Copper-Catalyzed Enantioconvergent Radical Deborylative Coupling of Racemic Benzylboronic Esters with Alkynes and Alkenylboronic Esters

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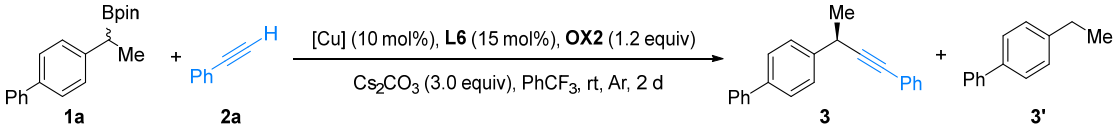
Table of contents

Supplementary Tables for experiments

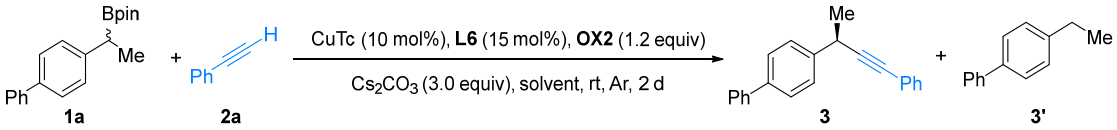
Table S1. Screening of copper salts[a]



Entry	[Cu]	Conv. (%)	Yield of **3** (%)	Ee of **3** (%)	Yield of **3′** (%)
1	CuI	65	58	93	< 5
2	CuBr	> 95	95	98	< 5
3	CuOTf	> 95	95	98	< 5
4	CuCN	> 95	85	98	10
5	$Cu(MeCN)_4PF_6$	50	40	98	8
6	$CuBr(PPh_3)_3$	70	20	98	45
7	$Cu(OTf)_2$	> 95	95	98	< 5
8	$Cu(OAc)_2$	> 95	90	91	6

[a]Standard reaction conditions: racemic benzylboronic esters **1a** (0.05 mmol, 1.0 equiv), alkyne **2a** (0.06 mmol, 1.2 equiv), **OX2** (0.06 mmol, 1.2 equiv), [Cu] (10 mol%), **L6** (15 mol%) and Cs_2CO_3 (3.0 equiv) in $PhCF_3$ (1.0 mL) at room temperature (rt) for 2 d under argon. Yield was based on ^1H NMR analysis of the crude product using 1,3,5-trimethylbenzene as an internal standard. Ee values were based on HPLC analysis.

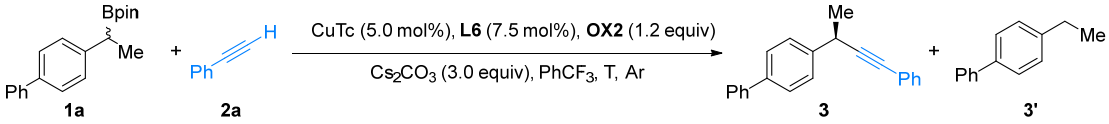
Table S2. Screening of solvent[a]



Entry	solvent	Conv. (%)	Yield of **3** (%)	Ee of **3** (%)	Yield of **3′** (%)
1	Et_2O	> 95	90	98	< 5
2	dioxane	> 95	20	98	80
3	THF	> 95	10	98	90
4	DCM	90	70	97	15
5	EA	> 95	20	98	80
6	$PhCF_3$	> 95	95	98	< 5
7	Toluene	90	86	98	< 5
8	MeCN	> 95	5	91	90
9	DMF	> 95	0	-	95

[a]Standard reaction conditions: racemic benzylboronic esters **1a** (0.05 mmol, 1.0 equiv), alkyne **2a** (0.06 mmol, 1.2 equiv), **OX2** (0.06 mmol, 1.2 equiv), CuTc (10 mol%), **L6** (15 mol%) and Cs_2CO_3 (3.0 equiv) in solvent (1.0 mL) at room temperature (rt) for 2 d under argon. Yield was based on ^1H NMR analysis of the crude product using 1,3,5-trimethylbenzene as an internal standard. Ee values were based on HPLC analysis.

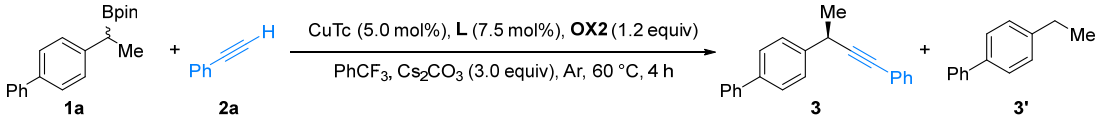
Table S3. Screening of reaction temperature[a]

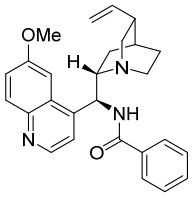


Entry	T	Reaction Time	Conv. (%)	Yield of **3** (%)	Ee of **3** (%)	Yield of **3′** (%)
1[b]	RT	2 days	> 95	95	98	< 5
2	RT	3 days	> 95	95	98	< 5
3	40 °C	12 h	> 95	95	98	< 5
4	60 °C	4 h	> 95	95	97	< 5
5[c]	40 °C	3 days	> 95	80	97	13

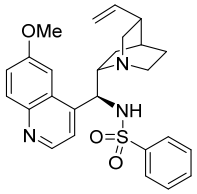
[a]Standard reaction conditions: racemic benzylboronic esters **1a** (0.05 mmol, 1.0 equiv), alkyne **2a** (0.06 mmol, 1.2 equiv), **OX2** (0.06 mmol, 1.2 equiv), CuTc (5.0 mol%), **L6** (7.5 mol%) and Cs_2CO_3 (3.0 equiv) in $PhCF_3$ (1.0 mL) under argon. Yield was based on ^1H NMR analysis of the crude product using 1,3,5-trimethylbenzene as an internal standard. Ee values were based on HPLC analysis. [b]CuTc (10 mol%), **L6** (15 mol%). [c]CuTc (1.0 mol%), **L6** (1.5 mol%).

Table S4. Screening of N,N-Ligands[a]

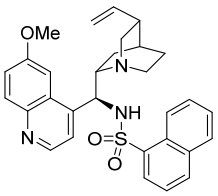




L8



L9

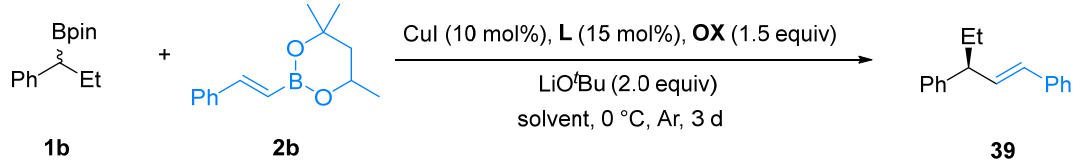


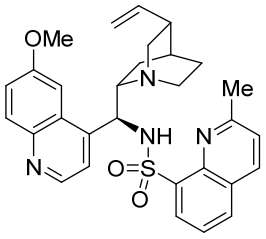
L10

Entry	L	Yield of **3** (%)	Ee of **3** (%)	Yield of **3′** (%)
1	**L8**	N.D	-	90
2	**L9**	N.D	-	81
3	**L10**	N.D	-	85

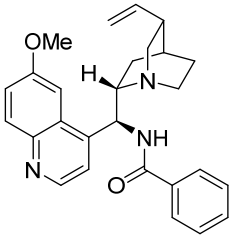
[a]Standard reaction conditions: racemic benzylboronic esters **1a** (0.05 mmol, 1.0 equiv), alkyne **2a** (0.06 mmol, 1.2 equiv), **OX2** (0.06 mmol, 1.2 equiv), CuTc (5.0 mol%), **L** (7.5 mol%), and Cs_2CO_3 (3.0 equiv) in $PhCF_3$ (1.0 mL) under argon, 60 °C, 4 h. Yield was based on ^1H NMR analysis of the crude product using 1,3,5-trimethylbenzene as an internal standard. N.D, not determined.

Table S5. Reaction condition optimizations for alkenylboronic esters[a]

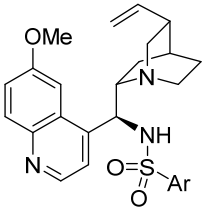




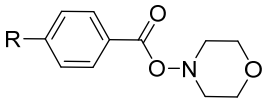
L7



L8



L9, Ar = Ph
L10, Ar = 1-naphthyl

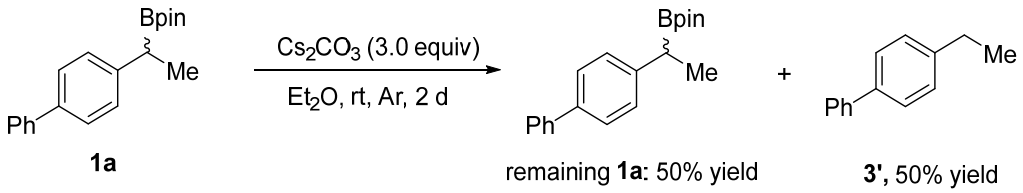


OX1, R = H
OX2, R = OMe
OX3, R = CF_3
OX4, R = pyrrolidin-1-yl

Entry	L	OX	Solvent	Yield of **39** (%)	Ee of **39** (%)
1	**L7**	**OX1**	DMF	85	88
2	**L7**	**OX2**	DMF	88	89
3	**L7**	**OX3**	DMF	65	88
4	**L7**	**OX4**	DMF	90	90
5	**L7**	**OX4**	DCM	< 5	-
6	**L7**	**OX4**	THF	38	96
7	**L7**	**OX4**	Et_2O	< 5	-
8	**L7**	**OX4**	EtOAc	22	90
9	**L7**	**OX4**	$PhCF_3$	< 5	-
10	**L7**	**OX4**	DMF/EtOAc (5:1)	85	90
11	**L7**	**OX4**	DMF/THF (5:1)	86	92
12	**L8**	**OX4**	DMF/THF (5:1)	7	50
13	**L9**	**OX4**	DMF/THF (5:1)	5	52
14	**L10**	**OX4**	DMF/THF (5:1)	5	32

[a]Standard reaction conditions: racemic benzylboronic esters **1b** (0.075 mmol, 1.5 equiv), alkenylboronic esters **2b** (0.05 mmol, 1.0 equiv), [**OX**] (0.075 mmol, 1.5 equiv), [Cu] (10 mol%), **L** (15 mol%), and LiO^{t}Bu (2.0 equiv) in solvent (0.5 mL) at 0 °C for 3 d 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 were based on HPLC analysis.

Supplementary schemes for experiments

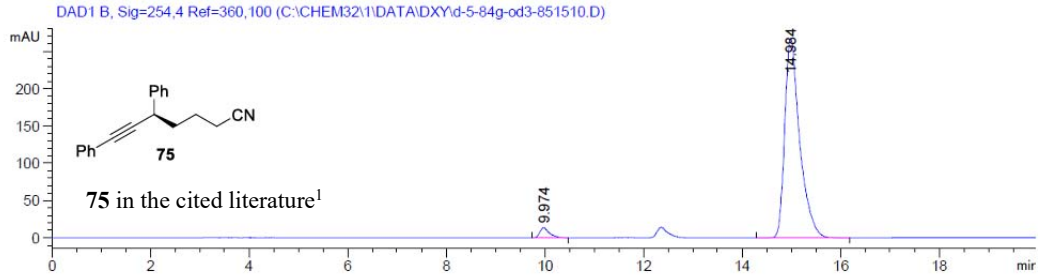


Scheme S1. Reaction of **1a** in the presence of Cs_2CO_3.

Assignment of absolute configurations

By comparing the HPLC spectra of **75** (The number in the cited literature[1]), the absolute configuration of **21** is specified as *R*, which is consistent with (*R*)-5,7-Diphenylhept-6-ynenitrile in the literature,[1] as shown below.

The HPLC spectra of **21** in reported literature[1]

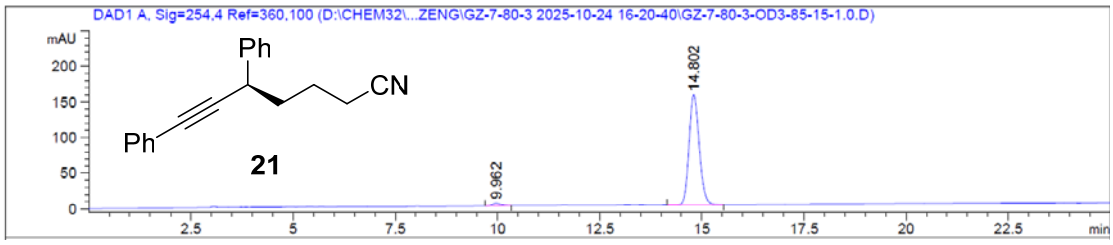


Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.974	BB	0.1996	189.63519	13.86204	3.2472
2	14.984	BV	0.3145	5650.36328	267.48099	96.7528
Totals :				5839.99847	281.34303	

HPLC analysis: Chiralcel OD3 (*n*-hexane/*i*-PrOH = 85/15, flow rate 1.0 mL/min, λ = 254 nm), t_R (minor) = 9.97 min, t_R (major) = 14.98 min.

The HPLC spectra of **21** in this work.



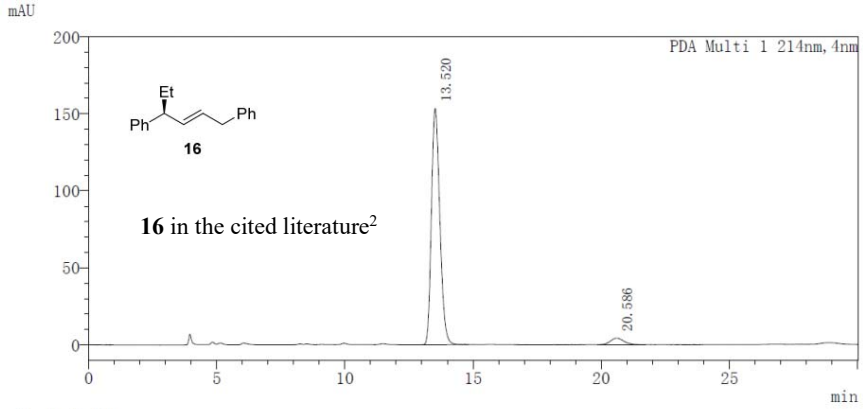
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.962	BB	0.2128	45.56939	3.18805	1.6871
2	14.802	BB	0.2666	2655.40527	154.40099	98.3129
Totals :				2700.97467	157.58904	

HPLC analysis: Chiralcel OD3 (*n*-hexane/*i*-PrOH = 85/15, flow rate 1.0 mL/min, λ = 254 nm), t_R (minor) = 9.96 min, t_R (major) = 14.80 min.

By comparing the HPLC spectra of **16** (The number in the cited literature[2]), the absolute configuration of **61** is specified as *S*, which is consistent with (*S*,*E*)-hex-2-ene-1,4-diyldibenzene in the literature,[2] as shown below.

The HPLC spectra of **61** in reported literature[2]



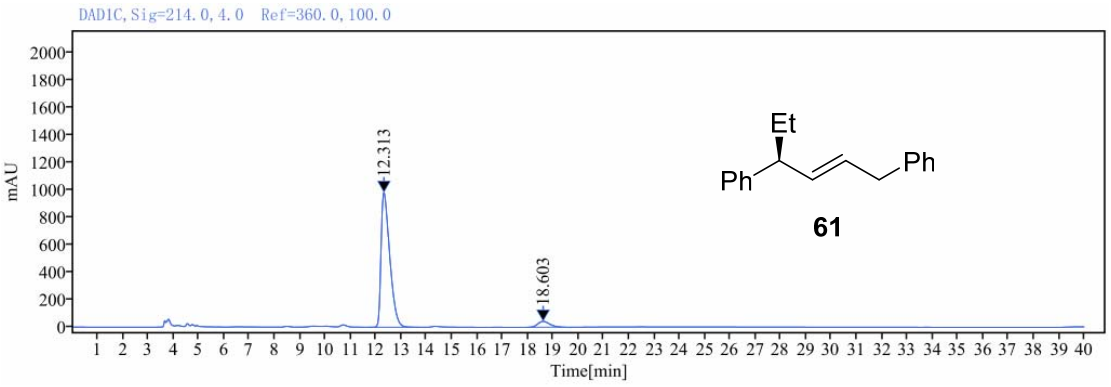
Peak Table

PDA Ch1 214nm

Peak#	Ret. Time	Area	Area%
1	13.520	3505032	95.847
2	20.586	151857	4.153

HPLC analysis: Chiralcel OJ-3 (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.8 mL/min, λ = 214 nm), t_R (major) = 13.52 min, t_R (minor) = 20.58 min.

The HPLC spectra of **61** in our work



Signal 1: DAD1C,Sig=214.0,4.0 Ref=360.0,100.0

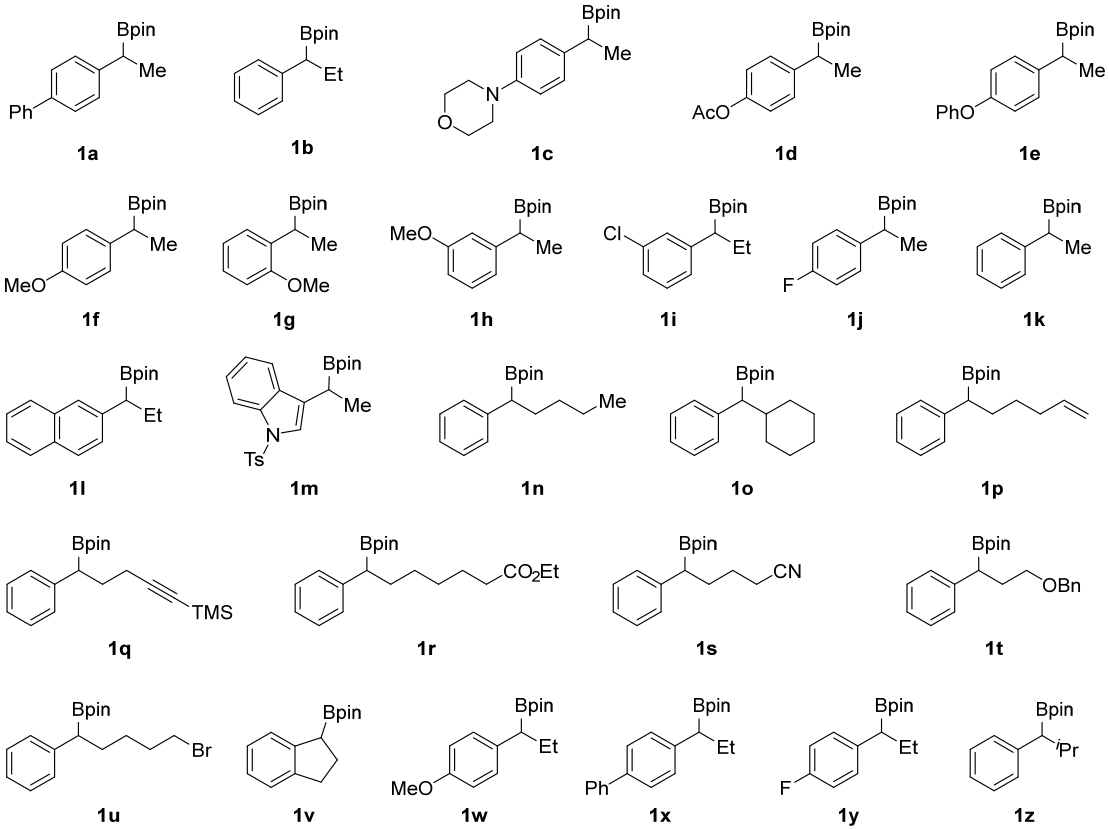
RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area%
12.313	BM m	1.91	23564.34	984.66	94.50
18.603	MM m	1.32	1372.20	42.76	5.50
	Totals	3.23	24936.54		

HPLC analysis: Chiralcel OJ-3 (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.8 mL/min, λ = 214 nm), t_R(major) = 12.31 min, t_R(minor) = 18.60 min.

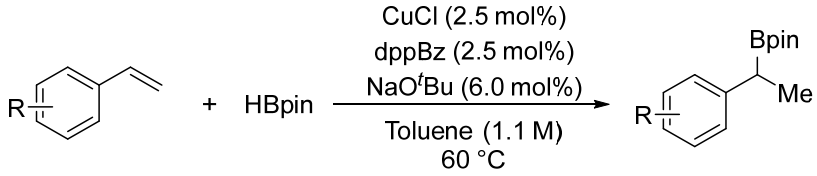
General Information

Most of the reactions were carried out under an argon atmosphere using Schlenk techniques. Reagents were purchased at the highest commercial quality and used without further purification unless otherwise stated. $PhCF_3$, THF, and DMF were purified and dried using a solvent-purification system that contained activated alumina under argon. CuTc was purchased from Adamas. CuI was purchased from Sigma-Aldrich. Cs_2CO_3 were purchased from Bide Pharmatech Ltd., which was dried at 250 °C for 3 h in vacuum. LiO^{t}Bu was purchased from J&K Scientific, which was dried at 150 °C for 3 h in vacuum. 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). As the eluent, the petroleum ether (PE), ethyl acetate (EtOAc), dichloromethane (CH_2Cl_2), and methanol (CH_3OH) were purchased from Shanghai Titan Scientific Co. Ltd without further purification. Visualization on TLC was achieved by the use of UV light (254 nm), iodine on silica gel, or basic $KMnO_4$ indicator. NMR spectra were recorded on Bruker DRX-400 at 400 MHz for ^{1}H NMR, 101 MHz for ^{13}C NMR, and 376 MHz for ^{19}F 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, quart; p, pentet, m, multiplet), 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 Agilent high-performance liquid chromatography (HPLC) with a Hatachi detector (at appropriate wavelength) or SHIMADZU LC-20AD with SPD-20AV detector or Waters instrument. Column conditions are reported in the experimental section below.

Synthesie of staring materials

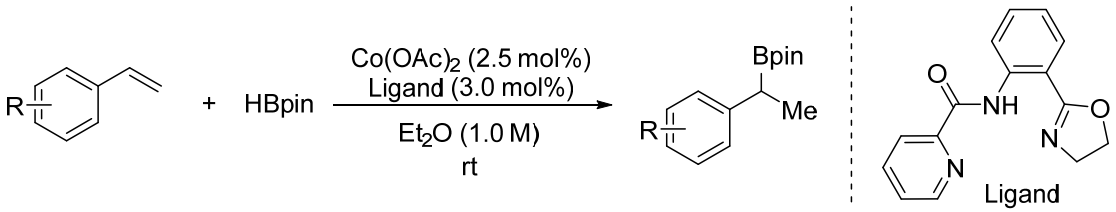


General Procedure 1:



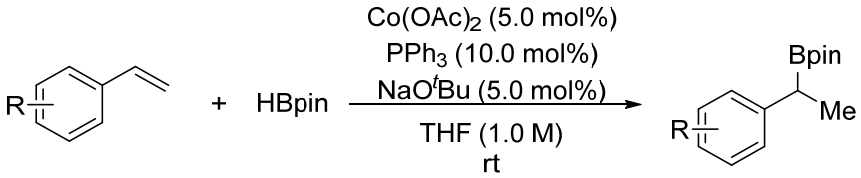
Using a variation of the procedure of Yun and co-workers,[3] an oven-dried flask was charged with CuCl (2.5 mol%), KO^{t}Bu (6.0 mol%), and dppBz (2.5 mol%), and purged with Ar. Anhydrous toluene (1.1 M) was added, and the mixture was stirred at room temperature for 10 min. Pinacolborane (1.2 equiv) was added, and the mixture was stirred for 10 min. The corresponding alkene (1.0 equiv) was added, and the mixture was heated to 60 °C for 16 h. Upon completion (as determined by TLC), the mixture was cooled to room temperature, passed through a bed of Celite eluting with EtOAc, and concentrated *in vacuo*. The crude material was purified by flash chromatography to give the corresponding boronic ester.

General Procedure 2:



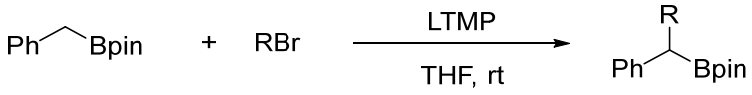
According to the reported literature,[4] to a flame-dried Schlenk flask cooled under nitrogen, $Co(OAc)_2$ (2.5 mol%), Ligand (3.0 mol%), Et_2O (1.0 M) were added. The mixture was stirred at room temperature for 30 min. Then, alkene (1.0 mmol), HBpin (1.2 mmol) were added in sequence and stirred at room temperature for 18 h. Upon completion (as determined by TLC), the mixture was passed through a bed of Celite eluting with EtOAc, and concentrated *in vacuo*. The crude material was purified by flash chromatography to give the corresponding boronic ester.

General Procedure 3:



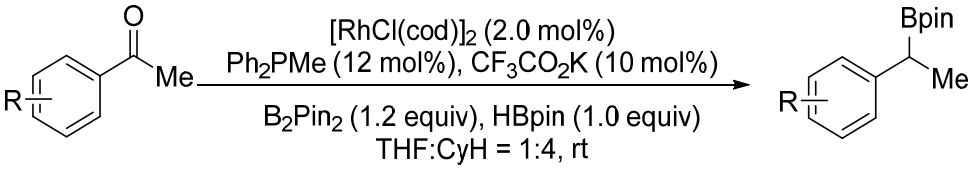
Using a variation of the procedure of Michael Findlater and co-workers,[5] an oven-dried flask was charged with cobalt(II) acetylacetonate (5.0 mol%), PPh_3 (10 mol%), NaO^tBu (5.0 mol%), and purged with Ar. Then, the corresponding alkene (1.0 equiv), HBpin (1.5 equiv), and anhydrous THF (1.0 M) were added separately, and the mixture was stirred at room temperature. Upon completion (as determined by TLC), the mixture was concentrated in vacuo, and then purified by column chromatography on silica gel using petroleum ether/ethyl acetate as eluent to give the corresponding boronic esters.

General Procedure 4:



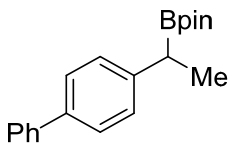
According to the reported literature,[6] a solution of 2,2,6,6-tetramethylpiperidine (1.1 equiv) in THF was cooled to 0 °C and treated with *n*-BuLi (1.1 equiv) dropwise. The reaction mixture was stirred for 15 min. The freshly prepared LTMP was added to a solution of benzylboronates (1.1 equiv) in THF dropwise over 2 minutes at 0 °C. After stirring at 0 °C for 30 min, the above reaction mixture was added to a solution of electrophile RBr (1.0 equiv) in THF dropwise. The reaction mixture was then stirred at room temperature for 12 h. The reaction was quenched with saturated aq. NH_4Cl was diluted with water and EtOAc. The aqueous phase was extracted with EtOAc. The combined organic layers were dried (Na_2SO_4) and concentrated in vacuo. The crude product was purified by flash column chromatography to give the corresponding boronic ester.

General Procedure 5:



According to the reported literature,[7] in a glove box, $[RhCl(cod)]_2$ (2.0 mol%), PPh_2Me (12 mol%), and anhydrous THF were placed in a round-bottom flask and stirred for 30 min. Then, CF_3COOK (10 mol%), B_2pin_2 (1.2 equiv), HBpin (1.0 equiv), and ketone (1.0 equiv) in CyH were added. The reaction mixture was sealed, removed from the glovebox, and stirred at room temperature for 24 hours. The mixture was quenched with saturated NH_4Cl, extracted with EtOAc, dried with Na_2SO_4, filtered, and concentrated. The residue was purified by silica gel chromatography to afford the desired product.

2-(1-([1,1'-Biphenyl]-4-yl)ethyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (1a)



1a

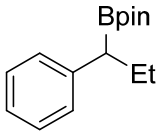
According to **General Procedure 1** with 4-vinyl-1,1'-biphenyl (10.0 mmol), the

reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1), which afforded the product **1a** (2.65 g, 86% yield) as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.62 – 7.55 (m, 2H), 7.53 – 7.47 (m, 2H), 7.44 – 7.38 (m, 2H), 7.34 – 7.26 (m, 3H), 2.48 (q, *J* = 7.5 Hz, 1H), 1.37 (d, *J* = 7.5 Hz, 3H), 1.23 (s, 6H), 1.22 (s, 6H).

The NMR spectrum was in accord with that reported in the literature.[8]

4,4,5,5-Tetramethyl-2-(1-phenylpropyl)-1,3,2-dioxaborolane (1b)



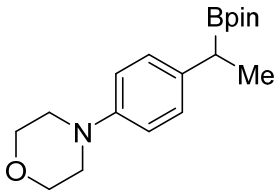
1b

According to **General Procedure 1** with (*E*)-prop-1-en-1-ylbenzene (10.0 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1), which afforded the product **1b** (1.79 g, 73% yield) as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.28 – 7.17 (m, 4H), 7.15 – 7.08 (m, 1H), 2.22 (t, *J* = 7.9 Hz, 1H), 1.94 – 1.81 (m, 1H), 1.74 – 1.61 (m, 1H), 1.20 (s, 6H), 1.18 (s, 6H), 0.91 (t, *J* = 7.3 Hz, 3H).

The NMR spectrum was in accord with that reported in the literature.[3]

4-(4-(1-(4,4,5,5-Tetramethyl-1,3,2-dioxaborolan-2-yl)ethyl)phenyl)morpholine (1c)



1c

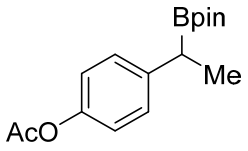
According to **General Procedure 5** with 1-(4-morpholinophenyl)ethan-1-one (3.0 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 10/1), which afforded the product **1c** (0.52 g, 55% yield) as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.19 – 7.06 (m, 2H), 6.88 – 6.78 (m, 2H), 3.93 – 3.78 (m, 4H), 3.15 – 3.05 (m, 4H), 2.36 (q, *J* = 7.5 Hz, 1H), 1.29 (d, *J* = 7.5 Hz, 3H), 1.21

(s, 6H), 1.20 (s, 6H).

The NMR spectrum was in accord with that reported in the literature.[7]

4-(1-(4,4,5,5-Tetramethyl-1,3,2-dioxaborolan-2-yl)ethyl)phenyl acetate (1c)



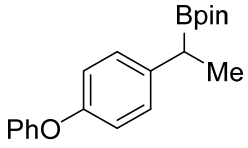
1d

According to **General Procedure 2** with 4-vinylphenyl acetate (5.0 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1), which afforded the product **1d** (0.94 g, 61% yield) as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.25 – 7.17 (m, 2H), 7.00 – 6.94 (m, 2H), 2.43 (q, *J* = 7.5 Hz, 1H), 2.27 (s, 3H), 1.31 (d, *J* = 7.5 Hz, 3H), 1.21 (s, 6H), 1.20 (s, 6H).

The NMR spectrum was in accord with that reported in the literature.[5]

4,4,5,5-Tetramethyl-2-(1-(4-phenoxyphenyl)ethyl)-1,3,2-dioxaborolane (1e)



1e

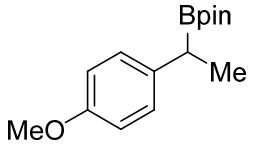
According to **General Procedure 2** with 1-phenoxy-4-vinylbenzene (5.0 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1), which afforded the product **1e** (1.24 g, 77% yield) as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.34 – 7.26 (m, 2H), 7.22 – 7.14 (m, 2H), 7.09 – 7.02 (m, 1H), 7.02 – 6.96 (m, 2H), 6.95 – 6.89 (m, 2H), 2.42 (q, *J* = 7.5 Hz, 1H), 1.32 (d, *J* = 7.5 Hz, 3H), 1.22 (s, 6H), 1.21 (s, 6H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 157.9, 154.6, 140.1, 129.7, 129.0, 122.9, 119.2, 118.6, 83.4, 24.7(4), 24.6(9), 17.3.

HRMS (ESI) *m/z* calcd. for $C_{20}H_{26}BO_3$ $[M + H]^+$ 325.1970, found 325.1956.

2-(1-(4-Methoxyphenyl)ethyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (1f)



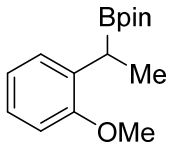
1f

According to **General Procedure 3** with 1-methoxy-4-vinylbenzene (5.0 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1), which afforded the product **1f** (1.05 g, 80% yield) as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.17 – 7.09 (m, 2H), 6.85 – 6.77 (m, 2H), 3.77 (s, 3H), 2.37 (q, *J* = 7.5 Hz, 1H), 1.30 (d, *J* = 7.5 Hz, 3H), 1.21 (s, 6H), 1.20 (s, 6H).

The NMR spectrum was in accord with that reported in the literature.[5]

2-(1-(2-Methoxyphenyl)ethyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (1g)



1g

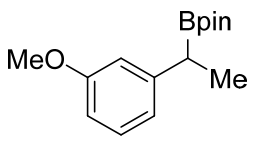
According to **General Procedure 1** with 1-methoxy-2-vinylbenzene (5.0 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1), which afforded the product **1g** (0.83 g, 63% yield) as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.19 – 7.08 (m, 2H), 6.89 (t, *J* = 7.4 Hz, 1H), 6.79 (d, *J* = 8.1 Hz, 1H), 3.78 (s, 3H), 2.45 (q, *J* = 7.5 Hz, 1H), 1.28 (d, *J* = 7.5 Hz, 3H), 1.22 (s, 6H), 1.22 (s, 6H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 156.9, 133.9, 128.4, 126.3, 120.8, 109.7, 83.0, 55.0, 24.8, 24.7, 15.2.

HRMS (ESI) *m/z* calcd. for $C_{15}H_{24}BO_3$ $[M + H]^+$ 263.1813, found 263.1803.

4,4,5,5-Tetramethyl-2-(1-(*m*-tolyl)ethyl)-1,3,2-dioxaborolane (1h)



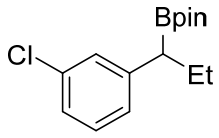
1h

According to **General Procedure 1** with 1-methoxy-3-vinylbenzene (5.0 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1), which afforded the product **1h** (1.11 g, 85% yield) as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.17 (t, *J* = 7.9 Hz, 1H), 6.86 – 6.75 (m, 2H), 6.68 (dd, *J* = 8.2, 2.6 Hz, 1H), 3.78 (s, 3H), 2.41 (q, *J* = 7.5 Hz, 1H), 1.32 (d, *J* = 7.5 Hz, 3H), 1.21 (s, 6H), 1.20 (s, 6H).

The NMR spectrum was in accord with that reported in the literature.[8]

2-(1-(3-Chlorophenyl)propyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (1i)



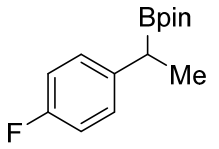
1i

According to **General Procedure 2** with (*E*)-1-chloro-3-(prop-1-en-1-yl)benzene (5.0 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1), which afforded the product **1i** (1.03 g, 74% yield) as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.21 – 7.05 (m, 4H), 2.19 (t, *J* = 7.9 Hz, 1H), 1.97 – 1.76 (m, 1H), 1.72 – 1.59 (m, 1H), 1.21 (s, 6H), 1.20 (s, 6H),0.90 (t, *J* = 7.3 Hz, 3H).

The NMR spectrum was in accord with that reported in the literature.[4]

2-(1-(4-Fluorophenyl)ethyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (1j)



1j

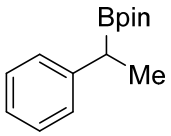
According to **General Procedure 1** with 1-fluoro-4-vinylbenzene (5.0 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1), which afforded the product **1j** (0.90 g, 72% yield) as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.20 – 7.13 (m, 2H), 6.98 – 6.89 (m, 2H), 2.41 (q, *J* = 7.5 Hz, 1H), 1.30 (d, *J* = 7.5 Hz, 3H), 1.21 (s, 6H), 1.20 (s, 6H).

^{19}F NMR (376 MHz, $CDCl_3$) δ −118.97.

The NMR spectrum was in accord with that reported in the literature.[8]

4,4,5,5-Tetramethyl-2-(1-phenylethyl)-1,3,2-dioxaborolane (1k)



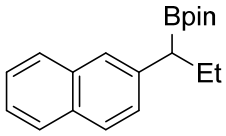
1k

According to **General Procedure 1** with styrene (10.0 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 100/1), which afforded the product **1k** (2.09 g, 90% yield) as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.29 – 7.18 (m, 4H), 7.16 – 7.09 (m, 1H), 2.43 (q, *J* = 7.5 Hz, 1H), 1.33 (d, *J* = 7.5 Hz, 3H), 1.21 (s, 6H), 1.19 (s, 6H).

The NMR spectrum was in accord with that reported in the literature.[8]

4,4,5,5-Tetramethyl-2-(1-(naphthalen-2-yl)propyl)-1,3,2-dioxaborolane (1l)



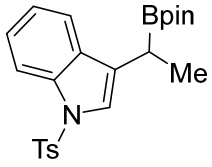
1l

According to **General Procedure 2** with (*E*)-2-(prop-1-en-1-yl)naphthalene (5.0 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1), which afforded the product **1l** (0.98 g, 67% yield) as a colorless oil.

^{1}H NMR (400 MHz,$CDCl_3$) δ 7.88 – 7.70 (m, 3H), 7.64 (s, 1H), 7.50 – 7.31 (m, 3H), 2.39 (t, *J* = 7.9 Hz, 1H), 2.06 – 1.90 (m, 1H), 1.84 – 1.69 (m, 1H), 1.21 (s, 6H), 1.19 (s, 6H), 0.94 (t, *J* = 7.3 Hz, 3H).

The NMR spectrum was in accord with that reported in the literature.[9]

3-(1-(4,4,5,5-Tetramethyl-1,3,2-dioxaborolan-2-yl)ethyl)-1-tosyl-1*H*-indole (1m)



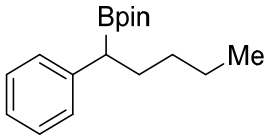
1m

According to **General Procedure 5** with 1-(1-tosyl-1*H*-indol-3-yl)ethan-1-one (3.0 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 20/1), which afforded the product **1m** (0.66 g, 52% yield) as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.95 (d, *J* = 8.2 Hz, 1H), 7.74 – 7.69 (m, 2H), 7.54 (d, *J* = 7.8 Hz, 1H), 7.34 (s, 1H), 7.30 – 7.24 (m, 2H), 7.19 – 7.16 (m, 2H), 2.53 (q, *J* = 7.4 Hz, 1H), 2.31 (s, 3H), 1.37 (d, *J* = 7.4 Hz, 3H), 1.18 (s, 6H), 1.17 (s, 6H).

The NMR spectrum was in accord with that reported in the literature.[7]

4,4,5,5-Tetramethyl-2-(1-phenylpentyl)-1,3,2-dioxaborolane (1n)



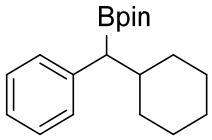
1n

According to **General Procedure 4** with 1-bromobutane (5.0 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1), which afforded the product **1n** (1.19 g, 87% yield) as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.29 – 7.17 (m, 4H), 7.14 – 7.10 (m, 1H), 2.29 (t, *J* = 7.9 Hz, 1H), 1.91 – 1.78 (m, 1H), 1.71 – 1.61 (m, 1H), 1.37 – 1.23 (m, 4H), 1.20 (s, 6H), 1.18 (s, 6H), 0.86 (t, *J* = 6.7 Hz, 3H).

The NMR spectrum was in accord with that reported in the literature.[6]

2-(Cyclohexyl(phenyl)methyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (1o)



1o

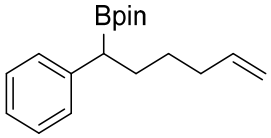
According to **General Procedure 4** with bromocyclohexane (5.0 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc

= 50/1), which afforded the product **1o** (1.28 g, 85% yield) as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.27 – 7.16 (m, 4H), 7.14 – 7.08 (m, 1H), 2.04 (d, *J* = 10.4 Hz, 1H), 1.88 – 1.76 (m, 2H), 1.74 – 1.67 (m, 1H), 1.64 – 1.53 (m, 2H), 1.50 – 1.40 (m, 1H), 1.36 – 1.25 (m, 1H), 1.19 (s, 6H), 1.17 (s, 6H), 1.15 – 0.98 (m, 2H), 0.77 – 0.65 (m, 1H).

The NMR spectrum was in accord with that reported in the literature.[6]

4,4,5,5-Tetramethyl-2-(1-phenylhex-5-en-1-yl)-1,3,2-dioxaborolane (1p)



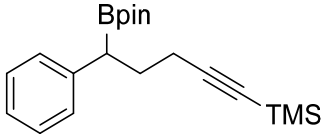
1p

According to **General Procedure 4** with 5-bromopent-1-ene (5.0 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1), which afforded the product **1p** (1.16 g, 81% yield) as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.29 – 7.16 (m, 4H), 7.14 – 7.06 (m, 1H), 5.77 (ddt, *J* = 16.9, 10.3, 6.6 Hz, 1H), 5.02 – 4.84 (m, 2H), 2.30 (t, *J* = 7.9 Hz, 1H), 2.11 – 1.97 (m, 2H), 1.92 – 1.78 (m, 1H), 1.72 – 1.61 (m, 1H), 1.44 – 1.32 (m, 2H), 1.19 (s, 6H), 1.17 (s, 6H).

The NMR spectrum was in accord with that reported in the literature.[6]

Trimethyl(5-phenyl-5-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)pent-1-yn-1-yl)silane (1q)



1q

According to **General Procedure 4** with (4-bromobut-1-yn-1-yl)trimethylsilane (5.0 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1), which afforded the product **1q** (1.50 g, 88% yield) as a colorless oil.

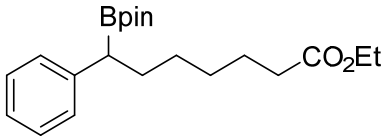
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.27 – 7.22 (m, 2H), 7.20 – 7.16 (m, 2H), 7.15 – 7.11 (m, 1H), 2.43 (dd, *J* = 9.2, 6.6 Hz, 1H), 2.26 – 2.09 (m, 2H), 2.09 – 2.00 (m, 1H), 1.94

– 1.81 (m, 1H), 1.21 (s, 6H), 1.18 (s, 6H), 0.14 (s, 9H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 142.3, 128.7, 128.5, 125.6, 107.5, 84.7, 83.5, 31.5, 24.8, 24.7, 19.3, 0.3.

HRMS (ESI) *m/z* calcd. for $C_{20}H_{32}BO_2Si$ $[M + H]^+$ 343.2259, found 343.2243.

Ethyl 7-phenyl-7-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)heptanoate (1r)



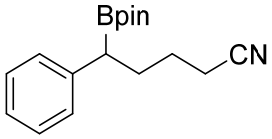
1r

According to **General Procedure 2** with ethyl (*E*)-7-phenylhept-6-enoate (3.0 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1), which afforded the product **1r** (0.67 g, 62% yield) as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.28 – 7.16 (m, 4H), 7.15 – 7.09 (m, 1H), 4.10 (q, *J* = 7.1 Hz, 2H), 2.33 – 2.20 (m, 3H), 1.90 – 1.78 (m, 1H), 1.68 – 1.54 (m, 3H), 1.36 – 1.26 (m, 4H), 1.24 (t, *J* = 7.2 Hz, 3H), 1.20 (s, 6H), 1.18 (s, 6H).

The NMR spectrum was in accord with that reported in the literature.[4]

5-Phenyl-5-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)pentanenitrile (1s)



1s

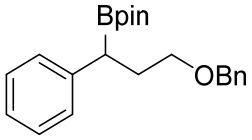
According to **General Procedure 4** with 4-bromobutanenitrile (5.0 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 20/1), which afforded the product **1s** (1.19 g, 84% yield) as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.29 – 7.22 (m, 2H), 7.20 – 7.11 (m, 3H), 2.33 – 2.22 (m, 3H), 2.01 – 1.90 (m, 1H), 1.85 – 1.74 (m, 1H), 1.66 – 1.52 (m, 2H), 1.21 (s, 6H), 1.18 (s, 6H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 142.1, 128.6, 128.4, 125.6, 119.8, 83.6, 31.5, 24.9, 24.7, 24.6, 17.2.

HRMS (ESI) *m/z* calcd. for $C_{17}H_{25}BNO_2$ $[M + H]^+$ 286.1973, found 286.1967.

2-(3-(Benzyloxy)-1-phenylpropyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (1t)



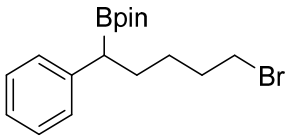
1t

According to **General Procedure 1** with (*E*)-(3-(benzyloxy)prop-1-en-1-yl)benzene (5.0 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1), which afforded the product **1t** (1.41 g, 80% yield) as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.36 – 7.29 (m, 4H), 7.28 – 7.17 (m, 5H), 7.15 – 7.08 (m, 1H), 4.52 – 4.40 (m, 2H), 3.49 – 3.32 (m, 2H), 2.49 (t, *J* = 7.9 Hz, 1H), 2.27 – 2.16 (m, 1H), 1.98 – 1.88 (m, 1H), 1.16 (s, 6H), 1.13 (s, 6H).

The NMR spectrum was in accord with that reported in the literature.[8]

2-(5-Bromo-1-phenylpentyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (1u)



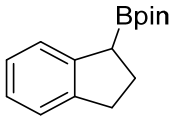
1u

According to **General Procedure 4** with 1,4-dibromobutane (5.0 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1), which afforded the product **1u** (1.06 g, 60% yield) as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.28 – 7.22 (m, 2H), 7.22 – 7.17 (m, 2H), 7.16 – 7.11 (m, 1H), 3.42 – 7.31 (m, 2H), 2.29 (t, *J* = 7.9 Hz, 1H), 1.92 – 1.79 (m, 3H), 1.73 – 1.62 (m, 1H), 1.49 – 1.34 (m, 2H), 1.21 (s, 6H), 1.19 (s, 6H).

The NMR spectrum was in accord with that reported in the literature.[6]

2-(2,3-Dihydro-1*H*-inden-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (1v)



1v

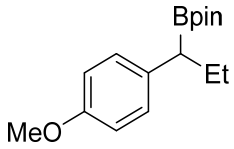
According to **General Procedure 3** with 1*H*-indene (5.0 mmol), the reaction mixture

was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1), which afforded the product **1v** (0.90 g, 76% yield) as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.31 – 7.26 (m, 1H), 7.22 – 7.17 (m, 1H), 7.14 – 7.05 (m, 2H), 3.01 – 2.84 (m, 2H), 2.72 (t, *J* = 8.7 Hz, 1H), 2.28 – 2.17 (m, 1H), 2.16 – 2.06 (m, 1H), 1.25 (s, 6H), 1.24 (s, 6H).

The NMR spectrum was in accord with that reported in the literature.[5]

2-(1-(4-Methoxyphenyl)propyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (1w)



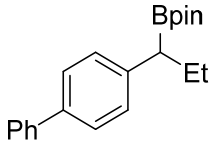
1w

According to **General Procedure 2** with (*E*)-1-methoxy-4-(prop-1-en-1-yl)benzene (5.0 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1), which afforded the product **1w** (1.20 g, 87% yield) as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.16 – 7.04 (m, 2H), 6.84 – 6.73 (m, 2H), 3.77 (s, 3H), 2.16 (t, *J* = 7.9 Hz, 1H), 1.98 – 1.74 (m, 1H), 1.69 – 1.54 (m, 1H), 1.21 (s, 6H), 1.19 (s, 6H), 0.89 (t, *J* = 7.3 Hz, 3H).

The NMR spectrum was in accord with that reported in the literature.[4]

2-(1-([1,1'-Biphenyl]-4-yl)propyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (1x)



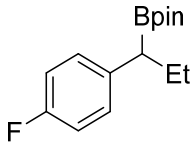
1x

According to **General Procedure 1** with (*E*)-4-(prop-1-en-1-yl)-1,1'-biphenyl (5.0 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1), which afforded the product **1x** (0.81 g, 50% yield) as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.60 – 7.56 (m, 2H), 7.52 – 7.47 (m, 2H), 7.42 – 7.36 (m, 2H), 7.31 – 7.25 (m, 3H), 2.27 (t, *J* = 7.8 Hz, 1H), 1.97 – 1.85 (m, 1H), 1.80 – 1.66 (m, 1H), 1.22 (s, 6H), 1.20 (s, 6H), 0.94 (t, *J* = 7.3 Hz, 3H).

The NMR spectrum was in accord with that reported in the literature.[4]

2-(1-(4-Fluorophenyl)propyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (1y)



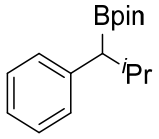
1y

According to **General Procedure 2** with (*E*)-1-fluoro-4-(prop-1-en-1-yl)benzene (5.0 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1), which afforded the product **1y** (0.68 g, 51% yield) as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.29 – 7.09 (m, 2H), 7.00 – 6.78 (m, 2H), 2.19 (t, *J* = 7.9 Hz, 1H), 1.93 – 1.73 (m, 1H), 1.72 – 1.54 (m, 1H), 1.21 (s, 6H), 1.19 (s, 6H), 0.89 (t, *J* = 7.3 Hz, 3H).

The NMR spectrum was in accord with that reported in the literature.[4]

4,4,5,5-Tetramethyl-2-(2-methyl-1-phenylpropyl)-1,3,2-dioxaborolane (1z)



1z

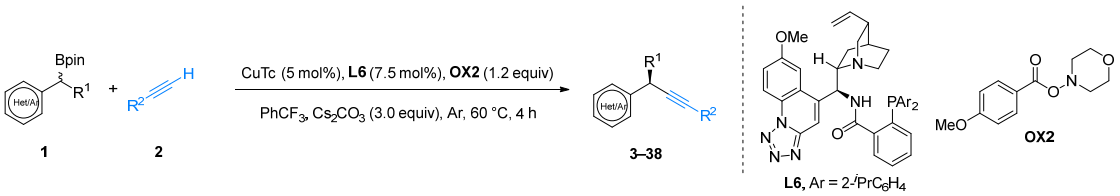
According to **General Procedure 4** with 2-bromopropane (5.0 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1), which afforded the product **1z** (1.01 g, 78% yield) as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.27 – 7.17 (m, 4H), 7.15 – 7.09 (m, 1H), 2.17 – 2.06 (m, 1H), 1.96 (d, *J* = 10.4 Hz, 1H), 1.20 (s, 6H), 1.17 (s, 6H), 1.03 (d, *J* = 6.5 Hz, 3H), 0.73 (d, *J* = 6.6 Hz, 3H).

The NMR spectrum was in accord with that reported in the literature.[6]

Enantioconvergent Deborylative Coupling with Alkynes

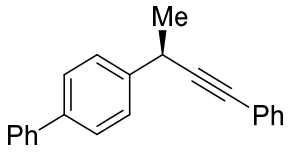
General procedure A:



1 2 3–38

An oven-dried resealable Schlenk tube equipped with a magnetic stirring bar was charged with CuTc (1.91 mg, 0.010 mmol, 5.0 mol%), chiral ligand **L6** (11.05 mg, 0.015 mmol, 7.5 mol%), and Cs_2CO_3 (192.0 mg, 0.60 mmol, 3.0 equiv). The tube was evacuated and backfilled with argon three times. Then racemic benzylboronic esters (0.20 mmol, 1.0 equiv), alkyne (0.24 mmol, 1.2 equiv), **OX2** (57.0 mg, 0.24 mmol, 1.2 equiv), and $PhCF_3$ (4.0 mL) were sequentially added into the mixture under argon. The tube was sealed, and the reaction mixture was allowed to stir at 60 °C for 4 h. Upon completion of the reaction (monitored by TLC), the mixture was then filtered through a pad of celite and rinsed with EtOAc. The filtrate was evaporated, and the residue was purified by column chromatography on silica gel to afford the desired product.

(*R*)-4-(4-Phenylbut-3-yn-2-yl)-1,1'-biphenyl (3)



3

According to **General procedure A** with 2-(1-([1,1'-biphenyl]-4-yl)ethyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane **1a** (61.6 mg, 0.20 mmol) and ethynylbenzene **2a** (26.4 μL, 0.24 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **3** as a white solid (52.6 mg, 93% yield, 97% ee).

HPLC analysis: Chiralcel OD3 (*n*-hexane/*i*-PrOH = 98/2, flow rate 0.8 mL/min, λ = 254 nm), t_R (minor) = 7.34 min, t_R (major) = 9.11 min.

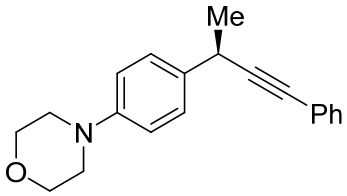
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 – 7.54 (m, 4H), 7.54 – 7.49 (m, 2H), 7.48 – 7.39 (m, 4H), 7.35 – 7.25 (m, 4H), 4.02 (q, J = 7.1 Hz, 1H), 1.61 (d, J = 7.2 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 142.5, 141.0, 139.8, 131.8, 128.9, 128.3, 127.9,

127.4(9), 127.4(5), 127.3, 127.2, 123.8, 92.6, 82.7, 32.3, 24.6.

HRMS (ESI) *m/z* calcd. for $C_{22}H_{19}$ $[M + H]^+$ 283.1481, found 283.1474.

(*R*)-4-(4-(4-Phenylbut-3-yn-2-yl)phenyl)morpholine (4)



4

According to **General procedure A** with 4-(4-(1-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)ethyl)phenyl)morpholine **1c** (63.5 mg, 0.20 mmol) and ethynylbenzene **2a** (26.4 μL, 0.24 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 10/1) to yield the product **4** as a white solid (35.5 mg, 61% yield, 95% ee).

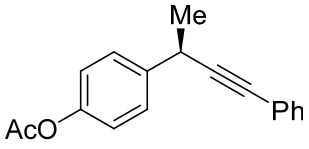
HPLC analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min, λ = 254 nm), t_R (minor) = 7.32 min, t_R (major) = 8.88 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.47 – 7.39 (m, 2H), 7.39 – 7.32 (m, 2H), 7.32 – 7.25 (m, 3H), 6.95 – 6.86 (m, 2H), 3.92 (q, *J* = 7.1 Hz, 1H), 3.88 – 3.83 (m, 4H), 3.19 – 3.10 (m, 4H), 1.55 (d, *J* = 7.1 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 150.2, 135.0, 131.7, 128.3, 127.8(0), 127.7(7), 123.9, 116.0, 93.2, 82.3, 67.1, 49.6, 31.7, 24.6.

HRMS (ESI) *m/z* calcd. for $C_{20}H_{22}NO$ $[M + H]^+$ 292.1696, found 292.1688.

(*R*)-4-(4-Phenylbut-3-yn-2-yl)phenyl acetate (5)



5

According to **General procedure A** with 4-(1-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)ethyl)phenyl acetate **1d** (58.0 mg, 0.20 mmol) and ethynylbenzene **2a** (26.4 μL, 0.24 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **5** as a colorless oil (32.8 mg, 62% yield, 96% ee).

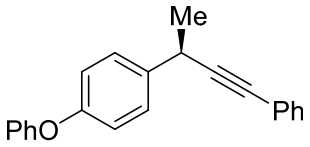
HPLC analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.8 mL/min, λ = 254 nm), t_R (minor) = 8.10 min, t_R (major) = 8.69 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.47 – 7.41 (m, 4H), 7.32 – 7.27 (m, 3H), 7.10 – 7.02 (m, 2H), 3.98 (q, *J* = 7.1 Hz, 1H), 2.29 (s, 3H), 1.57 (d, *J* = 7.2 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 169.7, 149.4, 140.9, 131.7, 128.3, 128.1, 127.9, 123.7, 121.7, 92.4, 82.7, 32.1, 24.6, 21.3.

HRMS (ESI) *m/z* calcd. for $C_{18}H_{17}O_2$ $[M + H]^+$ 265.1223, found 265.1218.

(*R*)-1-Phenoxy-4-(4-phenylbut-3-yn-2-yl)benzene (6)



6

According to **General procedure A** with 4,4,5,5-tetramethyl-2-(1-(4-phenoxyphenyl)ethyl)-1,3,2-dioxaborolane **1e** (64.8 mg, 0.20 mmol) and ethynylbenzene **2a** (26.4 μL, 0.24 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **6** as a colorless oil (52.6 mg, 88% yield, 96% ee).

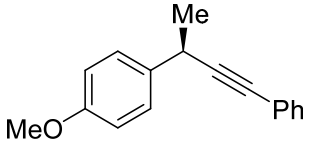
HPLC analysis: Chiralcel OJH (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.8 mL/min, λ = 254 nm), t_R (major) = 25.98 min, t_R (minor) = 32.67 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48 – 7.37 (m, 4H), 7.34 – 7.24 (m, 5H), 7.09 – 7.05 (m, 1H), 7.04 – 6.92 (m, 4H), 3.96 (q, *J* = 7.1 Hz, 1H), 1.57 (d, *J* = 7.2 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 157.5, 156.0, 138.3, 131.7, 129.8, 128.3, 127.9, 123.8, 123.2, 119.1, 118.9, 92.7, 82.6, 31.9, 24.7.

HRMS (ESI) *m/z* calcd. for $C_{22}H_{19}O$ $[M + H]^+$ 299.1430, found 299.1424.

(*R*)-1-Methoxy-4-(4-phenylbut-3-yn-2-yl)benzene (7)



7

According to **General procedure A** with 2-(1-(4-methoxyphenyl)ethyl)-4,4,5,5-

tetramethyl-1,3,2-dioxaborolane **1f** (52.4 mg, 0.20 mmol) and ethynylbenzene **2a** (26.4 μL, 0.24 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **7** as a colorless oil (33.1 mg, 70% yield, 97% ee).

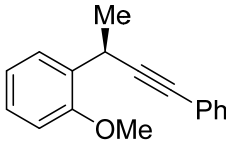
HPLC analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.8 mL/min, λ = 254 nm), t_R (minor) = 6.39 min, t_R (major) = 7.47 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48 – 7.40 (m, 2H), 7.39 – 7.33 (m, 2H), 7.32 – 7.25 (m, 3H), 6.93 – 6.84 (m, 2H), 3.93 (q, *J* = 7.1 Hz, 1H), 3.79 (s, 3H), 1.55 (d, *J* = 7.1 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 158.5, 135.6, 131.7, 128.3, 128.0, 127.8, 123.9, 114.0, 93.1, 82.4, 55.4, 31.8, 24.7.

HRMS (ESI) *m/z* calcd. for $C_{17}H_{17}O$ $[M + H]^+$ 237.1274, found 237.1268.

(*S*)-1-Methoxy-2-(4-phenylbut-3-yn-2-yl)benzene (8)



8

According to **General procedure A** with 2-(1-(4-methoxyphenyl)ethyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane **1g** (52.4 mg, 0.20 mmol) and ethynylbenzene **2a** (26.4 μL, 0.24 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **8** as a colorless oil (35.4 mg, 75% yield, 98% ee).

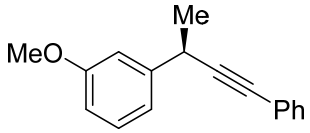
HPLC analysis: Chiralcel OJH (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.8 mL/min, λ = 254 nm), t_R (minor) = 12.54 min, t_R (major) = 16.61 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.65 (dd, *J* = 7.6, 1.7 Hz, 1H), 7.49 – 7.40 (m, 2H), 7.34 – 7.18 (m, 4H), 6.97 (td, *J* = 7.4, 1.2 Hz, 1H), 6.86 (dd, *J* = 8.2, 1.2 Hz, 1H), 4.39 (q, *J* = 7.0 Hz, 1H), 3.84 (s, 3H), 1.50 (d, *J* = 7.0 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 156.2, 131.8, 131.7, 128.3, 128.0, 127.9, 127.7, 124.1, 120.9, 110.5, 93.3, 81.8, 55.5, 26.3, 23.1.

HRMS (ESI) *m/z* calcd. for $C_{17}H_{17}O$ $[M + H]^+$ 237.1274, found 237.1268.

(*R*)-1-Methoxy-3-(4-phenylbut-3-yn-2-yl)benzene (9)



9

According to **General procedure A** with 2-(1-(3-methoxyphenyl)ethyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane **1h** (52.4 mg, 0.20 mmol) and ethynylbenzene **2a** (26.4 μL, 0.24 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **9** as a colorless oil (43.9 mg, 93% yield, 98% ee).

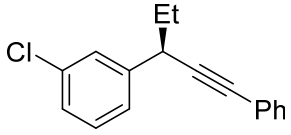
HPLC analysis: Chiralcel OJH (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.8 mL/min, λ = 254 nm), t_R (minor) = 12.94 min, t_R (major) = 22.37 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.45 – 7.41 (m, 2H), 7.33 – 7.20 (m, 4H), 7.07 – 7.00 (m, 2H), 6.80 – 6.77 (m, 1H), 3.95 (q, *J* = 7.1 Hz, 1H), 3.81 (s, 3H), 1.57 (d, *J* = 7.1 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 159.9, 145.1, 131.7, 129.7, 128.3, 127.9, 123.8, 119.5, 113.0, 112.0, 92.6, 82.6, 55.3, 32.6, 24.6.

HRMS (ESI) *m/z* calcd. for $C_{17}H_{17}O$ $[M + H]^+$ 237.1274, found 237.1270.

(*R*)-1-Chloro-3-(1-phenylpent-1-yn-3-yl)benzene (10)



10

According to **General procedure A** with 2-(1-(3-chlorophenyl)propyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane **1i** (56.1 mg, 0.20 mmol) and ethynylbenzene **2a** (26.4 μL, 0.24 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **10** as a colorless oil (43.2 mg, 85% yield, 97% ee).

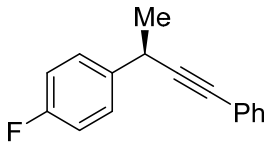
HPLC analysis: Chiralcel OJH (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.8 mL/min, λ = 254 nm), t_R (minor) = 6.67 min, t_R (major) = 7.74 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48 – 7.39 (m, 3H), 7.34 – 7.18 (m, 6H), 3.76 (dd, *J* = 7.8, 6.2 Hz, 1H), 2.01 – 1.72 (m, 2H), 1.05 (t, *J* = 7.3 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.2, 134.3, 131.8, 129.8, 128.4, 128.0, 127.9, 127.0, 125.9, 123.6, 90.6, 84.0, 39.8, 31.6, 11.9.

HRMS (ESI) *m/z* calcd. for $C_{17}H_{16}Cl$ $[M + H]^+$ 255.0935, found 255.0927.

(*R*)-1-Fluoro-4-(4-phenylbut-3-yn-2-yl)benzene (11)



11

According to **General procedure A** with 2-(1-(4-fluorophenyl)ethyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane **1j** (50.0 mg, 0.20 mmol) and ethynylbenzene **2a** (26.4 μL, 0.24 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 100/1) to yield the product **11** as a colorless oil (42.2 mg, 94% yield, 96% ee).

HPLC analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.5 mL/min, λ = 254 nm), t_R (minor) = 8.52 min, t_R (major) = 9.42 min.

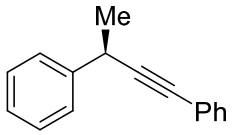
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48 – 7.36 (m, 4H), 7.32 – 7.27 (m, 3H), 7.09 – 6.97 (m, 2H), 3.96 (q, *J* = 7.1 Hz, 1H), 1.55 (d, *J* = 7.1 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 161.8 (d, *J* = 244.6 Hz), 139.1 (d, *J* = 3.1 Hz), 131.7, 128.5 (d, *J* = 8.0 Hz), 128.4, 128.0, 123.7, 115.4 (d, *J* = 21.3 Hz), 92.4, 82.7, 31.9, 24.7.

^{19}F NMR (376 MHz, $CDCl_3$) δ −116.52.

HRMS (ESI) *m/z* calcd. for $C_{16}H_{14}F$ $[M + H]^+$ 225.1074, found 225.1069.

(*R*)-But-1-yne-1,3-diyldibenzene (12)



12

According to **General procedure A** with 4,4,5,5-tetramethyl-2-(1-phenylethyl)-1,3,2-dioxaborolane **1k** (46.4 mg, 0.20 mmol) and ethynylbenzene **2a** (26.4 μL, 0.24 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 100/1) to yield the product **12** as a colorless oil (38.2 mg, 93% yield,

97% ee).

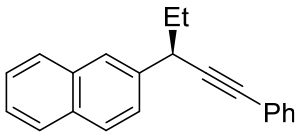
HPLC analysis: Chiralcel OJH (*n*-hexane/*i*-PrOH = 98/2, flow rate 0.5 mL/min, λ = 254 nm), t_R (minor) = 18.61 min, t_R (major) = 26.04 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.46 – 7.41 (m, 4H), 7.38 – 7.31 (m, 2H), 7.30 – 7.20 (m, 4H), 3.98 (q, *J* = 7.1 Hz, 1H), 1.58 (d, *J* = 7.1 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 143.4, 131.7, 128.7, 128.3, 127.9, 127.1, 126.8, 123.8, 92.7, 82.6, 32.6, 24.6.

HRMS (ESI) *m/z* calcd. for $C_{16}H_{15}$ $[M + H]^+$ 207.1168, found 207.1164.

(*R*)-2-(1-Phenylpent-1-yn-3-yl)naphthalene (13)



13

According to **General procedure A** with 4,4,5,5-tetramethyl-2-(1-(naphthalen-2-yl)propyl)-1,3,2-dioxaborolane **1l** (59.2 mg, 0.20 mmol) and ethynylbenzene **2a** (26.4 μL, 0.24 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 100/1) to yield the product **13** as a white solid (38.9 mg, 72% yield, 97% ee).

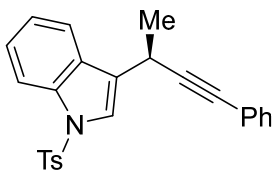
HPLC analysis: Chiralcel OJH (*n*-hexane/*i*-PrOH = 98/2, flow rate 0.5 mL/min, λ = 254 nm), t_R (minor) = 27.61 min, t_R (major) = 32.20 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.89 – 7.76 (m, 4H), 7.59 – 7.39 (m, 5H), 7.32 – 7.25 (m, 3H), 3.94 (t, *J* = 7.0 Hz, 1H), 2.02 – 1.89 (m, 2H), 1.08 (t, *J* = 7.3 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 139.5, 133.6, 132.6, 131.8, 128.4, 128.3, 127.9, 127.7, 126.2, 126.1(4), 126.1(1), 125.7, 123.9, 91.6, 83.7, 40.2, 31.6, 12.0.

HRMS (ESI) *m/z* calcd. for $C_{21}H_{19}$ $[M + H]^+$ 271.1481, found 271.1477.

(*S*)-3-(4-Phenylbut-3-yn-2-yl)-1-tosyl-1*H*-indole (14)



14

According to **General procedure A** with 3-(1-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)ethyl)-1-tosyl-1*H*-indole **1m** (85.1 mg, 0.20 mmol) and ethynylbenzene **2a** (26.4 μL, 0.24 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 20/1) to yield the product **14** as a colorless oil (55.9 mg, 70% yield, 99% ee).

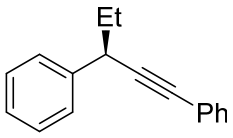
HPLC analysis: Chiralcel IC (*n*-hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min, λ = 254 nm), t_R (minor) = 10.09 min, t_R (major) = 12.25 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.98 (dt, *J* = 8.3, 1.0 Hz, 1H), 7.79 – 7.74 (m, 2H), 7.70 (dt, *J* = 7.7, 1.0 Hz, 1H), 7.55 (d, *J* = 1.1 Hz, 1H), 7.44 – 7.38 (m, 2H), 7.34 – 7.22 (m, 5H), 7.22 – 7.17 (m, 2H), 4.23 – 4.06 (m, 1H), 2.30 (s, 3H), 1.66 (d, *J* = 7.1 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 145.0, 135.7, 135.4, 131.7, 130.0, 129.5, 128.4, 128.1, 126.9, 124.8, 124.5, 123.5, 123.2, 122.7, 120.1, 113.9, 91.3, 81.9, 24.0, 21.9, 21.7.

HRMS (ESI) *m/z* calcd. for $C_{25}H_{22}NO_2S$ $[M + H]^+$ 400.1366, found 400.1355.

(*R*)-Pent-1-yne-1,3-diyldibenzene (15)



15

According to **General procedure A** with 4,4,5,5-tetramethyl-2-(1-phenylpropyl)-1,3,2-dioxaborolane **1b** (49.2 mg, 0.20 mmol) and ethynylbenzene **2a** (26.4 μL, 0.24 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether) to yield the product **15** as a colorless oil (38.8 mg, 88% yield, 98% ee).

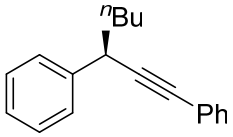
HPLC analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 99.5/0.5, flow rate 0.8 mL/min, λ = 254 nm), t_R (minor) = 5.65 min, t_R (major) = 6.22 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48 – 7.38 (m, 4H), 7.37 – 7.19 (m, 7H), 3.79 (dd, *J* = 7.7, 6.2 Hz, 1H), 1.97 – 1.76 (m, 2H), 1.05 (t, *J* = 7.4 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 142.1, 131.8, 128.6, 128.3, 127.8, 127.7, 126.8, 124.0, 91.6, 83.5, 40.1, 31.8, 12.0.

HRMS (ESI) *m/z* calcd. for $C_{17}H_{17}$ $[M + H]^+$ 221.1325, found 221.1320.

(*R*)-Hept-1-yne-1,3-diyldibenzene (16)



16

According to **General procedure A** with 4,4,5,5-tetramethyl-2-(1-phenylpentyl)-1,3,2-dioxaborolane **1n** (54.8 mg, 0.20 mmol) and ethynylbenzene **2a** (26.4 μL, 0.24 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether) to yield the product **16** as a colorless oil (40.1 mg, 81% yield, 97% ee).

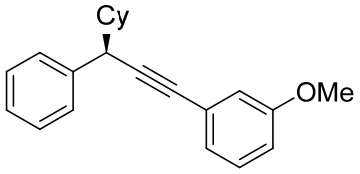
HPLC analysis: Chiralcel OJRH (MeCN/H_2O = 75/25, flow rate 0.8 mL/min, λ = 254 nm), t_R (major) = 15.05 min, t_R (minor) = 16.01 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48 – 7.39 (m, 4H), 7.35 – 7.31 (m, 2H), 7.30 – 7.20 (m, 4H), 3.83 (dd, *J* = 8.0, 6.5 Hz, 1H), 1.95 – 1.70 (m, 2H), 1.61 – 1.28 (m, 4H), 0.90 (t, *J* = 7.2 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 142.5, 131.8, 128.6, 128.3, 127.8, 127.6, 126.8, 124.0, 91.9, 83.3, 38.6, 38.5, 29.8, 22.6, 14.2.

HRMS (ESI) *m/z* calcd. for $C_{19}H_{21}$ $[M + H]^+$ 249.1638, found 249.1631.

(*R*)-1-(3-Cyclohexyl-3-phenylprop-1-yn-1-yl)-3-methoxybenzene (17)



17

According to **General procedure A** with 2-(cyclohexyl(phenyl)methyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane **1o** (60.1 mg, 0.20 mmol) and 1-ethynyl-3-methoxybenzene **2b** (30.5 μL, 0.24 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **17** as a colorless oil (27.4 mg, 45% yield, 96% ee).

HPLC analysis: Chiralcel OD3 (*n*-hexane/*i*-PrOH = 99 /1, flow rate 0.5 mL/min, λ = 254 nm), t_R (minor) = 8.21 min, t_R (major) = 8.87 min.

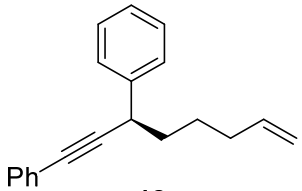
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.42 – 7.29 (m, 4H), 7.28 – 7.17 (m, 2H), 7.06 – 7.04 (m, 1H), 6.98 – 6.97 (m, 1H), 6.86 – 6.83 (m, 1H), 3.80 (s, 3H), 3.68 (d, *J* = 6.2 Hz, 1H), 1.89 – 1.86 (m, 1H), 1.78 – 1.60 (m, 6H), 1.32 – 1.08 (m, 6H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 159.4, 140.9, 129.4, 128.4, 128.3, 126.7, 125.1, 124.4,

116.7, 114.3, 90.8, 84.0, 55.4, 45.2, 44.8, 31.8, 29.7, 26.51, 26.47, 26.4.

HRMS (ESI) *m/z* calcd. for $C_{22}H_{25}O$ $[M + H]^+$ 305.1900, found 305.1893.

(*R*)-Oct-7-en-1-yne-1,3-diyldibenzene (18)



18

According to **General procedure A** with 4,4,5,5-tetramethyl-2-(1-phenylhex-5-en-1-yl)-1,3,2-dioxaborolane **1p** (56.4 mg, 0.20 mmol) and ethynylbenzene **2a** (26.4 μL, 0.24 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 100/1) to yield the product **18** as a colorless oil (43.1 mg, 83% yield, 98% ee).

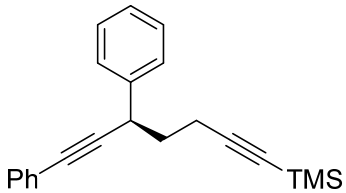
HPLC analysis: Chiralcel OJRH (MeCN/H_2O = 75/25, flow rate 0.8 mL/min, λ = 254 nm), t_R (major) = 15.13 min, t_R (minor) = 16.18 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48 – 7.38 (m, 4H), 7.37 – 7.20 (m, 6H), 5.80 (ddt, *J* = 16.9, 10.2, 6.7 Hz, 1H), 5.09 – 4.88 (m, 2H), 3.84 (t, *J* = 7.2 Hz, 1H), 2.26 – 1.99 (m, 2H), 1.95 – 1.75 (m, 2H), 1.74 – 1.48 (m, 2H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 142.3, 138.7, 131.8, 128.6, 128.3, 127.9, 127.6, 126.8, 123.9, 114.8, 91.6, 83.4, 38.4, 38.2, 33.5, 26.8.

HRMS (ESI) *m/z* calcd. for $C_{20}H_{21}$ $[M + H]^+$ 261.1638, found 261.1632.

(*R*)-(5,7-Diphenylhepta-1,6-diyn-1-yl)trimethylsilane (19)



19

According to **General procedure A** with trimethyl(5-phenyl-5-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)pent-1-yn-1-yl)silane **1q** (68.5 mg, 0.20 mmol) and ethynylbenzene **2a** (26.4 μL, 0.24 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether) to yield the product **19** as a colorless oil (58.2 mg, 92% yield, 98% ee).

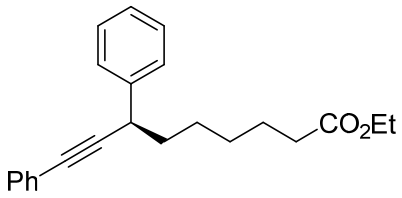
HPLC analysis: Chiralcel OJRH (MeCN/H_2O = 75/25, flow rate 0.8 mL/min, λ = 254 nm), t_R (minor) = 15.16 min, t_R (major) = 16.19 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.47 – 7.40 (m, 4H), 7.35 – 7.32 (m, 2H), 7.31 – 7.21 (m, 4H), 4.00 (dd, *J* = 8.1, 6.5 Hz, 1H), 2.54 – 2.27 (m, 2H), 2.21 – 1.91 (m, 2H), 0.17 (s, 9H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 141.3, 131.8, 128.7, 128.4, 128.0, 127.7, 127.1, 123.6, 106.5, 90.7, 85.5, 83.8, 37.6, 37.4, 18.1, 0.3.

HRMS (ESI) *m/z* calcd. for $C_{22}H_{25}Si$ $[M + H]^+$ 317.1720, found 317.1714.

Ethyl (*R*)-7,9-diphenylnon-8-ynoate (20)



20

According to **General procedure A** with ethyl 7-phenyl-7-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)heptanoate **1r** (72.1 mg, 0.20 mmol) and ethynylbenzene **2a** (26.4 μL, 0.24 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **20** as a colorless oil (57.5 mg, 86% yield, 97% ee).

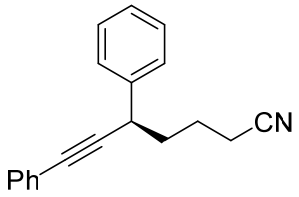
HPLC analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.8 mL/min, λ = 254 nm), t_R (minor) = 7.08 min, t_R (major) = 9.34 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48 – 7.38 (m, 4H), 7.36 – 7.30 (m, 2H), 7.30 – 7.20 (m, 4H), 4.10 (q, *J* = 7.1 Hz, 2H), 3.83 (t, *J* = 7.2 Hz, 1H), 2.28 (t, *J* = 7.5 Hz, 2H), 1.94 – 1.75 (m, 2H), 1.67 – 1.59 (m, 2H), 1.57 – 1.44 (m, 2H), 1.42 – 1.29 (m, 2H), 1.23 (t, *J* = 7.1 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 173.9, 142.2, 131.7, 128.6, 128.3, 127.8, 127.5, 126.8, 123.8, 91.6, 83.4, 60.3, 38.5, 38.4, 34.4, 28.9, 27.1, 24.9, 14.3.

HRMS (ESI) *m/z* calcd. for $C_{23}H_{27}O_2$ $[M + H]^+$ 335.2006, found 335.1997.

(*R*)-5,7-Diphenylhept-6-ynenitrile (21)



21

According to **General procedure A** with ethyl 5-phenyl-5-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)pentanenitrile **1s** (57.1 mg, 0.20 mmol) and ethynylbenzene **2a** (26.4 μL, 0.24 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 20/1) to yield the product **21** as a colorless oil (47.1 mg, 91% yield, 96% ee).

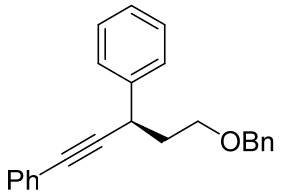
HPLC analysis: Chiralcel OD3 (*n*-hexane/*i*-PrOH = 85/15, flow rate 1.0 mL/min, λ = 254 nm), t_R (minor) = 9.96 min, t_R (major) = 14.80 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48 – 7.39 (m, 4H), 7.36 – 7.33 (m, 2H), 7.32 – 7.22 (m, 4H), 3.90 (dd, *J* = 7.9, 5.9 Hz, 1H), 2.35 (t, *J* = 7.0 Hz, 2H), 2.03 – 1.91 (m, 2H), 1.90 – 1.78 (m, 2H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 141.0, 131.7, 128.8, 128.4, 128.1, 127.4, 127.2, 123.3, 119.5, 90.1, 84.2, 37.7, 37.2, 23.3, 17.0.

HRMS (ESI) *m/z* calcd. for $C_{19}H_{18}N$ $[M + H]^+$ 260.1434, found 260.1430.

(*R*)-(5-(Benzyloxy)pent-1-yne-1,3-diyl)dibenzene (22)



22

According to **General procedure A** with 2-(3-(benzyloxy)-1-phenylpropyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane **1t** (70.5 mg, 0.20 mmol) and ethynylbenzene **2a** (26.4 μL, 0.24 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **22** as a colorless oil (54.7 mg, 84% yield, 97% ee).

HPLC analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.8 mL/min, λ = 254 nm), t_R (major) = 9.83 min, t_R (minor) = 14.64 min.

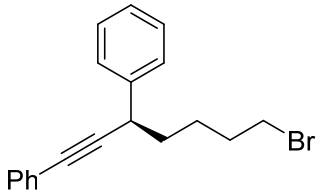
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.45 – 7.38 (m, 4H), 7.38 – 7.30 (m, 6H), 7.29 – 7.19

(m, 5H), 4.53 (s, 2H), 4.11 (t, *J* = 7.6 Hz, 1H), 3.74 (dt, *J* = 9.4, 6.5 Hz, 1H), 3.55 (dt, *J* = 9.5, 5.7 Hz, 1H), 2.11 (dt, *J* = 7.5, 6.0 Hz, 2H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 141.8, 138.6, 131.8, 128.7, 128.5, 128.3, 127.9, 127.8, 127.6(8), 127.6(6), 126.9, 123.8, 91.2, 83.5, 73.2, 67.9, 38.7, 35.1.

HRMS (ESI) *m/z* calcd. for $C_{24}H_{23}O$ $[M + H]^+$ 327.1743, found 327.1736.

(*R*)-(7-Bromohept-1-yne-1,3-diyl)dibenzene (23)



23

According to **General procedure A** with 2-(5-bromo-1-phenylpentyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane **1u** (70.6 mg, 0.20 mmol) and ethynylbenzene **2a** (26.4 μL, 0.24 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **23** as a colorless oil (59.2 mg, 91% yield, 98% ee).

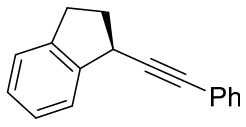
HPLC analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.8 mL/min, λ = 254 nm), t_R (minor) = 6.62 min, t_R (major) = 8.28 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.47 – 7.40 (m, 4H), 7.35 – 7.32 (m, 2H), 7.31 – 7.21 (m, 4H), 3.84 (t, *J* = 7.1 Hz, 1H), 3.39 (t, *J* = 6.8 Hz, 2H), 2.00 – 1.77 (m, 4H), 1.76 – 1.56 (m, 2H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 142.0, 131.8, 128.7, 128.3, 127.9, 127.5, 126.9, 123.7, 91.2, 83.7, 38.4, 37.8, 33.7, 32.6, 26.2.

HRMS (ESI) *m/z* calcd. for $C_{19}H_{20}Br$ $[M + H]^+$ 327.0743, found 327.0731.

(*S*)-1-(Phenylethynyl)-2,3-dihydro-1*H*-indene (24)



24

According to **General procedure A** with 2-(2,3-dihydro-1H-inden-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane **1v** (48.8 mg, 0.20 mmol) and ethynylbenzene **2a** (26.4 μL, 0.24 mmol), the reaction mixture was purified by column chromatography on silica

gel (petroleum ether/EtOAc = 100/1) to yield the product **24** as a colorless oil (38.9 mg, 89% yield, 92% ee).

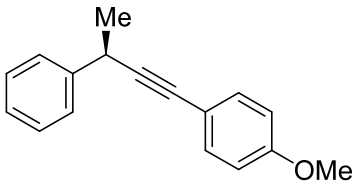
HPLC analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.8 mL/min, λ = 254 nm), t_R (minor) = 5.87 min, t_R (major) = 6.59 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.50 – 7.39 (m, 3H), 7.33 – 7.17 (m, 6H), 4.26 – 4.14 (m, 1H), 3.02 (ddd, *J* = 15.7, 8.7, 3.0 Hz, 1H), 2.97 – 2.84 (m, 1H), 2.59 (dtd, *J* = 12.5, 7.6, 3.0 Hz, 1H), 2.20 (dtd, *J* = 12.4, 9.6, 8.7 Hz, 1H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 143.7, 143.1, 131.8, 128.3, 127.8, 127.2, 126.8, 124.6, 124.4, 123.9, 91.7, 81.7, 37.0, 34.5, 31.7.

HRMS (ESI) *m/z* calcd. for $C_{17}H_{15}$ $[M + H]^+$ 219.1168, found 219.1163.

(*R*)-1-Methoxy-4-(3-phenylbut-1-yn-1-yl)benzene (25)



25

According to **General procedure A** with 4,4,5,5-tetramethyl-2-(1-phenylethyl)-1,3,2-dioxaborolane **1k** (46.4 mg, 0.20 mmol) and 1-ethynyl-4-methoxybenzene **2c** (31.1 μL, 0.24 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **25** as a colorless oil (44.7 mg, 95% yield, 97% ee).

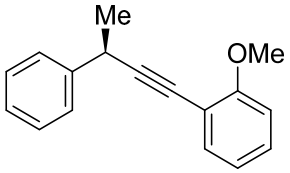
HPLC analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.8 mL/min, λ = 254 nm), t_R (minor) = 7.27 min, t_R (major) = 7.86 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48 – 7.42 (m, 2H), 7.41 – 7.30 (m, 4H), 7.26 – 7.20 (m, 1H), 6.85 – 6.78 (m, 2H), 3.96 (q, *J* = 7.1 Hz, 1H), 3.78 (s, 3H), 1.56 (d, *J* = 7.2 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 159.3, 143.7, 133.1, 128.6, 127.1, 126.7, 116.0, 113.9, 91.2, 82.3, 55.4, 32.6, 24.7.

HRMS (ESI) *m/z* calcd. for $C_{17}H_{17}O$ $[M + H]^+$ 237.1274, found 237.1269.

(*R*)-1-Methoxy-2-(3-phenylbut-1-yn-1-yl)benzene (26)



26

According to **General procedure A** with 4,4,5,5-tetramethyl-2-(1-phenylethyl)-1,3,2-dioxaborolane **1k** (46.4 mg, 0.20 mmol) and 1-ethynyl-2-methoxybenzene **2d** (31.0 μL, 0.24 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **26** as a colorless oil (42.5 mg, 90% yield, 97% ee).

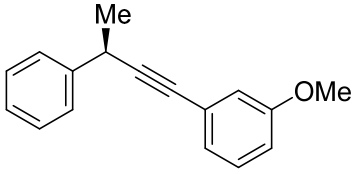
HPLC analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.8 mL/min, λ = 254 nm), t_R (minor) = 6.97 min, t_R (major) = 8.63 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.55 – 7.47 (m, 2H), 7.42 (dd, *J* = 7.5, 1.7 Hz, 1H), 7.36 – 7.30 (m, 2H), 7.28 – 7.18 (m, 2H), 6.93 – 6.80 (m, 2H), 4.04 (q, *J* = 7.1 Hz, 1H), 3.86 (s, 3H), 1.59 (d, *J* = 7.2 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 160.1, 143.6, 133.7, 129.3, 128.6, 127.1, 126.7, 120.5, 113.0, 110.7, 96.8, 78.8, 55.9, 32.9, 24.8.

HRMS (ESI) *m/z* calcd. for $C_{17}H_{17}O$ $[M + H]^+$ 237.1274, found 237.1269.

(*R*)-1-Methoxy-3-(3-phenylbut-1-yn-1-yl)benzene (27)



27

According to **General procedure A** with 4,4,5,5-tetramethyl-2-(1-phenylethyl)-1,3,2-dioxaborolane **1k** (46.4 mg, 0.20 mmol) and 1- ethynyl-3-methoxybenzene **2e** (30.5 μL, 0.24 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **27** as a colorless oil (43.7 mg, 93% yield, 97% ee).

HPLC analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 99.5/0.5, flow rate 0.8 mL/min, λ = 254 nm), t_R (minor) = 7.82 min, t_R (major) = 8.88 min.

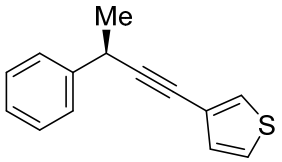
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.46 – 7.44 (m, 2H), 7.36 – 7.32 (m, 2H), 7.28 – 7.15 (m, 2H), 7.04 (dt, *J* = 7.5, 1.2 Hz, 1H), 6.97 (dd, *J* = 2.6, 1.4 Hz, 1H), 6.87 – 6.81 (m,

1H), 3.97 (q, *J* = 7.1 Hz, 1H), 3.78 (s, 3H), 1.58 (d, *J* = 7.2 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 159.8, 143.8, 129.8, 129.1, 127.5, 127.2, 125.3, 124.8, 117.0, 115.0, 93.0, 82.9, 55.8, 33.0, 25.0.

HRMS (ESI) *m/z* calcd. for $C_{17}H_{17}O$ $[M + H]^+$ 237.1274, found 237.1271.

(*R*)-3-(3-Phenylbut-1-yn-1-yl)thiophene (28)



28

According to **General procedure A** with 4,4,5,5-tetramethyl-2-(1-phenylethyl)-1,3,2-dioxaborolane **1k** (46.4 mg, 0.20 mmol) and 3-ethynylthiophene **2f** (23.6 μL, 0.24 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **28** as a colorless oil (40.5 mg, 96% yield, 96% ee).

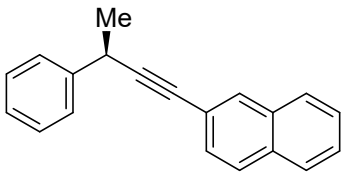
HPLC analysis: Chiralcel OJH (*n*-hexane/*i*-PrOH = 98/2, flow rate 0.5 mL/min, λ = 260 nm), t_R (minor) = 25.14 min, t_R (major) = 35.41 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.44 – 7.42 (m, 2H), 7.40 – 7.37 (m, 1H), 7.36 – 7.30 (m, 2H), 7.27 – 7.18 (m, 2H), 7.10 (dd, *J* = 4.9, 1.2 Hz, 1H), 3.95 (q, *J* = 7.2 Hz, 1H), 1.56 (d, *J* = 7.2 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 143.3, 130.2, 128.7, 128.0, 127.0, 126.8, 125.2, 122.8, 92.2, 77.5, 32.6, 24.6.

HRMS (ESI) *m/z* calcd. for $C_{14}H_{13}S$ $[M + H]^+$ 213.0732, found 213.0730.

(*R*)-2-(3-Phenylbut-1-yn-1-yl)naphthalene (29)



29

According to **General procedure A** with 4,4,5,5-tetramethyl-2-(1-phenylethyl)-1,3,2-dioxaborolane **1k** (46.4 mg, 0.20 mmol) and 2-ethynylnaphthalene **2g** (36.5 mg, 0.24 mmol), the reaction mixture was purified by column chromatography on silica gel

(petroleum ether/EtOAc = 50/1) to yield the product **29** as a colorless oil (48.5 mg, 95% yield, 96% ee).

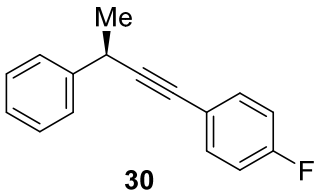
HPLC analysis: Chiralcel OJRH (MeCN/H_2O = 75/25, flow rate 0.8 mL/min, λ = 254 nm), t_R (minor) = 26.52 min, t_R (major) = 31.18 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.02 (d, *J* = 1.6 Hz, 1H), 7.88 – 7.77 (m, 3H), 7.61 – 7.53 (m, 3H), 7.53 – 7.48 (m, 2H), 7.45 – 7.38 (m, 2H), 7.36 – 7.28 (m, 1H), 4.09 (q, *J* = 7.1 Hz, 1H), 1.68 (d, *J* = 7.1 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 143.4, 133.1, 132.7, 131.3, 128.8, 128.7, 127.9, 127.8, 127.7, 127.1, 126.8, 126.5(2), 126.4(8), 121.2, 93.1, 82.9, 32.7, 24.7.

HRMS (ESI) *m/z* calcd. for $C_{20}H_{17}$ $[M + H]^+$ 257.1325, found 257.1319.

(*R*)-1-Fluoro-4-(3-phenylbut-1-yn-1-yl)benzene (30)



30

According to **General procedure A** with 4,4,5,5-tetramethyl-2-(1-phenylethyl)-1,3,2-dioxaborolane **1k** (46.4 mg, 0.20 mmol) and 1-ethynyl-4-fluorobenzene **2h** (27.5 μL, 0.24 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **30** as a colorless oil (42.6 mg, 95% yield, 96% ee).

HPLC analysis: Chiralcel OJRH (MeCN/H_2O = 75/25, flow rate 0.8 mL/min, λ = 254 nm), t_R (minor) = 13.87 min, t_R (major) = 16.51 min.

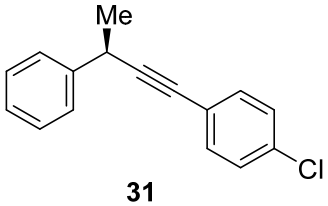
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.46 – 7.37 (m, 4H), 7.36 – 7.30 (m, 2H), 7.27 – 7.21 (m, 1H), 7.01 – 6.93 (m, 2H), 3.95 (q, *J* = 7.1 Hz, 1H), 1.56 (d, *J* = 7.2 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 162.3 (d, *J* = 248.4 Hz), 143.3, 133.5 (d, *J* = 8.3 Hz), 128.7, 127.0, 126.8, 119.9 (d, *J* = 3.6 Hz), 115.5 (d, *J* = 22.0 Hz), 92.4 (d, *J* = 1.5 Hz), 81.5, 32.5, 24.6.

^{19}F NMR (376 MHz, $CDCl_3$) δ −111.87.

HRMS (ESI) *m/z* calcd. for $C_{16}H_{14}F$ $[M + H]^+$ 225.1074, found 225.1070.

(*R*)-1-Chloro-4-(3-phenylbut-1-yn-1-yl)benzene (31)



31

According to **General procedure A** with 4,4,5,5-tetramethyl-2-(1-phenylethyl)-1,3,2-dioxaborolane **1k** (46.4 mg, 0.20 mmol) and 1-chloro-4-ethynylbenzene **2i** (32.8 mg, 0.24 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **31** as a colorless oil (44.2 mg, 92% yield, 96% ee).

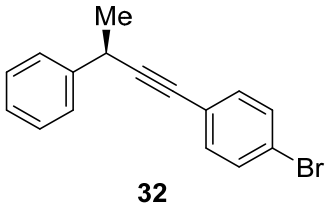
HPLC analysis: Chiralcel OJRH (MeCN/H_2O = 75/25, flow rate 0.8 mL/min, λ = 254 nm), t_R (minor) = 16.84 min, t_R (major) = 20.40 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.46 – 7.40 (m, 2H), 7.39 – 7.30 (m, 4H), 7.28 – 7.21 (m, 3H), 3.96 (q, *J* = 7.2 Hz, 1H), 1.57 (d, *J* = 7.1 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 143.2, 133.8, 133.0, 128.7, 128.6, 127.0, 126.9, 122.3, 93.8, 81.5, 32.6, 24.5.

HRMS (ESI) *m/z* calcd. for $C_{16}H_{14}Cl$ $[M + H]^+$ 241.0779, found 241.0777.

(*R*)-1-Bromo-4-(3-phenylbut-1-yn-1-yl)benzene (32)



32

According to **General procedure A** with 4,4,5,5-tetramethyl-2-(1-phenylethyl)-1,3,2-dioxaborolane **1k** (46.4 mg, 0.20 mmol) and 1-bromo-4-ethynylbenzene **2j** (43.4 mg, 0.24 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **32** as a colorless oil (51.6 mg, 91% yield, 96% ee).

HPLC analysis: Chiralcel OJRH (MeCN/H_2O = 75/25, flow rate 0.8 mL/min, λ = 254 nm), t_R (minor) = 18.11 min, t_R (major) = 21.63 min.

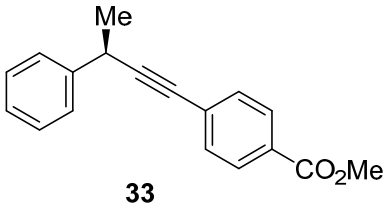
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.45 – 7.39 (m, 4H), 7.37 – 7.31 (m, 2H), 7.31 – 7.21 (m, 3H), 3.95 (q, *J* = 7.2 Hz, 1H), 1.57 (d, *J* = 7.1 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 143.1, 133.2, 131.6, 128.7, 127.0, 126.9, 122.8, 122.0,

94.0, 81.5, 32.6, 24.5.

HRMS (ESI) *m/z* calcd. for $C_{16}H_{14}Br$ $[M + H]^+$ 285.0273, found 285.0261.

Methyl (*R*)-4-(3-phenylbut-1-yn-1-yl)benzoate (33)



33

According to **General procedure A** with 4,4,5,5-tetramethyl-2-(1-phenylethyl)-1,3,2-dioxaborolane **1k** (46.4 mg, 0.20 mmol) and methyl 4-ethynylbenzoate **2k** (38.4 mg, 0.24 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **33** as a colorless oil (48.6 mg, 92% yield, 96% ee).

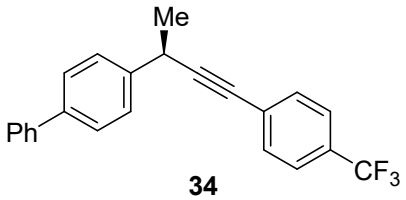
HPLC analysis: Chiralcel OJRH (MeCN/H_2O = 75/25, flow rate 0.8 mL/min, λ = 254 nm), t_R (minor) = 18.68 min, t_R (major) = 19.62 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.00 – 7.93 (m, 2H), 7.51 – 7.46 (m, 2H), 7.45 – 7.41 (m, 2H), 7.38 – 7.31 (m, 2H), 7.29 – 7.21 (m, 1H), 3.99 (q, *J* = 7.1 Hz, 1H), 3.90 (s, 3H), 1.59 (d, *J* = 7.1 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 166.7, 142.9, 131.7, 129.5, 129.2, 128.8, 128.6, 127.0, 126.9, 96.1, 81.9, 52.3, 32.7, 24.4.

HRMS (ESI) *m/z* calcd. for $C_{18}H_{17}O_2$ $[M + H]^+$ 265.1223, found 265.1219.

(*R*)-4-(4-(4-(Trifluoromethyl)phenyl)but-3-yn-2-yl)-1,1'-biphenyl (34)



34

According to **General procedure A** with 2-(1-([1,1'-biphenyl]-4-yl)ethyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane **1a** (61.6 mg, 0.20 mmol) and 1-ethynyl-4-(trifluoromethyl)benzene **2l** (39.2 μL, 0.24 mmol), the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **34** as a white solid (57.9 mg, 83% yield, 96% ee).

HPLC analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.8 mL/min, λ = 254 nm), t_R (minor) = 7.03 min, t_R (major) = 7.69 min.

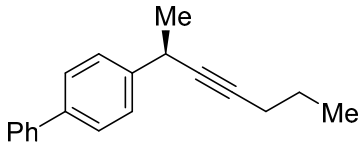
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 – 7.55 (m, 4H), 7.55 – 7.47 (m, 6H), 7.45 – 7.39 (m, 2H), 7.36 – 7.30 (m, 1H), 4.03 (q, *J* = 7.1 Hz, 1H), 1.62 (d, *J* = 7.2 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 142.0, 141.0, 140.0, 132.0, 129.7 (q, *J* = 32.7 Hz), 128.9, 127.7 (q, *J* = 1.0 Hz), 127.6, 127.5, 127.4, 127.2, 125.3 (q, *J* = 3.8 Hz), 124.2 (q, *J* = 272.2 Hz), 95.4, 81.5, 32.3, 24.3.

^{19}F NMR (376 MHz, $CDCl_3$) δ –62.63.

HRMS (ESI) *m/z* calcd. for $C_{23}H_{18}F_3$ $[M + H]^+$ 351.1355, found 351.1346.

(*R*)-4-(Hept-3-yn-2-yl)-1,1'-biphenyl (35)



35

According to **General procedure A** with 2-(1-([1,1'-biphenyl]-4-yl)ethyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane **1a** (61.6 mg, 0.20 mmol), pent-1-yne **2m** (23.7 μL, 0.24 mmol), CuTc (3.81 mg, 10 mol%) and **L6** (22.11 mg, 15 mol%) at rt for 3 days, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **35** as a colorless oil (26.9 mg, 54% yield, 99% ee).

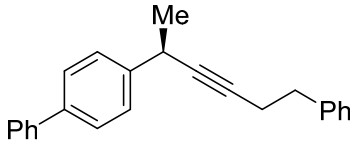
HPLC analysis: Chiralcel OJH (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.8 mL/min, λ = 254 nm), t_R (minor) = 11.39 min, t_R (major) = 12.78 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 – 7.52 (m, 4H), 7.49 – 7.38 (m, 4H), 7.37 – 7.29 (m, 1H), 3.85 – 3.73 (m, 1H), 2.22 (td, *J* = 7.0, 2.2 Hz, 2H), 1.60 – 1.53 (m, 2H), 1.50 (d, *J* = 7.0 Hz, 3H), 1.01 (t, *J* = 7.3 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 143.4, 141.2, 139.6, 128.9, 127.4, 127.3, 127.2(3), 127.2(0), 83.1, 82.5, 31.8, 25.0, 22.6, 21.0, 13.7.

HRMS (ESI) *m/z* calcd. for $C_{19}H_{21}$ $[M + H]^+$ 249.1638, found 249.1632.

(*R*)-4-(6-Phenylhex-3-yn-2-yl)-1,1'-biphenyl (36)



36

According to **General procedure A** with 2-(1-([1,1'-biphenyl]-4-yl)ethyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane **1a** (61.6 mg, 0.20 mmol), but-3-yn-1-ylbenzene **2n** (33.7 μL, 0.24 mmol), CuTc (3.81 mg, 10 mol%) and **L6** (22.11 mg, 15 mol%) at 40 °C for 12 h, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **36** as a colorless oil (52.8 mg, 85% yield, 98% ee).

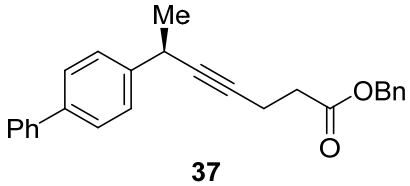
HPLC analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 99.5/0.5, flow rate 0.8 mL/min, λ = 254 nm), t_R (minor) = 27.81 min, t_R (major) = 29.67 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 – 7.56 (m, 2H), 7.55 – 7.49 (m, 2H), 7.46 – 7.40 (m, 2H), 7.40 – 7.36 (m, 2H), 7.36 – 7.27 (m, 3H), 7.26 – 7.21 (m, 3H), 3.82 – 3.69 (m, 1H), 2.85 (t, *J* = 7.5 Hz, 2H), 2.53 (td, *J* = 7.5, 2.2 Hz, 2H), 1.47 (d, *J* = 7.1 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 143.1, 141.2, 141.1, 139.6, 128.9, 128.7, 128.5, 127.4, 127.3(3), 127.2(5), 127.2, 126.3, 83.8, 81.8, 35.6, 31.7, 24.8, 21.2.

HRMS (ESI) *m/z* calcd. for $C_{24}H_{23}$ $[M + H]^+$ 311.1794, found 311.1786.

Benzyl (*R*)-6-([1,1'-biphenyl]-4-yl)hept-4-ynoate (37)



37

According to **General procedure A** with 2-(1-([1,1'-biphenyl]-4-yl)ethyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane **1a** (61.6 mg, 0.20 mmol), benzyl pent-4-ynoate **2o** (45.2 mg, 0.24 mmol), CuTc (3.81 mg, 10 mol%) and **L6** (22.11 mg, 15 mol%) at 40 °C for 12 h, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 20/1) to yield the product **37** as a colorless oil (66.3 mg, 90% yield, 98% ee).

HPLC analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.8 mL/min, λ = 254 nm), t_R (minor) = 24.44 min, t_R (major) = 28.23 min.

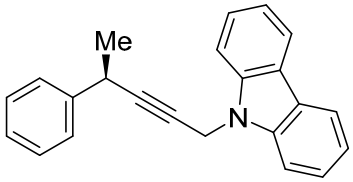
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.60 – 7.49 (m, 4H), 7.46 – 7.39 (m, 4H), 7.37 – 7.28

(m, 6H), 5.14 (s, 2H), 3.74 (qd, *J* = 7.2, 2.2 Hz, 1H), 2.69 – 2.55 (m, 4H), 1.46 (d, *J* = 7.1 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 172.1, 142.9, 141.1, 139.6, 136.0, 128.8, 128.7, 128.4, 128.3, 127.4, 127.3, 127.2(4), 127.1(8), 83.9, 80.4, 66.5, 34.2, 31.6, 24.7, 15.0.

HRMS (ESI) *m/z* calcd. for $C_{26}H_{25}O_2$ $[M + H]^+$ 369.1849, found 369.1840.

(*R*)-9-(4-Phenylpent-2-yn-1-yl)-9H-carbazole (38)



38

According to **General procedure A** with 4,4,5,5-tetramethyl-2-(1-phenylethyl)-1,3,2-dioxaborolane **1k** (46.4 mg, 0.20 mmol) and 9-(prop-2-yn-1-yl)-9H-carbazole **2p** (49.3 mg, 0.24 mmol), CuTc (3.81 mg, 10 mol%) and **L6** (22.11 mg, 15 mol%) at 40 °C for 12 h, the reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 20/1) to yield the product **38** as a white solid (57.5 mg, 93% yield, 97% ee).

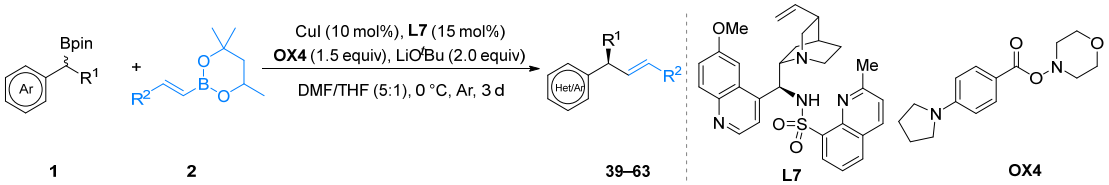
HPLC analysis: Chiralcel OJH (*n*-hexane/*i*-PrOH = 90/10, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 28.61 min, t_R (minor) = 37.24 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.12 – 8.03 (m, 2H), 7.51 – 7.42 (m, 4H), 7.28 – 7.21 (m, 6H), 7.20 – 7.14 (m, 1H), 5.02 (d, *J* = 2.0 Hz, 2H), 3.67 (qt, *J* = 7.1, 2.1 Hz, 1H), 1.37 (d, *J* = 7.2 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 142.9, 140.1, 128.6, 126.9, 126.8, 125.9, 123.3, 120.5, 119.4, 109.1, 87.3, 76.2, 33.0, 31.9, 24.3.

HRMS (ESI) *m/z* calcd. for $C_{23}H_{20}N$ $[M + H]^+$ 310.1590, found 310.1583.

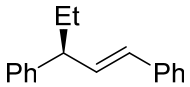
Enantioconvergent Deborylative Coupling with Alkenylbornic Esters



General procedure B:

An oven-dried resealable Schlenk tube equipped with a magnetic stir bar was charged with CuI (3.84 mg, 10 mol%), **L7** (15.84 mg, 15mol%), **OX4** (82.8 mg, 1.5 equiv), and LiO^{t}Bu (32.0 mg, 0.40 mmol, 2.0 equiv). The tube was evacuated and backfilled with argon three times. Then DMF/THF (2.0 mL, 5:1) was added under a counter flow of argon. Finally, racemic benzylboronic esters **1** (1.5 equiv) and alkenylboronic esters **2** (1.0 equiv) were sequentially added into the mixture, and the reaction mixture was stirred at 0 °C for 3 d. Upon completion of the reaction (monitored by TLC), the mixture was quenched with water. The mixture was extracted with EtOAc. The combined organic phase was dried over anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure. The crude product was purified by column chromatography on silica gel to provide the desired product.

(*S*,*E*)-Pent-1-ene-1,3-diyldibenzene (39)



39

According to the **general procedure B** with 4,4,5,5-tetramethyl-2-(1-phenylpropyl)-1,3,2-dioxaborolane **1b** (73.8 mg, 0.30 mmol) and (*E*)-4,4,6-trimethyl-2-styryl-1,3,2-dioxaborinane **2b** (46.0 mg, 0.20 mmol). The reaction mixture was purified by column chromatography on silica gel (petroleum ether) to yield the product **39** as a colorless oil (36.9 mg, 83% yield, 92% ee).

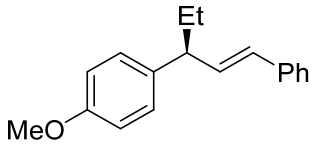
HPLC analysis: Chiralcel OJ-3 (*n*-hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 254 nm), t_R(major) = 10.19 min, t_R(minor) = 13.39 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.41 – 7.14 (m, 10H), 6.45 – 6.23 (m, 2H), 3.31 (q, *J* = 7.4 Hz, 1H), 1.93 – 1.72 (m, 2H), 0.91 (t, *J* = 7.4 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.7, 137.7, 134.4, 129.6, 128.6, 127.8, 127.1, 126.3, 126.3, 51.1, 28.9, 12.4.

The NMR spectra were in accord with those reported in the literature.[2]

(*S*,*E*)-1-Methoxy-4-(1-phenylpent-1-en-3-yl)benzene (40)



40

According to the **general procedure B** with 2-(1-(4-methoxyphenyl)propyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane **1w** (83.1 mg, 0.30 mmol), (*E*)-4,4,6-trimethyl-2-styryl-1,3,2-dioxaborinane **2b** (46.0 mg, 0.20 mmo), CuI (7.68mg, 20 mol%) and **L7** (31.68 mg, 30 mol%). The reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 20/1) to yield the product **40** as a colorless oil (29.2 mg, 58% yield, 86% ee).

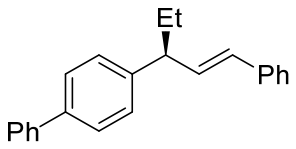
HPLC analysis: Chiralcel OJ-3 (*n*-hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 254 nm), t_R(major) = 14.68 min, t_R(minor) = 22.88 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.41 – 7.21 (m, 4H), 7.22 – 7.07 (m, 3H), 6.93 – 6.74 (m, 2H), 6.45 – 6.17 (m, 2H), 3.78 (s, 3H), 3.26 (q, *J* = 7.3 Hz, 1H), 1.94 – 1.63 (m, 2H), 0.90 (t, *J* = 7.3 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 158.1, 137.8, 136.7, 134.7, 129.3, 128.7, 128.6, 127.1, 126.2, 114.0, 55.4, 50.2, 28.9, 12.4.

HRMS (APCI) *m/z* calcd. for $C_{18}H_{21}O$ $[M+H]^+$ 253.1587, found: 253.1580.

(*S*,*E*)-4-(1-Phenylpent-1-en-3-yl)-1,1'-biphenyl (41)



41

According to the **general procedure B** with 2-(1-([1,1'-biphenyl]-4-yl)propyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane **1x** (96.7 mg, 0.30 mmol) and (*E*)-4,4,6-trimethyl-2-styryl-1,3,2-dioxaborinane **2b** (46.0 mg, 0.20 mmol). The reaction mixture was purified by column chromatography on silica gel (petroleum ether) to yield the product **41** as a colorless oil (37.5 mg, 63% yield, 86% ee).

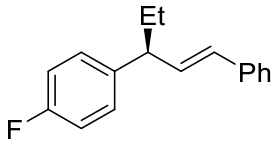
HPLC analysis: Chiralcel OJ-RH (MeCN/H_2O = 75/25, flow rate 0.8 mL/min, λ = 254 nm), t_R(major) = 38.87 min, t_R(minor) = 41.88 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 – 7.51 (m, 4H), 7.47 – 7.12 (m, 10H), 6.52 – 6.25 (m, 2H), 3.36 (q, *J* = 7.4 Hz, 1H), 2.06 – 1.73 (m, 2H), 0.95 (t, *J* = 7.4 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 143.8, 141.2, 139.3, 137.7, 134.2, 129.7, 128.9, 128.6, 128.2, 127.4, 127.1(9), 127.1(6), 126.3, 50.8, 28.9, 12.5.

The NMR spectra were in accord with those reported in the literature.[2]

(*S*,*E*)-1-Fluoro-4-(1-phenylpent-1-en-3-yl)benzene (42)



42

According to the **general procedure B** with 2-(1-(4-fluorophenyl)propyl)-4,4,5,5-tetr -amethyl-1,3,2-dioxaborolane **1y** (79.4 mg, 0.30 mmol) and (*E*)-4,4,6-trimethyl-2-styryl-1,3,2-dioxaborinane **2b** (46.0 mg, 0.20 mmo). The reaction mixture was purified by column chromatography on silica gel (petroleum ether) to yield the product **42** as a colorless oil (32.2 mg, 67% yield, 88% ee).

HPLC analysis: Chiralcel OJ-RH (MeCN/H_2O = 75/25, flow rate 0.8 mL/min, λ = 254 nm), t_R(major) = 15.58 min, t_R(minor) = 16.90 min.

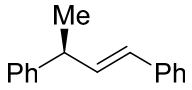
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37 – 7.22 (m, 4H), 7.23 – 7.14 (m, 3H), 7.07 – 6.90 (m, 2H), 6.46 – 6.10 (m, 2H), 3.29 (q, *J* = 7.4 Hz, 1H), 2.00 – 1.66 (m, 2H), 0.90 (t, *J* = 7.4 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 161.5 (d, *J* = 243.8 Hz), 140.2 (d, *J* = 3.1 Hz), 137.6, 134.1, 129.7, 129.2 (d, *J* = 7.8 Hz), 128.6, 127.3, 126.3, 115.3 (d, *J* = 21.1 Hz), 50.3, 29.0, 12.4.

^{19}F NMR (376 MHz, $CDCl_3$) δ −117.22.

HRMS (ESI) *m/z* calcd. for $C_{17}H_{18}F$ $[M+H]^+$ 241.1387, found: 241.1387.

(*S*,*E*)-But-1-ene-1,3-diyldibenzene (43)



43

According to the **general procedure B** with 4,4,5,5-tetramethyl-2-(1-phenylethyl)-1,3,2-dioxaborolane **1k** (69.8 mg, 0.30 mmol) and (*E*)-4,4,6-trimethyl-2-styryl-1,3,2-dioxaborinane **2b** (46.0 mg, 0.20 mmol). The reaction mixture was purified by column chromatography on silica gel (petroleum ether) to yield the product **43** as a colorless oil (35.8 mg, 86% yield, 87% ee).

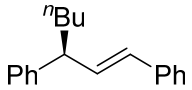
HPLC analysis: Chiralcel OJ-RH (MeCN/H_2O = 75/25, flow rate 0.8 mL/min, λ = 254 nm), t_R(minor) = 16.54 min, t_R(major) = 18.05 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.39 – 7.24 (m, 8H), 7.24 – 7.16 (m, 2H), 6.50 – 6.33 (m, 2H), 3.70 – 3.58 (m, 1H), 1.47 (d, *J* = 7.0 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 145.8, 137.7, 135.4, 128.6, 127.4, 127.2, 126.4, 126.3, 42.7, 21.4.

The NMR spectra were in accord with those reported in the literature.[2]

(*S*,*E*)-Hept-1-ene-1,3-diyldibenzene (44)



44

According to the **general procedure B** with 4,4,5,5-tetramethyl-2-(1-phenylpentyl) -1,3,2-dioxaborolane **1n** (82.3 mg, 0.30 mmol) and (*E*)-4,4,6-trimethyl-2-styryl-1,3,2-dioxaborinane **2b** (46.0 mg, 0.20 mmol). The reaction mixture was purified by column chromatography on silica gel (petroleum ether) to yield the product **44** as a colorless oil (40.1 mg, 80% yield, 91% ee).

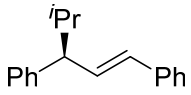
HPLC analysis: Chiralcel OD-3 (*n*-hexane/*i*-PrOH = 100/0, flow rate 0.8 mL/min, λ = 254 nm), t_R(minor) = 10.89 min, t_R(major) = 11.19 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40 – 7.10 (m, 10H), 6.47 – 6.24 (m, 2H), 3.39 (q, *J* = 7.4 Hz, 1H), 1.93 – 1.75 (m, 2H), 1.39 – 1.11 (m, 4H), 0.99 – 0.68 (m, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.9, 137.8, 134.6, 129.4, 128.6(1), 128.5(9), 127.8, 127.1, 126.2(9), 126.2(6), 49.3, 35.8, 30.0, 22.8, 14.2.

HRMS (APCI) *m/z* calcd. for $C_{19}H_{23}$ $[M+H]^+$ 251.1794, found: 251.1792.

(*S*,*E*)-(4-Methylpent-1-ene-1,3-diyl)dibenzene (45)



45

According to the **general procedure B** with 4,4,5,5-tetramethyl-2-(2-methyl-1-pheny lpropyl)-1,3,2-dioxaborolane **1z** (78.1 mg, 0.30 mmol) and (*E*)-4,4,6-trimethyl-2-styryl-1,3,2-dioxaborinane **2b** (46.0 mg, 0.20 mmol). The reaction mixture was purified by column chromatography on silica gel (petroleum ether) to yield the product **45** as a colorless oil (28.4 mg, 60% yield, 95% ee).

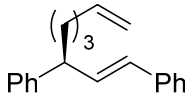
HPLC analysis: Chiralcel OJ-3 (*n*-hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 254 nm), t_R(major) = 7.47 min, t_R(minor) = 8.46 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48 – 7.09 (m, 10H), 6.48 – 6.27 (m, 2H), 3.15 – 2.97 (m, 1H), 2.15 – 1.97 (m, 1H), 1.00 (d, *J* = 6.6 Hz, 3H), 0.81 (d, *J* = 6.6 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.5, 137.8, 133.3, 130.4, 128.5(7), 128.5(5), 128.1, 127.1, 126.3, 126.2, 57.8, 33.3, 21.3, 21.1.

The NMR spectra were in accord with those reported in the literature.[2]

(*S*,*E*)-Octa-1,7-diene-1,3-diyldibenzene (46)



46

According to the **general procedure B** with 4,4,5,5-tetramethyl-2- (1-phenylhex-5-en-1-yl)-1,3,2-dioxaborolane **1p** (85.9 mg, 0.30 mmol) and (*E*)-4,4,6-trimethyl-2-styryl-1,3,2-dioxaborinane **2b** (46.0 mg, 0.20 mmol). The reaction mixture was purified by column chromatography on silica gel (petroleum ether) to yield the product **46** as a colorless oil (49.3 mg, 94% yield, 89% ee).

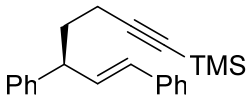
HPLC analysis: Chiralcel OD-3 (*n*-hexane/*i*-PrOH = 100/0, flow rate 1.0 mL/min, λ = 254 nm), t_R(minor) = 10.89 min, t_R(major) = 11.41 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.45 – 7.12 (m, 10H), 6.55 – 6.20 (m, 2H), 5.93 – 5.67 (m, 1H), 5.08 – 4.78 (m, 2H), 3.41 (q, *J* = 7.4 Hz, 1H), 2.17 – 1.97 (m, 2H), 1.89 – 1.69 (m, 2H), 1.52 – 1.29 (m, 2H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.7, 138.9, 137.7, 134.4, 129.5, 128.7, 128.6, 127.8, 127.2, 126.4, 126.3, 114.7, 49.2, 35.5, 33.9, 27.1.

HRMS (APCI) *m/z* calcd. for $C_{20}H_{23}$ $[M+H]^+$ 263.1794, found: 263.1789.

(*S*,*E*)-(5,7-Diphenylhept-6-en-1-yn-1-yl)trimethylsilane (47)



47

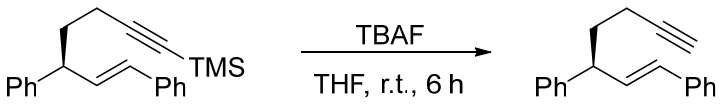
According to the **general procedure B** with trimethyl(5-phenyl-5-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)pent-1-yn-1-yl)silane **1q** (102.7 mg, 0.30 mmol) and (*E*)-4,4,6-trimethyl-2-styryl-1,3,2-dioxaborinane **2b** (46.0 mg, 0.20 mmo). The reaction mixture was purified by column chromatography on silica gel (petroleum ether) to yield the product **47** as a colorless oil (37.0 mg, 54% yield, 91% ee).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.56 – 7.10 (m, 10H), 6.62 – 6.25 (m, 2H), 3.58 (q, *J* = 7.6 Hz, 1H), 2.30 – 2.13 (m, 2H), 2.10 – 1.94 (m, 2H), 0.17 (s, 9H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 143.7, 137.5, 133.2, 130.2, 128.7, 128.6, 127.8, 127.3, 126.6, 126.3, 107.1, 85.3, 48.0, 34.7, 18.2, 0.3.

HRMS (APCI) *m/z* calcd. for $C_{22}H_{27}Si$ $[M+H]^+$ 319.1877, found: 319.1873.

*Note: The ee value (91%) of product **47** was determined by chiral HPLC analysis of **(S,E)-hept-1-en-6-yne-1,3-diyldibenzene(47')**, which was obtained by transformation of product **47**.*



47 **47'**

Under an argon atmosphere, to a solution of product **47** (31.9 mg, 0.10 mmol) in anhydrous THF (2.0 mL) was added tetrabutylammonium fluoride (TBAF, 0.20 mL, 2.0 equiv, 1.0 M in THF) at ice water bath. The reaction mixture was allowed to stir at room temperature for 6 h, and then quenched with water. The reaction mixture was extracted with EtOAc three times. The organic layers were combined and dried over anhydrous Na_2SO_4, filtered and concentrated under reduced pressure. The crude

product was purified by flash chromatography on silica gel using petroleum ether as eluent to provide the product **47′** as a colorless oil (20.2 mg, 82% yield, 91% ee).

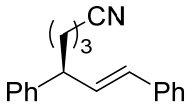
HPLC analysis: Chiralcel OJ-RH (MeCN/H_2O = 75/25, flow rate 0.8 mL/min, λ = 254 nm), t_R(major) = 12.73 min, t_R(minor) = 14.80 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.42 – 7.12 (m, 10H), 6.53 – 6.20 (m, 2H), 3.61 (q, *J* = 7.6 Hz, 1H), 2.28 – 2.12 (m, 2H), 2.09 – 1.96 (m, 2H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 143.6, 137.5, 133.2, 130.2, 128.8, 128.6, 127.8, 127.3, 126.7, 126.3, 84.2, 68.9, 47.8, 34.5, 16.7.

HRMS (APCI) *m/z* calcd. for $C_{19}H_{19}$ $[M+H]^+$ 247.1481, found: 247.1472.

(*S*,*E*)-5,7-diphenylhept-6-enenitrile (48)



48

According to the **general procedure B** with 5-phenyl-5-(4,4,5,5-tetramethyl-1,3,2--dioxaborolan-2-yl)pentanenitrile **1s** (85.6 mg, 0.30 mmol) and (*E*)-4,4,6-trimethyl-2-styryl-1,3,2-dioxaborinane **2b** (46.0 mg, 0.20 mmol). The reaction mixture was purified by column chromatography on silica gel (petroleum ether/ EtOAc = 10/1) to yield the product **48** as a colorless oil (43.9 mg, 84% yield, 90% ee).

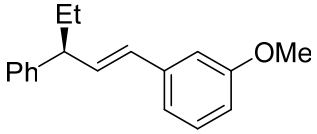
HPLC analysis: Chiralcel OD-3 (*n*-hexane/*i*-PrOH = 95/5, flow rate 1.0 mL/min, λ = 254 nm), t_R(major) = 25.85 min, t_R(minor) = 29.26 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40 – 7.16 (m, 10H), 6.52 – 6.22 (m, 2H), 3.43 (q, *J* = 7.6 Hz, 1H), 2.35 (t, *J* = 7.1 Hz, 2H), 2.07 – 1.86 (m, 2H), 1.79 – 1.59 (m, 2H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 143.5, 137.2, 133.1, 130.2, 128.9, 128.7, 127.6, 127.5, 126.8, 126.3, 119.7, 48.7, 34.8, 23.7, 17.3.

The NMR spectra were in accord with those reported in the literature.[2]

(*S*,*E*)-1-Methoxy-3-(3-phenylpent-1-en-1-yl)benzene (49)



49

According to the **general procedure B** with 4,4,5,5-tetramethyl-2-(1-phenylpropyl)-1,3,2-dioxaborolane **1b** (73.8 mg, 0.30 mmol) and (*E*)-2-(3-methoxystyryl)-4,4,6-trimethyl-1,3,2-dioxaborinane **2q** (52.1 mg, 0.20 mmo). The reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 20/1) to yield the product **49** as a colorless oil (32.3 mg, 64% yield, 92% ee).

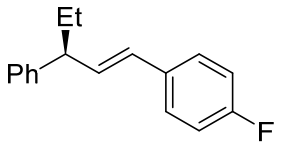
HPLC analysis: Chiralcel OJ-3 (*n*-hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min, λ = 254 nm), t_R(major) = 11.60 min, t_R(minor) = 14.99 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.35 – 7.28 (m, 2H), 7.27 – 7.13 (m, 4H), 6.99 – 6.66 (m, 3H), 6.43 – 6.26 (m, 2H), 3.80 (s, 3H), 3.30 (q, *J* = 7.2 Hz, 1H), 1.98 – 1.70 (m, 2H), 0.91 (t, *J* = 7.4 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 159.9, 144.6, 139.2, 134.7, 129.6, 129.5, 128.6, 127.8, 126.3, 119.0, 112.9, 111.5, 55.3, 51.1, 28.9, 12.4.

HRMS (APCI) *m/z* calcd. for $C_{18}H_{21}O$ $[M+H]^+$ 253.1587, found: 253.1578.

(*S*,*E*)-1-Fluoro-4-(3-phenylpent-1-en-1-yl)benzene (50)



50

According to the **general procedure B** with 4,4,5,5-tetramethyl-2-(1-phenylpropyl)-1,3,2-dioxaborolane **1b** (73.8 mg, 0.30 mmol) and (*E*)-2-(4-fluorostyryl)-4,4,6-trimethyl-1,3,2-dioxaborinane **2r** (49.7 mg, 0.20 mmol). The reaction mixture was purified by column chromatography on silica gel (petroleum ether) to yield the product **50** as a colorless oil (36.1 mg, 75% yield, 91% ee).

HPLC analysis: Chiralcel OJ-3 (*n*-hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 254 nm), t_R(major) = 12.99 min, t_R(minor) = 18.08 min.

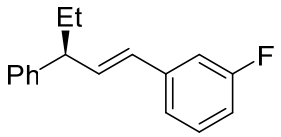
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.37 – 7.17 (m, 7H), 7.01 – 6.89 (m, 2H), 6.47 – 6.16 (m, 2H), 3.29 (q, *J* = 7.5 Hz, 1H), 1.95 – 1.74 (m, 2H), 0.91 (t, *J* = 7.3 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 162.1 (d, *J* = 245.8 Hz), 144.6, 134.1, 133.9 (d, *J* = 3.1 Hz), 128.6, 128.4, 127.8, 127.7 (d, *J* = 7.8 Hz), 126.4, 115.4 (d, *J* = 21.5 Hz), 51.1, 28.9, 12.4.

^{19}F NMR (376 MHz, $CDCl_3$) δ −115.51.

The NMR spectra were in accord with those reported in the literature.[2]

(*S*,*E*)-1-Fluoro-3-(3-phenylpent-1-en-1-yl)benzene (51)



51

According to the **general procedure B** with 4,4,5,5-tetramethyl-2-(1-phenylpropyl)-1,3,2-dioxaborolane **1b** (73.8 mg, 0.30 mmol) and (*E*)-2-(3-fluorostyryl)-4,4,6-trimethyl-1,3,2-dioxaborinane **2s** (49.7 mg, 0.20 mmol). The reaction mixture was purified by column chromatography on silica gel (petroleum ether) to yield the product **51** as a colorless oil (36.3 mg, 75% yield, 90% ee).

HPLC analysis: Chiralcel OJ-3 (*n*-hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 254 nm), t_R(major) = 7.55 min, t_R(minor) = 11.27 min.

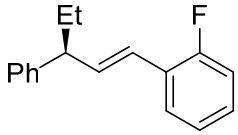
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.36 – 7.28 (m, 2H), 7.27 – 7.20 (m, 4H), 7.12 – 7.00 (m, 2H), 6.93 – 6.81 (m, 1H), 6.42 – 6.26 (m, 2H), 3.41 – 3.23 (m, 1H), 2.00 – 1.75 (m, 2H), 0.91 (t, *J* = 7.4 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 163.2 (d, *J* = 245.0 Hz), 144.3, 140.1 (d, *J* = 7.7 Hz), 135.8, 130.0 (d, *J* = 8.4 Hz), 128.7, 128.6 (d, *J* = 2.5 Hz), 127.8, 126.5, 122.1, 113.9 (d, *J* = 21.5 Hz), 112.7 (d, *J* = 21.7 Hz), 51.1, 28.8, 12.4.

^{19}F NMR (376 MHz, $CDCl_3$) δ −113.80.

HRMS (APCI) *m/z* calcd. for $C_{17}H_{18}F$ $[M+H]^+$ 241.1387, found: 241.1385.

(*S*,*E*)-1-Fluoro-2-(3-phenylpent-1-en-1-yl)benzene (52)



52

According to the **general procedure B** with 4,4,5,5-tetramethyl-2-(1-phenylpropyl)-1,3,2-dioxaborolane **1b** (73.8 mg, 0.30 mmol) and (*E*)-2-(2-fluorostyryl)-4,4,6-trimethyl-1,3,2-dioxaborinane **2t** (49.7 mg, 0.20 mmol). The reaction mixture was purified by column chromatography on silica gel (petroleum ether) to yield the product **52** as a colorless oil (35.1 mg, 73% yield, 90% ee).

HPLC analysis: Chiralcel OJ-3 (*n*-hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 254 nm), t_R(major) = 6.88 min, t_R(minor) = 8.57 min.

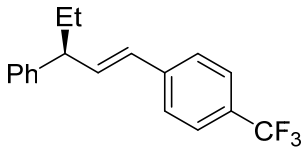
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.47 – 7.29 (m, 3H), 7.26 – 6.95 (m, 6H), 6.67 – 6.31 (m, 2H), 3.33 (q, *J* = 7.6 Hz, 1H), 2.00 – 1.73 (m, 2H), 0.92 (t, *J* = 7.4 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 160.2 (d, *J* = 248.4 Hz), 144.4, 136.9 (d, *J* = 4.4 Hz), 128.7, 128.3 (d, *J* = 8.4 Hz), 127.8, 127.2 (d, *J* = 3.9 Hz), 126.4, 125.5 (d, *J* = 12.4 Hz), 124.1 (d, *J* = 3.6 Hz), 121.9 (d, *J* = 3.7 Hz), 115.7 (d, *J* = 22.3 Hz), 51.6, 28.8, 12.4.

^{19}F NMR (376 MHz, $CDCl_3$) δ −118.69.

HRMS (APCI) *m/z* calcd. for $C_{17}H_{18}F$ $[M+H]^+$ 241.1387, found: 241.1381.

(*S*,*E*)-1-(3-Phenylpent-1-en-1-yl)-4-(trifluoromethyl)benzene (53)



53

According to the **general procedure B** with 4,4,5,5-tetramethyl-2-(1-phenylpropyl)-1,3,2-dioxaborolane **1b** (73.8 mg, 0.30 mmol) and (*E*)-4,4,6-trimethyl-2-(4-(trifluoromethyl)styryl)-1,3,2-dioxaborinane **2u** (59.7 mg, 0.20 mmol). The reaction mixture was purified by column chromatography on silica gel (petroleum ether) to yield the product **53** as a colorless oil (34.9 mg, 60% yield, 87% ee).

HPLC analysis: Chiralcel OJ-3 (*n*-hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 254 nm), t_R(major) = 7.23 min, t_R(minor) = 8.62 min.

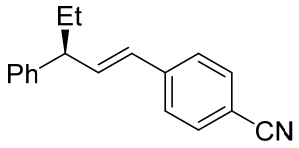
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.60 – 7.39 (m, 4H), 7.37 – 7.28 (m, 2H), 7.27 – 7.18 (m, 3H), 6.49 – 6.34 (m, 2H), 3.33 (q, *J* = 6.9 Hz, 1H), 2.00 – 1.78 (m, 2H), 0.92 (t, *J* = 7.3 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.0, 141.2, 137.2, 129.1 (q, *J* = 32.2 Hz), 128.7, 128.4, 127.8, 126.7 (q, *J* = 272.6 Hz), 126.5, 126.4, 125.5 (q, *J* = 3.9 Hz), 51.2, 28.8, 12.4.

^{19}F NMR (376 MHz, $CDCl_3$) δ −62.40.

HRMS (APCI) *m/z* calcd. for $C_{18}H_{18}F_3$ $[M+H]^+$ 291.1355, found: 291.1354.

(*S*,*E*)-4-(3-Phenylpent-1-en-1-yl)benzonitrile (54)



54

According to the **general procedure B** with 4,4,5,5-tetramethyl-2-(1-phenylpropyl)-1,3,2-dioxaborolane **1b** (73.8 mg, 0.30 mmol) and (*E*)-2-(4-isocyanostyryl)-4,4,6-trimethyl-1,3,2-dioxaborinane **2v** (51.1 mg, 0.20 mmol). The reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 10/1) to yield the product **54** as a colorless oil (32.7 mg, 66% yield, 87% ee).

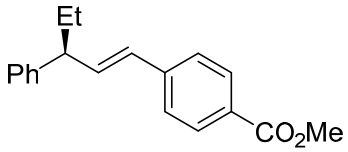
HPLC analysis: Chiralcel OJ-3 (*n*-hexane/*i*-PrOH = 90/10, flow rate 1.0 mL/min, λ = 254 nm), t_R(major) = 12.57 min, t_R(minor) = 14.29 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.59 – 7.37 (m, 4H), 7.37 – 7.29 (m, 2H), 7.27 – 7.17 (m, 3H), 6.54 – 6.29 (m, 2H), 3.34 (q, *J* = 7.5 Hz, 1H), 1.92 – 1.75 (m, 2H), 0.91 (t, *J* = 7.3 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 143.7, 142.2, 138.6, 132.5, 128.8, 128.1, 127.8, 126.7(3), 126.6(5), 119.2, 110.3, 51.2, 28.7, 12.4.

HRMS (APCI) *m/z* calcd. for $C_{18}H_{18}N$ $[M+H]^+$ 248.1434, found: 248.1428.

Methyl (*S,E*)-4-(3-phenylpent-1-en-1-yl)benzoate (55)



55

According to the **general procedure B** with 4,4,5,5-tetramethyl-2-(1-phenylpropyl)-1,3,2-dioxaborolane **1b** (73.8 mg, 0.30 mmol) and methyl (*E*)-4-(2-(4,4,6-trimethyl-1,3,2-dioxaborinan-2-yl)vinyl)benzoate **2w** (57.7 mg, 0.20 mmol). The reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 20/1) to yield the product **55** as a colorless oil (39.2 mg, 68% yield, 88% ee).

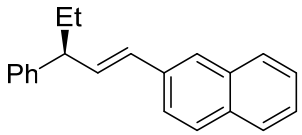
HPLC analysis: Chiralcel OJ-3 (*n*-hexane/*i*-PrOH = 85/15, flow rate 1.0 mL/min, λ = 254 nm), t_R(major) = 10.94 min, t_R(minor) = 17.08 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.01 – 7.86 (m, 2H), 7.44 – 7.16 (m, 7H), 6.62 – 6.27 (m, 2H), 3.89 (s, 3H), 3.32 (q, *J* = 7.2 Hz, 1H), 1.94 – 1.73 (m, 2H), 0.91 (t, *J* = 7.3 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 167.1, 144.0, 142.2, 137.3, 130.0, 128.8, 128.7, 128.6, 127.8, 126.5, 126.1, 52.1, 51.2, 28.7, 12.4.

HRMS (APCI) *m/z* calcd. for $C_{19}H_{21}O_2$ $[M+H]^+$ 281.1536, found: 281.1527.

(*S*,*E*)-2-(3-Phenylpent-1-en-1-yl)naphthalene (56)



56

According to the **general procedure B** with 4,4,5,5-tetramethyl-2-(1-phenylpropyl)-1,3,2-dioxaborolane **1b** (73.8 mg, 0.30 mmol) and (*E*)-4,4,6-trimethyl-2-(2-(naphthalen-2-yl)vinyl)-1,3,2-dioxaborinane **2x** (56.1 mg, 0.20 mmol). The reaction mixture was purified by column chromatography on silica gel (petroleum ether) to yield the product **56** as a colorless oil (33.4 mg, 62% yield, 91% ee).

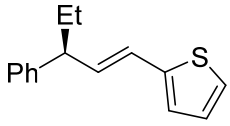
HPLC analysis: Chiralcel OJ-3 (*n*-hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 254 nm), t_R(major) = 23.76 min, t_R(minor) = 28.15 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.83 – 7.71 (m, 3H), 7.68 (s, 1H), 7.61 – 7.52 (m, 1H), 7.48 – 7.37 (m, 2H), 7.36 – 7.14 (m, 5H), 6.65 – 6.36 (m, 2H), 3.36 (q, *J* = 7.5 Hz, 1H), 1.99 – 1.74 (m, 2H), 0.94 (t, *J* = 7.4 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.6, 135.2, 134.9, 133.8, 132.9, 129.7, 128.6, 128.2, 128.0, 127.9, 127.8, 126.4, 126.3, 125.8, 125.7, 123.8, 51.3, 29.0, 12.5.

The NMR spectra were in accord with those reported in the literature.[2]

(*S*,*E*)-2-(3-Phenylpent-1-en-1-yl)thiophene (57)



57

According to the **general procedure B** with 4,4,5,5-tetramethyl-2-(1-phenylpropyl)-1,3,2-dioxaborolane **1b** (73.8 mg, 0.30 mmol) and (*E*)-4,4,6-trimethyl-2-(2-(thiophen-2-yl)vinyl)-1,3,2-dioxaborinane **2y** (47.3 mg, 0.20 mmol). The reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 50/1) to yield the product **57** as a colorless oil (29.1 mg, 65% yield, 89% ee).

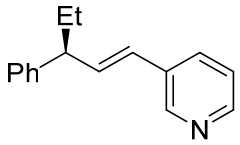
HPLC analysis: Chiralcel OJ-3 (*n*-hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 254 nm), t_R(major) = 13.72 min, t_R(minor) = 22.65 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.35 – 7.15 (m, 7H), 7.10 – 7.02 (m, 1H), 6.48 – 6.06 (m, 2H), 3.26 (q, *J* = 7.5 Hz, 1H), 1.92 – 1.72 (m, 2H), 0.90 (t, *J* = 7.3 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.6, 140.3, 134.3, 128.6, 127.8, 126.3, 125.9, 125.1, 123.8, 121.1, 51.0, 28.8, 12.4.

The NMR spectra were in accord with those reported in the literature.[2]

(*S*,*E*)-3-(3-Phenylpent-1-en-1-yl)pyridine (58)



58

According to the **general procedure B** with 4,4,5,5-tetramethyl-2-(1-phenylpropyl)-1,3,2-dioxaborolane **1b** (73.8 mg, 0.30 mmol) and (*E*)-3-(2-(4,4,6-trimethyl-1,3,2-dioxaborinan-2-yl)vinyl)pyridine **2z** (46.3 mg, 0.20 mmol). The reaction mixture was purified by column chromatography on silica gel (petroleum ether/EtOAc = 20/1) to yield the product **58** as a colorless oil (42.9 mg, 96% yield, 87% ee).

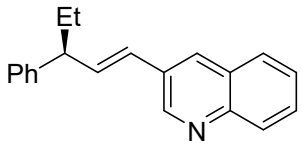
HPLC analysis: Chiralcel OJ-3 (*n*-hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 254 nm), t_R(major) = 18.26 min, t_R(minor) = 20.29 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.56 (s, 1H), 8.48 – 8.20 (m, 1H), 7.76 – 7.51 (m, 1H), 7.39 – 7.28 (m, 2H), 7.28 – 7.11 (m, 4H), 6.50 – 6.25 (m, 2H), 3.33 (q, *J* = 7.2 Hz, 1H), 1.95 – 1.71 (m, 2H), 0.92 (t, *J* = 7.3 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 148.3, 148.2, 144.0, 136.8, 133.3, 132.7, 128.7, 127.8, 126.5, 126.0, 123.5, 51.2, 28.7, 12.4.

The NMR spectra were in accord with those reported in the literature.[2]

(*S*,*E*)-3-(3-Phenylpent-1-en-1-yl)quinoline (59)



59

According to the **general procedure B** with 4,4,5,5-tetramethyl-2-(1-phenylpropyl)-

1,3,2-dioxaborolane **1b** (73.8 mg, 0.30 mmol) and (*E*)-3-(2-(4,4,6-trimethyl-1,3,2-dioxaborinan-2-yl)vinyl)quinoline **2aa** (56.3 mg, 0.20 mmo). The reaction mixture was purified by column chromatography on silica gel (petroleum ether/ EtOAc = 20/1) to yield the product **59** as a colorless oil (43.5 mg, 79% yield, 85% ee).

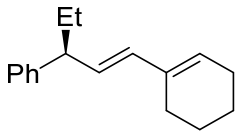
HPLC analysis: Chiralcel AD-H (*n*-hexane/*i*-PrOH = 97/3, flow rate 1.0 mL/min, λ = 254 nm), t_R(minor) = 17.81 min, t_R(major) = 24.56 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.96 (s, 1H), 8.08 – 7.96 (m, 2H), 7.83 – 7.70 (m, 1H), 7.69 – 7.60 (m, 1H), 7.56 – 7.45 (m, 1H), 7.41 – 7.32 (m, 2H), 7.30 – 7.17 (m, 3H), 6.66 – 6.47 (m, 2H), 3.39 (q, *J* = 7.2 Hz, 1H), 1.99 – 1.85 (m, 2H), 0.95 (t, *J* = 7.4 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 149.6, 147.4, 144.0, 137.1, 132.0, 130.6, 129.3, 129.0, 128.8, 128.2, 127.9, 127.8, 127.0, 126.6, 126.4, 51.4, 28.8, 12.5.

The NMR spectra were in accord with those reported in the literature.[2]

(*S*,*E*)-(1-(Cyclohex-1-en-1-yl)pent-1-en-3-yl)benzene (60)



60

According to the **general procedure B** with 4,4,5,5-tetramethyl-2-(1-phenylpropyl)-1,3,2-dioxaborolane **1b** (73.8 mg, 0.30 mmol) and (*E*)-2-(2-(cyclohex-1-en-1-yl)vinyl)-4,4,6-trimethyl-1,3,2-dioxaborinane **2ab** (46.9 mg, 0.20 mmol). The reaction mixture was purified by column chromatography on silica gel (petroleum ether) to yield the product **60** as a colorless oil (26.3 mg, 63% yield, 87% ee).

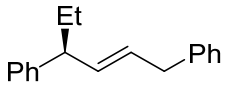
HPLC analysis: Chiralcel OJ-3 (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.8 mL/min, λ = 254 nm), t_R(major) = 9.23 min, t_R(minor) = 12.01 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.32 – 7.23 (m, 2H), 7.21 – 7.13 (m, 3H), 6.04 (d, *J* = 15.7 Hz, 1H), 5.76 – 5.46 (m, 2H), 3.16 (q, *J* = 7.6 Hz, 1H), 2.29 – 1.96 (m, 4H), 1.81 – 1.69 (m, 2H), 1.68 – 1.53 (m, 4H), 0.86 (t, *J* = 7.4 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 145.4, 135.7, 133.2, 130.2, 128.5, 128.1, 127.8, 126.1, 51.0, 29.2, 25.9, 24.8, 22.7(4), 22.6(5), 12.5.

The NMR spectra were in accord with those reported in the literature.[2]

(*S*,*E*)-Hex-2-ene-1,4-diyldibenzene (61)



61

According to the **general procedure B** with 4,4,5,5-tetramethyl-2-(1-phenylpropyl)-1,3,2-dioxaborolane **1b** (73.8 mg, 0.30 mmol) and (*E*)-4,4,6-trimethyl-2-(3-phenylprop-1-en-1-yl)-1,3,2-dioxaborinane **2ac** (48.9 mg, 0.20 mmol). The reaction mixture was purified by column chromatography on silica gel (petroleum ether) to yield the product **61** as a colorless oil (31.6 mg, 65% yield, 89% ee).

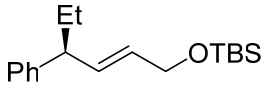
HPLC analysis: Chiralcel OJ-3 (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.8 mL/min, λ = 214 nm), t_R(major) = 12.31 min, t_R(minor) = 18.60 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.35 – 7.23 (m, 4H), 7.22 – 7.12 (m, 6H), 5.73 – 5.48 (m, 2H), 3.35 (d, *J* = 5.9 Hz, 2H), 3.14 (q, *J* = 7.3 Hz, 1H), 1.80 – 1.64 (m, 2H), 0.86 (t, *J* = 7.3 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 145.2, 141.0, 135.7, 128.8, 128.6, 128.4(9), 128.4(8), 127.7, 126.1, 126.0, 50.8, 39.2, 29.1, 12.4.

The NMR spectra were in accord with those reported in the literature.[2]

(*S*,*E*)-*tert*-Butyldimethyl((4-phenylhex-2-en-1-yl)oxy)silane (62)



62

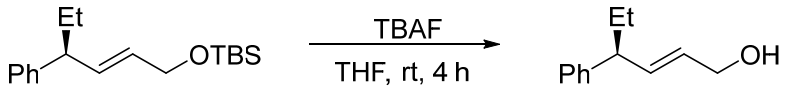
According to the **general procedure B** with 4,4,5,5-tetramethyl-2-(1-phenylpropyl)-1,3,2-dioxaborolane **1b** (73.8 mg, 0.30 mmo) and (*E*)-tert-butyldimethyl((3-(4,4,6-trimethyl-1,3,2-dioxaborinan-2-yl)allyl)oxy)silane **2ad** (56.9 mg, 0.20 mmo). The reaction mixture was purified by column chromatography on silica gel (petroleum ether) to yield the product **62** as a colorless oil (34.4 mg, 60% yield, 90% ee).

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.47 – 7.34 (m, 2H), 7.33 – 7.22 (m, 3H), 6.06 – 5.79 (m, 1H), 5.79 – 5.56 (m, 1H), 4.36 – 4.22 (m, 2H), 3.25 (q, *J* = 7.5 Hz, 1H), 1.96 – 1.76 (m, 2H), 1.00 (s, 9H), 0.96 (t, *J* = 7.4 Hz, 3H), 0.15 (s, 6H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.8, 134.6, 129.2, 128.5, 127.8, 126.2, 64.1, 50.4, 28.9, 26.1, 18.6, 12.3, –4.9.

The NMR spectra were in accord with those reported in the literature.[2]

Note: The ee value (90%) of product ***62*** *was determined by chiral HPLC analysis of* ***(S,E)*****-4-phenylhex-2-en-1-ol (62′)***, which was obtained by transformation of product* ***62***.



62 **62'**

Under an argon atmosphere, to a solution of product **62** (29.1 mg, 0.10 mmol) in anhydrous THF (2.0 mL) was added tetrabutylammonium fluoride (TBAF, 0.20 mL, 2.0 equiv, 1.0 M in THF) at an ice water bath. The reaction mixture was allowed to stir at room temperature for 4 h, and then quenched with water. The reaction mixture was extracted with EtOAc three times. The organic layers were combined and dried over anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure. The crudeproduct was purified by flash chromatography on silica gel using petroleum ether/ EtOAc = 20/1 as eluent to provide the product **62′** as a colorless oil (12.9 mg, 73% yield, 90% ee).

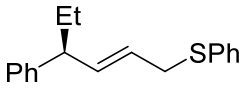
HPLC analysis: Chiralcel OJ-3 (*n*-hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 214 nm), t_R(major) = 25.66 min, t_R(minor) = 27.92 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.35 – 7.26 (m, 2H), 7.24 – 7.13 (m, 3H), 5.95 – 5.75 (m, 1H), 5.70 – 5.52 (m, 1H), 4.10 (d, *J* = 5.7 Hz, 2H), 3.15 (q, *J* = 7.5 Hz, 1H), 1.82 – 1.67 (m, 2H), 0.86 (t, *J* = 7.4 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.5, 136.6, 128.8, 128.6, 127.7, 126.3, 63.8, 50.5, 28.7, 12.3.

The NMR spectra were in accord with those reported in the literature.[2]

(*S,E*)-Phenyl(4-phenylhex-2-en-1-yl)sulfane (63)



63

According to the **general procedure B** with 4,4,5,5-tetramethyl-2-(1-phenylpropyl)-1,3,2-dioxaborolane **1b** (73.8 mg, 0.30 mmol) and (*E*)-4,4,6-trimethyl-2-(3-(phenylthio)prop-1-en-1-yl)-1,3,2-dioxaborinane **2ae** (55.3 mg, 0.20 mmol). The

reaction mixture was purified by column chromatography on silica gel (petroleum ether) to yield the product **63** as a colorless oil (51.7 mg, 94% yield, 87% ee).

HPLC analysis: Chiralcel OJ-3 (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.8 mL/min, λ = 254 nm), t_R(major) = 18.48 min, t_R(minor) = 27.11 min.

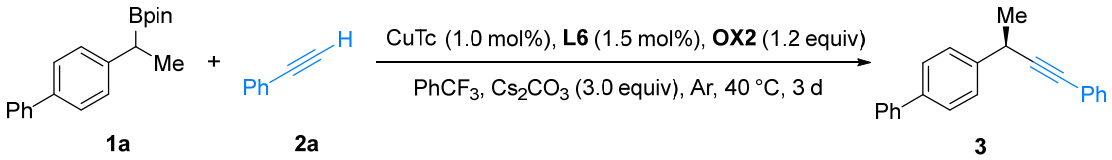
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.34 – 7.12 (m, 8H), 7.09 – 7.03 (m, 2H), 5.72 – 5.34 (m, 2H), 3.62 – 3.40 (m, 2H), 3.07 (q, *J* = 7.4 Hz, 1H), 1.75 – 1.57 (m, 2H), 0.76 (t, *J* = 7.4 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 144.5, 137.7, 135.9, 130.5, 128.8, 128.5, 127.7, 126.4, 126.2, 125.1, 50.4, 36.8, 28.6, 12.2.

The NMR spectra were in accord with those reported in the literature.[2]

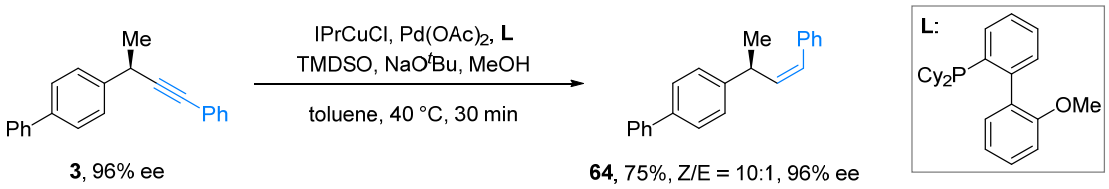
Synthetic utility

Gram-scale reaction



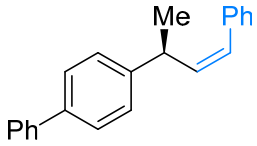
CuTc (7.64 mg, 0.04 mmol, 1.0 mol%), chiral ligand **L6** (44.16 mg, 0.06 mmol, 1.5 mol%), Cs_2CO_3 (3.84 g, 12.0 mmol, 3.0 equiv), and anhydrous $PhCF_3$ (80 mL) were sequentially added to an oven-dried flask equipped with a magnetic stir bar under argon atmosphere. After stirring at rt for 2 h, racemic benzylboronic esters **1a** (1.23 g, 4.0 mmol, 1.0 equiv), ethynylbenzene **2a** (0.53 mL, 4.80 mmol, 1.2 equiv), and **OX2** (1.14 g, 4.80 mmol, 1.20 equiv) were sequentially added into the mixture under argon. The flask was sealed, and the reaction mixture was allowed to stir at 40 °C for 3 d. Upon completion of the reaction (monitored by TLC), the mixture was then filtered through a pad of celite and rinsed with EtOAc. The filtrate was evaporated, and the residue was purified by column chromatography on silica gel to afford the desired product **3** (0.96 g, 85% yield, 96% ee) as a white solid.

Synthesis of 64



To a flamed Schlenk tube charged with a stir bar were added NaO^{t}Bu (38.4 mg, 0.40 mmol, 2.0 equiv), **3** (56.4 mg, 0.20 mmol, 1.0 equiv, 96% ee), $Pd(OAc)_2$ (2.24 mg, 0.010 mmol, 5.0 mol%), **L** (7.6 mg, 0.020 mmol, 10 mol%), IPrCuCl (9.76 mg, 0.020 mmol, 10 mol%), TMDSO (1,1,3,3-tetramethyldisiloxane) (53.6 mg, 0.40 mmol, 2.0 equiv), MeOH (19.2 mg, 0.6 mmol, 3.0 equiv), and toluene (2.0 mL). The reaction mixture was stirred at 40 °C for 30 min. Upon completion, the reaction mixture was filtered through a short plug of silica gel eluted with EtOAc and purified by column chromatography on silica gel (petroleum ether/EtOAc = 100/1) to afford **64** as a white solid (42.7mg, 75% yield, Z/E = 10:1, 96% ee).

(*S*,*Z*)-4-(4-phenylbut-3-en-2-yl)-1,1'-biphenyl (64)



64

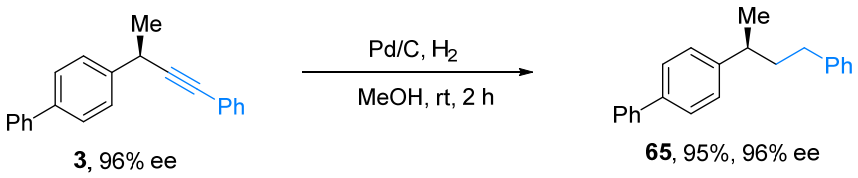
HPLC analysis: Chiralcel OD3 (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.8 mL/min, λ = 254 nm), t_R(major) = 6.20 min, t_R(minor) = 6.57 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.60 – 7.52 (m, 4H), 7.45 – 7.39 (m, 2H), 7.36 – 7.32 (m, 4H), 7.31 – 7.22 (m, 4H), 6.51 (d, *J* = 11.5 Hz, 1H), 5.86 (dd, *J* = 11.5, 10.4 Hz, 1H), 4.06 (dq, *J* = 11.5, 6.9 Hz, 1H), 1.43 (d, *J* = 6.9 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 145.4, 141.1, 139.2, 137.5, 137.0, 128.9, 128.8, 128.4, 128.1, 127.5, 127.4, 127.2(0), 127.1(6), 126.9, 37.6, 23.0.

HRMS (ESI) *m/z* calcd. for $C_{22}H_{21}$ $[M+H]^+$ 285.1638, found: 285.1633.

Synthesis of 65

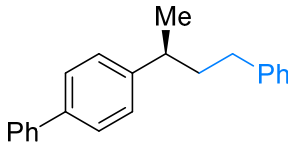


3, 96% ee

65, 95%, 96% ee

To a mixture of Pd/C (10.0 mg, 10% w/w Pd on carbon) in MeOH (2.0 mL) was added **3** (56.4 mg, 0.20 mmol, 1.0 equiv, 96% ee) under an argon atmosphere. Then, the reaction flask was evacuated and refilled with hydrogen through a balloon. The resulting reaction mixture was stirred under a hydrogen atmosphere at room temperature for 2 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 (petroleum ether/EtOAc = 100/1) to afford **65** as a colorless oil (54.5 mg, 95% yield, 96% ee).

(*S*)-4-(4-phenylbutan-2-yl)-1,1'-biphenyl (65)



65

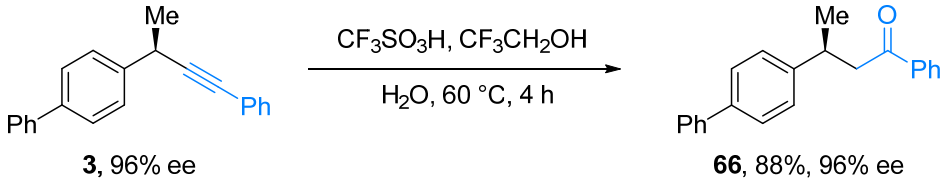
HPLC analysis: Chiralcel OD3 (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.8 mL/min, λ = 254 nm), t_R(minor) = 7.64 min, t_R(major) = 10.07 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.62 – 7.56 (m, 2H), 7.56 – 7.51 (m, 2H), 7.44 – 7.37 (m, 2H), 7.34 – 7.21 (m, 5H), 7.18 – 7.11 (m, 3H), 2.81 – 2.69 (m, 1H), 2.60 – 2.48 (m, 2H), 2.02 – 1.85 (m, 2H), 1.30 (d, *J* = 6.9 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 146.5, 142.6, 141.2, 139.0, 128.8, 128.5, 128.4, 127.6, 127.3, 127.1, 125.8, 40.1, 39.3, 34.1, 22.6.

HRMS (APCI) *m/z* calcd. for $C_{22}H_{23}$ $[M+H]^+$ 287.1794, found: 287.1788.

Synthesis of 66

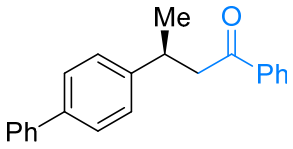


3, 96% ee

66, 88%, 96% ee

To a solution of **3** (56.4 mg, 0.20 mmol, 1.0 equiv, 96% ee) in CF_3CH_2OH (1.0 mL) were added CF_3SO_3H (6.0 mg, 0.04 mmol, 0.2 equiv) and H_2O (7.2 mg, 0.4 mmol, 2.0 equiv). The reaction mixture was stirred at 60 °C for 4 h. After evaporation under reduced pressure, the residue was purified with column chromatography on silica gel (petroleum ether/EtOAc = 20/1) to yield the product **66** as a white solid (52.9 mg, 88% yield, 96% ee).

(*S*)-3-([1,1'-biphenyl]-4-yl)-1-phenylbutan-1-one (66)



66

HPLC analysis: Chiralcel IA (*n*-hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min, λ = 254 nm), t_R(major) = 9.45 min, t_R(minor) = 13.43 min.

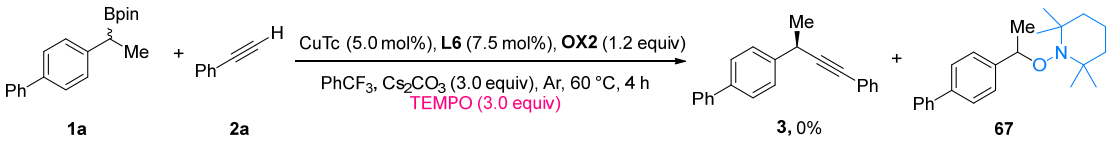
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.97 – 7.87 (m, 2H), 7.59 – 7.48 (m, 5H), 7.45 – 7.36 (m, 4H), 7.35 – 7.27 (m, 3H), 3.62 – 3.50 (m, 1H), 3.32 (dd, *J* = 16.6, 5.8 Hz, 1H), 3.20 (dd, *J* = 16.6, 8.1 Hz, 1H), 1.36 (d, *J* = 6.9 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 199.1, 145.8, 141.0, 139.3, 137.2, 133.1, 128.8, 128.7, 128.2, 127.4, 127.3, 127.2, 127.1, 47.0, 35.3, 22.0.

HRMS (ESI) *m/z* calcd. for $C_{22}H_{21}O$ $[M+H]^+$ 301.1587, found: 301.1583.

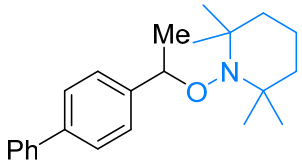
Mechanistic study

Control experiment with TEMPO



Under argon atmosphere, an oven-dried resealable Schlenk tube equipped with a magnetic stir bar was charged with 2-(1-([1,1'-biphenyl]-4-yl)ethyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane **1a** (61.6 mg, 0.20 mmol, 1.0 equiv), ethynylbenzene **2a** (26.4 μL, 0.24 mmol, 1.2 equiv), CuTc (1.91 mg, 0.010 mmol, 5.0 mol%), chiral ligand **L6** (11.05 mg, 0.015 mmol, 7.5 mol%), **OX2** (57.0 mg, 0.24 mmol, 1.2 equiv), Cs_2CO_3 (192.0 mg, 0.60 mmol, 3.0 equiv), (2,2,6,6 tetramethylpiperidin-1-yl)oxyl (TEMPO) (93.6 mg, 0.60 mmol, 3.0 equiv) and $PhCF_3$ (4.0 mL). The resulting reaction mixture was stirred at 60 °C for 4 h. Upon completion, the reaction was filtered through a pad of celite and rinsed with EtOAc. The filtrate was concentrated and the residue was purified by column chromatography on silica gel to afford **67** (37.6 mg, 56% yield). No product **3** was observed.

1-(1-([1,1'-Biphenyl]-4-yl)ethoxy)-2,2,6,6-tetramethylpiperidine (67)



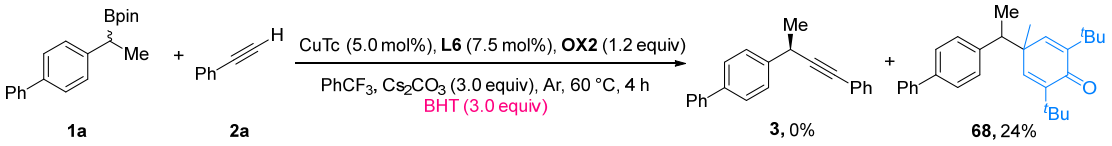
67

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.63 – 7.57 (m, 2H), 7.56 – 7.52 (m, 2H), 7.46 – 7.35 (m, 4H), 7.34 – 7.28 (m, 1H), 4.83 (q, J = 6.7 Hz, 1H), 1.61 – 1.45 (m, 6H), 1.43 – 1.25 (m, 6H), 1.18 (s, 3H), 1.05 (s, 3H), 0.72 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 145.0, 141.2, 139.7, 128.8, 127.18, 127.16, 127.1, 126.9, 82.9, 59.8, 40.5, 34.6, 34.4, 23.7, 20.5, 17.4.

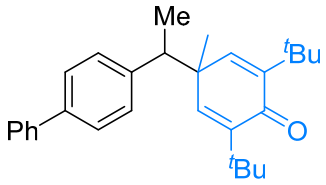
HRMS (ESI) *m/z* calcd. for $C_{23}H_{32}NO$ $[M+H]^+$ 338.2478, found: 338.2465.

Control experiment with BHT



Under argon atmosphere, an oven-dried resealable Schlenk tube equipped with a magnetic stir bar was charged with 2-(1-([1,1'-biphenyl]-4-yl)ethyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane **1a** (61.6 mg, 0.20 mmol, 1.0 equiv), ethynylbenzene **2a** (26.4 μL, 0.24 mmol, 1.2 equiv), CuTc (1.91 mg, 0.010 mmol, 5.0 mol%), chiral ligand **L6** (11.05 mg, 0.015 mmol, 7.5 mol%), **OX2** (57.0 mg, 0.24 mmol, 1.20 equiv), Cs_2CO_3 (192.0 mg, 0.60 mmol, 3.0 equiv), butylated hydroxytoluene (BHT) (132.2 mg, 0.60 mmol, 3.0 equiv) and $PhCF_3$ (4.0 mL). The resulting reaction mixture was stirred at 60 °C for 4 h. Upon completion, the reaction was filtered through a pad of celite and rinsed with EtOAc. The filtrate was concentrated and the residue was purified by column chromatography on silica gel to afford **68** (19.3 mg, 24% yield) with a trace amount of impurities. No product **3** was observed.

4-(1-([1,1'-Biphenyl]-4-yl)ethyl)-2,6-di-*tert*-butyl-4-methylcyclohexa-2,5-dien-1-one (68)



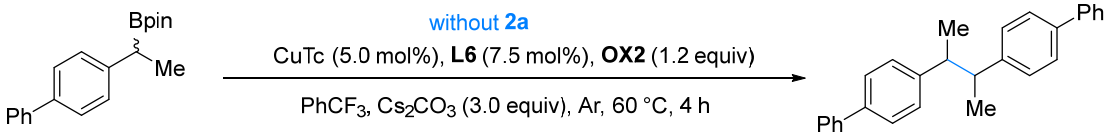
68

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.59 – 7.53 (m, 2H), 7.51 – 7.47 (m, 2H), 7.44 – 7.41 (m, 2H), 7.36 – 7.29 (m, 1H), 7.16 (d, J = 7.9 Hz, 2H), 6.58 (d, J = 2.8 Hz, 1H), 6.41 (d, J = 2.9 Hz, 1H), 2.95 (q, J = 7.1 Hz, 1H), 1.26 (s, 9H), 1.23 (d, J = 6.8 Hz, 3H), 1.17 (s, 3H), 1.16 (s, 9H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 186.5, 147.1, 146.9, 145.7, 144.9, 141.4, 141.0, 139.8, 129.3, 128.9, 127.3, 127.1, 126.5, 49.2, 42.9, 34.9, 30.4, 29.6, 29.5, 25.1, 16.3.

HRMS (ESI) *m/z* calcd. for $C_{29}H_{37}O$ $[M+H]^+$ 401.2839; found: 401.2828.

Control experiment without alkynes

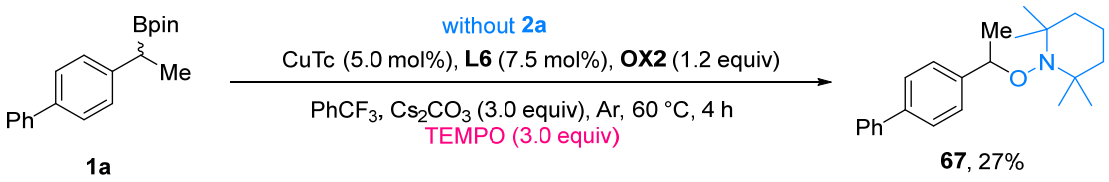


1a **69**, 10%

Under argon atmosphere, an oven-dried resealable Schlenk tube equipped with a magnetic stir bar was charged with CuTc (1.91 mg, 0.010 mmol, 5.0 mol%), chiral ligand **L6** (11.05 mg, 0.015 mmol, 7.5 mol%), 2-(1-([1,1'-biphenyl]-4-yl)ethyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane **1a** (61.6 mg, 0.20 mmol, 1.0 equiv), **OX2** (57.0 mg, 0.24 mmol, 1.2 equiv), Cs_2CO_3 (192.0 mg, 0.60 mmol, 3.0 equiv) and $PhCF_3$ (4.0 mL). The resulting reaction mixture was stirred at 60 °C for 4 h. Upon completion, the reaction was filtered through a pad of celite and rinsed with EtOAc. The filtrate was concentrated and the residue was purified by column chromatography on silica gel to afford **69** (7.3 mg, 10% yield, *meso*/*dl* = 2:1) as a white solid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.65 – 7.60 (m, 2H), 7.60 – 7.53 (m, 4H+2H), 7.47 – 7.32 (m, 6H+3H), 7.36 – 7.27 (m, 2H+2H), 7.17 – 7.05 (m, 2H+2H), 3.10 – 3.00 (m, 2H), 2.93 – 2.85 (m, 1H), 1.33 (d, J = 6.1 Hz, 6H), 1.11 (d, J = 6.2 Hz, 3H).

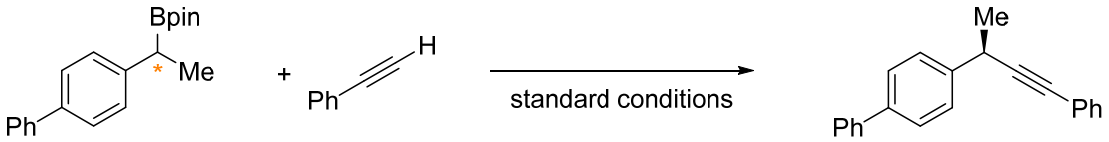
The spectroscopic data matches the previously reported data.[10]



1a **67**, 27%

Under argon atmosphere, an oven-dried resealable Schlenk tube equipped with a magnetic stir bar was charged with 2-(1-([1,1'-biphenyl]-4-yl)ethyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane **1a** (61.6 mg, 0.20 mmol, 1.0 equiv), CuTc (1.91 mg, 0.010 mmol, 5.0 mol%), chiral ligand **L6** (11.05 mg, 0.015 mmol, 7.5 mol%), **OX2** (57.0 mg, 0.24 mmol, 1.2 equiv), Cs_2CO_3 (192.0 mg, 0.60 mmol, 3.0 equiv), (2,2,6,6 tetramethylpiperidin-1-yl)oxyl (TEMPO) (93.6 mg, 0.60 mmol, 3.0 equiv) and $PhCF_3$ (4.0 mL). The resulting reaction mixture was stirred at 60 °C for 4 h. Upon completion, the reaction was filtered through a pad of celite and rinsed with EtOAc. The filtrate was concentrated and the residue was purified by column chromatography on silica gel to afford **67** (18.2 mg, 27% yield).

Experiments with enantioenriched benzylboronic esters



(*R*)-**1a**, 90% ee
(*S*)-**1a**, 96% ee

2a

3, 96%, 97% ee
3, 94%, 97% ee

According to **General procedure A** with ***R***- or ***S*-1a** (30.8 mg, 0.10 mmol), ethynylbenzene **2a** (13.2 μL, 0.12 mmol) at 60 °C for 4 h. Upon completion, the reaction mixture was filtered and washed by EtOAc. After evaporation, the thus-obtained residue was analyzed by ^{1}H NMR spectroscopy using 1,3,5-trimethybenzene as an internal standard. The product was then separated by preparative TLC. The ee values of **3** were determined by chiral HPLC analysis.

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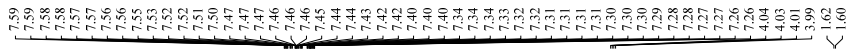
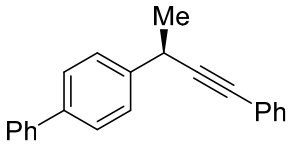
NMR Spectra





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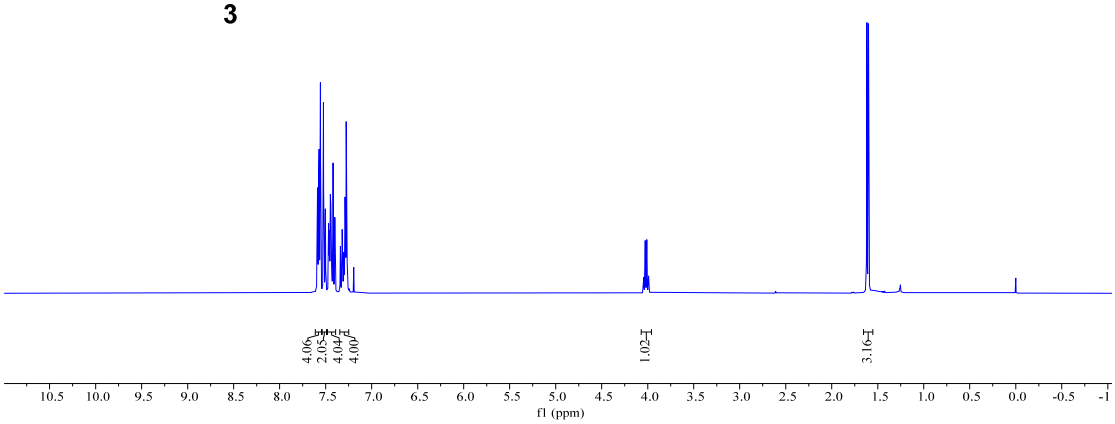

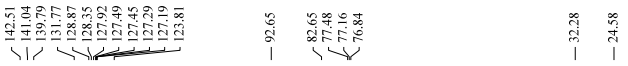

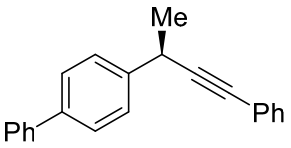

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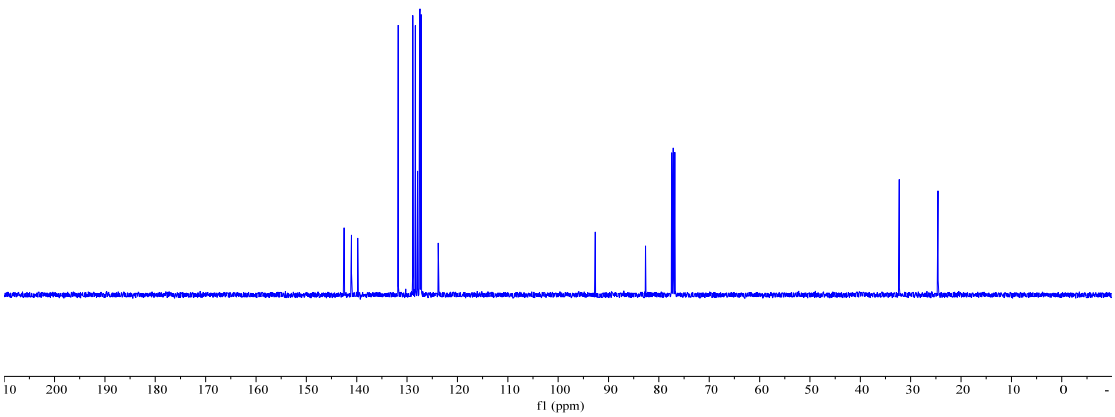


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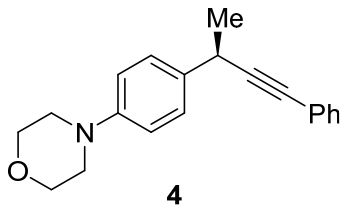
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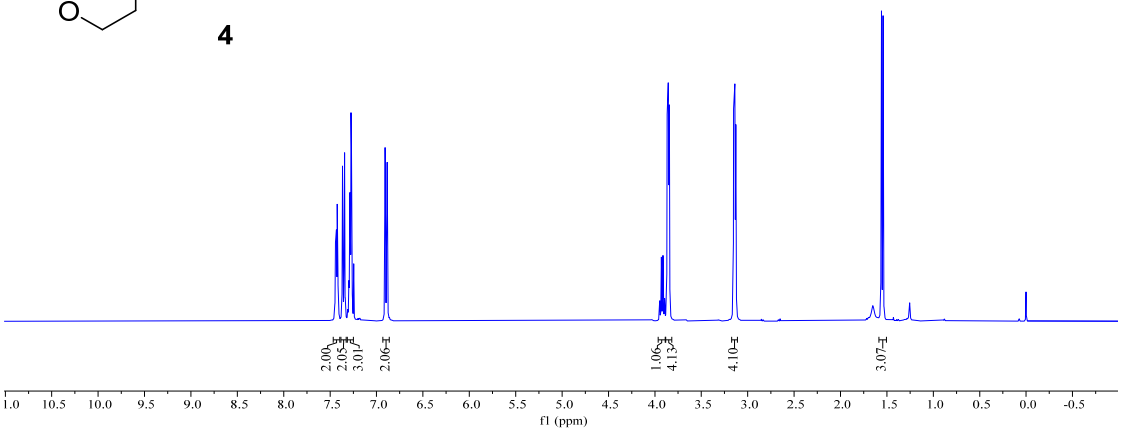
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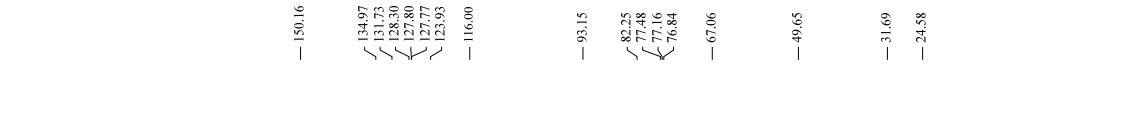
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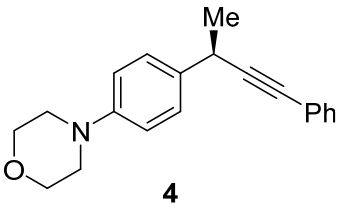
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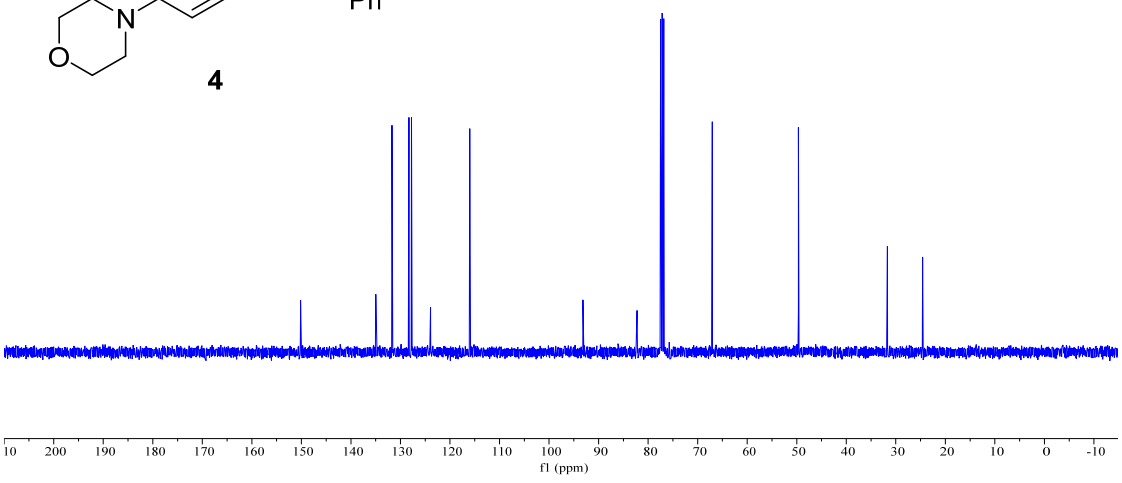
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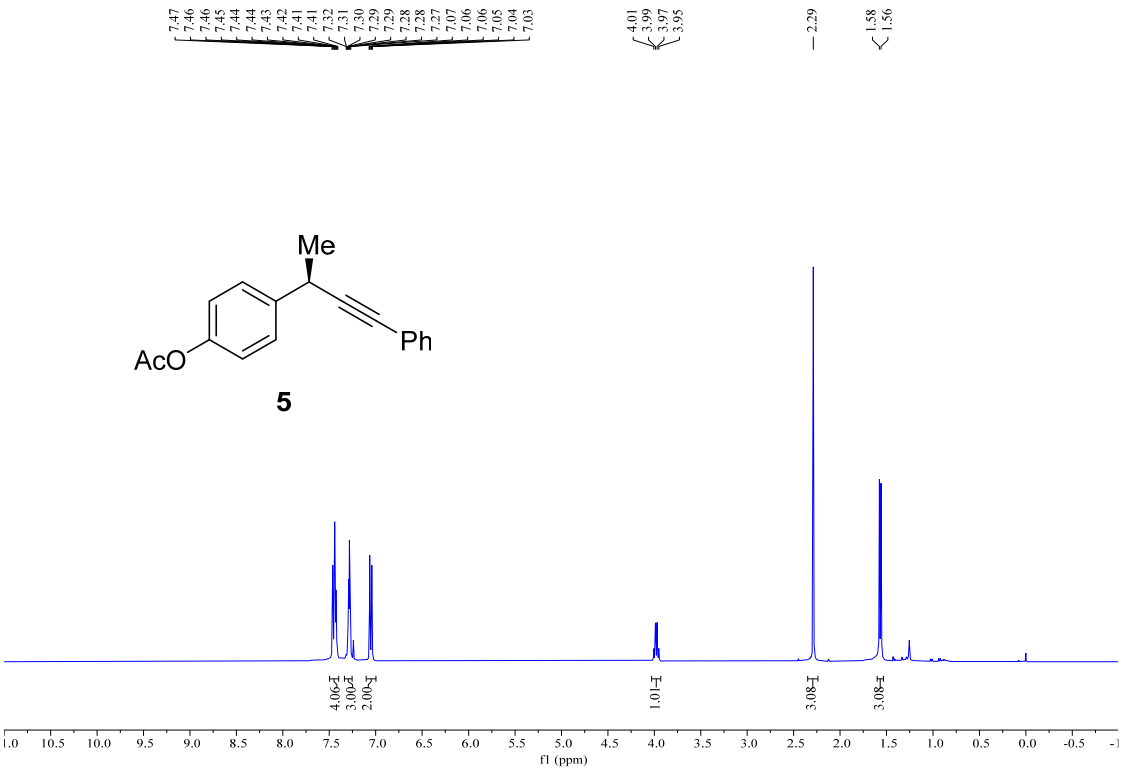
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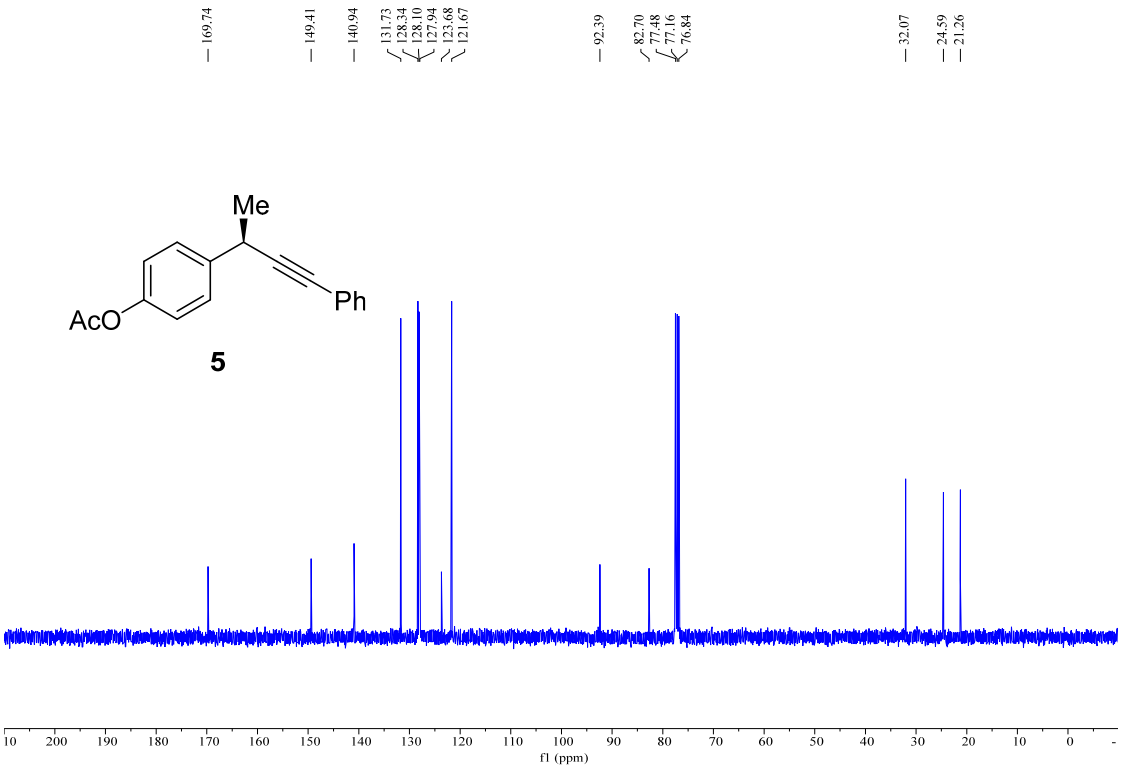
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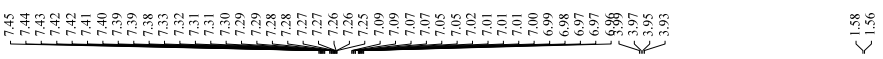
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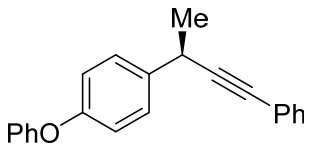
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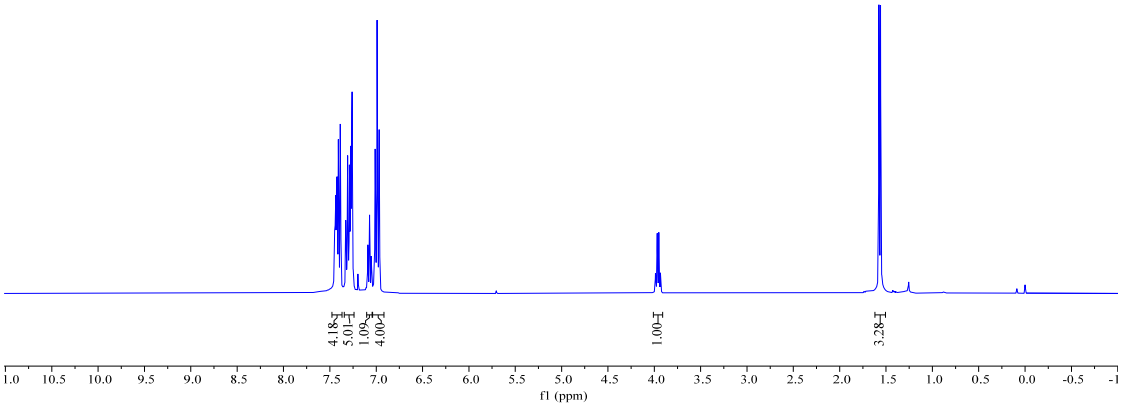
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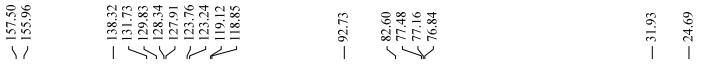
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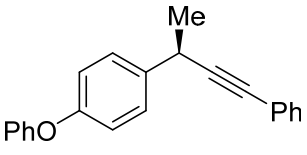
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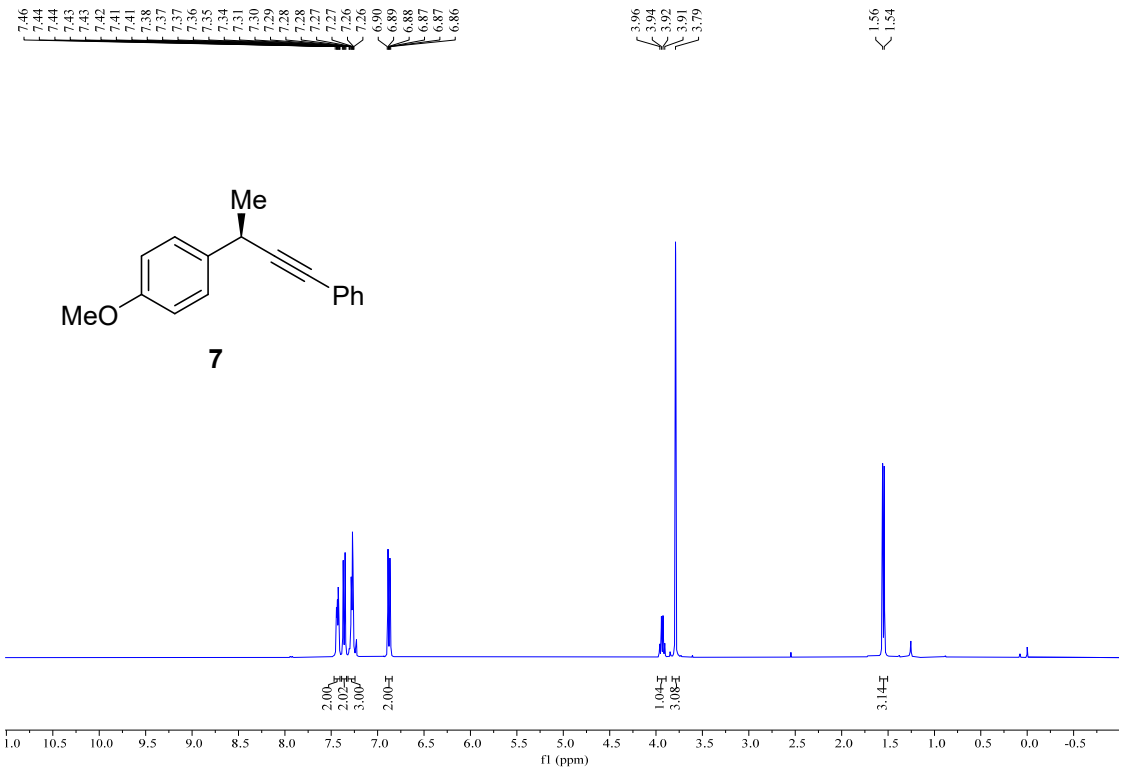
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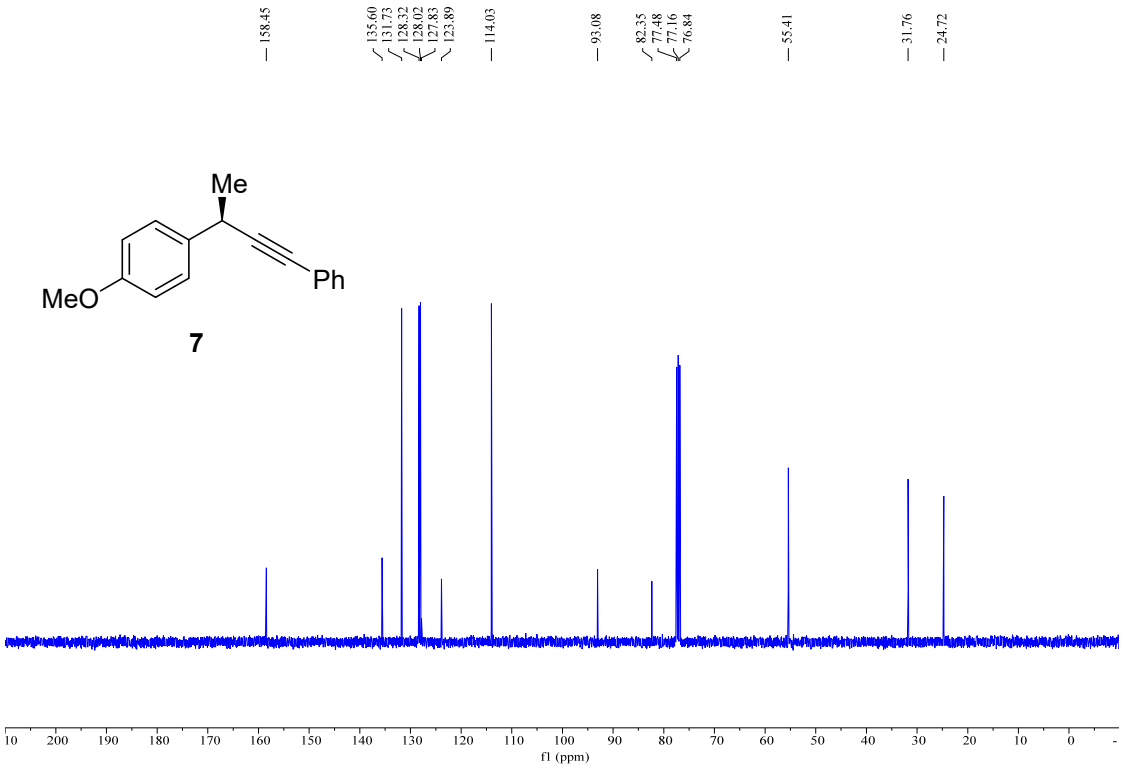
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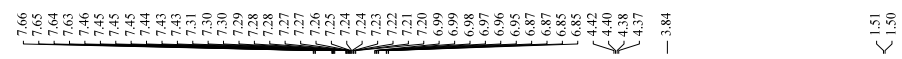
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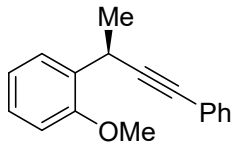
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Ph
OMe

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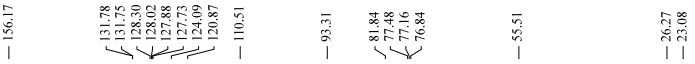
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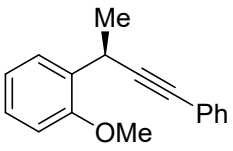
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OMe

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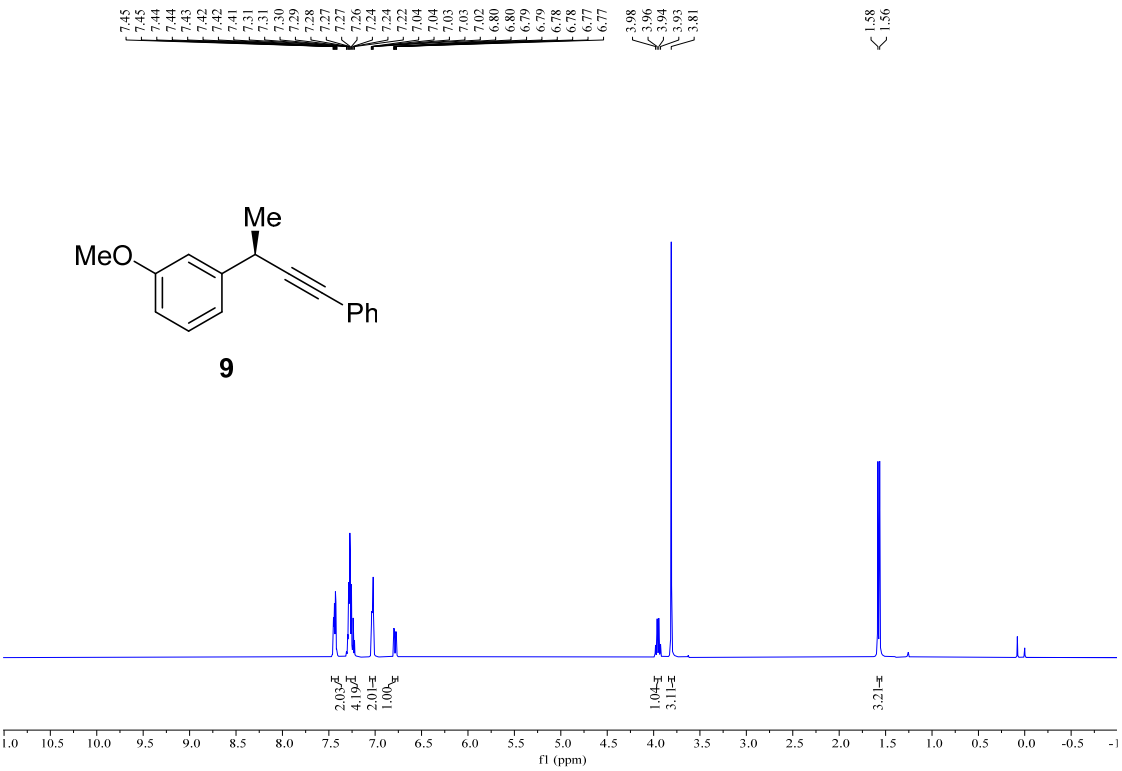
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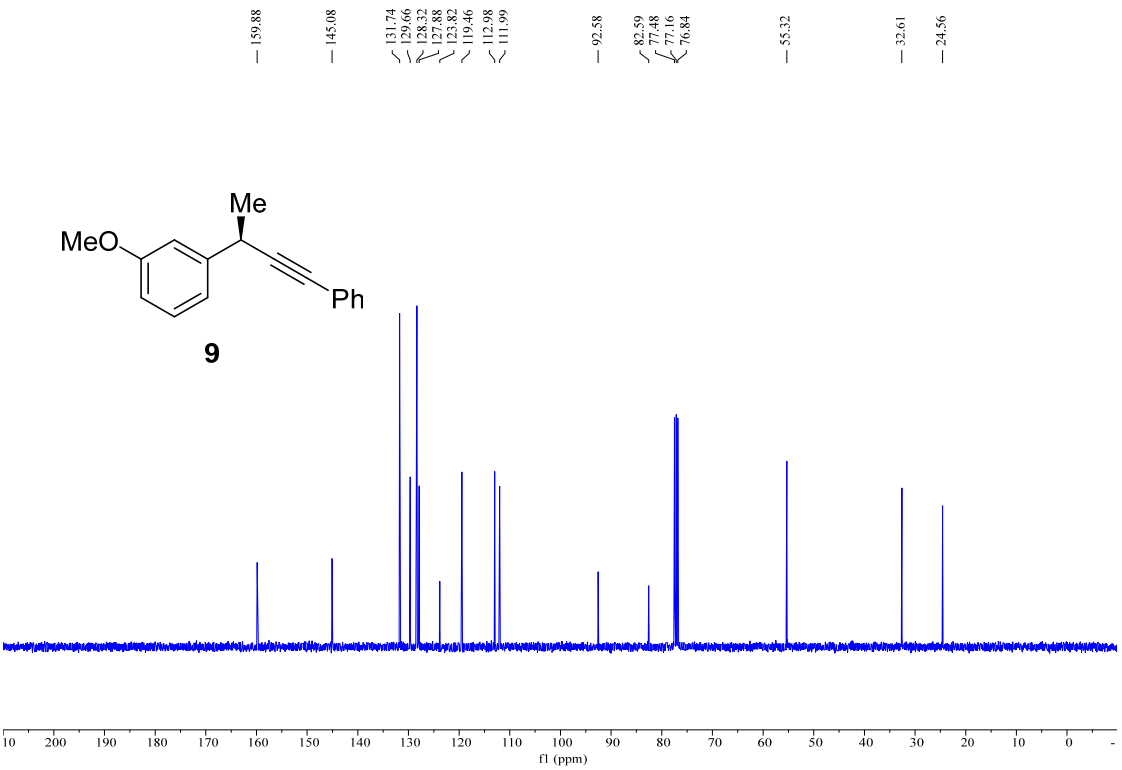
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Me
MeO
Ph
9
fl (ppm)


7.46
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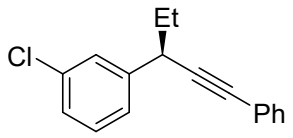
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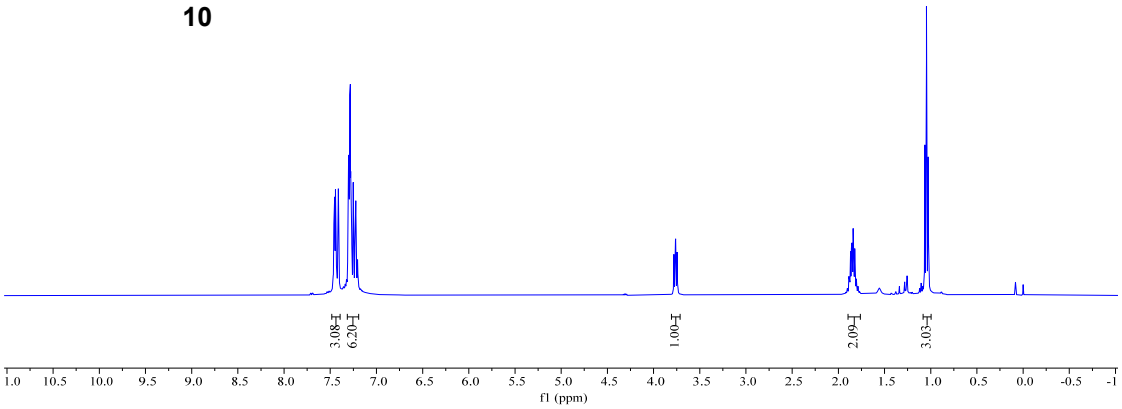
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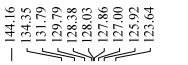
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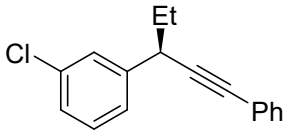
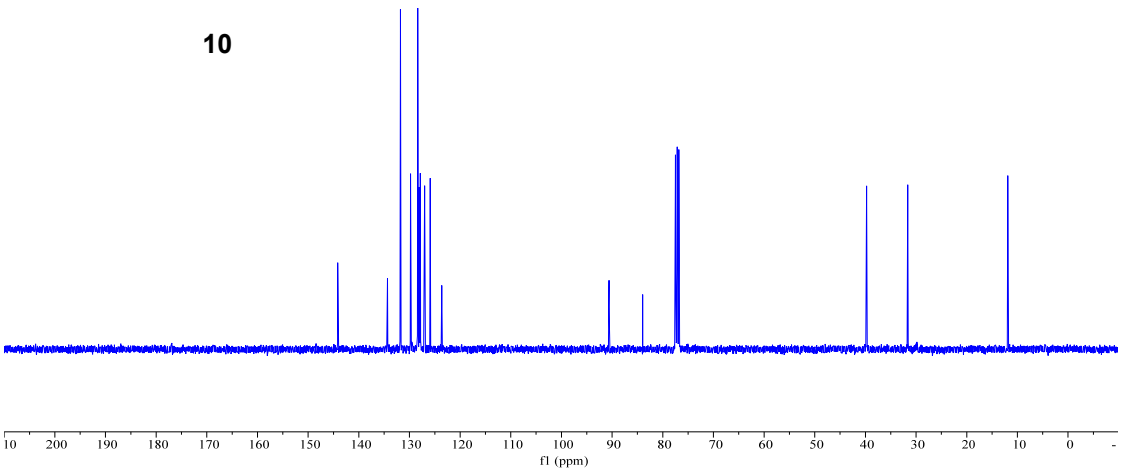
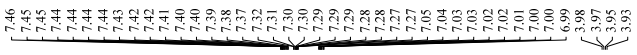

Et
Cl
Ph

10


10 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -
f1 (ppm)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7.45
7.44
7.44
7.44
7.44
7.43
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7.41
7.40
7.40
7.39
7.38
7.37
7.32
7.31
7.30
7.30
7.29
7.29
7.29
7.28
7.28
7.27
7.27
7.05
7.04
7.03
7.03
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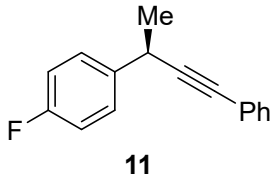
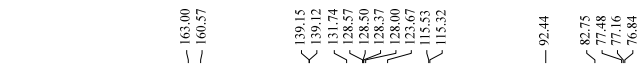
3.97
3.95
3.93
1.56
1.54


Me
F
Ph

11

4.04
3.02
2.00
1.01
3.13
1.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1
f1 (ppm)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128.57
128.50
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128.00
123.67
115.55
115.32
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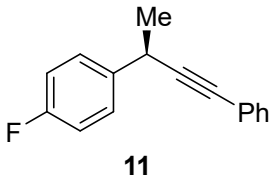
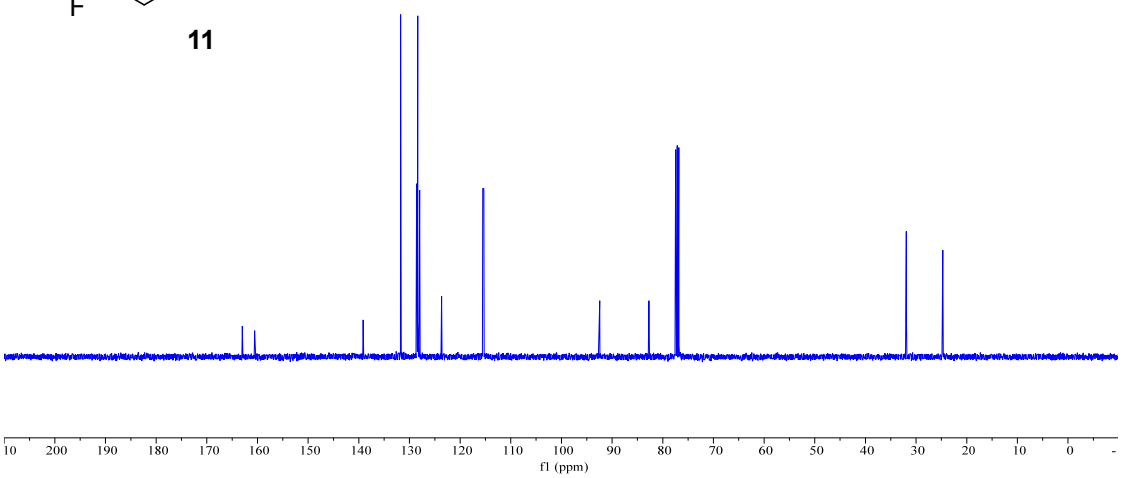
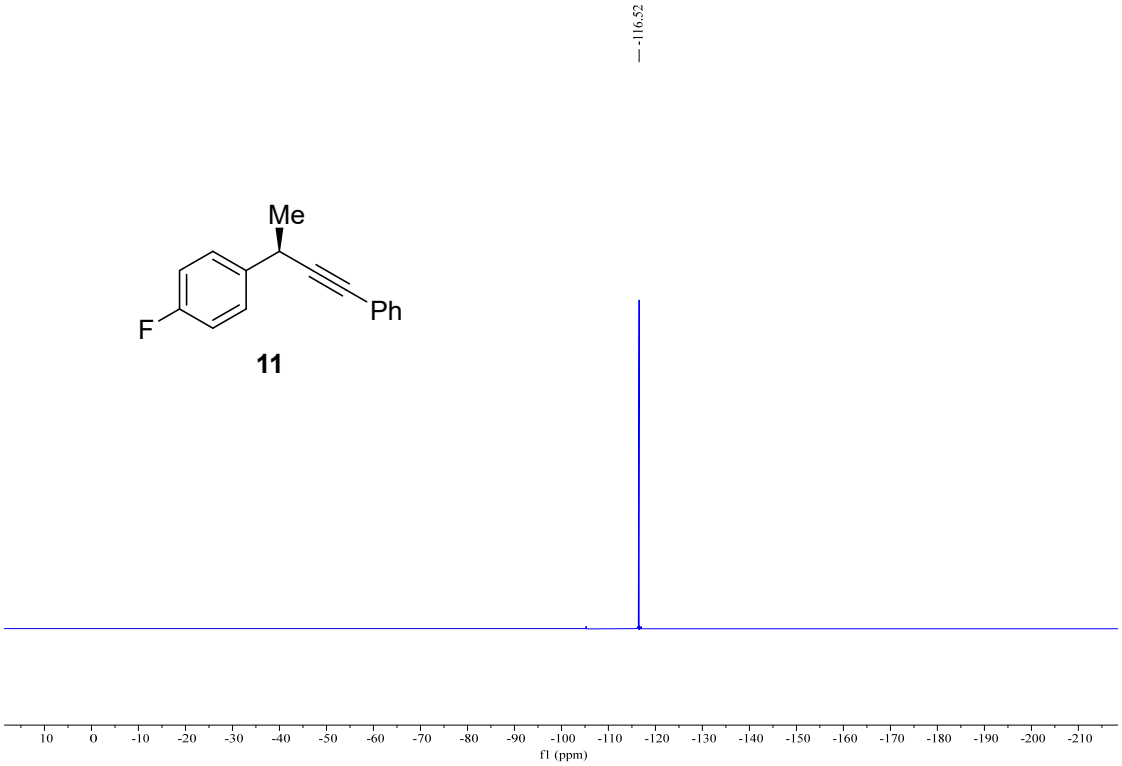
82.75
77.48
77.16
76.84
31.92
24.72

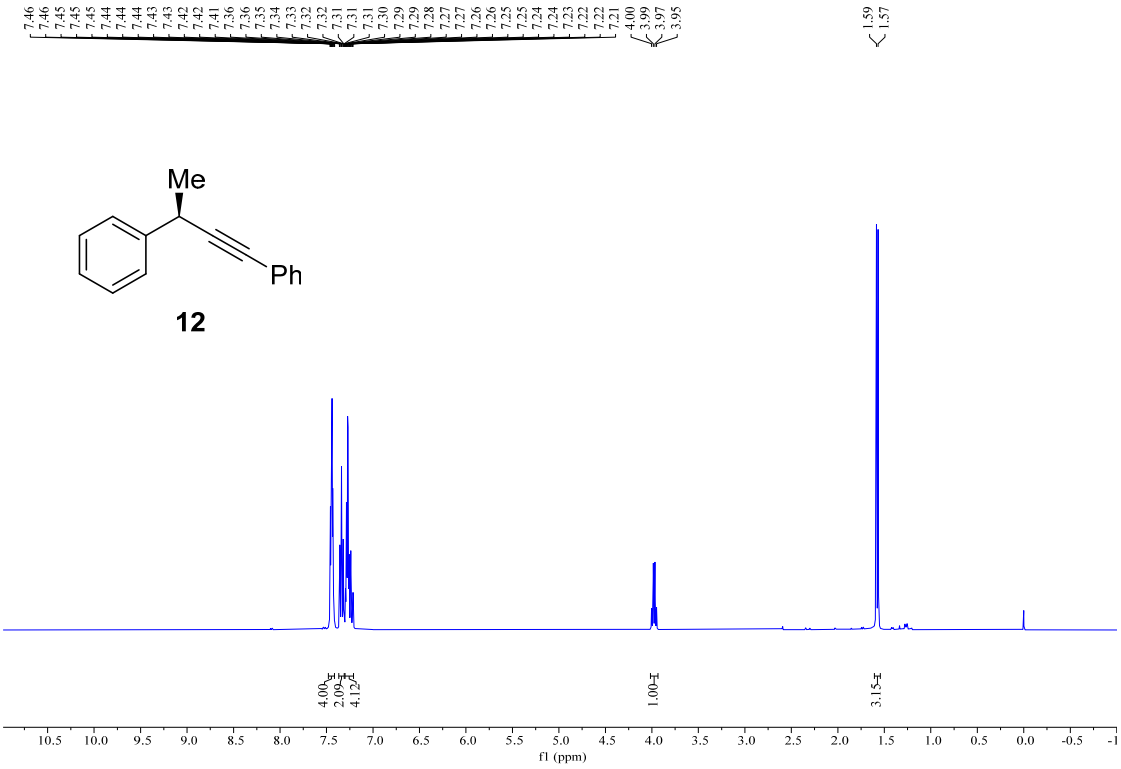

Me
F
Ph

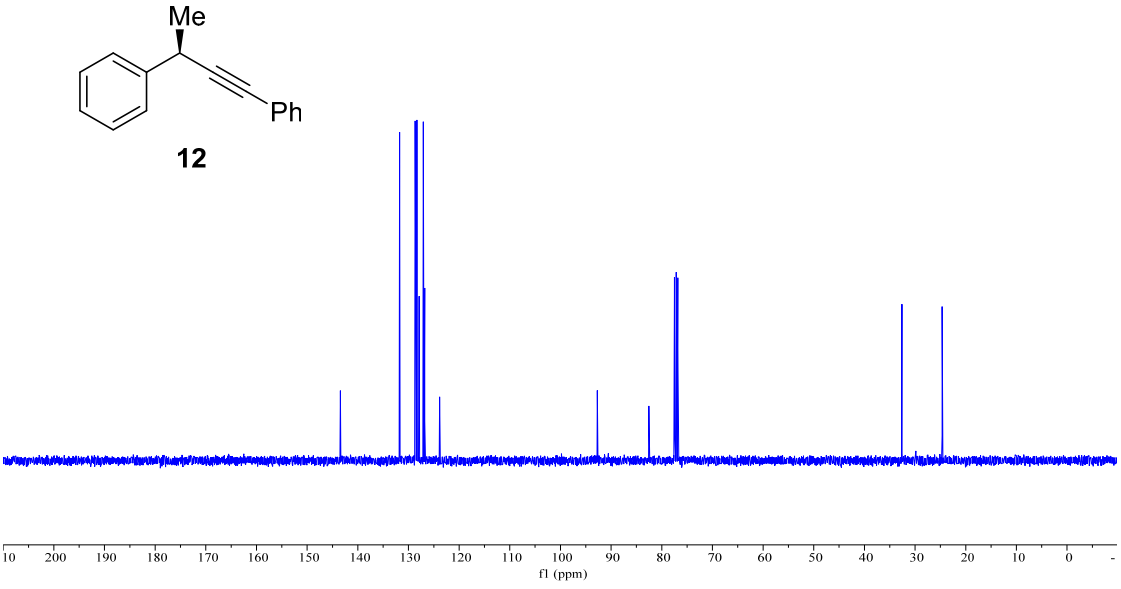
11

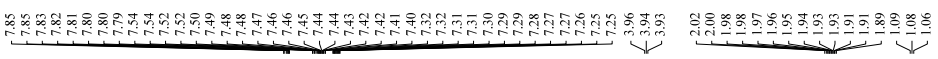

10 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -
f1 (ppm)


-116.52
Me
F
Ph
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)

11


Me
Ph
12
4.00
2.09
4.12
1.00
3.15
fl (ppm)


Me
Ph
12
fl (ppm)


7.85
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7.83
7.82
7.81
7.80
7.80
7.79
7.54
7.54
7.52
7.52
7.50
7.49
7.48
7.48
7.47
7.46
7.46
7.45
7.44
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7.40
7.32
7.32
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7.31
7.30
7.29
7.29
7.28
7.27
7.27
7.26
7.25
7.25
3.96
3.94
3.93
2.02
2.00
1.98
1.98
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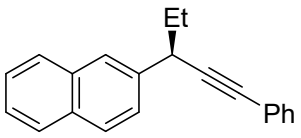
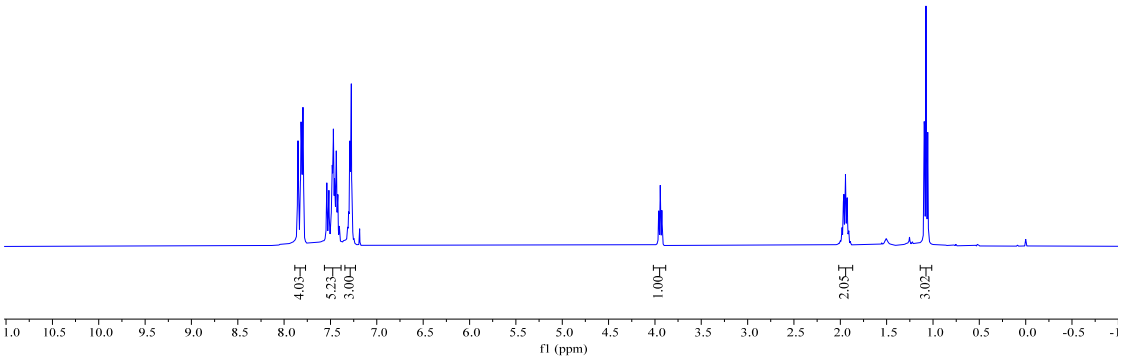
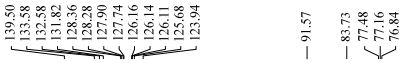
1.91
1.91
1.89
1.09
1.08
1.06


Et
Ph

13


4.03
5.23
3.00
1.00
2.05
3.02
1.0
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)


139.50
133.58
132.58
131.82
128.36
128.28
127.90
127.74
126.16
126.14
126.11
125.68
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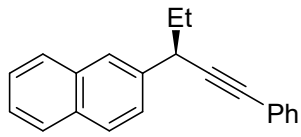
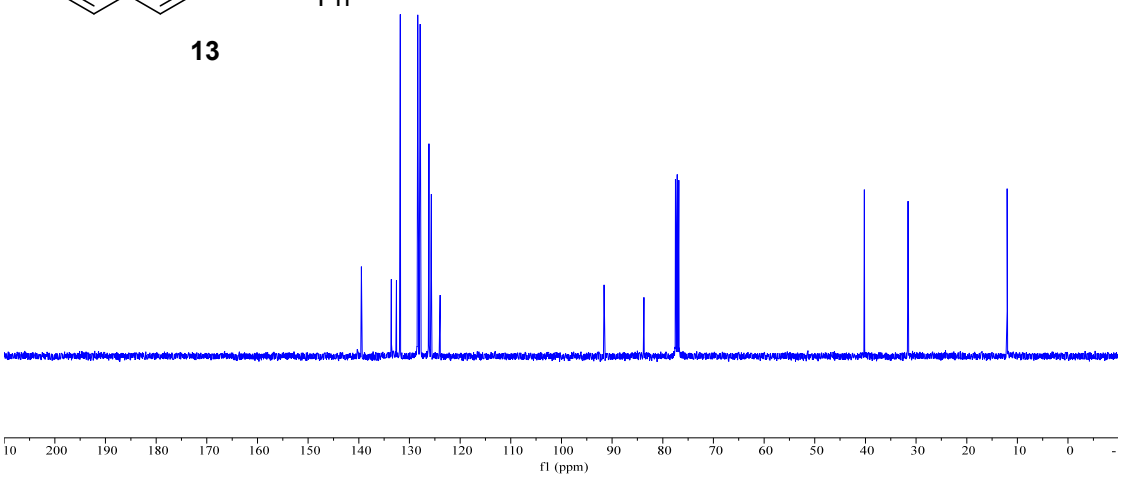
77.48
77.16
76.84
40.20
31.58
12.02


Et
Ph

13


10
200
190
180
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160
150
140
130
120
110
100
90
80
70
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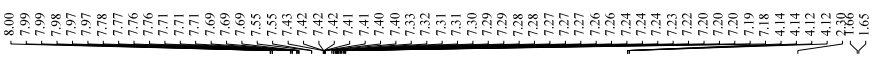
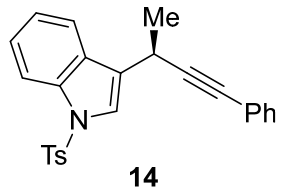
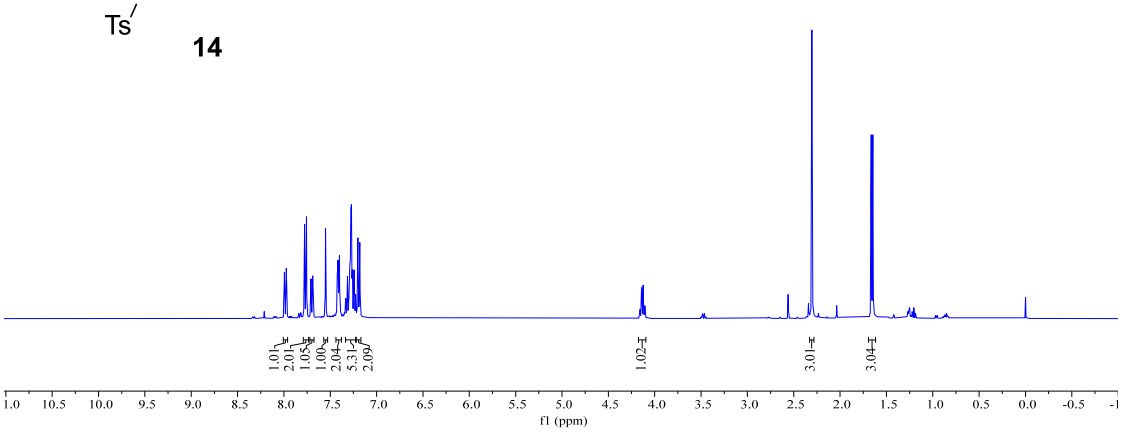
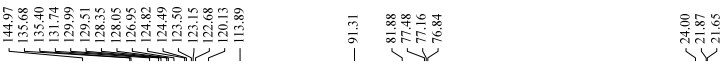
50
40
30
20
10
0
f1 (ppm)

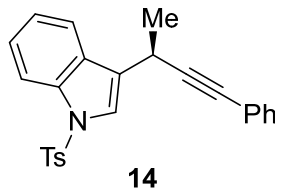



Me
Ph
N
Ts

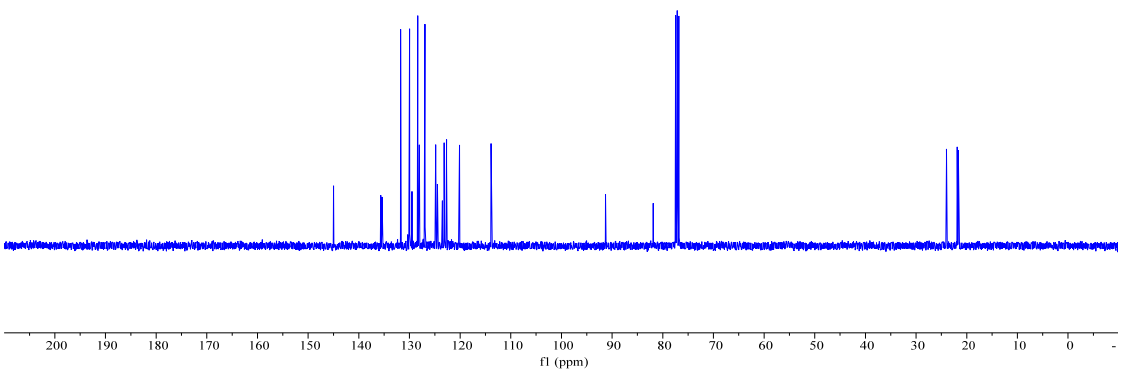
14


1.01
2.01
1.05
1.00
2.04
5.31
2.09
1.02
3.01
3.04
1.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)




Me
Ph
N
Ts

14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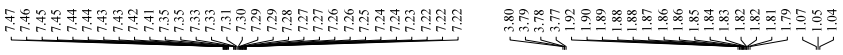
f1 (ppm)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7.28
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7.26
7.25
7.24
7.24
7.23
7.22
7.22
7.22
3.80
3.79
3.78
3.77
1.92
1.90
1.89
1.88
1.88
1.87
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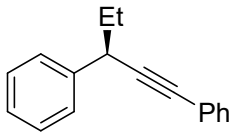
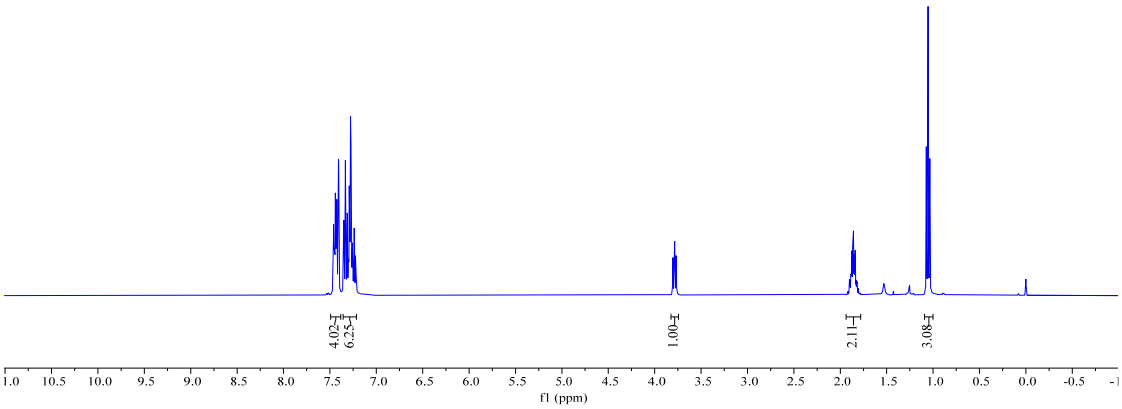
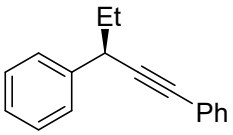
1.82
1.81
1.79
1.07
1.05
1.04


Et
Ph

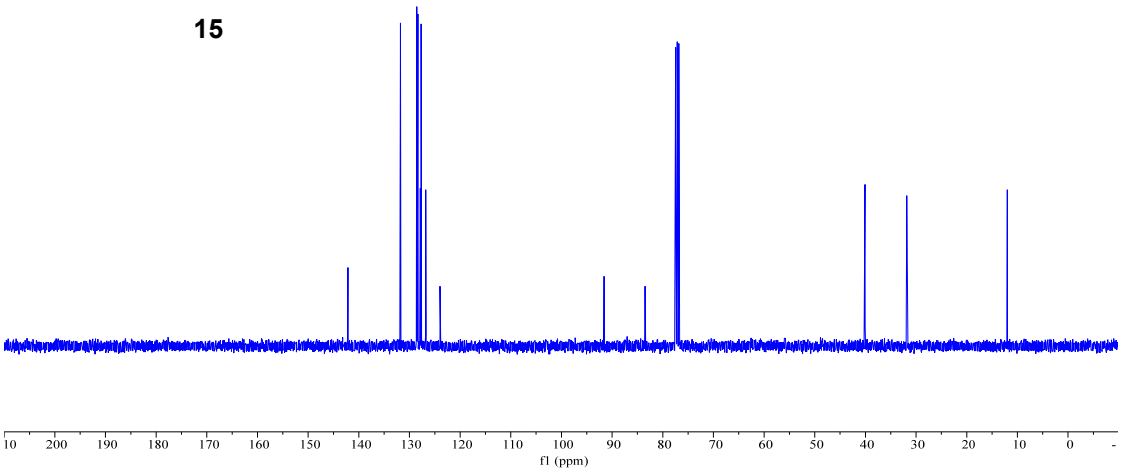
15

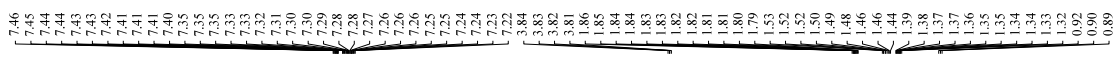

4.02
6.25
1.00
2.11
3.08
1.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

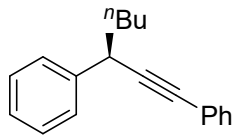

142.14
131.78
128.55
128.33
127.84
127.69
126.79
123.96
91.59
83.50
77.48
77.16
76.84
40.09
31.82
12.00


Et
Ph

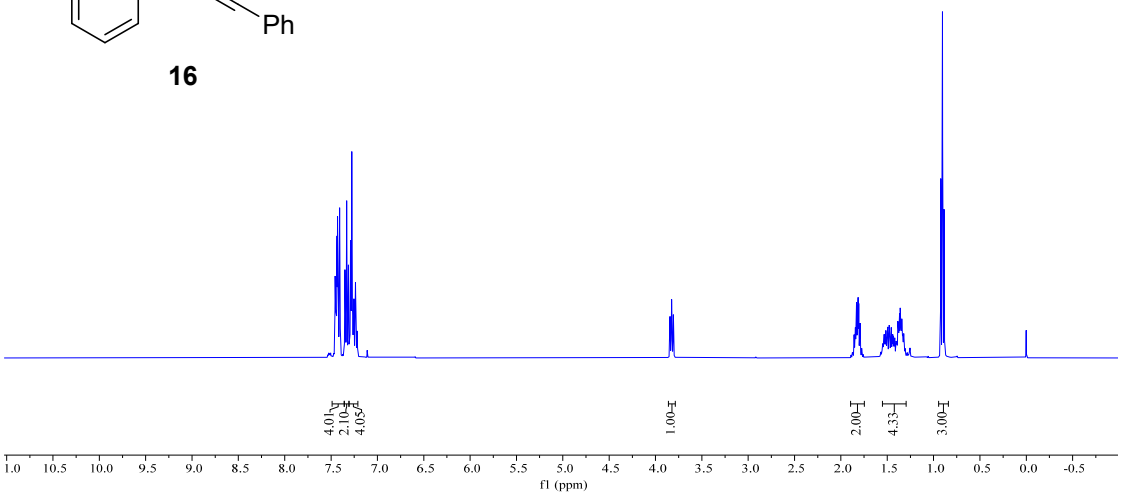
15


10 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


7.46 7.45 7.44 7.44 7.44 7.43 7.43 7.42 7.41 7.41 7.41 7.40 7.35 7.35 7.35 7.33 7.33 7.32 7.31 7.30 7.30 7.29 7.28 7.28 7.27 7.26 7.26 7.26 7.25 7.25 7.24 7.24 7.23 7.22
3.84 3.83 3.82 3.81 1.86 1.85 1.84 1.84 1.83 1.83 1.82 1.82 1.81 1.81 1.80 1.79 1.53 1.52 1.52 1.50 1.49 1.48 1.46 1.46 1.44 1.39 1.38 1.37 1.37 1.36 1.35 1.35 1.34 1.34 1.33 1.32 0.92 0.90 0.89


nBu
Ph

16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2.10
4.05
1.00
2.00
4.33
3.00
1.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)


142.50
131.77
128.58
128.33
127.83
127.62
126.75
123.98
91.89
83.28
77.48
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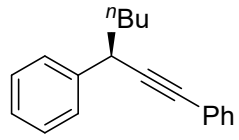
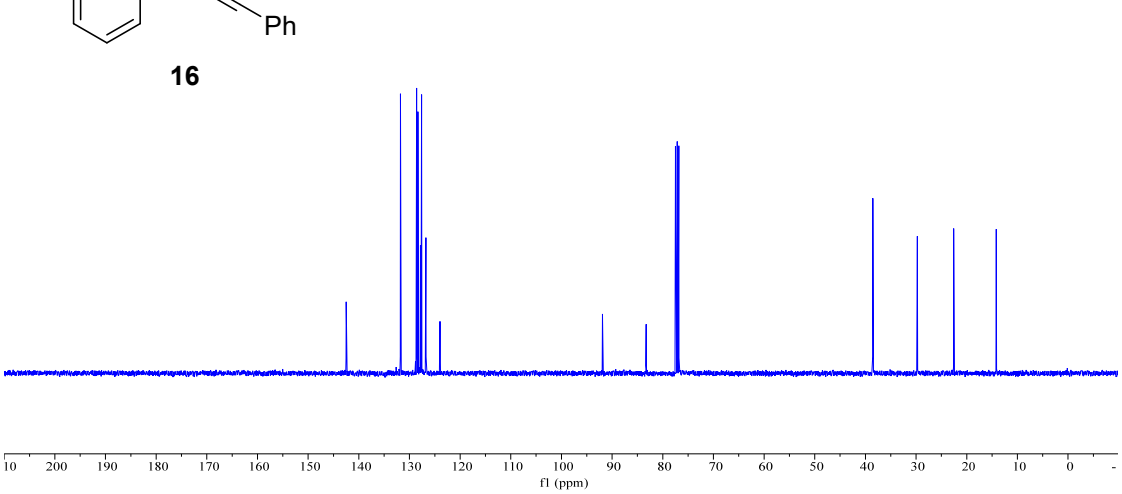
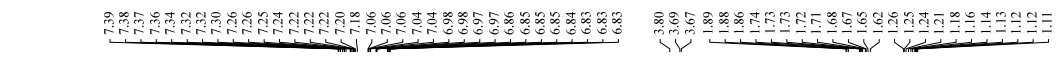
76.84
38.56
38.55
29.75
22.58
14.16


nBu
Ph

16


10 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -
f1 (ppm)


7.39
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7.25
7.24
7.22
7.22
7.22
7.20
7.18
7.06
7.06
7.06
7.04
7.04
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6.98
6.97
6.97
6.86
6.85
6.85
6.85
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6.83
6.83
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3.67
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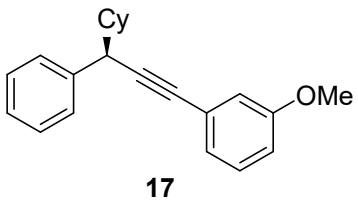
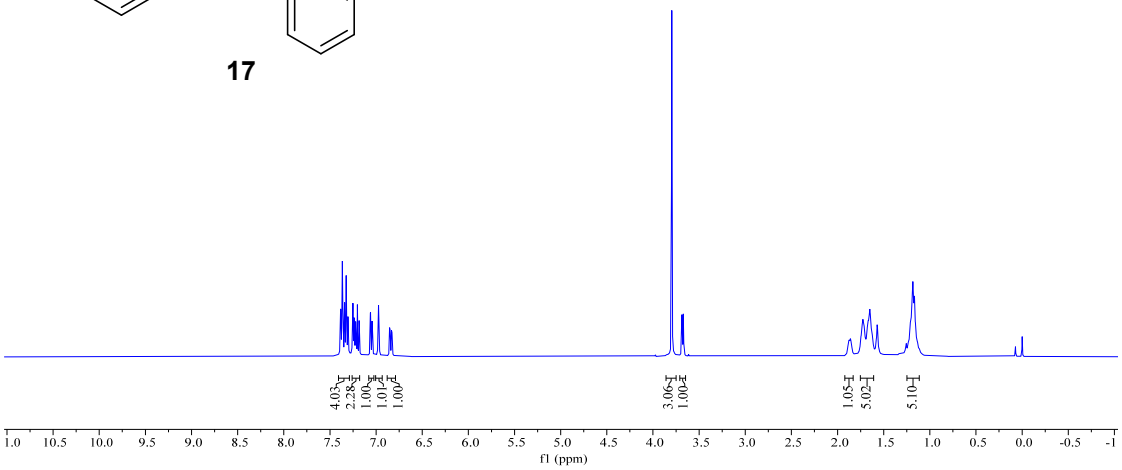
1.14
1.13
1.12
1.12
1.11


Cy
OMe

17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2.28
1.06
1.01
1.00
3.06
1.00
1.05
5.02
5.10
1.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1
f1 (ppm)


159.41
140.93
129.38
128.44
128.31
126.72
125.10
124.37
116.68
114.30
90.81
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31.81
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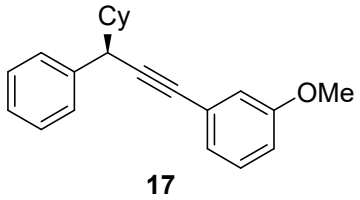
26.47
26.39


Cy
OMe

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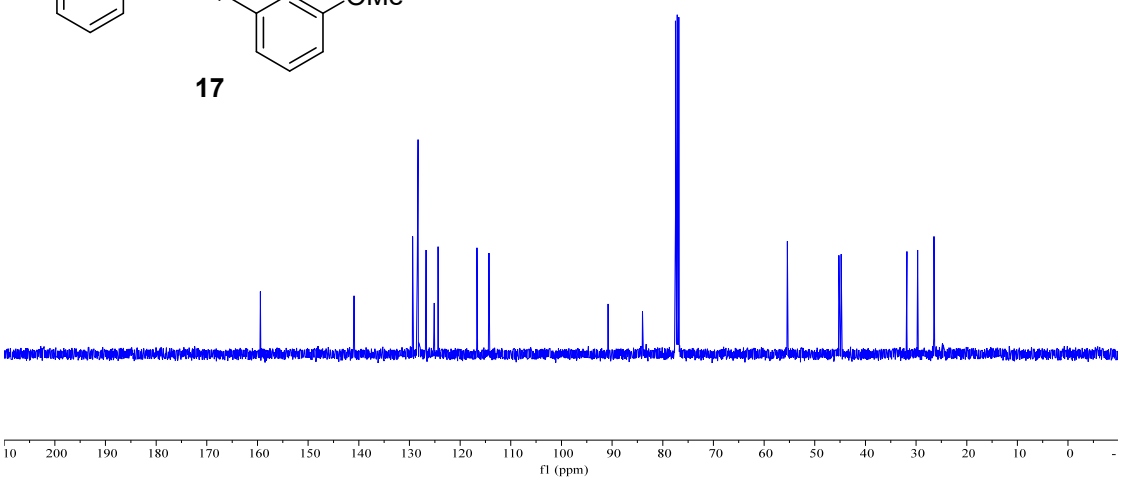
10 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -
f1 (ppm)


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7.45
7.44
7.43
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1.86
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1.84
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1.83
1.83
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1.63
1.61
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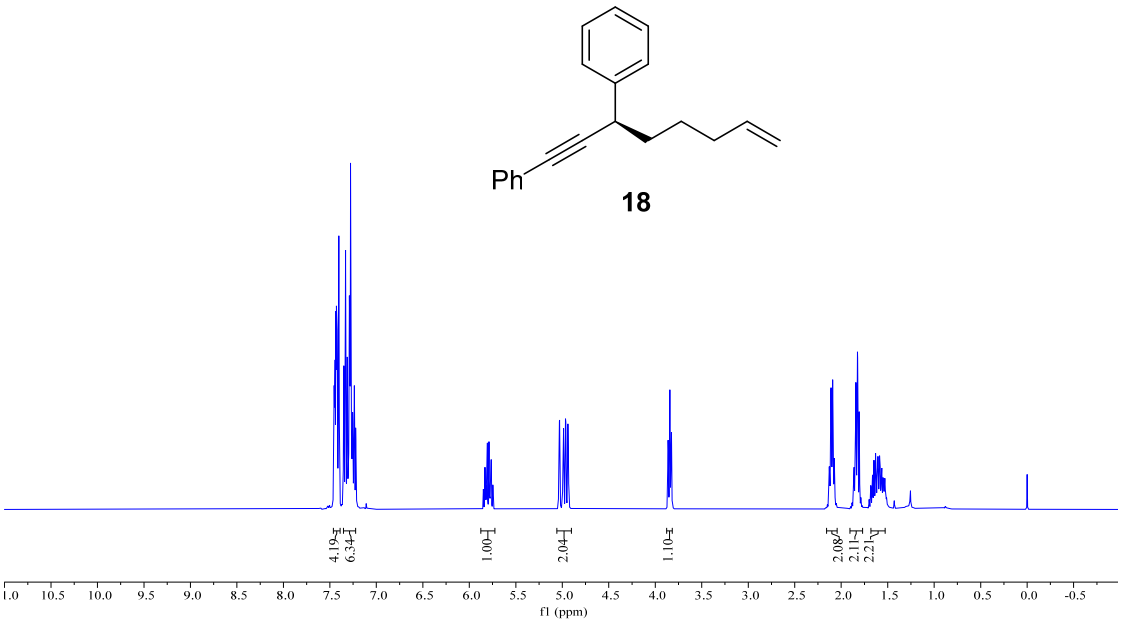
1.58
1.57
1.56


Ph
18
4.19
6.34
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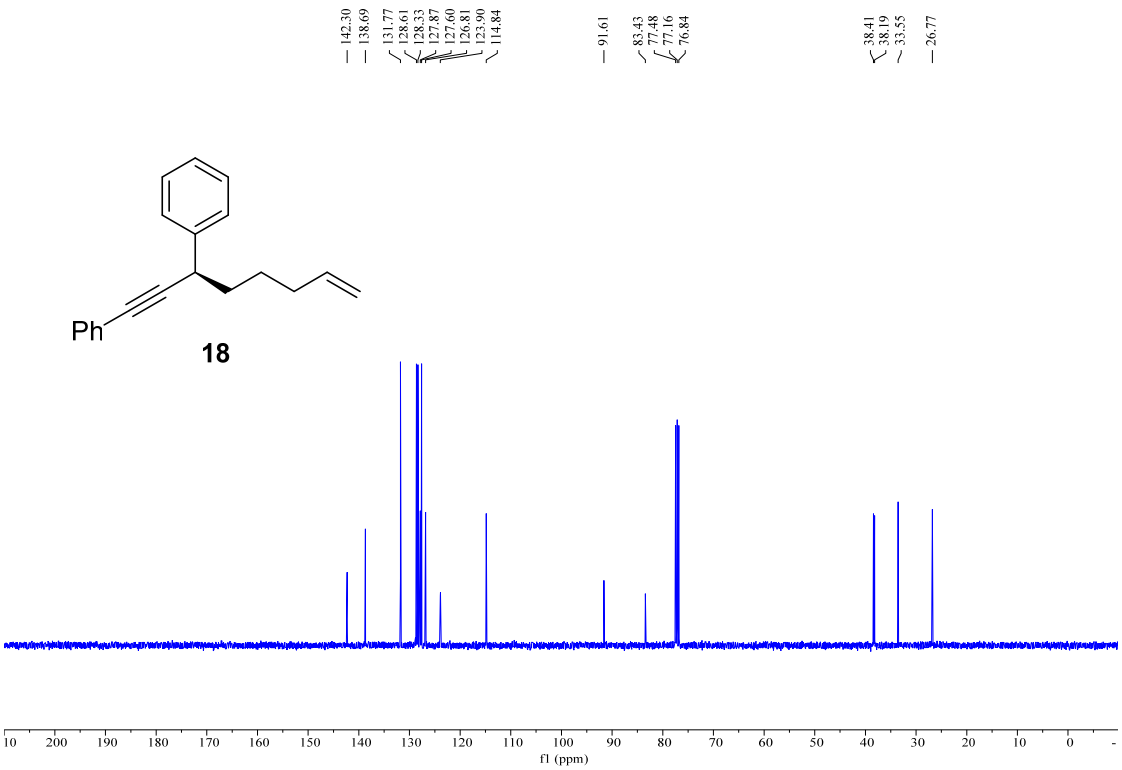
2.04
1.10
2.08
2.11
2.21
1.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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77.16
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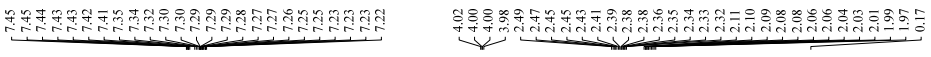
33.55
26.77
Ph
18
10 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -
f1 (ppm)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7.28
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7.25
7.25
7.23
7.23
7.23
7.22
4.02
4.00
4.00
3.98
2.49
2.47
2.45
2.45
2.43
2.41
2.39
2.38
2.38
2.36
2.35
2.34
2.33
2.32
2.11
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2.04
2.03
2.01
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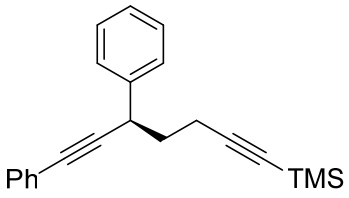
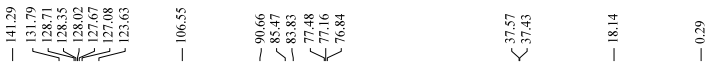
1.97
0.17


Ph
TMS

19

4.01
2.08
4.13
1.00
2.10
2.14
9.17
f1 (ppm)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76.84
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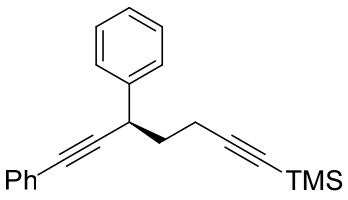
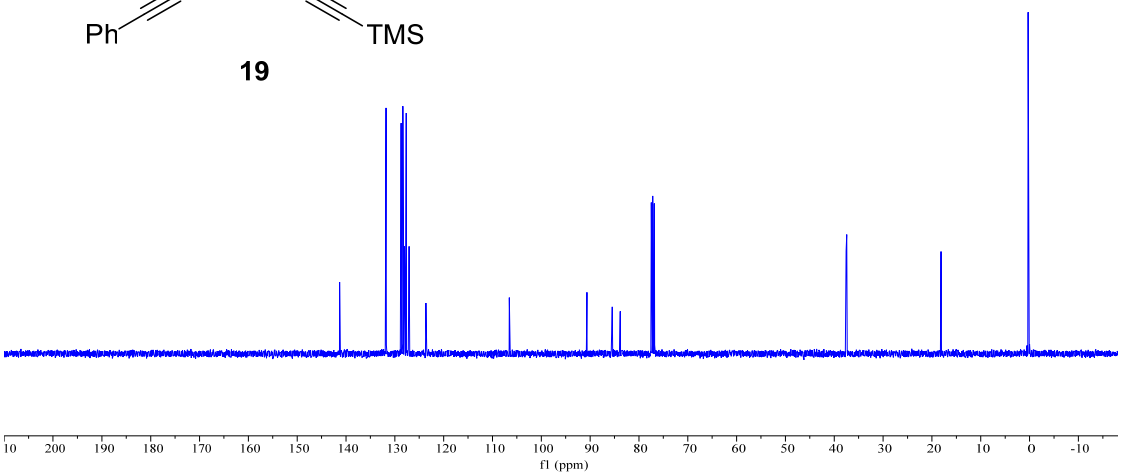
37.43
18.14
0.29


Ph
TMS

19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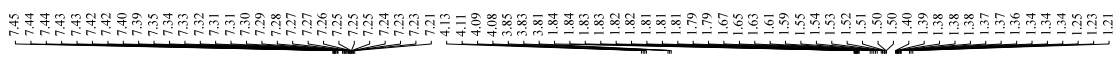
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7.24
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7.23
7.21
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4.11
4.09
4.08
3.85
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1.52
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1.39
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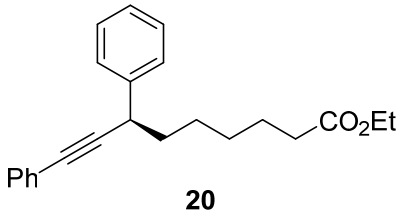
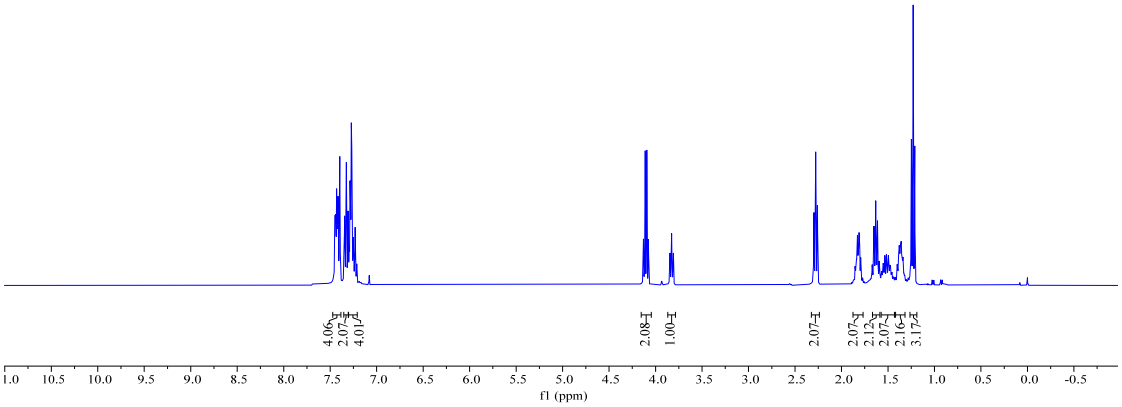

CO2Et
Ph

20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2.07
4.01
2.08
1.00
2.07
2.07
2.13
2.07
2.16
3.17
1.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)


173.86
142.24
131.72
128.57
128.29
127.83
127.54
126.77
123.84
91.59
83.38
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76.84
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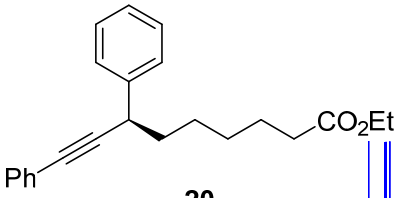
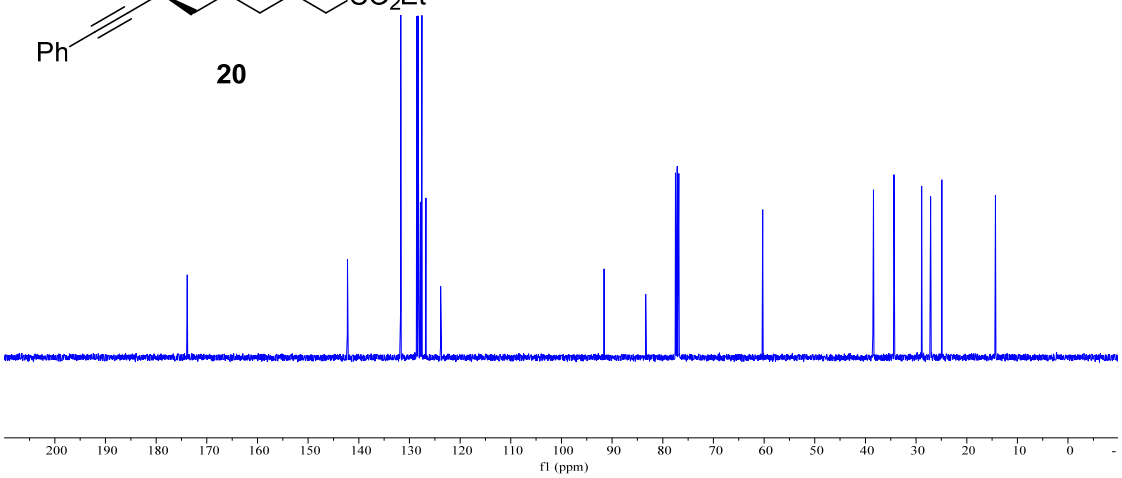
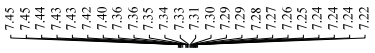
38.42
34.37
28.89
27.13
24.92
14.34


CO2Et
Ph

20


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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7.45
7.44
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7.43
7.42
7.40
7.36
7.36
7.35
7.34
7.33
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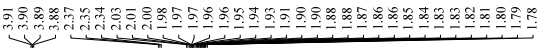
7.24
7.24
7.24
7.22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3.90
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3.88
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2.35
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2.03
2.01
2.00
1.98
1.97
1.97
1.96
1.96
1.95
1.94
1.93
1.91
1.90
1.90
1.88
1.88
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1.85
1.84
1.83
1.83
1.82
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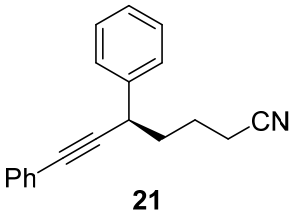
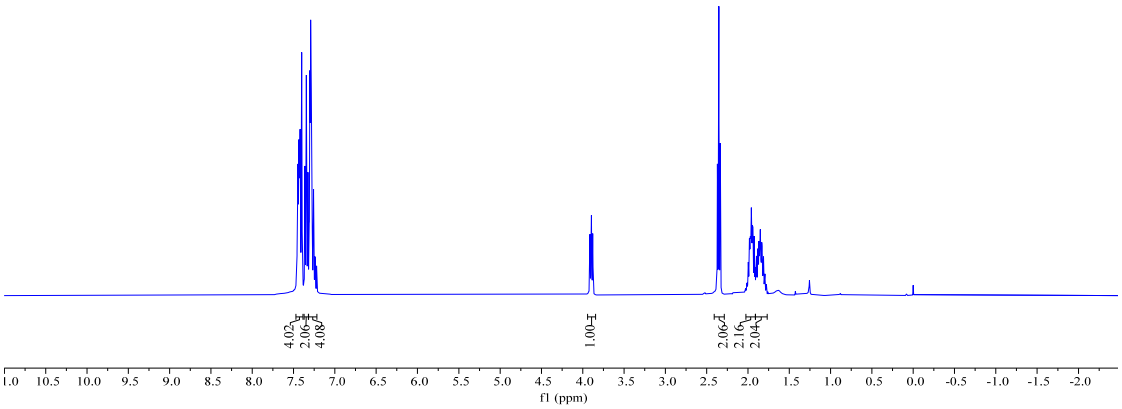
1.80
1.79
1.78


CN
Ph

21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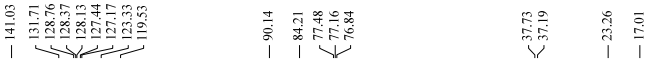
2.06
4.08
1.00
2.06
2.16
2.04
1.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0 -1.5 -2.0
f1 (ppm)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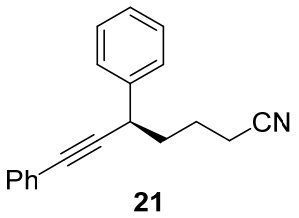
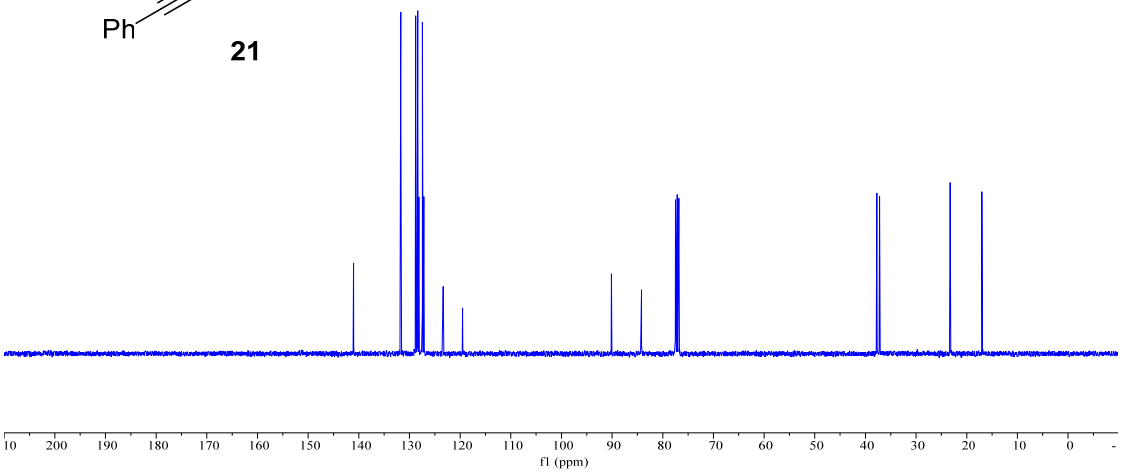
128.37
128.13
127.44
127.17
123.33
119.53
90.14
84.21
77.48
77.16
76.84
37.73
37.19
23.26
17.01


CN
Ph

21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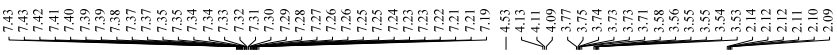
f1 (ppm)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7.24
7.23
7.23
7.22
7.21
7.21
7.19
4.53
4.13
4.11
4.09
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3.73
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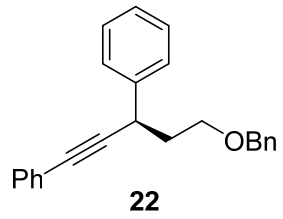
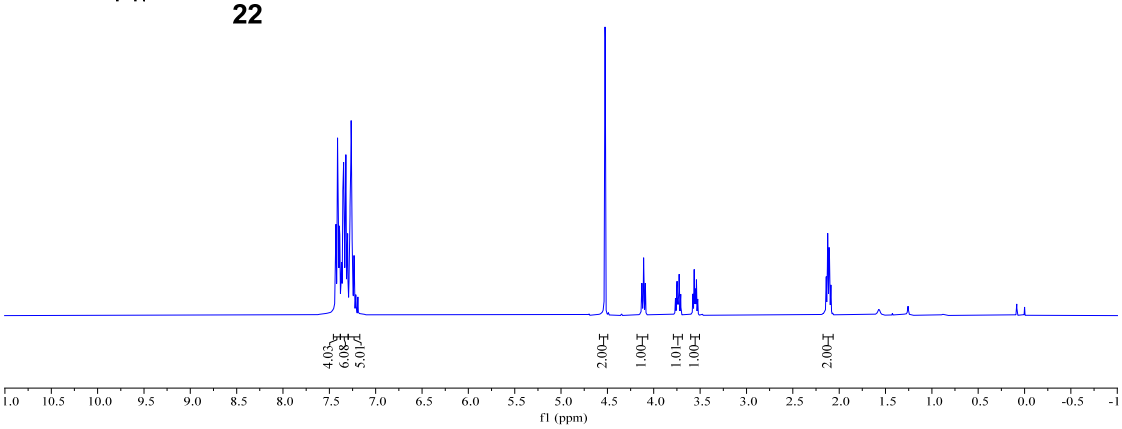
2.09


Ph
OBn

22


4.03
6.08
5.01
2.00
1.00
1.01
1.00
2.00
1.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1
f1 (ppm)


141.81
138.57
131.76
128.66
128.50
128.30
127.89
127.80
127.68
127.66
126.90
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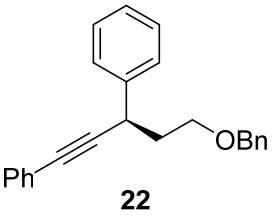
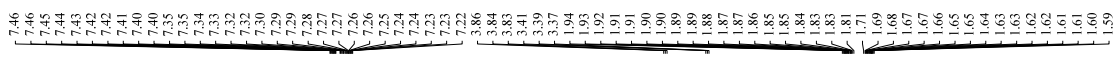
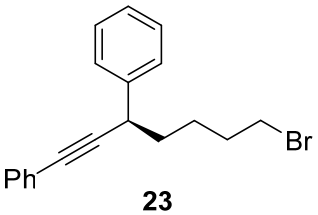
77.16
76.84
73.19
67.86
38.65
35.06


Ph
OBn

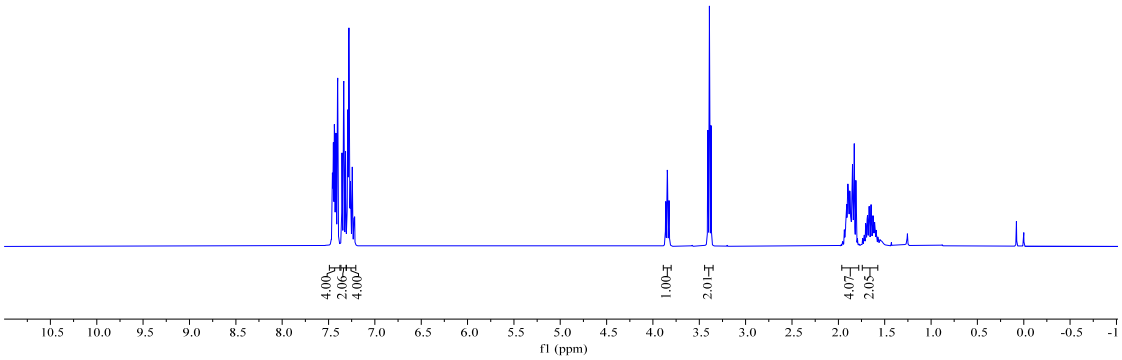
22

10 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -
f1 (ppm)




Ph
Br

23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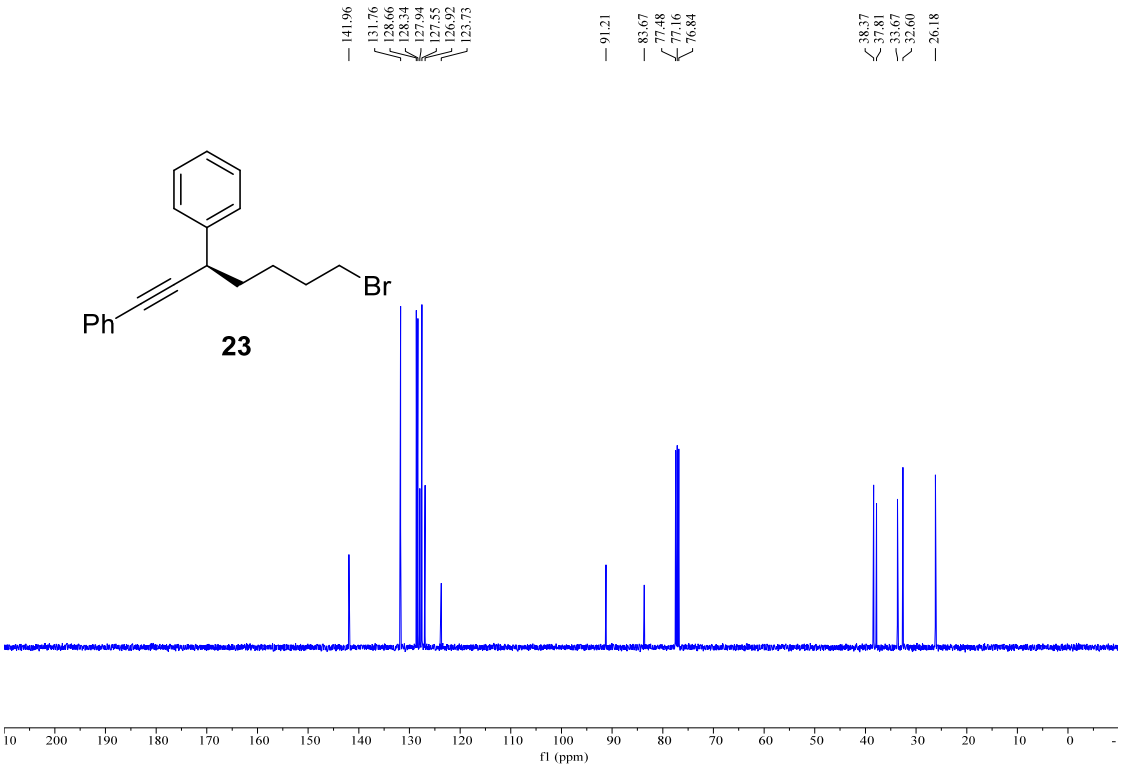
2.06
4.00
1.00
2.01
4.07
2.05
f1 (ppm)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127.55
126.92
123.73
91.21
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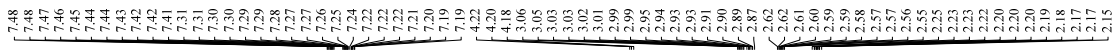
76.84
38.37
37.81
33.67
32.60
26.18
f1 (ppm)

Ph
Br

23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4.20
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3.03
3.03
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3.01
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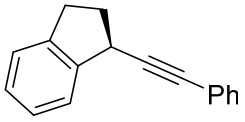
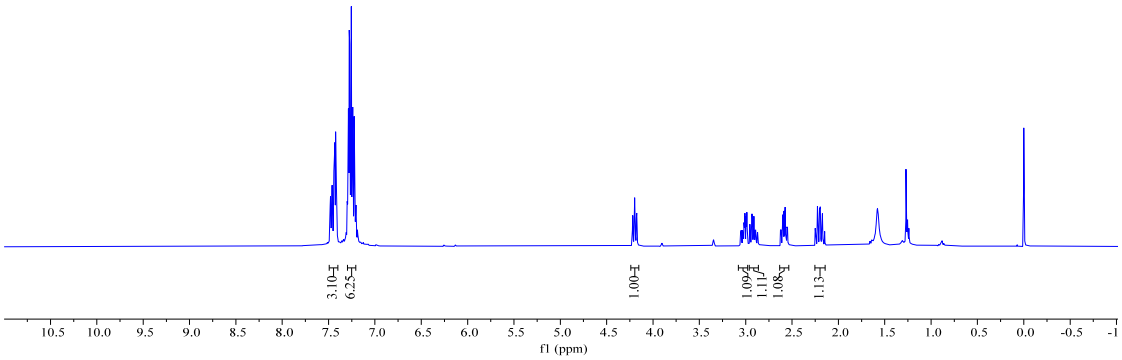
2.15


Ph

24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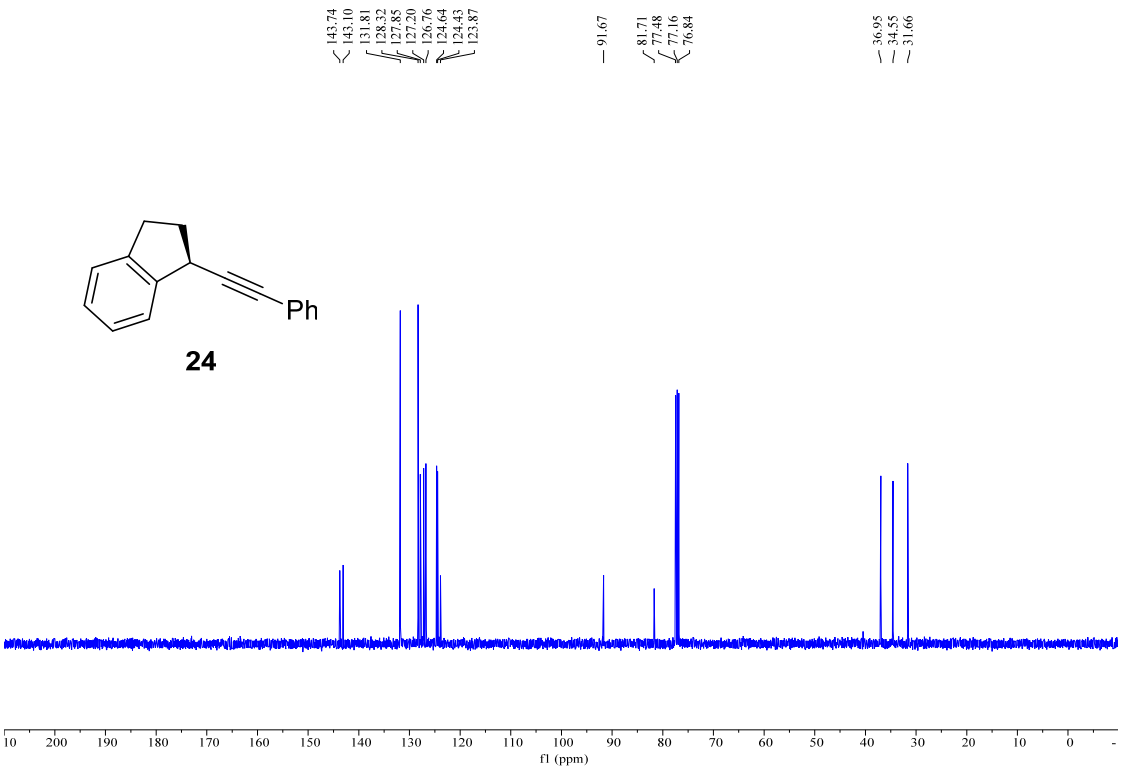
1.11
1.08
1.13
10.5
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
-1
f1 (ppm)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124.64
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123.87
91.67
81.71
77.48
77.16
76.84
36.95
34.55
31.66
Ph
24
10
200
190
180
170
160
150
140
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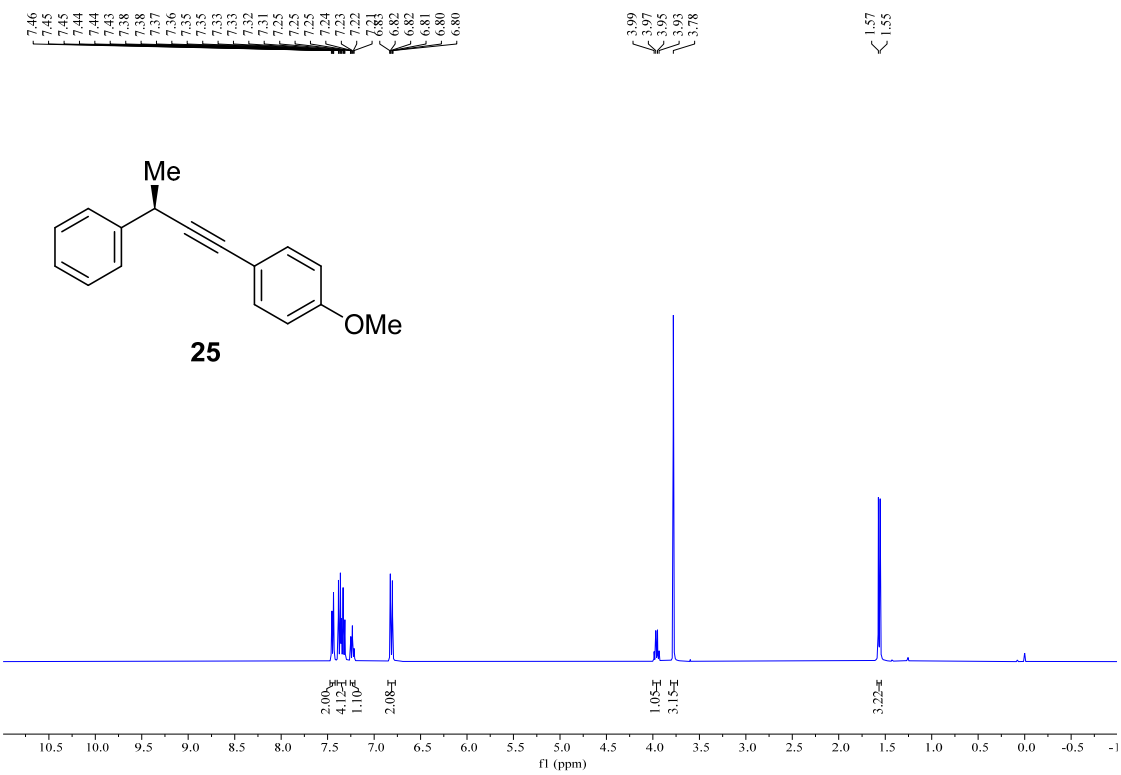
120
110
100
90
80
70
60
50
40
30
20
10
0
-
f1 (ppm)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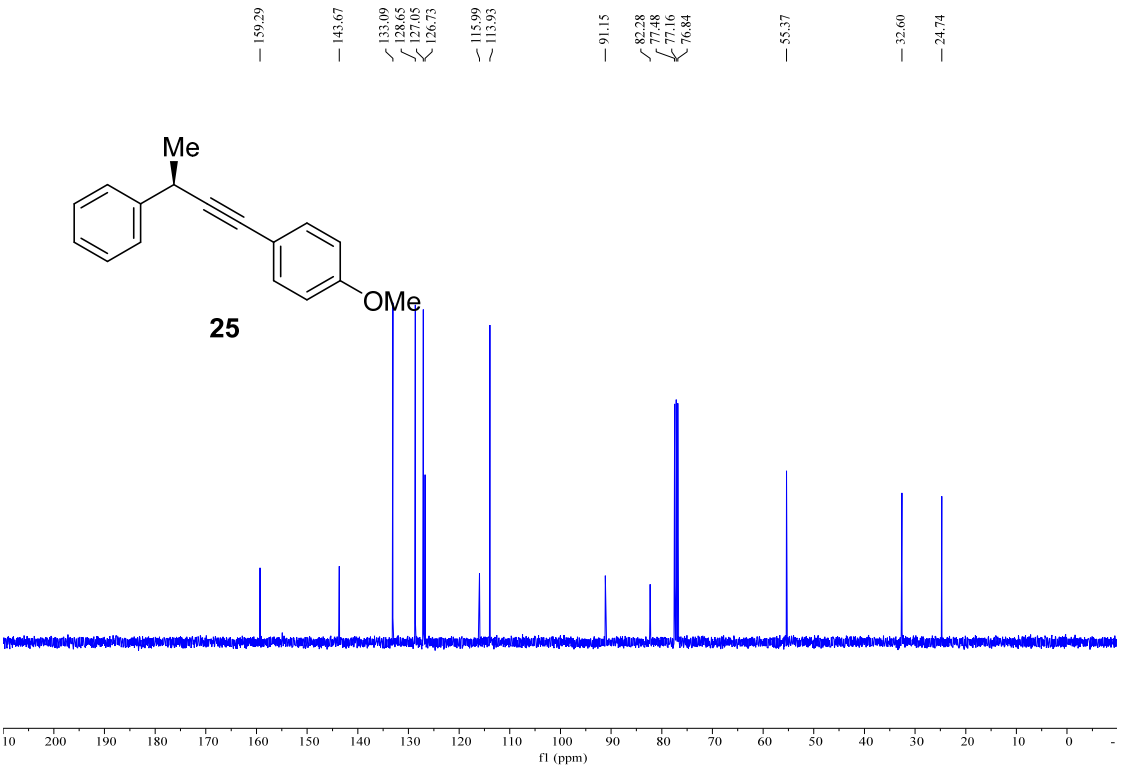
6.82
6.82
6.81
6.80
6.80
3.99
3.97
3.95
3.93
3.78
1.57
1.55
Me
OMe
25
2.00
4.12
1.10
2.08
1.05
3.15
3.22
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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126.73
115.99
113.93
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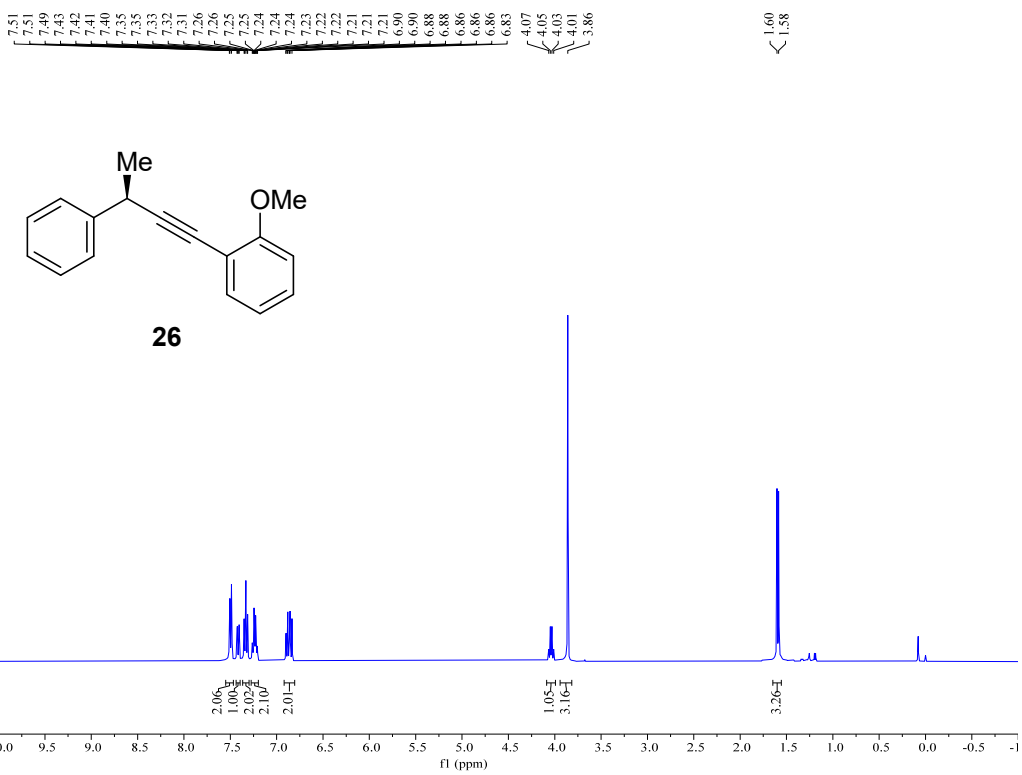
82.28
77.48
77.16
76.84
55.37
32.60
24.74
Me
OMe
25
10 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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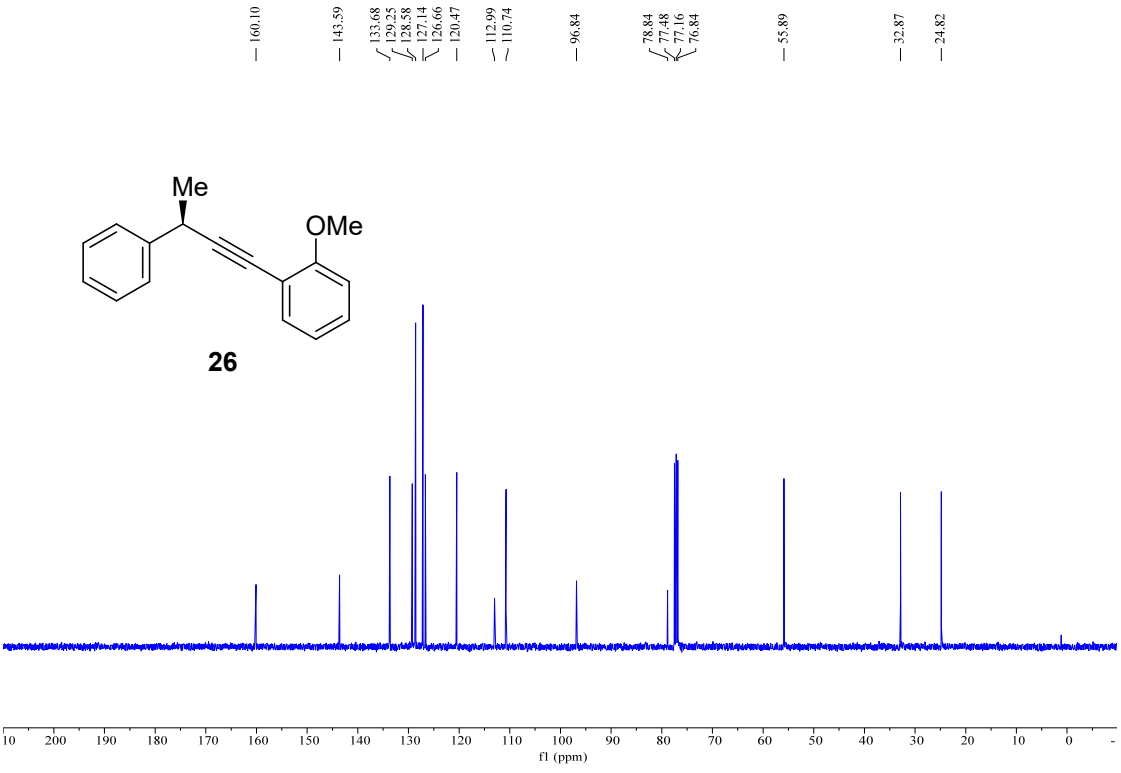
6.88
6.88
6.86
6.86
6.86
6.83
4.07
4.05
4.03
4.01
3.86
1.60
1.58
Me
OMe
26
2.06
1.00
2.02
2.10
2.01
1.05
3.16
3.26
1.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1
f1 (ppm)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78.84
77.48
77.16
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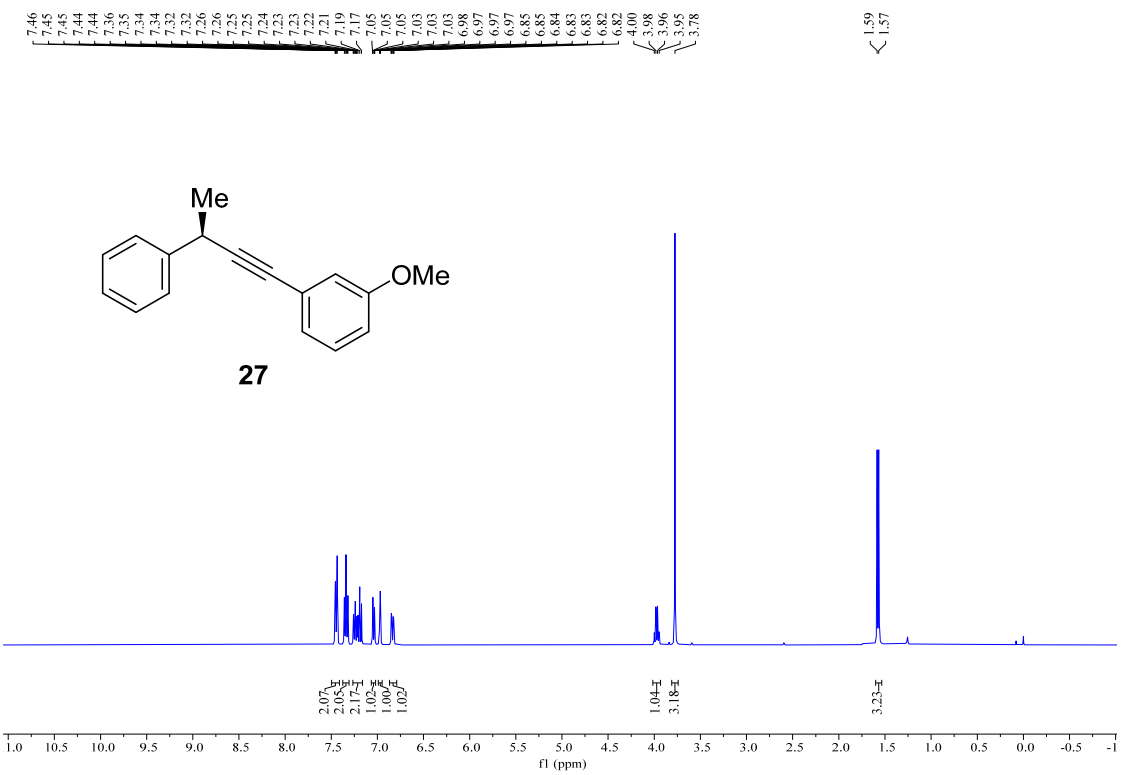
24.82
Me
OMe
26
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)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1.57
Me
OMe
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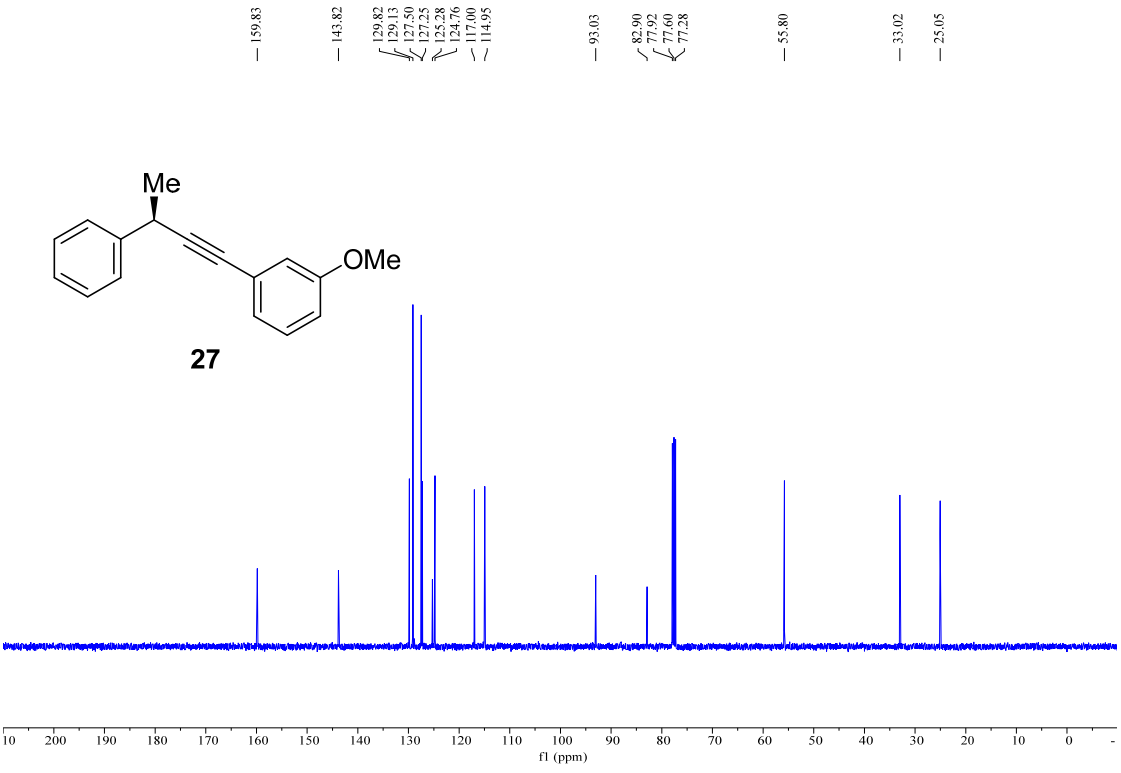
2.07
2.05
2.17
1.02
1.00
1.02
1.04
3.18
3.23
1.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1
f1 (ppm)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82.90
77.92
77.60
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OMe
27
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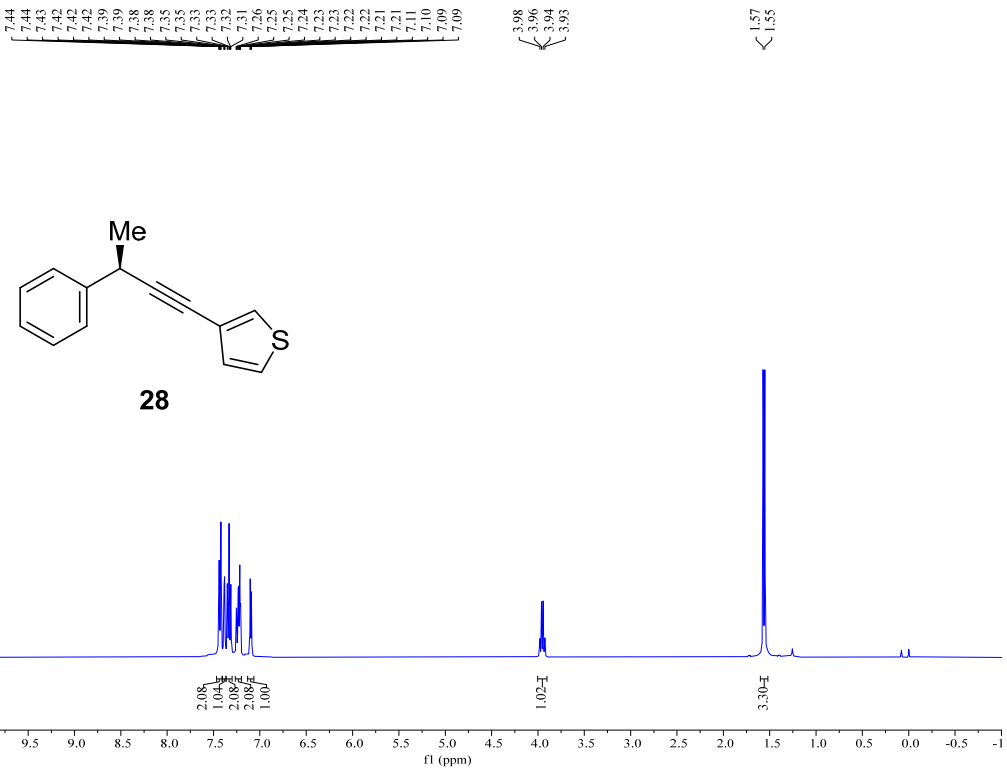
f1 (ppm)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7.21
7.21
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3.96
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3.93
1.57
1.55
Me
S
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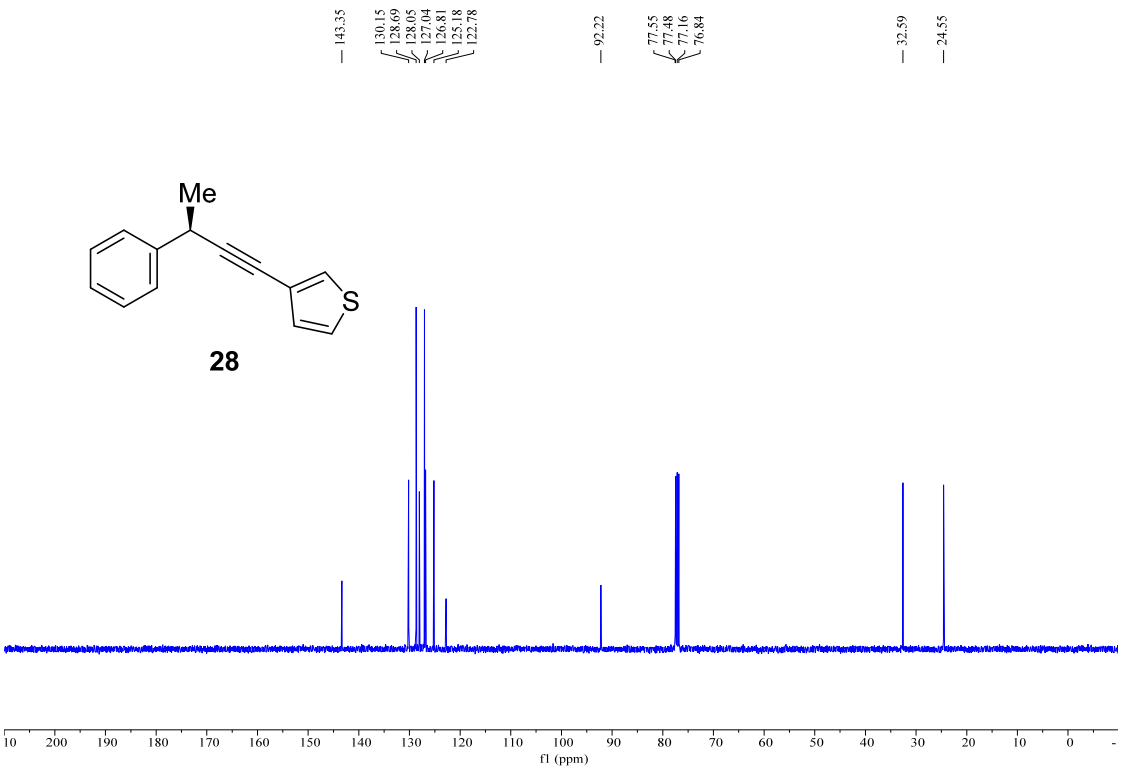
2.08
1.04
2.08
2.08
1.00
1.02
3.30
1.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1
f1 (ppm)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125.18
122.78
92.22
77.55
77.48
77.16
76.84
32.59
24.55
Me
S
28
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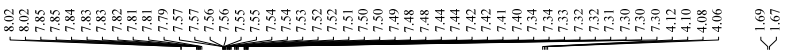
f1 (ppm)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7.83
7.82
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7.81
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7.50
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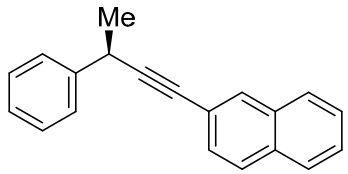
Me

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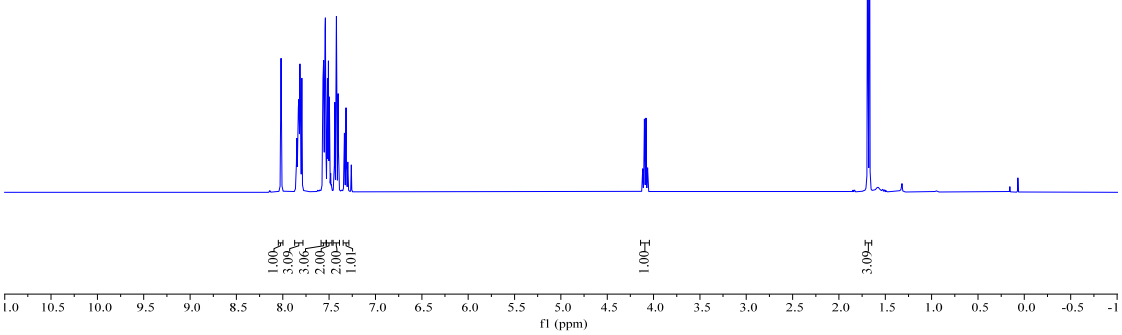
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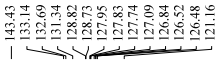
3.06
2.00
2.00
1.01
1.00
3.09
1.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1
f1 (ppm)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126.48
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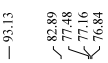
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76.84


32.70
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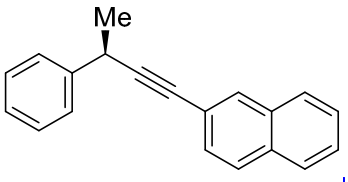
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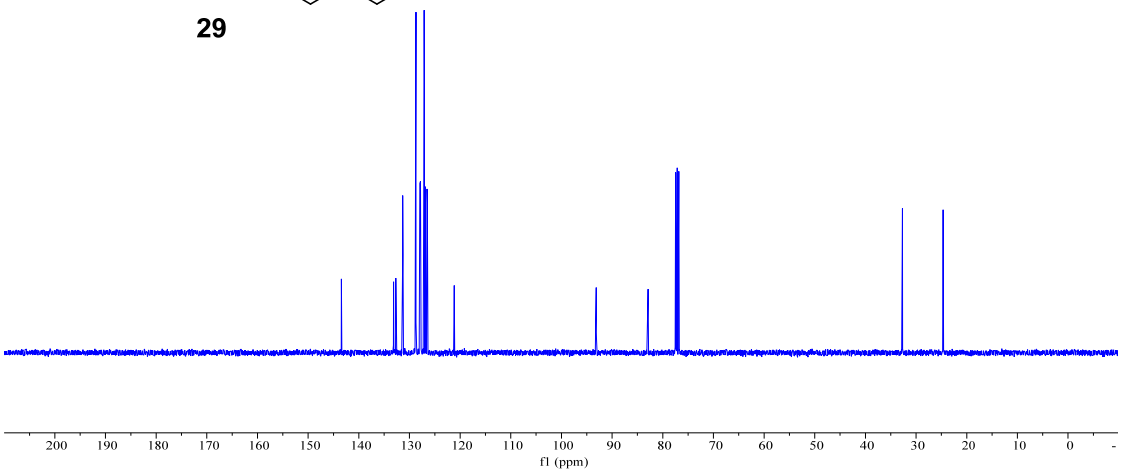
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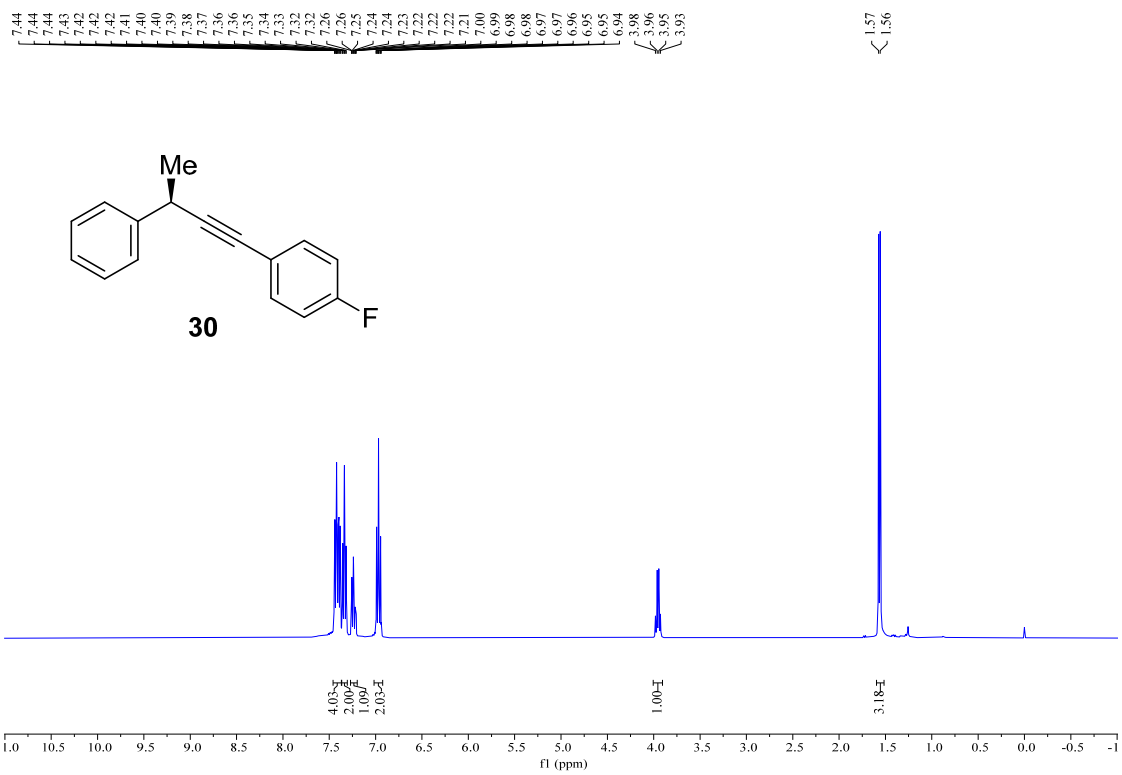
f1 (ppm)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7.33
7.32
7.32
7.26
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7.25
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7.23
7.22
7.22
7.22
7.21
7.00
6.99
6.98
6.98
6.97
6.97
6.96
6.95
6.95
6.94
3.98
3.96
3.95
3.93
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1.56
Me
F
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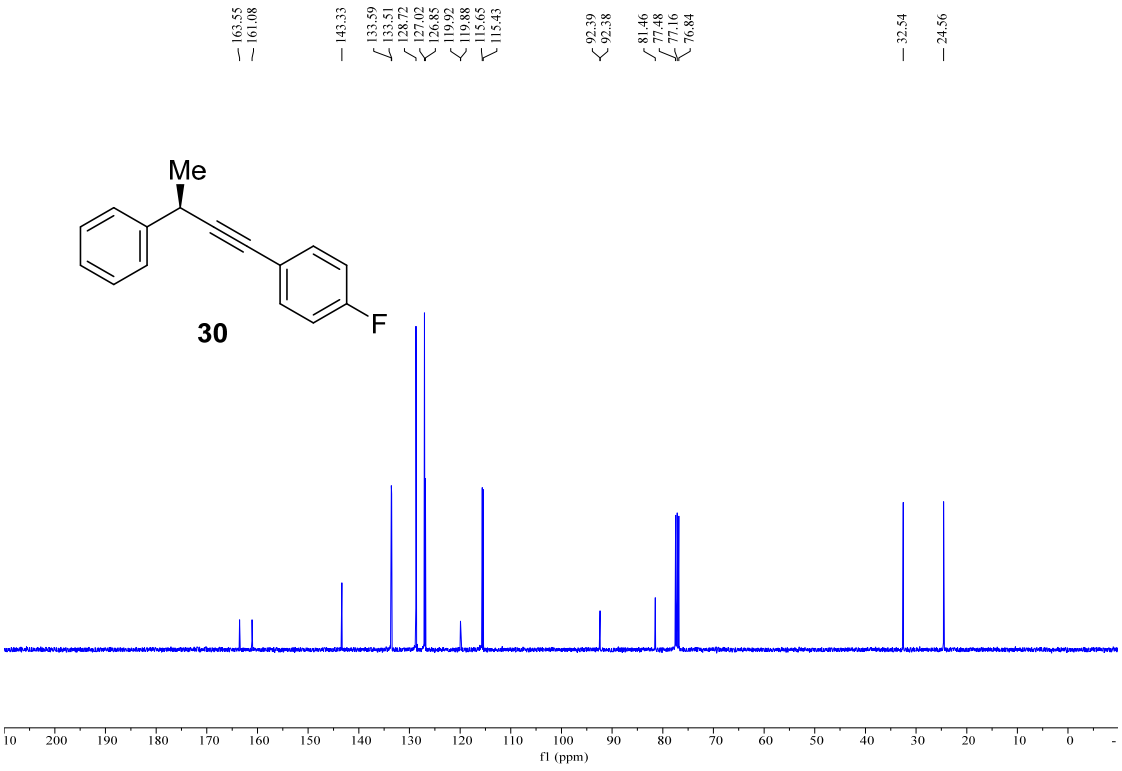
2.00
1.09
2.03
1.00
3.18
fl (ppm)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126.85
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119.88
115.65
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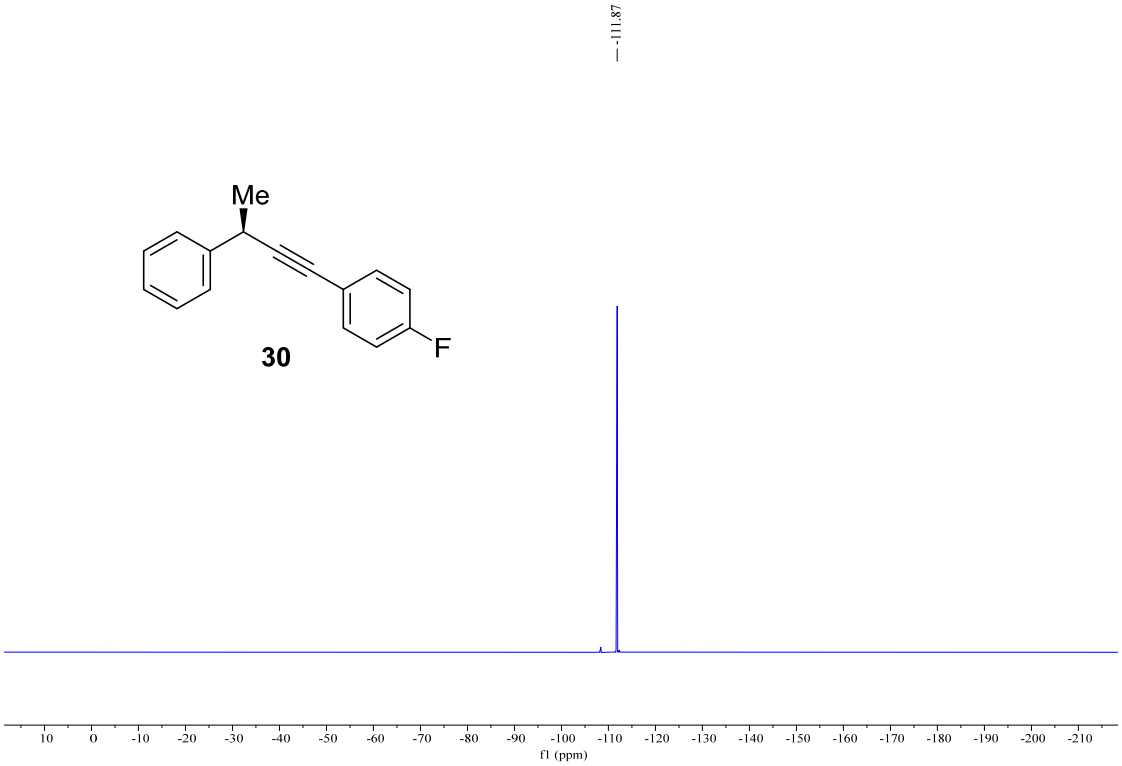
76.84
32.54
24.56
Me
F
30
fl (ppm)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-20
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-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
f1 (ppm)


7.44
7.43
7.43
7.42
7.42
7.41
7.41
7.37
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7.36
7.35
7.35
7.34
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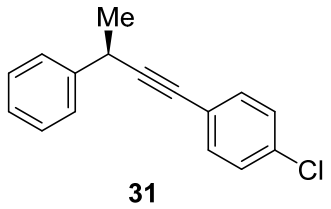
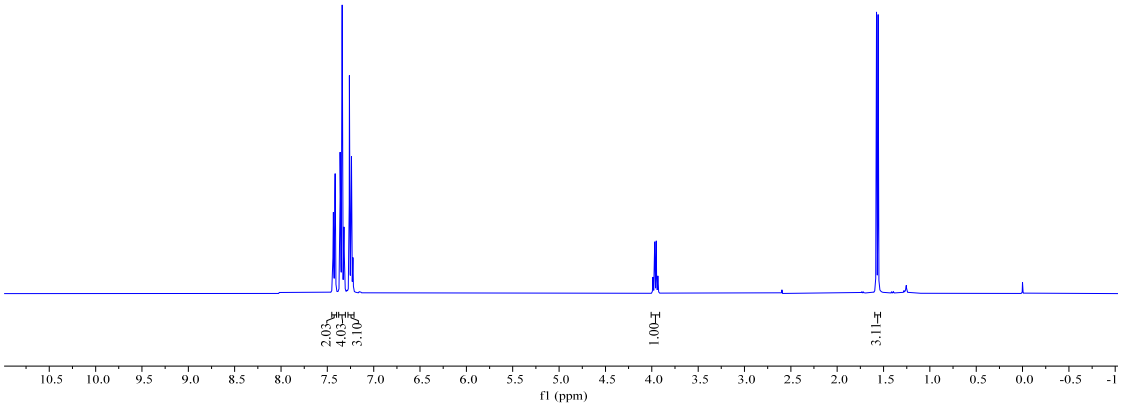
3.93
1.58
1.56


Me
Cl

31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8.5
8.0
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7.0
6.5
6.0
5.5
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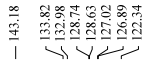
0.0
-0.5
-1
f1 (ppm)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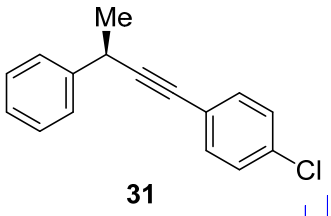
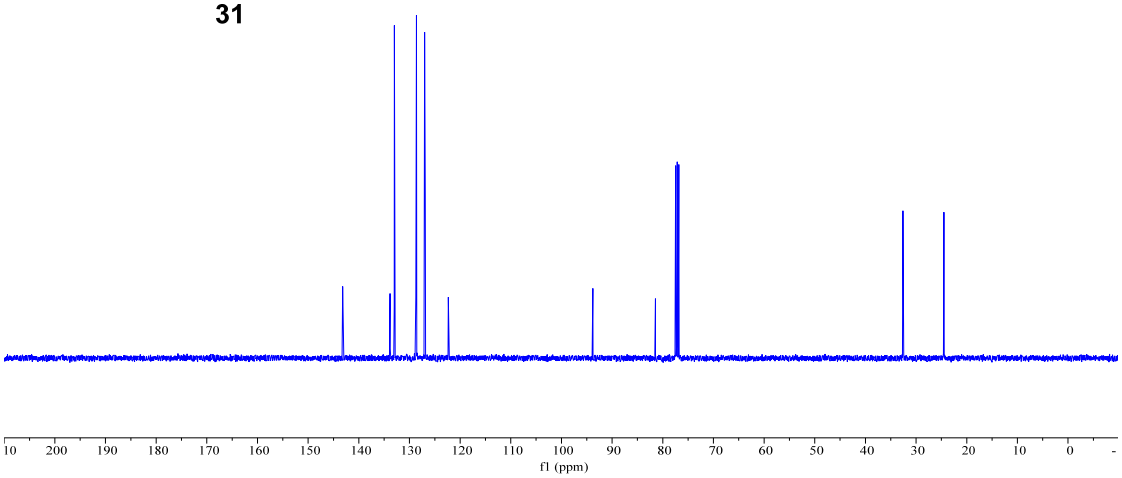
77.16
76.84
32.59
24.49


Me
Cl

31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200
190
180
170
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150
140
130
120
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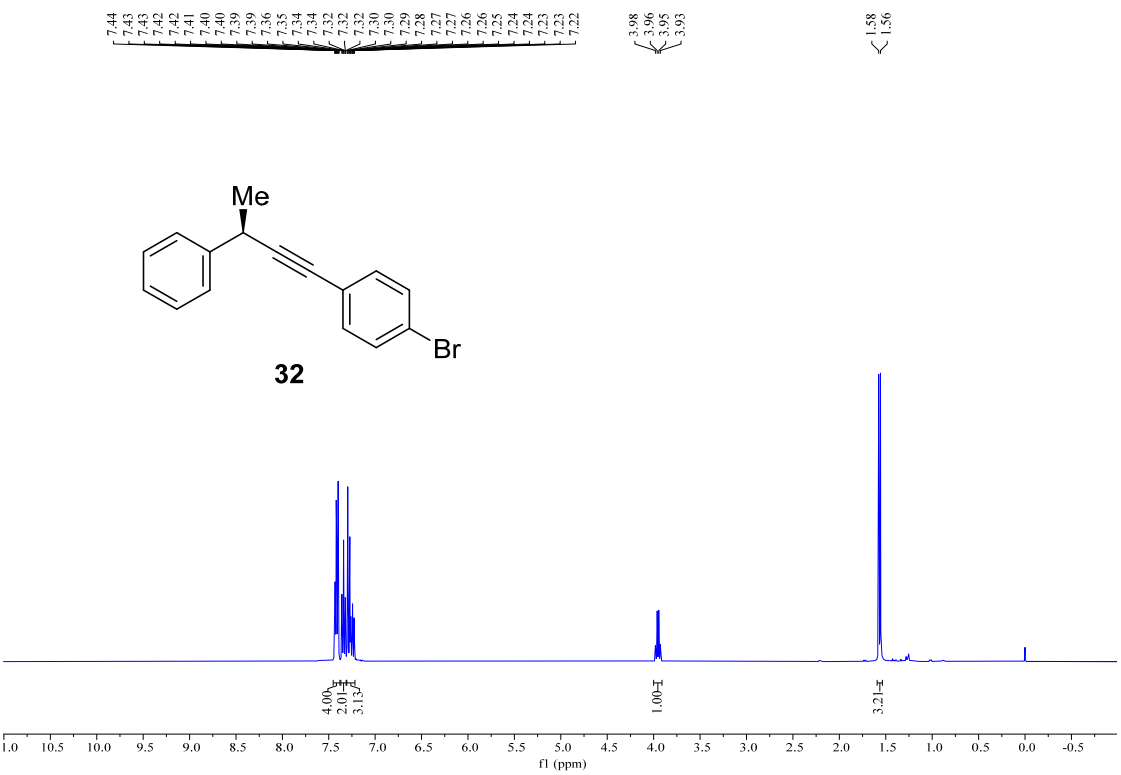
100
90
80
70
60
50
40
30
20
10
0
-
f1 (ppm)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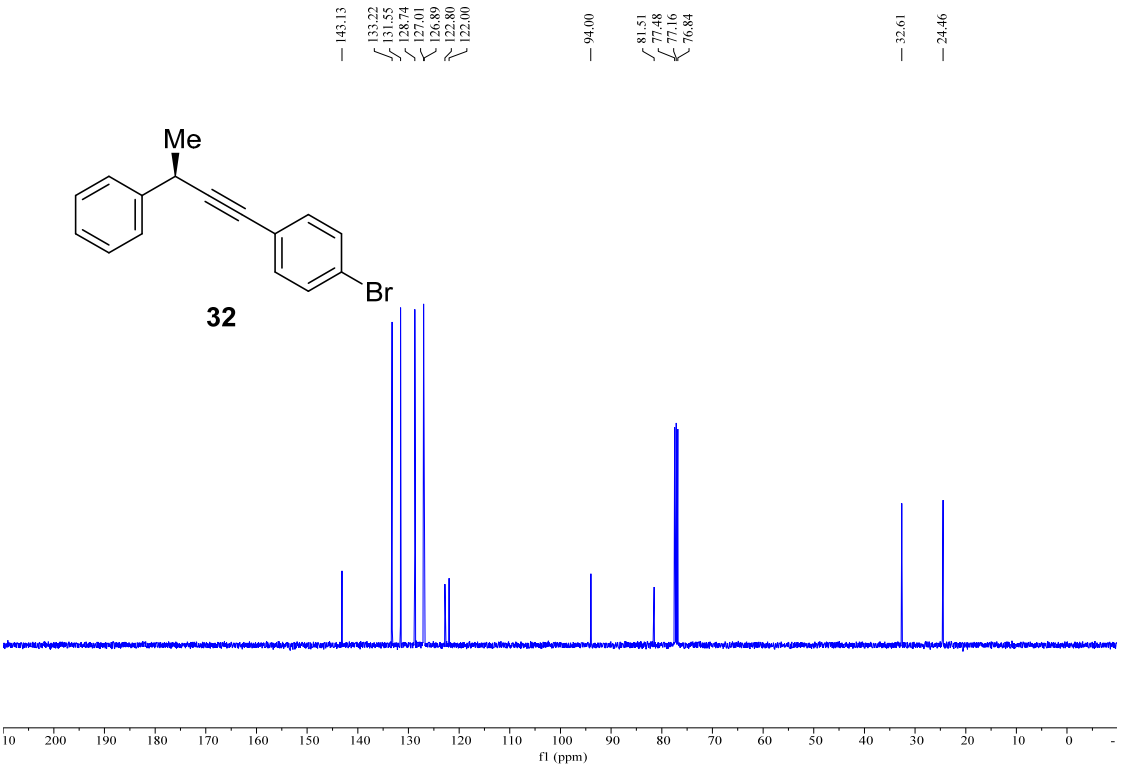
7.32
7.30
7.30
7.29
7.28
7.27
7.27
7.26
7.26
7.25
7.24
7.24
7.23
7.23
7.22
3.98
3.96
3.95
3.93
1.58
1.56
Me
Br
32
4.00
2.01
3.13
1.00
3.21
1.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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77.48
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76.84
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24.46
Me
Br
32
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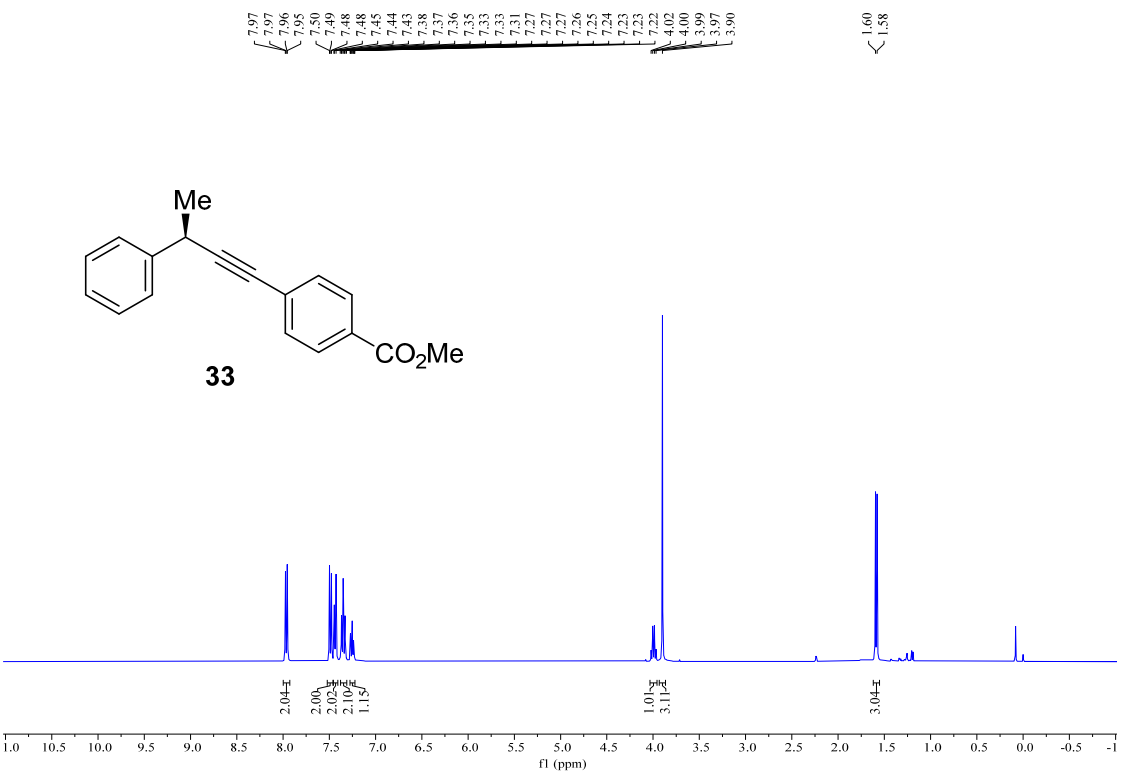
f1 (ppm)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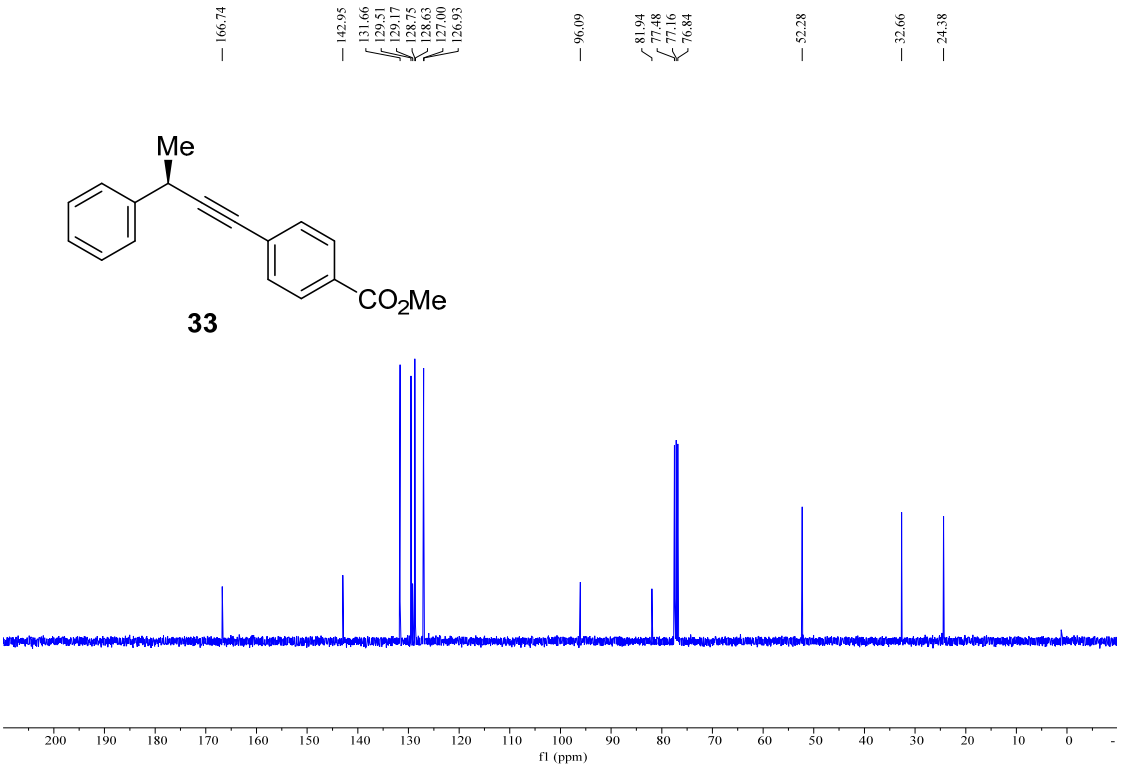
1.58
Me
CO2Me
33
2.04
2.00
2.02
2.10
1.15
1.01
3.11
3.04
1.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1
f1 (ppm)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127.00
126.93
96.09
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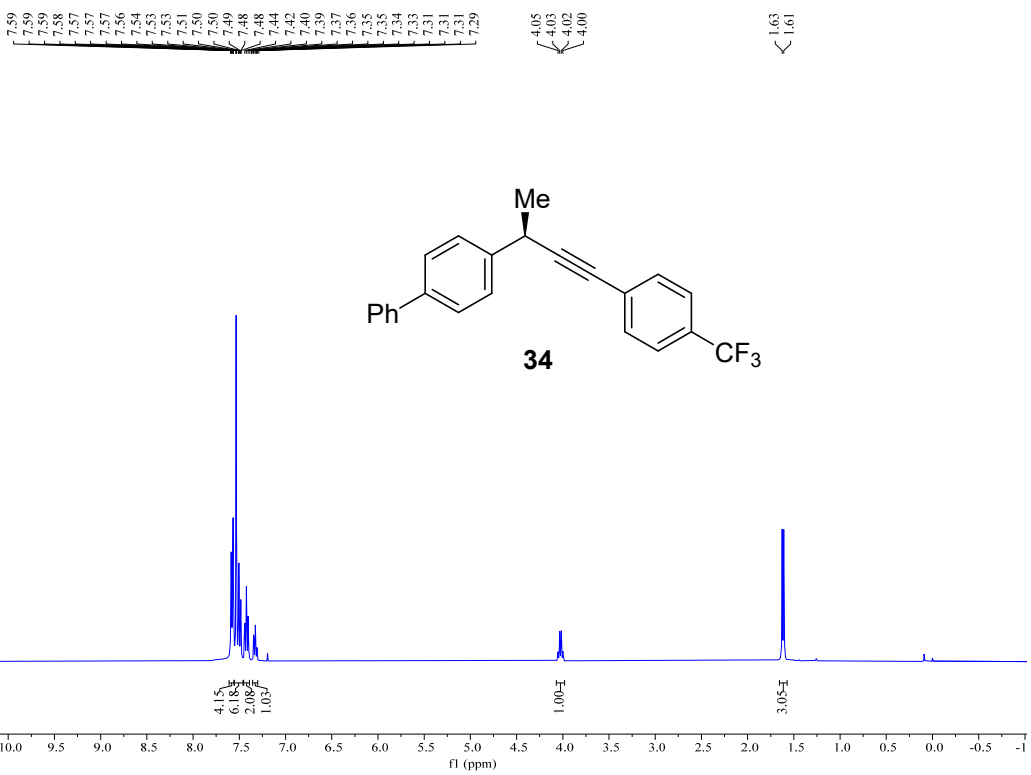
77.48
77.16
76.84
52.28
32.66
24.38
Me
CO2Me
33
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -
f1 (ppm)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7.31
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4.03
4.02
4.00
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Ph
CF3
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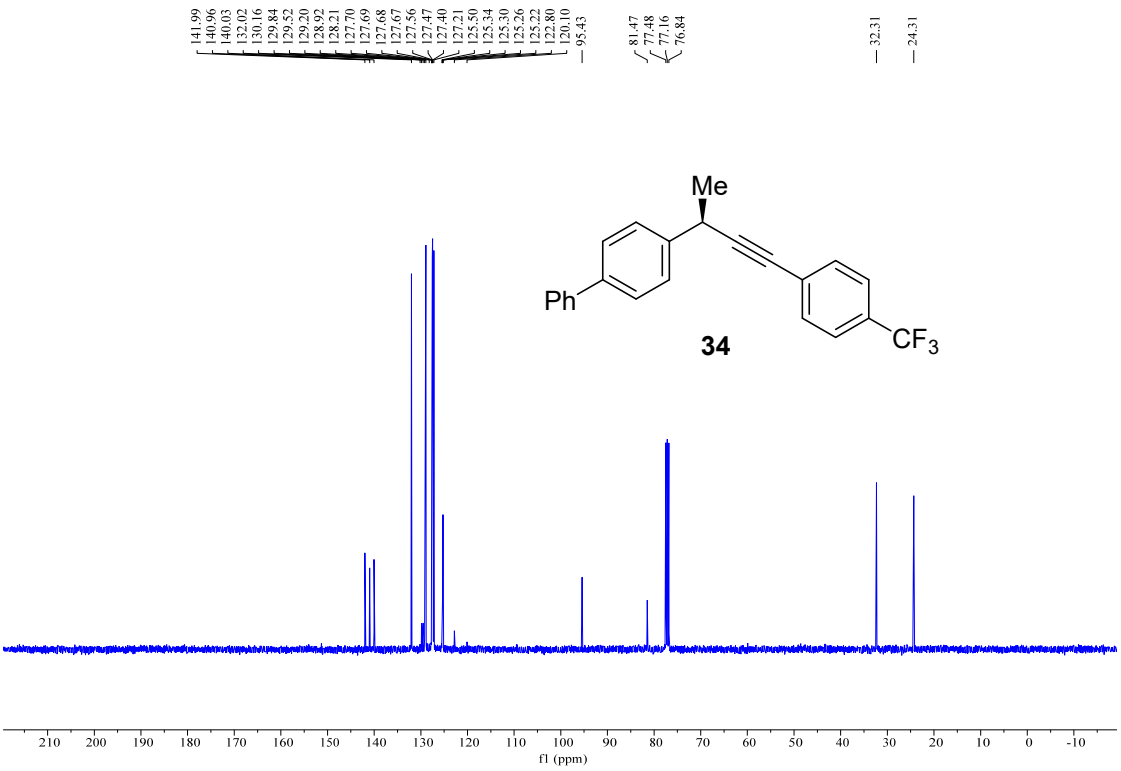
4.15
6.18
2.08
1.03
1.00
3.05
f1 (ppm)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127.21
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125.26
125.22
122.80
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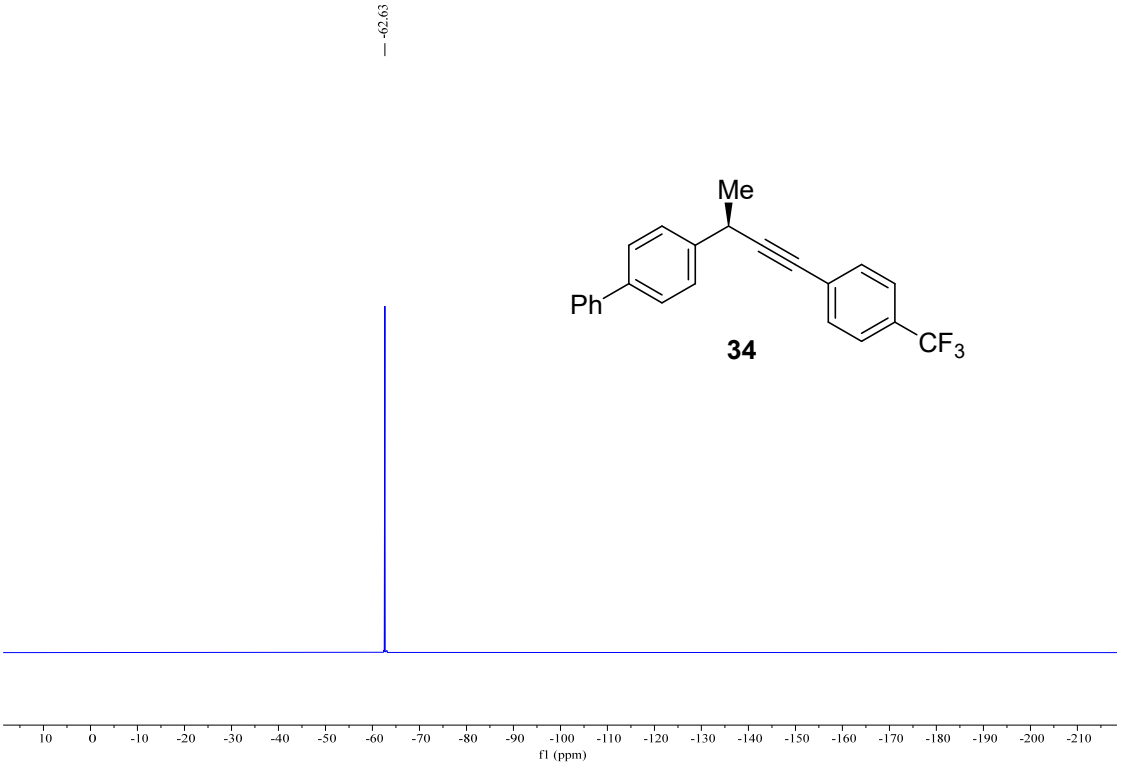
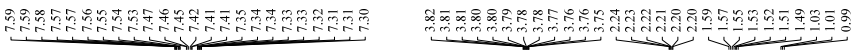
76.84
32.31
24.31
Me
Ph
CF3
34
f1 (ppm)


-62.63
Me
Ph
CF3
34
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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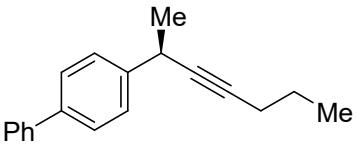
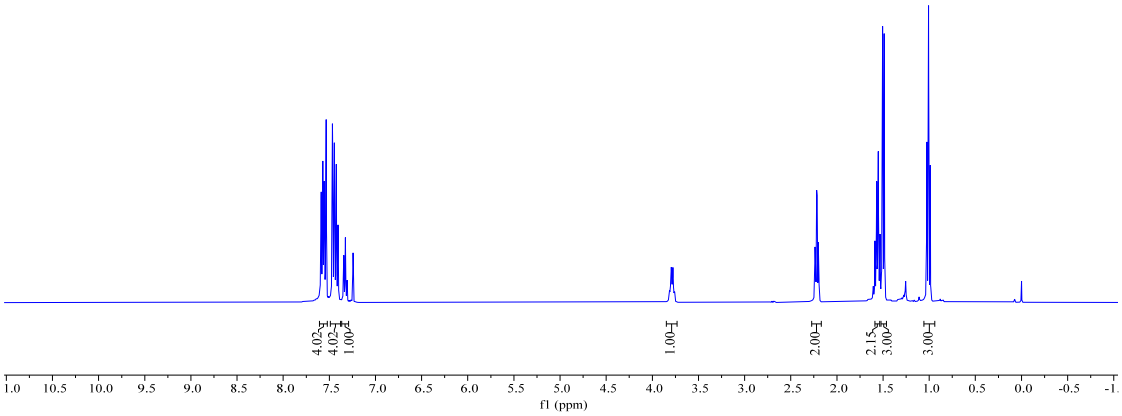
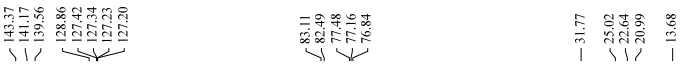
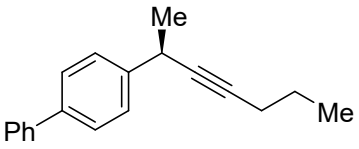
1.55
1.53
1.52
1.51
1.49
1.03
1.01
0.99


Me
Ph
Me

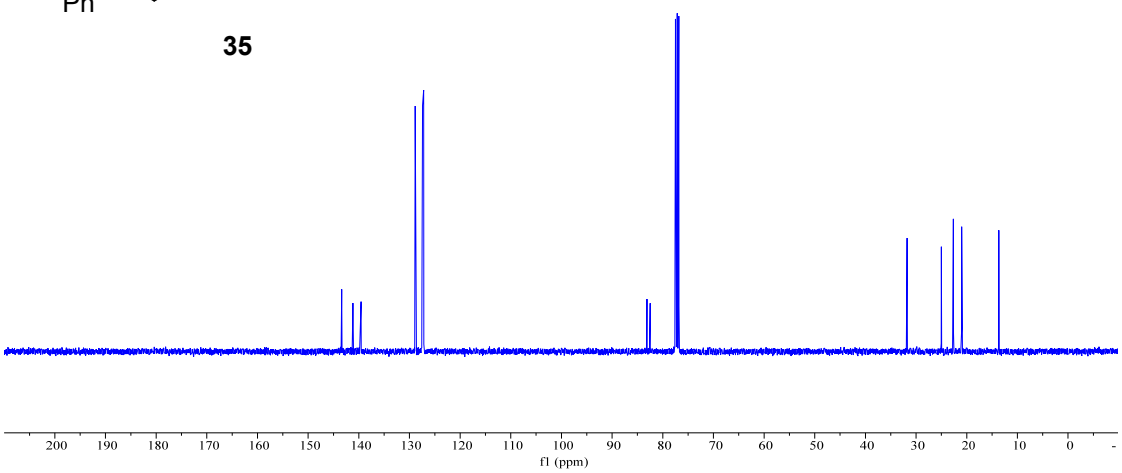
35

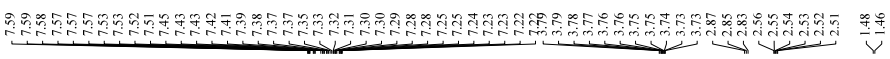

4.02
4.02
1.00
1.00
2.00
2.15
3.00
3.00
1.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.
f1 (ppm)

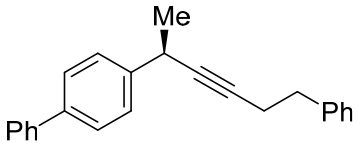

143.37
141.17
139.56
128.86
127.42
127.34
127.23
127.20
83.11
82.49
77.48
77.16
76.84
31.77
25.02
22.64
20.99
13.68


Me
Ph
Me

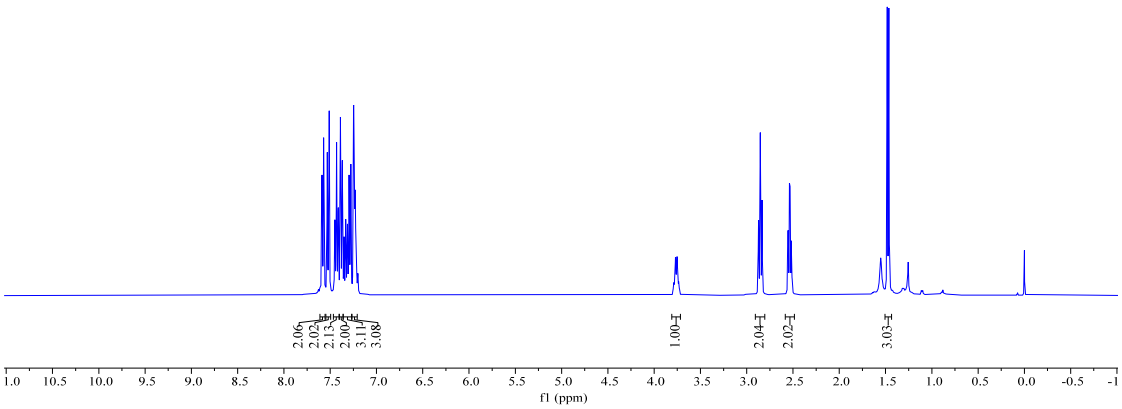
35

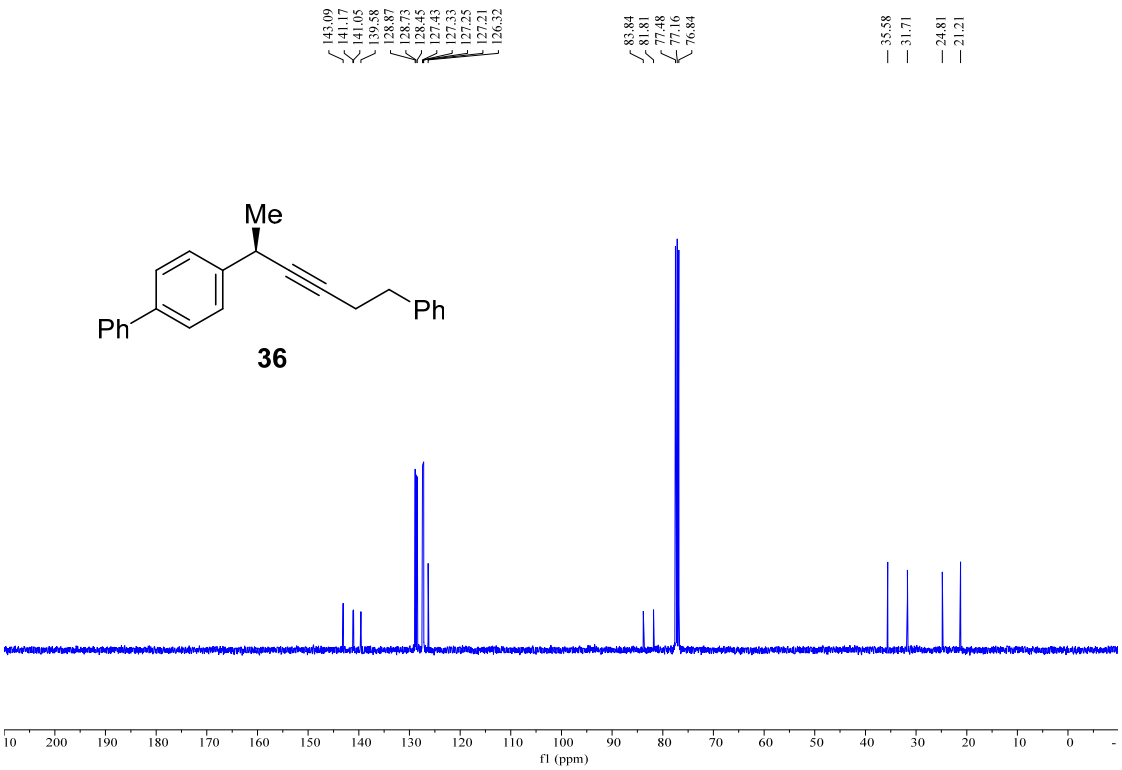

200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -
f1 (ppm)



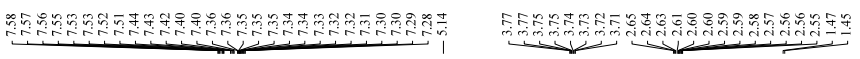

Me
Ph
Ph

36


2.06
2.02
2.13
2.00
3.11
3.08
1.00
2.04
2.02
3.03
1.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1
f1 (ppm)


Me
Ph
Ph
10 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -
f1 (ppm)

36


7.58
7.57
7.56
7.55
7.53
7.53
7.52
7.51
7.44
7.43
7.42
7.40
7.40
7.36
7.36
7.35
7.35
7.35
7.34
7.34
7.33
7.32
7.32
7.31
7.30
7.30
7.29
7.28
5.14
3.77
3.77
3.75
3.75
3.74
3.73
3.72
3.71
2.65
2.64
2.63
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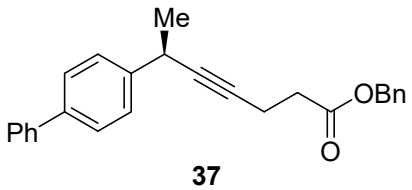
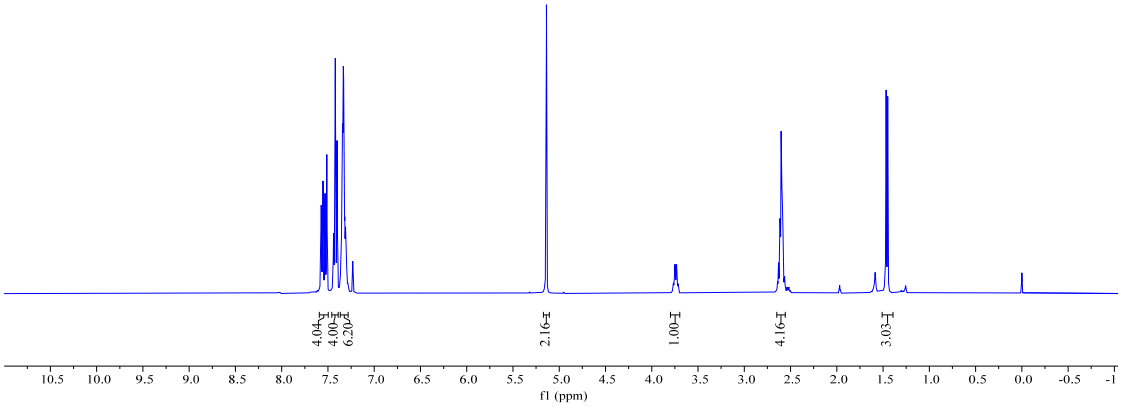
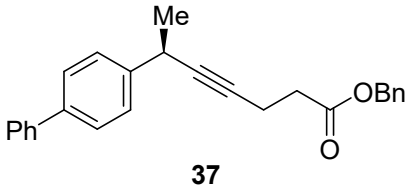
2.57
2.56
2.56
2.55
1.47
1.45


Me
OBn
Ph
O

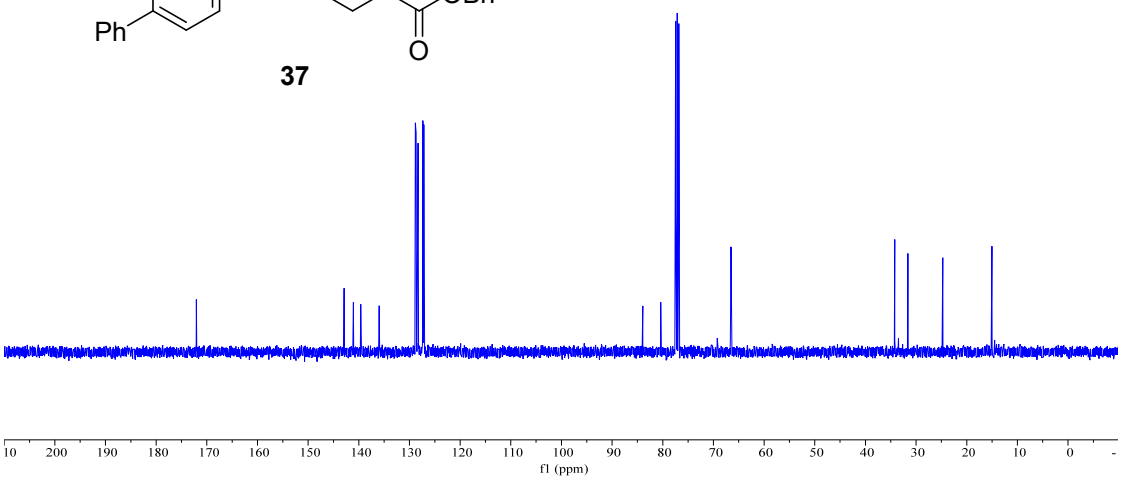
37

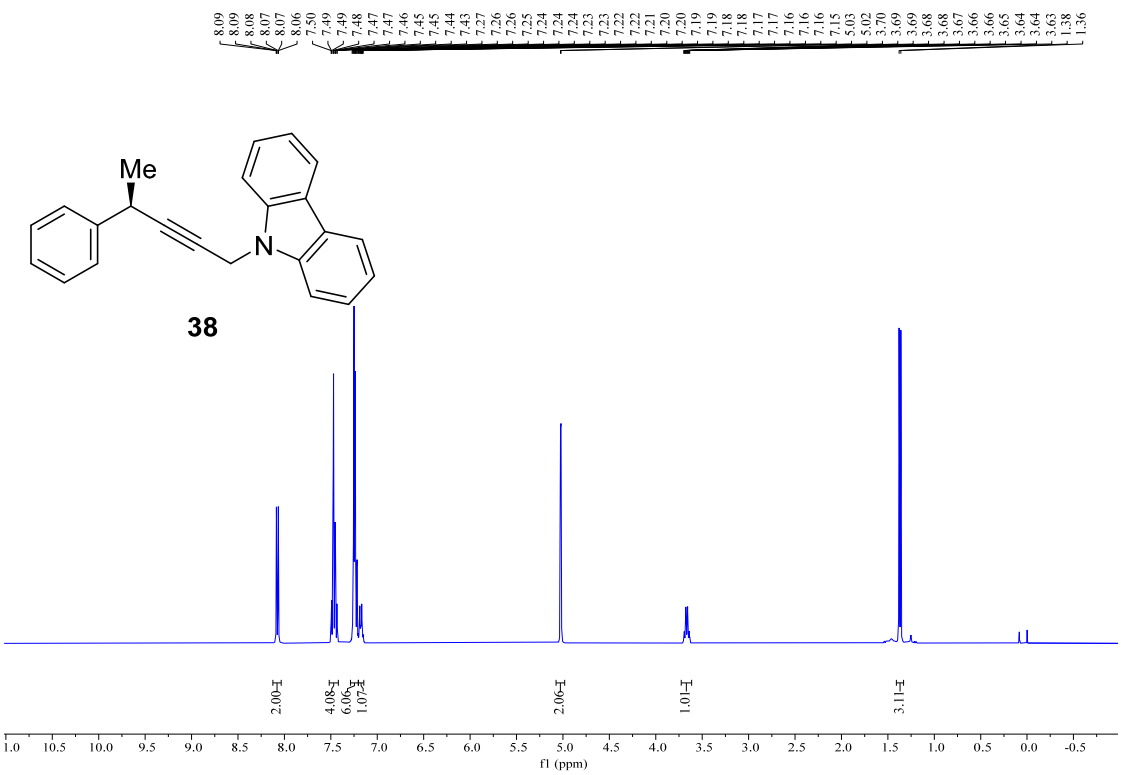

4.04
4.00
6.20
2.16
1.00
4.16
3.03
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1
f1 (ppm)

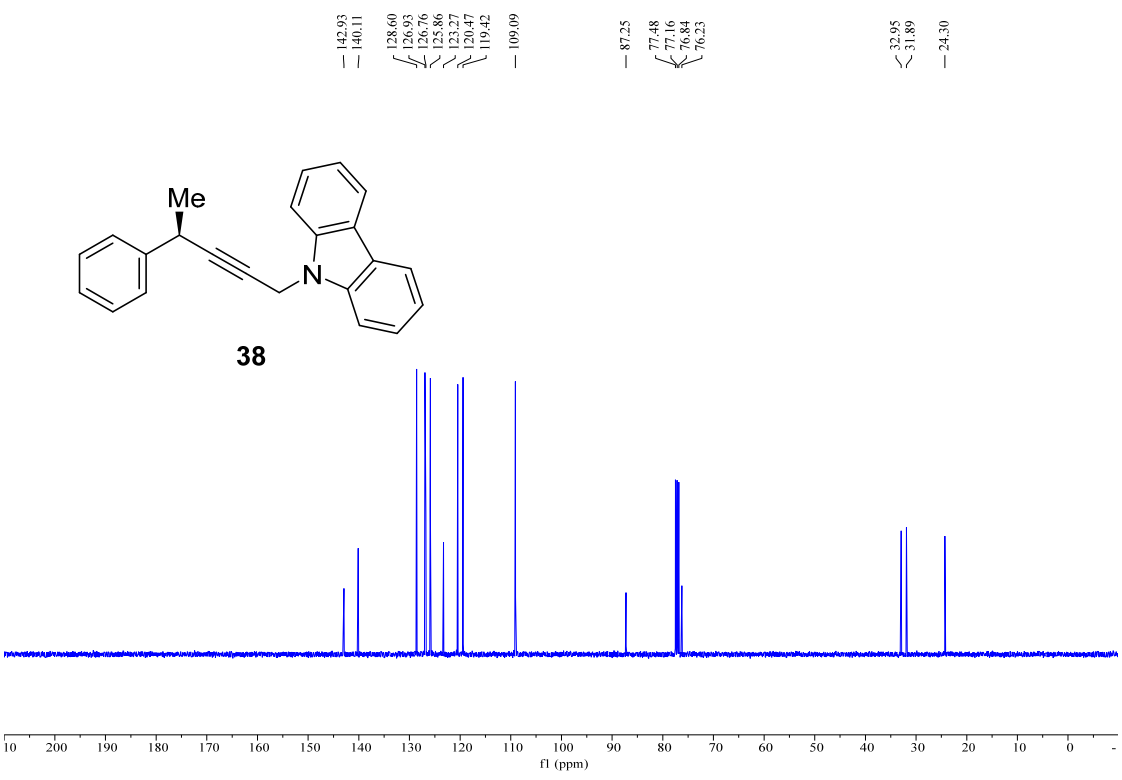

172.08
142.89
141.08
139.62
135.98
128.85
128.68
128.36
128.29
127.37
127.34
127.24
127.18
83.95
80.39
77.48
77.16
76.84
66.52
34.22
31.63
24.73
15.04

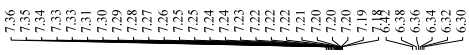

Me
OBn
Ph
O

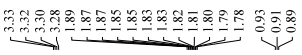
37

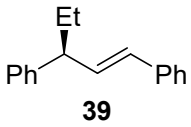

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -
f1 (ppm)


8.09 8.09 8.08 8.07 8.07 8.06 7.50 7.49 7.49 7.48 7.47 7.47 7.46 7.45 7.45 7.44 7.43 7.27 7.26 7.26 7.25 7.24 7.24 7.24 7.23 7.23 7.22 7.22 7.21 7.20 7.20 7.19 7.19 7.18 7.18 7.17 7.17 7.16 7.16 7.16 7.15 5.03 5.02 3.70 3.69 3.69 3.68 3.68 3.67 3.66 3.66 3.65 3.64 3.64 3.63 1.38 1.36
Me
N
38
2.00
4.08
6.06
1.07
2.06
1.01
3.11
1.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

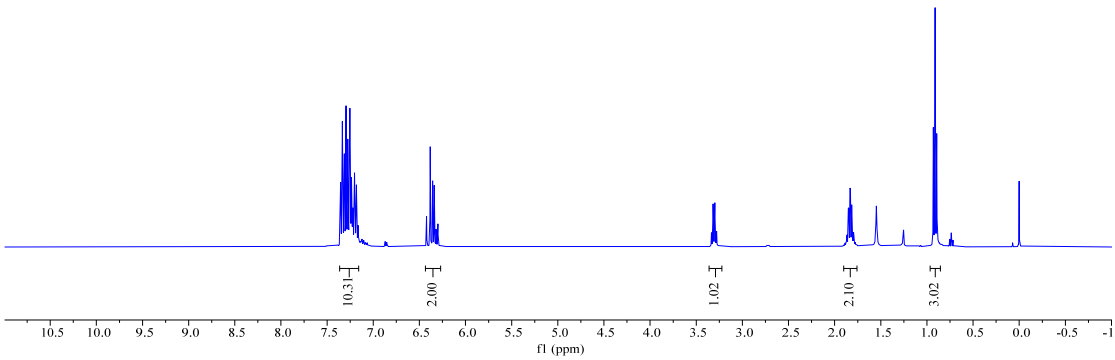

142.93 140.11 128.60 126.93 126.76 125.86 123.27 120.47 119.42 109.09 87.25 77.48 77.16 76.84 76.23 32.95 31.89 24.30
Me
N
38
10 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -
f1 (ppm)

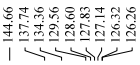

7.36
7.35
7.34
7.33
7.33
7.31
7.30
7.29
7.28
7.27
7.26
7.25
7.25
7.24
7.24
7.23
7.22
7.22
7.22
7.21
7.20
7.20
7.20
7.19
7.18
6.42
6.38
6.36
6.34
6.32
6.30

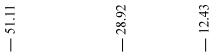

3.33
3.32
3.30
3.28
1.89
1.87
1.87
1.85
1.85
1.83
1.83
1.82
1.81
1.80
1.79
1.78
0.93
0.91
0.89

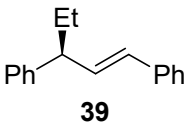

Et
Ph
Ph

39

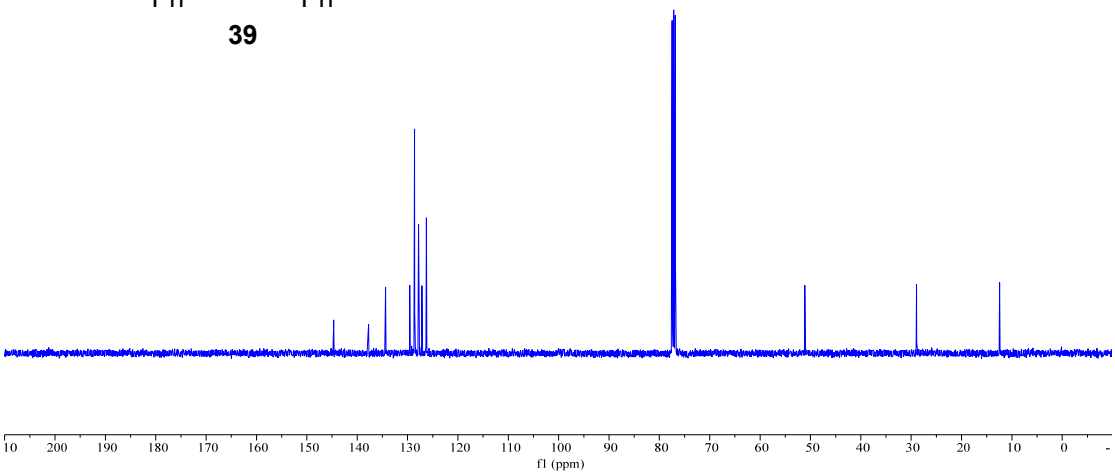

10.31
2.00
1.02
2.10
3.02
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1
f1 (ppm)


144.66
137.74
134.36
129.56
128.60
127.83
127.14
126.32
126.26

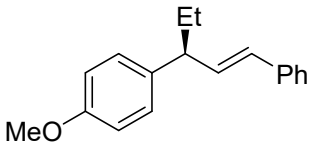

51.11
28.92
12.43


Et
Ph
Ph

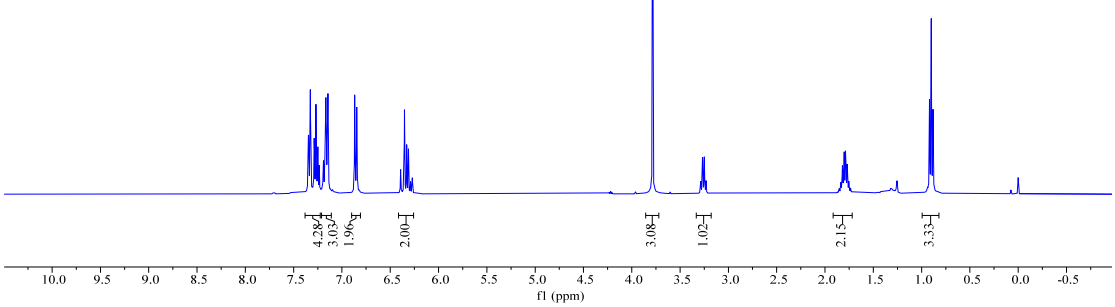
39


10 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -
f1 (ppm)

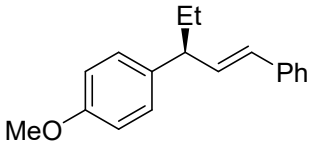

7.35
7.33
7.29
7.28
7.27
7.25
7.24
7.19
7.19
7.17
7.17
7.16
7.15
6.87
6.86
6.85
6.84
6.39
6.35
6.33
6.31
6.29
6.27
3.78
3.29
3.27
3.25
3.23
1.85
1.84
1.82
1.81
1.80
1.79
1.78
1.77
1.76
1.75
1.74
0.92
0.90
0.88


Et
Ph
MeO

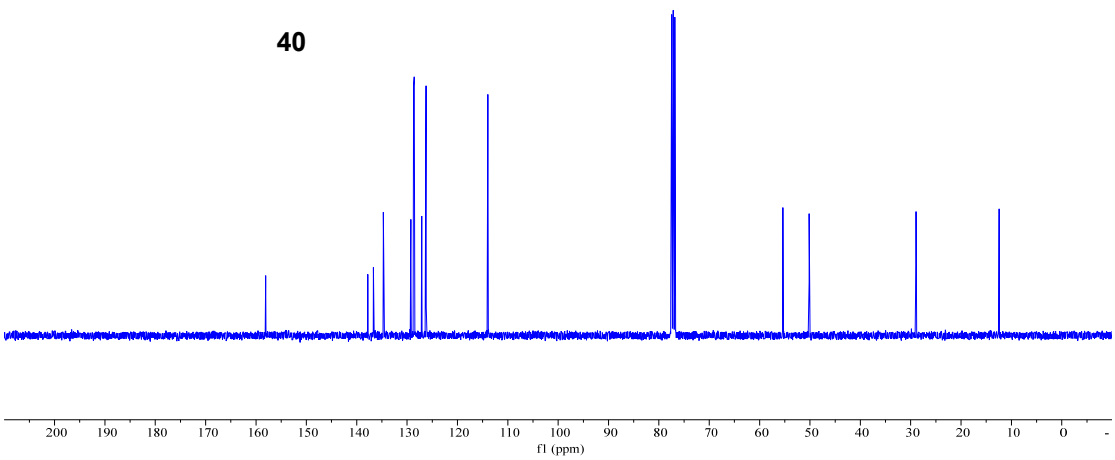
40

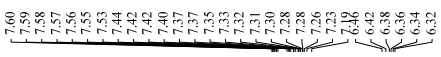

4.28
3.03
1.96
2.00
3.08
1.02
2.15
3.33
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

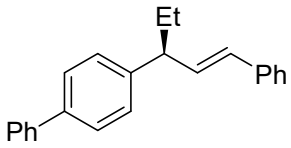

158.09
137.80
136.68
134.70
129.25
128.71
128.58
127.08
126.24
113.97
55.38
50.17
28.95
12.42


Et
Ph
MeO

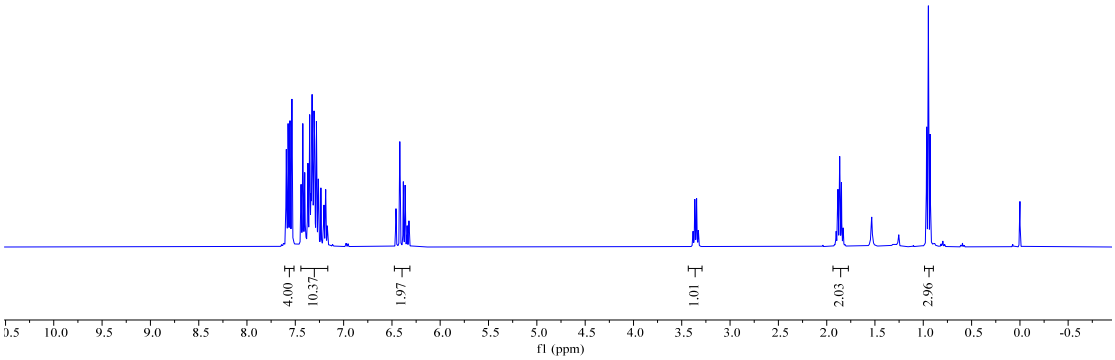
40


200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-
f1 (ppm)

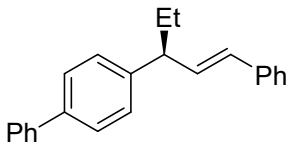

7.60
7.59
7.58
7.57
7.56
7.55
7.53
7.44
7.42
7.42
7.40
7.37
7.37
7.35
7.33
7.32
7.31
7.30
7.28
7.28
7.26
7.23
7.19
6.46
6.42
6.38
6.36
6.34
6.32
3.38
3.36
3.35
3.33
1.90
1.88
1.87
1.85
1.83
0.97
0.95
0.93


Et
Ph
Ph

41

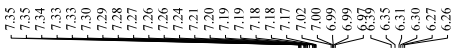

4.00
10.37
1.97
1.01
2.03
2.96
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)

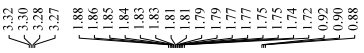

143.78
141.17
139.25
137.70
134.18
129.71
128.85
128.61
128.22
127.35
127.19
127.16
126.29
50.78
28.91
12.48

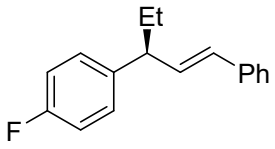

Et
Ph
Ph

41

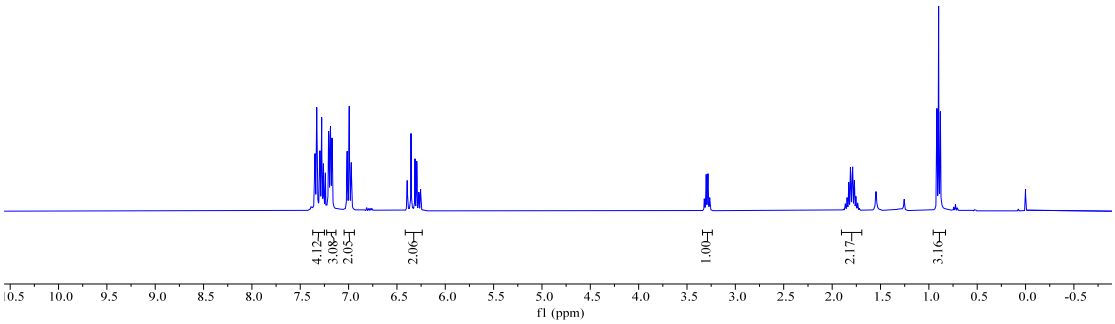
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

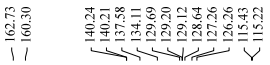

7.35
7.35
7.34
7.33
7.33
7.30
7.29
7.28
7.27
7.26
7.26
7.24
7.21
7.20
7.19
7.19
7.18
7.18
7.17
7.02
7.00
6.99
6.97
6.39
6.35
6.31
6.30
6.27
6.26

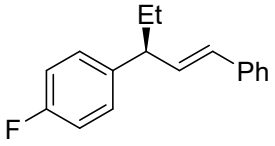

3.32
3.30
3.28
3.27
1.88
1.86
1.85
1.84
1.83
1.83
1.81
1.81
1.79
1.79
1.77
1.77
1.75
1.75
1.74
1.72
0.92
0.90
0.88


Et
Ph
F

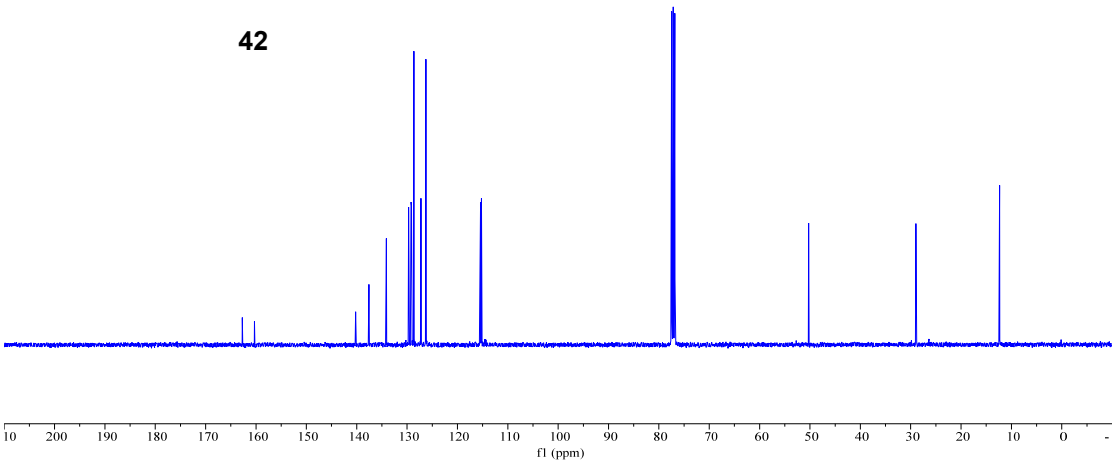
42

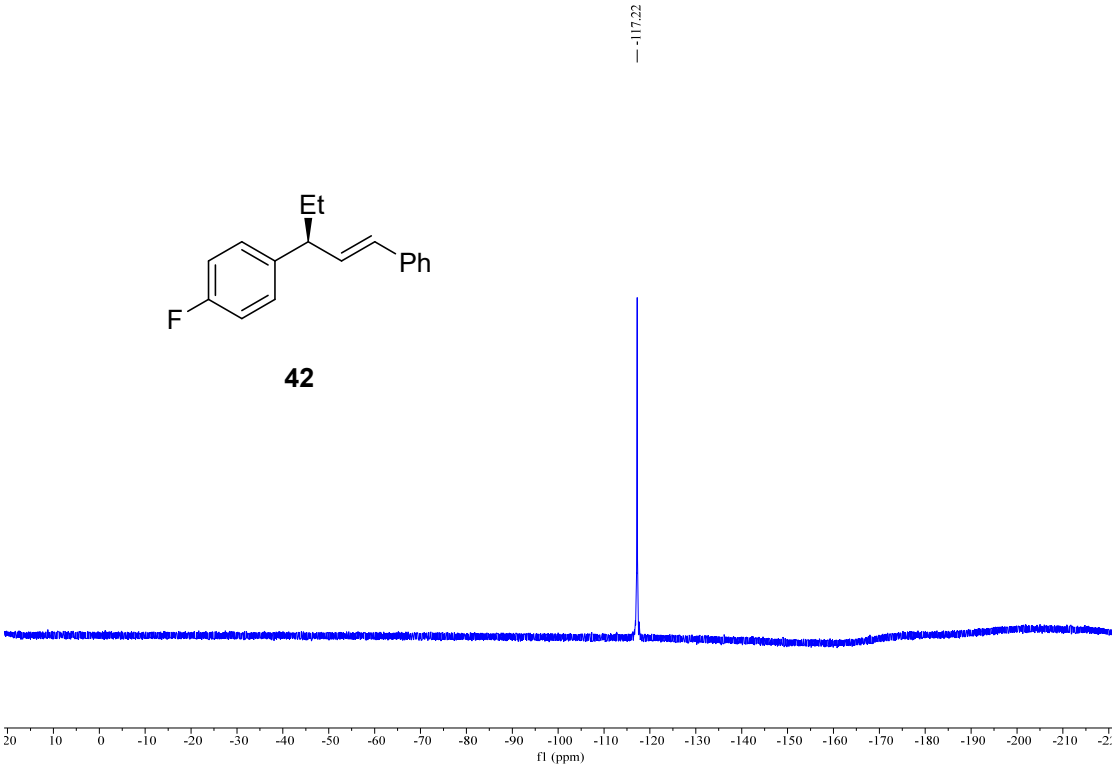

4.12
3.08
2.05
2.06
1.00
2.17
3.16
f1 (ppm)


162.73
160.30
140.24
140.21
137.58
134.11
129.69
129.20
129.12
128.64
127.26
126.26
115.43
115.22
50.26
28.98
12.35


Et
Ph
F

42


f1 (ppm)


-117.22
Et
Ph
F
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-10
-20
-30
-40
-50
-60
-70
-80
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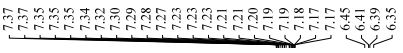
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
f1 (ppm)

42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7.17
7.17
6.45
6.41
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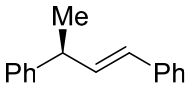
1.46


Me
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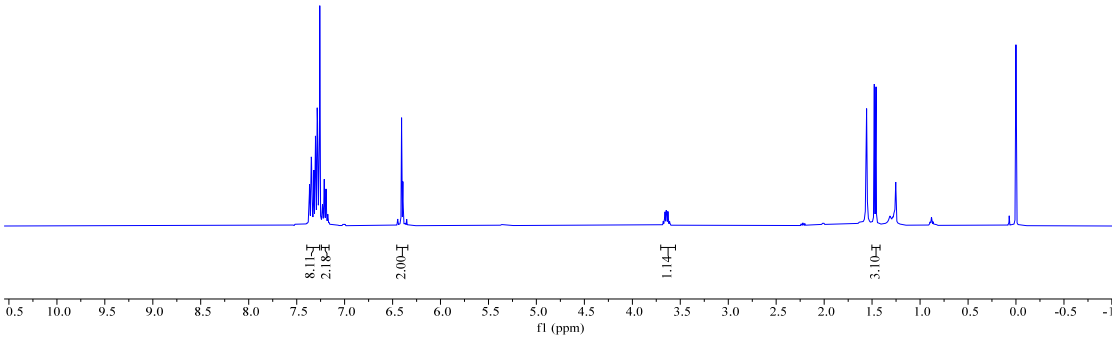
43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6.0
5.5
5.0
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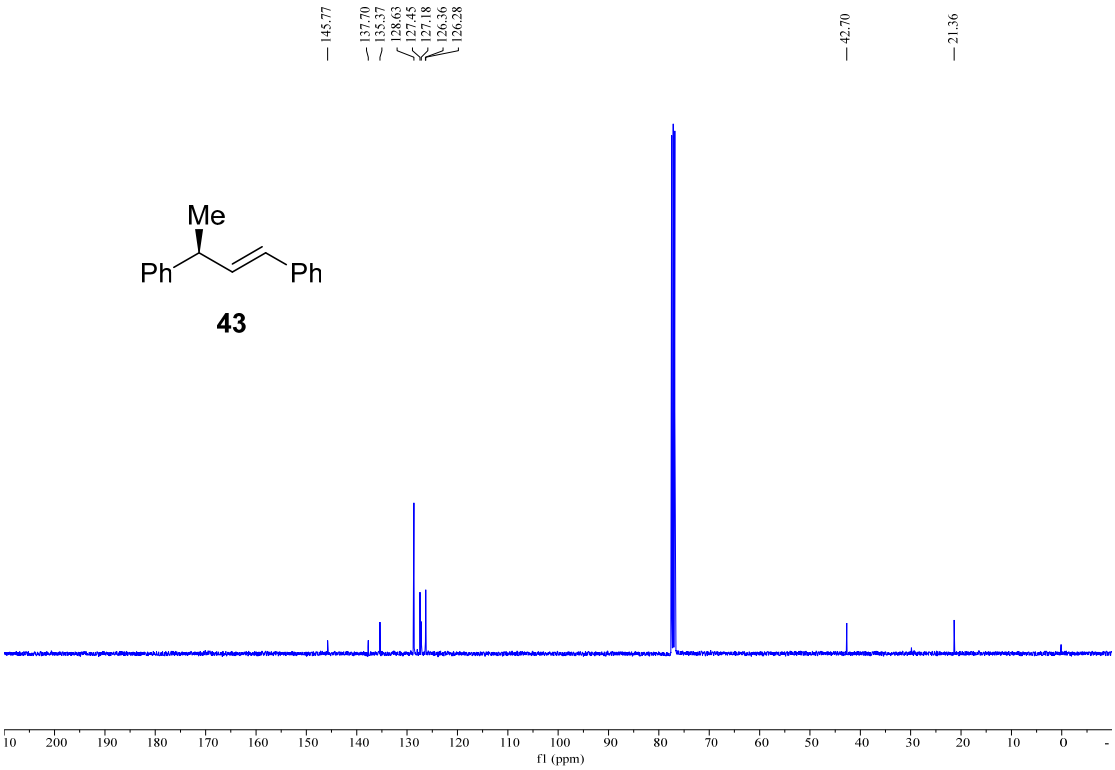
f1 (ppm)


145.77
137.70
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128.63
127.45
127.18
126.36
126.28
42.70
21.36
Me
Ph
Ph
43
10
200
190
180
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130
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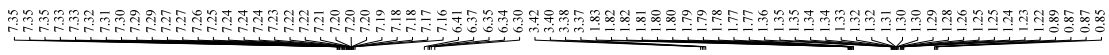
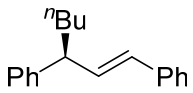
20
10
0
f1 (ppm)





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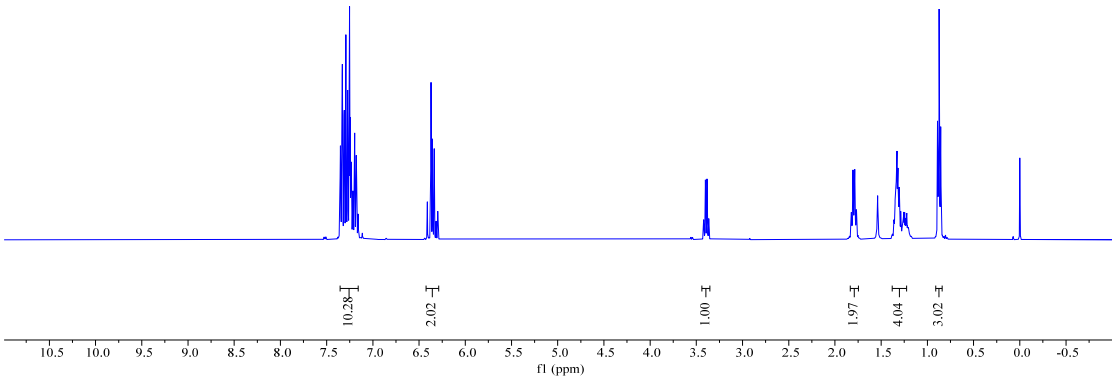

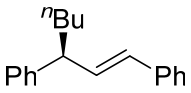

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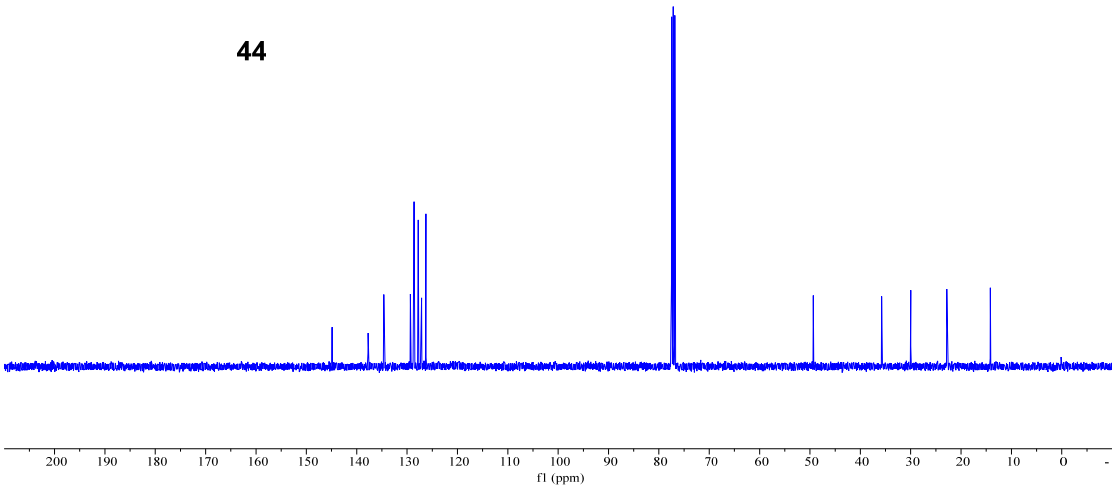


7.36
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7.19
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6.39
6.39
6.38
6.34
3.10
3.07
3.06
3.06
3.05
3.04
3.03
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3.02
3.01
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2.07
2.07
2.05
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2.04
2.03
2.02
2.02
2.01
2.00
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1.01
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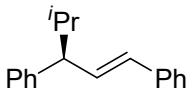
iPr
Ph
Ph

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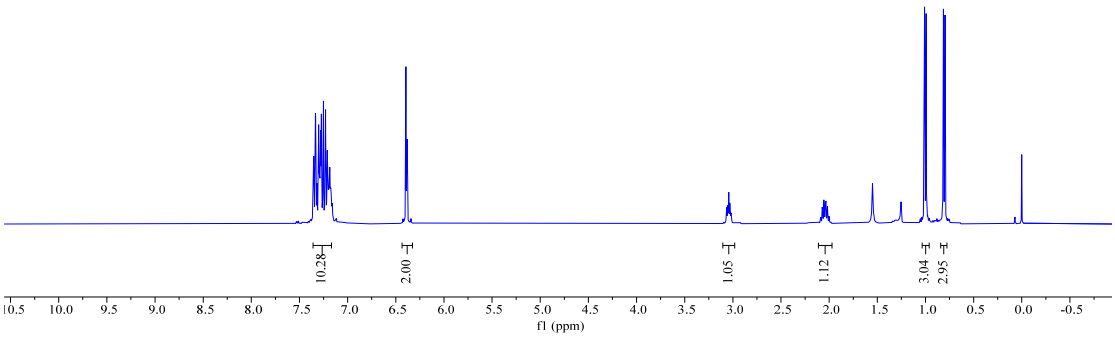
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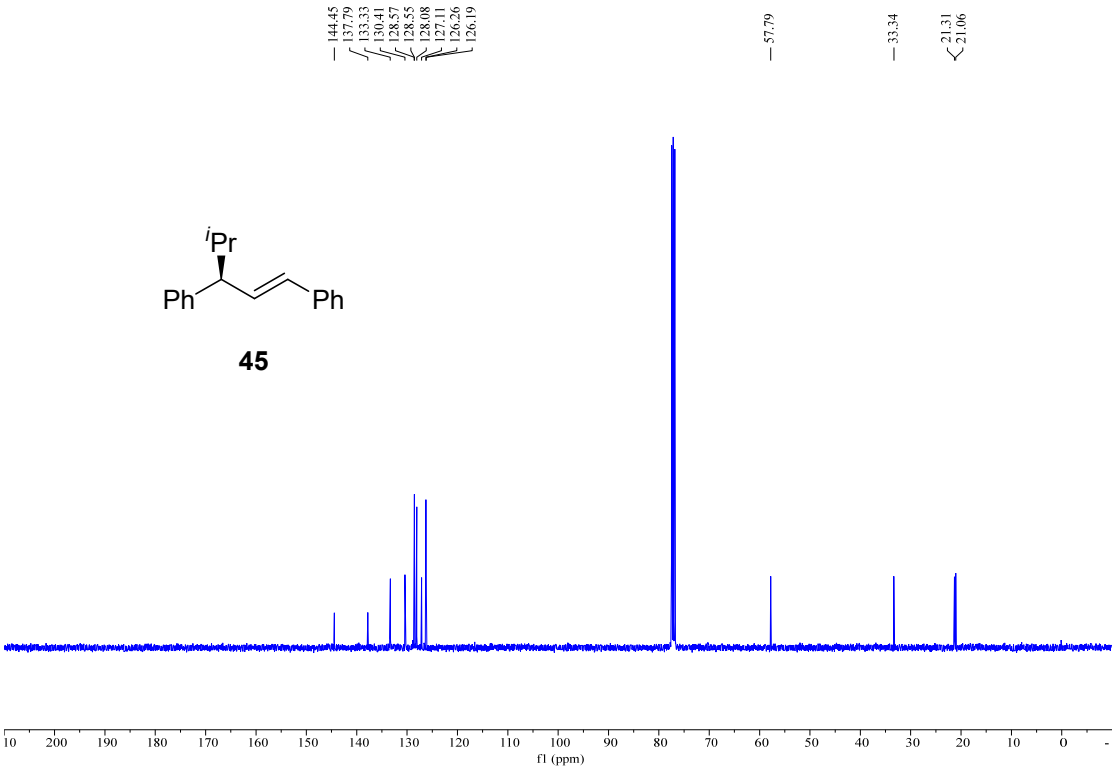
1.12
3.04
2.95
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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127.11
126.26
126.19
57.79
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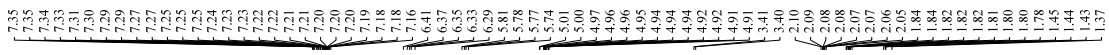
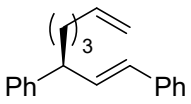
21.31
21.06
iPr
Ph
Ph
10 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -
f1 (ppm)

45





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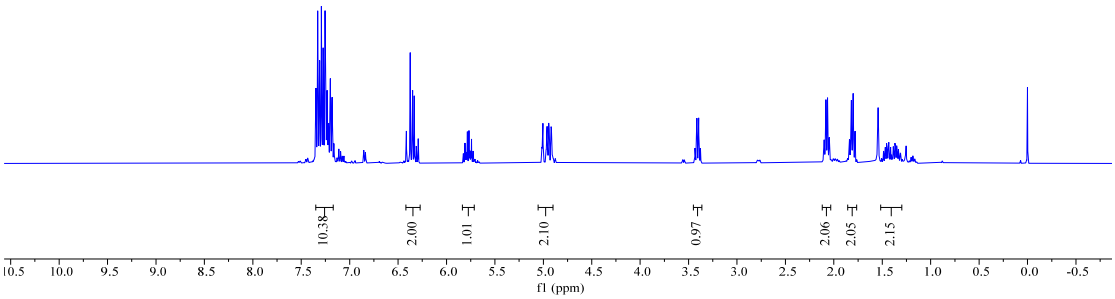

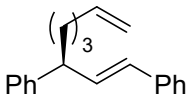

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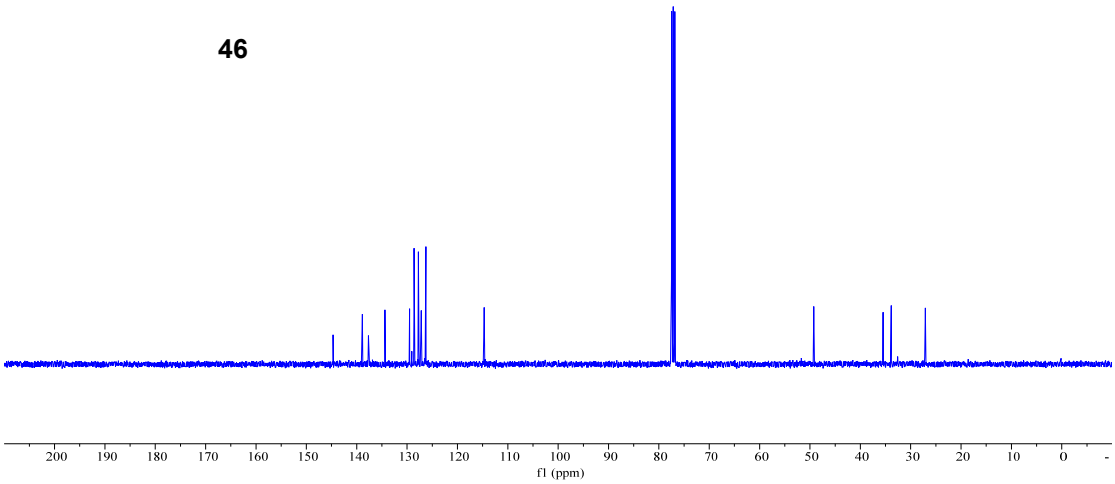

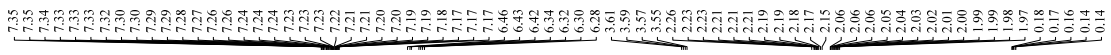

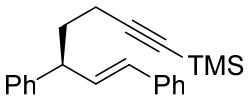

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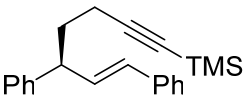

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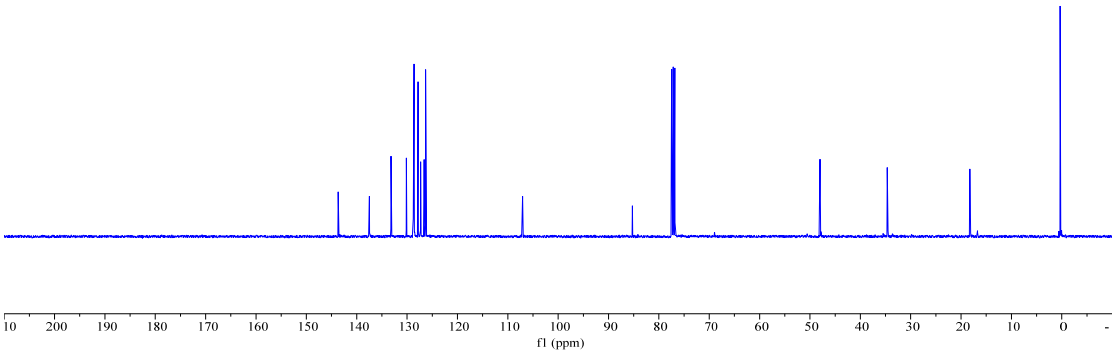

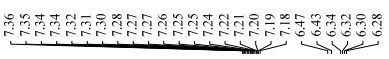
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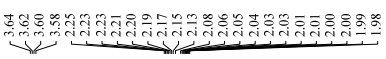
6.32
6.30
6.28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2.13
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2.01
2.01
2.00
2.00
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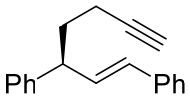
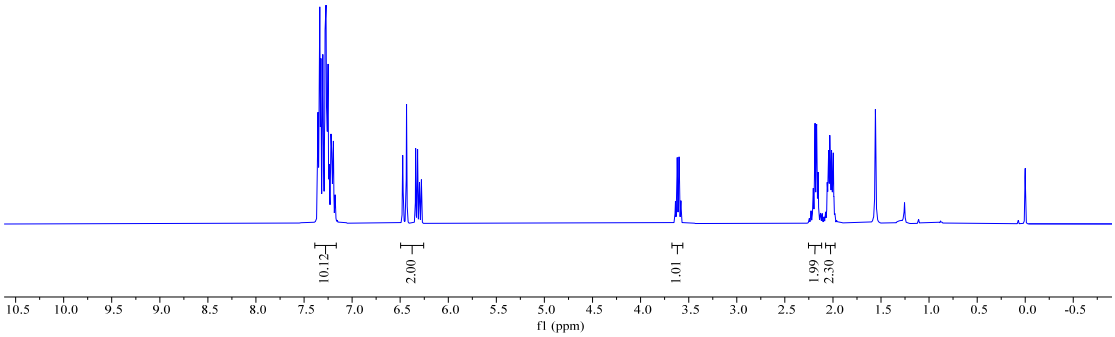
1.98


Ph
Ph

47'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8.5
8.0
7.5
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6.5
6.0
5.5
5.0
4.5
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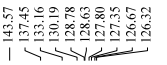
3.0
2.5
2.0
1.5
1.0
0.5
0.0
-0.5
f1 (ppm)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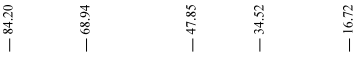
127.35
126.67
126.32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34.52
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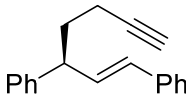
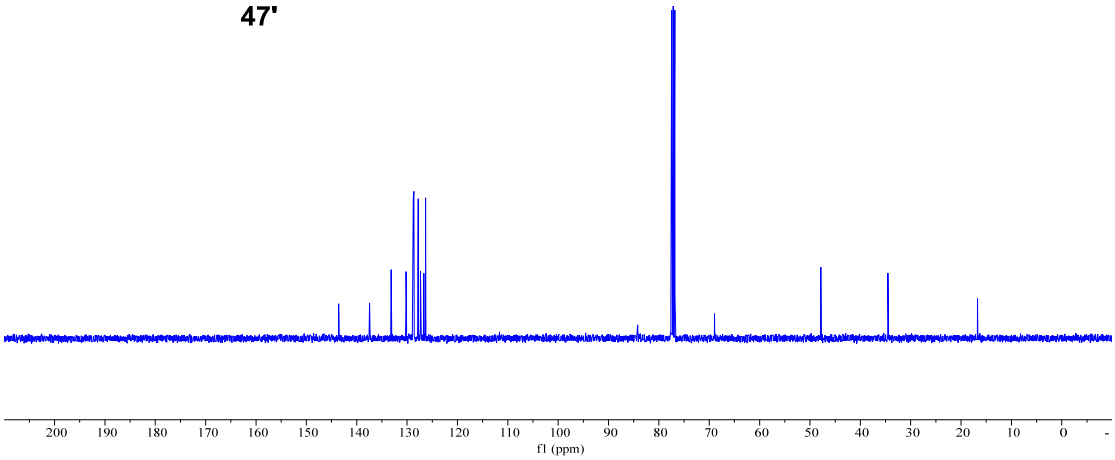

Ph
Ph

47'


200
190
180
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140
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120
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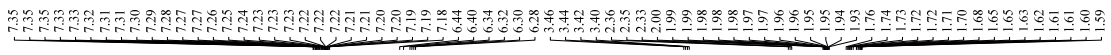
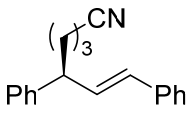
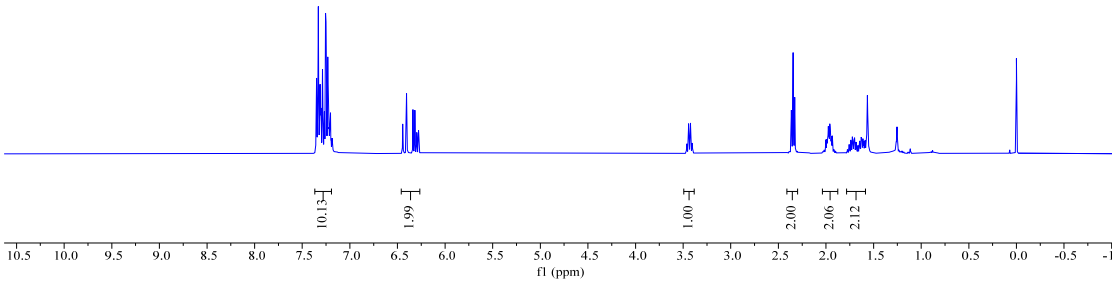
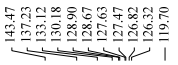
100
90
80
70
60
50
40
30
20
10
0
-
f1 (ppm)

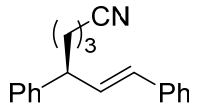




48







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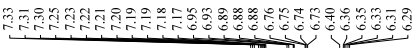
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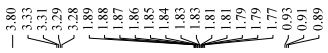
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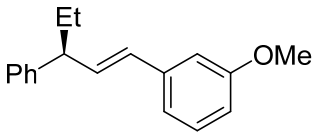
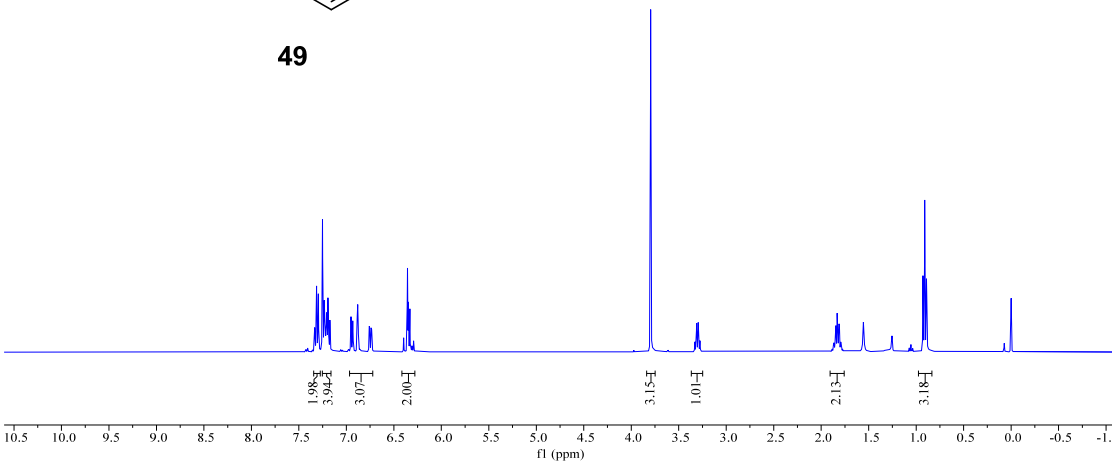
0.91
0.89


Et
Ph
OMe

49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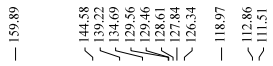
3.94
3.07
2.00
3.15
1.01
2.13
3.18
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.
f1 (ppm)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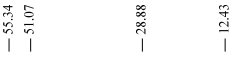
127.84
126.34
118.97
112.86
111.51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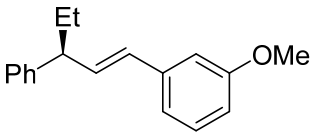
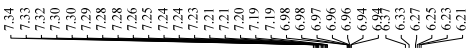

Et
Ph
OMe

49

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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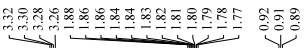
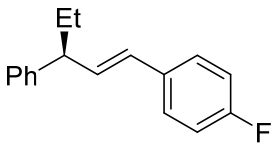
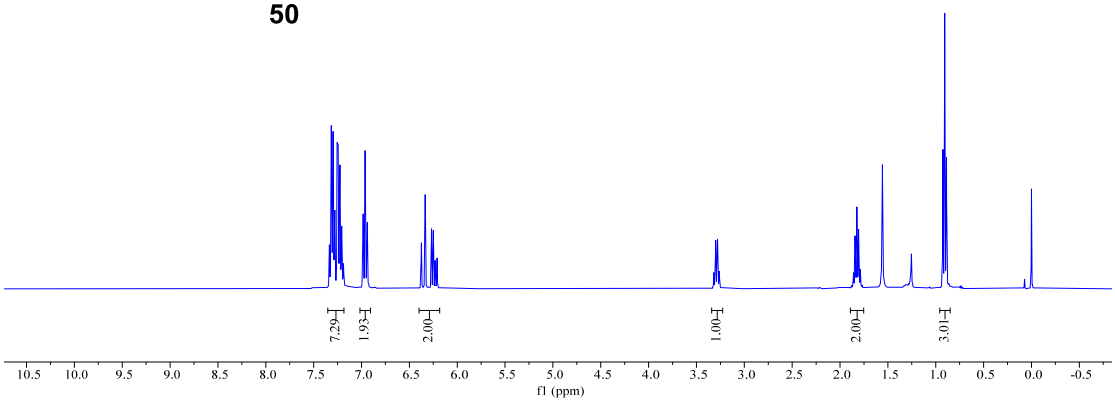
6.33
6.27
6.25
6.23
6.21

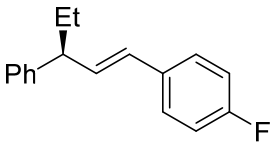

3.32
3.30
3.28
3.26
1.88
1.86
1.86
1.84
1.84
1.83
1.82
1.81
1.80
1.79
1.78
1.77
0.92
0.91
0.89


Et
Ph
F

50

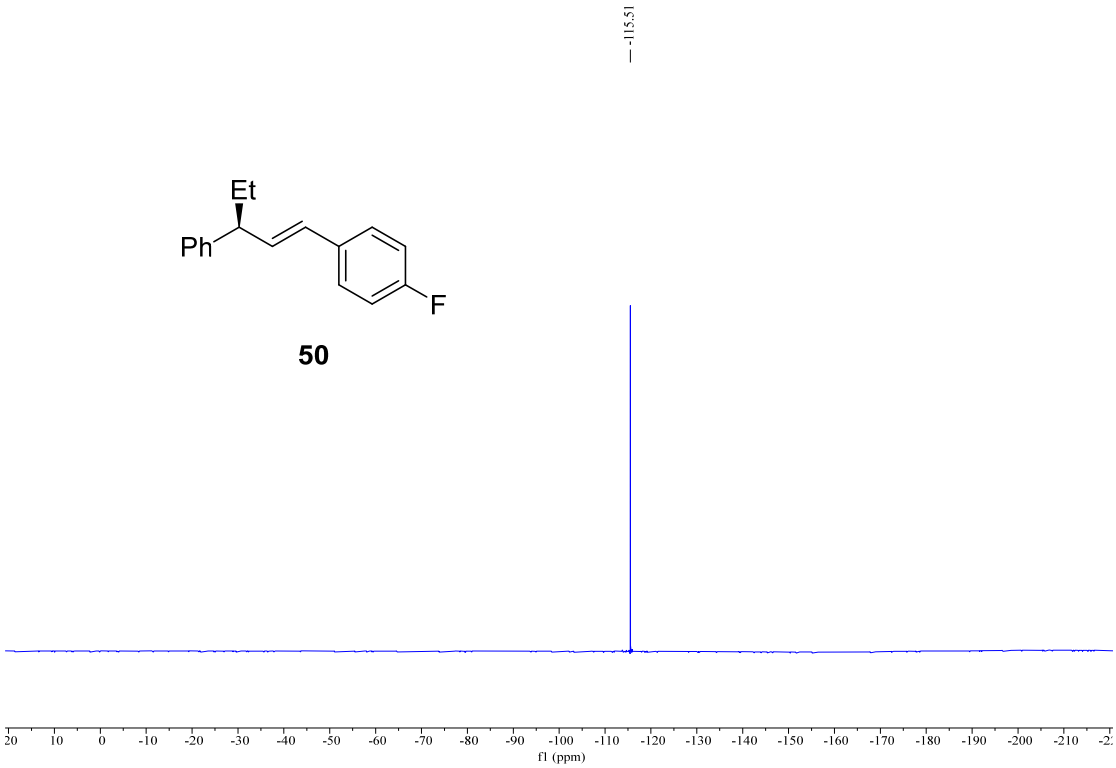

7.29
1.93
2.00
1.00
2.00
3.01
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)


163.34
160.90
144.55
134.14
133.90
133.87
128.64
128.39
127.80
127.72
127.64
126.38
115.54
115.33
51.10
28.91
12.43

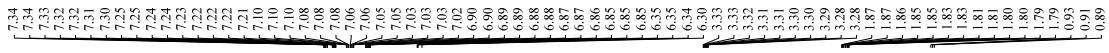

Et
Ph
F

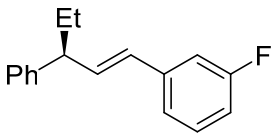
50

10 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -
f1 (ppm)

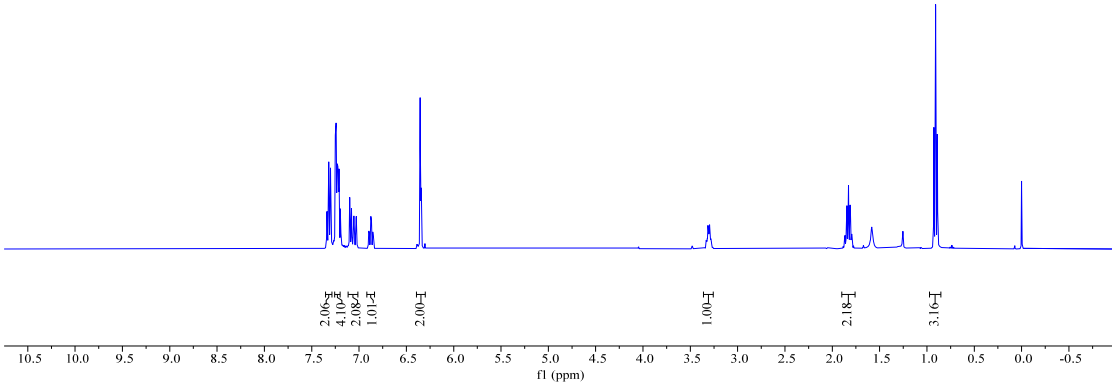

-115.51
Et
Ph
F
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
f1 (ppm)

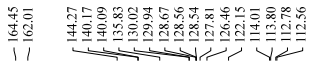
50

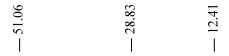


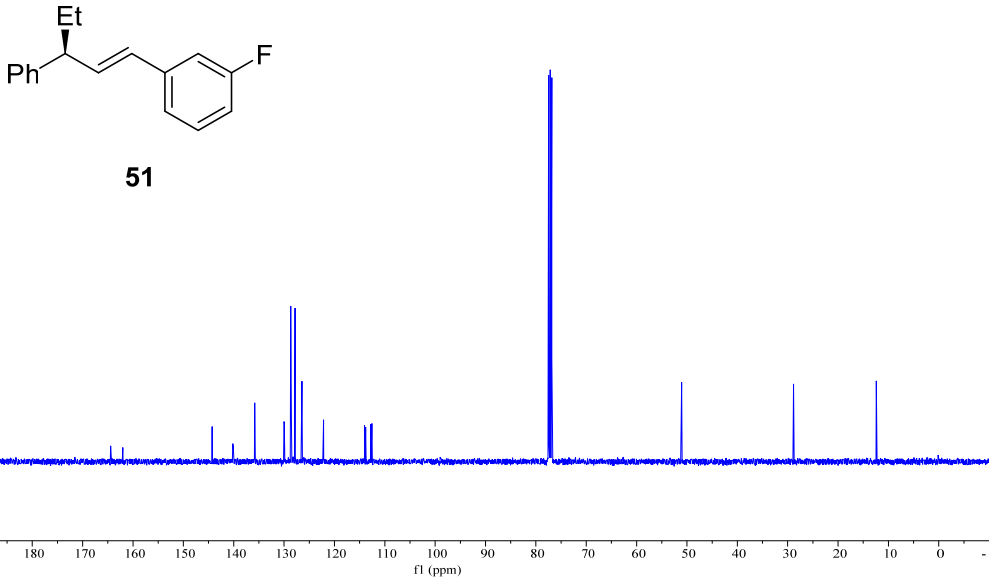

Et
Ph
F

51


2.06
4.10
2.08
1.01
2.00
1.00
2.18
3.16
f1 (ppm)

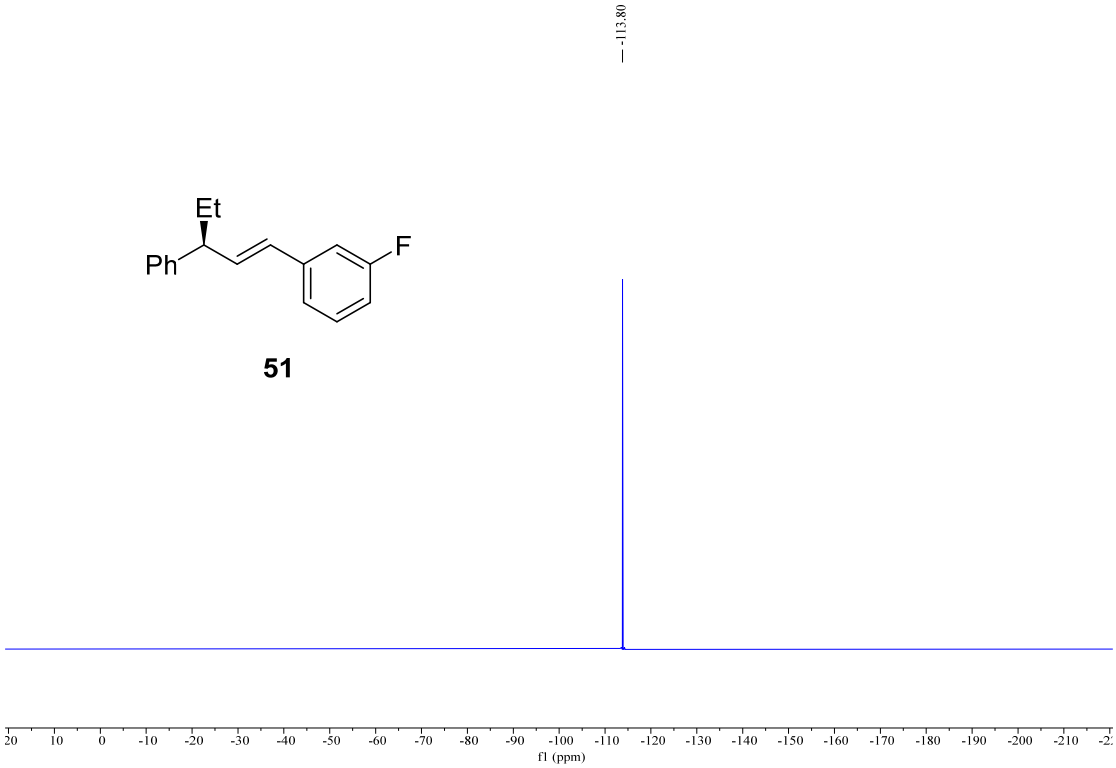




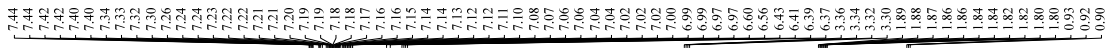

164.45
162.01
144.27
140.17
140.09
135.83
130.02
129.94
128.67
128.56
128.54
127.81
126.46
122.15
114.01
113.80
112.78
112.56
51.06
28.83
12.41
f1 (ppm)

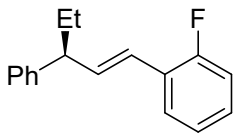
Et
Ph
F

51


-113.80
Et
Ph
F
20 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)

51





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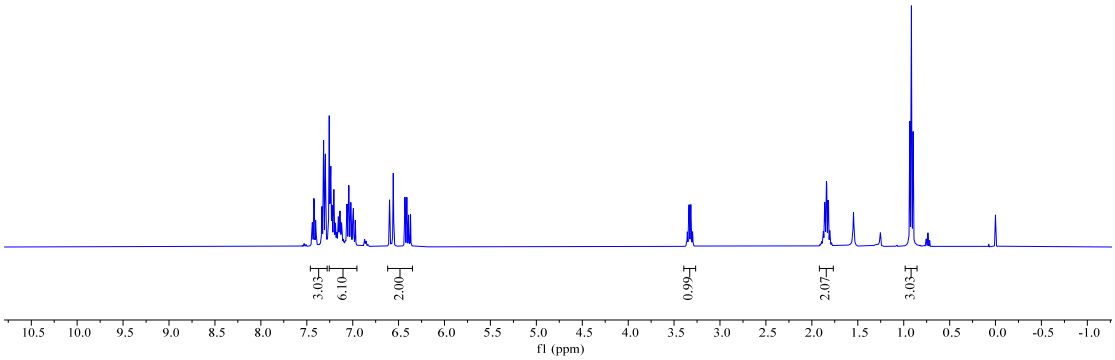
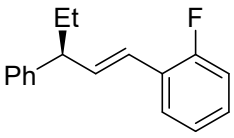
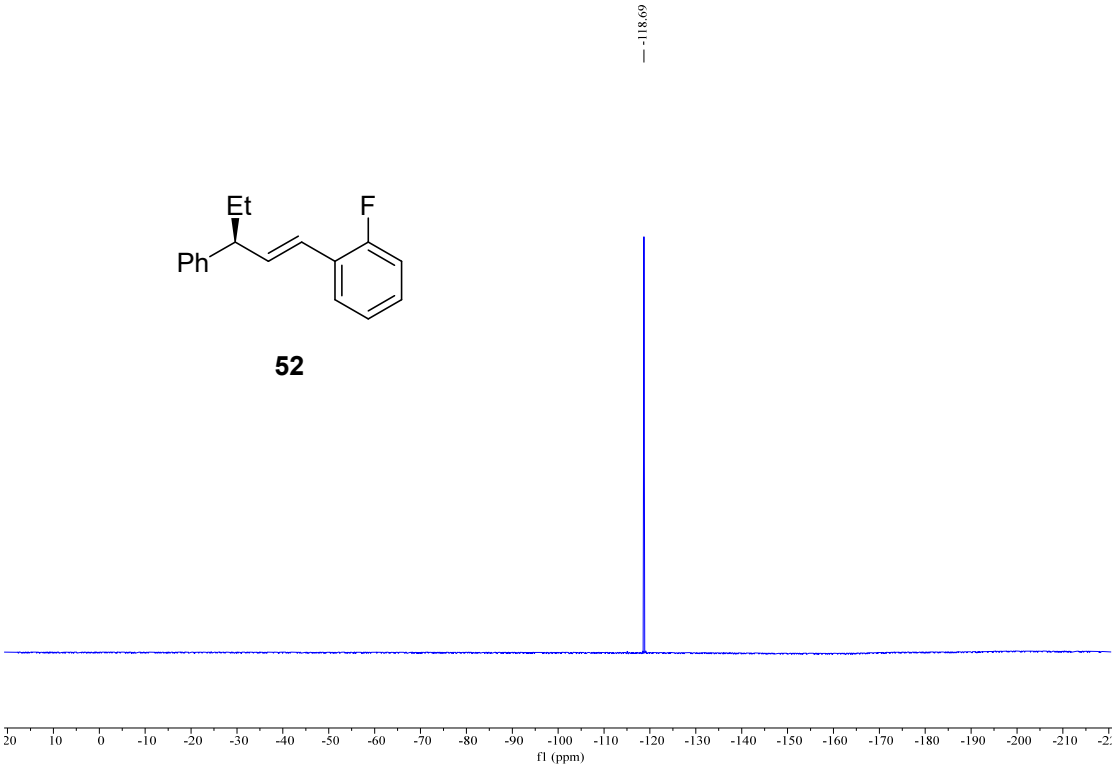




52


-118.69
Et
F
Ph
20
10
0
-10
-20
-30
-40
-50
-60
-70
-80
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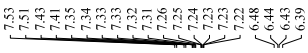
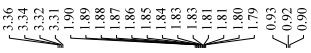
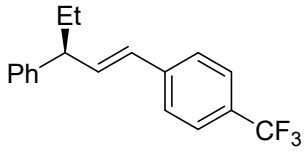
-130
-140
-150
-160
-170
-180
-190
-200
-210
f1 (ppm)

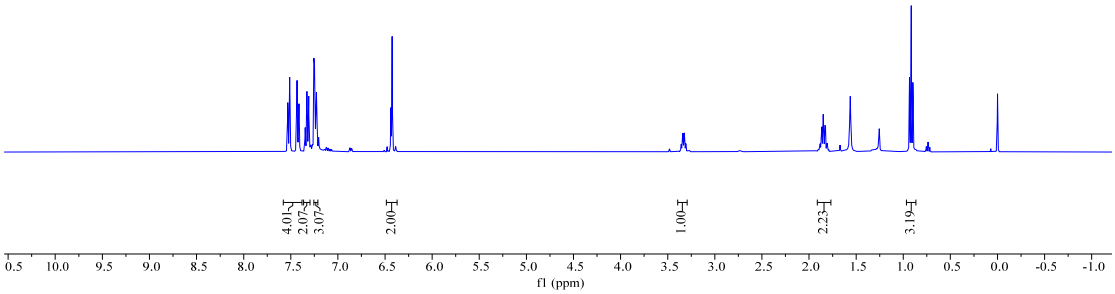
52


7.53
7.51
7.43
7.41
7.35
7.34
7.33
7.33
7.32
7.31
7.26
7.25
7.24
7.23
7.23
7.22
6.48
6.44
6.43
6.39

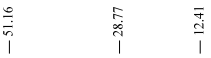

3.36
3.34
3.32
3.31
1.90
1.89
1.88
1.87
1.86
1.85
1.84
1.83
1.83
1.81
1.81
1.80
1.79
0.93
0.92
0.90

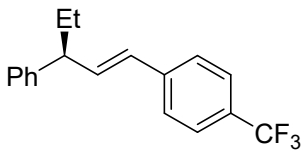

Et
Ph
CF3

53


4.01
2.07
3.07
2.00
1.00
2.23
3.19
0.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)

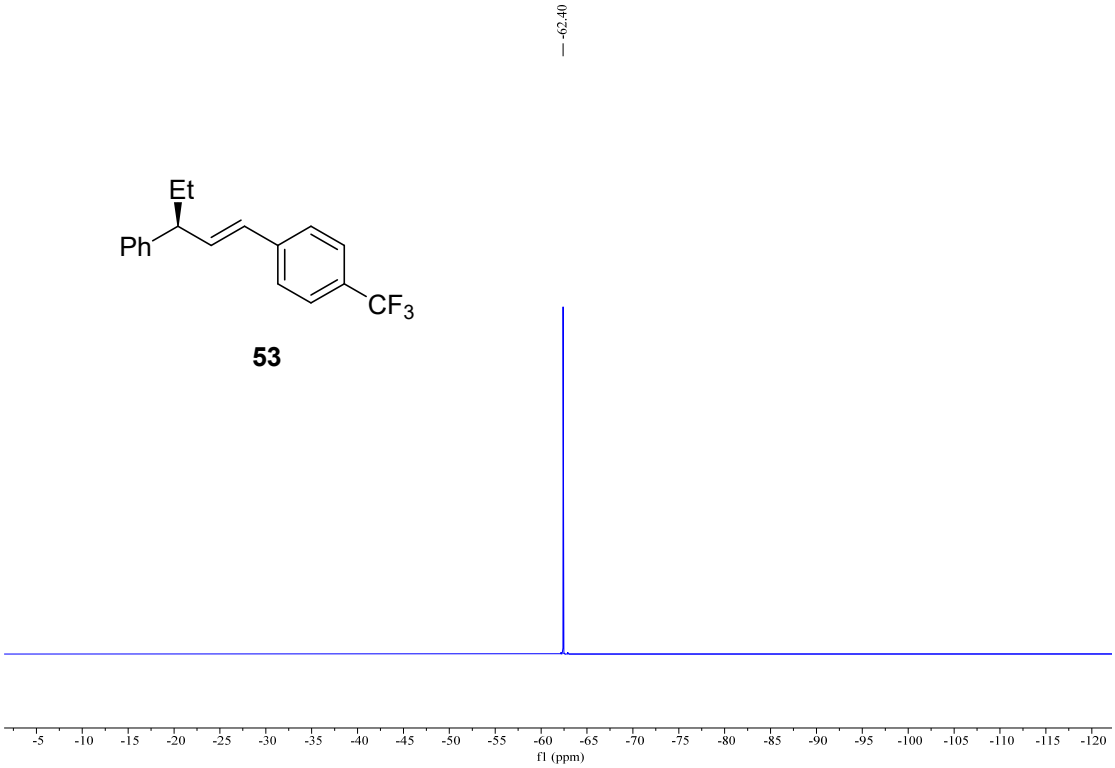

144.04
141.21
137.18
129.20
129.11
128.72
128.36
127.82
127.58
126.55
126.39
125.75
125.60
125.56
125.52
125.49
123.04


51.16
28.77
12.41

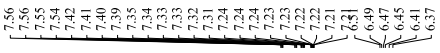

Et
Ph
CF3

53

10 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


-62.40
Et
Ph
CF3
-5 -10 -15 -20 -25 -30 -35 -40 -45 -50 -55 -60 -65 -70 -75 -80 -85 -90 -95 -100 -105 -110 -115 -120
f1 (ppm)

53


7.56
7.56
7.55
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7.42
7.41
7.40
7.39
7.35
7.34
7.33
7.33
7.32
7.31
7.24
7.24
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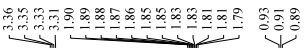
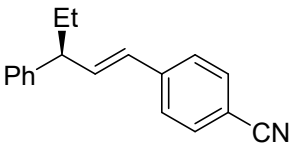
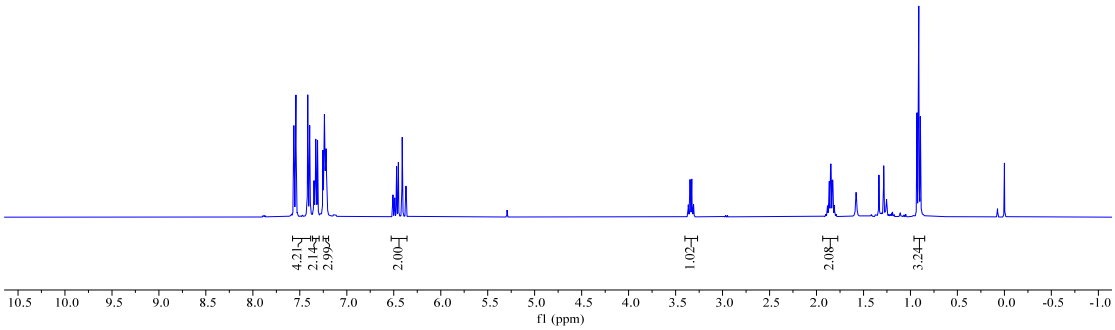
7.23
7.22
7.22
7.21
6.49
6.47
6.45
6.41
6.37

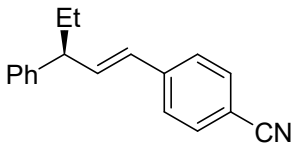

3.36
3.35
3.33
3.31
1.90
1.89
1.88
1.87
1.86
1.85
1.85
1.83
1.83
1.81
1.81
1.79
0.93
0.91
0.89


Et
Ph
CN

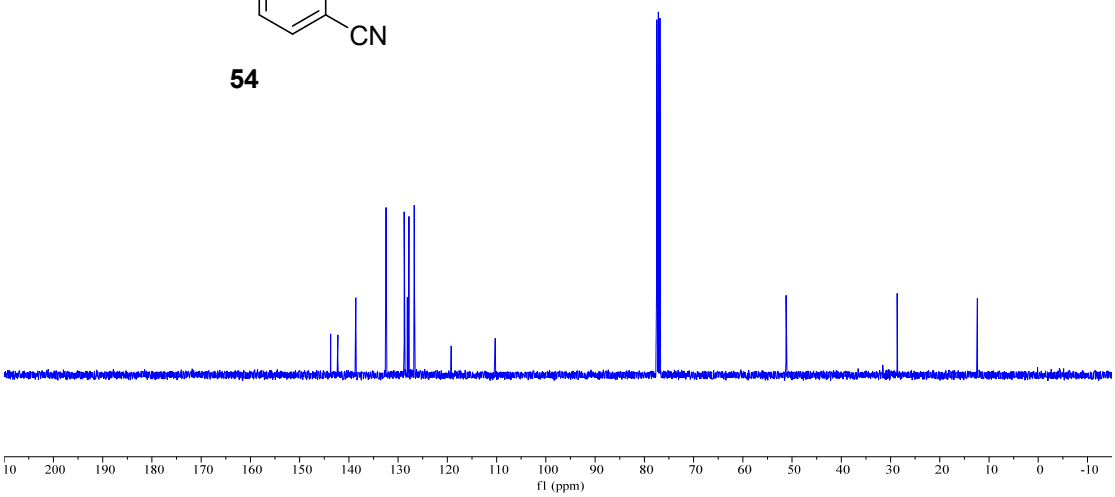
54

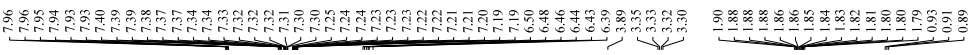

4.21
2.14
2.99
2.00
1.02
2.08
3.24
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)


143.69
142.23
138.61
132.45
128.77
128.14
127.80
126.73
126.65
119.23
110.29
51.22
28.67
12.38


Et
Ph
CN

54


210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


7.96
7.96
7.95
7.94
7.93
7.93
7.40
7.39
7.39
7.38
7.37
7.37
7.34
7.34
7.33
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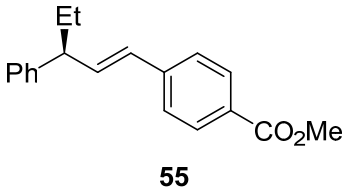
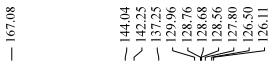
7.30
7.30
7.25
7.24
7.24
7.23
7.23
7.23
7.22
7.22
7.21
7.21
7.20
7.19
7.19
6.50
6.48
6.46
6.44
6.43
6.39
3.89
3.35
3.33
3.32
3.30
1.90
1.88
1.88
1.88
1.86
1.86
1.85
1.84
1.83
1.82
1.81
1.80
1.80
1.79
0.93
0.91
0.89


Et
Ph
CO2Me

55

2.00
7.20
2.00
3.01
0.99
2.05
3.07
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)


167.08
144.04
142.25
137.25
129.96
128.76
128.68
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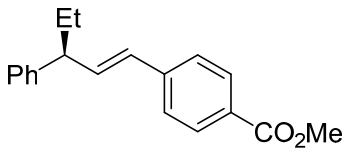
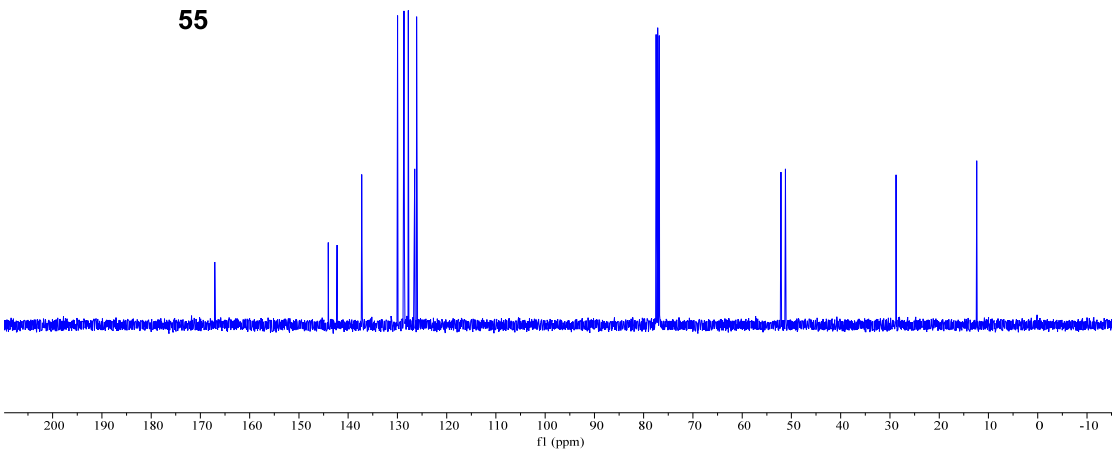
127.80
126.50
126.11
52.12
51.22
28.74
12.39


Et
Ph
CO2Me

55


200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


7.77
7.77
7.76
7.75
7.73
7.68
7.59
7.58
7.56
7.56
7.43
7.42
7.41
7.40
7.39
7.33
7.31
7.29
7.29
7.27
7.24
6.58
6.54
6.49
6.47
6.45
6.43
3.39
3.37
3.35
3.34
1.93
1.91
1.90
1.90
1.89
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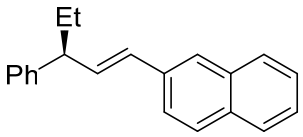
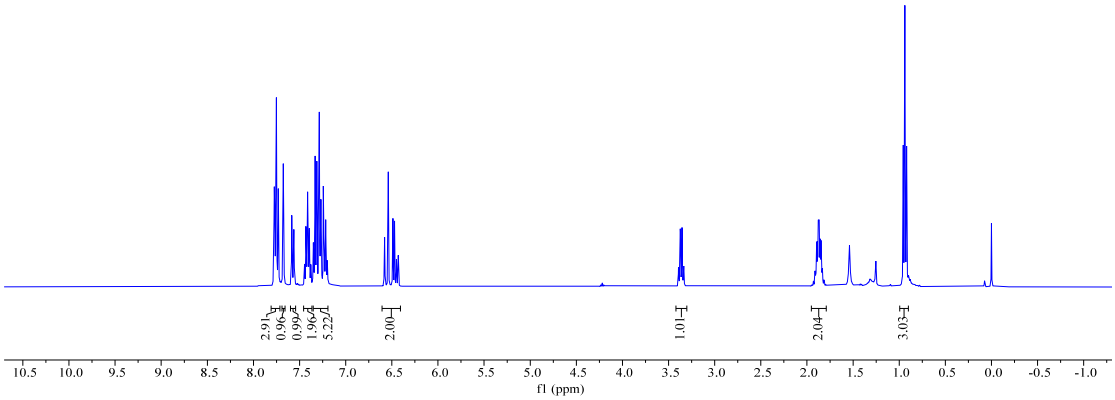
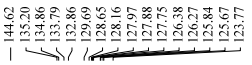
1.87
1.86
1.85
1.84
1.83
1.82
1.80
0.96
0.94
0.92


Et
Ph

56


2.91
0.96
0.99
1.96
5.22
2.00
1.01
2.04
3.03
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)


144.62
135.20
134.86
133.79
132.86
129.69
128.65
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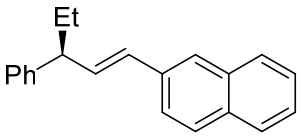
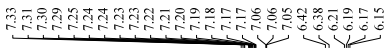
127.97
127.88
127.75
126.38
126.27
125.84
125.67
123.77
51.26
28.96
12.48


Et
Ph

56

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


7.33
7.31
7.30
7.29
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7.24
7.24
7.23
7.23
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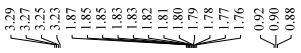
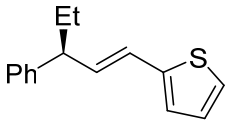
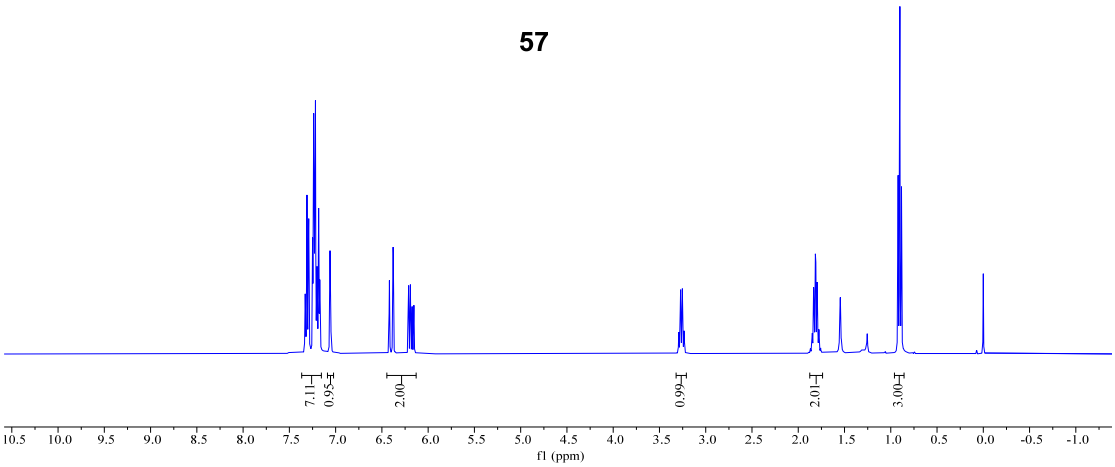
7.21
7.20
7.19
7.18
7.17
7.17
7.06
7.06
7.05
6.42
6.38
6.21
6.19
6.17
6.15


3.29
3.27
3.25
3.23
1.87
1.85
1.85
1.83
1.83
1.82
1.81
1.80
1.79
1.78
1.77
1.76
0.92
0.90
0.88


Et
Ph
S

57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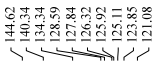
2.00
0.99
2.01
3.00
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)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128.59
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126.32
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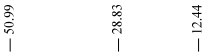
125.11
123.85
121.08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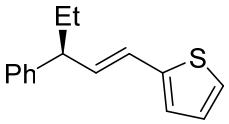
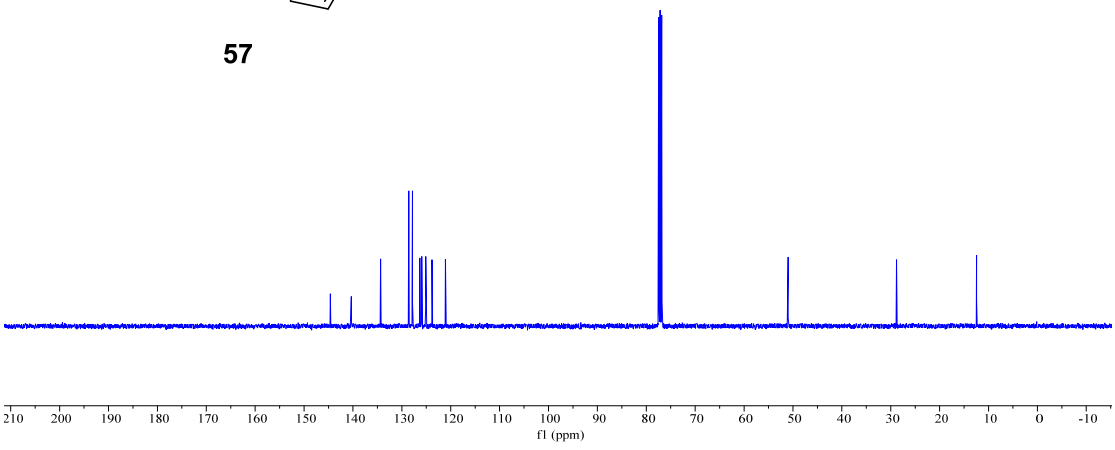
28.83
12.44


Et
Ph
S

57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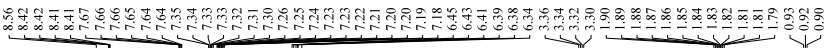
f1 (ppm)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7.32
7.31
7.30
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7.23
7.22
7.21
7.20
7.20
7.19
7.18
6.45
6.43
6.41
6.39
6.38
6.34
3.36
3.34
3.32
3.30
1.90
1.89
1.88
1.87
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1.85
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1.81
1.81
1.79
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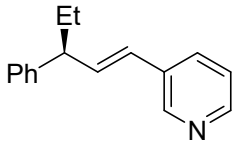
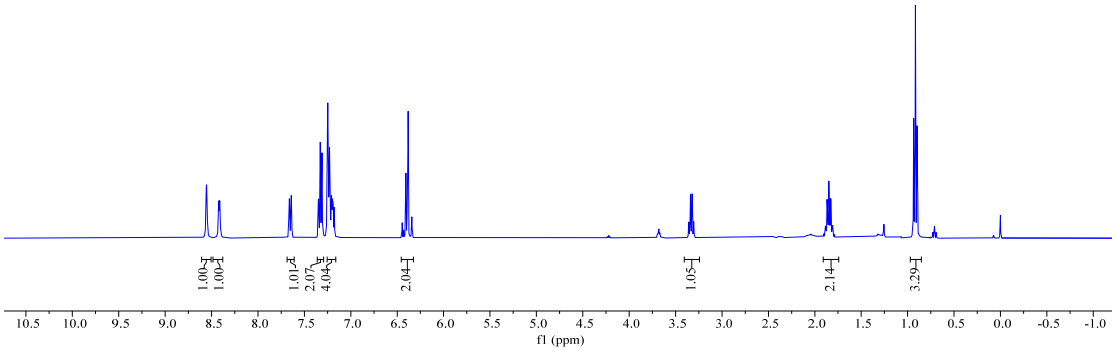
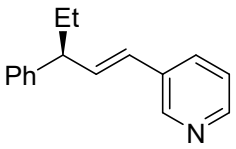
0.92
0.90


Et
Ph
N

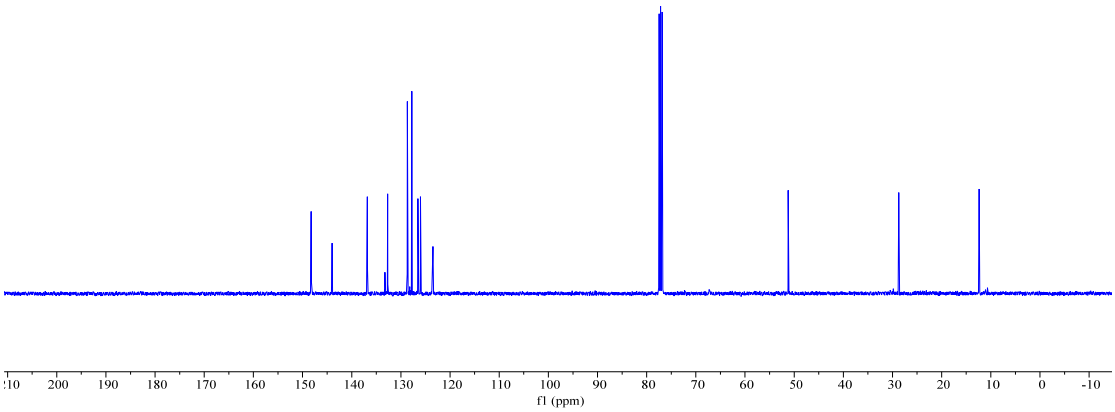
58


1.00
1.00
1.01
2.07
4.04
2.04
1.05
2.14
3.29
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)


148.25
148.22
144.00
136.81
133.26
132.68
128.70
127.78
126.53
126.00
123.46
51.23
28.74
12.39


Et
Ph
N

58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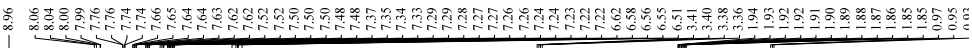
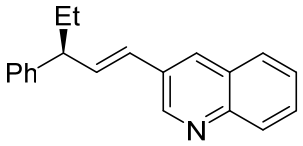
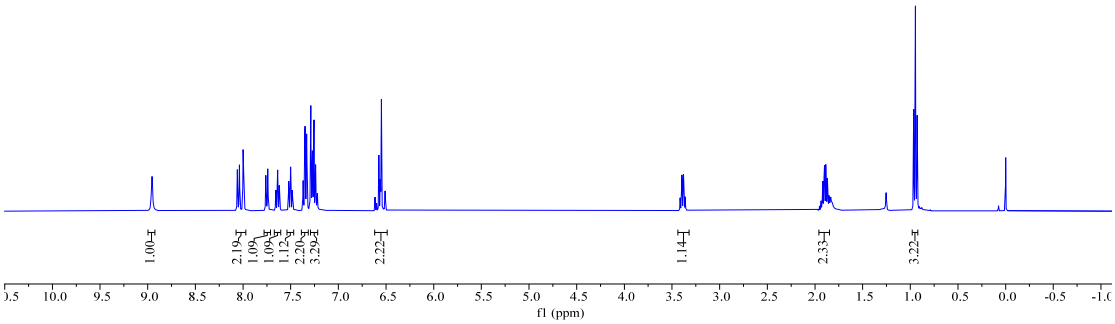
f1 (ppm)




Et
Ph
N

59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1.09
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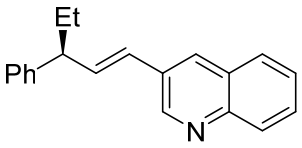
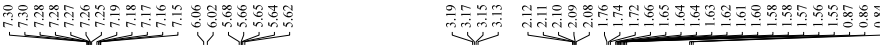
2.22
1.14
2.33
3.22
f1 (ppm)


Et
Ph
N

59

f1 (ppm)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7.15
6.06
6.02
5.68
5.66
5.65
5.64
5.62
3.19
3.17
3.15
3.13
2.12
2.11
2.10
2.09
2.08
1.76
1.74
1.72
1.66
1.65
1.64
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1.61
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1.58
1.58
1.57
1.56
1.55
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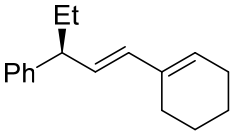
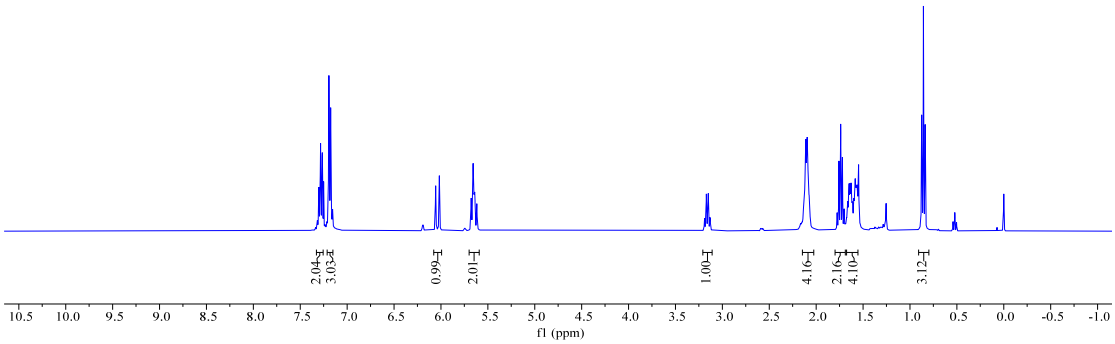
0.86


Et
Ph

60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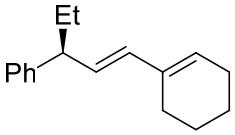
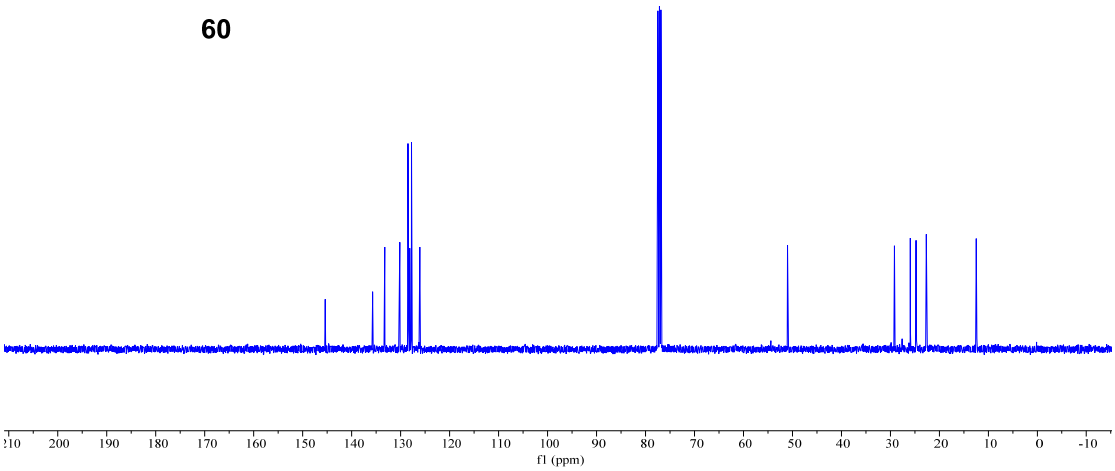
3.03
0.99
2.01
1.00
4.16
2.16
4.10
3.12
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)


145.38
135.70
133.23
130.17
128.50
128.14
127.76
126.08
51.01
29.17
25.94
24.77
22.74
22.65
12.46


Et
Ph

60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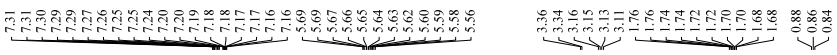
f1 (ppm)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7.17
7.17
7.16
7.16
5.69
5.69
5.67
5.66
5.65
5.64
5.63
5.62
5.60
5.59
5.58
5.56
3.36
3.34
3.16
3.15
3.13
3.11
1.76
1.76
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1.74
1.72
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1.70
1.70
1.68
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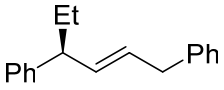
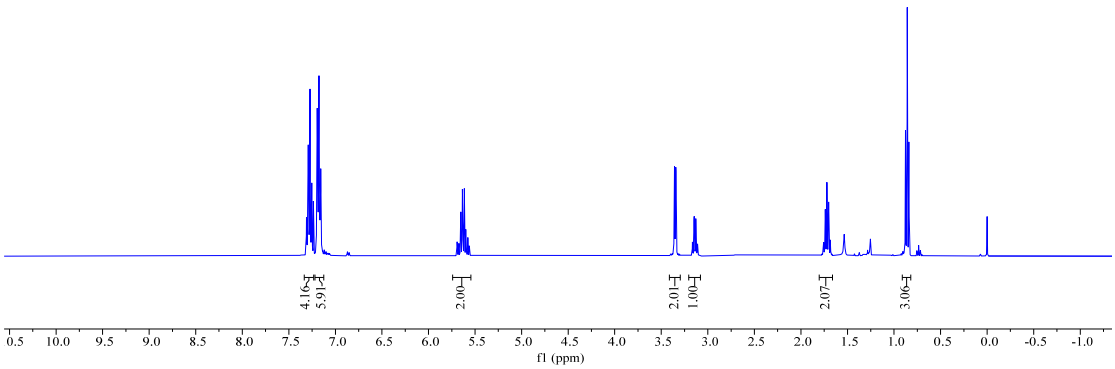
0.88
0.86
0.84


Et
Ph
Ph

61


4.16
5.91
2.00
2.01
1.00
2.07
3.06
0.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)


145.24
141.00
135.66
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128.49
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127.72
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126.04
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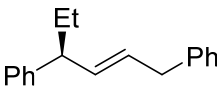
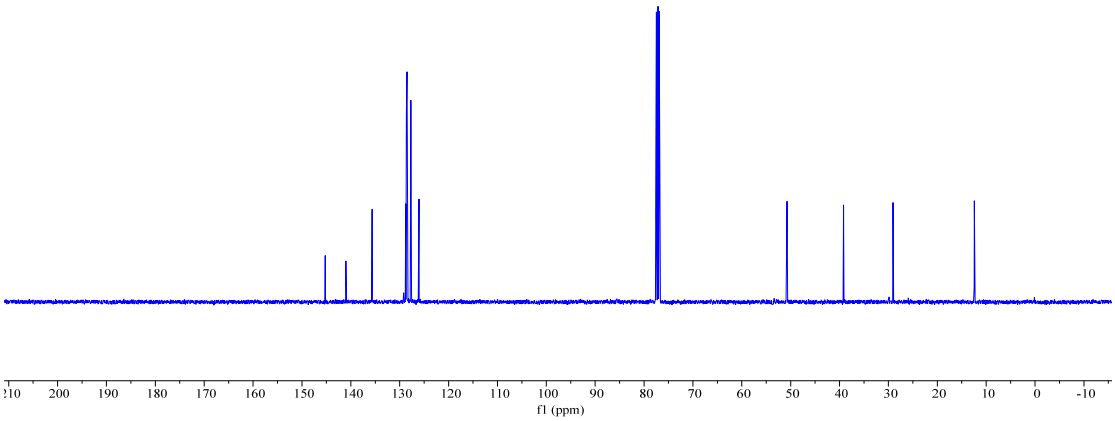
29.06
12.44


Et
Ph
Ph

61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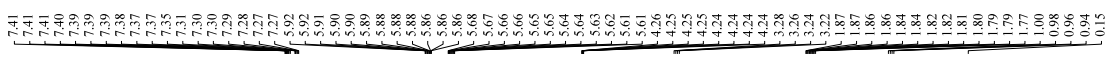
f1 (ppm)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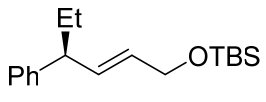
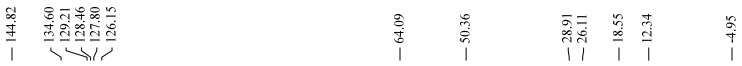

Et
Ph
OTBS

62

2.17
3.00
1.00
1.02
2.02
1.01
2.15
9.02
3.08
6.00
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.0
f1 (ppm)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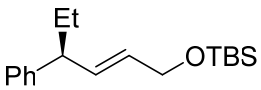
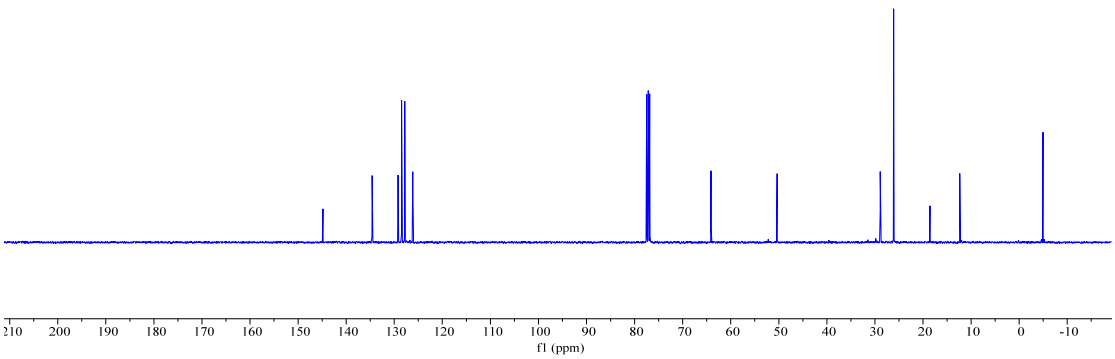
28.91
26.11
18.55
12.34
-4.95


Et
Ph
OTBS

62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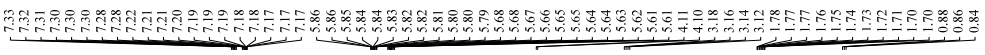
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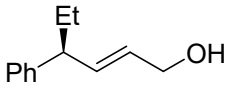
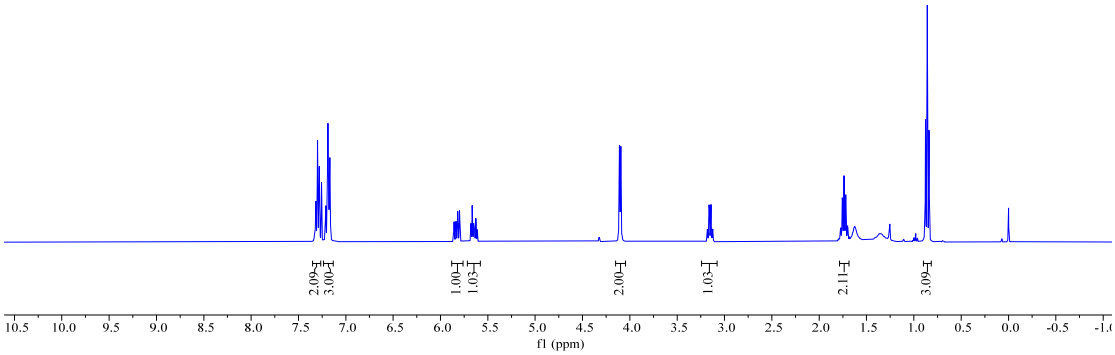
0.84


Et
Ph
OH

62'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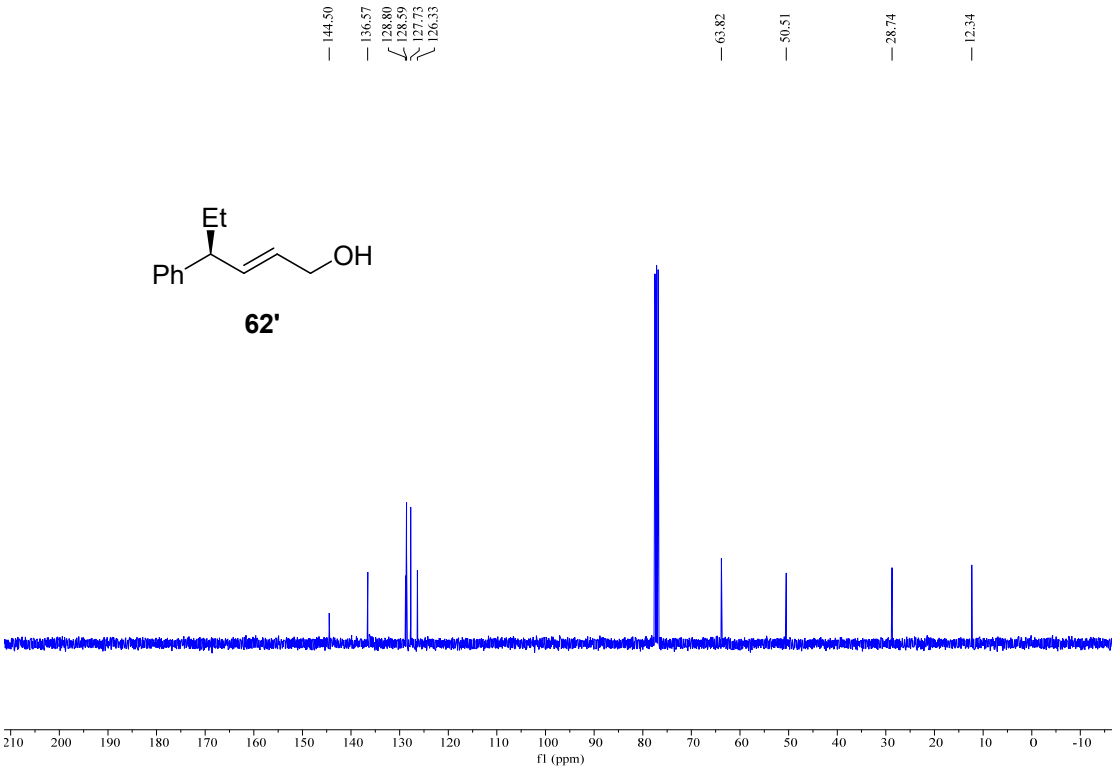
1.03
2.00
1.03
2.11
3.09
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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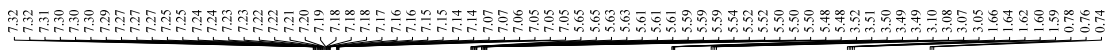
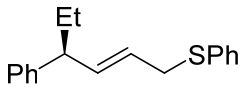
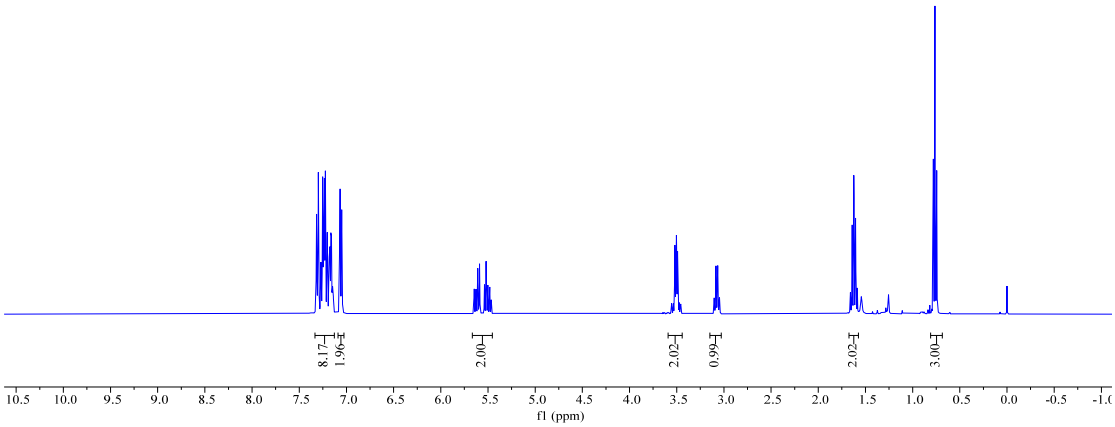
126.33
63.82
50.51
28.74
12.34
Et
Ph
OH
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

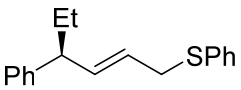
62'



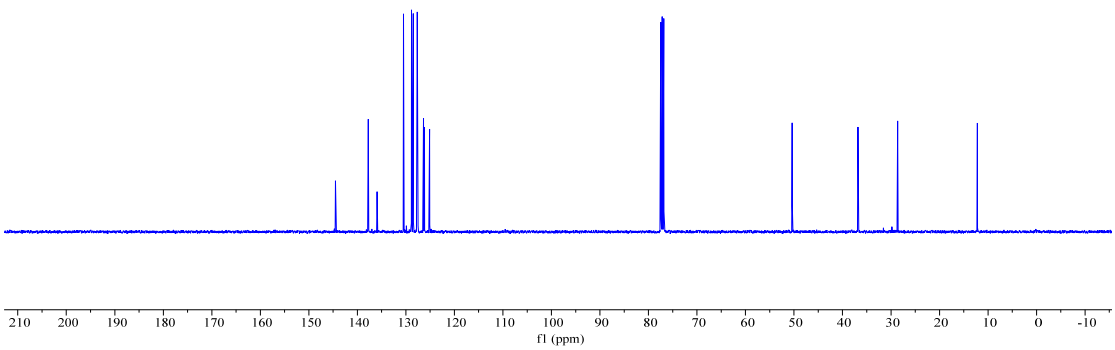


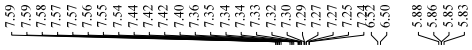
63





63

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7.32
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7.29
7.27
7.27
7.25
7.24
6.32
6.30
5.88
5.86
5.85
5.83
4.10
4.09
4.08
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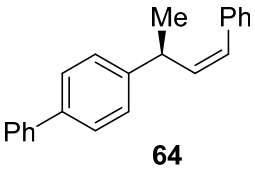
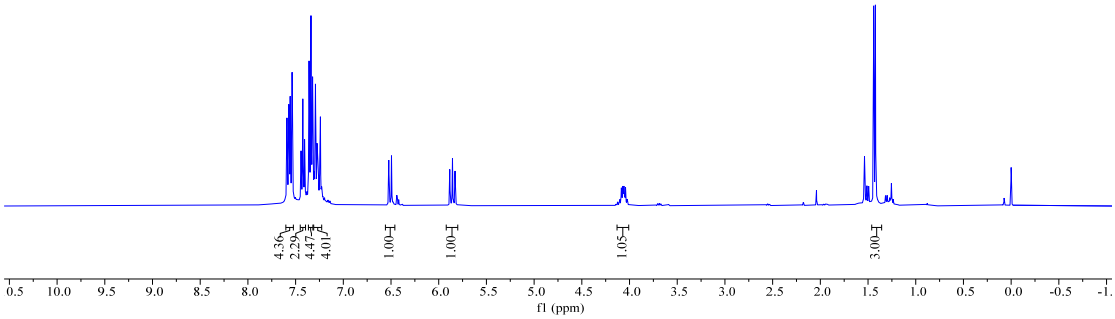
4.06
4.05
4.04
4.02
1.44
1.42


Me
Ph
Ph

64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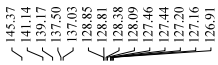
1.05
3.00
f1 (ppm)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128.85
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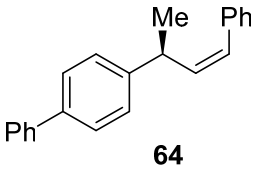
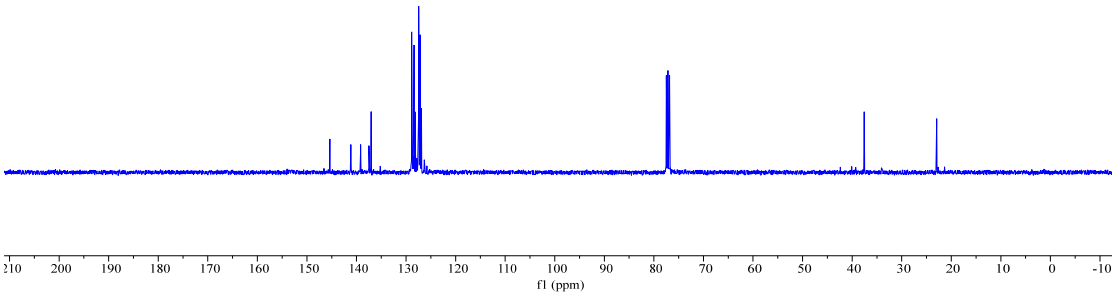
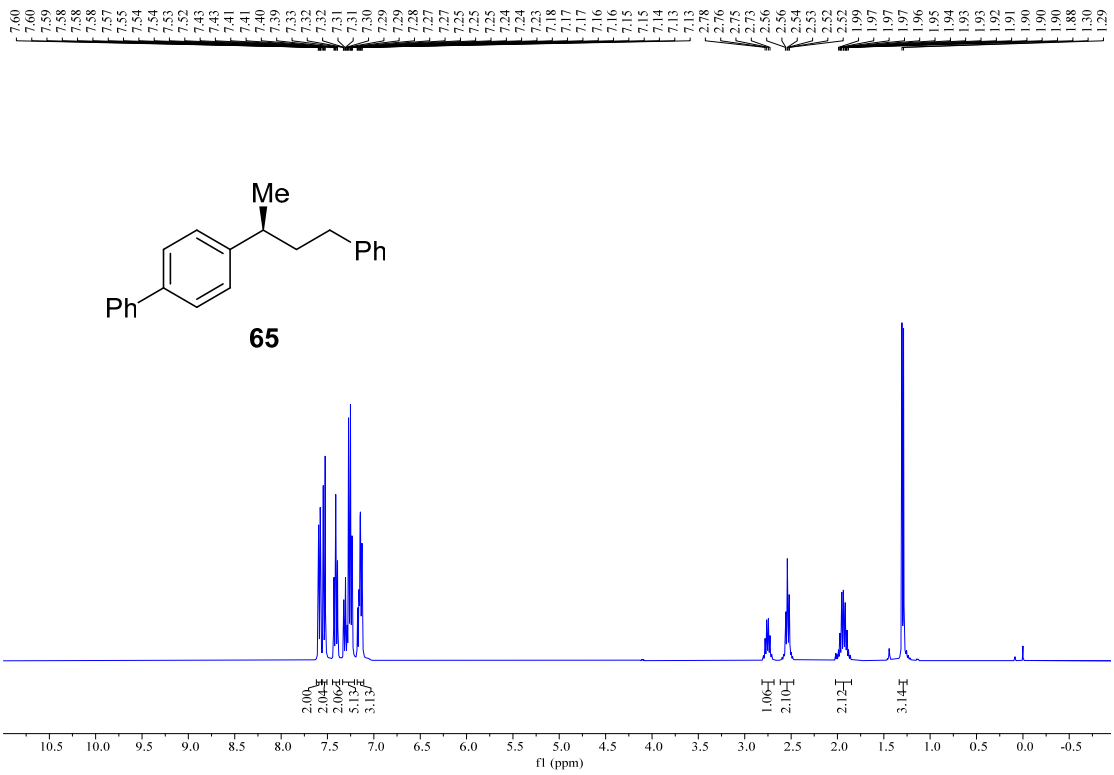
127.46
127.44
127.20
127.16
126.91
77.48
77.16
76.84
37.58
22.95


Me
Ph
Ph

64


f1 (ppm)


Me
Ph
Ph
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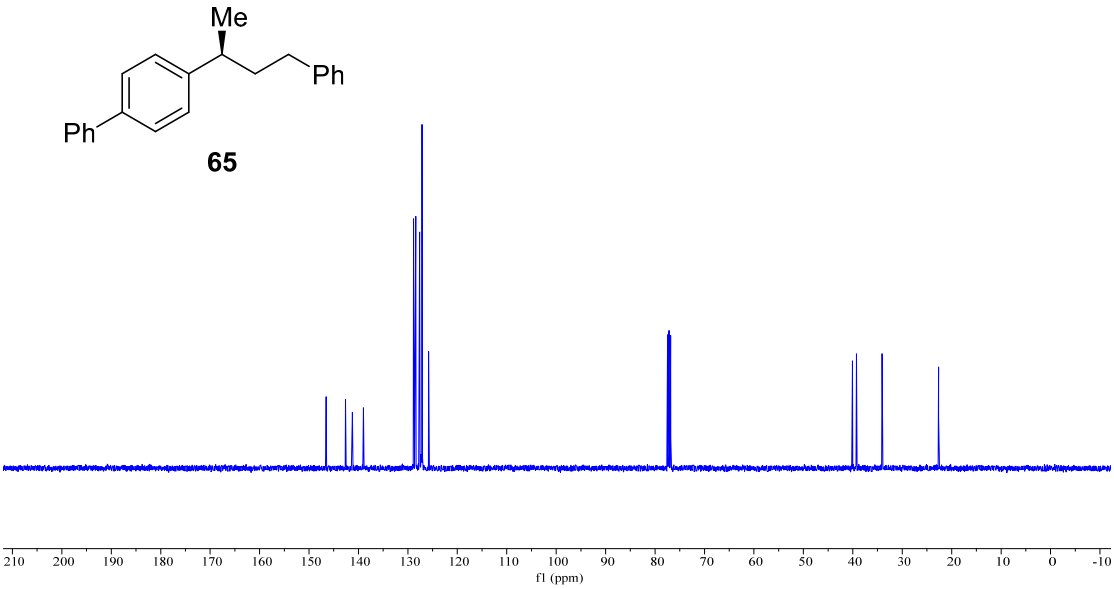
2.06
5.13
3.13
1.06
2.10
2.12
3.14
f1 (ppm)


Me
Ph
Ph
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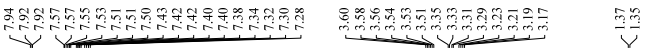
f1 (ppm)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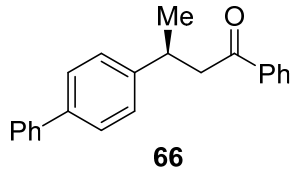
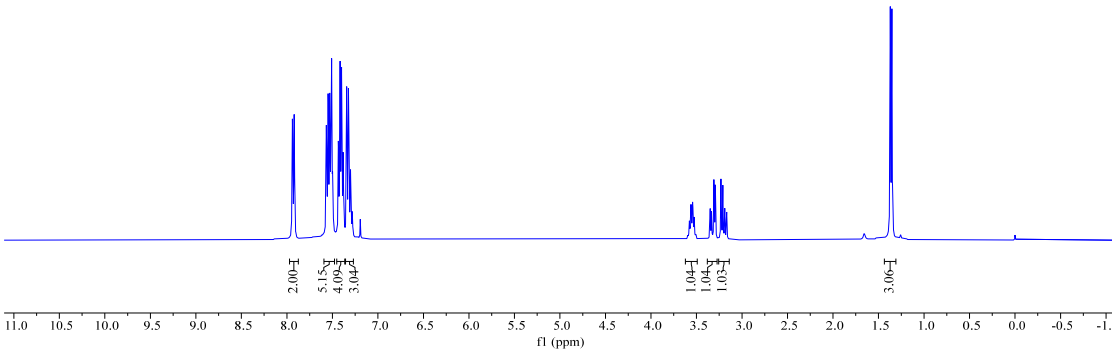
1.37
1.35


Me
O
Ph
Ph

66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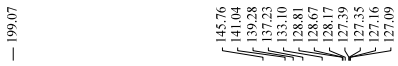
5.15
4.09
3.04
1.04
1.04
1.03
3.06
11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1.
f1 (ppm)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127.39
127.35
127.16
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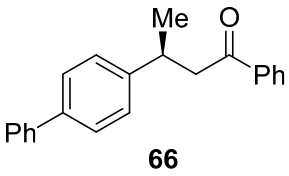
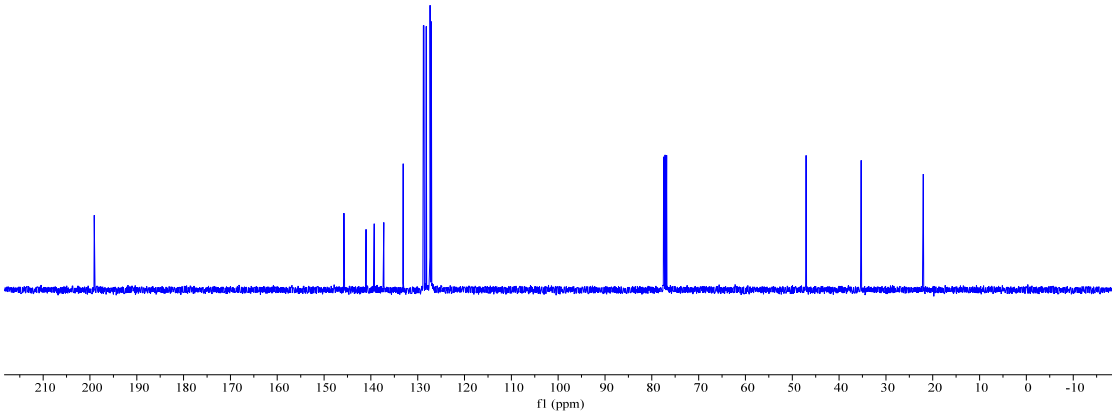
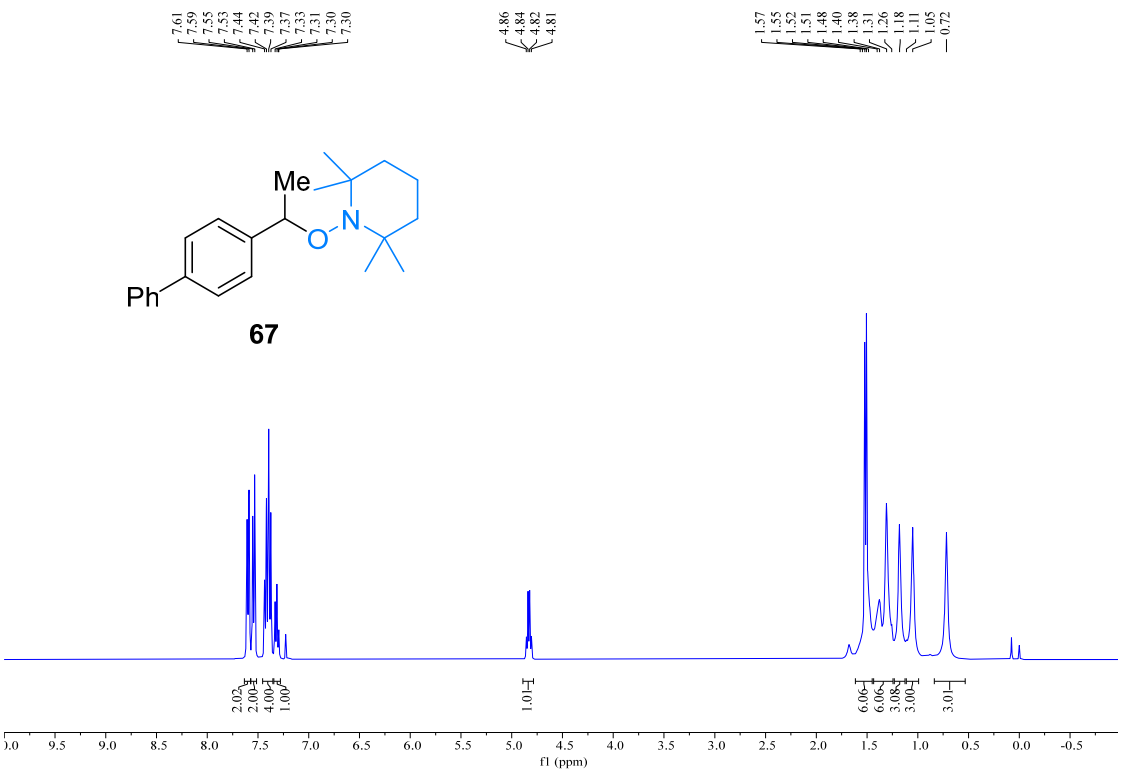
77.48
77.16
76.84
47.04
35.27
22.01


Me
O
Ph
Ph

66


210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)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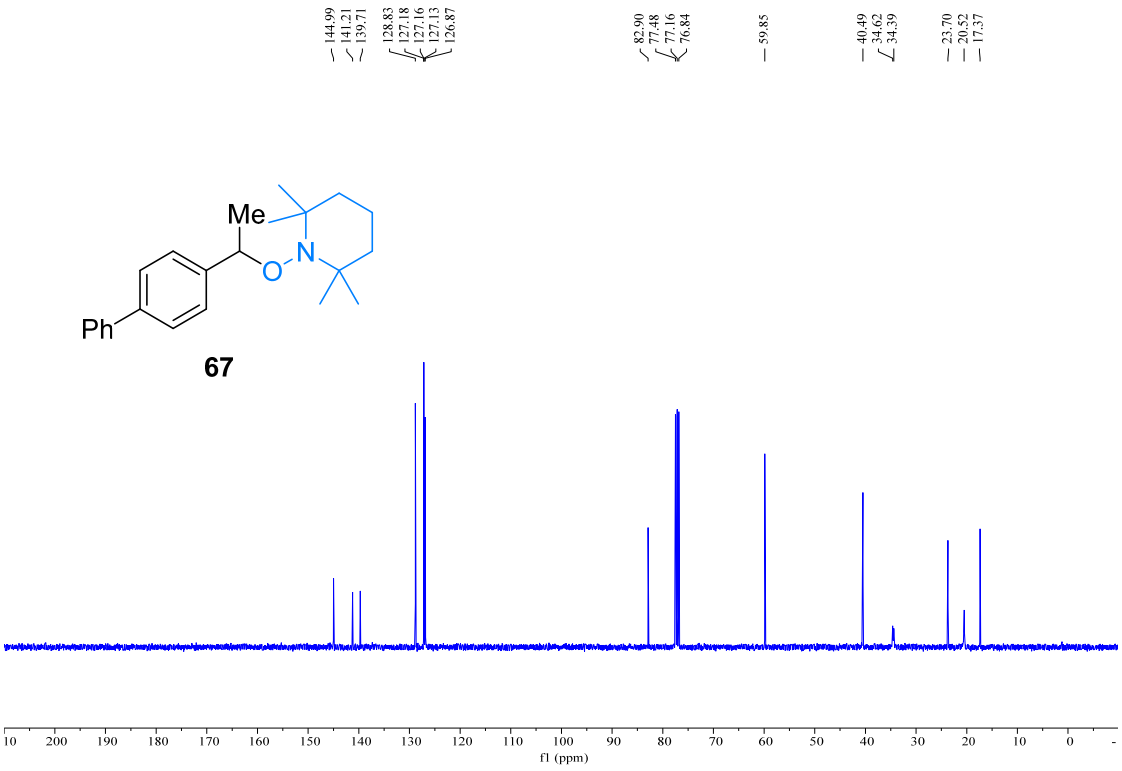
7.42
7.39
7.37
7.33
7.31
7.30
7.30
4.86
4.84
4.82
4.81
1.57
1.55
1.52
1.51
1.48
1.40
1.38
1.31
1.26
1.18
1.11
1.05
0.72
Me
O
N
Ph
67
2.02
2.00
4.00
1.00
1.01
6.06
6.06
3.08
3.00
3.01
f1 (ppm)


144.99
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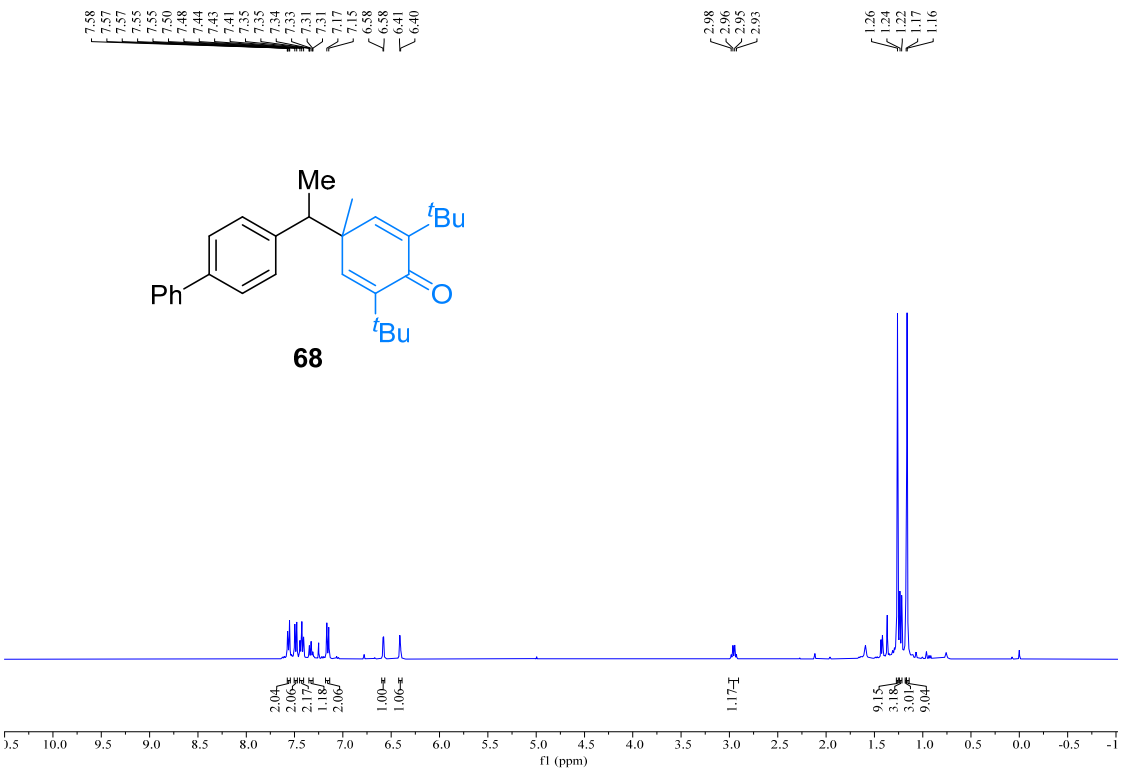
127.18
127.16
127.13
126.87
82.90
77.48
77.16
76.84
59.85
40.49
34.62
34.39
23.70
20.52
17.37
Me
O
N
Ph
67
f1 (ppm)


7.58
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7.57
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7.50
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7.41
7.35
7.35
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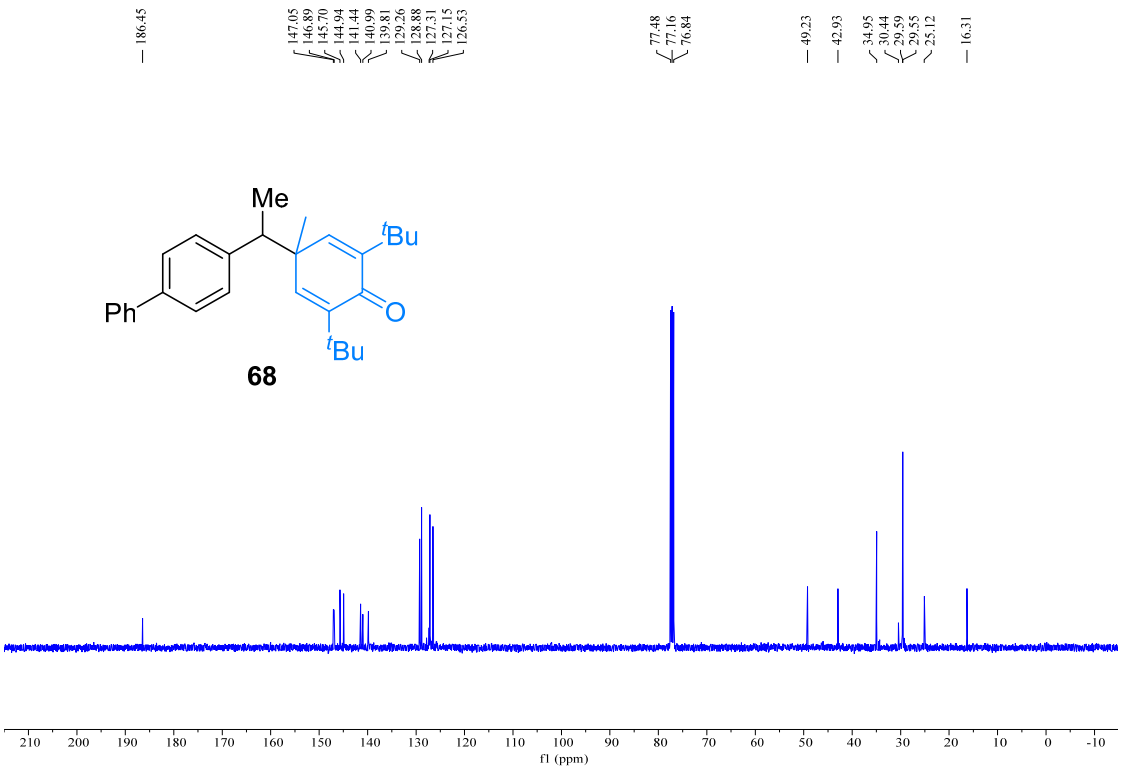
7.31
7.31
7.17
7.15
6.58
6.58
6.41
6.40
2.98
2.96
2.95
2.93
1.26
1.24
1.22
1.17
1.16
Me
tBu
Ph
O
tBu
68
2.04
2.06
2.17
1.18
2.06
1.00
1.06
1.17
9.15
3.18
3.01
9.04
f1 (ppm)


186.45
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141.44
140.99
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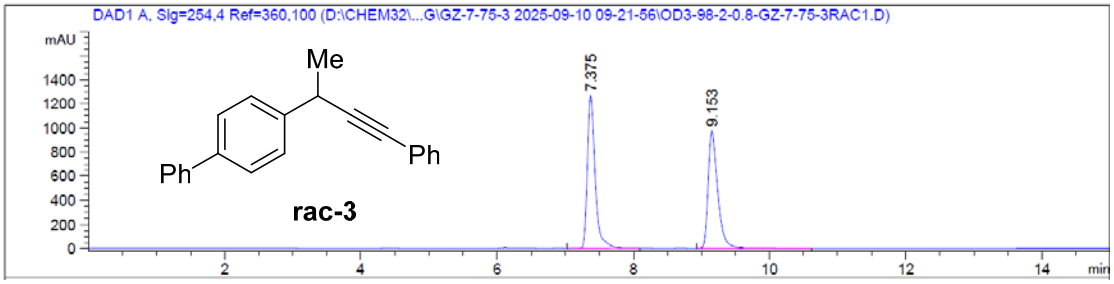
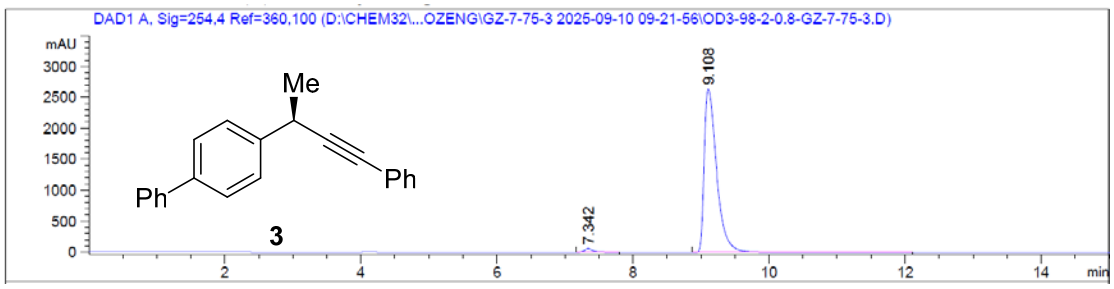
129.26
128.88
127.31
127.15
126.53
77.48
77.16
76.84
49.23
42.93
34.95
30.44
29.59
29.55
25.12
16.31
Me
tBu
Ph
O
tBu
68
f1 (ppm)

HPLC



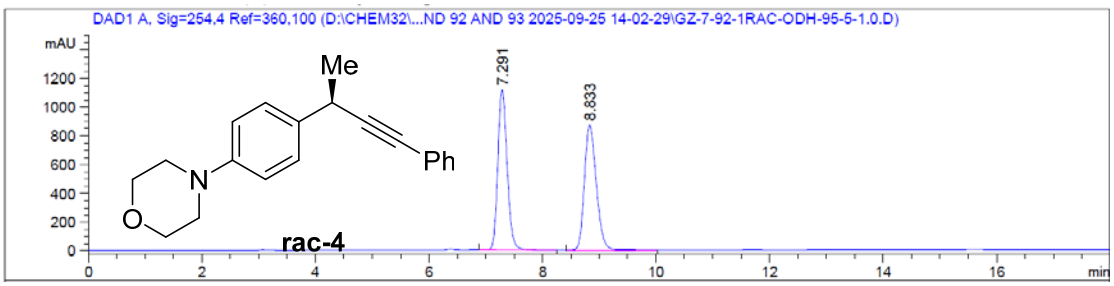
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.375	VB R	0.1173	9920.48047	1267.76563	50.6463
2	9.153	BV R	0.1490	9667.28125	979.79840	49.3537
Totals :				1.95878e4	2247.56403	



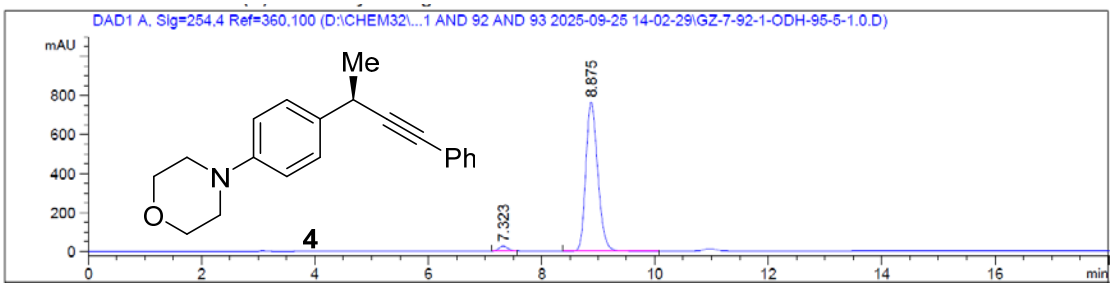
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.342	BB	0.1303	499.09149	58.05926	1.4865
2	9.108	BB	0.1925	3.30755e4	2633.85962	98.5135
Totals :				3.35746e4	2691.91888	



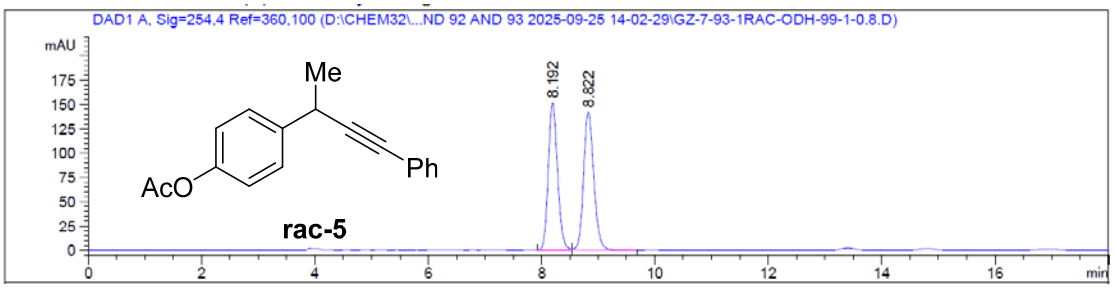
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.291	BB	0.1746	1.27126e4	1118.31372	50.1169
2	8.833	BB	0.2239	1.26533e4	868.73724	49.8831
Totals :				2.53658e4	1987.05096	



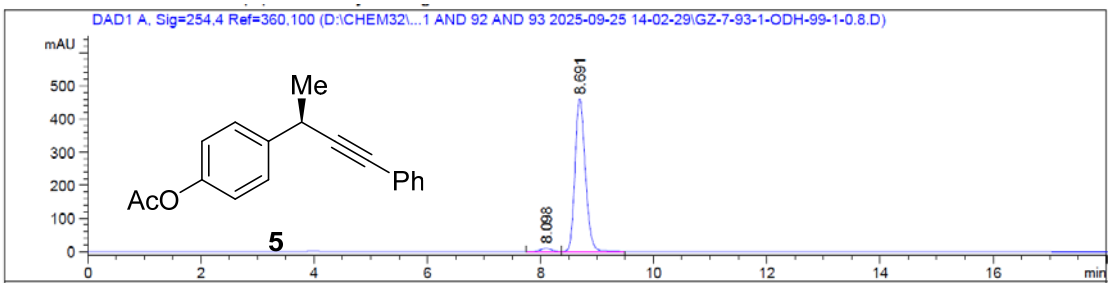
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.323	FM R	0.1909	290.71750	25.37594	2.5438
2	8.875	BB	0.2261	1.11376e4	763.80481	97.4562
Totals :				1.14283e4	789.18075	



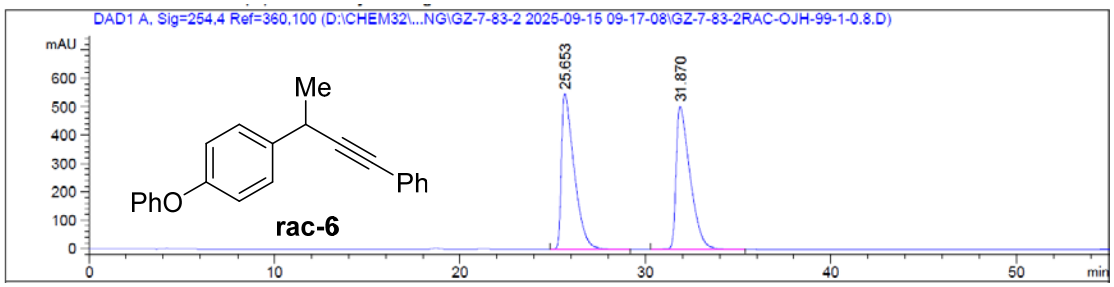
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.192	BV	0.1737	1710.67346	151.52742	49.1422
2	8.822	VB	0.1915	1770.39343	141.92952	50.8578
Totals :				3481.06689	293.45694	



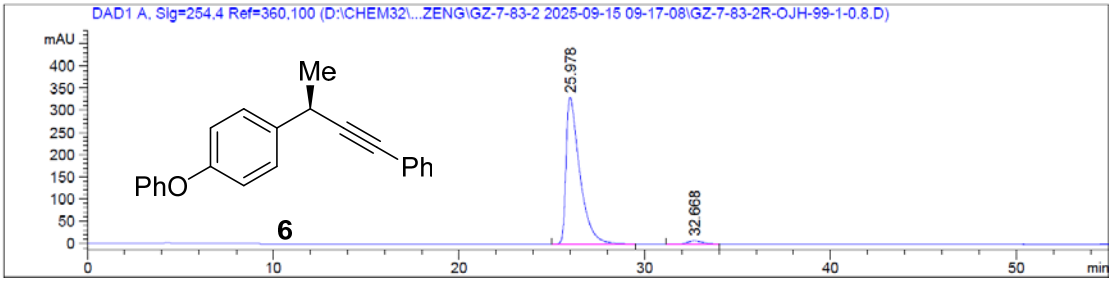
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.098	BV	0.1976	123.37916	9.61872	2.0695
2	8.691	MF R	0.2110	5838.28467	461.20953	97.9305
Totals :				5961.66383	470.82826	



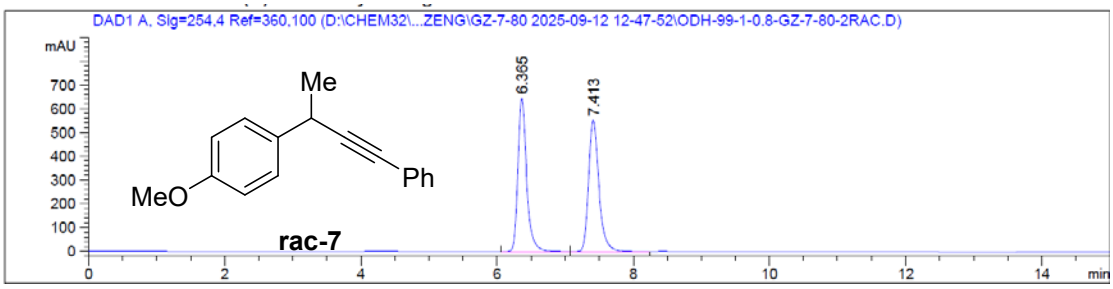
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	25.653	BB S	0.7098	2.60055e4	547.81659	49.8847
2	31.870	BB	0.7753	2.61258e4	503.57257	50.1153
Totals :				5.21312e4	1051.38916	



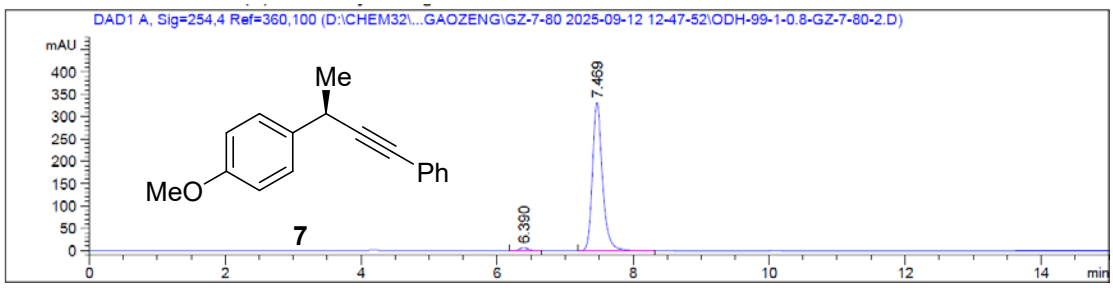
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	25.978	BB S	0.7542	1.68109e4	330.08008	97.8619
2	32.668	FM R	0.8708	367.29047	7.02940	2.1381
Totals :				1.71782e4	337.10948	



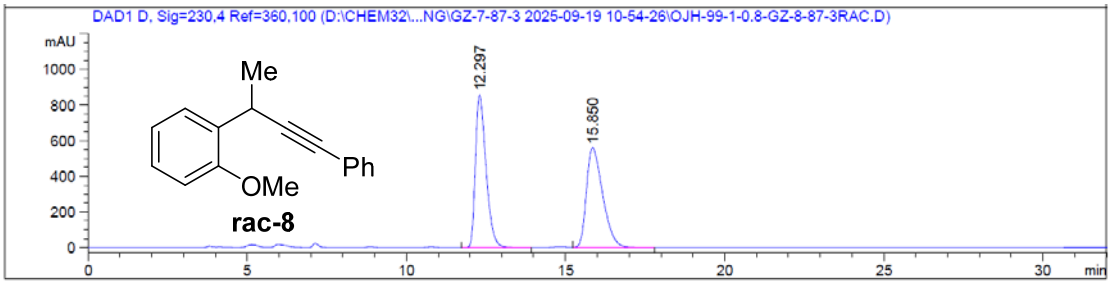
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.365	BB	0.1359	5748.22217	645.17627	49.7757
2	7.413	BB	0.1585	5800.02051	552.42932	50.2243
Totals :				1.15482e4	1197.60559	



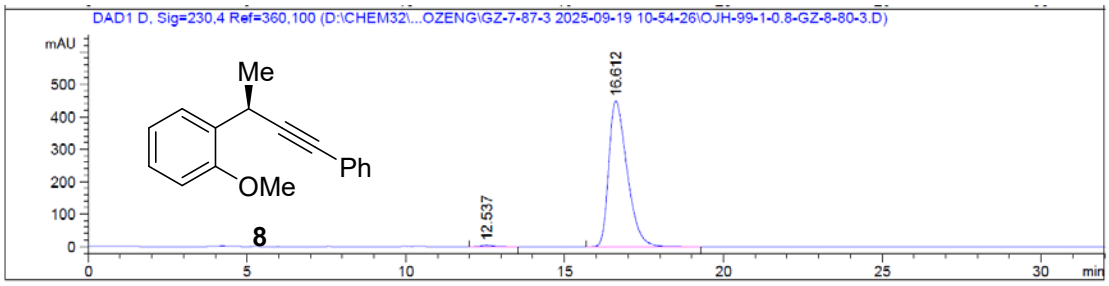
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.390	BB	0.1251	57.54586	7.06207	1.6535
2	7.469	BB	0.1582	3422.66431	332.32361	98.3465
Totals :				3480.21017	339.38568	



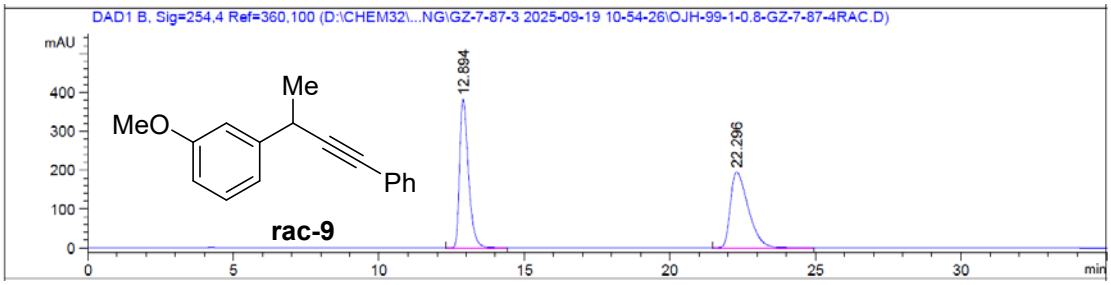
Signal 4: DAD1 D, Sig=230,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.297	BB	0.3566	1.98037e4	853.95612	49.8502
2	15.850	VB	0.5471	1.99227e4	559.93060	50.1498
Totals :				3.97264e4	1413.88672	



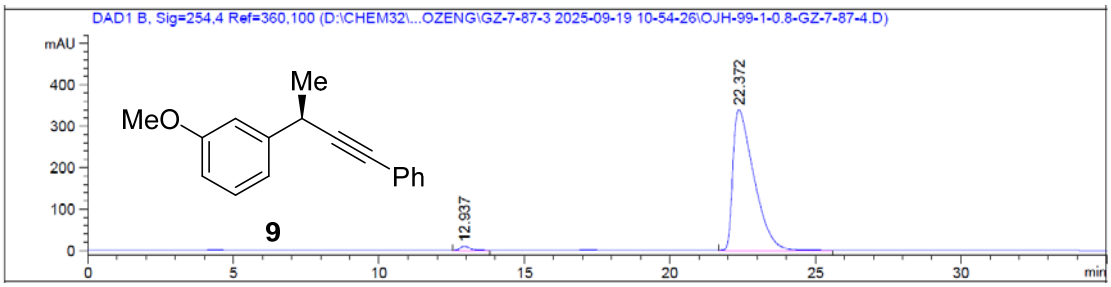
Signal 4: DAD1 D, Sig=230,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.537	MM R	0.5283	158.58543	5.00274	0.8738
2	16.612	BB	0.6143	1.79905e4	448.20001	99.1262
Totals :				1.81491e4	453.20275	



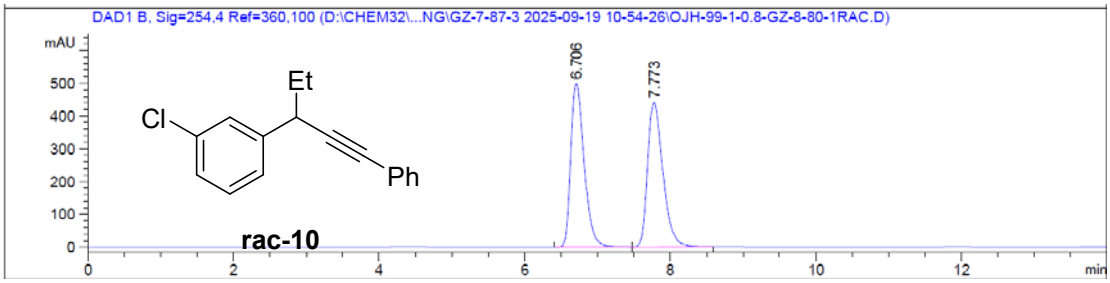
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.894	BB	0.3215	8044.67773	382.29630	49.2216
2	22.296	BB	0.6540	8299.12793	195.21677	50.7784
Totals :				1.63438e4	577.51306	



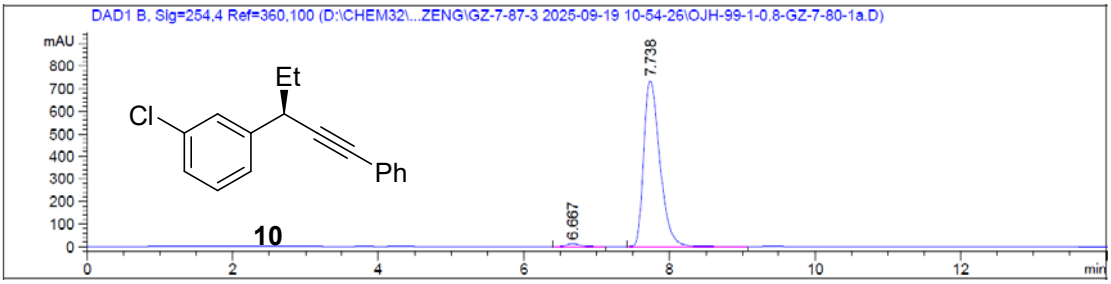
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.937	BB	0.3301	214.63274	9.85330	1.2480
2	22.372	BB	0.7458	1.69839e4	340.58698	98.7520
Totals :				1.71985e4	350.44028	



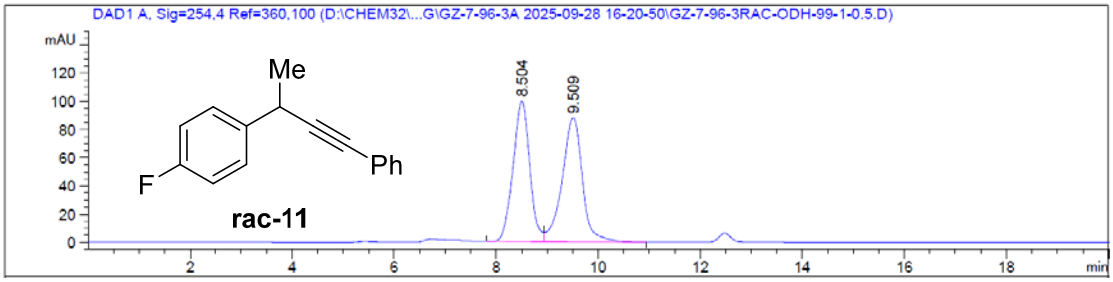
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.706	BB	0.1969	6359.54590	498.24072	49.6719
2	7.773	BB	0.2266	6443.54785	440.52591	50.3281
Totals :				1.28031e4	938.76663	



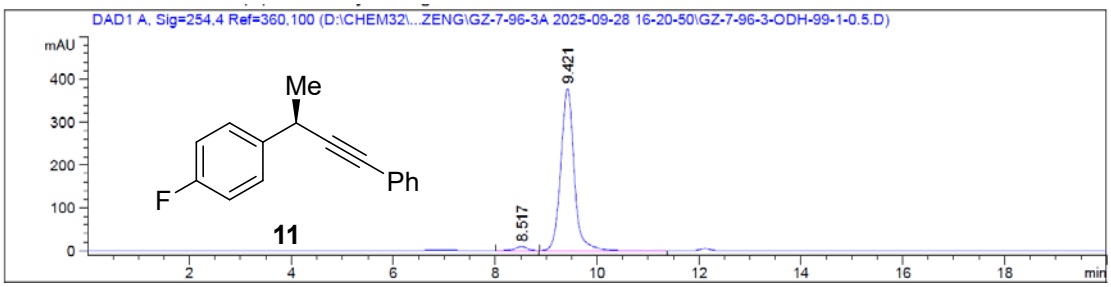
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.667	BB	0.1911	157.61469	12.67557	1.3746
2	7.738	BB	0.2399	1.13089e4	733.21021	98.6254
Totals :				1.14665e4	745.88578	



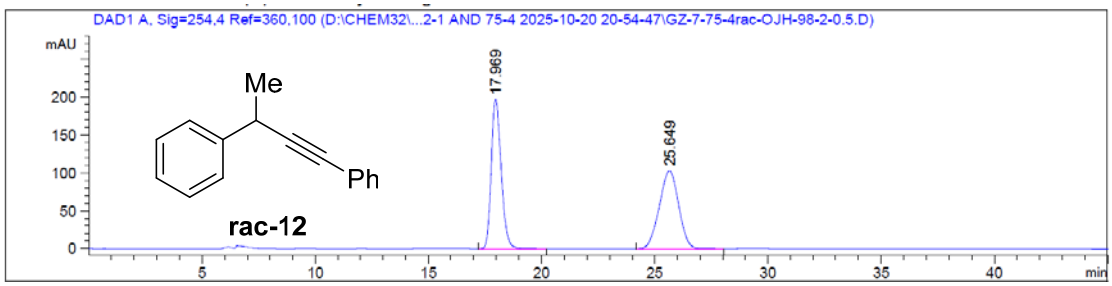
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.504	BV	0.3475	2264.74658	99.51179	48.3158
2	9.509	VB	0.4144	2422.63403	88.22770	51.6842
Totals :				4687.38062	187.73949	



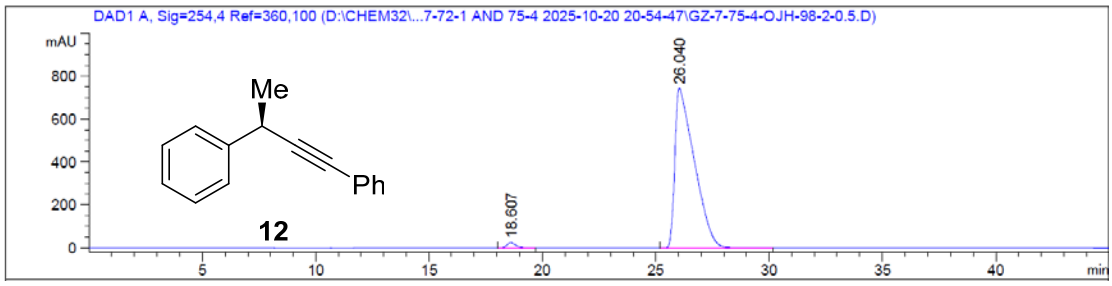
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.517	BB	0.2445	150.39655	9.40818	2.1323
2	9.421	BB	0.2790	6902.69824	378.11008	97.8677
Totals :				7053.09479	387.51826	



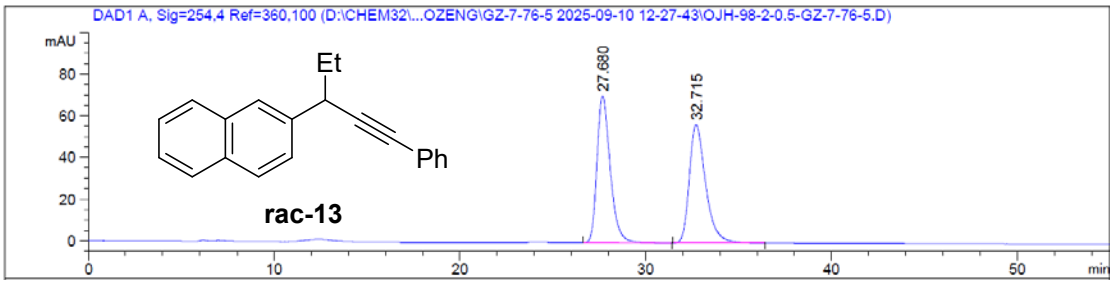
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	17.969	BB	0.4717	6004.69092	196.97467	49.6974
2	25.649	BB	0.9061	6077.81494	103.04205	50.3026
Totals :				1.20825e4	300.01672	



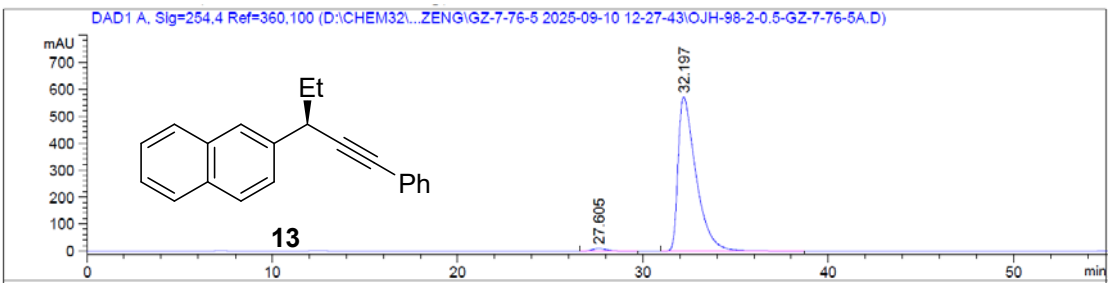
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	18.607	BB	0.4194	666.31958	24.33663	1.4873
2	26.040	BB	0.8890	4.41338e4	743.03430	98.5127
Totals :				4.48001e4	767.37093	



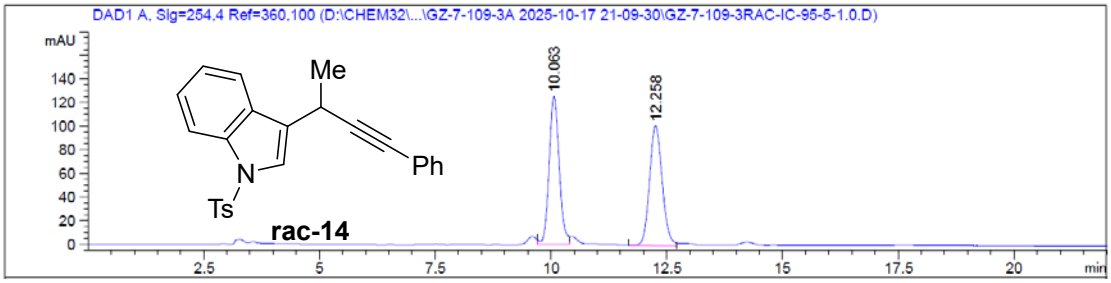
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	27.680	BB	0.7549	3472.83179	70.47392	50.0206
2	32.715	BB	0.9241	3469.96631	56.84613	49.9794
Totals :				6942.79810	127.32004	



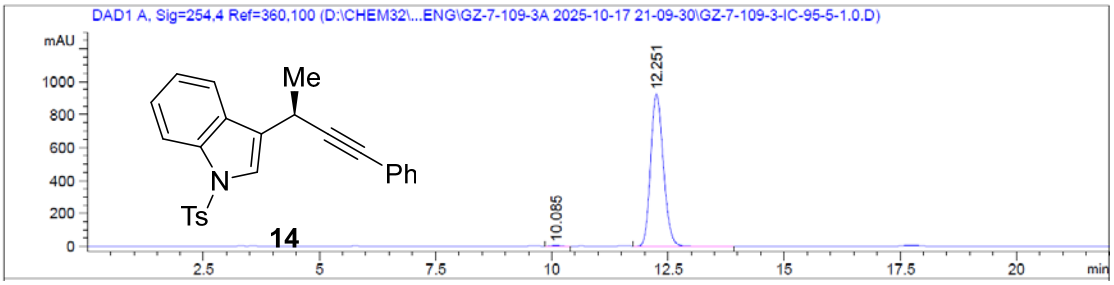
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	27.605	BB	0.7732	553.32483	10.63182	1.4195
2	32.197	BB	1.0008	3.84261e4	571.24725	98.5805
Totals :				3.89794e4	581.87907	



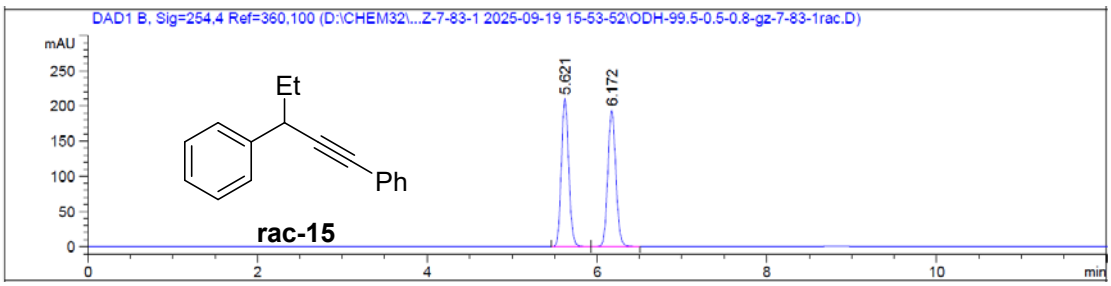
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.063	MF R	0.2522	1897.57605	125.39920	49.5513
2	12.258	FM R	0.3164	1931.93958	101.77998	50.4487
Totals :				3829.51563	227.17918	



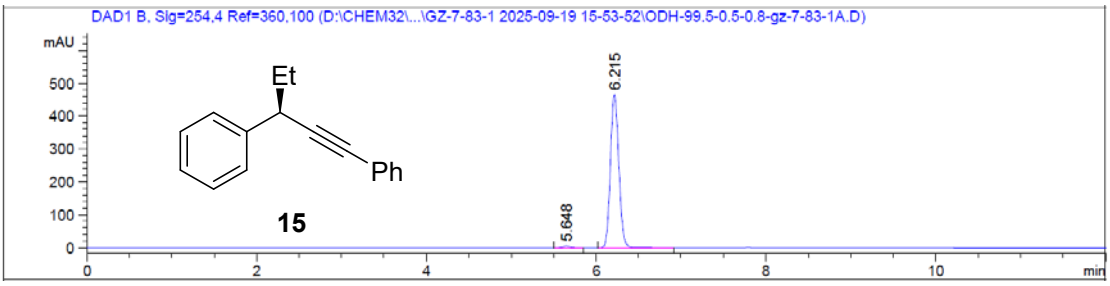
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.085	VB	0.2309	76.67541	5.17267	0.4313
2	12.251	FM R	0.3203	1.77028e4	921.29468	99.5687
Totals :				1.77795e4	926.46735	



Signal 2: DAD1 B, Sig=254,4 Ref=360,100

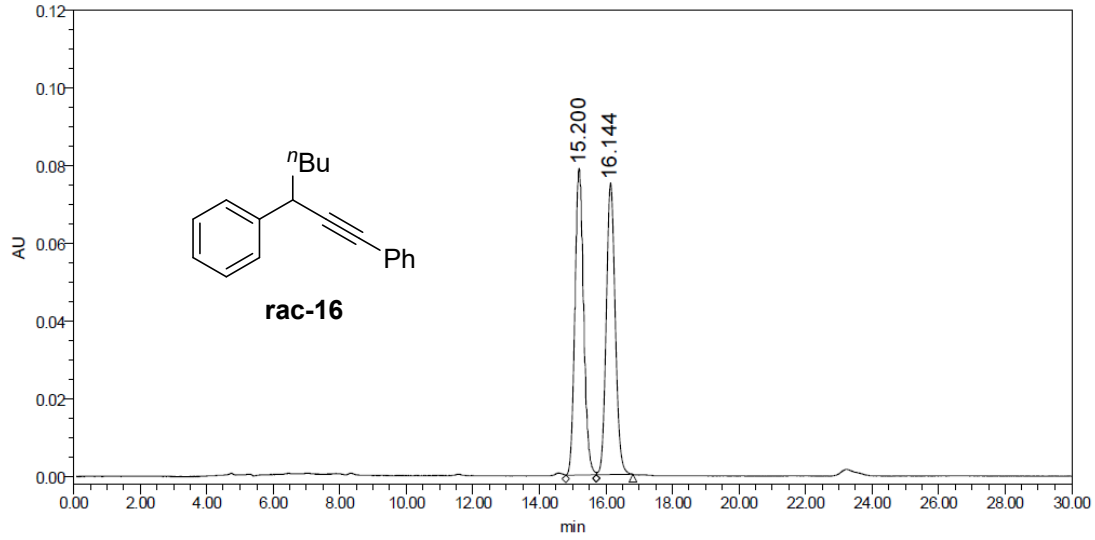
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	5.621	BB	0.0922	1264.22607	210.04688	49.8891
2	6.172	BB	0.1028	1269.84485	192.95053	50.1109
Totals :				2534.07092	402.99741	



Signal 2: DAD1 B, Sig=254,4 Ref=360,100

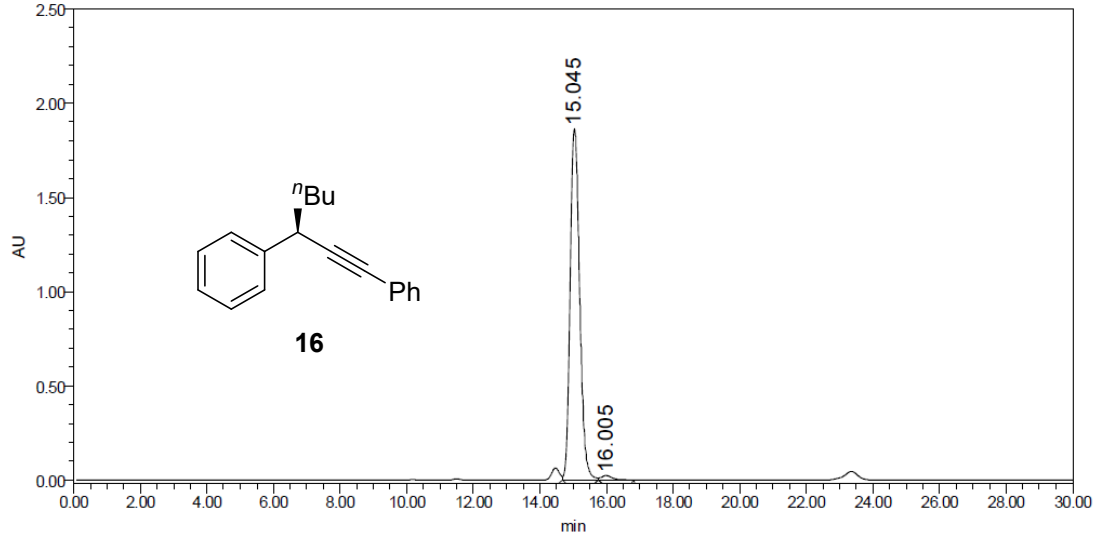
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	5.648	BB	0.0920	29.27223	4.87938	0.9110
2	6.215	BB	0.1059	3184.07715	465.16055	99.0890
Totals :				3213.34938	470.03993	

PDA 254nm

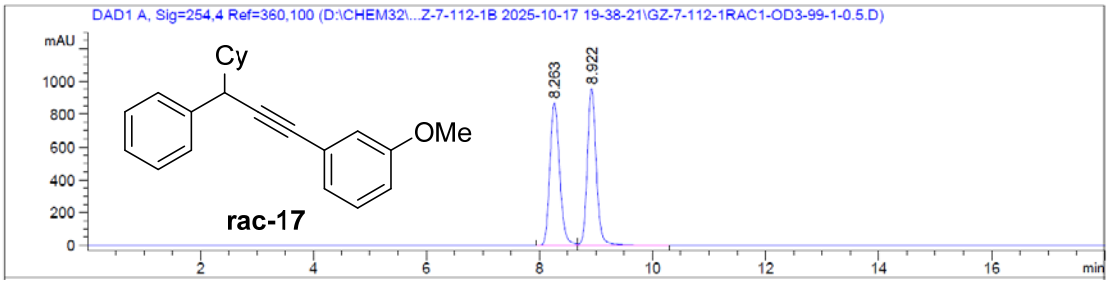


	RT	Area	% Area	Height
1	15.200	1414425	49.99	78844
2	16.144	1414813	50.01	74933

PDA 254nm



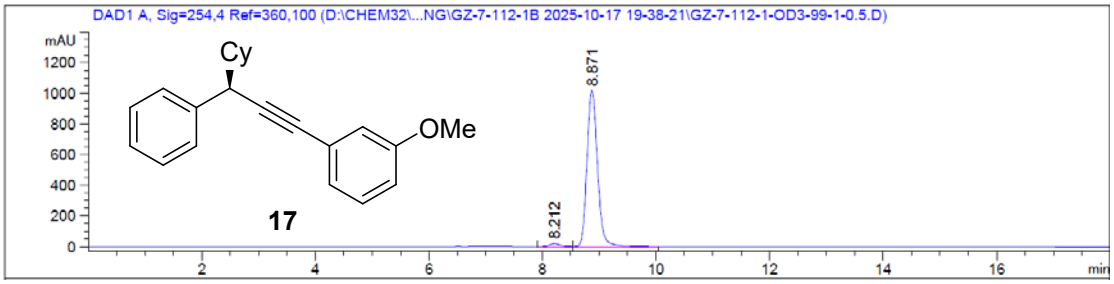
	RT	Area	% Area	Height
1	15.045	36735783	98.58	1864572
2	16.005	527839	1.42	23511



Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.263	BV	0.1888	1.04585e4	866.72479	49.7698
2	8.922	VB	0.1708	1.05552e4	955.81421	50.2302

Totals : 2.10137e4 1822.53900

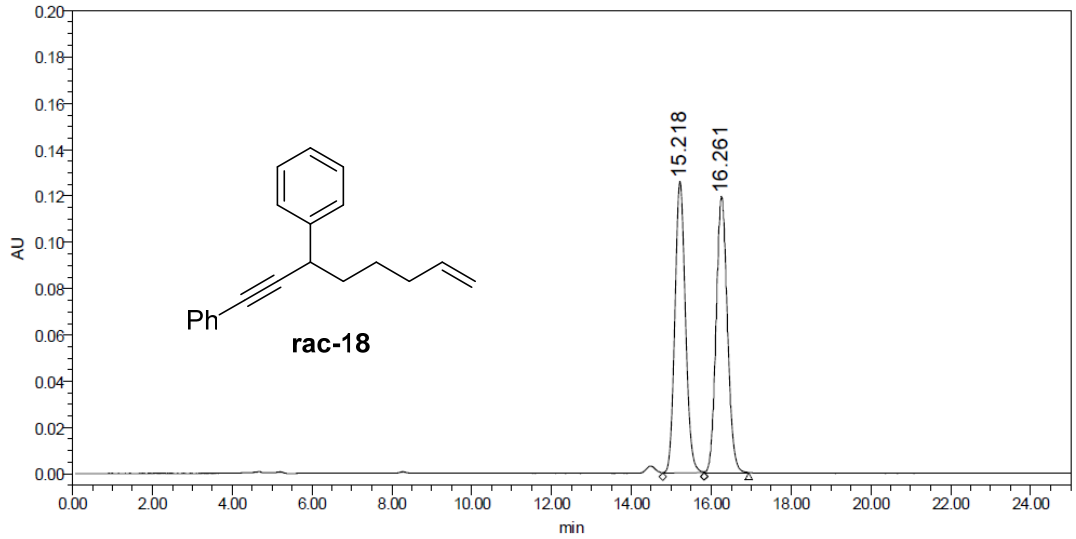


Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.212	BV	0.1961	244.27205	19.24740	1.8264
2	8.871	VB	0.2005	1.31306e4	1017.77307	98.1736

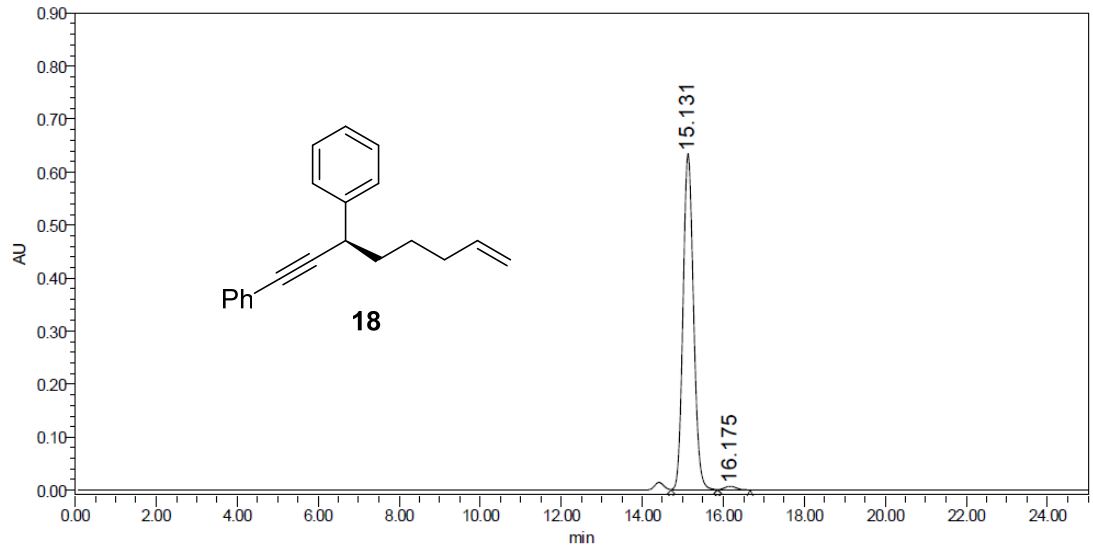
Totals : 1.33748e4 1037.02048

PDA 254nm



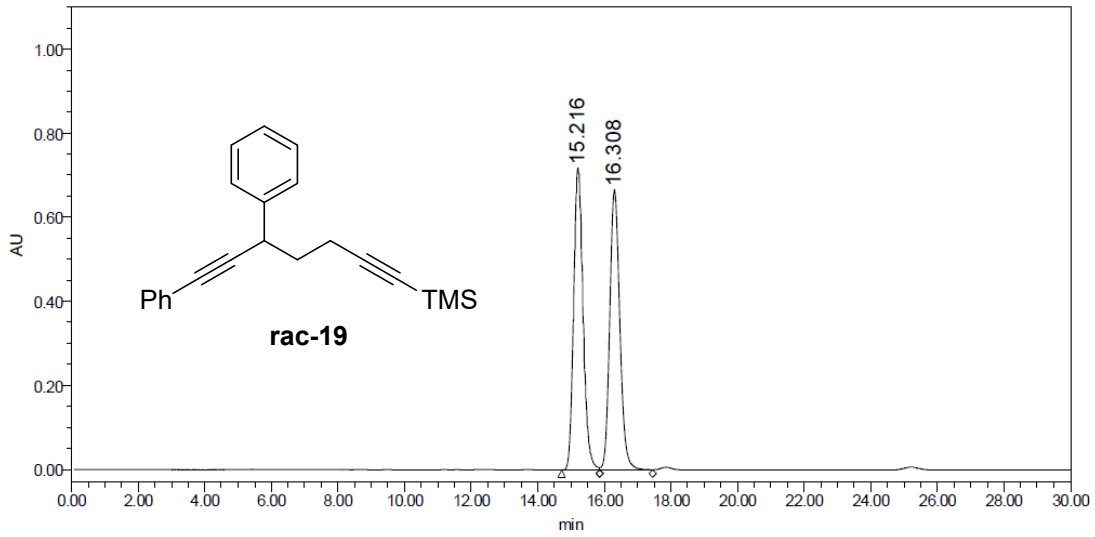
	RT	Area	% Area	Height
1	15.218	2328472	50.11	125805
2	16.261	2317814	49.89	119330

PDA 254nm



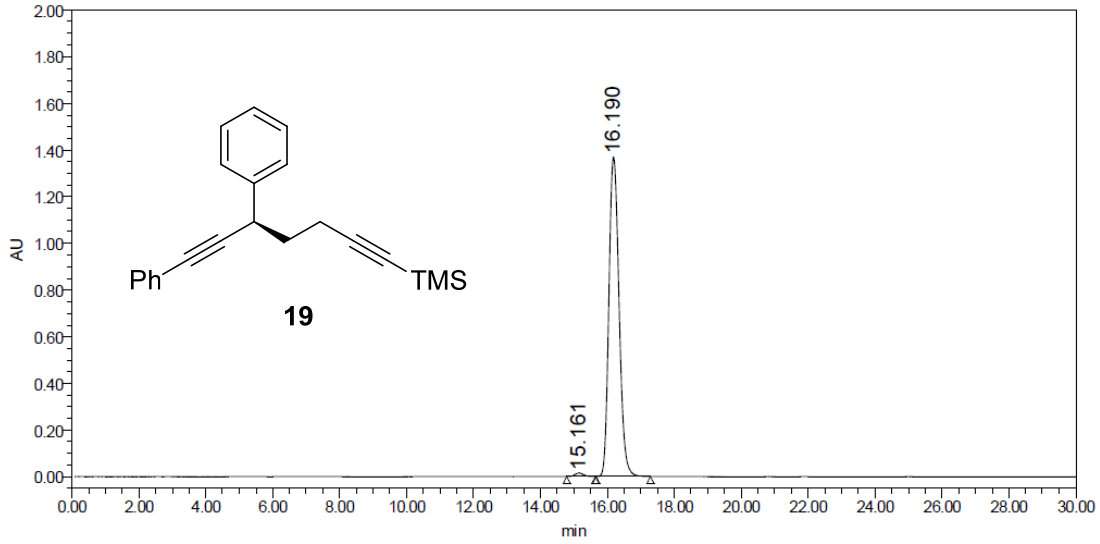
	RT	Area	% Area	Height
1	15.131	11500516	98.79	633304
2	16.175	140377	1.21	7006

PDA 254nm

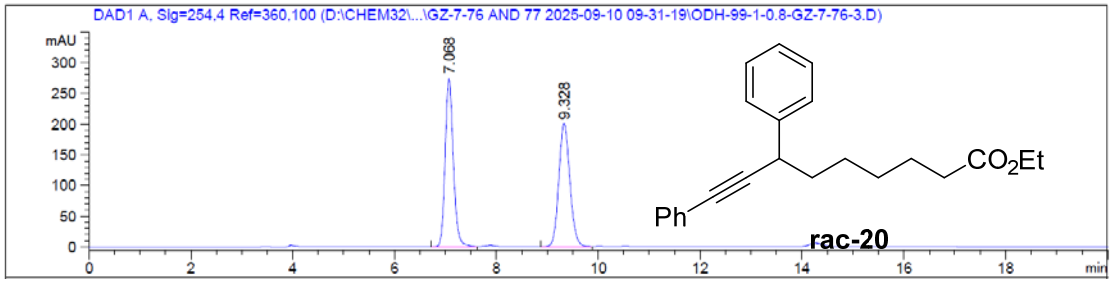


	RT	Area	% Area	Height
1	15.216	13896478	49.72	716432
2	16.308	14055392	50.28	665110

PDA 254nm

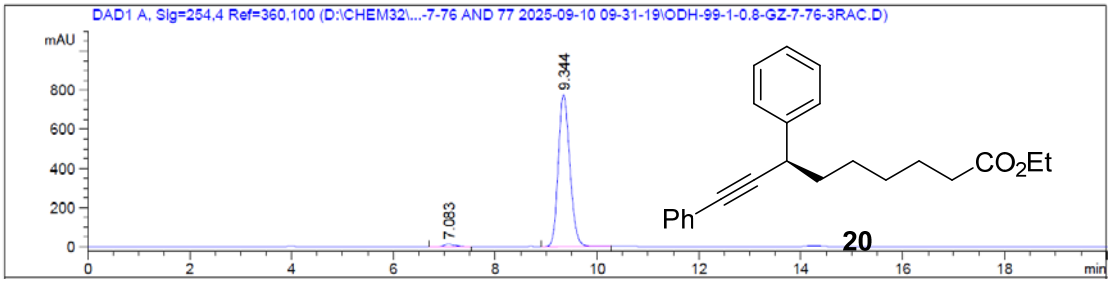


	RT	Area	% Area	Height
1	15.161	282885	0.96	15145
2	16.190	29067787	99.04	1369643



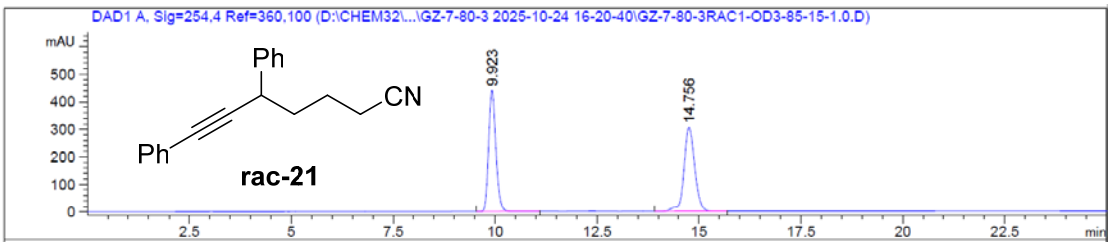
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.068	BB	0.1698	3039.04126	273.16208	50.1672
2	9.328	BB	0.2341	3018.78101	200.02747	49.8328
Totals :				6057.82227	473.18954	



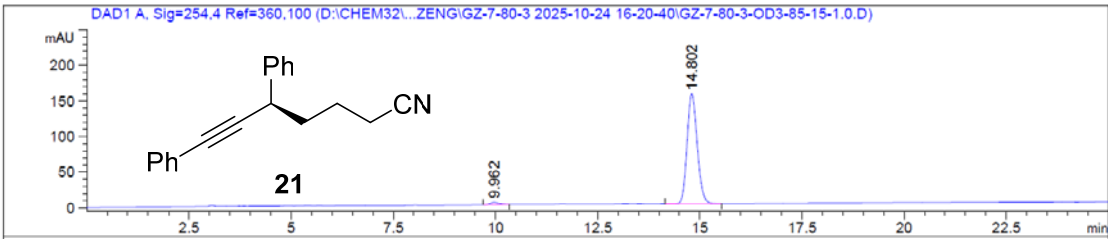
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.083	BB	0.1934	199.76033	15.00122	1.5999
2	9.344	BB	0.2467	1.22862e4	776.19324	98.4001
Totals :				1.24859e4	791.19446	



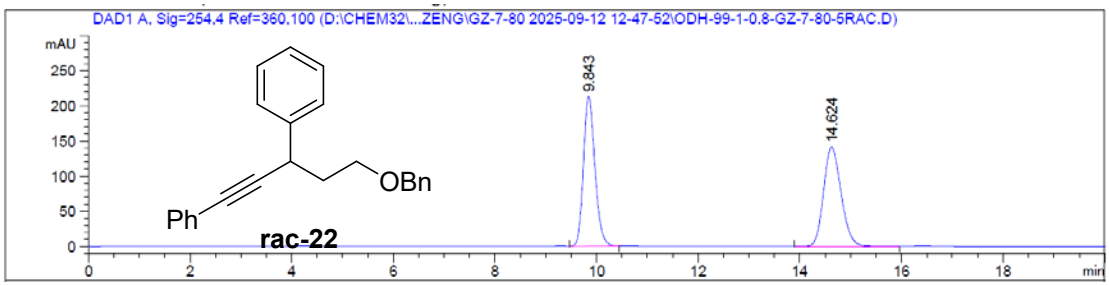
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.923	BB	0.1917	5395.21777	438.16003	49.4990
2	14.756	BB	0.2799	5504.43262	303.03244	50.5010
Totals :				1.08997e4	741.19247	



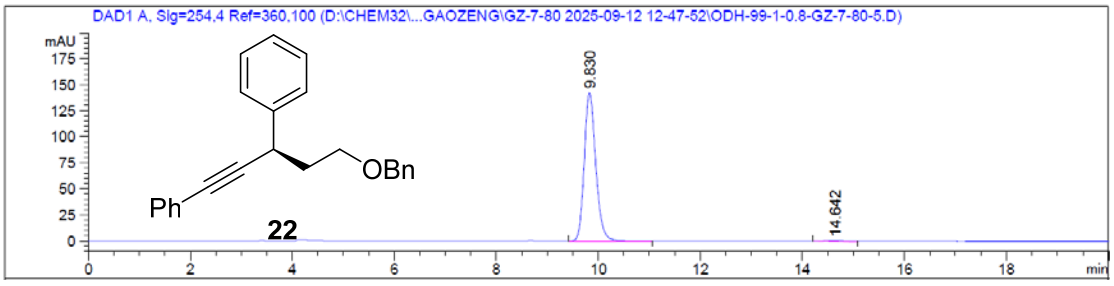
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.962	BB	0.2128	45.56939	3.18805	1.6871
2	14.802	BB	0.2666	2655.40527	154.40099	98.3129
Totals :				2700.97467	157.58904	



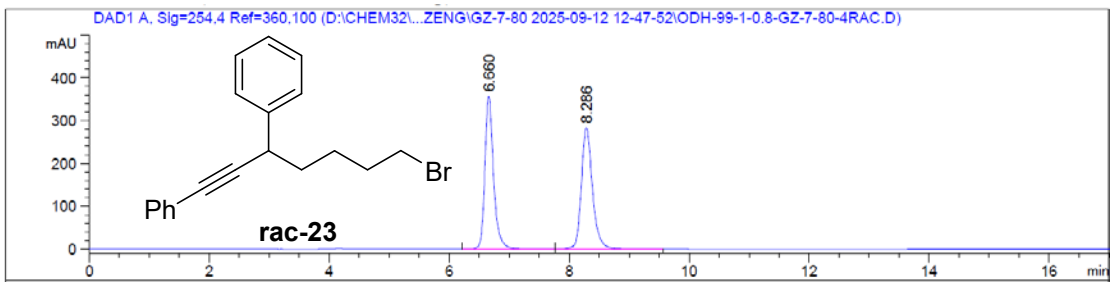
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.843	BB	0.2406	3333.45679	213.01114	49.7396
2	14.624	BB	0.3704	3368.35962	141.13338	50.2604
Totals :				6701.81641	354.14452	



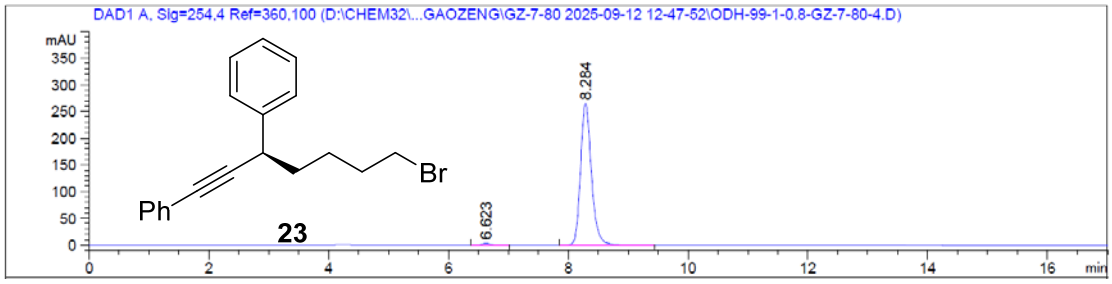
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.830	BB	0.2400	2221.96118	142.40558	98.5289
2	14.642	MM R	0.5800	33.17487	9.53259e-1	1.4711
Totals :				2255.13605	143.35884	



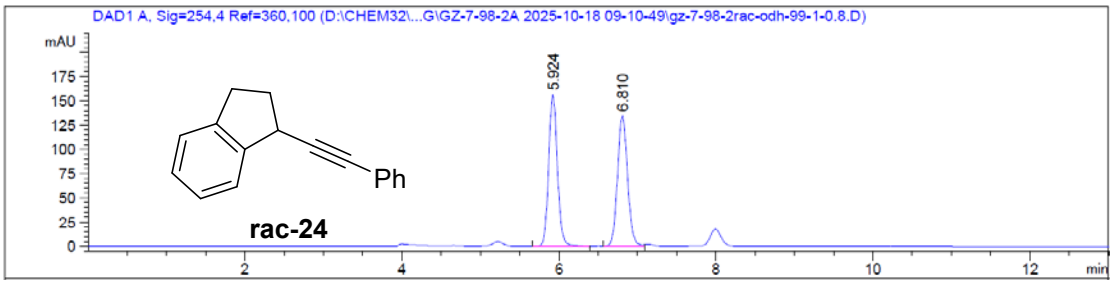
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.660	BB	0.1513	3597.16333	357.67346	49.5522
2	8.286	BB	0.1968	3662.17822	283.28091	50.4478
Totals :				7259.34155	640.95438	



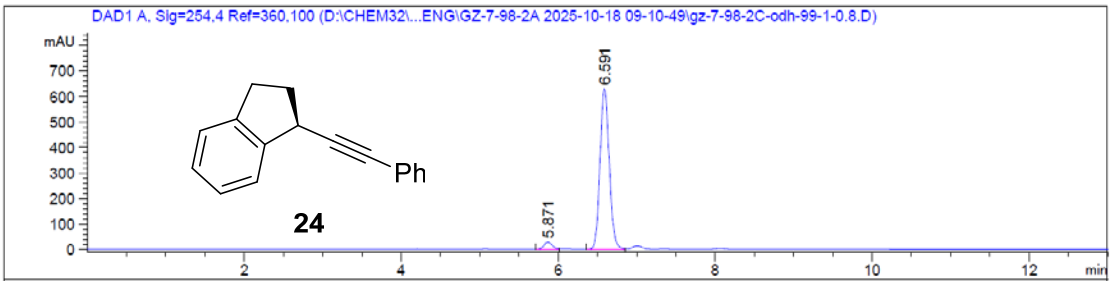
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.623	BB	0.1446	28.89386	3.04708	0.8591
2	8.284	BB	0.1929	3334.55273	264.89044	99.1409
Totals :				3363.44659	267.93752	



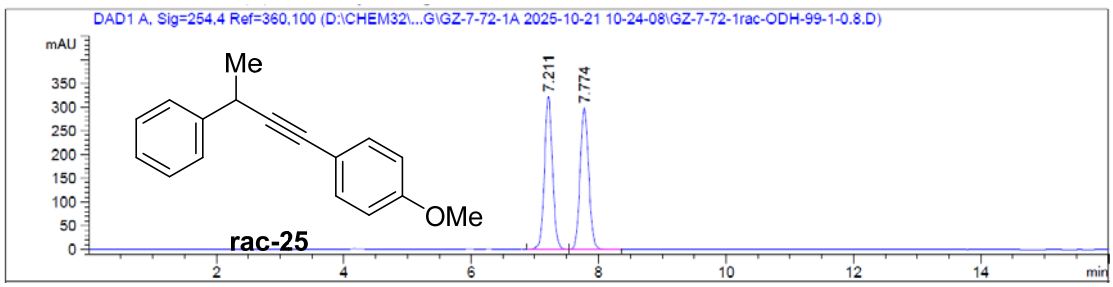
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	5.924	BB	0.1180	1203.76965	156.08958	50.0932
2	6.810	MF R	0.1487	1199.29114	134.44601	49.9068
Totals :				2403.06079	290.53560	



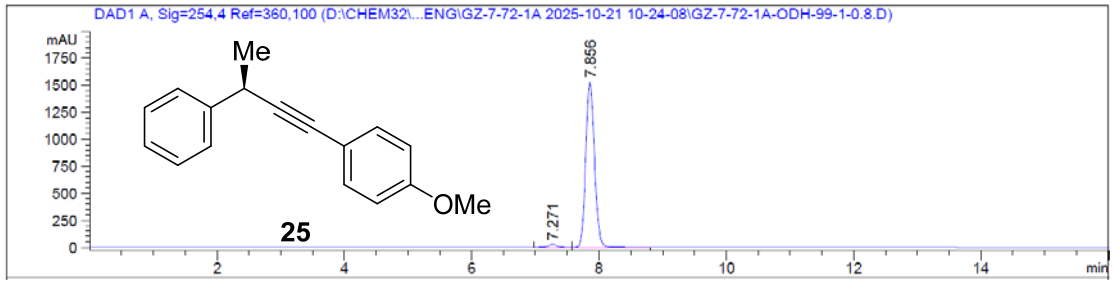
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	5.871	MF R	0.1190	212.58183	29.78444	3.9580
2	6.591	MF R	0.1366	5158.37549	629.39105	96.0420
Totals :				5370.95732	659.17550	



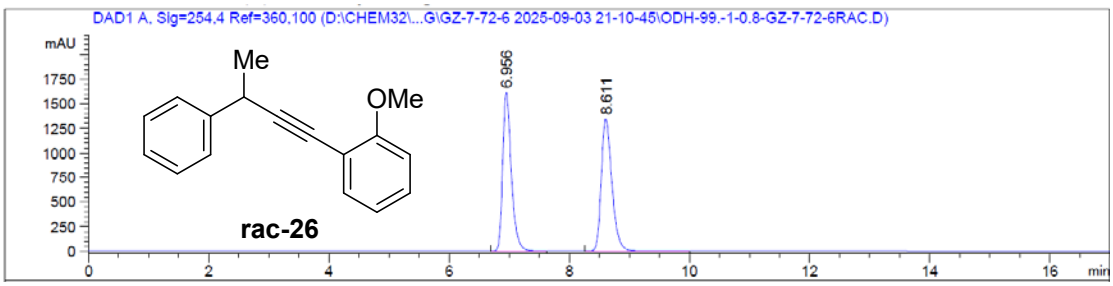
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.211	BB	0.1339	2809.05786	321.46185	50.2873
2	7.774	BB	0.1448	2776.96240	297.75241	49.7127
Totals :				5586.02026	619.21426	



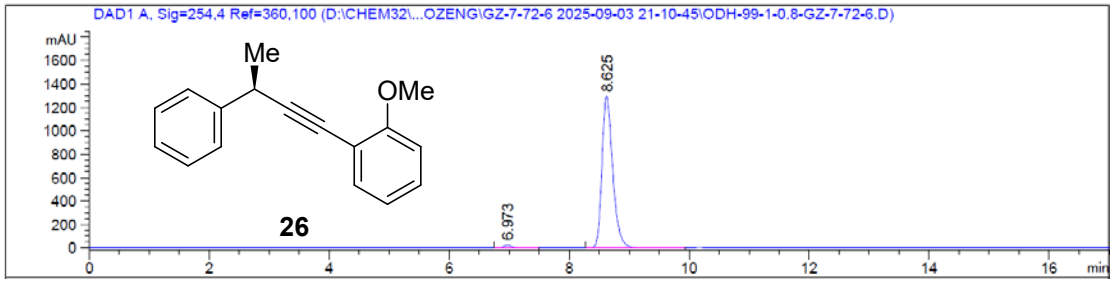
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.271	BB	0.1406	230.09953	24.71477	1.5582
2	7.856	BB	0.1489	1.45366e4	1529.55457	98.4418
Totals :				1.47667e4	1554.26934	



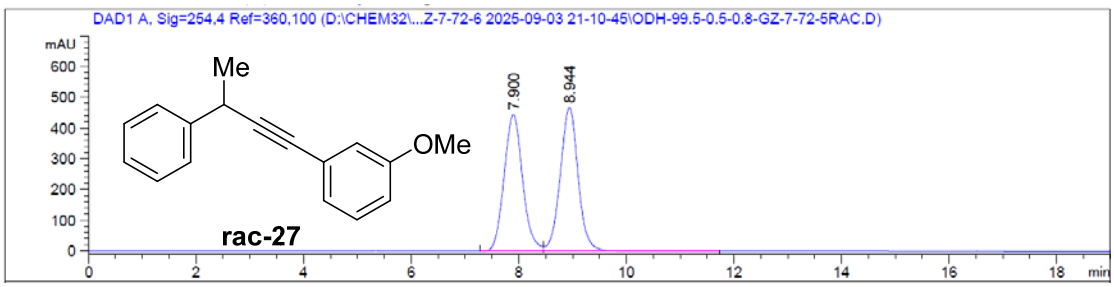
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.956	BB	0.1507	1.61425e4	1614.04944	49.3079
2	8.611	BB	0.1880	1.65957e4	1344.17114	50.6921
Totals :				3.27382e4	2958.22058	



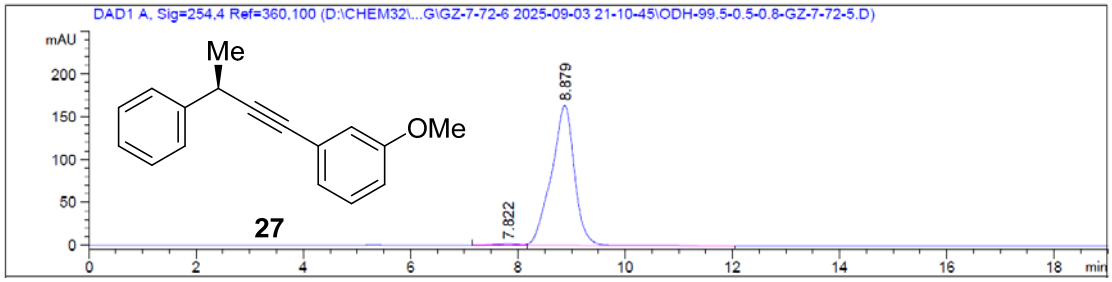
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.973	BB	0.1419	220.86897	23.44025	1.3485
2	8.625	BB	0.1919	1.61577e4	1291.67920	98.6515
Totals :				1.63786e4	1315.11945	



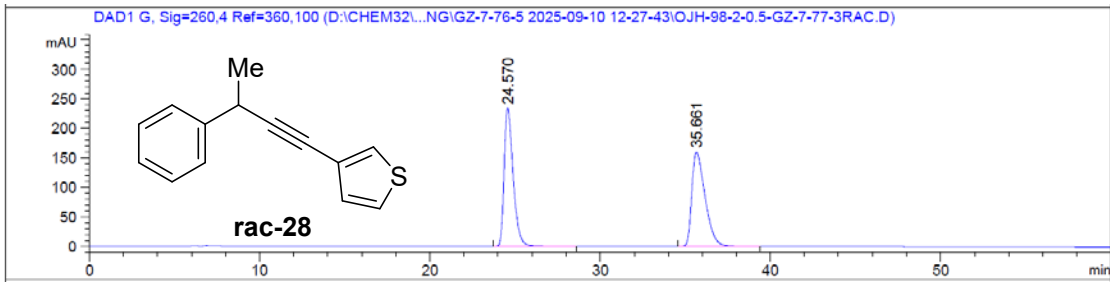
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.900	BV	0.3670	1.06174e4	443.97400	49.4774
2	8.944	VB	0.3544	1.08417e4	467.70285	50.5226
Totals :				2.14591e4	911.67685	



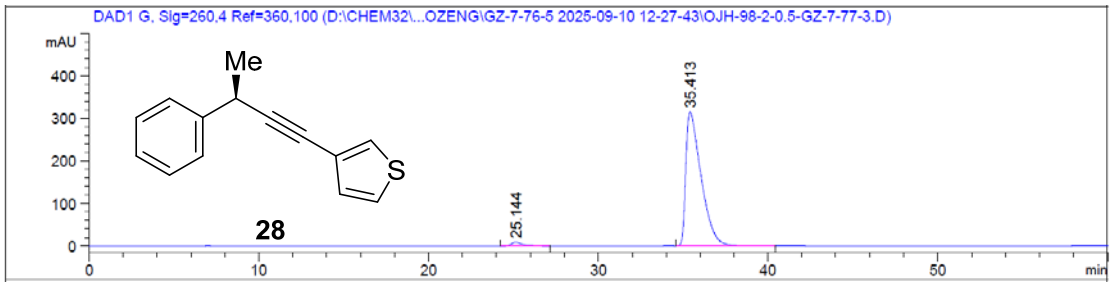
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.822	BV E	0.3900	63.18693	2.36284	1.2737
2	8.879	VB R	0.4328	4897.54590	163.83336	98.7263
Totals :				4960.73283	166.19620	



Signal 7: DAD1 G, Sig=260,4 Ref=360,100

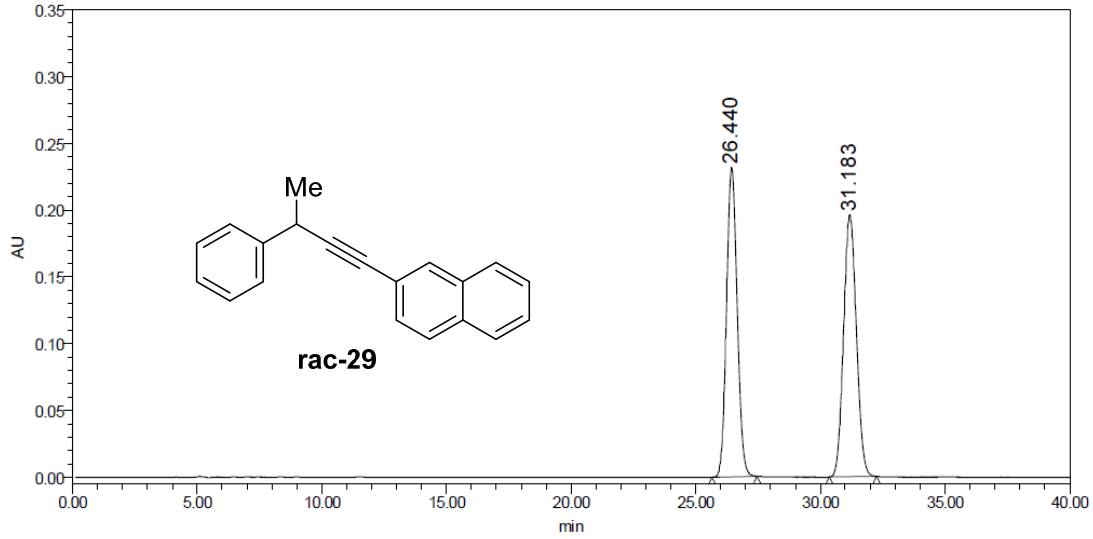
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	24.570	BB	0.5633	8674.83105	234.67828	49.9239
2	35.661	BB	0.8272	8701.26660	160.30858	50.0761
Totals :				1.73761e4	394.98686	



Signal 7: DAD1 G, Sig=260,4 Ref=360,100

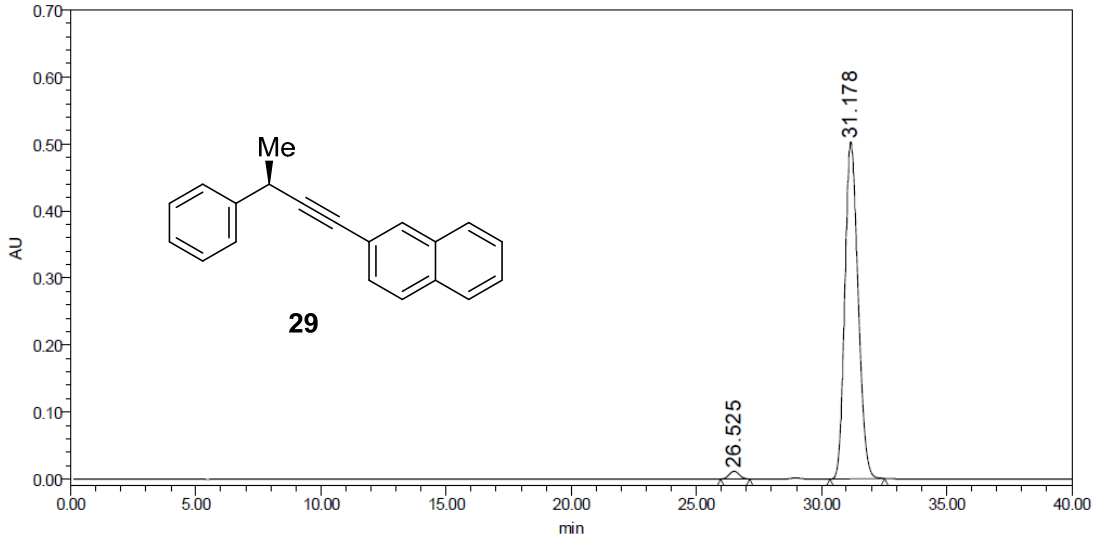
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	25.144	BB	0.6615	392.70929	8.65331	1.9630
2	35.413	BB	0.9247	1.96134e4	314.88443	98.0370
Totals :				2.00061e4	323.53774	

PDA 254nm



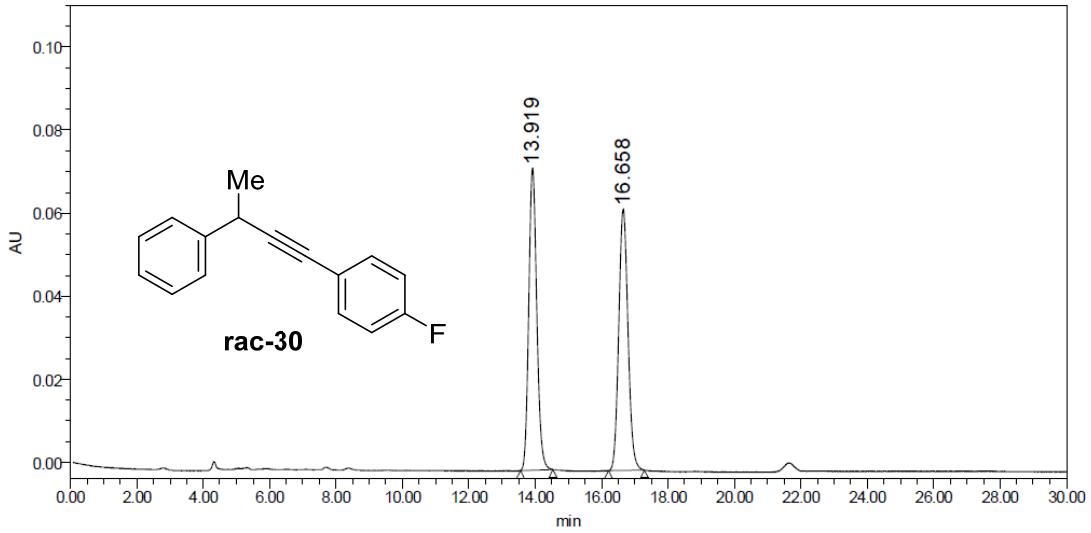
	RT	Area	% Area	Height
1	26.440	6899926	49.94	231513
2	31.183	6917028	50.06	195973

PDA 254nm



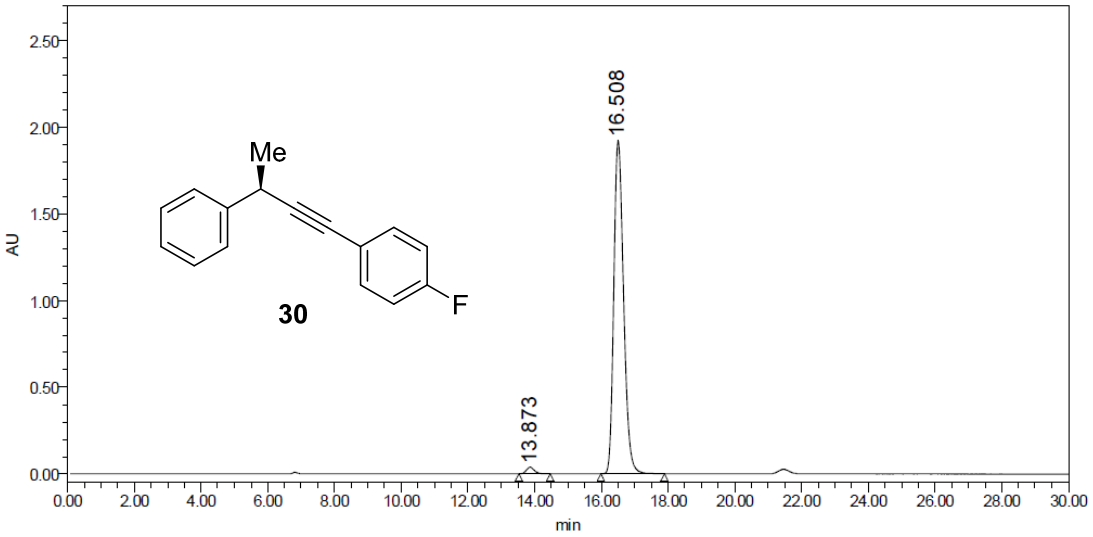
	RT	Area	% Area	Height
1	26.525	329031	1.77	11655
2	31.178	18291768	98.23	502500

PDA 230nm



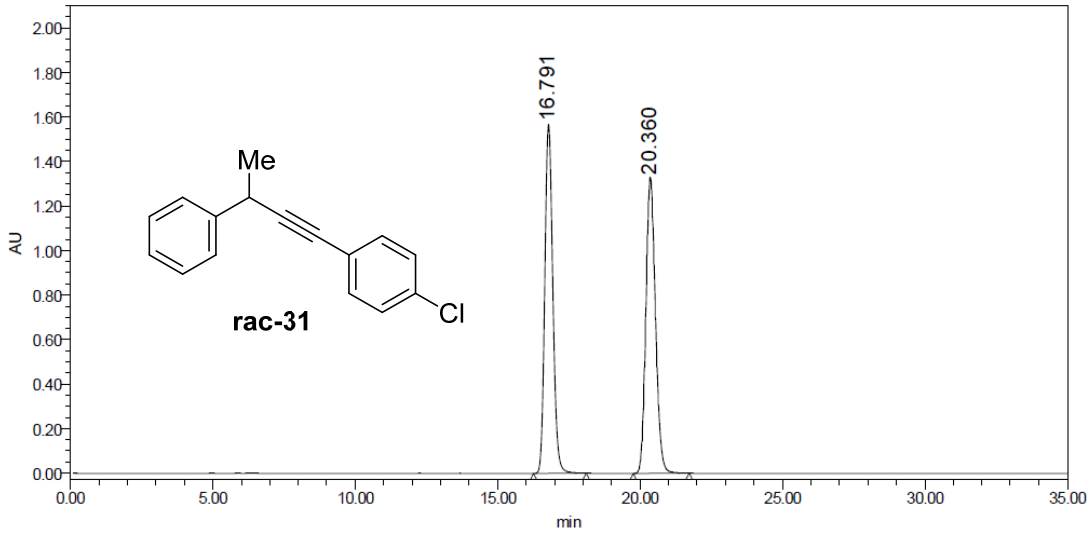
	RT	Area	% Area	Height
1	13.919	1228455	50.05	72833
2	16.658	1226041	49.95	62993

PDA 230nm



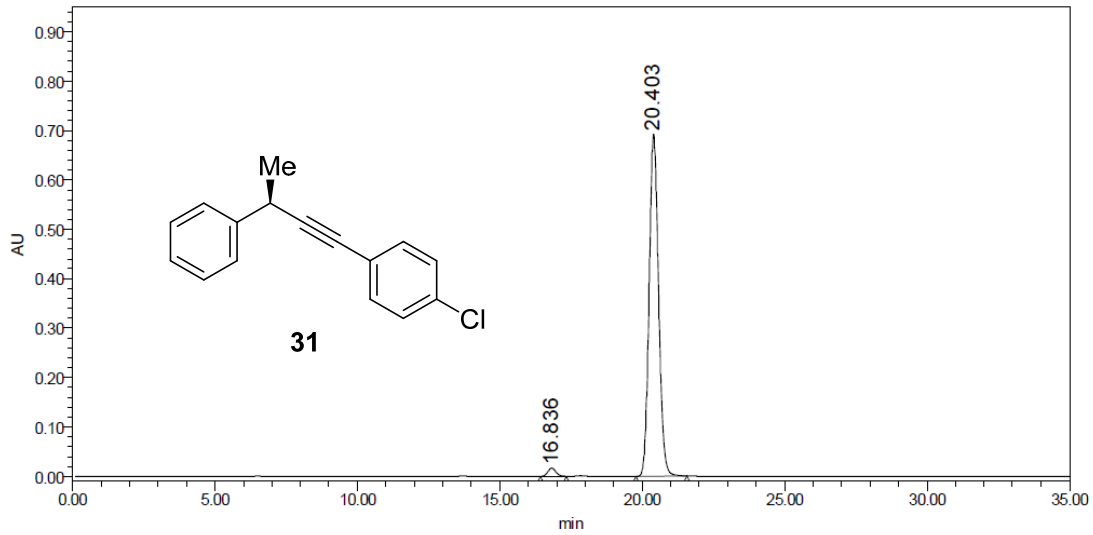
	RT	Area	% Area	Height
1	13.873	662500	1.65	38832
2	16.508	39498443	98.35	1921985

PDA 254nm



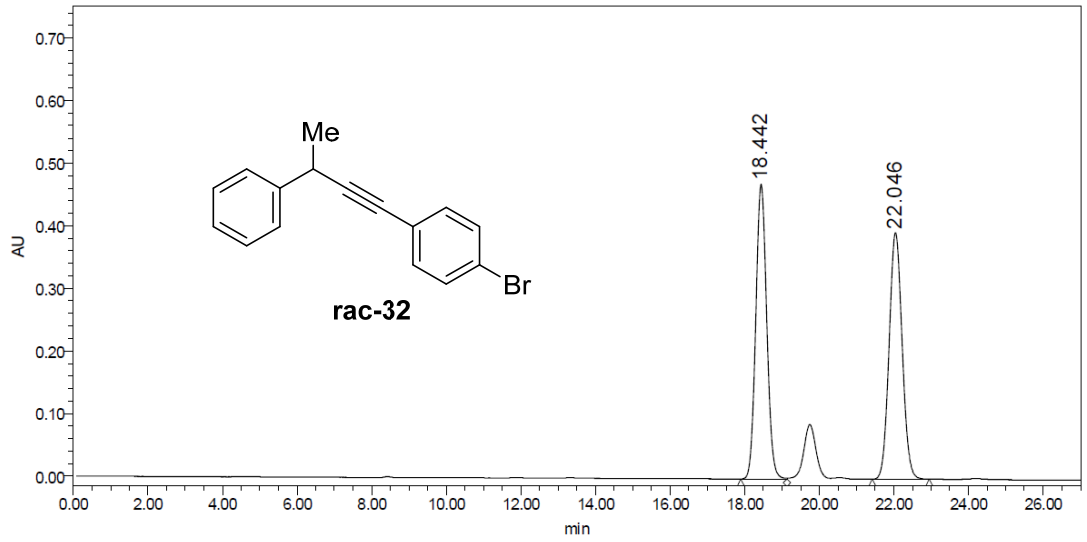
	RT	Area	% Area	Height
1	16.791	30879197	49.97	1565896
2	20.360	30922042	50.03	1327403

PDA 254nm



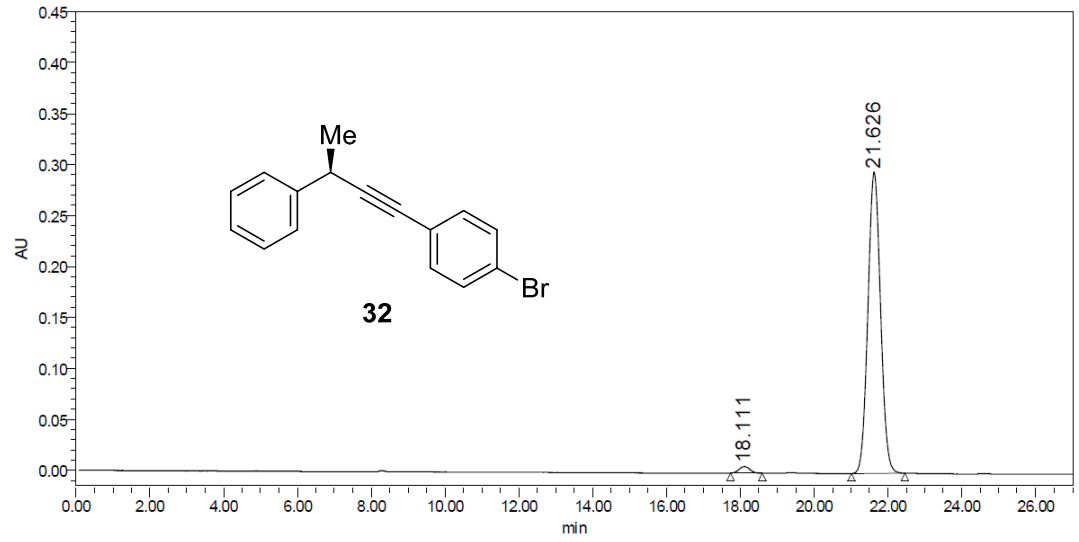
	RT	Area	% Area	Height
1	16.836	318229	1.96	16683
2	20.403	15878813	98.04	692037

PDA 254nm



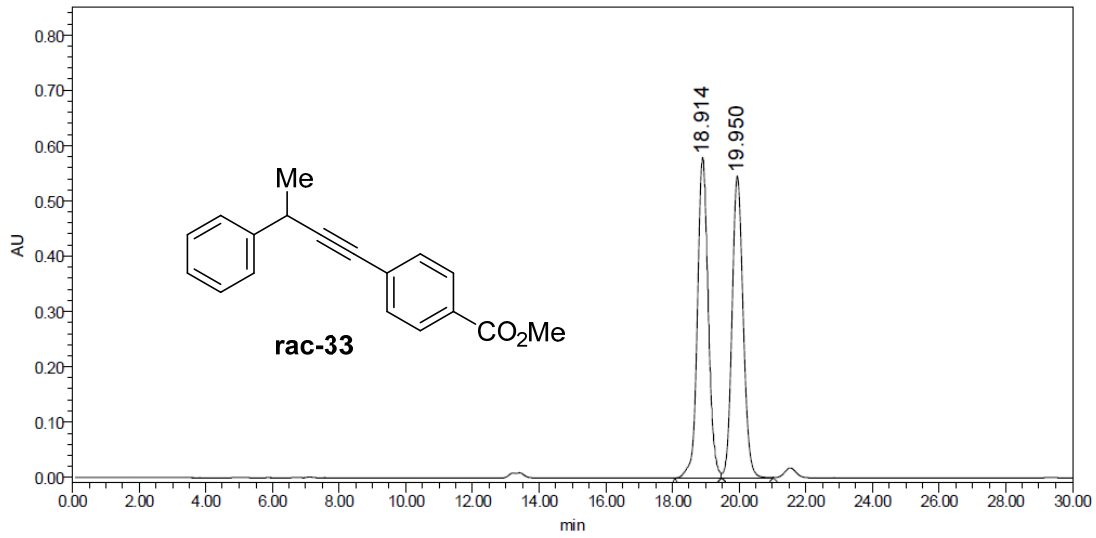
	RT	Area	% Area	Height
1	18.442	9652293	50.08	470733
2	22.046	9620351	49.92	393958

PDA 254nm



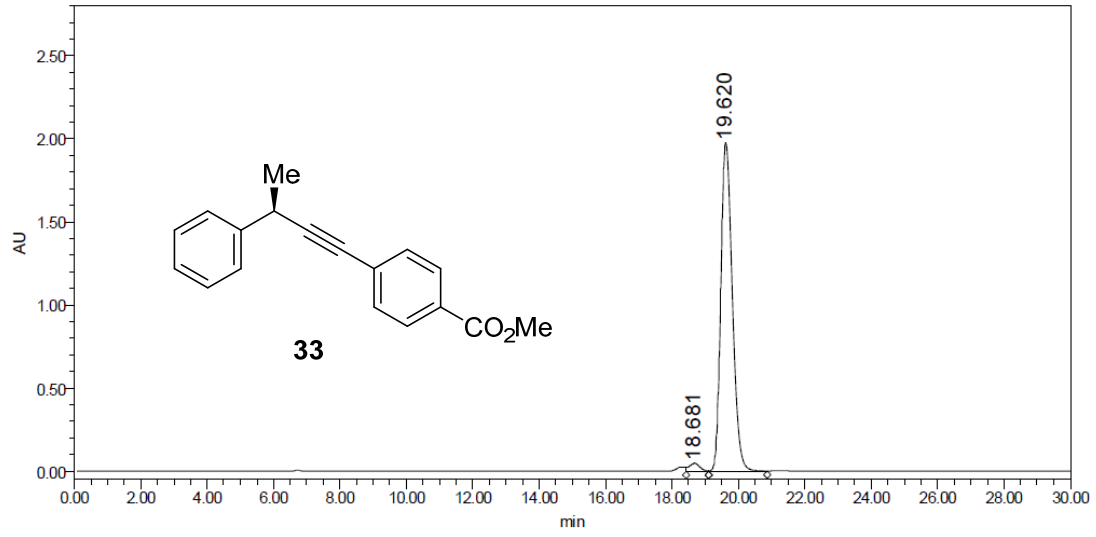
	RT	Area	% Area	Height
1	18.111	131684	1.83	6624
2	21.626	7073134	98.17	295411

PDA 254nm

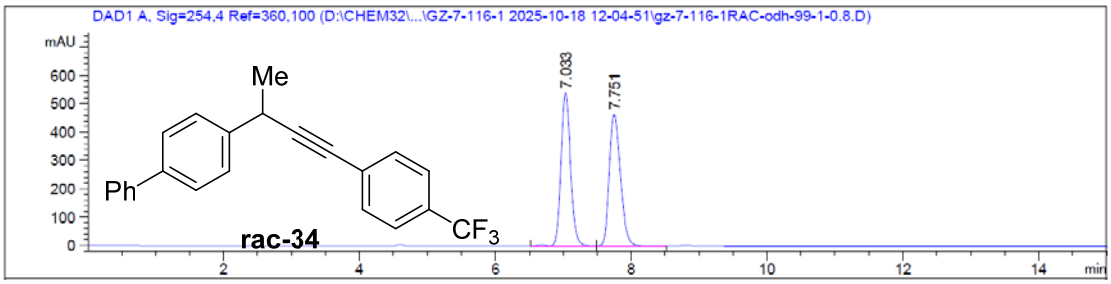


	RT	Area	% Area	Height
1	18.914	13043049	50.63	579317
2	19.950	12716246	49.37	545457

PDA 254nm

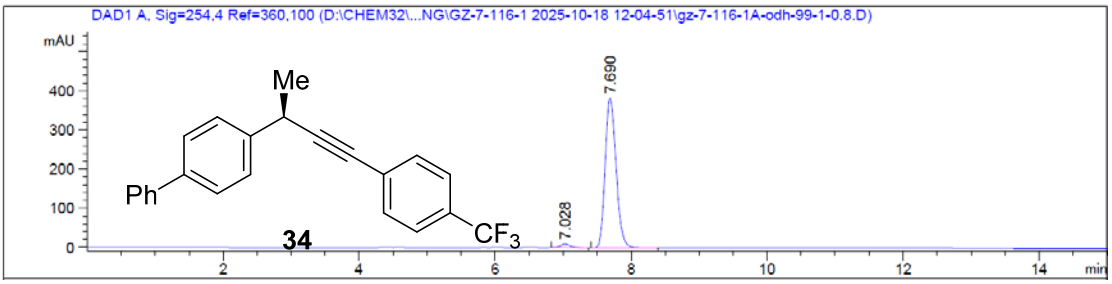


	RT	Area	% Area	Height
1	18.681	1051567	2.17	47743
2	19.620	47490089	97.83	1973724



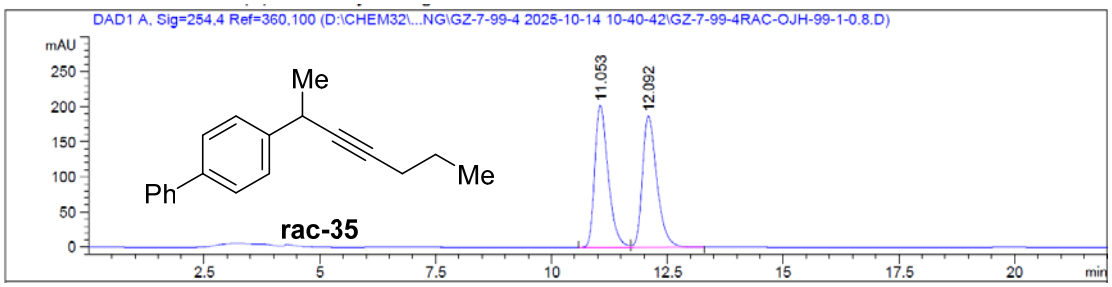
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.033	VB R	0.1513	5262.91797	538.70038	50.1407
2	7.751	BB	0.1737	5233.37939	463.74643	49.8593
Totals :				1.04963e4	1002.44681	



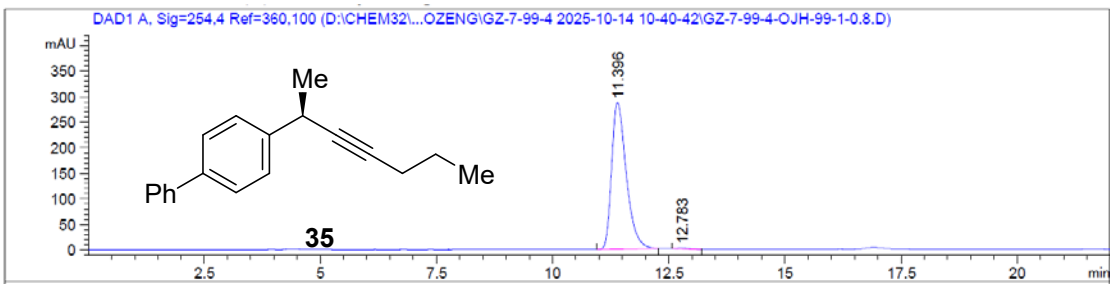
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.028	BB	0.1492	86.56104	8.92354	2.0099
2	7.690	BB	0.1706	4220.12744	382.76526	97.9901
Totals :				4306.68848	391.68880	



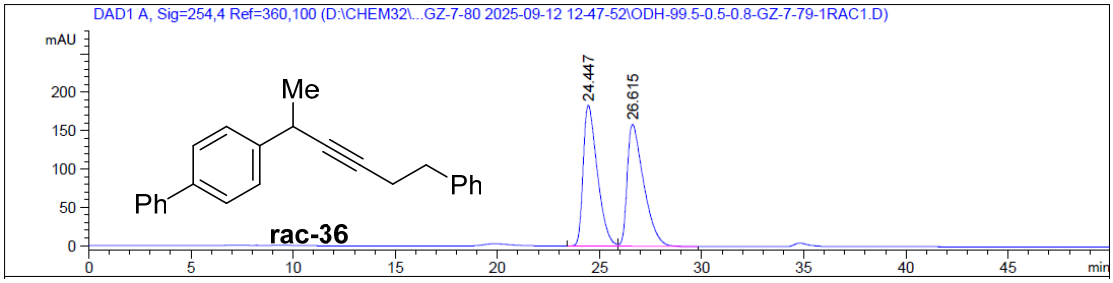
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.053	BV	0.3061	4053.42920	202.02292	49.8821
2	12.092	VB	0.3344	4072.59644	186.78122	50.1179
Totals :				8126.02563	388.80414	



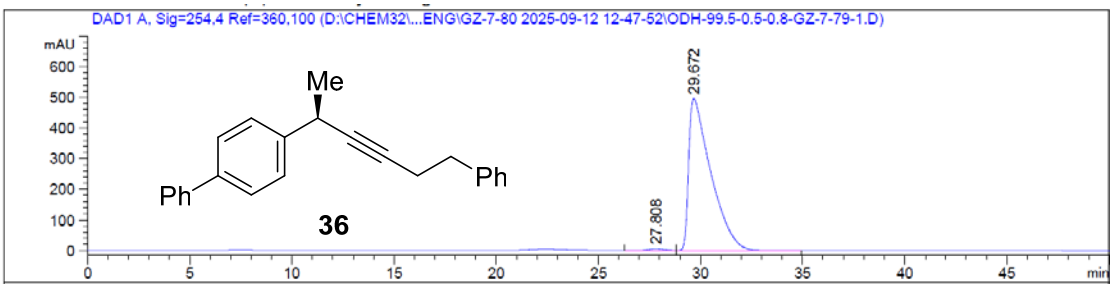
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.396	BB	0.3327	6285.53174	287.91104	99.5675
2	12.783	BB	0.2736	27.30438	1.61203	0.4325
Totals :				6312.83612	289.52308	



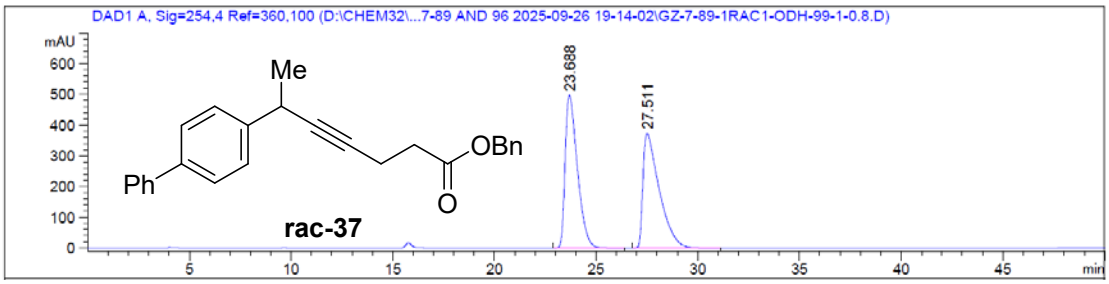
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	24.447	BV	0.7295	8851.25000	183.92393	49.8308
2	26.615	VB	0.8317	8911.34570	159.03514	50.1692
Totals :				1.77626e4	342.95908	



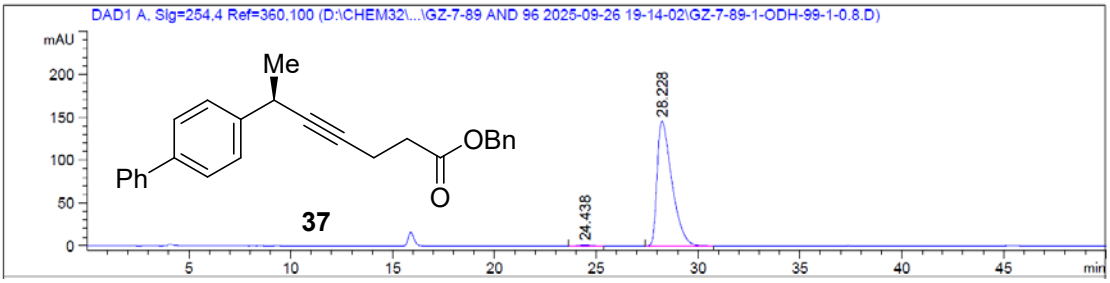
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	27.808	MF R	1.0021	388.77536	6.46616	1.0252
2	29.672	FM R	1.2611	3.75332e4	496.05115	98.9748
Totals :				3.79220e4	502.51731	



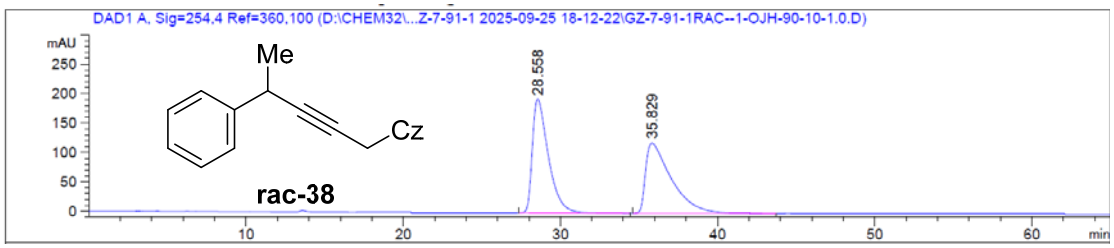
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	23.688	BB	0.6343	2.06997e4	496.59286	49.9631
2	27.511	BB	0.8157	2.07302e4	372.23236	50.0369
Totals :				4.14299e4	868.82523	



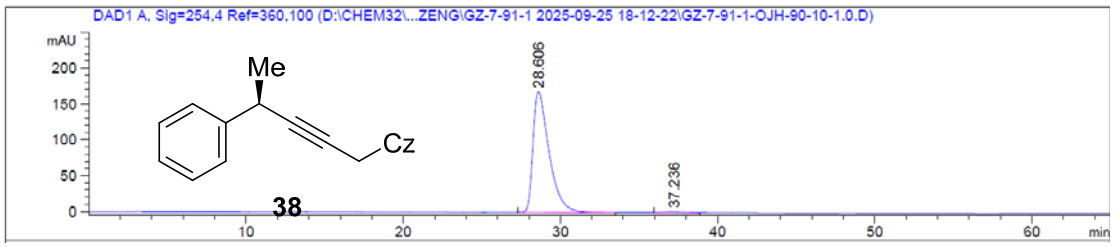
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	24.438	MM R	0.8921	72.76039	1.35938	0.9827
2	28.228	BB	0.7637	7331.64893	145.53282	99.0173
Totals :				7404.40932	146.89221	



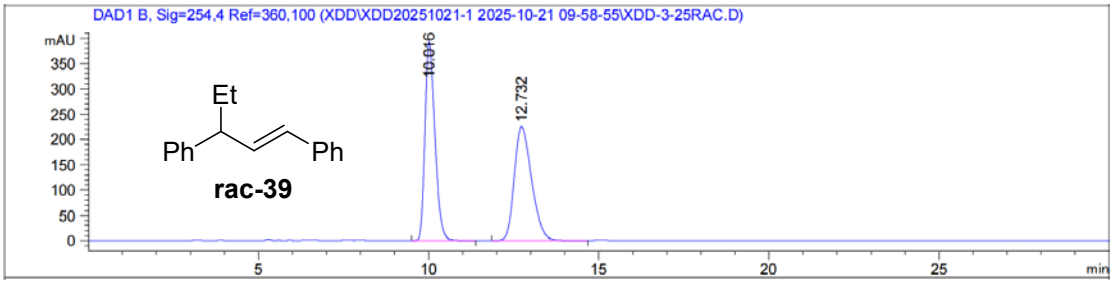
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	28.558	BB	1.0590	1.36376e4	193.33470	50.1668
2	35.829	BB	1.6201	1.35469e4	119.00443	49.8332
Totals :				2.71845e4	312.33913	



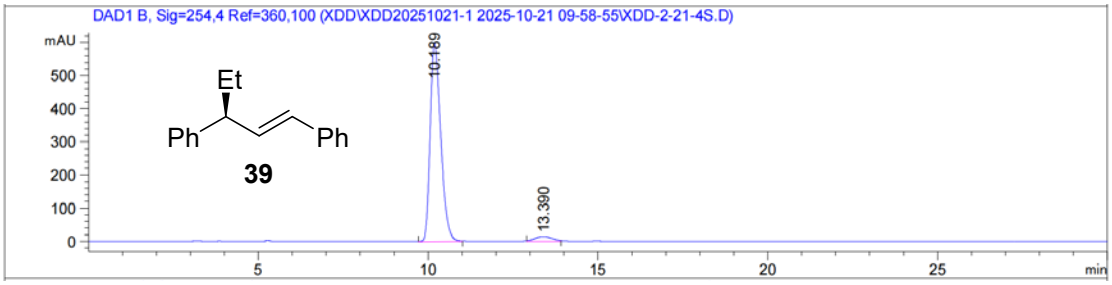
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	28.606	BB	1.0623	1.19370e4	168.14117	98.6215
2	37.236	MF R	1.9769	166.85733	1.40671	1.3785
Totals :				1.21039e4	169.54789	



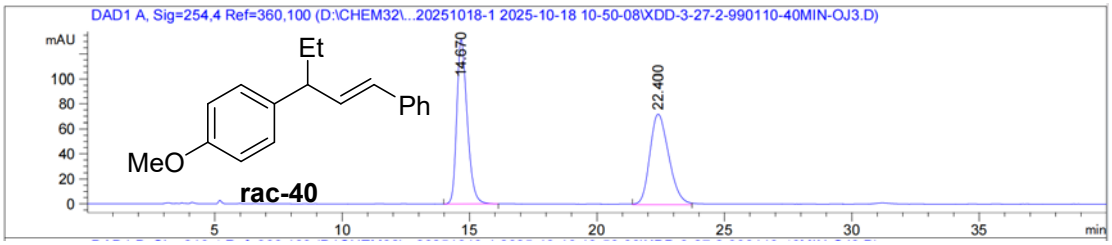
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.016	BB	0.3124	7956.22852	392.62085	49.9687
2	12.732	BB	0.5467	7966.19336	225.19421	50.0313
Totals :				1.59224e4	617.81506	



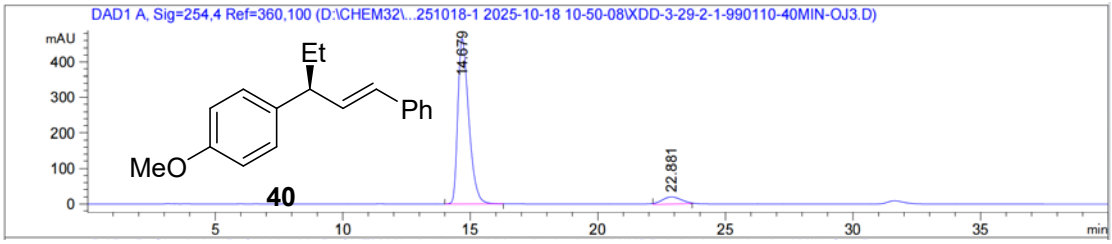
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.189	MM R	0.3600	1.29923e4	601.51746	95.9716
2	13.390	MM R	0.6089	545.35522	14.92782	4.0284
Totals :				1.35377e4	616.44528	



Signal 1: DAD1 A, Sig=254,4 Ref=360,100

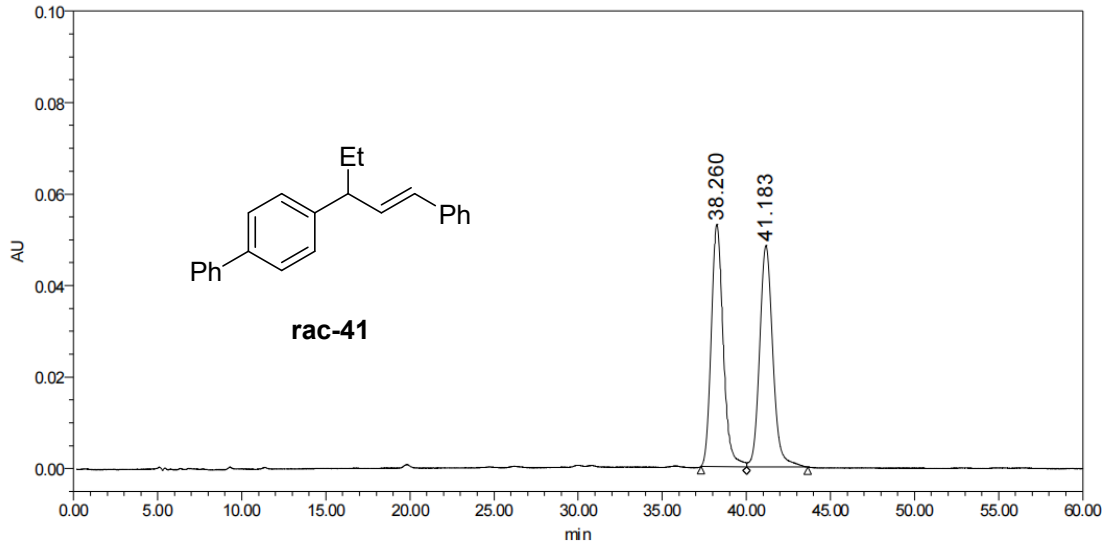
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	14.670	BB	0.4356	3763.94702	131.63051	50.1114
2	22.400	MM R	0.8643	3747.21118	72.25529	49.8886
Totals :				7511.15820	203.88580	



Signal 1: DAD1 A, Sig=254,4 Ref=360,100

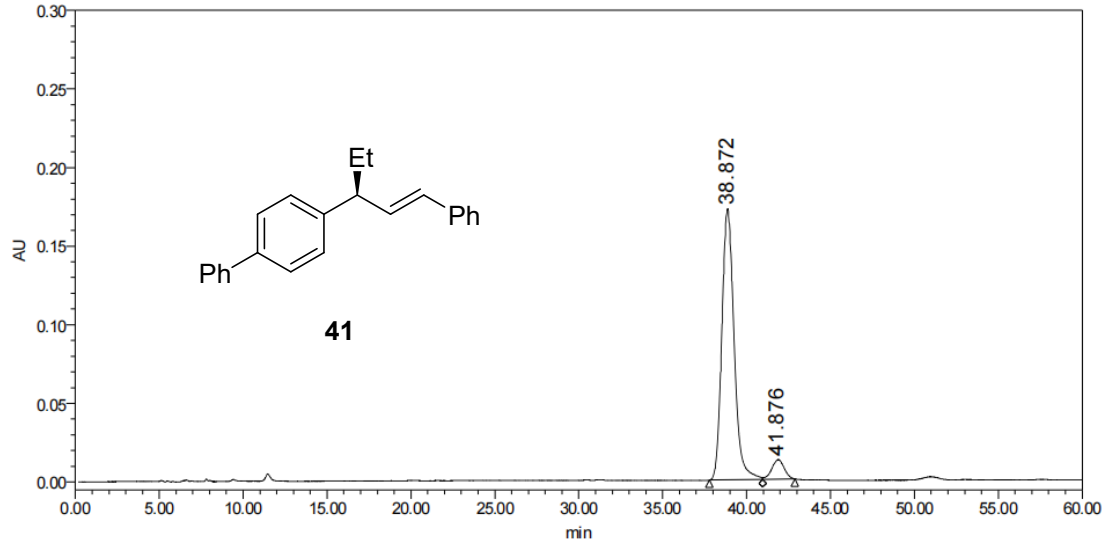
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	14.679	BB	0.4607	1.39112e4	465.41333	92.9025
2	22.881	MM R	0.8676	1062.78381	20.41704	7.0975
Totals :				1.49740e4	485.83037	

PDA 254nm

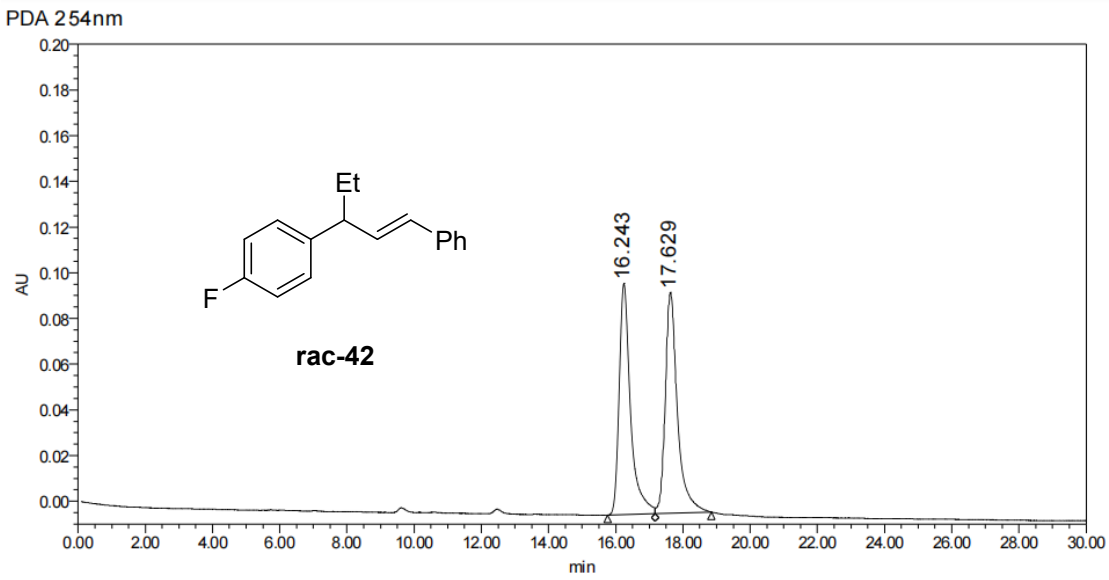


	RT	Area	% Area	Height
1	38.260	2609182	49.58	52977
2	41.183	2653791	50.42	48364

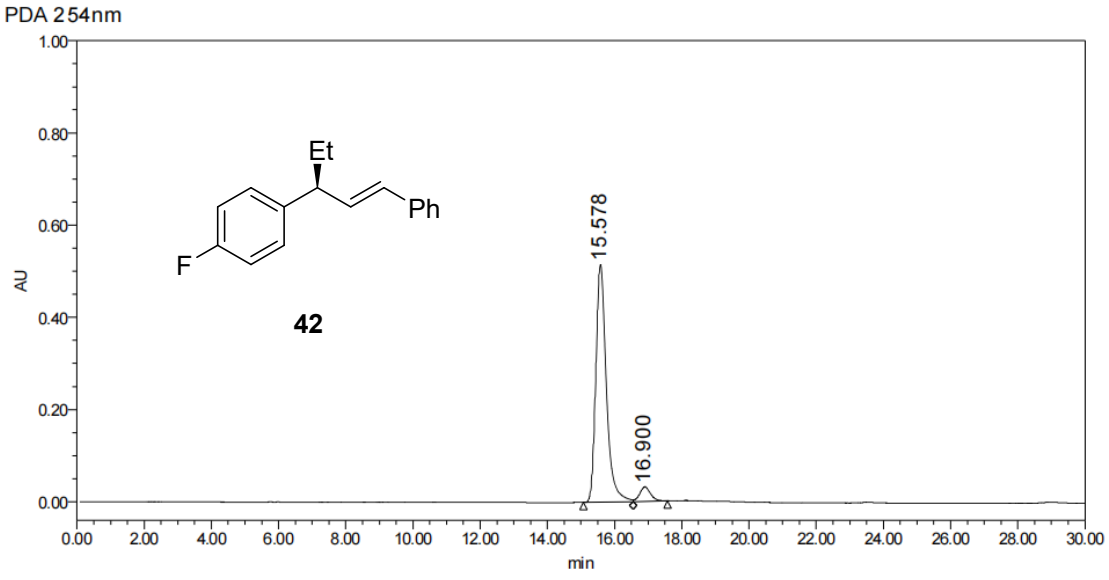
PDA 254nm



	RT	Area	% Area	Height
1	38.872	8596077	93.06	172306
2	41.876	640661	6.94	12387

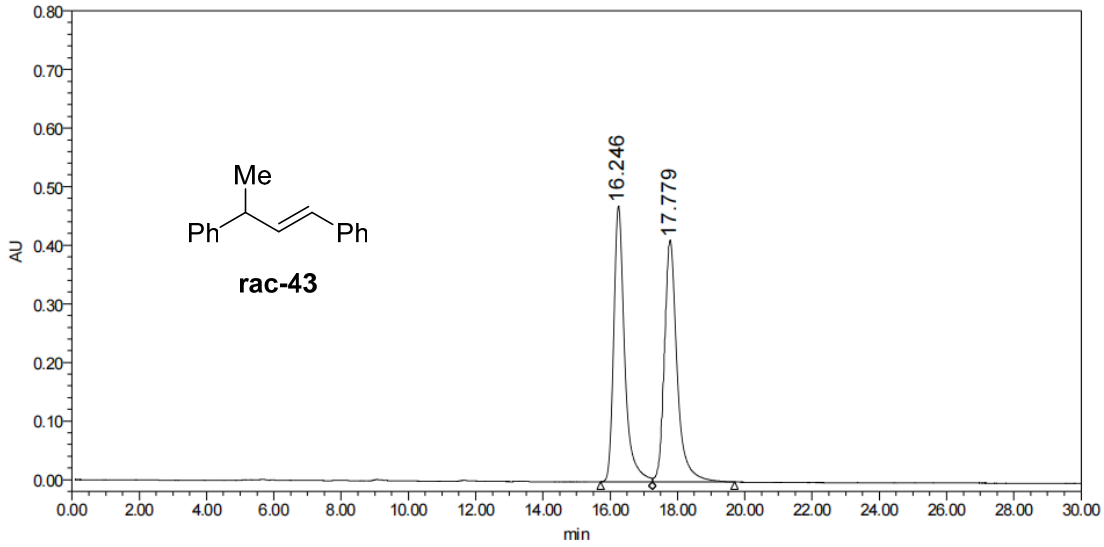


	RT	Area	% Area	Height
1	16.243	2394503	49.66	101165
2	17.629	2427181	50.34	96630



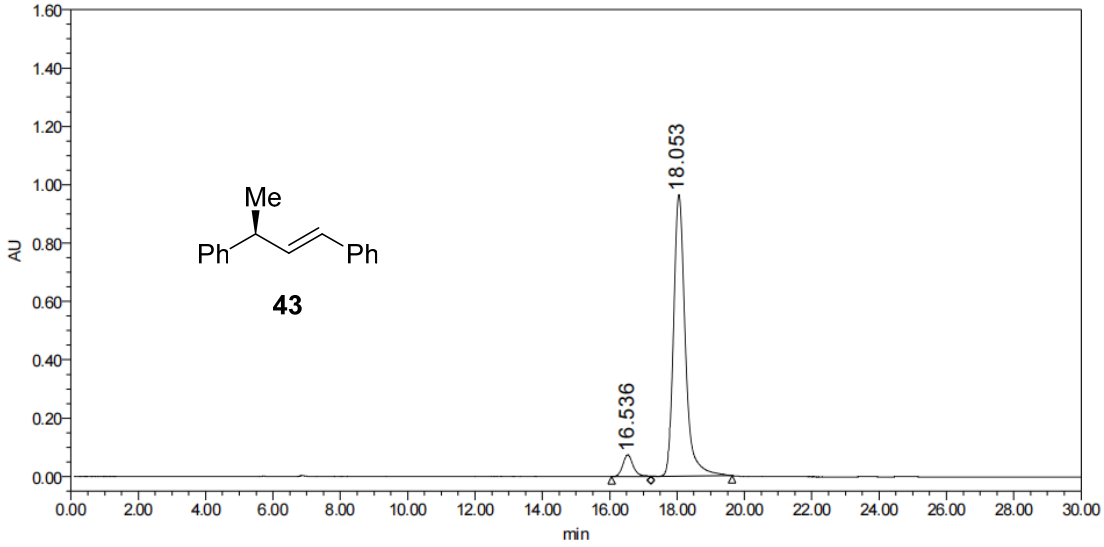
	RT	Area	% Area	Height
1	15.578	11144668	94.10	515319
2	16.900	698793	5.90	31179

PDA 254nm

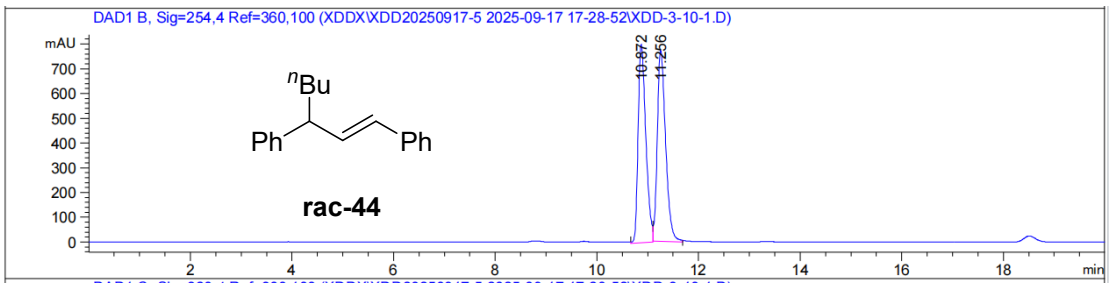


	RT	Area	% Area	Height
1	16.246	10686187	49.66	470682
2	17.779	10834137	50.34	412139

PDA 254nm

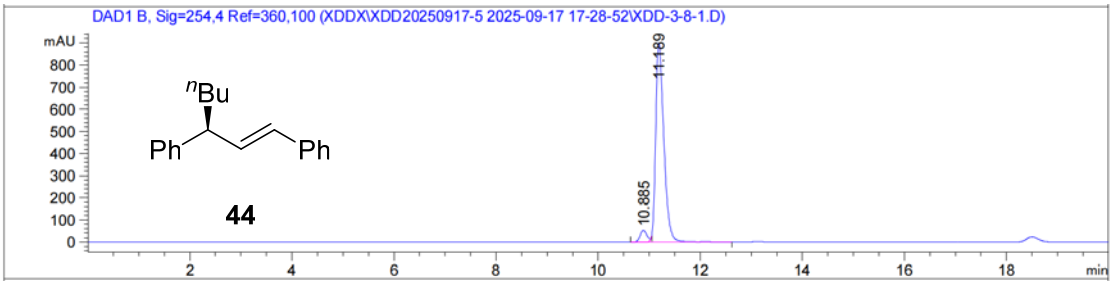


	RT	Area	% Area	Height
1	16.536	1582602	6.32	74521
2	18.053	23455174	93.68	964554



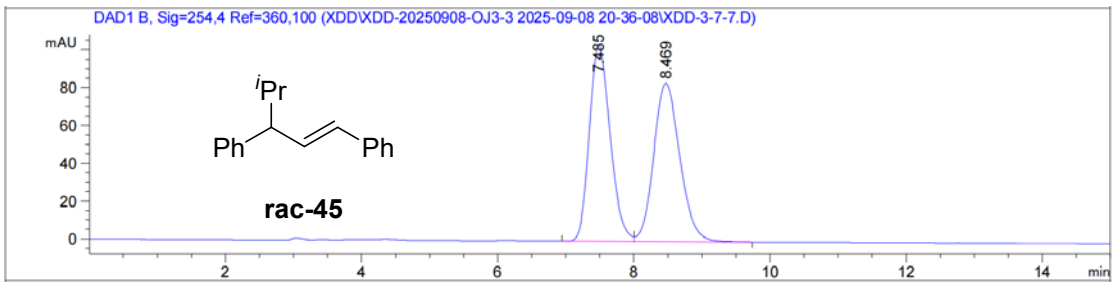
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.872	MM R	0.1757	8455.37988	801.87213	49.0583
2	11.256	MM R	0.1894	8779.98926	772.48956	50.9417
Totals :				1.72354e4	1574.36169	



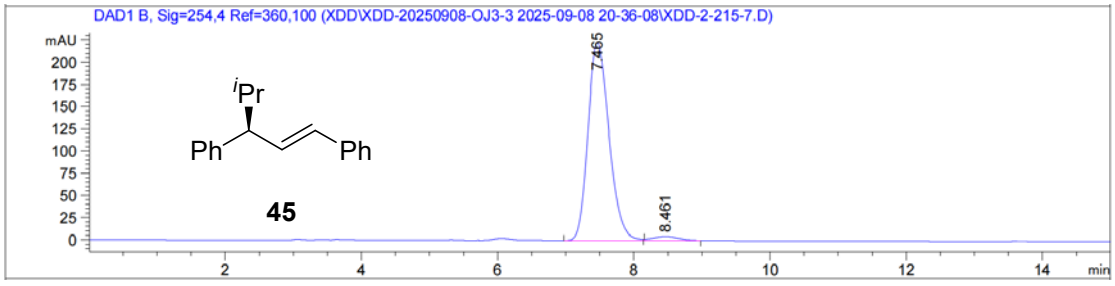
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.885	BV E	0.1482	483.42877	51.17725	4.6044
2	11.189	VV R	0.1697	1.00159e4	899.45331	95.3956
Totals :				1.04993e4	950.63055	



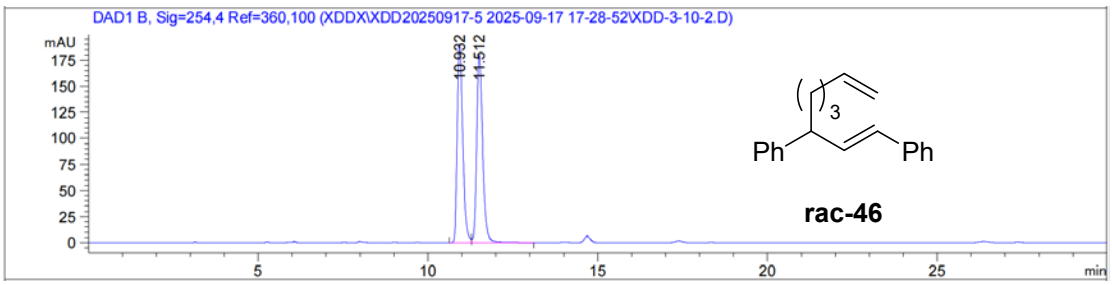
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.485	BV	0.3292	2207.32739	104.18640	49.6791
2	8.469	VB	0.4134	2235.84644	83.75655	50.3209
Totals :				4443.17383	187.94295	



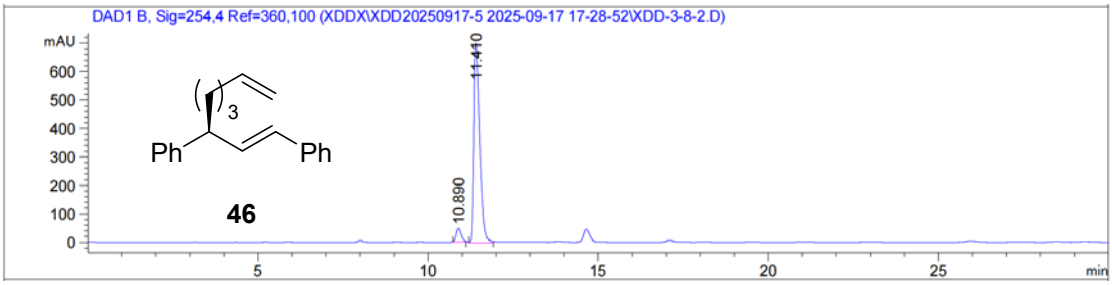
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.465	BV	0.3329	4795.87988	222.99860	97.3866
2	8.461	MM R	0.4457	128.69650	4.81261	2.6134
Totals :				4924.57639	227.81121	



Signal 2: DAD1 B, Sig=254,4 Ref=360,100

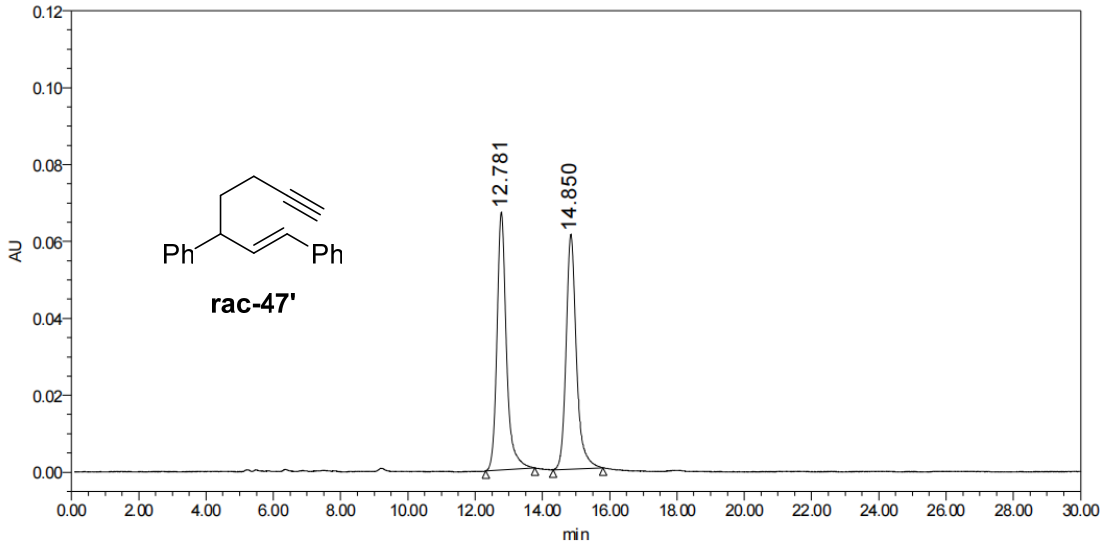
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.932	BV	0.1736	2146.87695	190.32608	49.4890
2	11.512	VB	0.1882	2191.21655	179.71709	50.5110
Totals :				4338.09351	370.04317	



Signal 2: DAD1 B, Sig=254,4 Ref=360,100

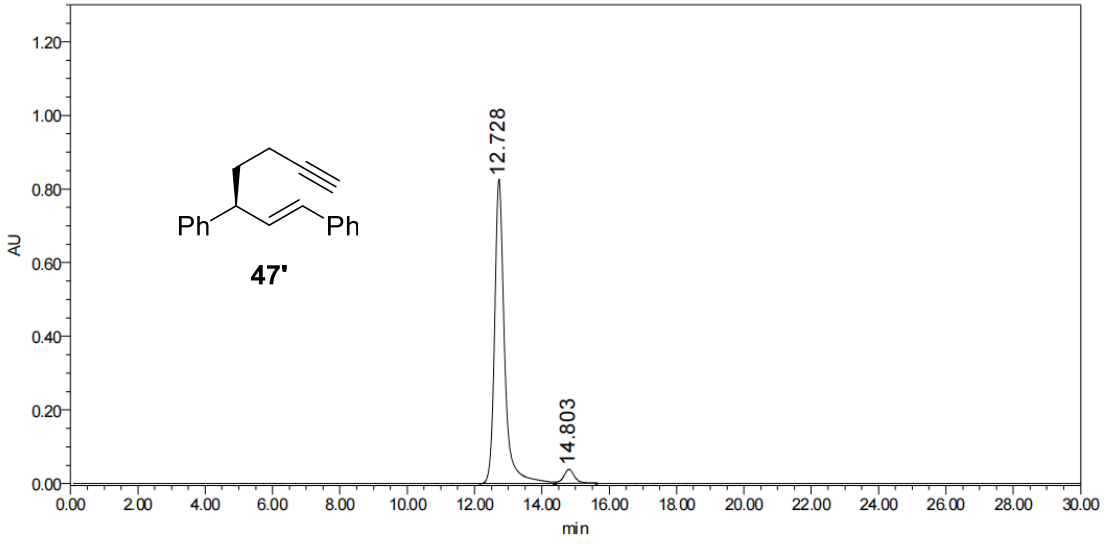
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.890	MM R	0.1756	510.83649	48.48644	5.6297
2	11.410	MM R	0.2031	8563.07910	702.56641	94.3703
Totals :				9073.91559	751.05285	

PDA 254nm

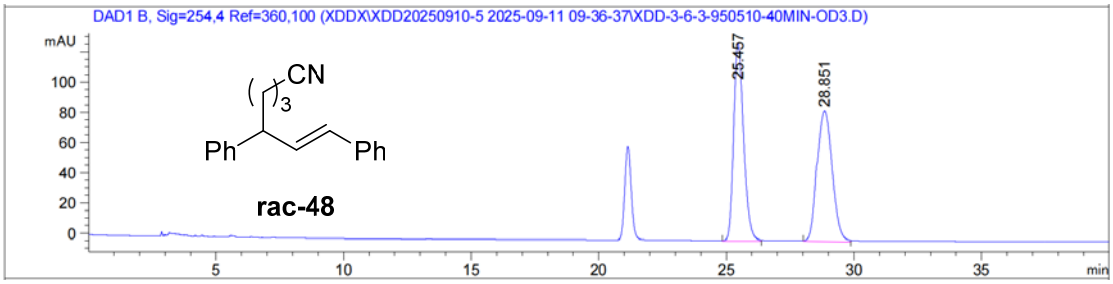


	RT	Area	% Area	Height
1	12.781	1320623	50.37	67059
2	14.850	1301044	49.63	60990

PDA 254nm

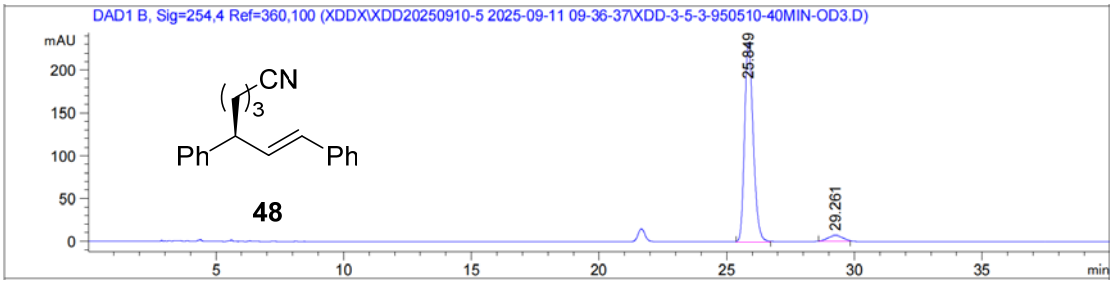


	RT	Area	% Area	Height
1	12.728	17081382	95.33	825378
2	14.803	836782	4.67	37954



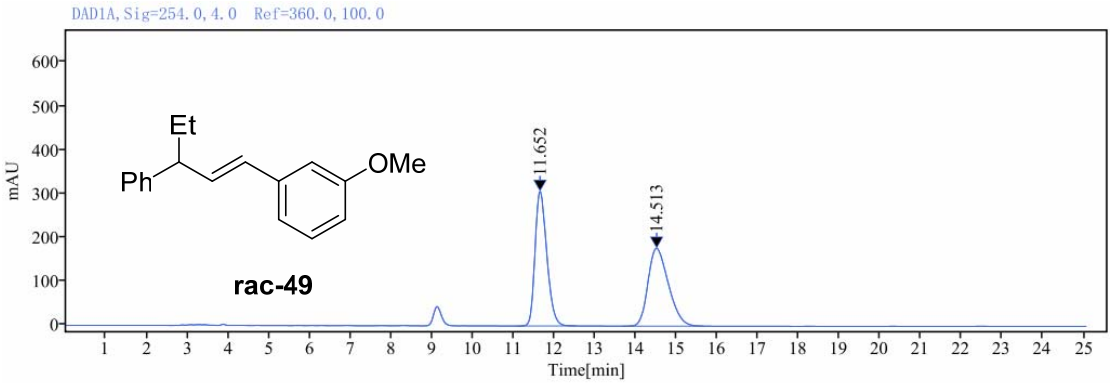
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	25.457	MM R	0.4541	3578.36011	131.34665	49.9339
2	28.851	MM R	0.6909	3587.83276	86.54641	50.0661
Totals :				7166.19287	217.89306	

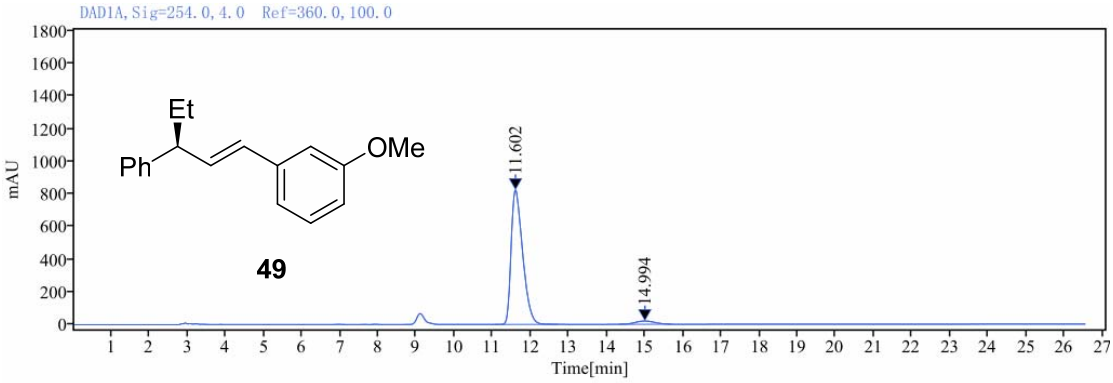


Signal 2: DAD1 B, Sig=254,4 Ref=360,100

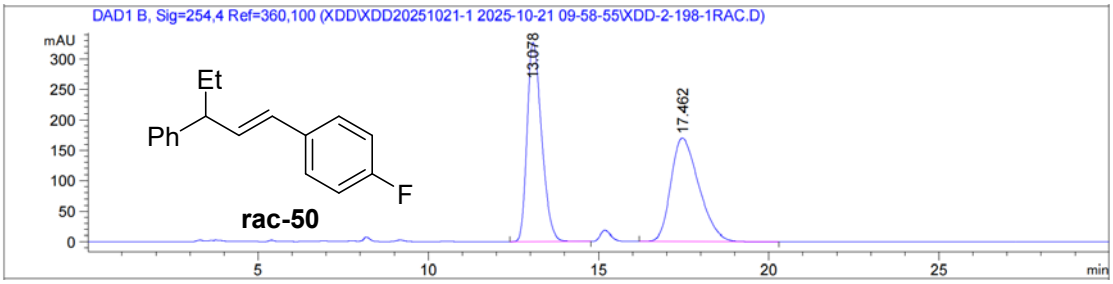
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	25.849	MM R	0.3923	5489.50146	233.23463	95.0818
2	29.261	MM R	0.6989	283.95206	6.77116	4.9182
Totals :				5773.45352	240.00579	



Signal 1:	DAD1A,Sig=254.0,4.0 Ref=360.0,100.0				
RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area%
11.652	BM m	1.46	6179.85	306.68	50.07
14.513	BM m	2.00	6162.16	177.43	49.93
	Totals	3.46	12342.01		

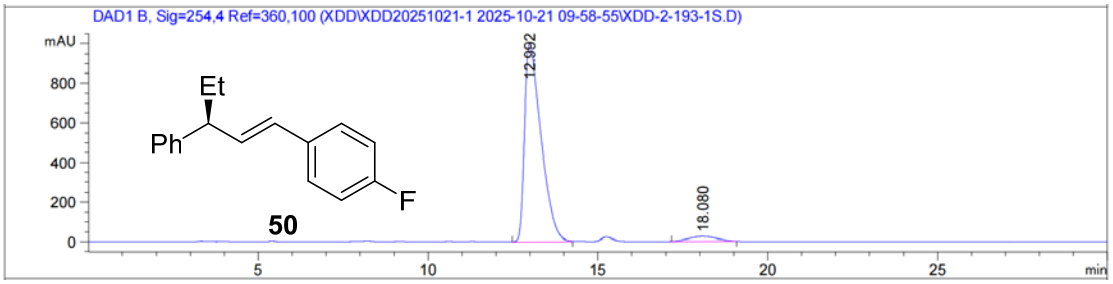


Signal 1:	DAD1A,Sig=254.0,4.0 Ref=360.0,100.0				
RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area%
11.602	BM m	1.64	17295.50	823.60	96.06
14.994	MM m	1.37	710.15	19.87	3.94
	Totals	3.02	18005.65		



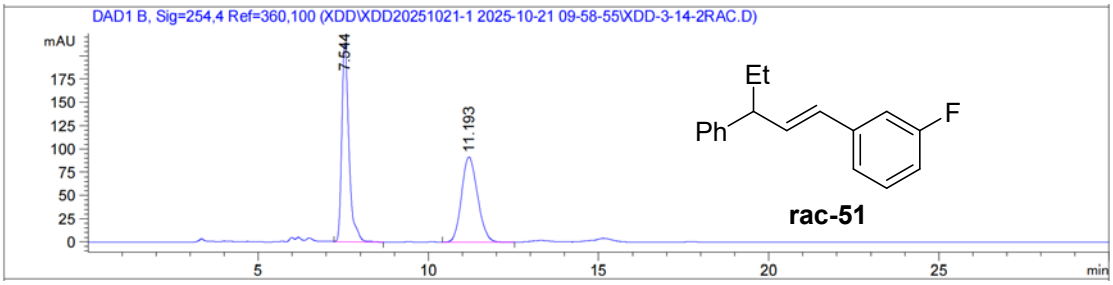
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	13.078	BB	0.4601	9682.20605	326.35947	49.9848
2	17.462	BB	0.8841	9688.10645	169.17937	50.0152
Totals :				1.93703e4	495.53883	



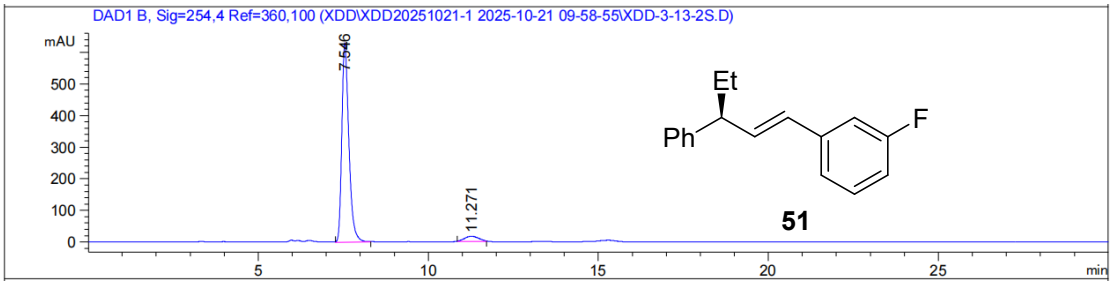
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.992	MM R	0.5625	3.39508e4	1005.96002	95.6932
2	18.080	MM R	0.9698	1528.01050	26.25957	4.3068
Totals :				3.54788e4	1032.21959	



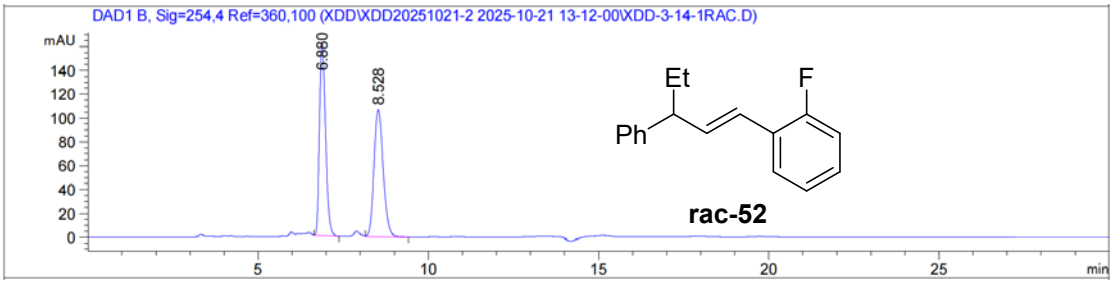
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.544	BB	0.2232	3130.42798	213.37328	51.1872
2	11.193	BB	0.5090	2985.21362	91.40977	48.8128
Totals :				6115.64160	304.78304	



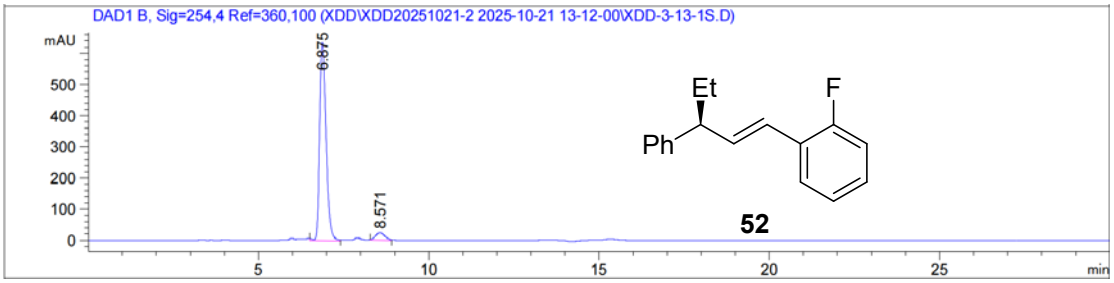
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.546	MM R	0.2410	9127.80469	631.19342	95.0360
2	11.271	MM R	0.4858	476.76816	16.35771	4.9640
Totals :				9604.57285	647.55113	



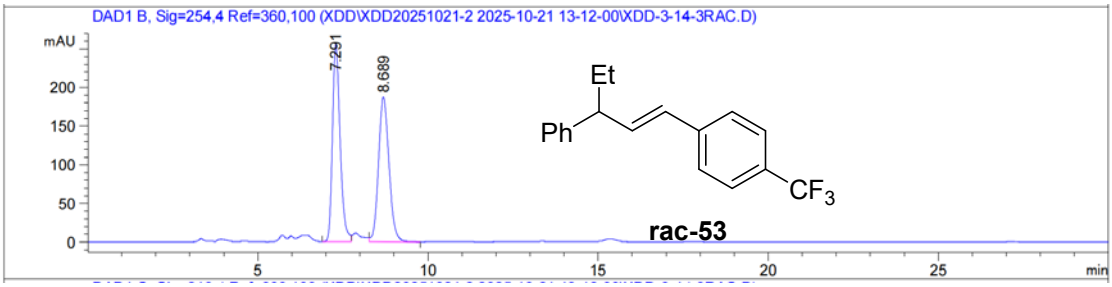
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.880	BB	0.1926	2012.46057	162.36659	49.9954
2	8.528	VB	0.2919	2012.83374	106.79015	50.0046
Totals :				4025.29431	269.15675	



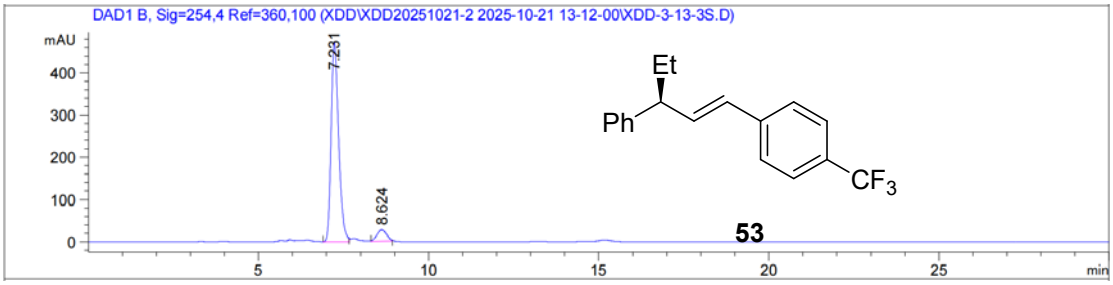
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.875	MM R	0.2187	8345.58496	635.89008	95.0522
2	8.571	MM R	0.3129	434.41858	23.14115	4.9478
Totals :				8780.00354	659.03122	



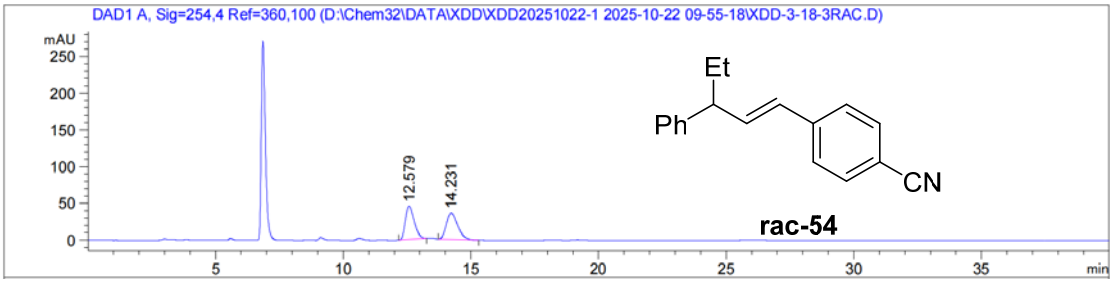
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.291	BV	0.2403	4014.11694	256.84698	50.0426
2	8.689	VB	0.3296	4007.28003	187.26936	49.9574
Totals :				8021.39697	444.11635	



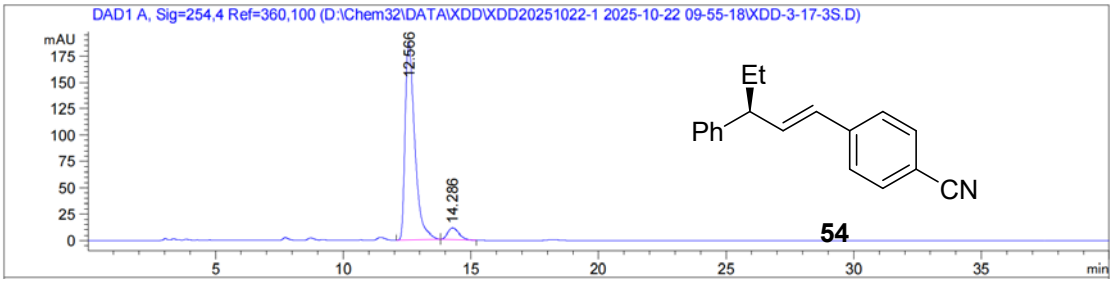
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.231	MM R	0.2561	7282.78711	473.96228	93.3139
2	8.624	MM R	0.3276	521.82721	26.54972	6.6861
Totals :				7804.61432	500.51200	



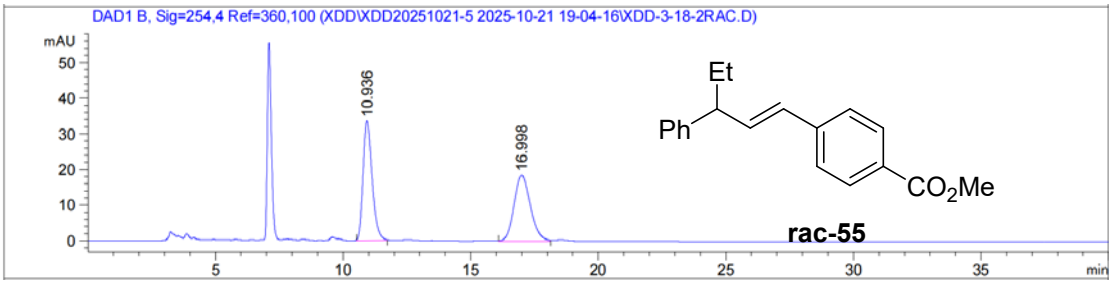
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.579	BB	0.3691	1093.04590	45.69416	49.6985
2	14.231	BB	0.4791	1106.30872	35.74802	50.3015
Totals :				2199.35461	81.44219	



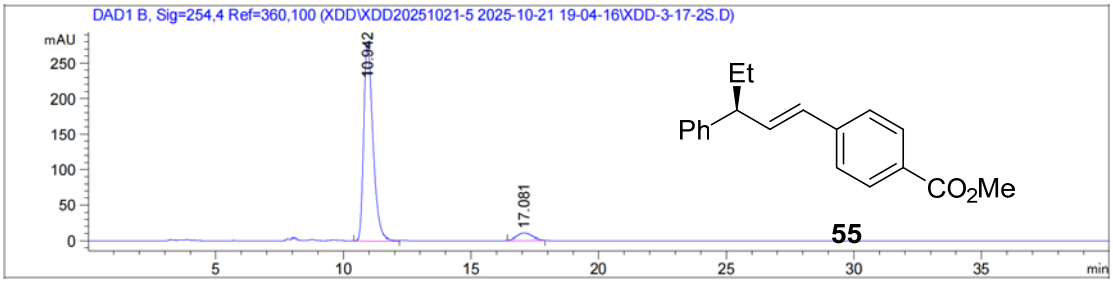
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.566	BB	0.3972	4923.65625	188.22948	93.7339
2	14.286	BB	0.4826	329.14713	10.76961	6.2661
Totals :				5252.80338	198.99908	



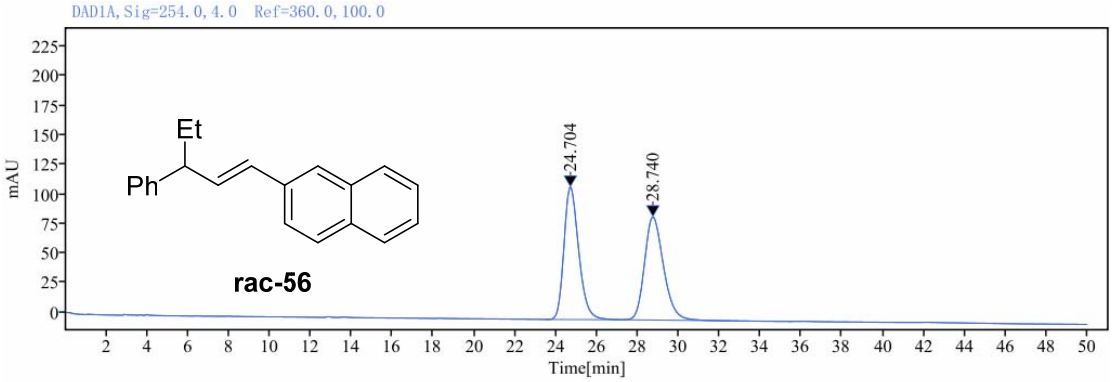
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.936	MM R	0.4115	827.75653	33.52396	50.0685
2	16.998	MM R	0.7440	825.49310	18.49215	49.9315
Totals :				1653.24963	52.01611	



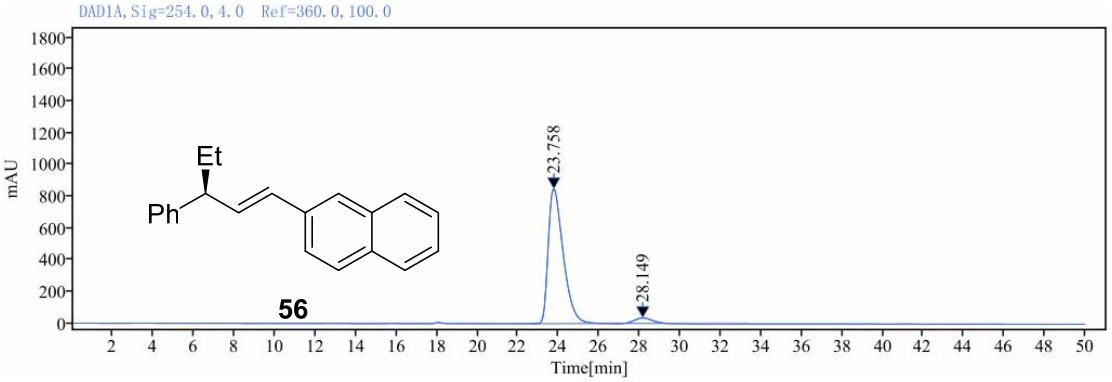
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.942	MM R	0.4200	7065.97559	280.36899	94.0955
2	17.081	MM R	0.7087	443.38663	10.42720	5.9045
Totals :				7509.36221	290.79618	



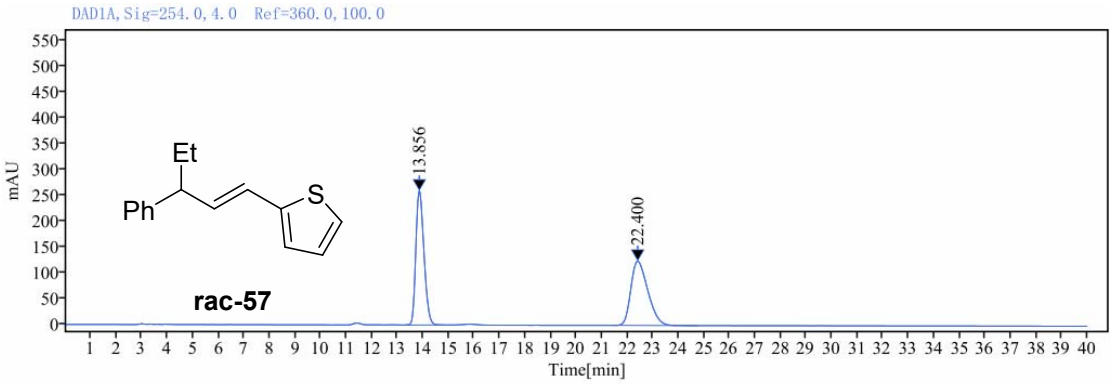
Signal 1: DAD1A,Sig=254.0,4.0 Ref=360.0,100.0

RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area%
24.704	BB	3.71	5626.84	111.98	49.95
28.740	BB	6.48	5638.98	87.21	50.05
	Totals	10.19	11265.82		



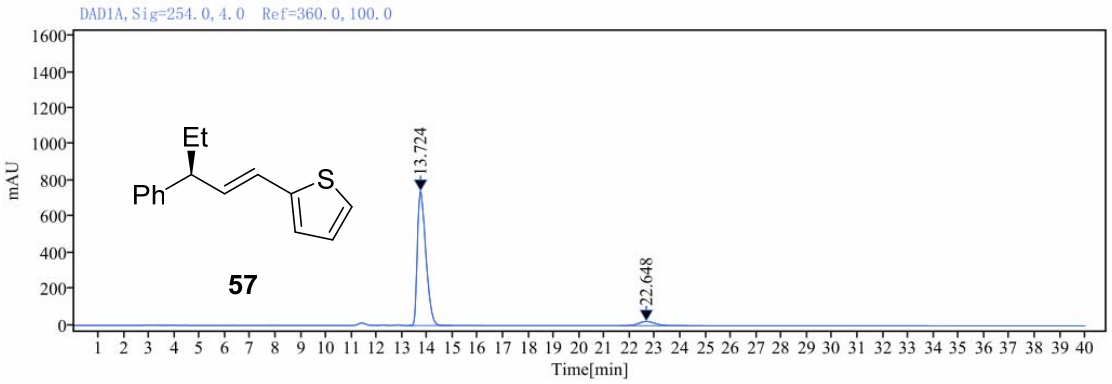
Signal 1: DAD1A,Sig=254.0,4.0 Ref=360.0,100.0

RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area%
23.758	BM m	4.42	43719.80	848.59	95.43
28.149	MM m	2.29	2092.57	34.65	4.57
	Totals	6.70	45812.36		



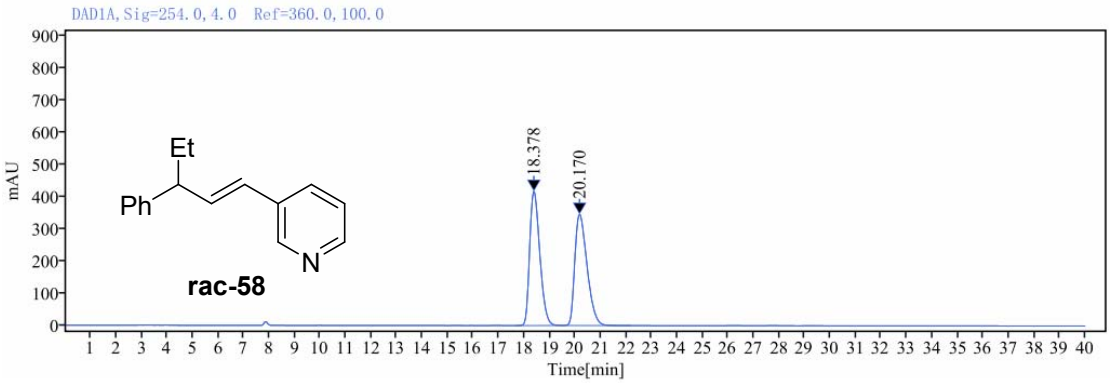
Signal 1: DAD1A,Sig=254.0,4.0 Ref=360.0,100.0

RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area%
13.856	BB	1.62	5737.02	259.73	50.01
22.400	BB	3.39	5734.99	124.53	49.99
	Totals	5.01	11472.01		



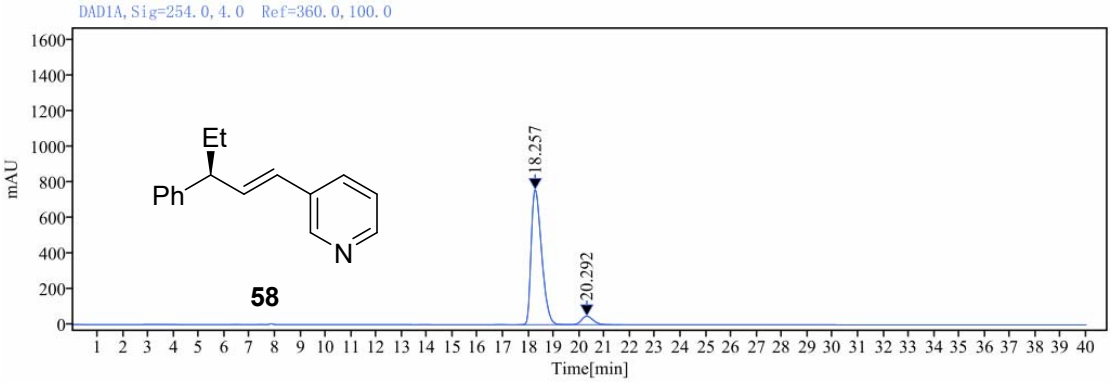
Signal 1: DAD1A,Sig=254.0,4.0 Ref=360.0,100.0

RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area%
13.724	BB	1.70	17333.37	741.95	94.29
22.648	BB	3.27	1049.62	23.23	5.71
	Totals	4.98	18382.99		



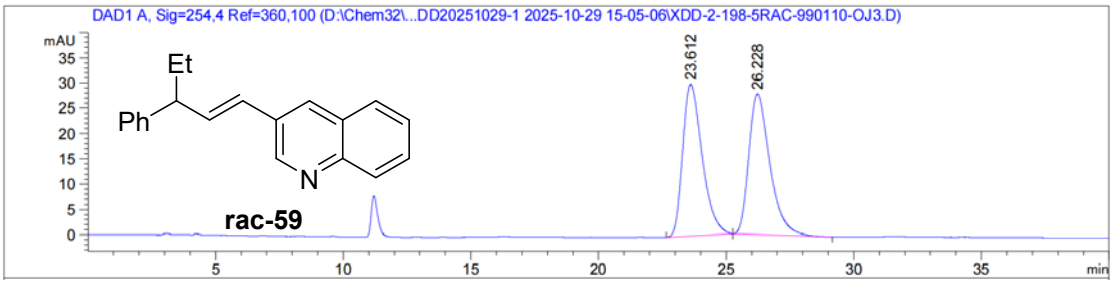
Signal 1: DAD1A,Sig=254.0,4.0 Ref=360.0,100.0

RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area%
18.378	BB	1.85	11493.11	416.53	49.97
20.170	BB	2.66	11506.21	345.19	50.03
	Totals	4.51	22999.32		



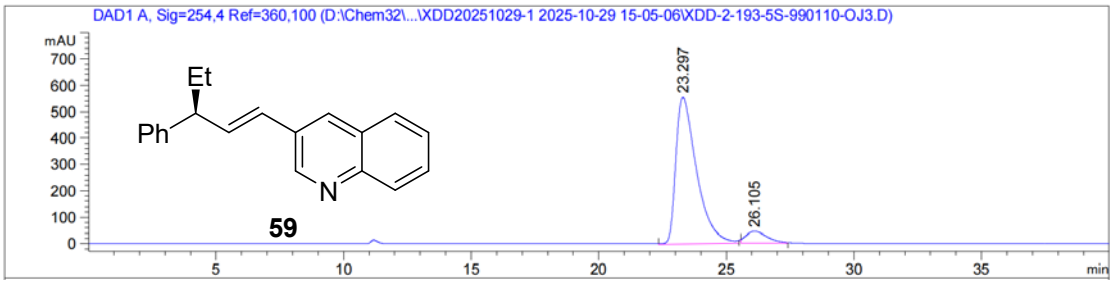
Signal 1: DAD1A,Sig=254.0,4.0 Ref=360.0,100.0

RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area%
18.257	BB	2.08	21728.23	759.35	93.46
20.292	BB	2.11	1521.31	47.48	6.54
	Totals	4.19	23249.54		



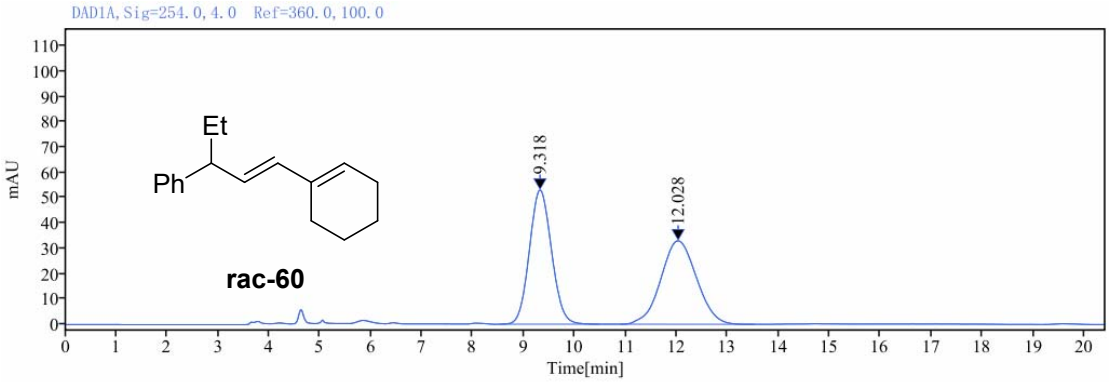
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	23.612	BB	0.8056	1591.25159	29.96323	49.9101
2	26.228	BB	0.8669	1596.98438	27.77102	50.0899
Totals :				3188.23596	57.73425	



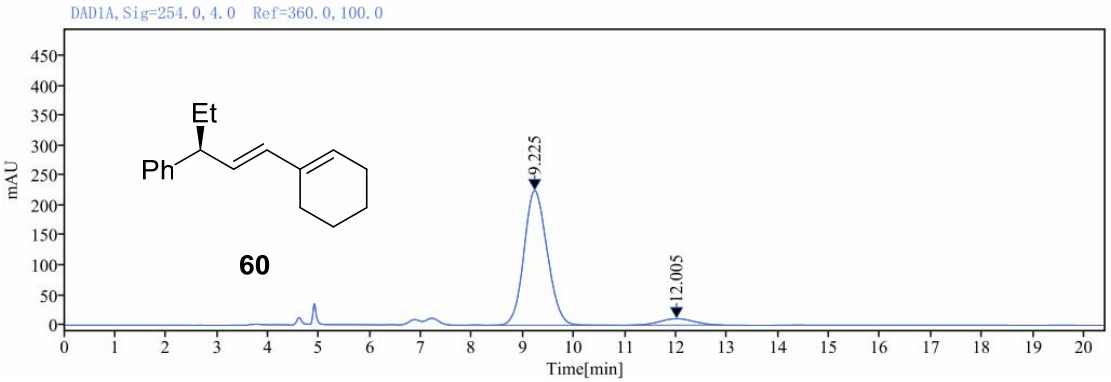
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	23.297	MM R	0.9468	3.15844e4	556.00513	92.4147
2	26.105	MM R	0.9580	2592.40186	45.09962	7.5853
Totals :				3.41768e4	601.10475	



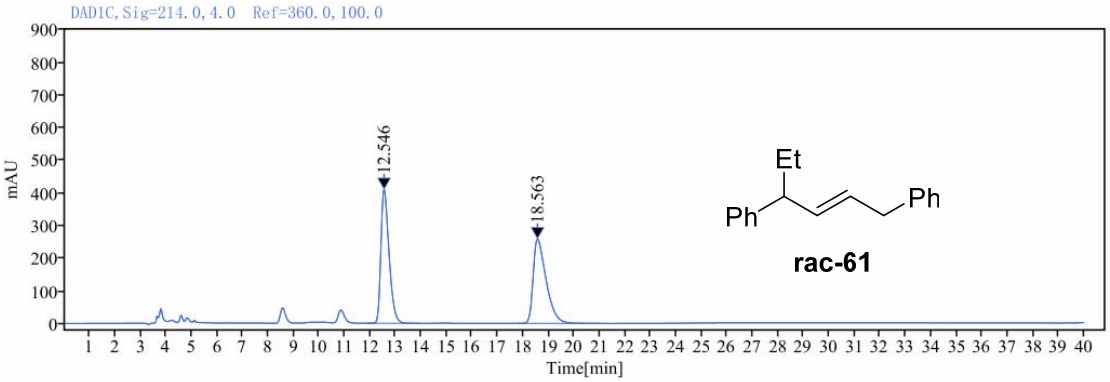
Signal 1: DAD1A,Sig=254.0,4.0 Ref=360.0,100.0

RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area%
9.318	BB	1.93	1597.39	52.99	49.90
12.028	BB	2.63	1603.76	32.98	50.10
	Totals	4.55	3201.15		



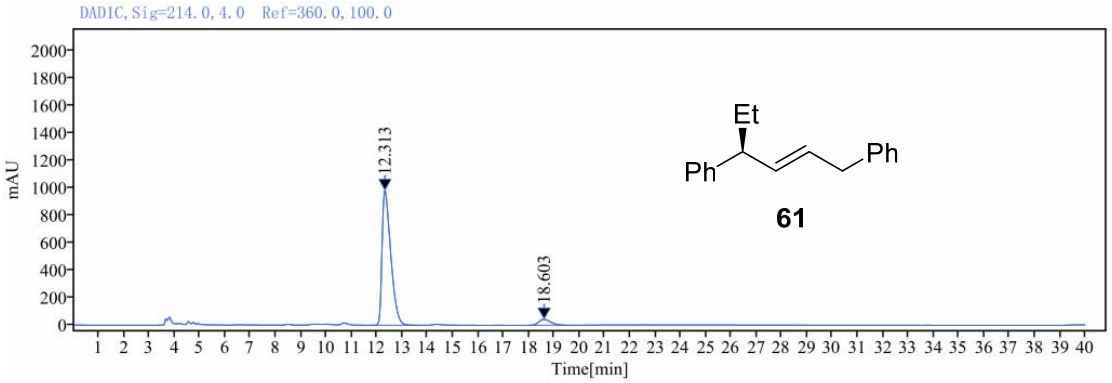
Signal 1: DAD1A,Sig=254.0,4.0 Ref=360.0,100.0

RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area%
9.225	BM m	2.67	7109.01	224.80	93.39
12.005	MM m	1.83	503.39	10.75	6.61
	Totals	4.50	7612.40		



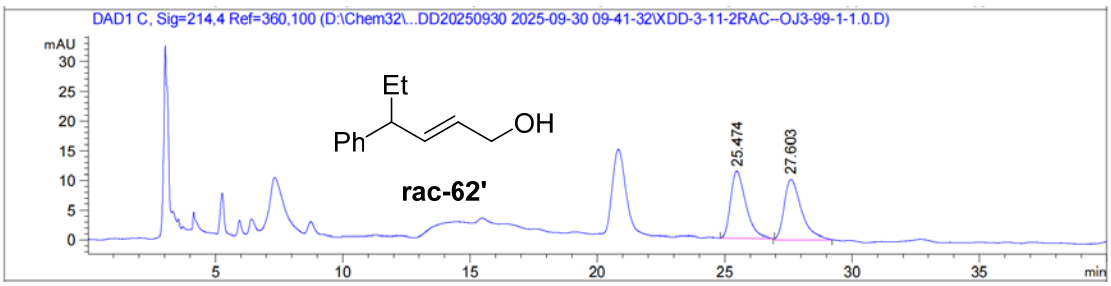
Signal 1: DAD1C,Sig=214.0,4.0 Ref=360.0,100.0

RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area%
12.546	BB	2.07	9088.69	409.43	49.87
18.563	BB	3.15	9134.50	258.61	50.13
	Totals	5.23	18223.19		



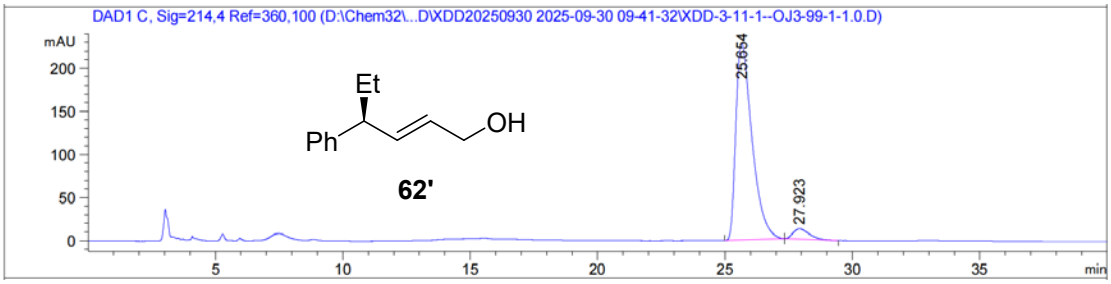
Signal 1: DAD1C,Sig=214.0,4.0 Ref=360.0,100.0

RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area%
12.313	BM m	1.91	23564.34	984.66	94.50
18.603	MM m	1.32	1372.20	42.76	5.50
	Totals	3.23	24936.54		



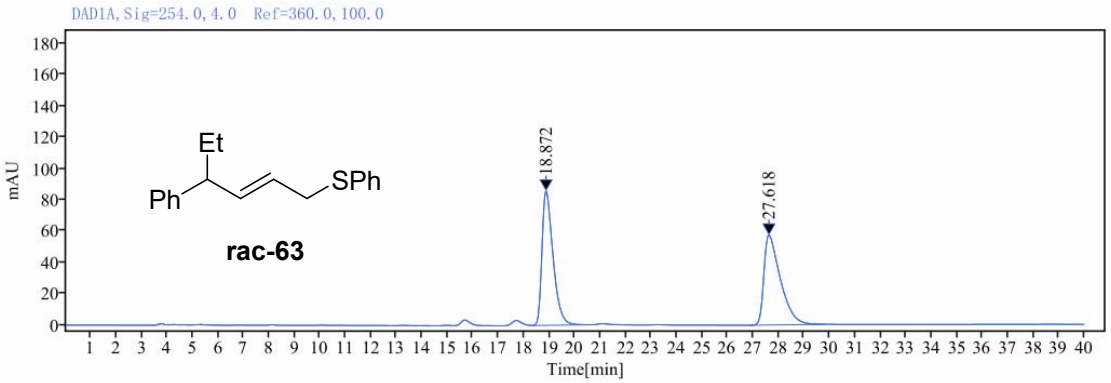
Signal 2: DAD1 B, Sig=210,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	25.472	MM	0.7248	642.24658	14.76789	50.6228
2	27.603	MM	0.7842	626.44348	13.31420	49.3772
Totals :				1268.69006	28.08209	

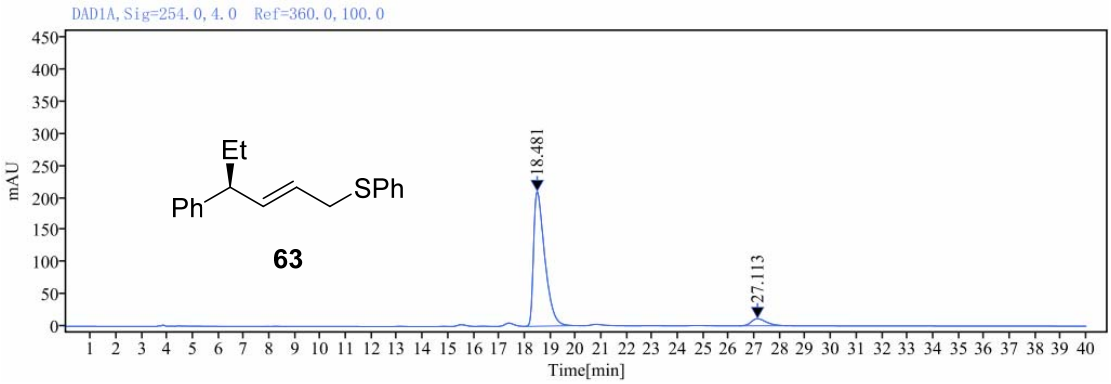


Signal 3: DAD1 C, Sig=214,4 Ref=360,100

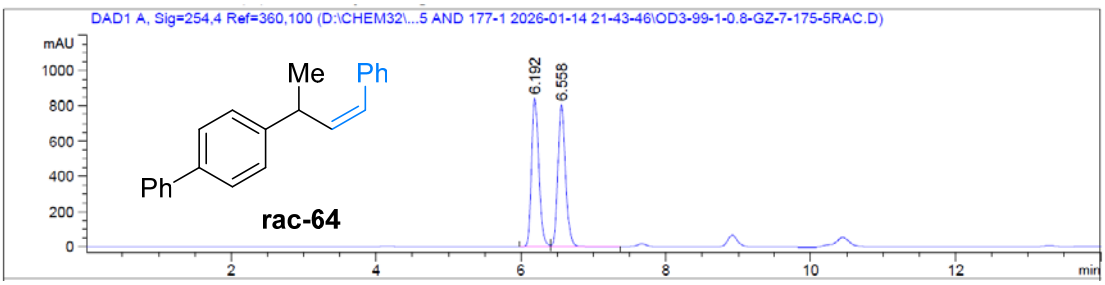
Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	25.654	BB	0.6724	1.00700e4	228.37332	94.9266
2	27.923	BB	0.6578	538.19348	12.03218	5.0734
Totals :				1.06082e4	240.40551	



Signal 1:	DAD1A,Sig=254.0,4.0 Ref=360.0,100.0				
RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area%
18.872	BB	2.31	2578.57	85.76	49.98
27.618	BM m	2.99	2580.77	57.42	50.02
	Totals	5.30	5159.34		

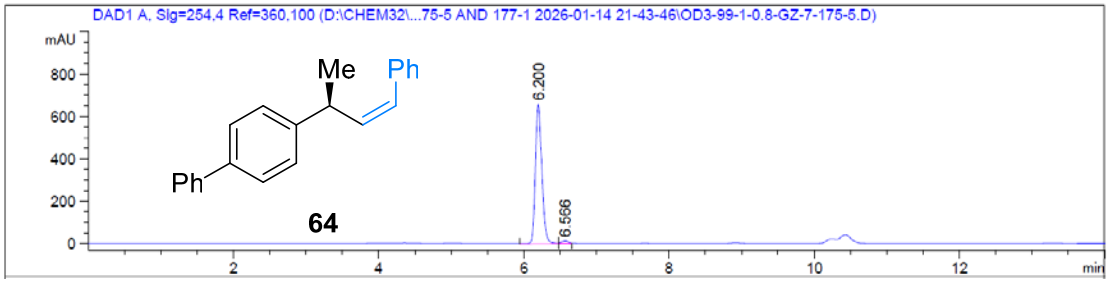


Signal 1:	DAD1A,Sig=254.0,4.0 Ref=360.0,100.0				
RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area%
18.481	BM m	2.03	6405.17	209.75	93.48
27.113	MM m	1.90	446.65	11.00	6.52
	Totals	3.93	6851.82		



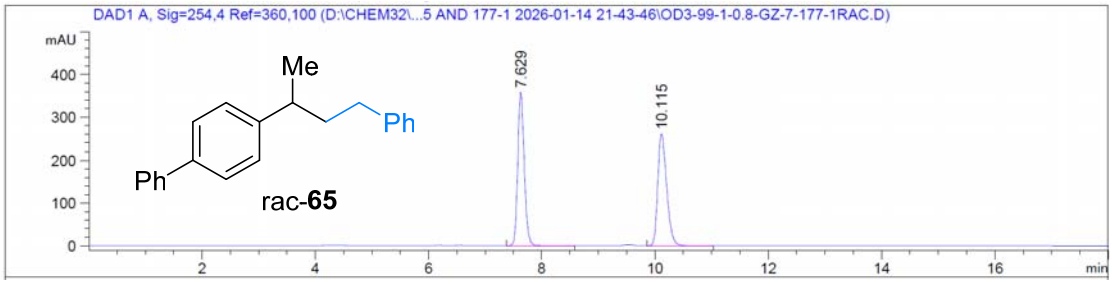
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.192	BV	0.1080	5903.42871	840.08545	49.8472
2	6.558	VB	0.1121	5939.62988	805.15912	50.1528
Totals :				1.18431e4	1645.24457	



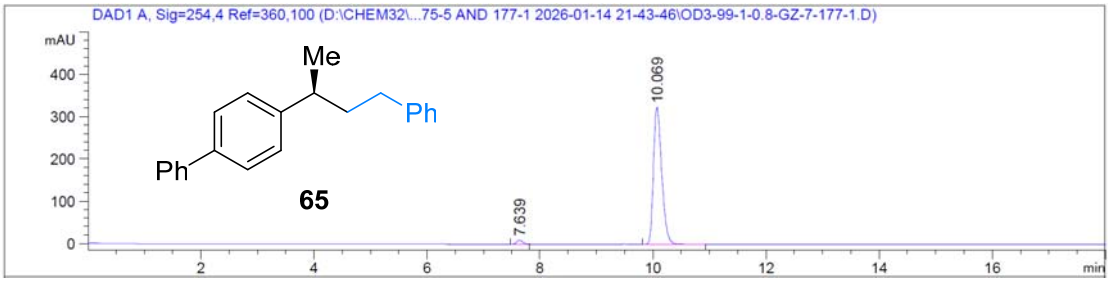
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.200	MF R	0.1046	4132.74658	658.47394	97.7062
2	6.566	MF R	0.1102	97.02081	14.67220	2.2938
Totals :				4229.76740	673.14614	



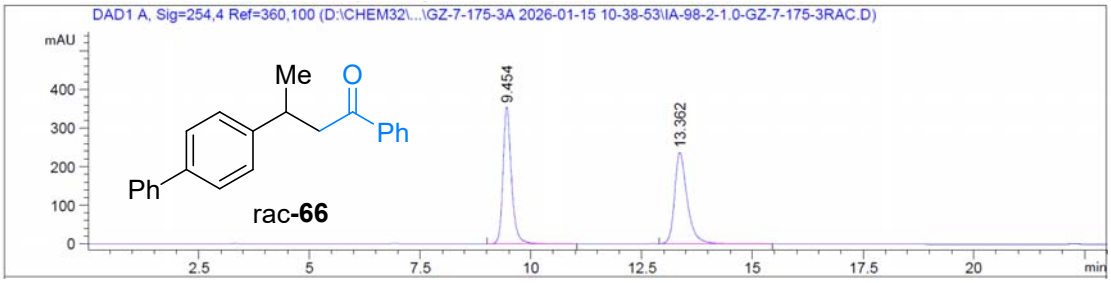
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.629	BB	0.1233	2860.47266	357.77963	50.2022
2	10.115	BB	0.1669	2837.42725	260.88217	49.7978
Totals :				5697.89990	618.66180	



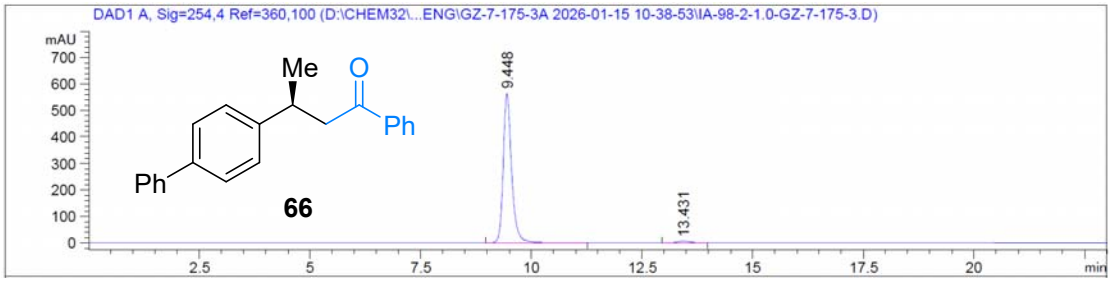
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.639	FM R	0.1235	73.64231	9.94201	2.1825
2	10.069	BB	0.1570	3300.62939	323.62689	97.8175
Totals :				3374.27171	333.56891	



Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.454	BB	0.1997	4736.53076	354.80252	50.3822
2	13.362	BB	0.2966	4664.66357	235.97949	49.6178
Totals :				9401.19434	590.78201	



Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.448	BB	0.1984	7476.94092	564.96722	98.2394
2	13.431	MF R	0.3286	133.99913	6.79692	1.7606
Totals :				7610.94005	571.76415	