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1. General information

All reactions were carried out in sealed air using oven dried glassware. 1,1,1,3,3,3-hexafluoro-2-propanol, 1,2-dichloroethane, tetrabutylammonium perchlorate, and graphite felt are all available from commercial sources. Deionized water is obtained by ultra pure water machine. The electrochemical instrument is HONGSHENGFENGC DPS-305BM. Column chromatography was performed on silica gel (200-300 mesh). NMR spectra were recorded in $CDCl_3$ on 500 MHz spectrometers. ^{1}H NMR chemical shifts (δ) are reported in parts per million relative to tetramethylsilane (0 ppm). The following abbreviations are used for multiplicities: s = singlet, d = doublet, t = triplet, q = quartet, dd = doublet of doublets, dt = doublet of triplets, and m = multiplet. HRMS were obtained on an Ultima Global spectrometer with an ESI source. Melting points are uncorrected.

2. Faradaic efficiency

The current efficiency c.e. (coulombic yield) for the products were given according to the following Faraday efficiency formula. They were presented in Table 2 and Scheme 2 in the main text.

$$\eta = \frac{z_p \cdot N_p \cdot F}{I \cdot t} \times 100\%$$

η: Faradaic efficiency in percent [%], z_p: Number of electrons per product [−], Np: Number of mols of the product [mol], F: Faraday constant [96 485 sA mol^{-1}], I: Current [mA], t: Time [s]

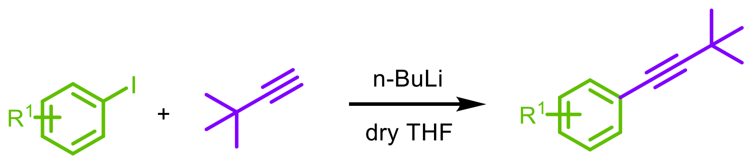
The calculation of the current efficiency of **3a** is as follows:

$$\eta = \frac{2 \cdot 0.84 \cdot 0.1 \cdot 96485}{5 \cdot 2.25 \cdot 3600} \times 100\% = 40\%$$

3. Preparation of the starting materials

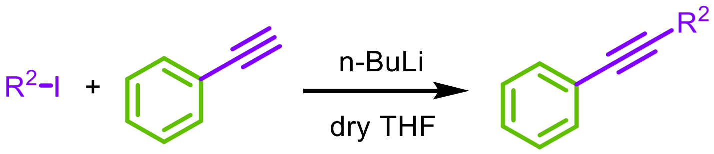
3.1 General procedure for the synthesis of alkynes

The compounds **1a-5a** were prepared according to previously described methods.[1]



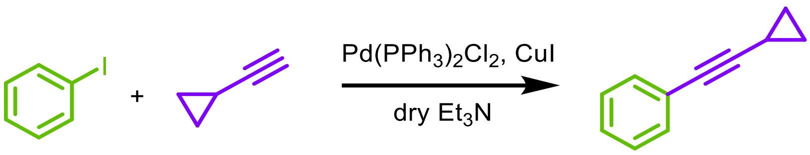
To a flame-dried round-bottom flask under N_2 was added alkyne (5.0 mmol, 1.0 eq.) followed by dry THF (25.0 mL, 0.2 M). Cool the flask to 0 °C. *n*-Butyllithium (4.0 mL, 2.5 M in hexanes, 10.0 mmol, 2.0 eq.) was added slowly and the reaction was allowed to stir for 1 hour. Iodoalkane (21.0 mmol, 2.1 eq.) was added at -20 °C and the reaction was allowed to stir at room temperature for 3 ~ 5 hour (when most of alkyne was consumed as detected by TLC). The reaction was quenched with a saturated solution of ammonium chloride and extracted with ethyl acetate. The organics were dried over $MgSO_4$ and the solvents were removed under reduced pressure. The residue was purified by silica chromatography to afford the corresponding compounds **1a-5a**.

The compounds **6a-8a, 12a** were prepared according to previously described methods.[1]



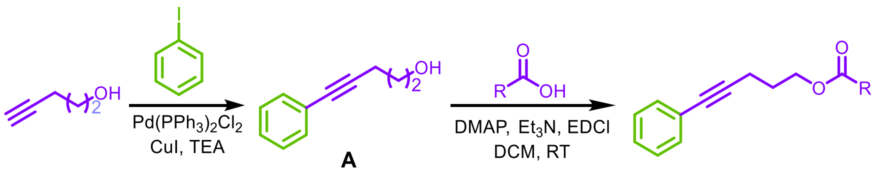
To a flame-dried round-bottom flask under N_2 was added alkyne (5.0 mmol, 1.0 eq.) followed by dry THF (25.0 mL, 0.2 M). Cool the flask to 0 °C. *n*-Butyllithium (4.0 mL, 2.5 M in hexanes, 10.0 mmol, 2.0 eq.) was added slowly and the reaction was allowed to stir for 1 hour. Iodoalkane (21.0 mmol, 2.1 eq.) was added at -20 °C and the reaction was allowed to stir at room temperature for 3 ~ 5 hour (when most of alkyne was consumed as detected by TLC). The reaction was quenched with a saturated solution of ammonium chloride and extracted with ethyl acetate. The organics were dried over $MgSO_4$ and the solvents were removed under reduced pressure. The residue was purified by silica chromatography to afford the corresponding compounds **6a-8a, 12a**.

The compounds **9a** were prepared according to previously described methods.[1]



To a 50 mL flame-dried round-bottom flask, under N_2, was added $PdCl_2(PPh_3)_2$ (0.05 mmol, 0.01 eq.), CuI (0.1 mmol, 0.02 eq.), iodobenzene (5.0 mmol, 1.0 eq.), cyclopropyl acetylene (6.0 mmol, 1.2 eq.) and dry Et_3N (10.0 mL), the reaction was allowed to stir at room temperature. The reaction was stirred overnight checked by TLC. The reaction is filtered over celite, washing with dichloromethane. The solvent was removed and the residue purified by flash column chromatography on silica gel to give compounds **9a**.

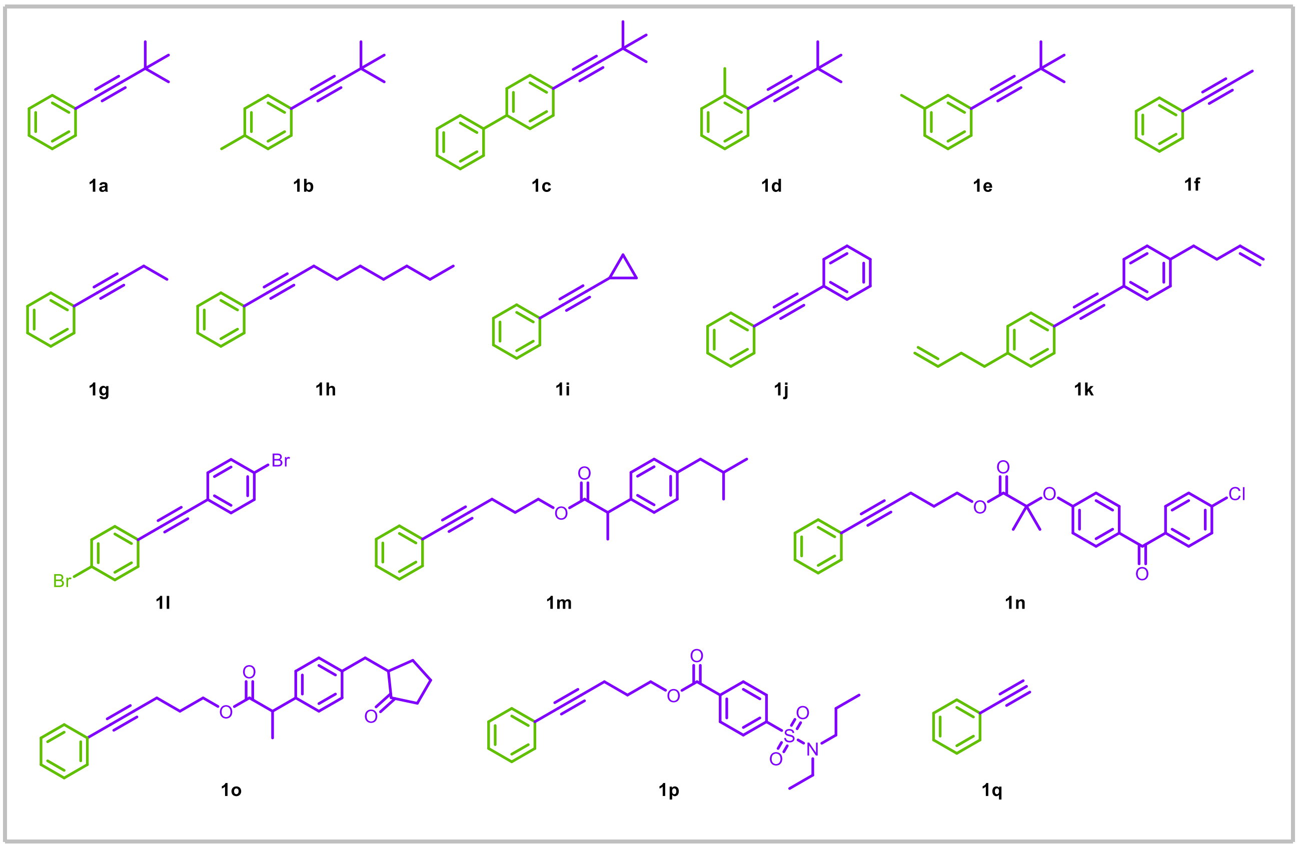
The compounds **13a-16a** were prepared according to previously described methods.[1]



Step 1: To a 50 mL flame-dried round-bottom flask, under N_2, was added $PdCl_2(PPh_3)_2$ (0.05 mmol, 0.01 eq.), CuI (0.1 mmol, 0.02 eq.), iodobenzene (6.0 mmol, 1.2 eq.), alkynol (5.0 mmol, 1.0 eq.) and dry Et_3N (10.0 mL), the reaction was allowed to stir at room temperature. The reaction was stirred overnight checked by TLC. The reaction is filtered over celite, washing with dichloromethane. The solvent was removed and the residue purified by flash column chromatography on silica gel to give compounds **A**.

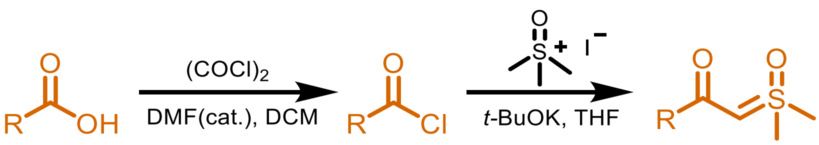
Step 2: To a solution of compound **A** (2.0 mmol, 1.0 eq.), DMAP (4-dimethylaminepyridine) (0.4 mmol, 0.2 eq.) and Et_3N (6.0 mmol, 3.0 eq.) in DCM (20.0 mL) at room temperature were added EDCI (1-ethyl-(3-(3-dimethylamino)propyl)-carbodiimide hydrochloride) (4.0 mmol, 2.0 eq.)

and pent-4-yn-1-ol (12.0 mmol, 1.2 eq.). The reaction mixture was stirred at room temperature for 6 h before quenched with H_2O (30.0 mL) and extracted 3 times with DCM (10.0 mL). The combined organic layer was dried over $MgSO_4$. The filtrate was concentrated in vacuo and the residue was purified by chromatography on silica gel, eluting with hexanes/EtOAc 15:1 (v/v) to afford **13a-16a**.



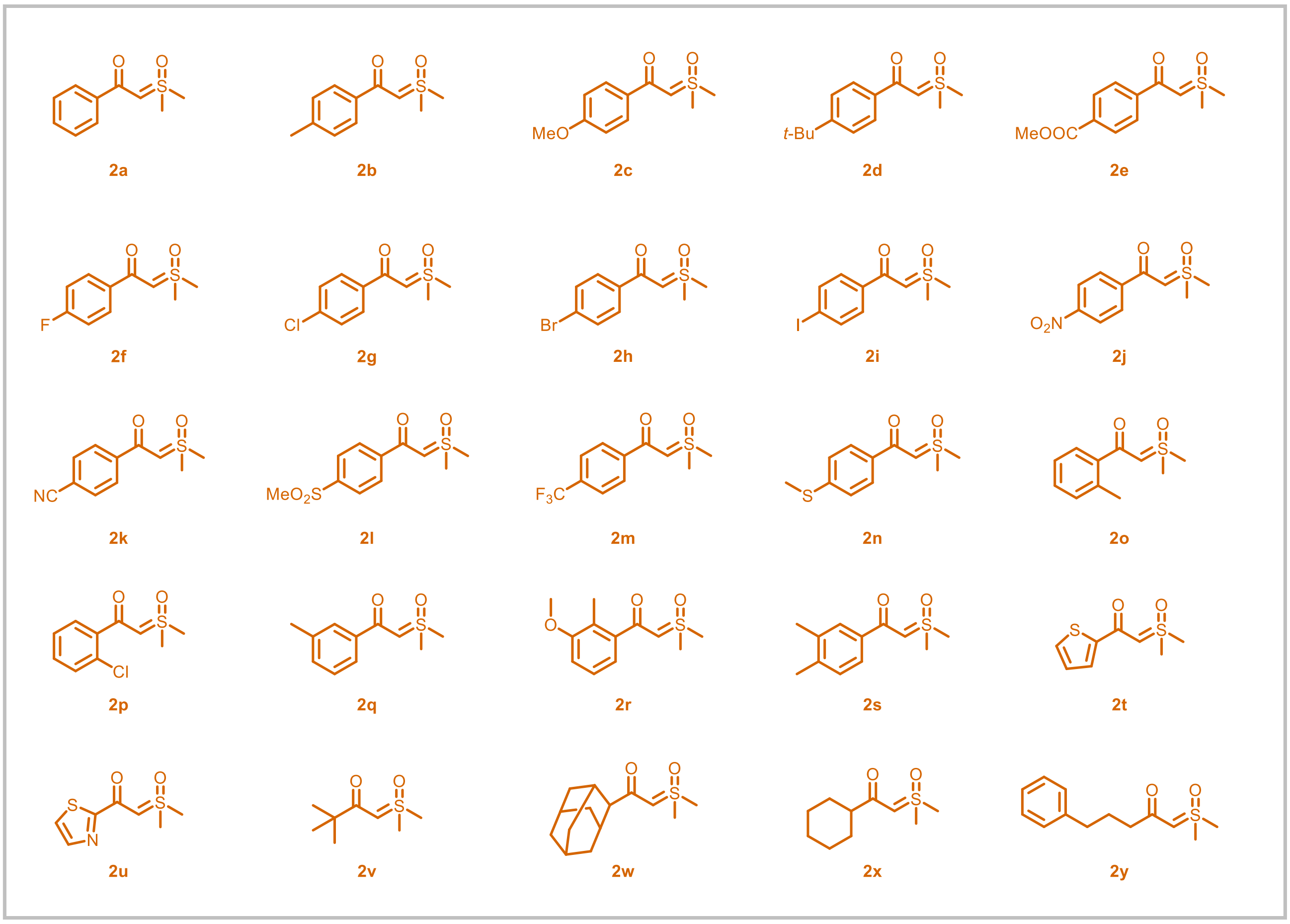
2.2 General procedure for the synthesis of sulfoxonium ylides

The compounds **2a-2y** were prepared according to previously described methods. [2,3]



Step 1: A round-bottom flask (25.0 mL) was charged with benzoic acid (7.0 mmol, 1.0 eq.), dry DCM (21.0 mL) and catalytic amount of DMF (3.0 drops). The reaction mixture was cooled to 0 °C and stirred for 10 minutes. Then, $(COCl)_2$ (10.5 mmol, 1.5 eq.) was added dropwise to the reaction mixture and stirred at 25 °C for 4~5 h. The resulting mixture was concentrated under reduced pressure to afford acid chloride quantitatively which was used directly without further purification for the next step.

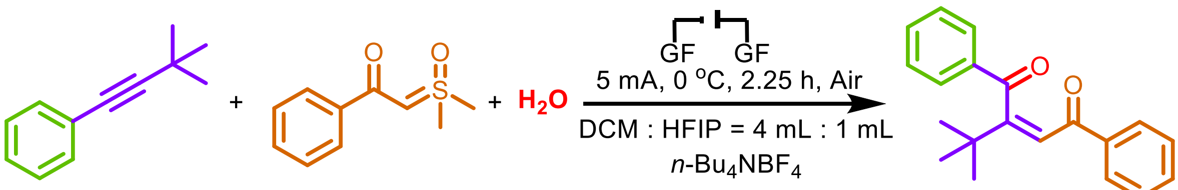
Step 2: To a stirred solution of potassium *tert*-butoxide (7.0 mmol) in THF (80.0 mL) was added trimethylsulfoxonium iodide (9.9 g, 45.0 mmol) at room temperature. The resulting mixture was refluxed for 2 h, and then cooled to 0 °C, which was followed by addition of benzoyl chloride (2.1 g, 15.0 mmol) in THF (10.0 mL). The reaction was allowed to room temperature and stirred for another 4 hours. Next, the solvent was evaporated, water (60.0 mL) and ethyl acetate (40.0 mL) were then added to the resulting slurry. The layers were separated and the aqueous layer was extracted with ethyl acetate and the organic layers were combined. The organic solution was dried over anhydrous $MgSO_4$, filtered, and evaporated to dryness.



3. General preparation of 1,4-dicarbonyl *Z*-alkenes

Figure S1. Components required for the reaction

Figure S2. Typical reaction set up



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

In an undivided cell (10 mL) equipped with a stir bar, **1a** (0.1 mmol, 1.0 eq.), **2a** (0.2 mmol, 2.0 eq.), H_2O (0.1 mmol， 1.0 eq.) and *n*-Bu_4NBF_4 (0.4 mmol, 4.0 eq.) were combined and added. The flask was equipped with a rubber stopper, a graphite felt anode (1.0 cm x 1.0 cm x 0.5 cm) and a graphite felt cathode (1.0 cm x 1.0 cm x 0.5 cm). Then DCM (4.0 mL) and 1,1,1,3,3,3-Hexafluoro-2-propanol (HFIP) (1.0 mL) and were injected respectively into the flask via syringes. The reaction mixture was stirred and electrolyzed in air for 2.25 hours at a constant current of 0 °C and 5 mA. After the reaction was complete, the residue was purified by column chromatography using petroleum ether and ethyl acetate as eluent, to afford the desired product **3a**.

4. Molecular structure and crystallographic data

Single-crystals of compound **3a** was grown from recrystallization by diffusion volatilization of hexane (69 °C)/dichloromethane (v/v, 3/1) at room temperature for 4 days. Single-crystal *X-ray* diffraction studies for compound **3a** was carried out on a XtaLAB AFC10 (RCD3): fixed-chi single diffractometer with mirror-monochromated Mo Kα radiation. Cell parameters were obtained by global refinement of the positions of all collected reflections. Intensities were S15 corrected for Lorentz and polarization effects and empirical absorption. The structures were solved by direct methods and refined by full-matrix least squares on F^2. All non-hydrogen atoms were refined anisotropically. All hydrogen atoms were placed in calculated positions. Structure solution and refinement were performed by using the SHELXL package. Displacement ellipsoid was drawn at the 50% probability level. The *X-ray* crystallographic files, in CIF format, are available from the Cambridge Crystallographic Data Centre on quoting the deposition number CCDC 2340616 for **3a**. Copies of this information may be obtained free of charge from The Director, CCDC, 12 Union Road, Cambridge CB2 IEZ, UK (Fax: +44-1223-336033; e-mail: deposit@ccdc.cam.ac.uk or www: http://www. ccdc.cam.ac.uk)

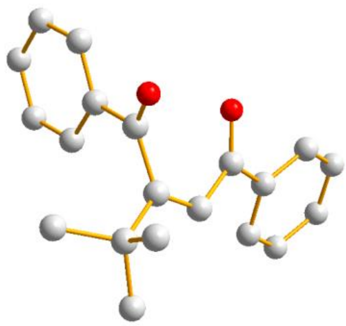


Figure S3. Crystallographic structure of **3a**

X-Ray crystallographic data compound **3a**

Identification code	MX13731
Empirical formula	$C_{20}H_{20}O_2$
Formula weight	292.36
Temperature/K	297.27(10)
Crystal system	monoclinic
Space group	P21/n

a/Å	10.7659(4)
b/Å	14.5214(5)
c/Å	11.4358(5)
α/°	90
β/°	110.658(5)
γ/°	90
Volume/$Å^3$	1672.87(12)
Z	4
ρcalcg/cm^3	1.161
μ/mm^{-1}	0.074
F(000)	624.0
Crystal size/mm^3	0.32 × 0.28 × 0.25
Radiation	Mo Kα (λ = 0.71073)
2Θ range for data collection/°	4.728 to 60.42
Index ranges	-12 ≤ h ≤ 15, -16 ≤ k ≤ 19, -15 ≤ l ≤ 16
Reflections collected	13131
Independent reflections	4101 [R_{int} = 0.0143, R_{sigma} = 0.0162]
Data/restraints/parameters	4101/0/202
Goodness-of-fit on F^2	1.090
Final R indexes [I>=2σ (I)]	R1 = 0.0537, wR_2 = 0.1632
Final R indexes [all data]	R1 = 0.0644, wR_2 = 0.1706
Largest diff. peak/hole / e $Å^{-3}$	0.34/-0.25

Single-crystals of compound **3al** was grown from recrystallization by diffusion volatilization of petroleum ether (60-90 °C)/dichloromethane (v/v, 3/1) at room temperature for 5 days. Single-crystal *X-ray* diffraction studies for compound **3al** was carried out on a XtaLAB AFC10 (RCD3): fixed-chi single diffractometer with mirror-monochromated Mo Kα radiation. Cell parameters were obtained by global refinement of the positions of all collected reflections. Intensities were S15 corrected for Lorentz and polarization effects and empirical absorption. The structures were solved by direct methods and refined by full-matrix least squares on F^2. All non-hydrogen atoms were refined anisotropically. All hydrogen atoms were placed in calculated positions. Structure solution and refinement were performed by using the SHELXL package. Displacement ellipsoid was drawn at the 50% probability level. The *X-ray* crystallographic files, in CIF format, are available from the Cambridge Crystallographic Data Centre on quoting the deposition number CCDC 2179302 for **3al**. Copies of this information may be obtained free of charge from The Director, CCDC, 12 Union Road, Cambridge CB2 IEZ, UK (Fax: +44-1223-336033; e-mail: deposit@ccdc.cam.ac.uk or www: http://www. ccdc.cam.ac.uk)

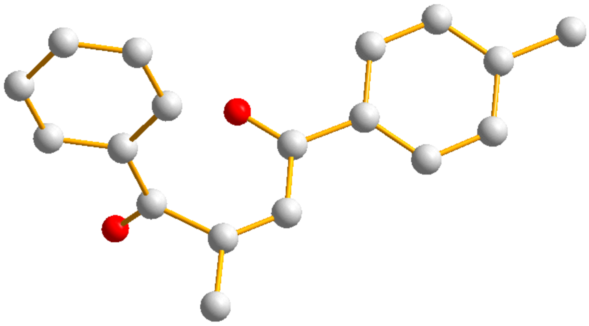


Figure S4. Crystallographic structure of **3al**

X-Ray crystallographic data compound **3al**

Identification code	MX10483
Empirical formula	$C_{18}H_{16}O_2$
Formula weight	264.31
Temperature/K	170.01(10)
Crystal system	orthorhombic
Space group	Pbca
a/Å	8.2970(3)
b/Å	11.4089(5)
c/Å	29.4395(11)
α/°	90
β/°	90
γ/°	90
Volume/Å^3	2786.73(19)
Z	8
ρ_{calc}g/cm^3	1.260
μ/mm^{-1}	0.081
F(000)	1120.0
Crystal size/mm^3	0.28 × 0.21 × 0.08
Radiation	Mo Kα (λ = 0.71073)
2Θ range for data collection/°	5.536 to 62.172
Index ranges	$-11 \le h \le 9$, $-15 \le k \le 14$, $-30 \le l \le 42$
Reflections collected	16298
Independent reflections	3902 [R_{int} = 0.0226, R_{sigma} = 0.0220]
Data/restraints/parameters	3902/0/183
Goodness-of-fit on F^2	1.056
Final R indexes [I>=2σ (I)]	R_1 = 0.0410, wR_2 = 0.1103

Final R indexes [all data]	R_1 = 0.0509, wR_2 = 0.1158
Largest diff. peak/hole / e Å^{-3}	0.36/-0.19

5. Computational studies Computational details

In this work, geometry optimizations and frequency calculation of all structures including reactants, intermediates, transition states, and products were computed with Gaussian 16, Revision A. 03 package, which was based on M06-2X density functional and 6-31G(d) basis set. All the stationary structures and transition state structures (TSs) were identified by no imaginary frequency and a single imaginary frequency. Meanwhile, Intrinsic Reaction Coordinate (IRC) calculations were used for all the TSs. The solvent effect of Dichloromethane (DCM) was evaluated through the SMD method based upon M06-2X density functional and 6-311++G(d,p) basis set. All reported energies are free energies at a concentration of 1 M and a temperature of 298.15 K.[4,5]

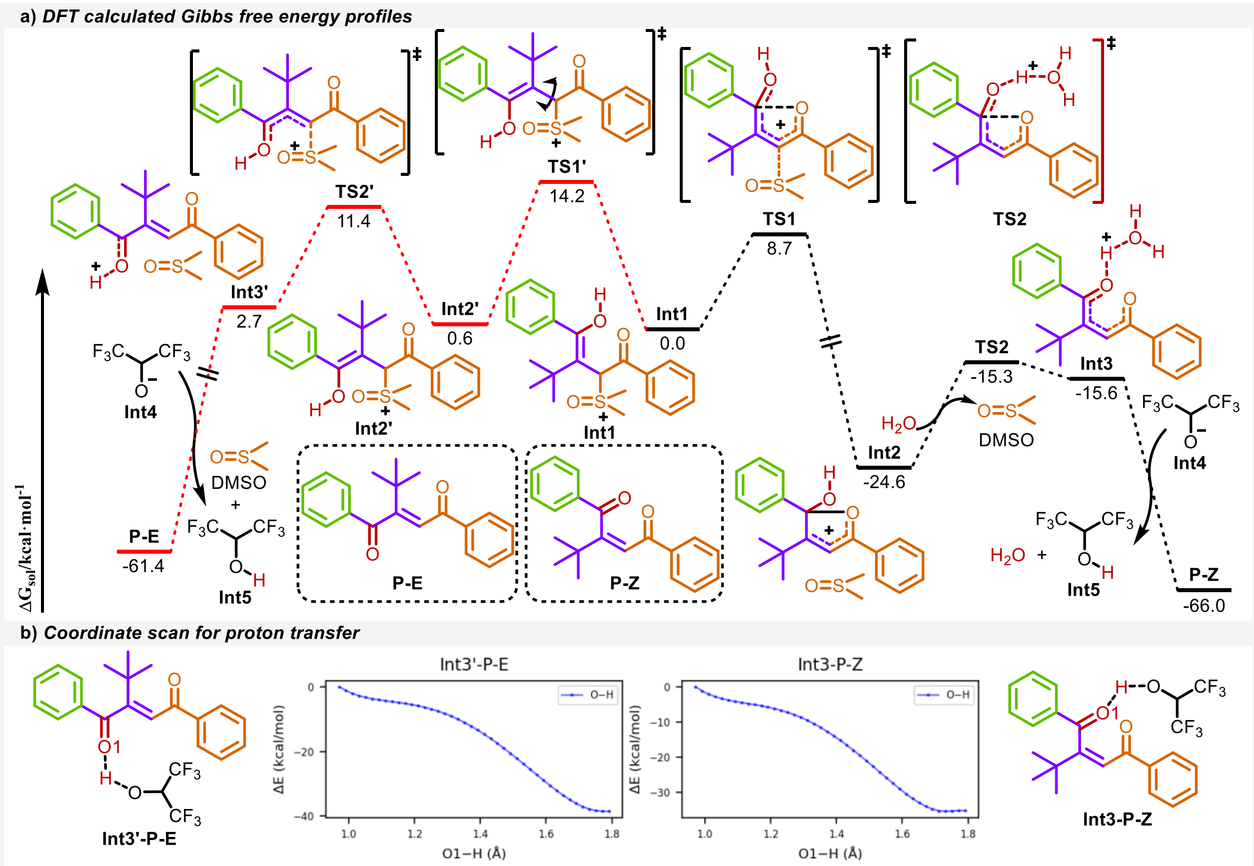


Figure S5. DFT calculations

Cartesian coordinates of the optimized structures:

Int1

E = -1477.921714 a.u.

1 1

O	0.39910500	27.54090400	4.89306300
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C	-0.69010300	24.74141200	6.90284300
H	-0.05642800	23.94672700	6.52810900
C	-1.67466200	24.41563000	7.82858900
H	-1.78553400	23.38841400	8.15341700
C	-2.51734300	25.40279800	8.32738700
C	-2.39011600	26.72126600	7.89207800
H	-3.05439500	27.48669300	8.27454100
C	-1.41719300	27.05107200	6.96304100
H	-1.31059300	28.06746100	6.60283000
C	0.47910700	26.50758300	5.49465200
C	1.70720300	25.56298600	5.23099500
H	1.31442200	24.55932700	5.06167000
C	2.57077600	25.98838100	4.07490600
C	2.58225500	25.01362600	2.89172600
C	3.12779300	27.20463300	4.17240600
C	3.73256600	28.06785300	3.13283000
C	2.89552300	28.70181600	2.21367400
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H	2.78589300	30.06599900	0.56082900
C	4.80427100	29.81841400	1.25938500
C	5.63785200	29.20209600	2.18881600
C	5.10213800	28.33819800	3.13519700
H	6.70383400	29.39521000	2.17482100
H	5.74942200	27.85185900	3.85858800
H	5.22401500	30.49364200	0.52320000
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H	3.04069200	26.33796100	1.20130100
H	4.47146200	25.70162600	2.01974500
H	3.49927700	24.65411100	0.98672900
C	3.15226400	23.66079800	3.36376700
H	4.21859800	23.74701900	3.59137800
H	2.64676300	23.24106700	4.23919200
H	3.05481000	22.92181100	2.56595500
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H	1.13652800	24.15749600	1.51833900
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H	0.71059100	25.77989000	2.07889300
H	-3.28163700	25.14403500	9.05078700
H	3.17566000	28.74342600	5.33282400
S	2.62372200	25.19321400	6.80586000
O	2.31517600	23.84613100	7.29016800
C	4.37598100	25.34183900	6.50164400
H	4.84162800	24.94105400	7.40267600
H	4.60554600	24.71485300	5.64223100
H	4.62933100	26.38368200	6.32677900
C	2.25776400	26.43186400	8.04532600
H	2.26323300	27.41241400	7.57580700
H	1.28244700	26.17583900	8.45650800
H	3.03153100	26.34010900	8.80751200

TS1’

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C	1.24013000	22.60273500	6.38515500
H	0.32440500	22.94670100	5.91901000
C	1.37009600	21.29427900	6.82400100
H	0.55103600	20.59735500	6.69509500
C	2.55305100	20.87840700	7.42963800
C	3.61057500	21.76954000	7.59071600
H	4.53173800	21.44178100	8.05678700
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H	4.33895500	23.74196900	7.25475600
C	2.06209800	24.89525900	6.07874300
C	3.19505000	25.95739100	6.08390400
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C	3.38491300	26.59110600	4.70328500
C	3.48745800	25.61367200	3.50178600
C	3.65951600	27.90646400	4.63922500
C	3.53887700	28.82488800	3.48830400
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H	1.48240500	28.31809400	3.14212000
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H	1.22209200	29.93490100	1.27261200
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C	4.60705200	29.65026400	3.12758500
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H	1.37126500	25.76113800	2.95421000
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C	4.14283600	26.27007500	2.27183000
H	3.48200400	26.95910600	1.75021700
H	5.06292200	26.79828800	2.52840700
H	4.40085400	25.47653400	1.56825700
C	4.45164900	24.48041200	3.91423500
H	4.60161800	23.80713800	3.06827400
H	5.42965200	24.87995900	4.19797700
H	4.07427400	23.86494600	4.73108600
H	2.65402900	19.85579900	7.77370900
H	3.76194300	29.46135100	5.77050100
S	2.55084600	27.13332000	7.41697000
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Int2’

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C	4.07110200	21.42530100	6.74055000
H	3.85110800	20.36977700	6.84349800

C	5.37011800	21.84527600	6.46451100
C	5.66135300	23.20110500	6.33753600
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H	4.88384400	25.19474300	6.34888200
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H	3.11028000	26.55171600	7.14625200
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C	2.37165000	25.76699700	3.78398600
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C	4.42244800	28.19690500	3.93236300
C	4.05892300	29.47932900	3.51321000
H	3.21066600	29.97454900	3.97586500
C	4.75072600	30.08606200	2.47333700
H	4.45506800	31.07026600	2.13034000
C	5.81775200	29.42669400	1.86904700
C	6.19978500	28.16283600	2.30774100
C	5.50352500	27.54488800	3.34003200
H	7.03974700	27.65805600	1.84573500
H	5.79782500	26.56136400	3.68954900
H	6.35609900	29.90181900	1.05759500
C	0.94968400	25.24348100	4.04937400
H	0.89207000	24.53248800	4.87753900
H	0.25869800	26.07544100	4.21795200
H	0.59249900	24.71166800	3.16611400
C	2.24127600	26.72393600	2.58387400
H	1.73275700	27.64825100	2.86815100
H	3.19897500	26.97828900	2.13386800
H	1.64531900	26.23414600	1.81076300
C	3.25903200	24.57988200	3.37333300
H	2.89513200	24.16571200	2.42966500
H	4.29290100	24.89353100	3.21956100
H	3.25347200	23.77679600	4.11126800
H	6.16096200	21.11265300	6.35327000
H	4.53944400	28.92277400	6.13322100
S	0.87794300	27.15196000	6.83011400
O	0.76949900	28.26830000	5.89083800
C	-0.69921800	26.29450700	6.95143400
H	-0.75040000	25.76116400	7.89490200
H	-1.43091500	27.10029400	6.87523000
H	-0.79262300	25.60435200	6.11862400

C	1.18525800	27.69771400	8.50170500
H	1.33494200	26.82054400	9.13229100
H	2.07910300	28.31973800	8.45751500
H	0.32580100	28.28167300	8.82953000

TS2’

E = -1477.895959 a.u.

1 1

O	3.65869400	23.42271500	5.35724100
O	1.58328600	27.89499300	4.56599100
C	2.72809800	24.16049400	7.39590100
C	2.70852300	25.24741100	8.27477400
H	2.98537300	26.24242100	7.94171900
C	2.38774700	25.05116000	9.61243800
H	2.39866600	25.88909000	10.29925900
C	2.06371000	23.77692700	10.07083300
C	2.08364200	22.69230500	9.19731000
H	1.83588100	21.70042200	9.55549100
C	2.42826500	22.87908800	7.86497600
H	2.44819400	22.04743600	7.17048600
C	3.06019800	24.28518000	5.94381700
C	2.55626800	25.53873900	5.25178600
H	2.32971100	26.33536900	5.95021800
C	2.67149500	25.91676700	3.92191300
C	2.91523800	24.99853300	2.69809400
C	2.46020000	27.31804100	3.76622700
C	3.15997600	28.19558100	2.83689900
C	2.45713800	29.20516000	2.16164000
H	1.37756400	29.28025800	2.25430700
C	3.13560100	30.05139400	1.29944200
H	2.59329400	30.80940200	0.74796800
C	4.51343000	29.91800100	1.13746500
C	5.21749800	28.93623000	1.83112100
C	4.54415500	28.06453300	2.67294300
H	6.29085400	28.85169100	1.71447400
H	5.08235000	27.30977500	3.23328100
H	5.04158900	30.58605900	0.46752400
C	4.37039800	24.52203700	2.57175600
H	5.04106000	25.34715000	2.32536900
H	4.72212500	24.02817600	3.47341400

H	4.43401300	23.80523800	1.74969200
C	1.96900000	23.78730000	2.83695700
H	2.12156600	23.20739900	3.74160600
H	0.92087300	24.09441500	2.79696000
H	2.13549200	23.11891400	1.99013700
C	2.51534900	25.68501500	1.37712100
H	2.46035700	24.92064100	0.60068600
H	1.52658600	26.15279500	1.43736200
H	3.23099700	26.43219500	1.03618700
H	1.80510600	23.62810300	11.11264400
H	1.64907000	28.86154600	4.51554700
S	0.14734000	24.60240700	5.74104600
O	-0.07489400	23.17061700	5.39190600
C	-0.59737300	24.91993100	7.35452000
H	-1.65165200	24.64645400	7.30570100
H	-0.07468000	24.28366100	8.06861700
H	-0.46771300	25.96903200	7.62007600
C	-0.91411000	25.63409000	4.71095600
H	-0.91682300	26.65135300	5.10076800
H	-0.50713100	25.62146000	3.70002300
H	-1.91475700	25.20179400	4.71167700

Int3’

E = -1477.916694 a.u.

1 1

O	3.50855200	23.71885100	5.31894400
O	2.01021800	28.38682000	4.32325100
C	2.69382500	24.54638000	7.37239600
C	2.03891900	25.55059400	8.09287600
H	1.71410000	26.46158400	7.60663500
C	1.73838100	25.35951000	9.43567600
H	1.22292400	26.13652800	9.98759900
C	2.09187300	24.17050900	10.06866400
C	2.75362900	23.17140200	9.35859600
H	3.03501700	22.24878500	9.85196500
C	3.05455600	23.35944400	8.01715400
H	3.56361700	22.59143800	7.44736600
C	3.01061200	24.64426100	5.91681800
C	2.78675000	25.96050100	5.22387600
H	2.77089000	26.81872900	5.88469300
C	2.74450900	26.20579100	3.89199200

C	2.57897100	25.24001500	2.69567500
C	2.81177000	27.63594300	3.63634600
C	3.73975100	28.26497600	2.71718500
C	3.36694200	29.42421000	2.01500000
H	2.35165200	29.80638600	2.07412300
C	4.27407100	30.02514000	1.16062700
H	3.98430500	30.89911900	0.59079100
C	5.55732700	29.49400900	1.02650100
C	5.93563000	28.35649500	1.73531900
C	5.02652400	27.72848200	2.57247100
H	6.93881200	27.96133900	1.63509800
H	5.31346500	26.85711000	3.14892200
H	6.26681600	29.97231300	0.36154800
C	3.87433900	24.51270200	2.30631400
H	4.59710800	25.18834300	1.84414100
H	4.32889900	24.02034900	3.16346400
H	3.63401100	23.74908500	1.56238700
C	1.49193800	24.21204200	3.06886500
H	1.84601100	23.49894800	3.80852700
H	0.60566900	24.70823100	3.46523300
H	1.22341300	23.65447100	2.16911000
C	2.05429300	26.00833400	1.46625400
H	1.75694900	25.28655900	0.70452900
H	1.16736400	26.60505000	1.70681700
H	2.80398400	26.65592900	1.00994700
H	1.85516900	24.02479300	11.11631700
H	2.21149500	29.33176600	4.21753500
S	-0.88279100	25.10958900	6.57898900
O	0.25539100	25.56560700	5.67409000
C	-0.52093100	23.39493100	7.02683300
H	-0.15489200	22.88272000	6.13588500
H	0.24513900	23.40005800	7.80033600
H	-1.42493400	22.92009400	7.40830500
C	-2.25003400	24.75699800	5.45105700
H	-3.09658100	24.35545800	6.00757700
H	-2.52768700	25.70017800	4.98439000
H	-1.90824200	24.05171500	4.69348800

P-E

E = -924.420552 a.u.

0 1

O	3.07695500	23.85947600	7.43017000
O	5.28409500	28.29371500	6.71305300
C	3.94333600	22.72506600	5.55014500
C	3.45066100	21.49519800	5.99199900
H	2.96479800	21.45149000	6.95967000
C	3.58609800	20.36519100	5.20042300
H	3.20673500	19.41116700	5.54789300
C	4.20968400	20.45693900	3.95757200
C	4.69616000	21.67961700	3.50869400
H	5.17789800	21.75080500	2.54040700
C	4.56513400	22.81266700	4.30375100
H	4.94413300	23.76481700	3.94704300
C	3.75477900	23.92285400	6.42959000
C	4.47960500	25.17157600	6.04293900
H	5.53082100	25.01372900	5.80351300
C	4.01748900	26.42671300	6.02058900
C	2.59133700	26.93268700	6.23274600
C	5.08833900	27.48009400	5.84117500
C	5.90295800	27.48245400	4.58264300
C	7.07602100	28.23948000	4.56080800
H	7.36279000	28.77405500	5.45893700
C	7.84655300	28.29767400	3.40925800
H	8.76233300	28.87732100	3.39855500
C	7.43977100	27.61536900	2.26450100
C	6.26197500	26.87608500	2.27339700
C	5.49650000	26.80379100	3.43211900
H	5.93826900	26.35814300	1.37790700
H	4.57356500	26.23406800	3.43859800
H	8.03980000	27.66539900	1.36283200
C	1.54782300	25.95041500	5.68136600
H	1.77946000	25.66180300	4.65130200
H	1.46087300	25.05043600	6.28507500
H	0.56862400	26.43520600	5.67728700
C	2.36750100	27.15457000	7.73802300
H	2.46195500	26.21031400	8.27547600
H	3.09766700	27.86196900	8.13433800
H	1.36437000	27.55879800	7.90427400
C	2.40944200	28.26835700	5.48791300
H	1.37454000	28.60156200	5.58949000
H	3.05139000	29.05252400	5.88966800
H	2.62007200	28.16223500	4.41867200
H	4.31518200	19.57306200	3.33850500

TS1

E = -1477.903446 a.u.

1 1

O	0.67127800	27.94895800	5.11426100
O	3.35079500	27.66891600	5.32006100
C	-0.37220700	26.39259900	6.55482600
C	-0.76794500	25.06545100	6.76234700
H	-0.39362400	24.25284600	6.15008300
C	-1.66443400	24.75970400	7.77859900
H	-1.97148300	23.73214100	7.93035500
C	-2.16259800	25.76948100	8.59710200
C	-1.77892800	27.09255300	8.38930700
H	-2.17465100	27.87904900	9.02051100
C	-0.89641700	27.40430300	7.36592900
H	-0.59954800	28.42965700	7.17933600
C	0.59019900	26.80651100	5.49591000
C	1.46975300	25.73471900	4.85994100
H	0.98409900	24.76964600	4.74530900
C	2.47501200	26.01878800	3.95036600
C	2.83605000	24.96708100	2.87043100
C	3.10488200	27.27648200	4.08284900
C	3.52357100	28.16258900	3.00834300
C	2.65895700	28.37410000	1.92771300
H	1.69854100	27.87231300	1.90901300
C	3.01847600	29.26560600	0.92941500
H	2.34570400	29.44947700	0.10092200
C	4.24278400	29.92775900	0.99655400
C	5.10488700	29.72039200	2.07163400
C	4.74178300	28.85232100	3.08908800
H	6.05849000	30.23216100	2.11098400
H	5.42561500	28.66302100	3.91099400
H	4.52597600	30.61404400	0.20722800
C	4.08287200	25.33649600	2.05517200
H	3.91595800	26.16105100	1.36290500
H	4.92926800	25.59423900	2.69896600
H	4.37855500	24.47092400	1.45971800
C	3.14417500	23.63288800	3.57918500
H	4.06283900	23.69298500	4.16707600
H	2.34781200	23.28302900	4.23862300
H	3.29832800	22.85847600	2.82515800

C	1.65061000	24.75927700	1.91593800
H	1.90073900	23.99868400	1.17313500
H	0.75584300	24.42144200	2.44451400
H	1.40059200	25.67608000	1.37872500
H	-2.85696000	25.52579900	9.39268500
H	3.53181500	28.62113800	5.35160700
S	2.40256300	24.80427000	6.95954800
O	2.16782000	23.33300200	6.97166800
C	4.17256000	25.12303800	6.87838000
H	4.65974700	24.38204300	7.51222200
H	4.49285100	25.00145500	5.84456400
H	4.37604000	26.13773700	7.21370300
C	2.05488500	25.48153700	8.59783100
H	2.18814200	26.56320700	8.57237800
H	1.02036600	25.23439300	8.83106900
H	2.73086800	25.01167200	9.31264300

Int2

E = -1477.963664 a.u.

1 1

O	1.70748500	28.48067500	4.76640900
O	3.88964600	28.97765000	4.22820900
C	0.38988400	27.50340500	6.45956300
C	0.11039600	26.37852300	7.25691200
H	0.68741400	25.46252200	7.15817200
C	-0.91790800	26.45264500	8.18251300
H	-1.14603300	25.59565700	8.80406100
C	-1.65843100	27.62498600	8.31470600
C	-1.38156800	28.74217100	7.52313300
H	-1.96531600	29.64701600	7.63673200
C	-0.36017800	28.68684600	6.59584200
H	-0.13041000	29.54223300	5.97236500
C	1.45233500	27.44128500	5.49868800
C	2.31404600	26.33609600	5.19685500
H	2.27659600	25.37296200	5.69537200
C	3.16181700	26.72835500	4.22175600
C	4.21696400	25.88732300	3.55843200
C	2.84629300	28.17537700	3.85921400
C	2.34668900	28.37454900	2.44330500
C	1.10955100	27.85934000	2.05684400
H	0.47325500	27.35763400	2.77896500

C	0.68835900	27.98627100	0.74165600
H	-0.27393500	27.58790200	0.44350600
C	1.49965900	28.62574400	-0.19330900
C	2.73062700	29.13998300	0.19163200
C	3.15899600	29.01225000	1.51019000
H	3.36466700	29.63786900	-0.53198900
H	4.13331900	29.39278100	1.79547400
H	1.16915300	28.72223900	-1.22055800
C	5.50200800	26.69011900	3.30525200
H	5.33980900	27.50633400	2.60113000
H	5.90346200	27.11105700	4.22809500
H	6.25092200	26.02196200	2.87562800
C	4.52944800	24.67828500	4.44981700
H	4.88152000	24.99227400	5.43540200
H	3.65449900	24.03918900	4.58701900
H	5.31322100	24.07918800	3.98331200
C	3.65898800	25.37525800	2.20928600
H	4.38605100	24.68187000	1.78066400
H	2.71752900	24.83901300	2.34766400
H	3.49889600	26.18152800	1.49320500
H	-2.46134100	27.67242900	9.04161300
H	3.71334900	29.88730100	3.95247400
S	2.59449600	22.47559400	7.21261800
O	1.96737700	23.80585400	6.82308100
C	1.21936700	21.30959000	7.29585300
H	1.56495600	20.35741200	7.69785900
H	0.43509100	21.73965800	7.91842000
H	0.85388700	21.17067700	6.28016000
C	2.90620600	22.59464100	8.98660800
H	3.24047500	21.63028800	9.36871500
H	3.68889800	23.33790500	9.12654400
H	1.99095300	22.91846800	9.48182300

TS2

E = -1001.209946 a.u.

1 1

O	1.50972100	28.77859700	4.67147000
O	4.06920700	28.95544700	4.02469000
C	0.37648900	27.69302500	6.43994300
C	0.40872600	26.67856600	7.40426100
H	1.18094200	25.91932400	7.39115600

C	-0.53855600	26.65641300	8.41756200
H	-0.50663500	25.87793000	9.16975300
C	-1.52743900	27.63386500	8.46490600
C	-1.56746800	28.64523600	7.50601700
H	-2.34178000	29.40151500	7.54680300
C	-0.61583400	28.68030800	6.50158500
H	-0.63387400	29.45741700	5.74715600
C	1.37310200	27.76719800	5.36227000
C	2.25197000	26.61719400	5.03880800
H	2.14780000	25.66939200	5.54552600
C	3.16208300	26.80429000	4.07594200
C	4.15989300	25.76830600	3.56320700
C	3.22049600	28.17253700	3.47235700
C	2.64118300	28.45845700	2.16418000
C	1.51179800	27.74980200	1.73005100
H	1.04234000	27.02627500	2.38742500
C	0.99215700	27.99046400	0.47165800
H	0.11368700	27.45368700	0.13582300
C	1.60666700	28.92196900	-0.36642600
C	2.73394600	29.61974600	0.05537000
C	3.25037600	29.39762100	1.32334100
H	3.21221700	30.33258800	-0.60467900
H	4.13789000	29.93033500	1.64295900
H	1.20491800	29.09946500	-1.35719700
C	5.56282800	26.39521400	3.49776500
H	5.61758300	27.20290100	2.76392200
H	5.87332900	26.79201000	4.46626500
H	6.27974900	25.63014700	3.19505800
C	4.18775300	24.55700300	4.49833500
H	4.44670500	24.84240200	5.52044600
H	3.23231900	24.02748800	4.50908000
H	4.94300600	23.85187300	4.14804700
C	3.74646700	25.30242800	2.15374500
H	4.43064000	24.51385400	1.83352500
H	2.73430300	24.89129500	2.14964500
H	3.79881500	26.10435600	1.41608500
H	-2.27107800	27.60905000	9.25288600
H	3.86582300	29.92571500	3.81871000
O	2.94848500	31.19589900	3.77785100
H	3.18040400	32.06266100	4.12156400
H	2.08700000	30.93498100	4.12618300

Int3

E = -1001.210140 a.u.

1 1

O	1.42003800	28.83410000	4.67576200
O	4.06743500	28.93935800	4.00892700
C	0.36809800	27.69773900	6.45985300
C	0.47395300	26.70408800	7.43987400
H	1.28362400	25.98469800	7.42190900
C	-0.44493700	26.65445700	8.47876400
H	-0.35452400	25.89269200	9.24331700
C	-1.47983200	27.58223200	8.53592500
C	-1.59260600	28.57319500	7.56196700
H	-2.40170000	29.29179000	7.60976600
C	-0.66836100	28.63683000	6.53321100
H	-0.74147600	29.39994400	5.76786900
C	1.33225200	27.81183200	5.34943200
C	2.21627300	26.66248700	5.00568700
H	2.09101100	25.71668700	5.51282500
C	3.14525100	26.79952700	4.05161900
C	4.12247500	25.71824900	3.58650200
C	3.27451000	28.14095600	3.41150600
C	2.69868600	28.44208900	2.11599800
C	1.58478400	27.71766800	1.66230700
H	1.13925800	26.96014900	2.29700000
C	1.04780600	27.99310000	0.41882800
H	0.18064300	27.44724200	0.06888700
C	1.63037300	28.97304900	-0.38595900
C	2.74312200	29.68655200	0.05254400
C	3.27500000	29.43200900	1.30575900
H	3.19515500	30.43619700	-0.58465400
H	4.15041100	29.97615200	1.63937500
H	1.21516700	29.17774200	-1.36598100
C	5.54278400	26.30808200	3.55268100
H	5.63993400	27.10168700	2.80713400
H	5.83390900	26.71418000	4.52350700
H	6.25049700	25.52206200	3.28402600
C	4.09093300	24.52531000	4.54384700
H	4.33194400	24.82225000	5.56703600
H	3.12112900	24.02263300	4.53945100
H	4.83481200	23.79307900	4.22611500
C	3.73940400	25.23710200	2.17457700

H	4.41796000	24.43255000	1.88355300
H	2.72118600	24.84195900	2.14996600
H	3.82494000	26.02583500	1.42557000
H	-2.20152100	27.53471300	9.34302200
H	3.84264200	29.91589300	3.81160500
O	2.90021100	31.13176800	3.79927000
H	3.10815800	31.98387500	4.19164500
H	2.05934100	30.81045900	4.15320500

P-Z

E = -924.425766 a.u.

0 1

O	0.62153800	28.93763400	5.13342200
O	3.30670000	29.86621900	3.68168800
C	-0.14345100	27.09628200	6.38838800
C	-0.07653700	25.72139000	6.61982100
H	0.73140900	25.13026000	6.20438000
C	-1.06691100	25.08807200	7.36268500
H	-1.01448400	24.01867100	7.53134200
C	-2.12190400	25.82595200	7.88670000
C	-2.19614300	27.19784600	7.65568500
H	-3.02094200	27.77274400	8.06073100
C	-1.21636700	27.82753000	6.90372500
H	-1.25988200	28.89062500	6.69876600
C	0.87198400	27.83426900	5.56857100
C	2.18601600	27.18267400	5.31380800
H	2.45671600	26.33729100	5.93350500
C	3.03536900	27.62836800	4.38124800
C	4.41102600	27.02061200	4.11899800
C	2.70164500	28.83374700	3.52080500
C	1.71952000	28.66852300	2.40090900
C	1.10814400	27.44959700	2.10886700
H	1.31809000	26.57552000	2.71548300
C	0.22181600	27.35227000	1.04224300
H	-0.25259400	26.40362700	0.81872800
C	-0.05786000	28.47171400	0.26660100
C	0.55018000	29.69105300	0.55645600
C	1.43706400	29.78839000	1.61797000
H	0.32883500	30.56455500	-0.04608900
H	1.92112500	30.72561300	1.86534500
H	-0.75167600	28.39567000	-0.56321100

C	5.48276800	27.96361500	4.69723800
H	5.43805700	28.95095000	4.24035100
H	5.34814500	28.08303200	5.77463200
H	6.47348200	27.53641000	4.51761400
C	4.55913400	25.64470800	4.77225300
H	4.51919300	25.70370300	5.86228600
H	3.78483700	24.95145500	4.43234800
H	5.52979700	25.22006500	4.50673200
C	4.62972300	26.87616600	2.60317300
H	5.61553800	26.44428000	2.41531000
H	3.88151200	26.22106600	2.14937200
H	4.58851700	27.84135300	2.09338200
H	-2.88935600	25.33209300	8.47210300

Int4

E = -789.211285 a.u.

-1 1

C	-10.25461800	10.97677700	-5.04458000
H	-9.69573200	9.98856800	-5.04456500
C	-9.66972100	11.67471100	-6.30001700
C	-9.66975000	11.67473400	-3.78914200
O	-11.55429000	10.95876000	-5.04459900
F	-10.04813900	12.95870100	-6.42515700
F	-8.30994100	11.68047100	-6.37606300
F	-10.08506700	11.04578200	-7.41557900
F	-10.04811300	12.95874900	-3.66407200
F	-8.30997400	11.68043200	-3.71303300
F	-10.08517900	11.04587000	-2.67357600

Int5

E = -789.775551 a.u.

0 1

C	-10.13814400	10.99276000	-5.04458100
H	-9.71572400	9.98324900	-5.04456500
C	-9.65480500	11.67665000	-6.32056700
C	-9.65484300	11.67667600	-3.76859500
O	-11.53354000	11.01824500	-5.04460600
H	-11.88470700	10.12561600	-5.04456800
F	-10.09313200	12.92587200	-6.41393700
F	-8.32161200	11.69178300	-6.38857300

F	-10.11043600	10.99556200	-7.37589900
F	-10.09315300	12.92590700	-3.67527300
F	-8.32165200	11.69178900	-3.70053800
F	-10.11052500	10.99562100	-2.71326300

H_2O

E = -76.398884 a.u.

0 1

O	4.44610400	29.59052700	4.21007000
H	5.40528700	29.61583100	4.21007000
H	4.14977500	30.50314000	4.21007000

DMSO

E = -553.136082 a.u.

0 1

S	2.90498700	25.34141200	6.78556300
O	3.00132300	24.09855600	7.62211400
C	4.61251500	25.79872200	6.37718100
H	5.19775900	25.77621800	7.29682200
H	4.98784000	25.04320800	5.68901700
H	4.64623800	26.78167100	5.90697400
C	2.61994900	26.70270900	7.95060000
H	2.69691900	27.66550600	7.44514700
H	1.61660600	26.57162200	8.35230800
H	3.34885000	26.61580600	8.75677400

6. Optimization of reaction conditions

Table S1. Screening of solvents

Entry	Deviation from standard conditions [a]	Yield (%) [b]
1	5 mL $CHCl_3$	NR[c]
2	5 mL ethyl acetate	Trace
3	5 mL MeCN	21%
4	5 mL THF	Trace
5	5 mL DCE	6%
6	5 mL $MeNO_2$	8%

[a]Reaction conditions: GF anode (1.0 cm x 1.0 cm x 0.5 cm), GF cathode (1.0 cm x 1.0 cm x 0.5 cm), undivided cell, constant current = 5 mA, **1a** (0.1 mmol, 1.0 eq.), **2a** (0.2 mmol, 2.0 eq.), H_2O

(0.1 mmol, 1.0 eq.) electrolyte (4.0 eq.), DCM = 4.0 mL, HFIP = 1.0 mL, 5 mA, 0 °C, Air, 2.25 h (4.20 F·mol^{-1}), [b]Isolated yields.

Table S2. Screening of quantity of electrolyte

Entry	Deviation from standard conditions [a]	Yield (%) [b]
1	0.2 mmol *n*-Bu_4NBF_4	65%

[a]Reaction conditions: GF anode (1.0 cm x 1.0 cm x 0.5 cm), GF cathode (1.0 cm x 1.0 cm x 0.5 cm), undivided cell, constant current = 5 mA, **1a** (0.1 mmol, 1.0 eq.), **2a** (0.2 mmol, 2.0 eq.), H_2O (0.1 mmol, 1.0 eq.) electrolyte (4.0 eq.), DCM = 4.0 mL, HFIP = 1.0 mL, 5 mA, 0 °C, Air, 2.25 h (4.20 F·mol^{-1}), [b]Isolated yields.

Table S3. Screening of experimental response time

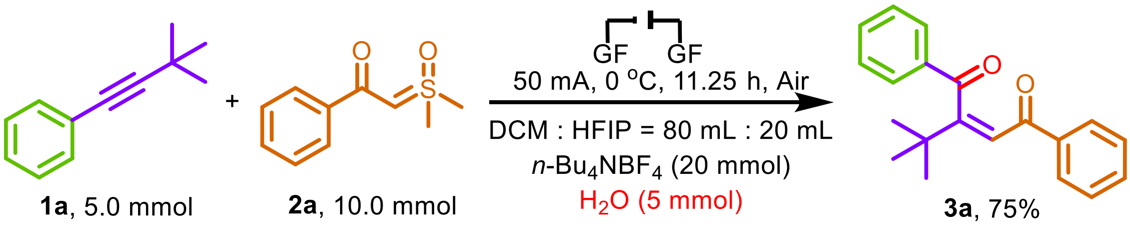
Entry	Deviation from standard conditions [a]	Yield (%) [b]
1	2 h	76%
2	2.5 h	62%

[a]Reaction conditions: GF anode (1.0 cm x 1.0 cm x 0.5 cm), GF cathode (1.0 cm x 1.0 cm x 0.5 cm), undivided cell, constant current = 5 mA, **1a** (0.1 mmol, 1.0 eq.), **2a** (0.2 mmol, 2.0 eq.), H_2O (0.1 mmol, 1.0 eq.) electrolyte (4.0 eq.), DCM = 4.0 mL, HFIP = 1.0 mL, 5 mA, 0 °C, Air, 2.25 h (4.20 F·mol^{-1}), [b]Isolated yields.

7. Gram-scale reaction

Figure S6. Components required for gram-scale reaction

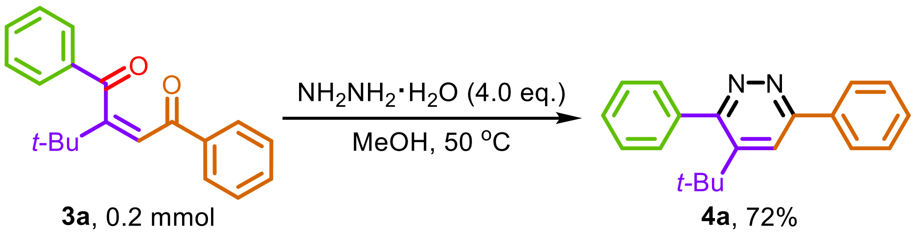
Figure S7. Typical reaction set up for gram-scale reaction



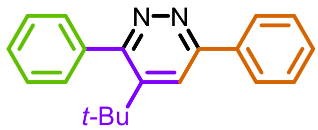
To the mixed solution of DCM (80.0 mL), HFIP (20.0 mL), H_2O (5.0 mmol, 1.0 eq.), alkyne **1a** (5.0 mmol, 1.0 eq.), sulfoxonium ylide **2a**（10.0 mmol, 2.0 eq.） and tetrabutylammonium tetrafluoroborate (20.0 mmol, 4.0 eq.) were added. Equipped with graphite felt (2.0 cm × 1.0 cm × 0.5 cm) as anode, graphite felt (2.0 cm × 1.0 cm × 0.5 cm) as cathode, non-separating electrolytic cell device. The reaction mixture was stirred at constant current of 50 mA at 0 °C in the air for 15 hours. After the reaction (monitored by TLC), the reaction system was dried with anhydrous $MgSO_4$, filtered, and concentrated under reduced pressure. The residue was purified by silica gel column chromatography and eluted with petroleum ether and ethyl acetate (PE/ EA = 20:1).

8. Synthetic Application

a) Synthesis of Product **4a**

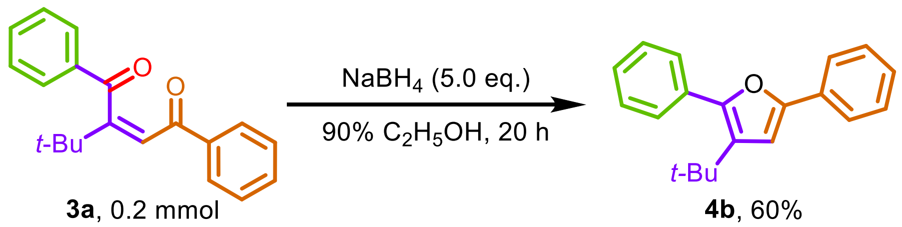


A flame-dried Schlenk-tube equipped with a magnetic stir bar was charged with **3a** (58.5 mg, 0.2 mmol, 1.0 eq.), sealed with a septum, and degassed by alternating vacuum evacuation and nitrogen backfilling (three times) before MeOH (2.0 mL) was added. Then, hydrazinium hydroxide solution (wt.% = 85%, 45.6 μL, 0.8 mmol, 4.0 eq.) were added successively by micro-syringe. The reaction mixture was then stirred at 50 °C for 5 h. After the reaction was complete, the solvent was removed under reduced pressure with the aid of a rotary evaporator. The crude residue was purified by silica gel column chromatography (PE:EtOAc = 10:1) to afford the desired product **4a** as a white sold in 72% yield (41.5 mg).[6]

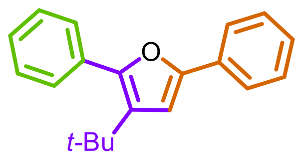


4-(tert-butyl)-3,6-diphenylpyridazine (4a)
41.5 mg, 72% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.13 (d, J = 7.0 Hz, 2H), 7.92 (s, 1H), 7.56 – 7.51 (m, 3H), 7.47 – 7.45 (m, 3H), 7.42 (dd, J = 6.1, 2.5 Hz, 2H), 1.27 (s, 9H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 161.2, 158.1, 148.4, 140.7, 136.8, 129.8, 129.0, 128.3, 127.8, 127.2, 121.8, 35.4, 31.2. HRMS (ESI-TOF, [M + H$^+$]): calcd for $C_{20}H_{20}N_2$ 289.1699, found 289.1703

b) Synthesis of Product **4b**



1,4-dicarbonyl *Z*-alkene **3a** (0.2 mmol, 58.5 mg) was added to a flask containing ethanol (90%) in an ice bath at 0 °C. $NaBH_4$ (1.0 mmol, 38.0 mg) was added and the mixture was kept stirring at 0 °C for 1 h. After that time, the ice bath was removed and the mixture was stirred at room temperature overnight. Water (40 mL) and aqueous HCl (2.0 M) were added to the mixture until pH 7 was reached. The resulting aqueous phase was washed with ethyl acetate (3 x 20.0 mL) and the combined organic phases were dried over $MgSO_4$ and filtered off. The organic solvent was removed under vacuum and the residue was purified by column chromatography using petroleum ether and ethyl acetate (100:1 v/v) as eluent. (33.1 mg, 60% yield).[6]



3-(tert-butyl)-2,5-diphenylfuran (4b)
33.1 mg, 60% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.68 (d, J = 7.3 Hz, 2H), 7.55 (dd, J = 7.7, 1.8 Hz, 2H), 7.45 – 7.34 (m, 5H), 7.25 – 7.23 (m, 1H), 6.74 (s, 1H), 1.27 (s, 9H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 151.4, 148.2, 133.8, 132.8, 130.9, 130.4, 128.6, 128.6, 128.5, 128.2, 127.8, 127.0, 123.6, 106.8, 31.8, 30.7. HRMS (ESI-TOF, [M + H$^+$]): calcd for $C_{20}H_{20}O$ 277.1587, found 277.1583

9. Cyclic voltammetry study

The cyclic voltammetry experiments were carried out with a computer-controlled electrochemical analyzer for electrochemical measurements. The data was collected with the CS300H potentiostat (Wuhan Coster Instrument Co., LTD).

Working electrode: The working electrode is a 3 mm diameter glassy carbon working electrode. Polished with 0.05 μm aluminum oxide and then sonicated in distilled water and ethanol before measurements.

Reference electrode: The reference electrode is SCE (saturated aqueous KCl) that was washed with water and ethanol before measurements.

Counter electrode: The counter electrode is a platinum wire that was polished with 0.05 μm aluminum oxide and then sonicated in distilled water and ethanol before measurements.

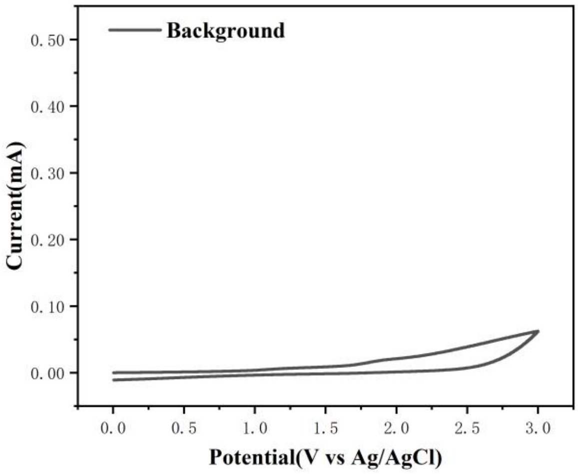


Figure S8. Cyclic voltammogram of **blank** sample

General procedure for cyclic voltammetry (CV): Cyclic voltammogram of **blank** sample was performed in a three-electrode cell at room temperature. The working electrode was a steady glassy carbon, the counter electrode was a platinum wire, and the reference was an Ag/AgCl electrode submerged in saturated aqueous KCl solution. A solution of *n*-Bu_4NBF_4 (0.1 mmol) in 4.0 mL DCM, 1.0 mL HFIP, and 1.8 µL H_2O was subject to cyclic voltammetry experiment. The scan rate was 100 mV/s, ranging from 0.0 V to 3.0 V.

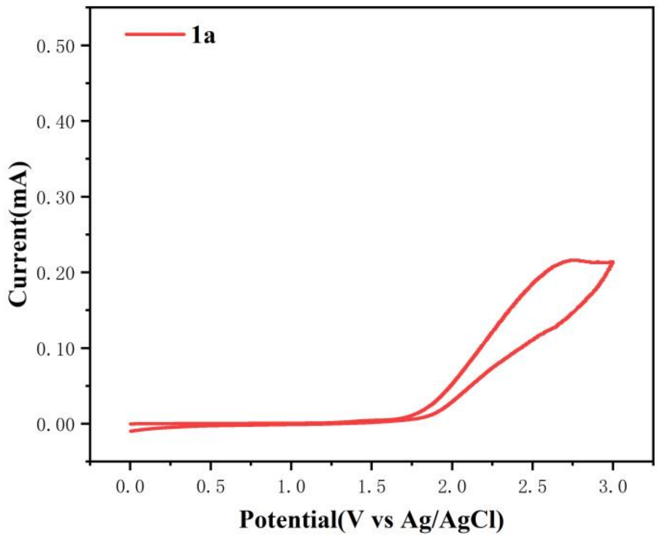


Figure S9. Cyclic voltammogram of **1a** sample

General procedure for cyclic voltammetry (CV): Cyclic voltammogram of **1a** sample was performed in a three-electrode cell at room temperature. The working electrode was a steady glassy carbon, the counter electrode was a platinum wire, and the reference was an Ag/AgCl electrode submerged in saturated aqueous KCl solution. A solution of **1a** (0.1 mmol) and *n*-Bu_4NBF_4 (0.1 mmol) in 4.0 mL DCM, 1.0 mL HFIP, and 1.8 μL H_2O was subject to cyclic voltammetry experiment. The scan rate was 100 mV/s, ranging from 0.0 V to 3.0 V.

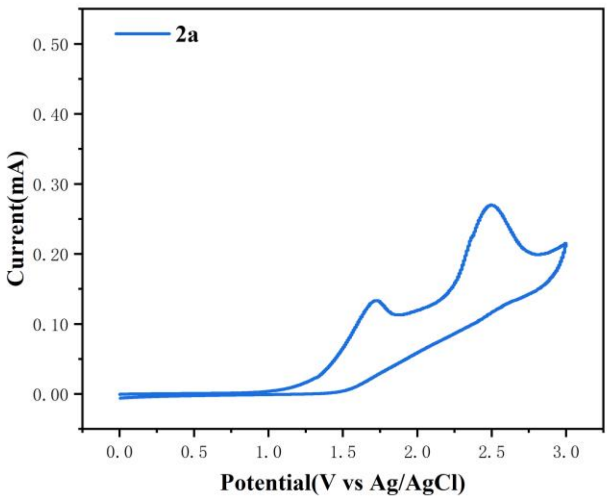


Figure S10. Cyclic voltammogram of **2a** sample

General procedure for cyclic voltammetry (CV): Cyclic voltammogram of **2a** sample was performed in a three-electrode cell at room temperature. The working electrode was a steady glassy carbon, the counter electrode was a platinum wire, and the reference was an Ag/AgCl electrode submerged in saturated aqueous KCl solution. A solution of **2a** (0.1 mmol) and *n*-Bu_4NBF_4 (0.1 mmol) in 4.0 mL DCM, 1.0 mL HFIP, and 1.8 μL H_2O was subject to cyclic voltammetry experiment. The scan rate was 100 mV/s, ranging from 0.0 V to 3.0 V.

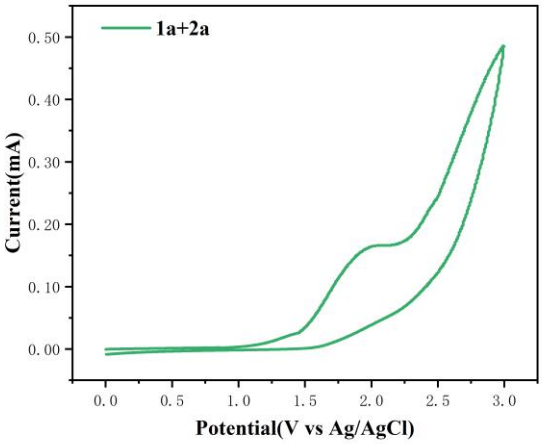


Figure S11. Cyclic voltammogram of **1a+2a** sample

General procedure for cyclic voltammetry (CV): Cyclic voltammogram of **1a+2a** sample was performed in a three-electrode cell at room temperature. The working electrode was a steady glassy carbon, the counter electrode was a platinum wire, and the reference was an Ag/AgCl electrode submerged in saturated aqueous KCl solution. A solution of **1a** (0.1 mmol), **2a** (0.2 mmol) and *n*-Bu_4NBF_4 (0.1 mmol) in 4.0 mL DCM, 1.0 mL HFIP, and 1.8 μL H_2O was subject to cyclic voltammetry experiment. The scan rate was 100 mV/s, ranging from 0.0 V to 3.0 V.

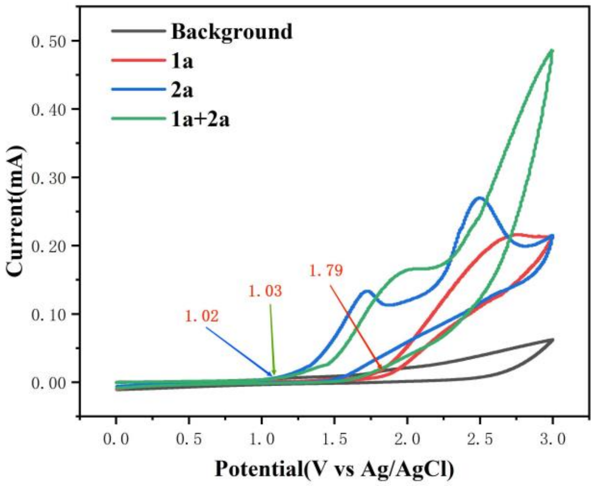


Figure S12. Cyclic voltammograms of **blank**, **1a**, **2a**, and **1a+2a**

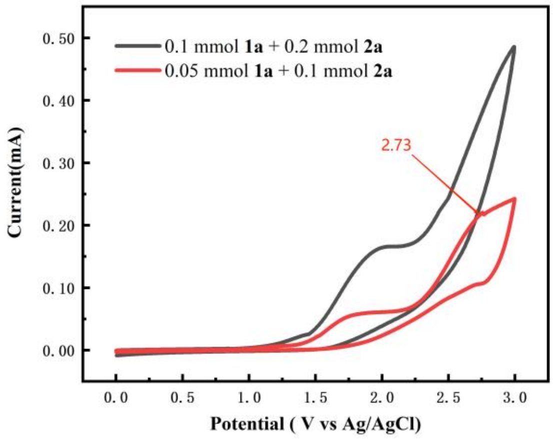


Figure S13. Cyclic voltammograms of **1a**+**2a**, and 0.5 eq. (**1a**+**2a**)

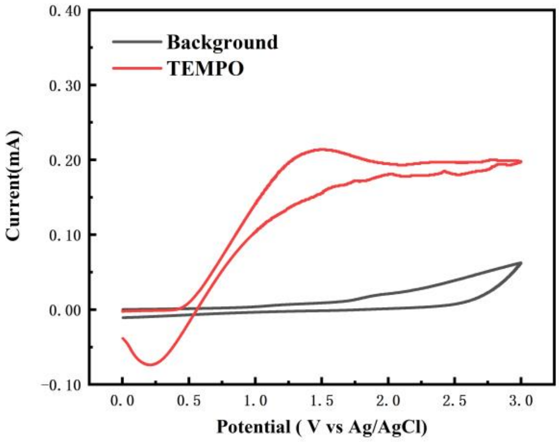


Figure S14. Cyclic voltammograms of **TEMPO**

General procedure for cyclic voltammetry (CV): Cyclic voltammogram of **TEMPO** sample was performed in a three-electrode cell at room temperature. The working electrode was a steady glassy carbon, the counter electrode was a platinum wire, and the reference was an Ag/AgCl electrode submerged in saturated aqueous KCl solution. A solution of **TEMPO** (0.1 mmol) and *n*-Bu_4NBF_4 (0.1 mmol) in 4.0 mL DCM, 1.0 mL HFIP, and 1.8 μL H_2O was subject to cyclic voltammetry experiment. The scan rate was 100 mV/s, ranging from 0.0 V to 3.0 V.

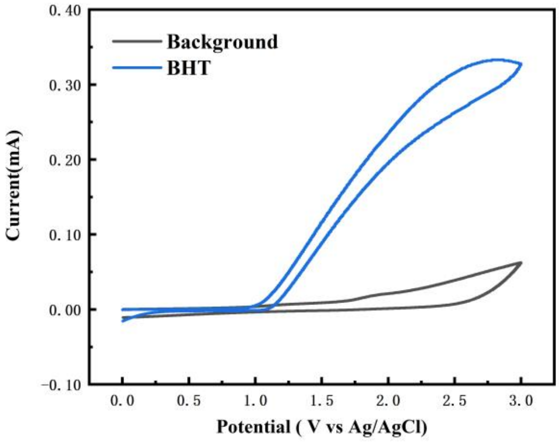


Figure S15. Cyclic voltammograms of **BHT**

General procedure for cyclic voltammetry (CV): Cyclic voltammogram of **BHT** sample was performed in a three-electrode cell at room temperature. The working electrode was a steady glassy carbon, the counter electrode was a platinum wire, and the reference was an Ag/AgCl electrode submerged in saturated aqueous KCl solution. A solution of **BHT** (0.1 mmol) and *n*-Bu_4NBF_4 (0.1 mmol) in 4.0 mL DCM, 1.0 mL HFIP, and 1.8 μL H_2O was subject to cyclic voltammetry experiment. The scan rate was 100 mV/s, ranging from 0.0 V to 3.0 V.

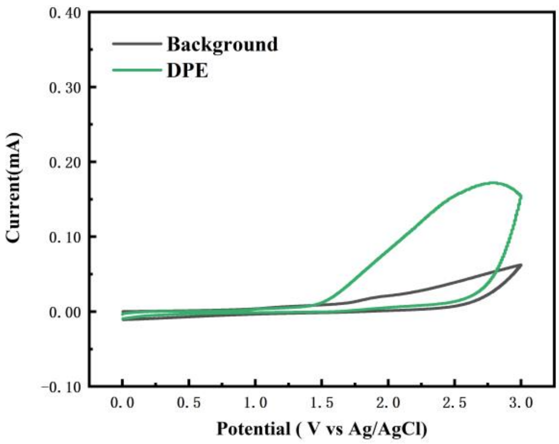


Figure S16. Cyclic voltammograms of **DPE**

General procedure for cyclic voltammetry (CV): Cyclic voltammogram of **DPE** sample was performed in a three-electrode cell at room temperature. The working electrode was a steady glassy carbon, the counter electrode was a platinum wire, and the reference was an Ag/AgCl electrode submerged in saturated aqueous KCl solution. A solution of **DPE** (0.1 mmol) and *n*-Bu_4NBF_4 (0.1 mmol) in 4.0 mL DCM, 1.0 mL HFIP, and 1.8 μL H_2O was subject to cyclic voltammetry experiment. The scan rate was 100 mV/s, ranging from 0.0 V to 3.0 V.

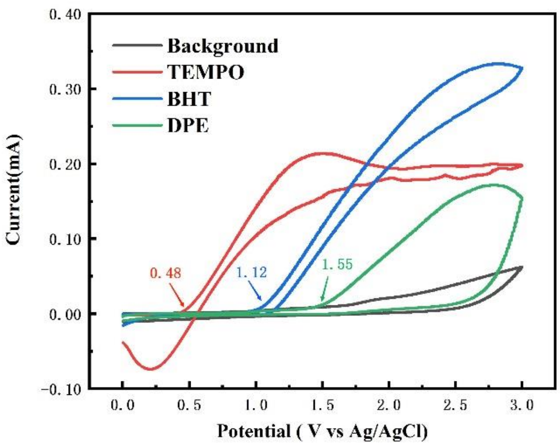
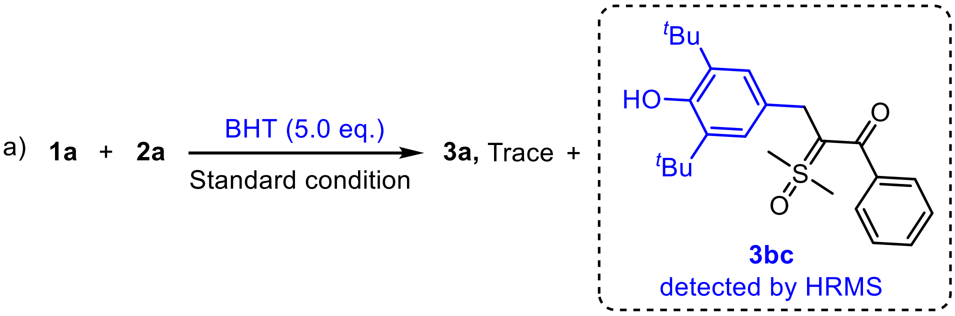


Figure S17. Cyclic voltammograms of **TEMPO**, **BHT**, **DPE**

The cyclic voltammetry in terms of **TEMPO**, **BHT** and **1,1-diphenylethylene** (**DPE**) was conducted and the results showed that the of onset potential **TEMPO** was 0.75 V, which was lower than that of **2a** (1.03 V), indicating that **TEMPO** was firstly oxidized. However, the fact that the onset potential of **BHT** was 1.12 V and the onset potential of **1,1-diphenylethylene** was 1.55 V, which was higher than that of **2a** (1.03 V), indicated that **2a** was first oxidized through the electrochemical reaction.

10. Control experiment

10.1 Radical trapping experiment



In an undivided cell (10 mL) equipped with a stir bar, **1a** (0.1 mmol, 1.0 eq.), **2a** (0.2 mmol, 2.0 eq.), H_2O (0.1 mmol， 1.0 eq.), butylated hydroxytoluene (BHT) (0.5 mmol, 5.0 eq.) and *n*-Bu_4NBF_4 (0.4 mmol, 4.0 eq.) were combined and added. The flask was equipped with a rubber stopper, a graphite felt anode (1.0 cm x 1.0 cm x 0.5 cm) and a graphite felt cathode (1.0 cm x 1.0 cm x 0.5 cm). Then DCM (4.0 mL) and 1,1,1,3,3,3-Hexafluoro-2-propanol (HFIP) (1.0 mL) and were injected respectively into the flask via syringes. The reaction mixture was stirred and

electrolyzed in air for 2.25 hours at a constant current of 0 °C and 5 mA. After the reaction was complete, no product **3a** was gained. **3bc** detected by HRMS.
HRMS (ESI-TOF, [M + H$^+$]): calcd for $C_{25}H_{34}O_3S$ 415.2301, found 415.2305

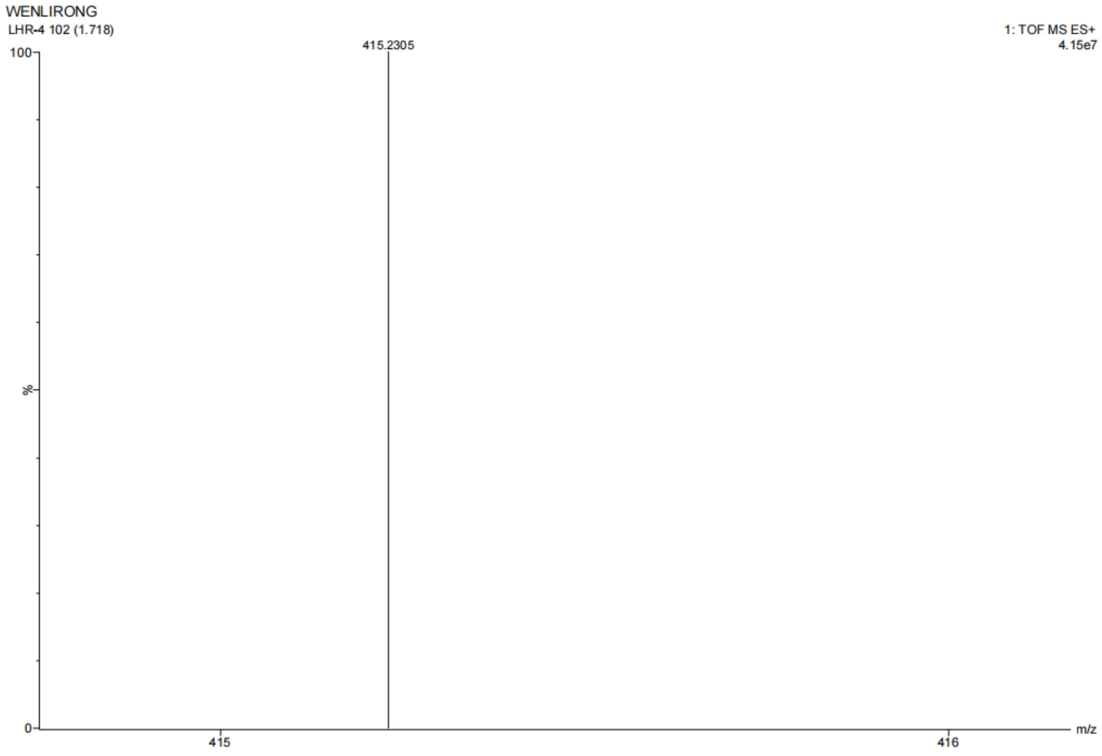
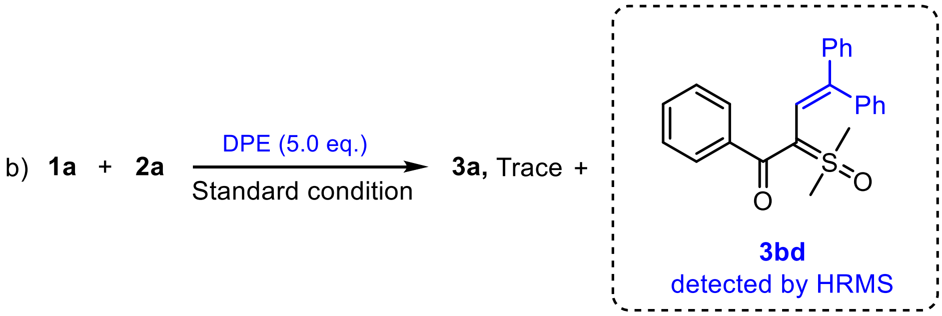


Figure S18. HRMS of **3bc**



In an undivided cell (10 mL) equipped with a stir bar, **1a** (0.1 mmol, 1.0 eq.), **2a** (0.2 mmol, 2.0 eq.), H_2O (0.1 mmol， 1.0 eq.), butylated 1,1-diphenylethylene (DPE) (0.5 mmol, 5.0 eq.) and *n*-Bu_4NBF_4 (0.4 mmol, 4.0 eq.) were combined and added. The flask was equipped with a rubber stopper, a graphite felt anode (1.0 cm x 1.0 cm x 0.5 cm) and a graphite felt cathode (1.0 cm x 1.0 cm x 0.5 cm). Then DCM (4.0 mL) and 1,1,1,3,3,3-Hexafluoro-2-propanol (HFIP) (1.0 mL) and were injected respectively into the flask via syringes. The reaction mixture was stirred and electrolyzed in air for 2.25 hours at a constant current of 0 °C and 5 mA. After the reaction was complete, no product **3a** was gained. **3bd** detected by HRMS.
HRMS (ESI-TOF, [M + H$^+$]): calcd for $C_{24}H_{22}O_2S$ 375.1413, found 375.1409

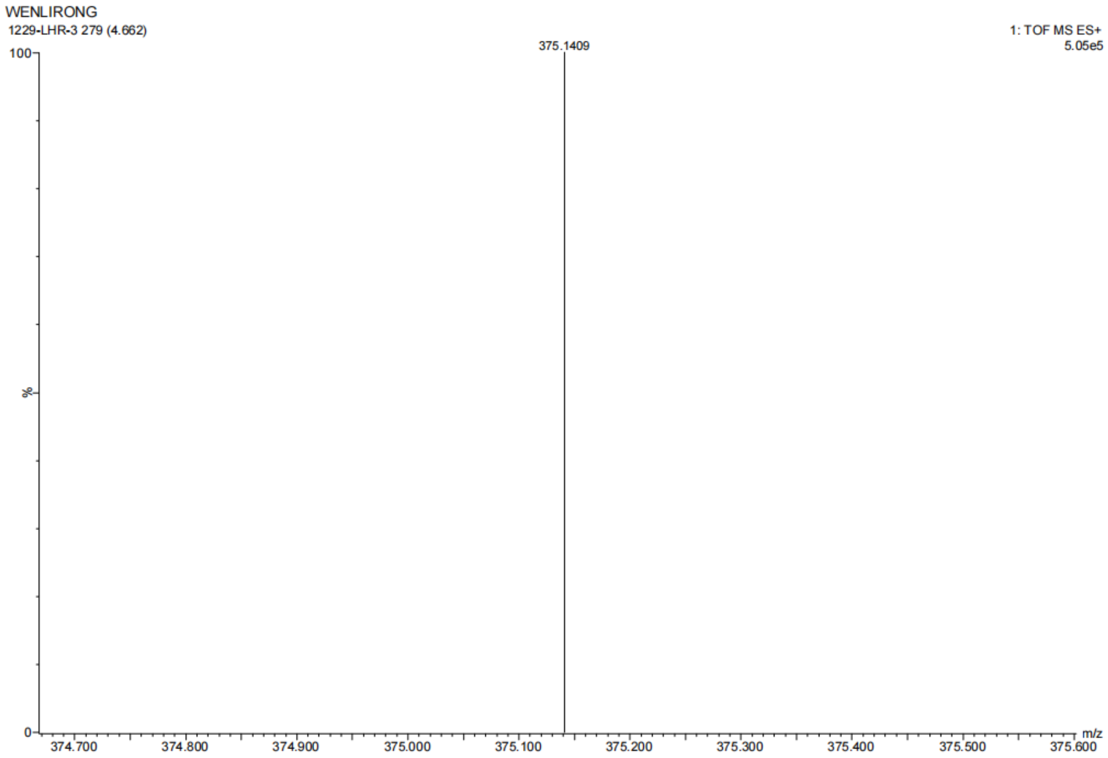
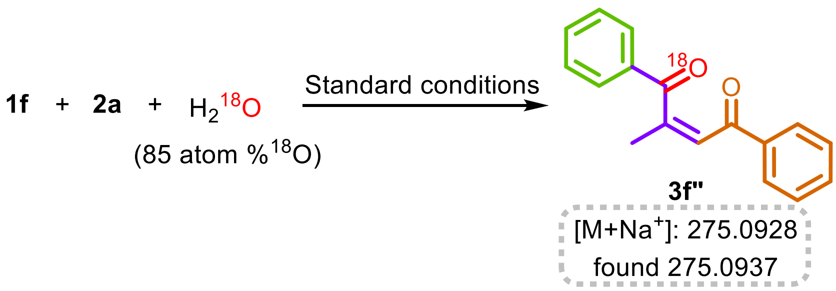


Figure S19. HRMS of **3bd**

10.2 ^{18}O-labeling experenments



In an undivided cell (10 mL) equipped with a stir bar, **1f** (0.1 mmol, 1.0 eq.), **2a** (0.2 mmol, 2.0 eq.), $H_2{}^{18}O$ (0.1 mmol， 1.0 eq.), and *n*-Bu_4NBF_4 (0.4 mmol, 4.0 eq.) were combined and added. The flask was equipped with a rubber stopper, a graphite felt anode (1.0 cm x 1.0 cm x 0.5 cm) and a graphite felt cathode (1.0 cm x 1.0 cm x 0.5 cm). Then DCM (4.0 mL) and 1,1,1,3,3,3-Hexafluoro-2-propanol (HFIP) (1.0 mL) and were injected respectively into the flask via syringes. The reaction mixture was stirred and electrolyzed in air for 2.25 hours at a constant current of 0 °C and 5 mA. After the reaction was complete, the residue was purified by column chromatography using petroleum ether and ethyl acetate as eluent, to afford the desired product **3f''**. **3f''** detected by HRMS.

HRMS (ESI-TOF, [M + Na$^+$]): calcd for $C_{17}H_{14}O^{18}O$ 275.0928, found 275.0937

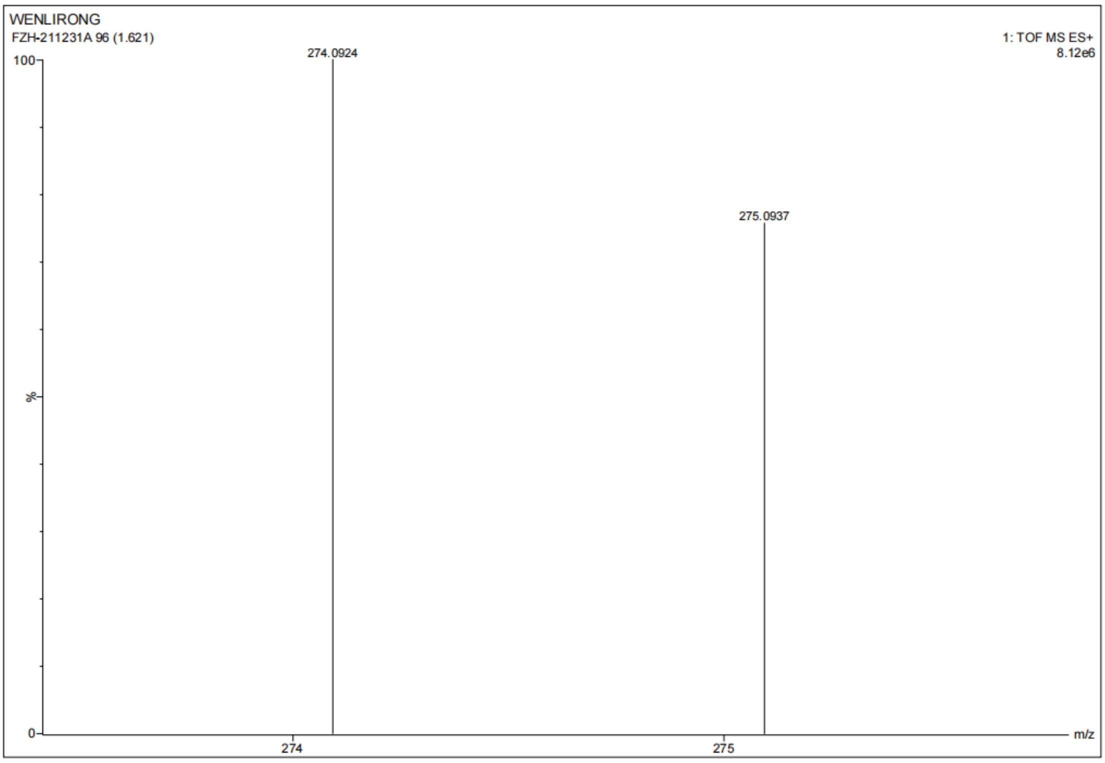


Figure S20. HRMS of **3f"**

10.3 Inert atmosphere and No H_2O

a) **1a** + **2a** $\xrightarrow[\text{Standard condition}]{N_2}$ **3a**, 73%

In an undivided cell (10 mL) equipped with a stir bar, **1a** (0.1 mmol, 1.0 eq.), **2a** (0.2 mmol, 2.0 eq.), H_2O (0.1 mmol， 1.0 eq.), and *n*-Bu_4NBF_4 (0.4 mmol, 4.0 eq.) were combined and added. The flask was equipped with a rubber stopper, a graphite felt anode (1.0 cm x 1.0 cm x 0.5 cm) and a graphite felt cathode (1.0 cm x 1.0 cm x 0.5 cm). Then DCM (4.0 mL) and 1,1,1,3,3,3-Hexafluoro-2-propanol (HFIP) (1.0 mL) and were injected respectively into the flask via syringes. The reaction mixture was stirred and electrolyzed in N_2 for 2.25 hours at a constant current of 0 ^oC and 5 mA. After the reaction was complete, the residue was purified by column chromatography using petroleum ether and ethyl acetate as eluent, to afford the desired product **3a**.

b) **1a** + **2a** $\xrightarrow[\text{Standard condition}]{Ar}$ **3a**, 75%

In an undivided cell (10 mL) equipped with a stir bar, **1a** (0.1 mmol, 1.0 eq.), **2a** (0.2 mmol, 2.0 eq.), H_2O (0.1 mmol， 1.0 eq.), and *n*-Bu_4NBF_4 (0.4 mmol, 4.0 eq.) were combined and added. The flask was equipped with a rubber stopper, a graphite felt anode (1.0 cm x 1.0 cm x 0.5 cm) and a graphite felt cathode (1.0 cm x 1.0 cm x 0.5 cm). Then DCM (4.0 mL) and

1,1,1,3,3,3-Hexafluoro-2-propanol (HFIP) (1.0 mL) and were injected respectively into the flask via syringes. The reaction mixture was stirred and electrolyzed in Argon (Ar) for 2.25 hours at a constant current of 0 °C and 5 mA. After the reaction was complete, the residue was purified by column chromatography using petroleum ether and ethyl acetate as eluent, to afford the desired product **3a**.

c) **1a** + **2a** $\xrightarrow[\text{Standard condition}]{N_2\text{, No } H_2O}$ **3a,** 8%

In an undivided cell (10 mL) equipped with a stir bar, **1a** (0.1 mmol, 1.0 eq.), **2a** (0.2 mmol, 2.0 eq.), and *n*-Bu_4NBF_4 (0.4 mmol, 4.0 eq.) were combined and added. The flask was equipped with a rubber stopper, a graphite felt anode (1.0 cm x 1.0 cm x 0.5 cm) and a graphite felt cathode (1.0 cm x 1.0 cm x 0.5 cm). Then DCM (4.0 mL) and 1,1,1,3,3,3-Hexafluoro-2-propanol (HFIP) (1.0 mL) and were injected respectively into the flask via syringes. The reaction mixture was stirred and electrolyzed in N_2 for 2.25 hours at a constant current of 0 °C and 5 mA. After the reaction was complete, the residue was purified by column chromatography using petroleum ether and ethyl acetate as eluent, to afford the desired product **3a**.

d) **1a** + **2a** $\xrightarrow[\text{Standard condition}]{\text{Ar, No } H_2O}$ **3a,** 10%

In an undivided cell (10 mL) equipped with a stir bar, **1a** (0.1 mmol, 1.0 eq.), **2a** (0.2 mmol, 2.0 eq.), and *n*-Bu_4NBF_4 (0.4 mmol, 4.0 eq.) were combined and added. The flask was equipped with a rubber stopper, a graphite felt anode (1.0 cm x 1.0 cm x 0.5 cm) and a graphite felt cathode (1.0 cm x 1.0 cm x 0.5 cm). Then DCM (4.0 mL) and 1,1,1,3,3,3-Hexafluoro-2-propanol (HFIP) (1.0 mL) and were injected respectively into the flask via syringes. The reaction mixture was stirred and electrolyzed in Argon (Ar) for 2.25 hours at a constant current of 0 °C and 5 mA. After the reaction was complete, the residue was purified by column chromatography using petroleum ether and ethyl acetate as eluent, to afford the desired product **3a**.

10.4 Intermediate detection

1a + **2a** + $\xrightarrow[\text{Standard conditions}]{\text{1 h}}$ **3a,** 35% + **Int2**

detected by HRMS

In an undivided cell (10 mL) equipped with a stir bar, **1a** (0.1 mmol, 1.0 eq.), **2a** (0.2 mmol, 2.0 eq.), H_2O (0.1 mmol， 1.0 eq.), and *n*-Bu_4NBF_4 (0.4 mmol, 4.0 eq.) were combined and added. The flask was equipped with a rubber stopper, a graphite felt anode (1.0 cm x 1.0 cm x 0.5 cm) and a graphite felt cathode (1.0 cm x 1.0 cm x 0.5 cm). Then DCM (4.0 mL) and 1,1,1,3,3,3-Hexafluoro-2-propanol (HFIP) (1.0 mL) and were injected respectively into the flask via syringes. The reaction mixture was stirred and electrolyzed in air for 1 hours at a constant current of 0 °C and 5 mA. After the reaction was complete, the residue was purified by column

chromatography using petroleum ether and ethyl acetate as eluent, to afford the desired product **3a**.
Int2 detected by HRMS.
HRMS (ESI-TOF, [M+]): calcd for $C_{20}H_{21}O_2^+$ 293.1536, found 293.1537

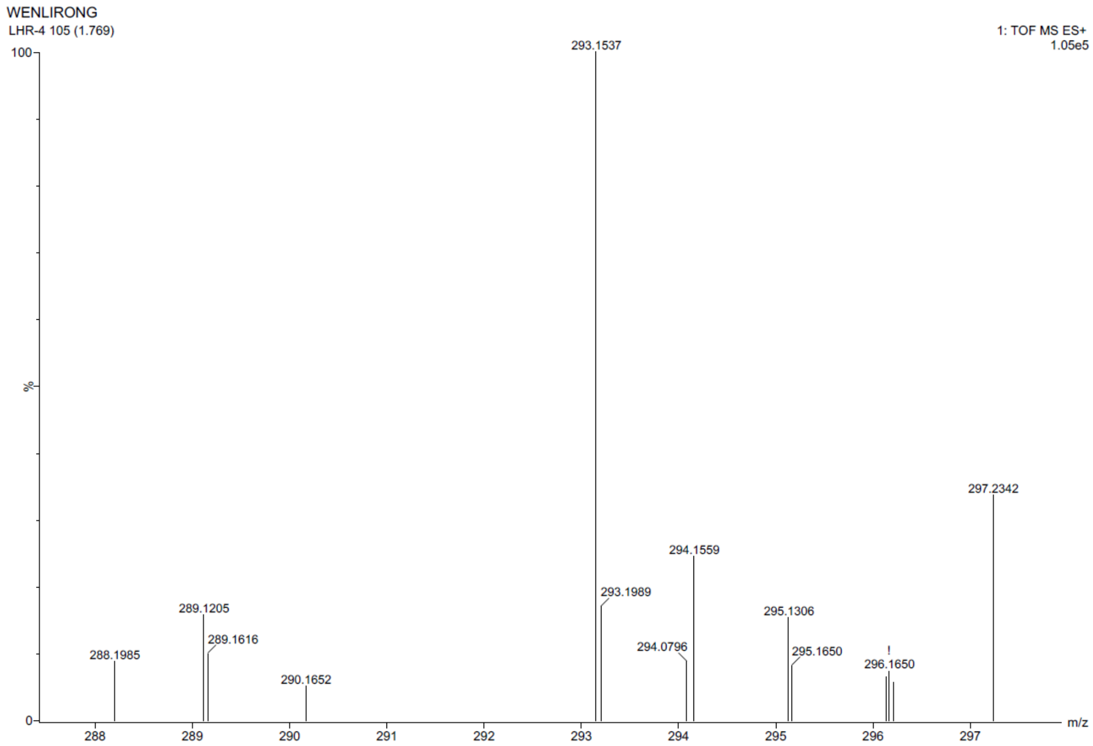
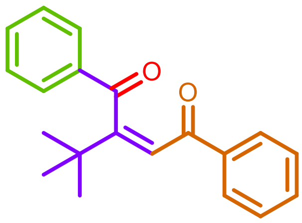
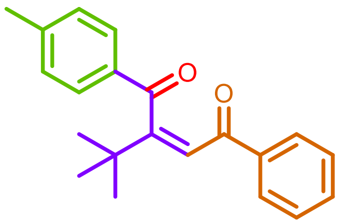


Figure S21. HRMS of **Int2**

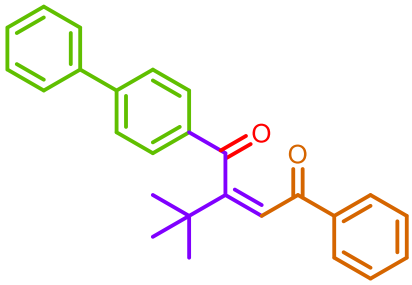
11. NMR Spectra for the Obtained Compound



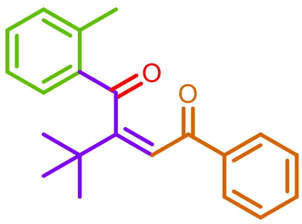
(*Z*)-2-(tert-butyl)-1,4-diphenylbut-2-ene-1,4-dione (3a)
24.5 mg, 84% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.97 – 7.91 (m, 4H), 7.58 (t, *J* = 7.4 Hz, 1H), 7.53 (t, *J* = 7.4 Hz, 1H), 7.49 – 7.43 (m, 4H), 7.29 (s, 1H), 1.31 (s, 9H).
^{13}C NMR (125 MHz, $CDCl_3$) δ 198.9, 188.5, 167.8, 137.3, 136.4, 132.9, 132.6, 128.4, 128.3, 128.2, 128.1, 120.3, 36.5, 29.6.
HRMS (ESI-TOF, [M + Na+]): calcd for $C_{20}H_{20}O_2$ 315.1356, found 315.1359



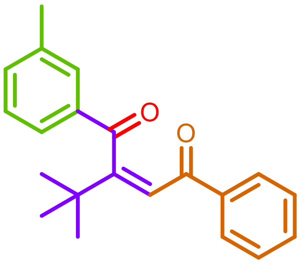
(*Z*)-2-(tert-butyl)-4-phenyl-1-(p-tolyl)but-2-ene-1,4-dione (3b)
21.8 mg, 71% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.90 (d, *J* = 7.3 Hz, 2H), 7.80 (d, *J* = 7.9 Hz, 2H), 7.54 (t, *J* = 7.4 Hz, 1H), 7.44 (t, *J* = 7.6 Hz, 2H), 7.23 (s, 1H), 7.21 (d, *J* = 8.0 Hz, 2H), 2.37 (s, 3H), 1.27 (s, 9H).
^{13}C NMR (125 MHz, $CDCl_3$) δ 198.8, 188.7, 168.1, 143.6, 137.6, 134.3, 133.0, 129.3, 128.7, 128.6, 128.5, 128.4, 120.3, 36.7, 29.9, 21.7.
HRMS (ESI-TOF, [M + H^{+}]): calcd for $C_{21}H_{22}O_2$ 307.1693, found 307.1693



(*Z*)-1-([1,1'-biphenyl]-4-yl)-2-(*tert*-butyl)-4-phenylbut-2-ene-1,4-dione (3c)
22.9 mg, 62% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.99 (d, *J* = 8.2 Hz, 2H), 7.93 (d, *J* = 7.4 Hz, 2H), 7.64 (d, *J* = 8.6 Hz, 2H), 7.60 (d, *J* = 7.0 Hz, 2H), 7.55 (d, *J* = 7.5 Hz, 1H), 7.47 – 7.43 (m, 4H), 7.37 (t, *J* = 7.3 Hz, 1H), 7.29 (s, 1H), 1.32 (s, 9H).
^{13}C NMR (125 MHz, $CDCl_3$) δ 198.8, 188.8, 168.1, 145.6, 140.1, 137.6, 135.5, 133.2, 128.9, 128.9, 128.7, 128.6, 128.5, 128.1, 127.4, 127.3, 120.5, 36.8, 29.9.
HRMS (ESI-TOF, [M + H^{+}]): calcd for $C_{26}H_{24}O_2$ 369.1849, found 369.1855



(*Z*)-2-(tert-butyl)-4-phenyl-1-(o-tolyl) but-2-ene-1,4-dione (3d)
23.3 mg, 76% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.79 (d, *J* = 7.6 Hz, 2H), 7.51 (d, *J* = 8.5 Hz, 1H), 7.45 (t, *J* = 7.4 Hz, 1H), 7.35 (t, *J* = 7.7 Hz, 2H), 7.25 (t, *J* = 7.5 Hz, 1H), 7.17 (d, *J* = 7.2 Hz, 1H), 7.09 (s, 1H), 7.06 (t, *J* = 7.6 Hz, 1H), 2.67 (s, 3H), 1.21 (s, 9H).
^{13}C NMR (125 MHz, $CDCl_3$) δ 201.0, 189.2, 169.2, 140.3, 137.7, 135.2, 133.0, 132.3, 131.9, 131.7, 128.6, 128.5, 125.3, 120.7, 36.9, 30.2, 22.2.
HRMS (ESI-TOF, [M + H^{+}]): calcd for $C_{21}H_{22}O_2$ 307.1693, found 307.1687



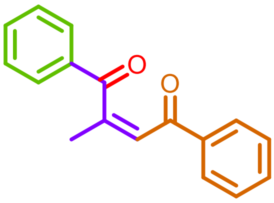
(*Z*)-2-(tert-butyl)-4-phenyl-1-(m-tolyl)but-2-ene-1,4-dione (3e)

21.3 mg, 70% yield.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.87 (dd, *J* = 8.4, 1.4 Hz, 2H), 7.76 (s, 1H), 7.60 (d, *J* = 7.5 Hz, 1H), 7.52 (t, *J* = 7.4 Hz, 1H), 7.41 (t, *J* = 7.6 Hz, 2H), 7.29 (d, *J* = 7.8 Hz, 1H), 7.24 (d, *J* = 3.8 Hz, 1H), 7.22 (s, 1H), 2.35 (s, 3H), 1.25 (s, 9H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 199.3, 188.7, 168.2, 138.4, 137.6, 136.6, 133.8, 133.1, 128.6, 128.5, 128.5, 128.4, 125.9, 120.4, 36.7, 29.9, 21.4.

HRMS (ESI-TOF, [M + H^+]): calcd for $C_{21}H_{22}O_2$ 307.1693, found 307.1698



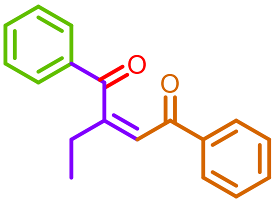
(*Z*)-2-methyl-1,4-diphenylbut-2-ene-1,4-dione (3f)

15.3 mg, 61% yield. The spectra matched with the previous report.[7]

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.93 – 7.91 (m, 4H), 7.55 (t, *J* = 7.4 Hz, 2H), 7.46 – 7.43 (m, 4H), 7.16 (s, 1H), 2.25 (s, 3H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 199.4, 188.1, 156.3, 136.9, 134.5, 133.3, 133.3, 128.8, 128.7, 128.6, 128.4, 122.9, 22.2.

HRMS (ESI-TOF, [M + Na^+]): calcd for $C_{17}H_{14}O_2$ 273.0886, found 273.0889



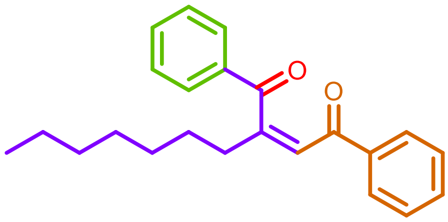
(*Z*)-2-ethyl-1,4-diphenylbut-2-ene-1,4-dione (3g)

16.4 mg, 62% yield.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.92 – 7.90 (m, 4H), 7.54 (q, *J* = 7.5 Hz, 2H), 7.46 – 7.42 (m, 4H), 7.12 (s, 1H), 2.57 (q, *J* = 6.6 Hz, 2H), 1.25 (t, *J* = 7.4 Hz, 3H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 199.3, 188.3, 161.6, 137.2, 135.2, 133.1, 128.7, 128.6, 128.6, 128.4, 121.1, 28.7, 11.6.

HRMS (ESI-TOF, [M + H^+]): calcd for $C_{18}H_{16}O_2$ 265.1223, found 265.1225



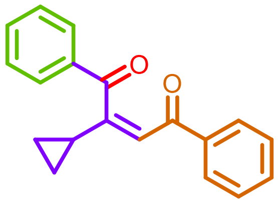
(*Z*)-2-heptyl-1,4-diphenylbut-2-ene-1,4-dione (3h)

16.3 mg, 49% yield.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.91 (d, *J* = 7.8 Hz, 4 H), 7.57 – 7.52 (m, 2H), 7.46 – 7.42 (m, 4H), 7.11 (s, 1H), 2.51 (t, *J* = 7.8 Hz, 2H), 1.66 – 1.59 (m, 2H), 1.39 – 1.36 (m, 2H), 1.32 – 1.25 (m, 6H), 0.88 (t, *J* = 6.7 Hz, 2H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 199.2, 188.3, 160.5, 137.2, 135.1, 133.1, 128.7, 128.6, 128.6, 128.4, 121.9, 35.7, 31.7, 29.2, 28.9, 27.2, 22.6, 14.0.

HRMS (ESI-TOF, [M + H^+]): calcd for $C_{23}H_{26}O_2$ 335.2006, found 335.2008



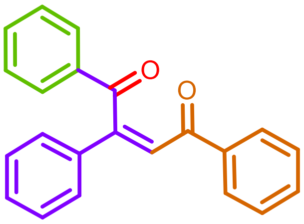
(*Z*)-2-cyclopropyl-1,4-diphenylbut-2-ene-1,4-dione (3i)

18.8 mg, 68% yield.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.94 (d, *J* = 7.7 Hz, 2H), 7.90 (d, *J* = 7.7 Hz, 2H), 7.54 (t, *J* = 7.5 Hz, 2H), 7.46 – 7.42 (m, 4H), 7.14 (s, 1H), 1.91 – 1.85 (m, 1H), 1.03 – 1.01 (m, 2H), 0.89 – 0.87 (m, 2H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 197.3, 187.5, 162.9, 137.3, 135.7, 133.2, 133.0, 128.7, 128.6, 128.5, 128.4, 119.9, 16.9, 9.0.

HRMS (ESI-TOF, [M + H^+]): calcd for $C_{19}H_{16}O_2$ 277.1223, found 277.1222



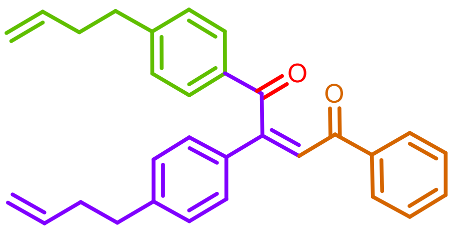
(*Z*)-1,2,4-triphenylbut-2-ene-1,4-dione (3j)

23.2 mg, 74% yield.

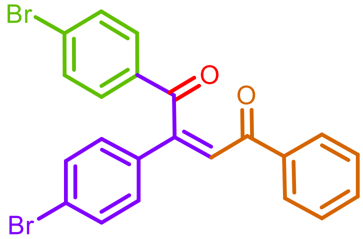
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.01 – 7.97 (m, 4H), 7.64 (s, 1H), 7.61 (dd, *J* = 8.0, 1.7 Hz, 2H), 7.59 – 7.56 (m, 1H), 7.54 – 7.51 (m, 1H), 7.47 (t, *J* = 7.7 Hz, 2H), 7.44 – 7.41 (m, 5H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 197.5, 188.2, 156.4, 137.3, 136.1, 134.8, 133.3, 133.3, 130.7, 129.2, 128.8, 128.7, 128.6, 127.3, 121.0.

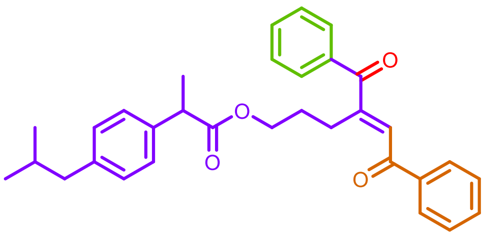
HRMS (ESI-TOF, [M + H^+]): calcd for $C_{22}H_{16}O_2$ 313.1223, found 313.1224



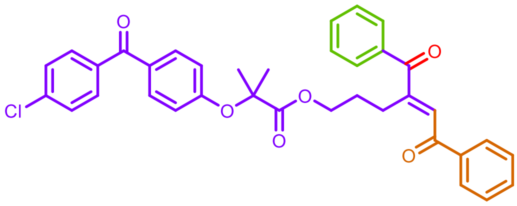
(*Z*)-1,2-bis(4-(but-3-en-1-yl)phenyl)-4-phenylbut-2-ene-1,4-dione (3k)
23.6 mg, 56% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.99 (d, *J* = 7.0 Hz, 2H), 7.90 (d, *J* = 8.2 Hz, 2H), 7.61 (s, 1H), 7.59 – 7.52 (m, 3H), 7.46 (t, *J* = 7.7 Hz, 2H), 7.23 (t, *J* = 7.9 Hz, 4H), 5.88 – 5.78 (m, 2H), 5.06 – 4.97 (m, 4H), 2.74 – 2.70 (m, 4H), 2.39 – 2.33 (m, 4H).
^{13}C NMR (125 MHz, $CDCl_3$) δ 197.4, 188.2, 156.5, 147.8, 145.1, 137.6, 137.5, 134.2, 133.2, 132.5, 129.3, 128.9, 128.9, 128.7, 128.6, 127.3, 119.9, 115.4, 115.3, 35.5, 35.2, 35.1, 34.9.
HRMS (ESI-TOF, [M + H^+]): calcd for $C_{30}H_{28}O_2$ 421.2162, found 421.2168



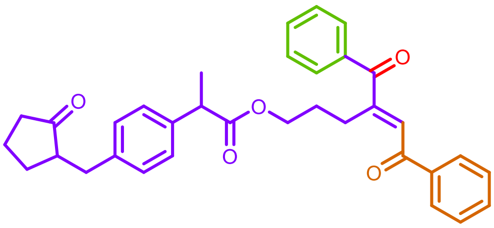
(*Z*)-1,2-bis(4-bromophenyl)-4-phenylbut-2-ene-1,4-dione (3l)
23.4 mg, 50% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.99 – 7.96 (m, 2H), 7.80 (d, *J* = 8.6 Hz, 2H), 7.62 (s, 1H), 7.60 – 7.54 (m, 5H), 7.50 – 7.43 (m, 4H).
^{13}C NMR (125 MHz, $CDCl_3$) δ 196.1, 188.1, 154.6, 137.0, 134.7, 133.7, 133.3, 132.6, 132.2, 130.1, 128.8, 128.7, 128.7, 125.6, 121.5.
HRMS (ESI-TOF, [M + Na^+]): calcd for $C_{22}H_{14}Br_2O_2$ 490.9253, found 490.9252



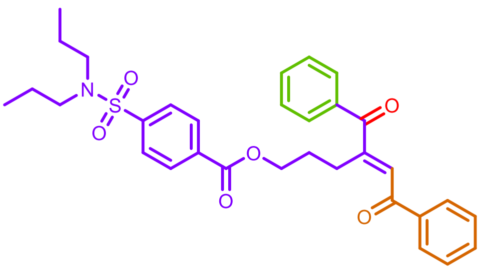
(*E*)-4-benzoyl-6-oxo-6-phenylhex-4-en-1-yl 2-(4-isobutylphenyl) propanoate (3m)
15.8 mg, 33% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.89 – 7.86 (m, 4H), 7.64 – 7.56 (m, 2H), 7.53 – 7.42 (m, 4H), 7.17 (d, *J* = 8.0 Hz, 2H), 7.05 (d, *J* = 5.6 Hz, 2H), 7.03 (s, 1H), 4.19 – 4.13 (m, 1H), 4.10 – 4.04 (m, 1H), 3.65 (q, *J* = 7.1 Hz, 1H), 2.88 – 2.83 (m, 2H), 2.40 (d, *J* = 7.2 Hz, 2H), 1.90 – 1.84 (m, 2H), 1.83 – 1.77 (m, 1H), 1.46 (d, *J* = 7.2 Hz, 3H), 0.87 (d, *J* = 6.6 Hz, 6H).
^{13}C NMR (125 MHz, $CDCl_3$) δ 197.8, 191.5, 174.7, 152.4, 140.4, 137.8, 137.4, 136.5, 133.6, 133.3, 130.9, 129.8, 129.2, 128.8, 128.7, 128.5, 127.2, 64.1, 45.1, 45.0, 30.1, 27.6, 26.0, 22.4, 18.4.
HRMS (ESI-TOF, [M + H^+]): calcd for $C_{32}H_{34}O_4$ 483.2530, found 483.2527



(*E*)-4-benzoyl-6-oxo-6-phenylhex-4-en-1-yl
2-(4-(4-chlorobenzoyl)phenoxy)-2-methylpropanoate (3n)
25.0 mg, 42% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.85 – 7.83 (m, 4H), 7.68 (dd, *J* = 8.6, 3.3 Hz, 4H), 7.61 (t, *J* = 7.4 Hz, 1H), 7.57 (t, *J* = 7.4 Hz, 1H), 7.49 (t, *J* = 7.7 Hz, 2H), 7.46 – 7.41 (m, 4H), 7.08 (s, 1H), 6.85 (d, *J* = 8.8 Hz, 2H), 4.25 (t, *J* = 6.4 Hz, 2H), 2.85 – 2.82 (m, 2H), 1.93 – 1.87 (m, 2H), 1.67 (s, 6H).
^{13}C NMR (125 MHz, $CDCl_3$) δ 197.7, 194.2, 191.4, 173.5, 159.7, 152.1, 138.3, 137.3, 136.4, 136.4, 133.7, 133.4, 132.0, 131.2, 131.1, 130.3, 129.8, 128.9, 128.7, 128.5, 128.5, 117.4, 79.5, 65.2, 27.7, 25.9, 25.5.
HRMS (ESI-TOF, [M + H^+]): calcd for $C_{36}H_{31}ClO_6$ 595.1882, found 595.1884

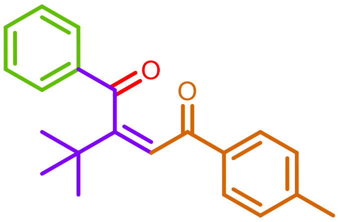


(*E*)-4-benzoyl-6-oxo-6-phenylhex-4-en-1-yl2-(4-((2-oxocyclopentyl)methyl)phenyl) propanoate (3o)
20.4 mg, 39% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.88 (d, *J* = 8.2 Hz, 4H), 7.62 (t, *J* = 7.3 Hz, 1H), 7.57 (d, *J* = 7.3 Hz, 1H), 7.53 – 7.45 (m, 4H), 7.18 (d, *J* = 8.0 Hz, 2H), 7.07 (d, *J* = 4.5 Hz, 2H), 7.06 (s, 1H), 4.19 – 4.13 (m, 1H), 4.10 – 4.04 (m, 1H), 3.65 (q, *J* = 7.2 Hz, 1H), 3.09 (dd, *J* = 13.9, 4.0 Hz, 1H), 2.88 – 2.83 (m, 2H), 2.48 – 2.43 (m, 1H), 2.43 – 2.28 (m, 2H), 2.14 – 2.06 (m, 2H), 1.95 – 1.83 (m, 3H), 1.74 – 1.63 (m, 2H), 1.45 (d, *J* = 7.2 Hz, 3H).
^{13}C NMR (125 MHz, $CDCl_3$) δ 197.7, 191.5, 174.6, 152.4, 138.7, 138.4, 137.4, 136.5, 133.7, 133.3, 130.9, 129.8, 129.0, 128.8, 128.7, 128.5, 127.6, 64.2, 51.0, 45.1, 38.2, 35.2, 29.2, 27.6, 26.0, 20.5, 18.4.
HRMS (ESI-TOF, [M + H^+]): calcd for $C_{34}H_{34}O_5$ 523.2479, found 523.2481

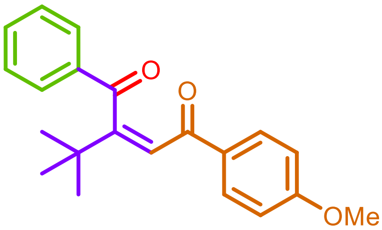


(*E*)-4-benzoyl-6-oxo-6-phenylhex-4-en-1-yl 4-(N,N-dipropylsulfamoyl)benzoate (3p)
22.5 mg, 40% yield.

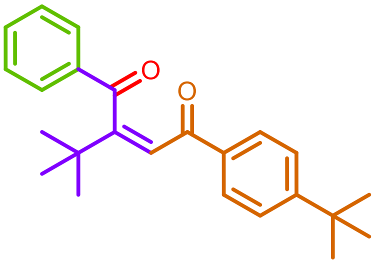
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.13 (d, *J* = 8.2 Hz, 2H), 7.90 – 7.84 (m, 6H), 7.63 (t, *J* = 7.4 Hz, 1H), 7.57 (t, *J* = 7.4 Hz, 1H), 7.51 (t, *J* = 7.6 Hz, 2H), 7.45 (t, *J* = 7.7 Hz, 2H), 7.13 (s, 1H), 4.41 (t, *J* = 6.3 Hz, 2H), 3.12 – 3.08 (m, 4H), 3.02 (t, *J* = 7.8 Hz, 2H), 2.09 – 2.03 (m, 2H), 1.58 – 1.52 (m, 4H), 0.87 (t, *J* = 7.4 Hz, 6H).
^{13}C NMR (125 MHz, $CDCl_3$) δ 197.8, 191.6, 165.2, 152.0, 144.1, 137.3, 136.4, 133.7, 133.6, 133.4, 131.4, 130.3, 129.8, 128.9, 128.7, 128.5, 126.9, 65.0, 50.0, 27.7, 26.0, 22.0, 11.2.
HRMS (ESI-TOF, [M + H$^+$]): calcd for $C_{32}H_{35}NO_6S$ 562.2258, found 562.2264



(*Z*)-2-(tert-butyl)-1-phenyl-4-(*p*-tolyl)but-2-ene-1,4-dione (3q)
23.3 mg, 76% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.90 (d, *J* = 7.5 Hz, 2H), 7.81 (d, *J* = 7.9 Hz, 2H), 7.49 (t, *J* = 7.4 Hz, 1H), 7.40 (t, *J* = 7.6 Hz, 2H), 7.24 (s, 2H), 7.23 (s, 1H), 2.40 (s, 3H), 1.27 (s, 9H).
^{13}C NMR (125 MHz, $CDCl_3$) δ 199.2, 188.3, 167.4, 144.0, 136.8, 135.1, 132.7, 129.3, 128.6, 128.5, 128.3, 120.6, 36.7, 29.9, 21.7.
HRMS (ESI-TOF, [M + H$^+$]): calcd for $C_{21}H_{22}O_2$ 307.1693, found 307.1693

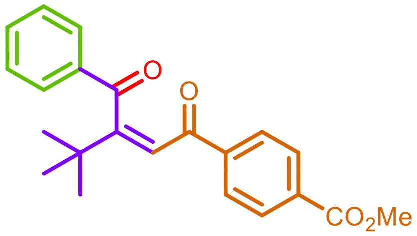


(Z)-2-(tert-butyl)-4-(4-methoxyphenyl)-1-phenylbut-2-ene-1,4-dione (3r)
26.6 mg, 83% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.90 (d, *J* = 9.0 Hz, 4H), 7.49 (t, *J* = 7.3 Hz, 1H), 7.40 (t, *J* = 7.5 Hz, 2H), 7.22 (s, 1H), 6.91 (d, *J* = 9.0 Hz, 2H), 3.85 (s, 3H), 1.26 (s, 9H).
^{13}C NMR (125 MHz, $CDCl_3$) δ 199.4, 187.2, 167.0, 163.6, 136.8, 132.8, 130.9, 130.5, 128.5, 128.3, 120.5, 113.8, 55.5, 36.6, 29.9.
HRMS (ESI-TOF, [M + H$^+$]): calcd for $C_{21}H_{22}O_3$ 323.1642, found 323.1649

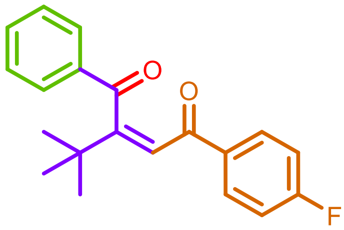


(*Z*)-2-(tert-butyl)-4-(4-(tert-butyl)phenyl)-1-phenylbut-2-ene-1,4-dione (3s)
23.0 mg, 66% yield.

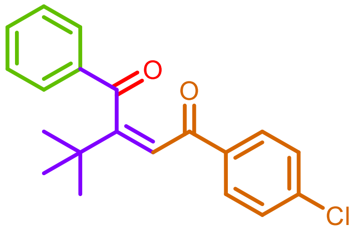
¹H NMR (500 MHz, $CDCl_3$) δ 7.90 (d, *J* = 7.1 Hz, 2H), 7.85 (d, *J* = 8.5 Hz, 2H), 7.51 – 7.44 (m, 3H), 7.39 (t, *J* = 7.5 Hz, 2H), 7.26 (s, 1H), 1.32 (s, 9H), 1.27 (s, 9H).
¹³C NMR (125 MHz, $CDCl_3$) δ 199.3, 188.3, 167.5, 156.9, 136.7, 135.0, 132.8, 128.5, 128.5, 128.3, 125.6, 120.6, 36.7, 35.1, 31.1, 29.9.
HRMS (ESI-TOF, [M + H$^+$]): calcd for $C_{24}H_{28}O_2$ 349.2162, found 349.2161



methyl (*Z*)-4-(3-benzoyl-4,4-dimethylpent-2-enoyl) benzoate (3t)
23.5 mg, 67% yield.
¹H NMR (500 MHz, $CDCl_3$) δ 8.09 (d, *J* = 8.3 Hz, 2H), 7.93 (d, *J* = 8.2 Hz, 2H), 7.89 (d, *J* = 7.2 Hz, 2H), 7.52 (t, *J* = 7.3 Hz, 1H), 7.42 (t, *J* = 7.6 Hz, 2H), 7.23 (s, 1H), 3.94 (s, 3H), 1.28 (s, 9H).
¹³C NMR (125 MHz, $CDCl_3$) δ 198.8, 188.2, 169.3, 166.1, 140.8, 136.5, 133.8, 133.0, 129.8, 128.6, 128.3, 128.3, 120.2, 52.4, 36.9, 29.8.
HRMS (ESI-TOF, [M + H$^+$]): calcd for $C_{22}H_{22}O_4$ 351.1591, found 351.1594

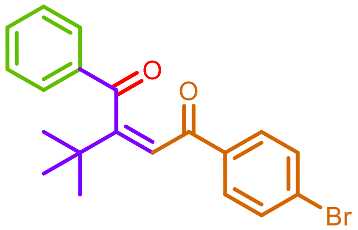


(Z)-2-(tert-butyl)-4-(4-fluorophenyl)-1-phenylbut-2-ene-1,4-dione (3u)
25.2 mg, 81% yield.
¹H NMR (500 MHz, $CDCl_3$) δ 7.94 – 7.88 (m, 1H), 7.51 (t, *J* = 7.4 Hz, 1H), 7.41 (t, *J* = 7.6 Hz, 2H), 7.20 (s, 1H), 7.11 (t, *J* = 8.5 Hz, 2H), 1.27 (s, 9H).
¹³C NMR (125 MHz, $CDCl_3$) δ 197.9, 186.2, 167.3, 163.7 (d, *J* = 255.1 Hz), 135.7, 133.0 (d, *J* = 3.0 Hz), 131.9, 130.1(d, *J* = 9.4 Hz), 127.5, 127.3, 119.2, 114.7 (d, *J* = 21.9 Hz), 35.7, 28.9.
HRMS (ESI-TOF, [M + H$^+$]): calcd for $C_{20}H_{19}FO_2$ 311.1442, found 311.1438

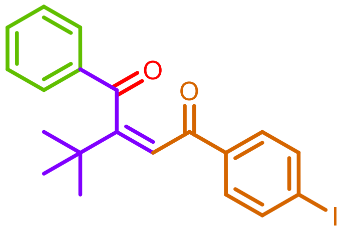


(*Z*)-2-(tert-butyl)-4-(4-chlorophenyl)-1-phenylbut-2-ene-1,4-dione (3v)
21.9 mg, 67% yield.
¹H NMR (500 MHz, $CDCl_3$) δ 7.89 (d, *J* = 6.9 Hz, 2H), 7.83 (d, *J* = 8.6 Hz, 2H), 7.51 (t, *J* = 7.3 Hz, 1H), 7.43 (d, *J* = 5.7 Hz, 2H), 7.41 (d, *J* = 6.6 Hz, 2H), 7.19 (s, 1H), 1.27 (s, 9H).

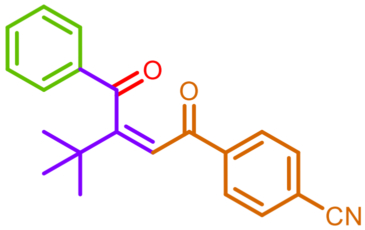
^{13}C NMR (125 MHz, $CDCl_3$) δ 198.9, 187.5, 168.7, 139.6, 136.6, 135.9, 132.9, 129.9, 128.9, 128.6, 128.3, 120.1, 36.8, 29.8.
HRMS (ESI-TOF, [M + H^+]): calcd for $C_{20}H_{19}ClO_2$ 327.1146, found 327.1141



(*Z*)-4-(4-bromophenyl)-2-(tert-butyl)-1-phenylbut-2-ene-1,4-dione (3w)
23.6 mg, 74% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.88 (d, *J* = 7.0 Hz, 2H), 7.75 (d, *J* = 8.6 Hz, 2H), 7.58 (d, *J* = 8.5 Hz, 2H), 7.53 – 7.49 (m, 1H), 7.41 (t, *J* = 7.7 Hz, 2H), 7.17 (s, 1H), 1.27 (s, 9H).
^{13}C NMR (125 MHz, $CDCl_3$) δ 198.9, 187.7, 168.8, 136.6, 136.3, 132.9, 131.9, 130.0, 128.6, 128.3, 120.0, 36.8, 29.8.
HRMS (ESI-TOF, [M + H^+]): calcd for $C_{20}H_{19}BrO_2$ 371.0641, found 371.0639

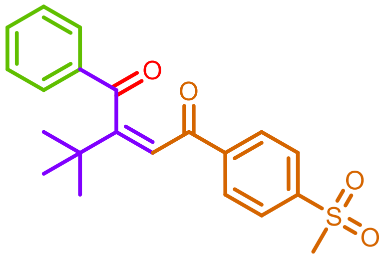


(Z)-2-(tert-butyl)-4-(4-iodophenyl)-1-phenylbut-2-ene-1,4-dione (3x)
22.1 mg, 53% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.91 (d, *J* = 7.5 Hz, 2H), 7.83 (d, *J* = 8.1 Hz, 2H), 7.62 (d, *J* = 8.0 Hz, 2H), 7.54 (t, *J* = 7.4 Hz, 1H), 7.44 (t, *J* = 7.5 Hz, 2H), 7.20 (s, 1H), 1.30 (s, 9H).
^{13}C NMR (125 MHz, $CDCl_3$) δ 198.9, 188.0, 168.8, 137.9, 136.8, 136.6, 132.9, 129.8, 128.6, 128.3, 119.9, 101.1, 36.8, 29.9.
HRMS (ESI-TOF, [M + H^+]): calcd for $C_{20}H_{19}IO_2$ 419.0502, found 419.0505



(*Z*)-4-(3-benzoyl-4,4-dimethylpent-2-enoyl) benzonitrile (3y)
21.6 mg, 65% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.96 (d, *J* = 8.5 Hz, 2H), 7.88 (d, *J* = 7.6 Hz, 2H), 7.73 (d, *J* = 8.2 Hz, 2H), 7.53 (t, *J* = 7.4 Hz, 1H), 7.42 (t, *J* = 7.6 Hz, 2H), 7.18 (s, 1H), 1.28 (s, 9H).
^{13}C NMR (125 MHz, $CDCl_3$) δ 198.6, 187.5, 170.4, 140.6, 136.4, 133.1, 132.5, 128.8, 128.6, 128.3, 119.6, 117.8, 116.3, 37.0, 29.8.

HRMS (ESI-TOF, [M + H$^+$]): calcd for $C_{21}H_{19}NO_2$ 318.1489, found 318.1490



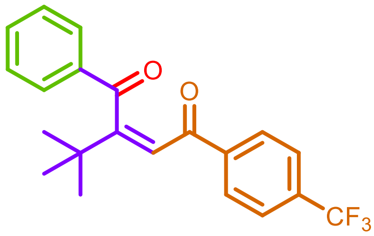
(*Z*)-2-(*tert*-butyl)-4-(4-(methylsulfonyl)phenyl)-1-phenylbut-2-ene-1,4-dione (3z)

23.2 mg, 63% yield.

^{1}**H NMR** (500 MHz, Chloroform-*d*) δ 8.05 – 7.99 (m, 4H), 7.88 (d, *J* = 7.4 Hz, 2H), 7.52 (t, *J* = 7.3 Hz, 1H), 7.42 (t, *J* = 7.6 Hz, 2H), 7.21 (s, 1H), 3.05 (s, 3H), 1.28 (s, 9H).

^{13}**C NMR** (125 MHz, $CDCl_3$) δ 198.7, 187.6, 170.5, 144.1, 141.6, 136.3, 133.2, 129.3, 128.7, 128.3, 127.8, 119.8, 44.3, 37.1, 29.8.

HRMS (ESI-TOF, [M + H$^+$]): calcd for $C_{21}H_{22}O_4S$ 371.1312, found 371.1310



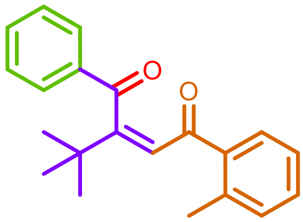
(*Z*)-2-(*tert*-butyl)-1-phenyl-4-(4-(trifluoromethyl)phenyl)but-2-ene-1,4-dione (3aa)

23.7 mg, 66% yield.

^{1}**H NMR** (500 MHz, $CDCl_3$) δ 7.98 (d, *J* = 8.0 Hz, 2H), 7.89 (d, *J* = 7.7 Hz, 2H), 7.70 (d, *J* = 8.0 Hz, 2H), 7.53 (t, *J* = 7.5 Hz, 1H), 7.43 (t, *J* = 7.6 Hz, 2H), 7.22 (s, 1H), 1.29 (s, 9H).

^{13}**C NMR** (125 MHz, $CDCl_3$) δ 198.7, 187.8, 169.7, 140.3, 136.5, 134.3 (q, *J* = 32.7 Hz), 133.0, 128.7, 128.6, 128.3, 125.7 (q, *J* = 3.8 Hz), 123.6 (d, *J* = 272.7 Hz), 120.0, 36.9, 29.8.

HRMS (ESI-TOF, [M + H$^+$]): calcd for $C_{21}H_{19}F_3O_2$ 361.1410, found 361.1411



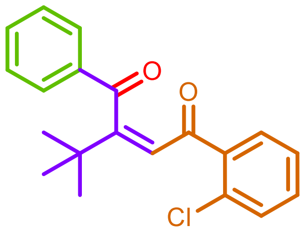
(*Z*)-2-(tert-butyl)-1-phenyl-4-(o-tolyl) but-2-ene-1,4-dione (3ab)

19.4 mg, 63% yield.

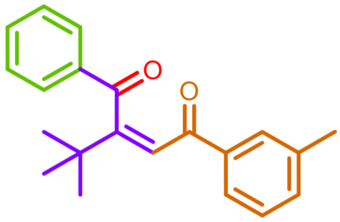
^{1}**H NMR** (500 MHz, $CDCl_3$) δ 7.90 (d, *J* = 7.5 Hz, 2H), 7.57 (d, *J* = 7.6 Hz, 1H), 7.51 (t, *J* = 7.4 Hz, 1H), 7.41 (t, *J* = 7.7 Hz, 2H), 7.34 (t, *J* = 7.4 Hz, 1H), 7.24 (d, *J* = 7.5 Hz, 1H), 7.17 (d, *J* = 7.5 Hz, 1H), 6.96 (s, 1H), 2.29 (s, 3H), 1.26 (s, 9H).

^{13}**C NMR** (125 MHz, $CDCl_3$) δ 198.9, 192.9, 166.2, 138.5, 138.1, 136.7, 132.9, 131.6, 131.3, 128.6, 128.5, 128.4, 125.5, 124.4, 36.6, 29.8, 20.5.

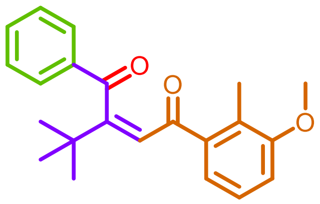
HRMS (ESI-TOF, [M + H$^+$]): calcd for $C_{21}H_{22}O_2$ 307.1693, found 307.1698



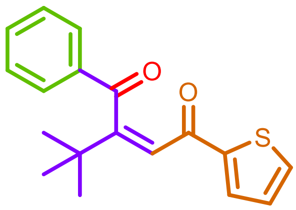
(*Z*)-2-(tert-butyl)-4-(2-chlorophenyl)-1-phenylbut-2-ene-1,4-dione (3ac)
25.5 mg, 78% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.96 (d, *J* = 7.3 Hz, 2H), 7.52 (t, *J* = 7.3 Hz, 1H), 7.45 – 7.38 (m, 5H), 7.29 – 7.27 (m, 1H), 7.02 (s, 1H), 1.26 (s, 9H).
^{13}C NMR (125 MHz, $CDCl_3$) δ 198.6, 190.8, 166.4, 138.9, 136.4, 133.0, 132.2, 131.5, 130.4, 130.2, 128.5, 128.4, 127.1, 124.6, 36.7, 29.6.
HRMS (ESI-TOF, [M + H^{+}]): calcd for $C_{20}H_{19}ClO_2$ 327.1146, found 327.1149



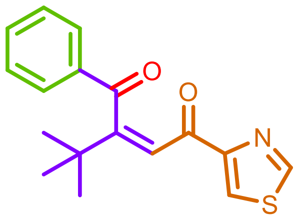
(*Z*)-2-(tert-butyl)-1-phenyl-4-(m-tolyl)but-2-ene-1,4-dione (3ad)
21.0 mg, 69% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.90 (d, *J* = 7.6 Hz, 2H), 7.71 (d, *J* = 9.7 Hz, 2H), 7.50 (t, *J* = 7.3 Hz, 1H), 7.40 (t, *J* = 7.6 Hz, 2H), 7.35 – 7.31 (m, 2H), 7.25 (s, 1H), 2.38 (s, 3H), 1.28 (s, 9H).
^{13}C NMR (125 MHz, $CDCl_3$) δ 199.2, 188.9, 167.8, 138.5, 137.5, 136.7, 133.9, 132.8, 129.0, 128.6, 128.5, 128.3, 125.7, 120.7, 36.8, 29.9, 21.4.
HRMS (ESI-TOF, [M + H^{+}]): calcd for $C_{21}H_{22}O_2$ 307.1693, found 307.1695



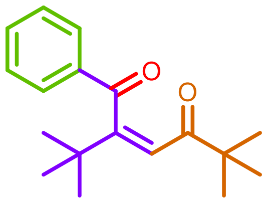
(*Z*)-2-(tert-butyl)-4-(3-methoxy-2-methylphenyl)-1-phenylbut-2-ene-1,4-dione (3ae)
16.8 mg, 50% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.91 (d, *J* = 7.2 Hz, 2H), 7.51 (t, *J* = 7.4 Hz, 1H), 7.42 (t, *J* = 7.5 Hz, 2H), 7.20 (t, *J* = 7.9 Hz, 1H), 7.07 (d, *J* = 7.6 Hz, 1H), 6.93 (d, *J* = 8.1 Hz, 1H), 6.88 (s, 1H), 3.82 (s, 3H), 2.14 (s, 3H), 1.24 (s, 9H).
^{13}C NMR (125 MHz, $CDCl_3$) δ 198.9, 193.4, 166.3, 158.1, 140.6, 136.6, 132.9, 128.5, 128.3, 126.2, 126.1, 124.9, 120.0, 112.6, 55.7, 36.7, 29.8, 12.7.
HRMS (ESI-TOF, [M + H^{+}]): calcd for $C_{22}H_{24}O_3$ 337.1798, found 337.1796



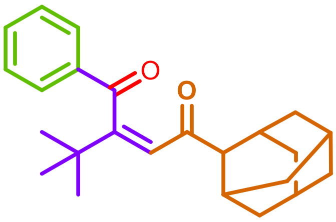
(*Z*)-2-(*tert*-butyl)-1-phenyl-4-(thiophen-2-yl)but-2-ene-1,4-dione (3af)
13.1 mg, 44% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.91 – 7.88 (m, 2H), 7.78 (dd, *J* = 3.8, 1.1 Hz, 1H), 7.63 (dd, *J* = 4.9, 1.1 Hz, 1H), 7.53 – 7.49 (m, 1H), 7.42 (t, *J* = 7.4 Hz, 2H), 7.14 (dd, *J* = 4.8, 3.9 Hz, 1H), 7.07 (s, 1H), 1.26 (s, 9H).
^{13}C NMR (125 MHz, $CDCl_3$) δ 198.8, 180.9, 167.8, 144.8, 136.7, 134.4, 132.9, 132.2, 128.6, 128.3, 128.2, 120.5, 36.7, 29.8.
HRMS (ESI-TOF, [M + H^{+}]): calcd for $C_{18}H_{18}O_2S$ 299.1100, found 299.1110



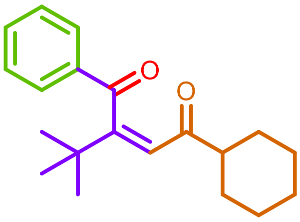
(*Z*)-2-(tert-butyl)-1-phenyl-4-(thiazol-5-yl) but-2-ene-1,4-dione (3ag)
18.0 mg, 60% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.97 (s, 1H), 8.51 (s, 1H), 7.88 (d, *J* = 6.7 Hz, 2H), 7.53 (t, *J* = 7.4 Hz, 1H), 7.43 (t, *J* = 7.7 Hz, 2H), 7.02 (s, 1H), 1.27 (s, 9H).
^{13}C NMR (125 MHz, $CDCl_3$) δ 198.3, 180.6, 169.7, 159.7, 147.0, 140.8, 136.4, 133.2, 128.7, 128.3, 120.1, 36.9, 29.8.
HRMS (ESI-TOF, [M + H^{+}]): calcd for $C_{17}H_{17}NO_2S$ 300.1053, found 300.1053



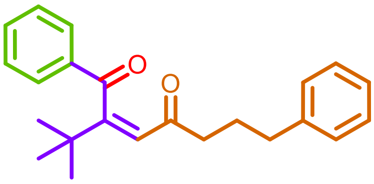
(Z)-2-(tert-butyl)-5,5-dimethyl-1-phenylhex-2-ene-1,4-dione (3ah)
16.0 mg, 59% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.82 (d, *J* = 7.5 Hz, 2H), 7.50 (t, *J* = 7.2 Hz, 1H), 7.41 (t, *J* = 7.6 Hz, 2H), 6.74 (s, 1H), 1.19 (s, 9H), 1.11 (s, 9H).
^{13}C NMR (125 MHz, $CDCl_3$) δ 202.4, 198.3, 165.3, 135.6, 131.7, 127.4, 127.1, 119.1, 42.2, 35.3, 28.8, 25.1.
HRMS (ESI-TOF, [M + H^{+}]): calcd for $C_{18}H_{24}O_2$ 273.1849, found 273.1853



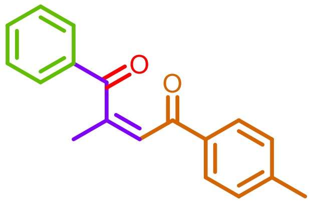
(*Z*)-4-(adamantan-2-yl)-2-(*tert*-butyl)-1-phenylbut-2-ene-1,4-dione (3ai)
18.1 mg, 52% yield.
[1]H NMR (500 MHz, $CDCl_3$) δ 7.81 (d, *J* = 7.2 Hz, 2H), 7.49 (t, *J* = 7.4 Hz, 1H), 7.40 (t, *J* = 7.6 Hz, 2H), 6.77 (s, 1H), 2.03 (t, *J* = 3.4 Hz, 3H), 1.75 (d, *J* = 3.0 Hz, 7H), 1.72 (s, 2H), 1.68 – 1.65 (m, 3H), 1.19 (s, 9H).
[13]C NMR (125 MHz, $CDCl_3$) δ 202.9, 199.4, 166.1, 136.6, 132.6, 128.4, 128.2, 119.7, 45.5, 37.9, 36.5, 36.4, 29.8, 27.8.
HRMS (ESI-TOF, [M + H^+]): calcd for $C_{24}H_{30}O_2$ 351.2319, found 351.2321



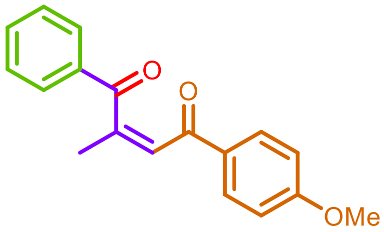
(*Z*)-2-(tert-butyl)-4-cyclohexyl-1-phenylbut-2-ene-1,4-dione (3aj)
15.8 mg, 53% yield.
[1]H NMR (500 MHz, $CDCl_3$) δ 7.82 (d, *J* = 7.6 Hz, 2H), 7.50 (t, *J* = 7.3 Hz, 1H), 7.40 (t, *J* = 7.6 Hz, 2H), 6.52 (s, 1H), 2.41 – 2.36 (m, 1H), 1.81 – 1.73 (m, 4H), 1.67 – 1.61 (m, 1H)., 1.25 – 1.21 (m, 4H), 1.19 (s, 9H).
[13]C NMR (125 MHz, $CDCl_3$) δ 201.5, 199.1, 165.8, 136.6, 132.7, 128.4, 128.2, 123.0, 50.6, 36.2, 29.8, 28.1, 25.8, 25.6.
HRMS (ESI-TOF, [M + H^+]): calcd for $C_{20}H_{26}O_2$ 299.2006, found 299.2006



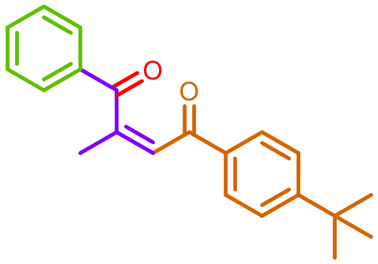
(*Z*)-2-(*tert*-butyl)-1,7-diphenylhept-2-ene-1,4-dione (3ak)
11.7 mg, 35% yield.
[1]H NMR (500 MHz, $CDCl_3$) δ 7.83 (d, *J* = 7.7 Hz, 2H), 7.51 (t, *J* = 7.1 Hz, 1H), 7.42 (t, *J* = 7.6 Hz, 2H), 7.27 – 7.24 (m, 2H), 7.18 (d, *J* = 6.5 Hz, 1H), 7.11 (d, *J* = 7.5 Hz, 2H), 6.40 (s, 1H), 2.54 (t, *J* = 7.5 Hz, 2H), 2.47 (t, *J* = 7.3 Hz, 2H), 1.86 – 1.80 (m, 2H), 1.17 (s, 9H).
[13]C NMR (125 MHz, $CDCl_3$) δ 199.1, 198.5, 165.6, 141.5, 136.7, 132.8, 128.5, 128.4, 128.3, 128.3, 125.9, 123.7, 42.4, 36.1, 34.9, 29.7, 24.9.
HRMS (ESI-TOF, [M + H^+]): calcd for $C_{23}H_{26}O_2$ 335.2006, found 335.2008



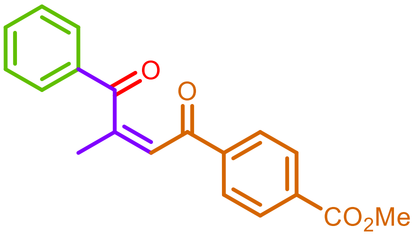
(*Z*)-2-methyl-1-phenyl-4-(p-tolyl) but-2-ene-1,4-dione (3al)
17.7 mg, 67% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.92 (d, *J* = 7.6 Hz, 2H), 7.82 (d, *J* = 8.0 Hz, 2H), 7.54 (t, *J* = 7.3 Hz, 1H), 7.44 (t, *J* = 7.6 Hz, 2H), 7.24 (d, *J* = 7.9 Hz, 2H), 7.15 (s, 1H), 2.40 (s, 3H), 2.24 (s, 3H).
^{13}C NMR (125 MHz, $CDCl_3$) δ 199.4, 187.7, 155.7, 144.1, 134.6, 134.5, 133.2, 129.3, 128.7, 128.7, 128.4, 123.0, 22.1, 21.7.
HRMS (ESI-TOF, [M + H^{+}]): calcd for $C_{18}H_{16}O_2$ 265.1223, found 265.1245



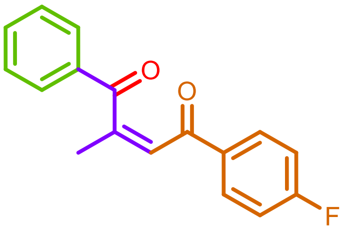
(*Z*)-4-(4-methoxyphenyl)-2-methyl-1-phenylbut-2-ene-1,4-dione (3am)
17.9 mg, 64% yield. The spectra matched with the previous report.[7]
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.90 – 7.86 (m, 4H), 7.60 (t, *J* = 7.4 Hz, 1H), 7.50 (t, *J* = 7.8 Hz, 2H), 7.07 (s, 1H), 6.93 (d, *J* = 8.9 Hz, 2H), 3.87 (s, 3H), 2.31 (s, 2H).
^{13}C NMR (125 MHz, $CDCl_3$) δ 198.4, 190.7, 163.9, 148.0, 136.4, 133.0, 131.4, 131.0, 130.6, 129.8, 128.6, 114.0, 55.5, 15.8.
HRMS (ESI-TOF, [M + H^{+}]): calcd for $C_{18}H_{16}O_3$ 281.1172, found 281.1195



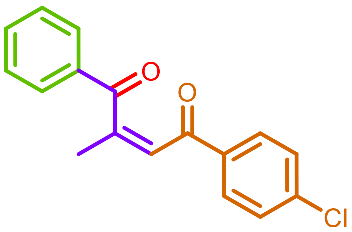
(*Z*)-4-(4-(*tert*-butyl) phenyl)-2-methyl-1-phenylbut-2-ene-1,4-dione (3an)
18.1 mg, 59% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.92 (d, *J* = 8.3 Hz, 2H), 7.86 (d, *J* = 8.4 Hz, 2H), 7.54 (t, *J* = 7.4 Hz, 1H), 7.47 – 7.44 (m, 4H), 7.16 (s, 1H), 2.25 (s, 3H), 1.33 (s, 9H).
^{13}C NMR (125 MHz, $CDCl_3$) δ 198.7, 186.8, 156.2, 154.8, 133.4, 133.2, 132.3, 127.8, 127.6, 127.4, 124.6, 122.0, 34.1, 30.0, 21.1.
HRMS (ESI-TOF, [M + H^{+}]): calcd for $C_{21}H_{22}O_2$ 307.1693, found 307.1694



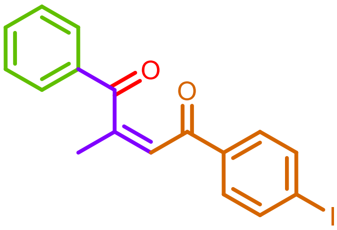
Methyl (*Z*)-4-(3-methyl-4-oxo-4-phenylbut-2-enoyl)benzoate (3ao)
18.8 mg, 61% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.10 (d, *J* = 8.4 Hz, 2H), 7.95 (d, *J* = 8.5 Hz, 2H), 7.91 (d, *J* = 8.0 Hz, 2H), 7.56 (t, *J* = 7.4 Hz, 1H), 7.46 (t, *J* = 7.6 Hz, 2H), 7.15 (s, 1H), 3.94 (s, 3H), 2.28 (s, 3H).
^{13}C NMR (125 MHz, $CDCl_3$) δ 199.1, 187.6, 166.2, 157.6, 140.2, 134.3, 133.9, 133.5, 129.9, 128.9, 128.4, 128.4, 122.6, 52.5, 22.3.
HRMS (ESI-TOF, [M + H$^+$]): calcd for $C_{19}H_{16}O_4$ 309.1121, found 309.1120



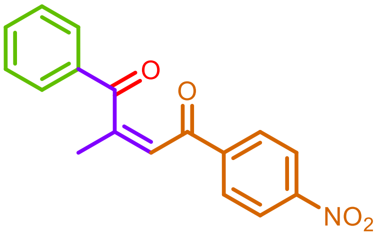
(*Z*)-4-(4-fluorophenyl)-2-methyl-1-phenylbut-2-ene-1,4-dione (3ap)
15.0 mg, 56% yield. The spectra matched with the previous report.[7]
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.99 – 7.93 (m, 4H), 7.58 (t, *J* = 7.6 Hz, 1H), 7.48 (t, *J* = 7.4 Hz, 2H), 7.16 – 7.12 (m, 3H), 2.28 (s, 3H).
^{13}C NMR (125 MHz, $CDCl_3$) δ 199.3, 186.6, 165.8 (d, *J* = 255.3 Hz), 156.7, 134.5, 133.4, 133.3 (d, *J* = 2.9 Hz), 131.3, 131.2, 128.8, 128.8, 128.4, 122.6, 115.9, 115.7, 22.2.
HRMS (ESI-TOF, [M + H$^+$]): calcd for $C_{17}H_{13}FO_2$ 269.0972, found 269.0990



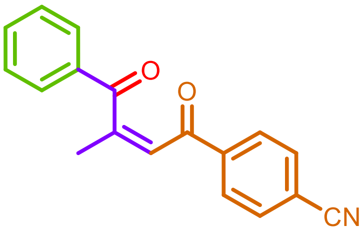
(*Z*)-4-(4-chlorophenyl)-2-methyl-1-phenylbut-2-ene-1,4-dione (3aq)
17.4 mg, 61% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.91 (d, *J* = 7.6 Hz, 2H), 7.85 (d, *J* = 8.3 Hz, 2H), 7.56 (t, *J* = 7.1 Hz, 1H), 7.45 (t, *J* = 7.7 Hz, 2H), 7.41 (d, *J* = 8.5 Hz, 2H), 7.10 (s, 1H), 2.26 (s, 3H).
^{13}C NMR (125 MHz, $CDCl_3$) δ 199.2, 186.9, 157.1, 139.8, 135.2, 134.4, 133.4, 130.0, 129.0, 128.8, 128.4, 122.4, 22.3.
HRMS (ESI-TOF, [M + H$^+$]): calcd for $C_{17}H_{13}ClO_2$ 285.0677, found 285.0699



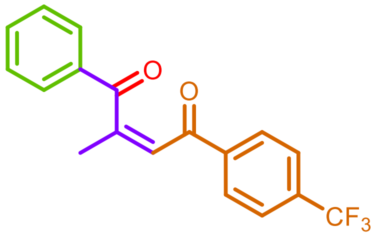
(*Z*)-4-(4-iodophenyl)-2-methyl-1-phenylbut-2-ene-1,4-dione (3ar)
23.7 mg, 63% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.90 (d, *J* = 7.7 Hz, 2H), 7.80 (d, *J* = 7.5 Hz, 2H), 7.61 (d, *J* = 8.2 Hz, 2H), 7.55 (t, *J* = 7.1 Hz, 1H), 7.45 (t, *J* = 7.5 Hz, 2H), 7.08 (s, 1H), 2.25 (s, 3H).
^{13}C NMR (125 MHz, $CDCl_3$) δ 199.2, 187.4, 157.2, 138.0, 136.2, 134.4, 133.4, 129.9, 128.8, 128.4, 122.3, 101.4, 22.3.
HRMS (ESI-TOF, [M + H$^+$]): calcd for $C_{17}H_{13}IO_2$ 377.0033, found 377.0046



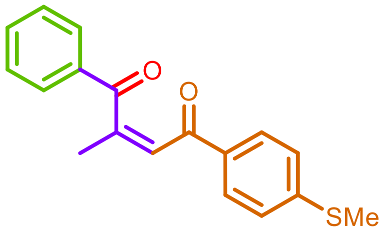
(*Z*)-2-methyl-4-(4-nitrophenyl)-1-phenylbut-2-ene-1,4-dione (3as)
14.8 mg, 50% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.29 (d, *J* = 5.4 Hz, 2H), 8.06 (d, *J* = 7.1 Hz, 2H), 7.91 (d, *J* = 5.7 Hz, 2H), 7.59 (t, *J* = 5.8 Hz, 1H), 7.47 (t, *J* = 5.3 Hz, 2H), 7.13 (s, 1H), 2.30 (s, 3H).
^{13}C NMR (125 MHz, $CDCl_3$) δ 198.7, 186.6, 159.0, 150.3, 141.5, 134.2, 133.7, 129.5, 128.9, 128.4, 123.9, 122.1, 22.5.
HRMS (ESI-TOF, [M + H$^+$]): calcd for $C_{17}H_{13}NO_4$ 296.0917, found 296.0940



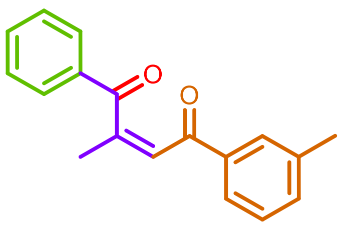
(*Z*)-4-(3-methyl-4-oxo-4-phenylbut-2-enoyl) benzonitrile (3at)
12.4 mg, 45% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.98 (d, *J* = 8.2 Hz, 2H), 7.90 (d, *J* = 7.0 Hz, 2H), 7.74 (d, *J* = 8.1 Hz, 2H), 7.58 (t, *J* = 7.4 Hz, 1H), 7.46 (t, *J* = 7.7 Hz, 2H), 7.10 (s, 1H), 2.28 (s, 3H).
^{13}C NMR (125 MHz, $CDCl_3$) δ 198.8, 186.8, 158.6, 140.0, 134.2, 133.6, 132.6, 132.5, 128.9, 128.4, 122.1, 117.8, 116.4, 22.4.
HRMS (ESI-TOF, [M + H$^+$]): calcd for $C_{18}H_{13}NO_2$ 276.1019, found 276.1019



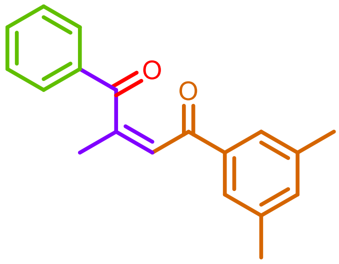
(*Z*)-2-methyl-1-phenyl-4-(4-(trifluoromethyl) phenyl) but-2-ene-1,4-dione (3au)
18.1 mg, 57% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.01 (d, *J* = 8.0 Hz, 2H), 7.91 (d, *J* = 7.5 Hz, 2H), 7.71 (d, *J* = 8.0 Hz, 2H), 7.57 (t, *J* = 7.3 Hz, 1H), 7.46 (t, *J* = 7.6 Hz, 2H), 7.14 (s, 1H), 2.29 (s, 3H).
^{13}C NMR (125 MHz, $CDCl_3$) δ 199.0, 187.2, 158.0, 139.6, 134.6, 134.3, 134.3, 133.6, 128.9 (d, *J* = 5.8 Hz), 128.4, 125.7 (q, *J* = 3.7 Hz), 123.5 (d, *J* = 272.8 Hz), 122.3, 22.4.
HRMS (ESI-TOF, [M + H$^+$]): calcd for $C_{18}H_{13}F_3O_2$ 319.0940, found 319.0961



(*Z*)-2-methyl-4-(4-(methylthio) phenyl)-1-phenylbut-2-ene-1,4-dione (3av)
18.9 mg, 64% yield.
^{1}H NMR (500 MHz, $CDCl_3$) δ 8.07 (d, *J* = 8.2 Hz, 2H), 8.02 (d, *J* = 8.2 Hz, 2H), 7.90 (d, *J* = 7.1 Hz, 2H), 7.58 (t, *J* = 7.2 Hz, 1H), 7.47 (t, *J* = 7.5 Hz, 2H), 7.13 (s, 1H), 3.06 (s, 3H), 2.29 (s, 3H).
^{13}C NMR (125 MHz, $CDCl_3$) δ 198.8, 186.9, 158.6, 144.2, 141.0, 134.2, 133.6, 129.3, 128.9, 128.4, 127.8, 122.2, 44.3, 22.4.
HRMS (ESI-TOF, [M + H$^+$]): calcd for $C_{18}H_{16}O_2S$ 297.0944, found 297.0945



(*Z*)-2-methyl-1-phenyl-4-(m-tolyl) but-2-ene-1,4-dione (3aw)
18.2 mg, 69% yield. The spectra matched with the previous report.[7]
^{1}H NMR (500 MHz, $CDCl_3$) δ 7.92 (d, *J* = 7.7 Hz, 2H), 7.72 (d, *J* = 2.2 Hz, 2H), 7.54 (t, *J* = 7.3 Hz, 1H), 7.44 (t, *J* = 7.7 Hz, 2H), 7.37 – 7.33 (m, 2H), 7.15 (s, 1H), 2.37 (s, 3H), 2.25 (s, 3H).
^{13}C NMR (125 MHz, $CDCl_3$) δ 199.4, 188.3, 156.1, 138.5, 136.9, 134.6, 134.0, 133.3, 129.2, 128.8, 128.5, 128.4, 125.8, 123.1, 22.2, 21.3.
HRMS (ESI-TOF, [M + H$^+$]): calcd for $C_{18}H_{16}O_2$ 265.1223, found 265.1227



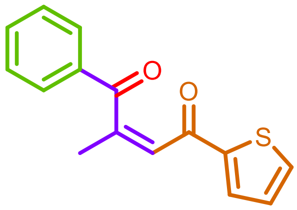
(*Z*)-4-(3,5-dimethylphenyl)-2-methyl-1-phenylbut-2-ene-1,4-dione (3ax)

15.6 mg, 56% yield.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.92 – 7.90 (m, 2H), 7.53 (d, *J* = 7.1 Hz, 3H), 7.44 (t, *J* = 7.7 Hz, 2H), 7.18 (s, 1H), 7.14 (d, *J* = 1.7 Hz, 1H), 2.34 (s, 6H), 2.25 (s, 3H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 199.4, 188.4, 155.8, 138.3, 137.0, 134.9, 134.6, 133.2, 128.7, 128.4, 126.4, 123.2, 22.1, 21.2.

HRMS (ESI-TOF, [M + H$^+$]): calcd for $C_{19}H_{18}O_2$ 279.1380, found 279.1378



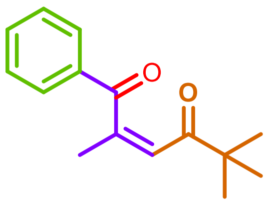
(*Z*)-2-methyl-1-phenyl-4-(thiophen-2-yl) but-2-ene-1,4-dione (3ay)

13.6 mg, 53% yield. The spectra matched with the previous report.[7]

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.87 (d, *J* = 7.6 Hz, 2H), 7.68 (d, *J* = 4.8 Hz, 1H), 7.63 – 7.62 (m, 2H), 7.51 (t, *J* = 7.7 Hz, 2H), 7.13 – 7.11 (m, 1H), 7.04 (d, *J* = 1.7 Hz, 1H), 2.44 (s, 3H).

^{13}C NMR (125 MHz, DCl_3) δ 198.1, 183.5, 150.6, 145.6, 136.0, 134.7, 133.3, 132.3, 129.8, 128.7, 128.6, 128.4, 16.1.

HRMS (ESI-TOF, [M + H$^+$]): calcd for $C_{15}H_{12}O_2S$ 257.0631, found 257.0631



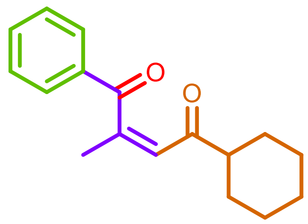
(*Z*)-2,5,5-trimethyl-1-phenylhex-2-ene-1,4-dione (3az)

15.9 mg, 69% yield.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.85 (d, *J* = 7.6 Hz, 2H), 7.54 (t, *J* = 7.0 Hz, 1H), 7.44 (t, *J* = 7.5 Hz, 2H), 6.64 (s, 1H), 2.13 (s, 3H), 1.12 (s, 9H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 202.9, 199.6, 154.9, 134.4, 133.2, 128.7, 128.3, 122.5, 42.8, 26.0, 21.8.

HRMS (ESI-TOF, [M + H$^+$]): calcd for $C_{15}H_{18}O_2$ 231.1380, found 231.1380



(*Z*)-4-cyclohexyl-2-methyl-1-phenylbut-2-ene-1,4-dione (3ba)

11.2 mg, 46% yield.

^{1}H NMR (500 MHz, $CDCl_3$) δ 7.88 (d, *J* = 7.7 Hz, 2H), 7.57 (t, *J* = 7.2 Hz, 1H), 7.47 (t, *J* = 7.6 Hz, 2H), 6.48 (s, 1H), 2.42 – 2.26 (m, 1H), 2.14 (s, 3H), 1.85 – 1.82 (m, 2H), 1.79 – 1.77 (m, 2H), 1.67 (d, *J* = 12.2 Hz, 1H), 1.29 – 1.25 (m, 4H), 1.20 – 1.15 (m, 1H).

^{13}C NMR (125 MHz, $CDCl_3$) δ 201.1, 199.6, 154.2, 134.4, 133.3, 128.7, 128.3, 125.3, 50.1, 27.9, 25.7, 25.5, 21.7.

HRMS (ESI-TOF, [M + H^+]): calcd for $C_{17}H_{20}O_2$ 257.1536, found 257.1537

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[4] Gaussian 16, Revision A.03, M. J. Frisch, G. W. Trucks, H. B. Schlegel, G. E. Scuseria, M. A. Robb, J. R. Cheeseman, G. Scalmani, V. Barone, G. A. Petersson, H. Nakatsuji, X. Li, M. Caricato, A. V. Marenich, J. Bloino, B. G. Janesko, R. Gomperts, B. Mennucci, H. P. Hratchian, J. V. Ortiz, A. F. Izmaylov, J. L. Sonnenberg, D. Williams-Young, F. Ding, F. Lipparini, F. Egidi, J. Goings, B. Peng, A. Petrone, T. Henderson, D. Ranasinghe, V. G. Zakrzewski, J. Gao, N. Rega, G. Zheng, W. Liang, M. Hada, M. Ehara, K. Toyota, R. Fukuda, J. Hasegawa, M. Ishida, T. Nakajima, Y. Honda, O. Kitao, H. Nakai, T. Vreven, K. Throssell, J. A. Montgomery, Jr., J. E. Peralta, F. Ogliaro, M. J. Bearpark, J. J. Heyd, E. N. Brothers, K. N. Kudin, V. N. Staroverov, T. A. Keith, R. Kobayashi, J. Normand, K. Raghavachari, A. P. Rendell, J. C. Burant, S. S. Iyengar, J. Tomasi, M. Cossi, J. M. Millam, M. Klene, C. Adamo, R. Cammi, J. W. Ochterski, R. L. Martin, K. Morokuma, O. Farkas, J. B. Foresman, and D. J. Fox, Gaussian, Inc., Wallingford CT, **2016**.

[5] A. V. Marenich, C. J. Cramer and D. G. Truhlar, *J. Phys. Chem. B.*, 2009, **113**, 6378-6396.

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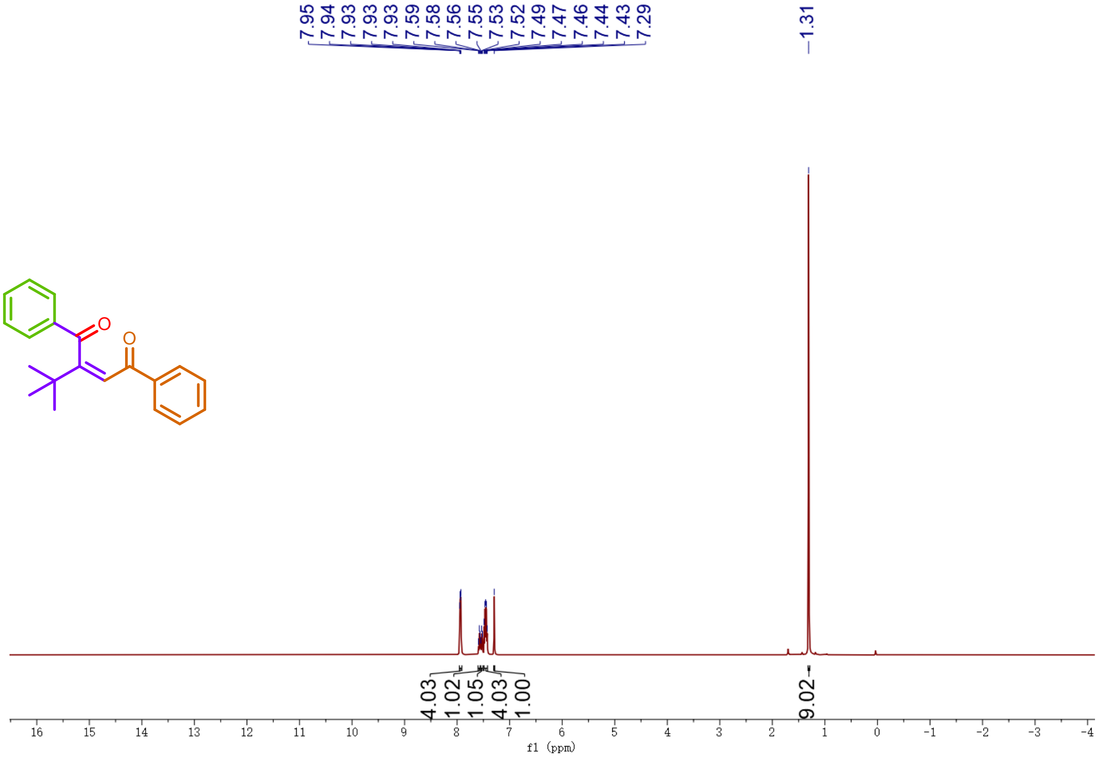
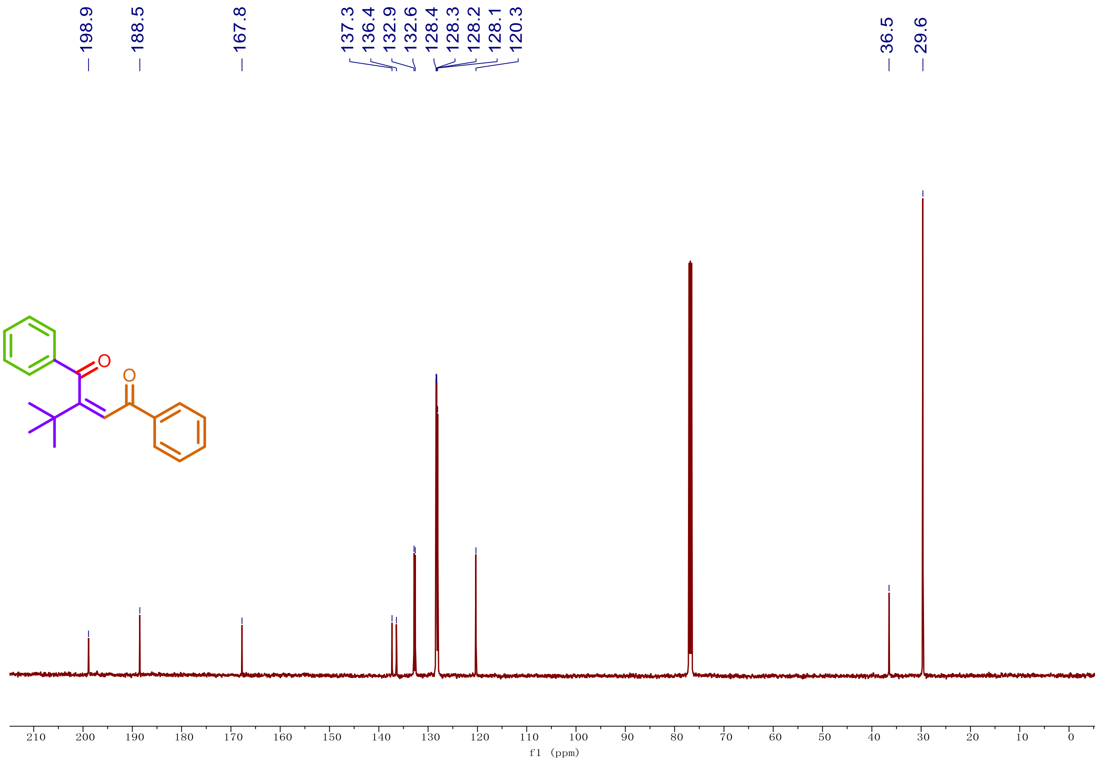
13. NMR Spectra

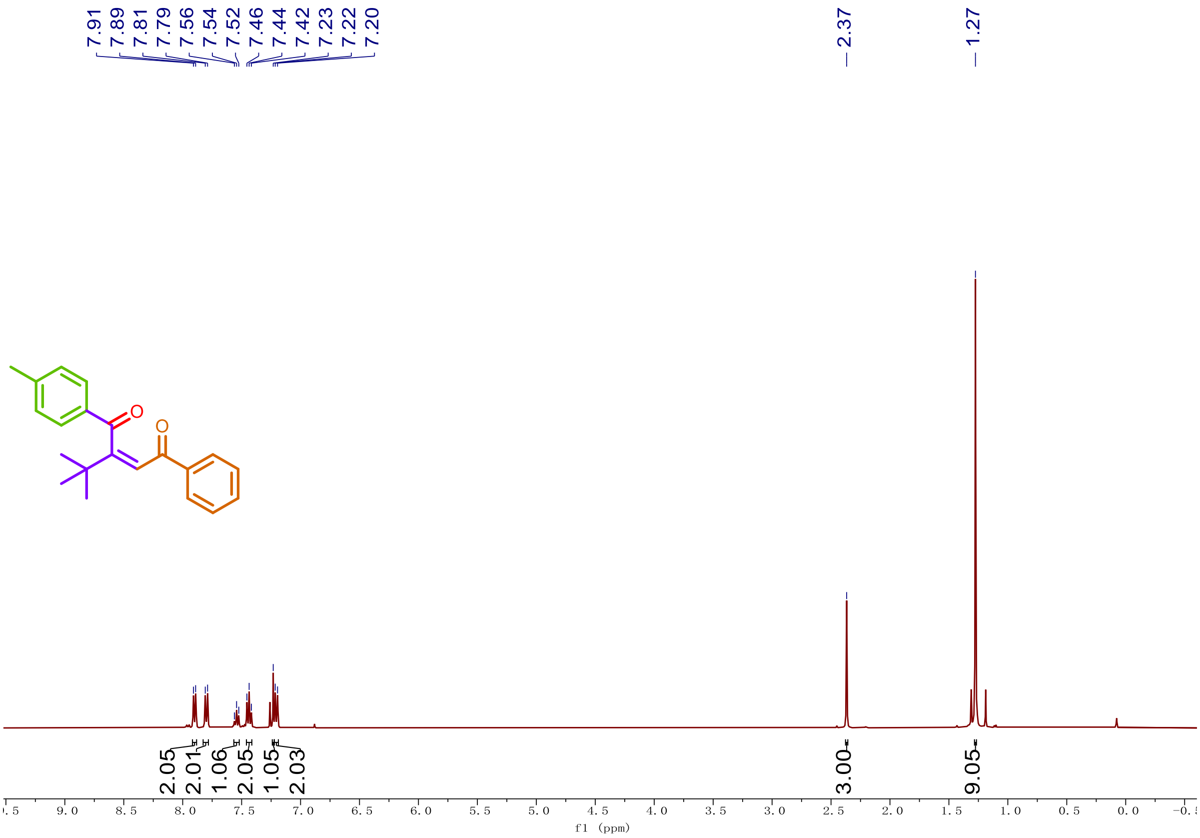
Compound 3a: [1]H NMR (500 MHz, $CDCl_3$)



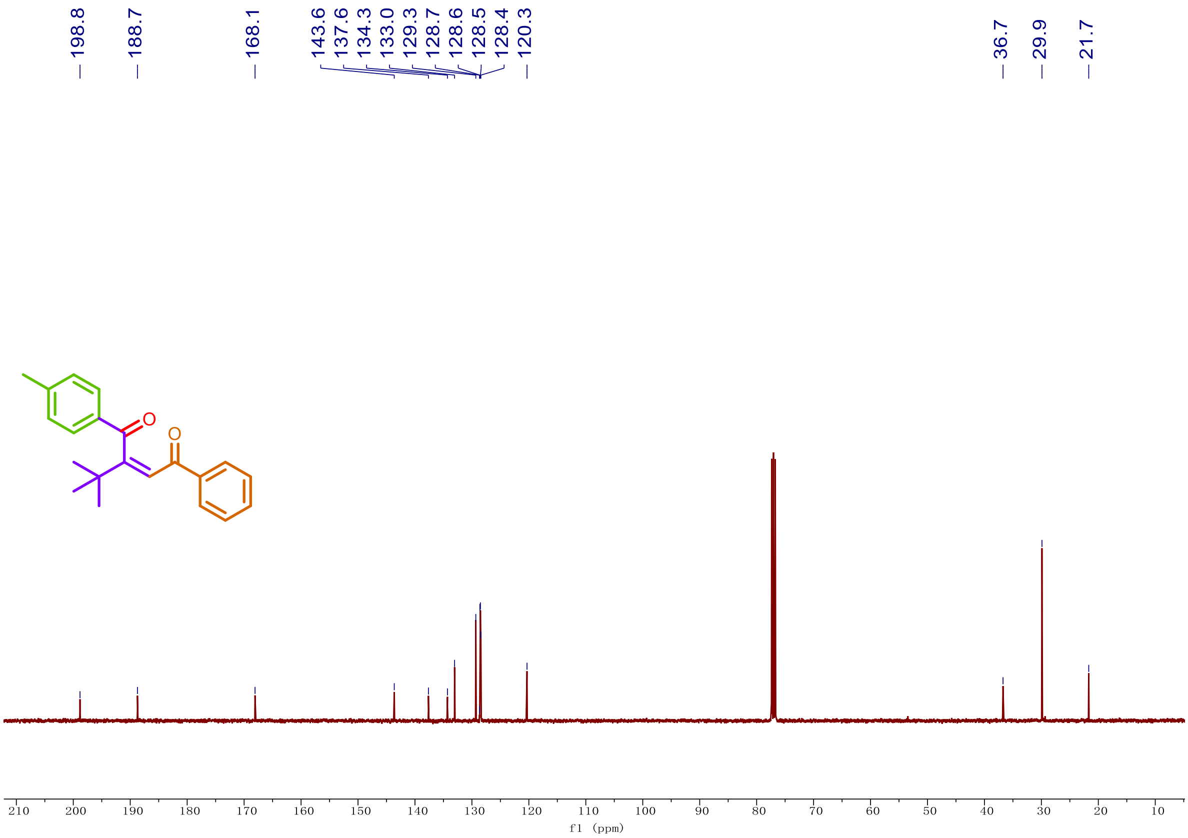
Compound 3a: [13]C NMR (125 MHz, $CDCl_3$)



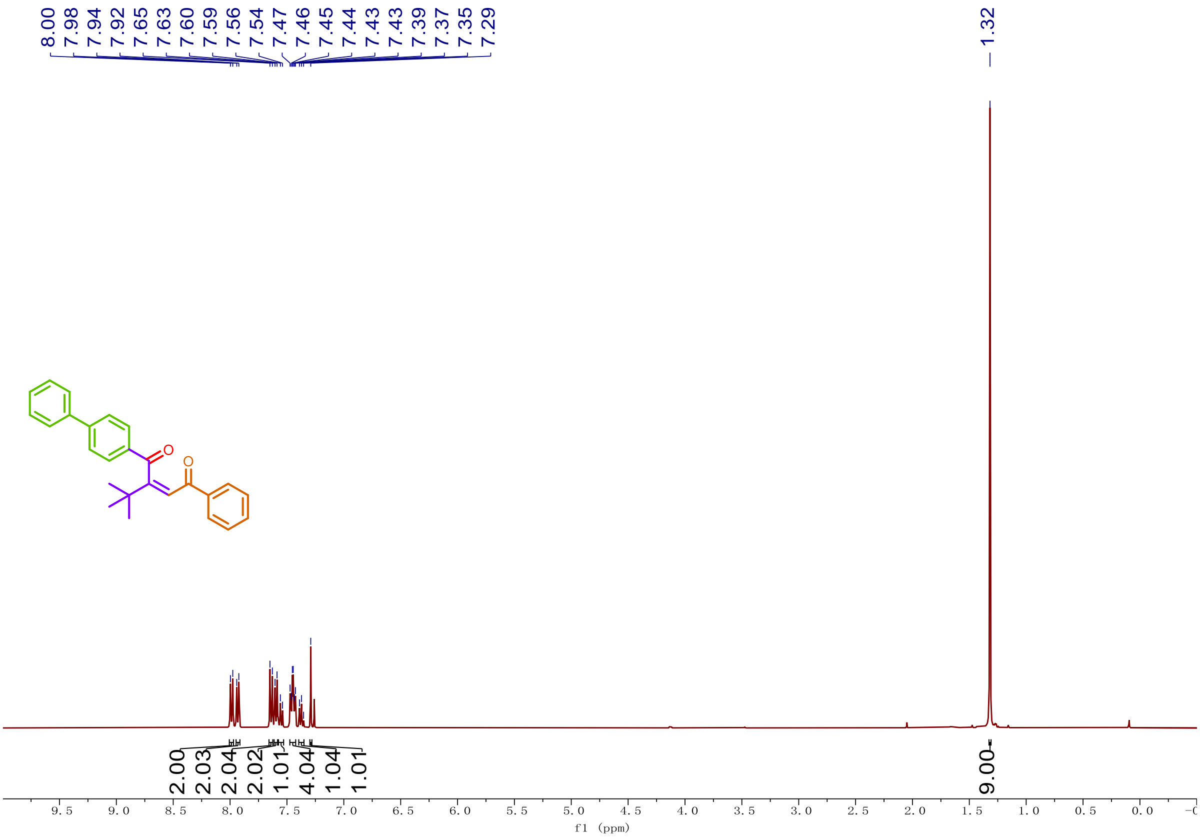
Compound 3b: ^{1}H NMR (500 MHz, $CDCl_3$)



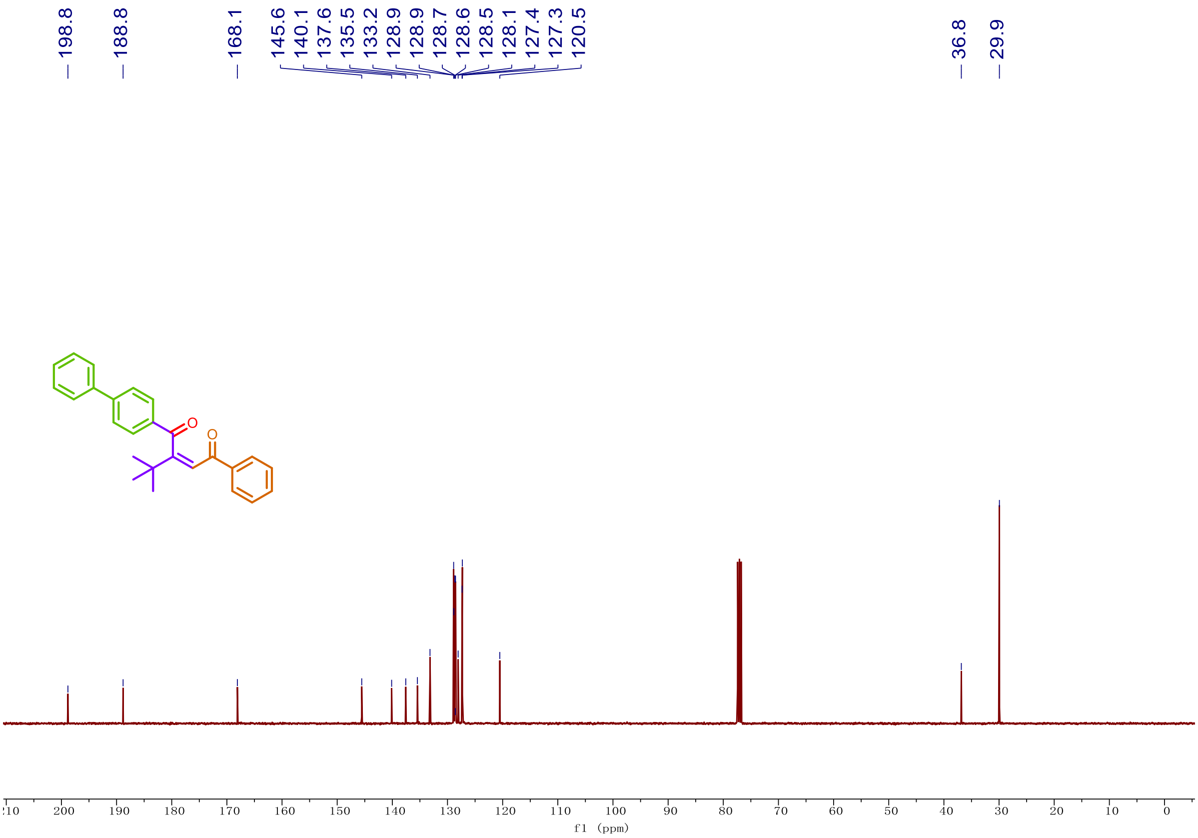
Compound 3b: ^{13}C NMR (125 MHz, $CDCl_3$)



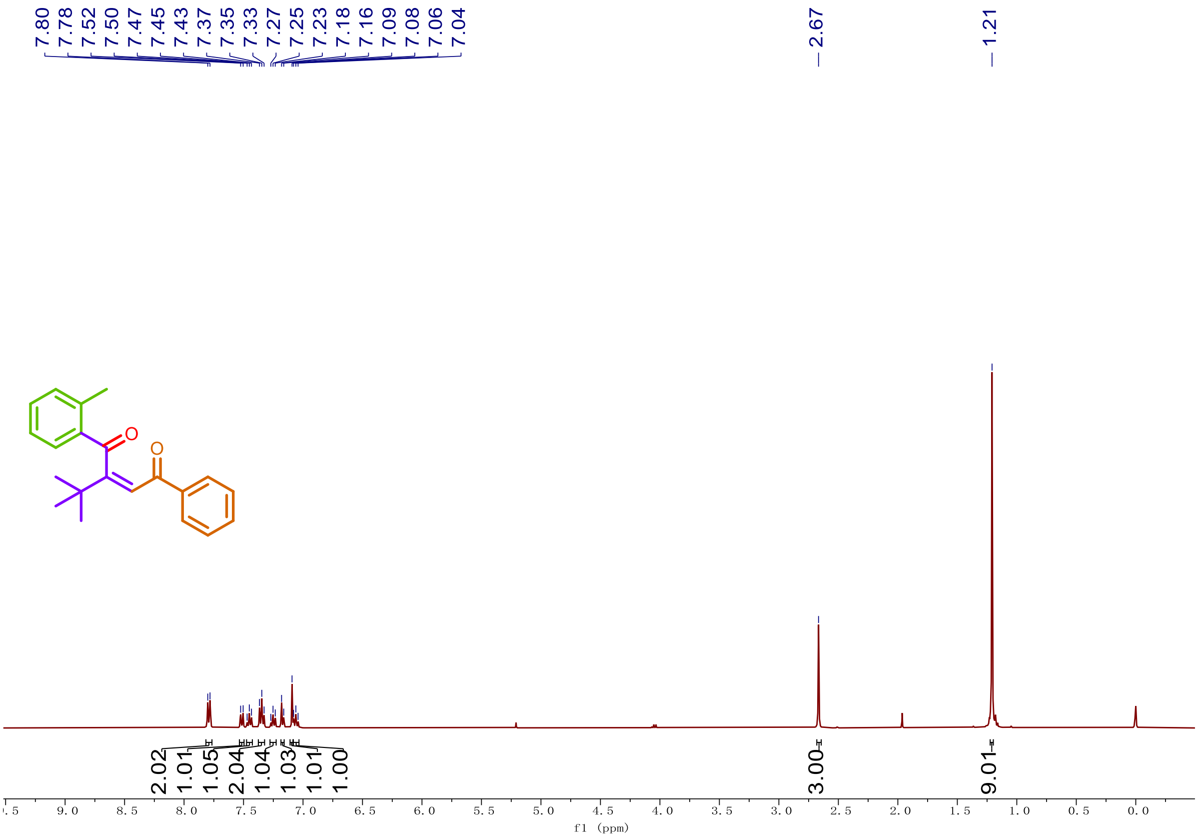
Compound 3c: ^{1}H NMR (500 MHz, $CDCl_3$)



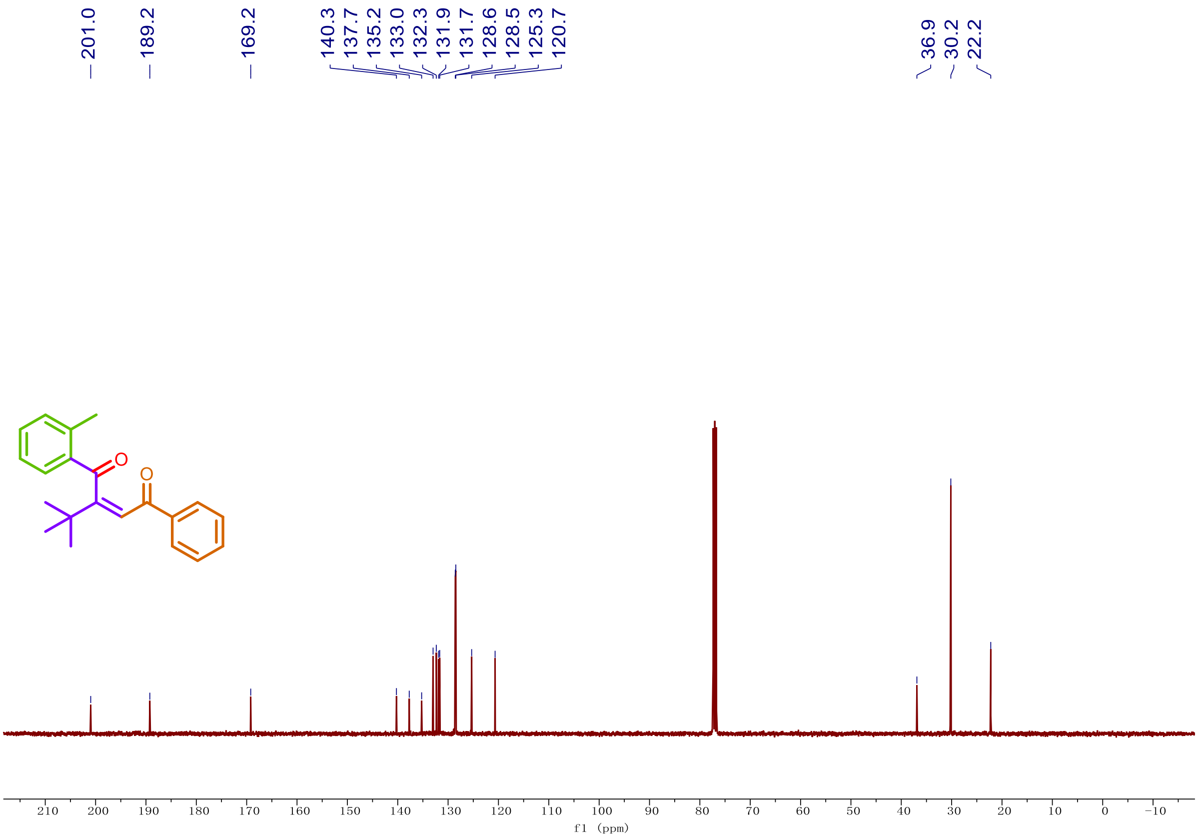
Compound 3c: ^{13}C NMR (125 MHz, $CDCl_3$)



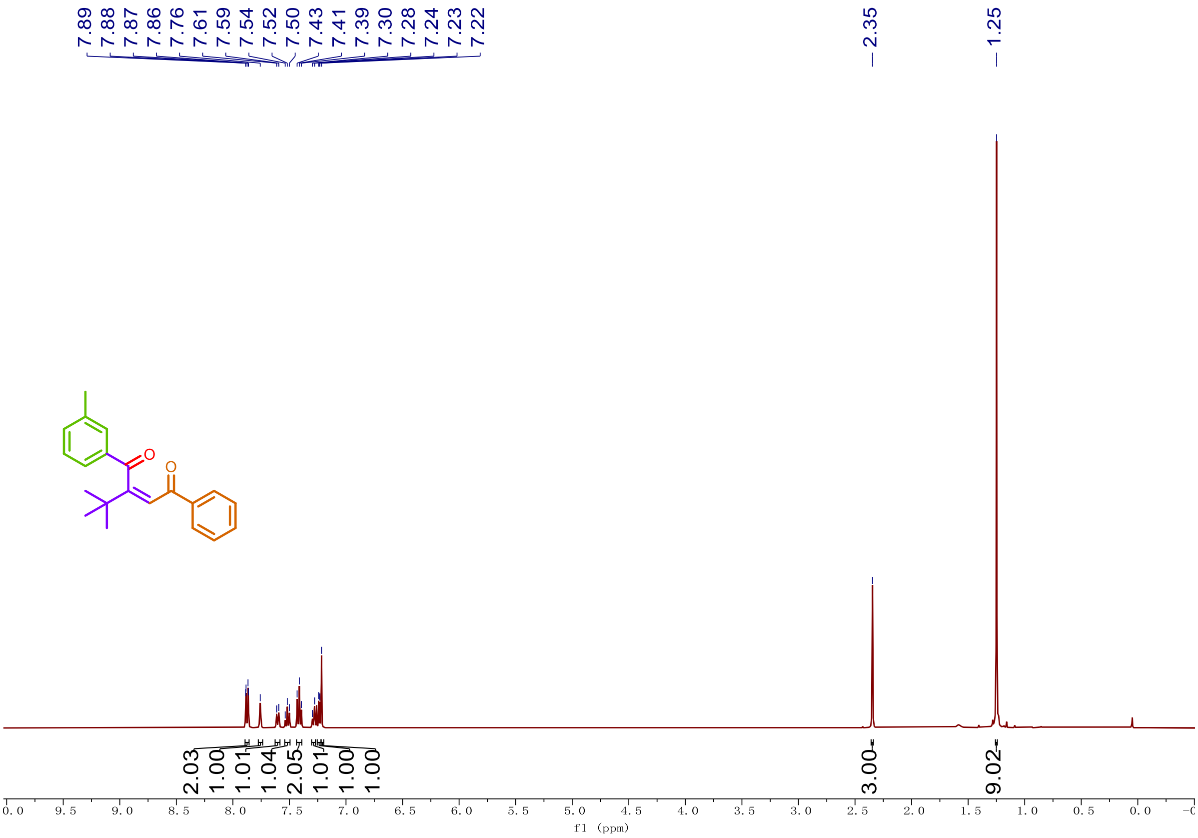
Compound 3d: ^{1}H NMR (500 MHz, $CDCl_3$)



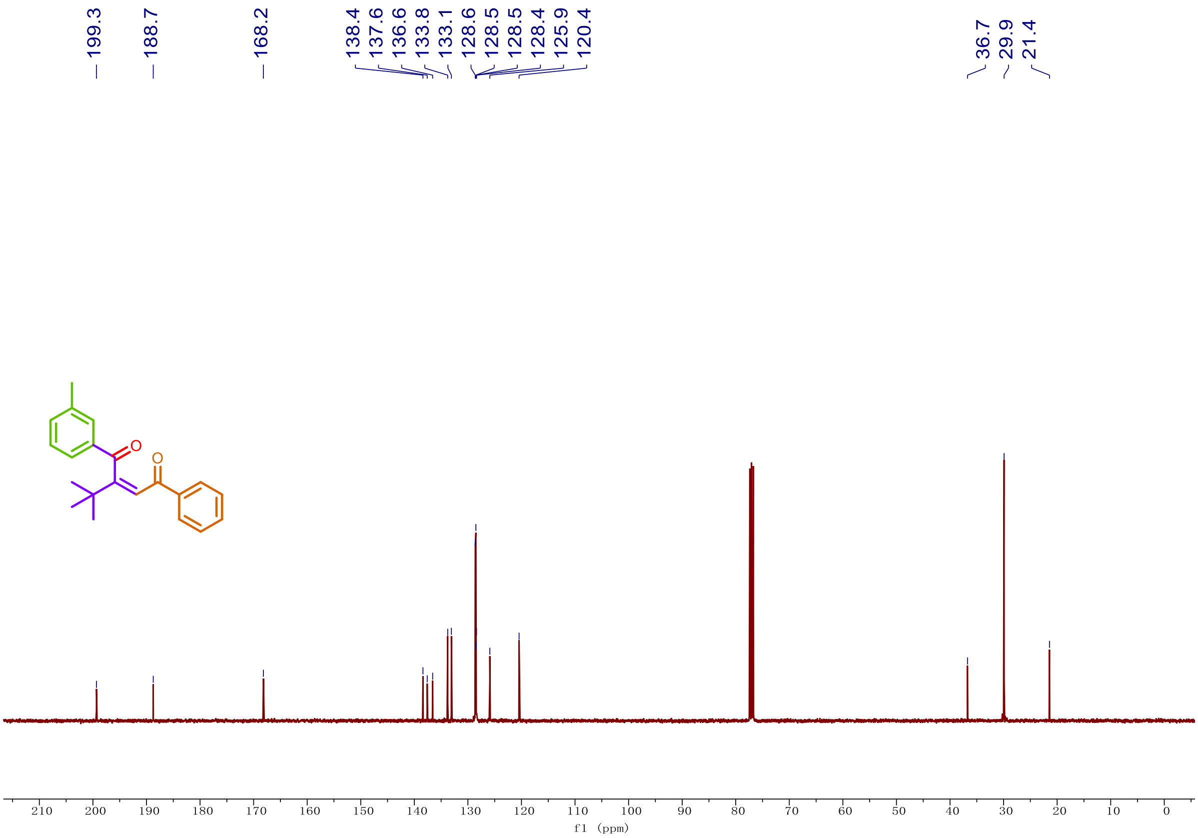
Compound 3d: ^{13}C NMR (125 MHz, $CDCl_3$)



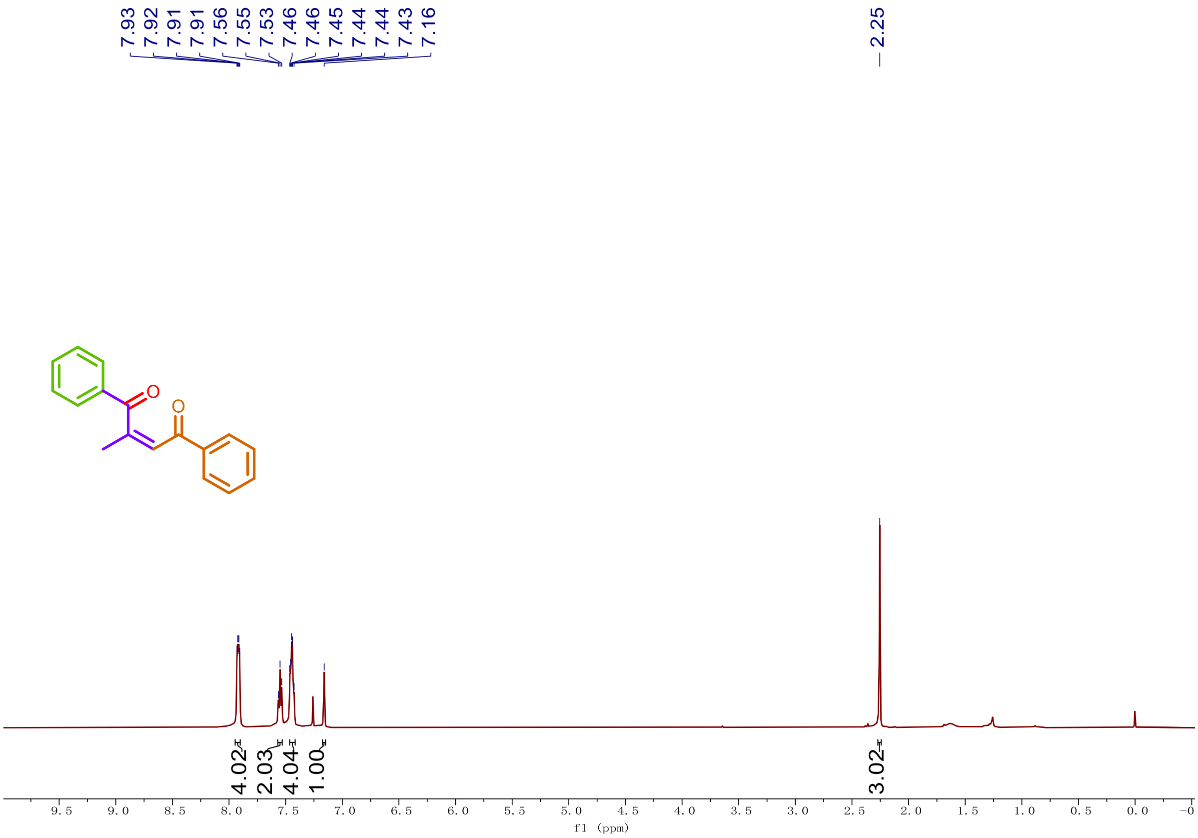
Compound 3e: **^{1}H NMR** (500 MHz, $CDCl_3$)



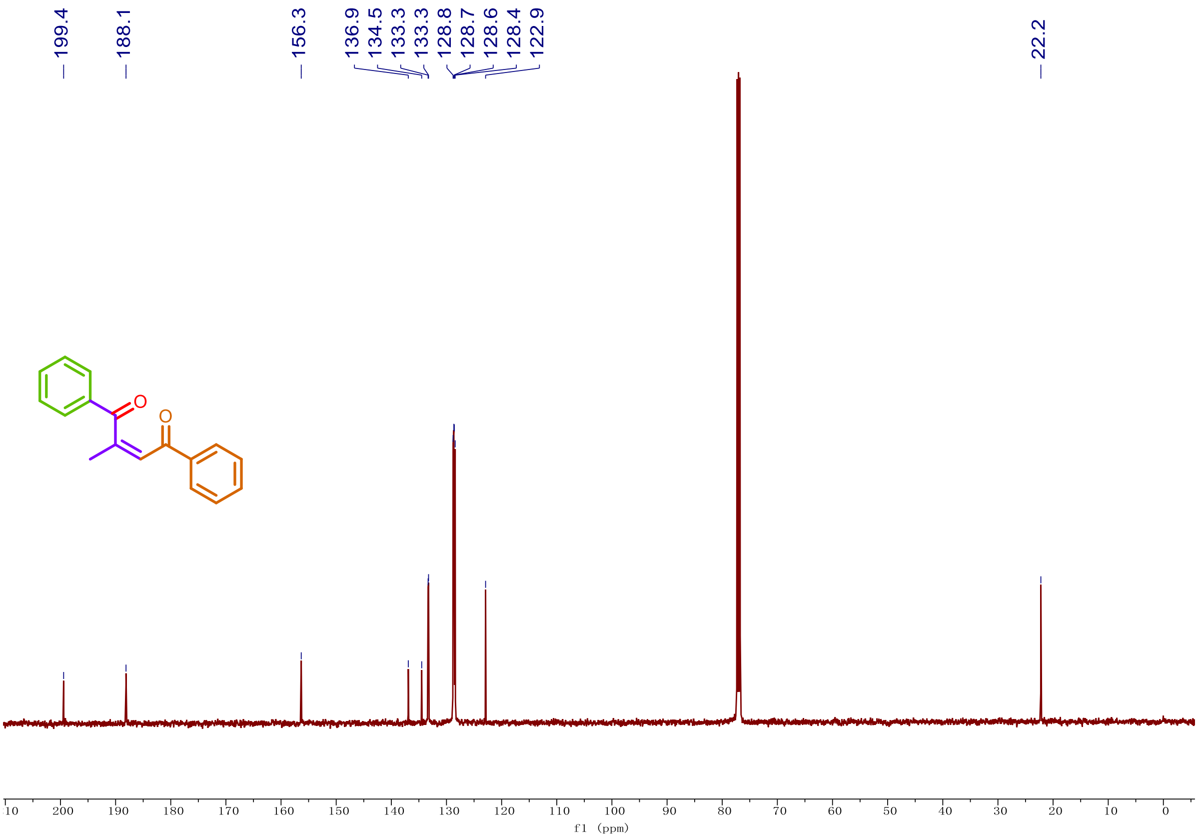
Compound 3e: **^{13}C NMR** (125 MHz, $CDCl_3$)



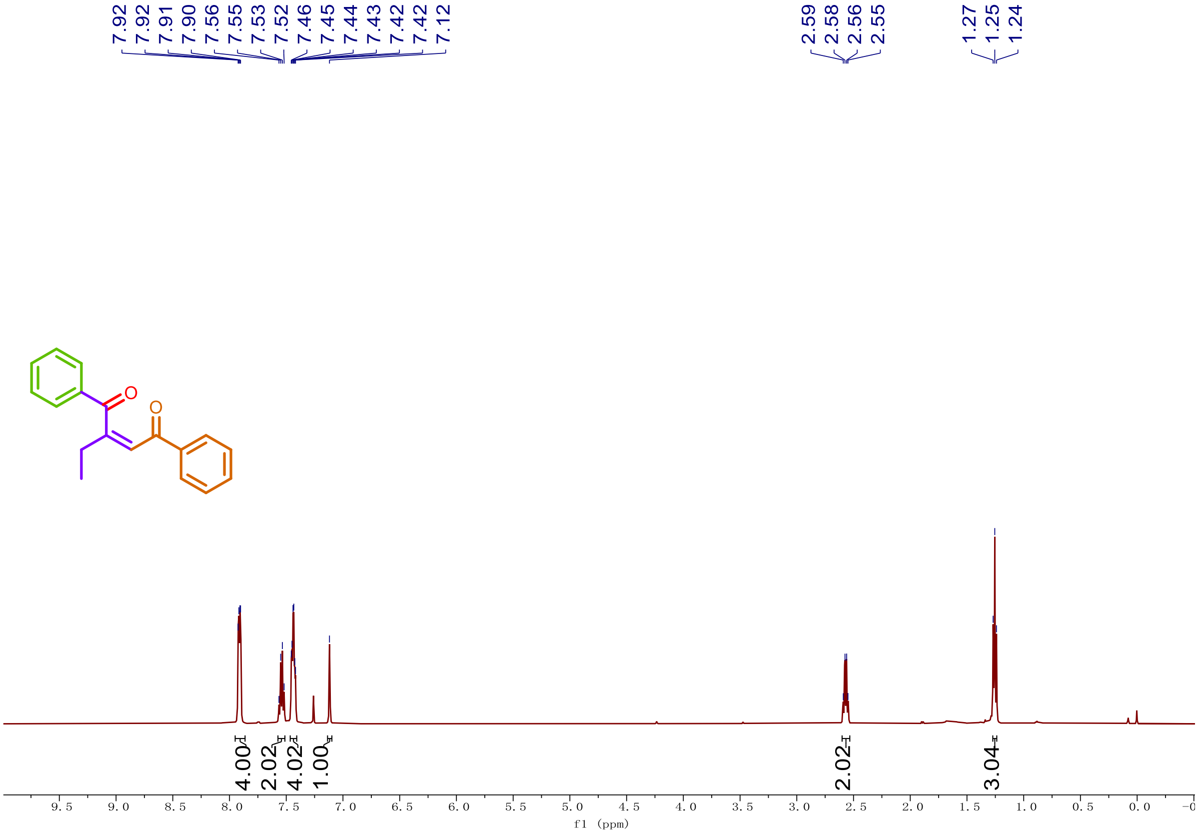
Compound 3f: ^{1}H NMR (500 MHz, $CDCl_3$)



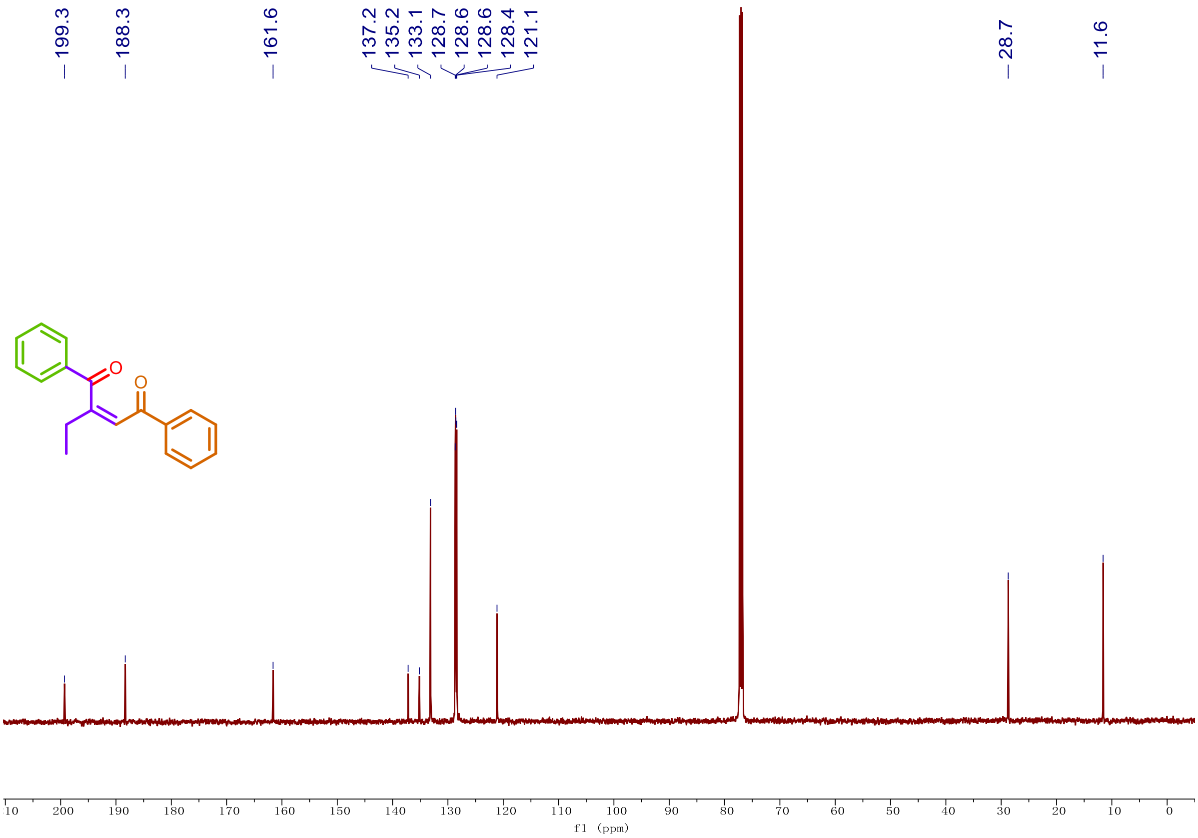
Compound 3f: ^{13}C NMR (125 MHz, $CDCl_3$)



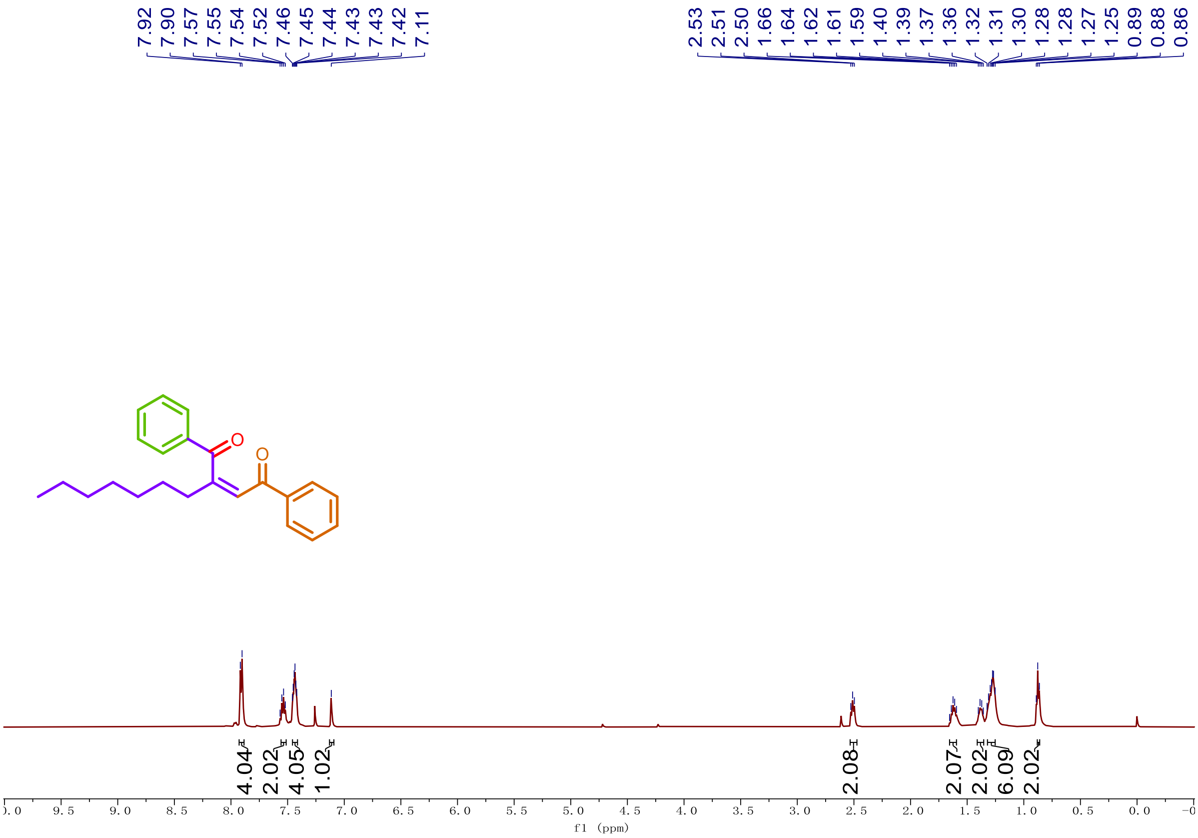
Compound 3g: ^{1}H NMR (500 MHz, $CDCl_3$)



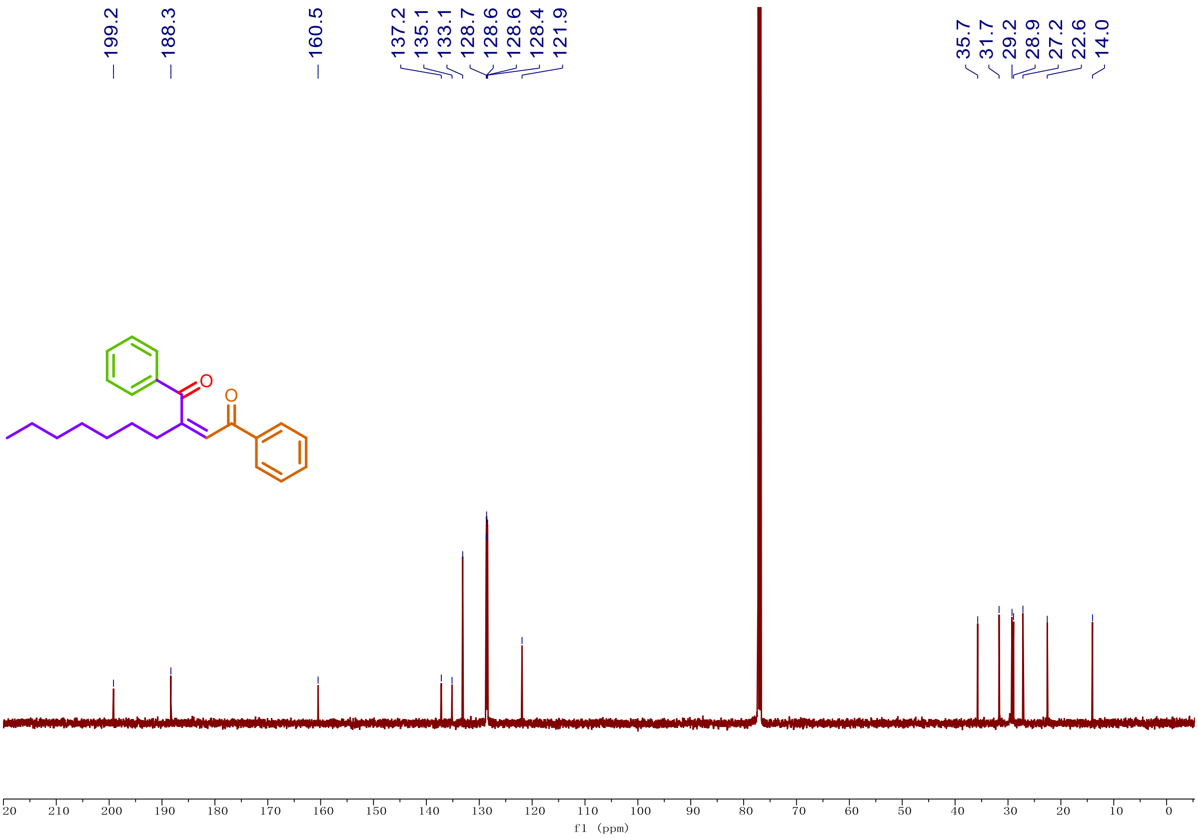
Compound 3g: ^{13}C NMR (125 MHz, $CDCl_3$)



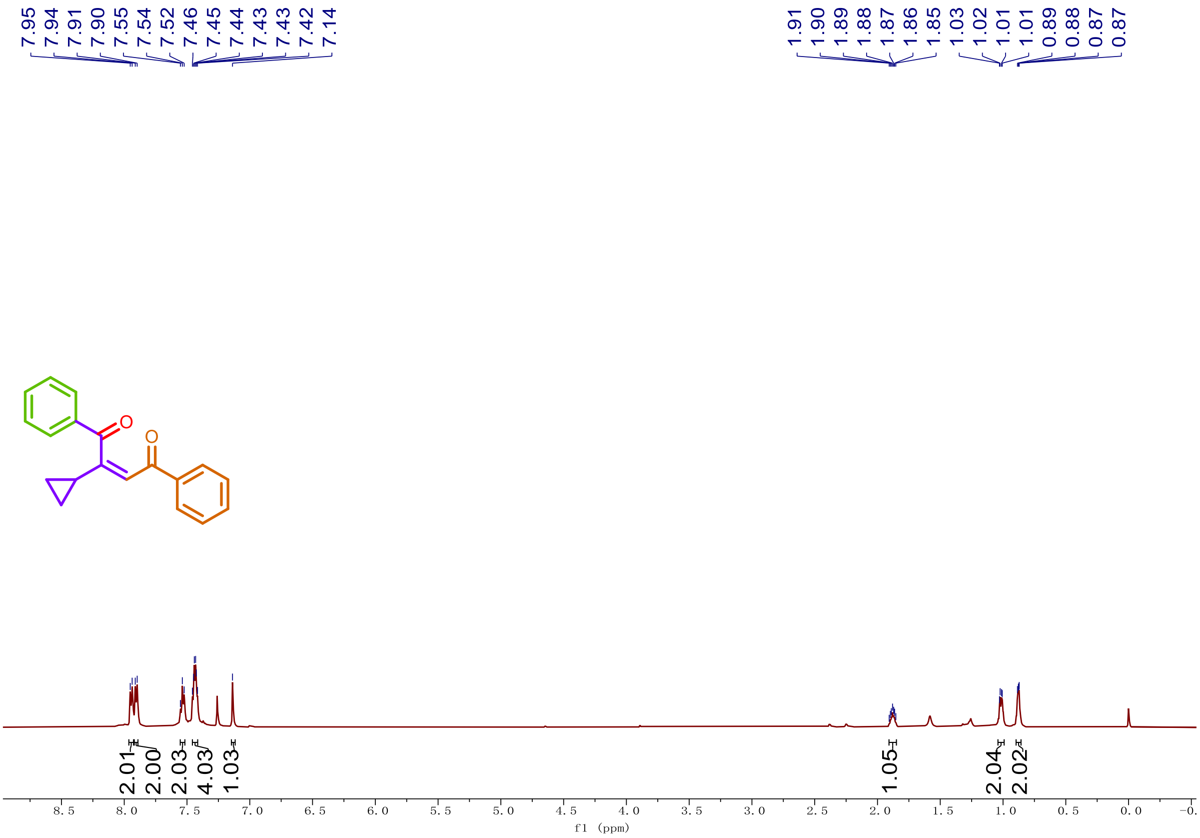
Compound 3h: ^{1}H NMR (500 MHz, $CDCl_3$)



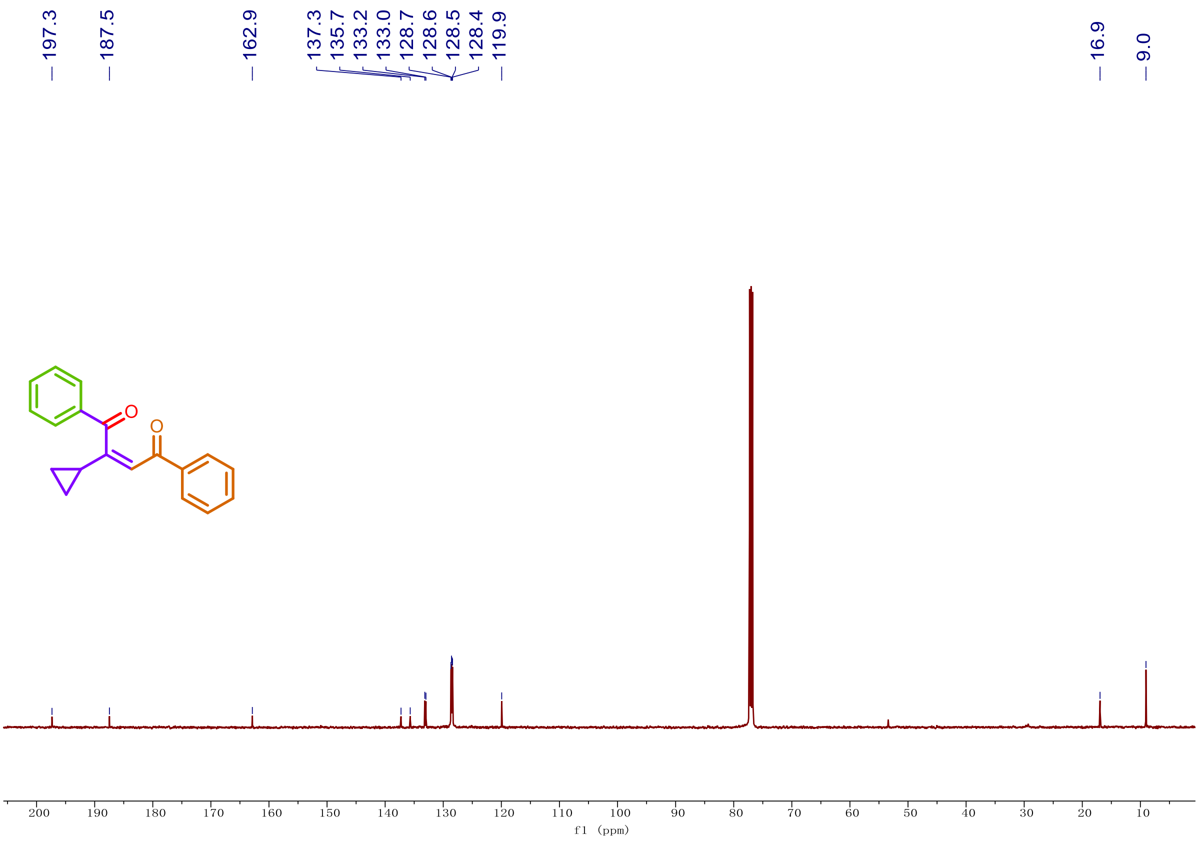
Compound 3h: ^{13}C NMR (125 MHz, $CDCl_3$)



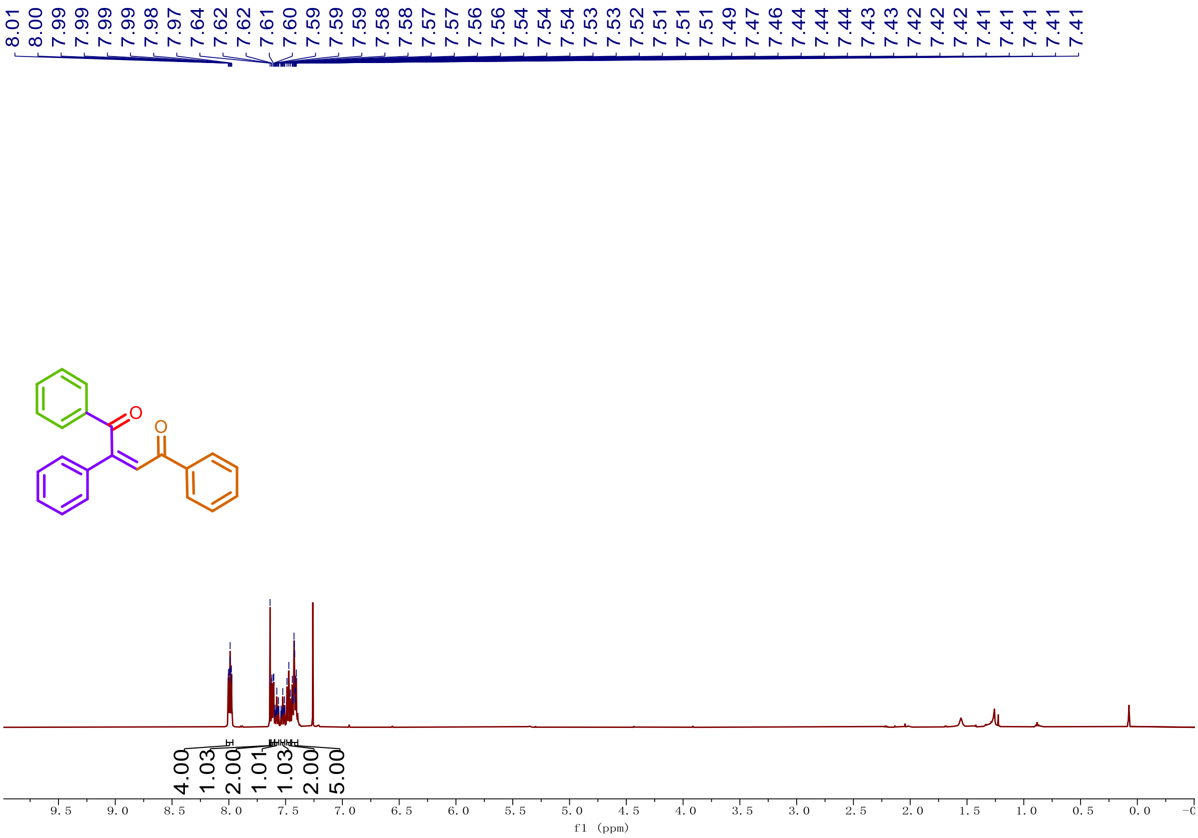
Compound 3i: ^{1}H NMR (500 MHz, $CDCl_3$)



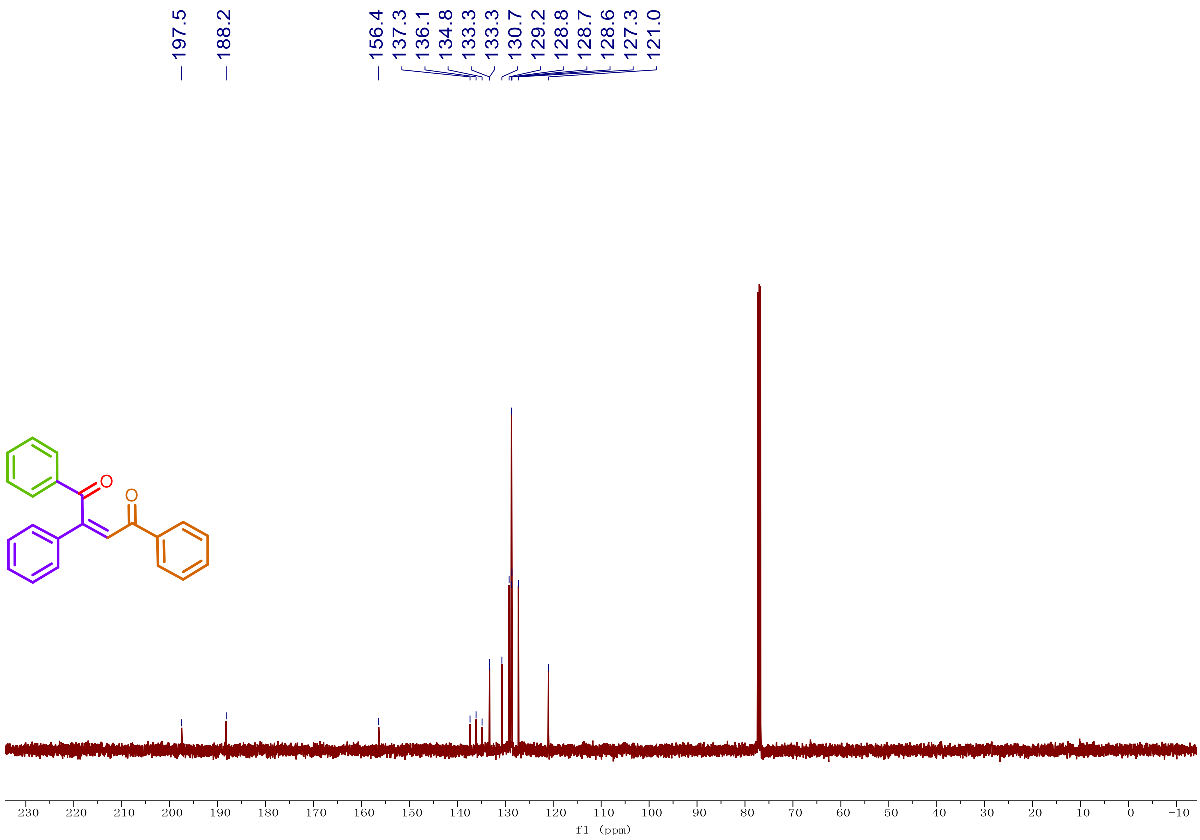
Compound 3i: ^{13}C NMR (125 MHz, $CDCl_3$)



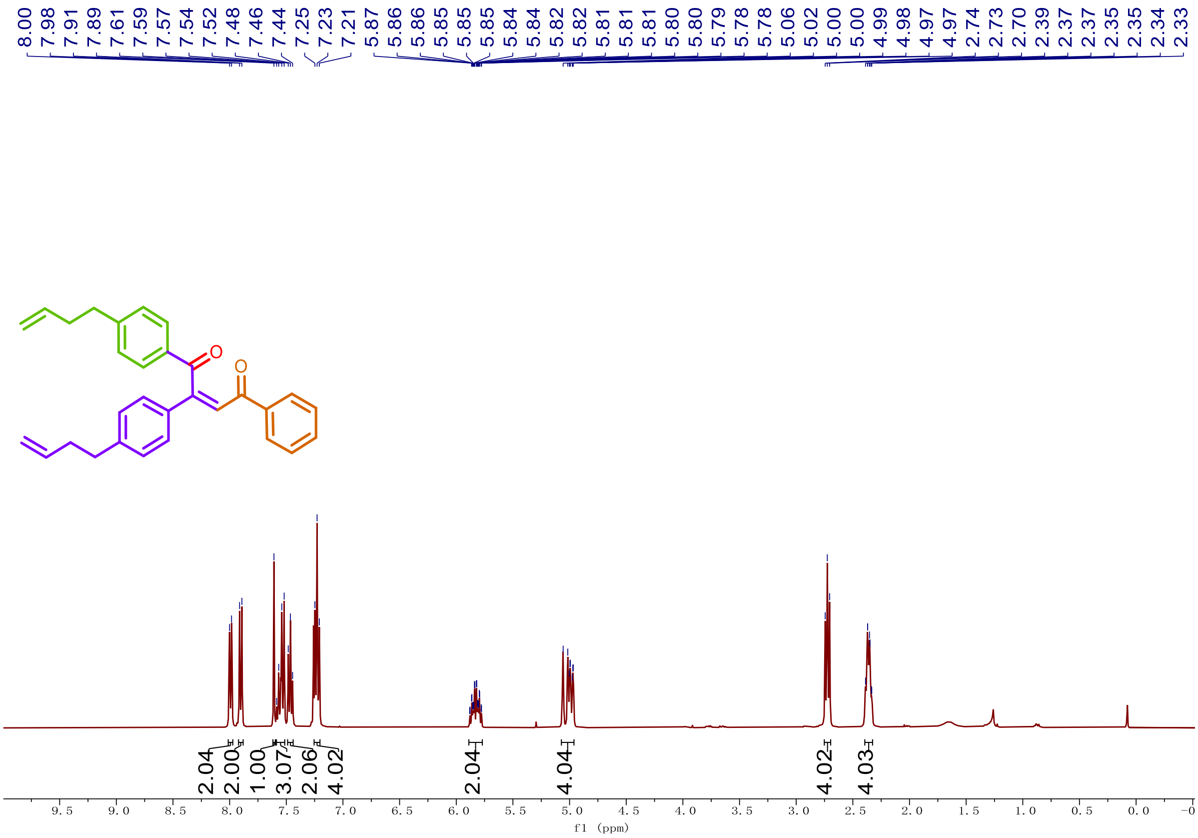
Compound 3j: ¹H NMR (500 MHz, $CDCl_3$)



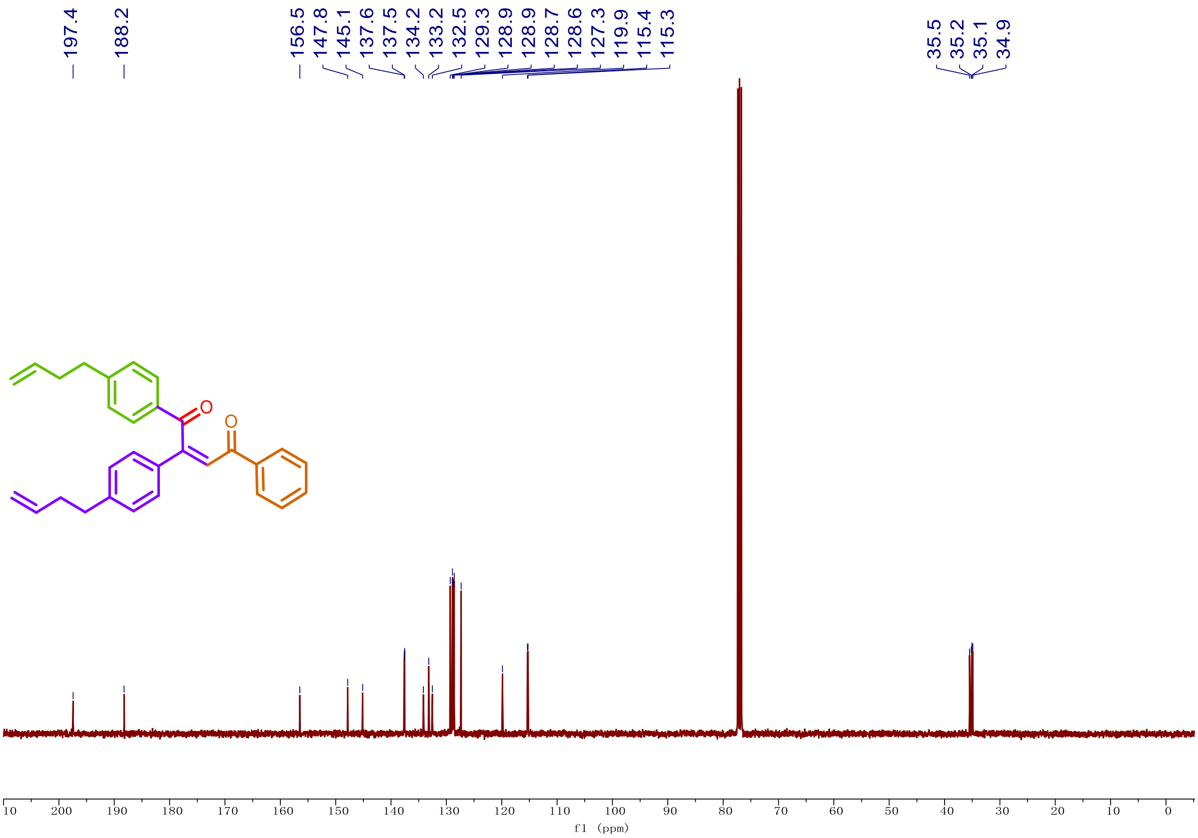
Compound 3j: ¹³C NMR (125 MHz, $CDCl_3$)



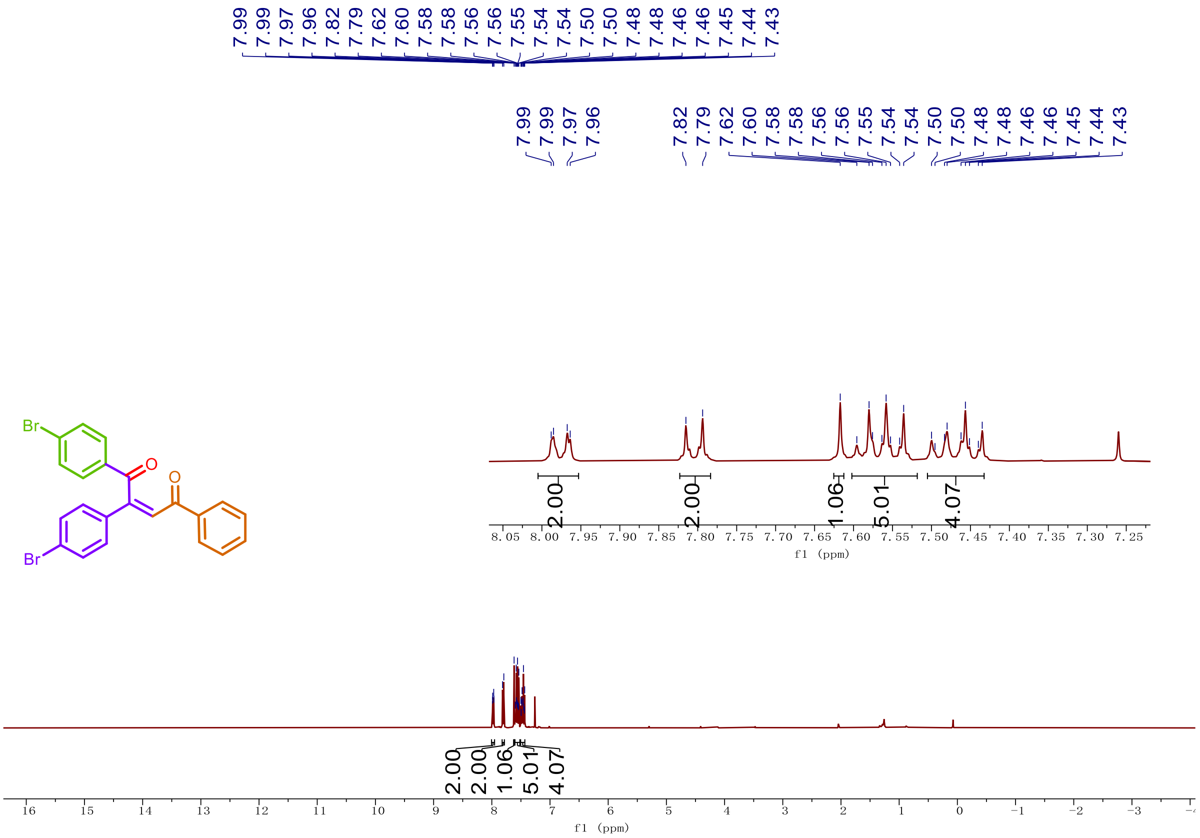
Compound 3k: ¹H NMR (500 MHz, $CDCl_3$)



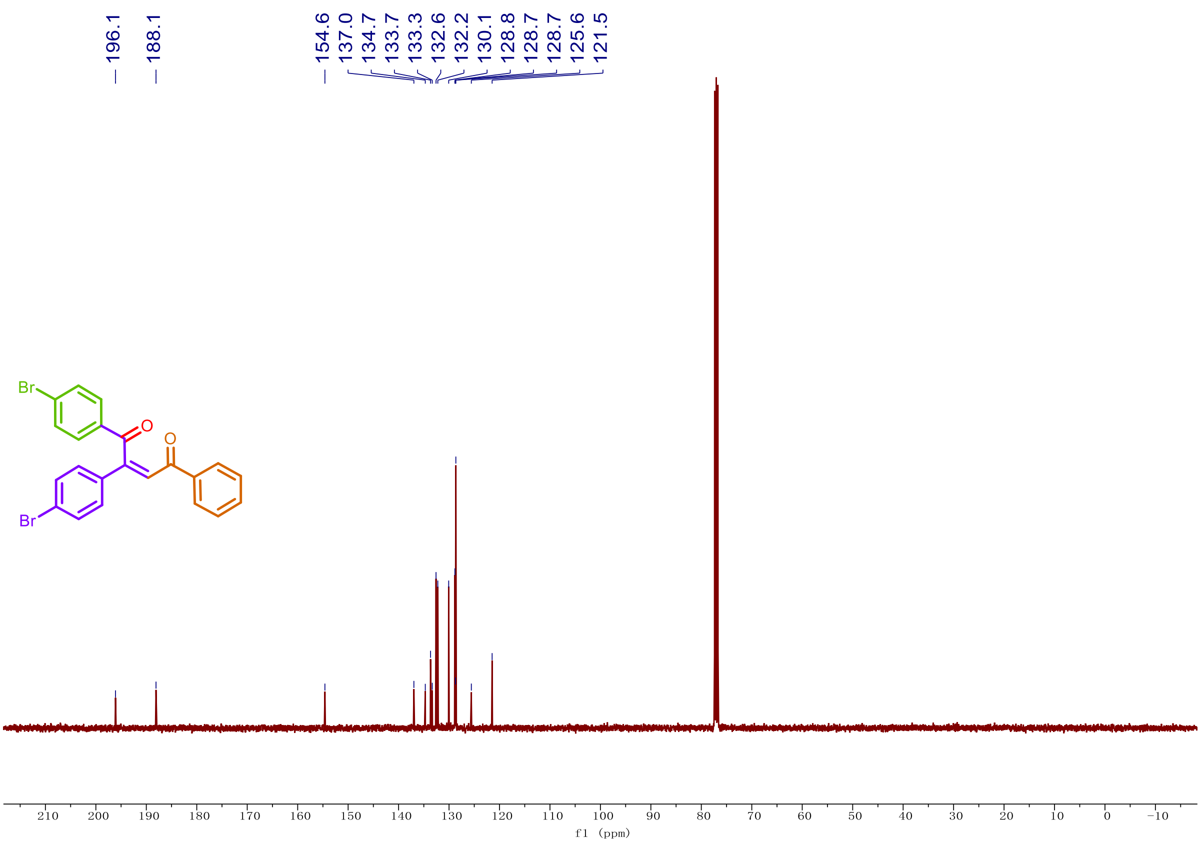
Compound 3k: ¹³C NMR (125 MHz, $CDCl_3$)



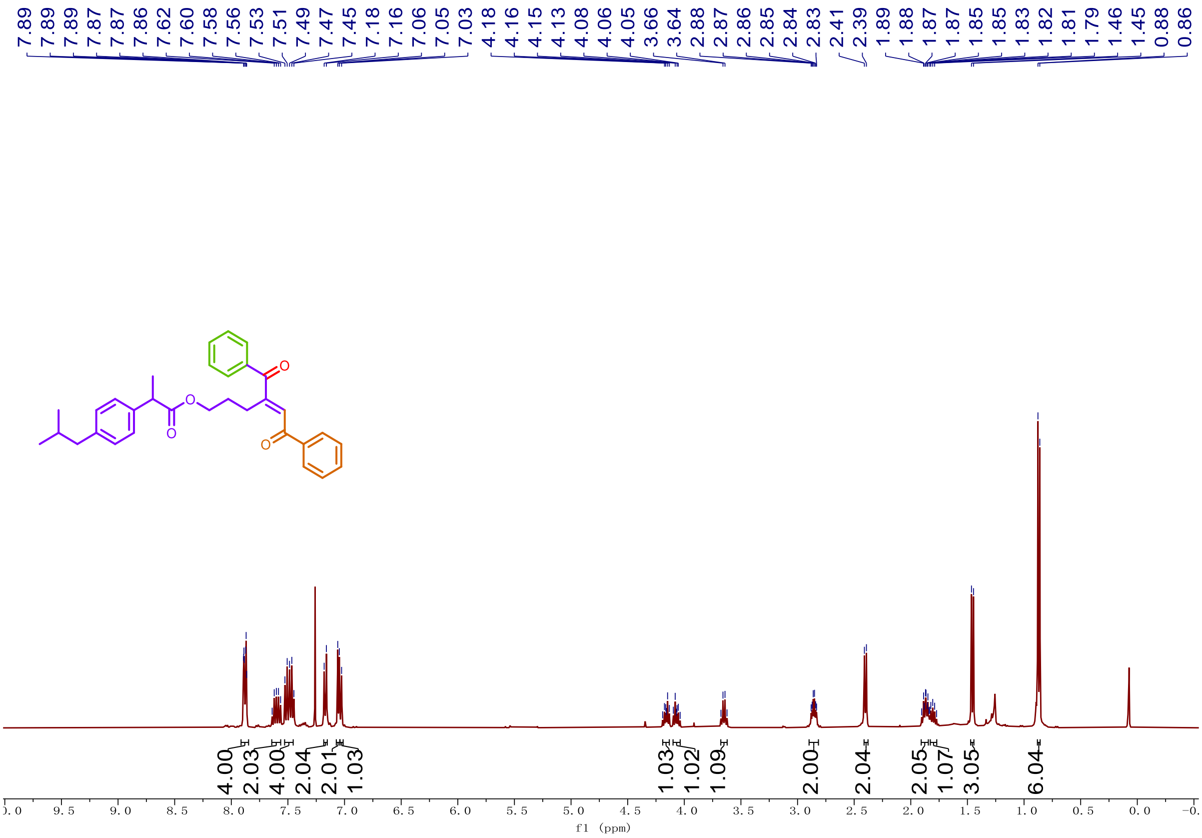
Compound 3l: ¹H NMR (500 MHz, $CDCl_3$)



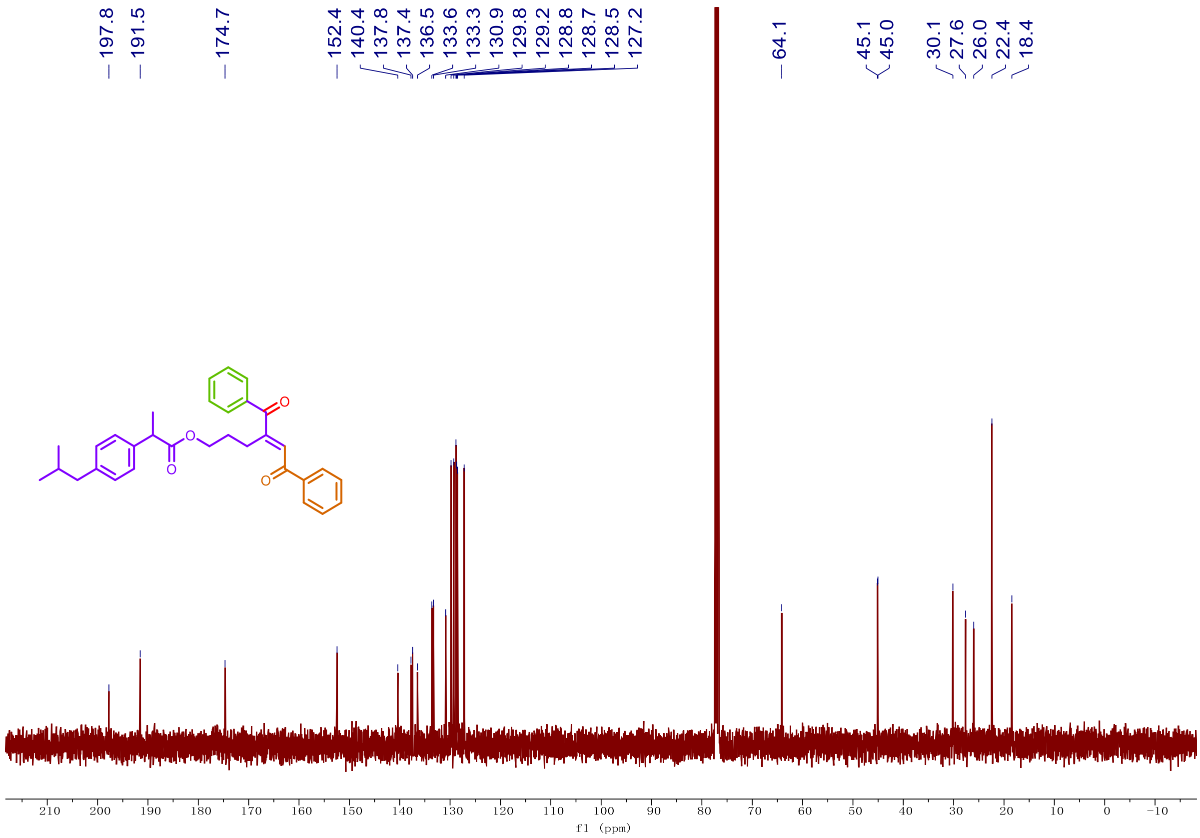
Compound 3l: ¹³C NMR (125 MHz, $CDCl_3$)



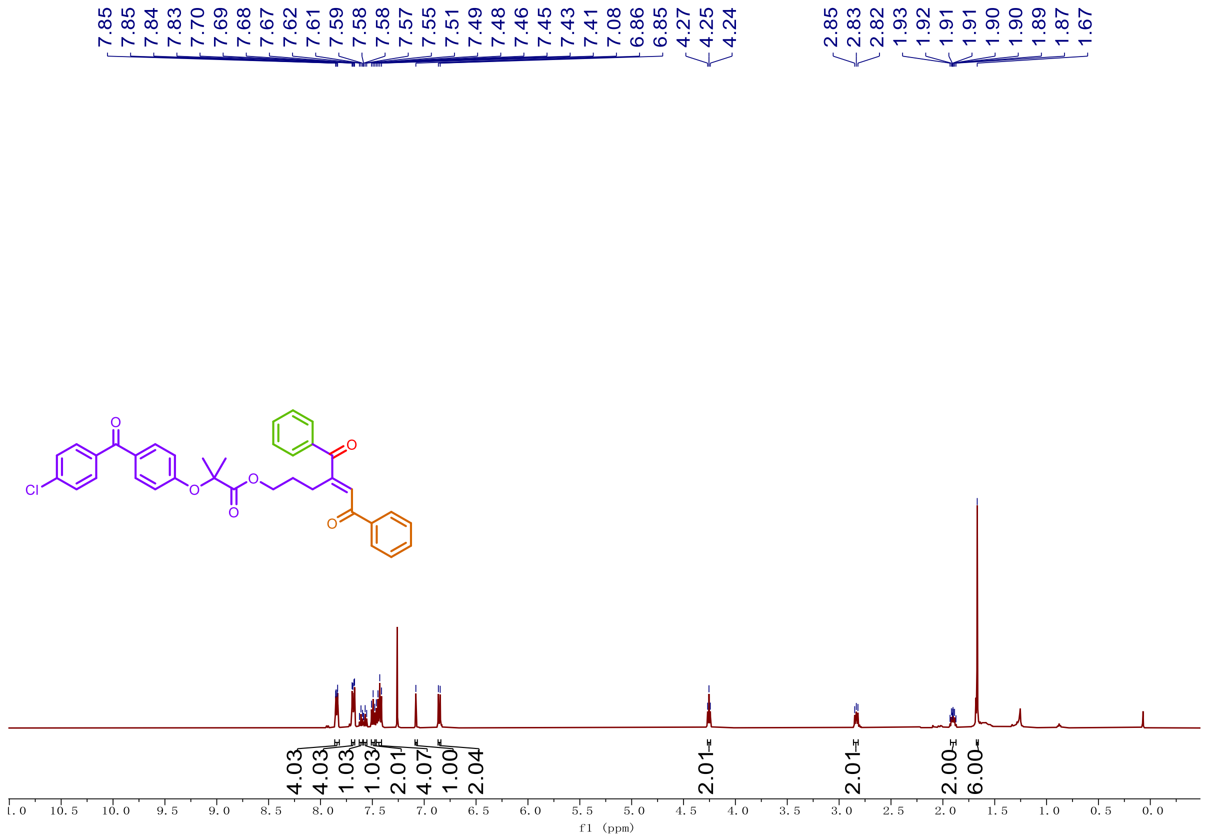
Compound 3m: ^{1}H NMR (500 MHz, $CDCl_3$)



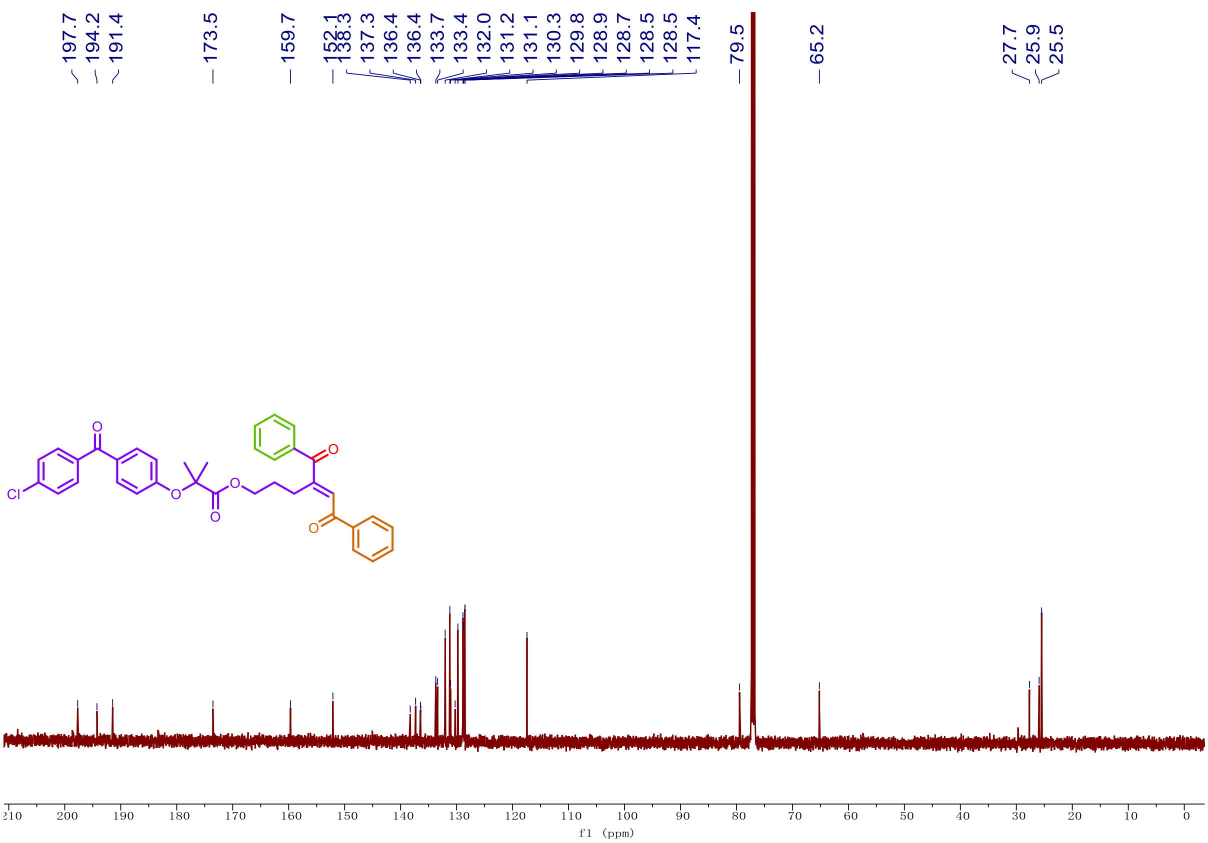
Compound 3m: ^{13}C NMR (125 MHz, $CDCl_3$)



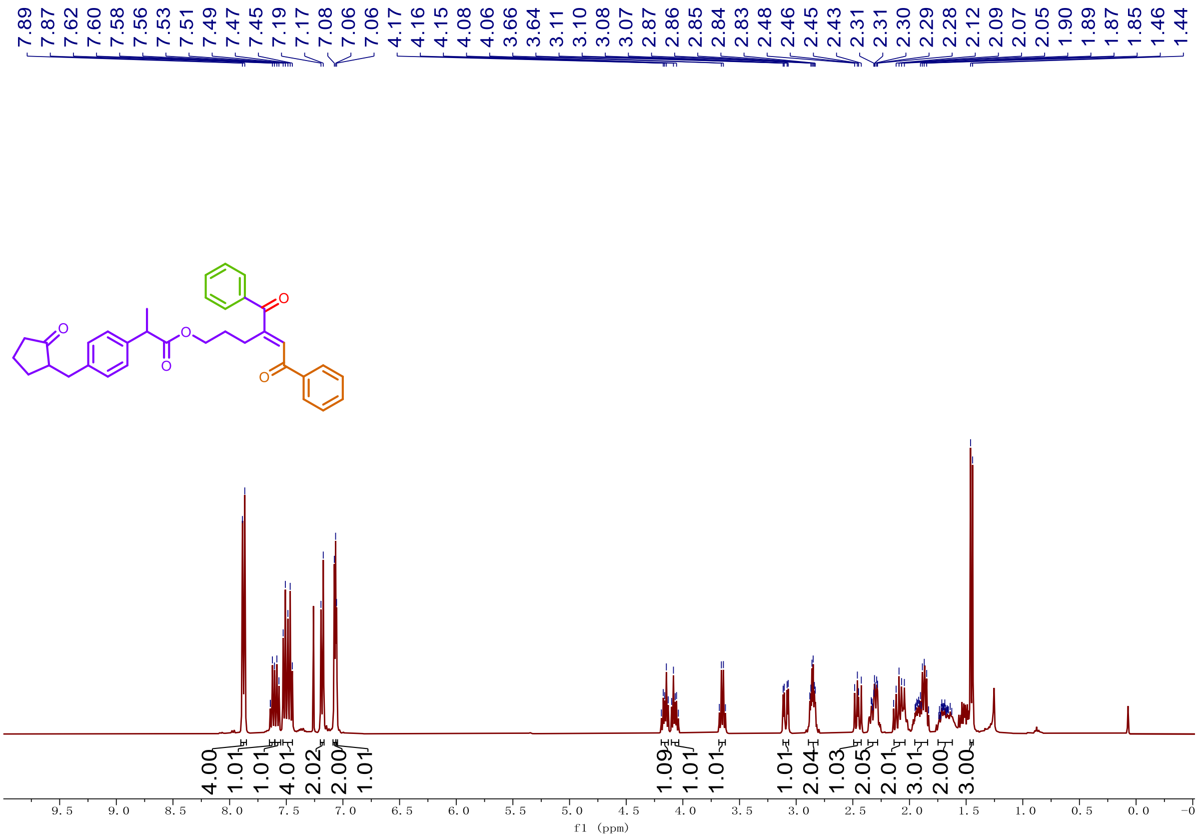
Compound 3n: ^{1}H NMR (500 MHz, $CDCl_3$)



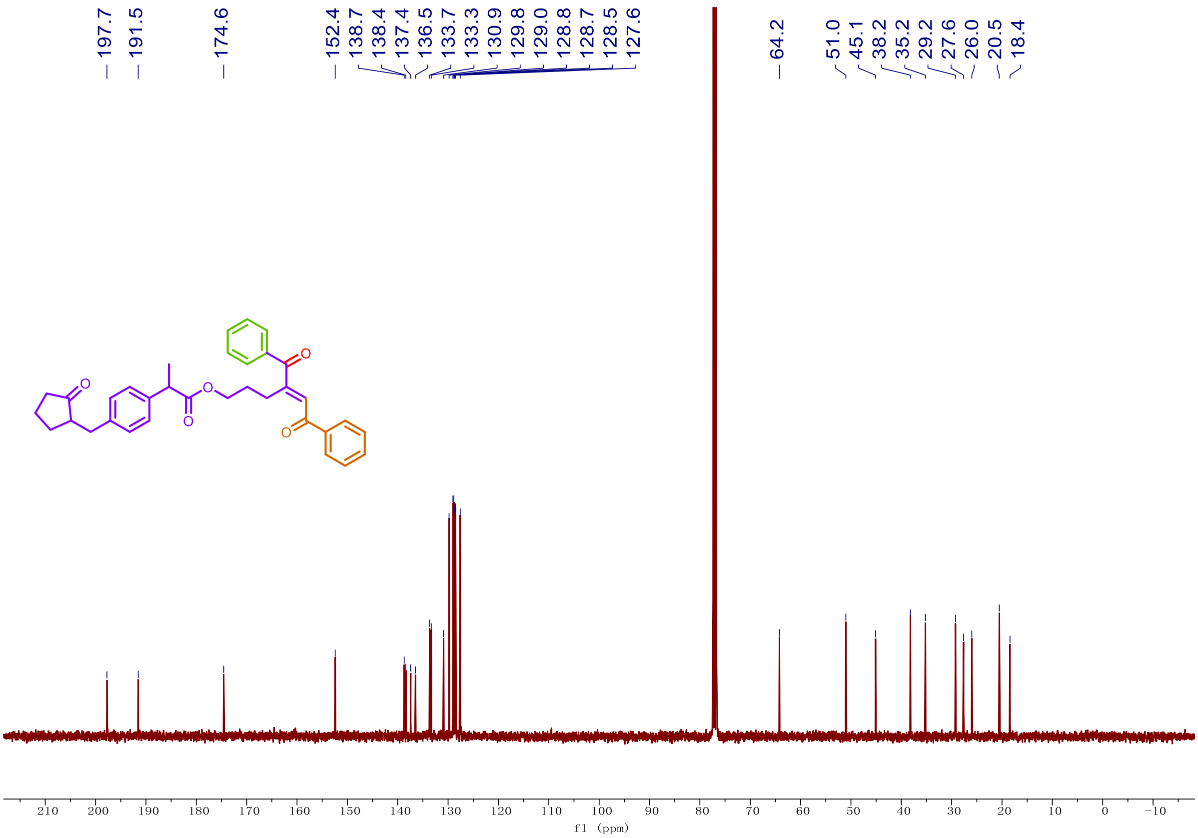
Compound 3n: ^{13}C NMR (125 MHz, $CDCl_3$)



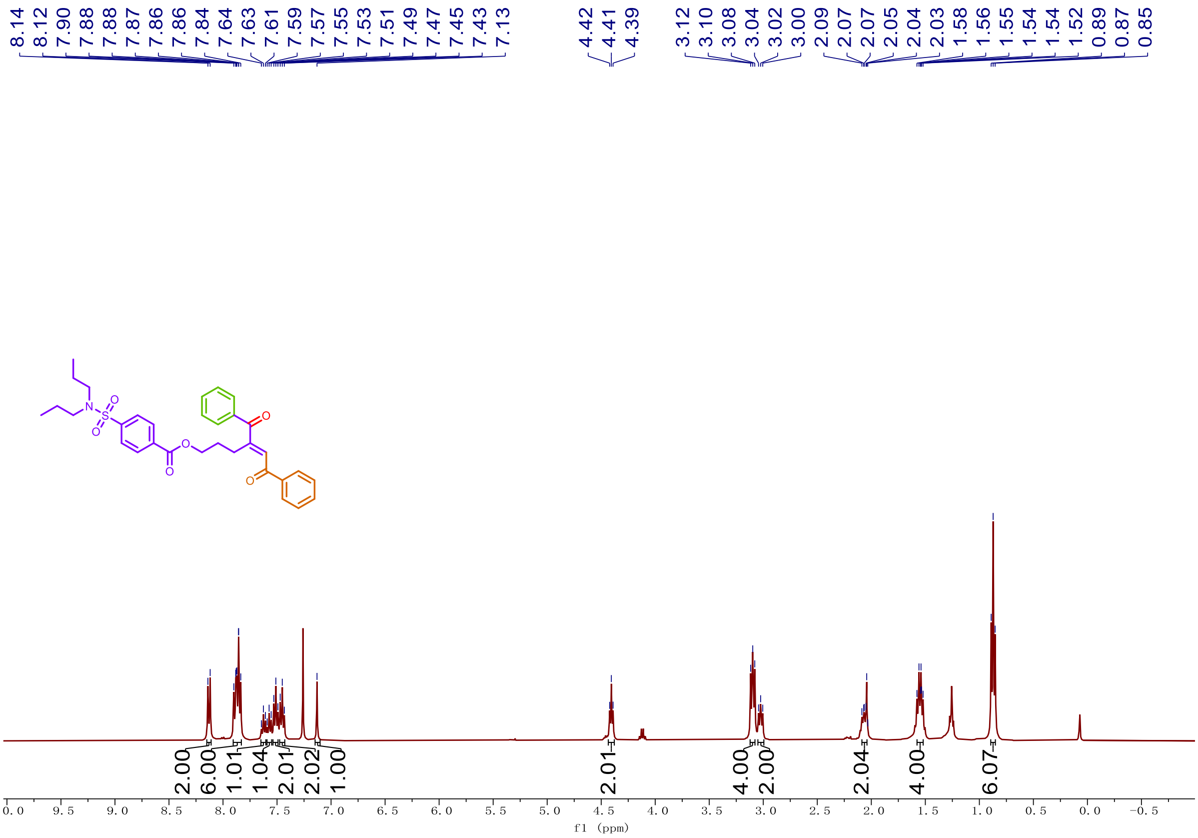
Compound 3o: ^{1}H NMR (500 MHz, $CDCl_3$)



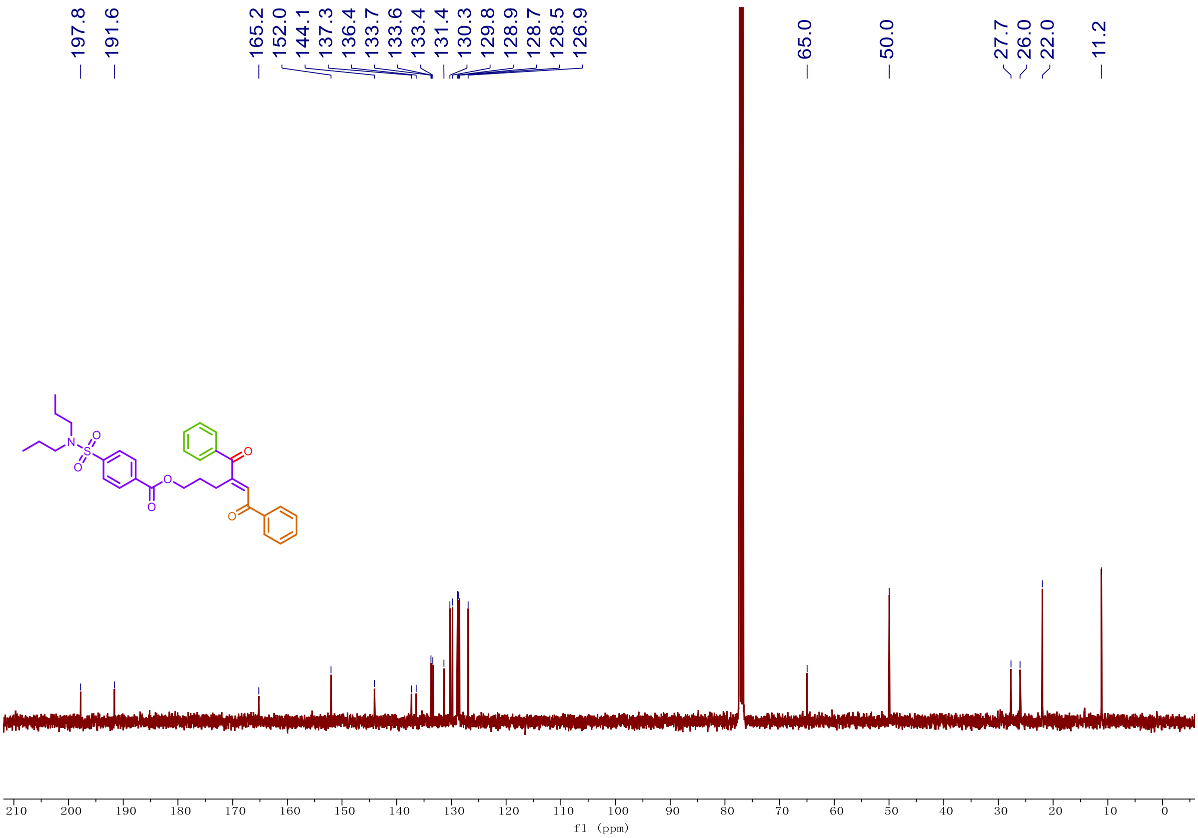
Compound 3o: ^{13}C NMR (125 MHz, $CDCl_3$)



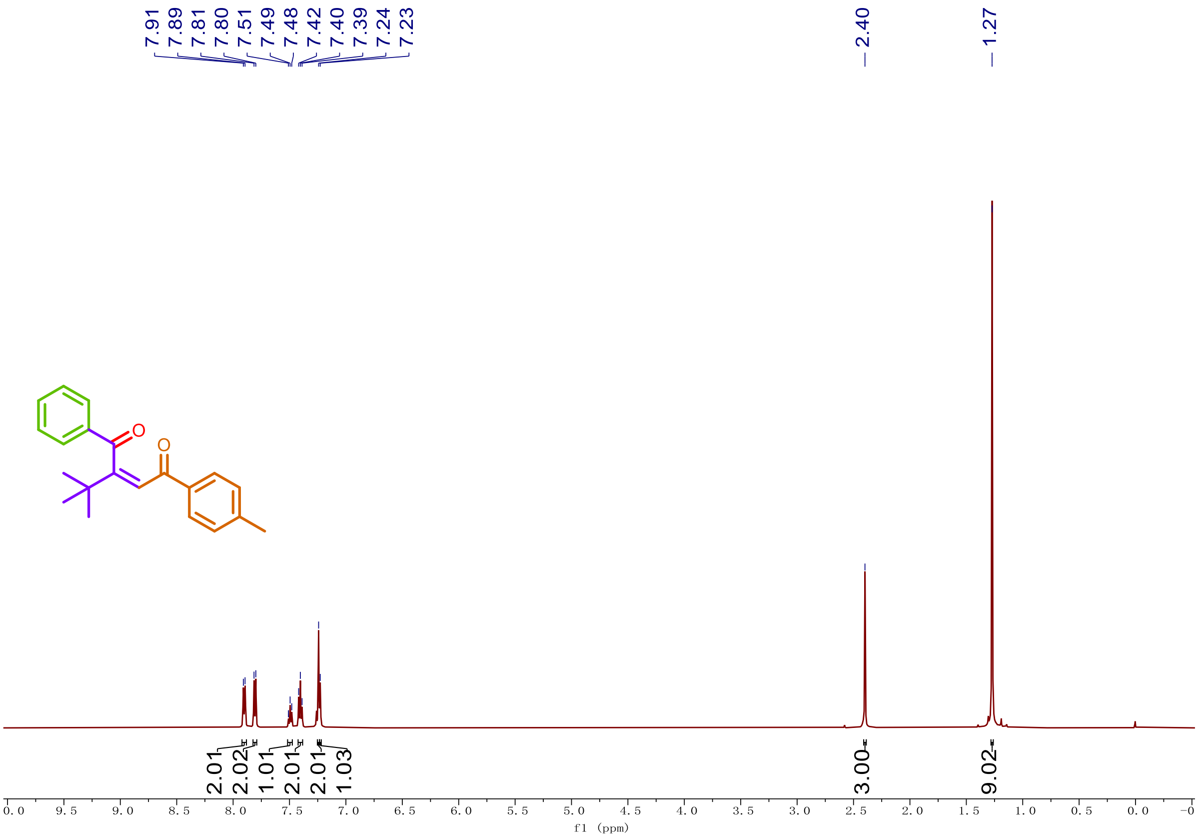
Compound 3p: ^{1}H NMR (500 MHz, $CDCl_3$)



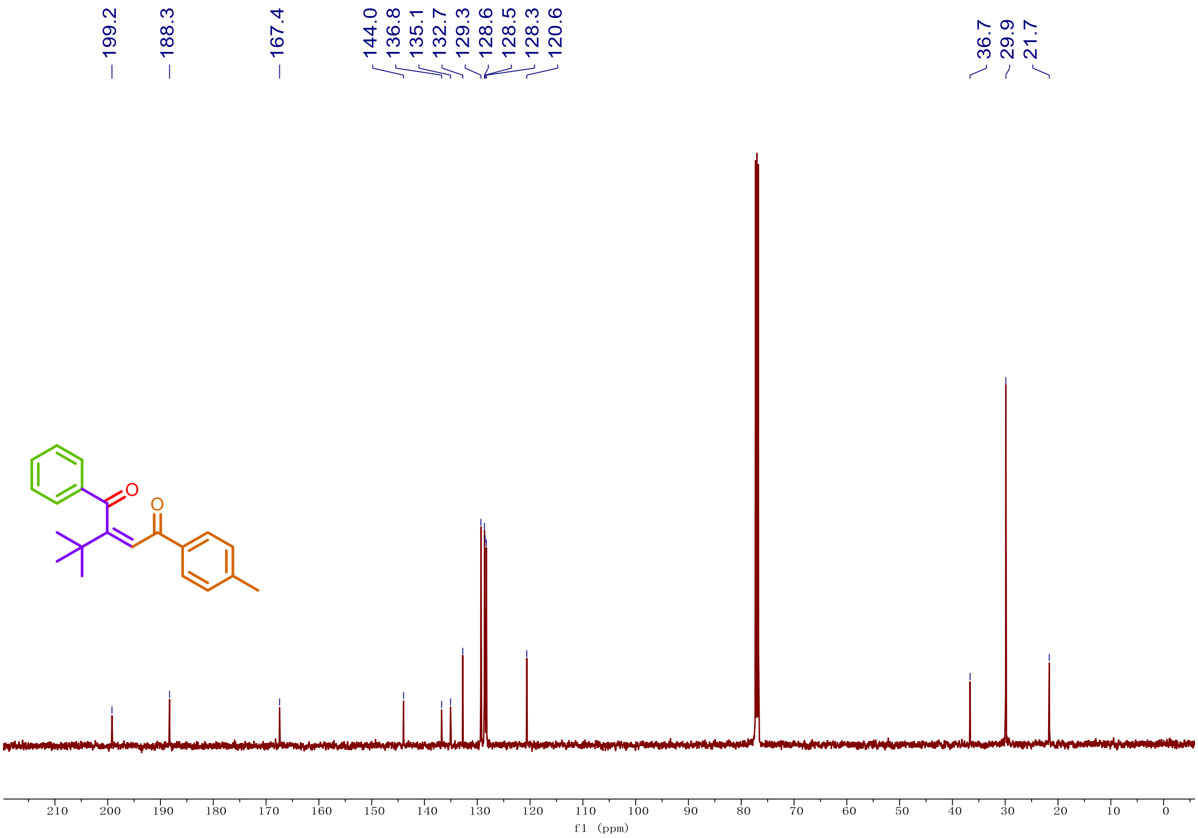
Compound 3p: ^{13}C NMR (125 MHz, $CDCl_3$)



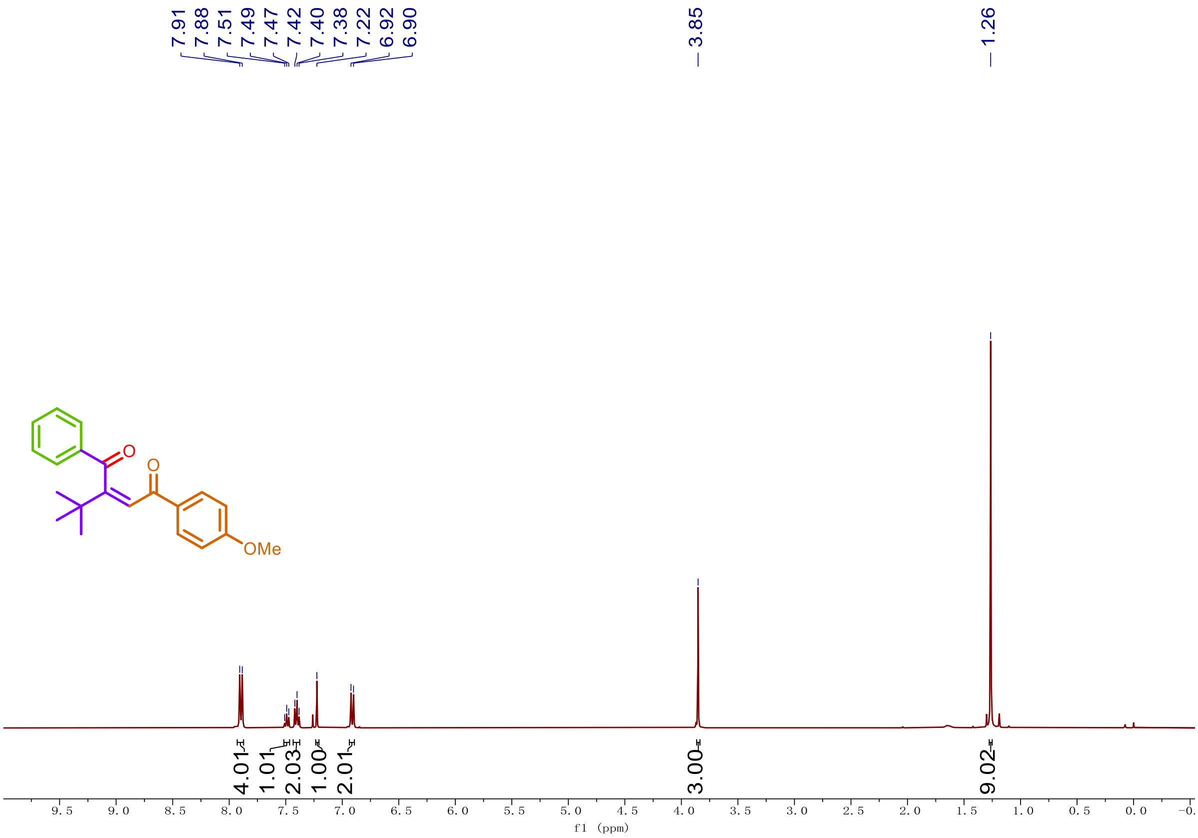
Compound 3q: ^{1}H NMR (500 MHz, $CDCl_3$)



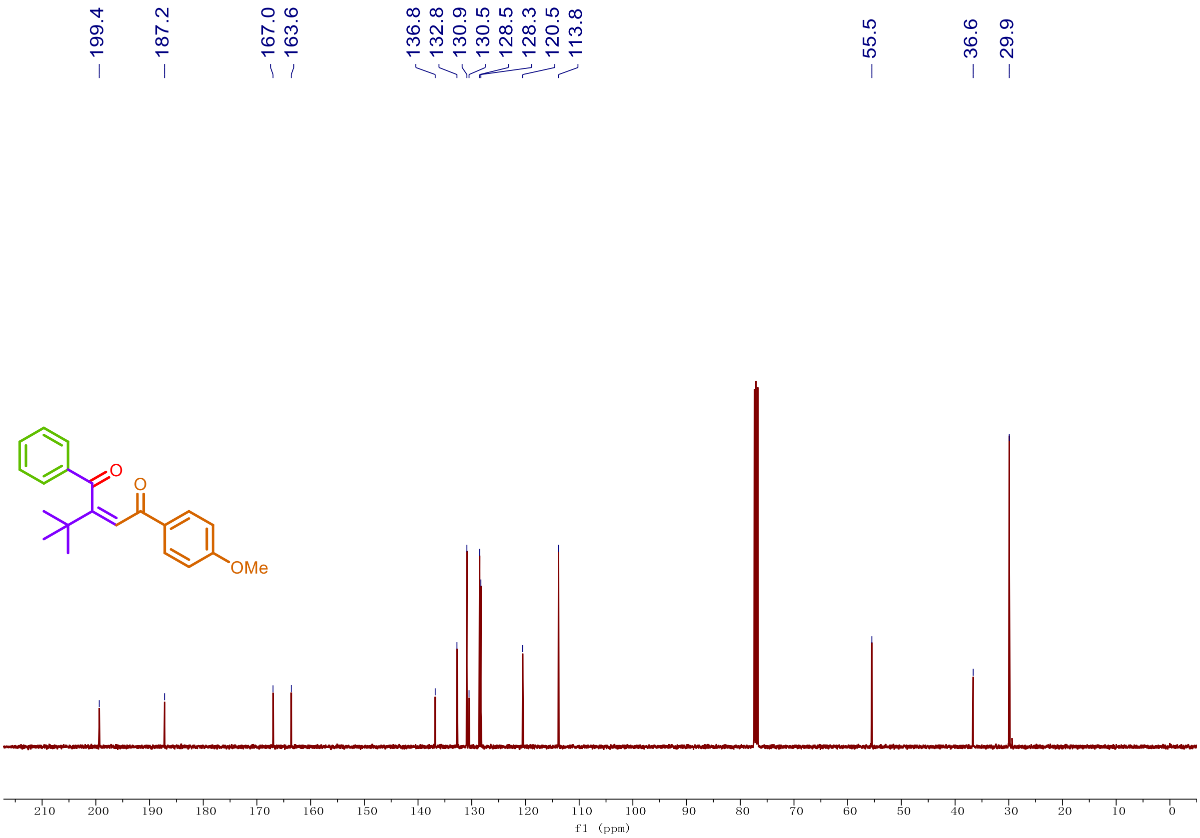
Compound 3q: ^{13}C NMR (125 MHz, $CDCl_3$)



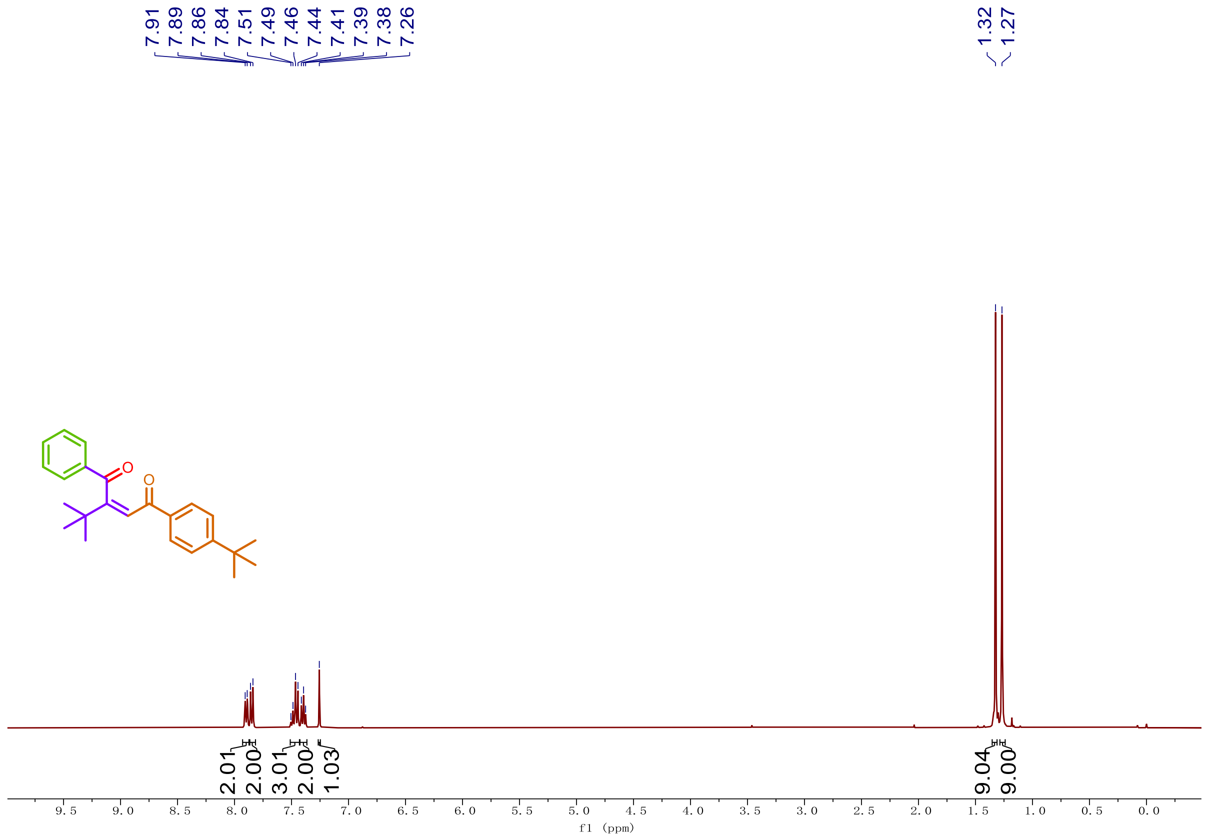
Compound 3r: ^{1}H NMR (500 MHz, $CDCl_3$)



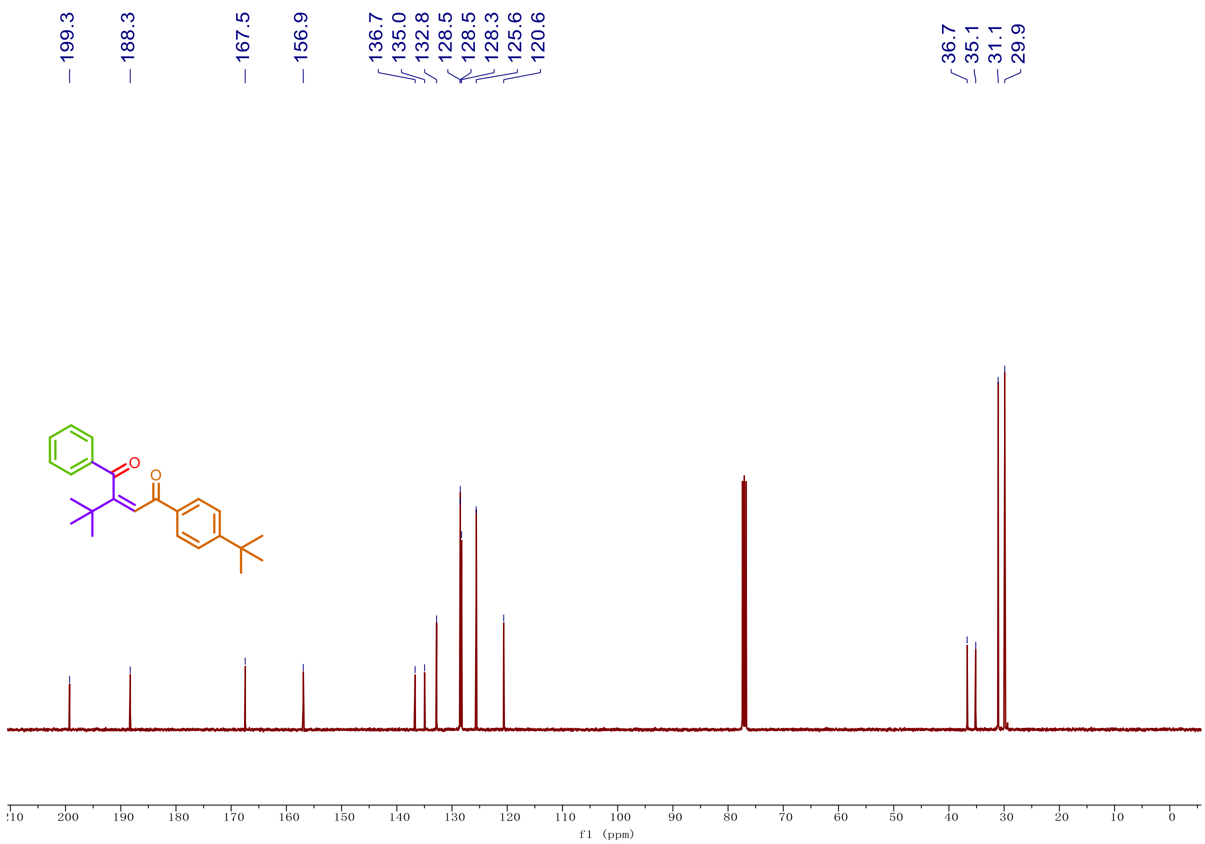
Compound 3r: ^{13}C NMR (125 MHz, $CDCl_3$)



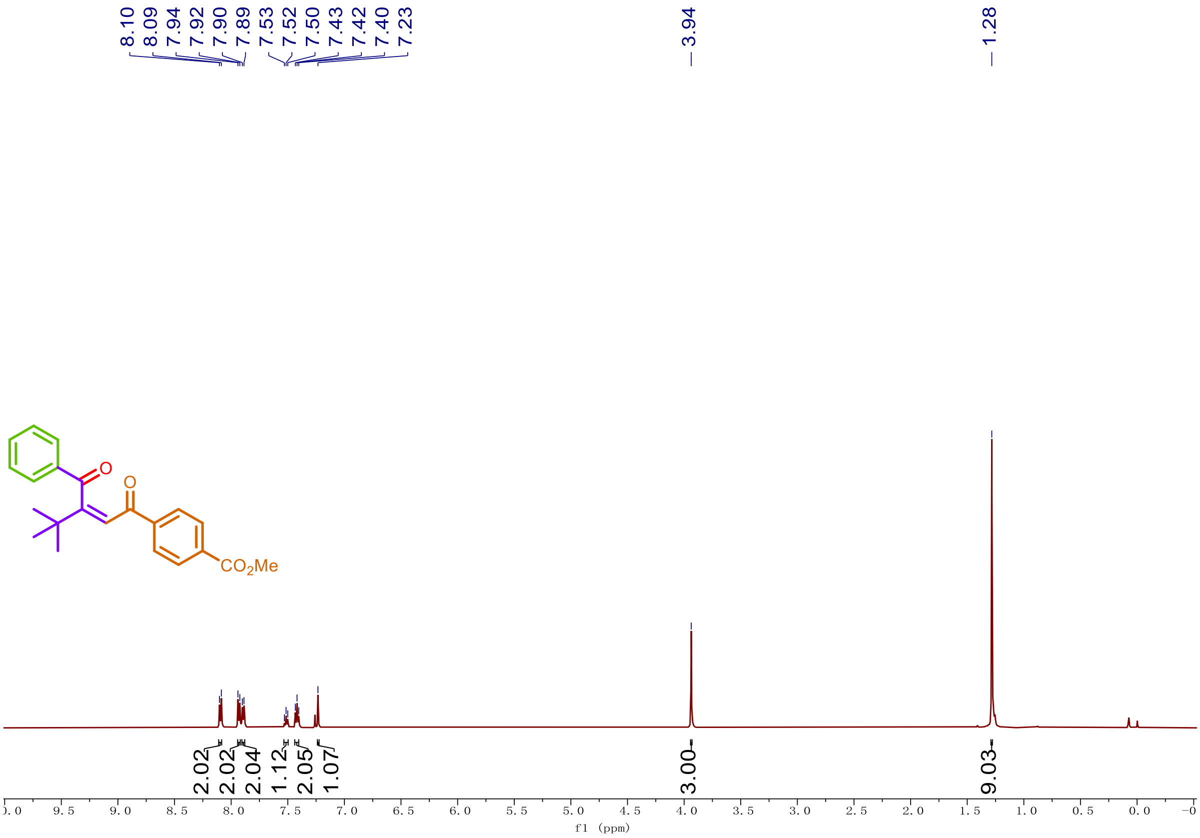
Compound 3s: ¹H NMR (500 MHz, $CDCl_3$)



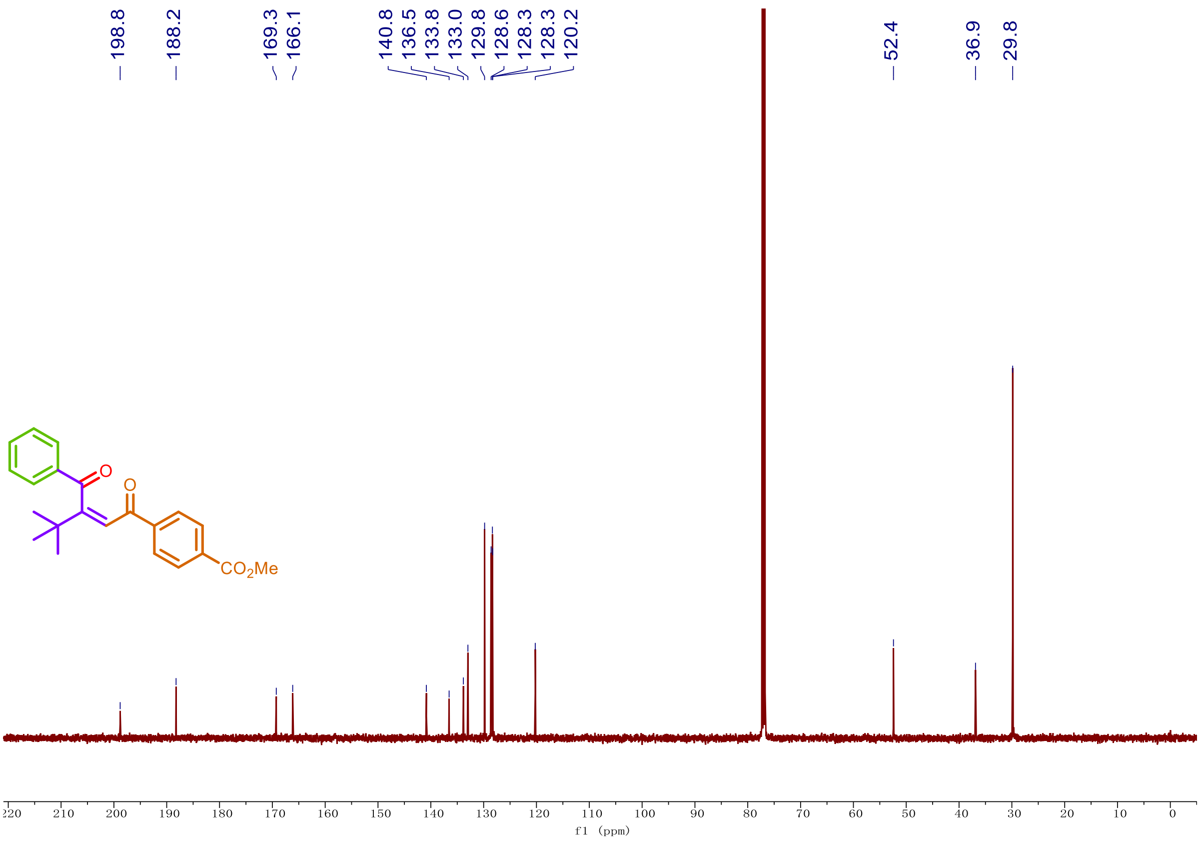
Compound 3s: ¹³C NMR (125 MHz, $CDCl_3$)



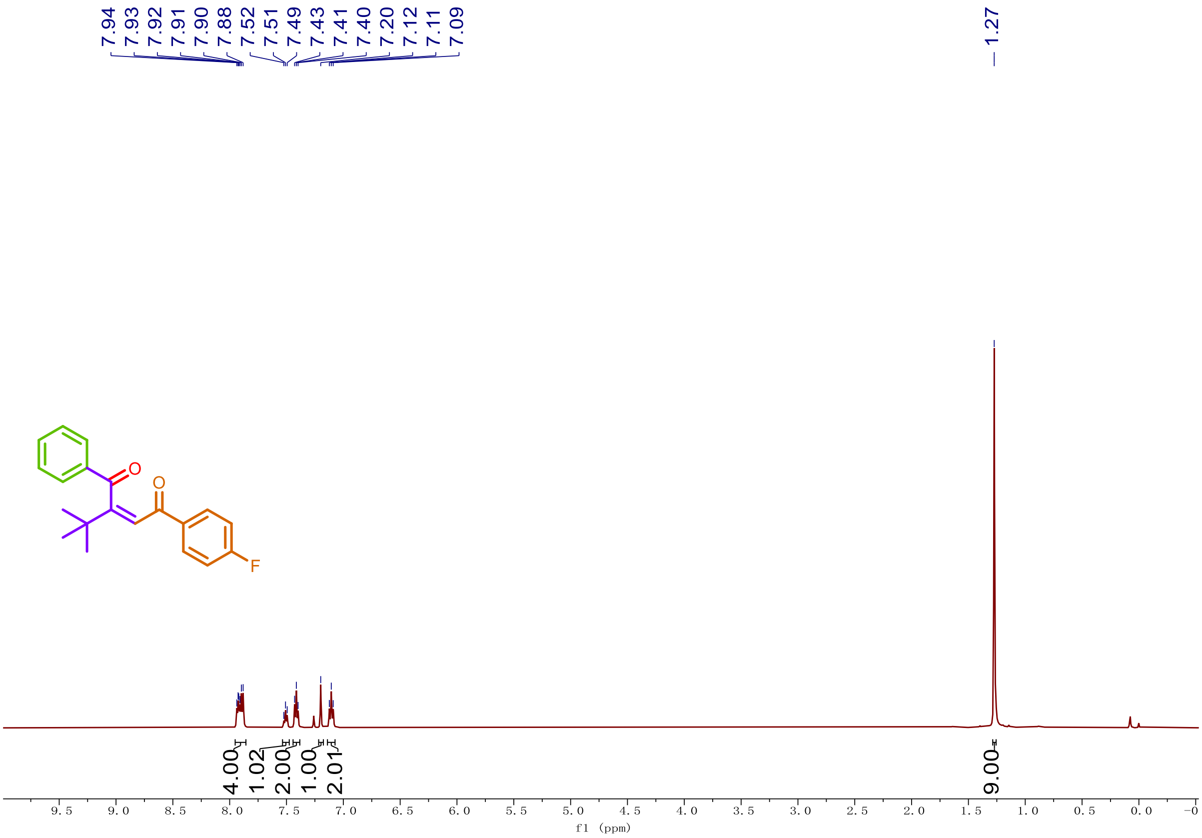
Compound 3t: ^{1}H NMR (500 MHz, $CDCl_3$)



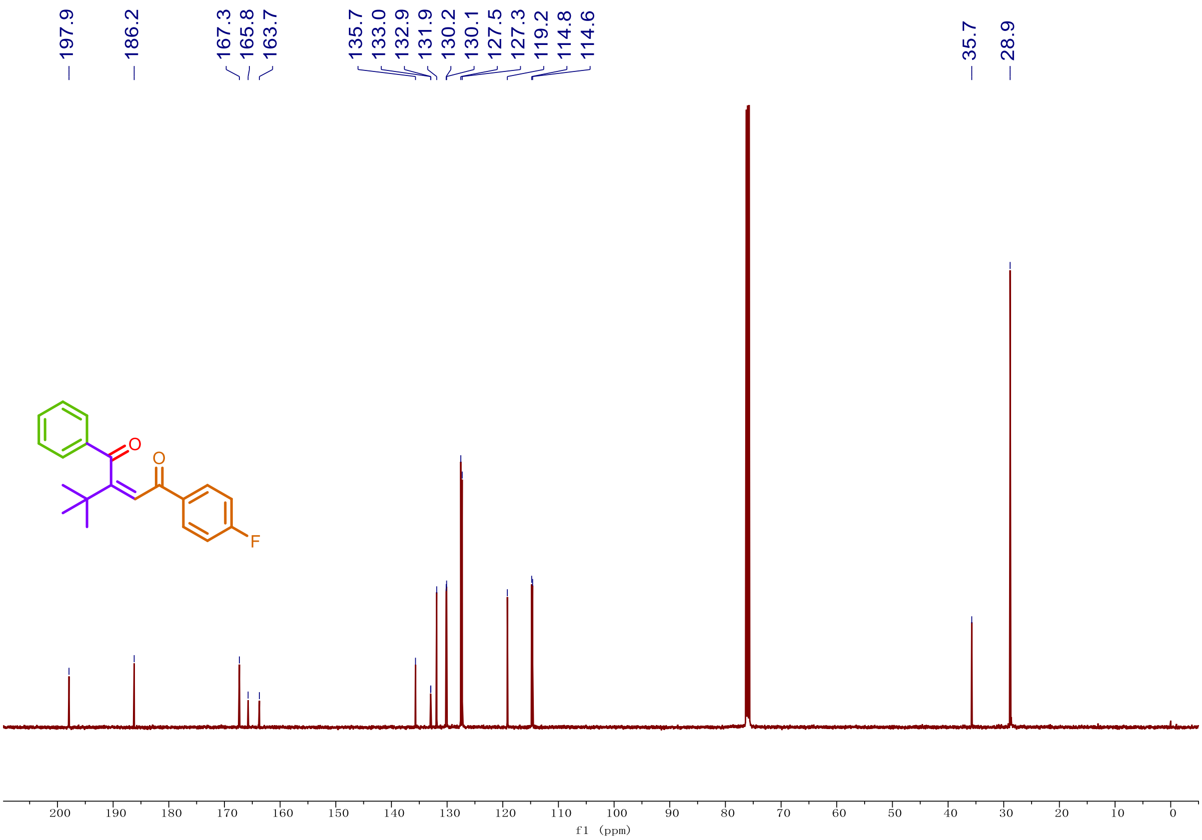
Compound 3t: ^{13}C NMR (125 MHz, $CDCl_3$)



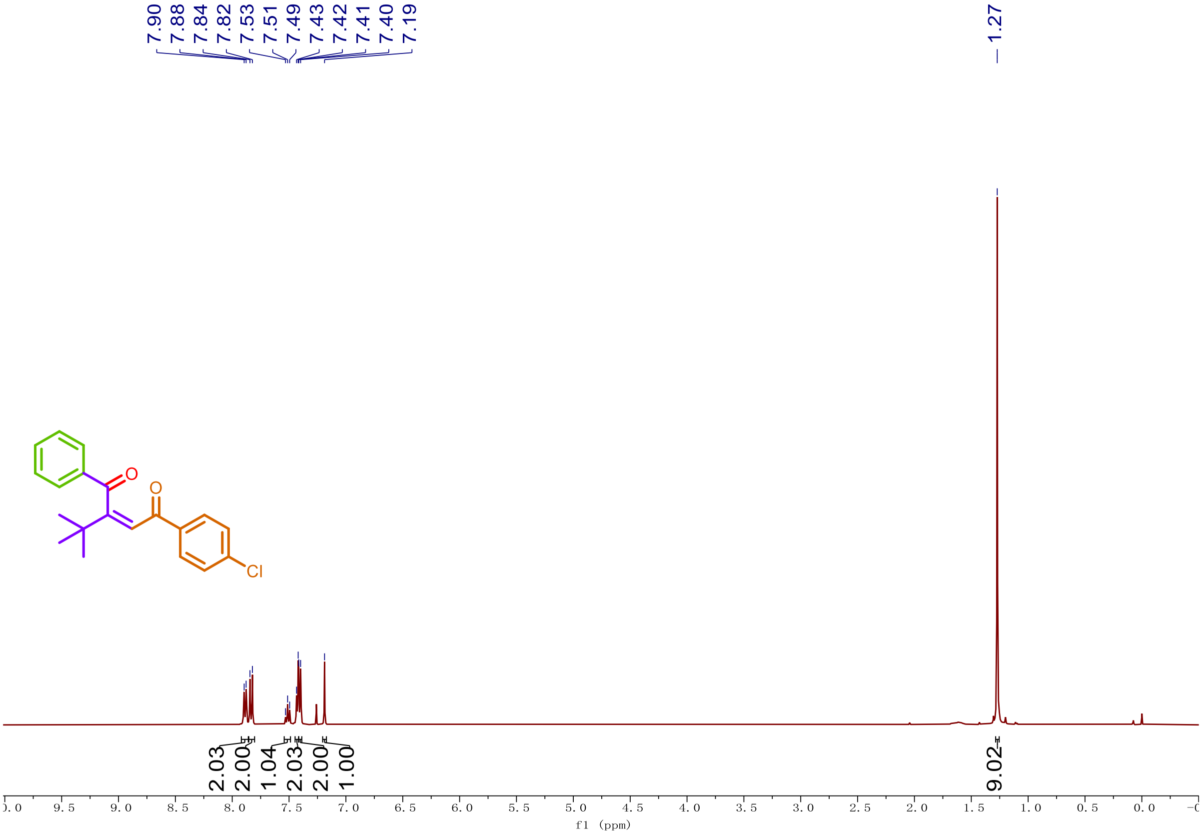
Compound 3u: ^{1}H NMR (500 MHz, $CDCl_3$)



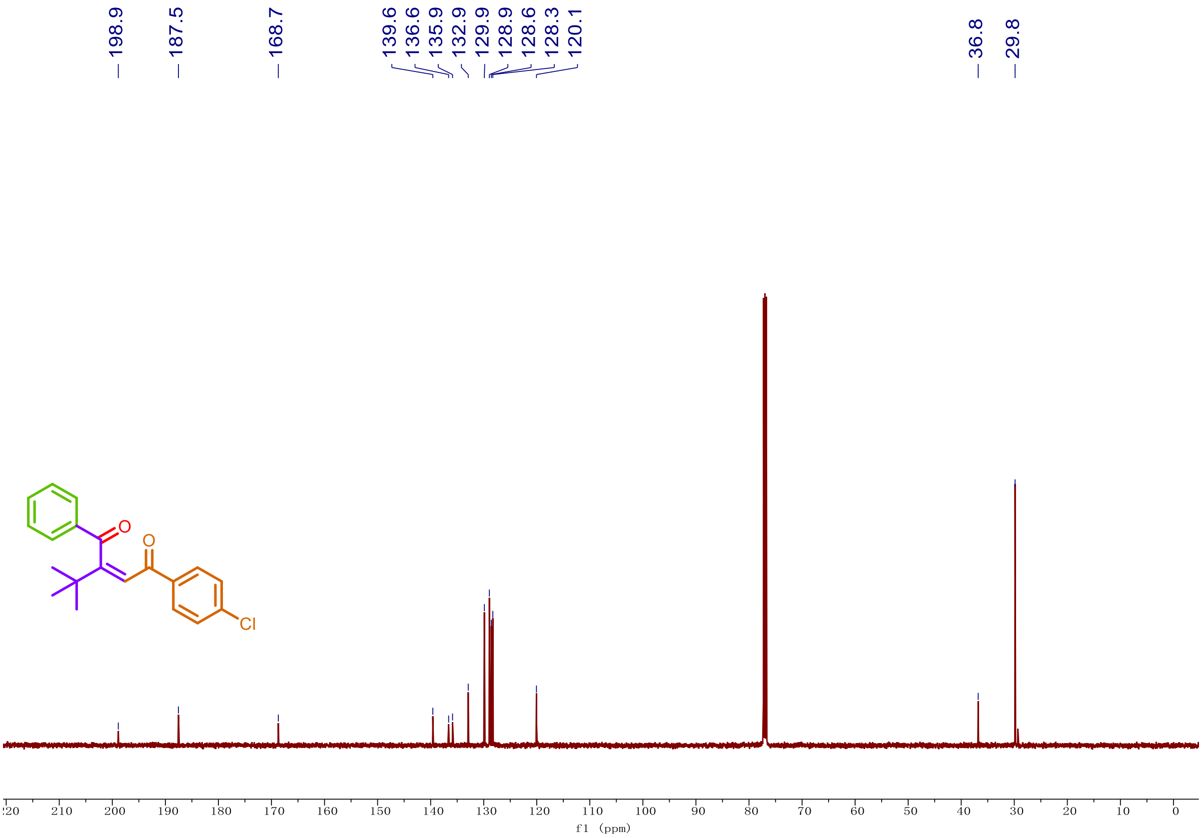
Compound 3u: ^{13}C NMR (125 MHz, $CDCl_3$)



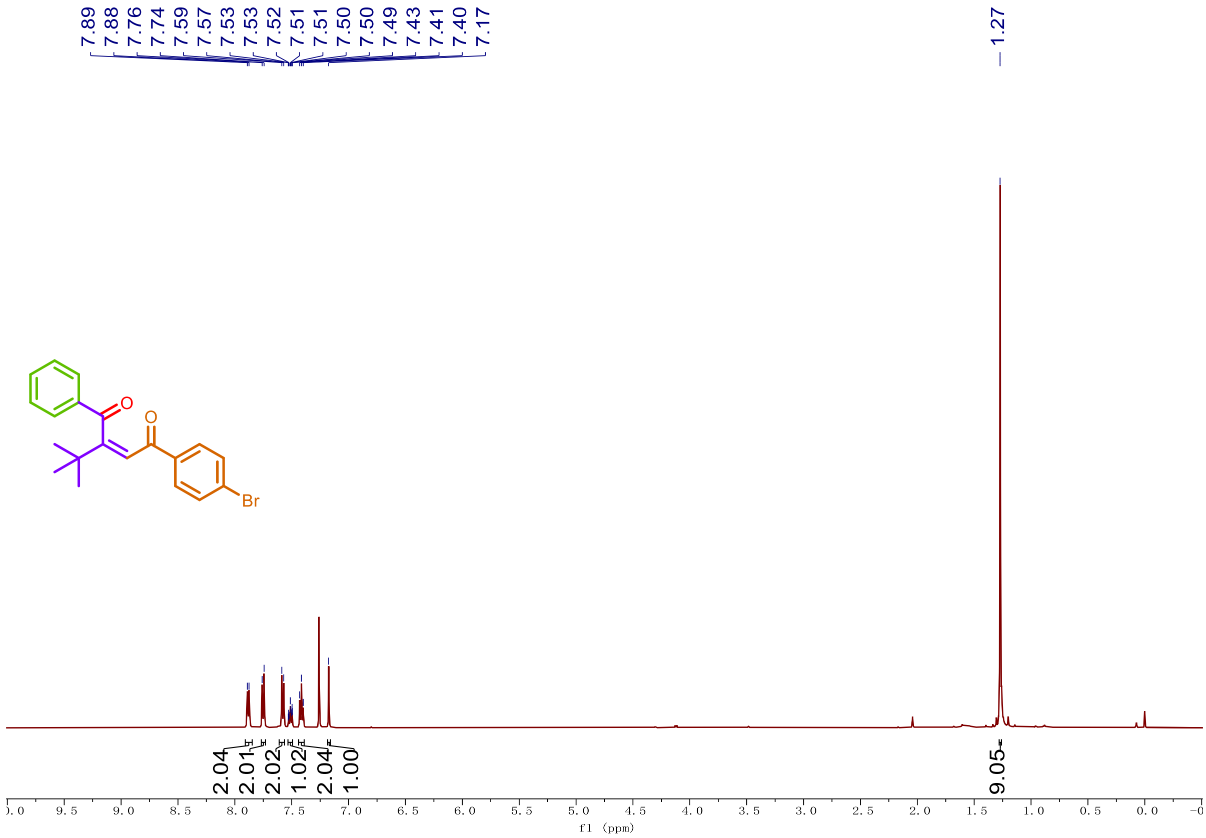
Compound 3v: ¹H NMR (500 MHz, $CDCl_3$)



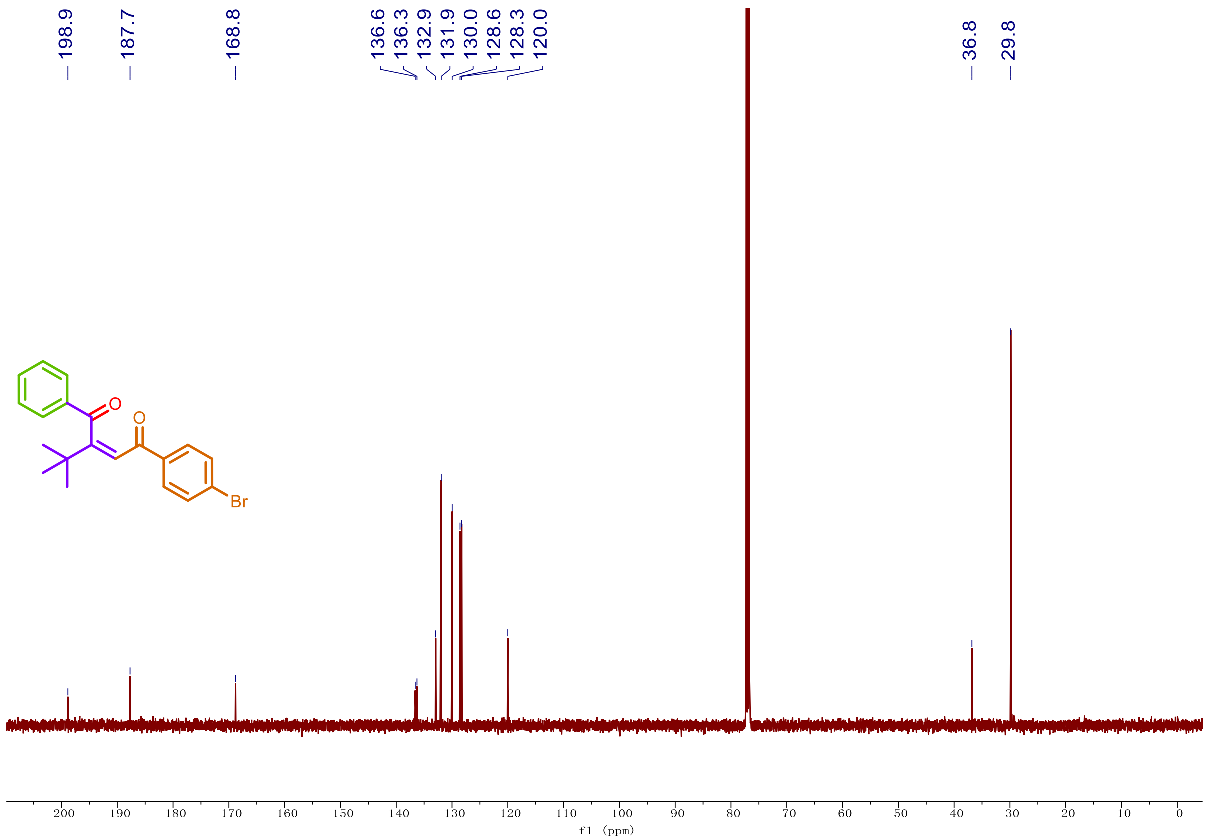
Compound 3v: ¹³C NMR (125 MHz, $CDCl_3$)



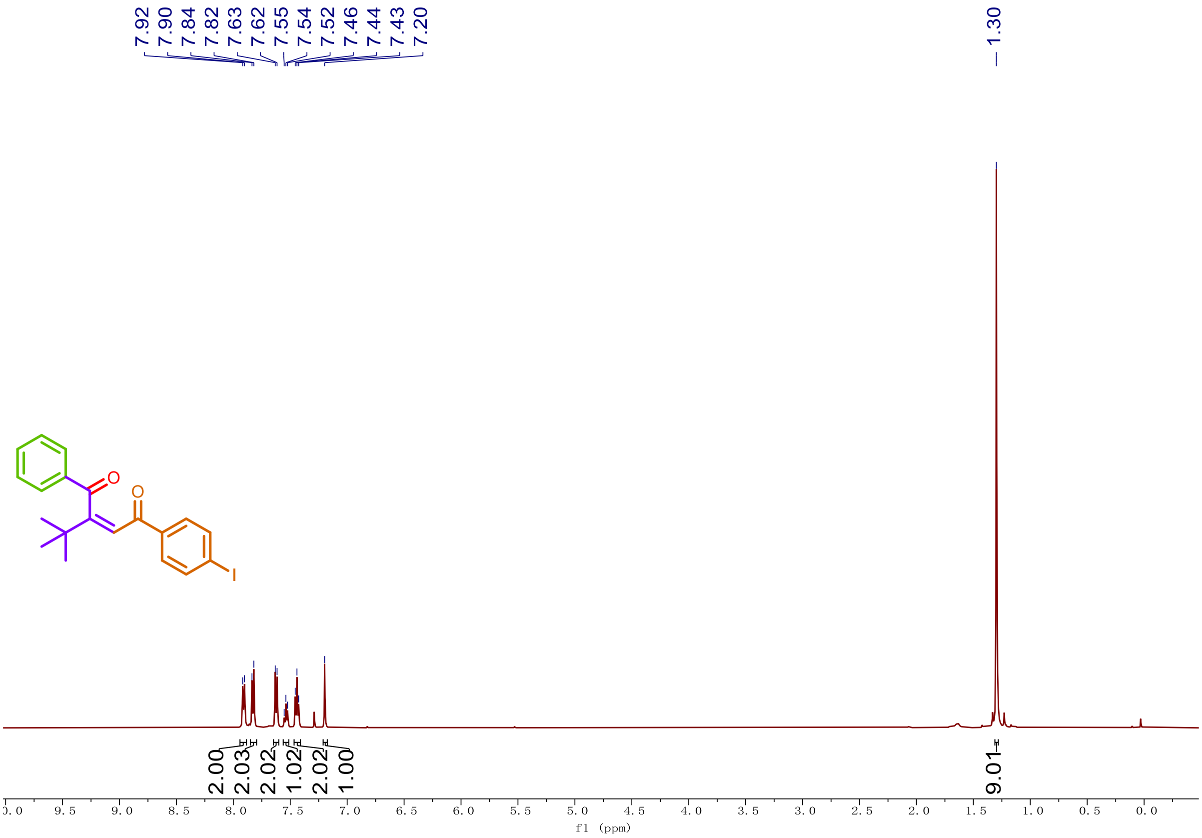
Compound 3w: ^{1}H NMR (500 MHz, $CDCl_3$)



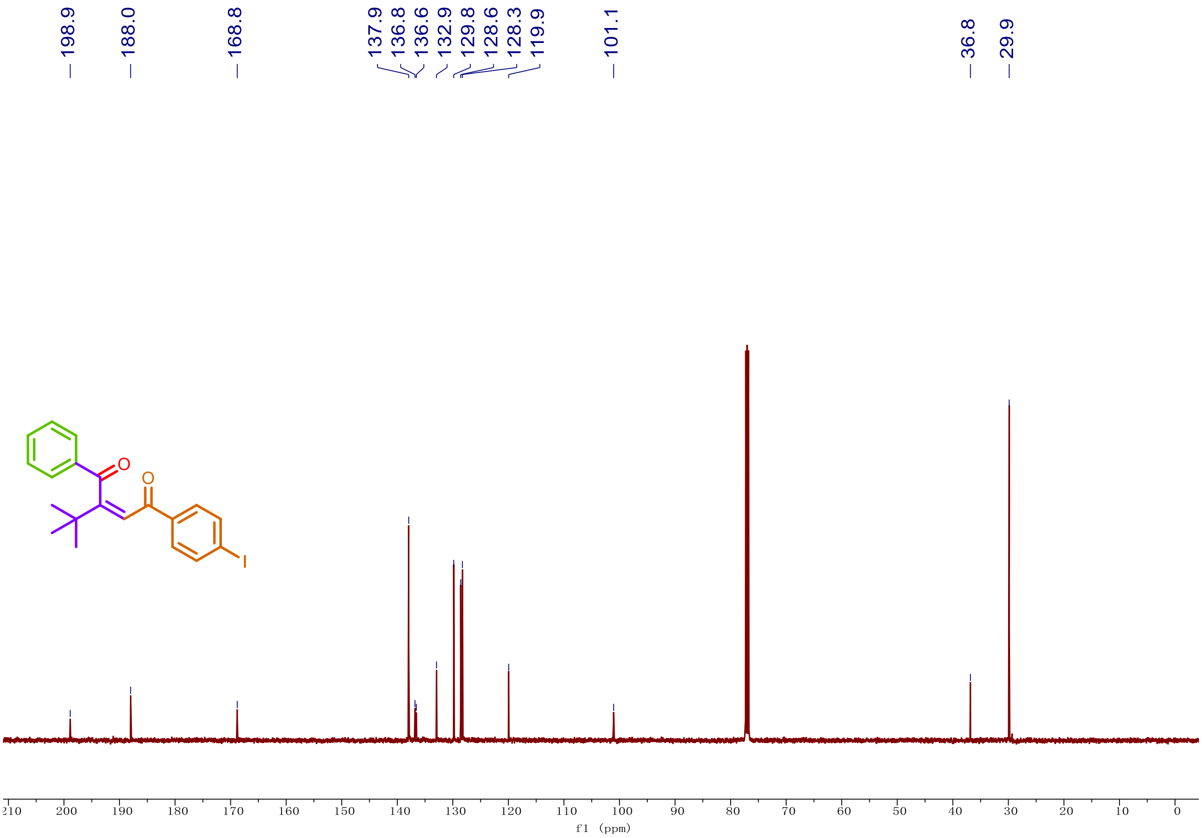
Compound 3w: ^{13}C NMR (125 MHz, $CDCl_3$)



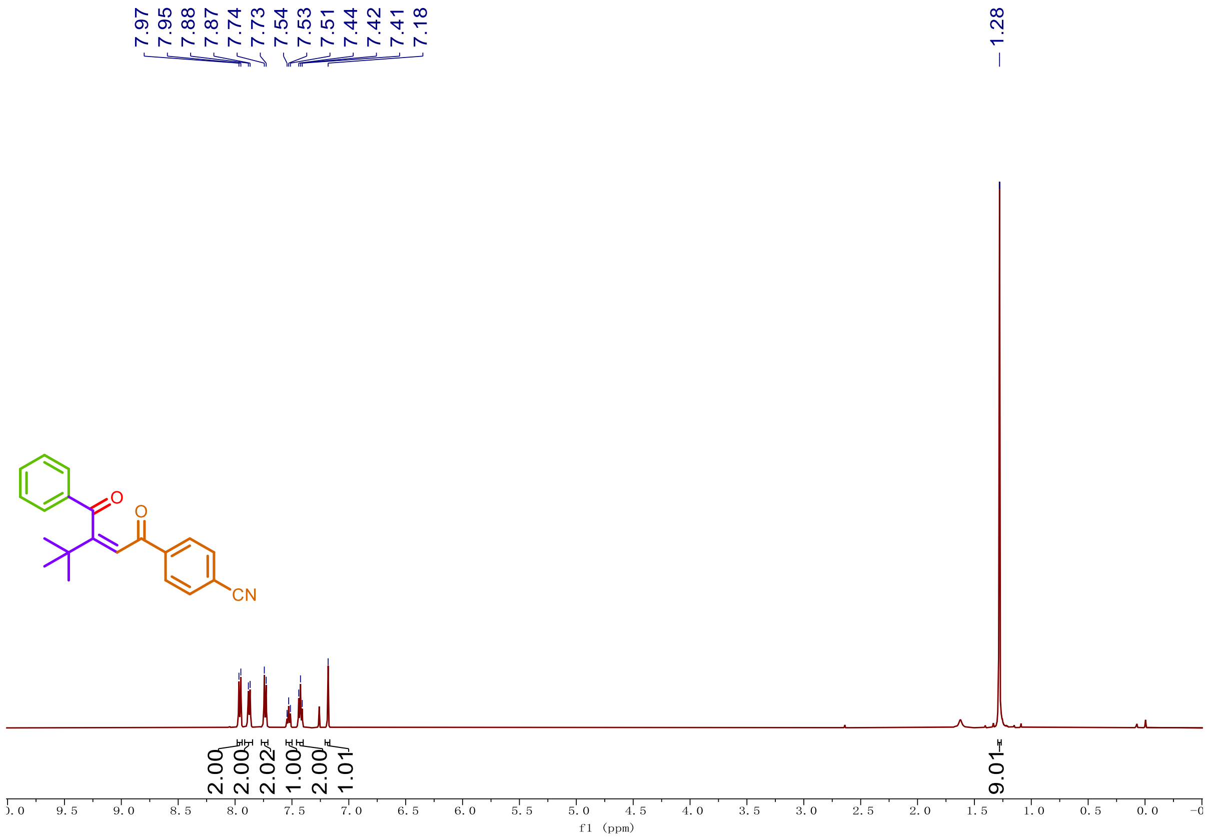
Compound 3x: ^{1}H NMR (500 MHz, $CDCl_3$)



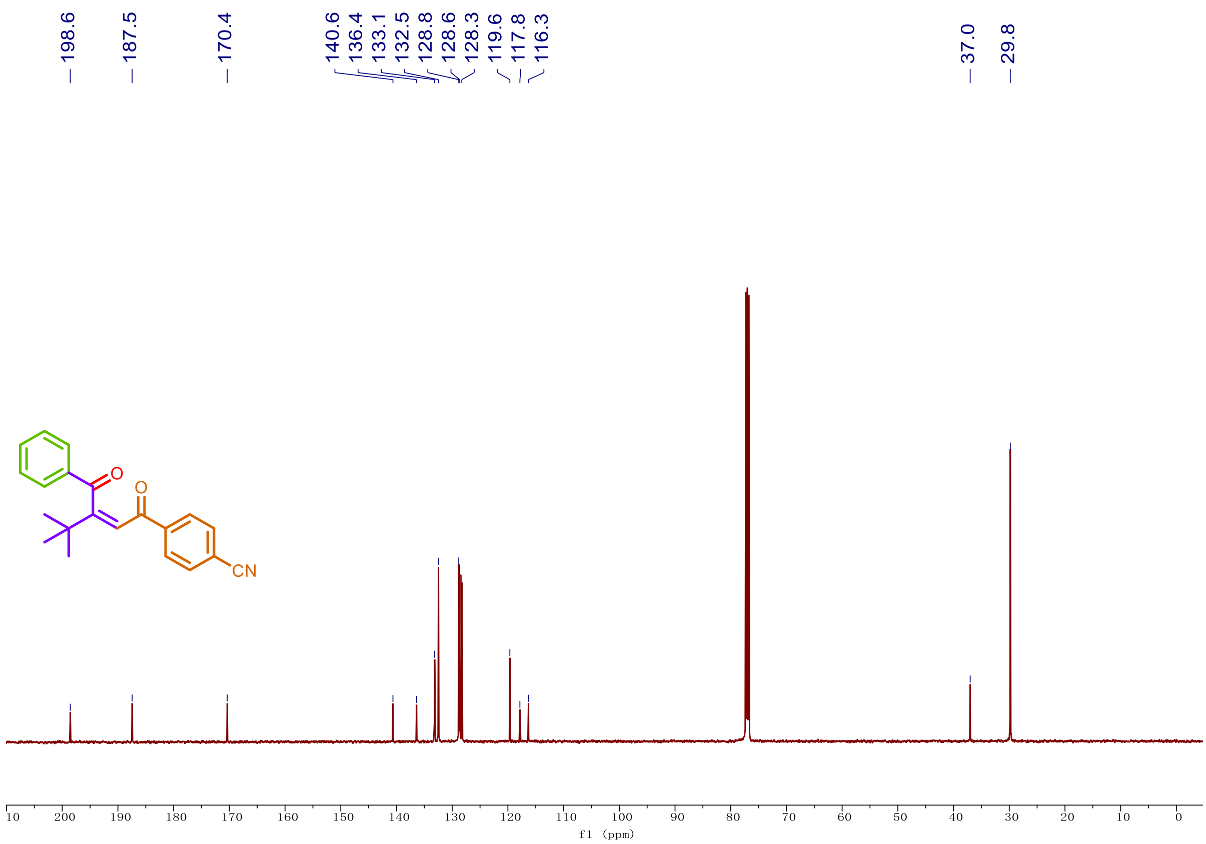
Compound 3x: ^{13}C NMR (125 MHz, $CDCl_3$)



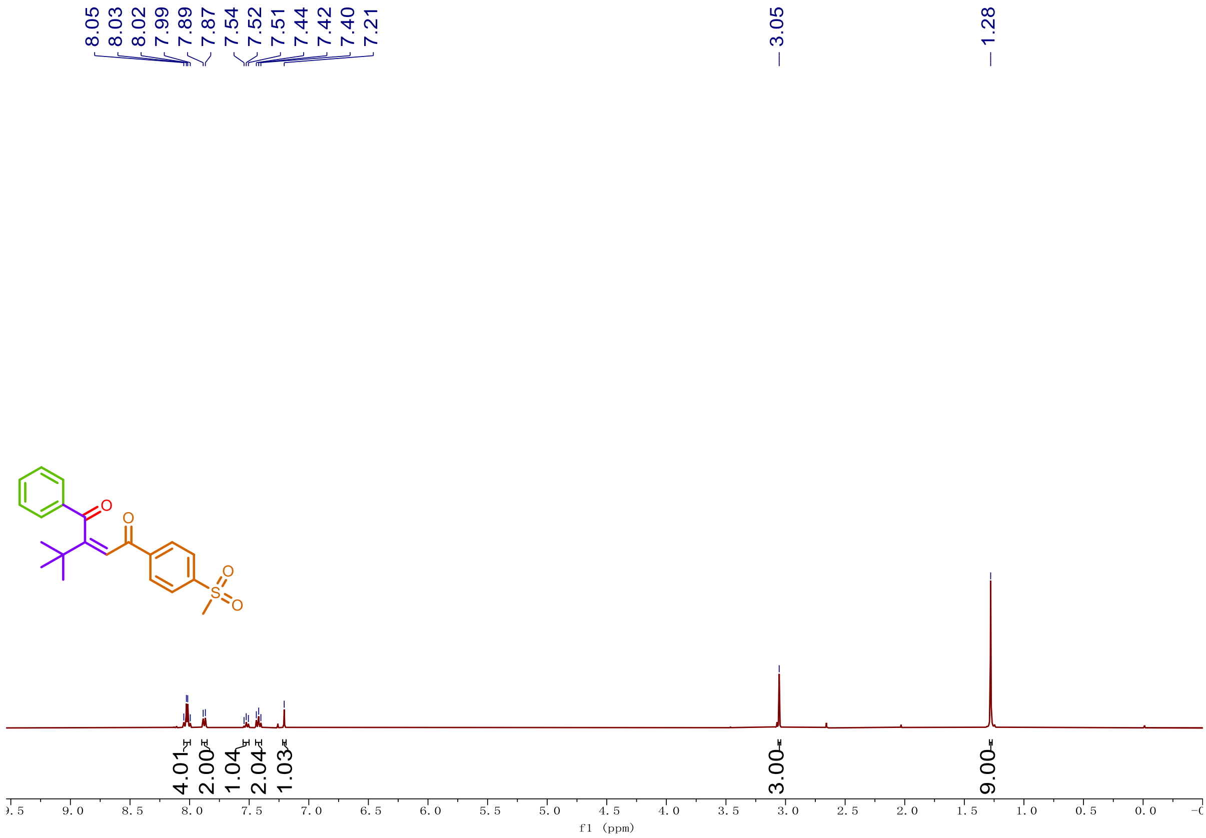
Compound 3y: ^{1}H NMR (500 MHz, $CDCl_3$)



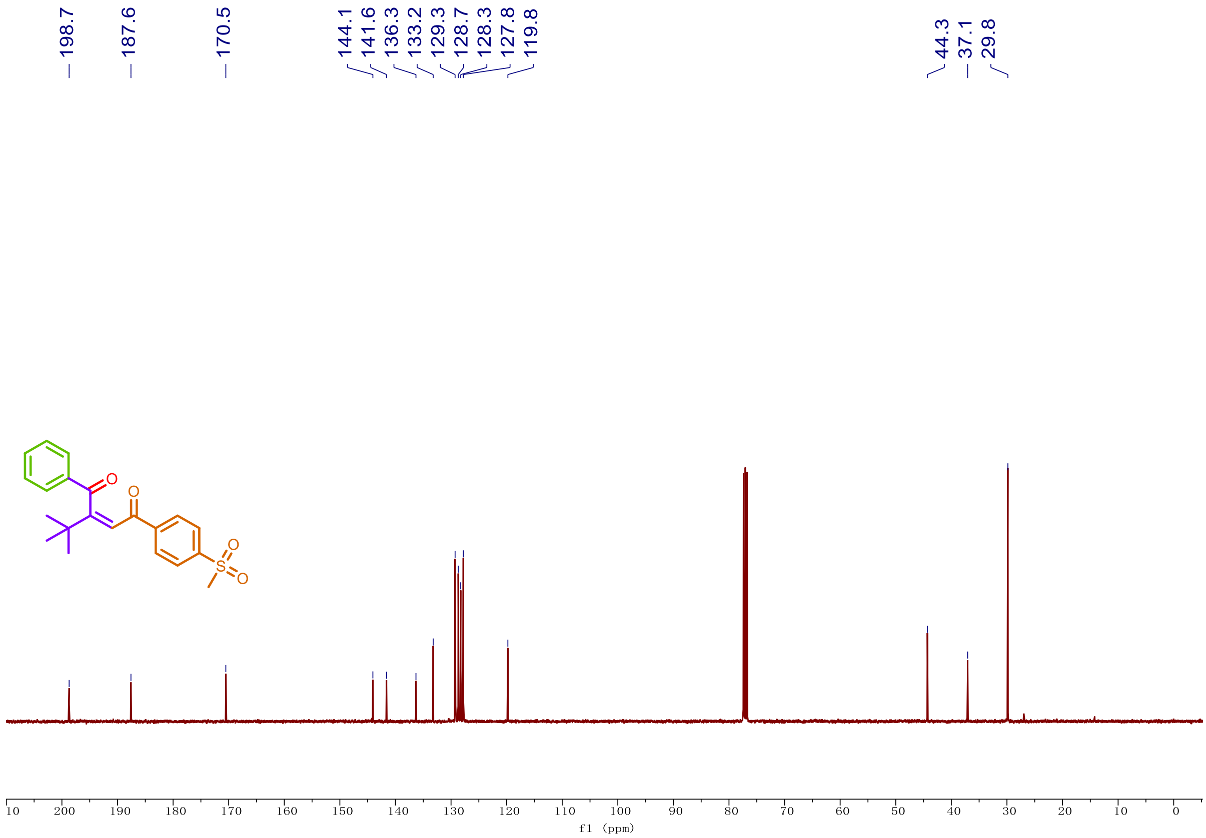
Compound 3y: ^{13}C NMR (125 MHz, $CDCl_3$)



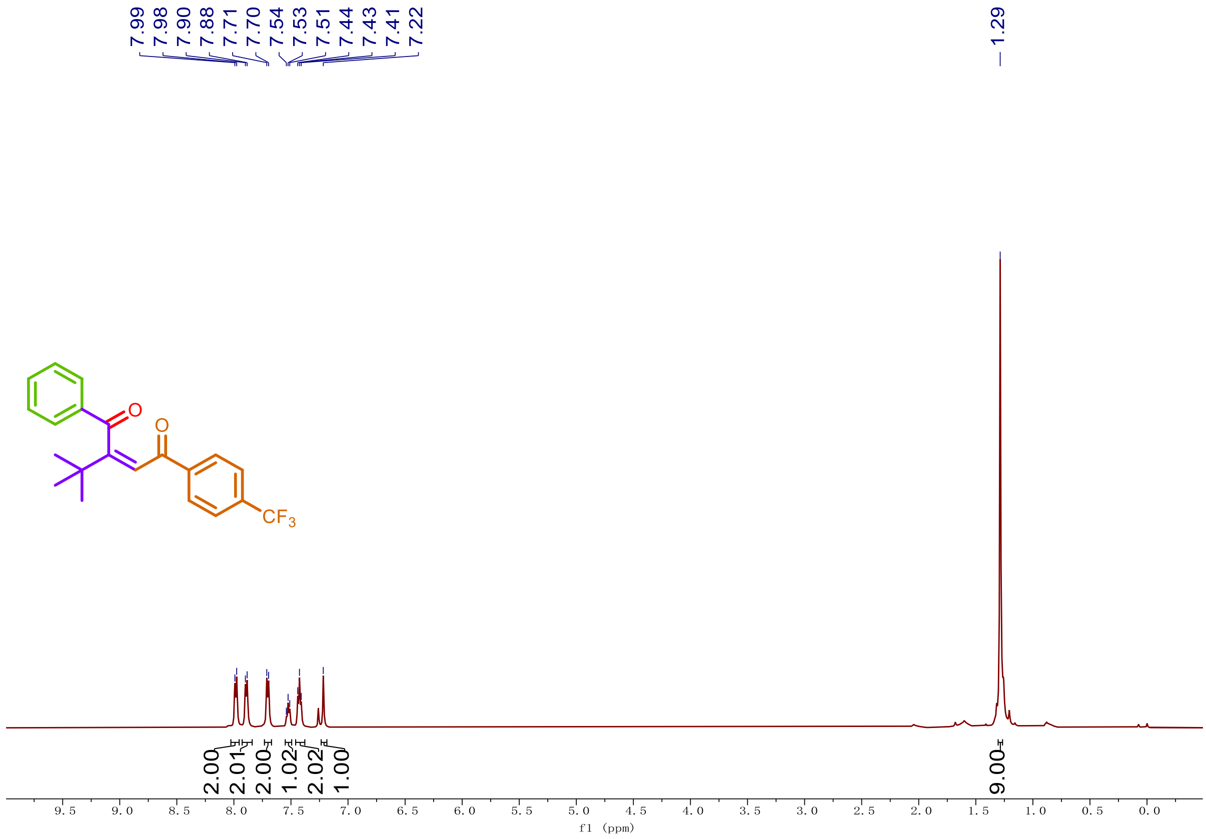
Compound 3z: ^{1}H NMR (500 MHz, $CDCl_3$)



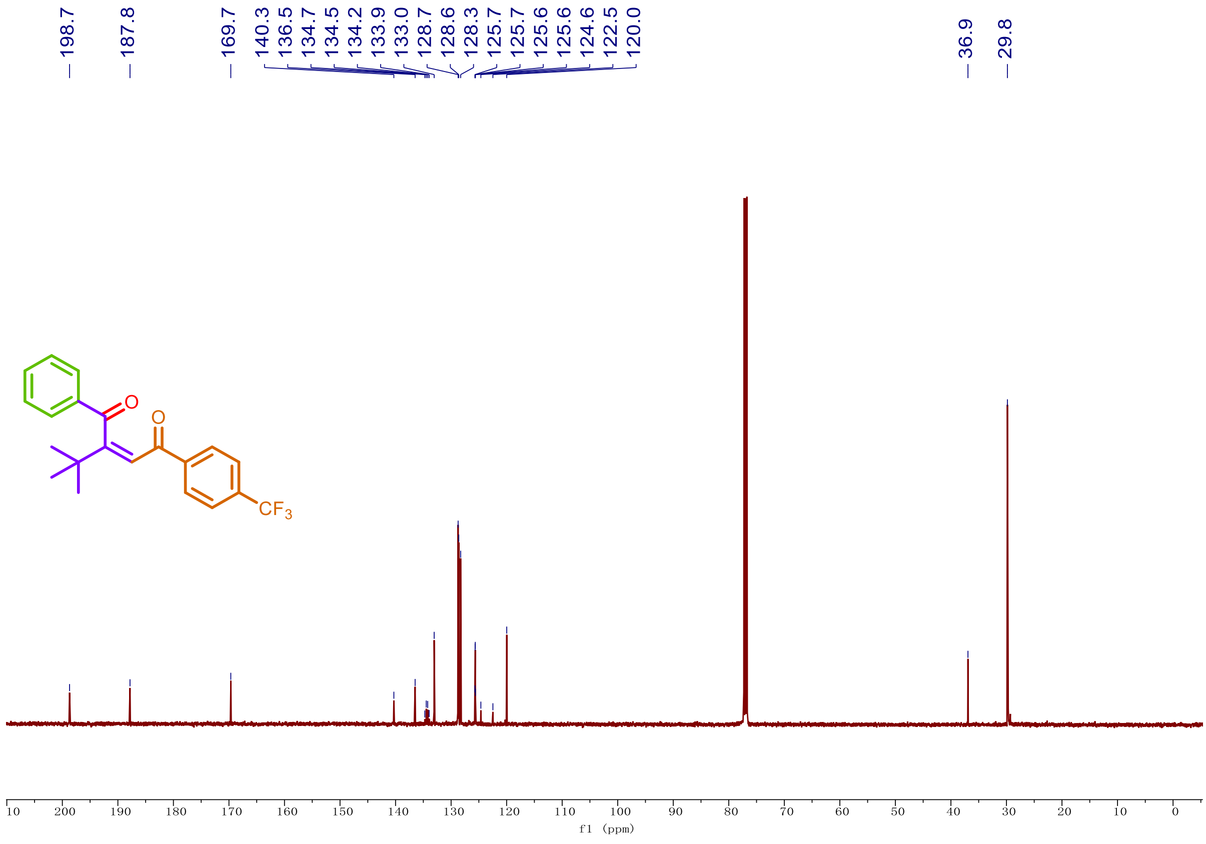
Compound 3z: ^{13}C NMR (125 MHz, $CDCl_3$)



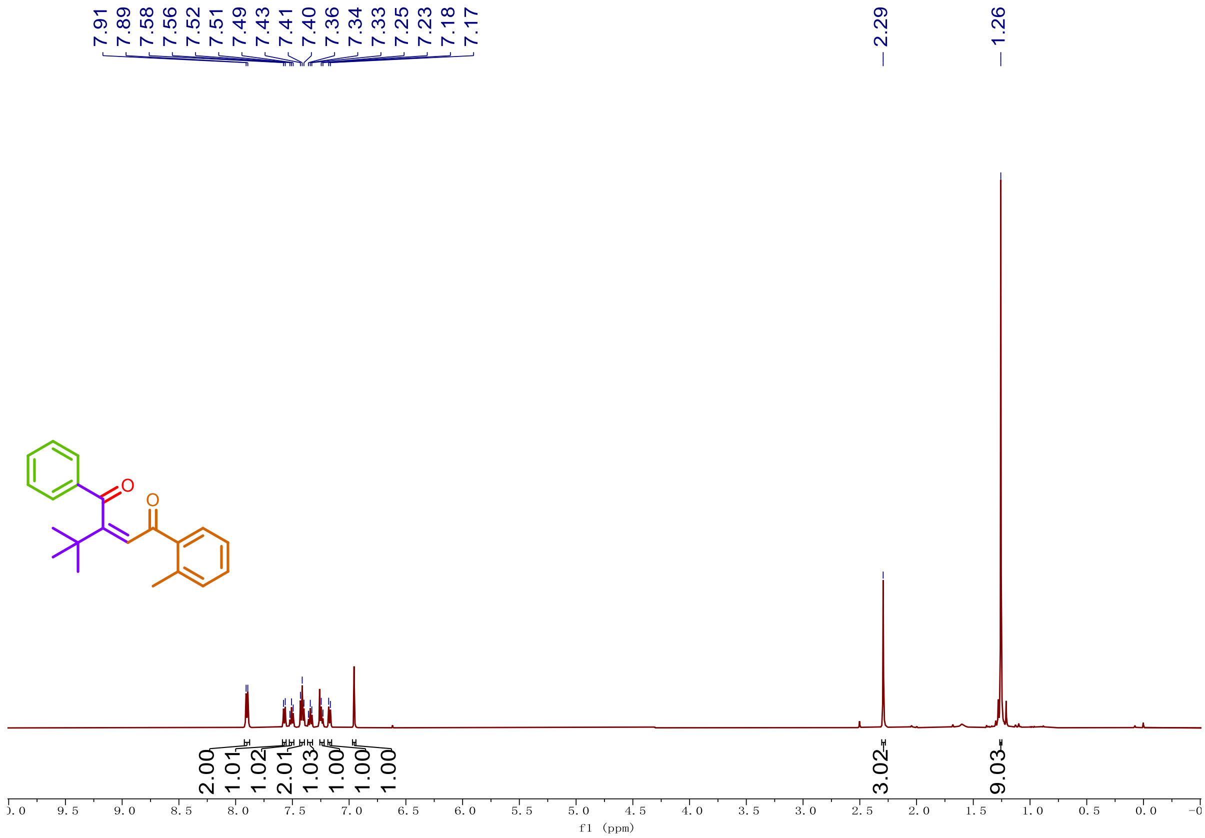
Compound 3aa: ^{1}H NMR (500 MHz, $CDCl_3$)



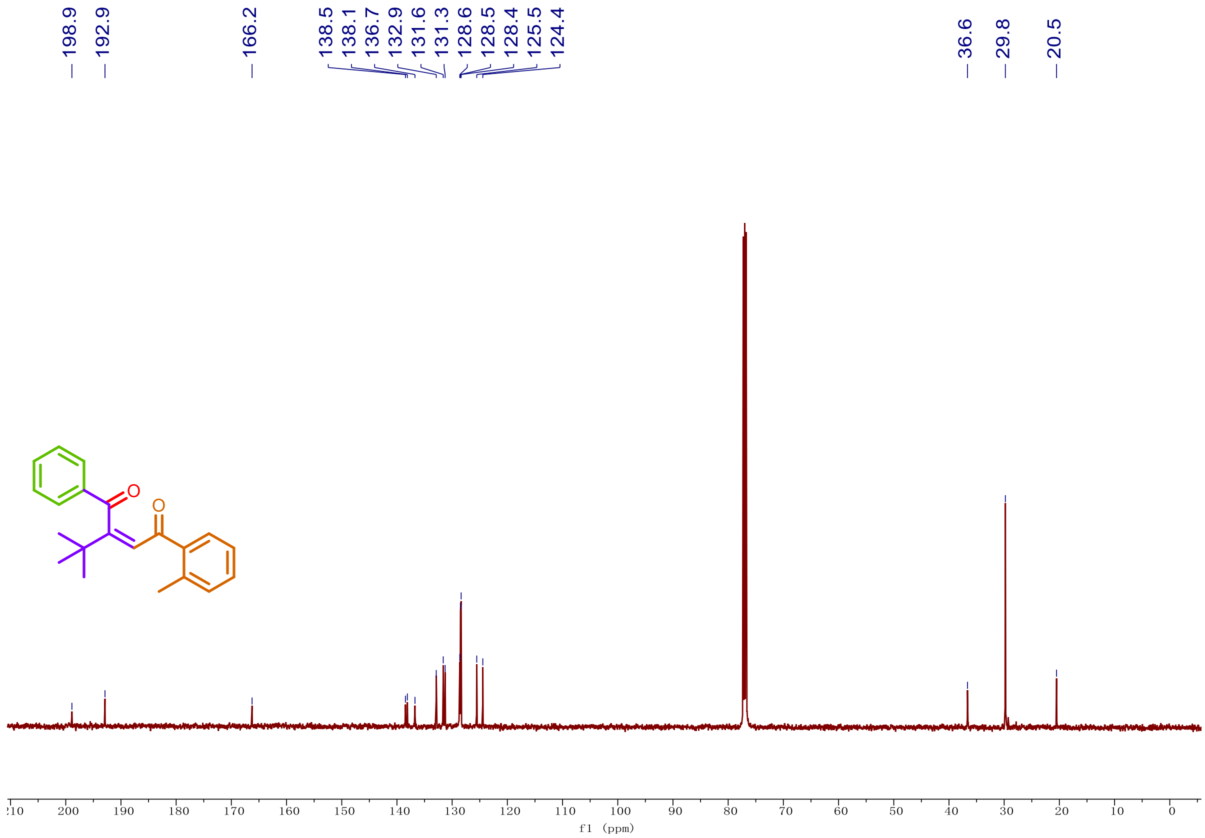
Compound 3aa: ^{13}C NMR (125 MHz, $CDCl_3$)



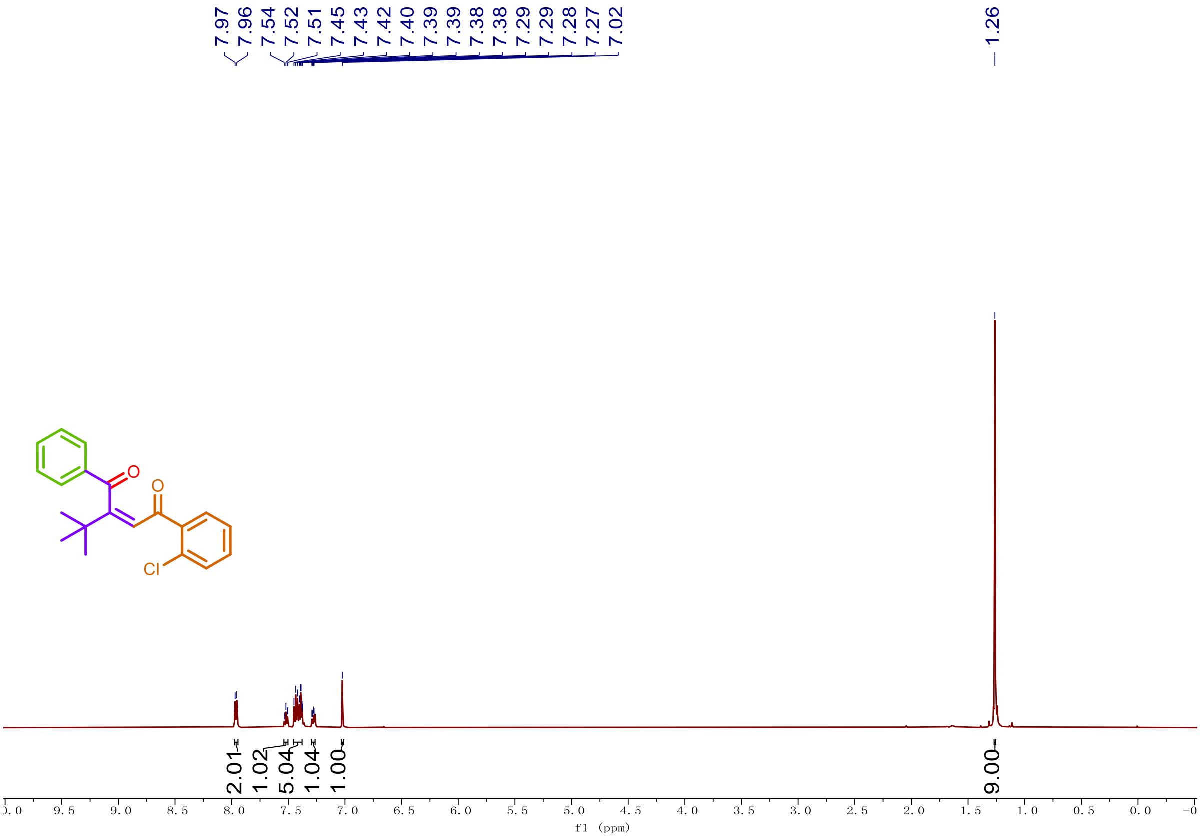
Compound 3ab: ^{1}H NMR (500 MHz, $CDCl_3$)



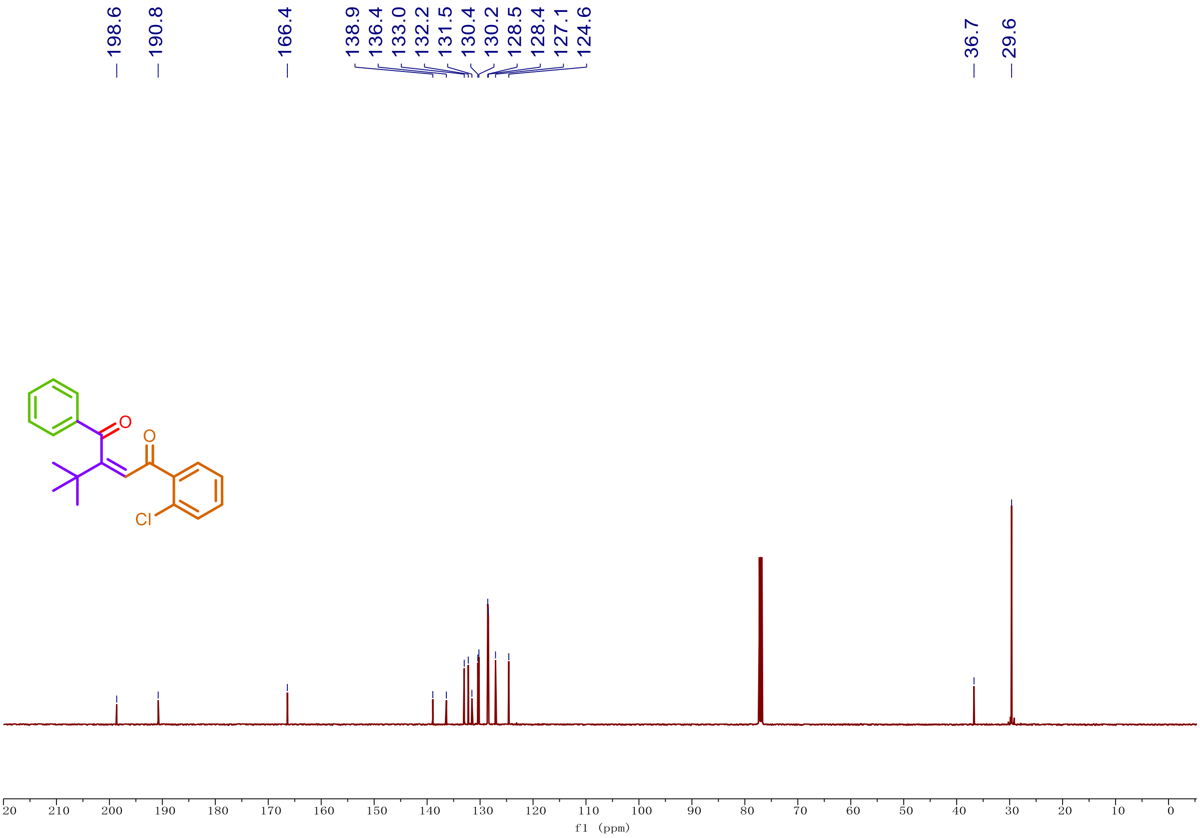
Compound 3ab: ^{13}C NMR (125 MHz, $CDCl_3$)



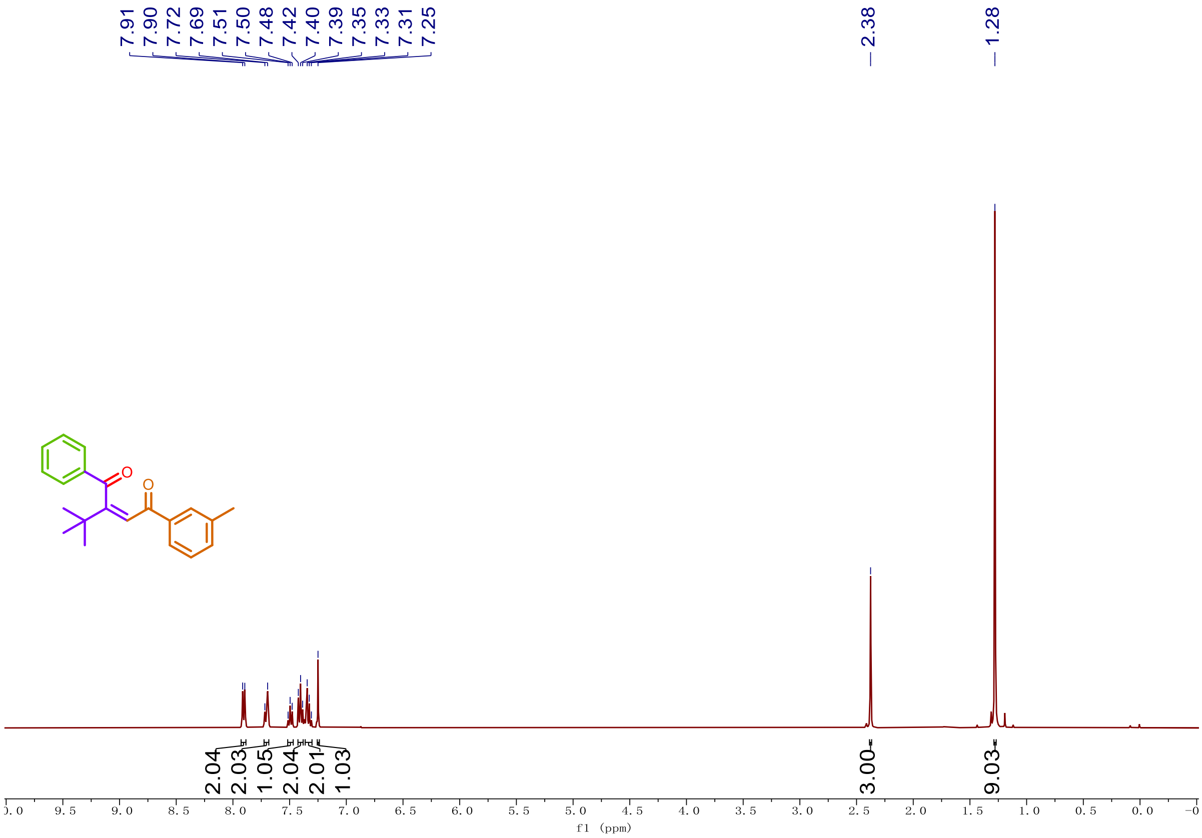
Compound 3ac: ¹H NMR (500 MHz, $CDCl_3$)



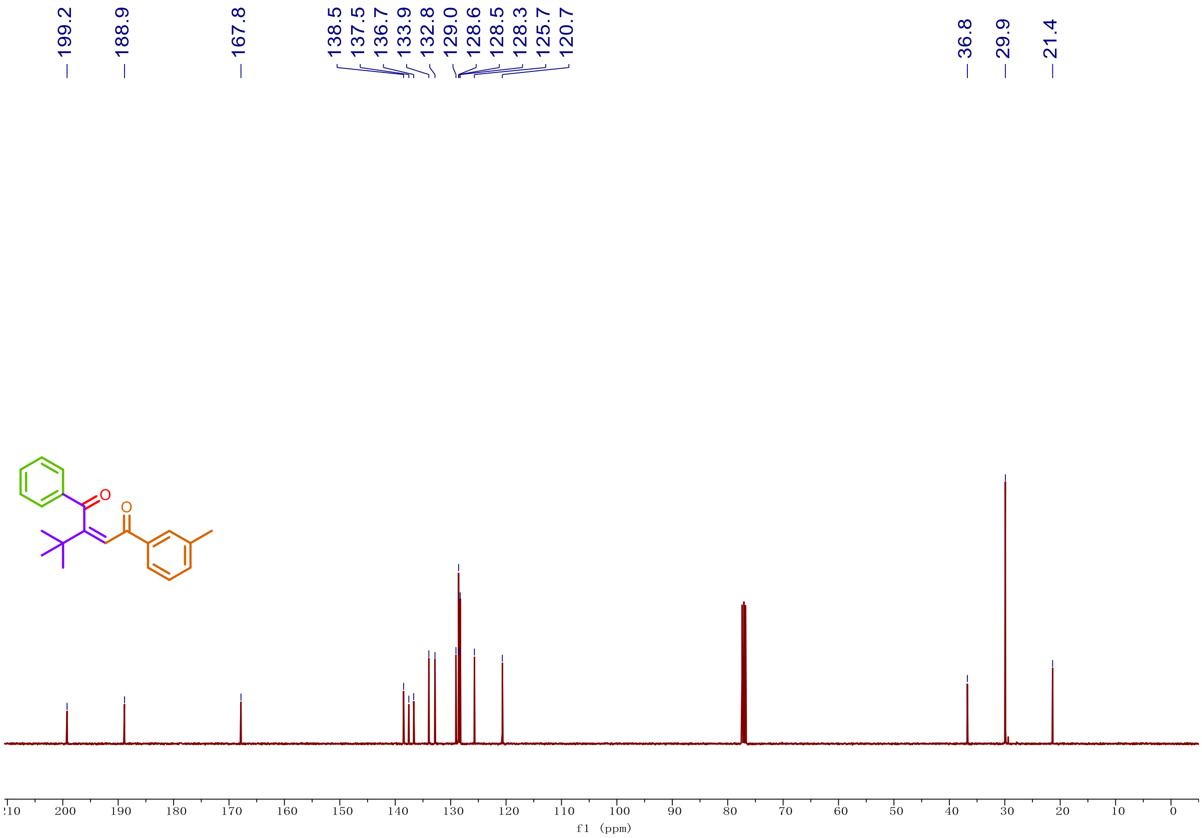
Compound 3ac: ¹³C NMR (125 MHz, $CDCl_3$)



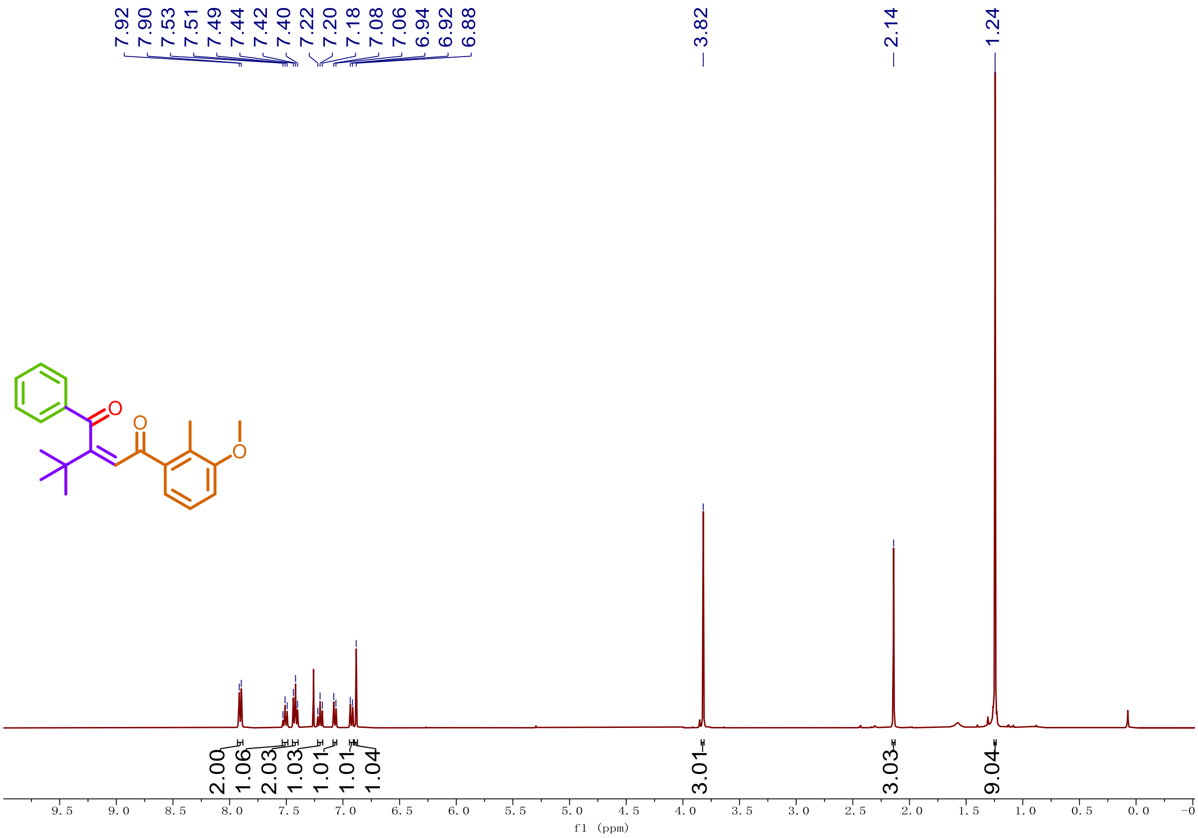
Compound 3ad: ^{1}H NMR (500 MHz, $CDCl_3$)



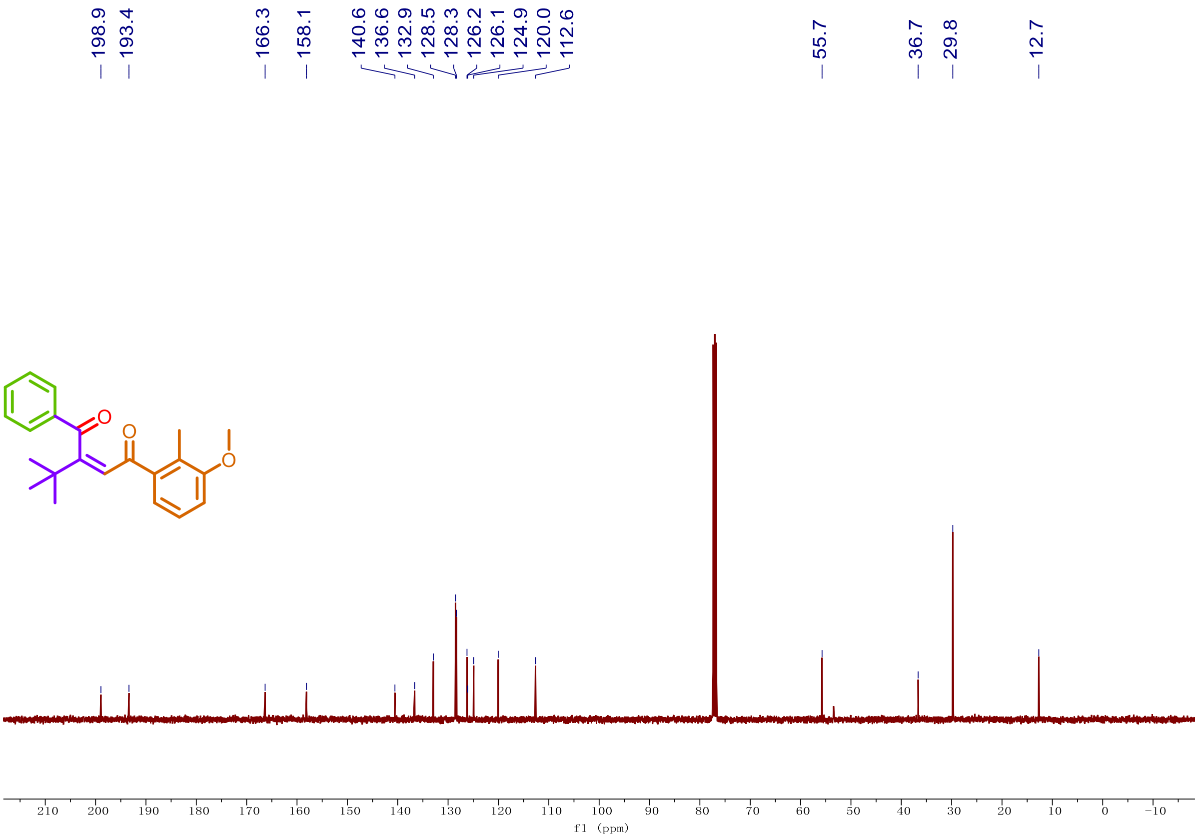
Compound 3ad: ^{13}C NMR (125 MHz, $CDCl_3$)



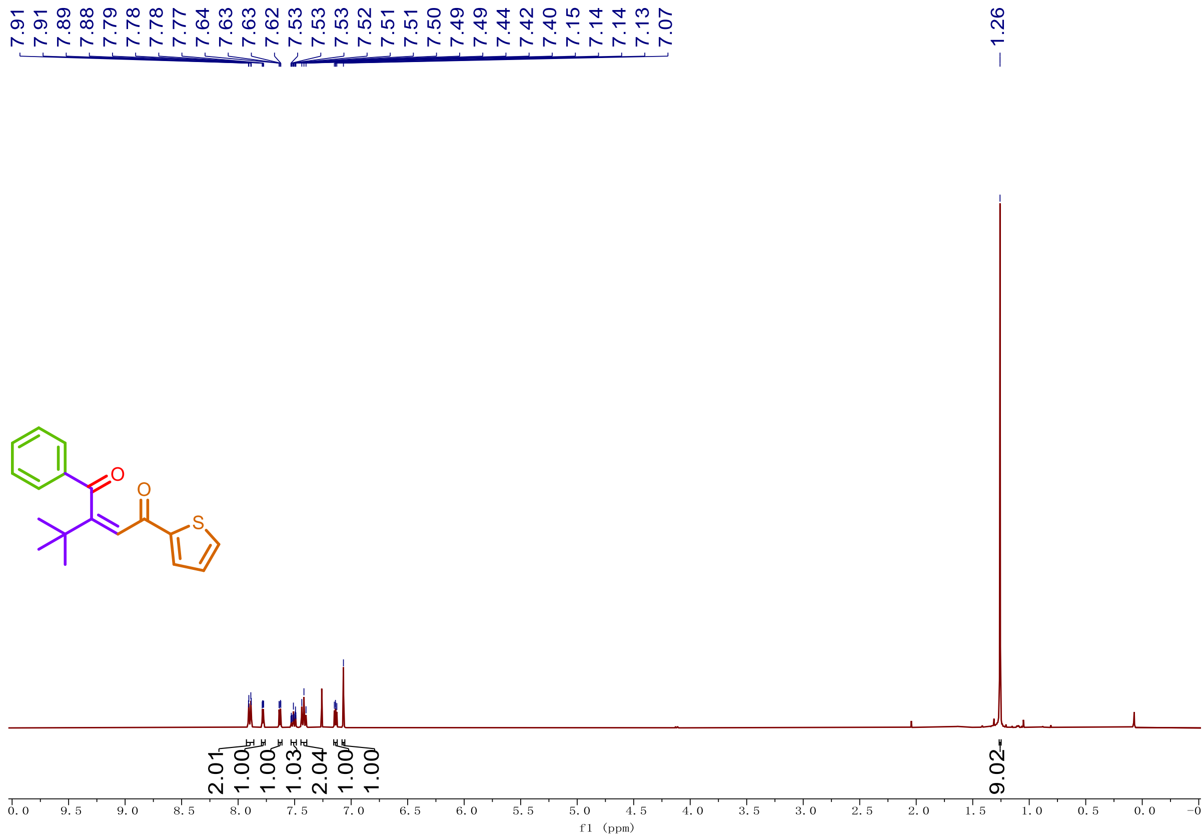
Compound 3ae: 1H NMR (500 MHz, $CDCl_3$)



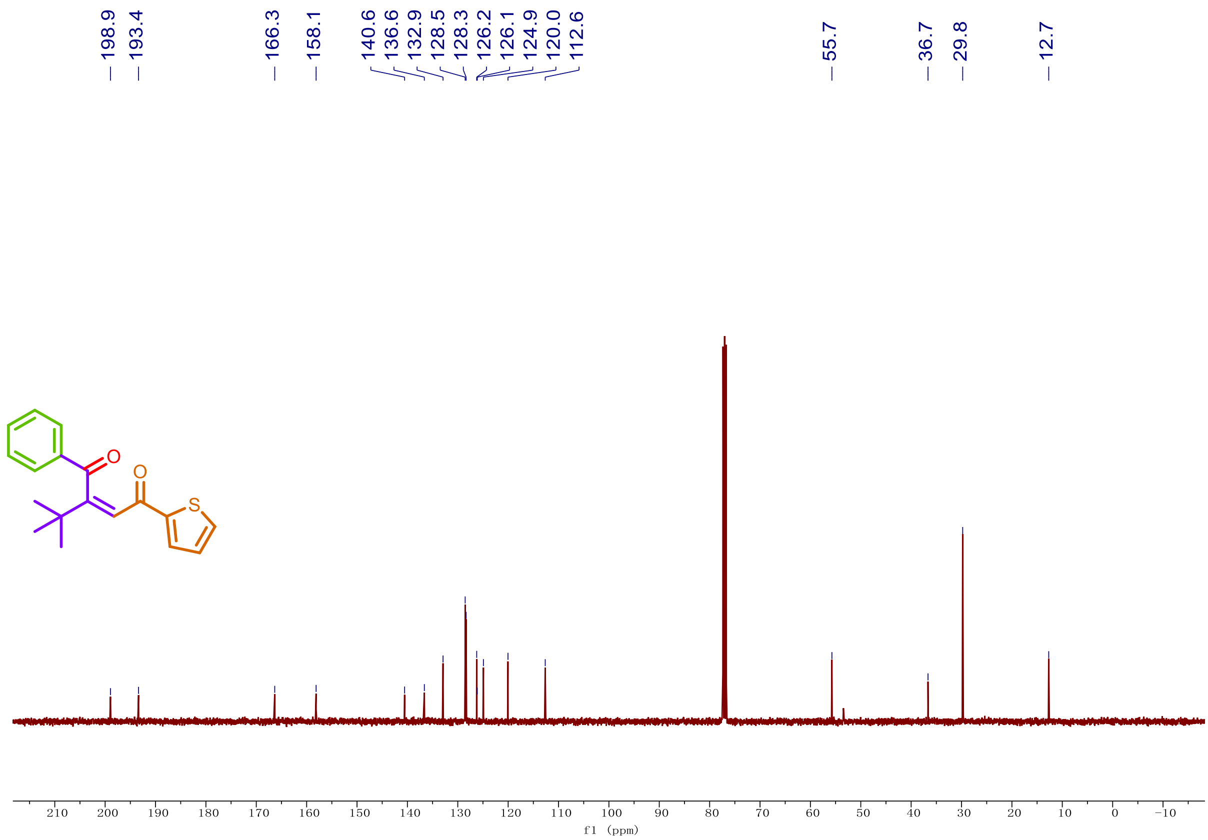
Compound 3ae: 13C NMR (125 MHz, $CDCl_3$)



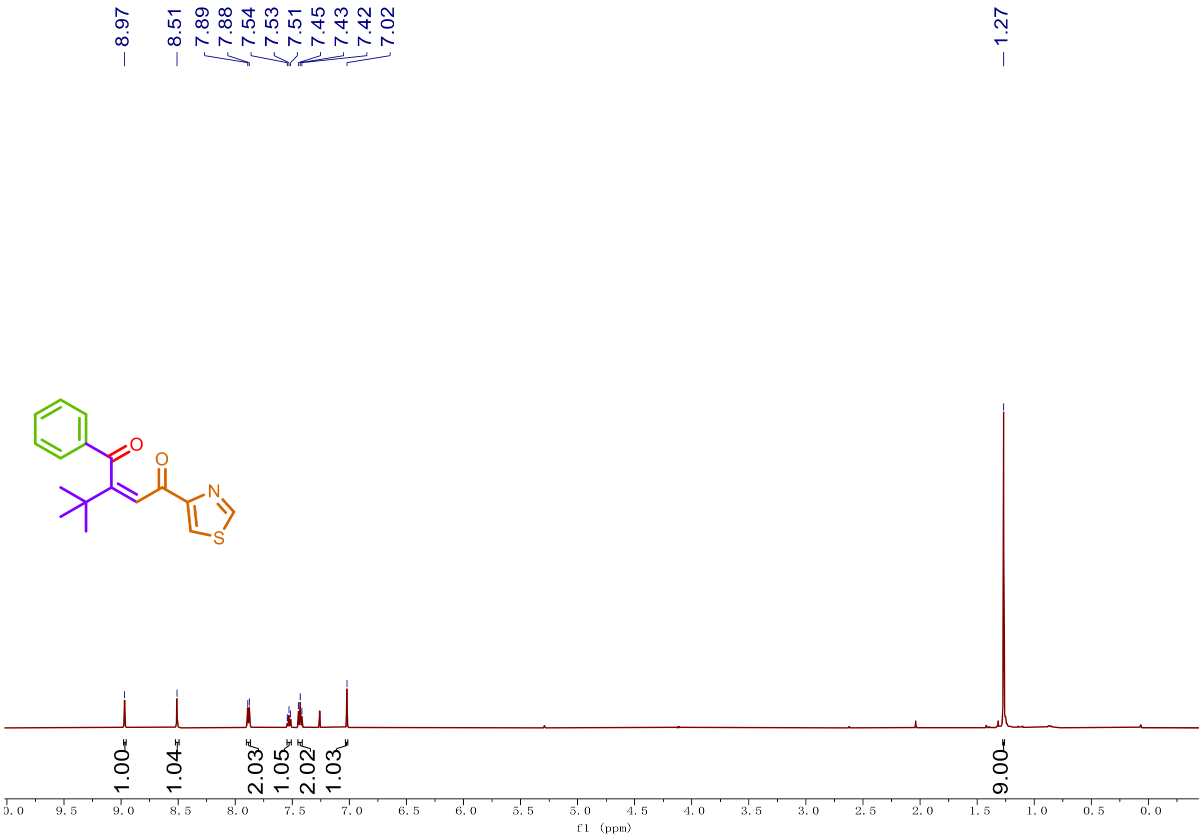
Compound 3af: **^{1}H NMR** (500 MHz, $CDCl_3$)



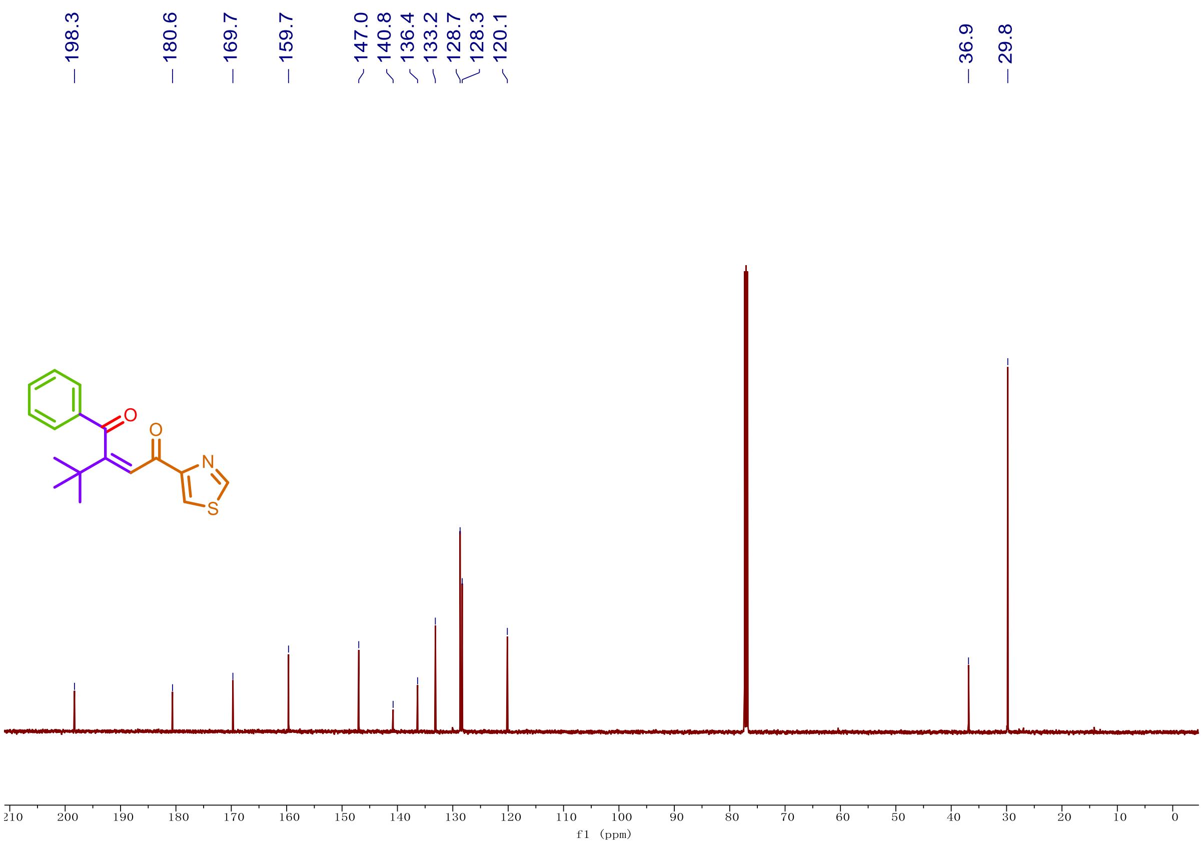
Compound 3af: **^{13}C NMR** (125 MHz, $CDCl_3$)



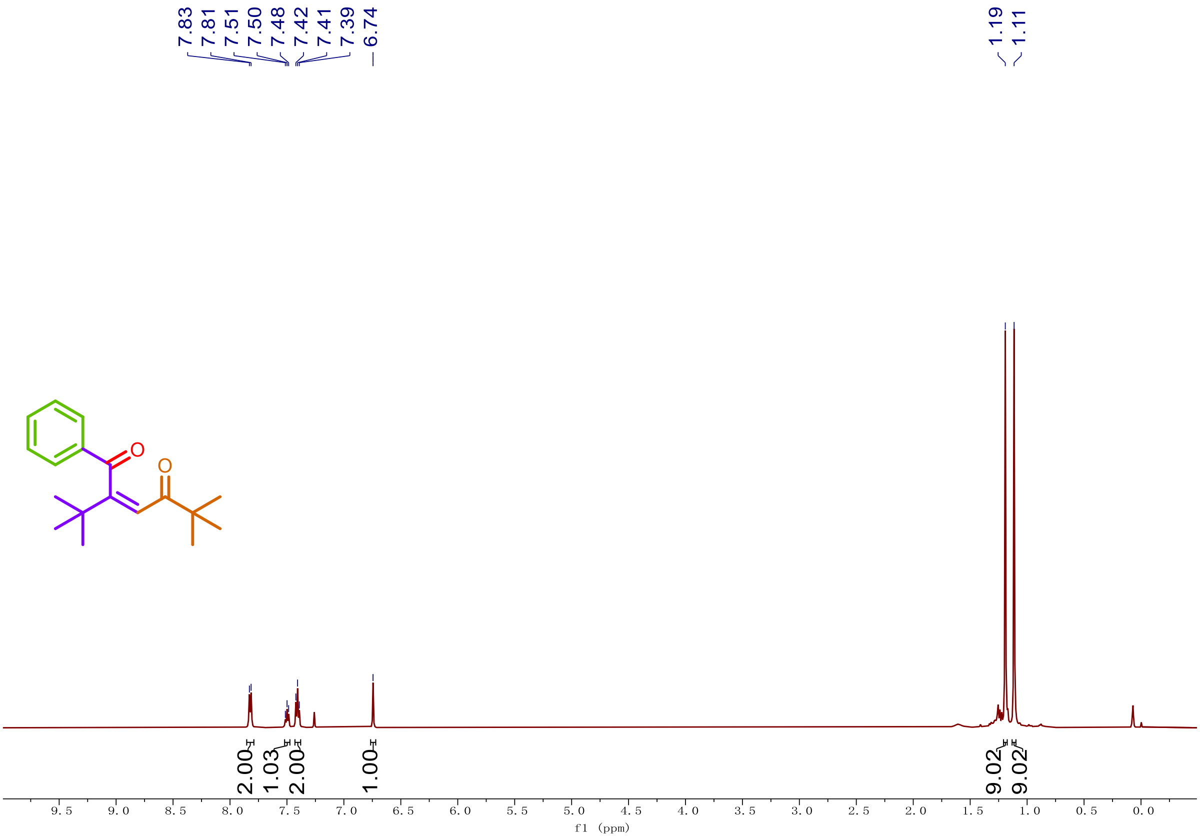
Compound 3ag: ^{1}H NMR (500 MHz, $CDCl_3$)



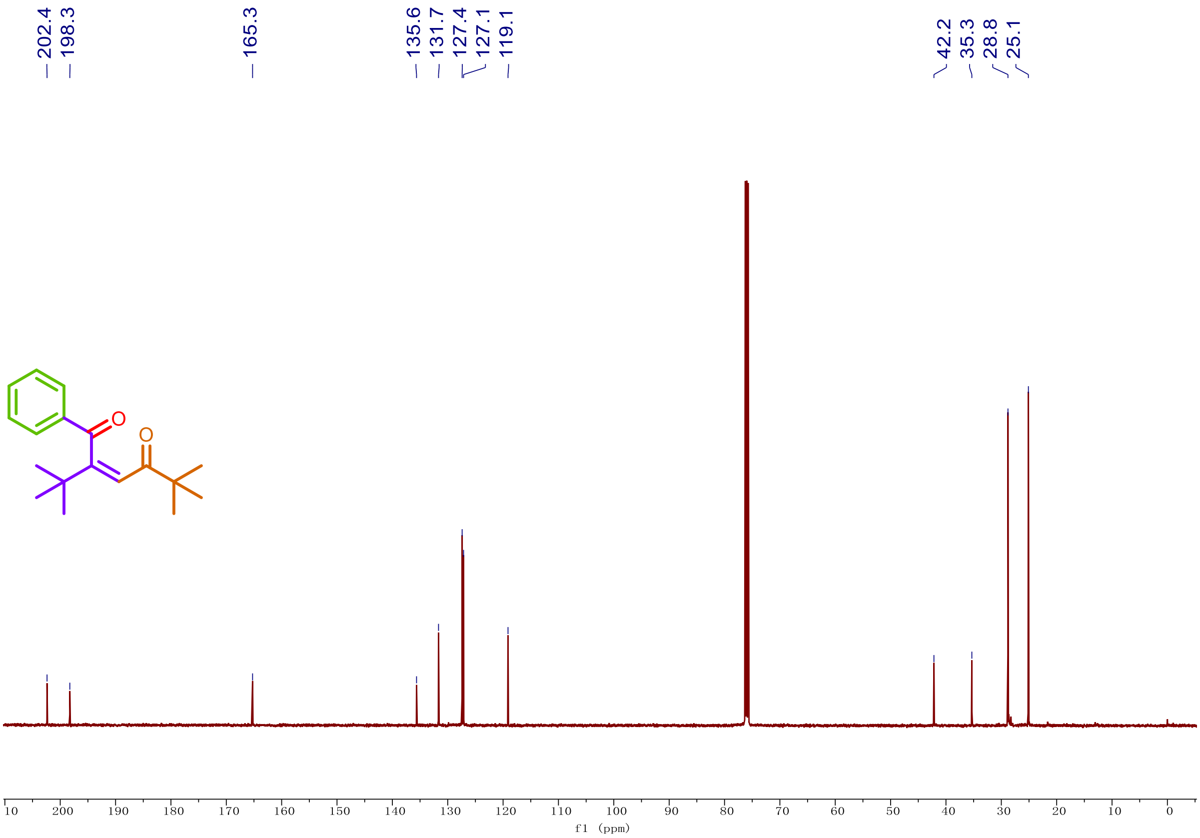
Compound 3ag: ^{13}C NMR (125 MHz, $CDCl_3$)



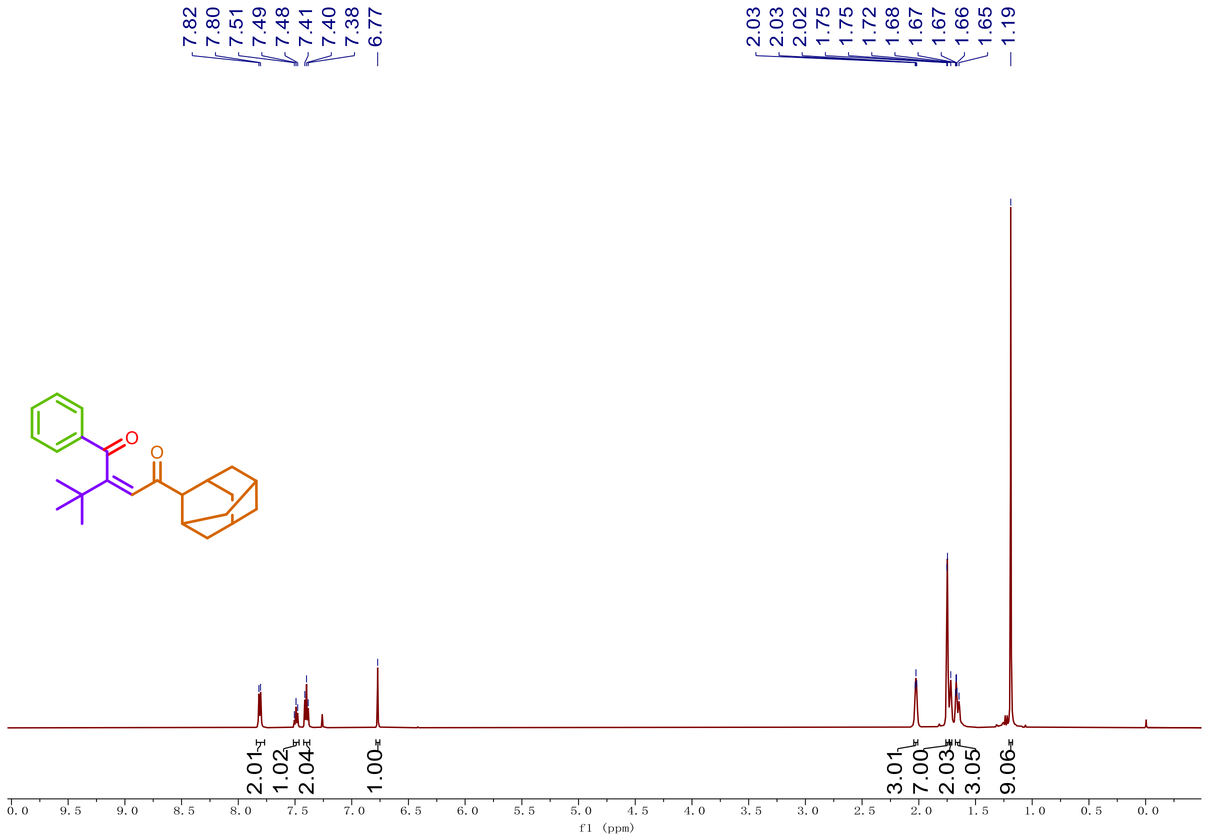
Compound 3ah: ^{1}H NMR (500 MHz, $CDCl_3$)



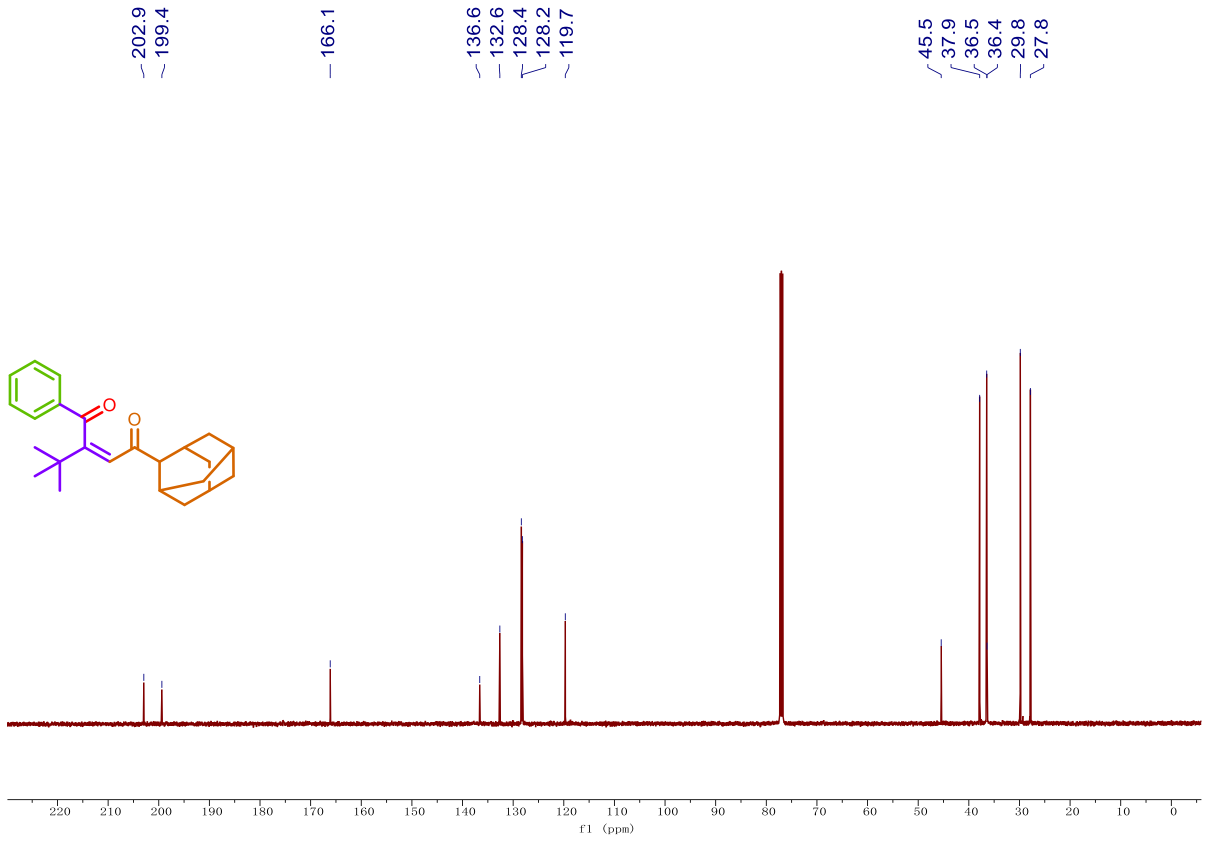
Compound 3ah: ^{13}C NMR (125 MHz, $CDCl_3$)



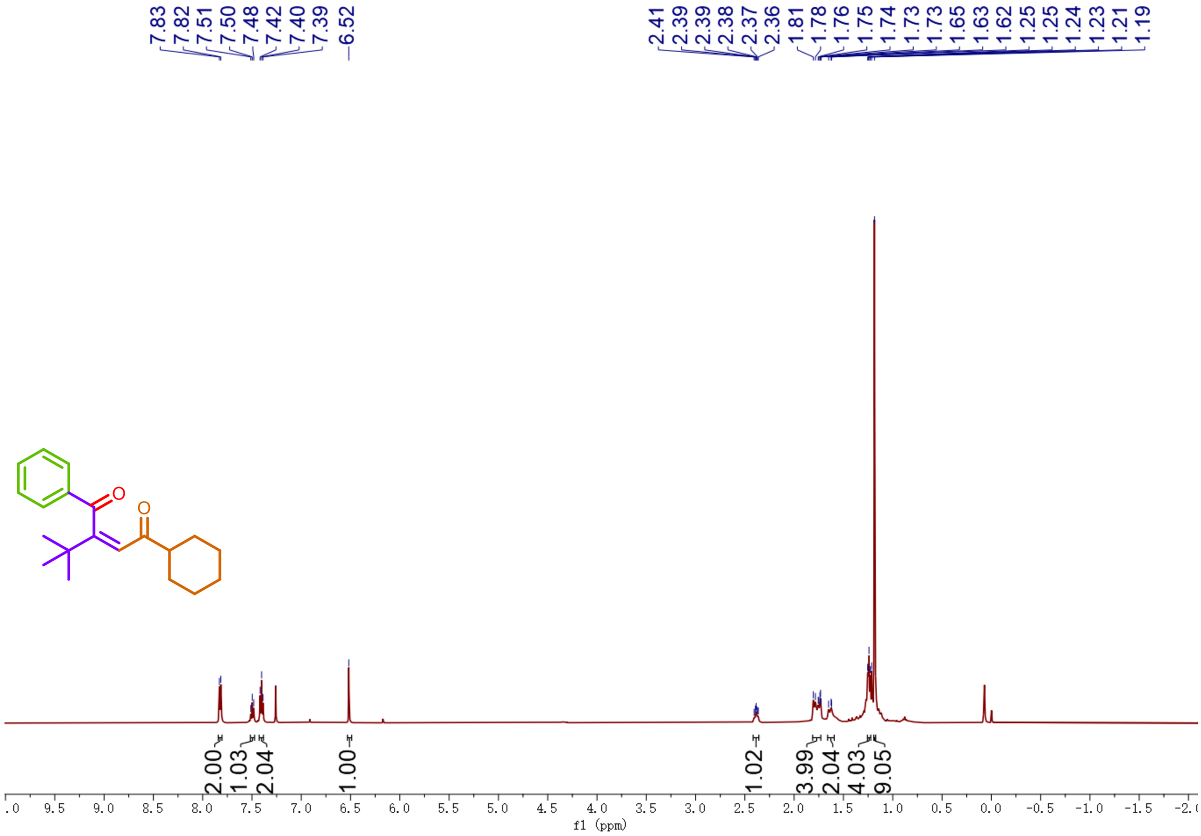
Compound 3ai: ^{1}H NMR (500 MHz, $CDCl_3$)



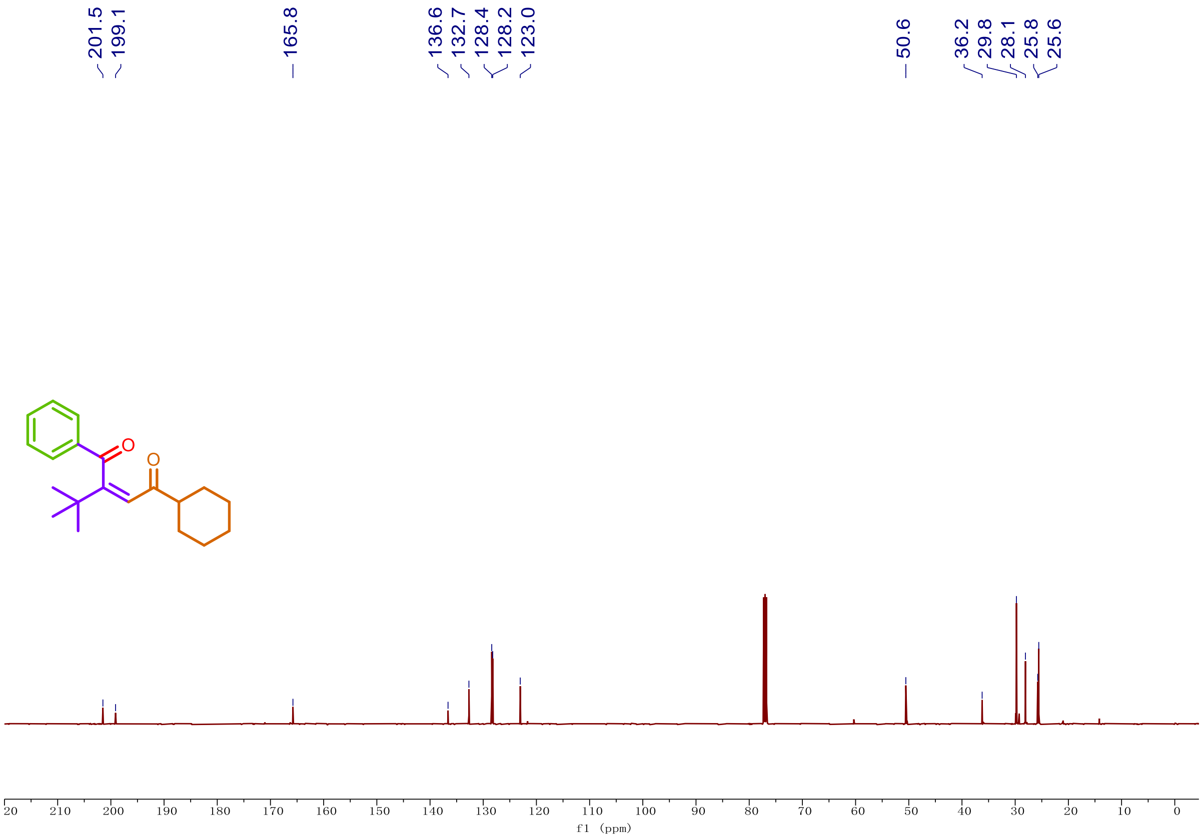
Compound 3ai: ^{13}C NMR (125 MHz, $CDCl_3$)



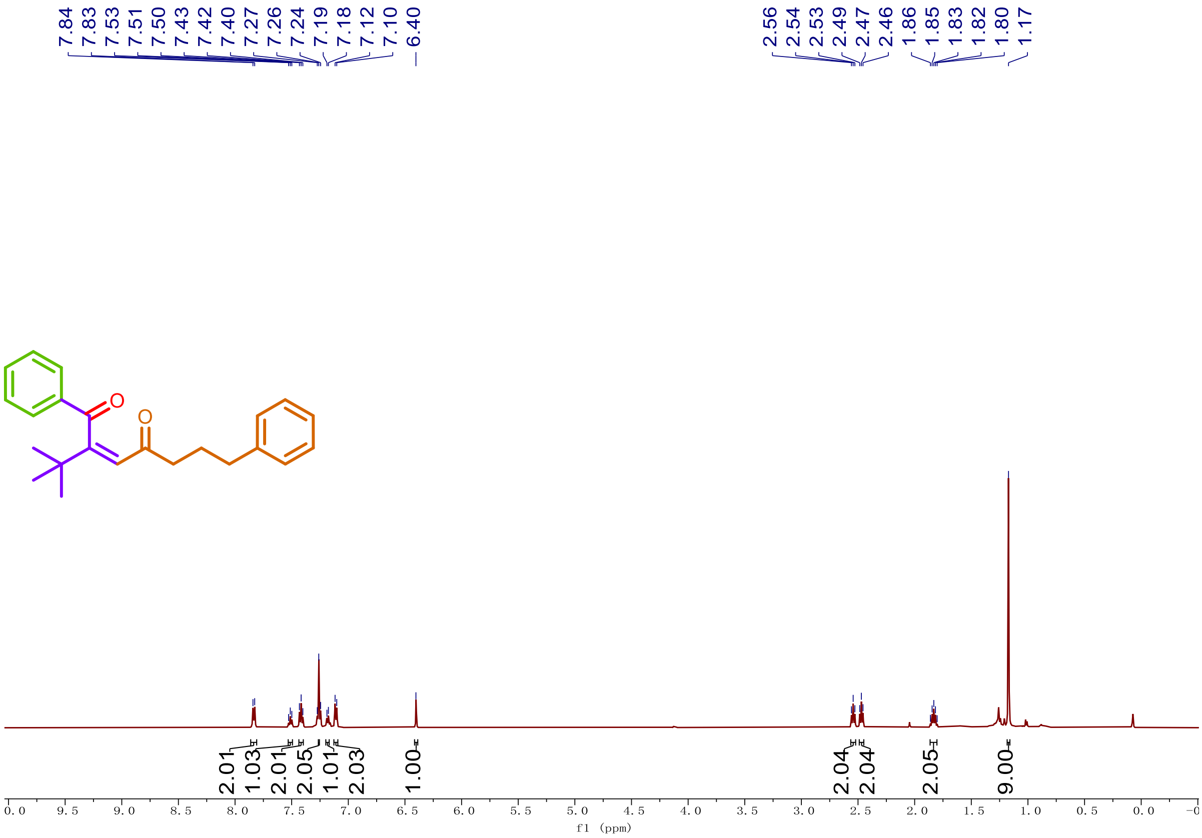
Compound 3aj: ¹H NMR (500 MHz, $CDCl_3$)



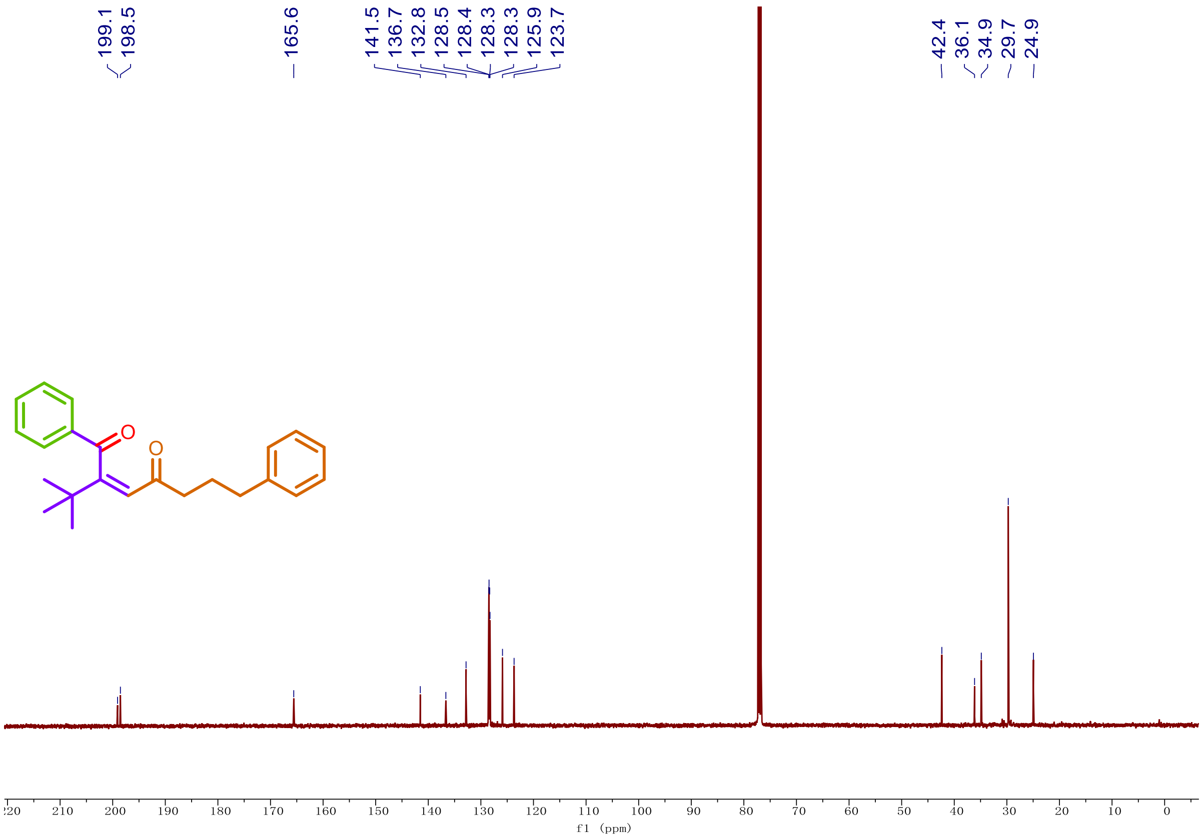
Compound 3aj: ¹³C NMR (125 MHz, $CDCl_3$)



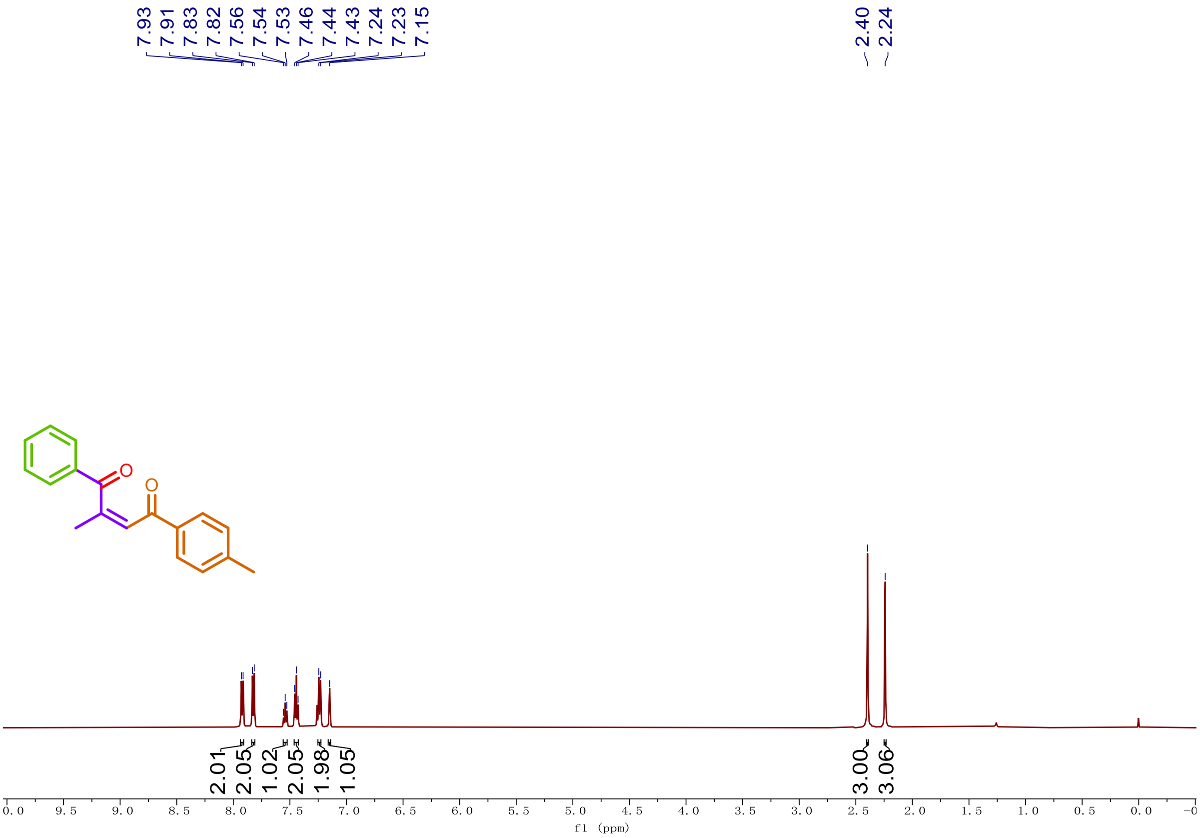
Compound 3ak: ^{1}H NMR (500 MHz, $CDCl_3$)



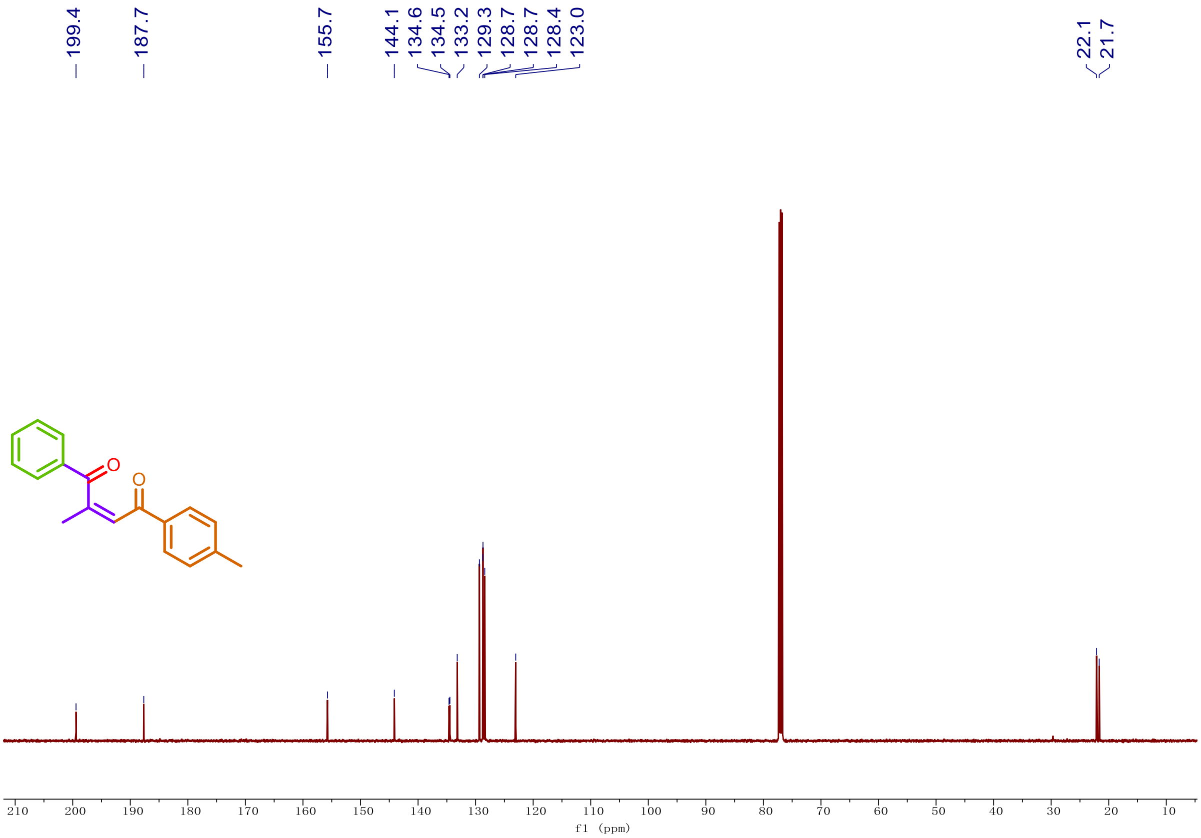
Compound 3ak: ^{13}C NMR (125 MHz, $CDCl_3$)



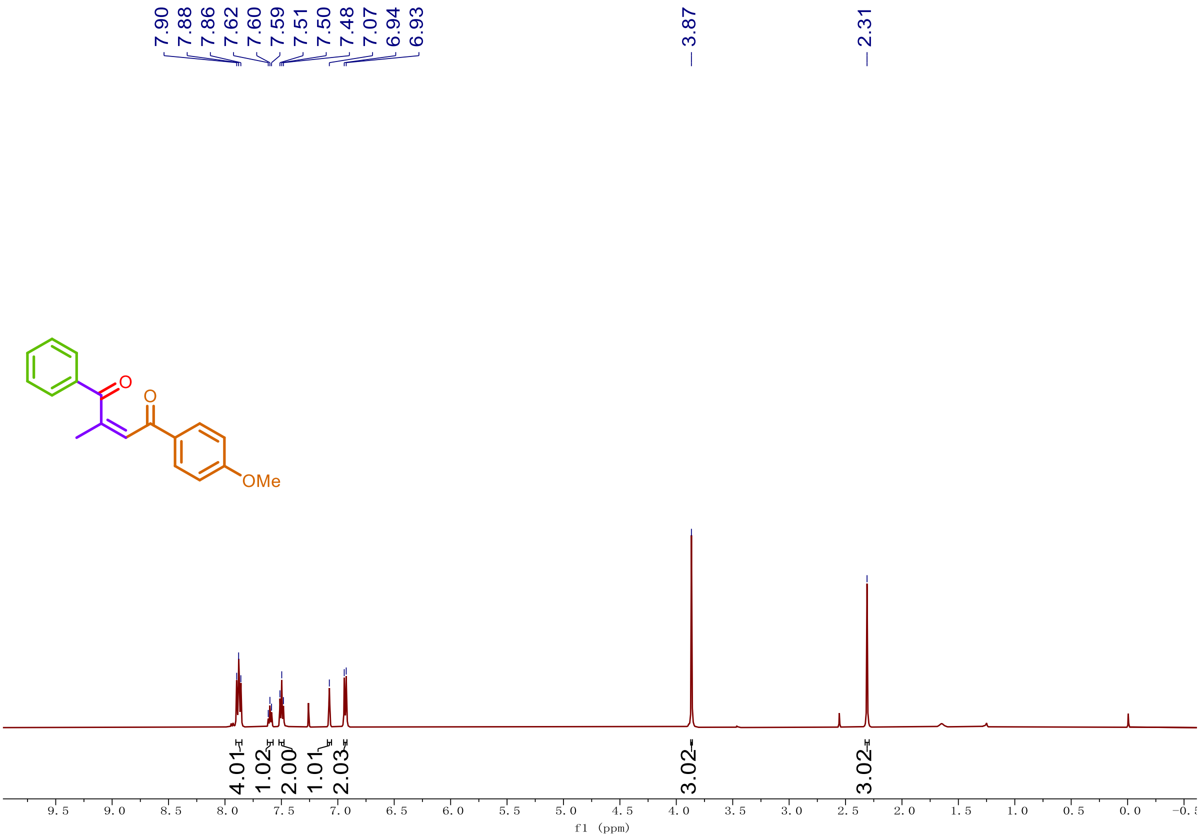
Compound 3al: ¹H NMR (500 MHz, $CDCl_3$)



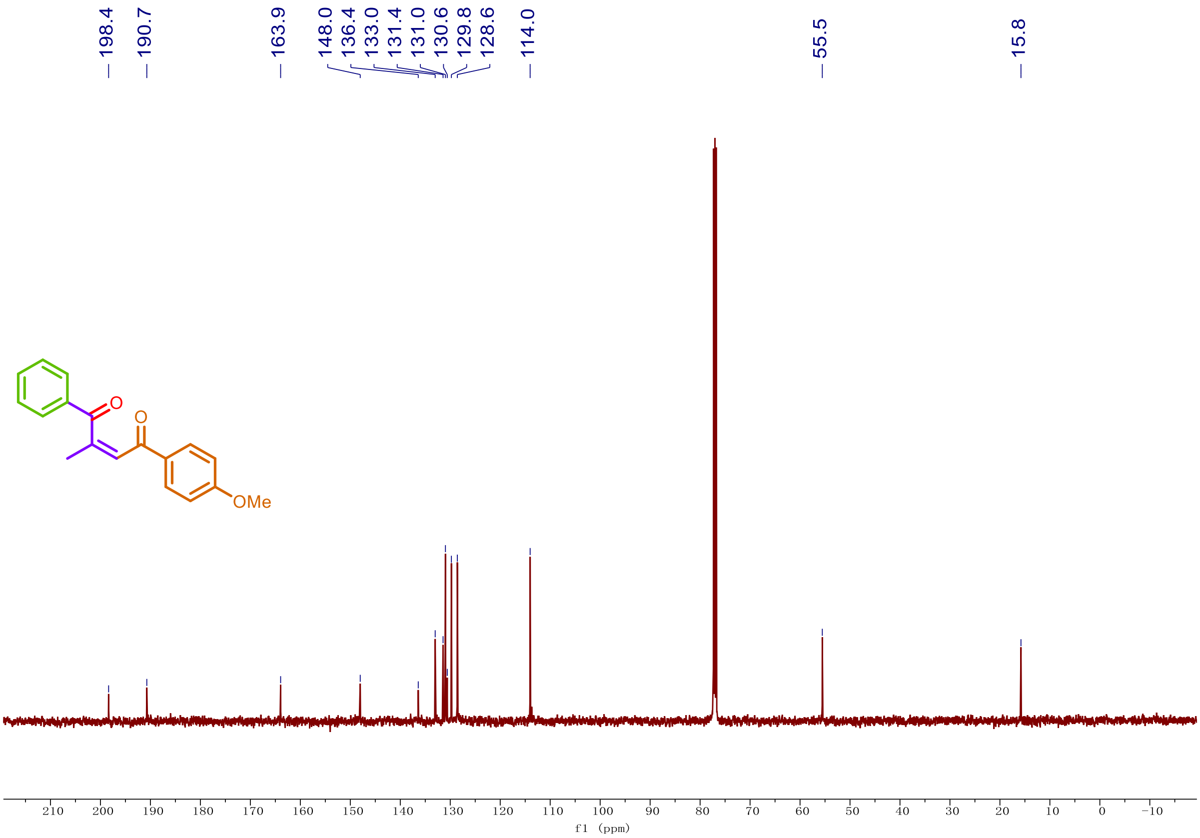
Compound 3al: ¹³C NMR (125 MHz, $CDCl_3$)



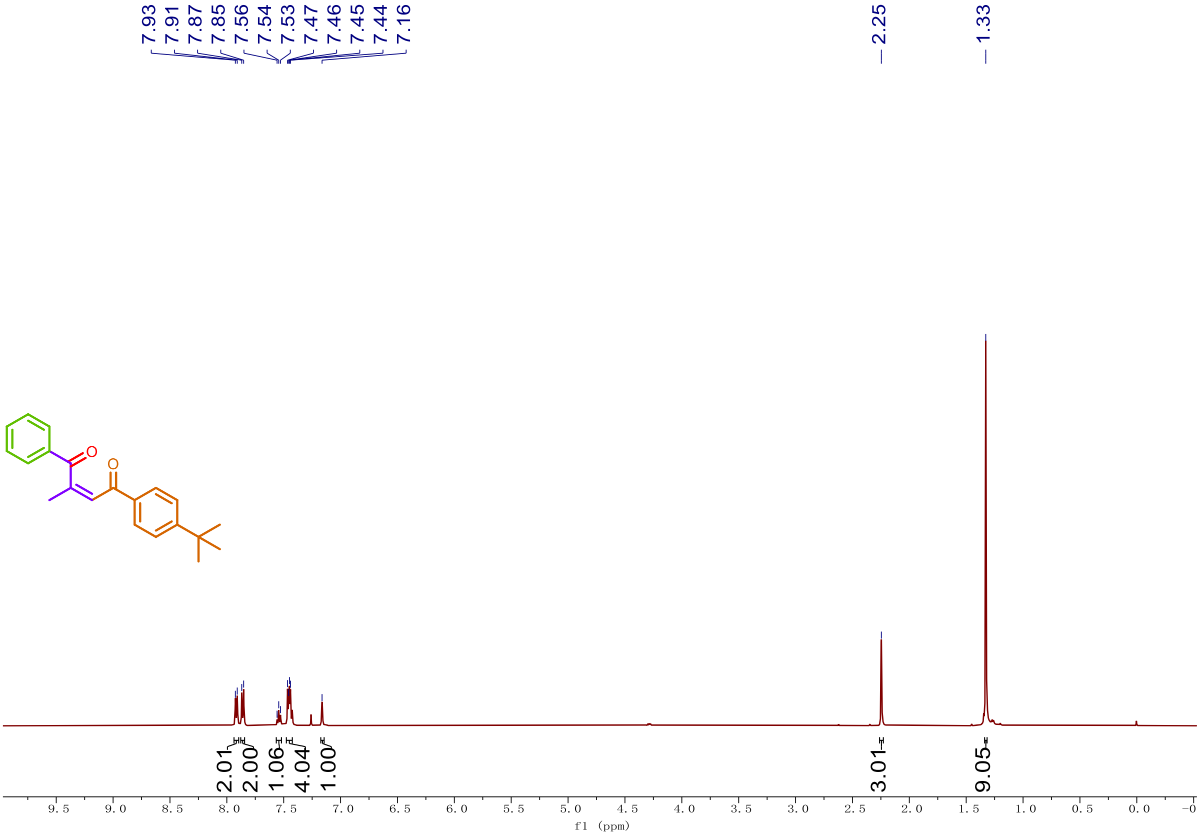
Compound 3am: ^{1}H NMR (500 MHz, $CDCl_3$)



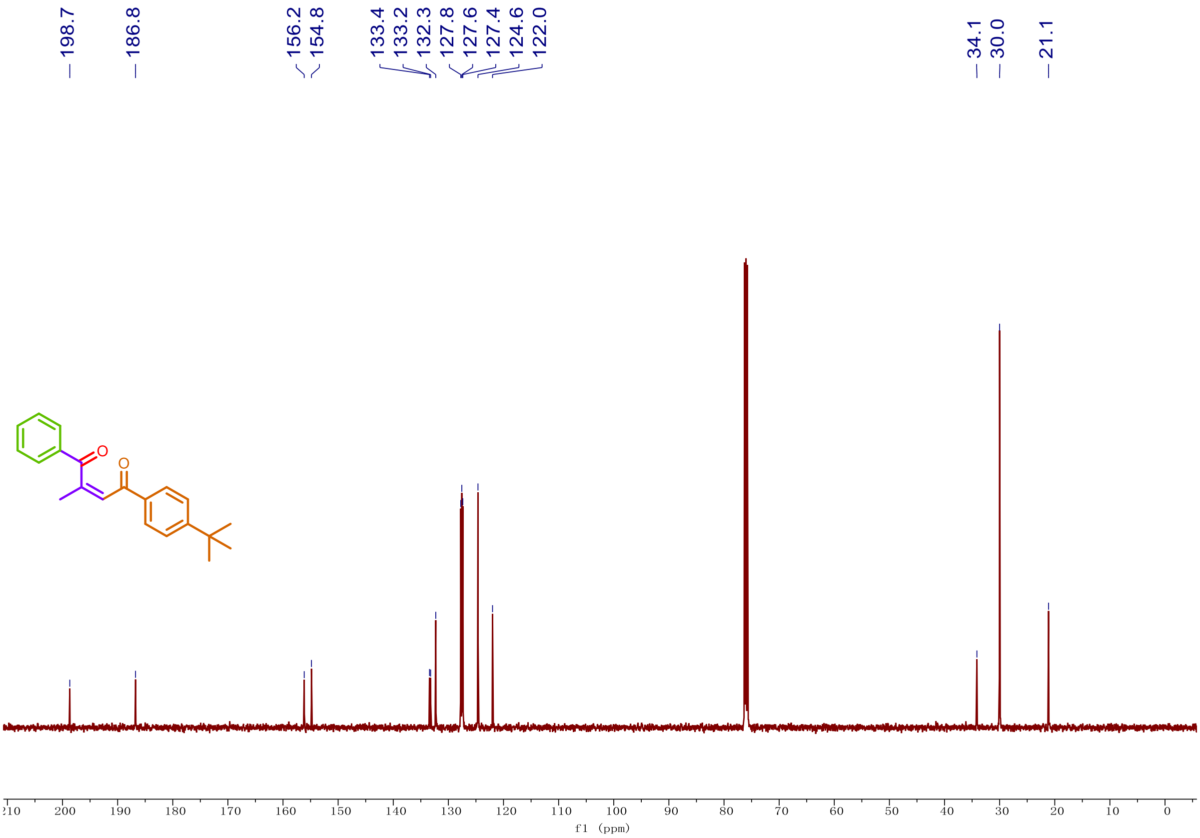
Compound 3am: ^{13}C NMR (125 MHz, $CDCl_3$)



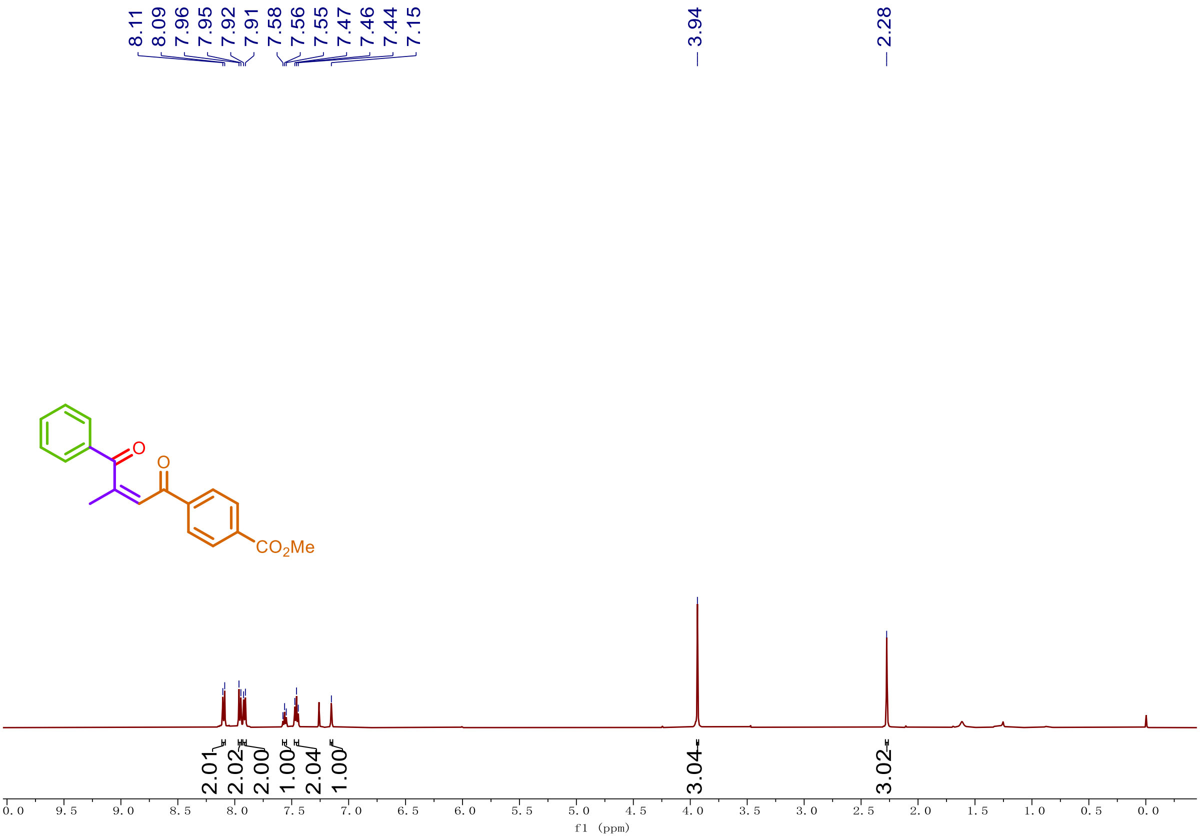
Compound 3an: ^{1}H NMR (500 MHz, $CDCl_3$)



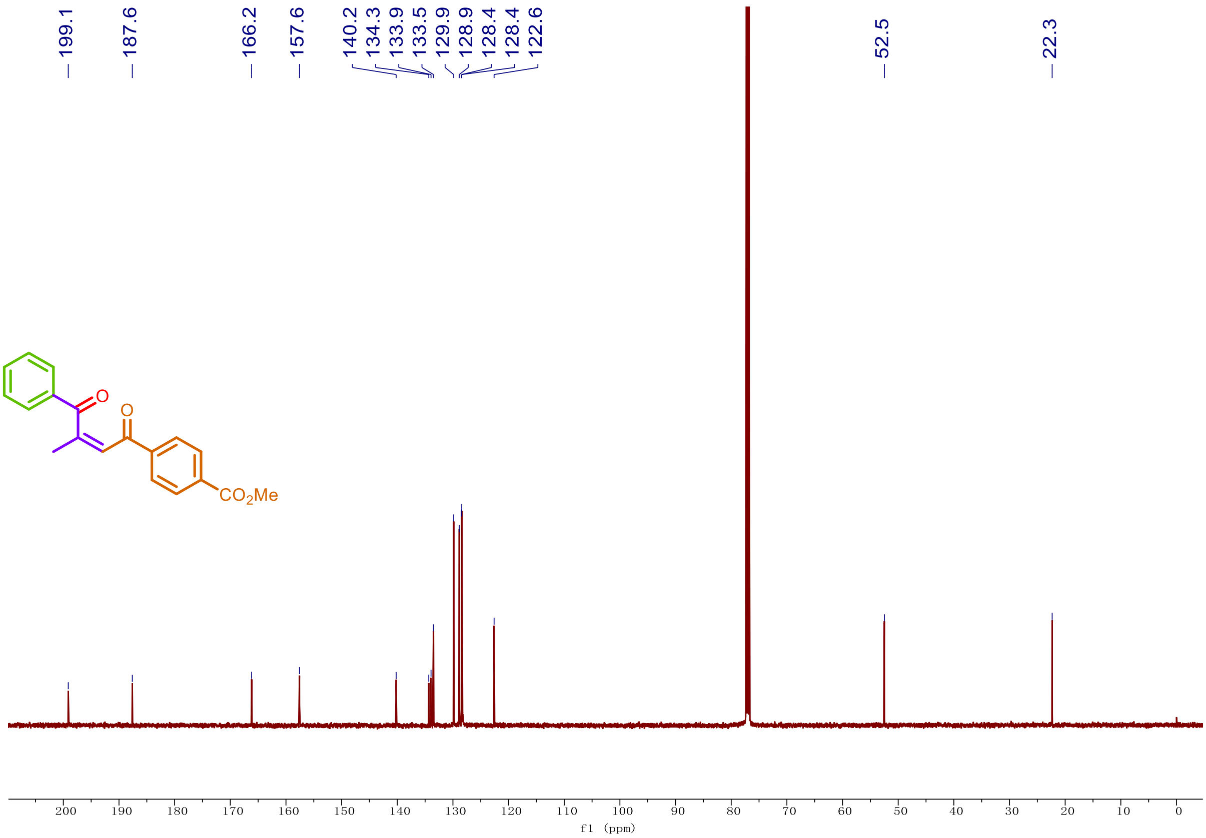
Compound 3an: ^{13}C NMR (125 MHz, $CDCl_3$)



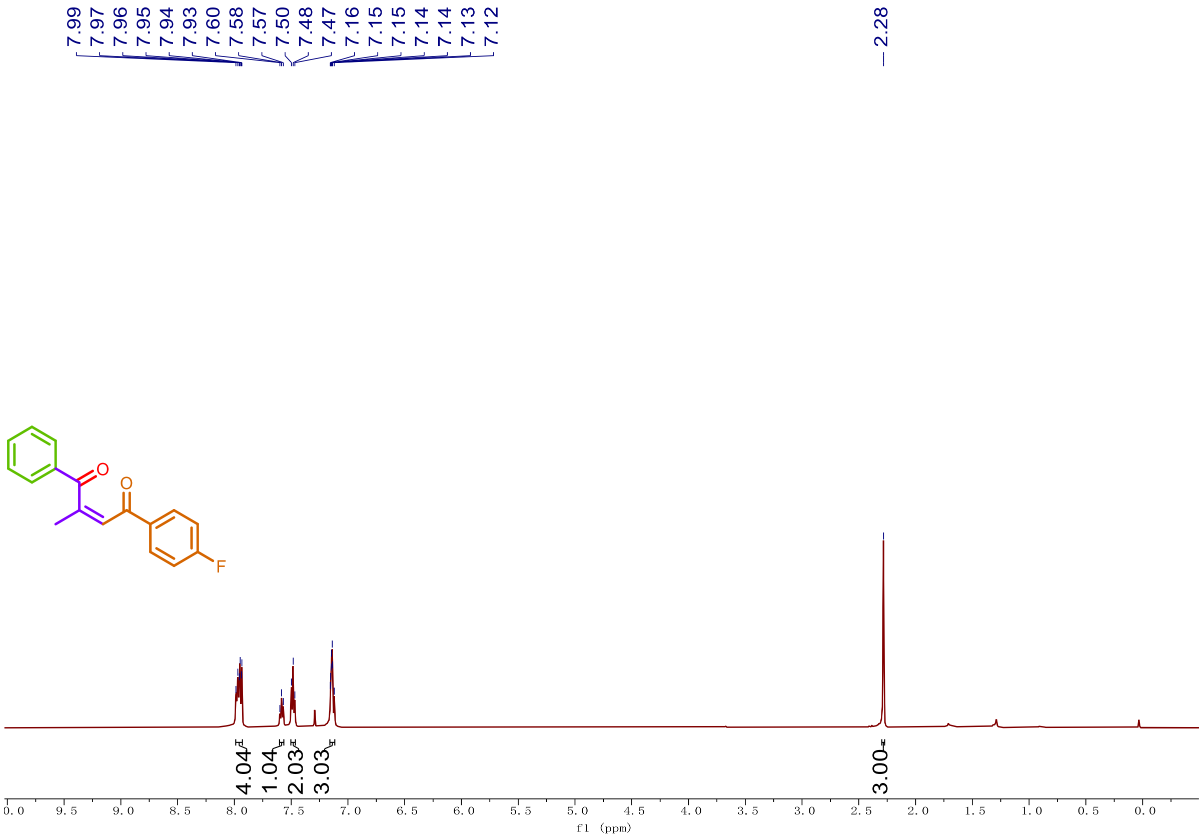
Compound 3ao: ^{1}H NMR (500 MHz, $CDCl_3$)



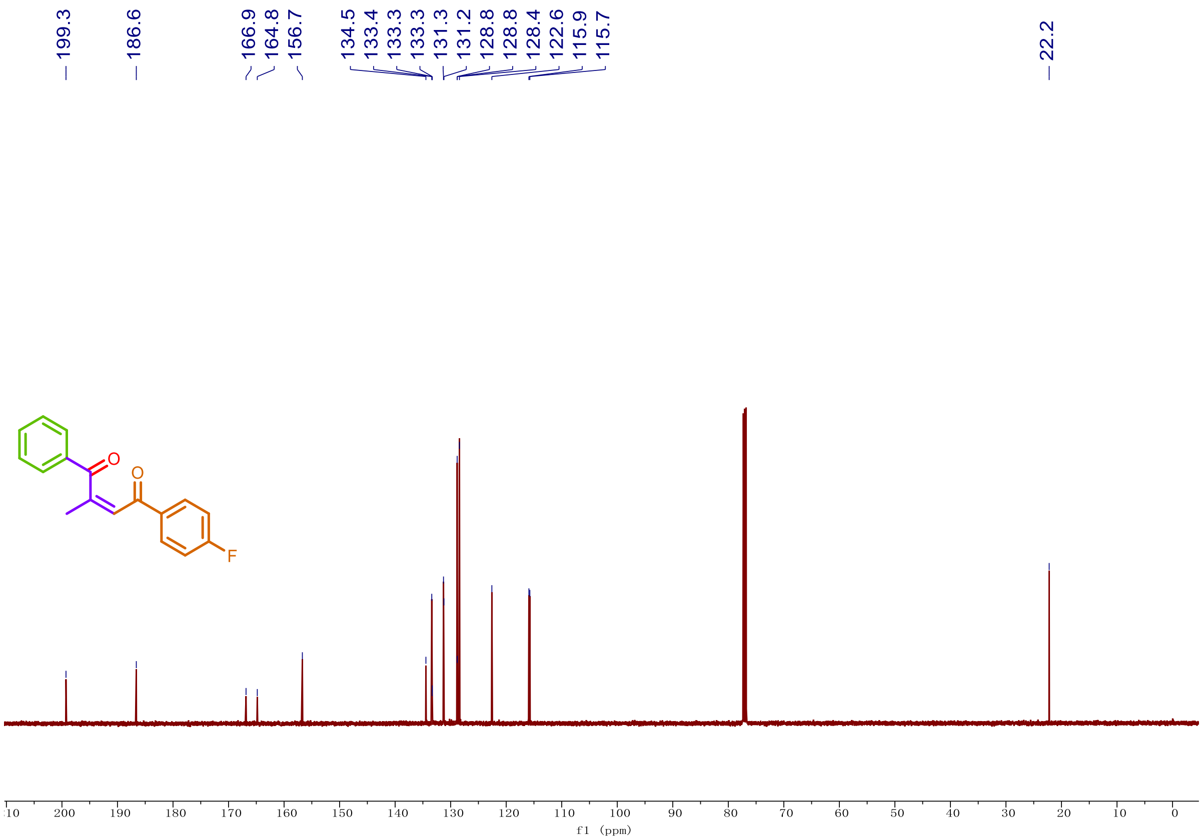
Compound 3ao: ^{13}C NMR (125 MHz, $CDCl_3$)



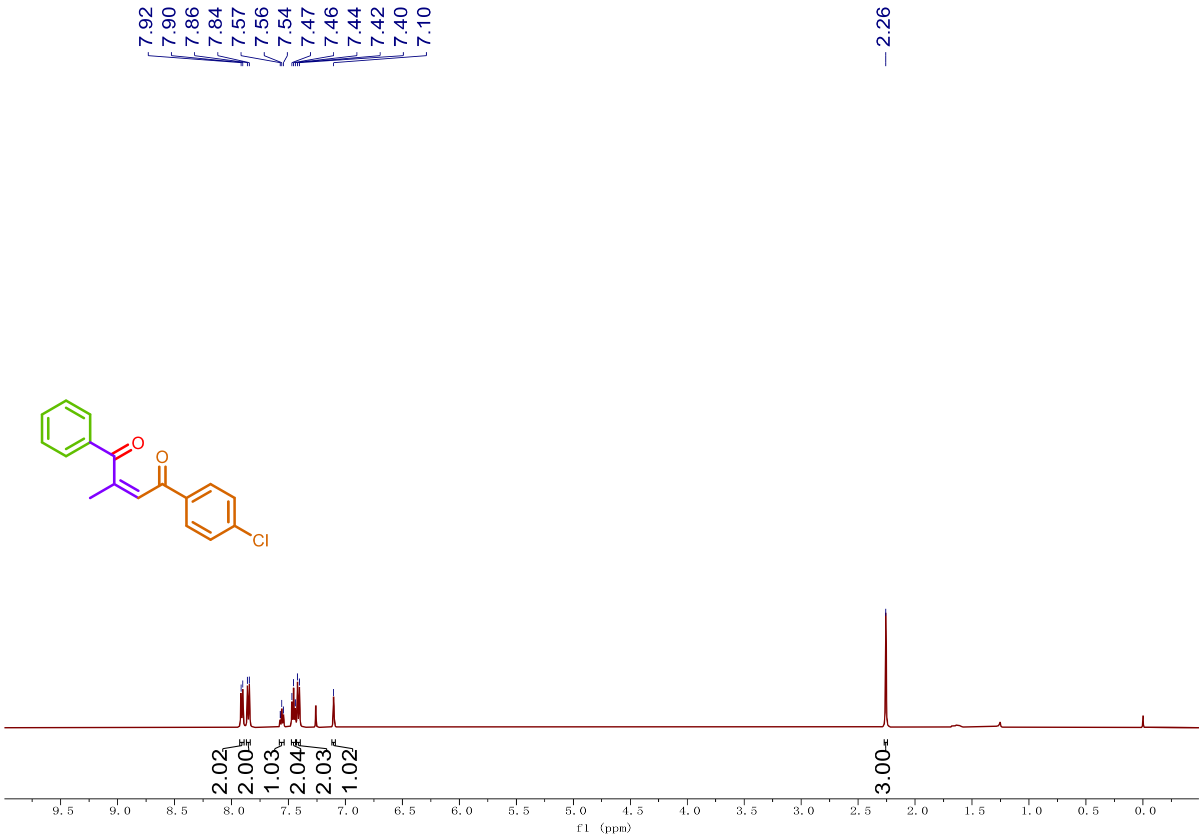
Compound 3ap: ¹H NMR (500 MHz, $CDCl_3$)



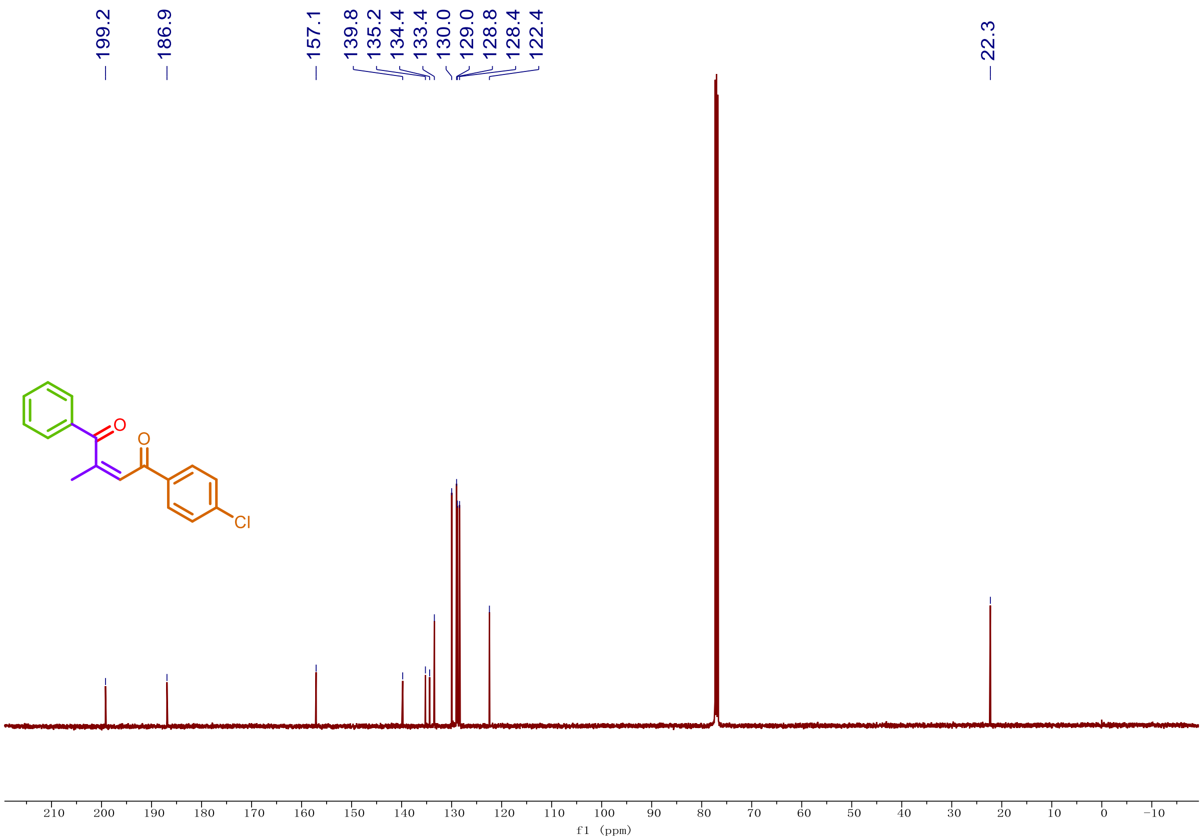
Compound 3ap: ¹³C NMR (125 MHz, $CDCl_3$)



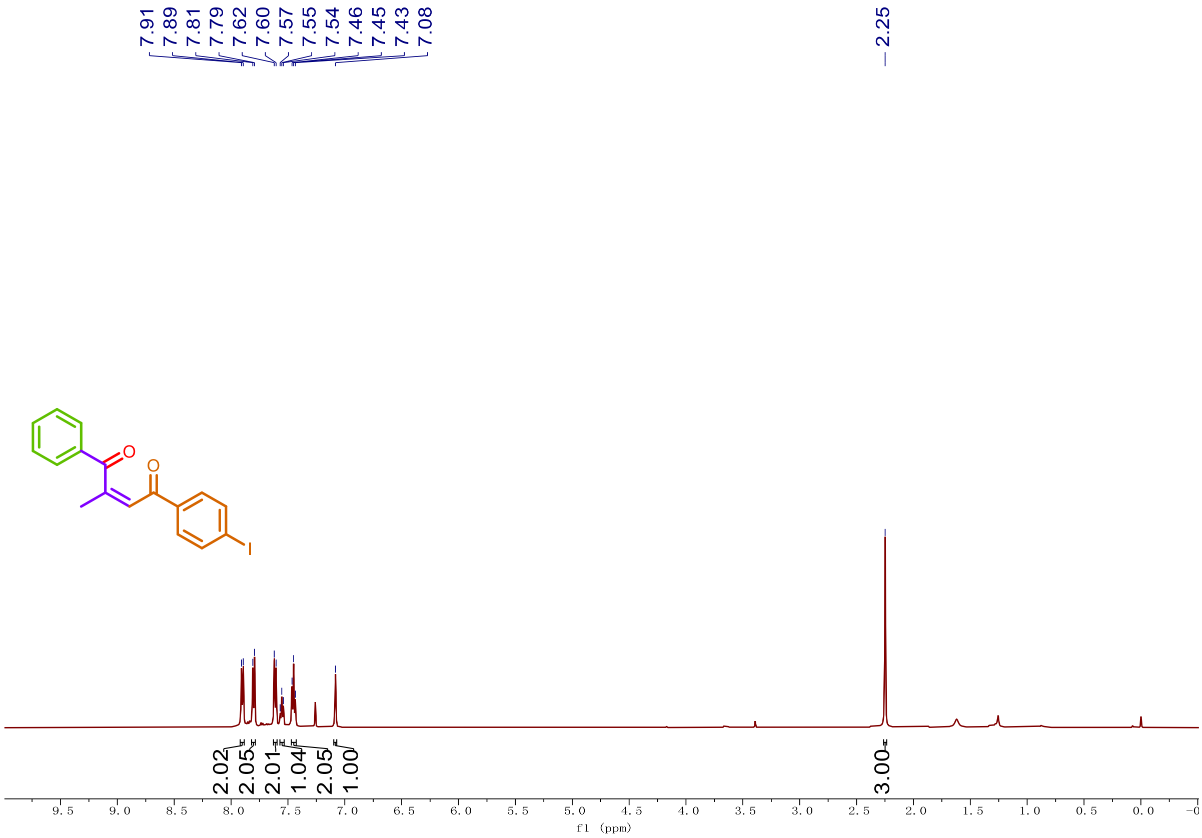
Compound 3aq: ^{1}H NMR (500 MHz, $CDCl_3$)



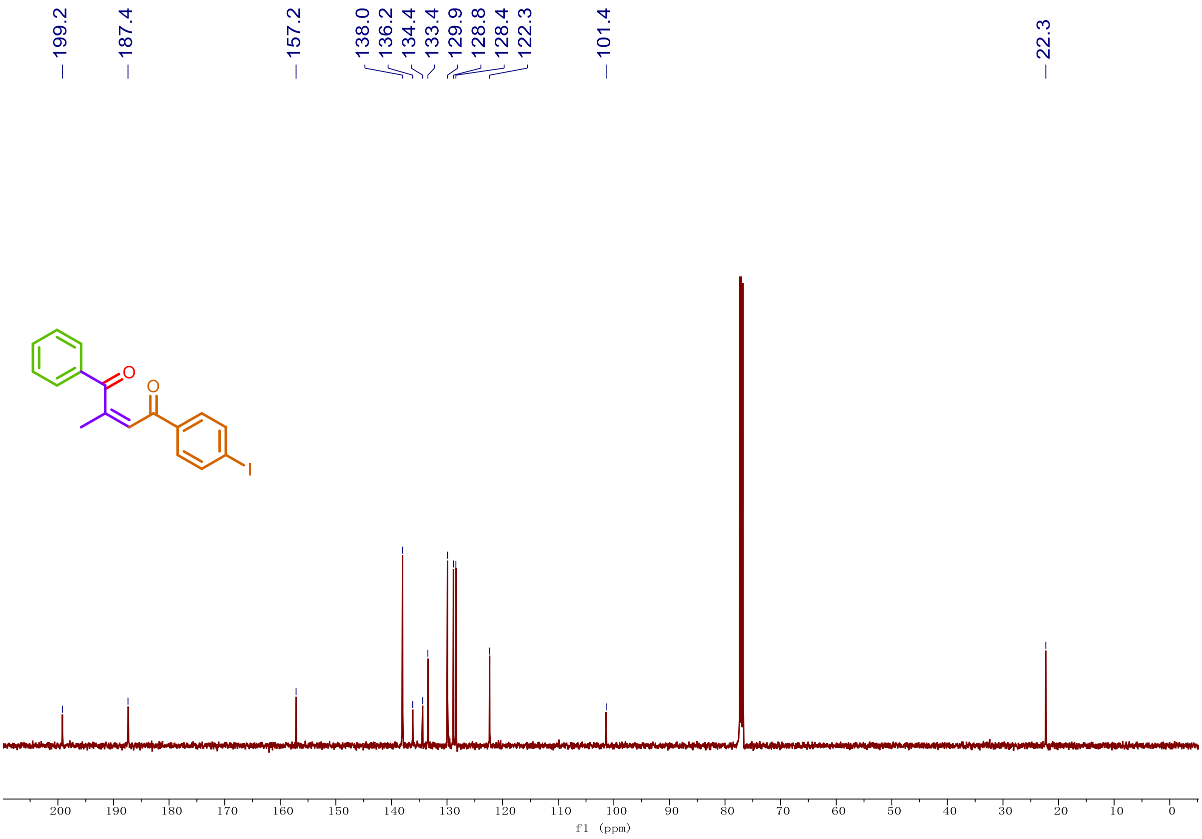
Compound 3aq: ^{13}C NMR (125 MHz, $CDCl_3$)



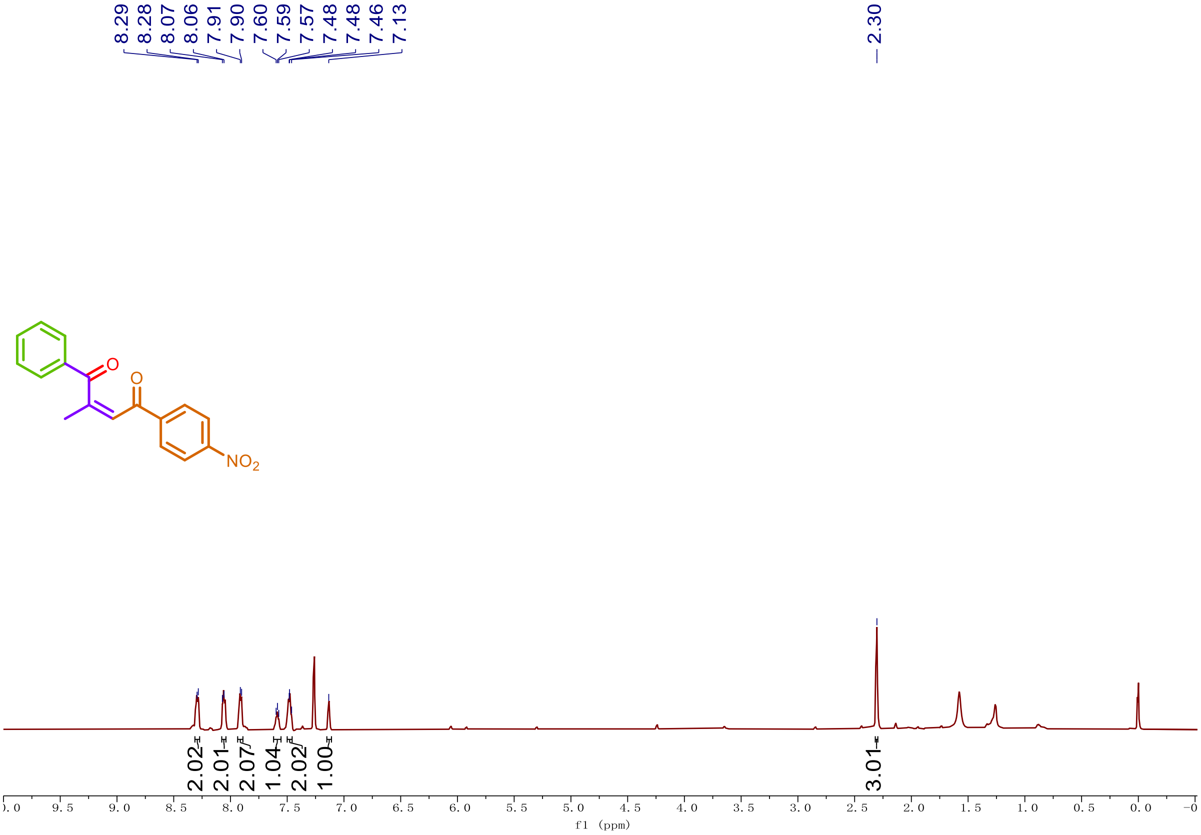
Compound 3ar: ¹H NMR (500 MHz, $CDCl_3$)



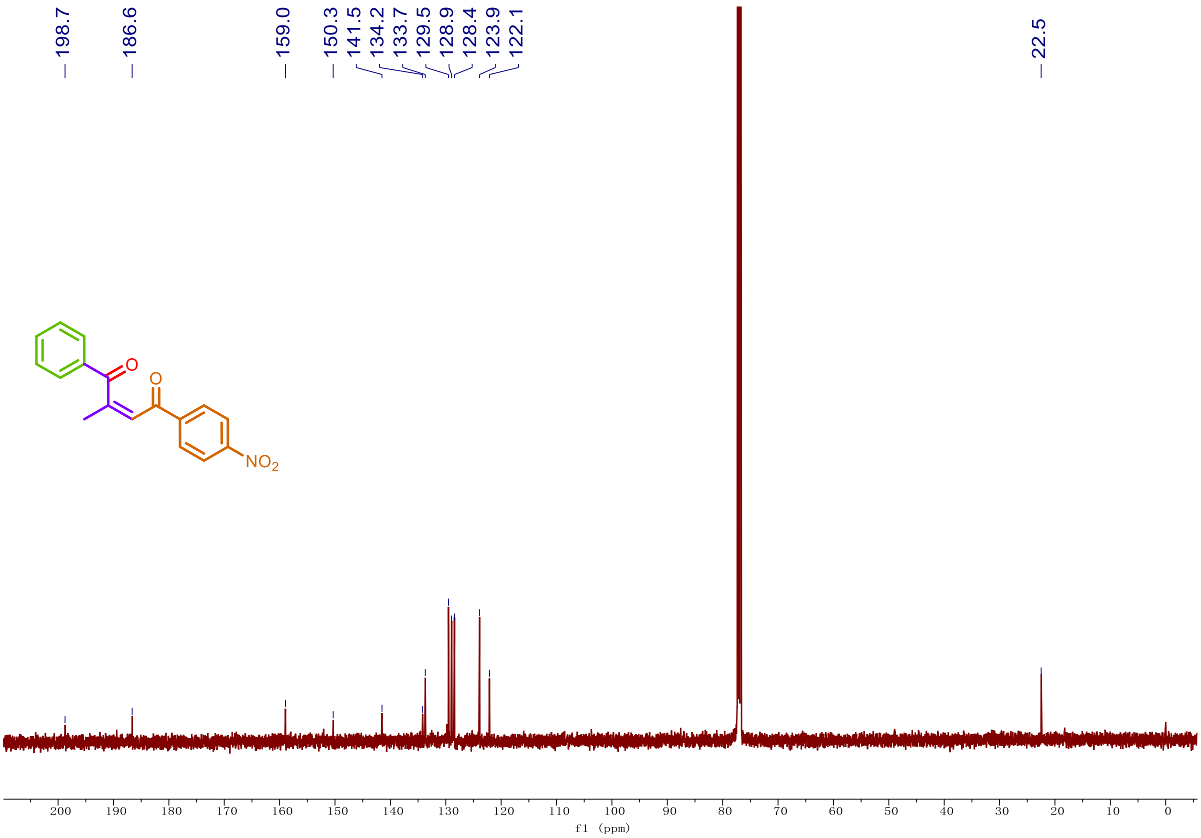
Compound 3ar: ¹³C NMR (125 MHz, $CDCl_3$)



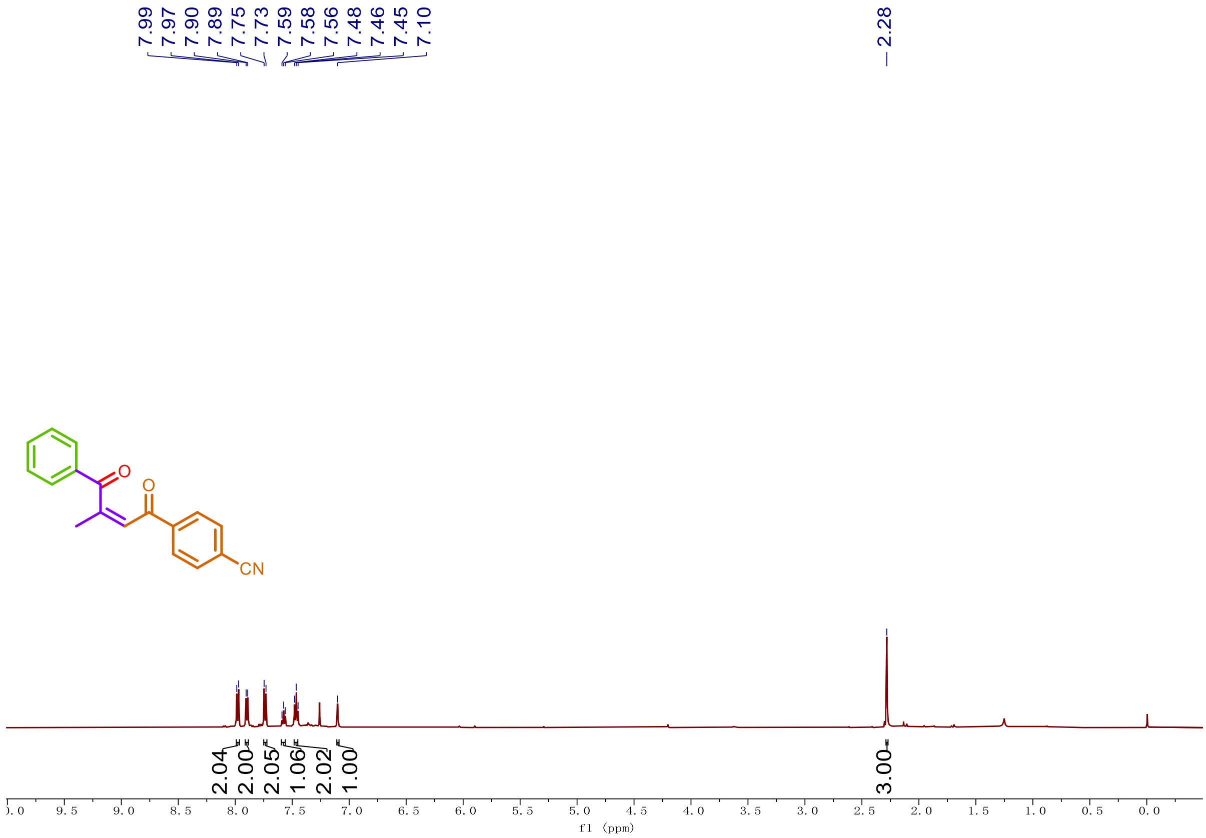
Compound 3as: ¹H NMR (500 MHz, $CDCl_3$)



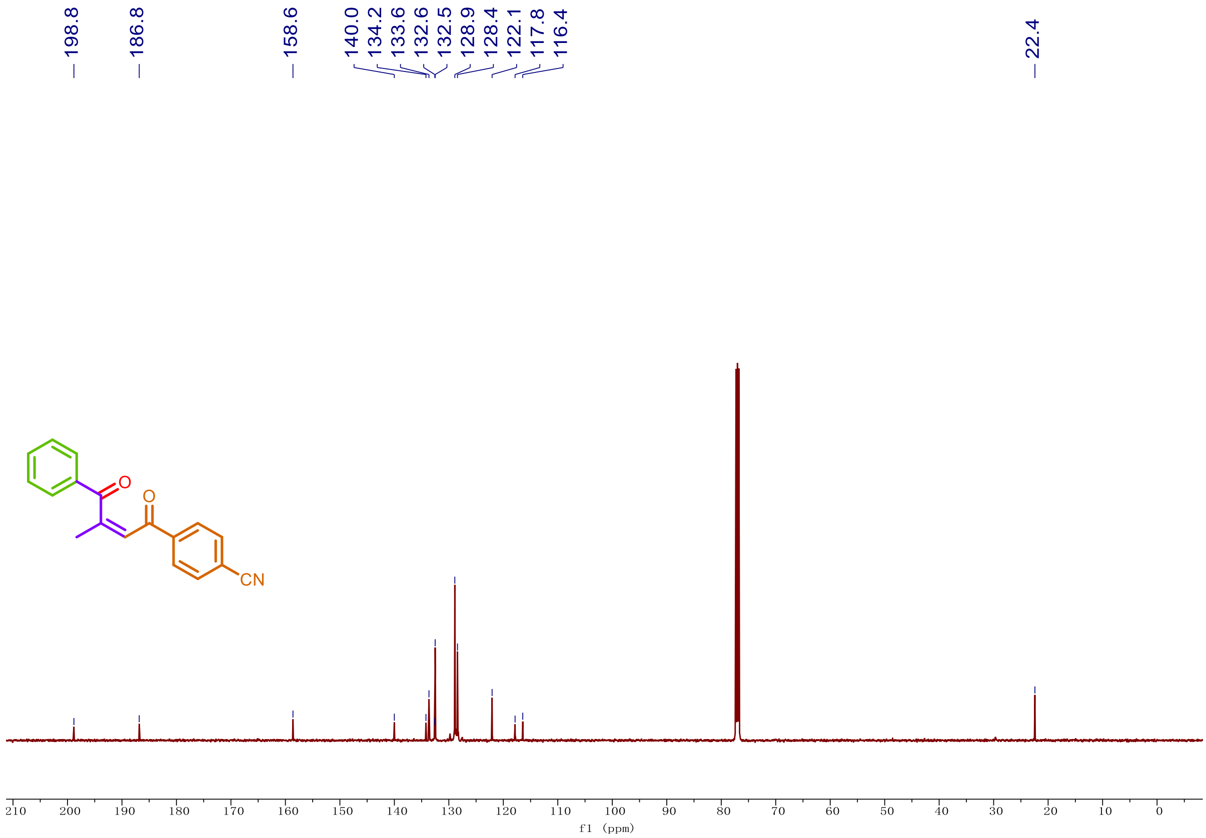
Compound 3as: ¹³C NMR (125 MHz, $CDCl_3$)



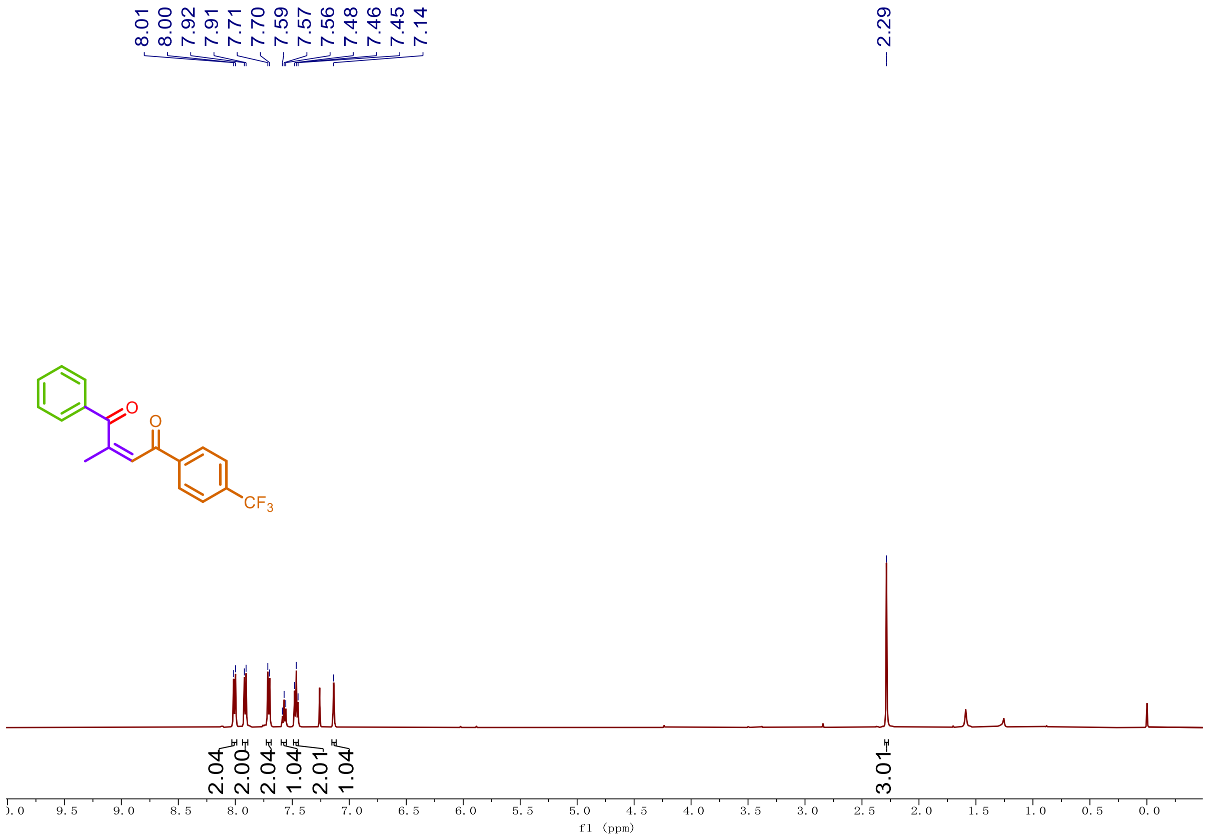
Compound 3at: ¹H NMR (500 MHz, $CDCl_3$)



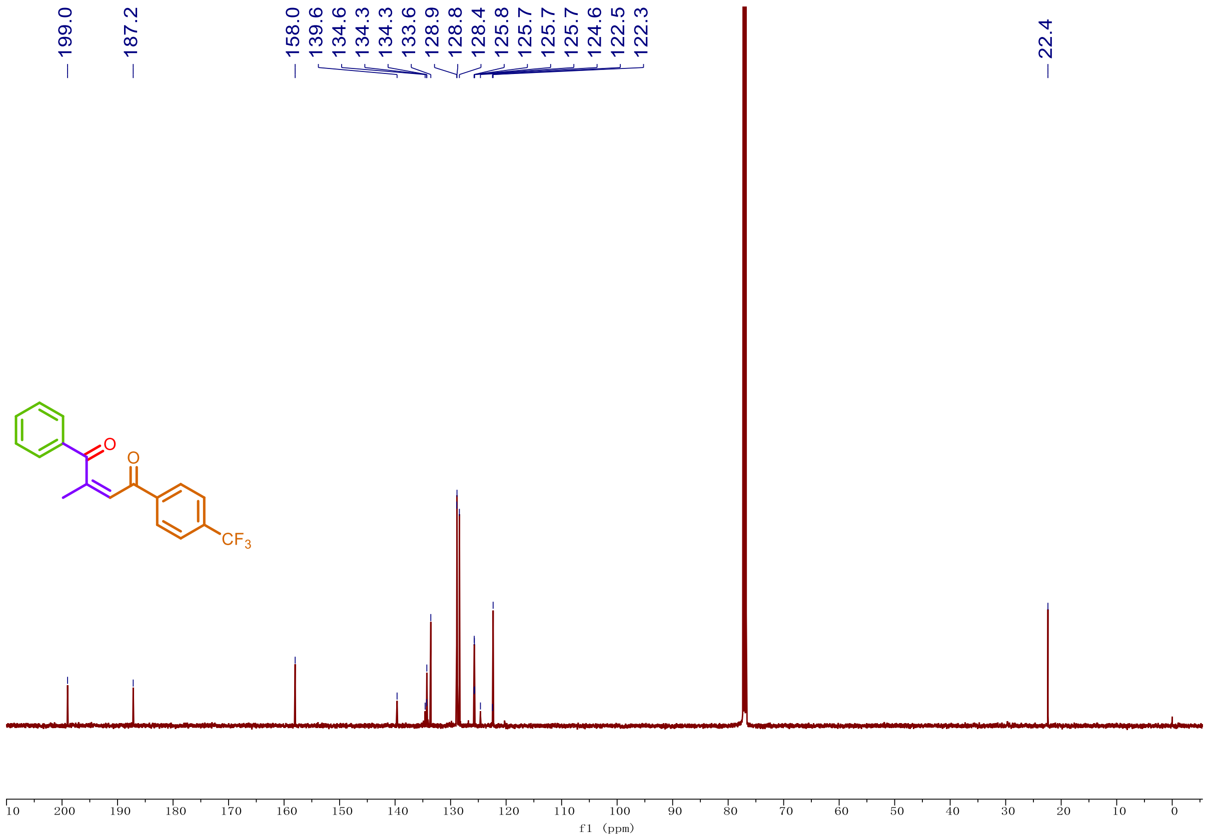
Compound 3at: ¹³C NMR (125 MHz, $CDCl_3$)



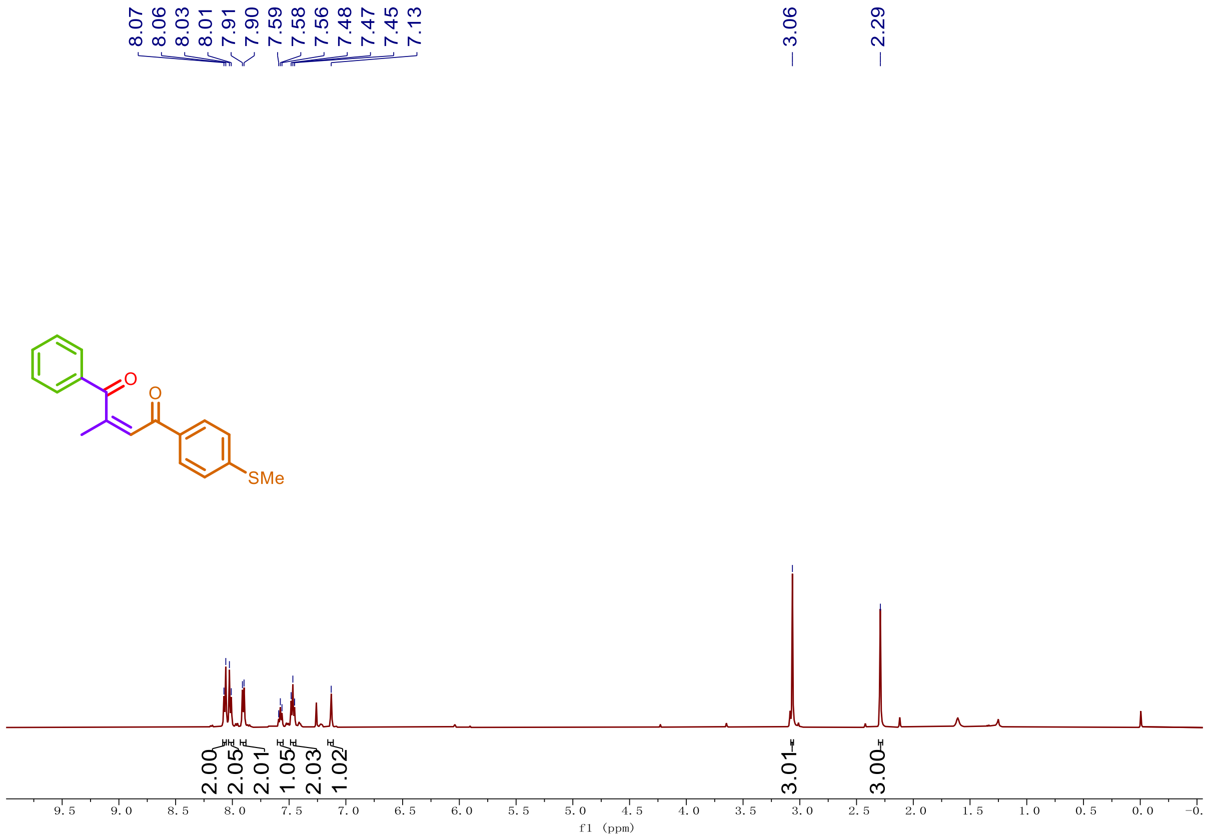
Compound 3au: ^{1}H NMR (500 MHz, $CDCl_3$)



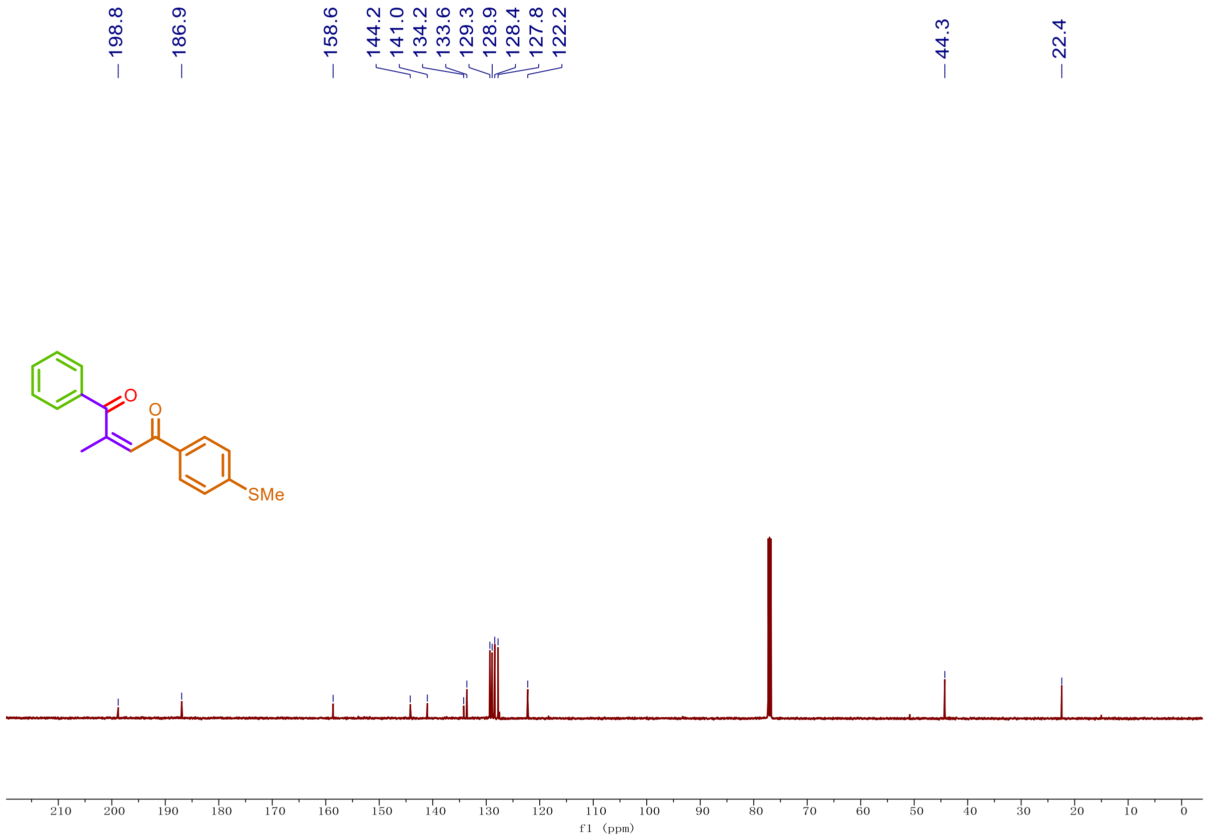
Compound 3au: ^{13}C NMR (125 MHz, $CDCl_3$)



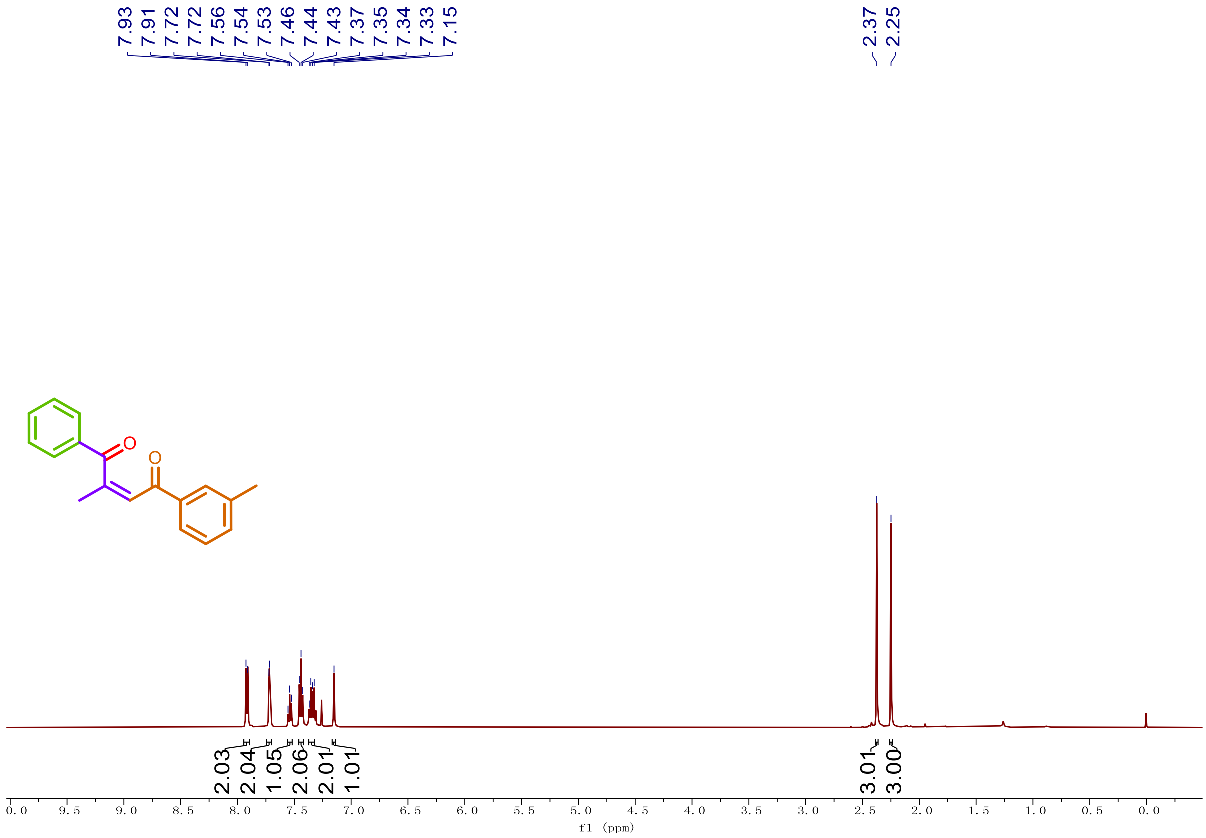
Compound 3av: ^{1}H NMR (500 MHz, $CDCl_3$)



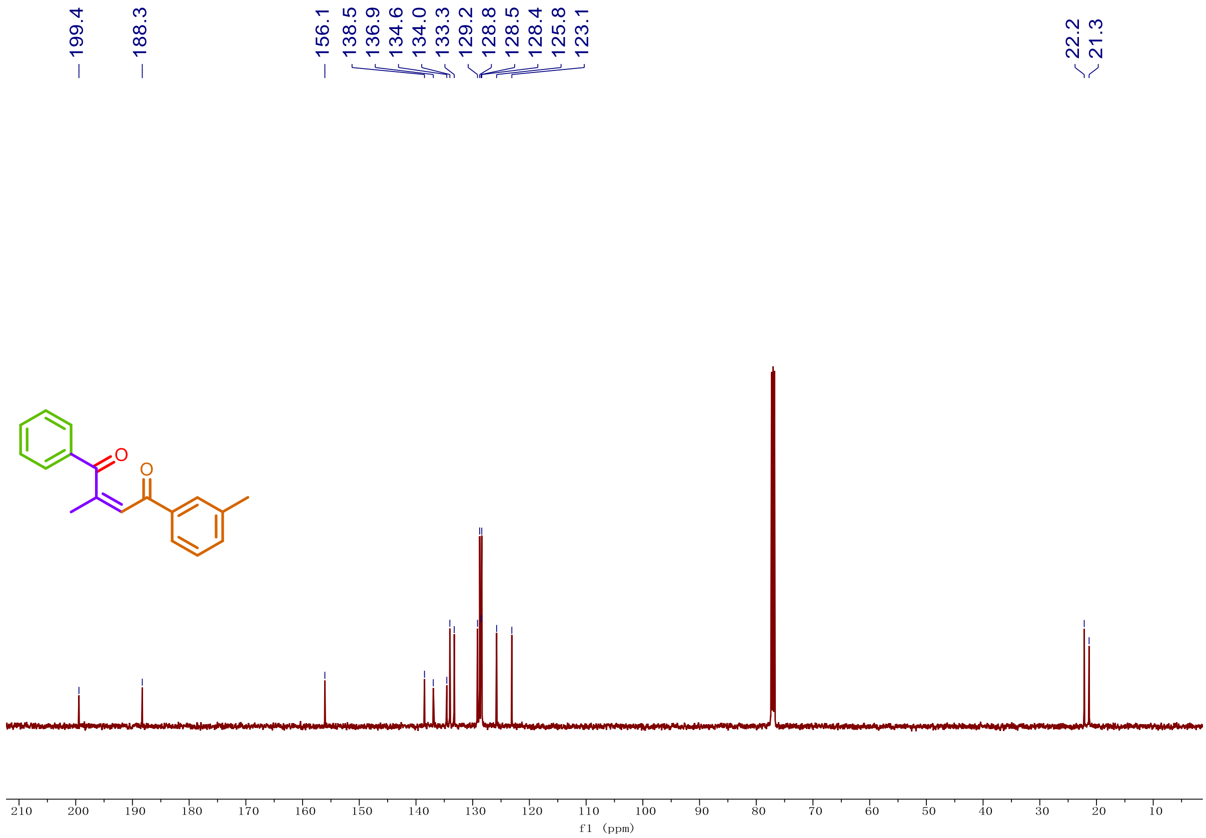
Compound 3av: ^{13}C NMR (125 MHz, $CDCl_3$)



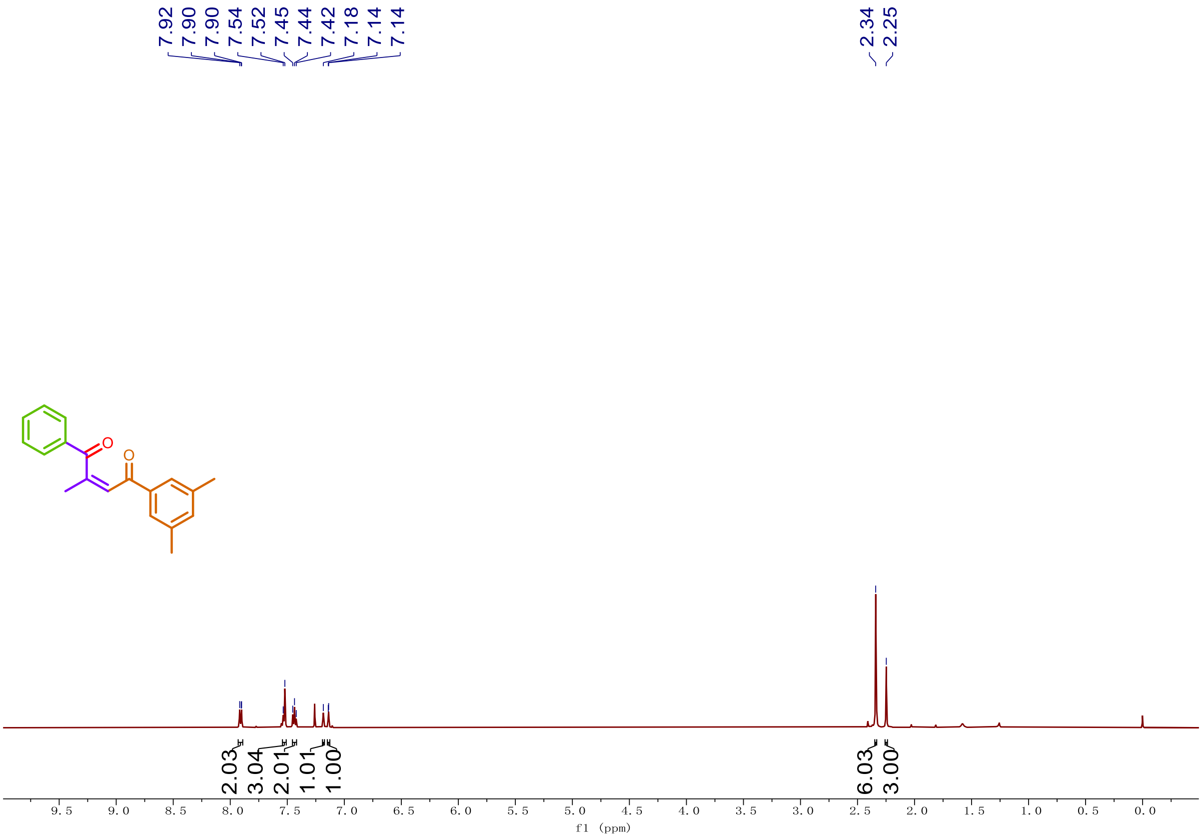
Compound 3aw: ^{1}H NMR (500 MHz, $CDCl_3$)



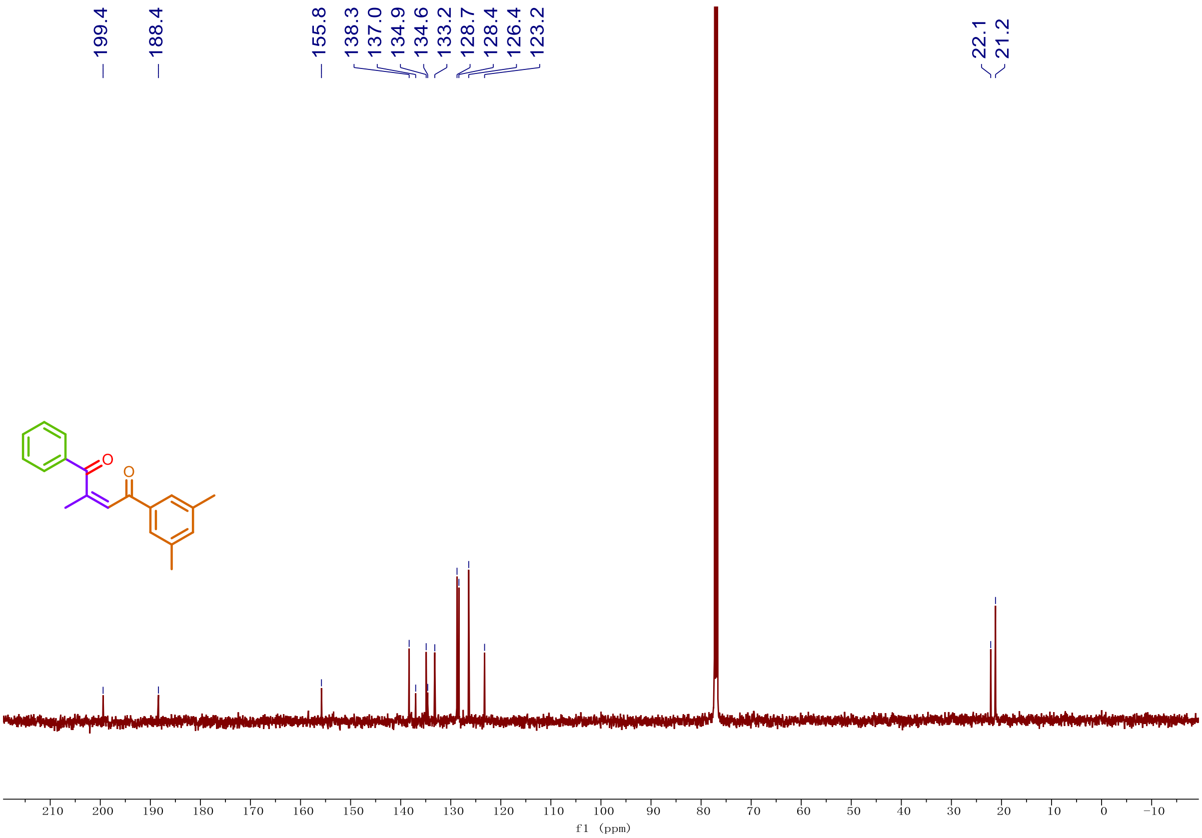
Compound 3aw: ^{13}C NMR (125 MHz, $CDCl_3$)



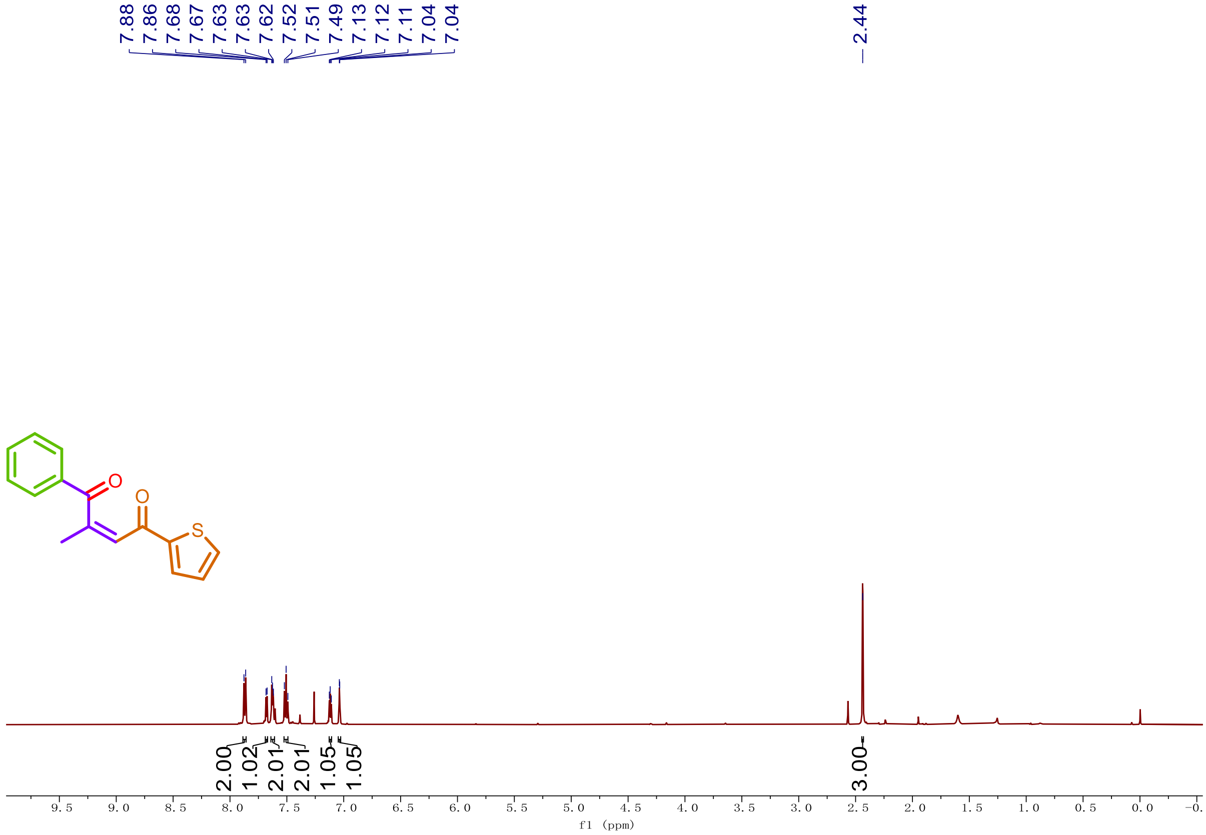
Compound 3ax: ^{1}**H NMR** (500 MHz, $CDCl_3$)



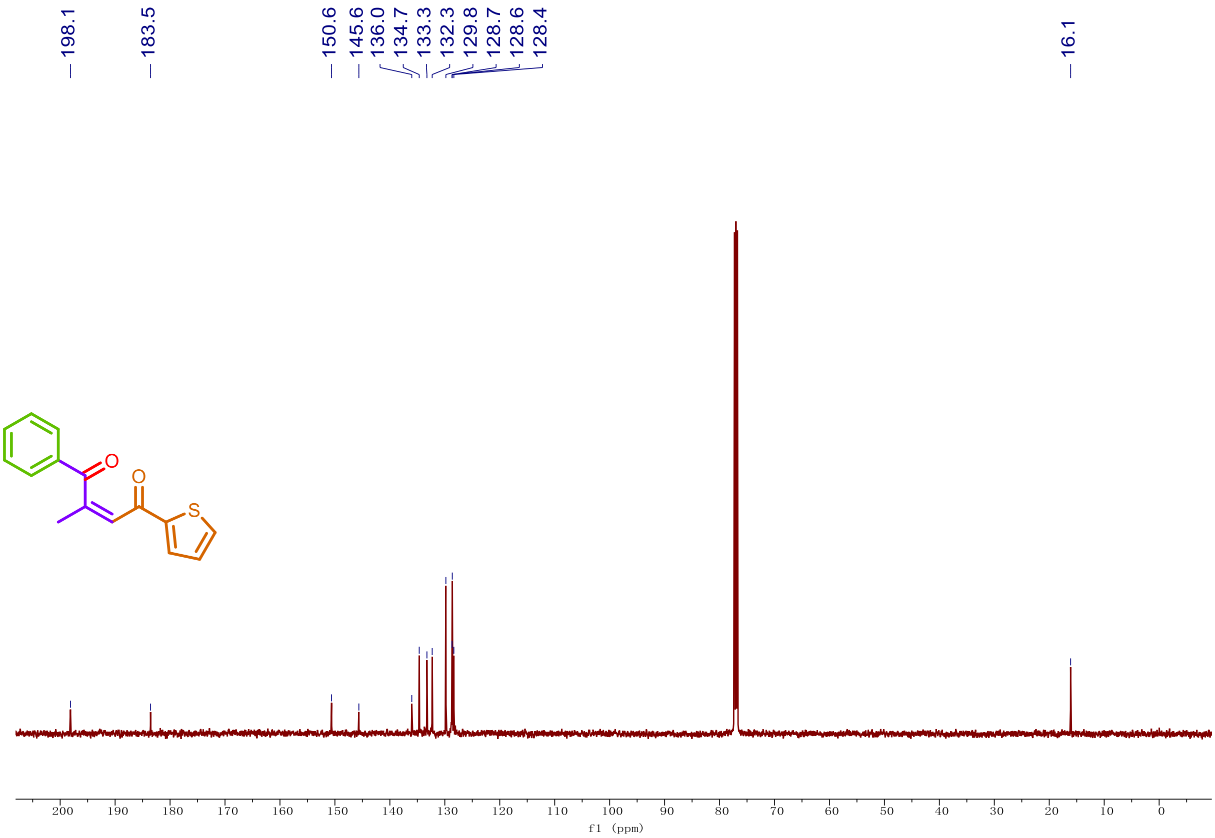
Compound 3ax: ^{13}**C NMR** (125 MHz, $CDCl_3$)



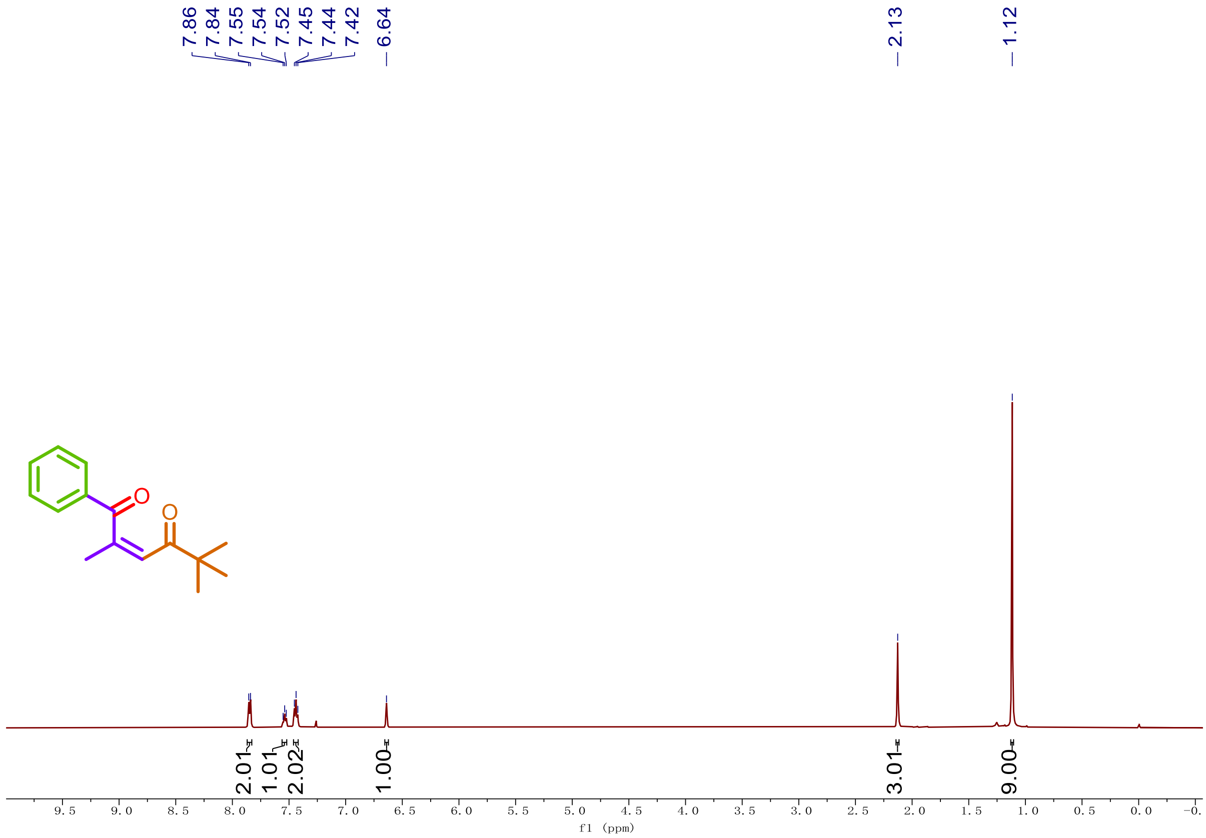
Compound 3ay: ^{1}H NMR (500 MHz, $CDCl_3$)



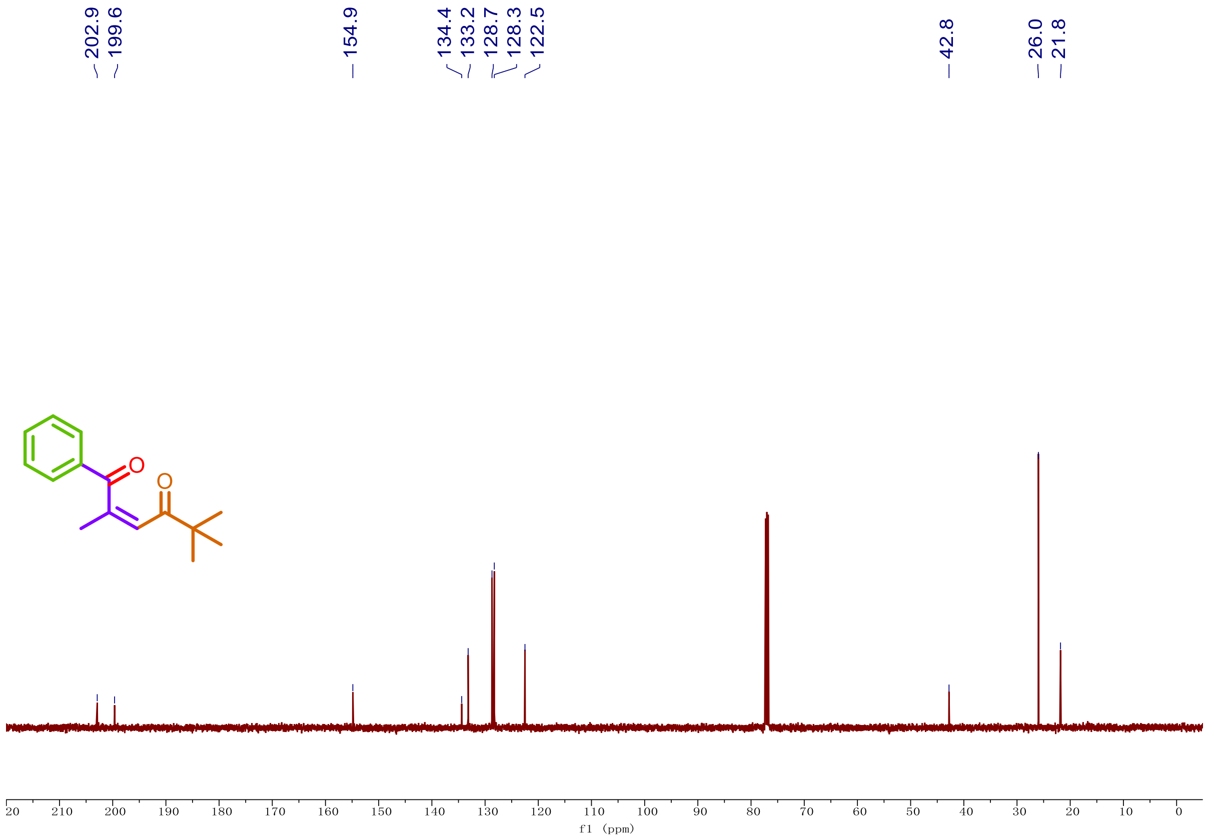
Compound 3ay: ^{13}C NMR (125 MHz, $CDCl_3$)



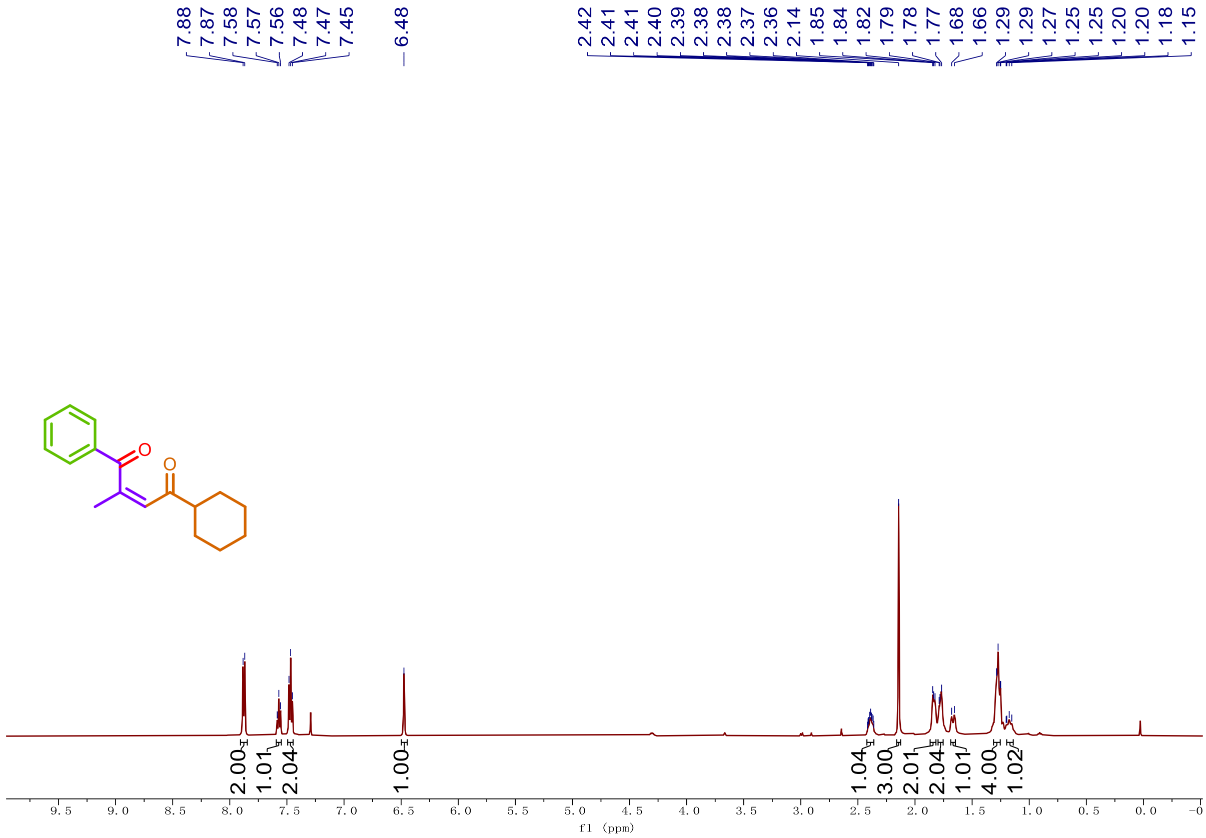
Compound 3az: ^{1}H NMR (500 MHz, $CDCl_3$)



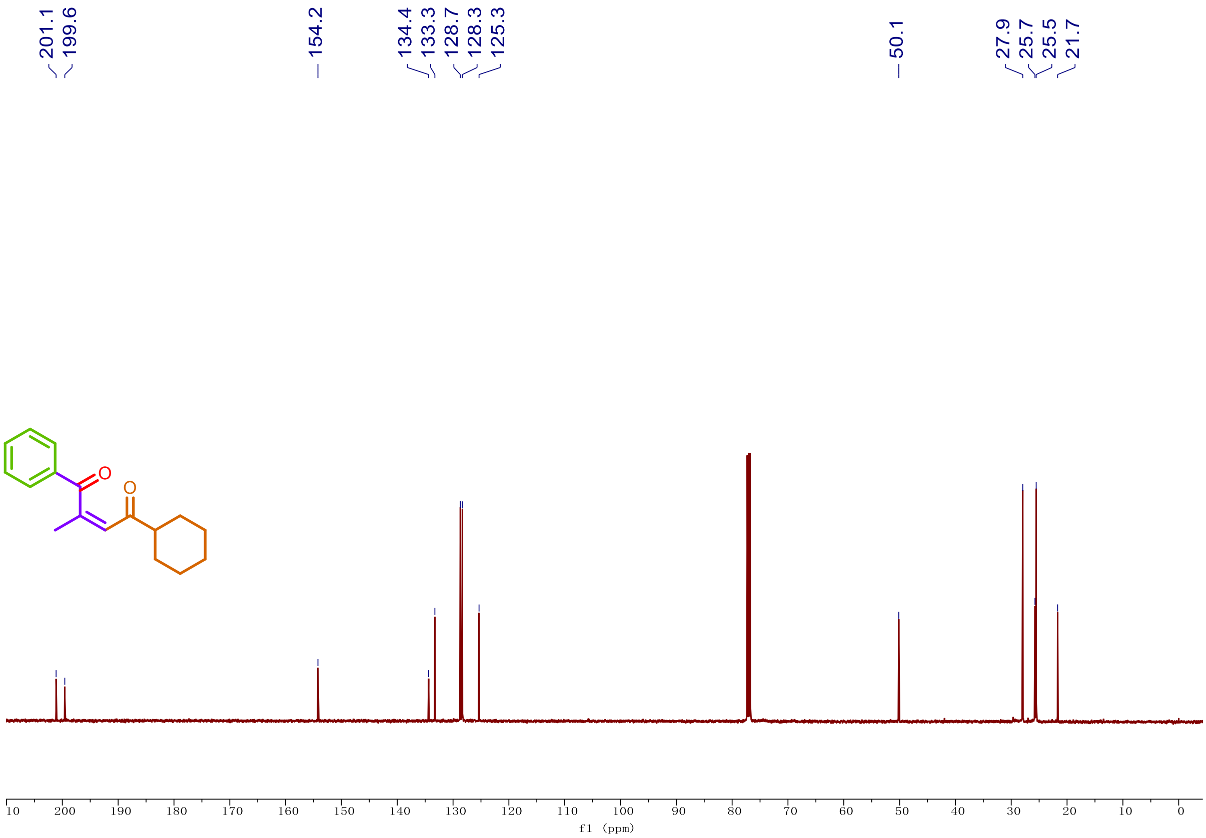
Compound 3az: ^{13}C NMR (125 MHz, $CDCl_3$)



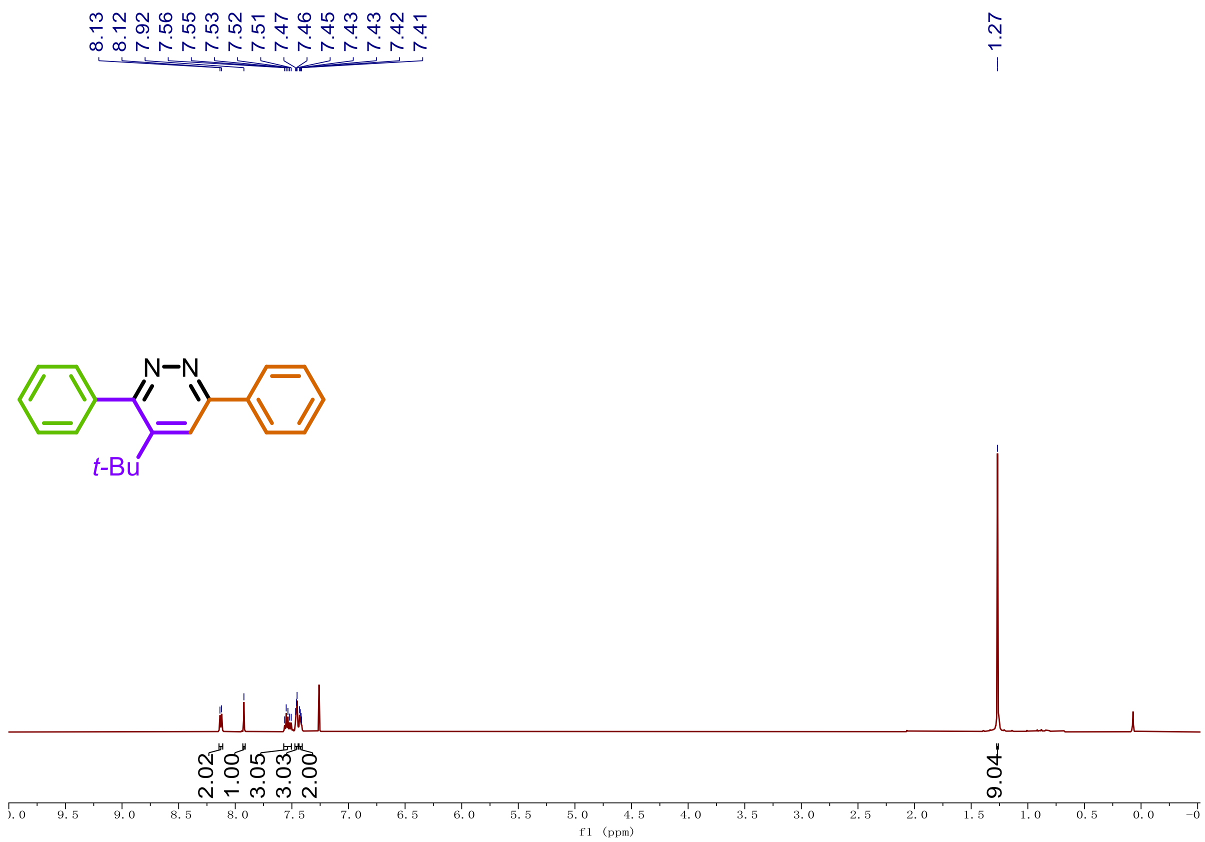
Compound 3ba: ^{1}H NMR (500 MHz, $CDCl_3$)



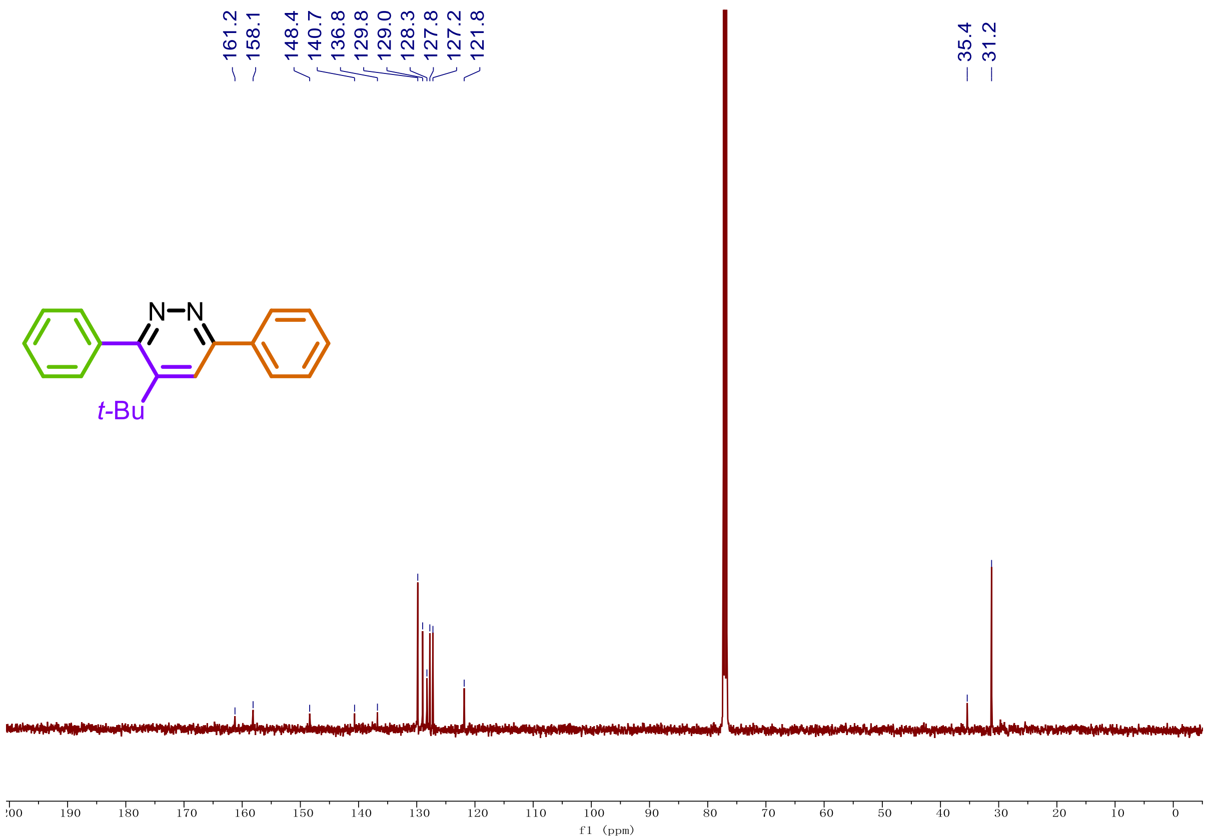
Compound 3ba: ^{13}C NMR (125 MHz, $CDCl_3$)



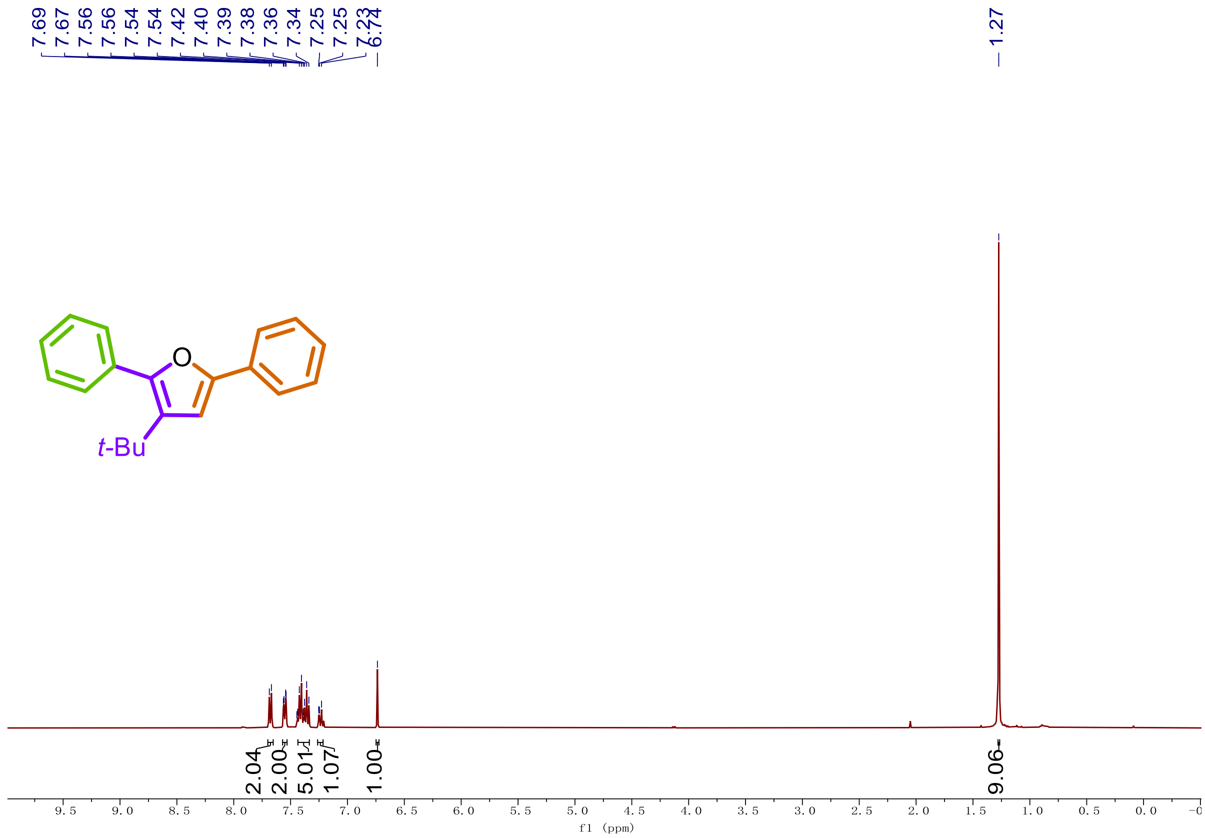
Compound 4a: ^{1}H NMR (500 MHz, $CDCl_3$)



Compound 4a: ^{13}C NMR (125 MHz, $CDCl_3$)



Compound 4b: ^{1}H NMR (500 MHz, $CDCl_3$)



Compound 4b: ^{13}C NMR (125 MHz, $CDCl_3$)