Supporting Information

Palladium-Catalyzed Defluorinative Alkynylation of Polyfluoroalkyl Ketones with Alkynes for the Synthesis of Fluorinated Fused Furans

Xue-Qiang Chu,* Man-Ling Zhi, Si-Xuan Zhang, Ya-Wen Wang, Weidong Rao, Haiyan Xu, and Zhi-Liang Shen*

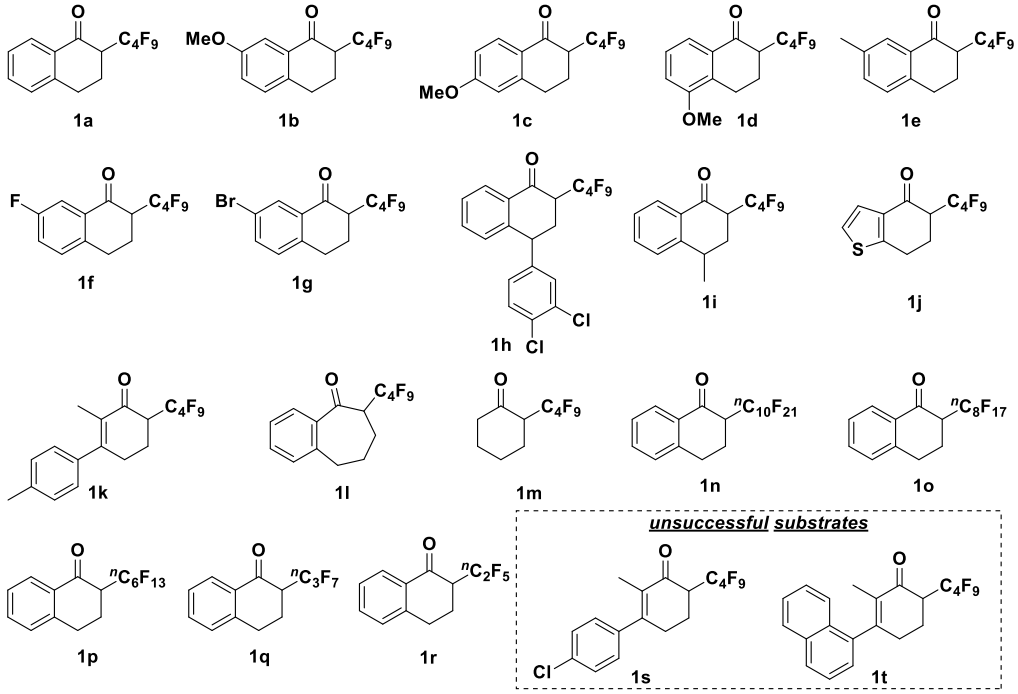
Table of Contents

1. General information

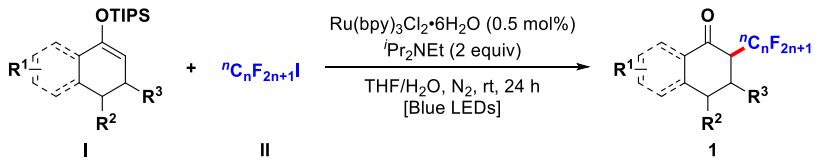
Unless otherwise stated, all reagents were purchased from commercial suppliers and used without further purification. All reactions were carried out under N_2 atmosphere using undistilled solvent. Melting points were recorded on an Electrothermal digital melting point apparatus. IR spectra were recorded on a FT-IR spectrophotometer using KBr optics. ^1H, ^{19}F, and ^{13}C NMR spectra were recorded in $CDCl_3$ on Bruker Avance or Joel 400 MHz spectrometers. The chemical shifts (δ) are reported in ppm and coupling constants (J) in Hz. High resolution mass spectra (HRMS) were obtained using a commercial apparatus (ESI Source). Column chromatography was generally performed on silica gel (300-400 mesh) and reactions were monitored by thin layer chromatography (TLC) using UV light to visualize the course of the reactions.

2. General procedures for the synthesis of α-perfluoroalkyl ketones

Various α-perfluoroalkyl ketones:



General procedure A[1]



According to MacMillan's reported method, a solution of enolsilane **I** (1.2 mmol), $Ru(bpy)_3Cl_2•6H_2O$ (4.5 mg, 0.006 mmol, 0.5 mol%), *N*-ethyl-*N*-isopropylpropan-2-amine (424.0 μL, 2.4 mmol), perfluoroalkyl iodide **II** (12 mmol), H_2O (32.0 μL, 17.8 mmol) in THF (6.0 mL) was stirred under nitrogen atmosphere (by 3 times' vacuum evacuation/N_2 backfill cycles) by irradiation with 8 W Blue LEDs at room temperature for 24 h. Upon completion of the reaction (indicated by TLC), solvent was removed under vacuum and the residue was purified by flash silica gel column chromatography (300-400 mesh) using petroleum ether/ethyl acetate (1:500) as eluent to afford the α-perfluoroalkyl ketone **1**.

Representative examples:

2-(Perfluorobutyl)-3,4-dihydronaphthalen-1(2*H*)-one (1a)[1]

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.08 – 8.01 (m, 1H), 7.57 – 7.49 (m, 1H), 7.35 (t, *J* = 7.6 Hz, 1H), 7.28 (s, 1H), 3.49 – 3.35 (m, 1H), 3.23 – 3.15 (m, 1H), 3.08 – 2.98 (m, 1H), 2.55 – 2.36 (m, 2H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -80.45 – -81.25 (m, 3F), -108.96 – -113.38 (m, 2F), -118.78 – -121.94 (m, 2F), -125.80 – -126.50 (m, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 190.3 (m), 142.9, 134.2, 132.3 (m), 128.7, 127.9, 127.0, 49.3 (t, *J* = 20.3 Hz), 27.1, 22.9 (m) ppm; carbons corresponding to the C_4F_9 group cannot be identified due to C-F coupling.

2,4'-Dimethyl-4-(perfluorobutyl)-5,6-dihydro-[1,1'-biphenyl]-3(4*H*)-one (1k)

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.25 – 7.20 (m, 2H), 7.13 – 7.08 (m, 2H), 3.36 – 3.22 (m, 1H), 2.87 – 2.75 (m, 1H), 2.72 – 2.60 (m, 1H), 2.38 (s, 3H), 1.77 (t, *J* = 1.9 Hz, 3H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -80.77 (t, *J* = 9.8 Hz, 3F), -109.70 – -114.25 (m, 2F), -119.29 – -122.06 (m, 2F), -125.98 (t, *J* = 15.4 Hz, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 191.7 (t, *J* = 1.4 Hz), 156.6, 138.4, 137.3, 132.1, 129.1, 127.0, 47.6 (t, *J* = 20.2 Hz), 30.7, 22.0 (m), 21.2, 13.3 ppm; carbons corresponding to the C_4F_9 group cannot be identified due to C-F coupling.

4'-Chloro-2-methyl-4-(perfluorobutyl)-5,6-dihydro-[1,1'-biphenyl]-3(4*H*)-one (1s)

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.34 (d, *J* = 8.4 Hz, 2H), 7.14 (d, *J* = 8.4 Hz, 2H), 3.35 – 3.20 (m, 1H), 2.83 – 2.71 (m, 1H), 2.70 – 2.58 (m, 1H), 2.46 – 2.29 (m, 2H), 1.79 (s, 3H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -80.80 – -80.92 (m, 3F), -110.28 – -114.09 (m, 2F), -119.53 – -121.96 (m, 2F), -125.96 – -126.14 (m, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 191.2, 154.9, 138.6, 134.2, 132.4, 128.6, 128.4, 47.6 (t, *J* = 20.6 Hz), 30.4, 21.8, 12.9 ppm; carbons corresponding to the C_4F_9 group cannot be identified due to C-F coupling.

2-Methyl-3-(naphthalen-1-yl)-6-(perfluorobutyl)cyclohex-2-en-1-one (1t)

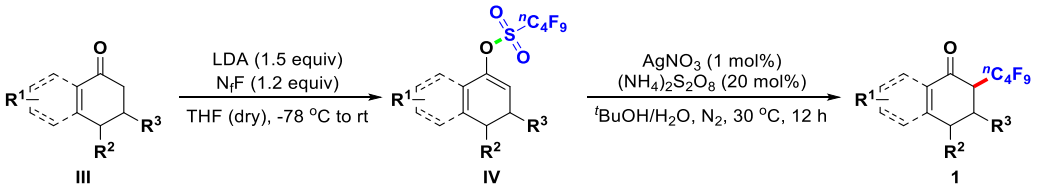
^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.93 – 7.86 (m, 1H), 7.83 (d, *J* = 8.3 Hz, 1H), 7.69 – 7.56 (m, 1H), 7.54 – 7.46 (m, 3H), 7.24 – 7.18 (m, 1H), 3.55 – 3.31 (m, 1H), 2.96 – 2.78 (m, 1H), 2.78 – 2.58 (m, 1H), 2.50 (d, *J* = 5.4 Hz, 2H), 1.56 (s, 3H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -80.80 (s, 3F), -109.50 – -113.97 (m, 2F), -119.36 – -122.12 (m, 2F), -125.92 (t, *J* = 12.4 Hz, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 191.3 (m), 156.2 (d, *J* = 18.6 Hz), 138.1 (d, *J* = 5.1 Hz), 134.2 (d, *J* = 9.4 Hz), 133.6, 129.1 (d, *J* = 9.3 Hz), 128.7 (d, *J* = 9.2 Hz), 128.2 (d, *J* = 7.5 Hz), 126.8 (d, *J* = 16.2 Hz), 126.2 (d, *J* = 5.1 Hz), 125.4 (d, *J* = 11.6 Hz), 124.3 (d, *J* = 4.8 Hz), 123.6 (d, *J* = 3.6 Hz), 47.7 (q, *J* = 20.0 Hz), 31.1 (d, *J* = 23.2 Hz), 22.3 (m), 12.9 ppm; carbons corresponding to the C_4F_9 group cannot be identified due to C-F coupling.

5-(Perfluorobutyl)-6,7-dihydrobenzo[*b*]thiophen-4(5*H*)-one (**1j**), 2-(perfluorodecyl)-3,4-dihydronaphthalen-1(2*H*)-one (**1n**), 2-(perfluorooctyl)-3,4-dihydronaphthalen-1(2*H*)-one (**1o**), 2-(perfluorohexyl)-3,4-dihydronaphthalen-1(2*H*)-one (**1p**), and 2-(perfluoroethyl)-3,4-dihydronaphthalen-1(2*H*)-one (**1r**) were synthesized according to general procedure A.

General procedure B[2]



Step 1: The solution of ketone **III** (5 mmol) in dry THF (25 mL) was cooled to -78 °C and then lithium diisopropylamide (LDA, 3.75 mL, 7.5 mmol, 2.0 mol/L in THF/hexane) was dropwise added to the reaction mixture. Nonafluorobutanesulfonyl fluoride (1.1 mL, 6 mmol) was added slowly by a syringe over 10 min. The reaction mixture was warmed to room temperature and stirred overnight. The reaction was then quenched by saturated NH_4Cl solution (20 mL) and extracted with EtOAc (20 mL x 3). The organic layer was washed with saturated brine twice, dried over $MgSO_4$, filtered, and concentrated under reduced pressure. The crude product was purified by flash column chromatography (300-400 mesh) on Et_3N-treated silica gel eluting with petroleum ether to afford enol nonaflate **IV**.

Step 2: A solution of enol nonaflate **IV** (0.8 mmol), $(NH_4)_2S_2O_8$ (0.16 mmol, 37 mg), and $AgNO_3$ (0.008 mmol, 1.4 mg) in ^{t}BuOH (2.0 mL) and H_2O (2.0 mL) was stirred vigorously under nitrogen atmosphere (by 3 times' vacuum evacuation/N_2 backfill cycles) at 30 °C for 12 h. Upon completion of the reaction (indicated by TLC), the reaction mixture was extracted with dichloromethane. The organic layer was separated and the aqueous layer was washed with dichloromethane (3×10 mL). The combined organic layers were dried over Na_2SO_4. The solvent was removed under vacuum and the residue was purified by flash silica gel column chromatography (300-400 mesh) using petroleum ether/ethyl acetate as eluent to afford α-perfluoroalkyl ketone **1**.

Representative examples:

7-Methoxy-2-(perfluorobutyl)-3,4-dihydronaphthalen-1(2*H*)-one (1b)

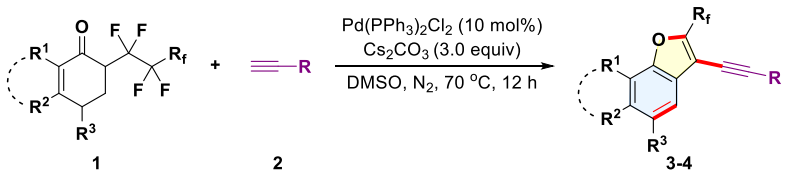
^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.02 (d, J = 8.8 Hz, 1H), 6.86 (dd, J = 8.8, 2.5 Hz, 1H), 6.70 (d, J = 2.4 Hz, 1H), 3.87 (s, 3H), 3.44 – 3.30 (m, 1H), 3.20 – 3.10 (m, 1H), 3.00 – 2.91 (m, 1H), 2.50 – 2.34 (m, 2H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -80.45 – -81.24 (m, 3F), -108.98 – -113.48 (m, 2F), -118.81 – -121.88 (m, 2F), -125.99 – -126.55 (m, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 188.8 (m), 164.1, 145.5, 130.3, 125.8, 113.7, 112.3, 55.4, 48.9 (t, J = 20.4 Hz), 27.3, 23.0 ppm; carbons corresponding to the C_4F_9 group cannot be identified due to C-F coupling.

6-Methoxy-2-(perfluorobutyl)-3,4-dihydronaphthalen-1(2*H*)-one (**1c**), 5-methoxy-2-(perfluorobutyl)-3,4-dihydronaphthalen-1(2*H*)-one (**1d**), 7-methyl-2-(perfluorobutyl)-3,4-dihydronaphthalen-1(2*H*)-one (**1e**), 7-fluoro-2-(perfluorobutyl)-3,4-dihydronaphthalen-1(2*H*)-one (**1f**), 7-bromo-2-(perfluorobutyl)-3,4-dihydronaphthalen-1(2*H*)-one (**1g**), 4-(3,4-dichlorophenyl)-2-(perfluorobutyl)-3,4-dihydronaphthalen-1(2*H*)-one (**1h**), 4-methyl-2-(perfluorobutyl)-3,4-dihydronaphthalen-1(2*H*)-one (**1i**), 6-(perfluorobutyl)-6,7,8,9-tetrahydro-5*H*-benzo[7]annulen-5-one (**1l**), 2-(perfluorobutyl)cyclohexan-1-one (**1m**), and 2-(perfluoropropyl)-3,4-dihydronaphthalen-1(2*H*)-one (**1r**) were synthesized according to general procedure B.

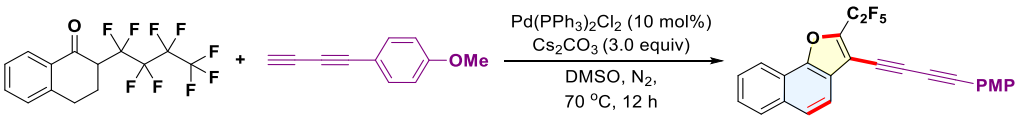
3. General procedures for the synthesis of naphtho[1,2-*b*]furan derivatives



1 2 3-4

A solution of fluoroalkyl ketones **1** (0.3 mmol), alkyne **2** (0.45 mmol), $Pd(PPh_3)_2Cl_2$ (21 mg, 0.03 mmol), and Cs_2CO_3 (293 mg, 0.9 mmol) in DMSO (3.0 mL) was stirred under N_2 atmosphere at 70 °C for 12 h. The reaction was then quenched by saturated NH_4Cl solution (20 mL) and extracted with EtOAc (20 mL x 3). The organic layer was washed with saturated brine twice, dried over $MgSO_4$, filtered, and concentrated under reduced pressure. The crude product was purified by flash column chromatography (300-400 mesh) using petroleum ether/ethyl acetate (500/1 ~ 50/1) as eluent to afford the pure products **3-4**.

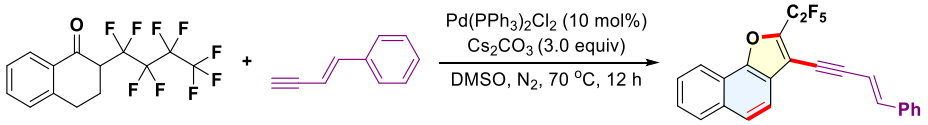
4. General procedure for the reaction of α-perfluorobutyl tetralone (1a) with 1-(buta-1,3-diyn-1-yl)-4-methoxybenzene (2q)



1a **2q** **5**, 34%

A solution of α-perfluorobutyl tetralone (**1a**, 73 mg, 0.2 mmol), 1-(buta-1,3-diyn-1-yl)-4-methoxybenzene (**2q**, 47 mg, 0.3 mmol), $Pd(PPh_3)_2Cl_2$ (14 mg, 0.02 mmol), and Cs_2CO_3 (196 mg, 0.6 mmol) in DMSO (2.0 mL) was stirred under N_2 atmosphere at 70 °C for 12 h. The reaction was then quenched by saturated NH_4Cl solution (20 mL) and extracted with EtOAc (20 mL x 3). The organic layer was washed with saturated brine twice, dried over $MgSO_4$, filtered, and concentrated under reduced pressure. The crude product was purified by flash column chromatography (300-400 mesh) using petroleum ether/ethyl acetate (500/1 ~ 100/1) as eluent to afford the pure product **5** (30 mg, 34% yield).

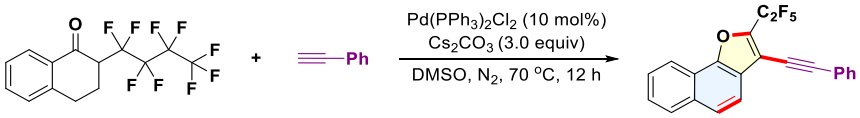
5. General procedure for the reaction of α-perfluorobutyl tetralone (1a) with (*E*)-but-1-en-3-yn-1-ylbenzene (2r)



1a **2r** **6**, 46%

A solution of α-perfluorobutyl tetralone (**1a**, 73 mg, 0.2 mmol), (*E*)-but-1-en-3-yn-1-ylbenzene (**2r**, 39 mg, 0.3 mmol), $Pd(PPh_3)_2Cl_2$ (14 mg, 0.02 mmol), and Cs_2CO_3 (196 mg, 0.6 mmol) in DMSO (2.0 mL) was stirred under N_2 atmosphere at 70 °C for 12 h. The reaction was then quenched by saturated NH_4Cl solution (20 mL) and extracted with EtOAc (20 mL x 3). The organic layer was washed with saturated brine twice, dried over $MgSO_4$, filtered, and concentrated under reduced pressure. The crude product was purified by flash column chromatography (300-400 mesh) using petroleum ether/ethyl acetate (500/1) as eluent to afford the pure product **6** (38 mg, 46% yield).

6. Large-scale synthesis of product 3aa

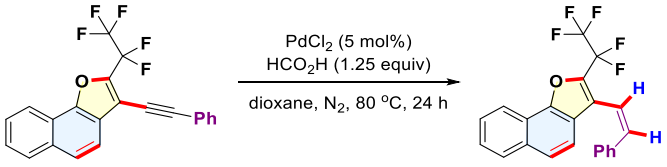


1a (5 mmol) **2a** (7.5 mmol) **3aa**, 58%

A solution of α-perfluorobutyl tetralone (**1a**, 1821 mg, 5 mmol), ethynylbenzene (**2a**, 766 mg, 7.5 mmol), $Pd(PPh_3)_2Cl_2$ (351 mg, 0.5 mmol), and Cs_2CO_3 (4887 mg, 15 mmol) in DMSO (50 mL) was stirred under N_2 atmosphere at 70 °C for 12 h. The reaction was then quenched by saturated NH_4Cl solution (100 mL) and extracted with EtOAc (50 mL x 3). The organic layer was washed with saturated brine twice, dried over $MgSO_4$, filtered, and concentrated under reduced pressure. The crude product was purified by flash column chromatography (300-400 mesh) using petroleum ether/ethyl acetate (500/1 ~ 200/1) as eluent to afford the pure product **3aa** (1130 mg, 58% yield).

7. Further applications for the synthesis of complex molecules

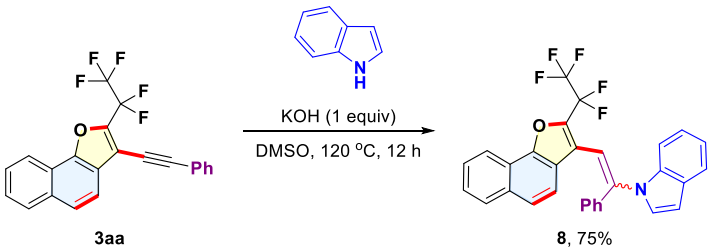
1) Reduction reaction of product 3aa



3aa **7**, 98%

A solution of **3aa** (77 mg, 0.2 mmol), $PdCl_2$ (2 mg, 0.01 mmol), and HCO_2H (12 mg, 0.25 mmol) in 1,4-dioxane (2 mL) was stirred under N_2 atmosphere at 80 °C for 24 h. The reaction was then quenched by saturated NH_4Cl solution (20 mL) and extracted with EtOAc (20 mL x 3). The organic layer was washed with saturated brine twice, dried over $MgSO_4$, filtered, and concentrated under reduced pressure. The crude product was purified by flash column chromatography (300-400 mesh) using petroleum ether/ethyl acetate (500/1) as eluent to afford the pure product **7** (66 mg, 98% yield).

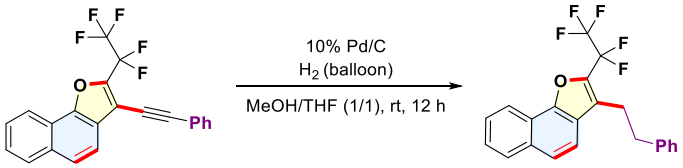
2) Hydroamination reaction of product 3aa with indole



3aa **8**, 75%

A solution of **3aa** (77 mg, 0.2 mmol), indole (47 mg, 0.4 mmol), and KOH (56 mg, 0.2 mmol) in DMSO (1 mL) was stirred under N_2 atmosphere at 120 °C for 12 h. The reaction was then quenched by saturated NH_4Cl solution (20 mL) and extracted with EtOAc (20 mL x 3). The organic layer was washed with saturated brine twice, dried over $MgSO_4$, filtered, and concentrated under reduced pressure. The crude product was purified by flash column chromatography (300-400 mesh) using petroleum ether/ethyl acetate (500/1 ~ 200/1) as eluent to afford the pure product **8** (58 mg, 75% yield).

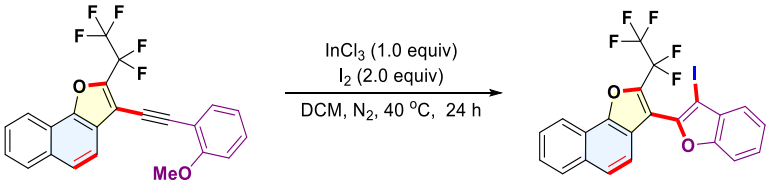
3) Reduction reaction of product 3aa



3aa **9**, 76%

A solution of **3aa** (77 mg, 0.02 mmol) and 10% Pd/C (21 mg) in MeOH/THF (1 mL/1 mL) was stirred under H_2 atmosphere at room temperature for 12 h. The mixture was filtered through celite pad, and washed with EtOAc (10 ml x 3). The filtrate was concentrated under reduced pressure. The crude product was purified by flash column chromatography (300-400 mesh) using petroleum ether/ethyl acetate (500/1) as eluent to afford the pure product **9** (60 mg, 76% yield).

4) Iodocyclization reaction of product 3ag

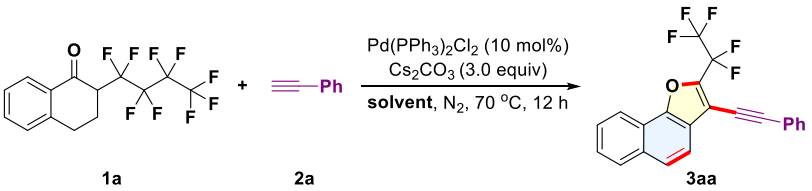


3ag **10**, 99%

A solution of **3ag** (42 mg, 0.1 mmol), $InCl_3$ (22 mg, 0.1 mmol), and I_2 (51 mg, 0.2 mmol) in DCM (3 mL) was stirred under N_2 atmosphere at 40 °C for 24 h. The reaction was then quenched by saturated NH_4Cl solution (20 mL) and extracted with EtOAc (20 mL x 3). The organic layer was washed with saturated brine twice, dried over $MgSO_4$, filtered, and concentrated under reduced pressure. The crude product was purified by flash column chromatography (300-400 mesh) using petroleum ether/ethyl acetate (200/1) as eluent to afford the pure product **10** (52 mg, 99% yield).

8. Optimization of reaction conditions

Table S1. Optimization of the reaction solvent[a]

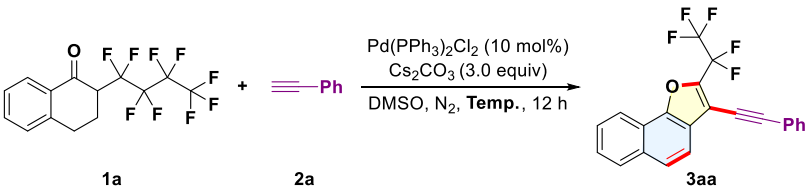


1a 2a 3aa

Entry	Solvent	Yield of 3aa (%)[b]
1	DMSO	58 (55)[c]
2	DMF	36
3	MeCN	14
4	$CHCl_3$	trace
5	1,4-dioxane	trace
6	toluene	trace
7	DCE	trace
8	^{t}BuOAc	<5
9	^{t}BuOH	<5

[a] Reaction conditions: 2-(perfluorobutyl)-3,4-dihydronaphthalen-1(2*H*)-one (**1a**, 0.30 mmol), phenylacetylene (**2a**, 0.45 mmol), $Pd(PPh_3)_2Cl_2$ (0.03 mmol), and Cs_2CO_3 (0.90 mmol) in solvent (2.0 mL) at 70 °C for 12 h under N_2. [b] Yields were determined by NMR analysis with 1,4-dimethoxybenzene as an internal standard. [c] Isolated yield.

Table S2. Optimization of the reaction temperature[a]

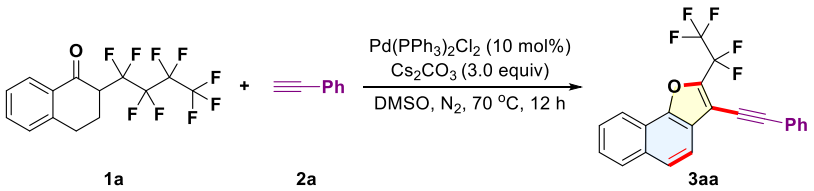


1a 2a 3aa

Entry	Temperature (°C)	Yield of 3aa (%)[b]
1	rt	34
2	50	52
3	70	58 (55)[c]
4	90	56

[a] Reaction conditions: 2-(perfluorobutyl)-3,4-dihydronaphthalen-1(2*H*)-one (**1a**, 0.30 mmol), phenylacetylene (**2a**, 0.45 mmol), $Pd(PPh_3)_2Cl_2$ (0.03 mmol), and Cs_2CO_3 (0.90 mmol) in DMSO (2.0 mL) at rt-90 °C for 12 h under N_2. [b] Yields were determined by NMR analysis with 1,4-dimethoxybenzene as an internal standard. [c] Isolated yield.

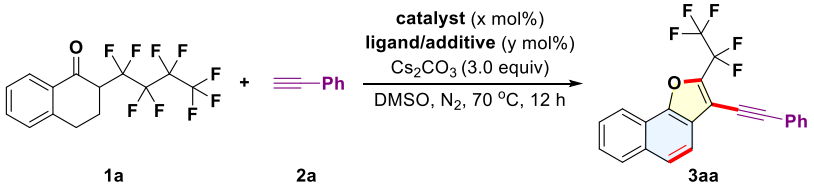
Table S3. Optimization of the reagent **1a**/**2a** ratio[a]



Entry	1a/2a	Yield of 3aa (%)[b]
1	1.2/1	50
2	1/1	56
3	1/1.2	58 (55)[c]
4	1/1.5	58 (55)[c]

[a] Reaction conditions: 2-(perfluorobutyl)-3,4-dihydronaphthalen-1(2*H*)-one (**1a**, 0.30-0.36 mmol), phenylacetylene (**2a**, 0.3-0.45 mmol), $Pd(PPh_3)_2Cl_2$ (0.03 mmol), and Cs_2CO_3 (0.90 mmol) in DMSO (2.0 mL) at 70 °C for 12 h under N_2. [b] Yields were determined by NMR analysis with 1,4-dimethoxybenzene as an internal standard. [c] Isolated yield.

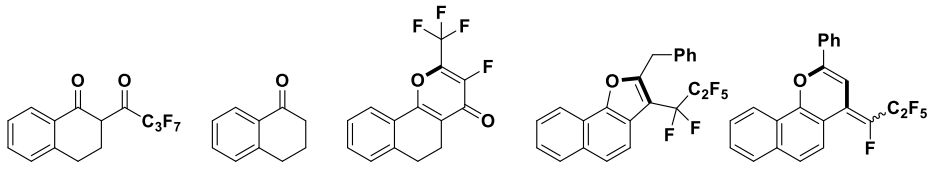
Table S4. Optimization of the catalysts and ligands[a]



Entry	Catalyst (x mol%)/Ligand or Additive (y mol%)	Yield of 3aa (%)[b]
1	$Pd(PPh_3)_2Cl_2$ (10)	58 (55)[c]
2	CuI (10)	0
3	$CoBr_2$/DPPE (10)	0
4	AgOAc (10)	0
5	$Ni(PPh_3)_2Cl_2$/XantPhos (10)	0
6	$Pd(PPh_3)_4$ (10)	40
7	$Pd_2(dba)_3{\cdot}CHCl_3$ (5)	40
8	$[PdCl(allyl)]_2$ (5)	36
9	$Pd(OAc)_2$/S-Phos (10)	20
10	$Pd(PPh_3)_2Cl_2$ (10)/1,10-Phenanthroline (10)	18[d]
11	$Pd(PPh_3)_2Cl_2$ (10)/2,2-Bipyridyl (10)	52[d]
12	$Pd(PPh_3)_2Cl_2$ (10)/DPPF (10)	56[d]
13	$Pd(PPh_3)_2Cl_2$ (10)/DPPE (10)	42[d]
14	$Pd(PPh_3)_2Cl_2$ (10)/DPPB (10)	48[d]
15	$Pd(PPh_3)_2Cl_2$ (10)/X-Phos (20)	58[d]
16	$Pd(PPh_3)_2Cl_2$ (10)/JohnPhos (20)	58[d]
17	$Pd(PPh_3)_2Cl_2$ (10)/BrettPhos (20)	46[d]
18	$Pd(PPh_3)_2Cl_2$ (10)/$(EtO)_2P(O)H$ (20)	26[d]
19	$Pd(PPh_3)_2Cl_2$ (10)/PCy_3 (20)	38[d]
20	$Pd(PPh_3)_2Cl_2$ (10)/TFP (20)	62[d]

21	$Pd(PPh_3)_2Cl_2$ (10)/Antioxidant 168 (20)	24[d]
22	$Pd(PPh_3)_2Cl_2$ (10)/CuI (10)	49[d]
23	$Pd(PPh_3)_2Cl_2$ (10)/$CoBr_2$ (10)	54[d]
24	$Pd(PPh_3)_2Cl_2$ (10)/$ZnBr_2$ (10)	27[d]
25	$Pd(PPh_3)_2Cl_2$ (10)/NaI (10)	52[d]
26	$Pd(PPh_3)_2Cl_2$ (10)/TBAB (100)	trace
27	**$Pd(PPh_3)_2Cl_2$ (10)**	**62 (58)[c,d,e]**

[a] Reaction conditions: 2-(perfluorobutyl)-3,4-dihydronaphthalen-1(2*H*)-one (**1a**, 0.3 mmol), phenylacetylene (**2a**, 0.36 mmol), catalyst (0.015-0.03 mmol), ligand (0-0.06 mmol), and Cs_2CO_3 (0.90 mmol) in DMSO (2.0 mL) at 70 °C for 12 h under N_2. [b] Yields were determined by NMR analysis with 1,4-dimethoxybenzene as an internal standard. [c] Isolated yield. [d] 0.45 mmol of **2a** was used. [e] In 3.0 mL of DMSO.



Notice: Moderate yield of the model reaction was obtained under the optimal reaction conditions because the starting material of 2-(perfluorobutyl)-3,4-dihydronaphthalen-1(2*H*)-one (**1a**) is unstable under the palladium catalytic system. 2-(2,2,3,3,4,4,4-Heptafluorobutanoyl)-3,4-dihydronaphthalen-1(2*H*)-one (*via* hydrodefluorination of **1a**), tetralone (*via* C-C bond cleavage of **1a**), 3-fluoro-2-(trifluoromethyl)-5,6-dihydro-4*H*-benzo[*h*]chromen-4-one (*via* self-cyclization), and some unidentified by-products were observed.

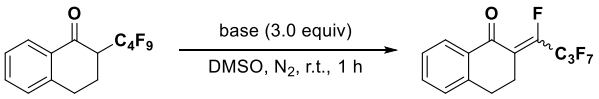
Table S5. Optimization of the base[a]

Entry	Base	Yield of 3aa (%)[b]
1	K_2CO_3	24
2	DABCO	48
3	DBU	<5
4	Et_3N	30
5	NaOH	trace
6	CsF	58
7	^{t}BuOK	18

[a] Reaction conditions: 2-(perfluorobutyl)-3,4-dihydronaphthalen-1(2*H*)-one (**1a**, 0.3 mmol), phenylacetylene (**2a**, 0.45 mmol), $Pd(PPh_3)_2Cl_2$ (0.03 mmol), and base (0.90 mmol) in DMSO (3.0 mL) at 70 °C for 12 h under N_2. [b] Yields were determined by NMR analysis with 1,4-dimethoxybenzene as an internal standard.

9. Mechanistic studies

1) Detection of the key intermediate 2-(1,4,4,4,4,4,4,4,4-octafluoro-4λ^8-but-2-yn-1-ylidene)-3,4-dihydronaphthalen-1(2*H*)-one (11)

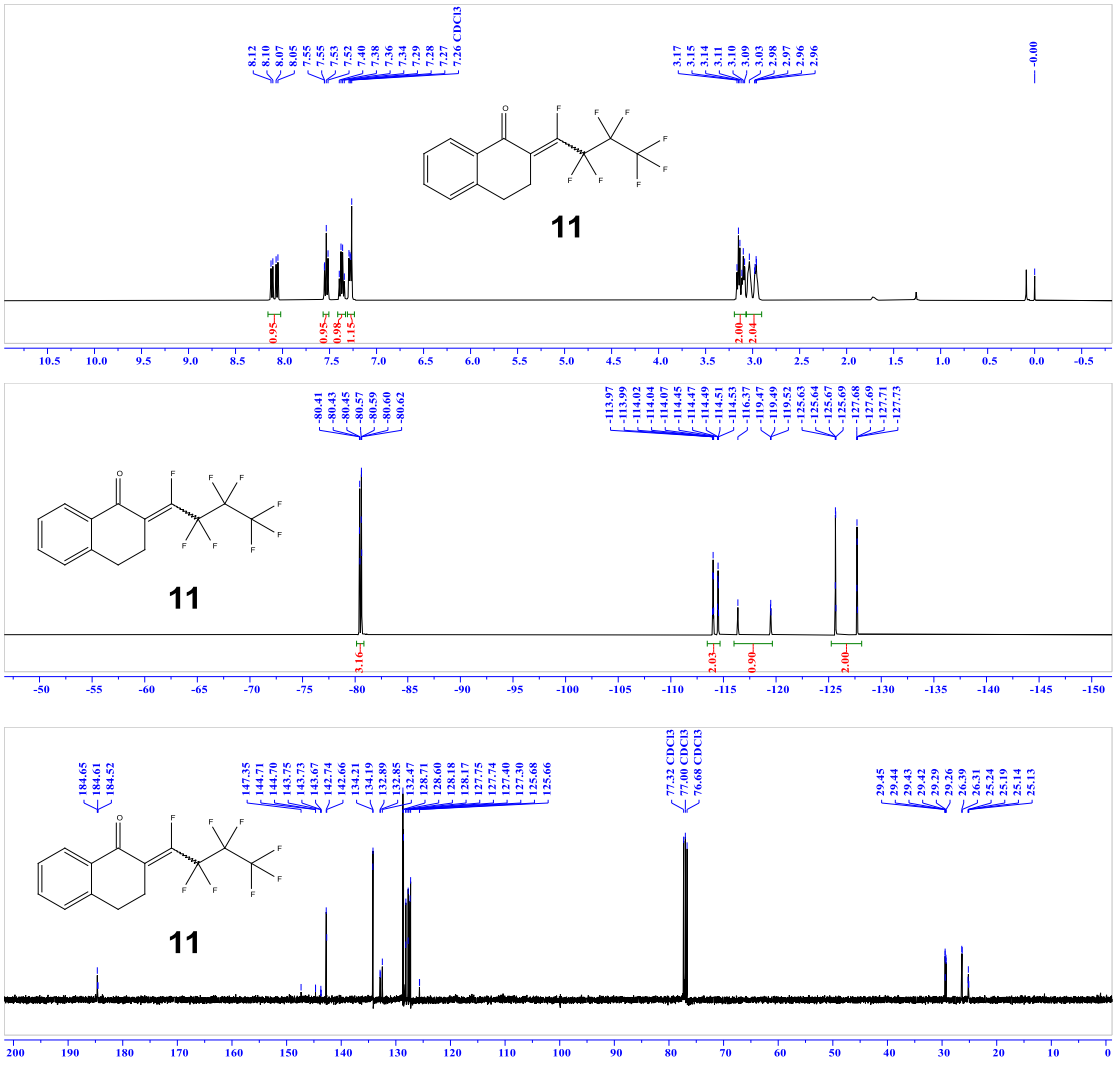


1a **11**

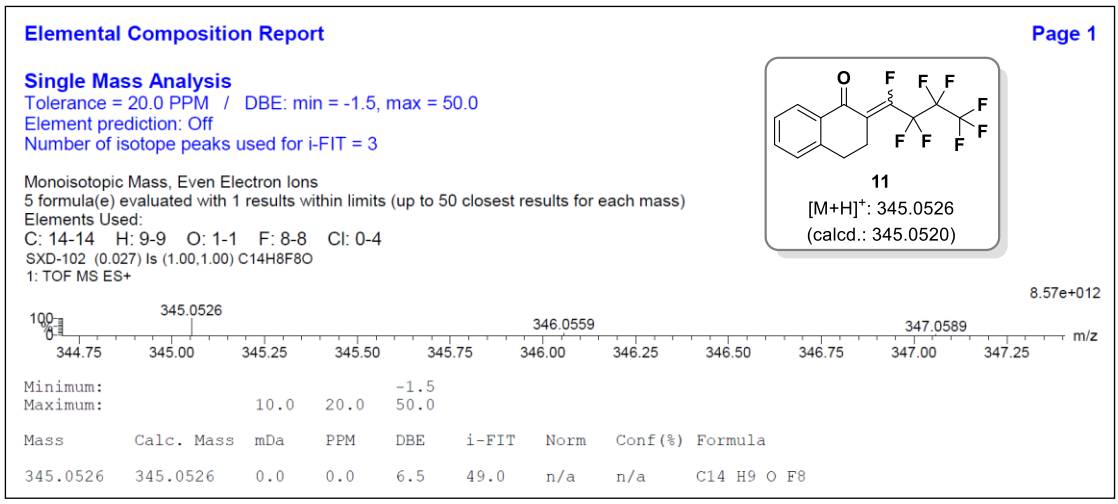
base	yield	base	yield	base	yield
Cs_2CO_3	82% (*Z*/*E* = 1/1)	Et_3N	95% (*Z*/*E* = 1/3)	NaOH	51% (*Z*/*E* = 1/2.6)
DABCO	0%	^{t}BuOK	37% (*Z*/*E* = 1/2.5)	$KHCO_3$	92% (*Z*/*E* = 1/1.2)

A solution of 2-(perfluorobutyl)-3,4-dihydronaphthalen-1(2*H*)-one (**1a**, 73 mg, 0.2 mmol) and base (0.6 mmol) in DMSO (2.0 mL) was stirred under N_2 atmosphere at room temperature for 1 h. The reaction was then quenched by saturated NH_4Cl solution (20 mL) and extracted with EtOAc (20 mL x 3). The organic layer was washed with saturated brine twice, dried over $MgSO_4$, filtered, and concentrated under reduced pressure. The crude product was purified by flash column chromatography (300-400 mesh) using petroleum ether/ethyl acetate (500/1) as eluent to afford the pure 2-(1,4,4,4,4,4,4,4,4-octafluoro-4λ^8-but-2-yn-1-ylidene)-3,4-dihydronaphthalen-1(2*H*)-one (**11**, 0~95% yield, *Z*/*E* = 1/1 ~ 1/3). **This result suggested that compound 11 was the possible reaction intermediate.**

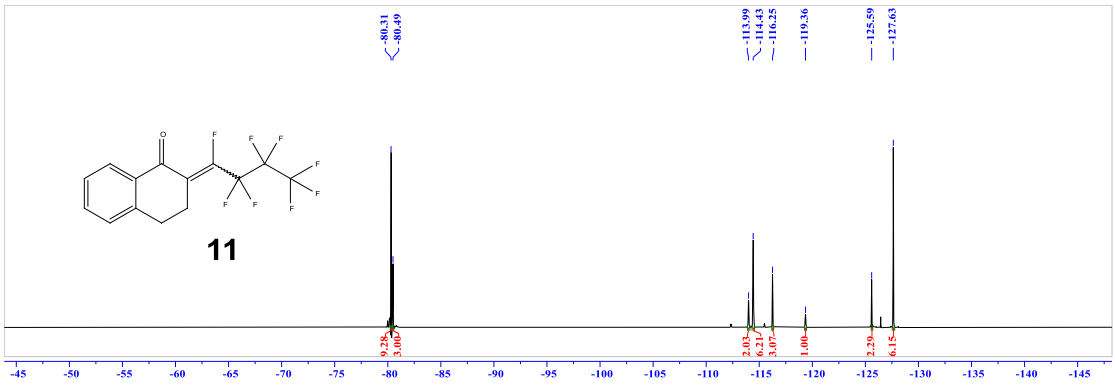
^{1}H, ^{19}F, and ^{13}C NMR spectra of compound 11 (Cs_2CO_3 as base):



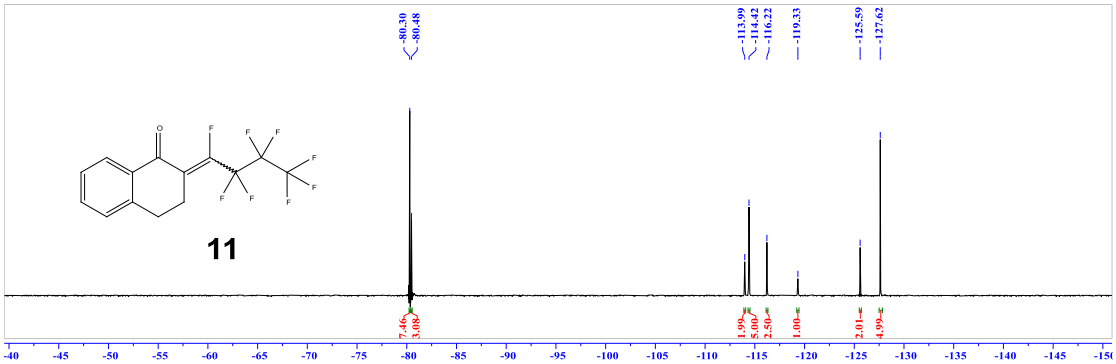
HRMS of compound 11:



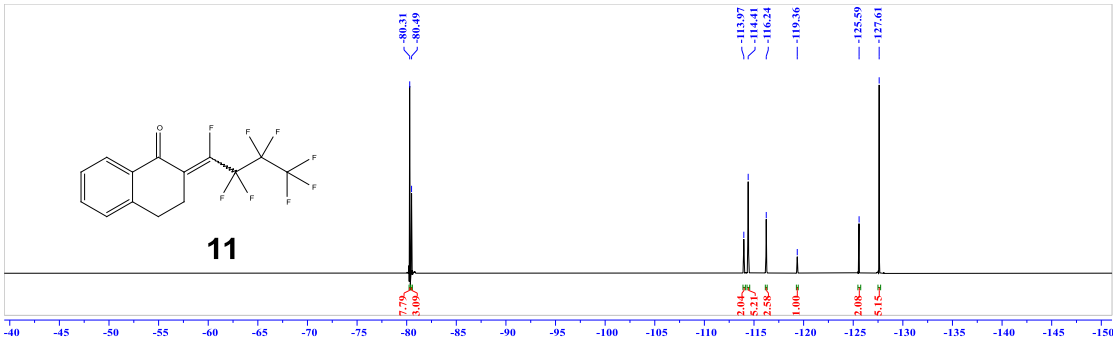
^{19}F NMR spectra of compound 11 (Et_3N as base):



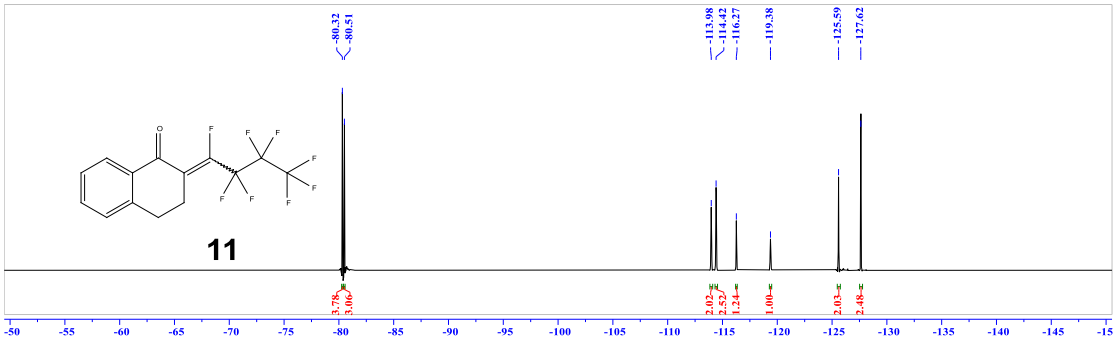
^{19}F NMR spectra of compound 11 (^{t}BuOK as base):



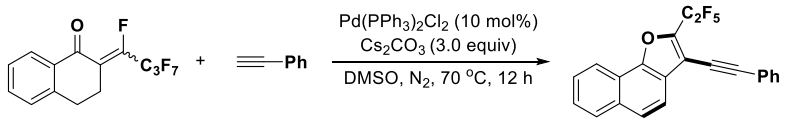
^{19}F NMR spectra of compound 11 (NaOH as base):



^{19}F spectra of compound 11 ($KHCO_3$ as base):



2) The reaction of compound 11 with ethynylbenzene (2a)



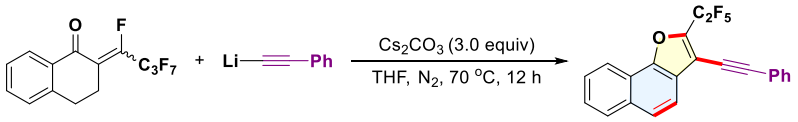
11 (*Z*/*E* = 1/1)
(*Z*/*E* = 1/3)

2a

3aa, 41%
44%

A solution of compound **11** (52 mg, 0.15 mmol), phenylacetylene (**2a**, 23 mg, 0.225 mmol), $Pd(PPh_3)_2Cl_2$ (11 mg, 0.015 mmol), and Cs_2CO_3 (147 mg, 0.45 mmol) in DMSO (2.0 mL) was stirred under N_2 atmosphere at 70 °C for 12 h. The reaction was then quenched by saturated NH_4Cl solution (20 mL) and extracted with EtOAc (20 mL x 3). The organic layer was washed with saturated brine twice, dried over $MgSO_4$, filtered, and concentrated under reduced pressure. The crude product was purified by flash column chromatography (300-400 mesh) using petroleum ether/ethyl acetate (200/1) as eluent to afford the pure product **3aa**. **This result further suggested that compound 11 was the possible reaction intermediate.**

3) The reaction of compound 11 with (phenylethynyl)lithium (12)



11 (*Z*/*E* = 1/1)

12

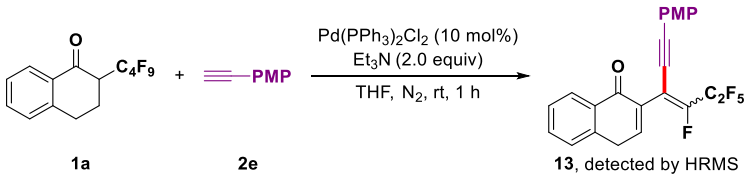
3aa, 0%

Step 1: A solution of phenylacetylene (**2a**, 31 mg, 0.3 mmol) in dry THF (2 mL) was cooled to -78 ℃ and then *n*-butyllithium (^{n}BuLi, 0.15 mL, 0.36 mmol, 2.5 mol/L in THF) was dropwise added to the reaction mixture over 1 h. After removal of the solvent of above reaction mixture, the formed crude (phenylethynyl)lithium (**12**) was directly

used in the next step without further purification.

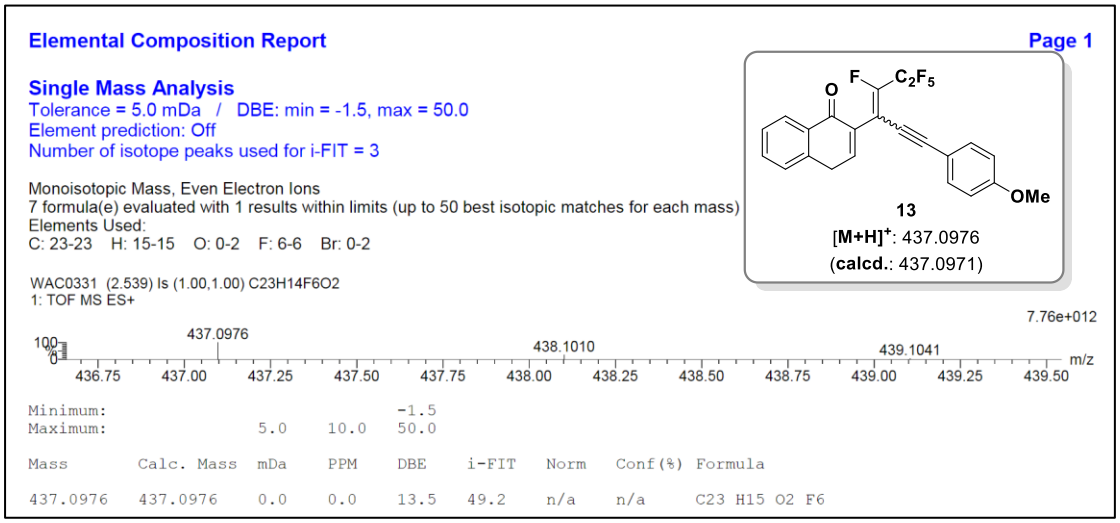
Step 2: A solution of compound **11** (69 mg, 0.2 mmol), (phenylethynyl)lithium (**12**), and Cs_2CO_3 (196 mg, 0.6 mmol) in THF (2.0 mL) was stirred under N_2 atmosphere at 70 °C for 12 h. No desired product **3aa** was obtained. **This result suggested that nucleophilic addition-elimination was not the main pathway for the intermolecular coupling.**

4) Detection of proposed endocyclic naphthalen-1(4*H*)-one 13

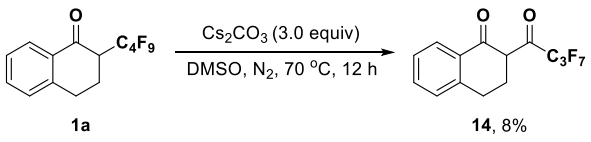


A solution of 2-(perfluorobutyl)-3,4-dihydronaphthalen-1(2*H*)-one (**1a**, 109 mg, 0.3 mmol), 1-ethynyl-4-methoxybenzene (**2e**, 59 mg, 0.45 mmol), $Pd(PPh_3)_2Cl_2$ (21 mg, 0.03 mmol), and Et_3N (61 mg, 0.6 mmol) in THF (3.0 mL) was stirred under N_2 atmosphere at room temperature for 1 h. **Proposed endocyclic naphthalen-1(4*H*)-one 13 could be detected by HRMS, suggesting that intermediate 13 might be involved in the reaction.**

HRMS of intermediate 13:



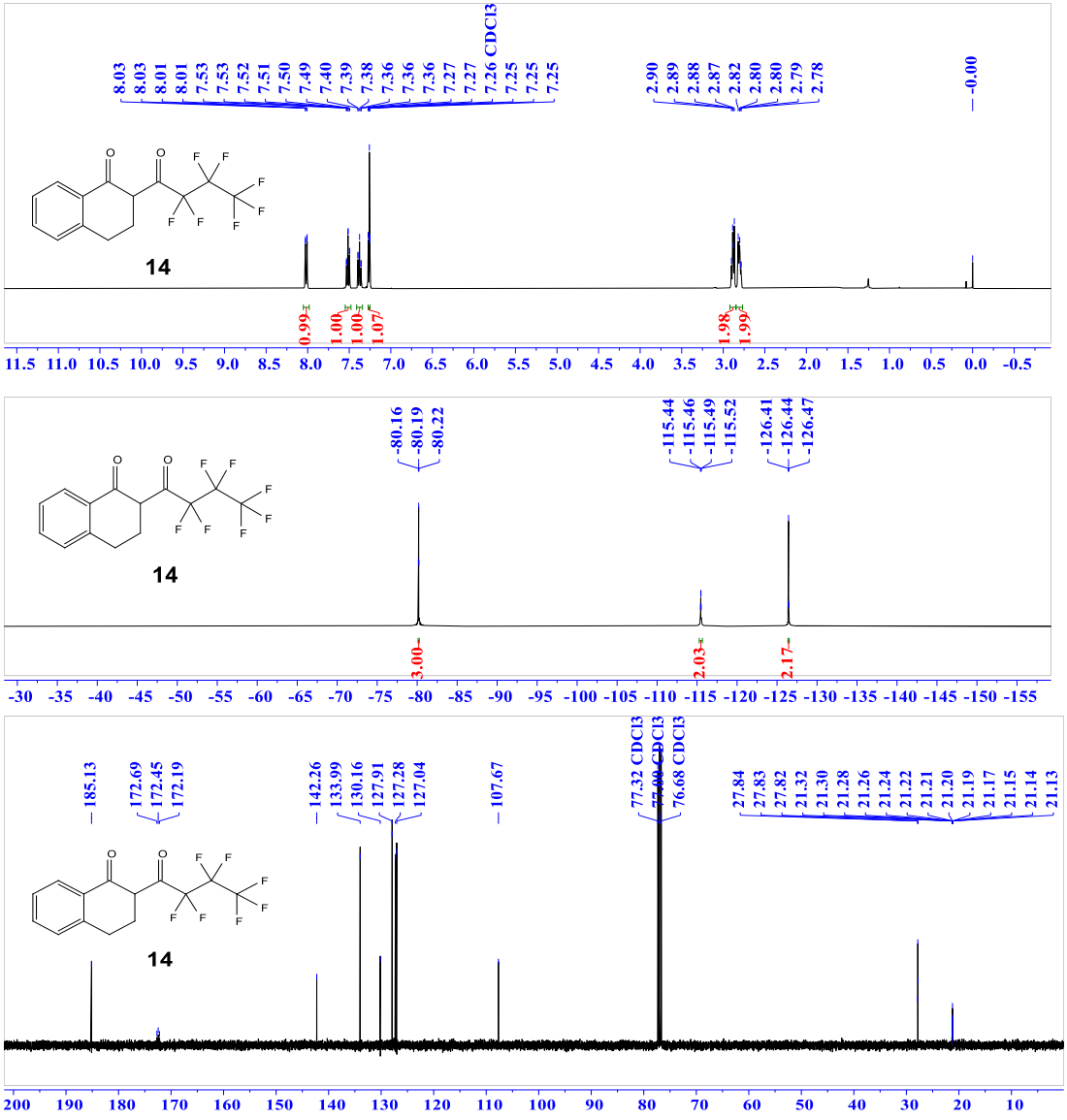
5) The formation of intermediate 2-(2,2,3,3,4,4,4-heptafluorobutanoyl)-3,4-dihydronaphthalen-1(2*H*)-one (14) in the absence of $Pd(PPh_3)_2Cl_2$ catalyst



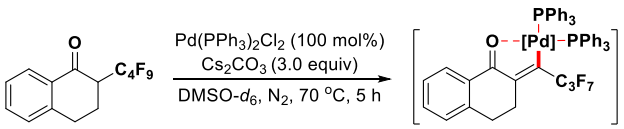
A solution of 2-(perfluorobutyl)-3,4-dihydronaphthalen-1(2*H*)-one (**1a**, 109 mg, 0.3 mmol) and Cs_2CO_3 (293 mg, 0.9 mmol) in DMSO (3.0 mL) was stirred under N_2 atmosphere at 70 °C for 12 h. The reaction was then quenched by saturated NH_4Cl solution (20 mL) and extracted with EtOAc (20 mL x 3). The organic layer was washed with saturated brine twice, dried over $MgSO_4$, filtered, and concentrated under reduced pressure. The crude product was purified by flash column chromatography (300-400 mesh) using petroleum ether/ethyl acetate (200/1) as eluent to afford the pure product **14** (8 mg, 8% yield). **This result suggested that compound 14 may also come from base-**

promoted fluorine elimination of 11 without involving Pd species.

NMR spectra of compound 14:

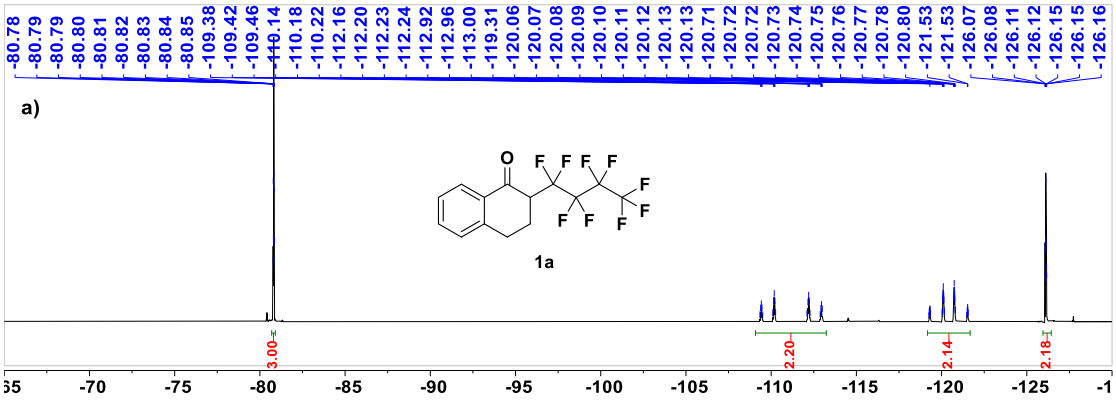


6) ^{19}F, ^{31}P NMR, and HRMS analysis of intermediate 15

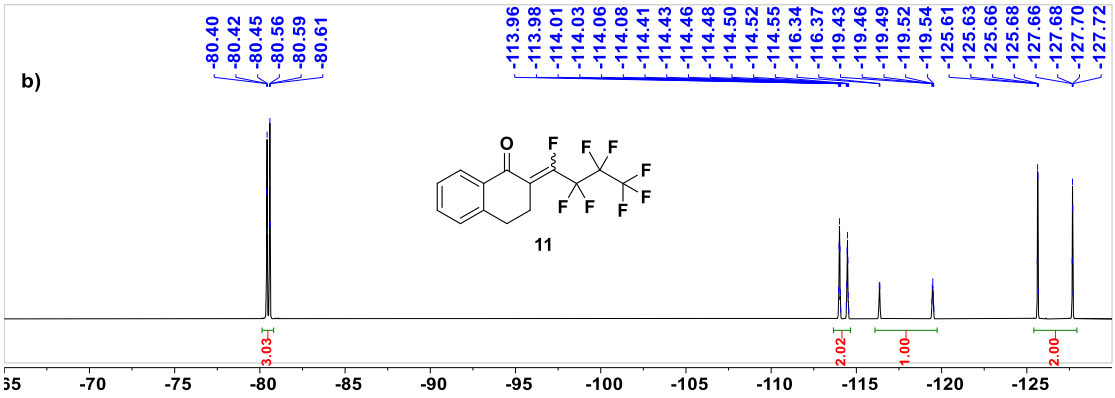


A solution of 2-(perfluorobutyl)-3,4-dihydronaphthalen-1(2*H*)-one (**1a**, 109 mg, 0.3 mmol), $Pd(PPh_3)_2Cl_2$ (211 mg, 0.3 mmol), and Cs_2CO_3 (293 mg, 0.9 mmol) in DMSO-d_6 (3.0 mL) was stirred under N_2 atmosphere at 70 °C for 5 h. **The reaction mixture was analyzed by ^{19}F and ^{31}P NMR.**

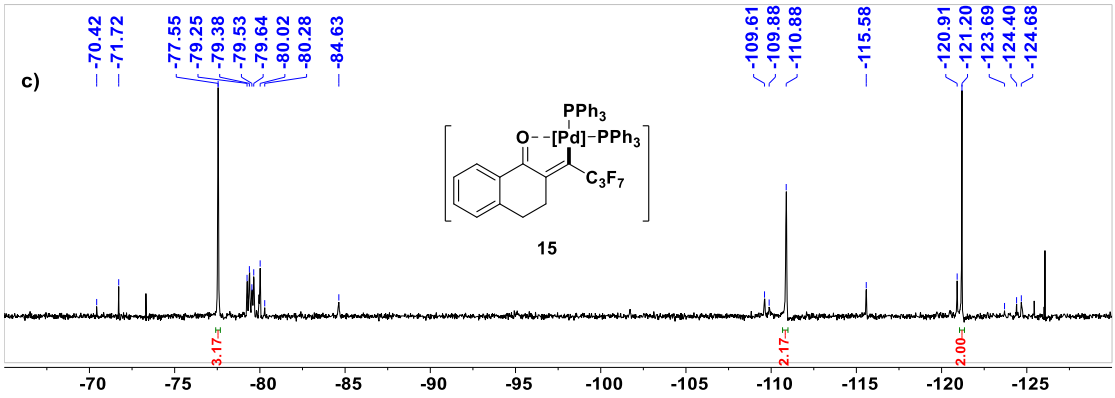
a) ^{19}F NMR spectra of compound 1a



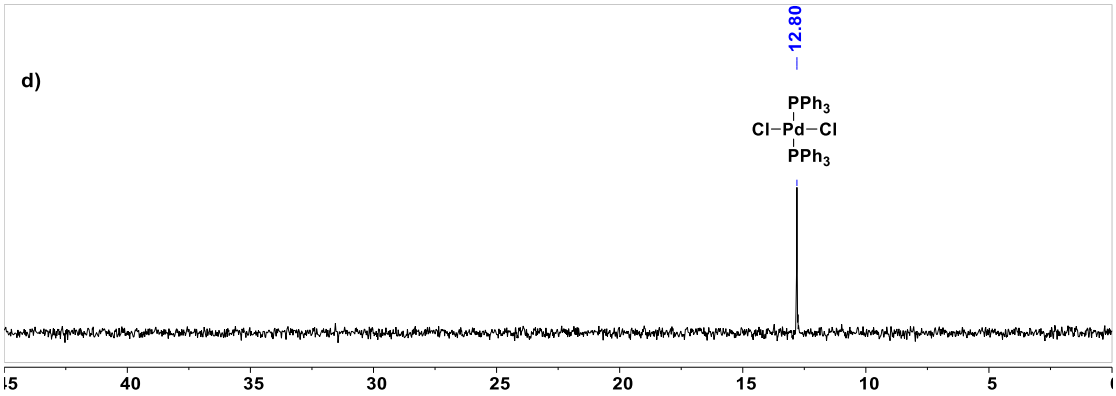
b) ^{19}F NMR spectra of intermediate 11



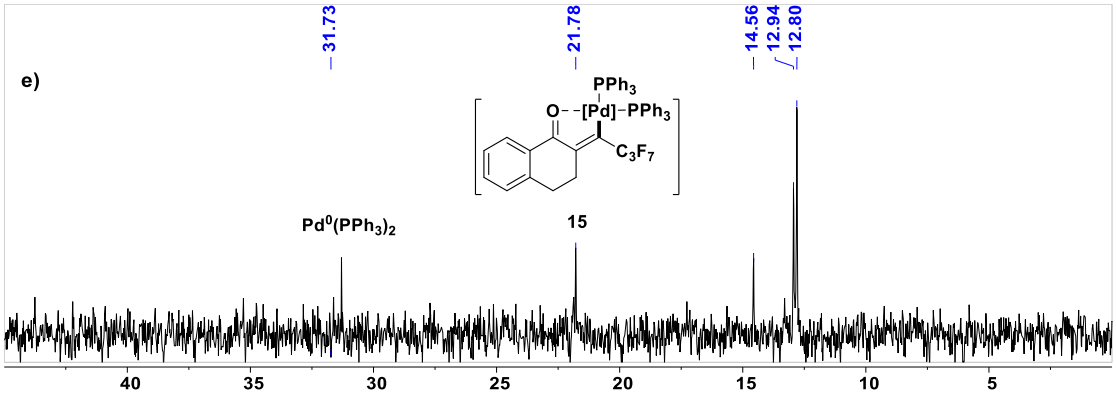
c) ^{19}F NMR spectra of reaction mixture



d) ^{31}P NMR spectra of $Pd(PPh_3)_2Cl_2$[3]



e) ^{31}P NMR spectra of reaction mixture[3]

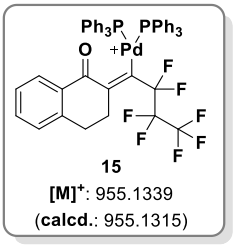


HRMS of vinylpalladium 15:

Elemental Composition Report Page 1

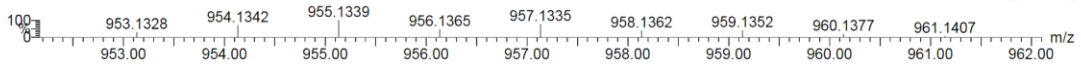
Single Mass Analysis
Tolerance = 5.0 mDa / DBE: min = -1.5, max = 50.0
Element prediction: Off
Number of isotope peaks used for i-FIT = 3

Monoisotopic Mass, Even Electron Ions
261 formula(e) evaluated with 1 results within limits (up to 50 best isotopic matches for each mass)
Elements Used:
C: 50-50 H: 38-38 O: 0-2 F: 7-7 S: 0-6 Br: 0-2 P: 0-2 Pd: 0-1



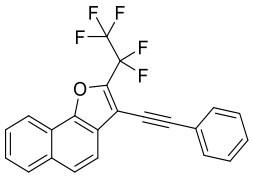
[M]$^+$: 955.1339
(calcd.: 955.1315)

WAC0331 (0.032) Is (1.00,1.00) C50H37F7OP2Pd
1: TOF MS ES+
2.39e+012



Minimum:				-1.5				
Maximum:		5.0	10.0	50.0				
Mass	Calc. Mass	mDa	PPM	DBE	i-FIT	Norm	Conf(%)	Formula
955.1339	955.1321	1.8	1.9	29.5	183.2	n/a	n/a	C50 H38 O F7 P2 Pd

10. Characterization data for products



2-(Perfluoroethyl)-3-(phenylethynyl)naphtho[1,2-*b*]furan (3aa):

Yield = 58% (67 mg). White solid. M.p. 125.2–126.9 °C.

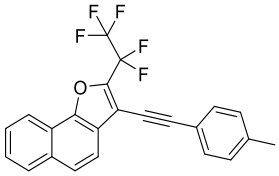
IR (KBr): ν = 3015, 2224, 1582, 808, 740 cm^{-1}.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.33 – 8.27 (m, 1H), 7.97 – 7.90 (m, 1H), 7.76 (s, 2H), 7.65 – 7.54 (m, 4H), 7.40 – 7.35 (m, 3H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -83.57 (t, J = 3.4 Hz, 3F), -114.34 (q, J = 3.4 Hz, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 151.0, 141.6 (t, $J_{C\text{-}F}$ = 30.1 Hz), 132.9, 132.5, 131.8, 129.1, 128.4, 127.1, 126.9, 125.3, 123.4, 122.3, 120.8, 120.3, 118.3, 109.4 (m), 98.1, 76.3 ppm; carbons corresponding to the C_2F_5 group cannot be identified due to C-F coupling.

HRMS (m/z): calcd for $C_{22}H_{12}F_5O$ $[M+H]^+$ 387.0803, found: 387.0805.



2-(Perfluoroethyl)-3-(*p*-tolylethynyl)naphtho[1,2-*b*]furan (3ab):

Yield = 64% (76 mg). White solid. M.p. 143.4-145.2 °C.

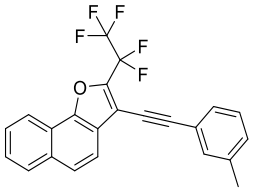
IR (KBr): ν = 3030, 2227, 1597, 1508, 809, 744 cm^{-1}.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.33 (d, J = 8.0 Hz, 1H), 7.97 (d, J = 8.0 Hz, 1H), 7.79 (t, J = 9.0 Hz, 2H), 7.69 – 7.63 (m, 1H), 7.62 – 7.56 (m, 1H), 7.50 (d, J = 8.0 Hz, 2H), 7.20 (d, J = 7.9 Hz, 2H), 2.39 (s, 3H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -83.56 (t, J = 3.9 Hz, 3F), -114.31 (q, J = 3.9 Hz, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 151.0 (t, $J_{C\text{-}F}$ = 1.4 Hz), 141.5 (t, $J_{C\text{-}F}$ = 30.1 Hz), 139.4, 133.0, 131.7, 129.2, 128.5, 127.2, 126.9, 125.3, 123.5 (t, $J_{C\text{-}F}$ = 1.3 Hz), 120.9, 120.4, 119.3, 118.4, 109.6 (m), 98.6 (t, $J_{C\text{-}F}$ = 1.4 Hz), 75.7 (t, $J_{C\text{-}F}$ = 1.4 Hz), 21.6 ppm; carbons corresponding to the C_2F_5 group cannot be identified due to C-F coupling.

HRMS (m/z): calcd for $C_{23}H_{14}F_5O$ $[M+H]^+$ 401.0959, found: 401.0957.



2-(Perfluoroethyl)-3-(*m*-tolylethynyl)naphtho[1,2-*b*]furan (3ac):

Yield = 65% (78 mg). Yellow solid. M.p. 119.2-119.9 °C.

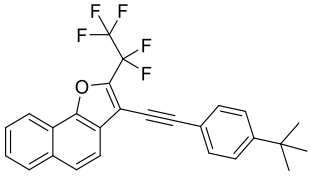
IR (KBr): ν = 2928, 2218, 1617, 807, 742 cm^{-1}.

^{1}H NMR (400 MHz, $CDCl_3$): δ 8.28 (d, J = 8.0 Hz, 1H), 7.91 (d, J = 7.9 Hz, 1H), 7.74 (d, J = 2.0 Hz, 2H), 7.64 – 7.52 (m, 2H), 7.40 (d, J = 7.0 Hz, 2H), 7.25 (t, J = 8.0 Hz, 1H), 7.18 (t, J = 6.0 Hz, 1H), 2.36 (s, 3H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -83.51 (t, J = 3.5 Hz, 3F), -114.24 (q, J = 3.5 Hz, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 151.0 (t, $J_{C\text{-}F}$ = 1.1 Hz), 141.5 (t, $J_{C\text{-}F}$ = 30.2 Hz), 138.2, 133.0, 132.3, 130.0, 128.9, 128.4, 128.4, 127.1, 126.9, 125.3, 123.5 (t, $J_{C\text{-}F}$ = 1.1 Hz), 122.1, 120.9, 120.3, 118.3, 109.5 (t, $J_{C\text{-}F}$ = 2.7 Hz), 98.4 (t, $J_{C\text{-}F}$ = 1.4 Hz), 75.9 (t, $J_{C\text{-}F}$ = 0.9 Hz), 21.2 ppm; carbons corresponding to the C_2F_5 group cannot be identified due to C-F coupling.

HRMS (m/z): calcd for $C_{23}H_{14}F_5O$ $[M+H]^+$ 401.0959, found: 401.0959.



3-((4-(*tert*-Butyl)phenyl)ethynyl)-2-(perfluoroethyl)naphtho[1,2-*b*]furan (3ad):

Yield = 64% (85 mg). Light yellow solid. M.p. 109.0-109.7 ºC.

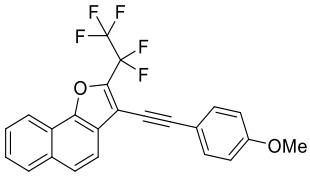
IR (KBr): ν = 2968, 2221, 1613, 812, 753 cm^{-1}.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.31 (d, J = 8.1 Hz, 1H), 7.94 (d, J = 8.0 Hz, 1H), 7.76 (d, J = 1.4 Hz, 2H), 7.66 – 7.51 (m, 4H), 7.41 (d, J = 8.4 Hz, 2H), 1.33 (s, 9H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -83.54 (t, J = 3.4 Hz, 3F), -114.29 (q, J = 3.4 Hz, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 152.6, 151.0 (m), 141.5 (t, $J_{C\text{-}F}$ = 31.9 Hz), 133.0, 131.6, 128.5, 127.1, 126.9, 125.5, 125.3, 123.5 (t, $J_{C\text{-}F}$ = 1.3 Hz), 120.9, 120.4, 119.3, 118.4, 109.5 (m), 98.3 (t, $J_{C\text{-}F}$ = 1.4 Hz), 75.7 (t, $J_{C\text{-}F}$ = 1.3 Hz), 34.9, 31.1 ppm; carbons corresponding to the C_2F_5 group cannot be identified due to C-F coupling.

HRMS (m/z): calcd for $C_{26}H_{20}F_5O$ $[M+H]^+$ 443.1429, found: 443.1427.



3-((4-Methoxyphenyl)ethynyl)-2-(perfluoroethyl)naphtho[1,2-*b*]furan (3ae):

Yield = 69% (86 mg). Light yellow solid. M.p. 138.0-139.8 ºC.

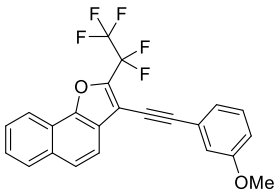
IR (KBr): ν = 3010, 2224, 1596, 1250, 834, 750 cm^{-1}.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.32 (d, J = 8.0 Hz, 1H), 7.95 (d, J = 7.9 Hz, 1H), 7.82 – 7.74 (m, 2H), 7.64 (ddd, J = 8.2, 7.1, 1.2 Hz, 1H), 7.61 – 7.51 (m, 3H), 6.94 – 6.88 (m, 2H), 3.83 (s, 3H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -83.56 (t, J = 4.1 Hz, 3F), -114.27 (q, J = 4.1 Hz, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 160.3, 151.0 (t, $J_{C\text{-}F}$ = 1.3 Hz), 141.2 (t, $J_{C\text{-}F}$ = 31.6 Hz), 133.4, 133.0, 128.5, 127.1, 126.9, 125.2, 123.5 (t, $J_{C\text{-}F}$ = 1.2 Hz), 120.9, 120.4, 118.4, 114.4, 114.1, 109.6 (m), 98.3 (t, $J_{C\text{-}F}$ = 1.4 Hz), 75.1 (t, $J_{C\text{-}F}$ = 1.3 Hz), 55.3 ppm; carbons corresponding to the C_2F_5 group cannot be identified due to C-F coupling.

HRMS (m/z): calcd for $C_{23}H_{14}F_5O_2$ $[M+H]^+$ 417.0908, found: 417.0906.



3-((3-Methoxyphenyl)ethynyl)-2-(perfluoroethyl)naphtho[1,2-*b*]furan (3af):

Yield = 57% (71 mg). Light yellow solid. M.p. 95.9-96.1 °C.

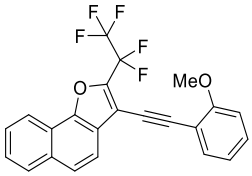
IR (KBr): ν = 3005, 2229, 1597, 1220, 815, 755 cm^{-1}.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.34 – 8.25 (m, 1H), 7.97 – 7.89 (m, 1H), 7.76 (s, 2H), 7.67 – 7.53 (m, 2H), 7.29 (t, J = 7.9 Hz, 1H), 7.23 – 7.17 (m, 1H), 7.11 (dd, J = 2.4, 1.3 Hz, 1H), 6.94 (ddd, J = 8.3, 2.6, 0.9 Hz, 1H), 3.83 (s, 3H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -83.53 (t, J = 3.0 Hz, 3F), -114.28 (q, J = 3.0 Hz, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 159.4, 151.0 (t, $J_{C\text{-}F}$ = 1.3 Hz), 141.7 (t, $J_{C\text{-}F}$ = 31.2 Hz), 133.0, 129.6, 128.5, 127.2, 126.9, 125.3, 124.4, 123.4 (t, $J_{C\text{-}F}$ = 1.2 Hz), 123.3, 120.9, 120.3, 118.3, 116.6, 115.6, 109.3 (m), 98.0 (t, $J_{C\text{-}F}$ = 1.6 Hz), 76.1 (t, $J_{C\text{-}F}$ = 1.3 Hz), 55.3 ppm; carbons corresponding to the C_2F_5 group cannot be identified due to C-F coupling.

HRMS (m/z): calcd for $C_{23}H_{14}F_5O_2$ $[M+H]^+$ 417.0908, found: 417.0904.



3-((2-Methoxyphenyl)ethynyl)-2-(perfluoroethyl)naphtho[1,2-*b*]furan (3ag):

Yield = 66% (83 mg). Light yellow solid. M.p. 75.3-75.8 °C.

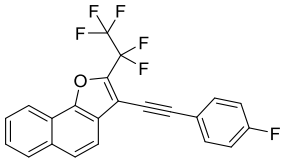
IR (KBr): ν = 2967, 2227, 1593, 1201, 806, 751 cm^{-1}.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.32 (d, J = 8.1 Hz, 1H), 7.95 (d, J = 8.1 Hz, 1H), 7.83 (d, J = 8.6 Hz, 1H), 7.77 (d, J = 8.6 Hz, 1H), 7.67 – 7.61 (m, 1H), 7.60 – 7.52 (m, 2H), 7.39 – 7.31 (m, 1H), 7.02 – 6.88 (m, 2H), 3.95 (s, 3H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -83.53 (t, J = 3.3 Hz, 3F), -114.26 (q, J = 3.3 Hz, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 160.4, 151.0 (t, $J_{C\text{-}F}$ = 1.3 Hz), 141.3 (t, $J_{C\text{-}F}$ = 30.2 Hz), 133.5, 133.0, 130.7, 128.5, 127.1, 126.8, 125.2, 123.7 (t, $J_{C\text{-}F}$ = 1.3 Hz), 120.9, 120.5, 120.4, 118.6, 111.7, 110.8, 109.8 (m), 94.8 (t, $J_{C\text{-}F}$ = 1.4 Hz), 80.3 (t, $J_{C\text{-}F}$ = 1.3 Hz), 55.9 ppm; carbons corresponding to the C_2F_5 group cannot be identified due to C-F coupling.

HRMS (m/z): calcd for $C_{23}H_{14}F_5O_2$ $[M+H]^+$ 417.0908, found: 417.0907.



3-((4-Fluorophenyl)ethynyl)-2-(perfluoroethyl)naphtho[1,2-*b*]furan (3ah):

Yield = 56% (68 mg). Light yellow solid. M.p. 141.6-143.2 °C.

IR (KBr): ν = 3067, 2226, 1616, 1200, 811, 747 cm^{-1}.

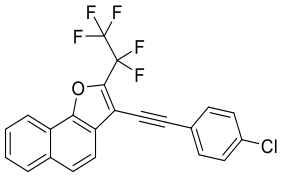
^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.34 – 8.28 (m, 1H), 7.95 (d, J = 7.9 Hz, 1H), 7.77 (d, J = 2.1 Hz, 2H), 7.64 (ddd, J = 8.2, 7.0, 1.2 Hz, 1H), 7.61 – 7.55 (m, 3H), 7.11 – 7.04 (m, 2H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -83.58 (t, J = 4.0 Hz, 3F), -109.19 – -109.26 (m, 1F), -114.35 (q, J = 4.0 Hz, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 163.0 (d, $J_{C\text{-}F}$ = 249.7 Hz), 151.0, 141.7 (t, $J_{C\text{-}F}$ = 30.5 Hz), 133.8 (d, $J_{C\text{-}F}$ = 8.5 Hz), 133.0, 128.5, 127.2, 127.0, 125.4, 123.4 (t, $J_{C\text{-}F}$ = 30.5 Hz), 120.9, 120.4, 118.4 (d, $J_{C\text{-}F}$ = 3.5 Hz), 118.2, 115.8 (d, $J_{C\text{-}F}$ = 22.1 Hz) 110.0 – 109.2 (m), 97.0 (t, $J_{C\text{-}F}$ = 1.2 Hz), 76.1 (q, $J_{C\text{-}F}$ = 1.3 Hz) ppm; carbons corresponding to

the C_2F_5 group cannot be identified due to C-F coupling.

HRMS (m/z): calcd for $C_{22}H_{11}F_6O$ $[M+H]^+$ 405.0709, found: 405.0713.



3-((4-Chlorophenyl)ethynyl)-2-(perfluoroethyl)naphtho[1,2-*b*]furan (3ai):

Yield = 49% (62 mg); 53% (67 mg). Light yellow solid. M.p. 167.4-168.5 °C.

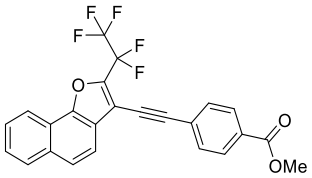
IR (KBr): ν = 3061, 2227, 1607, 1091, 824, 745 cm^{-1}.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.35 – 8.28 (m, 1H), 7.95 (d, J = 7.7 Hz, 1H), 7.81 – 7.73 (m, 2H), 7.67 – 7.62 (m, 1H), 7.61 – 7.56 (m, 1H), 7.54 – 7.48 (m, 2H), 7.38 – 7.32 (m, 2H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -83.56 (t, J = 4.1 Hz, 3F), -114.36 (q, J = 4.1 Hz, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 151.0 (t, $J_{C\text{-}F}$ = 1.3 Hz), 141.8 (t, $J_{C\text{-}F}$ = 31.8 Hz), 135.3, 133.0, 128.8, 128.5, 127.2, 127.0, 125.4, 123.3 (t, $J_{C\text{-}F}$ = 1.3 Hz), 120.9, 120.8, 120.4, 120.2, 118.2, 109.0 (m), 96.8 (t, $J_{C\text{-}F}$ = 1.7 Hz), 77.3 (t, $J_{C\text{-}F}$ = 1.3 Hz) ppm; carbons corresponding to the C_2F_5 group cannot be identified due to C-F coupling.

HRMS (m/z): calcd for $C_{22}H_{11}ClF_5O$ $[M+H]^+$ 421.0413, found: 421.0413.



Methyl 4-((2-(perfluoroethyl)naphtho[1,2-*b*]furan-3-yl)ethynyl)benzoate (3aj):

Yield = 57% (76 mg). Light yellow solid. M.p. 156.9-157.6 °C.

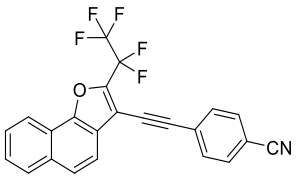
IR (KBr): ν = 2953, 2221, 1582, 1214, 812, 757 cm^{-1}.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.33 – 8.25 (m, 1H), 8.03 (d, J = 7.8 Hz, 2H), 7.98 – 7.90 (m, 1H), 7.82 – 7.71 (m, 2H), 7.66 – 7.55 (m, 4H), 3.93 (s, 3H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -83.55 (t, J = 3.1 Hz, 3F), -114.35 (t, J = 3.1 Hz, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 166.3, 151.1, 142.1 (t, $J_{C\text{-}F}$ = 32.2 Hz), 133.0, 131.7, 130.3, 129.6, 128.5, 127.2, 127.0, 126.8, 125.5, 123.2, 120.8, 120.3, 118.1, 108.8 (m), 97.1, 79.0, 52.3 ppm; carbons corresponding to the C_2F_5 group cannot be identified due to C-F coupling.

HRMS (m/z): calcd for $C_{24}H_{14}F_5O_3$ $[M+H]^+$ 445.0858, found: 445.0855.



4-((2-(Perfluoroethyl)naphtho[1,2-*b*]furan-3-yl)ethynyl)benzonitrile (3ak):

Yield = 39% (48 mg); 45% (55 mg). Light yellow solid. M.p. 179.7-180.1 °C.

IR (KBr): ν = 2971, 2227, 1608, 813, 747 cm^{-1}.

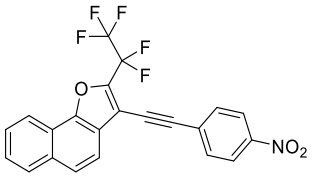
^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.33 (d, J = 8.1 Hz, 1H), 7.98 (d, J = 7.9 Hz, 1H), 7.84 – 7.73 (m, 2H), 7.70 – 7.59

(m, 6H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -83.55 (t, J = 3.4 Hz, 3F), -114.41 (q, J = 3.4 Hz, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 151.1, 142.5 (t, $J_{C\text{-}F}$ = 30.2 Hz), 133.0, 132.2, 132.1, 128.5, 127.4, 127.2, 127.0, 125.7, 123.1 (t, $J_{C\text{-}F}$ = 0.8 Hz), 120.9, 120.4, 118.3, 118.0, 112.4, 108.4 (m), 95.9 (t, $J_{C\text{-}F}$ = 1.4 Hz), 80.5 (t, $J_{C\text{-}F}$ = 0.8 Hz) ppm; carbons corresponding to the C_2F_5 group cannot be identified due to C-F coupling.

HRMS (m/z): calcd for $C_{23}H_{11}F_5NO$ $[M+H]^+$ 412.0755, found: 412.0755.



3-((4-Nitrophenyl)ethynyl)-2-(perfluoroethyl)naphtho[1,2-*b*]furan (3al):

Yield = 33% (42 mg); 43% (55 mg). Yellow solid. M.p. 199.4-200.8 °C.

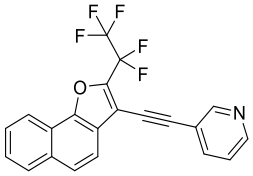
IR (KBr): ν = 2964, 2227, 1617, 1519, 811, 748 cm^{-1}.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.36 – 8.30 (m, 1H), 8.24 – 8.22 (m, 2H), 7.99 (d, J = 7.9 Hz, 1H), 7.83 (d, J = 8.6 Hz, 1H), 7.78 (s, 1H), 7.72 – 7.69 (m, 2H), 7.69 – 7.60 (m, 2H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -83.53 (t, J = 3.5 Hz, 3F), -114.40 (q, J = 3.5 Hz, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 151.2 (t, $J_{C\text{-}F}$ = 1.2 Hz), 147.5, 142.6 (t, J = 30.4 Hz), 133.0, 132.5, 128.9, 128.5, 127.4, 127.2, 125.7, 123.7, 123.0 (t, $J_{C\text{-}F}$ = 1.0 Hz), 120.8, 120.3, 117.9, 108.3 (m), 95.7 (t, J = 1.6 Hz), 81.3 (t, J = 1.2 Hz) ppm; carbons corresponding to the C_2F_5 group cannot be identified due to C-F coupling.

HRMS (m/z): calcd for $C_{22}H_{11}F_5NO_3$ $[M+H]^+$ 432.0654, found: 432.0661.



3-((2-(Perfluoroethyl)naphtho[1,2-*b*]furan-3-yl)ethynyl)pyridine (3am):

Yield = 45% (52 mg). Light yellow solid. M.p. 128.7-129.3 °C.

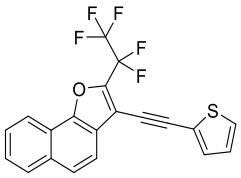
IR (KBr): ν = 3036, 2206, 1615, 1577, 802, 759 cm^{-1}.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.85 (s, 1H), 8.62 (d, J = 3.7 Hz, 1H), 8.34 (d, J = 8.0 Hz, 1H), 7.98 (d, J = 8.0 Hz, 1H), 7.89 (dt, J = 7.9, 1.8 Hz, 1H), 7.85 – 7.76 (m, 2H), 7.71 – 7.58 (m, 2H), 7.34 (dd, J = 7.7, 5.0 Hz, 1H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -83.56 (t, J = 3.7 Hz, 3F), -114.38 (q, J = 3.7 Hz, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 152.3, 151.1 (t, $J_{C\text{-}F}$ = 1.2 Hz), 149.4, 142.2 (t, $J_{C\text{-}F}$ = 30.7 Hz), 138.7, 133.0, 128.5, 127.3, 127.1, 125.6, 123.2 (t, $J_{C\text{-}F}$ = 1.2 Hz), 123.1 (t, $J_{C\text{-}F}$ = 1.2 Hz), 120.9, 120.4, 119.5 (m), 118.1, 108.6 (m), 94.5 (t, $J_{C\text{-}F}$ = 1.4 Hz), 79.6 (t, $J_{C\text{-}F}$ = 1.0 Hz) ppm; carbons corresponding to the C_2F_5 group cannot be identified due to C-F coupling.

HRMS (m/z): calcd for $C_{21}H_{11}F_5NO$ $[M+H]^+$ 388.0755, found: 388.0757.



2-(Perfluoroethyl)-3-(thiophen-2-ylethynyl)naphtho[1,2-*b*]furan (3an):

Yield = 41% (48 mg); 49% (57 mg). Light yellow solid. M.p. 104.3-106.1 ºC.

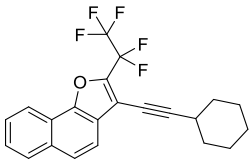
IR (KBr): ν = 2962, 2213, 1617, 1512, 811, 746 cm^{-1}.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.36 – 8.29 (m, 1H), 8.00 – 7.92 (m, 1H), 7.78 (d, J = 1.2 Hz, 2H), 7.68 – 7.55 (m, 2H), 7.42 – 7.36 (m, 2H), 7.06 (dd, J = 5.1, 3.6 Hz, 1H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -83.51 (t, J = 3.3 Hz, 3F), -114.28 (q, J = 3.3 Hz, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 151.0 (d, $J_{C\text{-}F}$ = 1.0 Hz), 141.6 (t, $J_{C\text{-}F}$ = 30.7 Hz), 133.1, 133.0, 128.5, 128.5, 127.3, 127.2, 127.0, 125.4, 123.3 (t, $J_{C\text{-}F}$ = 0.9 Hz), 122.1, 120.9, 120.4, 118.3, 109.1 (m), 91.2 (t, $J_{C\text{-}F}$ = 1.6 Hz), 80.0 (t, $J_{C\text{-}F}$ = 1.1 Hz) ppm; carbons corresponding to the C_2F_5 group cannot be identified due to C-F coupling.

HRMS (m/z): calcd for $C_{20}H_{10}F_5OS$ $[M+H]^+$ 393.0367, found: 393.0370.



3-(Cyclohexylethynyl)-2-(perfluoroethyl)naphtho[1,2-*b*]furan (3ao):

Yield = 54% (64 mg). Light yellow solid. M.p. 130.1-130.3 ºC.

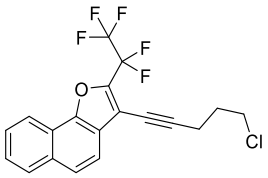
IR (KBr): ν = 2933, 2237, 1601, 810, 747 cm^{-1}.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.35 – 8.26 (m, 1H), 7.94 (d, J = 8.0 Hz, 1H), 7.77 – 7.68 (m, 2H), 7.65 – 7.54 (m, 2H), 2.77 – 2.71 (m, 1H), 1.95 – 1.90 (m, 2H), 1.83 – 1.77 (m, 2H), 1.69 – 1.53 (m, 3H), 1.47 – 1.37 (m, 3H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -83.69 (t, J = 3.8 Hz, 3F), -114.43 (q, J = 3.8 Hz, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 150.8 (d, $J_{C\text{-}F}$ = 1.0 Hz), 141.3 (t, $J_{C\text{-}F}$ = 30.2 Hz), 132.9, 128.4, 127.0, 126.7, 125.0, 123.9 (t, J = 1.0 Hz), 120.9, 120.4, 118.5, 110.0 (m), 104.0 (t, $J_{C\text{-}F}$ = 1.3 Hz), 67.6 (t, $J_{C\text{-}F}$ = 1.0 Hz), 32.3, 29.9, 25.9, 24.6 ppm; carbons corresponding to the C_2F_5 group cannot be identified due to C-F coupling.

HRMS (m/z): calcd for $C_{22}H_{18}F_5O$ $[M+H]^+$ 393.1272, found: 393.1272.



3-(5-Chloropent-1-yn-1-yl)-2-(perfluoroethyl)naphtho[1,2-*b*]furan (3ap):

Yield = 27% (32 mg); 33% (39 mg). Yellow solid. M.p. 57.0-57.6 ºC.

IR (KBr): ν = 2962, 2242, 1600, 811, 749 cm^{-1}.

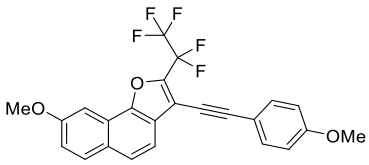
^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.32 (d, J = 8.1 Hz, 1H), 7.96 (d, J = 8.0 Hz, 1H), 7.80 – 7.68 (m, 2H), 7.67 – 7.56 (m, 2H), 3.77 (t, J = 6.3 Hz, 2H), 2.75 (t, J = 6.8 Hz, 2H), 2.17 – 2.10 (m, 2H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -83.70 (t, J = 4.0 Hz, 3F), -114.51 (q, J = 4.0 Hz, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 150.9 (t, $J_{C\text{-}F}$ = 1.1 Hz), 141.6 (t, $J_{C\text{-}F}$ = 29.7 Hz), 132.9, 128.5, 127.2, 126.9, 125.2, 123.7 (t, $J_{C\text{-}F}$ = 1.1 Hz), 120.9, 120.4, 118.3, 109.4 (m), 97.6 (t, $J_{C\text{-}F}$ = 1.4 Hz), 68.7 (t, $J_{C\text{-}F}$ = 1.1 Hz), 43.4,

31.1, 17.1 ppm; carbons corresponding to the C_2F_5 group cannot be identified due to C-F coupling.

HRMS (m/z): calcd for $C_{19}H_{13}ClF_5O$ $[M+H]^+$ 387.0570, found: 387.0571.



8-Methoxy-3-((4-methoxyphenyl)ethynyl)-2-(perfluoroethyl)naphtho[1,2-*b*]furan (3be):

Yield = 61% (54 mg). White solid. M.p. 159.0-160.3 °C.

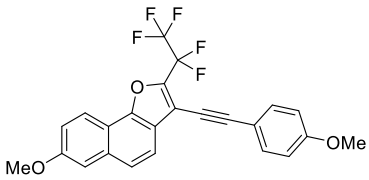
IR (KBr): ν = 2968, 2225, 1606, 1215, 835, 708 cm^{-1}.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.87 (d, J = 9.0 Hz, 1H), 7.72 (d, J = 8.5 Hz, 1H), 7.65 (d, J = 8.5 Hz, 1H), 7.60 – 7.51 (m, 3H), 7.23 (dd, J = 8.9, 2.6 Hz, 1H), 6.95 – 6.89 (m, 2H), 4.02 (s, 3H), 3.85 (s, 3H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -83.57 (t, J = 3.6 Hz, 3F), -114.39 (q, J = 3.6 Hz, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 160.2, 158.7, 150.5 (t, $J_{C\text{-}F}$ = 1.1 Hz), 141.1 (t, $J_{C\text{-}F}$ = 31.6 Hz), 133.4, 130.1, 128.1, 124.9, 124.0 (t, $J_{C\text{-}F}$ = 1.2 Hz), 121.9, 119.2, 115.9, 114.4, 114.1, 109.7 (m), 99.0, 98.1 (t, $J_{C\text{-}F}$ = 1.3 Hz), 75.2 (t, $J_{C\text{-}F}$ = 1.1 Hz), 55.6, 55.4 ppm; carbons corresponding to the C_2F_5 group cannot be identified due to C-F coupling.

HRMS (m/z): calcd for $C_{24}H_{16}F_5O_3$ $[M+H]^+$ 447.1014, found: 447.1013.



7-Methoxy-3-((4-methoxyphenyl)ethynyl)-2-(perfluoroethyl)naphtho[1,2-b]furan (3ce):

Yield = 66% (59 mg). Light yellow solid. M.p. 123.4-125.1 °C.

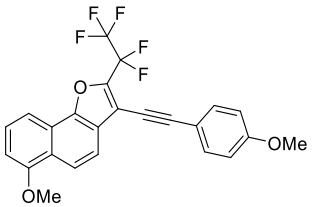
IR (KBr): ν = 2967, 2223, 1615, 1199, 830, 767 cm^{-1}.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.24 (d, J = 8.6 Hz, 1H), 7.76 (d, J = 8.6 Hz, 1H), 7.69 (d, J = 8.6 Hz, 1H), 7.58 – 7.52 (m, 2H), 7.34 – 7.27 (m, 2H), 6.96 – 6.88 (m, 2H), 3.96 (s, 3H), 3.85 (s, 3H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -83.59 (t, J = 3.5 Hz, 3F), -114.20 (q, J = 3.5 Hz, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 160.2, 158.5, 151.3 (t, $J_{C\text{-}F}$ = 1.2 Hz), 140.6 (t, $J_{C\text{-}F}$ = 30.7 Hz), 134.6, 133.4, 124.3, 122.0, 121.9, 119.2, 119.1, 116.0, 114.5, 114.1, 109.6 (m), 107.4, 98.1, 75.3, 55.4, 55.4 ppm; carbons corresponding to the C_2F_5 group cannot be identified due to C-F coupling.

HRMS (m/z): calcd for $C_{24}H_{16}F_5O_3$ $[M+H]^+$ 447.1014, found: 447.1017.



6-Methoxy-3-((4-methoxyphenyl)ethynyl)-2-(perfluoroethyl)naphtho[1,2-*b*]furan (3de):

Yield = 60% (53 mg). Yellow solid. M.p. 147.6-148.3 °C.

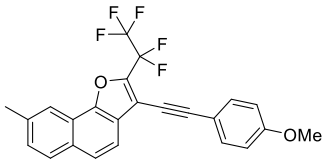
IR (KBr): ν = 2965, 2228, 1596, 1196, 800, 756 cm^{-1}.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.23 (d, J = 8.9 Hz, 1H), 7.91 (d, J = 8.3 Hz, 1H), 7.77 (d, J = 8.9 Hz, 1H), 7.60 – 7.52 (m, 3H), 6.99 – 6.89 (m, 3H), 4.04 (s, 3H), 3.85 (s, 3H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -83.57 (t, J = 3.7 Hz, 3F), -114.36 (q, J = 3.7 Hz, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 160.2, 155.9, 150.9 (t, $J_{C\text{-}F}$ = 1.2 Hz), 141.3 (t, $J_{C\text{-}F}$ = 30.4 Hz), 133.4, 127.6, 124.6, 124.0, 121.9, 119.2, 117.5, 114.4, 114.1, 112.5, 109.6 (m), 105.4, 98.2 (t, $J_{C\text{-}F}$ = 1.4 Hz), 75.2 (t, $J_{C\text{-}F}$ = 1.1 Hz), 55.7, 55.4 ppm; carbons corresponding to the C_2F_5 group cannot be identified due to C-F coupling.

HRMS (m/z): calcd for $C_{24}H_{16}F_5O_3$ $[M+H]^+$ 447.1014, found: 447.1013.



3-((4-Methoxyphenyl)ethynyl)-8-methyl-2-(perfluoroethyl)naphtho[1,2-*b*]furan (3ee):

Yield = 63% (54 mg). Yellow solid. M.p. 138.4-139.8 ºC.

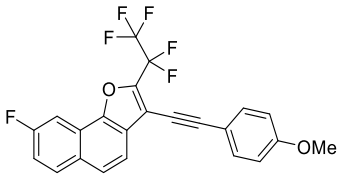
IR (KBr): ν = 3005, 2217, 1603, 1206, 810, 729 cm^{-1}.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.11 (s, 1H), 7.86 (d, J = 8.4 Hz, 1H), 7.79 – 7.68 (m, 2H), 7.56 (d, J = 8.8 Hz, 2H), 7.47 – 7.39 (m, 1H), 6.93 (d, J = 8.8 Hz, 2H), 3.86 (s, 3H), 2.60 (s, 3H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -83.57 (t, J = 3.4 Hz, 3F), -114.29 (q, J = 3.4 Hz, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 160.2, 150.7 (d, $J_{C\text{-}F}$ = 1.3 Hz), 141.1 (t, $J_{C\text{-}F}$ = 30.5 Hz), 137.3, 133.4, 131.2, 129.0, 128.3, 125.0, 123.6, 121.0, 119.5, 117.4, 114.4, 114.1, 109.6 (m), 98.1 (t, $J_{C\text{-}F}$ = 1.3 Hz), 75.2 (t, $J_{C\text{-}F}$ = 0.8 Hz), 55.3, 21.8 ppm; carbons corresponding to the C_2F_5 group cannot be identified due to C-F coupling.

HRMS (m/z): calcd for $C_{24}H_{16}F_5O_2$ $[M+H]^+$ 431.1065, found: 431.1070.



8-Fluoro-3-((4-methoxyphenyl)ethynyl)-2-(perfluoroethyl)naphtho[1,2-*b*]furan (3fe):

Yield = 54% (47 mg). Yellow solid. M.p. 158.6-159.1 ºC.

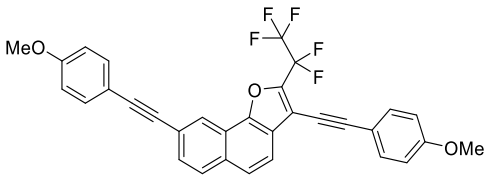
IR (KBr): ν = 2936, 2222, 1603, 1200, 832, 731 cm^{-1}.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.98 – 7.90 (m, 2H), 7.83 – 7.69 (m, 2H), 7.54 (d, J = 8.7 Hz, 2H), 7.35 (td, J = 8.8, 2.4 Hz, 1H), 6.92 (d, J = 8.7 Hz, 2H), 3.85 (s, 3H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -83.57 (t, J = 3.0 Hz, 3F), -111.15 – -111.21 (m, 1F), -114.45 (q, J = 3.0 Hz, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 161.4 (d, $J_{C\text{-}F}$ = 247.5 Hz), 160.3, 150.5 (m), 141.6 (t, $J_{C\text{-}F}$ = 31.8 Hz), 133.4, 131.1 (d, $J_{C\text{-}F}$ = 9.0 Hz), 129.8, 125.0, 124.3, 121.7 (d, $J_{C\text{-}F}$ = 10.0 Hz), 117.7, 116.8 (d, $J_{C\text{-}F}$ = 24.5 Hz), 114.2, 114.1, 109.7 (m), 104.8 (d, $J_{C\text{-}F}$ = 23.2 Hz), 98.5, 74.8, 55.4 ppm; carbons corresponding to the C_2F_5 group cannot be identified due to C-F coupling.

HRMS (m/z): calcd for $C_{23}H_{13}F_6O_2$ $[M+H]^+$ 435.0814, found: 435.0815.



3,8-Bis((4-methoxyphenyl)ethynyl)-2-(perfluoroethyl)naphtho[1,2-*b*]furan (3ge):

Yield = 39% (32 mg); 61% (50 mg). Yellow solid. M.p. 185.3-186.7 ºC.

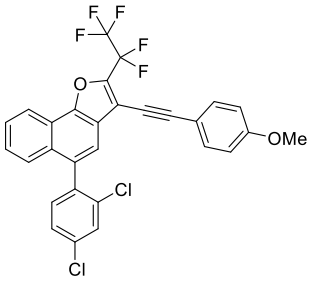
IR (KBr): ν = 2962, 2218, 1599, 1213, 832, 765 cm^{-1}.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.53 – 8.47 (m, 1H), 7.94 (d, J = 8.6 Hz, 1H), 7.84 – 7.74 (m, 2H), 7.69 (dd, J = 8.5, 1.6 Hz, 1H), 7.59 – 7.51 (m, 4H), 6.96 – 6.88 (m, 4H), 3.87 – 3.85 (m, 6H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -83.56 (t, J = 3.2 Hz, 3F), -114.44 (q, J = 3.2 Hz, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 160.3, 159.8, 150.4 (t, $J_{C\text{-}F}$ = 1.2 Hz), 141.8 (t, $J_{C\text{-}F}$ = 32.8 Hz), 133.4, 133.2, 131.9, 129.5, 128.5, 125.0, 124.1 (t, $J_{C\text{-}F}$ = 0.9 Hz), 123.3, 122.5, 120.7, 119.0, 115.0, 114.3, 114.1, 114.1, 109.8 (m), 98.4 (t, $J_{C\text{-}F}$ = 1.3 Hz), 91.1, 88.0, 74.9 (t, $J_{C\text{-}F}$ = 1.1 Hz), 55.4, 55.3 ppm; carbons corresponding to the C_2F_5 group cannot be identified due to C-F coupling.

HRMS (m/z): calcd for $C_{32}H_{20}F_5O_3$ $[M+H]^+$ 547.1327, found: 547.1329.



5-(2,4-Dichlorophenyl)-3-((4-methoxyphenyl)ethynyl)-2-(perfluoroethyl)naphtho[1,2-*b*]furan (3he):

Yield = 28% (32 mg); 30% (34 mg). Light yellow solid. M.p. 162.4-163.8 ºC.

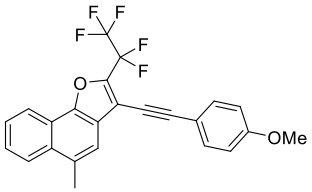
IR (KBr): ν = 2967, 2224, 1594, 1214, 823, 762 cm^{-1}.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.42 (d, J = 7.9 Hz, 1H), 7.85 (d, J = 8.5 Hz, 1H), 7.73 – 7.66 (m, 2H), 7.63 – 7.50 (m, 5H), 7.35 (dd, J = 8.2, 2.0 Hz, 1H), 6.93 – 6.86 (m, 2H), 3.84 (s, 3H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -83.55 (t, J = 3.2 Hz, 3F), -114.39 (q, J = 3.2 Hz, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 160.3, 150.8 (t, $J_{C\text{-}F}$ = 1.4 Hz), 141.6 (t, $J_{C\text{-}F}$ = 31.8 Hz), 140.2, 135.3, 133.4, 132.6, 132.0, 131.9, 131.1, 130.3, 129.6, 127.4, 127.3, 126.6, 122.8 (t, $J_{C\text{-}F}$ = 1.3 Hz), 121.1, 120.8, 119.4, 114.1, 114.1, 109.7 (m), 98.6 (t, $J_{C\text{-}F}$ = 1.3 Hz), 74.8 (t, $J_{C\text{-}F}$ = 1.1 Hz), 55.3 ppm; carbons corresponding to the C_2F_5 group cannot be identified due to C-F coupling.

HRMS (m/z): calcd for $C_{29}H_{16}Cl_2F_5O_2$ $[M+H]^+$ 561.0442, found: 561.0436.



3-((4-Methoxyphenyl)ethynyl)-5-methyl-2-(perfluoroethyl)naphtho[1,2-*b*]furan (3ie):

Yield = 34% (29 mg); 35% (30 mg). Yellow solid. M.p. 137.8-139.6 ºC.

IR (KBr): ν = 2918, 2222, 1612, 1217, 830, 756 cm^{-1}.

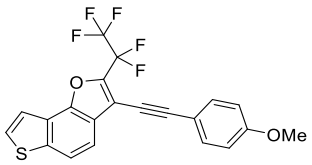
^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.38 – 8.32 (m, 1H), 8.11 – 8.04 (m, 1H), 7.69 – 7.60 (m, 3H), 7.58 – 7.53 (m, 2H), 6.96 – 6.89 (m, 2H), 3.85 (s, 3H), 2.77 (d, J = 1.1 Hz, 3H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -83.59 (t, J = 3.8 Hz, 3F), -114.22 (q, J = 3.8 Hz, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 160.2, 150.2 (t, $J_{C\text{-}F}$ = 1.4 Hz), 141.0 (t, $J_{C\text{-}F}$ = 31.8 Hz), 133.4, 132.2, 131.6, 128.3, 126.8, 126.7, 125.1, 123.0 (t, $J_{C\text{-}F}$ = 0.9 Hz), 121.0, 120.9, 118.3, 114.5, 114.1, 98.0 (t, $J_{C\text{-}F}$ = 1.4 Hz), 75.3 (t,

$J_{C\text{-}F}$ = 1.2 Hz), 55.4, 19.8 ppm; carbons corresponding to the C_2F_5 group cannot be identified due to C-F coupling.

HRMS (m/z): calcd for $C_{24}H_{16}F_5O_2$ $[M+H]^+$ 431.1065, found: 431.1064.



3-((4-Methoxyphenyl)ethynyl)-2-(perfluoroethyl)thieno[2,3-*g*]benzofuran (3je):

Yield = 58% (47 mg). White solid. M.p. 135.8-136.9 °C.

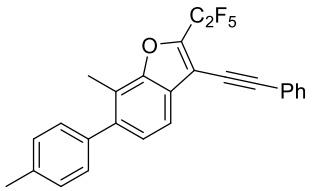
IR (KBr): ν = 2971, 2220, 1615, 1508, 1219, 828, 718 cm^{-1}.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.86 (dd, J = 8.5, 0.6 Hz, 1H), 7.76 – 7.69 (m, 2H), 7.61 (d, J = 5.5 Hz, 1H), 7.57 – 7.51 (m, 2H), 6.95 – 6.88 (m, 2H), 3.85 (s, 3H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -83.59 (t, J = 4.2 Hz, 3F), -114.46 (q, J = 4.2 Hz, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 160.3, 149.5 (t, $J_{C\text{-}F}$ = 1.0 Hz), 140.6, 140.6 (t, $J_{C\text{-}F}$ = 30.2 Hz), 133.4, 128.0, 125.3 (t, $J_{C\text{-}F}$ = 0.9 Hz), 123.6, 119.0, 118.9, 117.1, 114.4, 114.1, 109.5 (m), 98.4 (t, $J_{C\text{-}F}$ = 1.5 Hz), 75.1 (t, $J_{C\text{-}F}$ = 0.9 Hz), 55.3 ppm; carbons corresponding to the C_2F_5 group cannot be identified due to C-F coupling.

HRMS (m/z): calcd for $C_{21}H_{12}F_5O_2S$ $[M+H]^+$ 423.0473, found: 423.0474.



7-Methyl-2-(perfluoroethyl)-3-(phenylethynyl)-6-(p-tolyl)benzofuran (3ke):

Yield = 14% (12 mg). White solid. M.p. 62.7-63.9 °C.

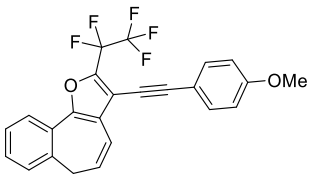
IR (KBr): ν = 3026, 2228, 1586, 1208, 806, 758 cm^{-1}.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.67 (d, J = 8.1 Hz, 1H), 7.63 – 7.58 (m, 2H), 7.56 – 7.50 (m, 2H), 7.42 – 7.38 (m, 3H), 7.37 – 7.32 (m, 3H), 2.47 (s, 3H), 2.43 (s, 3H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -83.58 (t, J = 2.9 Hz, 3F), -114.96 (q, J = 2.9 Hz, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 154.4, 142.5 (t, $J_{C\text{-}F}$ = 30.2 Hz), 141.5, 137.2 (d, $J_{C\text{-}F}$ = 38.6 Hz), 132.5, 131.8, 129.4, 129.1 (d, $J_{C\text{-}F}$ = 13.8 Hz), 129.0, 128.4 (d, $J_{C\text{-}F}$ = 12.4 Hz), 126.8, 125.8 (t, $J_{C\text{-}F}$ = 1.2 Hz), 122.4, 121.0 (d, $J_{C\text{-}F}$ = 47.3 Hz), 118.2, 108.5 (m), 81.5, 73.9, 21.2, 12.7 ppm; carbons corresponding to the C_8F_{17} group cannot be identified due to C-F coupling.

HRMS (m/z): calcd for $C_{26}H_{18}F_5O$ $[M+H]^+$ 441.1272, found: 441.1279.



3-((4-Methoxyphenyl)ethynyl)-2-(perfluoroethyl)-6*H*-benzo[6,7]cyclohepta[1,2-*b*]furan (3le):

Yield = 26% (25 mg). White solid. M.p. 66.8-67.5 °C.

IR (KBr): ν = 2958, 2222, 1595, 1226, 834, 767 cm^{-1}.

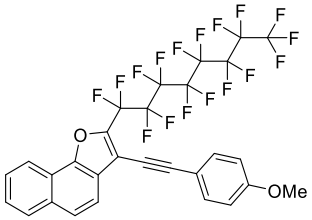
^{1}H NMR (400 MHz, $CDCl_3$): δ = 7.75 (d, J = 7.7 Hz, 1H), 7.49 (d, J = 8.4 Hz, 2H), 7.44 (d, J = 7.4 Hz, 1H), 7.37

(t, J = 7.5 Hz, 1H), 7.28 (d, J = 7.7 Hz, 1H), 6.89 (d, J = 8.4 Hz, 2H), 6.63 (d, J = 9.8 Hz, 1H), 5.99 – 5.86 (m, 1H), 3.84 (s, 3H), 3.24 (d, J = 6.7 Hz, 2H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -83.73 (t, J = 3.3 Hz, 3F), -114.54 (q, J = 3.3 Hz, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 160.2, 153.9 (t, $J_{C\text{-}F}$ = 2.1 Hz), 139.0 (t, $J_{C\text{-}F}$ = 31.6 Hz), 135.0, 133.3, 130.6, 128.7, 127.8, 126.6, 125.9, 125.0, 123.7, 119.9, 114.4, 114.0, 112.7 (m), 97.8 (t, $J_{C\text{-}F}$ = 1.4 Hz), 75.2 (t, $J_{C\text{-}F}$ = 1.4 Hz), 55.3, 34.1 ppm; carbons corresponding to the C_2F_5 group cannot be identified due to C-F coupling.

HRMS (m/z): calcd for $C_{24}H_{16}F_5O_2$ $[M+H]^+$ 431.1065, found: 431.1064.



3-((4-Methoxyphenyl)ethynyl)-2-(perfluorooctyl)naphtho[1,2-*b*]furan (3ne):

Yield = 57% (81 mg). White solid. M.p. 125.6-125.9 °C.

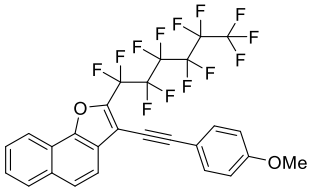
IR (KBr): ν = 2974, 2226, 1612, 1212, 813, 748 cm^{-1}.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.34 (d, J = 8.0 Hz, 1H), 7.97 (d, J = 8.0 Hz, 1H), 7.82 – 7.78 (m, 2H), 7.70 – 7.64 (m, 1H), 7.62 – 7.58 (m, 1H), 7.57 – 7.51 (m, 2H), 6.95 – 6.89 (m, 2H), 3.85 (s, 3H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -80.65 (t, J = 9.9 Hz, 3F), -110.89 – -111.23 (m, 2F), -121.45 – -121.96 (m, 6F), -122.01 – -122.24 (m, 2F), -122.44 – -122.85 (m, 2F), -125.90 – -126.28 (m, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 160.3, 151.1 (t, $J_{C\text{-}F}$ = 1.0 Hz), 141.4 (t, $J_{C\text{-}F}$ = 31.5 Hz), 133.4, 133.0, 128.5, 127.2, 126.9, 125.2, 123.6, 121.0, 120.4, 118.5, 114.4, 114.1, 110.0 (m), 98.1 (t, $J_{C\text{-}F}$ = 1.5 Hz), 75.1 (t, $J_{C\text{-}F}$ = 1.0 Hz), 55.3 ppm; carbons corresponding to the C_8F_{17} group cannot be identified due to C-F coupling.

HRMS (m/z): calcd for $C_{29}H_{14}F_{17}O_2$ $[M+H]^+$ 717.0717, found: 717.0726.



3-((4-Methoxyphenyl)ethynyl)-2-(perfluorohexyl)naphtho[1,2-*b*]furan (3oe):

Yield = 48% (59 mg). Light yellow solid. M.p. 104.3-106.1 °C.

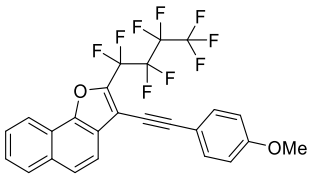
IR (KBr): ν = 2970, 2221, 1610, 1216, 812, 719 cm^{-1}.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.34 (d, J = 8.0 Hz, 1H), 7.97 (d, J = 7.9 Hz, 1H), 7.80 (d, J = 1.2 Hz, 2H), 7.69 – 7.63 (m, 1H), 7.60 (ddd, J = 8.2, 7.0, 1.3 Hz, 1H), 7.57 – 7.52 (m, 2H), 6.95 – 6.89 (m, 2H), 3.85 (s, 3H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -80.64 (t, J = 9.8 Hz, 3F), -110.89 – -111.22 (m, 2F), -121.67 – -121.98 (m, 2F), -122.01 – -122.35 (m, 2F), -122.40 – -122.76 (m, 2F), -125.90 – -126.10 (m, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 160.3, 151.1 (t, $J_{C\text{-}F}$ = 1.4 Hz), 141.4 (t, $J_{C\text{-}F}$ = 31.1 Hz), 133.4, 133.0, 128.5, 127.2, 126.9, 125.2, 123.5, 120.9, 120.4, 118.5, 114.4, 114.1, 110.0 (m), 98.1 (t, $J_{C\text{-}F}$ = 1.6 Hz), 75.2 (t, $J_{C\text{-}F}$ = 1.0 Hz), 55.3 ppm; carbons corresponding to the C_6F_{13} group cannot be identified due to C-F coupling.

HRMS (m/z): calcd for $C_{27}H_{14}F_{13}O_2$ $[M+H]^+$ 617.0781, found: 617.0790.



3-((4-Methoxyphenyl)ethynyl)-2-(perfluorobutyl)naphtho[1,2-*b*]furan (3pe):

Yield = 58% (60 mg). Yellow solid. M.p. 85.6-87.2 °C.

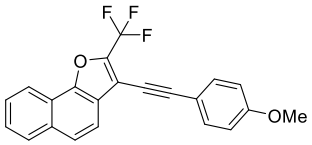
IR (KBr): ν = 2958, 2222, 1596, 1242, 896, 749 cm^{-1}.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.34 (d, J = 8.1 Hz, 1H), 7.97 (d, J = 7.8 Hz, 1H), 7.80 (d, J = 1.2 Hz, 2H), 7.69 – 7.63 (m, 1H), 7.60 (ddd, J = 8.2, 7.0, 1.4 Hz, 1H), 7.57 – 7.52 (m, 2H), 6.97 – 6.88 (m, 2H), 3.85 (s, 3H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -80.73 (t, J = 9.7 Hz, 3F), -111.28 (t, J = 11.0 Hz, 2F), -123.01 – -123.19 (m, 2F), -125.88 – -126.16 (m, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 160.3, 151.1 (t, $J_{C\text{-}F}$ = 1.1 Hz), 141.3 (t, $J_{C\text{-}F}$ = 30.9 Hz), 133.4, 133.0, 128.5, 127.2, 126.9, 125.2, 123.5 (t, $J_{C\text{-}F}$ = 1.3 Hz), 120.9, 120.4, 118.5, 114.4, 114.1, 110.0 (m), 98.1 (t, $J_{C\text{-}F}$ = 1.5 Hz), 75.2 (t, $J_{C\text{-}F}$ = 1.4 Hz), 55.3 ppm; carbons corresponding to the C_4F_9 group cannot be identified due to C-F coupling.

HRMS (m/z): calcd for $C_{25}H_{14}F_9O_2$ $[M+H]^+$ 517.0845, found: 517.0845.



3-((4-Methoxyphenyl)ethynyl)-2-(trifluoromethyl)naphtho[1,2-*b*]furan (3qe):

Yield = 27% (20 mg); 51% (38 mg). Light yellow solid. M.p. 131.6-132.5 °C.

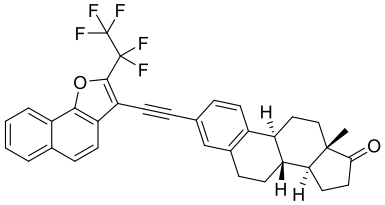
IR (KBr): ν = 2963, 2222, 1599, 1190, 808, 748 cm^{-1}.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.26 (d, J = 8.0 Hz, 1H), 7.89 (d, J = 8.0 Hz, 1H), 7.71 (s, 2H), 7.61 – 7.55 (m, 1H), 7.55 – 7.45 (m, 3H), 6.88 – 6.81 (m, 2H), 3.77 (s, 3H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -62.32 (s, 3F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 160.3, 150.3 (q, $J_{C\text{-}F}$ = 1.1 Hz), 142.1 (t, $J_{C\text{-}F}$ = 30.0 Hz), 133.4, 133.0, 128.5, 127.1, 126.8, 125.2, 123.3, 121.0, 120.4, 120.0 (q, $J_{C\text{-}F}$ = 267.3 Hz), 118.6, 114.4, 114.1, 98.1 (q, $J_{C\text{-}F}$ = 1.6 Hz), 75.1 (q, $J_{C\text{-}F}$ = 1.1 Hz), 55.3 ppm.

HRMS (m/z): calcd for $C_{22}H_{14}F_3O_2$ $[M+H]^+$ 367.0940, found: 367.0944.



(8*R*,9*S*,13*S*,14*S*)-13-Methyl-3-((2-(perfluoroethyl)naphtho[1,2-*b*]furan-3-yl)ethynyl)-6,7,8,9,11,12,13,14,15,16-decahydro-17*H*-cyclopenta[*a*]phenanthren-17-one (4):

Yield = 45% (60 mg). Light yellow solid. M.p. 178.2-179.8 °C.

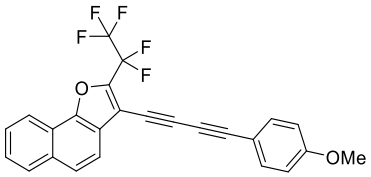
IR (KBr): ν = 2967, 2222, 1736, 1553, 1206, 817, 754 cm^{-1}.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.34 (d, J = 8.1 Hz, 1H), 7.98 (d, J = 7.9 Hz, 1H), 7.80 (s, 2H), 7.70 – 7.57 (m, 2H), 7.43 – 7.28 (m, 3H), 3.02 – 2.89 (m, 2H), 2.56 – 2.39 (m, 2H), 2.38 – 2.27 (m, 1H), 2.22 – 1.95 (m, 4H), 1.68 – 1.45 (m, 6H), 0.93 (s, 3H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -83.55 (t, J = 3.6 Hz, 3F), -114.35 (q, J = 3.6 Hz, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 220.8, 151.0 (t, $J_{C\text{-}F}$ = 1.1 Hz), 144.1 (t, $J_{C\text{-}F}$ = 9.1 Hz), 141.3, 136.8, 132.9, 132.2, 129.1, 128.5, 127.2, 126.9, 125.5, 125.3, 123.5 (t, $J_{C\text{-}F}$ = 1.0 Hz), 120.9, 120.4, 119.6, 118.4, 109.5 (m), 98.3 (t, $J_{C\text{-}F}$ = 1.3 Hz), 75.6 (t, $J_{C\text{-}F}$ = 0.8 Hz), 50.4, 47.9, 44.5, 37.9, 35.8, 31.5, 29.1, 26.3, 25.5, 21.5, 13.8 ppm; carbons corresponding to the C_2F_5 group cannot be identified due to C-F coupling.

HRMS (m/z): calcd for $C_{34}H_{28}F_5O_2$ $[M+H]^+$ 563.2004, found: 563.2003.



3-((4-Methoxyphenyl)buta-1,3-diyn-1-yl)-2-(perfluoroethyl)naphtho[1,2-*b*]furan (5):

Yield = 34% (30 mg). Pink solid. M.p. 134.0-134.8 ºC.

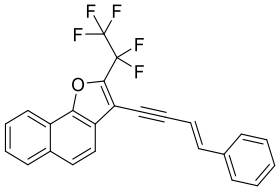
IR (KBr): ν = 2976, 2214, 1602, 1210, 828, 758 cm^{-1}.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.33 (d, J = 8.1 Hz, 1H), 7.98 (d, J = 7.8 Hz, 1H), 7.84 – 7.76 (m, 2H), 7.70 – 7.59 (m, 2H), 7.56 – 7.50 (m, 2H), 6.93 – 6.86 (m, 2H), 3.85 (s, 3H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -83.54 (t, J = 4.0 Hz, 3F), -114.51 (q, J = 4.0 Hz, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 160.7, 151.0 (t, $J_{C\text{-}F}$ = 0.9 Hz), 143.4 (t, $J_{C\text{-}F}$ = 30.0 Hz), 134.3, 133.0, 128.5, 127.3, 127.1, 125.6, 123.8, 120.9, 120.4, 118.3, 114.2, 113.0, 108.4 (m), 84.2, 82.5 (t, $J_{C\text{-}F}$ = 1.7 Hz), 72.3 (t, $J_{C\text{-}F}$ = 1.3 Hz), 67.6 (t, $J_{C\text{-}F}$ = 1.0 Hz), 55.4 ppm; carbons corresponding to the C_2F_5 group cannot be identified due to C-F coupling.

HRMS (m/z): calcd for $C_{25}H_{14}F_5O_2$ $[M+H]^+$ 441.0908, found: 441.0910.



(*E*)-2-(Perfluoroethyl)-3-(4-phenylbut-3-en-1-yn-1-yl)naphtho[1,2-*b*]furan (6):

Yield = 46% (38 mg). Light yellow solid. M.p. 139.7-141.5 ºC.

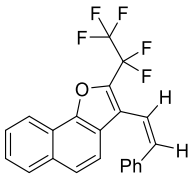
IR (KBr): ν = 3027, 2202, 1581, 809, 740 cm^{-1}.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.30 (d, J = 8.1 Hz, 1H), 7.94 (d, J = 7.9 Hz, 1H), 7.76 (d, J = 1.6 Hz, 2H), 7.67 – 7.54 (m, 2H), 7.45 (d, J = 7.2 Hz, 2H), 7.39 – 7.29 (m, 3H), 7.15 (d, J = 16.3 Hz, 1H), 6.45 (d, J = 16.3 Hz, 1H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -83.54 (t, J = 2.7 Hz, 3F), -114.33 (q, J = 2.7 Hz, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 151.0 (t, J = 1.1 Hz), 143.1, 141.4 (t, $J_{C\text{-}F}$ = 31.0 Hz), 135.8, 132.9, 129.1, 128.8, 128.4, 127.1, 126.9, 126.5, 125.3, 123.5 (t, $J_{C\text{-}F}$ = 1.3 Hz), 120.9, 120.3, 118.3, 109.5 (m), 107.2, 97.5, 78.3 (t, J = 1.2 Hz) ppm; carbons corresponding to the C_2F_5 group cannot be identified due to C-F coupling.

HRMS (m/z): calcd for $C_{24}H_{14}F_5O$ $[M+H]^+$ 413.0959, found: 413.0956.



(*Z*)-2-(Perfluoroethyl)-3-styrylnaphtho[1,2-*b*]furan (7):

Yield = 98% (66 mg). Yellow solid. M.p. 75.7-77.3 °C.

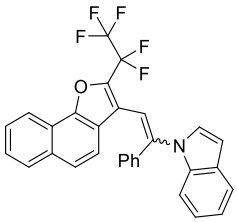
IR (KBr): ν = 3034, 1595, 814, 753 cm^{-1}.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.34 (d, J = 8.2 Hz, 1H), 7.84 (d, J = 8.2 Hz, 1H), 7.65 – 7.58 (m, 1H), 7.56 – 7.50 (m, 1H), 7.39 (d, J = 8.8 Hz, 1H), 7.17 (dd, J = 7.2, 2.5 Hz, 2H), 7.14 – 7.08 (m, 3H), 6.96 (d, J = 12.2 Hz, 1H), 6.91 (d, J = 8.7 Hz, 1H), 6.69 (dt, J = 12.1, 3.5 Hz, 1H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -83.73 (t, J = 3.6 Hz, 3F), -114.21 (q, J = 3.6 Hz, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 151.4 (t, $J_{C\text{-}F}$ = 1.1 Hz), 137.0 (t, $J_{C\text{-}F}$ = 30.4 Hz), 136.3, 135.2 (t, $J_{C\text{-}F}$ = 1.6 Hz), 132.4, 128.9, 128.3, 128.3, 127.8, 126.8, 126.6, 124.1, 123.4 (t, $J_{C\text{-}F}$ = 2.2 Hz), 121.4 (t, $J_{C\text{-}F}$ = 1.0 Hz), 121.0, 120.4, 119.8, 116.1 ppm; carbons corresponding to the C_2F_5 group cannot be identified due to C-F coupling.

HRMS (m/z): calcd for $C_{22}H_{14}F_5O$ $[M+H]^+$ 389.0959, found: 389.0953.



1-(2-(2-(Perfluoroethyl)naphtho[1,2-*b*]furan-3-yl)-1-phenylvinyl)-1*H*-indole (8):

Yield = 75% (58 mg, *Z*/*E* = 1/3). White solid. M.p. 73.0-74.3 °C.

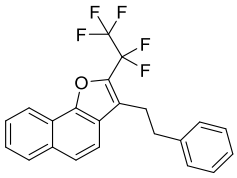
IR (KBr): ν = 3028, 1563, 1212, 810, 743 cm^{-1}.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.36 – 8.22 (m, 1H), 7.83 – 7.65 (m, 1H), 7.64 – 7.31 (m, 7H), 7.27 – 7.22 (m, 1H), 7.19 – 6.97 (m, 5H), 6.94 – 6.85 (m, 1H), 6.67 – 6.38 (m, 2H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -83.35 – -83.55 (m, 3F), -113.20 – -113.85 (m, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 150.9 (m), 141.8 (t, $J_{C\text{-}F}$ = 1.4 Hz), 137.3, 136.1, 135.5, 132.4, 129.7, 129.7, 129.2, 129.0, 128.8, 128.1, 127.5, 126.7, 126.5, 124.3, 122.4, 121.4 (m), 120.9, 120.7, 120.5, 120.3, 118.3, 112.2, 108.9 (m), 104.6 (m) ppm; carbons corresponding to the C_2F_5 group cannot be identified due to C-F coupling.

HRMS (m/z): calcd for $C_{30}H_{19}F_5NO$ $[M+H]^+$ 504.1381, found: 504.1378.



2-(Perfluoroethyl)-3-phenethylnaphtho[1,2-*b*]furan (9):

Yield = 76% (60 mg). Light yellow solid. M.p. 68.6-69.9 °C.

IR (KBr): ν = 3025, 1523, 802, 753 cm^{-1}.

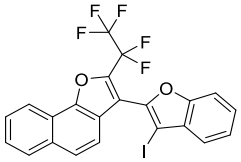
^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.37 – 8.30 (m, 1H), 7.97 – 7.92 (m, 1H), 7.69 (d, J = 8.6 Hz, 1H), 7.64 (t, J = 7.1 Hz, 1H), 7.60 – 7.55 (m, 1H), 7.50 (d, J = 8.6 Hz, 1H), 7.31 – 7.27 (m, 2H), 7.22 – 7.16 (m, 3H), 3.24 – 3.16 (m,

2H), 3.04 – 2.97 (m, 2H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -83.94 (t, J = 2.8 Hz, 3F), -113.65 (q, J = 2.8 Hz, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 151.1 (t, $J_{C\text{-}F}$ = 1.2 Hz), 142.6 (t, $J_{C\text{-}F}$ = 30.2 Hz), 140.8, 132.5, 128.5, 128.4, 128.3, 128.2, 126.9, 126.5, 126.3, 124.3, 123.3, 121.1, 120.5, 117.9, 36.7, 25.6 (t, $J_{C\text{-}F}$ = 1.9 Hz) ppm; carbons corresponding to the C_2F_5 group cannot be identified due to C-F coupling.

HRMS (m/z): calcd for $C_{22}H_{16}F_5O$ $[M+H]^+$ 391.1116, found: 391.1115.



3-(3-Iodobenzofuran-2-yl)-2-(perfluoroethyl)naphtho[1,2-*b*]furan (10):

Yield = 99% (52 mg). White solid. M.p. 118.3-119.7 °C.

IR (KBr): ν = 2923, 1537, 1220, 809, 745, 562 cm^{-1}.

^{1}H NMR (400 MHz, $CDCl_3$): δ = 8.40 (d, J = 8.2 Hz, 1H), 7.97 (d, J = 8.1 Hz, 1H), 7.77 (d, J = 8.7 Hz, 1H), 7.71 – 7.65 (m, 1H), 7.65 – 7.51 (m, 4H), 7.48 – 7.36 (m, 2H) ppm.

^{19}F NMR (376 MHz, $CDCl_3$): δ = -83.12 (t, J = 3.3 Hz, 3F), -114.03 (q, J = 3.3 Hz, 2F) ppm.

^{13}C NMR (100 MHz, $CDCl_3$): δ = 154.9, 151.3, 145.8, 140.0 (t, $J_{C\text{-}F}$ = 32.3 Hz), 132.9, 131.1, 128.5, 127.3, 127.1, 126.3, 125.4, 123.8, 122.2, 121.8, 121.0, 120.4, 119.4, 116.3 (m), 111.6, 68.5 ppm; carbons corresponding to the C_2F_5 group cannot be identified due to C-F coupling.

HRMS (m/z): calcd for $C_{22}H_{11}F_5IO_2$ $[M+H]^+$ 528.9718, found: 528.9719.

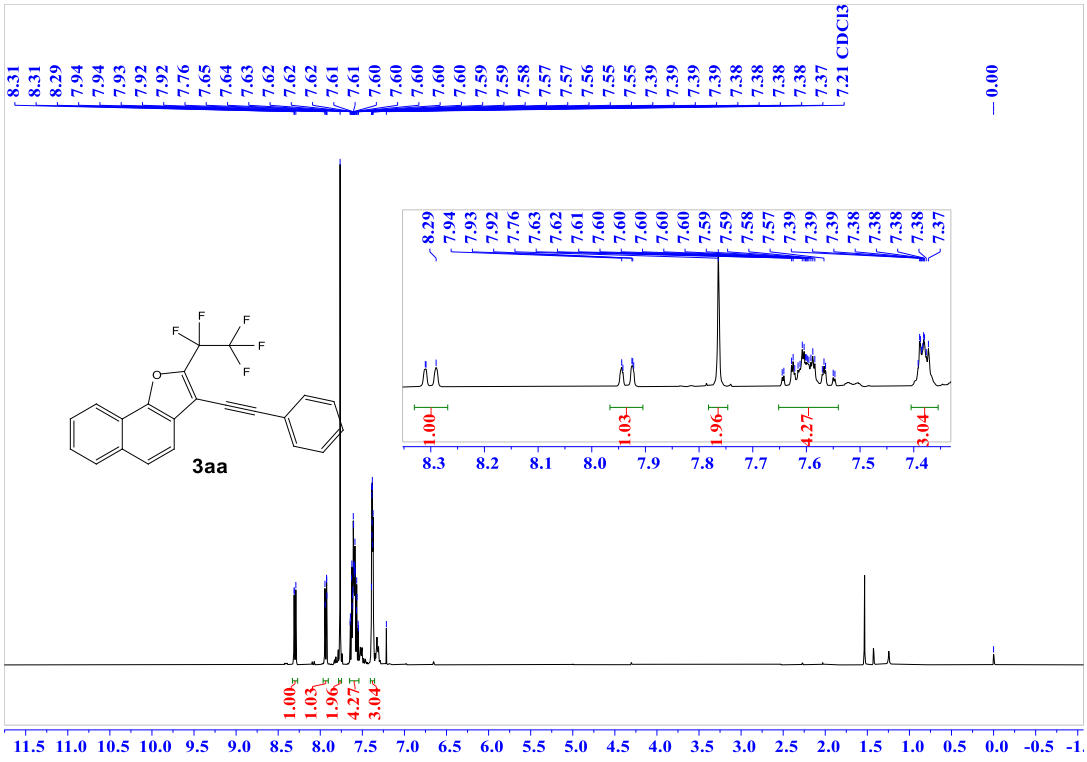
11. References

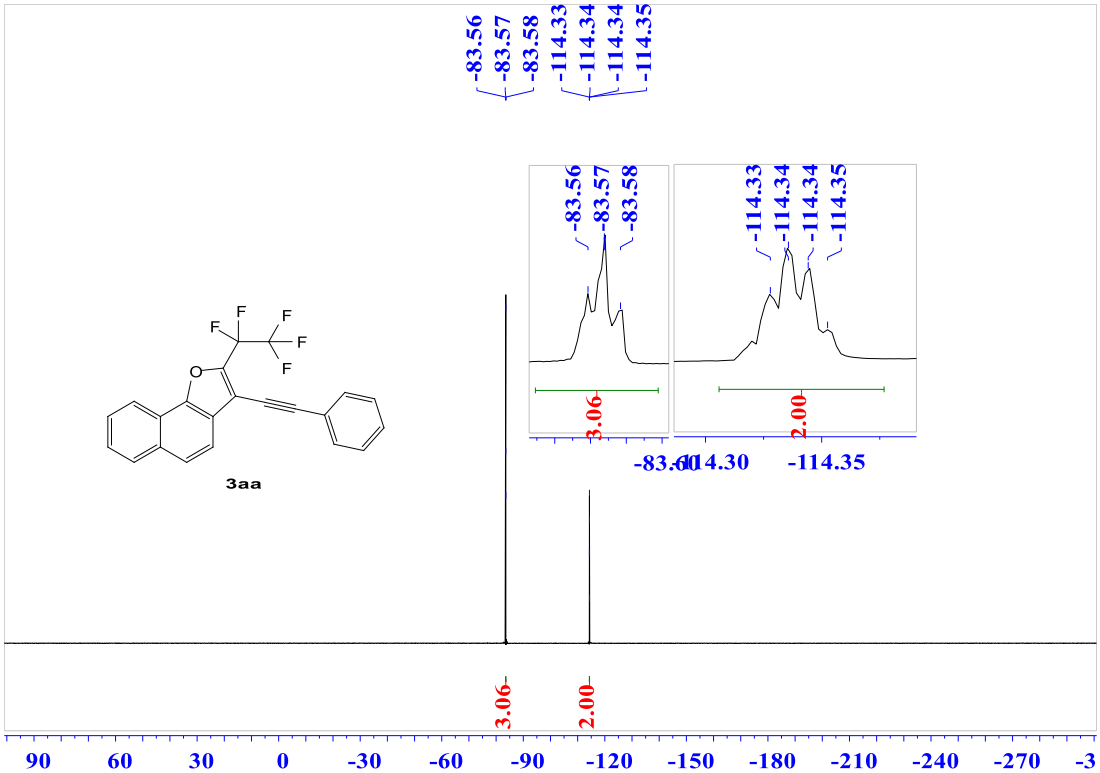
[1] P. V. Pham, D. A. Nagib, D. W. C. MacMillan, *Angew. Chem. Int. Ed.* **2011**, *50*, 6119–6122.

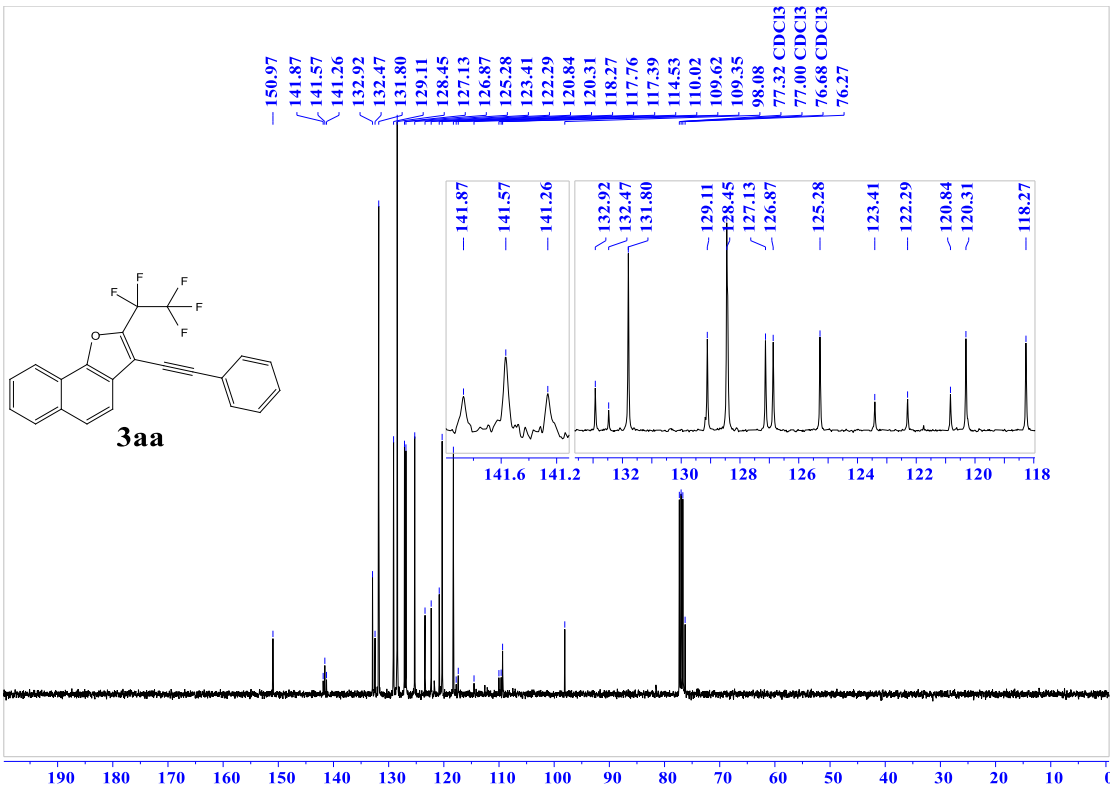
[2] (a) X. Su, H. Huang, Y. Yuan, Y. Li, *Angew. Chem., Int. Ed.* **2017**, *56*, 1338–1341. (b) T. Xie, Y.-W. Zhang, L.-L. Liu, Z.-L. Shen, T.-P. Loh, X.-Q. Chu, *Chem. Commun.* **2018**, *54*, 12722–12725.

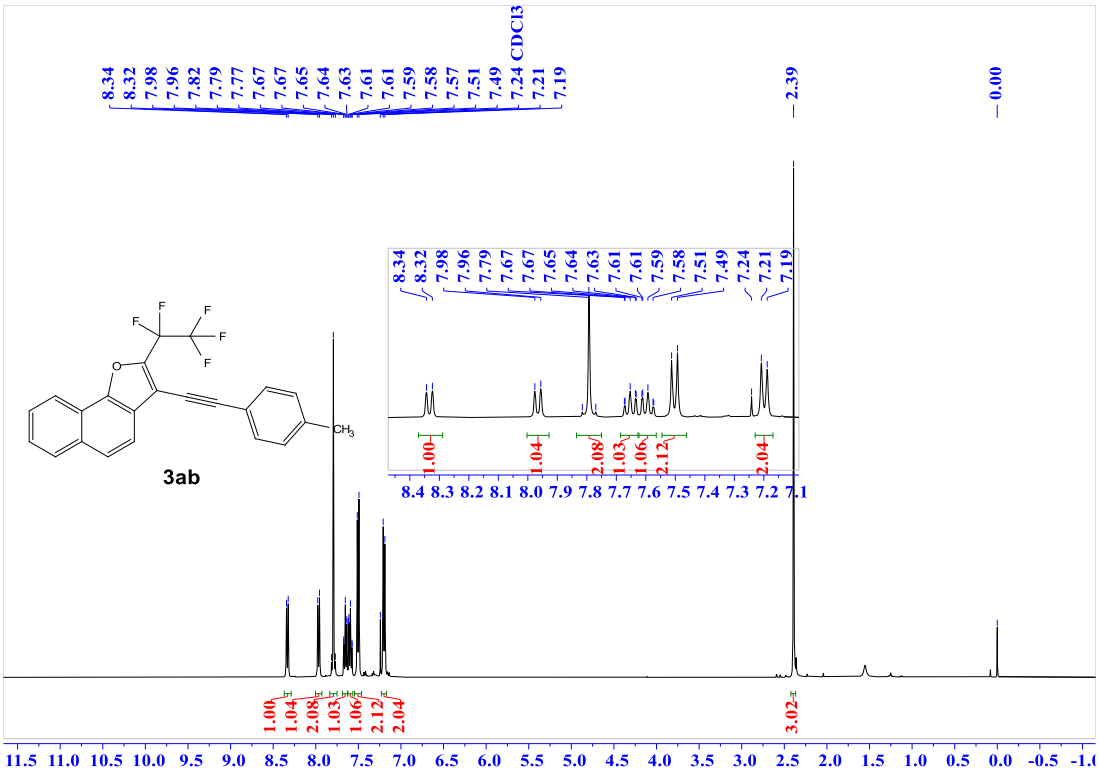
[3] (a) M. Gazvoda, M. Virant, B. Pinter, J. Košmrlj, *Nat. Commun.* **2018**, *9*, 4814. (b) J. Vicente, J.-A. Abad, J. Lopez-Serrano, *Organometallics* **2005**, *24,* 5044-5057. (c) C. Amatore, S. Bensalem, S. Ghalem, A. Jutand, *J. Organomet. Chem.* **2004**, *689*, 4642–4646.

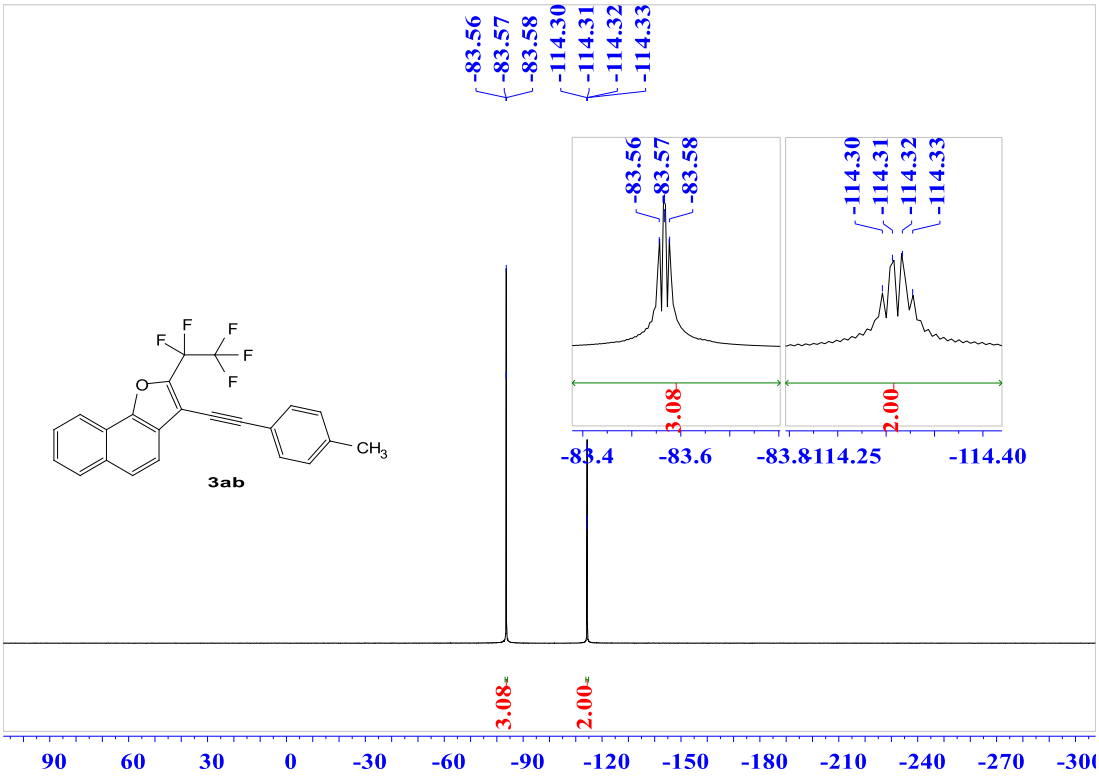
12. ^{1}H, ^{19}F, and ^{13}C NMR spectra of products

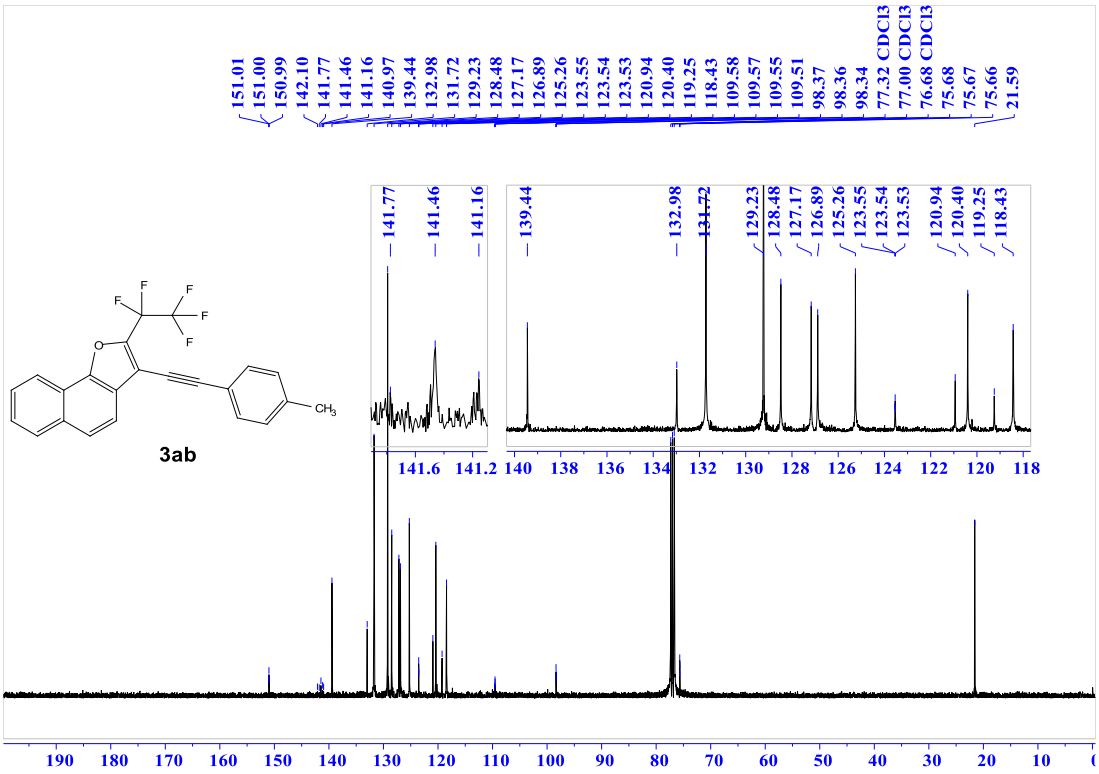


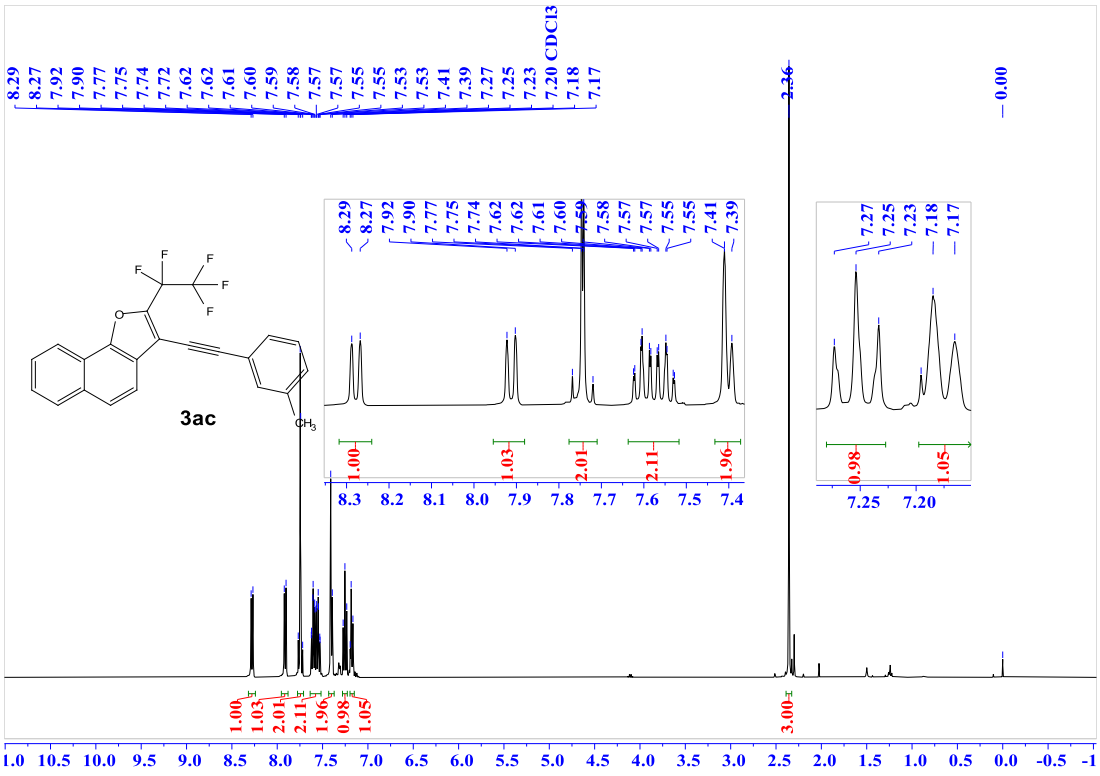


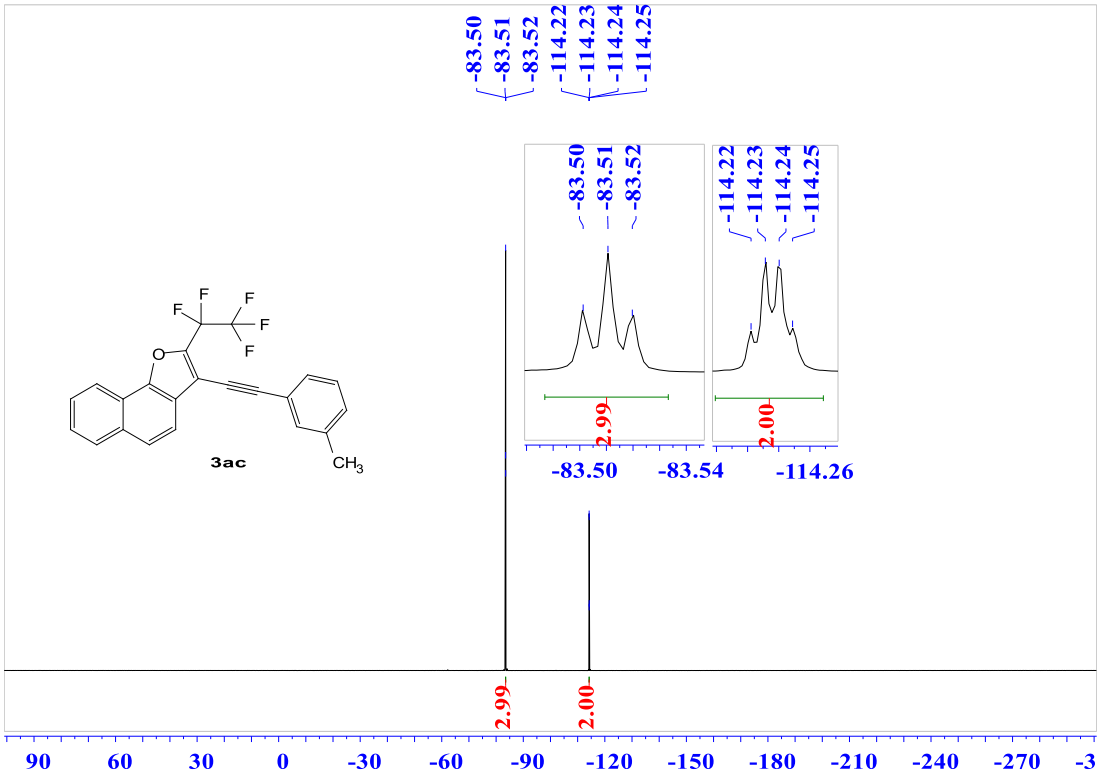

150.97
141.87
141.57
141.26
132.92
132.47
131.80
129.11
128.45
127.13
126.87
125.28
123.41
122.29
120.84
120.31
118.27
117.76
117.39
114.53
110.02
109.62
109.35
98.08
77.32 CDCl3
77.00 CDCl3
76.68 CDCl3
76.27
3aa

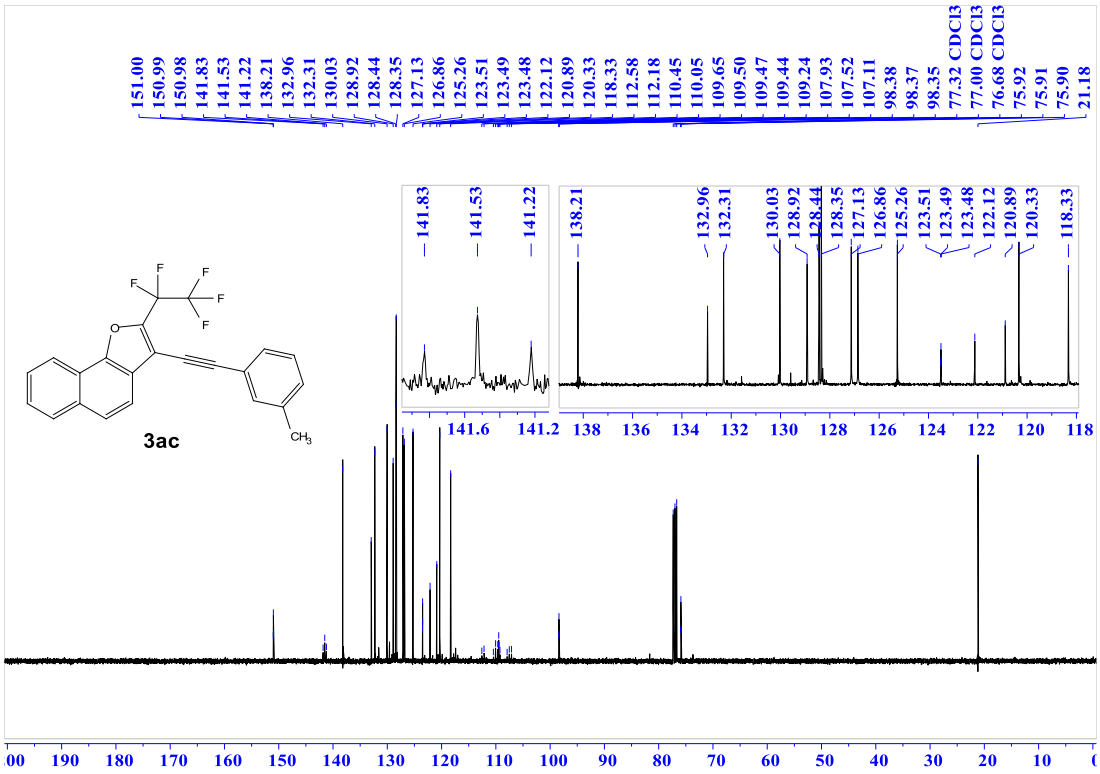

8.34
8.32
7.98
7.96
7.82
7.79
7.77
7.67
7.67
7.65
7.64
7.63
7.61
7.61
7.59
7.58
7.57
7.51
7.49
7.24 CDCl3
7.21
7.19
2.39
0.00
3ab
1.00
1.04
2.08
1.03
1.06
2.12
3.02
2.04

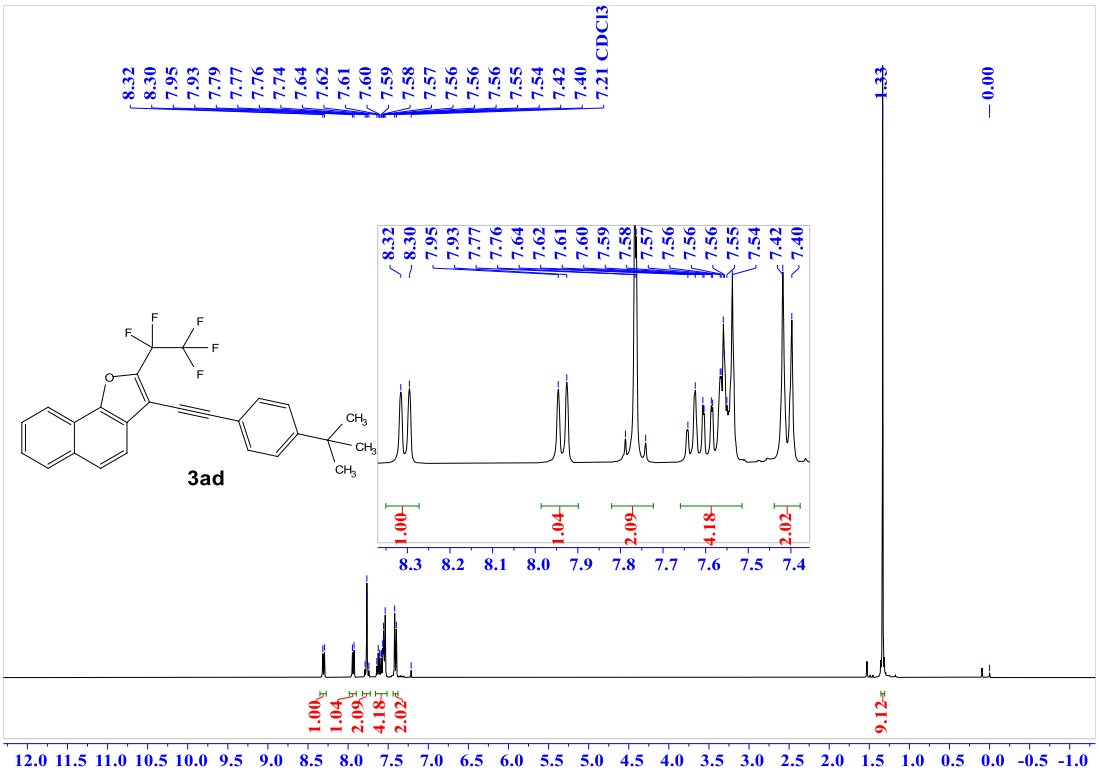

-83.56
-83.57
-83.58
-114.30
-114.31
-114.32
-114.33
3ab
3.08
2.00

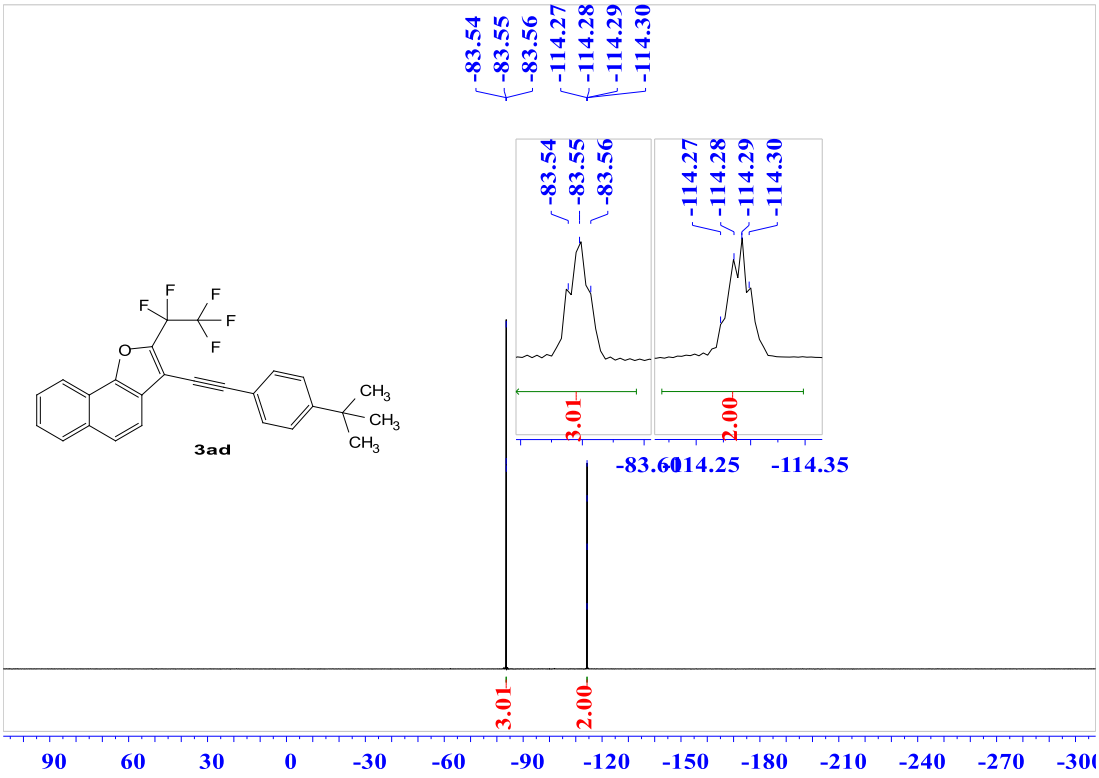

151.01
151.00
150.99
142.10
141.77
141.46
141.16
140.97
139.44
132.98
131.72
129.23
128.48
127.17
126.89
125.26
123.55
123.54
123.53
120.94
120.40
119.25
118.43
109.58
109.57
109.55
109.51
98.37
98.36
98.34
77.32 CDCl3
77.00 CDCl3
76.68 CDCl3
75.68
75.67
75.66
21.59
141.77
141.46
141.16
139.44
132.98
131.72
129.23
128.48
127.17
126.89
125.26
123.55
123.54
123.53
120.94
120.40
119.25
118.43
F
F
F
F
F
O
CH3
3ab
141.6
141.2
140
138
136
134
132
130
128
126
124
122
120
118
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10

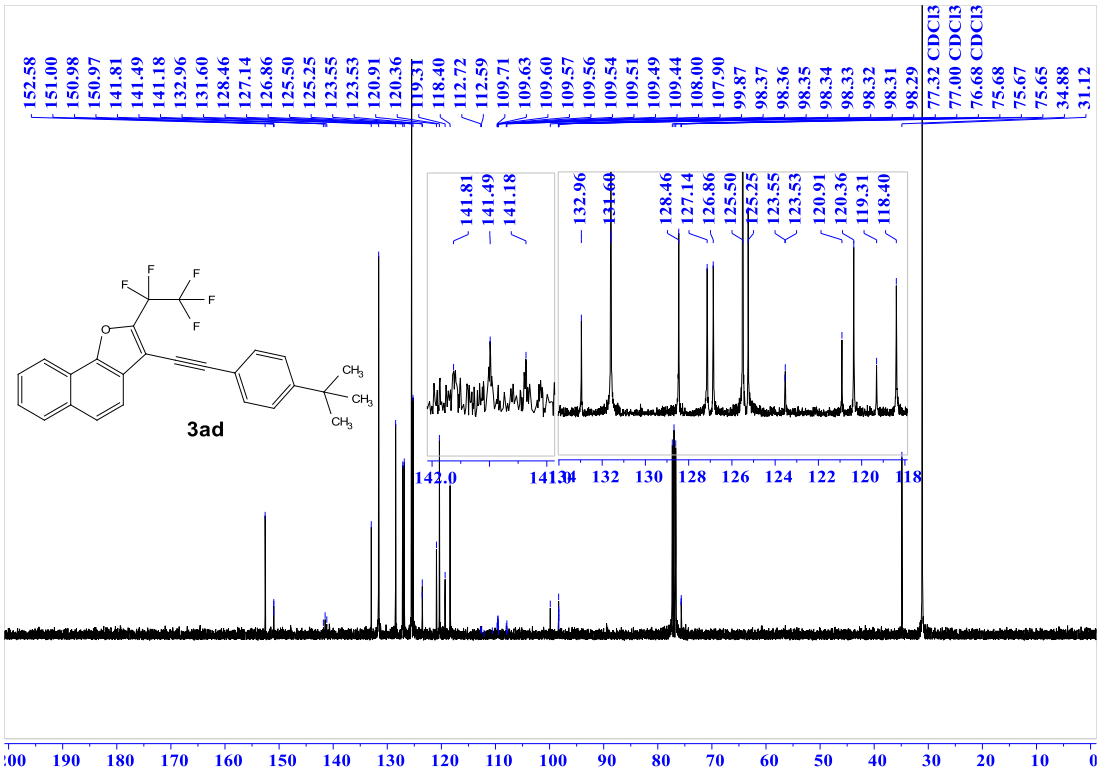

8.29
8.27
7.92
7.90
7.77
7.75
7.74
7.72
7.62
7.62
7.61
7.60
7.59
7.58
7.57
7.57
7.55
7.55
7.53
7.53
7.41
7.39
7.27
7.25
7.23
CDCl3
7.18
7.17
2.36
0.00
3ac
1.00
1.03
2.01
2.11
1.96
0.98
1.05
3.00

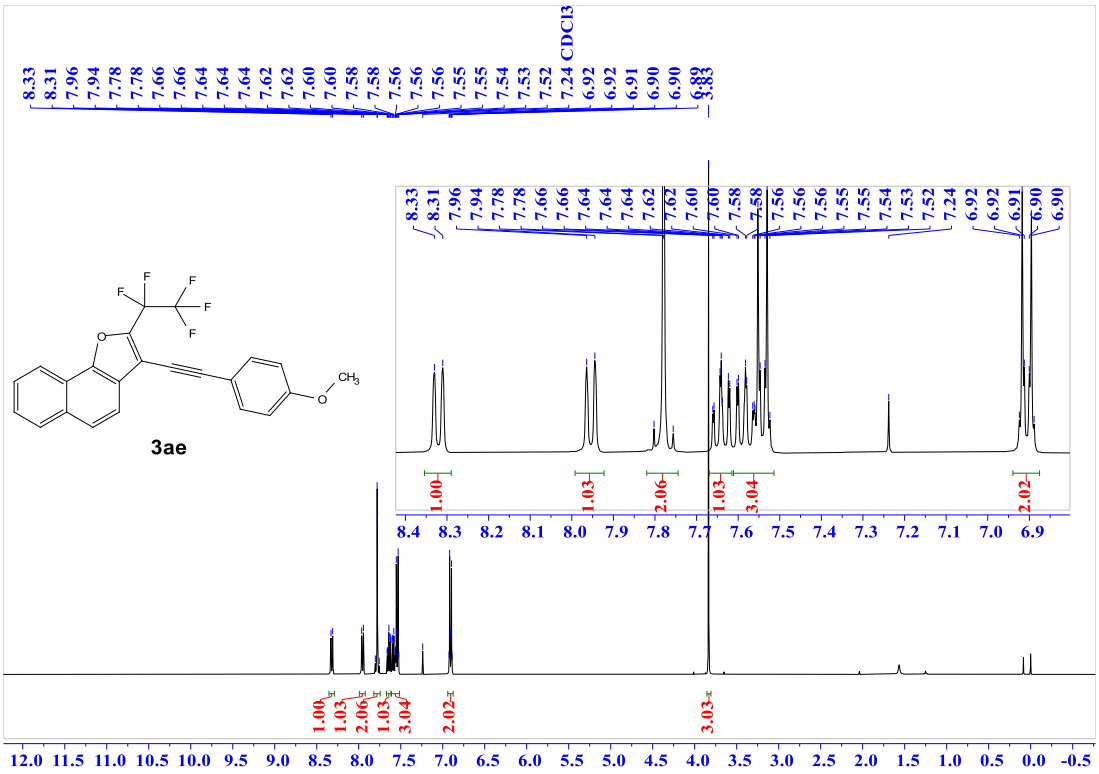

-83.50
-83.51
-83.52
-114.22
-114.23
-114.24
-114.25
3ac
2.99
2.00
-83.50
-83.54
-114.26

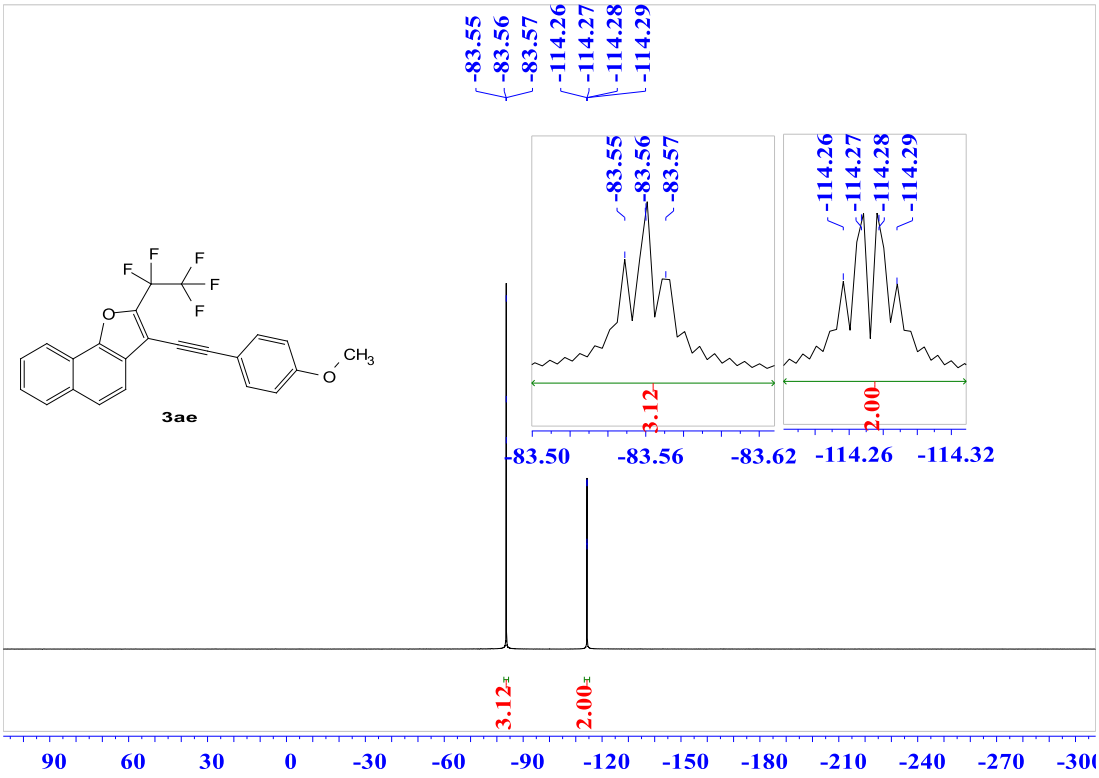

151.00
150.99
150.98
141.83
141.53
141.22
138.21
132.96
132.31
130.03
128.92
128.44
128.35
127.13
126.86
125.26
123.51
123.49
123.48
122.12
120.89
120.33
118.33
112.58
112.18
110.45
110.05
109.65
109.50
109.47
109.44
109.24
107.93
107.52
107.11
98.38
98.37
98.35
77.32 CDCl3
77.00 CDCl3
76.68 CDCl3
75.92
75.91
75.90
21.18
3ac
141.83
141.53
141.22
138.21
132.96
132.31
130.03
128.92
128.44
128.35
127.13
126.86
125.26
123.51
123.49
123.48
122.12
120.89
120.33
118.33

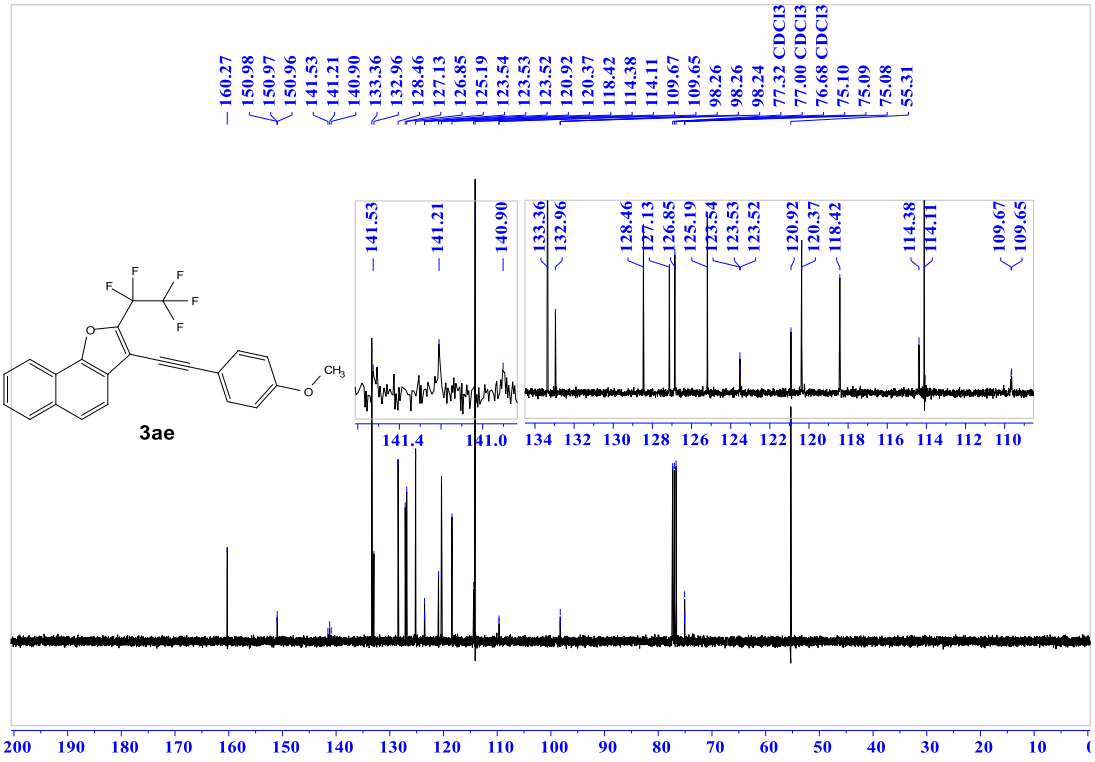

8.32
8.30
7.95
7.93
7.79
7.77
7.76
7.74
7.64
7.62
7.61
7.60
7.59
7.58
7.57
7.56
7.56
7.56
7.55
7.54
7.42
7.40
7.21 CDCl3
1.33
0.00
3ad
1.00
1.04
2.09
4.18
2.02
9.12

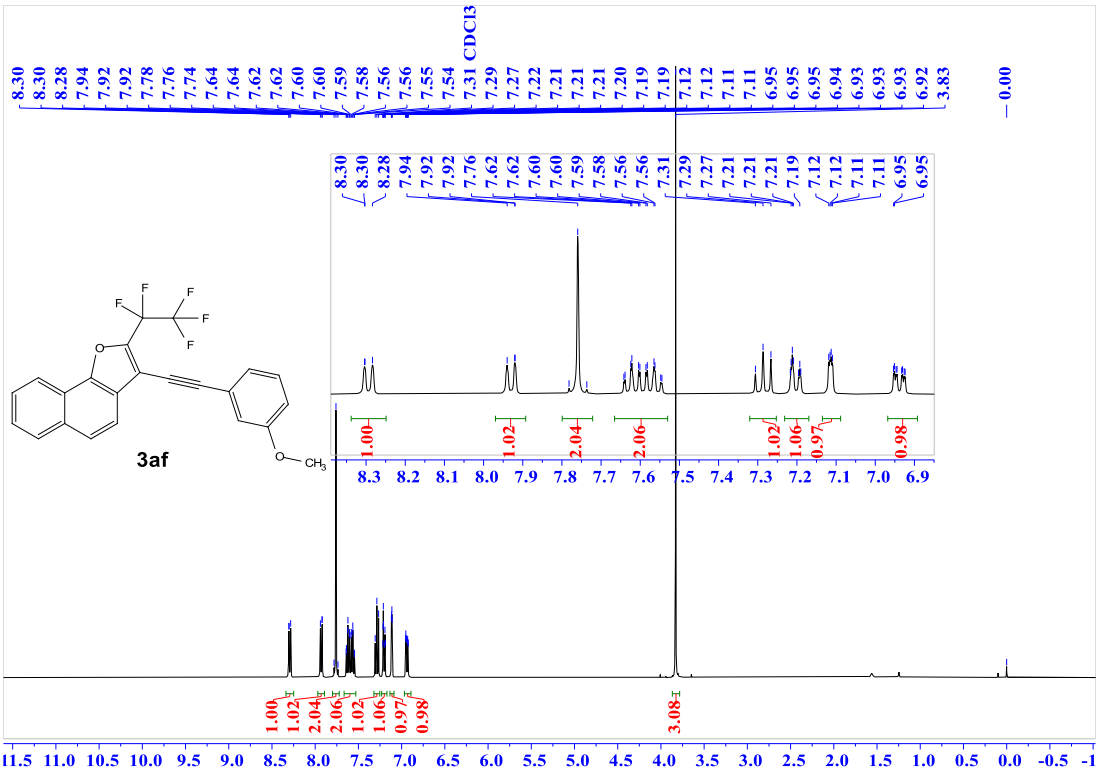

-83.54
-83.55
-83.56
-114.27
-114.28
-114.29
-114.30
3ad
3.01
2.00
-83.60
-114.25
-114.35

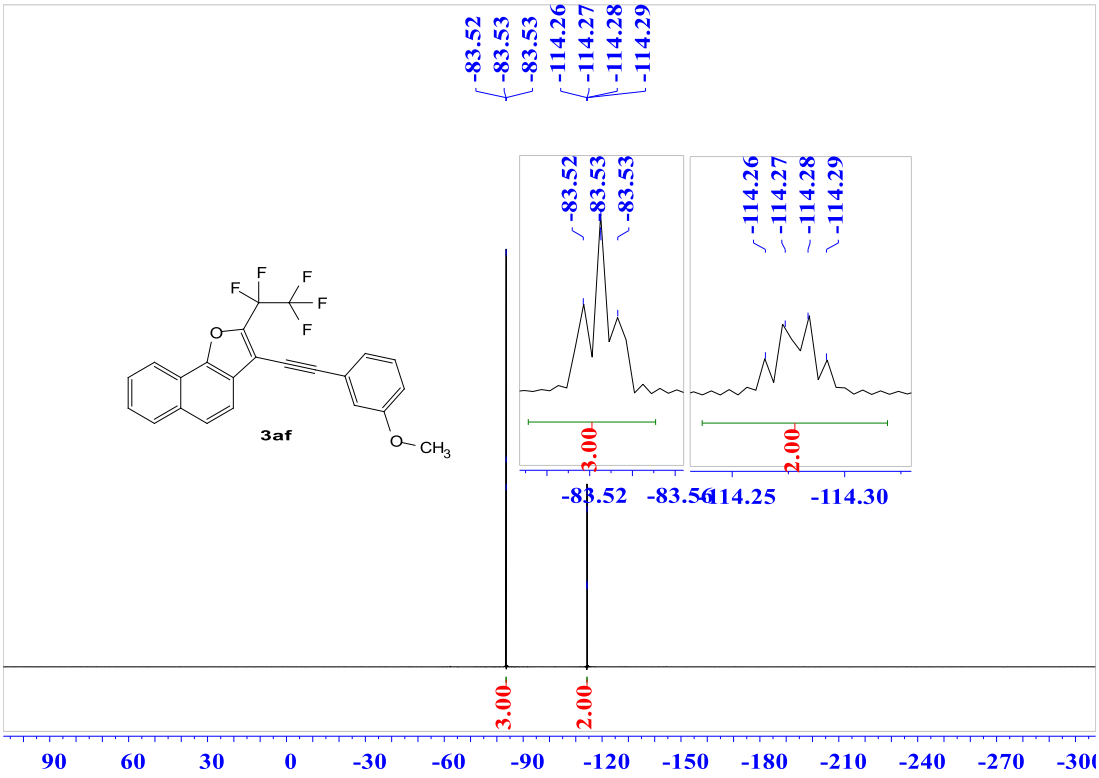

152.58
151.00
150.98
150.97
141.81
141.49
141.18
132.96
131.60
128.46
127.14
126.86
125.50
125.25
123.55
123.53
120.91
120.36
119.31
118.40
112.72
112.59
109.71
109.63
109.60
109.57
109.56
109.54
109.51
109.49
109.44
108.00
107.90
99.87
98.37
98.36
98.35
98.34
98.33
98.32
98.31
98.29
77.32 CDCl3
77.00 CDCl3
76.68 CDCl3
75.68
75.67
75.65
34.88
31.12
3ad

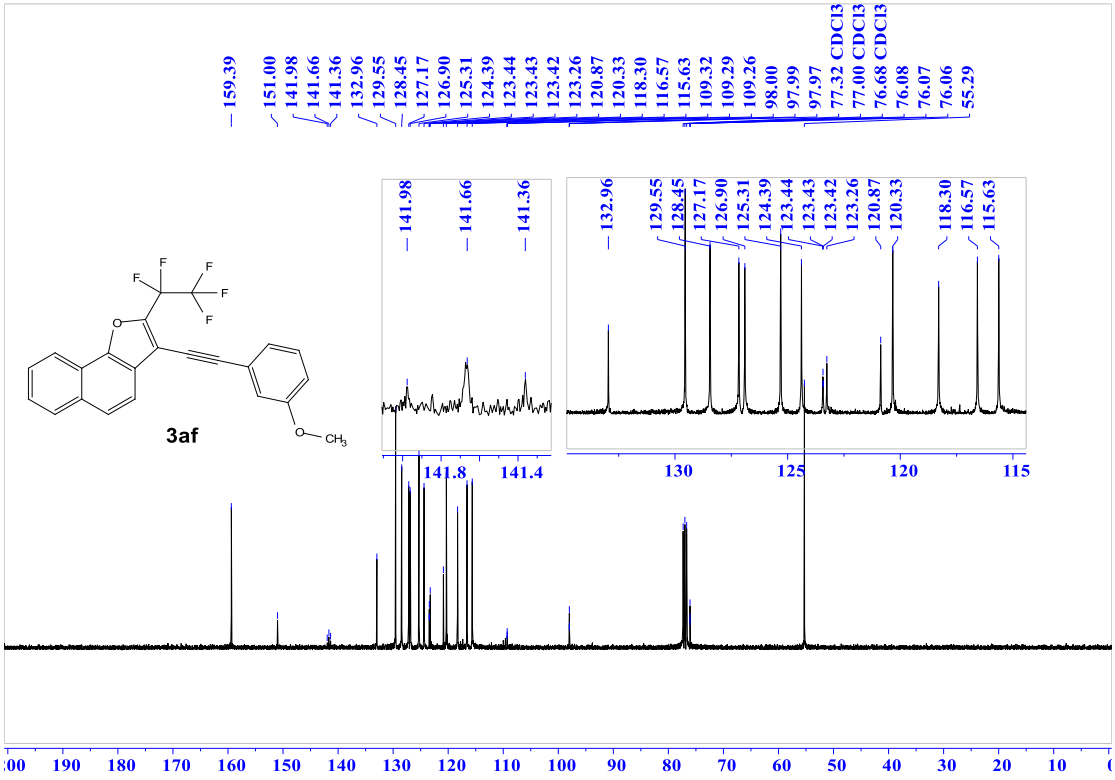

CDCl3
3ae

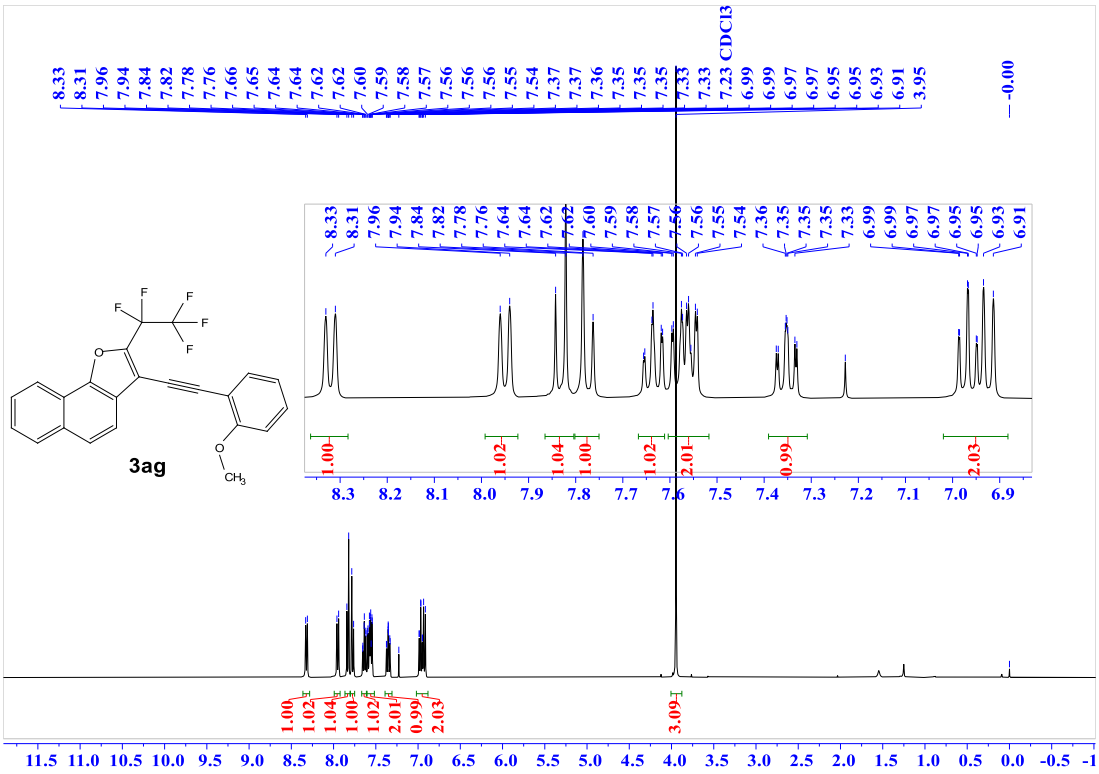

3ae

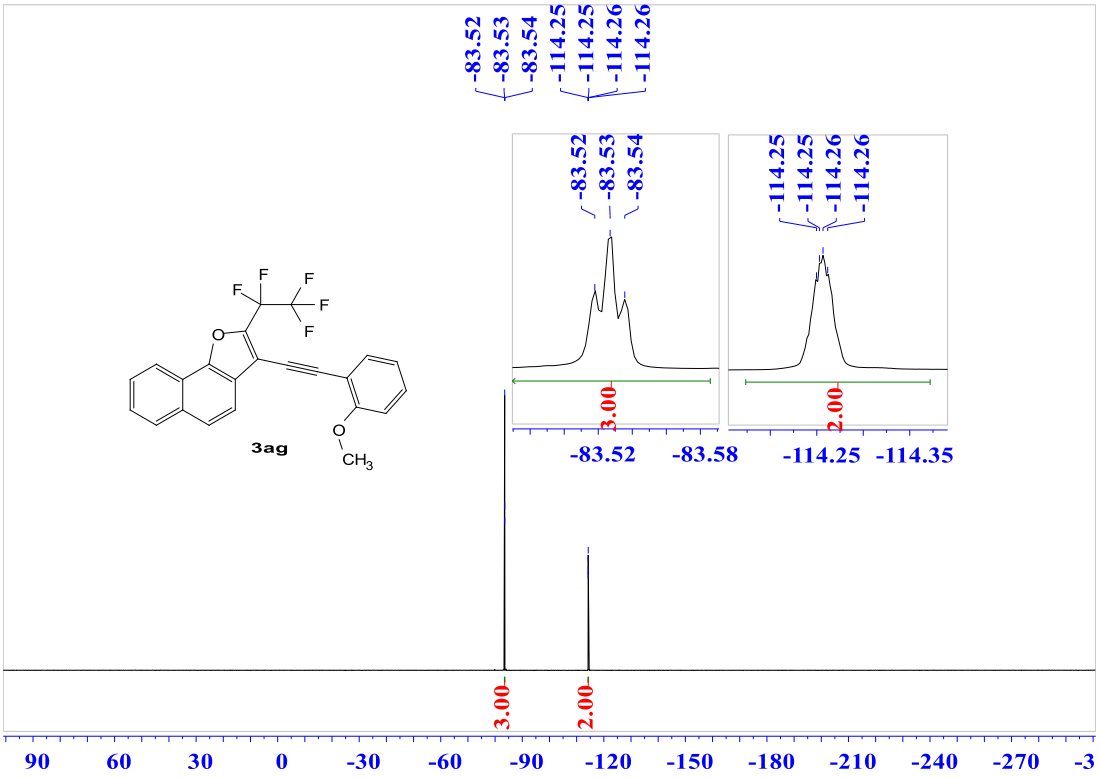

160.27
150.98
150.97
150.96
141.53
141.21
140.90
133.36
132.96
128.46
127.13
126.85
125.19
123.54
123.53
123.52
120.92
120.37
118.42
114.38
114.11
109.67
109.65
98.26
98.24
77.32 CDCl3
77.00 CDCl3
76.68 CDCl3
75.10
75.09
75.08
55.31
3ae

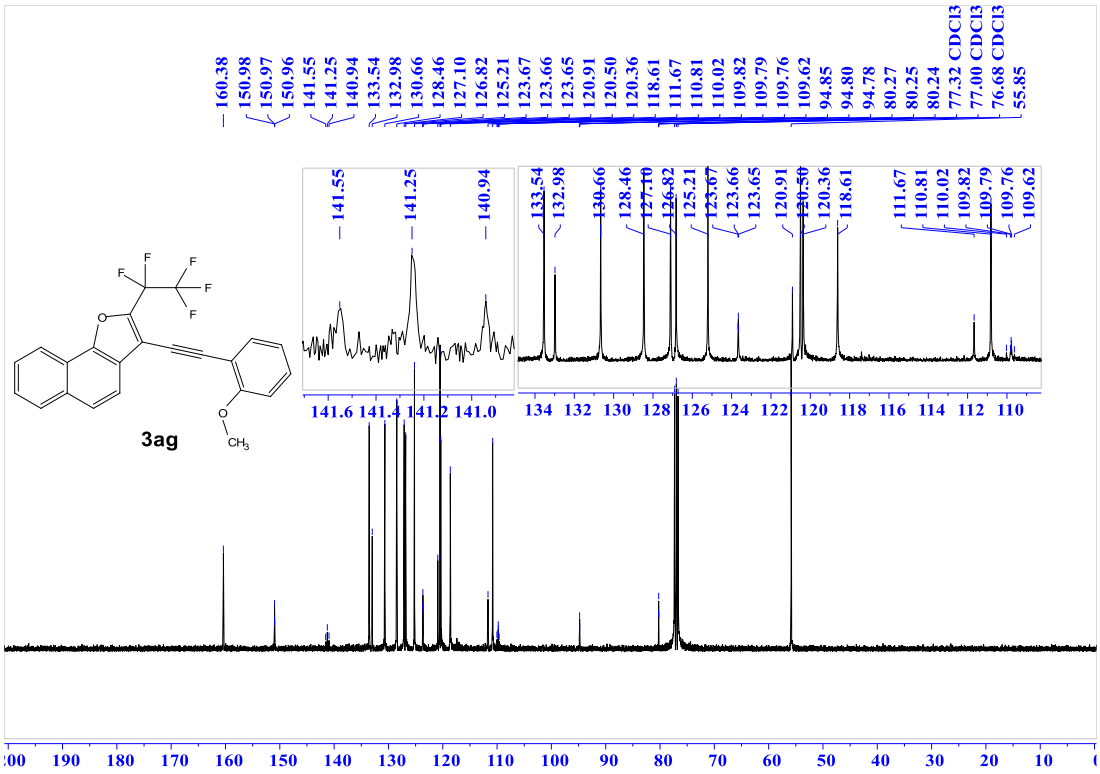

CDCl3
3af

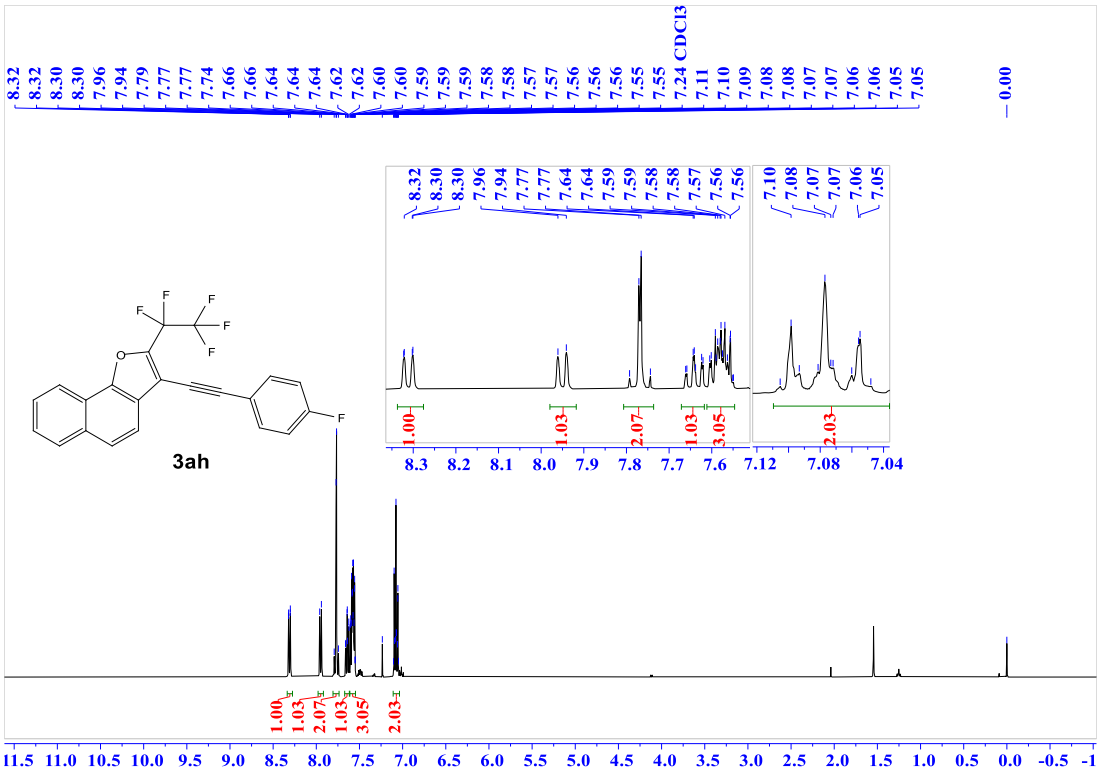

3af

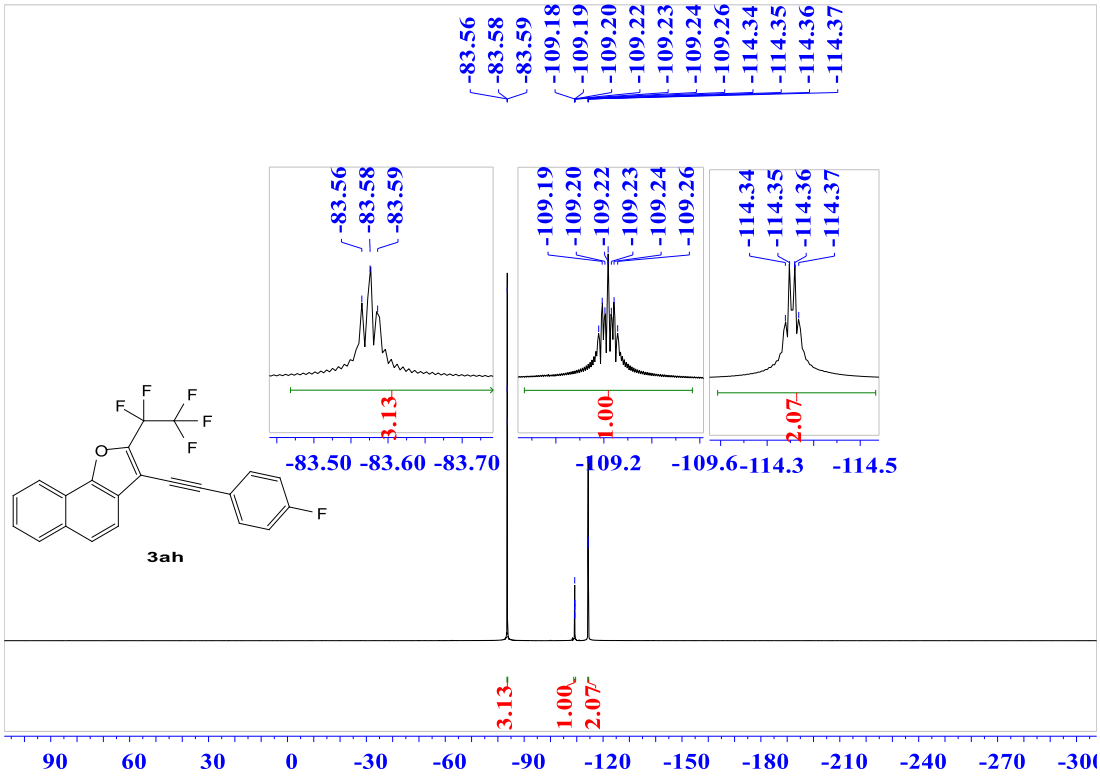

159.39
151.00
141.98
141.66
141.36
132.96
129.55
128.45
127.17
126.90
125.31
124.39
123.44
123.43
123.42
123.26
120.87
120.33
118.30
116.57
115.63
109.32
109.29
109.26
98.00
97.99
97.97
77.32 CDCl3
77.00 CDCl3
76.68 CDCl3
76.08
76.07
76.06
55.29
3af

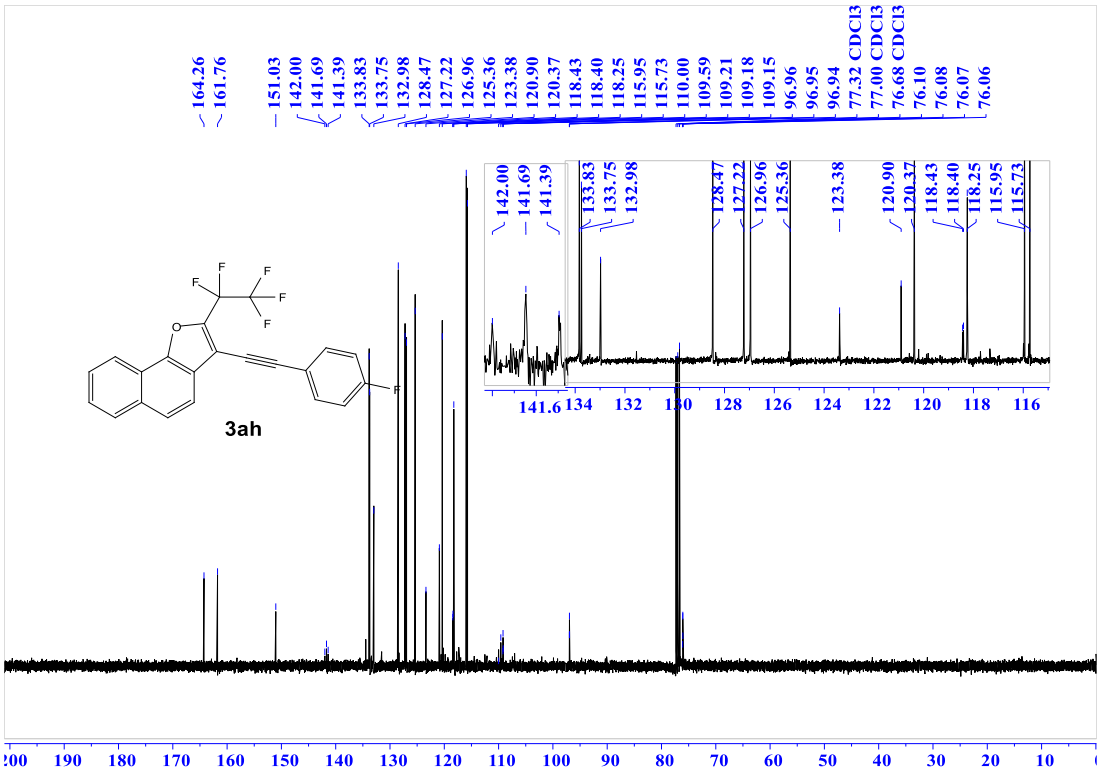

8.33 8.31 7.96 7.94 7.84 7.82 7.78 7.76 7.66 7.65 7.64 7.64 7.62 7.62 7.60 7.59 7.58 7.57 7.56 7.56 7.55 7.54 7.37 7.36 7.35 7.35 7.33 7.23 CDCl3 6.99 6.99 6.97 6.97 6.95 6.95 6.93 6.91 3.95 -0.00
1.00 1.02 1.04 1.00 1.02 2.01 0.99 2.03 3.09
3ag

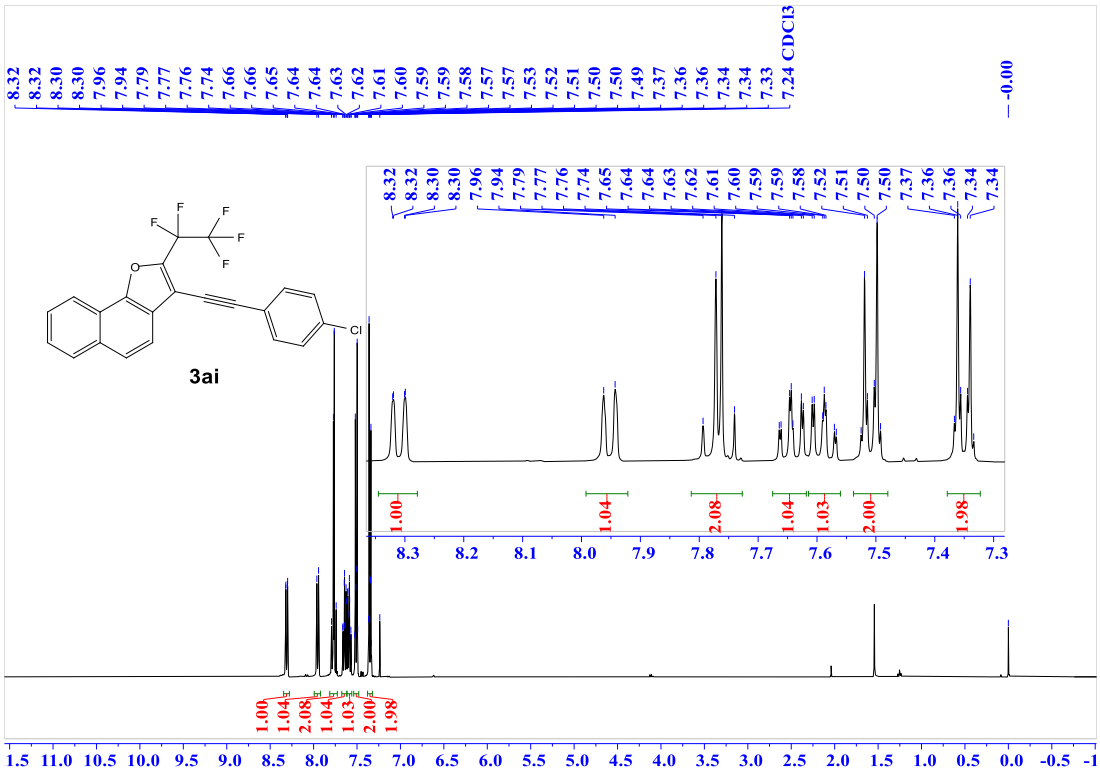

-83.52 -83.53 -83.54 -114.25 -114.25 -114.26 -114.26
3.00 2.00
3ag

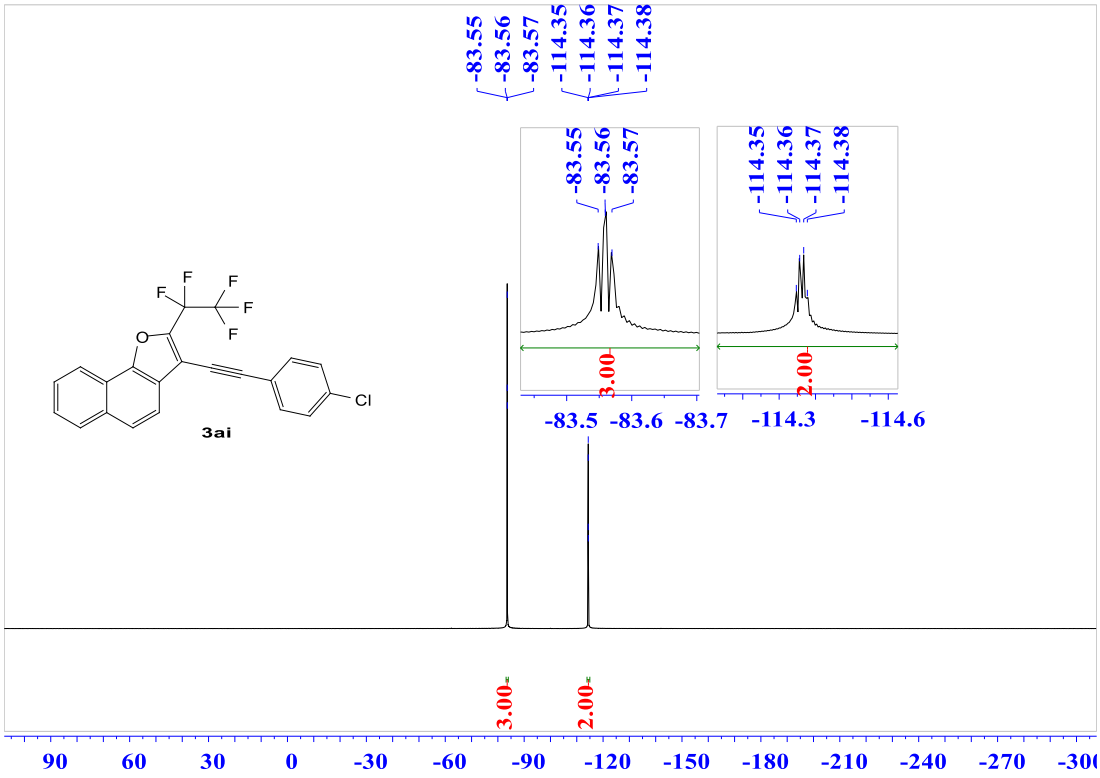

160.38
150.98
150.97
150.96
141.55
141.25
140.94
133.54
132.98
130.66
128.46
127.10
126.82
125.21
123.67
123.66
123.65
120.91
120.50
120.36
118.61
111.67
110.81
110.02
109.82
109.79
109.76
109.62
94.85
94.80
94.78
80.27
80.25
80.24
77.32 CDCl3
77.00 CDCl3
76.68 CDCl3
55.85
3ag

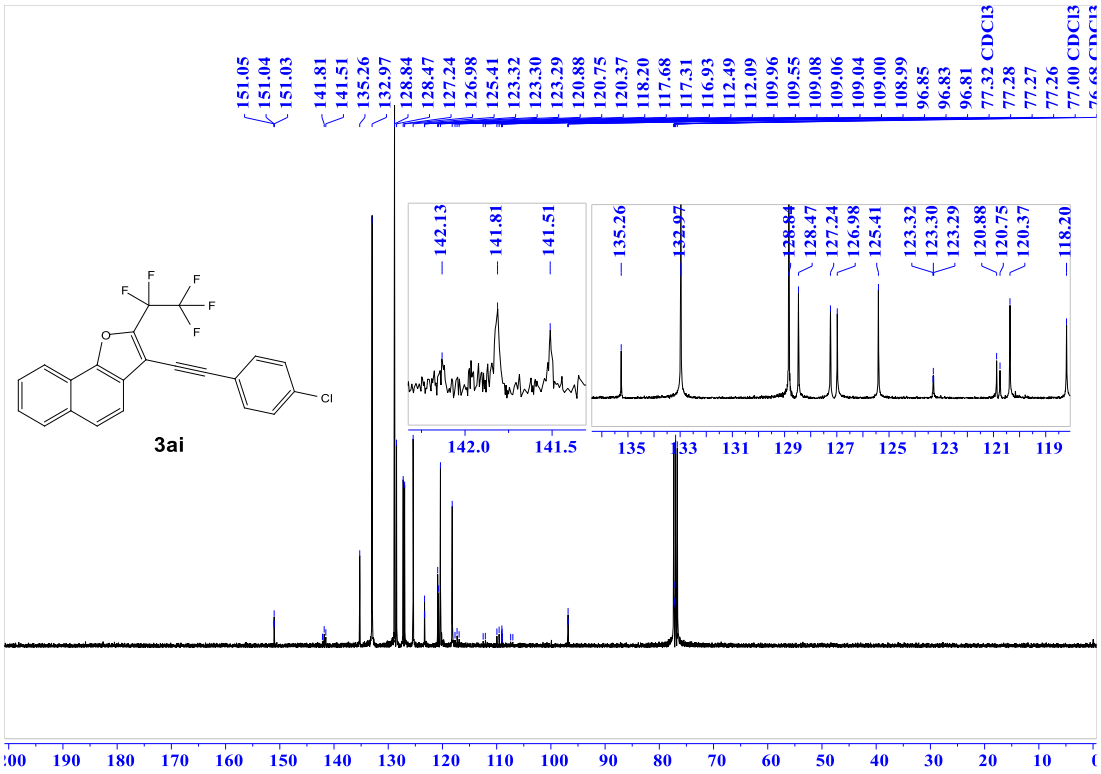

3ah

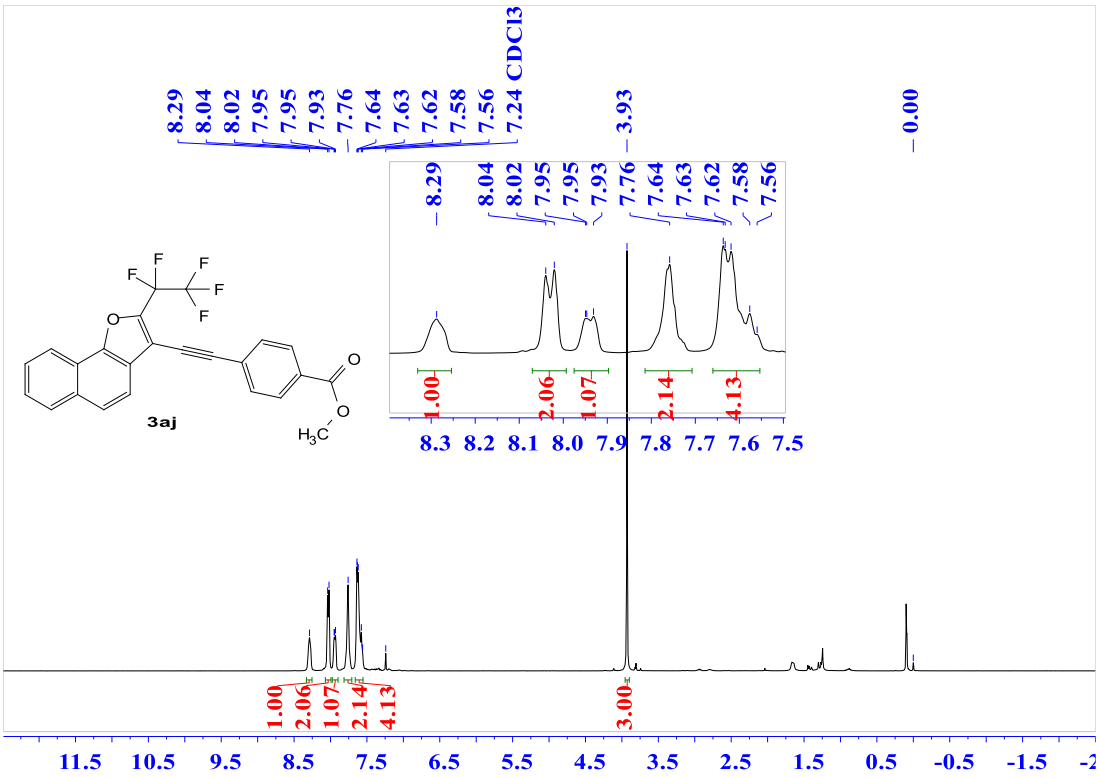

3ah

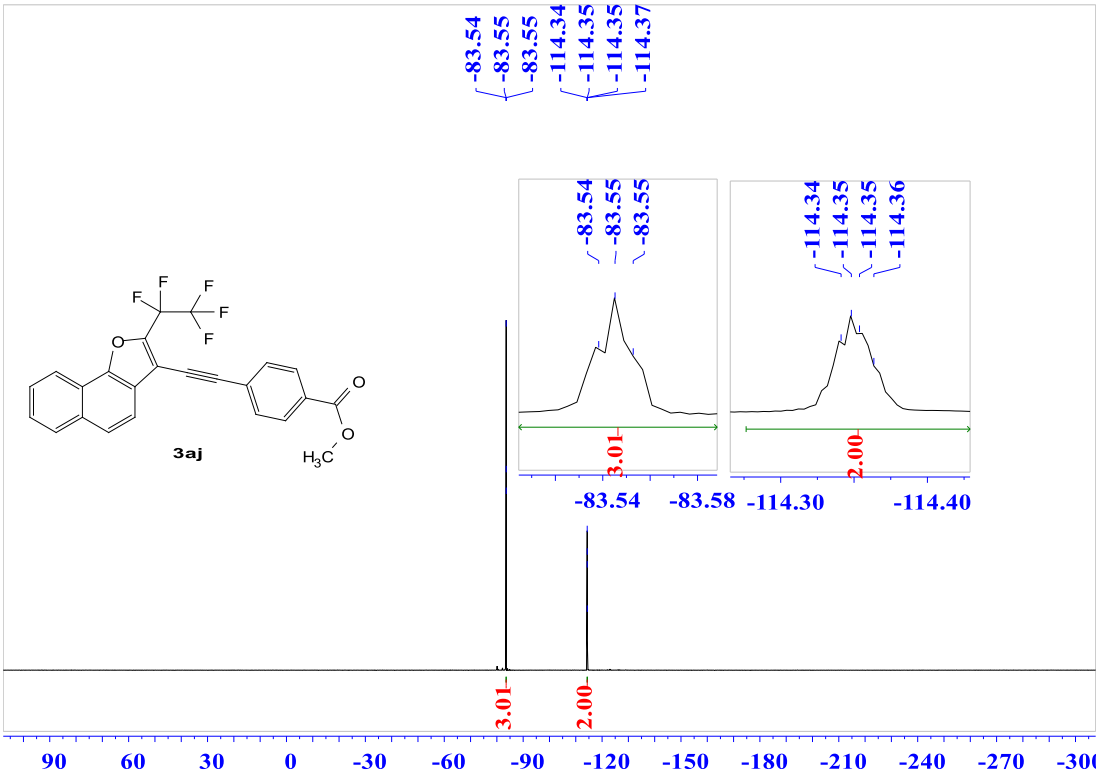

164.26
161.76
151.03
142.00
141.69
141.39
133.83
133.75
132.98
128.47
127.22
126.96
125.36
123.38
120.90
120.37
118.43
118.40
118.25
115.95
115.73
110.00
109.59
109.21
109.18
109.15
96.96
96.95
96.94
77.32 CDCl3
77.00 CDCl3
76.68 CDCl3
76.10
76.08
76.07
76.06
3ah

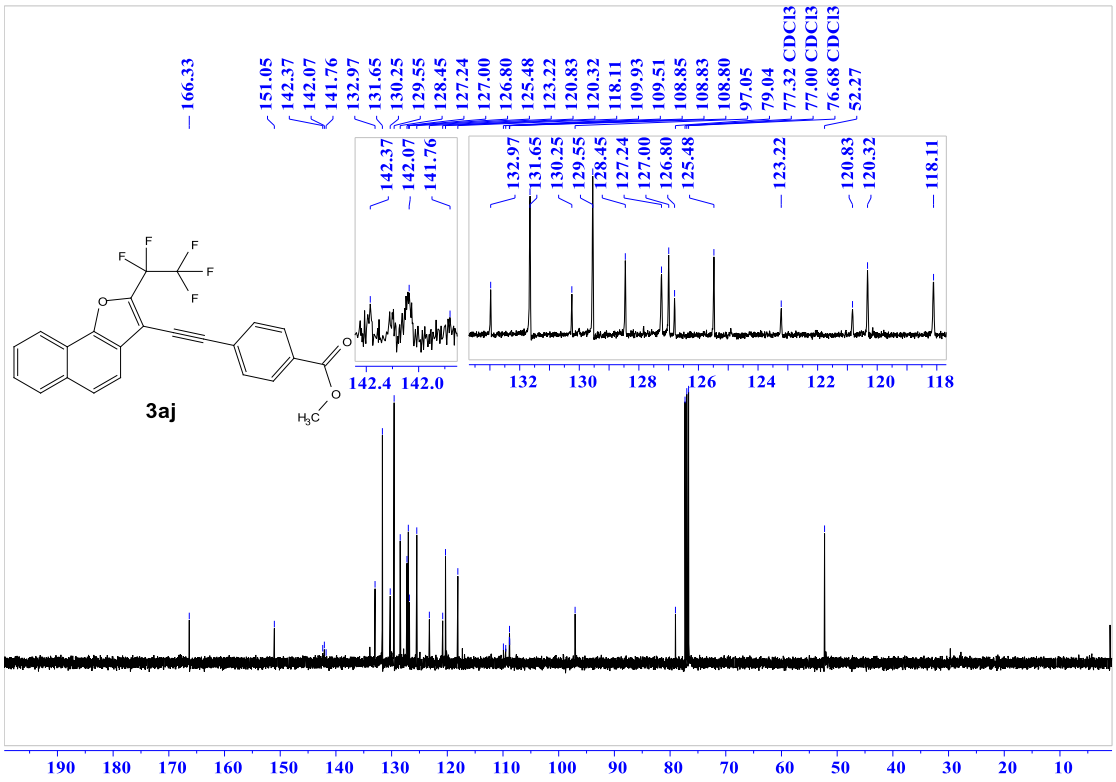

3ai

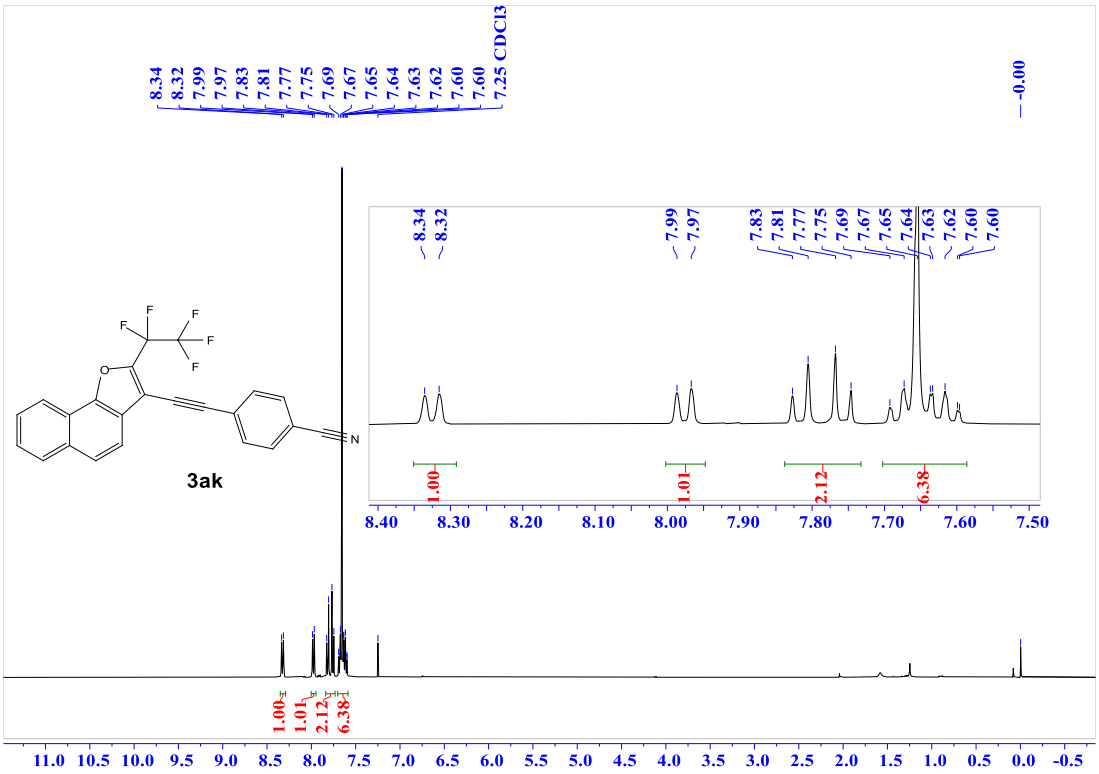

3ai

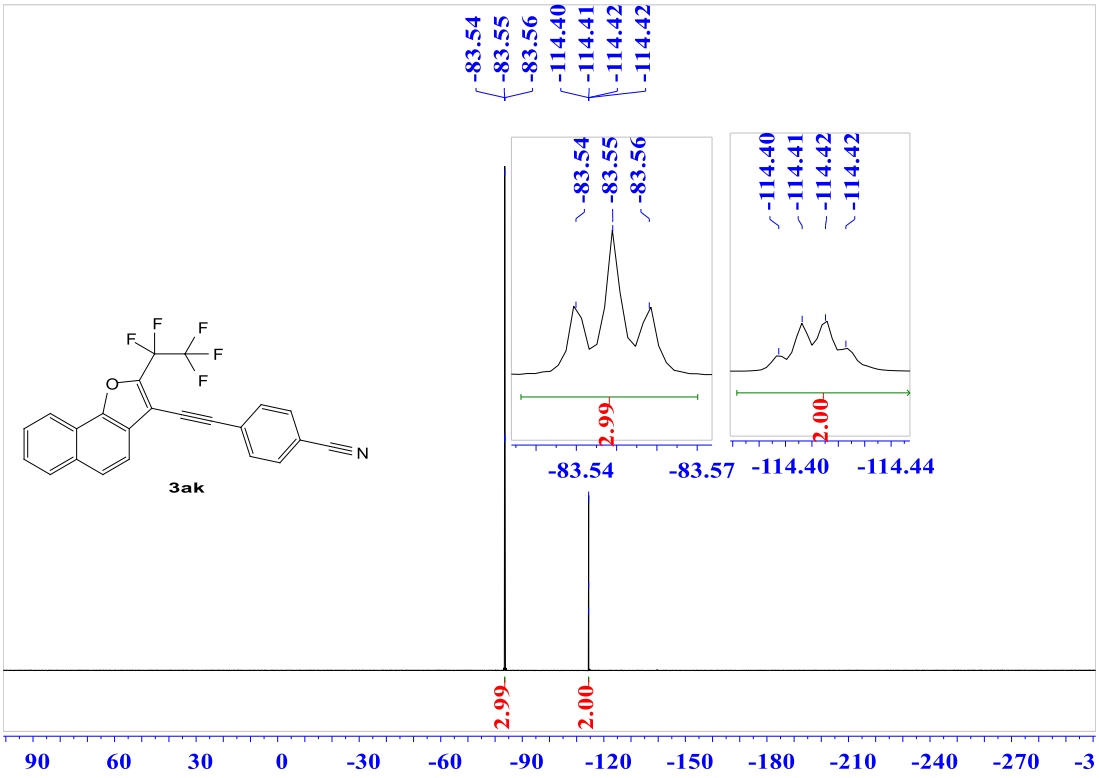

151.05
151.04
151.03
141.81
141.51
135.26
132.97
128.84
128.47
127.24
126.98
125.41
123.32
123.30
123.29
120.88
120.75
120.37
118.20
117.68
117.31
116.93
112.49
112.09
109.96
109.55
109.08
109.06
109.04
109.00
108.99
96.85
96.83
96.81
77.32 CDCl3
77.28
77.27
77.26
77.00 CDCl3
142.13
141.81
141.51
135.26
132.97
128.84
128.47
127.24
126.98
125.41
123.32
123.30
123.29
120.88
120.75
120.37
118.20
142.0
141.5
135
133
131
129
127
125
123
121
119
F
F
F
F
F
O
Cl
3ai
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10

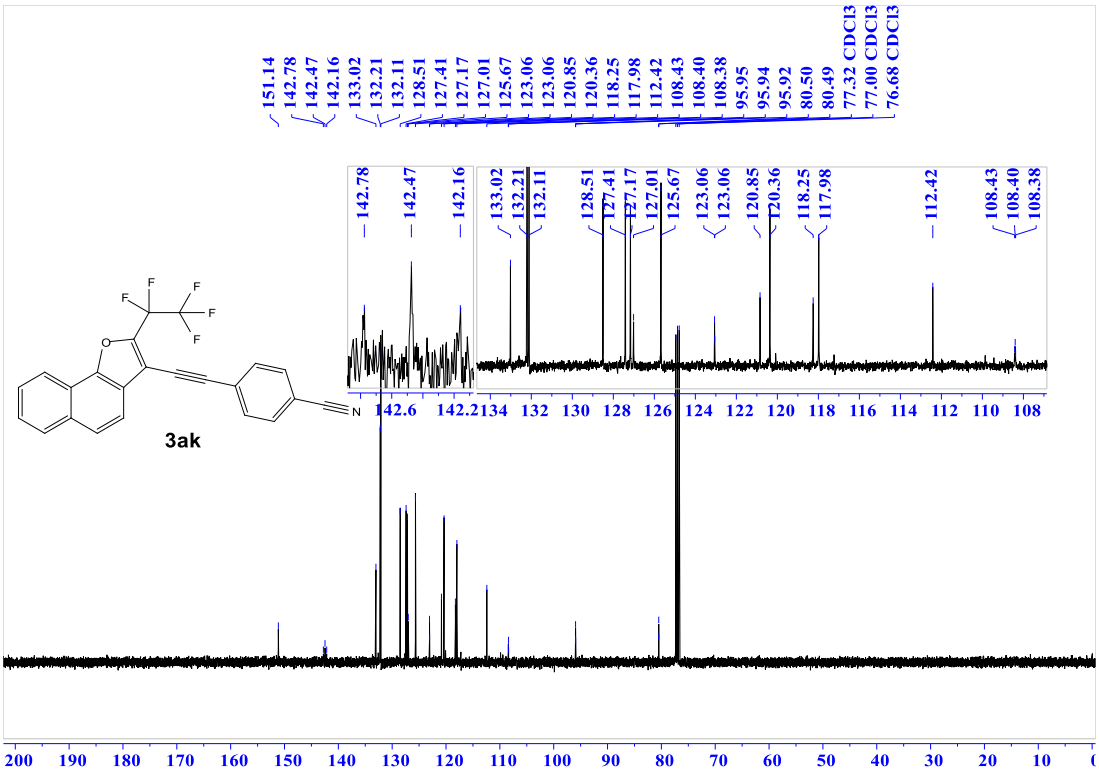

8.29
8.04
8.02
7.95
7.95
7.93
7.76
7.64
7.63
7.62
7.58
7.56
7.24 CDCl3
3.93
0.00
1.00
2.06
1.07
2.14
4.13
3.00
3aj

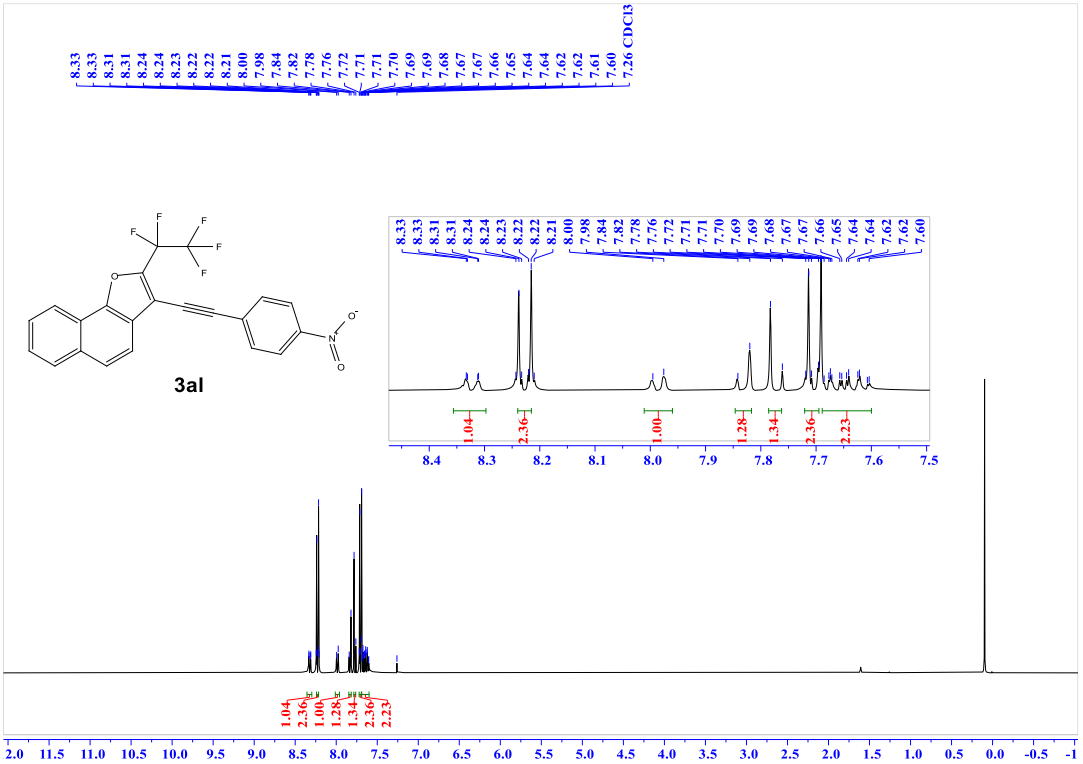

-83.54
-83.55
-83.55
-114.34
-114.35
-114.35
-114.37
3.01
2.00
3aj

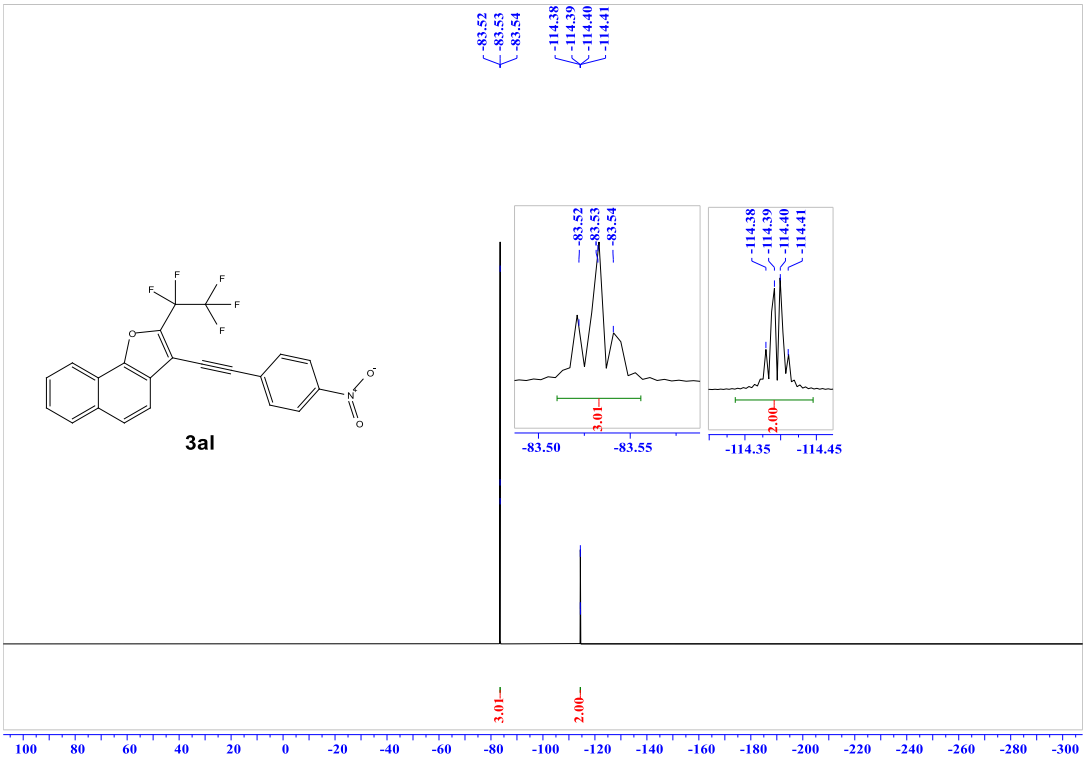

166.33
151.05
142.37
142.07
141.76
132.97
131.65
130.25
129.55
128.45
127.24
127.00
126.80
125.48
123.22
120.83
120.32
118.11
109.93
109.51
108.85
108.83
108.80
97.05
79.04
77.32 CDCl3
77.00 CDCl3
76.68 CDCl3
52.27
3aj
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10

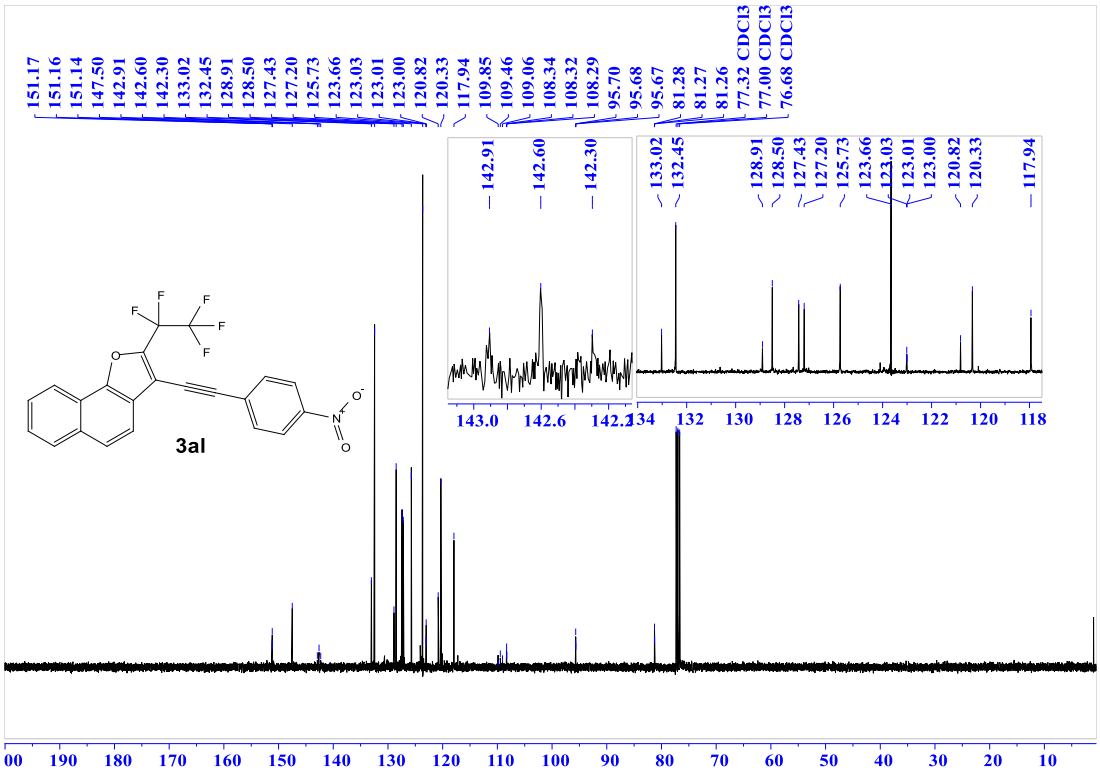

8.34
8.32
7.99
7.97
7.83
7.81
7.77
7.75
7.69
7.67
7.65
7.64
7.63
7.62
7.60
7.60
7.25 CDCl3
-0.00
3ak
1.00
1.01
2.12
6.38

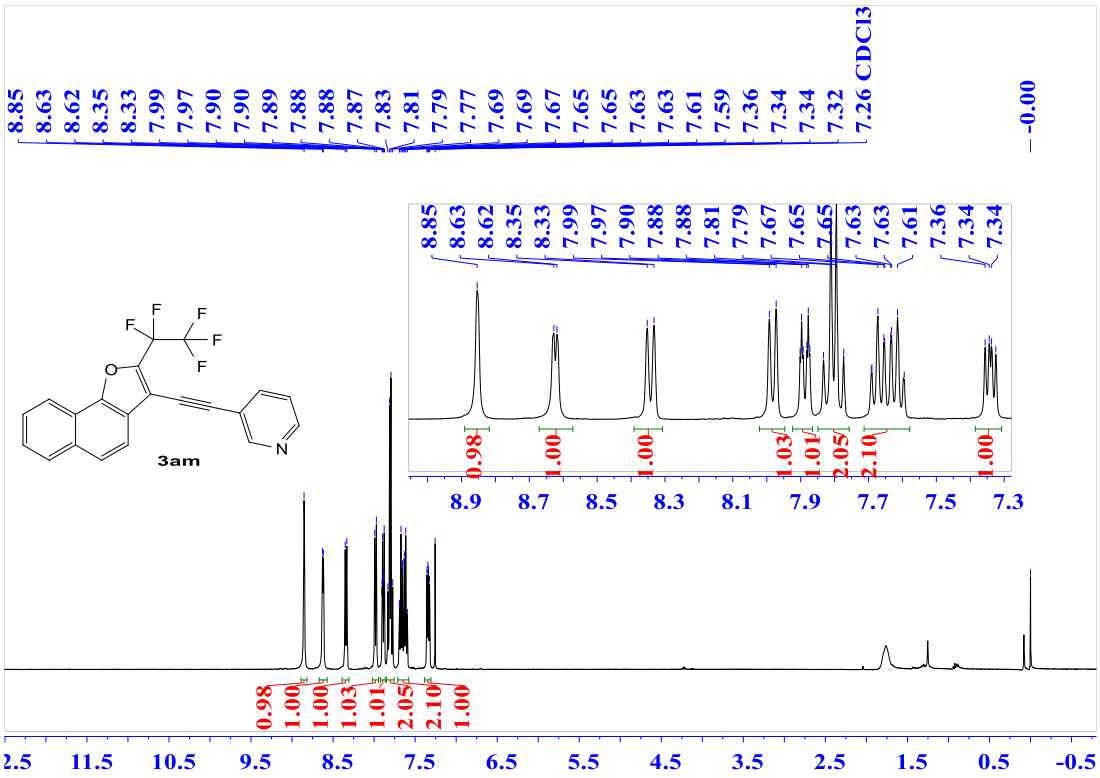

-83.54
-83.55
-83.56
-114.40
-114.41
-114.42
-114.42
3ak
2.99
2.00
-83.54
-83.57
-114.40
-114.44

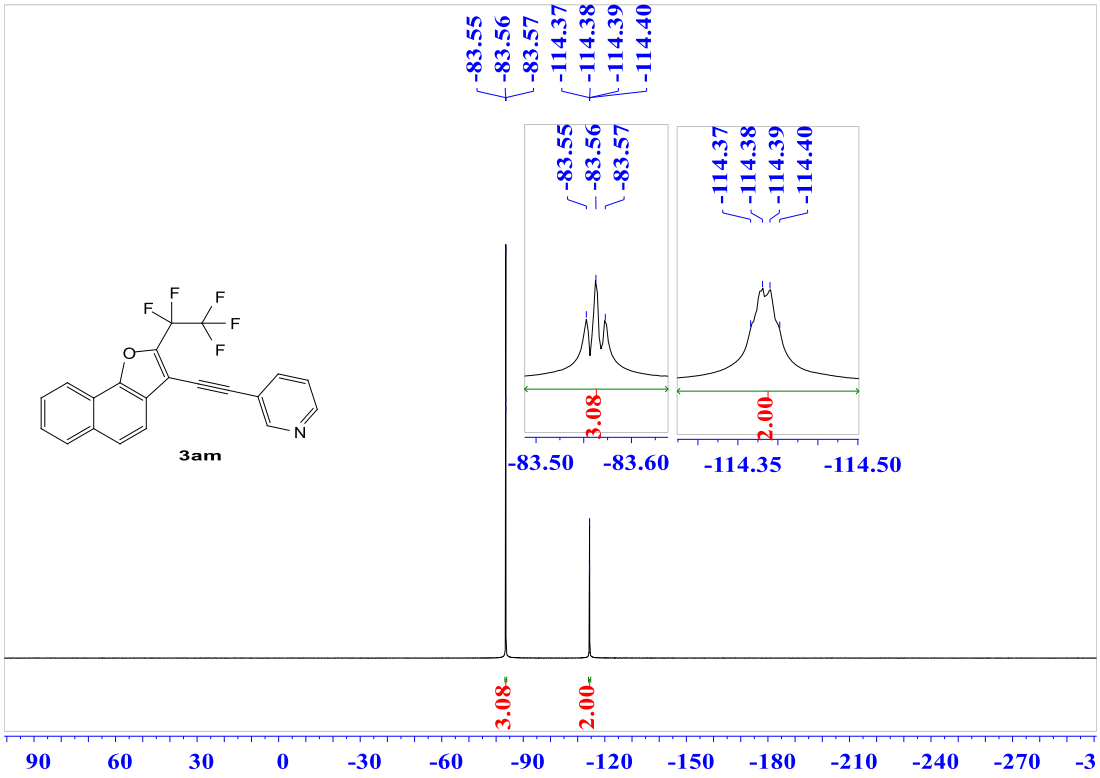

151.14
142.78
142.47
142.16
133.02
132.21
132.11
128.51
127.41
127.17
127.01
125.67
123.06
123.06
120.85
120.36
118.25
117.98
112.42
108.43
108.40
108.38
95.95
95.94
95.92
80.50
80.49
77.32 CDCl3
77.00 CDCl3
76.68 CDCl3
3ak

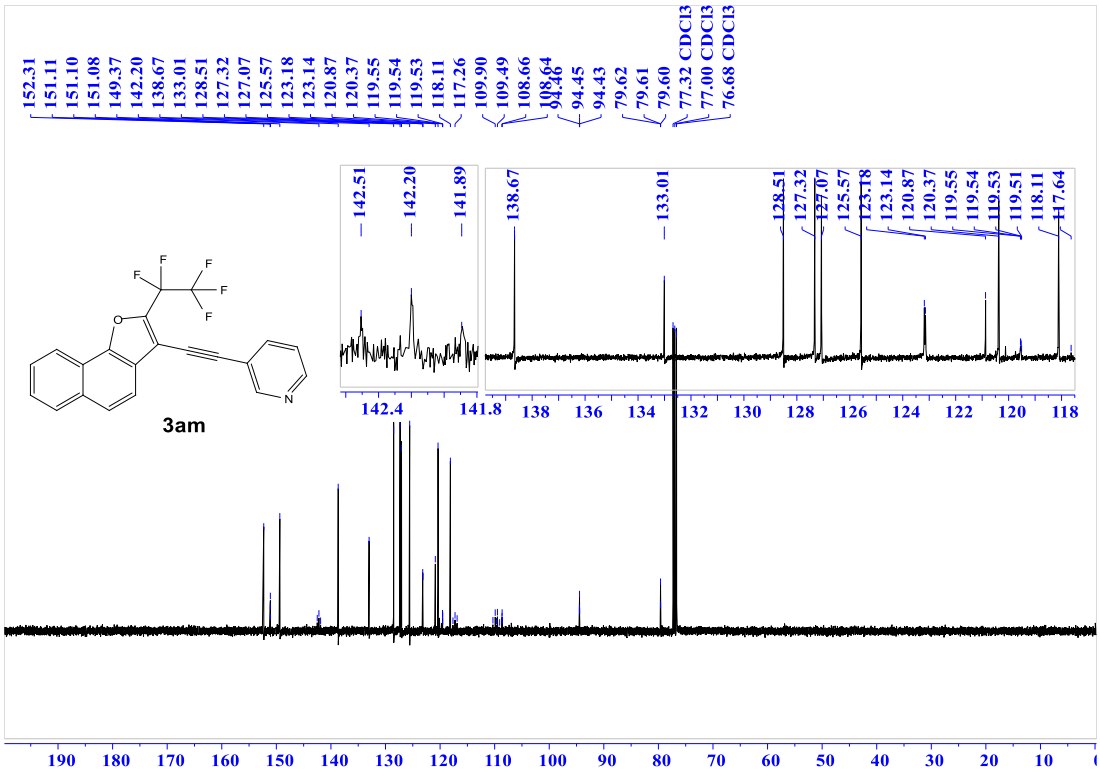

8.33 8.33 8.31 8.31 8.24 8.24 8.23 8.22 8.22 8.21 8.00 7.98 7.84 7.82 7.78 7.76 7.72 7.71 7.71 7.70 7.69 7.69 7.68 7.67 7.67 7.66 7.65 7.64 7.64 7.62 7.61 7.60 7.26 CDCl3
3al
1.04 2.36 1.00 1.28 1.34 2.36 2.23
2.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1

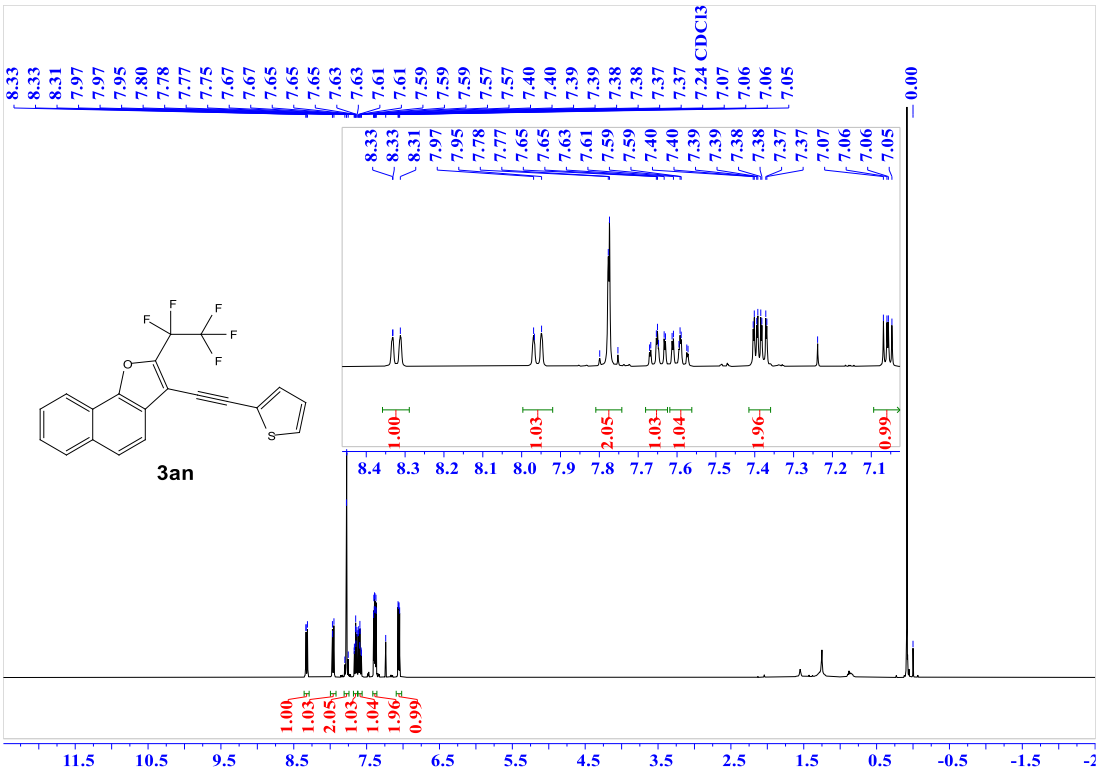

-83.52 -83.53 -83.54 -114.38 -114.39 -114.40 -114.41
3al
3.01 2.00
-83.50 -83.55 -114.35 -114.45
100 80 60 40 20 0 -20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220 -240 -260 -280 -300

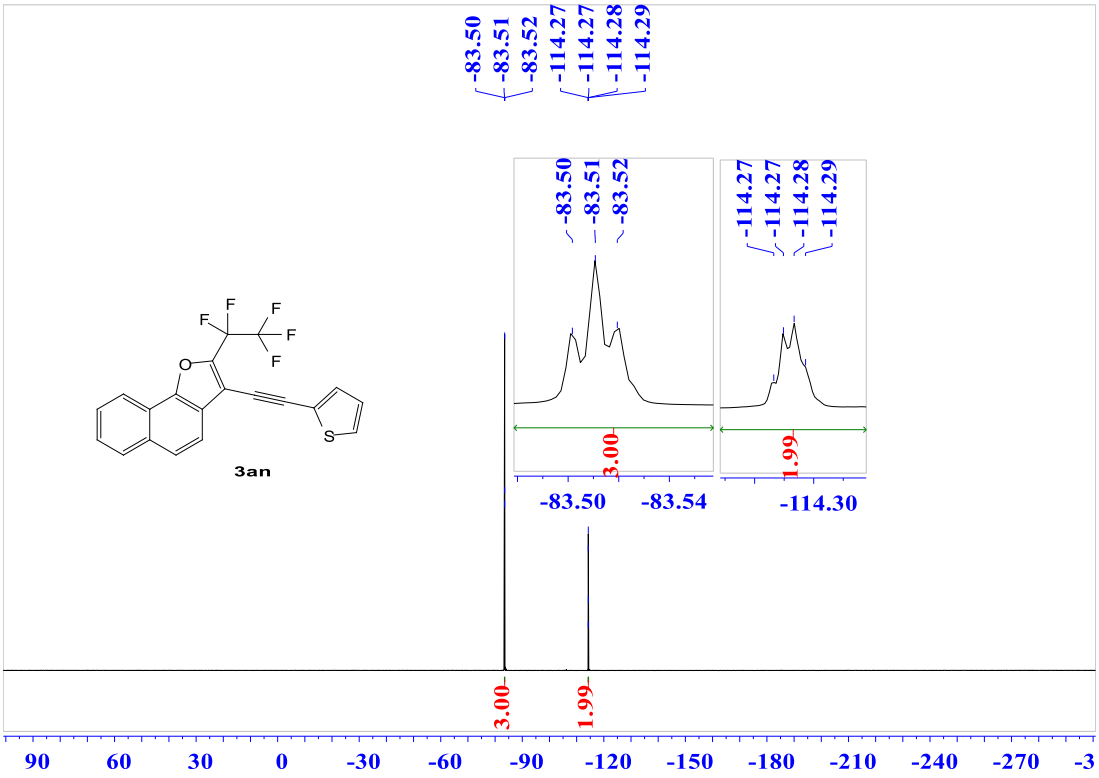

151.17
151.16
151.14
147.50
142.91
142.60
142.30
133.02
132.45
128.91
128.50
127.43
127.20
125.73
123.66
123.03
123.01
123.00
120.82
120.33
117.94
109.85
109.46
109.06
108.34
108.32
108.29
95.70
95.68
95.67
81.28
81.27
81.26
77.32 CDCl3
77.00 CDCl3
76.68 CDCl3
3al
143.0
142.6
142.2
134
132
130
128
126
124
122
120
118
00
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10

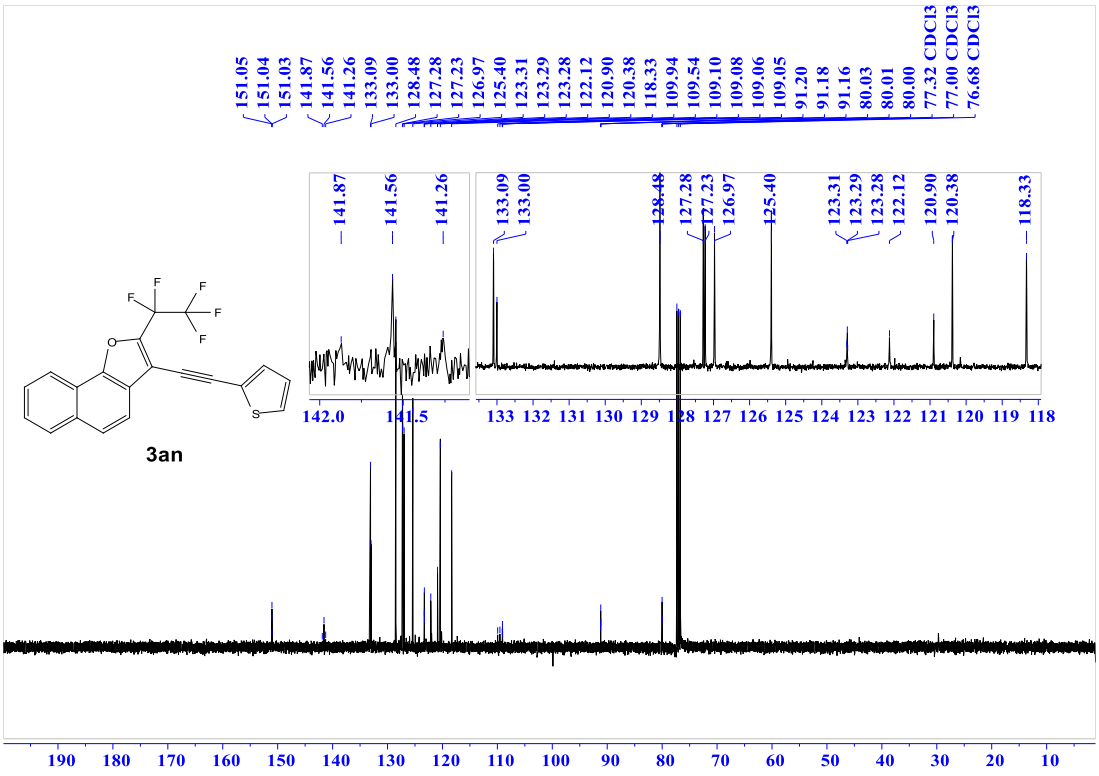

8.85 8.63 8.62 8.35 8.33 7.99 7.97 7.90 7.90 7.89 7.88 7.88 7.87 7.83 7.81 7.79 7.77 7.69 7.69 7.67 7.65 7.65 7.63 7.63 7.61 7.59 7.36 7.34 7.34 7.32 7.26 CDCl3
-0.00
3am
0.98 1.00 1.00 1.03 1.01 2.05 2.10 1.00
12.5 11.5 10.5 9.5 8.5 7.5 6.5 5.5 4.5 3.5 2.5 1.5 0.5 -0.5

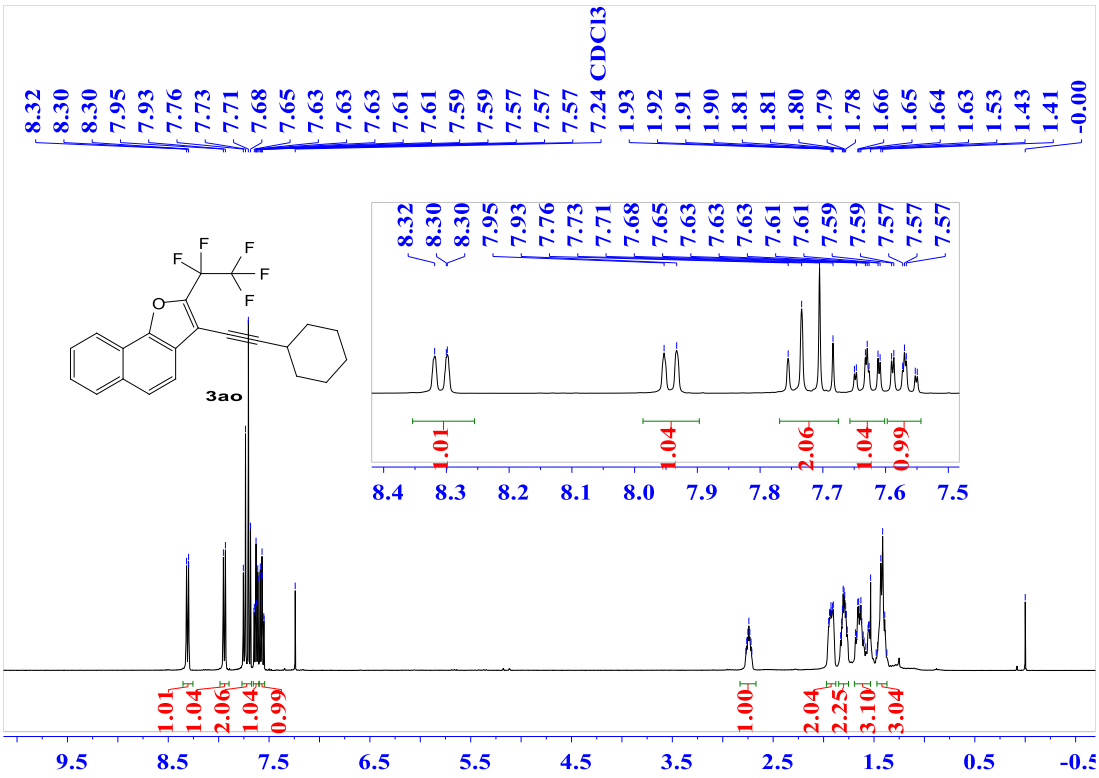

-83.55 -83.56 -83.57 -114.37 -114.38 -114.39 -114.40
3am
3.08 2.00
-83.50 -83.60 -114.35 -114.50
90 60 30 0 -30 -60 -90 -120 -150 -180 -210 -240 -270 -3

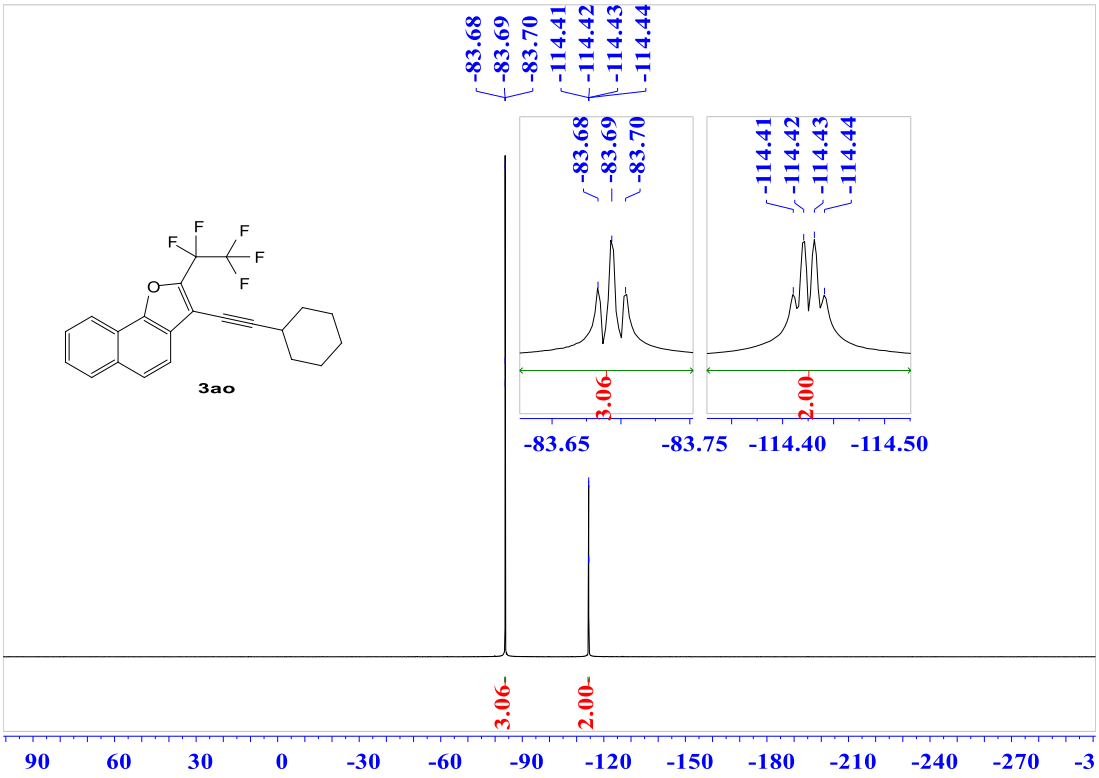

152.31
151.11
151.10
151.08
149.37
142.20
138.67
133.01
128.51
127.32
127.07
125.57
123.18
123.14
120.87
120.37
119.55
119.54
119.53
118.11
117.26
109.90
109.49
108.66
108.64
94.46
94.45
94.43
79.62
79.61
79.60
77.32 CDCl3
77.00 CDCl3
76.68 CDCl3
142.51
142.20
141.89
138.67
133.01
128.51
127.32
127.07
125.57
123.18
123.14
120.87
120.37
119.55
119.54
119.53
119.51
118.11
117.64
3am

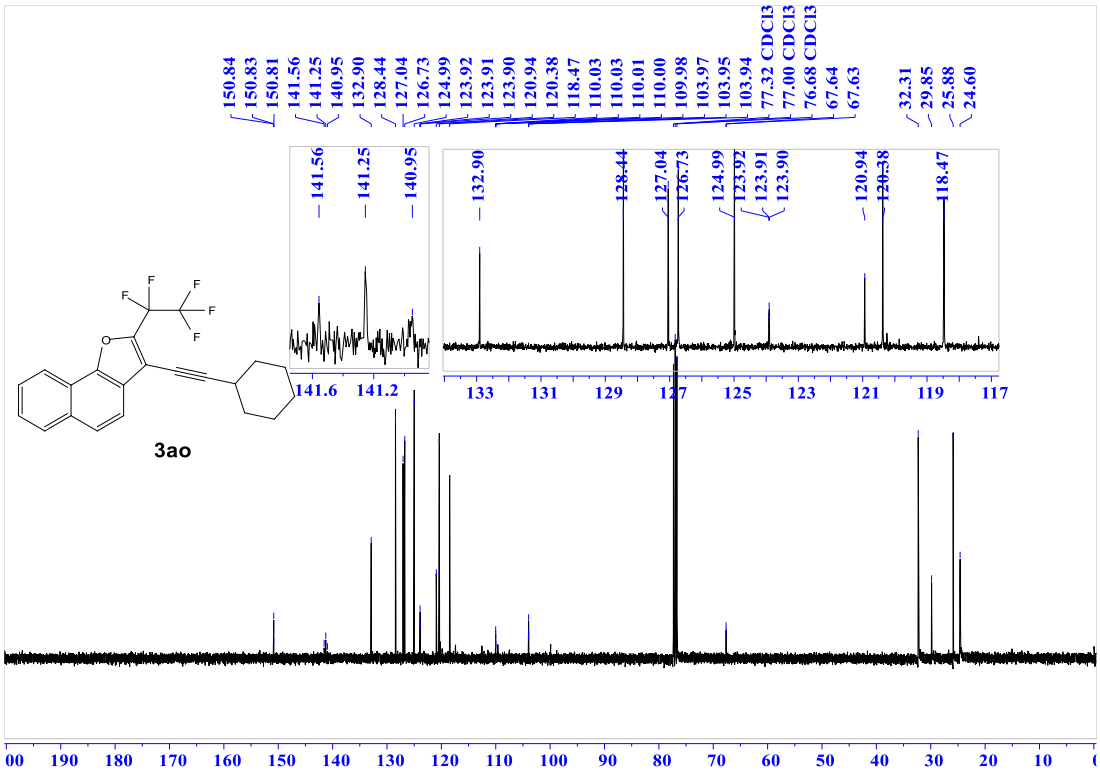

3an

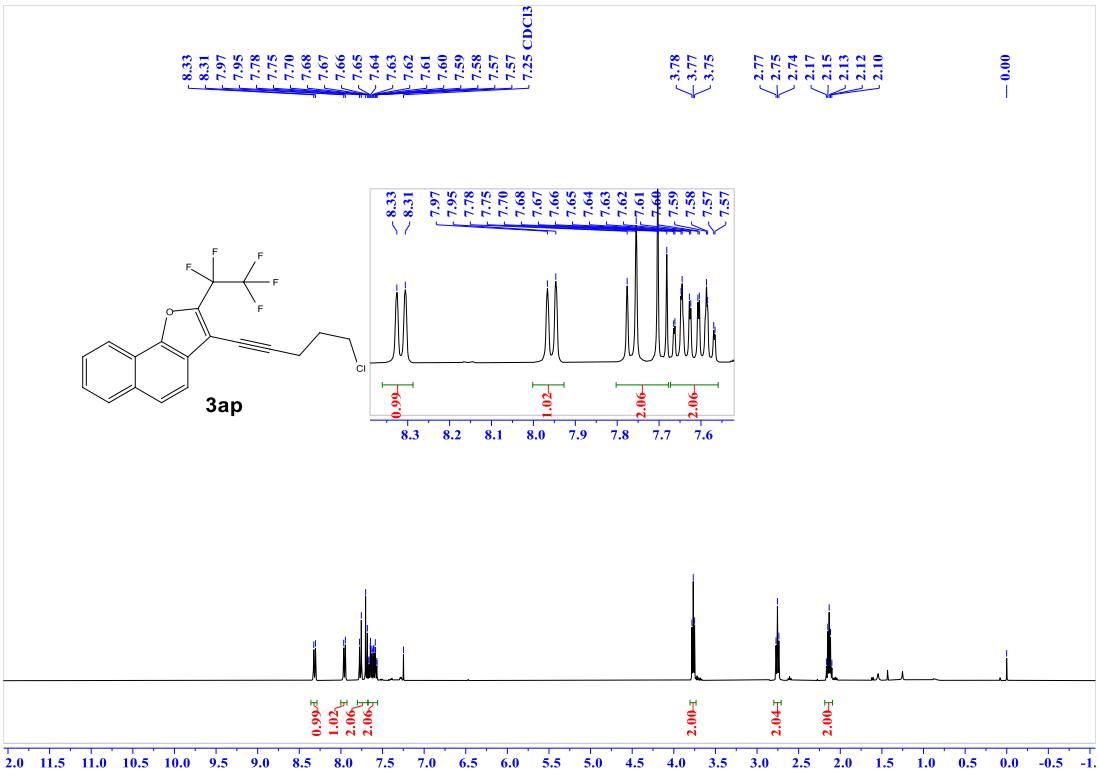

3an

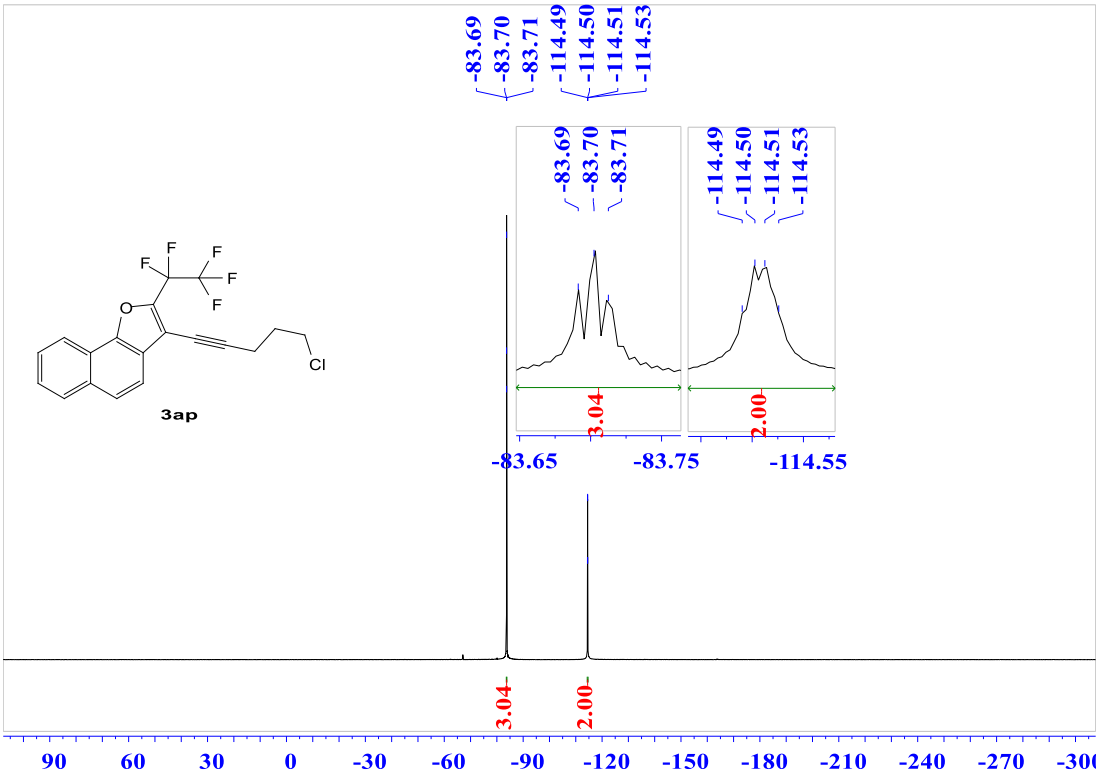

151.05
151.04
151.03
141.87
141.56
141.26
133.09
133.00
128.48
127.28
127.23
126.97
125.40
123.31
123.29
123.28
122.12
120.90
120.38
118.33
109.94
109.54
109.10
109.08
109.06
109.05
91.20
91.18
91.16
80.03
80.01
80.00
77.32 CDCl3
77.00 CDCl3
76.68 CDCl3
F
F
F
F
F
O
S
3an
142.0
141.5
133
132
131
130
129
128
127
126
125
124
123
122
121
120
119
118
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10

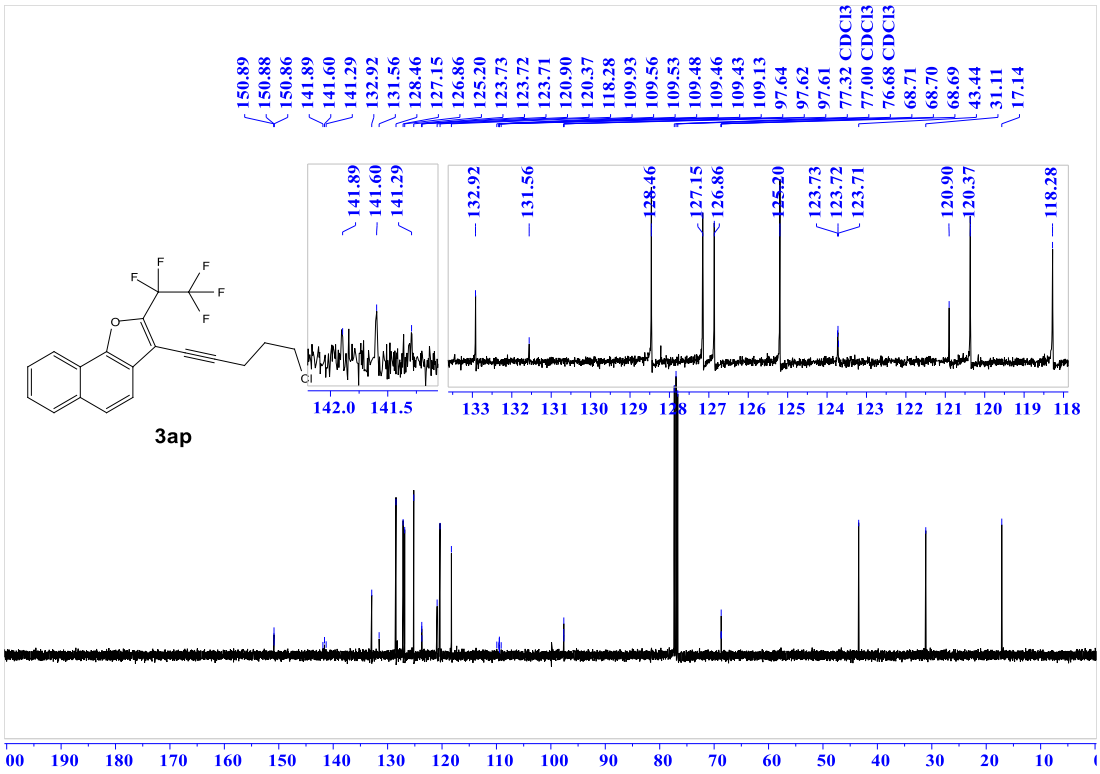

8.32 8.30 8.30 7.95 7.93 7.76 7.73 7.71 7.68 7.65 7.63 7.63 7.63 7.61 7.61 7.59 7.59 7.57 7.57 7.57 7.24 CDCl3 1.93 1.92 1.91 1.90 1.81 1.81 1.80 1.79 1.78 1.66 1.65 1.64 1.63 1.53 1.43 1.41 -0.00
3ao
1.01 1.04 2.06 1.04 0.99 1.00 2.04 2.25 3.10 3.04
9.5 8.5 7.5 6.5 5.5 4.5 3.5 2.5 1.5 0.5

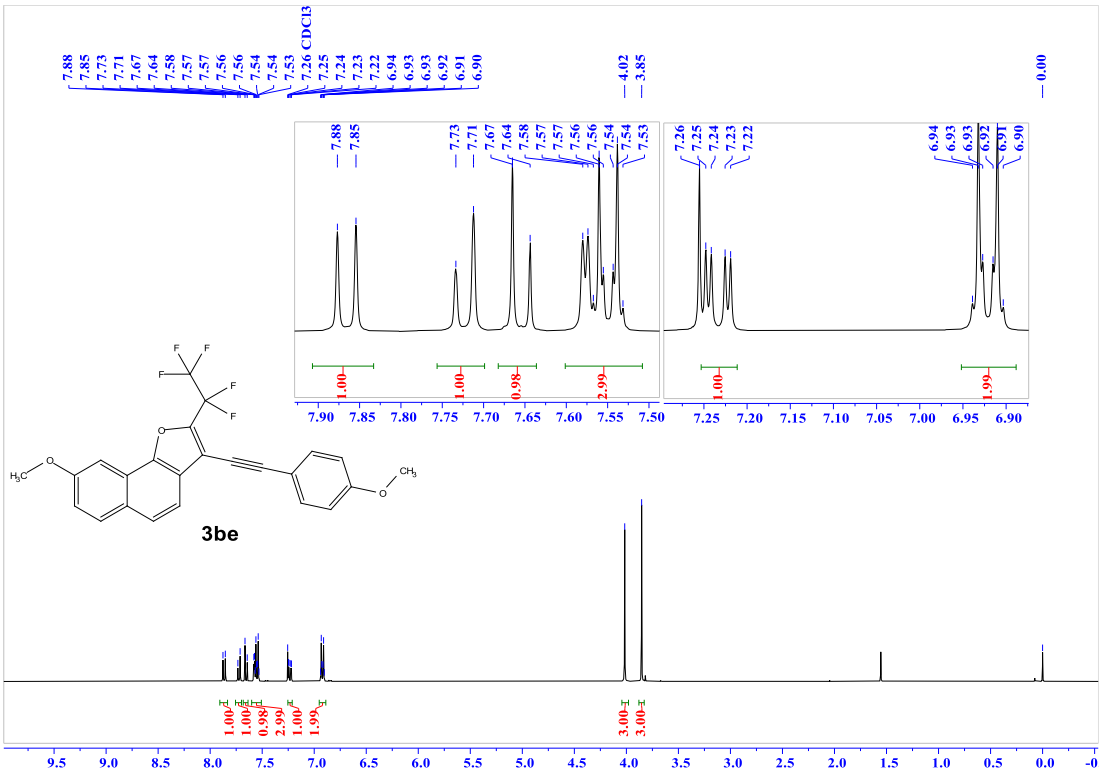

-83.68 -83.69 -83.70 -114.41 -114.42 -114.43 -114.44
3ao
3.06 2.00
-83.65 -83.75 -114.40 -114.50
90 60 30 0 -30 -60 -90 -120 -150 -180 -210 -240 -270

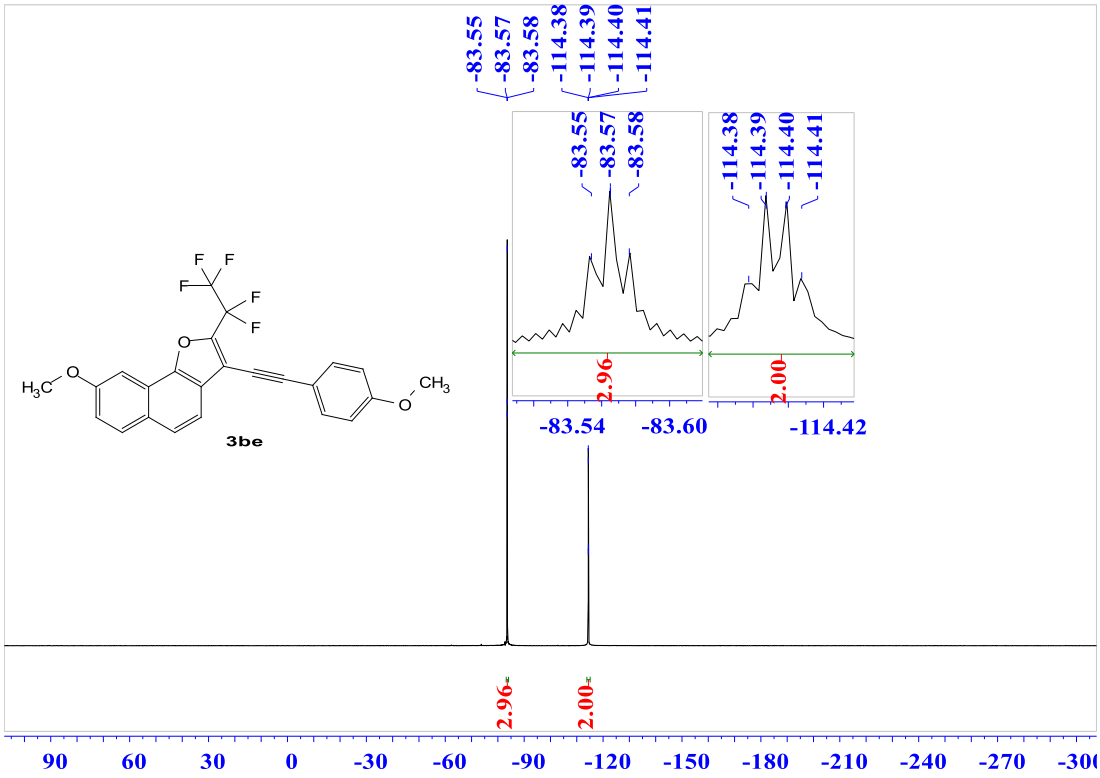

150.84
150.83
150.81
141.56
141.25
140.95
132.90
128.44
127.04
126.73
124.99
123.92
123.91
123.90
120.94
120.38
118.47
110.03
110.03
110.01
110.00
109.98
103.97
103.95
103.94
77.32 CDCl3
77.00 CDCl3
76.68 CDCl3
67.64
67.63
32.31
29.85
25.88
24.60
3ao

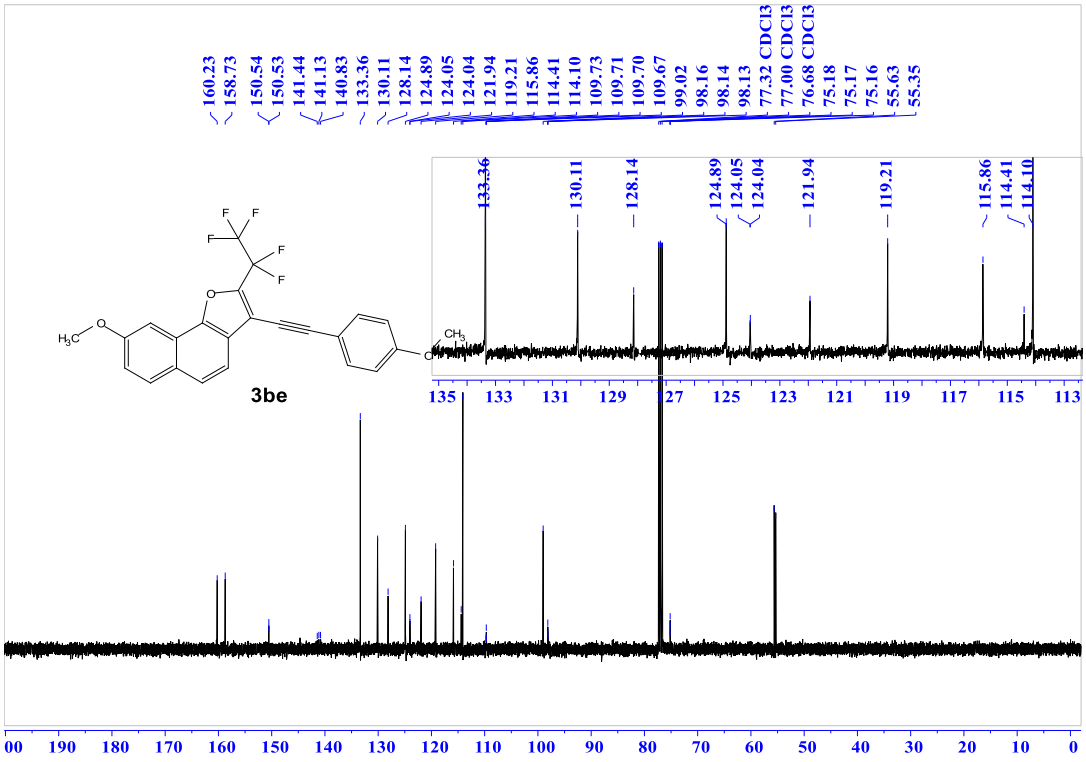

8.33
8.31
7.97
7.95
7.78
7.75
7.70
7.68
7.67
7.66
7.65
7.64
7.63
7.62
7.61
7.60
7.59
7.58
7.57
7.57
7.25 CDCl3
3.78
3.77
3.75
2.77
2.75
2.74
2.17
2.15
2.13
2.12
2.10
0.00
3ap
0.99
1.02
2.06
2.06
2.00
2.04
2.00

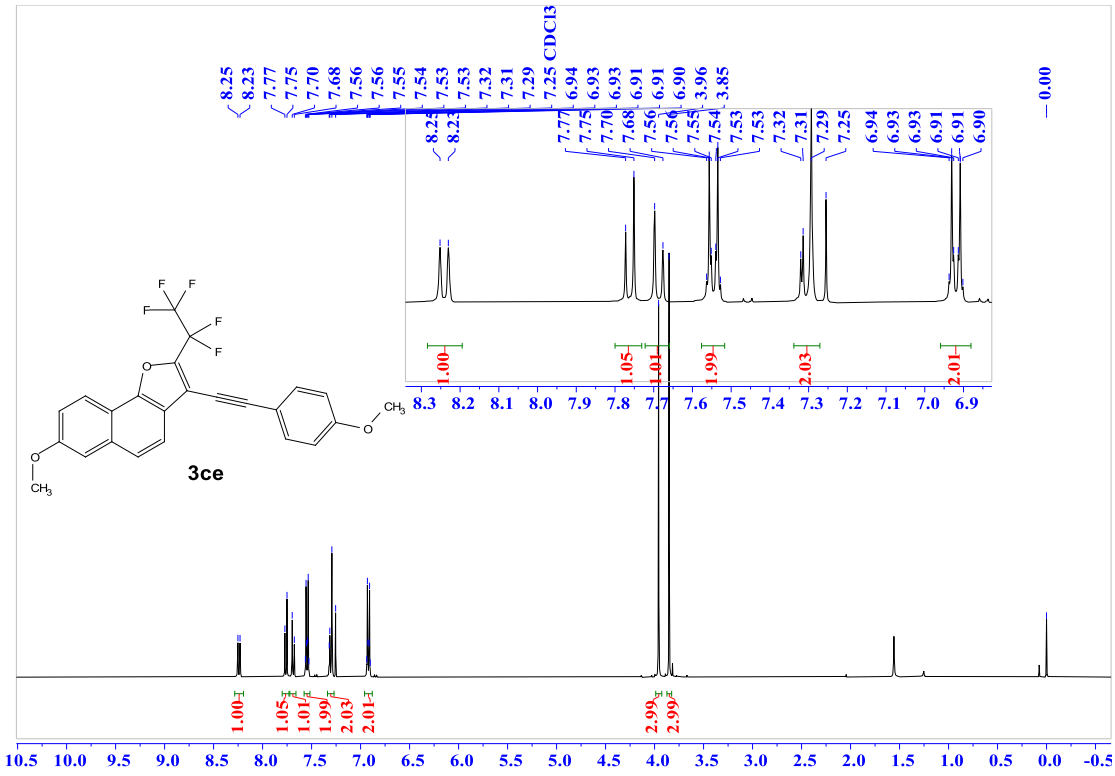

-83.69
-83.70
-83.71
-114.49
-114.50
-114.51
-114.53
3ap
3.04
2.00
-83.65
-83.75
-114.55

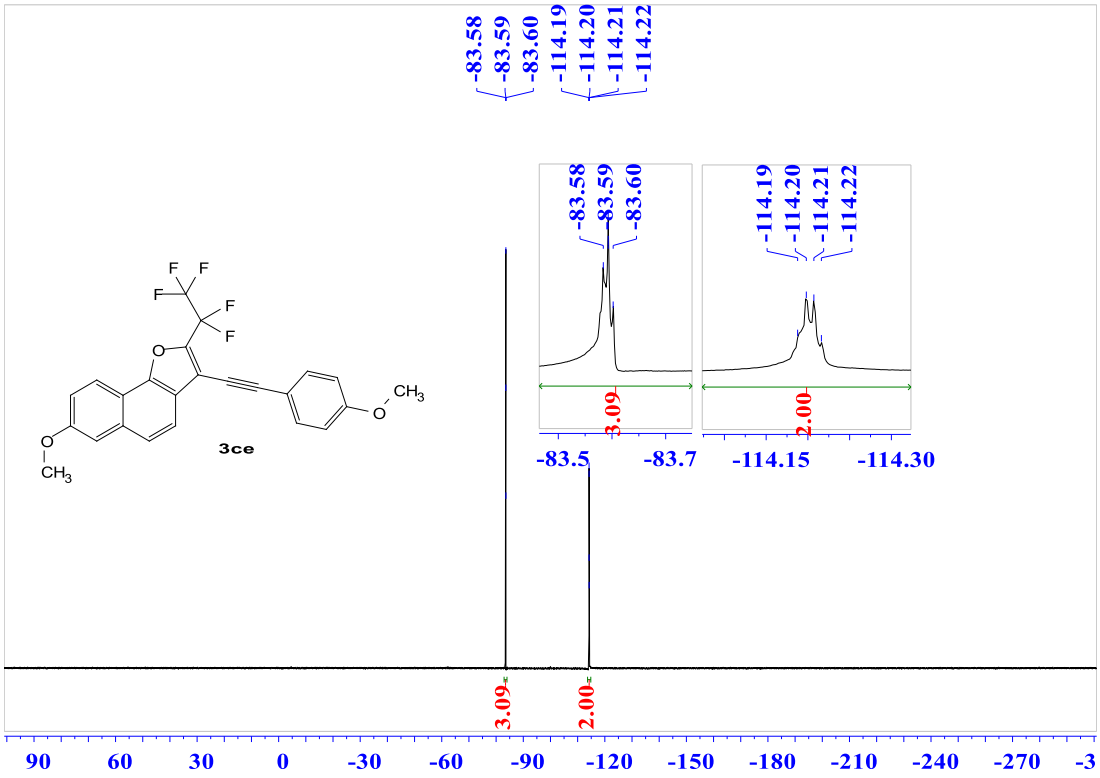

150.89
150.88
150.86
141.89
141.60
141.29
132.92
131.56
128.46
127.15
126.86
125.20
123.73
123.72
123.71
120.90
120.37
118.28
109.93
109.56
109.53
109.48
109.46
109.43
109.13
97.64
97.62
97.61
77.32 CDCl3
77.00 CDCl3
76.68 CDCl3
68.71
68.70
68.69
43.44
31.11
17.14
F
F
F
F
F
O
Cl
3ap
142.0
141.5
133
132
131
130
129
128
127
126
125
124
123
122
121
120
119
118
00
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10

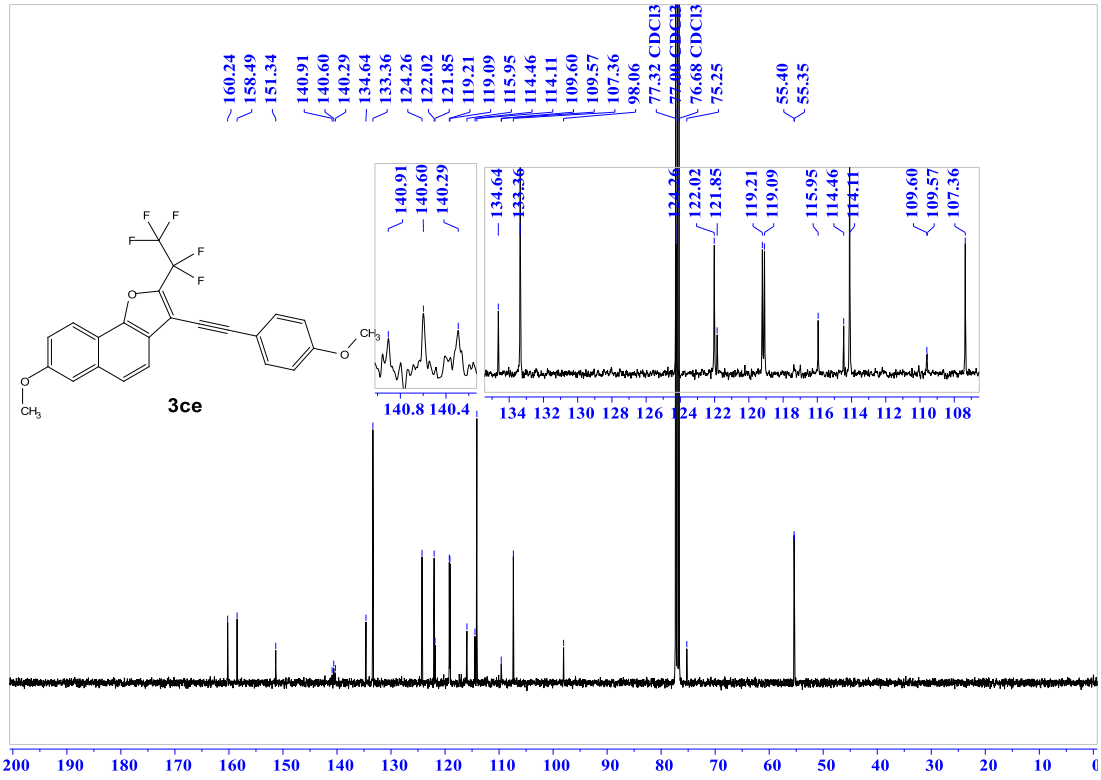

7.88
7.85
7.73
7.71
7.67
7.64
7.58
7.57
7.57
7.56
7.56
7.54
7.54
7.53
7.26 CDCl3
7.25
7.24
7.23
7.22
6.94
6.93
6.93
6.92
6.91
6.90
4.02
3.85
0.00
1.00
1.00
0.98
2.99
1.00
1.99
3.00
3.00
3be

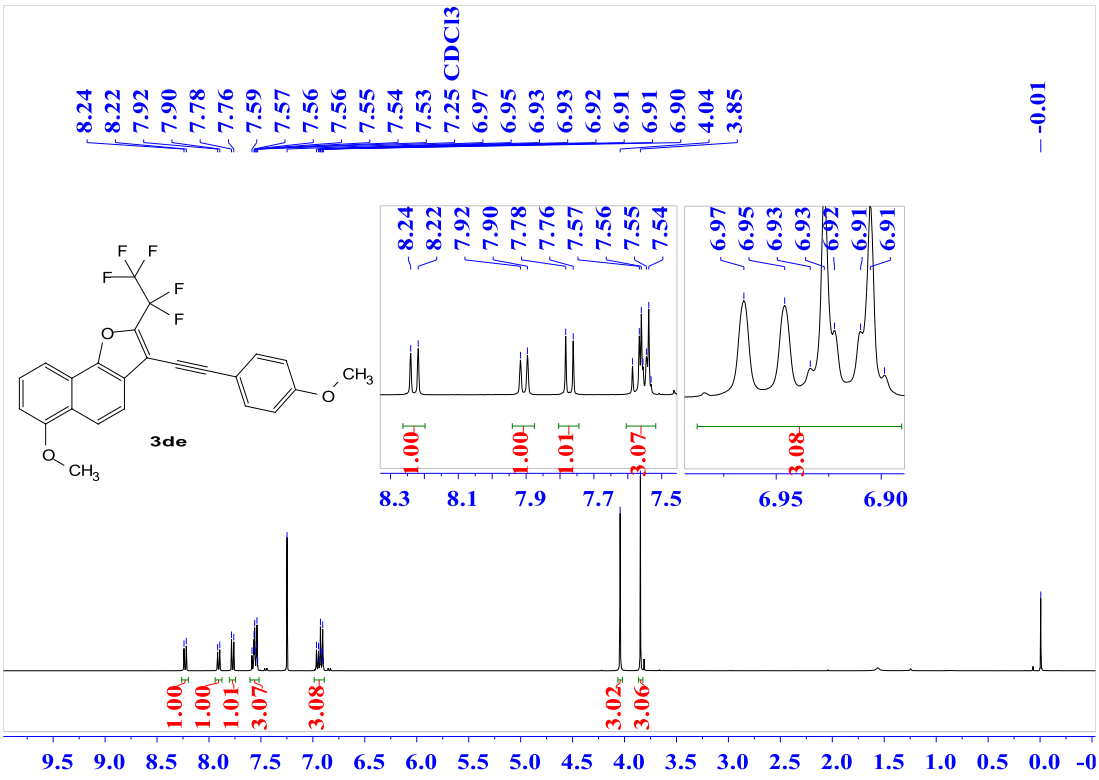

-83.55
-83.57
-83.58
-114.38
-114.39
-114.40
-114.41
2.96
2.00
-83.54
-83.60
-114.42
3be

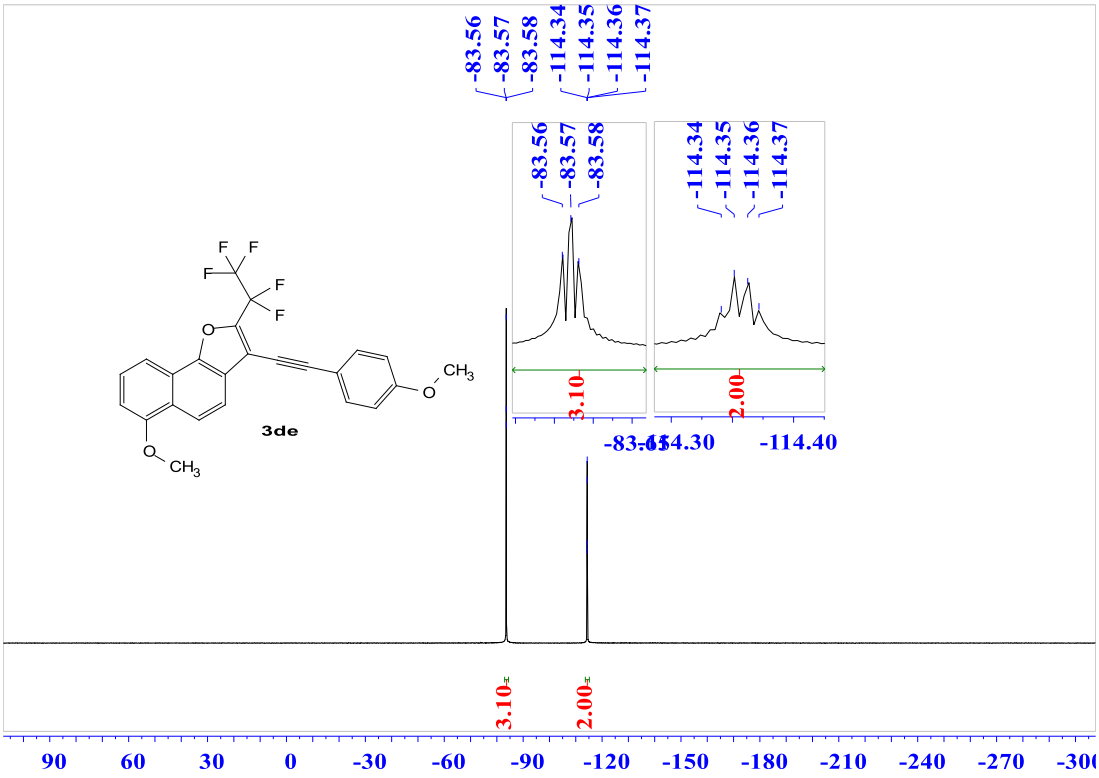

160.23
158.73
150.54
150.53
141.44
141.13
140.83
133.36
130.11
128.14
124.89
124.05
124.04
121.94
119.21
115.86
114.41
114.10
109.73
109.71
109.70
109.67
99.02
98.16
98.14
98.13
77.32 CDCl3
77.00 CDCl3
76.68 CDCl3
75.18
75.17
75.16
55.63
55.35
3be

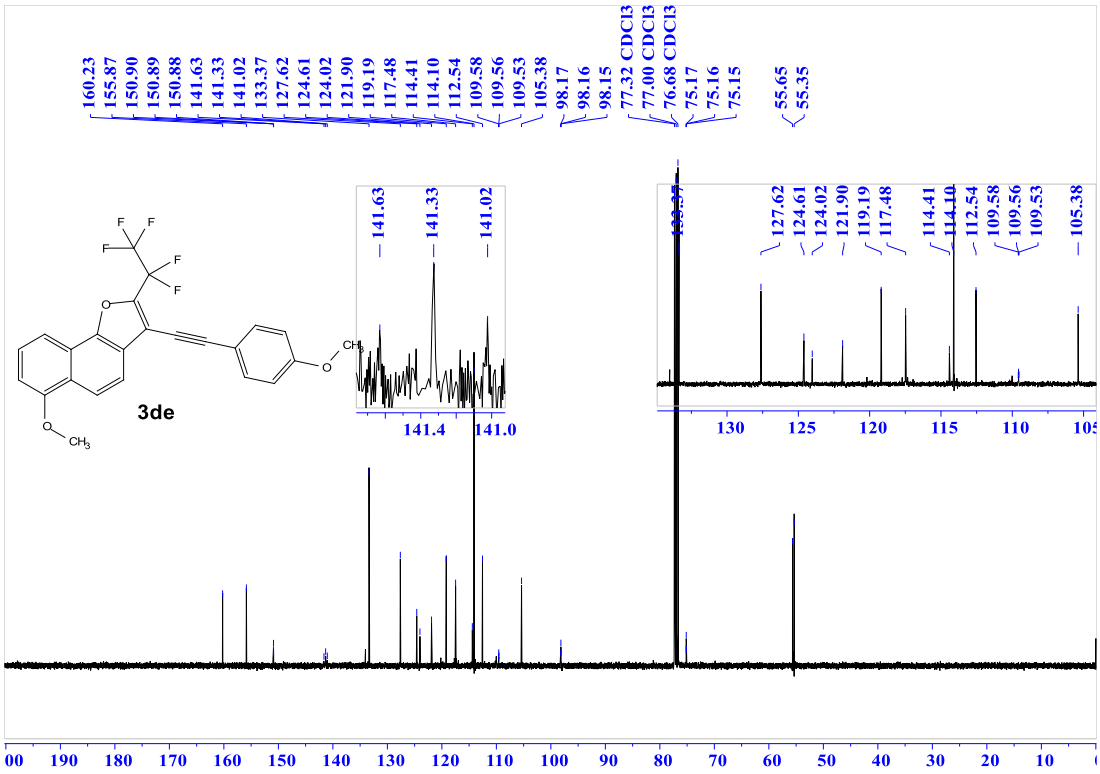

CDCl3
3ce

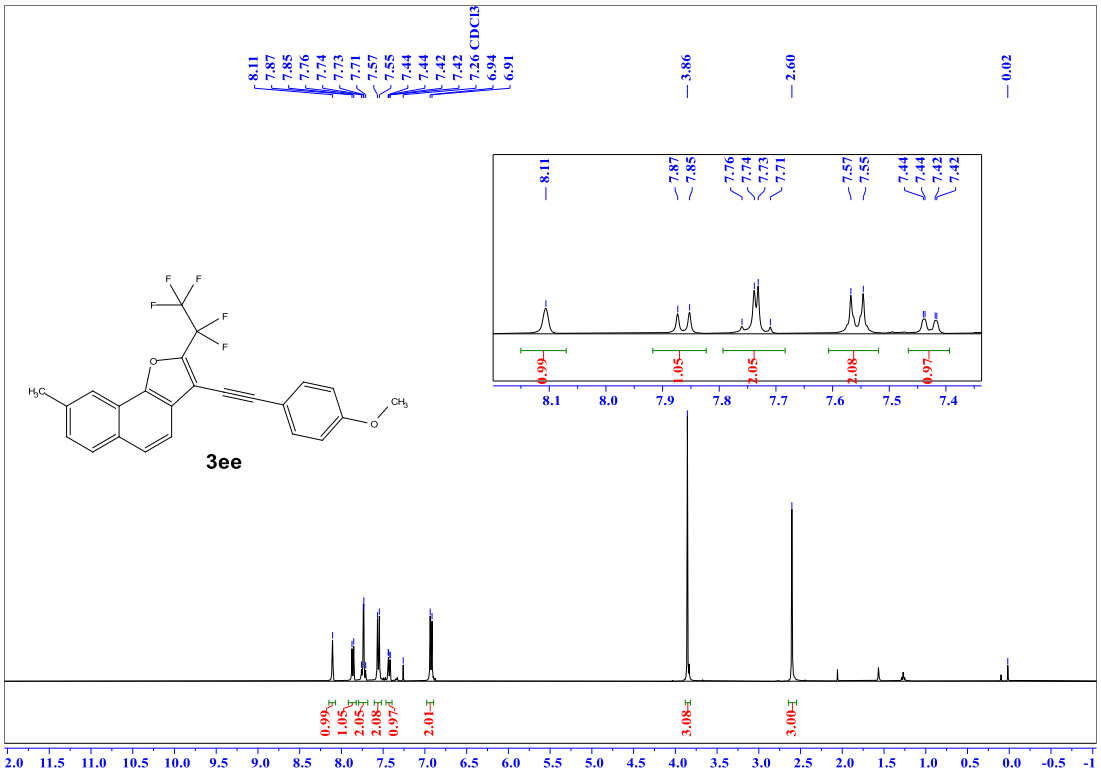

3ce

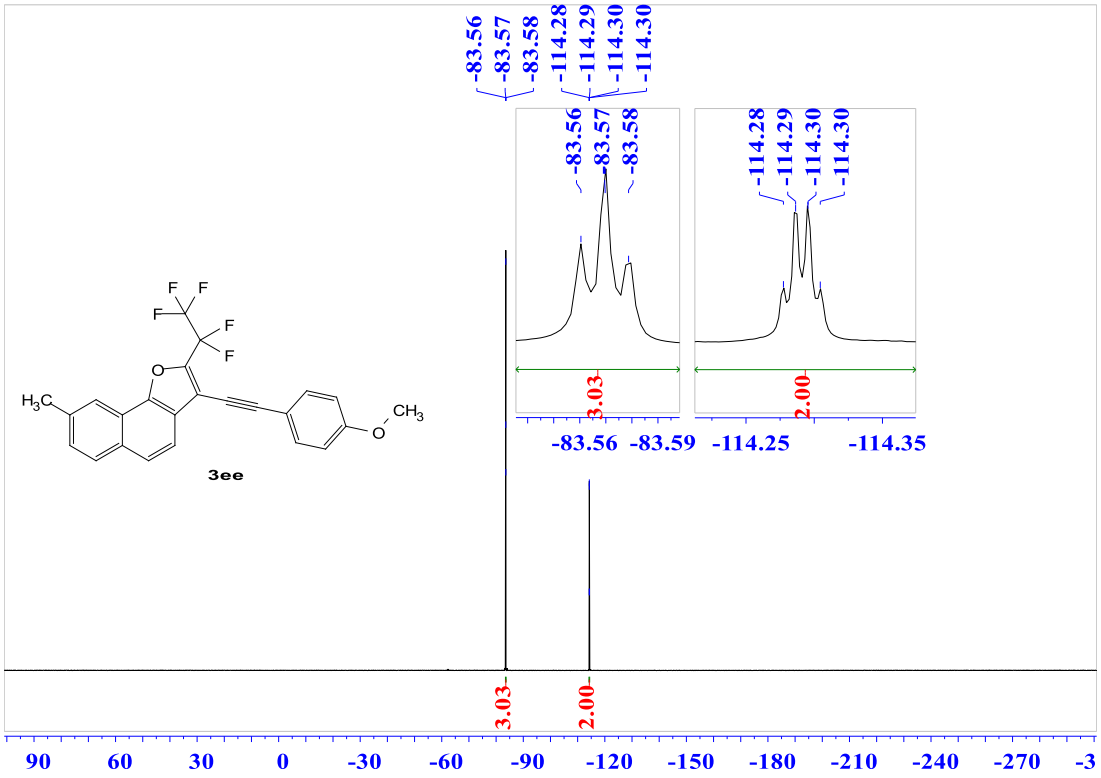

160.24
158.49
151.34
140.91
140.60
140.29
134.64
133.36
124.26
122.02
121.85
119.21
119.09
115.95
114.46
114.11
109.60
109.57
107.36
98.06
77.32 CDCl3
76.68 CDCl3
75.25
55.40
55.35
3ce
140.8 140.4
134 132 130 128 126 124 122 120 118 116 114 112 110 108
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10

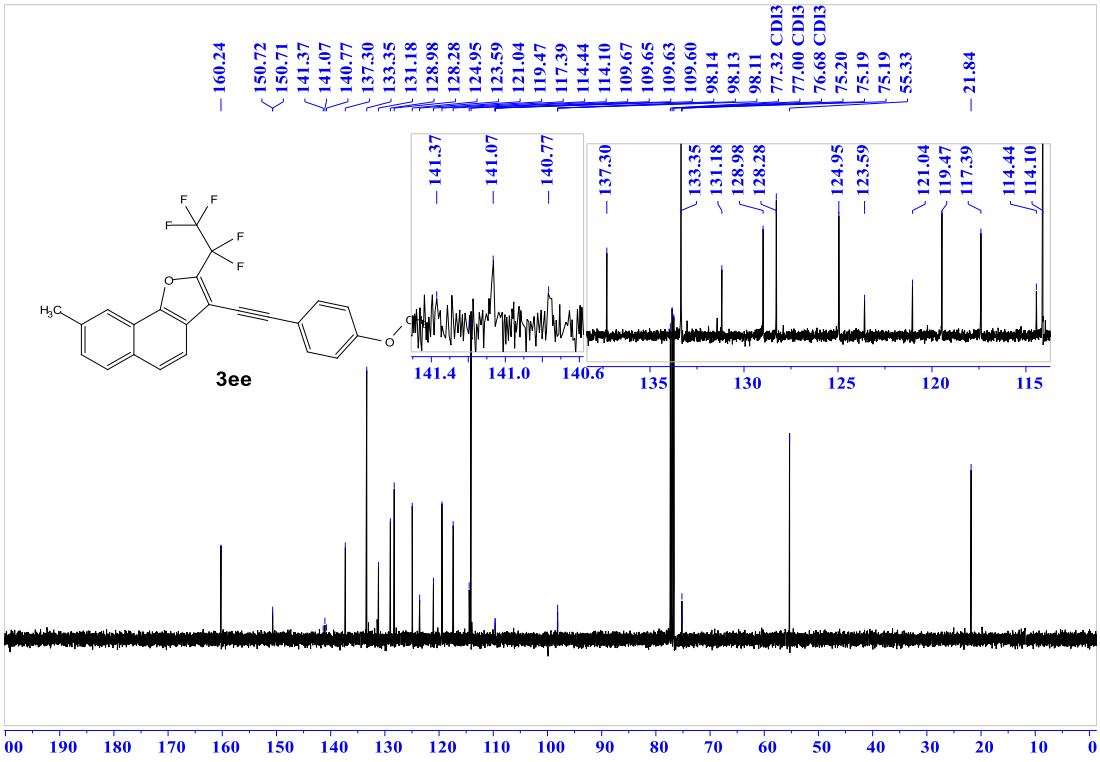

8.24
8.22
7.92
7.90
7.78
7.76
7.59
7.57
7.56
7.56
7.55
7.54
7.53
7.25 CDCl3
6.97
6.95
6.93
6.93
6.92
6.91
6.91
6.90
4.04
3.85
-0.01
3de
1.00
1.00
1.01
3.07
3.08
3.02
3.06
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0

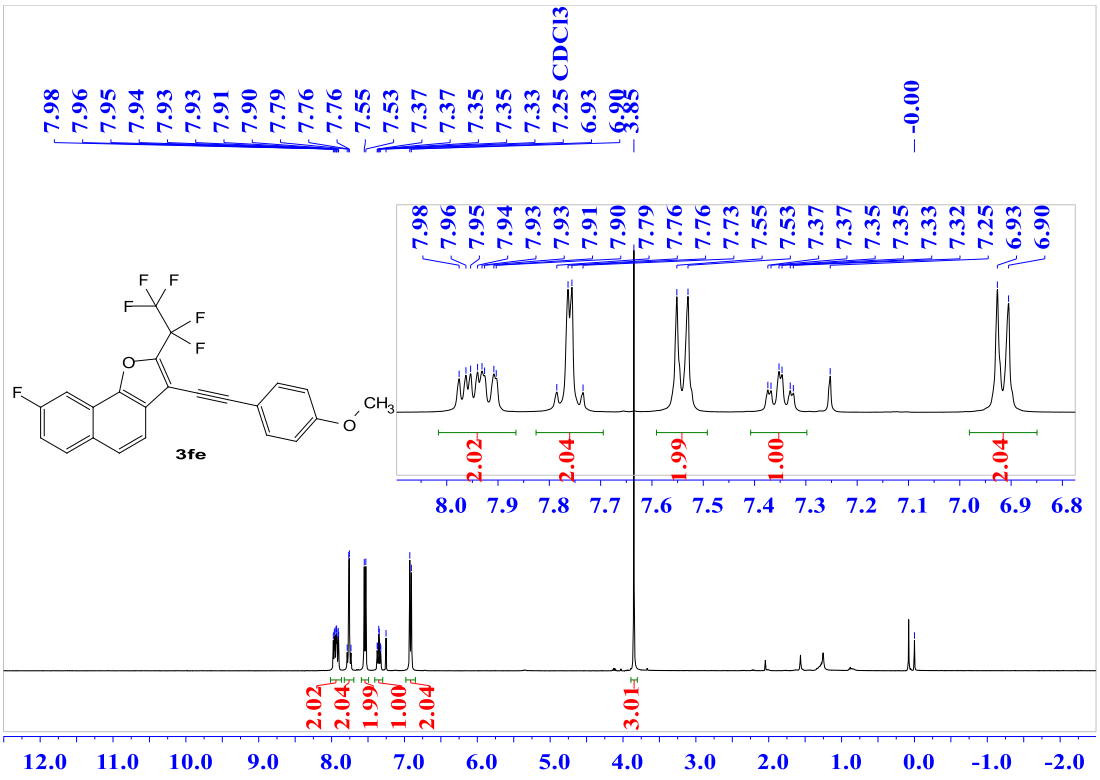

-83.56
-83.57
-83.58
-114.34
-114.35
-114.36
-114.37
3de
3.10
2.00
-114.30
-114.40
3.10
2.00
90 60 30 0 -30 -60 -90 -120 -150 -180 -210 -240 -270

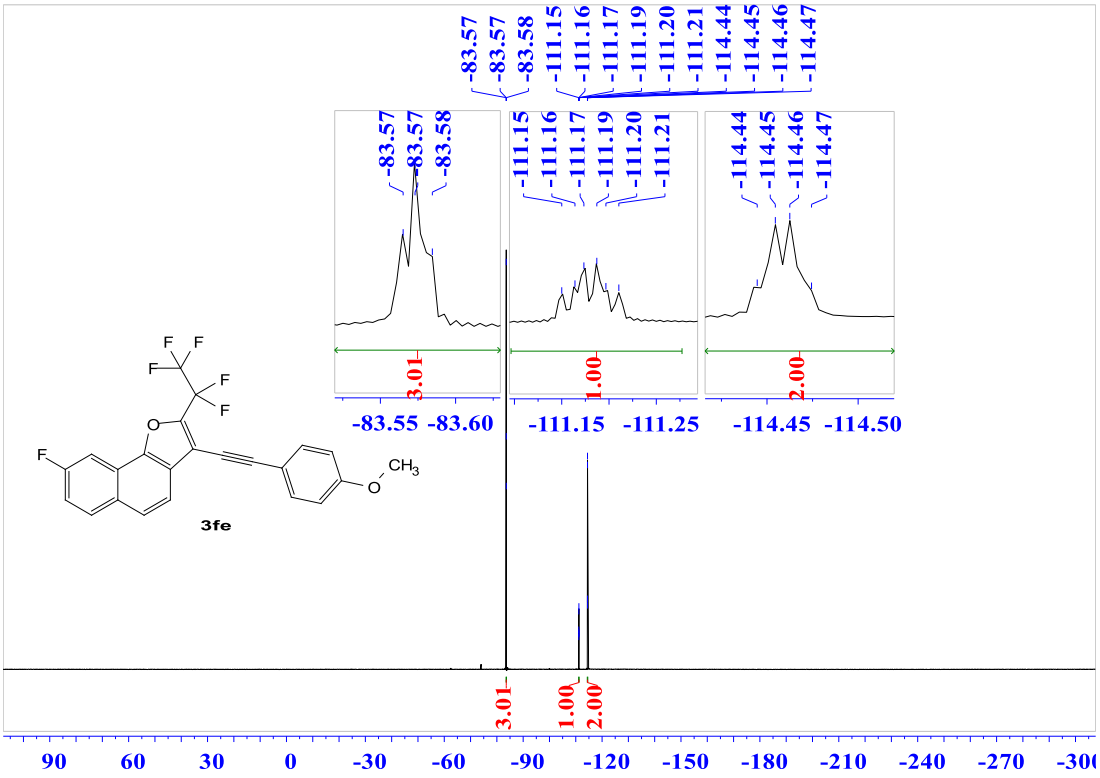

160.23
155.87
150.90
150.89
150.88
141.63
141.33
141.02
133.37
127.62
124.61
124.02
121.90
119.19
117.48
114.41
114.10
112.54
109.58
109.56
109.53
105.38
98.17
98.16
98.15
77.32 CDCl3
77.00 CDCl3
76.68 CDCl3
75.17
75.16
75.15
55.65
55.35
3de
141.4
141.0
130
125
120
115
110
00
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10

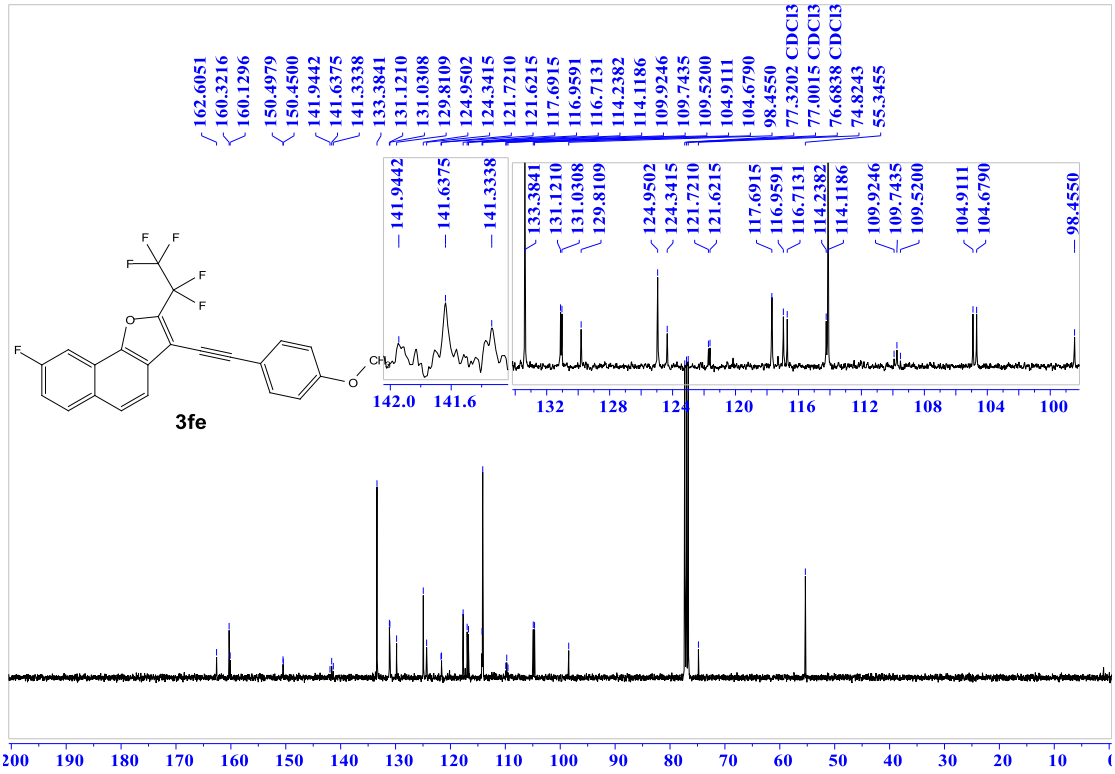

8.11
7.87
7.85
7.76
7.74
7.73
7.71
7.57
7.55
7.44
7.44
7.42
7.42
7.26 CDCl3
6.94
6.91
3.86
2.60
0.02
3ee

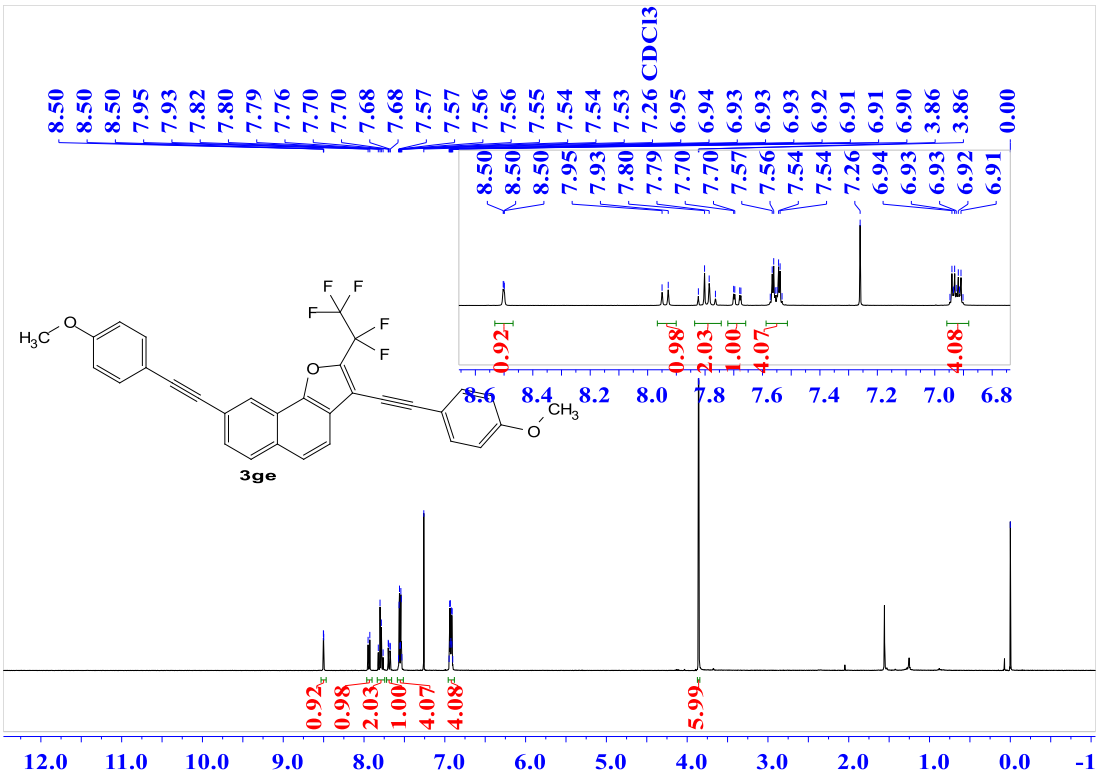

-83.56
-83.57
-83.58
-114.28
-114.29
-114.30
-114.30
3.03
2.00
-83.56 -83.59 -114.25 -114.35
3ee

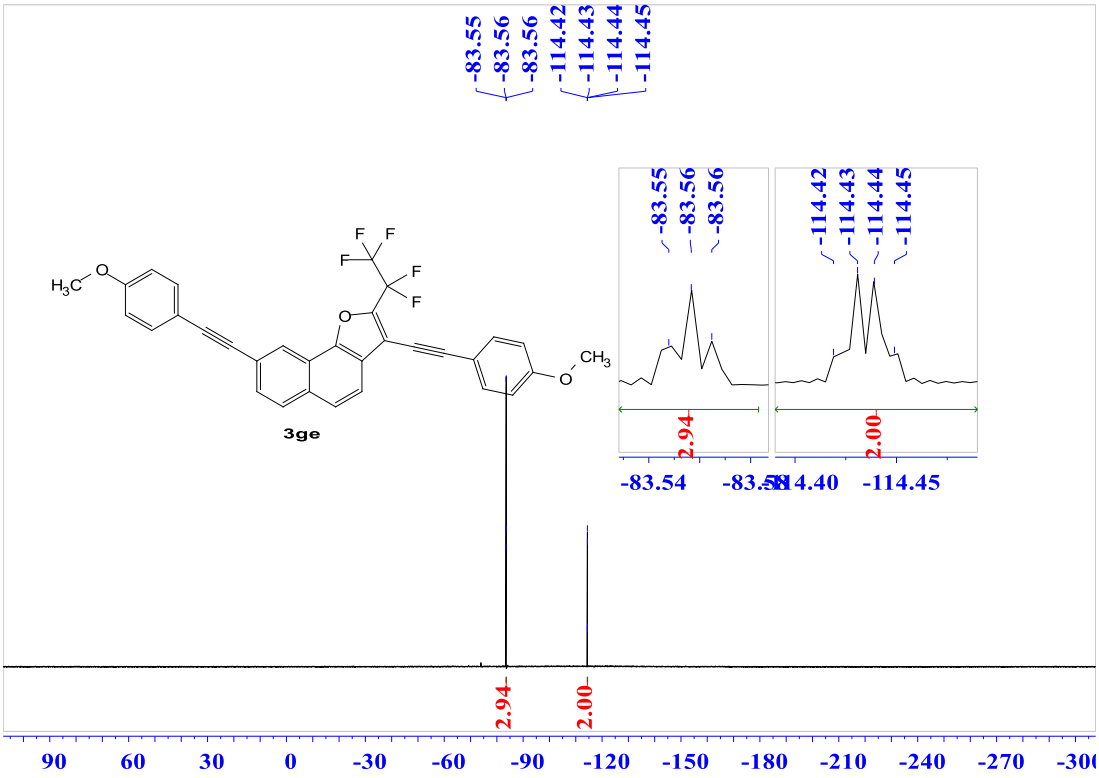

160.24
150.72
150.71
141.37
141.07
140.77
137.30
133.35
131.18
128.98
128.28
124.95
123.59
121.04
119.47
117.39
114.44
114.10
109.67
109.65
109.63
109.60
98.14
98.13
98.11
77.32 CDl3
77.00 CDl3
76.68 CDl3
75.20
75.19
75.19
55.33
21.84
3ee

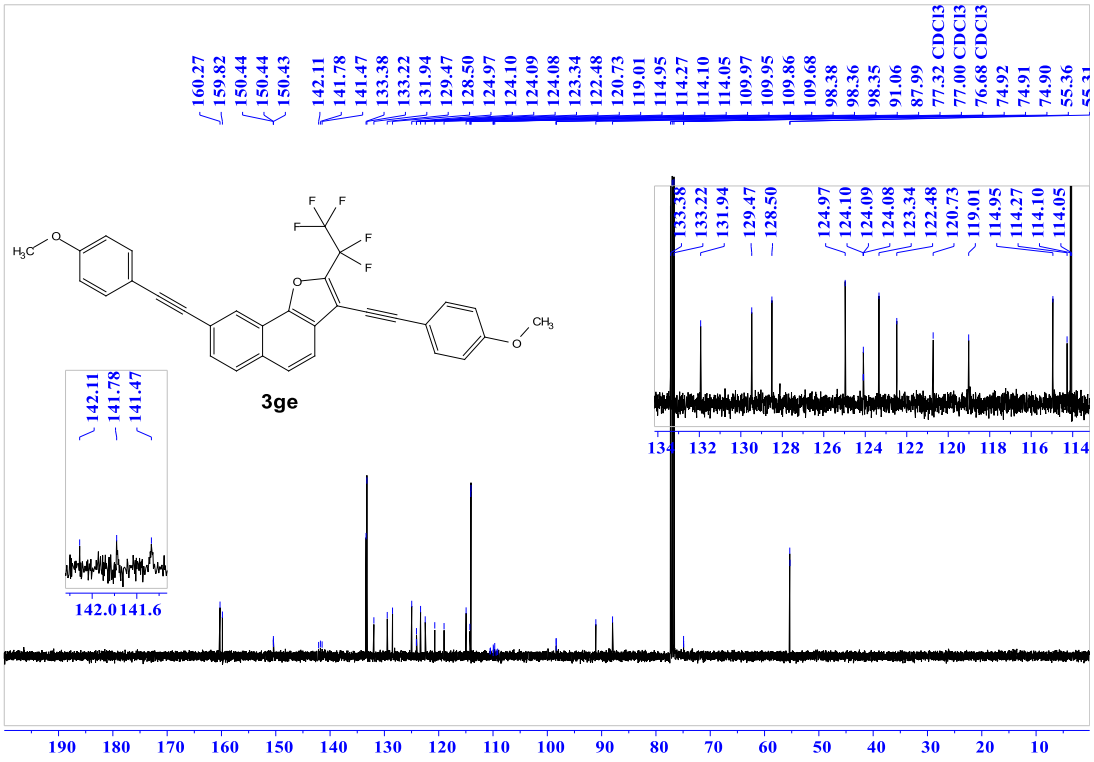

7.98 7.96 7.95 7.94 7.93 7.93 7.91 7.90 7.79 7.76 7.76 7.55 7.53 7.37 7.37 7.35 7.35 7.33 7.25 CDCl3 6.93 6.90 3.85
-0.00
7.98 7.96 7.95 7.94 7.93 7.93 7.91 7.90 7.79 7.76 7.76 7.73 7.55 7.53 7.37 7.37 7.35 7.35 7.33 7.32 7.25 6.93 6.90
2.02 2.04 1.99 1.00 2.04
8.0 7.9 7.8 7.7 7.6 7.5 7.4 7.3 7.2 7.1 7.0 6.9 6.8
2.02 2.04 1.99 1.00 2.04 3.01
12.0 11.0 10.0 9.0 8.0 7.0 6.0 5.0 4.0 3.0 2.0 1.0 0.0 -1.0 -2.0
3fe

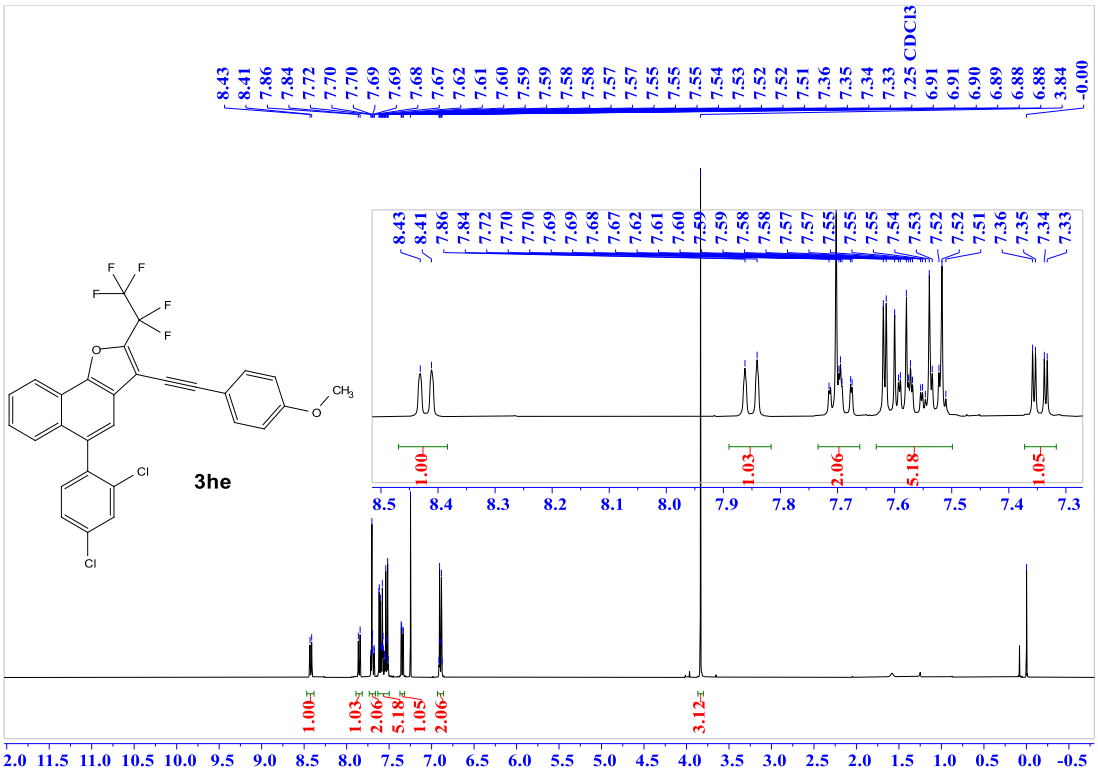

-83.57 -83.57 -83.58 -111.15 -111.16 -111.17 -111.19 -111.20 -111.21 -114.44 -114.45 -114.46 -114.47
-83.57 -83.57 -83.58 -111.15 -111.16 -111.17 -111.19 -111.20 -111.21 -114.44 -114.45 -114.46 -114.47
3.01 1.00 2.00
-83.55 -83.60 -111.15 -111.25 -114.45 -114.50
3.01 1.00 2.00
90 60 30 0 -30 -60 -90 -120 -150 -180 -210 -240 -270 -300
3fe

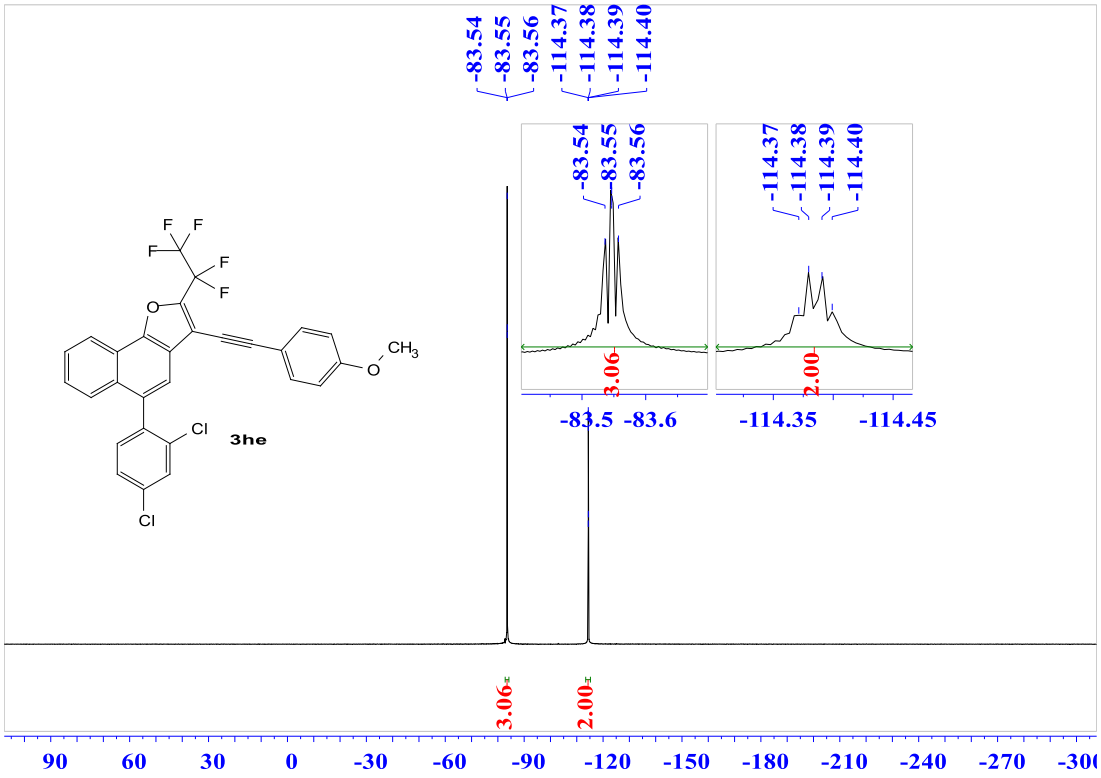

162.6051
160.3216
160.1296
150.4979
150.4500
141.9442
141.6375
141.3338
133.3841
131.1210
131.0308
129.8109
124.9502
124.3415
121.7210
121.6215
117.6915
116.9591
116.7131
114.2382
114.1186
109.9246
109.7435
109.5200
104.9111
104.6790
98.4550
77.3202 CDCl3
77.0015 CDCl3
76.6838 CDCl3
74.8243
55.3455
3fe
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10

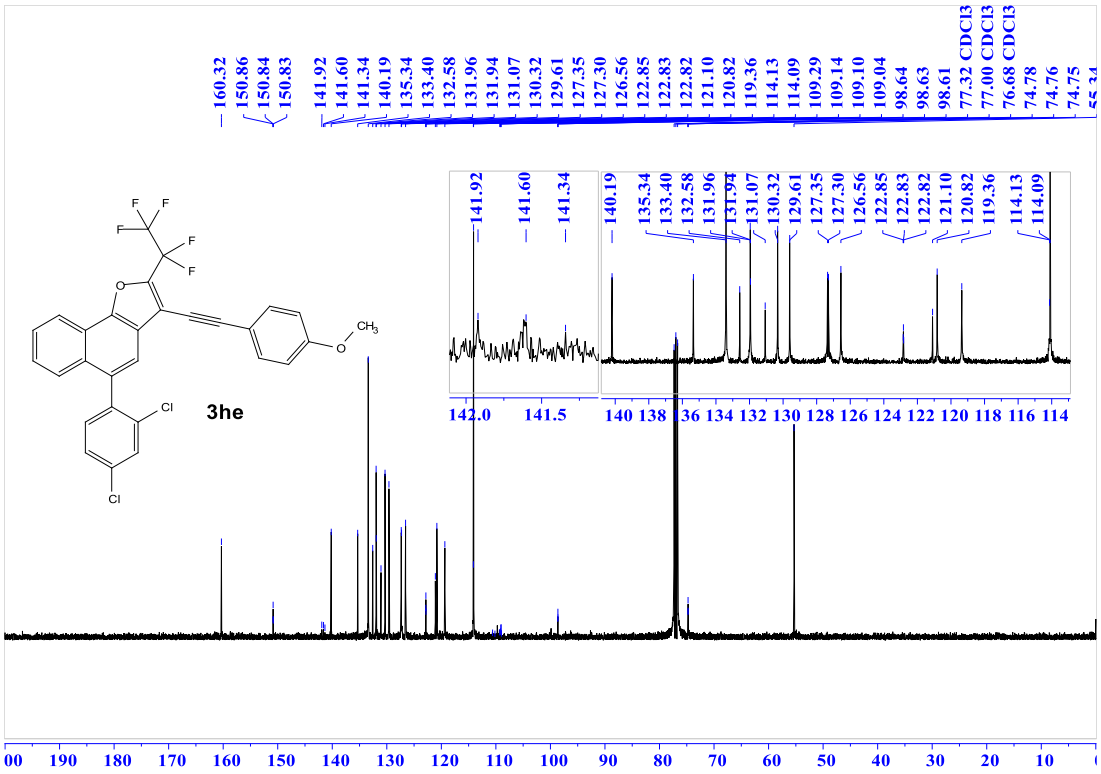

CDCl3
3ge

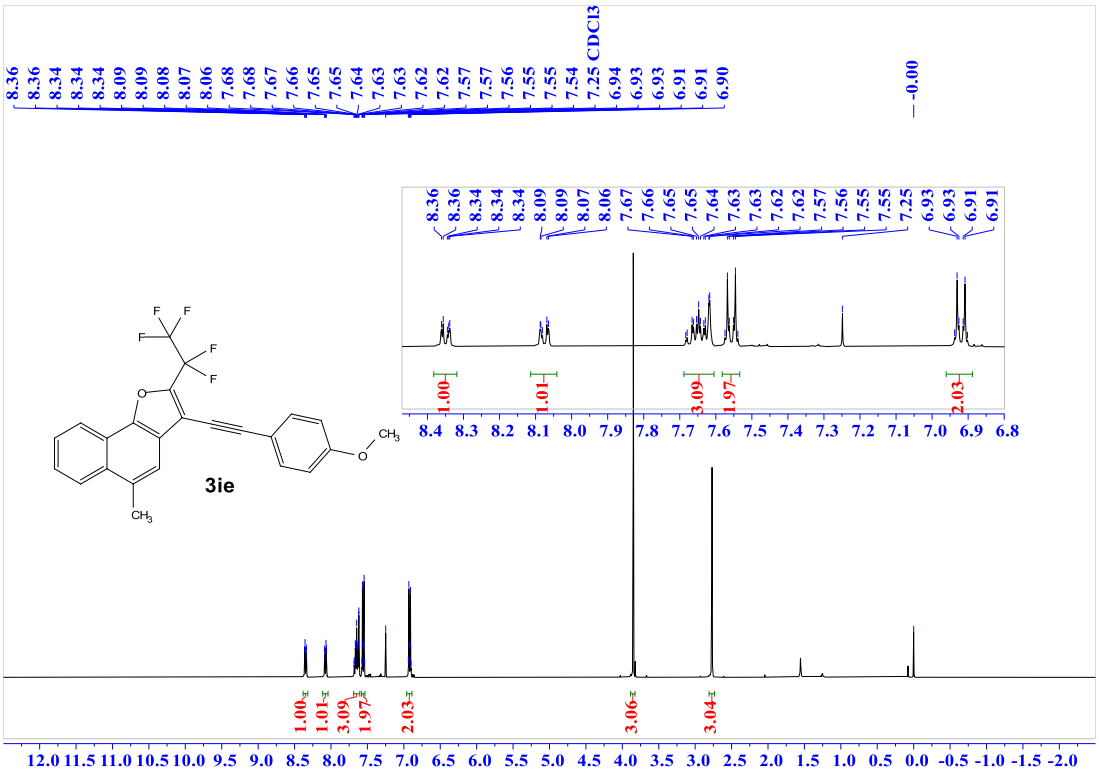

3ge

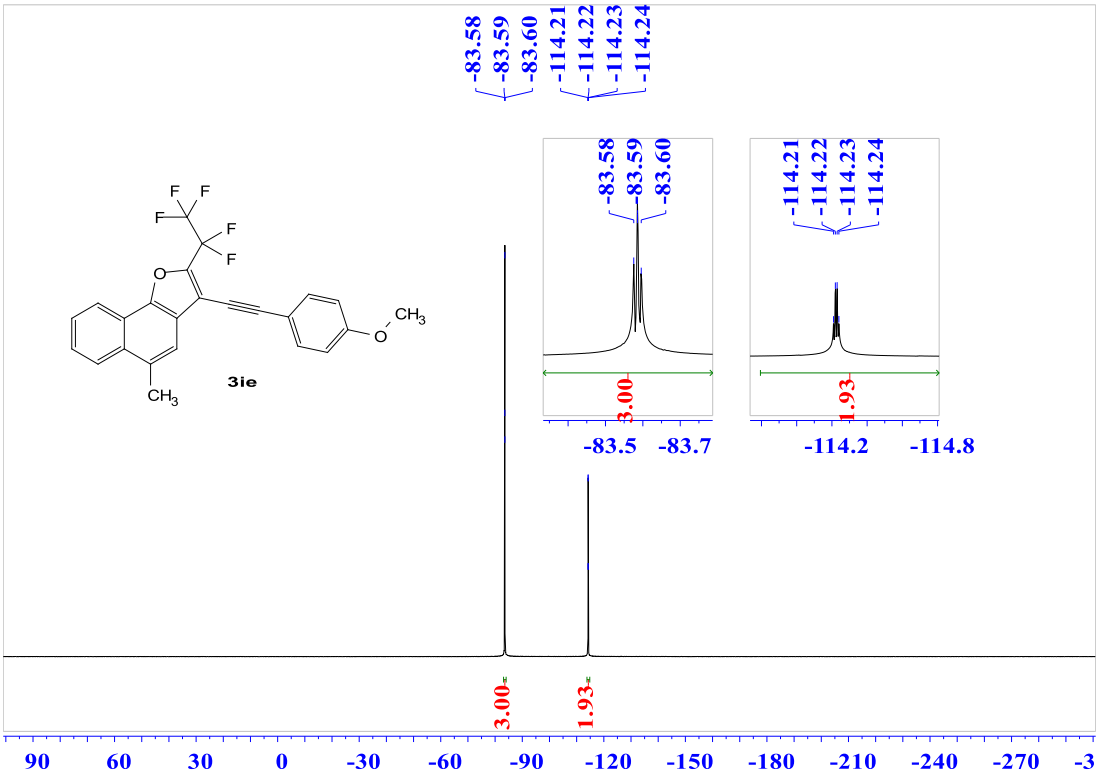

160.27
159.82
150.44
150.44
150.43
142.11
141.78
141.47
133.38
133.22
131.94
129.47
128.50
124.97
124.10
124.09
124.08
123.34
122.48
120.73
119.01
114.95
114.27
114.10
114.05
109.97
109.95
109.86
109.68
98.38
98.36
98.35
91.06
87.99
77.32 CDCl3
77.00 CDCl3
76.68 CDCl3
74.92
74.91
74.90
55.36
55.31
3ge
142.0 141.6
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10

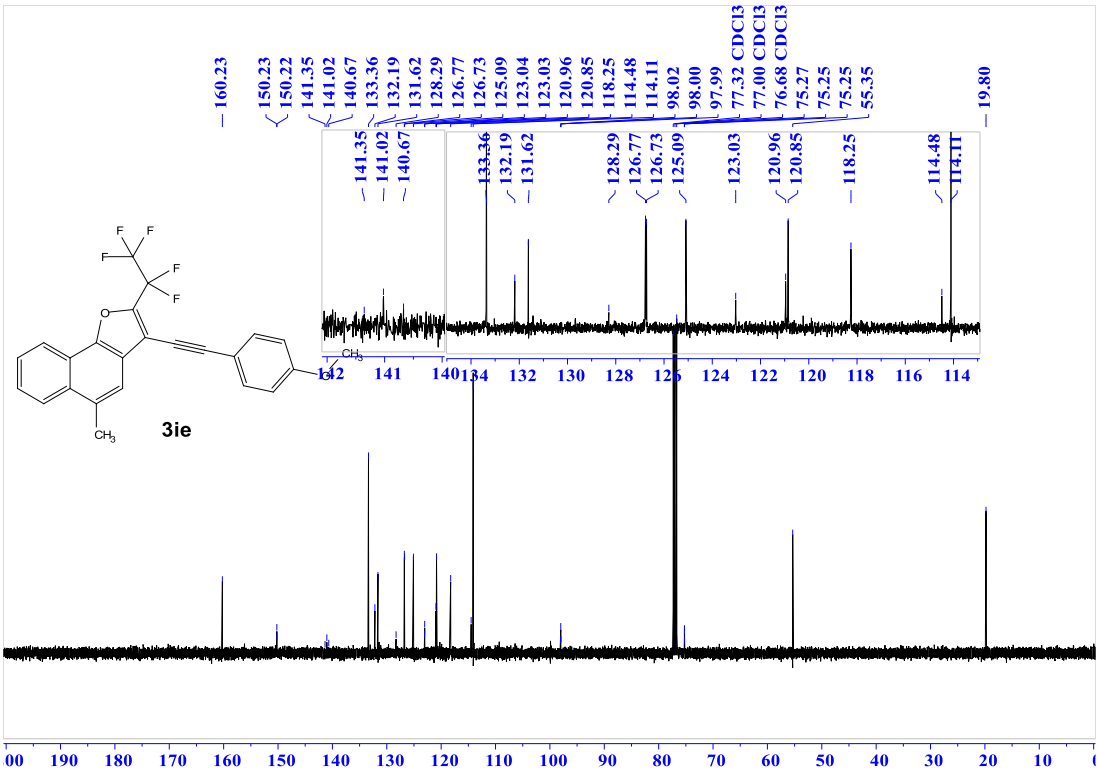

3he

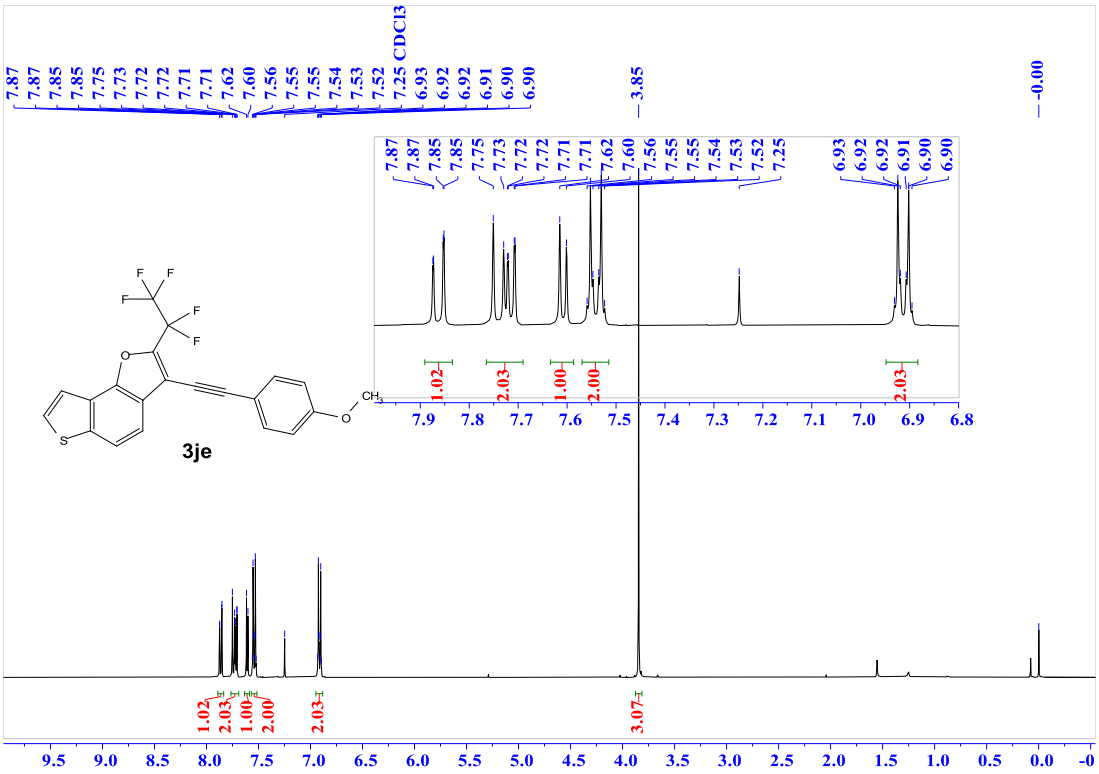

3he

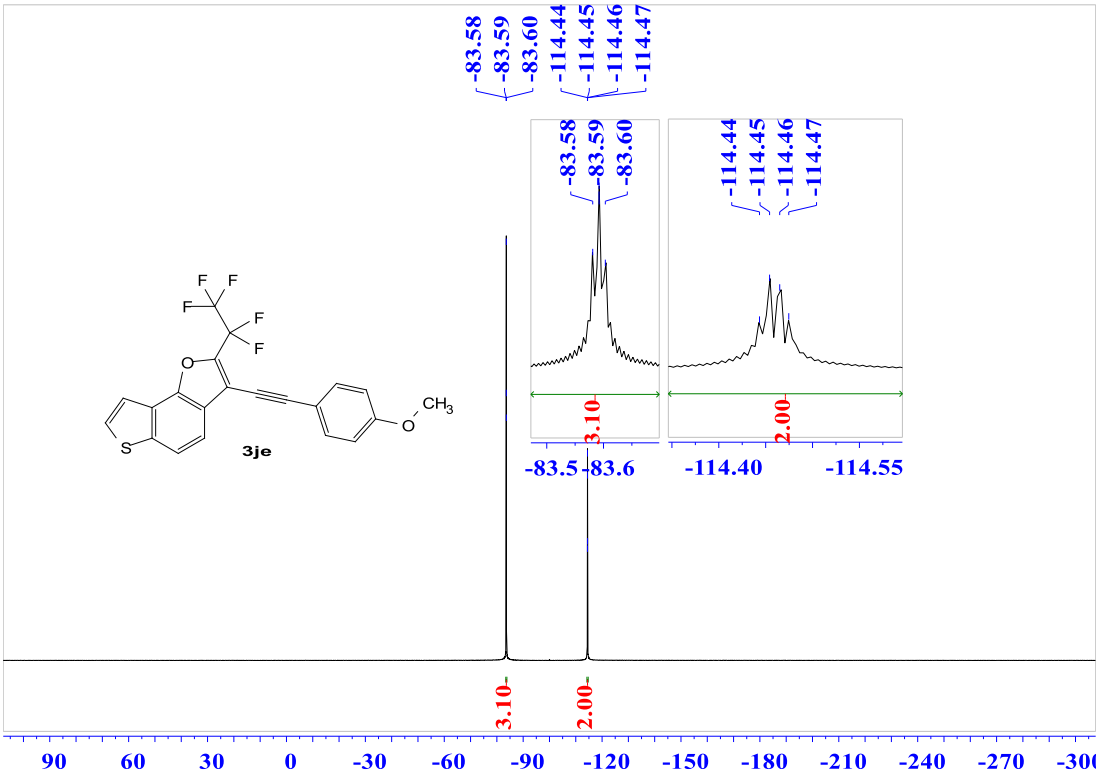

160.32
150.86
150.84
150.83
141.92
141.60
141.34
140.19
135.34
133.40
132.58
131.96
131.94
131.07
130.32
129.61
127.35
127.30
126.56
122.85
122.83
122.82
121.10
120.82
119.36
114.13
114.09
109.29
109.14
109.10
109.04
98.64
98.63
98.61
77.32 CDCl3
77.00 CDCl3
76.68 CDCl3
74.78
74.76
74.75
3he
142.0
141.5
140 138 136 134 132 130 128 126 124 122 120 118 116 114
00 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10

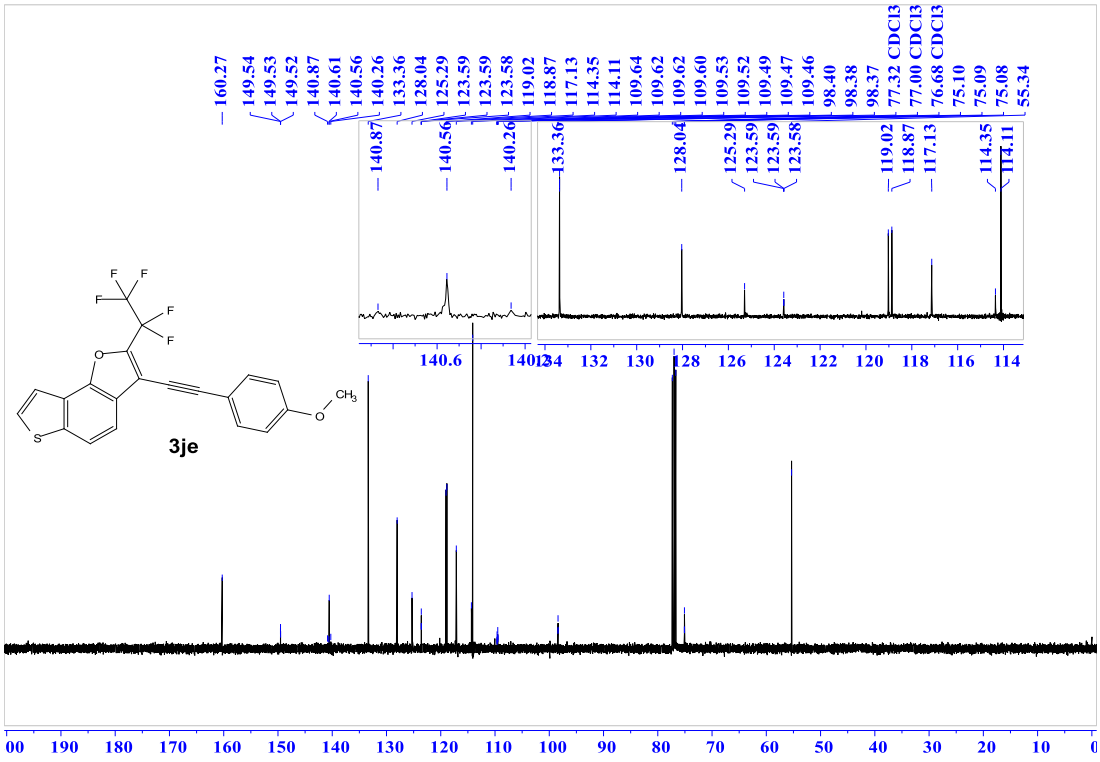

8.36 8.36 8.34 8.34 8.34 8.09 8.09 8.08 8.07 8.06 7.68 7.68 7.67 7.66 7.65 7.65 7.64 7.63 7.63 7.62 7.62 7.57 7.57 7.56 7.55 7.55 7.54 7.25 CDCl3 6.94 6.93 6.93 6.91 6.91 6.90
-0.00
3ie
1.00 1.01 3.09 1.97 2.03 3.06 3.04
12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2.0

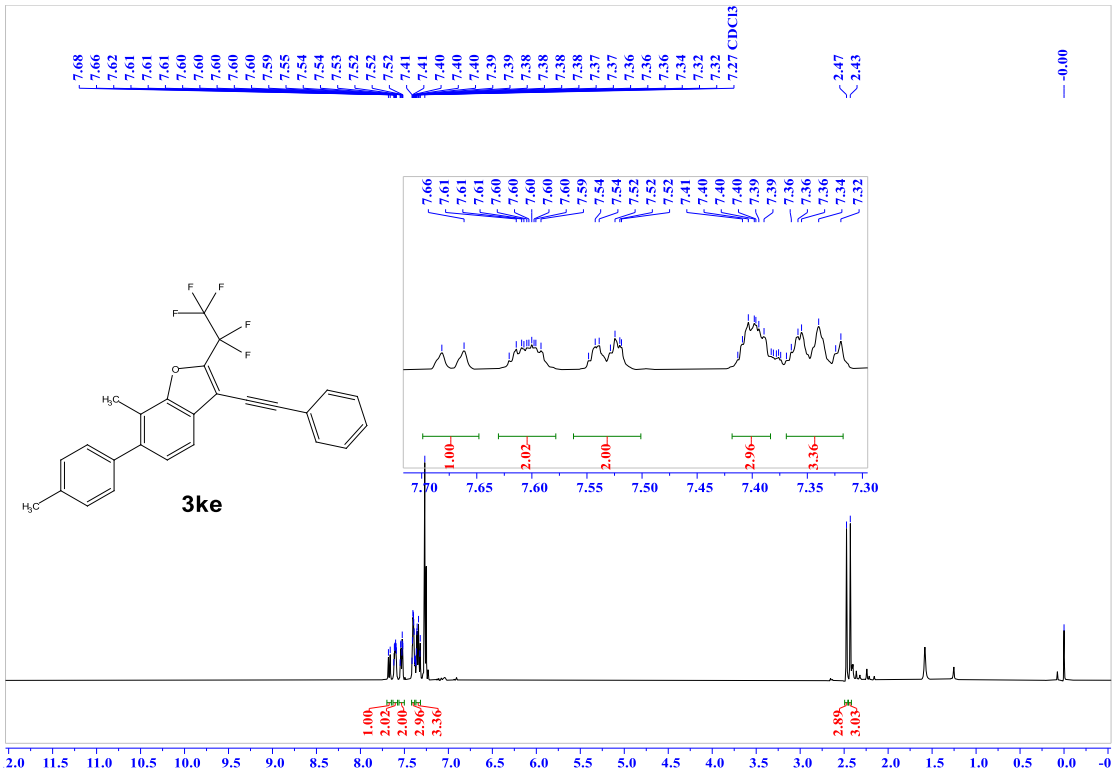

-83.58 -83.59 -83.60 -114.21 -114.22 -114.23 -114.24
3ie
3.00 1.93
-83.5 -83.7 -114.2 -114.8
3.00 1.93
90 60 30 0 -30 -60 -90 -120 -150 -180 -210 -240 -270 -3

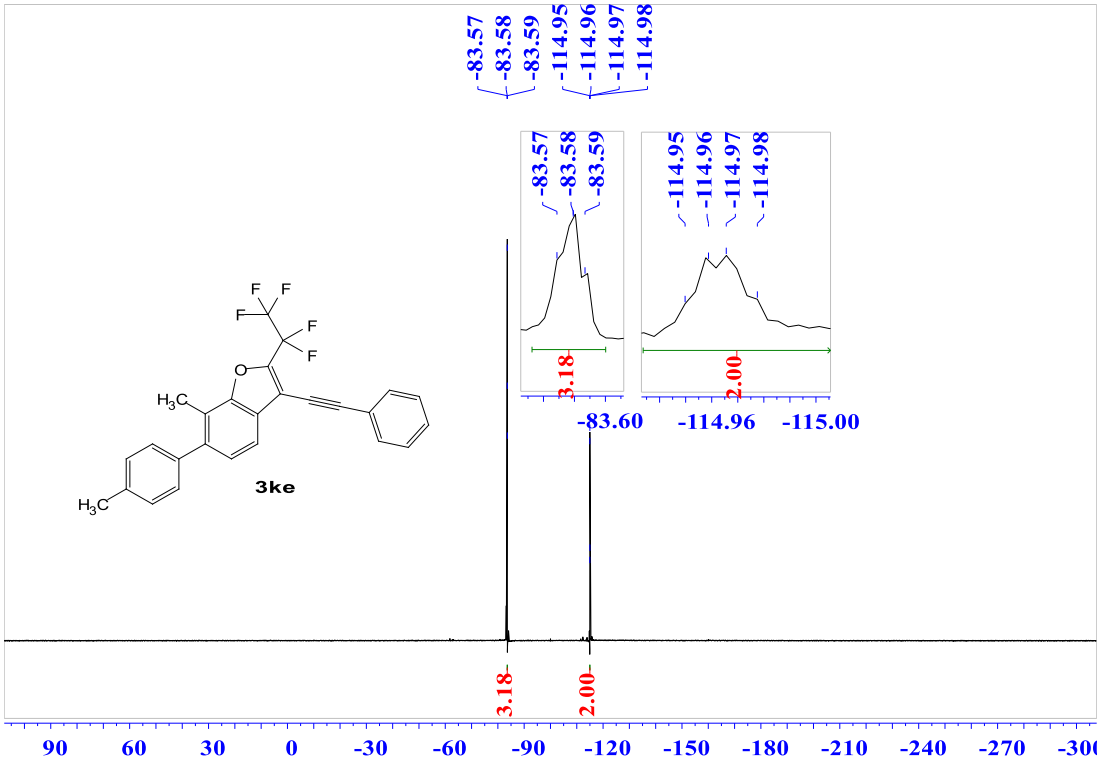

160.23
150.23
150.22
141.35
141.02
140.67
133.36
132.19
131.62
128.29
126.77
126.73
125.09
123.04
123.03
120.96
120.85
118.25
114.48
114.11
98.02
98.00
97.99
77.32 CDCl3
77.00 CDCl3
76.68 CDCl3
75.27
75.25
75.25
55.35
19.80
3ie

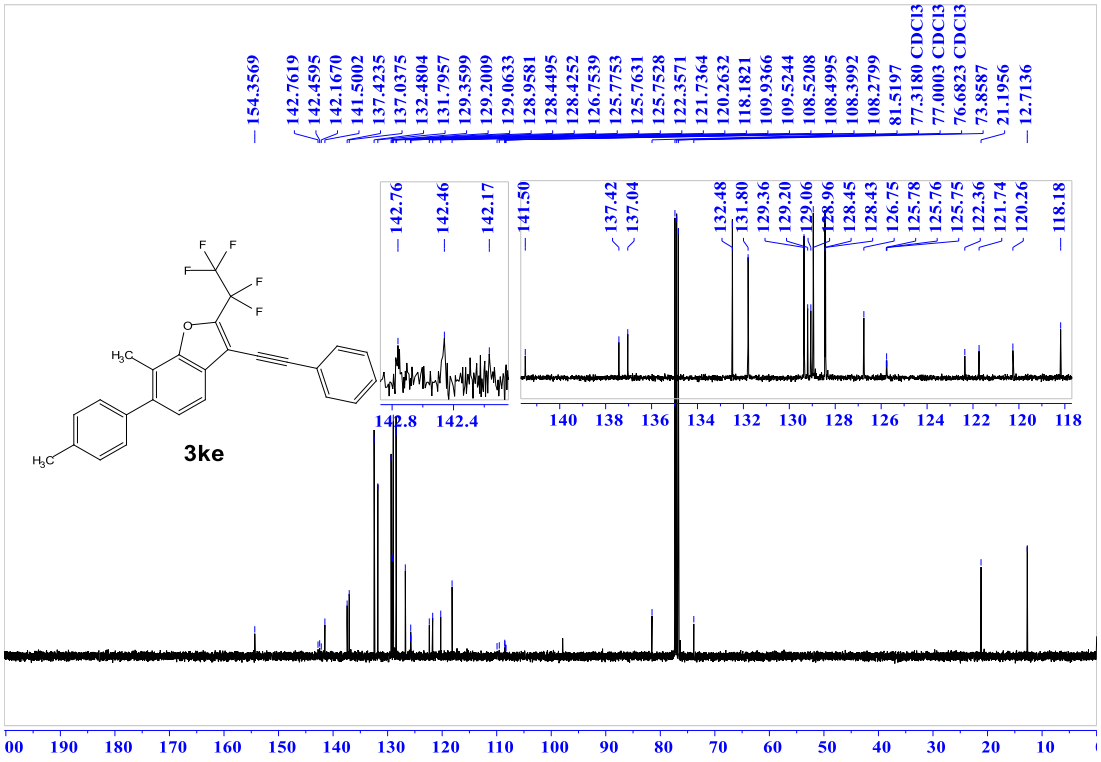

7.87
7.87
7.85
7.85
7.75
7.73
7.72
7.72
7.71
7.71
7.62
7.60
7.56
7.55
7.55
7.54
7.53
7.52
7.25 CDCl3
6.93
6.92
6.92
6.91
6.90
6.90
3.85
-0.00
1.02
2.03
1.00
2.00
2.03
3.07
3je

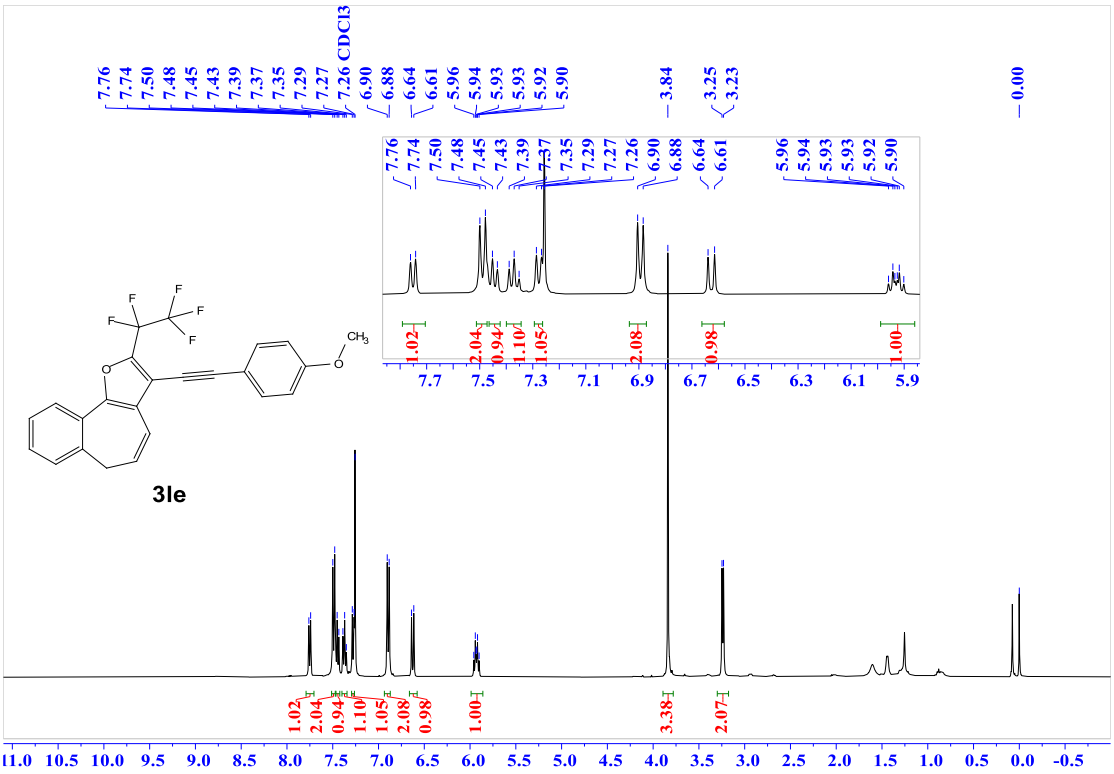

-83.58
-83.59
-83.60
-114.44
-114.45
-114.46
-114.47
3.10
2.00
3je

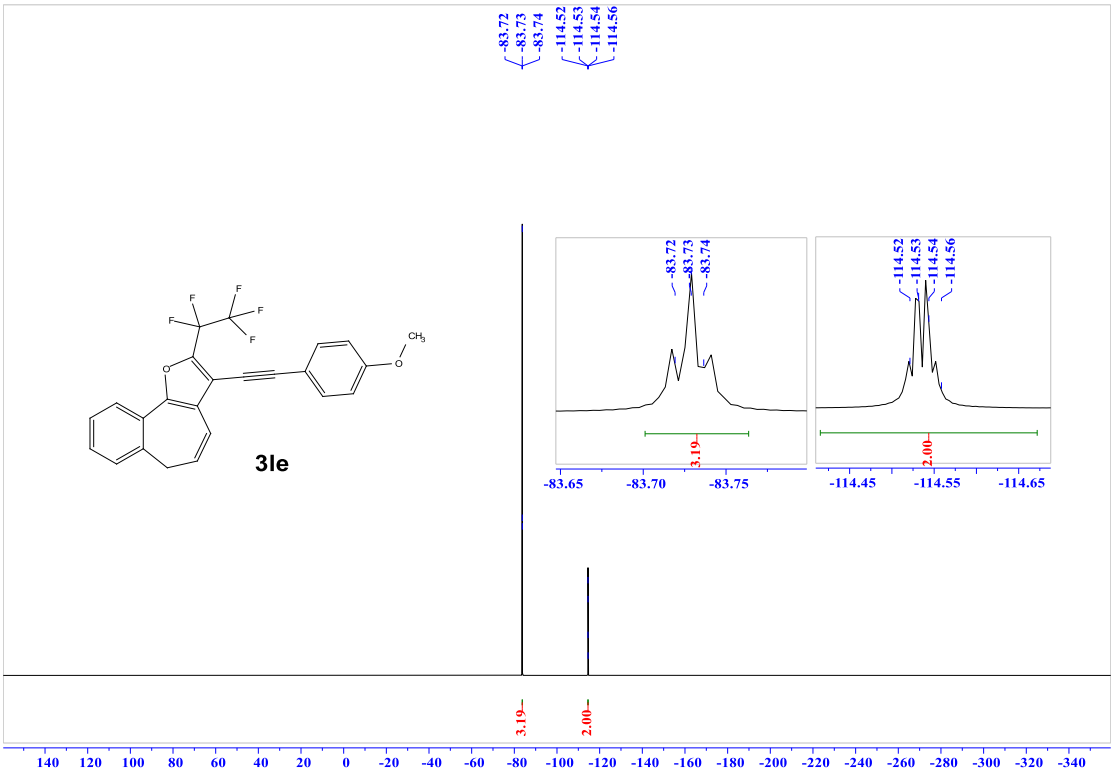

160.27
149.54
149.53
149.52
140.87
140.61
140.56
140.26
133.36
128.04
125.29
123.59
123.59
123.58
119.02
118.87
117.13
114.35
114.11
109.64
109.62
109.62
109.60
109.53
109.52
109.49
109.47
109.46
98.40
98.38
98.37
77.32 CDCl3
77.00 CDCl3
76.68 CDCl3
75.10
75.09
75.08
55.34
140.87
140.56
140.26
133.36
128.04
125.29
123.59
123.59
123.58
119.02
118.87
117.13
114.35
114.11
F
F
F
F
F
O
S
O
CH3
3je

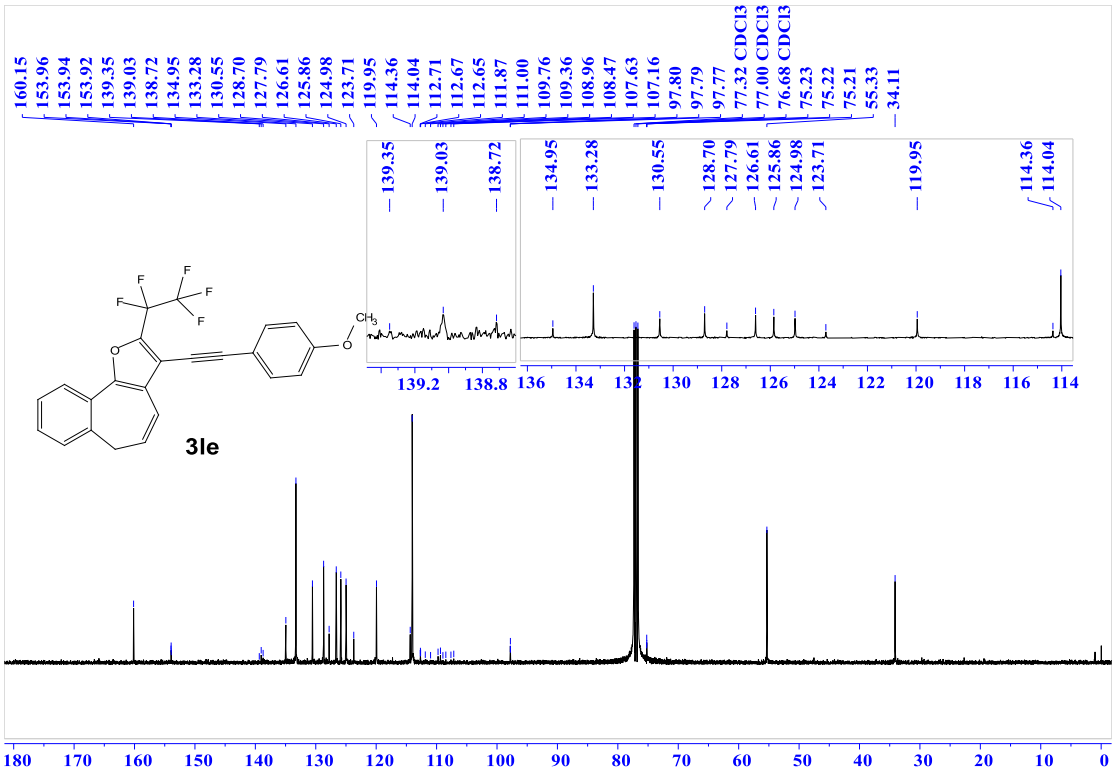

7.68 7.66 7.62 7.61 7.61 7.61 7.60 7.60 7.60 7.60 7.60 7.59 7.55 7.54 7.54 7.53 7.52 7.52 7.52 7.41 7.41 7.40 7.40 7.40 7.39 7.39 7.38 7.38 7.38 7.37 7.37 7.36 7.36 7.34 7.32 7.32 7.27 CDCl3
2.47 2.43
-0.00
3ke
1.00 2.02 2.00 2.96 3.36
2.89 3.03
2.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0

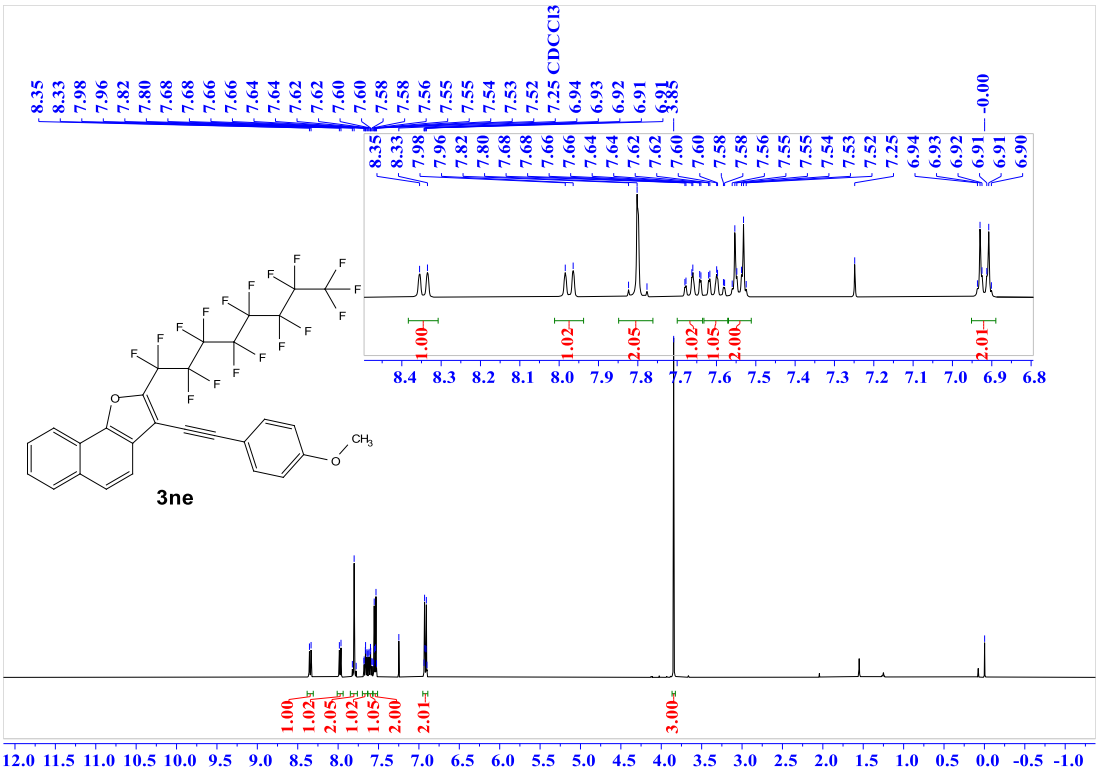

-83.57 -83.58 -83.59 -114.95 -114.96 -114.97 -114.98
3ke
3.18 2.00
-83.60 -114.96 -115.00
90 60 30 0 -30 -60 -90 -120 -150 -180 -210 -240 -270 -300

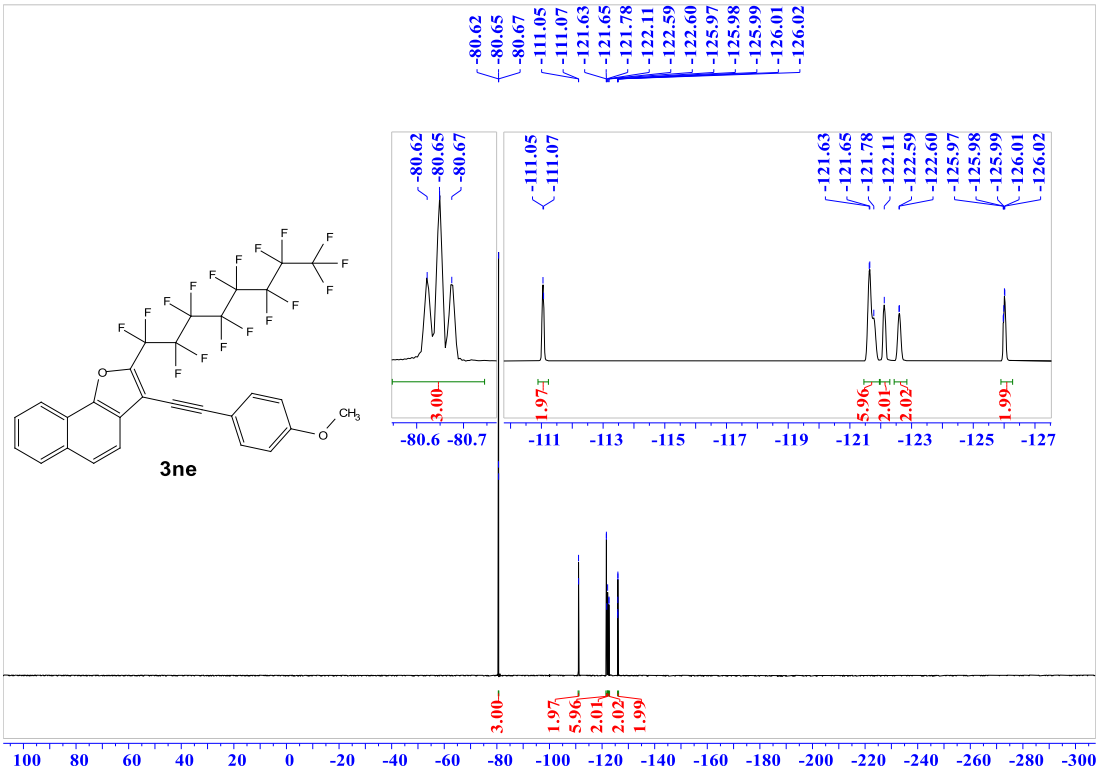

154.3569
142.7619
142.4595
142.1670
141.5002
137.4235
137.0375
132.4804
131.7957
129.3599
129.2009
129.0633
128.9581
128.4495
128.4252
126.7539
125.7753
125.7631
125.7528
122.3571
121.7364
120.2632
118.1821
109.9366
109.5244
108.5208
108.4995
108.3992
108.2799
81.5197
77.3180 CDCl3
77.0003 CDCl3
76.6823 CDCl3
73.8587
21.1956
12.7136
142.76
142.46
142.17
141.50
137.42
137.04
132.48
131.80
129.36
129.20
129.06
128.96
128.45
128.43
126.75
125.78
125.76
125.75
122.36
121.74
120.26
118.18
3ke

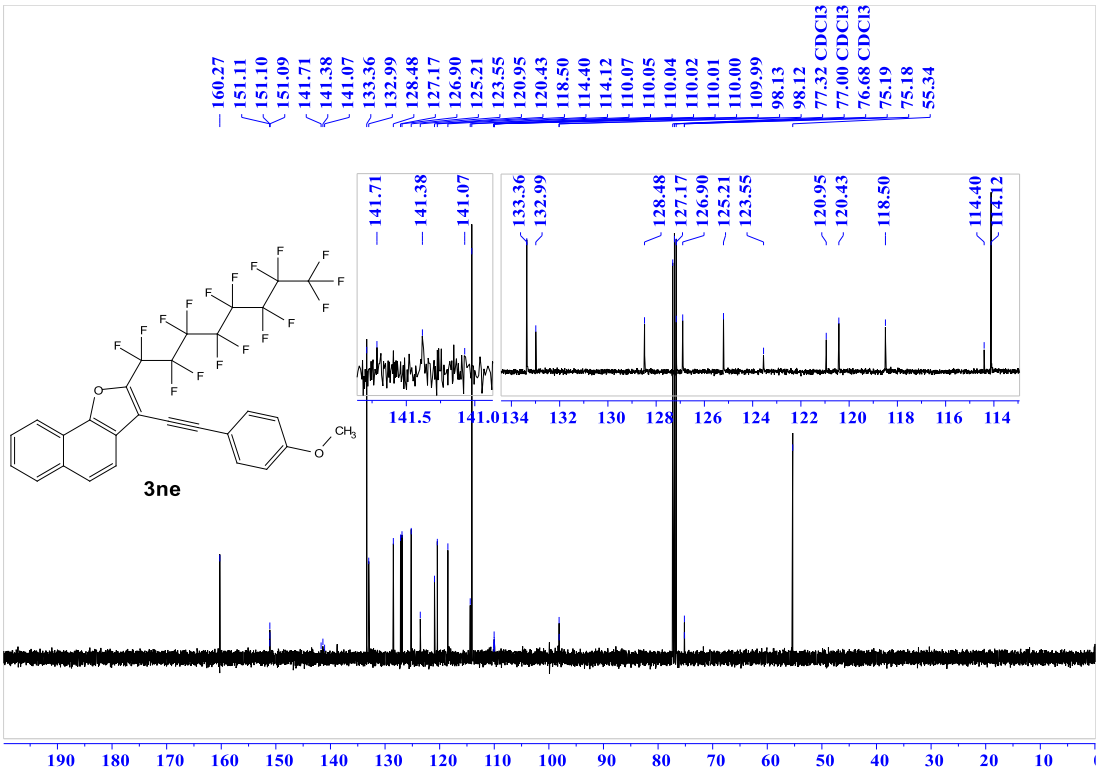

7.76 7.74 7.50 7.48 7.45 7.43 7.39 7.37 7.35 7.29 7.27 7.26 CDCl3 6.90 6.88 6.64 6.61 5.96 5.94 5.93 5.93 5.92 5.90 3.84 3.25 3.23 0.00
1.02 2.04 0.94 1.10 1.05 2.08 0.98 1.00 3.38 2.07
3Ie

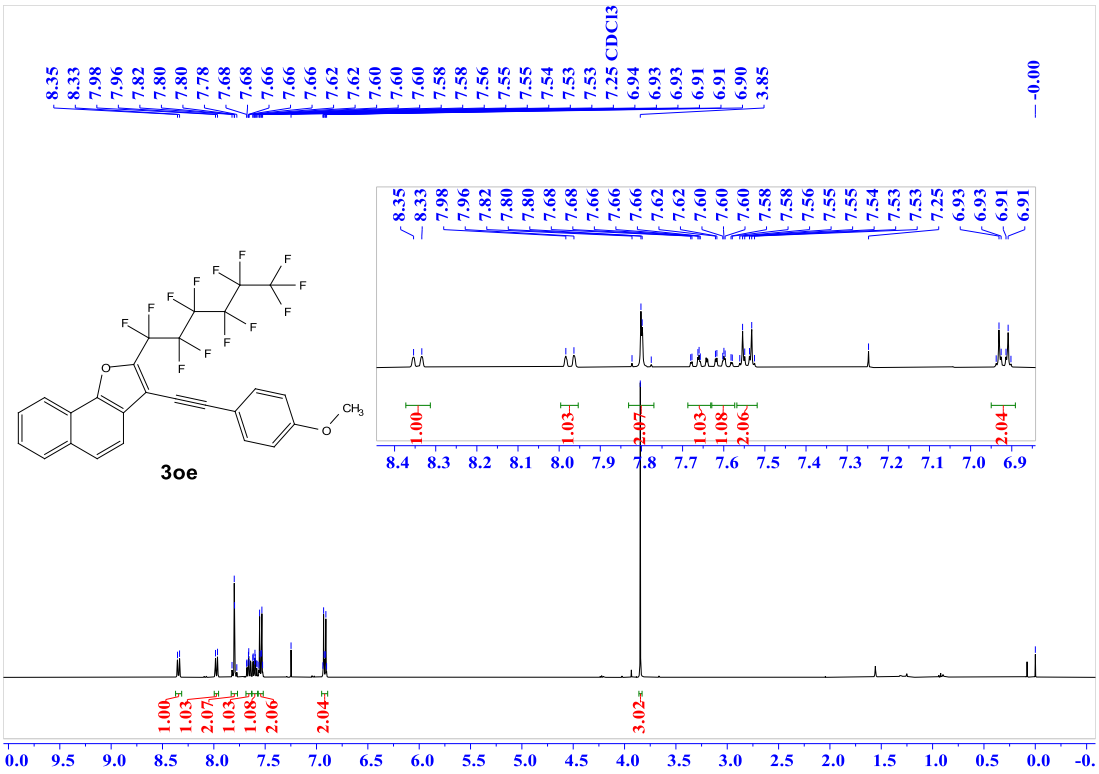

-83.72 -83.73 -83.74 -114.52 -114.53 -114.54 -114.56
3.19 2.00
3Ie

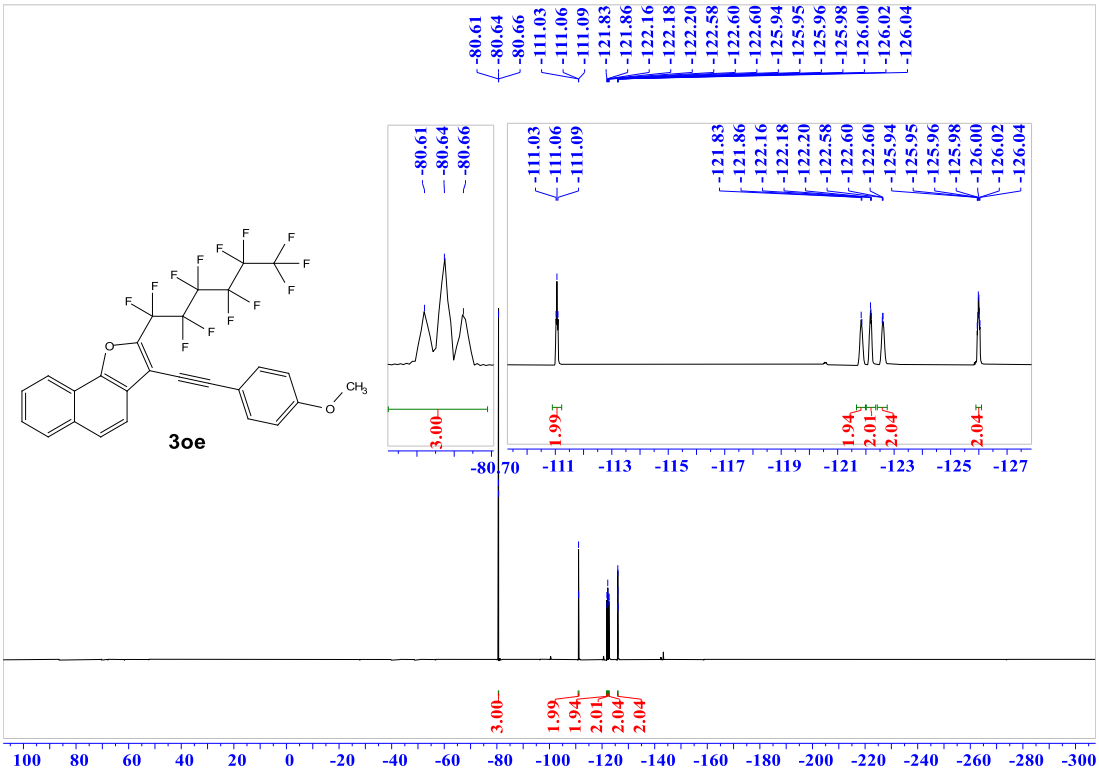

160.15
153.96
153.94
153.92
139.35
139.03
138.72
134.95
133.28
130.55
128.70
127.79
126.61
125.86
124.98
123.71
119.95
114.36
114.04
112.71
112.67
112.65
111.87
111.00
109.76
109.36
108.96
108.47
107.63
107.16
97.80
97.79
97.77
77.32 CDCl3
77.00 CDCl3
76.68 CDCl3
75.23
75.22
75.21
55.33
34.11
3Ie
180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0

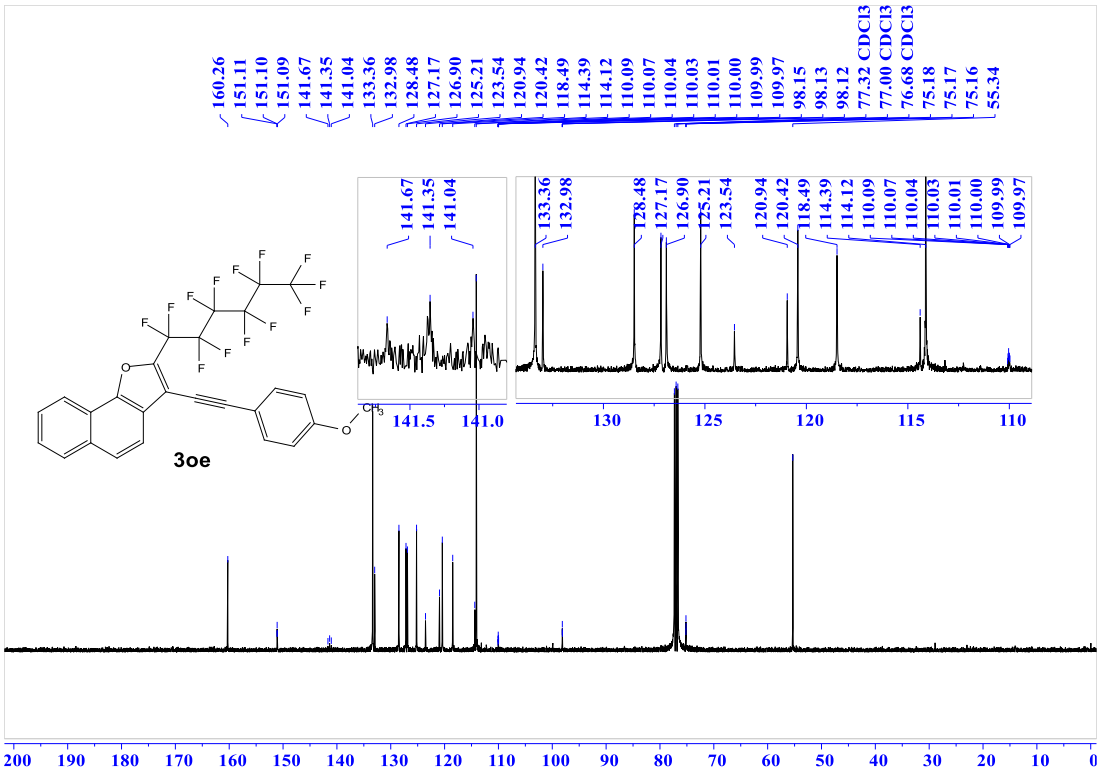

CDCCl3
3ne

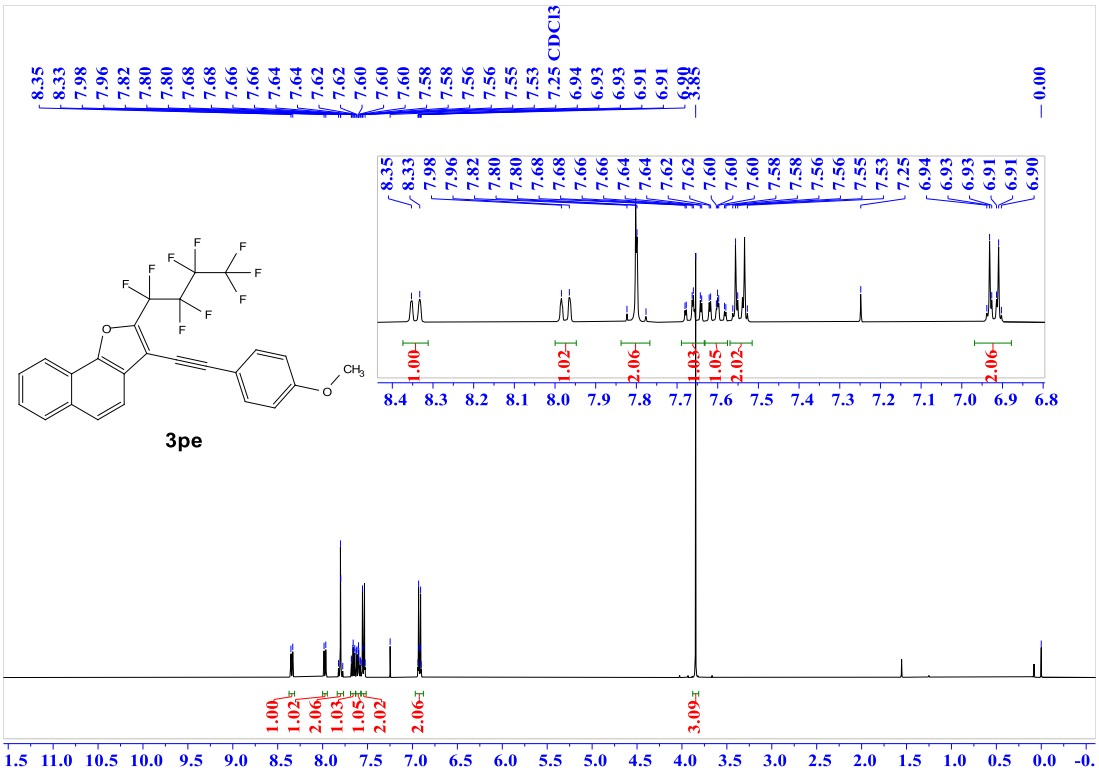

3ne

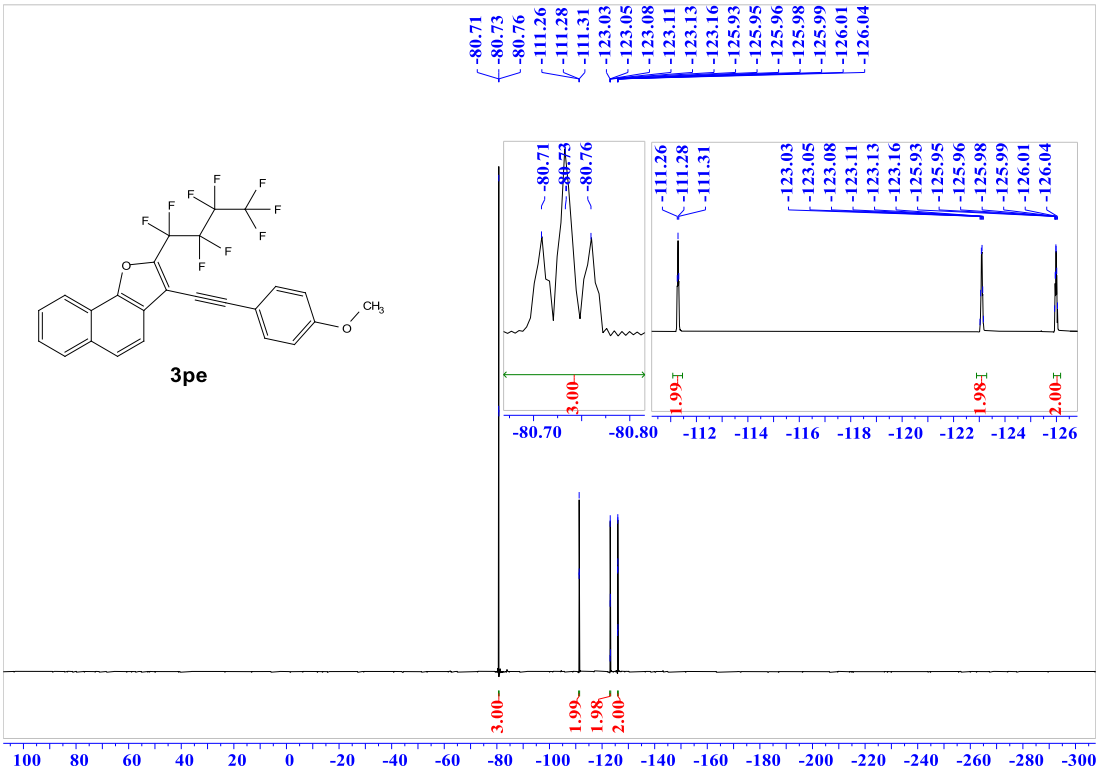

160.27
151.11
151.10
151.09
141.71
141.38
141.07
133.36
132.99
128.48
127.17
126.90
125.21
123.55
120.95
120.43
118.50
114.40
114.12
110.07
110.05
110.04
110.02
110.01
110.00
109.99
98.13
98.12
77.32 CDCl3
77.00 CDCl3
76.68 CDCl3
75.19
75.18
55.34
3ne
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10

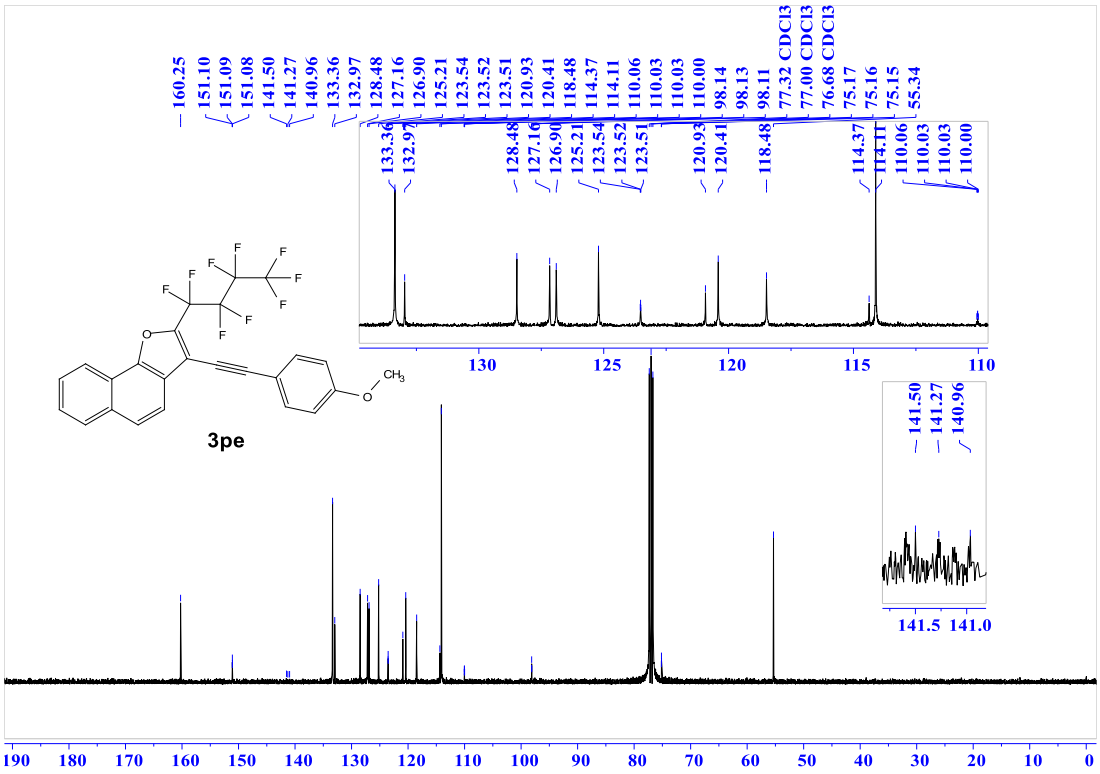

CDCl3
3oe

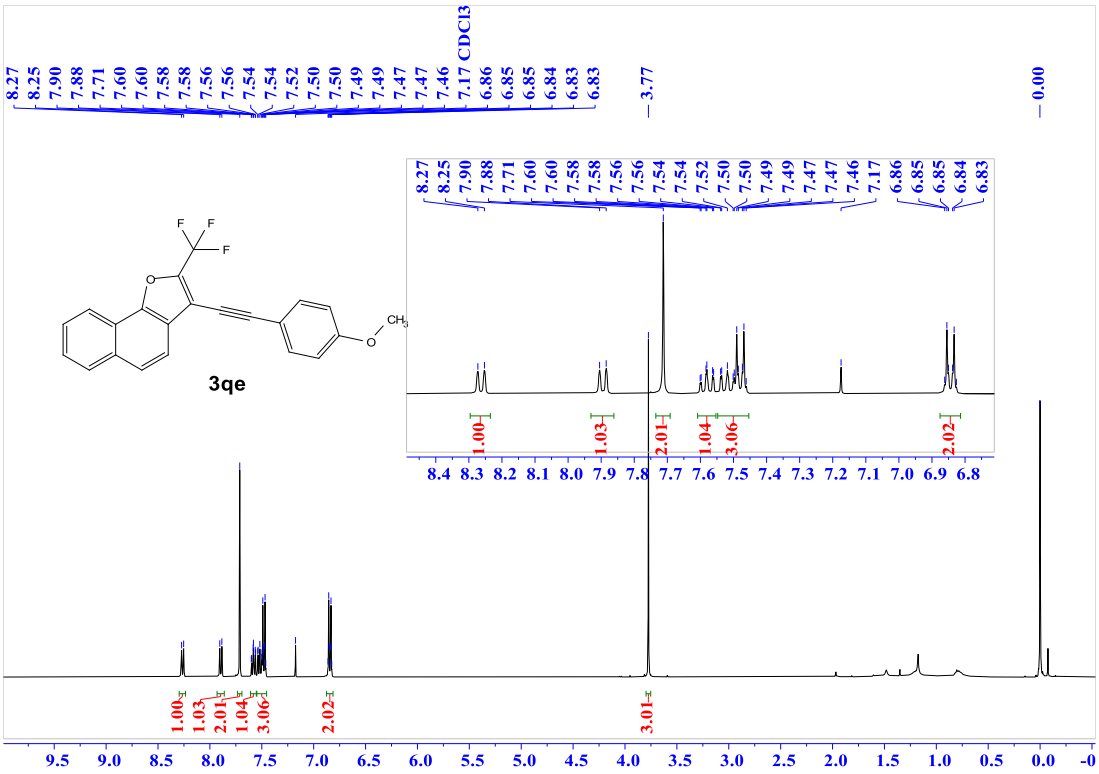

3oe

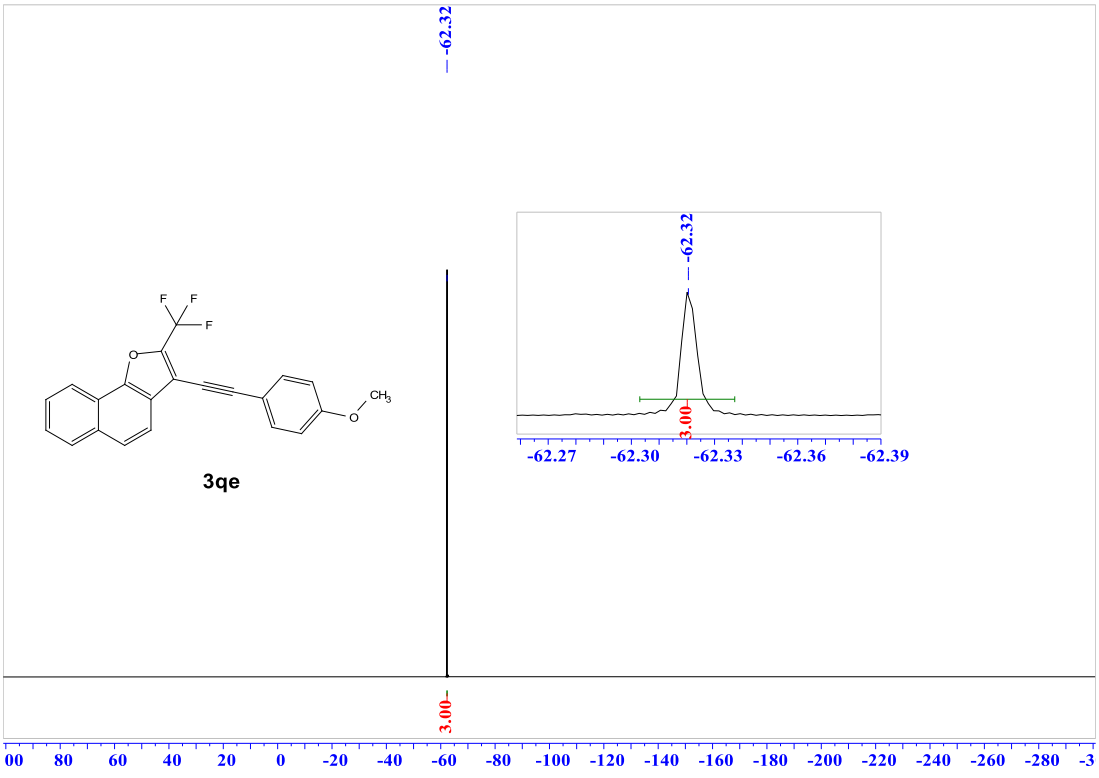

160.26
151.11
151.10
151.09
141.67
141.35
141.04
133.36
132.98
128.48
127.17
126.90
125.21
123.54
120.94
120.42
118.49
114.39
114.12
110.09
110.07
110.04
110.03
110.01
110.00
109.99
109.97
98.15
98.13
98.12
77.32 CDCl3
77.00 CDCl3
76.68 CDCl3
75.18
75.17
75.16
55.34
3oe
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0

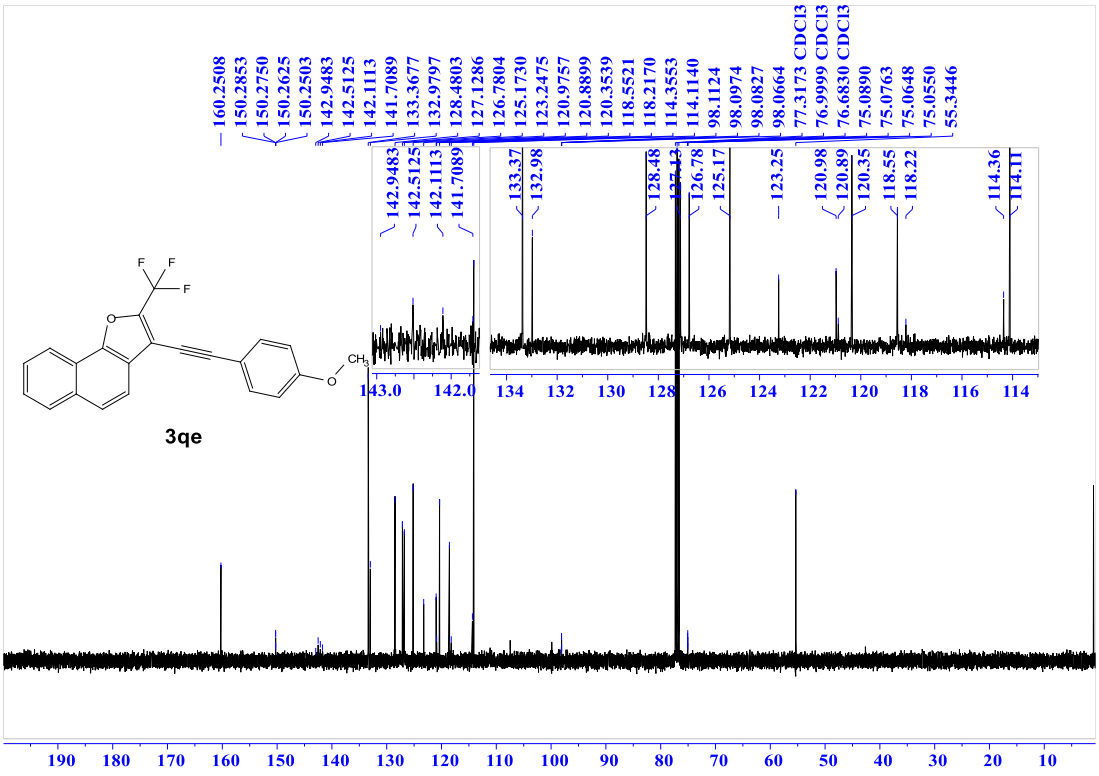

3pe

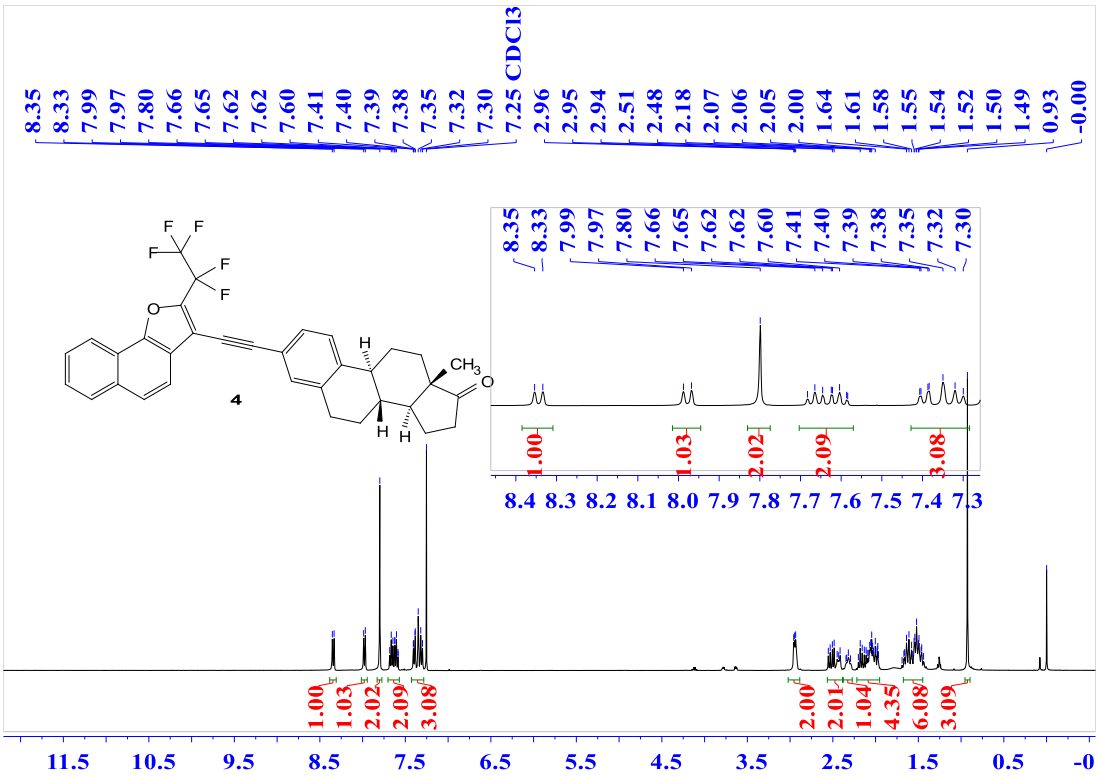

3pe

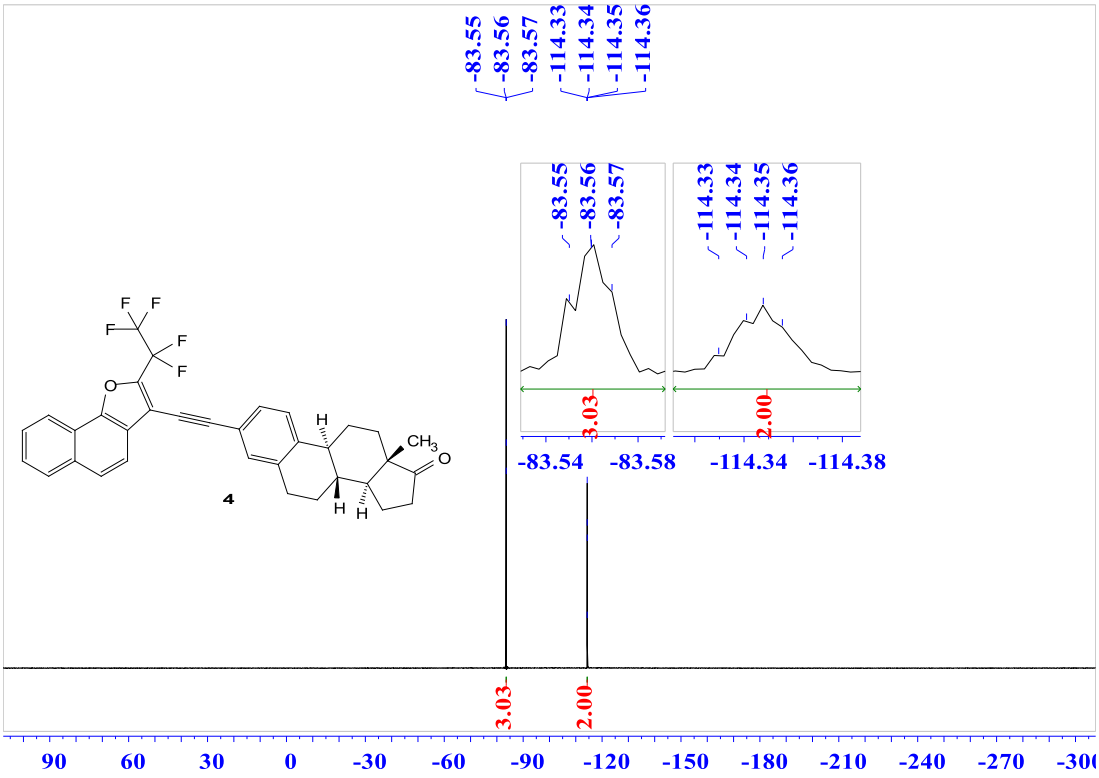

160.25
151.10
151.09
151.08
141.50
141.27
140.96
133.36
132.97
128.48
127.16
126.90
125.21
123.54
123.52
123.51
120.93
120.41
118.48
114.37
114.11
110.06
110.03
110.03
110.00
98.14
98.13
98.11
77.32 CDCl3
77.00 CDCl3
76.68 CDCl3
75.17
75.16
75.15
55.34
3pe
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
130 125 120 115 110
141.5 141.0

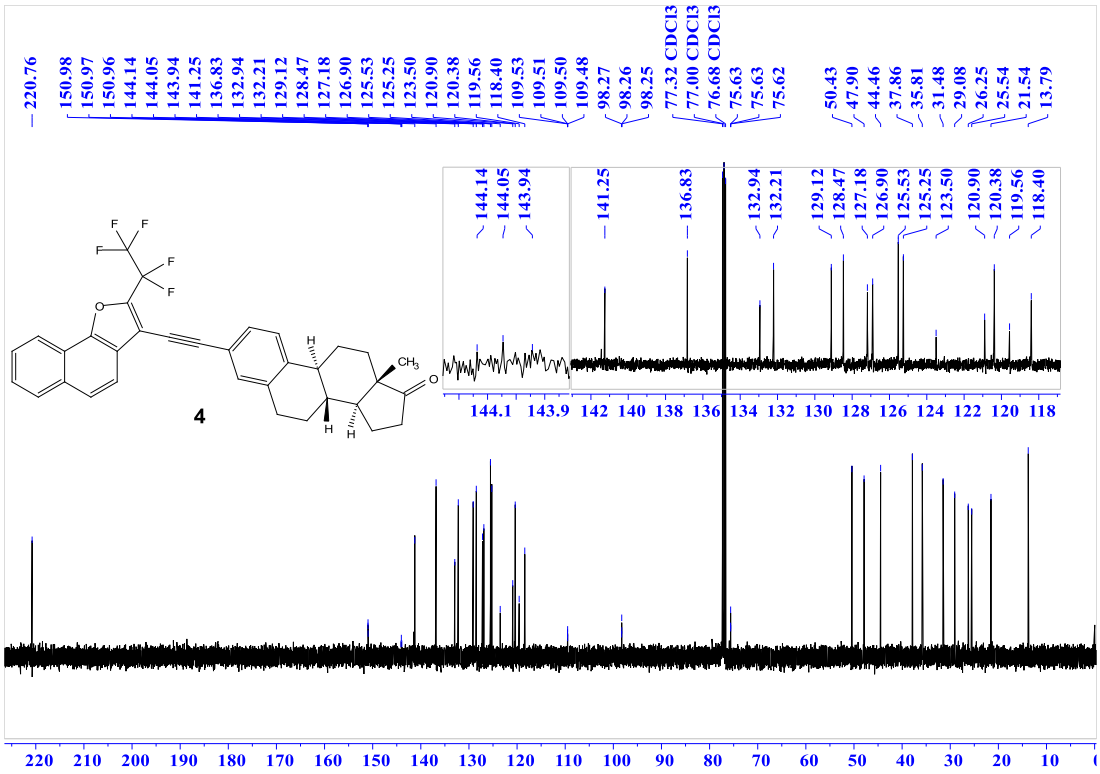

8.27 8.25 7.90 7.88 7.71 7.60 7.60 7.58 7.58 7.56 7.56 7.54 7.54 7.52 7.50 7.50 7.49 7.49 7.47 7.47 7.46 7.17 CDCl3 6.86 6.85 6.85 6.84 6.83 6.83
3.77
0.00
3qe
1.00 1.03 2.01 1.04 3.06 2.02 3.01
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0

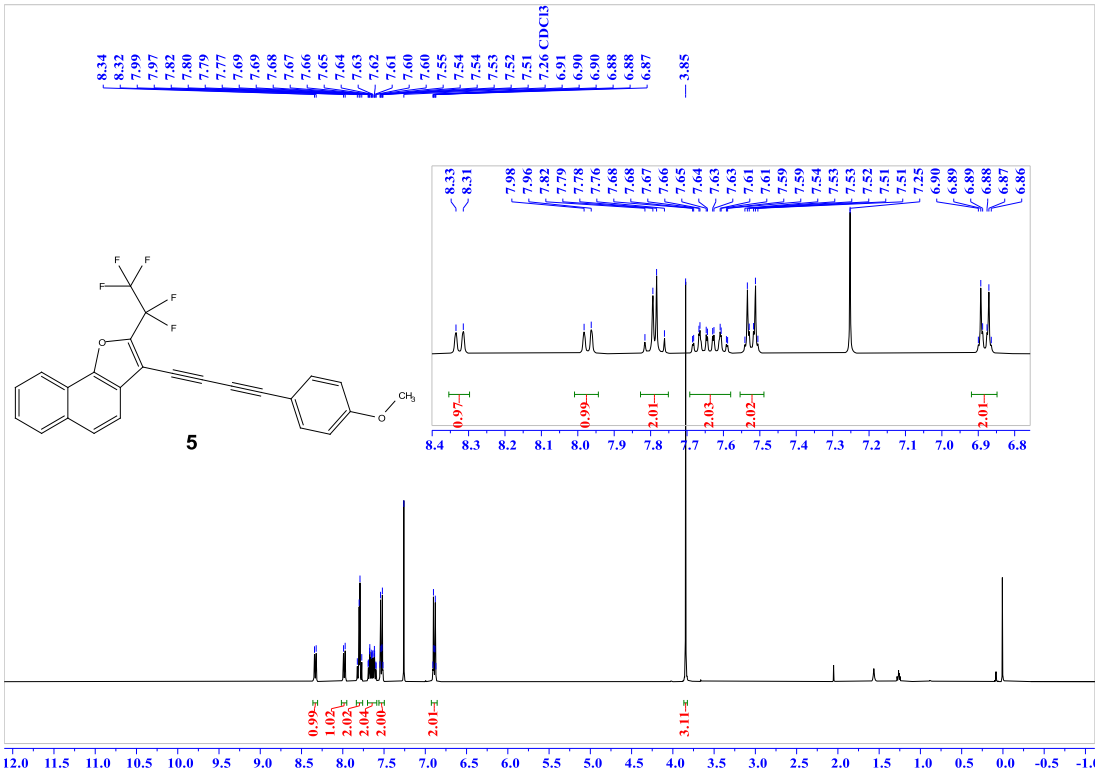

-62.32
3qe
-62.32
3.00
-62.27 -62.30 -62.33 -62.36 -62.39
3.00
00 80 60 40 20 0 -20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220 -240 -260 -280 -3

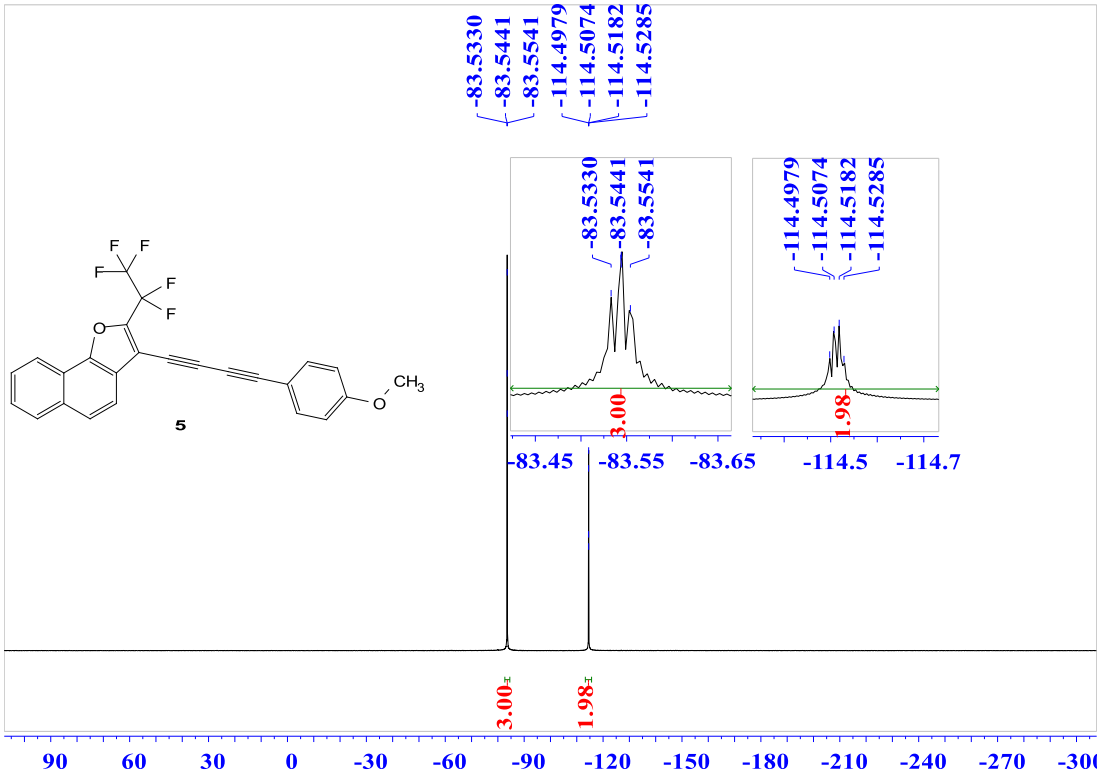

160.2508
150.2853
150.2750
150.2625
150.2503
142.9483
142.5125
142.1113
141.7089
133.3677
132.9797
128.4803
127.1286
126.7804
125.1730
123.2475
120.9757
120.8899
120.3539
118.5521
118.2170
114.3553
114.1140
98.1124
98.0974
98.0827
98.0664
77.3173 CDCl3
76.9999 CDCl3
76.6830 CDCl3
75.0890
75.0763
75.0648
75.0550
55.3446
142.9483
142.5125
142.1113
141.7089
133.37
132.98
128.48
127.13
126.78
125.17
123.25
120.98
120.89
120.35
118.55
118.22
114.36
114.11
F
F
F
O
O
CH3
3qe
143.0
142.0
134
132
130
128
126
124
122
120
118
116
114
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10

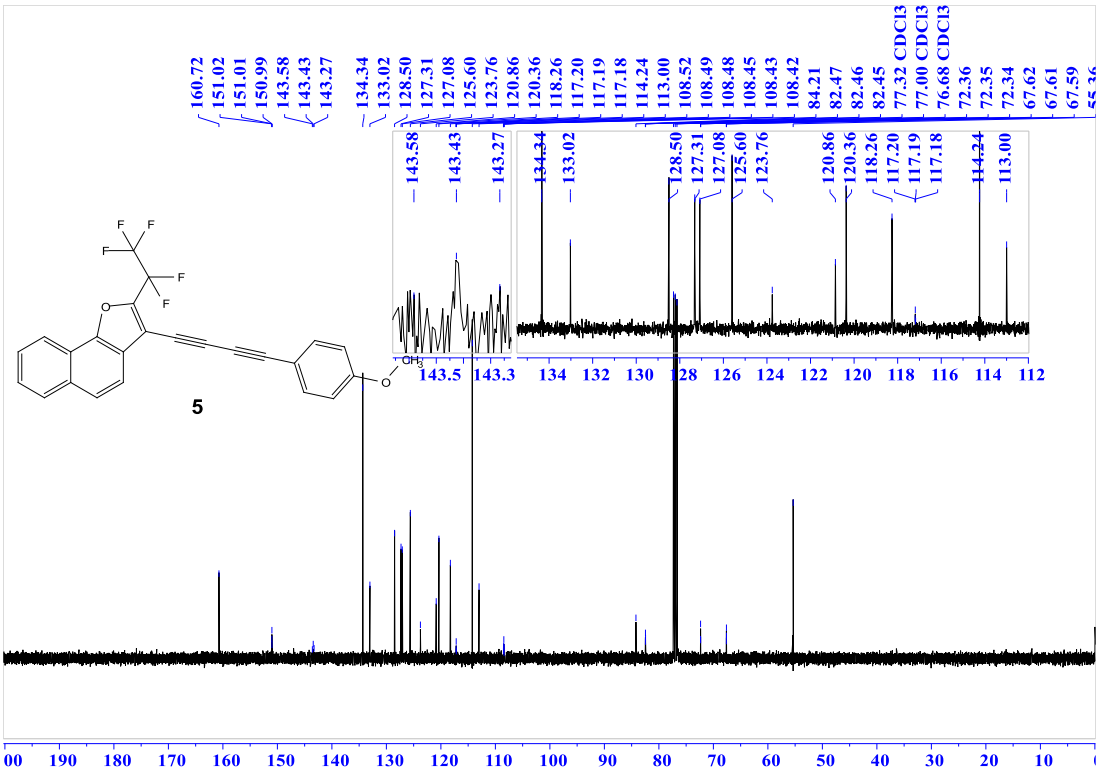

8.35 8.33 7.99 7.97 7.80 7.66 7.65 7.62 7.62 7.60 7.41 7.40 7.39 7.38 7.35 7.32 7.30 7.25 CDCl3 2.96 2.95 2.94 2.51 2.48 2.18 2.07 2.06 2.05 2.00 1.64 1.61 1.58 1.55 1.54 1.52 1.50 1.49 0.93 -0.00
F F F F F O H CH3 O H H 4
1.00 1.03 2.02 2.09 3.08 2.00 2.01 1.04 4.35 6.08 3.09
11.5 10.5 9.5 8.5 7.5 6.5 5.5 4.5 3.5 2.5 1.5 0.5 -0

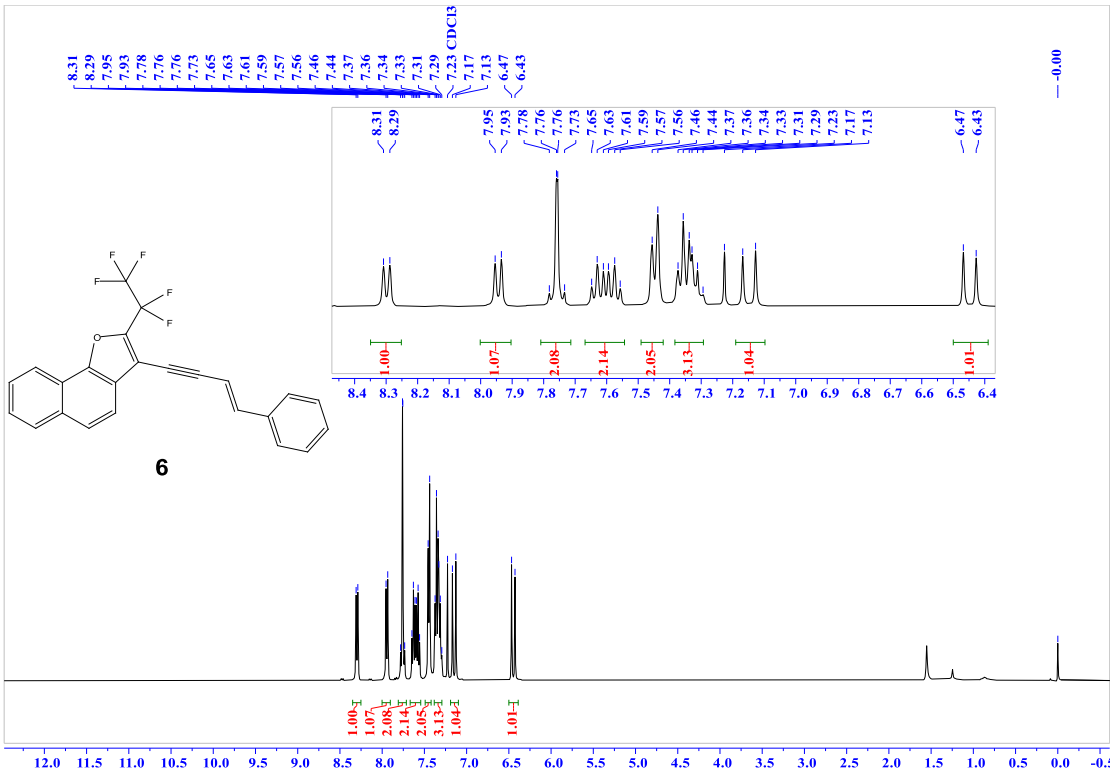

-83.55 -83.56 -83.57 -114.33 -114.34 -114.35 -114.36
F F F F F O H CH3 O H H 4
3.03 2.00
-83.54 -83.58 -114.34 -114.38
3.03 2.00
90 60 30 0 -30 -60 -90 -120 -150 -180 -210 -240 -270 -30

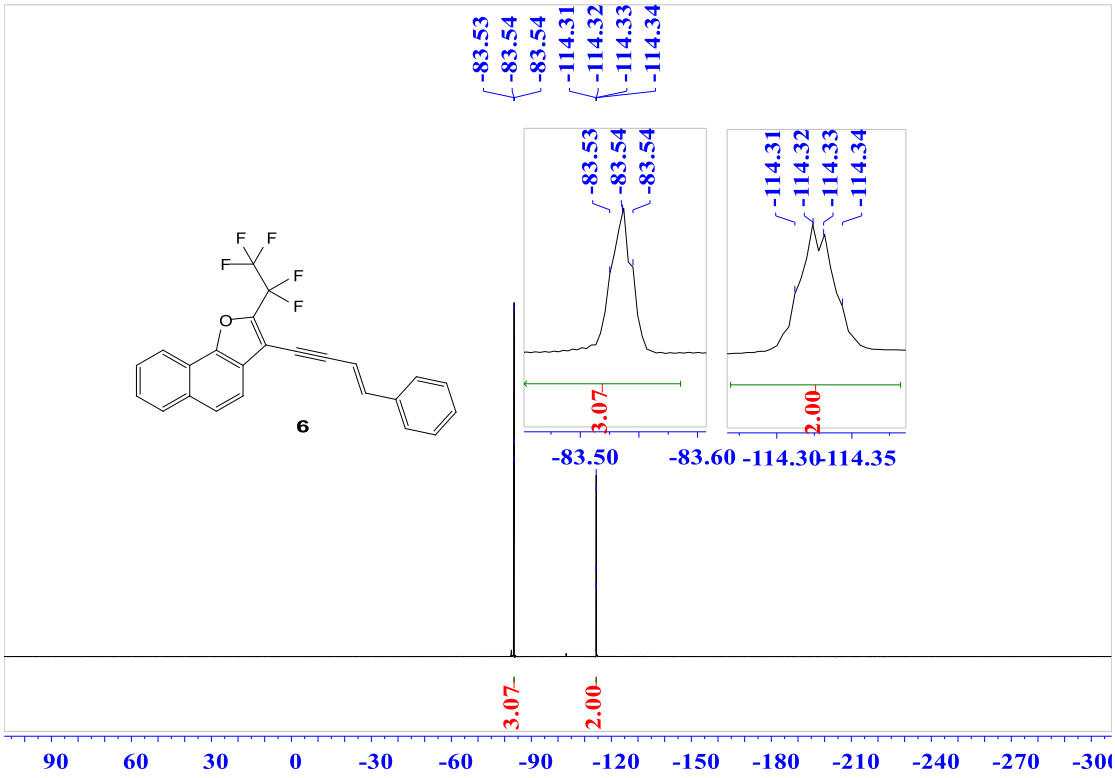

220.76
150.98
150.97
150.96
144.14
144.05
143.94
141.25
136.83
132.94
132.21
129.12
128.47
127.18
126.90
125.53
125.25
123.50
120.90
120.38
119.56
118.40
109.53
109.51
109.50
109.48
98.27
98.26
98.25
77.32 CDCl3
77.00 CDCl3
76.68 CDCl3
75.63
75.63
75.62
50.43
47.90
44.46
37.86
35.81
31.48
29.08
26.25
25.54
21.54
13.79
4
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10

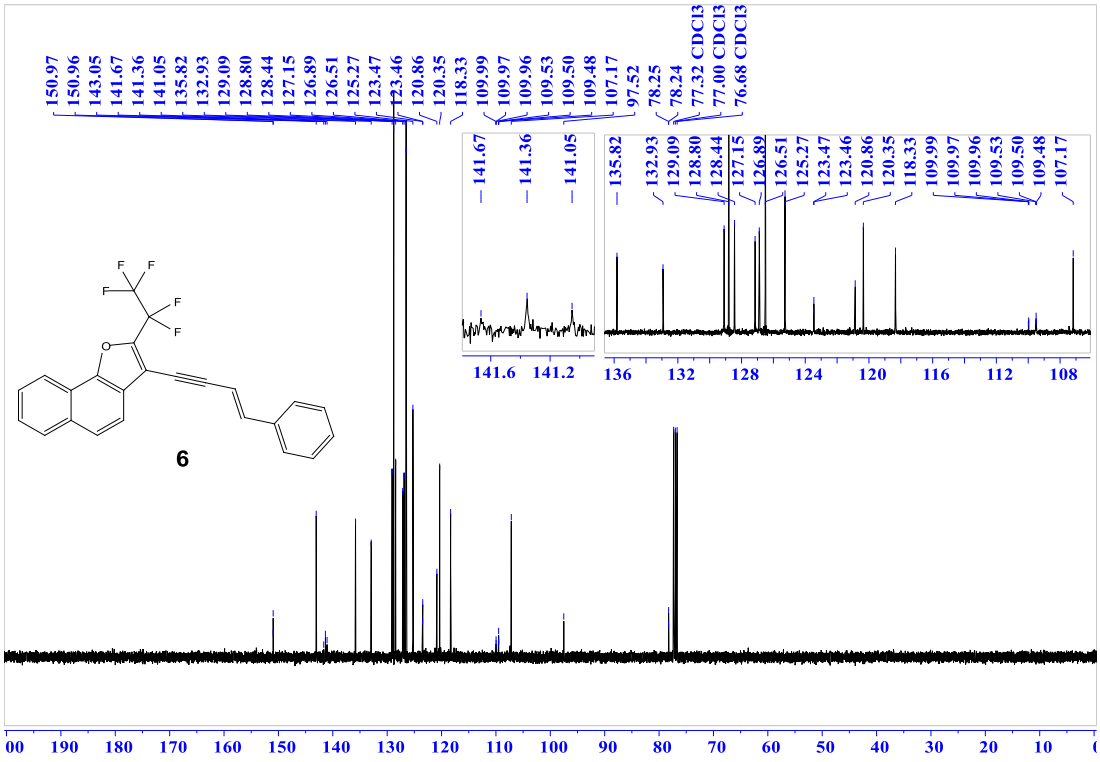

8.34 8.32 7.99 7.97 7.82 7.80 7.79 7.77 7.69 7.69 7.68 7.67 7.66 7.65 7.64 7.63 7.62 7.61 7.60 7.60 7.55 7.54 7.54 7.53 7.52 7.51 7.26 CDCl3 6.91 6.90 6.90 6.88 6.88 6.87 3.85
8.33 8.31 7.98 7.96 7.82 7.79 7.78 7.76 7.68 7.68 7.67 7.66 7.65 7.64 7.63 7.63 7.61 7.61 7.59 7.59 7.54 7.53 7.53 7.52 7.51 7.51 7.25 6.90 6.89 6.89 6.88 6.87 6.86
0.97 0.99 2.01 2.03 2.02 2.01
8.4 8.3 8.2 8.1 8.0 7.9 7.8 7.7 7.6 7.5 7.4 7.3 7.2 7.1 7.0 6.9 6.8
5
0.99 1.02 2.02 2.04 2.00 2.01 3.11
12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5

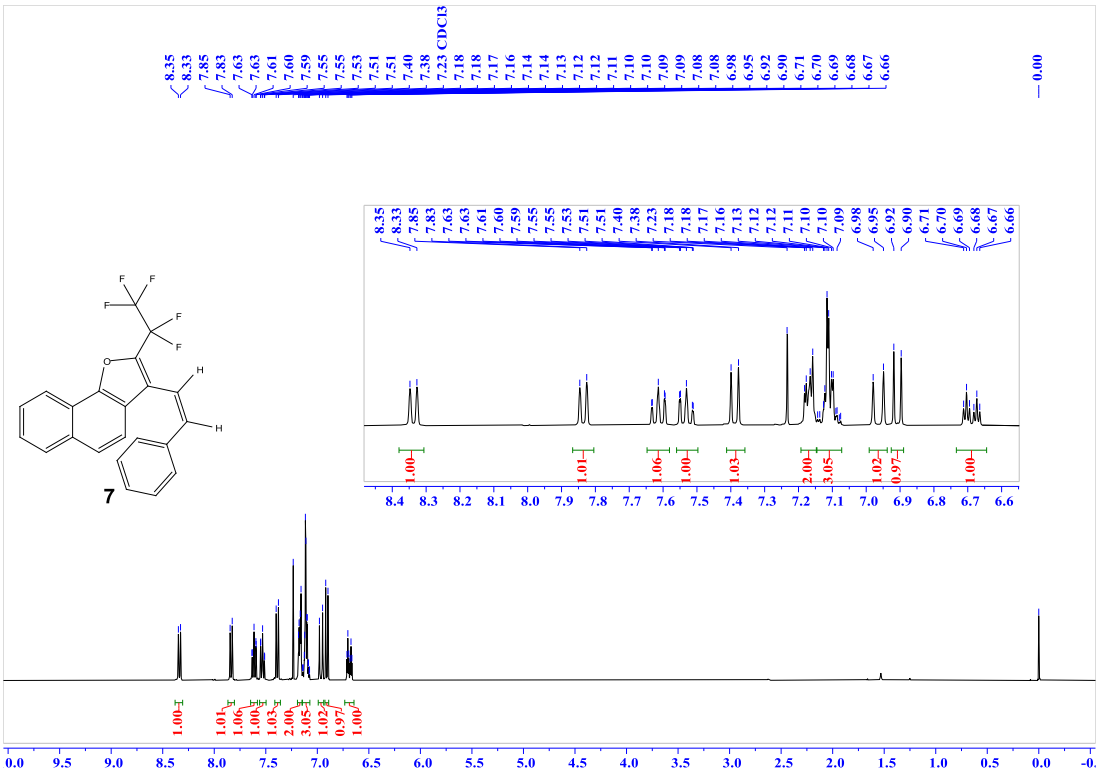

-83.5330 -83.5441 -83.5541 -114.4979 -114.5074 -114.5182 -114.5285
-83.5330 -83.5441 -83.5541
-114.4979 -114.5074 -114.5182 -114.5285
3.00
1.98
-83.45 -83.55 -83.65 -114.5 -114.7
5
3.00 1.98
90 60 30 0 -30 -60 -90 -120 -150 -180 -210 -240 -270

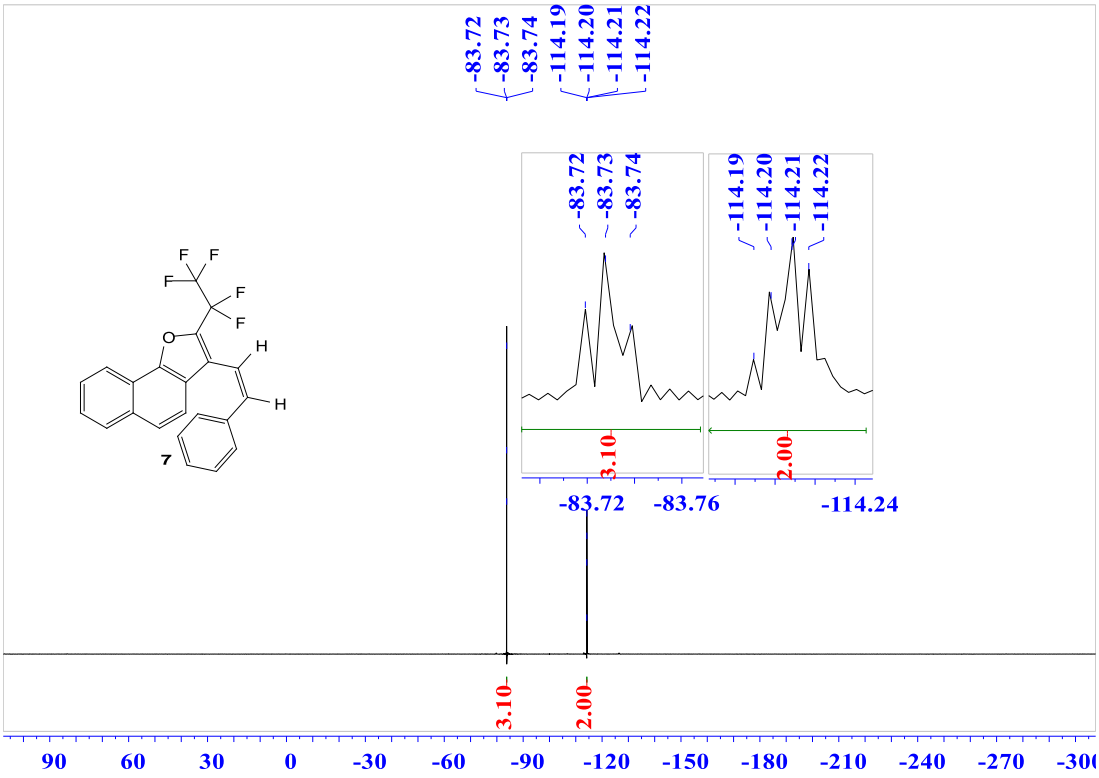

160.72
151.02
151.01
150.99
143.58
143.43
143.27
134.34
133.02
128.50
127.31
127.08
125.60
123.76
120.86
120.36
118.26
117.20
117.19
117.18
114.24
113.00
108.52
108.49
108.48
108.45
108.43
108.42
84.21
82.47
82.46
82.45
77.32 CDCl3
77.00 CDCl3
76.68 CDCl3
72.36
72.35
72.34
67.62
67.61
67.59
143.58
143.43
143.27
134.34
133.02
128.50
127.31
127.08
125.60
123.76
120.86
120.36
118.26
117.20
117.19
117.18
114.24
113.00
F
F
F
F
F
O
O
CH3
5
143.5
143.3
134
132
130
128
126
124
122
120
118
116
114
112
00
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10

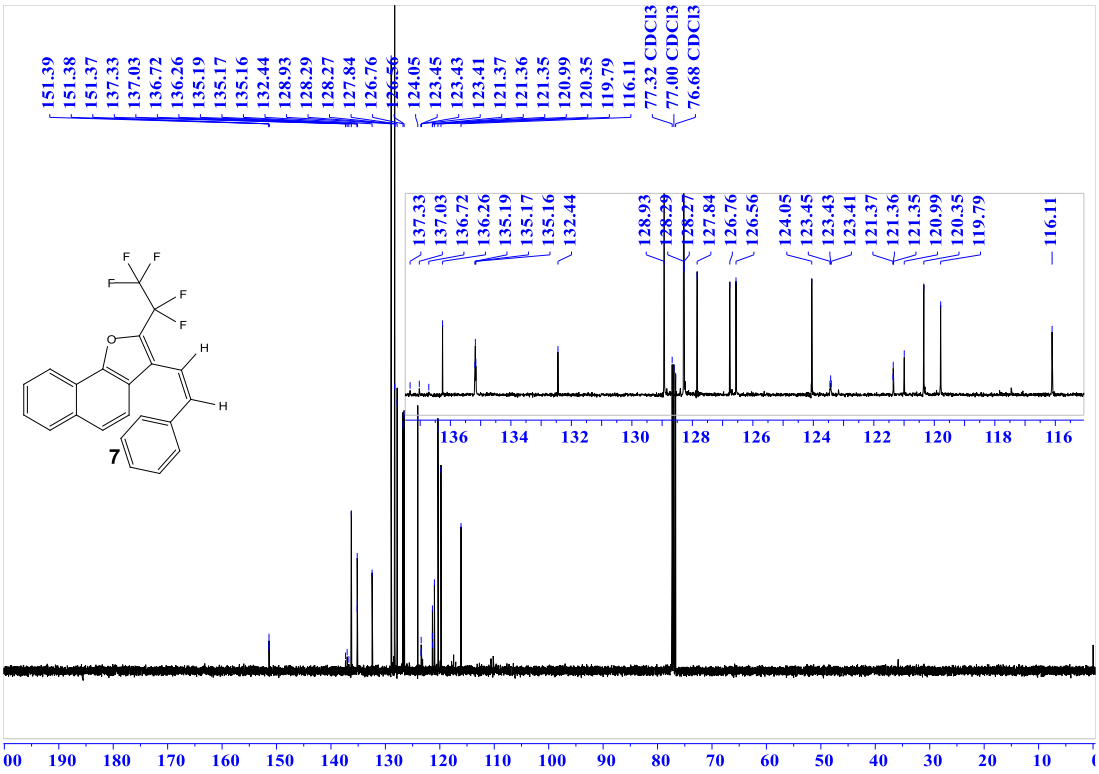

8.31
8.29
7.95
7.93
7.78
7.76
7.76
7.73
7.65
7.63
7.61
7.59
7.57
7.56
7.46
7.44
7.37
7.36
7.34
7.33
7.31
7.29
7.23 CDCl3
7.17
7.13
6.47
6.43
-0.00
1.00
1.07
2.08
2.14
2.05
3.13
1.04
1.01
6

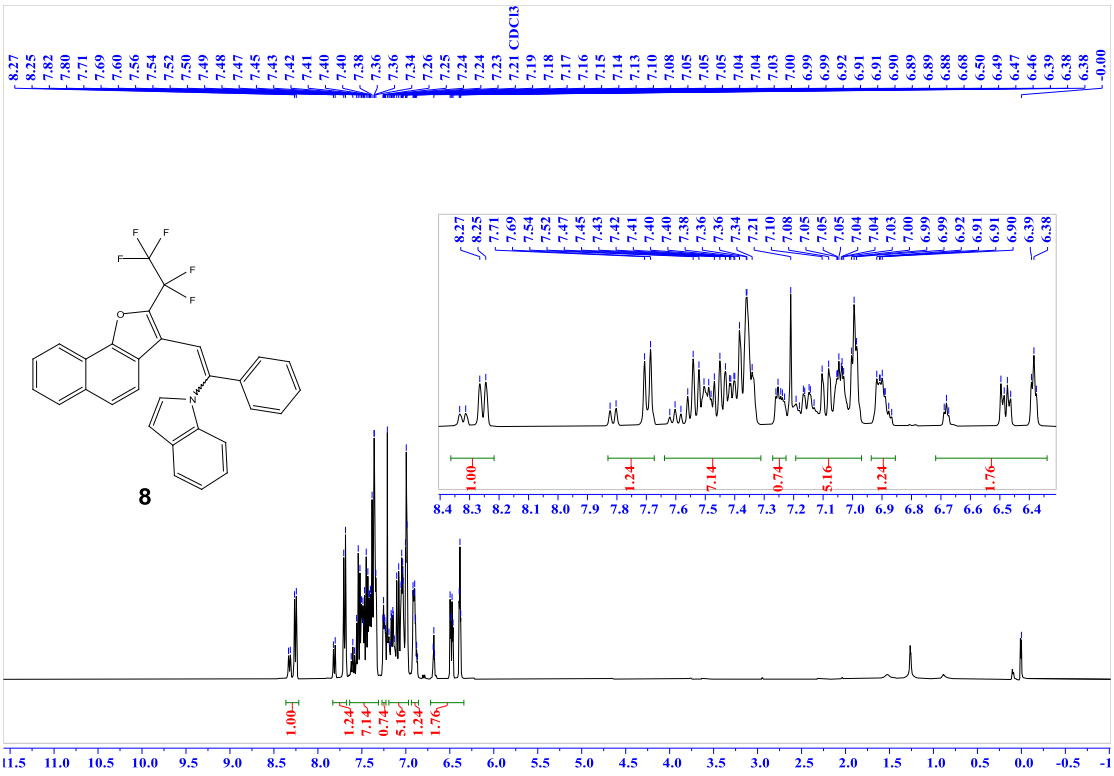

-83.53
-83.54
-83.54
-114.31
-114.32
-114.33
-114.34
3.07
2.00
6

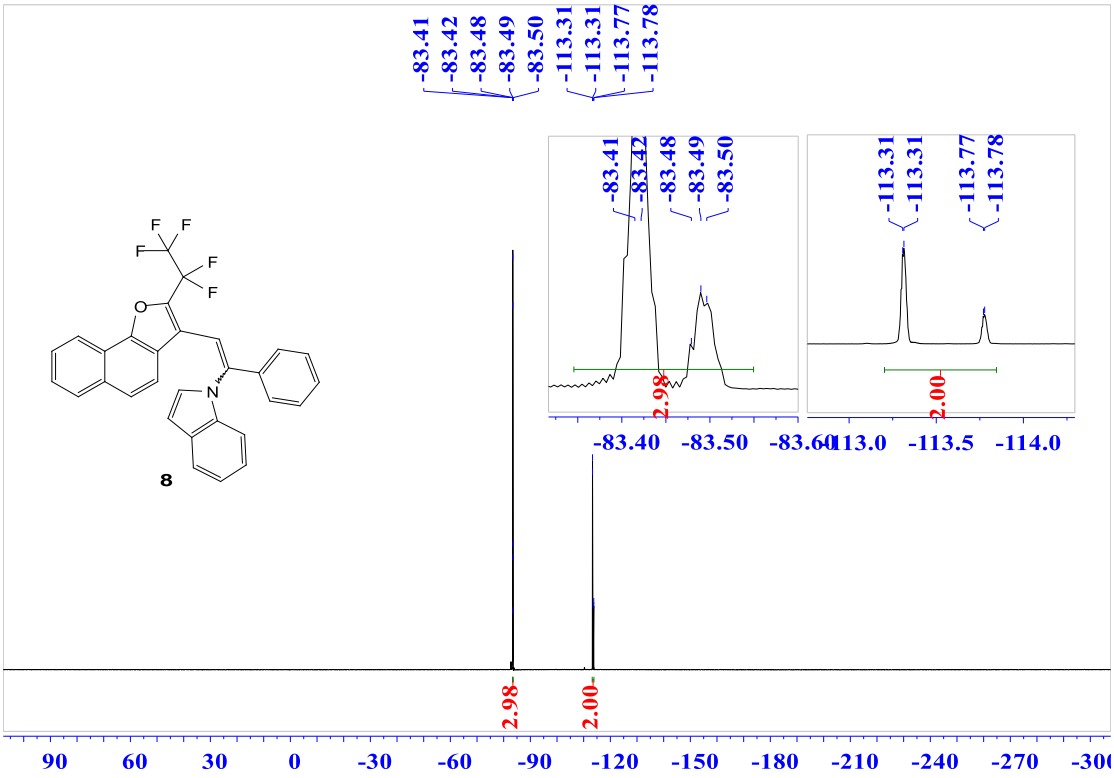

150.97
150.96
143.05
141.67
141.36
141.05
135.82
132.93
129.09
128.80
128.44
127.15
126.89
126.51
125.27
123.47
123.46
120.86
120.35
118.33
109.99
109.97
109.96
109.53
109.50
109.48
107.17
97.52
78.25
78.24
77.32 CDCl3
77.00 CDCl3
76.68 CDCl3
141.67
141.36
141.05
135.82
132.93
129.09
128.80
128.44
127.15
126.89
126.51
125.27
123.47
123.46
120.86
120.35
118.33
109.99
109.97
109.96
109.53
109.50
109.48
107.17
F
F
F
F
F
O
6

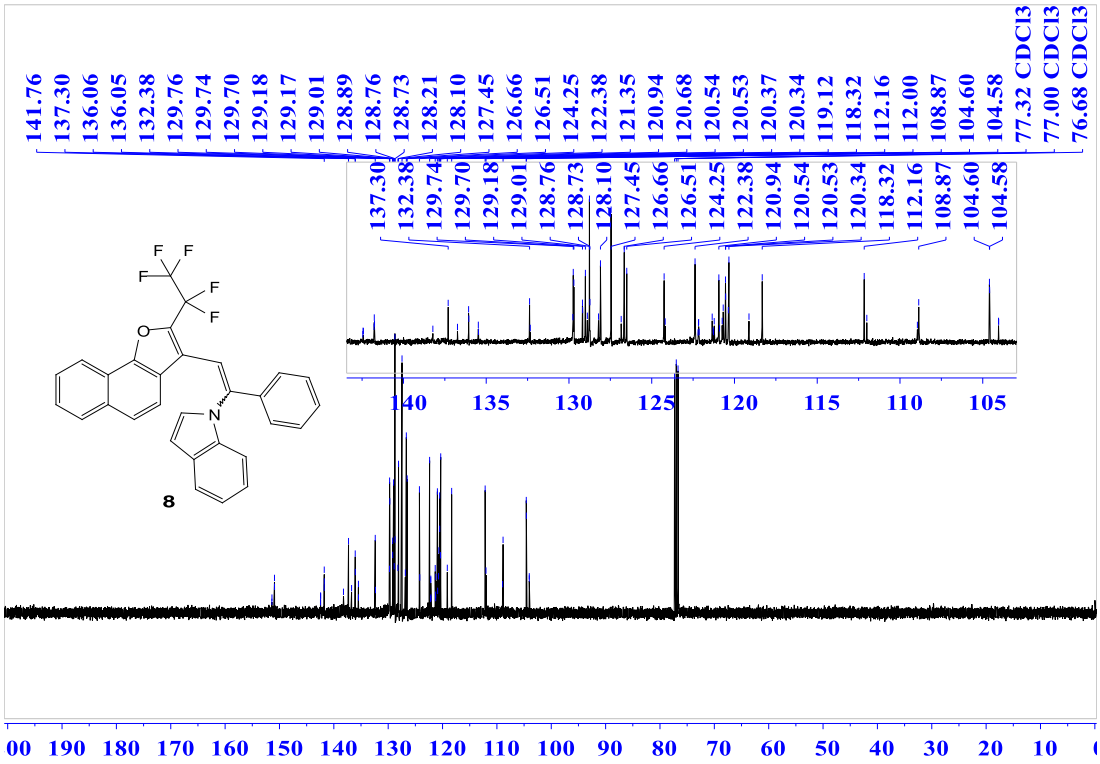

8.35 8.33 7.85 7.83 7.63 7.63 7.61 7.60 7.59 7.55 7.55 7.53 7.51 7.51 7.40 7.38 7.23 CDCl3 7.18 7.18 7.17 7.16 7.14 7.14 7.13 7.12 7.12 7.11 7.10 7.10 7.09 7.09 7.08 7.08 6.98 6.95 6.92 6.90 6.71 6.70 6.69 6.68 6.67 6.66 0.00
F F F F F O H H
7
1.00 1.01 1.06 1.00 1.03 2.00 3.05 1.02 0.97 1.00
0.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0

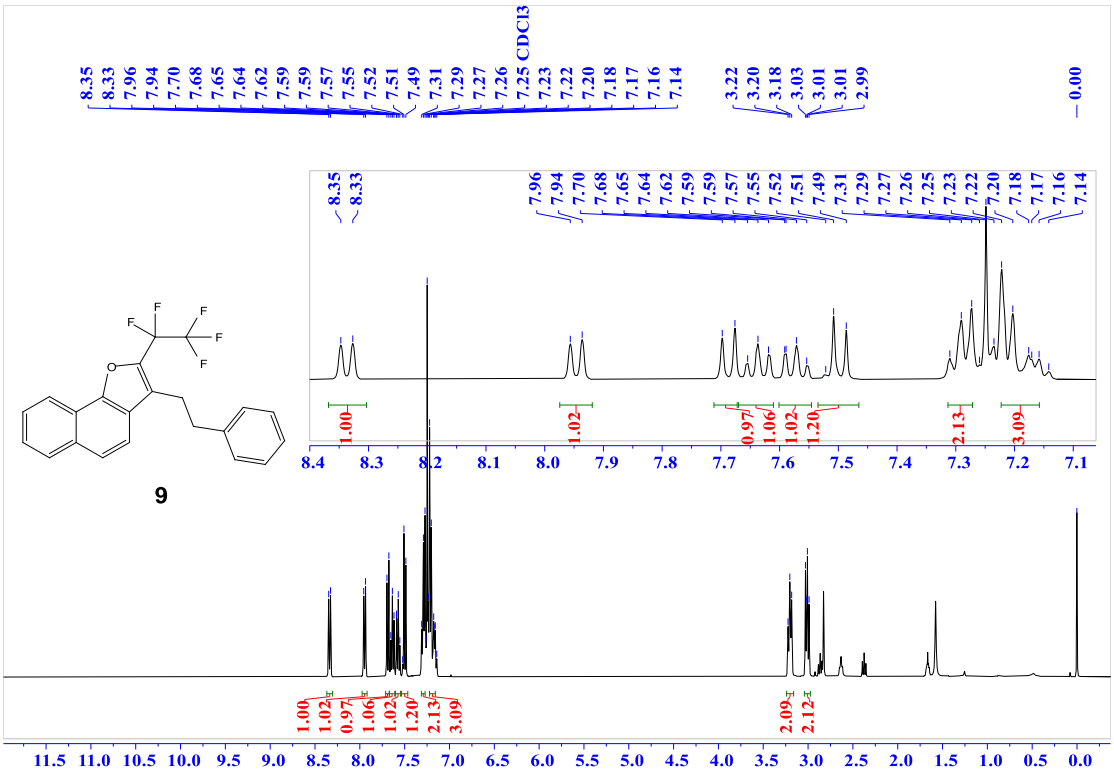

-83.72 -83.73 -83.74 -114.19 -114.20 -114.21 -114.22
F F F F F O H H
7
3.10 2.00
-83.72 -83.76 -114.24
3.10 2.00
90 60 30 0 -30 -60 -90 -120 -150 -180 -210 -240 -270

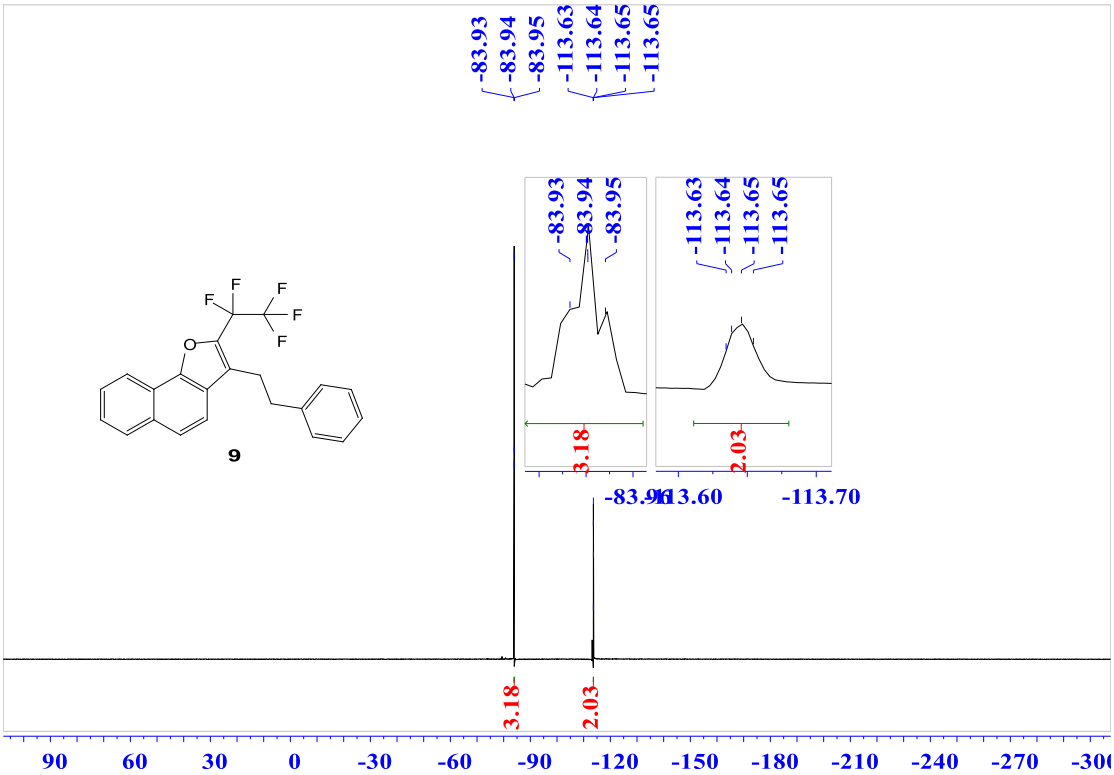

151.39
151.38
151.37
137.33
137.03
136.72
136.26
135.19
135.17
135.16
132.44
128.93
128.29
128.27
127.84
126.76
126.56
124.05
123.45
123.43
123.41
121.37
121.36
121.35
120.99
120.35
119.79
116.11
77.32 CDCl3
77.00 CDCl3
76.68 CDCl3
F
F
F
F
F
O
H
H
7

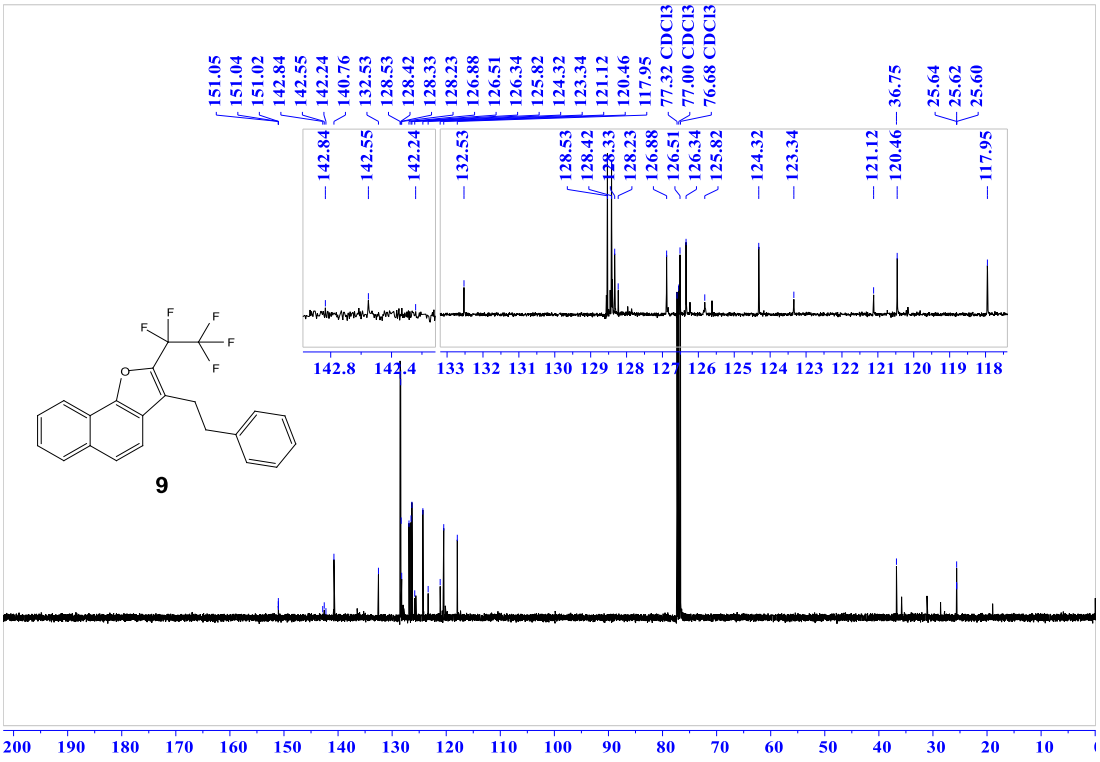

8.27 8.25 7.82 7.80 7.71 7.69 7.60 7.56 7.54 7.52 7.50 7.49 7.48 7.47 7.45 7.43 7.42 7.41 7.40 7.40 7.40 7.38 7.36 7.36 7.34 7.26 7.25 7.24 7.24 7.23 7.21 CDCl3 7.19 7.18 7.17 7.16 7.15 7.14 7.13 7.10 7.08 7.05 7.05 7.05 7.04 7.04 7.03 7.00 6.99 6.99 6.92 6.91 6.91 6.90 6.89 6.89 6.88 6.68 6.50 6.49 6.47 6.46 6.39 6.38 6.38 -0.00
8
1.00 1.24 7.14 0.74 5.16 1.24 1.76

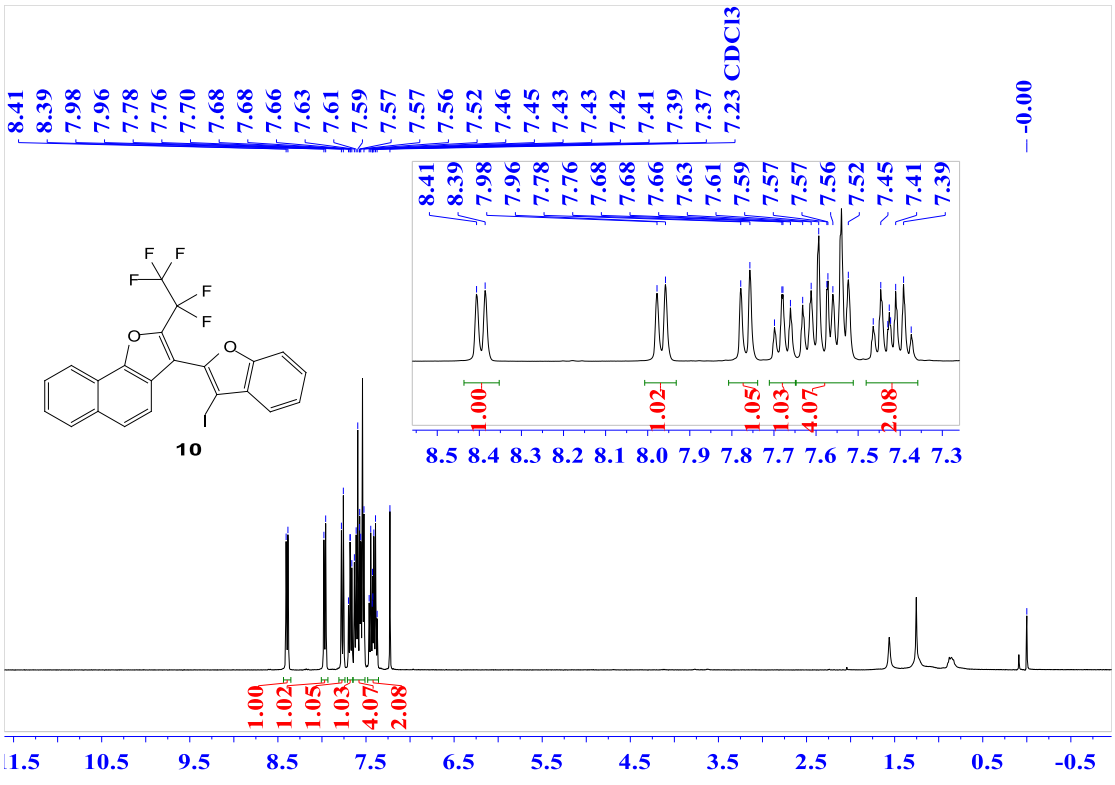

-83.41 -83.42 -83.48 -83.49 -83.50 -113.31 -113.31 -113.77 -113.78
8
2.98
2.00

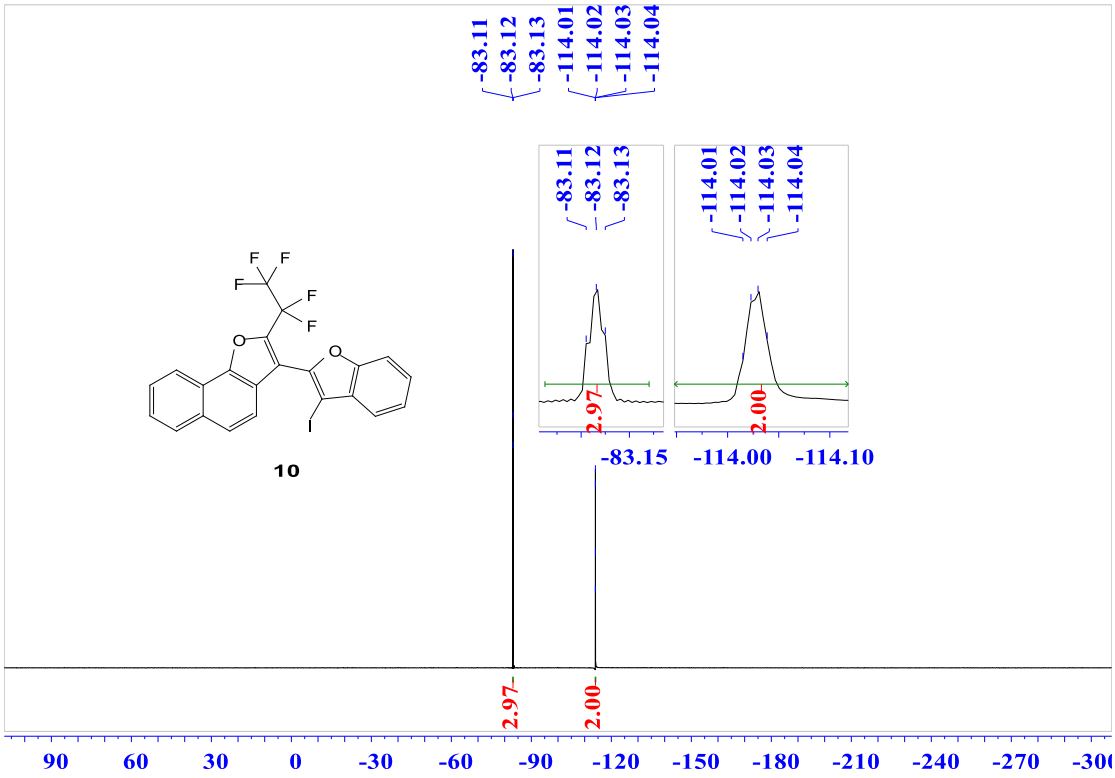

141.76
137.30
136.06
136.05
132.38
129.76
129.74
129.70
129.18
129.17
129.01
128.89
128.76
128.73
128.21
128.10
127.45
126.66
126.51
124.25
122.38
121.35
120.94
120.68
120.54
120.53
120.37
120.34
119.12
118.32
112.16
112.00
108.87
104.60
104.58
77.32 CDCl3
77.00 CDCl3
76.68 CDCl3
F
F
F
F
F
O
N
8

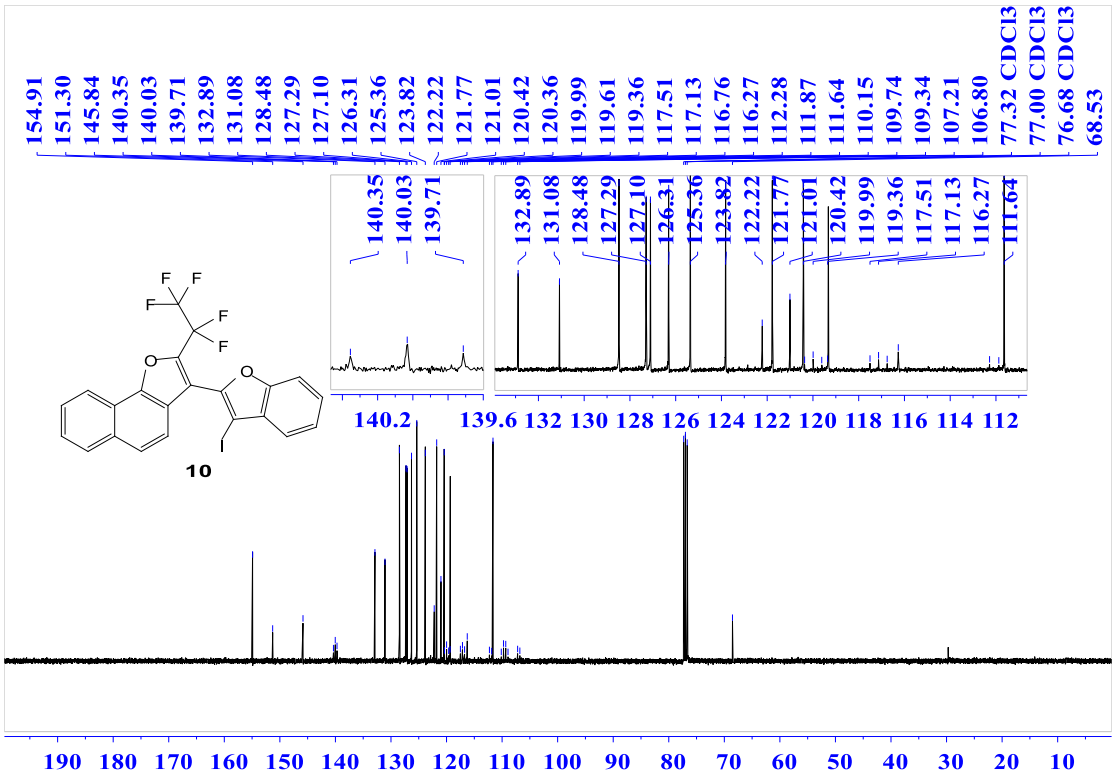

8.35 8.33 7.96 7.94 7.70 7.68 7.65 7.64 7.62 7.59 7.59 7.57 7.55 7.52 7.51 7.49 7.31 7.29 7.27 7.26 CDCl3 7.23 7.22 7.20 7.18 7.17 7.16 7.14 3.22 3.20 3.18 3.03 3.01 3.01 2.99 0.00
1.00 1.02 0.97 1.06 1.02 1.20 2.13 3.09
2.09 2.12
9


-83.93 -83.94 -83.95 -113.63 -113.64 -113.65 -113.65
3.18 2.03
-83.96 -113.60 -113.70
9


151.05
151.04
151.02
142.84
142.55
142.24
140.76
132.53
128.53
128.42
128.33
128.23
126.88
126.51
126.34
125.82
124.32
123.34
121.12
120.46
117.95
77.32 CDCl3
77.00 CDCl3
76.68 CDCl3
36.75
25.64
25.62
25.60
F
F
F
F
F
O
9
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10


8.41 8.39 7.98 7.96 7.78 7.76 7.70 7.68 7.68 7.66 7.63 7.61 7.59 7.57 7.57 7.56 7.52 7.46 7.45 7.43 7.43 7.42 7.41 7.39 7.37 7.23 CDCl3
-0.00
10
1.00 1.02 1.05 1.03 4.07 2.08
1.5 10.5 9.5 8.5 7.5 6.5 5.5 4.5 3.5 2.5 1.5 0.5 -0.5


-83.11 -83.12 -83.13 -114.01 -114.02 -114.03 -114.04
10
2.97 2.00
-83.15 -114.00 -114.10
90 60 30 0 -30 -60 -90 -120 -150 -180 -210 -240 -270


154.91
151.30
145.84
140.35
140.03
139.71
132.89
131.08
128.48
127.29
127.10
126.31
125.36
123.82
122.22
121.77
121.01
120.42
120.36
119.99
119.61
119.36
117.51
117.13
116.76
116.27
112.28
111.87
111.64
110.15
109.74
109.34
107.21
106.80
77.32 CDCl3
77.00 CDCl3
76.68 CDCl3
68.53
F
F
F
F
F
O
O
10
140.35
140.03
139.71
132.89
131.08
128.48
127.29
127.10
126.31
125.36
123.82
122.22
121.77
121.01
120.42
119.99
119.36
117.51
117.13
116.27
111.64
140.2
139.6 132 130 128 126 124 122 120 118 116 114 112
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10