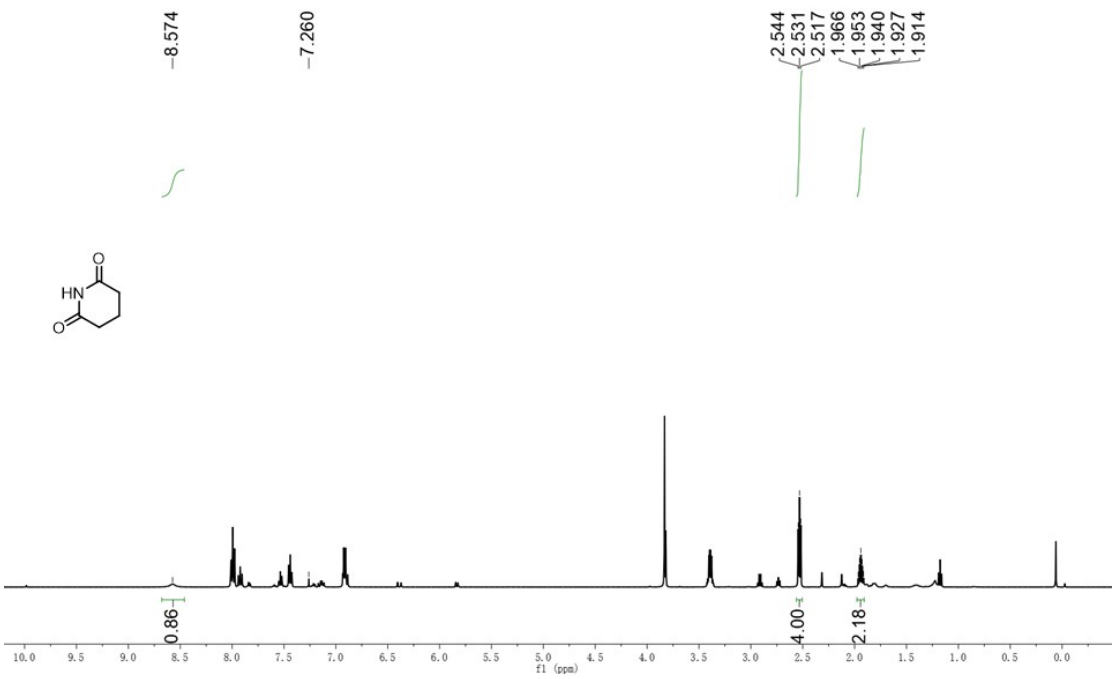


Figure S3. NMR spectrum of **3ad** crude product

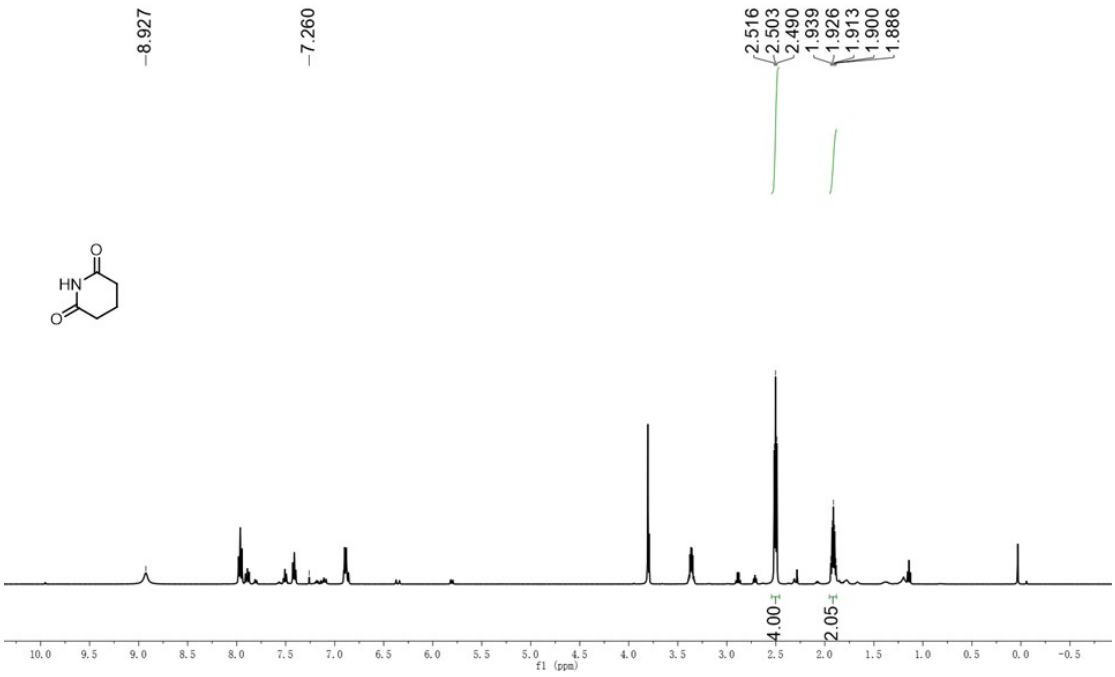
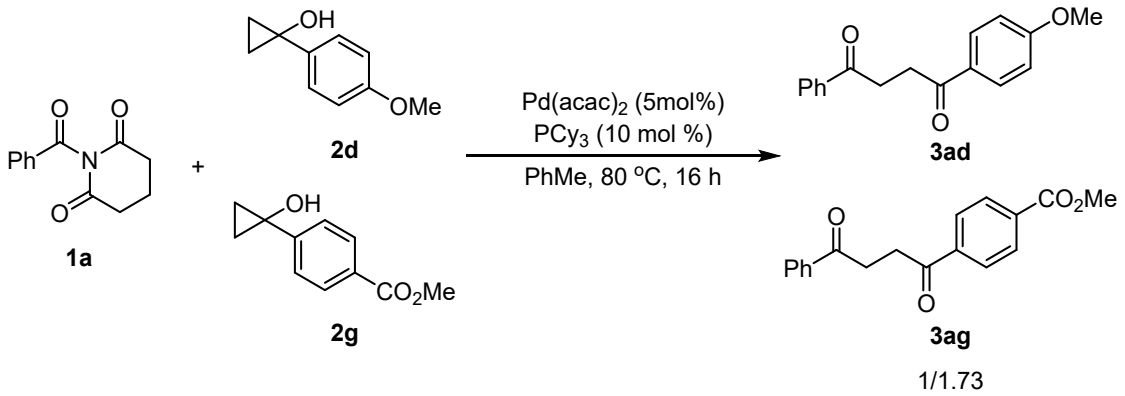


Figure S4. NMR spectrum of **3ad** crude product after 0.2 mmol glutarimide added

Competition experiment



A 10 mL oven-dried reaction vessel equipped with a magnetic stir bar was charged with **1a** (0.2 mmol, 1.0 equiv, 43.4 mg), **2d** (0.2 mmol, 1.0 equiv, 32.8 mg), **2i** (0.2 mmol, 1.0 equiv, 38.4 mg) and $Pd(acac)_2$ (0.01 mol, 0.05 equiv, 3.1 mg). The vessel was capped with a rubber septum and then transferred to the glove. PCy_3 (10 mol %, 0.02 mmol, 5.6 mg) then was added and removed from glove. The reaction mixture was resolved in Toluene (2 mL) and allowed to stir at 80 °C for 16 h. After completion of reaction as monitored by TLC, solvent was removed under reduced pressure and the crude was subjected to perform an NMR test. NMR spectrum indicates ratio of **3ad** vs **3ai** is 1/1.73.

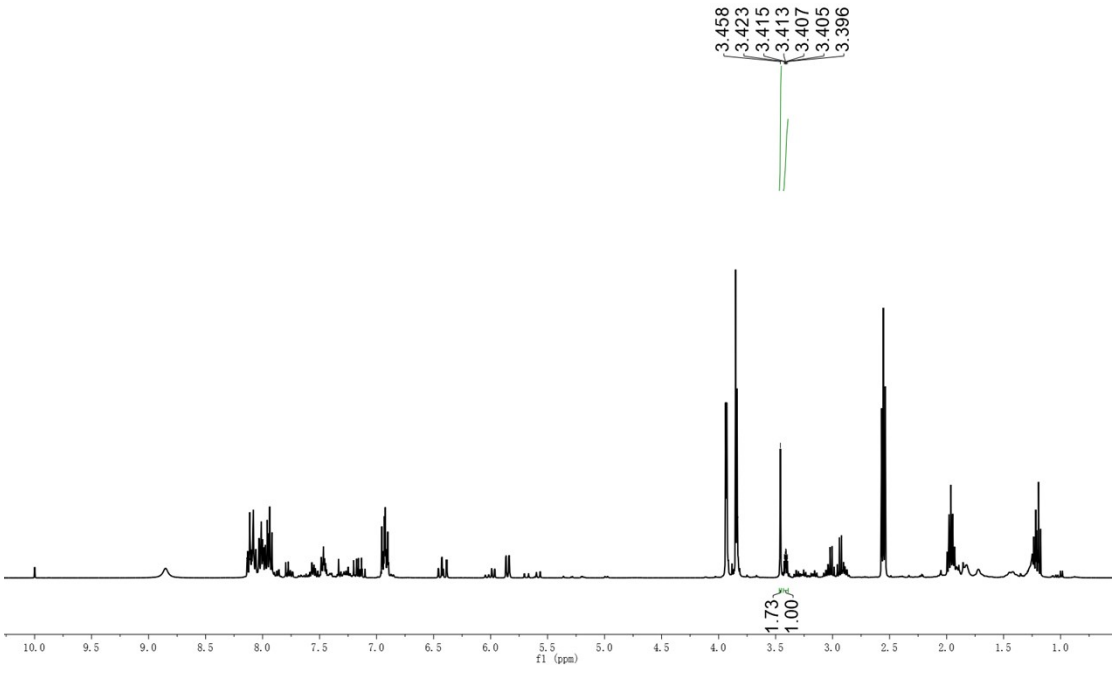
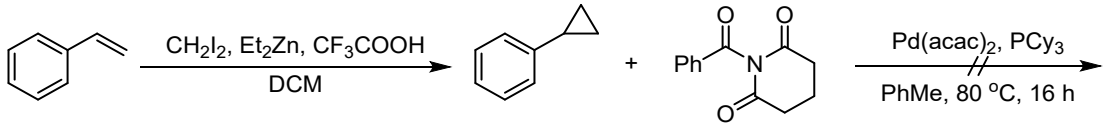
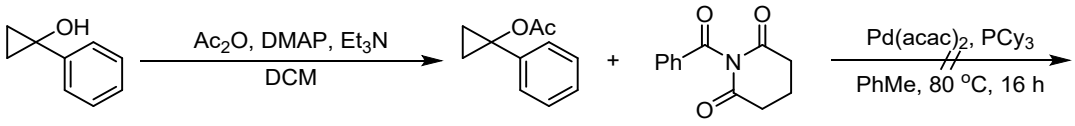


Figure S5. NMR spectrum of **3ad** and **3ai** crude product

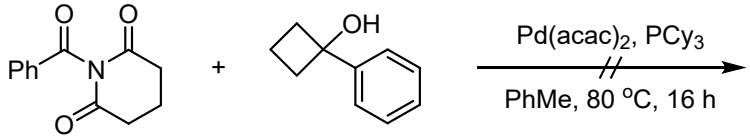
Control experiments



Phenylcyclopropane (**2aO**) was obtained as colorless liquid according to the literature reported before.[32] To a 10 mL dry test tube with stir bar was added *N*-glutarimide benzamide **1a** (0.2 mmol, 1.0 equiv, 43.4 mg), $Pd(acac)_2$ (0.01 mmol, 5 mol %, 3.1 mg). The vessel was capped with a rubber septum and then transferred to the glove. PCy_3 (0.02 mmol, 10 mol %, 5.6 mg) then was added and removed from glove. Phenylcyclopropane (0.25 mmol, 1.25 equiv, 29.5 mg) dissolved in 2 mL Toluene was added and stand for 16 h at 80 °C, after completion of reaction, TLC indicated that no desired product was yielded.



1-Phenylcyclopropyl acetate (**2aA**) was prepared according to the literature before.[33] To a 10 mL dry test tube with stir bar was added *N*-glutarimide benzamide **1a** (0.2 mmol, 1.0 equiv, 43.4 mg), $Pd(acac)_2$ (5 mol %, 0.01 mmol, 3.1 mg). The vessel was capped with a rubber septum and then transferred to the glove. PCy_3 (0.02 mmol, 10 mol %, 5.6 mg) then was added and removed from glove. 1-phenylcyclopropyl acetate (0.25 mmol, 1.25 equiv, 44 mg) dissolved in 2 mL Toluene was added and stand for 16 h at 80 °C, after completion of reaction, TLC indicated that no desired product was yielded.



To a 10 mL dry test tube with stir bar was added *N*-glutarimide benzamide **1a** (0.2 mmol, 1.0 equiv, 43.4 mg), 1-phenylcyclobutan-1-ol (1.25 equiv, 37 mg) and $Pd(acac)_2$ (5 mol %, 0.01 mmol, 3.1 mg). The vessel was capped with a rubber septum and then transferred to the glove. PCy_3 (0.02 mmol, 10 mol %, 5.6 mg) then was added and removed from glove. The reaction mixture was dissolved in 2 mL Toluene and stand for 16 h at 80 °C, after cooling to room temperature, TLC indicated that no desired product was yielded.

Proposed mechanism

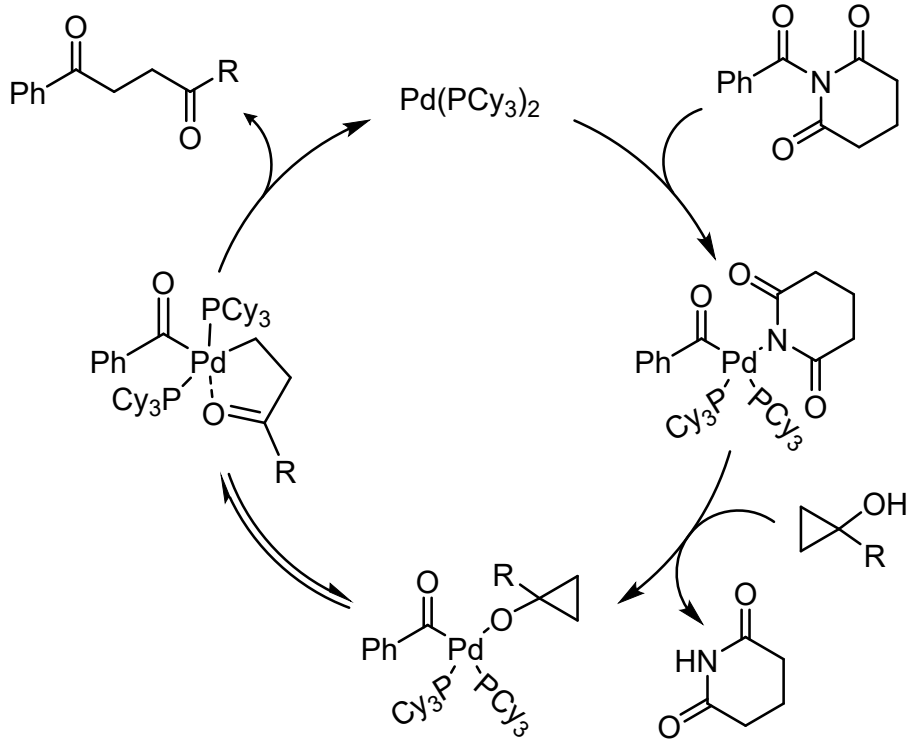
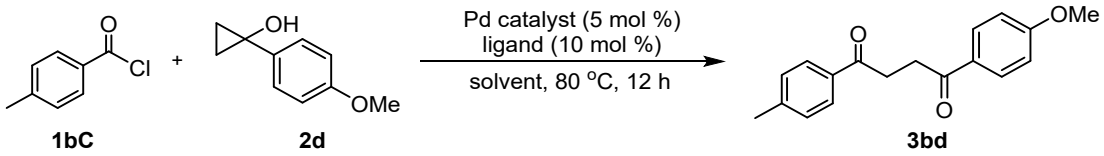


Figure S6. Proposed mechanistic cycle

Exploration for the cross-coupling reaction of acid chloride with cyclopropanol

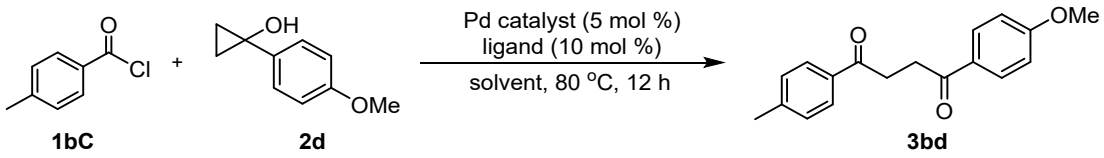
Table S12. Screening for the catalyst and solvent



Entry	catalyst	ligand	solvent	yield[b]
1	$Pd(P^tBu_3)_2$	DPE-Phos	PhMe	15%
2	$Pd_2(dba)_3$	DPE-Phos	PhMe	9%
3	$Pd(OAc)_2$	DPE-Phos	PhMe	10%
4	$Pd(acac)_2$	DPE-Phos	PhMe	ND
5	$Pd(PPh_3)_4$	DPE-Phos	PhMe	10%
6	$Pd(acac)_2$	PCy_3	PhMe	ND
7	$Pd(P^tBu_3)_2$	DPE-Phos	MeCN	12%

8	$Pd(P^tBu_3)_2$	DPE-Phos	THF	7%
9	$Pd(P^tBu_3)_2$	DPE-Phos	MeOH	ND

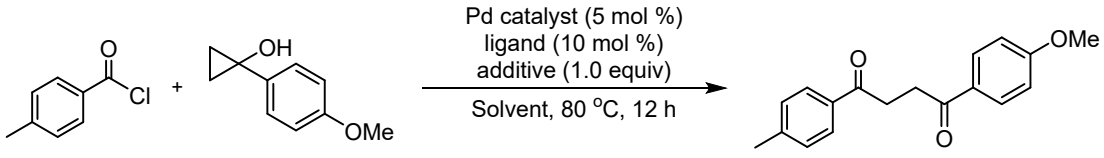
Table S13. Screening for the catalyst and solvent



1bC **2d** **3bd**

Entry	catalyst	ligand	solvent	yield[b]
1	$Pd(P^tBu_3)_2$	X-Phos	PhMe	14%
2	$Pd(P^tBu_3)_2$	Dppbz	PhMe	ND
3	$Pd(P^tBu_3)_2$	BINAP	PhMe	10%
4	$Pd(P^tBu_3)_2$	Dppm	PhMe	15%
5	$Pd(P^tBu_3)_2$	Dppe	PhMe	13%
6	$Pd(P^tBu_3)_2$	Dppf	PhMe	19%
7	$Pd(P^tBu_3)_2$	PPh_3	PhMe	12%
8	$Pd(P^tBu_3)_2$	PCy_3	PhMe	6%

Table S14. Screening for the additive



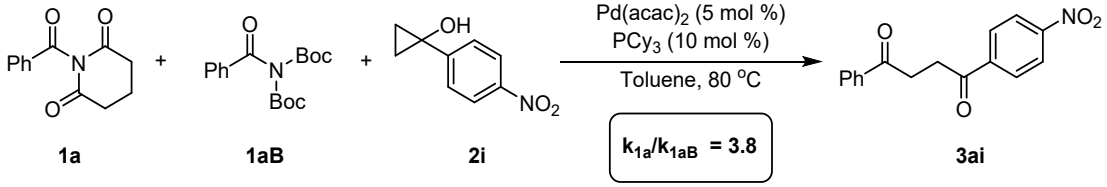
1bC **2d** **3bd**

Entry	catalyst	ligand	additive	solvent	T	yield[b]
1	$Pd(PPh_3)_4$	---	---	THF	RT	ND
2	$Pd(P^tBu_3)_2$	---	---	PhMe	80 °C	ND
3	$Pd(P^tBu_3)_2$	PPh_3	Et_3N	PhMe	80 °C	30%
4	$Pd(P^tBu_3)_2$	PPh_3	K_2CO_3	PhMe	80 °C	35%
5	$Pd(P^tBu_3)_2$	PPh_3	KO^tBu	PhMe	80 °C	ND
6	$Pd(P^tBu_3)_2$	Dppf	Et_3N	PhMe	80 °C	40%
7	$Pd(P^tBu_3)_2$	Dppf	K_2CO_3	PhMe	80 °C	36%

8	$Pd(P^tBu_3)_2$	Dppf	KO^tBu	PhMe	80 °C	ND

Unless otherwise noted, all reactions were performed on 0.2 mmol acid chloride with 1.0 equiv of the cyclopropanol under nitrogen for 12 h.

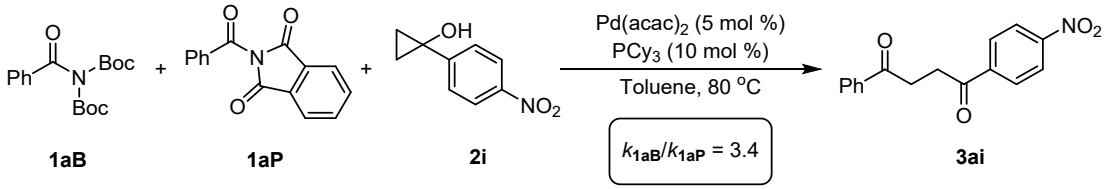
Kinetic competition experiment



1a **1aB** **2i** **3ai**

A 10 mL oven-dried reaction vessel equipped with a magnetic stir bar was charged with **1a** (0.1 mmol, 1.0 equiv, 21.7 mg), **1aB** (0.1 mmol, 1.0 equiv, 32.1 mg), **2i** (0.3 mmol, 3.0 equiv, 53.7 mg), and $Pd(acac)_2$ (0.005 mol, 0.05 equiv, 1.6 mg). The vessel was capped with a rubber septum and then transferred to the glove. PCy_3 (10 mol %, 0.01 mmol, 2.8 mg) then was added and removed from glove. The reaction mixture was resolved in toluene (1 mL) and allowed to stir at 80 °C for 1 h. The mixture was allowed to room temperature after 1 h, and filtered through celite, then concentrated under vacuum. The crude substrate-product mixture was purified by flash chromatography (Petroleum ether / Ethyl acetate = 5/1 then Petroleum ether/ Dichloromethane = 1:2) to give the substrates mixture (**1a** and **1aB**).

Time	Concentration of **1a**	Concentration of **1aB**
0 h	0.1 mol/L	0.1 mol/L
1 h	0.06525 mol/L	0.08925 mol/L



1aB **1aP** **2i** **3ai**

A 10 mL oven-dried reaction vessel equipped with a magnetic stir bar was charged with **1aP** (0.1 mmol, 1.0 equiv, 25.1 mg), **1aB** (0.1 mmol, 1.0 equiv, 32.1 mg), **2i** (0.3 mmol, 3.0 equiv, 53.7 mg), and $Pd(acac)_2$ (0.005 mol, 0.05 equiv, 1.6 mg). The vessel was capped with a rubber septum and then transferred to the glove. PCy_3 (10 mol %, 0.01 mmol, 2.8 mg) then was added and removed from glove. The reaction mixture was resolved in toluene (1 mL) and allowed to stir at 80 °C for 1 h. The mixture was allowed to room temperature after 1 h, and filtered through celite, then concentrated under vacuum. The crude substrate-product mixture was purified by flash chromatography (Petroleum ether / Ethyl acetate = 5/1 then Petroleum ether/ Dichloromethane = 1:2) to give the substrates mixture (**1aB** and **1aP**).

Time	Concentration of **1aB**	Concentration of **1aP**
0 h	0.1 mol/L	0.1 mol/L
1 h	0.087 mol/L	0.096 mol/L

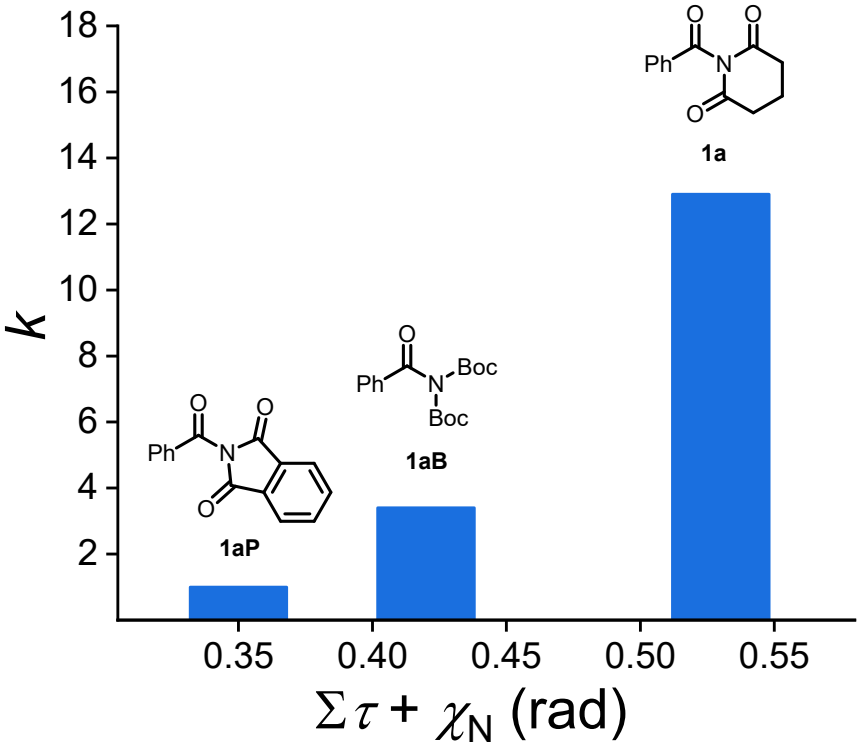
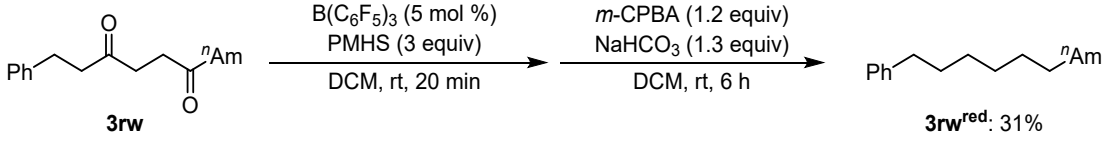


Figure S7. Relative reactivity versus the additive parameter of the three amides

Reactivity order chemistry set

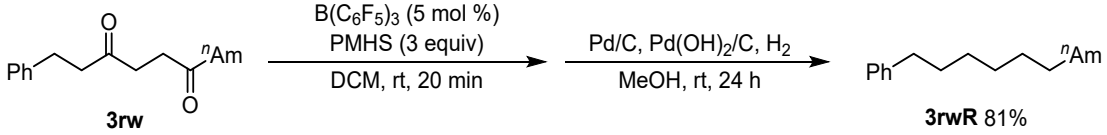
{(**1a**, R, P, $k_{\mathbf{1a}}$-12.9, EC),
(**1aB**, R, P, $k_{\mathbf{1aB}}$-3.4, EC),
(**1aP**, R, P, $k_{\mathbf{1aP}}$-1, EC)},
where R = **2i**, P = **3ai**,
EC = $Pd(acac)_2$ (5 mol %)/PCy_3 (10 mol %)/Toluene/80 °C/1 h

Reduction of γ-diketones to alkane

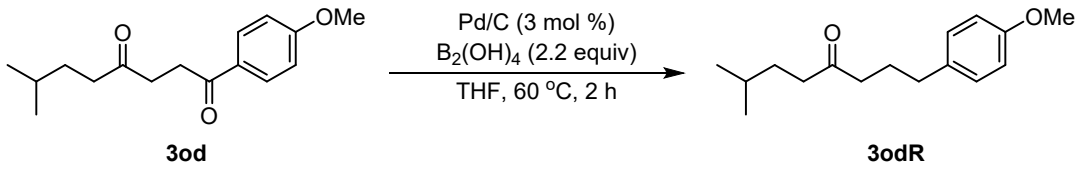


According to the literature reported,[34] to a solution of 1, 4 - diketones compound **3rw** (0.2 mmol, 1.0 equiv, 52 mg) in dry CH_2Cl_2 (2 mL) and tris (pentafluoro phenyl) borane (5 mol %, 0.01 mmol, 5.1 mg) was slowly added polymethylhydrosiloxane (0.6 mmol, 3 equiv, 134 mg, 133 µL) at room temperature. After 20 min, a vigorous effervescence (like foam) was observed. At this point, the reaction mixture was dissolved in hexane and filtered through a silica gel pad using hexane. Evaporation of the solvents afforded the product in crude form (alkane and alkene product presumably). To eliminate alkene product and acquire pure alkane product, we converted alkene product to epoxides according to the literature.[35] To a 10 mL dried test tube was added alkene -

alkane crude product (1.0 equiv, 0.2 mmol), $NaHCO_3$ (1.3 equiv, 0.26 mmol, 21.8 mg) and CH_2Cl_2 (1 mL) under N_2 atmosphere. The test tube was then added *m*-CPBA (1.2 equiv, 0.24 mmol, 41.4 mg) dissolved in CH_2Cl_2 (1 mL) dropwise at 0 °C. The reaction was then stirred for an additional 1 h and then allowed to warm to room temperature. After completion of the reaction (TLC monitoring), the reaction mixture is quenched with aqueous $Na_2S_2O_4$, and the aqueous phase is extracted with CH_2Cl_2. The combined organic layers are washed successively with a saturated solution of $NaHCO_3$ and brine and dried over Na_2SO_4. The filtrate was concentrated under reduced pressure and the crude product was purified by silica gel column chromatography (eluent: n-hexane) afforded the corresponding alkane product (**3rwR**) with 31% yields (14.3 mg) as colorless liquid. ^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.31 – 7.26 (m, 2H), 7.21 – 7.15 (m, 3H), 2.61 (t, J = 8.0 Hz, 2H), 1.66 – 1.59 (m, 2H), 1.36 – 1.25 (m, 16H), 0.89 (t, J = 7.0 Hz, 3H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 142.96, 128.38, 128.19, 125.51, 35.99, 31.92, 31.53, 29.67, 29.63, 29.60, 29.52, 29.35, 22.69, 14.12. The spectroscopic data of product (**3rwR**) matched literature values.[36]



Crude alkane and alkene product was obtained according to the procedure in 0.2 mmol scale, the crude product was mixed with MeOH (2 mL), $Pd(OH)_2$/C (15 mg), and Pd/C (15 mg) and the suspension was kept under H_2 atmosphere for 24 h at room temperature. Filtration through a Celite pad followed by evaporation and chromatography on silica gel (eluent: n-hexane) afforded the products (**3rwR**) with 81% yields (37.8 mg) as colorless liquid. ^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.31 - 7.26 (m, 2H), 7.22 - 7.16 (m, 3H), 2.62 (t, J = 8.0 Hz, 2H), 1.67 - 1.59 (m, 2H), 1.36 – 1.26 (m, 16H), 0.90 (t, J = 7.0 Hz, 3H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 142.95, 128.38, 128.19, 125.51, 36.00, 31.92, 31.53, 29.67, 29.64, 29.60, 29.53, 29.35, 22.69, 14.12.



According to the literature reported[37], Reactions were carried out on 0.2 mmol scale. A 10 mL reaction vessel equipped with a magnetic stir bar was charged with 12 mg of 5 weight % of Pd/C (3 mol%), 39.4 mg of tetrahydroxydiboron (2.2 equiv), and 52 mg of the diketones **3od** (0.2 mmol) in 2 mL THF, then the reaction mixture was stirred at 60 °C for 2 h. The crude mixture was passed through Celite plug rinsing the reaction vial with DCM; the eluent was removed by rotary evaporation, followed by flash column chromatography (Petroleum ether / Ethyl acetate = 10/1) to afford the product (**3odR**) with 67% yields (33.1 mg) as colorless liquid. ^{1}H NMR (500 MHz, Chloroform-*d*) δ 7.10 – 7.06 (m, 2H), 6.84 – 6.80 (m, 2H), 3.78 (s, 3H), 2.55 (t, J = 7.5 Hz, 2H), 2.38 (dt, J = 19.5, 7.5 Hz, 4H), 1.87 (p, J = 7.5 Hz, 2H), 1.56 – 1.47 (m, 1H), 1.47 – 1.41 (m, 2H), 0.87 (d, J = 6.5 Hz, 6H). ^{13}C NMR (126 MHz, Chloroform-*d*) δ 211.32, 157.79, 133.66, 129.29, 113.72, 55.19, 41.79, 40.84, 34.16, 32.58, 27.66, 25.46, 22.29. HRMS (ESI) m/z calcd. for $C_{19}H_{18}O_2$ $[M+H]^+$ 249.1849, found 249.1842.

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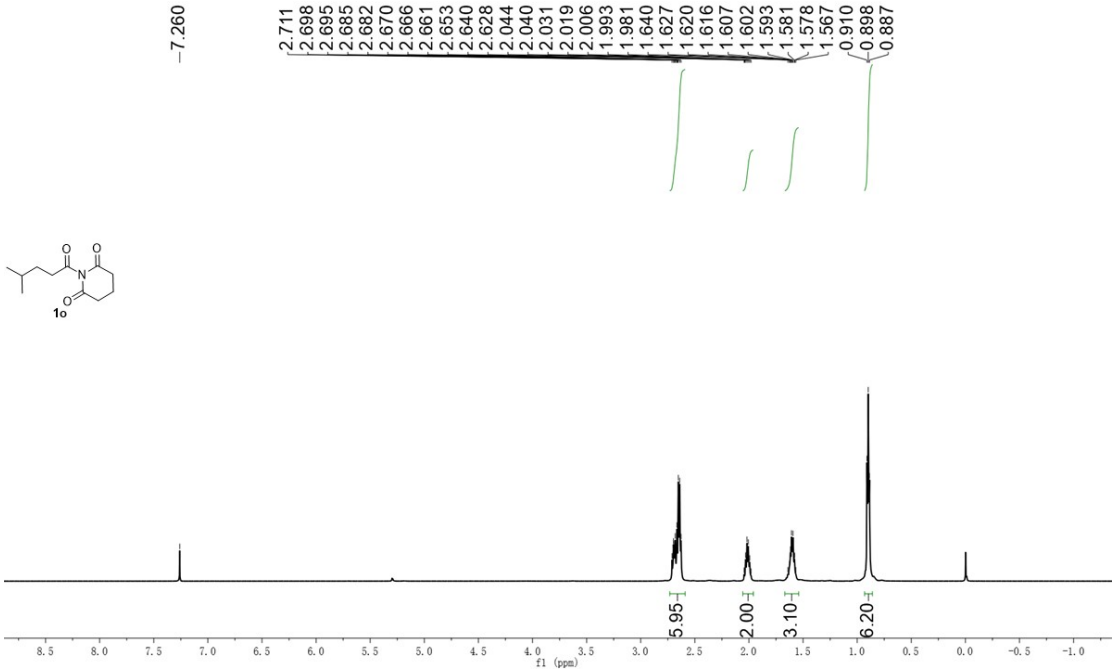
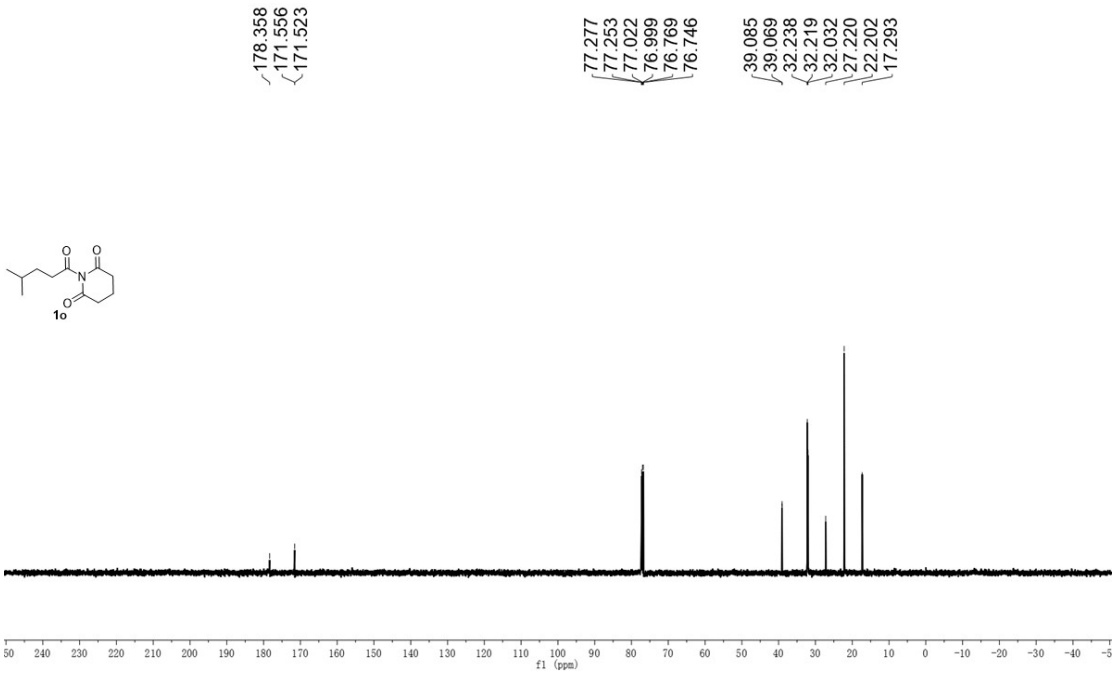
NMR spectra

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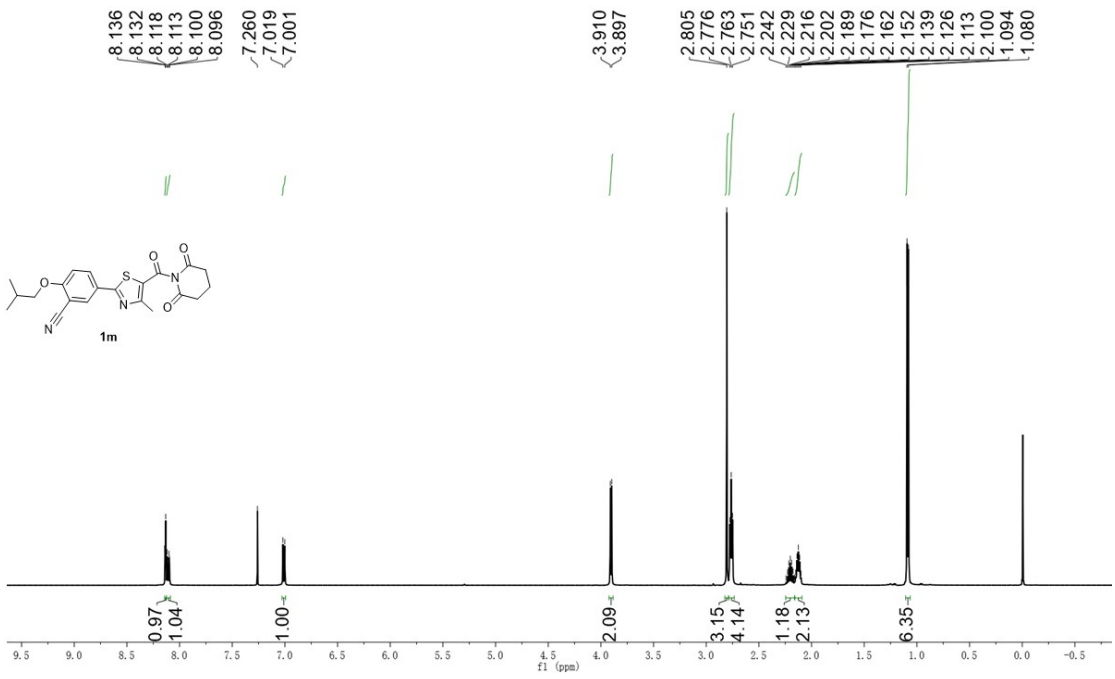
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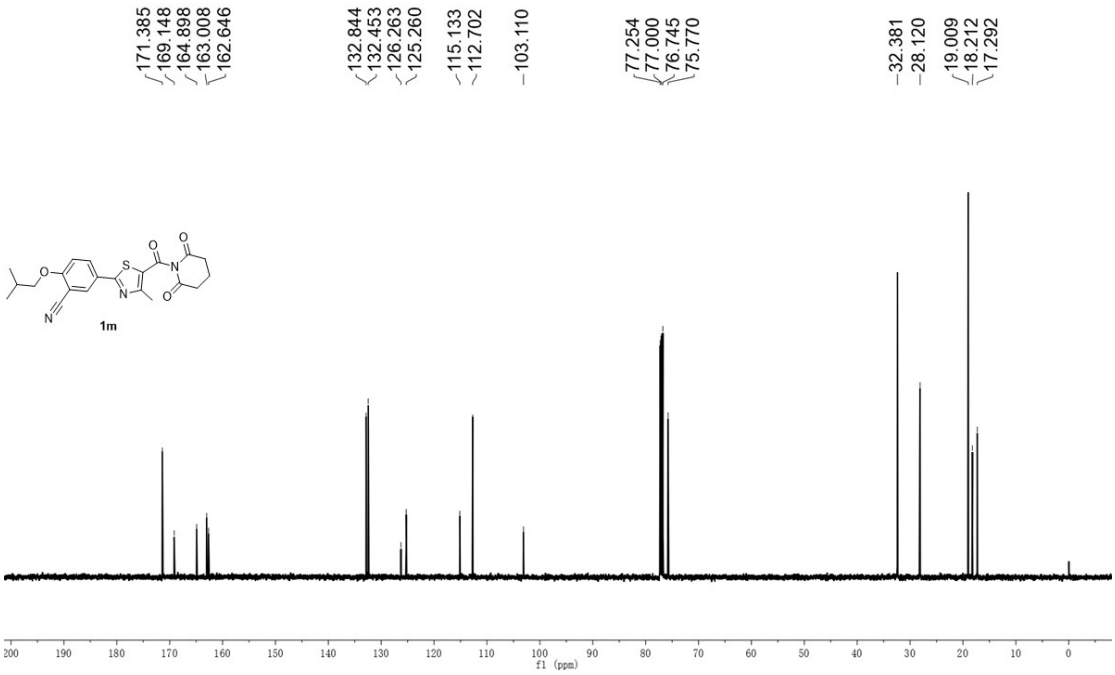
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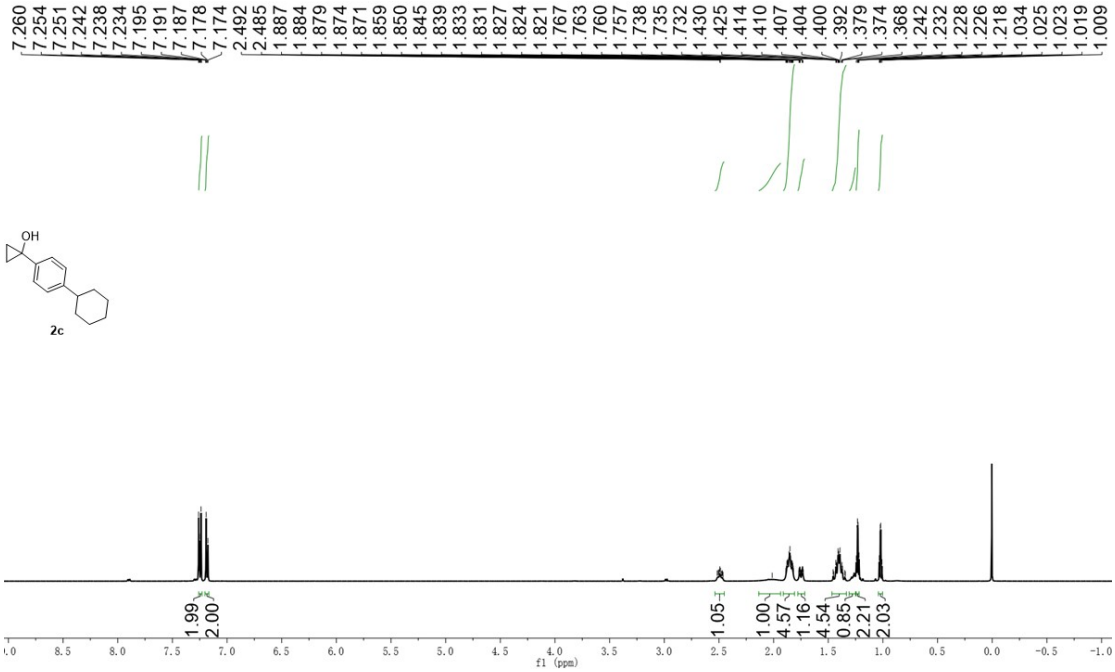
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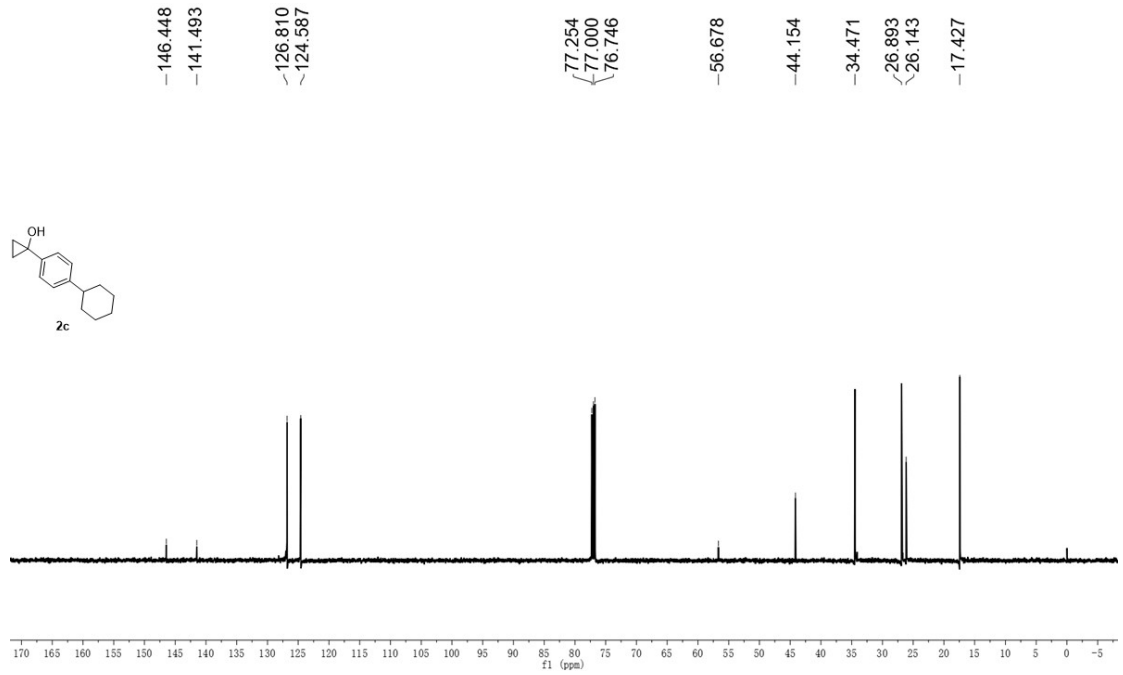
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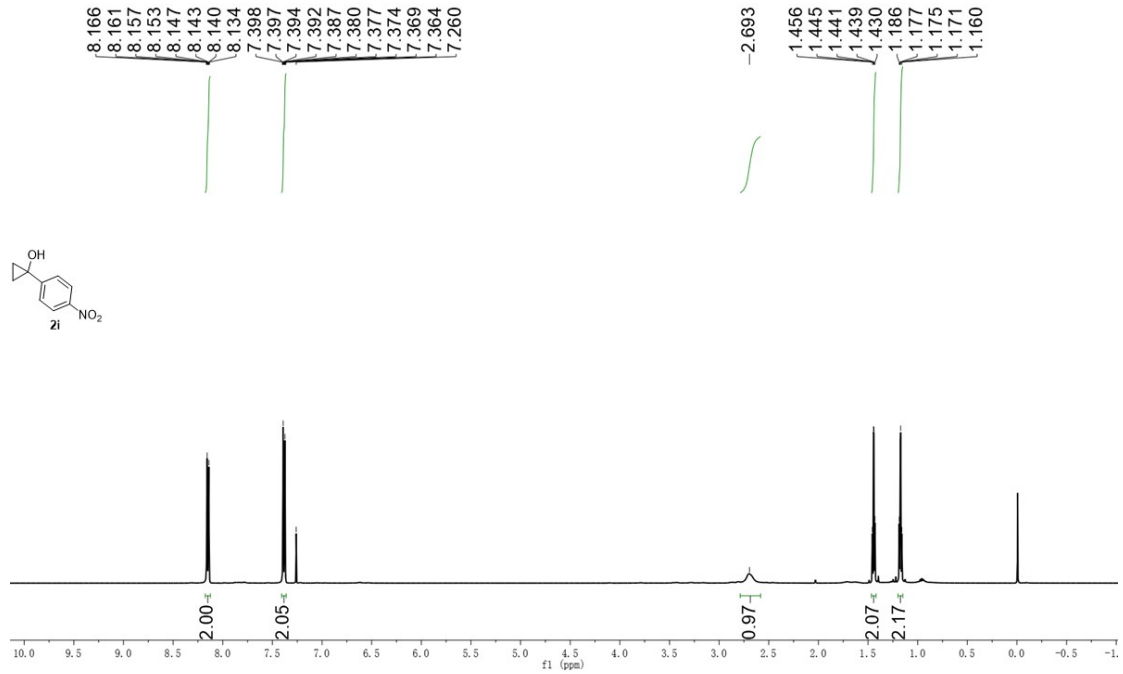
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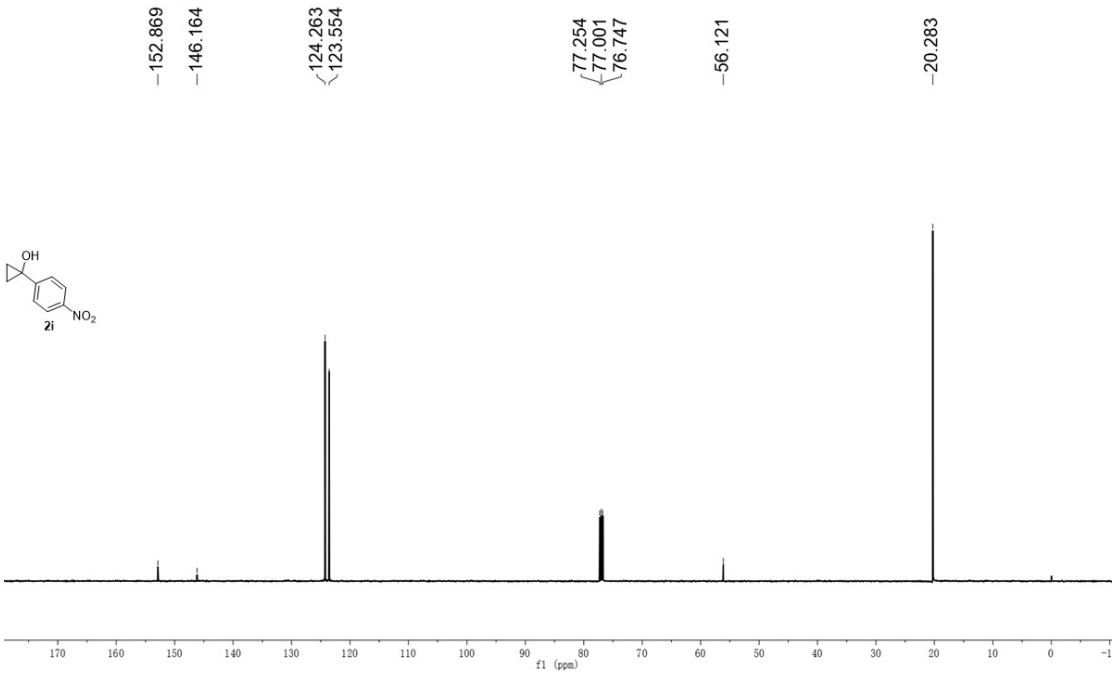
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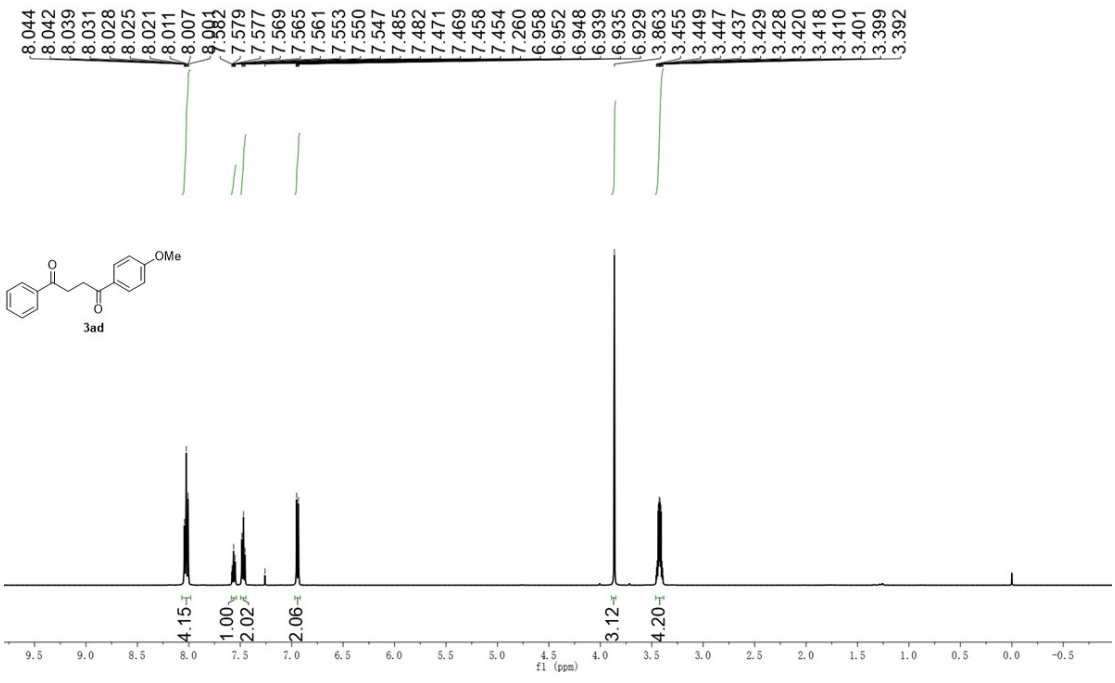
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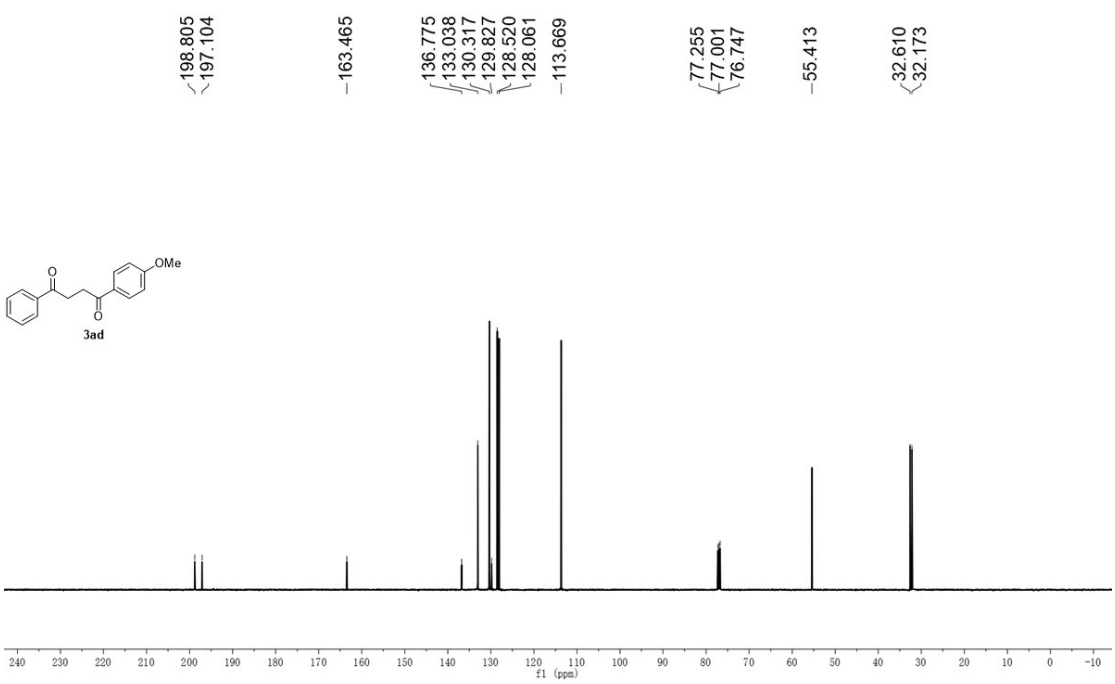
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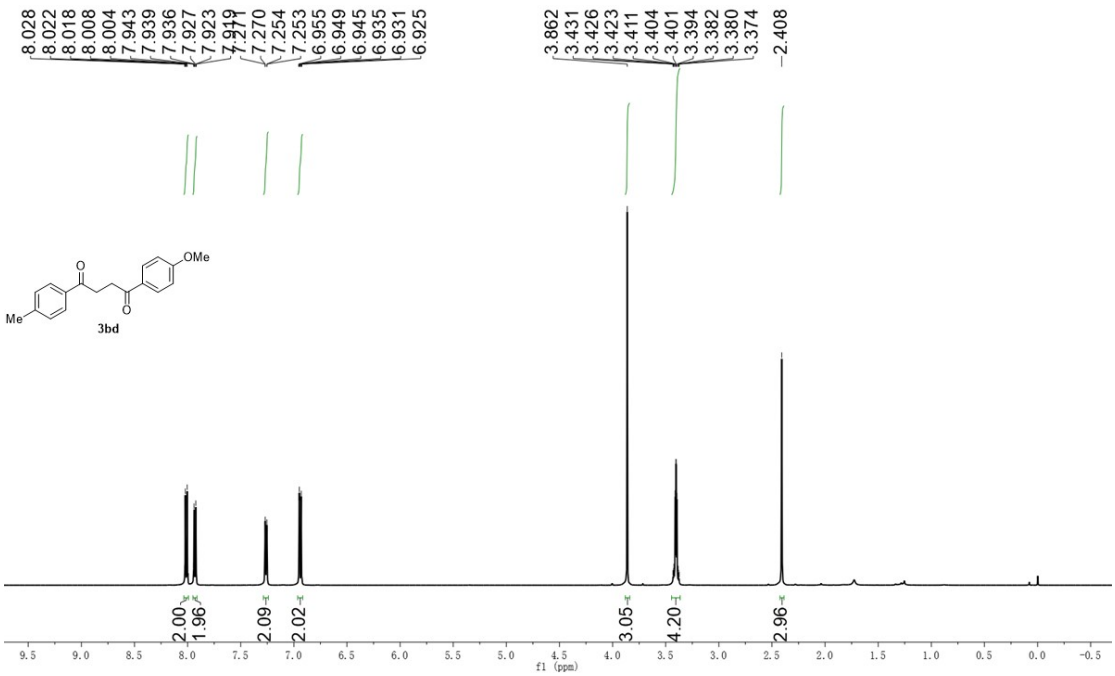
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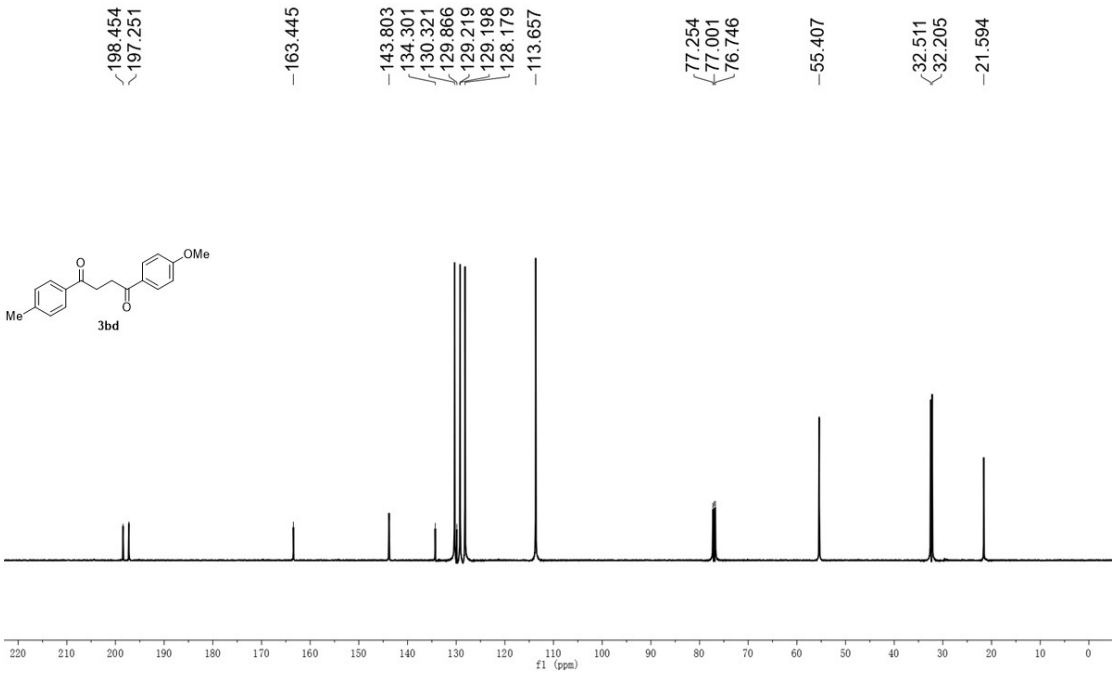
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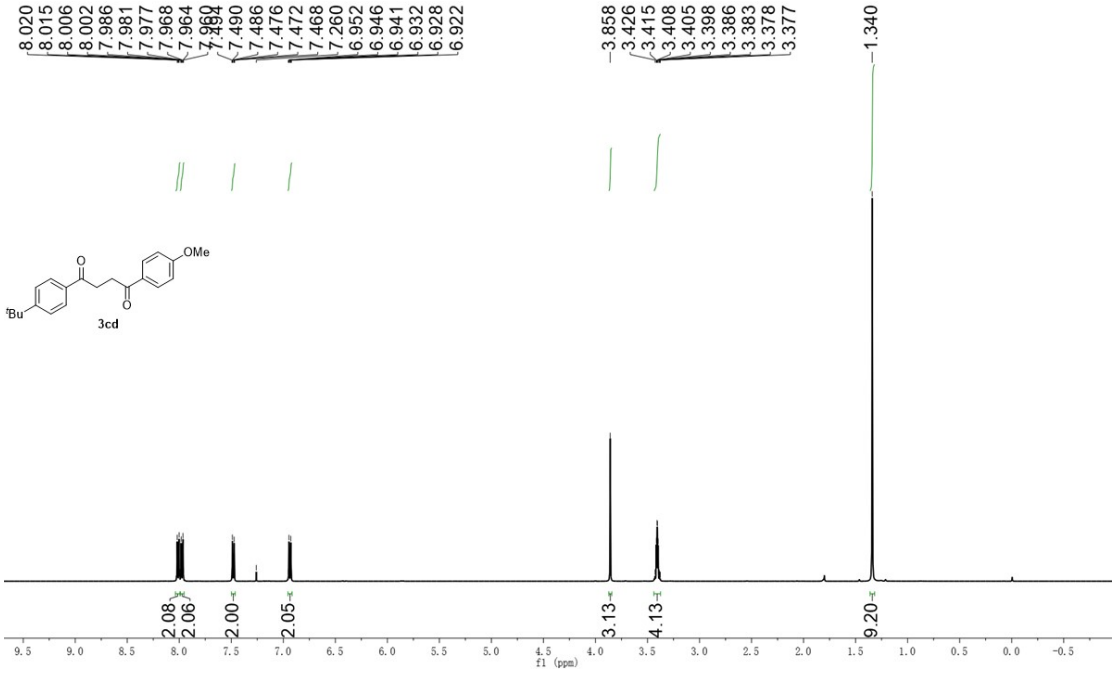
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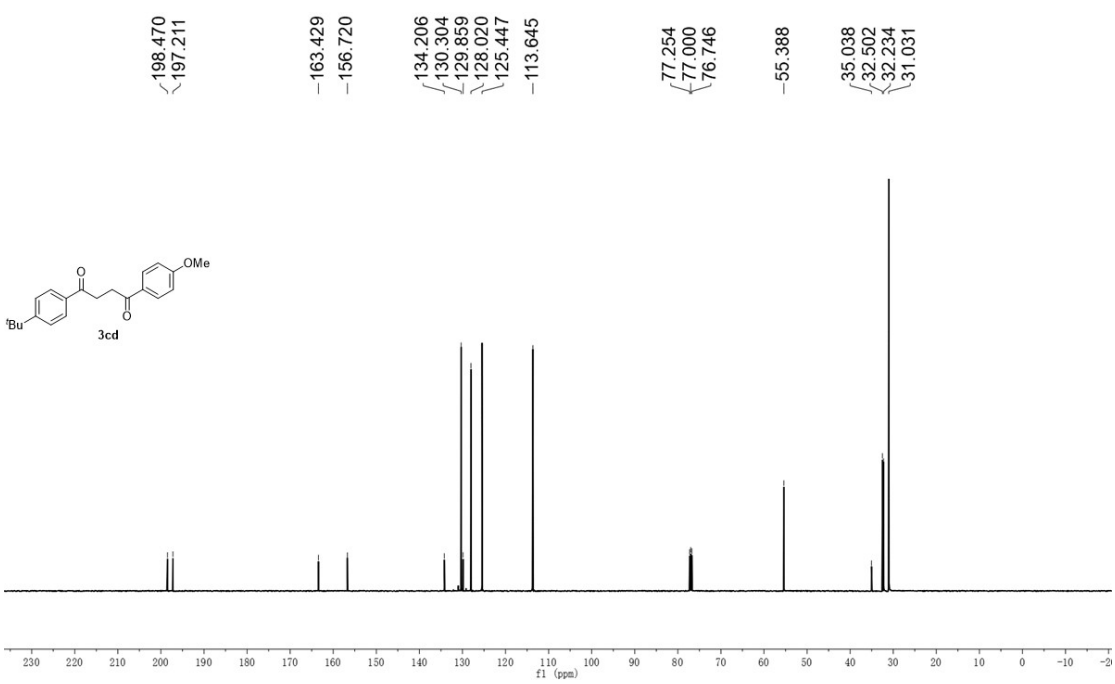
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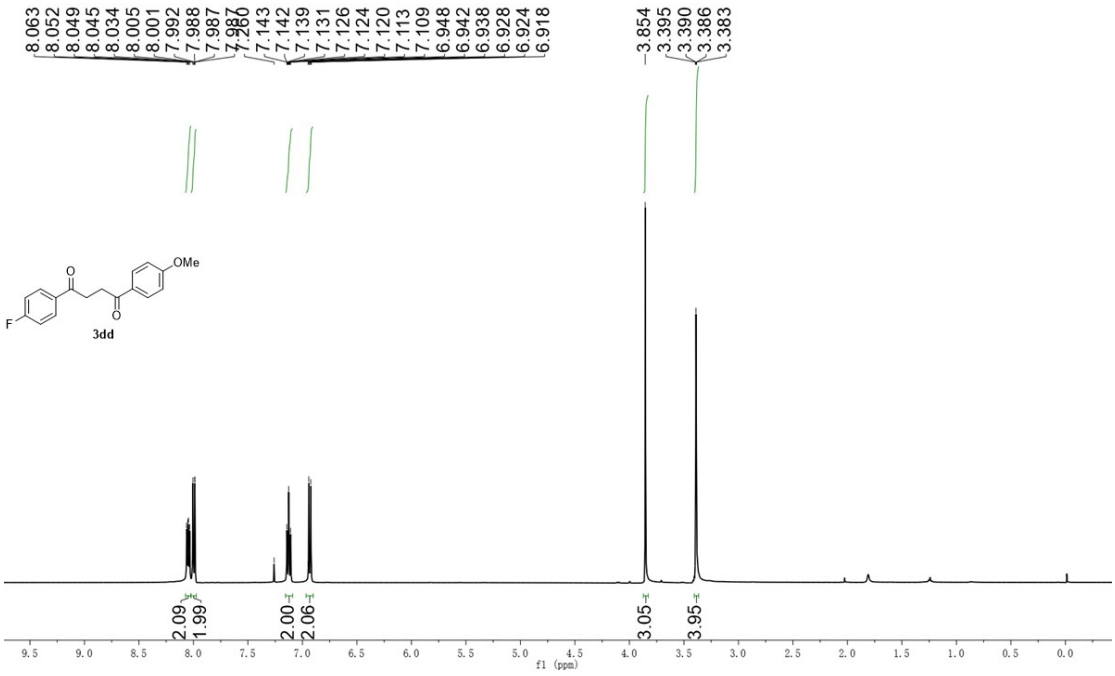
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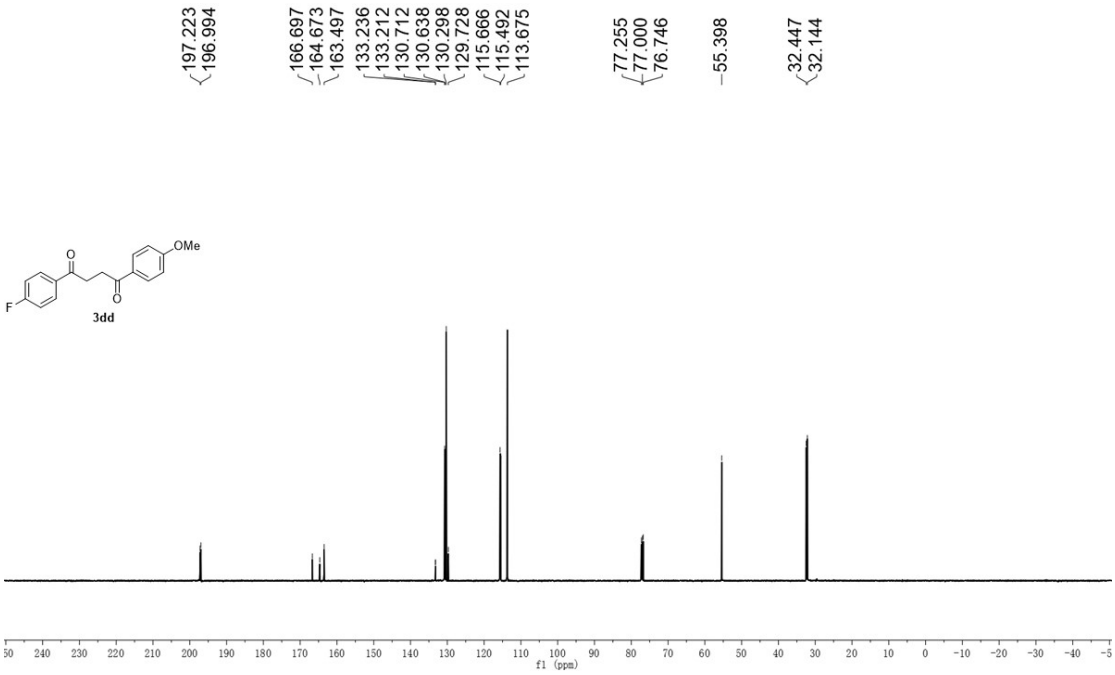
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76.746
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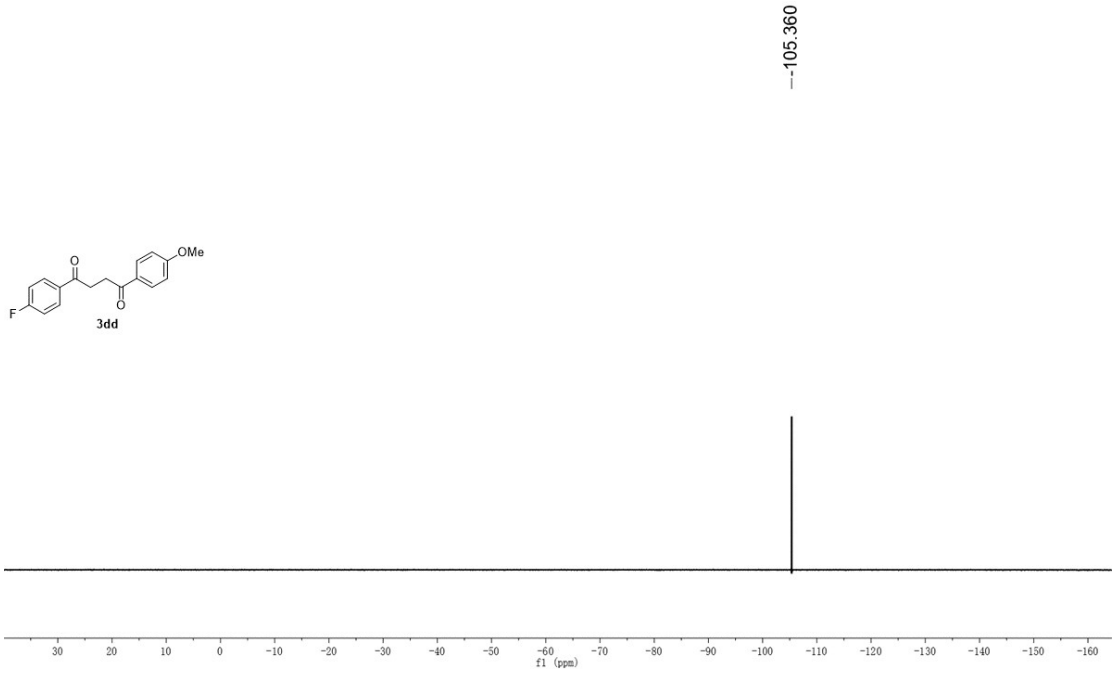
OMe
O
O
F
3dd
f1 (ppm)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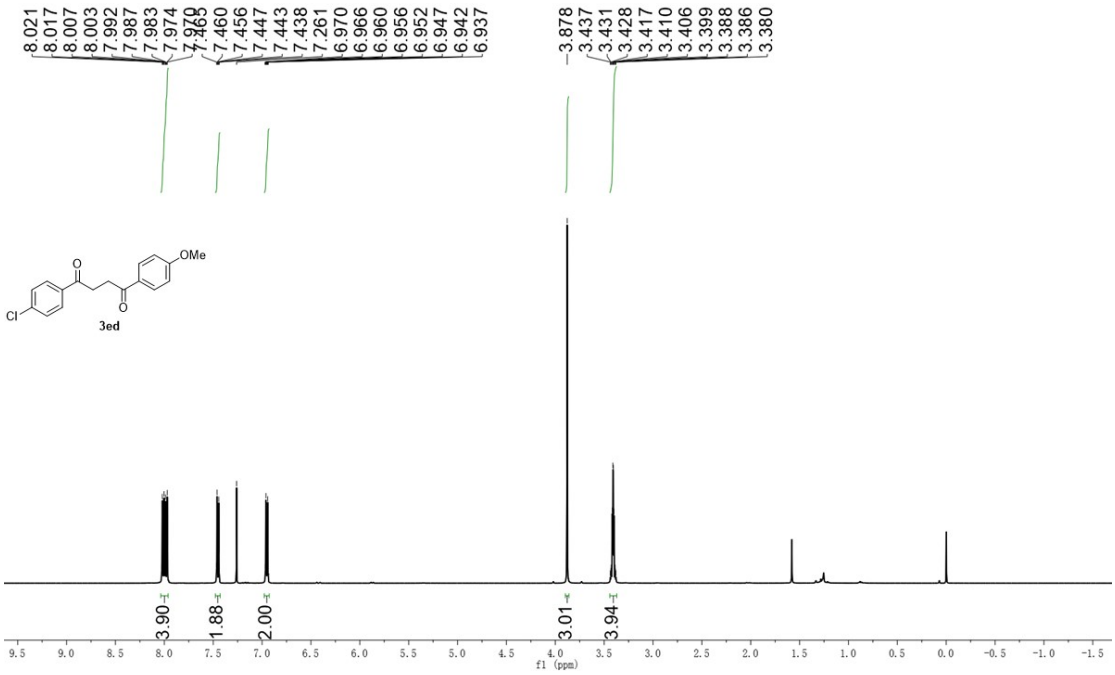
f1 (ppm)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7.438
7.261
6.970
6.966
6.960
6.956
6.952
6.947
6.942
6.937
3.878
3.437
3.431
3.428
3.417
3.410
3.406
3.399
3.388
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OMe
Cl
O
O
3ed
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2.00
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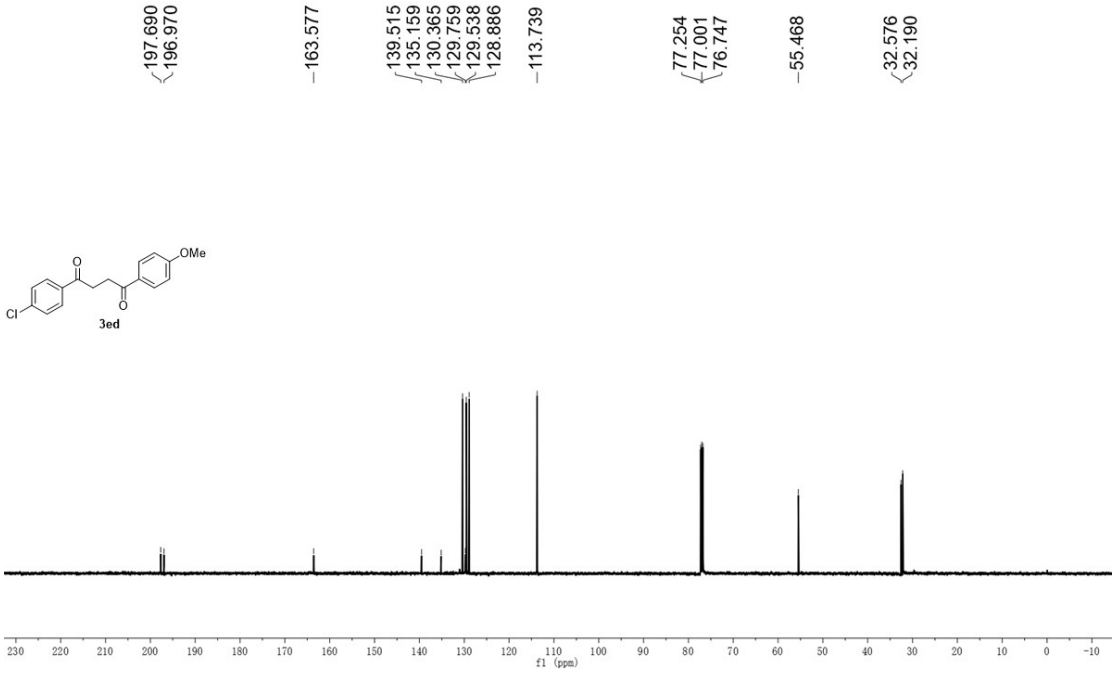
3.94
f1 (ppm)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129.538
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77.001
76.747
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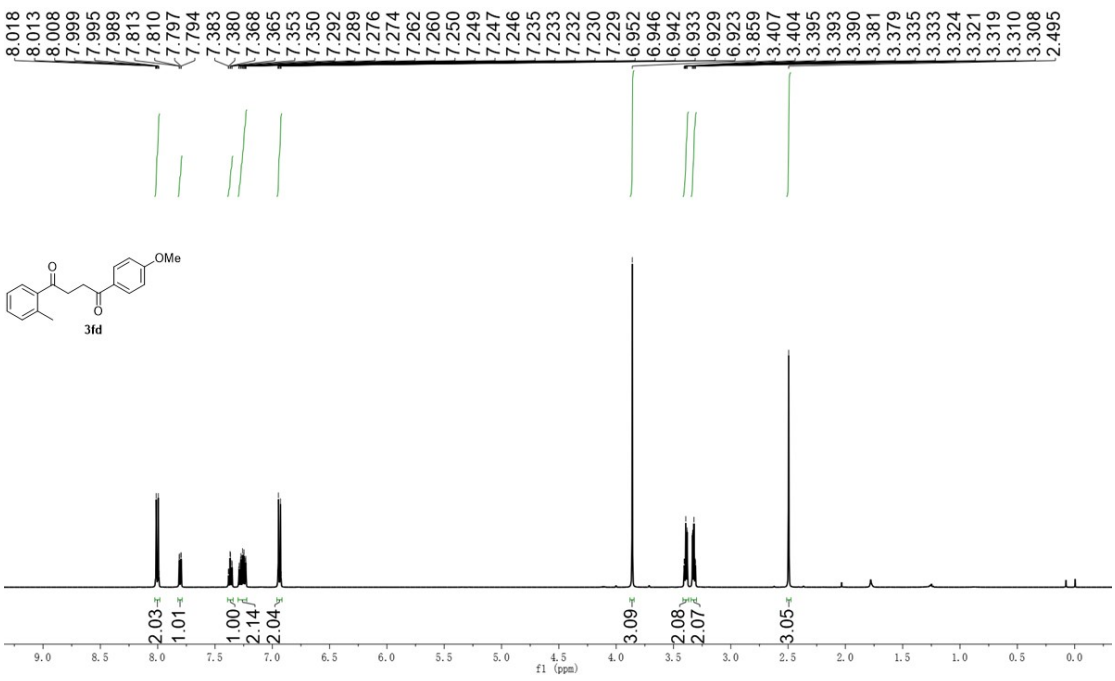
32.576
32.190
OMe
Cl
O
O
3ed
f1 (ppm)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7.810
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7.794
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7.380
7.368
7.365
7.353
7.350
7.292
7.289
7.276
7.274
7.262
7.260
7.250
7.249
7.247
7.246
7.235
7.233
7.232
7.230
7.229
6.952
6.946
6.942
6.933
6.929
6.923
3.859
3.407
3.404
3.395
3.393
3.390
3.381
3.379
3.335
3.333
3.324
3.321
3.319
3.310
3.308
2.495
OMe
O
O
3fd
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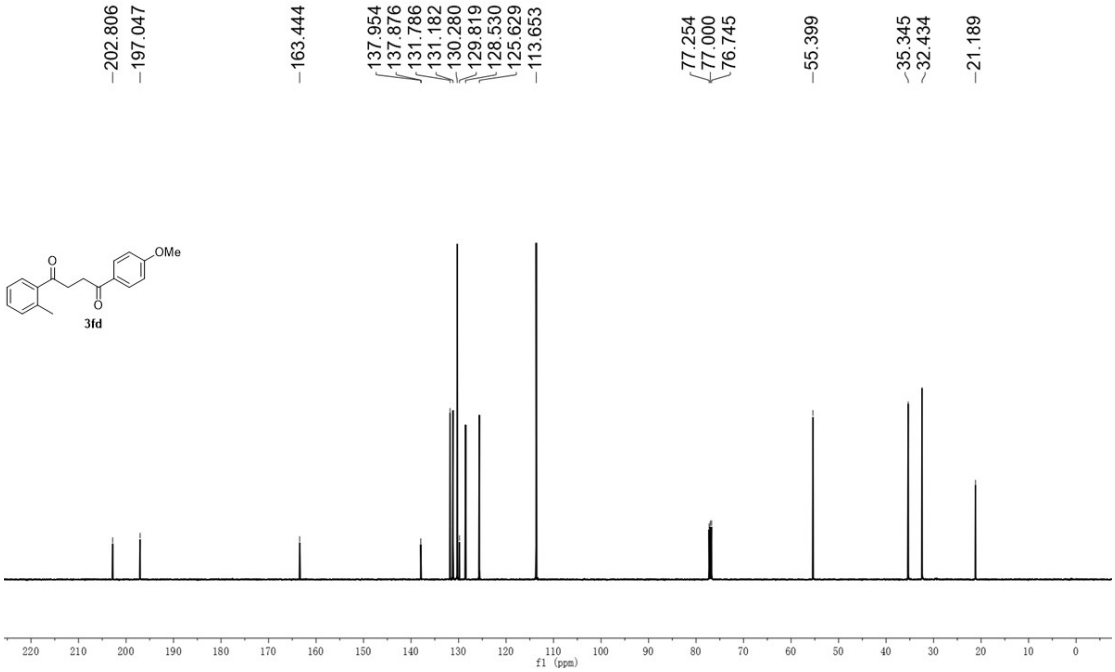
1.01
1.00
2.14
2.04
3.09
2.08
2.07
3.05
f1 (ppm)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131.182
130.280
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128.530
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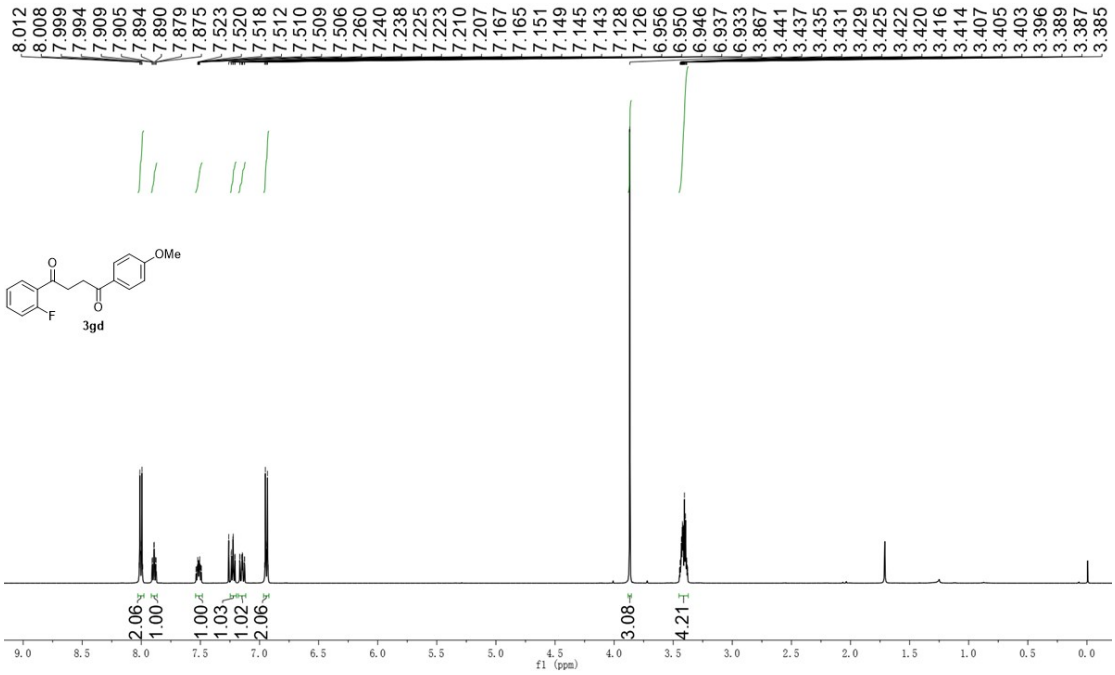
76.745
55.399
35.345
32.434
21.189
OMe
O
O
3fd
f1 (ppm)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8.008
7.999
7.994
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7.890
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7.875
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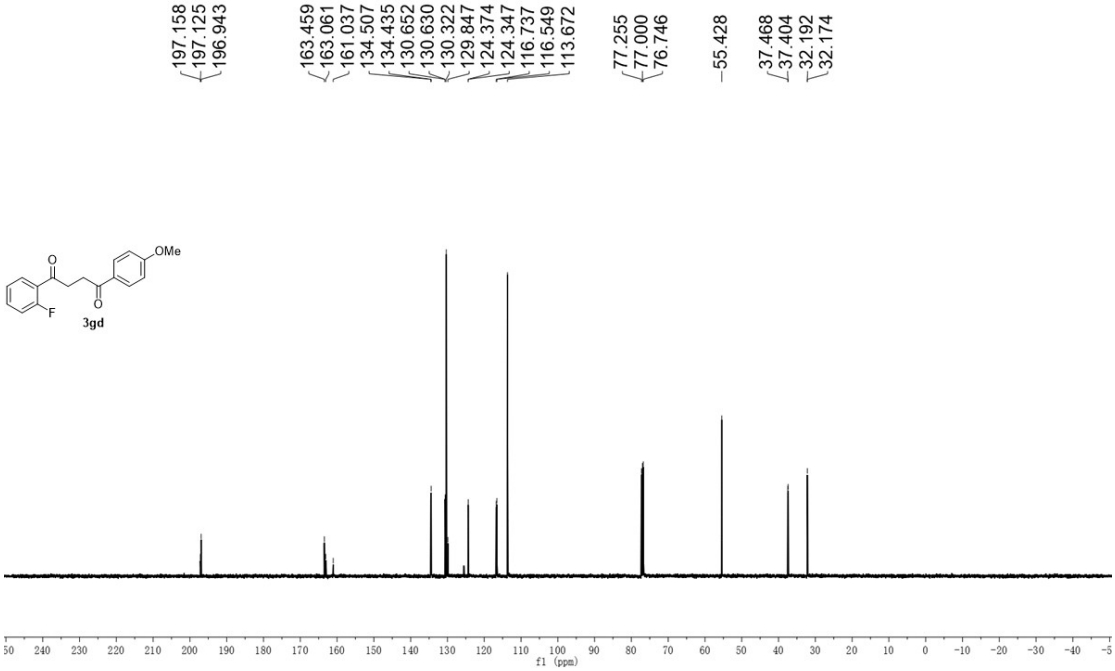
7.518
7.512
7.510
7.509
7.506
7.260
7.240
7.238
7.225
7.223
7.210
7.207
7.167
7.165
7.151
7.149
7.145
7.143
7.128
7.126
6.956
6.950
6.946
6.937
6.933
3.867
3.441
3.437
3.435
3.431
3.429
3.425
3.422
3.420
3.416
3.414
3.407
3.405
3.403
3.396
3.389
3.387
3.385
OMe
O
O
F
3gd
2.06
1.00
1.00
1.03
1.02
2.06
3.08
4.21
f1 (ppm)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134.507
134.435
130.652
130.630
130.322
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124.374
124.347
116.737
116.549
113.672
77.255
77.000
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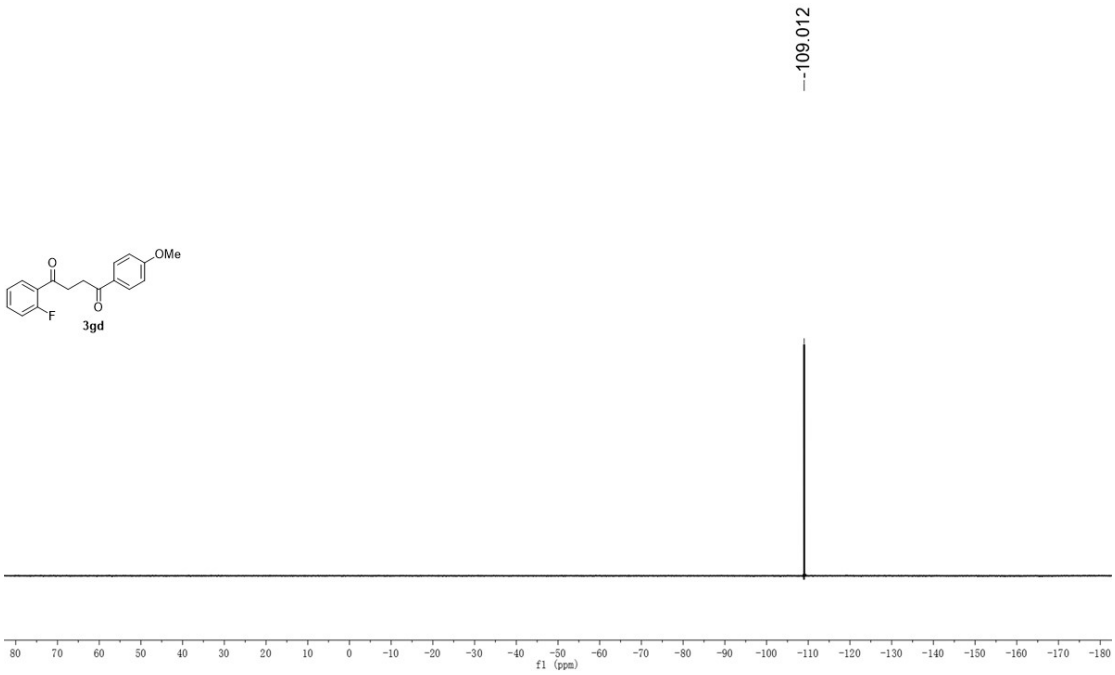
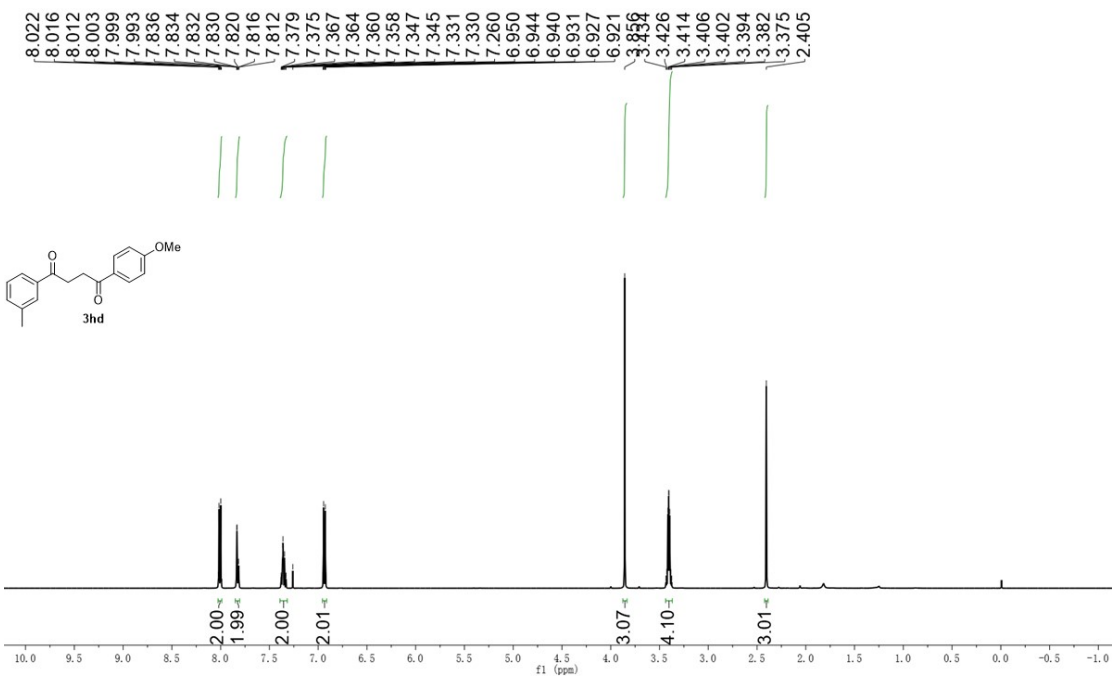
55.428
37.468
37.404
32.192
32.174
OMe
O
O
F
3gd
f1 (ppm)


-109.012
OMe
O
O
F
3gd
80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180
f1 (ppm)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8.016
8.012
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7.993
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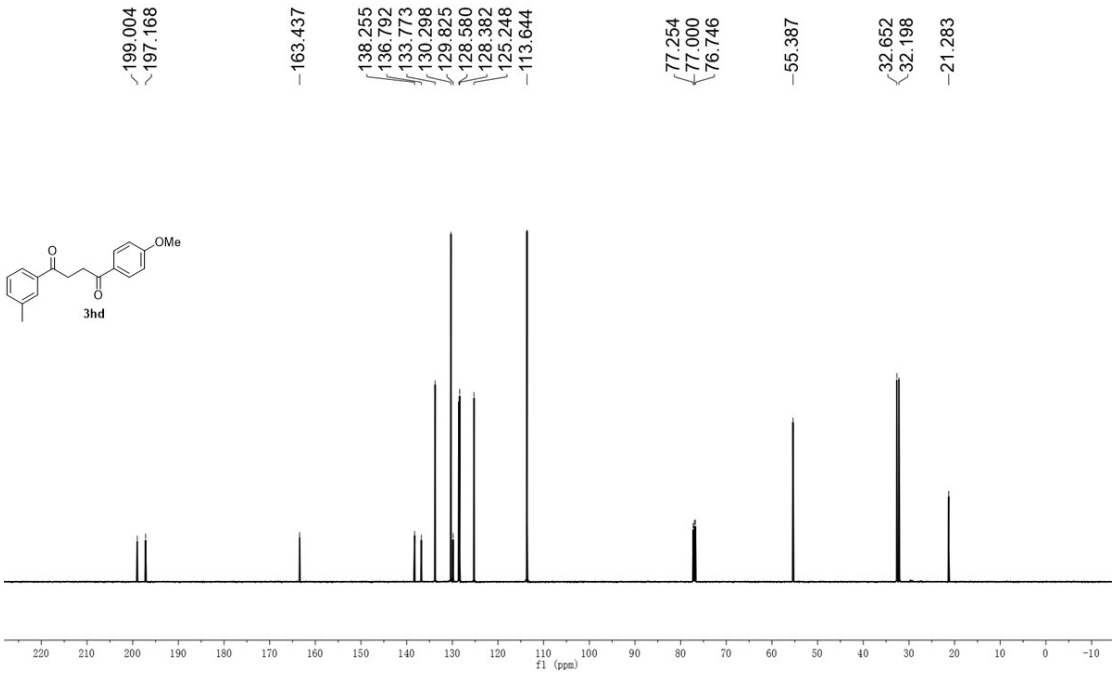
7.834
7.832
7.830
7.820
7.816
7.812
7.379
7.375
7.367
7.364
7.360
7.358
7.347
7.345
7.331
7.330
7.260
6.950
6.944
6.940
6.931
6.927
6.921
3.426
3.414
3.406
3.402
3.394
3.382
3.375
2.405
OMe
O
O
3hd
2.00
1.99
2.00
2.01
3.07
4.10
3.01
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)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197.168
163.437
138.255
136.792
133.773
130.298
129.825
128.580
128.382
125.248
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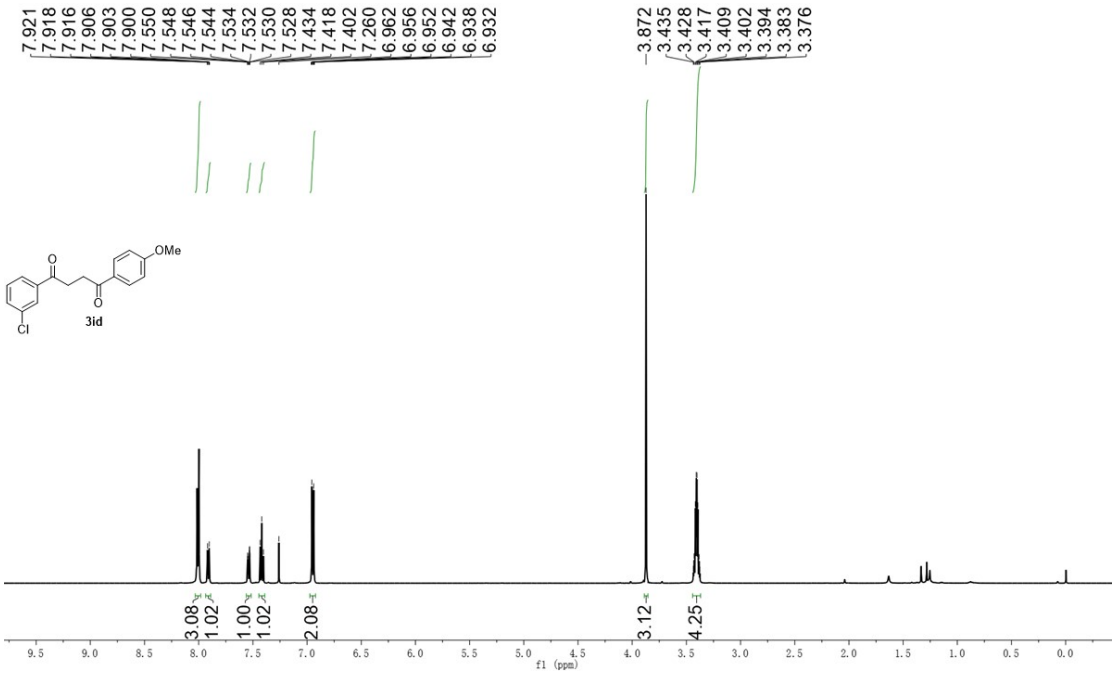
77.254
77.000
76.746
55.387
32.652
32.198
21.283
OMe
O
O
3hd
f1 (ppm)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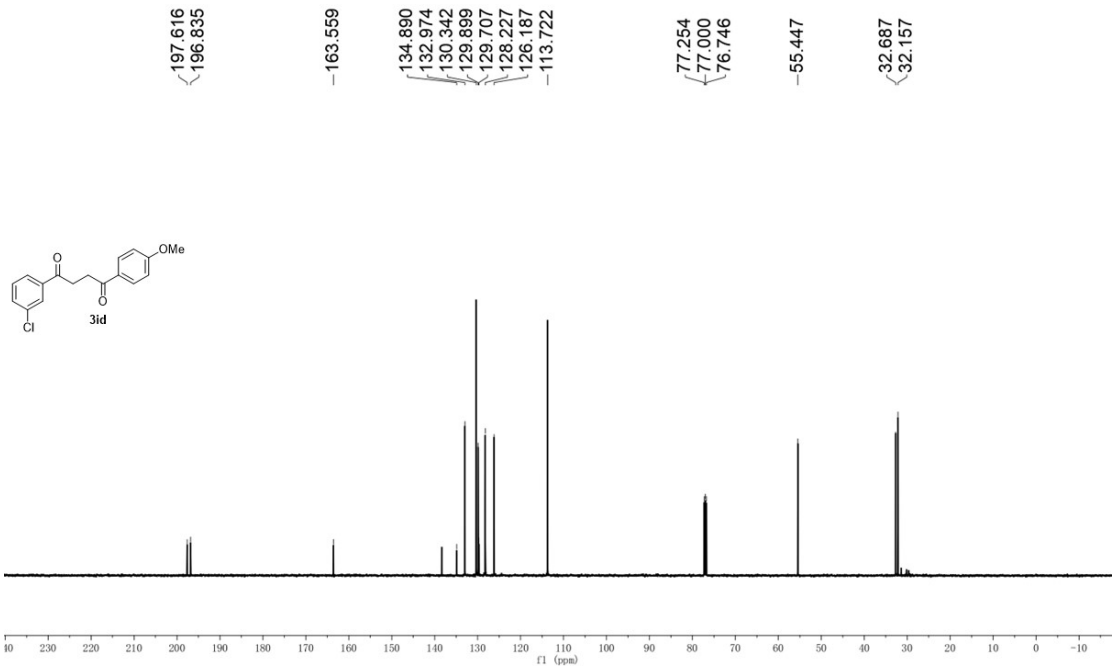
7.918
7.916
7.906
7.903
7.900
7.550
7.548
7.546
7.544
7.534
7.532
7.530
7.528
7.434
7.418
7.402
7.260
6.962
6.956
6.952
6.942
6.938
6.932
3.872
3.435
3.428
3.417
3.409
3.402
3.394
3.383
3.376
OMe
O
O
Cl
3id
3.08
1.02
1.00
1.02
2.08
3.12
4.25
f1 (ppm)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130.342
129.899
129.707
128.227
126.187
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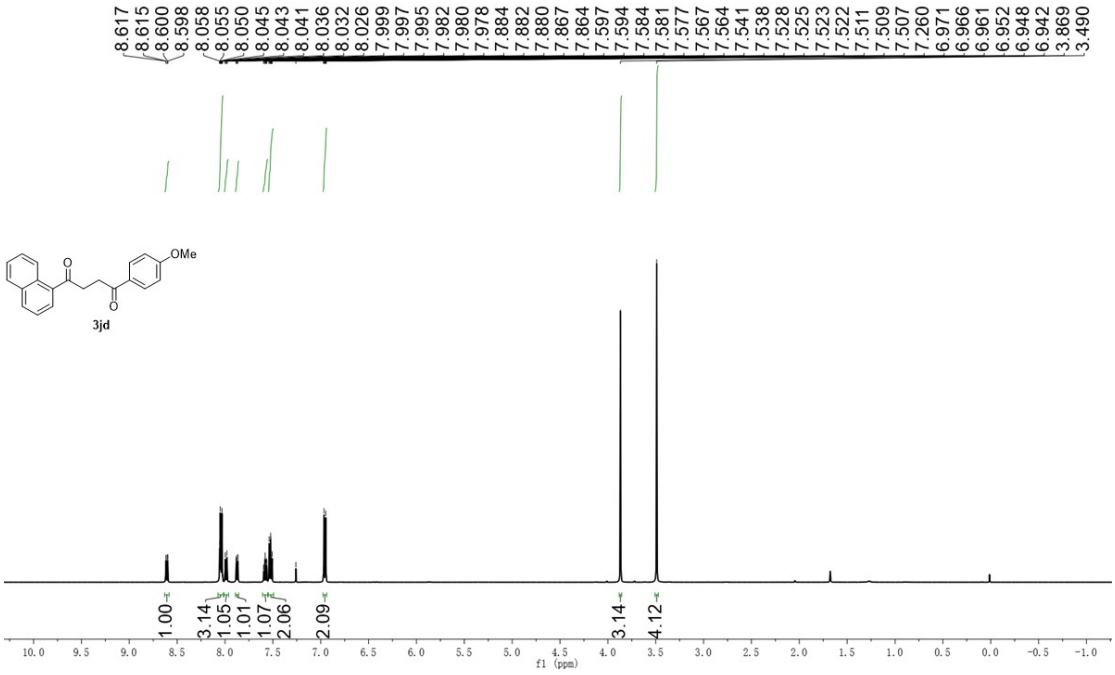
77.000
76.746
55.447
32.687
32.157
OMe
O
O
Cl
3id
f1 (ppm)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8.615
8.600
8.598
8.058
8.055
8.050
8.045
8.043
8.041
8.036
8.032
8.026
7.999
7.997
7.995
7.982
7.980
7.978
7.884
7.882
7.880
7.867
7.864
7.597
7.594
7.584
7.581
7.577
7.567
7.564
7.541
7.538
7.528
7.525
7.523
7.522
7.511
7.509
7.507
7.260
6.971
6.966
6.961
6.952
6.948
6.942
3.869
3.490
OMe
O
O
3jd
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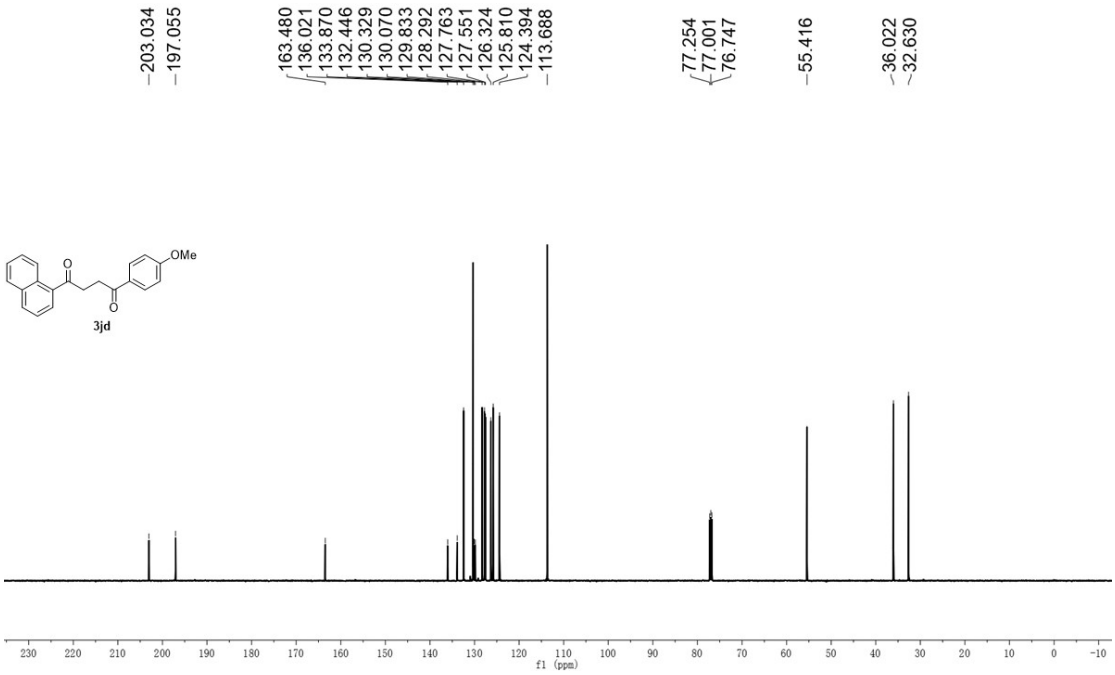
3.14
1.05
1.01
1.07
2.06
2.09
3.14
4.12
f1 (ppm)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133.870
132.446
130.329
130.070
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128.292
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127.551
126.324
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124.394
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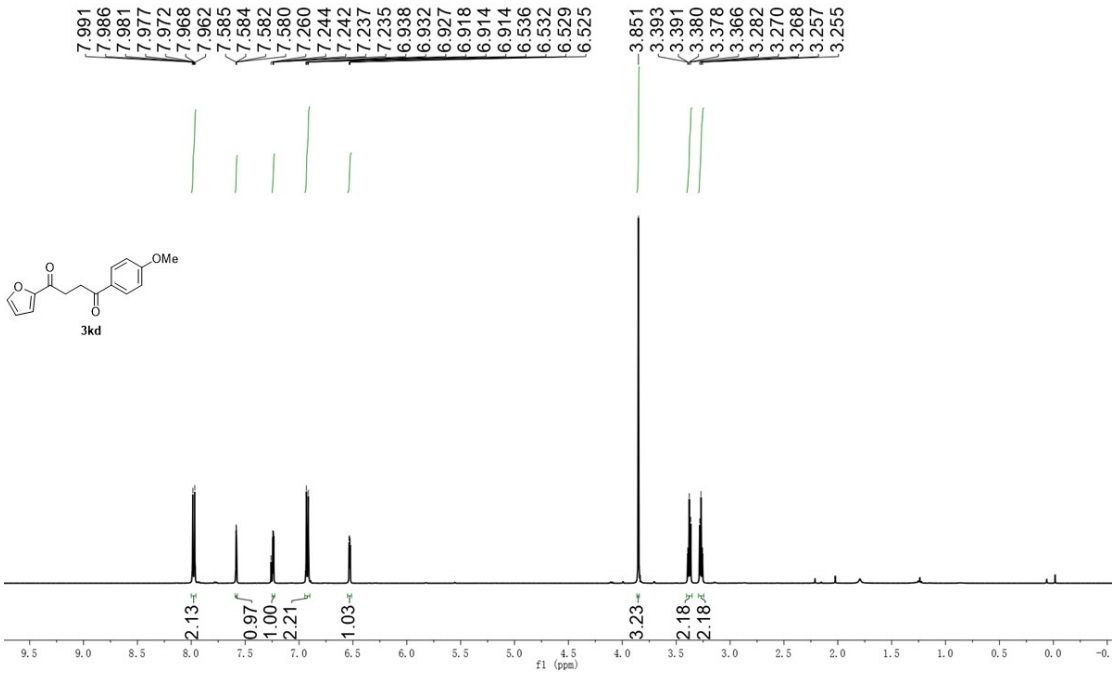
77.254
77.001
76.747
55.416
36.022
32.630
OMe
3jd
f1 (ppm)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7.962
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7.584
7.582
7.580
7.260
7.244
7.242
7.237
7.235
6.938
6.932
6.927
6.918
6.914
6.914
6.536
6.532
6.529
6.525
3.851
3.393
3.391
3.380
3.378
3.366
3.282
3.270
3.268
3.257
3.255
OMe
3kd
2.13
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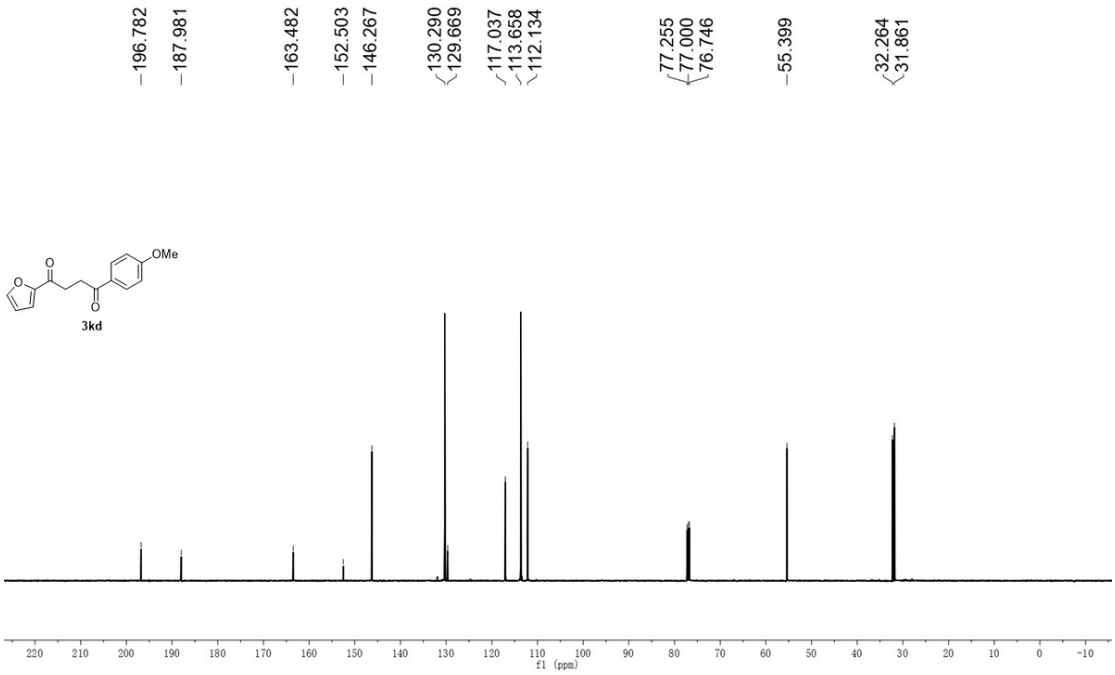
1.03
3.23
2.18
2.18
f1 (ppm)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129.669
117.037
113.658
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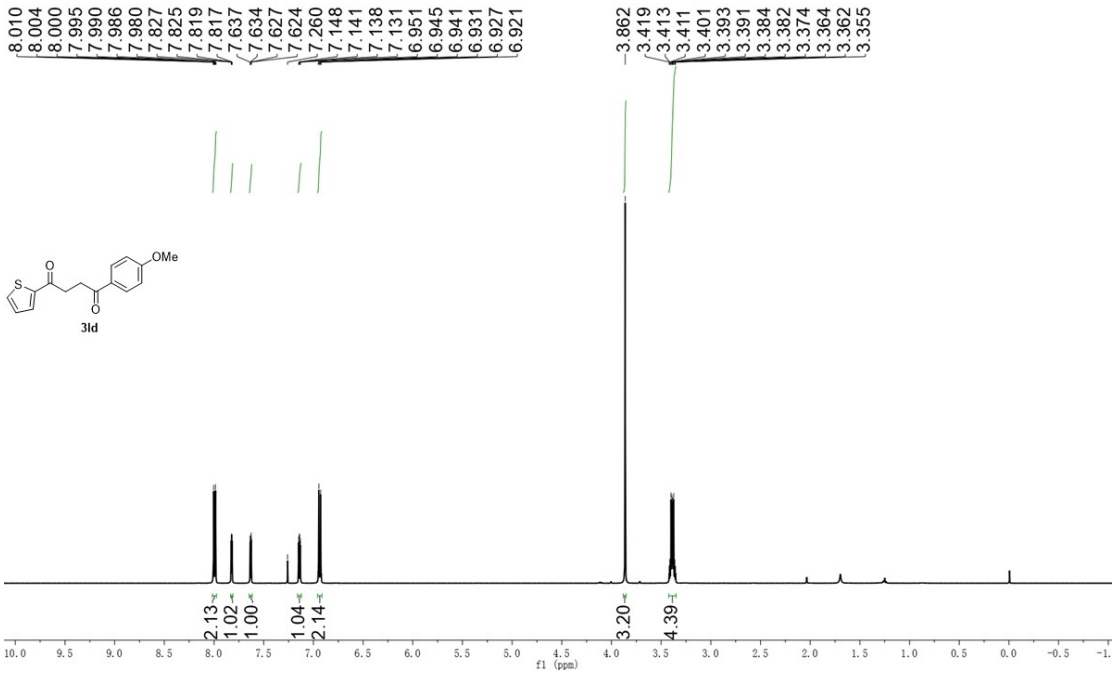
76.746
55.399
32.264
31.861
OMe
O
O
O
3kd
f1 (ppm)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8.000
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7.990
7.986
7.980
7.827
7.825
7.819
7.817
7.637
7.634
7.627
7.624
7.260
7.148
7.141
7.138
7.131
6.951
6.945
6.941
6.931
6.927
6.921
3.862
3.419
3.413
3.411
3.401
3.393
3.391
3.384
3.382
3.374
3.364
3.362
3.355
OMe
S
O
O
3ld
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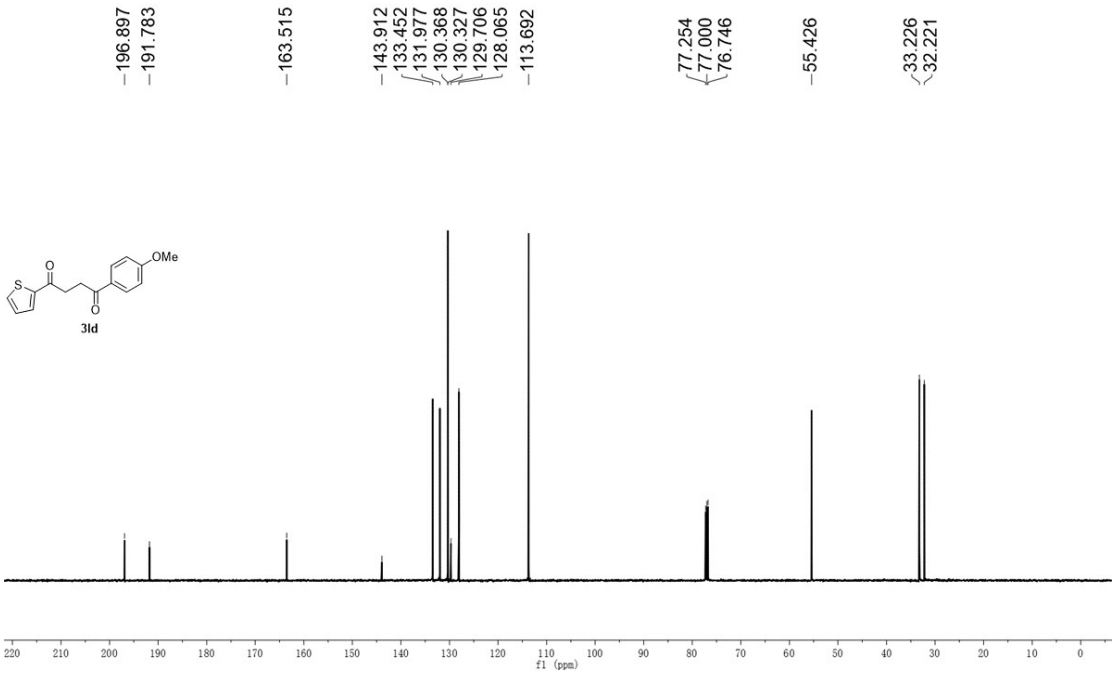
4.39
f1 (ppm)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130.327
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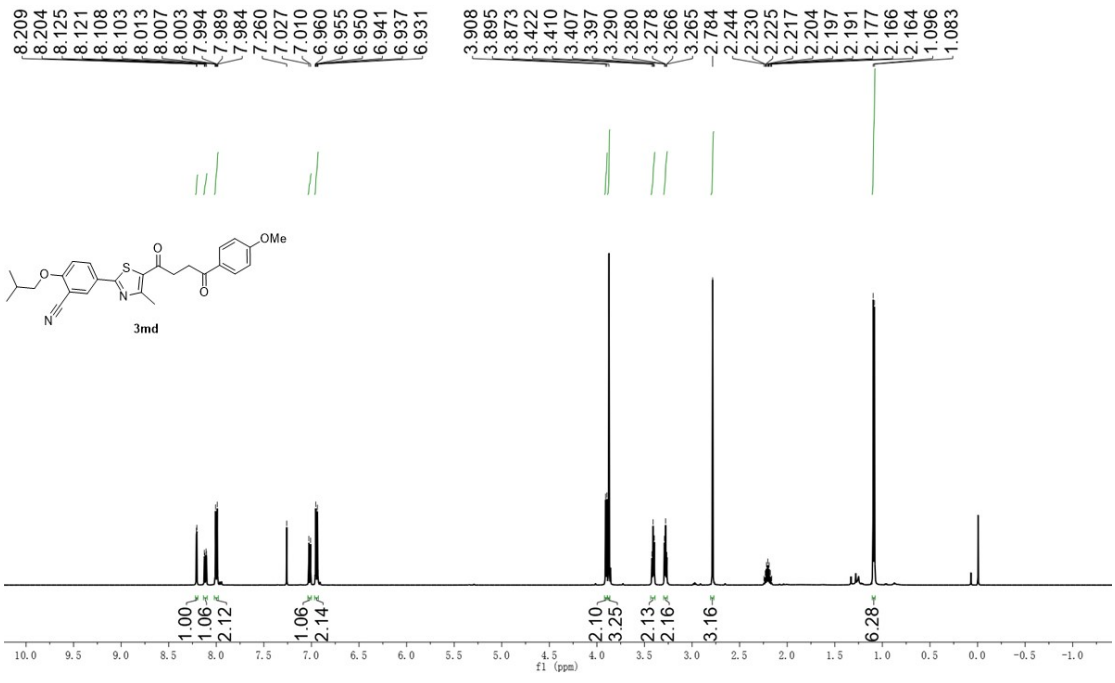
77.254
77.000
76.746
55.426
33.226
32.221
OMe
3ld
f1 (ppm)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8.103
8.013
8.007
8.003
7.994
7.989
7.984
7.260
7.027
7.010
6.960
6.955
6.950
6.941
6.937
6.931
3.908
3.895
3.873
3.422
3.410
3.407
3.397
3.290
3.280
3.278
3.266
3.265
2.784
2.244
2.230
2.225
2.217
2.204
2.197
2.191
2.177
2.166
2.164
1.096
1.083
OMe
3md
1.00
1.06
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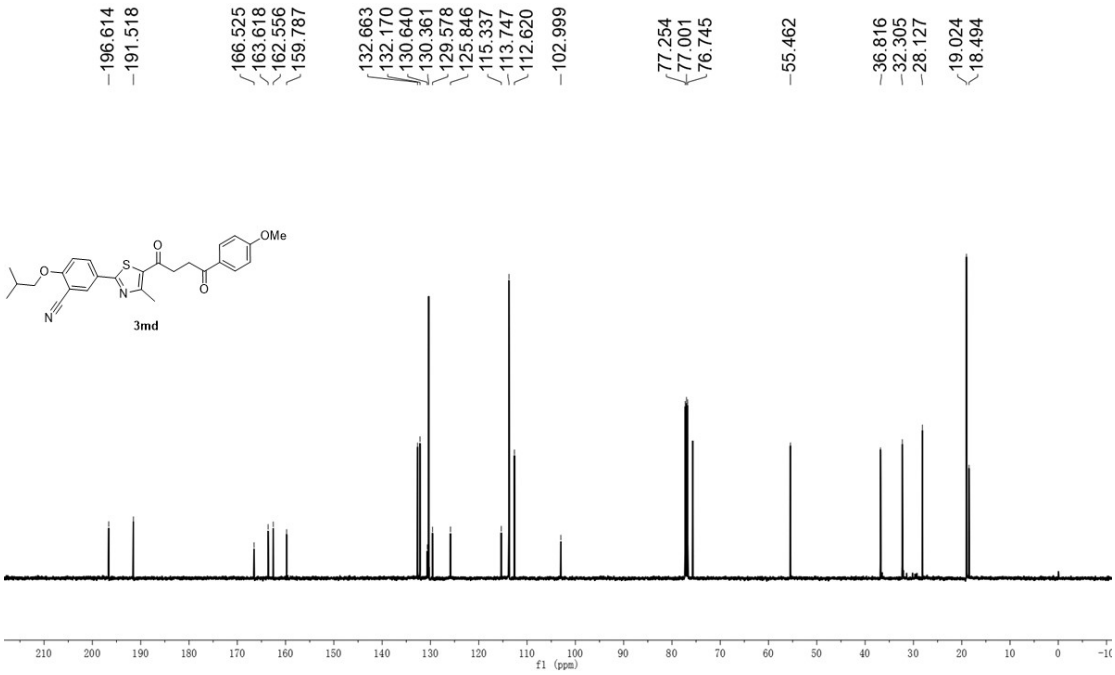
1.06
2.14
2.10
3.25
2.13
2.16
3.16
6.28
f1 (ppm)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125.846
115.337
113.747
112.620
102.999
77.254
77.001
76.745
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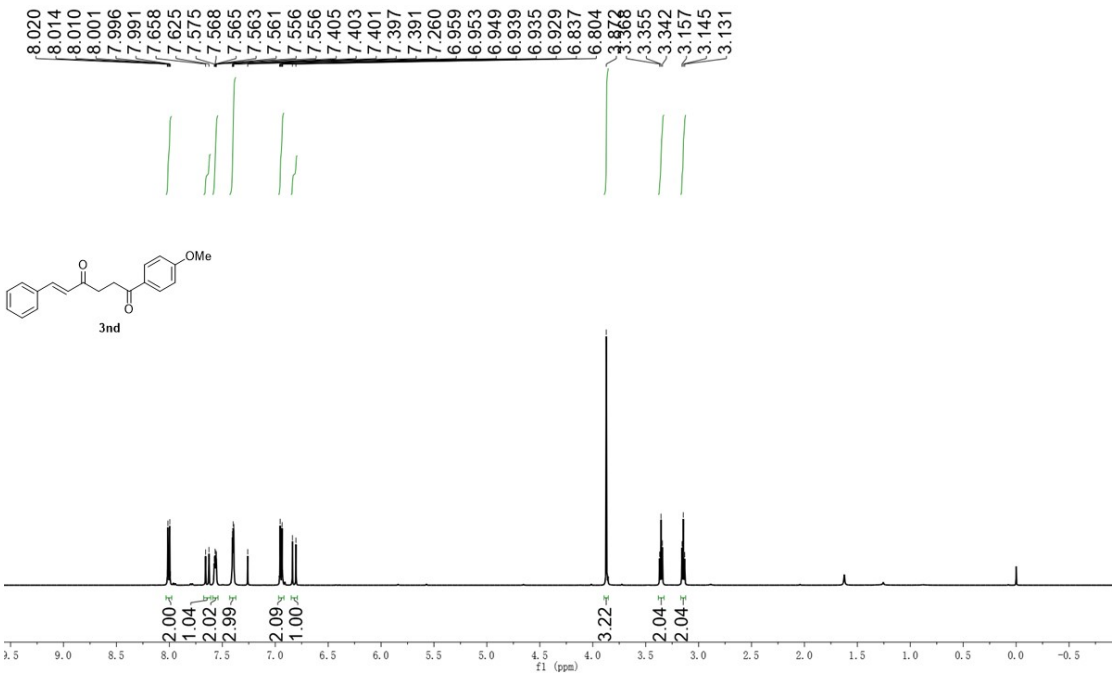
28.127
19.024
18.494
OMe
O
S
N
O
O
N
3md
f1 (ppm)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7.568
7.565
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7.561
7.556
7.556
7.405
7.403
7.401
7.397
7.391
7.260
6.959
6.953
6.949
6.939
6.935
6.929
6.837
6.804
3.372
3.368
3.355
3.342
3.157
3.145
3.131
OMe
O
O
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1.04
2.02
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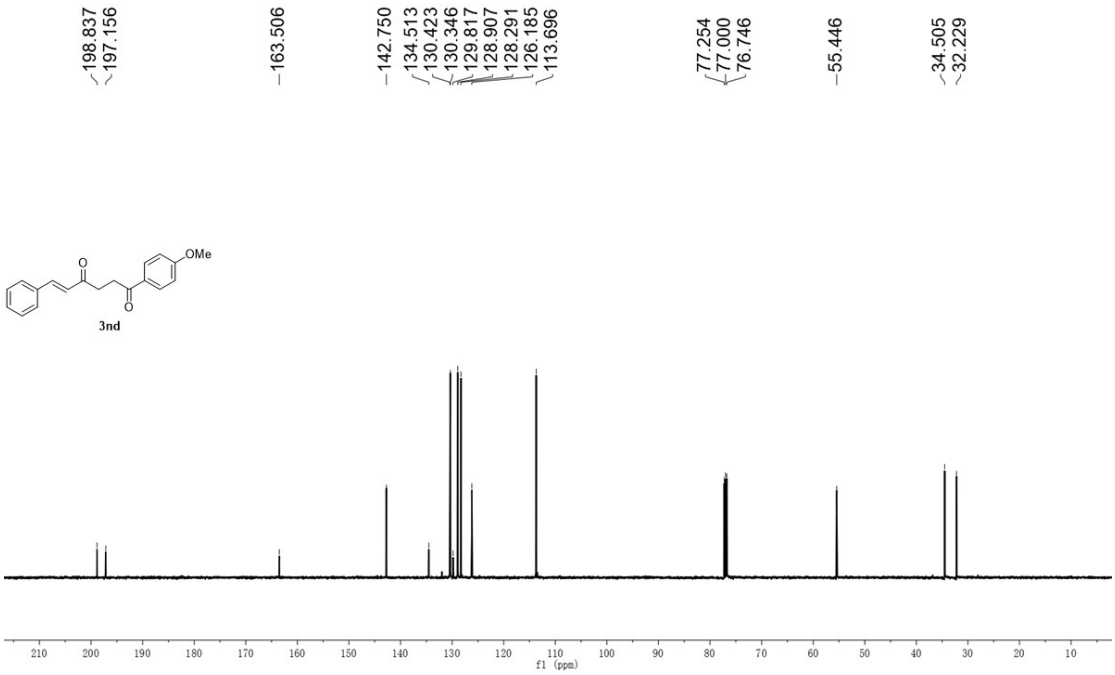
2.09
1.00
3.22
2.04
2.04
f1 (ppm)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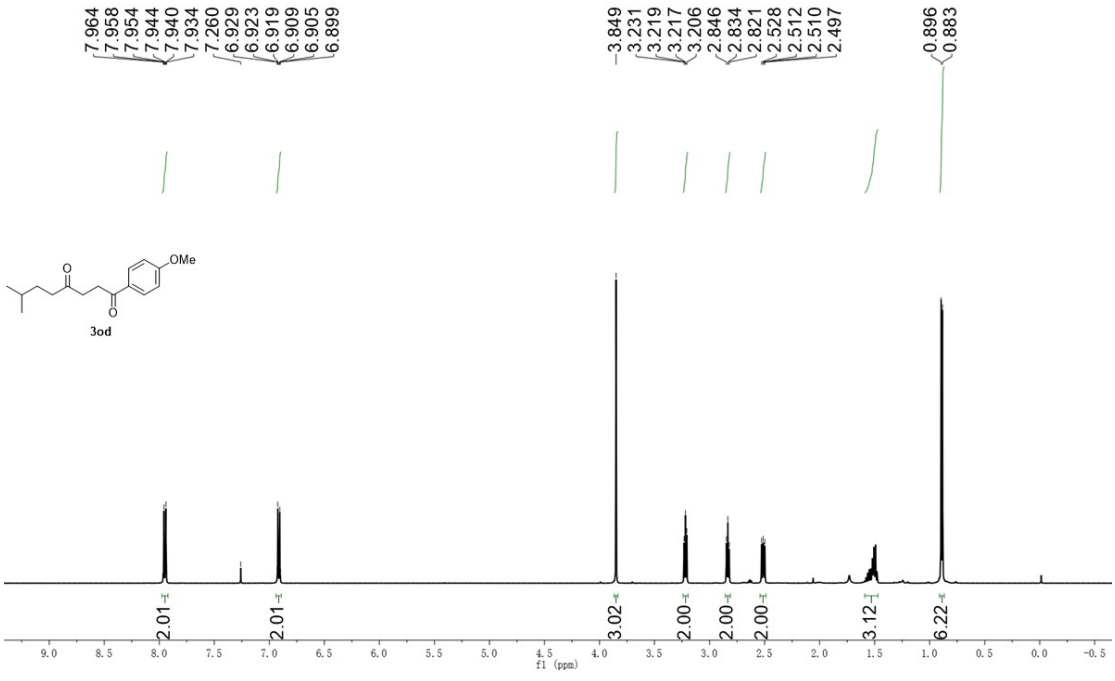
130.423
130.346
129.817
128.907
128.291
126.185
113.696
77.254
77.000
76.746
55.446
34.505
32.229
OMe
O
O
3nd
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
f1 (ppm)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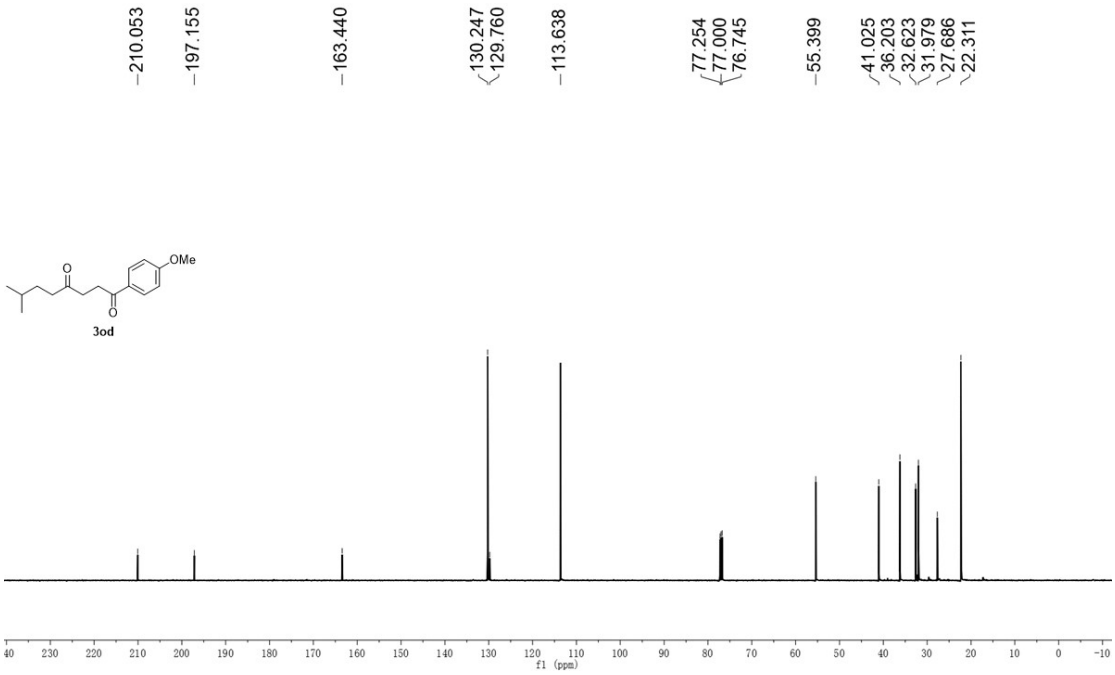
7.944
7.940
7.934
7.260
6.929
6.923
6.919
6.909
6.905
6.899
3.849
3.231
3.219
3.217
3.206
2.846
2.834
2.821
2.528
2.512
2.510
2.497
0.896
0.883
OMe
O
O
3od
2.01
2.01
3.02
2.00
2.00
2.00
3.12
6.22
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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77.000
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36.203
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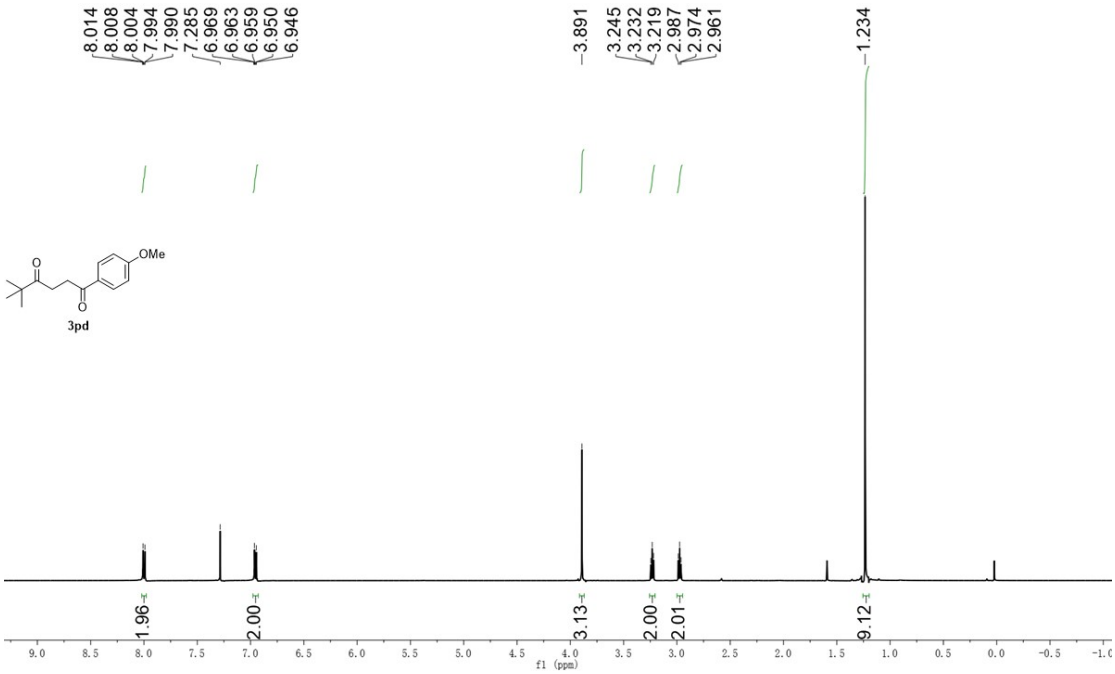
31.979
27.686
22.311
OMe
O
O
3od
f1 (ppm)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6.959
6.950
6.946
3.891
3.245
3.232
3.219
2.987
2.974
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O
O
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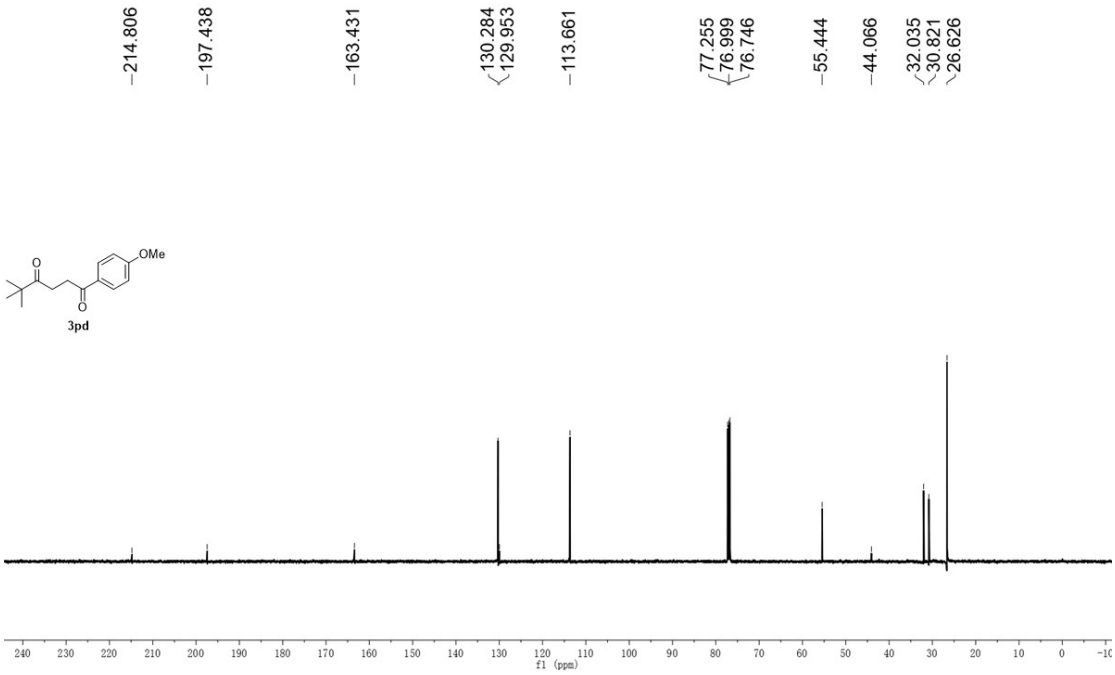
2.01
9.12
f1 (ppm)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32.035
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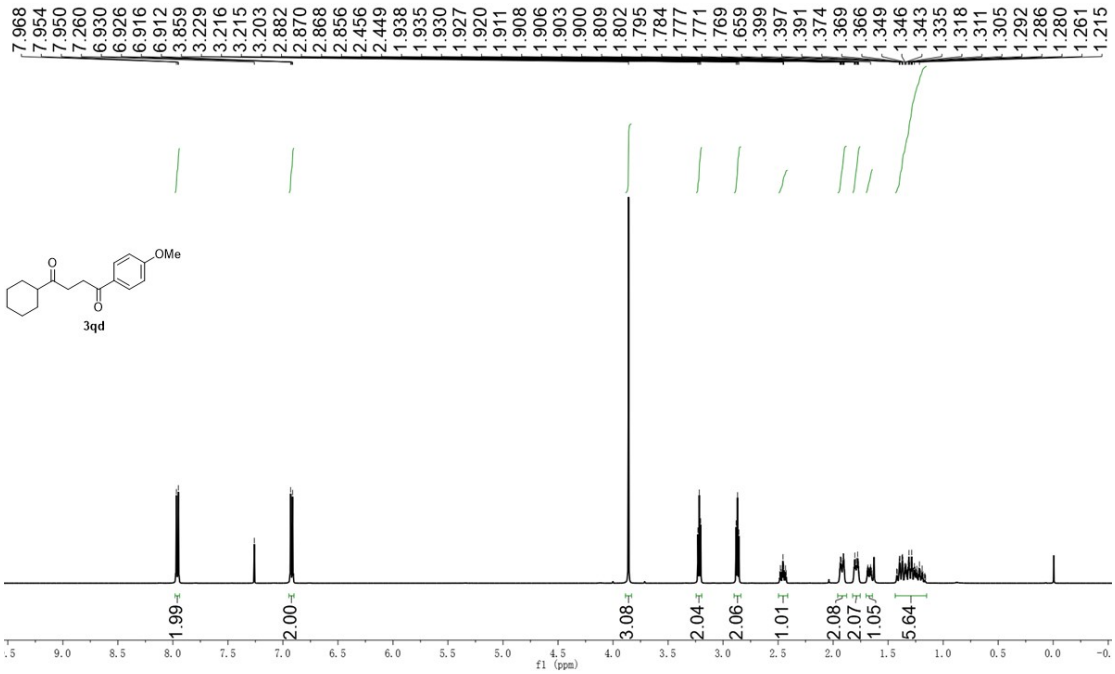
OMe
O
O
3pd
f1 (ppm)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3.215
3.203
2.882
2.870
2.868
2.856
2.456
2.449
1.938
1.935
1.930
1.927
1.920
1.911
1.908
1.906
1.903
1.900
1.809
1.802
1.795
1.784
1.777
1.771
1.769
1.659
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1.397
1.391
1.374
1.369
1.366
1.349
1.346
1.343
1.335
1.318
1.311
1.305
1.292
1.286
1.280
1.261
1.215
OMe
O
O
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2.06
1.01
2.08
2.07
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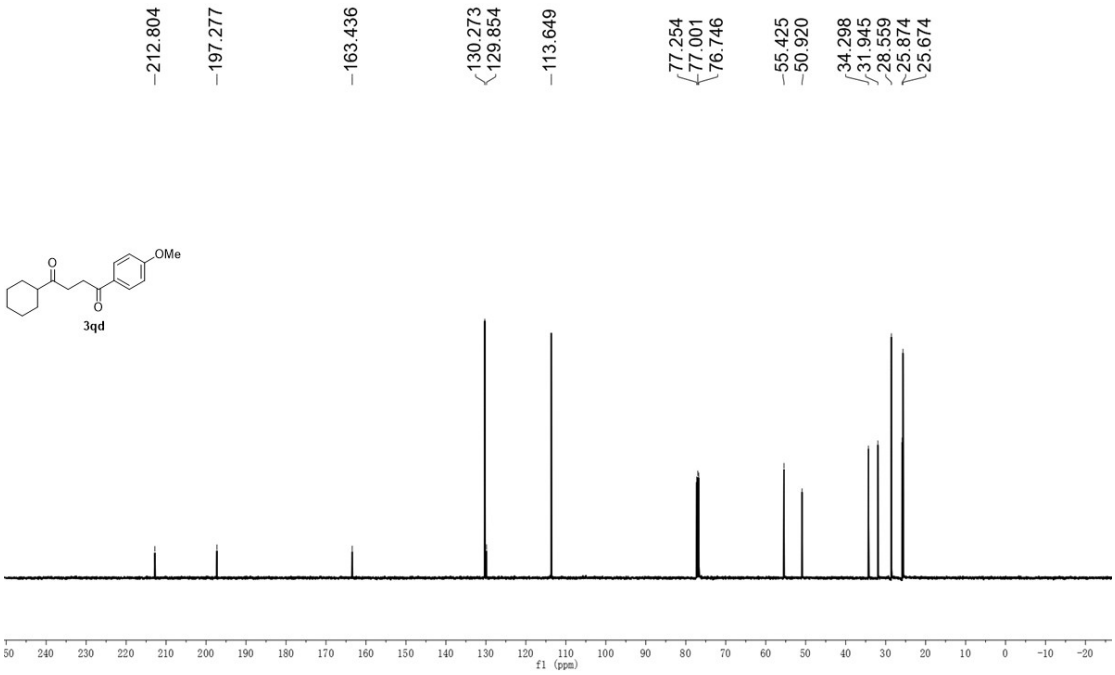
5.64
f1 (ppm)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77.254
77.001
76.746
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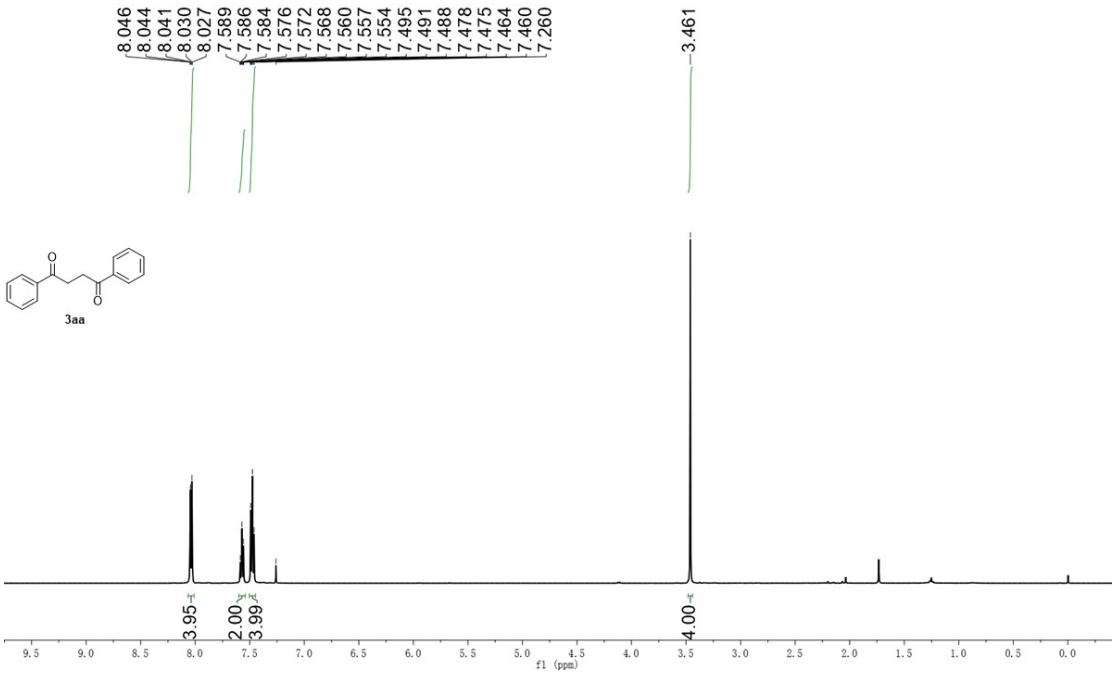
31.945
28.559
25.874
25.674
OMe
3qd
f1 (ppm)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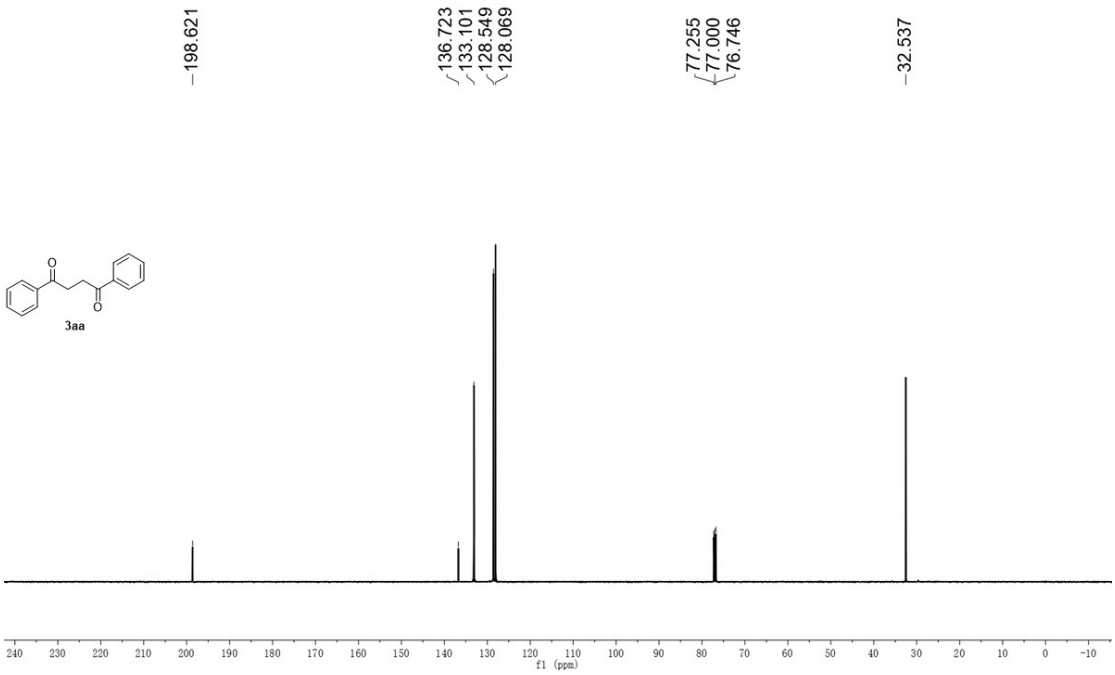
7.584
7.576
7.572
7.568
7.560
7.557
7.554
7.495
7.491
7.488
7.478
7.475
7.464
7.460
7.260
3.461
3aa
3.95
2.00
3.99
4.00
f1 (ppm)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76.746
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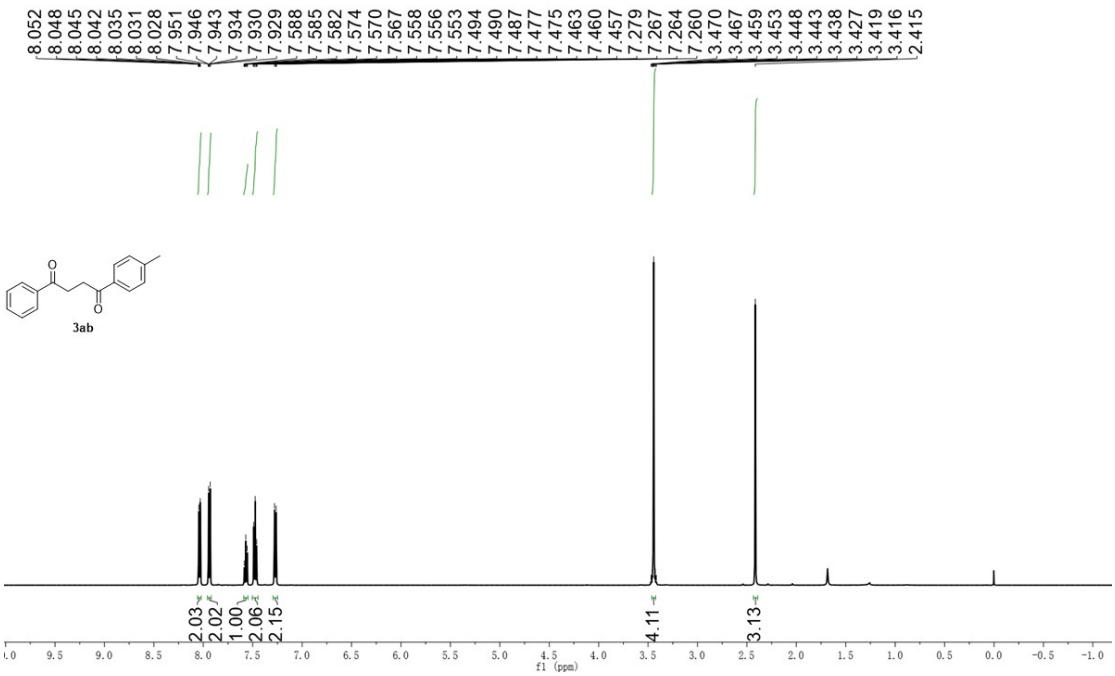
3aa
f1 (ppm)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8.031
8.028
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7.934
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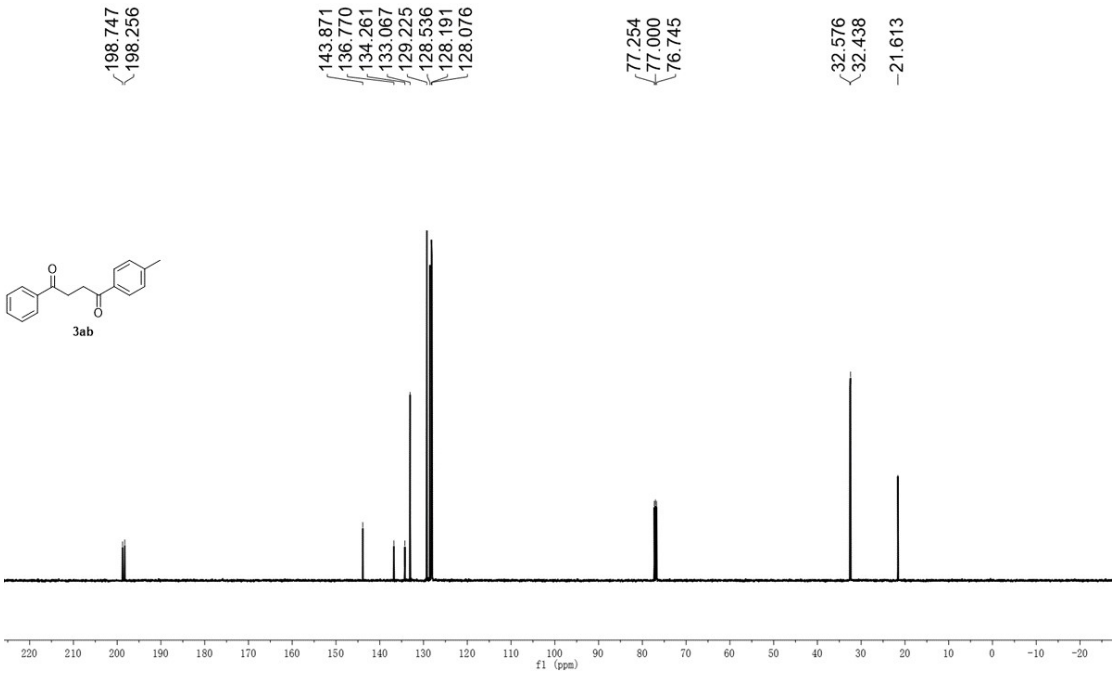
7.929
7.588
7.585
7.582
7.574
7.570
7.567
7.558
7.556
7.553
7.494
7.490
7.487
7.477
7.475
7.463
7.460
7.457
7.279
7.267
7.264
7.260
3.470
3.467
3.459
3.453
3.448
3.443
3.438
3.427
3.419
3.416
2.415
3ab
2.03
2.02
1.00
2.06
2.15
4.11
3.13
f1 (ppm)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143.871
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76.745
32.576
32.438
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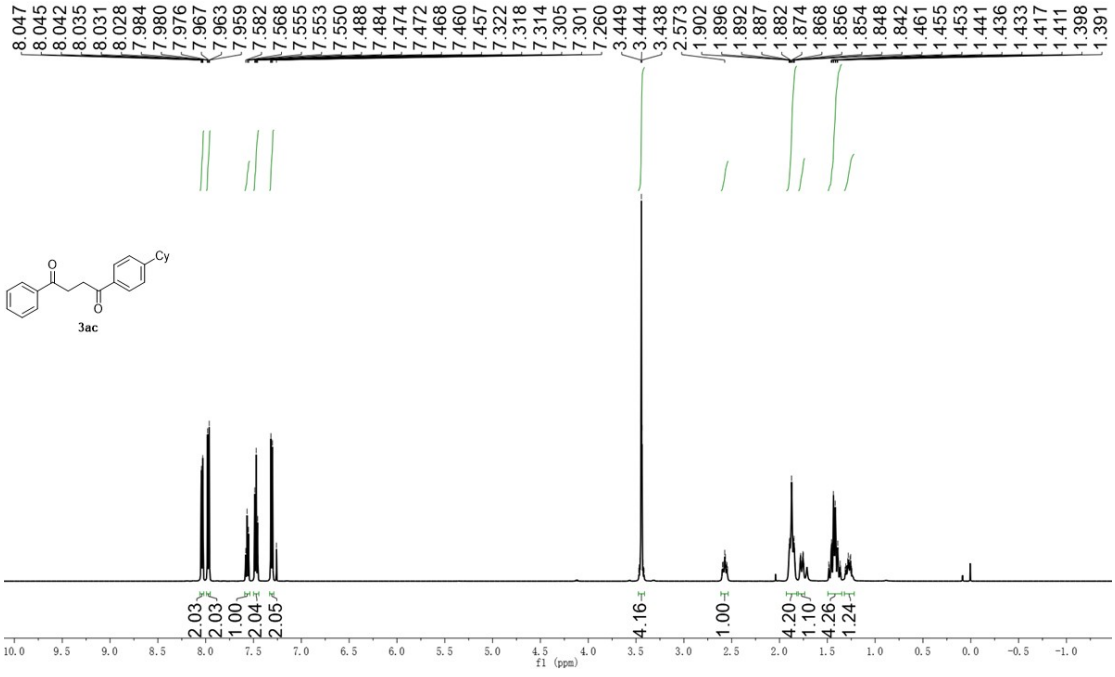
3ab
f1 (ppm)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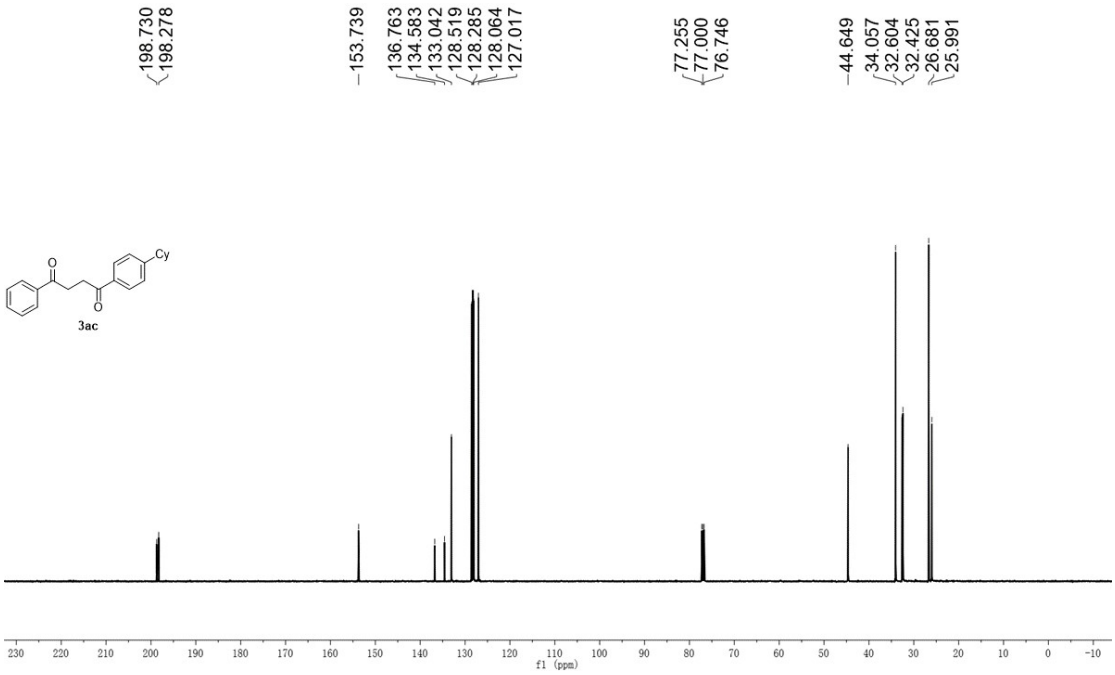
7.582
7.568
7.555
7.553
7.550
7.488
7.484
7.474
7.472
7.468
7.460
7.457
7.322
7.318
7.314
7.305
7.301
7.260
3.449
3.444
3.438
2.573
1.902
1.896
1.892
1.887
1.882
1.874
1.868
1.856
1.854
1.848
1.842
1.461
1.455
1.453
1.441
1.436
1.433
1.417
1.411
1.398
1.391
Cy
3ac
2.03
2.03
1.00
2.04
2.05
4.16
1.00
4.20
1.10
4.26
1.24
f1 (ppm)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128.285
128.064
127.017
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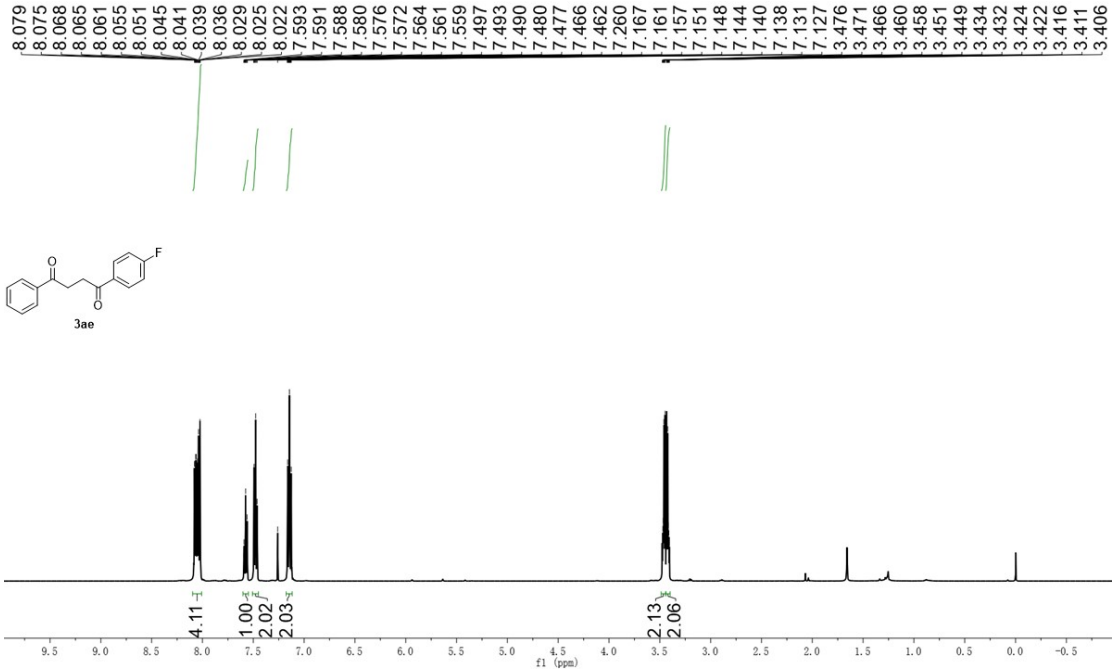
76.746
44.649
34.057
32.604
32.425
26.681
25.991
Cy
3ac
f1 (ppm)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8.061
8.055
8.051
8.045
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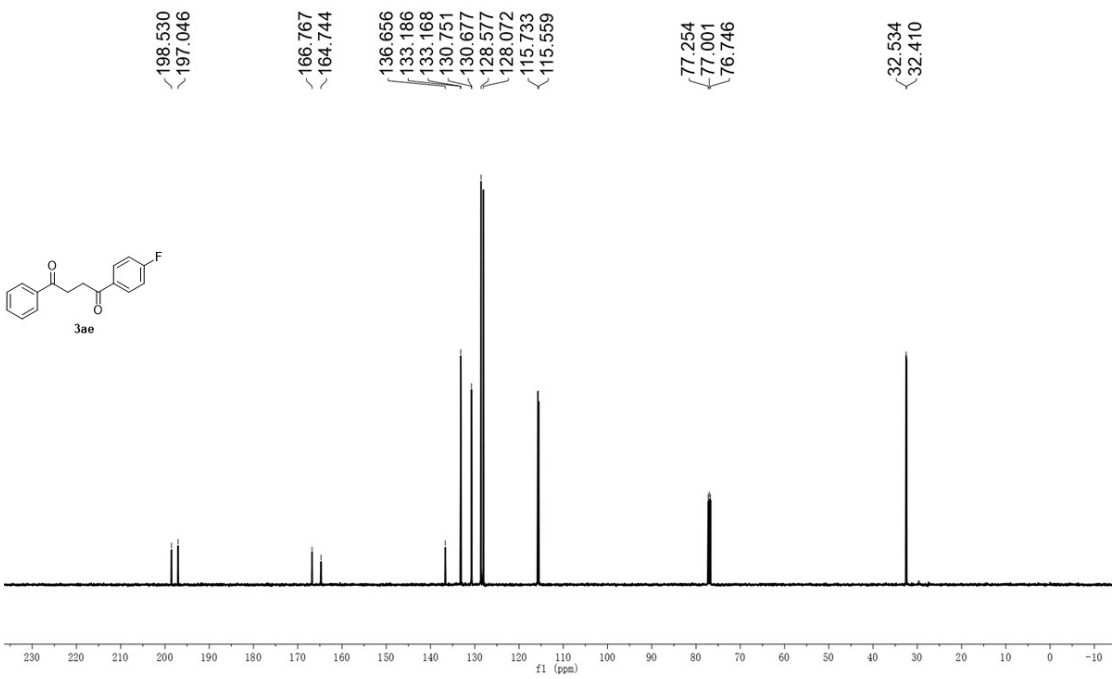
8.039
8.036
8.029
8.025
8.022
7.593
7.591
7.588
7.580
7.576
7.572
7.564
7.561
7.559
7.497
7.493
7.490
7.480
7.477
7.466
7.462
7.260
7.167
7.161
7.157
7.151
7.148
7.144
7.140
7.138
7.131
7.127
3.476
3.471
3.466
3.460
3.458
3.451
3.449
3.434
3.432
3.424
3.422
3.416
3.411
3.406
F
3ae
4.11
1.00
2.02
2.03
2.13
2.06
f1 (ppm)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115.559
77.254
77.001
76.746
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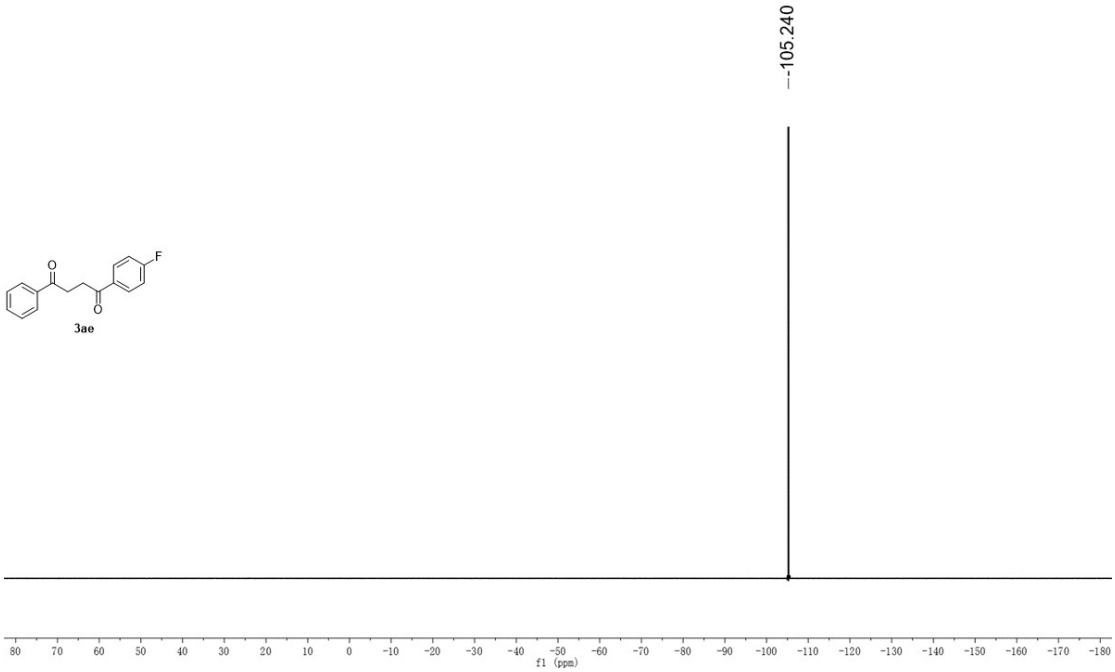
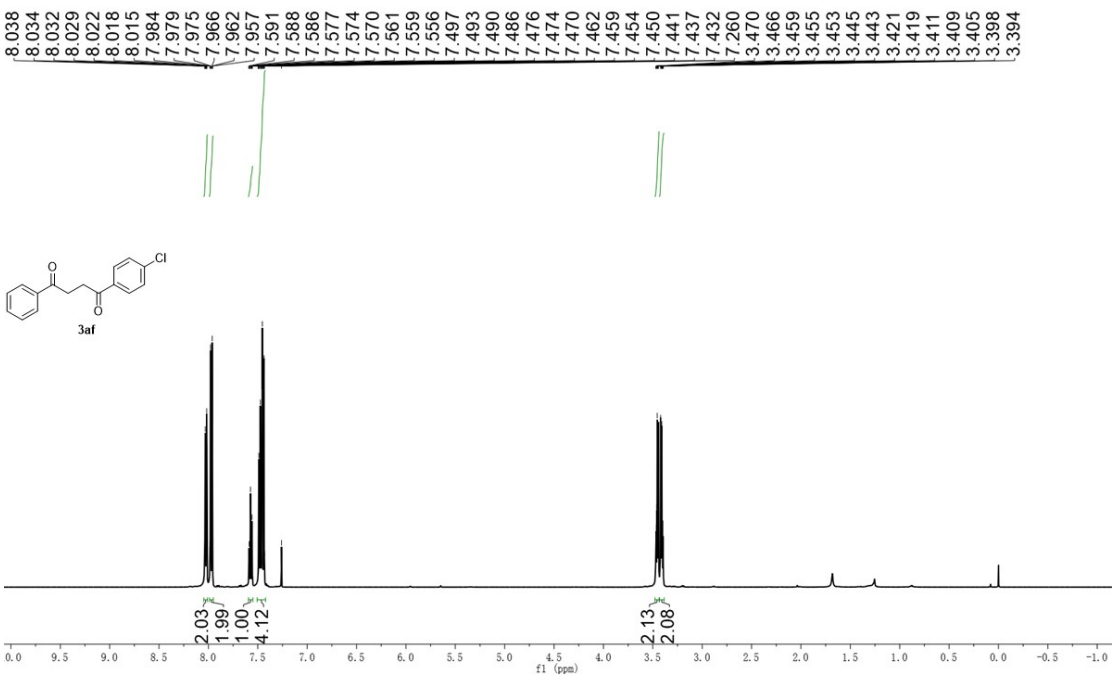
32.410
3ae
f1 (ppm)


-105.240
3ae
f1 (ppm)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8.018
8.015
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7.957
7.591
7.588
7.586
7.577
7.574
7.570
7.561
7.559
7.556
7.497
7.493
7.490
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7.476
7.474
7.470
7.462
7.459
7.454
7.450
7.441
7.437
7.432
7.260
3.470
3.466
3.459
3.455
3.453
3.445
3.443
3.421
3.419
3.411
3.409
3.405
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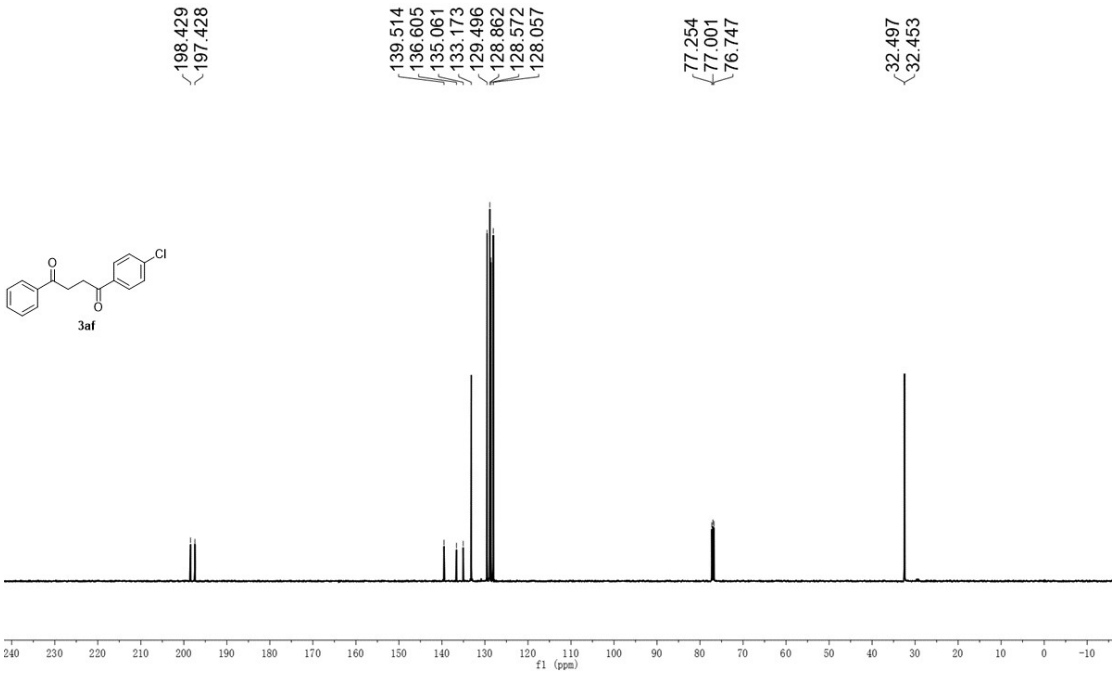
Cl
O
O
3af
2.03
1.99
1.00
4.12
2.13
2.08
f1 (ppm)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135.061
133.173
129.496
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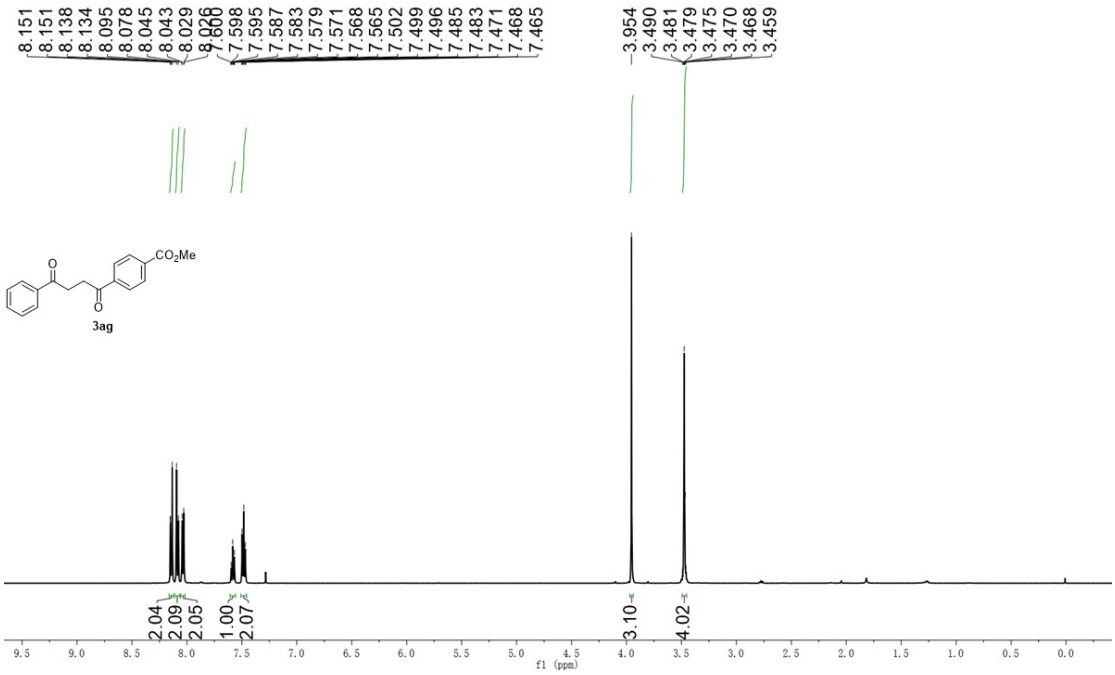
128.572
128.057
77.254
77.001
76.747
32.497
32.453
Cl
O
O
3af
f1 (ppm)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8.043
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7.595
7.587
7.583
7.579
7.571
7.568
7.565
7.502
7.499
7.496
7.485
7.483
7.471
7.468
7.465
3.954
3.490
3.481
3.479
3.475
3.470
3.468
3.459
CO2Me
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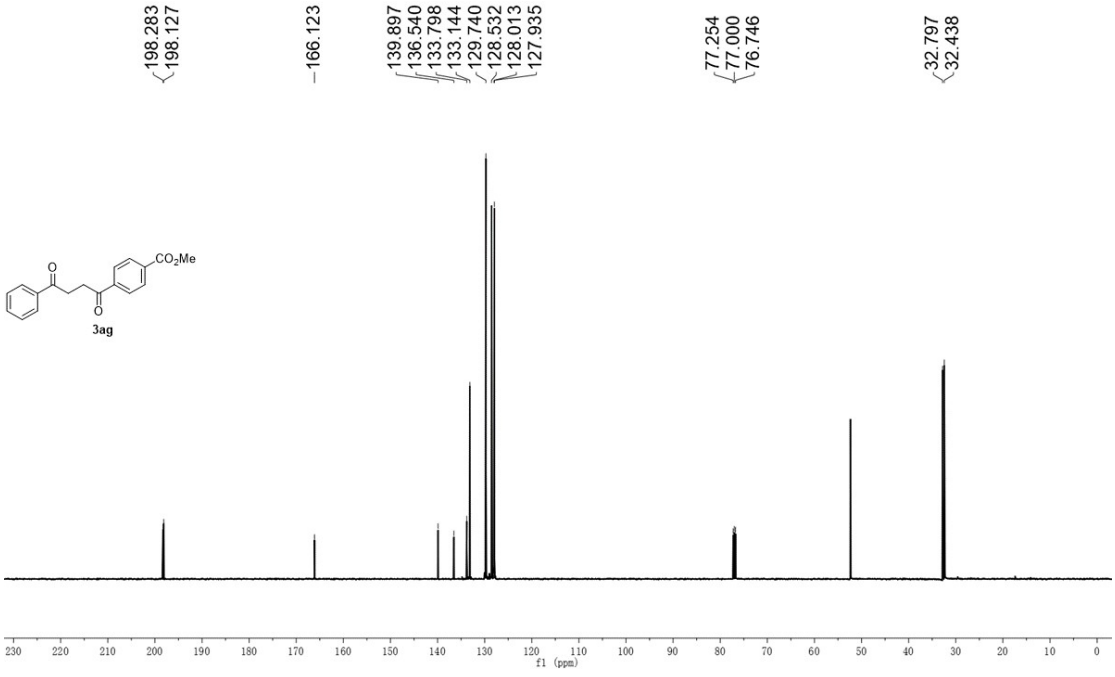
O
3ag
2.04
2.09
2.05
1.00
2.07
3.10
4.02
f1 (ppm)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77.000
76.746
32.797
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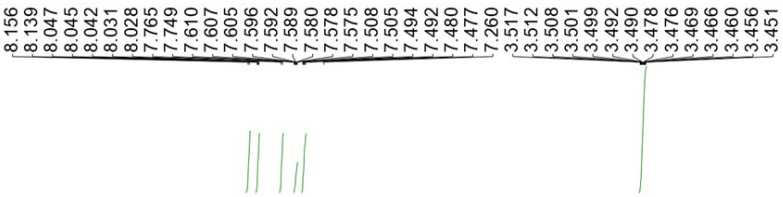
CO2Me
O
O
3ag
f1 (ppm)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7.589
7.580
7.578
7.575
7.508
7.505
7.494
7.492
7.480
7.477
7.260
3.517
3.512
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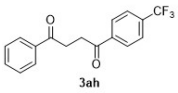
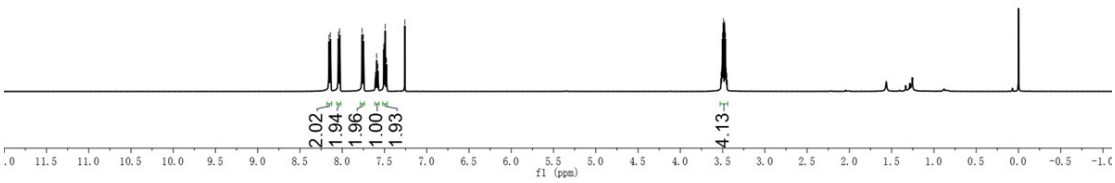
3.456
3.451


O
O
CF3

3ah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1.94
1.96
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4.13
f1 (ppm)


198.301
197.815

139.459
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133.299
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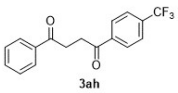
125.646


77.254
77.000
76.746


32.792
32.553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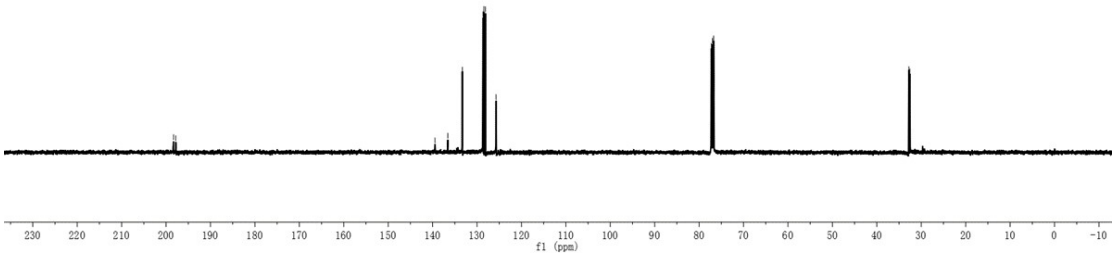
O
CF3

3ah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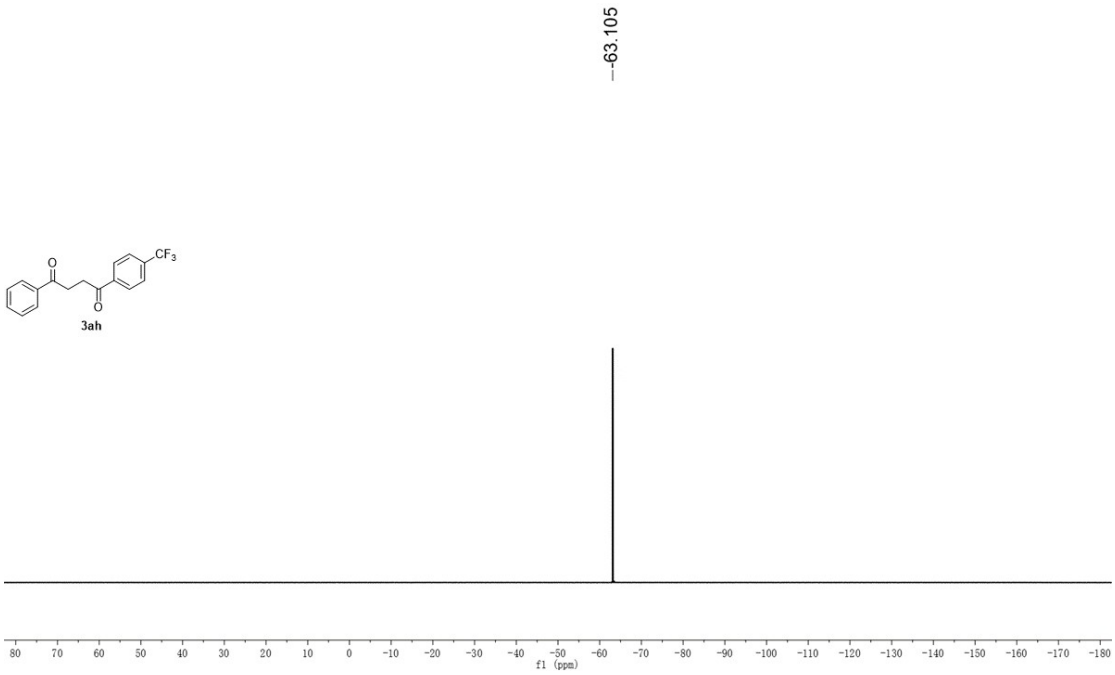
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O
O
3ah
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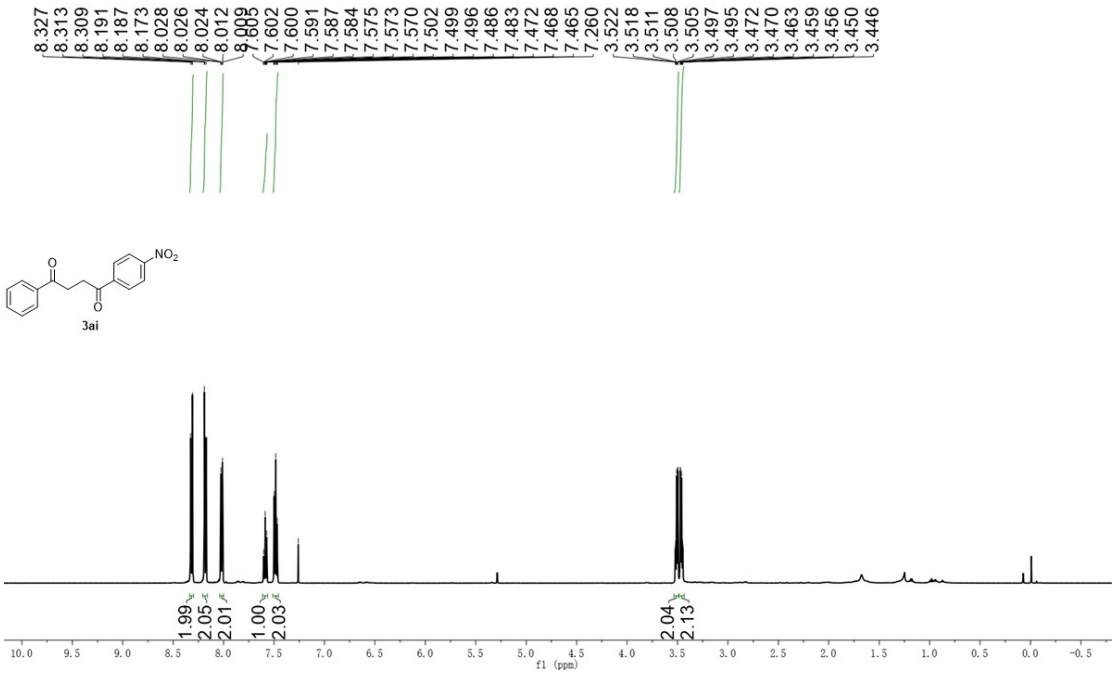
f1 (ppm)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7.587
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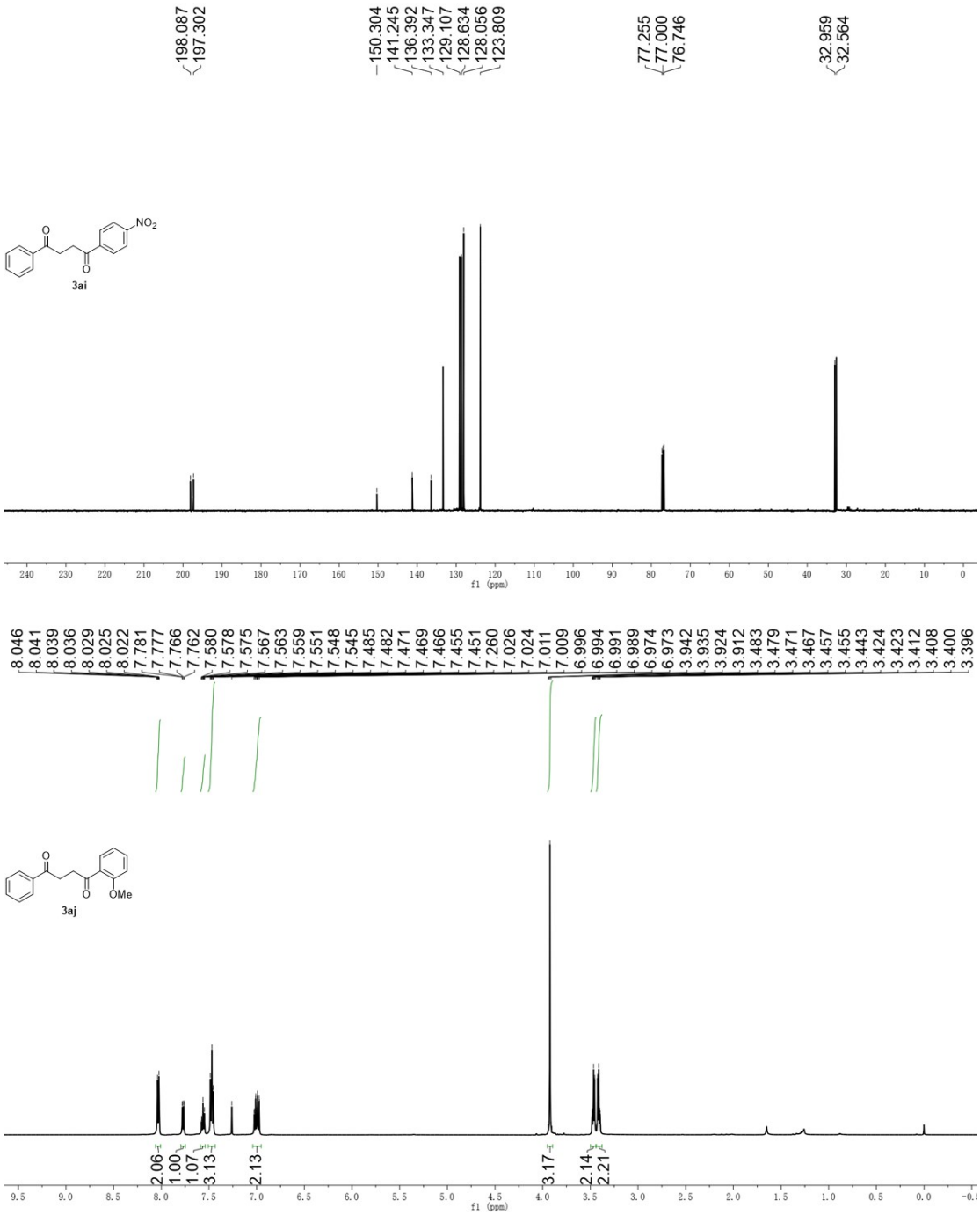
7.575
7.573
7.570
7.502
7.499
7.496
7.486
7.483
7.472
7.468
7.465
7.260
3.522
3.518
3.511
3.508
3.505
3.497
3.495
3.472
3.470
3.463
3.459
3.456
3.450
3.446
NO2
O
O
3ai
1.99
2.05
2.01
1.00
2.03
2.04
2.13
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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123.809
77.255
77.000
76.746
32.959
32.564
NO2
3ai
f1 (ppm)
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8.041
8.039
8.036
8.029
8.025
8.022
7.781
7.777
7.766
7.762
7.580
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7.575
7.567
7.563
7.559
7.551
7.548
7.545
7.485
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7.469
7.466
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6.991
6.989
6.974
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3.471
3.467
3.457
3.455
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3.424
3.423
3.412
3.408
3.400
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O
OMe
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2.06
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1.07
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3.17
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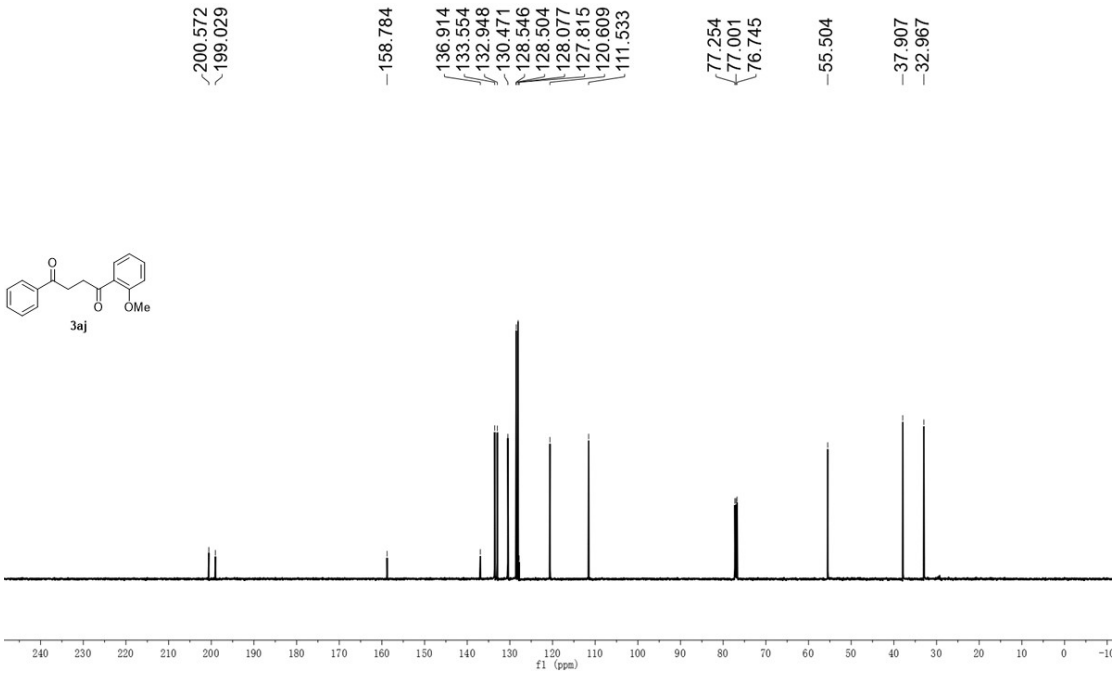
2.21
f1 (ppm)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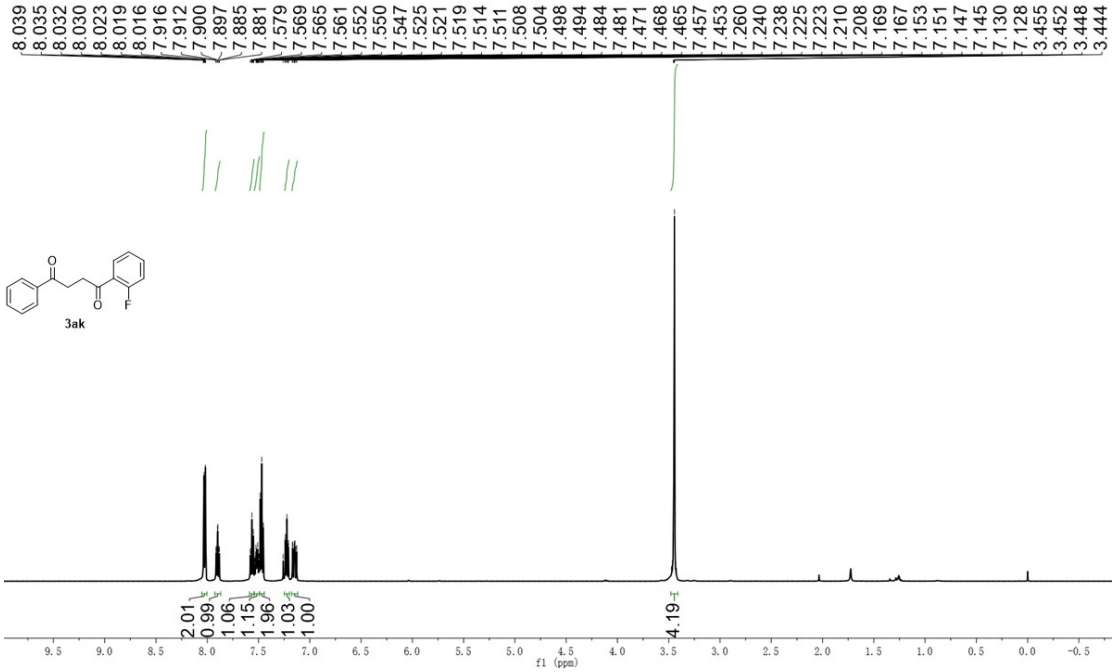
55.504
37.907
32.967
O
O
OMe
3aj
f1 (ppm)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7.561
7.552
7.550
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7.519
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7.508
7.504
7.498
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7.484
7.481
7.471
7.468
7.465
7.457
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7.223
7.210
7.208
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7.167
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7.151
7.147
7.145
7.130
7.128
3.455
3.452
3.448
3.444
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O
F
3ak
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0.99
1.06
1.15
1.96
1.03
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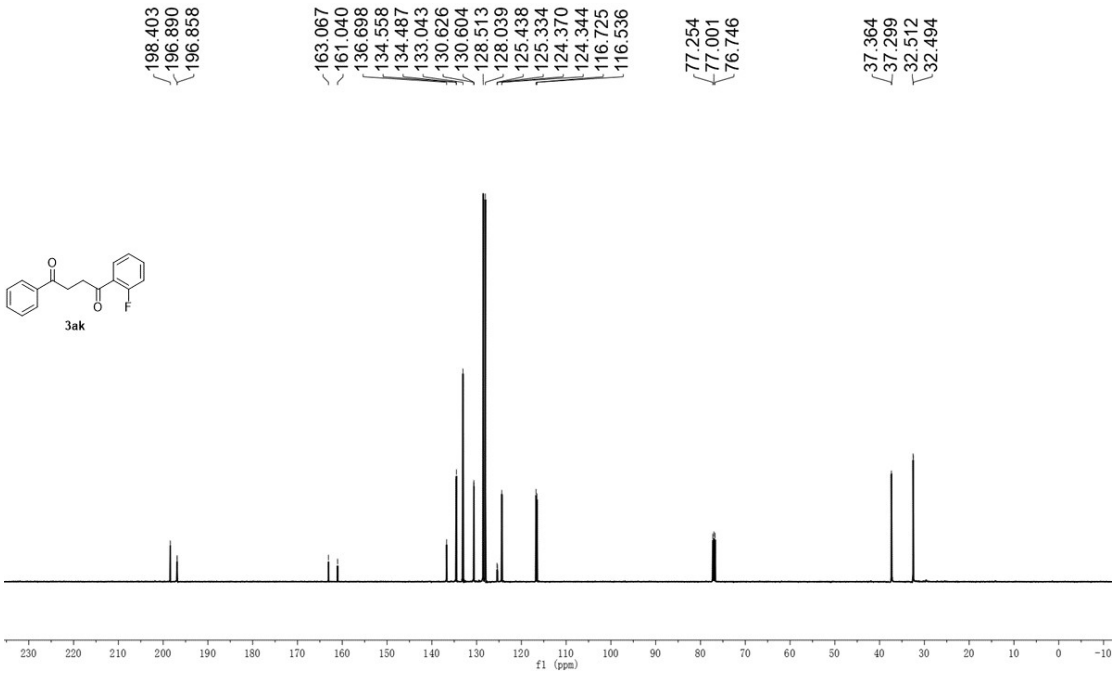
4.19
f1 (ppm)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125.334
124.370
124.344
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77.001
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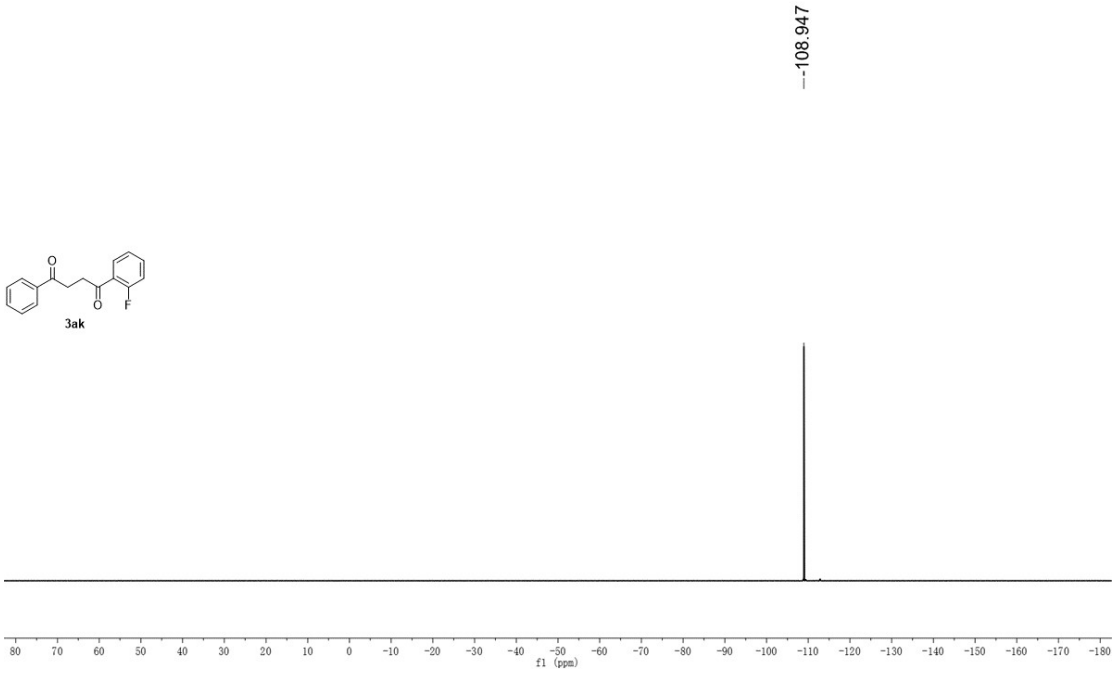
f1 (ppm)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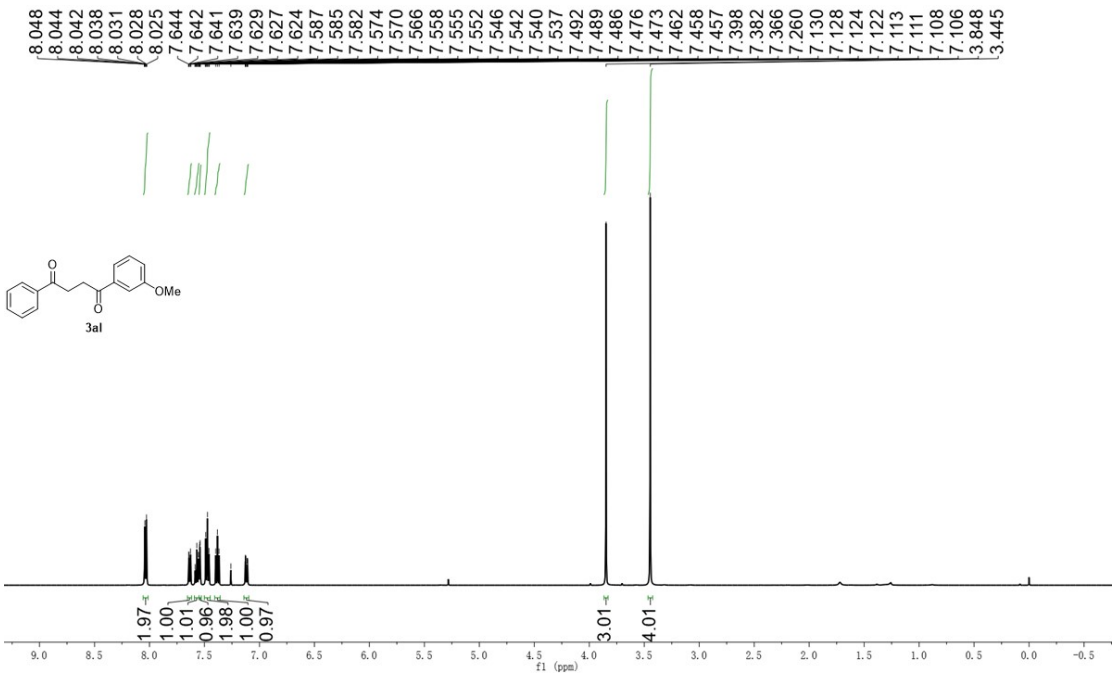
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7.587
7.585
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7.555
7.552
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7.366
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7.128
7.124
7.122
7.113
7.111
7.108
7.106
3.848
3.445
OMe
3al
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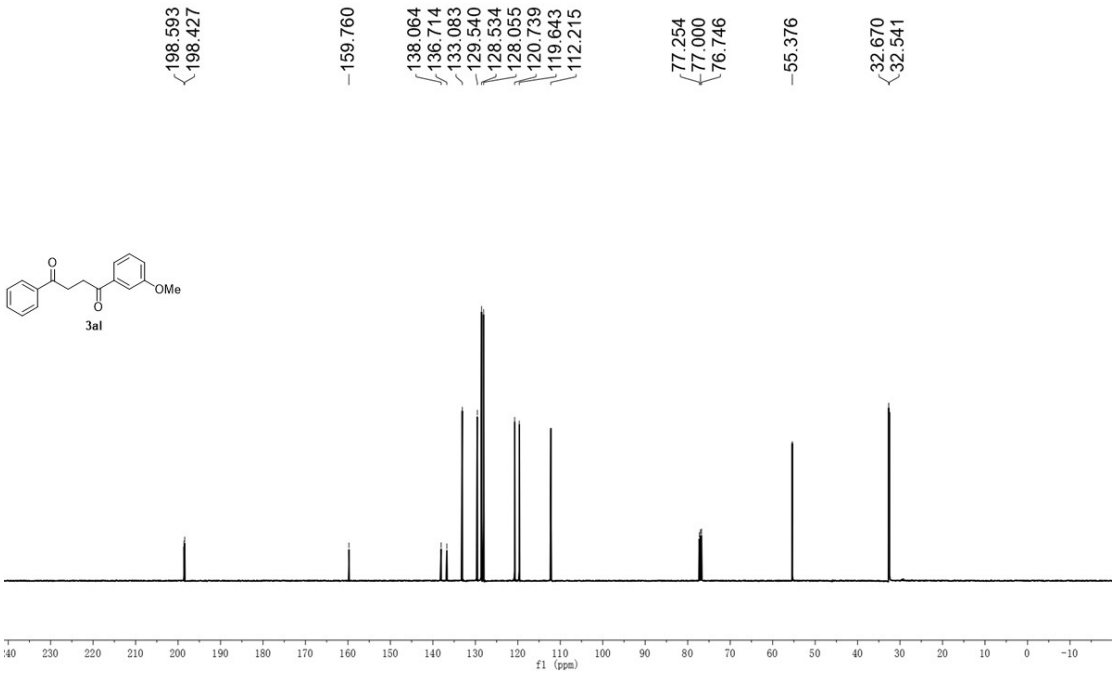
f1 (ppm)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76.746
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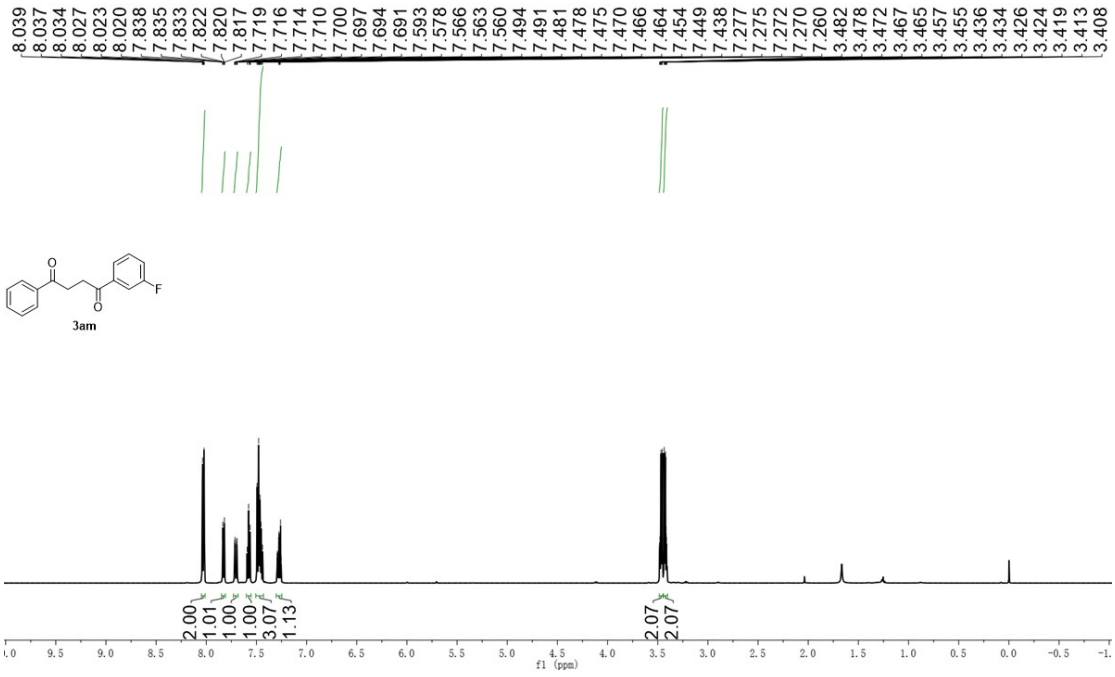
32.541
OMe
3al
f1 (ppm)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7.817
7.719
7.716
7.714
7.710
7.700
7.697
7.694
7.691
7.593
7.578
7.566
7.563
7.560
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7.491
7.481
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7.475
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7.466
7.464
7.454
7.449
7.438
7.277
7.275
7.272
7.270
7.260
3.482
3.478
3.472
3.467
3.465
3.457
3.455
3.436
3.434
3.426
3.424
3.419
3.413
3.408
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O
F
3am
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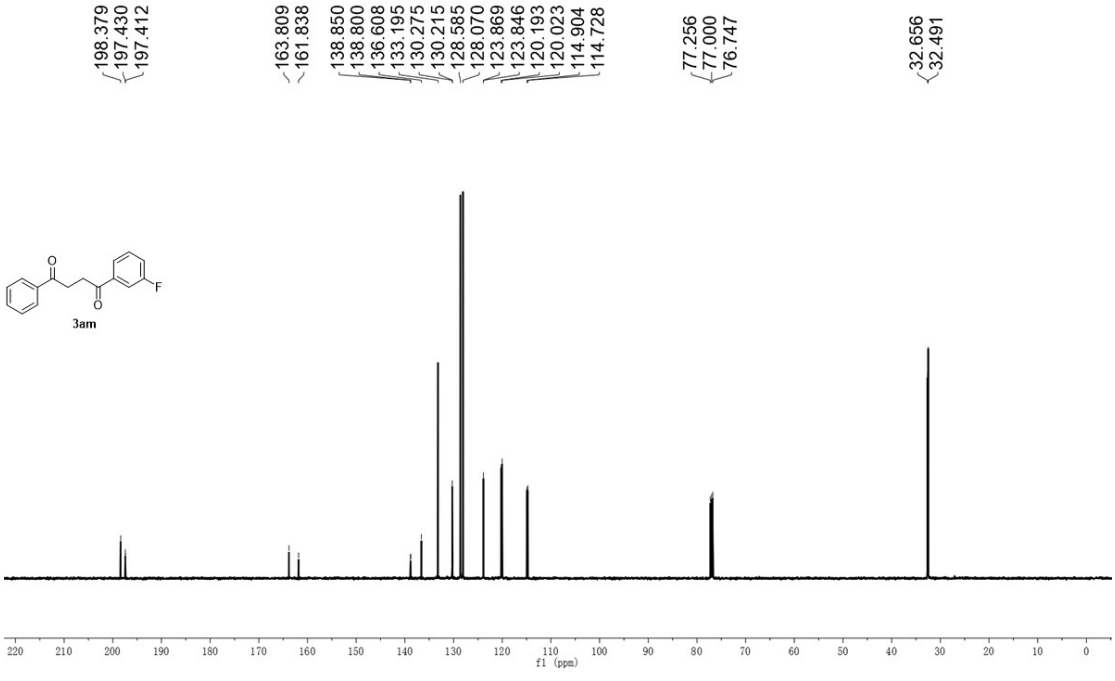
1.01
1.00
1.00
3.07
1.13
2.07
2.07
f1 (ppm)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136.608
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130.275
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128.070
123.869
123.846
120.193
120.023
114.904
114.728
77.256
77.000
76.747
32.656
32.491
O
O
F
3am
f1 (ppm)


O
O
F

3am

-111.894
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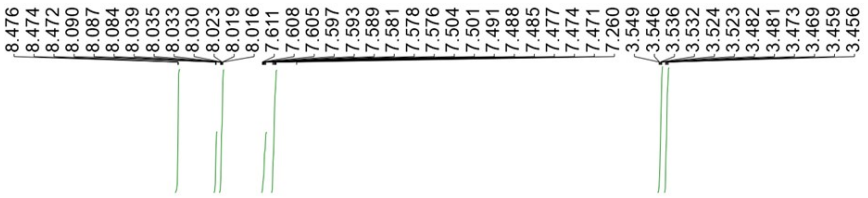
f1 (ppm)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8.030
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7.608
7.605
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7.593
7.589
7.581
7.578
7.576
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7.501
7.491
7.488
7.485
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7.474
7.471
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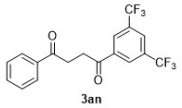
3.459
3.456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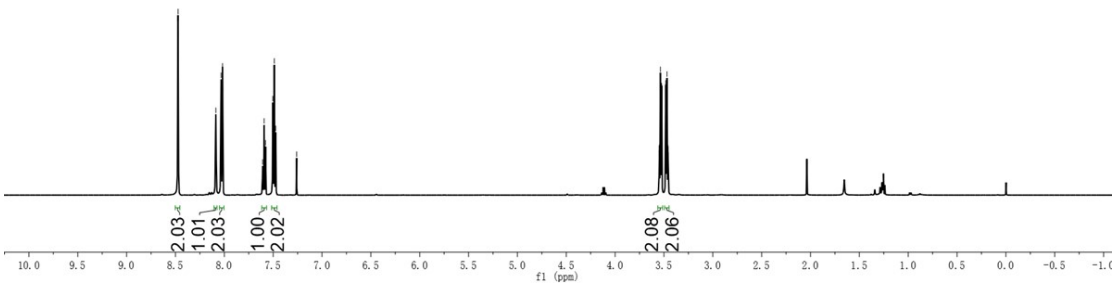
CF3
CF3

3an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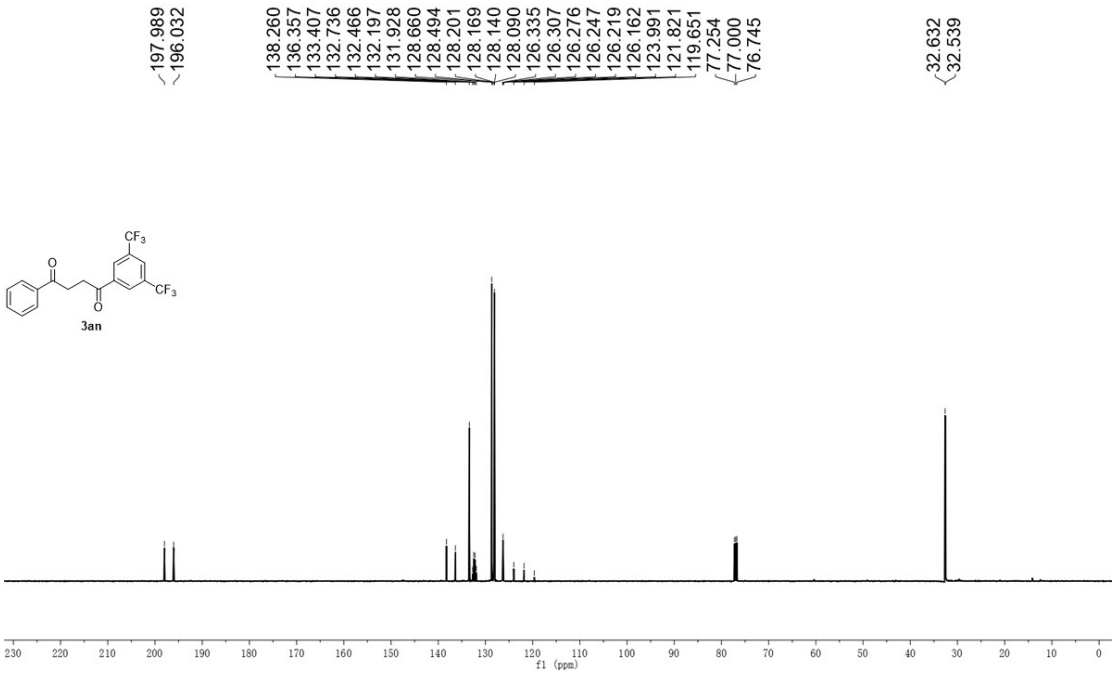
1.01
2.03
1.00
2.02
2.08
2.06
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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132.197
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128.169
128.140
128.090
126.335
126.307
126.276
126.247
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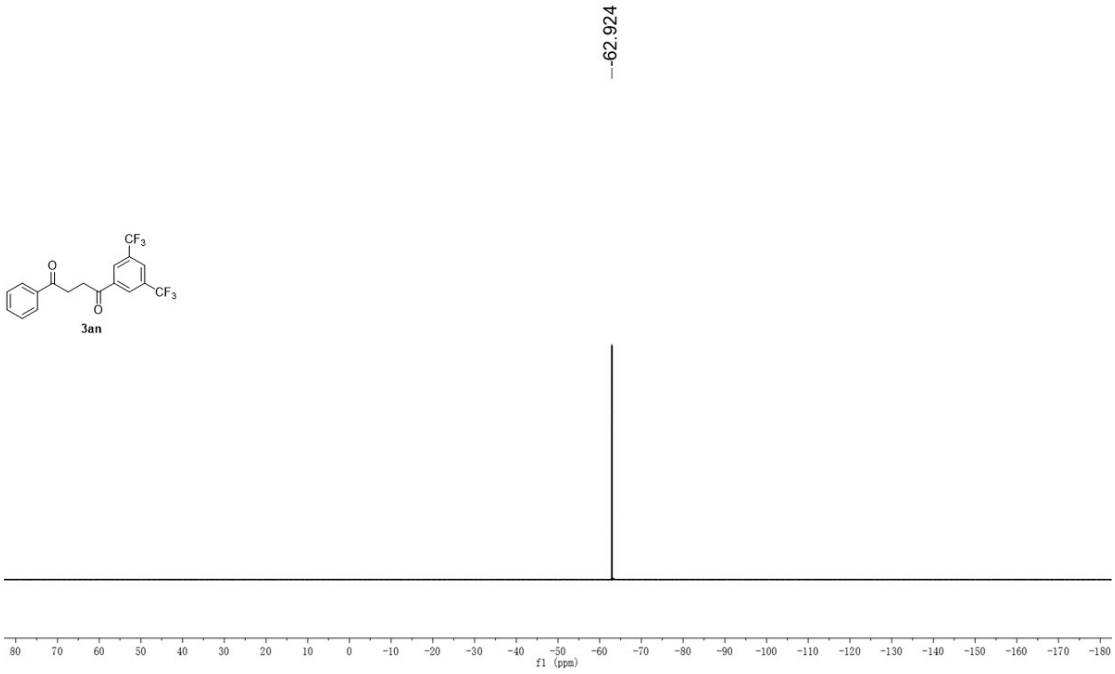
77.000
76.745
32.632
32.539
3an
f1 (ppm)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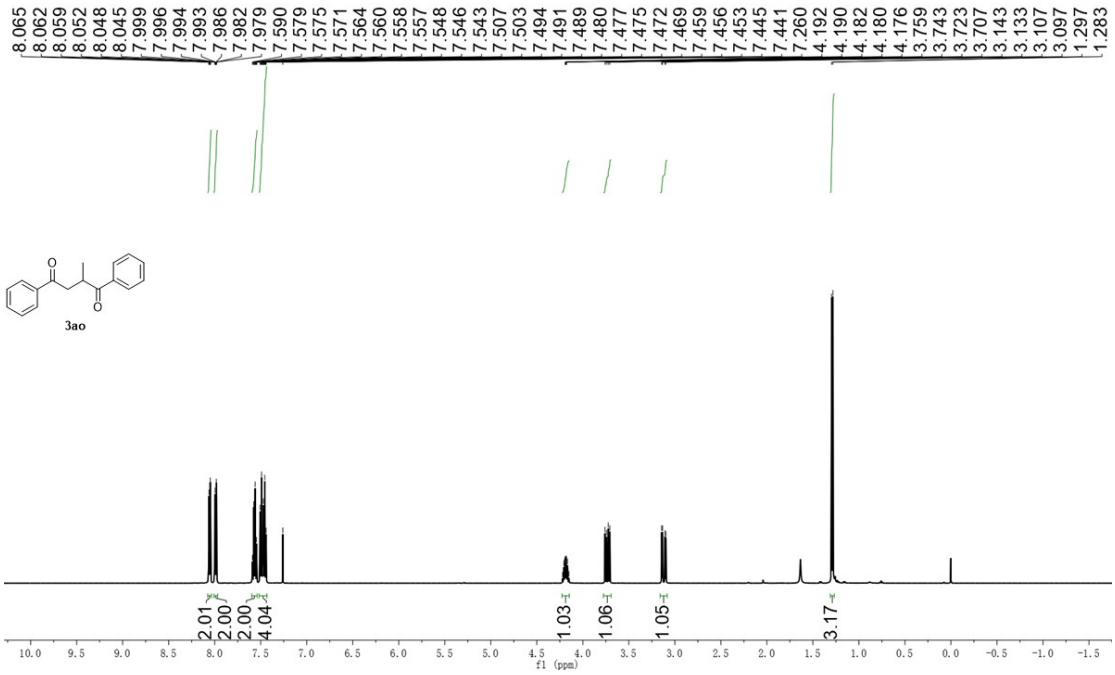
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8.052
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8.045
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7.996
7.994
7.993
7.986
7.982
7.979
7.590
7.579
7.575
7.571
7.564
7.560
7.558
7.557
7.548
7.546
7.543
7.507
7.503
7.494
7.491
7.489
7.480
7.477
7.475
7.472
7.469
7.459
7.456
7.453
7.445
7.441
7.260
4.192
4.190
4.182
4.180
4.176
3.759
3.743
3.723
3.707
3.143
3.133
3.107
3.097
1.297
1.283
3ao
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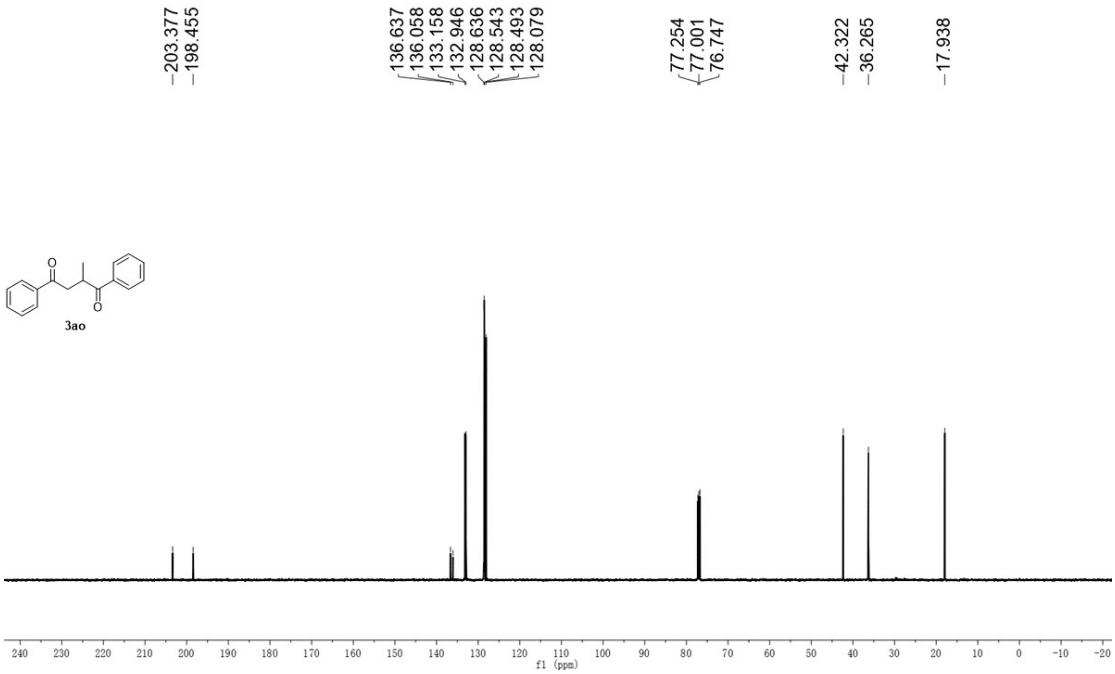
2.00
2.00
4.04
1.03
1.06
1.05
3.17
f1 (ppm)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76.747
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36.265
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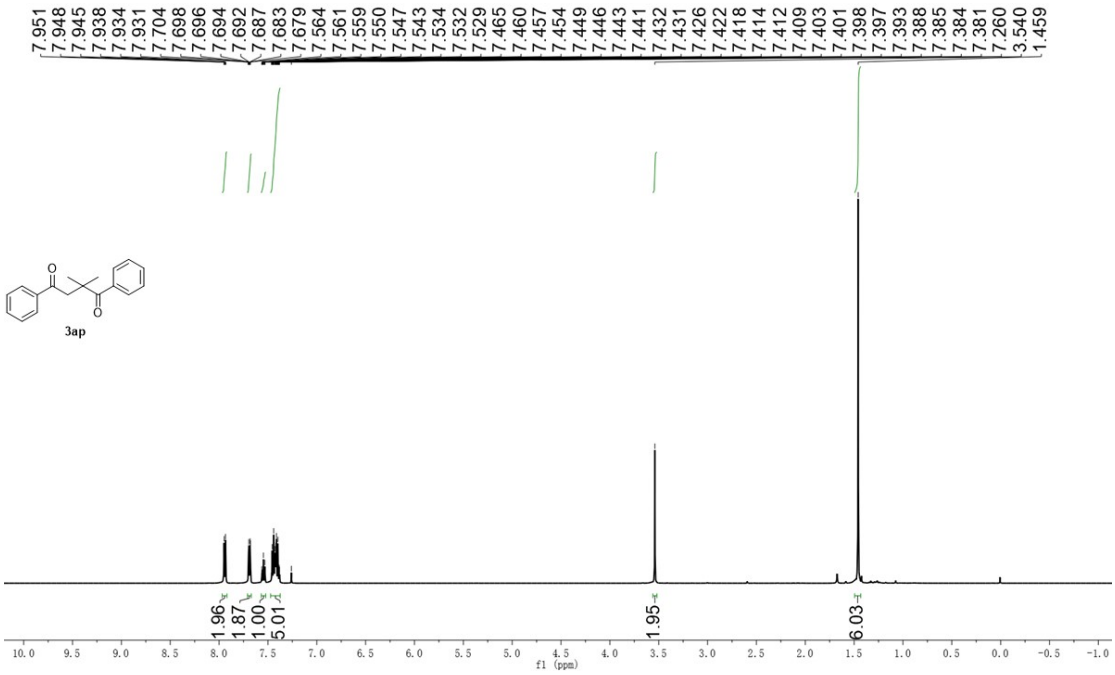
3ao
f1 (ppm)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7.687
7.683
7.679
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7.561
7.559
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7.547
7.543
7.534
7.532
7.529
7.465
7.460
7.457
7.454
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7.446
7.443
7.441
7.432
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7.426
7.422
7.418
7.414
7.412
7.409
7.403
7.401
7.398
7.397
7.393
7.388
7.385
7.384
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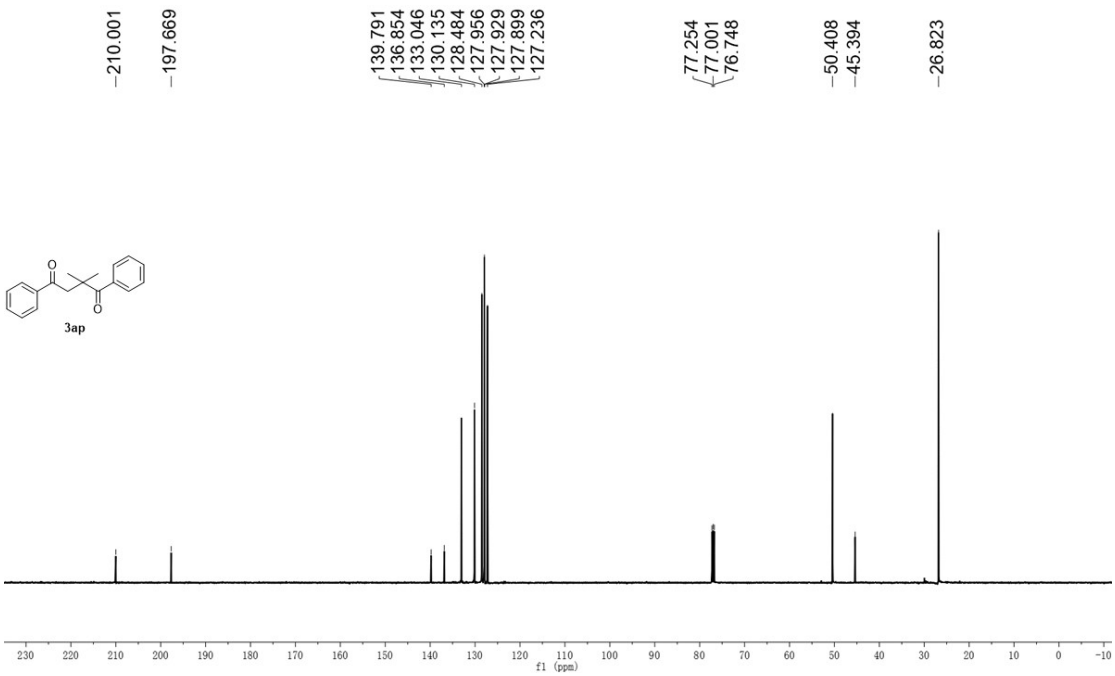
1.96
1.87
1.00
5.01
1.95
6.03
f1 (ppm)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127.956
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127.236
77.254
77.001
76.748
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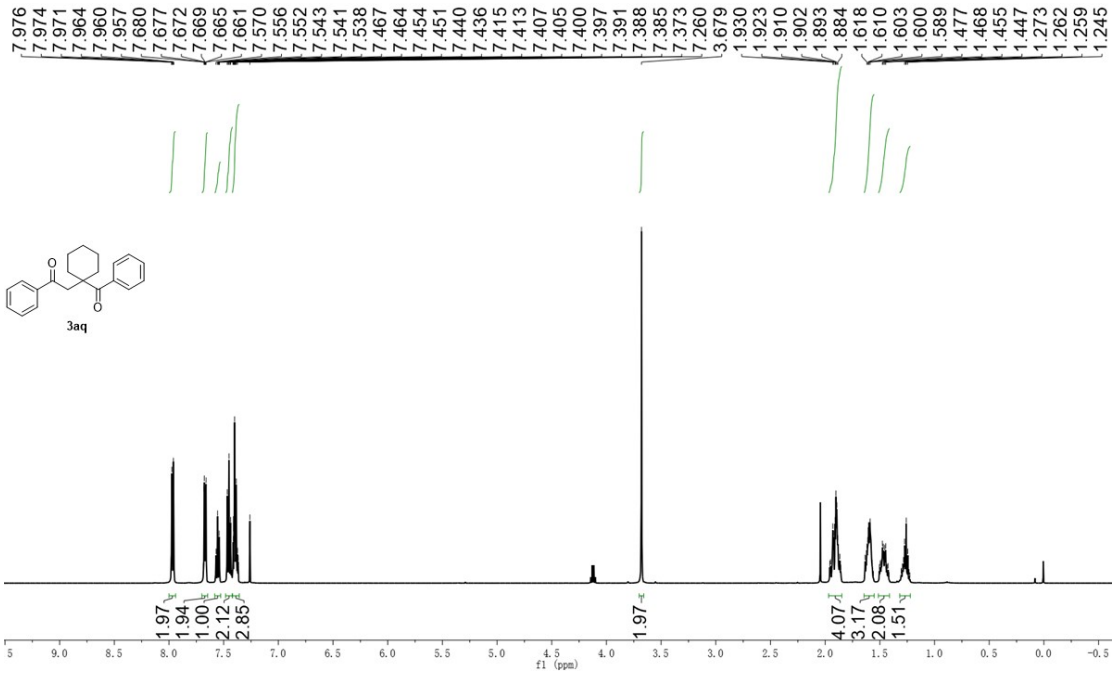
45.394
26.823
3ap
f1 (ppm)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7.680
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7.570
7.556
7.552
7.543
7.541
7.538
7.467
7.464
7.454
7.451
7.440
7.436
7.415
7.413
7.407
7.405
7.400
7.397
7.391
7.388
7.385
7.373
7.260
3.679
1.930
1.923
1.910
1.902
1.893
1.884
1.618
1.610
1.603
1.600
1.589
1.477
1.468
1.455
1.447
1.273
1.262
1.259
1.245
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2.85
1.97
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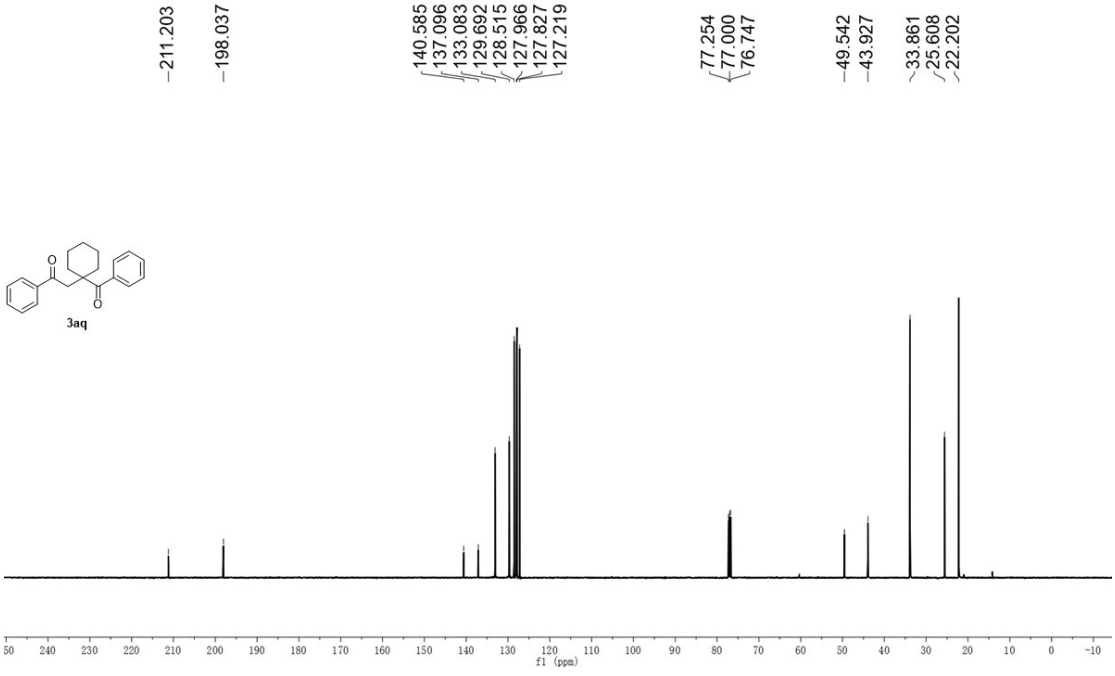
3.17
2.08
1.51
f1 (ppm)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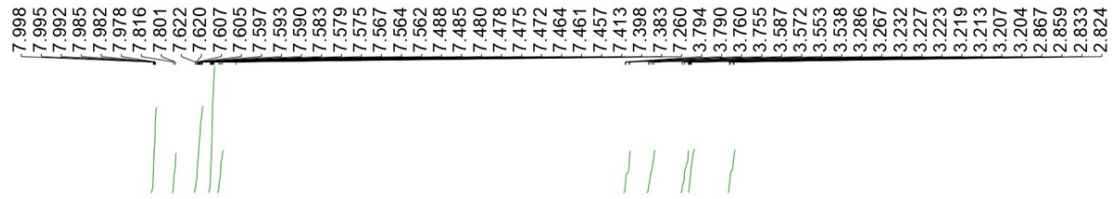
77.000
76.747
49.542
43.927
33.861
25.608
22.202
3aq
f1 (ppm)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7.620
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7.605
7.597
7.593
7.590
7.583
7.579
7.575
7.567
7.564
7.562
7.488
7.485
7.480
7.478
7.475
7.472
7.464
7.461
7.457
7.413
7.398
7.383
7.260
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3.790
3.760
3.755
3.587
3.572
3.553
3.538
3.286
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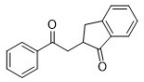
2.824



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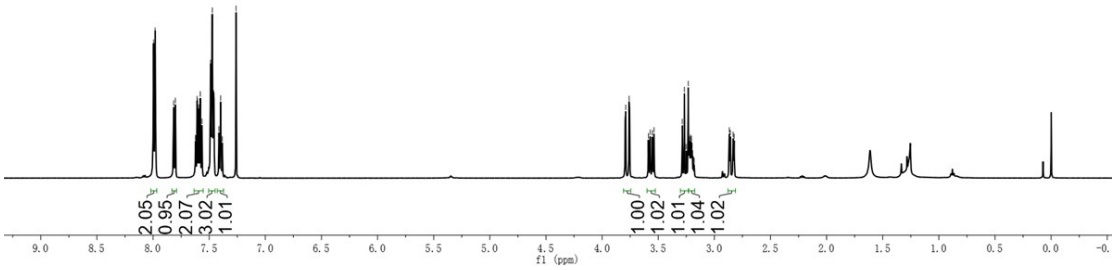
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1.01
1.00
1.02
1.01
1.04
1.02
f1 (ppm)


207.886
197.946
153.578
136.512
136.439
134.805
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127.407
126.541
123.889
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77.001
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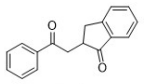
40.017
33.574



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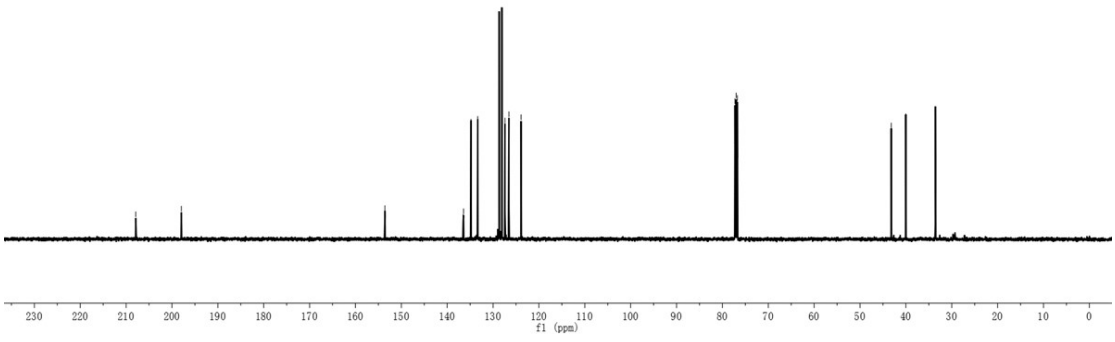
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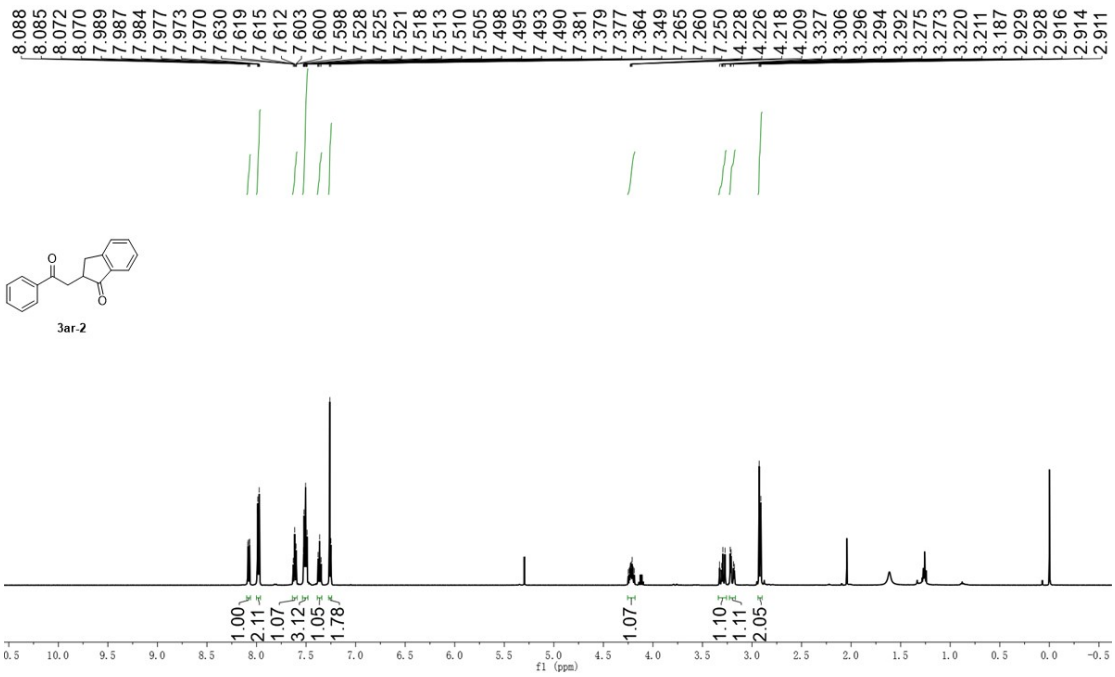
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7.612
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7.600
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7.518
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7.495
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7.379
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7.250
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4.226
4.218
4.209
3.327
3.306
3.296
3.294
3.292
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3.273
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3.211
3.187
2.929
2.928
2.916
2.914
2.911
3ar-2
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1.07
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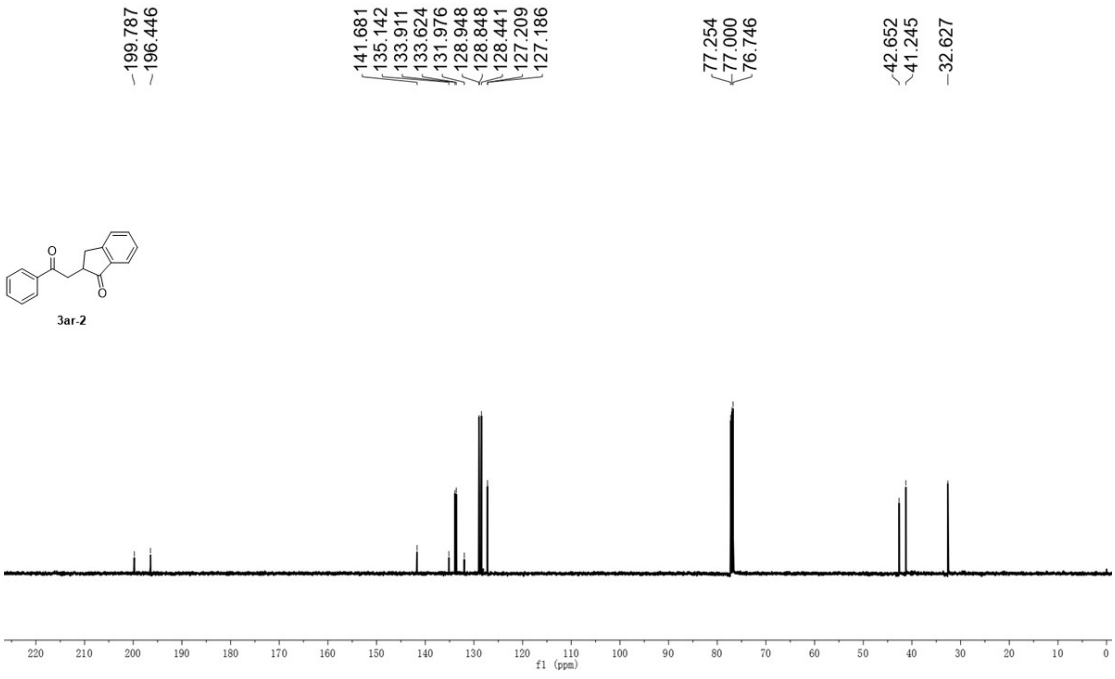
1.05
1.78
1.07
1.10
1.11
2.05
f1 (ppm)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128.848
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127.186
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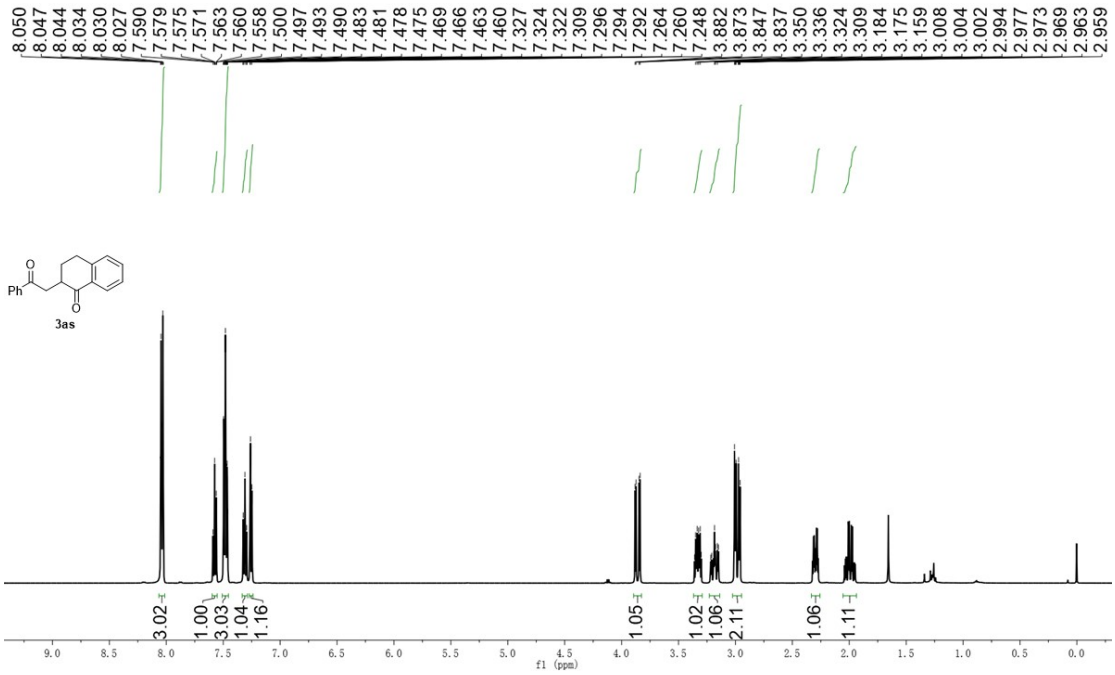
77.000
76.746
42.652
41.245
32.627
3ar-2
f1 (ppm)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7.571
7.563
7.560
7.558
7.500
7.497
7.493
7.490
7.483
7.481
7.478
7.475
7.469
7.466
7.463
7.460
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7.324
7.322
7.309
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7.294
7.292
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7.260
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3.873
3.847
3.837
3.350
3.336
3.324
3.309
3.184
3.175
3.159
3.008
3.004
3.002
2.994
2.977
2.973
2.969
2.963
2.959
O
Ph
O
3as
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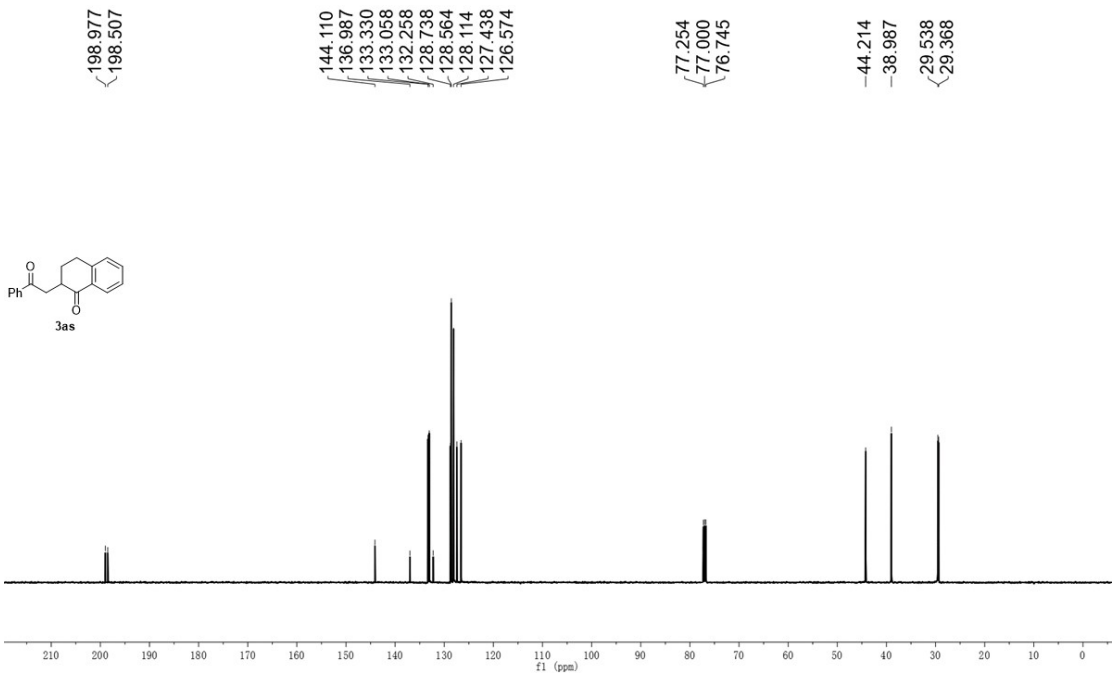
1.04
1.16
1.05
1.02
1.06
2.11
1.06
1.11
f1 (ppm)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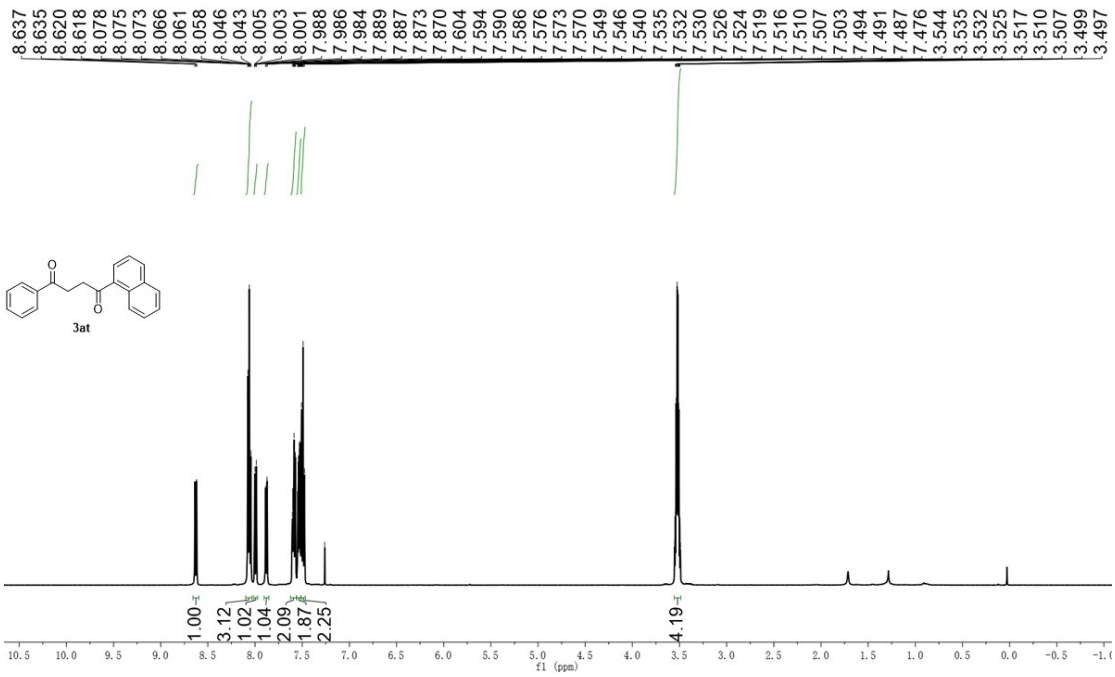
29.538
29.368
O
Ph
O
3as
f1 (ppm)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8.003
8.001
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7.986
7.984
7.889
7.887
7.873
7.870
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7.590
7.586
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7.476
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3.532
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3.507
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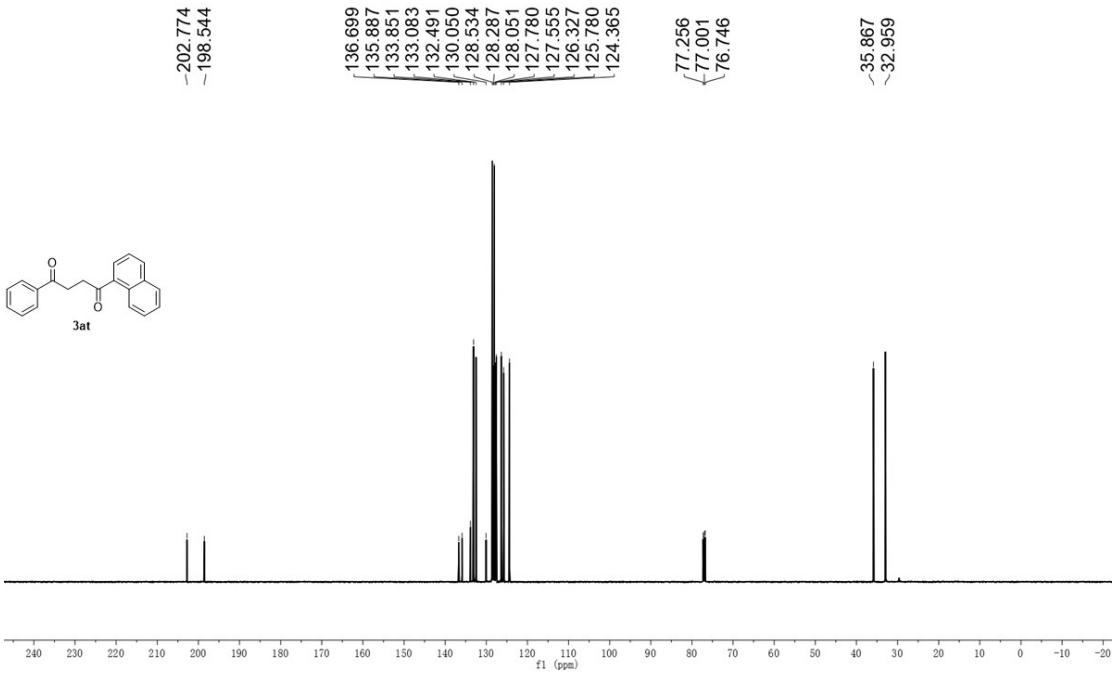
4.19
f1 (ppm)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77.256
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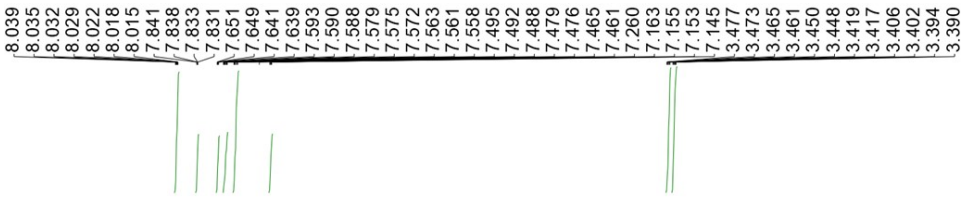
3at
f1 (ppm)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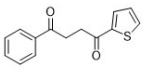
3.394
3.390



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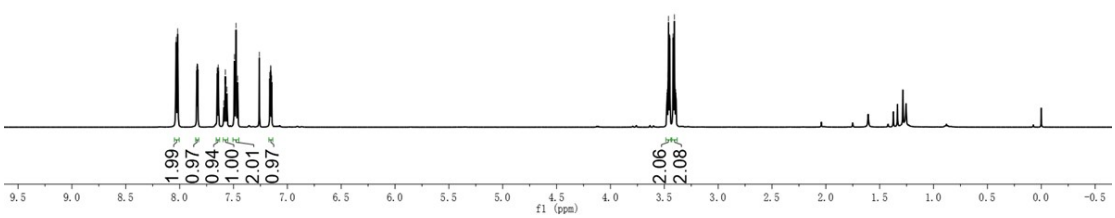
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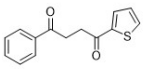
0.97
0.94
1.00
2.01
0.97
2.06
2.08
f1 (ppm)


198.413
191.585
143.869
136.626
133.528
133.180
132.009
128.584
128.094
77.255
77.000
76.746
33.153
32.592



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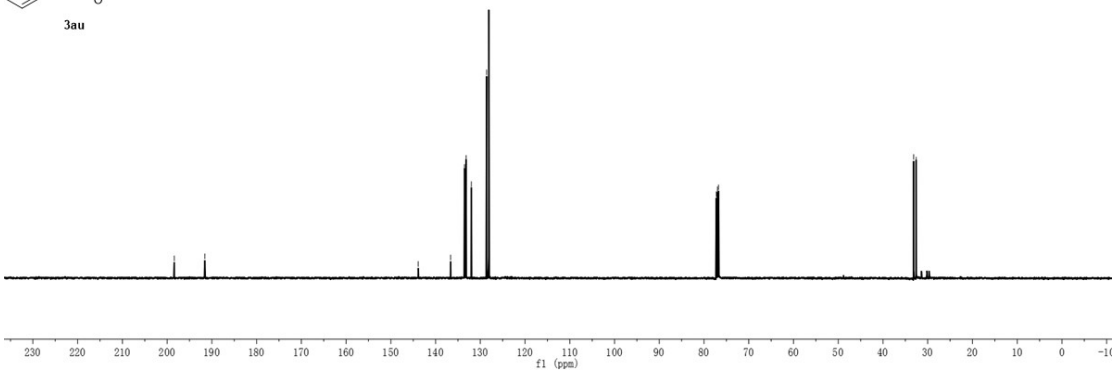
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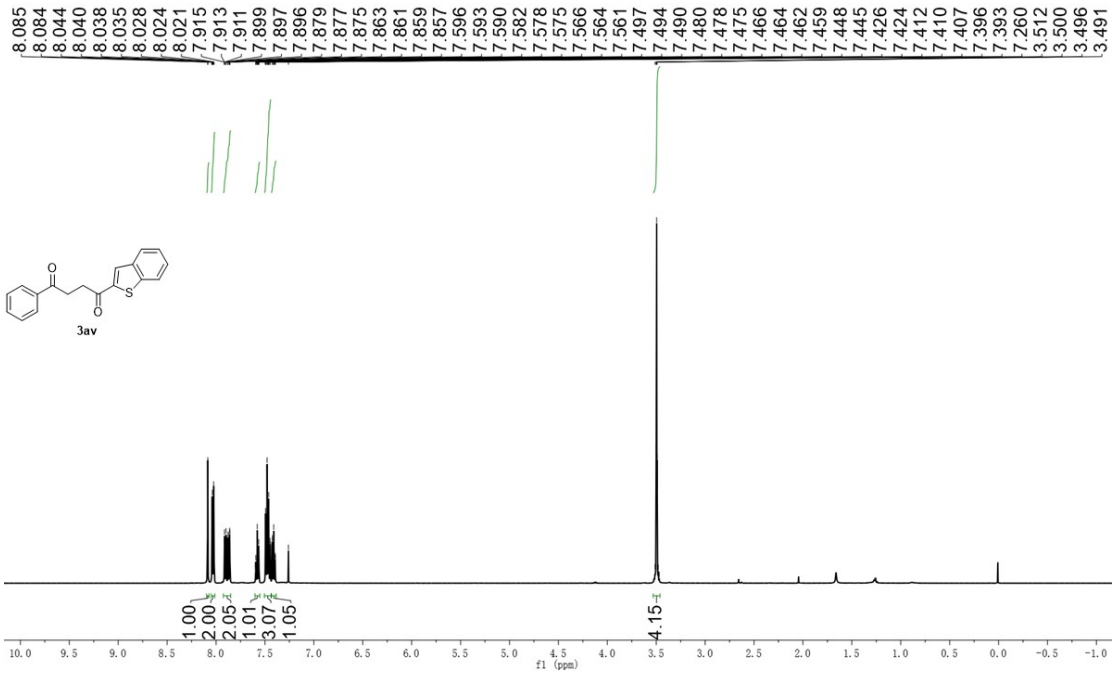
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8.084
8.044
8.040
8.038
8.035
8.028
8.024
8.021
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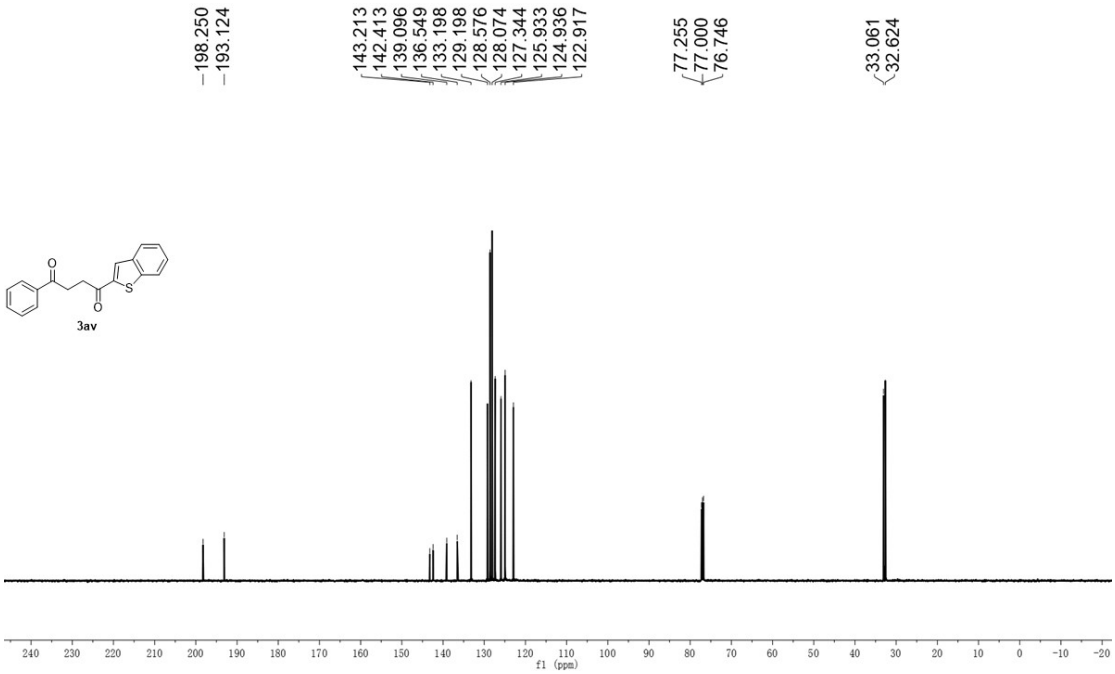
7.913
7.911
7.899
7.897
7.896
7.879
7.877
7.875
7.863
7.861
7.859
7.857
7.596
7.593
7.590
7.582
7.578
7.575
7.566
7.564
7.561
7.497
7.494
7.490
7.480
7.478
7.475
7.466
7.464
7.462
7.459
7.448
7.445
7.426
7.424
7.412
7.410
7.407
7.396
7.393
7.260
3.512
3.500
3.496
3.491
3av
1.00
2.00
2.05
1.01
3.07
1.05
4.15
f1 (ppm)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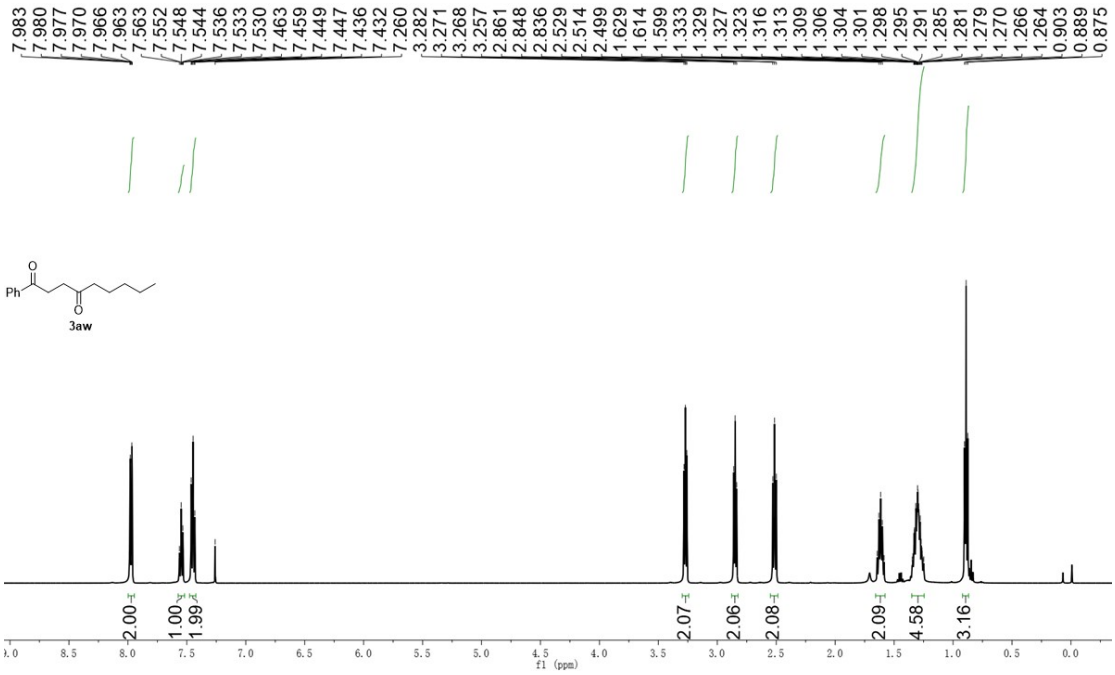
193.124
143.213
142.413
139.096
136.549
133.198
129.198
128.576
128.074
127.344
125.933
124.936
122.917
77.255
77.000
76.746
33.061
32.624
3av
f1 (ppm)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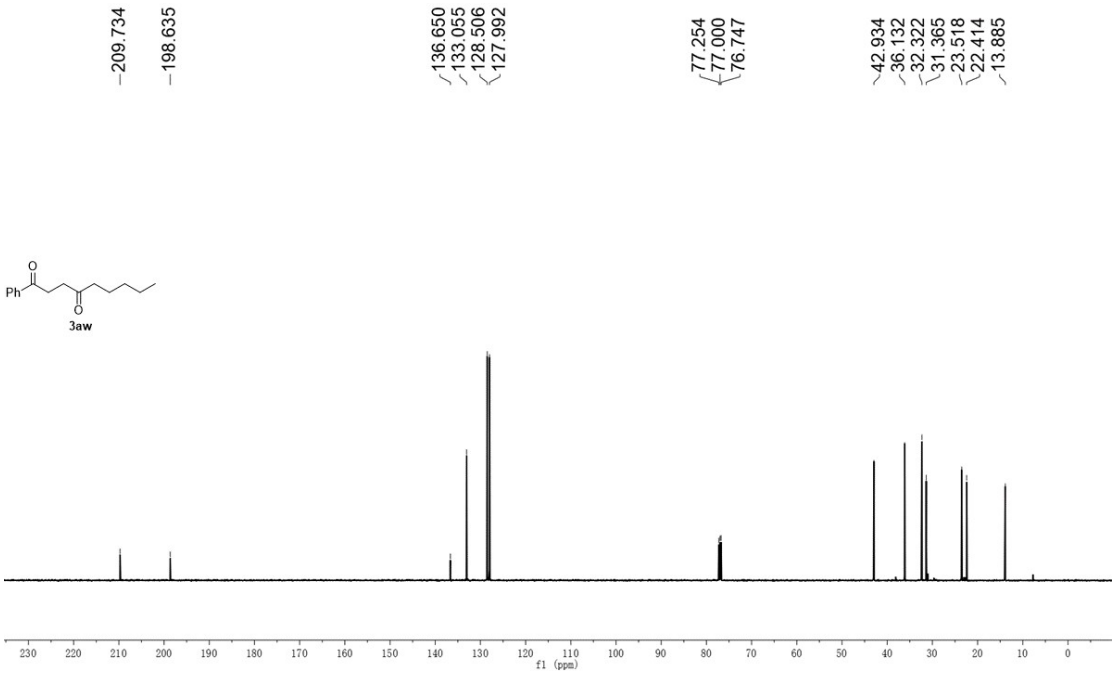
7.980
7.977
7.970
7.966
7.963
7.563
7.552
7.548
7.544
7.536
7.533
7.530
7.463
7.459
7.449
7.447
7.436
7.432
7.260
3.282
3.271
3.268
3.257
2.861
2.848
2.836
2.529
2.514
2.499
1.629
1.614
1.599
1.333
1.329
1.327
1.323
1.316
1.313
1.309
1.306
1.304
1.301
1.298
1.295
1.291
1.285
1.281
1.279
1.270
1.266
1.264
0.903
0.889
0.875
O
Ph
O
3aw
2.00
1.00
1.99
2.07
2.06
2.08
2.09
4.58
3.16
f1 (ppm)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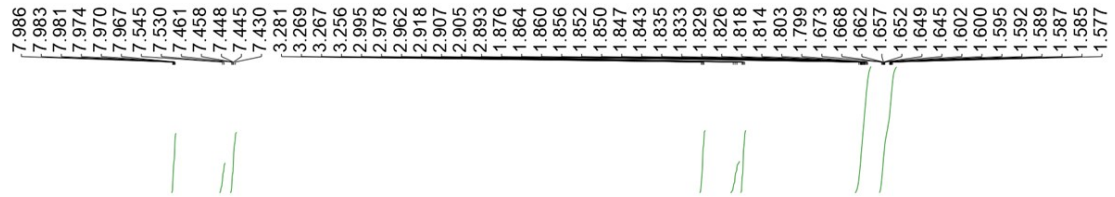
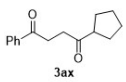
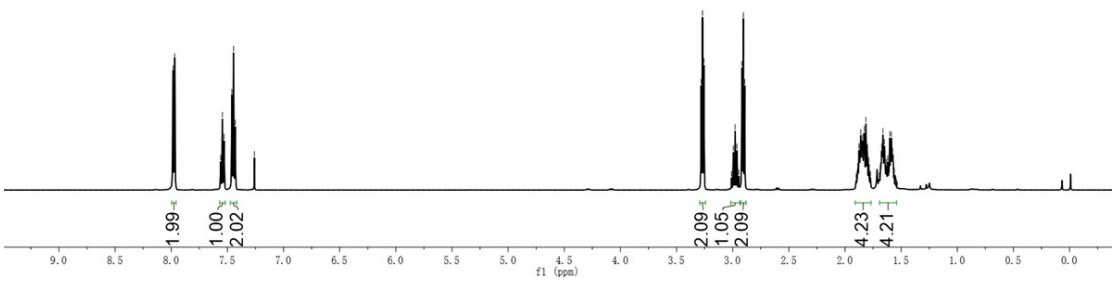
198.635
136.650
133.055
128.506
127.992
77.254
77.000
76.747
42.934
36.132
32.322
31.365
23.518
22.414
13.885
O
Ph
O
3aw
f1 (ppm)

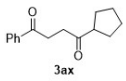

7.986
7.983
7.981
7.974
7.970
7.967
7.545
7.530
7.461
7.458
7.448
7.445
7.430
3.281
3.269
3.267
3.256
2.995
2.978
2.962
2.918
2.907
2.905
2.893
1.876
1.864
1.860
1.856
1.852
1.850
1.847
1.843
1.835
1.833
1.829
1.826
1.818
1.814
1.803
1.799
1.673
1.668
1.662
1.657
1.652
1.649
1.645
1.602
1.600
1.595
1.592
1.589
1.587
1.585
1.577


Ph
O
O

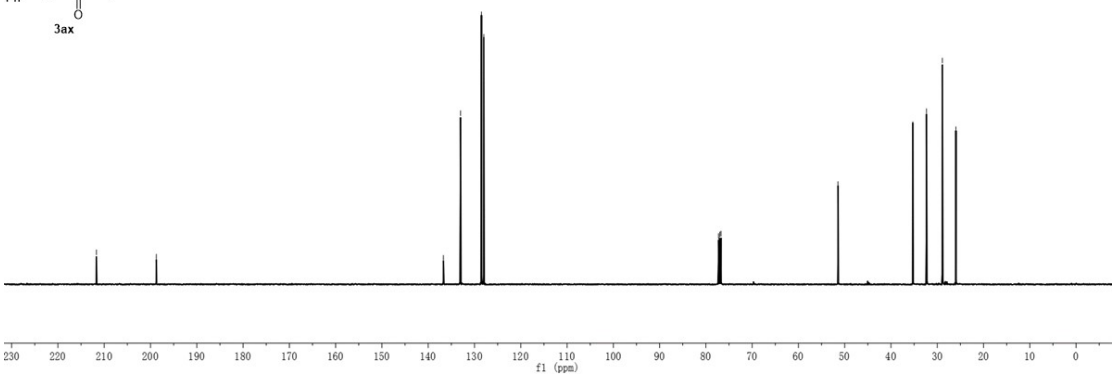
3ax

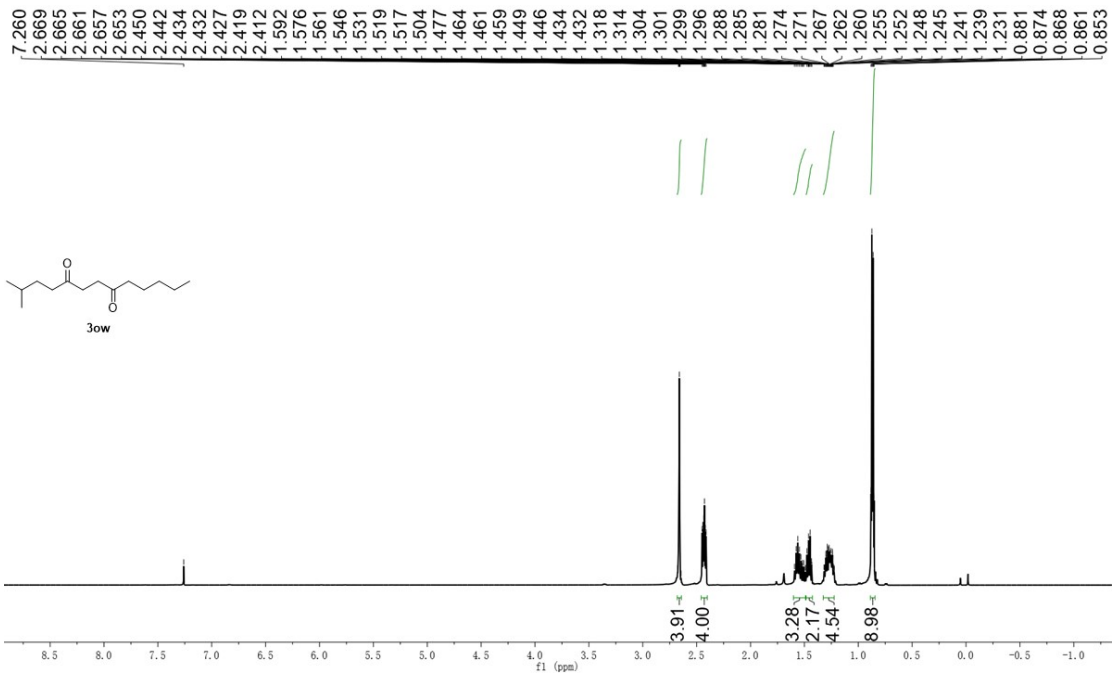

1.99
1.00
2.02
2.09
1.05
2.09
4.23
4.21
f1 (ppm)


211.699
198.741
136.711
133.014
128.492
127.991
77.255
77.000
76.746
51.443
35.285
32.335
28.902
25.971


Ph
O
O

3ax


f1 (ppm)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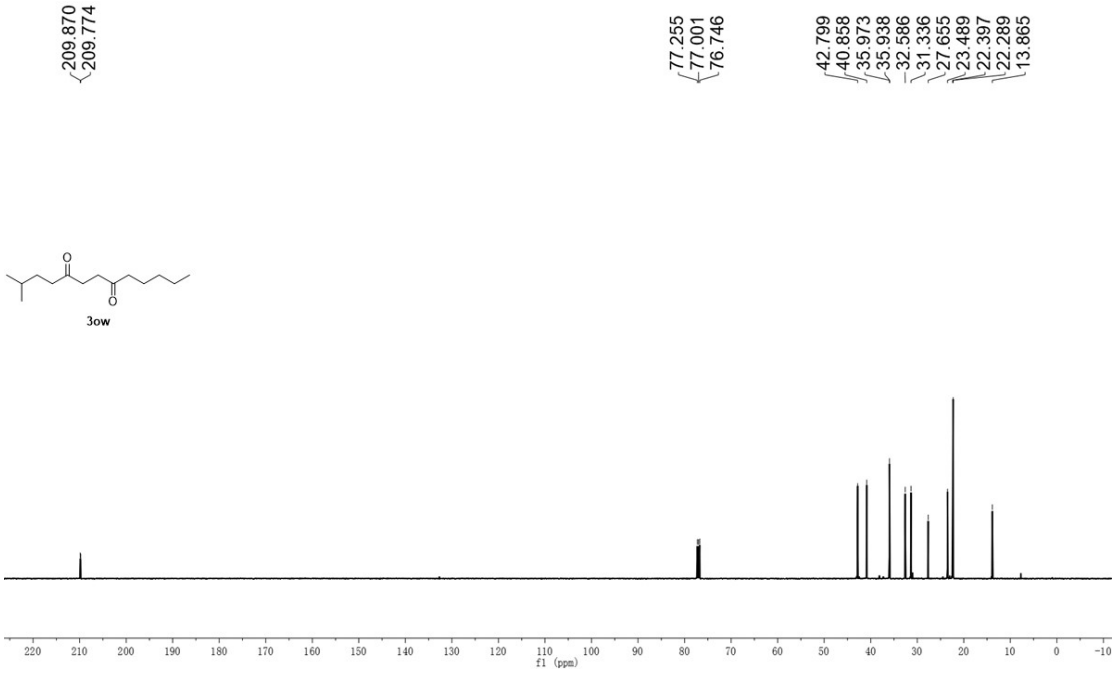
2.669
2.665
2.661
2.657
2.653
2.450
2.442
2.434
2.432
2.427
2.419
2.412
1.592
1.576
1.561
1.546
1.531
1.519
1.517
1.504
1.477
1.464
1.461
1.459
1.449
1.446
1.434
1.432
1.318
1.314
1.304
1.301
1.299
1.296
1.288
1.285
1.281
1.274
1.271
1.267
1.262
1.260
1.255
1.252
1.248
1.245
1.241
1.239
1.231
0.881
0.874
0.868
0.861
0.853
3.91
4.00
3.28
2.17
4.54
8.98
f1 (ppm)

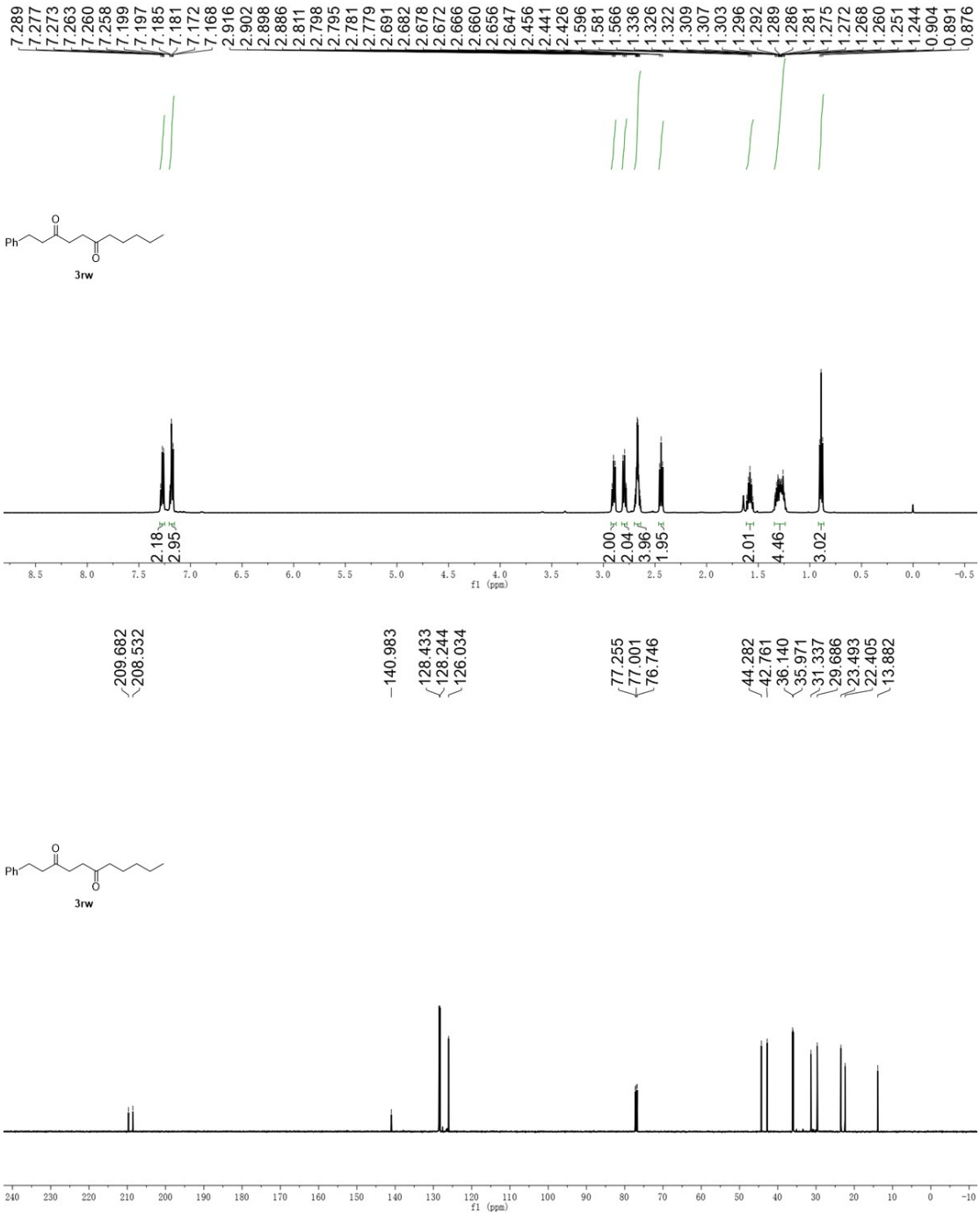
O
O

3ow


209.870
209.774
77.255
77.001
76.746
42.799
40.858
35.973
35.938
32.586
31.336
27.655
23.489
22.397
22.289
13.865
f1 (ppm)

O
O

3ow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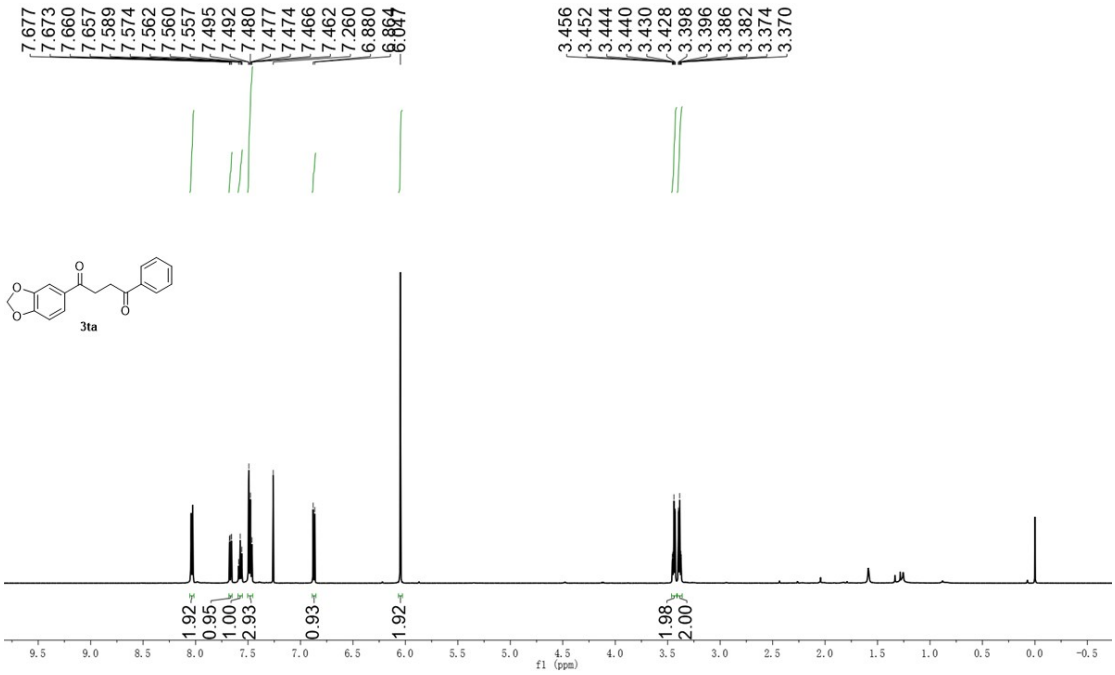
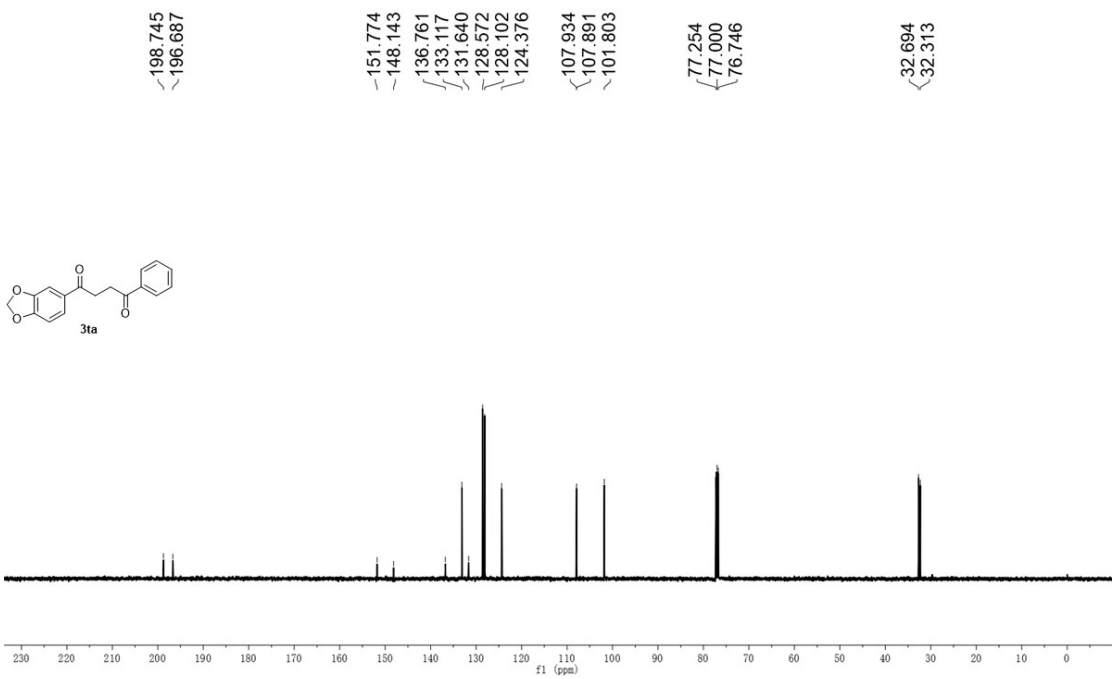
7.277
7.273
7.263
7.260
7.258
7.199
7.197
7.185
7.181
7.172
7.168
2.916
2.902
2.898
2.886
2.811
2.798
2.795
2.781
2.779
2.691
2.682
2.678
2.672
2.666
2.660
2.656
2.647
2.456
2.441
2.426
1.596
1.581
1.566
1.336
1.326
1.322
1.309
1.307
1.303
1.296
1.292
1.289
1.286
1.281
1.275
1.272
1.268
1.260
1.251
1.244
0.904
0.891
0.876
Ph
O
O
3rw
2.18
2.95
2.00
2.04
3.96
1.95
2.01
4.46
3.02
f1 (ppm)
209.682
208.532
140.983
128.433
128.244
126.034
77.255
77.001
76.746
44.282
42.761
36.140
35.971
31.337
29.686
23.493
22.405
13.882
Ph
O
O
3rw
f1 (ppm)


7.677
7.673
7.660
7.657
7.589
7.574
7.562
7.560
7.557
7.495
7.492
7.480
7.477
7.474
7.466
7.462
7.260
6.880
6.864
6.847
3.456
3.452
3.444
3.440
3.430
3.428
3.398
3.396
3.386
3.382
3.374
3.370
3ta
1.92
0.95
1.00
2.93
0.93
1.92
1.98
2.00
f1 (ppm)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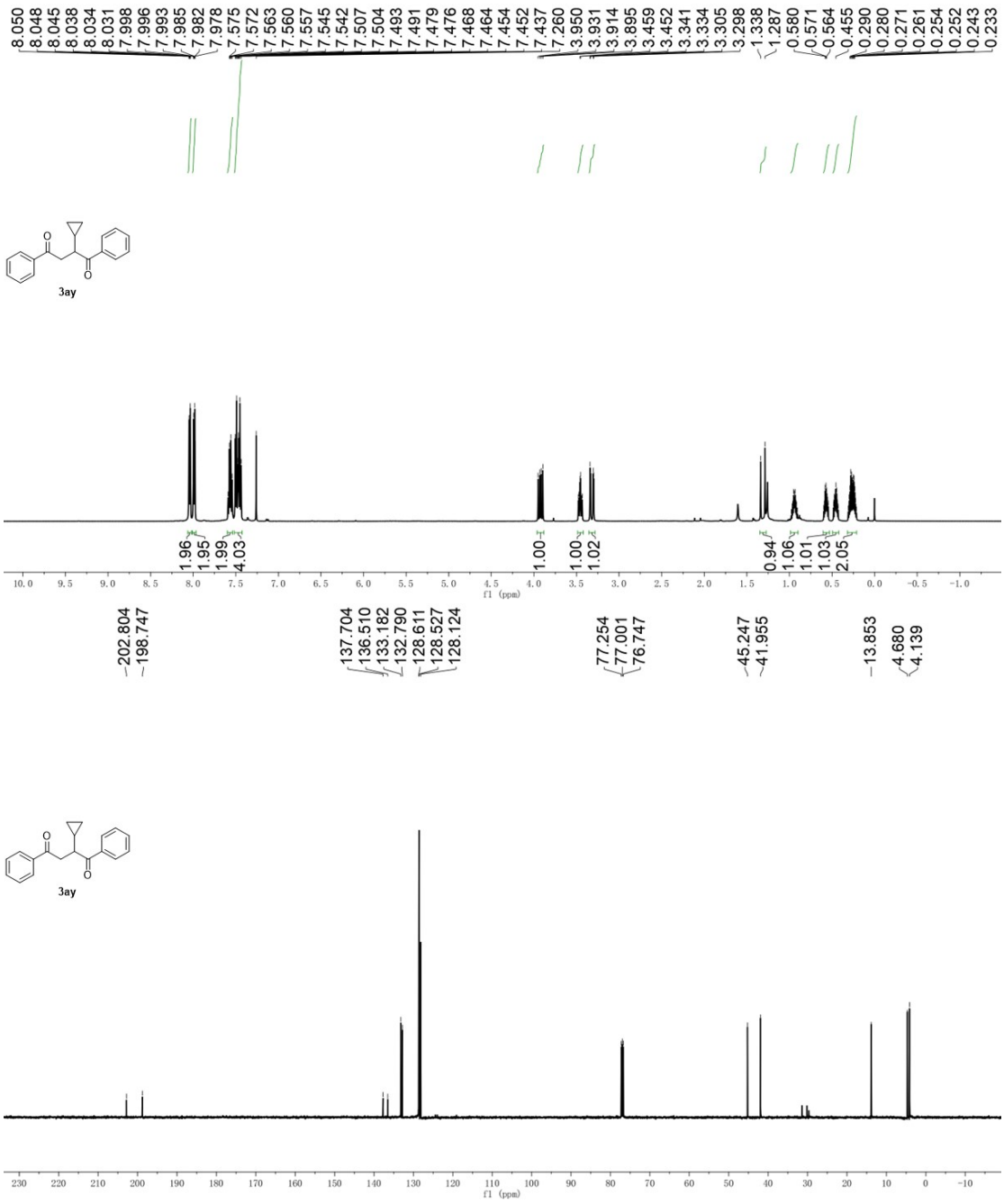
196.687
151.774
148.143
136.761
133.117
131.640
128.572
128.102
124.376
107.934
107.891
101.803
77.254
77.000
76.746
32.694
32.313
3ta
f1 (ppm)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8.045
8.038
8.034
8.031
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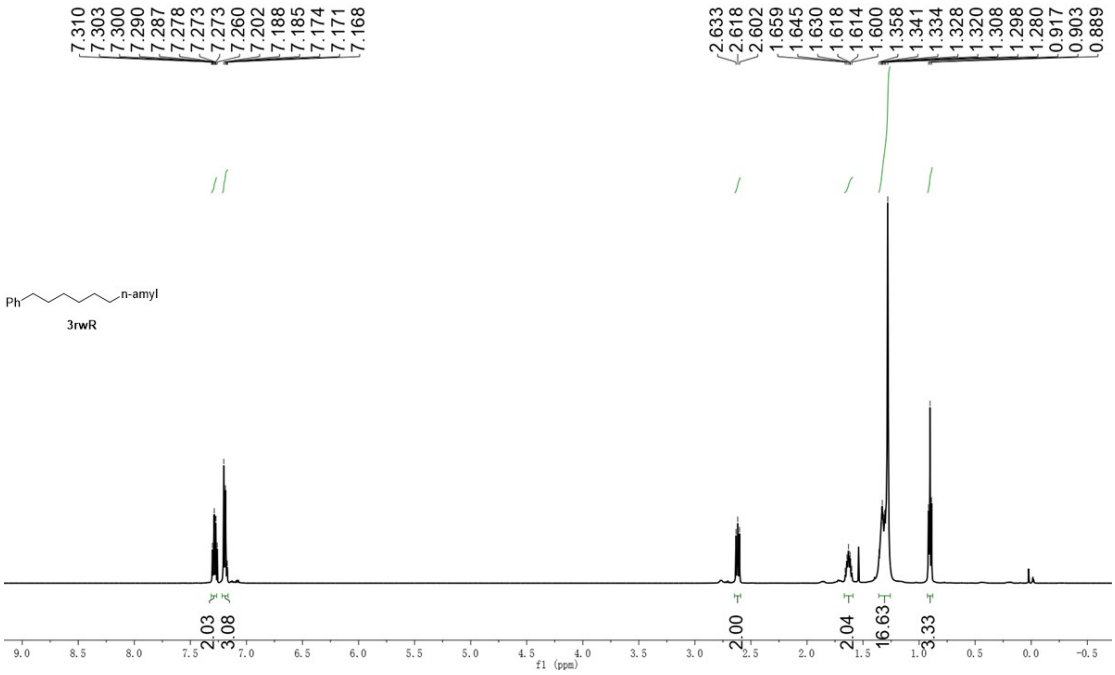
7.996
7.993
7.985
7.982
7.978
7.575
7.572
7.563
7.560
7.557
7.545
7.542
7.507
7.504
7.493
7.491
7.479
7.476
7.468
7.464
7.454
7.452
7.437
7.260
3.950
3.931
3.914
3.895
3.459
3.452
3.341
3.334
3.305
3.298
1.338
1.287
0.580
0.571
0.564
0.455
0.290
0.280
0.271
0.261
0.254
0.252
0.243
0.233
3ay
1.96
1.95
1.99
4.03
1.00
1.00
1.02
0.94
1.06
1.01
1.03
2.05
f1 (ppm)
202.804
198.747
137.704
136.510
133.182
132.790
128.611
128.527
128.124
77.254
77.001
76.747
45.247
41.955
13.853
4.680
4.139
3ay
f1 (ppm)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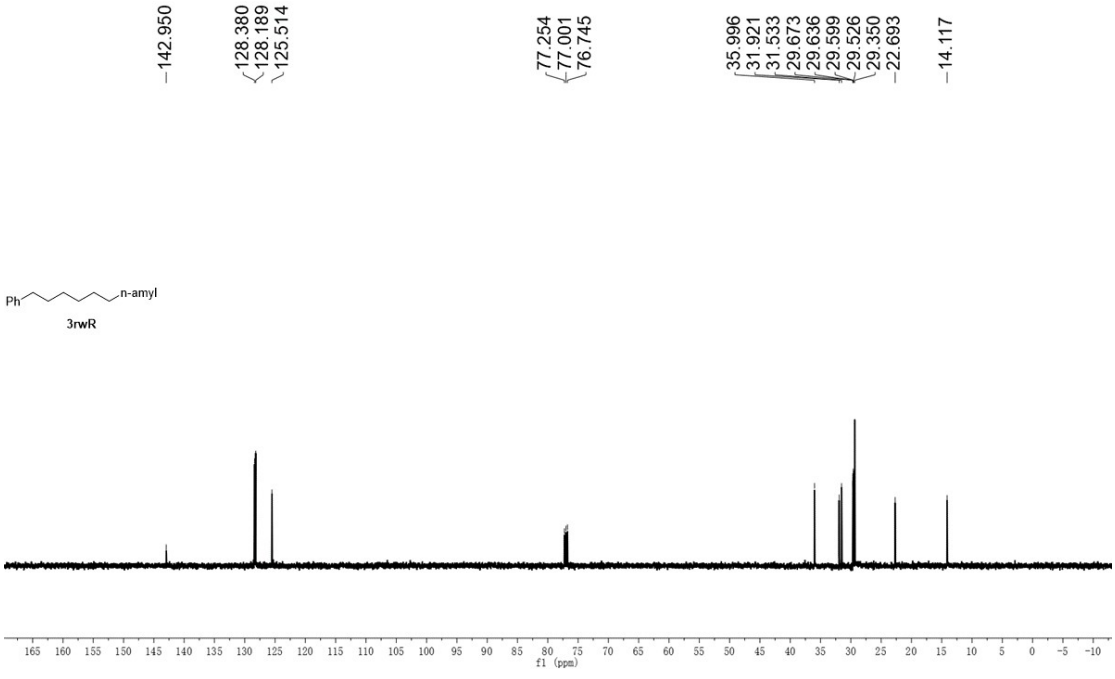
7.303
7.300
7.290
7.287
7.278
7.273
7.273
7.260
7.202
7.188
7.185
7.174
7.171
7.168
2.633
2.618
2.602
1.659
1.645
1.630
1.618
1.614
1.600
1.358
1.341
1.334
1.328
1.320
1.308
1.298
1.280
0.917
0.903
0.889
Ph
n-amyl
3rwR
2.03
3.08
2.00
2.04
16.63
3.33
f1 (ppm)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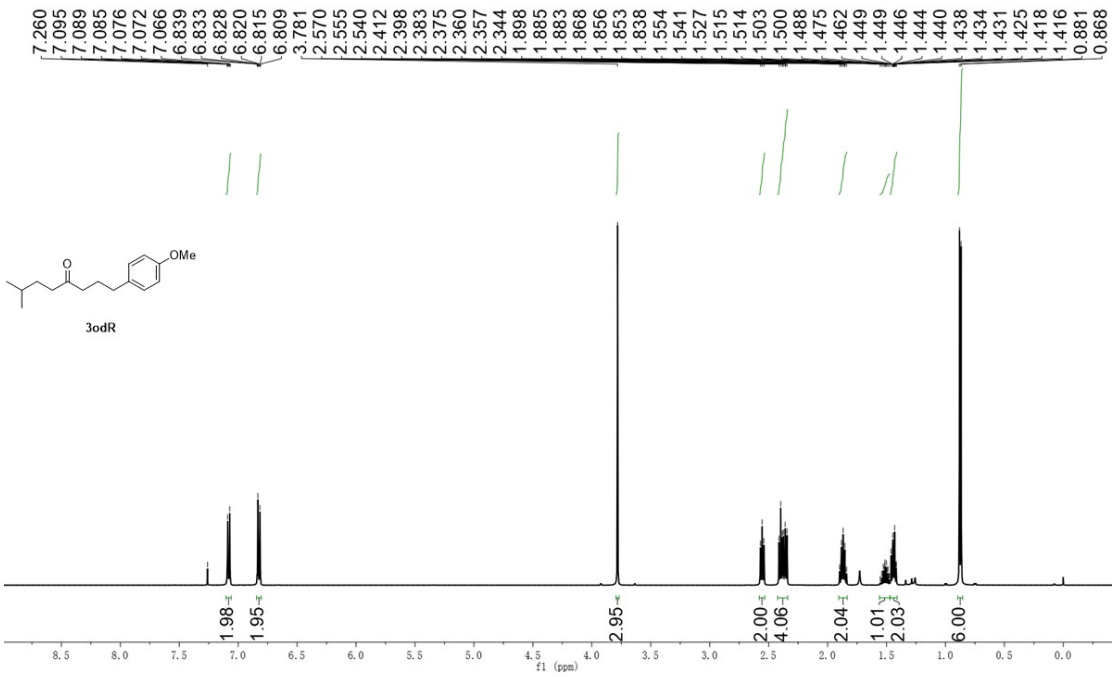
128.380
128.189
125.514
77.254
77.001
76.745
35.996
31.921
31.533
29.673
29.636
29.599
29.526
29.350
22.693
14.117
Ph
n-amyl
3rwR
f1 (ppm)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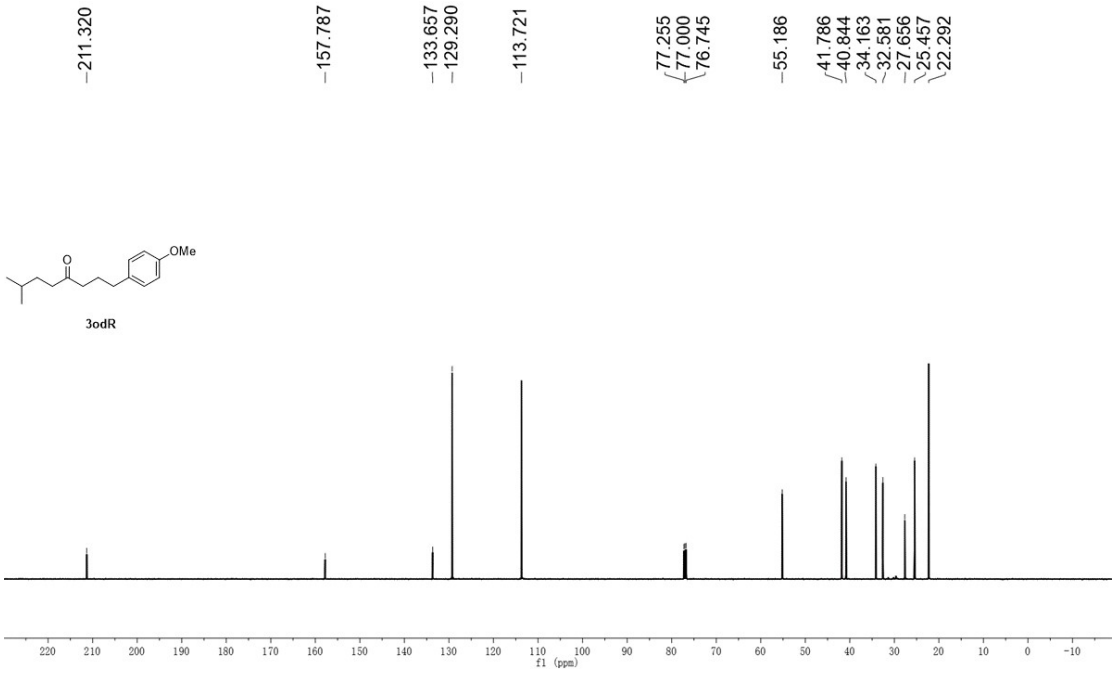
7.089
7.085
7.076
7.072
7.066
6.839
6.833
6.828
6.820
6.815
6.809
3.781
2.570
2.555
2.540
2.412
2.398
2.383
2.375
2.360
2.357
2.344
1.898
1.885
1.883
1.868
1.856
1.853
1.838
1.554
1.541
1.527
1.515
1.514
1.503
1.500
1.488
1.475
1.462
1.449
1.449
1.446
1.444
1.440
1.438
1.434
1.431
1.425
1.418
1.416
0.881
0.868
OMe
O
3odR
1.98
1.95
2.95
2.00
4.06
2.04
1.01
2.03
6.00
f1 (ppm)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157.787
133.657
129.290
113.721
77.255
77.000
76.745
55.186
41.786
40.844
34.163
32.581
27.656
25.457
22.292
OMe
O
3odR
f1 (ppm)