Supplementary Information

Synthesis of phenolic derivatives via photoredox formal [4 + 2] tandem annulation of α-bromoketones and terminal alkynes

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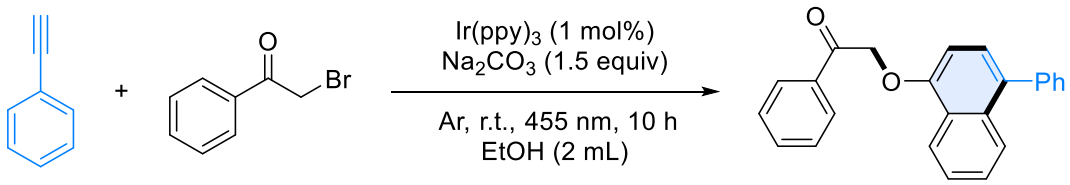
I. General considerations

Unless otherwise stated, commercially available chemicals were used without treatment. Solvents were degassed by bubbling Ar for 10 min before use. Reactions were monitored by Thin Layer Chromatography (TLC) using silica gel F254 plates. Products were purified by column chromatography over 300-400 mesh silica gel under a positive pressure of air. ^{1}H NMR, ^{19}F NMR, ^{13}C NMR and DEPT NMR spectra were recorded at 25 °C on a Bruker Ascend^{TM} 400 spectrometer using tetramethylsilane (TMS) as an internal standard. High-resolution mass spectra (HRMS) were obtained using a Thermofisher Orbitrap Exploris Liquid mass coupling instrument (Vanquish FLex-Exploris120). Cyclic voltammetry studies were carried out on a CHI600E electrochemical workstation (Shanghai CH Instruments Co, China). The emission spectra were recorded on a Cary Eclipse Fluorescence Spectrophotometer (Agilent Technologies). The photochemical setup used in this research is shown in Figure S1. Photoreactors were bought from GeAo Chem (containing 24 small LEDs, 1 W for every LED, and every reaction tube is irradiated by six LEDs).

Figure S1 Photochemical setup

II. Optimization of reaction conditions

Table S1 Optimization of **2a** loading[a]

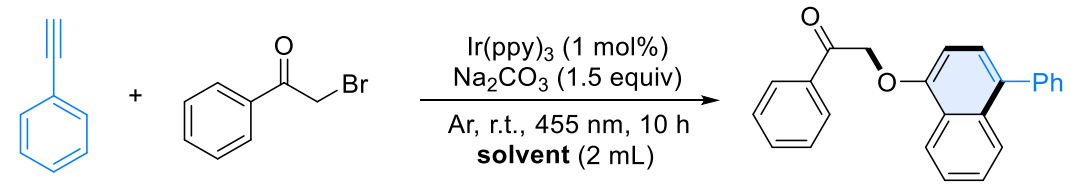


1a, 0.3 mmol **2a**, ***W*** mmol **3a**

entry	*W*	yield[b] (%)
1	0.3	4
2	0.45	5
3	0.6	7
4	**0.75**	**14**
5	0.9	4
6	1.05	4
7	1.2	4

[a]Reaction conditions: **1a** (0.3 mmol), **2a** (*W* mmol), Na_2CO_3, $Ir(ppy)_3$, EtOH (2.0 mL), 6 W blue LEDs (λ_{max} = 455 nm), Ar, room temperature, 10 h. [b]Yields were determined by ^1H NMR analysis using 1,3,5-trimethoxybenzene as an internal standard.

Table S2 Optimization of solvent[a]



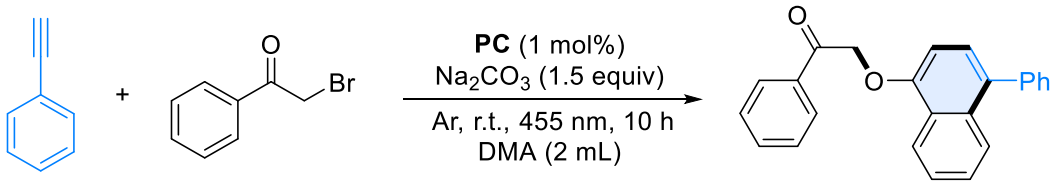
1a, 0.3 mmol **2a**, 0.75 mmol **3a**

entry	solvent	yield[b] (%)
1	Acetone	0
2	DCE	0
3	Toluene	0
4	$PhCF_3$	0
5	EtOAc	0

6	1,4-Dioxane	0
7	MeCN	0
8	CH_3NO_2	0
9	THF	11
10	DMF	14
11	**DMA**	**29**
12	DMSO	21
13	MeOH	13
14	EtOH	14
15	HFIP	5
16	CF_3CH_2OH	0
17	Cyclohexane	0

[a]Reaction conditions: **1a** (0.3 mmol), **2a** (0.75 mmol), Na_2CO_3 (0.45 mmol), $Ir(ppy)_3$ (0.003 mmol), solvent (2.0 mL), 6 W blue LEDs (λ_{max} = 455 nm), Ar, room temperature, 10 h. [b]Yields were determined by ^1H NMR analysis using 1,3,5-trimethoxybenzene as an internal standard.

Table S3 Optimization of PC[a]



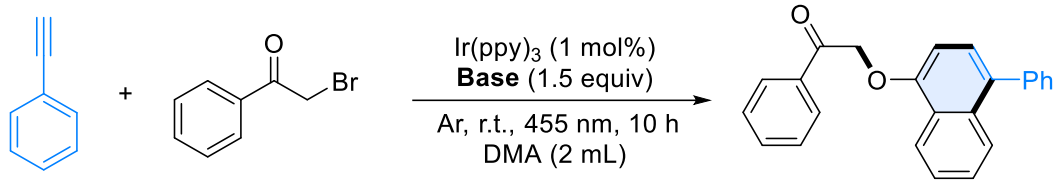
1a, 0.3 mmol **2a**, 0.75 mmol **3a**

entry	PC	yield[b] (%)
1	none	10
2	4CzIPN	10
3	Mes-Acr$^+$ClO$_4^-$	15
4	$Ru(bpy)_3Cl_2$	21
5	**$Ir(ppy)_3$**	**29**
6	$Ir(dtbbpy)(ppy)_2]PF_6$	22
7	$(Ir[dF(CF_3)ppy]_2(dtbpy))PF_6$	trace
8[c]	Eosin Y	14
9[c]	Rose Bengal	7
10[c]	Rhodamine B	3
11[c]	Fluorescein	16

12[c]	Thioxanthen-9-one	10

[a]Reaction conditions: **1a** (0.3 mmol), **2a** (0.75 mmol), Na_2CO_3 (0.45 mmol), PC (0.003 mmol), DMA (2.0 mL), 6 W blue LEDs (λ_{max} = 455 nm), Ar, room temperature, 10 h. [b]Yields were determined by ^{1}H NMR analysis using 1,3,5-trimethoxybenzene as an internal standard. [c]PC is 5 mol%.

Table S4 Optimization of Base[a]

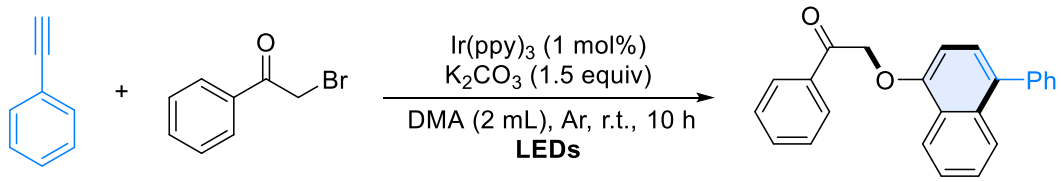


1a, 0.3 mmol **2a**, 0.75 mmol **3a**

entry	Base	yield[b] (%)
1	none	0
2	Li_2CO_3	0
3	Na_2CO_3	29
4	**K_2CO_3**	**40**
5	Cs_2CO_3	25
6	$NaHCO_3$	0
7	$KHCO_3$	0
8	KOAc	0
9	KH_2PO_4	trace
10	K_2HPO_4	0
11	K_3PO_4	4
12	KF	0
13	KOH	2
14	2,6-Dimethylpyridine	0
15	*N*,*N*-Diisopropylethylamine	0
16	^{t}BuOK	trace
17	^{t}BuOLi	trace

[a]Reaction conditions: **1a** (0.3 mmol), **2a** (0.75 mmol), Base (0.45 mmol), $Ir(ppy)_3$ (0.003 mmol), DMA (2.0 mL), 6 W blue LEDs (λ_{max} = 455 nm), Ar, room temperature, 10 h. [b]Yields were determined by ^{1}H NMR analysis using 1,3,5-trimethoxybenzene as an internal standard.

Table S5 Optimization of the wavelength of the light source[a]

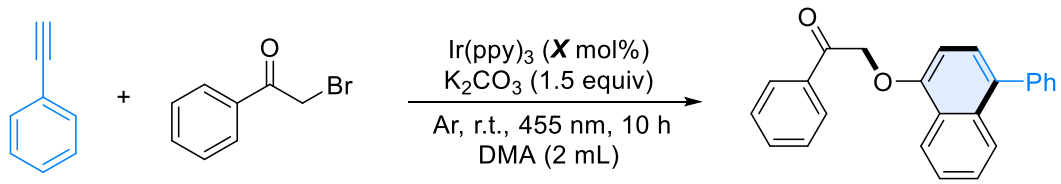


1a, 0.3 mmol **2a**, 0.75 mmol **3a**

entry	LEDs	yield[b] (%)
1	UVA (365 nm)	0
2	purple (395 nm)	13
3	**blue (455 nm)**	**40**
4	white	32
5	green (525 nm)	26

[a]Reaction conditions: **1a** (0.3 mmol), **2a** (0.75 mmol), K_2CO_3 (0.45 mmol), $Ir(ppy)_3$ (0.003 mmol), DMA (2.0 mL), 6 W LEDs, Ar, room temperature, 10 h. [b]Yields were determined by ^1H NMR analysis using 1,3,5-trimethoxybenzene as an internal standard.

Table S6 Optimization of PC loadings[a]

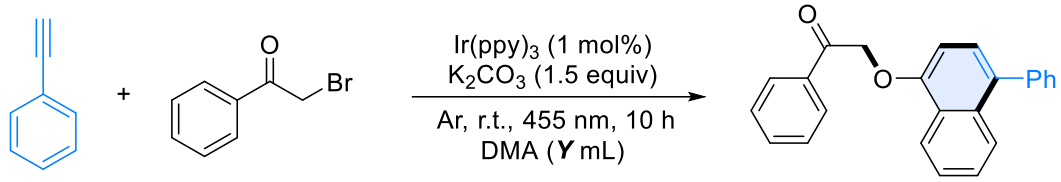


1a, 0.3 mmol **2a**, 0.75 mmol **3a**

entry	*X*	yield[b] (%)
1	0	trace
2	0.1	19
3	0.2	26
4	0.5	34
5	0.75	38
6	**1.0**	**40**
7	2.0	trace

[a]Reaction conditions: **1a** (0.3 mmol), **2a** (0.75 mmol), K_2CO_3 (0.45 mmol), $Ir(ppy)_3$, DMA (2.0 mL), 6 W blue LEDs (λ_{max} = 455 nm), Ar, room temperature, 10 h. [b]Yields were determined by ^1H NMR analysis using 1,3,5-trimethoxybenzene as an internal standard.

Table S7 Optimization of solvent loadings[a]

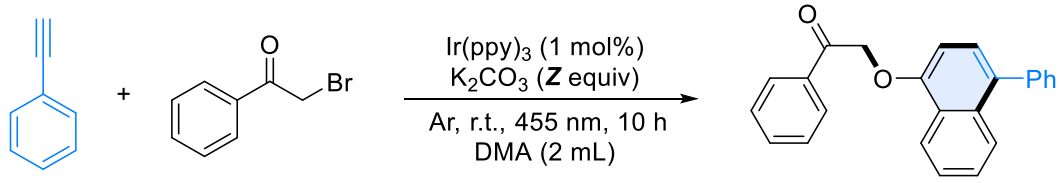


1a, 0.3 mmol **2a**, 0.75 mmol **3a**

entry	*Y*	yield[b] (%)
1	0	8
2	0.1	13
3	0.25	11
4	0.5	14
5	0.75	15
6	1.0	22
7	**2.0**	**40**
8	3.0	31
9	4.0	24
10	5.0	3
11	7.5	trace
12	10.0	trace

[a]Reaction conditions: **1a** (0.3 mmol), **2a** (0.75 mmol), K_2CO_3 (0.45 mmol), $Ir(ppy)_3$ (0.003 mmol), DMA (*Y* mL), 6 W blue LEDs (λ_{max} = 455 nm), Ar, room temperature, 10 h. [b]Yields were determined by ^1H NMR analysis using 1,3,5-trimethoxybenzene as an internal standard.

Table S8 Optimization of base loadings[a]



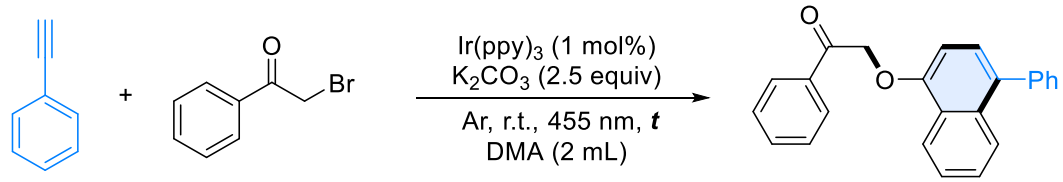
1a, 0.3 mmol **2a**, 0.75 mmol **3a**

entry	*Z*	yield[b] (%)
1	0	8
2	0.2	13
3	0.5	11

4	1.0	14
5	1.5	15
6	2.0	22
7	**2.5**	**40**
8	3.0	31

[a]Reaction conditions: **1a** (0.3 mmol), **2a** (0.75 mmol), K_2CO_3, $Ir(ppy)_3$ (0.003 mmol), DMA (2 mL), 6 W blue LEDs (λ_{max} = 455 nm), Ar, room temperature, 10 h. [b]Yields were determined by ^1H NMR analysis using 1,3,5-trimethoxybenzene as an internal standard.

Table S9 Optimization of reaction time[a]

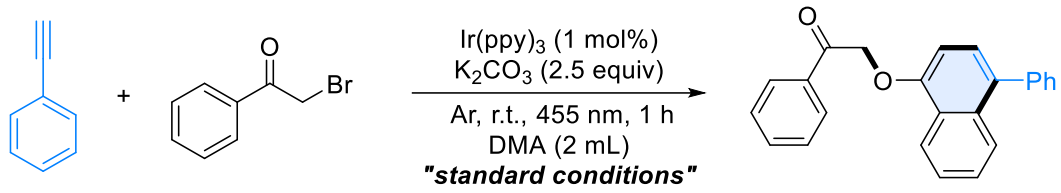


1a, 0.3 mmol **2a**, 0.75 mmol **3a**

entry	*t* (h)	yield[b] (%)
1	0.25	26
2	0.5	35
3	0.75	37
4	**1**	**50**
5	3	40
6	5	32
7	7	37
8	9	36
9	10	40
10	12	32
11	18	12

[a]Reaction conditions: **1a** (0.3 mmol), **2a** (0.75 mmol), K_2CO_3 (0.75 mmol), $Ir(ppy)_3$ (0.003 mmol), DMA (2 mL), 6 W blue LEDs (λ_{max} = 455 nm), Ar, room temperature, *t*. [b]Yields were determined by ^1H NMR analysis using 1,3,5-trimethoxybenzene as an internal standard.

Table S10 Other control experiments[a]



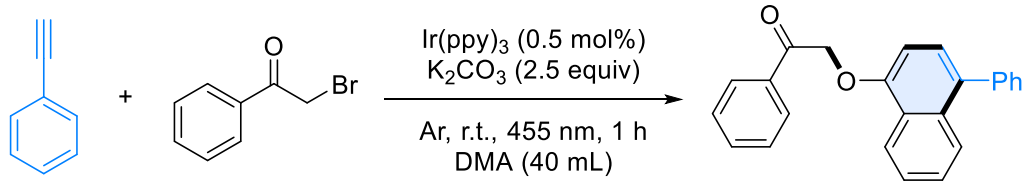
1a, 0.3 mmol **2a**, 0.75 mmol **3a**

entry	variation from standard conditions	yield[b] (%)
1	**none**	**50 (57)[c]**
2	no light	6
3	under an air atmosphere	trace

[a]Reaction conditions: **1a** (0.3 mmol), **2a** (0.75 mmol), K_2CO_3 (0. 75 mmol), $Ir(ppy)_3$ (0.003 mmol), DMA (2 mL), 6 W blue LEDs (λ_{max} = 455 nm), Ar, room temperature, 1 h. [b]Yields were determined by ^1H NMR analysis using 1,3,5-trimethoxybenzene as an internal standard. [c]Yield of isolated product.

III. Experimental procedures

1. Gram-scale synthesis



1a, 6 mmol **2a**, 15 mmol **3a1**, 0.87 g, 43% yield

A 100-mL pear-shaped flask, equipped with a magnetic stirring bar, was charged sequentially with **1a** (6.0 mmol, 0.66 mL), **2a** (2.5 equiv, 15 mmol, 3.0 g), K_2CO_3 (2.5 equiv, 15 mmol, 2073.1 mg) and $Ir(ppy)_3$ (0.5 mol%, 0.03 mmol, 19.7 mg) under argon, followed by the addition of degassed DMA (40.0 mL). The mixture was stirred under blue-LED irradiation (25 W × 2, λ_{max} = 455 nm) at room temperature for 1 h (Figure S2). The residue obtained after evaporation of the solvent was purified by column chromatography on silica gel (petroleum ether–ethyl acetate) to afford **3a1** (43%, 0.87 g) as a pale yellow solid.

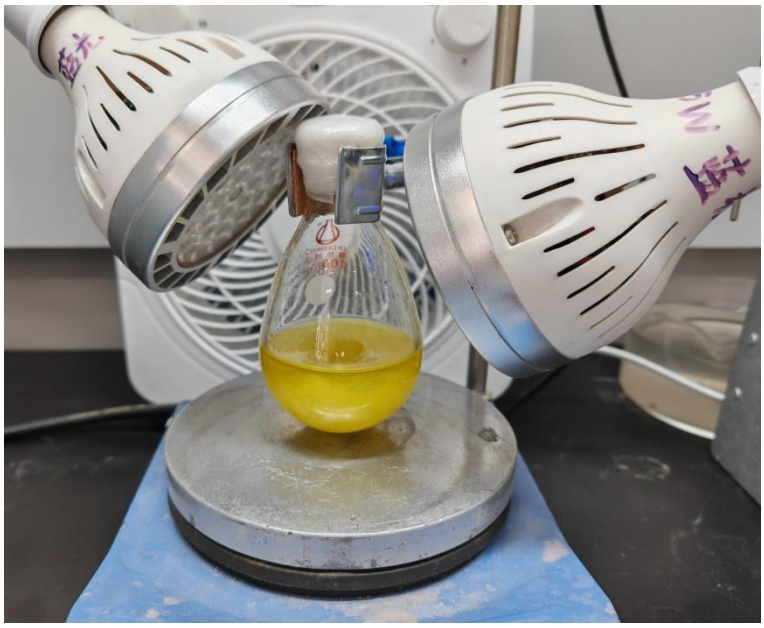
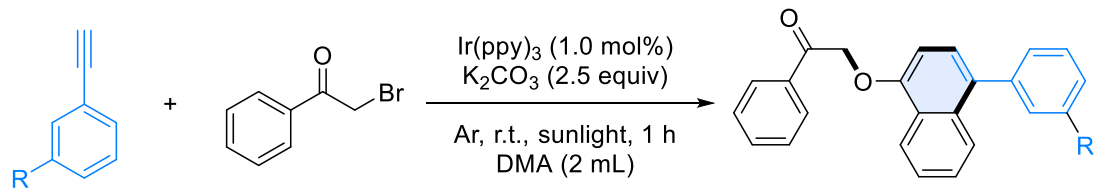


Figure S2 Setup for gram-scale synthesis

2. Sunlight experiment



1a, R = H or
1e1, R = Me,
0.3 mmol

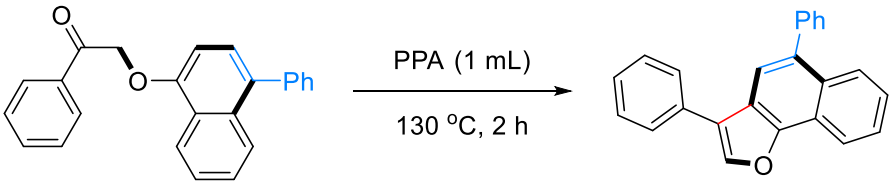
2a, 0.75 mmol

3a, 47% yield
or
3e1, 62% yield

A custom-made cell, equipped with a magnetic stirring bar, was charged sequentially with **1a** (0.3 mmol, 33 μL) or **1e1** (0.3 mmol, 37 μL), **2a** (2.5 equiv, 0.75 mmol, 149.3 mg), K_2CO_3 (2.5 equiv, 0.75 mmol, 103.7 mg) and $Ir(ppy)_3$ (1.0 mol%, 0.003 mmol, 2.0 mg) under argon, followed by the addition of degassed DMA (2.0 mL). The mixture was stirred under sunlight irradiation (Figure S3) at room temperature for 1 h. The residue obtained after evaporation of the solvent was purified by column chromatography on silica gel (petroleum ether–ethyl acetate) to afford **3a1** as a pale yellow solid (47.3 mg, 47% yield) or **3e1** as a pale yellow oil (65.7 mg, 62% yield).

Figure S3 Setup for natural sunlight experiment

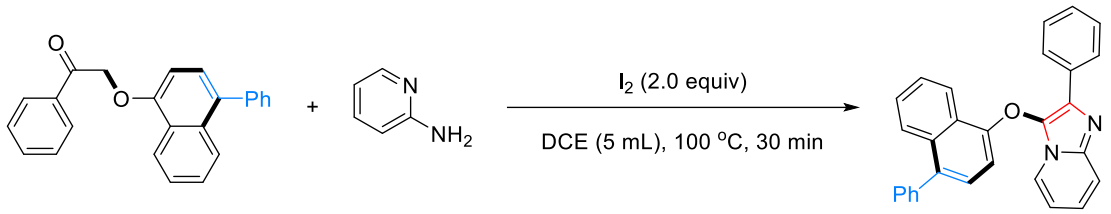
3. Product transformation



3a, 0.2 mmol

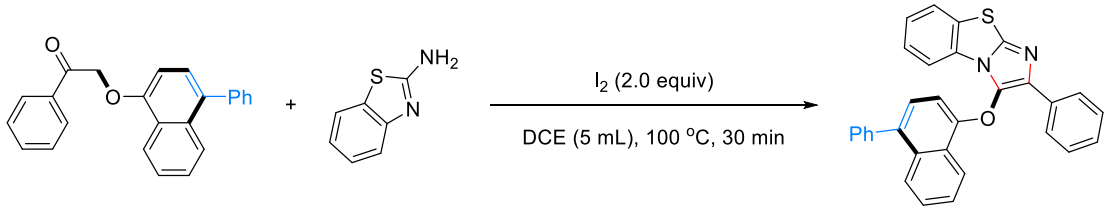
4, 52% yield

To a pressure-resistant tube with a magnetic stir bar, sequentially add **3a** (0.2 mmol) and polyphosphoric acid (PPA, 1 mL). Heat the mixture and stir in an oil bath at 130°C for 2 hours. After the reaction, pour the mixture into ice water and extract with dichloromethane (3 × 10 mL). Combine the organic layers, wash with saturated $NaHCO_3$ solution, then dry over anhydrous Na_2SO_4, filter, and concentrate. Purify the crude product by column chromatography using silica gel as the stationary phase and petroleum ether as the eluent, obtaining **4**, 3,5-diphenylnaphtho[1,2-*b*]furan (33.5 mg, 52% yield).[1]



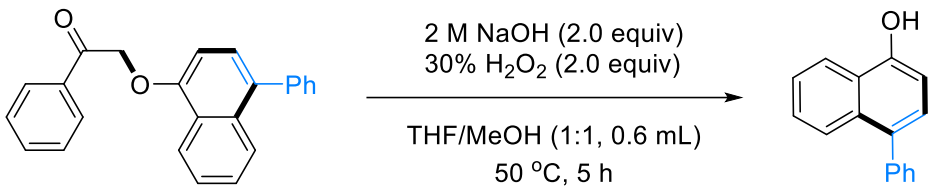
3a, 0.2 mmol 0.6 mmol **5**, 78% yield

To a pressure-resistant tube with a magnetic stir bar, sequentially add **3a** (0.2 mmol), 2-aminopyridine (0.6 mmol), I_2 (0.4 mmol), and DEC (5.0 mL). Heat and stir the mixture in an oil bath at 100°C for 30 minutes. After the reaction, cool the mixture to room temperature, then add 15 mL of saturated sodium thiosulfate solution. Extract with CH_2Cl_2 (3 × 10 mL), combine the organic layers, dry over anhydrous Na_2SO_4, filter, and concentrate. Purify the crude product by column chromatography with silica gel as the stationary phase and petroleum ether/ethyl acetate as the eluent, obtaining **5**, 2-phenyl-3-((4-phenylnaphthalen-1-yl)oxy)imidazo[1,2-*a*]pyridine (64.3 mg, 78% yield).[2]



0.2 mmol 0.6 mmol **6**, 65% yield

To a pressure-resistant tube with a magnetic stir bar, sequentially add **3a** (0.2 mmol), 2-aminobenzothiazole (0.6 mmol), I_2 (0.4 mmol), and DCE (5.0 mL). Heat and stir the mixture in an oil bath at 100°C for 30 minutes. After the reaction, cool the mixture to room temperature, then add 15 mL of saturated sodium thiosulfate solution. Extract with CH_2Cl_2 (3 × 10 mL), combine the organic layers, dry over anhydrous Na_2SO_4, filter, and concentrate. Purify the crude product by column chromatography with silica gel as the stationary phase and petroleum ether/ethyl acetate as the eluent, yielding **6**, 2-phenyl-3-((4-phenylnaphthalen-1-yl)oxy)benzo[*d*]imidazo[2,1-*b*]thiazole (60.8 mg, 65% yield).[2]



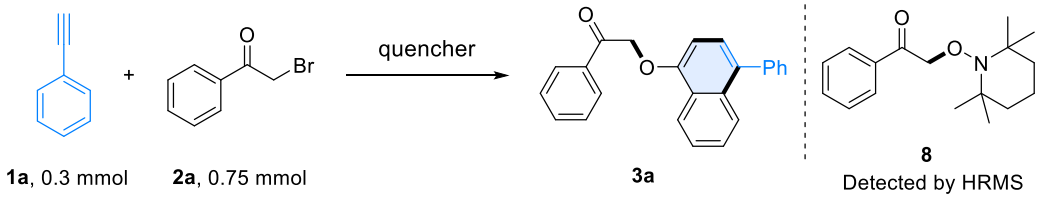
0.2 mmol

7, 42% yield

To a pressure-resistant tube with a magnetic stir bar, sequentially add **3a** (0.2 mmol), 2 M NaOH (0.4 mmol), 30% H_2O_2 (0.4 mmol), followed by THF (0.3 mL) and MeOH (0.3 mL). Heat the mixture and stir in an oil bath at 50°C for 5 hours. After the reaction, cool the mixture to room temperature, acidify with 0.5 M HCl to Ph = 3, and extract with CH_2Cl_2 (3 × 2 mL). Combine the organic layers, dry over anhydrous Na_2SO_4, filter, and concentrate. Purify the crude product by column chromatography with silica gel as the stationary phase and petroleum ether/ethyl acetate as the eluent, obtaining **7**, 4-phenylnaphthalen-1-ol (18.5 mg, 42% yield).[3]

IV. Mechanistic investigations

1. Quenching experiments



1a, 0.3 mmol **2a**, 0.75 mmol **3a** **8** Detected by HRMS

quencher (equiv)	scavenger for	^{1}H NMR yield of **3a1** (%)
TEMPO (2)	radical	0
BHT (1)	radical	9
DPE (2)	radical	0
*p*DNB(1)	SET	0
$CuCl_2$(1)	single electron	0
CCl_4(2)	single electron	17
none	-	50

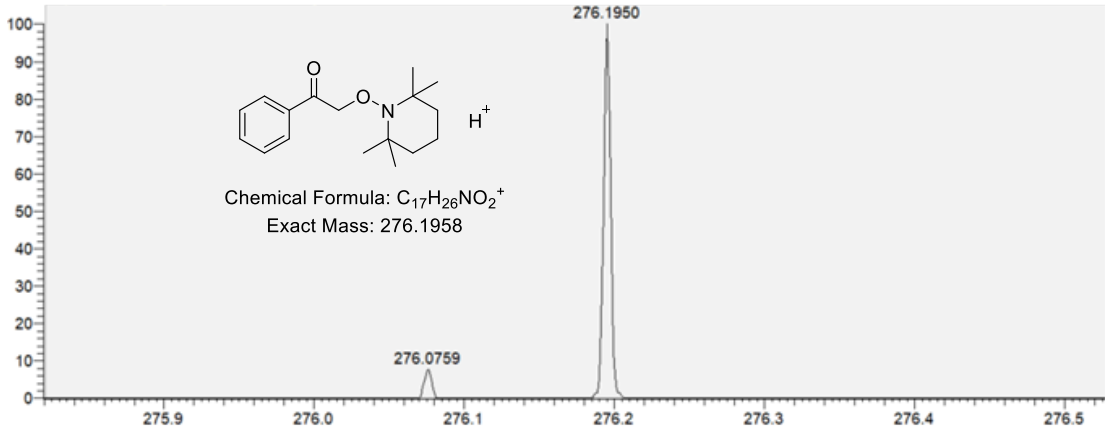


Figure S4 HRMS analysis for radical adduct

A custom-made cell (Figure S1), equipped with a magnetic stirring bar, was charged sequentially with **1a1** (0.3 mmol, 33 µL), **2a** (2.5 equiv, 0.75 mmol, 149.3 mg), K_2CO_3 (2.5 equiv, 0.75 mmol, 103.7 mg) and $Ir(ppy)_3$ (1.0 mol%, 0.003 mmol, 2.0 mg) and a scavenger under argon, followed by the addition of degassed DMA (2.0 mL). The mixture was stirred under blue LED irradiation at room temperature for 1 h. The yields of the product **3a1** formed were determined by ^1H NMR analysis using 1,3,5-trimethoxybenzene as an internal standard.

2. On-off experiments

Benzotrifluoride (1.0 equiv) was added as an internal standard to the reactions of **1f1** with **2a** under standard condition before reaction. 0.05 mL of the crude reaction solution was taken out each time via a syringe and was subjected to ^{19}F NMR analysis after filtered by a filter membrane with pore size of 0.45 µm (Figure S5).

	A(X)	B(Y)
Long Name	Time	19F NMR yield
Units	min	%
Comments		light on-off
1	0	0
2	10	17.31
3	20	17.46
4	30	30.71
5	40	30.81
6	50	36.14
7	60	36.2

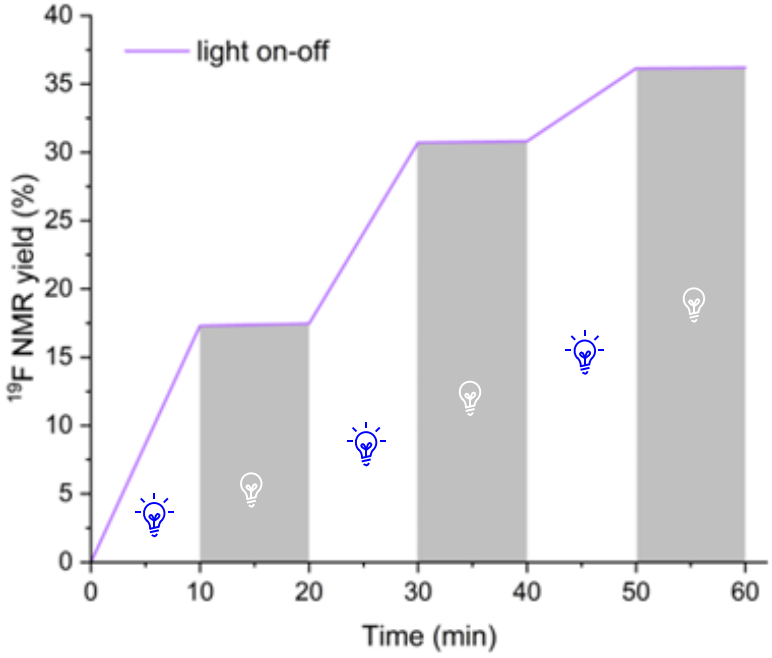


Figure S5 On-off experiments

3. Cyclic voltammetry studies

General procedure: Cyclic voltammetries were performed in a three-electrode cell at room temperature under argon (IUPAC plotting convention) on a CHI600E electrochemical workstation (Shanghai CH Instruments Co., China). The working electrode was a glassy carbon (GC, d = 3 mm) disk electrode, and the counter electrode was a platinum wire. The reference is the saturated calomel electrode. 10 mL MeCN solution containing 1.0 mmol nBu$_4$NBF$_4$ was poured into the electrochemical cell in all experiments. The scan rate was 0.05 V/s, starting point is zero.

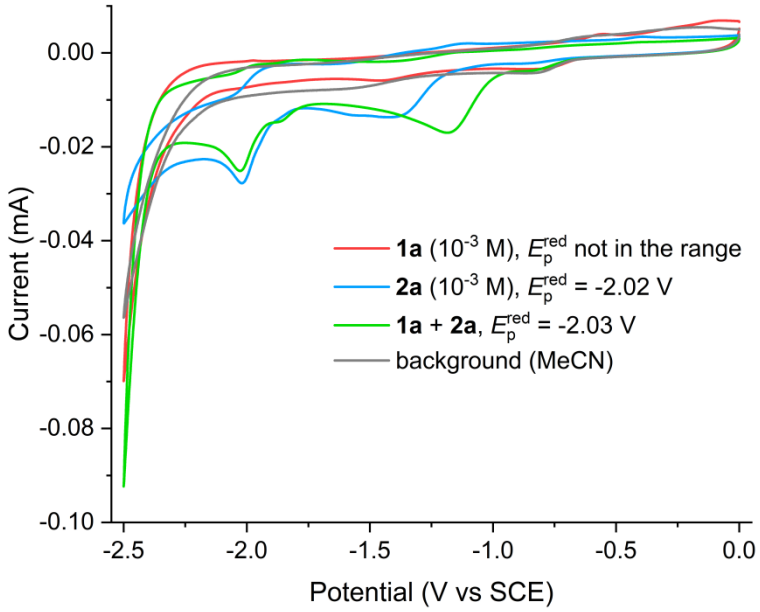


Figure S6 Cathodic cyclic voltammograms of **1a** (10^{-3} M), **2a** (10^{-3} M) and an equimolar mixture of **1a** and **2a** (10^{-3} M) in MeCN under Ar

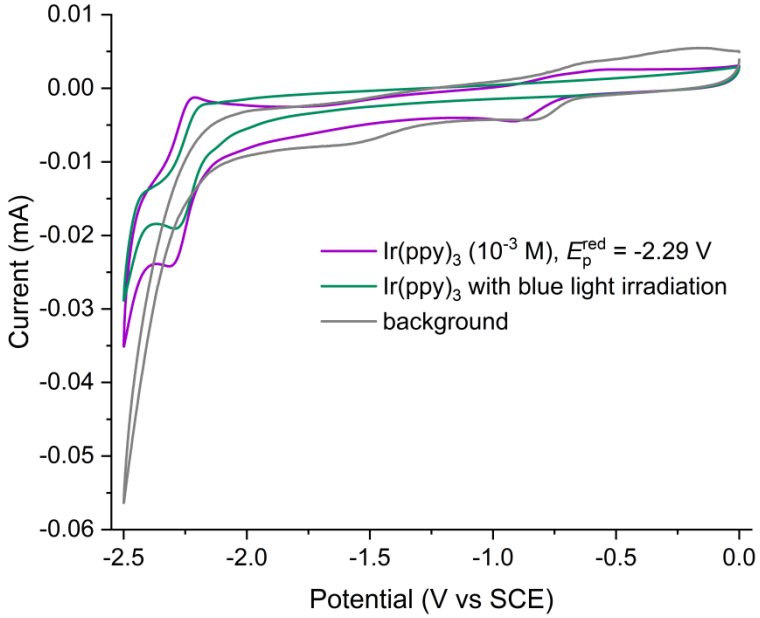


Figure S7 Cathodic cyclic voltammograms of $Ir(ppy)_3$ (10^{-3} M) in MeCN under Ar

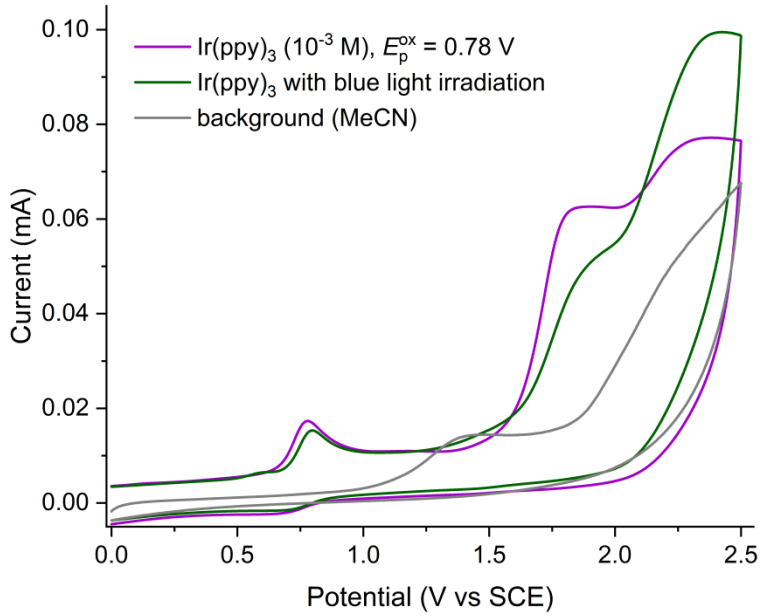


Figure S8 Anodic cyclic voltammograms of $Ir(ppy)_3$ (10^{-3} M) in MeCN under Ar

4. Fluorescence spectra

Fluorescence spectra were collected on a Cary Eclipse Fluorescence Spectrophotometer (Agilent Technologies). It has been established that **2a** could attenuate $Ir(ppy)_3$ fluorescence, although those experiments were somewhat troubled by aggregation-induced emission (AIE).

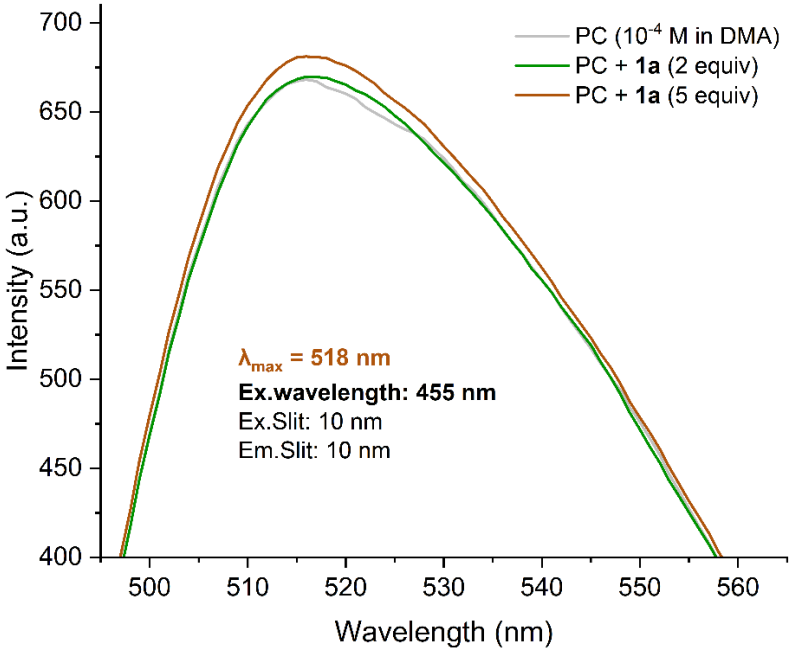


Figure S9 Fluorescence quenching of $Ir(ppy)_3$ (10^{-4} M) in the presence of **1a** in DMA.

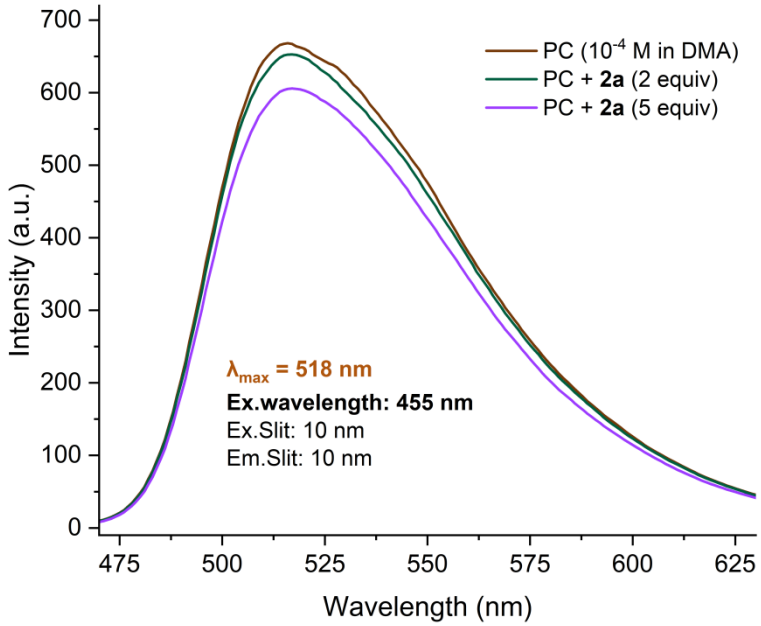
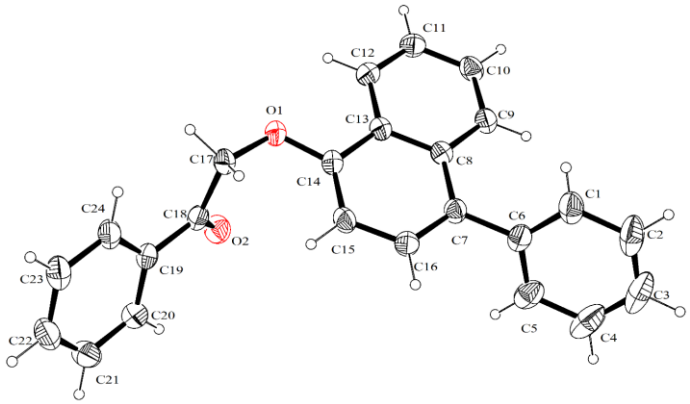


Figure S10 Fluorescence quenching of $Ir(ppy)_3$ (10^{-4} M) in the presence of **2a** in DMA.

V. Crystallographic Data

Single crystals of **3a** suitable for X-ray crystallography were obtained by vapor diffusion at room temperature from petroleum ether/diethyl ether (4:1, v/v) solvent system. A suitable crystal was selected and mounted on a Bruker D8 QUEST diffractometer. The crystal was kept at 200.0(2) K during data collection.

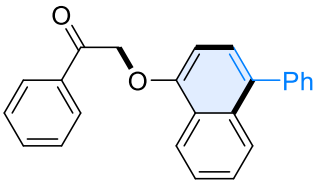
X-ray crystallographic data for compound 3a (thermal ellipsoids shown at 50% probability, CDCC number: 2447914).



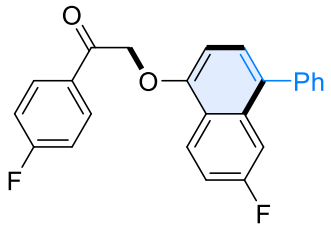
CCDC number	2447914
Empirical formula	$C_{24}H_{18}O_2$

Formula weight	338.38
Temperature/K	150.0
Crystal system	triclinic
Space group	$P\bar{1}$ (2)
a/Å	9.6426(3)
b/Å	12.3442(3)
c/Å	15.2224(4)
α/°	90.9720(10)
β/°	103.3140(10)
γ/°	96.0790(10)
Volume/Å^3	1751.71(8)
Z	2
ρ_{calc}g/cm^3	1.283
μ/mm^{-1}	0.634
F(000)	712
Crystal size/mm^3	0.42×0.3×0.22
Crystal colour	colourless
Crystal shape	block
Radiation	CuK$_\alpha$ (λ=1.54178 Å)
2Θ range/°	5.97 to 136.56 (0.83 Å)
Index ranges	$-10 \le h \le 11$ $-14 \le k \le 14$ $-18 \le l \le 18$
Reflections collected	26293
Independent reflections	6410[R_{int} = 0.0649, R_{sigma} = 0.0543]
Data/restraints/parameters	6410/0/469
Goodness-of-fit on F^2	1.248
Final R indexes [I>=2σ (I)]	R_1 = 0.0542, wR_2 = 0.1536
Final R indexes [all data]	R_1 = 0.0641, wR_2 = 0.1609
Largest diff. peak/hole / e Å^{-3}	0.40/−0.46

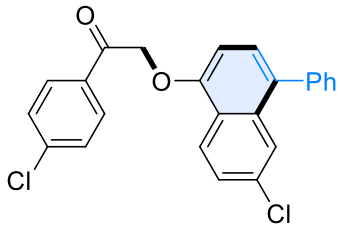
VI. Spectral data of products



1-Phenyl-2-((4-phenylnaphthalen-1-yl)oxy)ethan-1-one (**3a**), isolated by flash column chromatography (petroleum ether/EtOAc = 40:1, v/v), 57% yield (57.4 mg), pale yellow solid: m.p. 113 − 114 °C. R_f (petroleum ether/EtOAc = 10:1, v/v) 0.33. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.45 – 8.43 (m, 1H), 8.08 (dd, *J* = 8.4, 1.4 Hz, 2H), 7.87 – 7.84 (m, 1H), 7.62 (dd, *J* = 7.4, 7.4 Hz, 1H), 7.53 – 7.45 (m, 8H), 7.41 – 7.37 (m, 1H), 7.28 (d, *J* = 7.9 Hz, 1H), 6.82 (d, *J* = 7.9 Hz, 1H), 5.46 (s, 2H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 194.6, 153.3, 140.7, 134.7, 133.9, 133.8, 132.7, 130.2, 128.9, 128.3, 128.2, 127.0, 126.7, 126.5, 125.8, 125.7, 125.5, 122.4, 104.8, 71.3. HRMS (ESI-TOF) Calcd for $C_{24}H_{18}NaO_2^+$ ([M+Na]$^+$) 361.1199. Found 361.1198.

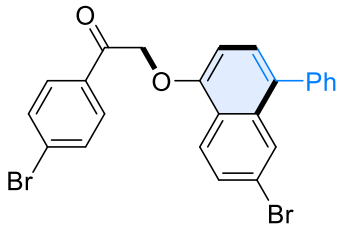


2-((6-Fluoro-4-phenylnaphthalen-1-yl)oxy)-1-(4-fluorophenyl)ethan-1-one (**3a1**), isolated by flash column chromatography (petroleum ether/EtOAc = 40:1, v/v), 52% yield (58.8 mg), pale yellow oil. R_f (petroleum ether/EtOAc = 10:1, v/v) 0.33. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.41 (dd, *J* = 9.3, 5.9 Hz, 1H), 8.11 (dd, *J* = 8.8, 5.3 Hz, 2H), 7.49 – 7.45 (m, 3H), 7.43 – 7.38 (m, 3H), 7.31 – 7.24 (m, 2H), 7.18 (dd, *J* = 8.6, 8.6 Hz, 2H), 6.76 (d, *J* = 7.9 Hz, 1H), 5.42 (s, 2H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 192.9, 166.2 (d, *J* = 256.4 Hz), 161.6 (d, *J* = 246.1 Hz), 153.3 (d, *J* = 1.0 Hz), 140.1, 134.0 (d, *J* = 8.9 Hz), 133.4 (d, *J* = 5.2 Hz), 131.1 (d, *J* = 9.4 Hz), 130.0, 128.4, 127.8, 127.3, 125.1 (d, *J* = 9.3 Hz), 122.6, 116.1 (d, *J* = 22.0 Hz), 115.5 (d, *J* = 25.0 Hz), 109.5 (d, *J* = 22.1 Hz), 104.1 (d, *J* = 2.2 Hz), 71.1. ^{19}F NMR (376 MHz, $CDCl_3$) δ -103.04 – -103.11 (m, 1F), -113.06 – -113.13 (m, 1F). HRMS (ESI-TOF) Calcd for $C_{24}H_{16}F_2NaO_2^+$ ([M+Na]$^+$) 397.1011. Found 397.1012.

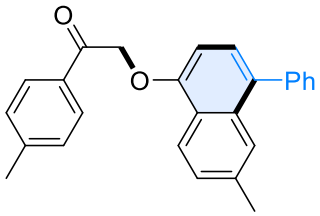


2-((6-Chloro-4-phenylnaphthalen-1-yl)oxy)-1-(4-chlorophenyl)ethan-1-one (**3a2**), isolated by flash column chromatography (petroleum ether/EtOAc = 60:1, v/v), 52% yield (63.7 mg), pale yellow solid: m.p. 142 − 143 °C. R_f (petroleum ether/EtOAc = 15:1, v/v) 0.33. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.33 (d, *J* = 9.0 Hz, 1H), 7.98 (d, *J* = 8.5 Hz, 2H), 7.82 (d, *J* = 2.1 Hz, 1H), 7.49 – 7.45 (m, 4H), 7.44 – 7.39 (m, 4H), 7.28 (d, *J*

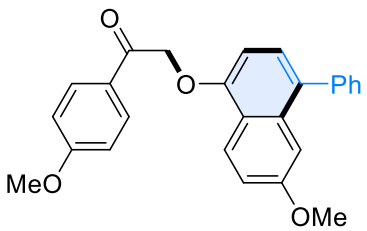
= 7.9 Hz, 1H), 6.76 (d, J = 7.9 Hz, 1H), 5.38 (s, 2H). $^{13}C\{^1H\}$ NMR (101 MHz, $CDCl_3$) δ 193.3, 153.1, 140.6, 139.8, 133.5, 133.2, 133.1, 132.8, 130.1, 129.7, 129.3, 128.5, 127.8, 127.4, 126.4, 124.7, 124.2, 123.9, 105.0, 71.1. HRMS (ESI-TOF) Calcd for $C_{24}H_{16}Cl_2NaO_2^+$ ($[M+Na]^+$) 429.0420. Found 429.0414.



2-((6-Bromo-4-phenylnaphthalen-1-yl)oxy)-1-(4-bromophenyl)ethan-1-one (**3a3**), isolated by flash column chromatography (petroleum ether/EtOAc = 40:1, v/v), 40% yield (59.9 mg), pale yellow solid: m.p. 82 − 83 °C. R_f (petroleum ether/EtOAc = 10:1, v/v) 0.33. ^1H NMR (400 MHz, $CDCl_3$) δ 8.27 (d, J = 8.9 Hz, 1H), 7.99 (d, J = 2.0 Hz, 1H), 7.93 (d, J = 8.6 Hz, 2H), 7.66 (d, J = 8.6 Hz, 2H), 7.58 (dd, J = 9.0, 2.0 Hz, 1H), 7.50 – 7.46 (m, 2H), 7.44 – 7.40 (m, 3H), 7.29 (d, J = 7.9 Hz, 1H), 6.80 (d, J = 7.9 Hz, 1H), 5.41 (s, 2H). $^{13}C\{^1H\}$ NMR (101 MHz, $CDCl_3$) δ 193.5, 153.1, 139.8, 133.9, 133.3, 133.2, 132.3, 130.1, 129.8, 129.4, 128.9, 128.5, 128.0, 127.8, 127.4, 124.2, 124.1, 121.6, 105.2, 71.1. HRMS (ESI-TOF) Calcd for $C_{24}H_{16}Br_2NaO_2^+$ ($[M+Na]^+$) 518.9389. Found 518.9382.

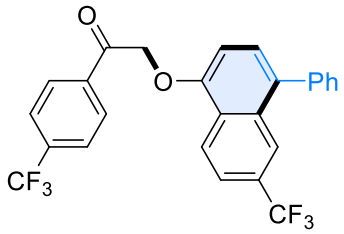


2-((6-Methyl-4-phenylnaphthalen-1-yl)oxy)-1-(*p*-tolyl)ethan-1-one (**3a4**), isolated by flash column chromatography (petroleum ether/EtOAc = 40:1, v/v), 60% yield (66.0 mg), pale yellow solid: m.p. 86 − 87 °C. R_f (petroleum ether/EtOAc = 10:1, v/v) 0.33. ^1H NMR (400 MHz, $CDCl_3$) δ 8.33 (d, J = 8.6 Hz, 1H), 7.98 (d, J = 7.9 Hz, 2H), 7.61 (s, 1H), 7.47 – 7.39 (m, 5H), 7.35 – 7.22 (m, 4H), 6.74 (d, J = 7.9 Hz, 1H), 5.41 (s, 2H), 2.42 (s, 6H). $^{13}C\{^1H\}$ NMR (101 MHz, $CDCl_3$) δ 194.3, 153.4, 144.9, 140.9, 136.5, 133.1, 132.9, 132.3, 130.2, 129.5, 128.5, 128.2, 127.6, 126.9, 126.7, 124.8, 123.9, 122.3, 104.1, 71.2, 21.9, 21.8. HRMS (ESI-TOF) Calcd for $C_{26}H_{22}NaO_2^+$ ($[M+Na]^+$) 389.1512. Found 389.1510.

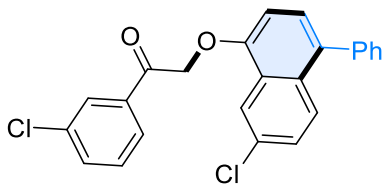


2-((6-Methoxy-4-phenylnaphthalen-1-yl)oxy)-1-(4-methoxyphenyl)ethan-1-one (**3a5**), isolated by flash column chromatography (petroleum ether/EtOAc = 40:1, v/v), 29%

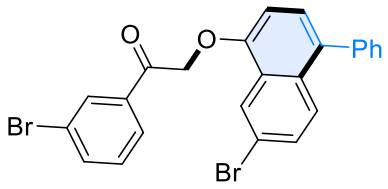
yield (35.0 mg), pale yellow oil. R_f (petroleum ether/EtOAc = 10:1, v/v) 0.33. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.34 (d, J = 9.1 Hz, 1H), 8.06 (d, J = 8.9 Hz, 2H), 7.46 (d, J = 4.4 Hz, 4H), 7.39 (dq, J = 8.7, 4.2 Hz, 1H), 7.25 – 7.23 (m, 1H), 7.19 – 7.14 (m, 2H), 6.96 (d, J = 8.9 Hz, 2H), 6.69 (d, J = 7.9 Hz, 1H), 5.37 (s, 2H), 3.87 (s, 3H), 3.75 (s, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 193.2, 164.1, 158.3, 153.6, 140.9, 134.1, 132.6, 130.7, 130.0, 128.3, 127.8, 127.5, 126.9, 124.2, 120.9, 117.4, 114.0, 104.7, 103.0, 71.1, 55.5, 55.2. HRMS (ESI-TOF) Calcd for $C_{26}H_{22}NaO_4^+$ ([M+Na]$^+$) 421.1410. Found 421.1410.



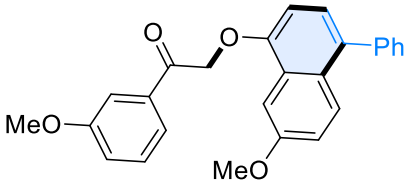
2-((4-Phenyl-6-(trifluoromethyl)naphthalen-1-yl)oxy)-1-(4-(trifluoromethyl)phenyl)ethan-1-one (**3a6**), isolated by flash column chromatography (petroleum ether/EtOAc = 40:1, v/v), 33% yield (47.2 mg), pale yellow solid: m.p. 101 − 102 °C. R_f (petroleum ether/EtOAc = 10:1, v/v) 0.33. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.52 (d, J = 8.8 Hz, 1H), 8.20 – 8.17 (m, 3H), 7.80 (d, J = 8.2 Hz, 2H), 7.69 (dd, J = 8.9, 1.8 Hz, 1H), 7.52 – 7.49 (m, 2H), 7.47 – 7.39 (m, 4H), 6.93 (d, J = 7.9 Hz, 1H), 5.51 (s, 2H). ^{13}C{^{1}H} NMR (101 MHz, CDCl3) δ 193.5, 152.8, 139.5, 137.1 (d, J = 0.9 Hz), 135.5, 135.1, 134.9, 131.7, 130.0, 128.7, 128.6, 127.9, 127.6, 126.9 (d, J = 0.7 Hz), 126.0 (q, J = 11.3 Hz), 124.3 (q, J = 273.5 Hz), 123.61 (q, J = 4.9 Hz), 123.58, 123.4 (q, J = 273.9 Hz), 121.2 (q, J = 3.2 Hz), 106.7, 71.3. ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.31 (s, 3F), -63.24 (s, 3F). HRMS (ESI-TOF) Calcd for $C_{26}H_{16}F_6NaO_2^+$ ([M+Na]$^+$) 497.0947. Found 497.0943.



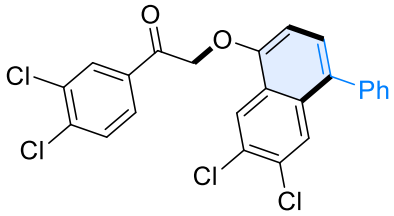
2-((7-Chloro-4-phenylnaphthalen-1-yl)oxy)-1-(3-chlorophenyl)ethan-1-one (**3b1**), isolated by flash column chromatography (petroleum ether/EtOAc = 40:1, v/v), 47% yield (57.4 mg), pale yellow oil. R_f (petroleum ether/EtOAc = 10:1, v/v) 0.33. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.44 (dd, J = 8.4, 1.3 Hz, 1H), 8.04 (dd, J = 1.9, 1.9 Hz, 1H), 7.94 (d, J = 7.9 Hz, 1H), 7.62 – 7.60 (m, 1H), 7.55 (dd, J = 7.4, 1.3 Hz, 1H), 7.47 (dd, J = 7.9, 7.8 Hz, 1H), 7.43 – 7.39 (m, 1H), 7.37 – 7.35 (m, 3H), 7.30 (dd, J = 6.7, 3.0 Hz, 2H), 7.25 (d, J = 2.4 Hz, 1H), 6.80 (d, J = 8.0 Hz, 1H), 5.44 (s, 2H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 193.1, 153.1, 143.4, 136.0, 135.3, 134.0, 133.0, 131.4, 130.5, 130.3, 129.8, 129.5, 128.4, 127.9, 127.3, 126.6, 126.4, 125.5, 121.8, 105.0, 71.2. HRMS (ESI-TOF) Calcd for $C_{24}H_{16}Cl_2NaO_2^+$ ([M+Na]$^+$) 429.0420. Found 429.0421.



2-((7-Bromo-4-phenylnaphthalen-1-yl)oxy)-1-(3-bromophenyl)ethan-1-one (**3b2**), isolated by flash column chromatography (petroleum ether/EtOAc = 40:1, v/v), 46% yield (67.8 mg), pale yellow oil. R_f (petroleum ether/EtOAc = 10:1, v/v) 0.33. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.49 (dd, J = 8.4, 1.3 Hz, 1H), 8.20 (dd, J = 1.8, 1.9 Hz, 1H), 7.98 (d, J = 7.9 Hz, 1H), 7.82 (dd, J = 7.4, 1.3 Hz, 1H), 7.76 (ddd, J = 8.0, 2.0, 1.0 Hz, 1H), 7.42 – 7.34 (m, 5H), 7.32 – 7.28 (m, 3H), 6.81 (d, J = 8.0 Hz, 1H), 5.44 (s, 2H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 193.0, 153.1, 142.8, 136.9, 136.2, 134.6, 133.9, 131.3, 130.7, 130.5, 130.4, 130.1, 128.4, 128.0, 127.4, 126.8, 126.7, 125.8, 122.5, 120.1, 105.0, 71.2. HRMS (ESI-TOF) Calcd for $C_{24}H_{16}Br_2NaO_2^+$ ([M+Na]$^+$) 516.9409. Found 516.9404.

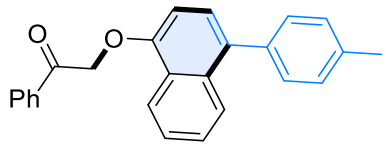


2-((7-Methoxy-4-phenylnaphthalen-1-yl)oxy)-1-(3-methoxyphenyl)ethan-1-one (**3b3**), isolated by flash column chromatography (petroleum ether/EtOAc = 28:1, v/v), 47% yield (56.6 mg), pale yellow solid: m.p. 149 − 150 °C. R_f (petroleum ether/EtOAc = 7:1, v/v) 0.33. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.07 (dd, J = 8.5, 1.1 Hz, 1H), 7.65 (d, J = 7.7 Hz, 1H), 7.59 (dd, J = 2.6, 1.5 Hz, 1H), 7.42 (q, J = 7.6 Hz, 2H), 7.35 – 7.26 (m, 5H), 7.16 (dd, J = 8.2, 2.3 Hz, 1H), 7.13 (d, J = 7.9 Hz, 1H), 6.84 (d, J = 7.5 Hz, 1H), 6.79 (d, J = 7.9 Hz, 1H), 5.44 (s, 2H), 3.86 (s, 3H), 3.46 (s, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 194.3, 160.0, 156.5, 153.1, 145.4, 136.0, 132.4, 129.9, 128.9, 128.4, 127.5, 126.6, 125.8, 125.5, 124.5, 120.8, 120.5, 115.0, 112.5, 107.3, 105.2, 71.4, 55.5, 55.3. HRMS (ESI-TOF) Calcd for $C_{26}H_{22}NaO_4^+$ ([M+Na]$^+$) 421.1410. Found 421.1410.

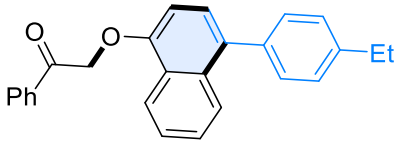


2-((6,7-Dichloro-4-phenylnaphthalen-1-yl)oxy)-1-(3,4-dichlorophenyl)ethan-1-one (**3c**), isolated by flash column chromatography (petroleum ether/EtOAc = 28:1, v/v), 25% yield (35.4 mg), pale yellow oil. R_f (petroleum ether/EtOAc = 7:1, v/v) 0.33. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.35 (d, J = 9.1 Hz, 1H), 8.16 (d, J = 2.0 Hz, 1H), 7.89 (dd, J = 8.3, 2.1 Hz, 1H), 7.59 (dd, J = 13.4, 8.7 Hz, 2H), 7.37 – 7.35 (m, 3H), 7.31 (d, J = 8.0 Hz, 1H), 7.28 – 7.26 (m, 3H), 6.81 (d, J = 8.1 Hz, 1H), 5.42 (s, 2H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 192.2, 153.0, 143.4, 138.9, 134.1, 133.9, 133.8, 133.2, 131.8, 131.1, 130.8, 130.3, 129.6, 129.1, 127.5, 127.3, 127.2, 126.7, 125.9, 122.3, 105.2, 71.2.

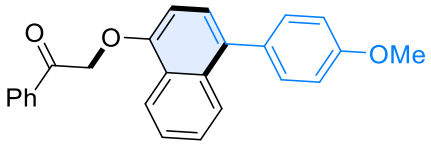
HRMS (ESI-TOF) Calcd for $C_{24}H_{14}Cl_4NaO_2^+$ ([M+Na]$^+$) 496.9640. Found 498.9641.



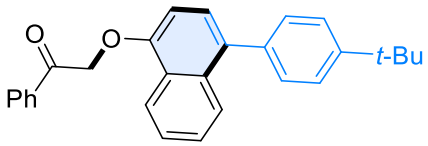
1-Phenyl-2-((4-(*p*-tolyl)naphthalen-1-yl)oxy)ethan-1-one (**3d1**), isolated by flash column chromatography (petroleum ether/EtOAc = 40:1, v/v), 51% yield (53.4 mg), pale yellow oil. R_f (petroleum ether/EtOAc = 10:1, v/v) 0.33. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.43 (dd, *J* = 8.6, 1.3 Hz, 1H), 8.08 (dd, *J* = 8.4, 1.3 Hz, 2H), 7.87 (dd, *J* = 7.7, 1.2 Hz, 1H), 7.63 (dd, *J* = 7.3, 7.5 Hz, 1H), 7.53 – 7.43 (m, 4H), 7.35 (d, *J* = 8.2 Hz, 2H), 7.29 – 7.25 (m, 3H), 6.81 (d, *J* = 7.9 Hz, 1H), 5.47 (s, 2H), 2.44 (s, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 194.6, 153.1, 137.7, 136.7, 134.7, 133.9, 133.8, 132.7, 130.1, 129.0, 128.9, 128.3, 126.6, 126.4, 125.9, 125.7, 125.4, 122.4, 104.9, 71.3, 21.3. HRMS (ESI-TOF) Calcd for $C_{25}H_{21}O_2^+$ ([M+H]$^+$) 353.1536. Found 353.1541.



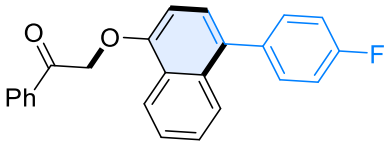
2-((4-(4-Ethylphenyl)naphthalen-1-yl)oxy)-1-phenylethan-1-one (**3d2**), isolated by flash column chromatography (petroleum ether/EtOAc = 40:1, v/v), 43% yield (47.5 mg), pale yellow oil. R_f (petroleum ether/EtOAc = 10:1, v/v) 0.33. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.43 (d, *J* = 8.3 Hz, 1H), 8.08 (d, *J* = 6.8 Hz, 2H), 7.89 (d, *J* = 8.0 Hz, 1H), 7.62 (dd, *J* = 7.5, 7.4 Hz, 1H), 7.53 – 7.48 (m, 3H), 7.47 – 7.43 (m, 1H), 7.38 (d, *J* = 8.0 Hz, 2H), 7.31 – 7.27 (m, 3H), 6.81 (d, *J* = 7.9 Hz, 1H), 5.46 (s, 2H), 2.74 (q, *J* = 7.6 Hz, 2H), 1.32 (t, *J* = 7.56 Hz, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 194.6, 153.1, 143.0, 137.9, 134.7, 133.9, 133.8, 132.8, 130.2, 128.9, 128.3, 127.8, 126.6, 126.5, 125.9, 125.7, 125.4, 122.4, 104.9, 71.2, 28.6, 15.6. HRMS (ESI-TOF) Calcd for $C_{26}H_{22}NaO_2^+$ ([M+Na]$^+$) 389.1512. Found 389.1512.



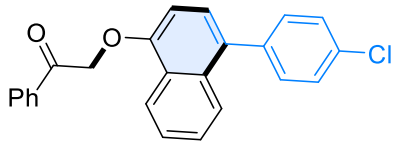
2-((4-(4-Methoxyphenyl)naphthalen-1-yl)oxy)-1-phenylethan-1-one (**3d3**), isolated by flash column chromatography (petroleum ether/EtOAc = 40:1, v/v), 53% yield (58.9 mg), pale yellow oil. R_f (petroleum ether/EtOAc = 10:1, v/v) 0.33. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.44 – 8.42 (m, 1H), 8.08 – 8.06 (m, 2H), 7.88 – 7.86 (m, 1H), 7.62 (dd, *J* = 7.5, 7.3 Hz, 1H), 7.52 – 7.48 (m, 3H), 7.47 - 7.43 (m, 1H), 7.37 (d, *J* = 8.7 Hz, 2H), 7.25 (d, *J* = 7.8 Hz, 1H), 7.00 (d, *J* = 8.7 Hz, 2H), 6.80 (d, *J* = 7.9 Hz, 1H), 5.45 (s, 2H), 3.87 (s, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 194.6, 158.7, 153.1, 134.7, 133.9, 133.4, 133.0, 132.9, 131.2, 128.9, 128.3, 126.7, 126.5, 125.9, 125.7, 125.4, 122.4, 113.7, 104.9, 71.2, 55.4. HRMS (ESI-TOF) Calcd for $C_{25}H_{21}O_3^+$ ([M+H]$^+$) 369.1485. Found 369.1488.



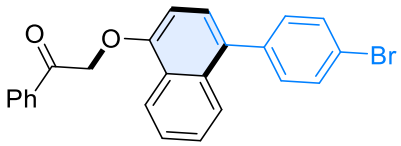
2-((4-(4-(*Tert*-butyl)phenyl)naphthalen-1-yl)oxy)-1-phenylethan-1-one (**3d4**), isolated by flash column chromatography (petroleum ether/EtOAc = 40:1, v/v), 53% yield (62.3 mg), pale yellow oil. R_f (petroleum ether/EtOAc = 10:1, v/v) 0.33. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.43 (d, *J* = 9.1 Hz, 1H), 8.08 (d, *J* = 8.0 Hz, 2H), 7.92 (d, *J* = 8.3 Hz, 1H), 7.62 (dd, *J* = 7.3, 7.6 Hz, 1H), 7.52 – 7.45 (m, 6H), 7.39 (d, *J* = 8.0 Hz, 2H), 7.29 (d, *J* = 7.8 Hz, 1H), 6.81 (d, *J* = 7.9 Hz, 1H), 5.46 (s, 2H), 1.40 (s, 9H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 194.6, 153.1, 149.8, 137.6, 134.7, 133.9, 133.8, 132.8, 129.9, 128.9, 128.3, 126.6, 126.5, 126.0, 125.7, 125.4, 125.2, 122.4, 104.9, 71.2, 34.6, 31.5. HRMS (ESI-TOF) Calcd for $C_{28}H_{27}O_2^+$ ([M+H]$^+$) 395.2006. Found 395.2006.



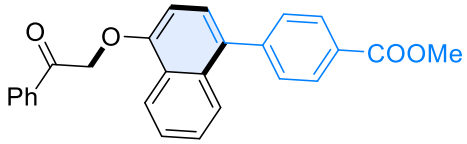
2-((4-(4-Fluorophenyl)naphthalen-1-yl)oxy)-1-phenylethan-1-one (**3d5**), isolated by flash column chromatography (petroleum ether/EtOAc = 40:1, v/v), 29% yield (31.0 mg), pale yellow solid: m.p. 132 − 133 °C. R_f (petroleum ether/EtOAc = 10:1, v/v) 0.33. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.45 – 8.43 (m, 1H), 8.09 – 8.06 (m, 2H), 7.80 – 7.78 (m, 1H), 7.63 (dd, *J* = 7.4, 7.4 Hz, 1H), 7.51 (dd, *J* = 7.8, 7.4 Hz, 3H), 7.46 (ddd, *J* = 8.3, 6.8, 1.6 Hz, 1H), 7.41 – 7.38 (m, 2H), 7.25 – 7.23 (m, 1H), 7.15 (dd, *J* = 8.7, 8.7 Hz, 2H), 6.80 (d, *J* = 7.9 Hz, 1H), 5.47 (s, 2H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 194.5, 162.1 (d, *J* = 245.7 Hz), 153.4, 136.6 (d, *J* = 3.3 Hz), 134.7, 134.0, 132.7 (d, *J* = 5.3 Hz), 131.7(d, *J* = 7.9 Hz), 128.9, 128.3, 126.9, 126.6, 125.7, 125.5 (d, *J* = 3.2 Hz), 122.5, 115.2, 115.0, 104.8, 71.2. ^{19}F NMR (376 MHz, $CDCl_3$) δ -115.79 – -115.86 (m, 1F). HRMS (ESI-TOF) Calcd for $C_{24}H_{17}FNaO_2^+$ ([M+Na]$^+$) 379.1105. Found 379.1105.



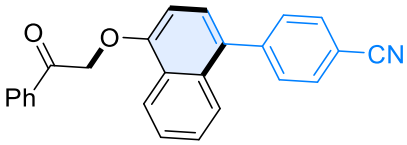
2-((4-(4-Chlorophenyl)naphthalen-1-yl)oxy)-1-phenylethan-1-one (**3d6**), isolated by flash column chromatography (petroleum ether/EtOAc = 40:1, v/v), 49% yield (54.8 mg), pale yellow solid: m.p. 126 − 127 °C. R_f (petroleum ether/EtOAc = 10:1, v/v) 0.33. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.44 (dd, *J* = 8.6, 1.4 Hz, 1H), 8.09 – 8.07 (m, 2H), 7.80 – 7.78 (m, 1H), 7.63 (dd, *J* = 7.4, 7.4 Hz, 1H), 7.54 – 7.43 (m, 6H), 7.38 (d, *J* = 8.5 Hz, 2H), 7.25 (d, *J* = 7.0 Hz, 1H), 6.81 (d, *J* = 7.9 Hz, 1H), 5.48 (s, 2H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 194.4, 153.5, 139.1, 134.7, 134.0, 133.0, 132.5, 132.4, 131.5, 128.9, 128.4, 128.3, 126.9, 126.6, 125.7, 125.6, 125.4, 122.5, 104.8, 71.2. HRMS (ESI-TOF) Calcd for $C_{24}H_{17}ClNaO_2^+$ ([M+Na]$^+$) 395.0809. Found 395.0809.



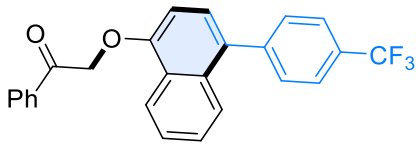
2-((4-(4-Bromophenyl)naphthalen-1-yl)oxy)-1-phenylethan-1-one (**3d7**), isolated by flash column chromatography (petroleum ether/EtOAc = 40:1, v/v), 41% yield (50.8 mg), pale yellow solid: m.p. 116 − 117 °C. R_f (petroleum ether/EtOAc = 10:1, v/v) 0.33. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.44 (d, *J* = 8.1 Hz, 1H), 8.07 (d, *J* = 7.4 Hz, 2H), 7.79 (d, *J* = 8.3 Hz, 1H), 7.64 – 7.61 (m, 1H), 7.58 (d, *J* = 8.3 Hz, 2H), 7.52 (d, *J* = 7.7 Hz, 2H), 7.47 (dd, *J* = 13.5, 6.4 Hz, 2H), 7.31 (d, *J* = 8.3 Hz, 2H), 7.23 (d, *J* = 8.1 Hz, 1H), 6.79 (d, *J* = 7.9 Hz, 1H), 5.47 (s, 2H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 194.4, 153.5, 139.6, 134.6, 134.0, 132.41, 132.38, 131.9, 131.4, 128.9, 128.3, 127.0, 126.6, 125.7, 125.6, 125.4, 122.5, 121.2, 104.7, 71.1. HRMS (ESI-TOF) Calcd for $C_{24}H_{17}BrNaO_2^+$ ([M+Na]$^+$) 439.0304. Found 439.0303.



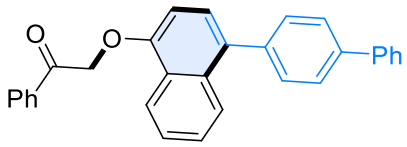
Methyl 4-(4-(2-oxo-2-phenylethoxy)naphthalen-1-yl)benzoate (**3d8**), isolated by flash column chromatography (petroleum ether/EtOAc = 20:1, v/v), 41% yield (48.3 mg), pale yellow solid: m.p. 130 − 131 °C. R_f (petroleum ether/EtOAc = 5:1, v/v) 0.33. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.46 (dd, *J* = 8.5, 1.3 Hz, 1H), 8.13 (d, *J* = 8.3 Hz, 2H), 8.09 – 8.06 (m, 2H), 7.81 (dd, *J* = 7.8, 1.2 Hz, 1H), 7.63 (dd, *J* = 7.5, 7.4 Hz, 1H), 7.53 (dd, *J* = 8.2, 2.2 Hz, 4H), 7.50 – 7.40 (m, 2H), 7.28 (d, *J* = 7.9 Hz, 1H), 6.81 (d, *J* = 7.9 Hz, 1H), 5.48 (s, 2H), 3.96 (s, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 194.3, 167.1, 153.8, 145.5, 134.6, 134.0, 132.6, 132.3, 130.2, 129.6, 128.9, 128.7, 128.3, 127.1, 126.7, 125.73, 125.67, 125.4, 122.6, 104.7, 71.1, 52.2. HRMS (ESI-TOF) Calcd for $C_{26}H_{20}NaO_4^+$ ([M+Na]$^+$) 419.1254. Found 419.1252.



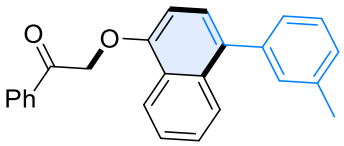
4-(4-(2-Oxo-2-phenylethoxy)naphthalen-1-yl)benzonitrile (**3d9**), isolated by flash column chromatography (petroleum ether/EtOAc = 40:1, v/v), 33% yield (36.1 mg), pale yellow solid: m.p. 143 − 144 °C. R_f (petroleum ether/EtOAc = 10:1, v/v) 0.33. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.49 – 8.46 (m, 1H), 8.09 – 8.07 (m, 2H), 7.77 – 7.74 (m, 3H), 7.65 (dd, *J* = 7.4, 7.4 Hz, 1H), 7.58 – 7.48 (m, 6H), 7.27 – 7.25 (m, 1H), 6.82 (d, *J* = 7.9 Hz, 1H), 5.51 (s, 2H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 194.2, 154.1, 145.6, 134.6, 134.1, 132.1, 132.0, 131.6, 130.9, 128.9, 128.3, 127.3, 126.9, 125.8, 125.7, 125.0, 122.7, 119.1, 110.8, 104.7, 71.1. HRMS (ESI-TOF) Calcd for $C_{25}H_{17}NNaO_2^+$ ([M+Na]$^+$) 386.1151. Found 386.1148.



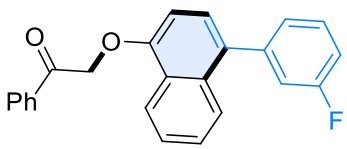
1-Phenyl-2-((4-(4-(trifluoromethyl)phenyl)naphthalen-1-yl)oxy)ethan-1-one (**3d10**), isolated by flash column chromatography (petroleum ether/EtOAc = 60:1, v/v), 41% yield (50.4 mg), pale yellow solid: m.p. 122 − 123 °C. R_f (petroleum ether/EtOAc = 15:1, v/v) 0.33. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.47 (dd, *J* = 8.6, 1.3 Hz, 1H), 8.10 – 8.07 (m, 2H), 7.78 (dd, *J* = 7.8, 1.2 Hz, 1H), 7.72 (d, *J* = 8.1 Hz, 2H), 7.64 (dd, *J* = 7.4, 7.4 Hz, 1H), 7.57 (d, *J* = 8.1 Hz, 2H), 7.55 – 7.46 (m, 4H), 7.27 (d, *J* = 7.9 Hz, 1H), 6.82 (d, *J* = 7.9 Hz, 1H), 5.50 (s, 2H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 194.3, 153.8, 144.4 (d, *J* = 1.0 Hz), 134.6, 134.0, 132.3, 132.2, 130.5, 128.9, 128.3, 127.1, 126.8, 125.7, 125.3, 125.2 (q, *J* = 3.7 Hz), 124.4 (q, *J* = 273.1 Hz), 122.6, 120.3, 104.7, 71.1. ^{19}F NMR (376 MHz, $CDCl_3$) δ -62.31 (s, 3F). HRMS (ESI-TOF) Calcd for $C_{25}H_{18}F_3O_2^+$ ([M+H]$^+$) 407.1253. Found 407.1252.



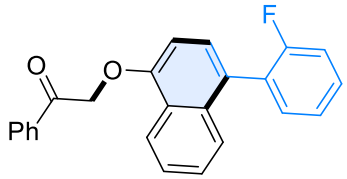
2-((4-([1,1'-Biphenyl]-4-yl)naphthalen-1-yl)oxy)-1-phenylethan-1-one (**3d11**), isolated by flash column chromatography (petroleum ether/EtOAc = 40:1, v/v), 43% yield (53.5 mg), pale yellow solid: m.p. 166 − 167 °C. R_f (petroleum ether/EtOAc = 10:1, v/v) 0.33. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.46 (dd, *J* = 8.5, 1.4 Hz, 1H), 8.09 – 8.07 (m, 2H), 7.94 (dd, *J* = 7.7, 1.3 Hz, 1H), 7.69 (dd, *J* = 7.5, 7.5 Hz, 4H), 7.62 (dd, *J* = 7.4, 7.4 Hz, 1H), 7.54 – 7.45 (m, 8H), 7.35 (dd, *J* = 20.9, 7.6 Hz, 2H), 6.83 (d, *J* = 7.9 Hz, 1H), 5.47 (s, 2H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 194.5, 153.4, 140.9, 139.8, 139.7, 134.7, 134.0, 133.3, 132.7, 130.6, 128.90, 128.86, 128.3, 127.3, 127.1, 127.0, 126.8, 126.6, 125.81, 125.75, 125.5, 122.5, 104.9, 71.2. HRMS (ESI-TOF) Calcd for $C_{30}H_{22}NaO_2^+$ ([M+Na]$^+$) 437.1512. Found 437.1510.



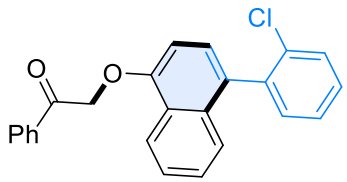
1-Phenyl-2-((4-(*m*-tolyl)naphthalen-1-yl)oxy)ethan-1-one (**3e1**), isolated by flash column chromatography (petroleum ether/EtOAc = 40:1, v/v), 68% yield (72.0 mg), pale yellow oil. R_f (petroleum ether/EtOAc = 10:1, v/v) 0.33. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.43 (d, *J* = 7.7 Hz, 1H), 8.06 (d, *J* = 7.3 Hz, 2H), 7.87 (d, *J* = 8.4 Hz, 1H), 7.61 (dd, *J* = 7.4, 7.4 Hz, 1H), 7.51 – 7.42 (m, 4H), 7.35 (dd, *J* = 7.5, 7.5 Hz, 1H), 7.27 – 7.20 (m, 4H), 6.79 (d, *J* = 7.9 Hz, 1H), 5.44 (s, 2H), 2.41 (s, 3H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 194.6, 153.2, 140.6, 137.9, 134.7, 134.0, 133.9, 132.7, 131.0, 128.9, 128.3, 128.1, 127.8, 127.3, 126.7, 126.5, 125.9, 125.7, 125.4, 122.4, 104.8, 71.2, 21.6. HRMS (ESI-TOF) Calcd for $C_{25}H_{20}NaO_2^+$ ([M+Na]$^+$) 375.1356. Found 375.1356.



2-((4-(3-Fluorophenyl)naphthalen-1-yl)oxy)-1-phenylethan-1-one (**3e2**), isolated by flash column chromatography (petroleum ether/EtOAc = 40:1, v/v), 41% yield (43.5 mg), pale yellow oil. R_f (petroleum ether/EtOAc = 10:1, v/v) 0.33. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.45 (dd, *J* = 8.1, 1.6 Hz, 1H), 8.09 (d, *J* = 7.0 Hz, 2H), 7.84 (d, *J* = 7.5 Hz, 1H), 7.64 (dd, *J* = 7.4, 7.4 Hz, 1H), 7.55 – 7.46 (m, 4H), 7.45 – 7.40 (m, 1H), 7.28 (d, *J* = 7.8 Hz, 1H), 7.23 (d, *J* = 7.6 Hz, 1H), 7.17 (ddd, *J* = 9.7, 2.3, 1.8 Hz, 1H), 7.10 (ddd, *J* = 8.6, 8.5, 2.6 Hz, 1H), 6.81 (d, *J* = 7.9 Hz, 1H), 5.49 (s, 2H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 194.4, 162.7 (d, *J* = 245.9 Hz), 153.6, 142.9 (d, *J* = 7.8 Hz), 134.6, 134.0, 132.4 (d, *J* = 2.1 Hz), 129.7 (d, *J* = 8.4 Hz), 128.9, 128.3, 127.0, 126.6, 126.0 (d, *J* = 2.9 Hz), 125.7, 125.6, 125.5, 122.5, 117.1 (d, *J* = 21.2 Hz), 114.9 (d, *J* = 21.0 Hz), 104.7, 71.2. ^{19}F NMR (376 MHz, $CDCl_3$) δ -113.59 – -113.65 (m, 1F). HRMS (ESI-TOF) Calcd for $C_{24}H_{17}FNaO_2^+$ ([M+Na]$^+$) 379.1105. Found 379.1103.

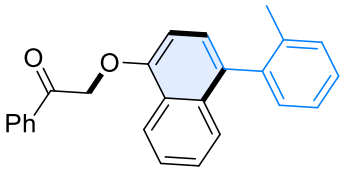


2-((4-(2-Fluorophenyl)naphthalen-1-yl)oxy)-1-phenylethan-1-one (**3f1**), isolated by flash column chromatography (petroleum ether/EtOAc = 40:1, v/v), 48% yield (50.9 mg), pale yellow solid: m.p. 136 − 137 °C. R_f (petroleum ether/EtOAc = 10:1, v/v) 0.33. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.45 – 8.43 (m, 1H), 8.10 – 8.07 (m, 2H), 7.65 – 7.60 (m, 2H), 7.51 (dd, *J* = 7.9, 7.8 Hz, 3H), 7.46 (ddd, *J* = 8.2, 6.8, 1.6 Hz, 1H), 7.43 – 7.35 (m, 1H), 7.38 – 7.37 (m, 1H), 7.30 (d, *J* = 7.8 Hz, 1H), 7.26 – 7.24 (m, 1H), 7.22 – 7.17 (m, 1H), 6.83 (d, *J* = 8.0 Hz, 1H), 5.46 (s, 2H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 194.5, 160.3 (d, *J* = 246.2 Hz), 153.9, 134.7, 134.0, 132.8, 132.6 (d, *J* = 3.5 Hz), 129.3 (d, *J* = 8.0 Hz), 128.9, 128.3, 127.9 (d, *J* = 16.3 Hz), 127.4, 127.2, 126.9, 125.62 (d, *J* = 1.4 Hz), 125.58, 124.1 (d, *J* = 3.7 Hz), 122.4, 115.7 (d, *J* = 22.4 Hz), 104.7, 71.2. ^{19}F NMR (376 MHz, $CDCl_3$) δ -113.81 – -113.86 (m, 1F). HRMS (ESI-TOF) Calcd for $C_{24}H_{17}FNaO_2^+$ ([M+Na]$^+$) 379.1105. Found 379.1103.

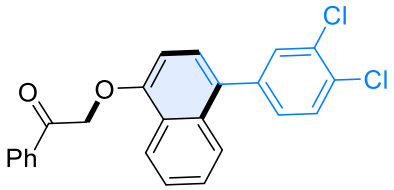


2-((4-(2-Chlorophenyl)naphthalen-1-yl)oxy)-1-phenylethan-1-one (**3f2**), isolated by flash column chromatography (petroleum ether/EtOAc = 40:1, v/v), 52% yield (57.7 mg), pale yellow oil. R_f (petroleum ether/EtOAc = 10:1, v/v) 0.33. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.44 (d, *J* = 8.3 Hz, 1H), 8.09 – 8.06 (m, 2H), 7.63 (dd, *J* = 7.4, 7.4 Hz, 1H), 7.53 – 7.48 (m, 4H), 7.43 (dd, *J* = 4.7, 1.3 Hz, 2H), 7.38 – 7.33 (m, 3H), 7.25 – 7.23

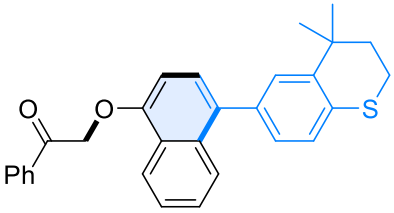
(m, 1H), 6.82 (d, J = 7.9 Hz, 1H), 5.47 (s, 2H). $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 194.5, 153.7, 139.2, 134.7, 134.4, 134.0, 132.7, 132.5, 130.9, 129.5, 128.90, 128.86, 128.4, 126.9, 126.8, 126.6, 125.7, 125.53, 125.47, 122.5, 104.6, 71.2. HRMS (ESI-TOF) Calcd for $C_{24}H_{17}ClNaO_2^+$ ($[M+Na]^+$) 395.0809. Found 395.0805.



1-Phenyl-2-((4-(*o*-tolyl)naphthalen-1-yl)oxy)ethan-1-one (**3f3**), isolated by flash column chromatography (petroleum ether/EtOAc = 40:1, v/v), 68% yield (71.6 mg), pale yellow oil. R_f (petroleum ether/EtOAc = 10:1, v/v) 0.33. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.43 (d, J = 8.4 Hz, 1H), 8.11 – 8.08 (m, 2H), 7.64 (dd, J = 7.4, 7.4 Hz, 1H), 7.54 – 7.47 (m, 3H), 7.41 – 7.39 (m, 2H), 7.33 (dd, J = 6.3, 1.7 Hz, 2H), 7.29 – 7.25 (m, 1H), 7.21 (dd, J = 10.1, 7.4 Hz, 2H), 6.82 (d, J = 7.8 Hz, 1H), 5.48 (s, 2H), 2.01 (s, 3H). $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 194.6, 153.2, 140.1, 137.2, 134.7, 133.9, 133.2, 133.0, 130.7, 129.8, 128.9, 128.4, 127.5, 126.7, 126.2, 125.9, 125.6, 125.5, 125.4, 122.4, 104.8, 71.3, 20.2. HRMS (ESI-TOF) Calcd for $C_{25}H_{20}NaO_2^+$ ($[M+Na]^+$) 375.1356. Found 375.1359.

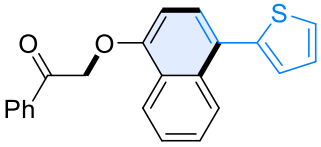


2-((4-(3,4-Dichlorophenyl)naphthalen-1-yl)oxy)-1-phenylethan-1-one (**3g**), isolated by flash column chromatography (petroleum ether/EtOAc = 40:1, v/v), 37% yield (45.1 mg), white solid: m.p. 150 − 151 °C. R_f (petroleum ether/EtOAc = 10:1, v/v) 0.33. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.47 – 8.44 (m, 1H), 8.08 – 8.05 (m, 2H), 7.77 (dd, J = 8.5, 1.3 Hz, 1H), 7.63 (dd, J = 7.4, 7.4 Hz, 1H), 7.54 – 7.47 (m, 6H), 7.27 (dd, J = 8.2, 2.1 Hz, 1H), 7.23 (d, J = 7.9 Hz, 1H), 6.78 (d, J = 7.9 Hz, 1H), 5.48 (s, 2H). $^{13}C\{^{1}H\}$ NMR (101 MHz, $CDCl_3$) δ 194.3, 153.8, 140.7, 134.6, 134.0, 132.33, 132.26, 131.9, 131.2, 131.1, 130.2, 129.6, 128.9, 128.3, 127.2, 126.8, 125.75, 125.71, 125.1, 122.6, 104.6, 71.1. HRMS (ESI-TOF) Calcd for $C_{24}H_{16}Cl_2NaO_2^+$ ($[M+Na]^+$) 429.0420. Found 429.0419.

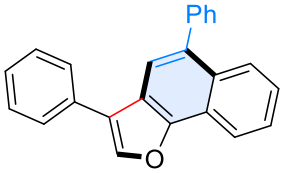


2-((4-(4,4-Dimethylthiochroman-6-yl)naphthalen-1-yl)oxy)-1-phenylethan-1-one (**3h**), isolated by flash column chromatography (petroleum ether/EtOAc = 40:1, v/v), 56% yield (74.0 mg), pale yellow solid: m.p. 108 − 109 °C. R_f (petroleum ether/EtOAc =

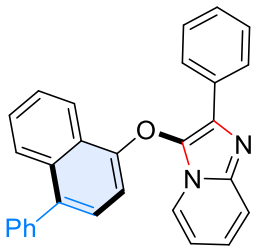
10:1, v/v) 0.33. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.43 (dd, *J* = 8.5, 1.4 Hz, 1H), 8.10 – 8.07 (m, 2H), 7.88 (dd, *J* = 8.6, 1.2 Hz, 1H), 7.63 (dd, *J* = 7.5, 7.5 Hz, 1H), 7.54 – 7.44 (m, 5H), 7.27 (d, *J* = 7.8 Hz, 1H), 7.19 – 7.12 (m, 2H), 6.81 (d, *J* = 7.9 Hz, 1H), 5.48 (s, 2H), 3.10 – 3.07 (m, 2H), 2.04 – 2.01 (m, 2H), 1.35 (s, 6H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 194.6, 153.1, 141.8, 136.4, 134.7, 134.0, 133.7, 132.7, 130.5, 128.9, 128.6, 128.3, 127.8, 126.7, 126.4, 125.8, 125.7, 125.4, 122.4, 104.9, 71.2, 37.9, 33.1, 30.4, 23.2. HRMS (ESI-TOF) Calcd for $C_{29}H_{26}NaO_2S^+$ ([M+Na]$^+$) 461.1546. Found 461.1545.



1-Phenyl-2-((4-(thiophen-2-yl)naphthalen-1-yl)oxy)ethan-1-one (**3i**), isolated by flash column chromatography (petroleum ether/EtOAc = 40:1, v/v), 33% yield (34.5 mg), pale yellow oil. R_f (petroleum ether/EtOAc = 10:1, v/v) 0.33. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.45 – 8.42 (m, 1H), 8.16 – 8.14 (m, 1H), 8.06 (d, *J* = 7.1 Hz, 2H), 7.62 (dd, *J* = 7.4, 7.4 Hz, 1H), 7.53 – 7.42 (m, 4H), 7.43 (d, *J* = 7.9 Hz, 1H), 7.38 (dd, *J* = 4.9, 1.4 Hz, 1H), 7.18 – 7.14 (m, 2H), 6.77 (d, *J* = 7.9 Hz, 1H), 5.46 (s, 2H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 194.3, 153.8, 141.8, 134.6, 134.0, 133.0, 128.9, 128.3, 128.0, 127.23, 127.17, 125.8, 125.74, 125.70, 125.6, 125.3, 122.4, 104.7, 71.1. HRMS (ESI-TOF) Calcd for $C_{22}H_{17}O_2S^+$ ([M+H]$^+$) 345.0944. Found 345.0941.

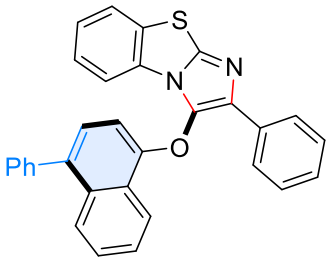


3,5-Diphenylnaphtho[1,2-*b*]furan (**4**), isolated by flash column chromatography (petroleum ether), 52% yield (33.5 mg), white solid: m.p. 138 − 139 °C. R_f (petroleum ether) 0.33. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.42 (d, *J* = 8.2 Hz, 1H), 7.96 – 7.92 (m, 2H), 7.84 (s, 1H), 7.71 – 7.69 (m, 2H), 7.62 (ddd, *J* = 8.1, 6.8, 1.1 Hz, 1H), 7.54 – 7.42 (m, 8H), 7.39– 7.35 (m, 1H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 151.1, 141.2, 140.7, 136.4, 132.1, 130.4, 129.9, 129.0, 128.3, 127.7, 127.5, 127.2, 127.0, 126.4, 125.4, 123.6, 121.7, 121.3, 120.3, 119.6. HRMS (ESI-TOF) Calcd for $C_{24}H_{17}O^+$ ([M+H]$^+$) 321.1274. Found 321.1275.

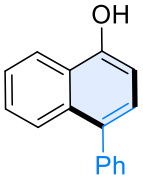


2-Phenyl-3-((4-phenylnaphthalen-1-yl)oxy)imidazo[1,2-*a*]pyridine (**5**), isolated by flash column chromatography (petroleum ether/EtOAc = 12:1, v/v), 78% yield (64.3

mg), pale yellow oil. R_f (petroleum ether/EtOAc = 3:1, v/v) 0.33. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.70 (d, J = 8.3 Hz, 1H), 8.13 – 8.10 (m, 2H), 7.98 (d, J = 8.5 Hz, 1H), 7.72 – 7.66 (m, 3H), 7.59 (ddd, J = 8.4, 6.8, 1.3 Hz, 1H), 7.49 – 7.34 (m, 7H), 7.29 – 7.25 (m, 1H), 7.20 (ddd, J = 9.2, 6.7, 1.3 Hz, 1H), 7.13 (d, J = 7.9 Hz, 1H), 6.73 (ddd, J = 7.8, 6.8, 1.1 Hz, 1H), 6.58 (d, J = 7.9 Hz, 1H). ^{13}C{^{1}H} NMR (101 MHz, CDCl3) δ 150.8, 140.1, 136.0, 133.1, 132.5, 131.5, 130.1, 129.9, 128.8, 128.3, 127.8, 127.3, 127.2, 126.6, 126.43, 126.40, 126.3, 124.8, 124.5, 121.7, 117.9, 112.4, 106.8. HRMS (ESI-TOF) Calcd for $C_{29}H_{21}N_2O^+$ ([M+H]$^+$) 413.1648. Found 413.1647.



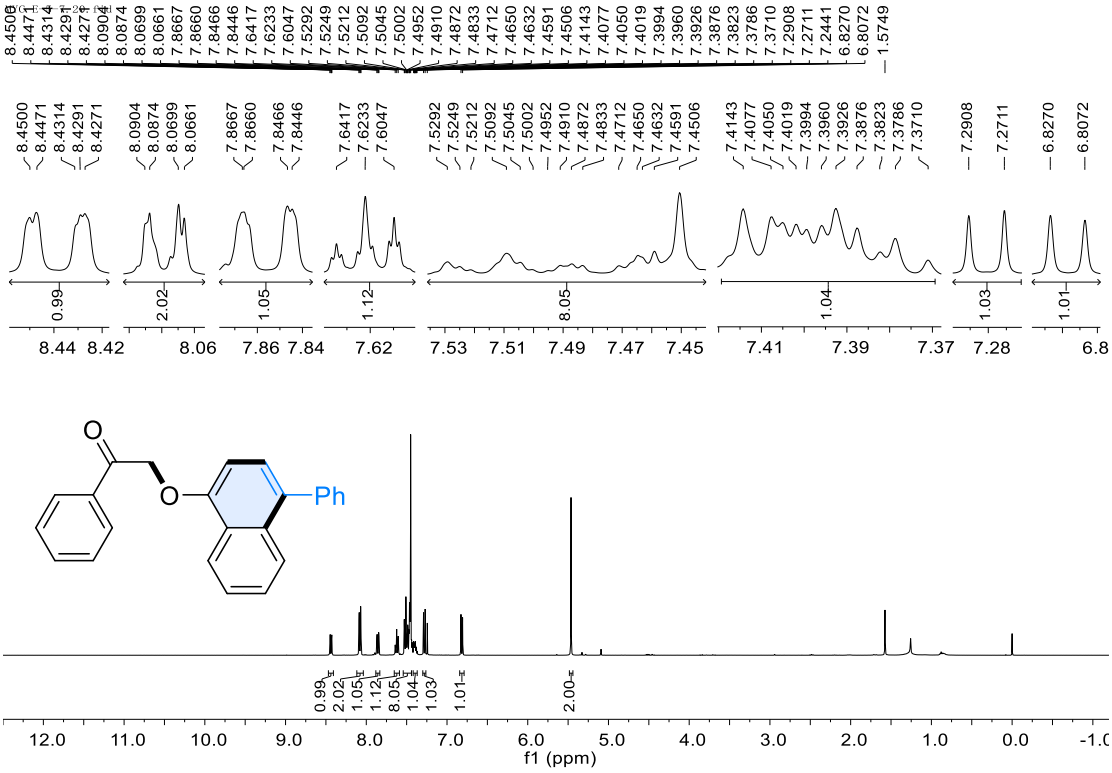
2-Phenyl-3-((4-phenylnaphthalen-1-yl)oxy)benzo[*d*]imidazo[2,1-*b*]thiazole (**6**), isolated by flash column chromatography (petroleum ether/EtOAc = 40:1, v/v), 65% yield (60.8 mg), pale yellow solid: m.p. 123 − 124 °C. R_f (petroleum ether/EtOAc = 10:1, v/v) 0.33. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.71 (d, J = 8.2 Hz, 1H), 8.01 (d, J = 8.6 Hz, 1H), 7.95 (d, J = 7.1 Hz, 2H), 7.74 (ddd, J = 8.2, 6.8, 1.2 Hz, 1H), 7.66 – 7.60 (m, 2H), 7.47 – 7.37 (m, 5H), 7.35 – 7.29 (m, 3H), 7.26 – 7.18 (m, 2H), 7.16 – 7.11 (m, 2H), 6.81 (d, J = 7.9 Hz, 1H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 151.3, 142.6, 140.1, 136.0, 133.2, 133.1, 132.6, 132.4, 131.7, 130.1, 130.0, 128.7, 128.3, 127.3, 127.22, 127.17, 126.8, 126.52, 126.51, 126.4, 125.5, 124.9, 124.6, 124.0, 121.6, 113.3, 107.1. HRMS (ESI-TOF) Calcd for $C_{31}H_{21}N_2OS^+$ ([M+H]$^+$) 469.1369. Found 469.1369.



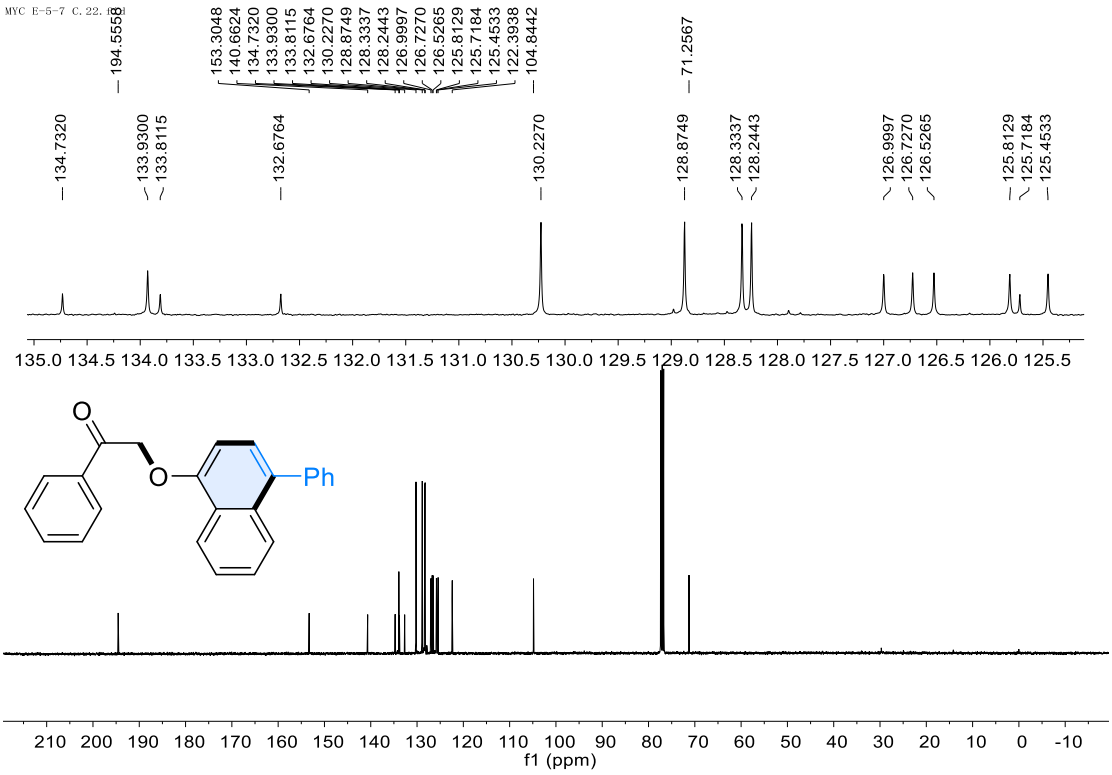
4-Phenylnaphthalen-1-ol (**7**),[4] isolated by flash column chromatography (petroleum ether/EtOAc = 20:1, v/v), 42% yield (18.5 mg), R_f (petroleum ether/EtOAc = 5:1, v/v) 0.33. ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.26 (d, J = 8.2 Hz, 1H), 7.88 (d, J = 8.4 Hz, 1H), 7.53 – 7.38 (m, 7H), 7.26 (d, J = 6.3 Hz, 1H), 6.87 (d, J = 7.7 Hz, 1H), 5.34 (s, 1H). ^{13}C{^{1}H} NMR (101 MHz, $CDCl_3$) δ 150.9, 140.8, 133.3, 132.7, 130.3, 128.3, 126.9, 126.8, 126.6, 126.0, 125.2, 124.4, 121.8, 108.2. HRMS (ESI-TOF) Calcd for $C_{16}H_{13}O^+$ ([M+H]$^+$) 221.0961. Found 221.0959.

VII. Copies of ^{1}H, ^{19}F, ^{13}C and DEPT NMR spectra

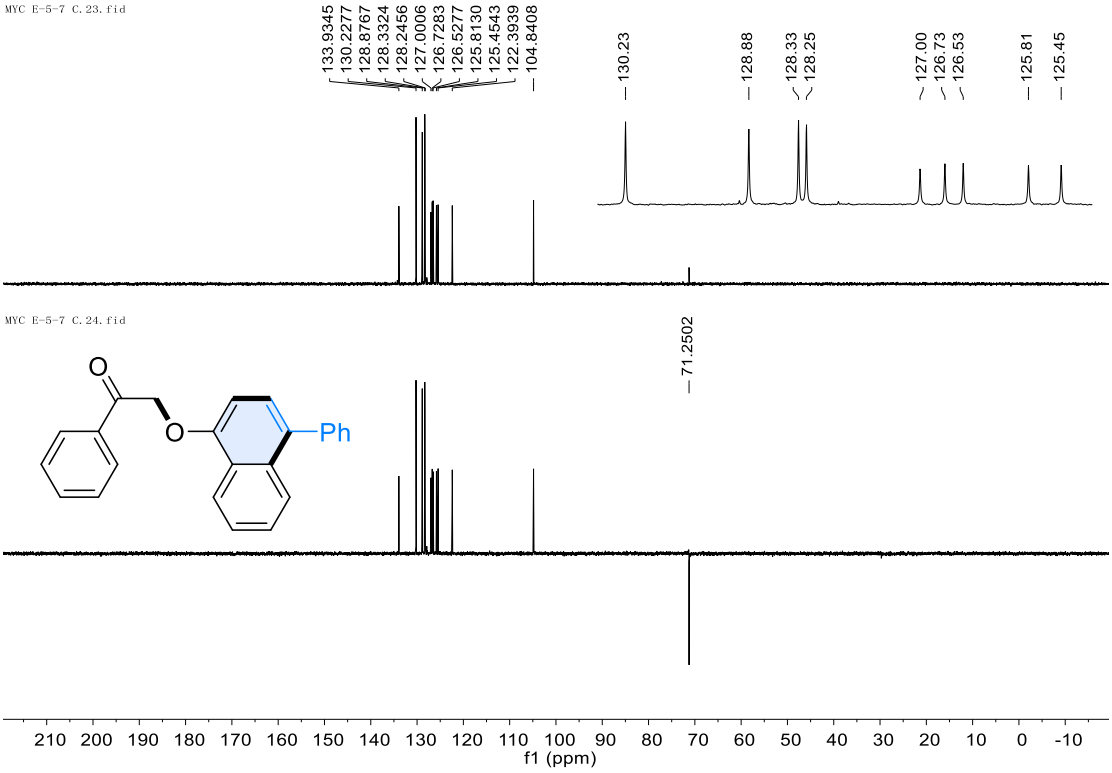
3a, ^{1}H NMR (400 MHz, $CDCl_3$)



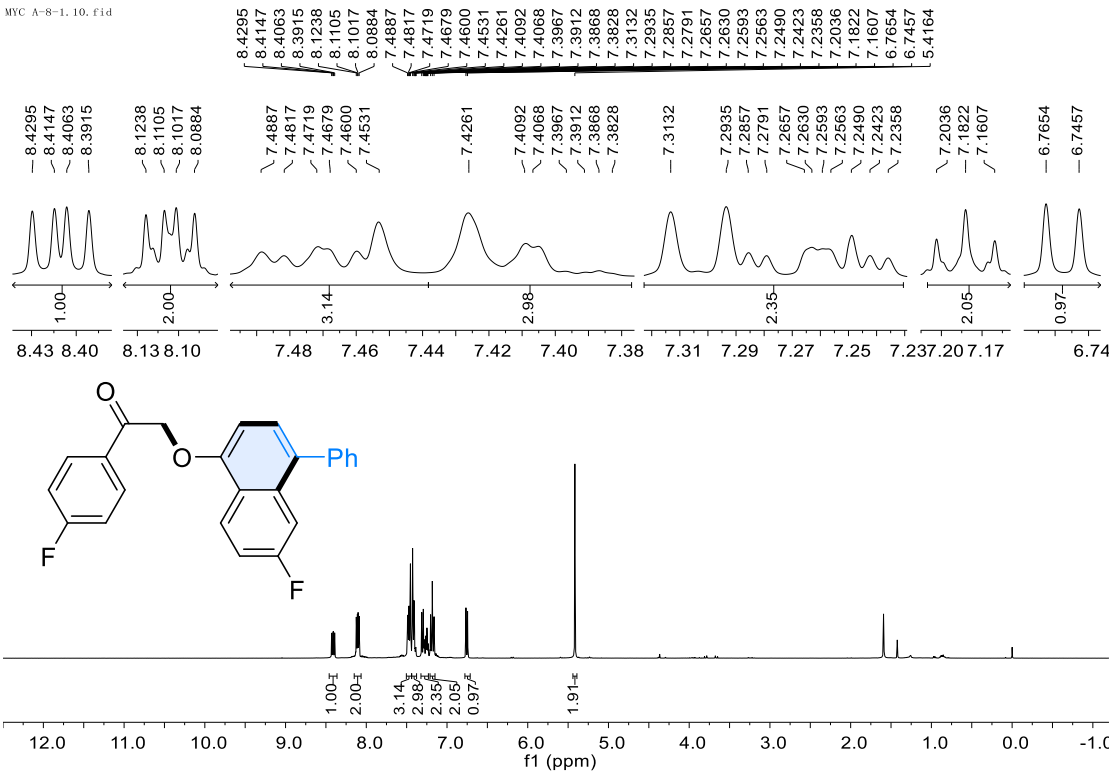
3a, ^{13}C NMR (101 MHz, $CDCl_3$)



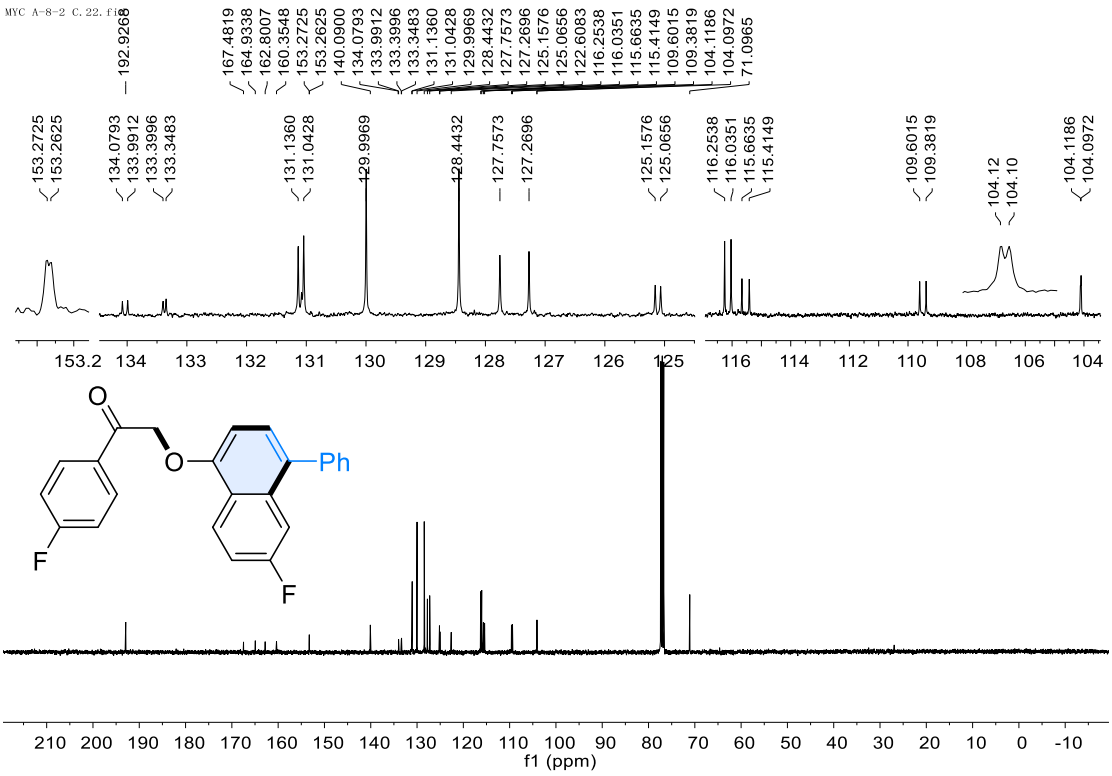
3a, DEPT 90 and DEPT 135 (101 MHz, $CDCl_3$)



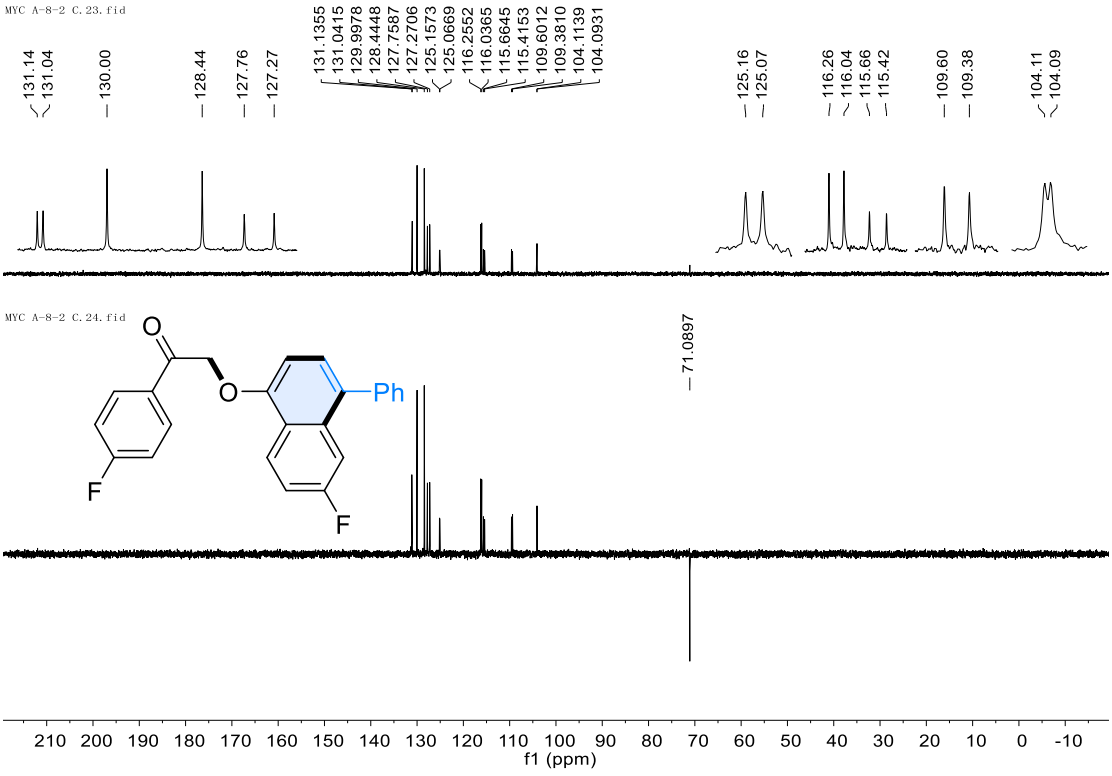
3a1, ^{1}H NMR (400 MHz, $CDCl_3$)



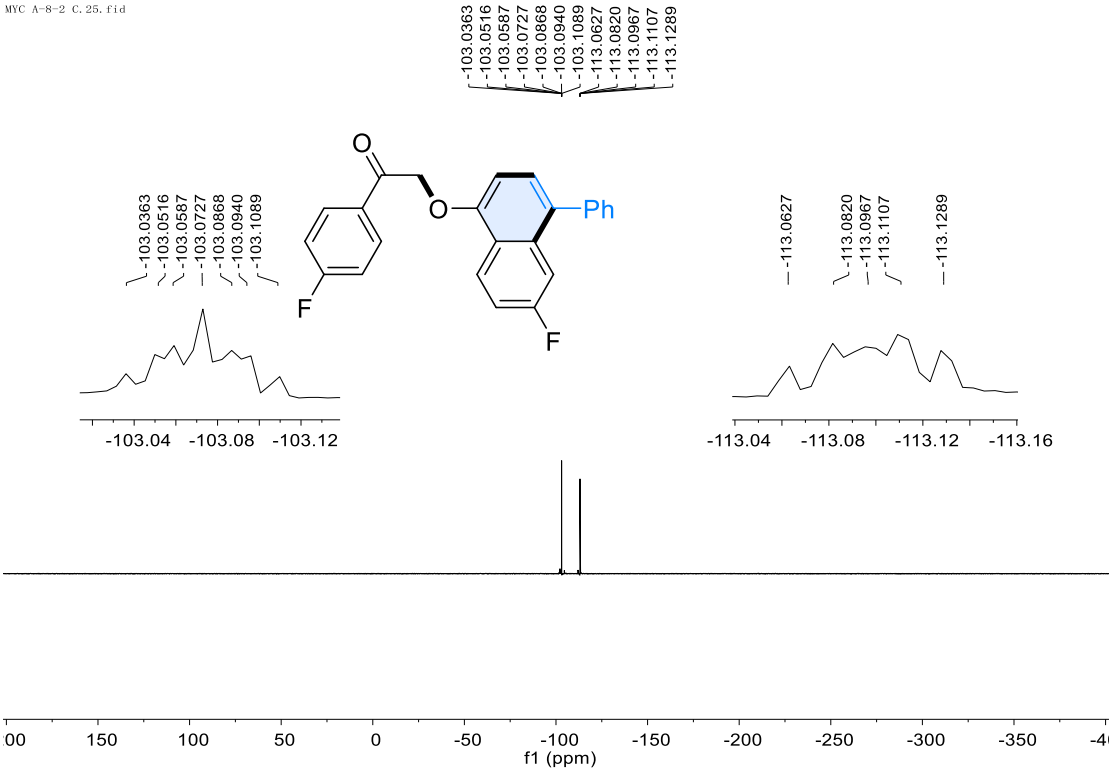
3a1, ^{13}C NMR (101 MHz, $CDCl_3$)



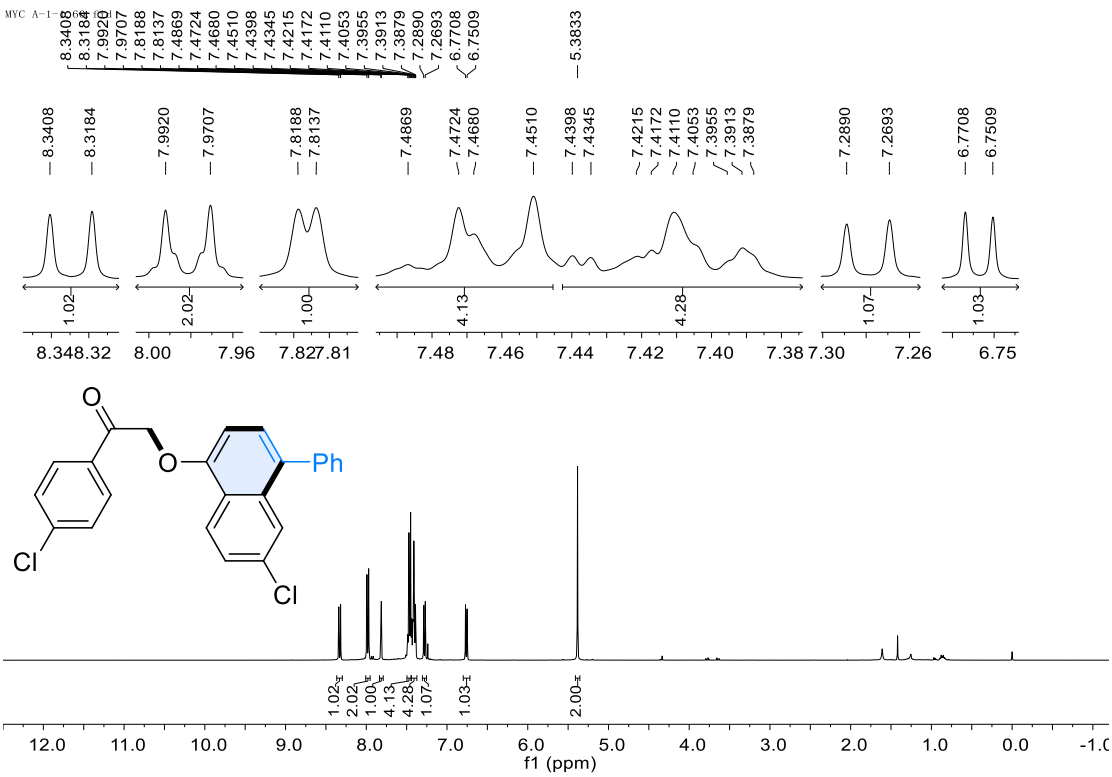
3a1, DEPT 90 and DEPT 135 (101 MHz, $CDCl_3$)



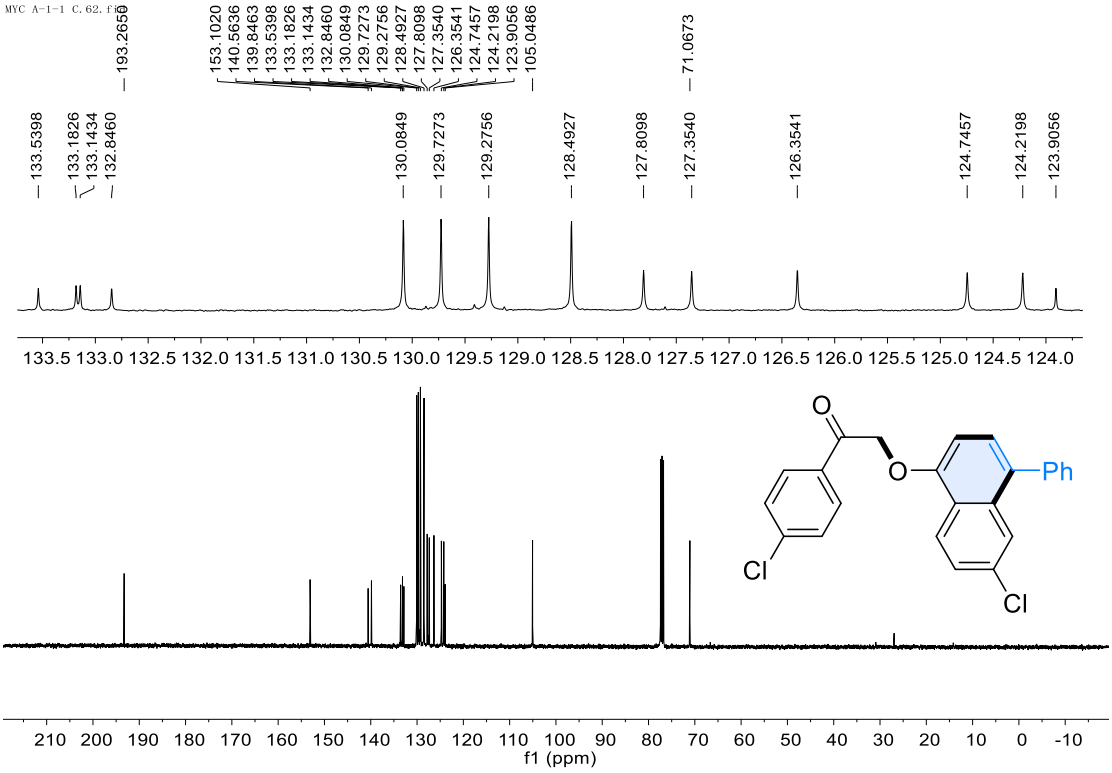
3a1, ^{19}F NMR (376 MHz, $CDCl_3$)



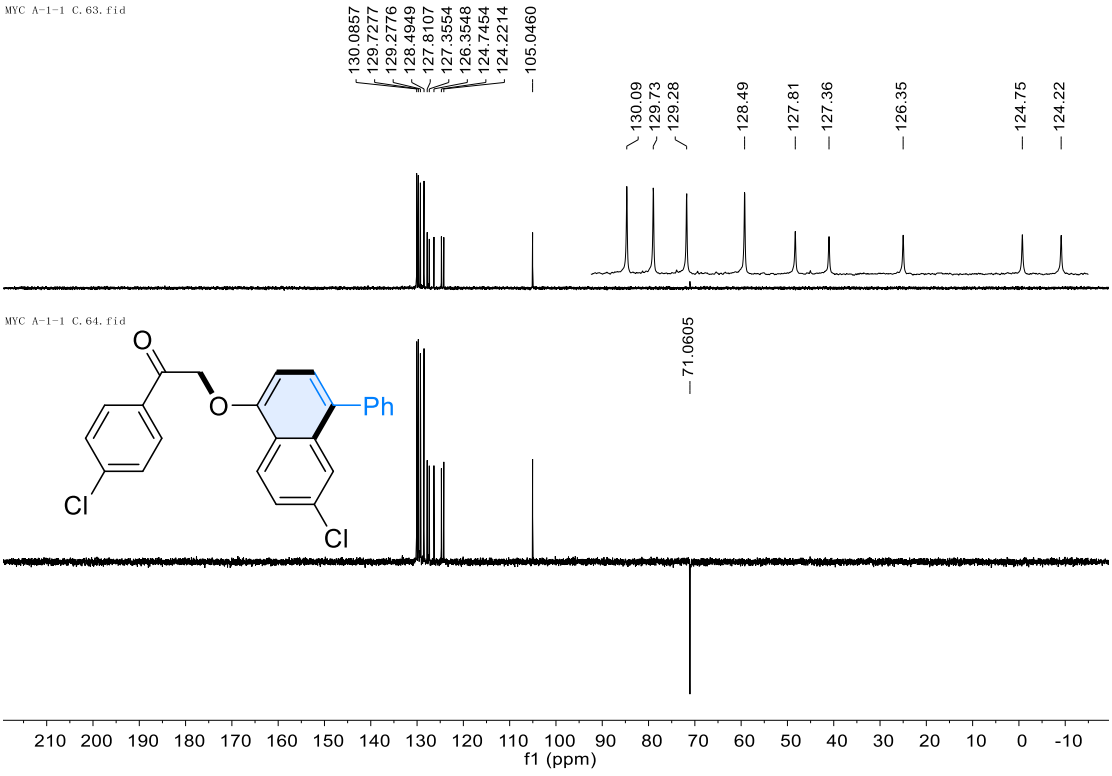
3a2, ^{1}H NMR (400 MHz, $CDCl_3$)



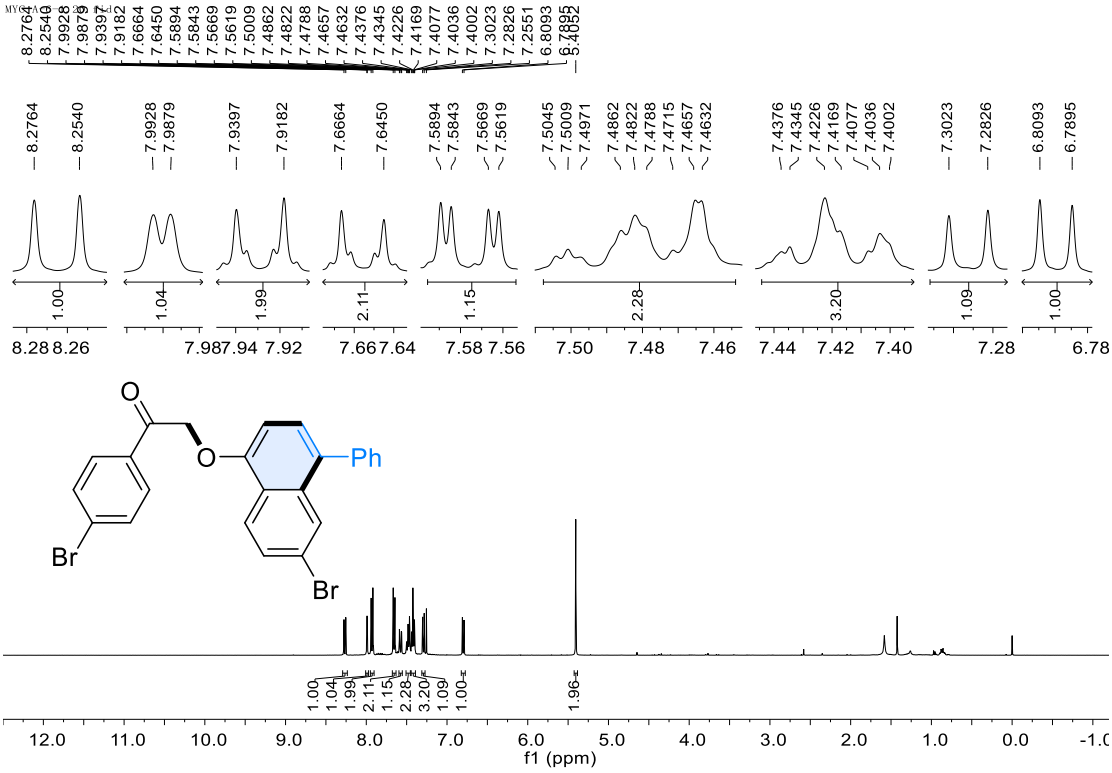
3a2, ^{13}C NMR (101 MHz, $CDCl_3$)



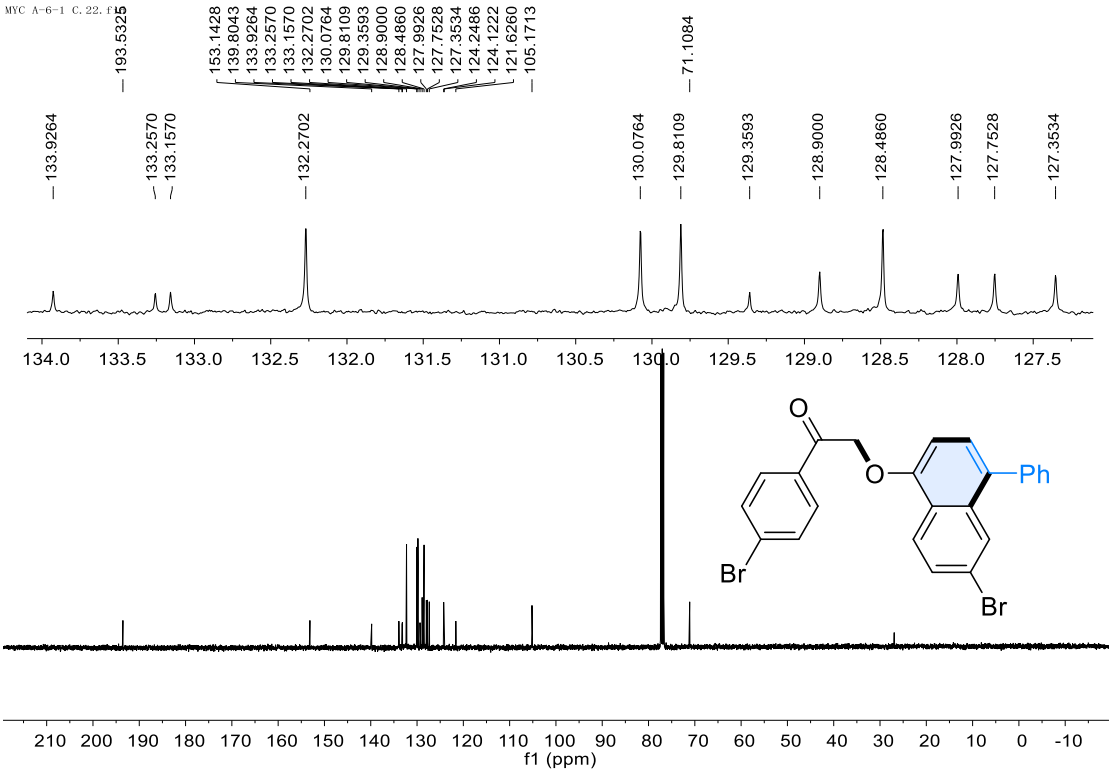
3a2, DEPT 90 and DEPT 135 (101 MHz, $CDCl_3$)



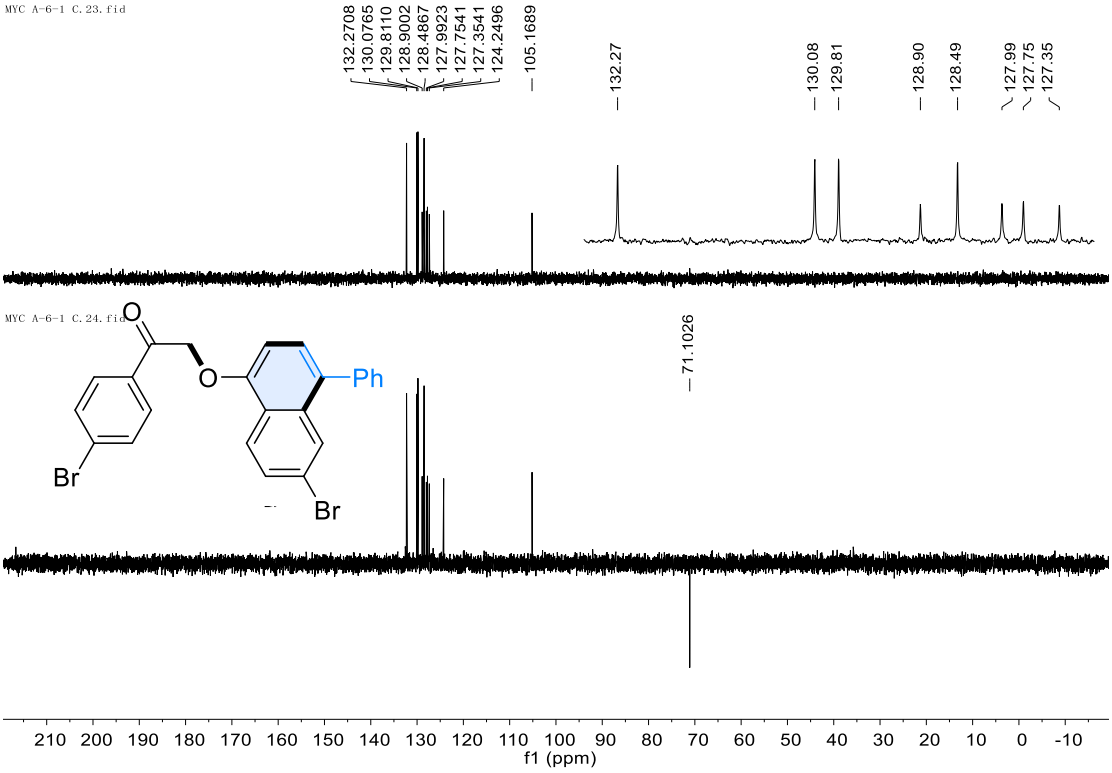
3a3, ^{1}H NMR (400 MHz, $CDCl_3$)



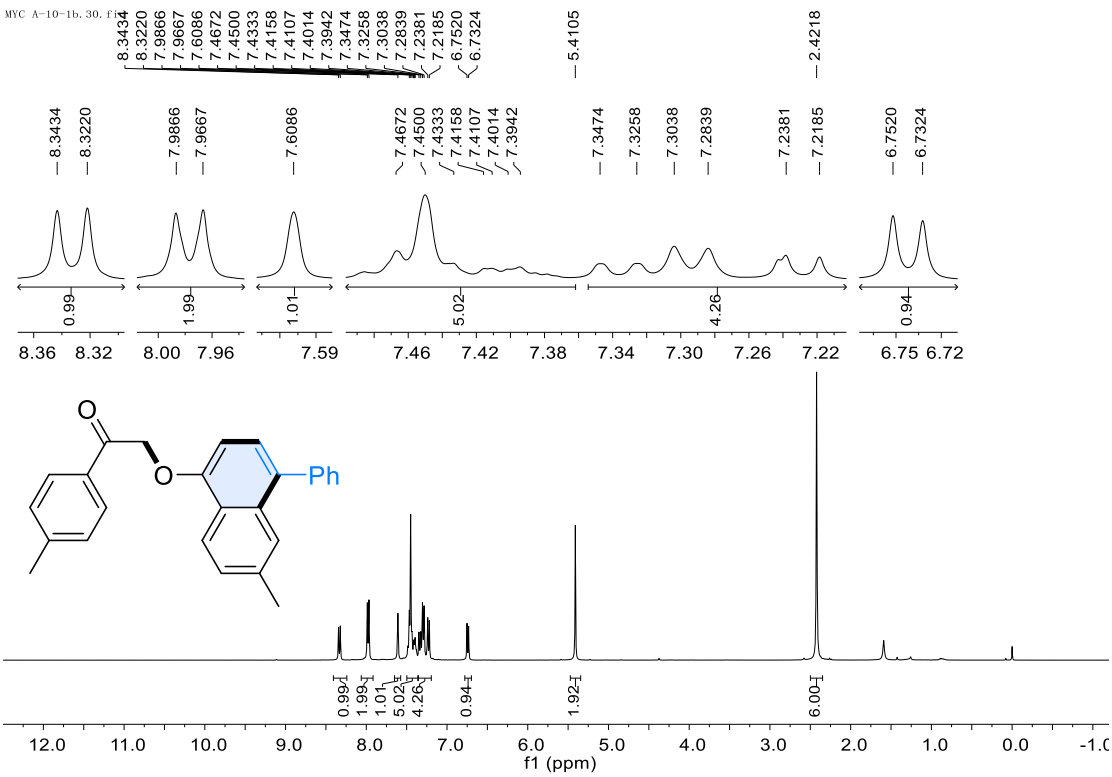
3a3, ^{13}C NMR (101 MHz, $CDCl_3$)



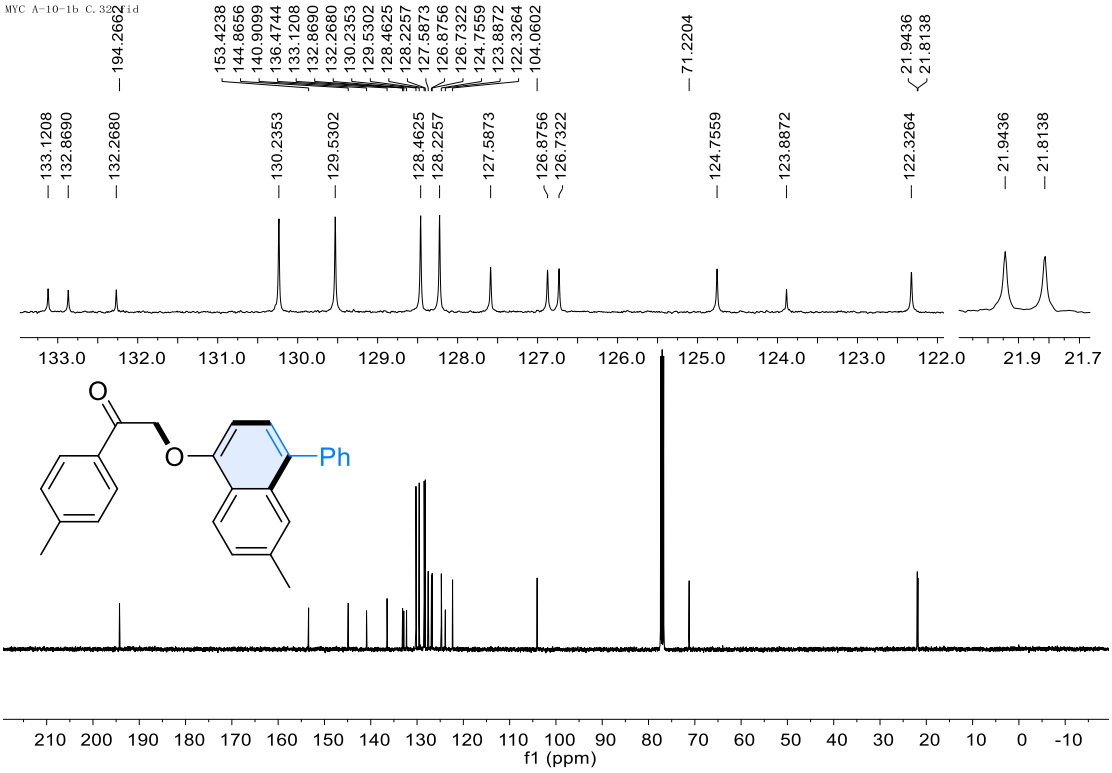
3a3, DEPT 90 and DEPT 135 (101 MHz, $CDCl_3$)



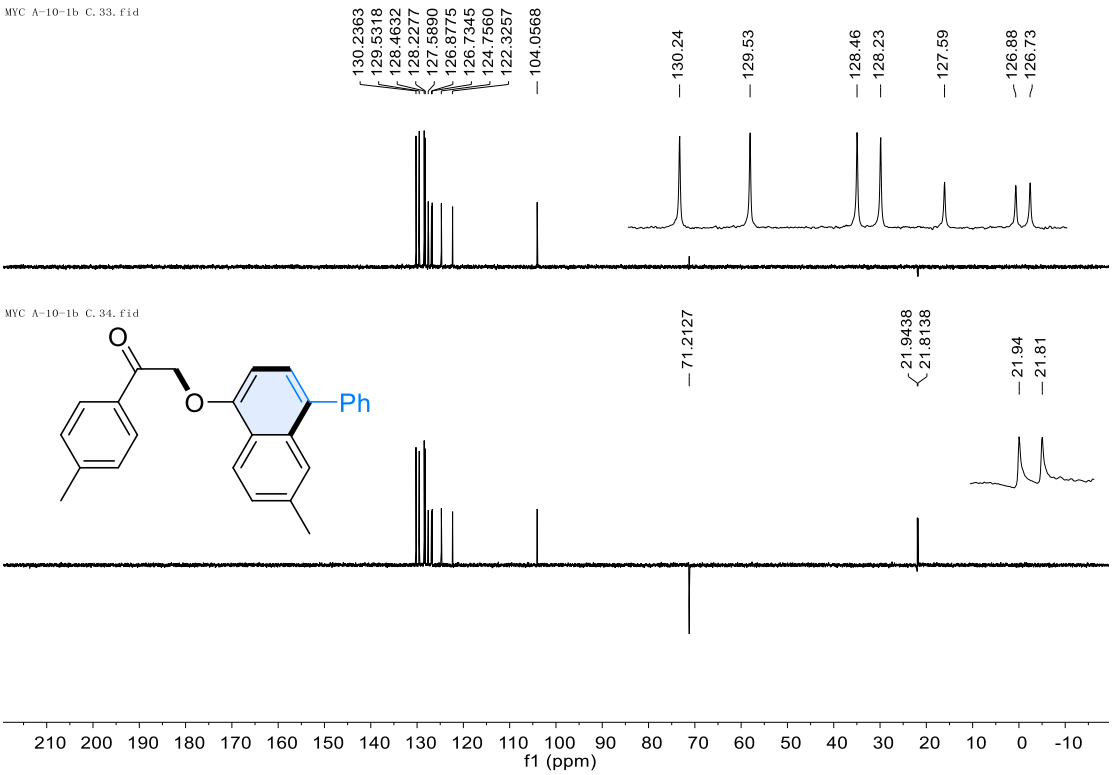
3a4, ^{1}H NMR (400 MHz, $CDCl_3$)



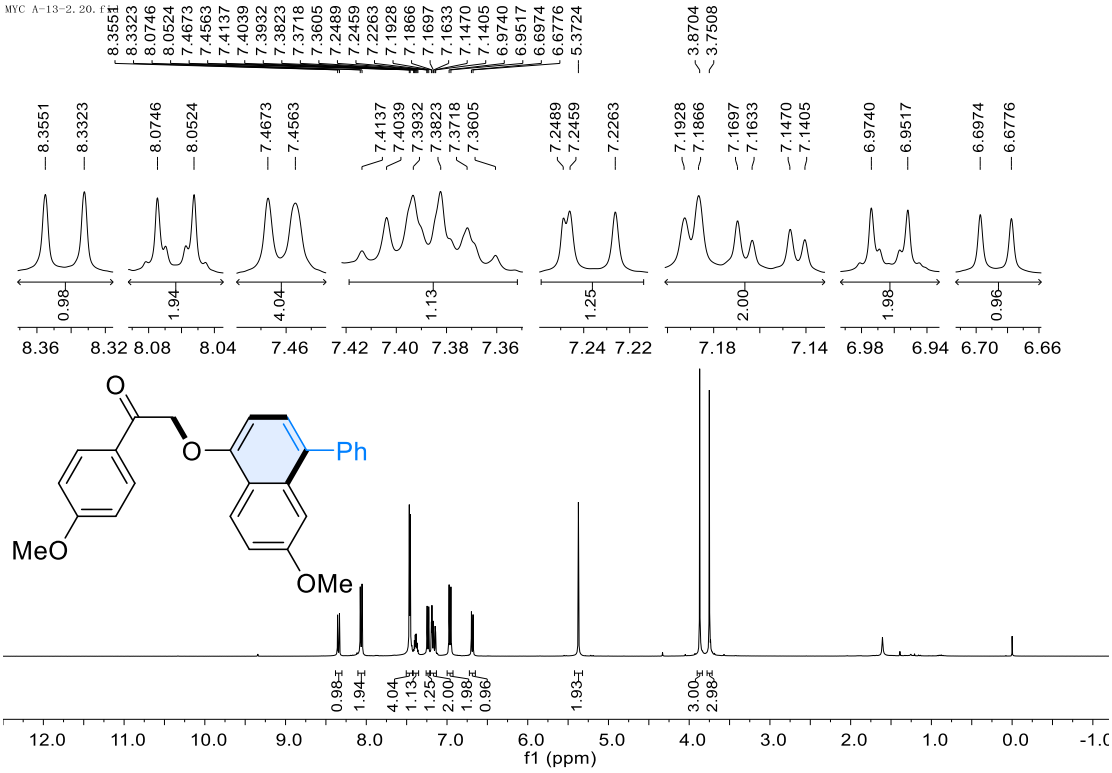
3a4, ^{13}C NMR (101 MHz, $CDCl_3$)



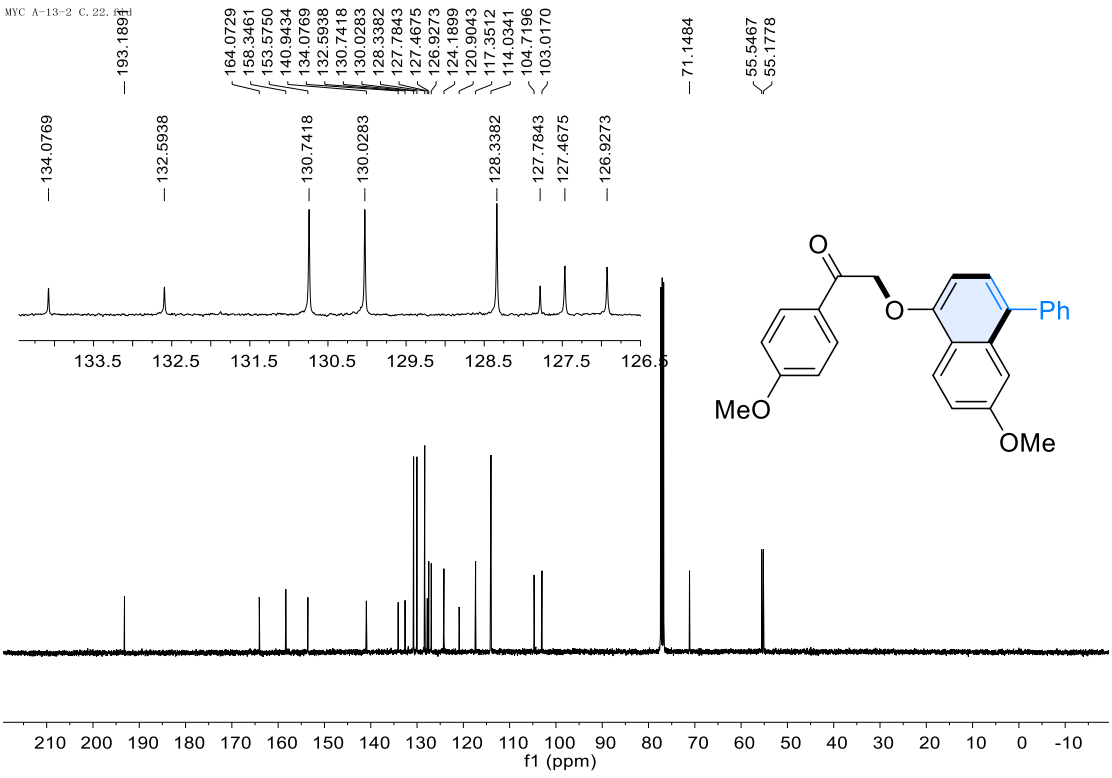
3a4, DEPT 90 and DEPT 135 (101 MHz, $CDCl_3$)



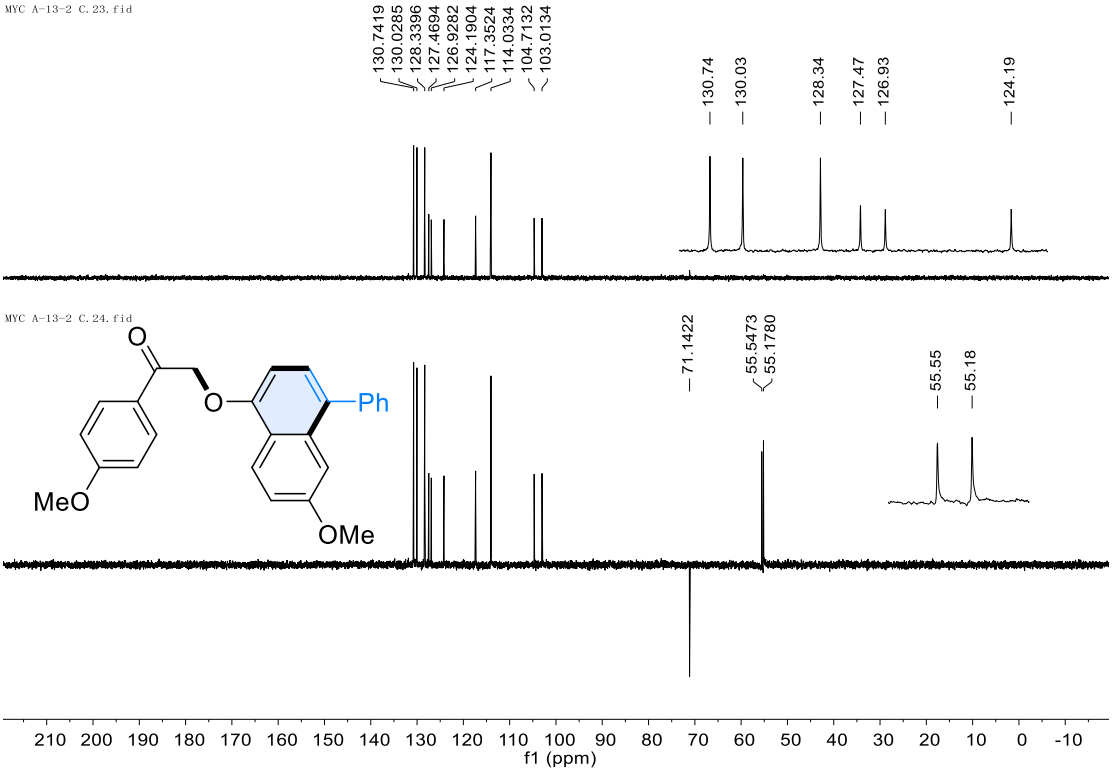
3a5, ^{1}H NMR (400 MHz, $CDCl_3$)



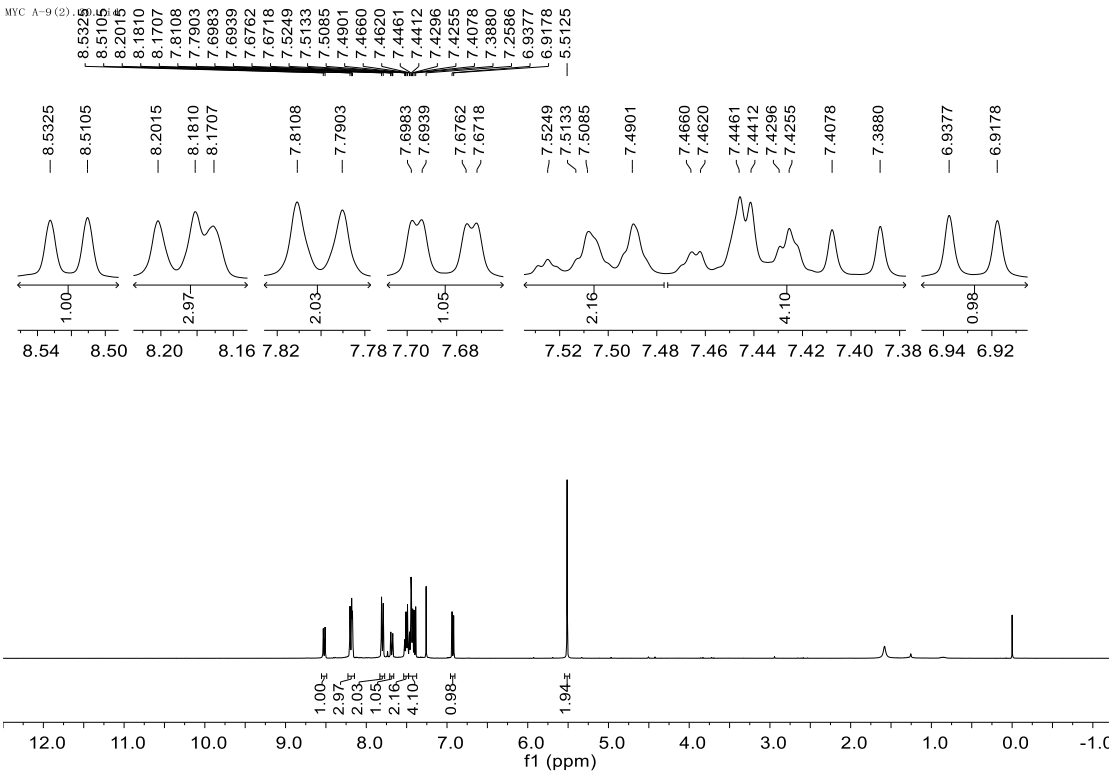
3a5, ^{13}C NMR (101 MHz, $CDCl_3$)



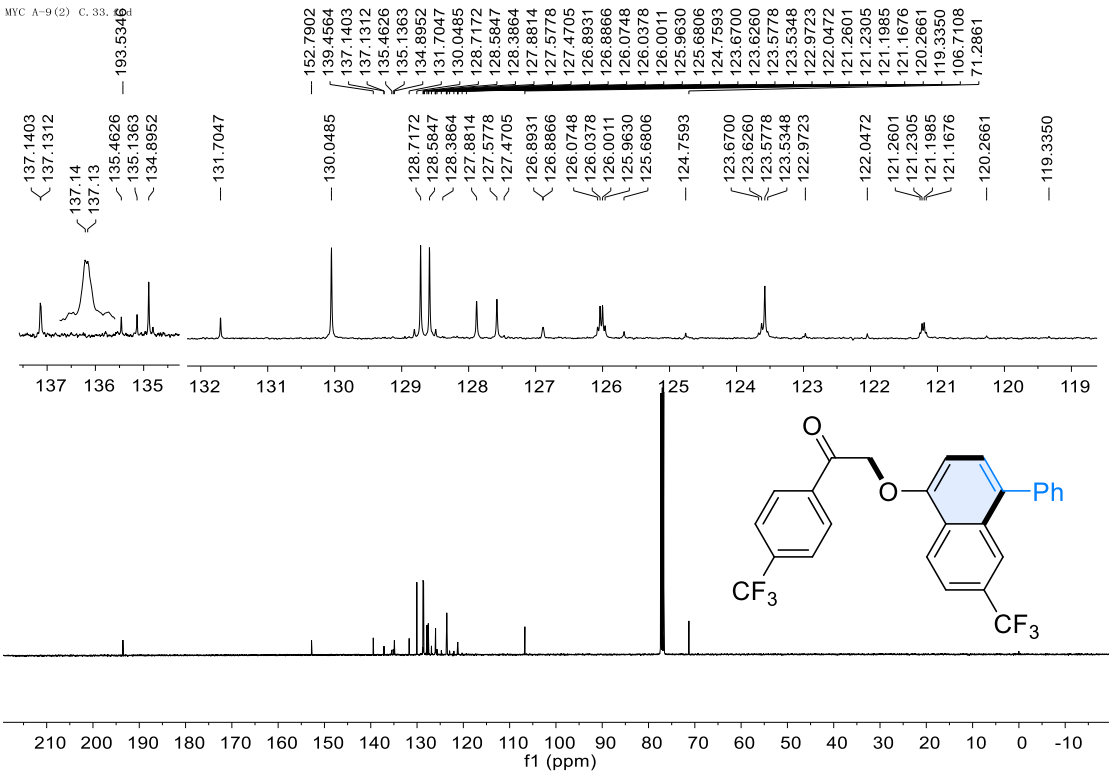
3a5, DEPT 90 and DEPT 135 (101 MHz, $CDCl_3$)



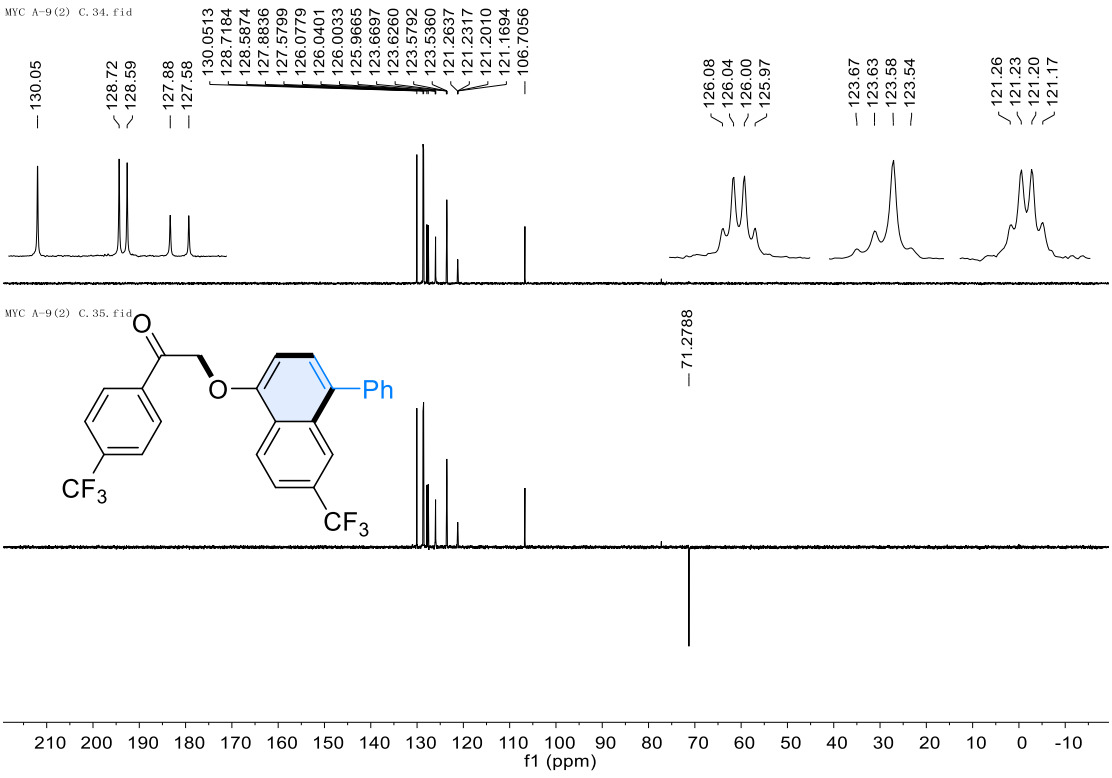
3a6, ^1H NMR (400 MHz, $CDCl_3$)



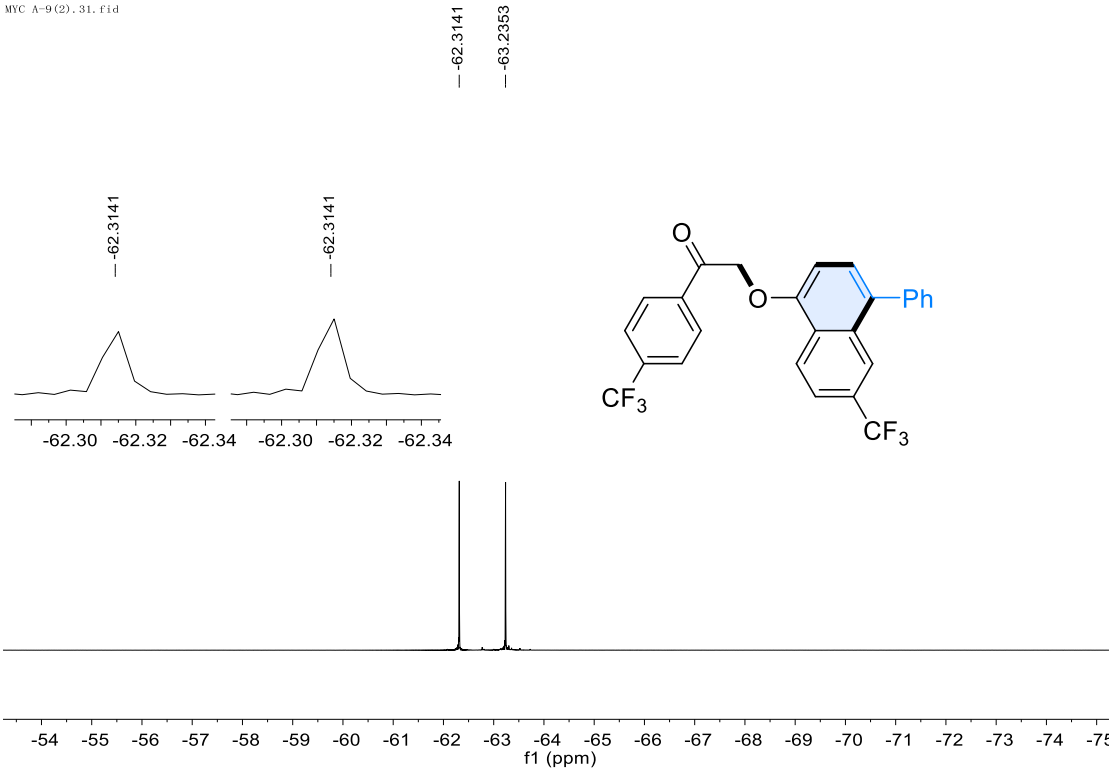
3a6, ^{13}C NMR (101 MHz, $CDCl_3$)



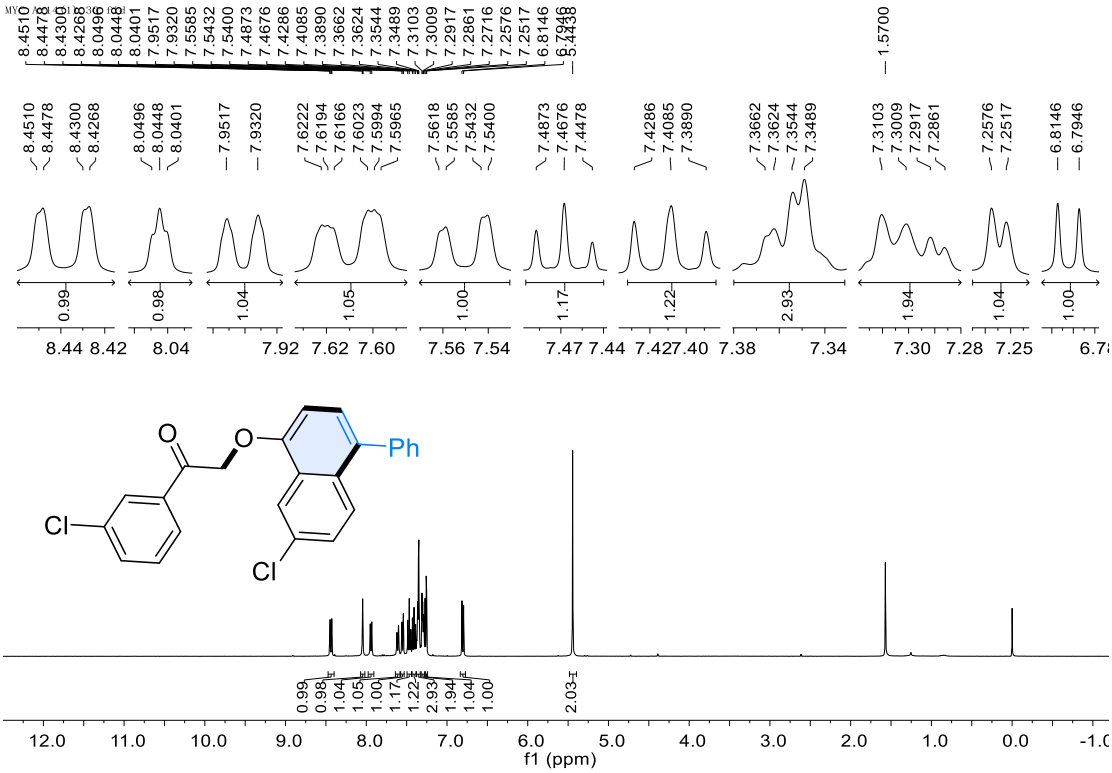
3a6, DEPT 90 and DEPT 135 (101 MHz, $CDCl_3$)



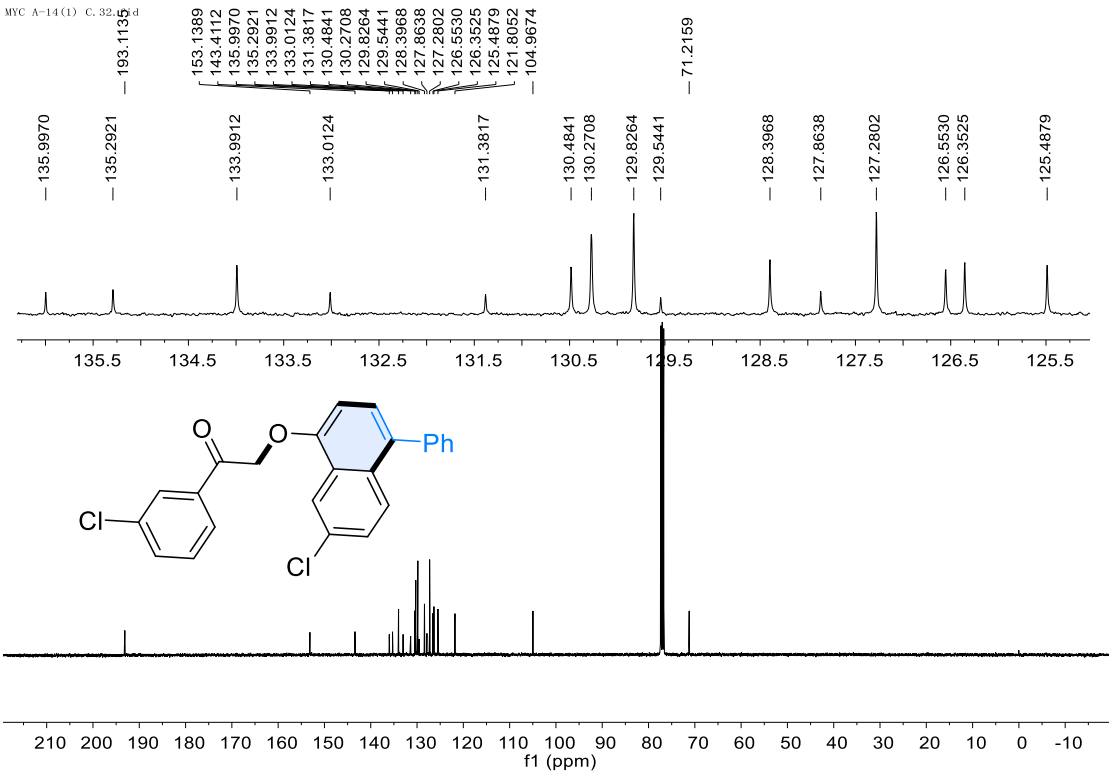
3a6, ^{19}F NMR (376 MHz, $CDCl_3$)



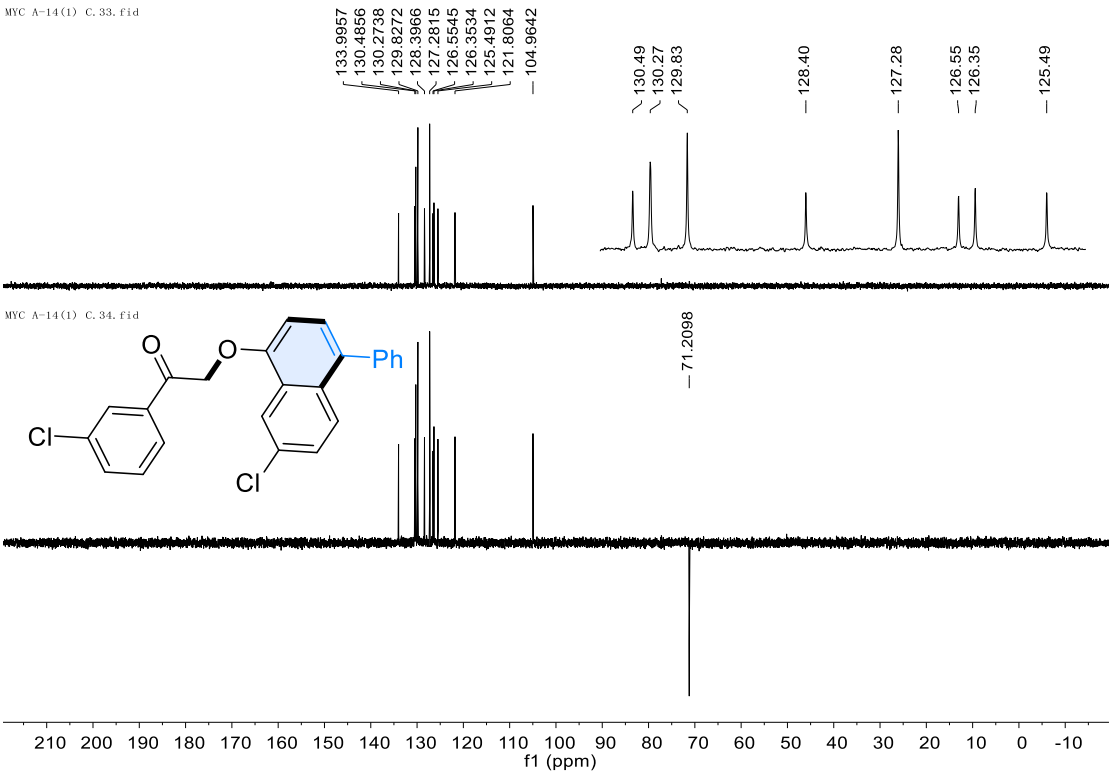
3b1, ^{1}H NMR (400 MHz, $CDCl_3$)



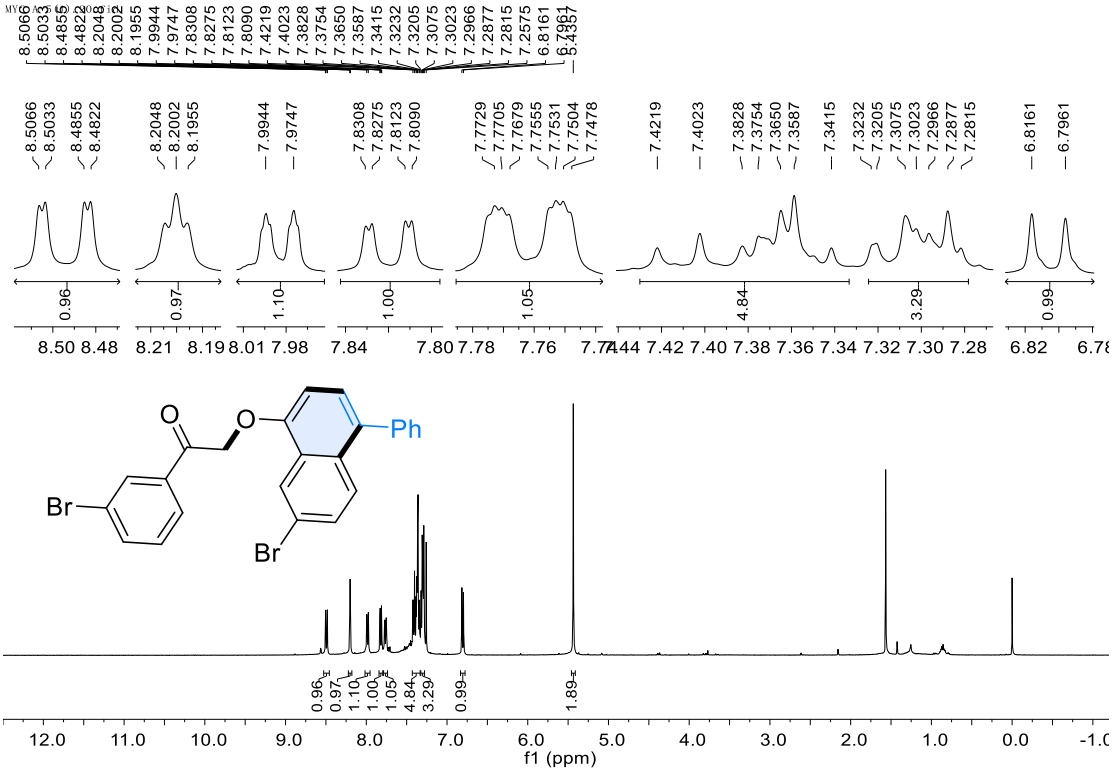
3b1, ^{13}C NMR (101 MHz, $CDCl_3$)



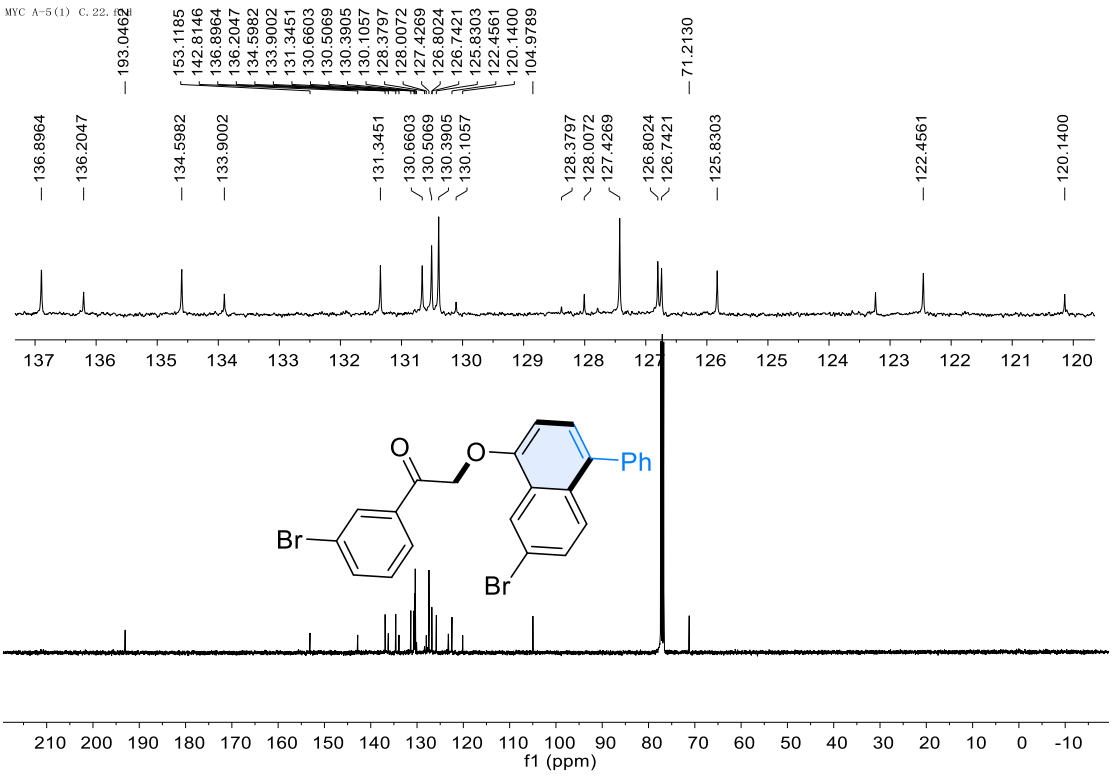
3b1, DEPT 90 and DEPT 135 (101 MHz, $CDCl_3$)



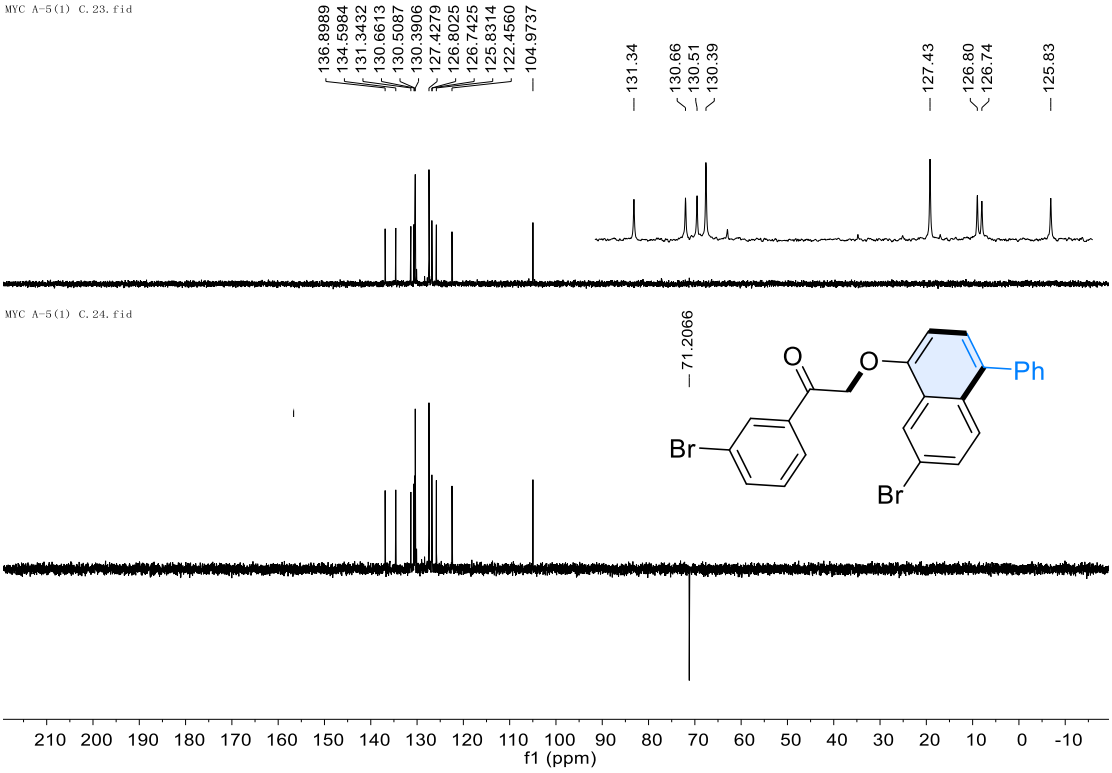
3b2, ^{1}H NMR (400 MHz, $CDCl_3$)



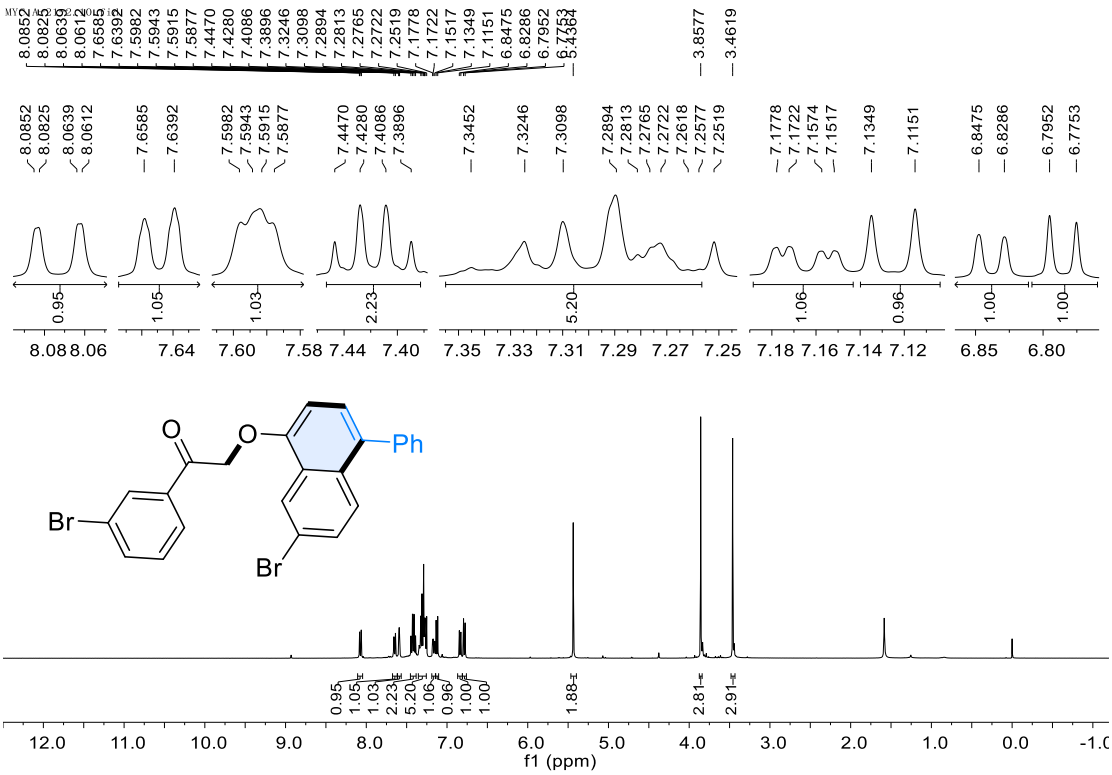
3b2, ^{13}C NMR (101 MHz, $CDCl_3$)



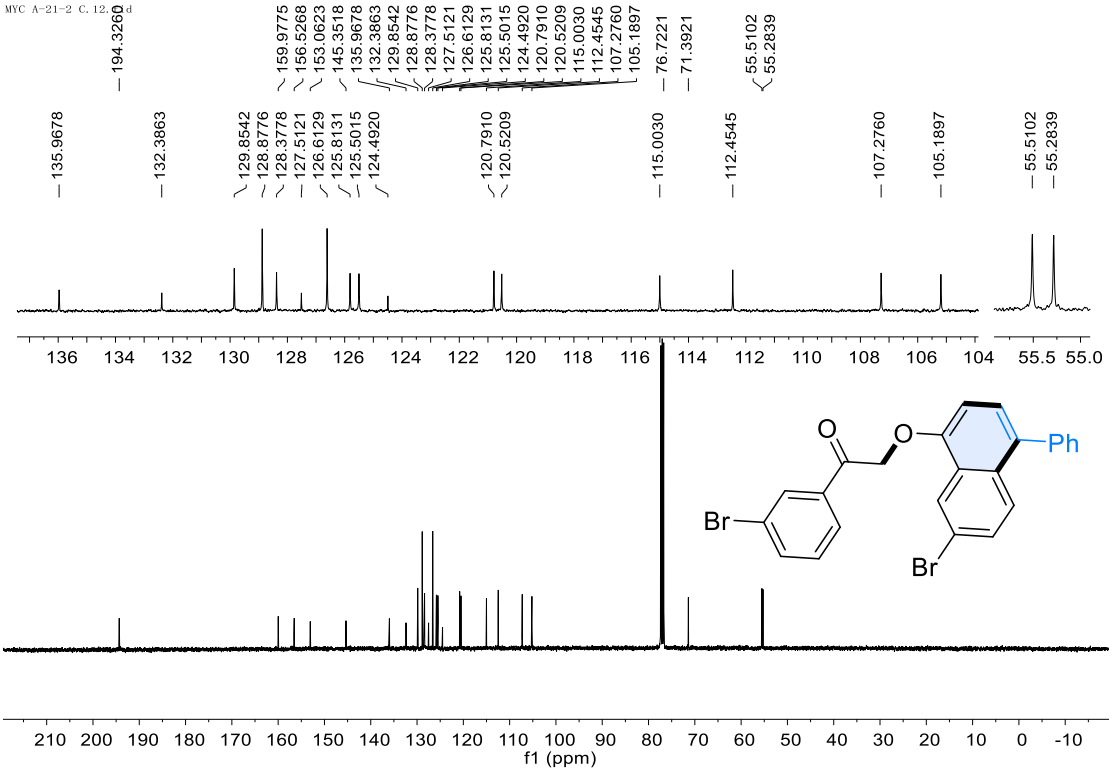
3b2, DEPT 90 and DEPT 135 (101 MHz, $CDCl_3$)



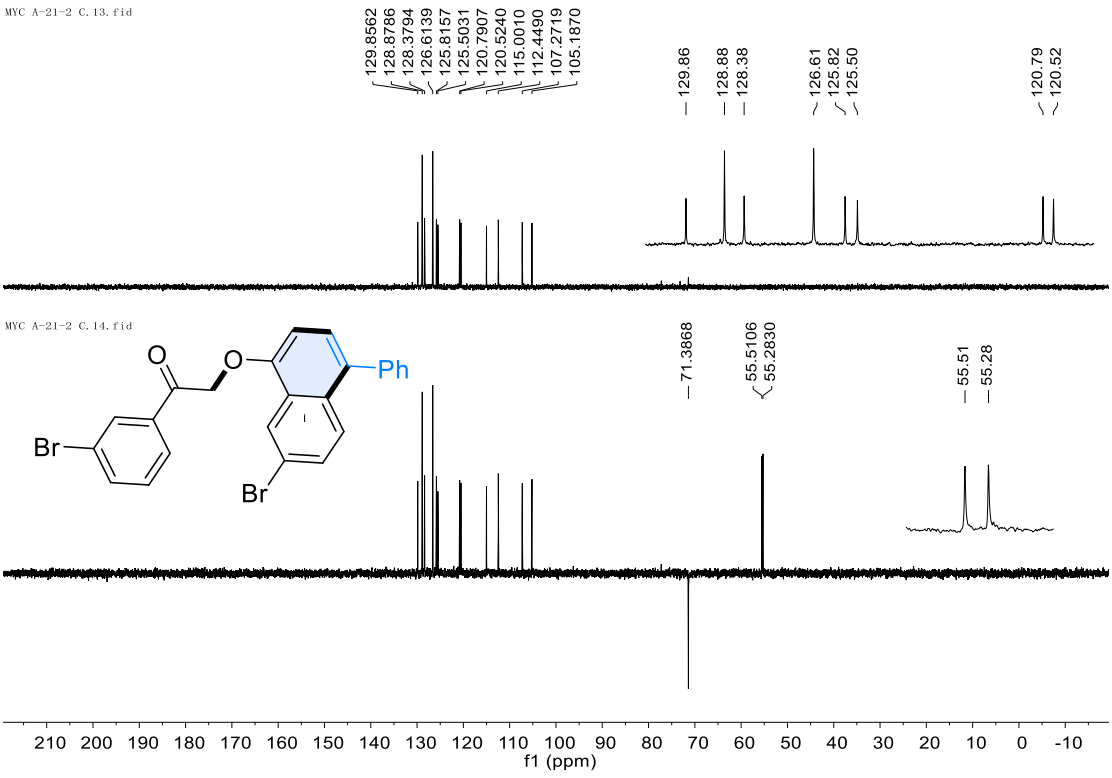
3b3, ^1H NMR (400 MHz, $CDCl_3$)



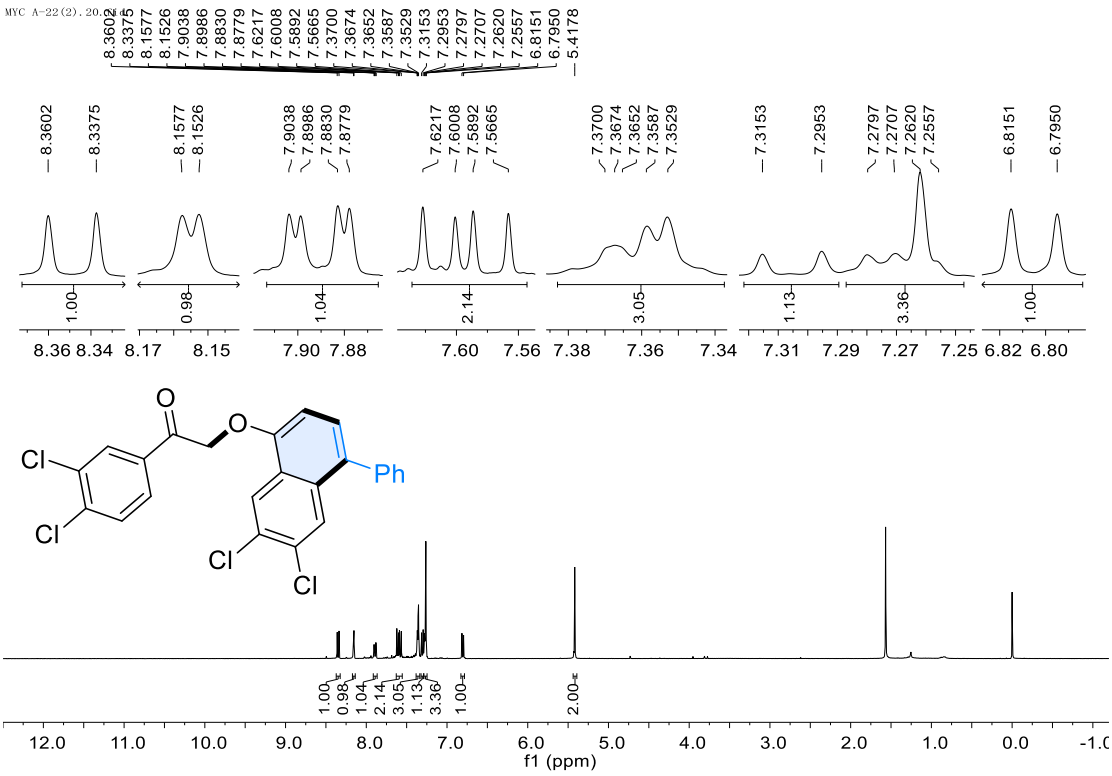
3b3, ^{13}C NMR (101 MHz, $CDCl_3$)



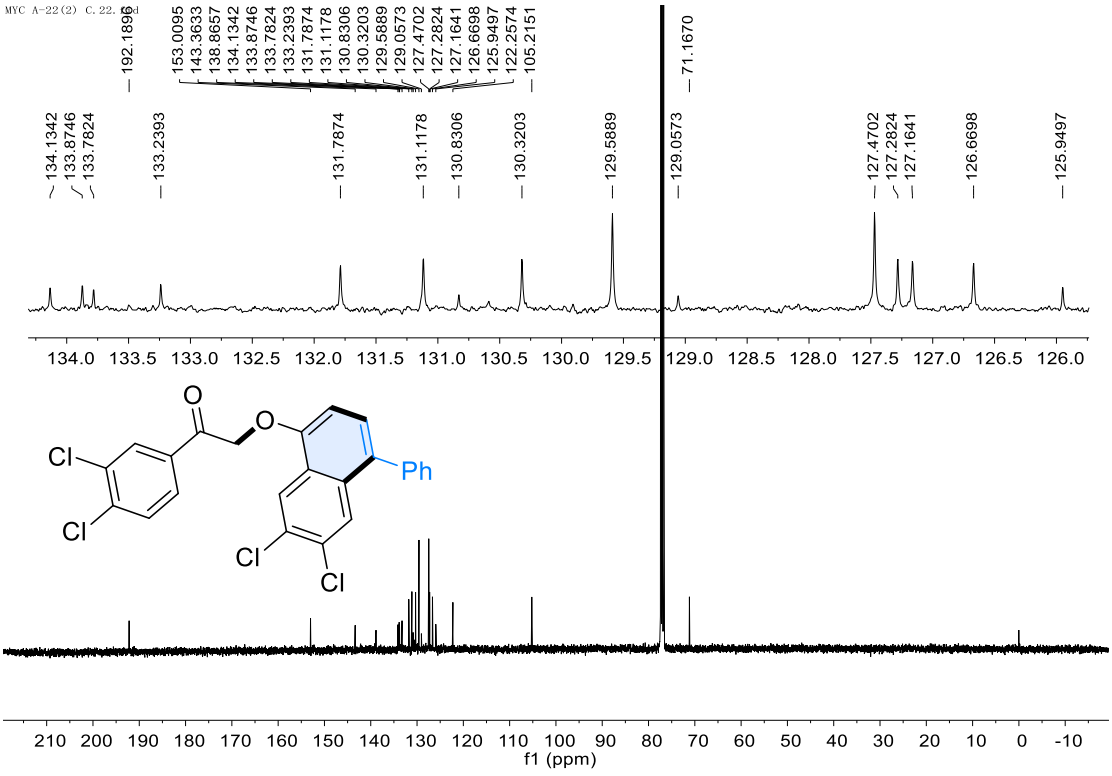
3b3, DEPT 90 and DEPT 135 (101 MHz, $CDCl_3$)



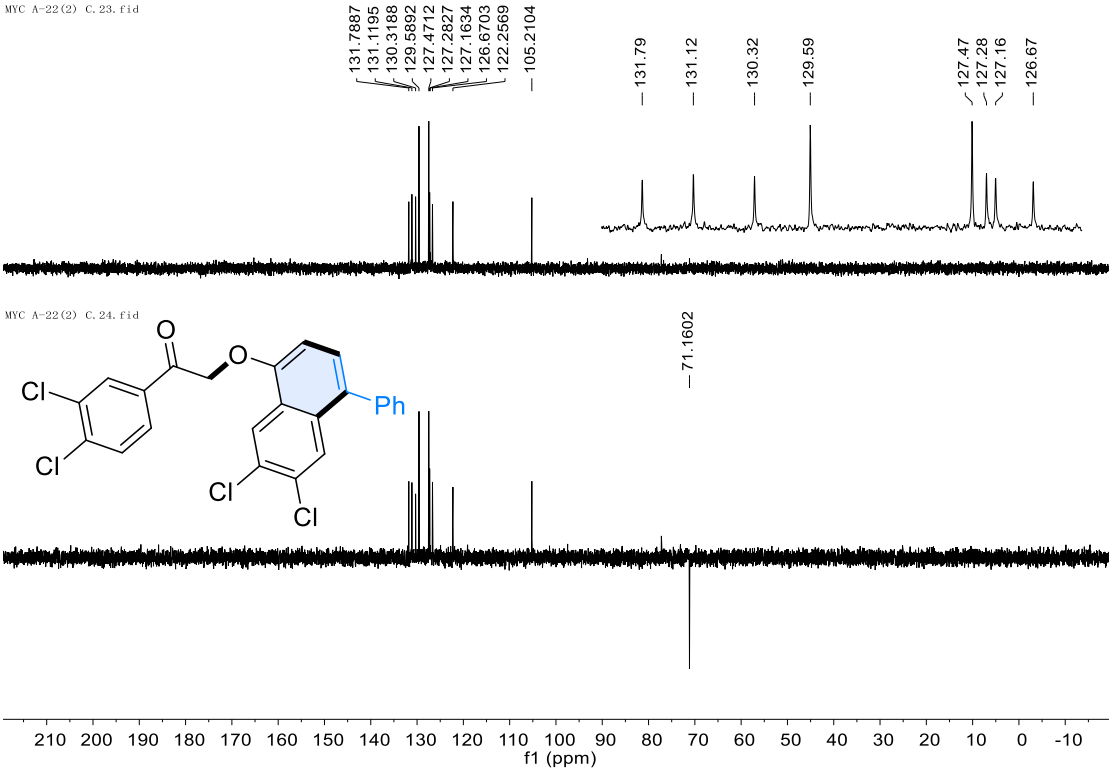
3c, ^{1}H NMR (400 MHz, $CDCl_3$)



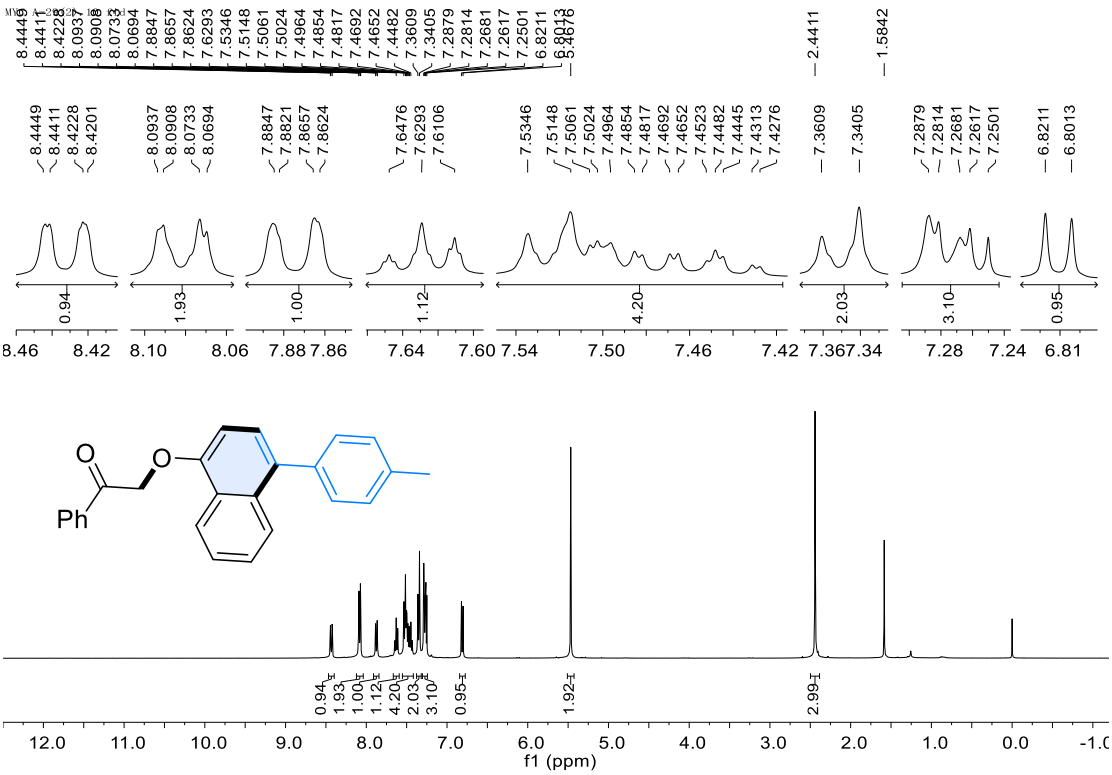
3c, ^{13}C NMR (101 MHz, $CDCl_3$)



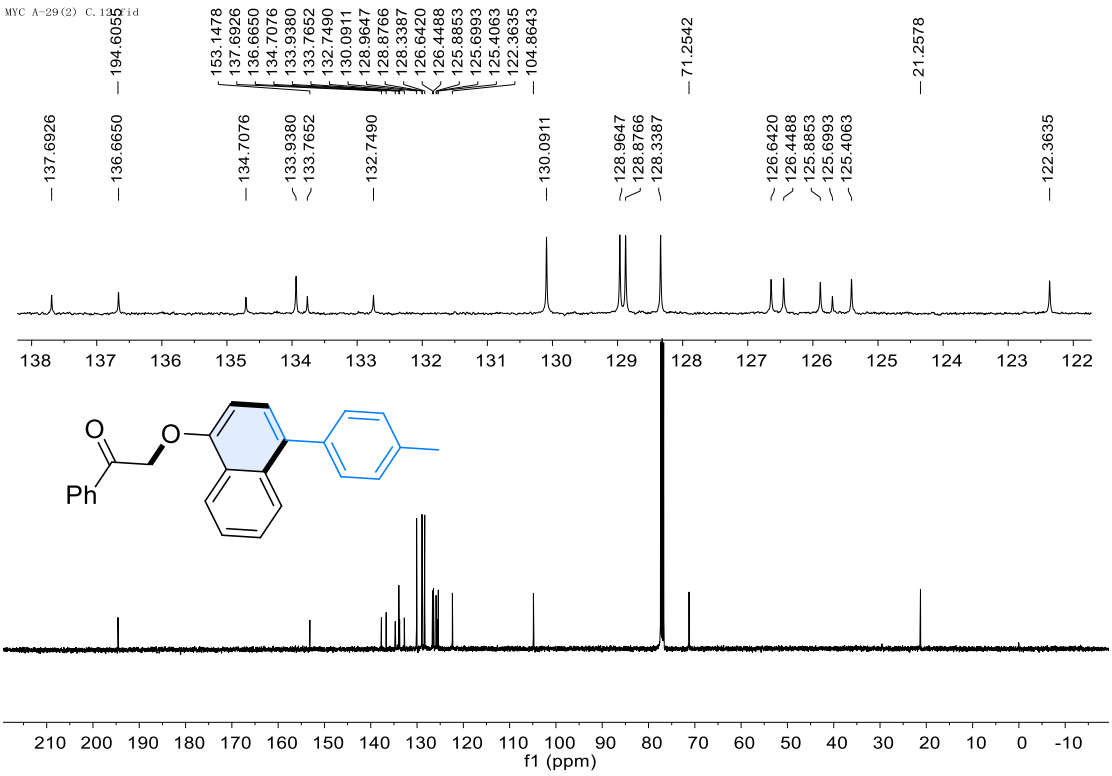
3c, DEPT 90 and DEPT 135 (101 MHz, $CDCl_3$)



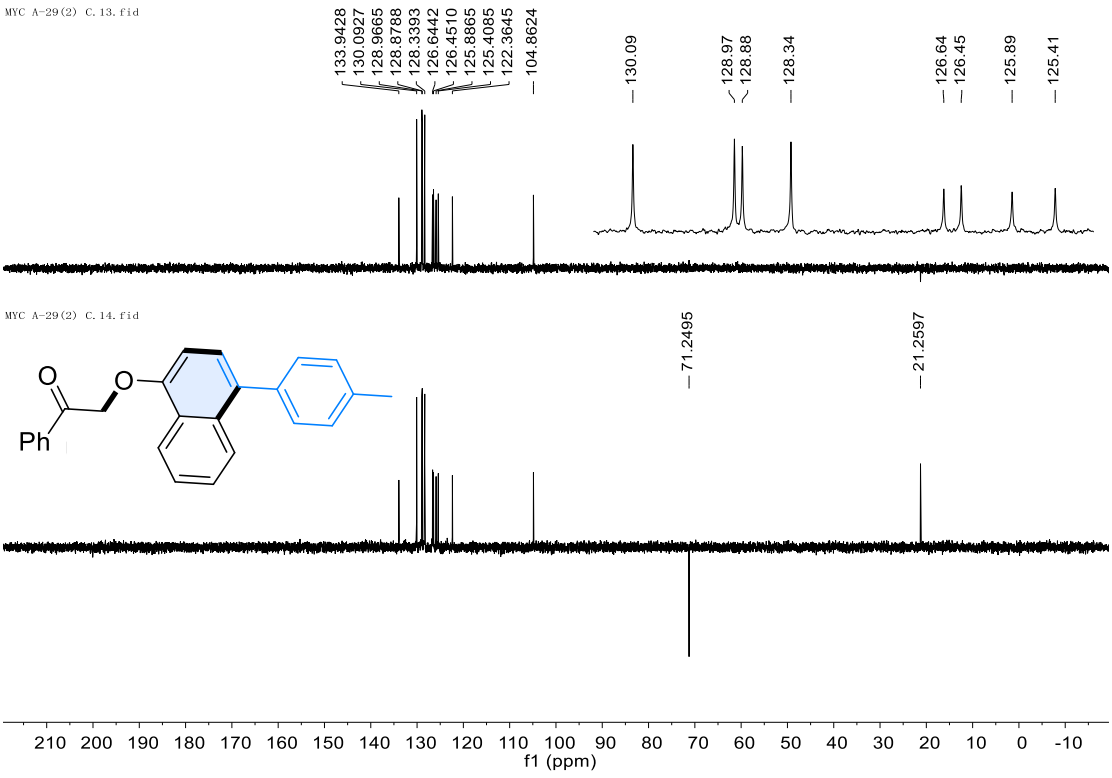
3d1, ^{1}H NMR (400 MHz, $CDCl_3$)



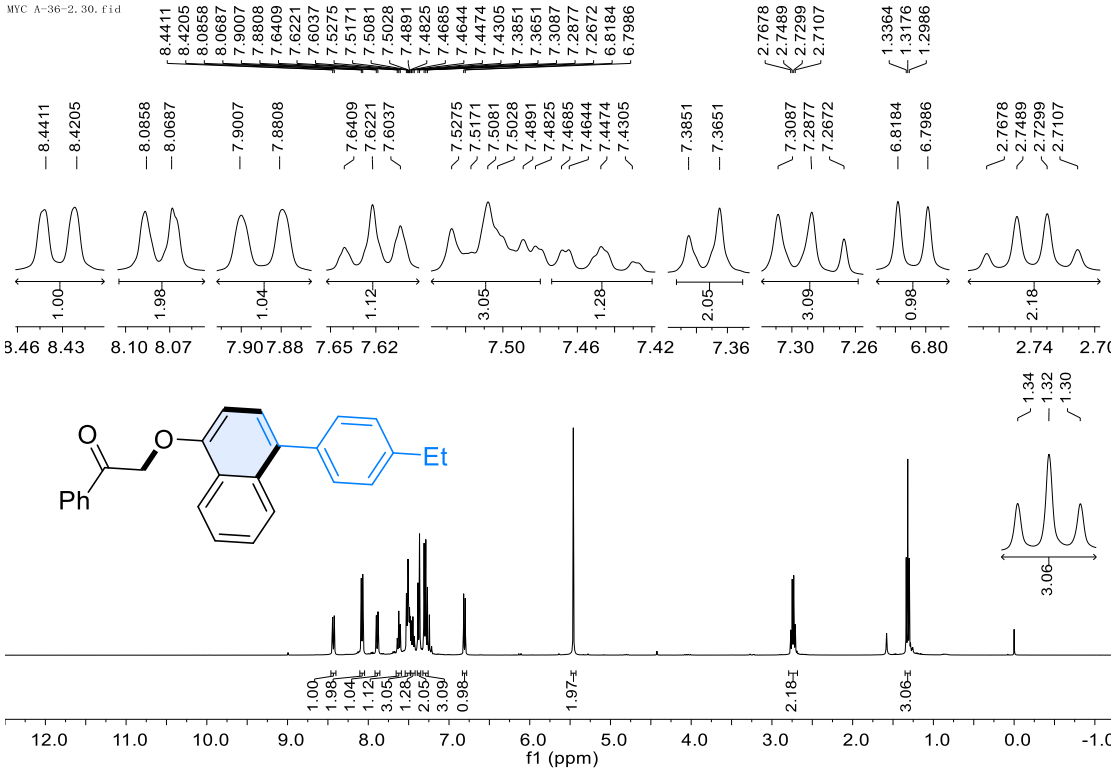
3d1, ^{13}C NMR (101 MHz, $CDCl_3$)



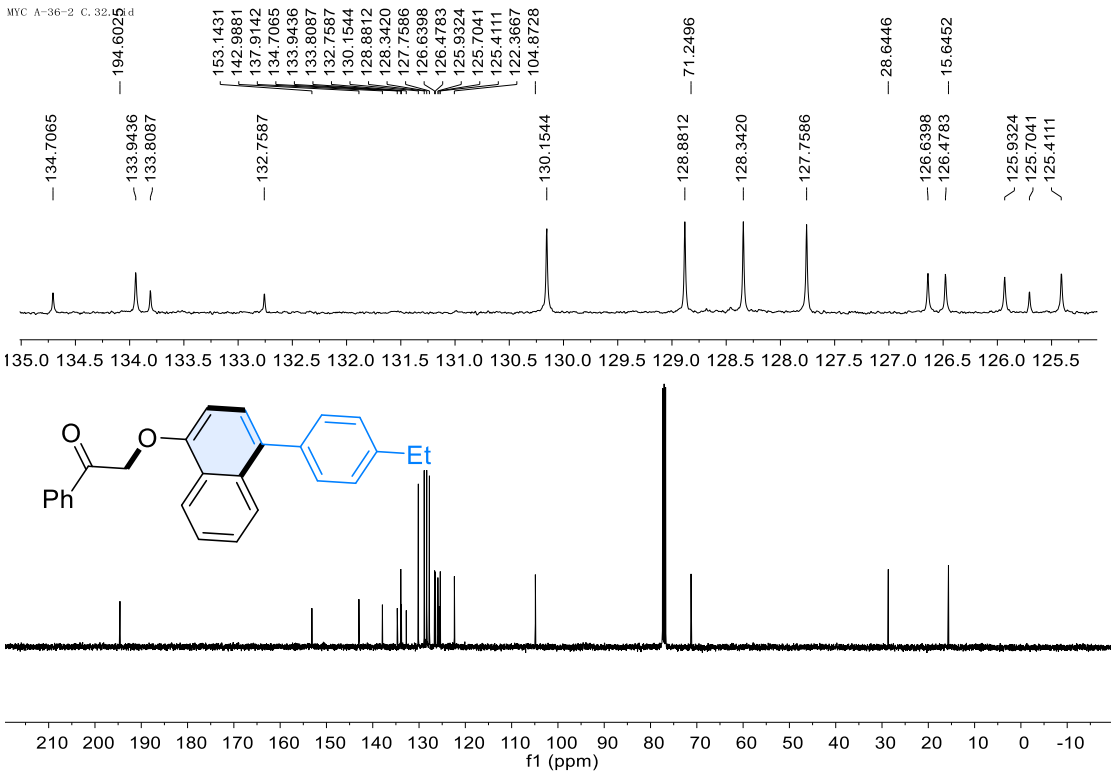
3d1, DEPT 90 and DEPT 135 (101 MHz, $CDCl_3$)



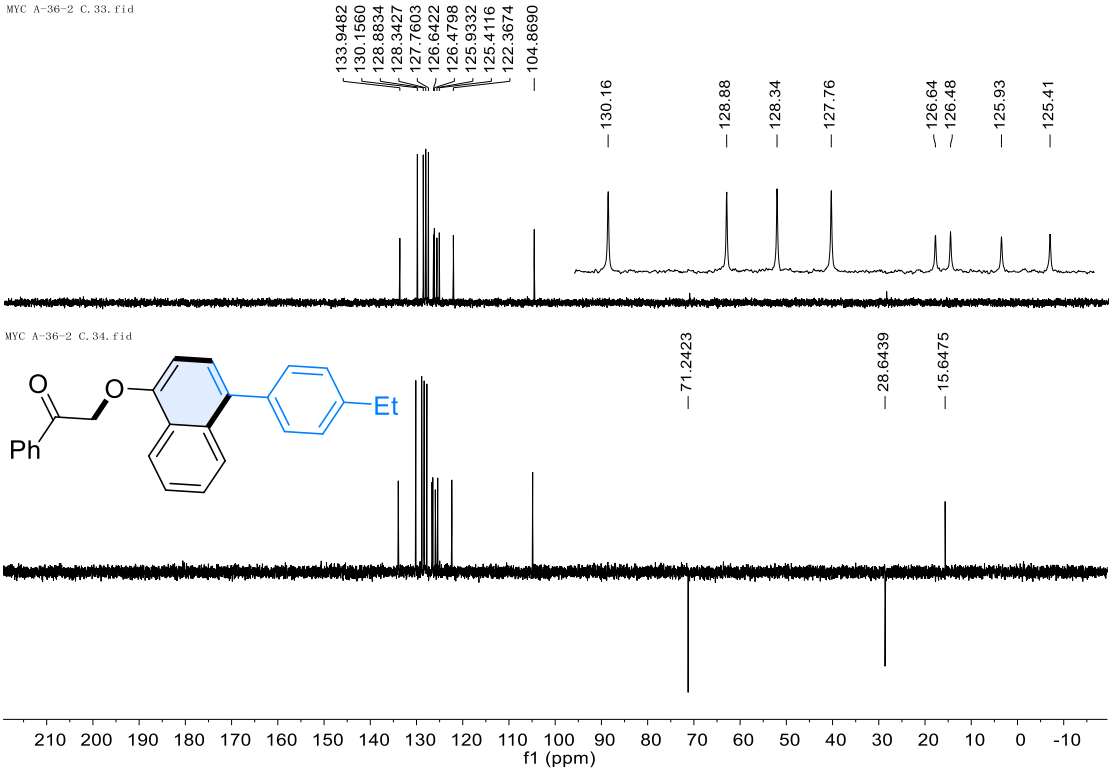
3d2, ^{1}H NMR (400 MHz, $CDCl_3$)



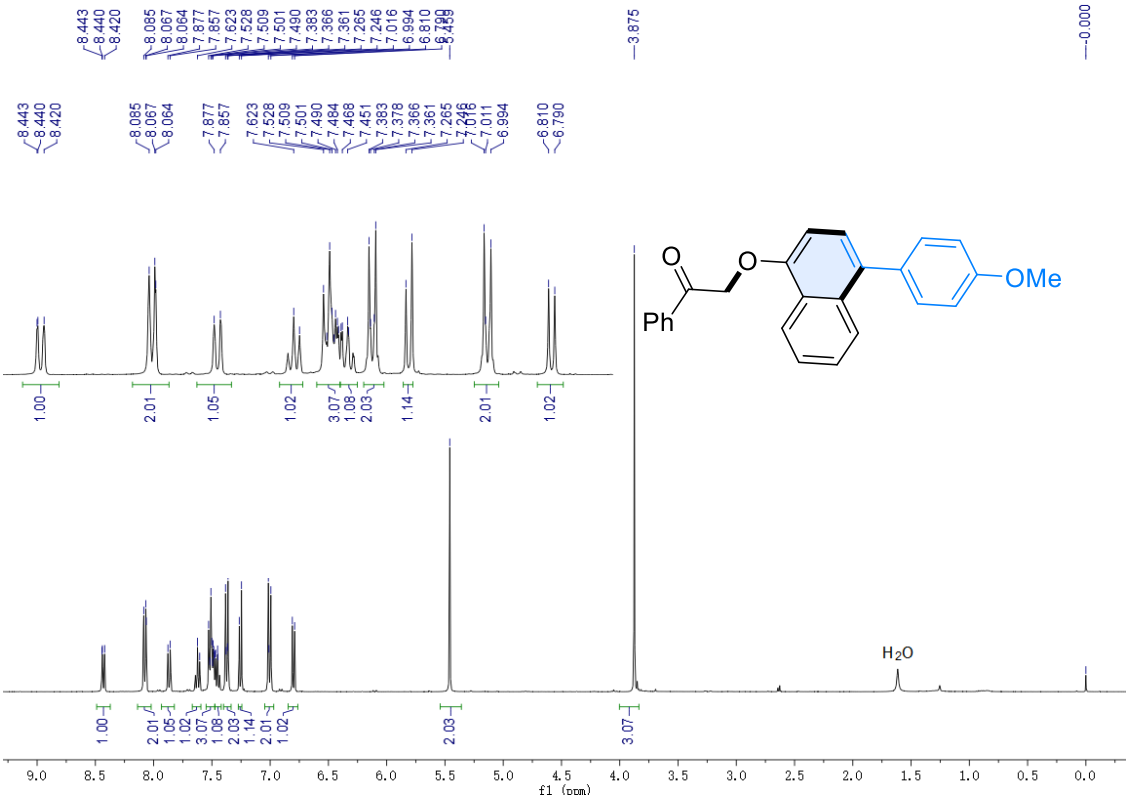
3d2, ^{13}C NMR (101 MHz, $CDCl_3$)



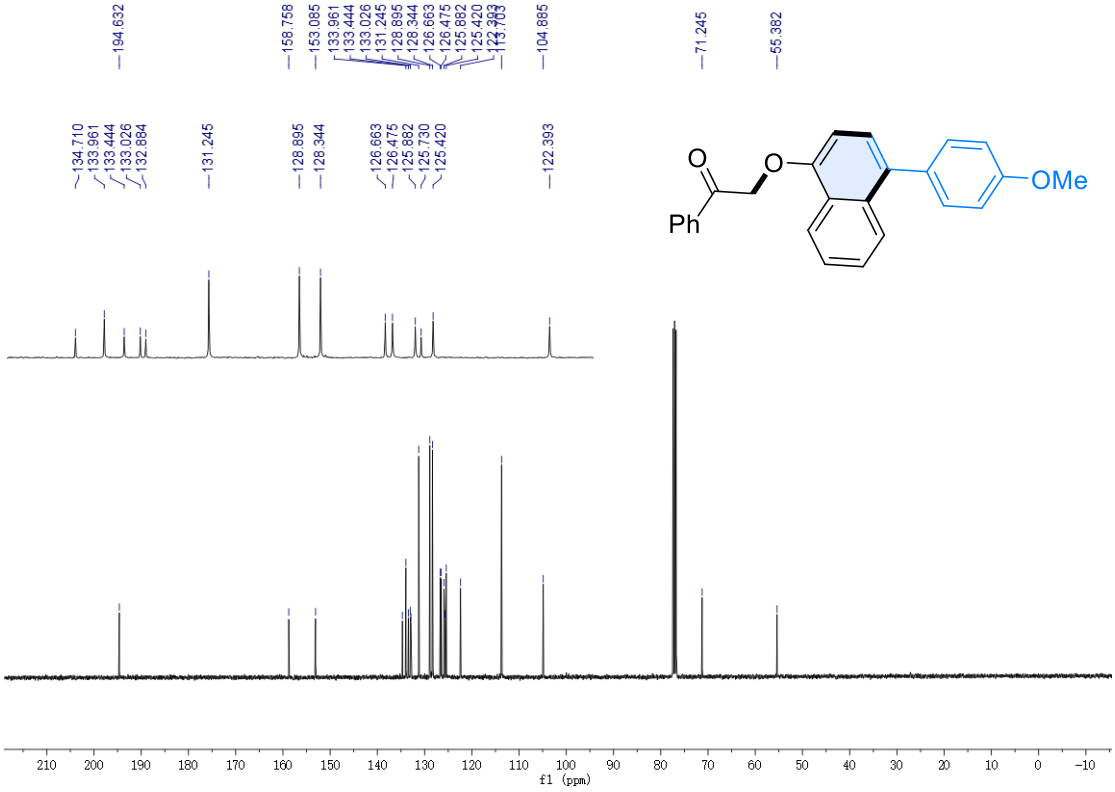
3d2, DEPT 90 and DEPT 135 (101 MHz, $CDCl_3$)



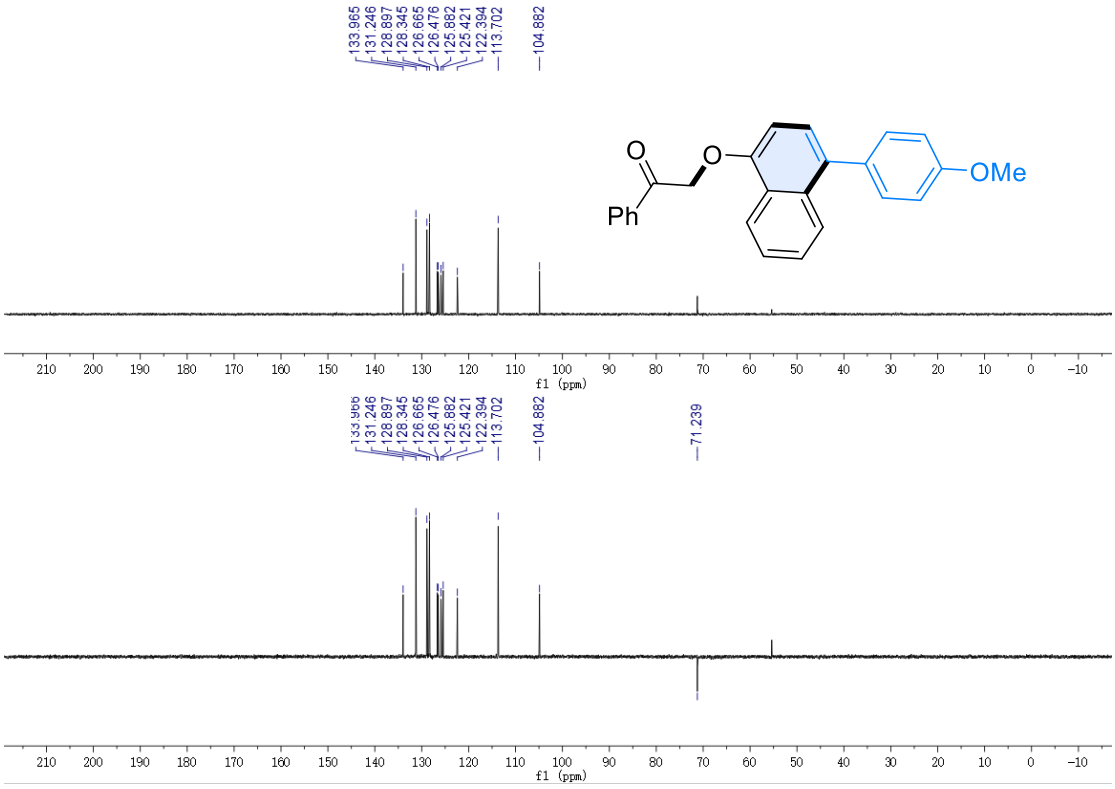
3d3, ^1H NMR (400 MHz, $CDCl_3$)



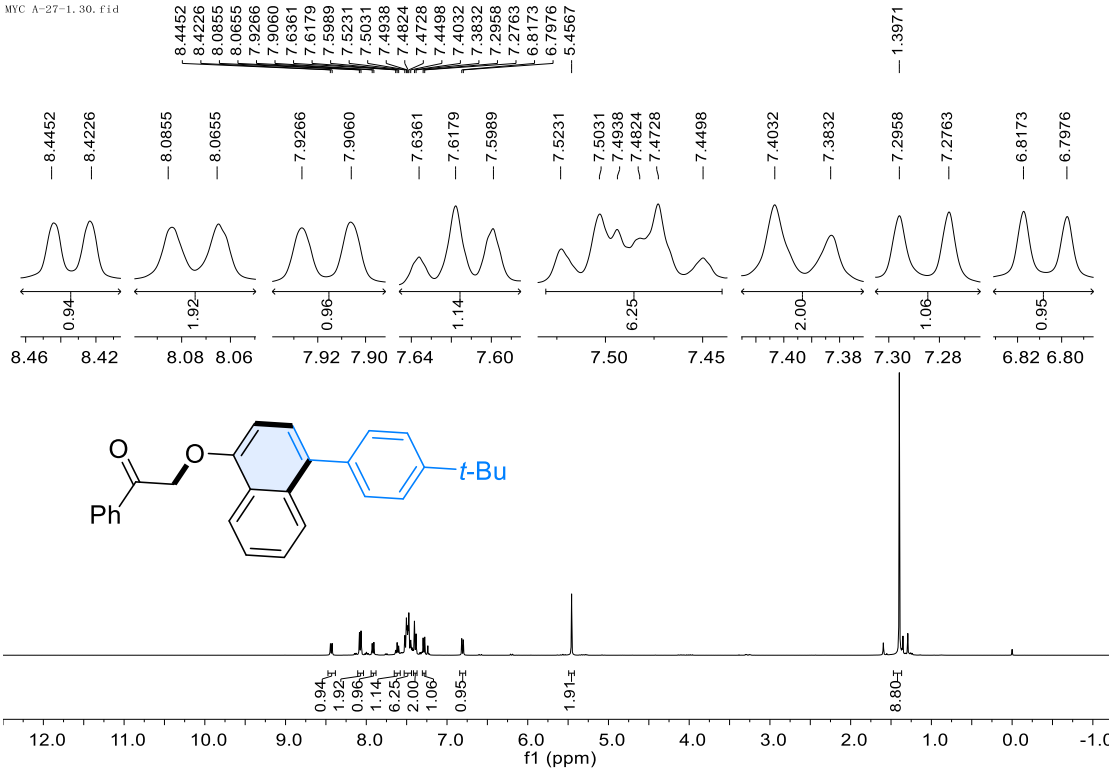
3d3, ^{13}C NMR (101 MHz, $CDCl_3$)



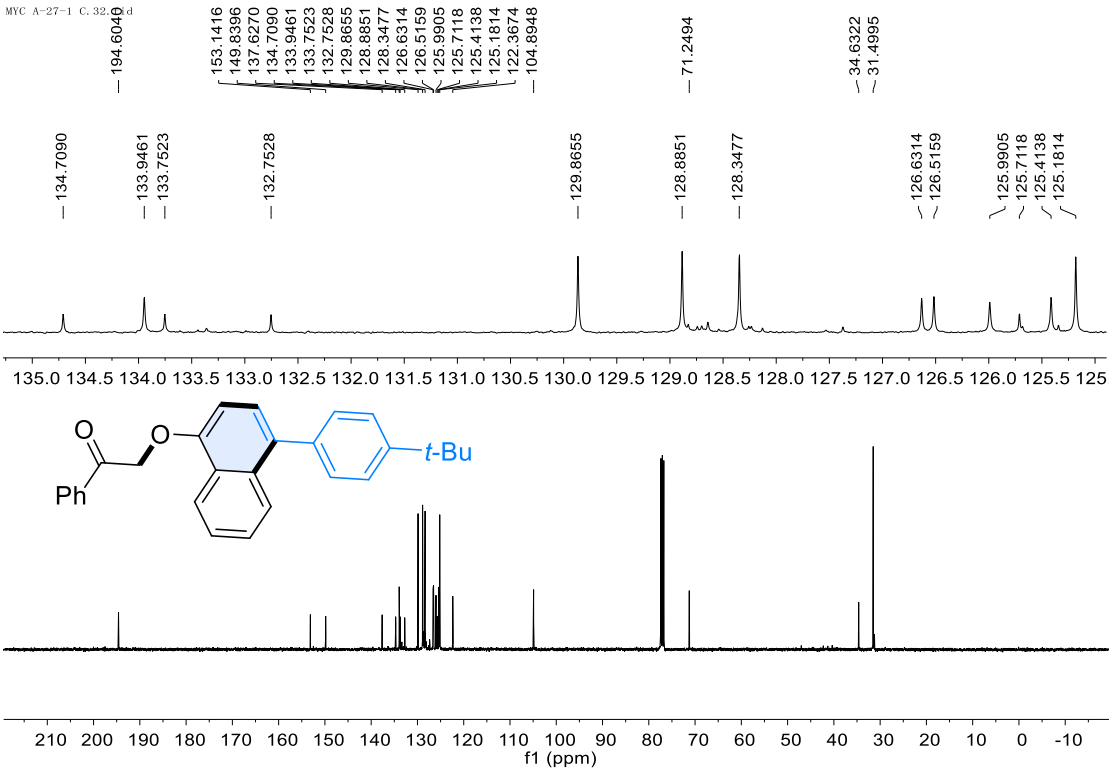
3d3, DEPT 90 and DEPT 135 (101 MHz, $CDCl_3$)



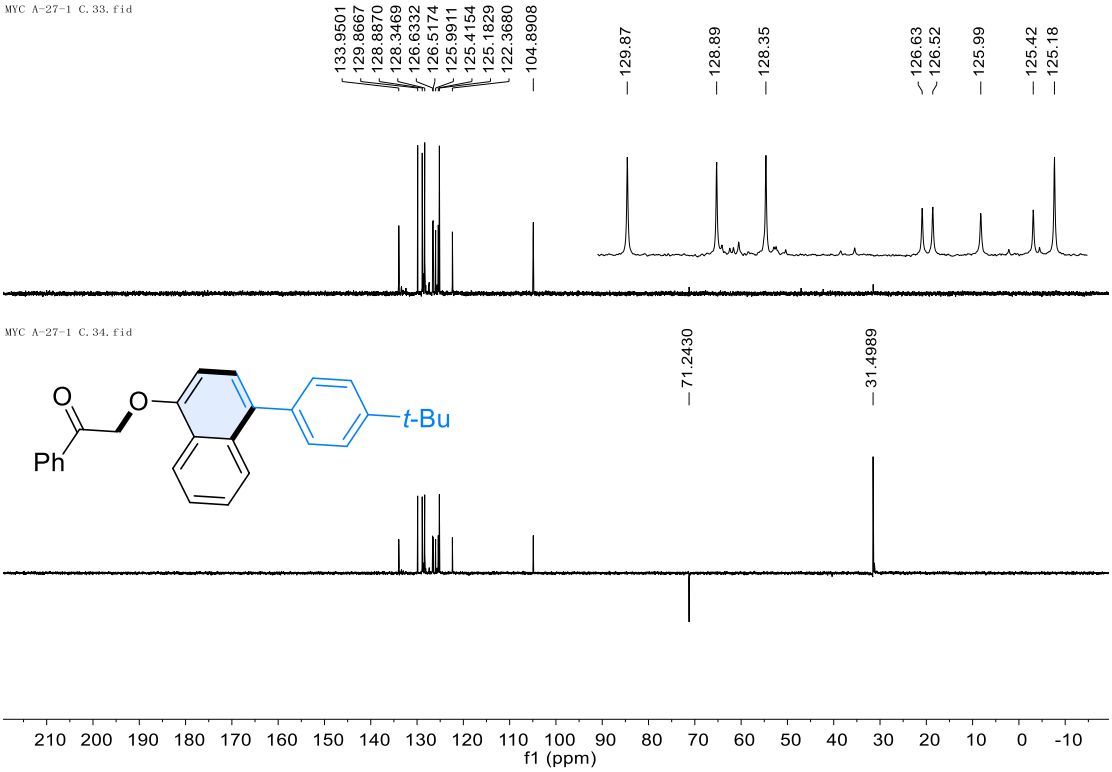
3d4, ^{1}H NMR (400 MHz, $CDCl_3$)



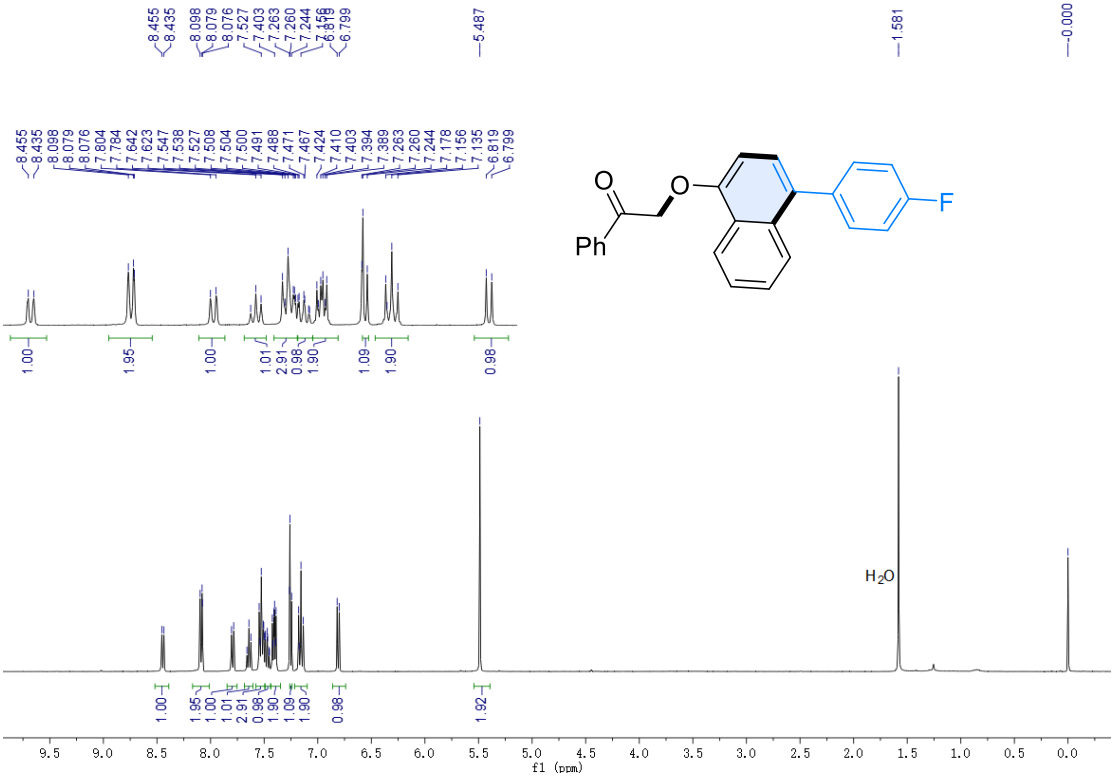
3d4, ^{13}C NMR (101 MHz, $CDCl_3$)



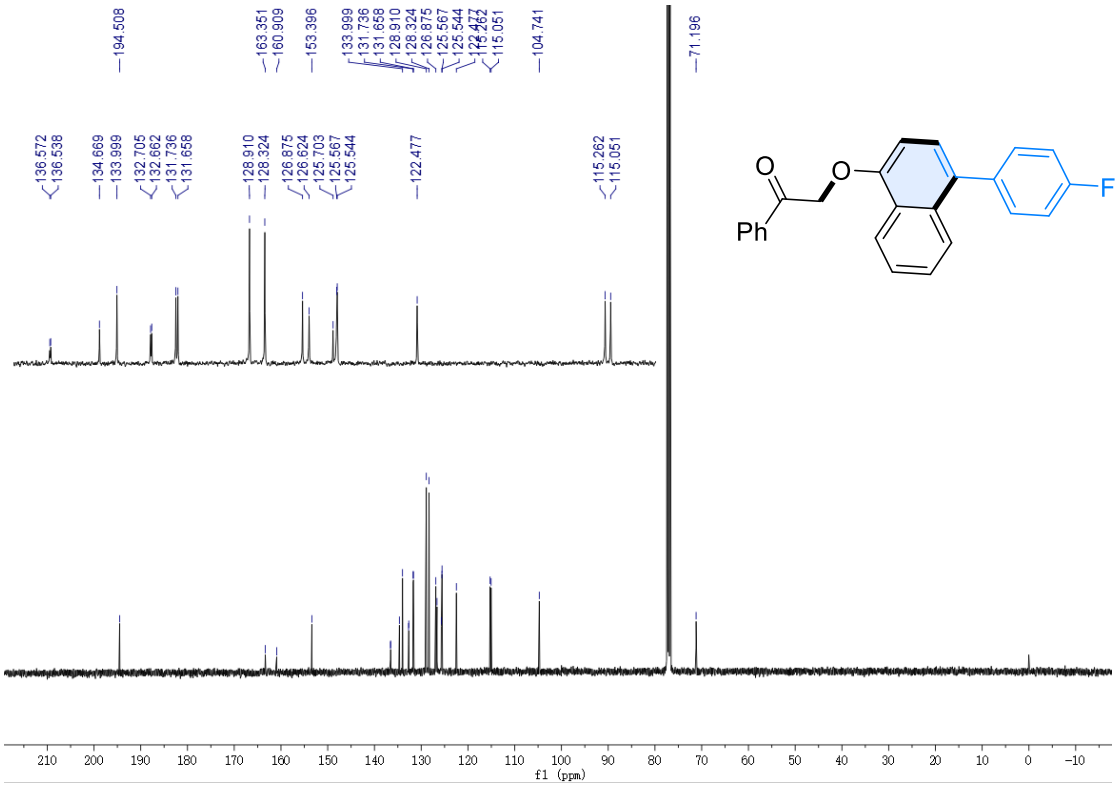
3d4, DEPT 90 and DEPT 135 (101 MHz, $CDCl_3$)



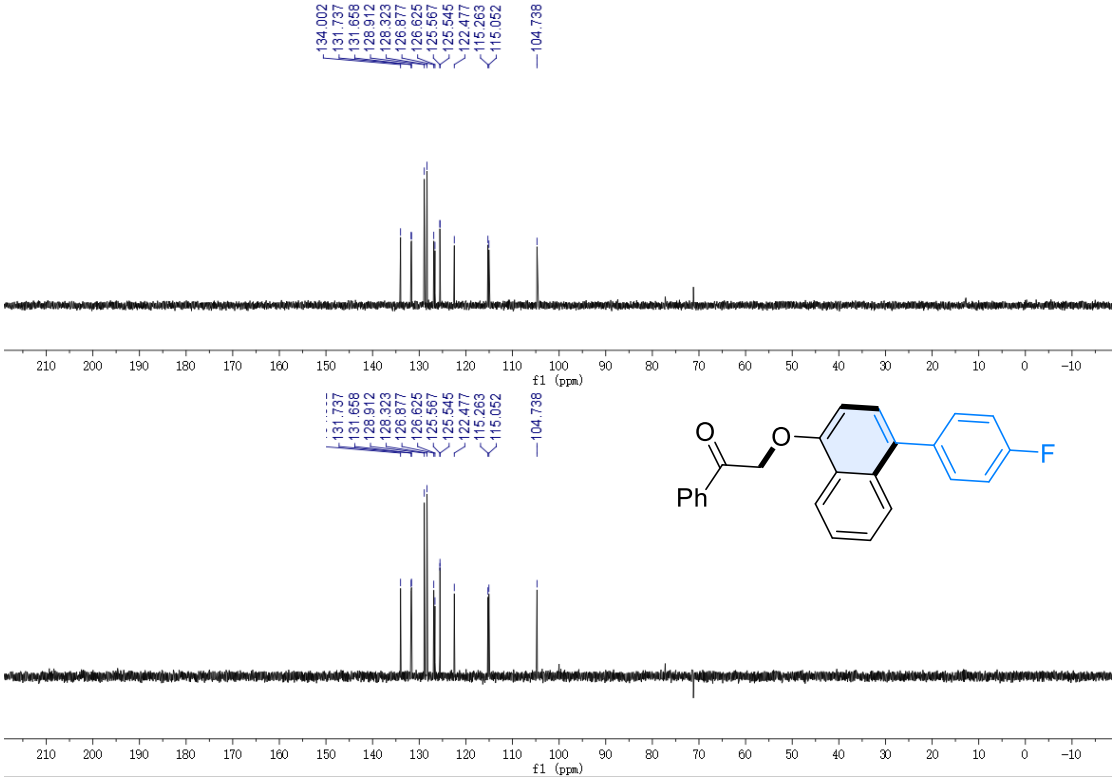
3d5, ^1H NMR (400 MHz, $CDCl_3$)



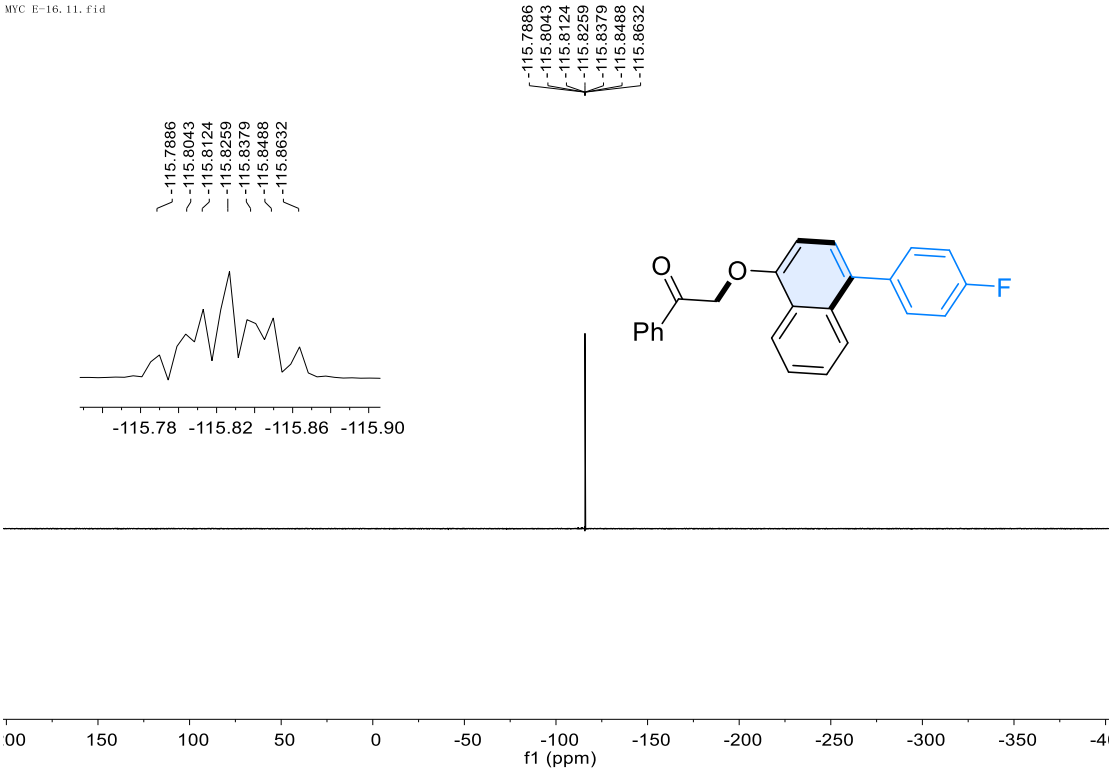
3d5, ^{13}C NMR (101 MHz, $CDCl_3$)



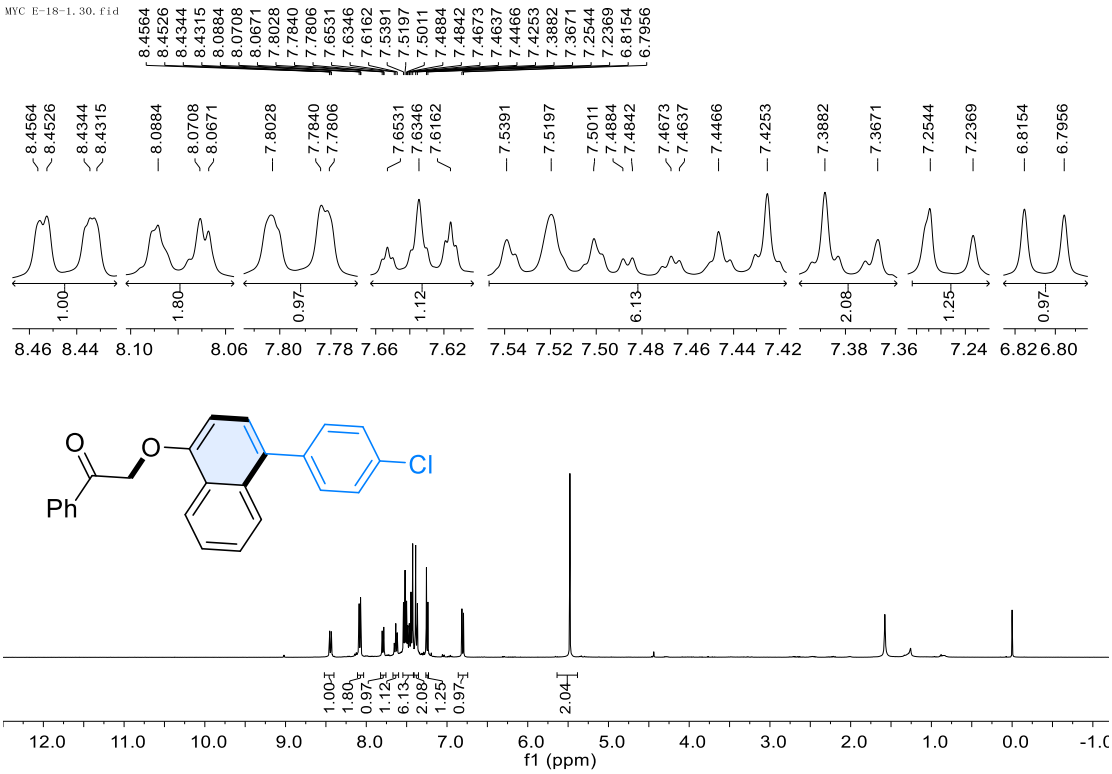
3d5, DEPT 90 and DEPT 135 (101 MHz, $CDCl_3$)



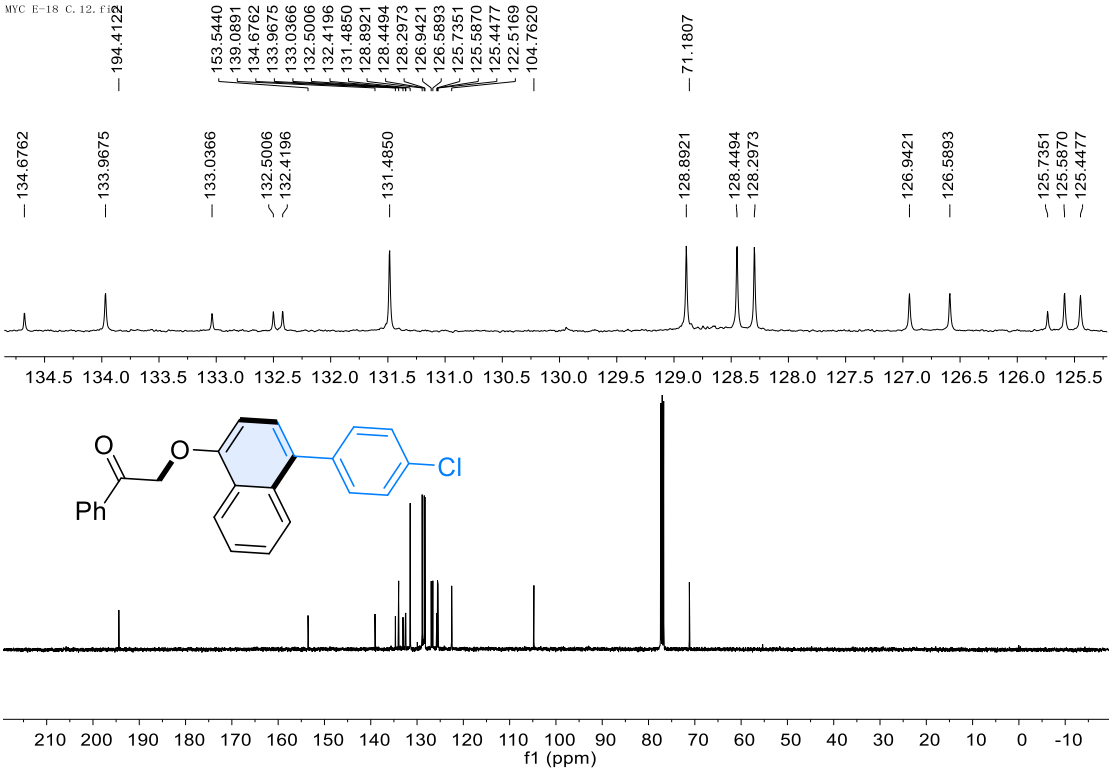
3d5, ^{19}F NMR (376 MHz, $CDCl_3$)



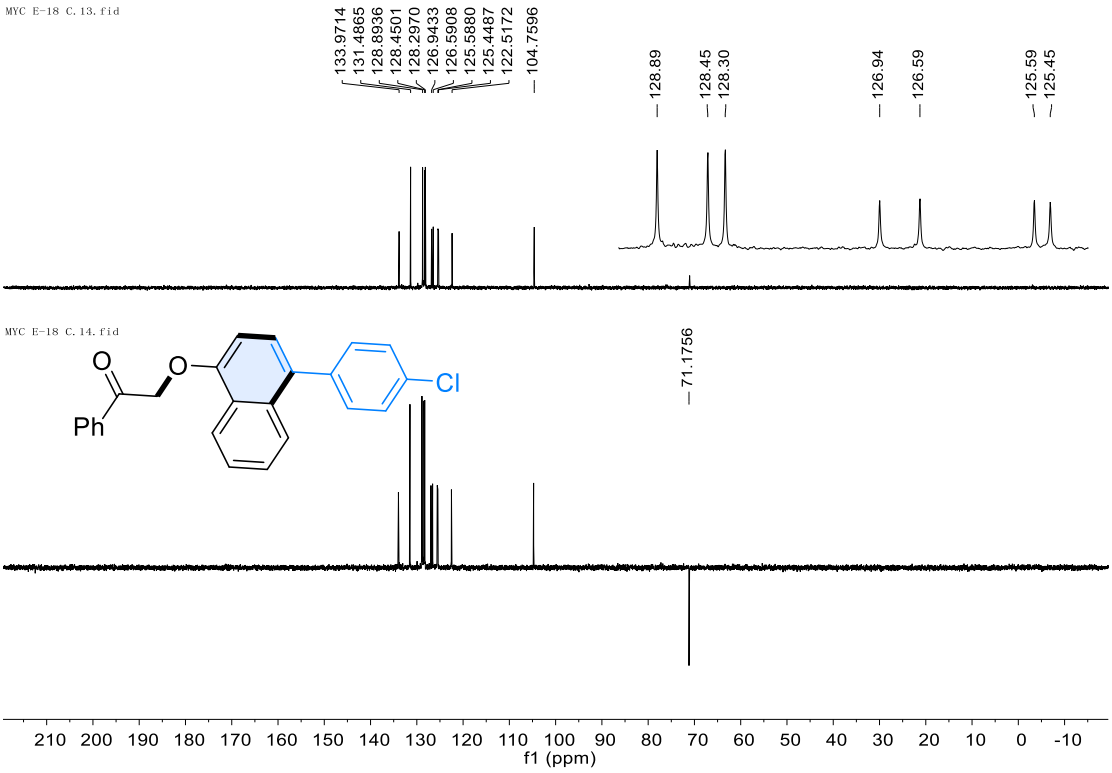
3d6, ^{1}H NMR (400 MHz, $CDCl_3$)



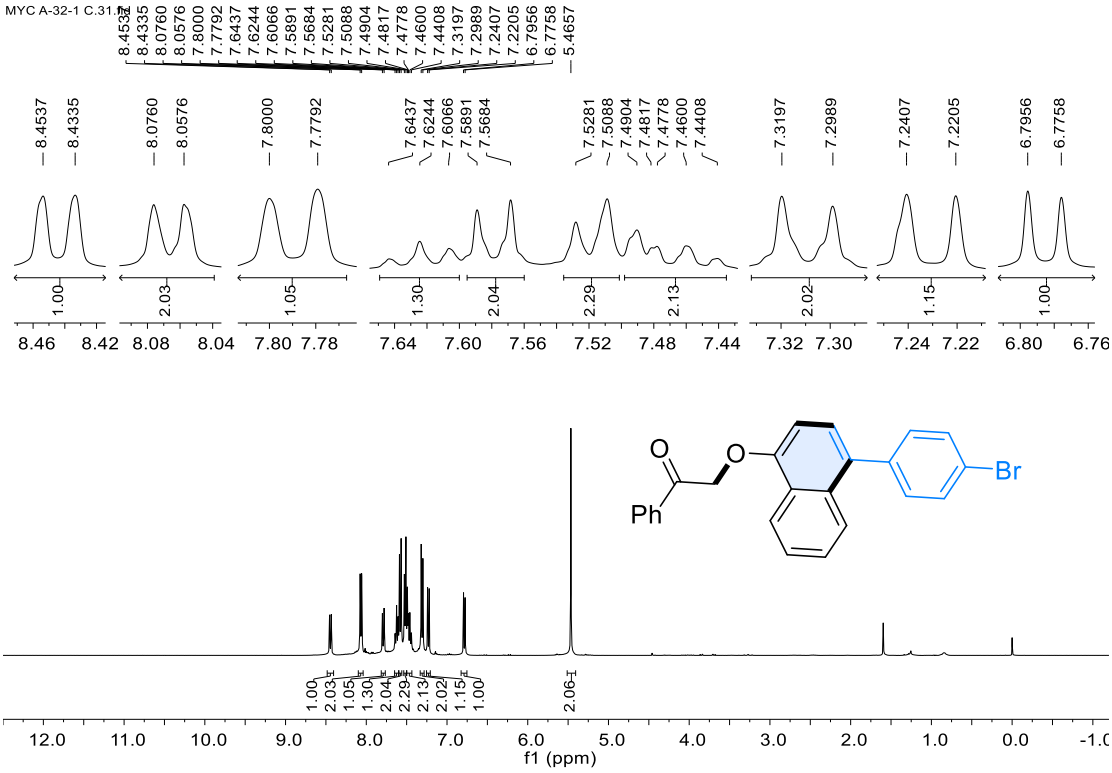
3d6, ^{13}C NMR (101 MHz, $CDCl_3$)



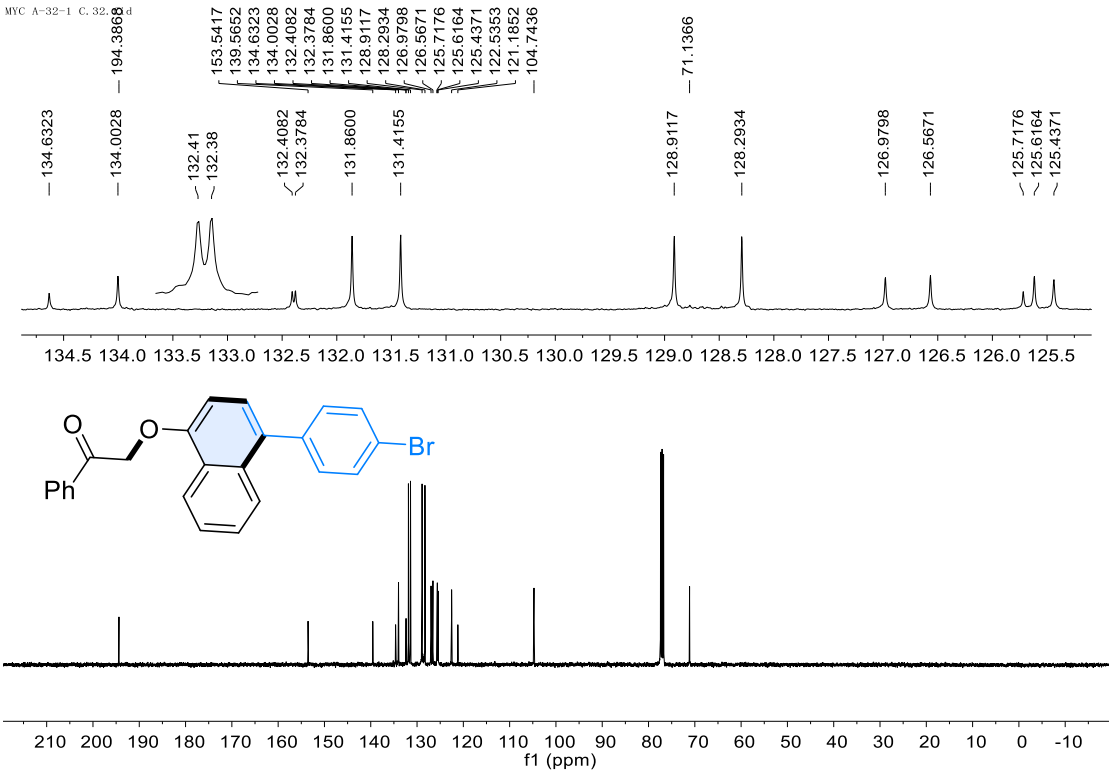
3d6, DEPT 90 and DEPT 135 (101 MHz, $CDCl_3$)



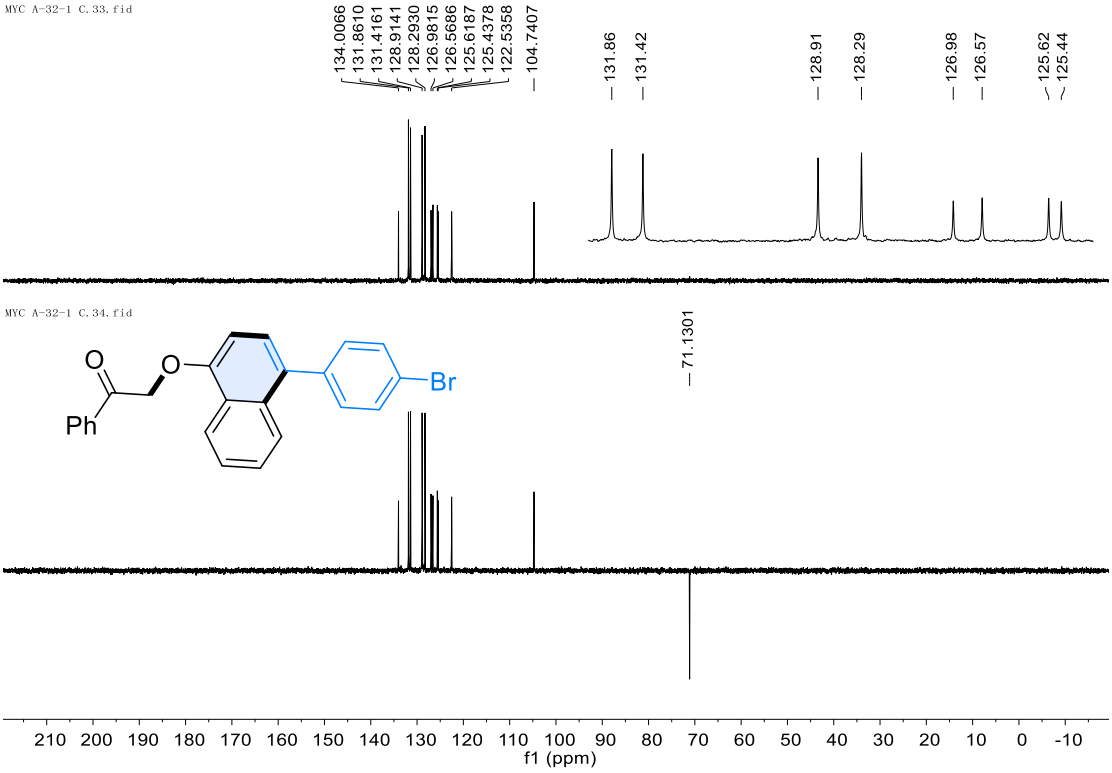
3d7, ^{1}H NMR (400 MHz, $CDCl_3$)



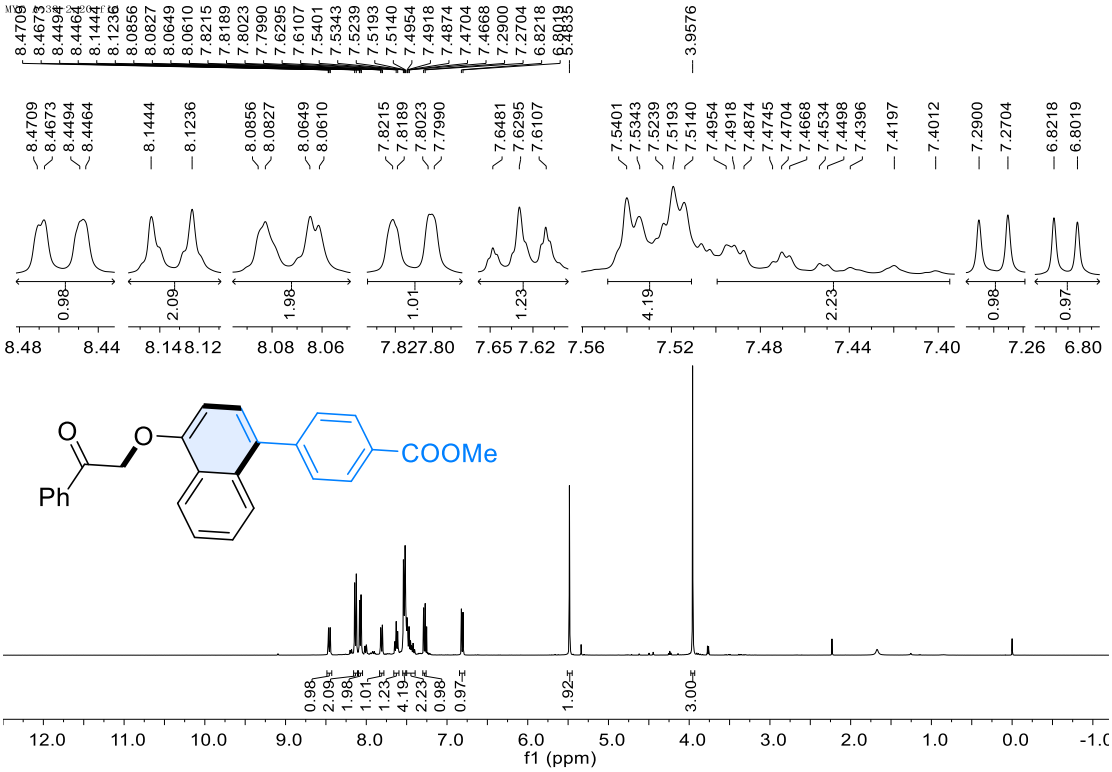
3d7, ^{13}C NMR (101 MHz, $CDCl_3$)



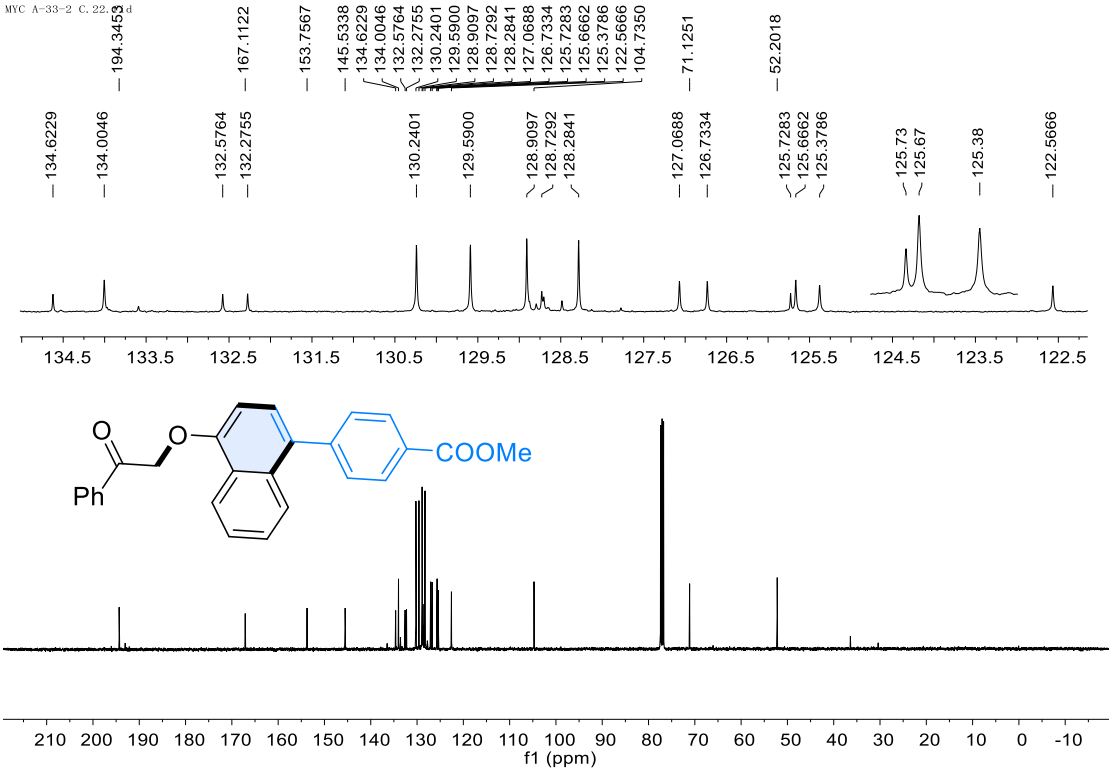
3d7, DEPT 90 and DEPT 135 (101 MHz, $CDCl_3$)



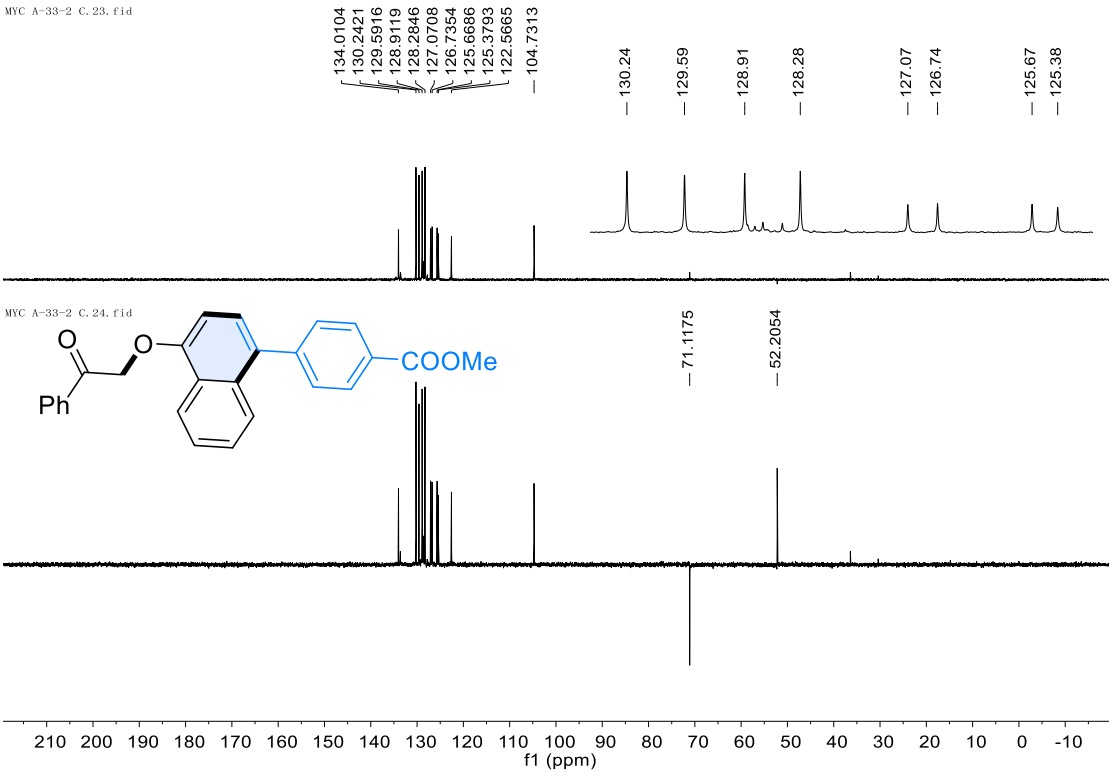
3d8, ^1H NMR (400 MHz, $CDCl_3$)



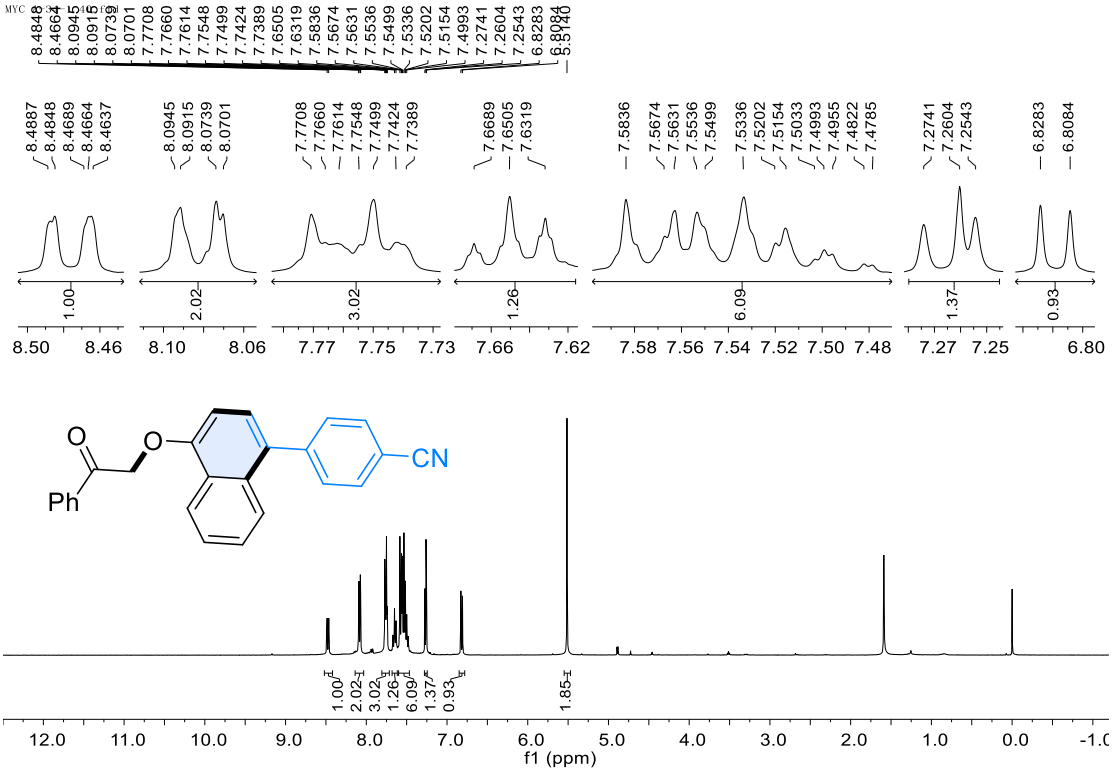
3d8, ^{13}C NMR (101 MHz, $CDCl_3$)



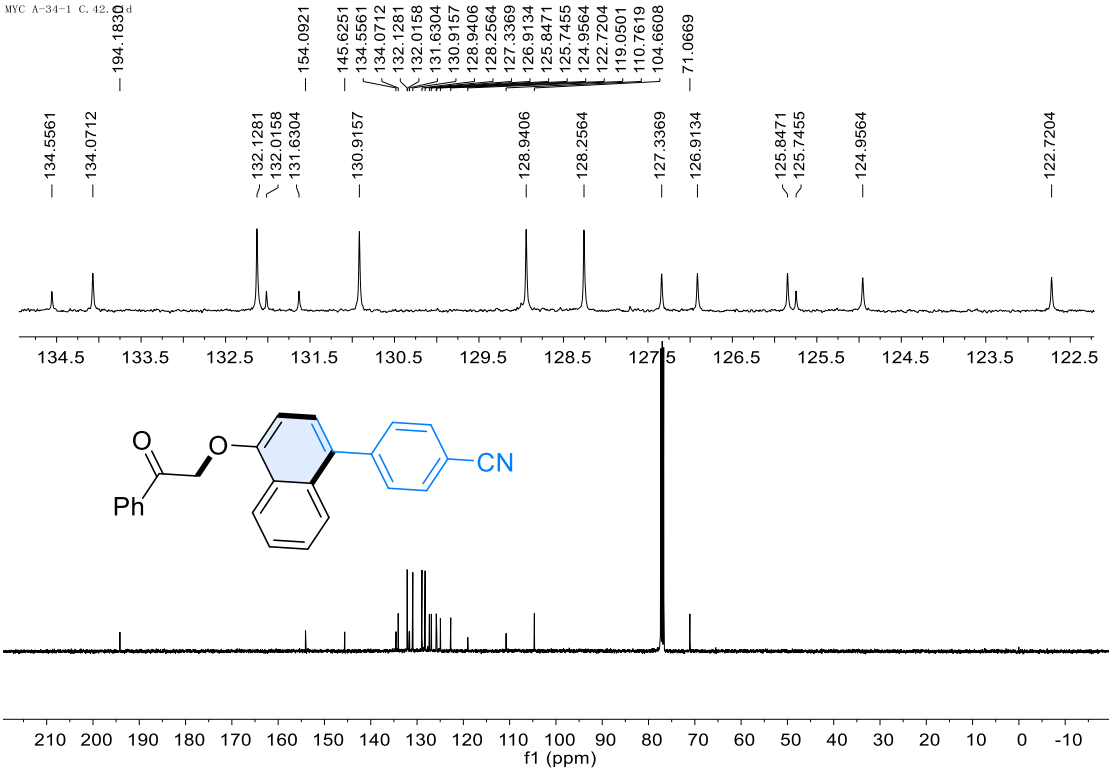
3d8, DEPT 90 and DEPT 135 (101 MHz, $CDCl_3$)



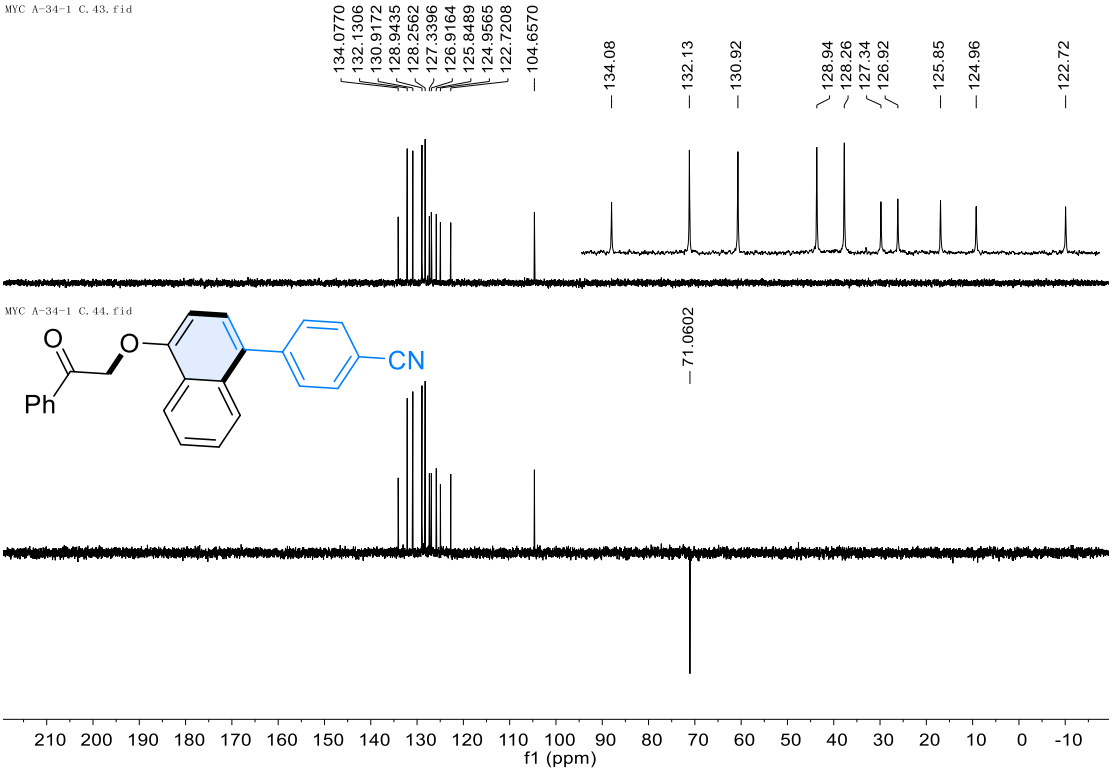
3d9, ^{1}H NMR (400 MHz, $CDCl_3$)



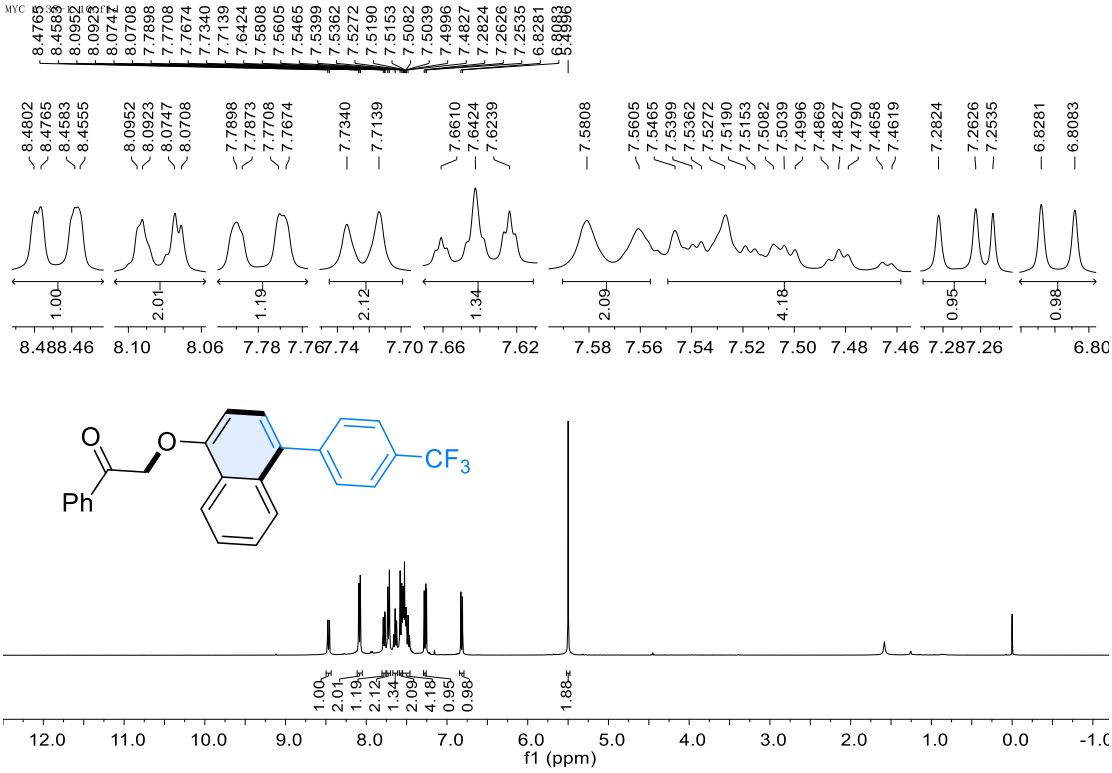
3d9, ^{13}C NMR (101 MHz, $CDCl_3$)



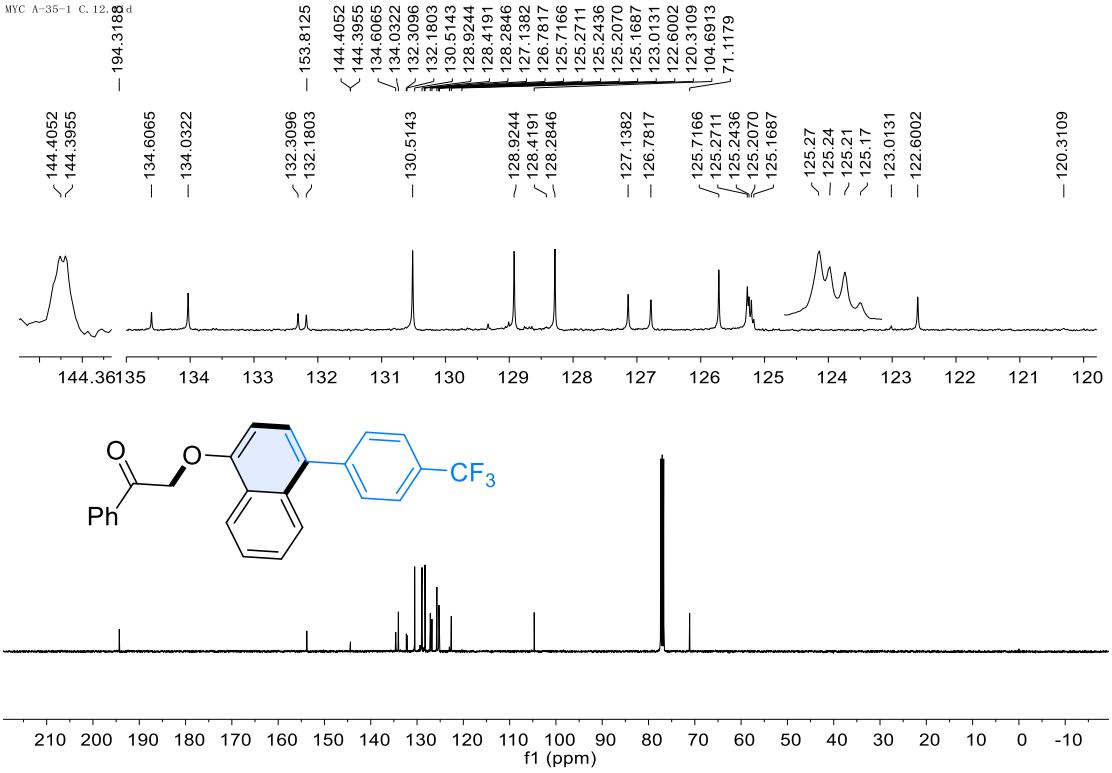
3d9, DEPT 90 and DEPT 135 (101 MHz, $CDCl_3$)



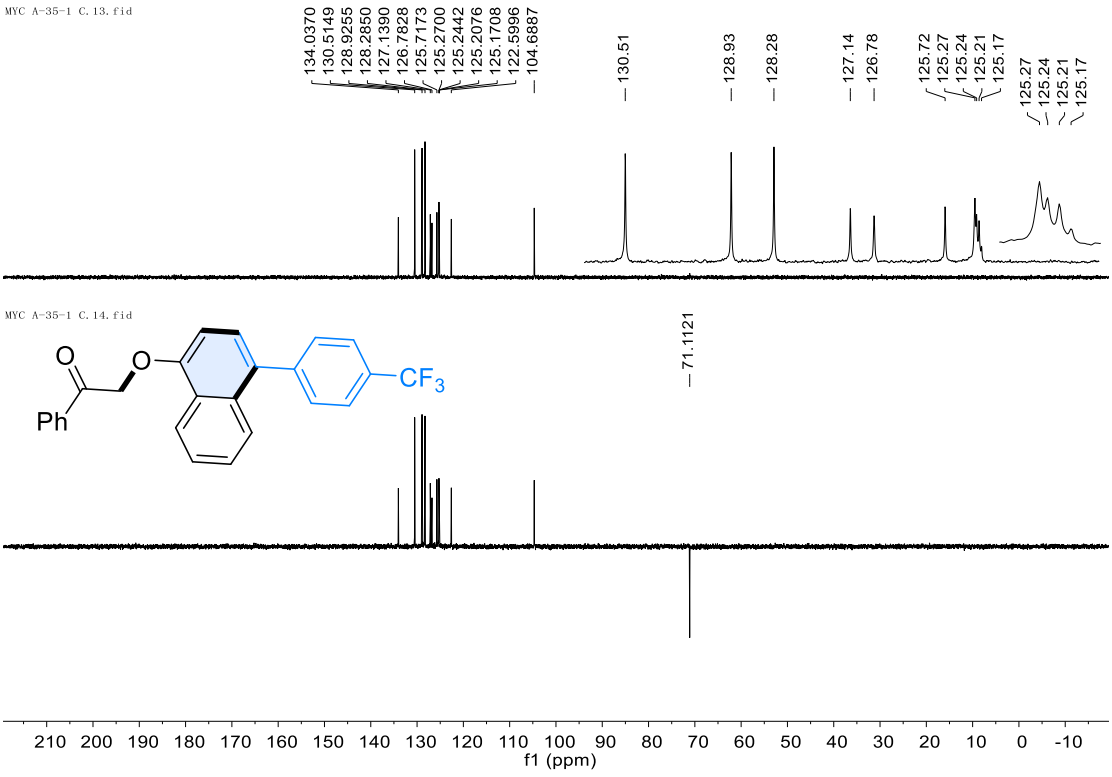
3d10, ^1H NMR (400 MHz, $CDCl_3$)



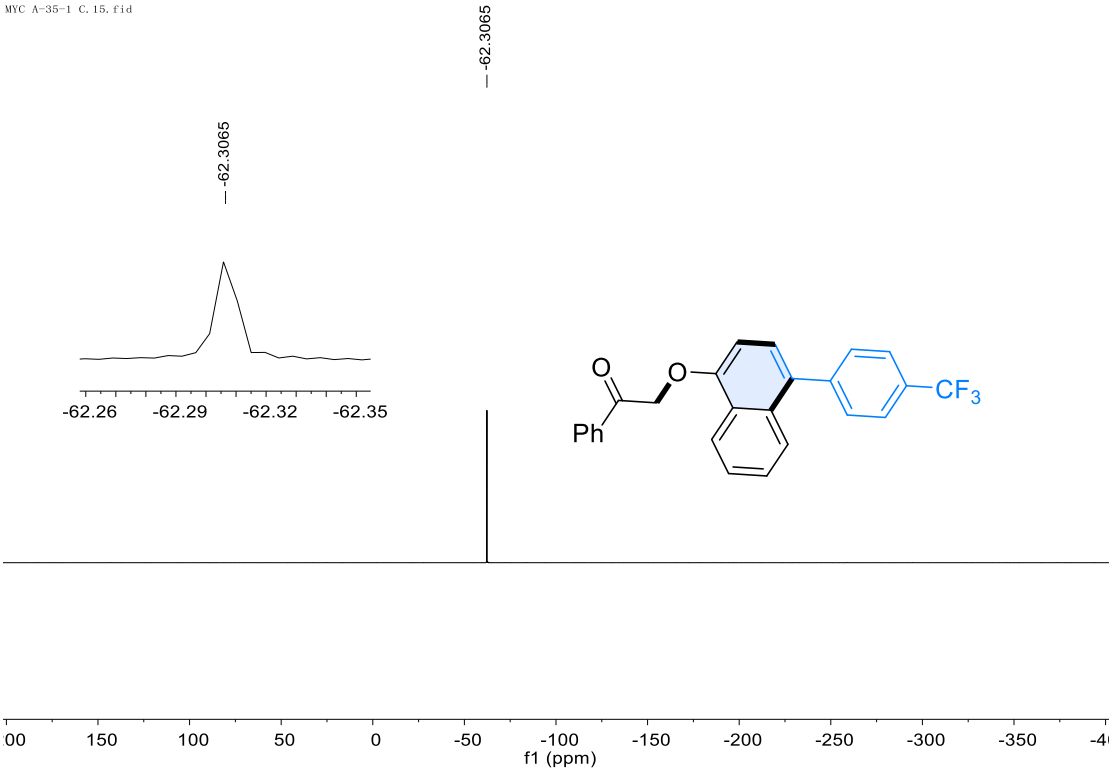
3d10, ^{13}C NMR (101 MHz, $CDCl_3$)



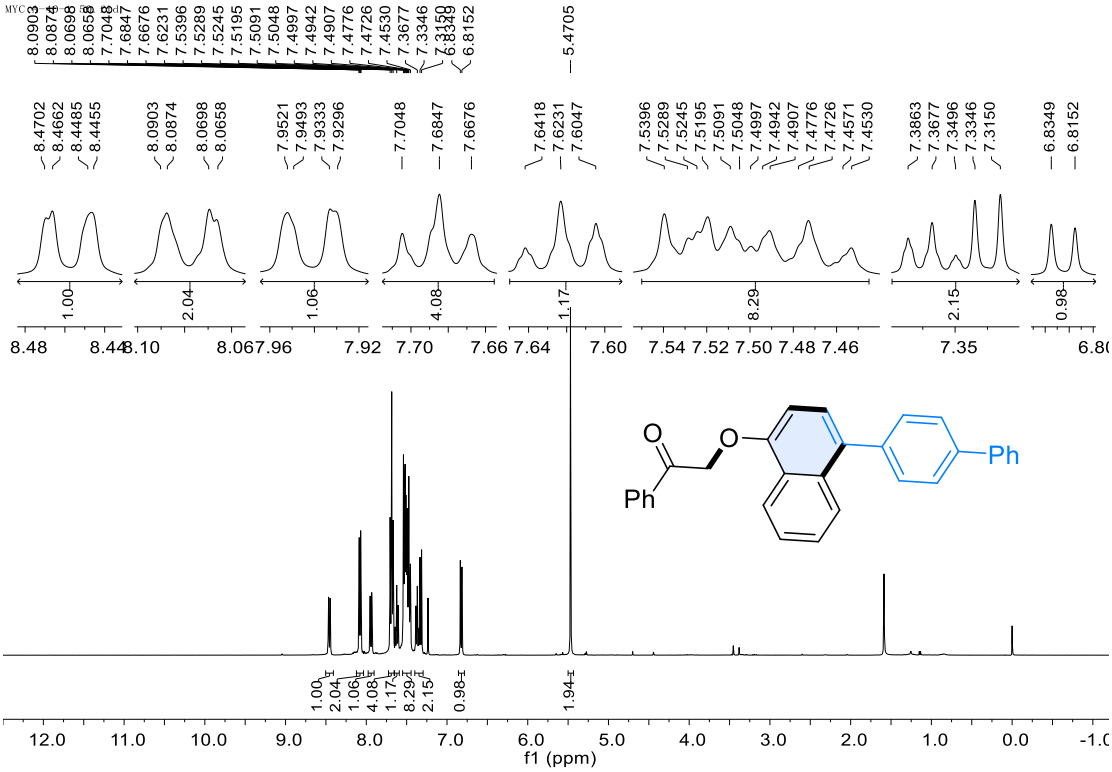
3d10, DEPT 90 and DEPT 135 (101 MHz, $CDCl_3$)



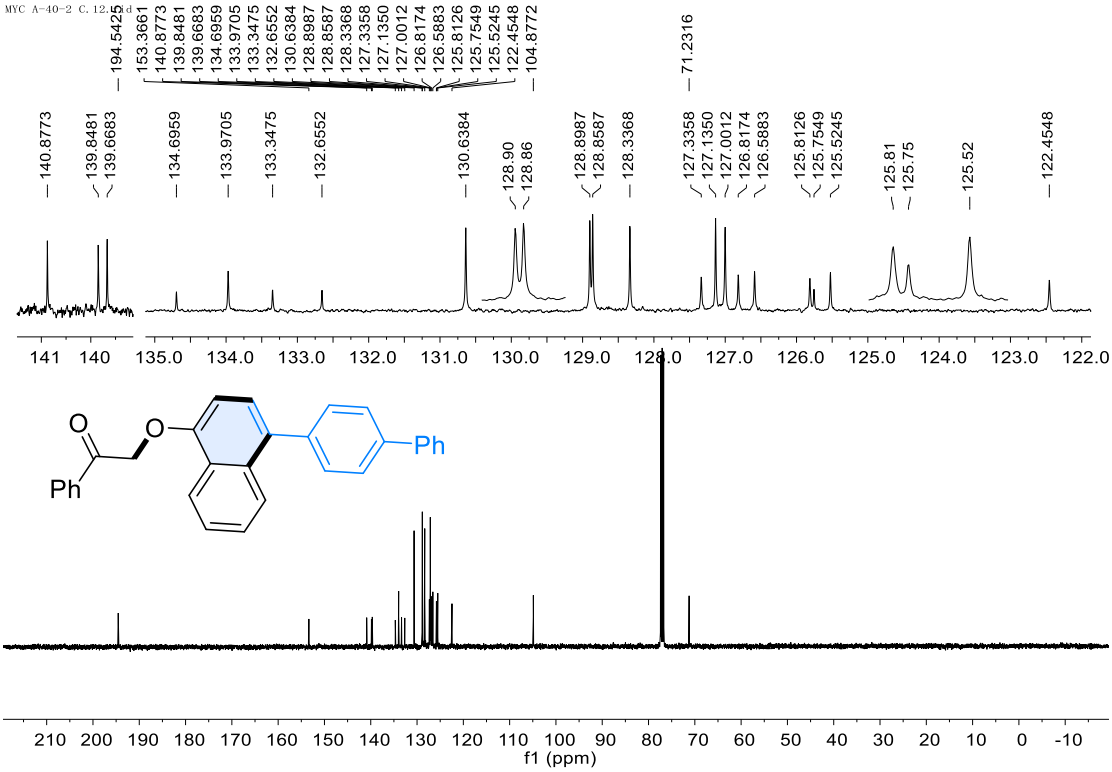
3d10, ^{19}F NMR (376 MHz, $CDCl_3$)



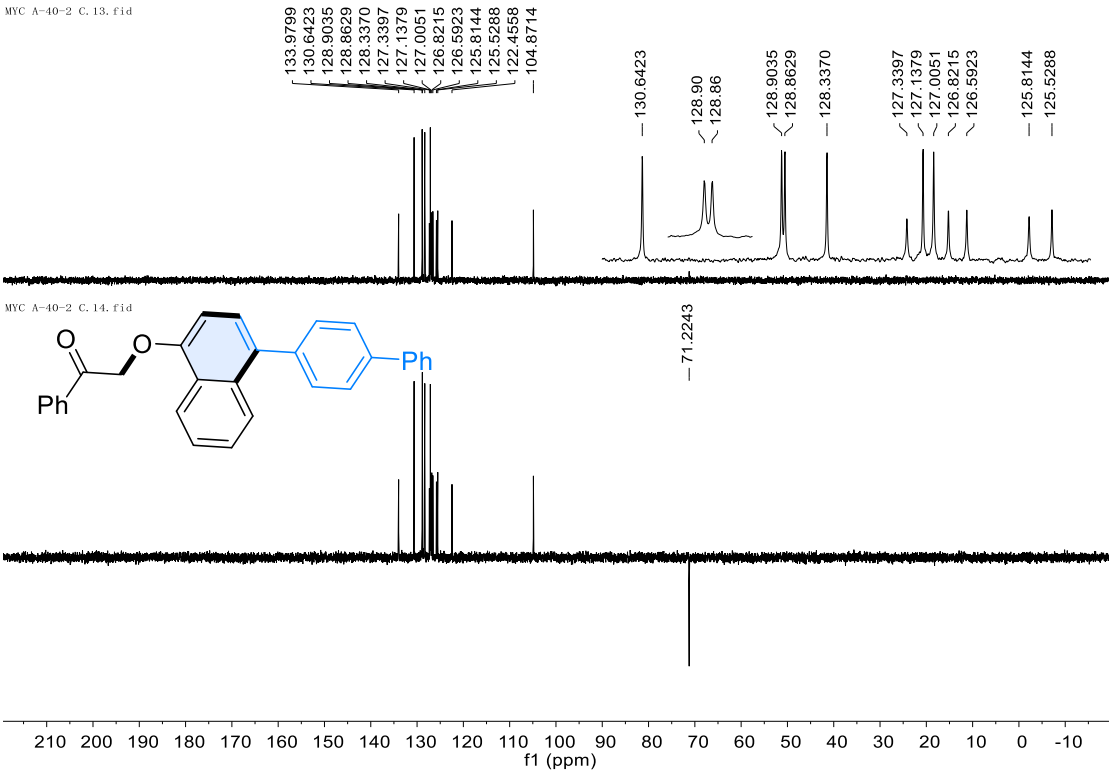
3d11, ^{1}H NMR (400 MHz, $CDCl_3$)



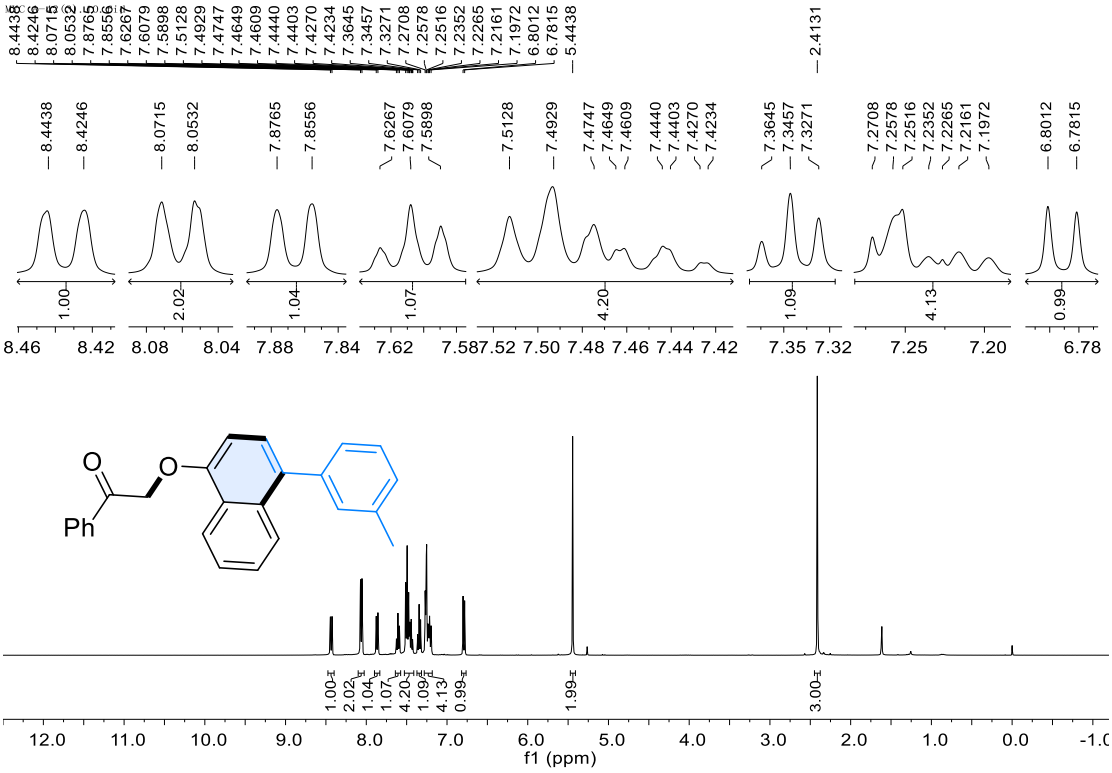
3d11, ^{13}C NMR (101 MHz, $CDCl_3$)



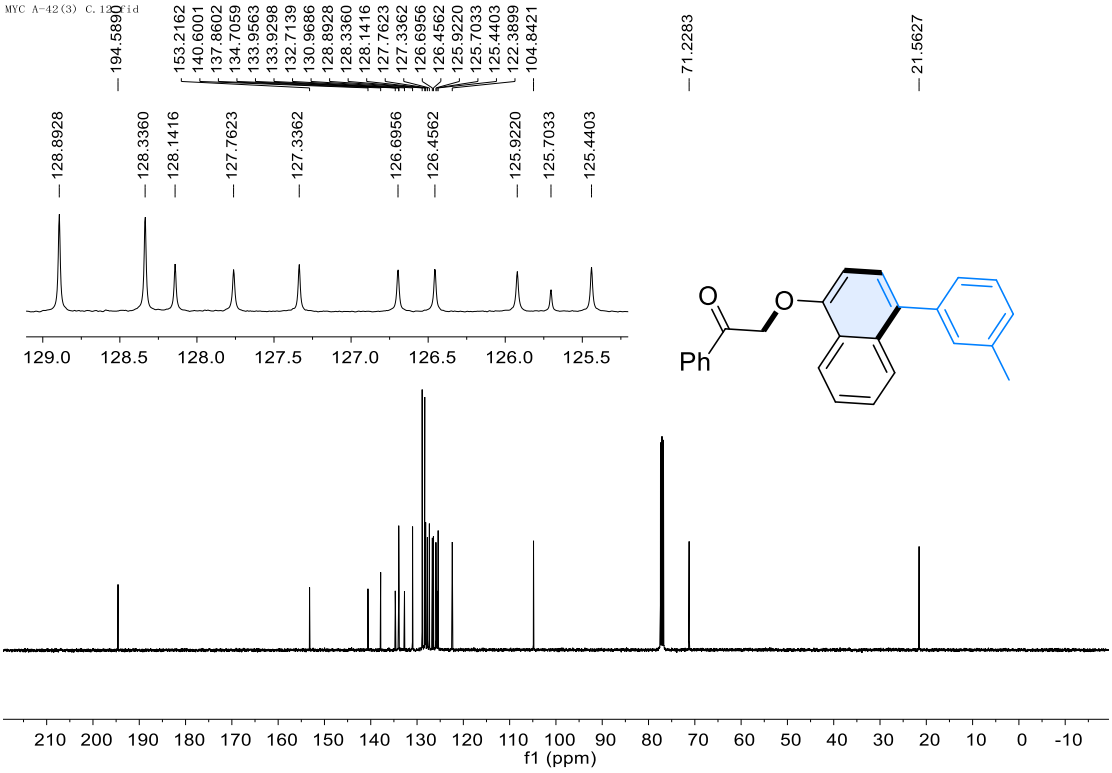
3d11, DEPT 90 and DEPT 135 (101 MHz, $CDCl_3$)



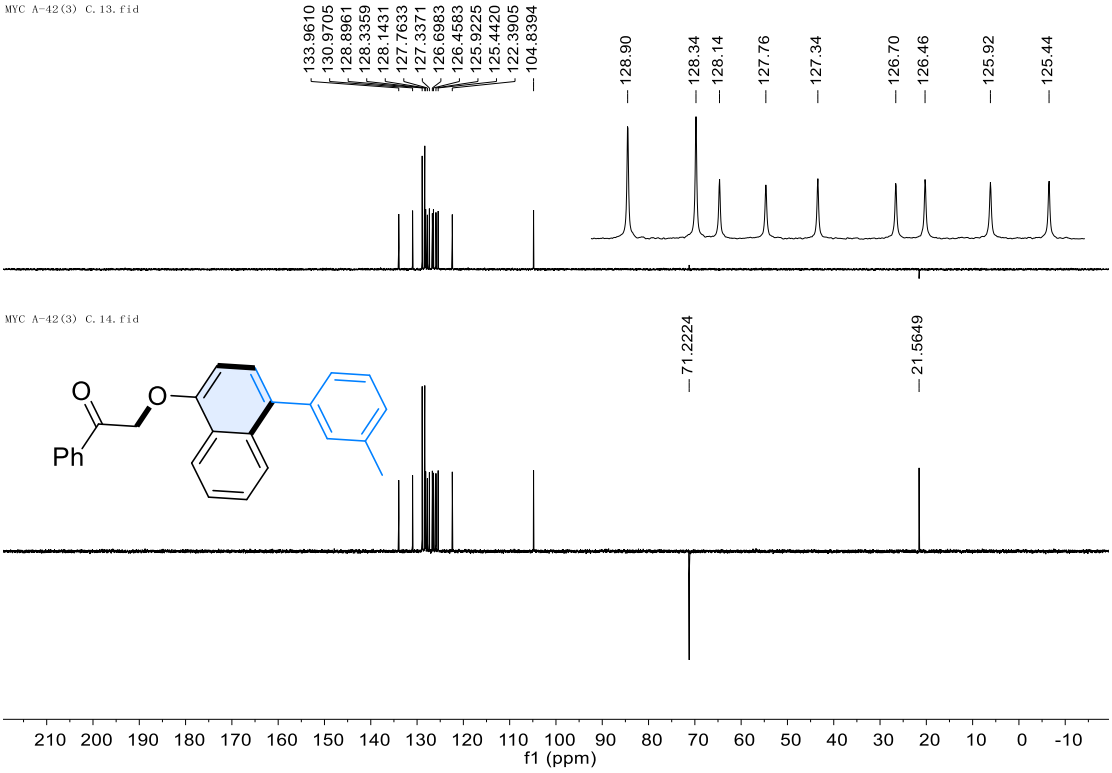
3e1, ^{1}H NMR (400 MHz, $CDCl_3$)



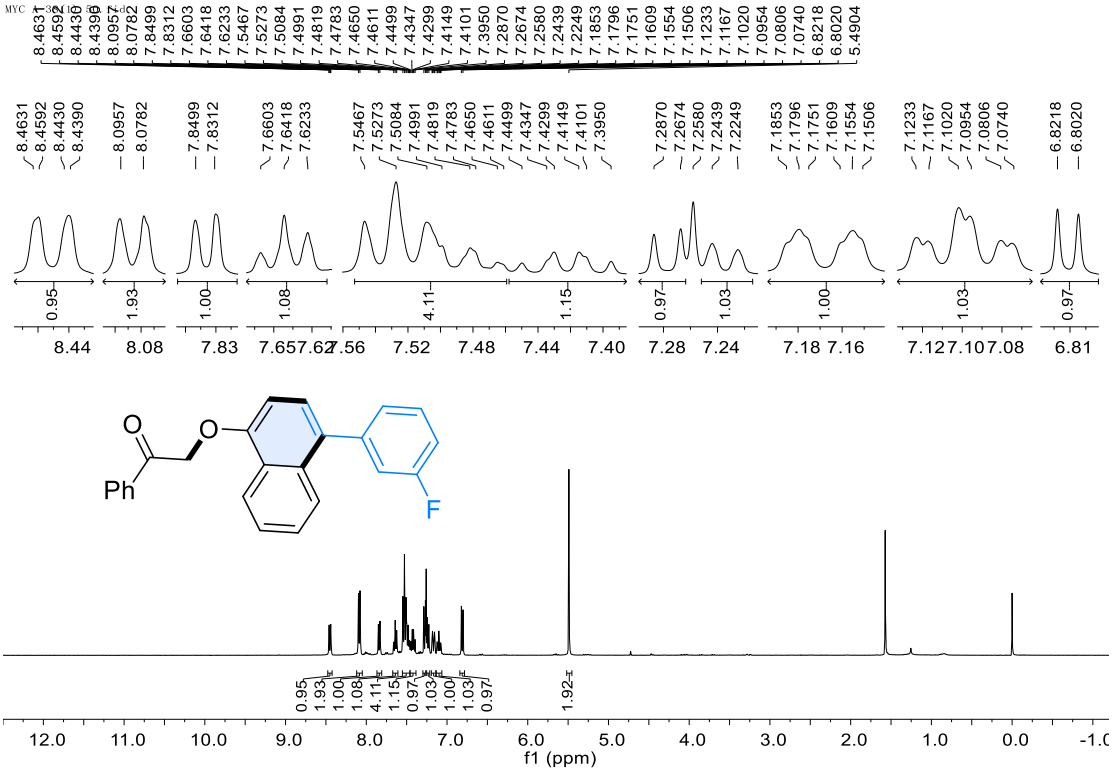
3e1, ^{13}C NMR (101 MHz, $CDCl_3$)



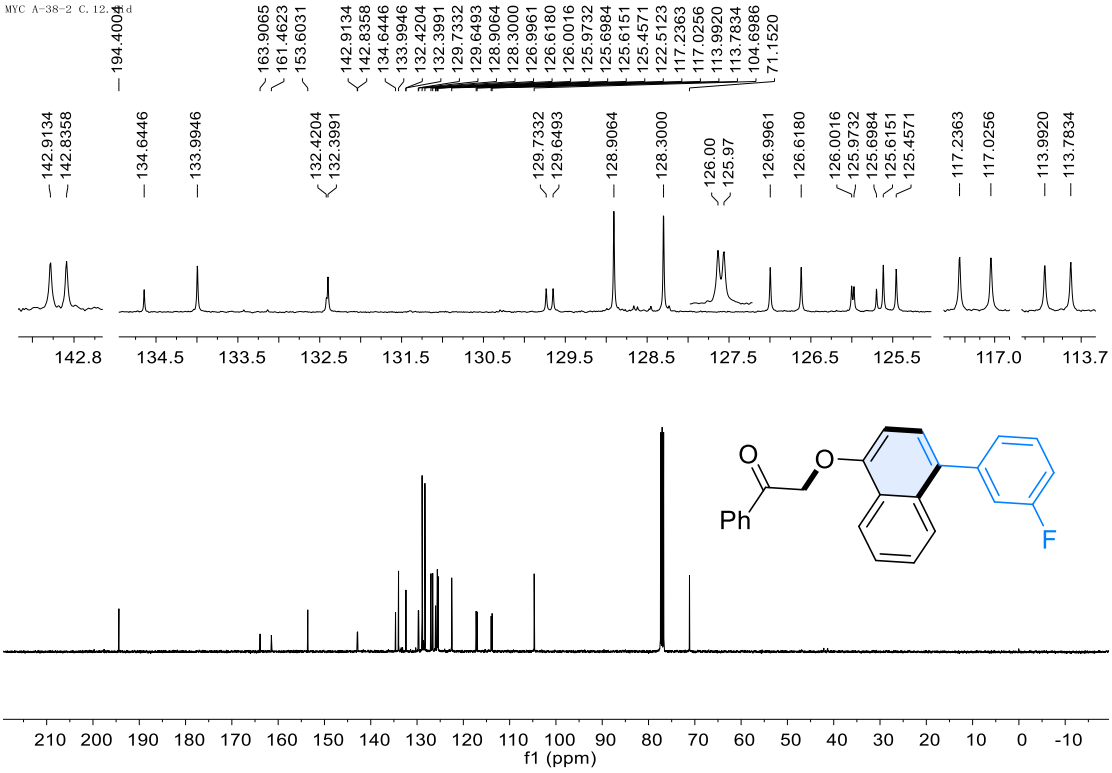
3e1, DEPT 90 and DEPT 135 (101 MHz, $CDCl_3$)



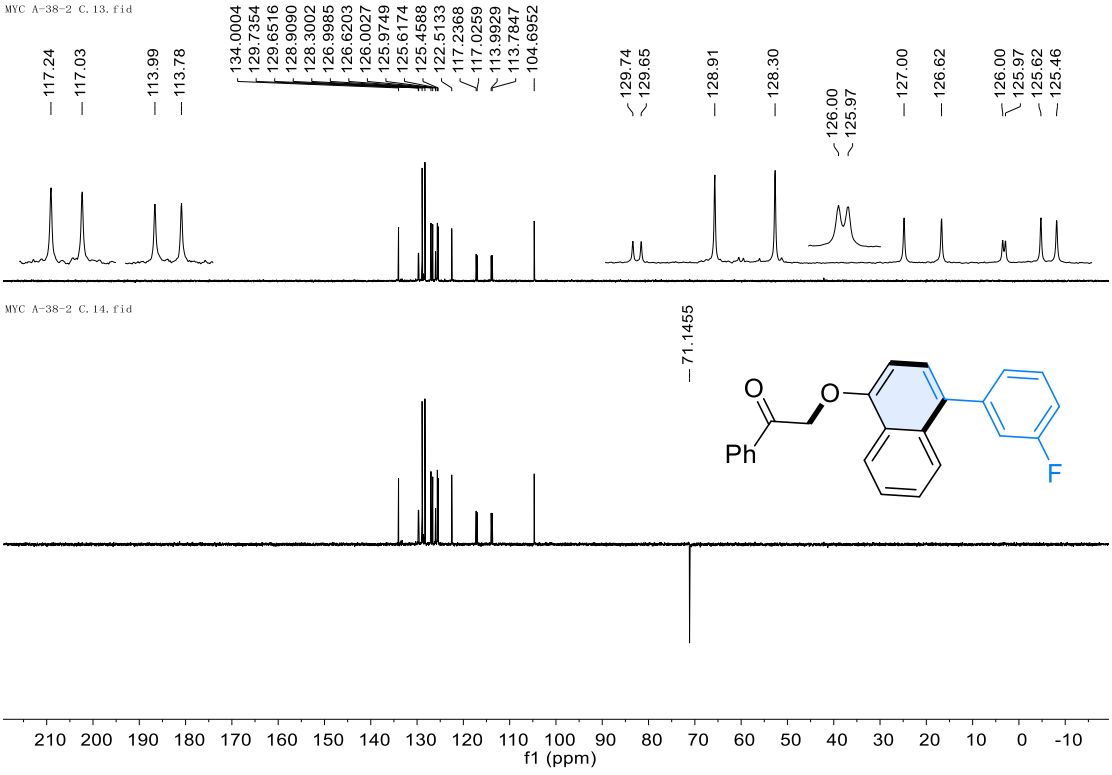
3e2, ^{1}H NMR (400 MHz, $CDCl_3$)



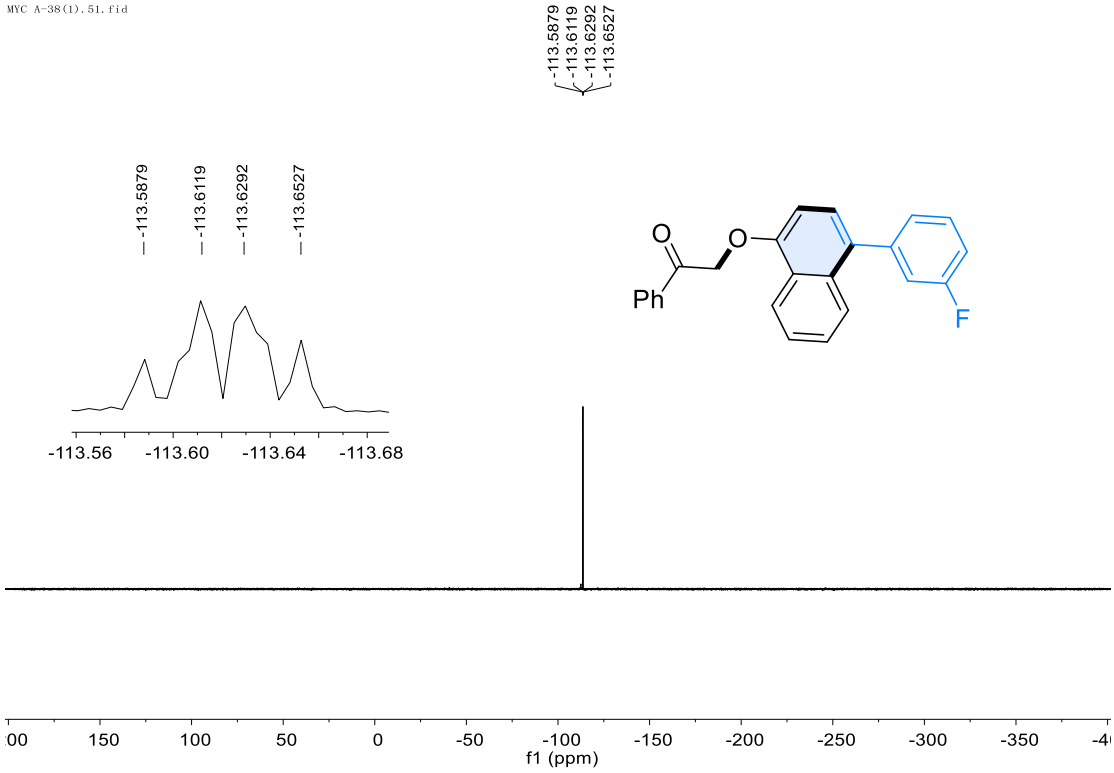
3e2, ^{13}C NMR (101 MHz, $CDCl_3$)



3e2, DEPT 90 and DEPT 135 (101 MHz, $CDCl_3$)



3e2, ^{19}F NMR (376 MHz, $CDCl_3$)



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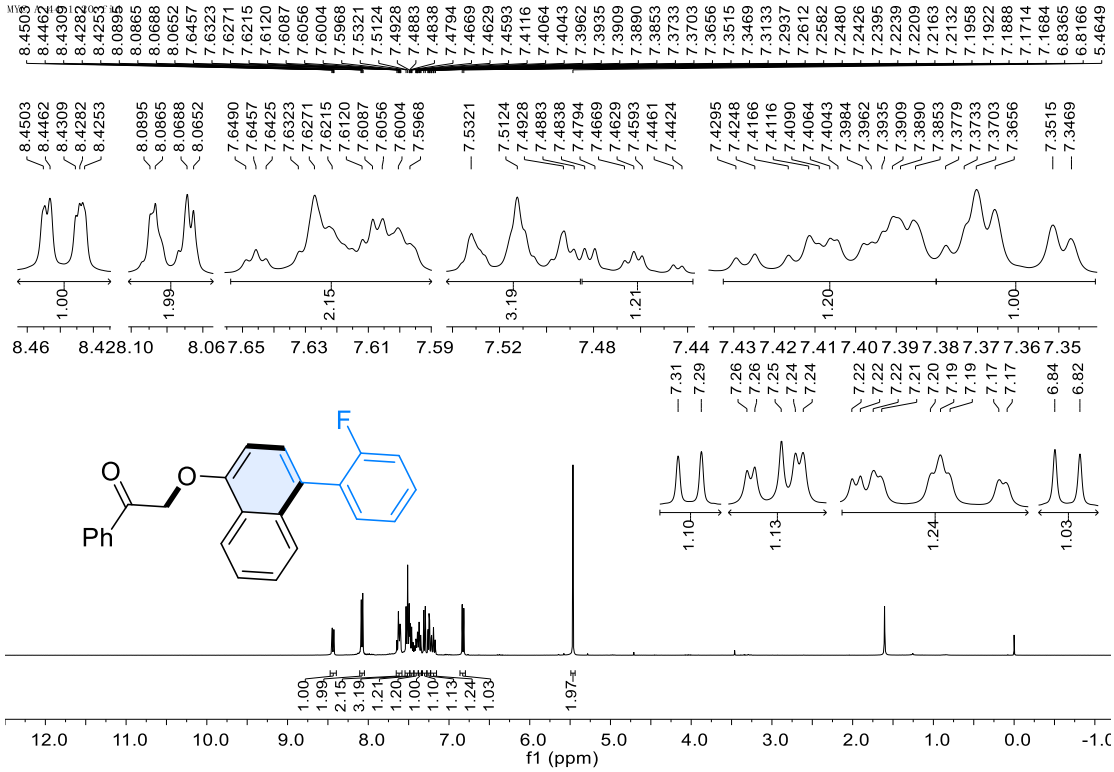
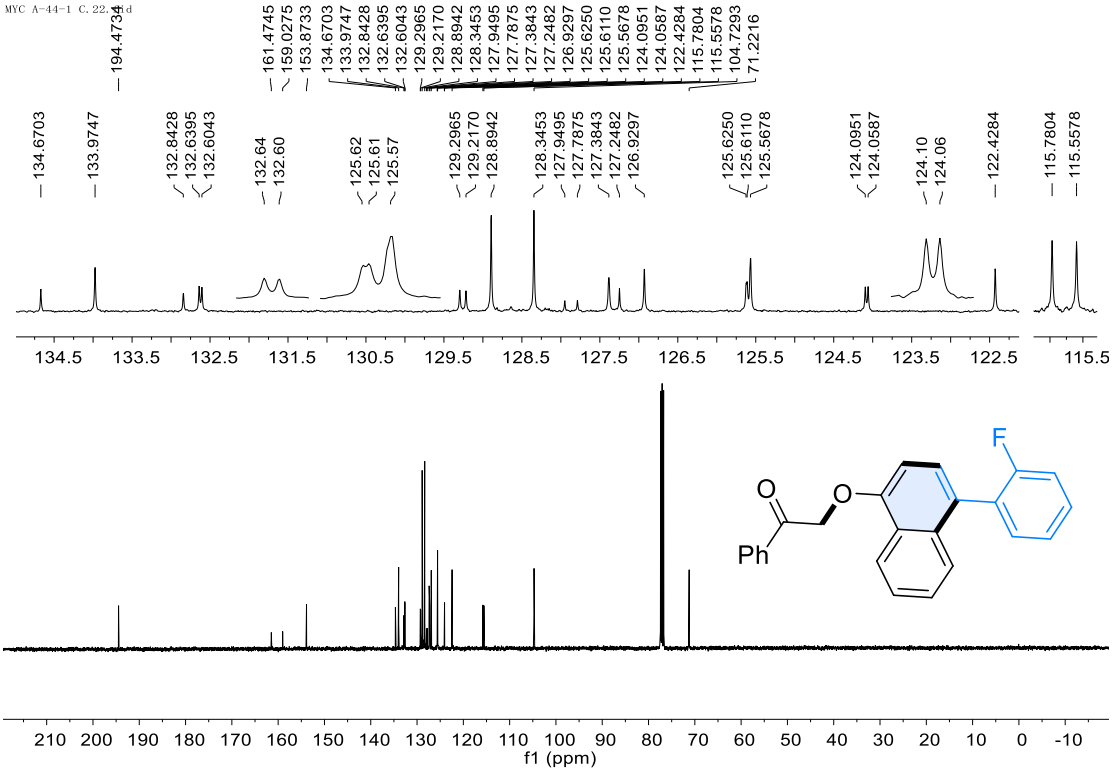
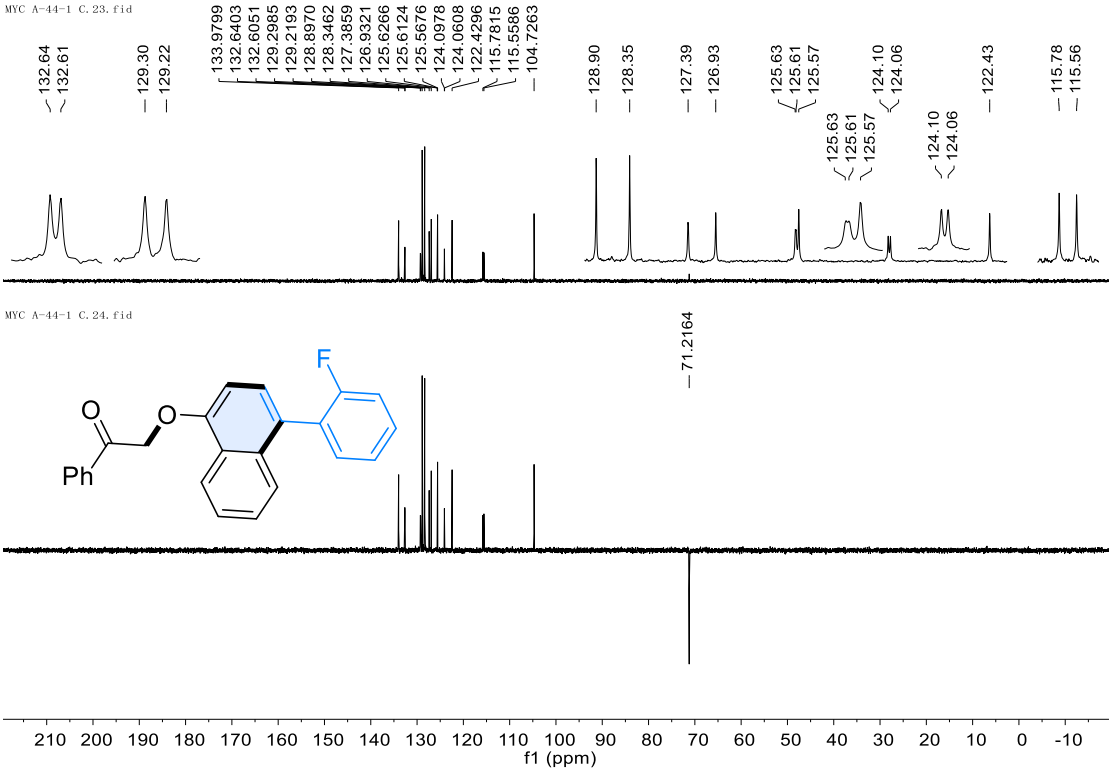


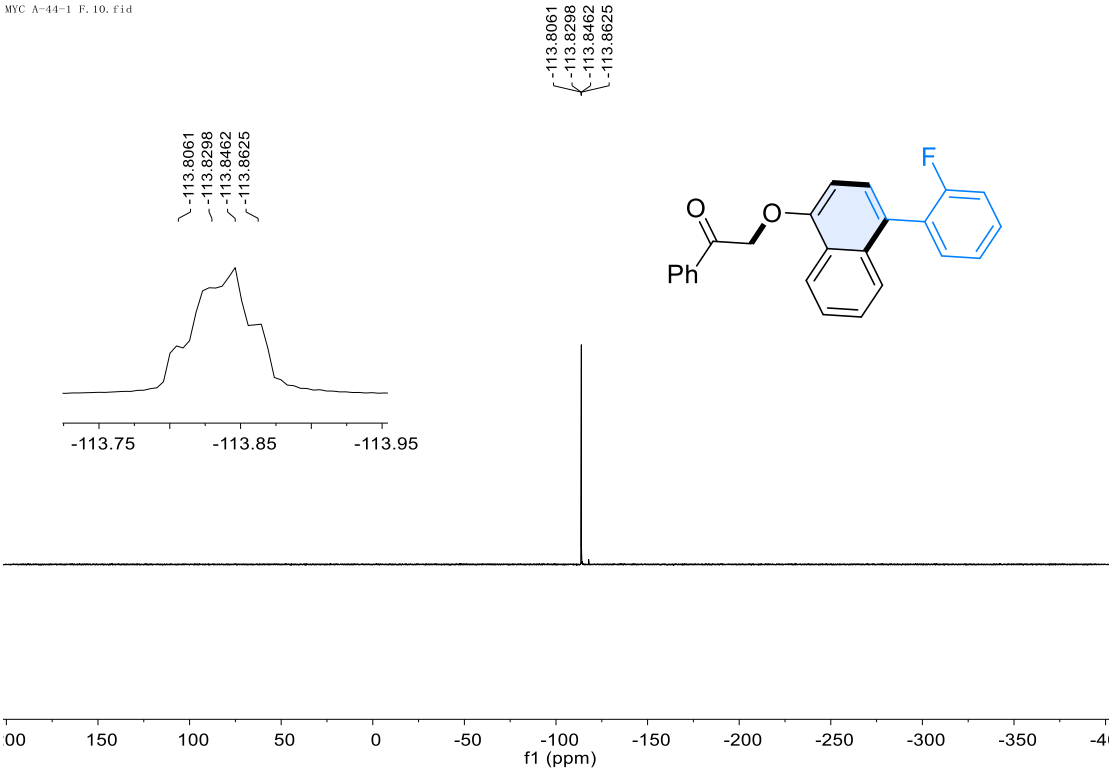
3f1, ^{13}C NMR (101 MHz, $CDCl_3$)



3f1, DEPT 90 and DEPT 135 (101 MHz, $CDCl_3$)



3f1, ^{19}F NMR (376 MHz, $CDCl_3$)



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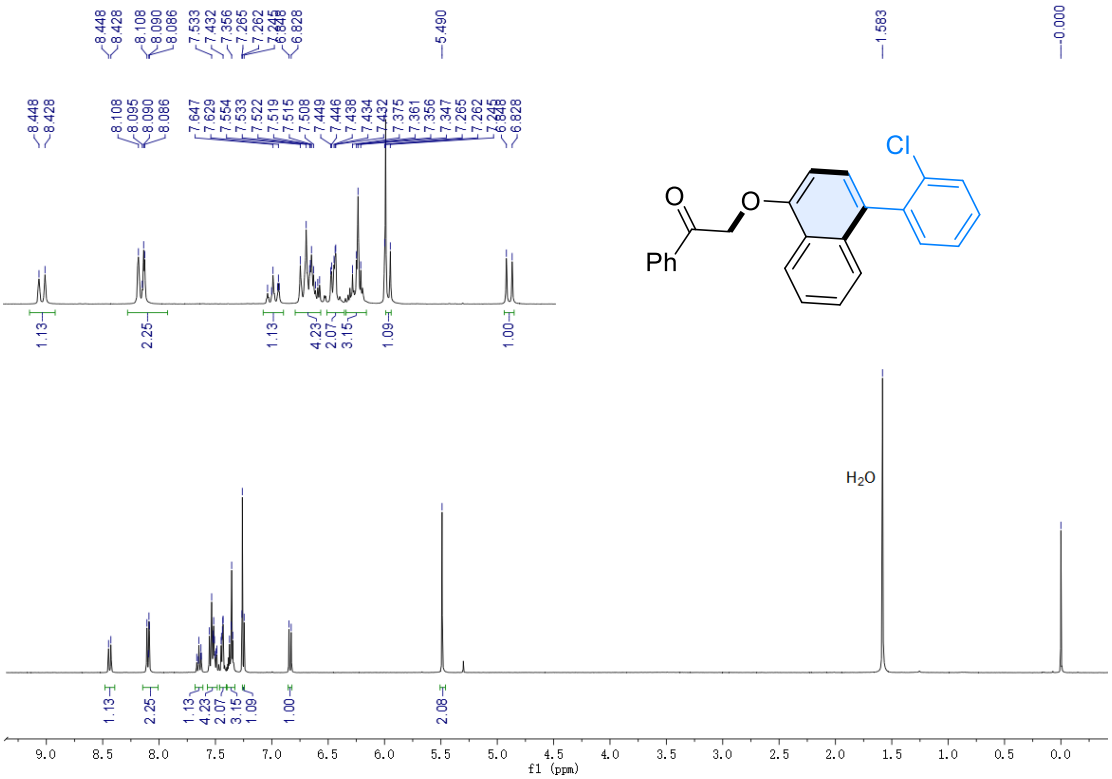

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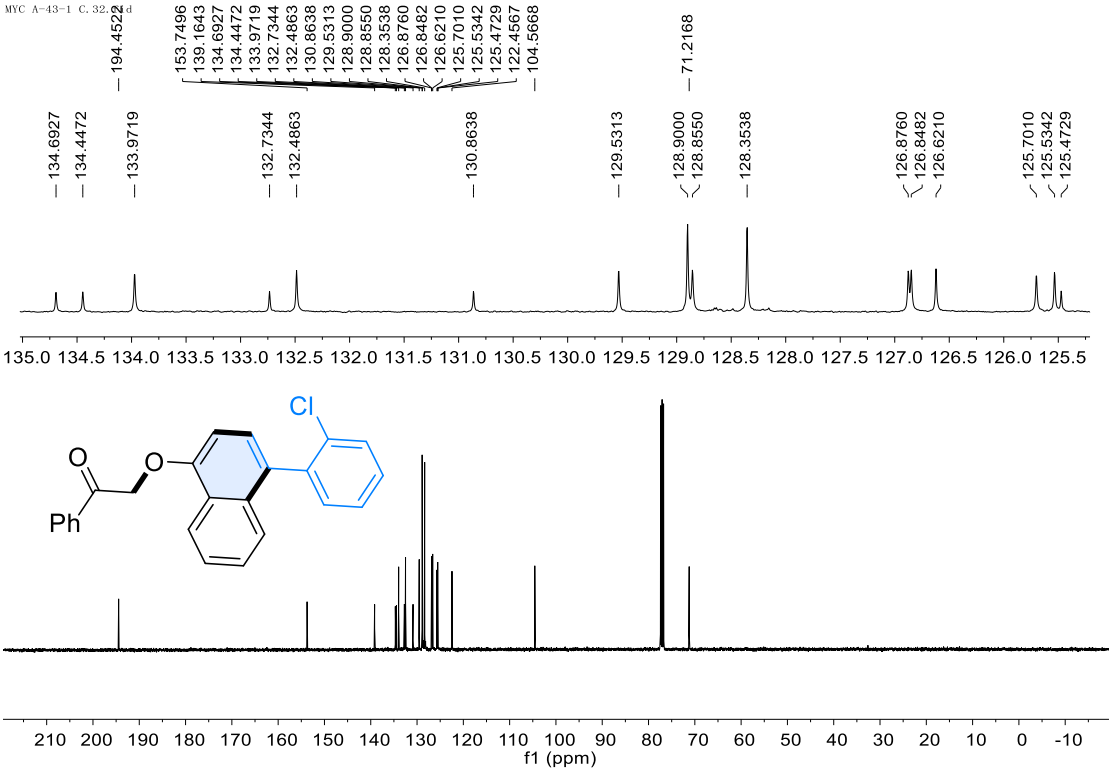
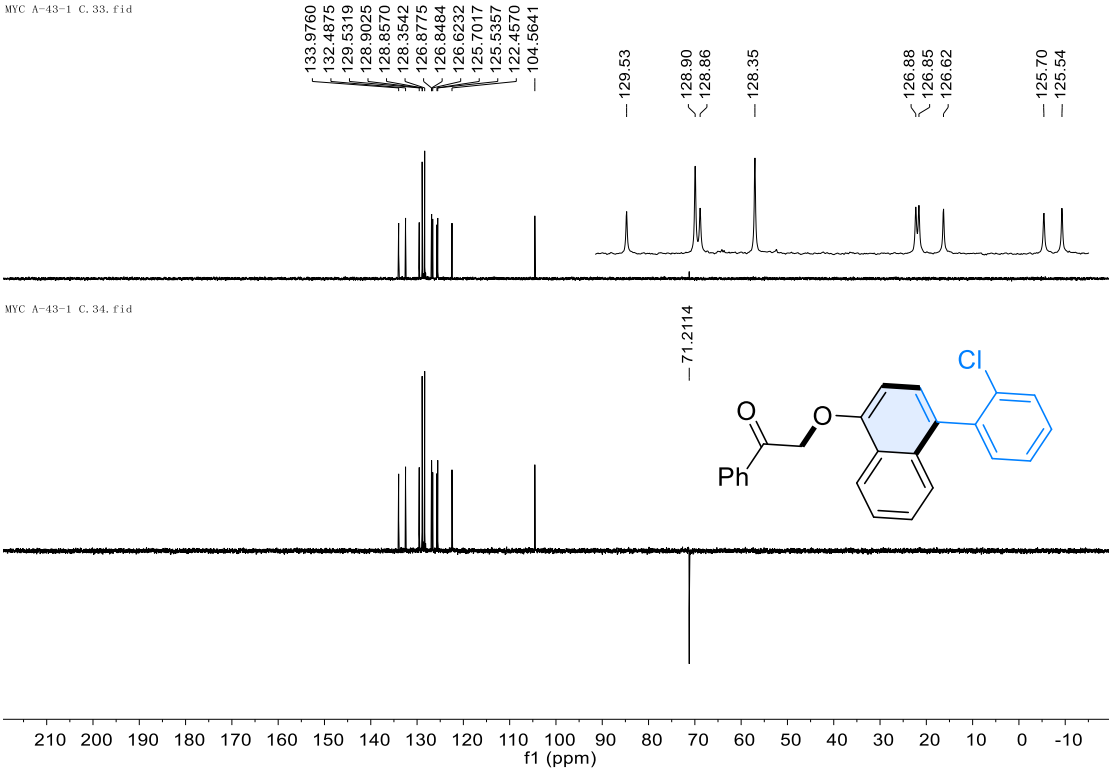
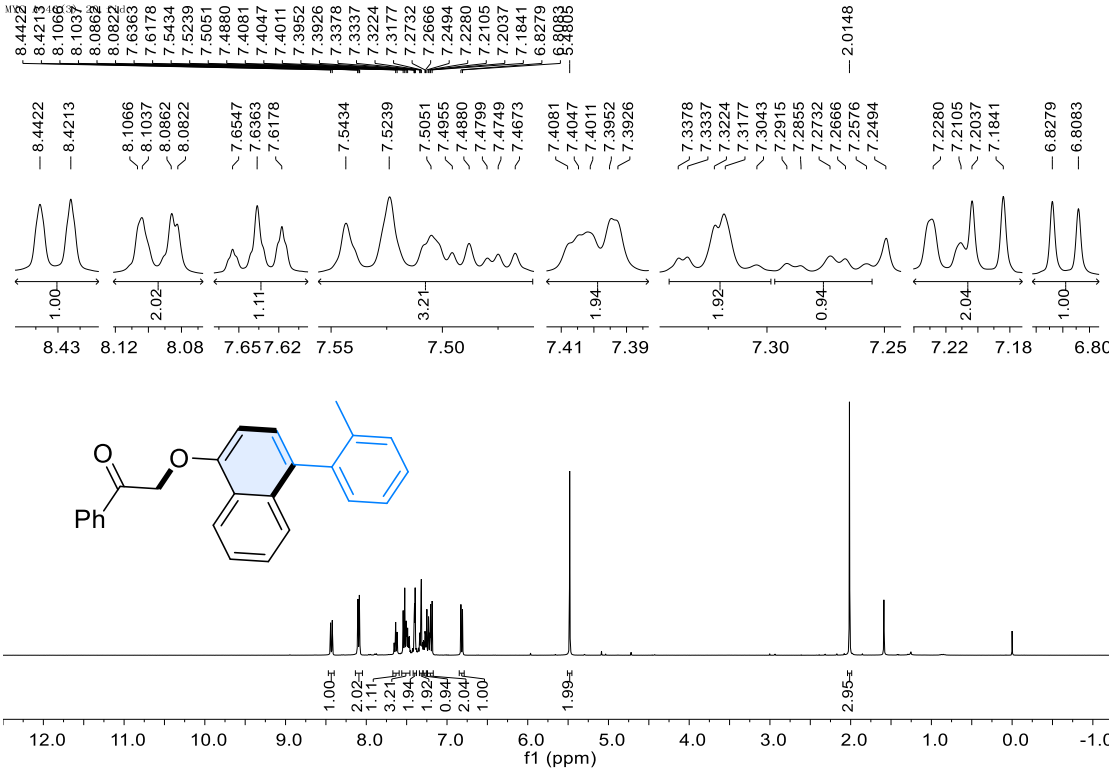


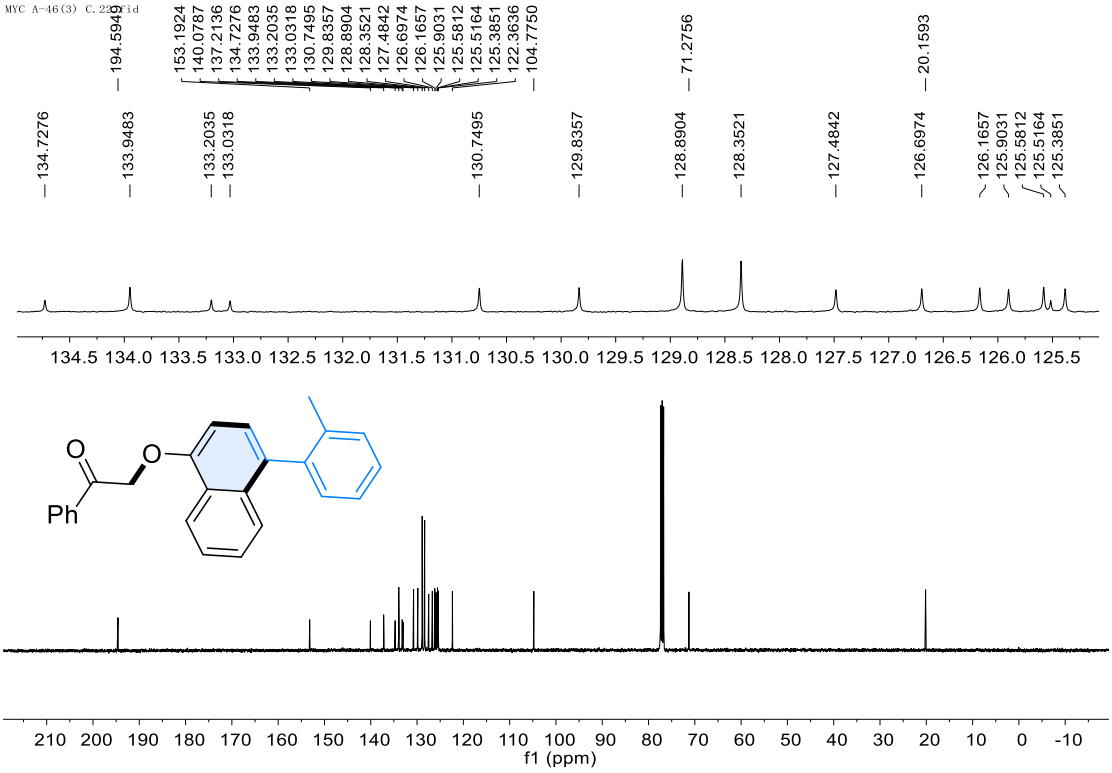
3f2, DEPT 90 and DEPT 135 (101 MHz, $CDCl_3$)



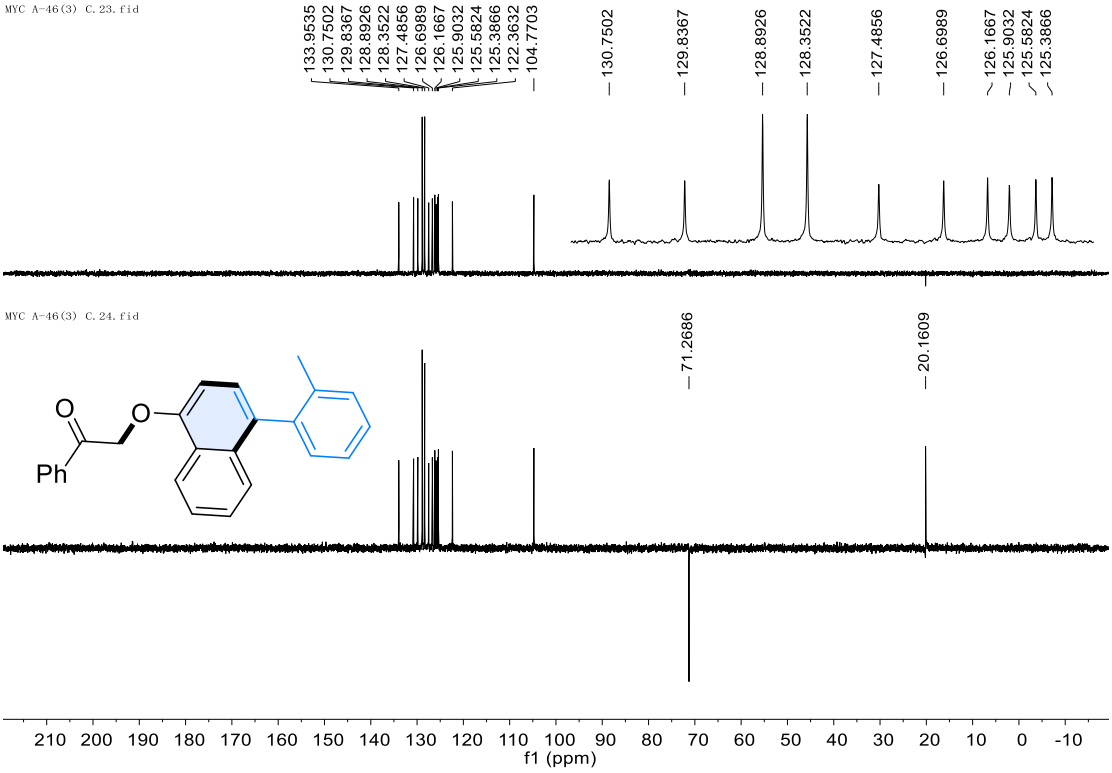
3f3, ^{1}H NMR (400 MHz, $CDCl_3$)



3f3, ^{13}C NMR (101 MHz, $CDCl_3$)



3f3, DEPT 90 and DEPT 135 (101 MHz, $CDCl_3$)



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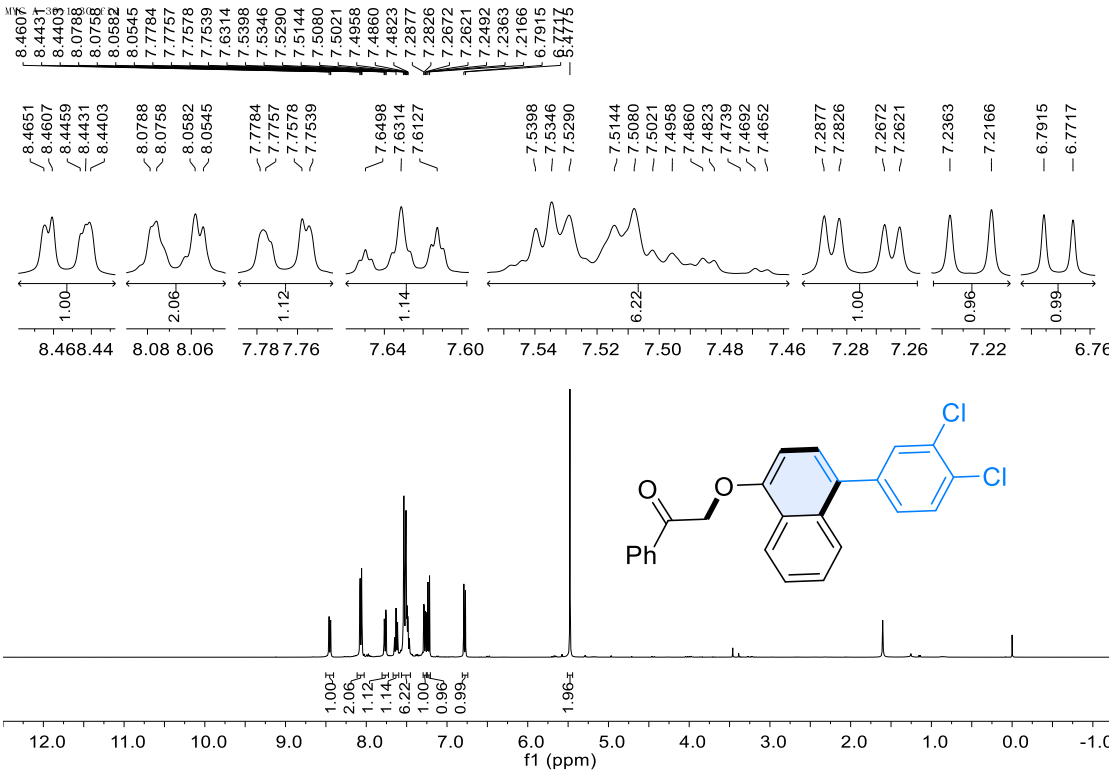
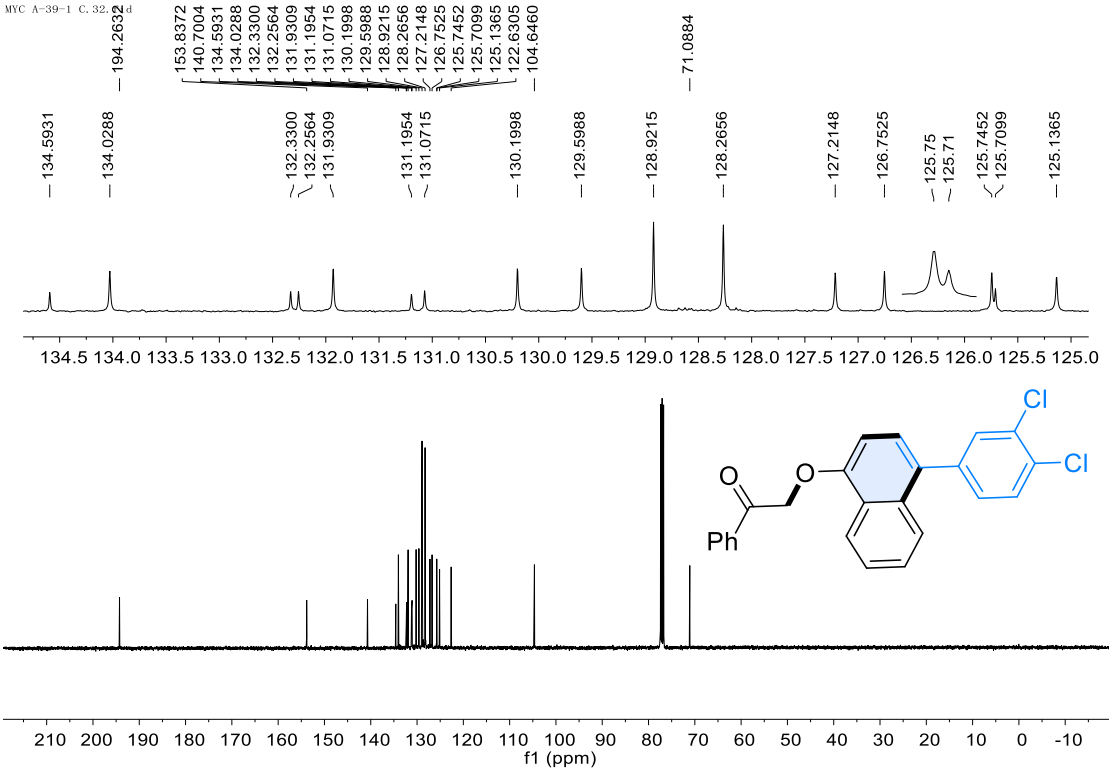
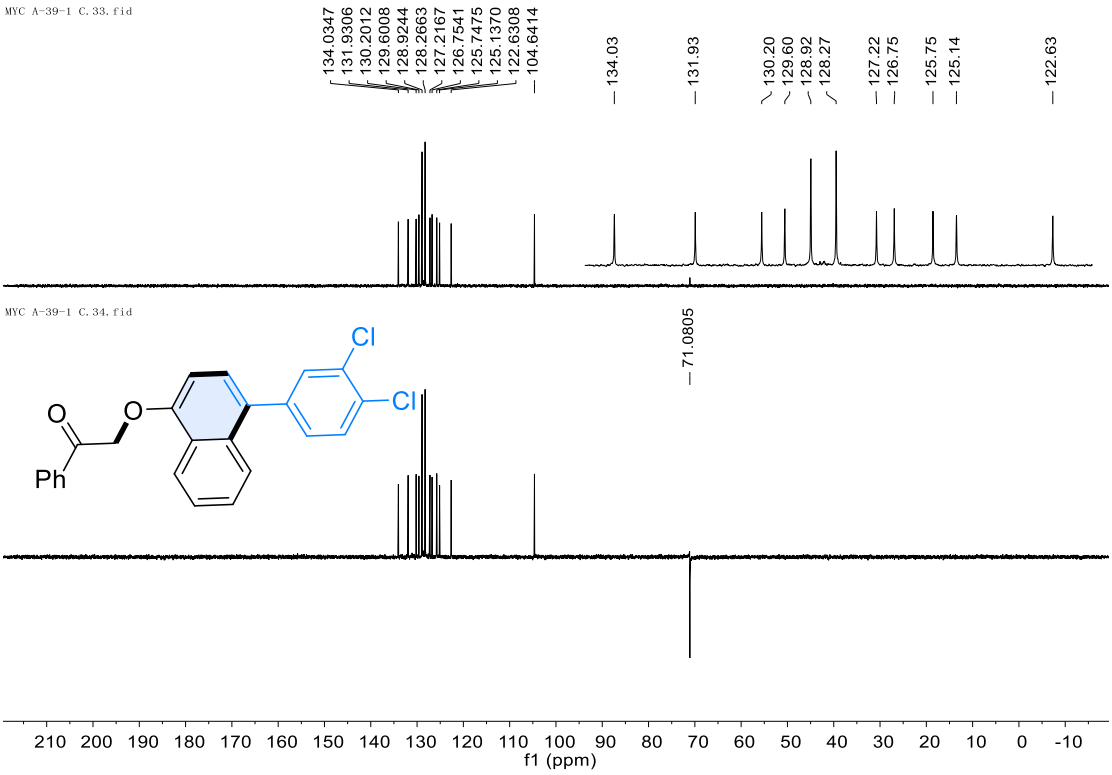


3g, ^{13}C NMR (101 MHz, $CDCl_3$)



3g, DEPT 90 and DEPT 135 (101 MHz, $CDCl_3$)



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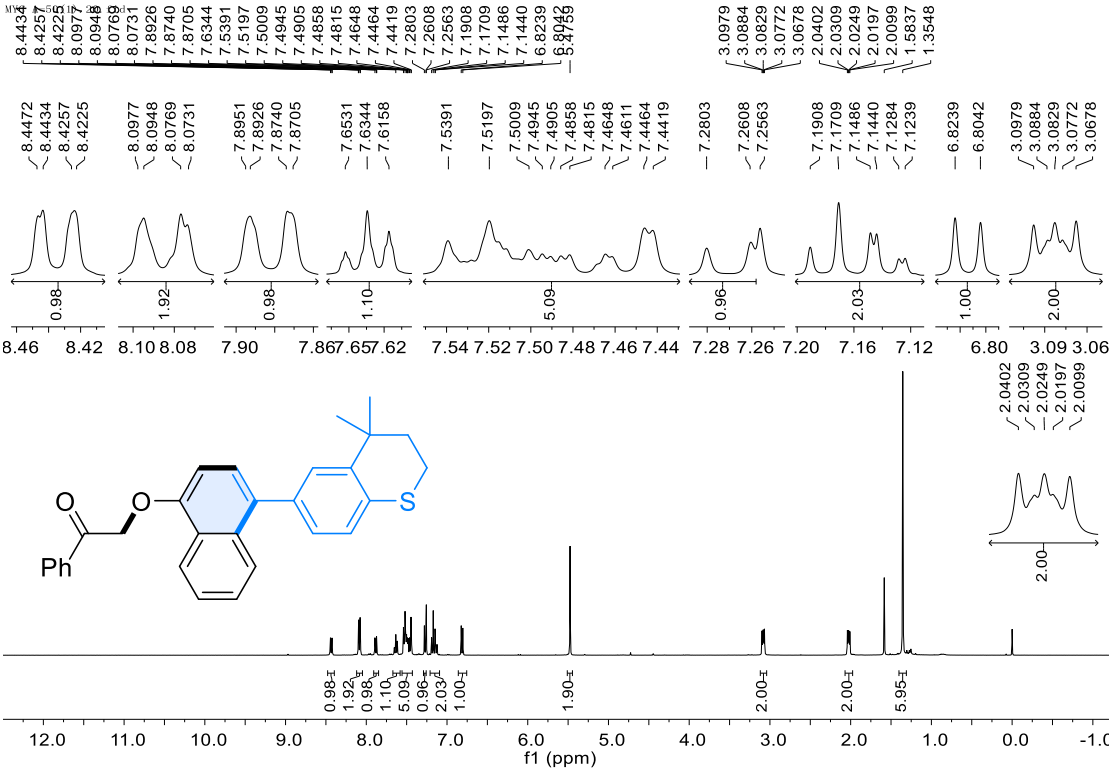
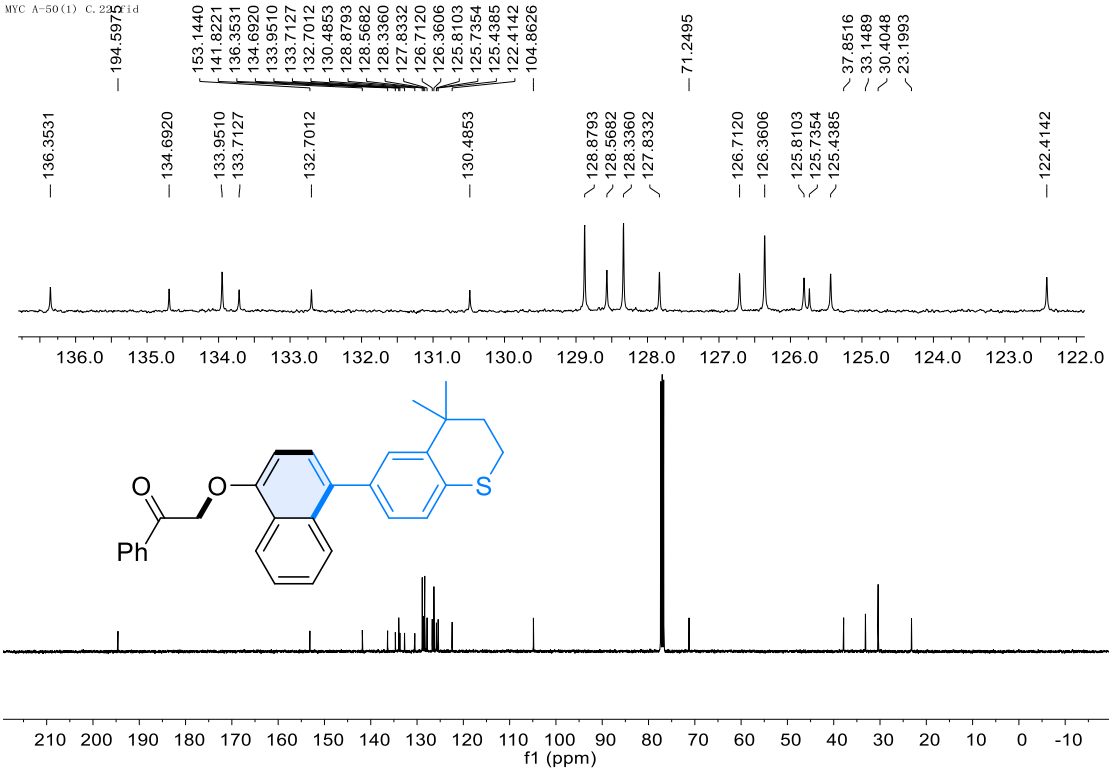
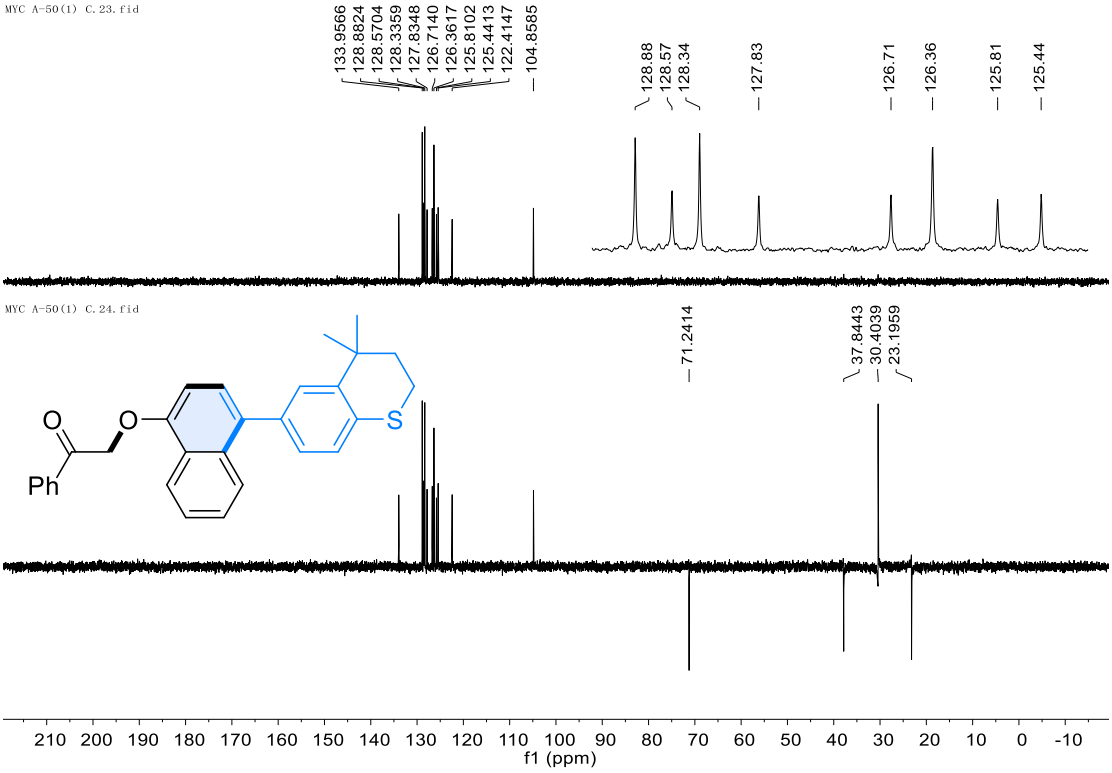


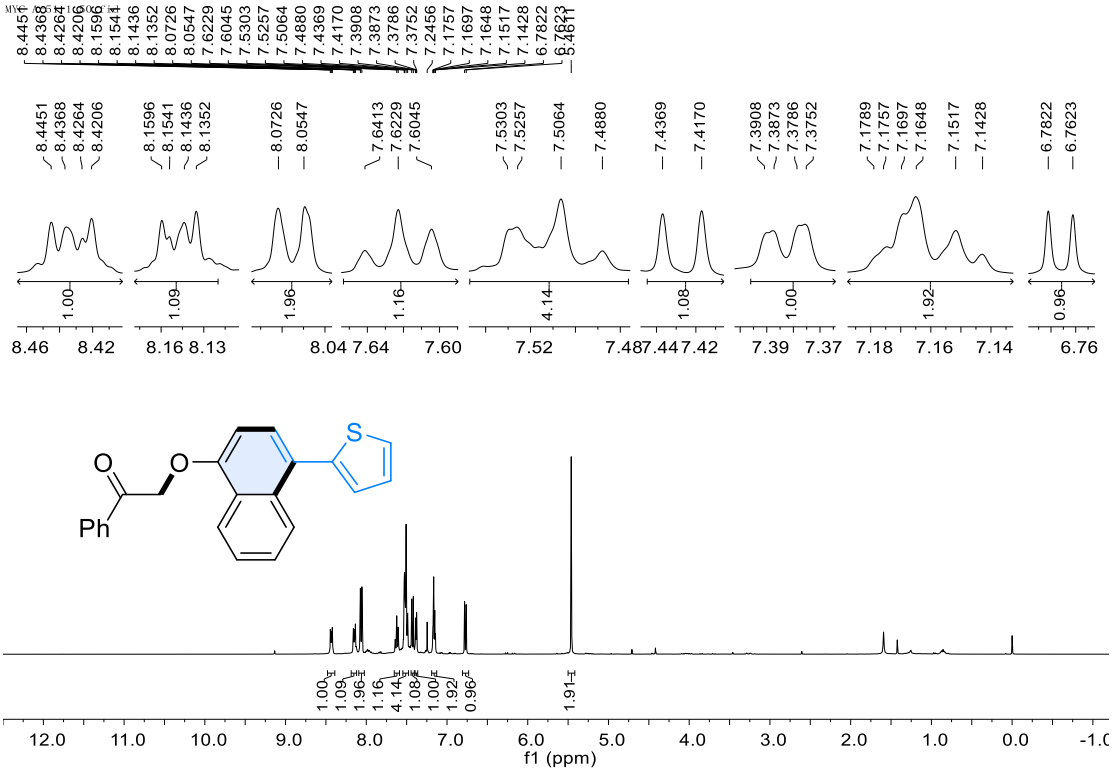
3h, ^{13}C NMR (101 MHz, $CDCl_3$)



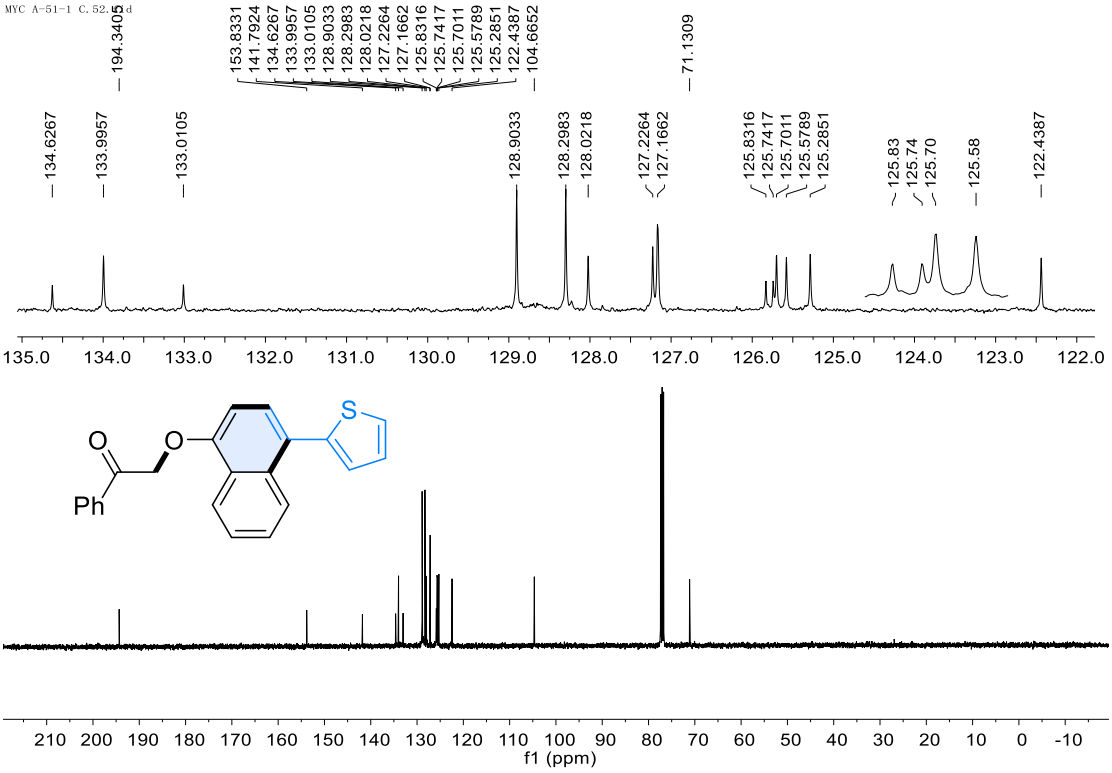
3h, DEPT 90 and DEPT 135 (101 MHz, $CDCl_3$)



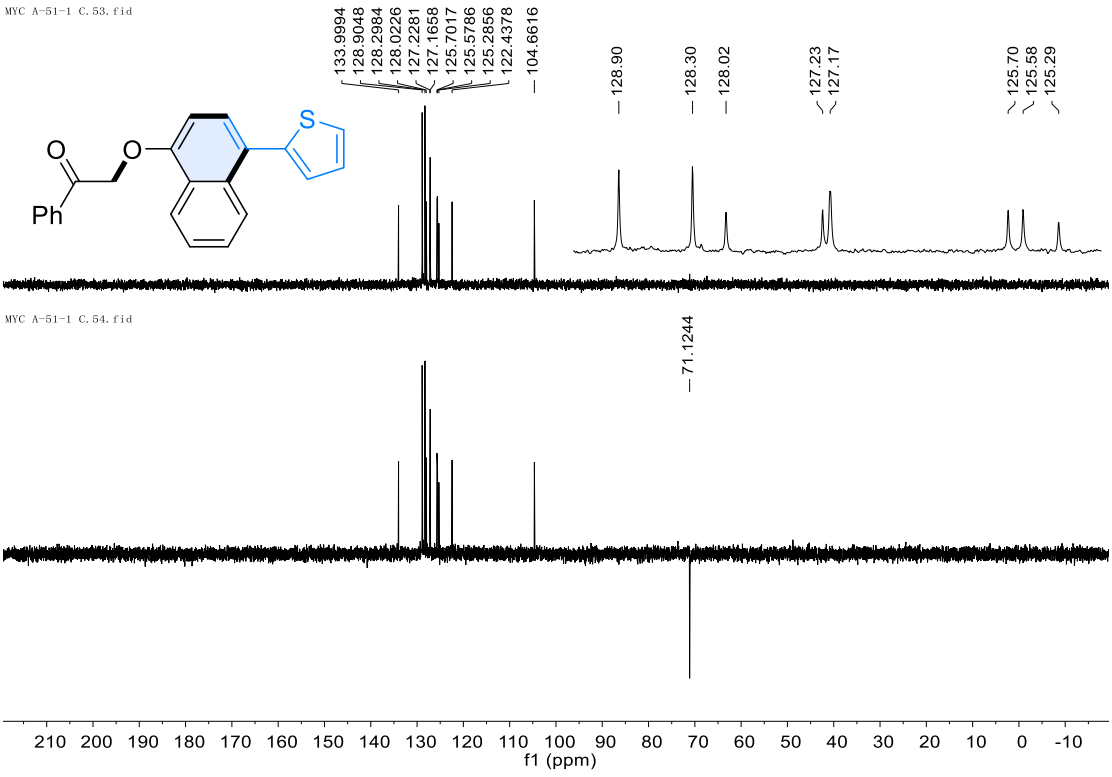
3i, ^{1}H NMR (400 MHz, $CDCl_3$)



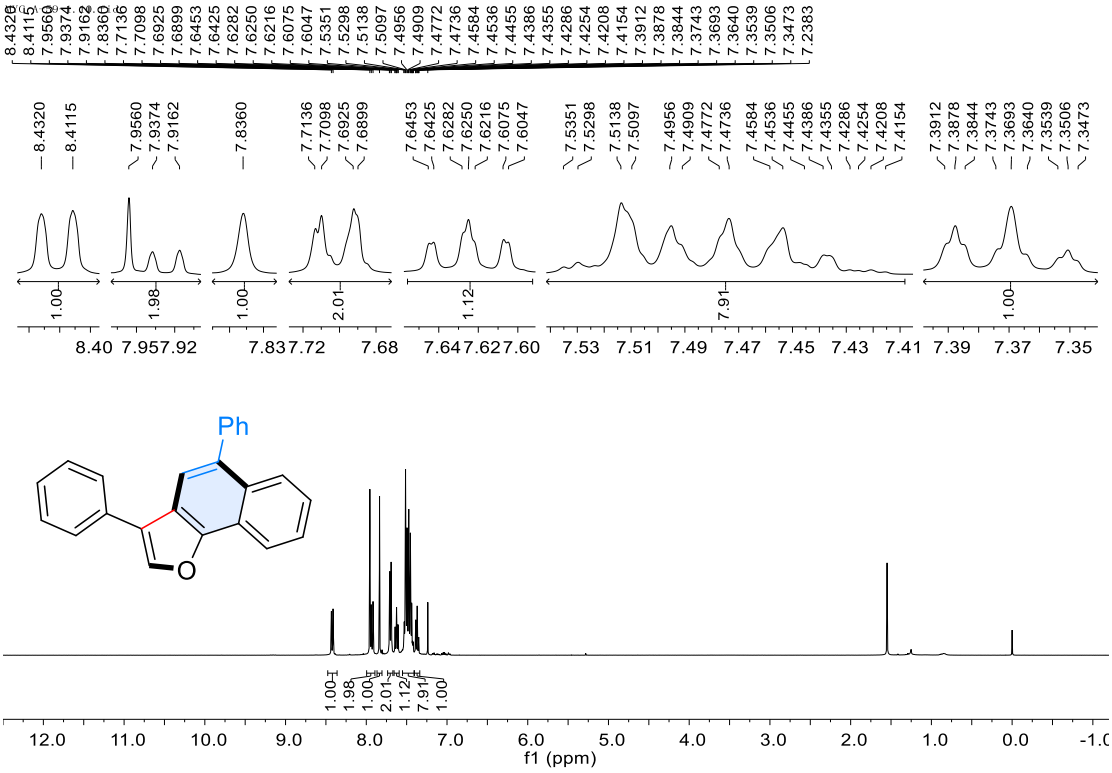
3i, ^{13}C NMR (101 MHz, $CDCl_3$)



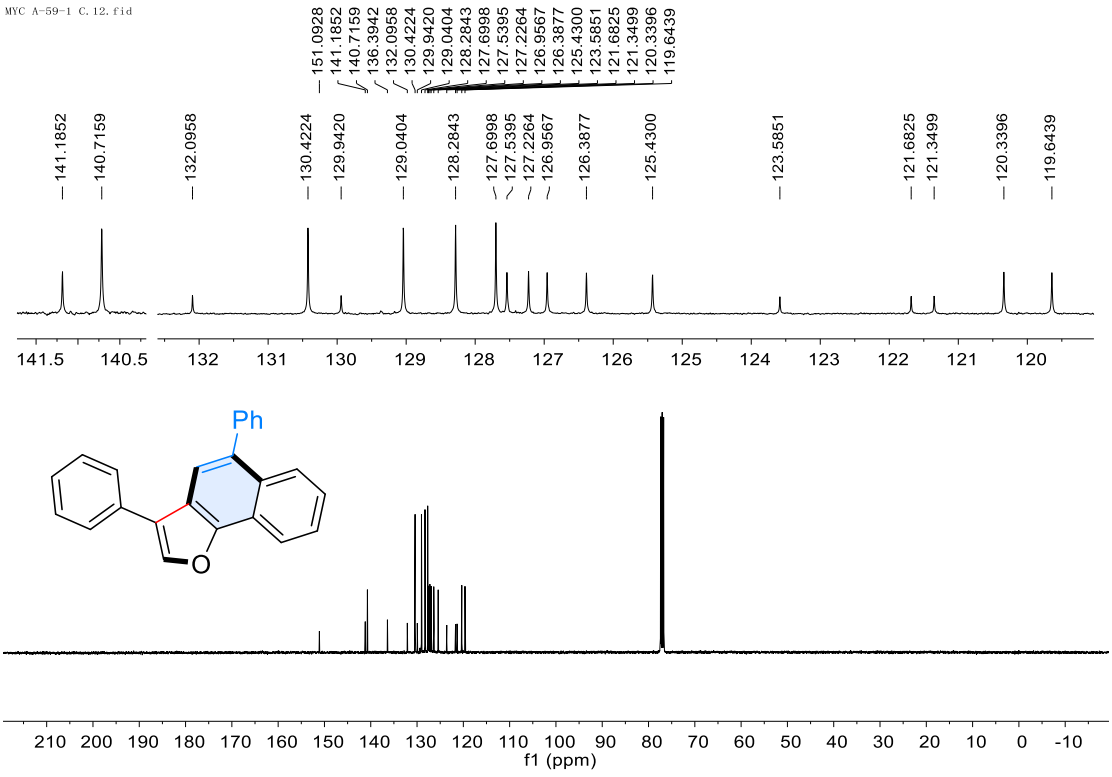
3i, DEPT 90 and DEPT 135 (101 MHz, $CDCl_3$)



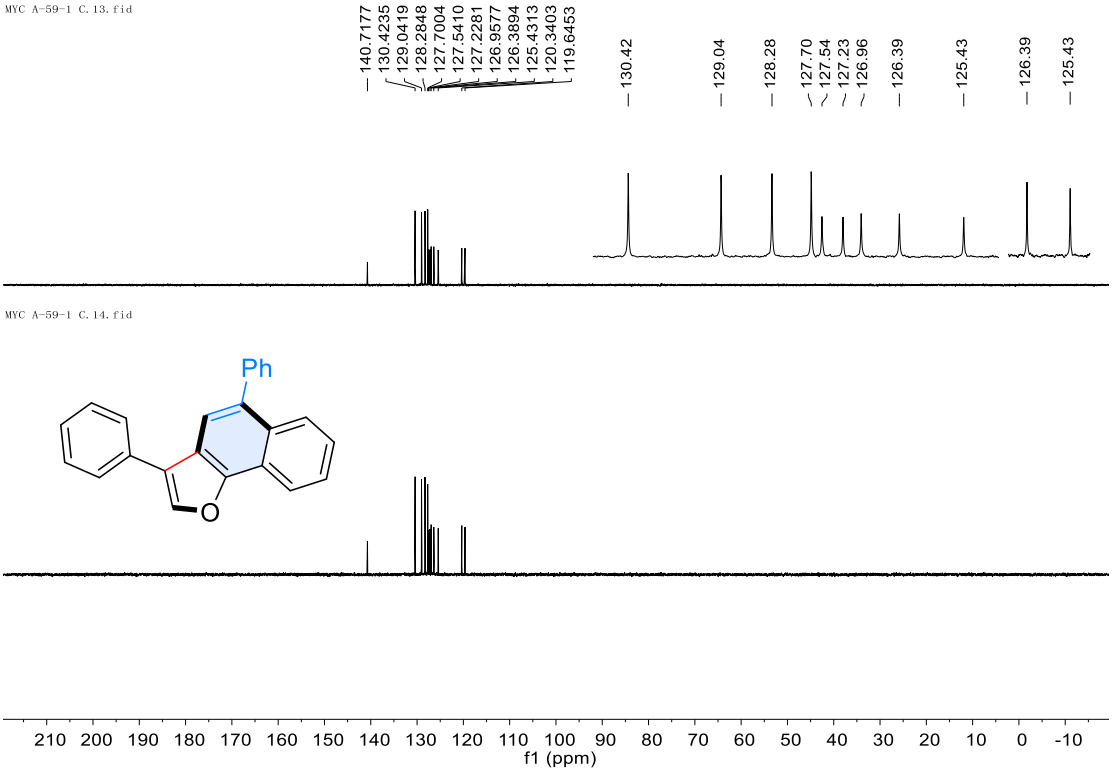
4, ^{1}H NMR (400 MHz, $CDCl_3$)



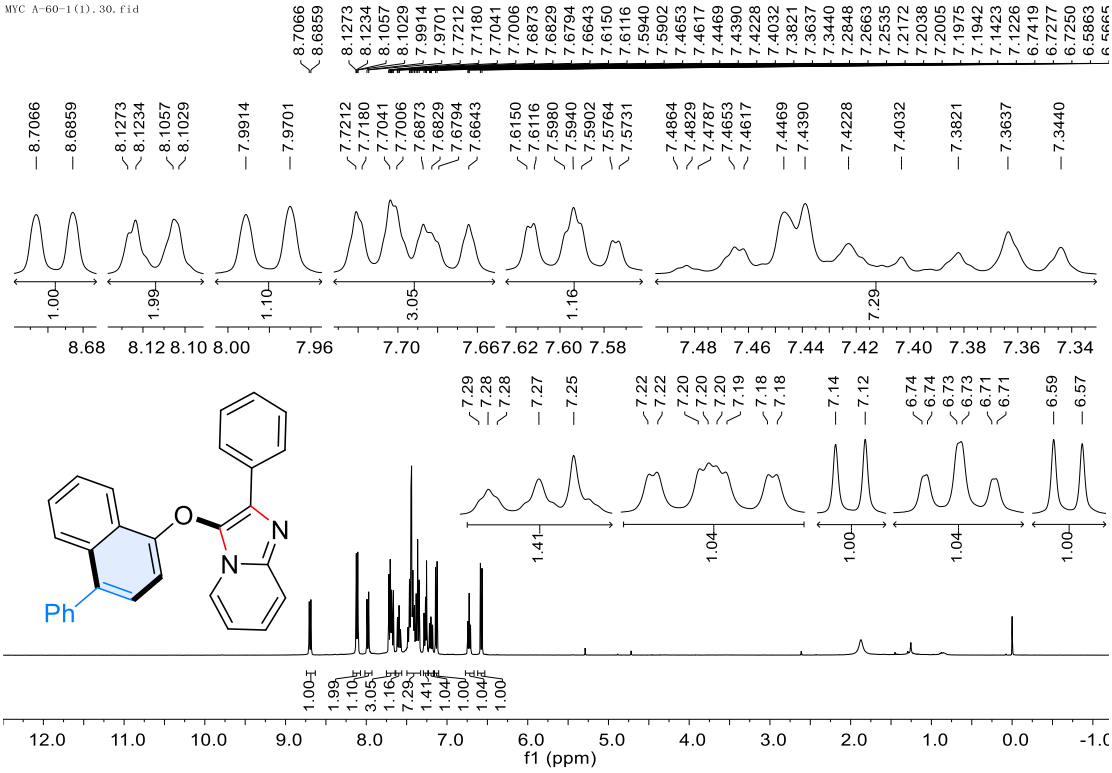
4, ^{13}C NMR (101 MHz, $CDCl_3$)



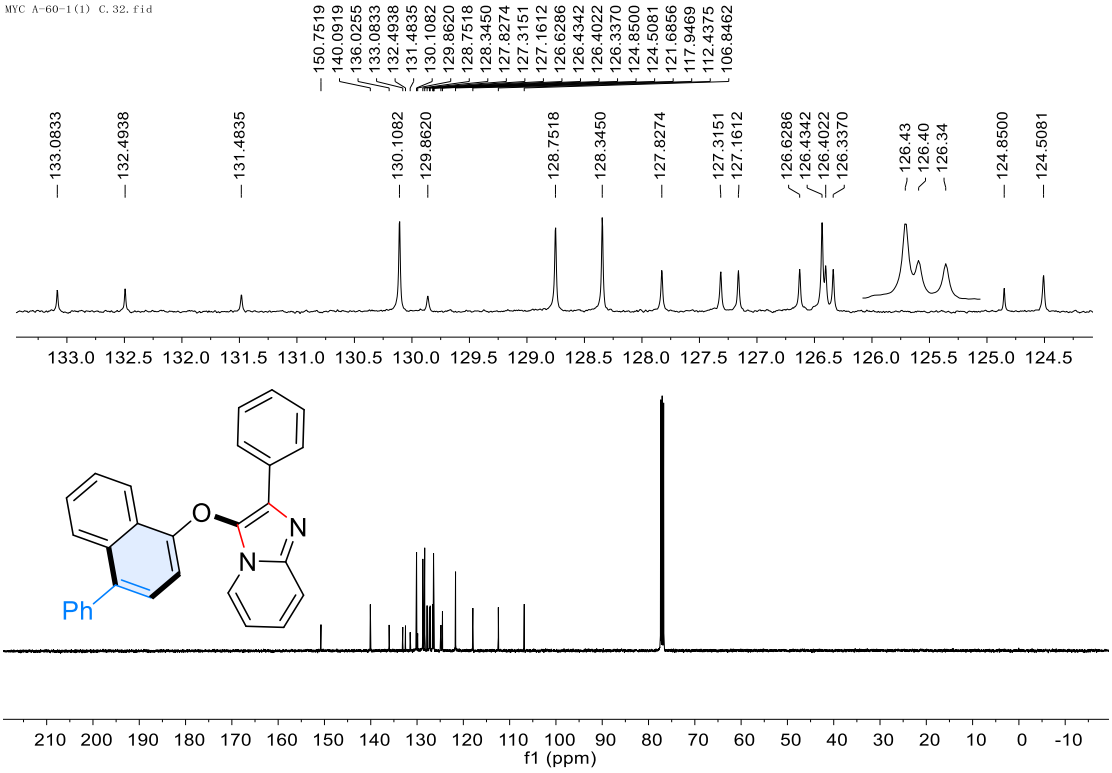
4, DEPT 90 and DEPT 135 (101 MHz, $CDCl_3$)



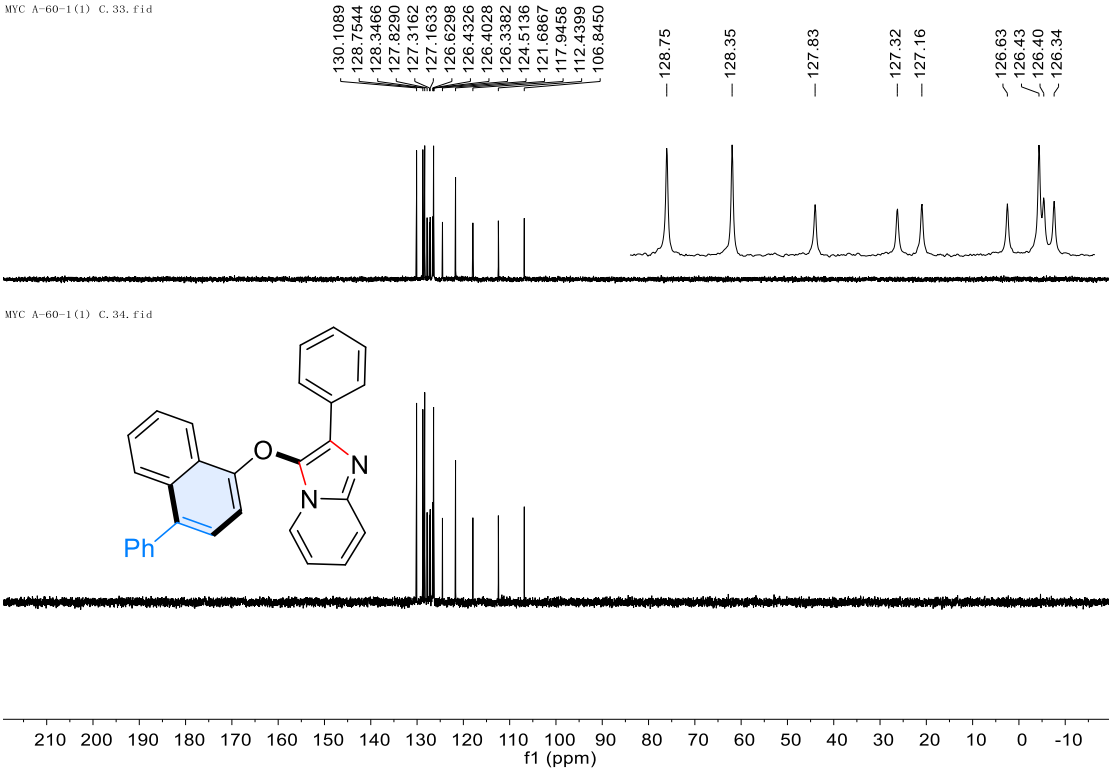
5, ^{1}H NMR (400 MHz, $CDCl_3$)



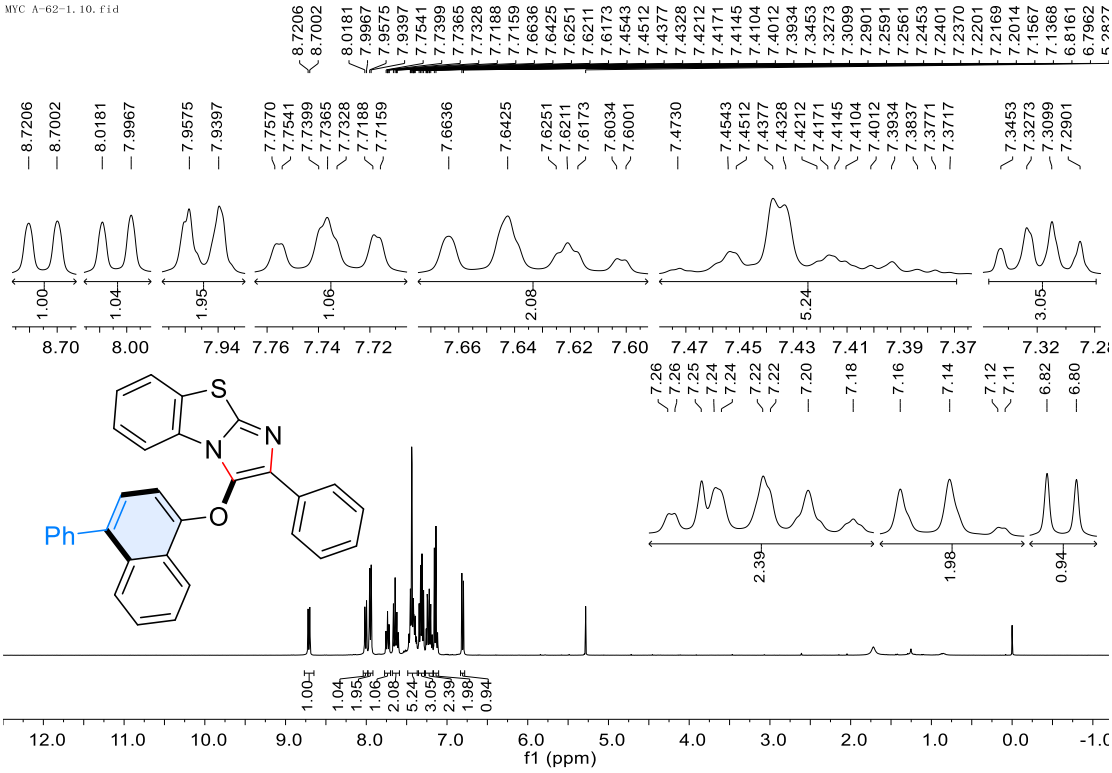
5, ^{13}C NMR (101 MHz, $CDCl_3$)



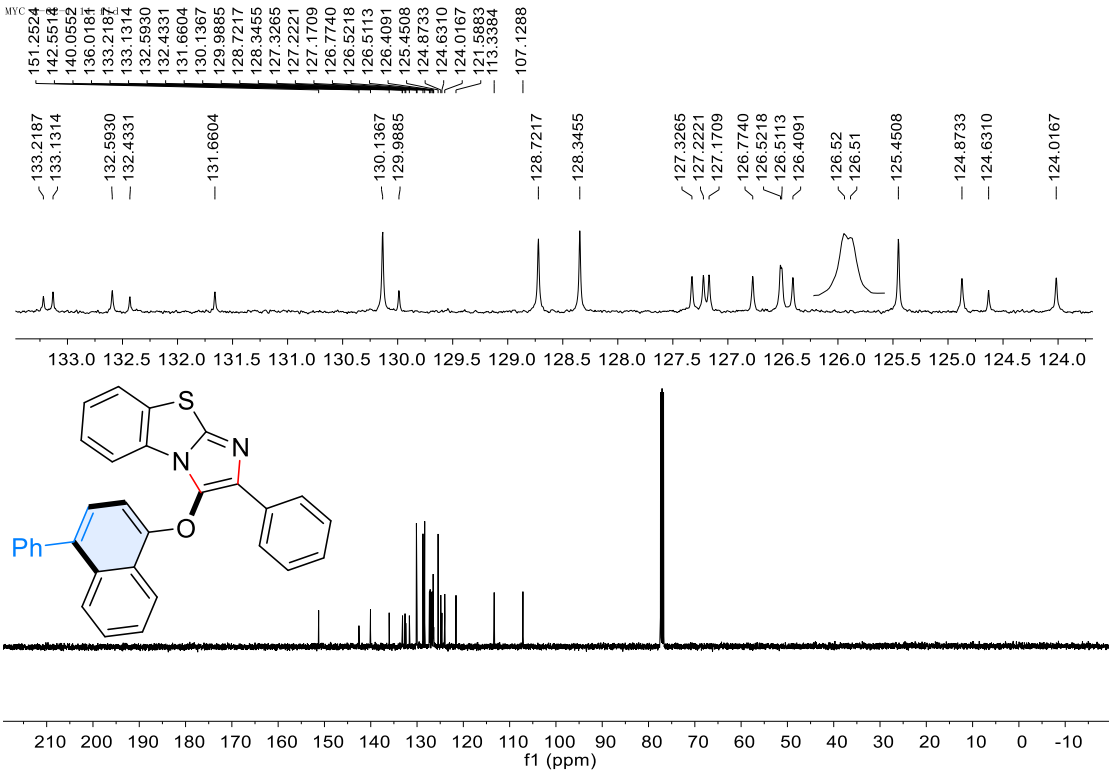
5, DEPT 90 and DEPT 135 (101 MHz, $CDCl_3$)



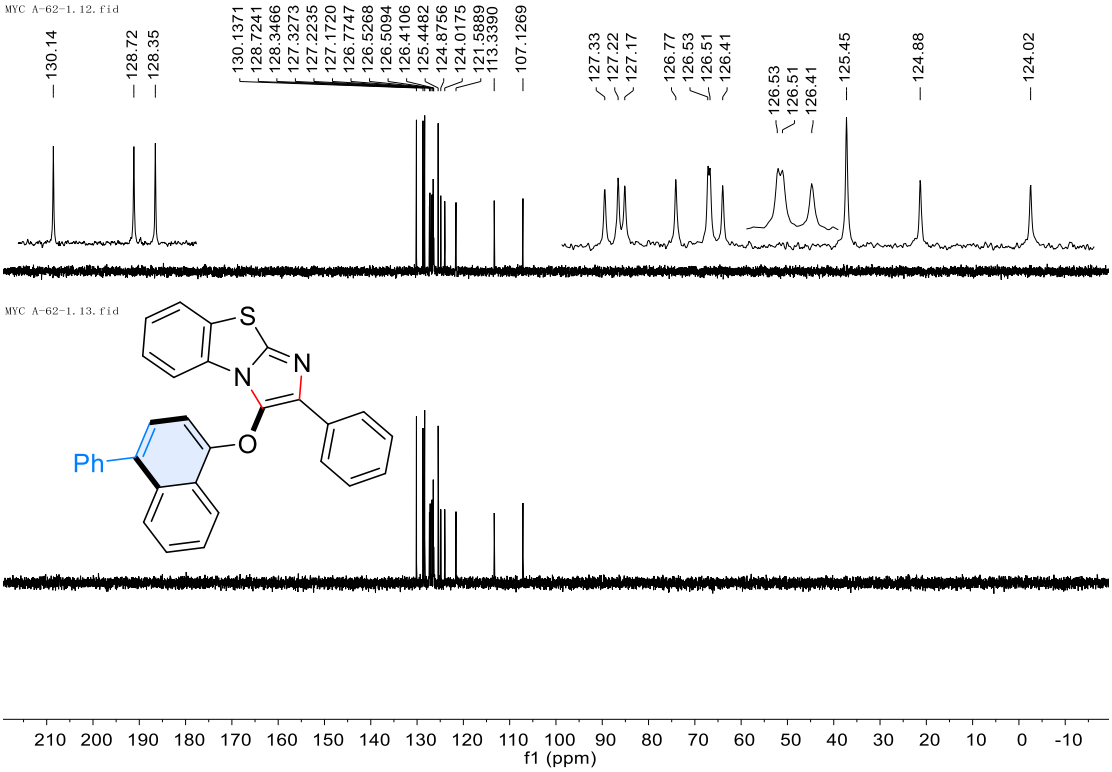
6, ^{1}H NMR (400 MHz, $CDCl_3$)



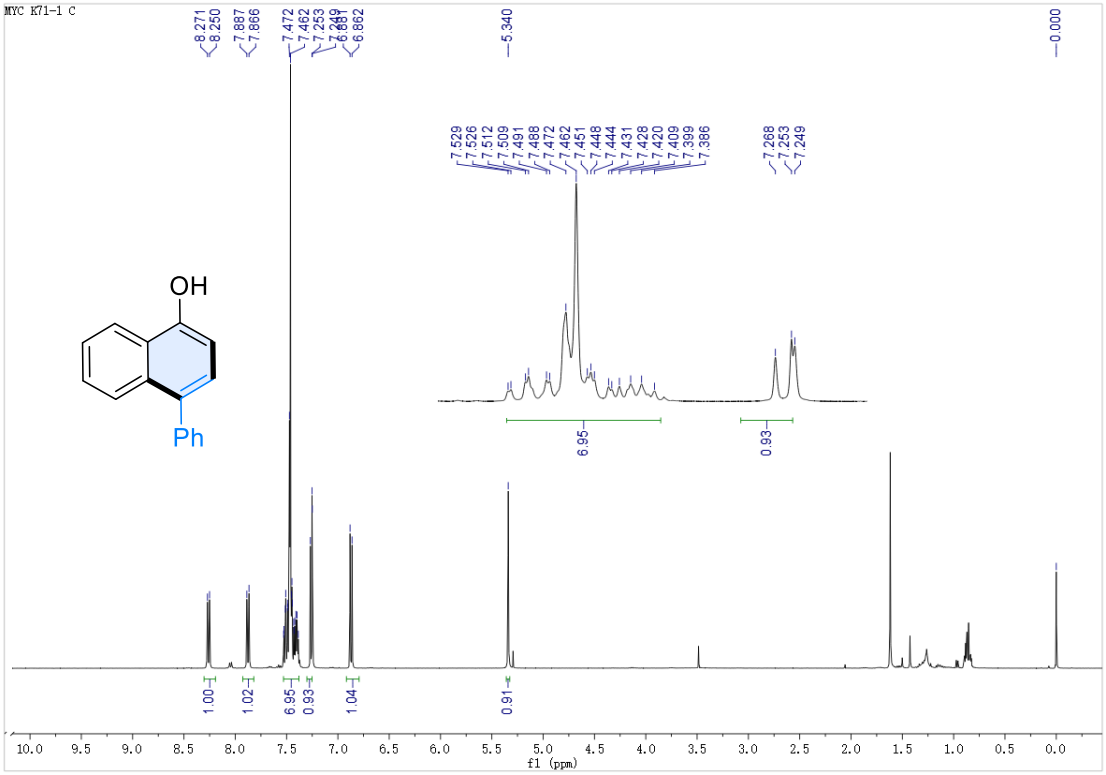
6, ^{13}C NMR (101 MHz, $CDCl_3$)



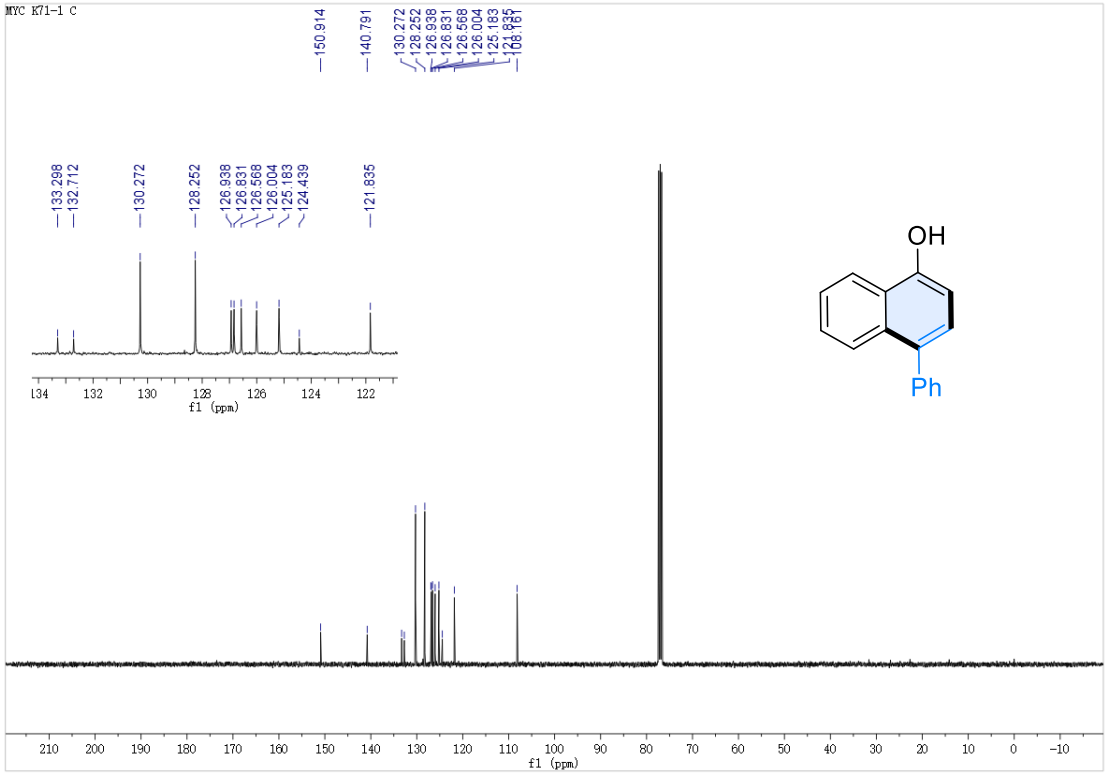
6, DEPT 90 and DEPT 135 (101 MHz, $CDCl_3$)



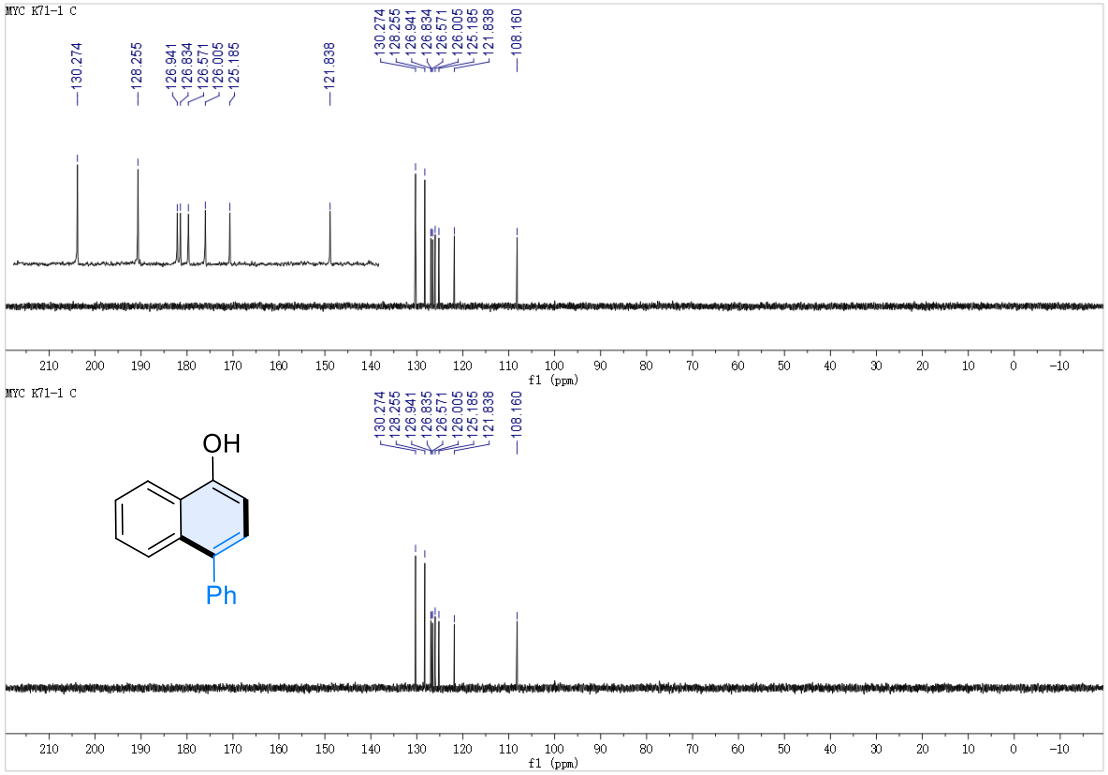
7, ^1H NMR (400 MHz, $CDCl_3$)



7, ^{13}C NMR (101 MHz, $CDCl_3$)



7, DEPT 90 and DEPT 135 (101 MHz, $CDCl_3$)



VIII. References

1. Z. Ma, M. Zhou, L. Ma, M. Zhang, *J. Chem. Res.* **2020**, *44*, 426–436.
2. Y. Guo, Y. Wang, H. Xue, S. Cao, Y. Zhao, *Tetrahedron* **2019**, *75*, 1481–1491.
3. G. Han, T. Yan, W. Zhang, Y. C. Zhang, D. Y. Lee, Z. Cao, Y. Sun, *ACS Catal.* **2019**, *9*, 11341–11349.
4. M. Kadarauch, T. A. Moss, R. J. Phipps, *J. Am. Chem. Soc.* **2024**, *146*, 34970–34978.