Supporting Information

Copper-Catalyzed Enantioconvergent Radical Suzuki-Miyaura C(sp^3)–C(sp^2) Cross-Coupling

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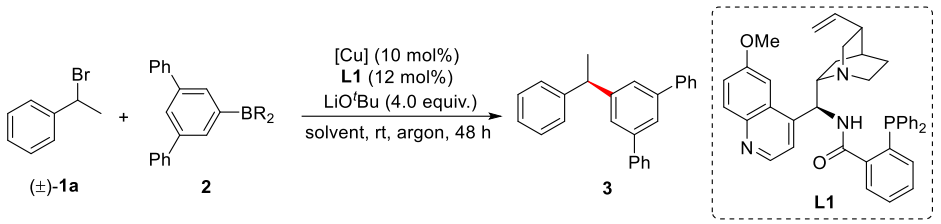
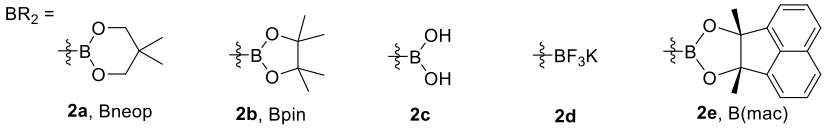
The optimization of reaction conditions

Table S1. Initial Screening of Reaction Conditions[a]

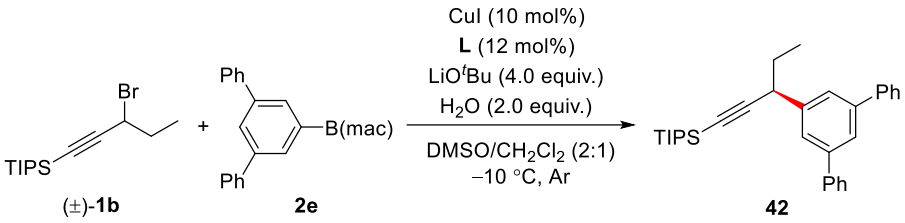


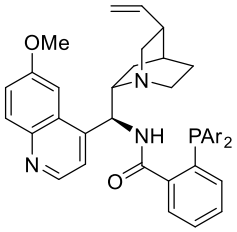


Entry	**2**	[Cu]	Solvent	Yield	Ee
1	**2a**	CuI	DMSO	0	/
2	**2b**	CuI	DMSO	0	/
3	**2c**	CuI	DMSO	0	/
4	**2d**	CuI	DMSO	0	/
5	**2e**	CuI	DMSO	0	/
6	**2a**	CuI	CH_2Cl_2	0	/
7	**2a**	CuI	DCE	0	/
8	**2a**	CuI	toluene	0	/
9	**2a**	CuI	CH_3CN	0	/
10	**2a**	CuI	EtOAc	0	/
11	**2a**	CuI	Et_2O	0	/
12	**2a**	CuI	THF	0	/
13[b]	**2a**	CuI	DMSO	39%	31%

[a]Reaction conditions: (±)-**1a** (0.075 mmol), **2** (0.05 mmol), CuI (10 mol%), **L1** (12 mol%), LiO^{t}Bu (4.0 equiv.) in solvent (0.60 mL) at room temperature for 24 h under argon. Yield was based on ^{1}H NMR analysis of the crude product using 1,3,5-trimethoxybenzene as an internal standard. Ee values based on HPLC analysis. [b]H_2O (2.0 equiv.) was added.

Table S2. Screening of Reaction Conditions for Propargyl Bromides[a]



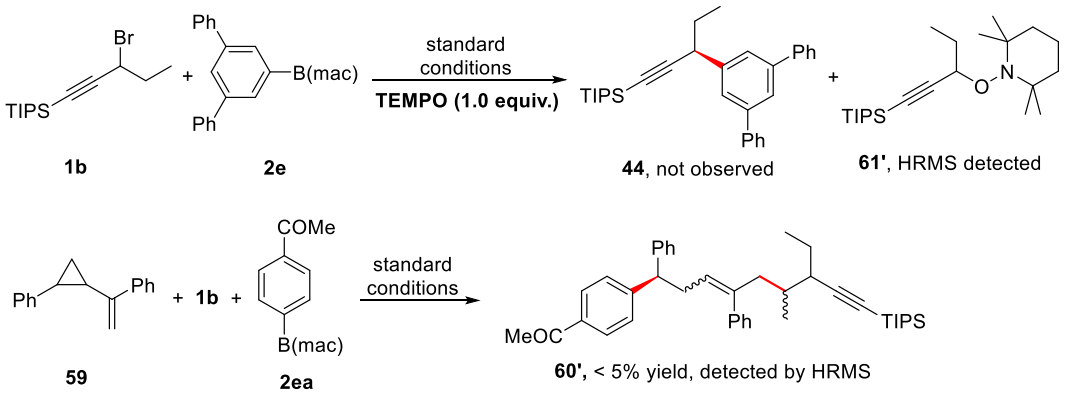


L1, Ar = Ph
L2, Ar = 3,5-^{t}Bu$_2$C$_6$H$_3$
L3, Ar = 2,4,6-Me$_3$C$_6$H$_2$
L4, Ar = 2,6-Me$_2$C$_6$H$_3$
L5, Ar = 1-naphthyl
L6, Ar = 9-phenanthryl

Entry	L	Yield	Ee
1	**L4**	47%	63%
2	**L1**	82%	54%
3	**L2**	88%	57%
4	**L3**	35%	59%
5	**L5**	53%	75%
6	**L6**	52%	92%
7[b,c]	**L6**	43%	86%
8[b]	**L6**	**68%**	**94%**
9[d]	**L6**	62%	94%

[a]Reaction conditions: (±)-**1b** (0.075 mmol), **2e** (0.05 mmol), CuI (10 mol%), **L** (12 mol%), LiO^{t}Bu (4.0 equiv.) and H_2O (2.0 equiv.) in DMSO/CH_2Cl_2 (0.60 mL, v/v = 2:1) at –10 °C for 120 h under argon. Yield was based on ^{1}H NMR analysis of the crude product using 1,3,5-trimethoxybenzene as an internal standard. Ee values based on HPLC analysis. [b]LiO^{t}Bu (6.0 equiv.) and H_2O (3.0 equiv.). [c]Utilizing Bpin-derived boronate ester **2b** instead of **2e**. [d]LiO^{t}Bu (8.0 equiv.) and H_2O (4.0 equiv.).

Scheme S1. Control experiment with propargyl bromides



General information

All reactions were carried out under argon atmosphere using Schlenk techniques. Reagents were purchased at the highest commercial quality and used without further purification, unless otherwise stated. Analytical thin layer chromatography (TLC) was performed on precoated silica gel 60 GF254 plates. Flash column chromatography was performed using Tsingdao silica gel (60, particle size 0.040–0.063 mm). Visualization on TLC was achieved by use of UV light (254 nm) or iodine. NMR spectra were recorded on Bruker DPX-400 spectrometer at 400 MHz for ^{1}H NMR, 100 MHz for ^{13}C NMR, 376 MHz for ^{19}F NMR and 128 MHz for ^{11}B NMR, respectively, in $CDCl_3$ with tetramethylsilane (TMS) as internal standard. The chemical shifts are expressed in ppm and coupling constants are given in Hz. Data for ^{1}H NMR are recorded as follows: chemical shift (ppm), multiplicity (s, singlet; d, doublet; t, triplet; q, quarter; p, pentet; m, multiplet; br, broad), coupling constant (Hz), integration. Data for ^{13}C NMR are reported in terms of chemical shift (δ, ppm). Mass spectrometric data were obtained using Bruker Apex IV RTMS. Enantiomeric excess (ee) was determined using SHIMADZU LC-20AD with SPD-20AV detector or Agilent high-performance liquid chromatography (HPLC) with Hatachi detector (at appropriate wavelength). Column conditions are reported in the experimental section below.

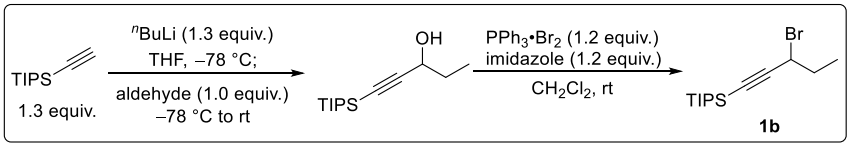
The synthesis of alkyl bromide substrates

The alkyl bromides **1a**, **1d–1z**, **1aa–1ad** were synthesized according to the reported literature.[1]

The Synthesis of Propargyl Bromides

The propargyl bromides were synthesized according to the reported procedure.[2]

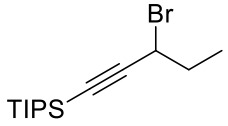
General procedure for preparation of (3-bromopent-1-yn-1-yl)triisopropylsilane (1b):



^{n}BuLi (2.4 M in hexane, 10.8 mL, 26 mmol, 1.3 equiv.) was added dropwise into a solution of triisopropylsilacetylene (5.8 mL, 26 mmol, 1.3 equiv.) in anhydrous THF (50.0 mL) at −78 °C. The mixture was stirred at room temperature for 30 min and cooled to −78 °C. Propionaldehyde (1.4 mL, 20 mmol, 1.0 equiv.) was added dropwise. Then the mixture was warmed up to room temperature and stirred for overnight. The mixture was quenched by a saturated aq. NH_4Cl (20 mL), extracted with EtOAc (3 × 30 mL), and dried over Na_2SO_4. The organic phase was concentrated in vacuum and then subjected to flash chromatography to afford the desired 1-(triisopropylsilyl)pent-1-yn-3-ol.

A 100-mL flask was charged with imidazole (0.82 g, 12.0 mmol, 1.2 equiv.), evacuated, and back-filled with argon. CH_2Cl_2 (30 mL) was added via syringe, followed by the addition of the 1-(triisopropylsilyl)pent-1-yn-3-ol (2.40 g, 10.0 mmol, 1.0 equiv.). The solution was stirred for 15 min, and then dibromotriphenylphosphorane (5.1 g, 12.0 mmol, 1.2 equiv.) was added and the reaction mixture was stirred at room temperature. Upon completion (monitored by TLC), the reaction was quenched by the addition of silica gel. The solvent was removed under reduced pressure, and then the plug of silica gel was subjected to flash chromatography to afford the desired product **1b**.

(3-bromopent-1-yn-1-yl)triisopropylsilane (1b)



1b

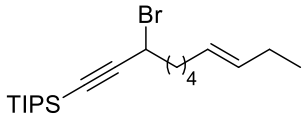
Following the above general procedure, the title compound **1b** was prepared from 1-(triisopropylsilyl)pent-1-yn-3-ol (2.40 g, 10 mmol, 1.0 equiv.) as a colorless oil (1.76 g, 58% yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ 4.53 (t, *J* = 6.4 Hz, 1H), 2.11 – 1.96 (m, 2H), 1.12 (t, *J* = 7.2 Hz, 3H), 1.08 (s, 21H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 105.7, 88.8, 39.1, 33.1, 18.5, 11.6, 11.1.

HRMS (ESI) *m/z* calcd. for $C_{14}H_{28}BrSi$ $[M + H]^+$ 303.1138, found 303.1137.

(*E*)-(3-bromoundec-8-en-1-yn-1-yl)triisopropylsilane (1af)



1af

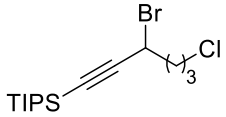
Following the above general procedure, the title compound **1af** was prepared from (*E*)-1-(triisopropylsilyl)undec-8-en-1-yn-3-ol (1.94 g, 6.0 mmol, 1.0 equiv.) as a pale yellow oil (1.27 g, 55% yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ 5.43 – 5.25 (m, 2H), 4.54 (t, *J* = 6.4 Hz, 1H), 2.13 – 1.94 (m, 6H), 1.65 – 1.50 (m, 2H), 1.47 – 1.34 (m, 2H), 1.07 (s, 21H), 0.96 (t, *J* = 7.6 Hz, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 132.0, 128.6, 105.9, 88.7, 39.8, 37.3, 28.8, 27.0, 26.8, 20.5, 18.6, 18.53, 18.48, 14.3, 11.2.

HRMS (ESI) *m/z* calcd. for $C_{20}H_{38}BrSi$ $[M + H]^+$ 385.1921, found 385.1915.

(3-bromo-6-chlorohex-1-yn-1-yl)triisopropylsilane (1ag)



1ag

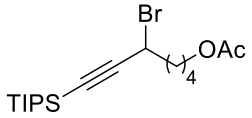
Following the above general procedure, the title compound **1ag** was prepared from 6-chloro-1-(triisopropylsilyl)hex-1-yn-3-ol (0.87 g, 3.0 mmol, 1.0 equiv.) as a pale yellow oil (0.35 g, 34% yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ 4.61 (t, *J* = 6.0 Hz, 1H), 3.64 – 3.57 (m, 2H), 2.22 – 2.14 (m, 2H), 2.12 – 2.02 (m, 2H), 1.08 (s, 21H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 105.1, 89.5, 43.9, 36.8, 36.2, 30.1, 18.5, 11.1.

HRMS (ESI) *m/z* calcd. for $C_{14}H_{27}BrClSi$ $[M + H]^+$ 337.0748, found 337.0746.

5-bromo-7-(triisopropylsilyl)hept-6-yn-1-yl acetate (1ah)



1ah

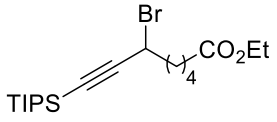
Following the above general procedure, the title compound **1ah** was prepared from 5-hydroxy-7-(triisopropylsilyl)hept-6-yn-1-yl acetate (0.85 g, 2.6 mmol, 1.0 equiv.) as a pale yellow oil (0.50 g, 50% yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ 4.56 (t, *J* = 6.8 Hz, 1H), 4.07 (t, *J* = 6.0 Hz, 2H), 2.09 – 1.98 (m, 5H), 1.72 – 1.59 (m, 4H), 1.07 (s, 21H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 171.1, 105.6, 89.0, 64.1, 39.3, 36.9, 27.7, 23.9, 20.9, 18.53, 18.47, 11.1.

HRMS (ESI) *m/z* calcd. for $C_{18}H_{34}BrO_2Si$ $[M + H]^+$ 389.1506, found 389.1504.

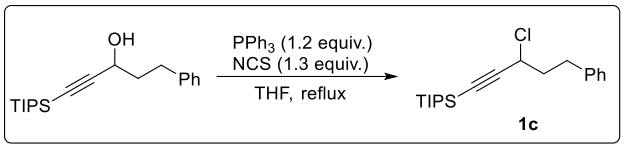
ethyl 6-bromo-8-(triisopropylsilyl)oct-7-ynoate (1ai)



1ai

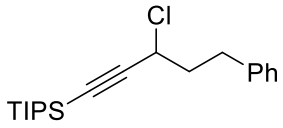
Following the above general procedure, the title compound **1ai** was prepared from ethyl 6-hydroxy-8-(triisopropylsilyl)oct-7-ynoate (1.75 g, 5.1 mmol, 1.0 equiv.) as a pale yellow oil (0.68 g, 41% yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ 4.55 (t, *J* = 6.4 Hz, 1H), 4.13 (q, *J* = 7.2 Hz, 2H), 2.32 (t, *J* = 7.2 Hz, 2H), 2.09 – 1.95 (m, 2H), 1.74 – 1.53 (m, 4H), 1.26 (t, *J* = 7.2 Hz, 3H), 1.07 (s, 21H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 173.3, 105.6, 88.9, 60.2, 39.4, 37.0, 34.1, 26.8, 24.0, 18.5, 14.2, 11.1.
HRMS (ESI) *m/z* calcd. for $C_{19}H_{36}BrO_2Si$ $[M + H]^+$ 403.1662, found 403.1662.



Following the procedure reported in the literature,[3] 5-phenyl-1-(triisopropylsilyl)pent-1-yn-3-ol (3.17 g, 10 mmol, 1.0 equiv.) was added to a solution of triphenylphosphine (3.15 g, 12.0 mmol, 1.2 equiv.) in THF (20 mL). *N*-Chlorosuccinimide (1.74 g, 13.0 mmol, 1.3 equiv.) was added in portions over 10 minutes and the reaction heated to reflux. After 19 hours the mixture was allowed to cool to room temperature before pentane (20 mL) was added. The solvent was removed under reduced pressure, and was subjected to flash chromatography to afford the desired product **1c**.

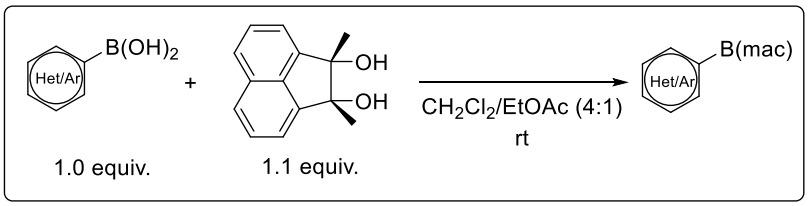
(3-chloro-5-phenylpent-1-yn-1-yl)triisopropylsilane (1c)



1c

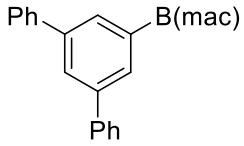
Following the above general procedure, the title compound **1c** was prepared from 5-phenyl-1-(triisopropylsilyl)pent-1-yn-3-ol (3.17 g, 10 mmol, 1.0 equiv.) as a colorless oil (1.70 g, 43% yield).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.32 – 7.25 (m, 2H), 7.24 – 7.16 (m, 3H), 4.49 (t, *J* = 6.8 Hz, 1H), 2.94 – 2.81 (m, 2H), 2.32–2.19 (m, 2H), 1.09 (s, 21H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 140.3, 128.6, 128.5, 126.2, 105.1, 88.1, 48.1, 41.0, 32.4, 18.60, 11.1.
HRMS (ESI) *m/z* calcd. for $C_{20}H_{32}ClSi$ $[M + H]^+$ 335.1956, found 335.1953.

The synthesis of boron reagents



The boron reagents were synthesized according to the reported procedure.[4] To a 100-mL flask equipped with a stir bar was added (hetero)aryl boronic acid (10 mmol, 1.0 equiv.) and 1,2-dimethylacenaphthylene-1,2-diol (2.17 g, 11 mmol, 1.1 equiv.). Then CH_2Cl_2/EtOAc (4:1, 20 mL) was added to dissolve the reactants. The reaction was allowed to stir at room temperature for 3 hours, then the reaction mixture was concentrated. The crude product was purified by silica gel chromatography to afford the desired product.

8-([1,1':3',1''-terphenyl]-5'-yl)-6b,9a-dimethyl-6b,9a-dihydroacenaphtho[1,2-d][1,3,2]dioxaborole (2e)



2e

Following the above general procedure, the title compound **2e** was prepared from (3,5-diphenylphenyl)boronic acid (5.48 g, 20 mmol, 1.0 equiv.) and 1,2-dimethylacenaphthylene-1,2-diol (4.34 g, 22 mmol, 1.1 equiv.) as a white solid (7.90 g, 87% yield).

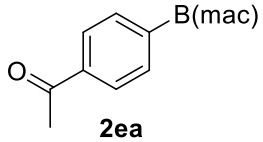
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.00 (s, 2H), 7.82 (s, 1H), 7.75 (d, *J* = 8.0 Hz, 2H), 7.68 – 7.49 (m, 8H), 7.45 – 7.20 (m, 6H), 1.87 (s, 6H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 144.7, 141.01, 140.00, 134.8, 132.5, 131.1, 128.8, 128.6, 128.4, 127.2, 125.3, 119.6, 92.5, 22.2.

^{11}B NMR (128 MHz, $CDCl_3$) δ 30.8.

HRMS (ESI) *m/z* calcd. for $C_{32}H_{26}BO_2$ $[M + H]^+$ 453.2020, found 453.2012.

1-(4-(6b,9a-dimethyl-6b,9a-dihydroacenaphtho[1,2-d][1,3,2]dioxaborol-8-yl)phenyl)ethan-1-one (2ea)



2ea

Following the above general procedure, the title compound **2ea** was prepared from (4-acetylphenyl)boronic acid (0.49 g, 3.0 mmol, 1.0 equiv.) and 1,2-dimethylacenaphthylene-1,2-diol (0.65 g, 3.3 mmol, 1.1 equiv.) as a white solid (0.91 g, 89% yield).

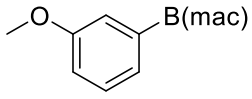
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.85 (s, 4H), 7.82 – 7.77 (m, 2H), 7.66 – 7.57 (m, 4H), 2.57 (s, 3H), 1.88 (s, 6H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 198.42, 144.5, 138.9, 135.0, 134.7, 131.4, 128.5, 127.2, 125.4, 119.6, 92.7, 26.7, 22.1.

^{11}B NMR (128 MHz, $CDCl_3$) δ 31.2.

HRMS (ESI) *m/z* calcd. for $C_{22}H_{20}BO_3$ $[M + H]^+$ 343.1500, found 343.1502.

8-(3-methoxyphenyl)-6b,9a-dimethyl-6b,9a-dihydroacenaphtho[1,2-d][1,3,2]dioxaborole (2eb)



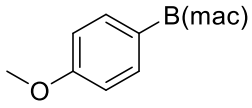
2eb

Following the above general procedure, the title compound **2eb** was prepared from (3-methoxyphenyl)boronic acid (0.46 g, 3.0 mmol, 1.0 equiv.) and 1,2-dimethylacenaphthylene-1,2-diol (0.65 g, 3.3 mmol, 1.1 equiv.) as a white solid (0.78 g, 79% yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 (d, *J* = 7.2 Hz, 2H), 7.65 – 7.54 (m, 4H), 7.36 (d, *J* = 7.2 Hz, 1H), 7.29 (s, 1H), 7.21 (t, *J* = 7.6 Hz, 1H), 6.97 – 6.88 (m, 1H), 3.76 (s, 3H), 1.86 (s, 6H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 158.9, 144.7, 134.7, 131.3, 128.8, 128.4, 127.2, 125.2, 119.5, 118.8, 117.8, 92.4, 55.2, 22.2.
^{11}B NMR (128 MHz, $CDCl_3$) δ 30.5.
HRMS (ESI) *m/z* calcd. for $C_{21}H_{20}BO_3$ $[M + H]^+$ 331.1500, found 331.1501.

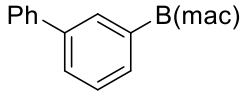
8-(4-methoxyphenyl)-6b,9a-dimethyl-6b,9a-dihydroacenaphtho[1,2-d][1,3,2]dioxaborole (2ec)



2ec

Following the above general procedure, the title compound **2ec** was prepared from (4-methoxyphenyl)boronic acid (0.46 g, 3.0 mmol, 1.0 equiv.) and 1,2-dimethylacenaphthylene-1,2-diol (0.65 g, 3.3 mmol, 1.1 equiv.) as a white solid (0.85 g, 86% yield).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.81–7.74 (m, 2H), 7.70 (d, *J* = 8.8 Hz, 2H), 7.64–7.55 (m, 4H), 6.82 (d, *J* = 8.8 Hz, 2H), 3.77 (s, 3H), 1.86 (s, 6H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 162.0, 144.9, 136.5, 134.8, 131.3, 128.4, 125.2, 119.5, 113.2, 92.2, 55.0, 22.2.
^{11}B NMR (128 MHz, $CDCl_3$) δ 31.2.
HRMS (ESI) *m/z* calcd. for $C_{21}H_{20}BO_3$ $[M + H]^+$ 331.1500, found 331.1495.

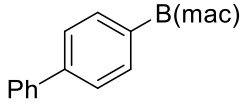
8-([1,1'-biphenyl]-3-yl)-6b,9a-dimethyl-6b,9a-dihydroacenaphtho[1,2-d][1,3,2]dioxaborole (2ed)



2ed

Following the above general procedure, the title compound **2ed** was prepared from 3-biphenylboronic acid (0.59 g, 3.0 mmol, 1.0 equiv.) and 1,2-dimethylacenaphthylene-1,2-diol (0.65 g, 3.3 mmol, 1.1 equiv.) as a white solid (1.03 g, 91% yield).
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.01 (s, 1H), 7.81–7.71 (m, 3H), 7.66–7.50 (m, 7H), 7.42–7.32 (m, 3H), 7.32–7.24 (m, 1H), 1.86 (s, 6H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 144.7, 141.1, 140.4, 134.7, 133.7, 133.6, 131.3, 129.9, 128.6, 128.4, 128.0, 127.2, 127.1, 125.3, 119.6, 92.4, 22.2.
^{11}B NMR (128 MHz, $CDCl_3$) δ 30.3.
HRMS (ESI) *m/z* calcd. for $C_{26}H_{22}BO_2$ $[M + H]^+$ 377.1707, found 377.1704.

8-([1,1'-biphenyl]-4-yl)-6b,9a-dimethyl-6b,9a-dihydroacenaphtho[1,2-d][1,3,2]dioxaborole (2ee)

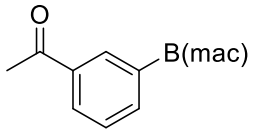


2ee

Following the above general procedure, the title compound **2ee** was prepared from 4-biphenylboronic acid (0.59 g, 3.0 mmol, 1.0 equiv.) and

1,2-dimethylacenaphthylene-1,2-diol (0.65 g, 3.3 mmol, 1.1 equiv.) as a white solid (1.02 g, 90% yield).
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.84 (d, *J* = 8.4 Hz, 2H), 7.78 (d, J_1= 7.2 Hz, J_2= 1.6 Hz, 2H), 7.65–7.50 (m, 8H), 7.43–7.36 (m, 2H), 7.34–7.28 (m, 1H), 1.87 (s, 6H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 144.8, 143.7, 140.9, 135.3, 134.8, 131.3, 128.7, 128.4, 127.5, 127.1, 126.3, 125.3, 119.6, 92.4, 22.2.
^{11}B NMR (128 MHz, $CDCl_3$) δ 31.8.
HRMS (ESI) *m/z* calcd. for $C_{26}H_{22}BO_2$ $[M + H]^+$ 377.1707, found 377.1703.

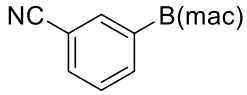
1-(3-(6b,9a-dimethyl-6b,9a-dihydroacenaphtho[1,2-d][1,3,2]dioxaborol-8-yl)phenyl)ethan-1-one (2ef)



2ef

Following the above general procedure, the title compound **2ef** was prepared from (3-acetylphenyl)boronic acid (0.49 g, 3.0 mmol, 1.0 equiv.) and 1,2-dimethylacenaphthylene-1,2-diol (0.65 g, 3.3 mmol, 1.1 equiv.) as a white solid (0.87 g, 85% yield).
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.32 (s, 1H), 8.02 – 7.90 (m, 2H), 7.84 – 7.73 (m, 2H), 7.68 – 7.56 (m, 4H), 7.38 (t, *J* = 7.6 Hz, 1H), 2.58 (s, 3H), 1.88 (s, 6H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 198.3, 144.5, 139.4, 136.3, 134.8, 134.7, 131.3, 130.7, 128.5, 127.9, 125.3, 119.6, 92.6, 26.7, 22.1.
^{11}B NMR (128 MHz, $CDCl_3$) δ 30.1.
HRMS (ESI) *m/z* calcd. for $C_{22}H_{20}BO_3$ $[M + H]^+$ 343.1500, found 343.1500.

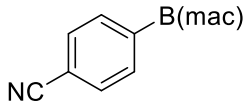
3-(6b,9a-dimethyl-6b,9a-dihydroacenaphtho[1,2-d][1,3,2]dioxaborol-8-yl)benzonitrile (2eg)



2eg

Following the above general procedure, the title compound **2eg** was prepared from (3-cyanophenyl)boronic acid (0.44 g, 3.0 mmol, 1.0 equiv.) and 1,2-dimethylacenaphthylene-1,2-diol (0.65 g, 3.3 mmol, 1.1 equiv.) as a white solid (0.74 g, 76% yield).
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.04 (s, 1H), 7.93 (d, *J* = 7.6 Hz, 1H), 7.83 – 7.75 (m, 2H), 7.66 – 7.55 (m, 5H), 7.35 (t, *J* = 7.6 Hz, 1H), 1.87 (s, 6H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 144.2, 138.7, 138.4, 134.6, 134.3, 131.3, 128.5, 128.2, 125.4, 119.6, 118.7, 111.9, 92.9, 22.0.
^{11}B NMR (128 MHz, $CDCl_3$) δ 29.1.
HRMS (ESI) *m/z* calcd. for $C_{21}H_{17}BNO_2$ $[M + H]^+$ 326.1347, found 326.1348.

4-(6b,9a-dimethyl-6b,9a-dihydroacenaphtho[1,2-d][1,3,2]dioxaborol-8-yl)benzonitrile (2eh)



2eh

Following the above general procedure, the title compound **2eh** was prepared from (4-cyanophenyl)boronic acid (0.44 g, 3.0 mmol, 1.0 equiv.) and 1,2-dimethylacenaphthylene-1,2-diol (0.65 g, 3.3 mmol, 1.1 equiv.) as a white solid (0.76 g, 78% yield).

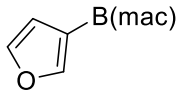
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.84 (d, *J* = 8.4 Hz, 2H), 7.82 – 7.77 (m, 2H), 7.66 – 7.59 (m, 4H), 7.57 (d, *J* = 8.4 Hz, 2H), 1.88 (s, 6H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 144.3, 135.1, 134.7, 131.4, 131.0, 128.5, 125.5, 119.6, 118.8, 114.5, 92.9, 22.1.

^{11}B NMR (128 MHz, $CDCl_3$) δ 31.2.

HRMS (ESI) *m/z* calcd. for $C_{21}H_{17}BNO_2$ $[M + H]^+$ 326.1347, found 326.1348.

8-(furan-3-yl)-6b,9a-dimethyl-6b,9a-dihydroacenaphtho[1,2-d][1,3,2]dioxaborole (2ei)



2ei

Following the above general procedure, the title compound **2ei** was prepared from furan-3-ylboronic acid (0.34 g, 3.0 mmol, 1.0 equiv.) and 1,2-dimethylacenaphthylene-1,2-diol (0.65 g, 3.3 mmol, 1.1 equiv.) as a white solid (0.75 g, 86% yield).

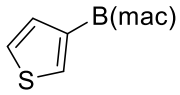
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.81 – 7.75 (m, 2H), 7.73 (s, 1H), 7.64 – 7.54 (m, 4H), 7.38 (t, *J* = 1.6 Hz, 1H), 6.57 – 6.51 (m, 1H), 1.84 (s, 6H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 151.2, 144.6, 142.8, 134.7, 131.3, 128.4, 125.3, 119.5, 113.0, 92.1, 22.1.

^{11}B NMR (128 MHz, $CDCl_3$) δ 29.5.

HRMS (ESI) *m/z* calcd. for $C_{18}H_{16}BO_3$ $[M + H]^+$ 291.1187, found 291.1184.

6b,9a-dimethyl-8-(thiophen-3-yl)-6b,9a-dihydroacenaphtho[1,2-d][1,3,2]dioxaborole (2ej)



2ej

Following the above general procedure, the title compound **2ej** was prepared from thiophen-3-ylboronic acid (0.38 g, 3.0 mmol, 1.0 equiv.) and 1,2-dimethylacenaphthylene-1,2-diol (0.65 g, 3.3 mmol, 1.1 equiv.) as a white solid (0.76 g, 83% yield).

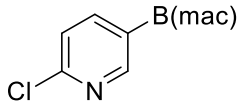
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.87 (d, *J* = 3.6 Hz, 1H), 7.76 (dd, J_1= 6.8 Hz, J_2= 3.6 Hz, 2H), 7.63 – 7.53 (m, 4H), 7.35 (d, *J* = 4.8 Hz, 1H), 7.27 – 7.21 (m, 1H), 1.84 (s, 6H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 144.6, 136.5, 134.7, 132.0, 131.3, 128.4, 125.3, 125.2, 119.5, 92.2, 22.1.

^{11}B NMR (128 MHz, $CDCl_3$) δ 28.8.

HRMS (ESI) *m/z* calcd. for $C_{18}H_{16}BO_2S$ $[M + H]^+$ 307.0959, found 307.0957.

2-chloro-5-(6b,9a-dimethyl-6b,9a-dihydroacenaphtho[1,2-d][1,3,2]dioxaborol-8-yl)pyridine (2ek)



2ek

Following the above general procedure, the title compound **2ek** was prepared from (6-chloropyridin-3-yl)boronic acid (0.47 g, 3.0 mmol, 1.0 equiv.) and 1,2-dimethylacenaphthylene-1,2-diol (0.65 g, 3.3 mmol, 1.1 equiv.) as a white solid (0.80 g, 79% yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.67 (s, 1H), 7.94 (d, *J* = 8.0 Hz, 1H), 7.80 (s, 2H), 7.61 (s, 4H), 7.24 (d, *J* = 8.0 Hz, 1H), 1.87 (s, 6H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 155.7, 154.2, 144.8, 144.1, 134.7, 131.3, 128.5, 125.5, 123.6, 119.7, 92.9, 22.1.

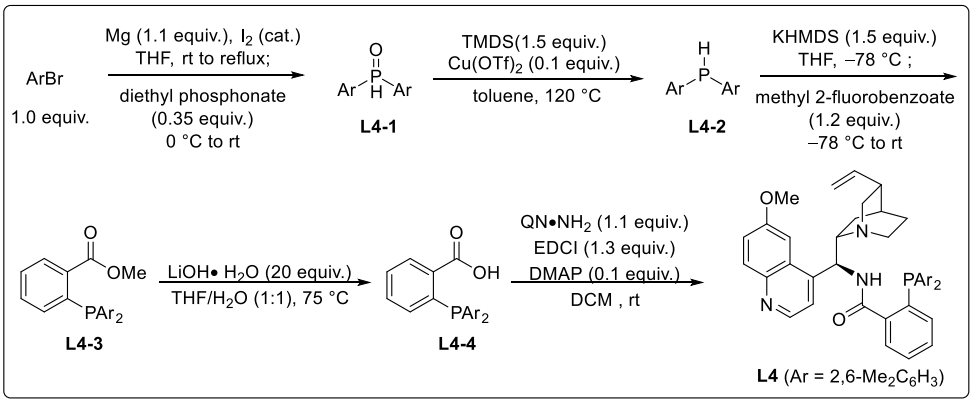
^{11}B NMR (128 MHz, $CDCl_3$) δ 30.3.

HRMS (ESI) *m/z* calcd. for $C_{19}H_{16}BClNO_2$ $[M + H]^+$ 336.0957, found 336.0958.

The synthesis of ligands

The ligands **L1**–**L7** were synthesized according to the reported patent.[5]

General procedure for preparation of L4, **L6 and L7**.



Diethyl phosphonate (1.35 mL, 10.5 mmol) was added dropwise at 0 °C to a solution of arylmagnesium bromide in THF (40 mL) which was prepared from aryl bromides (30.0 mmol) and magnesium (0.79 g, 33.0 mmol). The mixture was stirred for 30 minutes at 0 °C. Upon completion (monitored by TLC), the mixture was quenched by a saturated aq. NH_4Cl (30 mL), extracted with EtOAc (3 × 30 mL), and dried over Na_2SO_4. The organic phase was concentrated in vacuum and the residue was purified by column chromatography on silica gel using dichloromethane/methanol = 10/1 as eluent to give the diarylphosphine oxide **L4-1** (2.58 g, 10.0 mmol, 95% yield).

The diarylphosphine oxide **L4-1** (2.58 g, 10.0 mmol) and $Cu(OTf)_2$ (0.36 g, 1.0 mmol, 0.1 equiv.) were added in a 50 mL Schlenk tube at room temperature. Then TMDS (2.65 mL, 15 mmol, 1.5 equiv.) and toluene (20 mL) were added under argon flow. The reaction mixture was stirred for 12 h at 120 °C. After the reaction was completed, the solvent was removed under vacuum. Then the residue was purified by column chromatography on silica gel using petroleum ether as eluent to give the diarylphosphane **L4-2** (2.42 g, 10.0 mmol, quantitative yield).

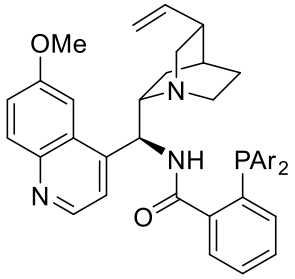
The diarylphosphane **L4-2** (2.42 g, 10.0 mmol) was placed in a Schlenk flask and

dissolved in THF (20 mL). The reaction mixture was cooled to −78 °C, KHMDS (1.0 M in THF, 15 mL, 15 mmol, 1.5 equiv.) was added via syringe. The reaction mixture was then warmed to room temperature and stirred for 30 minutes. The reaction mixture was cooled to −78 °C again and methyl-2-fluorobenzoate (1.5 mL, 12 mmol, 1.2 equiv.) was added dropwise. After the addition, the reaction mixture was warmed to room temperature and stirred for 30 minutes. The mixture was quenched with NH_4Cl aqueous (20 mL) and was extracted with EtOAc (3 × 30 mL). The combined organic layers were dried over Na_2SO_4, filtered and evaporated in vacuo. The crude was purified by flash chromatography on silica gel using petroleum ether/ethyl acetate = 20:1 as eluent to provide the product **L4-3** (3.50 g, 9.3 mmol, 93% yield).

The compound **L4-3** (3.50 g, 9.3 mmol) was charged into a round bottom flask equipped with reflux condenser and was dissolved in THF (20 mL) at room temperature. Water (20 mL) was added into this solution followed by $LiOH·H_2O$ (7.80 g, 186 mmol, 20 equiv.). The reaction mixture was stirred at 75 °C for 36 h. Then the mixture was cooled to room temperature and extracted with EtOAc (3 × 30 mL). The combined organic layers were dried over Na_2SO_4, filtered and evaporated in vacuo. The crude was purified by flash chromatography on silica gel using dichloromethane/methanol = 5:1 as eluent to provide the product **L4-4** (2.65 g, 7.3 mmol, 78% yield).

To an oven-dried flask was added **L4-4** (1.81 g, 5.0 mmol), quinine-derived chiral amine[5] (1.77 g, 5.5 mmol, 1.1 equiv.), DMAP (61.0 mg, 0.5 mmol, 0.1 equiv.) and EDCI (1.25 g, 6.5 mmol, 1.3 equiv.), followed by the addition of DCM (20 mL). The reaction mixture was stirred for 6 h at room temperature. After completion (monitored by TLC), the reaction mixture was directly subjected to flash chromatography on silica gel using dichloromethane/methanol = 10:1 as eluent to afford the desired product **L4** (2.40 g, 3.6 mmol, 72% yield).

The ligand **L7** was synthesized from quinidine-derived chiral amine according to the above procedure.



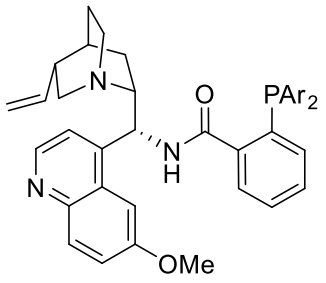
L4 (Ar = 2,6-$Me_2C_6H_3$)

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.41 (d, *J* = 4.8 Hz, 1H), 8.27 (br, 1H), 7.96 (d, *J* = 9.2 Hz, 1H), 7.88 – 7.78 (m, 1H), 7.69 (d, *J* = 2.8 Hz, 1H), 7.39 – 7.29 (m, 2H), 7.23 – 7.09 (m, 4H), 7.06 – 6.96 (m, 2H), 6.96 – 6.89 (m, 2H), 6.69 (br, 1H), 5.82 – 5.67 (m, 1H), 5.52 (br, 1H), 4.98 (d, *J* = 9.2 Hz, 1H), 4.95 (s, 1H), 3.92 (s, 3H), 3.33 – 3.15 (m, 2H), 2.92 (br, 1H), 2.78 – 2.61 (m, 2H), 2.31 – 2.21 (m, 1H), 2.09 (s, 6H), 1.96 (s, 6H), 1.71 – 1.50 (m, 3H), 1.47 – 1.32 (m, 1H), 0.96 – 0.80 (m, 1H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 168.2, 157.7, 147.6, 145.1, 144.5, 143.2, 143.0, 142.5, 142.4, 141.4, 141.3, 141.0, 134.7, 134.5, 133.5, 133.1, 133.0, 132.7, 131.4, 129.8, 129.24, 129.20, 129.17, 129.1, 128.9, 128.5, 128.4, 121.4, 118.6, 114.3, 101.9, 60.2, 56.0, 55.5, 41.0, 39.5, 27.9, 27.3, 26.0, 23.0, 22.8, 22.7, 22.5.

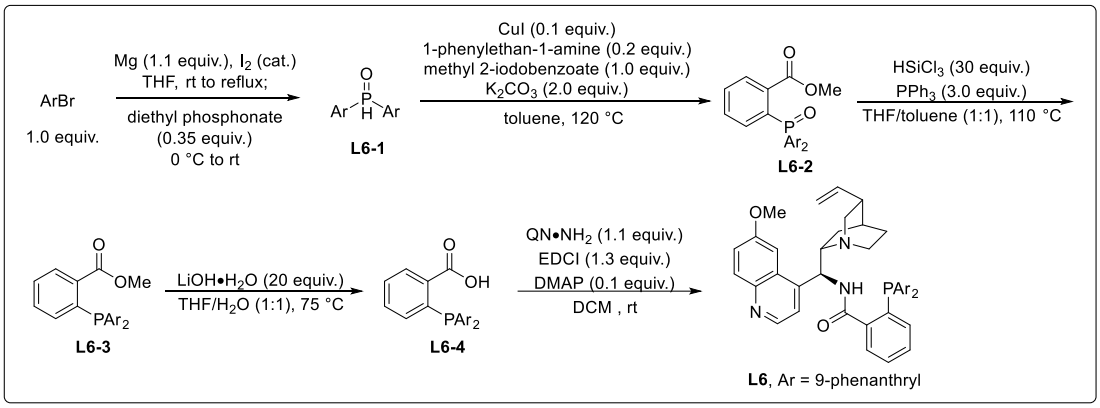
^{31}P NMR (162 MHz, $CDCl_3$) δ -28.4

HRMS (ESI) *m/z* calcd. for $C_{43}H_{47}N_3O_2P$ $[M + H]^+$ 668.3400, found 668.3401.



L7 (Ar = 2,6-$Me_2C_6H_3$)

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.47 (br, 1H), 8.34 (d, *J* = 4.4 Hz, 1H), 7.94 (d, *J* = 9.2 Hz, 1H), 7.90 – 7.81 (m, 1H), 7.60 (d, *J* = 2.4 Hz, 1H), 7.38 – 7.29 (m, 2H), 7.22 – 7.10 (m, 4H), 7.07 – 6.90 (m, 4H), 6.66 (br, 1H), 5.98 – 5.84 (m, 1H), 5.57 – 5.41 (m, 1H), 5.19 – 5.03 (m, 2H), 3.93 (s, 3H), 3.06 – 2.78 (m, 5H), 2.35 – 2.23 (m, 1H), 2.13 (s, 6H), 1.97 (s, 6H), 1.63 (br, 1H), 1.58 – 1.44 (m, 2H), 1.30 – 1.21 (m, 1H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 168.2, 157.6, 147.5, 145.7, 144.4, 143.4, 143.2, 142.5, 142.3, 141.2, 140.9, 140.5, 134.6, 134.4, 133.4, 133.2, 133.0, 132.7, 132.6, 131.3, 130.0, 129.8, 129.32, 129.28, 129.2, 129.1, 129.0, 128.5, 128.44, 128.40, 121.8, 118.5, 114.6, 101.3, 60.5, 55.4, 49.2, 46.9, 39.0, 27.2, 26.6, 25.3, 23.0, 22.9, 22.7, 22.5.
^{31}P NMR (162 MHz, $CDCl_3$) δ -28.3
HRMS (ESI) *m/z* calcd. for $C_{43}H_{47}N_3O_2P$ $[M + H]^+$ 668.3400, found 668.3401.



Diethyl phosphonate (4.50 mL, 35 mmol, 0.35 equiv.) was added dropwise at 0 °C to a solution of arylmagnesium bromide in THF (150 mL) which was prepared from aryl bromides (100 mmol) and magnesium (2.64 g, 110 mmol, 1.1 equiv.). The mixture was stirred for 30 minutes at 0 °C. Upon completion (monitored by TLC), the mixture was quenched by a saturated aq. NH_4Cl (50 mL), The reaction was diluted with EtOAc, filtered through a frit funnel and washed with EtOAc. Then the solid residue was dried under vacuum to give the diarylphosphine oxide **L6-1** (8.28 g, 20.6 mmol, 59% yield).

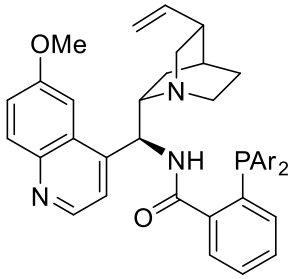
In a oven-dried Schlenk tube (100 mL) was placed CuI (380 mg, 2.0 mmol, 0.1 equiv.) under argon atmosphere. Then 1-phenylethan-1-amine (0.52 mL, 4.0 mmol, 0.2 equiv.) was added, followed by methyl 2-iodobenzoate (2.94 mL, 20 mmol, 1.0 equiv.). After 5 minutes, toluene (50 mL) was added followed by **L6-1** (8.05 g, 20 mmol). After the mixture was stirred for 5 minutes, anhydrous K_2CO_3 (5.5 g, 40 mmol, 2.0 equiv.) was added and the reaction mixture was stirred at 120 °C for 48 h under argon atmosphere. Then the mixture was allowed to cool to room temperature and was filtered through a short plug of Celite under reduce pressure. Celite was washed three times with EtOAc and the filtrate was evaporated under reduced pressure. The

residue was purified by column chromatography on silica gel using petroleum ether/ethyl acetate = 3:1 as eluent to give the diarylphosphane **L6-2** (8.75 g, 16.3 mmol, 82% yield).

The compound **L6-2** (3.76 g, 7.0 mmol, 1.0 equiv.) and PPh_3 (5.50 g, 21 mmol, 3.0 equiv.) was placed in a Schlenk flask and dissolved in toluene/THF (1:1, 40 mL) under argon atmosphere. Trichlorosilane (21 mL, 210 mmol, 30 equiv.) was slowly added to the mixture via syringe. The reaction mixture was slowly warmed to 110 °C and was stirred for 3 d at this temperature. Then the mixture was carefully quenched by a saturated aq. NH_4Cl (50 mL) at 0 °C and diluted with EtOAc. The HCl (conc.) was added carefully until the mixture became clear. The combined organic layers were dried over Na_2SO_4, filtered and evaporated in vacuo. The crude was purified by flash chromatography on silica gel using petroleum ether/ethyl acetate = 20:1 as eluent to provide the product **L6-3** (3.02 g, 5.8 mmol, 83% yield).

The compound **L6-3** (2.60 g, 5.0 mmol) was charged into a round bottom flask equipped with reflux condenser and was dissolved in THF (20 mL) at room temperature. Water (20 mL) was added into this solution followed by $LiOH·H_2O$ (4.20 g, 100 mmol, 20 equiv.). The reaction mixture was stirred at 75 °C for 36 h. Then the mixture was cooled to room temperature and extracted with EtOAc (3 × 30 mL). The combined organic layers were dried over Na_2SO_4, filtered and evaporated in vacuo. The crude was purified by flash chromatography on silica gel using dichloromethane/methanol = 5:1 as eluent to provide the product **L4-4** (1.78 g, 3.5 mmol, 70% yield).

To an oven-dried flask was added **L6-4** (1.27 g, 2.5 mmol), quinine-derived chiral amine (0.89 g, 2.75 mmol, 1.1 equiv.), DMAP (30.5 mg, 0.25 mmol, 0.1 equiv.) and EDCI (0.62 g, 3.25 mmol, 1.3 equiv.), followed by the addition of DCM (10 mL). The reaction mixture was stirred for 6 h at room temperature. After completion (monitored by TLC), the reaction mixture was directly subjected to flash chromatography on silica gel using dichloromethane/methanol = 10:1 as eluent to afford the desired product **L6** (1.60 g, 2.0 mmol, 80% yield).



L6, Ar = 9-phenanthryl

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.93 – 8.15 (m, 7H), 7.99 – 6.81 (m, 21H), 5.37 (br, 2H), 5.01 – 4.57 (m, 2H), 3.87 (s, 3H), 3.01 (br, 1H), 2.40 (br, 2H), 2.00 (br, 1H), 1.86 (s, 3H), 1.53 – 1.30 (m, 3H), 0.68 (br, 1H).

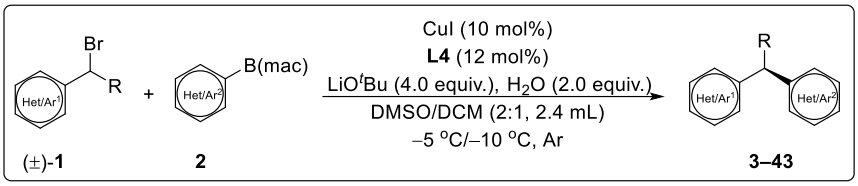
^{13}C NMR (100 MHz, $CDCl_3$) δ 169.0, 157.5, 147.2, 144.6, 144.2, 141.1, 135.4, 134.9, 133.2, 133.1, 133.0, 132.9, 131.3, 131.2, 130.9, 130.8, 130.4, 130.21, 130.16, 130.1, 129.5, 128.9, 128.8, 127.5, 127.4, 127.2, 127.1, 126.9, 126.8, 126.7, 126.5, 123.0, 122.8, 122.5, 122.3, 121.3, 114.1, 60.1, 55.5, 54.8, 50.6, 40.7, 39.0, 27.6, 27.1, 25.6.

^{31}P NMR (162 MHz, $CDCl_3$) δ -25.7

HRMS (ESI) *m/z* calcd. for $C_{55}H_{47}N_3O_2P$ $[M + H]^+$ 812.3400, found 812.3399.

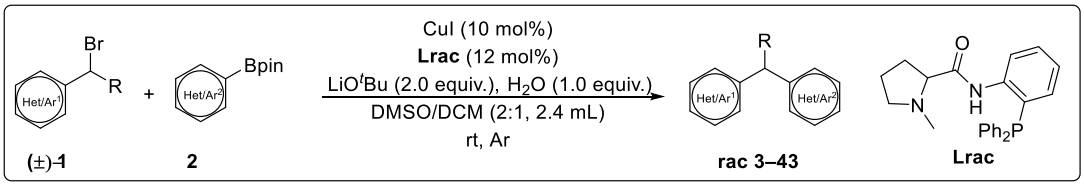
Experimental Procedures

Copper-Catalyzed Enantioconvergent Radical Suzuki-Miyaura C(sp^3)–C(sp^2) Cross-Coupling

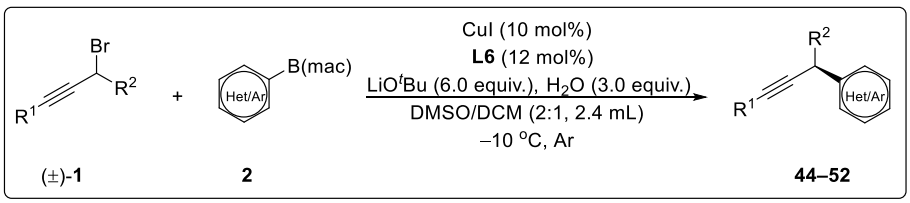


General Procedure A

Under argon atmosphere, an oven-dried resealable Schlenk tube equipped with a magnetic stir bar was charged with **2** (0.20 mmol, 1.0 equiv.), CuI (3.8 mg, 0.020 mmol, 10 mol%), **L4** (16.0 mg, 0.024 mmol, 12 mol%), LiO^{t}Bu (64.0 mg, 0.80 mmol, 4.0 equiv.). Then DMSO/CH_2Cl_2 (2:1, 2.4 mL) and H_2O (7.2 mg, 0.40 mmol, 2.0 equiv.) was added. The reaction mixture was stirred for several minutes to dissolve the reactants. Lastly, alkyl halide **1** (0.30 mmol, 1.5 equiv.) was slowly added into the mixture *via* microsyringe, and the reaction mixture was stirred at –5 °C or –10 °C and stopped at the designated time. Upon completion (monitored by TLC), the reaction mixture was poured into water (10 mL), then extracted with DCM (3 × 5 mL). The filtrate was dried with anhydride Na_2SO_4, then was purified by column chromatography on silica gel to afford the desired products.



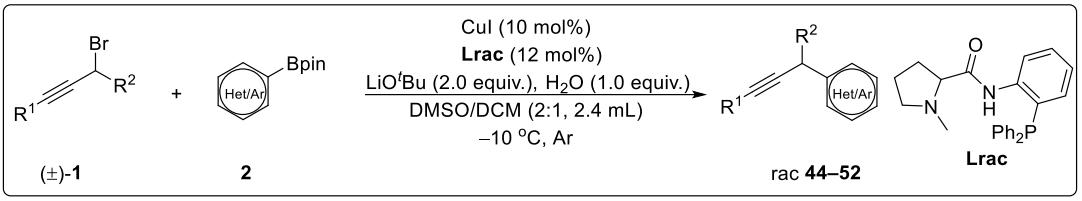
The racemates of products were prepared following the procedure: under argon atmosphere, an oven-dried resealable Schlenk tube equipped with a magnetic stir bar was charged with **2** (0.20 mmol, 1.0 equiv.), CuI (3.8 mg, 0.02 mmol, 10 mol%), **Lrac** (9.3 mg, 0.024 mmol, 12 mol%), LiO^{t}Bu (32.0 mg, 0.40 mmol, 2.0 equiv.). Then DMSO/CH_2Cl_2 (2:1, 2.4 mL) and H_2O (3.6 mg, 0.20 mmol, 1.0 equiv.) was added. The reaction mixture was stirred for several minutes to dissolve the reactants. Lastly, alkyl halide **1** (0.30 mmol, 1.5 equiv.) was slowly added into the mixture *via* microsyringe, and the reaction mixture was stirred for 0.5 h to 2.0 h at room temperature. Upon completion (monitored by TLC), the reaction mixture was poured into water (10 mL), then extracted with DCM (3 × 5 mL). The filtrate was dried with anhydride Na_2SO_4, then was purified by column chromatography on silica gel to afford the desired products.



General Procedure B

Under argon atmosphere, an oven-dried resealable Schlenk tube equipped with a magnetic stir bar was charged with **2** (0.20 mmol, 1.0 equiv.), CuI (3.8 mg, 0.020

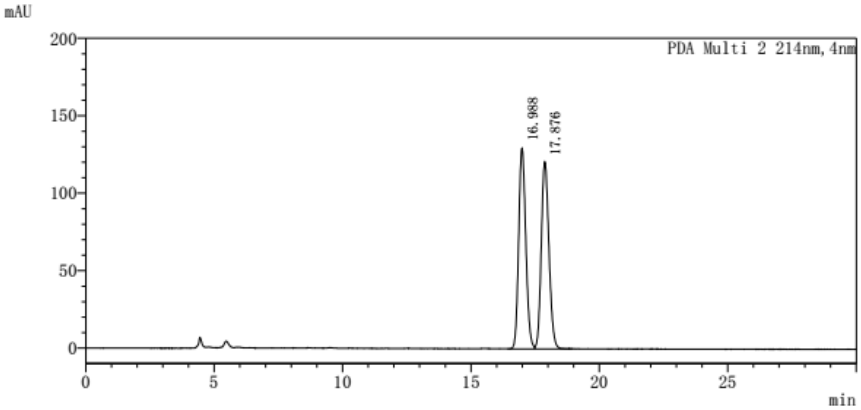
mmol, 10 mol%), **L6** (19.7 mg, 0.024 mmol, 12 mol%), LiO^{t}Bu (96.0 mg, 1.20 mmol, 6.0 equiv.). Then DMSO/CH_2Cl_2 (2:1, 2.4 mL) and H_2O (10.8 mg, 0.60 mmol, 3.0 equiv.) was added. The reaction mixture was stirred for several minutes to dissolve the reactants. Lastly, alkyl halide **1** (0.30 mmol, 1.5 equiv.) was slowly added into the mixture *via* microsyringe, and the reaction mixture was stirred at −10 °C and stopped at the designated time. Upon completion (monitored by TLC), the reaction mixture was poured into water (10 mL), then extracted with DCM (3 × 5 mL). The filtrate was dried with anhydride Na_2SO_4, then was purified by column chromatography on silica gel to afford the desired products.



The racemates of products were prepared following the procedure: under argon atmosphere, an oven-dried resealable Schlenk tube equipped with a magnetic stir bar was charged with **2** (0.20 mmol, 1.0 equiv.), CuI (3.8 mg, 0.02 mmol, 10 mol%), **L**rac (9.3 mg, 0.024 mmol, 12 mol%), LiO^{t}Bu (32.0 mg, 0.40 mmol, 2.0 equiv.). Then DMSO/CH_2Cl_2 (2:1, 2.4 mL) and H_2O (3.6 mg, 0.20 mmol, 1.0 equiv.) was added. The reaction mixture was stirred for several minutes to dissolve the reactants. Lastly, alkyl halide **1** (0.30 mmol, 1.5 equiv.) was slowly added into the mixture *via* microsyringe, and the reaction mixture was stirred at −10 °C. Upon completion (monitored by TLC), the reaction mixture was poured into water (10 mL), then extracted with DCM (3 × 5 mL). The filtrate was dried with anhydride Na_2SO_4, then was purified by column chromatography on silica gel to afford the desired products.

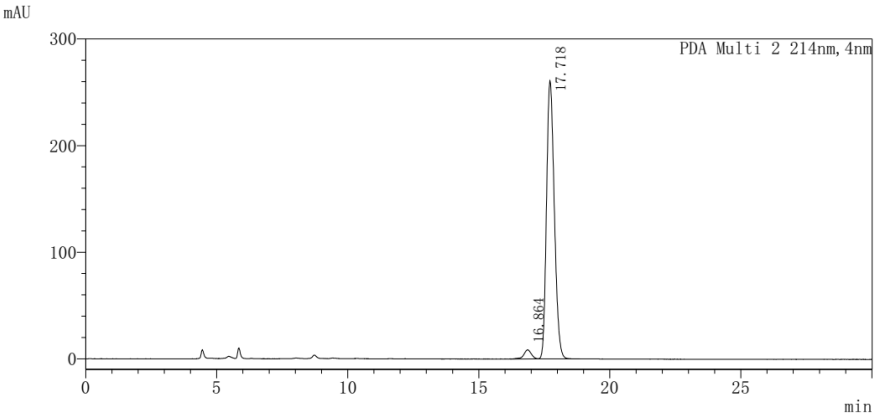
Determination of absolute configuration

The absolute configuration of **29** was determined by comparing the HPLC spectrum (Figure S1) and specific rotation with those reported in literature.[6] ($[\alpha]_D^{24.7}$ = –9.9 (c 0.60, $CHCl_3$, 94% ee). Lit.[6] $[\alpha]_D^{25.1}$ = –7.8 (c 0.78, $CHCl_3$), 92% ee}) The product **29** was determined to be of an "*R*" absolute configuration according to the reported data.



PDA Ch2 214nm

Peak#	Ret. Time	Area	Area%
1	16.988	2496686	49.873
2	17.876	2509360	50.127



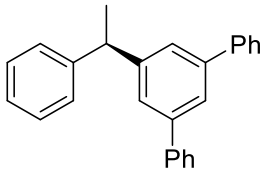
PDA Ch2 214nm

Peak#	Ret. Time	Area	Area%
1	16.864	174488	3.131
2	17.718	5398845	96.869

Figure S1. Determination of absolute stereochemistry

Characteristic data of products 3–52

(*R*)-1,3-diphenyl-5-(1-phenylethyl)benzene (3)



3

According to the general procedure **A**, substrate **1a** (55.5 mg, 0.30 mmol) and **2e** (90.4 mg, 0.20 mmol) was employed to yield the product **3** as a pale yellow oil (52.3 mg, 78% yield, 94% ee).

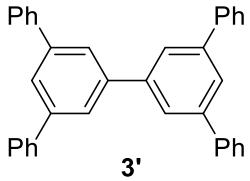
HPLC analysis: Chiralcel OD (hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 6.08 min, t_R (minor) = 7.37 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.68 – 7.55 (m, 5H), 7.46 – 7.39 (m, 6H), 7.37 – 7.26 (m, 6H), 7.22 – 7.14 (m, 1H), 4.27 (q, *J* = 7.2 Hz, 1H), 1.73 (d, *J* = 7.2 Hz, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 147.3, 146.1, 141.8, 141.3, 128.7, 128.4, 127.6, 127.32, 127.30, 126.1, 125.6, 124.1, 45.0, 22.0.

HRMS (ESI) *m/z* calcd. for $C_{26}H_{23}$ $[M + H]^+$ 335.1794, found 335.1792.

5',5''-diphenyl-1,1':3',1'':3'',1'''-quaterphenyl (3')



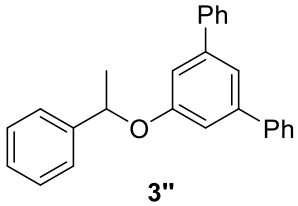
3'

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.89 (d, *J* = 1.6 Hz, 4H), 7.85 – 7.82 (m, 2H), 7.75 – 7.69 (m, 8H), 7.53 – 7.46 (m, 8H), 7.44 – 7.37 (m, 4H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 142.5, 142.3, 141.1, 128.9, 127.6, 127.4, 125.4, 125.3.

HRMS (ESI) *m/z* calcd. for $C_{36}H_{27}$ $[M + H]^+$ 459.2107, found 459.2099.

5',5''-diphenyl-1,1':3',1'':3'',1'''-quaterphenyl (3'')



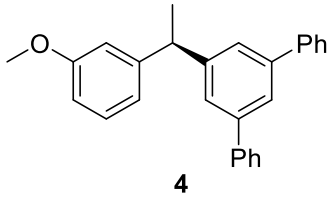
3''

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.57 – 7.51 (m, 4H), 7.46 – 7.30 (m, 11H), 7.30 – 7.23 (m, 1H), 7.09 (d, *J* = 1.6 Hz, 2H), 5.44 (q, *J* = 6.4 Hz, 1H), 1.69 (d, *J* = 6.4 Hz, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 158.7, 143.1, 142.9, 141.1, 128.70, 128.68, 127.6, 127.42, 127.2, 125.6, 118.8, 113.8, 76.2, 24.4.

HRMS (ESI) *m/z* calcd. for $C_{26}H_{23}O$ $[M + H]^+$ 351.1743, found 351.1735.

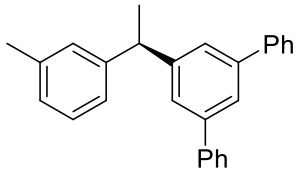
(*R*)-1,3-diphenyl-5-(1-(3-methoxyphenylethyl))benzene (4)



4

According to the **general procedure A**, substrate **1d** (64.5 mg, 0.30 mmol) and **2e** (90.4 mg, 0.20 mmol) was employed to yield the product **4** as a pale yellow oil (58.3 mg, 80% yield, 94% ee).
HPLC analysis: Chiralcel ADH (hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min, λ = 254 nm), t_R (minor) = 5.34 min, t_R (major) = 5.71 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.67 – 7.55 (m, 5H), 7.47 – 7.38 (m, 6H), 7.36 – 7.29 (m, 2H), 7.24 – 7.17 (m, 1H), 6.92 – 6.84 (m, 2H), 6.72 (d, *J* = 5.6 Hz, 1H), 4.24 (q, *J* = 7.2 Hz, 1H), 3.75 (s, 3H), 1.71 (d, *J* = 6.8 Hz, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 159.6, 147.7, 147.2, 141.8, 141.3, 129.4, 128.7, 127.31, 127.29, 125.5, 124.1, 120.1, 113.9, 110.9, 55.1, 45.0, 21.9.
HRMS (ESI) *m/z* calcd. for $C_{27}H_{25}O$ $[M + H]^+$ 365.1900, found 365.1901.

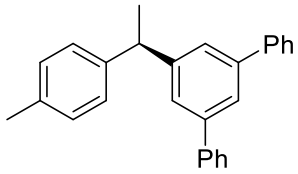
(*R*)-1,3-diphenyl-5-(1-(3-methylphenylethyl))benzene (5)



5

According to the **general procedure A**, substrate **1e** (59.7 mg, 0.30 mmol) and **2e** (90.4 mg, 0.20 mmol) was employed to yield the product **5** as a pale yellow oil (43.5 mg, 62% yield, 94% ee).
HPLC analysis: Chiralcel OD (hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 5.29 min, t_R (minor) = 6.72 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.66 – 7.56 (m, 5H), 7.47 – 7.38 (m, 6H), 7.36 – 7.29 (m, 2H), 7.22 – 7.16 (m, 2H), 7.13 – 7.07 (m, 2H), 4.24 (q, *J* = 7.2 Hz, 1H), 2.30 (s, 3H), 1.71 (d, *J* = 7.2 Hz, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 147.6, 143.1, 141.8, 141.4, 135.6, 129.1, 128.7, 127.5, 127.30, 127.28, 125.5, 124.0, 44.6, 22.0, 21.0.
HRMS (ESI) *m/z* calcd. for $C_{27}H_{25}$ $[M + H]^+$ 349.1951, found 349.1938.

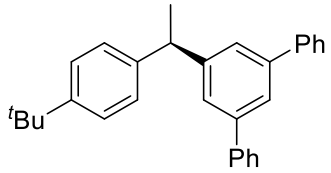
(*R*)-1,3-diphenyl-5-(1-(4-methylphenylethyl))benzene (6)



6

According to the **general procedure A**, substrate **1f** (59.7 mg, 0.30 mmol) and **2e** (90.4 mg, 0.20 mmol) was employed to yield the product **6** as a pale yellow oil (48.7 mg, 70% yield, 93% ee).
HPLC analysis: Chiralcel OD (hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 5.32 min, t_R (minor) = 5.98 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.67 – 7.57 (m, 5H), 7.48 – 7.38 (m, 6H), 7.36 – 7.29 (m, 2H), 7.17 (d, *J* = 7.8 Hz, 1H), 7.10 (s, 2H), 6.99 (d, *J* = 7.8 Hz, 1H), 4.23 (q, *J* = 7.2 Hz, 1H), 2.30 (s, 3H), 1.71 (d, *J* = 7.2 Hz, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 147.5, 146.0, 141.8, 141.4, 137.9, 128.7, 128.4, 128.3, 127.3, 126.9, 125.6, 124.6, 124.0, 45.0, 22.0, 21.5.
HRMS (ESI) *m/z* calcd. for $C_{27}H_{25}$ $[M + H]^+$ 349.1951, found 349.1954.

(*R*)-1,3-diphenyl-5-(1-(4-*tert*-butylphenylethyl))benzene (7)



7

According to the **general procedure A**, substrate **1g** (72.4 mg, 0.30 mmol) and **2e** (90.4 mg, 0.20 mmol) was employed to yield the product **7** as a pale yellow solid (45.1 mg, 58% yield, 97% ee).

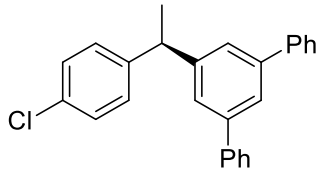
HPLC analysis: Chiralcel IA (hexane/*i*-PrOH = 99.5/0.5, flow rate 0.4 mL/min, λ = 254 nm), t_R (minor) = 12.15 min, t_R (major) = 12.68 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.66 – 7.58 (m, 5H), 7.47 – 7.40 (m, 6H), 7.37 – 7.28 (m, 4H), 7.26 – 7.20 (m, 2H), 4.25 (q, *J* = 7.2 Hz, 1H), 1.73 (d, *J* = 7.2 Hz, 3H), 1.29 (s, 9H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 148.8, 147.5, 143.0, 141.8, 141.4, 128.7, 127.32, 127.30, 127.1, 125.6, 125.3, 124.0, 44.6, 34.3, 31.4, 22.0.

HRMS (ESI) *m/z* calcd. for $C_{30}H_{31}$ $[M + H]^+$ 391.2420, found 391.2413.

(*R*)-1,3-diphenyl-5-(1-(4-chlorophenylethyl))benzene (8)



8

According to the **general procedure A**, substrate **1h** (65.9 mg, 0.30 mmol) and **2e** (90.4 mg, 0.20 mmol) was employed to yield the product **8** as a pale yellow oil (49.4 mg, 67% yield, 85% ee).

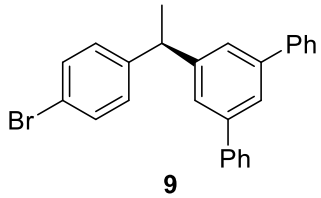
HPLC analysis: Chiralcel OD (hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 6.48 min, t_R (minor) = 7.71 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.66 – 7.56 (m, 5H), 7.47 – 7.40 (m, 4H), 7.39 (d, *J* = 2.0 Hz, 2H), 7.37 – 7.31 (m, 2H), 7.28 – 7.19 (m, 4H), 4.24 (q, *J* = 7.2 Hz, 1H), 1.70 (d, *J* = 7.2 Hz, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 146.8, 144.6, 142.0, 141.2, 131.8, 129.0, 128.8, 128.5, 127.4, 127.3, 125.5, 124.3, 44.4, 21.9.

HRMS (ESI) *m/z* calcd. for $C_{26}H_{22}{}^{35}Cl$ $[M + H]^+$ 369.1405, found 369.1402.

(*R*)-1,3-diphenyl-5-(1-(4-bromophenylethyl))benzene (9)



9

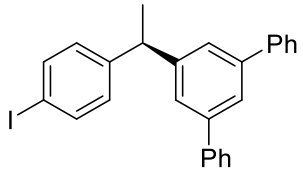
According to the **general procedure A**, substrate **1i** (79.2 mg, 0.30 mmol) and **2e** (90.4 mg, 0.20 mmol) was employed to yield the product **9** as a pale yellow oil (55.4 mg, 67% yield, 86% ee).

HPLC analysis: Chiralcel OD (hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 7.09 min, t_R (minor) = 8.42 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.65 – 7.56 (m, 5H), 7.46 – 7.37 (m, 8H), 7.37 – 7.31 (m, 2H), 7.16 (d, *J* = 8.4 Hz, 2H), 4.22 (q, *J* = 7.0 Hz, 1H), 1.69 (d, *J* = 7.0 Hz, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 146.7, 145.1, 142.0, 141.2, 131.5, 129.4, 128.8, 127.4, 127.3, 125.4, 124.3, 120.0, 44.4, 21.8.
HRMS (ESI) *m/z* calcd. for $C_{26}H_{22}{}^{79}Br$ $[M + H]^+$ 413.0899, found 413.0895.

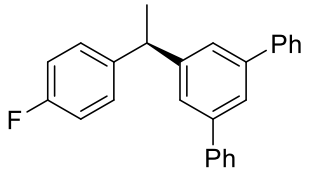
(*R*)-1,3-diphenyl-5-(1-(4-iodophenylethyl))benzene (10)



10

According to the **general procedure A**, substrate **1j** (93.3 mg, 0.30 mmol) and **2e** (90.4 mg, 0.20 mmol) was employed to yield the product **10** as a colorless oil (55.7 mg, 60% yield, 87% ee).
HPLC analysis: Chiralcel OD (hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 7.55 min, t_R (minor) = 8.69 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.65 – 7.55 (m, 7H), 7.45 – 7.31 (m, 8H), 7.03 (d, *J* = 8.4 Hz, 2H), 4.20 (q, *J* = 7.2 Hz, 1H), 1.68 (d, *J* = 7.2 Hz, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 146.6, 145.8, 142.0, 141.1, 137.5, 129.7, 128.75, 128.71, 127.4, 127.31, 127.27, 125.4, 124.3, 91.4, 44.5, 21.8.
HRMS (ESI) *m/z* calcd. for $C_{26}H_{22}I$ $[M + H]^+$ 461.0761, found 461.0764.

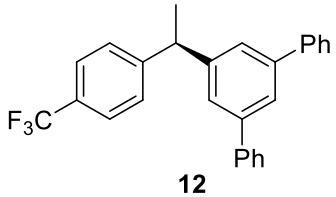
(*R*)-1,3-diphenyl-5-(1-(4-fluorophenylethyl))benzene (11)



11

According to the **general procedure A**, substrate **1k** (60.9 mg, 0.30 mmol) and **2e** (90.4 mg, 0.20 mmol) was employed to yield the product **11** as a pale yellow oil (41.2 mg, 58% yield, 87% ee).
HPLC analysis: Chiralcel OD (hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 6.6 min, t_R (minor) = 8.2 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.67 – 7.54 (m, 5H), 7.47 – 7.37 (m, 6H), 7.34 (t, *J* = 7.4 Hz, 2H), 7.27 – 7.21 (m, 2H), 6.97 (t, *J* = 8.8 Hz, 2H), 4.25 (q, *J* = 7.2 Hz, 1H), 1.70 (d, *J* = 7.2 Hz, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 161.3 (d, *J* = 242.6 Hz), 147.2, 141.9, 141.7 (d, $J_{C\text{-}F}$ = 3.1 Hz), 141.2, 129.0 (d, $J_{C\text{-}F}$ = 7.8 Hz), 128.8, 127.4, 127.3, 125.5, 124.2, 115.2 (d, $J_{C\text{-}F}$ = 21.0 Hz), 44.2, 22.1
^{19}F NMR (376 MHz, $CDCl_3$) δ –117.1.
HRMS (ESI) *m/z* calcd. for $C_{26}H_{22}F$ $[M + H]^+$ 353.1700, found 353.1703.

(*R*)-1,3-diphenyl-5-(1-(4-trifluorophenylethyl))benzene (12)



12

According to the **general procedure A**, substrate **1l** (75.9 mg, 0.30 mmol) and **2e** (90.4 mg, 0.20 mmol) was employed to yield the product **12** as a pale yellow oil (44.2 mg, 55% yield, 79% ee).

HPLC analysis: Chiralcel OD (hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 6.45 min, t_R (minor) = 7.10 min.

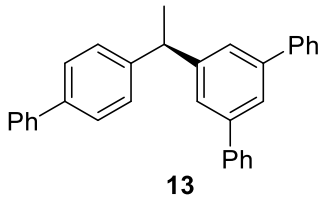
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.65 (t, *J* = 1.6 Hz, 1H), 7.63 – 7.58 (m, 4H), 7.55 (d, *J* = 8.4 Hz, 2H), 7.47 – 7.38 (m, 8H), 7.37 – 7.32 (m, 2H), 4.32 (q, *J* = 7.2 Hz, 1H), 1.74 (d, *J* = 7.2 Hz, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 150.2, 146.3, 142.1, 141.1, 128.8, 128.5 (q, J_{C-F} = 32.2 Hz), 128.0, 127.5, 127.3, 125.5, 125.4 (q, J_{C-F} = 3.8 Hz), 124.5, 124.3 (q, J_{C-F} = 270.2 Hz), 44.9, 21.7.

^{19}F NMR (376 MHz, $CDCl_3$) δ –62.3.

HRMS (ESI) *m/z* calcd. for $C_{27}H_{22}F_3$ $[M + H]^+$ 403.1668, found 403.1669.

(*R*)-1,3-diphenyl-5-(1-(4-*tert*-butylphenylethyl))benzene (13)



13

According to the **general procedure A**, substrate **1m** (78.4 mg, 0.30 mmol) and **2e** (90.4 mg, 0.20 mmol) was employed to yield the product **13** as a white solid (43.6 mg, 53% yield, 94% ee).

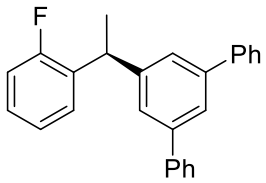
HPLC analysis: Chiralcel OD (hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min, λ = 254 nm), t_R (minor) = 8.58 min, t_R (major) = 19.91 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.66 – 7.59 (m, 5H), 7.58 – 7.50 (m, 4H), 7.47 (d, *J* = 1.6 Hz, 2H), 7.46 – 7.27 (m, 11H), 4.31 (q, *J* = 7.2 Hz, 1H), 1.76 (d, *J* = 7.2 Hz, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 147.3, 145.2, 141.9, 141.3, 140.9, 139.0, 128.74, 128.69, 128.0, 127.34, 127.31, 127.2, 127.05, 126.99, 125.6, 124.2, 44.7, 22.0.

HRMS (ESI) *m/z* calcd. for $C_{32}H_{27}$ $[M + H]^+$ 411.2107, found 411.2104.

(*S*)-5'-(1-(2-fluorophenyl)ethyl)-1,1':3',1''-terphenyl (14)



14

According to the **general procedure A**, substrate **1n** (60.9 mg, 0.30 mmol) and **2e** (90.4 mg, 0.20 mmol) was employed to yield the product **14** as a white solid (10.0 mg, 14% yield, 80% ee).

HPLC analysis: Chiralcel ODH (hexane/*i*-PrOH = 99/1, flow rate 0.6 mL/min, λ = 254 nm), t_R (major) = 8.98 min, t_R (minor) = 9.46 min.

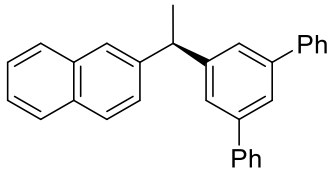
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.66 – 7.57 (m, 5H), 7.46 (d, *J* = 1.6 Hz, 2H), 7.44 – 7.38 (m, 4H), 7.36 – 7.25 (m, 3H), 7.19 – 7.12 (m, 1H), 7.10 – 7.04 (m, 1H), 7.04 – 6.96 (m, 1H), 4.60 (q, *J* = 7.2 Hz, 1H), 1.72 (d, *J* = 7.2 Hz, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 160.6 (d, J_{C-F} = 244.2 Hz), 146.0, 141.9, 141.3, 133.0 (d, *J* = 14.4 Hz), 128.7, 128.5 (d, J_{C-F} = 4.4 Hz), 127.8 (d, J_{C-F} = 8.2 Hz), 127.34, 127.31, 125.5, 124.3, 124.1 (d, J_{C-F} = 3.4 Hz), 115.4 (d, J_{C-F} = 22.3 Hz), 37.6 (d, J_{C-F} = 2.6 Hz), 20.8.

^{19}F NMR (376 MHz, $CDCl_3$) δ – 117.5

HRMS (ESI) *m/z* calcd. for $C_{26}H_{22}F$ $[M + H]^+$ 353.1700, found 353.1694.

(*R*)-1,3-diphenyl-5-(1-phenylethyl)naphthalene (15)



15

According to the **general procedure A**, substrate **1o** (70.5 mg, 0.30 mmol) and **2e** (90.4 mg, 0.20 mmol) was employed to yield the product **15** as a white solid (24.6 mg, 32% yield, 91% ee).

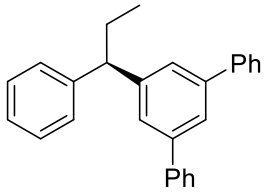
HPLC analysis: Chiralcel OD (hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 5.38 min, t_R (minor) = 6.19 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.82 – 7.72 (m, 4H), 7.66 – 7.56 (m, 5H), 7.49 – 7.36 (m, 9H), 7.35 – 7.29 (m, 2H), 4.43 (q, *J* = 7.2 Hz, 1H), 1.82 (d, *J* = 7.2 Hz, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 147.2, 143.5, 141.9, 141.3, 133.5, 132.1, 128.7, 128.0, 127.8, 127.6, 127.33, 127.30, 126.8, 125.9, 125.7, 125.4, 124.2, 45.1, 21.9.

HRMS (ESI) *m/z* calcd. for $C_{30}H_{25}$ $[M + H]^+$ 385.1951, found 385.1953.

(*R*)-1,3-diphenyl-5-(1-henylpropyl)benzene (16)



16

According to the **general procedure A**, substrate **1p** (59.1 mg, 0.30 mmol) and **2e** (90.4 mg, 0.20 mmol) was employed to yield the product **16** as a pale yellow oil (37.9 mg, 53% yield, 94% ee).

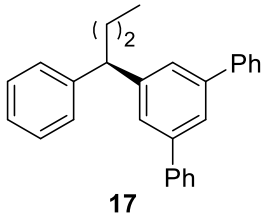
HPLC analysis: Chiralcel OD (hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 5.26 min, t_R (minor) = 6.15 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.65 – 7.57 (m, 5H), 7.47 – 7.38 (m, 6H), 7.36 – 7.24 (m, 6H), 7.19 – 7.13 (m, 1H), 3.91 (t, *J* = 7.8 Hz, 1H), 2.16 (hep, *J* = 7.4 Hz, 2H), 0.95 (t, *J* = 7.2 Hz, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 146.1, 144.9, 141.8, 141.3, 128.7, 128.4, 127.9, 127.3, 126.1, 125.9, 124.1, 53.5, 28.7, 12.9.

HRMS (ESI) *m/z* calcd. for $C_{27}H_{25}$ $[M + H]^+$ 349.1951, found 349.1954.

(*R*)-1,3-diphenyl-5-(1-phenylpropyl)benzene (17)

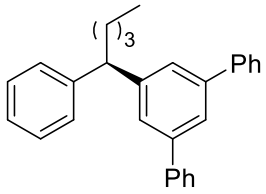


17

According to the **general procedure A**, substrate **1q** (63.9 mg, 0.30 mmol) and **2e** (90.4 mg, 0.20 mmol) was employed to yield the product **17** as a white solid (42.1 mg, 58% yield, 94% ee).

HPLC analysis: Chiralcel ODH (hexane/*i*-PrOH = 99.5/0.5, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 6.54 min, t_R (minor) = 7.27 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.64 – 7.56 (m, 5H), 7.48 – 7.38 (m, 6H), 7.37 – 7.24 (m, 6H), 7.20 – 7.13 (m, 1H), 4.03 (t, *J* = 7.6 Hz, 1H), 2.12 (q, *J* = 6.0 Hz, 2H), 1.42 – 1.28 (m, 2H), 0.95 (t, *J* = 7.4 Hz, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 146.3, 145.0, 141.8, 141.4, 128.7, 128.5, 127.9, 127.3, 126.1, 125.8, 124.1, 51.3, 38.0, 21.2, 14.1.
HRMS (ESI) *m/z* calcd. for $C_{26}H_{27}$ $[M + H]^+$ 363.2107, found 363.2105.

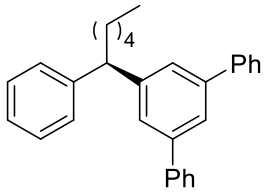
(*R*)-1,3-diphenyl-5-(1-phenylbutyl)benzene (18)



18

According to the **general procedure A**, substrate **1r** (63.9 mg, 0.30 mmol) and **2e** (90.4 mg, 0.20 mmol) was employed to yield the product **18** as a pale yellow oil (42.1 mg, 54% yield, 95% ee).
HPLC analysis: Chiralcel ODH (hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 4.68 min, t_R (minor) = 5.25 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.65 – 7.57 (m, 5H), 7.48 – 7.40 (m, 6H), 7.37 – 7.25 (m, 6H), 7.20 – 7.14 (m, 1H), 4.01 (t, *J* = 7.8 Hz, 1H), 2.14 (q, *J* = 7.2 Hz, 2H), 1.43 – 1.24 (m, 4H), 0.88 (t, *J* = 7.0 Hz, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 146.4, 145.1, 141.8, 141.4, 128.7, 128.5, 127.9, 127.3, 126.1, 125.8, 124.1, 51.6, 35.5, 30.3, 22.7, 14.0.
HRMS (ESI) *m/z* calcd. for $C_{29}H_{29}$ $[M + H]^+$ 377.2264, found 377.2266.

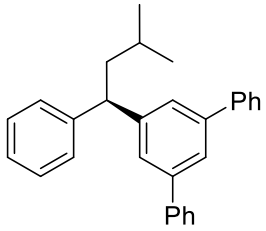
(*R*)-1,3-diphenyl-5-(1-phenylbutyl)benzene (19)



19

According to the **general procedure A**, substrate **1s** (72.4 mg, 0.30 mmol) and **2e** (90.4 mg, 0.20 mmol) was employed to yield the product **19** as a pale yellow oil (45.3 mg, 58% yield, 92% ee).
HPLC analysis: Chiralcel OD (hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 4.61 min, t_R (minor) = 5.53 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.64 – 7.57 (m, 5H), 7.48 – 7.39 (m, 6H), 7.37 – 7.25 (m, 6H), 7.20 – 7.14 (m, 1H), 4.01 (t, *J* = 7.6 Hz, 1H), 2.22 – 2.05 (m, 2H), 1.38 – 1.21 (m, 6H), 0.85 (t, *J* = 6.8 Hz, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 146.4, 145.1, 141.8, 141.4, 128.7, 128.5, 127.9, 127.3, 126.1, 125.8, 124.1, 51.6, 35.8, 31.9, 27.8, 22.5, 14.1.
HRMS (ESI) *m/z* calcd. for $C_{30}H_{31}$ $[M + H]^+$ 391.2420, found 391.2422.

(*R*)-1,3-diphenyl-5-(1-phenylisobutyl)benzene (20)



20

According to the **general procedure A**, substrate **1t** (68.1 mg, 0.30 mmol) and **2e** (90.4 mg, 0.20 mmol) was employed to yield the product **20** as a white solid (47.4 mg, 63% yield, 95% ee).

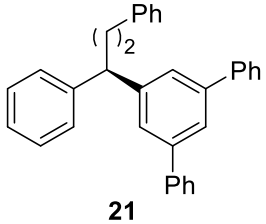
HPLC analysis: Chiralcel ODH (hexane/*i*-PrOH = 99.5/0.5, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 5.79 min, t_R (minor) = 6.44 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.63 – 7.56 (m, 5H), 7.48 – 7.39 (m, 6H), 7.37 – 7.25 (m, 6H), 7.20 – 7.13 (m, 1H), 4.15 (t, *J* = 7.8 Hz, 1H), 2.02 (t, *J* = 7.4 Hz, 2H), 1.60 – 1.47 (m, 1H), 0.95 (d, *J* = 6.8 Hz, 6H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 146.3, 145.0, 141.8, 141.4, 128.7, 128.5, 127.9, 127.3, 126.1, 125.8, 124.1, 49.1, 45.1, 25.6, 22.8, 22.6.

HRMS (ESI) *m/z* calcd. for $C_{29}H_{29}$ $[M + H]^+$ 377.2264, found 377.2262.

(*R*)-1,3-diphenyl-5-(1-phenyl(phenethyl))benzene (21)



21

According to the **general procedure A**, substrate **1u** (82.6 mg, 0.30 mmol) and **2e** (90.4 mg, 0.20 mmol) was employed to yield the product **21** as a pale yellow oil (59.8 mg, 70% yield, 92% ee).

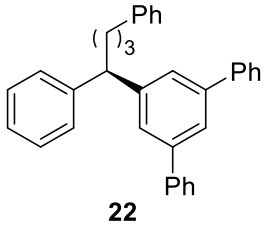
HPLC analysis: Chiralcel OD (hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 6.00 min, t_R (minor) = 6.83 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.65 – 7.56 (m, 5H), 7.48 – 7.39 (m, 6H), 7.37 – 7.23 (m, 8H), 7.22 – 7.12 (m, 4H), 4.05 (t, *J* = 7.6 Hz, 1H), 2.71 – 2.58 (m, 2H), 2.56 – 2.41 (m, 2H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 145.9, 144.5, 142.0, 141.9, 141.3, 128.7, 128.6, 128.5, 128.4, 127.9, 127.35, 127.30, 126.3, 125.9, 125.8, 124.2, 50.9, 37.3, 34.2.

HRMS (ESI) *m/z* calcd. for $C_{33}H_{29}$ $[M + H]^+$ 425.2264, found 425.2261.

(*R*)-1,3-diphenyl-5-(1-phenyl(phenethyl))benzene (22)

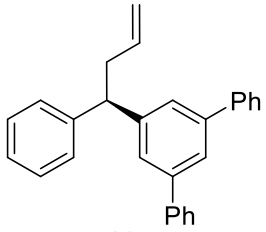


22

According to the **general procedure A**, substrate **1v** (86.8 mg, 0.30 mmol) and **2e** (90.4 mg, 0.20 mmol) was employed to yield the product **22** as a pale yellow oil (57.6 mg, 66% yield, 96% ee).

HPLC analysis: Chiralcel OD (hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 7.28 min, t_R (minor) = 11.62 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.63 – 7.54 (m, 5H), 7.46 – 7.38 (m, 6H), 7.37 – 7.30 (m, 2H), 7.30 – 7.19 (m, 6H), 7.19 – 7.09 (m, 4H), 4.03 (t, *J* = 7.8 Hz, 1H), 2.66 (t, *J* = 7.6 Hz, 2H), 2.26 – 2.08 (m, 2H), 1.67 (hep, *J* = 7.7 Hz, 2H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 146.0, 144.8, 142.2, 141.8, 141.3, 128.7, 128.49, 128.46, 128.4, 128.3, 127.8, 127.30, 126.2, 125.8, 125.7, 124.1, 51.5, 35.8, 35.2, 29.8.
HRMS (ESI) *m/z* calcd. for $C_{34}H_{31}$ $[M + H]^+$ 439.2420, found 439.2423.

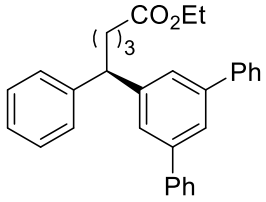
(*R*)-1,3-diphenyl-5-(1-phenylallyl)benzene (23)



23

According to the **general procedure A**, substrate **1w** (63.3 mg, 0.30 mmol) and **2e** (90.4 mg, 0.20 mmol) was employed to yield the product **23** as a white solid (22.1 mg, 31% yield, 94% ee).
HPLC analysis: Chiralcel OD (hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 5.49 min, t_R (minor) = 6.12 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.64 – 7.57 (m, 5H), 7.47 – 7.39 (m, 6H), 7.37 – 7.25 (m, 6H), 7.21 – 7.15 (m, 1H), 5.85 – 5.70 (m, 1H), 5.08 (d, *J* = 18 Hz, 1H), 4.99 (d, *J* = 10 Hz, 1H), 4.14 (t, *J* = 8.0 Hz, 1H), 2.92 (t, *J* = 8.0 Hz, 2H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 145.5, 144.3, 141.8, 141.3, 136.7, 128.7, 128.5, 127.9, 127.34, 127.29, 126.3, 125.9, 124.2, 116.5, 51.5, 40.0.
HRMS (ESI) *m/z* calcd. for $C_{26}H_{25}$ $[M + H]^+$ 361.1951, found 361.1948.

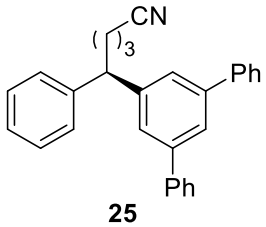
(*R*)-1,3-diphenyl-5-(1-phenyl(ethoxy-4-oxobutyl))benzene (24)



24

According to the **general procedure A**, substrate **1x** (85.6 mg, 0.30 mmol) and **2e** (90.4 mg, 0.20 mmol) was employed to yield the product **24** as a colorless oil (37.2 mg, 43% yield, 93% ee).
HPLC analysis: Chiralcel OD (hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min, λ = 254 nm), t_R (minor) = 8.08 min, t_R (major) = 8.93 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.65 – 7.56 (m, 5H), 7.47 – 7.39 (m, 6H), 7.37 – 7.25 (m, 6H), 7.22 – 7.14 (m, 1H), 4.10 (q, *J* = 7.2 Hz, 2H), 4.04 (t, *J* = 7.6 Hz, 1H), 2.34 (t, *J* = 7.4 Hz, 2H), 2.24 – 2.12 (m, 2H), 1.74 – 1.60 (m, 2H), 1.21 (t, *J* = 7.2 Hz, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 173.4, 145.8, 144.5, 141.9, 141.2, 128.7, 128.5, 127.8, 127.32, 127.28, 126.3, 125.7, 124.2, 60.2, 51.4, 35.1, 34.2, 23.5, 14.2.
HRMS (ESI) *m/z* calcd. for $C_{31}H_{31}O_2$ $[M + H]^+$ 435.2319, found 435.2305.

(*R*)-1,3-diphenyl-5-(1-phenylcyanopropyl)benzene (25)



25

According to the **general procedure A**, substrate **1y** (71.4 mg, 0.30 mmol) and **2e** (90.4 mg, 0.20 mmol) was employed to yield the product **25** as a pale yellow oil (37.8 mg, 49% yield, 89% ee).

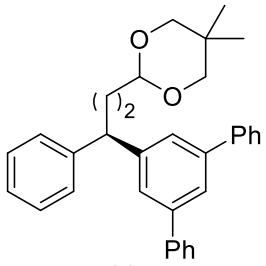
HPLC analysis: Chiralcel OD (hexane/*i*-PrOH = 80/20, flow rate 1.0 mL/min, λ = 254 nm), t_R (minor) = 17.01 min, t_R (major) = 18.98 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.65 – 7.56 (m, 5H), 7.48 – 7.40 (m, 6H), 7.39 – 7.29 (m, 6H), 7.22 – 7.16 (m, 1H), 4.03 (d, *J* = 7.8 Hz, 1H), 2.41 – 2.22 (m, 4H), 1.75 – 1.59 (m, 2H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 145.1, 143.7, 142.1, 141.1, 128.8, 128.7, 127.7, 127.4, 127.3, 126.6, 125.5, 124.5, 119.5, 50.9, 34.5, 24.0, 17.2.

HRMS (ESI) *m/z* calcd. for $C_{29}H_{26}N$ $[M + H]^+$ 388.2060, found 388.2059.

(*R*)-1,3-diphenyl-5-(1-phenyl(phenethyl))benzene (26)



26

According to the **general procedure A**, substrate **1z** (47.0 mg, 0.15 mmol) and **2e** (45.2 mg, 0.10 mmol) was employed to yield the product **26** as a colorless oil (17.2 mg, 37% yield, 93% ee).

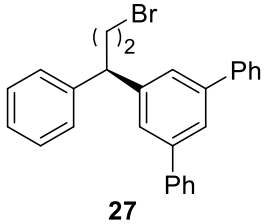
HPLC analysis: Chiralcel OD (hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 7.82 min, t_R (minor) = 10.47 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.64 – 7.56 (m, 5H), 7.48 – 7.39 (m, 6H), 7.37 – 7.25 (m, 6H), 7.20 – 7.13 (m, 1H), 4.43 (t, *J* = 5.0 Hz, 1H), 4.02 (t, *J* = 7.4 Hz, 1H), 3.58 (d, *J* = 11.2 Hz, 2H), 3.39 (d, *J* = 10.8 Hz, 2H), 2.34 – 2.23 (m, 2H), 1.74 – 1.63 (m, 2H), 1.17 (s, 3H), 0.70 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 145.9, 144.6, 141.8, 141.4, 128.7, 128.5, 127.9, 127.32, 127.28, 126.2, 125.9, 124.1, 102.0, 51.5, 33.5, 30.1, 29.8, 23.0, 21.8.

HRMS (ESI) *m/z* calcd. for $C_{33}H_{35}O_2$ $[M + H]^+$ 463.2632, found 463.2635.

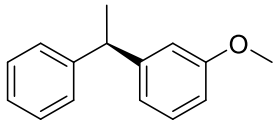
(*R*)-1,3-diphenyl-5-(1-phenylbromoethyl)benzene (27)



27

According to the **general procedure A**, substrate **1aa** (83.4 mg, 0.30 mmol) and **2e** (90.4 mg, 0.20 mmol) was employed to yield the product **27** as a white solid (39.4 mg, 46% yield, 92% ee).
HPLC analysis: Chiralcel OD (hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 8.78 min, t_R (minor) = 11.35 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.65 – 7.55 (m, 5H), 7.47 – 7.40 (m, 6H), 7.37 – 7.27 (m, 6H), 7.24 – 7.17 (m, 1H), 4.33 (t, *J* = 7.6 Hz, 1H), 3.37 (t, *J* = 6.6 Hz, 2H), 2.66 (q, *J* = 7.2 Hz, 2H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 144.5, 143.1, 142.1, 141.1, 128.8, 128.7, 127.9, 127.5, 127.3, 126.7, 125.7, 124.6, 49.3, 38.3, 32.0.
HRMS (ESI) *m/z* calcd. for $C_{27}H_{24}{}^{79}Br$ $[M + H]^+$ 427.1056, found 427.1058.

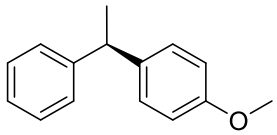
(*R*)-1-methoxy-3-(1-phenylethyl)benzene (28)



28

According to the **general procedure A**, substrate **1a** (55.5 mg, 0.30 mmol) and **2eb** (66.0 mg, 0.20 mmol) was employed to yield the product **28** as a pale yellow oil (26.4 mg, 62% yield, 94% ee).
HPLC analysis: Chiralcel OJ (hexane/*i*-PrOH = 90/10, flow rate 1.0 mL/min, λ = 230 nm), t_R (major) = 13.43 min, t_R (minor) = 14.61 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.31 – 7.14 (m, 6H), 6.85 – 6.79 (m, 1H), 6.79 – 6.76 (m, 1H), 6.74 – 6.68 (m, 1H), 4.15 (q, *J* = 7.2 Hz, 1H), 3.76 (s, 3H), 1.62 (d, *J* = 7.6 Hz, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 159.6, 148.0, 146.1, 129.3, 128.3, 127.5, 126.0, 120.1, 113.8, 110.9, 55.1, 44.8, 21.8.
HRMS (ESI) *m/z* calcd. for $C_{15}H_{17}O$ $[M + H]^+$ 213.1274, found 213.1274.

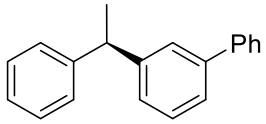
(*R*)-1-methoxy-4-(1-phenylethyl)benzene (29)



29

According to the **general procedure A**, substrate **1a** (55.5 mg, 0.30 mmol) and **2ec** (66.0 mg, 0.20 mmol) was employed to yield the product **29** as a pale yellow oil (23.2 mg, 55% yield, 94% ee).
HPLC analysis: Chiralcel OJH (hexane/*i*-PrOH = 90/10, flow rate 0.7 mL/min, λ = 214 nm), t_R (minor) = 16.86 min, t_R (major) = 17.72 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.31 – 7.24 (m, 2H), 7.22 – 7.09 (m, 5H), 6.82 (d, *J* = 8.8 Hz, 2H), 4.10 (q, *J* = 7.6 Hz, 1H), 3.76 (s, 3H), 1.61 (d, *J* = 7.2 Hz, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 157.8, 146.7, 138.5, 128.5, 128.3, 127.5, 125.9, 113.7, 55.2, 43.9, 22.0.
HRMS (ESI) *m/z* calcd. for $C_{15}H_{17}O$ $[M + H]^+$ 213.1274, found 213.1272.

(*R*)-1-phenyl-3-(1-phenylethyl)benzene (30)



30

According to the **general procedure A**, substrate **1a** (55.5 mg, 0.30 mmol) and **2ed** (75.2 mg, 0.20 mmol) was employed to yield the product **30** as a colorless oil (26.4 mg, 51% yield, 94% ee).

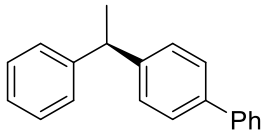
HPLC analysis: Chiralcel OD (hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 4.84 min, t_R (minor) = 5.37 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.55 (d, *J* = 8.0 Hz, 2H), 7.45 (s, 1H), 7.43 – 7.37 (m, 3H), 7.37 – 7.23 (m, 6H), 7.22 – 7.14 (m, 2H), 4.21 (q, *J* = 7.2 Hz, 1H), 1.68 (d, *J* = 7.2 Hz, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 146.8, 146.2, 141.4, 141.3, 128.8, 128.7, 128.4, 127.6, 127.20, 127.17, 126.58, 126.56, 126.1, 124.9, 44.9, 21.9

HRMS (ESI) *m/z* calcd. for $C_{20}H_{17}$ $[M-H]^+$ 257.1325, found 257.1324.

(*R*)-1-phenyl-4-(1-phenylethyl)benzene (31)



31

According to the **general procedure A**, substrate **1a** (55.5 mg, 0.30 mmol) and **2ee** (75.2 mg, 0.20 mmol) was employed to yield the product **31** as a white solid (29.6 mg, 57% yield, 94% ee).

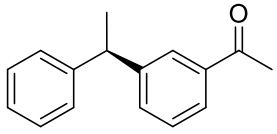
HPLC analysis: Chiralcel OD (hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min, λ = 254 nm), t_R (minor) = 5.32 min, t_R (major) = 6.09 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.56 (d, *J* = 6.8 Hz, 2H), 7.51 (d, *J* = 8.4 Hz, 2H), 7.40 (t, *J* = 4.6 Hz, 2H), 7.34 – 7.23 (m, 7H), 7.23 – 7.16 (m, 1H), 4.19 (q, *J* = 7.2 Hz, 1H), 1.67 (d, *J* = 7.2 Hz, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 146.2, 145.5, 141.0, 138.9, 128.7, 128.4, 128.0, 127.6, 127.1, 127.02, 126.99, 126.1, 44.4, 21.8.

HRMS (ESI) *m/z* calcd. for $C_{20}H_{19}$ $[M + H]^+$ 259.1481, found 259.1483.

(*R*)-1-phenyl-3-(1-phenylethyl)benzene (32)



32

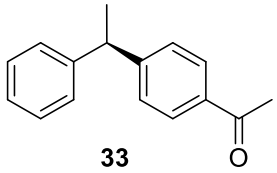
According to the **general procedure A**, substrate **1a** (55.5 mg, 0.30 mmol) and **2ef** (68.4 mg, 0.20 mmol) was employed to yield the product **32** as a colorless oil (22.4 mg, 50% yield, 93% ee).

HPLC analysis: Chiralcel AS (hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min, λ = 254 nm), t_R (minor) = 9.30 min, t_R (major) = 10.10 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86 (s, 1H), 7.77 (d, *J* = 8.0 Hz, 1H), 7.44 – 7.33 (m, 2H), 7.32 – 7.16 (m, 5H), 4.22 (q, *J* = 7.2 Hz, 1H), 2.57 (s, 3H), 1.67 (d, *J* = 7.2 Hz, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 198.3, 146.9, 145.6, 137.2, 132.5, 128.6, 128.5, 127.5, 127.2, 126.33, 126.26, 44.7, 26.7, 21.7.
HRMS (ESI) *m/z* calcd. for $C_{16}H_{17}O$ $[M + H]^+$ 225.1274, found 225.1266.

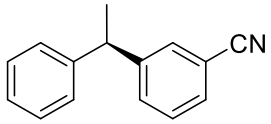
(*R*)-1-phenyl-4-(1-phenylethyl)benzene (33)



33

According to the **general procedure A**, substrate **1a** (55.5 mg, 0.30 mmol) and **2ea** (68.4 mg, 0.20 mmol) was employed to yield the product **33** as a pale yellow oil (27.2 mg, 61% yield, 93% ee).
HPLC analysis: Chiralcel IF (hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min, λ = 254 nm), t_R (minor) = 9.52 min, t_R (major) = 10.50 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.87 (d, *J* = 8.4 Hz, 2H), 7.34 – 7.25 (m, 4H), 7.23 – 7.15 (m, 3H), 4.19 (q, *J* = 7.2 Hz, 1H), 2.55 (s, 3H), 1.64 (d, *J* = 7.2 Hz, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 197.7, 151.9, 145.2, 135.1, 128.50, 128.45, 127.7, 127.5, 126.3, 44.7, 26.5, 21.5.
HRMS (ESI) *m/z* calcd. for $C_{16}H_{17}O$ $[M + H]^+$ 225.1274, found 225.1266.

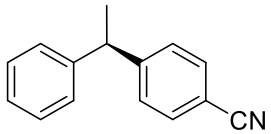
(*R*)-1-cyano-3-(1-phenylethyl)benzene (34)



34

According to the **general procedure A**, substrate **1a** (55.5 mg, 0.30 mmol) and **2eg** (65.0 mg, 0.20 mmol) was employed to yield the product **34** as a colorless oil (15.9 mg, 38% yield, 83% ee).
HPLC analysis: Chiralcel AS (hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min, λ = 230 nm), t_R (major) = 7.30 min, t_R (minor) = 7.80 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.50 (s, 1H), 7.46 (t, *J* = 8.0 Hz, 2H), 7.39 – 7.34 (m, 1H), 7.33 – 7.27 (m, 2H), 7.25 – 7.15 (m, 3H), 4.17 (9, *J* = 7.6 Hz, 1H), 1.64 (d, *J* = 7.2 Hz, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 147.8, 144.7, 132.2, 131.1, 129.8, 129.1, 128.6, 127.5, 126.6, 119.0, 112.3, 44.3, 21.5.
HRMS (ESI) *m/z* calcd. for $C_{15}H_{14}N$ $[M + H]^+$ 208.1121, found 208.1115.

(*R*)-1-cyano-4-(1-phenylethyl)benzene (35)

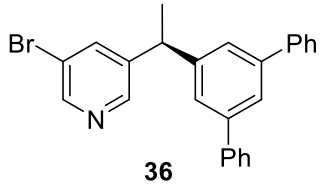


35

According to the **general procedure A**, substrate **1a** (55.5 mg, 0.30 mmol) and **2eh** (65.0 mg, 0.20 mmol) was employed to yield the product **35** as a white solid (23.4 mg, 56% yield, 85% ee).
HPLC analysis: Chiralcel ASH (hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 230 nm), t_R (major) = 14.18 min, t_R (minor) = 15.89 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.56 (d, *J* = 8.4 Hz, 2H), 7.34 – 7.27 (m, 4H), 7.24 – 7.14 (m, 3H), 4.19 (q, *J* = 7.2 Hz, 1H), 1.64 (d, *J* = 7.2 Hz, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 151.9, 144.6, 132.2, 128.6, 128.4, 127.5, 126.6, 119.0, 109.9, 44.8, 21.4.
HRMS (ESI) *m/z* calcd. for $C_{15}H_{14}N$ $[M + H]^+$ 208.1121, found 208.1114.

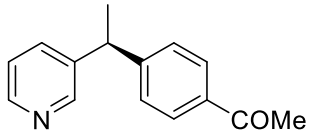
(*S*)-3-(1-([1,1':3',1''-terphenyl]-5'-yl)ethyl)-5-bromopyridine (36)



36

According to the **general procedure A**, substrate **1ab** (79.5 mg, 0.30 mmol) and **2e** (90.4 mg, 0.20 mmol) was employed to yield the product **36** as a pale yellow solid (44.3 mg, 53% yield, 71% ee).
HPLC analysis: Chiralcel ADH (hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min, λ = 254 nm), t_R (minor) = 8.54 min, t_R (major) = 9.31 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.52 (s, 2H), 7.69 (d, *J* = 12.0 Hz, 2H), 7.60 (d, *J* = 7.2 Hz, 4H), 7.49 – 7.32 (m, 8H), 4.27 (q, *J* = 6.8 Hz, 1H), 1.74 (d, *J* = 7.2 Hz, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 148.7, 147.5, 145.1, 143.2, 142.3, 140.9, 137.5, 128.8, 127.5, 127.3, 125.3, 124.8, 120.8, 42.3, 21.4.
HRMS (ESI) *m/z* calcd. for $C_{25}H_{21}N^{79}Br$ $[M + H]^+$ 414.0852, found 414.0841.

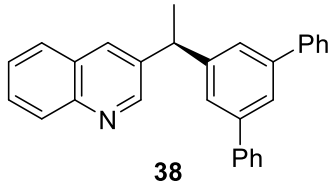
(*S*)-1-(4-(1-(pyridin-3-yl)ethyl)phenyl)ethan-1-one (37)



37

According to the **general procedure A**, substrate **1ac** (55.8 mg, 0.30 mmol) and **2e** (90.4 mg, 0.20 mmol) was employed to yield the product **37** as a pale yellow solid (17.2 mg, 38% yield, 90% ee).
HPLC analysis: Chiralcel AD (hexane/*i*-PrOH = 90/10, flow rate 1.0 mL/min, λ = 254 nm), t_R (minor) = 15.28 min, t_R (major) = 16.41 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.65 – 8.35 (m, 2H), 7.90 (d, *J* = 8.4 Hz, 2H), 7.55 – 7.44 (m, 1H), 7.31 (d, *J* = 8.4 Hz, 2H), 7.25 – 7.18 (m, 1H), 4.24 (q, *J* = 7.2 Hz, 1H), 2.58 (s, 3H), 1.69 (d, *J* = 7.2 Hz, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 197.6, 150.5, 149.3, 147.9, 140.6, 135.5, 134.8, 128.7, 127.7, 123.5, 42.4, 26.5, 21.2.
HRMS (ESI) *m/z* calcd. for $C_{15}H_{16}NO$ $[M + H]^+$ 226.1226, found 226.1227.

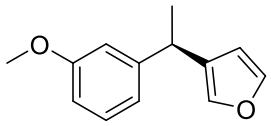
(*S*)-3-(1-([1,1':3',1''-terphenyl]-5'-yl)ethyl)quinolone (38)



38

According to the **general procedure A**, substrate **1ad** (70.8 mg, 0.30 mmol) and **2e** (90.4 mg, 0.20 mmol) was employed to yield the product **38** as a white solid (53.7 mg, 70% yield, 91% ee).
HPLC analysis: Chiralcel ADH (hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min, λ = 254 nm), t_R (minor) = 14.61 min, t_R (major) = 16.84 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.89 (d, *J* = 2.4 Hz, 1H), 8.08 (d, *J* = 8.4 Hz, 1H), 8.01 (d, *J* = 2.0 Hz, 1H), 7.77 (dd, J_1 = 8.4 Hz, J_2 = 1.4 Hz, 1H), 7.70 – 7.55 (m, 6H), 7.53 – 7.38 (m, 7H), 7.37 – 7.31 (m, 2H), 4.49 (q, *J* = 7.2 Hz, 1H), 1.85 (d, *J* = 7.2 Hz, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 151.7, 146.8, 145.9, 142.2, 141.0, 138.6, 133.1, 129.1, 128.9, 128.7, 128.0, 127.6, 127.5, 127.3, 126.7, 125.5, 124.6, 42.8, 21.7.
HRMS (ESI) *m/z* calcd. for $C_{29}H_{24}N$ $[M + H]^+$ 386.1903, found 386.1892.

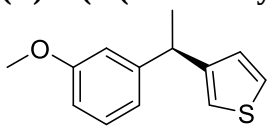
(*R*)-3-(1-(3-methoxyphenyl)ethyl)furan (39)



39

According to the **general procedure A**, substrate **1d** (43.0 mg, 0.20 mmol) and **2ei** (58.0 mg, 0.20 mmol) was employed to yield the product **39** as a pale yellow oil (29.2 mg, 72% yield, 93% ee).
HPLC analysis: Chiralcel IF (hexane/*i*-PrOH = 98/2, flow rate 0.6 mL/min, λ = 214 nm), t_R (minor) = 6.87 min, t_R (major) = 7.31 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.36 – 7.31 (m, 1H), 7.26 – 7.17 (m, 2H), 6.82 (d, *J* = 7.6 Hz, 1H), 6.79 – 6.71 (m, 2H), 6.21 (s, 1H), 3.93 (q, *J* = 7.2 Hz, 1H), 3.78 (s, 3H), 1.54 (d, *J* = 6.8 Hz, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 159.6, 147.7, 142.9, 138.7, 130.1, 129.3, 119.7, 113.3, 111.2, 110.4, 55.1, 36.4, 21.9.
HRMS (ESI) *m/z* calcd. for $C_{13}H_{15}O_2$ $[M + H]^+$ 203.1067, found 203.1067.

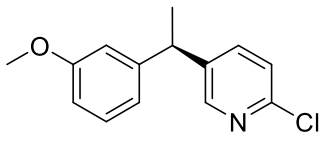
(*R*)-3-(1-(3-methoxyphenyl)ethyl)thiophene (40)



40

According to the **general procedure A**, substrate **1d** (43.0 mg, 0.20 mmol) and **2ej** (61.2 mg, 0.20 mmol) was employed to yield the product **40** as a pale yellow oil (26.1 mg, 60% yield, 94% ee).
HPLC analysis: Chiralcel OD (hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min, λ = 254 nm), t_R (minor) = 6.52 min, t_R (major) = 7.37 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.25 – 7.17 (m, 2H), 6.99 – 6.95 (m, 1H), 6.88 (dd, J_1= 4.8 Hz, J_2= 1.2 Hz, 1H), 6.80 (d, *J* = 7.6 Hz, 1H), 6.77 – 6.70 (m, 2H), 4.12 (q, *J* = 7.2 Hz, 1H), 3.77 (s, 3H), 1.62 (d, *J* = 7.2 Hz, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 159.6, 147.9, 147.0, 129.3, 127.8, 125.3, 119.9, 119.8, 113.5, 111.1, 55.1, 40.8, 22.1.
HRMS (ESI) *m/z* calcd. for $C_{13}H_{15}OS$ $[M + H]^+$ 219.0838, found 219.0832.

(*R*)-2-chloro-5-(1-(3-methoxyphenyl)ethyl)pyridine (41)



41

According to the **general procedure A**, substrate **1d** (64.5 mg, 0.30 mmol) and **2ek** (67.0 mg, 0.20 mmol) was employed to yield the product **41** as a pale yellow oil (29.8 mg, 60% yield, 84% ee).

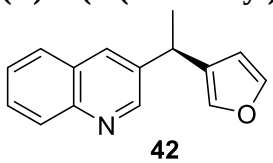
HPLC analysis: Chiralcel OD (hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 10.14 min, t_R (minor) = 11.39 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.29 (d, *J* = 2.8 Hz, 1H), 7.44 (dd, J_1= 8.4 Hz, J_2= 2.8 Hz, 1H), 7.28 – 7.16 (m, 2H), 6.82 – 6.67 (m, 3H), 4.12 (q, *J* = 7.2 Hz, 1H), 3.77 (s, 3H), 1.63 (d, *J* = 7.2 Hz, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 159.8, 149.1, 148.8, 146.0, 140.4, 137.9, 129.6, 123.9, 119.7, 113.6, 111.4, 55.1, 41.7, 21.3.

HRMS (ESI) *m/z* calcd. for $C_{14}H_{15}ClNO$ $[M + H]^+$ 248.0837, found 248.0834.

(*R*)-3-(1-(furan-3-yl)ethyl)quinoline (42)



42

According to the **general procedure A**, substrate **1ad** (70.8 mg, 0.30 mmol) and **2ei** (68.4 mg, 0.20 mmol) was employed to yield the product **42** as a pale yellow oil (25.1 mg, 56% yield, 75% ee).

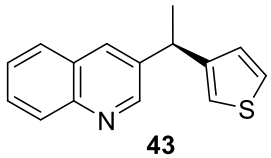
HPLC analysis: Chiralcel AD (hexane/*i*-PrOH = 80/20, flow rate 1.0 mL/min, λ = 230 nm), t_R (minor) = 6.32 min, t_R (major) = 7.55 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.83 (d, *J* = 2.4 Hz, 1H), 8.08 (d, *J* = 8.4 Hz, 1H), 7.92 (d, *J* = 2.0 Hz, 1H), 7.77 (d, *J* = 8.0 Hz, 1H), 7.70 – 7.63 (m, 1H), 7.56 – 7.48 (m, 1H), 7.33 (d, *J* = 2.0 Hz, 1H), 6.37 – 6.28 (m, 1H), 6.13 (d, *J* = 3.2 Hz, 1H), 4.35 (q, *J* = 7.2 Hz, 1H), 1.72 (d, *J* = 7.2 Hz, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 157.5, 151.0, 147.1, 141.7, 136.7, 133.3, 129.1, 128.9, 128.0, 127.6, 126.6, 110.1, 105.5, 37.0, 20.1.

HRMS (ESI) *m/z* calcd. for $C_{15}H_{14}NO$ $[M + H]^+$ 224.1070, found 224.1063.

(*R*)-3-(1-(thiophen-3-yl)ethyl)quinoline (43)



43

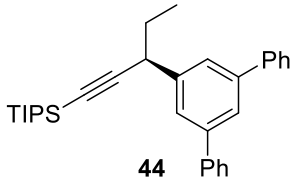
According to the **general procedure A**, substrate **1ad** (70.8 mg, 0.30 mmol) and **2ej** (61.2 mg, 0.20 mmol) was employed to yield the product **43** as a pale yellow oil (26.0 mg, 54% yield, 82% ee).

HPLC analysis: Chiralcel AD (hexane/*i*-PrOH = 80/20, flow rate 1.0 mL/min, λ = 254 nm), t_R (minor) = 6.67 min, t_R (major) = 8.60 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.81 (d, *J* = 2.4 Hz, 1H), 8.08 (d, *J* = 8.4 Hz, 1H), 7.89 (d, *J* = 2.4 Hz, 1H), 7.75 (d, *J* = 8.0 Hz, 1H), 7.70 – 7.62 (m, 1H), 7.51 (t, *J* = 8.4 Hz, 1H), 7.31 – 7.23 (m, 1H), 7.07 – 7.00 (m, 1H), 6.96 – 6.86 (m, 1H), 4.38 (q, *J* = 7.2 Hz, 1H), 1.75 (d, *J* = 7.2 Hz, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 151.4, 146.9, 145.7, 138.8, 133.0, 129.1, 128.8, 128.1, 127.5, 127.5, 126.6, 126.0, 120.5, 38.4, 22.0.
HRMS (ESI) *m/z* calcd. for $C_{15}H_{14}NS$ $[M + H]^+$ 240.0841, found 240.0833.

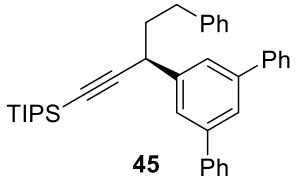
(*S*)-(3-([1,1':3',1''-terphenyl]-5'-yl)pent-1-yn-1-yl)triisopropylsilane (44)



44

According to the **general procedure B**, substrate **1b** (90.9 mg, 0.30 mmol) and **2e** (90.4 mg, 0.20 mmol) was employed to yield the product **44** as a pale yellow oil (59.2 mg, 65% yield, 94% ee).
HPLC analysis: Chiralcel ADH (hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 254 nm), t_R (minor) = 3.32 min, t_R (major) = 3.56 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.77 – 7.68 (m, 7H), 7.52 (d, J = 7.2 Hz, 4H), 7.47 – 7.40 (m, 2H), 3.88 (dd, J_1 = 8.0 Hz, J_2 = 5.4 Hz, 1H), 2.05 – 1.82 (m, 2H), 1.19 (s, 21H), 1.16 (t, J = 7.6 Hz, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 143.0, 141.8, 141.2, 128.7, 127.4, 127.3, 125.5, 124.4, 109.6, 83.9, 40.6, 32.2, 18.7, 11.7, 11.4.
HRMS (ESI) *m/z* calcd. for $C_{32}H_{41}Si$ $[M + H]^+$ 453.2972, found 453.2959.

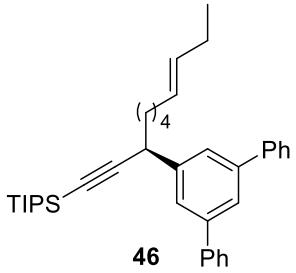
(*S*)-(3-([1,1':3',1''-terphenyl]-5'-yl)-5-phenylpent-1-yn-1-yl)triisopropylsilane (45)



45

According to the **general procedure B**, substrate **1ae** (113.9 mg, 0.30 mmol) and **2e** (90.4 mg, 0.20 mmol) was employed to yield the product **45** as a pale yellow oil (76.1 mg, 72% yield, 94% ee).
HPLC analysis: Chiralcel ADH (hexane/*i*-PrOH = 99/1, flow rate 0.6 mL/min, λ = 254 nm), t_R (minor) = 5.82 min, t_R (major) = 6.16 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.70 – 7.60 (m, 7H), 7.44 (t, J = 7.6 Hz, 4H), 7.39 – 7.32 (m, 2H), 7.31 – 7.25 (m, 2H), 7.23 – 7.15 (m, 3H), 3.85 (dd, J_1 = 8.8 Hz, J_2 = 5.6 Hz, 1H), 2.99 – 2.81 (m, 2H), 2.21 – 2.05 (m, 2H), 1.15 (s, 21H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 142.8, 141.9, 141.7, 141.1, 128.7, 128.5, 128.4, 127.4, 127.3, 125.9, 125.4, 124.5, 109.3, 84.6, 40.9, 38.5, 33.7, 18.8, 11.4.
HRMS (ESI) *m/z* calcd. for $C_{38}H_{45}Si$ $[M + H]^+$ 529.3285, found 529.3272.

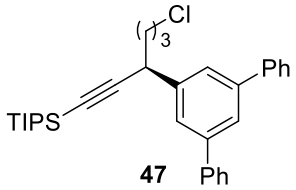
(*S*,*E*)-(3-([1,1':3',1''-terphenyl]-5'-yl)undec-8-en-1-yn-1-yl)triisopropylsilane (46)



46

According to the **general procedure B**, substrate **1af** (115.3 mg, 0.30 mmol) and **2e** (90.4 mg, 0.20 mmol) was employed to yield the product **46** as a pale yellow oil (75.4 mg, 70% yield, 93% ee).
HPLC analysis: Chiralcel ADH (hexane/*i*-PrOH = 100/0, flow rate 1.0 mL/min, λ = 254 nm), t_R (minor) = 4.63 min, t_R (major) = 5.11 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.69 – 7.60 (m, 7H), 7.45 (d, J = 8.4 Hz, 4H), 7.39 – 7.33 (m, 2H), 5.40 – 5.26 (m, 2H), 3.84 (dd, J_1 = 8.4 Hz, J_2 = 5.8 Hz, 1H), 2.08 – 1.96 (m, 4H), 1.88 – 1.75 (m, 2H), 1.65 – 1.57 (m, 1H), 1.49 – 1.28 (m, 3H), 1.17 – 1.04 (m, 21H), 0.93 (t, J = 7.6 Hz, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 143.3, 141.8, 141.2, 131.8, 129.0, 128.7, 127.4, 127.3, 125.4, 124.4, 109.8, 83.8, 39.2, 39.0, 29.4, 27.04, 27.00, 20.5, 18.7, 14.4, 11.3.
HRMS (ESI) *m/z* calcd. for $C_{38}H_{51}Si$ $[M + H]^+$ 535.3755, found 535.3761.

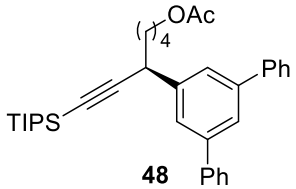
(S)-(3-([1,1':3',1''-terphenyl]-5'-yl)-6-chlorohex-1-yn-1-yl)triisopropylsilane (47)



47

According to the **general procedure B**, substrate **1ag** (100.8 mg, 0.30 mmol) and **2e** (90.4 mg, 0.20 mmol) was employed to yield the product **47** as a pale yellow oil (45.8 mg, 46% yield, 84% ee).
HPLC analysis: Chiralcel ADH (hexane/*i*-PrOH = 100/0, flow rate 1.0 mL/min, λ = 254 nm), t_R (minor) = 6.91 min, t_R (major) = 8.04 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.70 – 7.59 (m, 7H), 7.49 – 7.41 (m, 4H), 7.40 – 7.32 (m, 2H), 3.96 – 3.85 (m, 1H), 3.64 – 3.52 (m, 2H), 2.13 – 1.96 (m, 3H), 1.96 – 1.87 (m, 1H), 1.19 – 1.05 (m, 21H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 142.4, 142.0, 141.0, 128.8, 127.4, 127.3 125.3, 124.6, 108.8, 84.7, 44.7, 38.2, 36.1, 30.2, 18.7, 11.3.
HRMS (ESI) *m/z* calcd. for $C_{33}H_{42}ClSi$ $[M + H]^+$ 501.2739, found 501.2735.

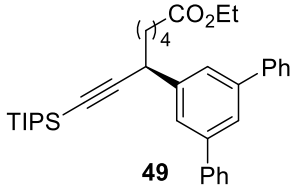
(S)-5-([1,1':3',1''-terphenyl]-5'-yl)-7-(triisopropylsilyl)hept-6-yn-1-yl acetate (48)



48

According to the **general procedure B**, substrate **1ah** (116.4 mg, 0.30 mmol) and **2e** (90.4 mg, 0.20 mmol) was employed to yield the product **48** as a pale yellow oil (55.6 mg, 52% yield, 84% ee).
HPLC analysis: Chiralcel AD (hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min, λ = 254 nm), t_R (minor) = 4.09 min, t_R (major) = 4.37 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.71 – 7.60 (m, 7H), 7.45 (d, J = 7.2 Hz, 4H), 7.40 – 7.33 (m, 2H), 4.10 – 4.01 (m, 2H), 3.88 (dd, J_1 = 8.4 Hz, J_2 = 5.6 Hz, 1H), 2.01 (s, 3H), 1.92 – 1.61 (m, 6H), 1.11 (s, 21H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 171.2, 142.9, 141.9, 141.1, 128.7, 127.4, 127.3, 125.4, 124.5, 109.4, 84.1, 64.4, 38.9, 38.7, 28.3, 23.8, 20.9, 18.7, 11.3.
HRMS (ESI) *m/z* calcd. for $C_{36}H_{47}O_2Si$ $[M + H]^+$ 539.3340, found 539.3347.

ethyl (S)-6-([1,1':3',1''-terphenyl]-5'-yl)-8-(triisopropylsilyl)oct-7-ynoate (49)



49

According to the **general procedure B**, substrate **1ai** (120.7 mg, 0.30 mmol) and **2e** (90.4 mg, 0.20 mmol) was employed to yield the product **49** as a pale yellow oil (50.7 mg, 46% yield, 90% ee).

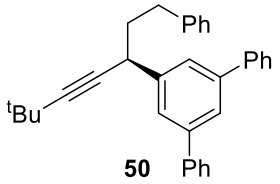
HPLC analysis: Chiralcel IG (hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min, λ = 254 nm), t_R (minor) = 4.24 min, t_R (major) = 4.79 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.71 – 7.58 (m, 7H), 7.50 – 7.40 (m, 4H), 7.39 – 7.31 (m, 2H), 4.09 (q, *J* = 7.2 Hz, 2H), 3.91 – 3.79 (m, 1H), 2.29 (t, *J* = 7.2 Hz, 2H), 1.93 – 1.76 (m, 2H), 1.74 – 1.52 (m, 4H), 1.21 (t, *J* = 7.2 Hz, 3H), 1.11 (s, 21H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 173.6, 143.0, 141.8, 141.1, 128.8, 127.4, 127.2, 125.4, 124.4, 109.5, 84.0, 60.2, 38.9, 38.7, 34.2, 26.9, 24.6, 18.7, 14.2, 11.3.

HRMS (ESI) *m/z* calcd. for $C_{37}H_{49}O_2Si$ $[M + H]^+$ 553.3496, found 553.3502.

(*S*)-5'-(6,6-dimethyl-1-phenylhept-4-yn-3-yl)-1,1':3',1''-terphenyl (50)



50

According to the **general procedure B**, substrate **1aj** (83.7 mg, 0.30 mmol) and **2e** (90.4 mg, 0.20 mmol) was employed to yield the product **50** as a pale yellow oil (64.9 mg, 76% yield, 86% ee).

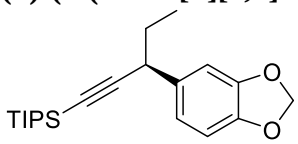
HPLC analysis: Chiralcel ADH (hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 254 nm), t_R (minor) = 4.15 min, t_R (major) = 4.65 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.69 – 7.61 (m, 5H), 7.58 (s, 2H), 7.45 (t, *J* = 7.6 Hz, 4H), 7.40 – 7.33 (m, 2H), 7.31 – 7.25 (m, 2H), 7.24 – 7.15 (m, 3H), 3.73 (dd, J_1 = 8.8 Hz, J_2 = 6.0 Hz, 1H), 2.92 – 2.72 (m, 2H), 2.16 – 1.98 (m, 2H), 1.32 (s, 9H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 143.8, 141.9, 141.8, 141.3, 128.8, 128.5, 128.3, 127.3, 127.2, 125.8, 125.4, 124.4, 93.1, 79.5, 40.8, 37.3, 33.7, 31.4, 27.6.

HRMS (ESI) *m/z* calcd. for $C_{33}H_{33}$ $[M + H]^+$ 429.2577, found 429.2572.

(S)-(3-(benzo[d][1,3]dioxol-5-yl)pent-1-yn-1-yl)triisopropylsilane (51)



51

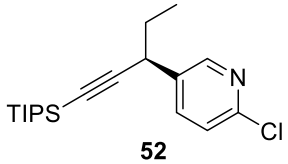
According to the **general procedure B**, substrate **1b** (90.9 mg, 0.30 mmol) and **2el** (68.8 mg, 0.20 mmol) was employed to yield the product **51** as a pale yellow oil (30.9 mg, 45% yield, 80% ee).

HPLC analysis: Chiralcel ODH (hexane/*i*-PrOH = 100/0, flow rate 1.0 mL/min, λ = 254 nm), t_R (minor) = 5.75 min, t_R (major) = 6.10 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 6.89 (d, *J* = 1.6 Hz, 1H), 6.82 (dd, J_1 = 8.0 Hz, J_2 = 2.0 Hz, 1H), 6.74 (d, *J* = 8.0 Hz, 1H), 5.93 (dd, J_1 = 4.0 Hz, J_2 = 1.6 Hz, 2H), 3.57 (dd, J_1

= 8.0 Hz, J_2 = 5.6 Hz, 1H), 1.84–1.62 (m, 2H), 1.13 – 1.06 (m, 21H), 1.00 (t, J = 7.2 Hz, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 147.5, 146.1, 136.0, 120.5, 109.9, 108.1, 107.9, 100.9, 83.3, 40.1, 32.2, 18.7, 11.6, 11.3.
HRMS (ESI) *m/z* calcd. for $C_{21}H_{33}O_2Si$ $[M + H]^+$ 345.2244, found 345.2244.

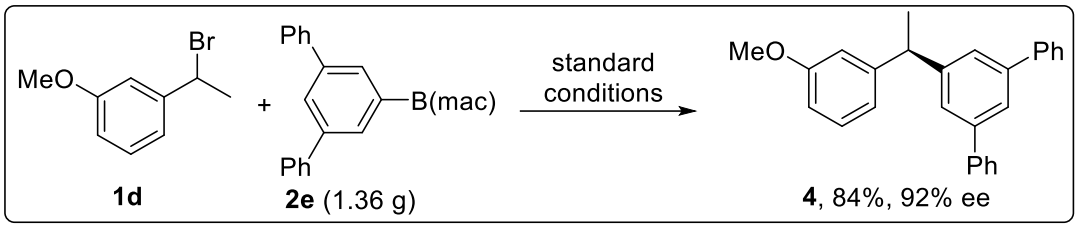
(S)-2-chloro-5-(1-(triisopropylsilyl)pent-1-yn-3-yl)pyridine (52)



52

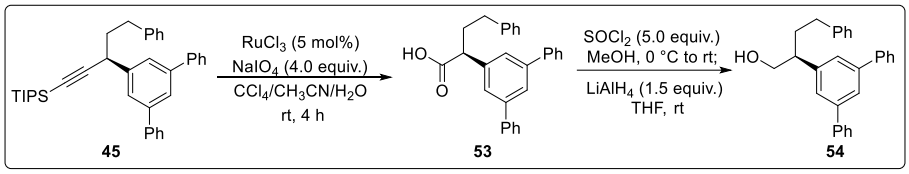
According to the **general procedure B**, substrate **1b** (90.9 mg, 0.30 mmol) and **2ek** (67.0 mg, 0.20 mmol) was employed to yield the product **52** as a pale yellow oil (23.9 mg, 36% yield, 90% ee).
HPLC analysis: Chiralcel IG (hexane/*i*-PrOH = 99/1, flow rate 0.3 mL/min, λ = 254 nm), t_R (minor) = 14.43 min, t_R (major) = 15.06 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.40 (d, J = 3.6 Hz, 1H), 7.67 (dd, J_1 = 8.4 Hz, J_2 = 2.8 Hz, 1H), 7.29 (d, J = 8.4 Hz, 1H), 3.68 (dd, J_1 = 8.4 Hz, J_2 = 5.6 Hz, 1H), 1.86 – 1.68 (m, 2H), 1.08 (s, 21H), 1.03 (t, J = 7.2 Hz, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 149.7, 148.9, 137.9, 136.4, 123.9, 107.6, 84.8, 37.2, 31.6, 18.6, 11.3, 11.2.
HRMS (ESI) *m/z* calcd. for $C_{19}H_{31}ClNSi$ $[M + H]^+$ 336.1909, found 336.1912.

The large-scale synthesis of 4



According to the **General procedure A**: under argon atmosphere, an oven-dried round bottom flask equipped with a magnetic stir bar was charged with **2e** (1.36 g, 3.0 mmol, 1.0 equiv.), CuI (57.0 mg, 0.30 mmol, 10 mol%), **L4** (240 mg, 0.36 mmol, 12 mol%), LiO^tBu (960 mg, 12 mmol, 4.0 equiv.). Then DMSO/CH_2Cl_2 (2:1, 36 mL) and H_2O (108 μL, 6.0 mmol, 2.0 equiv.) was added. The reaction mixture was stirred for several minutes to dissolve the reactants. Lastly, alkyl halide **1d** (0.97 g, 4.5 mmol, 1.5 equiv.) was slowly added into the mixture *via* microsyringe, and the reaction mixture was stirred for 72 h at –5 °C. Upon completion (monitored by TLC), the reaction mixture was poured into water (50 mL), then extracted with DCM (3 × 20 mL). The filtrate was dried with anhydride Na_2SO_4, then was purified by column chromatography on silica gel to afford the desired products **4** (0.92 g, 84% yield, 92% ee).

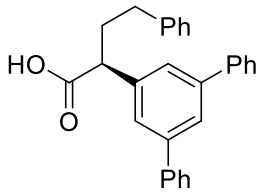
The transformations



To a mixture of $RuCl_3$ (0.75 mg, 0.005 mmol, 5.0 mol%) and sodium periodate (85.5 mg, 0.40 mmol, 4.0 equiv.) in a mixed solvent of CCl_4 (0.2 mL) and water (0.3 mL) was added a solution of **45** (52.9 mg, 0.10 mmol, 1.0 equiv., 94% ee) in CH_3CN (0.2 mL) in one portion. The reaction mixture was stirred at room temperature for 4 h, and then, was concentrated. The residue was purified by column chromatography on silica gel to afford the product **53** as a white solid (34.9 mg, 89% yield).

To a solution of **53** (39.2 mg, 0.10 mmol, 1.0 equiv.) in MeOH (1.0 mL) was added $SOCl_2$ (59.5 mg, 0.5 mmol, 5.0 equiv.) dropwise at 0 °C. Then, the reaction mixture was warmed up to room temperature and stirred for another 3 h. After completion of reaction, the reaction mixture was concentrated and the residue was purified by column chromatography on silica gel (petroleum ether/EtOAc = 20:1) to afford the product in quantitative yield. Then the obtained product was dissolved in anhydrous THF (1.0 mL), followed by the addition of $LiAlH_4$ (5.7 mg, 0.15 mmol, 1.5 equiv.) powder slowly at 0 °C. Then it was stirred at room temperature for 3 h. Upon completion (monitored by TLC), the reaction was quenched with wet Na_2SO_4 (0.2 mL water per gram) and filtered, and the solid was washed with THF. The organic phase was concentered and purified with by column chromatography on silica gel to afford the product **54** as a colorless oil (35.2 mg, 93% yield, 94% ee).

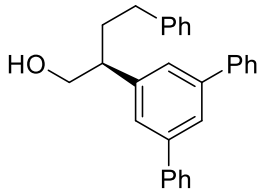
(S)-2-([1,1':3',1''-terphenyl]-5'-yl)-4-phenylbutanoic acid (53)



53

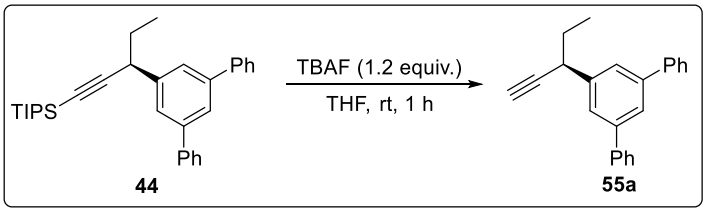
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.72 (t, *J* = 1.6 Hz, 1H), 7.67 – 7.59 (m, 4H), 7.52 (d, *J* = 1.6 Hz, 2H), 7.49 – 7.41 (m, 4H), 7.40 – 7.33 (m, 2H), 7.30 – 7.25 (m, 2H), 7.21 – 7.13 (m, 3H), 3.71 (t, *J* = 7.6 Hz, 1H), 2.67 (t, *J* = 8.0 Hz, 2H), 2.58 – 2.47 (m, 1H), 2.28 – 2.17 (m, 1H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 179.1, 142.3, 141.0, 140.8, 139.2, 128.8, 128.5, 128.4, 127.5, 127.3, 126.1, 125.9, 125.5, 50.8, 34.5, 33.6.
HRMS (ESI) *m/z* calcd. for $C_{28}H_{25}O_2$ $[M + H]^+$ 393.1849, found 393.1846.

(S)-2-([1,1':3',1''-terphenyl]-5'-yl)-4-phenylbutan-1-ol (54)



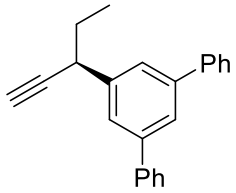
54

HPLC analysis: Chiralcel OD (hexane/*i*-PrOH = 80/20, flow rate 1.0 mL/min, λ = 254 nm), t_R (minor) = 9.52 min, t_R (major) = 11.46 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.72 – 7.69 (m, 1H), 7.67 – 7.61 (m, 4H), 7.49 – 7.43 (m, 4H), 7.20 (d, *J* = 1.6 Hz, 2H), 7.40 – 7.34 (m, 2H), 7.29 – 7.22 (m, 2H), 7.20 – 7.11 (m, 3H), 3.83 (d, *J* = 6.4 Hz, 2H), 2.99 – 2.88 (m, 1H), 2.70 – 2.51 (m, 2H), 2.20 – 1.96 (m, 2H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 143.1, 142.2, 141.9, 141.1, 128.8, 128.4, 128.3, 127.5, 127.3, 126.0, 125.8, 124.8, 67.5, 48.3, 33.6, 33.5.
HRMS (ESI) *m/z* calcd. for $C_{28}H_{27}O$ $[M + H]^+$ 379.2056, found 379.2047.



To a solution of **44** (45.2 mg, 0.10 mmol, 1.0 equiv., 94% ee) in THF (1.0 mL) was added TBAF (0.24 mmol, 1.2 equiv.) and the resulting mixture was stirred at room temperature for 1 h. After completion of the reaction (monitored by TLC), the mixture was concentrated under reduced pressure and purified by column chromatography to yield **55a** as a colorless oil (26.3 mg, 89% yield, 94% ee).

(R)-5'-(pent-1-yn-3-yl)-1,1':3',1''-terphenyl (55a)



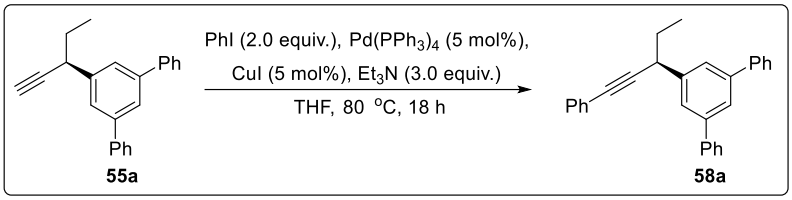
55a

HPLC analysis: Chiralcel OJH (hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 254 nm), t_R (minor) = 19.58 min, t_R (major) = 24.14 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.70 – 7.62 (m, 5H), 7.57 (d, *J* = 1.6 Hz, 2H), 7.50 – 7.42 (m, 4H), 7.40 – 7.33 (m, 2H), 3.75 – 3.66 (m, 1H), 2.32 (d, *J* = 2.4 Hz, 1H), 1.97 – 1.83 (m, 2H), 1.07 (t, *J* = 7.2 Hz, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 142.4, 142.0, 141.1, 128.8, 127.4, 127.3, 125.4, 124.7, 85.7, 71.3, 39.3, 31.4, 11.8.

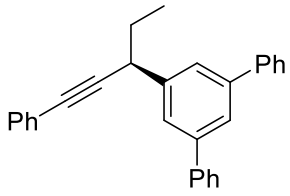
HRMS (ESI) *m/z* calcd. for $C_{23}H_{21}$ $[M + H]^+$ 297.1638, found 297.1637.



55a **58a**

Under argon atmosphere, an oven-dried resealable Schlenk tube equipped with a magnetic stir bar was charged with CuI (0.95 mg, 0.005 mmol, 5 mol%), $Pd(PPh_3)_4$ (5.8 mg, 0.005 mmol, 5 mol%). Then THF was added，followed by PhI (0.20 mmol, 2.0 equiv.), alkyne **55a** (29.6 mg, 0.10 mmol, 1.0 equiv., 94% ee) and Et_3N (0.30 mmol, 3.0 equiv.). The reaction mixture was stirred at 80 °C for 18 h. Upon completion (monitored by TLC), the reaction mixture was purified by column chromatography on silica gel to afford the desired products **58a** (23.7 mg, 64% yield, 94% ee).

(S)-5'-(1-phenylpent-1-yn-3-yl)-1,1':3',1''-terphenyl (58a)



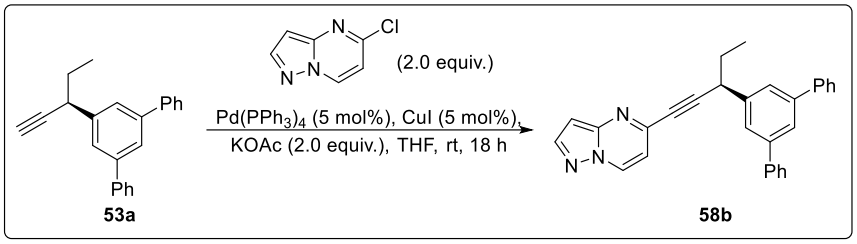
58a

HPLC analysis: Chiralcel OD-3 (hexane/*i*-PrOH = 99/1, flow rate 0.5 mL/min, λ = 254 nm), t_R (minor) = 10.74 min, t_R (major) = 14.27 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.72 – 7.61 (m, 7H), 7.50 – 7.42 (m, 6H), 7.40 – 7.34 (m, 2H), 7.33 – 7.27 (m, 3H), 3.92 (t, *J* = 7.2 Hz, 1H), 2.04 – 1.88 (m, 2H), 1.13 (t, *J* = 7.2 Hz, 3H).

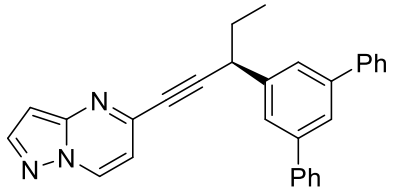
^{13}C NMR (100 MHz, $CDCl_3$) δ 143.1, 142.0, 141.2, 131.7, 128.8, 128.2, 127.8, 127.4, 127.3, 125.5, 124.7, 123.8, 91.3, 83.6, 40.2, 31.8, 12.0.

HRMS (ESI) *m/z* calcd. for $C_{29}H_{25}$ $[M + H]^+$ 373.1951, found 373.1949.



Under argon atmosphere, an oven-dried resealable Schlenk tube equipped with a magnetic stir bar was charged with CuI (0.95 mg, 0.005 mmol, 5 mol%), $Pd(PPh_3)_4$ (5.8 mg, 0.005 mmol, 5 mol%) and KOAc (0.20 mmol, 2.0 equiv.). Then THF was added， followed by 5-chloropyrazolo[1,5-a]pyrimidine (0.20 mmol, 2.0 equiv.), alkyne **55a** (29.6 mg, 0.10 mmol, 1.0 equiv., 94% ee). The reaction mixture was stirred at room temperature for 18 h. Upon completion (monitored by TLC), the reaction mixture was purified by column chromatography on silica gel to afford the desired products **58b** (30.8 mg, 75% yield, 93% ee).

(S)-5-(3-([1,1':3',1''-terphenyl]-5'-yl)pent-1-yn-1-yl)pyrazolo[1,5-a]pyrimidine (58b)



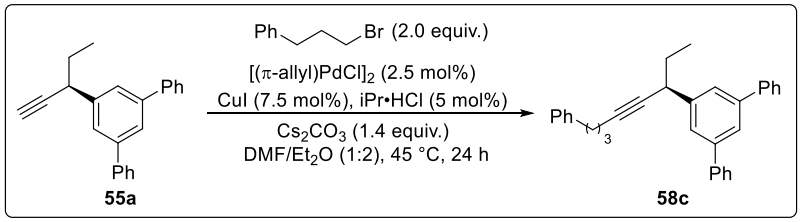
58b

HPLC analysis: Chiralcel OD-3 (hexane/*i*-PrOH = 85/15, flow rate 0.8 mL/min, λ = 254 nm), t_R (minor) = 14.09 min, t_R (major) = 17.83 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.60 (dd, J_1 = 7.2 Hz, J_2 = 1.2 Hz, 1H), 8.12 (d, J = 2.4 Hz, 1H), 7.73 – 7.70 (m, 1H), 7.68 – 7.63 (m, 4H), 7.60 (d, J = 1.6 Hz, 2H), 7.50 – 7.43 (m, 4H), 7.41 – 7.34 (m, 2H), 6.87 (d, J = 7.2 Hz, 1H), 6.68 (d, J = 1.2 Hz, 1H), 3.98 (t, J = 7.2 Hz, 1H), 2.13 – 1.98 (m, 2H), 1.14 (t, J = 7.2 Hz, 3H).

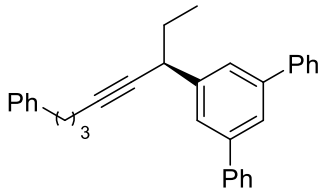
^{13}C NMR (100 MHz, $CDCl_3$) δ 148.1, 145.6, 142.5, 142.2, 141.6, 141.0, 134.5, 128.8, 127.5, 127.3, 125.4, 125.0, 110.9, 97.3, 95.9, 82.1, 40.2, 31.1, 12.1.

HRMS (ESI) *m/z* calcd. for $C_{29}H_{24}N_3$ $[M + H]^+$ 414.1965, found 414.1962.



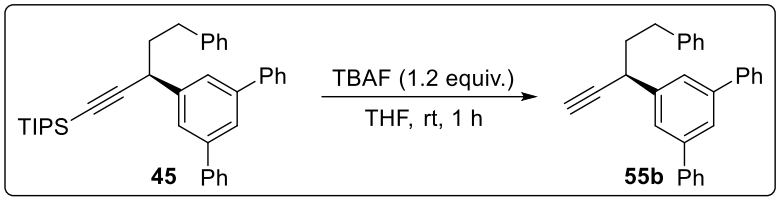
Under argon atmosphere, an oven-dried resealable Schlenk tube equipped with a magnetic stir bar was charged with CuI (1.43 mg, 0.0075 mmol, 7.5 mol%), [(*π*-allyl)PdCl]$_2$ (0.91 mg, 0.0025 mmol, 2.5 mol%), iPr·HCl (2.13 mg, 0.005 mmol, 5 mol%) and $CsCO_3$ (49.9 mg, 0.14 mmol, 1.4 equiv.). A mixture of DMF and Et_2O (1:2, 1.2 mL) was added，followed by (3-bromopropyl)benzene (0.20 mmol, 2.0 equiv.) and alkyne **55a** (29.6 mg, 0.10 mmol, 1.0 equiv., 94% ee). The reaction mixture was stirred at 45 °C for 24 h. Upon completion (monitored by TLC), the reaction mixture was purified by column chromatography on silica gel to afford the desired products **58c** (18.9 mg, 46% yield, 90% ee).

(S)-5'-(8-phenyloct-4-yn-3-yl)-1,1':3',1''-terphenyl (58c)



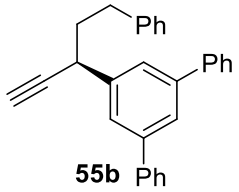
58c

HPLC analysis: Chiralcel ADH (hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min, λ = 254 nm), t_R (minor) = 5.83 min, t_R (major) = 7.07 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.70 – 7.62 (m, 5H), 7.58 (d, *J* = 2.0 Hz, 2H), 7.48 – 7.40 (m, 4H), 7.39 – 7.33 (m, 2H), 7.28 – 7.22 (m, 2H), 7.21 – 7.12 (m, 3H), 3.75 – 3.65 (m, 1H), 2.77 (t, *J* = 6.4 Hz, 2H), 2.29 (td, J_1= 6.8 Hz, J_2= 2.0 Hz, 2H), 1.95 – 1.77 (m, 4H), 1.07 (t, *J* = 7.2 Hz, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 143.8, 141.82, 141.79, 141.3, 128.8, 128.5, 128.3, 127.34, 127.31, 125.8, 125.5, 124.5, 83.1, 82.1, 39.7, 34.9, 32.0, 30.7, 18.4, 12.0.
HRMS (ESI) *m/z* calcd. for $C_{32}H_{31}$ $[M + H]^+$ 415.2420, found 415.2415.

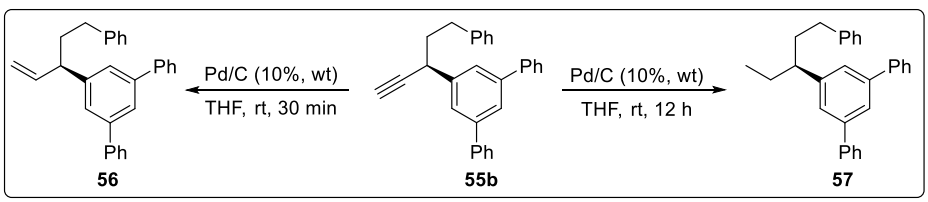


To a solution of **45** (52.9 mg, 0.10 mmol, 1.0 equiv., 94% ee) in THF (1.0 mL) was added TBAF (0.24 mmol, 1.2 equiv.) and the resulting mixture was stirred at room temperature for 1 h. After completion of the reaction (monitored by TLC), the mixture was concentrated under reduced pressure and purified by column chromatography to yield **55b** as a colorless oil (32.6 mg, 88% yield, 94% ee).

(R)-5'-(5-phenylpent-1-yn-3-yl)-1,1':3',1''-terphenyl (55b)



HPLC analysis: Chiralcel ADH (hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 7.80 min, t_R (minor) = 8.50 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.71 – 7.61 (m, 5H), 7.56 (d, *J* = 1.6 Hz, 2H), 7.50 – 7.42 (m, 4H), 7.40 – 7.34 (m, 2H), 7.32 – 7.26 (m, 2H), 7.24 – 7.16 (m, 3H), 3.80 – 3.71 (m, 1H), 2.94 – 2.75 (m, 2H), 2.39 (d, *J* = 2.4 Hz, 1H), 2.25 – 2.10 (m, 2H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 142.3, 142.1, 141.3, 141.0, 128.8, 128.5, 128.4, 127.5, 127.3, 126.0, 125.3, 124.8, 85.5, 71.8, 39.9, 37.1, 33.5.
HRMS (ESI) *m/z* calcd. for $C_{29}H_{25}$ $[M + H]^+$ 373.1951, found 373.1944.

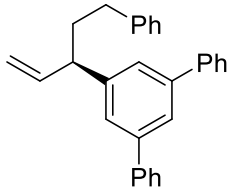


To a mixture of Pd/C (3.0 mg, 10% w/w Pd on carbon) in THF (1.0 mL) was added **55b** (37.2 mg, 0.10 mmol, 1.0 equiv., 94% ee) under argon atmosphere. Then, the

reaction flask was evacuated and refilled with hydrogen through a balloon. The resulting reaction mixture was stirred under the hydrogen atmosphere at room temperature for 30 min. After completion, the reaction mixture was filtered and rinsed with CH_2Cl_2. The filtrate was concentrated under reduced pressure and the residue was purified by column chromatography on silica gel to afford **56** as a colorless oil (34.6 mg, 92% yield, 95% ee)

To a mixture of Pd/C (10.0 mg, 10% w/w Pd on carbon) in THF (1.0 mL) was added **55b** (37.2 mg, 0.10 mmol, 1.0 equiv., 94% ee) under argon atmosphere. Then, the reaction flask was evacuated and refilled with hydrogen through a balloon. The resulting reaction mixture was stirred under the hydrogen atmosphere at room temperature for 12 h. After completion, the reaction mixture was filtered and rinsed with CH_2Cl_2. The filtrate was concentrated under reduced pressure and the residue was purified by column chromatography on silica gel to afford **57** as a colorless oil (35.9 mg, 95% yield, 90% ee)

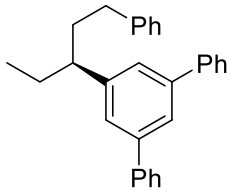
(R)-5'-(5-phenylpent-1-en-3-yl)-1,1':3',1''-terphenyl (56)



56

HPLC analysis: Chiralcel ADH (hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min, λ = 254 nm), t_R (minor) = 4.98 min, t_R (major) = 5.44 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.70 – 7.60 (m, 5H), 7.49 – 7.42 (m, 4H), 7.40 (d, *J* = 1.6 Hz, 2H), 7.39 – 7.32 (m, 2H), 7.31 – 7.24 (m, 2H), 7.21 – 7.13 (m, 3H), 6.15 – 5.98 (m, 1H), 5.20 – 5.06 (m, 2H), 3.42 (q, *J* = 7.6 Hz, 1H), 2.74 – 2.56 (m, 2H), 2.14 (q, *J* = 8.0 Hz, 2H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 145.2, 142.1, 142.0, 141.9, 141.3, 128.7, 128.5, 128.3, 127.4, 127.3, 125.8, 125.6, 124.3, 114.7, 49.5, 37.0, 33.8.
HRMS (ESI) *m/z* calcd. for $C_{29}H_{27}$ $[M + H]^+$ 375.2107, found 375.2104.

(S)-5'-(1-phenylpentan-3-yl)-1,1':3',1''-terphenyl (57)

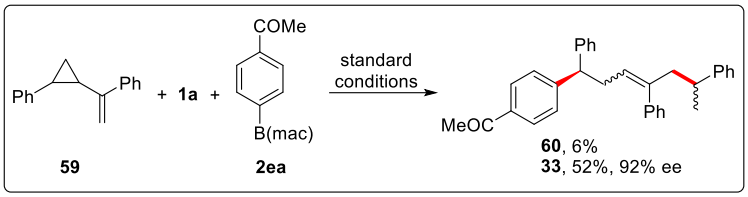


57

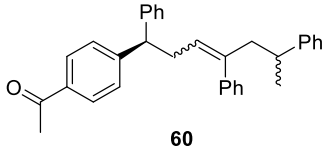
HPLC analysis: Chiralcel OD-3 (hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 5.72 min, t_R (minor) = 6.22 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.72 – 7.62 (m, 5H), 7.51 – 7.42 (m, 4H), 7.40 – 7.32 (m, 4H), 7.29 – 7.23 (m, 2H), 7.19 – 7.08 (m, 3H), 2.65 – 2.48 (m, 3H), 2.13 – 1.95 (m, 2H), 1.85 – 1.62 (m, 2H), 0.84 (t, *J* = 7.2 Hz, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 146.5, 142.5, 141.7, 141.5, 128.7, 128.4, 128.3, 127.3, 125.7, 125.6, 124.0, 47.6, 38.1, 33.9, 29.8, 12.2.
HRMS (ESI) *m/z* calcd. for $C_{29}H_{29}$ $[M + H]^+$ 377.2264, found 377.2258.

Mechanistic Studies

Radical clock experiment with benzyl bromides



Under argon atmosphere, an oven-dried resealable Schlenk tube equipped with a magnetic stir bar was charged with **2ea** (68.4 mg, 0.20 mmol, 1.0 equiv.), CuI (3.8 mg, 0.020 mmol, 10 mol%), **L4** (16.0 mg, 0.024 mmol, 12 mol%), LiO^tBu (64.0 mg, 0.80 mmol, 4.0 equiv.). Then DMSO/CH_2Cl_2 (2:1, 2.4 mL) and H_2O (7.2 mg, 0.40 mmol, 2.0 equiv.) was added. The reaction mixture was stirred for several minutes to dissolve the reactants. Last alkyl halide **1a** (55.5 mg, 0.30 mmol, 1.5 equiv.) and (1-(2-phenylcyclopropyl)vinyl)benzene **59** (88.0 mg, 0.40 mmol, 2.0 equiv.) were slowly sequentially added into the mixture *via* microsyringe, and the reaction mixture was stirred at –5 °C for 48 h. Upon completion (monitored by TLC), the reaction mixture was poured into water (10 mL), then extracted with DCM (3 × 5 mL). The filtrate was dried with anhydride Na_2SO_4, then was purified by column chromatography on silica gel to afford **60** as a mixture of diastereomers (5.2 mg, 6% yield) and **33** (23.4 mg, 52% yield, 92% ee).



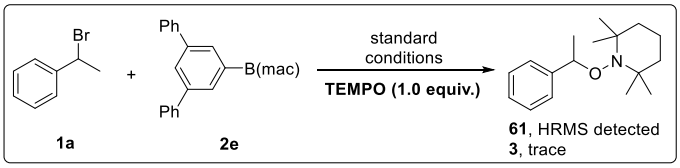
60

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.92 – 7.82 (m, 2H), 7.31 – 7.07 (m, 17H), 5.40 (t, *J* = 7.2 Hz, 1H), 3.78 (t, *J* = 6.0 Hz, 1H), 2.84 – 2.61 (m, 5H), 2.59 – 2.55 (m, 3H), 1.22 – 1.15 (m, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 197.8, 150.3, 150.1, 146.8, 143.7, 143.6, 143.0, 140.11, 140.06, 135.3, 135.2, 128.6, 128.55, 128.50, 128.23, 128.20, 127.93, 127.88, 127.81, 127.78, 127.1, 126.7, 126.6, 126.5, 126.4, 126.1, 51.1, 39.1, 39.0, 38.1, 34.2, 29.7, 26.5, 21.1.

HRMS (ESI) *m/z* calcd. for $C_{33}H_{33}O$ $[M + H]^+$ 445.2526, found 445.2528.

TEMPO inhibiting experiment with benzyl bromides



Under argon atmosphere, an oven-dried resealable Schlenk tube equipped with a magnetic stir bar was charged with **2e** (90.4 mg, 0.20 mmol, 1.0 equiv.), CuI (3.8 mg, 0.020 mmol, 10 mol%), **L4** (16.0 mg, 0.024 mmol, 12 mol%), LiO^tBu (64.0 mg, 0.80 mmol, 4.0 equiv.) and TEMPO (62.4 mg, 0.40 mmol, 2.0 equiv.). Then DMSO/CH_2Cl_2 (2:1, 2.4 mL) and H_2O (7.2 mg, 0.40 mmol, 2.0 equiv.) was added. The reaction mixture was stirred for several minutes to dissolve the reactants. Last alkyl halide **1a** (55.5mg, 0.30 mmol, 1.5 equiv.) was slowly added into the mixture *via* microsyringe, and the reaction mixture was stirred at –5 °C for 48 h. The reaction

mixture was monitored by TLC. Trace amount of product **3** was observed and **61** could be detected by HRMS analysis.

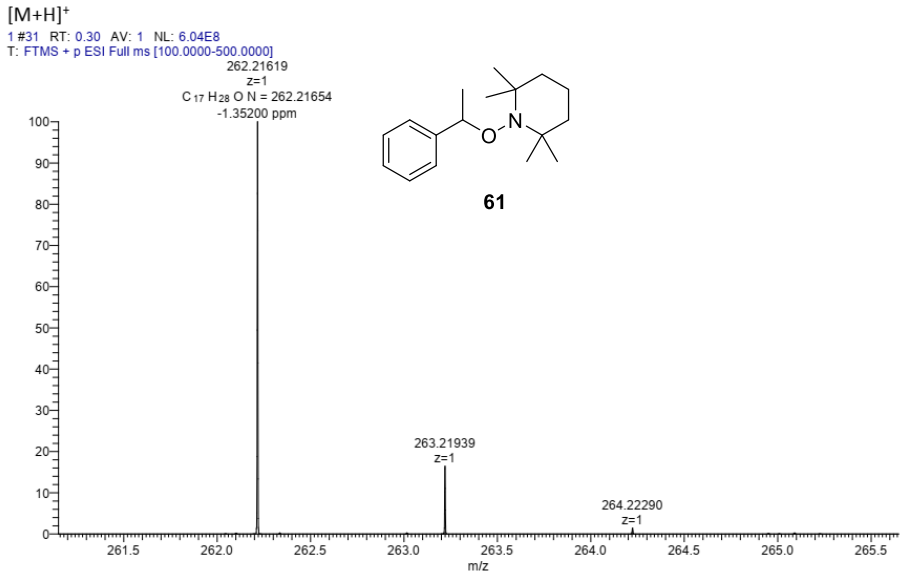
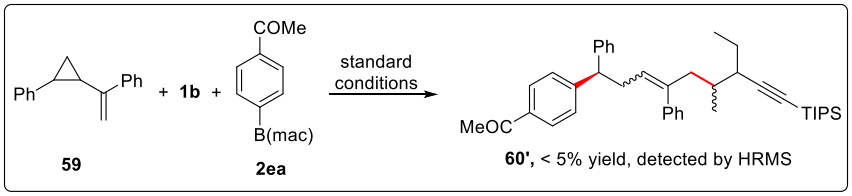


Figure S2. HRMS data of **61**

Radical clock experiment with propargyl bromides



Under argon atmosphere, an oven-dried resealable Schlenk tube equipped with a magnetic stir bar was charged with **2ea** (68.4 mg, 0.20 mmol, 1.0 equiv.), CuI (3.8 mg, 0.020 mmol, 10 mol%), **L6** (19.7 mg, 0.024 mmol, 12 mol%), LiO^tBu (96.0 mg, 1.20 mmol, 6.0 equiv.). Then DMSO/CH_2Cl_2 (2:1, 2.4 mL) and H_2O (10.8 mg, 0.60 mmol, 3.0 equiv.) was added. The reaction mixture was stirred for several minutes to dissolve the reactants. Lastly alkyl halide **1b** (90.9 mg, 0.30 mmol, 1.5 equiv.) and (1-(2-phenylcyclopropyl)vinyl)benzene **59** (88.0 mg, 0.40 mmol, 2.0 equiv.) were slowly sequentially added into the mixture *via* microsyringe, and the reaction mixture was stirred at –10 °C for 120 h. The reaction mixture was monitored by TLC. Trace amount of product **60'** was observed and could be detected by HRMS analysis.

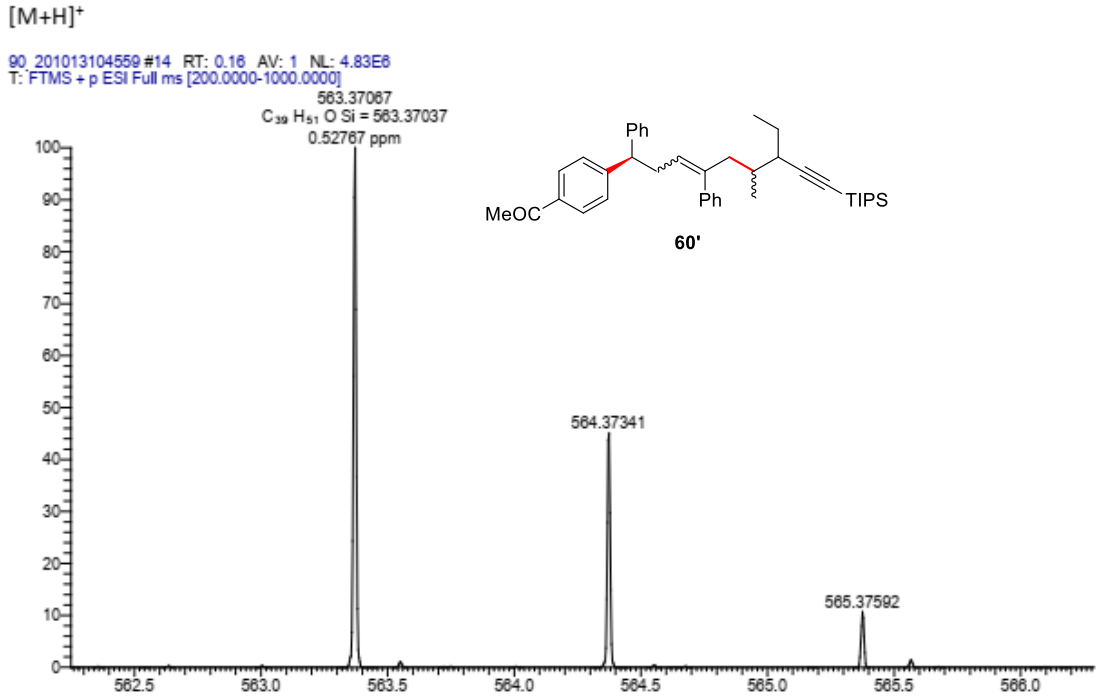
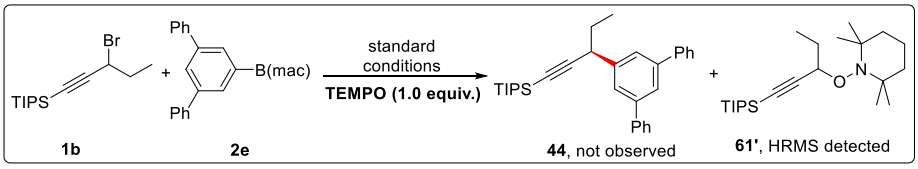


Figure S3. HRMS data of **60'**

TEMPO inhibiting experiment with propargyl bromides



Under argon atmosphere, an oven-dried resealable Schlenk tube equipped with a magnetic stir bar was charged with **2e** (90.4 mg, 0.20 mmol, 1.0 equiv.), CuI (3.8 mg, 0.020 mmol, 10 mol%), **L6** (19.7 mg, 0.024 mmol, 12 mol%), LiO^tBu (96.0 mg, 1.20 mmol, 6.0 equiv.) and TEMPO (62.4 mg, 0.40 mmol, 2.0 equiv.). Then DMSO/CH_2Cl_2 (2:1, 2.4 mL) and H_2O (10.8 mg, 0.60 mmol, 3.0 equiv.) was added. The reaction mixture was stirred for several minutes to dissolve the reactants. Lastly alkyl halide **1b** (90.9 mg, 0.30 mmol, 1.5 equiv.) was slowly added into the mixture *via* microsyringe, and the reaction mixture was stirred at −10 °C for 120 h. The reaction mixture was monitored by TLC. No product **44** was observed and **61'** could be detected by HRMS analysis.

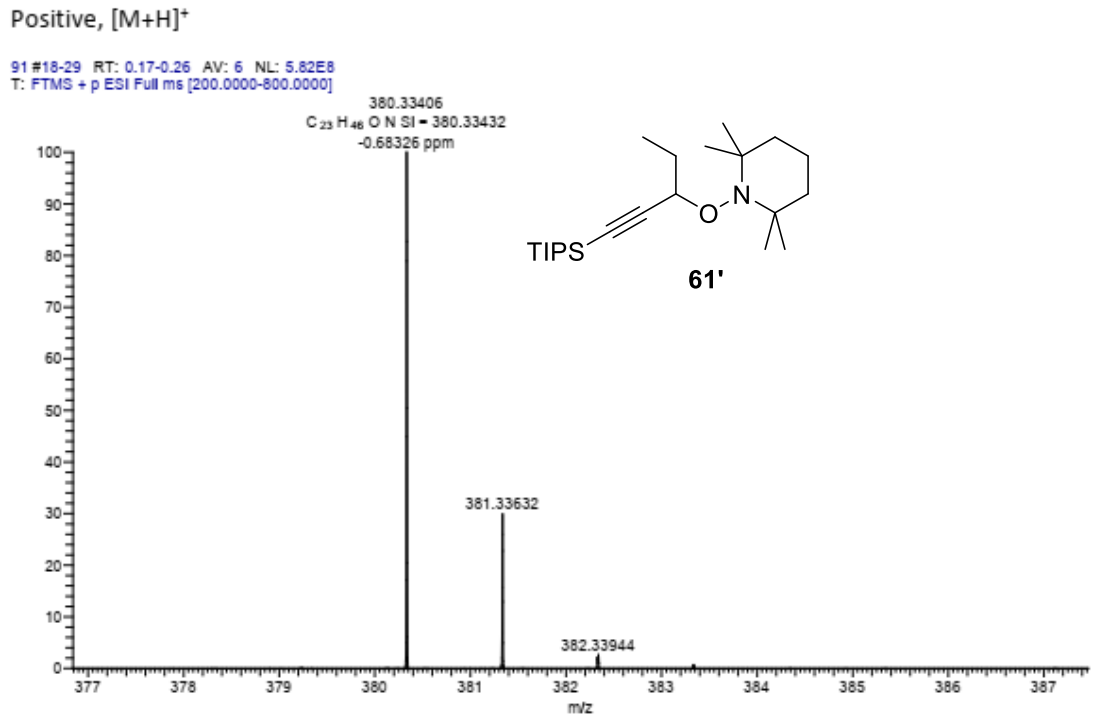
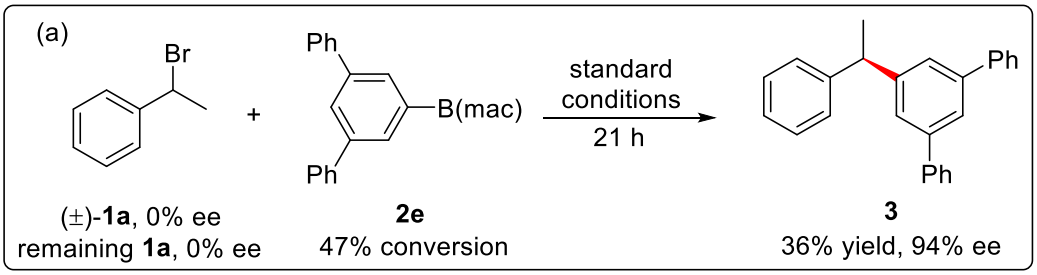
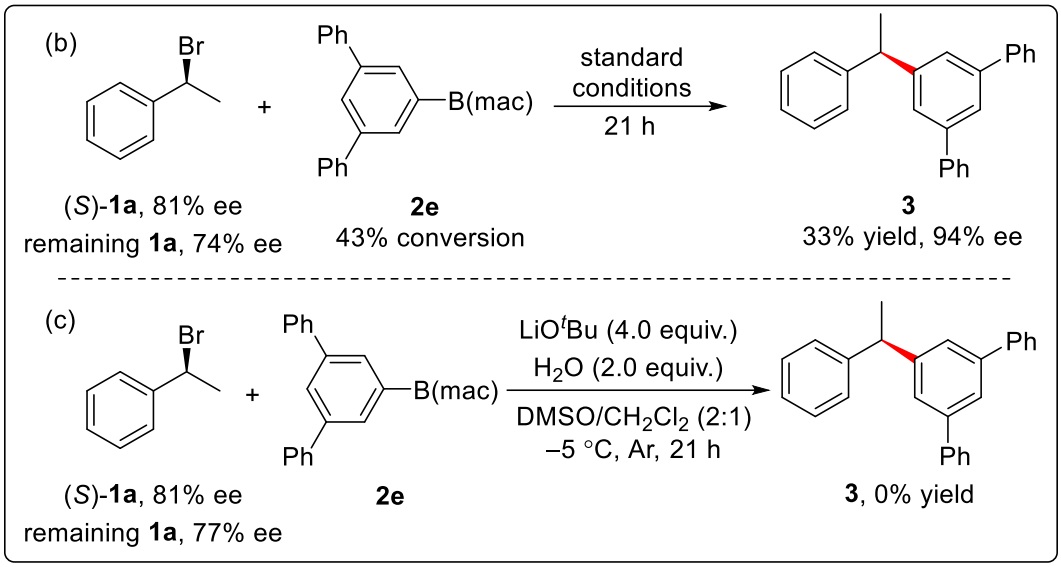


Figure S4. HRMS data of **61'**

Experiments with racemic and enantioenriched alkyl bromide 1a



According to **General procedure A**, substrate (±)-**1a** (27.8 mg, 0.15 mmol, 1.5 equiv.) and **2e** (45.2 mg, 0.10 mmol, 1.0 equiv.) was stirred for 21 h to afford the product **3** (12.1 mg, 36% yield, 94% ee) and the remaining **1a** (0% ee).



According to **General procedure A**, substrate (*S*)-**1a** (27.8 mg, 81% ee, 0.15 mmol, 1.5 equiv.)[7] and **2e** (45.2 mg, 0.10 mmol, 1.0 equiv.) was stirred for 21 h to afford the product **3** (11.1 mg, 33% yield, 94% ee) and the remaining **1a** (74% ee). In the absence of CuI and **L4**, the substrate (*S*)-**1a** (27.8 mg, 81% ee, 0.15 mmol, 1.5 equiv.) and **2e** (45.2 mg, 0.10 mmol, 1.0 equiv.) was stirred for 21 h to produce the remaining (*S*)-**1a** with 77% ee.

References

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(3) Eccleshare, L.; Lozada-Rodríguez, L.; Cooper, P.; Burroughs, L.; Ritchie, J.; Lewis, W.; Woodward, S. Diversification of *ortho*-Fused Cycloocta-2,5-dien-1-one Cores and Eight- to Six-Ring Conversion by σ Bond C-C Cleavage. *Chem. Eur.J.* **2016**, *22*, 12542–12547.

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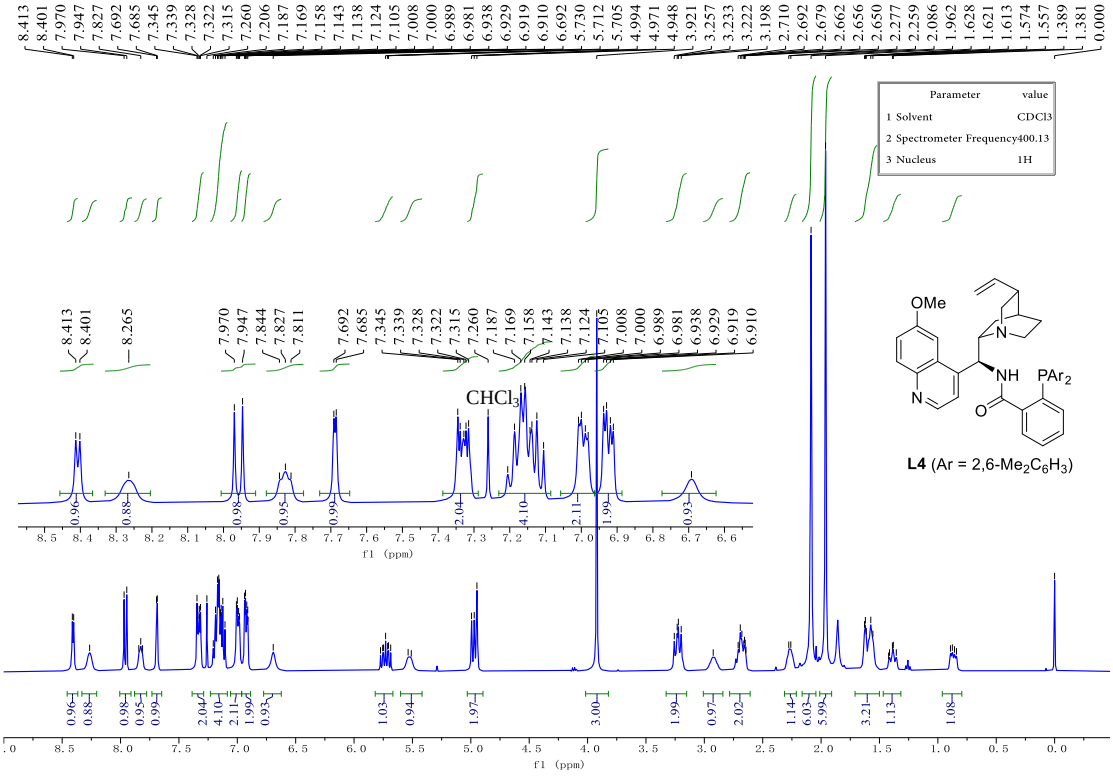
(7) Li, C. *et al*. Transition-metal-free stereospecific cross-coupling with alkenylboronic acids as nucleophiles. *J. Am. Chem. Soc.* 138, 10774–10777 (2016).

NMR Spectra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OMe
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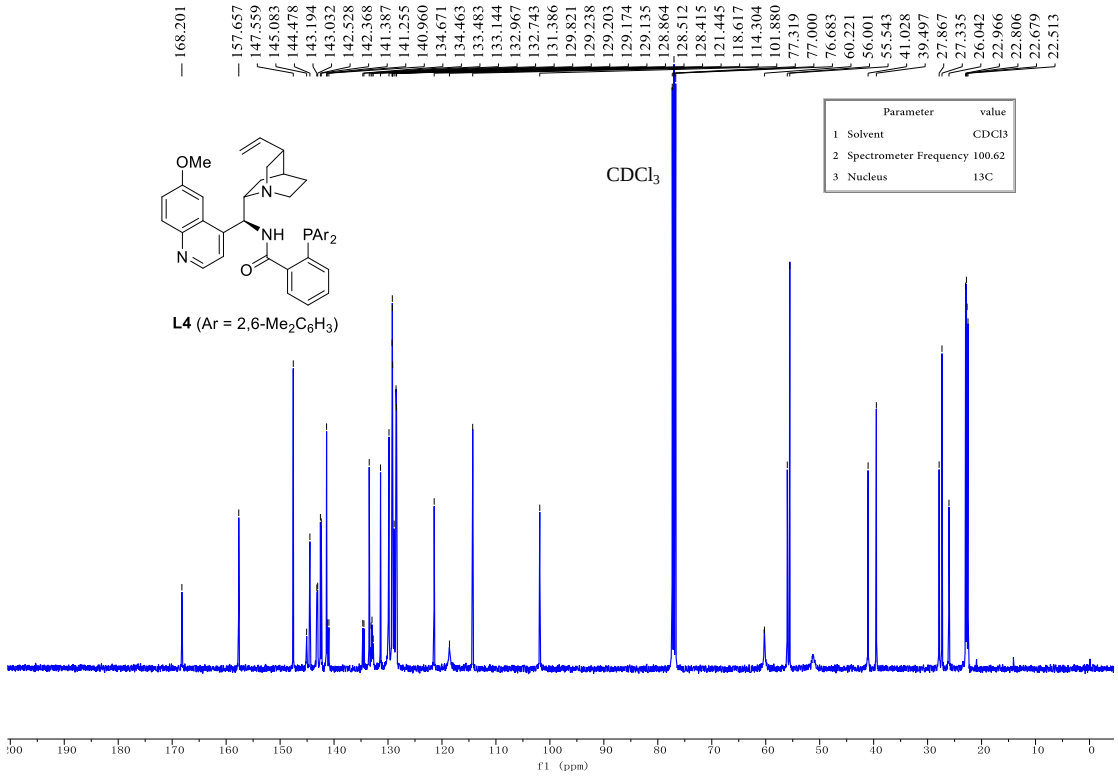
NH
PAr2
O
L4 (Ar = 2,6-Me2C6H3)
f1 (ppm)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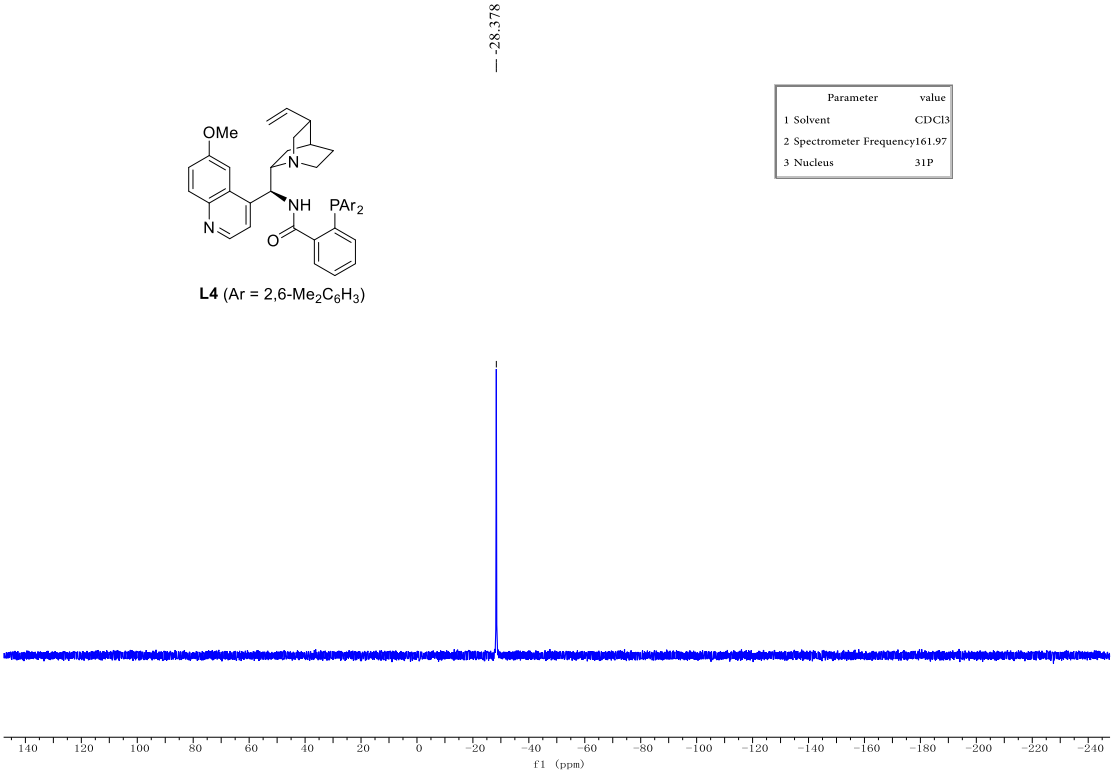
2 Spectrometer Frequency 100.62
3 Nucleus 13C
CDCl3
OMe
N
NH
PAr2
O
L4 (Ar = 2,6-Me2C6H3)
f1 (ppm)


-28.378
Parameter value
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2 Spectrometer Frequency 161.97
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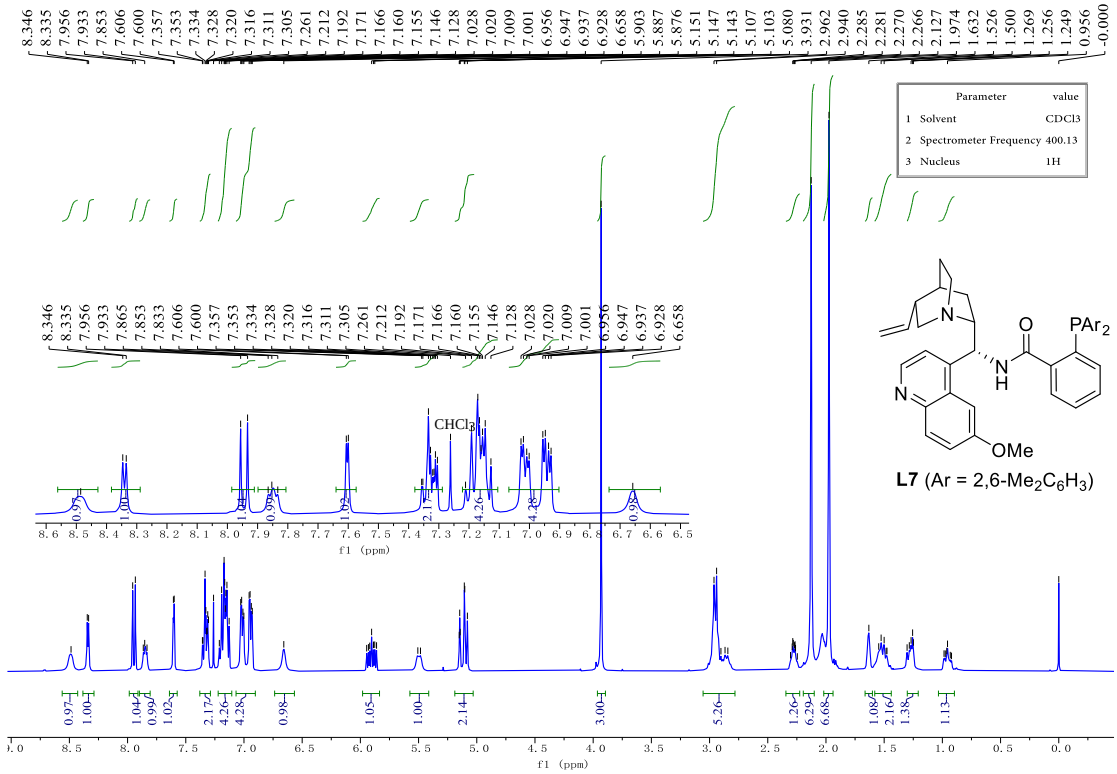
OMe
N
NH
PAr2
O
N
L4 (Ar = 2,6-Me2C6H3)
f1 (ppm)


Parameter value
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2 Spectrometer Frequency 400.13
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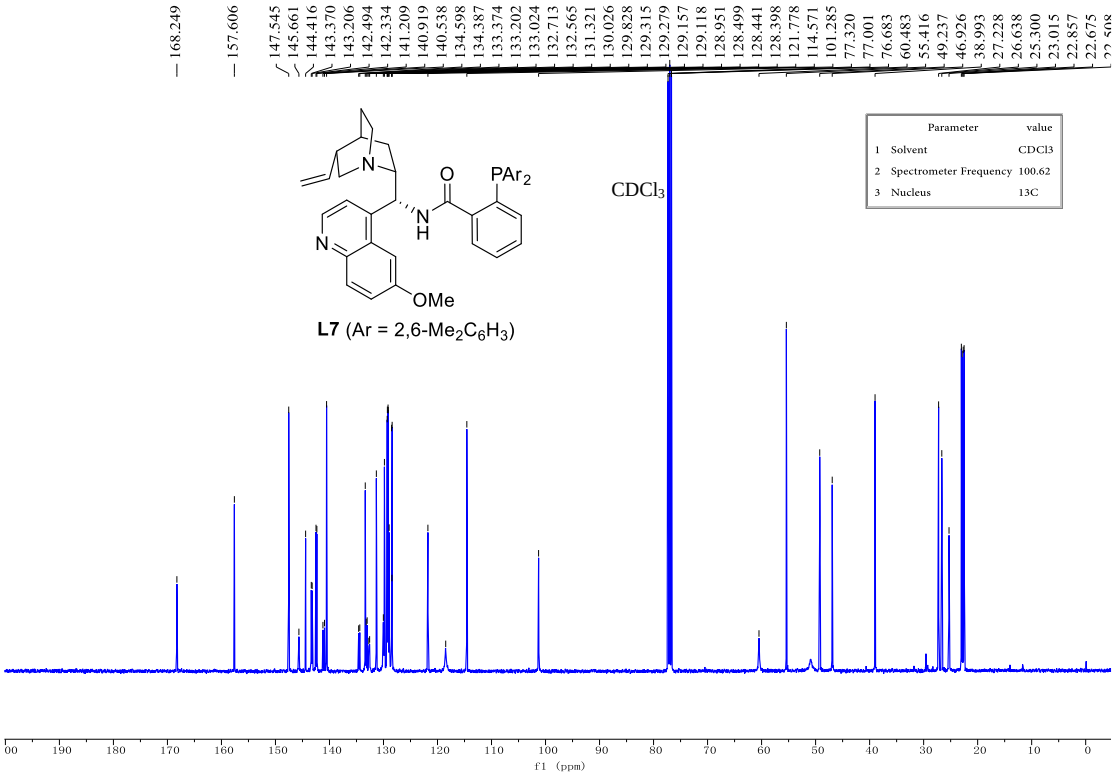
O
PAr2
N
H
OMe
L7 (Ar = 2,6-Me2C6H3)
f1 (ppm)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145.661
144.416
143.370
143.206
142.494
142.334
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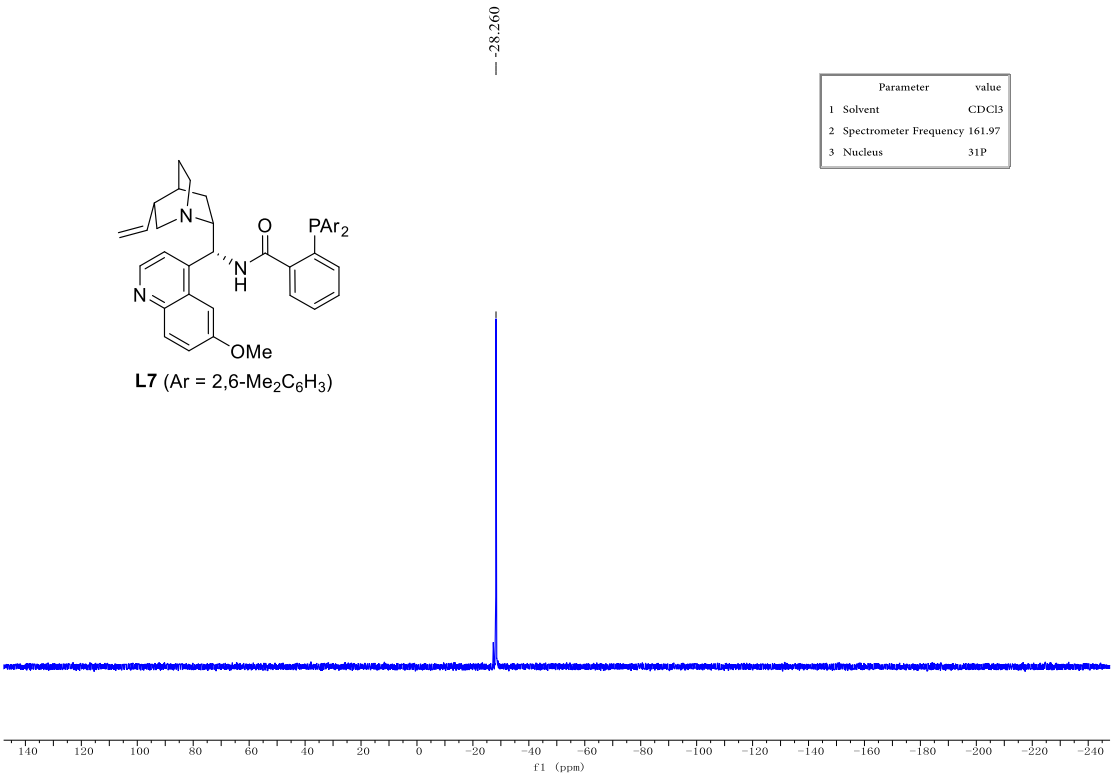
140.538
134.598
134.387
133.374
133.202
133.024
132.713
132.565
131.321
130.026
129.828
129.315
129.279
129.157
129.118
128.951
128.499
128.441
128.398
121.778
114.571
101.285
77.320
77.001
76.683
60.483
55.416
49.237
46.926
38.993
27.228
26.638
25.300
23.015
22.857
22.675
CDCl3
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
N
O
PAr2
N
H
N
OMe
L7 (Ar = 2,6-Me2C6H3)
f1 (ppm)


-28.260
Parameter value
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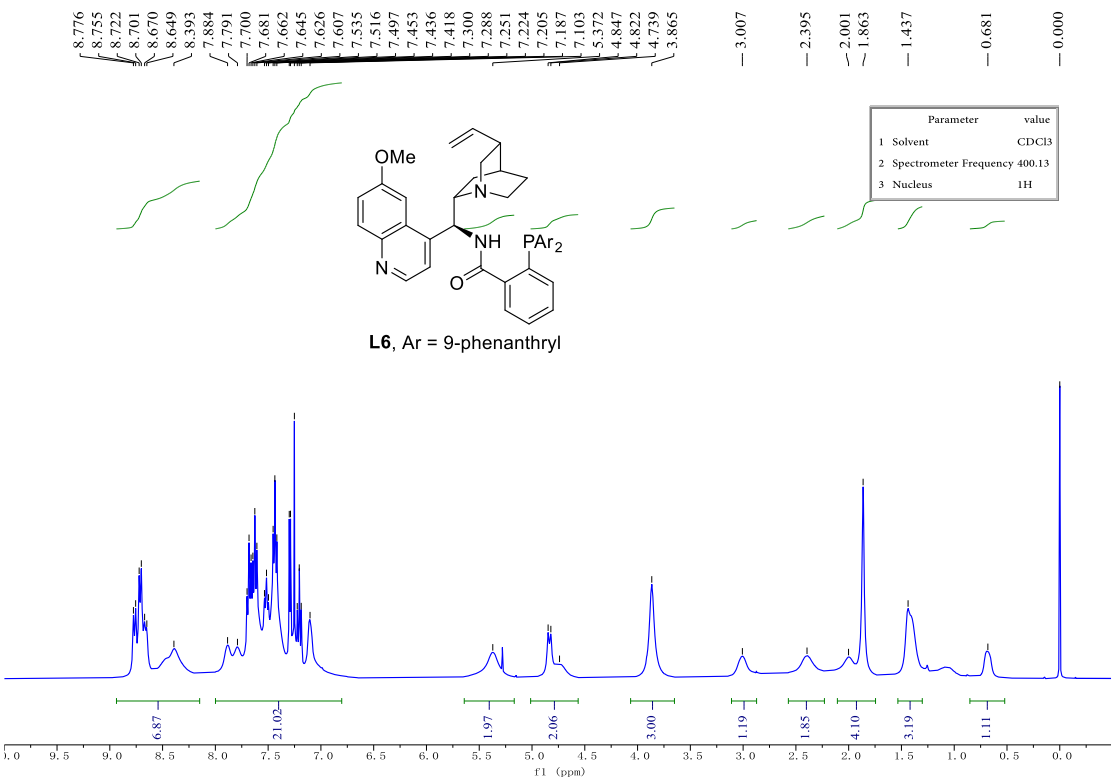
2 Spectrometer Frequency 161.97
3 Nucleus 31P
N
O
PAr2
N
H
N
OMe
L7 (Ar = 2,6-Me2C6H3)
f1 (ppm)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8.755
8.722
8.701
8.670
8.649
8.393
7.884
7.791
7.700
7.681
7.662
7.645
7.626
7.607
7.535
7.516
7.497
7.453
7.436
7.418
7.300
7.288
7.251
7.224
7.205
7.187
7.103
5.372
4.847
4.822
4.739
3.865
3.007
2.395
2.001
1.863
1.437
0.681
0.000
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
OMe
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NH
PAr2
O
N
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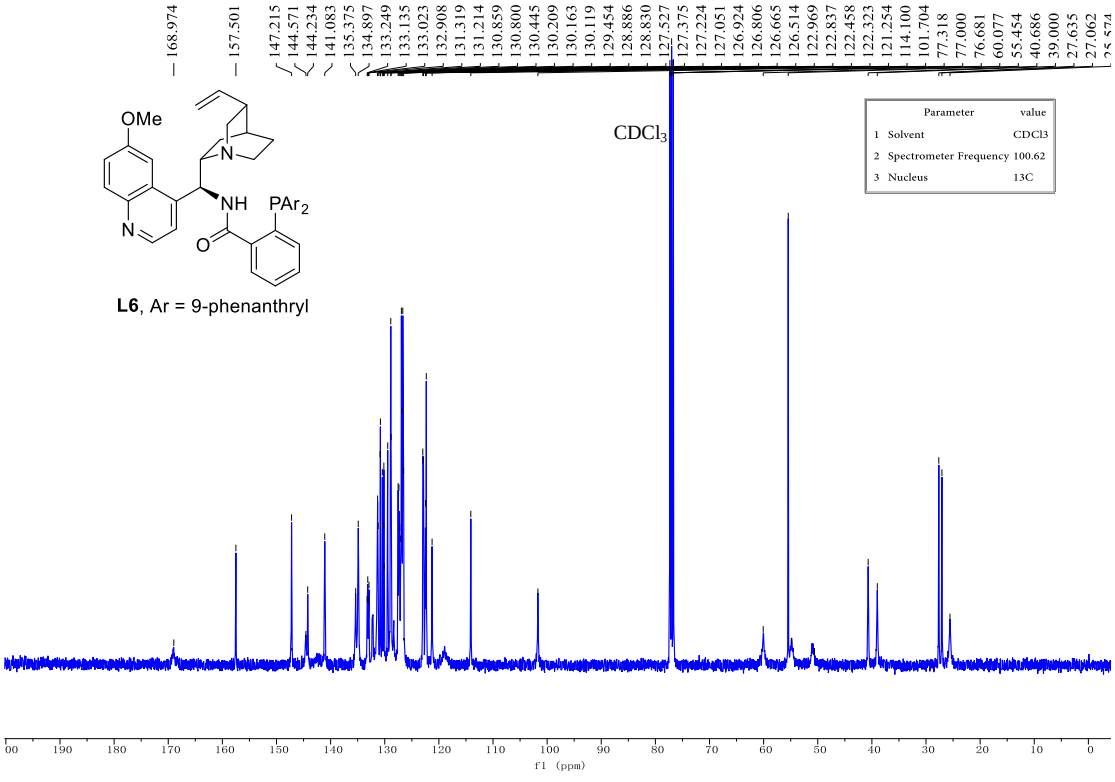
1.19
1.85
4.10
3.19
1.11
f1 (ppm)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144.234
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133.023
132.908
131.319
131.214
130.859
130.800
130.445
130.209
130.163
130.119
129.454
128.886
128.830
127.527
127.375
127.224
127.051
126.924
126.806
126.665
126.514
122.969
122.837
122.458
122.323
121.254
114.100
101.704
77.318
77.000
76.681
60.077
55.454
40.686
39.000
27.635
27.062
CDCl3
Parameter value
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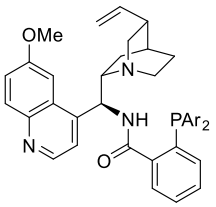
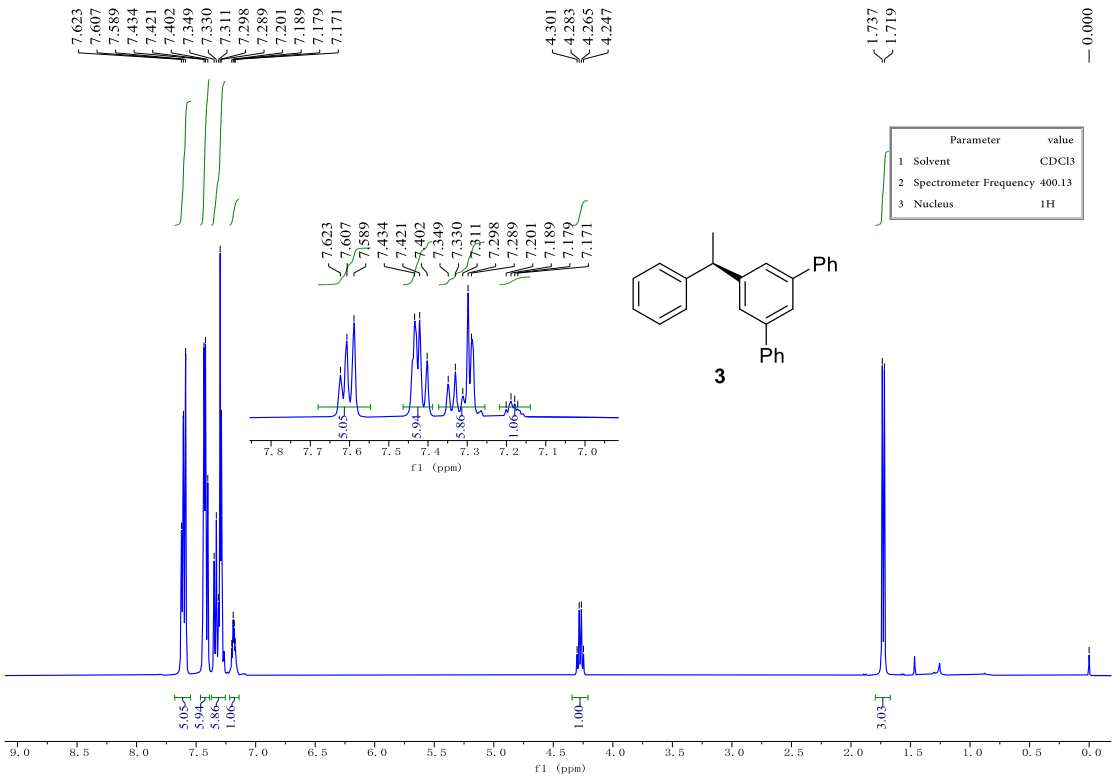
2 Spectrometer Frequency 100.62
3 Nucleus 13C
OMe
N
NH
PAr2
O
N
L6, Ar = 9-phenanthryl
f1 (ppm)



L6, Ar = 9-phenanthryl



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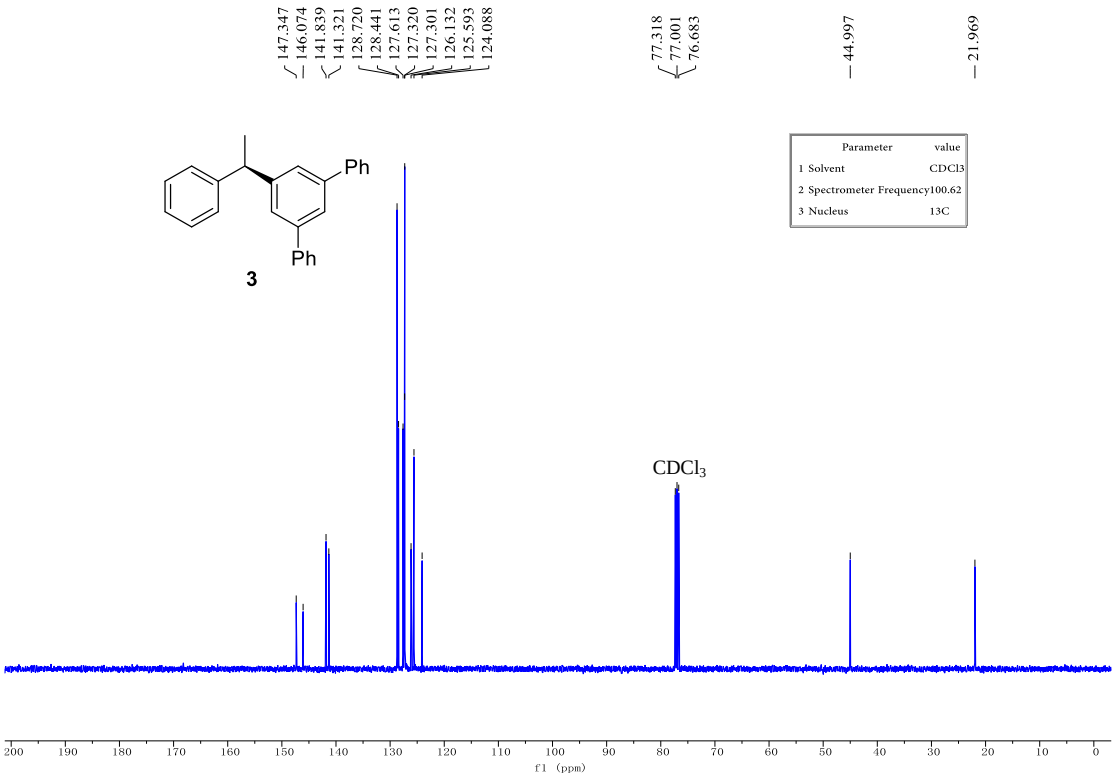
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127.320
127.301
126.132
125.593
124.088
77.318
77.001
76.683
44.997
21.969
Ph
Ph
3
Parameter value
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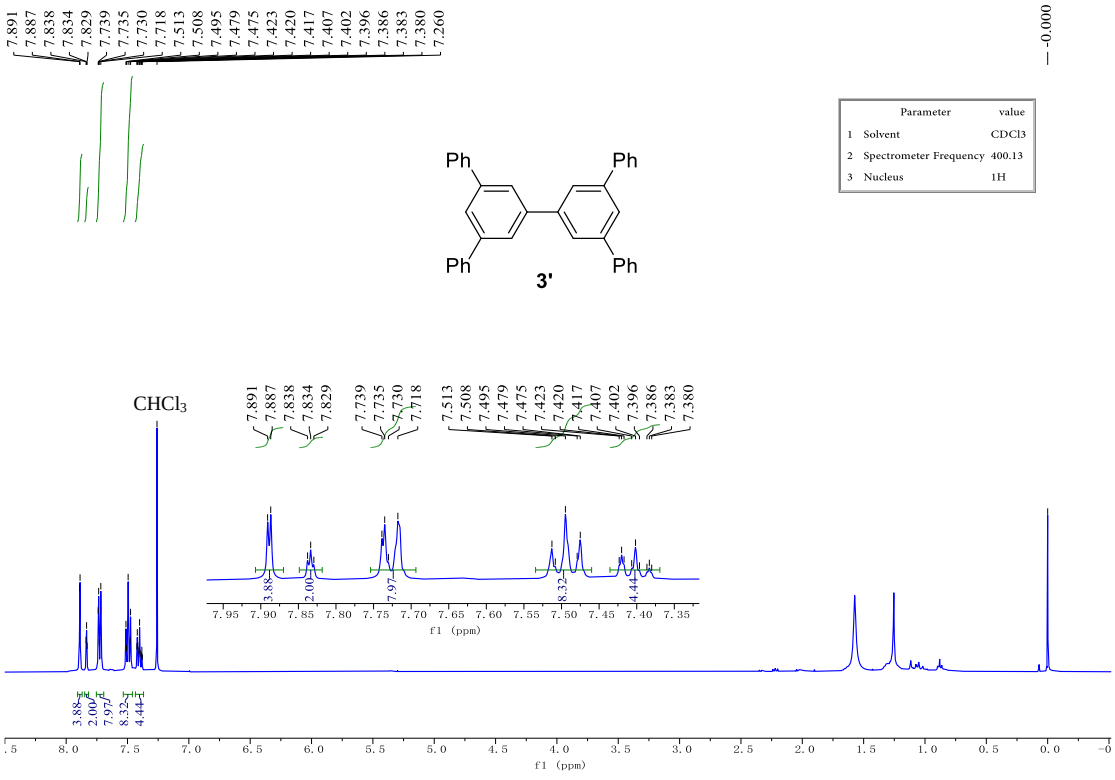
2 Spectrometer Frequency 100.62
3 Nucleus 13C
CDCl3
f1 (ppm)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7.829
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7.735
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7.513
7.508
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7.475
7.423
7.420
7.417
7.407
7.402
7.396
7.386
7.383
7.380
7.260
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Ph
Ph
Ph
Ph
3'
Parameter value
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3 Nucleus 1H
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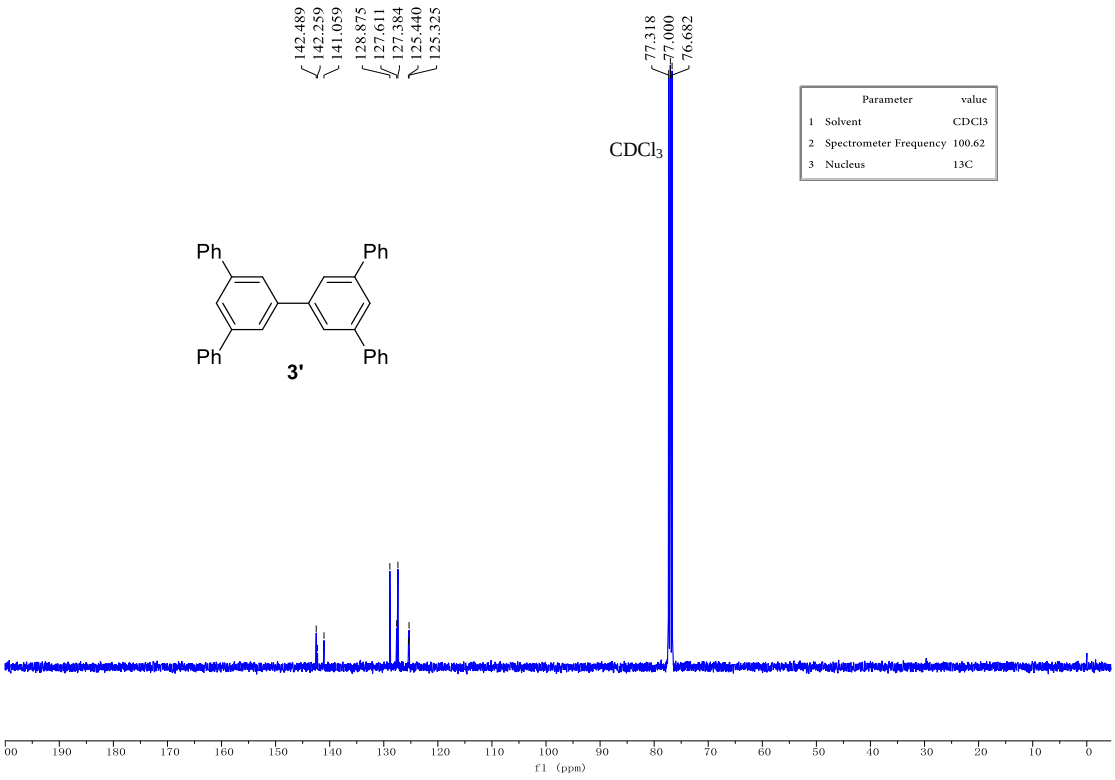
2.00
7.97
8.32
4.44
f1 (ppm)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128.875
127.611
127.384
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125.325
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77.000
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CDCl3
Parameter value
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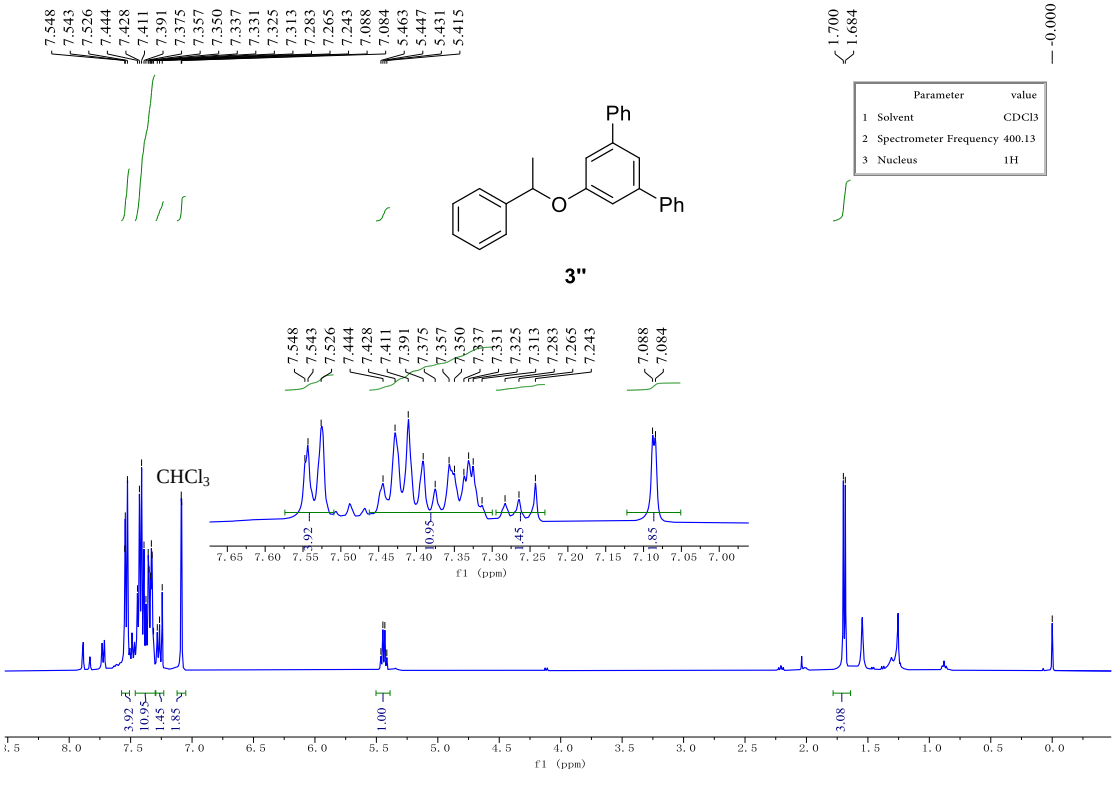
2 Spectrometer Frequency 100.62
3 Nucleus 13C
Ph
Ph
Ph
Ph
3'
f1 (ppm)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7.526
7.444
7.428
7.411
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7.350
7.337
7.331
7.325
7.313
7.283
7.265
7.243
7.088
7.084
5.463
5.447
5.431
5.415
1.700
1.684
0.000
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
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O
Ph
3"
CHCl3
3.92
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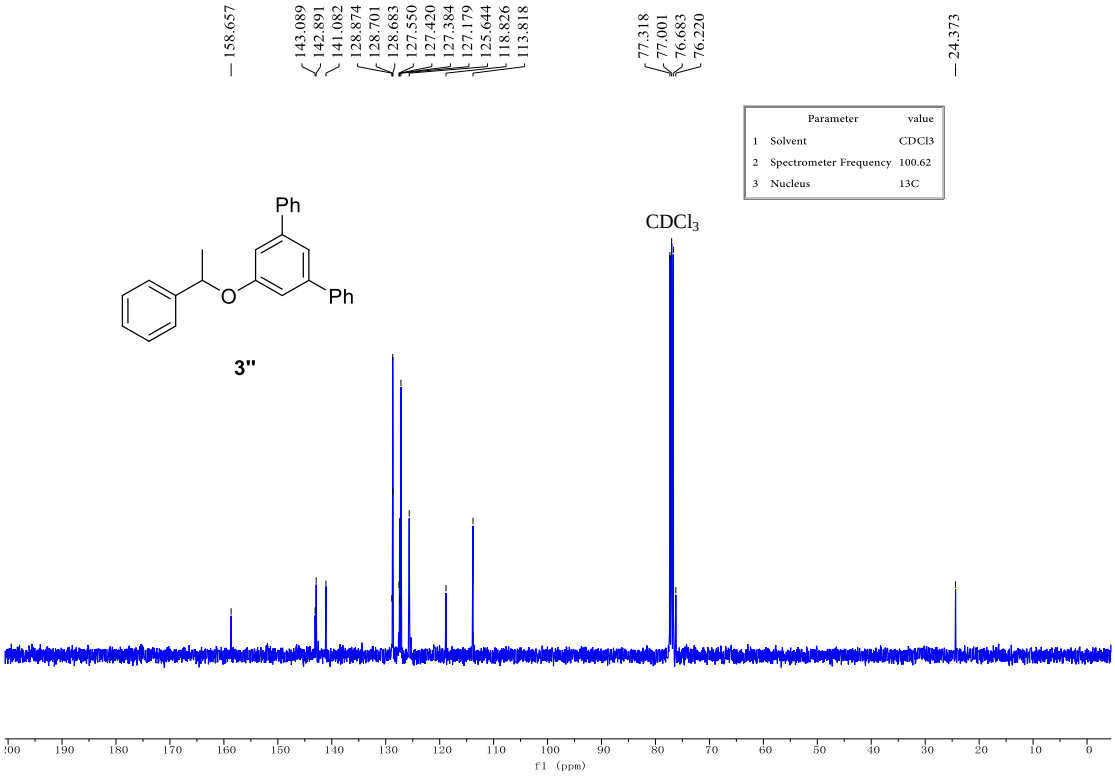
1.45
1.85
1.00
3.08
f1 (ppm)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127.550
127.420
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127.179
125.644
118.826
113.818
77.318
77.001
76.683
76.220
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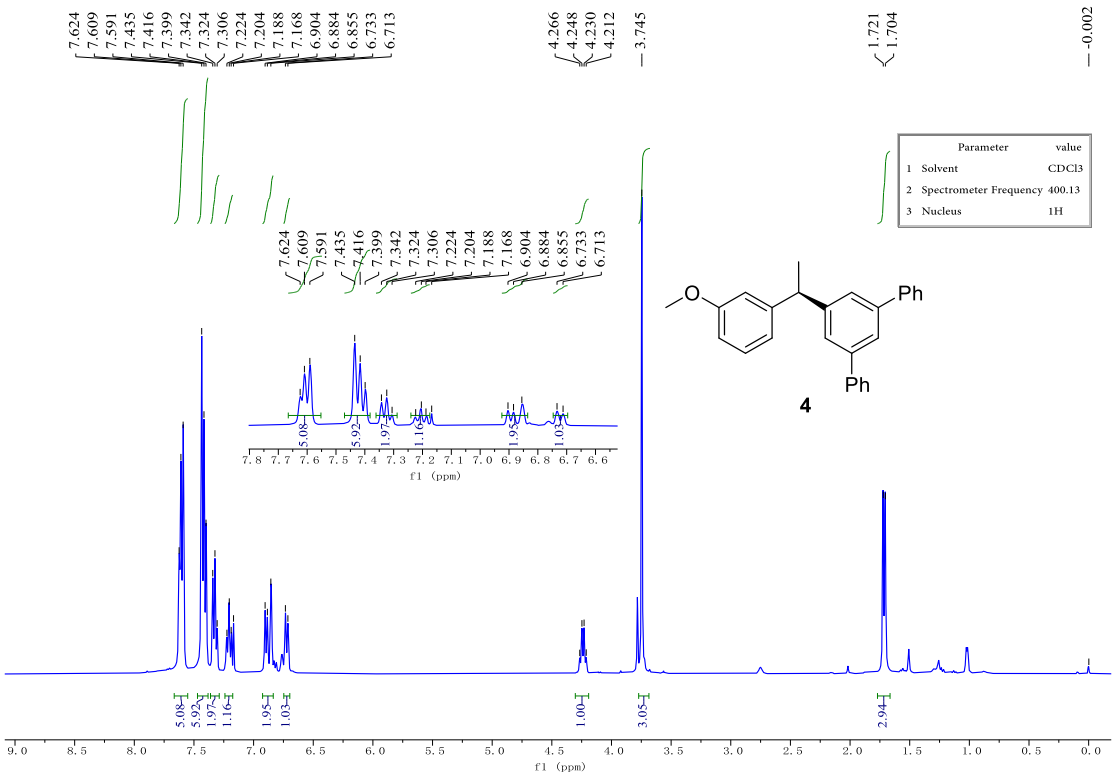
2 Spectrometer Frequency 100.62
3 Nucleus 13C
Ph
O
Ph
3''
CDCl3
f1 (ppm)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7.224
7.204
7.188
7.168
6.904
6.884
6.855
6.733
6.713
4.266
4.248
4.230
4.212
3.745
1.721
1.704
-0.002
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
O
Ph
Ph
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5.92
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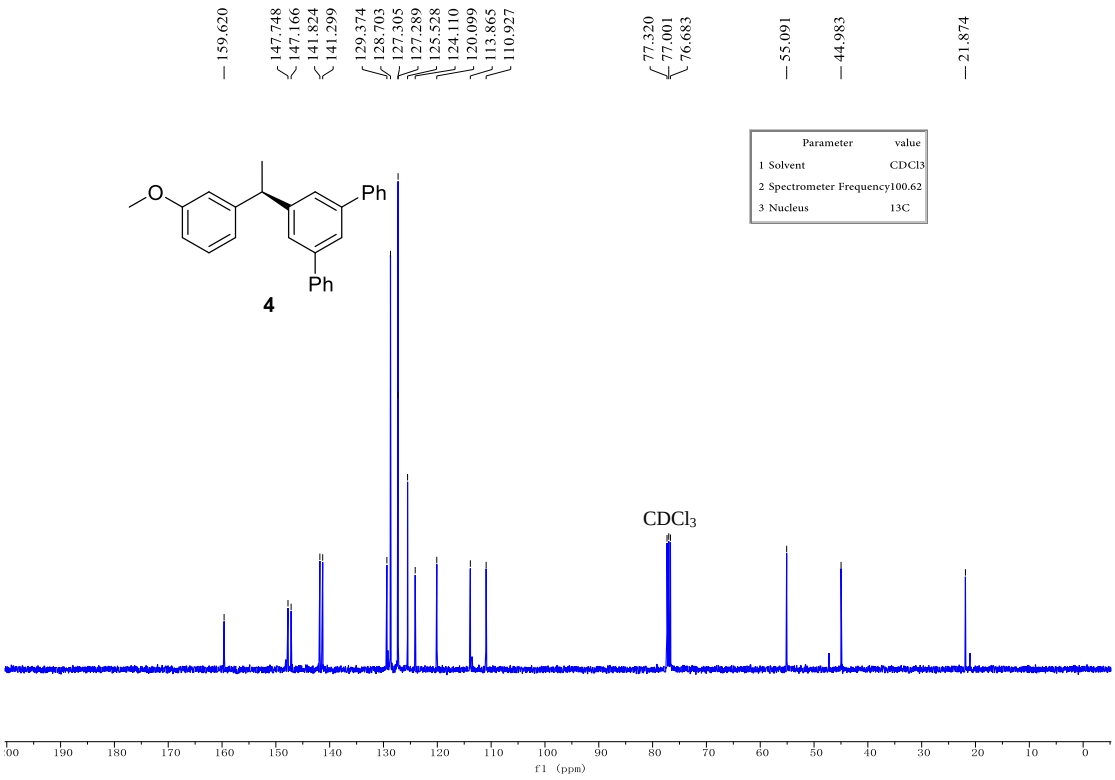
1.95
1.03
1.00
3.05
2.94
f1 (ppm)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125.528
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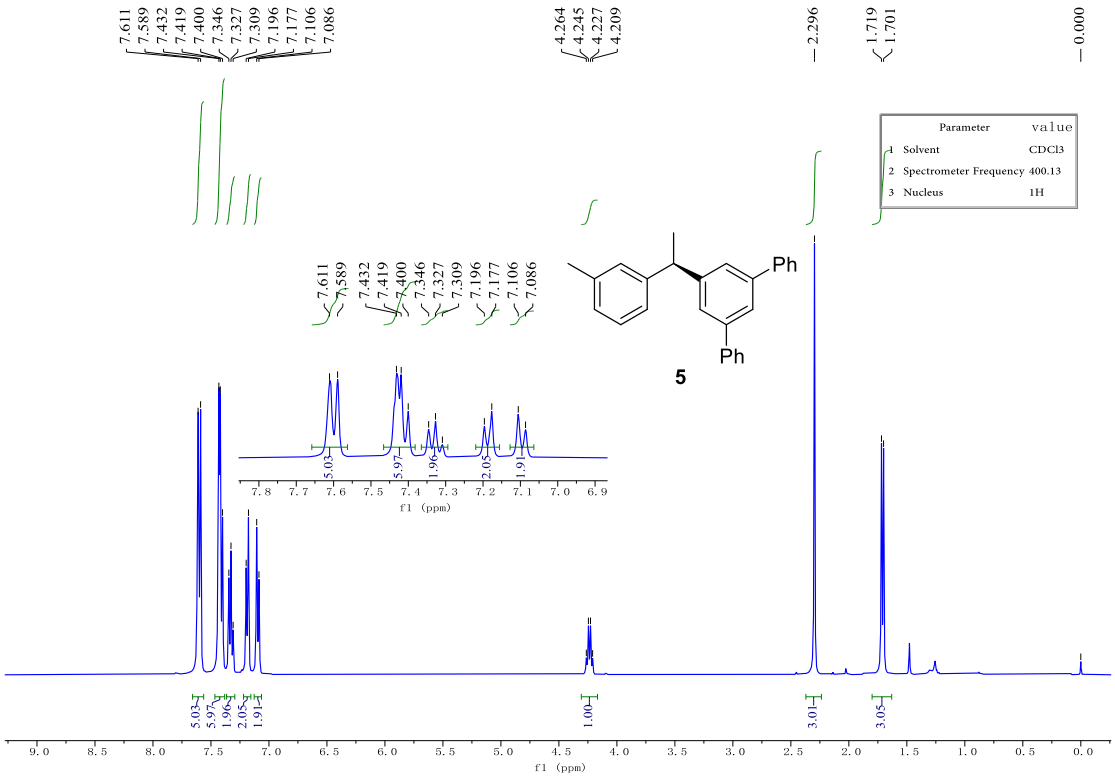
120.099
113.865
110.927
77.320
77.001
76.683
55.091
44.983
21.874
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
O
Ph
Ph
4
CDCl3
f1 (ppm)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7.589
7.432
7.419
7.400
7.346
7.327
7.309
7.196
7.177
7.106
7.086
4.264
4.245
4.227
4.209
2.296
1.719
1.701
0.000
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
Ph
Ph
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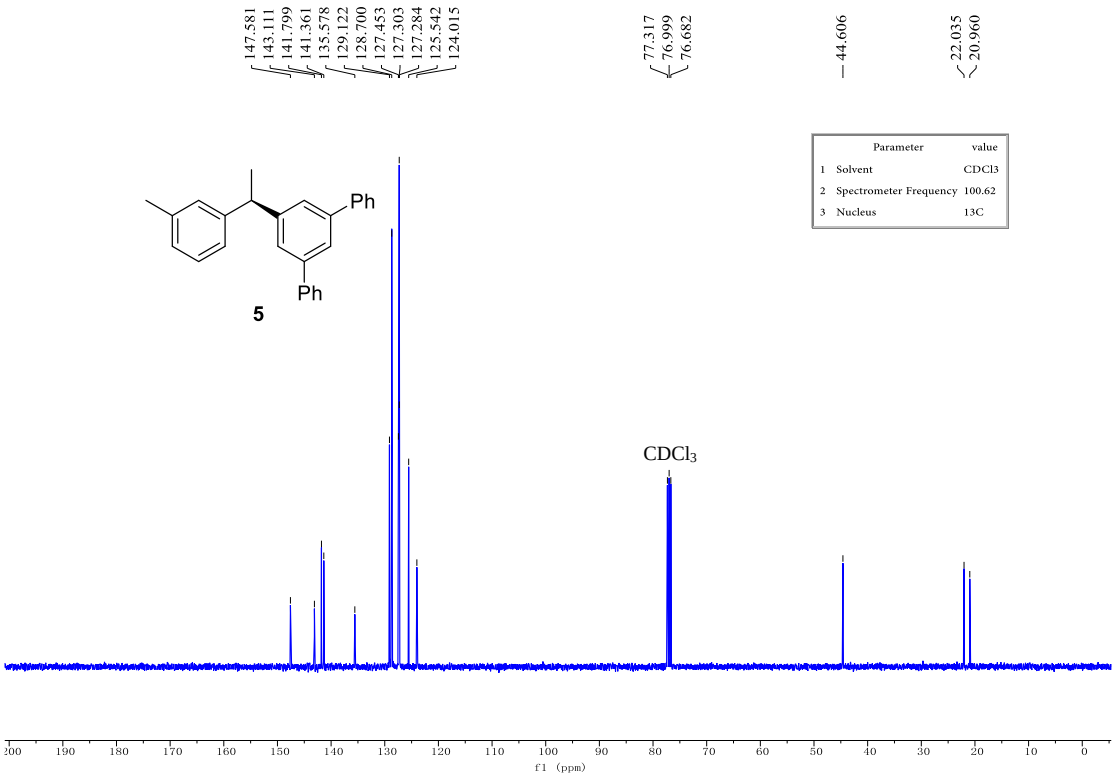
1.96
2.05
1.91
1.00
3.01
3.05
f1 (ppm)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76.999
76.682
44.606
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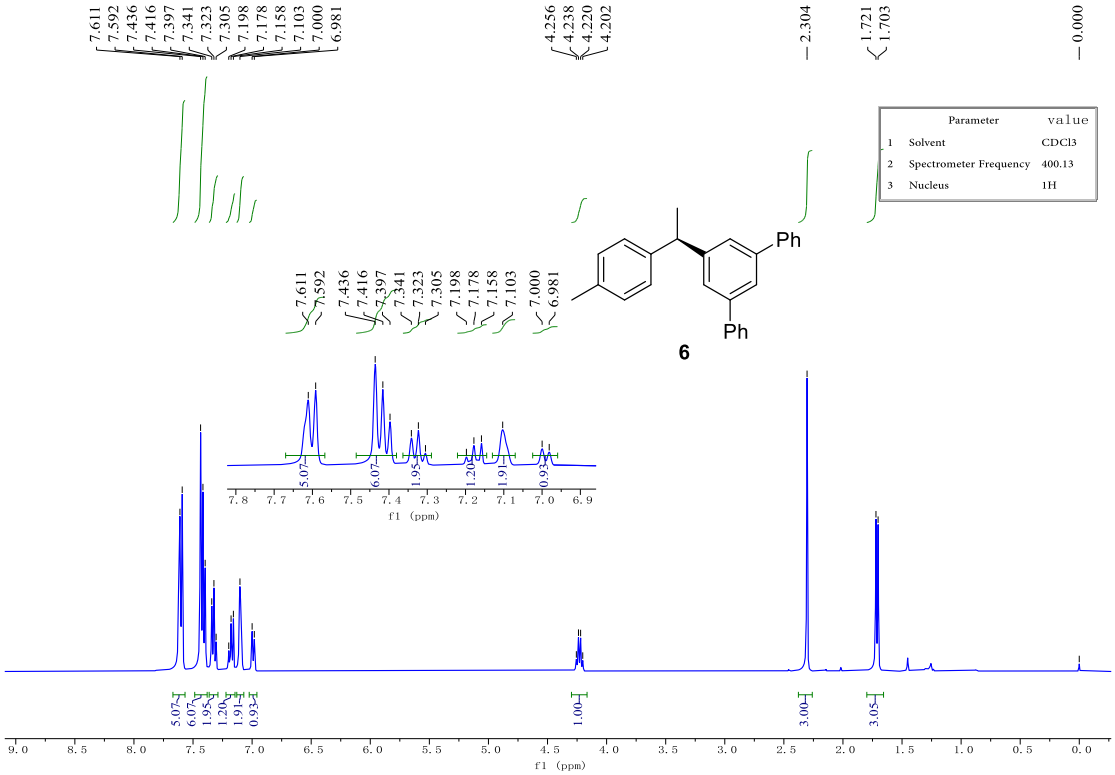
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
Ph
Ph
5
CDCl3
f1 (ppm)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7.158
7.103
7.000
6.981
4.256
4.238
4.220
4.202
2.304
1.721
1.703
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Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
Ph
Ph
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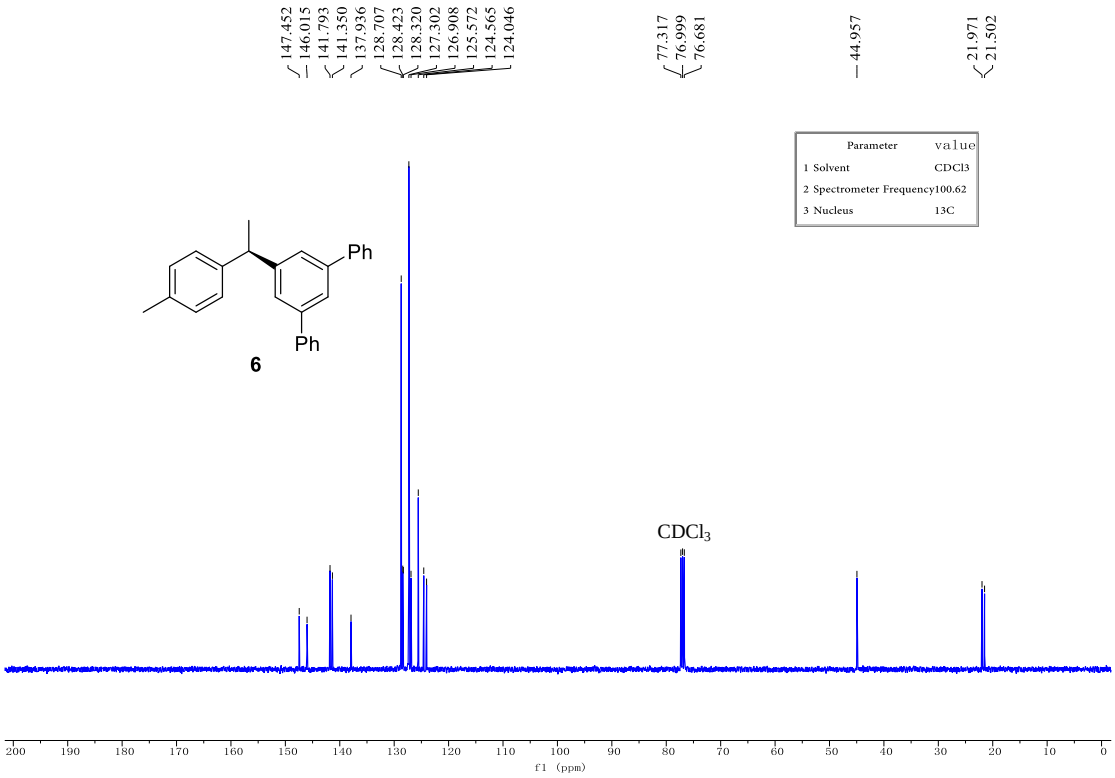
f1 (ppm)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124.046
77.317
76.999
76.681
44.957
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Parameter value
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2 Spectrometer Frequency100.62
3 Nucleus 13C
Ph
Ph
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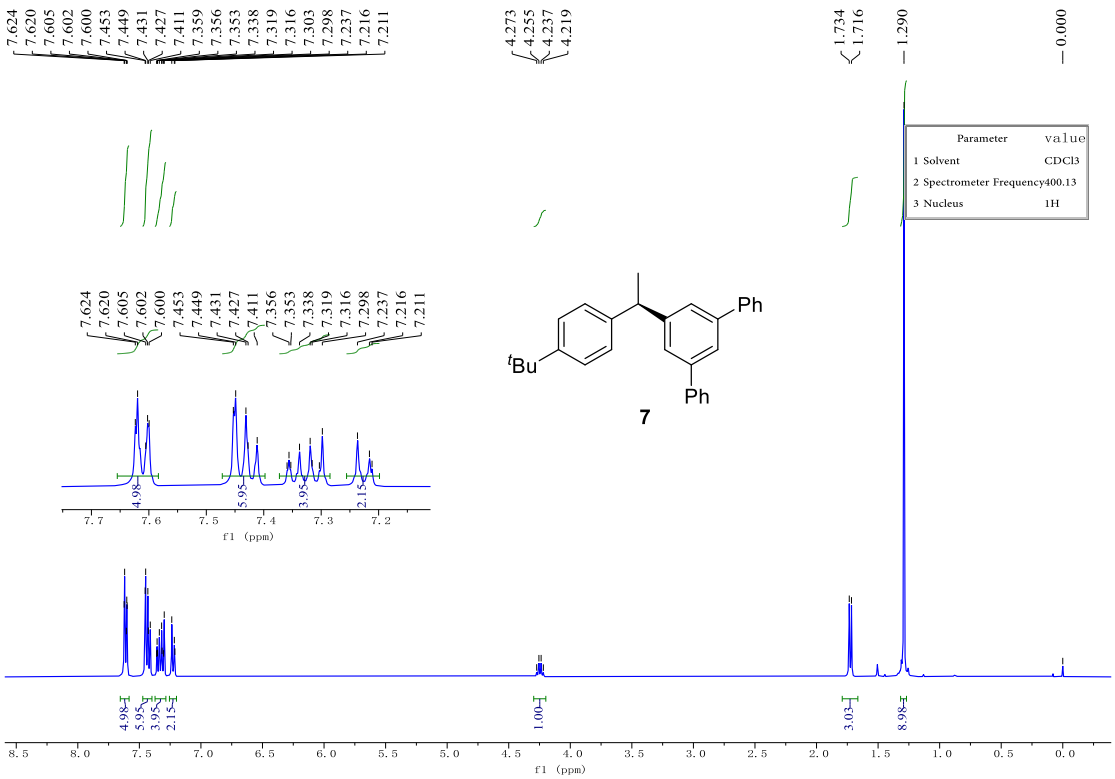
CDCl3
f1 (ppm)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7.431
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7.353
7.338
7.319
7.316
7.303
7.298
7.237
7.216
7.211
4.273
4.255
4.237
4.219
1.734
1.716
1.290
0.000
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency400.13
3 Nucleus 1H
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Ph
Ph
7
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3.95
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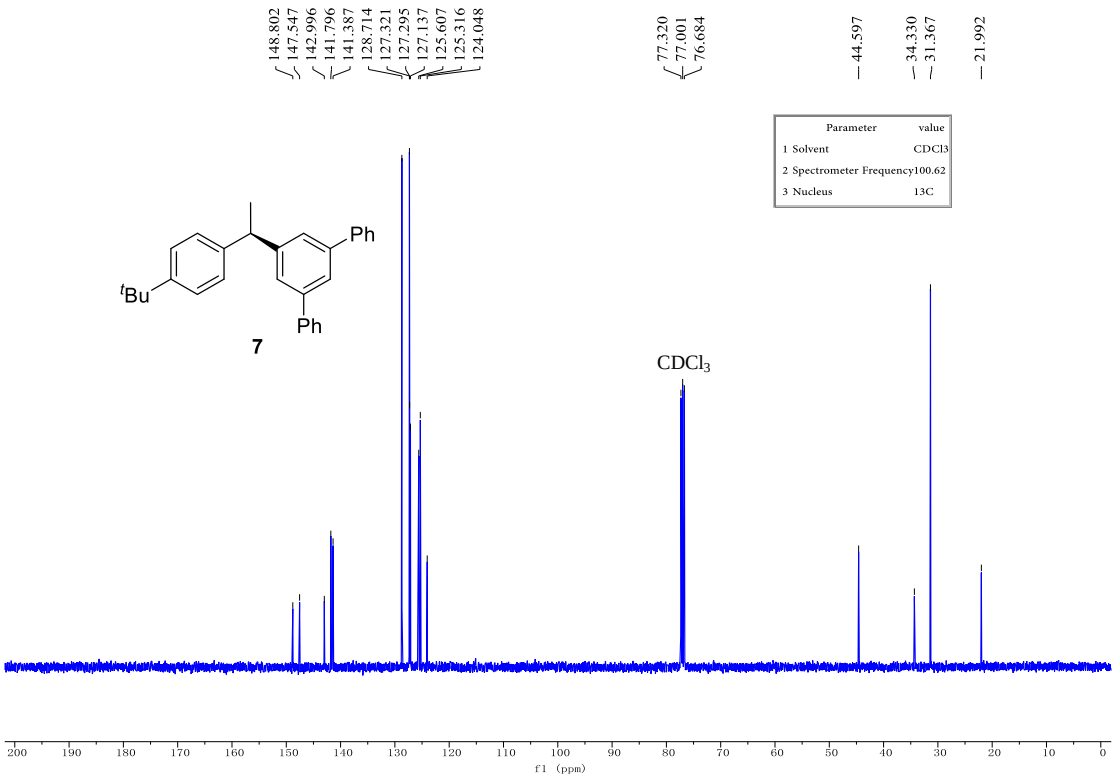
1.00
3.03
8.98
f1 (ppm)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77.001
76.684
44.597
34.330
31.367
21.992
Parameter value
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2 Spectrometer Frequency 100.62
3 Nucleus 13C
Ph
tBu
Ph
7
CDCl3
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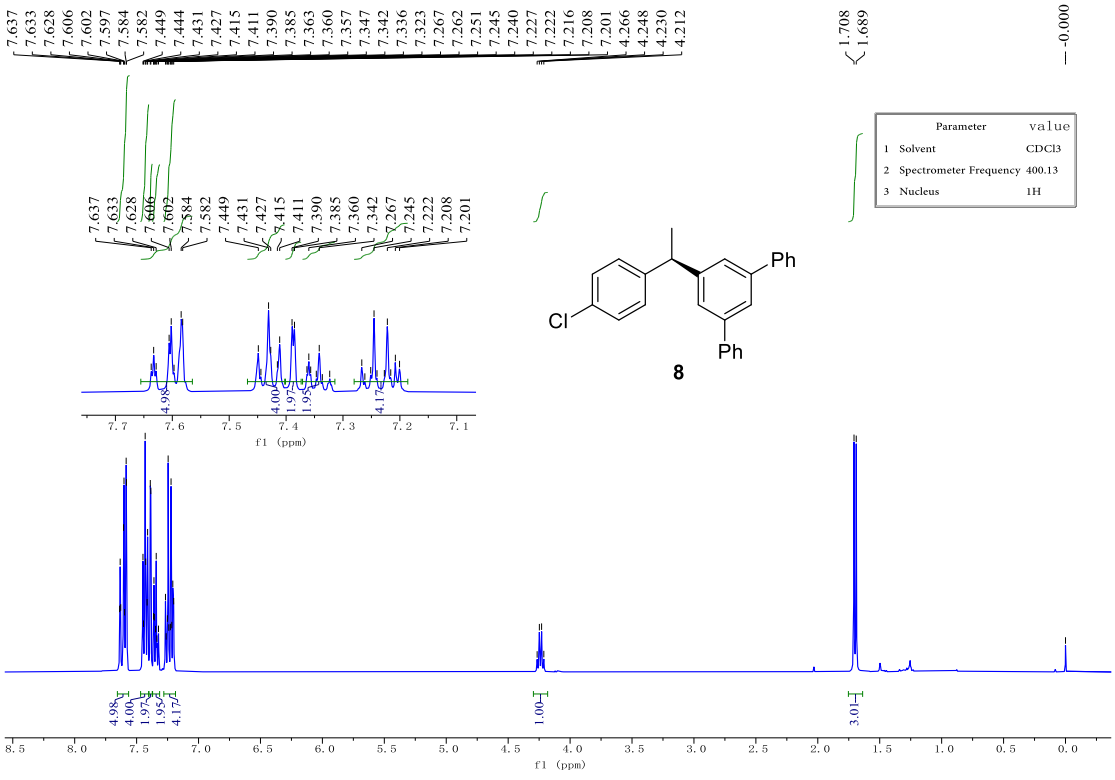
f1 (ppm)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7.411
7.390
7.385
7.363
7.360
7.357
7.347
7.342
7.336
7.323
7.267
7.262
7.251
7.245
7.240
7.227
7.222
7.216
7.208
7.201
4.266
4.248
4.230
4.212
1.708
1.689
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Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
Cl
Ph
Ph
8
4.98
4.00
1.97
1.95
4.17
1.00
3.01
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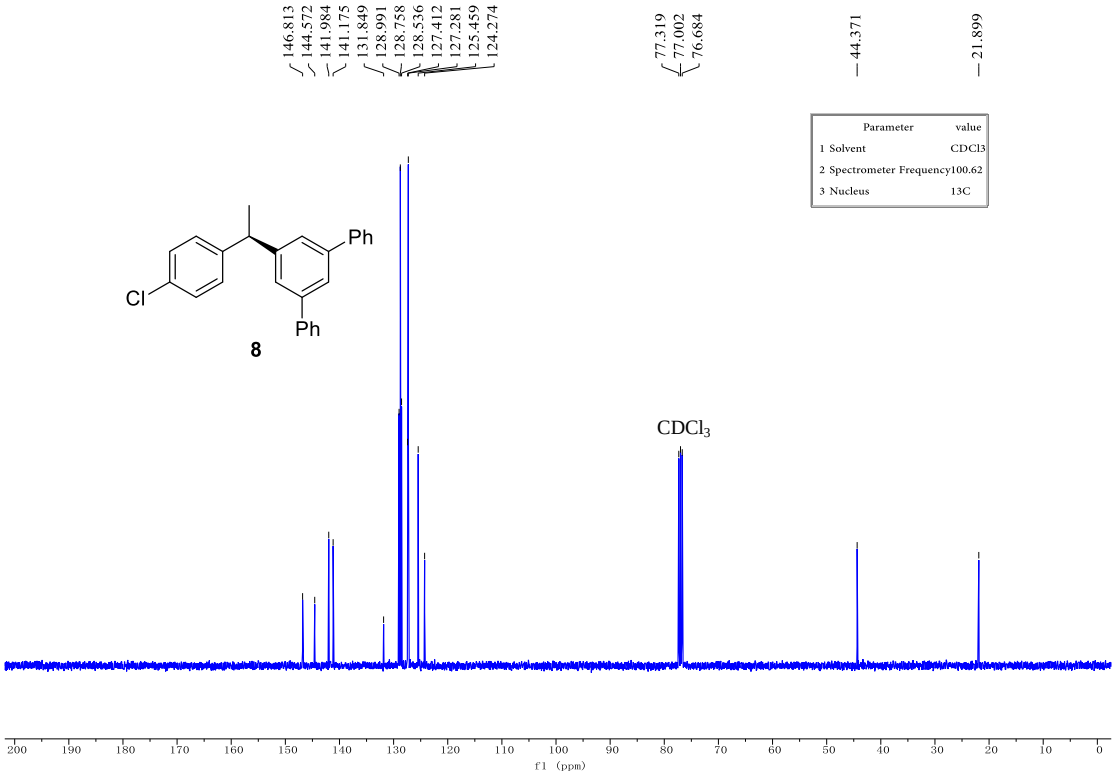
f1 (ppm)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124.274
77.319
77.002
76.684
44.371
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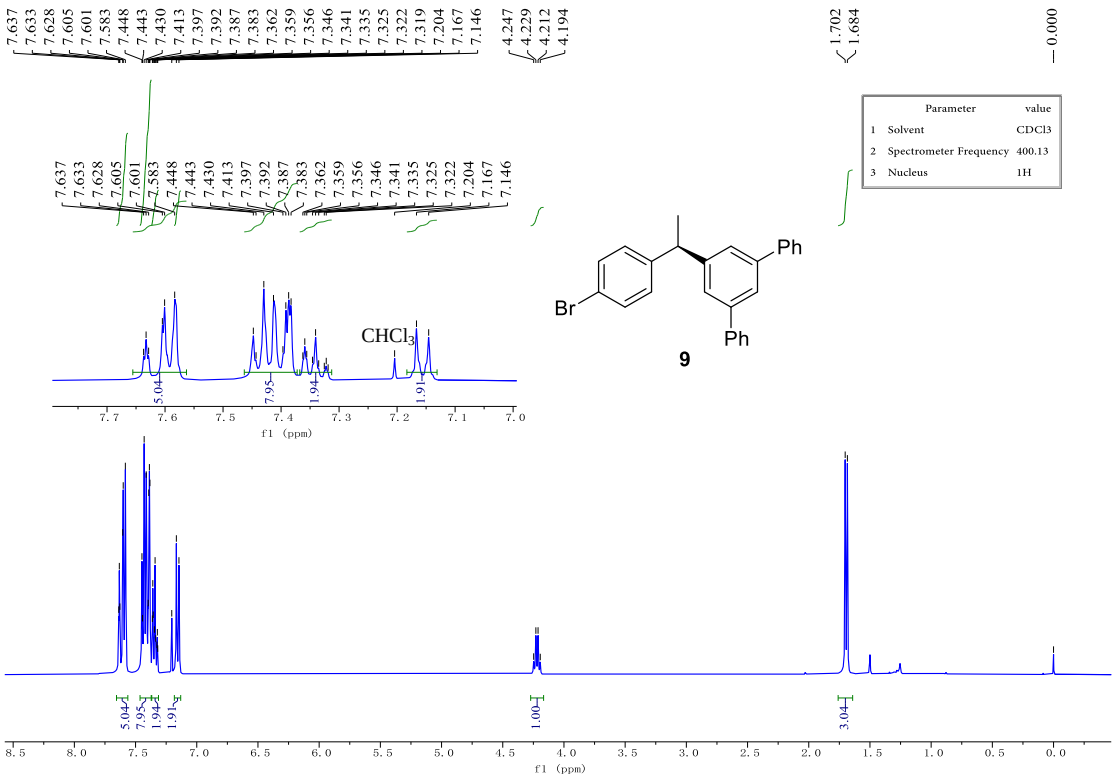
2 Spectrometer Frequency 100.62
3 Nucleus 13C
Ph
Cl
Ph
8
CDCl3
f1 (ppm)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7.362
7.359
7.356
7.346
7.341
7.335
7.325
7.322
7.319
7.204
7.167
7.146
4.247
4.229
4.212
4.194
1.702
1.684
0.000
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
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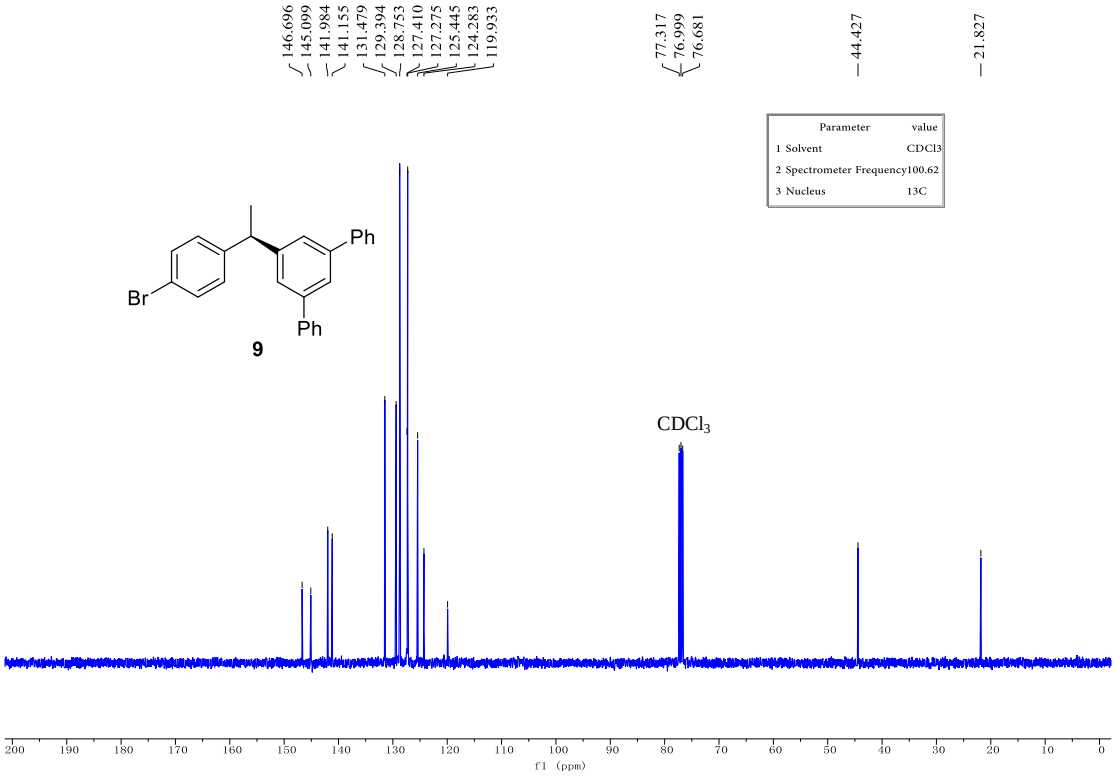
7.95
1.94
1.91
1.00
3.04
Br
Ph
Ph
9
f1 (ppm)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77.317
76.999
76.681
44.427
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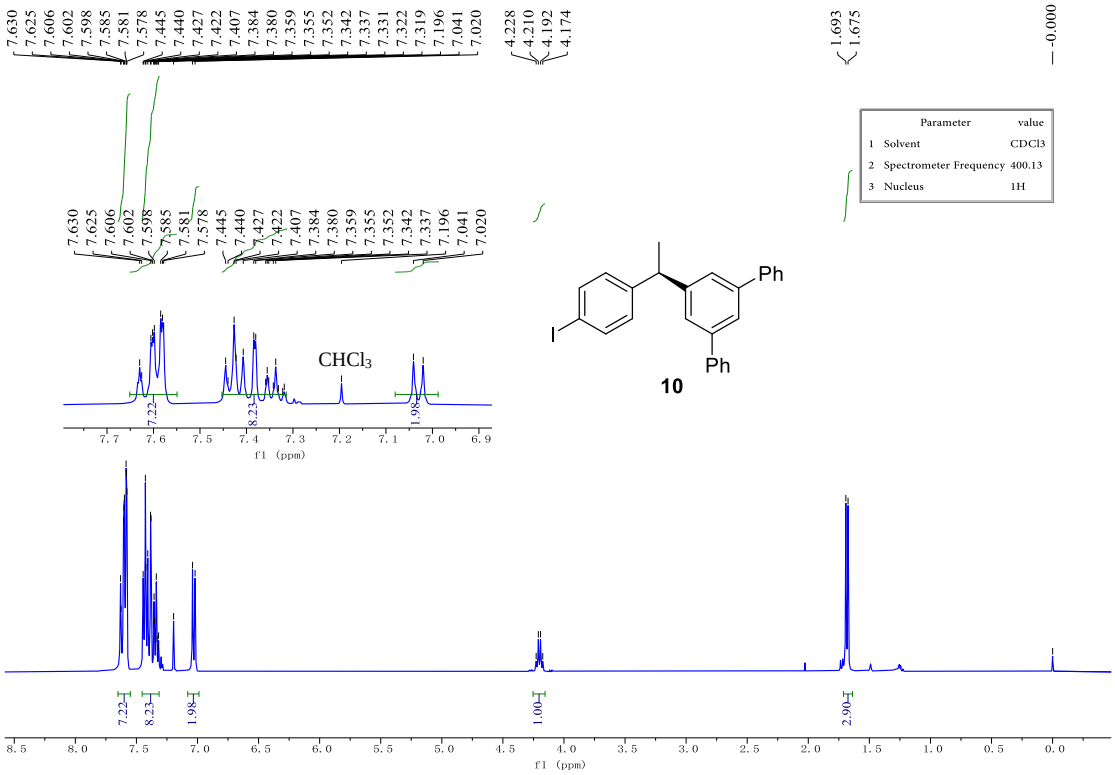
3 Nucleus 13C
Br
Ph
Ph
9
CDCl3
f1 (ppm)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7.440
7.427
7.422
7.407
7.384
7.380
7.359
7.355
7.352
7.342
7.337
7.331
7.322
7.319
7.196
7.041
7.020
4.228
4.210
4.192
4.174
1.693
1.675
-0.000
Parameter value
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2 Spectrometer Frequency 400.13
3 Nucleus 1H
CHCl3
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2.90
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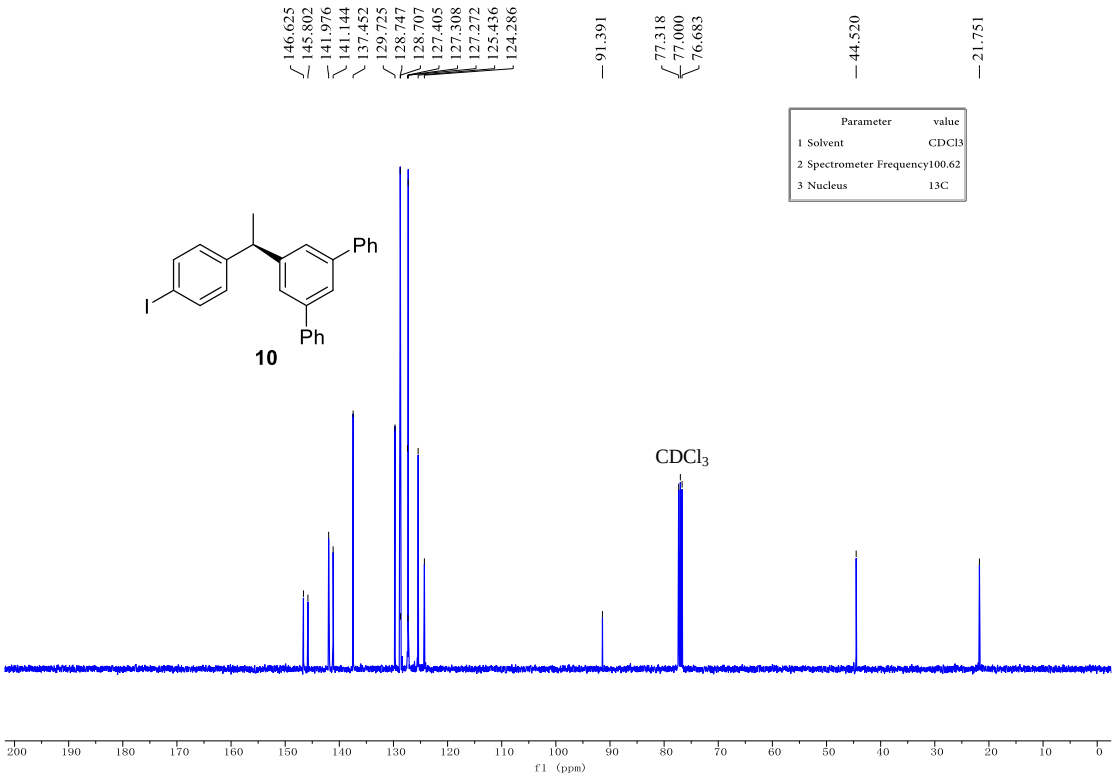
Ph
10
f1 (ppm)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125.436
124.286
91.391
77.318
77.000
76.683
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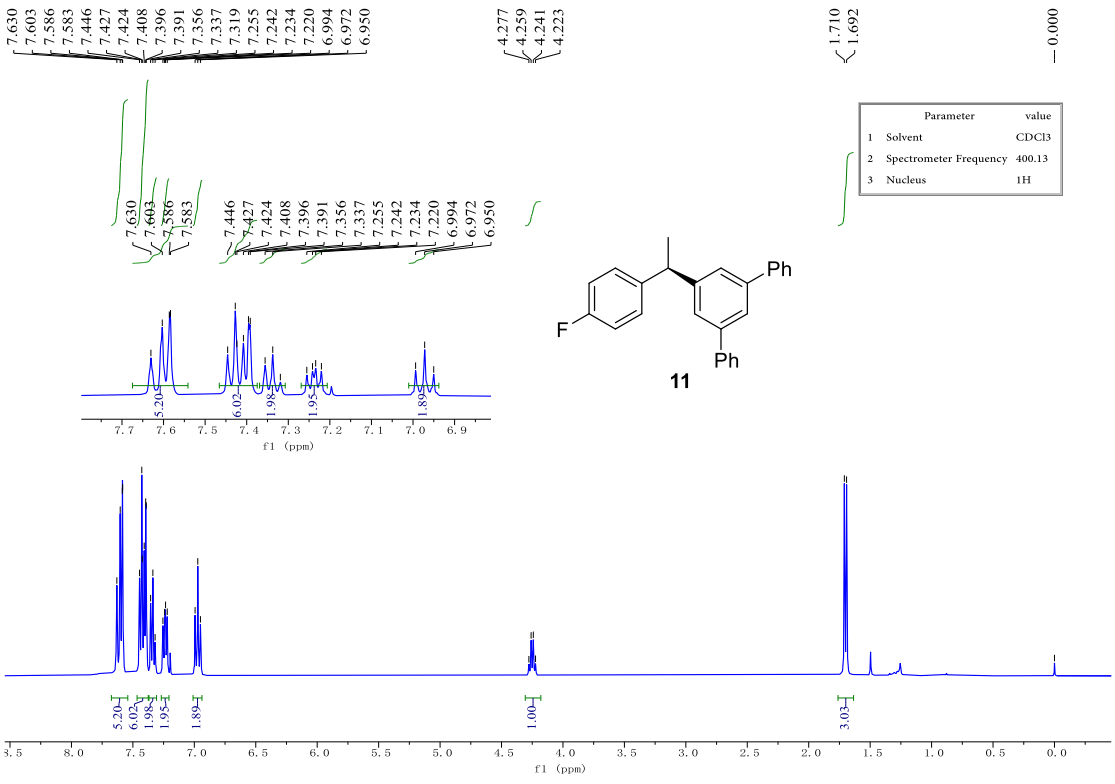
2 Spectrometer Frequency 100.62
3 Nucleus 13C
Ph
I
Ph
10
CDCl3
f1 (ppm)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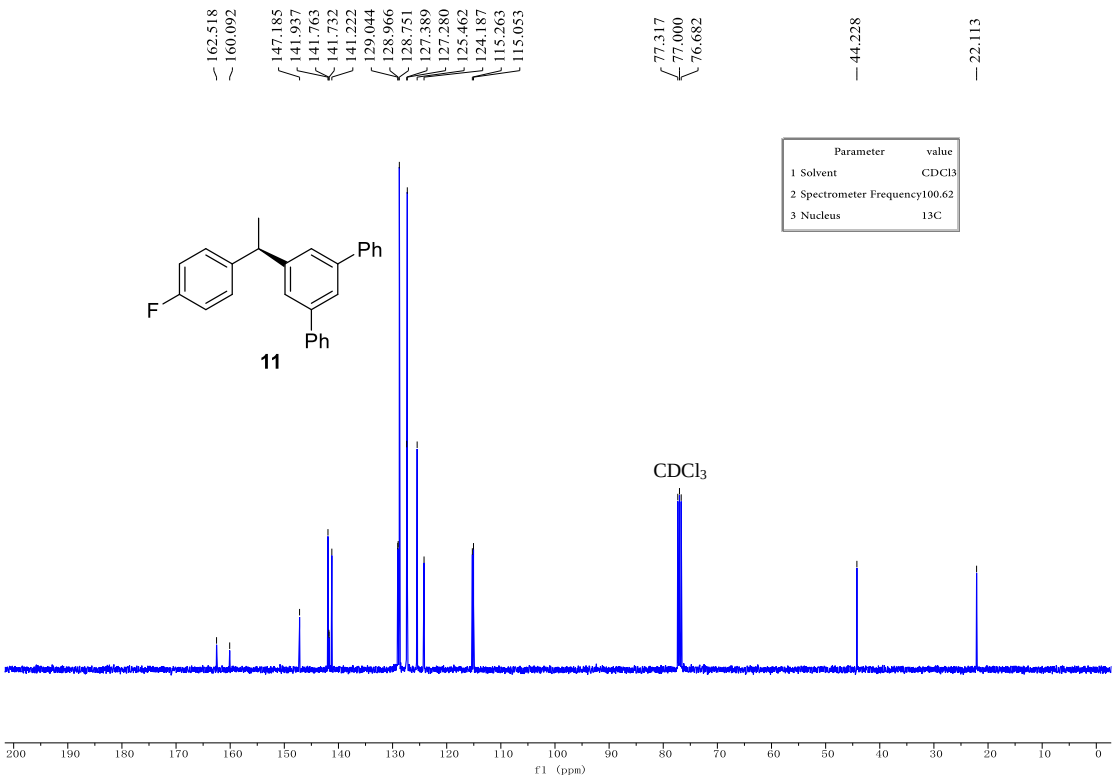
7.319
7.255
7.242
7.234
7.220
6.994
6.972
6.950
4.277
4.259
4.241
4.223
1.710
1.692
0.000
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
F
Ph
Ph
11
5.20
6.02
1.98
1.95
1.89
1.00
3.03
f1 (ppm)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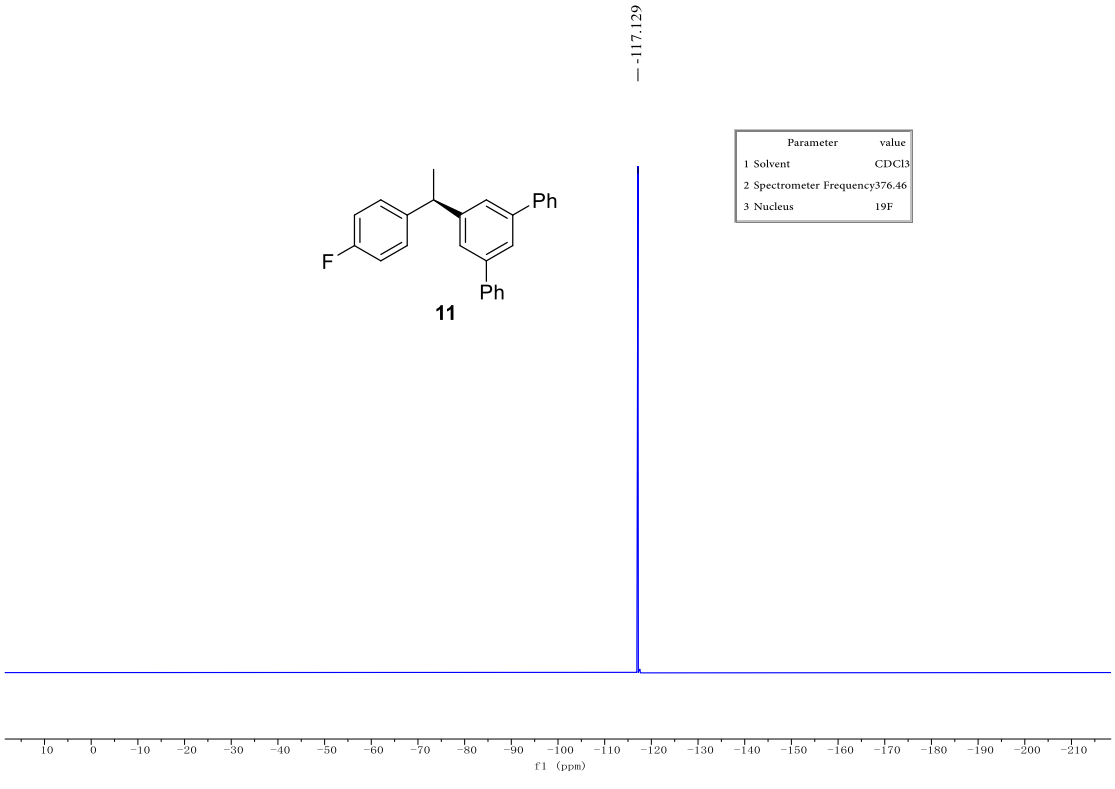
127.280
125.462
124.187
115.263
115.053
77.317
77.000
76.682
44.228
22.113
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
Ph
F
Ph
11
CDCl3
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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Parameter value
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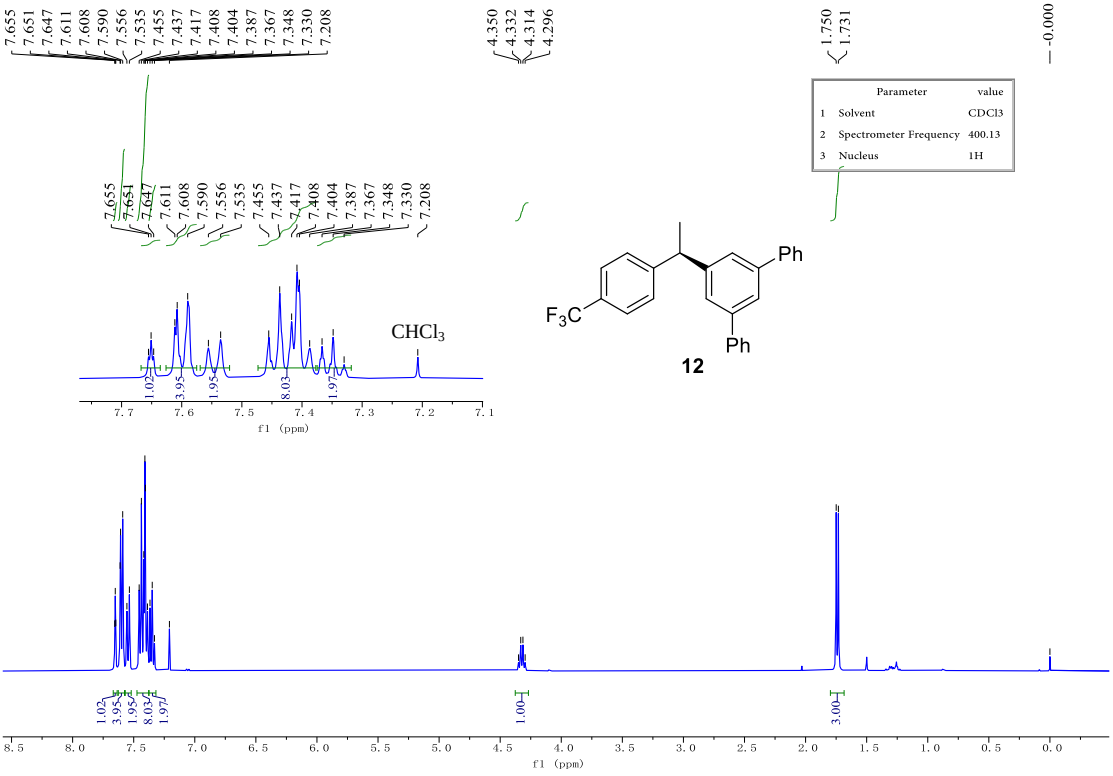
2 Spectrometer Frequency 376.46
3 Nucleus 19F
Ph
F
Ph
11
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)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7.367
7.348
7.330
7.208
4.350
4.332
4.314
4.296
1.750
1.731
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Parameter value
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2 Spectrometer Frequency 400.13
3 Nucleus 1H
CHCl3
Ph
Ph
F3C
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1.97
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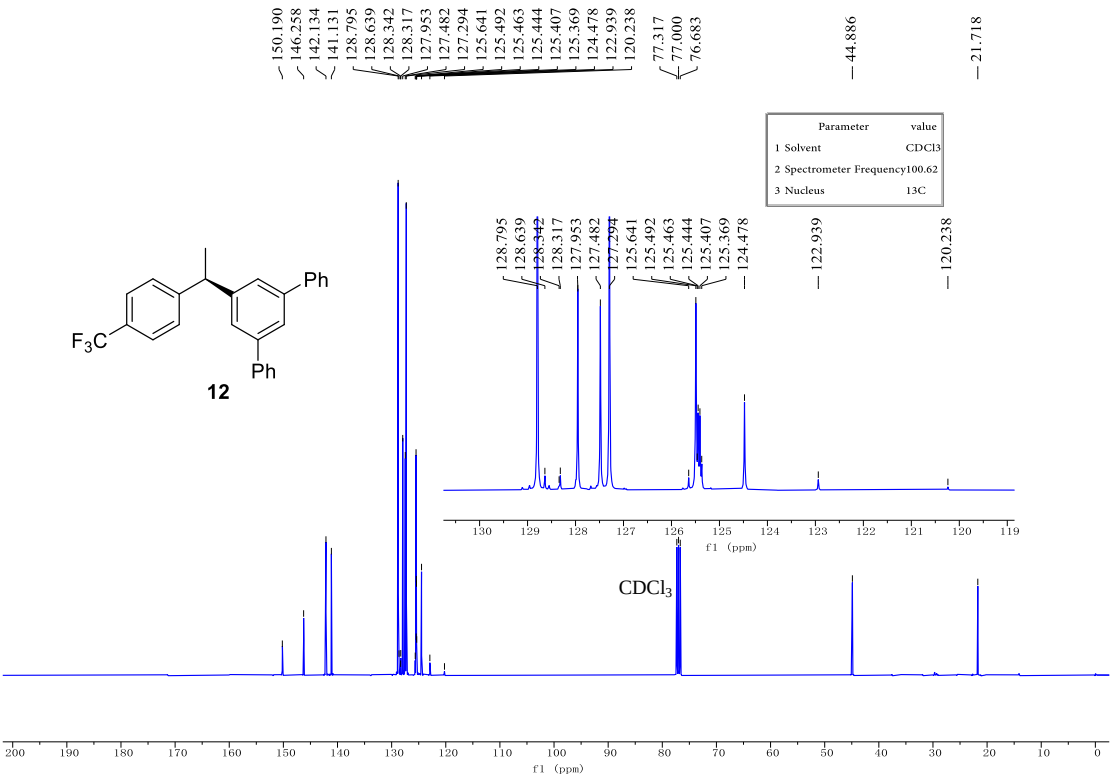
3.00
f1 (ppm)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127.294
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125.463
125.444
125.407
125.369
124.478
122.939
120.238
77.317
77.000
76.683
44.886
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Parameter value
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2 Spectrometer Frequency 100.62
3 Nucleus 13C
Ph
Ph
F3C
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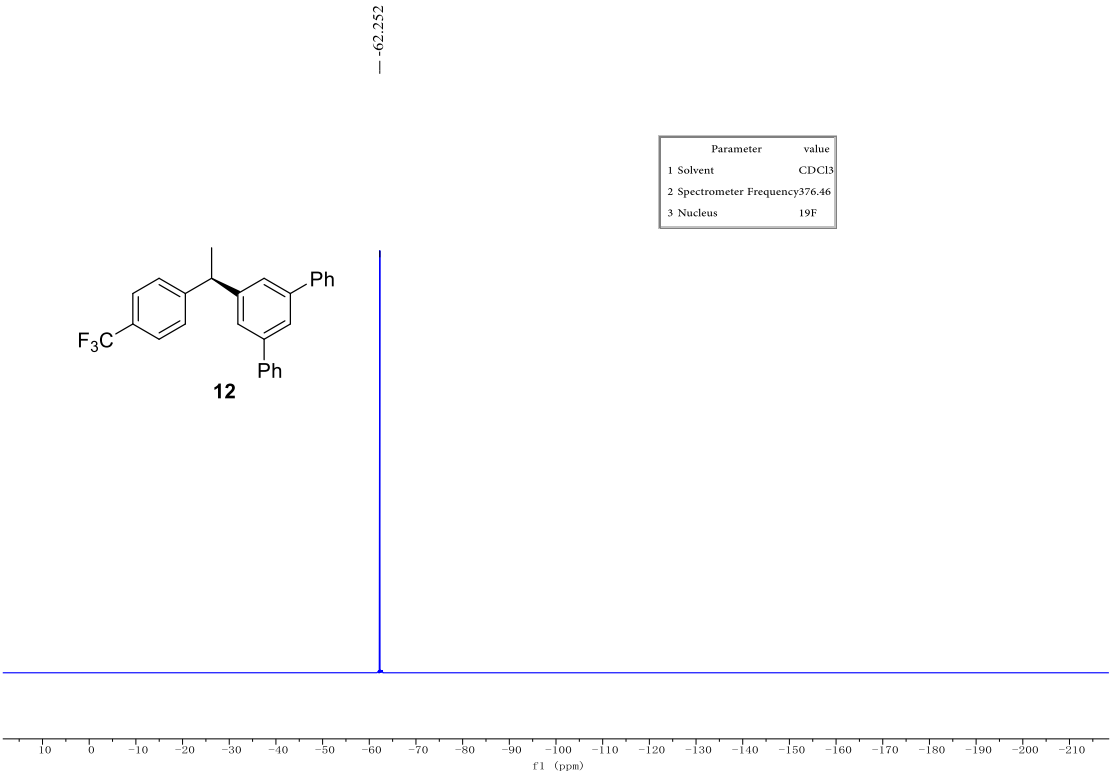
CDCl3
f1 (ppm)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F3C
Ph
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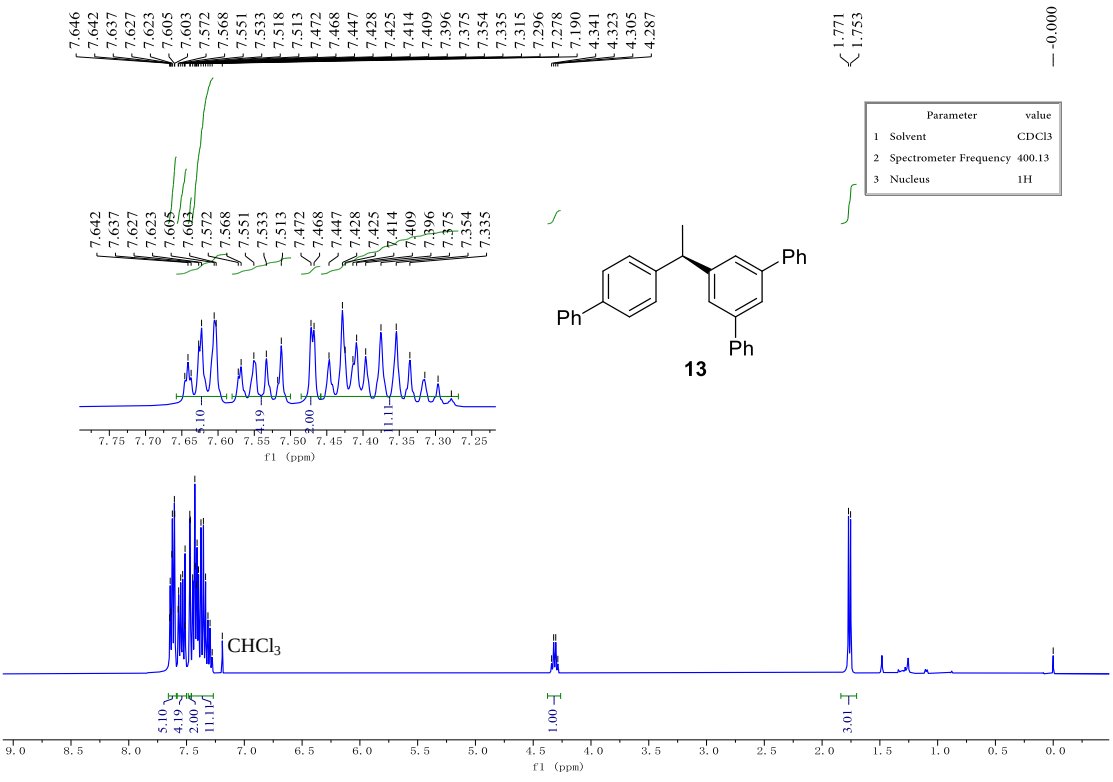
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7.513
7.472
7.468
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7.428
7.425
7.414
7.409
7.396
7.375
7.354
7.335
7.315
7.296
7.278
7.190
4.341
4.323
4.305
4.287
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1.753
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Parameter value
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2 Spectrometer Frequency 400.13
3 Nucleus 1H
Ph
Ph
Ph
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1.00
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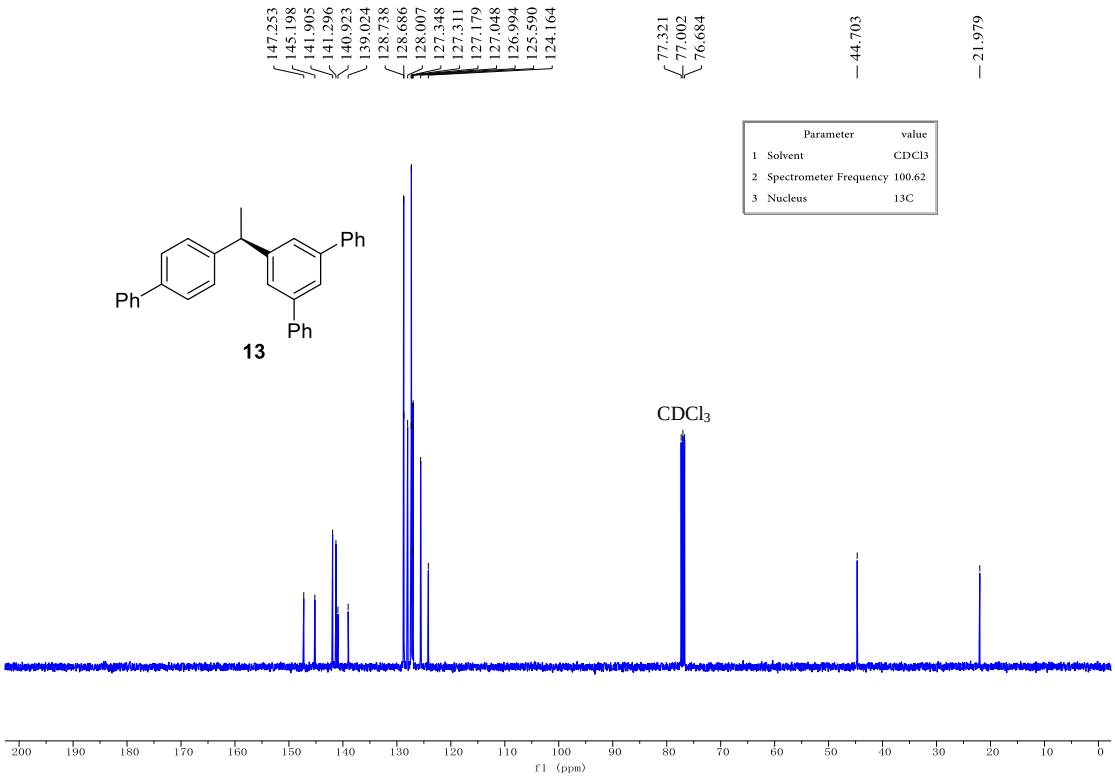
CHCl3
f1 (ppm)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127.048
126.994
125.590
124.164
77.321
77.002
76.684
44.703
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3 Nucleus 13C
Ph
Ph
Ph
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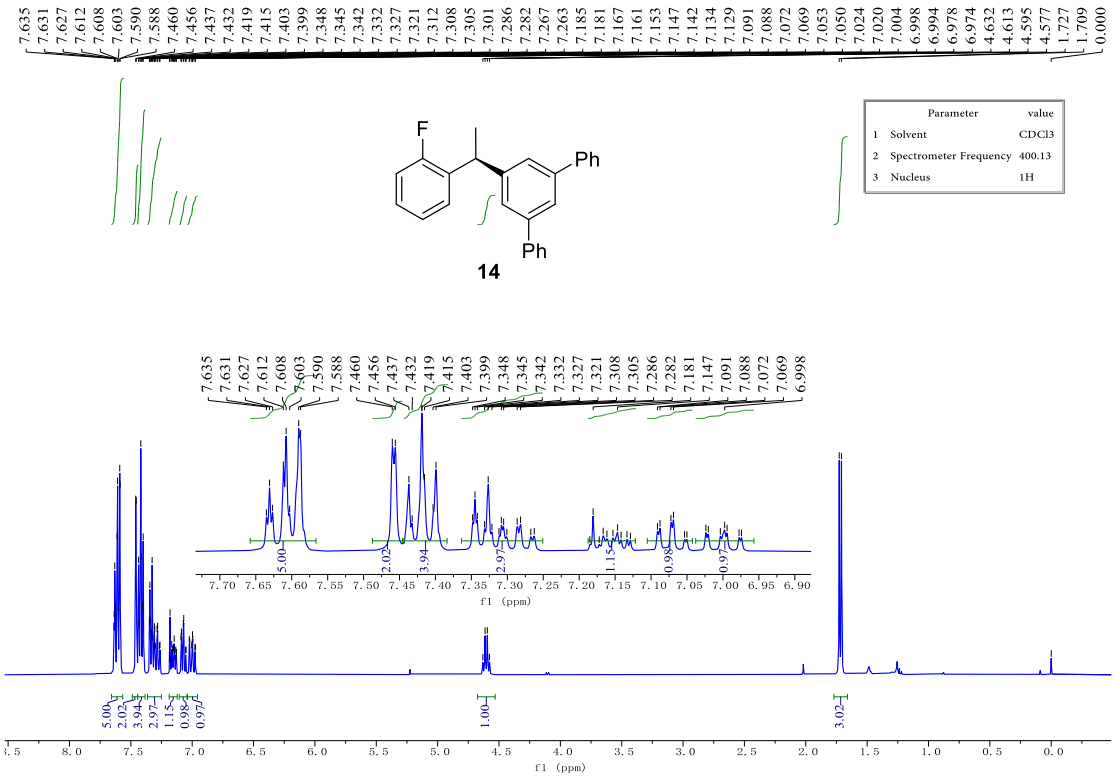
CDCl3
f1 (ppm)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7.399
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7.342
7.332
7.327
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Parameter value
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2 Spectrometer Frequency 400.13
3 Nucleus 1H
F
Ph
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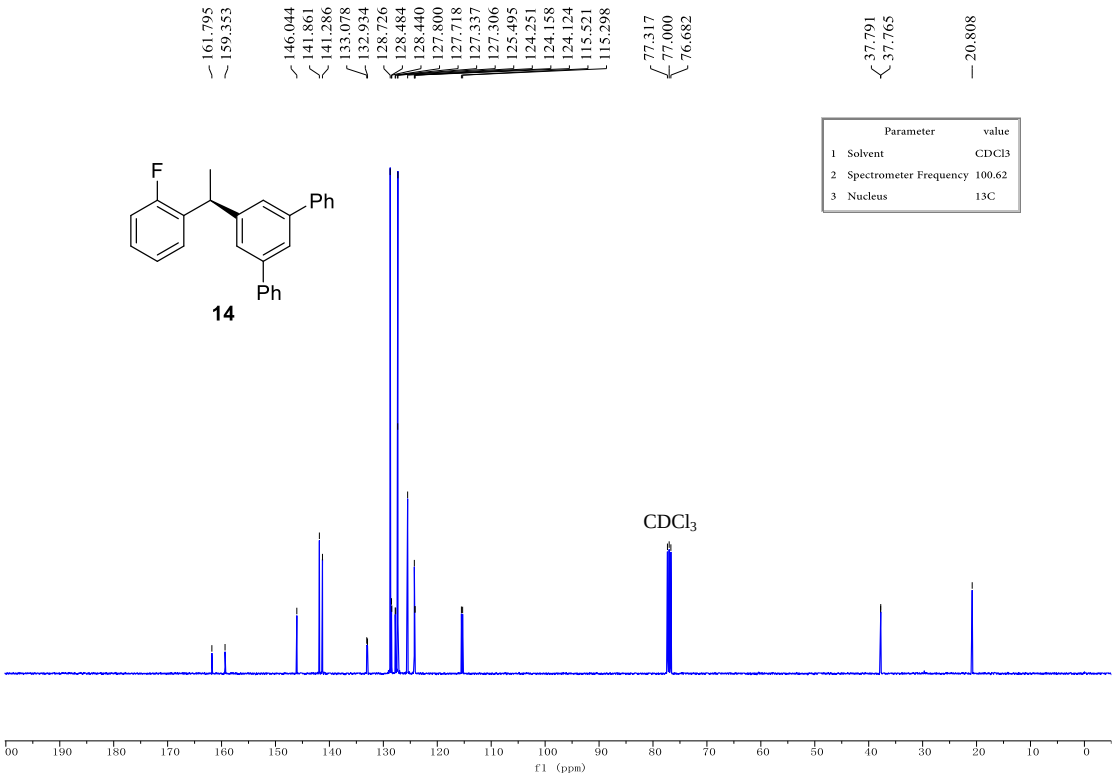
f1 (ppm)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127.718
127.337
127.306
125.495
124.251
124.158
124.124
115.521
115.298
77.317
77.000
76.682
37.791
37.765
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Parameter value
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2 Spectrometer Frequency 100.62
3 Nucleus 13C
F
Ph
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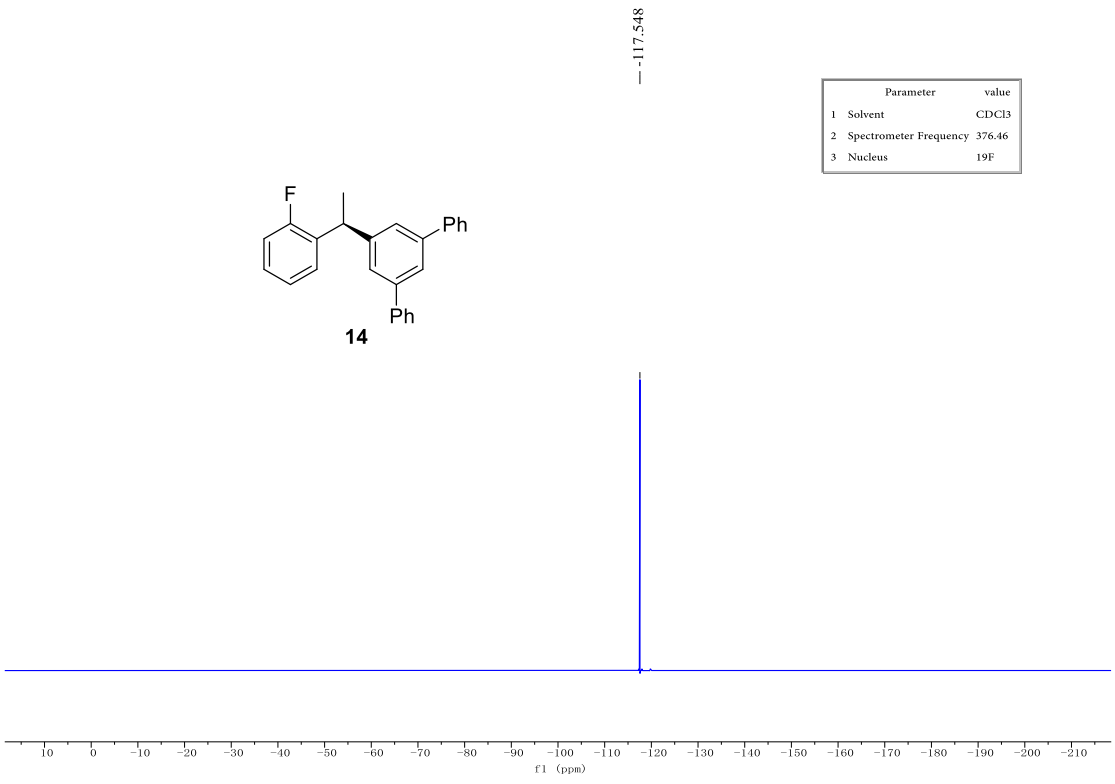
CDCl3
f1 (ppm)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Parameter value
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2 Spectrometer Frequency 376.46
3 Nucleus 19F
F
Ph
Ph
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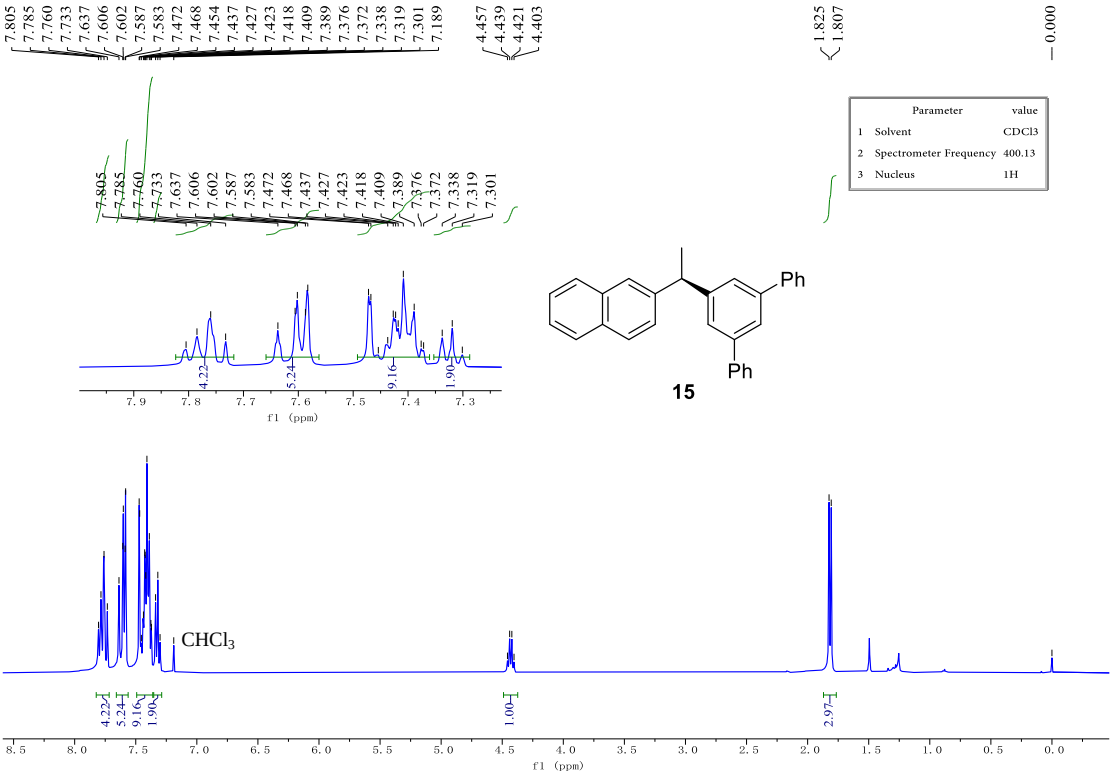
f1 (ppm)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7.418
7.409
7.389
7.376
7.372
7.338
7.319
7.301
7.189
4.457
4.439
4.421
4.403
1.825
1.807
0.000
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
Ph
Ph
15
4.22
5.24
9.16
1.90
f1 (ppm)
CHCl3
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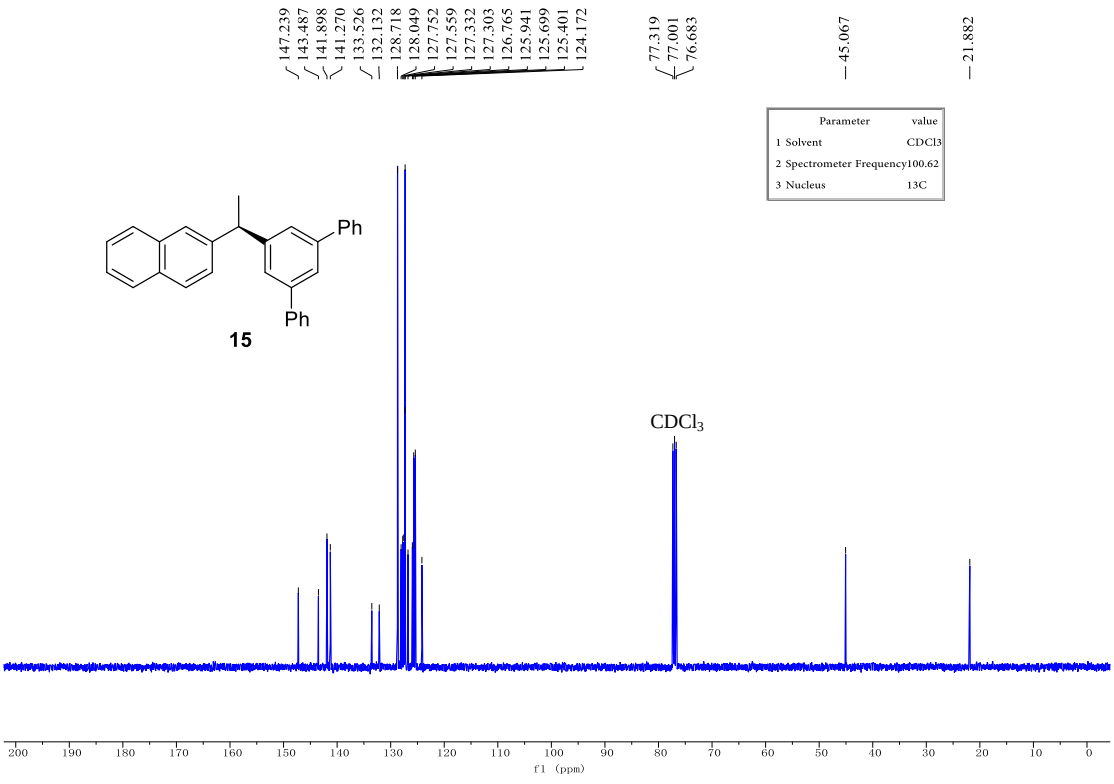
9.16
1.90
1.00
2.97
f1 (ppm)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125.941
125.699
125.401
124.172
77.319
77.001
76.683
45.067
21.882
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3 Nucleus 13C
Ph
Ph
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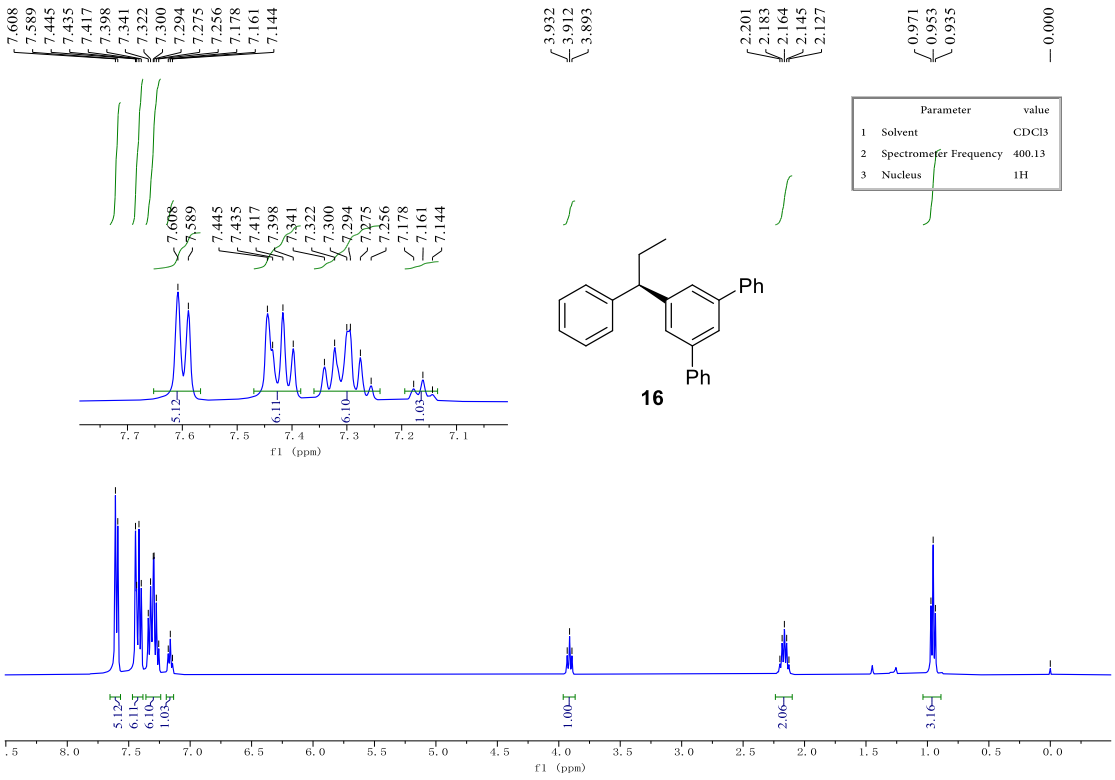
CDCl3
f1 (ppm)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7.161
7.144
3.932
3.912
3.893
2.201
2.183
2.164
2.145
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Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
Ph
Ph
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6.11
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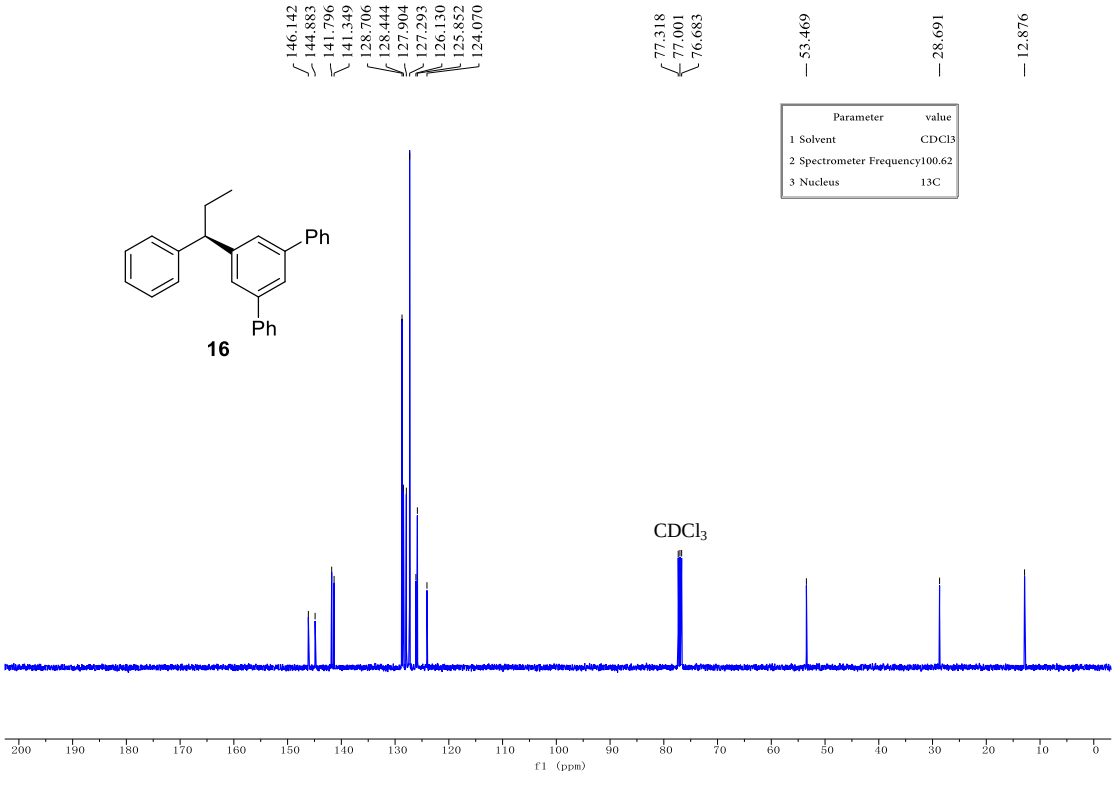
2.06
3.16
f1 (ppm)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141.796
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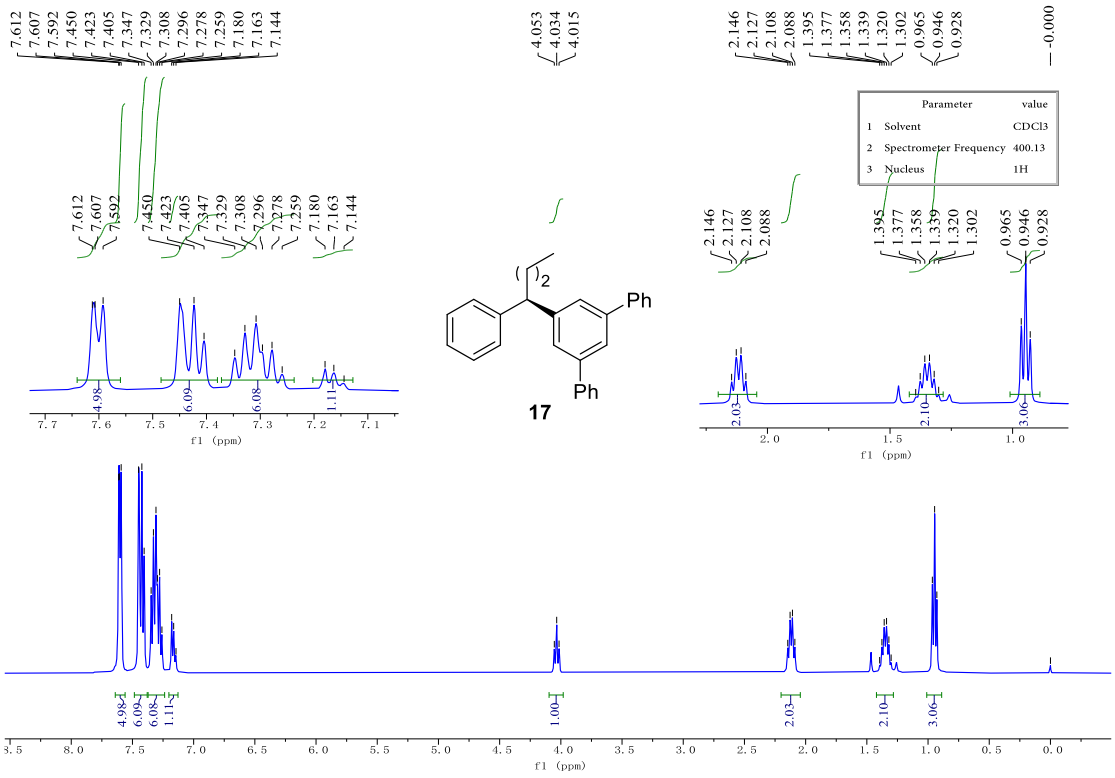
128.444
127.904
127.293
126.130
125.852
124.070
77.318
77.001
76.683
53.469
28.691
12.876
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
Ph
Ph
16
CDCl3
f1 (ppm)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7.607
7.592
7.450
7.423
7.405
7.347
7.329
7.308
7.296
7.278
7.259
7.180
7.163
7.144
4.053
4.034
4.015
2.146
2.127
2.108
2.088
1.395
1.377
1.358
1.339
1.320
1.302
0.965
0.946
0.928
-0.000
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
Ph
Ph
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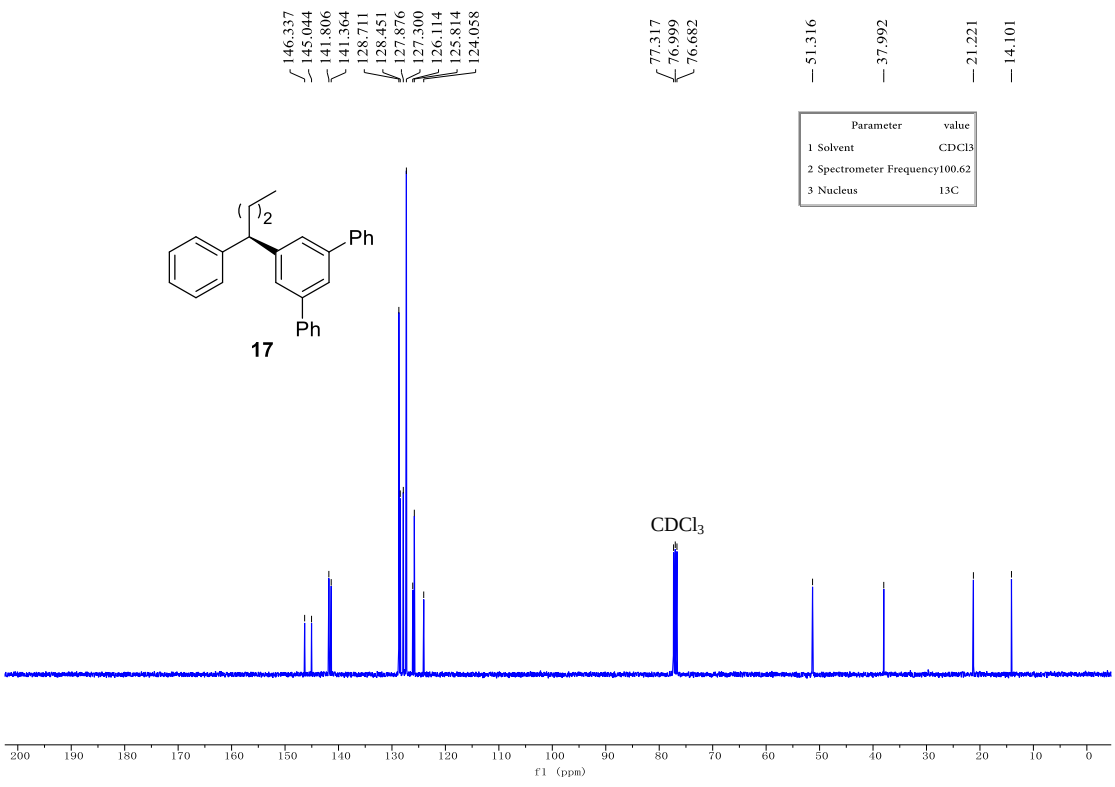
4.98
6.09
6.08
1.11
2.03
2.10
3.06
1.00
f1 (ppm)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141.806
141.364
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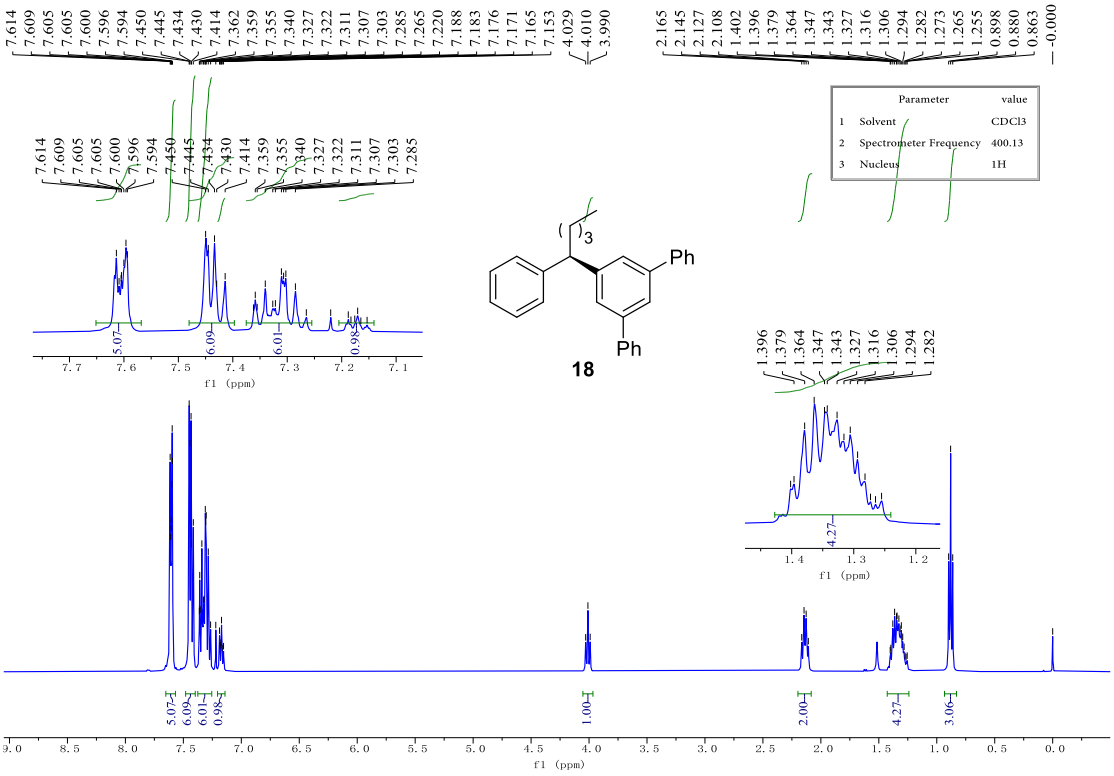
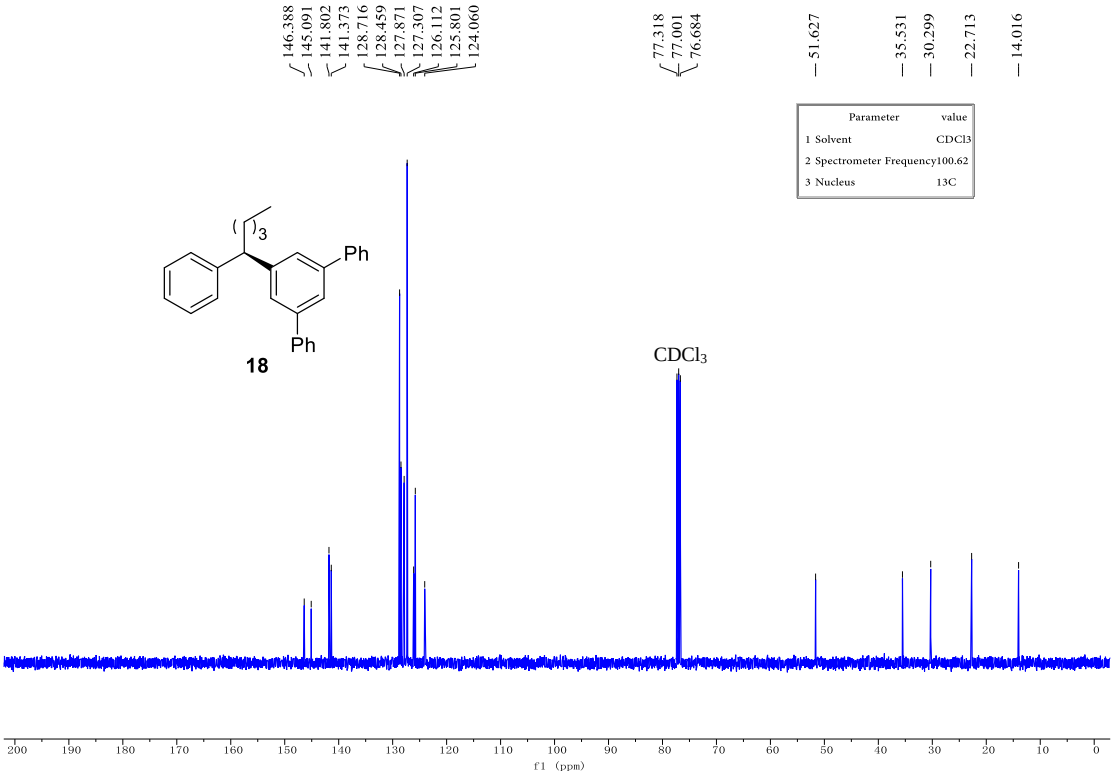
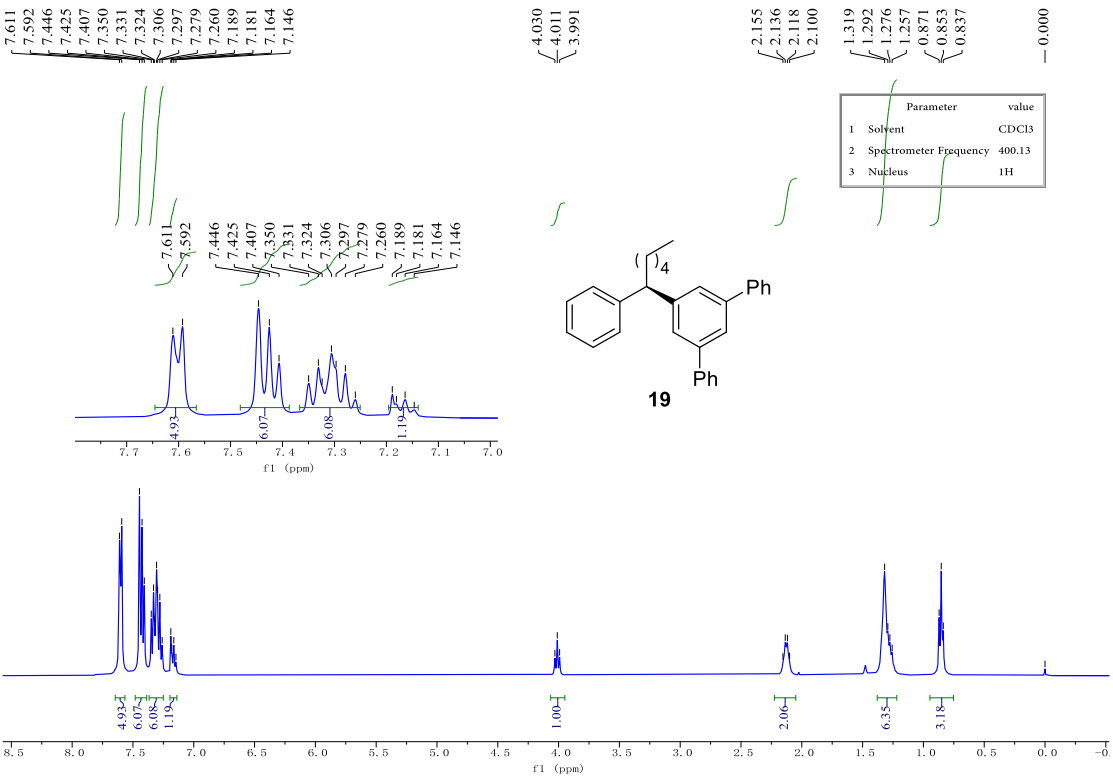
128.451
127.876
127.300
126.114
125.814
124.058
77.317
76.999
76.682
51.316
37.992
21.221
14.101
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
Ph
Ph
17
CDCl3
f1 (ppm)


Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
18
f1 (ppm)


Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
18
CDCl3
f1 (ppm)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7.592
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7.425
7.407
7.350
7.331
7.324
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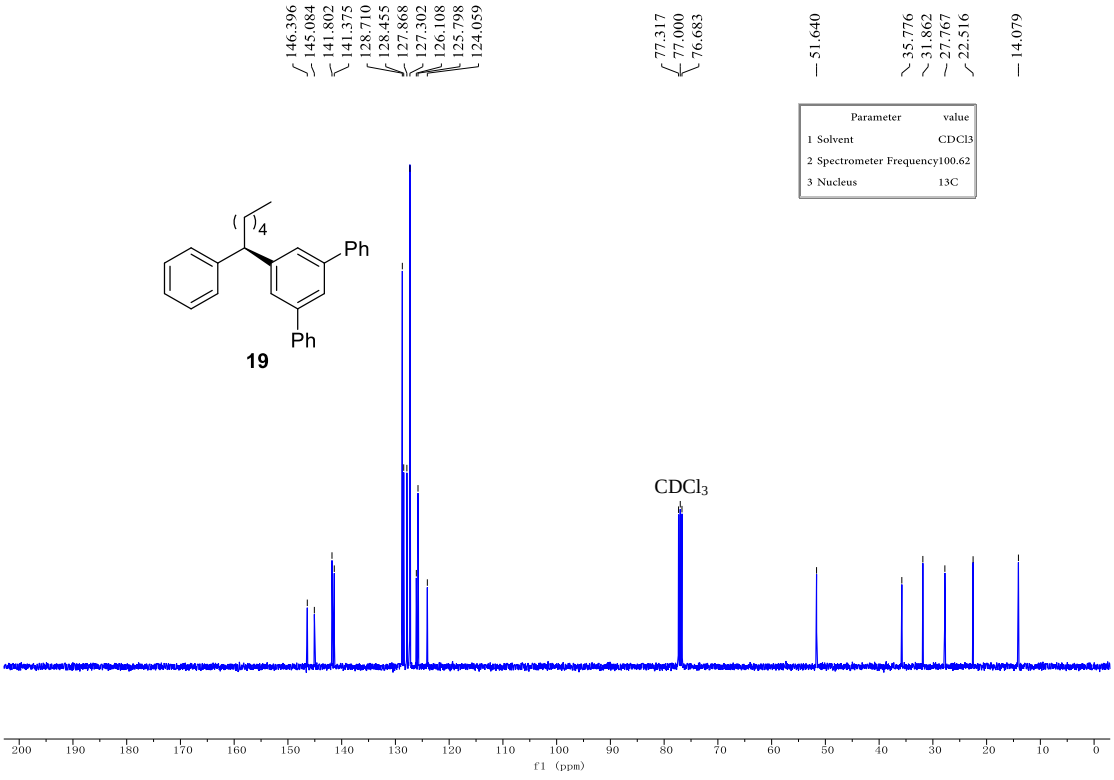
7.297
7.279
7.260
7.189
7.181
7.164
7.146
4.030
4.011
3.991
2.155
2.136
2.118
2.100
1.319
1.292
1.276
1.257
0.871
0.853
0.837
0.000
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
4.93
6.07
6.08
1.19
1.00
2.06
6.35
3.18
f1 (ppm)
Ph
Ph
19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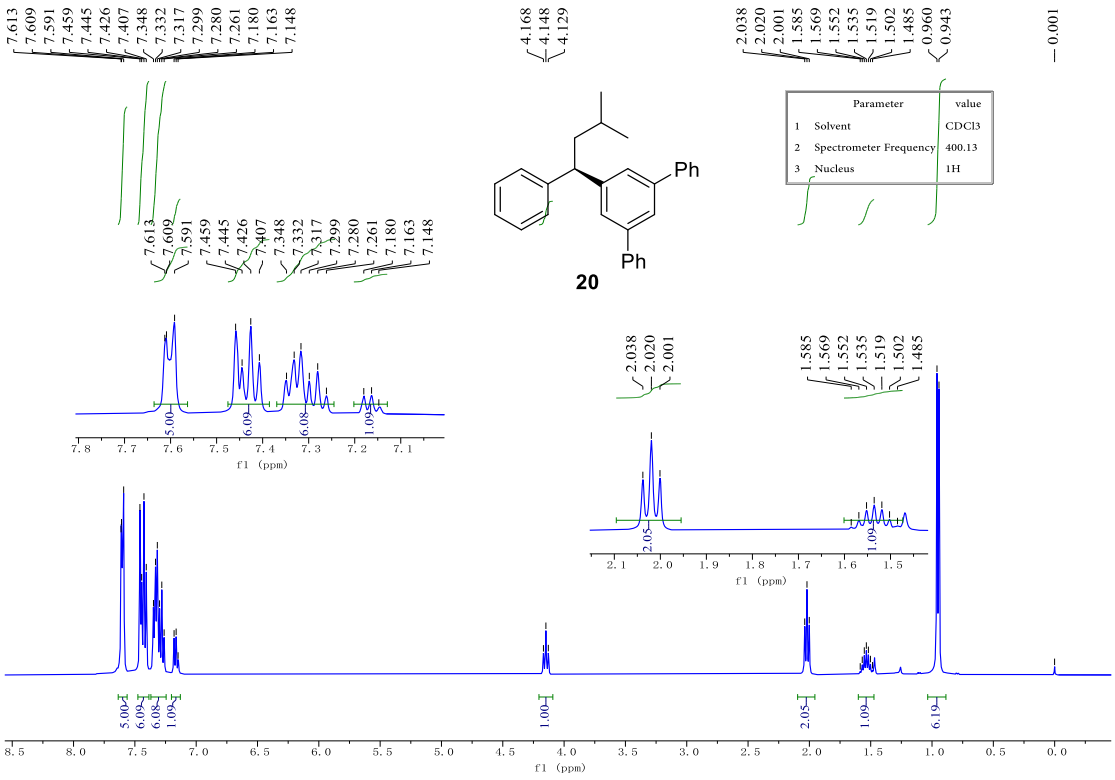
141.802
141.375
128.710
128.455
127.868
127.302
126.108
125.798
124.059
77.317
77.000
76.683
51.640
35.776
31.862
27.767
22.516
14.079
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
CDCl3
f1 (ppm)
Ph
Ph
19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7.591
7.459
7.445
7.426
7.407
7.348
7.332
7.317
7.299
7.280
7.261
7.180
7.163
7.148
4.168
4.148
4.129
2.038
2.020
2.001
1.585
1.569
1.552
1.535
1.519
1.502
1.485
0.960
0.943
0.001
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
Ph
Ph
20
f1 (ppm)
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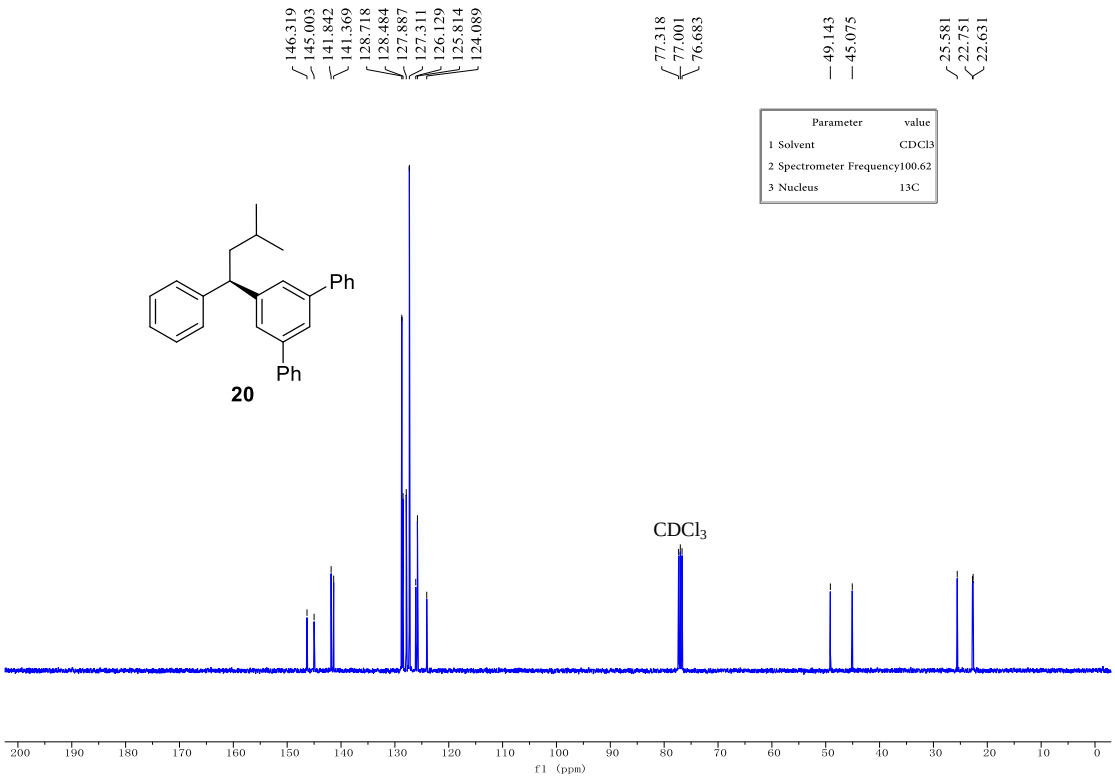
6.09
6.08
1.09
2.05
1.00
6.19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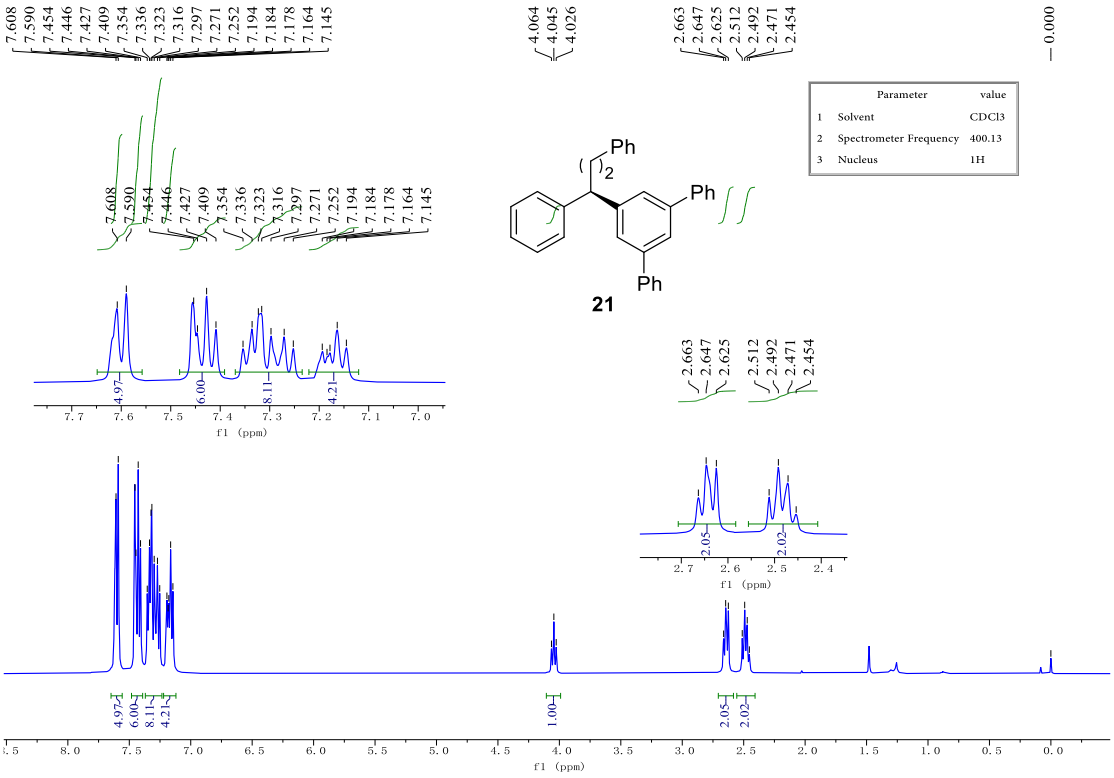
145.003
141.842
141.369
128.718
128.484
127.887
127.311
126.129
125.814
124.089
77.318
77.001
76.683
49.143
45.075
25.581
22.751
22.631
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
Ph
Ph
20
CDCl3
f1 (ppm)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7.446
7.427
7.409
7.354
7.336
7.323
7.316
7.297
7.271
7.252
7.194
7.184
7.178
7.164
7.145
4.064
4.045
4.026
2.663
2.647
2.625
2.512
2.492
2.471
2.454
0.000
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
Ph
Ph
Ph
21
4.97
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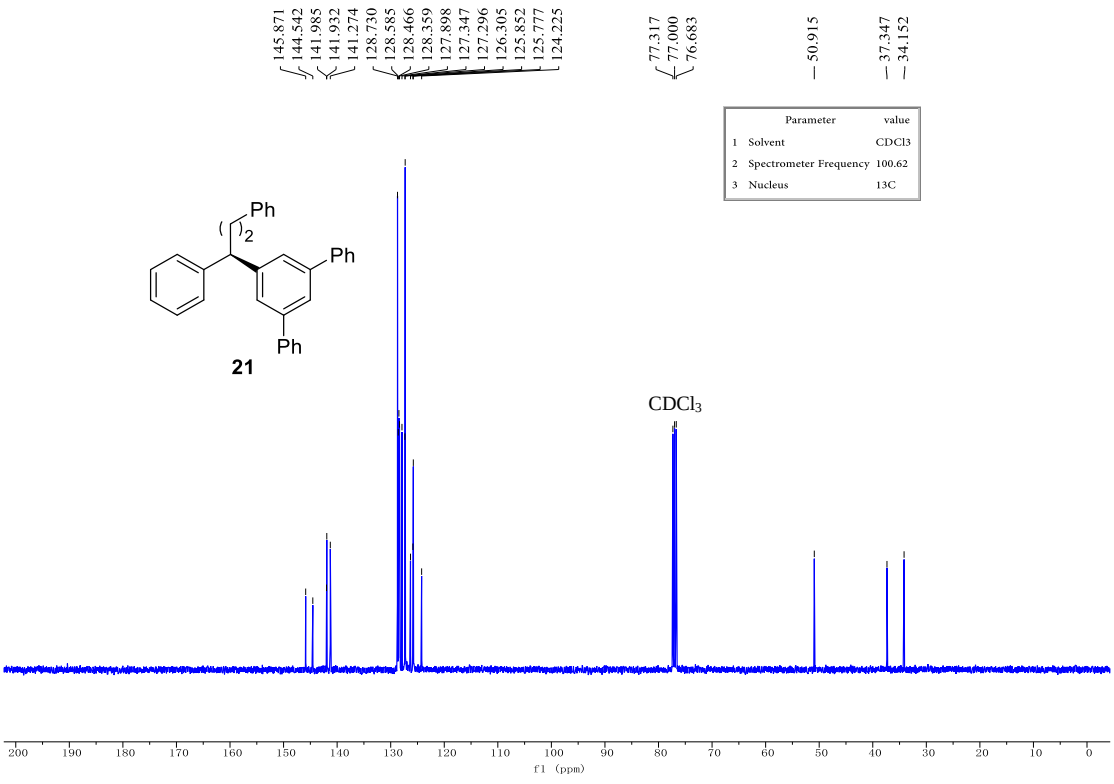
8.11
4.21
1.00
2.05
2.02
f1 (ppm)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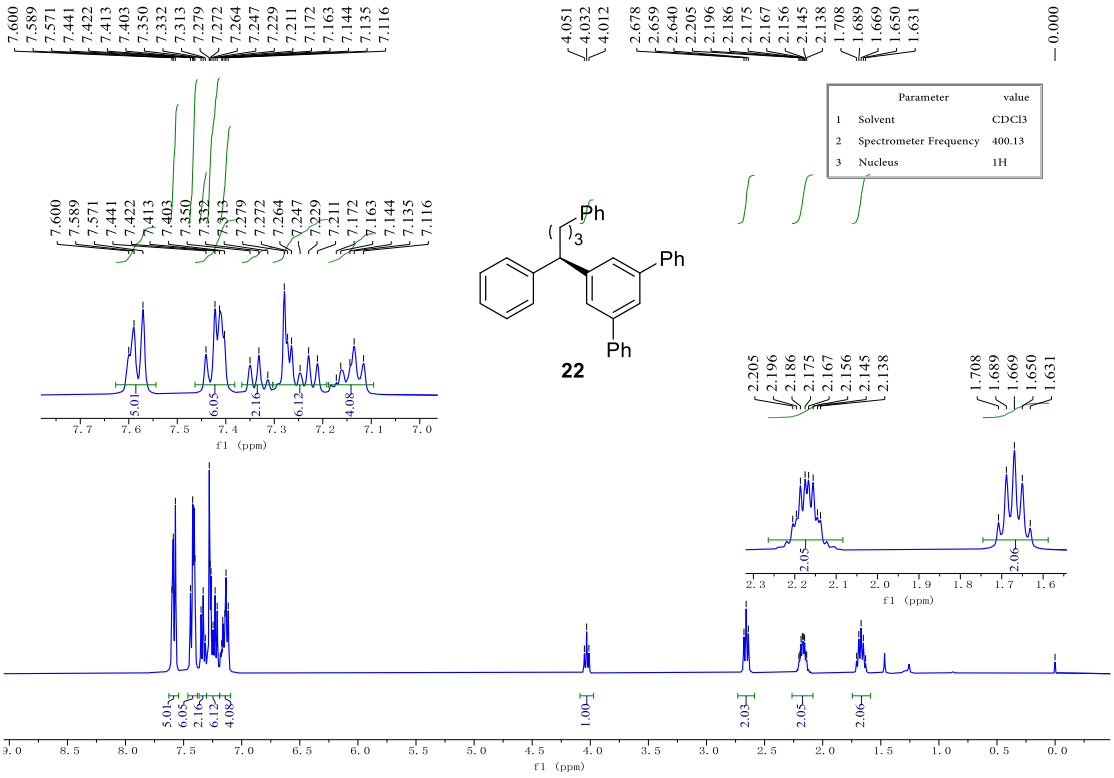
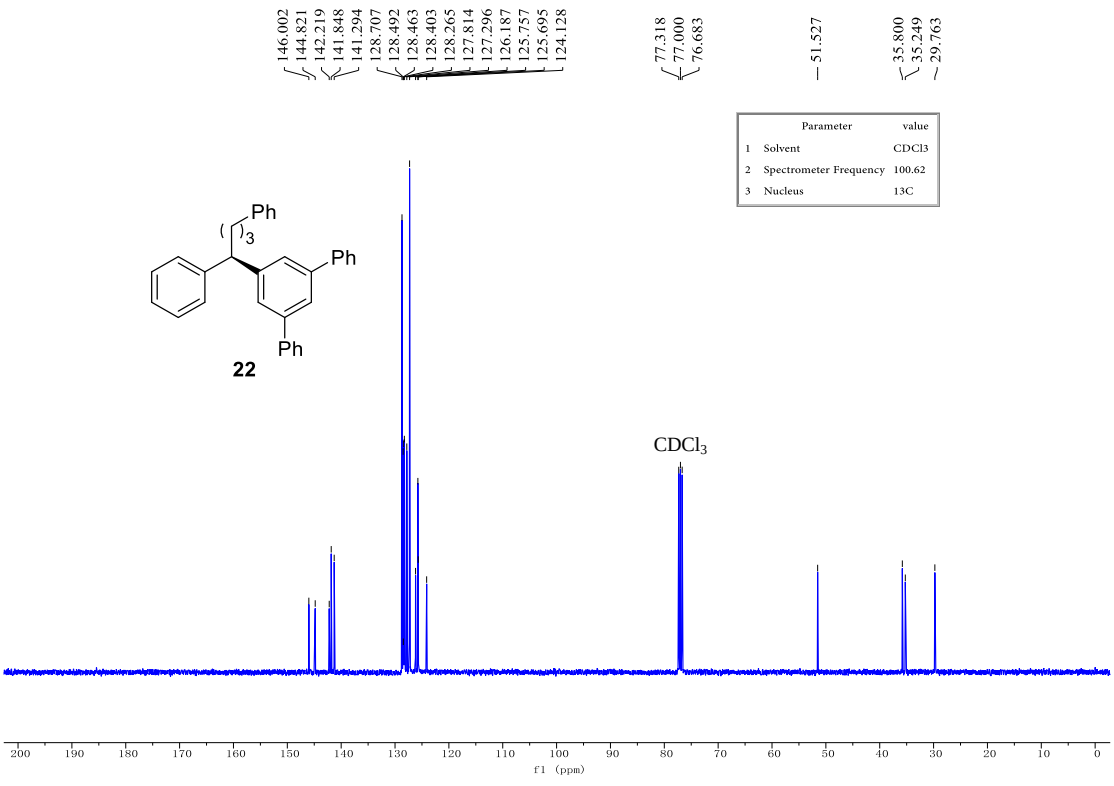
141.985
141.932
141.274
128.730
128.585
128.466
128.359
127.898
127.347
127.296
126.305
125.852
125.777
124.225
77.317
77.000
76.683
50.915
37.347
34.152
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
Ph
Ph
Ph
21
CDCl3
f1 (ppm)


7.600 7.589 7.571 7.441 7.422 7.413 7.403 7.350 7.332 7.313 7.279 7.272 7.264 7.247 7.229 7.211 7.172 7.163 7.144 7.135 7.116
4.051 4.032 4.012
2.678 2.659 2.640 2.205 2.196 2.186 2.175 2.167 2.156 2.145 2.138
1.708 1.689 1.669 1.650 1.631
0.000
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
Ph
3
Ph
Ph
22
5.01 6.05 2.16 6.12 4.08
1.00
2.03
2.05
2.06
f1 (ppm)


146.002 144.821 142.219 141.848 141.294 128.707 128.492 128.463 128.403 128.265 127.814 127.296 126.187 125.757 125.695 124.128
77.318 77.000 76.683
51.527
35.800 35.249 29.763
Parameter value
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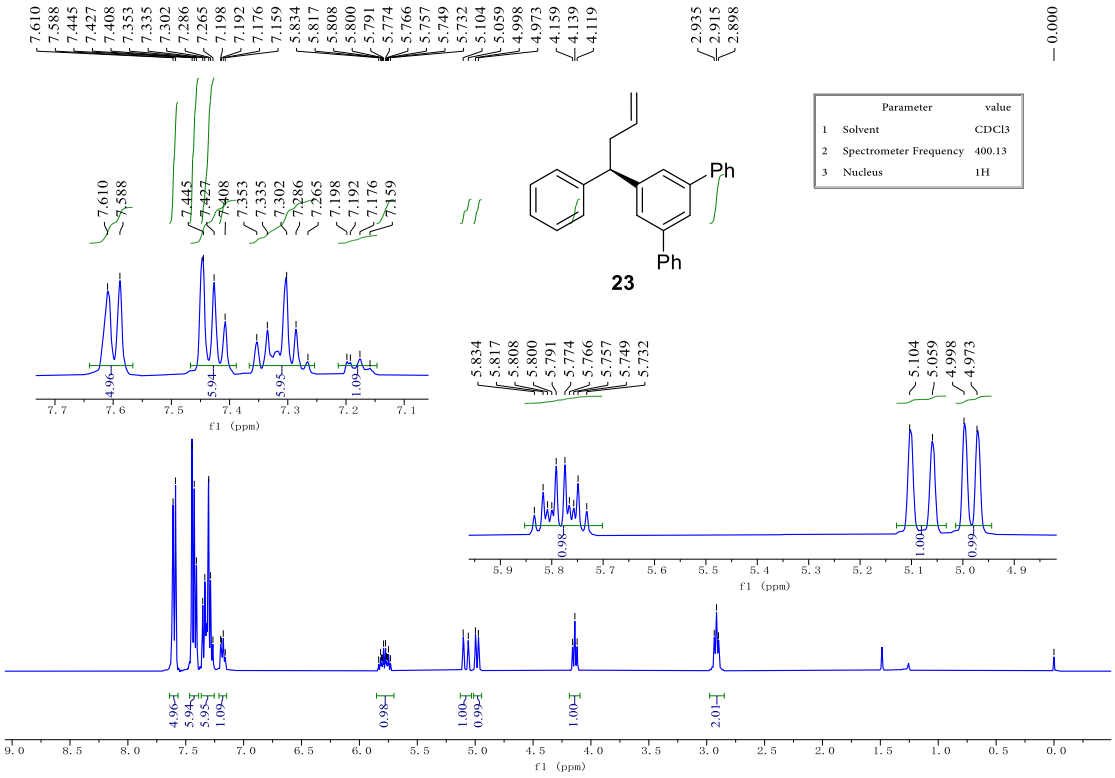
2 Spectrometer Frequency 100.62
3 Nucleus 13C
Ph
3
Ph
Ph
22
CDCl3
f1 (ppm)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7.588
7.445
7.427
7.408
7.353
7.335
7.302
7.286
7.265
7.198
7.192
7.176
7.159
5.834
5.817
5.808
5.800
5.791
5.774
5.766
5.757
5.749
5.732
5.104
5.059
4.998
4.973
4.159
4.139
4.119
2.935
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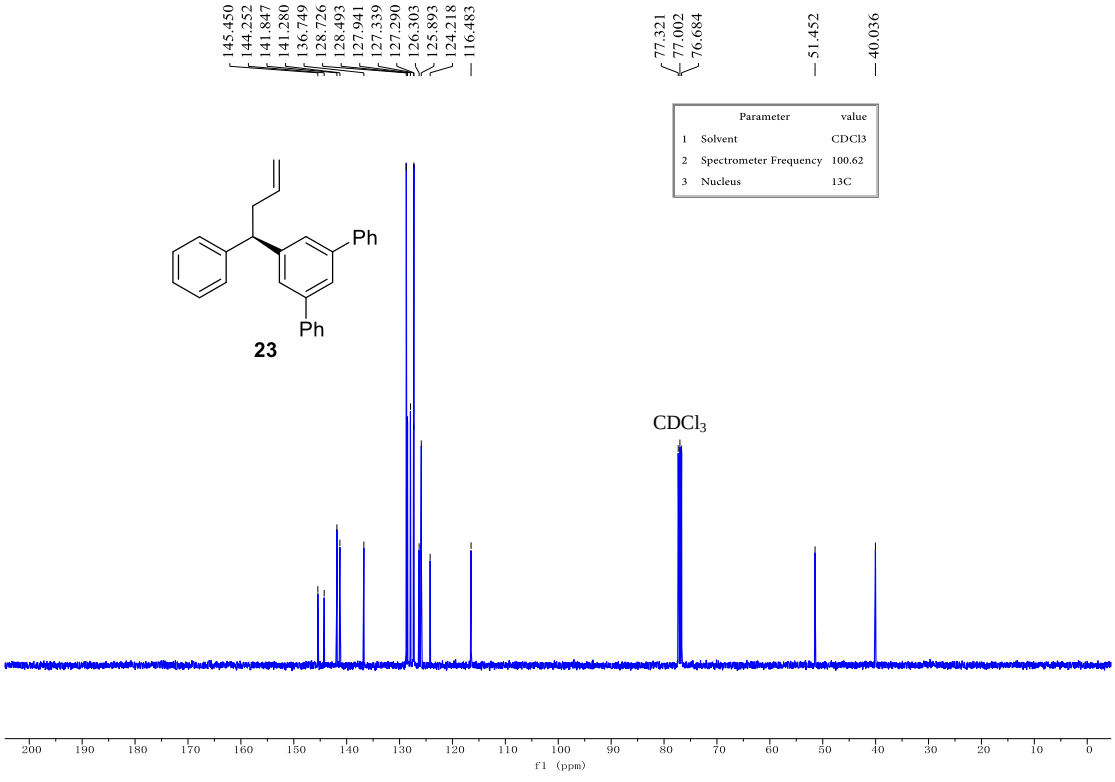
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
Ph
Ph
23
f1 (ppm)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141.847
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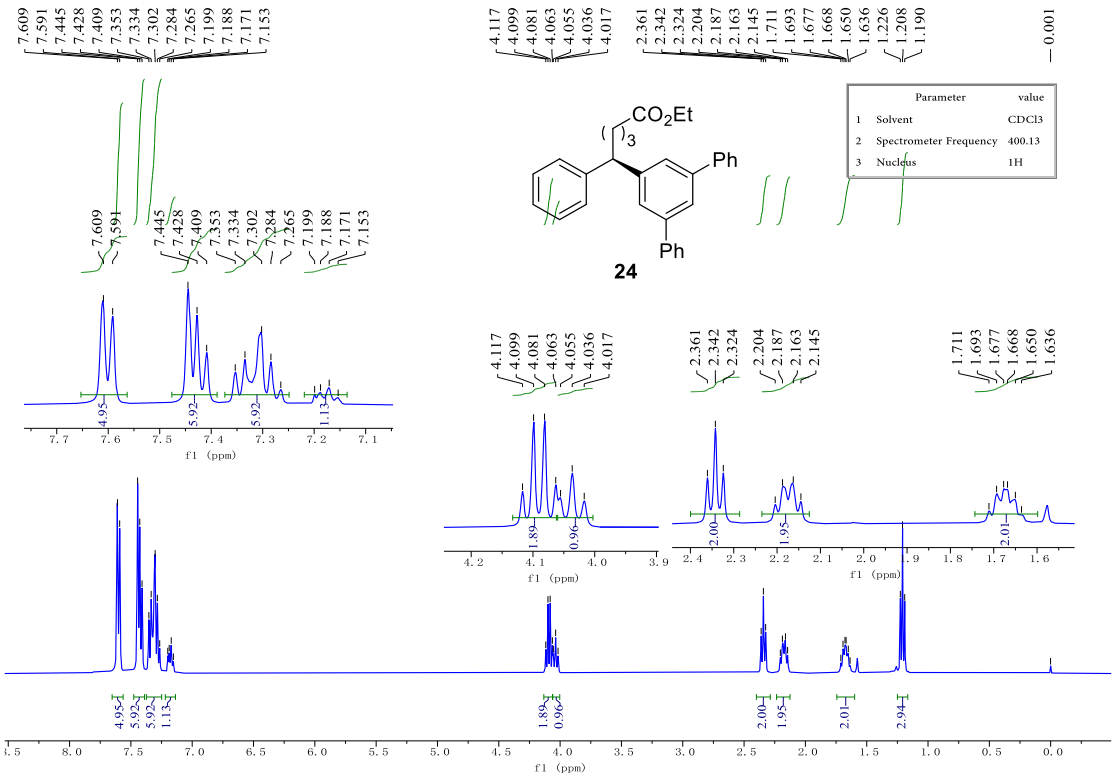
128.493
127.941
127.339
127.290
126.303
125.893
124.218
116.483
77.321
77.002
76.684
51.452
40.036
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
Ph
Ph
23
CDCl3
f1 (ppm)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7.445
7.428
7.409
7.353
7.334
7.302
7.284
7.265
7.199
7.188
7.171
7.153
4.117
4.099
4.081
4.063
4.055
4.036
4.017
2.361
2.342
2.324
2.204
2.187
2.163
2.145
1.711
1.693
1.677
1.668
1.650
1.636
1.226
1.208
1.190
0.001
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
CO2Et
3
Ph
Ph
24
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5.92
1.13
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1.95
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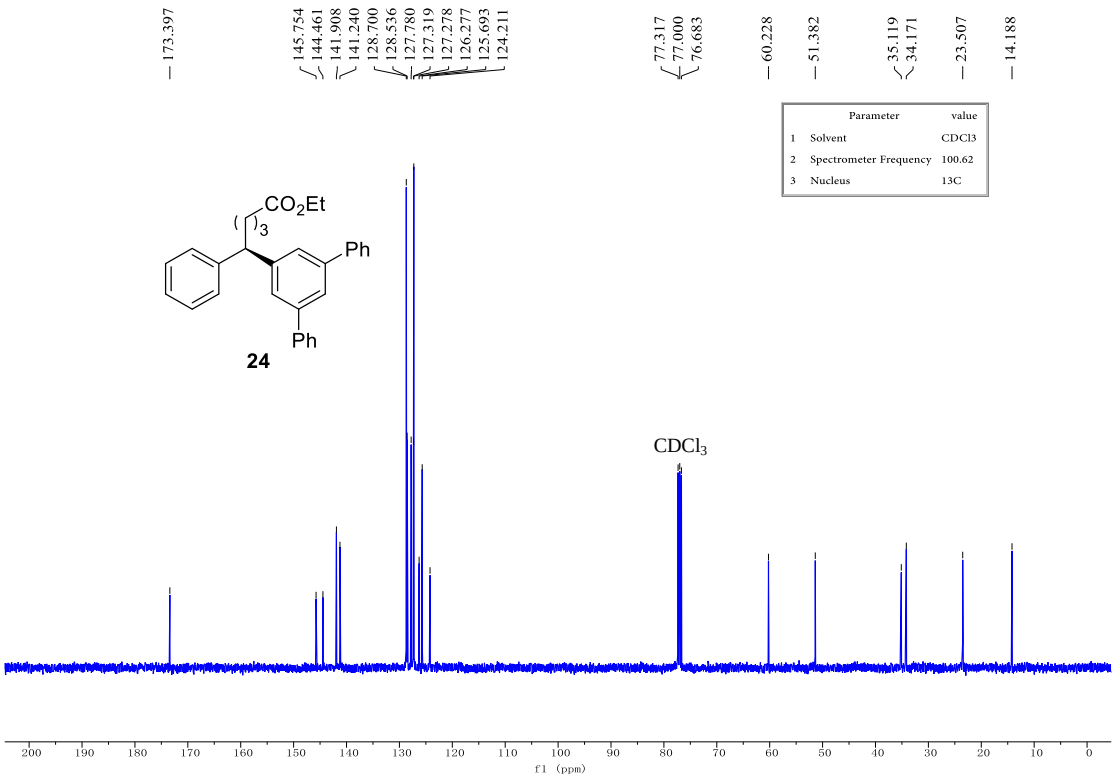
2.94
f1 (ppm)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127.278
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124.211
77.317
77.000
76.683
60.228
51.382
35.119
34.171
23.507
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Parameter value
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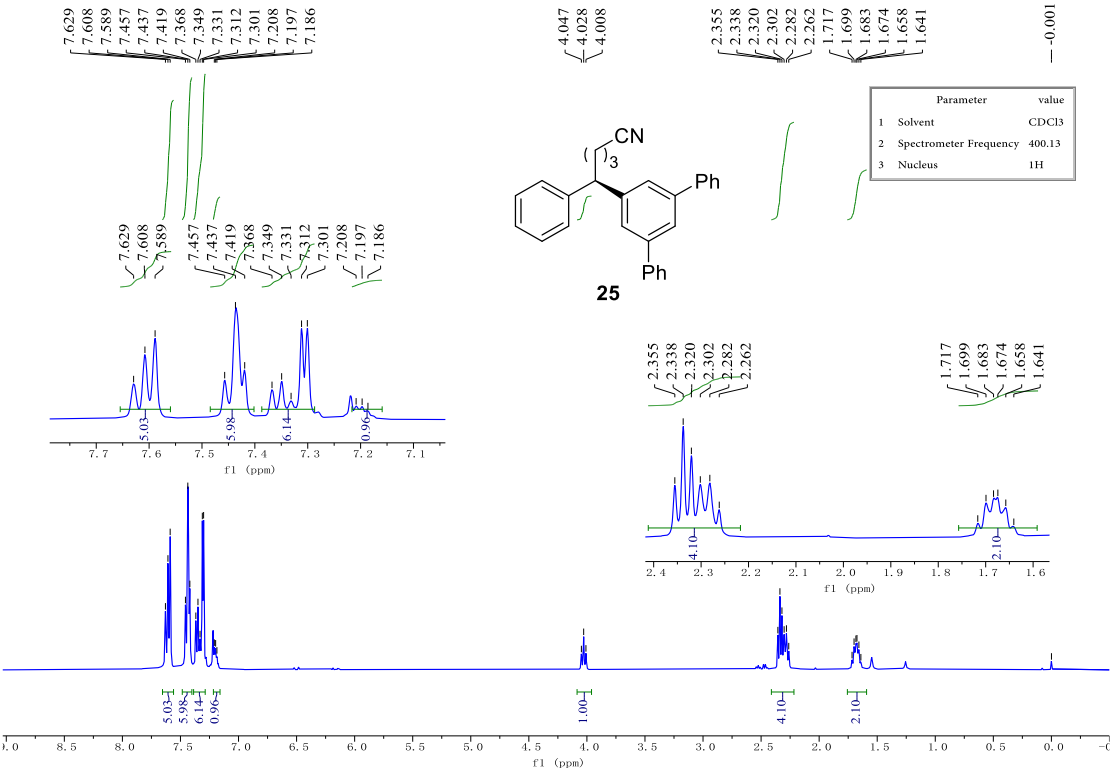
2 Spectrometer Frequency 100.62
3 Nucleus 13C
CO2Et
3
Ph
Ph
24
CDCl3
f1 (ppm)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7.349
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7.312
7.301
7.208
7.197
7.186
4.047
4.028
4.008
2.355
2.338
2.320
2.302
2.282
2.262
1.717
1.699
1.683
1.674
1.658
1.641
-0.001
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
CN
3
Ph
Ph
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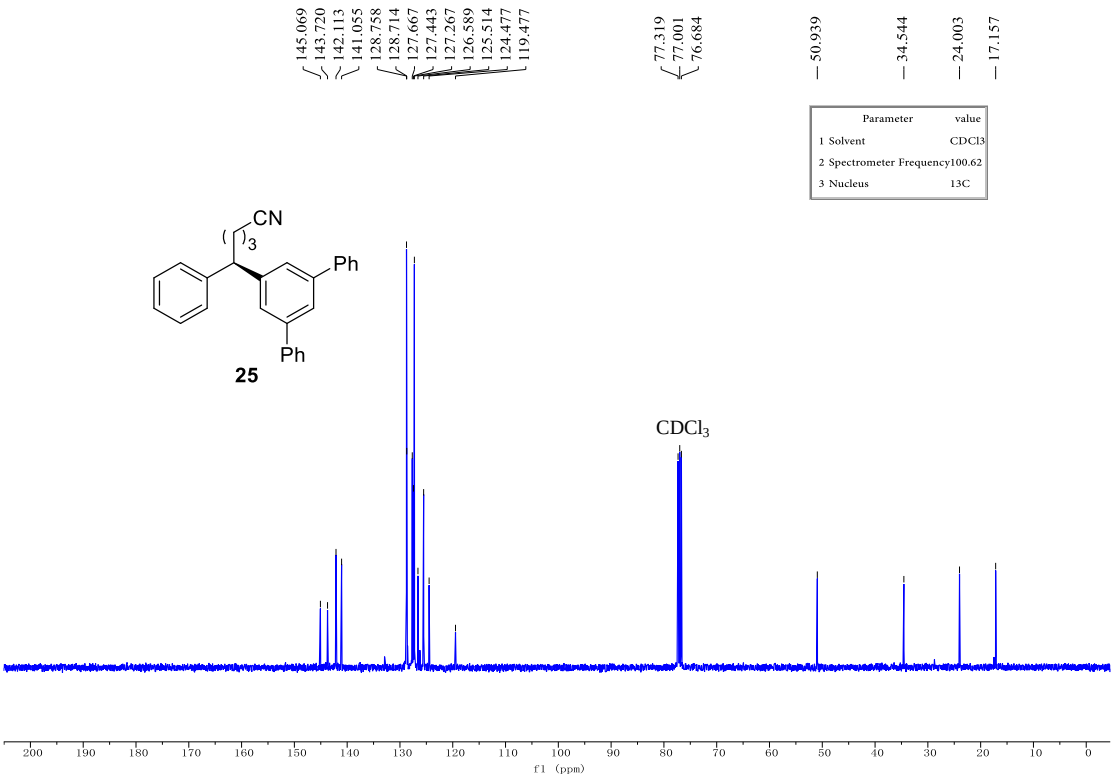
5.98
6.14
0.96
4.10
2.10
1.00
f1 (ppm)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127.443
127.267
126.589
125.514
124.477
119.477
77.319
77.001
76.684
50.939
34.544
24.003
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Parameter value
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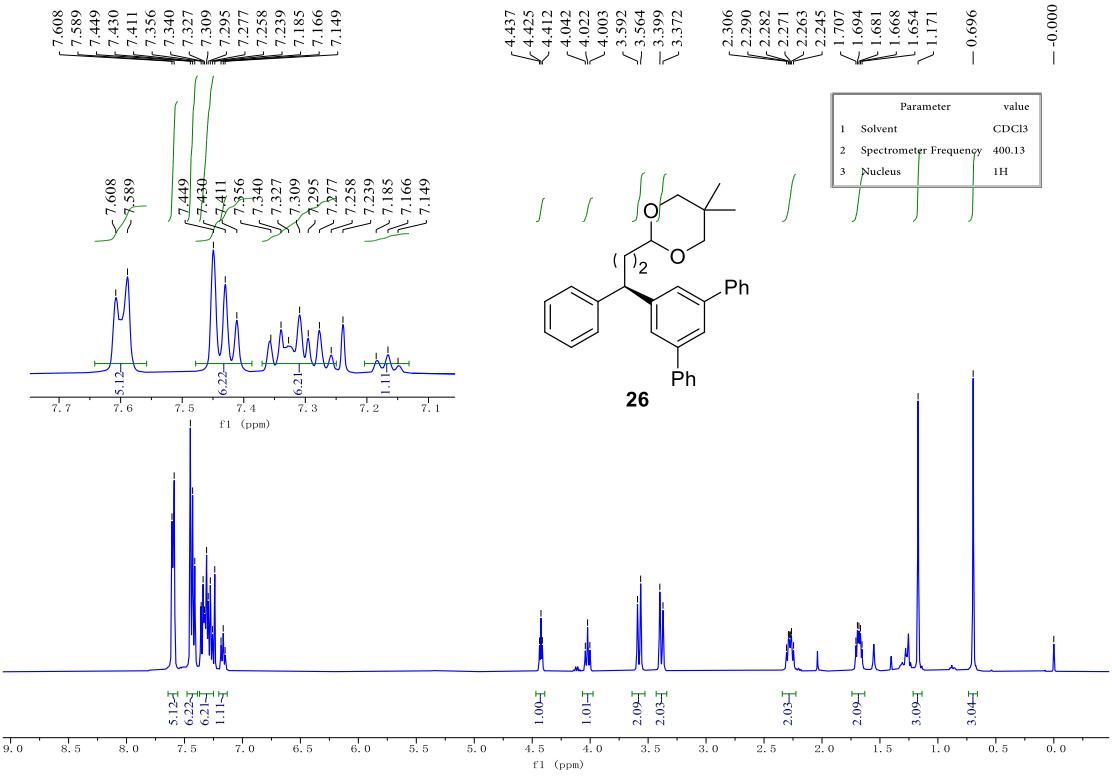
2 Spectrometer Frequency 100.62
3 Nucleus 13C
CN
3
Ph
Ph
25
CDCl3
f1 (ppm)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7.295
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7.258
7.239
7.185
7.166
7.149
4.437
4.425
4.412
4.042
4.022
4.003
3.592
3.564
3.399
3.372
2.306
2.290
2.282
2.271
2.263
2.245
1.707
1.694
1.681
1.668
1.654
1.171
0.696
-0.000
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
Ph
Ph
26
5.12
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6.21
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2.03
2.09
3.09
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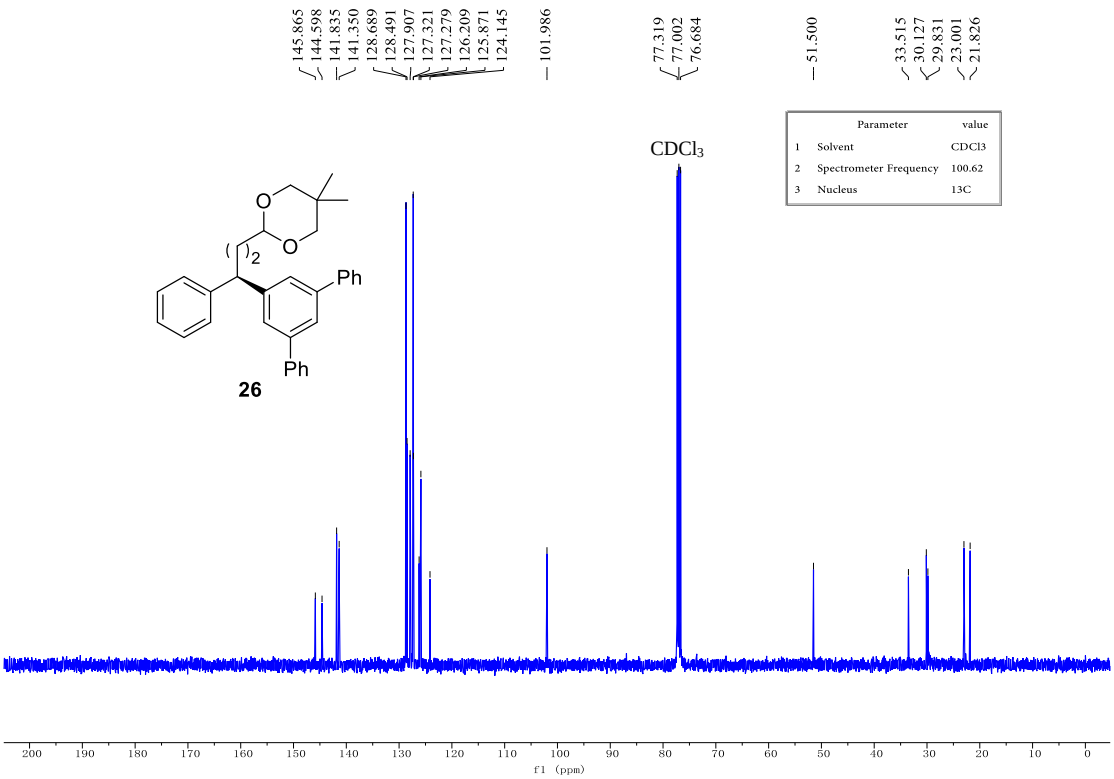
f1 (ppm)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127.321
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101.986
77.319
77.002
76.684
51.500
33.515
30.127
29.831
23.001
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CDCl3
Parameter value
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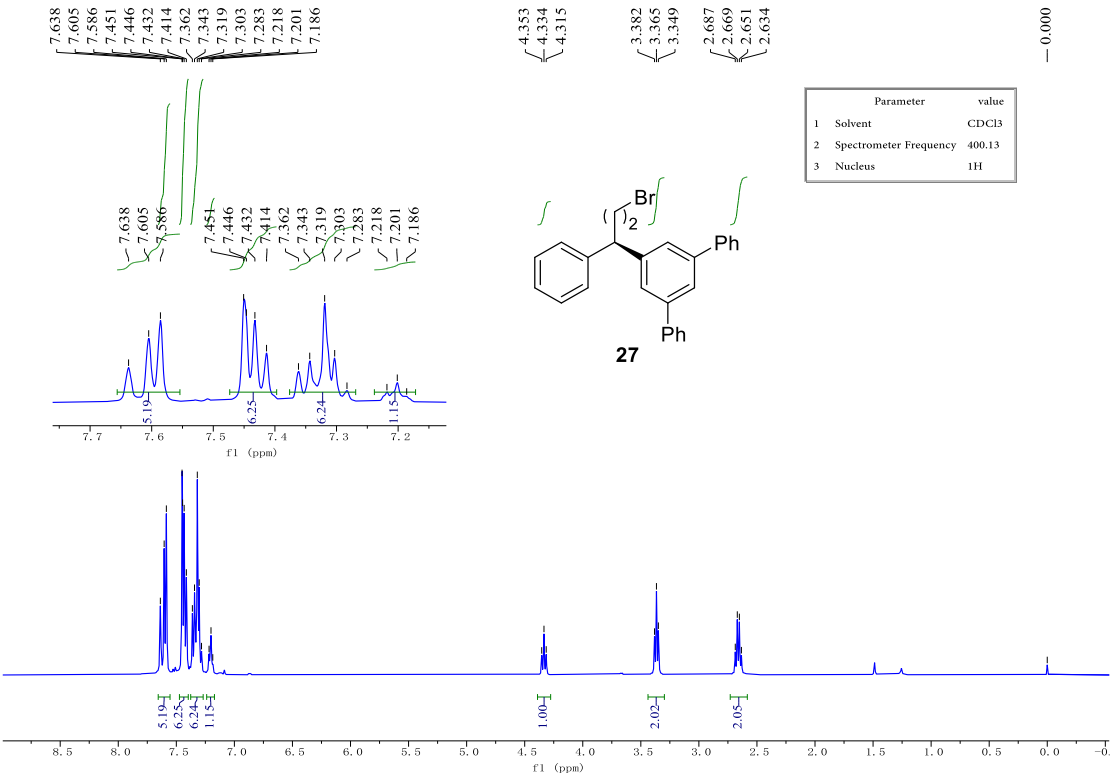
2 Spectrometer Frequency 100.62
3 Nucleus 13C
Ph
Ph
26
f1 (ppm)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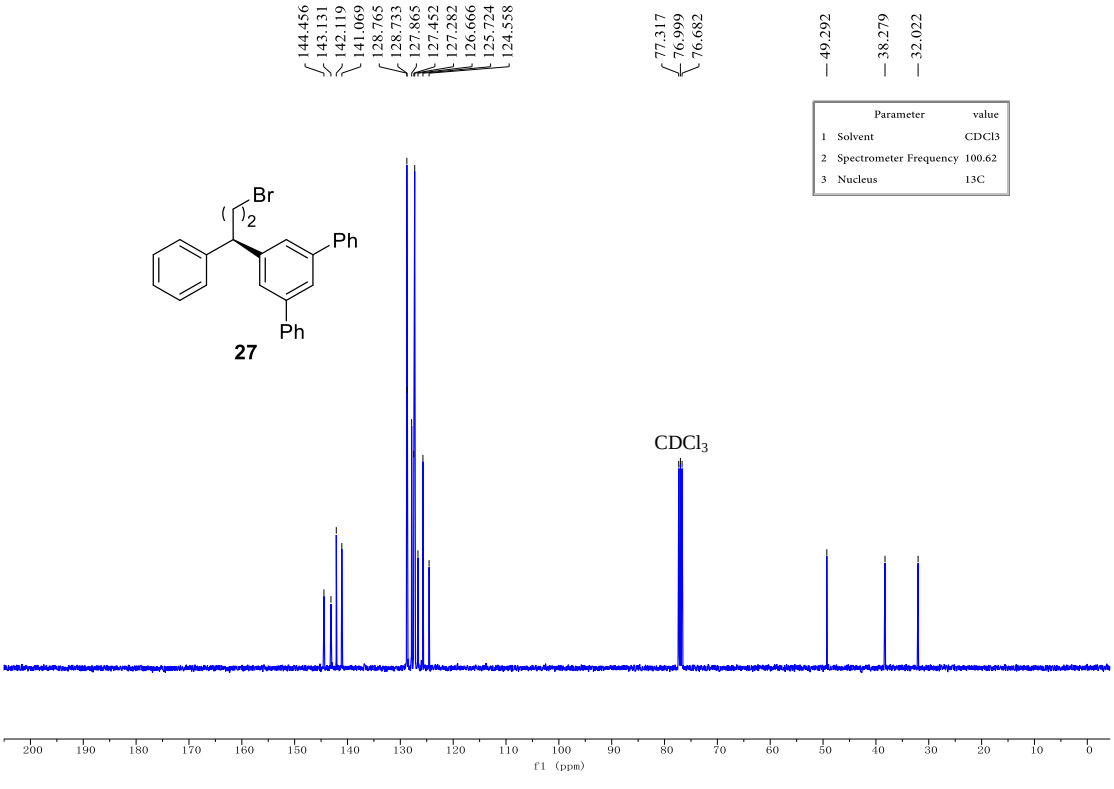
7.446
7.432
7.414
7.362
7.343
7.319
7.303
7.283
7.218
7.201
7.186
4.353
4.334
4.315
3.382
3.365
3.349
2.687
2.669
2.651
2.634
0.000
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
Br
2
Ph
Ph
27
5.19
6.25
6.24
1.15
1.00
2.02
2.05
f1 (ppm)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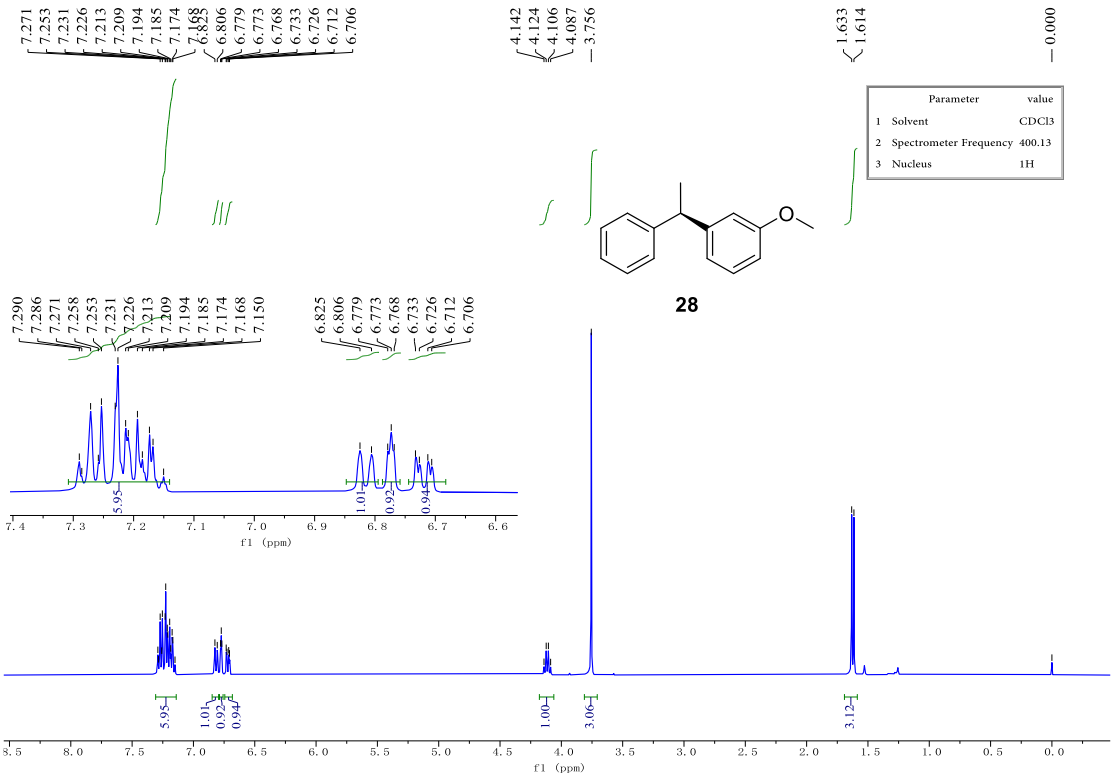
128.733
127.865
127.452
127.282
126.666
125.724
124.558
77.317
76.999
76.682
49.292
38.279
32.022
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
Br
2
Ph
Ph
27
CDCl3
f1 (ppm)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7.209
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7.185
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7.168
6.825
6.806
6.779
6.773
6.768
6.733
6.726
6.712
6.706
4.142
4.124
4.106
4.087
3.756
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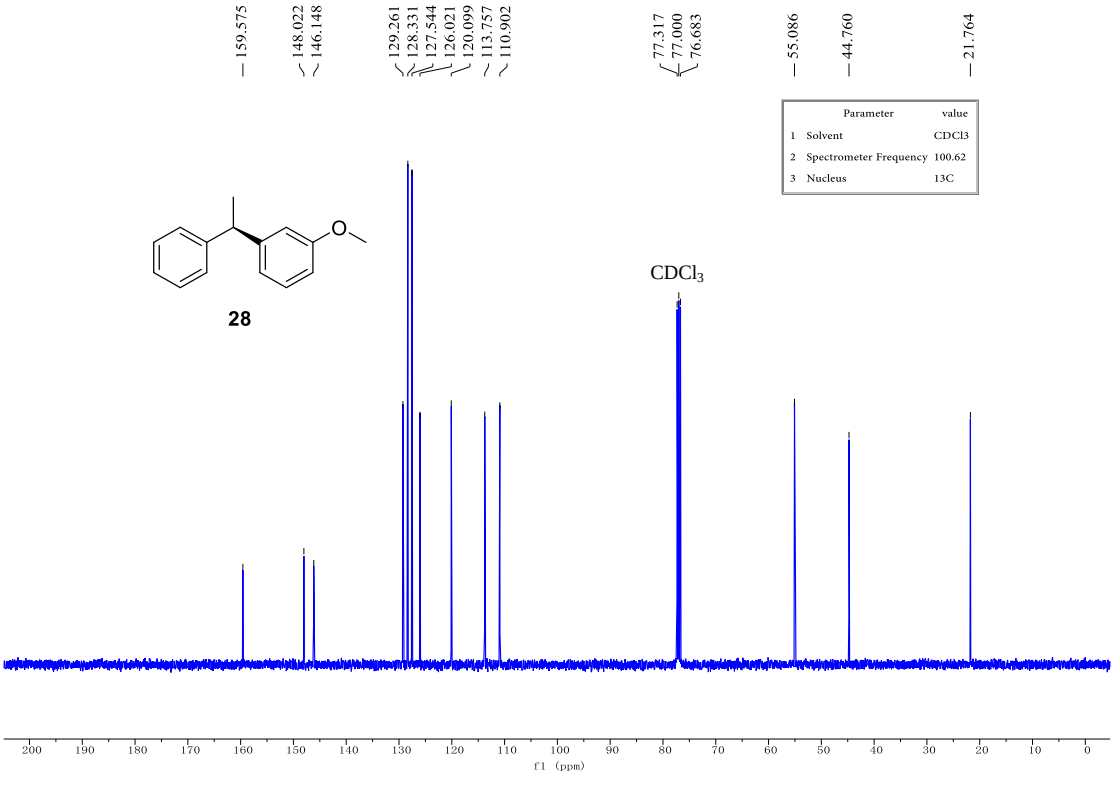
1.614
0.000
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
28
f1 (ppm)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77.317
77.000
76.683
55.086
44.760
21.764
Parameter value
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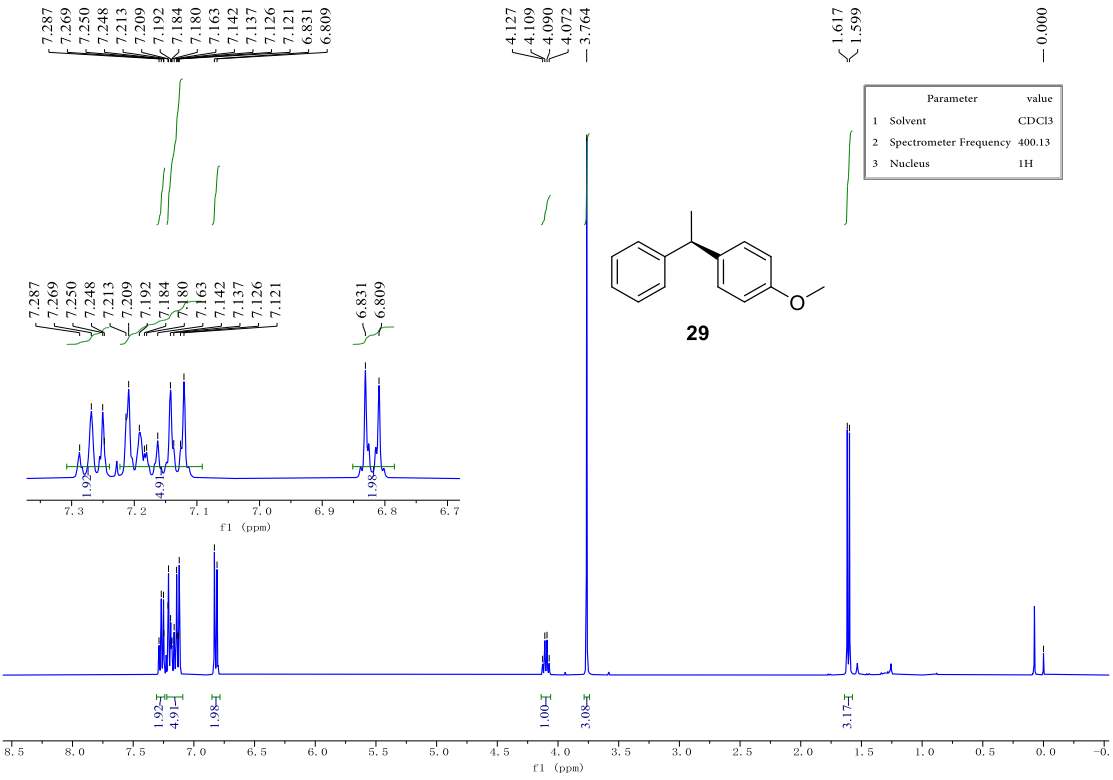
2 Spectrometer Frequency 100.62
3 Nucleus 13C
28
CDCl3
f1 (ppm)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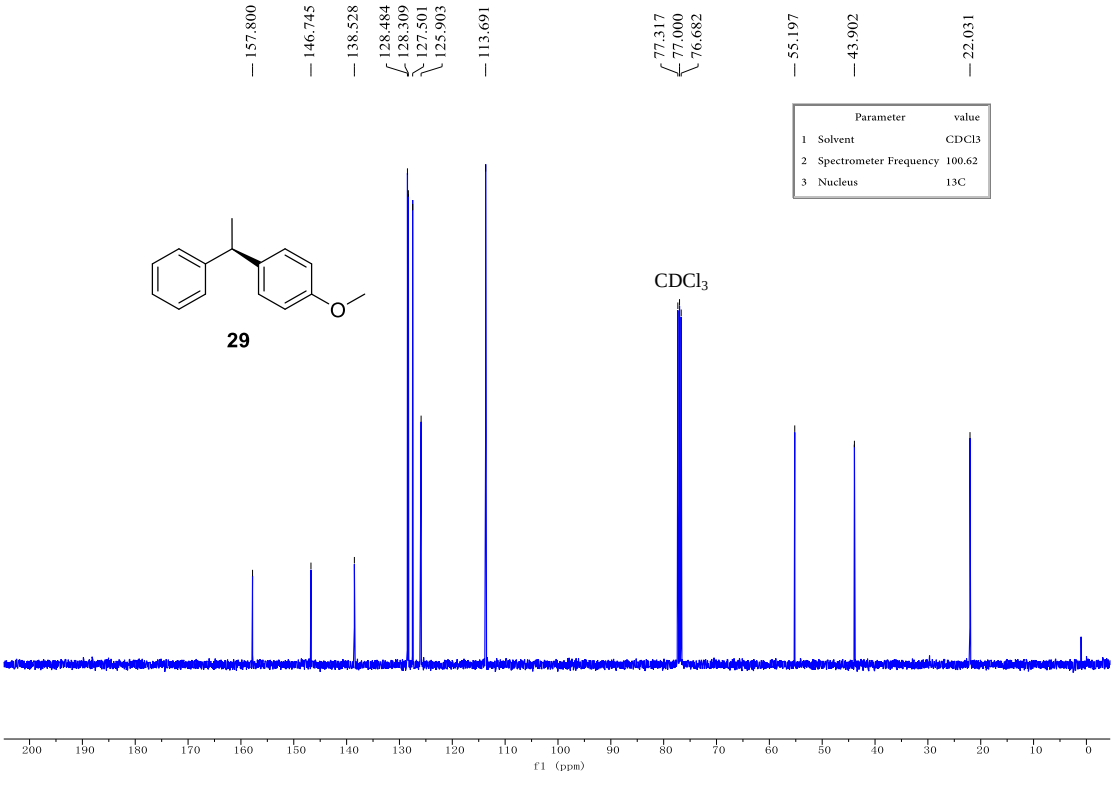
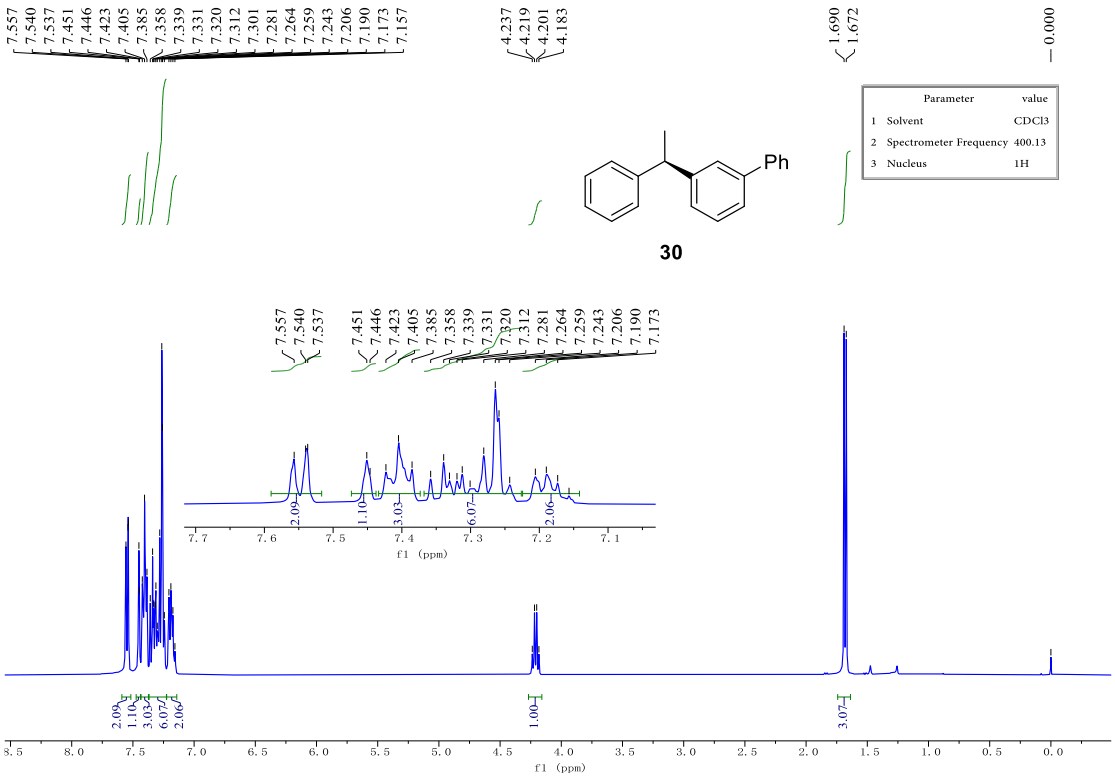
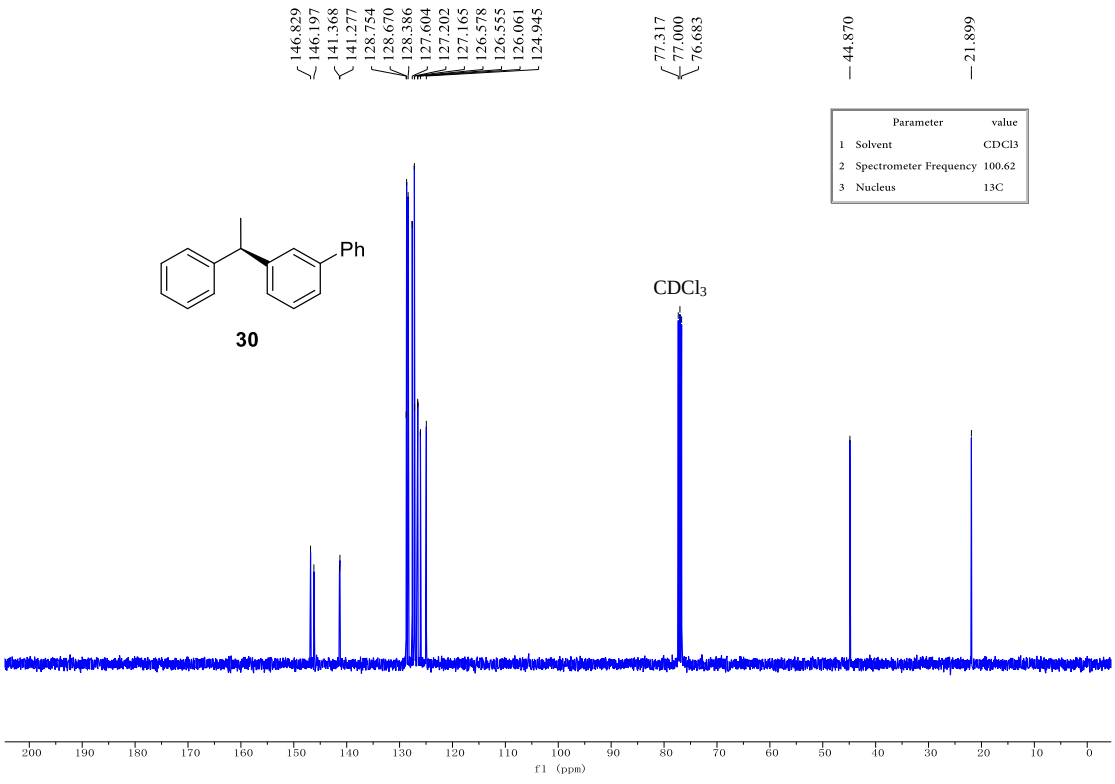
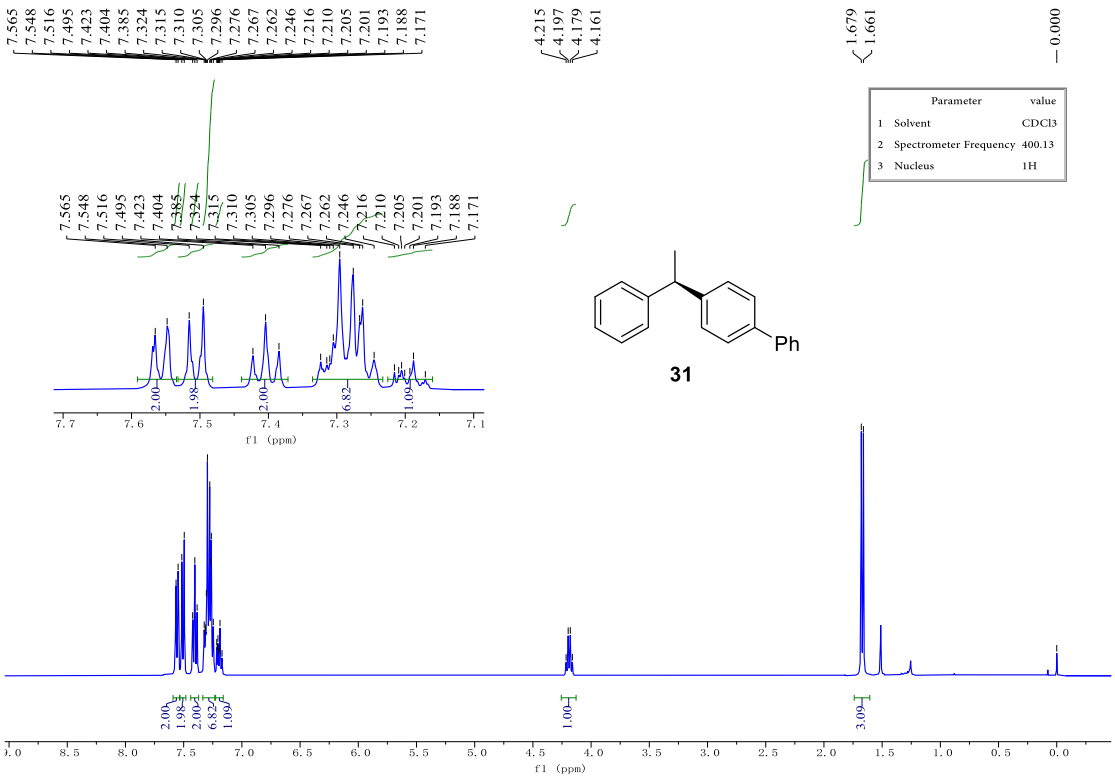
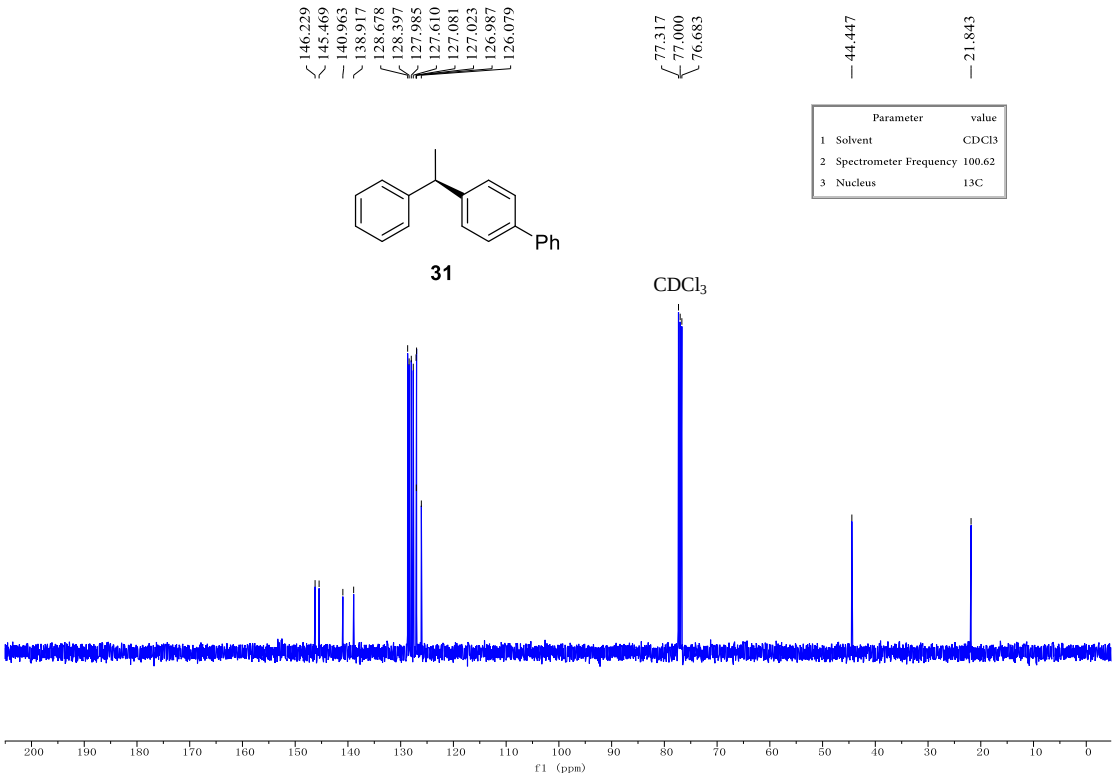
7.142
7.137
7.126
7.121
6.831
6.809
4.127
4.109
4.090
4.072
3.764
1.617
1.599
0.000
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
29
1.92
4.91
1.98
1.00
3.08
3.17
f1 (ppm)

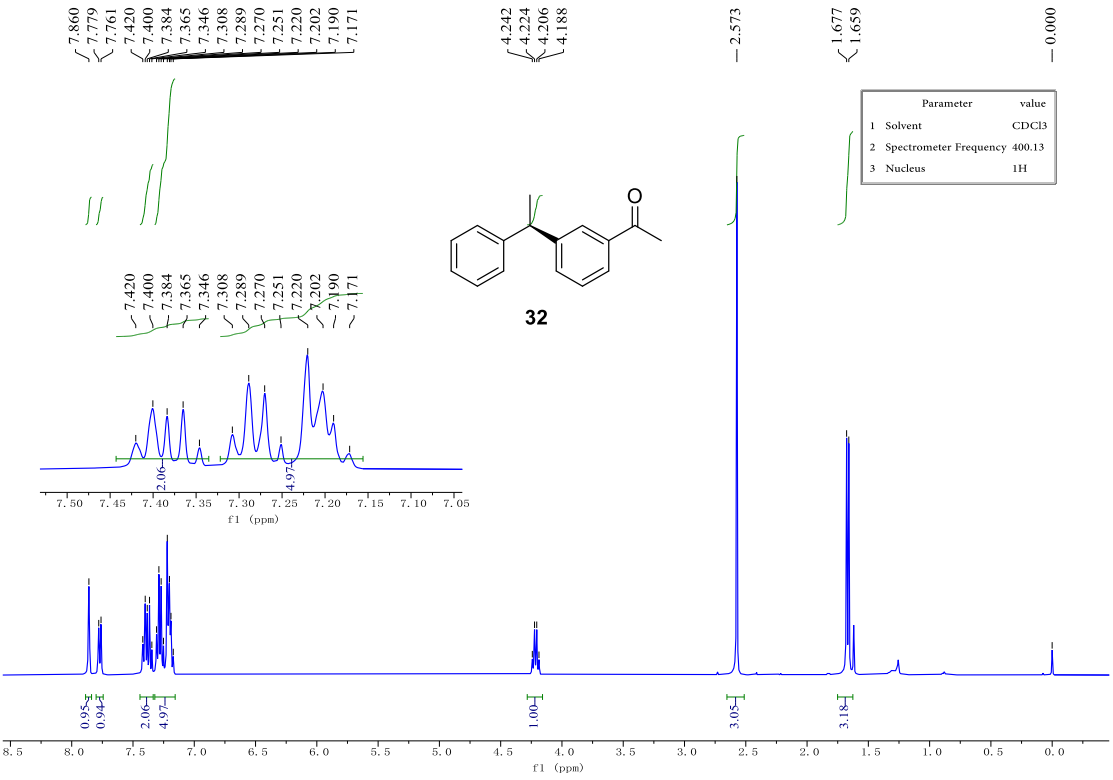

157.800
146.745
138.528
128.484
128.309
127.501
125.903
113.691
77.317
77.000
76.682
55.197
43.902
22.031
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
29
CDCl3
f1 (ppm)

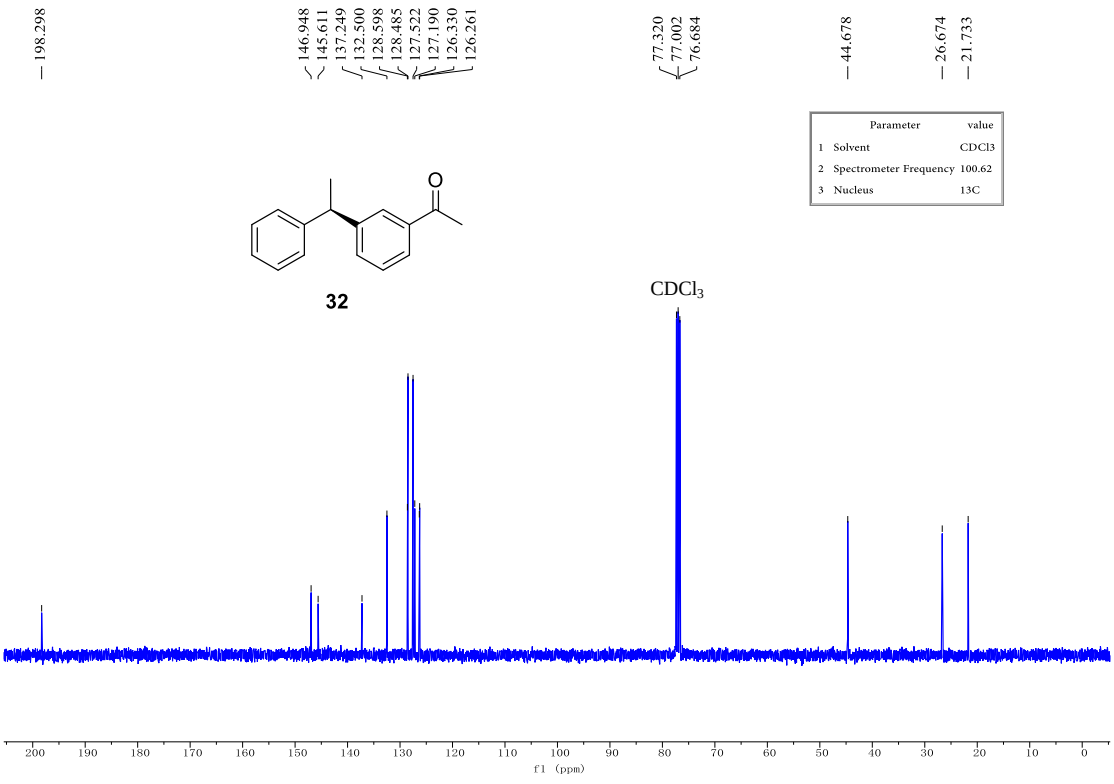

7.557
7.540
7.537
7.451
7.446
7.423
7.405
7.385
7.358
7.339
7.331
7.320
7.312
7.301
7.281
7.264
7.259
7.243
7.206
7.190
7.173
7.157
4.237
4.219
4.201
4.183
1.690
1.672
0.000
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
Ph
30
2.09
1.10
3.03
6.07
2.06
1.00
3.07
f1 (ppm)

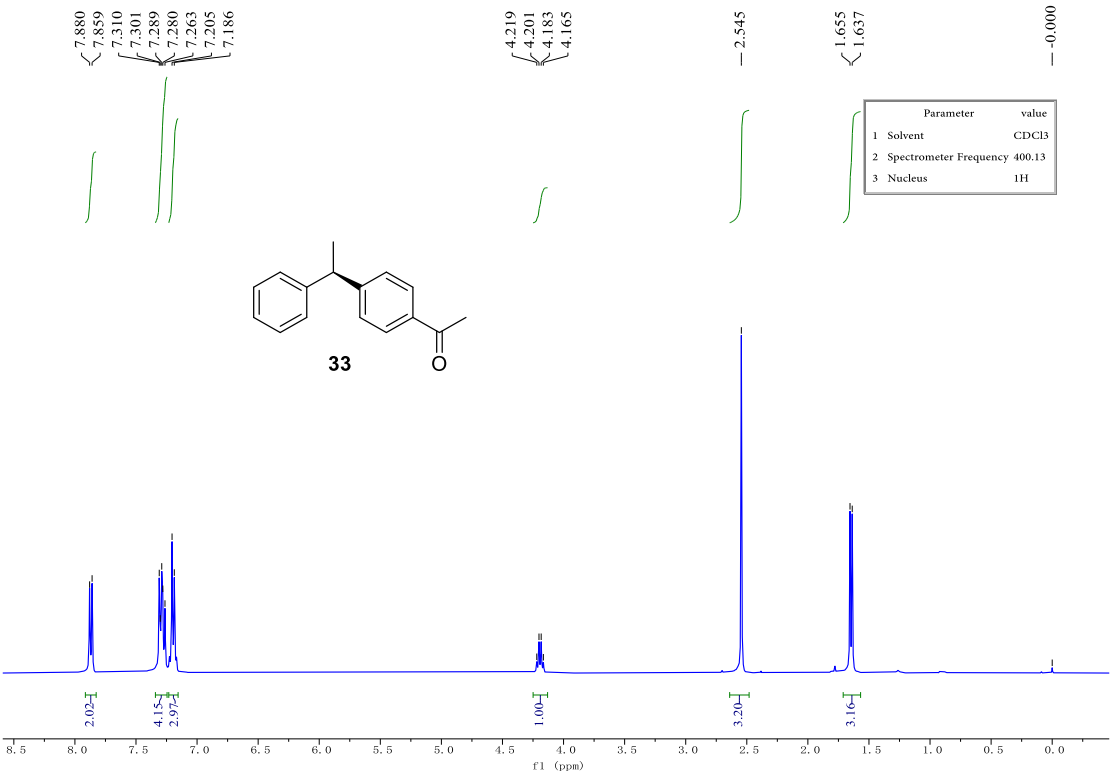

146.829
146.197
141.368
141.277
128.754
128.670
128.386
127.604
127.202
127.165
126.578
126.555
126.061
124.945
77.317
77.000
76.683
44.870
21.899
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
Ph
30
CDCl3
f1 (ppm)

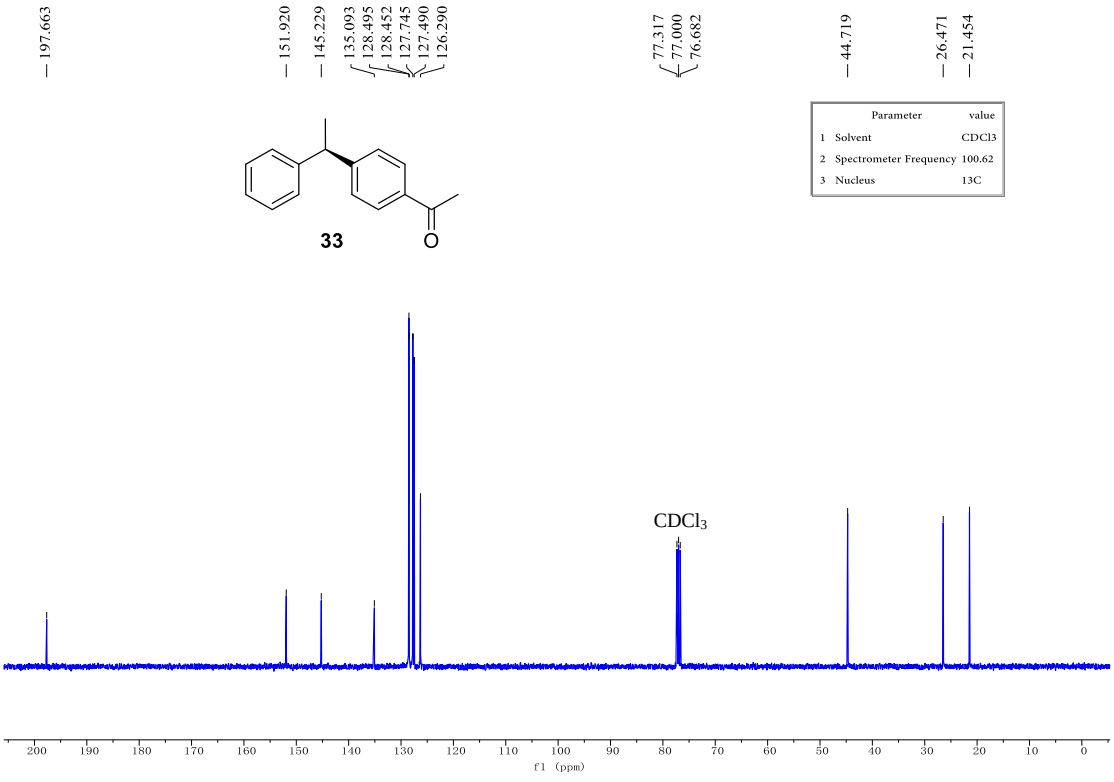

7.565
7.548
7.516
7.495
7.423
7.404
7.385
7.324
7.315
7.310
7.305
7.296
7.276
7.267
7.262
7.246
7.216
7.210
7.205
7.201
7.193
7.188
7.171
4.215
4.197
4.179
4.161
1.679
1.661
0.000
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
Ph
31
2.00
1.98
2.00
6.82
1.09
1.00
3.09
f1 (ppm)

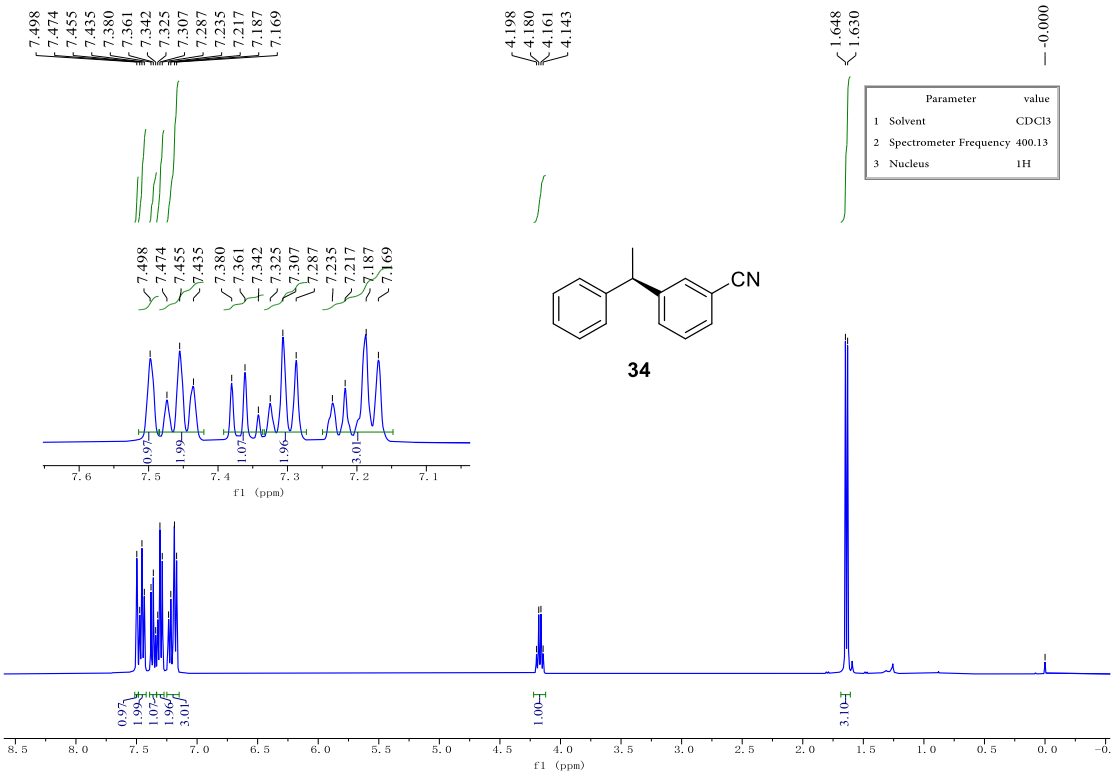

146.229
145.469
140.963
138.917
128.678
128.397
127.985
127.610
127.081
127.023
126.987
126.079
77.317
77.000
76.683
44.447
21.843
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
Ph
31
CDCl3
f1 (ppm)

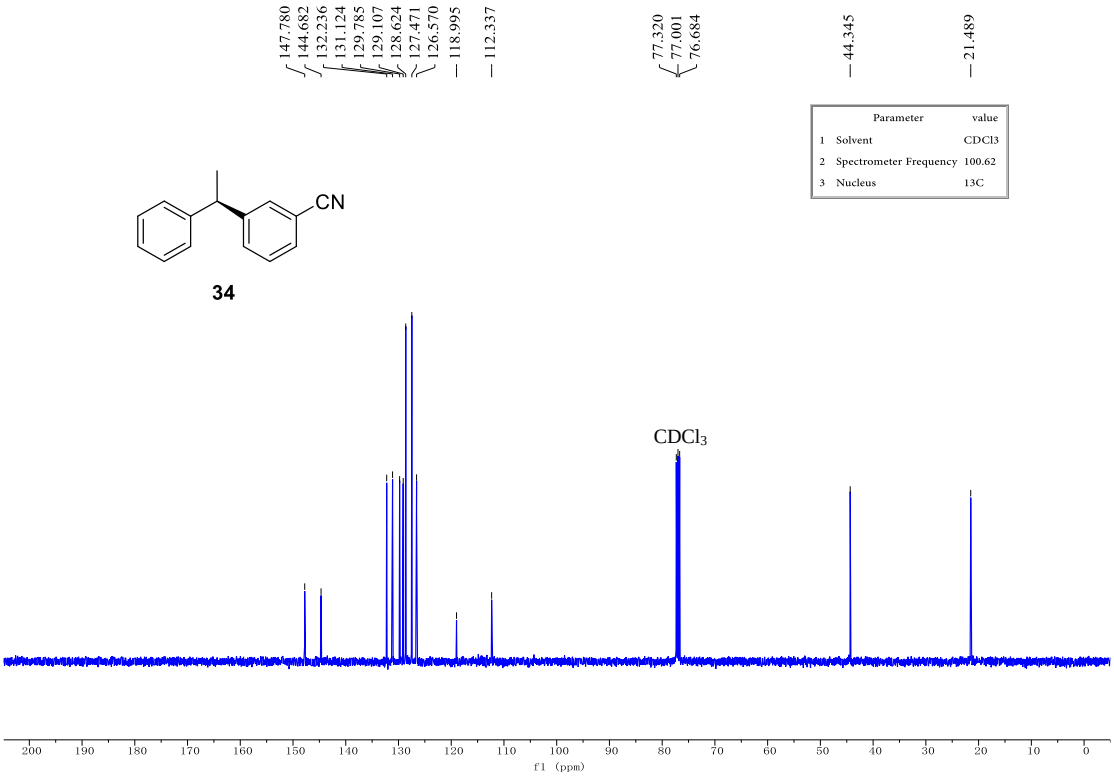

7.860
7.779
7.761
7.420
7.400
7.384
7.365
7.346
7.308
7.289
7.270
7.251
7.220
7.202
7.190
7.171
4.242
4.224
4.206
4.188
2.573
1.677
1.659
0.000
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
O
32
2.06
4.97
f1 (ppm)
0.95
0.94
2.06
4.97
1.00
3.05
3.18
f1 (ppm)


198.298
146.948
145.611
137.249
132.500
128.598
128.485
127.522
127.190
126.330
126.261
77.320
77.002
76.684
44.678
26.674
21.733
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
O
32
CDCl3
f1 (ppm)


7.880
7.859
7.310
7.301
7.289
7.280
7.263
7.205
7.186
4.219
4.201
4.183
4.165
2.545
1.655
1.637
-0.000
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
33
O
2.02
4.15
2.97
1.00
3.20
3.16
f1 (ppm)


197.663
151.920
145.229
135.093
128.495
128.452
127.745
127.490
126.290
77.317
77.000
76.682
44.719
26.471
21.454
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
33
O
CDCl3
f1 (ppm)


7.498
7.474
7.455
7.435
7.380
7.361
7.342
7.325
7.307
7.287
7.235
7.217
7.187
7.169
4.198
4.180
4.161
4.143
1.648
1.630
-0.000
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
CN
34
0.97
1.99
1.07
1.96
3.01
1.00
3.10
f1 (ppm)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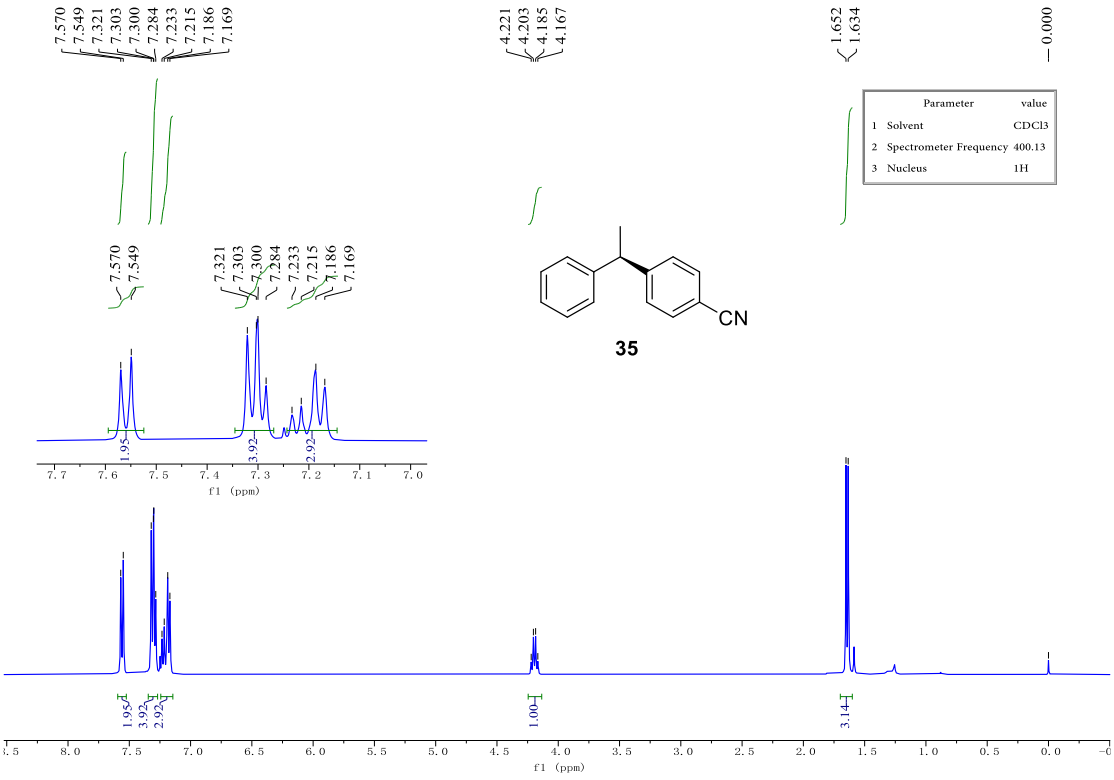
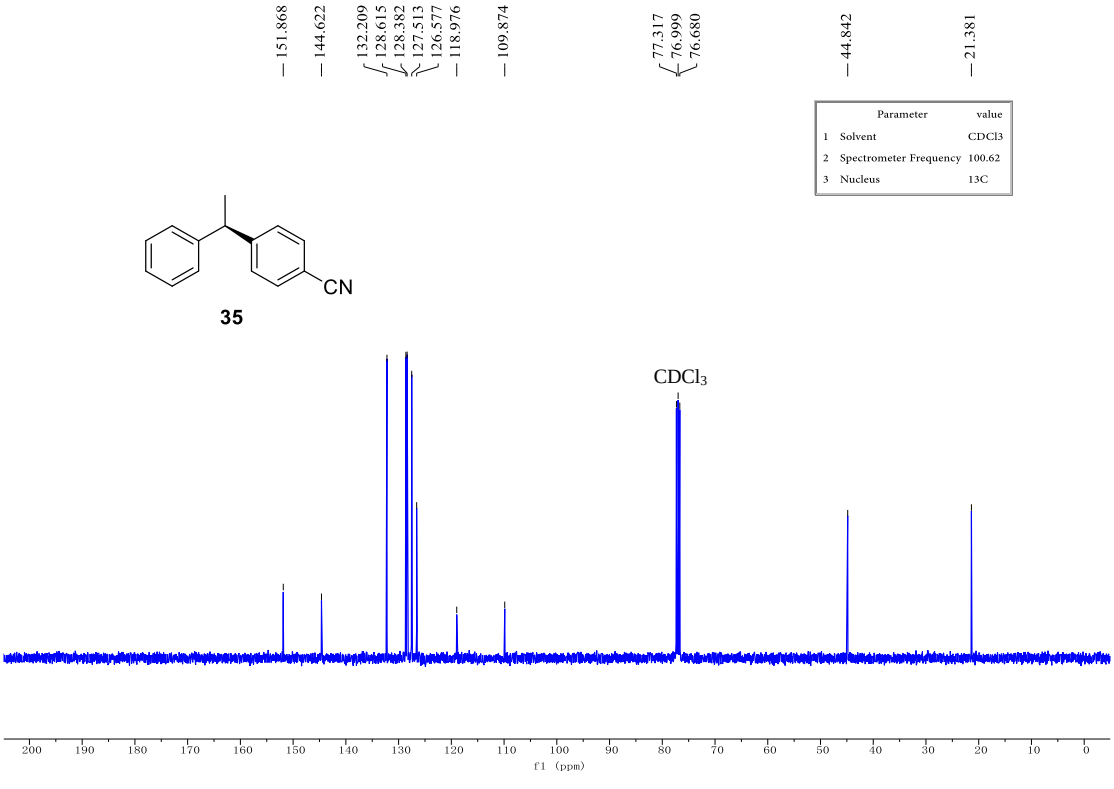
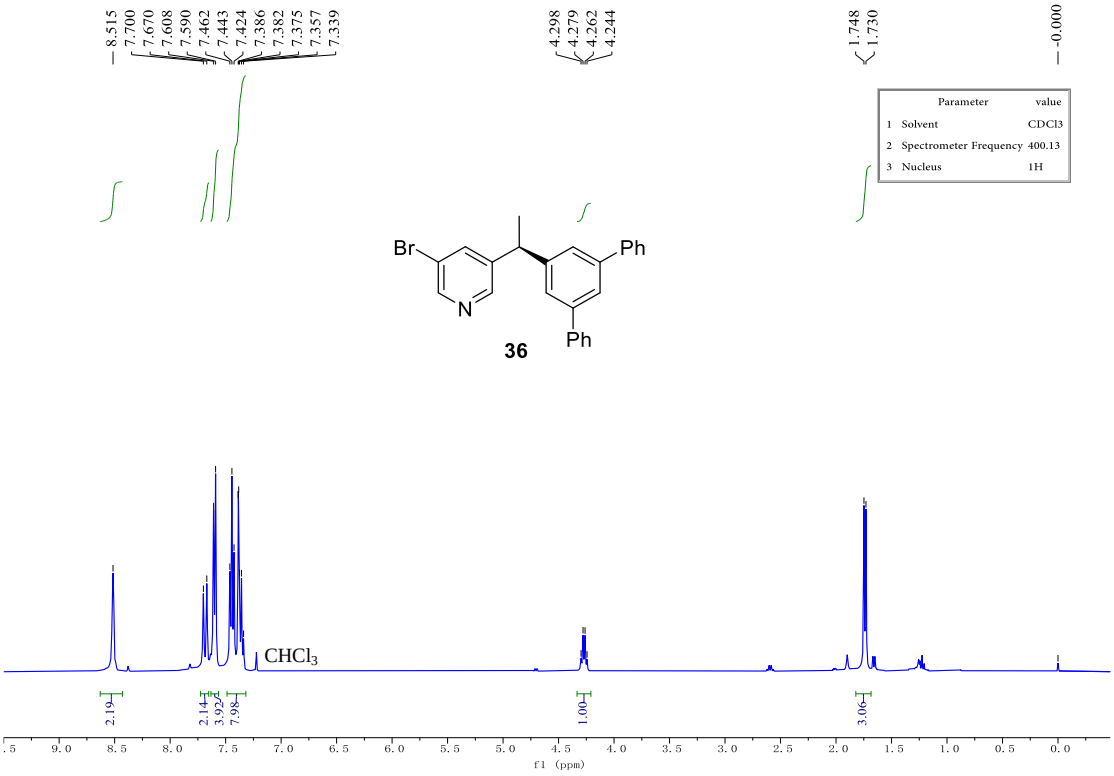
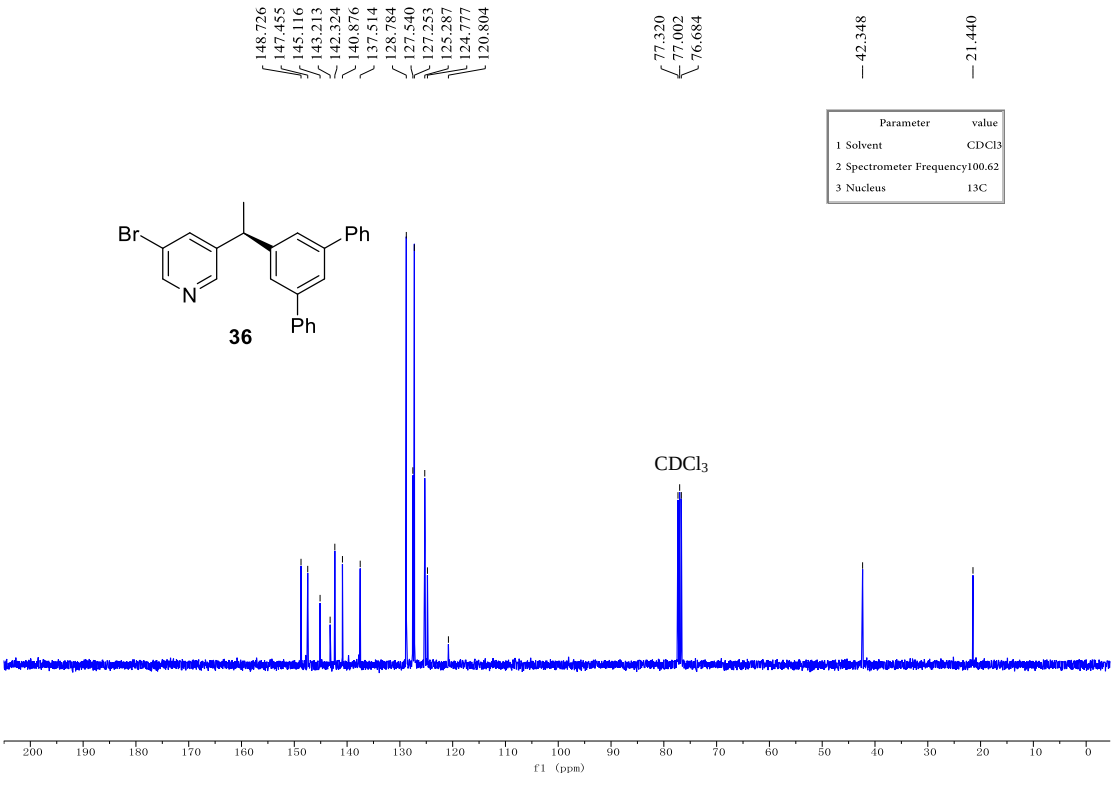
132.236
131.124
129.785
129.107
128.624
127.471
126.570
118.995
112.337
77.320
77.001
76.684
44.345
21.489
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
CN
34
CDCl3
f1 (ppm)


7.570
7.549
7.321
7.303
7.300
7.284
7.233
7.215
7.186
7.169
4.221
4.203
4.185
4.167
1.652
1.634
0.000
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
CN
35
1.95
3.92
2.92
1.00
3.14
f1 (ppm)


151.868
144.622
132.209
128.615
128.382
127.513
126.577
118.976
109.874
77.317
76.999
76.680
44.842
21.381
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
CN
35
CDCl3
f1 (ppm)


8.515
7.700
7.670
7.608
7.590
7.462
7.443
7.424
7.386
7.382
7.375
7.357
7.339
4.298
4.279
4.262
4.244
1.748
1.730
0.000
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
Br
N
Ph
Ph
36
CHCl3
2.19
2.14
3.92
7.98
1.00
3.06
f1 (ppm)


148.726
147.455
145.116
143.213
142.324
140.876
137.514
128.784
127.540
127.253
125.287
124.777
120.804
77.320
77.002
76.684
42.348
21.440
Parameter value
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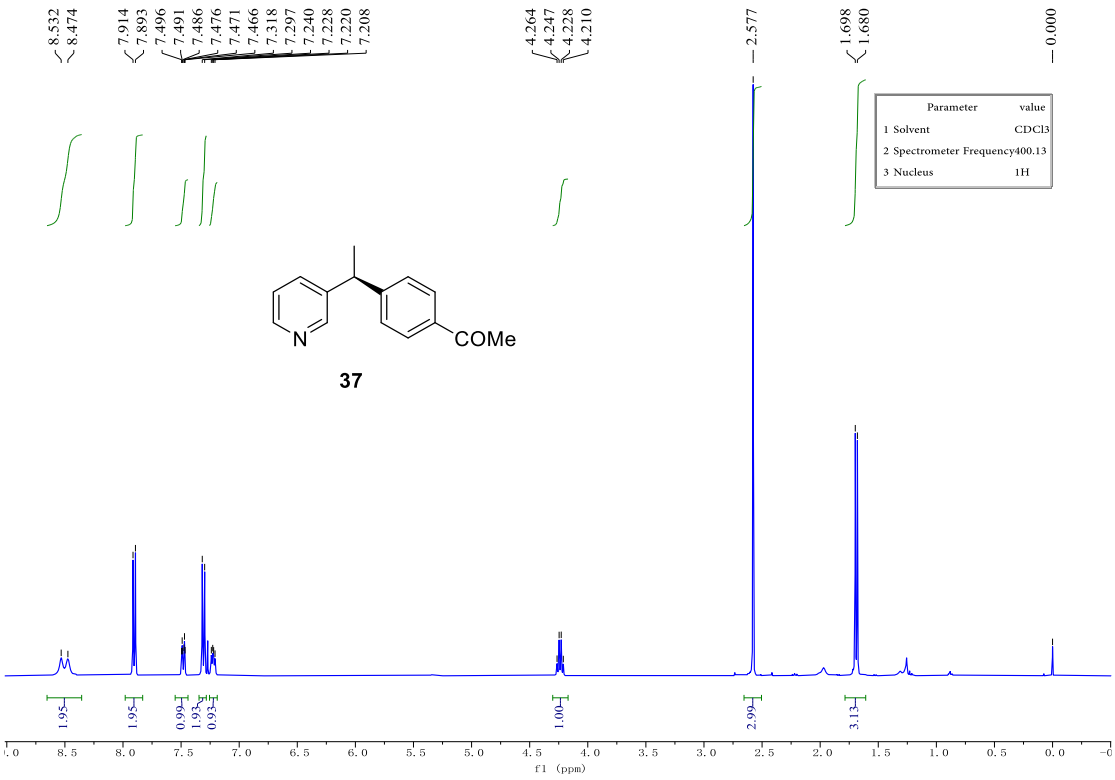
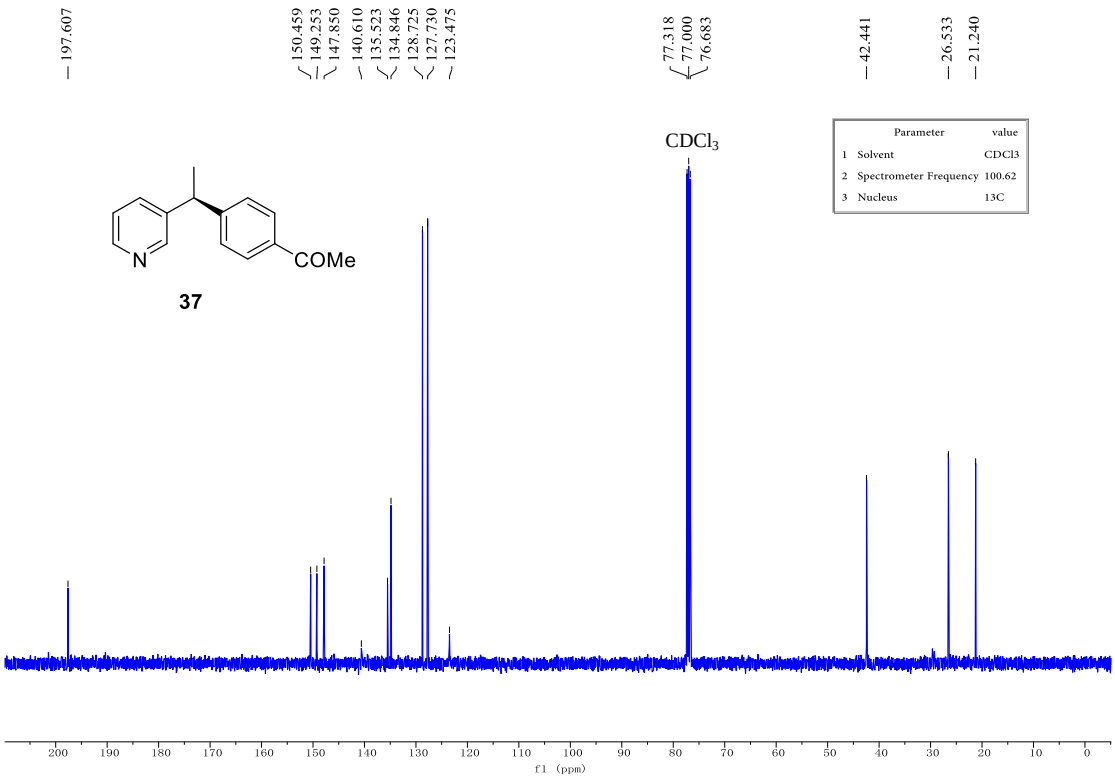
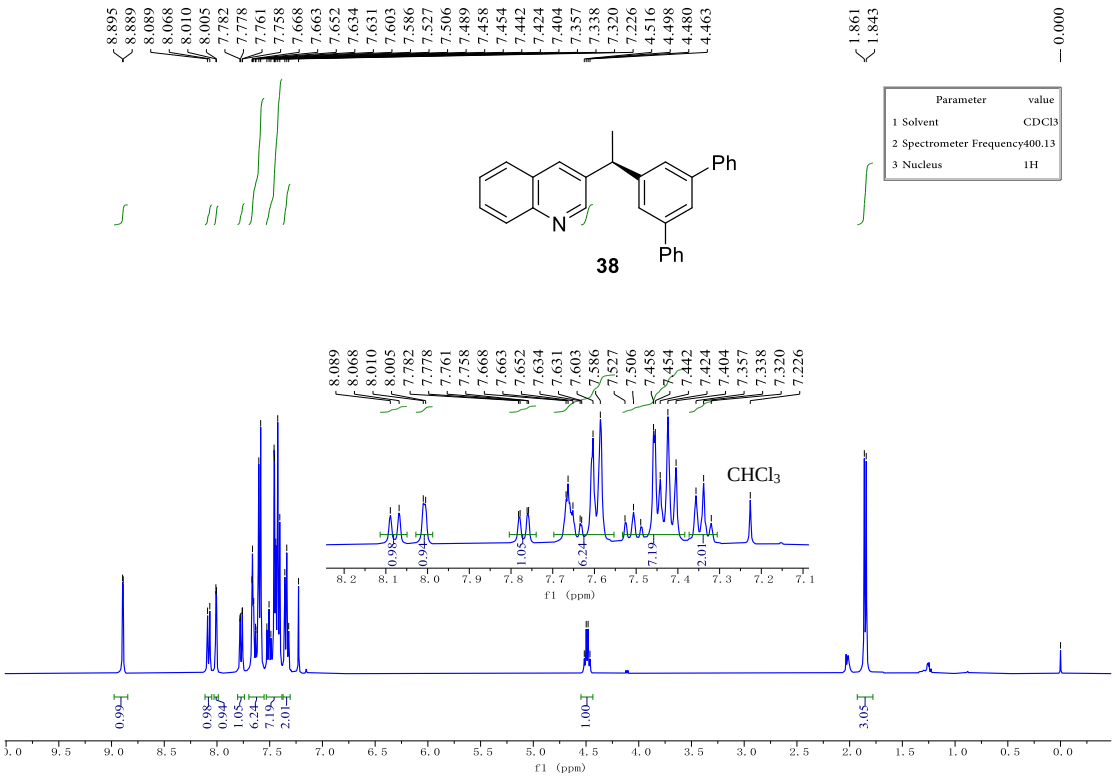
2 Spectrometer Frequency 100.62
3 Nucleus 13C
Br
N
Ph
Ph
36
CDCl3
f1 (ppm)


8.532
8.474
7.914
7.893
7.496
7.491
7.486
7.476
7.471
7.466
7.318
7.297
7.240
7.228
7.220
7.208
4.264
4.247
4.228
4.210
2.577
1.698
1.680
0.000
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
N
COMe
37
1.95
1.95
0.99
1.93
0.93
1.00
2.99
3.13
f1 (ppm)


197.607
150.459
149.253
147.850
140.610
135.523
134.846
128.725
127.730
123.475
77.318
77.000
76.683
42.441
26.533
21.240
CDCl3
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
N
COMe
37
f1 (ppm)


8.895
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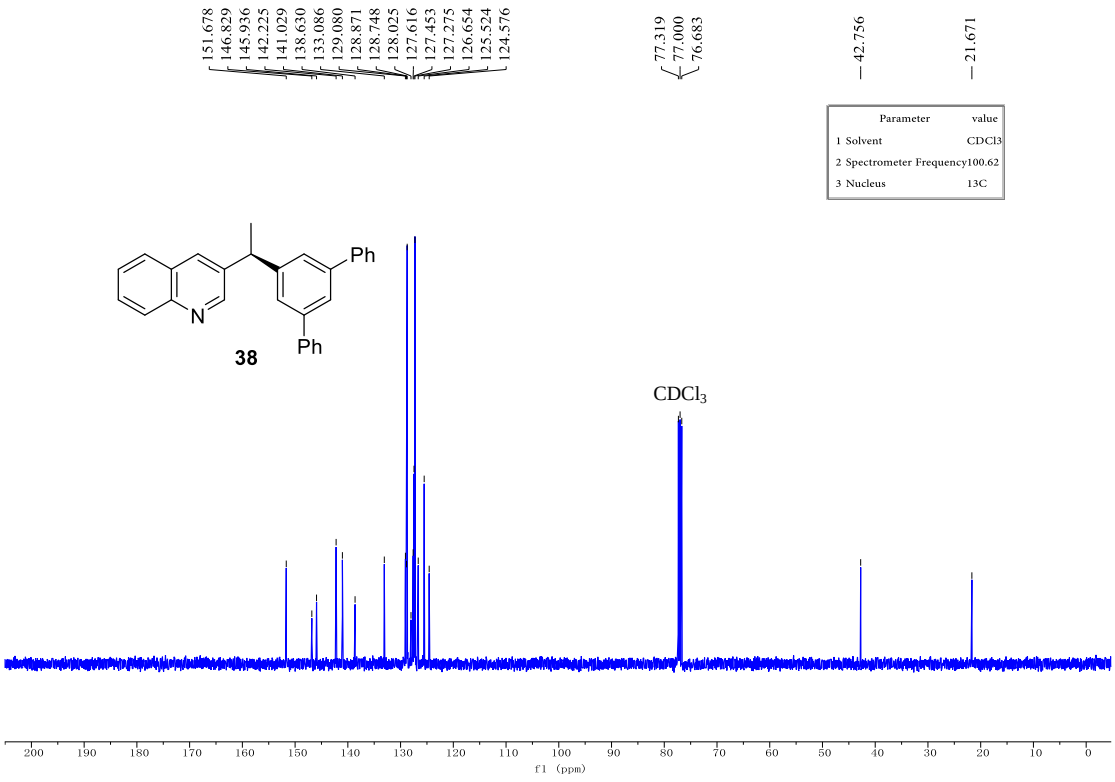
8.089
8.068
8.010
8.005
7.782
7.778
7.761
7.758
7.668
7.663
7.652
7.634
7.631
7.603
7.586
7.527
7.506
7.489
7.458
7.454
7.442
7.424
7.404
7.357
7.338
7.320
7.226
4.516
4.498
4.480
4.463
1.861
1.843
0.000
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency400.13
3 Nucleus 1H
Ph
N
Ph
38

8.089
8.068
8.010
8.005
7.782
7.778
7.761
7.758
7.668
7.663
7.652
7.634
7.631
7.603
7.586
7.527
7.506
7.458
7.454
7.442
7.424
7.404
7.357
7.338
7.320
7.226
CHCl3
0.98
0.94
1.05
6.24
7.19
2.01
f1 (ppm)
0.99
0.98
0.94
1.05
6.24
7.19
2.01
1.00
3.05
f1 (ppm)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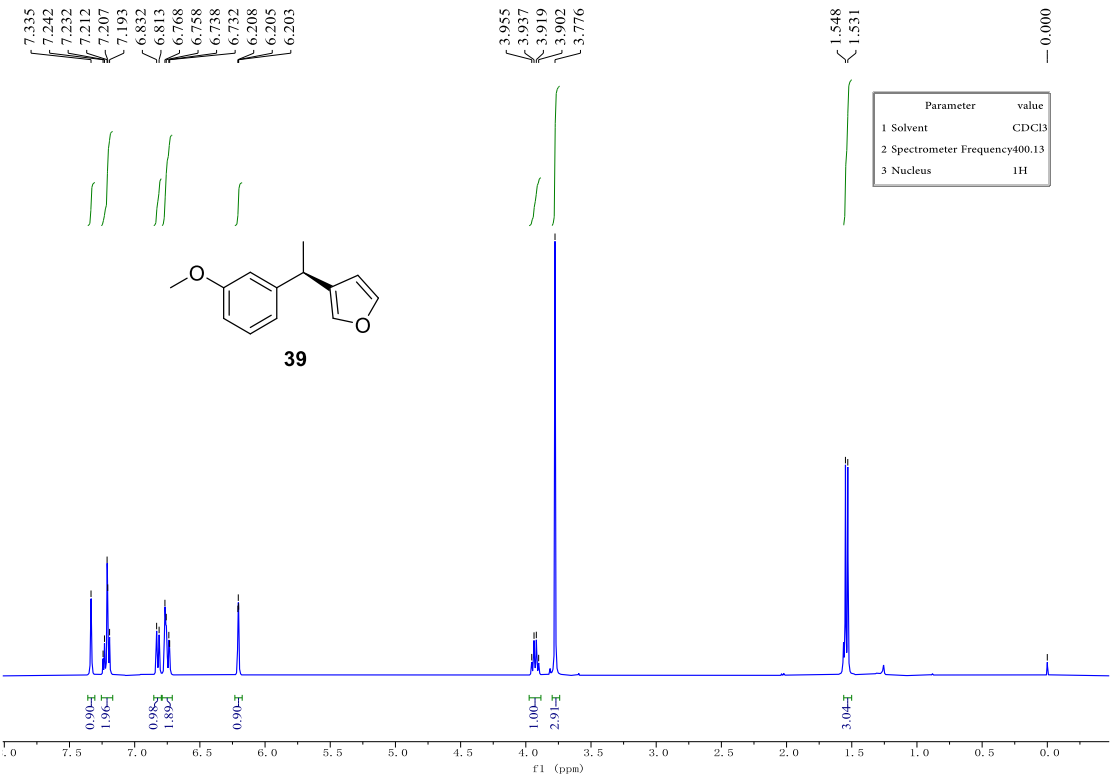
145.936
142.225
141.029
138.630
133.086
129.080
128.871
128.748
128.025
127.616
127.453
127.275
126.654
125.524
124.576
77.319
77.000
76.683
42.756
21.671
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency100.62
3 Nucleus 13C
Ph
N
Ph
38
CDCl3
f1 (ppm)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7.232
7.212
7.207
7.193
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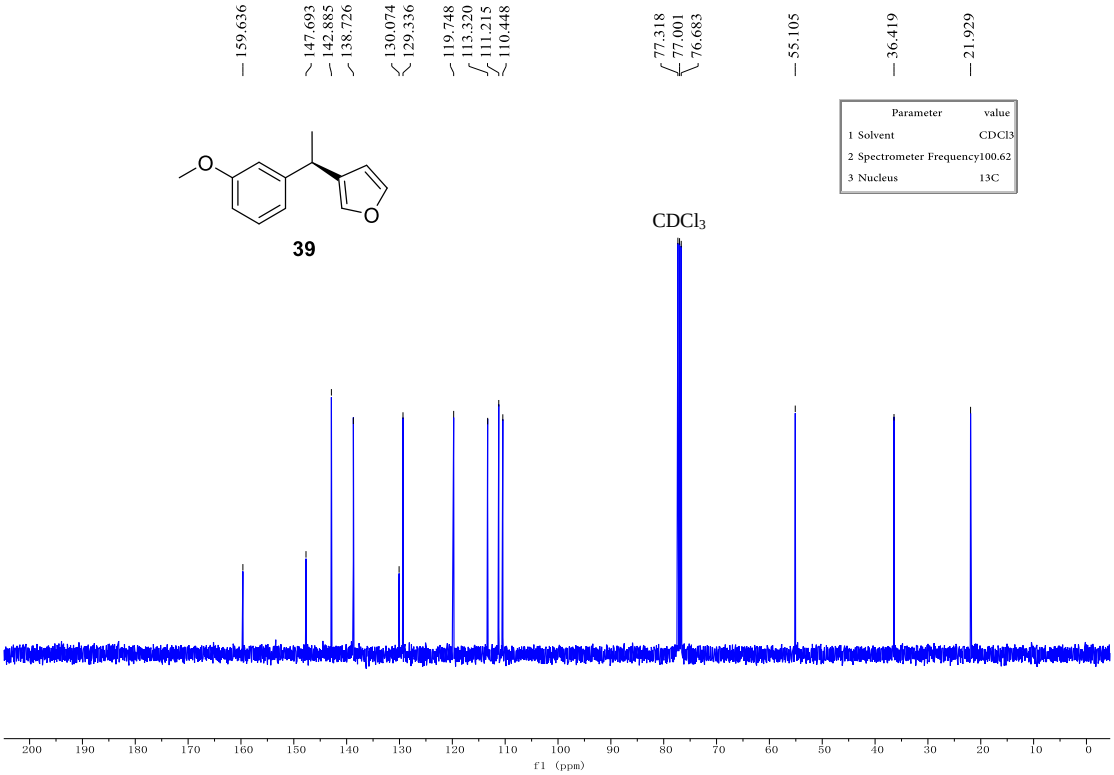
6.813
6.768
6.758
6.738
6.732
6.208
6.205
6.203
3.955
3.937
3.919
3.902
3.776
1.548
1.531
0.000
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency400.13
3 Nucleus 1H
O
O
39
0.90
1.96
0.98
1.89
0.90
1.00
2.91
3.04
f1 (ppm)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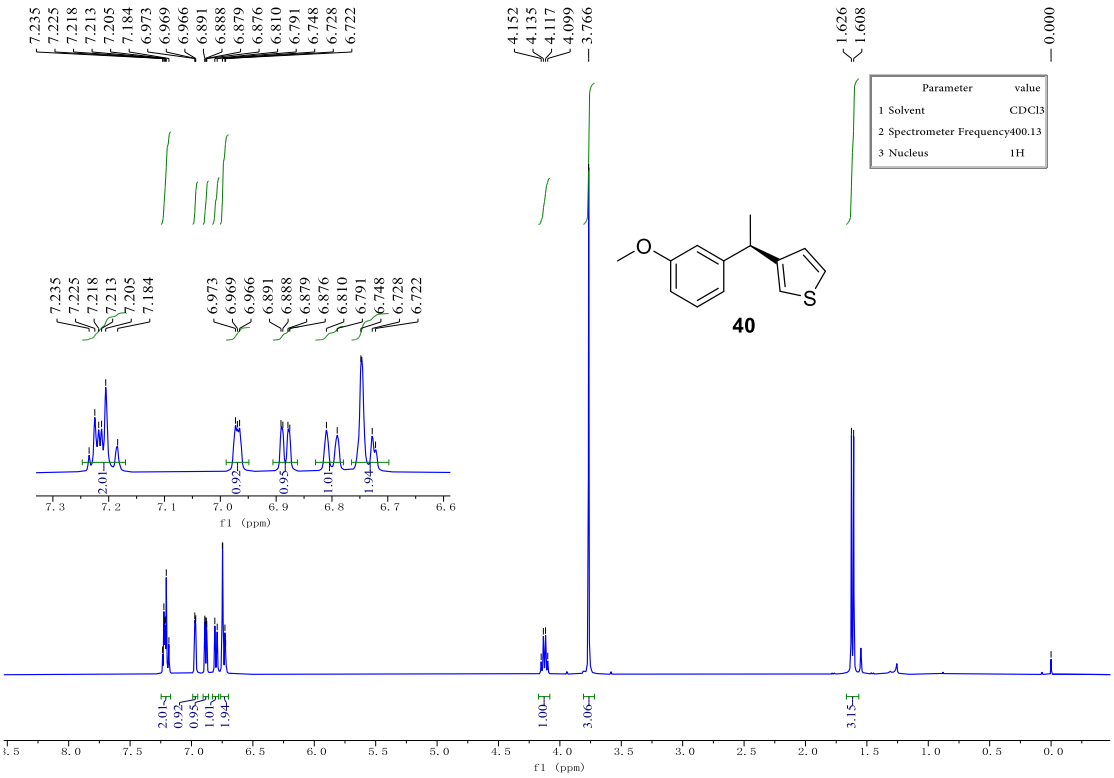
147.693
142.885
138.726
130.074
129.336
119.748
113.320
111.215
110.448
77.318
77.001
76.683
55.105
36.419
21.929
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency100.62
3 Nucleus 13C
O
O
39
CDCl3
f1 (ppm)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7.213
7.205
7.184
6.973
6.969
6.966
6.891
6.888
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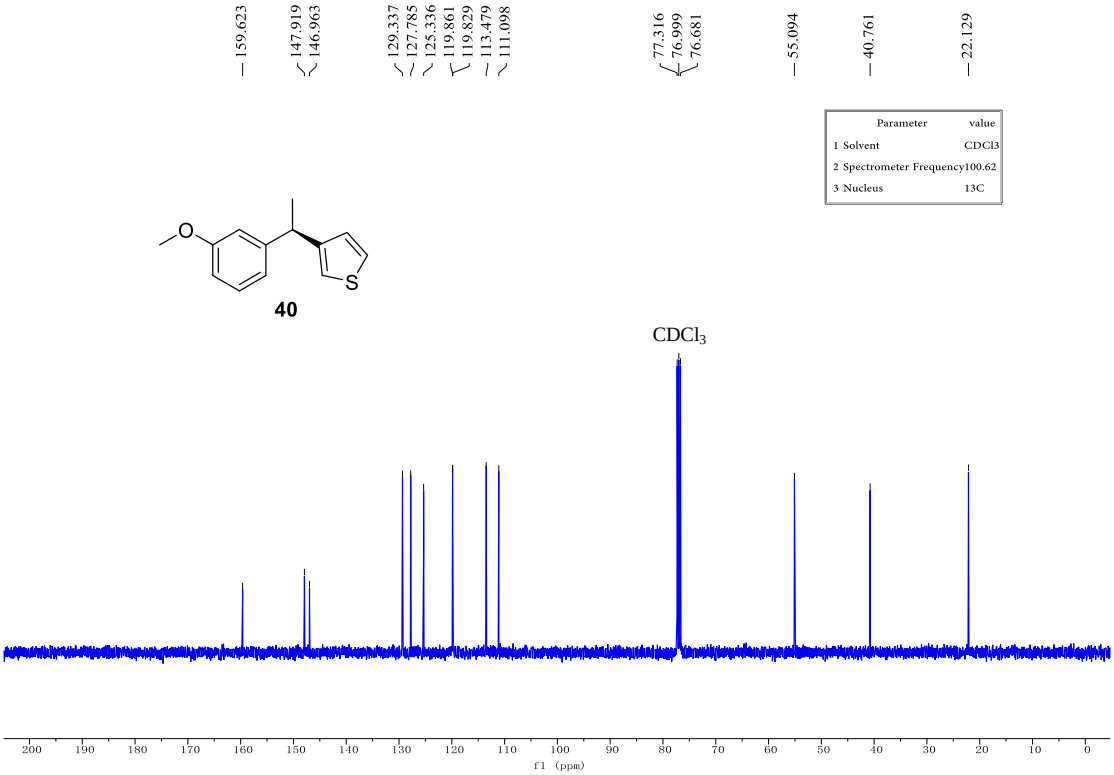
6.876
6.810
6.791
6.748
6.728
6.722
4.152
4.135
4.117
4.099
3.766
1.626
1.608
0.000
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency400.13
3 Nucleus 1H
O
S
40
f1 (ppm)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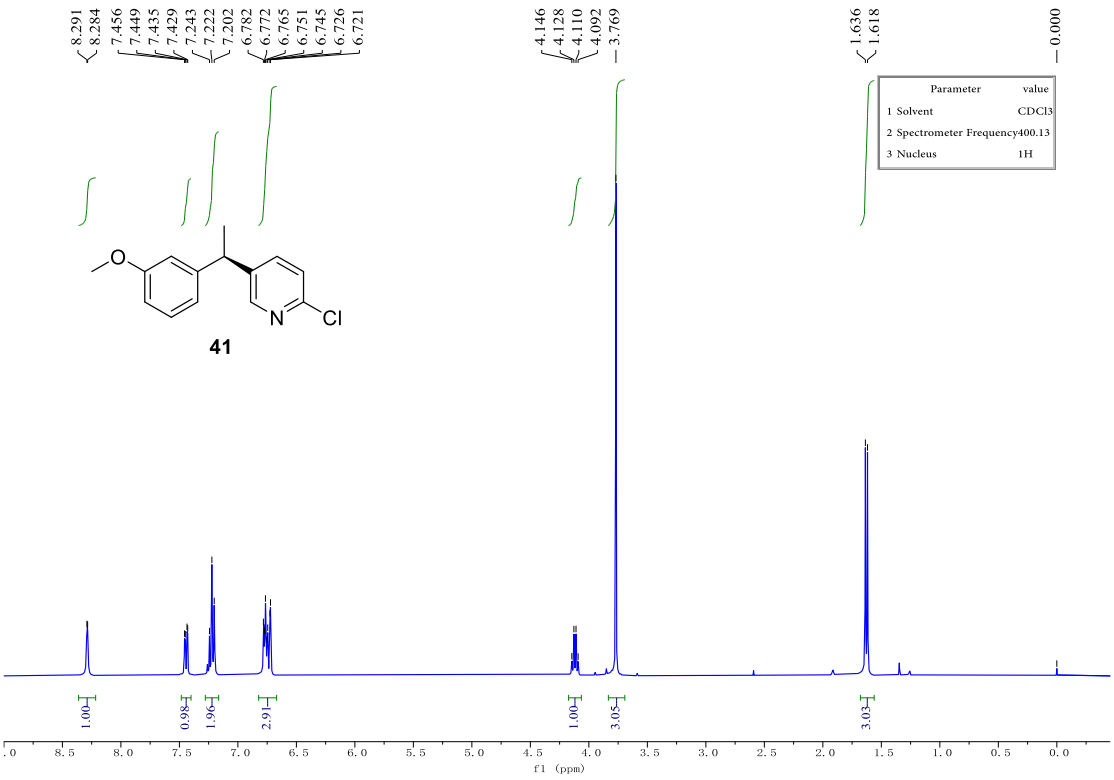
129.337
127.785
125.336
119.861
119.829
113.479
111.098
77.316
76.999
76.681
55.094
40.761
22.129
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency100.62
3 Nucleus 13C
O
S
40
CDCl3
f1 (ppm)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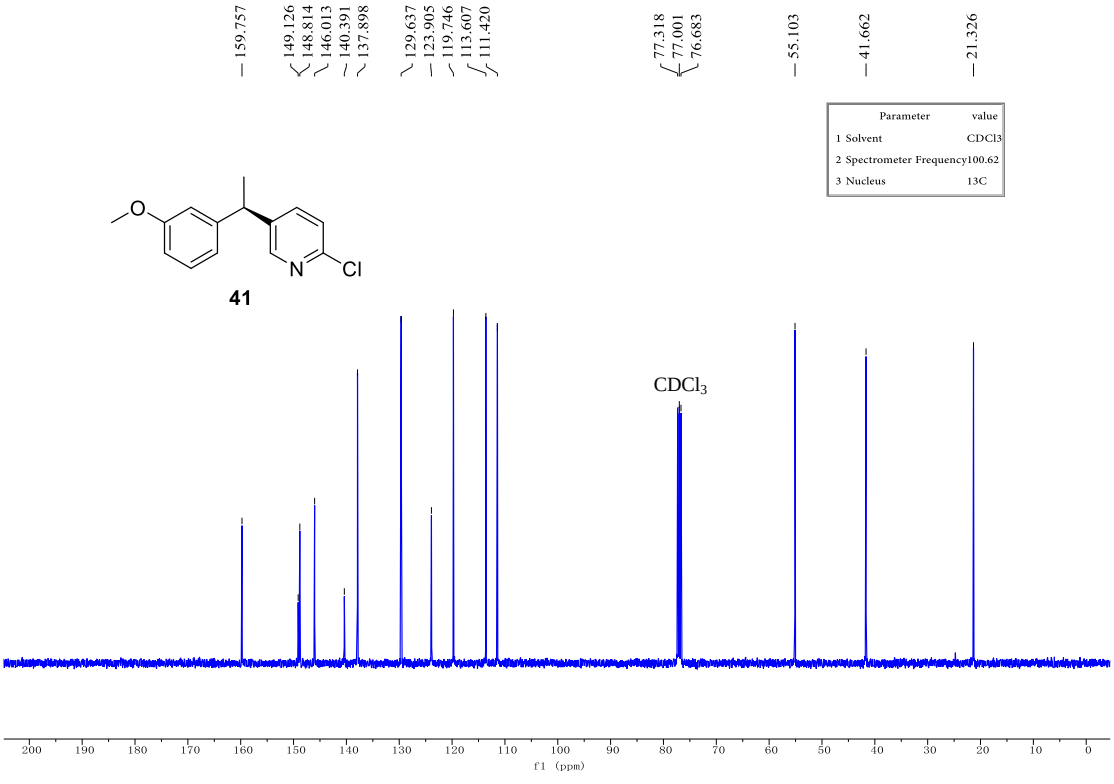
7.435
7.429
7.243
7.222
7.202
6.782
6.772
6.765
6.751
6.745
6.726
6.721
4.146
4.128
4.110
4.092
3.769
1.636
1.618
0.000
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
O
N
Cl
41
1.00
0.98
1.96
2.91
1.00
3.05
3.03
f1 (ppm)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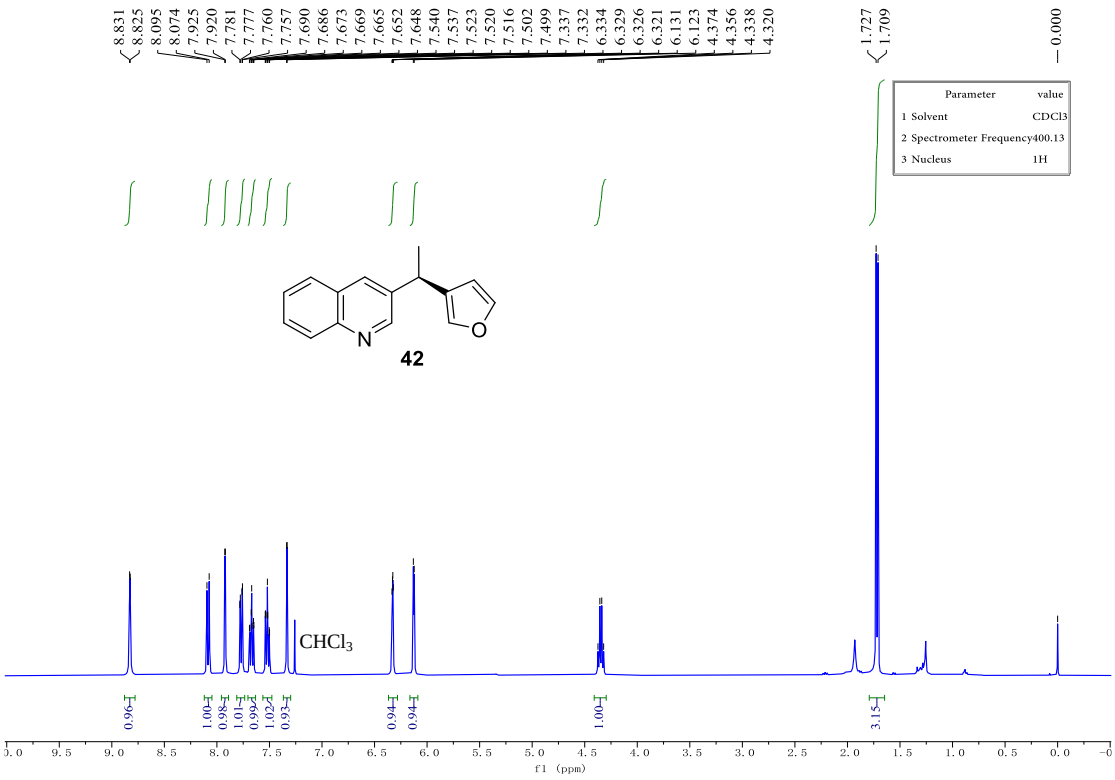
129.637
123.905
119.746
113.607
111.420
77.318
77.001
76.683
55.103
41.662
21.326
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
O
N
Cl
41
CDCl3
f1 (ppm)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8.074
7.925
7.920
7.781
7.777
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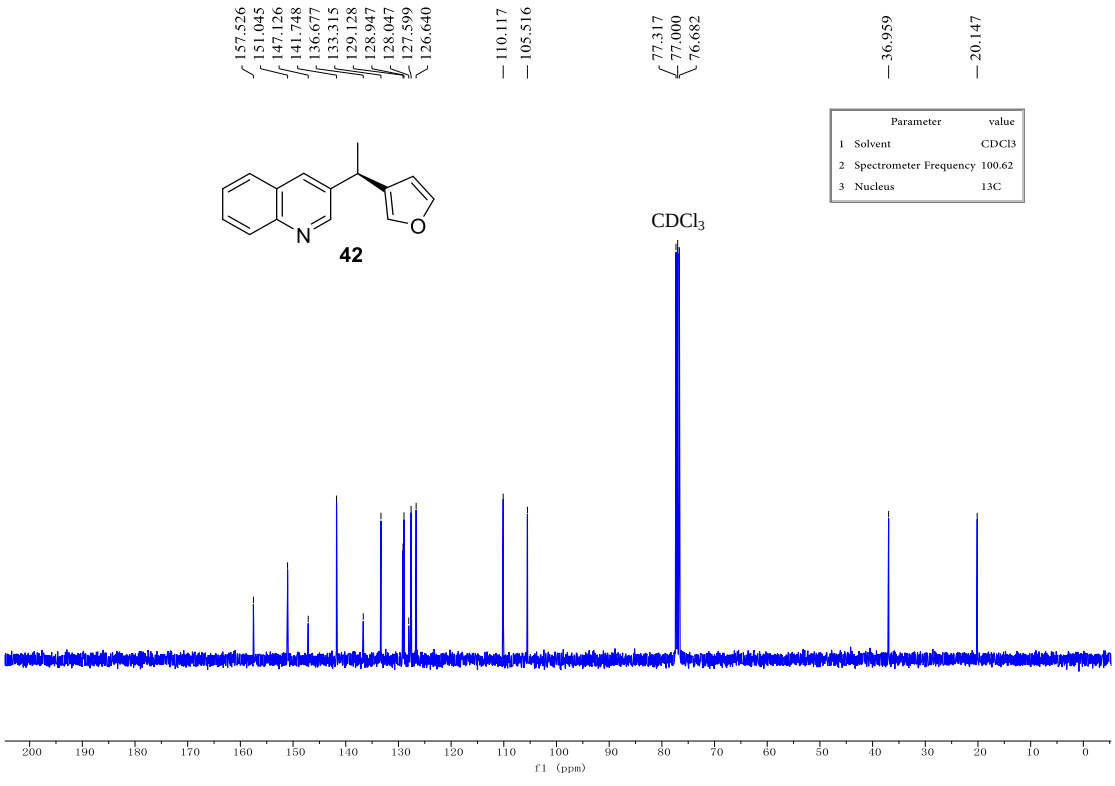
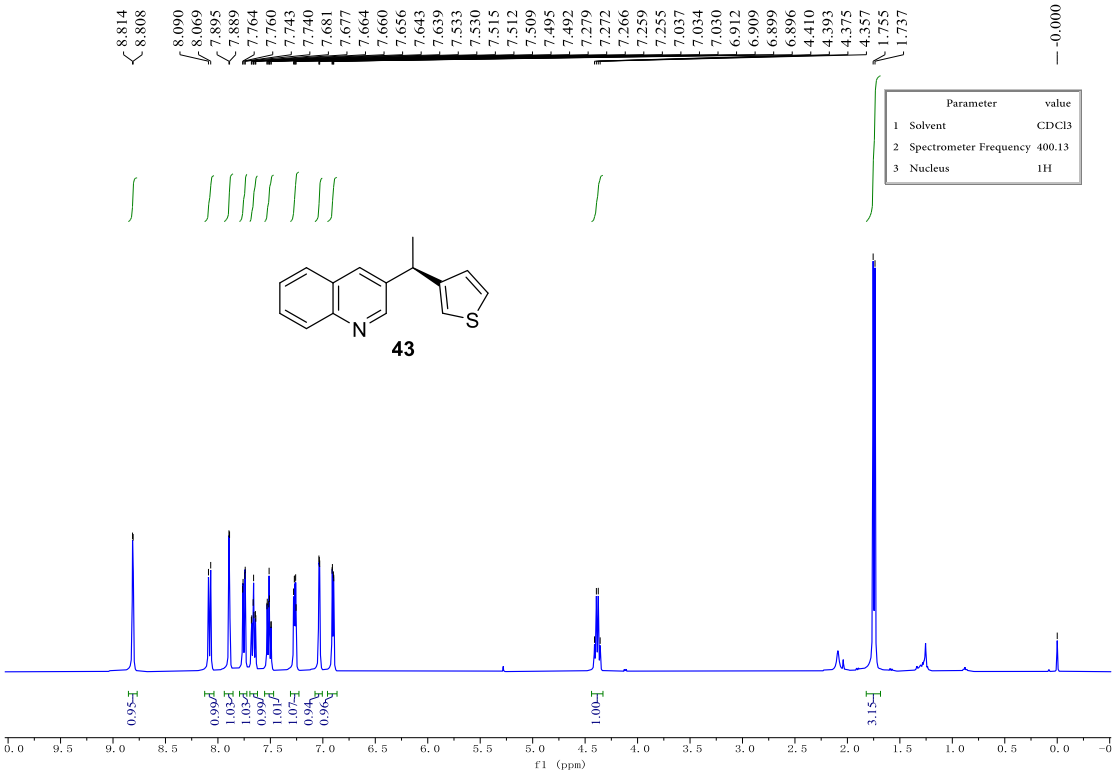
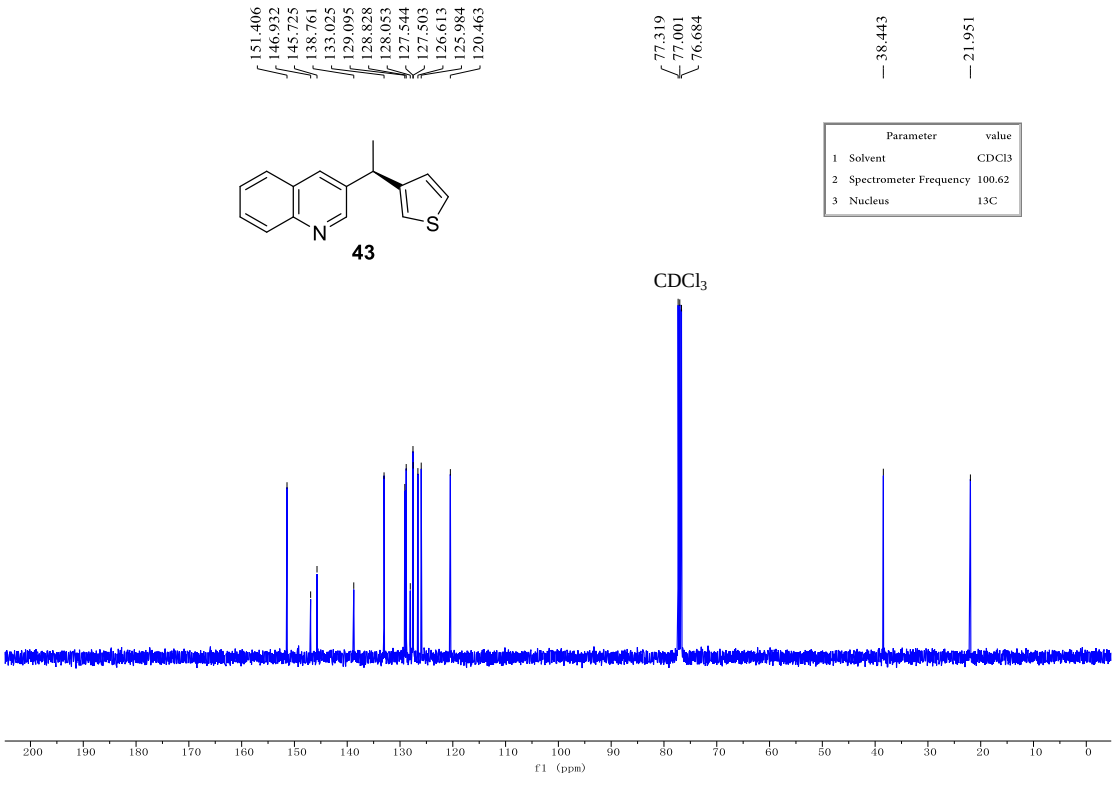
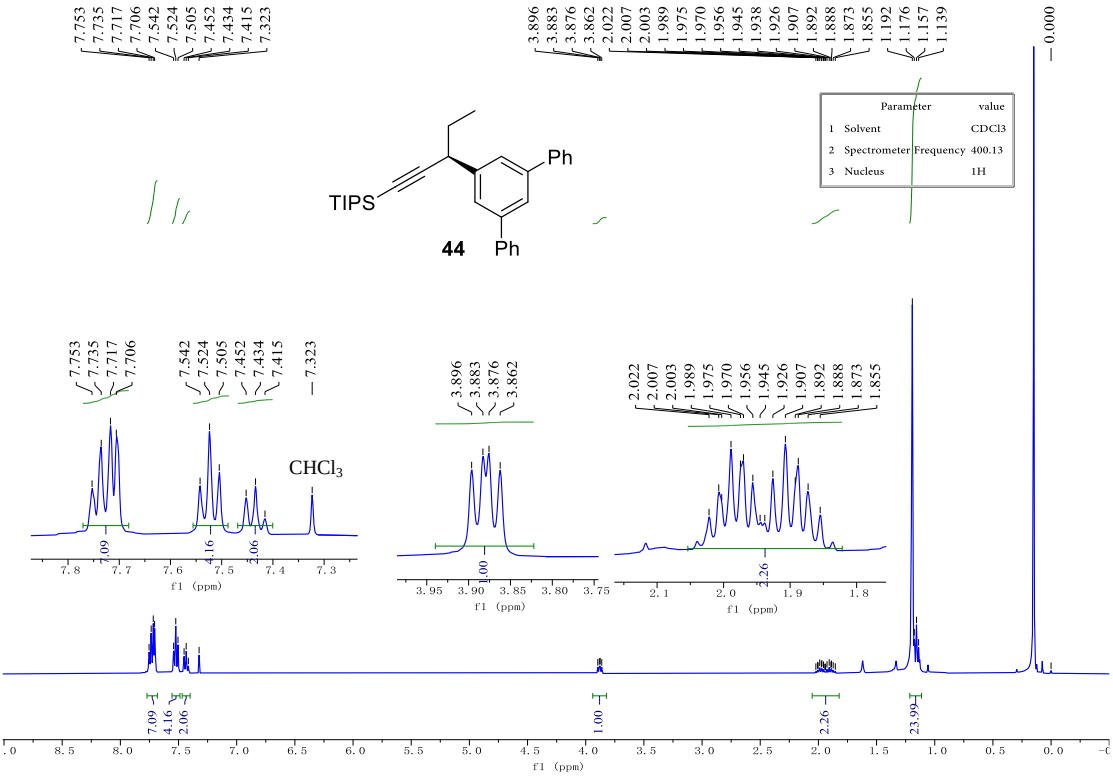
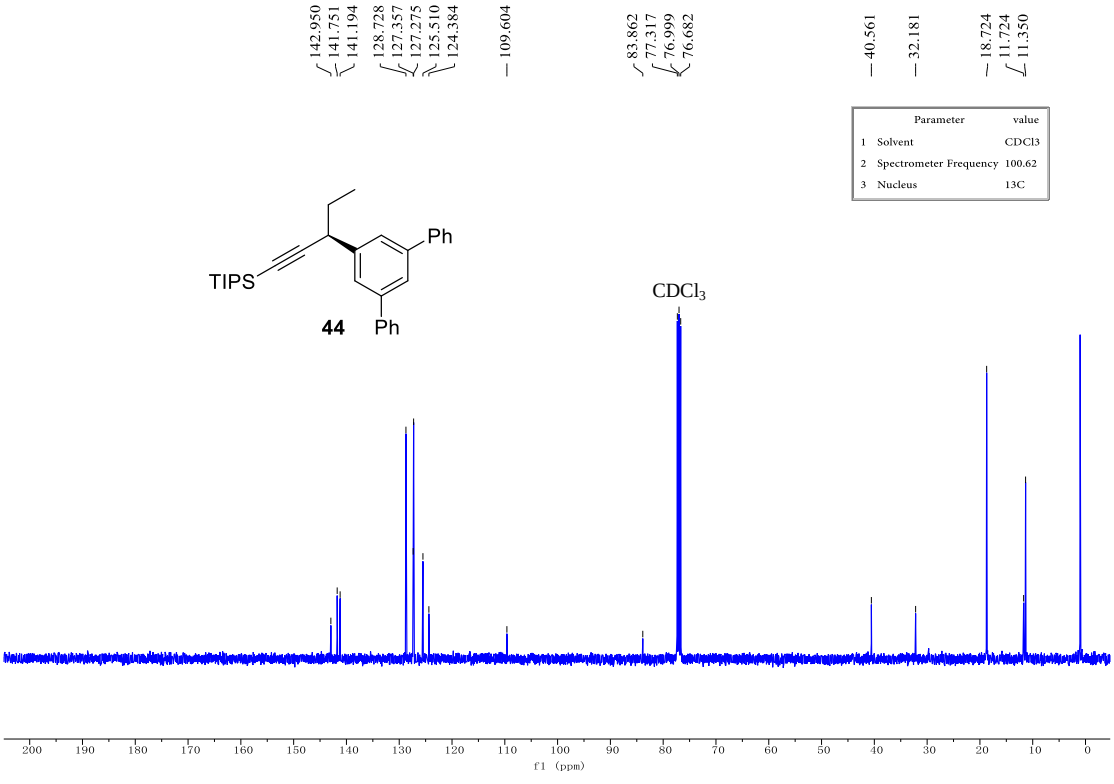
7.757
7.690
7.686
7.673
7.669
7.665
7.652
7.648
7.540
7.537
7.523
7.520
7.516
7.502
7.499
7.337
7.332
6.334
6.329
6.326
6.321
6.131
6.123
4.374
4.356
4.338
4.320
1.727
1.709
0.000
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
N
O
42
CHCl3
0.96
1.00
0.98
1.01
0.99
1.02
0.93
0.94
0.94
1.00
3.15
f1 (ppm)

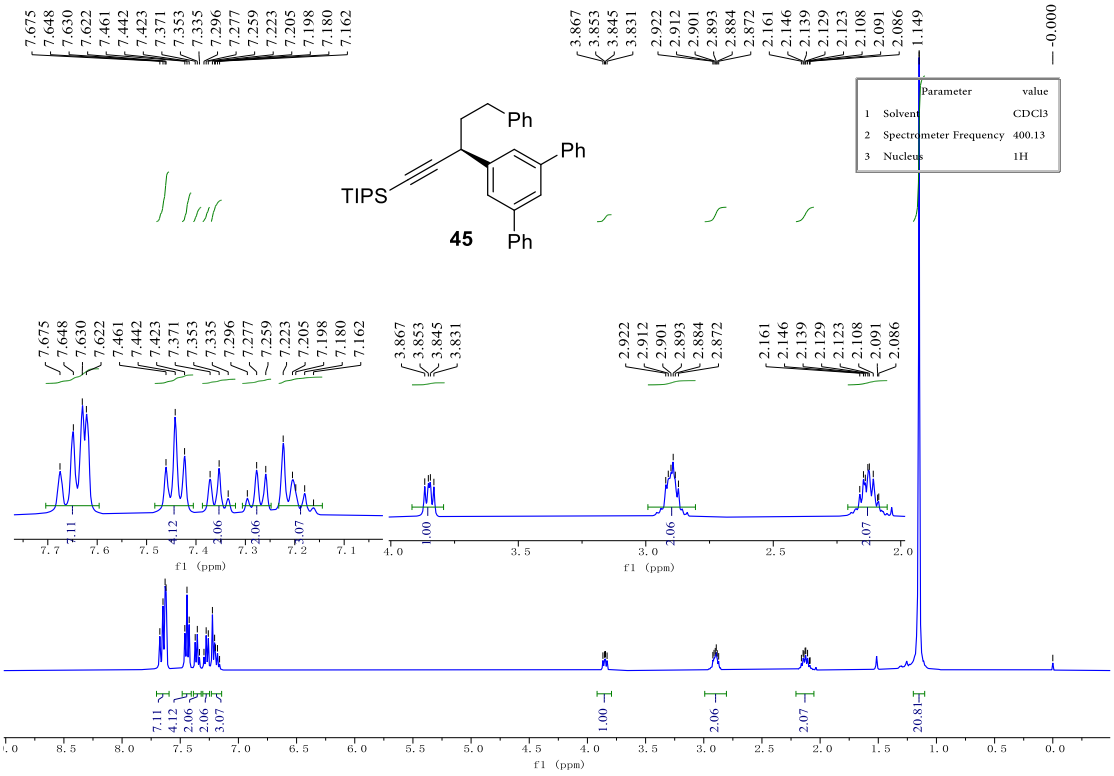

157.526
151.045
147.126
141.748
136.677
133.315
129.128
128.947
128.047
127.599
126.640
110.117
105.516
77.317
77.000
76.682
36.959
20.147
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
N
O
42
CDCl3
f1 (ppm)

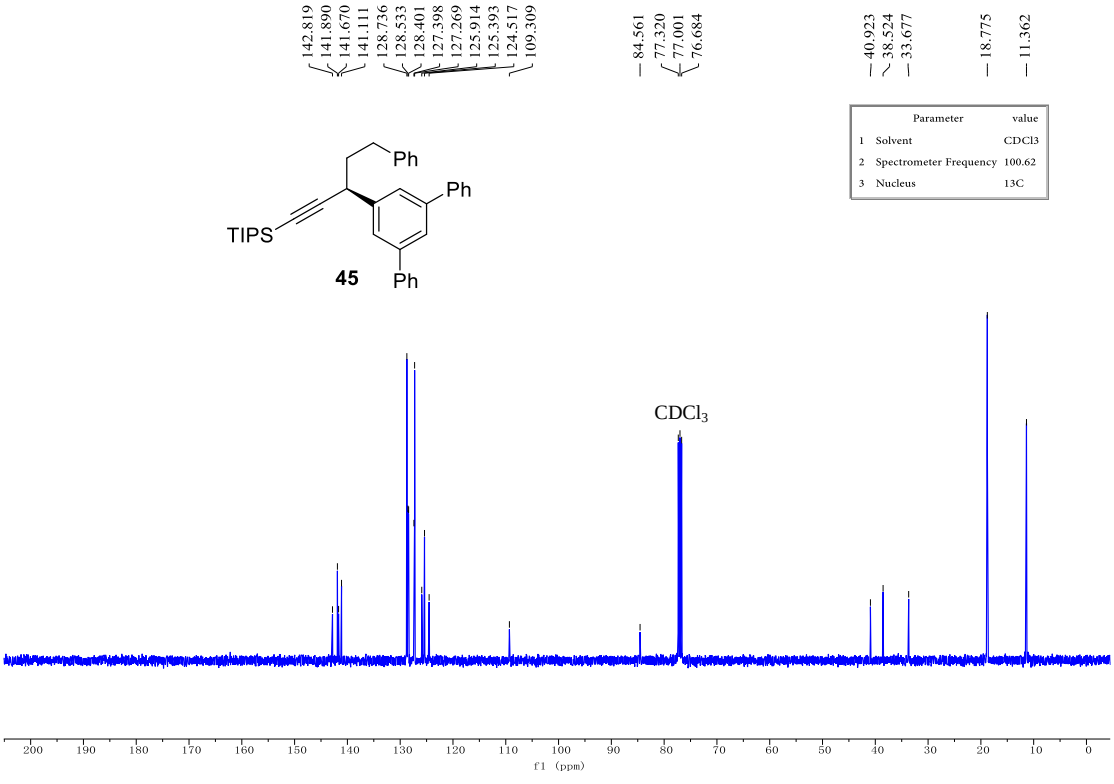

8.814
8.808
8.090
8.069
7.895
7.889
7.764
7.760
7.743
7.740
7.681
7.677
7.664
7.660
7.656
7.643
7.639
7.533
7.530
7.515
7.512
7.509
7.495
7.492
7.279
7.272
7.266
7.259
7.255
7.037
7.034
7.030
6.912
6.909
6.899
6.896
4.410
4.393
4.375
4.357
1.755
1.737
-0.000
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
43
0.95
0.99
1.03
1.03
0.99
1.01
1.07
0.94
0.96
1.00
3.15
f1 (ppm)

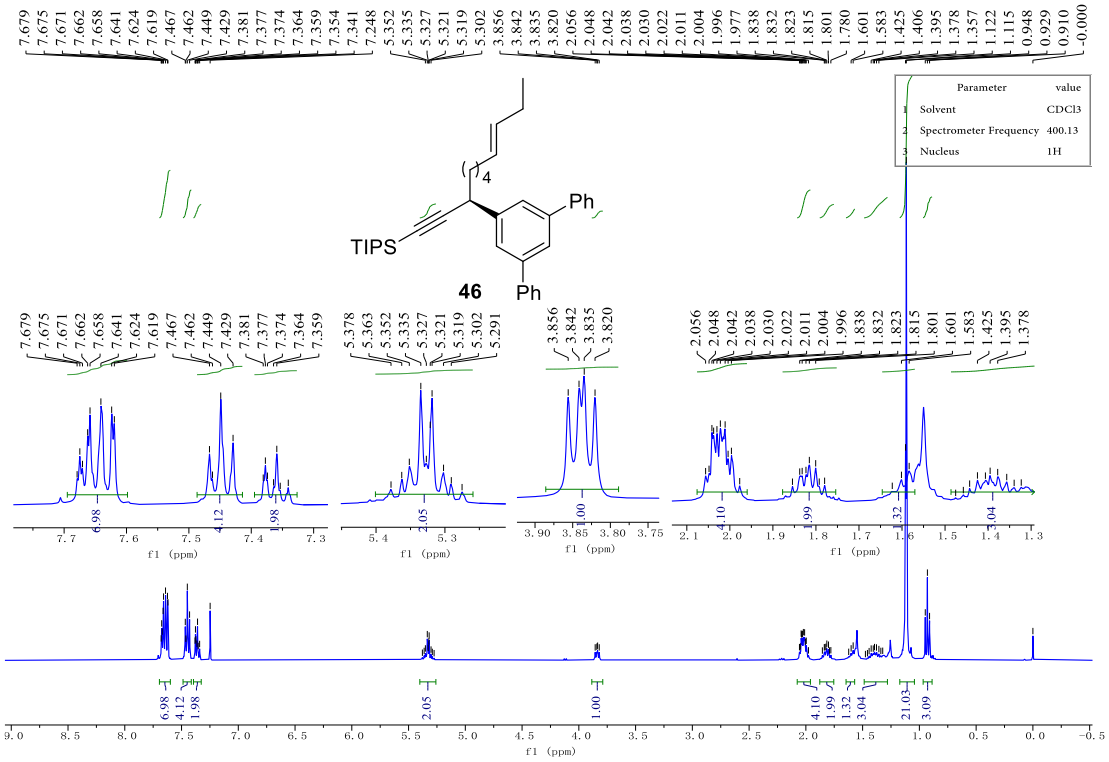

151.406
146.932
145.725
138.761
133.025
129.095
128.828
128.053
127.544
127.503
126.613
125.984
120.463
77.319
77.001
76.684
38.443
21.951
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
43
CDCl3
f1 (ppm)

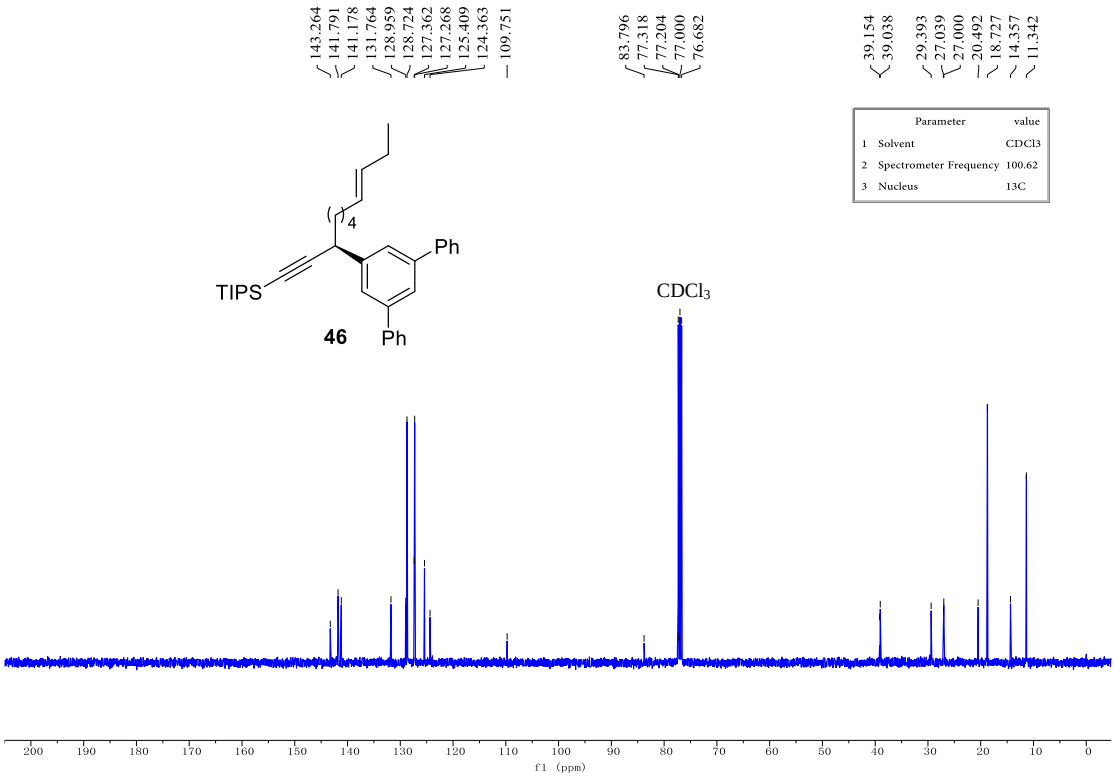

7.753
7.735
7.717
7.706
7.542
7.524
7.505
7.452
7.434
7.415
7.323
3.896
3.883
3.876
3.862
2.022
2.007
2.003
1.989
1.975
1.970
1.956
1.945
1.938
1.926
1.907
1.892
1.888
1.873
1.855
1.192
1.176
1.157
1.139
0.000
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
TIPS
Ph
Ph
44
CHCl3
7.09
4.16
2.06
1.00
2.26
23.99
f1 (ppm)

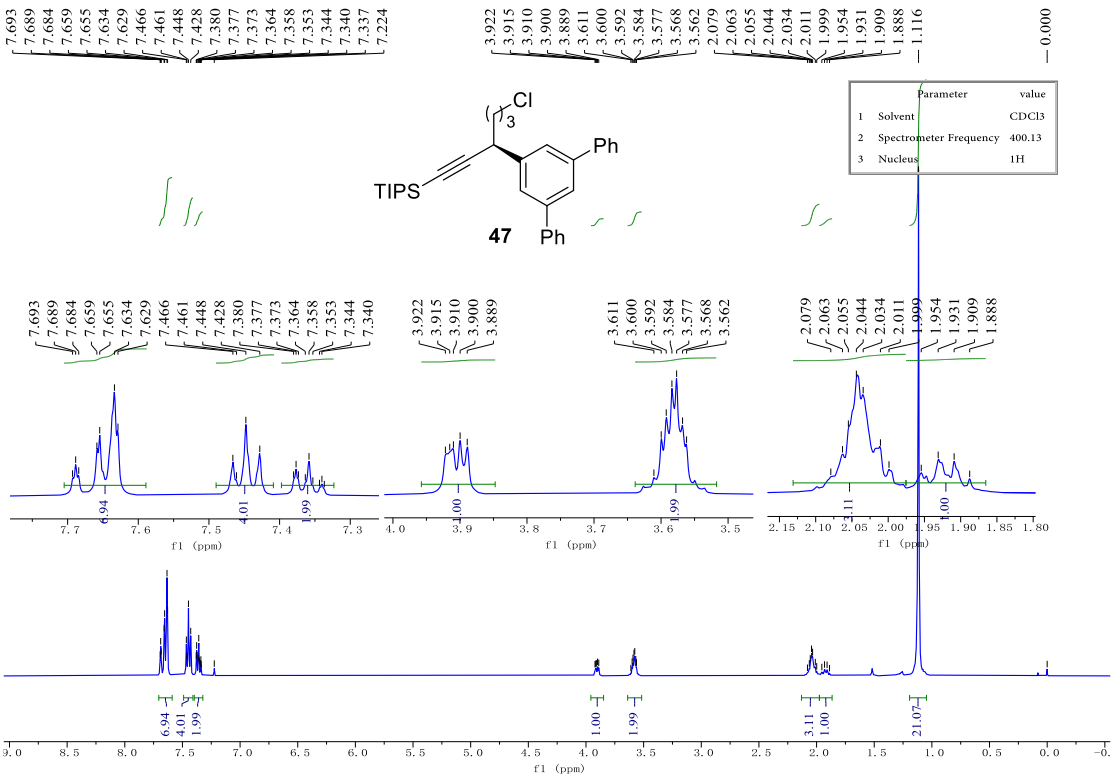

142.950
141.751
141.194
128.728
127.357
127.275
125.510
124.384
109.604
83.862
77.317
76.999
76.682
40.561
32.181
18.724
11.724
11.350
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
TIPS
Ph
Ph
44
CDCl3
f1 (ppm)

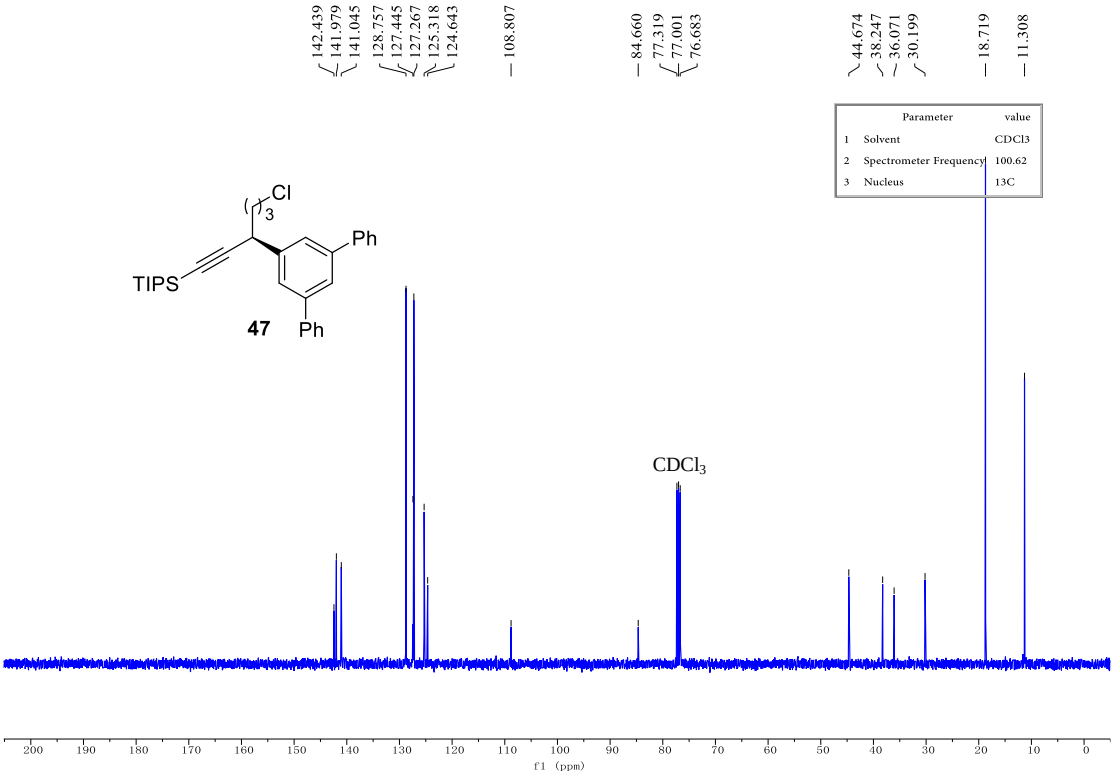

7.675
7.648
7.630
7.622
7.461
7.442
7.423
7.371
7.353
7.335
7.296
7.277
7.259
7.223
7.205
7.198
7.180
7.162
3.867
3.853
3.845
3.831
2.922
2.912
2.901
2.893
2.884
2.872
2.161
2.146
2.139
2.129
2.123
2.108
2.091
2.086
1.149
-0.000
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
Ph
Ph
TIPS
45
Ph
7.11
4.12
2.06
2.06
2.06
3.07
1.00
2.06
2.07
20.81
f1 (ppm)

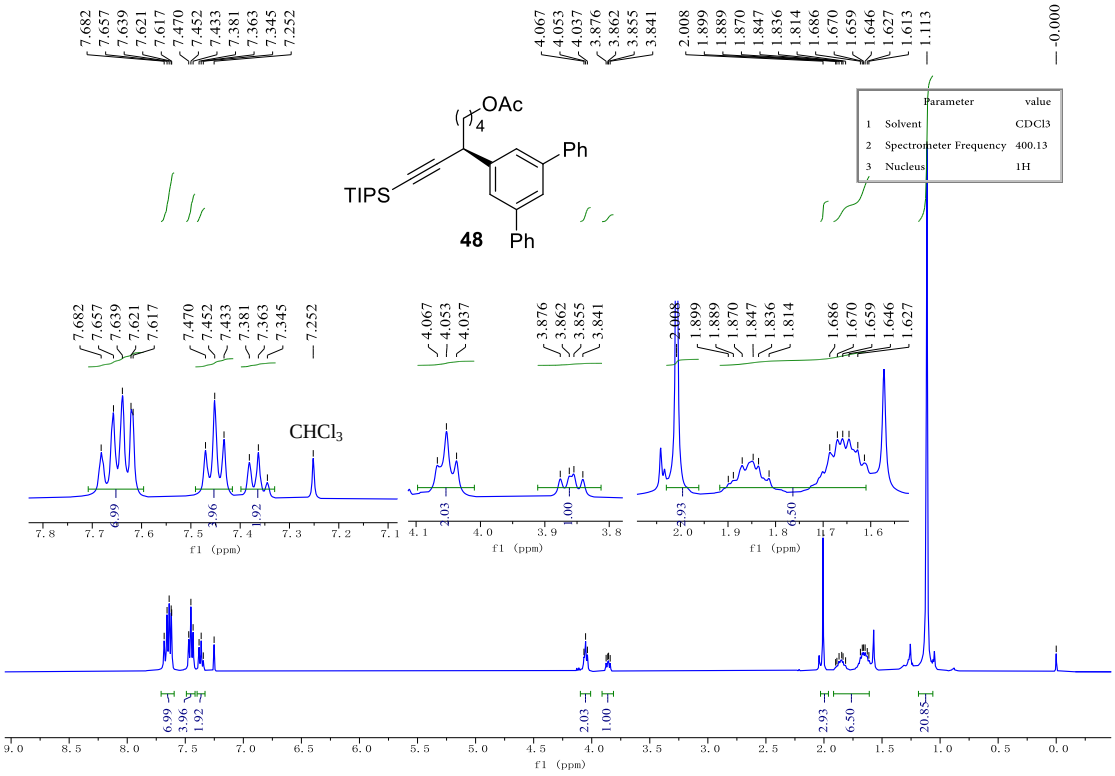

142.819
141.890
141.670
141.111
128.736
128.533
128.401
127.398
127.269
125.914
125.393
124.517
109.309
84.561
77.320
77.001
76.684
40.923
38.524
33.677
18.775
11.362
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
Ph
Ph
TIPS
45
Ph
CDCl3
f1 (ppm)

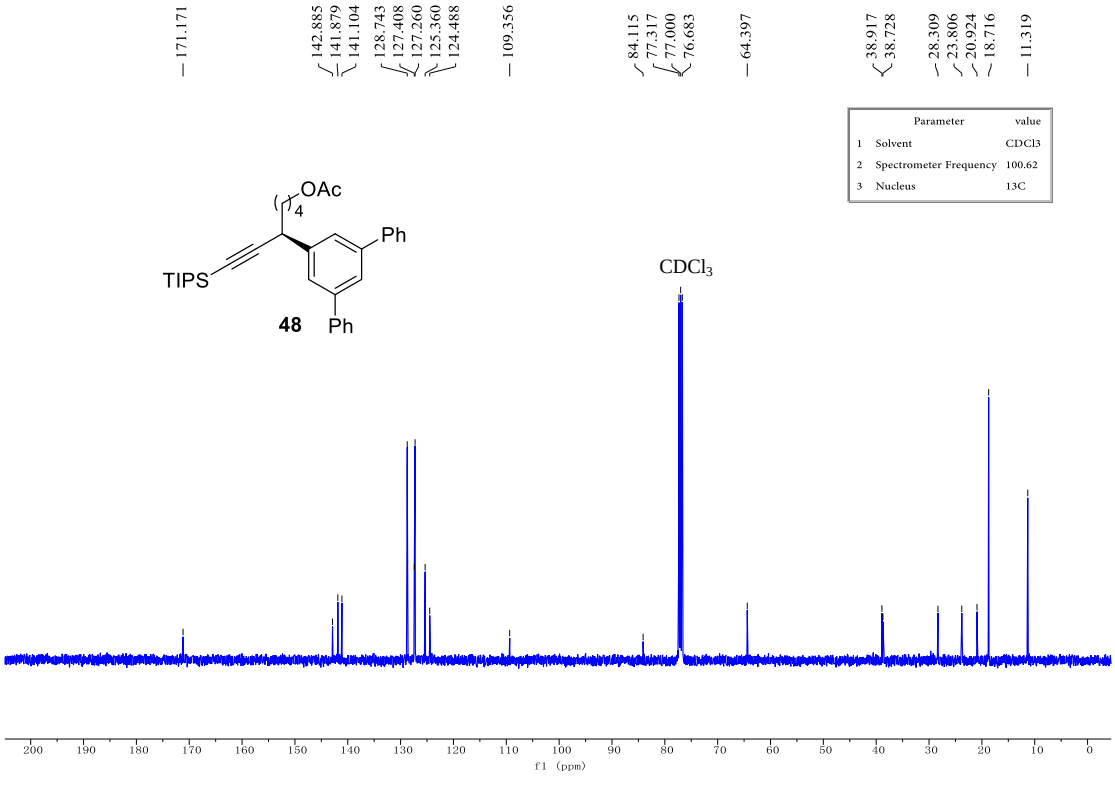

TIPS
Ph
Ph
46
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
f1 (ppm)

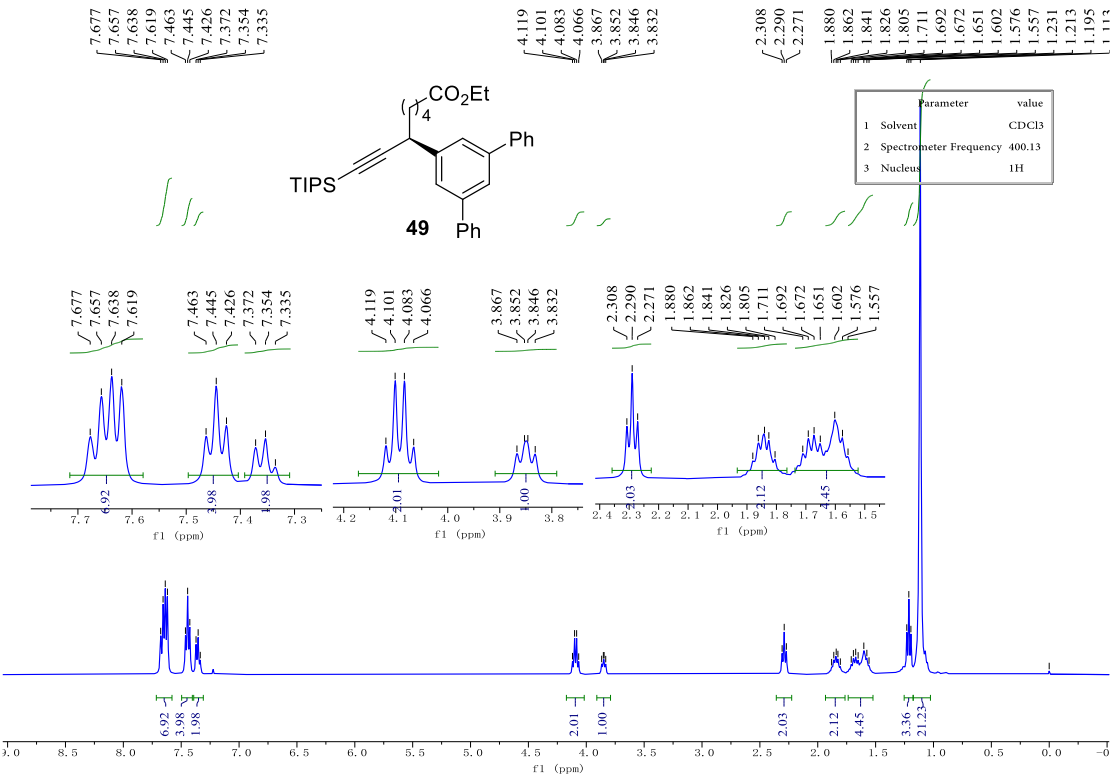

TIPS
Ph
Ph
46
CDCl3
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
f1 (ppm)

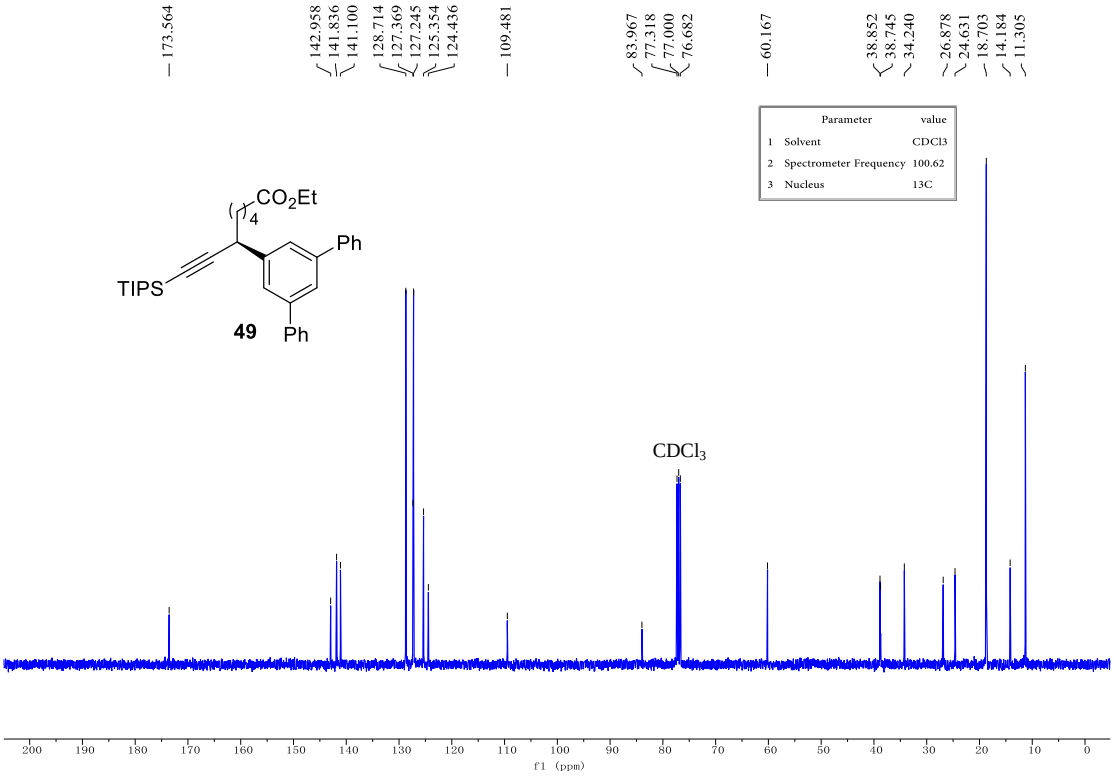

7.693 7.689 7.684 7.659 7.655 7.634 7.629 7.466 7.461 7.448 7.428 7.380 7.377 7.373 7.364 7.358 7.353 7.344 7.340 7.337 7.224
3.922 3.915 3.910 3.900 3.889 3.611 3.600 3.592 3.584 3.577 3.568 3.562 2.079 2.063 2.055 2.044 2.034 2.011 1.999 1.954 1.931 1.909 1.888 1.116 0.000
Cl
3
Ph
TIPS
47
Ph
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
6.94
4.01
1.99
1.00
1.99
3.11
1.00
21.07
f1 (ppm)

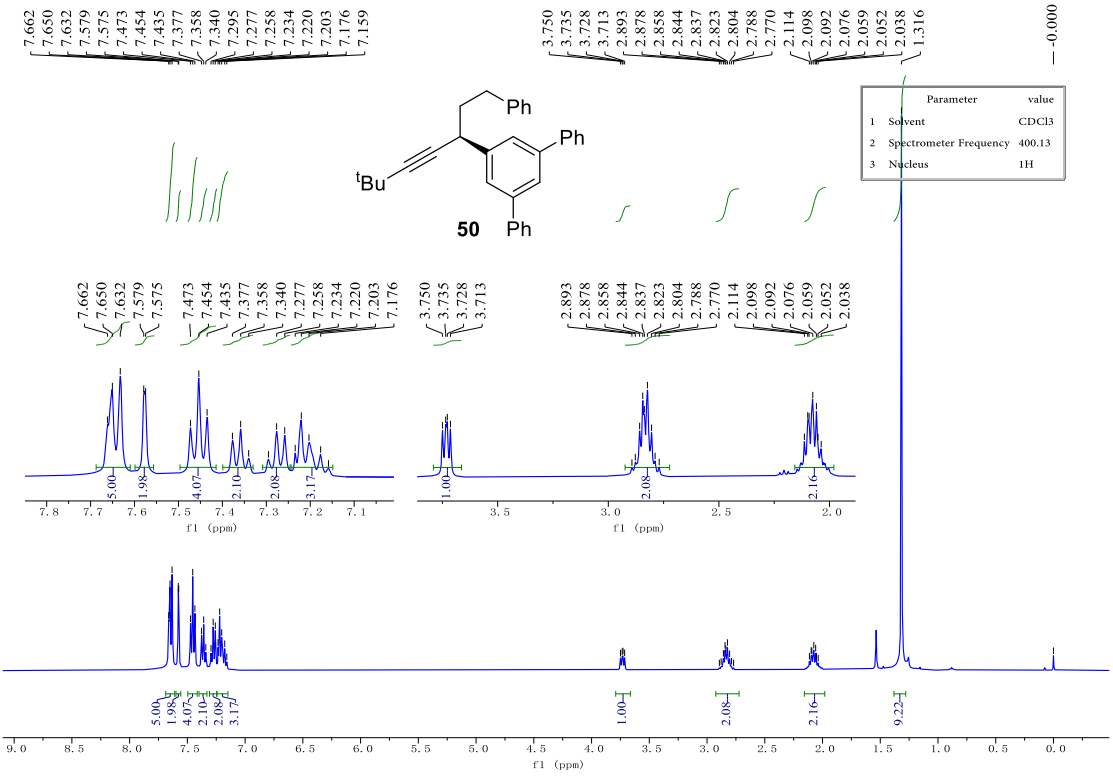

142.439 141.979 141.045 128.757 127.445 127.267 125.318 124.643 108.807 84.660 77.319 77.001 76.683 44.674 38.247 36.071 30.199 18.719 11.308
Cl
3
Ph
TIPS
47
Ph
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
CDCl3
f1 (ppm)

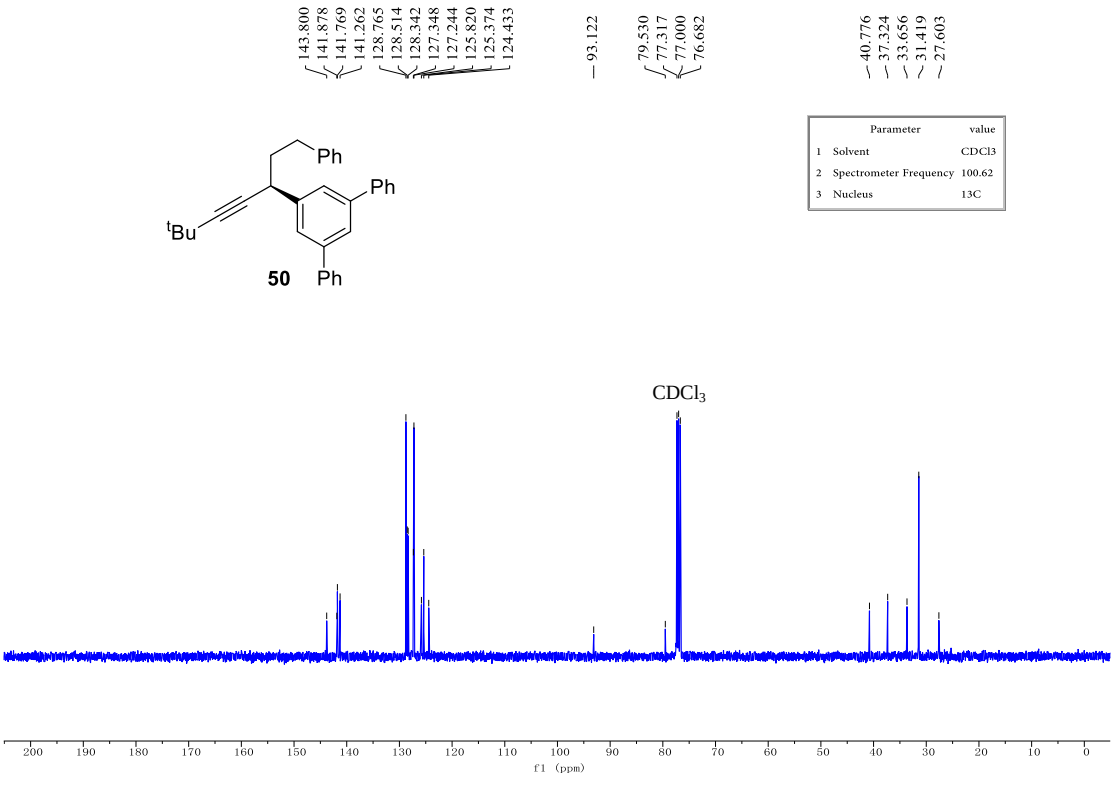

7.682 7.657 7.639 7.621 7.617 7.470 7.452 7.433 7.381 7.363 7.345 7.252
4.067 4.053 4.037 3.876 3.862 3.855 3.841
2.008 1.899 1.889 1.870 1.847 1.836 1.814 1.686 1.670 1.659 1.646 1.627 1.613 1.113
-0.000
OAc
4
Ph
TIPS
48
Ph
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
CHCl3
6.99 3.96 1.92 2.03 1.00 2.93 6.50 20.85
f1 (ppm)

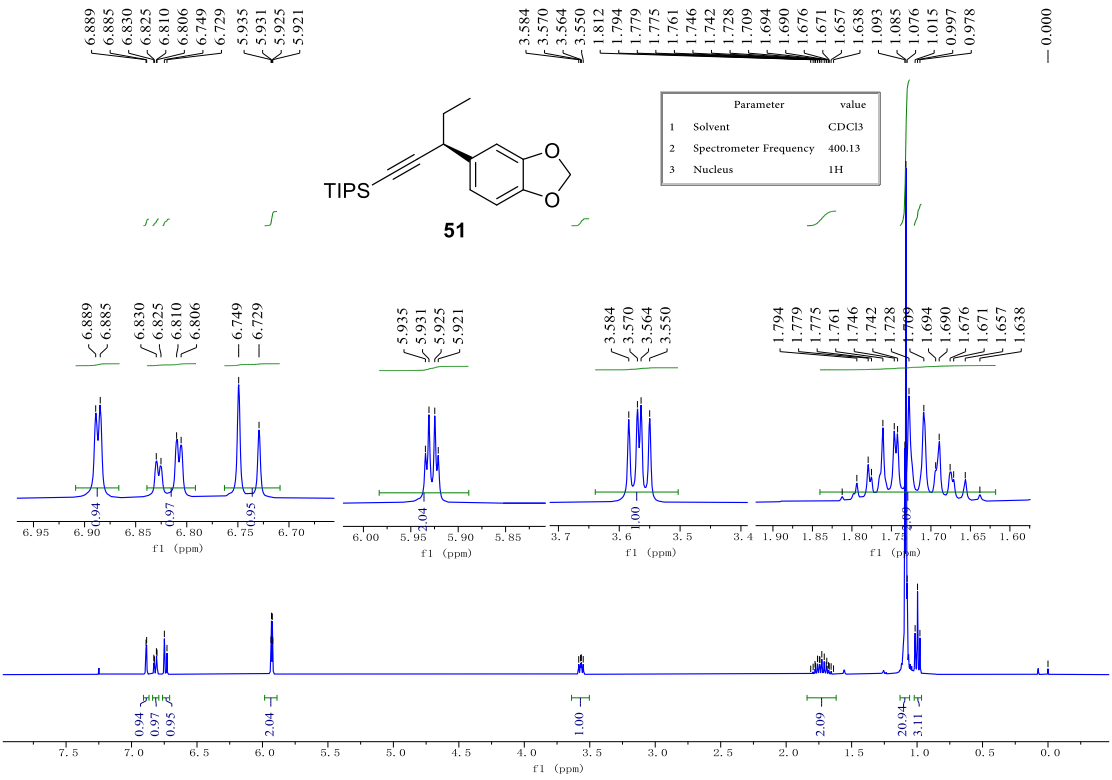

171.171
142.885 141.879 141.104 128.743 127.408 127.260 125.360 124.488
109.356
84.115 77.317 77.000 76.683
64.397
38.917 38.728 28.309 23.806 20.924 18.716 11.319
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
OAc
4
Ph
TIPS
48
Ph
CDCl3
f1 (ppm)

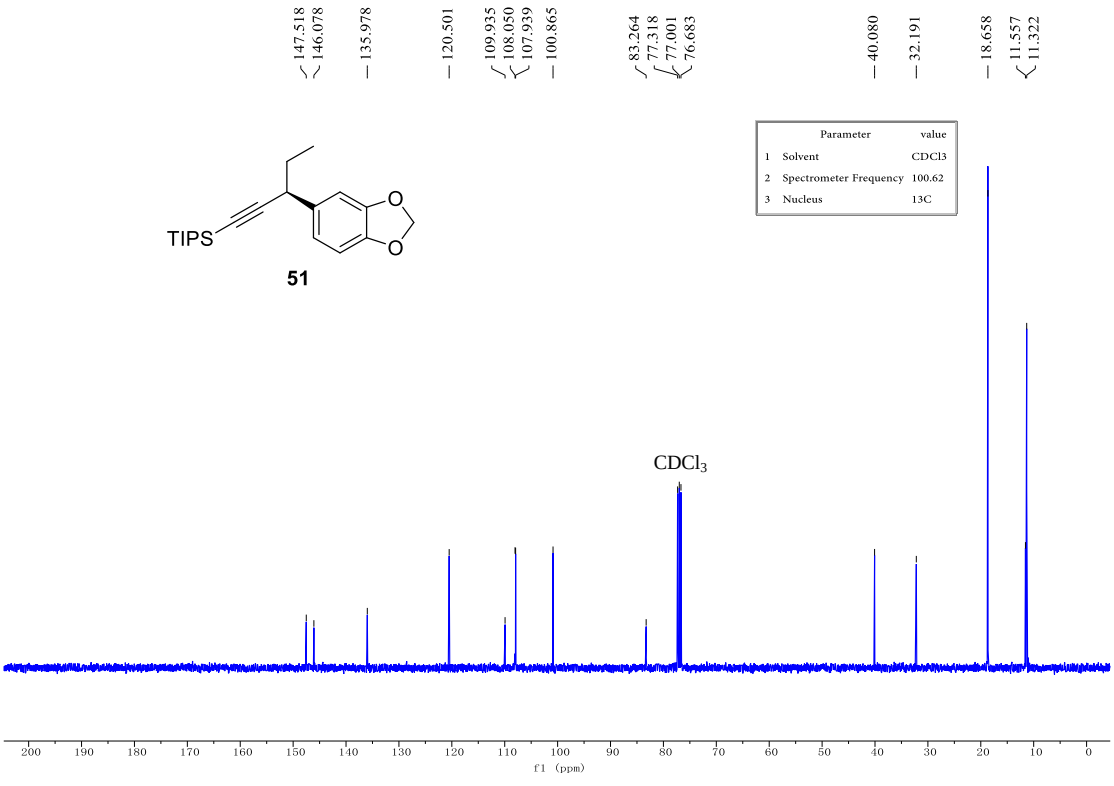

7.677 7.657 7.638 7.619 7.463 7.445 7.426 7.372 7.354 7.335
4.119 4.101 4.083 4.066 3.867 3.852 3.846 3.832
2.308 2.290 2.271 1.880 1.862 1.841 1.826 1.805 1.711 1.692 1.672 1.651 1.602 1.576 1.557 1.231 1.213 1.195
CO2Et
4
Ph
TIPS
49
Ph
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
6.92 3.98 1.98 2.01 1.00 2.03 2.12 4.45 3.36 21.23
f1 (ppm)

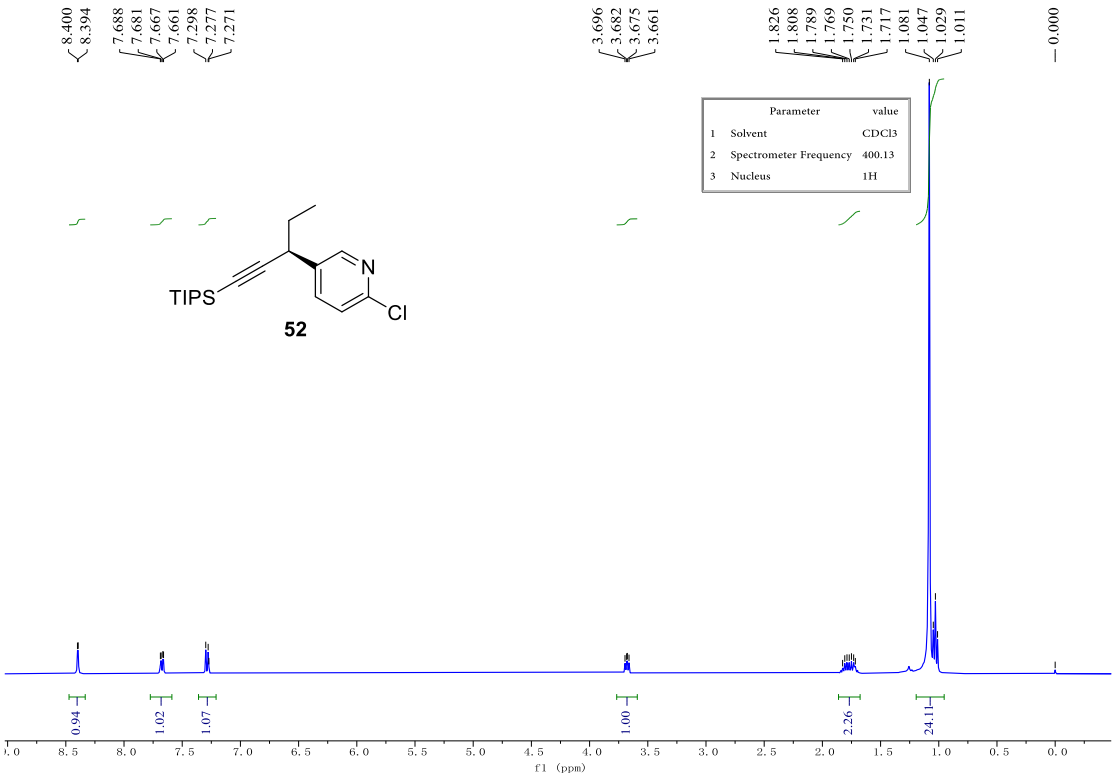

173.564
142.958 141.836 141.100 128.714 127.369 127.245 125.354 124.436
109.481
83.967 77.318 77.000 76.682
60.167
38.852 38.745 34.240 26.878 24.631 18.703 14.184 11.305
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
CO2Et
4
Ph
TIPS
49
Ph
CDCl3
f1 (ppm)


7.662 7.650 7.632 7.579 7.575 7.473 7.454 7.435 7.377 7.358 7.340 7.295 7.277 7.258 7.234 7.220 7.203 7.176 7.159
3.750 3.735 3.728 3.713 2.893 2.878 2.858 2.844 2.837 2.823 2.804 2.788 2.770 2.114 2.098 2.092 2.076 2.059 2.052 2.038 1.316
-0.000
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
Ph
Ph
tBu
50
Ph
f1 (ppm)


143.800 141.878 141.769 141.262 128.765 128.514 128.342 127.348 127.244 125.820 125.374 124.433
93.122
79.530 77.317 77.000 76.682
40.776 37.324 33.656 31.419 27.603
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
Ph
Ph
tBu
50
Ph
CDCl3
f1 (ppm)


6.889
6.885
6.830
6.825
6.810
6.806
6.749
6.729
5.935
5.931
5.925
5.921
3.584
3.570
3.564
3.550
1.812
1.794
1.779
1.775
1.761
1.746
1.742
1.728
1.709
1.694
1.690
1.676
1.671
1.657
1.638
1.093
1.085
1.076
1.015
0.997
0.978
0.000
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
TIPS
O
O
51
0.94
0.97
0.95
2.04
1.00
2.09
20.94
3.11
f1 (ppm)


147.518
146.078
135.978
120.501
109.935
108.050
107.939
100.865
83.264
77.318
77.001
76.683
40.080
32.191
18.658
11.557
11.322
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
TIPS
O
O
51
CDCl3
f1 (ppm)


8.400
8.394
7.688
7.681
7.667
7.661
7.298
7.277
7.271
3.696
3.682
3.675
3.661
1.826
1.808
1.789
1.769
1.750
1.731
1.717
1.081
1.047
1.029
1.011
0.000
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
TIPS
N
Cl
52
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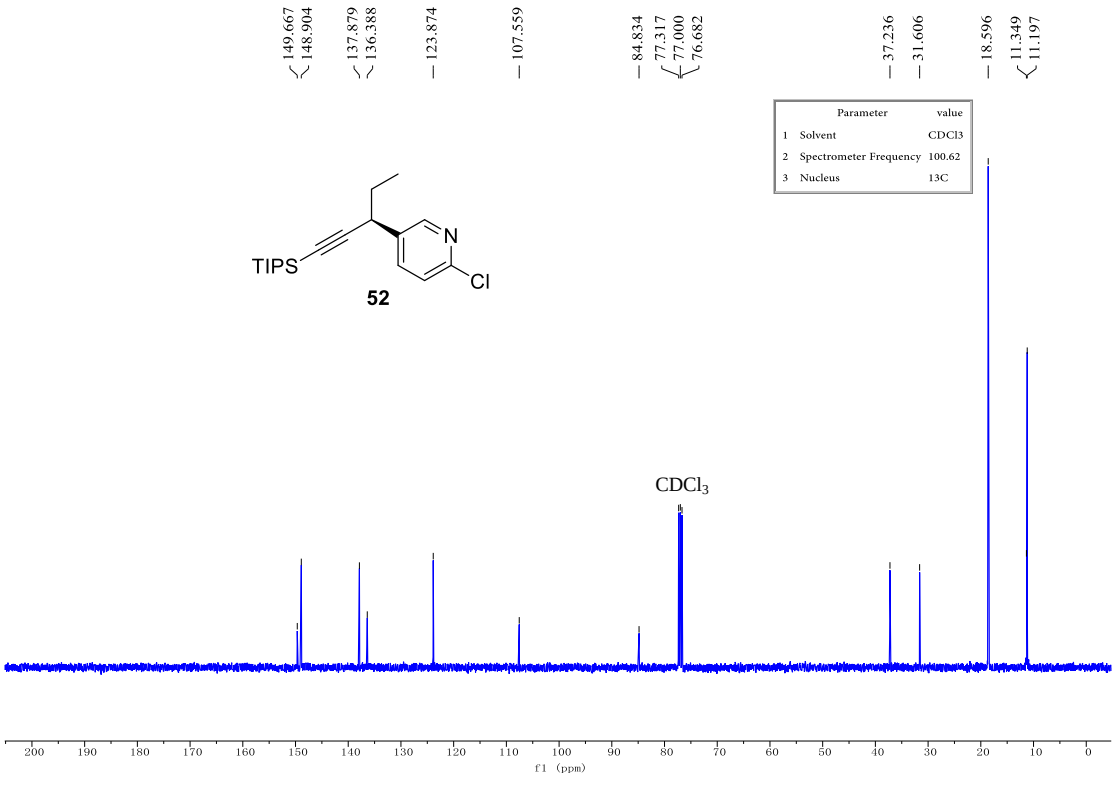
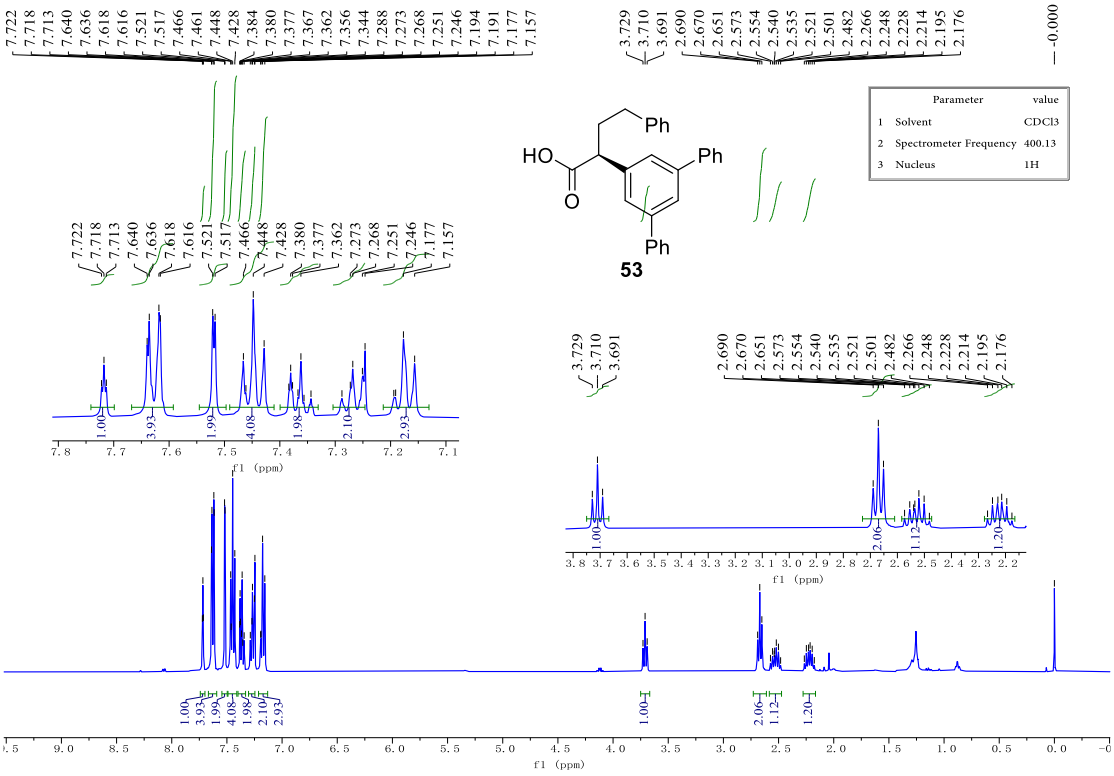
1.02
1.07
1.00
2.26
24.11
f1 (ppm)


149.667
148.904
137.879
136.388
123.874
107.559
84.834
77.317
77.000
76.682
37.236
31.606
18.596
11.349
11.197
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
TIPS
N
Cl
52
CDCl3
f1 (ppm)


7.722 7.718 7.713 7.640 7.636 7.618 7.616 7.521 7.517 7.466 7.461 7.448 7.428 7.384 7.380 7.377 7.367 7.362 7.356 7.344 7.288 7.273 7.268 7.251 7.246 7.194 7.191 7.177 7.157
3.729 3.710 3.691 2.690 2.670 2.651 2.573 2.554 2.540 2.535 2.521 2.501 2.482 2.266 2.248 2.228 2.214 2.195 2.176
-0.000
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
HO
O
Ph
Ph
Ph
53
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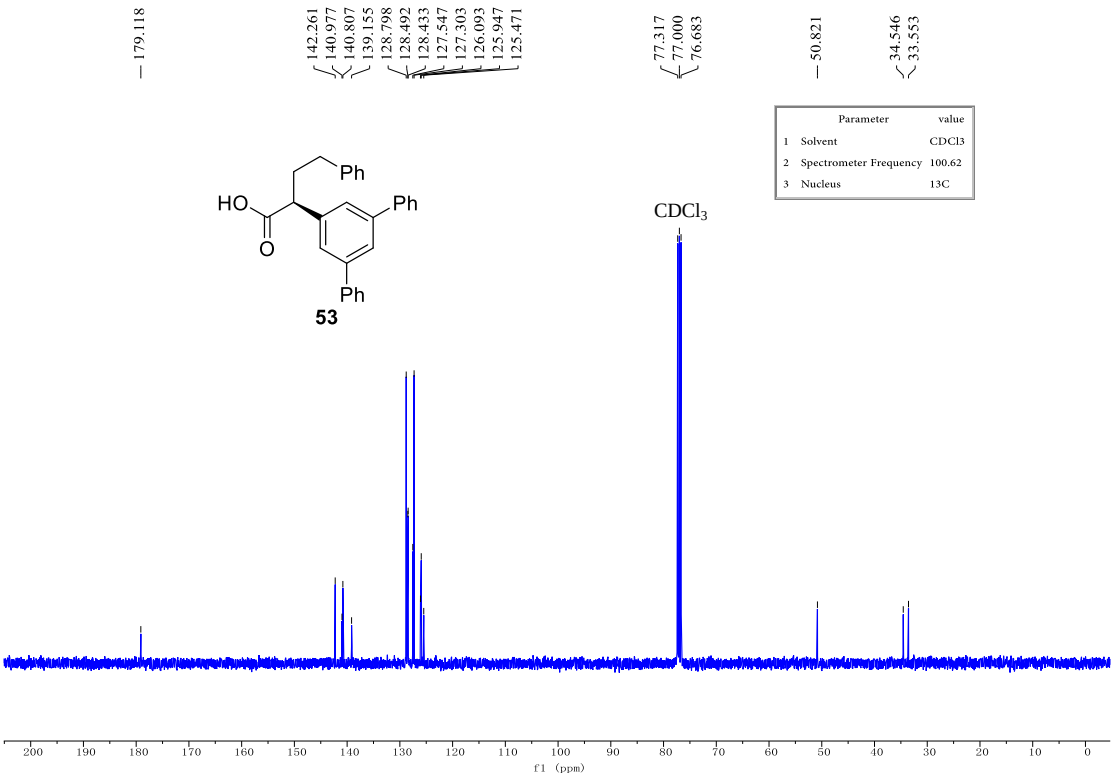
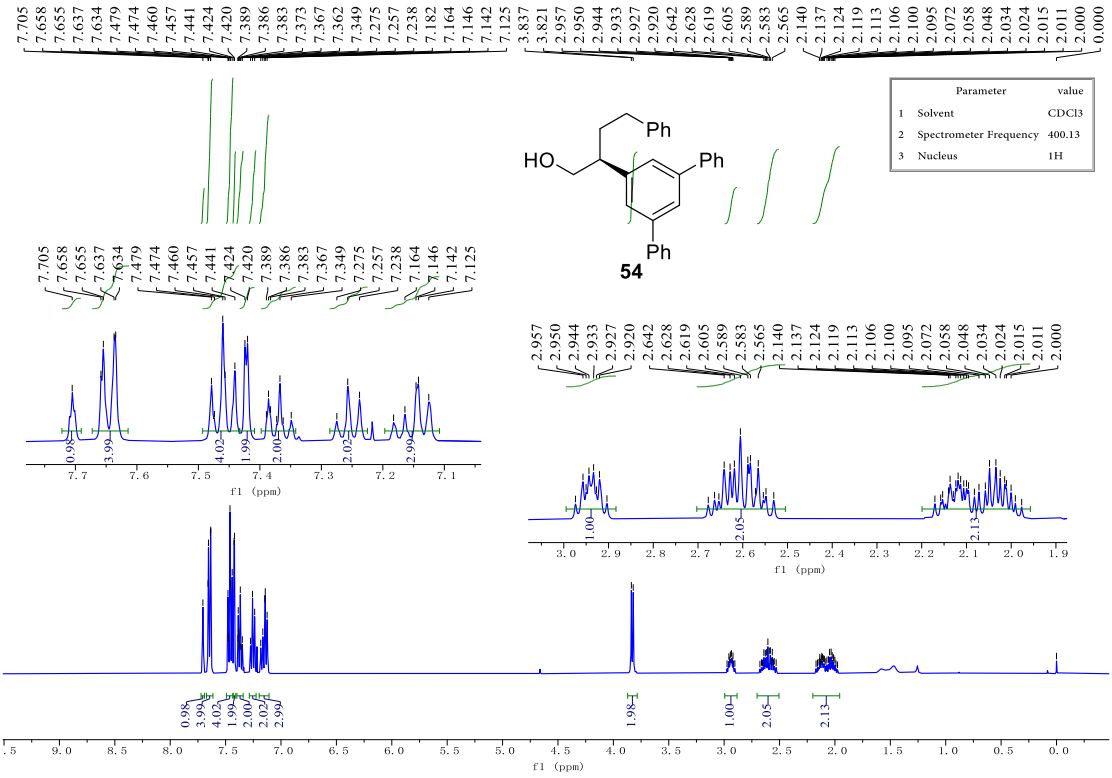
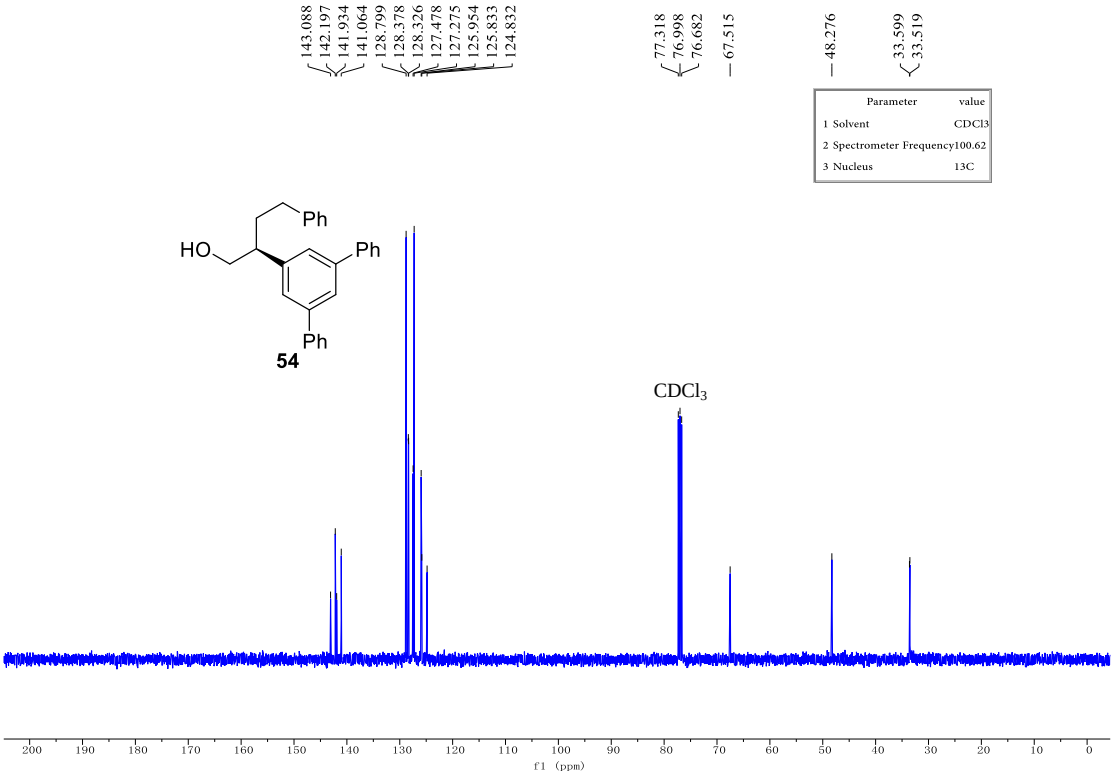
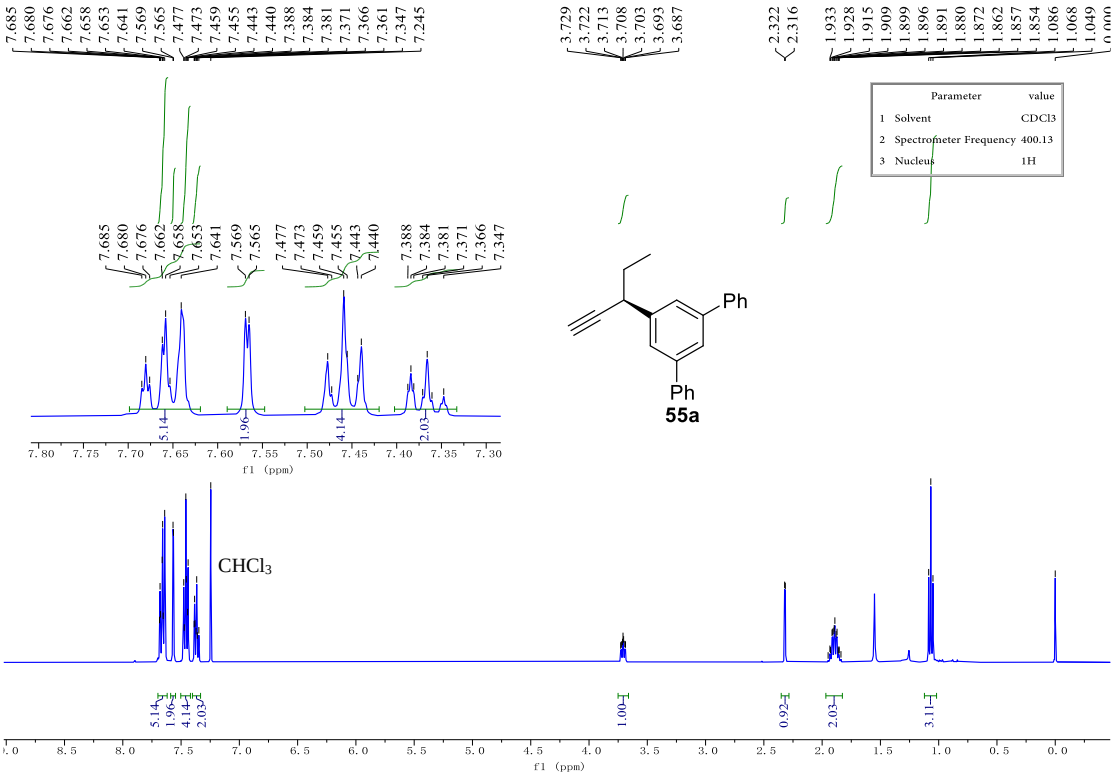
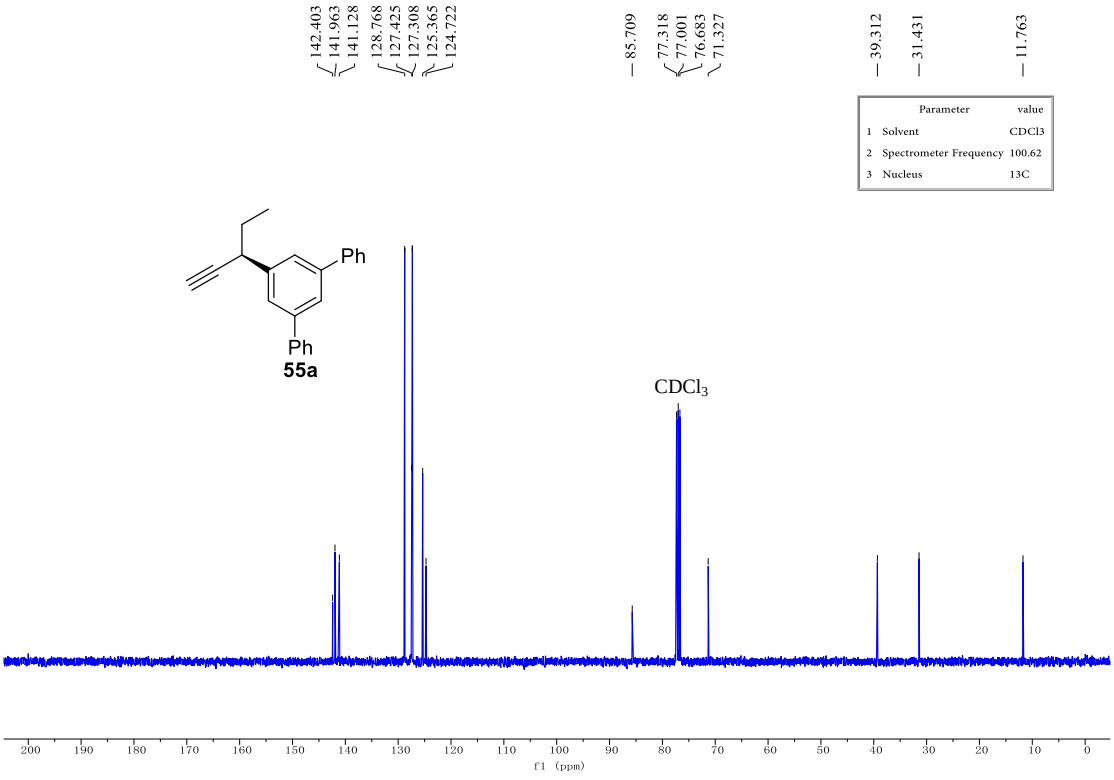
1.00 2.06 1.12 1.20
f1 (ppm)

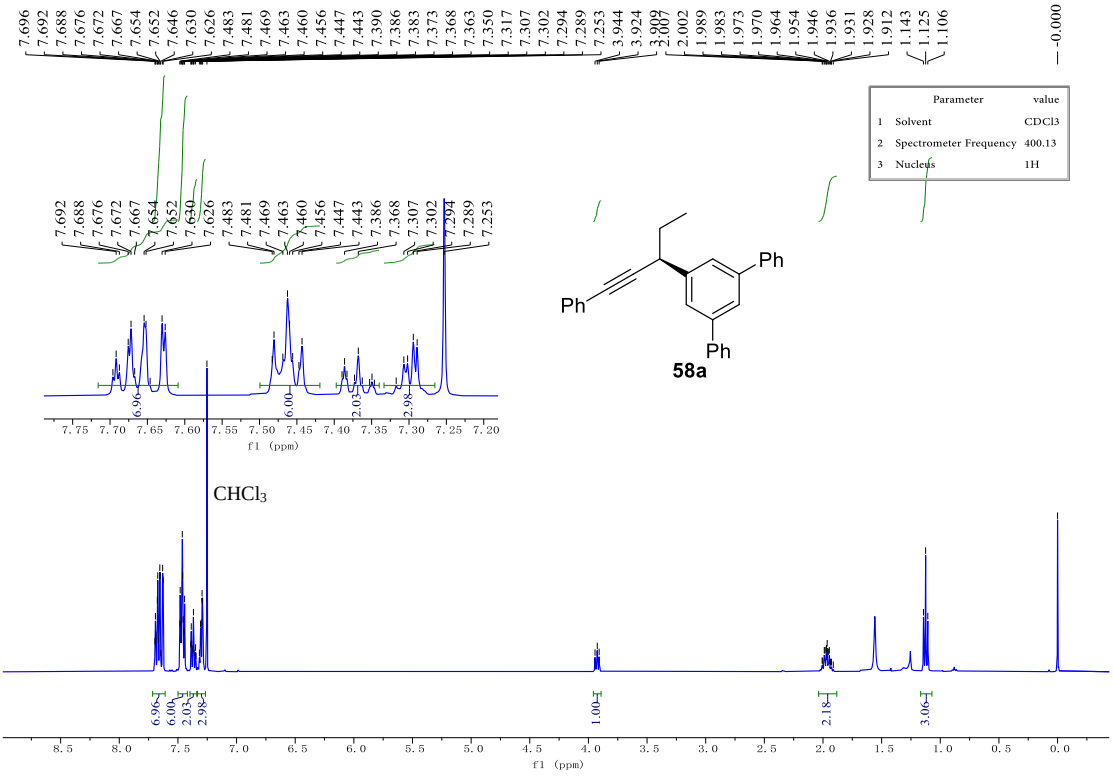

179.118
142.261 140.977 140.807 139.155 128.798 128.492 128.433 127.547 127.303 126.093 125.947 125.471
77.317 77.000 76.683
50.821
34.546 33.553
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
HO
O
Ph
Ph
Ph
53
CDCl3
f1 (ppm)

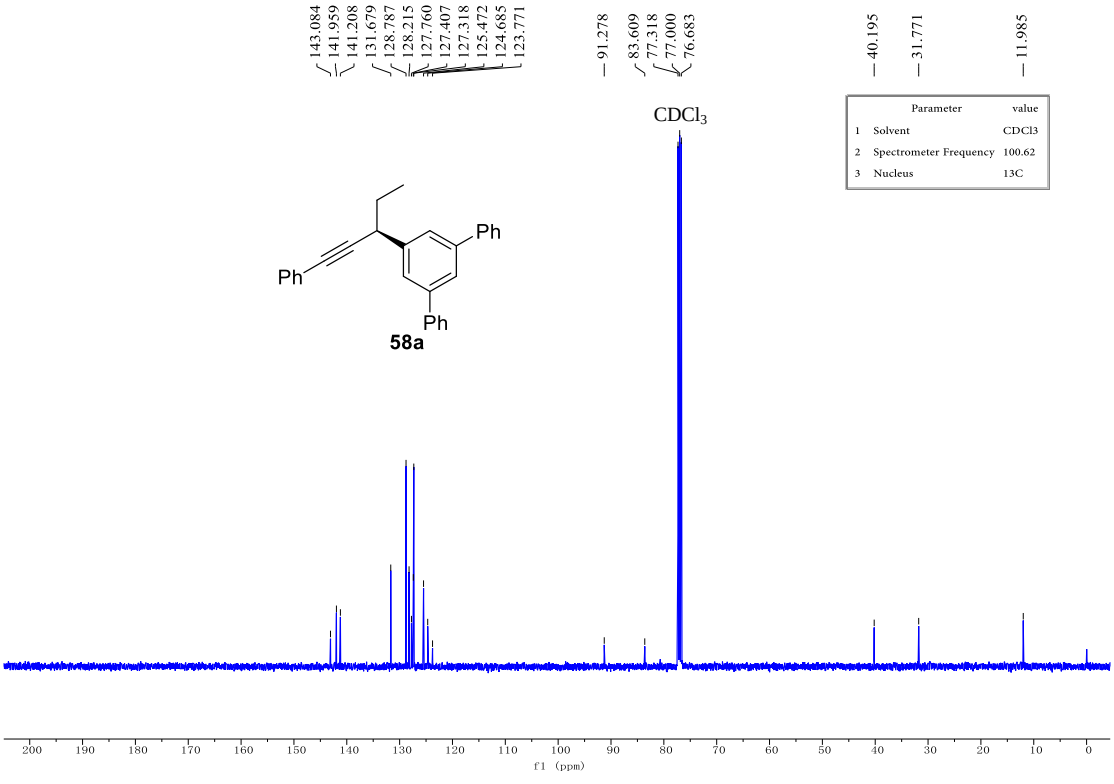

Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
HO
Ph
Ph
Ph
54
f1 (ppm)


Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
HO
Ph
Ph
Ph
54
CDCl3
f1 (ppm)


7.685 7.680 7.676 7.662 7.658 7.653 7.641 7.569 7.565 7.477 7.473 7.459 7.455 7.443 7.440 7.388 7.384 7.381 7.371 7.366 7.361 7.347 7.245
3.729 3.722 3.713 3.708 3.703 3.693 3.687
2.322 2.316
1.933 1.928 1.915 1.909 1.899 1.896 1.891 1.880 1.872 1.862 1.857 1.854 1.086 1.068 1.049
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
Ph
Ph
55a
CHCl3
f1 (ppm)


142.403 141.963 141.128 128.768 127.425 127.308 125.365 124.722
85.709
77.318 77.001 76.683 71.327
39.312
31.431
11.763
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
Ph
Ph
55a
CDCl3
f1 (ppm)


7.696 7.692 7.688 7.676 7.672 7.667 7.654 7.652 7.646 7.630 7.626 7.483 7.481 7.469 7.463 7.460 7.456 7.447 7.443 7.390 7.386 7.383 7.373 7.368 7.363 7.350 7.317 7.307 7.302 7.294 7.289 7.253 3.944 3.924 3.909 3.007 2.002 1.989 1.983 1.973 1.970 1.964 1.954 1.946 1.936 1.931 1.928 1.912 1.143 1.125 1.106 -0.000
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
Ph
Ph
Ph
58a
6.96 6.00 2.03 2.98
f1 (ppm)
CHCl3
6.96 6.00 2.03 2.98 1.00 2.18 3.06
f1 (ppm)


143.084 141.959 141.208 131.679 128.787 128.215 127.760 127.407 127.318 125.472 124.685 123.771 91.278 83.609 77.318 77.000 76.683 40.195 31.771 11.985
Parameter value
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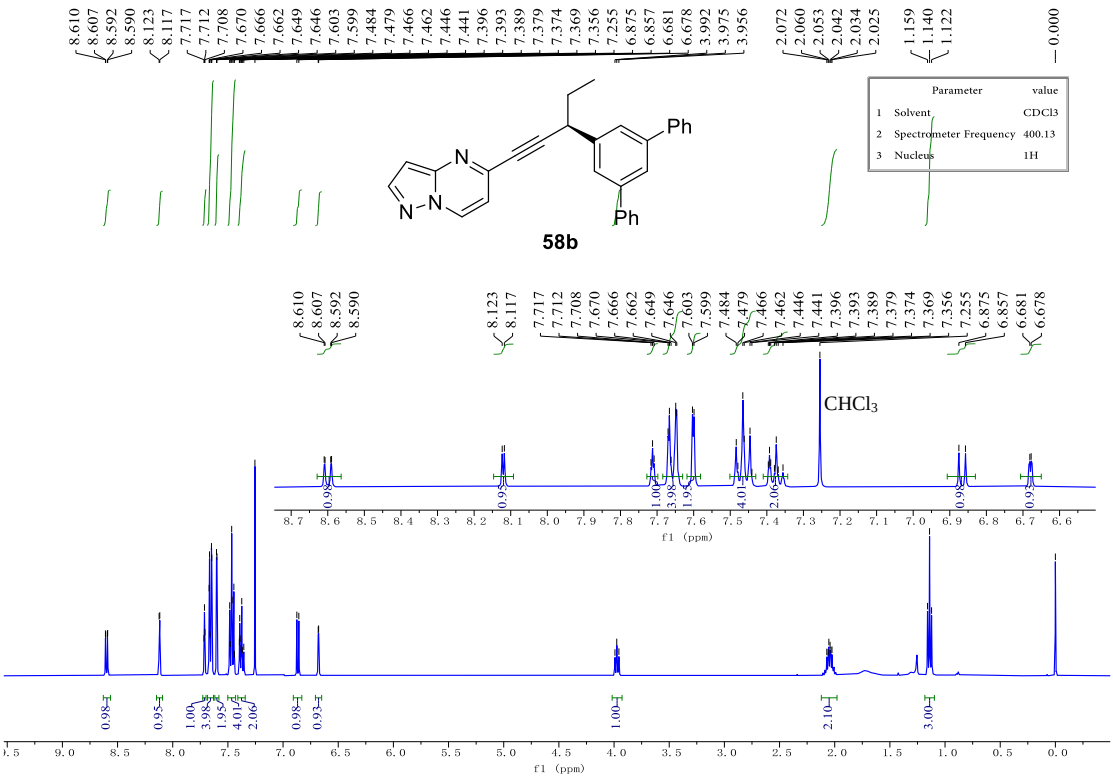
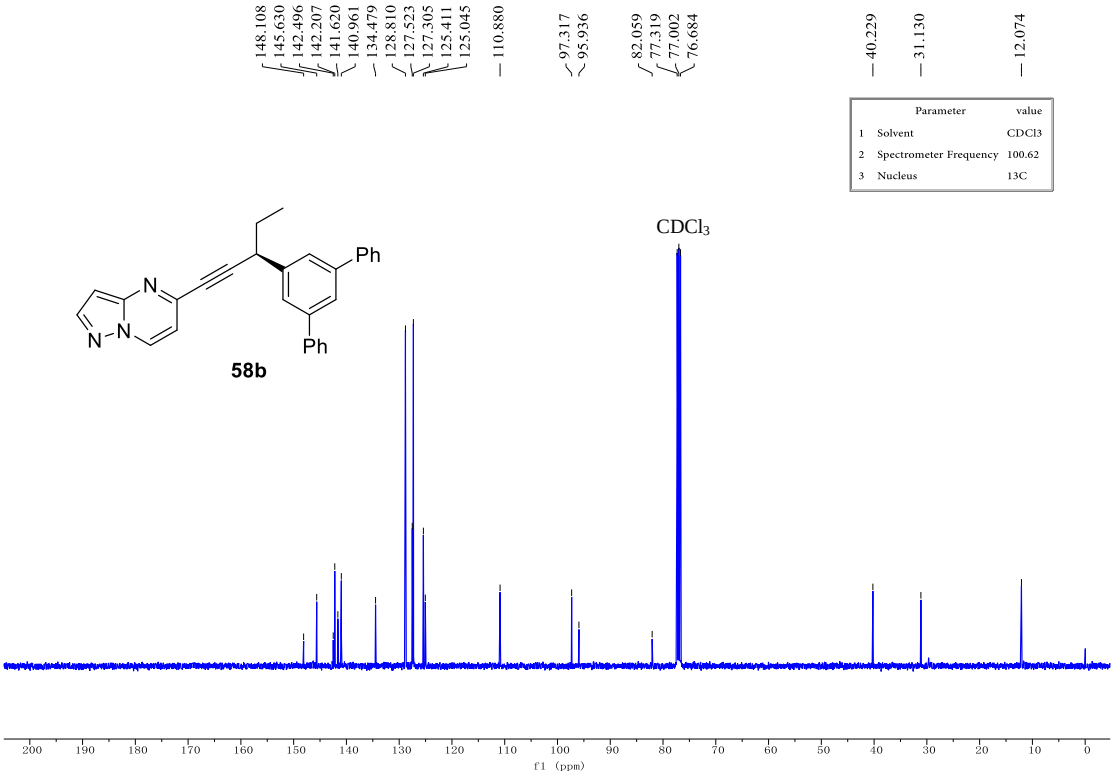
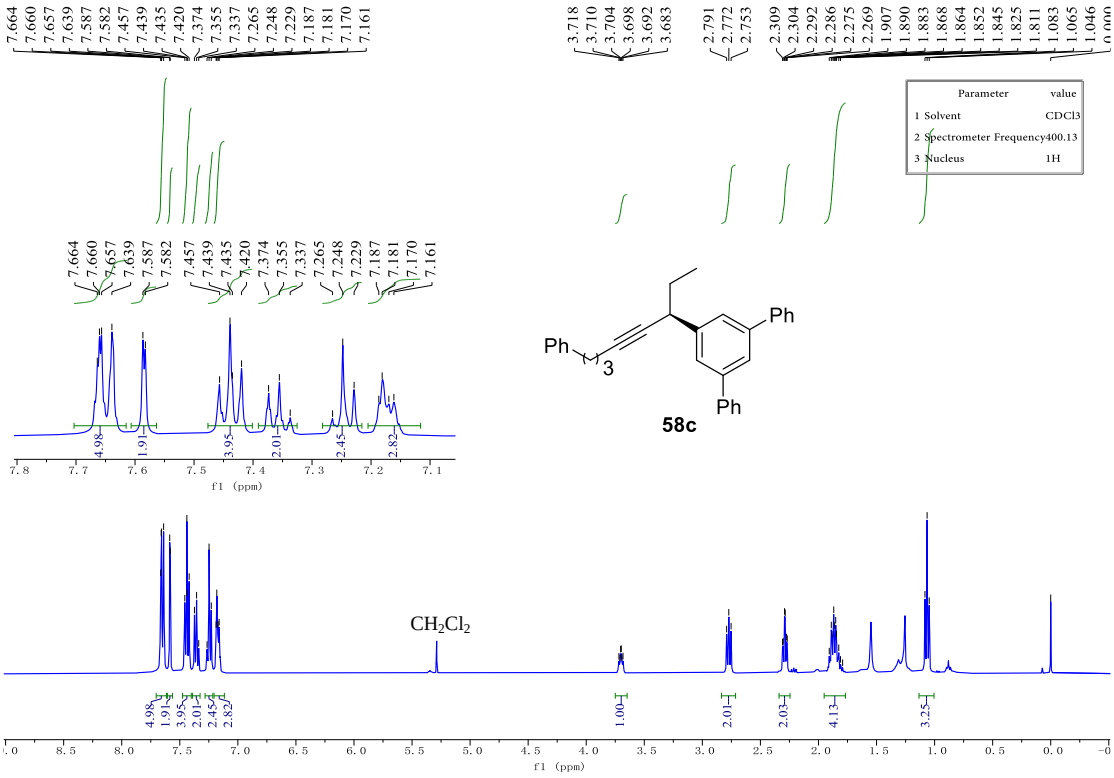
2 Spectrometer Frequency 100.62
3 Nucleus 13C
CDCl3
Ph
Ph
Ph
58a
f1 (ppm)


8.610 8.607 8.592 8.590 8.123 8.117 7.717 7.712 7.708 7.670 7.666 7.662 7.649 7.646 7.603 7.599 7.484 7.479 7.466 7.462 7.446 7.441 7.396 7.393 7.389 7.379 7.374 7.369 7.356 7.255 6.875 6.857 6.681 6.678 3.992 3.975 3.956 2.072 2.060 2.053 2.042 2.034 2.025 1.159 1.140 1.122 0.000
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
Ph
Ph
N
N
N
58b
CHCl3
f1 (ppm)


148.108 145.630 142.496 142.207 141.620 140.961 134.479 128.810 127.523 127.305 125.411 125.045 110.880 97.317 95.936 82.059 77.319 77.002 76.684 40.229 31.130 12.074
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
Ph
Ph
N
N
N
58b
CDCl3
f1 (ppm)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7.657
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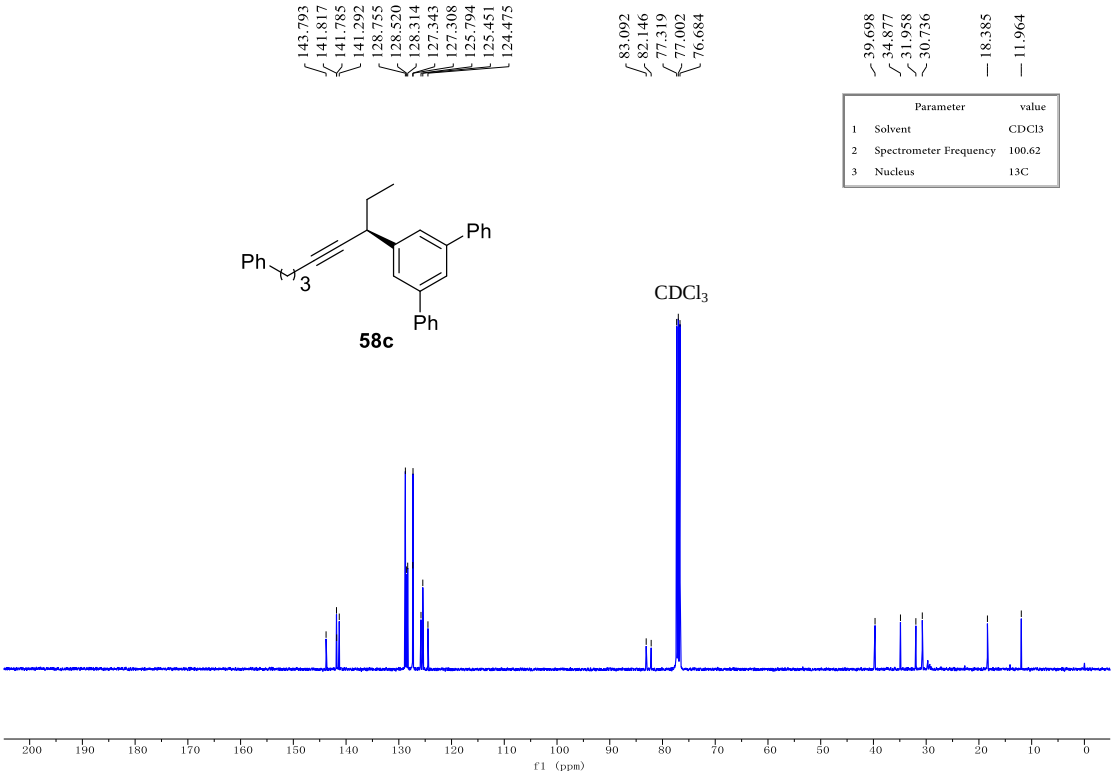
7.587
7.582
7.457
7.439
7.435
7.420
7.374
7.355
7.337
7.265
7.248
7.229
7.187
7.181
7.170
7.161
3.718
3.710
3.704
3.698
3.692
3.683
2.791
2.772
2.753
2.309
2.304
2.292
2.286
2.275
2.269
1.907
1.890
1.883
1.868
1.864
1.852
1.845
1.825
1.811
1.083
1.065
1.046
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
Ph
3
Ph
Ph
58c
4.98
1.91
3.95
2.01
2.45
2.82
f1 (ppm)
CH2Cl2
1.00
2.01
2.03
4.13
3.25
f1 (ppm)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141.785
141.292
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128.520
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127.343
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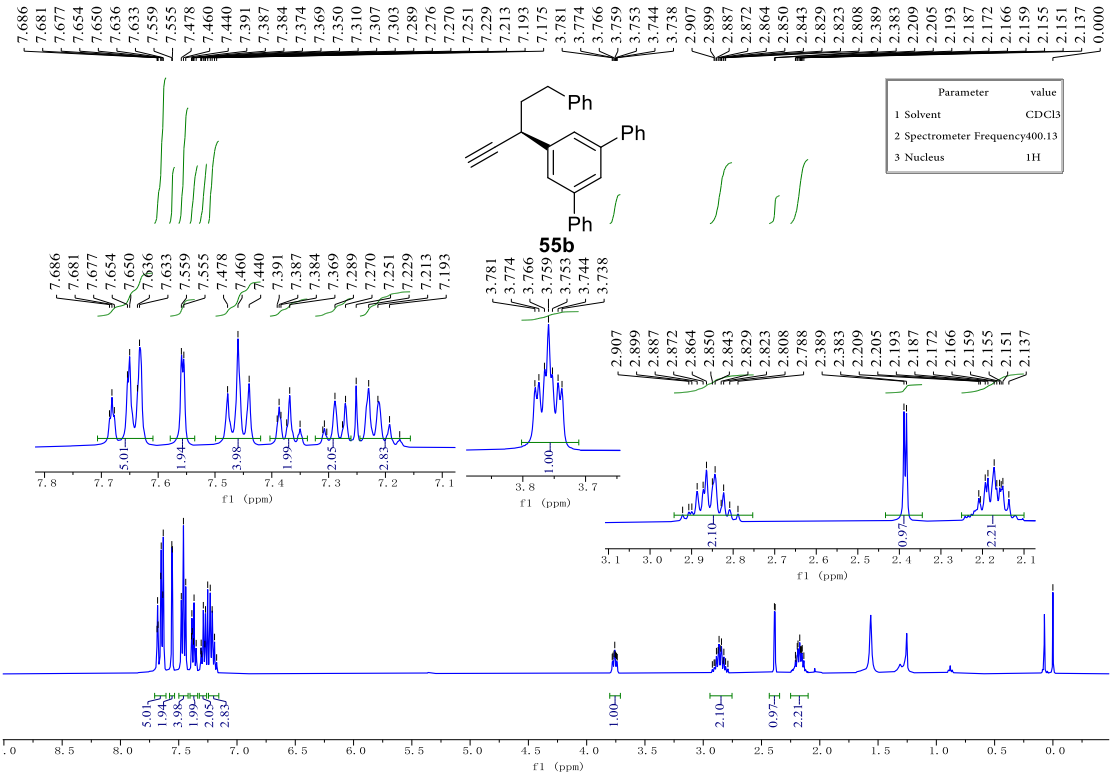
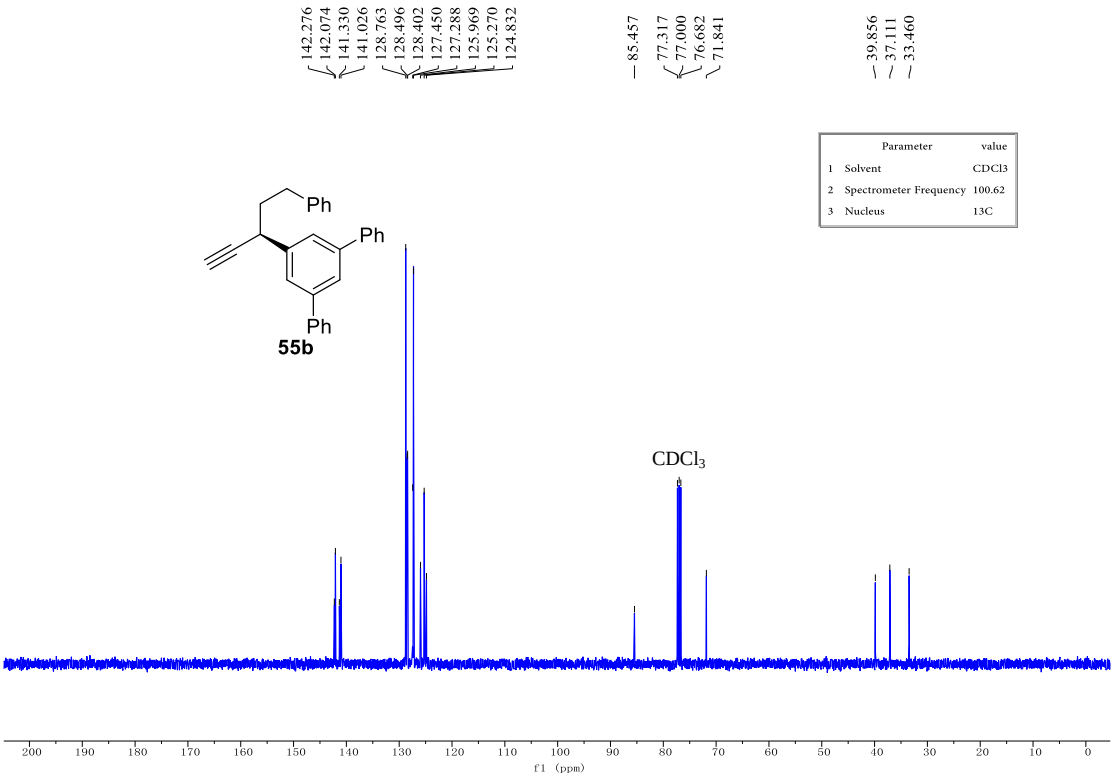
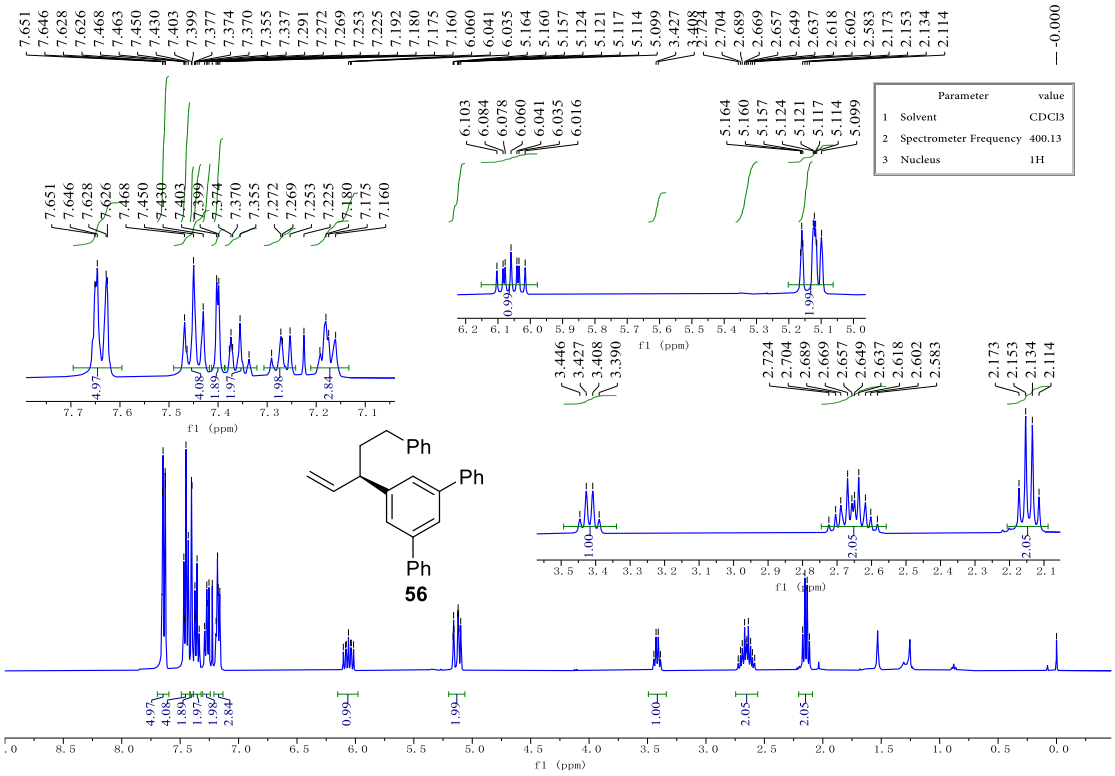
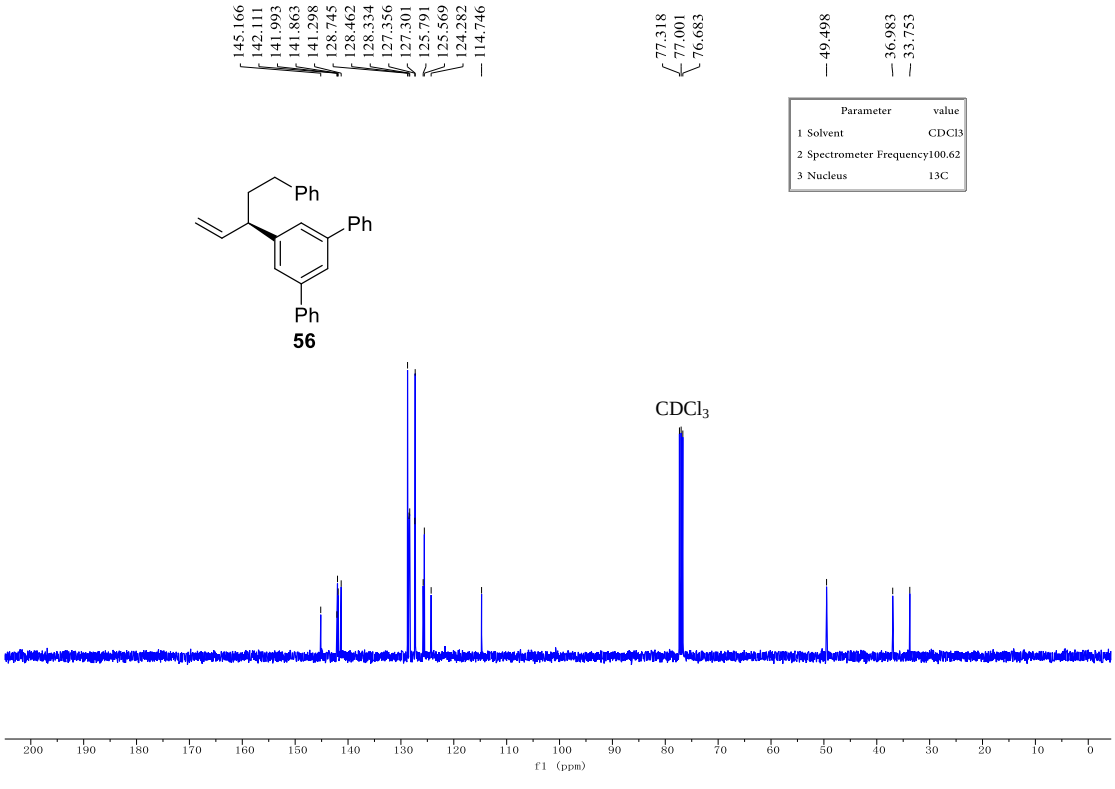
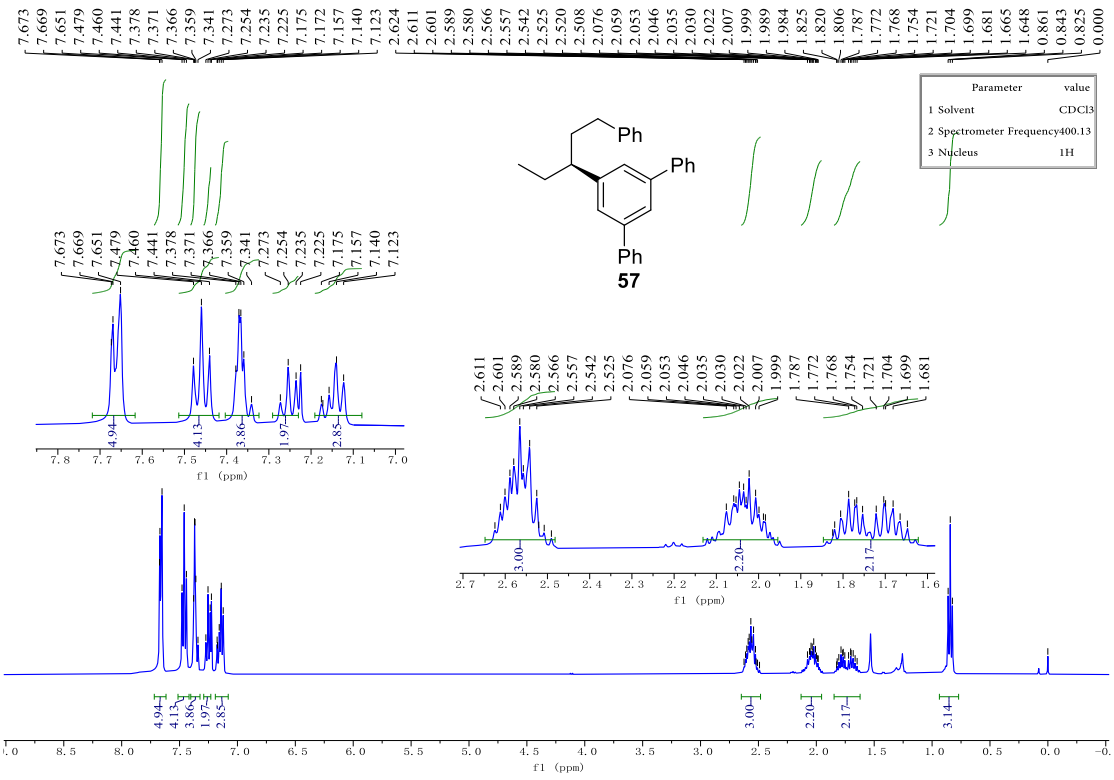
125.794
125.451
124.475
83.092
82.146
77.319
77.002
76.684
39.698
34.877
31.958
30.736
18.385
11.964
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
Ph
3
Ph
Ph
58c
CDCl3
f1 (ppm)

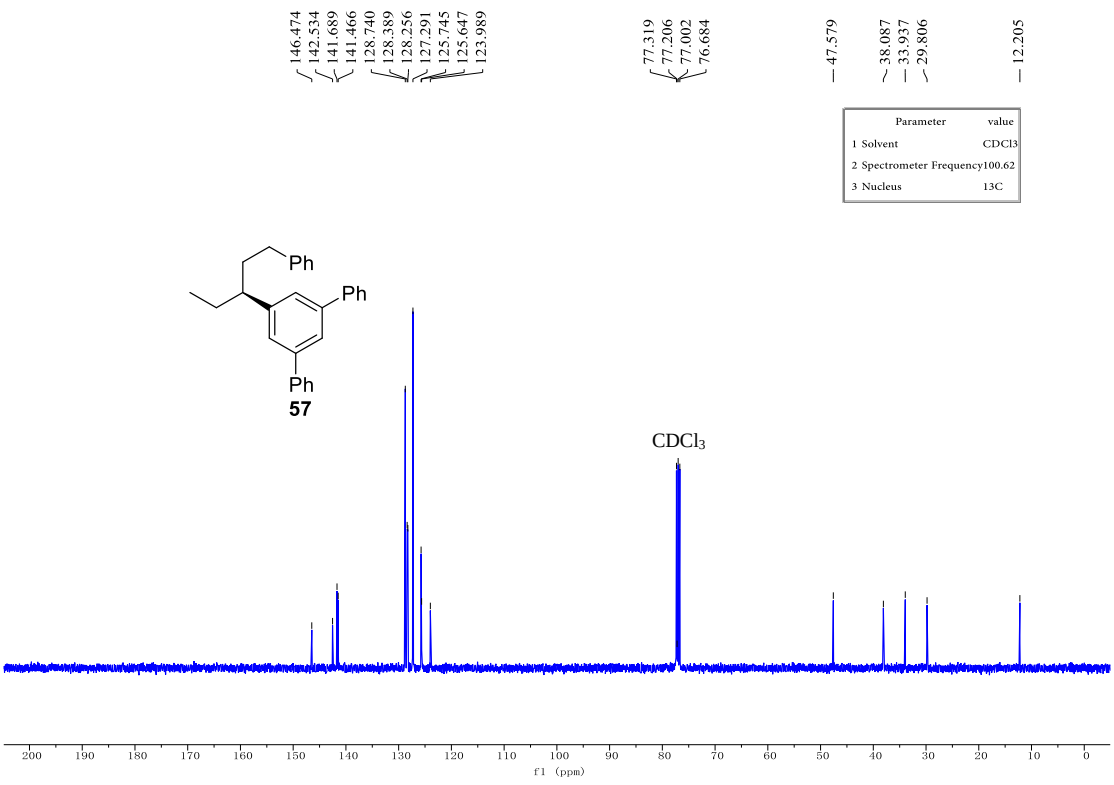

Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
Ph
Ph
Ph
55b
f1 (ppm)

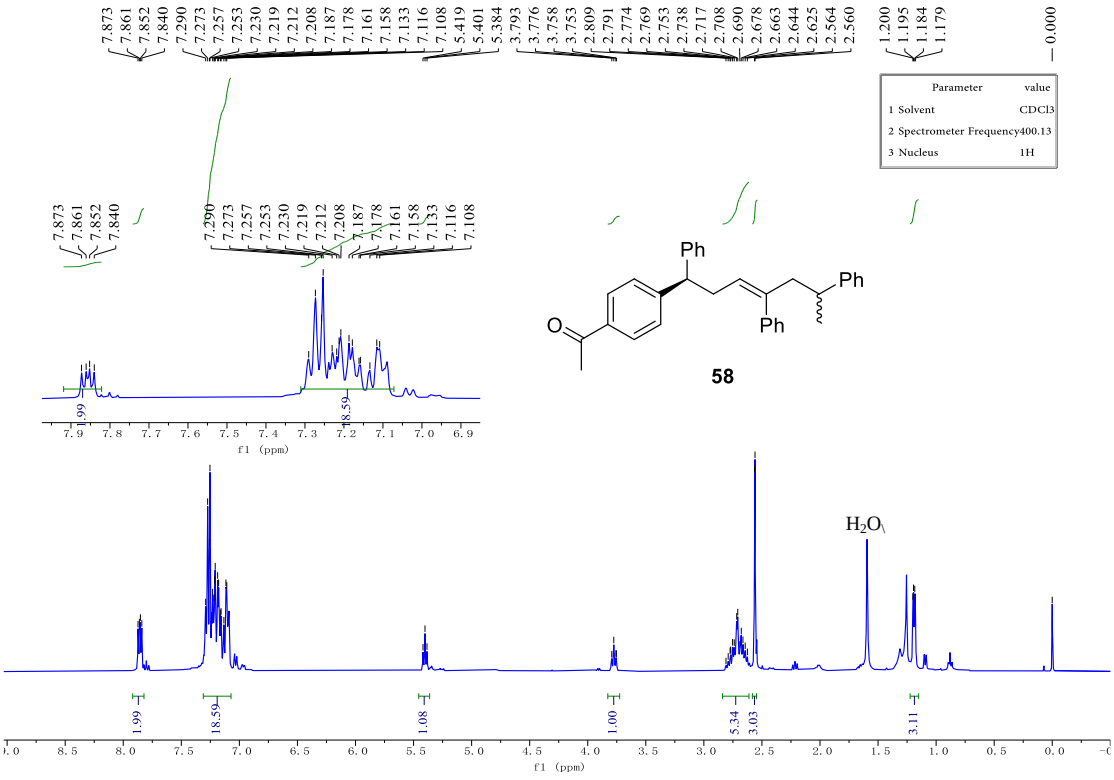

Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
Ph
Ph
Ph
55b
CDCl3
f1 (ppm)


Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
Ph
Ph
Ph
56
f1 (ppm)


Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
Ph
Ph
Ph
56
CDCl3
f1 (ppm)


Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency400.13
3 Nucleus 1H
Ph
Ph
Ph
57
f1 (ppm)


Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency100.62
3 Nucleus 13C
Ph
Ph
Ph
57
CDCl3
f1 (ppm)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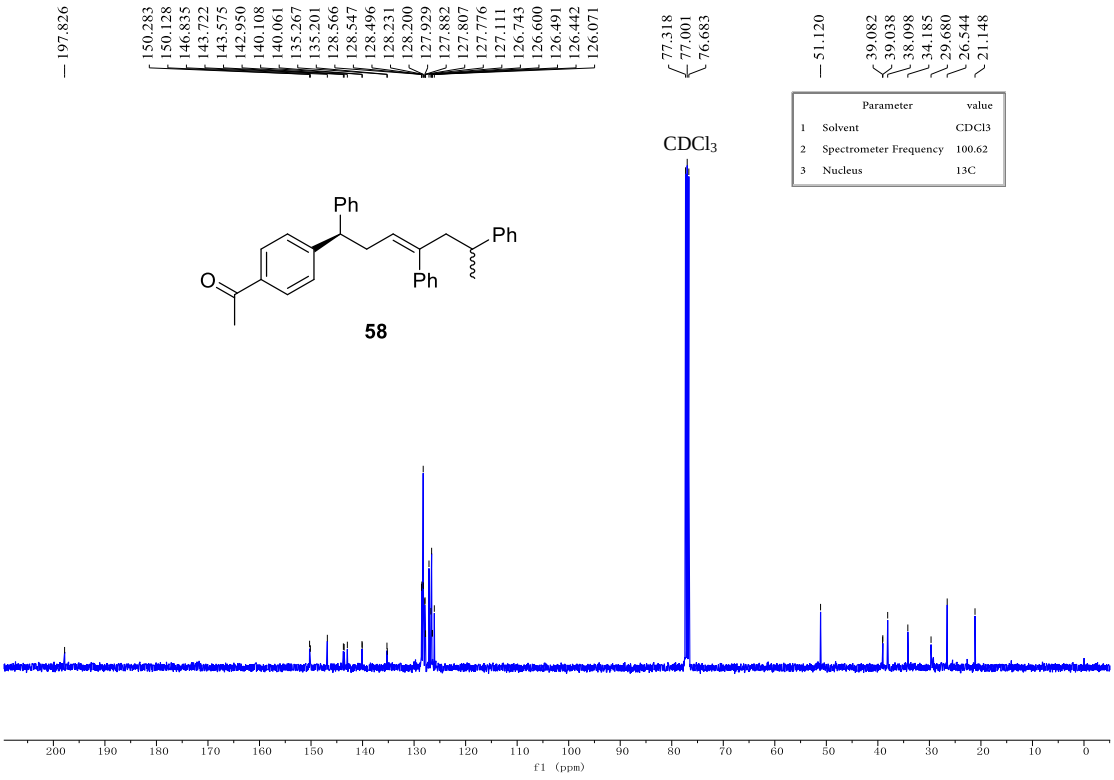
7.257
7.253
7.230
7.219
7.212
7.208
7.187
7.178
7.161
7.158
7.133
7.116
7.108
5.419
5.401
5.384
3.793
3.776
3.758
3.753
2.809
2.791
2.774
2.769
2.753
2.738
2.717
2.708
2.690
2.678
2.663
2.644
2.625
2.564
2.560
1.200
1.195
1.184
1.179
0.000
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 400.13
3 Nucleus 1H
Ph
Ph
Ph
O
58
H2O
1.99
18.59
1.08
1.00
5.34
3.03
3.11
f1 (ppm)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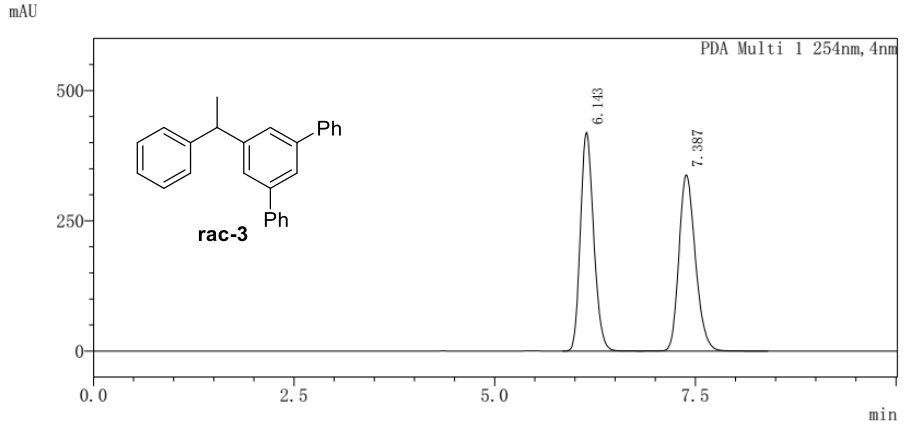
143.575
142.950
140.108
140.061
135.267
135.201
128.566
128.547
128.496
128.231
128.200
127.929
127.882
127.807
127.776
127.111
126.743
126.600
126.491
126.442
126.071
77.318
77.001
76.683
51.120
39.082
39.038
38.098
34.185
29.680
26.544
21.148
Parameter value
1 Solvent CDCl3
2 Spectrometer Frequency 100.62
3 Nucleus 13C
CDCl3
Ph
Ph
Ph
O
58
f1 (ppm)

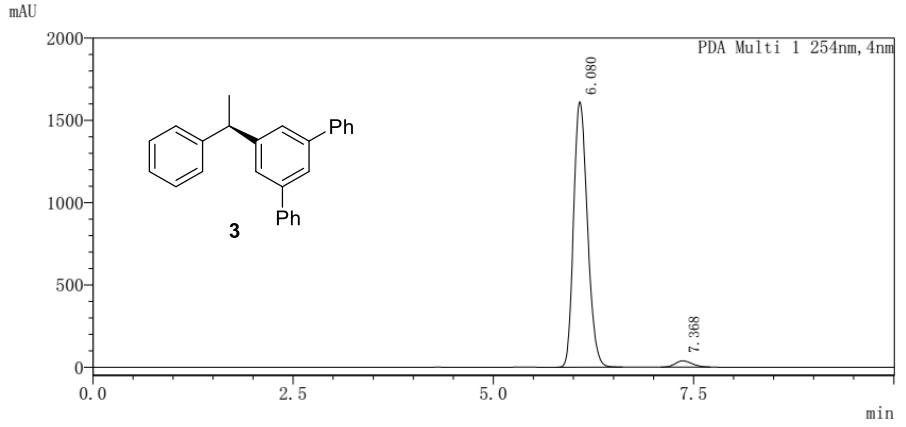
HPLC Spectra



Peak Table

PDA Ch1 254nm

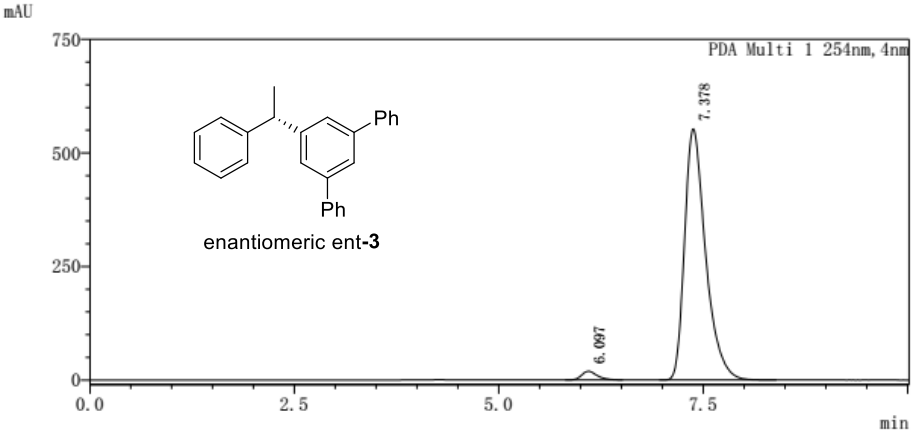
Peak#	Ret. Time	Area	Area%
1	6.143	4838408	49.996
2	7.387	4839192	50.004



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	6.080	19377511	97.183
2	7.368	561695	2.817

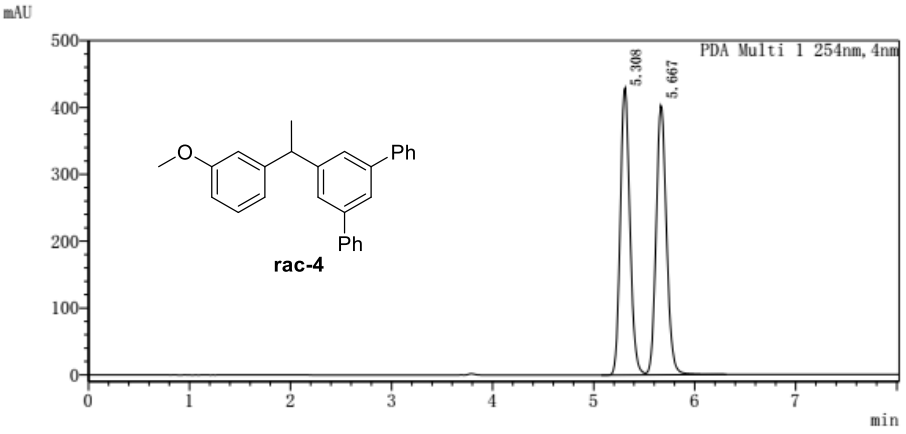


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	6.097	253255	2.494
2	7.378	9902453	97.506

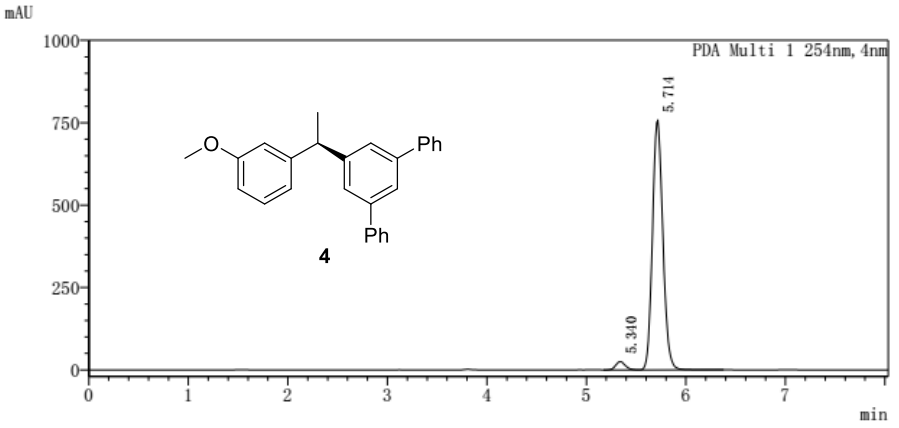
Chiralcel OD: hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	5.308	2846143	49.722
2	5.667	2877957	50.278

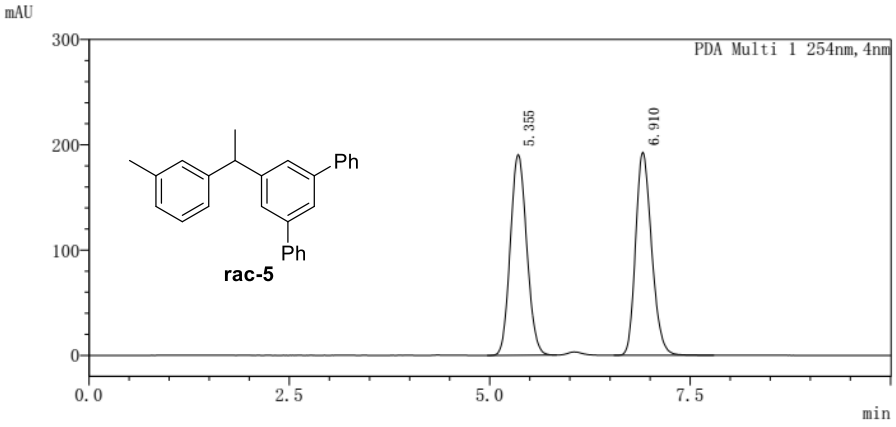


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	5.340	168013	2.957
2	5.714	5513130	97.043

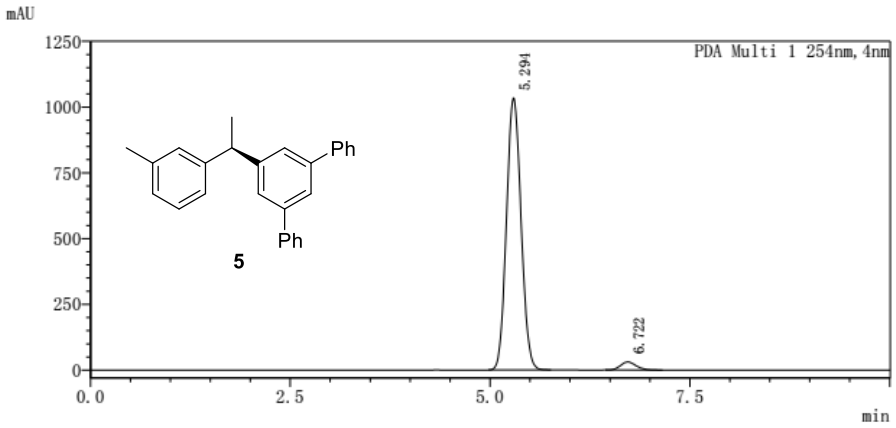
Chiralcel ADH: hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	5.355	2714125	50.272
2	6.910	2684772	49.728

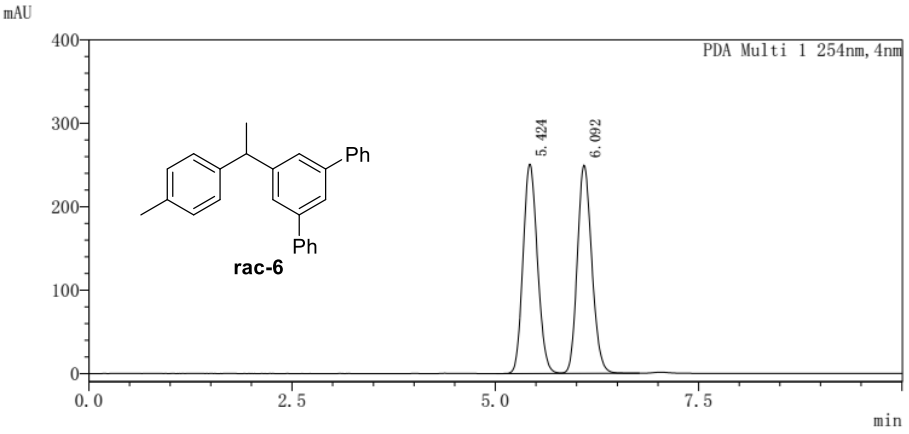


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	5.294	13092437	96.933
2	6.722	414279	3.067

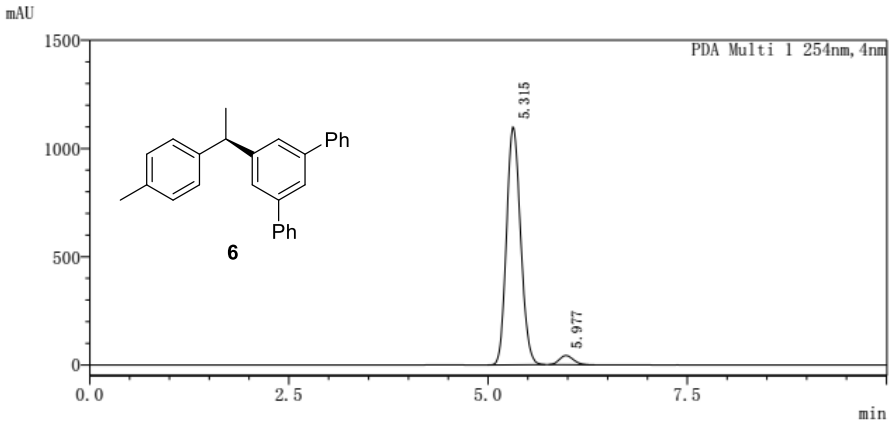
Chiralcel OD : hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	5.424	3096571	50.042
2	6.092	3091323	49.958

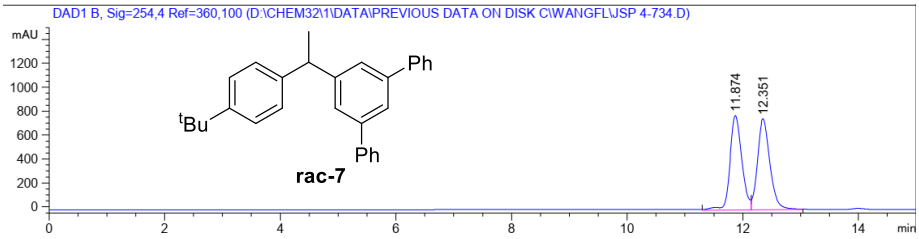


Peak Table

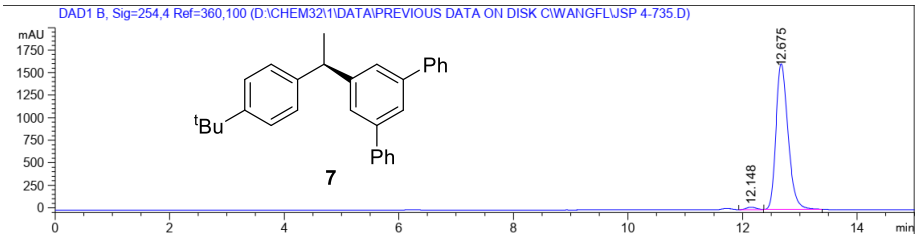
PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	5.315	13484884	96.291
2	5.977	519471	3.709

Chiralcel OD: hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min

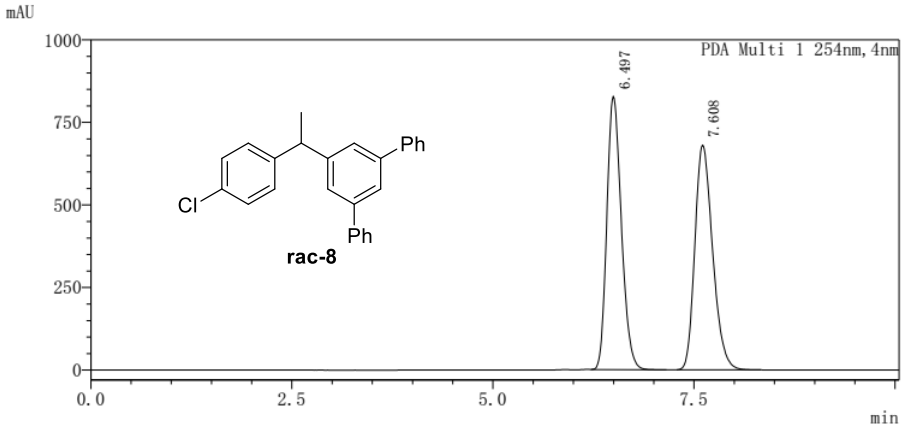


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.874	MF R	0.2363	1.12218e4	791.46405	49.6266
2	12.351	FM R	0.2481	1.13907e4	765.23071	50.3734



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.148	MM R	0.2156	371.48965	28.72055	1.5408
2	12.675	MM R	0.2436	2.37383e4	1624.46045	98.4592

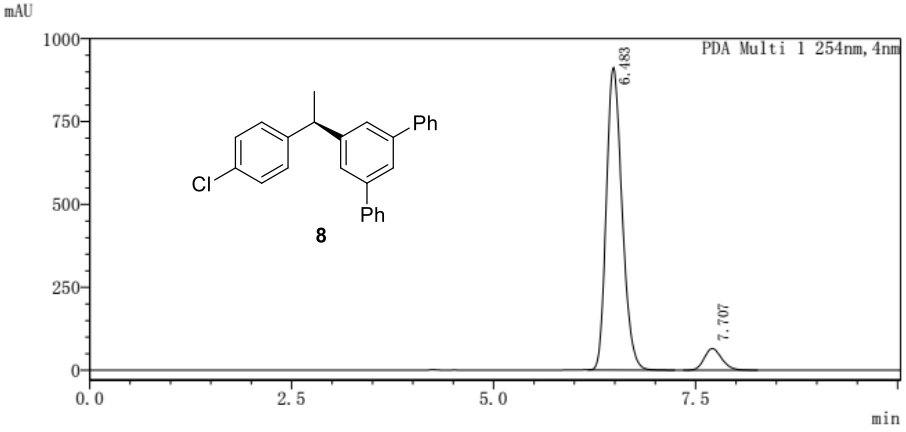
Chiralcel IA: hexane/*i*-PrOH = 99.5/0.5, flow rate 0.4 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	6.497	10385148	49.828
2	7.608	10456976	50.172

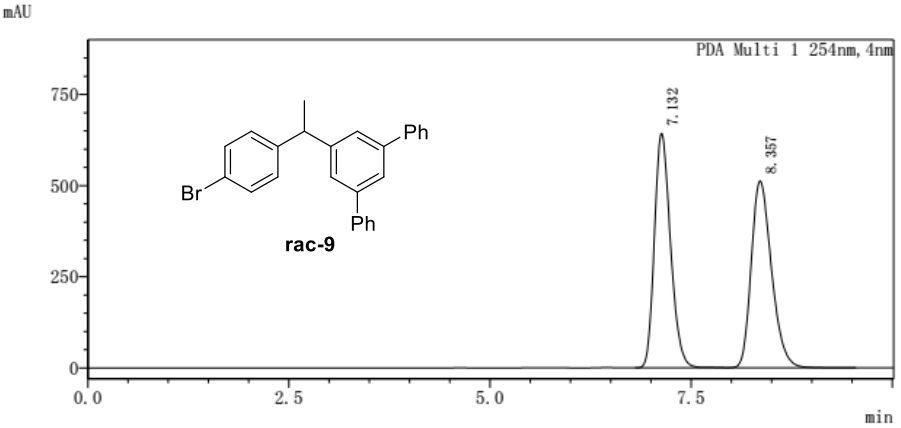


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	6.483	12377554	92.585
2	7.707	991344	7.415

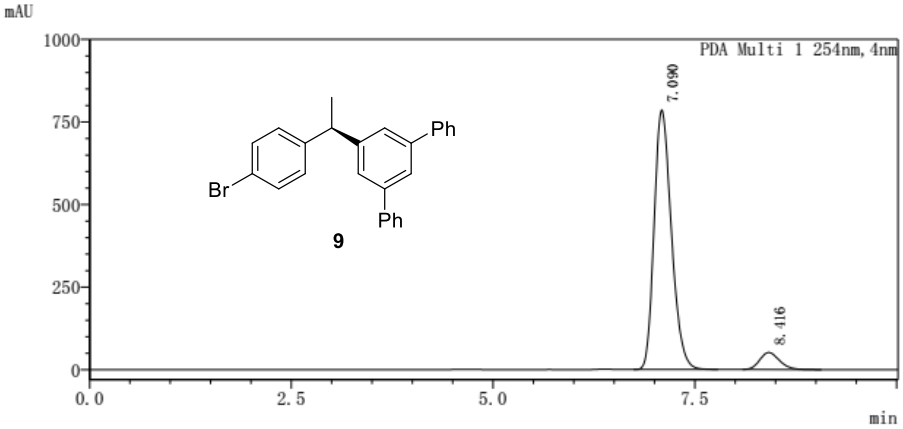
Chiralcel OD: hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	7.132	8969826	49.923
2	8.357	8997525	50.077

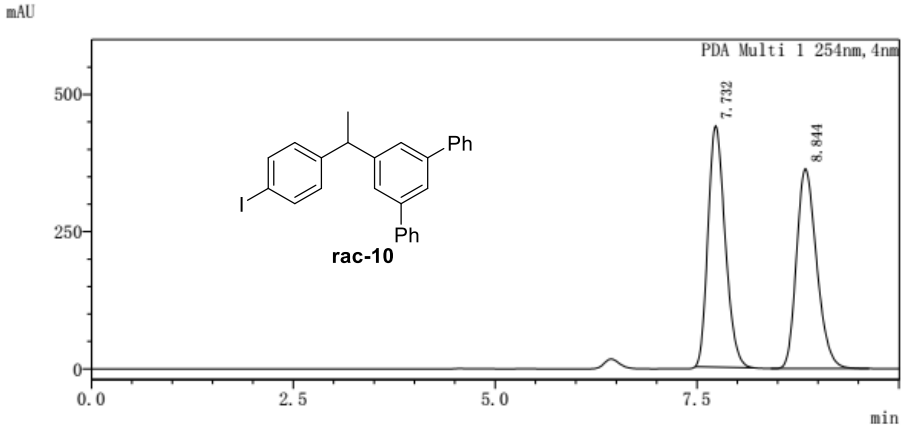


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	7.090	11694437	93.055
2	8.416	872774	6.945

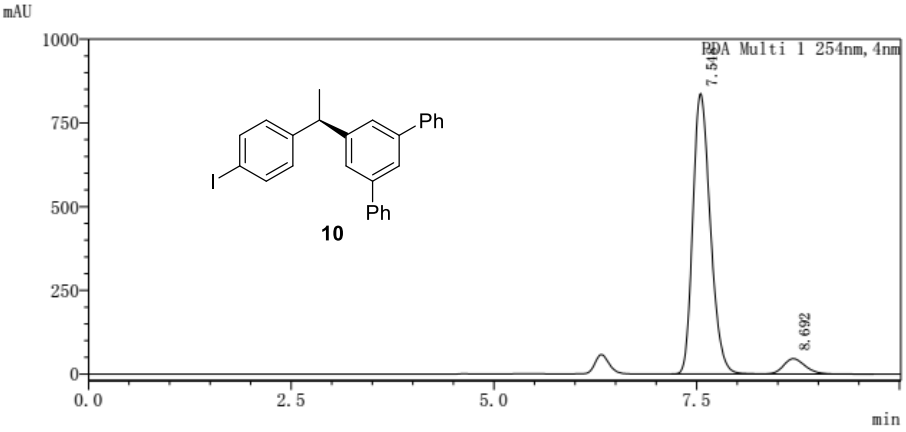
Chiralcel OD: hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	7.732	6494257	50.596
2	8.844	6341309	49.404

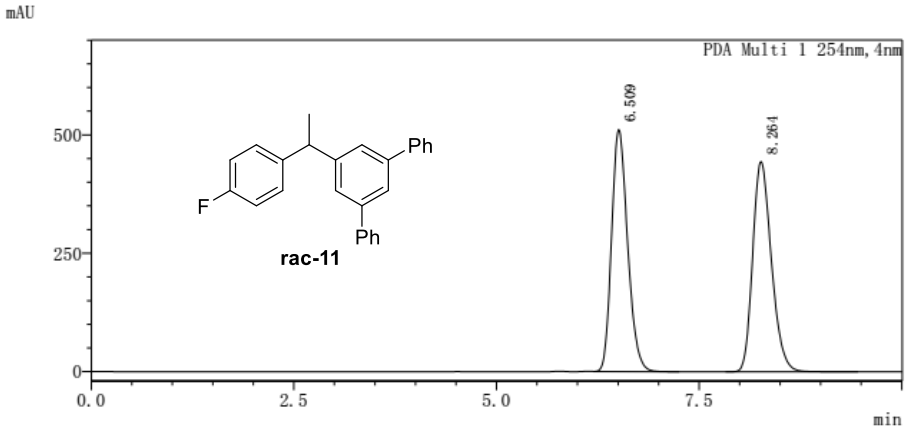


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	7.548	12573491	93.601
2	8.692	859629	6.399

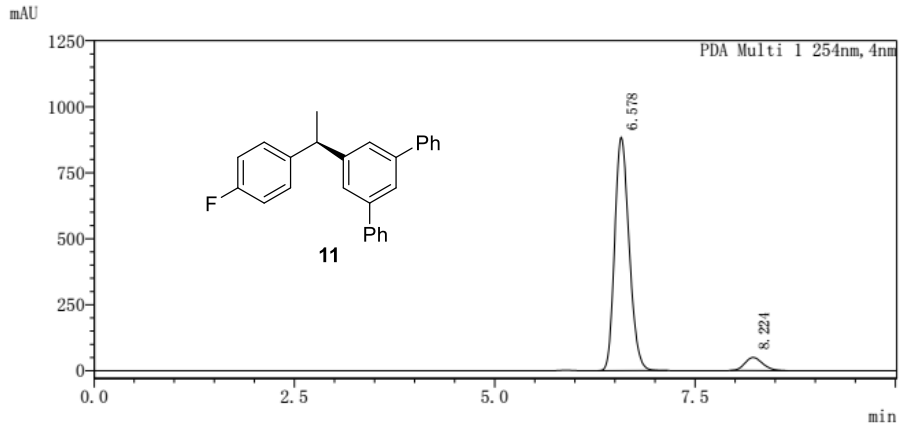
Chiralcel OD: hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	6.509	7039826	49.628
2	8.264	7145460	50.372

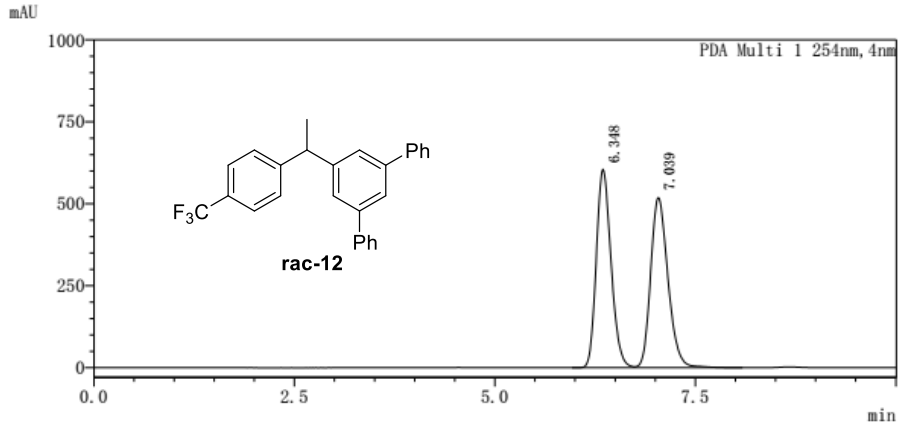


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	6.578	11101145	93.501
2	8.224	771641	6.499

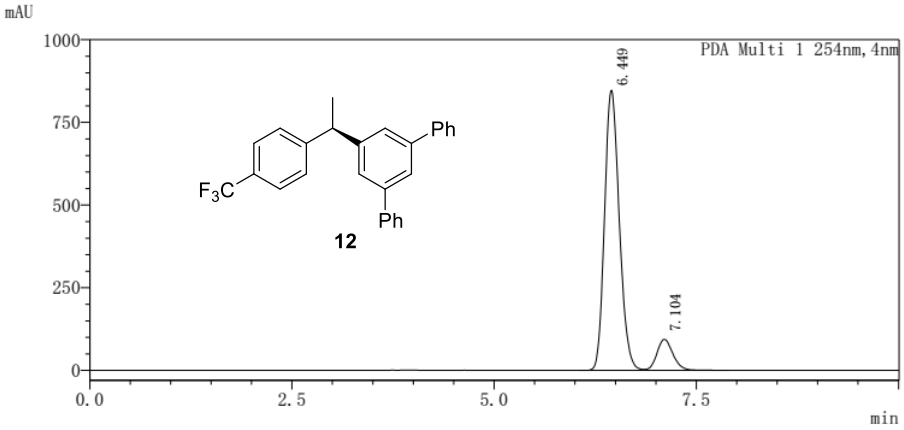
Chiralcel OD: hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	6.348	7736811	49.807
2	7.039	7796907	50.193

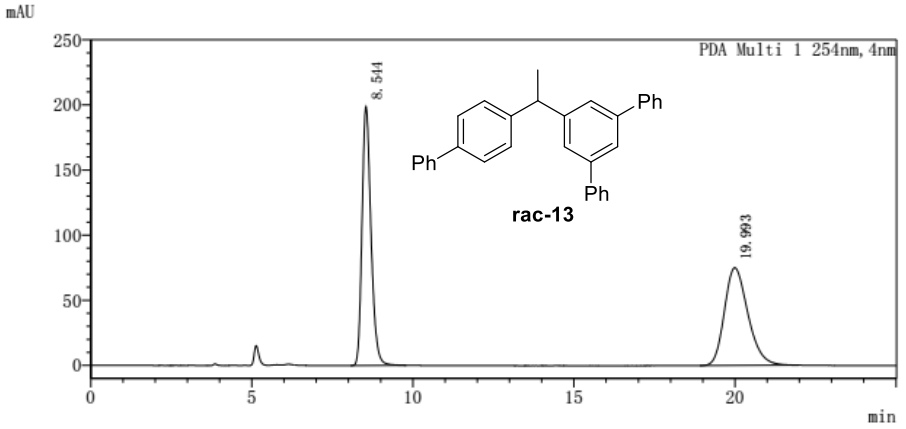


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	6.449	10731811	89.244
2	7.104	1293492	10.756

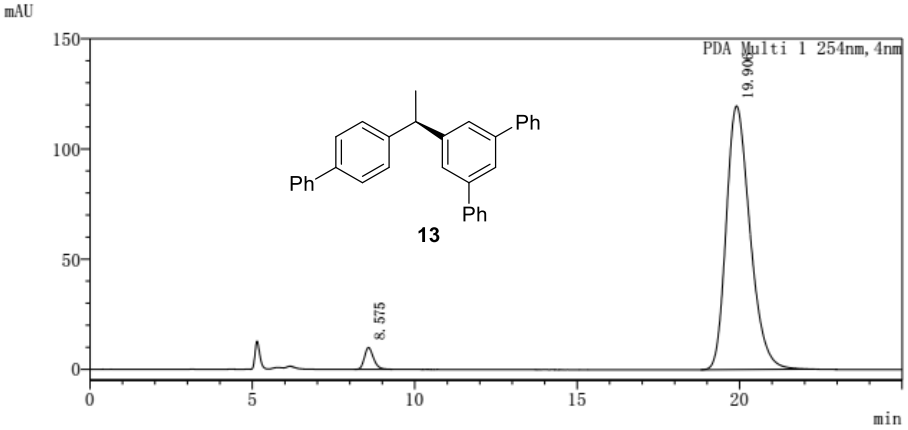
Chiralcel OD: hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	8.544	3840740	50.180
2	19.993	3813125	49.820

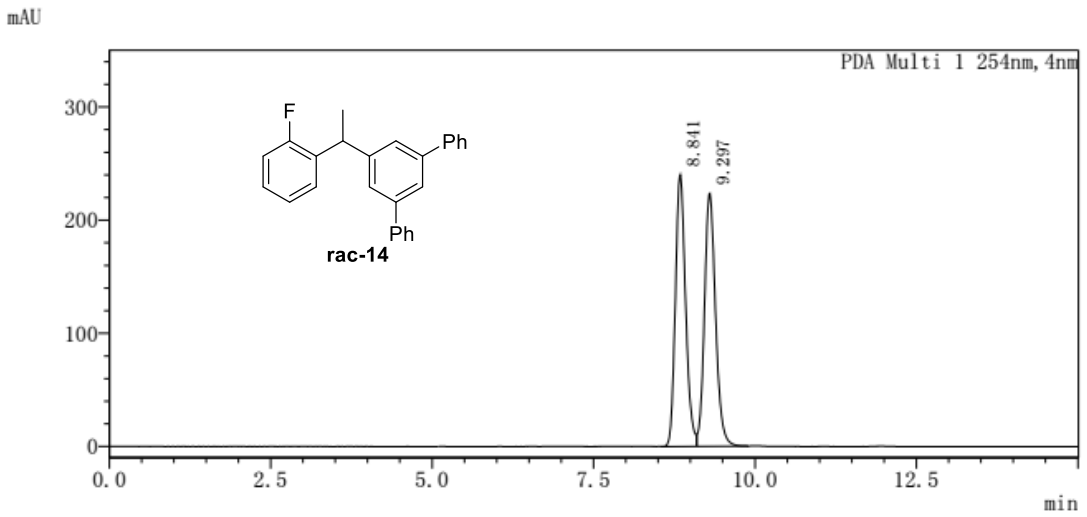


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	8.575	191679	3.050
2	19.906	6092053	96.950

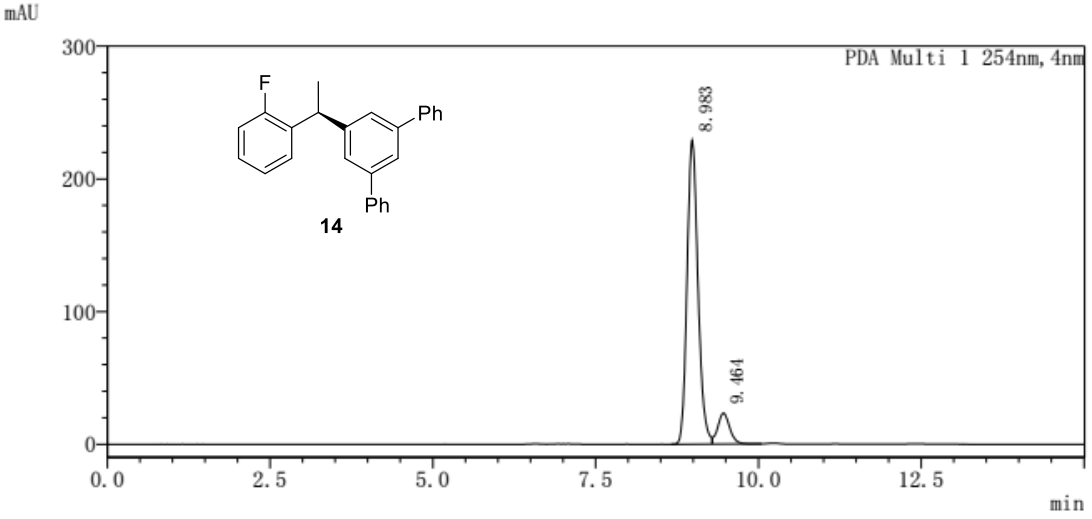
Chiralcel OD: hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	8.841	2642310	49.777
2	9.297	2665993	50.223

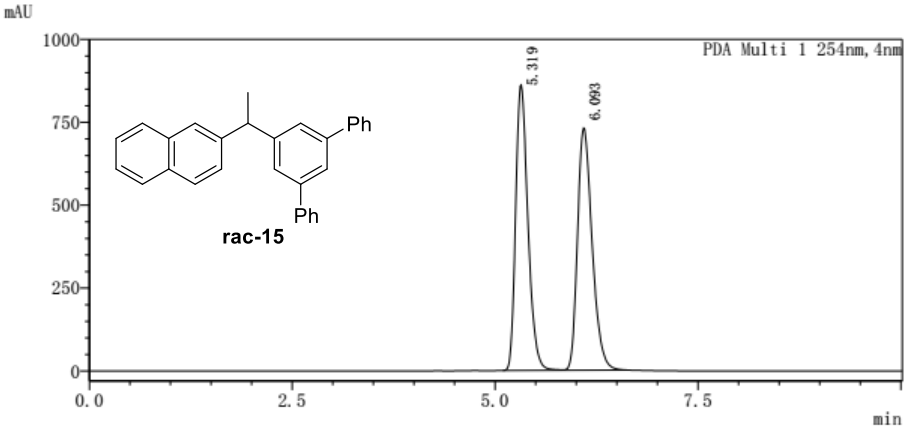


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	8.983	2671517	89.999
2	9.464	296879	10.001

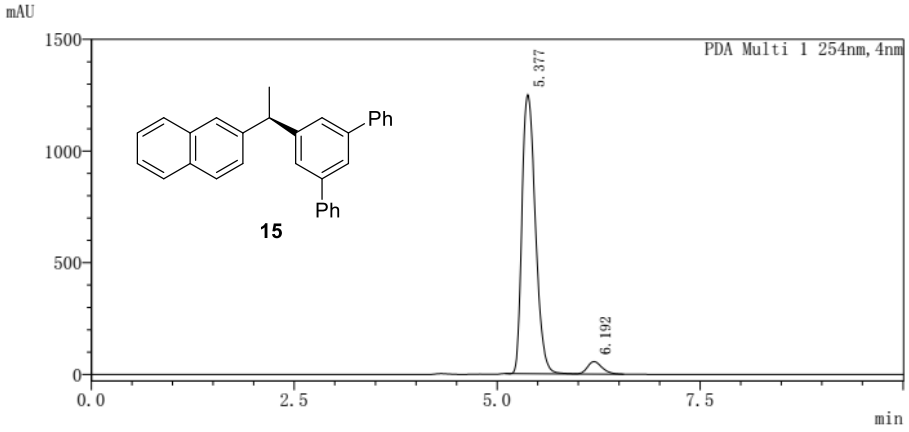
Chiralcel ODH: hexane/*i*-PrOH = 99/1, flow rate 0.6 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	5.319	9051491	49.719
2	6.093	9153885	50.281

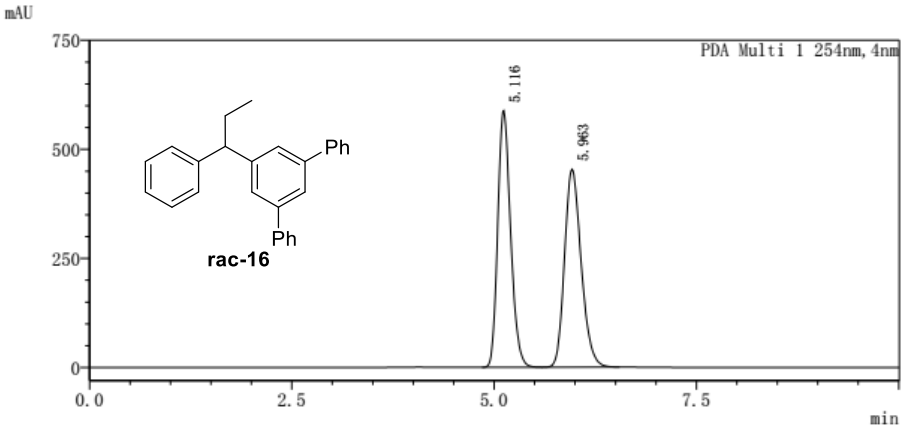


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	5.377	14363436	95.372
2	6.192	697015	4.628

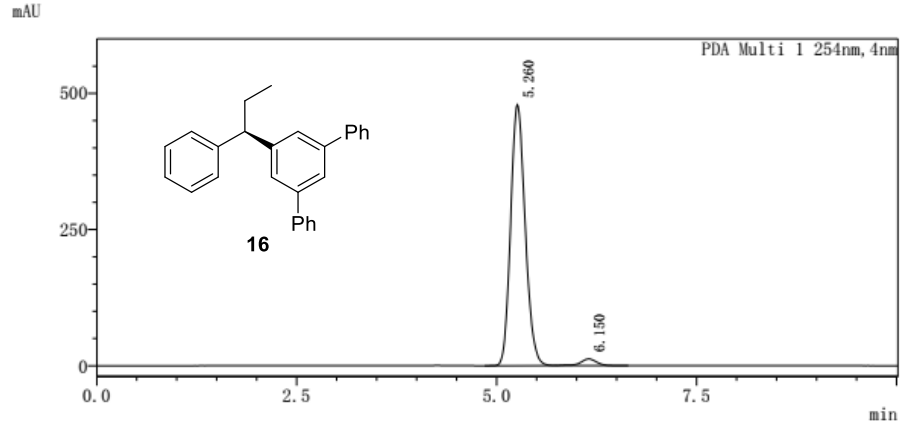
Chiralcel OD: hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	5.116	6495797	49.993
2	5.963	6497540	50.007

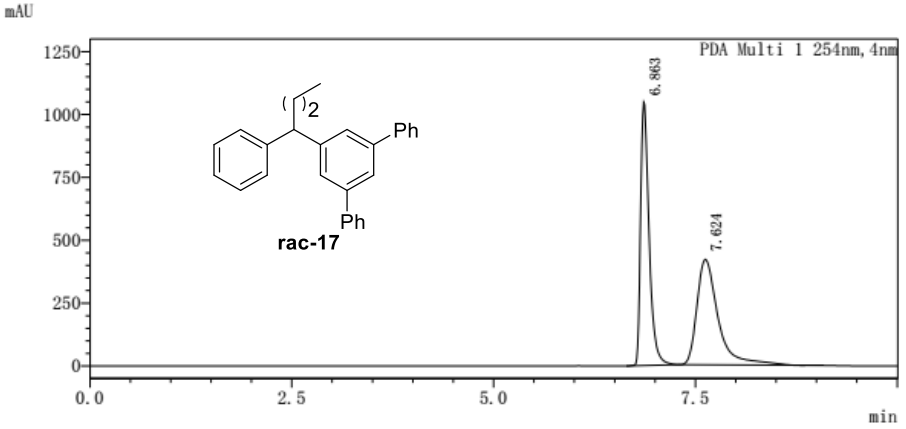


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	5.260	6073320	97.131
2	6.150	179420	2.869

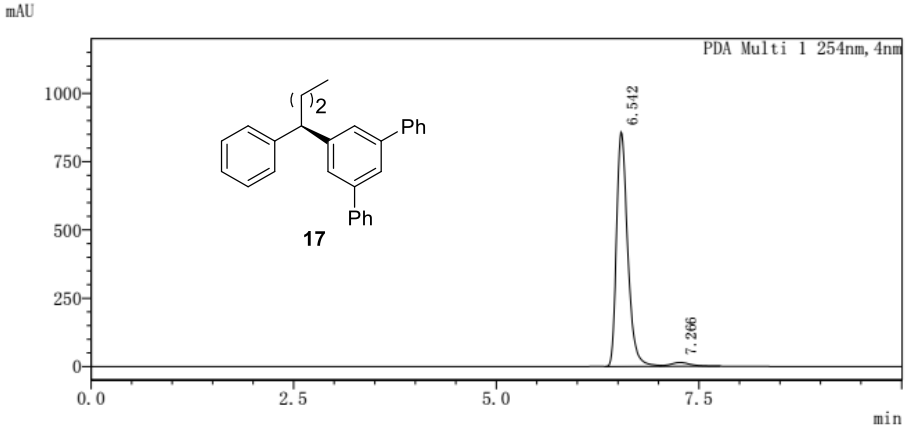
Chiralcel OD: hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	6.863	7685025	50.025
2	7.624	7677424	49.975

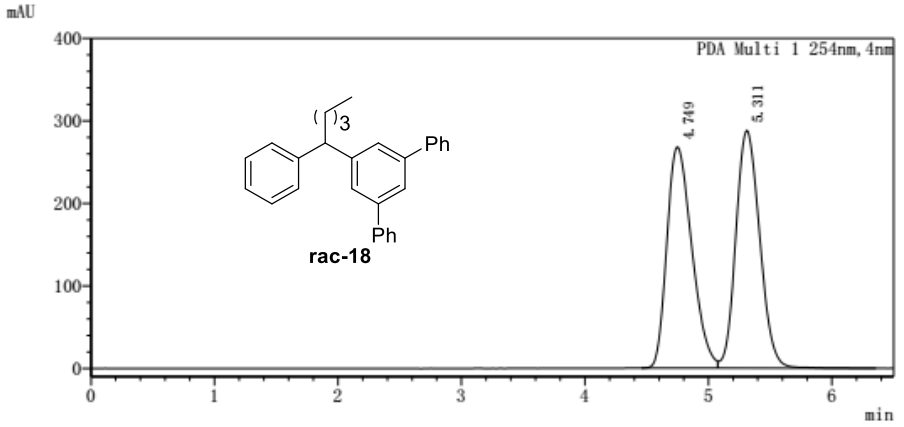


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	6.542	8237369	97.169
2	7.266	240030	2.831

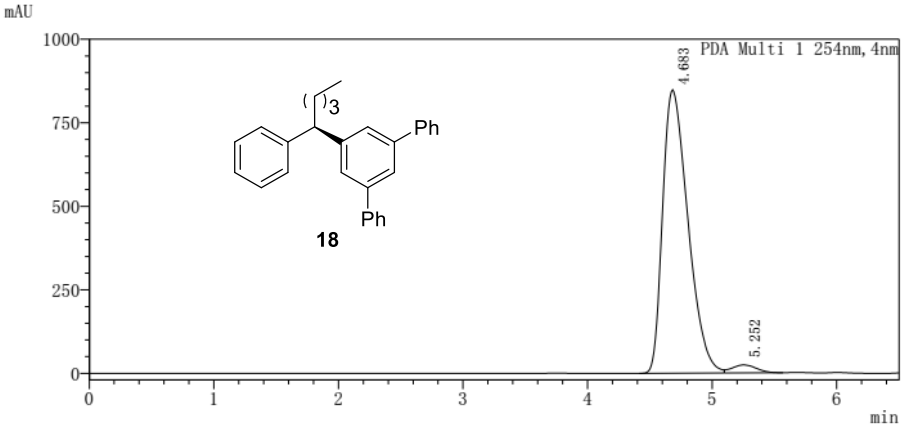
Chiralcel ODH: hexane/*i*-PrOH = 99.5/0.5, flow rate 1.0 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	4.749	3773225	49.336
2	5.311	3874770	50.664

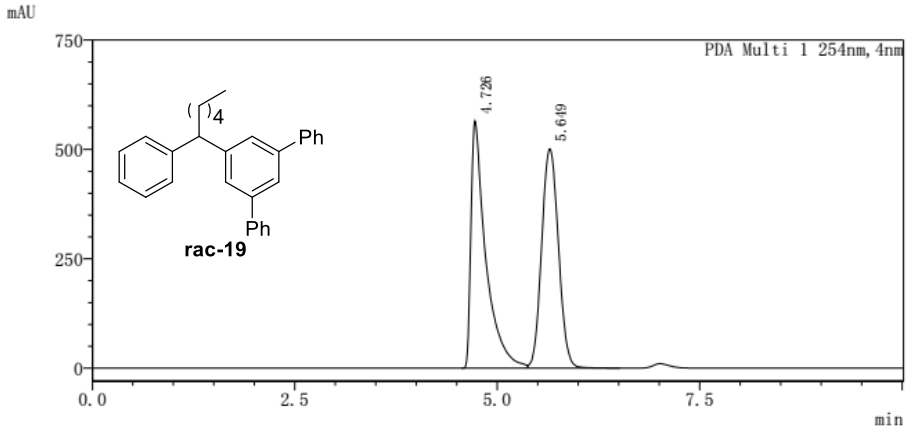


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	4.683	11972390	97.348
2	5.252	326161	2.652

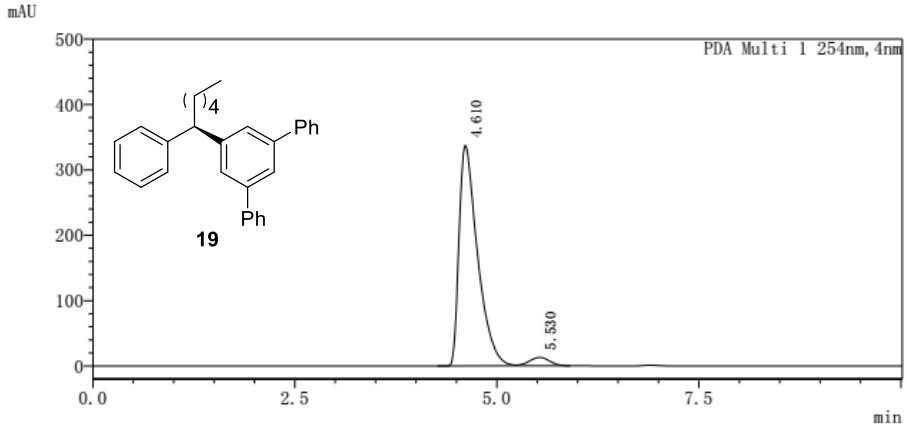
Chiralcel ODH: hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	4.726	7215758	49.916
2	5.649	7240038	50.084

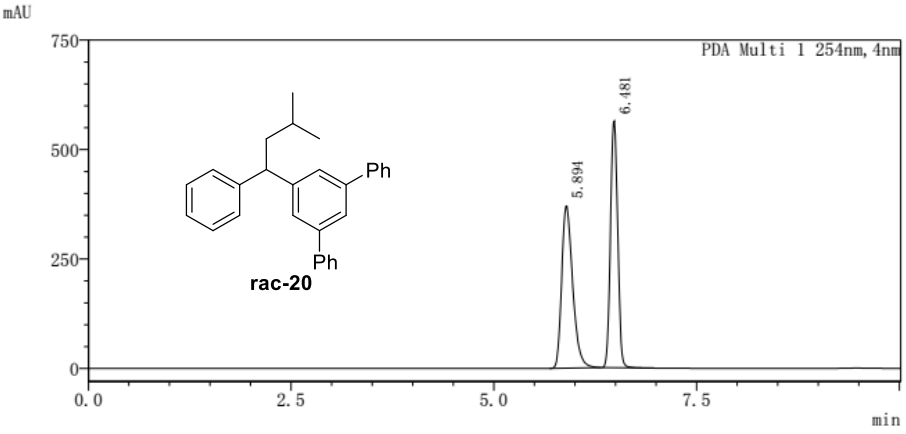


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	4.610	5368193	96.023
2	5.530	222337	3.977

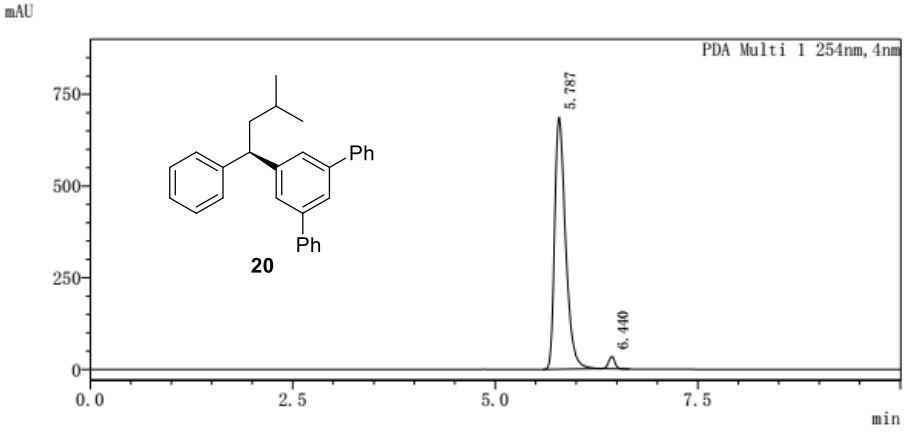
Chiralcel OD: hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	5.894	3508359	49.971
2	6.481	3512418	50.029

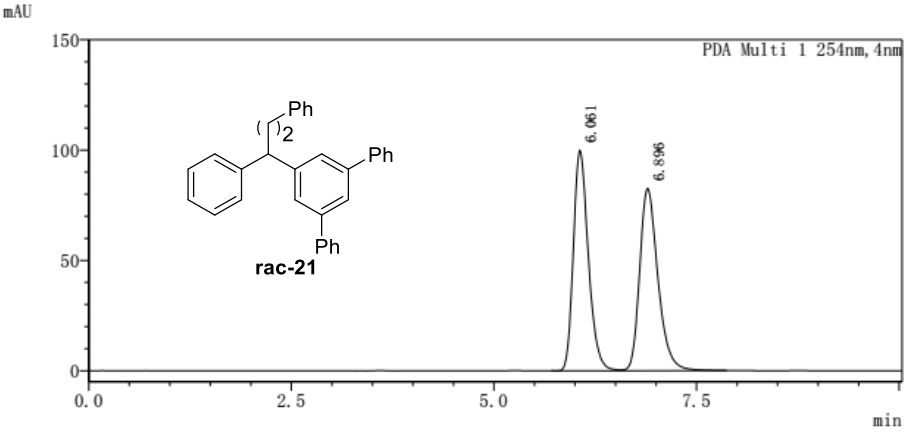


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	5.787	6465164	97.273
2	6.440	181220	2.727

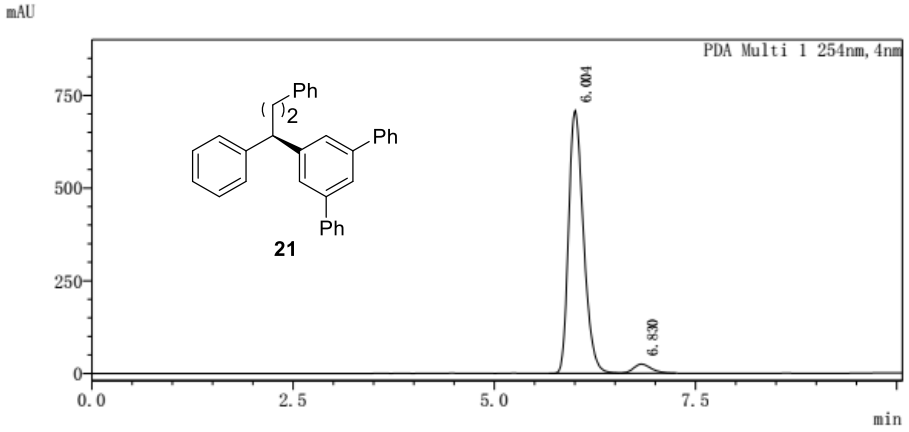
Chiralcel ODH: hexane/*i*-PrOH = 99.5/0.5, flow rate 1.0 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	6.061	1285054	49.780
2	6.896	1296390	50.220

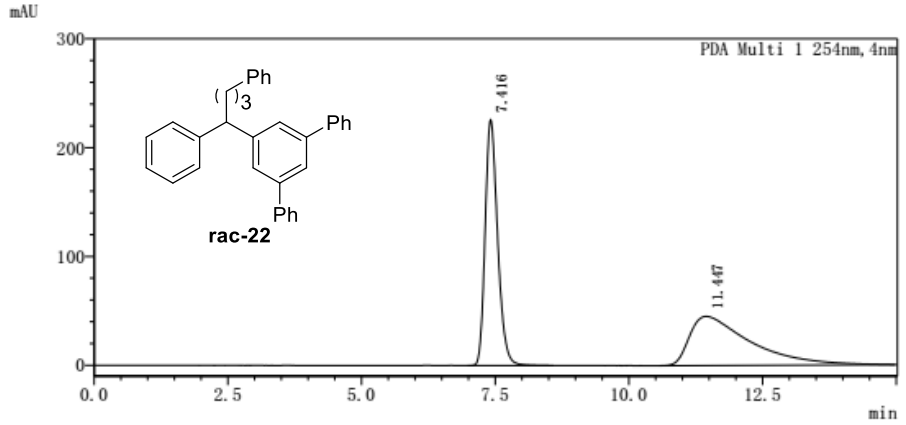


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	6.004	9122745	95.999
2	6.830	380189	4.001

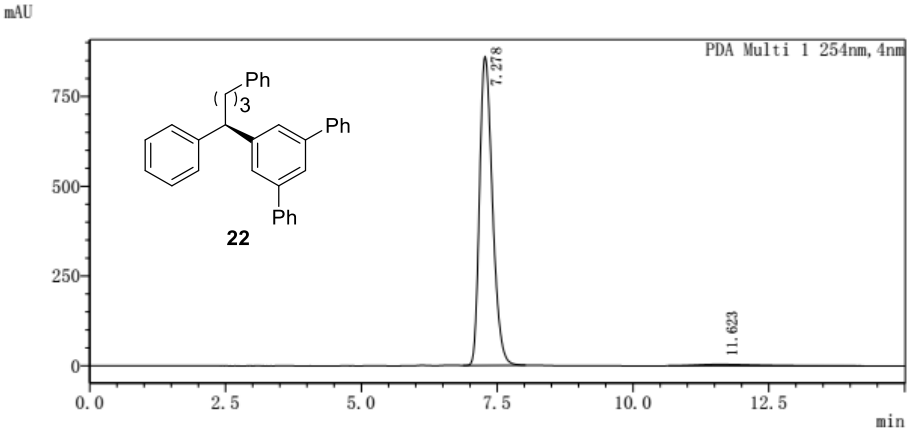
Chiralcel OD: hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	7.416	3664710	50.739
2	11.447	3557919	49.261

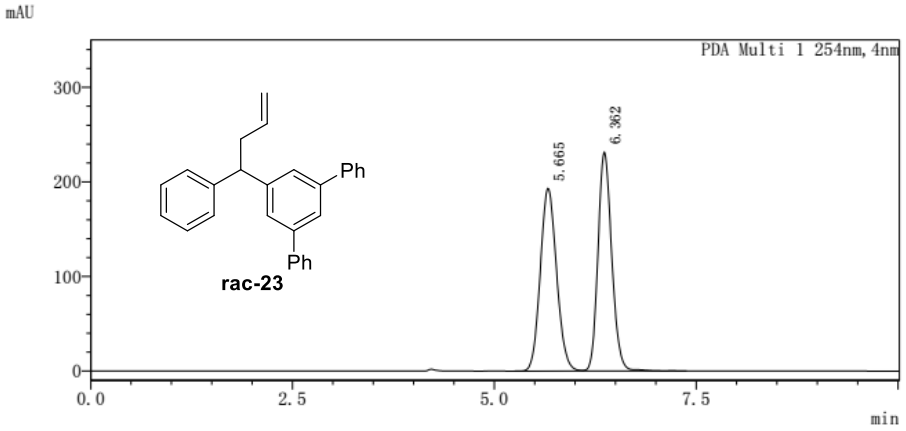


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	7.278	14174000	97.884
2	11.623	306349	2.116

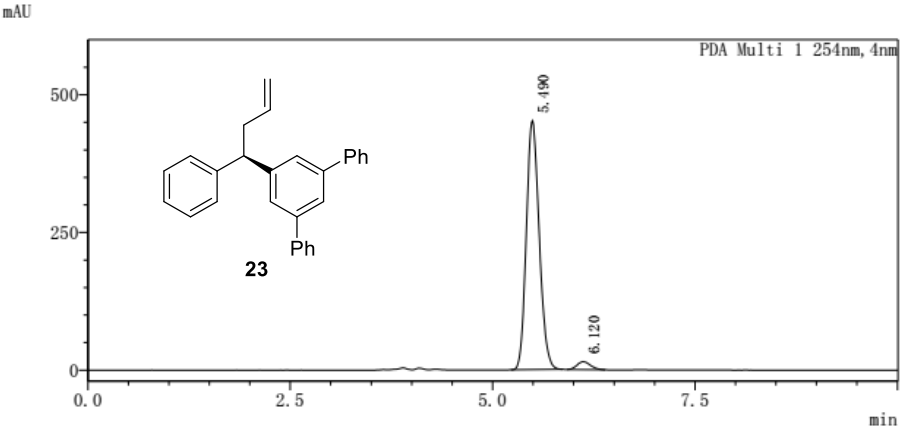
Chiralcel OD: hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	5.665	2719943	49.802
2	6.362	2741589	50.198

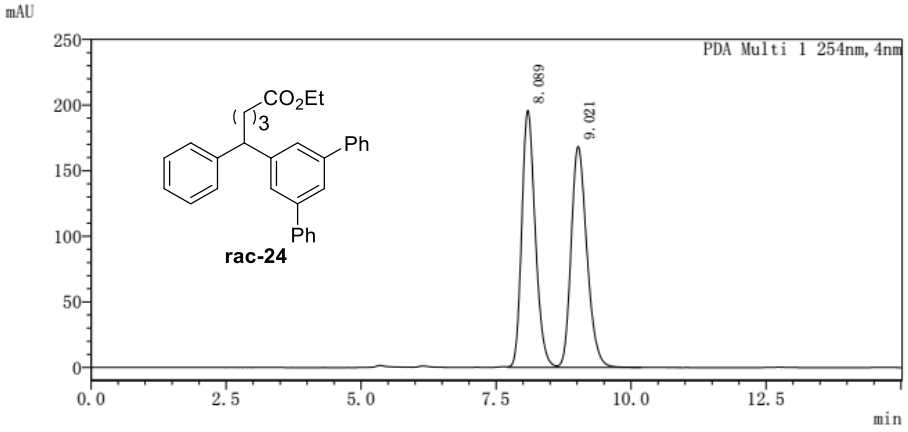


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	5.490	5001628	96.808
2	6.120	164890	3.192

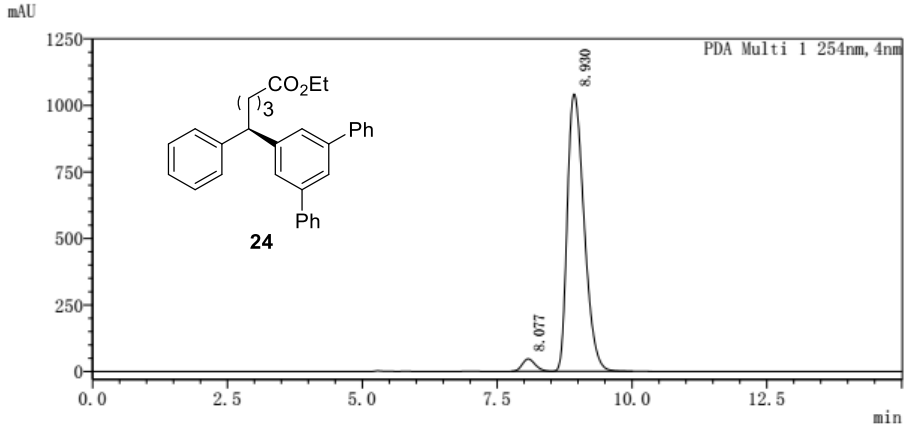
Chiralcel OD: hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	8.089	3412442	49.908
2	9.021	3425067	50.092

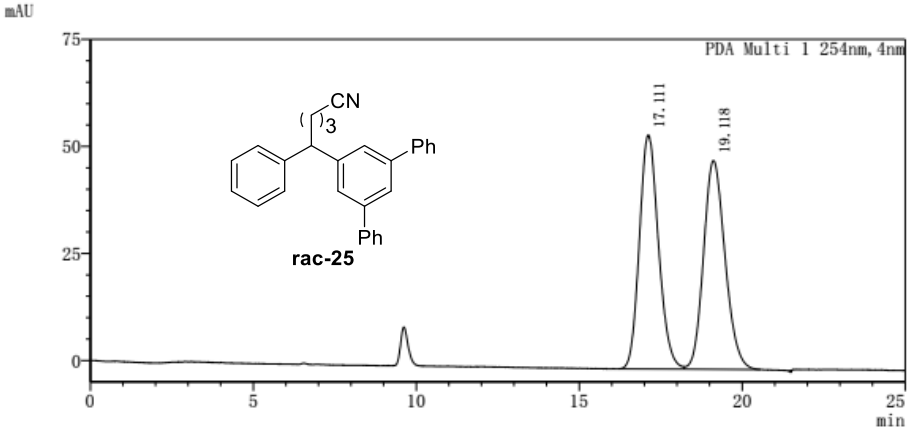


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	8.077	791208	3.387
2	8.930	22570524	96.613

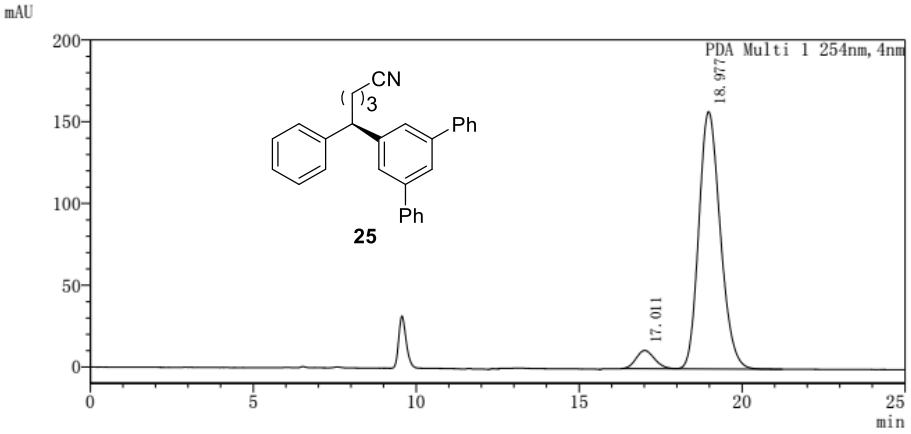
Chiralcel OD: hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	17.111	2225620	49.822
2	19.118	2241544	50.178

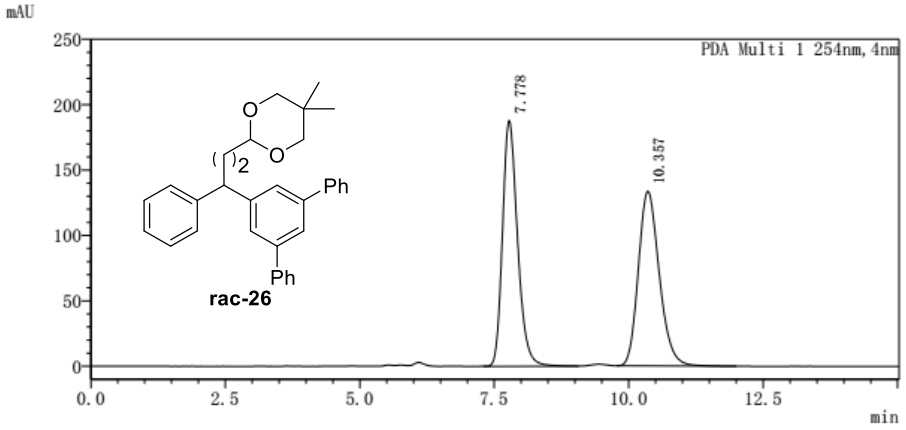


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	17.011	438116	5.734
2	18.977	7203086	94.266

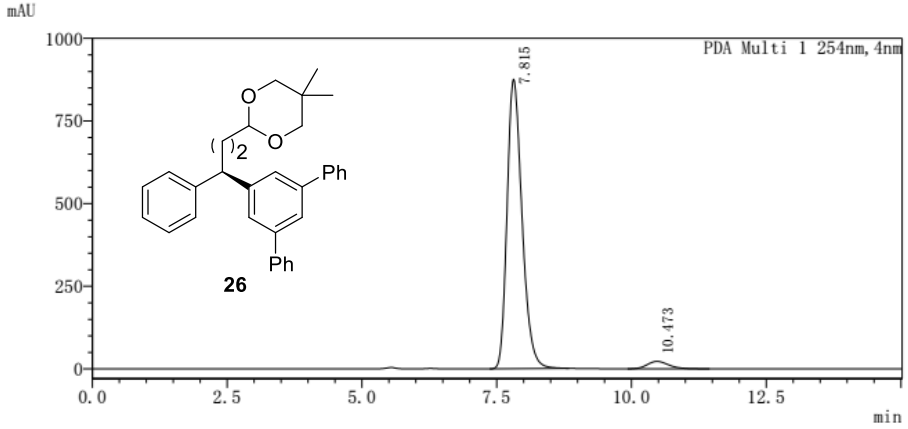
Chiralcel OD: hexane/*i*-PrOH = 80/20, flow rate 1.0 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	7.778	3649999	50.190
2	10.357	3622387	49.810

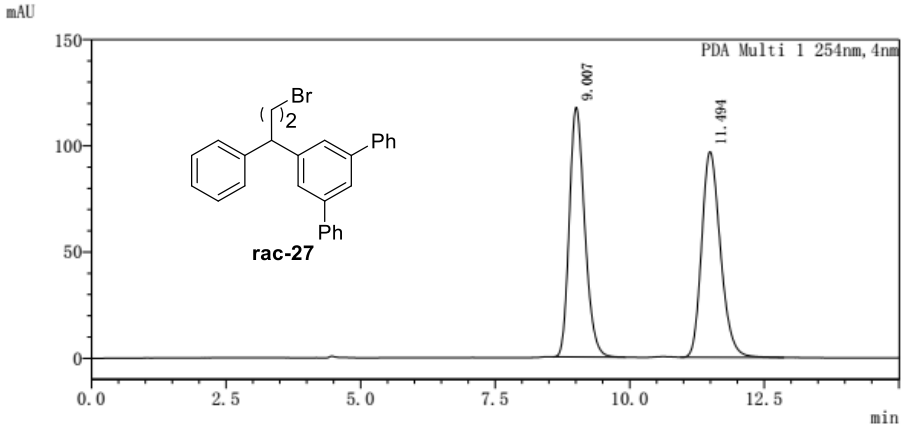


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	7.815	16907809	96.471
2	10.473	618479	3.529

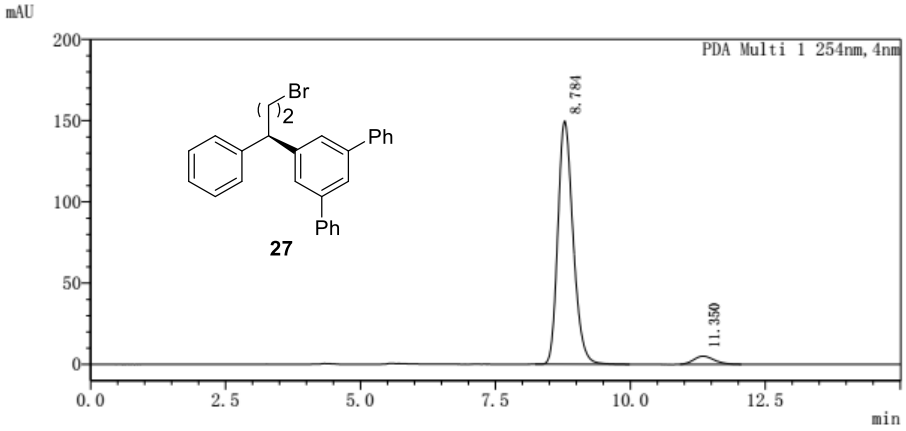
Chiralcel OD: hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	9.007	2338685	49.863
2	11.494	2351572	50.137

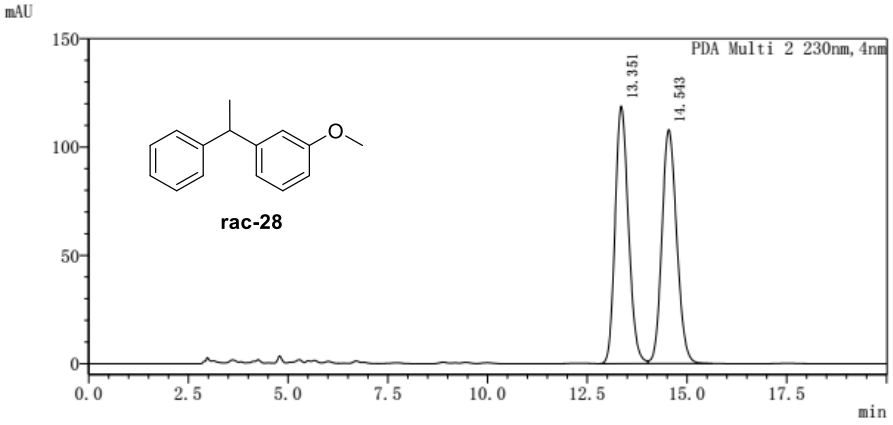


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	8.784	2942046	95.762
2	11.350	130194	4.238

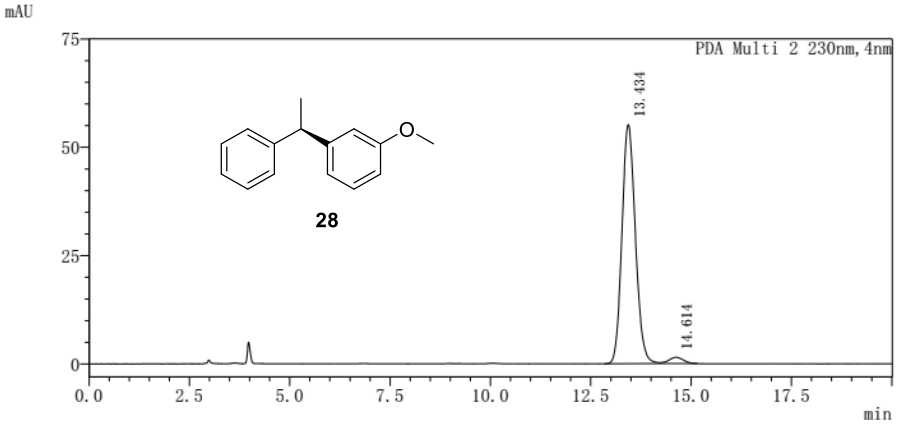
Chiralcel OD: hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min



Peak Table

PDA Ch2 230nm

Peak#	Ret. Time	Area	Area%
1	13.351	2767733	49.769
2	14.543	2793423	50.231

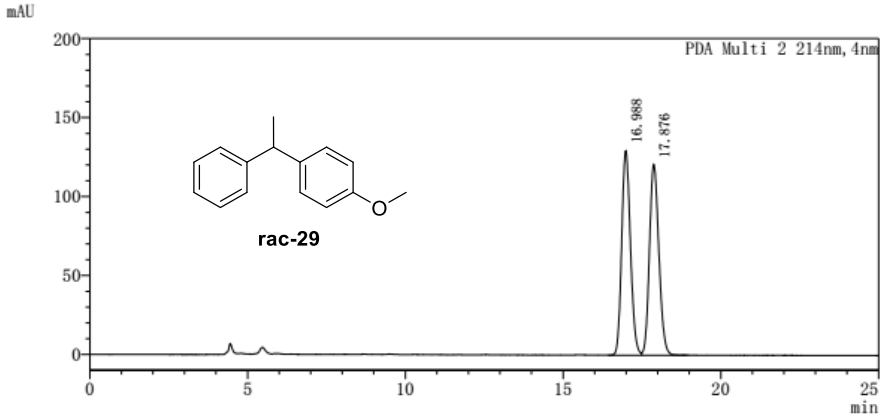


Peak Table

PDA Ch2 230nm

Peak#	Ret. Time	Area	Area%
1	13.434	1283771	97.173
2	14.614	37348	2.827

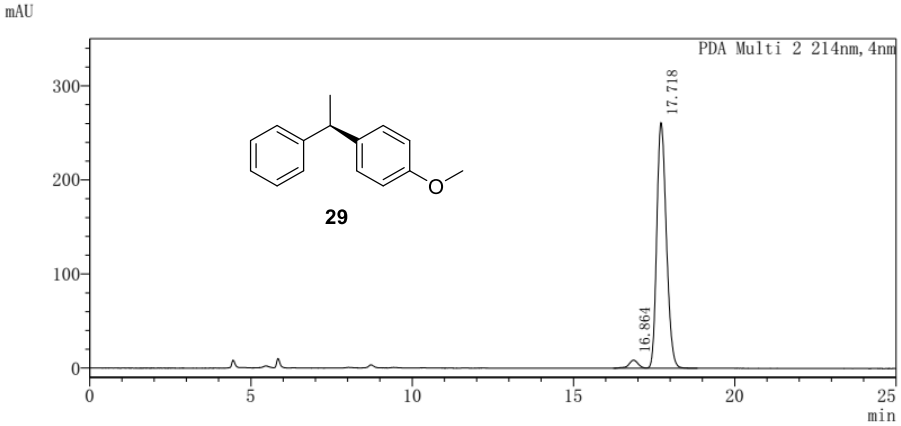
Chiralcel OJ: hexane/*i*-PrOH = 90/10, flow rate 1.0 mL/min



Peak Table

PDA Ch2 214nm

Peak#	Ret. Time	Area	Area%
1	16.988	2496686	49.873
2	17.876	2509360	50.127

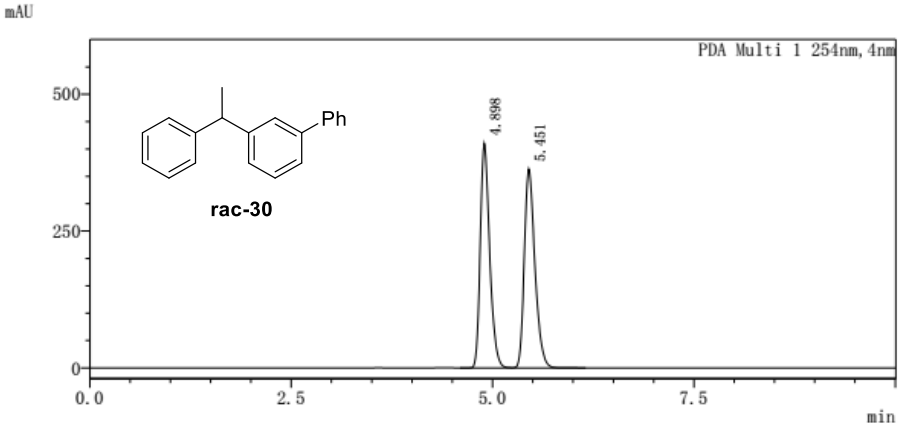


Peak Table

PDA Ch2 214nm

Peak#	Ret. Time	Area	Area%
1	16.864	174488	3.131
2	17.718	5398845	96.869

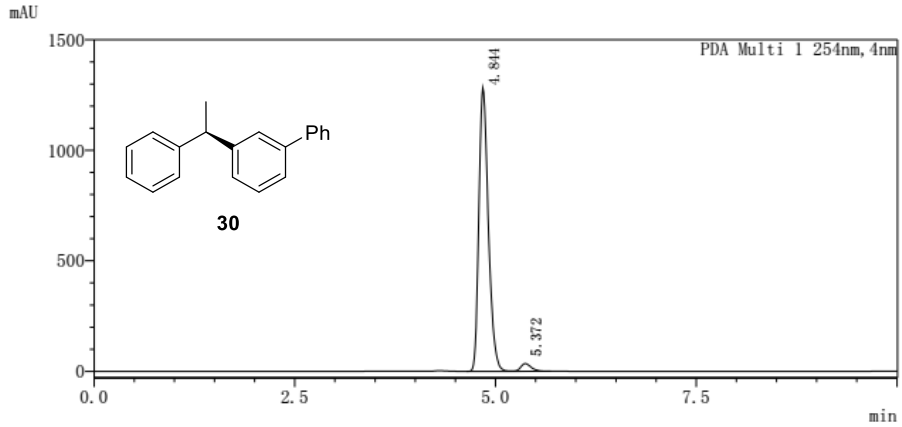
Chiralcel OJH: hexane/*i*-PrOH = 90/10, flow rate 0.7 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	4.898	3330652	49.920
2	5.451	3341309	50.080

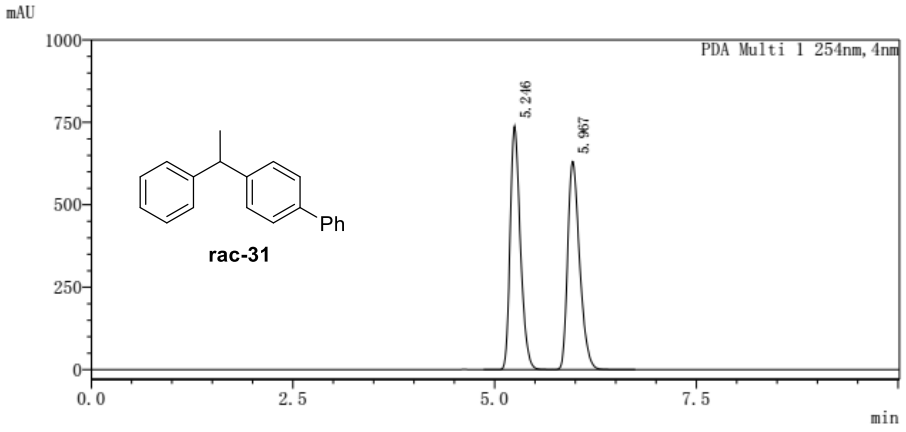


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	4.844	10550118	97.091
2	5.372	316075	2.909

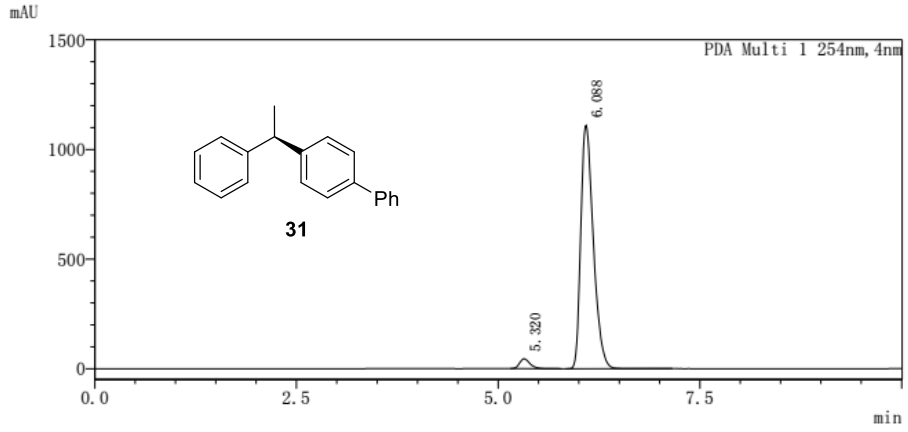
Chiralcel OD: hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	5.246	6513702	49.992
2	5.967	6515848	50.008

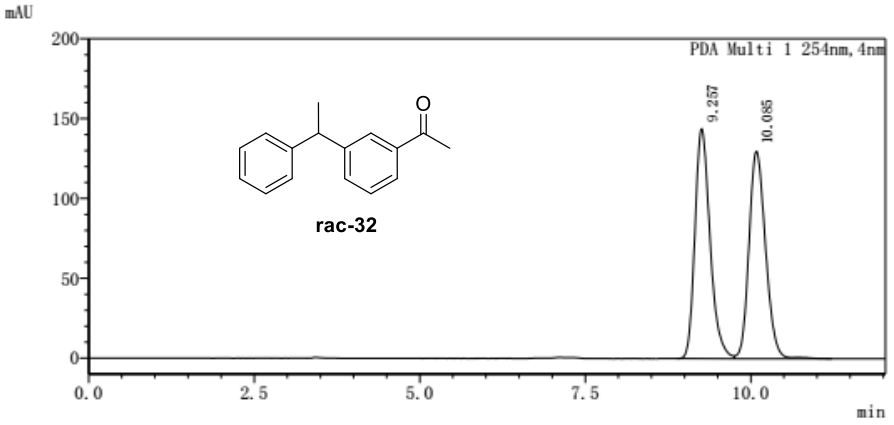


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	5.320	396850	3.208
2	6.088	11972845	96.792

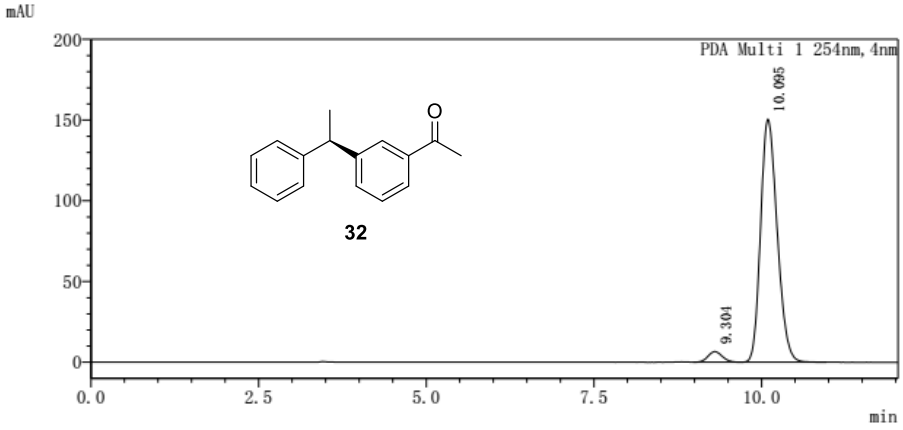
Chiralcel OD: hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	9.257	2293583	50.332
2	10.085	2263285	49.668

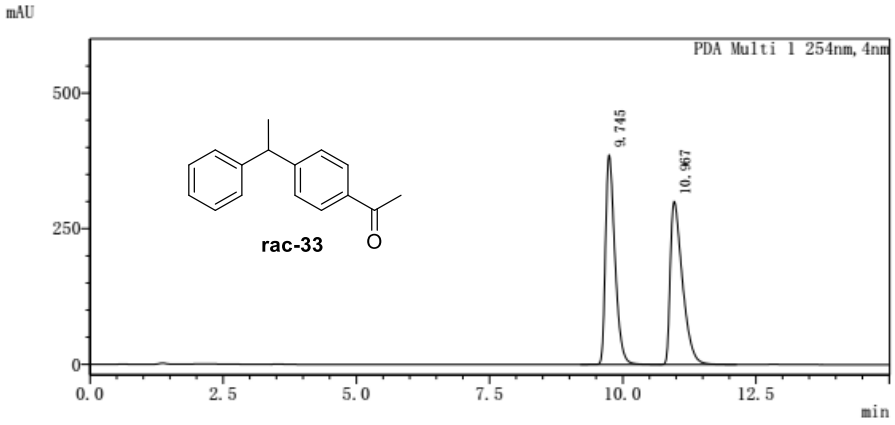


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	9.304	98575	3.666
2	10.095	2590508	96.334

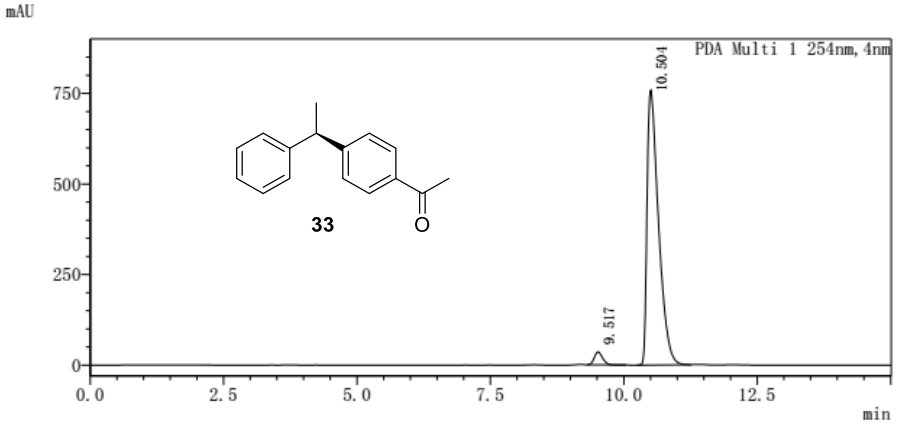
Chiralcel AS: hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	9.745	4785342	49.991
2	10.967	4787132	50.009

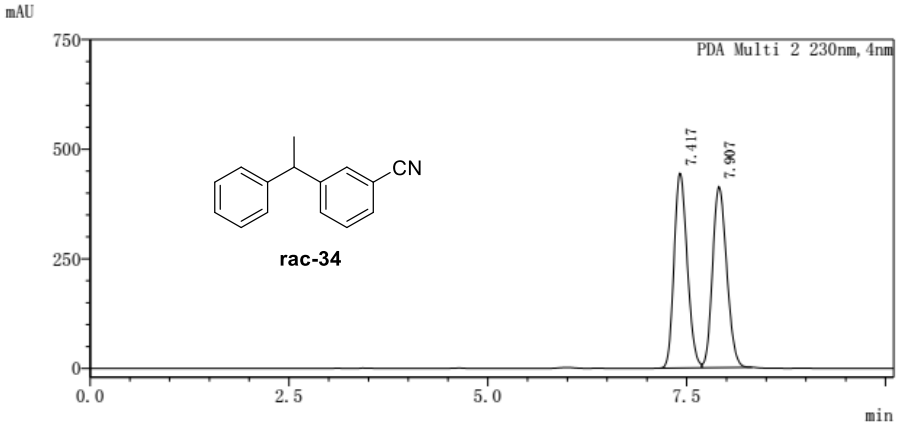


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	9.517	385084	3.295
2	10.504	11301409	96.705

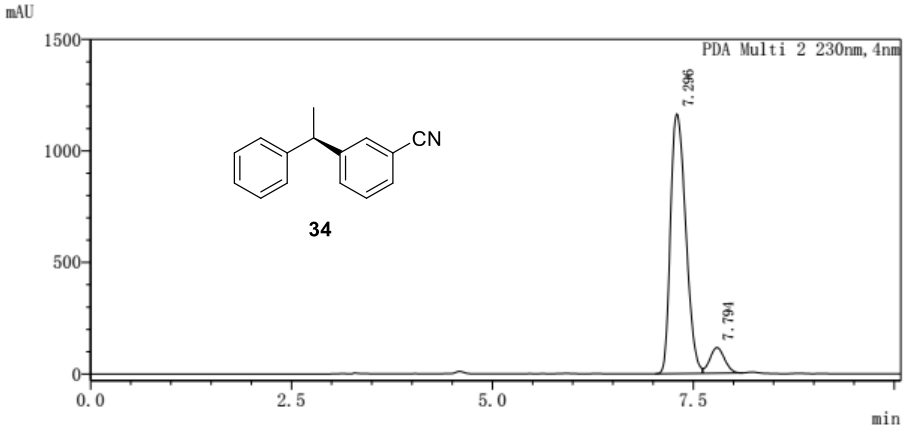
Chiralcel IF: hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min



Peak Table

PDA Ch2 230nm

Peak#	Ret. Time	Area	Area%
1	7.417	5114846	50.046
2	7.907	5105344	49.954

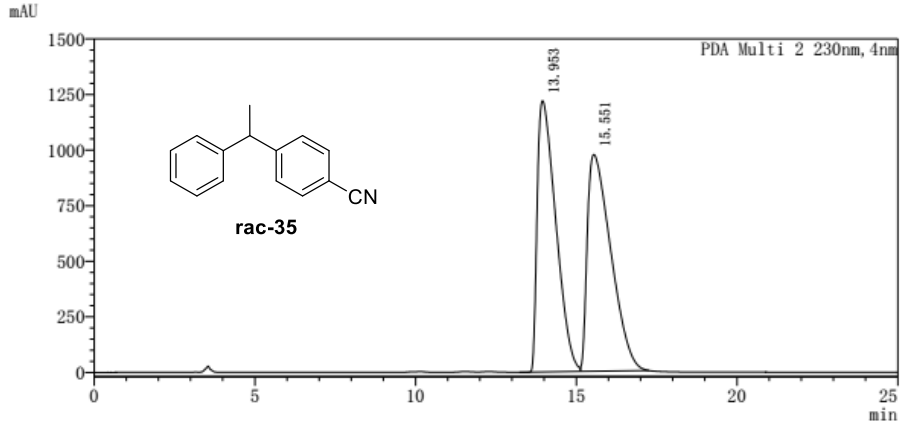


Peak Table

PDA Ch2 230nm

Peak#	Ret. Time	Area	Area%
1	7.296	15388862	91.319
2	7.794	1462897	8.681

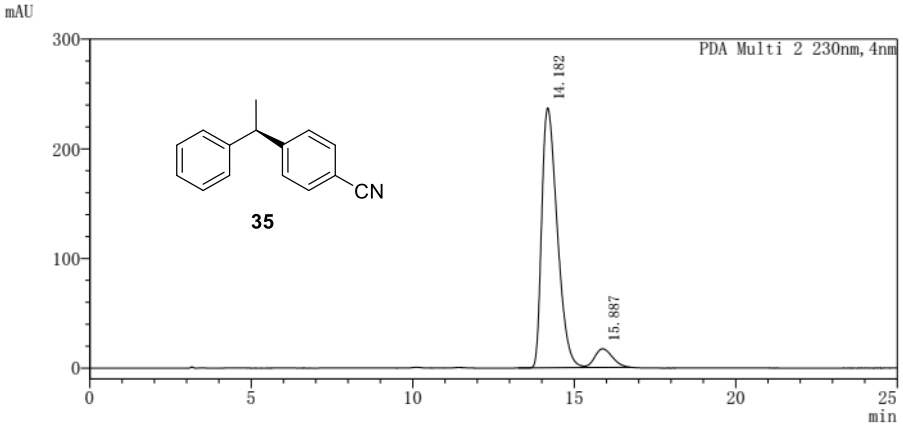
Chiralcel AS: hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min



Peak Table

PDA Ch2 230nm

Peak#	Ret. Time	Area	Area%
1	13.953	49053756	49.660
2	15.551	49725494	50.340

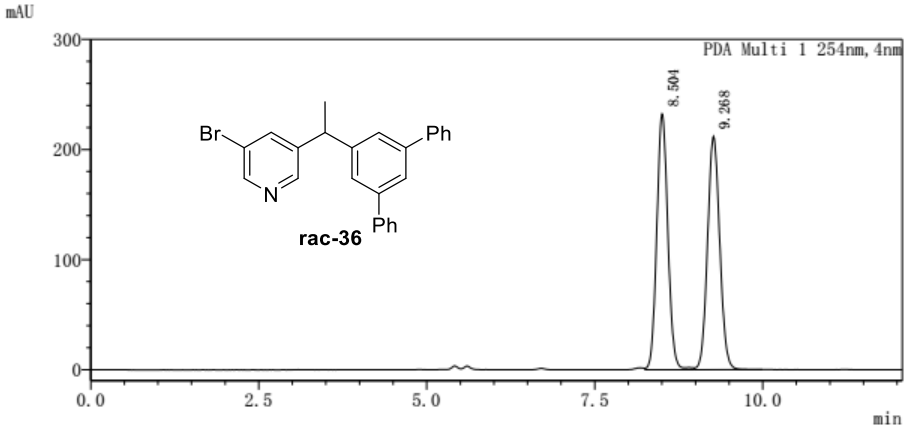


Peak Table

PDA Ch2 230nm

Peak#	Ret. Time	Area	Area%
1	14.182	7915659	92.476
2	15.887	643991	7.524

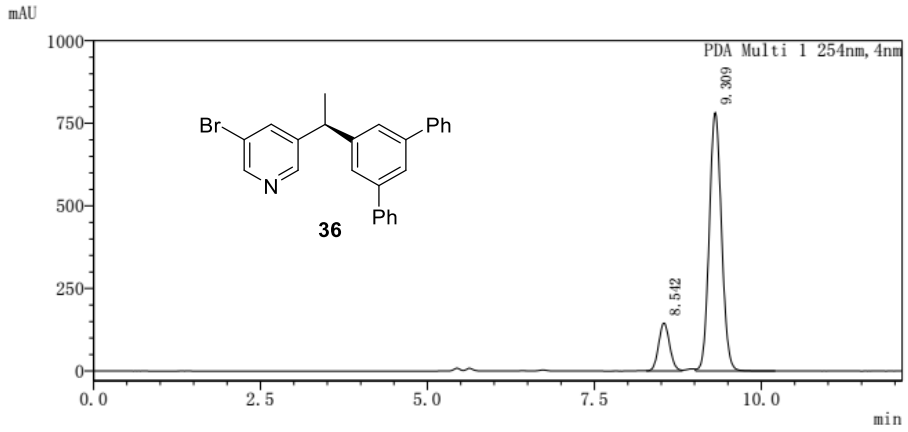
Chiralcel ASH: hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	8.504	2672464	49.937
2	9.268	2679172	50.063

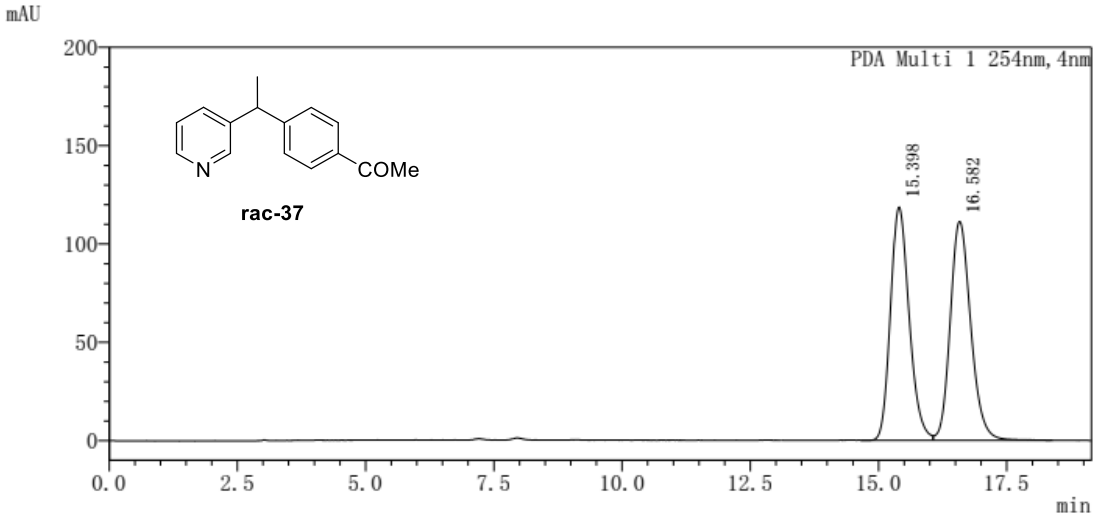


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	8.542	1678836	14.351
2	9.309	10019624	85.649

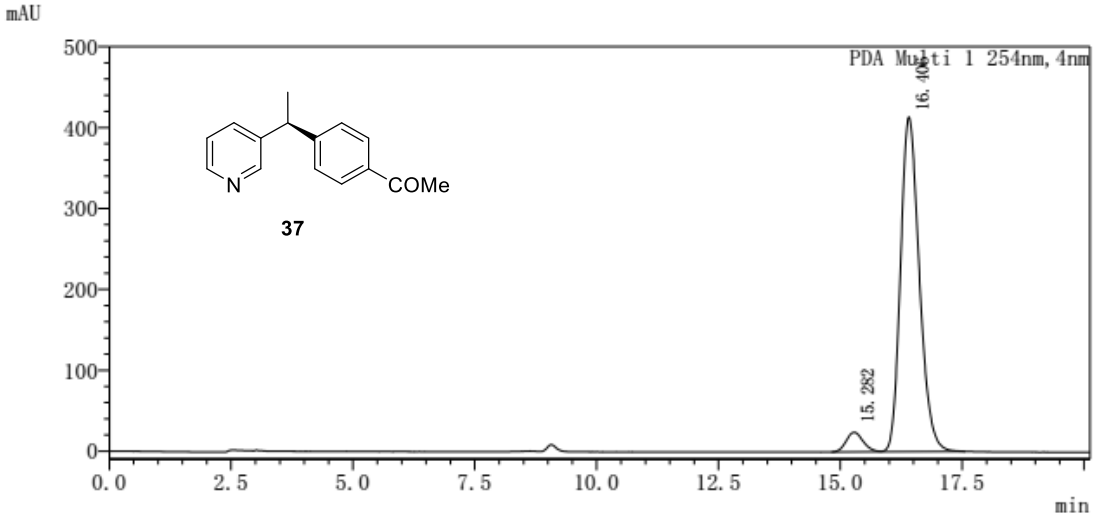
Chiralcel ADH: hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	15.398	3005020	49.367
2	16.582	3082123	50.633

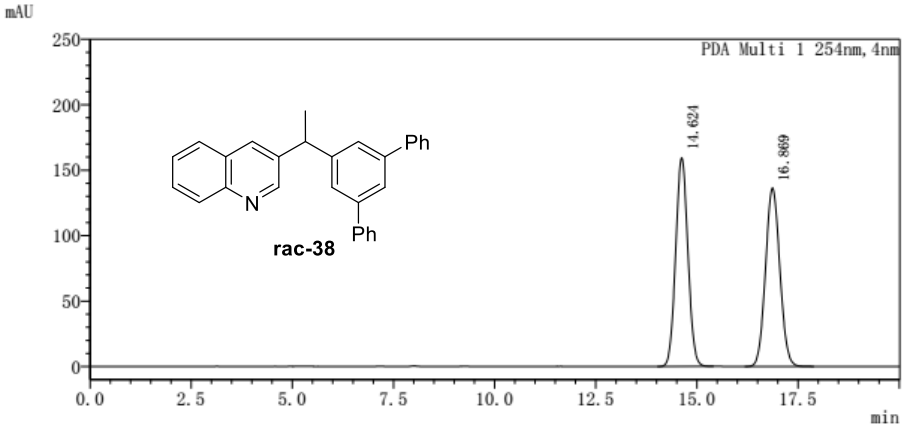


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	15.282	585756	5.011
2	16.406	11103862	94.989

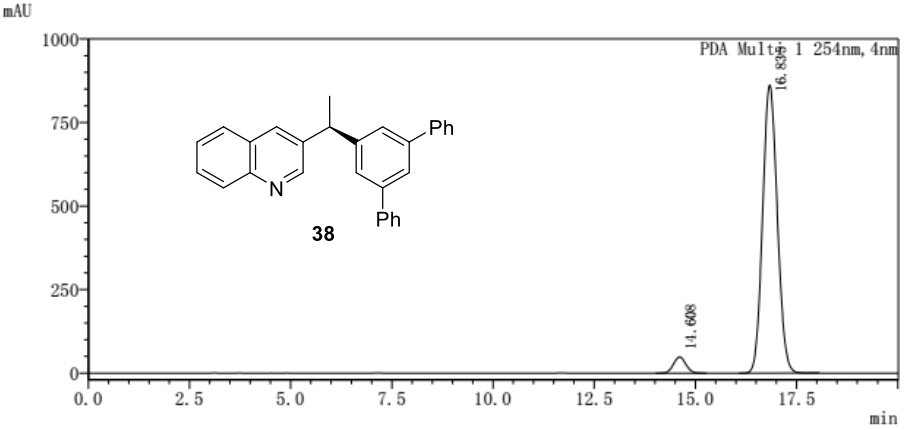
Chiralcel AD: hexane/*i*-PrOH = 90/10, flow rate 1.0 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	14.624	3353521	49.951
2	16.869	3360107	50.049

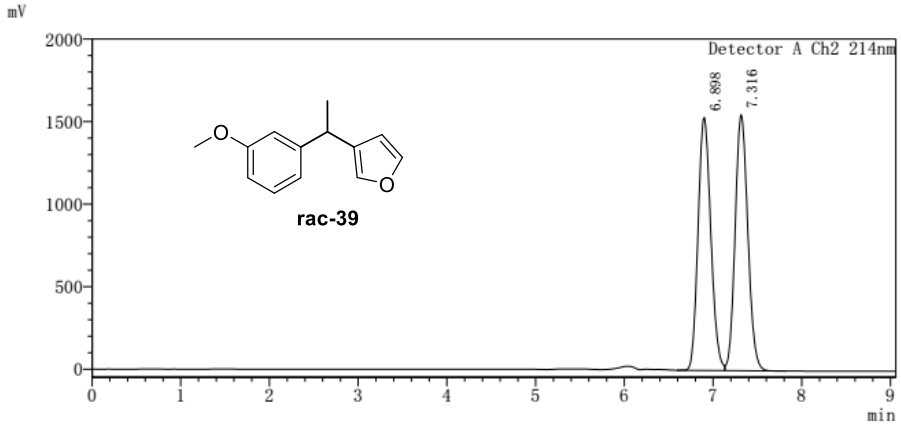


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	14.608	1026570	4.512
2	16.835	21726990	95.488

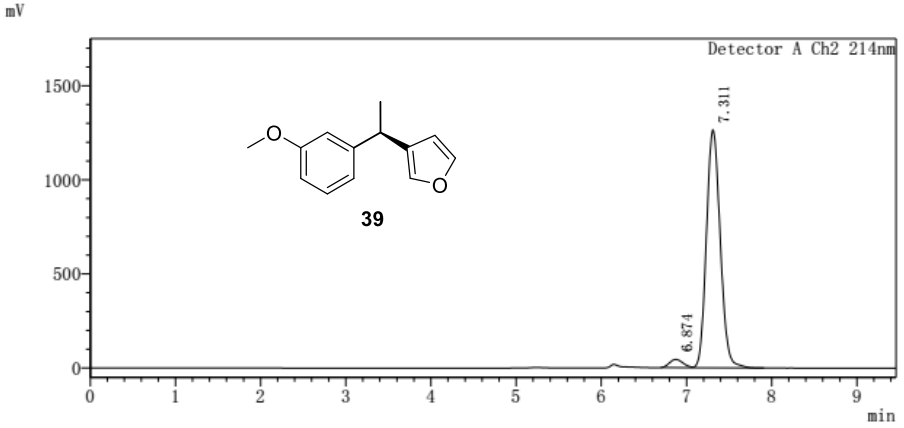
Chiralcel ADH: hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min



Peak Table

Detector A Ch2 214nm

Peak#	Ret. Time	Area	Area%
1	6.898	15313475	49.838
2	7.316	15413271	50.162

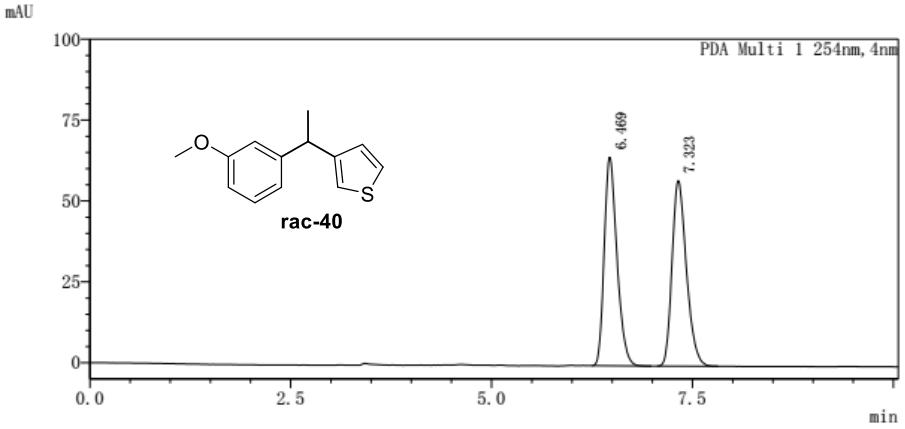


Peak Table

Detector A Ch2 214nm

Peak#	Ret. Time	Area	Area%
1	6.874	477950	3.248
2	7.311	14236994	96.752

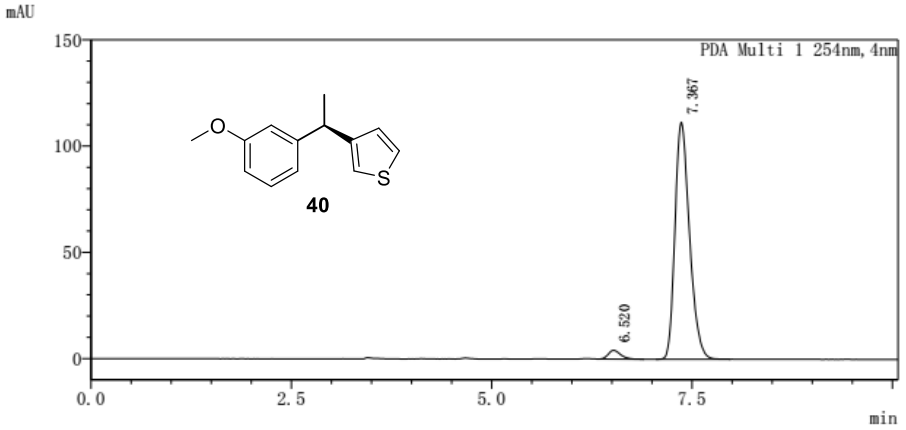
Chiralcel IF: hexane/*i*-PrOH = 98/2, flow rate 0.6 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	6.469	712087	49.868
2	7.323	715849	50.132

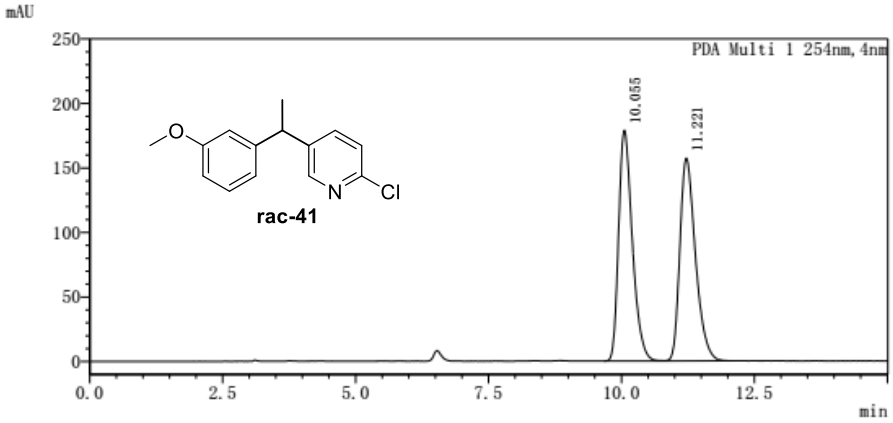


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	6.520	43822	3.018
2	7.367	1408163	96.982

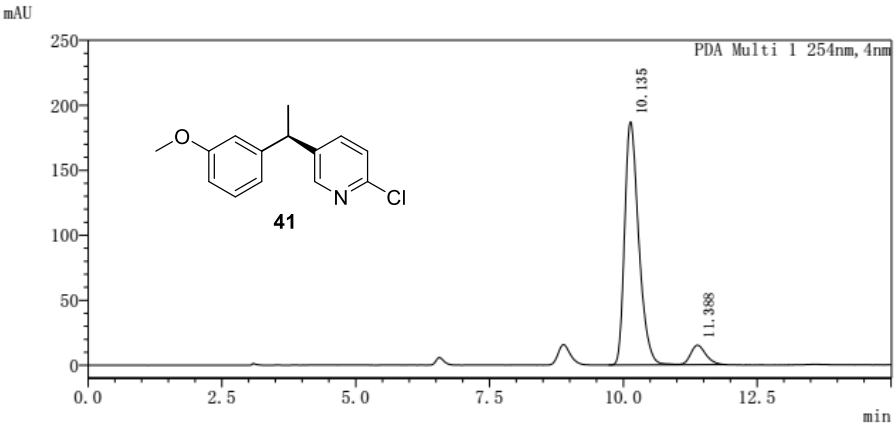
Chiralcel OD: hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	10.055	3207052	50.031
2	11.221	3203024	49.969

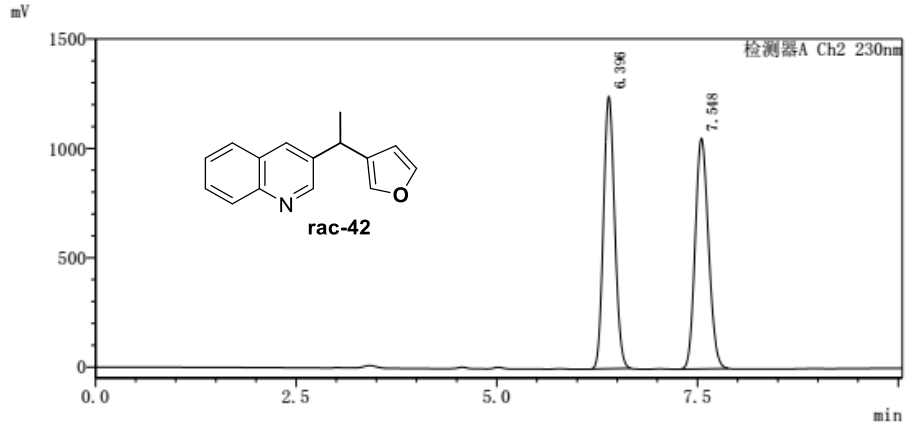


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	10.135	3428597	91.968
2	11.388	299426	8.032

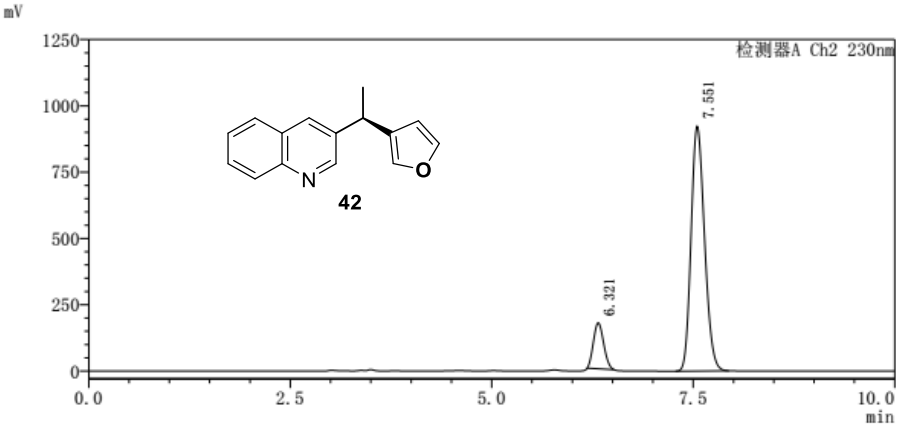
Chiralcel OD: hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min



Peak Table

检测器A Ch2 230nm

Peak#	Ret. Time	Area	Area%
1	6.396	12013421	49.730
2	7.548	12143869	50.270

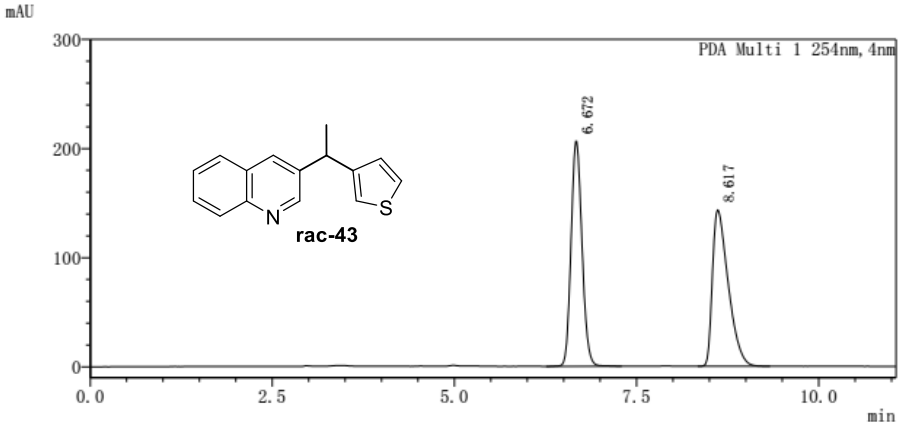


Peak Table

检测器A Ch2 230nm

Peak#	Ret. Time	Area	Area%
1	6.321	1536757	12.528
2	7.551	10729424	87.472

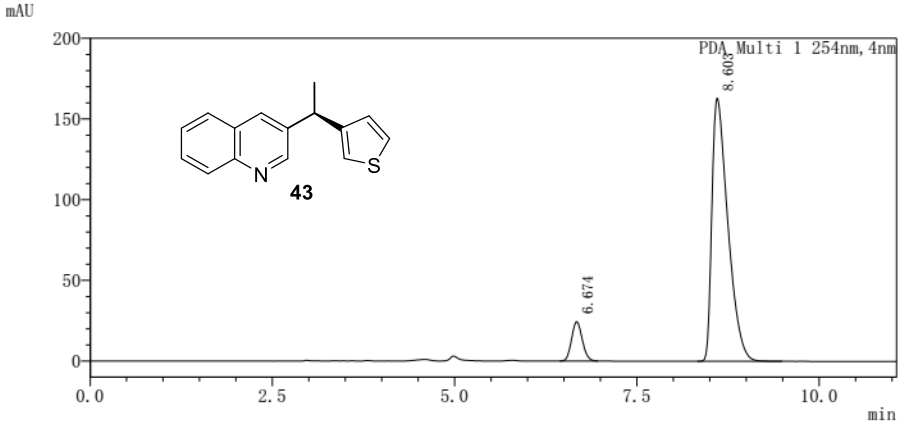
Chiralcel AD: hexane/*i*-PrOH = 80/20, flow rate 1.0 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	6.672	2157919	49.853
2	8.617	2170672	50.147

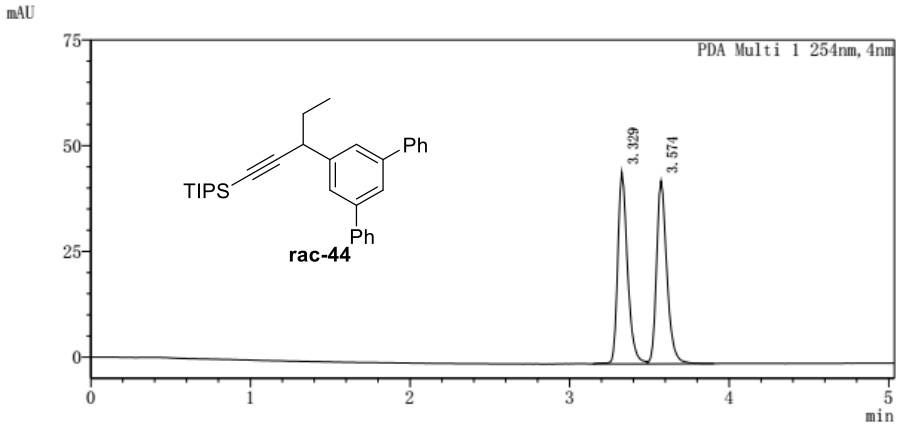


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	6.674	247740	9.059
2	8.603	2486970	90.941

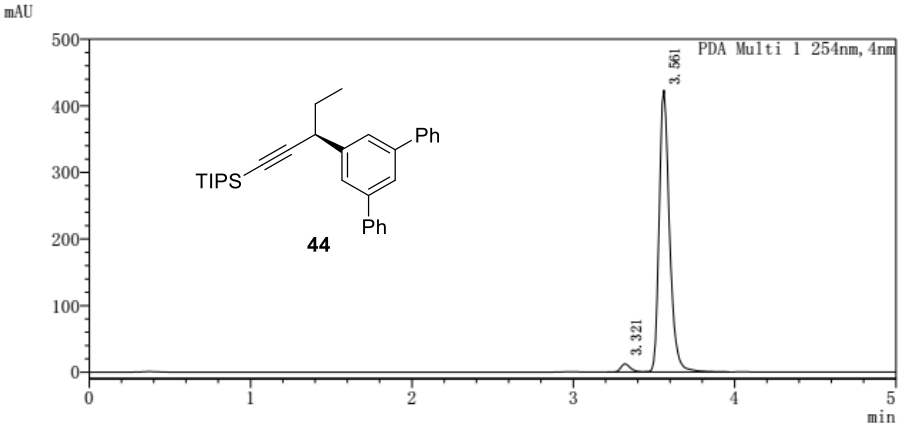
Chiralcel AD: hexane/*i*-PrOH = 80/20, flow rate 1.0 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	3.329	193926	49.987
2	3.574	194024	50.013

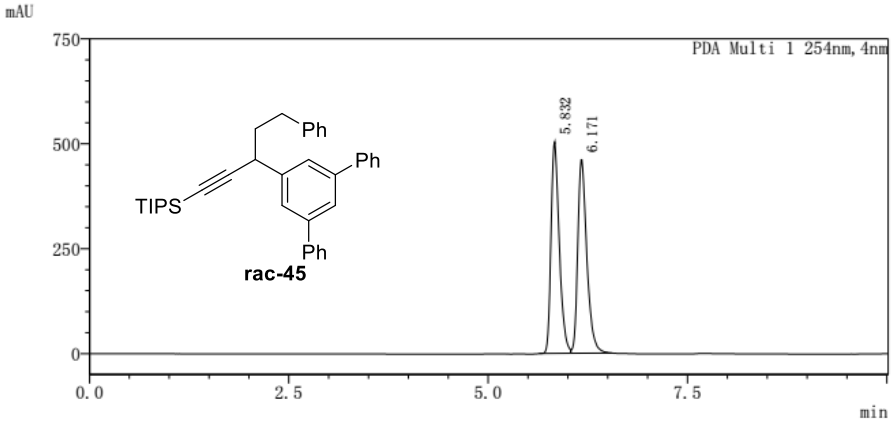


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	3.321	52045	2.687
2	3.561	1885017	97.313

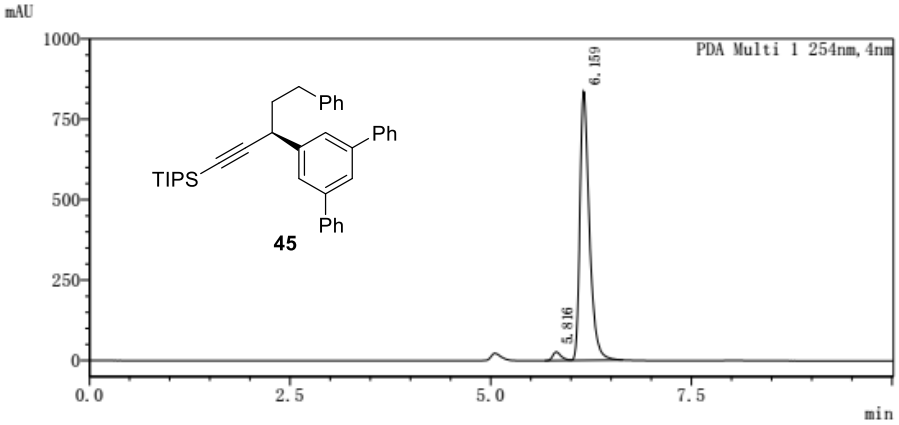
Chiralcel ADH: hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	5.832	3641416	49.831
2	6.171	3666183	50.169

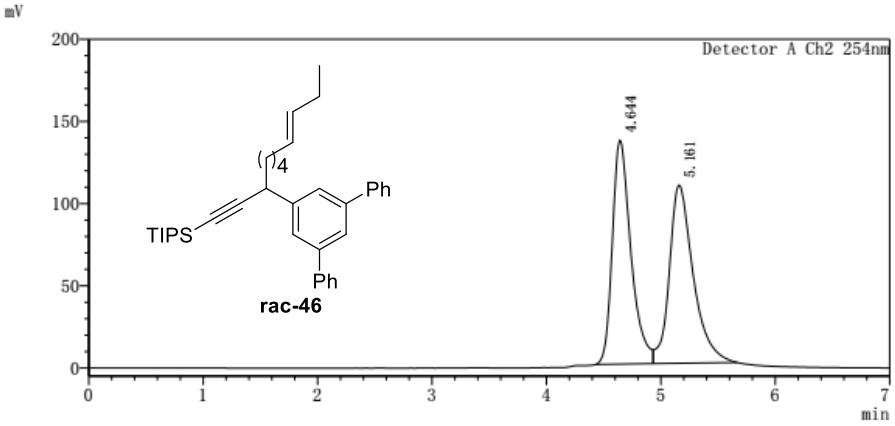


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	5.816	198346	2.803
2	6.159	6878675	97.197

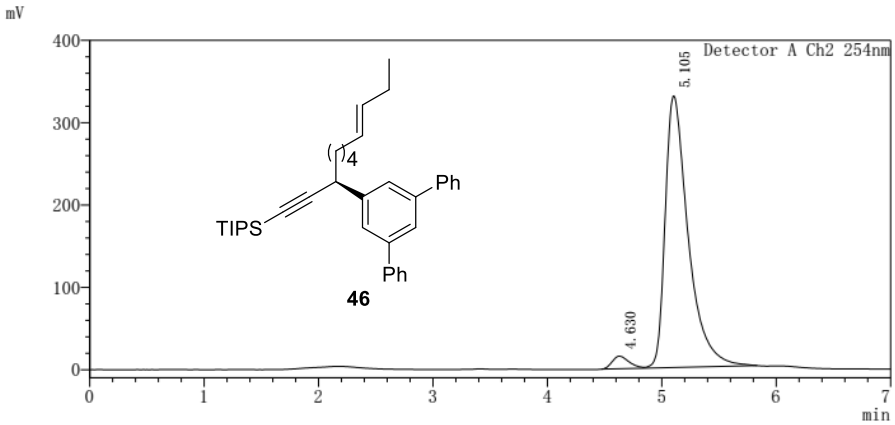
Chiralcel ADH: hexane/*i*-PrOH = 99/1, flow rate 0.6 mL/min



Peak Table

Detector A Ch2 254nm

Peak#	Ret. Time	Area	Area%
1	4.644	1539988	49.456
2	5.161	1573837	50.544

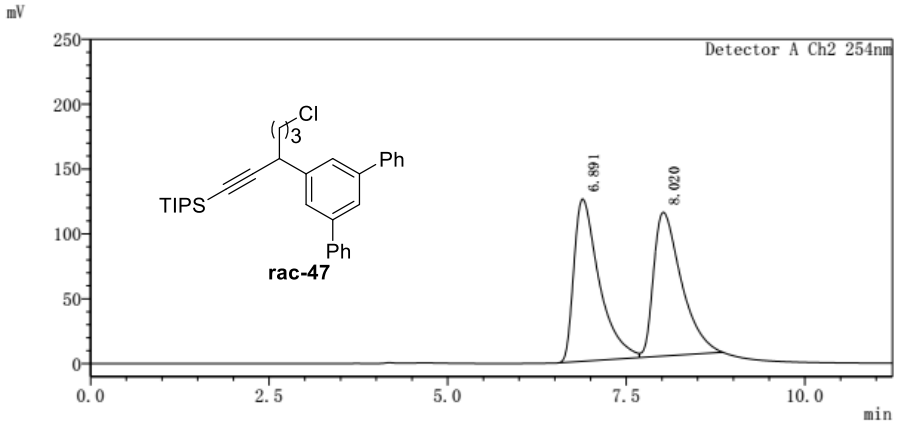


Peak Table

Detector A Ch2 254nm

Peak#	Ret. Time	Area	Area%
1	4.630	157676	3.299
2	5.105	4622204	96.701

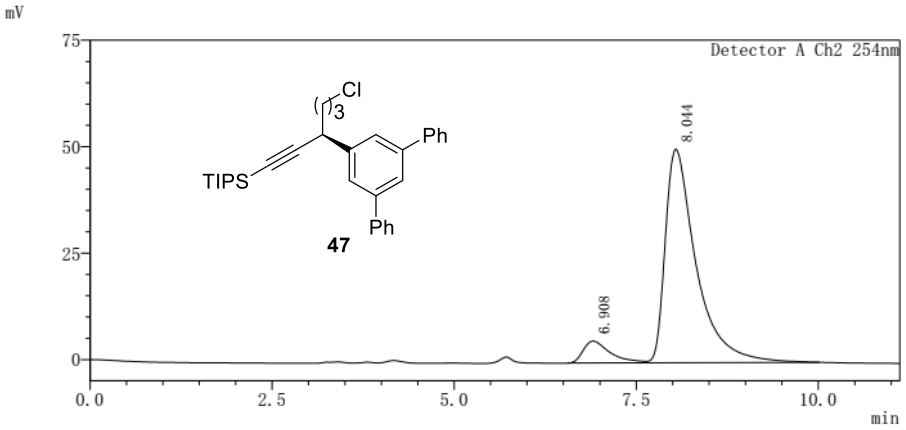
Chiralcel ADH: hexane/*i*-PrOH = 100/0, flow rate 1.0 mL/min



Peak Table

Detector A Ch2 254nm

Peak#	Ret. Time	Area	Area%
1	6.891	3096124	50.630
2	8.020	3019040	49.370

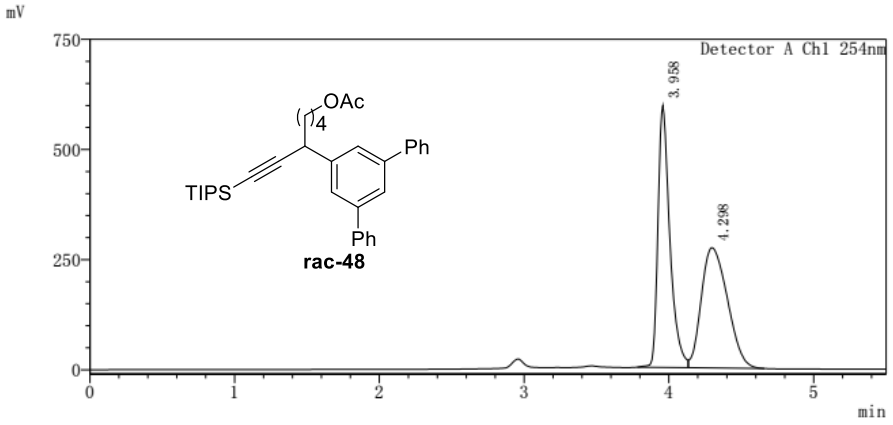


Peak Table

Detector A Ch2 254nm

Peak#	Ret. Time	Area	Area%
1	6.908	133220	8.245
2	8.044	1482451	91.755

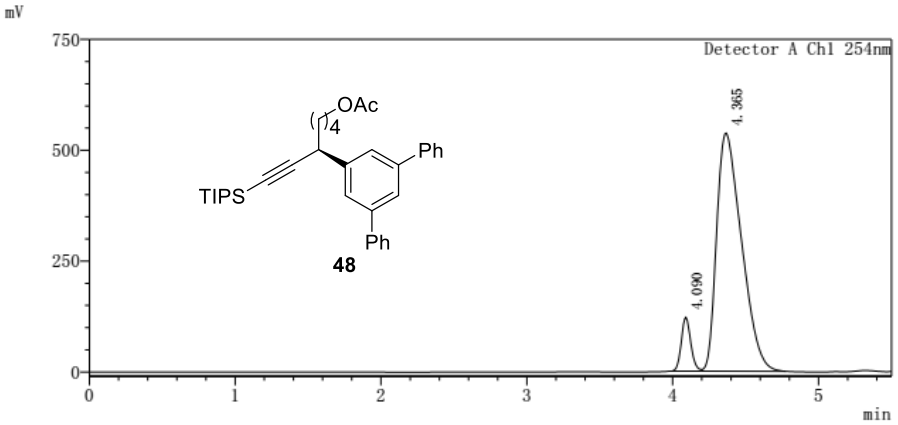
Chiralcel ADH: hexane/*i*-PrOH = 100/0, flow rate 1.0 mL/min



Peak Table

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	3.958	3404449	49.807
2	4.298	3430841	50.193

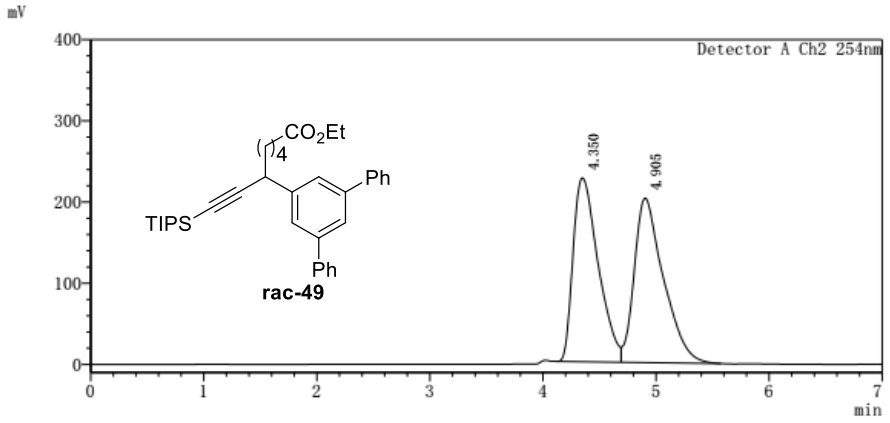


Peak Table

Detector A Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	4.090	548456	7.927
2	4.365	6370228	92.073

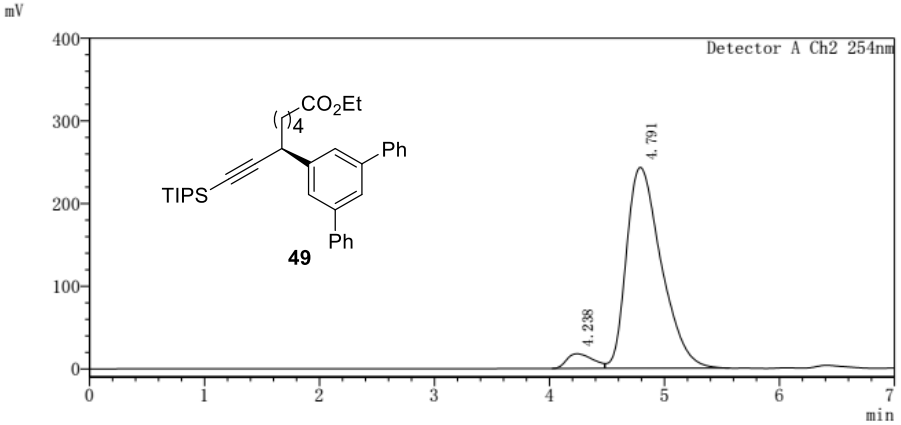
Chiralcel AD: hexane/*i*-PrOH = 98/1, flow rate 1.0 mL/min



Peak Table

Detector A Ch2 254nm

Peak#	Ret. Time	Area	Area%
1	4.350	3498245	49.053
2	4.905	3633349	50.947

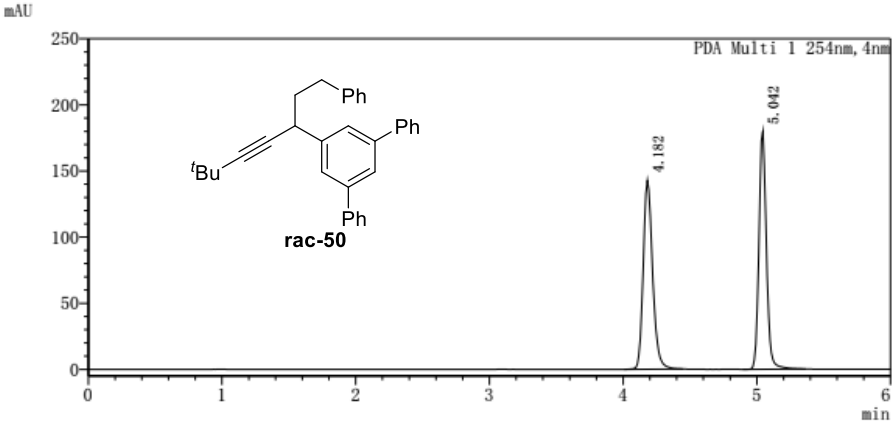


Peak Table

Detector A Ch2 254nm

Peak#	Ret. Time	Area	Area%
1	4.238	282211	5.225
2	4.791	5119343	94.775

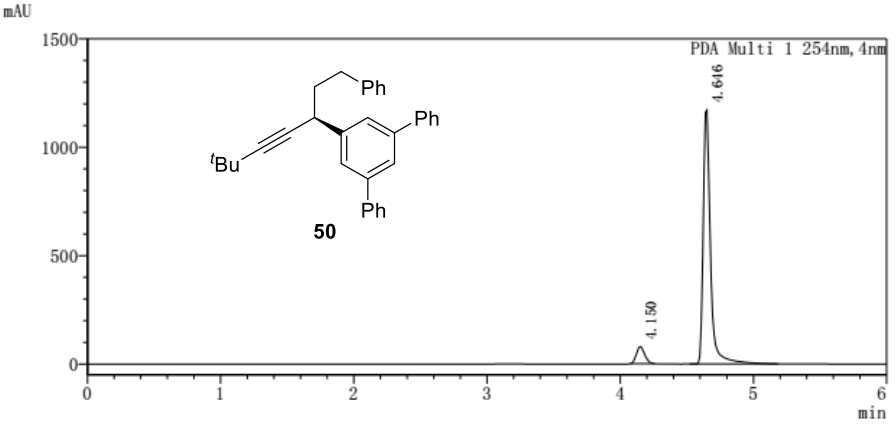
Chiralcel IG: hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	4.182	701039	50.129
2	5.042	697427	49.871

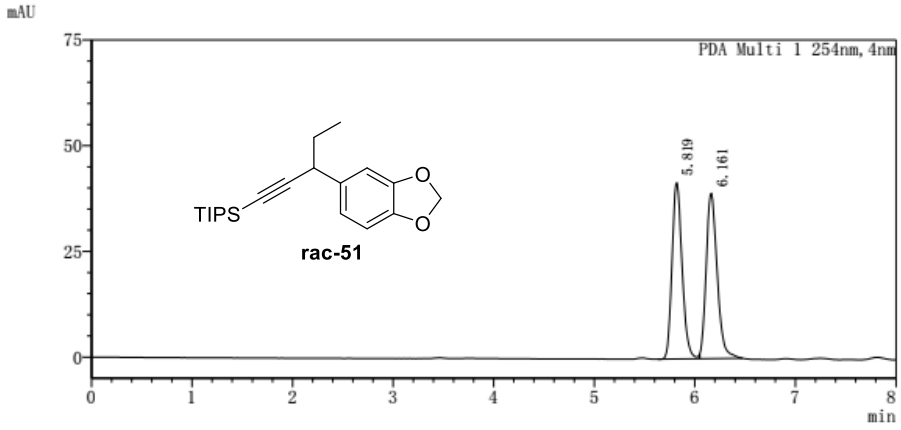


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	4.150	339580	7.100
2	4.646	4443001	92.900

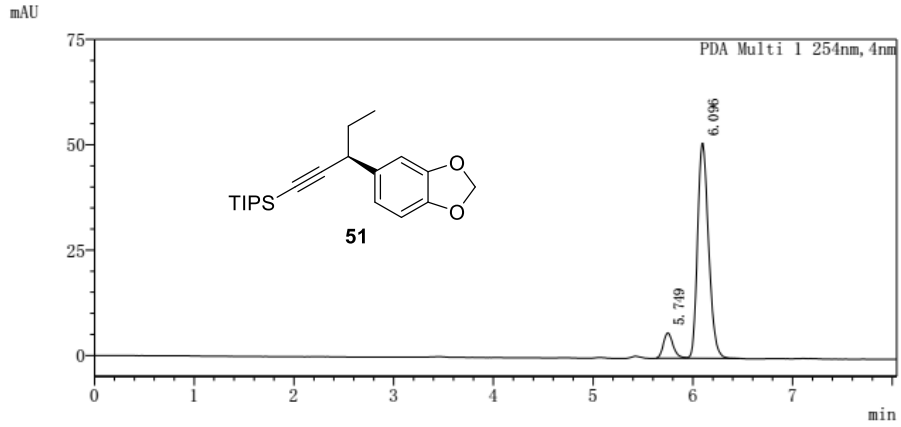
Chiralcel ADH: hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	5.819	290565	49.426
2	6.161	297315	50.574

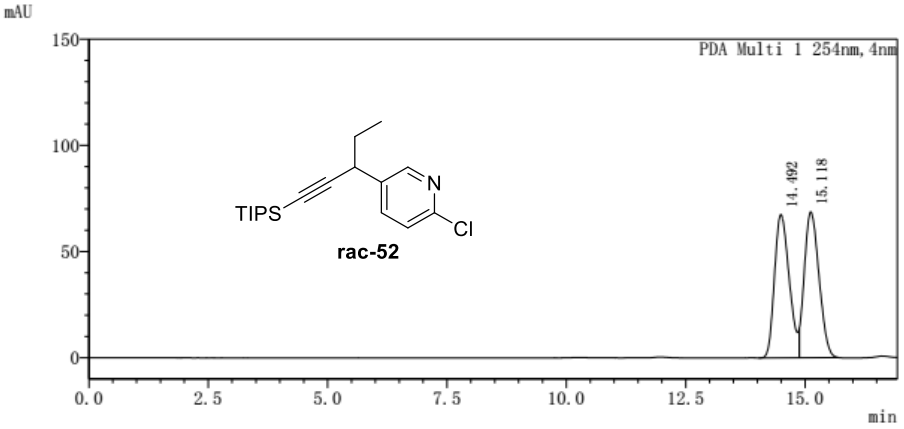


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	5.749	40631	9.369
2	6.096	393026	90.631

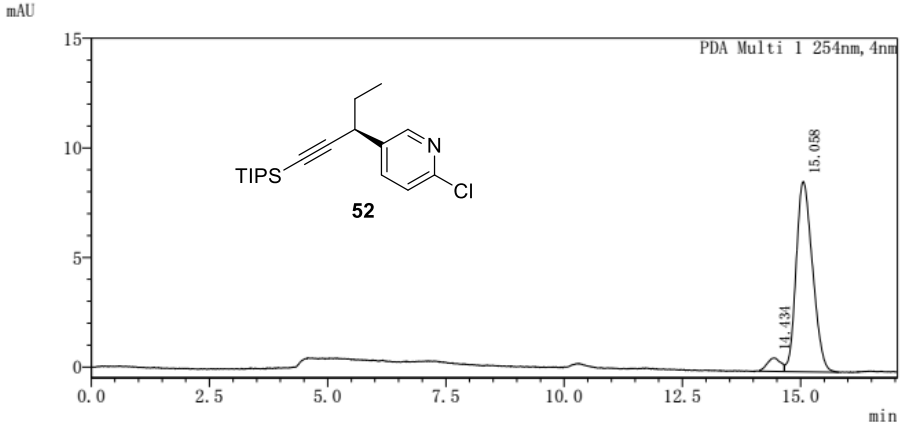
Chiralcel ODH: hexane/*i*-PrOH = 100/0, flow rate 1.0 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	14.492	1460050	49.901
2	15.118	1465827	50.099

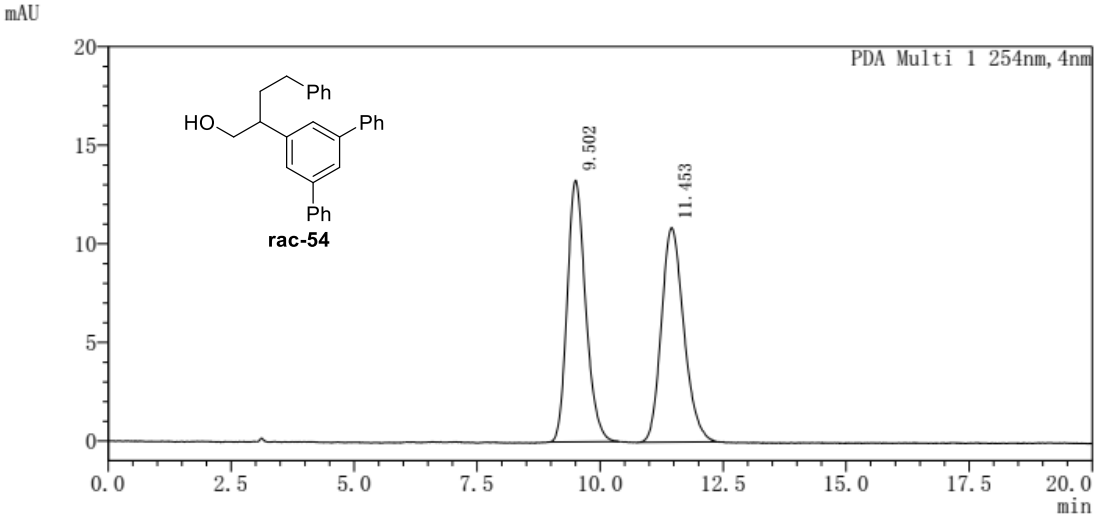


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	14.434	12182	5.482
2	15.058	210021	94.518

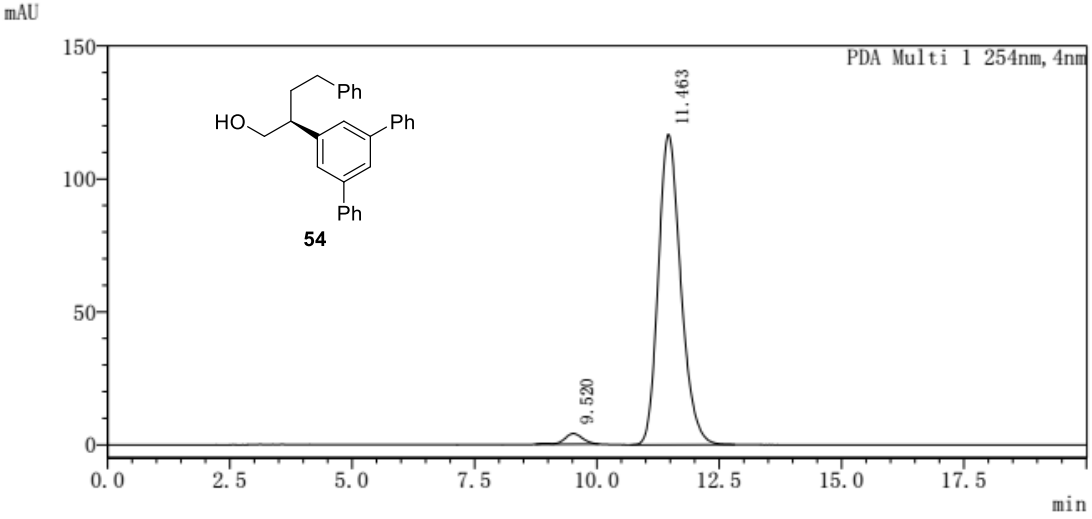
Chiralcel IG: hexane/*i*-PrOH = 99/1, flow rate 0.3 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	9.502	345273	49.947
2	11.453	346007	50.053

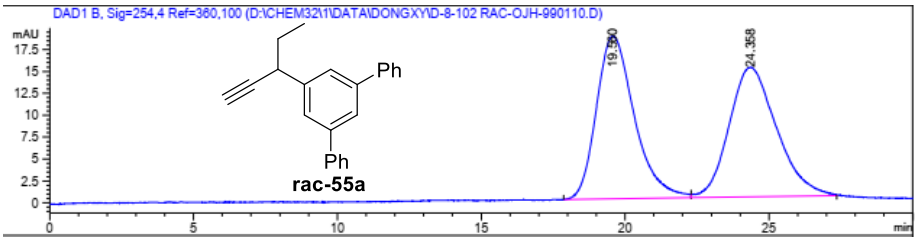


Peak Table

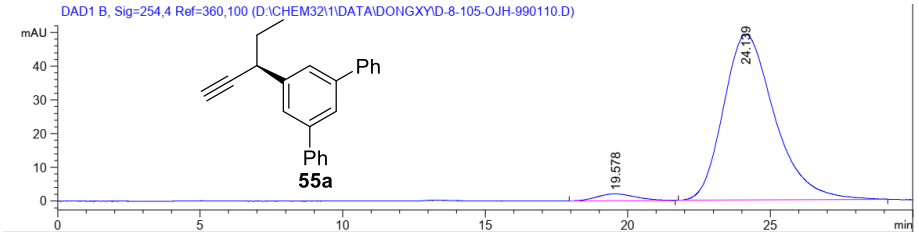
PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	9.520	102705	2.678
2	11.463	3732052	97.322

Chiralcel OD: hexane/*i*-PrOH = 80/20, flow rate 1.0 mL/min

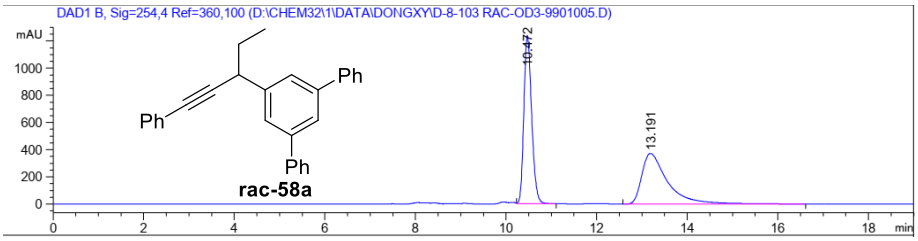


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	19.560	MF R	1.5229	1696.89136	18.57099	50.0166
2	24.358	FM R	1.9117	1695.76746	14.78436	49.9834

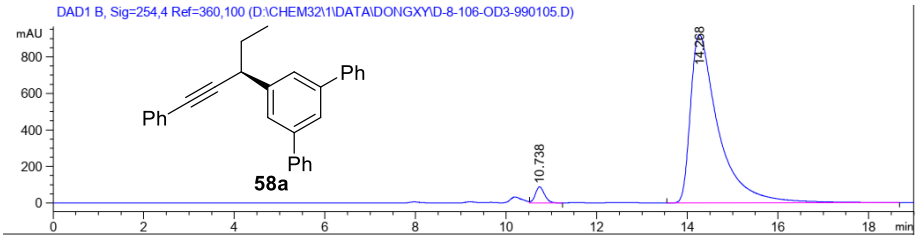


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	19.578	MM R	1.5755	193.64632	2.04848	3.0685
2	24.139	MM R	2.0715	6117.19971	49.21728	96.9315

Chiralcel OJH: hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min

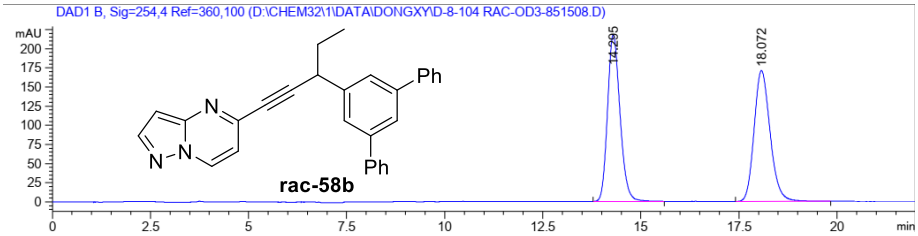


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.472	VB	0.1835	1.48046e4	1237.92676	50.1609
2	13.191	BB	0.5764	1.47096e4	372.77698	49.8391

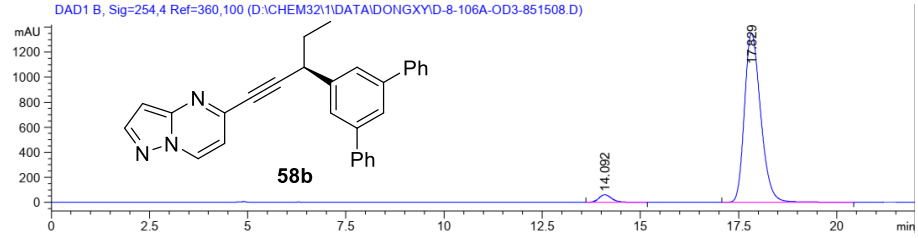


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.738	VB	0.2155	1226.10803	87.48770	3.0167
2	14.268	BB	0.6254	3.94175e4	920.92584	96.9833

Chiralcel OD-3: hexane/*i*-PrOH = 99/1, flow rate 0.5 mL/min

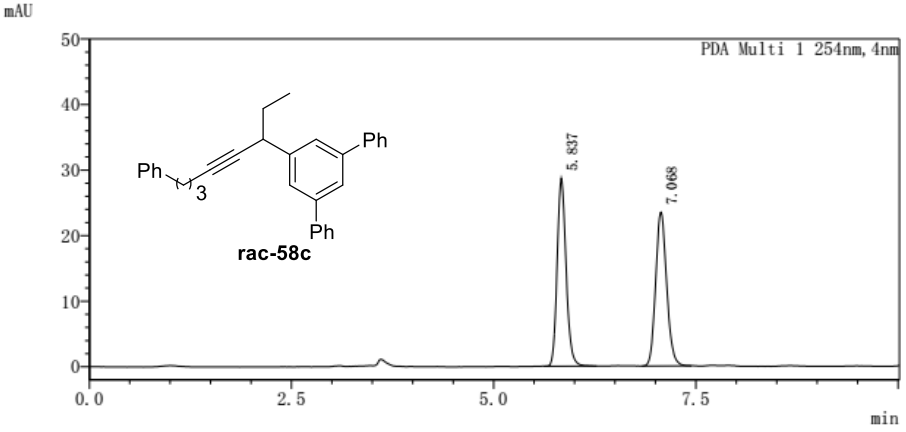


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	14.295	BB	0.3408	4792.51953	217.69144	49.7160
2	18.072	BB	0.4373	4847.26758	170.70816	50.2840



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	14.092	BB	0.3452	1331.90063	59.95338	3.3384
2	17.829	BB	0.4406	3.85645e4	1352.62866	96.6616

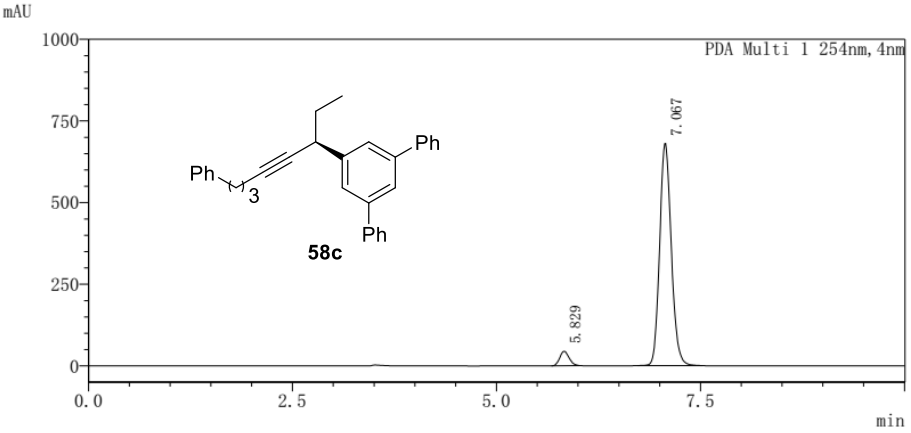
Chiralcel OD-3: hexane/*i*-PrOH = 85/15, flow rate 0.8 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	5.837	220824	49.871
2	7.068	221970	50.129

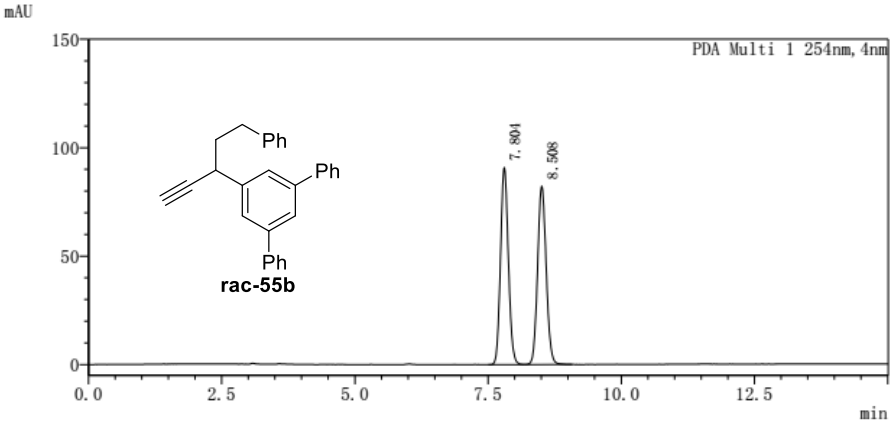


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	5.829	350295	4.945
2	7.067	6733931	95.055

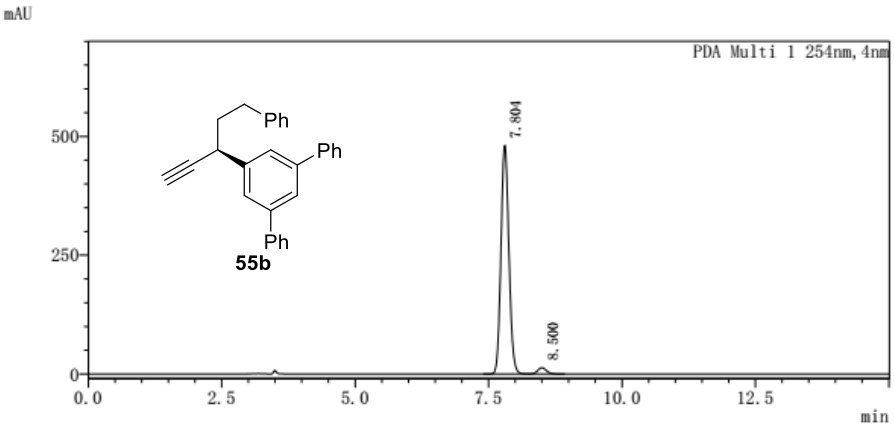
Chiralcel ADH: hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	7.804	927700	50.107
2	8.508	923736	49.893

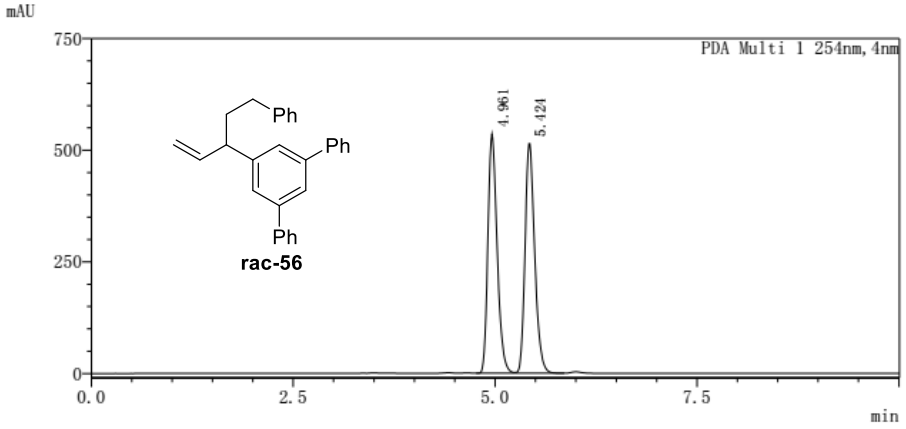


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	7.804	4969415	97.087
2	8.500	149119	2.913

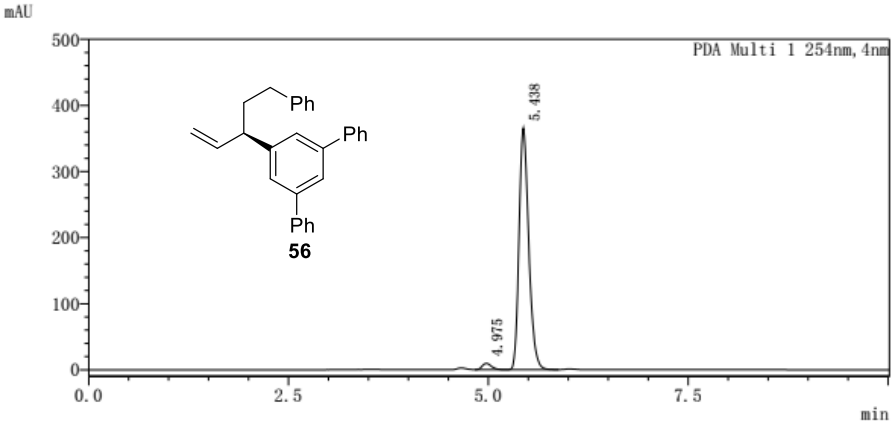
Chiralcel ADH: hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	4.961	4261676	49.850
2	5.424	4287295	50.150

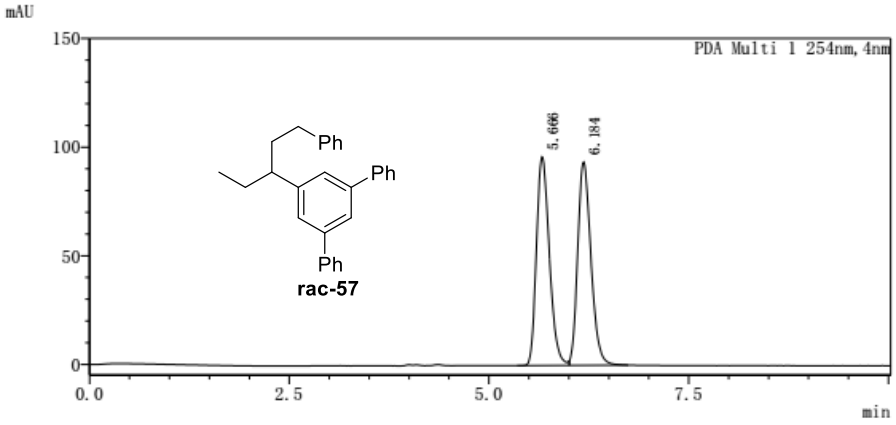


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	4.975	76693	2.430
2	5.438	3078785	97.570

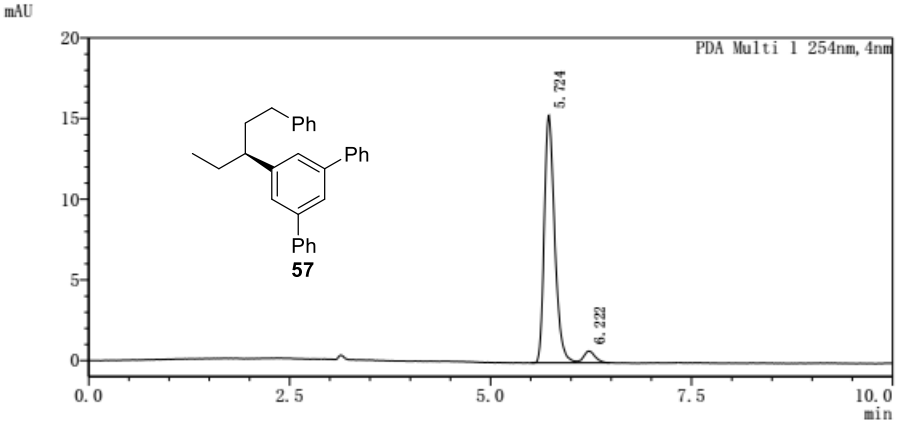
Chiralcel ADH: hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min



Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	5.666	1080528	50.033
2	6.184	1079095	49.967

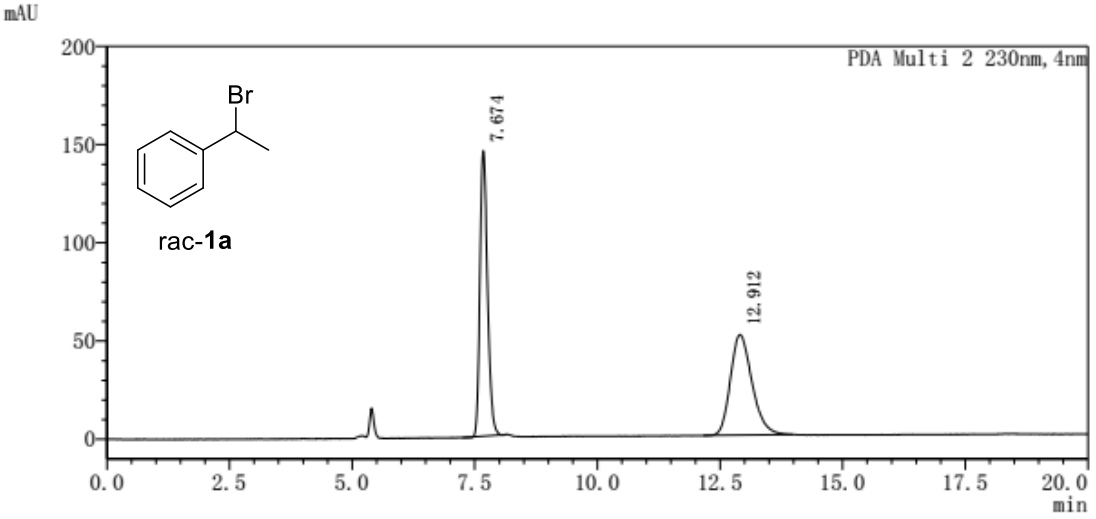


Peak Table

PDA Ch1 254nm

Peak#	Ret. Time	Area	Area%
1	5.724	138171	95.002
2	6.222	7269	4.998

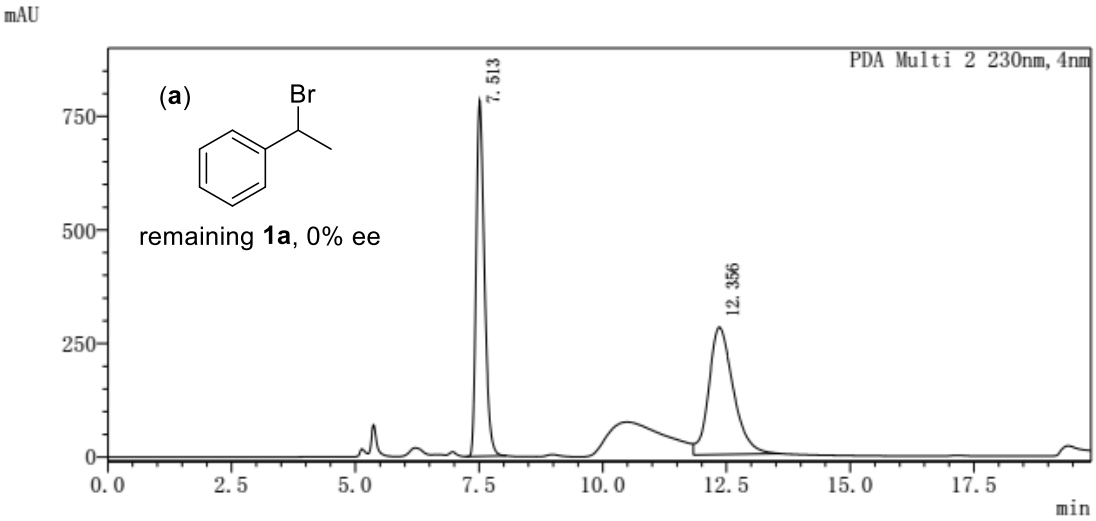
Chiralcel OD-3: hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min



Peak Table

PDA Ch2 230nm

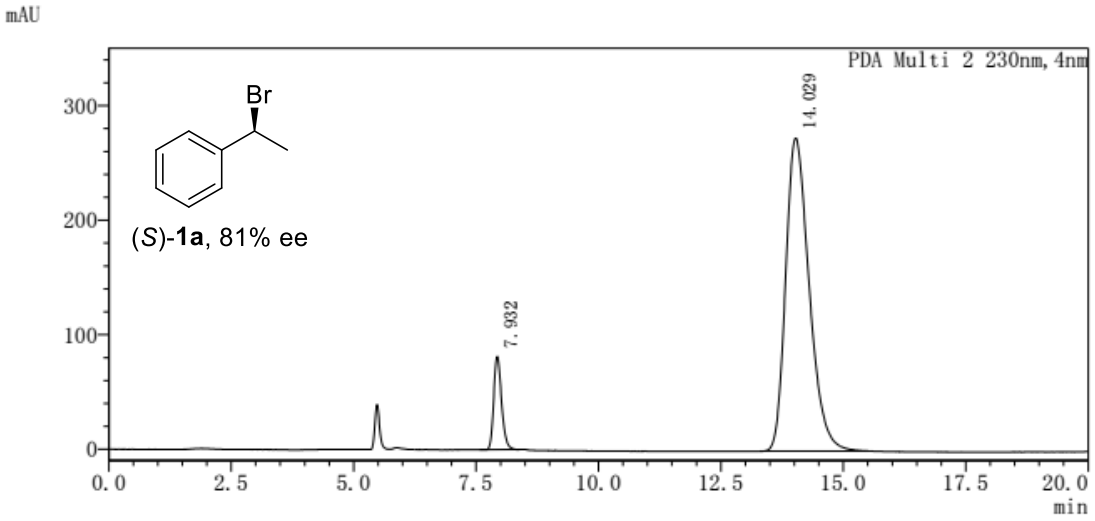
Peak#	Ret. Time	Area	Area%
1	7.674	1552684	49.695
2	12.912	1571728	50.305



Peak Table

PDA Ch2 230nm

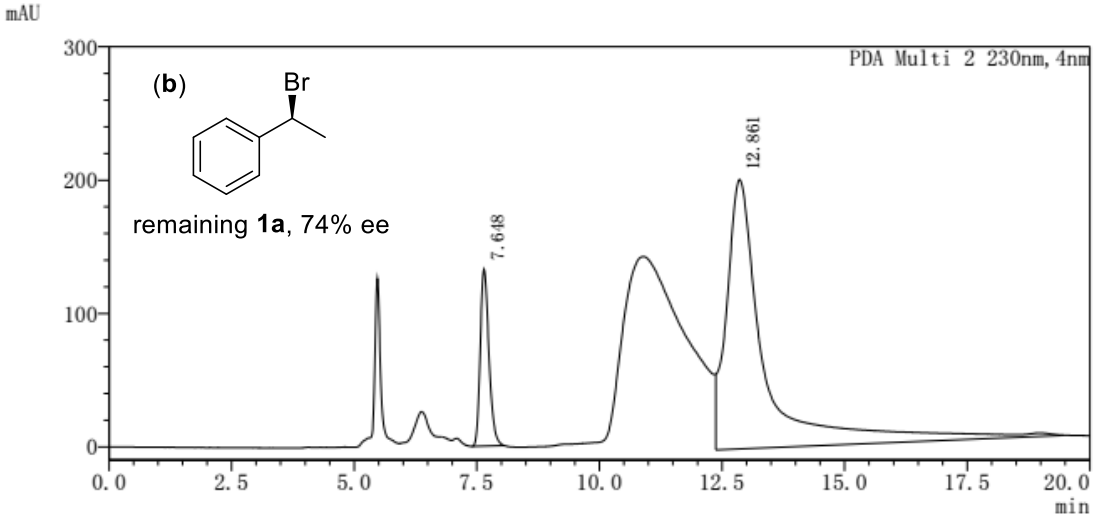
Peak#	Ret. Time	Area	Area%
1	7.513	9099053	48.561
2	12.356	9638141	51.439



Peak Table

PDA Ch2 230nm

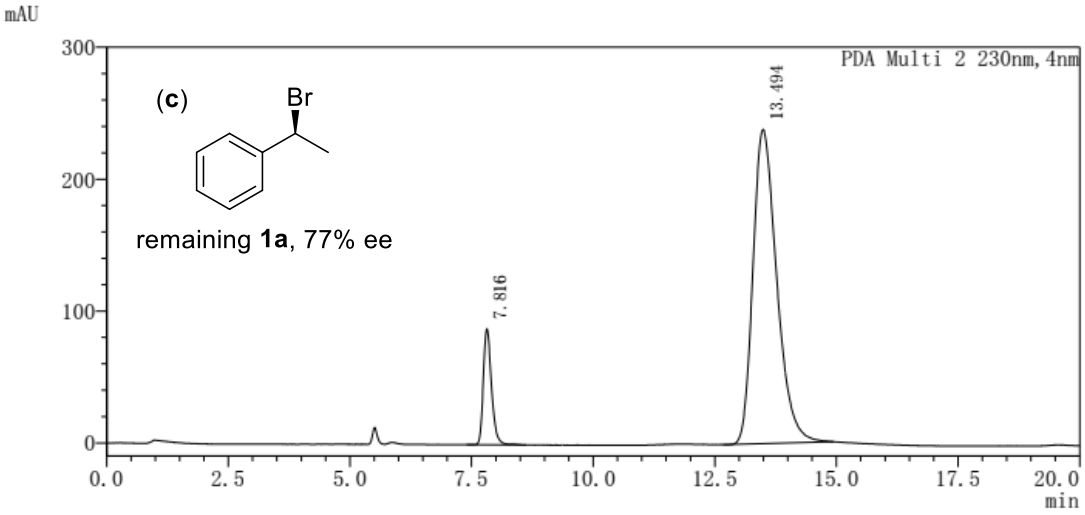
Peak#	Ret. Time	Area	Area%
1	7.932	901992	9.006
2	14.029	9113854	90.994



Peak Table

PDA Ch2 230nm

Peak#	Ret. Time	Area	Area%
1	7.648	1636444	12.873
2	12.861	11075725	87.127



Peak Table

PDA Ch2 230nm

Peak#	Ret. Time	Area	Area%
1	7.816	1035365	11.343
2	13.494	8092763	88.657

Chiralcel AY-3: hexane/*i*-PrOH = 100/0, flow rate 0.8 mL/min