Supporting information

Enantioselective Copper-Catalyzed Synthesis of Axially Chiral Deuterated Biaryl Ethers and Phenols from Cyclic Iodonium Salts

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1. General Information

Copper catalysts were purchased from Acros, Aldrich, and Strem. Other chemicals were purchased from Bidepharm, Adamas, and Energy chemicals, and were directly used without further purifications. Yields for all compounds were determined by the column chromatography which was generally performed on silica gel (200-300 mesh) using petroleum ether (PE)/EtOAc as eluent, and reactions were monitored by thin layer chromatography (TLC) on a glass pate coated with silica gel with fluorescent indicator (GF254) using UV light and iodine chromogenic method. ^{1}H and ^{13}C NMR spectra were collected on a Zhong Ke Oxford Quantum-I Plus 400 MHz at room temperature. ^{1}H NMR spectra were reported in parts per million (ppm) downfield of tetramethylsilane (TMS) and were referenced to the signal of TMS (0 ppm). ^{13}C NMR spectra were reported in ppm relative to residual $CHCl_3$ (77.00 ppm). Coupling constants, *J*, are reported in hertz (Hz). HRMS was performed on Bruker Apex II FT-ICR mass instrument (ESI). The enantiomeric excess (ee) of the products was determined by chiral HPLC (Agilent iQ 1260-G6160) using Daicel CHIRALCEL® columns and Daicel CHIRALPAK® columns (internal diameter 4.6 mm, column length 250 mm, particle size 5 μm). Optical rotations were measured on an AUTOPOL IV Automatic polarimeter (Rudolph Research Analytical).

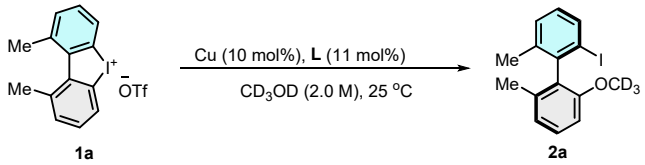
L1-**L10** were obtained from commercial suppliers (Daicel Chiraltech and BidePharm.) and used without further purification. Cyclic diaryliodonium salts **1** was prepared according to the reported procedures[1].

2. Optimization of Reaction Parameters

General Procedure

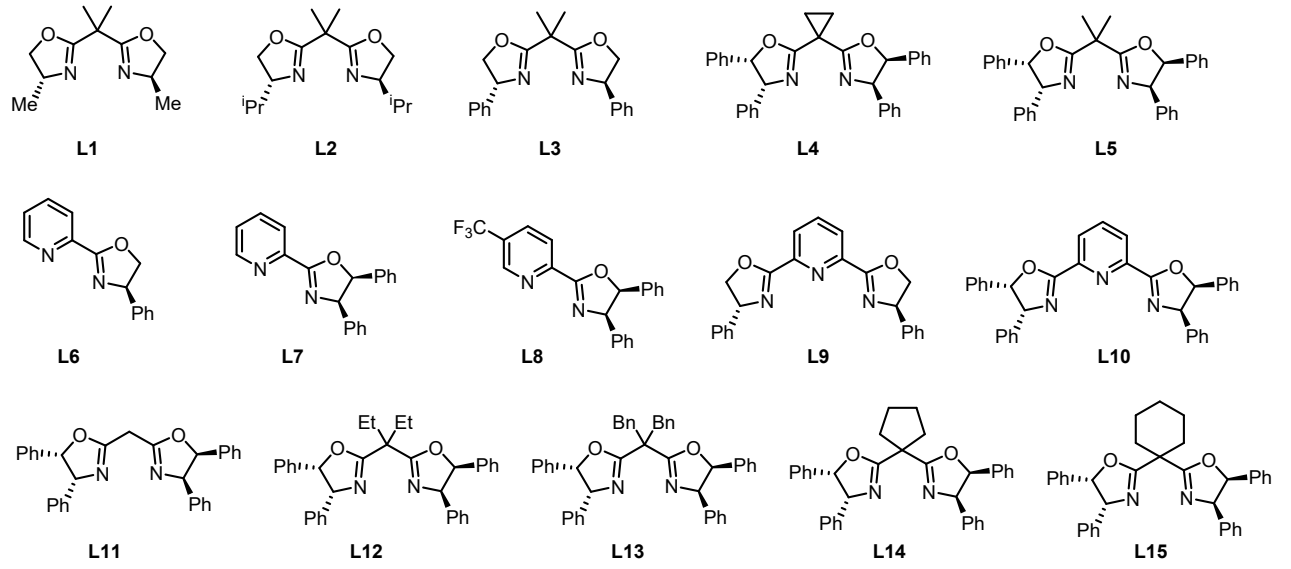
To a 5 mL reaction tube with a stir bar was charged with Catalyst (10 mol %, 0.01 mmol), L (11 mol%, 0.011 mmol) and cyclic diaryliodonium salts **1a** (45.6 mg, 0.1 mmol), The tube was sealed with rubber septum, then evacuated and backfilled with nitrogen for three cycles, CD_3OD (0.05 mL, 2.0 M) was added. The reaction mixture was stirred at appreciate temperature for 6 h. The reaction mixture was quenched with water (10.0 mL), and extracted with ethyl acetate (3 × 15.0 mL). The combined organic layers were washed with water, brine, dried over anhydrous Na_2SO_4, and concentrated under reduced pressure. The residue was purified by flash chromatography on silica gel to afford the desired product **2a**.

Table S1. Effect of catalysts and ligands[a]



entry	Catalyst	ligand	yield (%)	ee (%)
1	CuI	**L1**	88	3
2	CuI	**L2**	90	6
3	CuI	**L3**	90	27
4	CuI	**L4**	95	89
5	CuI	**L5**	89	60
6	CuI	**L6**	80	0
7	CuI	**L7**	86	6
8	CuI	**L8**	50	3
9	CuI	**L9**	79	0
10	CuI	**L10**	86	0
11	CuBr	**L4**	90	90
12	**CuSCN**	**L4**	**99**	**96**
13	CuOTf	**L4**	85	91
14	CuTc	**L4**	90	93
15	CuOAc	**L4**	88	86
16	CuSCN	**L5**	90	54

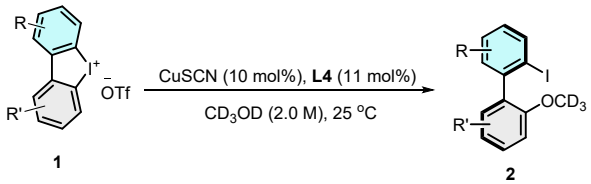
17	CuSCN	**L11**	98	0
18	CuSCN	**L12**	96	68
19	CuSCN	**L13**	84	81
20	CuSCN	**L14**	95	92
21	CuSCN	**L15**	95	92



[a]Reaction conditions: **1a** (0.1 mmol), catalyst (0.01 mmol) and ligand (0.011 mmol) were used, the yields were determined by the column chromatography.

3. Enantioselective Copper-Catalyzed Synthesis of Axially Chiral Deuterated Biaryl Ethers and Phenols from Cyclic Iodonium Salts

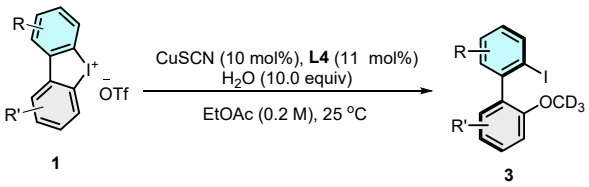
3.1 General Procedure A



To a 5 mL reaction tube with a stir bar was charged with CuSCN (2.5 mg, 10 mol%, 0.01 mmol), **L4** (10.6 mg, 11 mol%, 0.011 mmol) and cyclic diaryliodonium salts **1** (0.2 mmol), The tube was sealed with rubber septum, then evacuated and backfilled with nitrogen for three cycles, CD_3OD (0.1 mL, 2.0 M) was added. The reaction mixture was stirred at appreciate temperature for 6 h. The reaction mixture was quenched with water (10.0 mL), and extracted with ethyl acetate (3 × 15.0 mL). The combined organic layers were washed with water, brine, dried over anhydrous Na_2SO_4, and

concentrated under reduced pressure. The residue was purified by flash chromatography on silica gel to afford the desired product **2**.

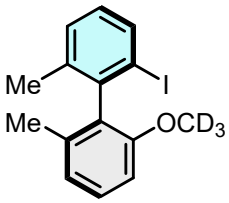
3.2 General Procedure B



To a 5 mL reaction tube with a stir bar was charged with CuSCN (2.5 mg, 10 mol %, 0.01 mmol), **L4** (10.6 mg, 11 mol%, 0.011 mmol), H_2O (36 μL, 10.0 equiv, 2.0 mmol) and cyclic diaryliodonium salts **1** (0.2 mmol), The tube was sealed with rubber septum, then EtOAc (1.0 mL, 0.2 M) was added. The reaction mixture was stirred at appreciate temperature for 6 h. The reaction mixture was quenched with water (10.0 mL), and extracted with ethyl acetate (3 × 15.0 mL). The combined organic layers were washed with water, brine, dried over anhydrous Na_2SO_4, and concentrated under reduced pressure. The residue was purified by flash chromatography on silica gel to afford the desired product **3**.

3.3 Characterization Data of Products

(*R*)-2-iodo-2'-(methoxy-d_3)-6,6'-dimethyl-1,1'-biphenyl (2a)



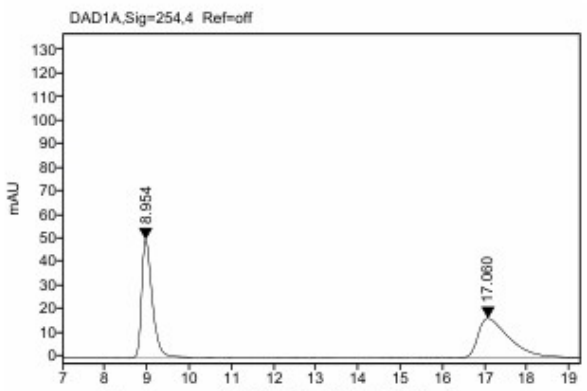
This compound was prepared according to the **General procedure A** from the reaction of **1a** (91.2 mg, 0.2 mmol).

67.5 mg, 99% yield, 96% ee, white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.69 (d, *J* = 7.9 Hz, 1H), 7.22 (t, *J* = 7.9 Hz, 1H), 7.17 (d, *J* = 7.7 Hz, 1H), 6.91 – 6.81 (m, 2H), 6.75 (d, *J* = 8.2 Hz, 1H), 1.94 (s, 3H), 1.85 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$) δ** 156.2, 142.4, 138.2, 137.0, 136.4, 132.7, 129.5, 128.7, 128.6, 122.4, 108.4, 101.7, 63.8-62.8 (m), 21.3, 19.4. **HRMS (ESI):** $[M+H]^+$ calcd for $C_{15}H_{13}D_3IO$ 342.0249, found 342.0240.

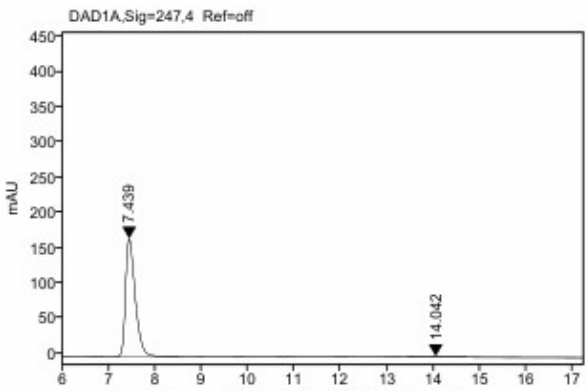
Chiral HPLC: CHIRALPAK OX-H, 25 °C, iPrOH-hexanes 1.0/99.0, 1.0 mL/min, 247 nm. t_R(major) = 7.4 min, t_R(minor) = 14.0 min.

$[\alpha]_D^{25}$ = -9.2° (c = 1.01, CH_2Cl_2)



Signal: DAD1A,Sig=254,4 Ref=off

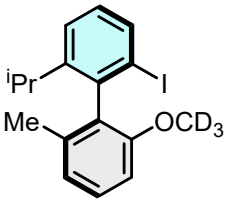
RT [min]	Area	Area%
8.954	854.01	50.35
17.060	842.07	49.65
Sum	1696.08	



Signal: DAD1A,Sig=247,4 Ref=off

RT [min]	Area	Area%
7.439	2415.42	98.14
14.042	45.87	1.86
Sum	2461.29	

(*R*)-2-iodo-6-isopropyl-2'-(methoxy-d_3)-6'-methyl-1,1'-biphenyl (2b)



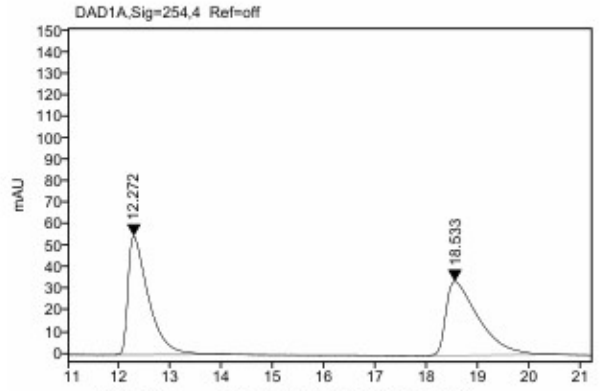
This compound was prepared according to the **General procedure A** from the reaction of **1b** (96.8 mg, 0.2 mmol).

65.0 mg, 88% yield, >99% ee, white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (dd, *J* = 7.9, 1.3 Hz, 1H), 7.39 (t, *J* = 8.0 Hz, 1H), 7.26 – 7.21 (m, 1H), 7.02 (dd, *J* = 7.9, 1.1 Hz, 1H), 6.94 (t, *J* = 7.7 Hz, 1H), 6.81 (dd, *J* = 8.2, 1.1 Hz, 1H), 2.52 – 2.37 (m, 1H), 2.04 (s, 3H), 1.21 (d, *J* = 6.9 Hz, 3H), 1.07 (d, *J* = 6.8 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$) δ** 155.9, 147.5, 142.3, 138.6, 136.3, 129.4, 129.1, 128.6, 125.1, 117.9, 108.2, 102.6, 55.2-54.6 (m), 30.2, 24.0, 23.9, 21.7. **HRMS (ESI):** $[M+H]^+$ calcd for $C_{17}H_{17}D_3IO$ 370.0742, found 370.0744.

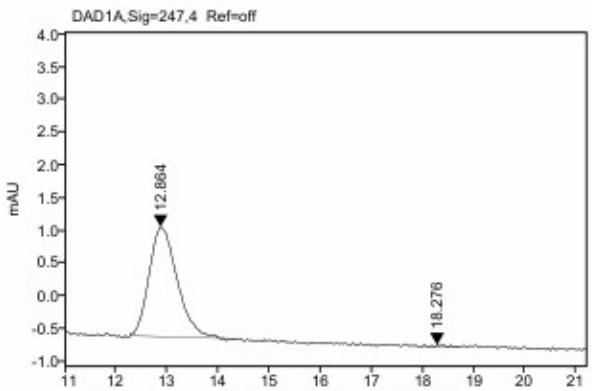
Chiral HPLC: CHIRALPAK OX-H, 25 °C, iPrOH-hexanes 1.0/99.0, 1.0 mL/min, 247 nm. t_R(major) = 12.8 min, t_R(minor) = 18.2 min.

$[\alpha]_D^{25}$ = -2.0° (c = 1.05, CH_2Cl_2)



Signal: DAD1A,Sig=254,4 Ref=off

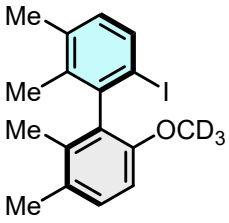
RT [min]	Area	Area%
12.272	1524.64	50.28
18.533	1507.54	49.72
Sum	3032.18	



Signal: DAD1A,Sig=247,4 Ref=off

RT [min]	Area	Area%
12.864	63.60	99.79
18.276	0.14	0.21
Sum	63.73	

(*R*)-2-iodo-2'-(methoxy-d_3)-4,4',6,6'-tetramethyl-1,1'-biphenyl (2c)



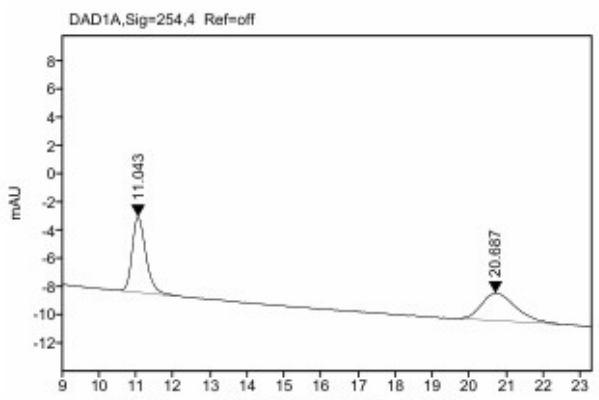
This compound was prepared according to the **General procedure A** from the reaction of **1c** (96.8 mg, 0.2 mmol).

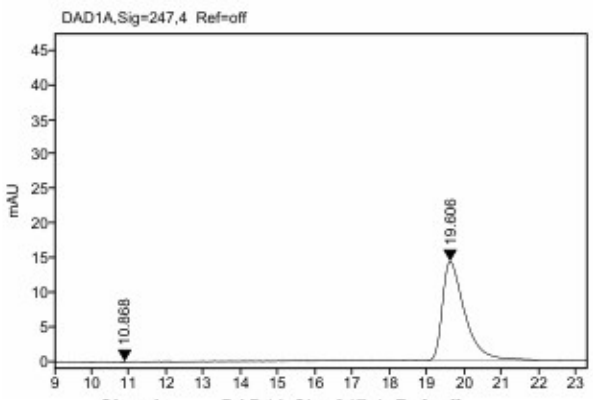
68.6 mg, 93% yield, >99% ee, white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.59 (d, *J* = 8.0 Hz, 1H), 7.09 (d, *J* = 8.3 Hz, 1H), 6.78 (d, *J* = 8.0 Hz, 1H), 6.66 (d, *J* = 8.4 Hz, 1H), 2.20 (s, 3H), 2.20 (s, 3H), 1.85 (s, 3H), 1.73 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$) δ** 154.5, 142.6, 136.9, 136.6, 135.7, 135.4, 133.5, 130.3, 129.4, 128.8, 108.1, 98.6, 54.9-52.5 (m), 20.3, 19.8, 17.8, 16.0. **HRMS (ESI):** $[M+H]^+$ calcd for $C_{17}H_{17}D_3IO$ 370.0742, found 370.0740.

Chiral HPLC: CHIRALPAK OX-H, 25 °C, iPrOH-hexanes 1.0/99.0, 1.0 mL/min, 247nm. t_R(minor) = 10.8 min, t_R(major) = 19.6 min.

$[\alpha]_D^{25}$ = +13.0° (c = 1.5, CH_2Cl_2)





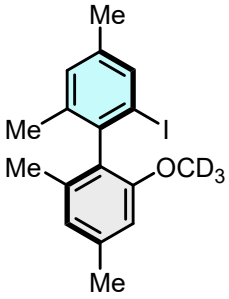
Signal: DAD1A,Sig=254,4 Ref=off

RT [min]	Area	Area%
11.043	137.83	52.46
20.687	124.89	47.54
Sum	262.72	

Signal: DAD1A,Sig=247,4 Ref=off

RT [min]	Area	Area%
10.868	0.08	0.01
19.606	590.57	99.99
Sum	590.64	

(*R*)-2-iodo-2'-(methoxy-d_3)-4,4',6,6'-tetramethyl-1,1'-biphenyl (2d)



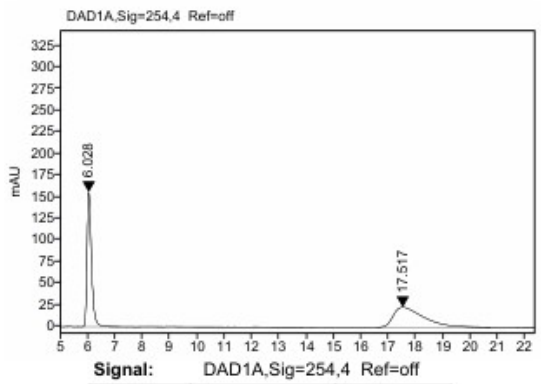
This compound was prepared according to the **General procedure A** from the reaction of **1d** (96.8 mg, 0.2 mmol).

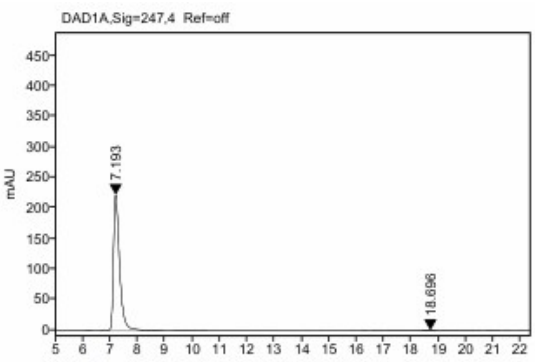
65.7 mg, 89% yield, >99% ee, white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.60 (s, 1H), 7.05 (s, 1H), 6.73 (s, 1H), 6.63 (s, 1H), 2.38 (s, 3H), 2.30 (s, 3H), 1.97 (s, 3H), 1.88 (s, 3H).**^{13}C NMR (101 MHz, $CDCl_3$) δ** 156.3, 139.5, 138.4, 138.3, 138.2, 137.9, 136.8, 130.5, 129.7, 123.1, 109.4, 102.1, 55.6-54.6 (m), 21.8, 21.3, 20.6, 19.4. **HRMS (ESI):** $[M+H]^+$ calcd for $C_{17}H_{17}D_3IO$ 370.0742, found 370.0740.

Chiral HPLC: CHIRALPAK OX-H, 25 °C, iPrOH-hexanes 1.0/99.0, 1.0 mL/min, 247 nm. t_R(major) = 7.2 min, t_R(minor) = 18.7 min.

$[\alpha]_D^{25}$ = -10.0° (c = 1.3, CH_2Cl_2)





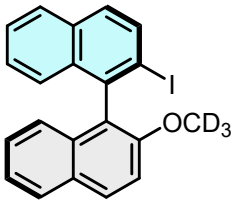
Signal: DAD1A,Sig=254,4 Ref=off

RT [min]	Area	Area%
6.028	1764.76	50.17
17.517	1753.13	49.83
Sum	3517.90	

Signal: DAD1A,Sig=247,4 Ref=off

RT [min]	Area	Area%
7.193	3394.61	100.00
18.696	0.09	0.00
Sum	3394.71	

(*R*)-2-iodo-2'-(methoxy-d_3)-1,1'-binaphthalene (2e)



This compound was prepared according to the **General procedure A** from the reaction of **1e** (105.6 mg, 0.2 mmol).

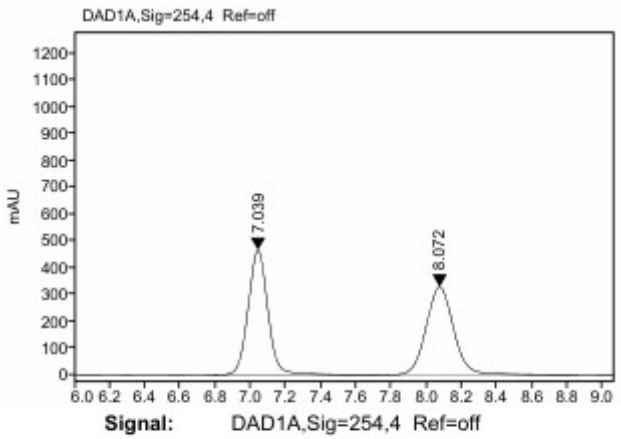
62.8 mg, 76% yield, 92% ee, white solid.

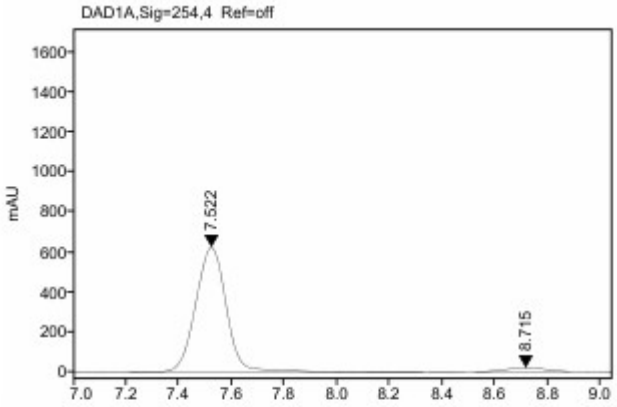
^{1}H NMR (400 MHz, DMSO-d_6) δ 8.04 (dd, J = 9.0, 3.4 Hz, 2H), 7.92 – 7.83 (m, 2H), 7.66 (d, J = 8.7 Hz, 1H), 7.50 – 7.42 (m, 2H), 7.37 – 7.31 (m, 1H), 7.24 – 7.15 (m, 2H), 6.96 (dd, J = 8.4, 1.0 Hz, 1H). **^{13}C NMR (101 MHz, DMSO-d_6) δ** 154.2, 139.8, 135.6, 133.8, 132.9, 130.1, 129.1, 129.0, 128.0, 127.9, 126.8, 126.7, 126.2, 125.7, 124.6, 123.8, 113.8, 100.5, 61.0-60.1 (m).

HRMS (ESI): $[M+H]^+$ calcd for $C_{21}H_{13}D_3IO$ 414.0429, found 414.0435.

Chiral HPLC: CHIRALPAK OX-H, 25 °C, iPrOH-hexanes 2.0/98.0, 1.0 mL/min, 254 nm. t_R(major) = 7.5 min, t_R(minor) = 8.7 min.

$[\alpha]_D^{25}$ = -1.0° (c = 0.5, CH_2Cl_2)





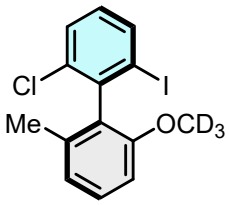
Signal: DAD1A,Sig=254,4 Ref=off

RT [min]	Area	Area%
7.039	3605.11	50.49
8.072	3535.32	49.51
Sum	7140.43	

Signal: DAD1A,Sig=254,4 Ref=off

RT [min]	Area	Area%
7.522	5065.27	96.12
8.715	204.22	3.88
Sum	5269.49	

(*R*)-2-chloro-6-iodo-2'-(methoxy-d_3)-6'-methyl-1,1'-biphenyl (2f)



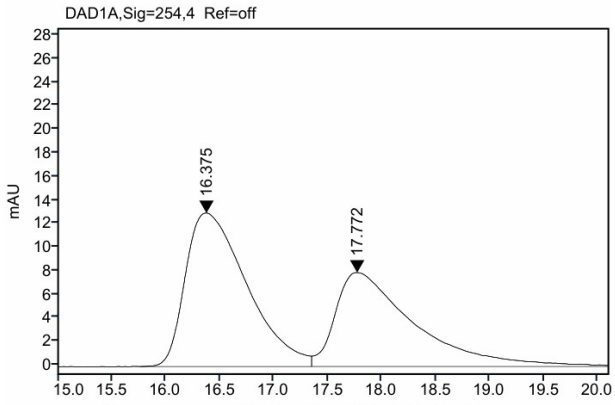
This compound was prepared according to the **General procedure A** from the reaction of **1f** (95.2 mg, 0.2 mmol).

67.3 mg, 93% yield, 92% ee, white solid.

^{1}H NMR (400 MHz, DMSO-d_6) δ 7.84 (dd, *J* = 7.9, 1.2 Hz, 1H), 7.47 (dd, *J* = 8.0, 1.2 Hz, 1H), 7.32 (t, *J* = 8.0 Hz, 1H), 6.97 (t, *J* = 8.0 Hz, 1H), 6.92 (d, *J* = 7.7 Hz, 1H), 6.83 (d, *J* = 8.3 Hz, 1H), 1.98 (s, 3H). **^{13}C NMR (101 MHz, DMSO-d_6) δ** 156.2, 141.6, 137.4, 136.3, 133.7, 131.5, 129.7, 129.3, 129.2, 122.2, 108.6, 101.7, 55.3-53.4 (m), 19.3. **HRMS (ESI):** $[M+H]^+$ calcd for $C_{14}H_{10}D_3ClIO$ 361.9882, found 361.9880.

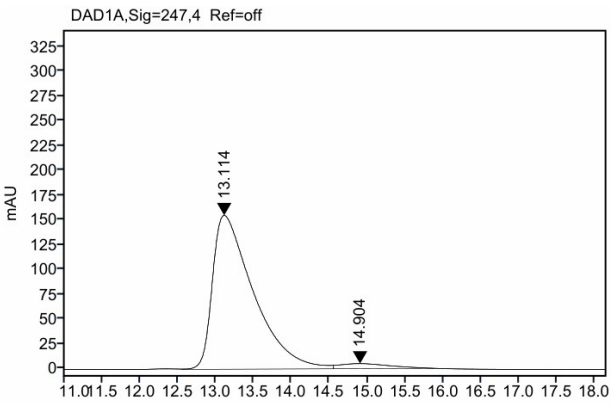
Chiral HPLC: CHIRALPAK OX-H, 25 °C, iPrOH-hexanes 1.0/99.0, 1.0 mL/min, 247 nm. t_R(major) = 13.1 min, t_R(minor) = 14.9 min.

$[\alpha]_D^{25}$ = -11.5° (c = 1.1, CH_2Cl_2)



Signal: DAD1A,Sig=254,4 Ref=off

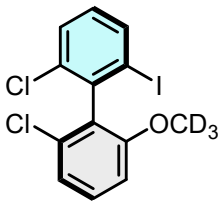
RT [min]	Area	Area%
16.375	516.86	56.06
17.772	405.10	43.94
Sum	921.96	



Signal: DAD1A,Sig=247,4 Ref=off

RT [min]	Area	Area%
13.114	5839.01	96.14
14.904	234.17	3.86
Sum	6073.18	

(*R*)-2,2'-dichloro-6-iodo-6'-(methoxy-d_3)-1,1'-biphenyl (2g)



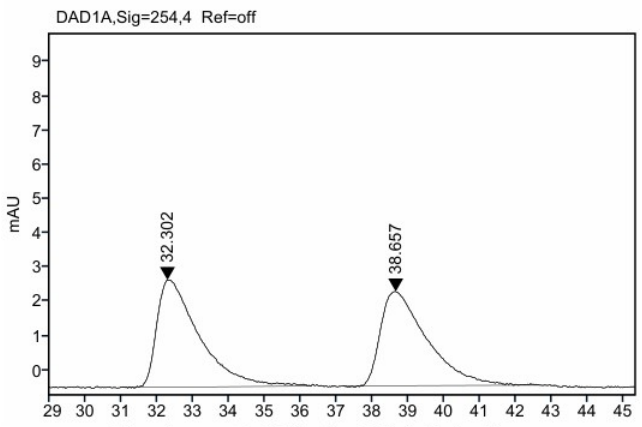
This compound was prepared according to the **General procedure A** from the reaction of **1g** (99.4 mg, 0.2 mmol).

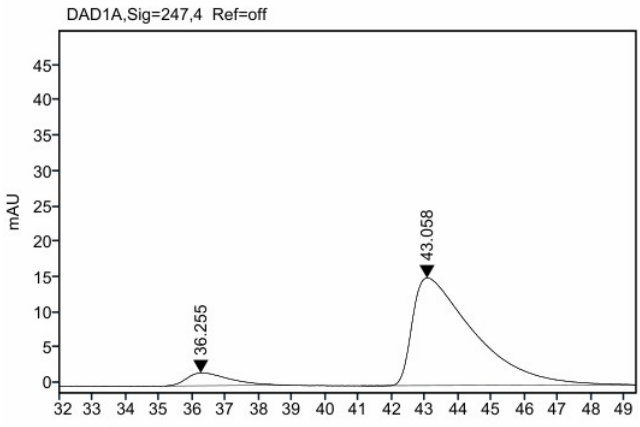
72.6 mg, 95% yield, 85% ee, white solid.

^{1}H NMR (400 MHz, DMSO-d_6) δ 7.84 (dd, *J* = 7.9, 1.1 Hz, 1H), 7.47 (dd, *J* = 8.0, 1.1 Hz, 1H), 7.35 (t, *J* = 8.2 Hz, 1H), 7.12 (dd, *J* = 8.1, 1.1 Hz, 1H), 7.01 (t, *J* = 8.0 Hz, 1H), 6.90 (dd, *J* = 8.3, 1.0 Hz, 1H). **^{13}C NMR (101 MHz, DMSO-d_6) δ** 157.5, 139.9, 137.3, 134.2, 134.0, 130.7, 130.2, 129.7, 129.2, 121.5, 109.5, 101.1, 58.1-55.7 (m). **HRMS (ESI):** $[M+H]^+$ calcd for $C_{13}H_7D_3Cl_2IO$ 381.9336, found 381.9337.

Chiral HPLC: CHIRALPAK OX-H, 25 °C, iPrOH-hexanes 1.0/99.0, 1.0 mL/min, 247 nm. t_R(major) = 36.2 min, t_R(minor) = 43.0 min.

$[\alpha]_D^{25}$ = -5.0° (c = 1.2, CH_2Cl_2)





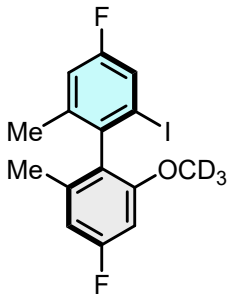
Signal: DAD1A,Sig=254,4 Ref=off

RT [min]	Area	Area%
32.302	255.94	51.05
38.657	245.45	48.95
Sum	501.38	

Signal: DAD1A,Sig=247,4 Ref=off

RT [min]	Area	Area%
36.255	161.88	7.66
43.058	1952.69	92.34
Sum	2114.57	

(*R*)-4,4'-difluoro-2-iodo-2'-(methoxy-d_3)-6,6'-dimethyl-1,1'-biphenyl (2h)



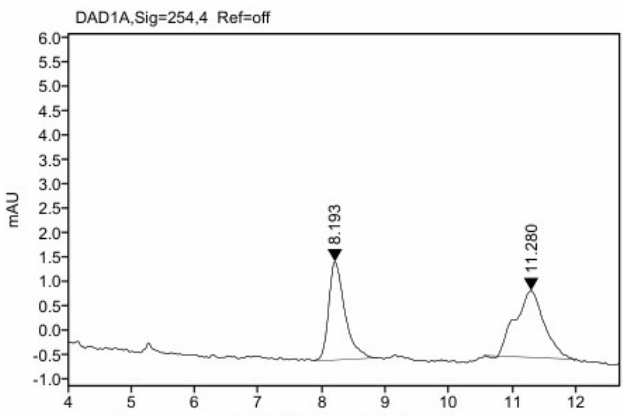
This compound was prepared according to the **General procedure A** from the reaction of **1h** (98.4 mg, 0.2 mmol).

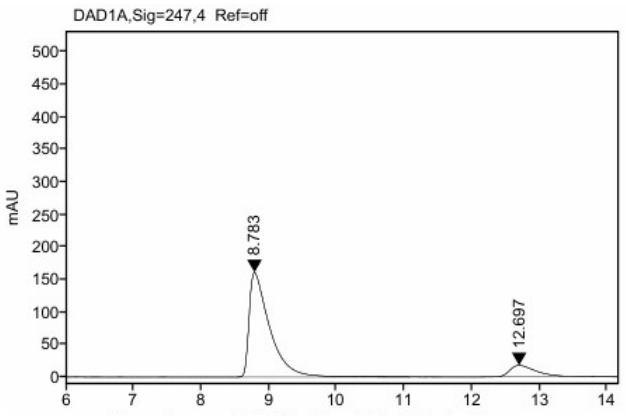
61.0 mg, 81% yield, 78% ee, white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.49 (dd, J = 7.9, 2.7 Hz, 1H), 6.99 (dd, J = 9.3, 2.7 Hz, 1H), 6.63 (dd, J = 9.3, 2.5 Hz, 1H), 6.55 (dd, J = 10.8, 2.5 Hz, 1H), 2.00 (s, 3H), 1.90 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$) δ** 163.1 (d, $J_{C\text{-}F}$ = 245.3 Hz), 161.2 (d, $J_{C\text{-}F}$ = 250.2 Hz), 157.5 (d, $J_{C\text{-}F}$ = 16.0f Hz), 139.8 (d, $J_{C\text{-}F}$ = 7.1 Hz), 138.8 (d, $J_{C\text{-}F}$ = 10.1 Hz), 137.6, 127.4, 123.3 (d, $J_{C\text{-}F}$ = 23.2 Hz), 116.7 (d, $J_{C\text{-}F}$ = 21.2 Hz), 108.7 (d, $J_{C\text{-}F}$ = 21.2 Hz), 101.2 (d, $J_{C\text{-}F}$ = 8.1 Hz), 96.9 (d, $J_{C\text{-}F}$ = 26.3 Hz), 56.1-53.6 (m), 21.6, 19.6. **HRMS (ESI):** $[M+H]^+$ calcd for $C_{15}H_{11}D_3F_2IO$ 378.0240, found 378.0240.

Chiral HPLC: CHIRALPAK OX-H, 25 °C, iPrOH-hexanes 1.0/99.0, 1.0 mL/min, 247 nm. t_R(major) = 8.8 min, t_R(minor) = 12.7 min.

$[\alpha]_D^{25}$ = -3.8° (c = 1.0, CH_2Cl_2)





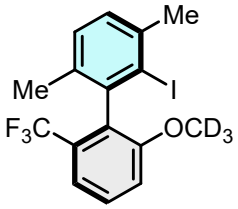
Signal: DAD1A,Sig=254,4 Ref=off

RT [min]	Area	Area%
8.193	35.70	45.38
11.280	42.97	54.62
Sum	78.67	

Signal: DAD1A,Sig=247,4 Ref=off

RT [min]	Area	Area%
8.783	3400.34	88.93
12.697	423.45	11.07
Sum	3823.80	

(*R*)-2-iodo-2'-(methoxy-d_3)-3,6-dimethyl-6'-(trifluoromethyl)-1,1'-biphenyl (2i)



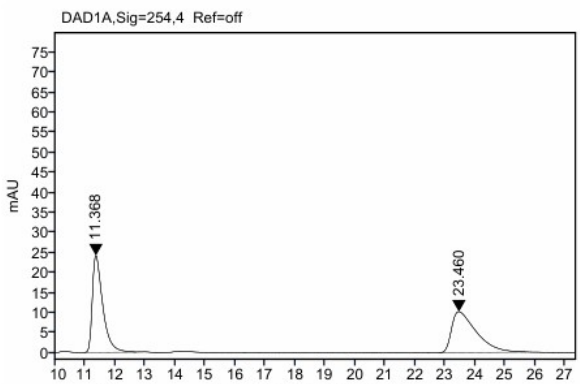
This compound was prepared according to the **General procedure A** from the reaction of **1i** (104.8 mg, 0.2 mmol).

75.5 mg, 88% yield, 40% ee, white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.54 – 7.45 (m, 1H), 7.41 – 7.35 (m, 1H), 7.15 (dd, *J* = 15.2, 7.4 Hz, 3H), 2.48 (s, 3H), 1.98 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$) δ** 157.0, 140.1, 139.0, 135.5, 132.6, 129.2, 129.0, 128.8, 123.5 (q, $J_{C\text{-}F}$ = 275.7 Hz), 118.3 (q, $J_{C\text{-}F}$ = 6.1 Hz), 114.5, 108.4, 57.2-53.7 (m), 29.3, 21.1. **HRMS (ESI):** $[M+H]^+$ calcd for $C_{16}H_{12}D_3F_3IO$ 410.0302, found 410.0306.

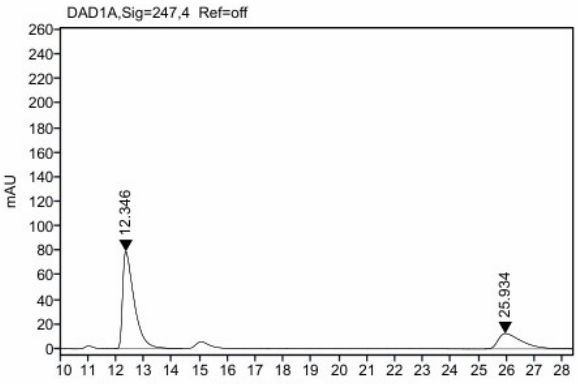
Chiral HPLC: CHIRALPAK OX-H, 25 °C, iPrOH-hexanes 1.0/99.0, 1.0 mL/min, 247 nm. t_R(major) = 12.3 min, t_R(minor) = 25.9 min.

$[\alpha]_D^{25}$ = -6.8° (c = 1.2, CH_2Cl_2)



Signal: DAD1A,Sig=254,4 Ref=off

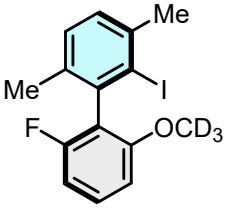
RT [min]	Area	Area%
11.368	583.89	50.08
23.460	582.00	49.92
Sum	1165.89	



Signal: DAD1A,Sig=247,4 Ref=off

RT [min]	Area	Area%
12.346	2284.10	75.41
25.934	744.80	24.59
Sum	3028.90	

(*R*)-2'-fluoro-2-iodo-6'-(methoxy-d_3)-3,6-dimethyl-1,1'-biphenyl (2j)



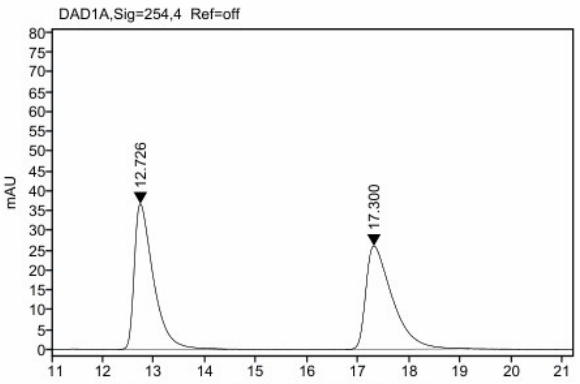
This compound was prepared according to the **General procedure A** from the reaction of **1j** (98.8 mg, 0.2 mmol).

63.2 mg, 88% yield, 40% ee, white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.30 (t, *J* = 7.9 Hz, 1H), 7.19 (dd, *J* = 8.4, 5.6 Hz, 1H), 6.98 – 6.89 (m, 2H), 6.83 (d, *J* = 8.2 Hz, 1H), 1.99 (s, 3H), 1.90 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$) δ** 160.3 (d, $J_{C\text{-}F}$ = 243.4 Hz), 156.1, 144.4, 136.9, 133.4 (d, $J_{C\text{-}F}$ = 3.0 Hz), 131.7, 130.7 (d, $J_{C\text{-}F}$ = 8.1 Hz), 128.9, 122.5, 113.7 (d, $J_{C\text{-}F}$ = 24.2 Hz), 108.5, 88.8 (d, $J_{C\text{-}F}$ = 24.2 Hz), 55.1-53.3 (m), 20.5, 19.3. **HRMS (ESI):** $[M+H]^+$ calcd for $C_{15}H_{12}D_3FIO$ 360.0334, found 360.0339.

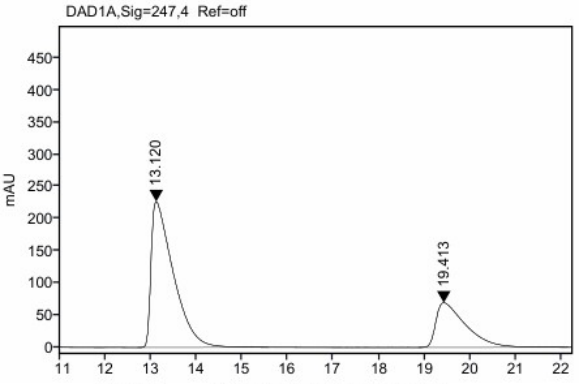
Chiral HPLC: CHIRALPAK OX-H, 25 °C, iPrOH-hexanes 1.0/99.0, 1.0 mL/min, 247 nm. t_R(major) = 13.1 min, t_R(minor) = 19.4 min.

$[\alpha]_D^{25}$ = -4.0° (c = 1.3, CH_2Cl_2)



Signal: DAD1A,Sig=254,4 Ref=off

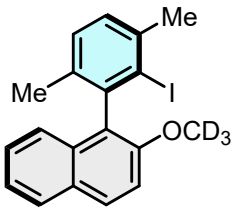
RT [min]	Area	Area%
12.726	946.30	50.23
17.300	937.78	49.77
Sum	1884.08	



Signal: DAD1A,Sig=247,4 Ref=off

RT [min]	Area	Area%
13.120	7657.44	70.87
19.413	3147.01	29.13
Sum	10804.46	

(*R*)-1-(2-iodo-3,6-dimethylphenyl)-2-(methoxy-d_3)naphthalene (2k)



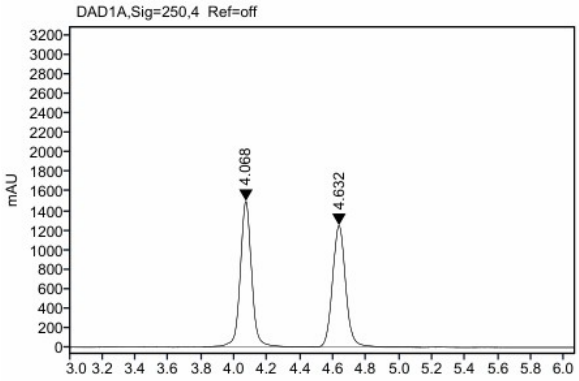
This compound was prepared according to the **General procedure A** from the reaction of **1k** (101.2 mg, 0.2 mmol).

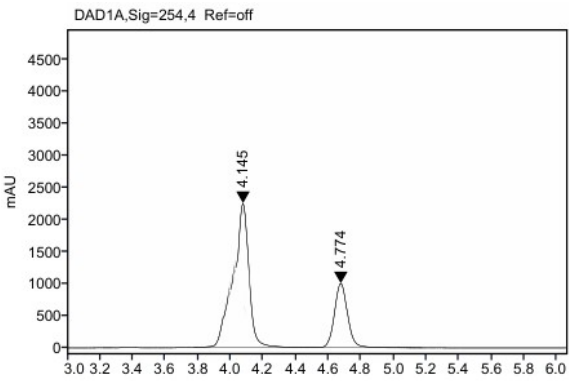
61.0 mg, 78% yield, 42% ee, white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.94 (d, *J* = 9.0 Hz, 1H), 7.88 – 7.80 (m, 1H), 7.37 (d, *J* = 9.1 Hz, 1H), 7.35 – 7.28 (m, 2H), 7.23 – 7.19 (m, 2H), 7.14 – 7.07 (m, 1H), 2.52 (s, 3H), 1.92 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$) δ** 153.1, 141.7, 139.6, 136.0, 132.3, 129.4, 129.4, 129.0, 128.6, 128.0, 127.9, 126.7, 124.1, 123.6, 113.6, 109.4, 57.5-55.6 (m), 29.53, 21.10. **HRMS (ESI):** $[M+H]^+$ calcd for $C_{19}H_{15}D_3IO$ 392.0585, found 392.0582.

Chiral HPLC: CHIRALPAK OX-H, 25 °C, iPrOH-hexanes 3.0/97.0, 1.0 mL/min, 250 nm. t_R(major) = 4.1 min, t_R(minor) = 4.7 min.

$[\alpha]_D^{25}$ = +24.1° (c = 1.3, CH_2Cl_2)





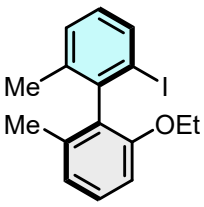
Signal: DAD1A,Sig=250,4 Ref=off

RT [min]	Area	Area%
4.068	7137.75	50.64
4.632	6957.61	49.36
Sum	14095.36	

Signal: DAD1A,Sig=254,4 Ref=off

RT [min]	Area	Area%
4.145	17989.88	71.09
4.774	7321.65	28.91
Sum	25311.53	

(*R*)-2-ethoxy-2'-iodo-6,6'-dimethyl-1,1'-biphenyl (3a)



This compound was prepared according to the **General procedure A** from the reaction of **1a** (91.2 mg, 0.2 mmol), but EtOH (0.1 mL) instead of CD_3OD.

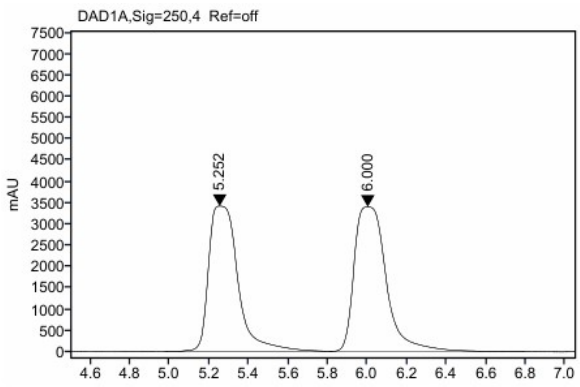
65.4 mg, 93% yield, 96% ee, white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.68 (d, *J* = 7.9 Hz, 1H), 7.21 – 7.17 (m, 1H), 7.17 – 7.13 (m, 1H), 6.85 (t, *J* = 7.7 Hz, 1H), 6.81 (d, *J* = 7.6 Hz, 1H), 6.73 (d, *J* = 8.2 Hz, 1H), 3.91 (q, *J* = 7.0 Hz, 2H), 1.94 (s, 3H), 1.85 (s, 3H), 1.12 (t, *J* = 7.0 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$) δ** 155.4, 142.6, 138.2, 137.0, 136.2, 133.1, 129.4, 128.5, 128.4, 122.2, 109.6, 101.7, 63.7, 21.3, 19.5, 14.8. **HRMS (ESI):** $[M+H]^+$ calcd for $C_{16}H_{18}IO$ 353.0397, found 353.0401.

Chiral HPLC: CHIRALPAK OX-H, 25 °C, iPrOH-hexanes 1.0/99.0, 1.0 mL/min, 250 nm. t_R(major)

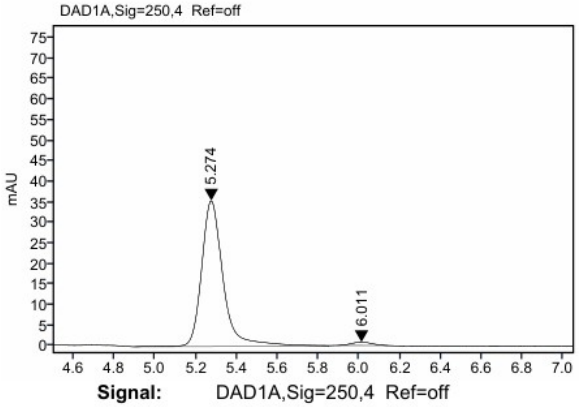
= 5.3 min, t_R(minor) = 6.0 min.

$[\alpha]_D^{25}$ = -12.6° (c = 1.3, CH_2Cl_2)



Signal: DAD1A,Sig=250,4 Ref=off

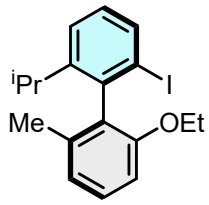
RT [min]	Area	Area%
5.252	35784.27	47.99
6.000	38784.40	52.01
Sum	74568.67	



Signal: DAD1A,Sig=250,4 Ref=off

RT [min]	Area	Area%
5.274	263.99	97.88
6.011	5.72	2.12
Sum	269.71	

(*R*)-2-ethoxy-2'-iodo-6'-isopropyl-6-methyl-1,1'-biphenyl (3b)



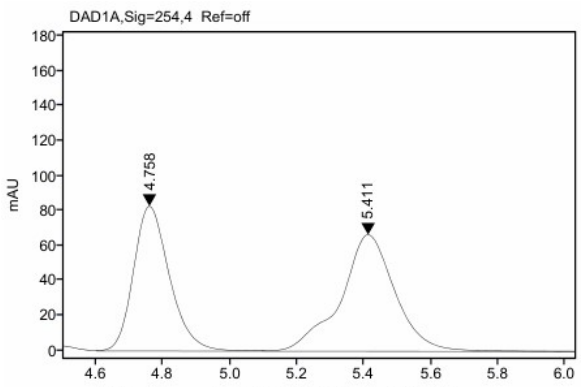
This compound was prepared according to the **General procedure A** from the reaction of **1b** (96.8 mg, 0.2 mmol), but EtOH (0.1 mL) instead of CD_3OD.

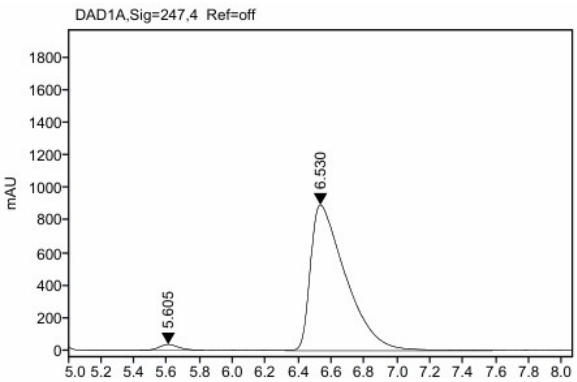
66.9 mg, 88% yield, 99% ee, white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.82 – 7.70 (m, 1H), 7.36 (t, *J* = 8.0 Hz, 1H), 7.30 – 7.18 (m, 1H), 7.00 (dd, *J* = 7.9, 1.1 Hz, 1H), 6.92 (t, *J* = 7.7 Hz, 1H), 6.79 (dd, *J* = 8.2, 1.1 Hz, 1H), 4.05 – 3.91 (m, 2H), 2.50 – 2.33 (m, 1H), 2.04 (s, 3H), 1.23 – 1.16 (m, 6H), 1.06 (d, *J* = 6.9 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$) δ** 155.2, 147.5, 142.4, 138.6, 136.2, 132.0, 129.3, 128.9, 128.4, 117.7, 109.3, 102.6, 63.8, 30.2, 24.0, 23.9, 21.7, 14.7. **HRMS (ESI):** $[M+H]^+$ calcd for $C_{18}H_{22}IO$ 381.0710, found 381.0709.

Chiral HPLC: CHIRALPAK OX-H, 25 °C, iPrOH-hexanes 1.0/99.0, 1.0 mL/min, 254 nm. t_R(minor) = 5.6 min, t_R(major) = 6.5 min.

$[\alpha]_D^{25}$ = -53.0° (c = 1.5, CH_2Cl_2)





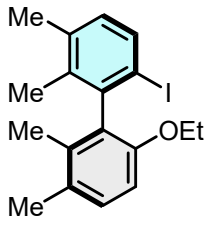
Signal: DAD1A,Sig=254,4 Ref=off

RT [min]	Area	Area%
4.758	622.51	45.18
5.411	755.33	54.82
Sum	1377.84	

Signal: DAD1A,Sig=247,4 Ref=off

RT [min]	Area	Area%
5.605	277.92	2.03
6.530	13435.36	97.97
Sum	13713.29	

(*R*)-6-ethoxy-6'-iodo-2,2',3,3'-tetramethyl-1,1'-biphenyl (3c)



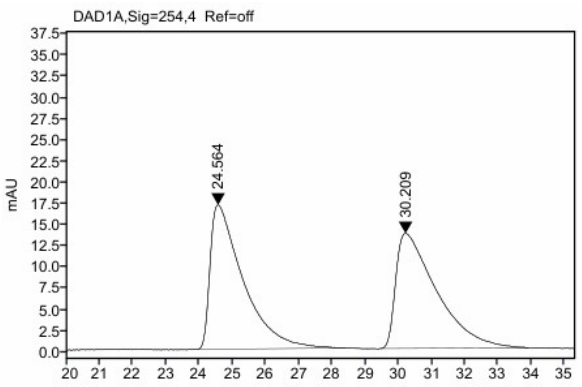
This compound was prepared according to the **General procedure A** from the reaction of **1c** (96.8 mg, 0.2 mmol), but EtOH (0.1 mL) instead of CD_3OD.

61.0 mg, 80% yield, 97% ee, white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.65 (d, *J* = 7.9 Hz, 1H), 7.13 (d, *J* = 8.3 Hz, 1H), 6.84 (d, *J* = 8.0 Hz, 1H), 6.72 (d, *J* = 8.3 Hz, 1H), 4.03 – 3.89 (m, 2H), 2.27 (s, 3H), 2.26 (s, 3H), 1.93 (s, 3H), 1.80 (s, 3H), 1.21 – 1.11 (m, 3H). **^{13}C NMR (101 MHz, $CDCl_3$) δ** 153.7, 142.7, 136.9, 136.4, 135.5, 135.5, 134.1, 130.1, 129.3, 128.6, 109.5, 98.6, 63.8, 20.3, 19.8, 17.8, 16.1, 14.8. **HRMS (ESI):** $[M+H]^+$ calcd for $C_{18}H_{22}IO$ 381.0710, found 381.0709.

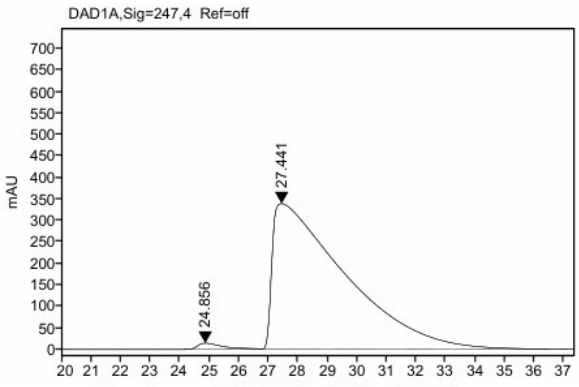
Chiral HPLC: CHIRALPAK OX-H, 25 °C, iPrOH-hexanes 1.0/99.0, 1.0 mL/min, 247 nm. t_R(minor) = 24.8 min, t_R(major) = 27.4 min.

$[\alpha]_D^{25}$ = -16.0° (c = 1.2, CH_2Cl_2)



Signal: DAD1A,Sig=254,4 Ref=off

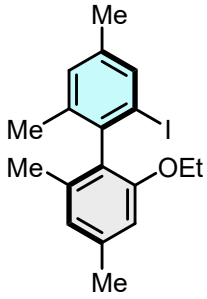
RT [min]	Area	Area%
24.564	1173.01	50.36
30.209	1156.20	49.64
Sum	2329.21	



Signal: DAD1A,Sig=247,4 Ref=off

RT [min]	Area	Area%
24.856	915.58	1.55
27.441	58299.15	98.45
Sum	59214.74	

(*R*)-2-ethoxy-2'-iodo-4,4',6,6'-tetramethyl-1,1'-biphenyl (3d)



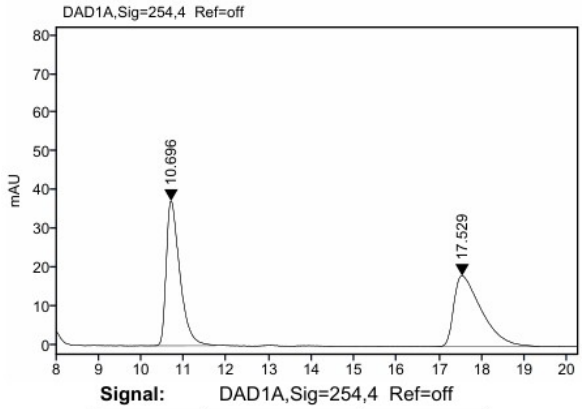
This compound was prepared according to the **General procedure A** from the reaction of **1d** (96.8 mg, 0.2 mmol), but EtOH (0.1 mL) instead of CD_3OD.

68.4 mg, 82% yield, 82% ee, white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.59 (s, 1H), 7.03 (s, 1H), 6.71 (s, 1H), 6.62 (s, 1H), 3.98 (q, *J* = 7.1 Hz, 2H), 2.37 (s, 3H), 2.30 (s, 3H), 1.97 (s, 3H), 1.88 (s, 3H), 1.20 (t, *J* = 7.0 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$) δ** 155.5, 139.6, 138.2, 138.1, 137.8, 136.8, 136.7, 130.4, 130.2, 122.9, 110.6, 102.1, 63.7, 21.7, 21.3, 20.5, 19.5, 14.9. **HRMS (ESI):** $[M+H]^+$ calcd for $C_{18}H_{22}IO$ 381.0710, found 381.0709.

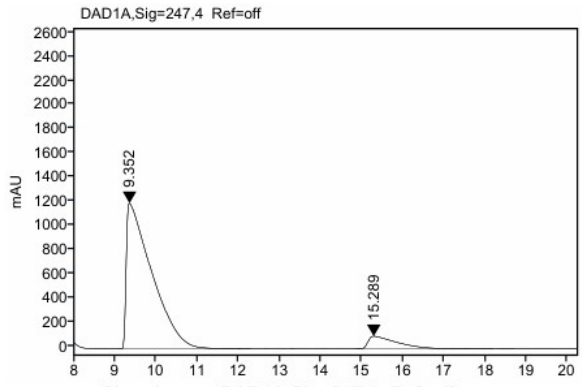
Chiral HPLC: CHIRALPAK OX-H, 25 °C, iPrOH-hexanes 1.0/99.0, 1.0 mL/min, 247 nm. t_R(major) = 9.3 min, t_R(minor) = 15.3 min.

$[\alpha]_D^{25}$ = -7.0° (c = 1.2, CH_2Cl_2)



Signal: DAD1A,Sig=254,4 Ref=off

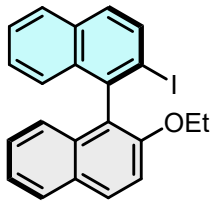
RT [min]	Area	Area%
10.696	832.10	50.17
17.529	826.38	49.83
Sum	1658.48	



Signal: DAD1A,Sig=247,4 Ref=off

RT [min]	Area	Area%
9.352	51904.01	91.02
15.289	5121.08	8.98
Sum	57025.09	

(*R*)-2-ethoxy-2'-iodo-1,1'-binaphthalene (3e)



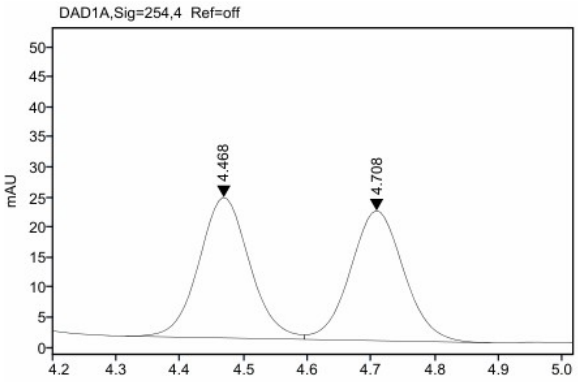
This compound was prepared according to the **General procedure A** from the reaction of **1e** (105.6 mg, 0.2 mmol), but EtOH (0.1 mL) instead of CD_3OD.

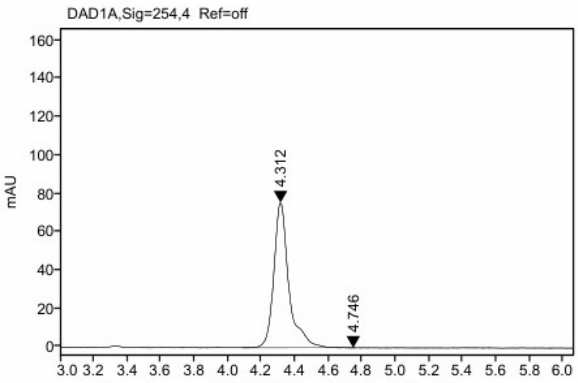
70.4 mg, 83% yield, >99% ee, white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.02 (dd, *J* = 15.6, 8.9 Hz, 2H), 7.88 (d, *J* = 8.2 Hz, 2H), 7.65 (d, *J* = 8.8 Hz, 1H), 7.49 – 7.39 (m, 2H), 7.36 – 7.31 (m, 1H), 7.25 – 7.14 (m, 3H), 6.97 (d, *J* = 7.5 Hz, 1H), 4.17 – 4.05 (m, 2H), 1.12 (t, *J* = 7.0 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$) δ** 135.6, 129.9, 128.9, 128.0, 126.9, 126.7, 126.1, 124.7, 123.7, 115.2, 64.9, 15.1. **HRMS (ESI):** $[M+H]^+$ calcd for $C_{22}H_{18}IO$ 425.0397, found 425.0394.

Chiral HPLC: CHIRALPAK OX-H, 25 °C, iPrOH-hexanes 2.0/98.0, 1.0 mL/min, 254 nm. t_R(major) = 4.3 min, t_R(minor) = 4.7 min.

$[\alpha]_D^{25}$ = -17.6° (c = 1.5, CH_2Cl_2)





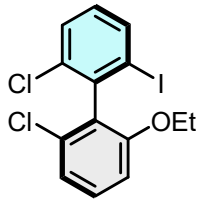
Signal: DAD1A,Sig=254,4 Ref=off

RT [min]	Area	Area%
4.468	129.45	50.69
4.708	125.94	49.31
Sum	255.39	

Signal: DAD1A,Sig=254,4 Ref=off

RT [min]	Area	Area%
4.312	472.64	99.98
4.746	0.08	0.02
Sum	472.72	

(*R*)-2,2'-dichloro-6-ethoxy-6'-iodo-1,1'-biphenyl (3f)



This compound was prepared according to the **General procedure A** from the reaction of **1g** (99.4 mg, 0.2 mmol), but EtOH (0.1 mL) instead of CD_3OD.

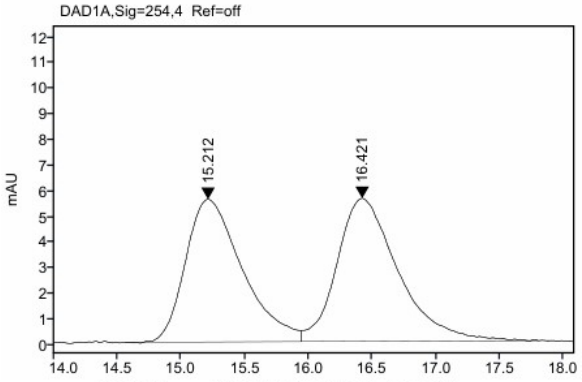
62.9 mg, 80% yield, 71% ee, white solid.

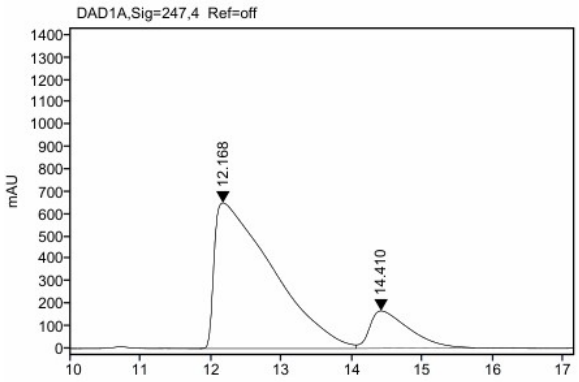
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.83 (dd, *J* = 7.9, 1.1 Hz, 1H), 7.46 (dd, *J* = 8.0, 1.2 Hz, 1H), 7.32 (t, *J* = 8.2 Hz, 1H), 7.10 (dd, *J* = 8.0, 1.0 Hz, 1H), 7.00 (t, *J* = 8.0 Hz, 1H), 6.89 (dd, *J* = 8.4, 0.9 Hz, 1H), 4.10 – 3.98 (m, 2H), 1.24 (t, *J* = 7.0 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$) δ** 156.9, 140.0, 137.2, 134.2, 134.0, 131.0, 130.1, 130.0, 129.1, 121.3, 110.5, 101.1, 64.5, 14.6. **HRMS (ESI):** $[M+H]^+$ calcd for $C_{14}H_{12}Cl_2IO$ 392.9304, found 392.9300.

Chiral HPLC: CHIRALPAK OX-H, 25 °C, iPrOH-hexanes 1.0/99.0, 1.0 mL/min, 247 nm. t_R(major)

= 12.2 min, t_R(major) = 14.7 min.

$[\alpha]_D^{25}$ = -36.3° (c = 1.2, CH_2Cl_2)





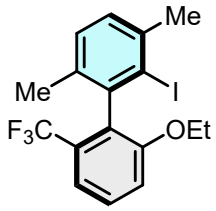
Signal: DAD1A,Sig=254,4 Ref=off

RT [min]	Area	Area%
15.212	172.15	48.12
16.421	185.57	51.88
Sum	357.73	

Signal: DAD1A,Sig=247,4 Ref=off

RT [min]	Area	Area%
12.168	37320.48	85.25
14.410	6456.30	14.75
Sum	43776.78	

(*R*)-2'-ethoxy-2-iodo-3,6-dimethyl-6'-(trifluoromethyl)-1,1'-biphenyl (3g)



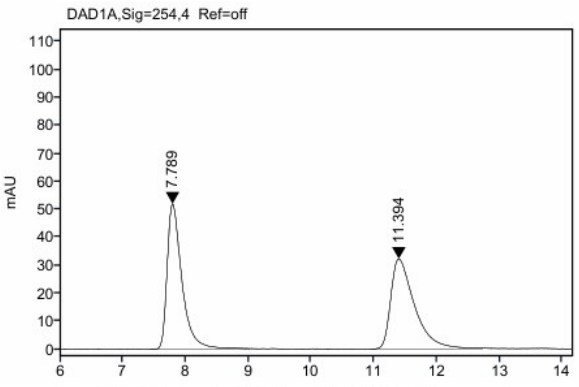
This compound was prepared according to the **General procedure A** from the reaction of **1i** (104.8 mg, 0.2 mmol), but EtOH (0.1 mL) instead of CD_3OD.

44.0 mg, 96% yield, 61% ee, white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.51 – 7.43 (m, 1H), 7.35 (d, *J* = 7.2 Hz, 1H), 7.18 – 7.06 (m, 3H), 4.08 – 3.97 (m, 2H), 2.47 (s, 3H), 1.97 (s, 3H), 1.20 (t, *J* = 7.0 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$) δ** 156.2, 140.2, 138.8, 135.5, 132.9, 129.4, 129.1, 128.9, 128.6, 123.5 (q, J_{C-F} = 275.7 Hz), 118.0 (q, J_{C-F} = 5.1 Hz), 115.4, 108.4, 64.3, 29.4, 21.1, 14.5. **HRMS (ESI):** $[M+H]^+$ calcd for $C_{17}H_{17}F_3IO$ 421.0271, found 421.0274.

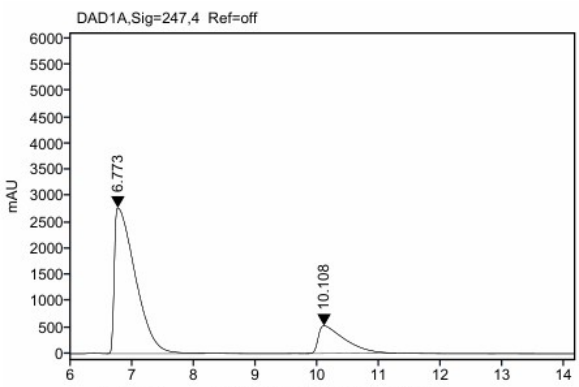
Chiral HPLC: CHIRALPAK OX-H, 25 °C, iPrOH-hexanes 1.0/99.0, 1.0 mL/min, 247 nm. t_R(major) = 6.7 min, t_R(minor) = 10.1 min.

$[\alpha]_D^{25}$ = -44.3° (c = 1.3, CH_2Cl_2)



Signal: DAD1A,Sig=254,4 Ref=off

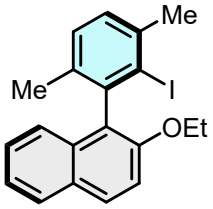
RT [min]	Area	Area%
7.789	847.40	50.09
11.394	844.38	49.91
Sum	1691.78	



Signal: DAD1A,Sig=247,4 Ref=off

RT [min]	Area	Area%
6.773	65511.50	80.74
10.108	15624.12	19.26
Sum	81135.62	

(*R*)-2-ethoxy-1-(2-iodo-3,6-dimethylphenyl)naphthalene (3h)



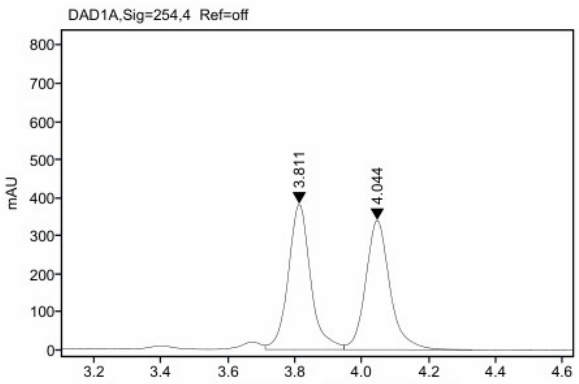
This compound was prepared according to the **General procedure A** from the reaction of **1k** (101.2 mg, 0.2 mmol), but EtOH (0.1 mL) instead of CD_3OD.

67.7 mg, 94% yield, 33% ee, white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.90 (d, *J* = 9.0 Hz, 1H), 7.87 – 7.80 (m, 1H), 7.38 – 7.29 (m, 3H), 7.19 (s, 2H), 7.13 – 7.07 (m, 1H), 4.23 – 4.08 (m, 2H), 2.52 (s, 3H), 1.92 (s, 3H), 1.25 (t, *J* = 7.0 Hz, 3H). **^{13}C NMR (101 MHz, $CDCl_3$) δ** δ 152.5, 141.8, 139.4, 136.0, 132.5, 129.2, 129.0, 128.5, 128.4, 128.0, 127.9, 126.5, 124.2, 123.6, 114.9, 109.4, 64.6, 29.5, 21.1, 15.2. **HRMS (ESI):** $[M+H]^+$ calcd for $C_{20}H_{20}IO$ 403.0553, found 403.0556.

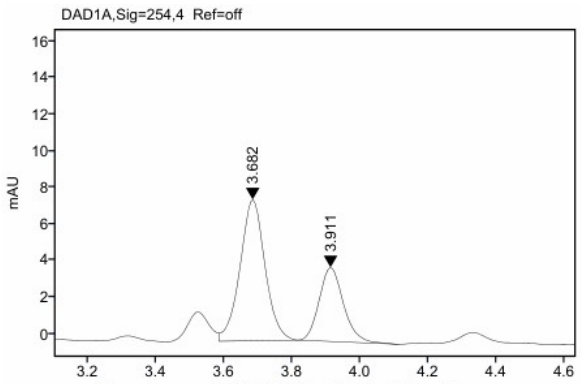
Chiral HPLC: CHIRALPAK OX-H, 25 °C, iPrOH-hexanes 2.0/98.0, 1.0 mL/min, 254 nm. t_R(major) = 3.7 min, t_R(minor) = 3.9 min.

$[\alpha]_D^{25}$ = +5.8° (c = 1.1, CH_2Cl_2)



Signal: DAD1A,Sig=254,4 Ref=off

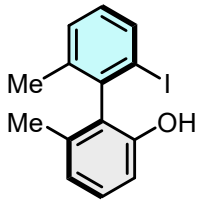
RT [min]	Area	Area%
3.811	1769.71	50.92
4.044	1705.87	49.08
Sum	3475.57	



Signal: DAD1A,Sig=254,4 Ref=off

RT [min]	Area	Area%
3.682	39.46	66.18
3.911	20.16	33.82
Sum	59.62	

(*R*)-2'-iodo-6,6'-dimethyl-[1,1'-biphenyl]-2-ol (3i)



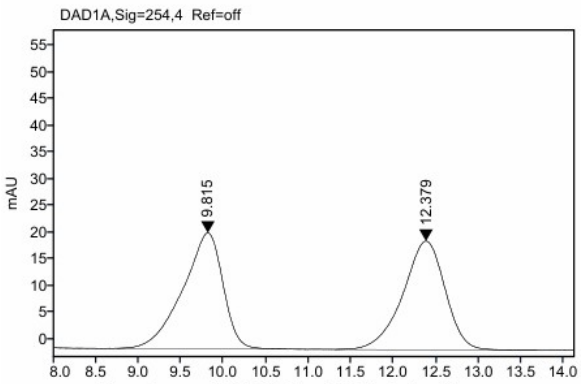
This compound was prepared according to the **General procedure B** from the reaction of **1a** (91.2 mg, 0.2 mmol).

64.1 mg, 99% yield, 99% ee, colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, *J* = 7.9 Hz, 1H), 7.25 (d, *J* = 7.6 Hz, 1H), 7.16 (t, *J* = 8.1 Hz, 1H), 6.96 (t, *J* = 7.8 Hz, 1H), 6.82 (d, *J* = 7.5 Hz, 1H), 6.78 (d, *J* = 8.1 Hz, 1H), 4.29 (s, 1H), 2.00 (s, 3H), 1.87 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$) δ** 151.8, 139.6, 139.5, 137.3, 136.8, 130.4, 130.2, 130.1, 129.1, 122.2, 112.9, 102.4, 21.3, 19.5. **HRMS (ESI):** $[M+H]^+$ calcd for $C_{14}H_{14}IO$ 325.0084, found 325.0081.

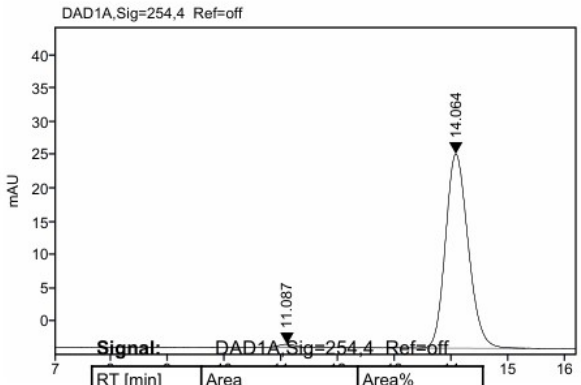
Chiral HPLC: CHIRALPAK OJ-H, 25 °C, iPrOH-hexanes 5.0/95.0, 1.0 mL/min, 254 nm. t_R(minor) = 11.1 min, t_R(major) = 14.1 min.

$[\alpha]_D^{25}$ = +10.5° (c = 1.0, CH_2Cl_2)



Signal: DAD1A,Sig=254,4 Ref=off

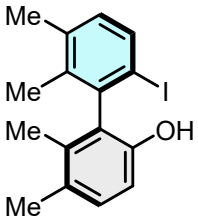
RT [min]	Area	Area%
9.815	712.95	50.27
12.379	705.30	49.73
Sum	1418.25	



Signal: DAD1A,Sig=254,4 Ref=off

RT [min]	Area	Area%
11.087	7.44	0.91
14.064	811.88	99.09
Sum	819.32	

(*R*)-6'-iodo-2',3',5,6-tetramethyl-[1,1'-biphenyl]-2-ol (3j)



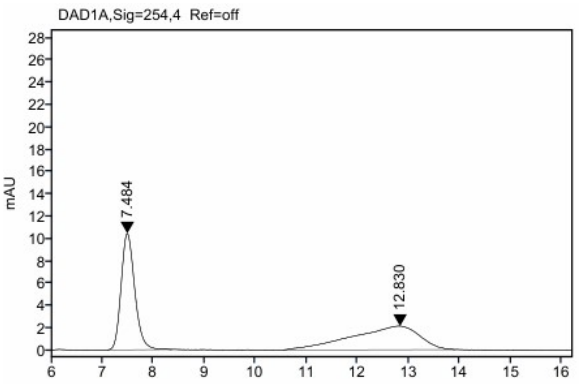
This compound was prepared according to the **General procedure B** from the reaction of **1c** (96.8 mg, 0.2 mmol).

69.7 mg, 99% yield, 97% ee, colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.72 (d, *J* = 8.0 Hz, 1H), 7.10 (d, *J* = 8.2 Hz, 1H), 6.92 (d, *J* = 8.0 Hz, 1H), 6.76 (d, *J* = 8.2 Hz, 1H), 4.26 (s, 1H), 2.29 (s, 3H), 2.25 (s, 3H), 1.98 (s, 3H), 1.82 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$) δ** 149.9, 139.7, 138.3, 137.7, 136.6, 134.8, 131.6, 131.0, 130.2, 128.5, 112.3, 99.0, 20.3, 19.8, 17.7, 16.2. **HRMS (ESI):** $[M+H]^+$ calcd for $C_{16}H_{18}IO$ 353.0397, found 353.0400.

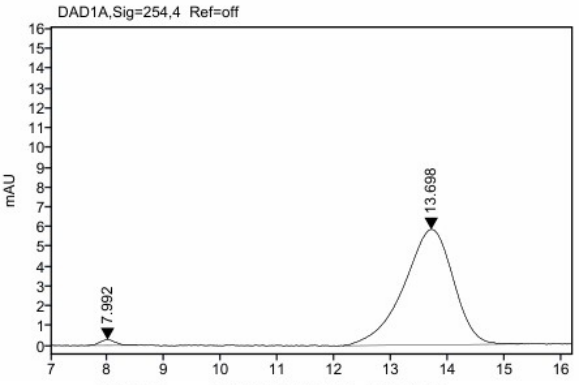
Chiral HPLC: CHIRALPAK OJ-H, 25 °C, iPrOH-hexanes 5.0/95.0, 1.0 mL/min, 254 nm. t_R(minor) = 8.0 min, t_R(major) = 13.7 min.

$[\alpha]_D^{25}$ = +21.2° (c = 1.01, CH_2Cl_2)



Signal: DAD1A,Sig=254,4 Ref=off

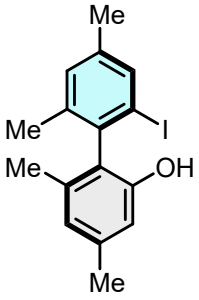
RT [min]	Area	Area%
7.484	193.13	49.95
12.830	193.49	50.05
Sum	386.62	



Signal: DAD1A,Sig=254,4 Ref=off

RT [min]	Area	Area%
7.992	5.58	1.55
13.698	354.27	98.45
Sum	359.84	

(*R*)-2'-iodo-4,4',6,6'-tetramethyl-[1,1'-biphenyl]-2-ol (3k)



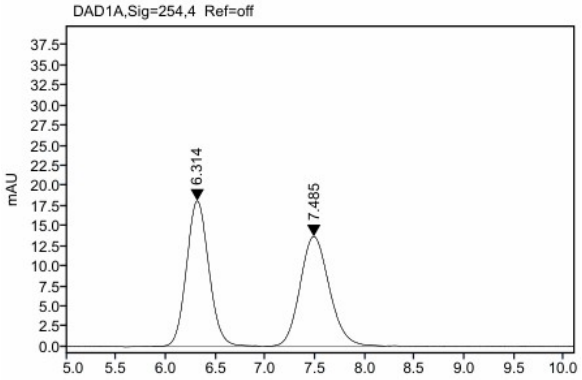
This compound was prepared according to the **General procedure B** from the reaction of **1d** (96.8 mg, 0.2 mmol).

64.1 mg, 91% yield, 90% ee, colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.67 (s, 1H), 7.12 (s, 1H), 6.70 (s, 1H), 6.67 (s, 1H), 4.36 (s, 1H), 2.34 (s, 3H), 2.32 (s, 3H), 2.03 (s, 3H), 1.90 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$) δ** 151.9, 140.1, 139.3, 139.1, 137.7, 136.5, 136.4, 131.4, 127.2, 123.0, 113.4, 102.8, 21.4, 21.3, 20.6, 19.5. **HRMS (ESI):** $[M+Na]^+$ calcd for $C_{16}H_{17}INaO$ 375.0216, found 375.0220.

Chiral HPLC: CHIRALPAK OJ-H, 25 °C, iPrOH-hexanes 5.0/95.0, 1.0 mL/min, 254 nm. t_R(minor) = 6.5 min, t_R(major) = 7.7 min.

$[\alpha]_D^{25}$ = -5.2° (c = 1.0, CH_2Cl_2)



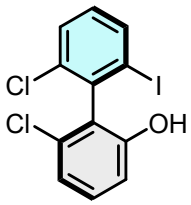
Signal: DAD1A,Sig=254,4 Ref=off

RT [min]	Area	Area%
6.314	283.16	50.44
7.485	278.26	49.56
Sum	561.41	

Signal: DAD1A,Sig=254,4 Ref=off

RT [min]	Area	Area%
6.523	36.32	5.39
7.767	638.00	94.61
Sum	674.31	

(*R*)-2',6-dichloro-6'-iodo-[1,1'-biphenyl]-2-ol (3l)



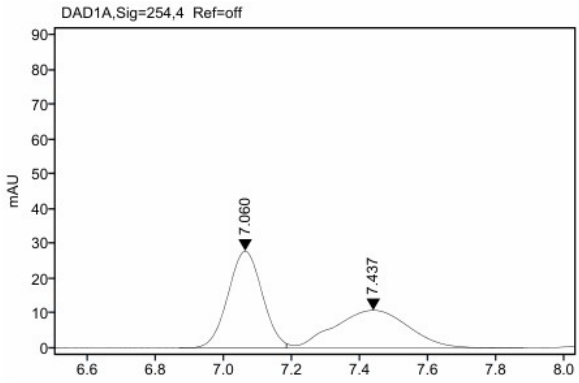
This compound was prepared according to the **General procedure B** from the reaction of **1g** (99.4 mg, 0.2 mmol).

67.9 mg, 93% yield, >99% ee, colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.90 (dd, *J* = 8.1, 1.1 Hz, 1H), 7.53 (dd, *J* = 8.1, 1.1 Hz, 1H), 7.28 (t, *J* = 8.1 Hz, 1H), 7.14 – 7.03 (m, 2H), 6.91 (d, *J* = 8.2 Hz, 1H), 4.81 (s, 1H). **^{13}C NMR (101 MHz, $CDCl_3$) δ** 153.2, 137.9, 137.8, 134.9, 133.9, 131.3, 130.5, 129.8, 128.6, 121.7, 114.4, 101.6. **HRMS (ESI):** $[M+H]^+$ calcd for $C_{12}H_8Cl_2IO$ 364.8991, found 364.8990.

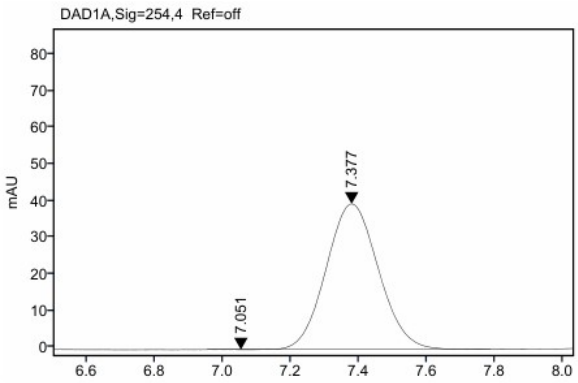
Chiral HPLC: CHIRALPAK AD-H, 25 °C, iPrOH-hexanes 10.0/90.0, 1.0 mL/min, 254 nm. t_R(minor) = 7.0 min, t_R(major) = 7.4 min.

$[\alpha]_D^{25}$ = -50.8° (c = 1.5, CH_2Cl_2)



Signal: DAD1A,Sig=254,4 Ref=off

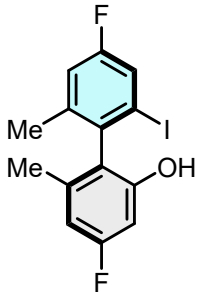
RT [min]	Area	Area%
7.060	194.72	54.00
7.437	165.90	46.00
Sum	360.62	



Signal: DAD1A,Sig=254,4 Ref=off

RT [min]	Area	Area%
7.051	0.02	0.01
7.377	427.55	99.99
Sum	427.57	

(*R*)-4,4'-difluoro-2'-iodo-6,6'-dimethyl-[1,1'-biphenyl]-2-ol (3m)



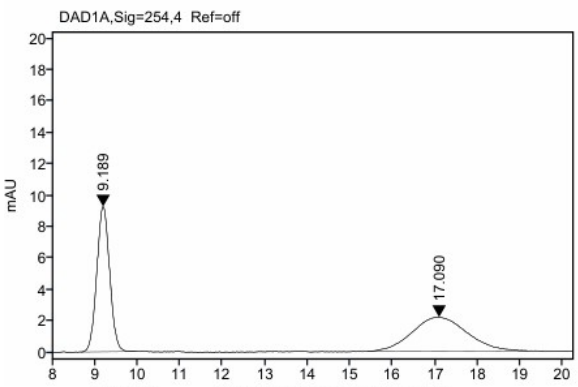
This compound was prepared according to the **General procedure B** from the reaction of **1h** (98.4 mg, 0.2 mmol).

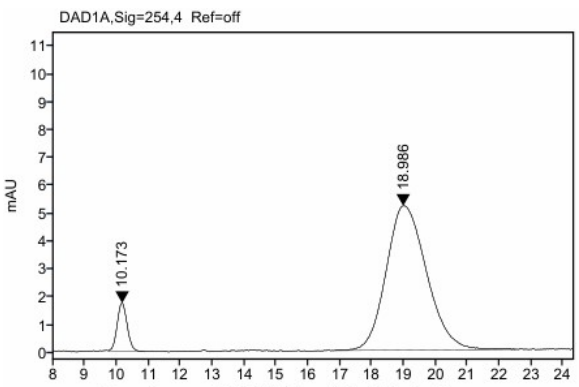
67.7 mg, 94% yield, 85% ee, colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.58 (dd, *J* = 7.8, 2.6 Hz, 1H), 7.08 (dd, *J* = 9.0, 2.7 Hz, 1H), 6.63 (dd, *J* = 9.3, 2.6 Hz, 1H), 6.58 (dd, *J* = 9.8, 2.6 Hz, 1H), 4.59 (s, 1H), 2.07 (s, 3H), 1.91 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$) δ** 163.7 (d, $J_{C\text{-}F}$ = 114.1 Hz), 161.3 (d, $J_{C\text{-}F}$ = 121.2 Hz), 153.2 (d, $J_{C\text{-}F}$ = 12.1 Hz), 141.4 (d, $J_{C\text{-}F}$ = 8.1 Hz), 138.8 (d, $J_{C\text{-}F}$ = 10.1 Hz), 134.8 (d, $J_{C\text{-}F}$ = 4.0 Hz), 125.1 (d, $J_{C\text{-}F}$ = 4.0 Hz), 124.4 (d, $J_{C\text{-}F}$ = 23.2 Hz), 117.6 (d, $J_{C\text{-}F}$ = 21.2 Hz), 109.3 (d, $J_{C\text{-}F}$ = 21.2 Hz), 102.2 (d, $J_{C\text{-}F}$ = 9.1 Hz), 100.7 (d, $J_{C\text{-}F}$ = 25.2 Hz), 21.5, 19.7.

HRMS (ESI): $[M+H]^+$ calcd for $C_{14}H_{12}F_2IO$ 360.9895, found 360.9899.

Chiral HPLC: CHIRALPAK OJ-H, 25 °C, iPrOH-hexanes 5.0/95.0, 1.0 mL/min, 254 nm. t_R(minor) = 10.2 min, t_R(major) = 19.0 min.





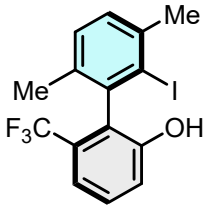
Signal: DAD1A,Sig=254,4 Ref=off

RT [min]	Area	Area%
9.189	195.05	50.27
17.090	192.98	49.73
Sum	388.03	

Signal: DAD1A,Sig=254,4 Ref=off

RT [min]	Area	Area%
10.173	37.53	7.59
18.986	456.72	92.41
Sum	494.25	

(*R*)-2'-iodo-3',6'-dimethyl-6-(trifluoromethyl)-[1,1'-biphenyl]-2-ol (3n)



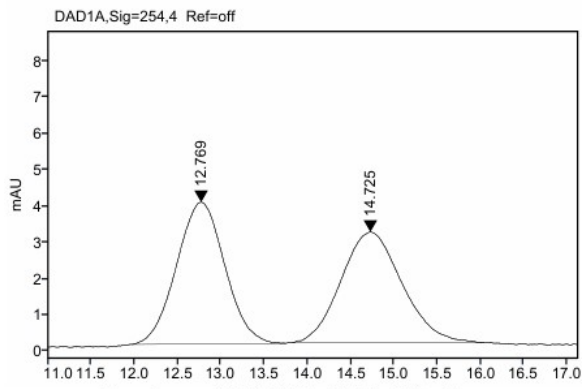
This compound was prepared according to the **General procedure B** from the reaction of **1i** (104.8 mg, 0.2 mmol).

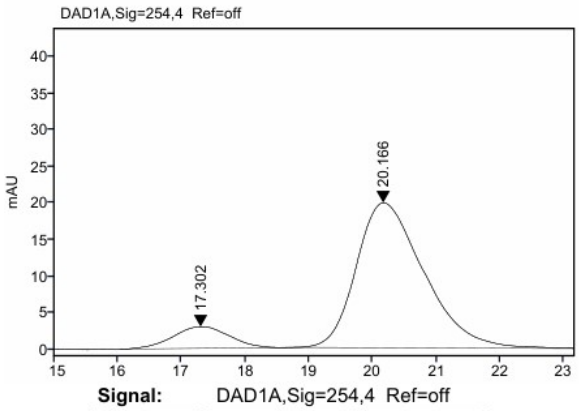
75.2 mg, 96% yield, 78% ee, colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.45 (t, *J* = 8.0 Hz, 1H), 7.40 – 7.34 (m, 1H), 7.26 – 7.17 (m, 3H), 4.76 (s, 1H), 2.49 (s, 3H), 2.03 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$) δ** 152.8, 140.7, 137.0, 130.4, 130.1, 129.7, 129.2, 129.0, 128.7, 123.5 (q, J_{C-F} = 275.73 Hz), 119.4, 118.7 (q, J_{C-F} = 5.1 Hz), 108.z9, 29.4, 21.0. **HRMS (ESI):** $[M+H]^+$ calcd for $C_{15}H_{13}F_3IO$ 392.9958, found 392.9951.

Chiral HPLC: CHIRALPAK OJ-H, 25 °C, iPrOH-hexanes 5.0/95.0, 1.0 mL/min, 254 nm. t_R(minor) = 17.3 min, t_R(major) = 20.2 min.

$[\alpha]_D^{25}$ = -42.1° (c = 1.2, CH_2Cl_2)





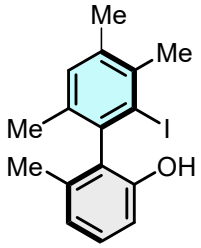
Signal: DAD1A,Sig=254,4 Ref=off

RT [min]	Area	Area%
12.769	151.39	50.23
14.725	150.01	49.77
Sum	301.40	

Signal: DAD1A,Sig=254,4 Ref=off

RT [min]	Area	Area%
17.302	181.33	11.03
20.166	1462.24	88.97
Sum	1643.57	

(*R*)-2'-iodo-3',4',6,6'-tetramethyl-[1,1'-biphenyl]-2-ol (3o)[2]

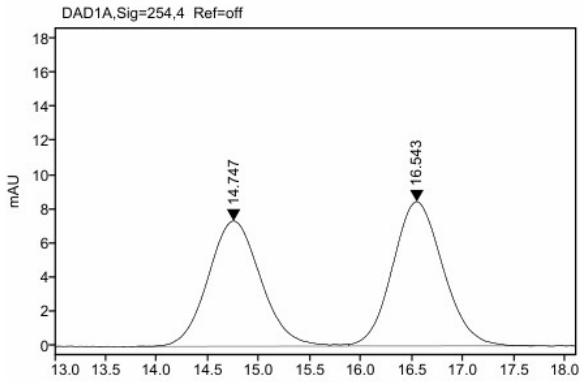


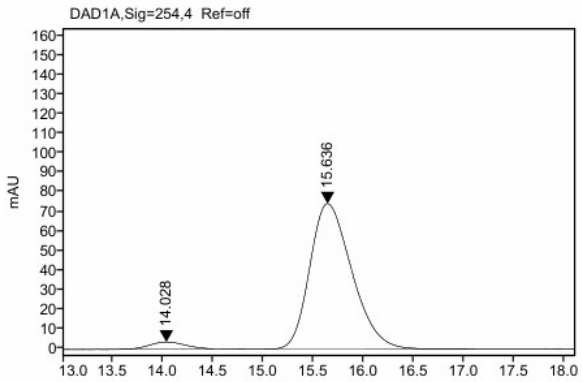
This compound was prepared according to the **General procedure B** from the reaction of **1l** (96.8 mg, 0.2 mmol).

56.3 mg, 80% yield, 92% ee, colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.21 (t, *J* = 7.9 Hz, 1H), 7.09 (s, 1H), 6.85 (dd, *J* = 12.9, 7.7 Hz, 2H), 4.45 (s, 1H), 2.49 (s, 3H), 2.39 (s, 3H), 1.99 (s, 3H), 1.92 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$) δ** 151.9, 138.7, 137.6, 137.4, 136.8, 136.1, 132.2, 131.7, 128.8, 122.1, 112.7, 110.6, 26.3, 21.8, 20.8, 19.6. **HRMS (ESI):** $[M+Na]^+$ calcd for $C_{16}H_{17}INaO$ 375.0216 found 375.0210.

Chiral HPLC: CHIRALPAK OJ-H, 25 °C, iPrOH-hexanes 5.0/95.0, 1.0 mL/min, 254 nm. t_R(minor) = 14.0 min, t_R(major) = 15.6 min.





Signal: DAD1A,Sig=254,4 Ref=off

RT [min]	Area	Area%
14.747	263.21	47.54
16.543	290.46	52.46
Sum	553.67	

Signal: DAD1A,Sig=254,4 Ref=off

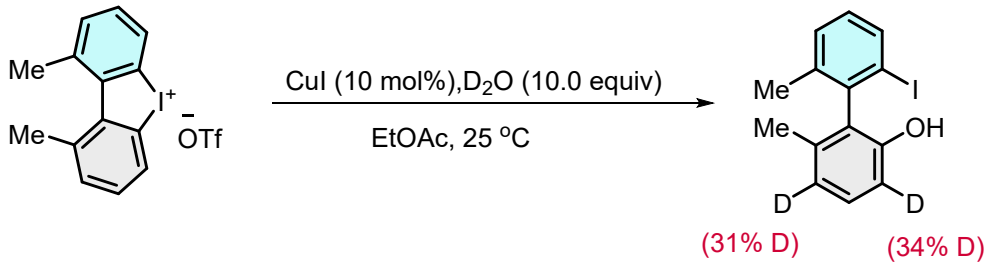
RT [min]	Area	Area%
14.028	89.58	3.94
15.636	2185.20	96.06
Sum	2274.78	

4. Gram-scale reaction and Control Experiment

4.1 Gram-scale reaction

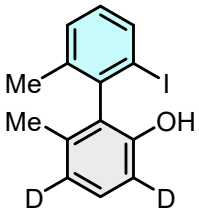
To a 50 mL reaction tube with a stir bar was charged with CuSCN (41.5 mg, 10 mol%, 0.16 mmol), **L4** (175.0 mg, 11 mol%, 0.182 mmol) and cyclic diaryliodonium salts **1a** (1.50 g, 3.3 mmol), The tube was sealed with rubber septum, then evacuated and backfilled with nitrogen for three cycles, CD_3OD (1.6 mL, 2.0 M) was added. The reaction mixture was stirred at appreciate temperature for 6 h. The reaction mixture was quenched with water (20.0 mL), and extracted with ethyl acetate (3 × 15.0 mL). The combined organic layers were washed with water, brine, dried over anhydrous Na_2SO_4, and concentrated under reduced pressure. The residue was purified by flash chromatography on silica gel to afford the desired product **2a** in 1.05g (93% yield, 96% ee).

4.2 Deuterium experiment



To a 5 mL reaction tube with a stir bar was charged with CuI (3.8 mg, 10 mol %, 0.01 mmol), D_2O (36 μL, 10.0 equiv, 2.0 mmol) and cyclic diaryliodonium salts **1** (0.2 mmol), The tube was sealed with rubber septum, then evacuated and backfilled with nitrogen for three cycles, dry EtOAc (1.0 mL, 0.2 M) was added. The reaction mixture was stirred at appreciate temperature for 6 h. The reaction mixture was quenched with water (10.0 mL), and extracted with ethyl acetate (3 × 15.0 mL). The combined organic layers were washed with water, brine, dried over anhydrous Na_2SO_4, and concentrated under reduced pressure. The residue was purified by flash chromatography on silica gel to afford the desired product **4**.

2'-iodo-6,6'-dimethyl-[1,1'-biphenyl]-3,5-*d*$_2$-2-ol (4)

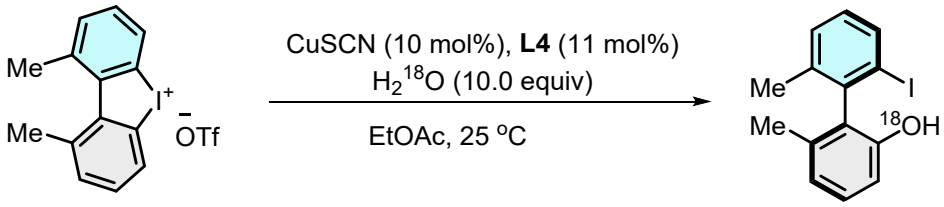


(31% D) (34% D) 60.6 mg, 93% yield.

^{1}H NMR (400 MHz, DMSO-*d*$_6$) δ 9.12 (d, *J* = 1.4 Hz, 1H), 7.74 (d, *J* = 7.8 Hz, 1H), 7.29 (d, *J* = 7.5 Hz, 1H), 7.11 – 7.05 (m, 1H), 6.97 (t, *J* = 7.7 Hz, 1H), 6.76 (d, *J* = 5.4 Hz, 0.66H), 6.74 (d, *J* = 4.7 Hz, 0.69H), 1.96 (s, 3H), 1.81 (s, 3H).

^{13}C NMR (400 MHz, DMSO-*d*$_6$) δ 154.2, 143.0, 138.4, 136.5, 130.9, 130.0, 129.3, 128.9, 128.8, 121.0, 113.5, 102.7, 21.5, 19.8.

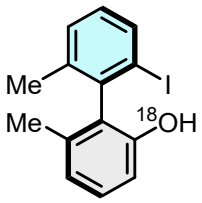
4.3 ^{18}O-Lable experiment



To a 5 mL reaction tube with a stir bar was charged with CuSCN (2.5 mg, 10 mol %, 0.01 mmol), **L4** (10.6 mg, 11 mol%, 0.011 mmol), $H_2{}^{18}O$ (36 μL, 10.0 equiv, 2.0 mmol) and cyclic diaryliodonium salts **1** (0.2 mmol), The tube was sealed with rubber septum, then EtOAc (1.0 mL, 0.2 M) was added. The reaction mixture was stirred at appreciate temperature for 6 h. The reaction mixture was quenched

with water (10.0 mL), and extracted with ethyl acetate (3 × 15.0 mL). The combined organic layers were washed with water, brine, dried over anhydrous Na_2SO_4, and concentrated under reduced pressure. The residue was purified by flash chromatography on silica gel to afford the desired product **5**.

(*R*)- 2'-iodo-6,6'-dimethyl-[1,1'-biphenyl]-2-ol-^{18}O (5)[2]



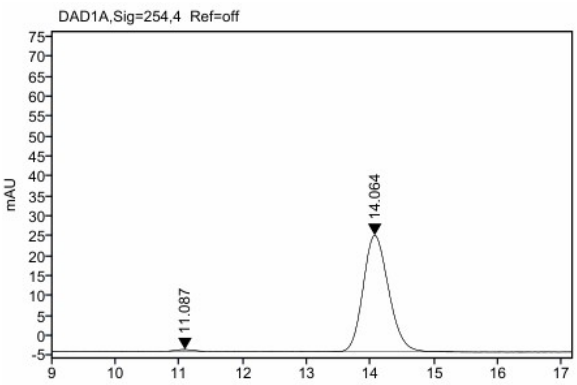
54.0 mg, 88% yield, 98% ^{18}O, 98% ee.

^{1}H NMR (400 MHz, DMSO-d_6) δ 9.13 (s, 1H), 7.74 (dd, *J* = 7.7, 1.0 Hz, 1H), 7.29 (dt, *J* = 7.5, 1.0 Hz, 1H), 7.08 (t, *J* = 7.8 Hz, 1H), 6.98 (t, *J* = 7.7 Hz, 1H), 6.76 (d, *J* = 4.1 Hz, 1H), 6.74 (d, *J* = 3.6 Hz, 1H), 1.95 (s, 3H), 1.81 (s, 3H).

^{13}C NMR (400 MHz, DMSO-d_6) δ 154.2, 143.0, 138.4, 136.5, 130.9, 130.0, 129.4, 128.9, 121.0, 113.5, 102.7, 21.5, 19.9. **HRMS (ESI):** $[M+H]^+$ calcd for $C_{14}H_{14}I^{18}O$ 327.0126, found 327.0129.

Chiral HPLC: CHIRALPAK OJ-H, 25 °C, iPrOH-hexanes 5.0/95.0, 1.0 mL/min, 254 nm. t_R(minor) = 11.1 min, t_R(major) = 14.1 min.

$[\alpha]_D^{25}$ = +8.2° (c = 1.0, CH_2Cl_2)

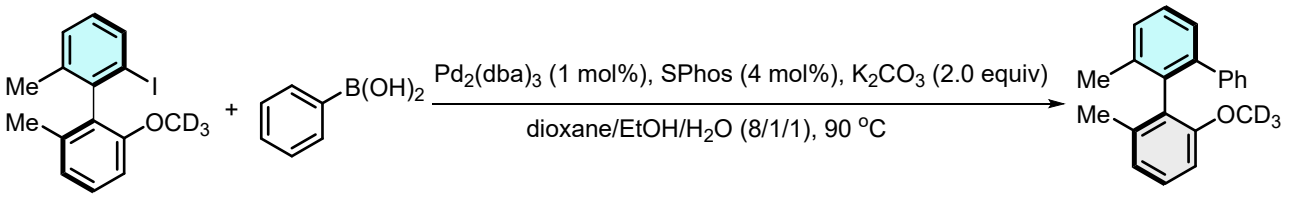


Signal: DAD1A,Sig=254,4 Ref=off

RT [min]	Area	Area%
11.087	7.44	0.91
14.064	811.88	99.09
Sum	819.32	

5. Further Applications

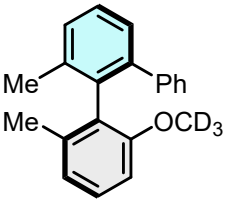
5.1 Suzuki Cross-Coupling Reaction



2a **6**, 88% yield, 96% ee

In a 20 mL seal tube equipped with a stir bar were added **2a** (68.2 mg, 0.2 mmol), phenylboronic acid (36.6 mg, 0.3 mmol, 1.5 equiv), $Pd_2(dba)_3$ (3.7 mg, 0.004 mmol, 2 mol %), S-Phos (3.3 mg, 0.008 mmol, 4 mol %), and K_3PO_4 (127.4 mg, 0.6 mmol, 3.0 equiv) in dry Dioxane/EtOH/H_2O (8/1/1, 2.0 mL). The tube was sealed with a Teflon cap, and the mixture was stirred at 90 °C for 24 h. After consumption of the starting material, it was cooled to room temperature and diluted with EtOAc (20 mL). The organic layer was washed with water and brine, then dried over anhydrous Na_2SO_4. After filtration, the filtrate was concentrated under reduced pressure and the residue was purified by column chromatography on silica gel to afford **6**.

(*R*)-2-(methoxy-*d*$_3$)-6,6'-dimethyl-1,1':2',1''-terphenyl (6)

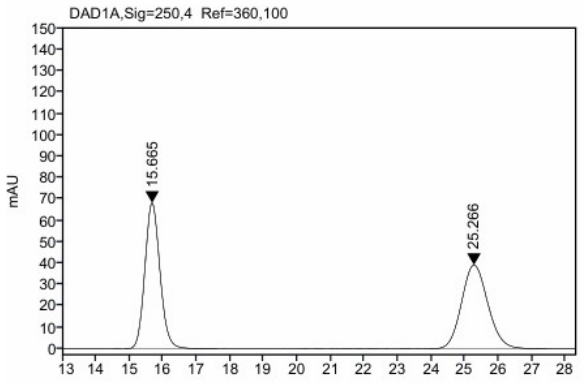


51.2 mg, 88% yield, 96% ee, white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.27 – 7.11 (m, 5H), 7.05 – 6.92 (m, 3H), 6.82 (d, *J* = 7.5 Hz, 1H), 6.73 (d, *J* = 8.2 Hz, 1H), 6.58 (dd, *J* = 8.0, 3.8 Hz, 1H), 1.94 (s, 3H), 1.89 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$) δ** 156.8, 137.6, 137.5, 136.6, 130.2, 129.6, 128.7, 127.8, 127.3, 127.2, 127.1, 126.2, 125.6, 122.2, 108.1, 107.4, 54.7-54.4 (m), 20.0, 19.5. **HRMS (ESI):** $[M+H]^+$ calcd for $C_{21}H_{18}D_3O$ 292.1775, found 292.1782.

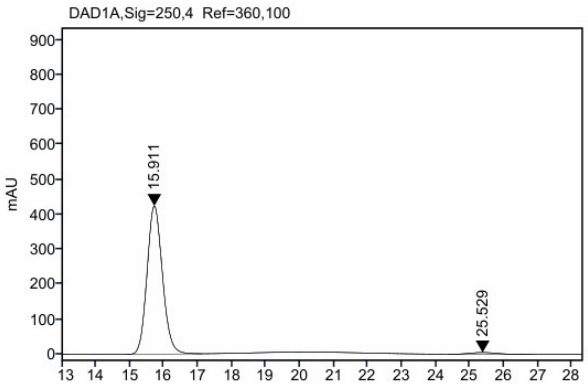
Chiral HPLC: CHIRALPAK OX-H, 25 °C, iPrOH-hexanes 0.5/99.5, 0.8 mL/min, 250 nm. t_R(major) = 15.9 min, t_R(minor) = 25.5 min.

$[\alpha]_D^{25}$ = -15.7° (c = 1.0, CH_2Cl_2)



Signal: DAD1A,Sig=250,4 Ref=360,100

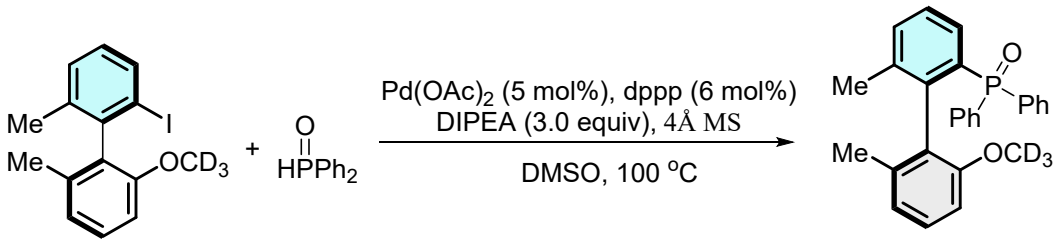
RT [min]	Area	Area%
15.665	2143.88	50.06
25.266	2138.45	49.94
Sum	4282.33	



Signal: DAD1A,Sig=250,4 Ref=360,100

RT [min]	Area	Area%
15.911	13359.05	98.05
25.529	265.75	1.95
Sum	13624.80	

5.2 C–P Cross-Coupling Reaction

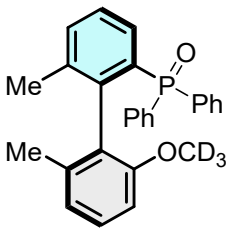


2a

7, 92% yield, 93% ee

In a 20 mL seal tube equipped with a stir bar were added **2a** (68.2 mg, 0.2 mmol), diphenyl phosphine oxide (44.5 mg, 0.22 mmol, 1.1 equiv), $Pd(OAc)_2$ (2.2 mg, 0.01 mmol, 5 mol%), dppp (4.4 mg, 0.012 mmol, 6 mol%), 4Å MS (20 mg) in anhydrous DMSO (2.0 mL). Then DIPEA (105 μL, 0.6 mmol, 3.0 equiv) was added and stirred at 100 ℃ for 24 h. After consumption of the starting material, it was cooled to room temperature and diluted with EtOAc (20 mL). The organic layer was washed with water and brine, then dried over anhydrous Na_2SO_4. After filtration, the filtrate was concentrated under reduced pressure and the residue was purified by column chromatography on silica gel (PE/ethyl acetate = 2:1) to afford **7**.

(*R*)-(2'-(methoxy-d_3)-6,6'-dimethyl-[1,1'-biphenyl]-2-yl)diphenylphosphine oxide (7)

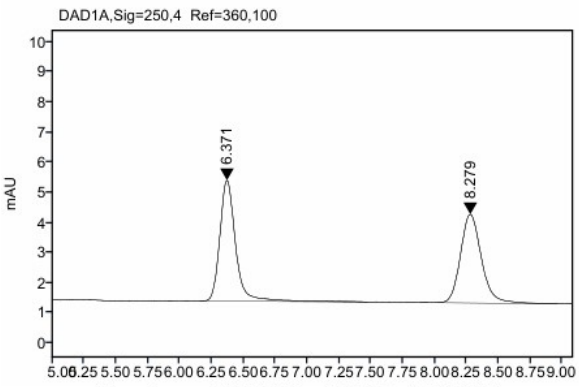


76.4 mg, 92% yield, 93% ee, yellow solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.74 – 7.66 (m, 2H), 7.47 – 7.31 (m, 9H), 7.24 – 7.16 (m, 2H), 7.00 (t, *J* = 7.9 Hz, 1H), 6.70 (d, *J* = 7.6 Hz, 1H), 6.19 (d, *J* = 8.2 Hz, 1H), 1.92 (s, 3H), 1.89 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$) δ** 155.6, 142.2, 142.2, 138.8, 138.5, 138.4, 134.2, 133.4, 133.4, 133.2, 133.1, 132.1, 132.0, 131.9, 131.7, 131.6, 131.3, 131.3, 131.2, 131.1, 131.1, 131.00, 130.4, 130.3, 128.5, 128.0, 127.9, 127.3, 127.2, 126.6, 126.5, 126.4, 121.9, 53.7-52.4 (m), 20.2, 19.6. **HRMS (ESI):** $[M+H]^+$ calcd for $C_{27}H_{23}D_3O_2P$ 416.1853, found 416.1855.

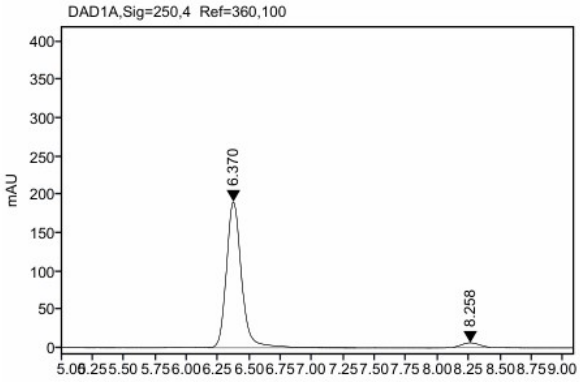
Chiral HPLC: CHIRALPAK IA, 25 °C, iPrOH-hexanes 20.0/8.0, 1.0 mL/min, 250 nm. t_R(major) = 6.4 min, t_R(minor) = 8.2 min.

$[\alpha]_D^{25}$ = --25.0° (c = 1.3, CH_2Cl_2)



Signal: DAD1A,Sig=250,4 Ref=360,100

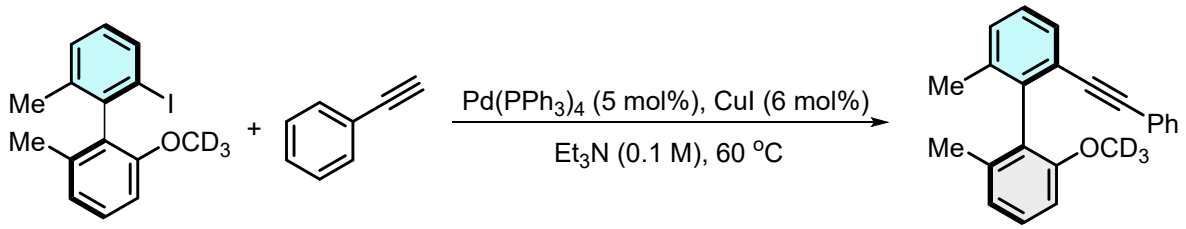
RT [min]	Area	Area%
6.371	34.68	50.80
8.279	33.58	49.20
Sum	68.26	



Signal: DAD1A,Sig=250,4 Ref=360,100

RT [min]	Area	Area%
6.370	1601.90	96.74
8.258	53.92	3.26
Sum	1655.82	

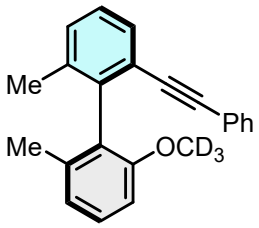
5.3 Sonogashira Cross-Coupling Reaction



2a **8**, 93% yield, 96% ee

In a 20 mL seal tube equipped with a stir bar were added **2a** (68.2 mg, 0.2 mmol), $Pd(PPh_3)_4$ (11.6 mg, 0.010 mmol, 5 mol%), and CuI (2.1 mg, 0.012 mmol, 6 mol%) in Et_3N (2.0 mL). Then phenylacetylene (44.0 μL, 0.40 mmol, 2.0 equiv) was added, and the reaction was stirred at 60 °C for 24 h. After consumption of the starting material, it was cooled to room temperature and diluted with EtOAc (20 mL). The organic layer was washed with water and brine, then dried over anhydrous Na_2SO_4. After filtration, the filtrate was concentrated under reduced pressure and the residue was purified by column chromatography on silica gel to afford **8**.

(*R*)-2-(methoxy-d_3)-2',6-dimethyl-6'-(phenylethynyl)-1,1'-biphenyl (8)

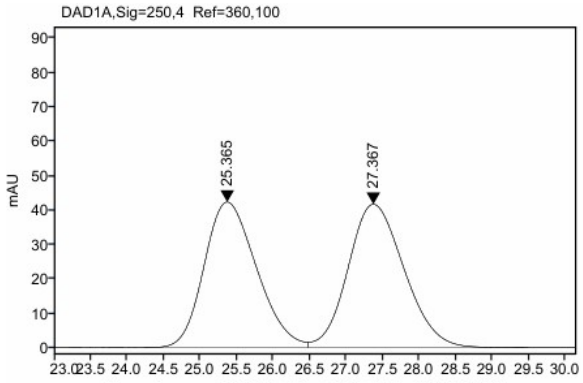


58.6 mg, 93% yield, 96% ee, white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.45 (dd, *J* = 6.9, 2.1 Hz, 1H), 7.29 – 7.21 (m, 3H), 7.21 – 7.14 (m, 3H), 7.06 – 7.00 (m, 2H), 6.93 (d, *J* = 7.6 Hz, 1H), 6.82 (d, *J* = 8.2 Hz, 1H), 2.04 (s, 3H), 2.00 (s, 3H). **^{13}C NMR (101 MHz, $CDCl_3$) δ** 156.9, 140.6, 137.8, 137.0, 131.3, 129.7, 129.0, 128.9, 128.1, 128.0, 127.6, 126.9, 123.6, 123.3, 122.2, 108.3, 91.3, 89.1, 56.4-54.4 (m), 19.9, 19.5. **HRMS (ESI):** $[M+H]^+$ calcd for $C_{23}H_{18}D_3O$ 316.1775, found 316.1776.

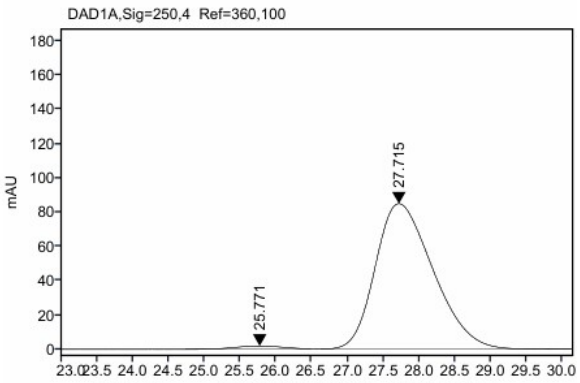
Chiral HPLC: CHIRALPAK OX-H, 25 °C, iPrOH-hexanes 0.2/99.8, 0.8 mL/min, 250 nm. t_R(minor) = 25.7 min, t_R(major) = 27.7 min.

$[\alpha]_D^{25}$ = -20.5° (c = 1.1, CH_2Cl_2)



Signal: DAD1A,Sig=250,4 Ref=360,100

RT [min]	Area	Area%
25.365	2113.97	48.70
27.367	2226.89	51.30
Sum	4340.86	



Signal: DAD1A,Sig=250,4 Ref=360,100

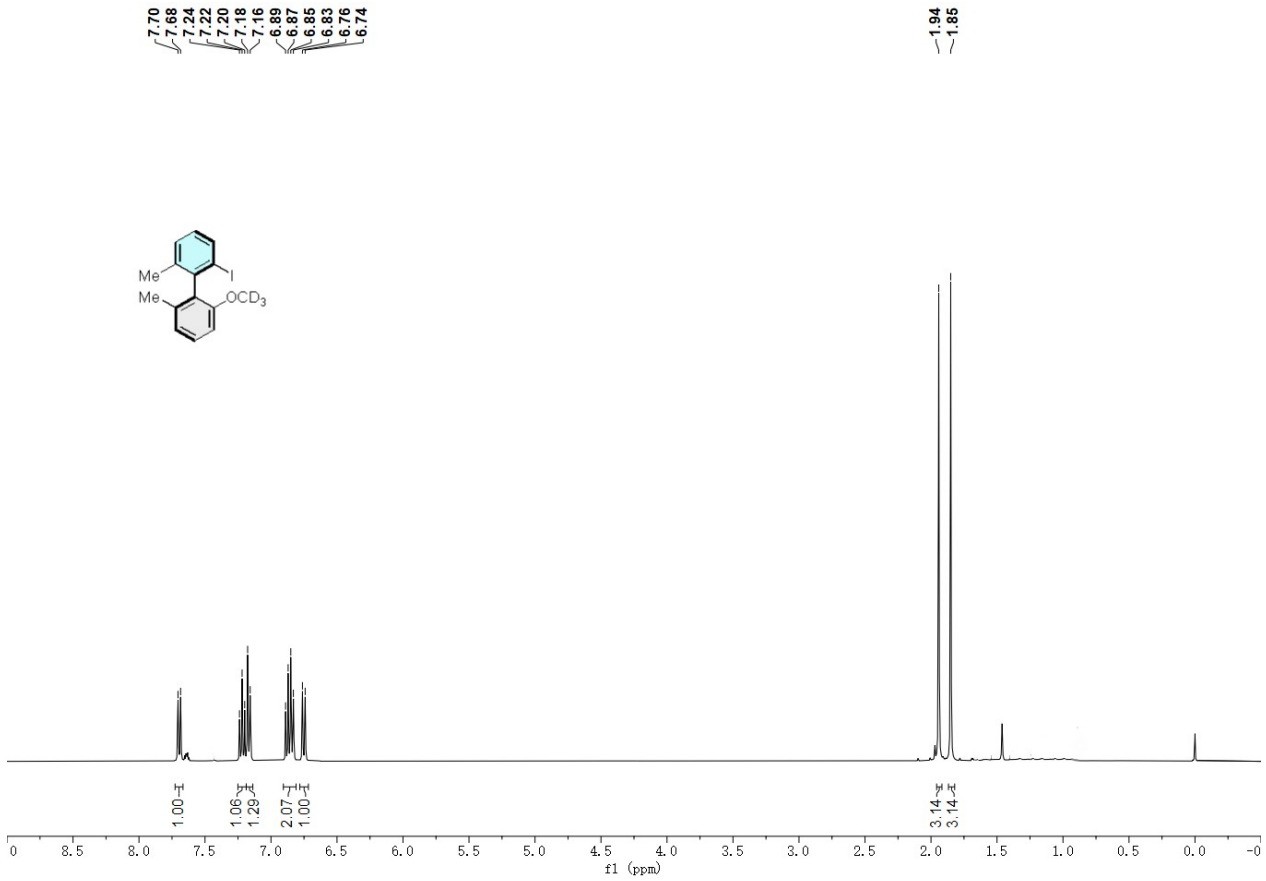
RT [min]	Area	Area%
25.771	83.80	1.72
27.715	4778.53	98.28
Sum	4862.34	

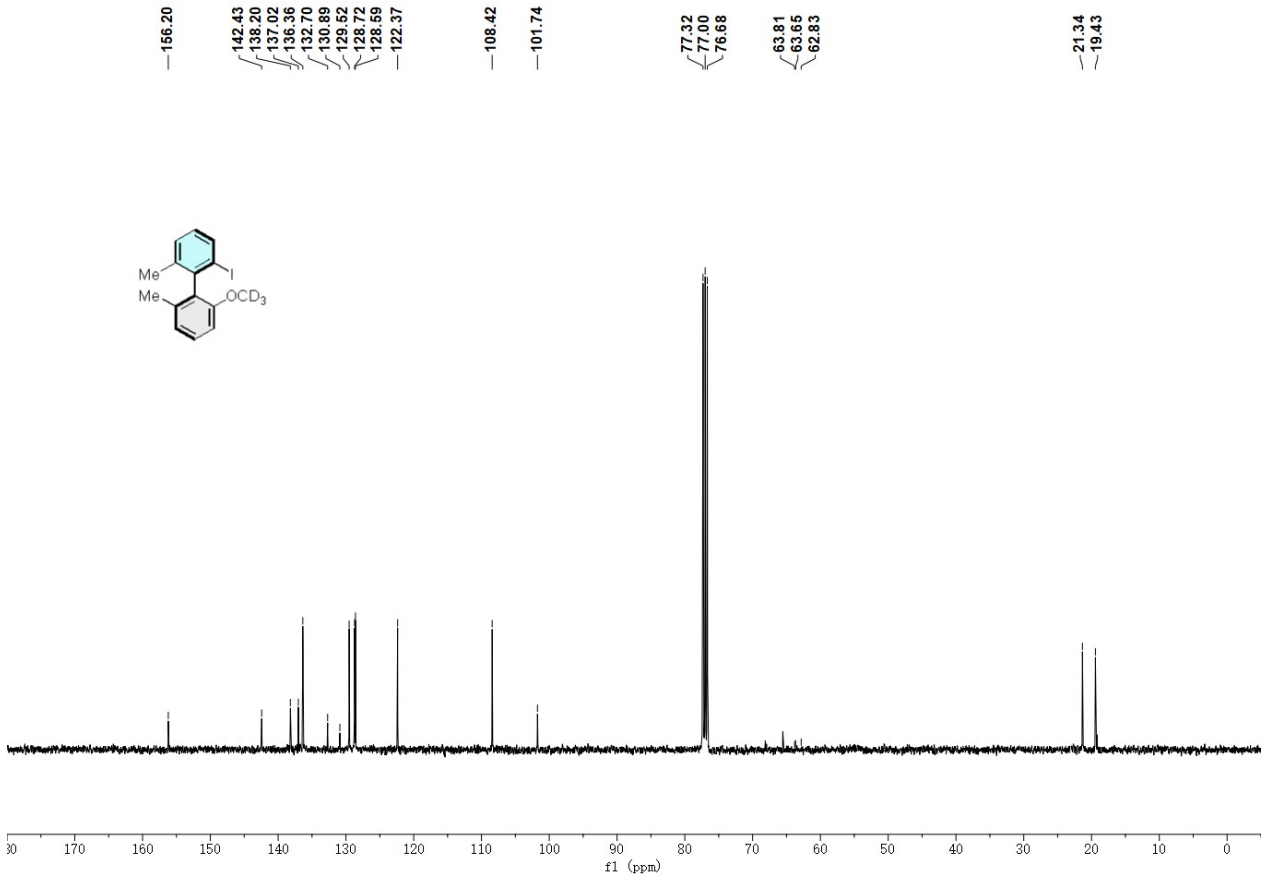
6. References

1. (a) Zhu, K.; Xu, K.; Fang, Q.; Wang, Y.; Tang, B.; Zhang, F. Enantioselective Synthesis of Axially Chiral Biaryls via Cu-Catalyzed Acyloxylation of Cyclic Diaryliodonium Salts. *ACS Catal.* **2019**, *9*, 4951−4957. (b) Zhao, K.; Duan, L.; Xu, S.; Jiang, J.; Fu, Y.; Gu, Z. Enhanced Reactivity by Torsional Strain of Cyclic Diaryliodonium in CuCatalyzed Enantioselective Ring-Opening Reaction. *Chem* **2018**, *4*, 599−612. (c) Liu, X.; Ye, Z.; Liu, J.; Wu, Y.; Zhang, F. Asymmetric Synthesis of Biaryl Sulfilimines Bearing Multiple Chiral Elements Involving Cyclic Diaryliodoniums. *Org. Lett.* **2025**, *27*, 6695–6701.
2. Xu, H.; Huang, Y.; Hong, B.; Gu, Z. Enantioselective Preparation of ^{18}O-Labeled Phenolic Biaryl Atropisomers via Cu-Catalyzed Ring-Opening of Cyclic Diaryliodoniums. *Adv. Synth. Catal.* **2025**, *367*, e70031.

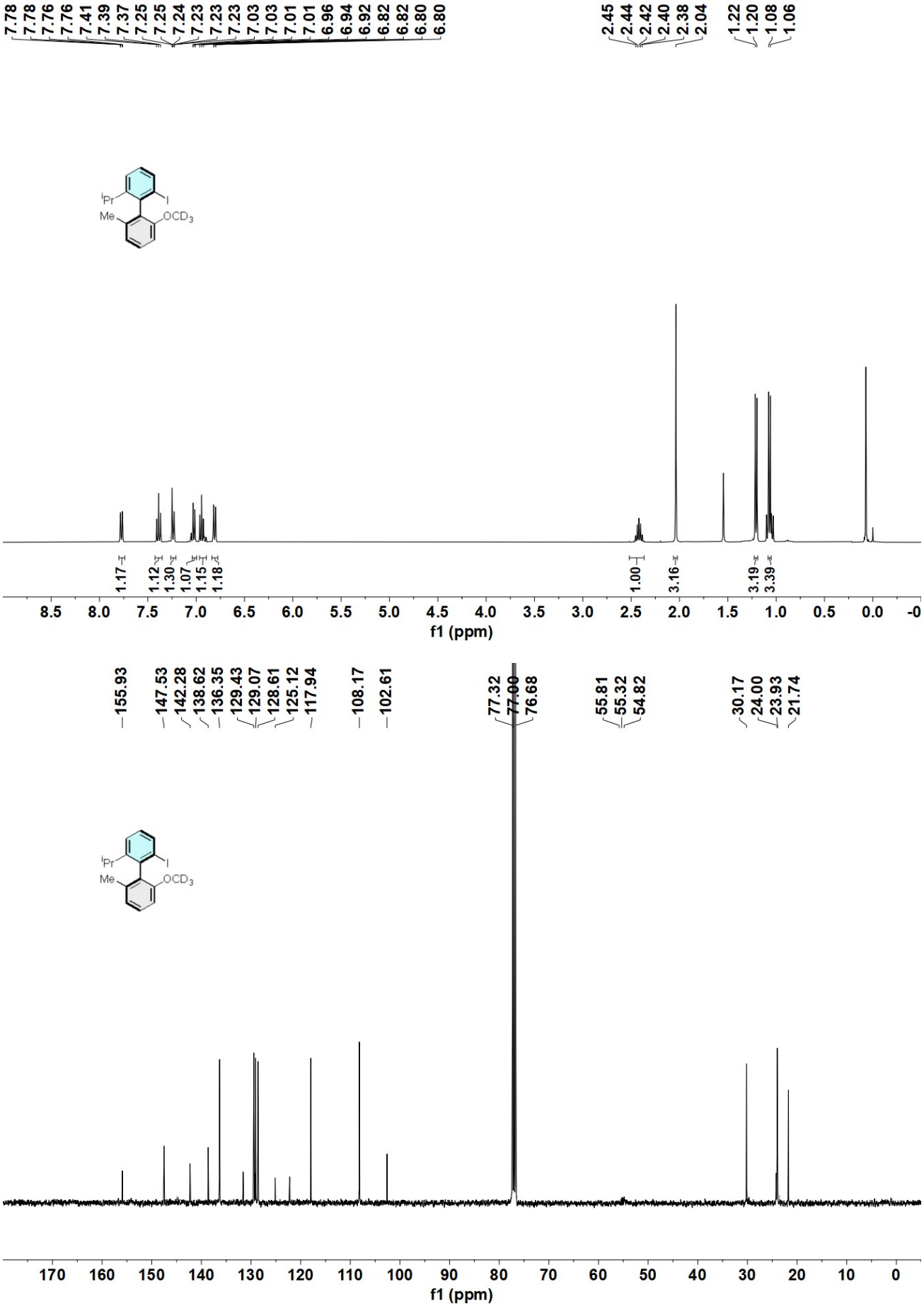
7. Copies of NMR Spectra

2a, ^{1}H NMR (400 MHz, $CDCl_3$); ^{13}C NMR (101 MHz, $CDCl_3$)

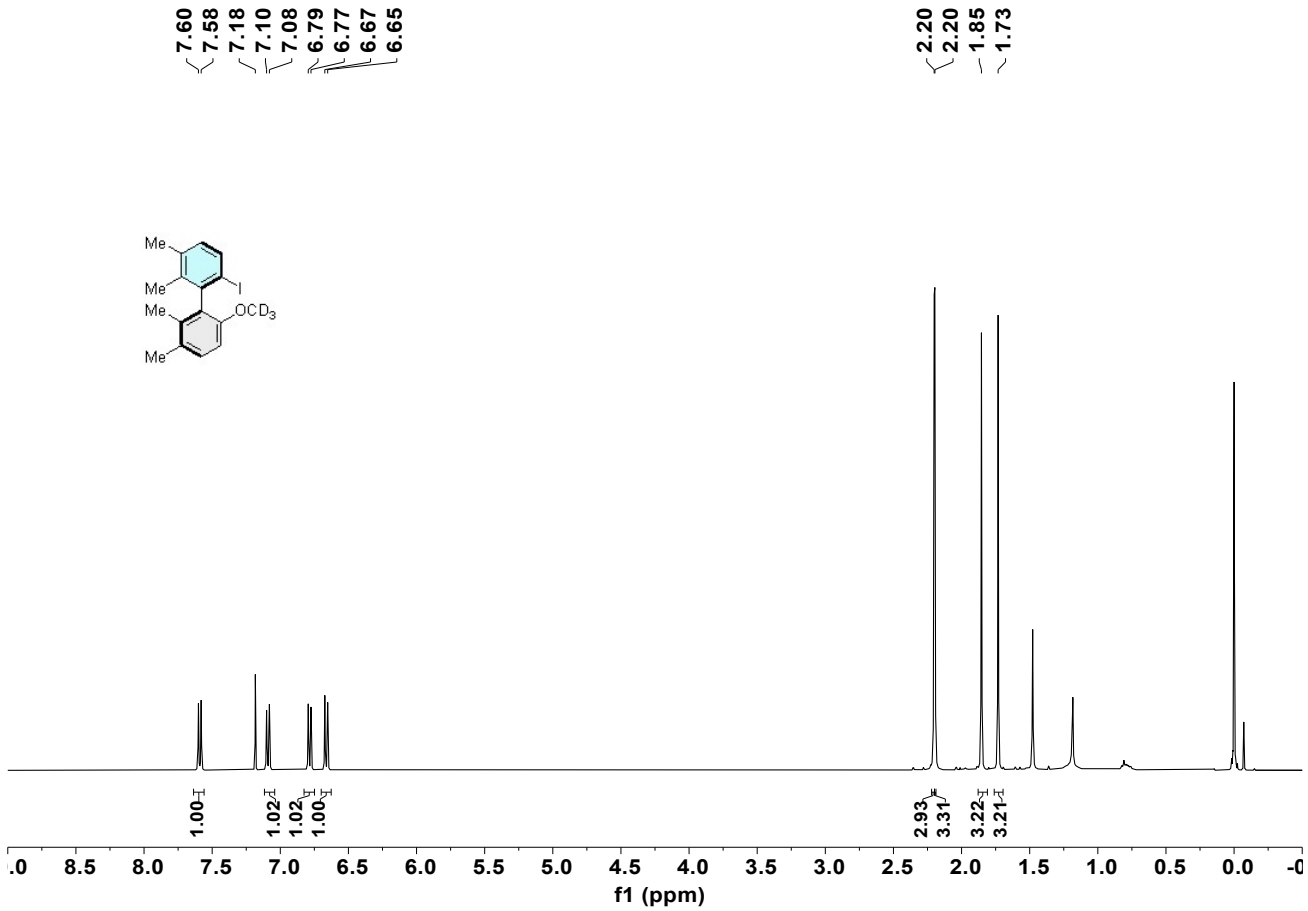


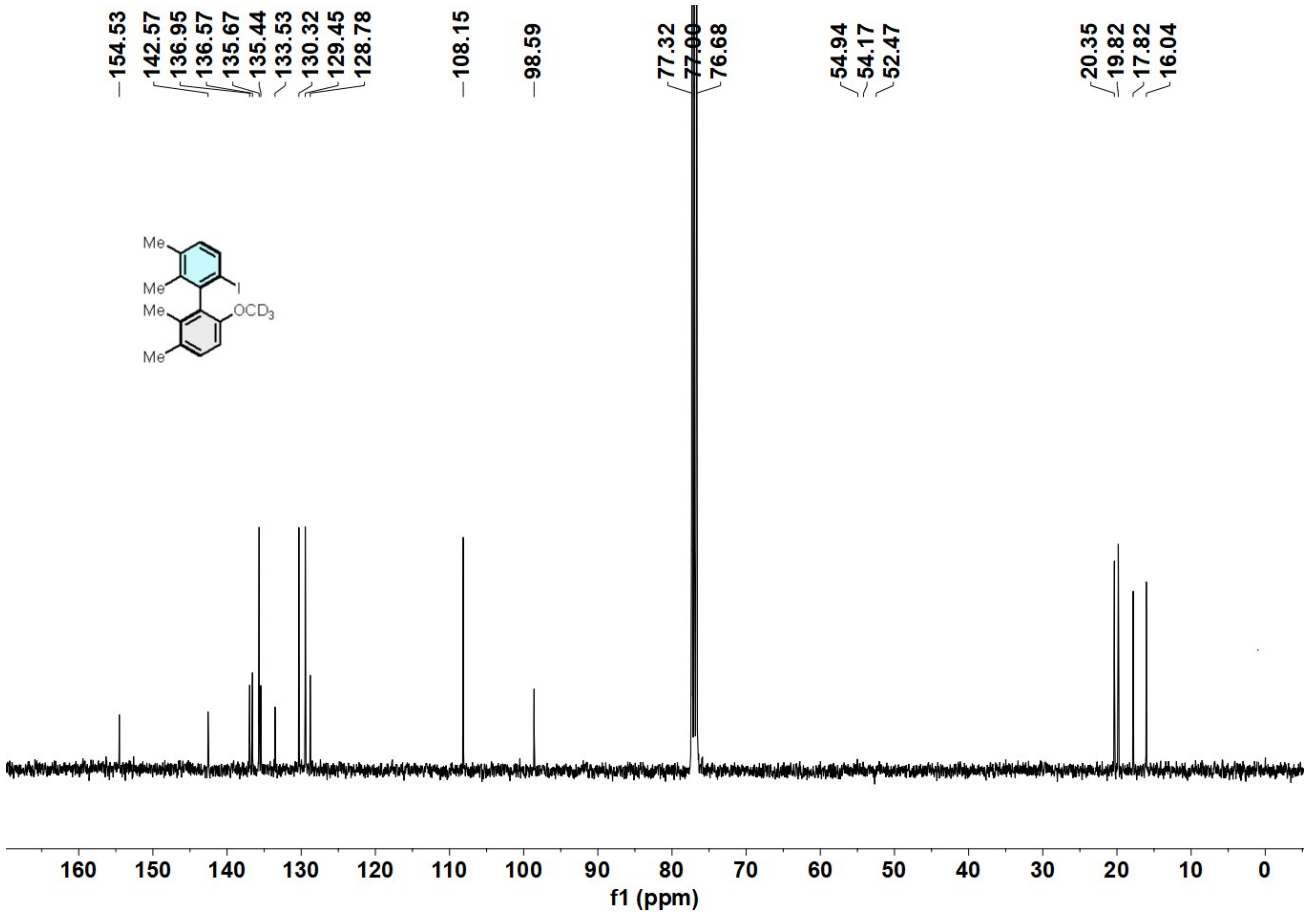


2b, ^{1}H NMR (400 MHz, $CDCl_3$); ^{13}C NMR (101 MHz, $CDCl_3$)

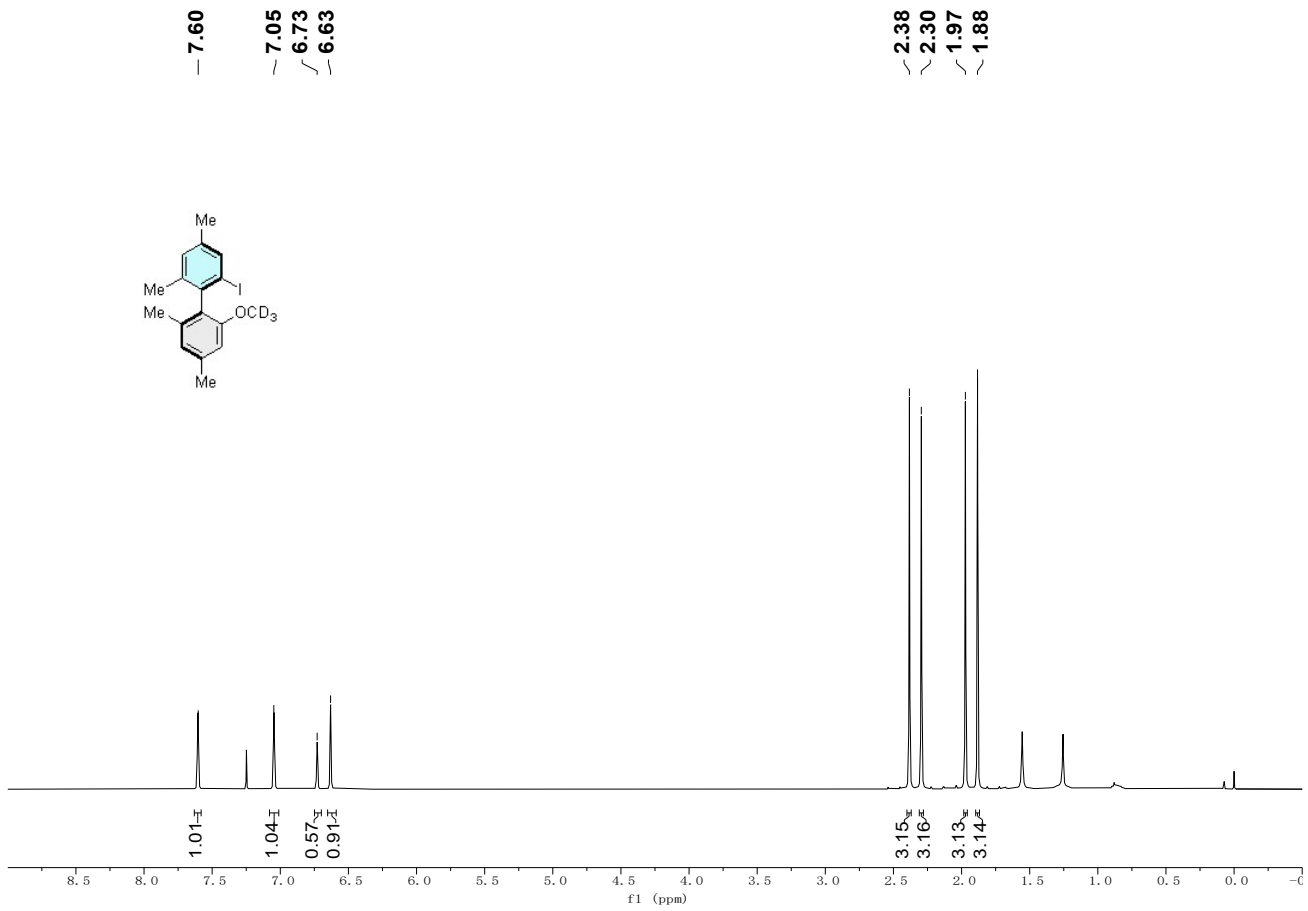


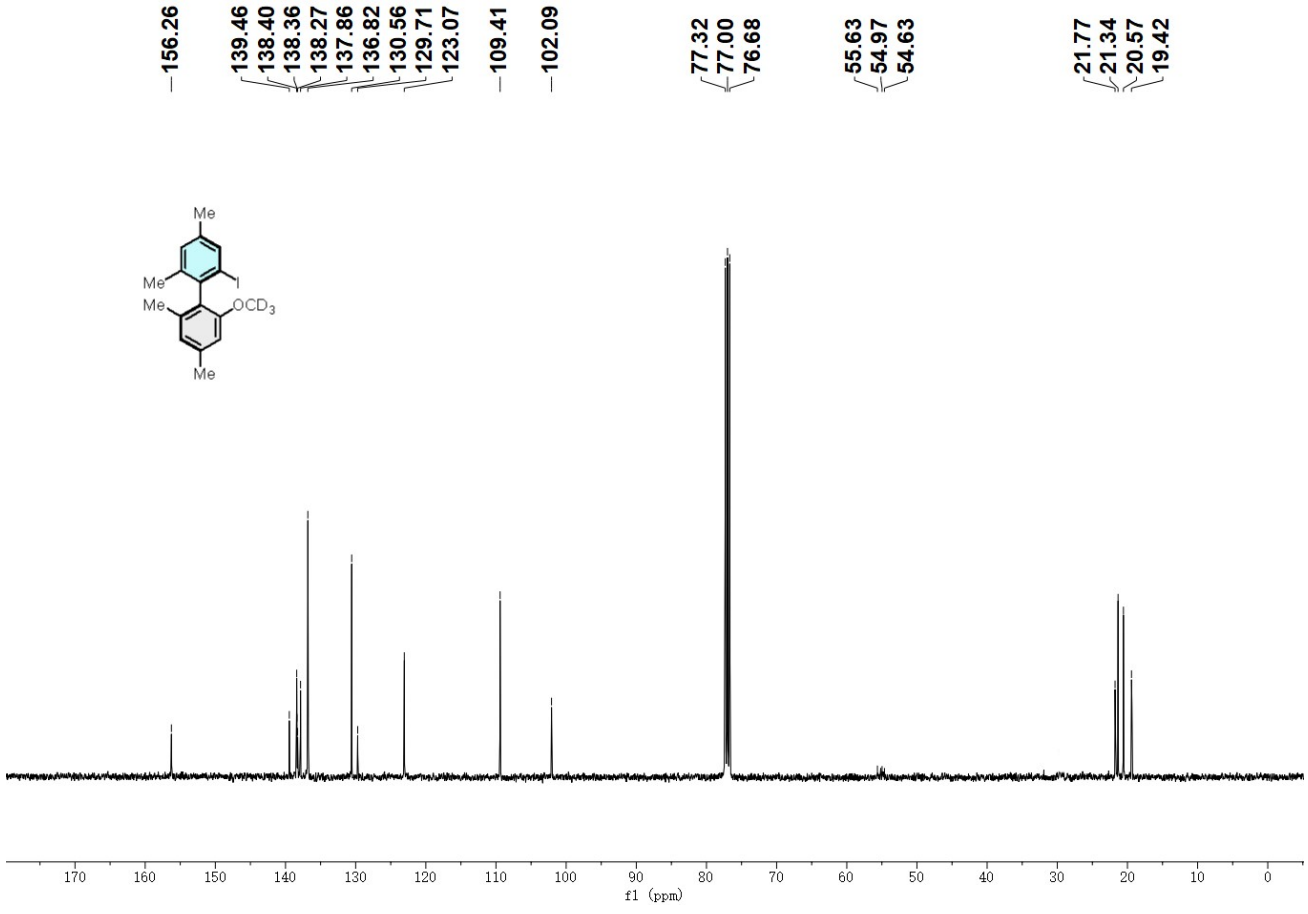
2c, ^{1}H NMR (400 MHz, $CDCl_3$); ^{13}C NMR (101 MHz, $CDCl_3$)



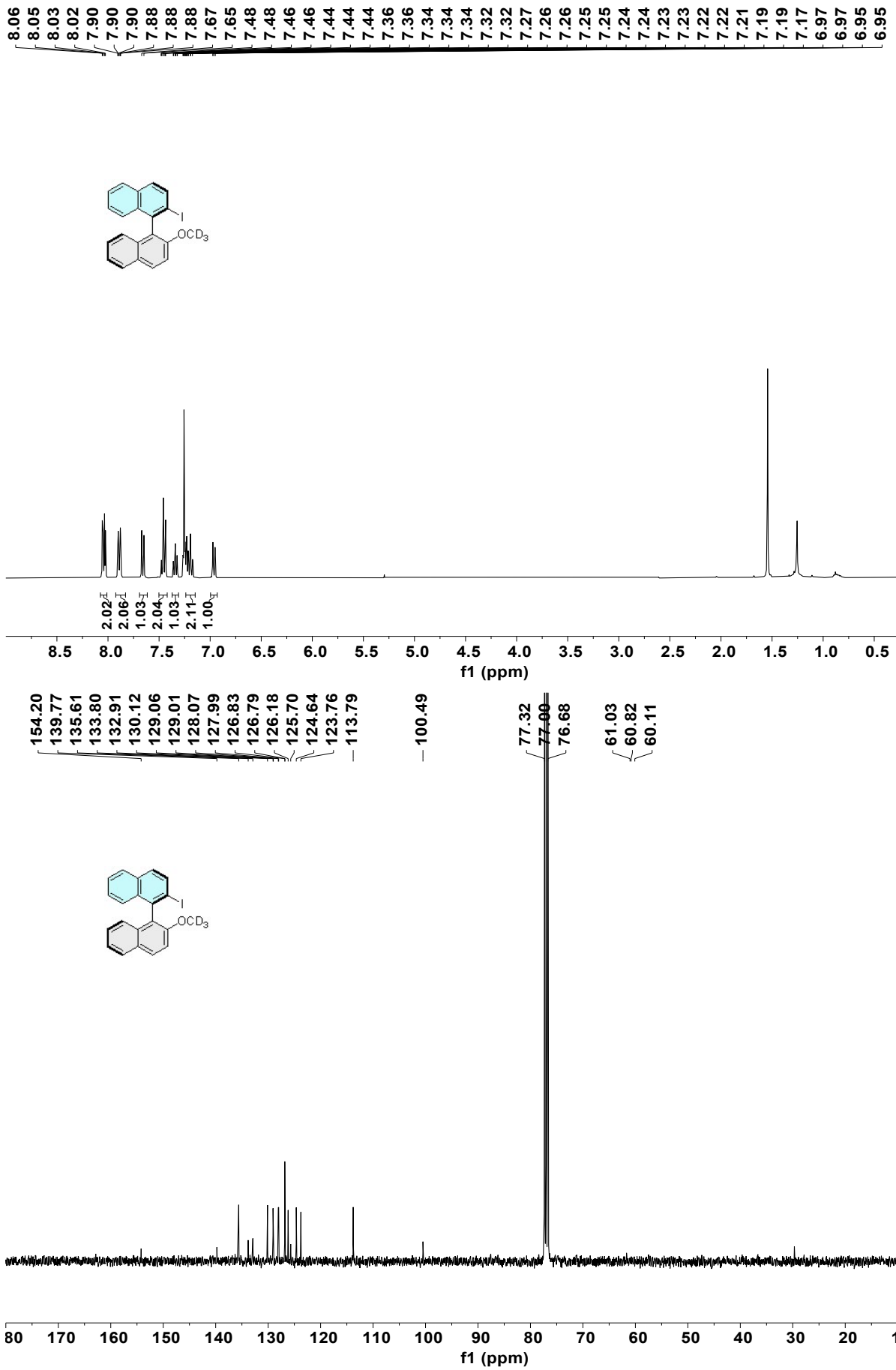


2d, ^{1}H NMR (400 MHz, $CDCl_3$); ^{13}C NMR (101 MHz, $CDCl_3$)

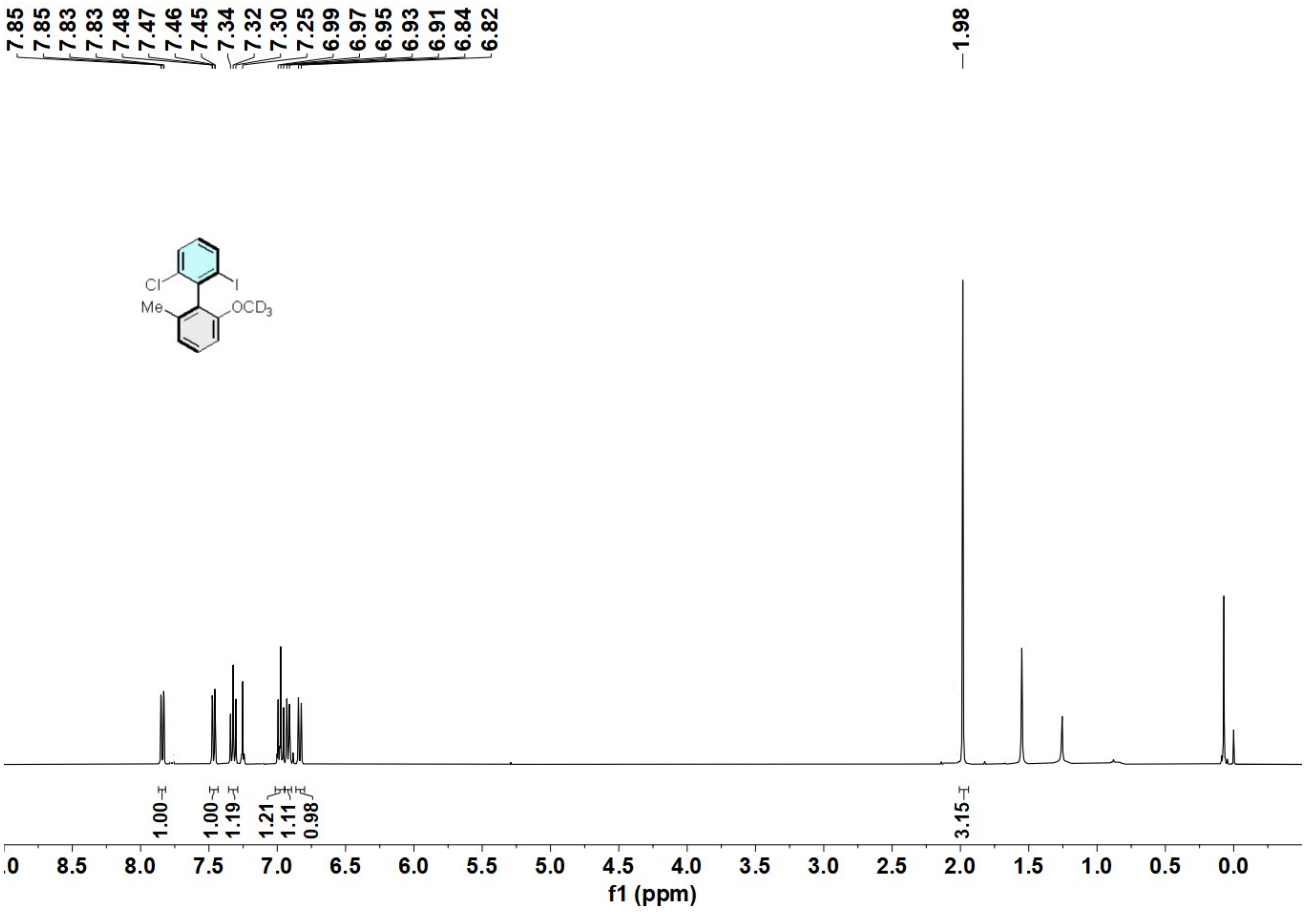


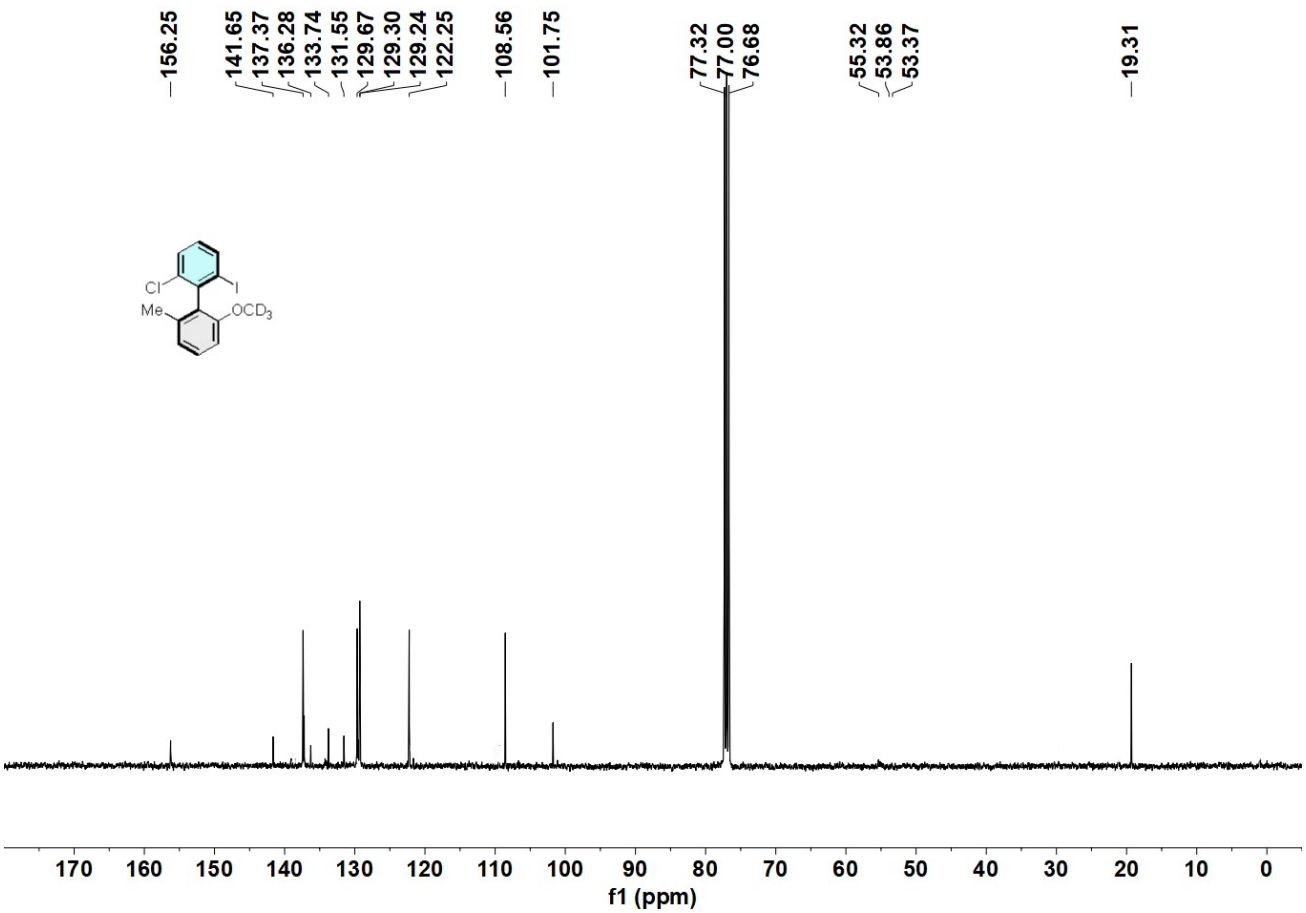


2e, ^{1}H NMR (400 MHz, $CDCl_3$); ^{13}C NMR (101 MHz, $CDCl_3$)

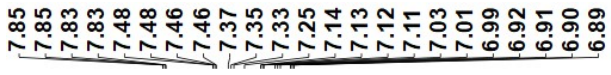


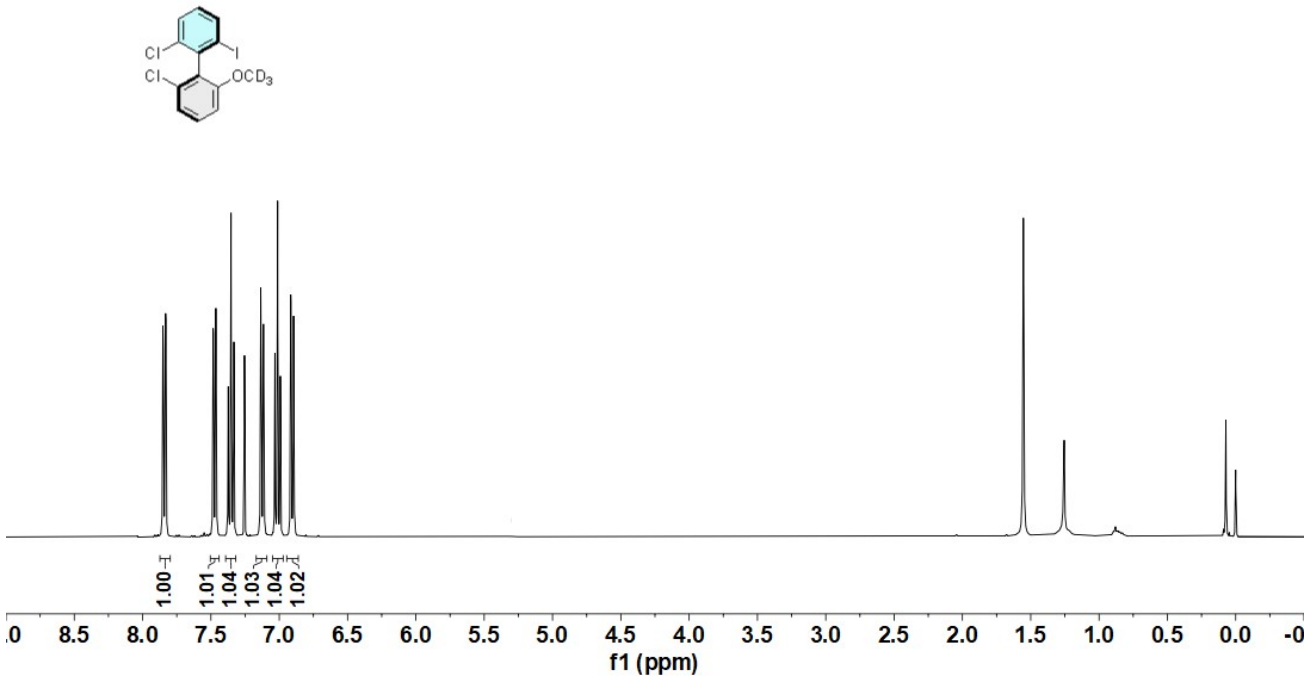
2f, ^{1}H NMR (400 MHz, $CDCl_3$); ^{13}C NMR (101 MHz, $CDCl_3$)

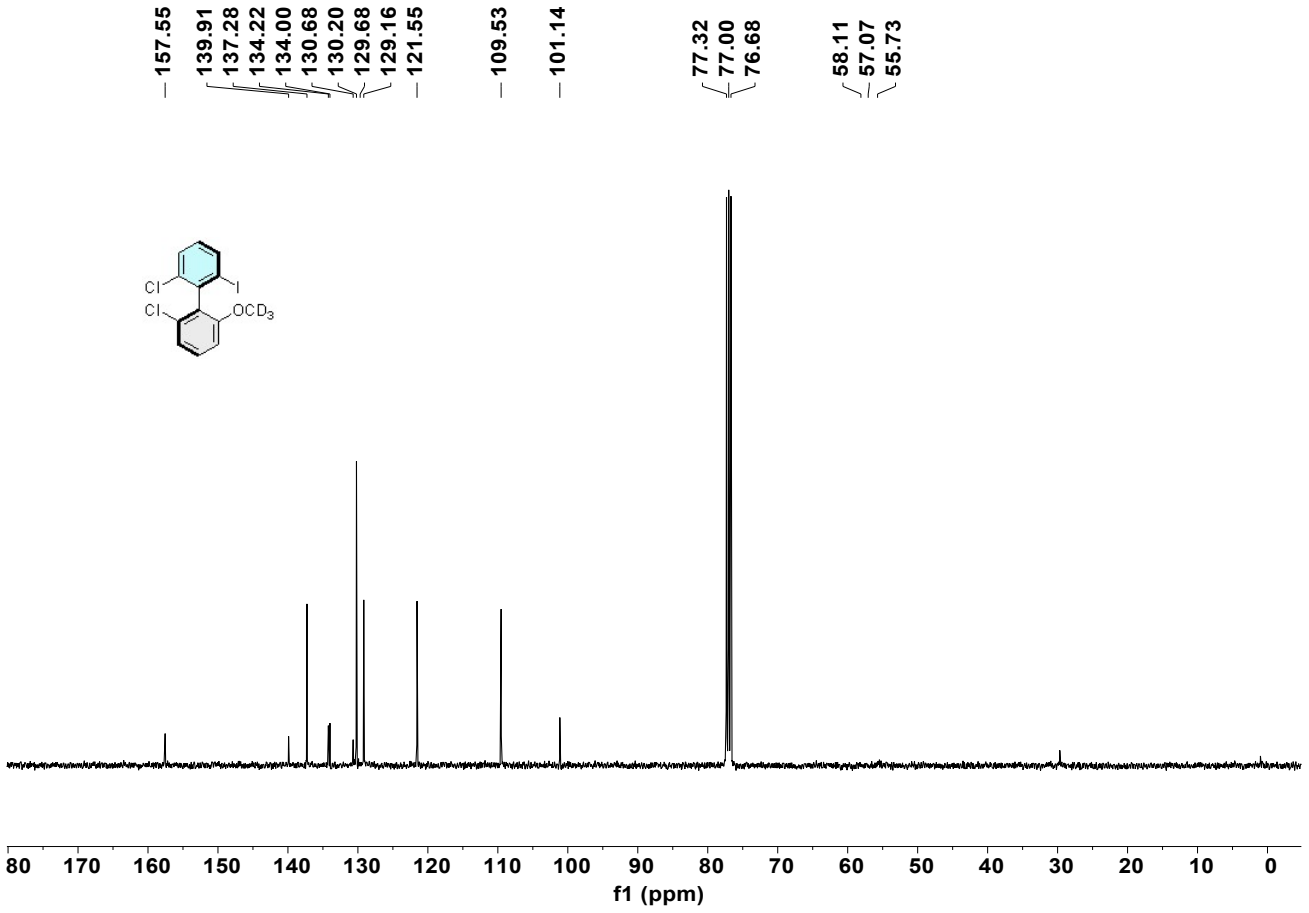




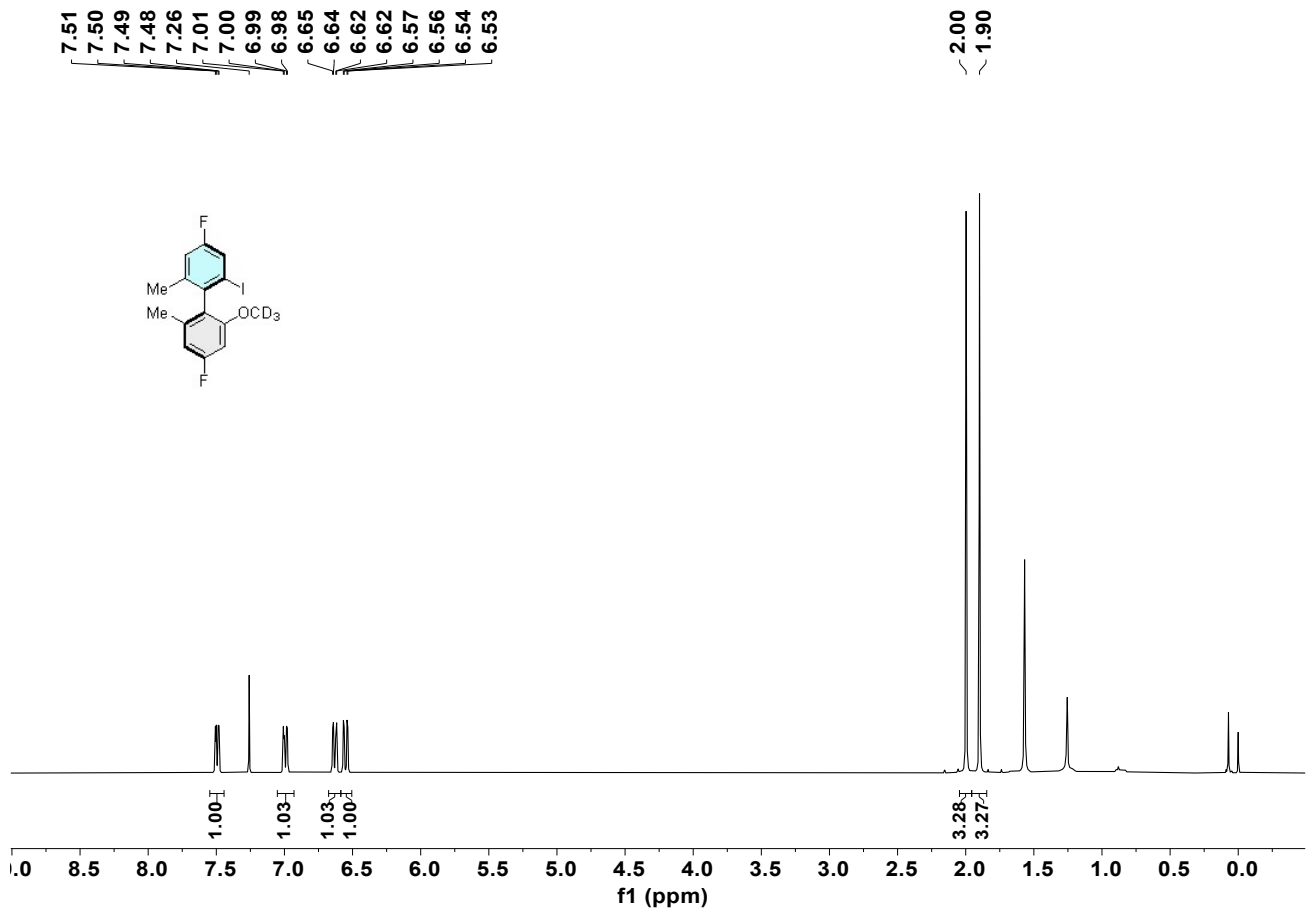
2g, ^{1}H NMR (400 MHz, $CDCl_3$); ^{13}C NMR (101 MHz, $CDCl_3$)

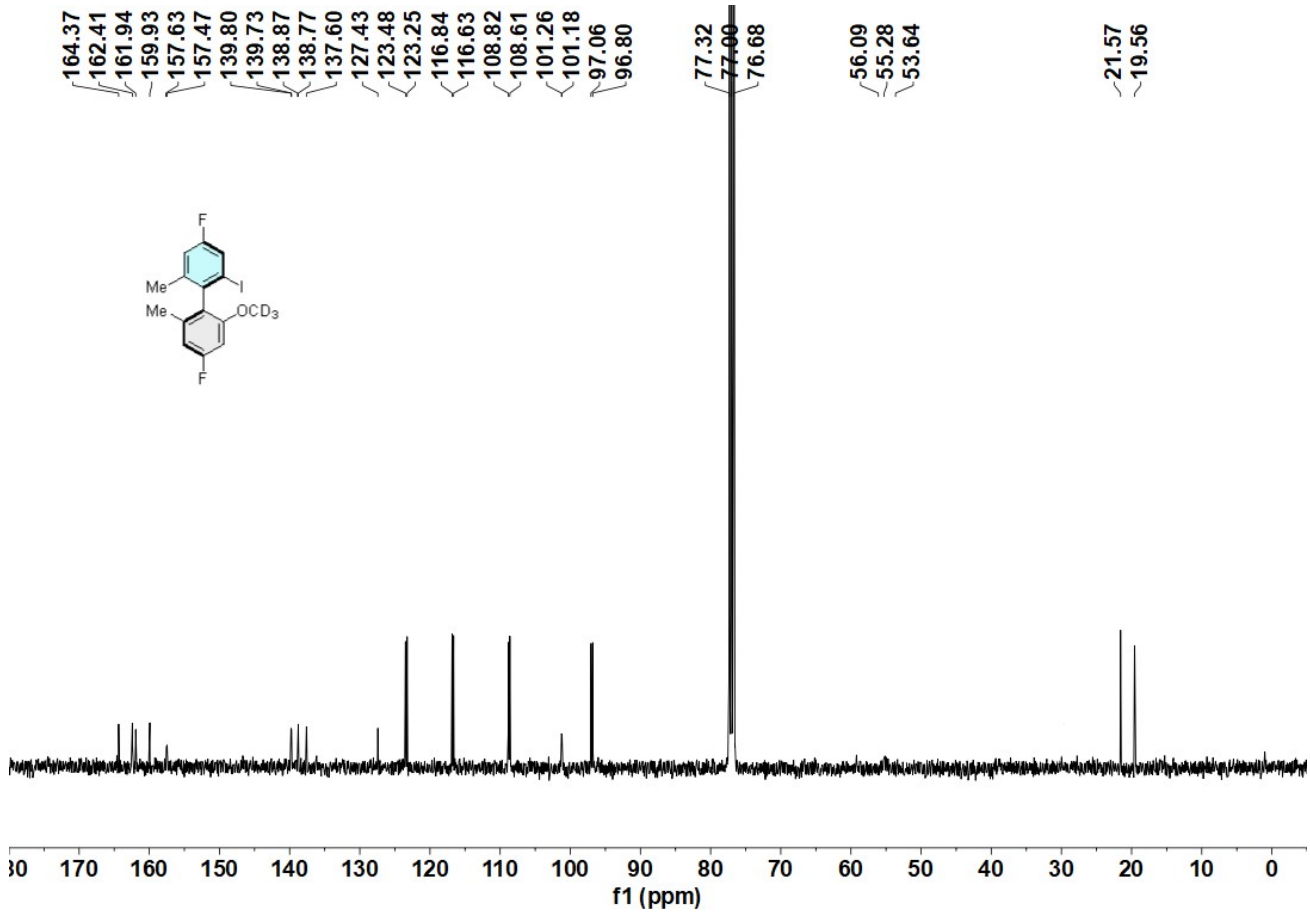




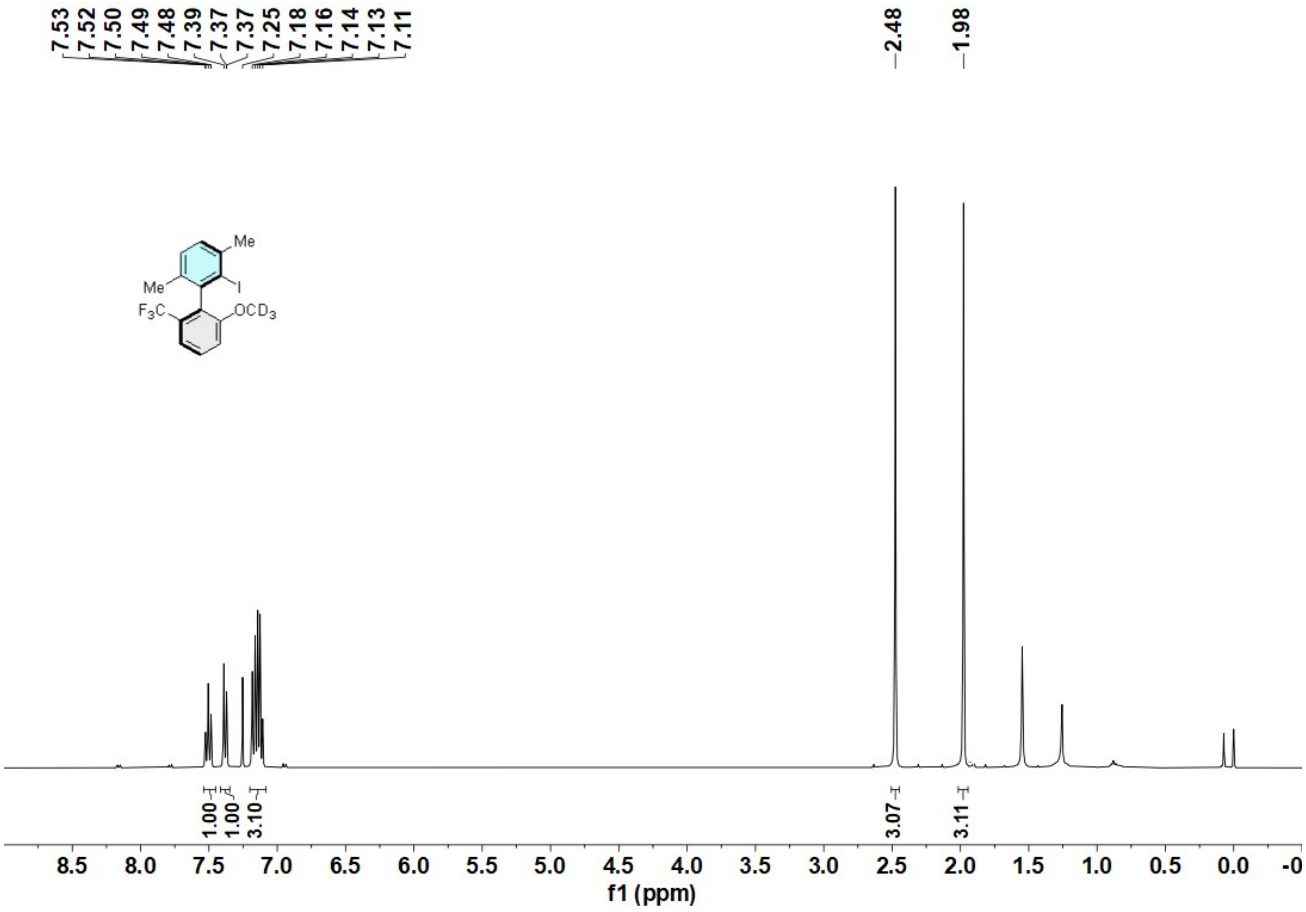


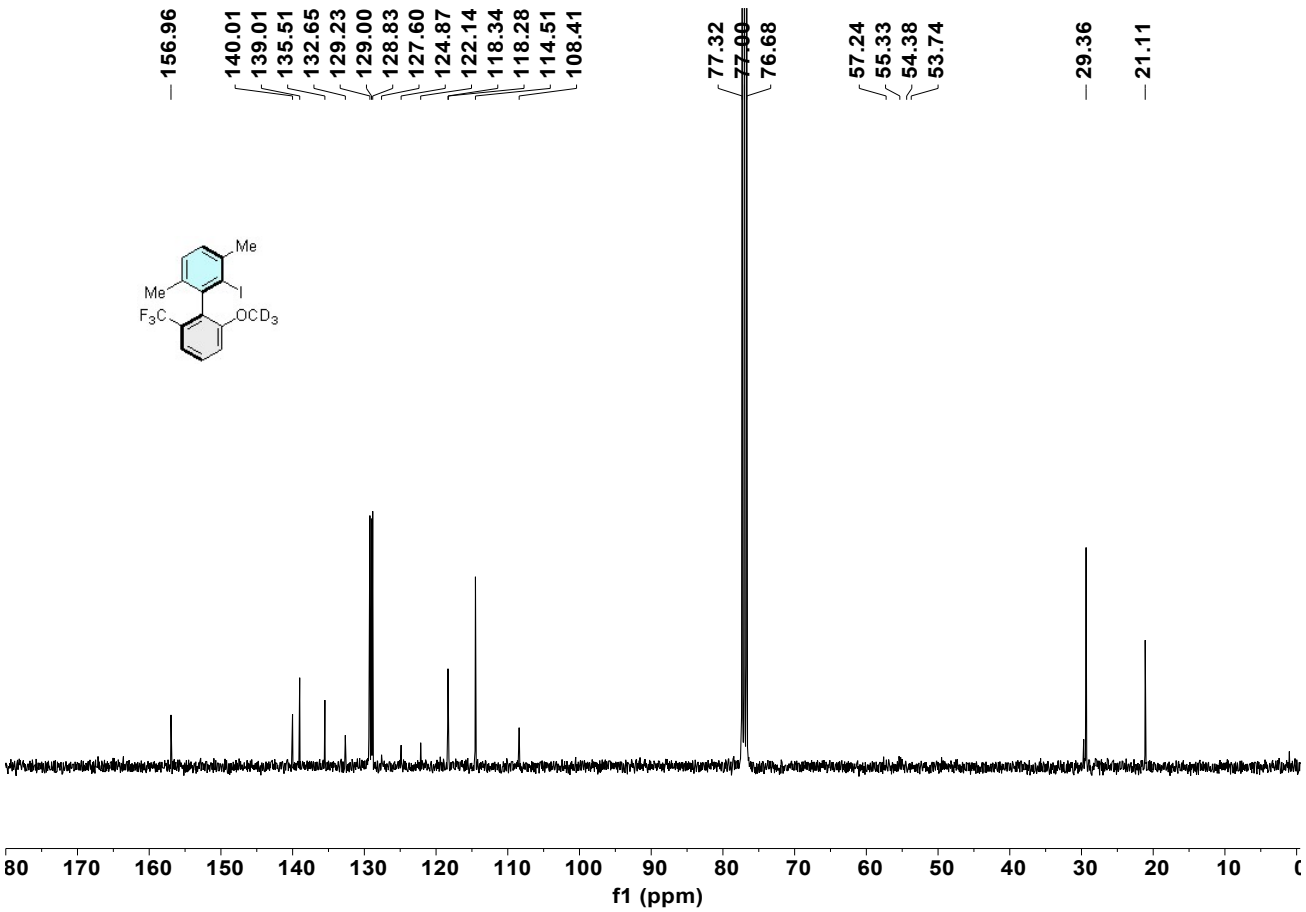
2h, ^{1}H NMR (400 MHz, $CDCl_3$); ^{13}C NMR (101 MHz, $CDCl_3$)



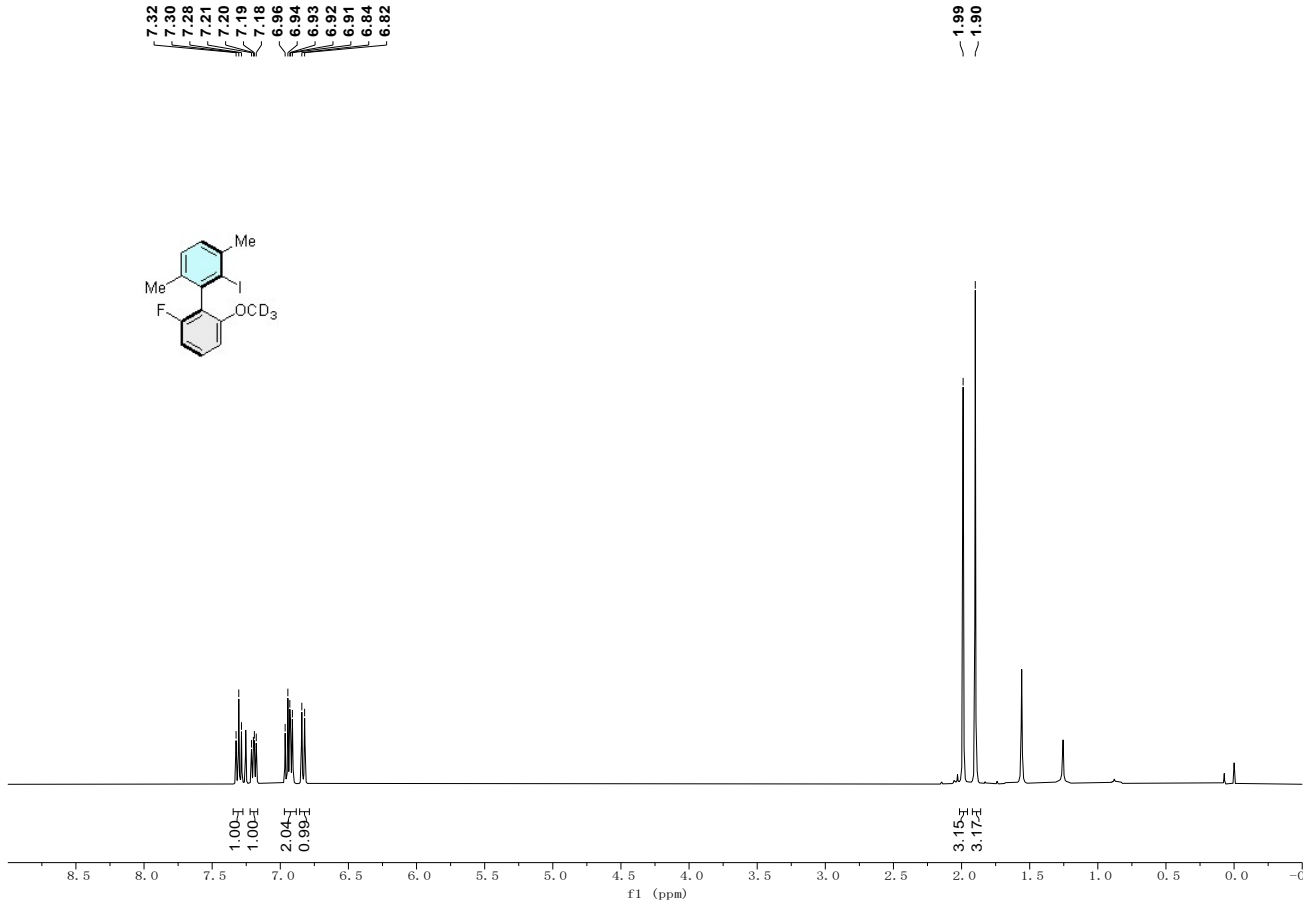


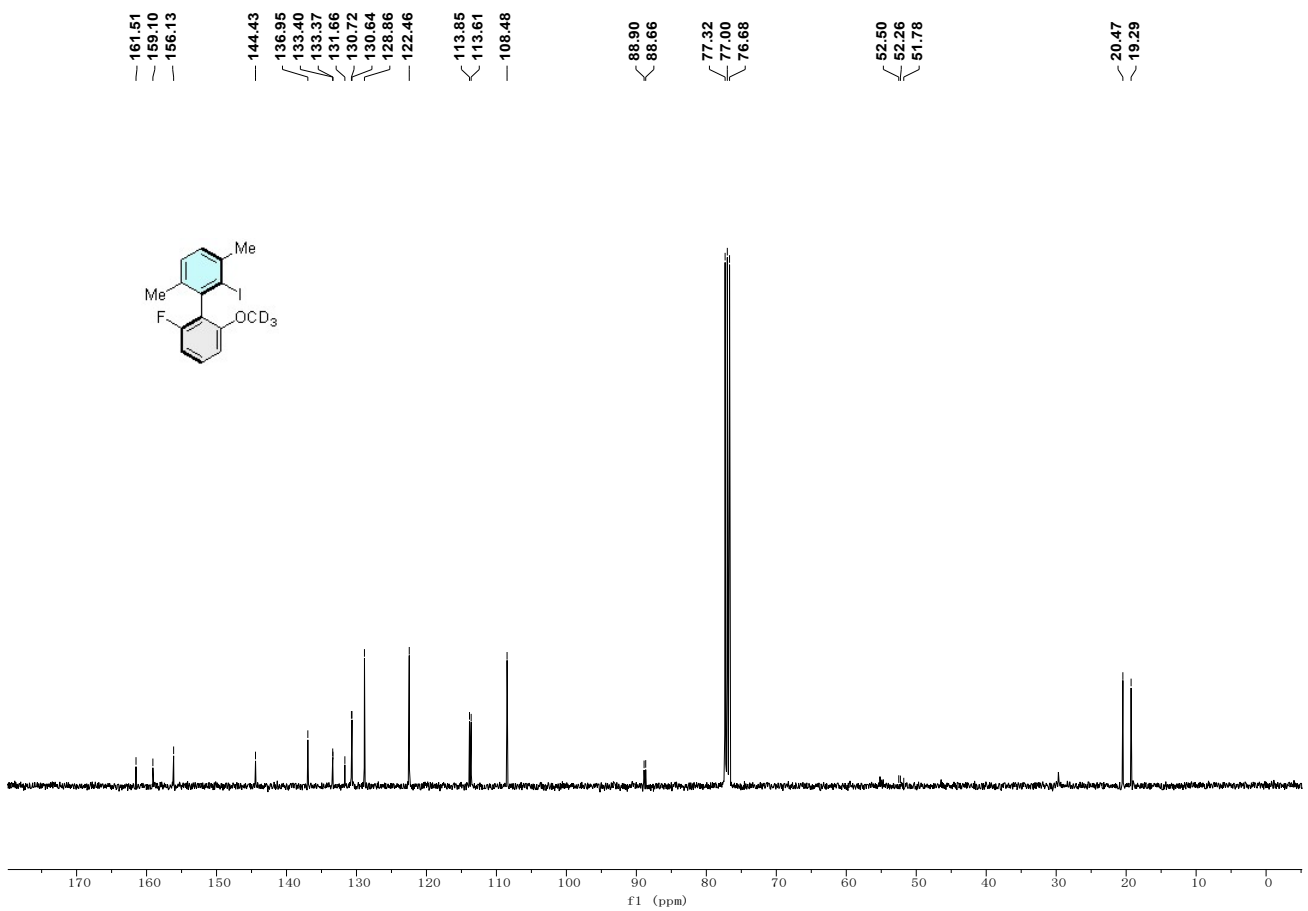
2i, ^{1}H NMR (400 MHz, $CDCl_3$); ^{13}C NMR (101 MHz, $CDCl_3$)



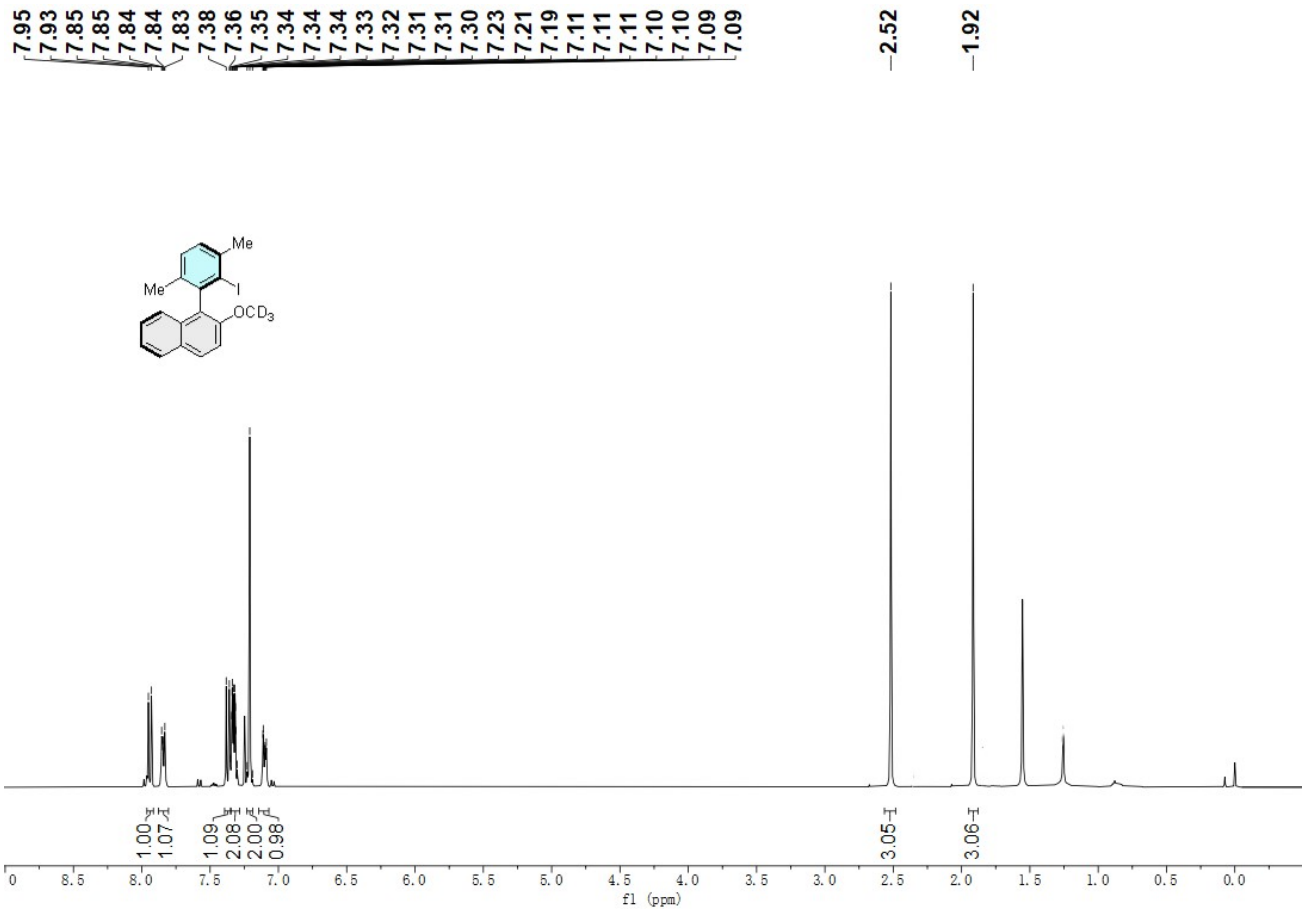


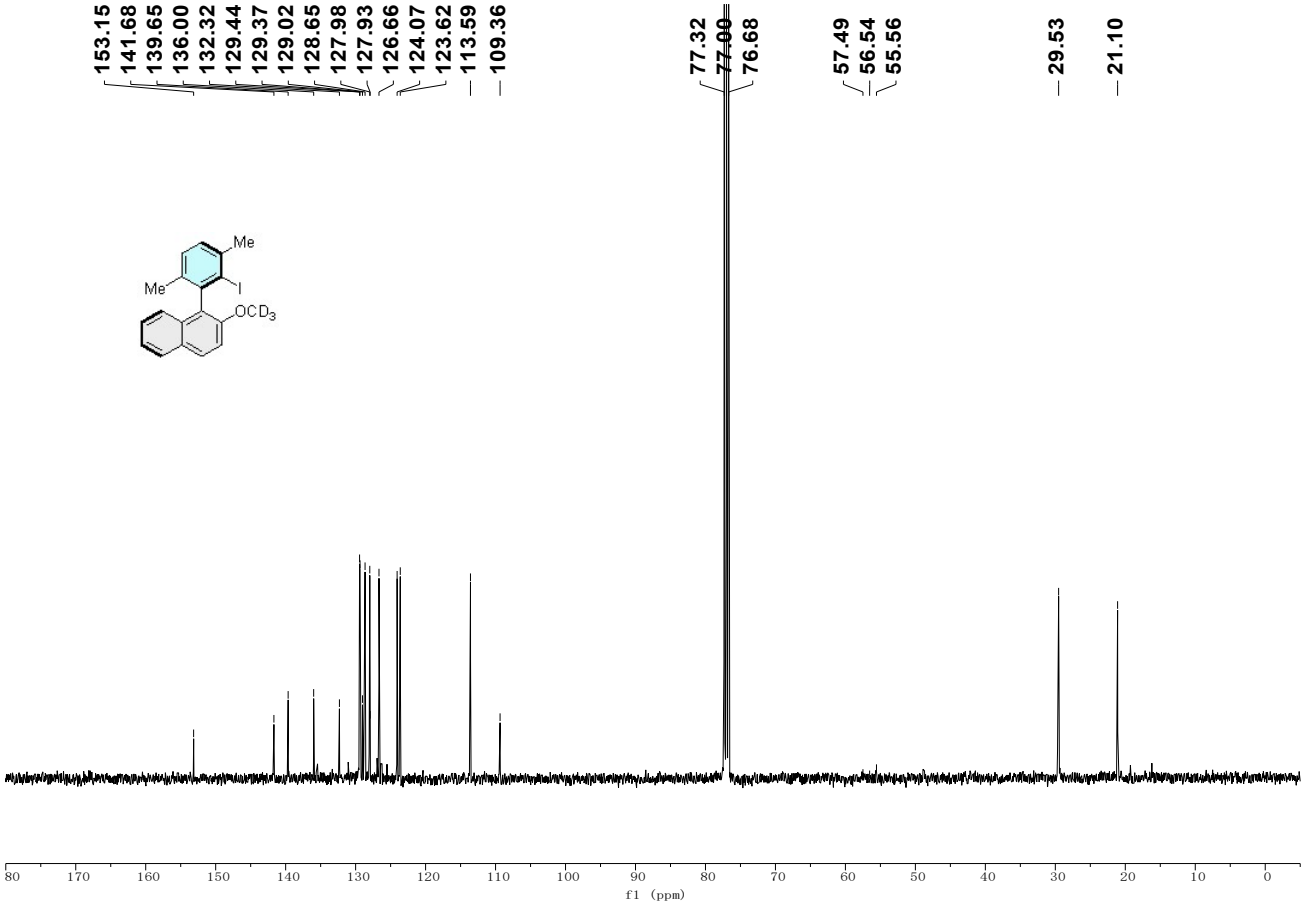
2j, ^{1}H NMR (400 MHz, $CDCl_3$); ^{13}C NMR (101 MHz, $CDCl_3$)





2k, ^{1}H NMR (400 MHz, $CDCl_3$); ^{13}C NMR (101 MHz, $CDCl_3$)





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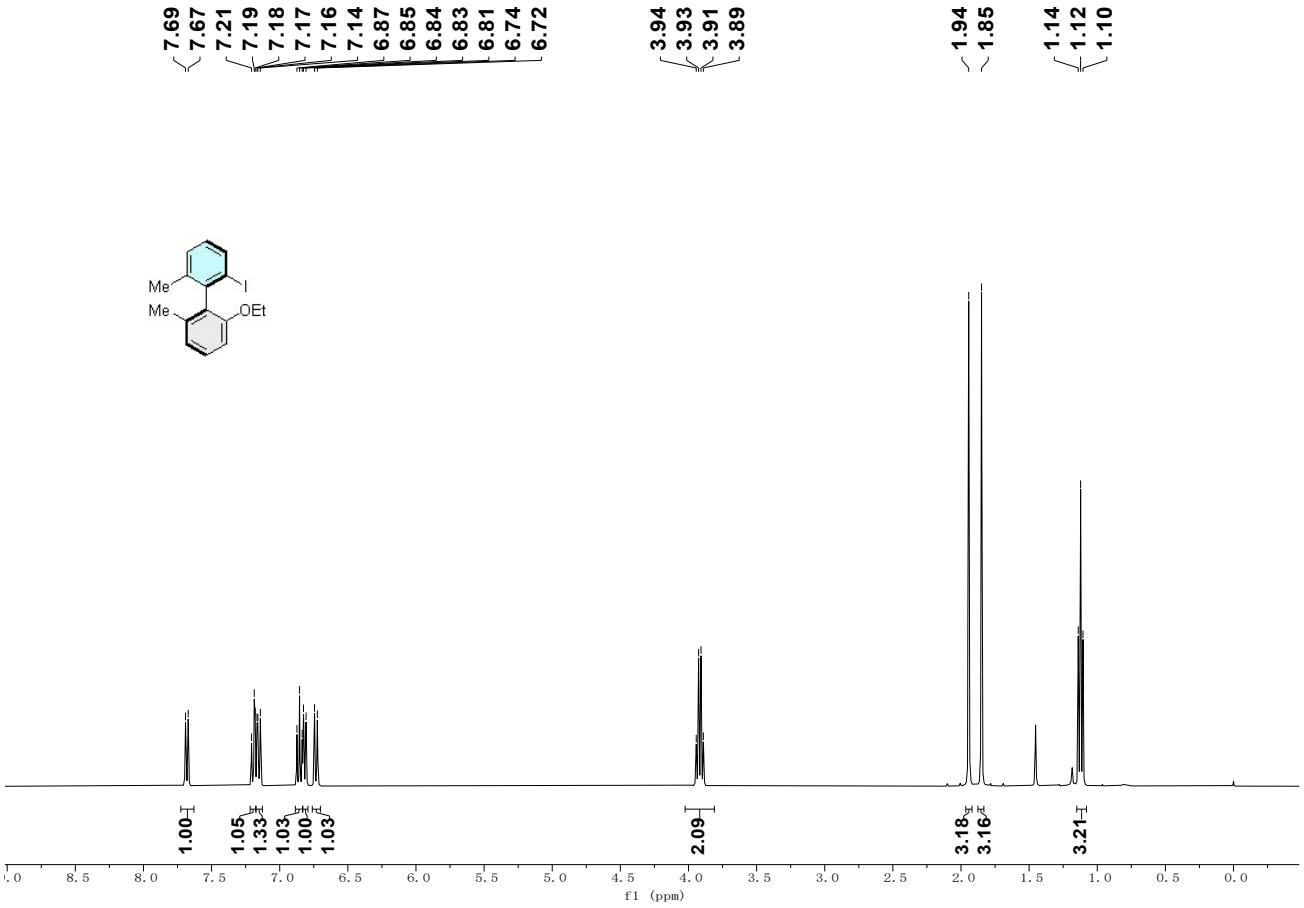
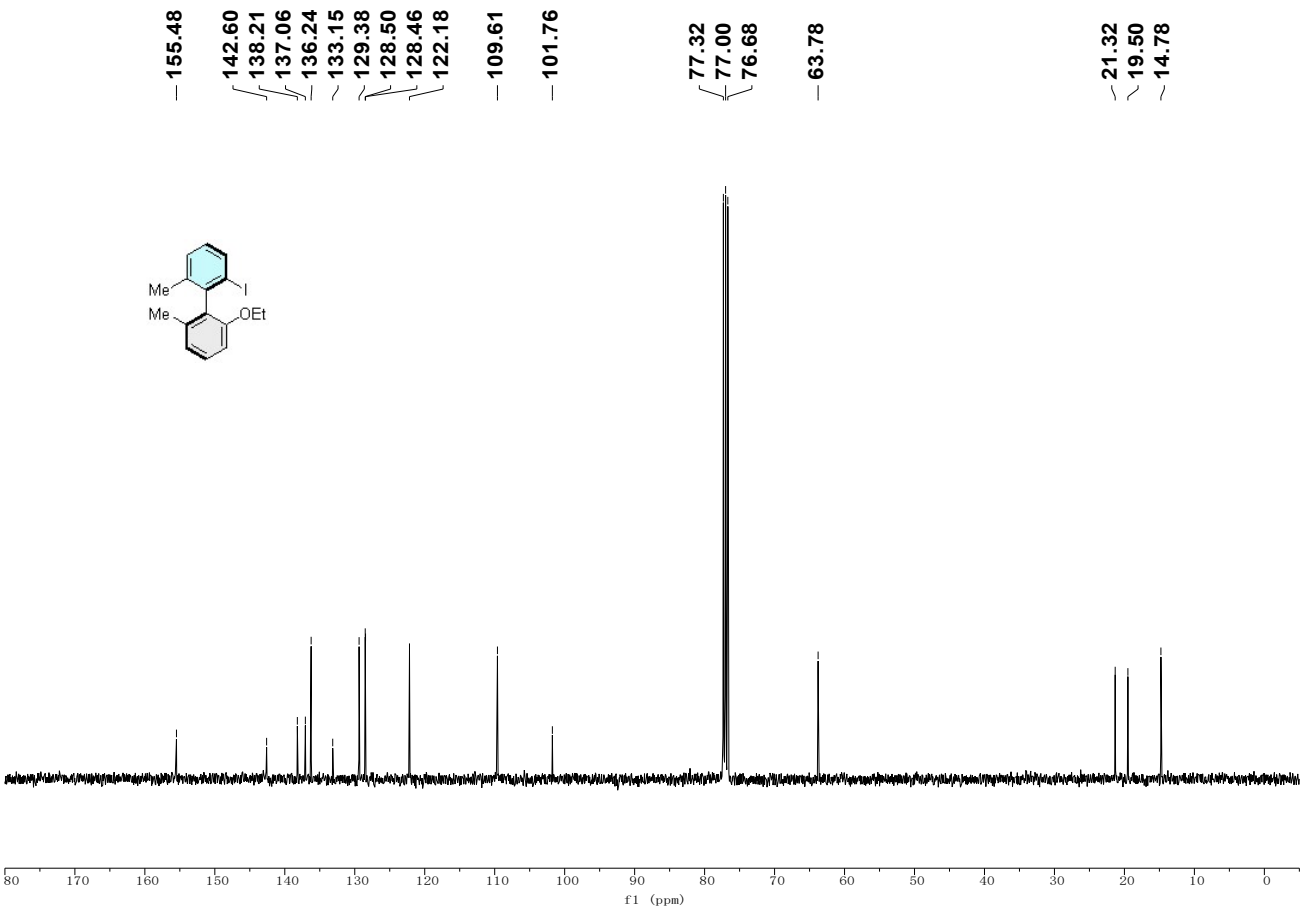
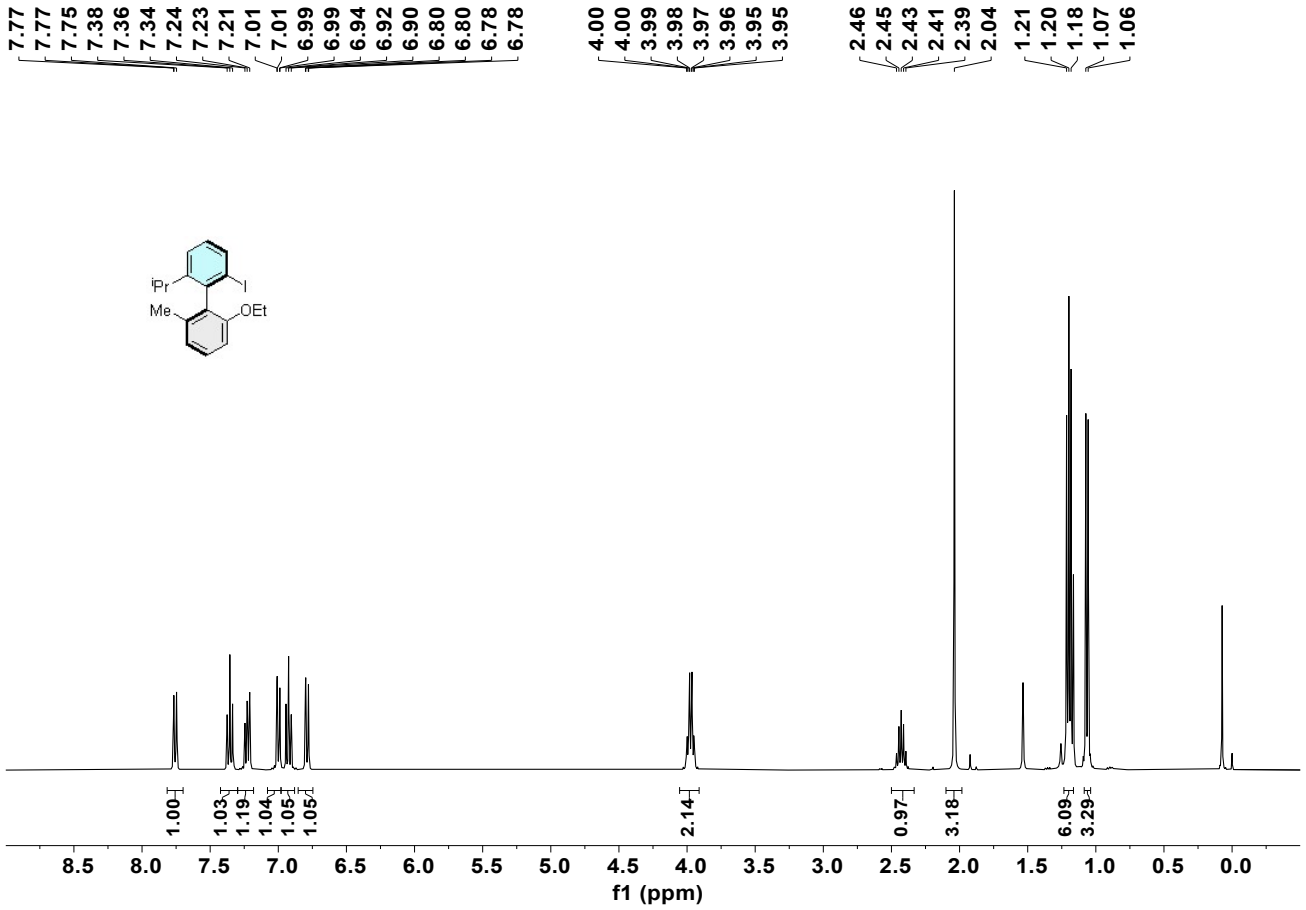
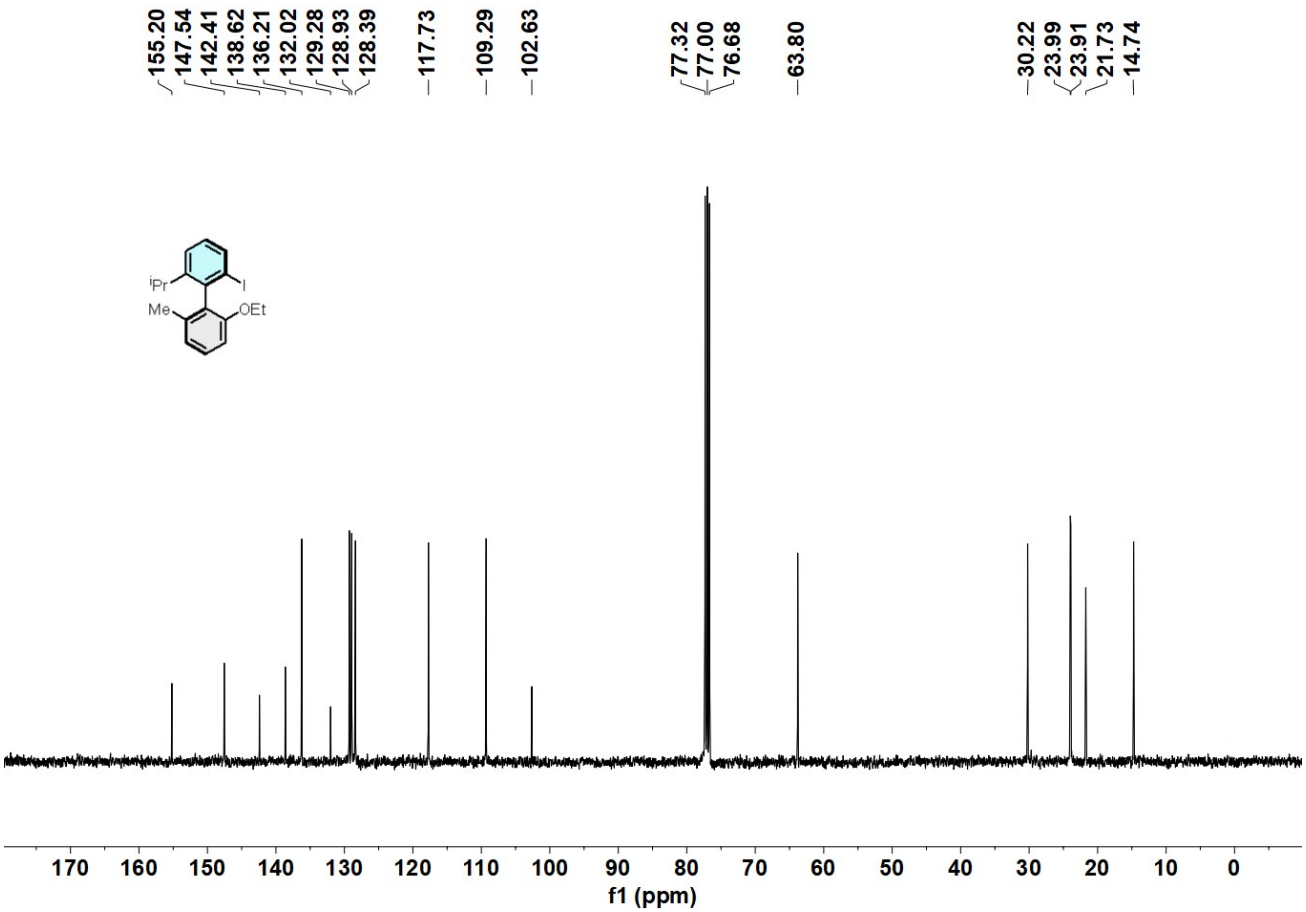


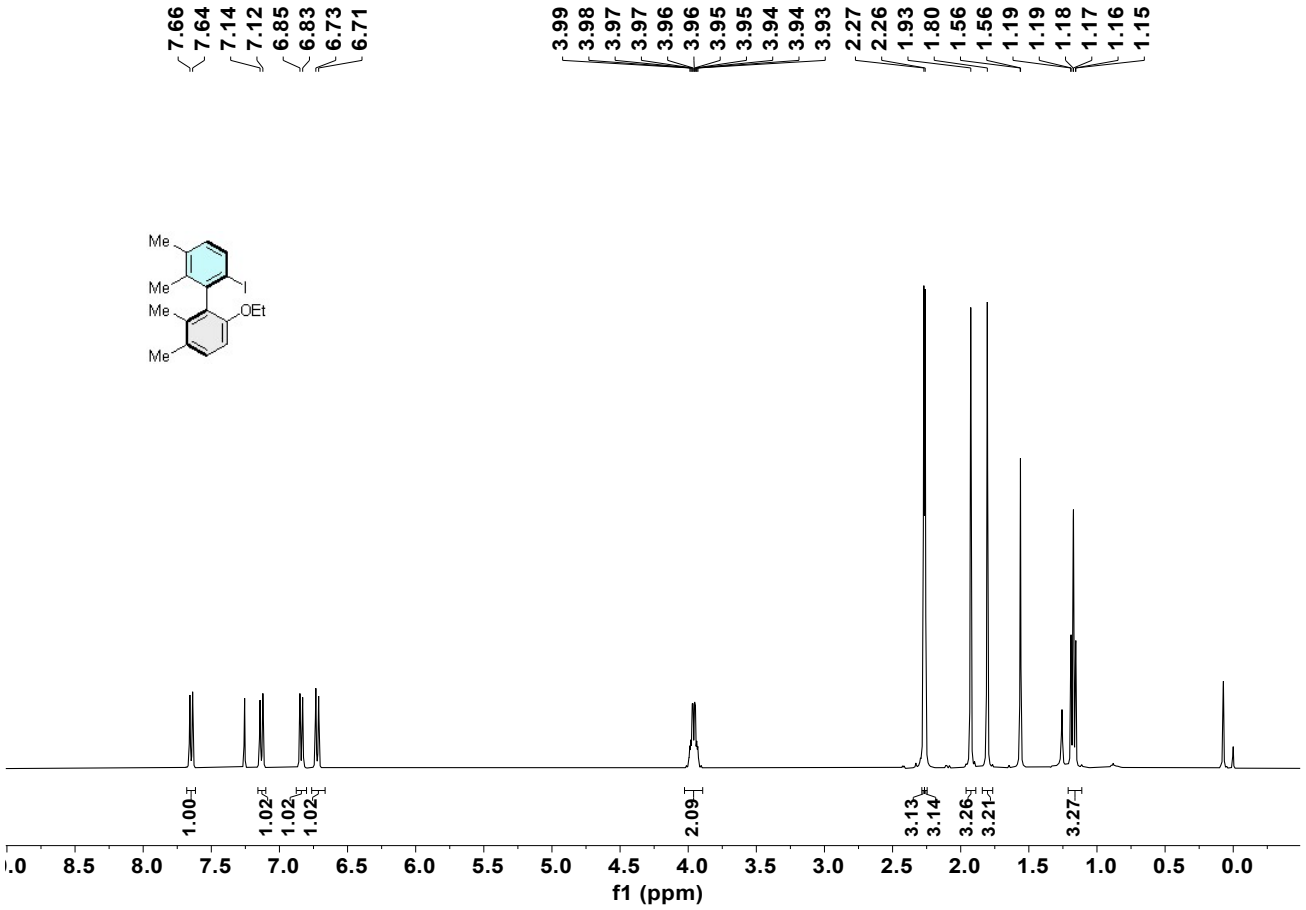


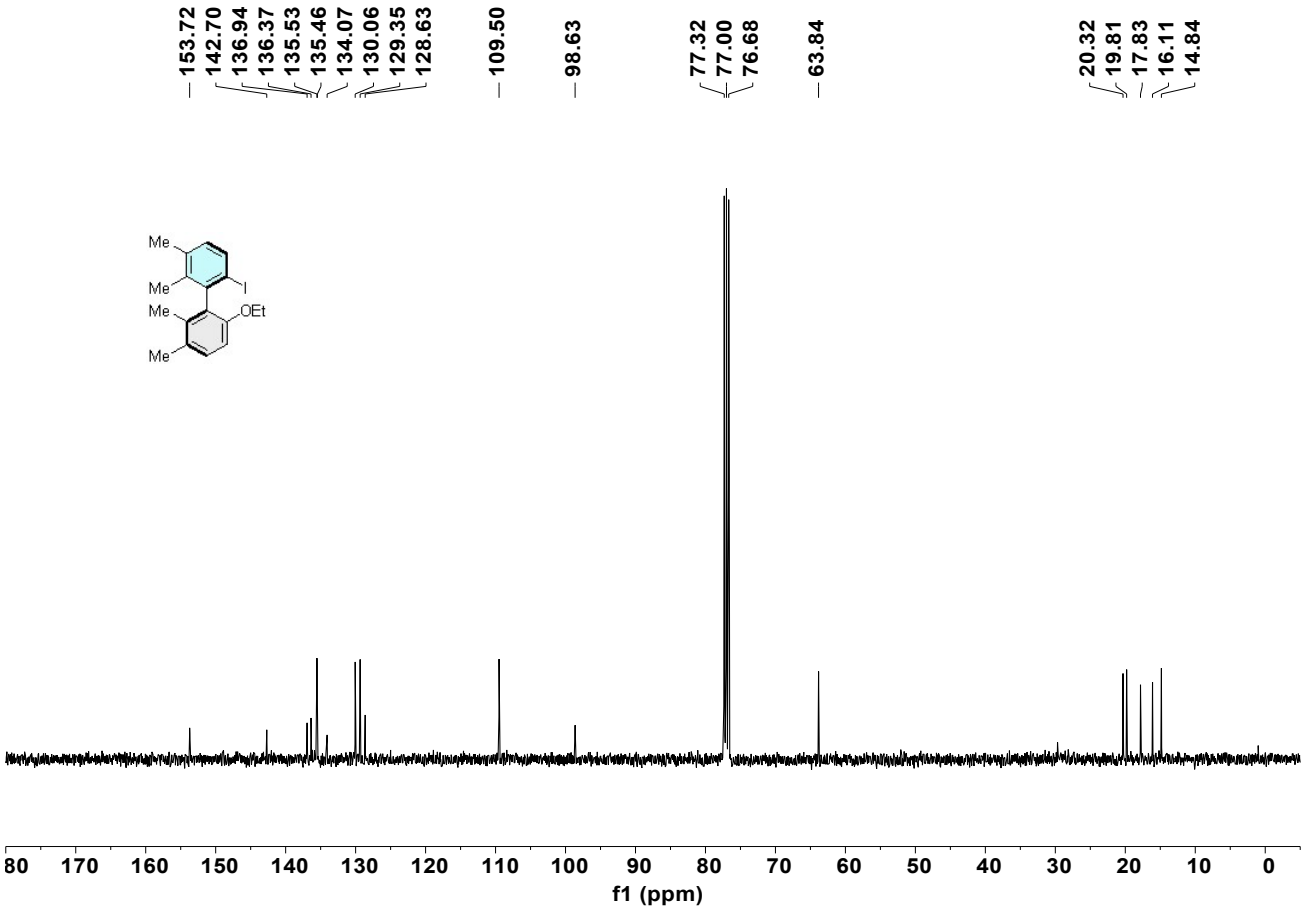
2m, ^{1}H NMR (400 MHz, $CDCl_3$); ^{13}C NMR (101 MHz, $CDCl_3$)



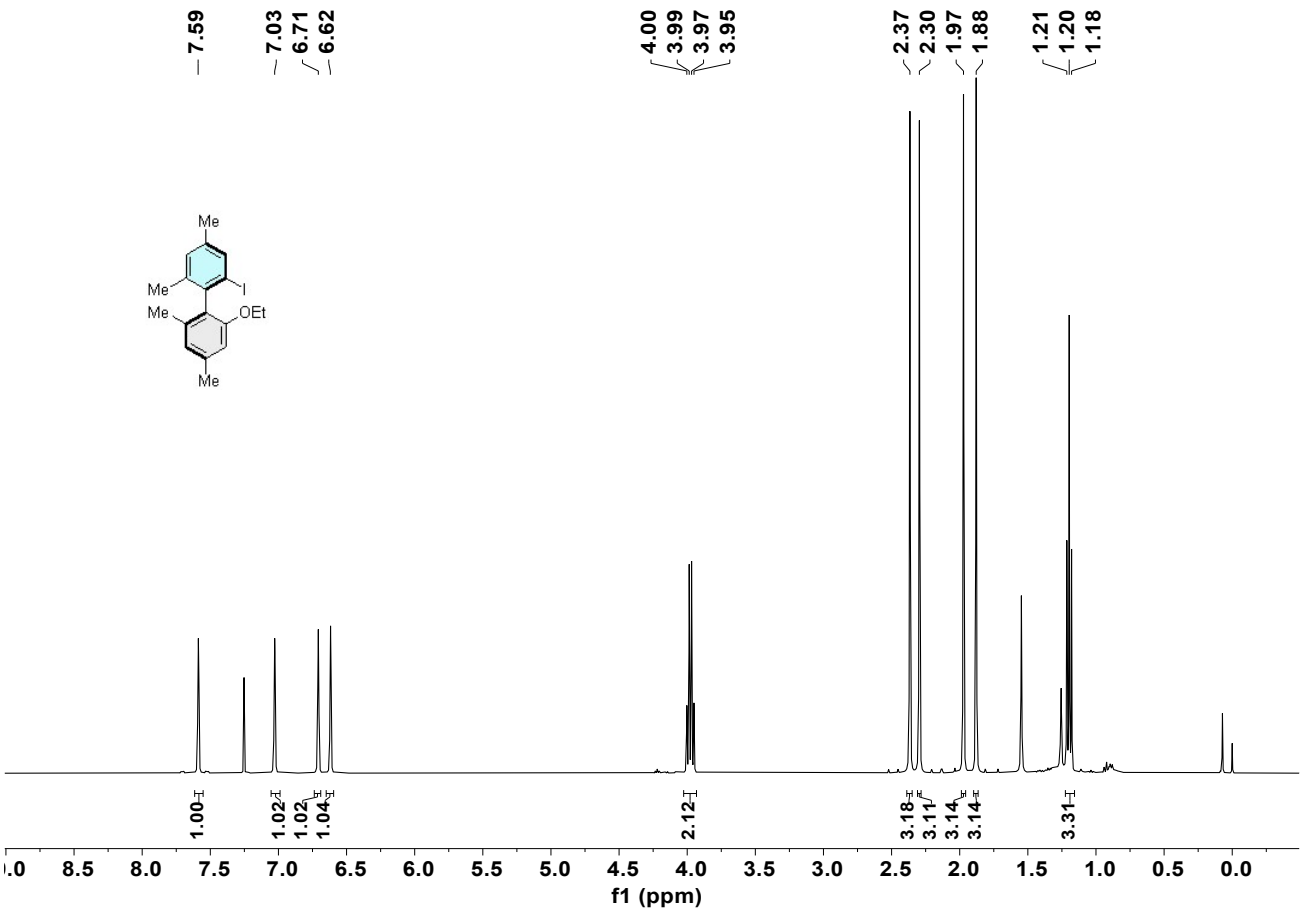


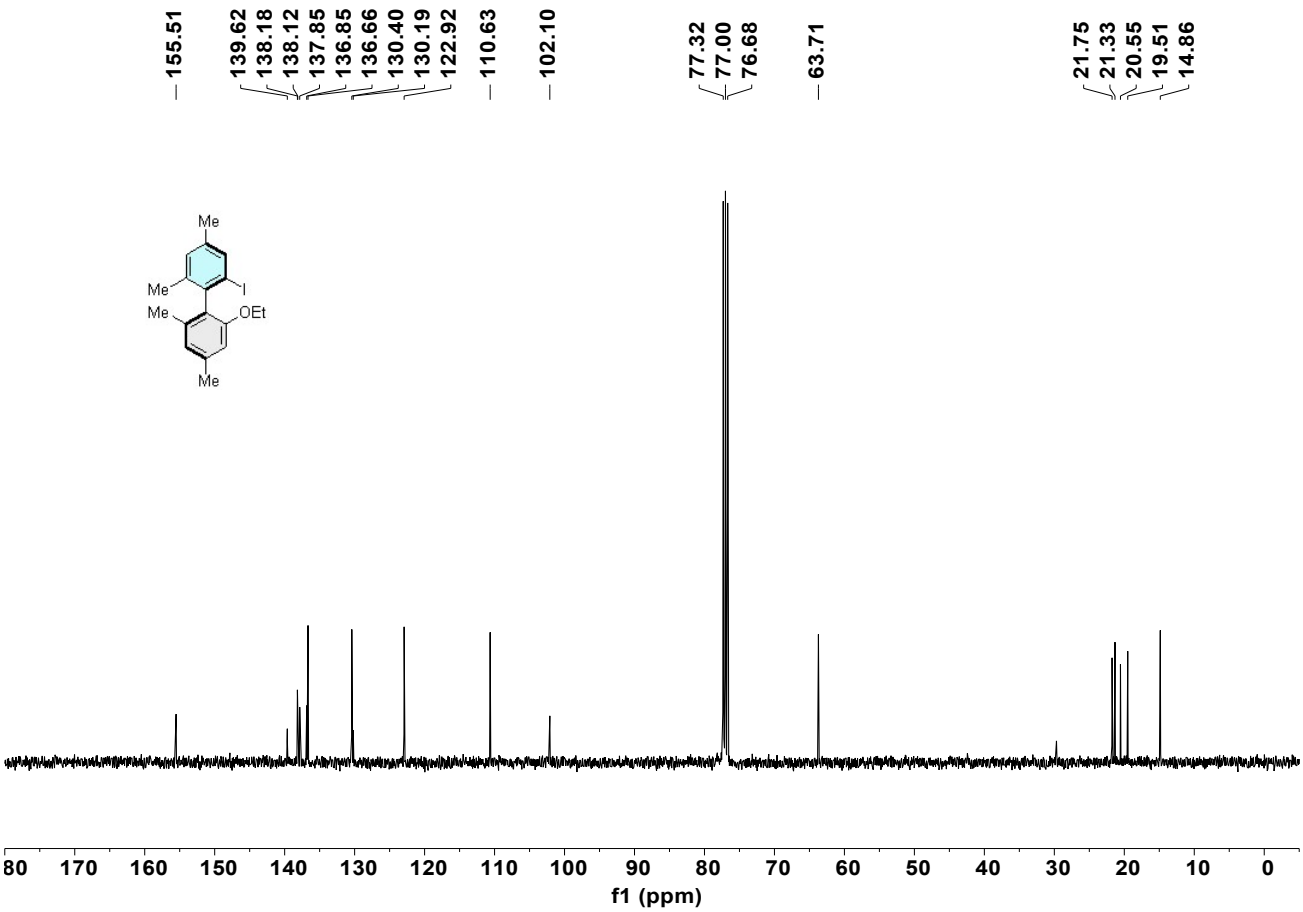
2n, ^{1}H NMR (400 MHz, $CDCl_3$); ^{13}C NMR (101 MHz, $CDCl_3$)



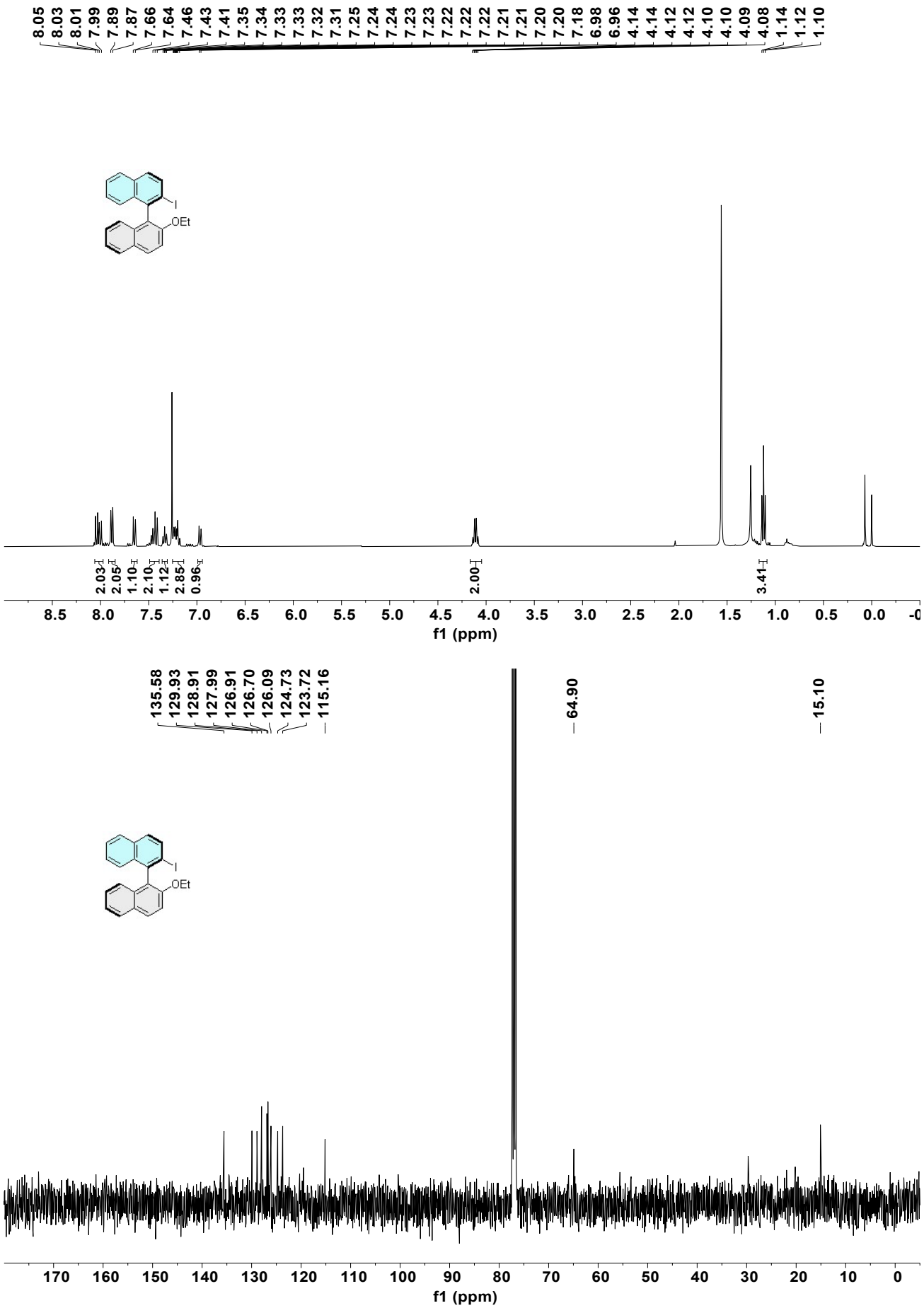


2o, ^{1}H NMR (400 MHz, $CDCl_3$); ^{13}C NMR (101 MHz, $CDCl_3$)

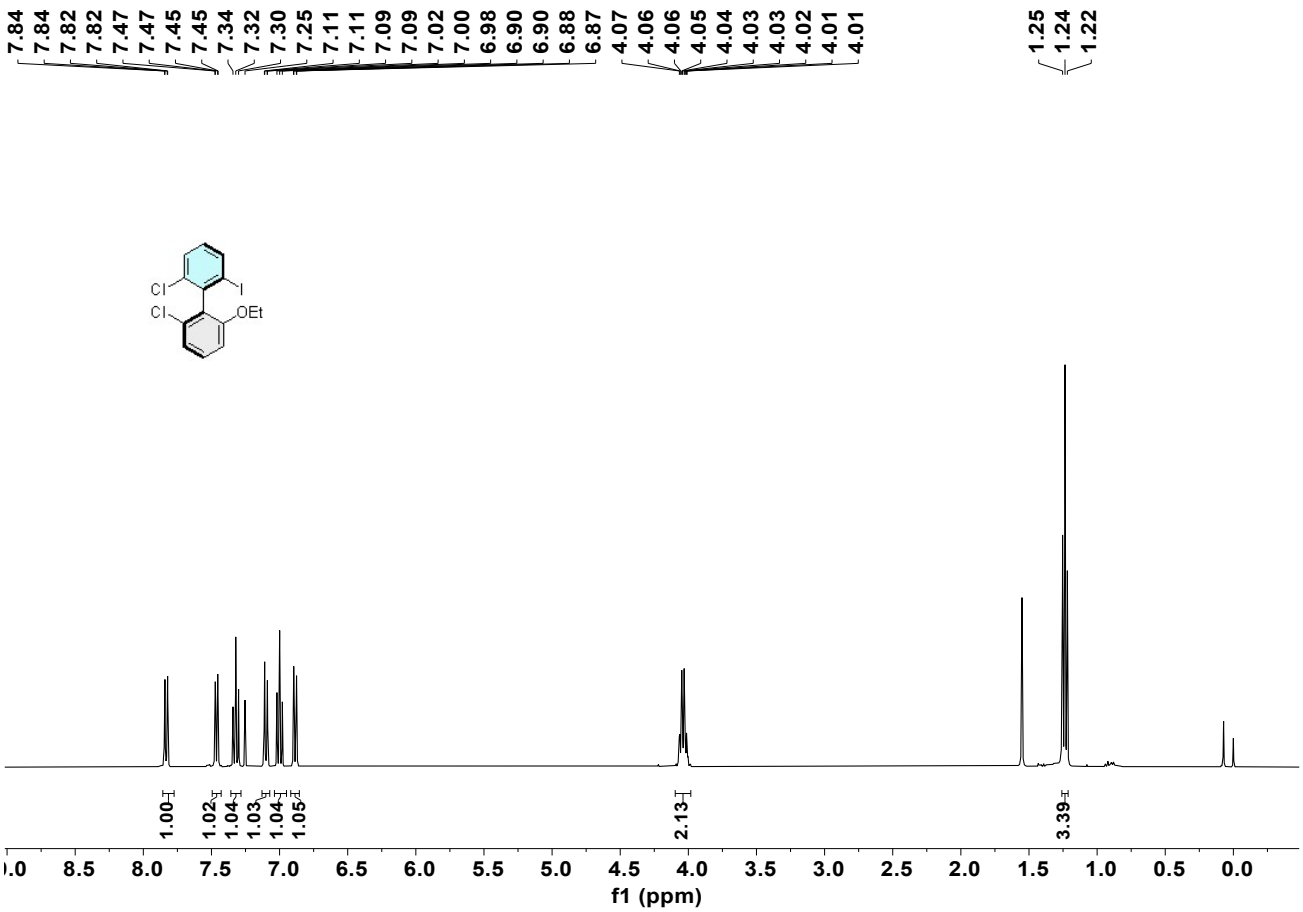


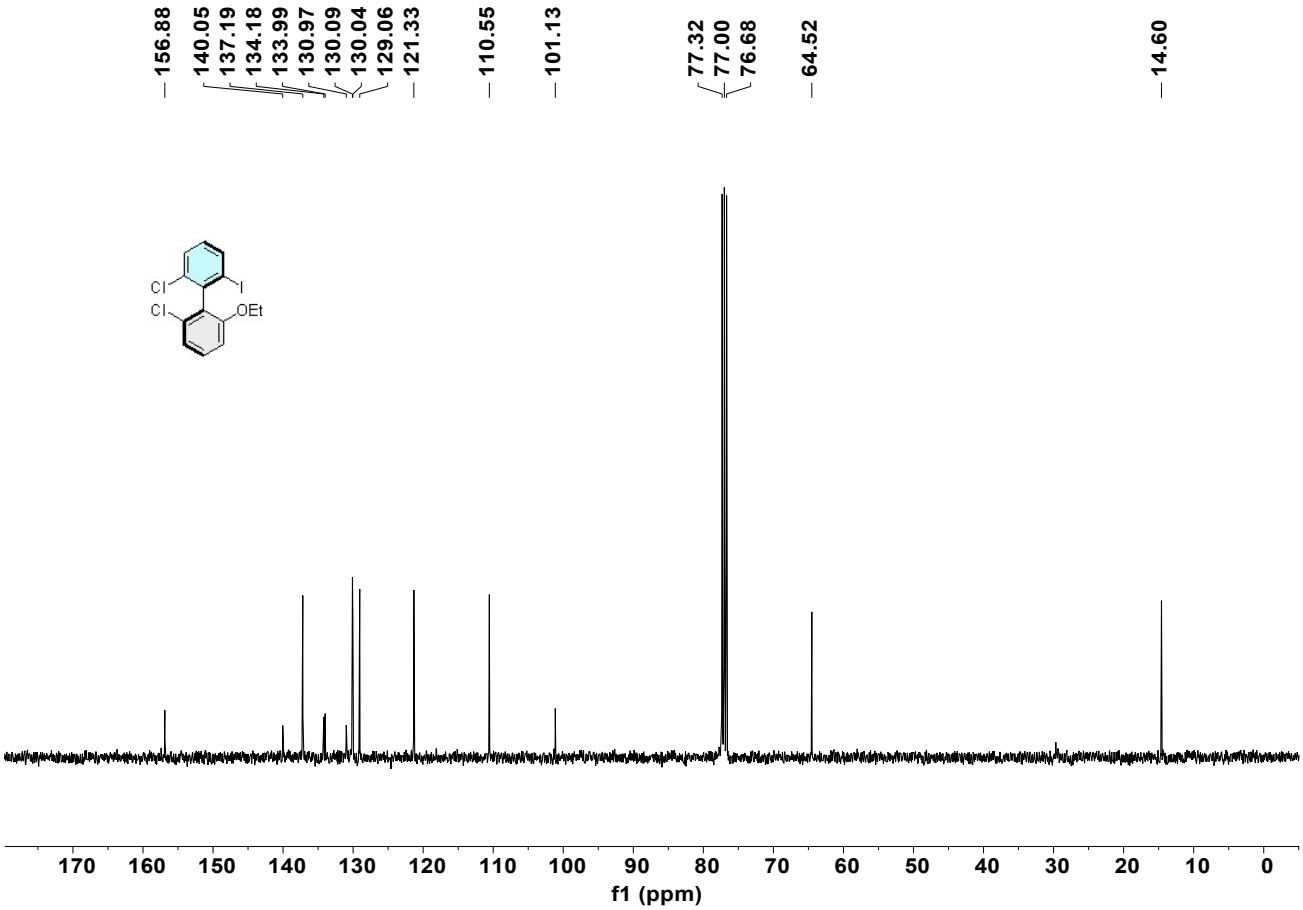


2p, ^{1}H NMR (400 MHz, $CDCl_3$); ^{13}C NMR (101 MHz, $CDCl_3$)

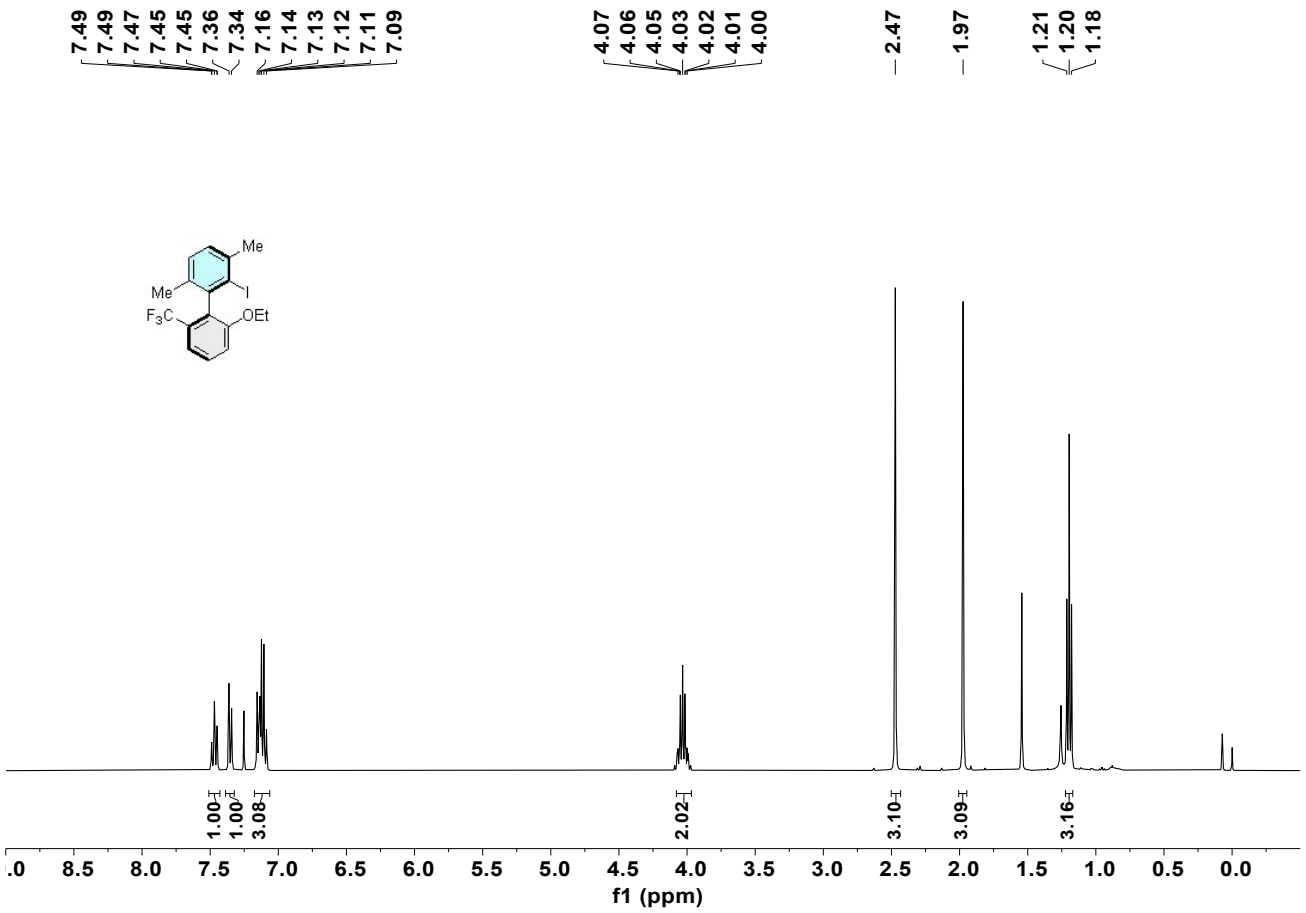


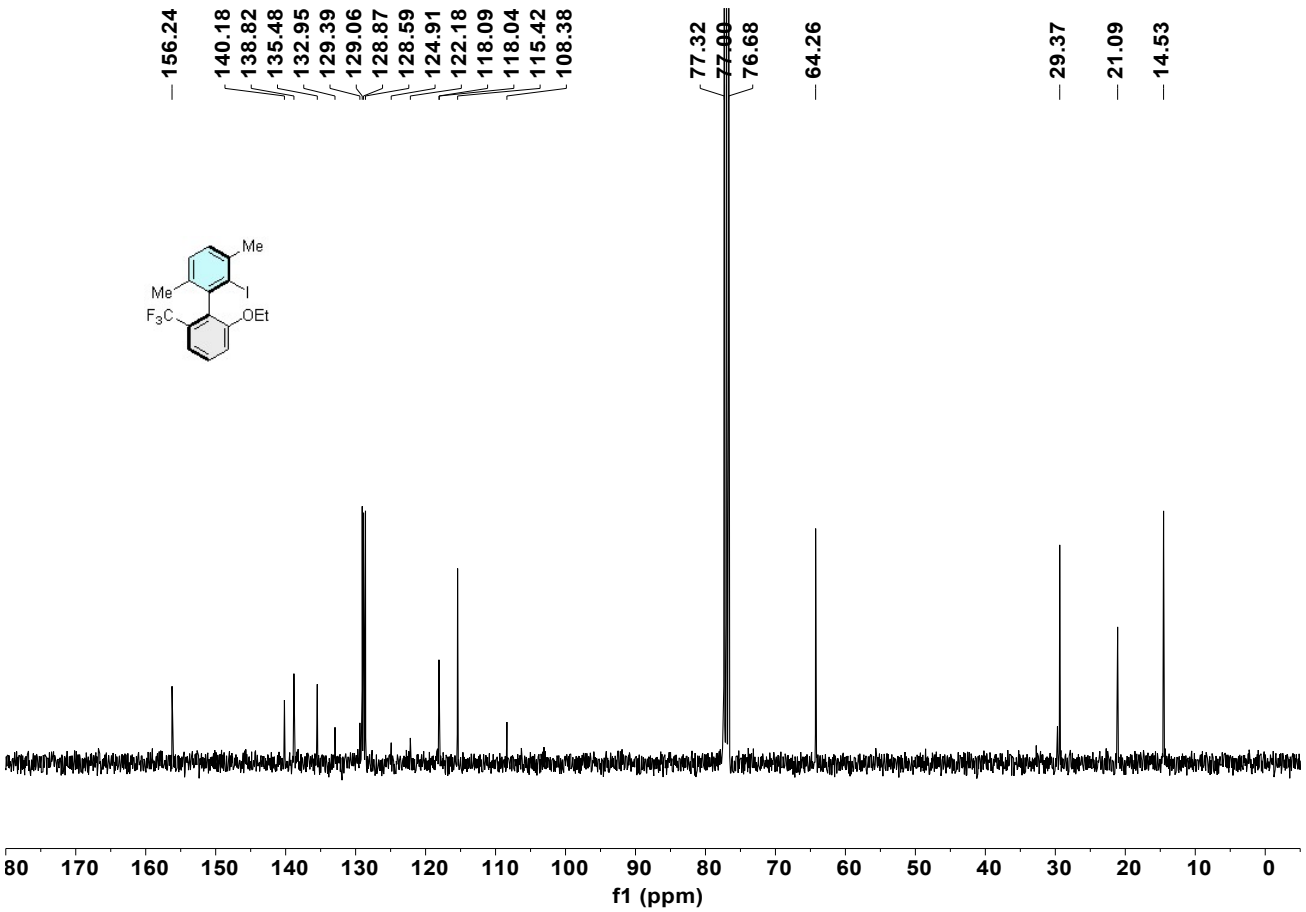
2q, ^{1}H NMR (400 MHz, $CDCl_3$); ^{13}C NMR (101 MHz, $CDCl_3$)



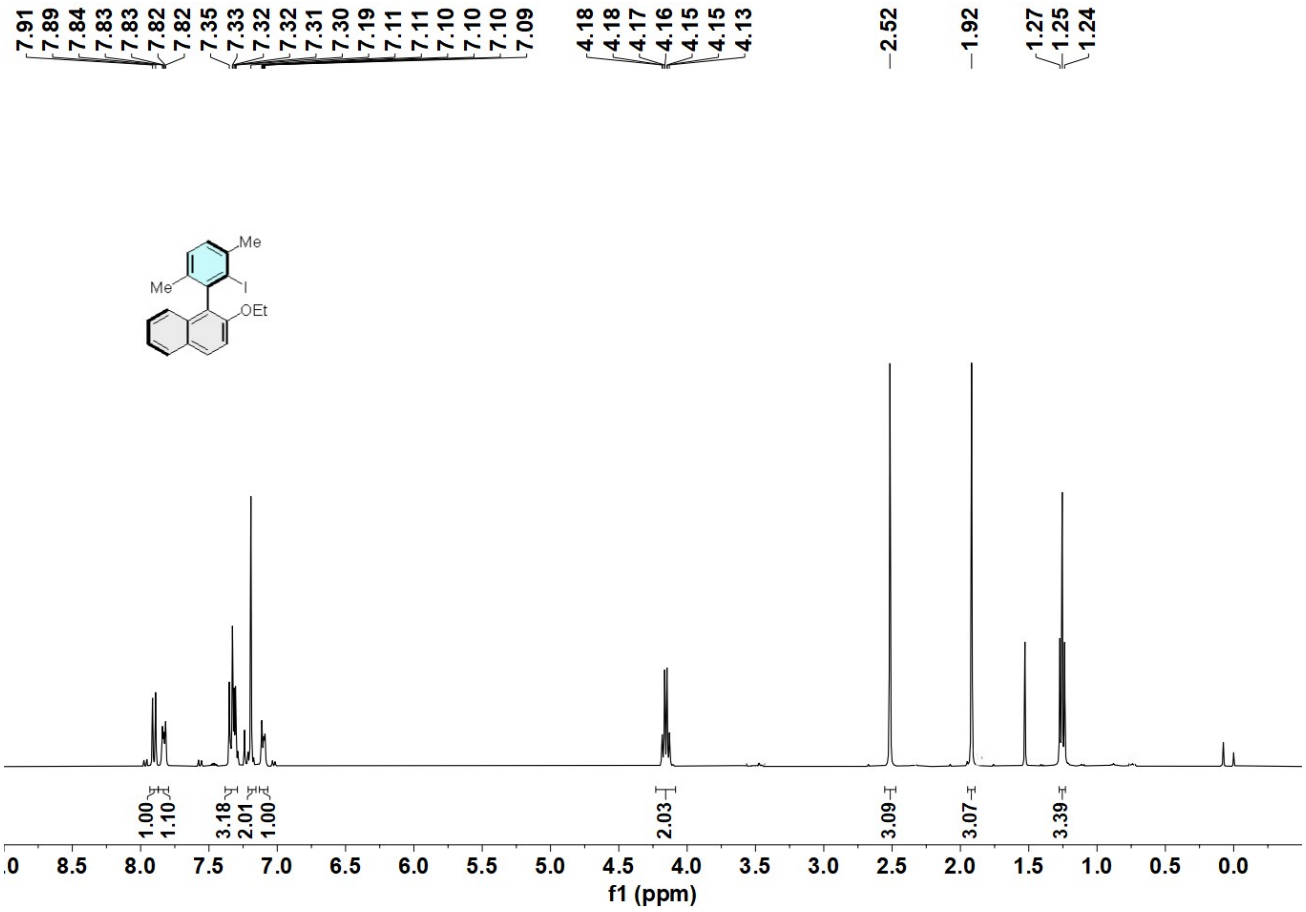


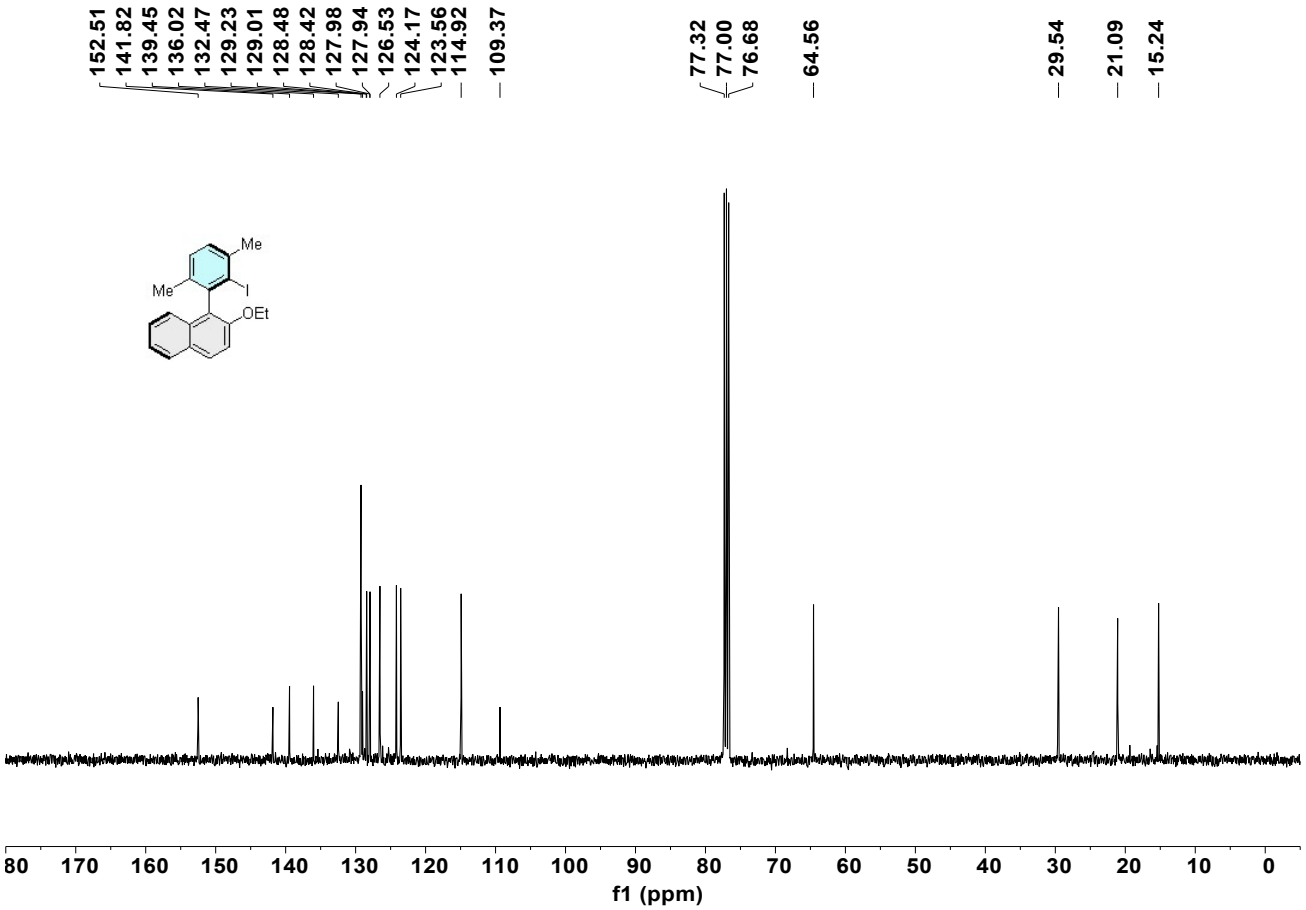
2r, ^{1}H NMR (400 MHz, $CDCl_3$); ^{13}C NMR (101 MHz, $CDCl_3$)



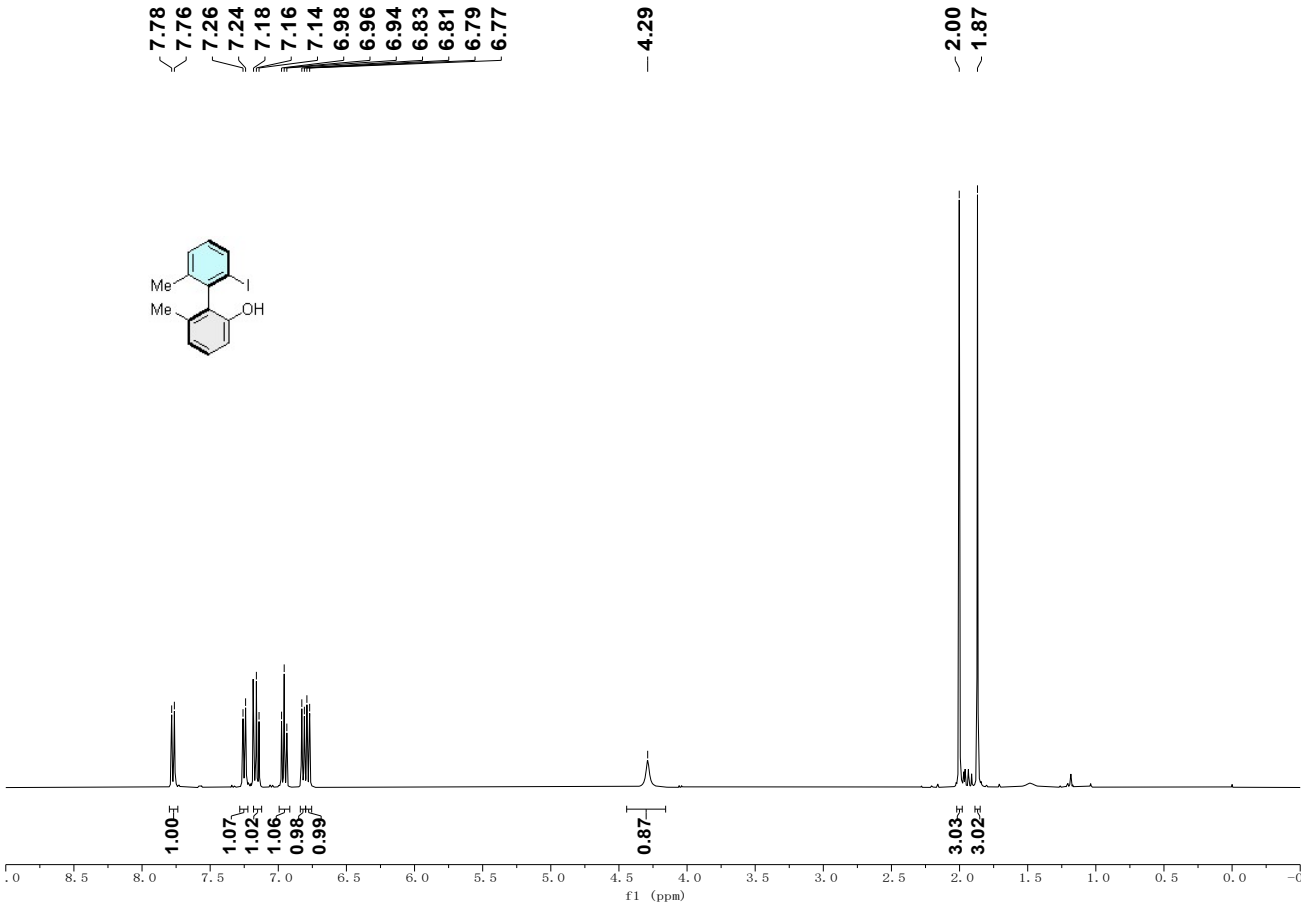


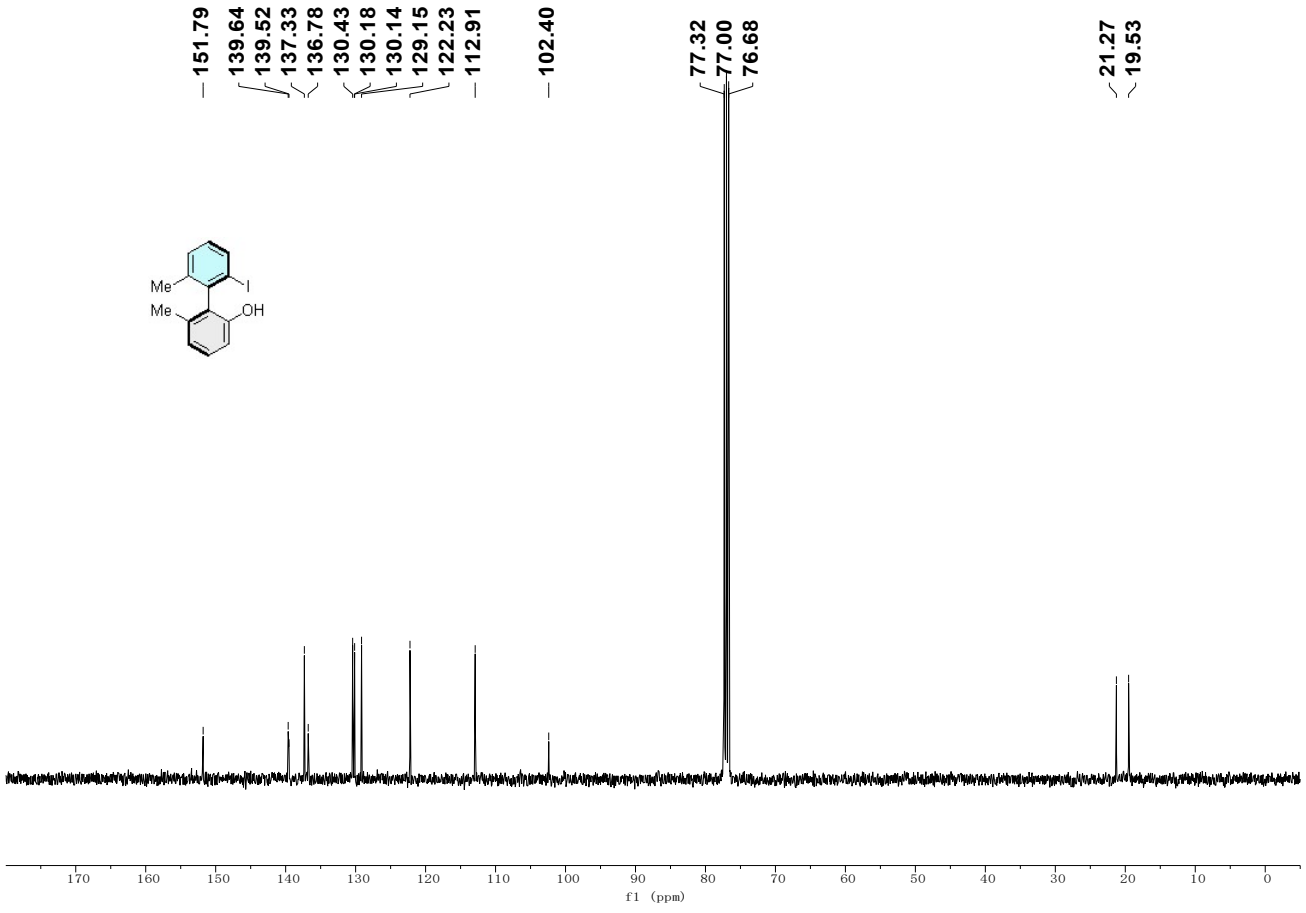
2s, ^{1}H NMR (400 MHz, $CDCl_3$); ^{13}C NMR (101 MHz, $CDCl_3$)



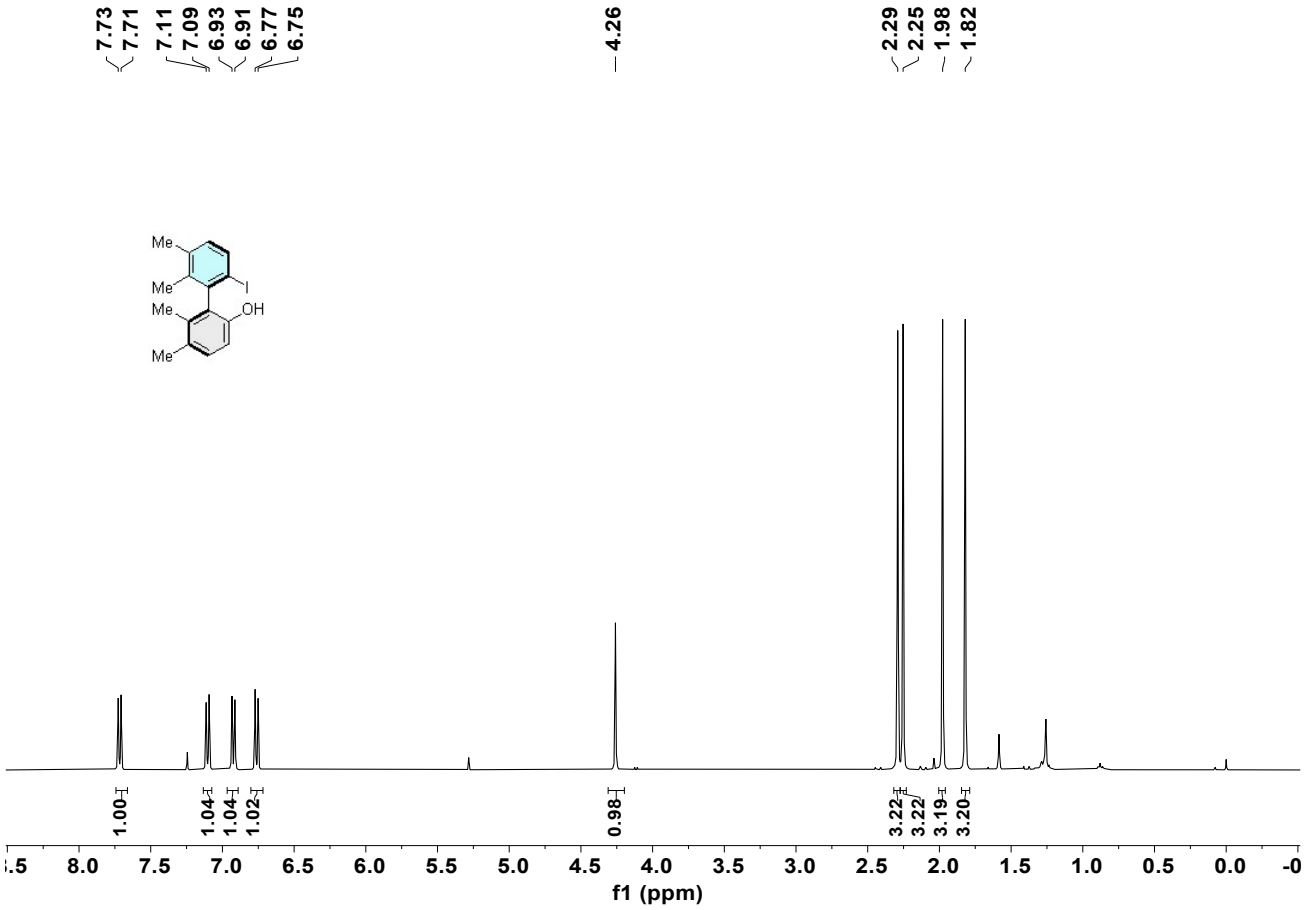


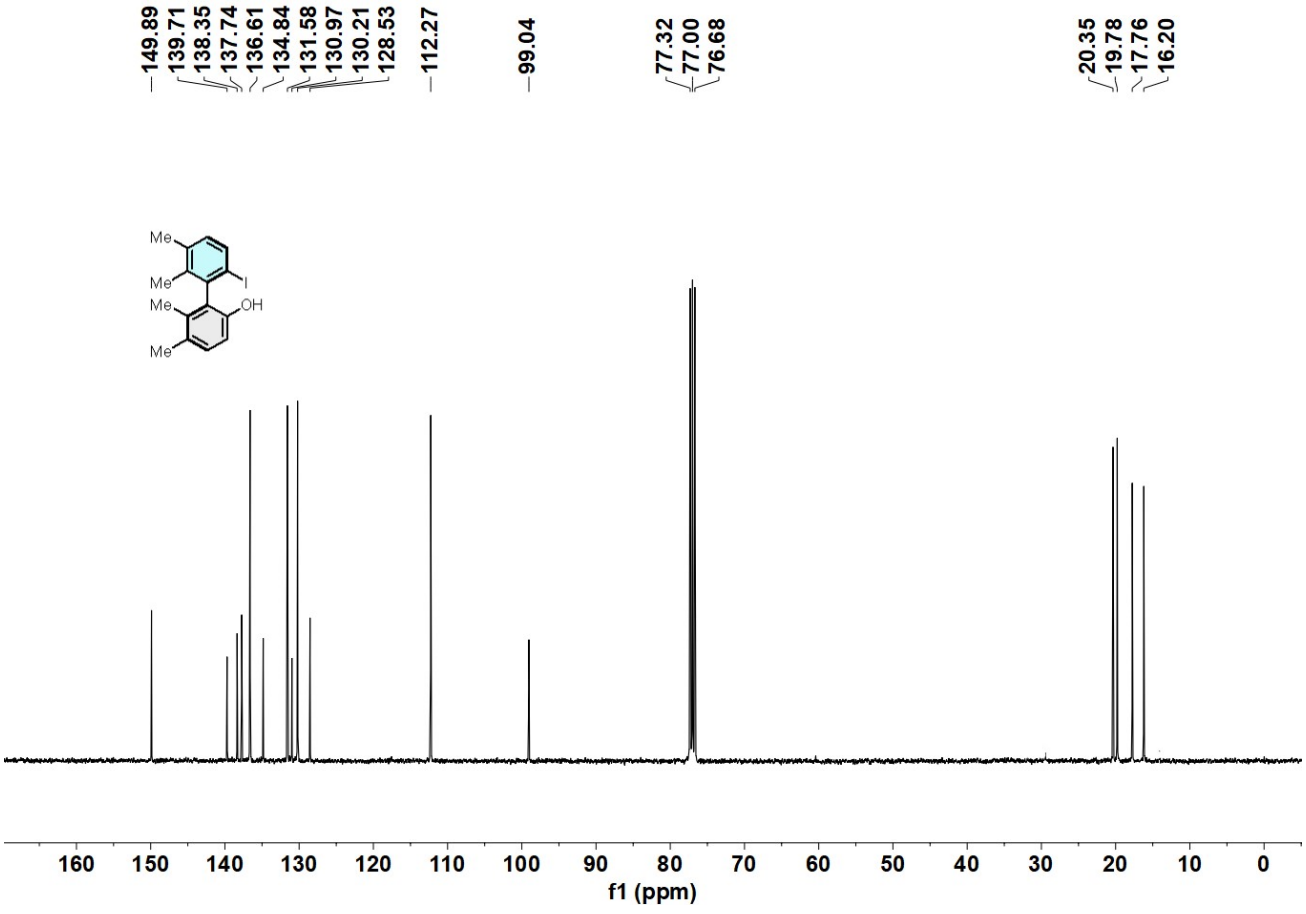
2t, ^{1}H NMR (400 MHz, $CDCl_3$); ^{13}C NMR (101 MHz, $CDCl_3$)



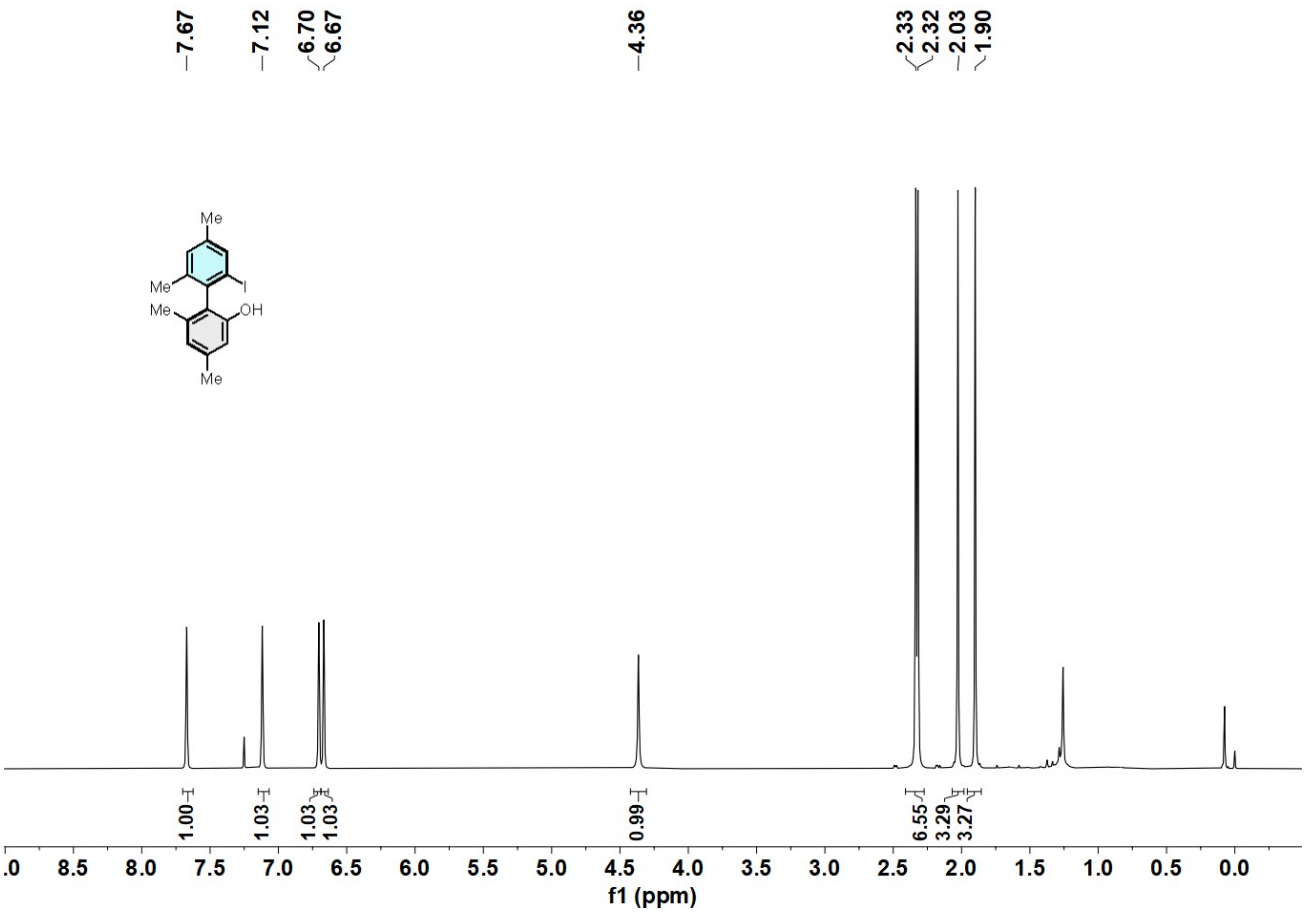


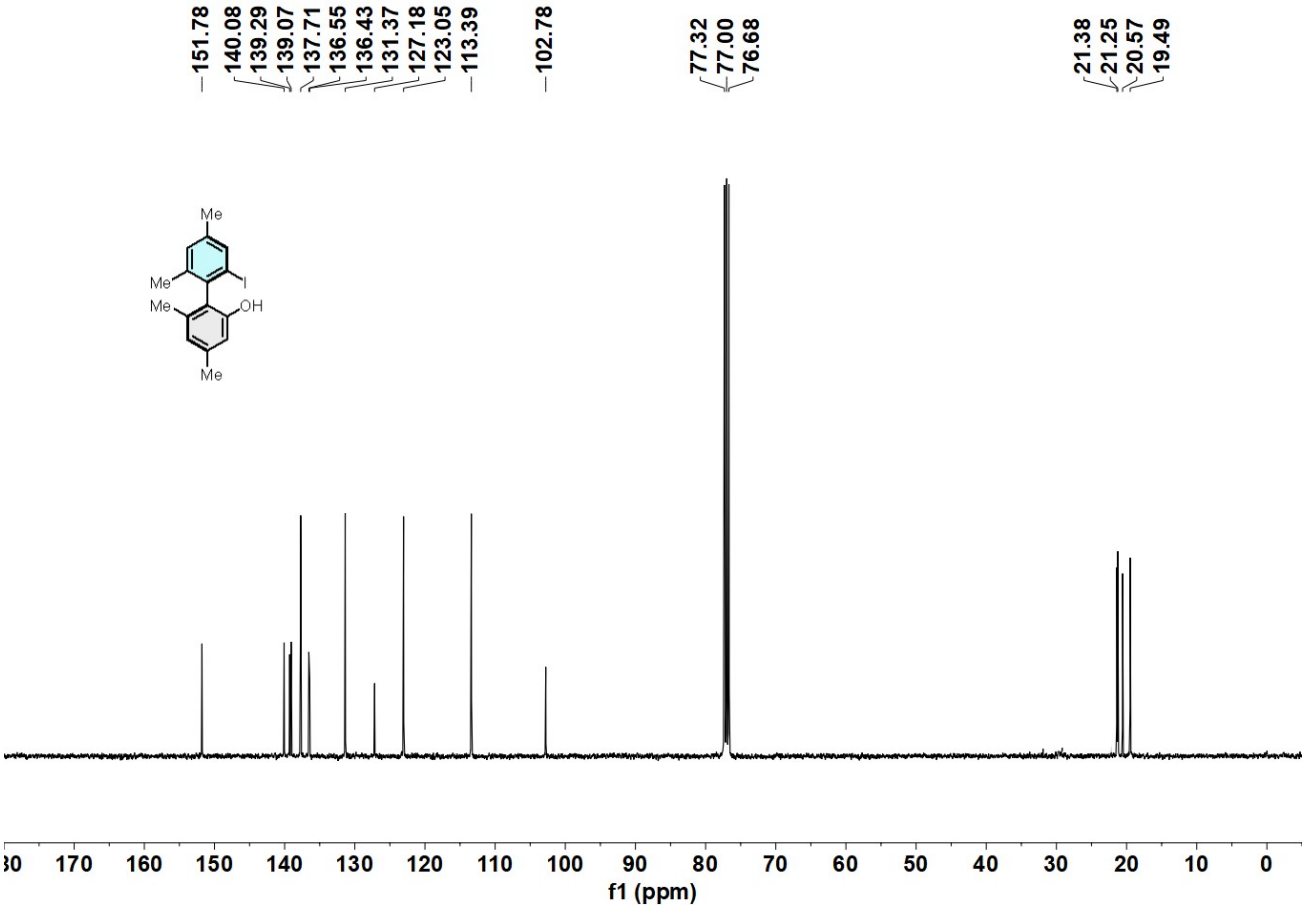
2u, ^{1}H NMR (400 MHz, $CDCl_3$); ^{13}C NMR (101 MHz, $CDCl_3$)



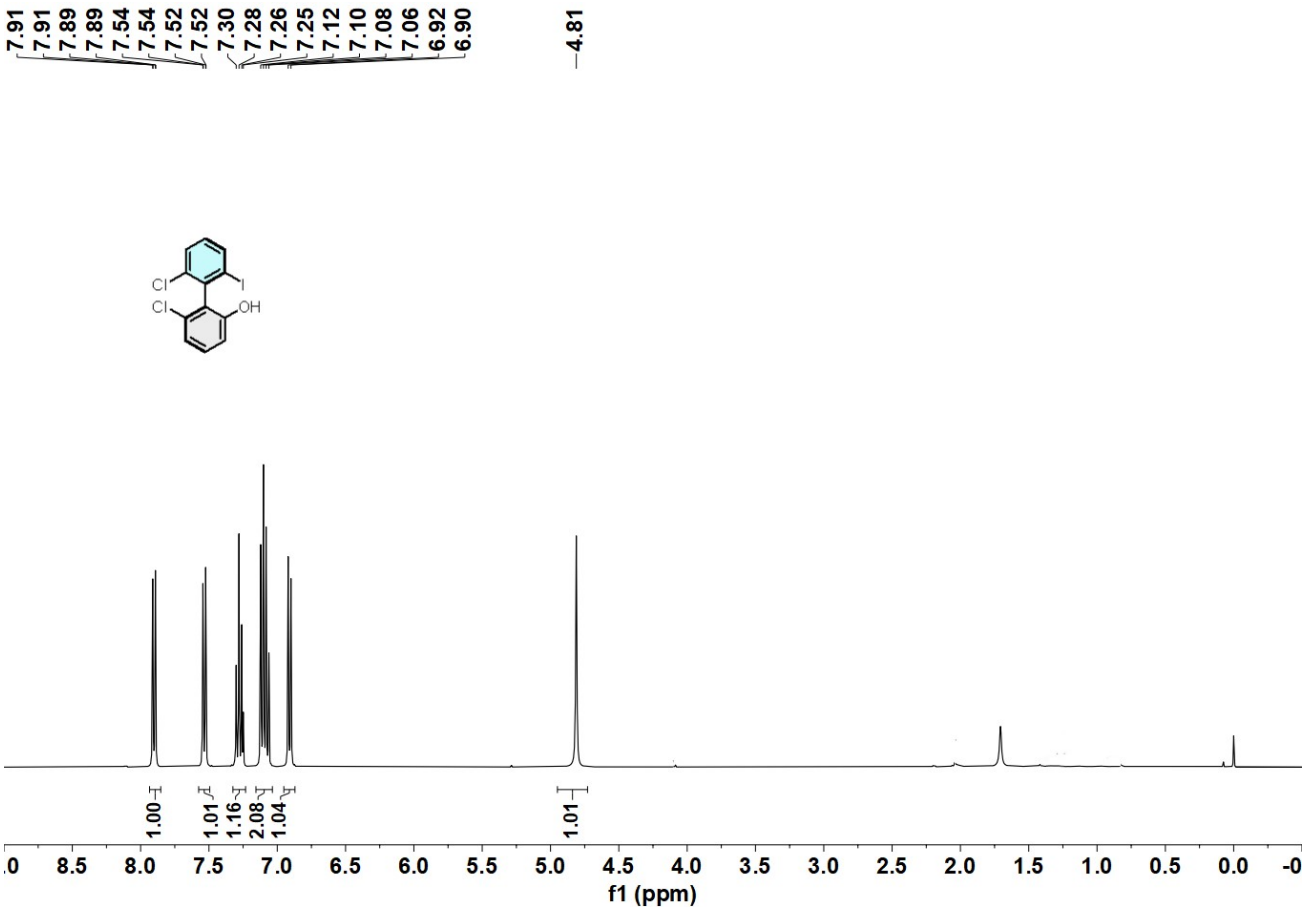


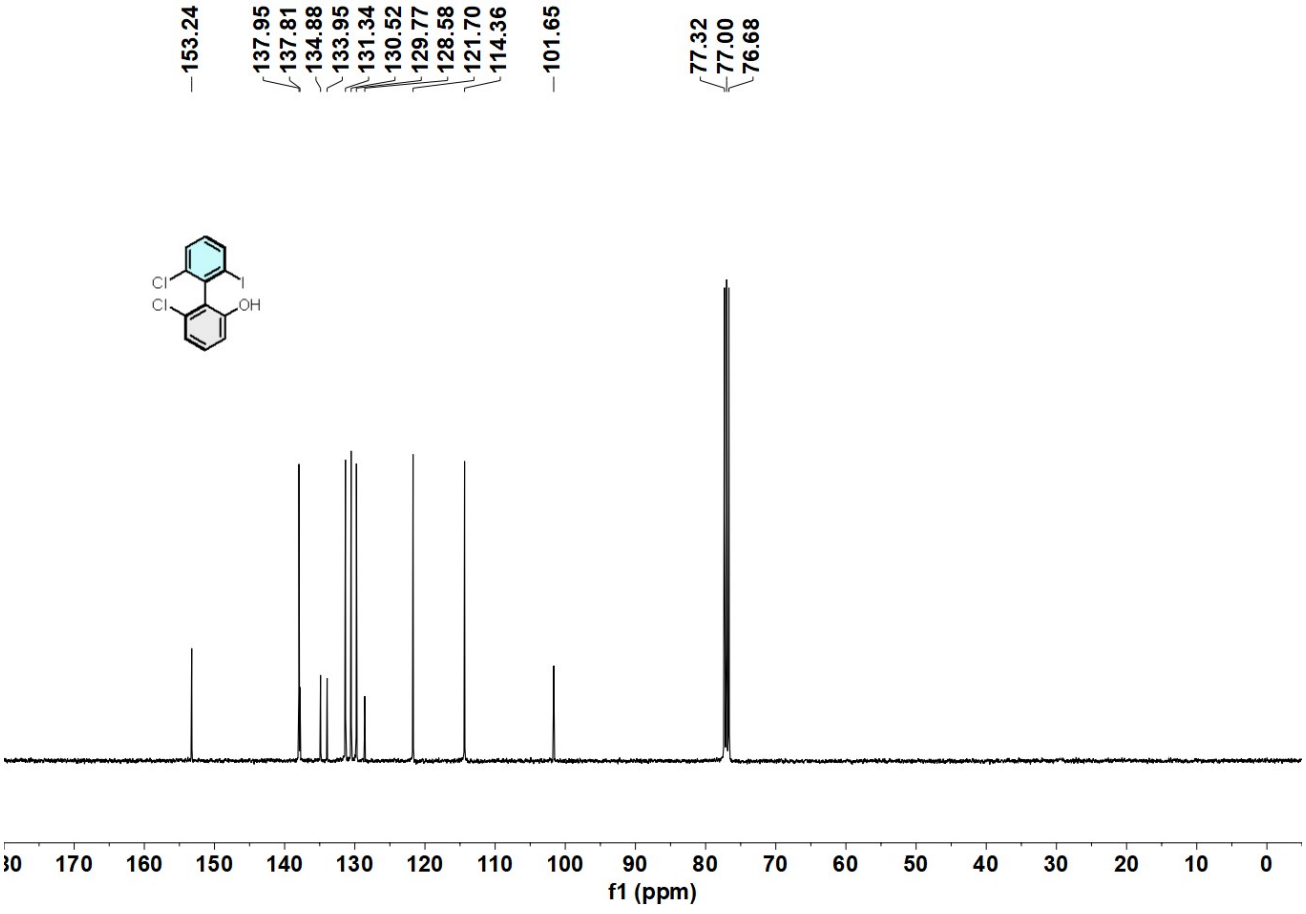
2v, ^{1}H NMR (400 MHz, $CDCl_3$); ^{13}C NMR (101 MHz, $CDCl_3$)



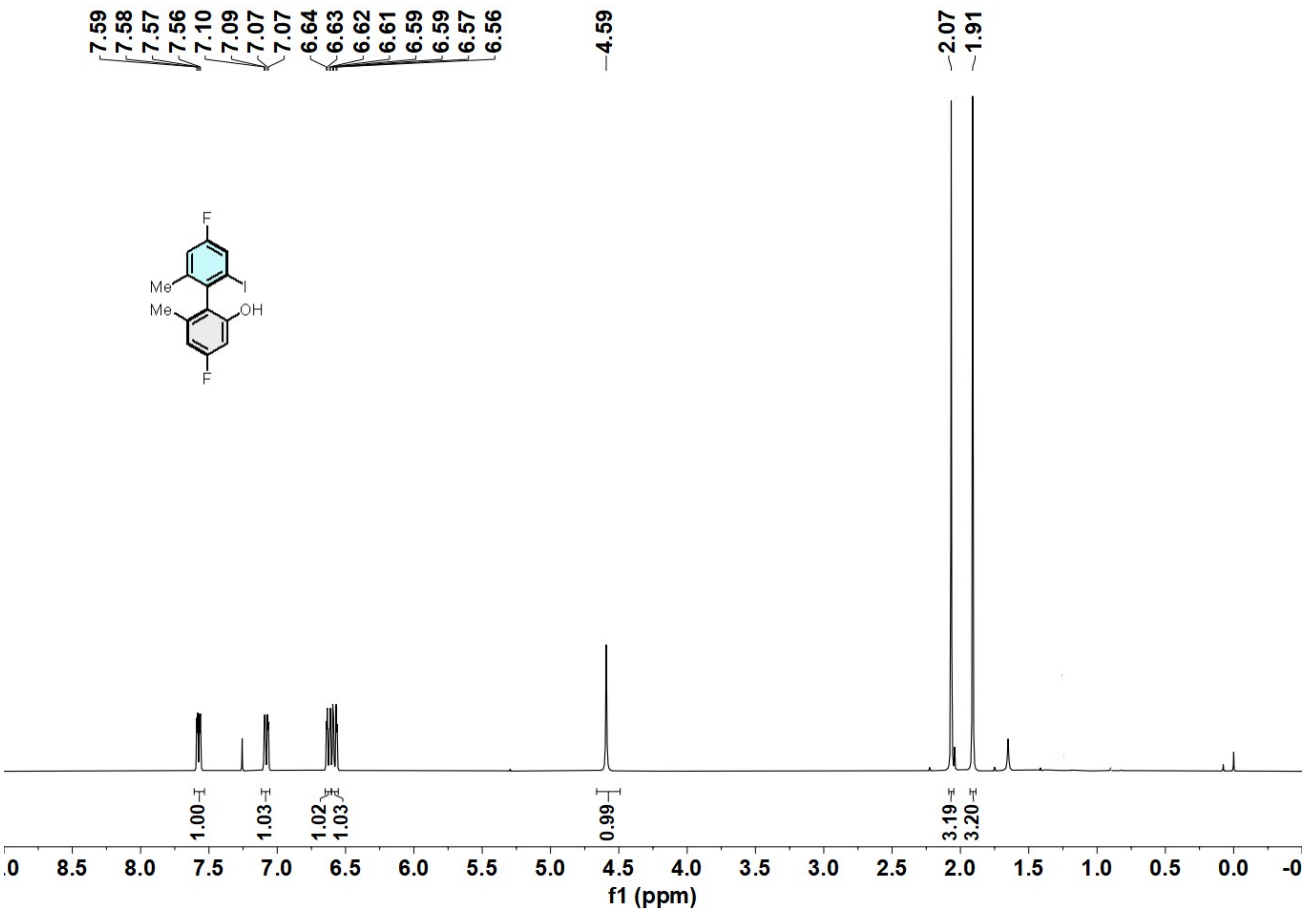


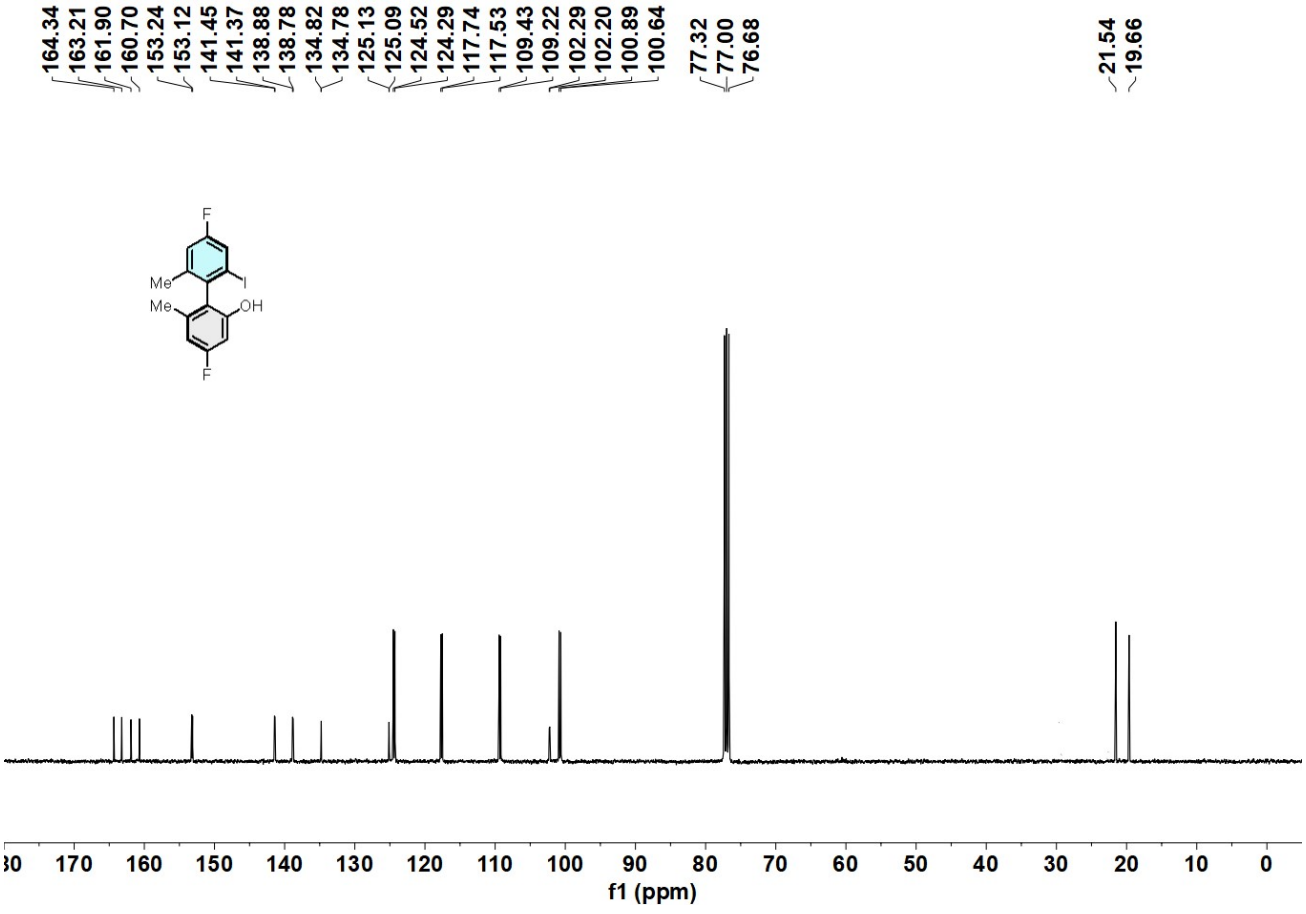
2w, ^{1}H NMR (400 MHz, $CDCl_3$); ^{13}C NMR (101 MHz, $CDCl_3$)



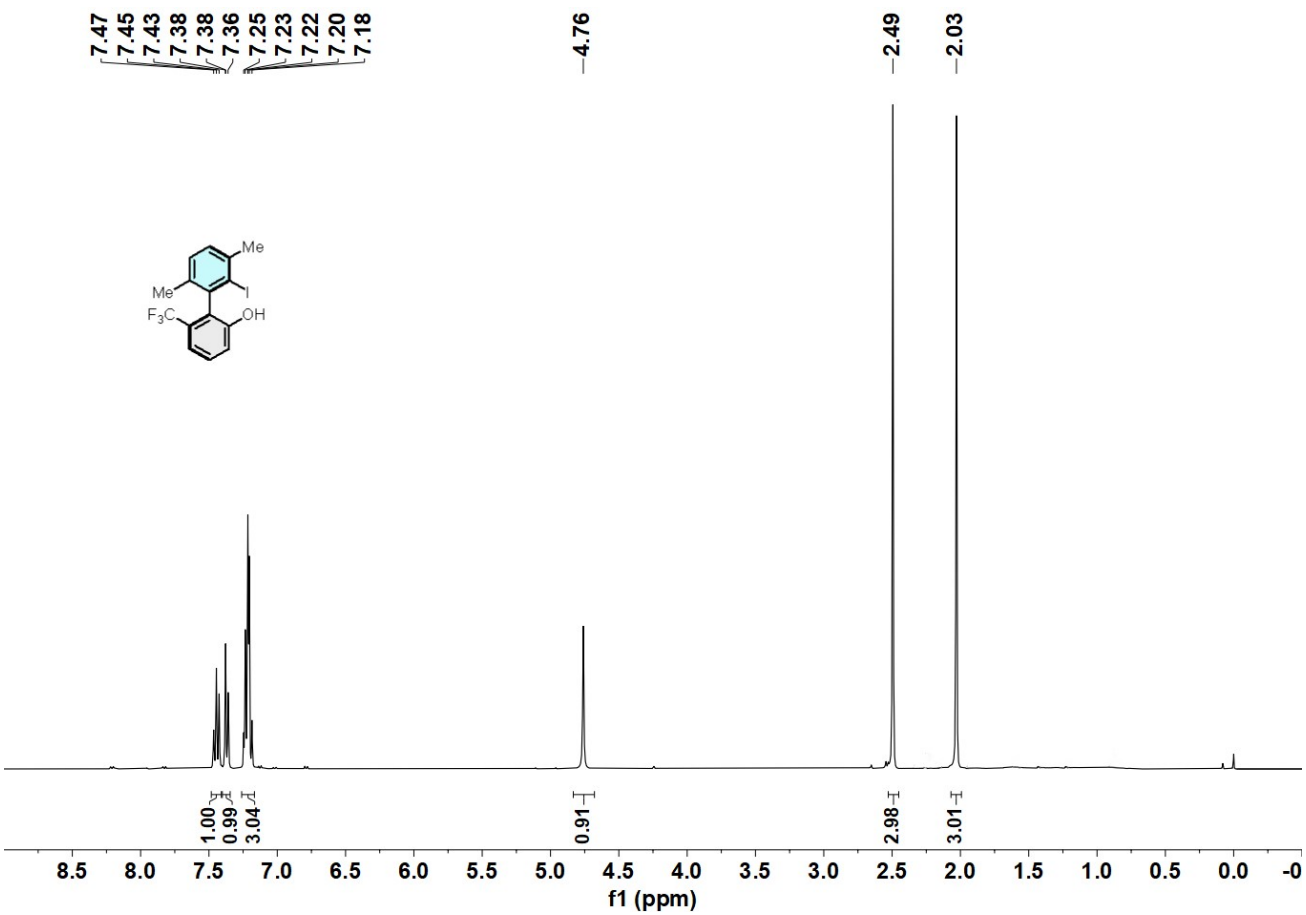


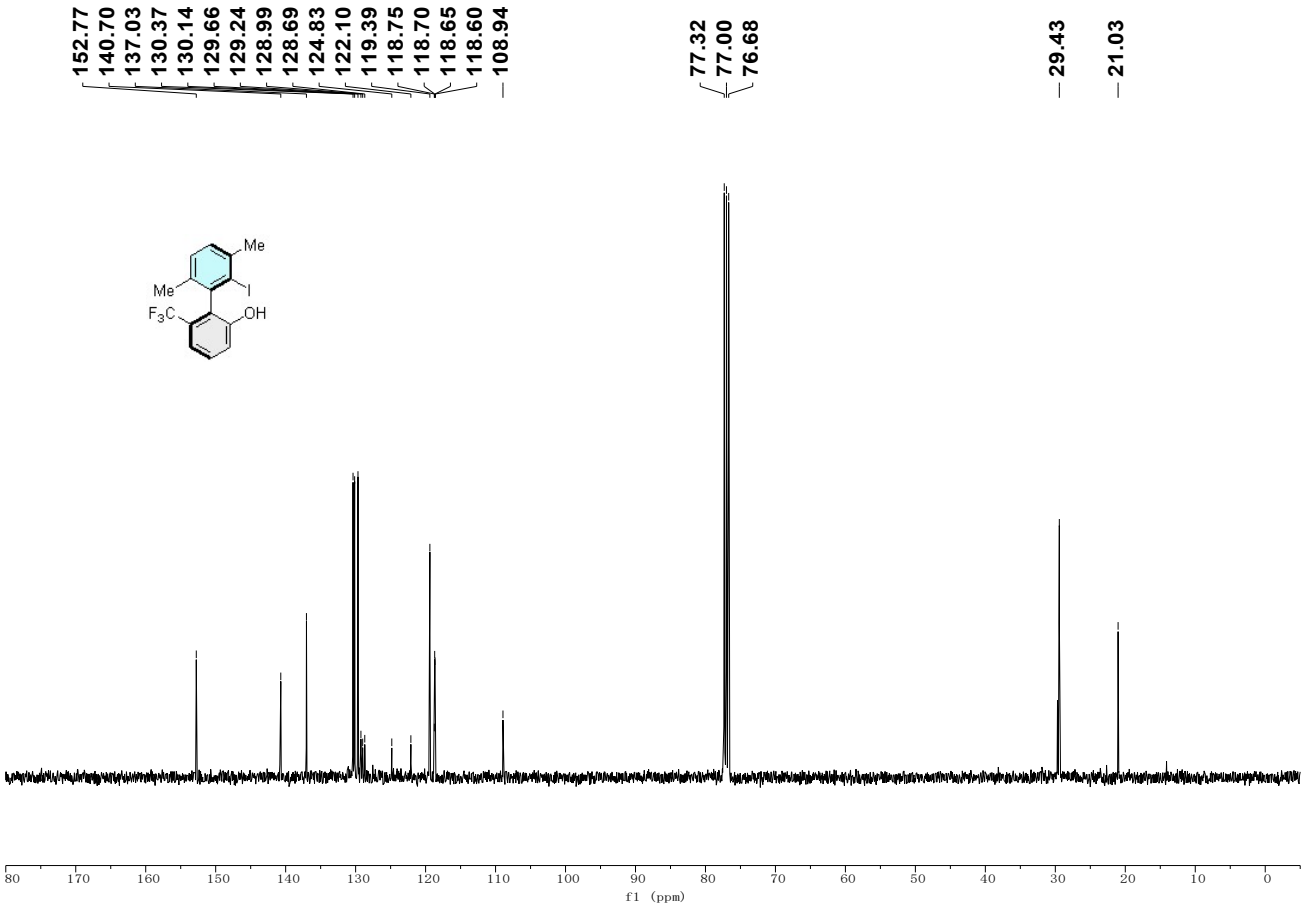
2x, ^{1}H NMR (400 MHz, $CDCl_3$); ^{13}C NMR (101 MHz, $CDCl_3$)



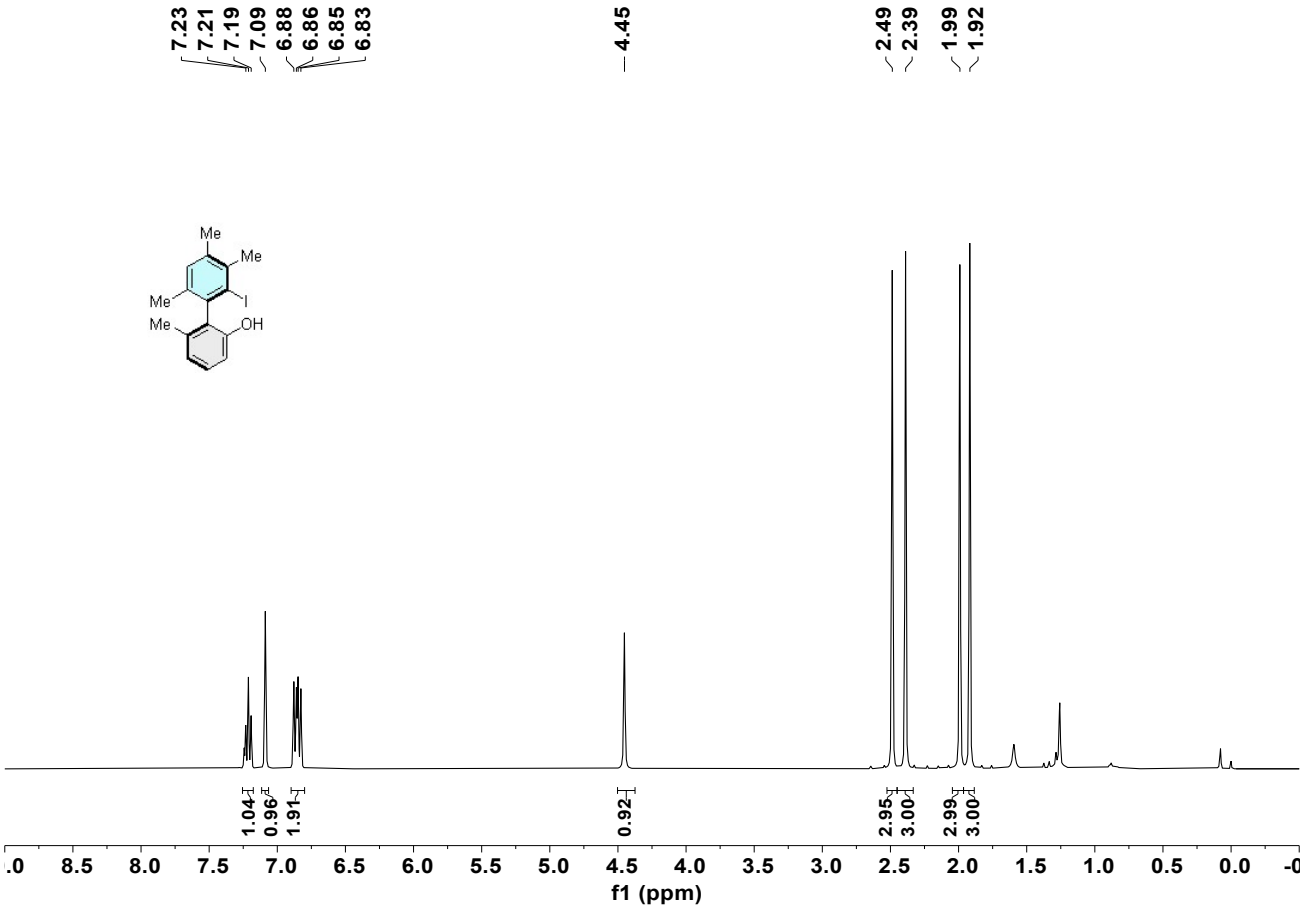


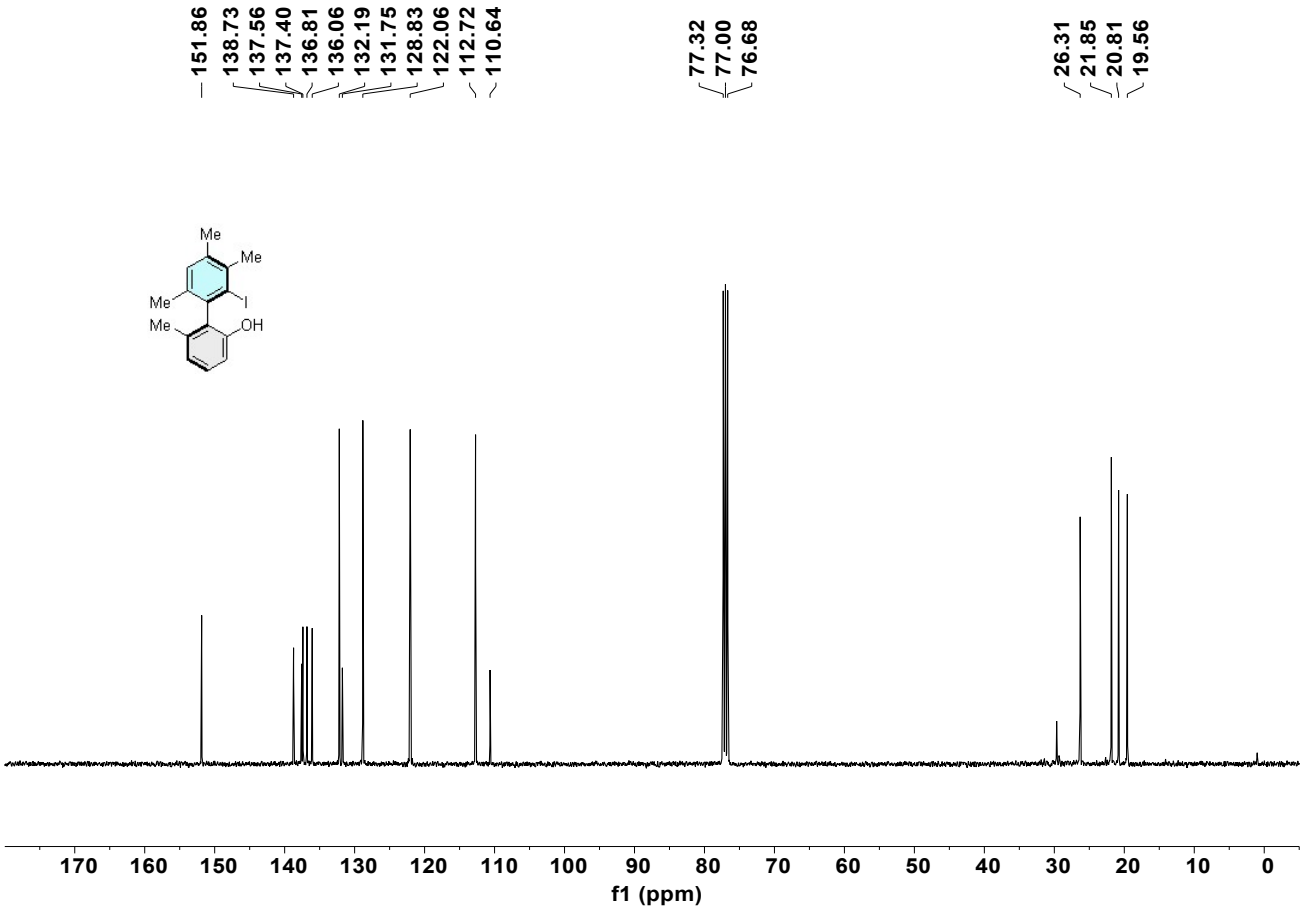
2y, ^{1}H NMR (400 MHz, $CDCl_3$); ^{13}C NMR (101 MHz, $CDCl_3$)



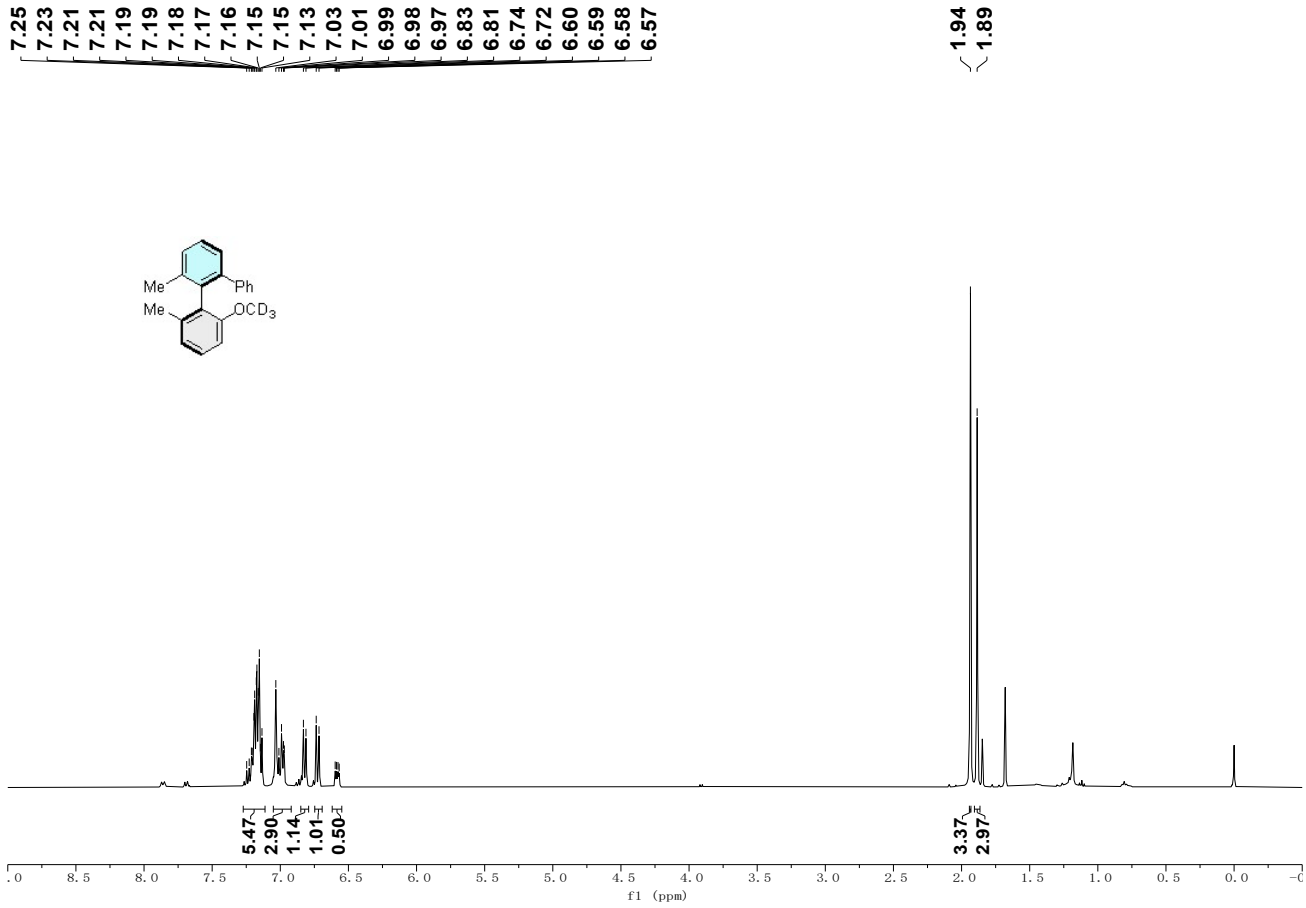


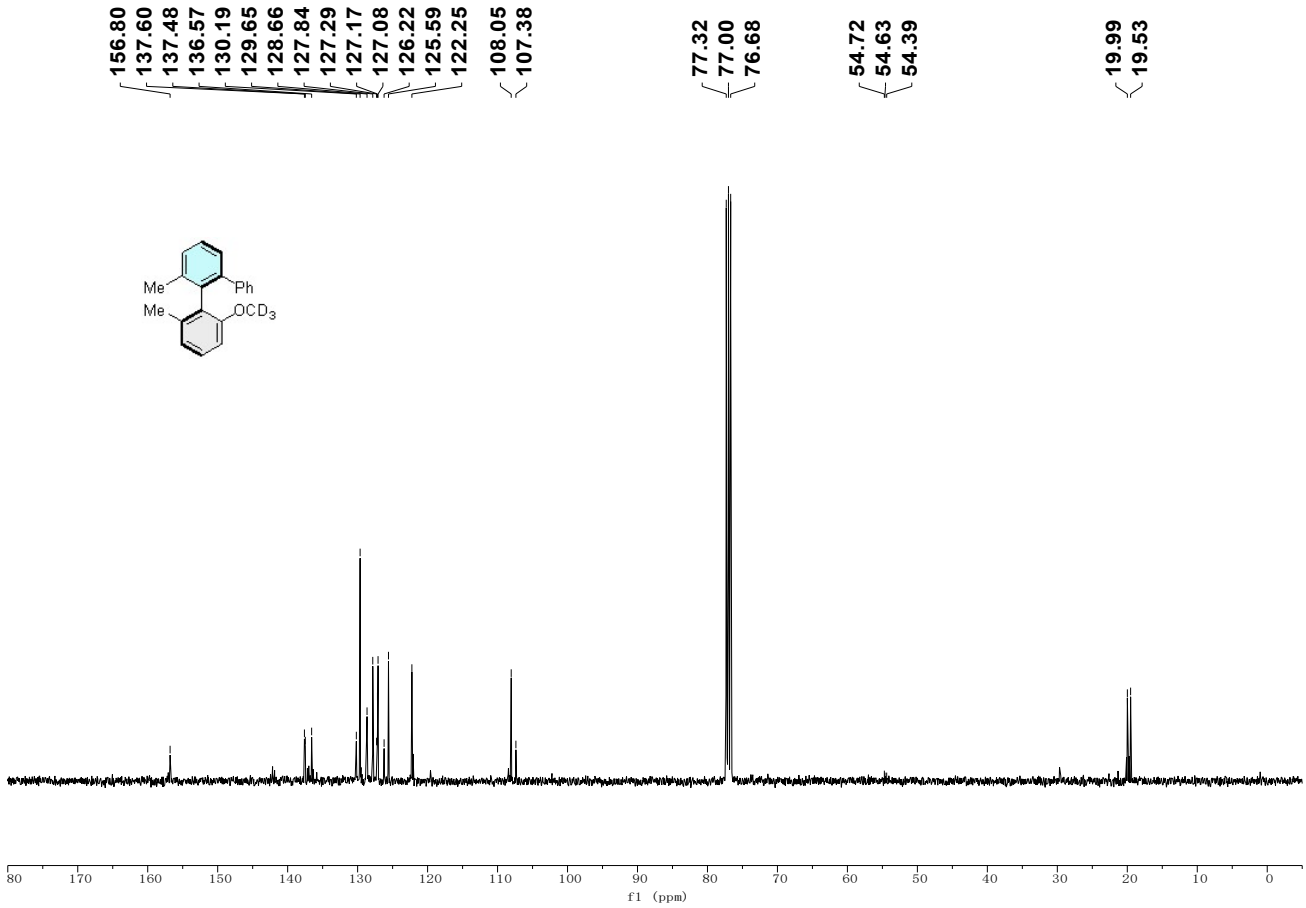
2z, ^{1}H NMR (400 MHz, $CDCl_3$); ^{13}C NMR (101 MHz, $CDCl_3$)



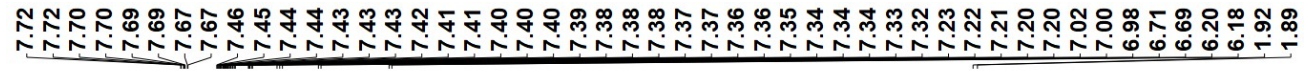


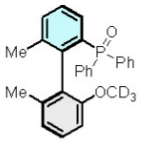
3, ^{1}H NMR (400 MHz, $CDCl_3$); ^{13}C NMR (101 MHz, $CDCl_3$)

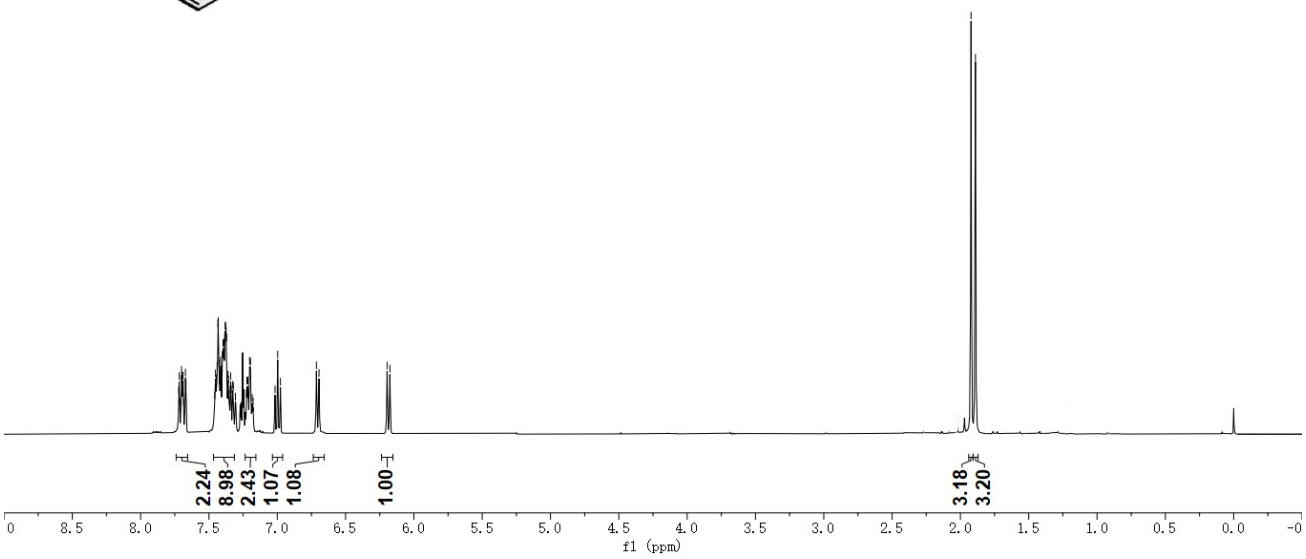


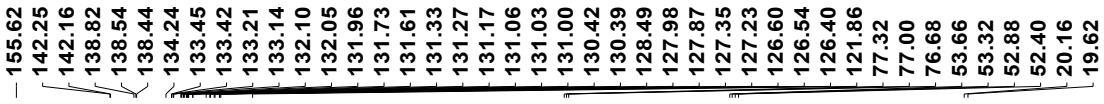


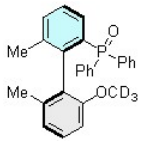
4, ^{1}H NMR (400 MHz, $CDCl_3$); ^{13}C NMR (101 MHz, $CDCl_3$)

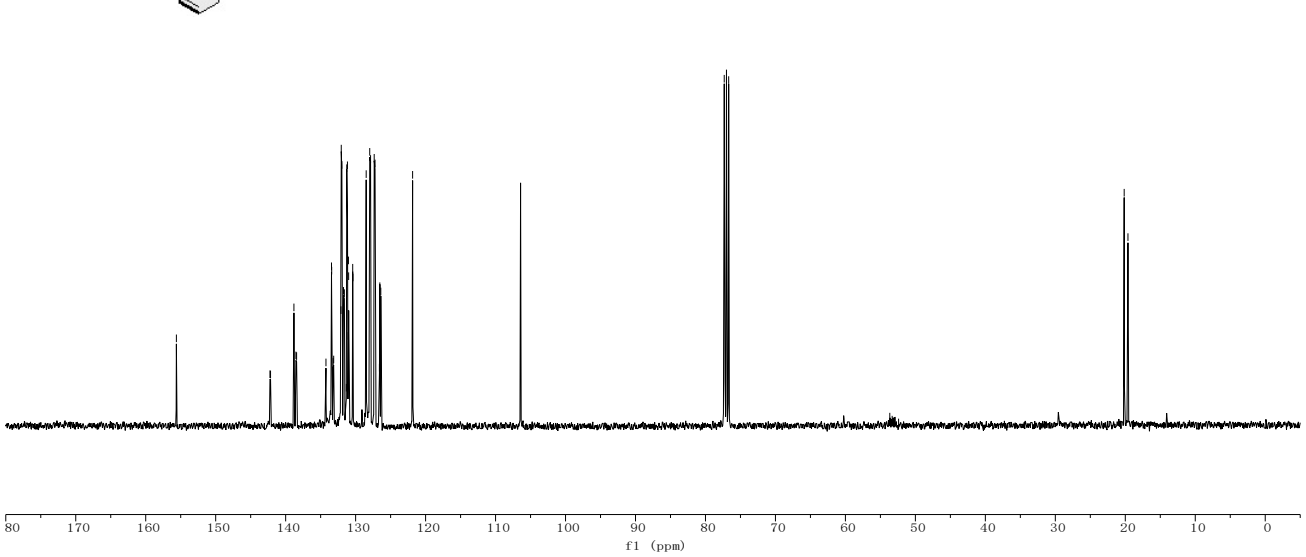




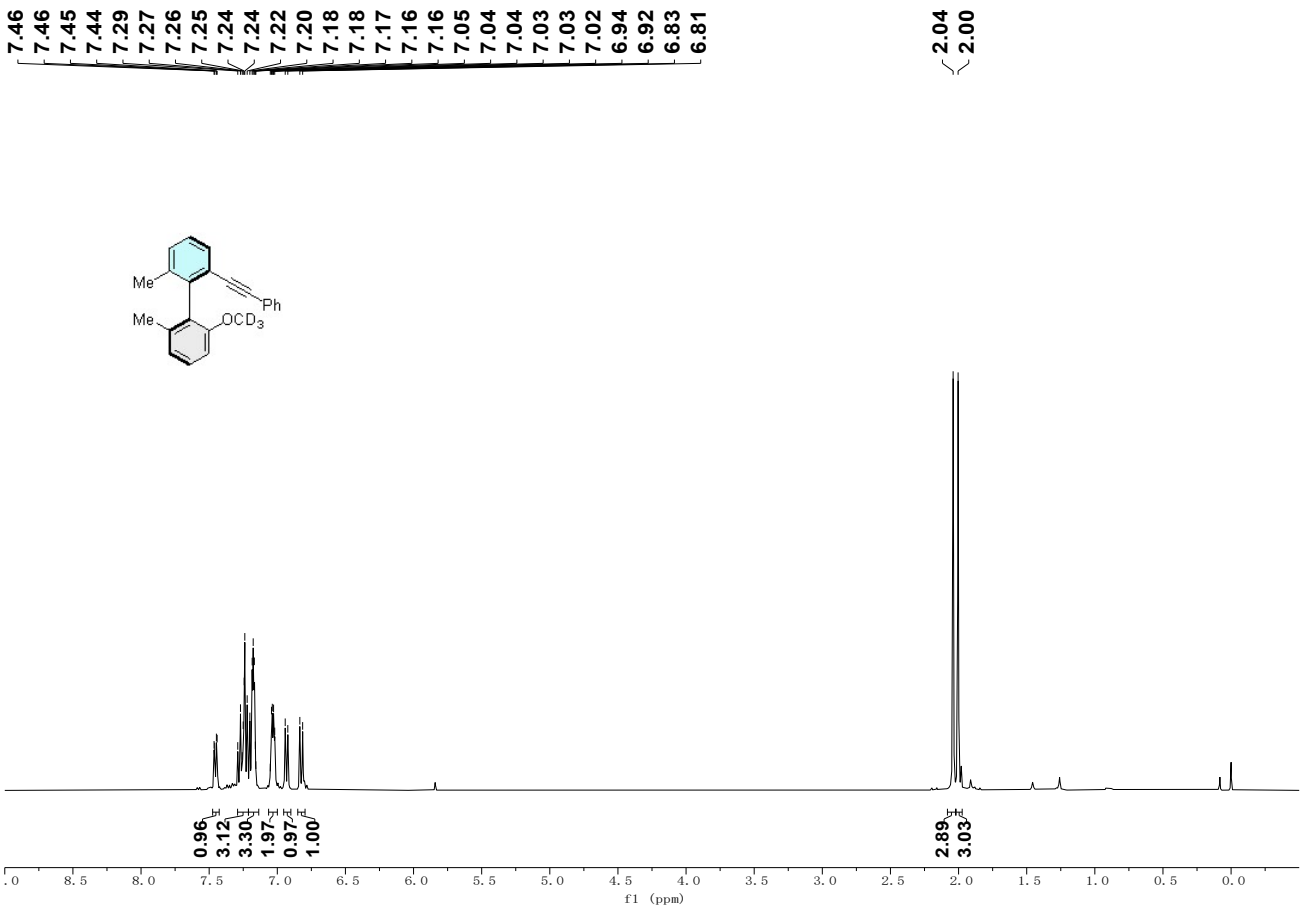


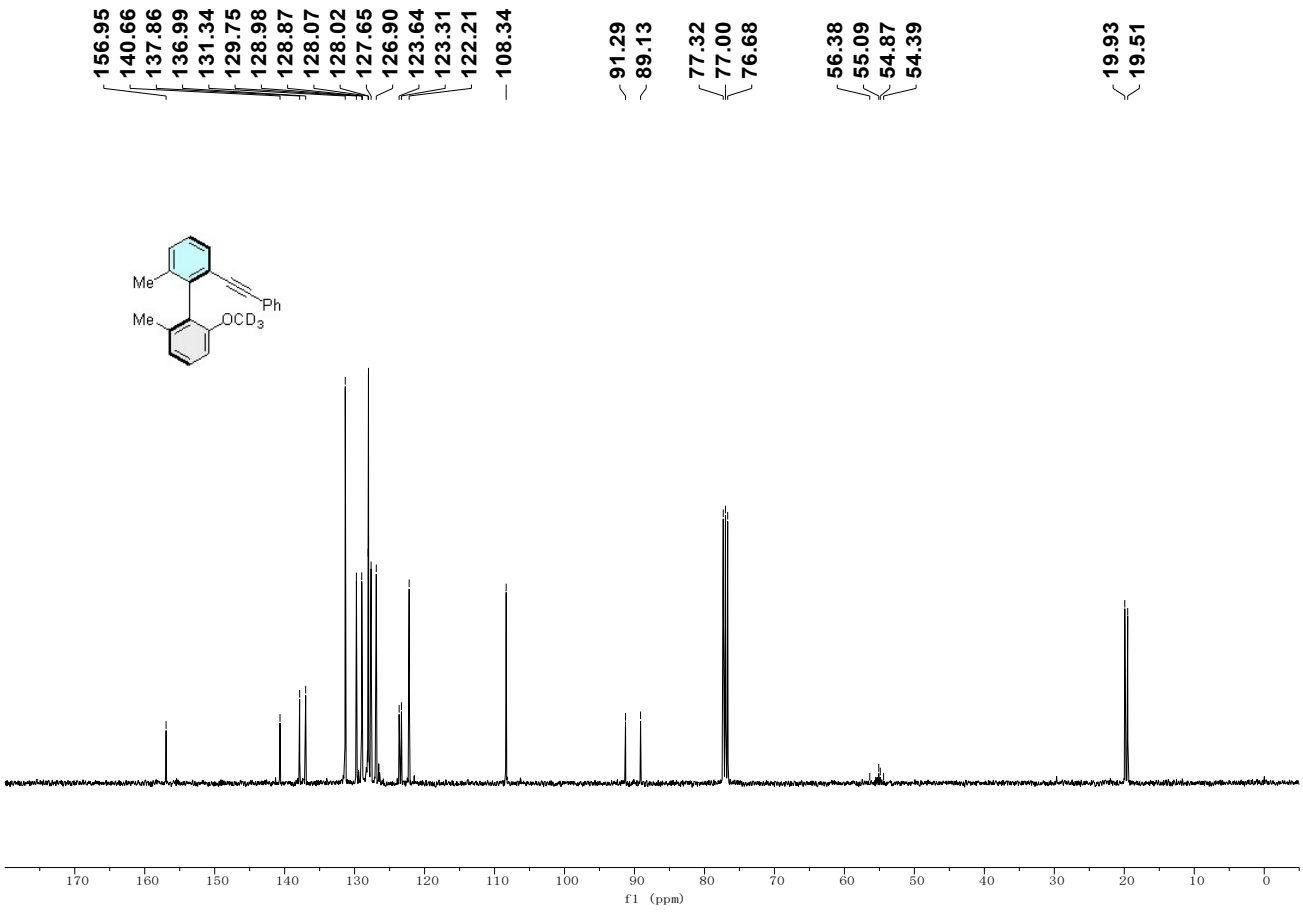




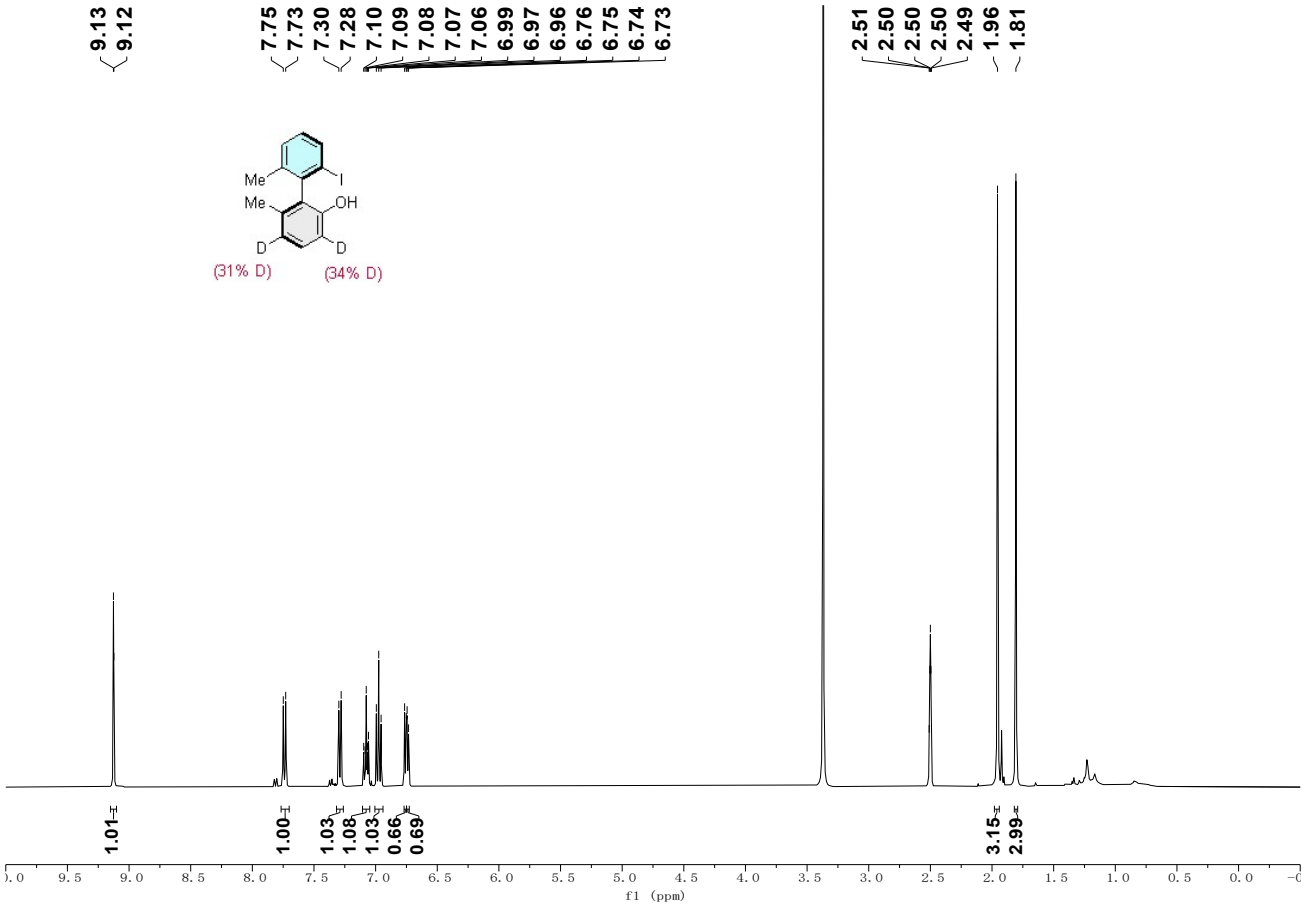


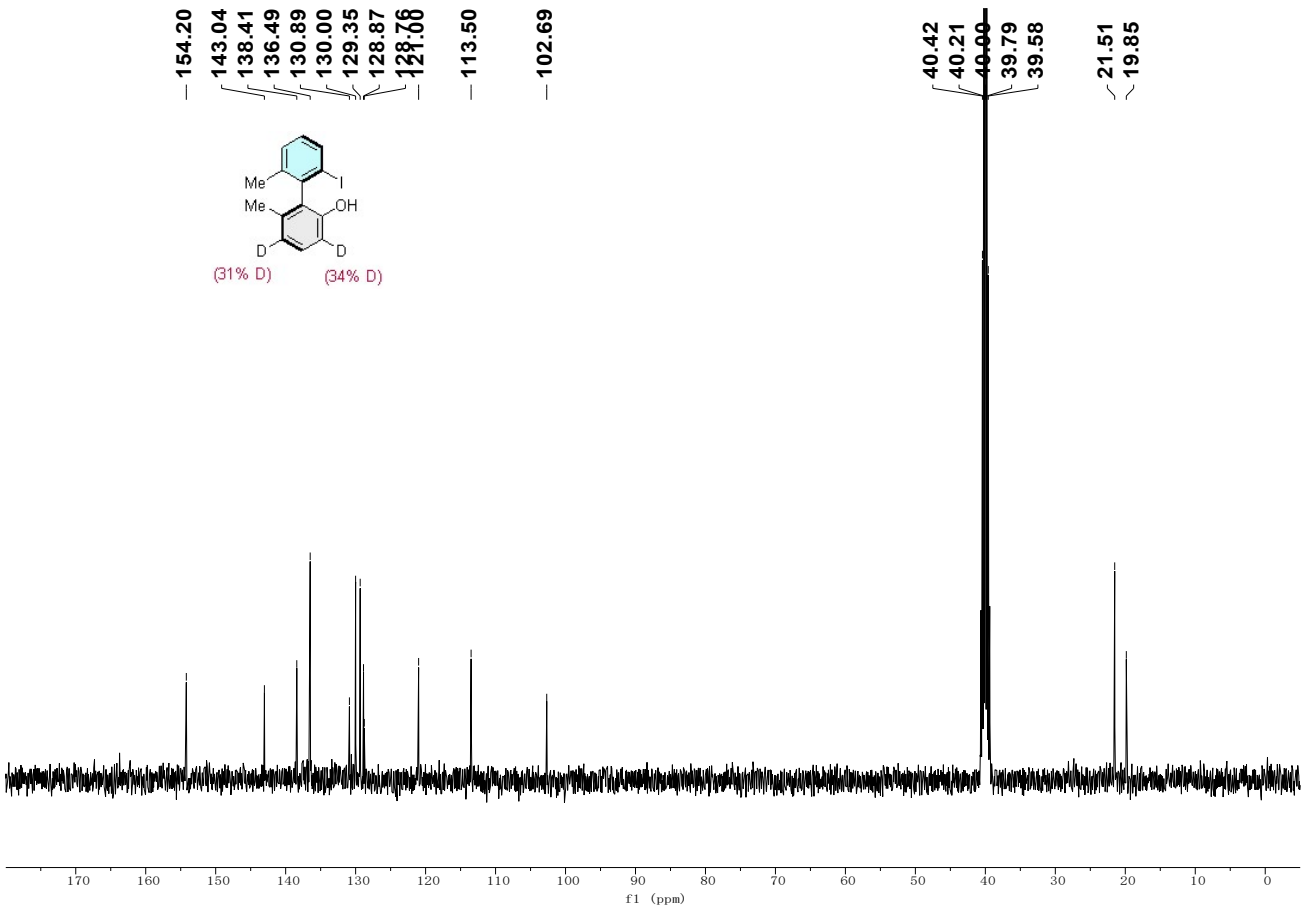
5, ^{1}H NMR (400 MHz, $CDCl_3$); ^{13}C NMR (101 MHz, $CDCl_3$)





6, ^{1}H NMR (400 MHz, DMSO-d_6); ^{13}C NMR (101 MHz, DMSO-d_6)





7, ^{1}H NMR (400 MHz, DMSO-d_6); ^{13}C NMR (101 MHz, DMSO-d_6)