Supporting Information for

Copper-Catalyzed Asymmetric Radical 1,2-Carboalkynylation of Alkenes with Alkyl Halides and Terminal Alkynes

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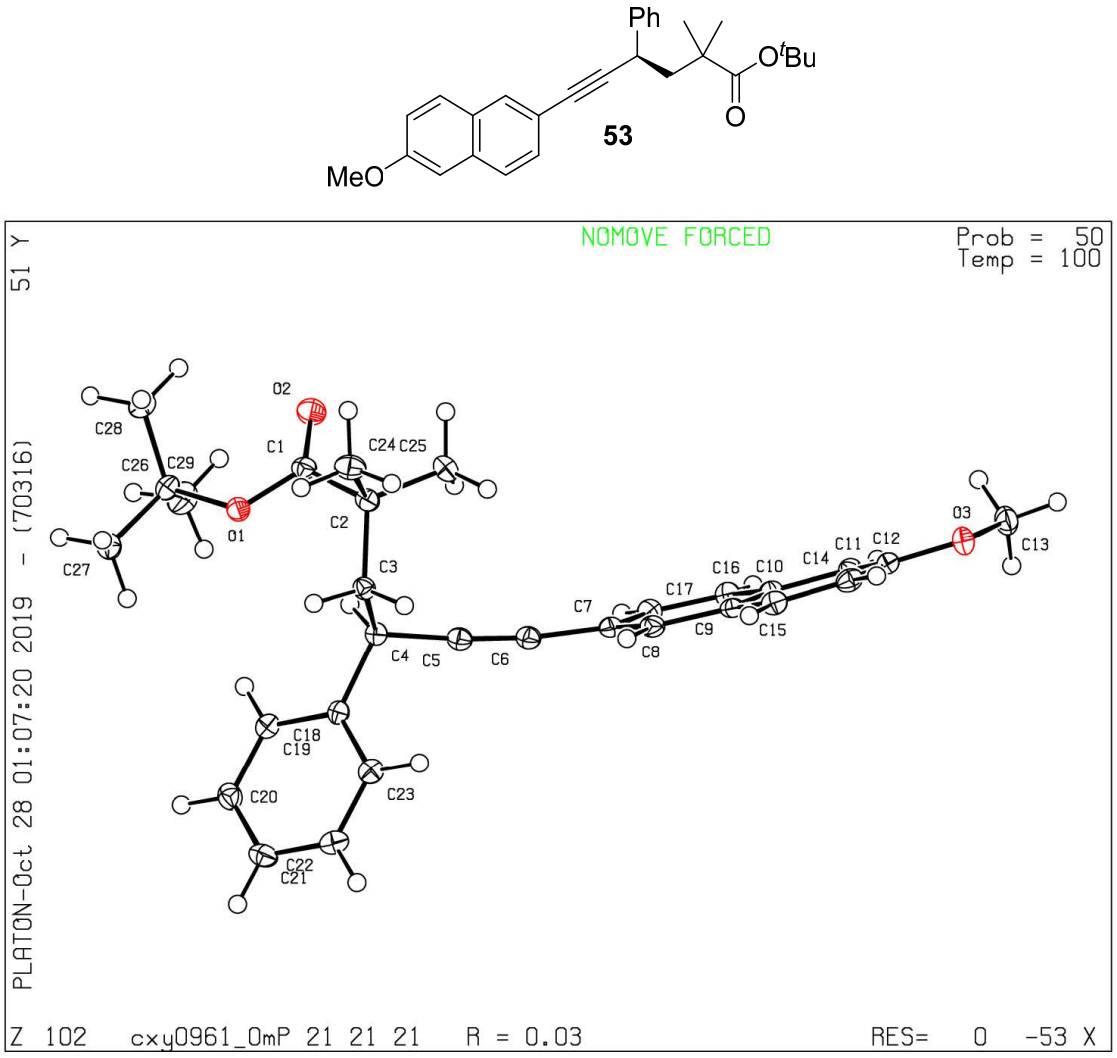


Figure S1. The X ray structure of **53**.

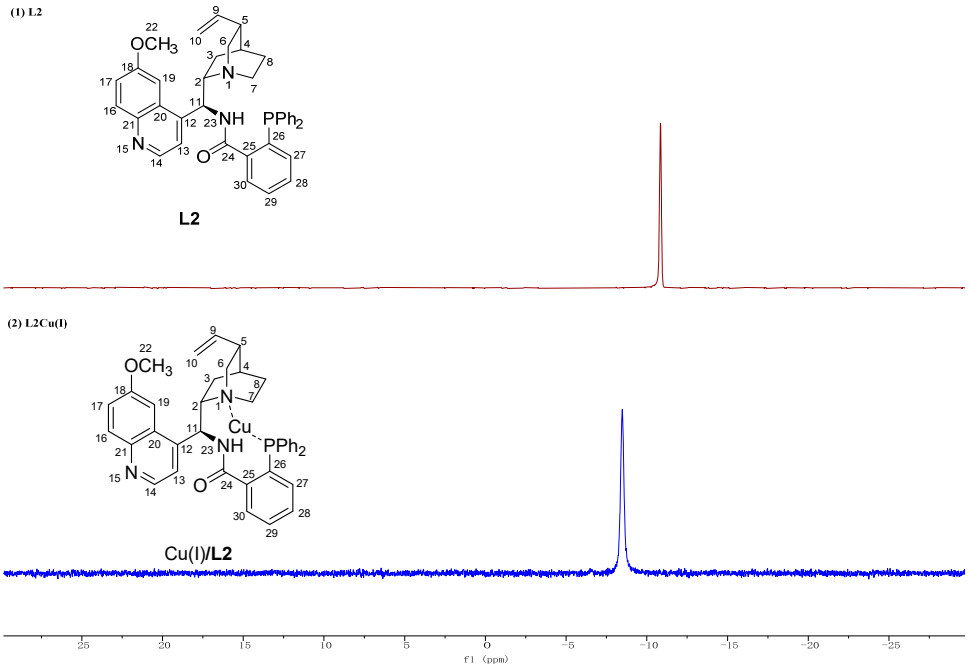


Figure S2. Stacking of ^{31}P NMR spectra. Red: **L2**, δ^{31}P = −10.8 ppm; Blue: **L2**Cu(I), δ^{31}P = −8.4 ppm.

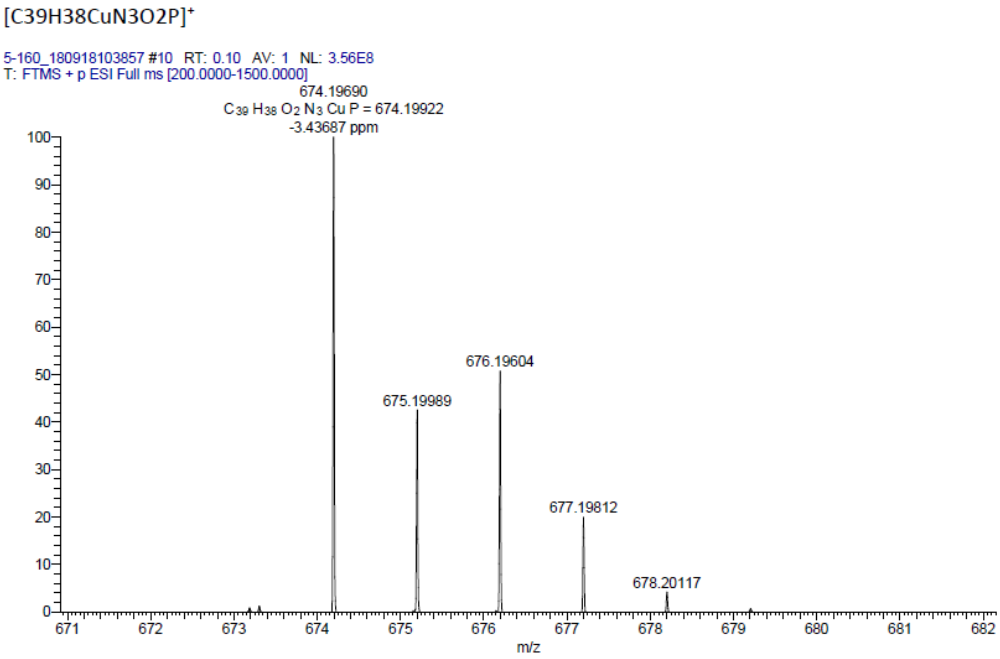
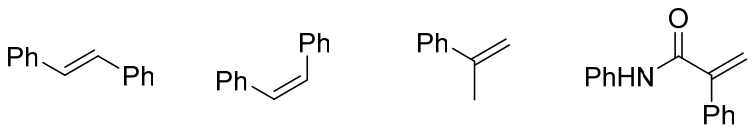
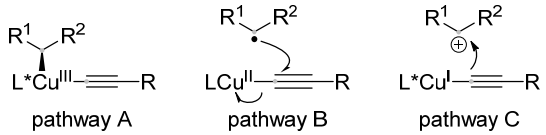


Figure S3. The HRMS of **L2**Cu complex. The sample was prepared by mixing CuI and **L2** in CH_3CN.

Scheme S1. Unsuccessful alkene substrates



Scheme S2. Alternative pathways for the C–C bond formation[1]

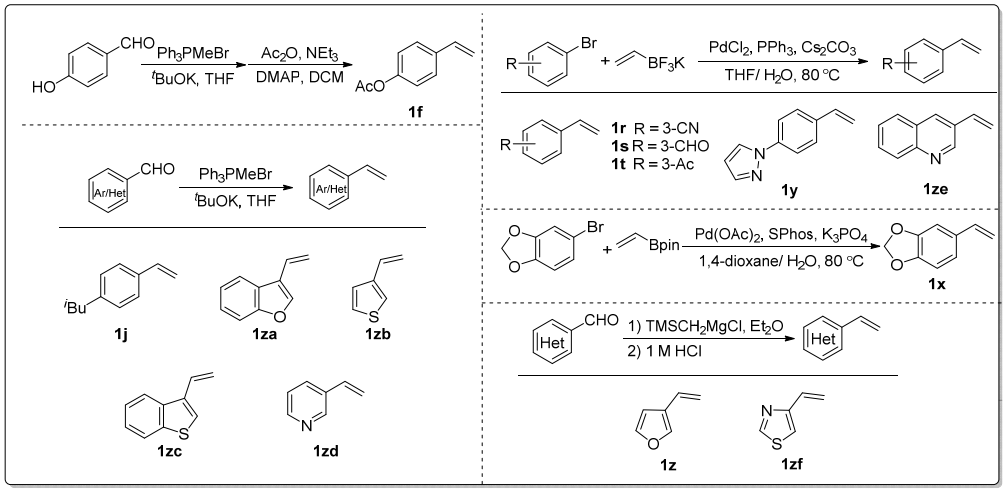


General information

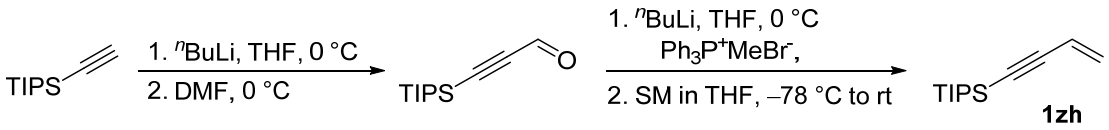
Most of reactions were carried out under argon atmosphere using Schlenk techniques. Reagents were purchased at the highest commercial quality and used without further purification, unless otherwise stated. CuI was purchased from Sigma-Aldrich. CuOAc was purchased from TCI. 1,4-Dioxane was purchased from Aladdin, which was redistilled with sodium and benzophenone under argon atmosphere. Analytical thin layer chromatography (TLC) was performed on precoated silica gel 60 GF254 plates. Flash column chromatography was performed using Tsingdao silica gel (60, particle size 0.040–0.063 mm). Visualization on TLC was achieved by use of UV light (254 nm), iodine, or basic $KMnO_4$ indicator. NMR spectra were recorded on Bruker DRX-400 and DPX-600 spectrometers at 400 or 600 MHz for ^1H NMR, 100 or 150 MHz for ^{13}C NMR, and 376 MHz for ^{19}F NMR, respectively, in $CDCl_3$ with tetramethylsilane (TMS) as an internal standard. The chemical shifts were expressed in ppm and coupling constants were given in Hz. Data for ^1H NMR were recorded as follows: chemical shift (ppm), multiplicity (s, singlet; d, doublet; t, triplet; q, quarter; p, pentet, m, multiplet; br, broad), coupling constant (Hz), integration. Data for ^{13}C NMR were reported in terms of chemical shift (δ, ppm). EPR spectra were recorded on Bruker EMX^{plus}-10/12. 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 an appropriate wavelength). Column conditions were reported in the experimental section below.

The synthesis of substrates

Most of alkenes, alkynes, and radical precursors were purchased from commercial sources. The alkenes **1f**[2], **1j**[3], **1za**–**1zd**[3], **1r**–**1t**[4], **1y**[4], **1ze**[4],**1x**[5], **1z**[6], and **1zf**[6] were synthesized according to the reported literature. The radical precursors **3c**[7,8] and **3d**[9] were synthesized according to the reported literature. All the characterization data are consistent with those in the reported literature.



Synthesis of 1zh



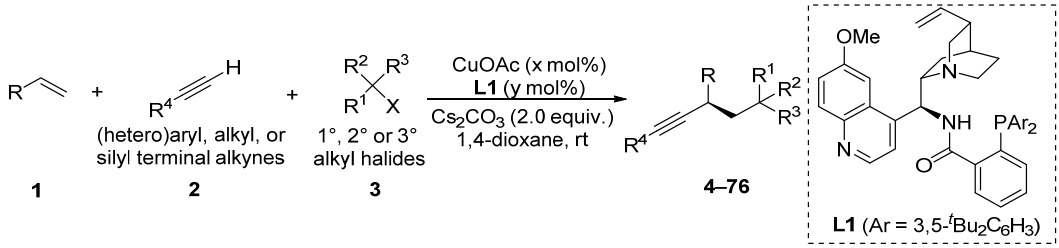
^{n}BuLi (2.4 M in hexane, 23.0 ml, 55.0 mmol, 1.1 equiv.) was added dropwise into a solution of triisopropylsilacetylene (9.1 g, 50.0 mmol, 1.0 equiv.) in anhydrous THF (100.0 ml) at 0 °C. The mixture was stirred at room temperature for 30 min and cooled to 0 °C. DMF (4.0 g, 55.0 mmol, 1.1 equiv.) was added dropwise and refluxed for 1 h. After cooling down, the mixture was quenched by 5% aq. H_2SO_4 to a slightly acidic pH, then weakly basic by addition of a saturated aq. $NaHCO_3$. The mixture was extracted with Et_2O, washed by brine and dried over Na_2SO_4. The organic phase was concentrated in vacuum. The crude aldehyde was used without further purification.

To a solution of methyltriphenylphosphonium bromide (21.4 g, 60 mmol, 1.2 equiv.) in THF (120.0 ml) at 0 °C, ^{n}BuLi (2.4 M in hexane, 25.0 ml, 60.0 mmol, 1.2 equiv.) was added dropwise. The mixture was stirred at room temperature for 1 h then cooled to –78 °C. A solution of aldehyde (10.5 g, 50.0 mmol, 1.0 equiv.) in THF (120.0 ml) was added dropwise and warm up to room temperature for another 18 h. After completion (monitored by TLC), the reaction was quenched by H_2O and extracted with Et_2O. The organic phase was washed by brine, dried over Na_2SO_4 and concentrated in vacuum. The residue was purified by column chromatography to afford the **1zh** (3.6 g, 35% yield) as a red liquid.

^{1}H NMR (400 MHz, $CDCl_3$) δ 5.84 (dd, *J* = 17.6, 11.1 Hz, 1H), 5.67 (dd, *J* = 17.6, 2.4 Hz, 1H), 5.48 (dd, *J* = 11.1, 2.4 Hz, 1H), 1.10 – 1.06 (m, 21H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 127.5, 117.5, 105.7, 94.8, 91.3, 18.6, 11.3.

Asymmetric radical 1,2-carboalkynylation of alkenes with alkyl halides and terminal alkynes



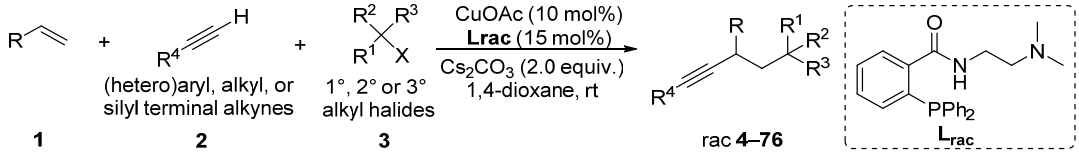
General procedure A:

Under argon atmosphere, an oven-dried resealable Schlenk tube equipped with a magnetic stir bar was charged with CuOAc (1.84 mg, 0.015 mmol, 7.5 mol%), **L1** (12.5 mg, 0.015 mmol, 7.5 mol%), Cs_2CO_3 (130.4 mg, 0.40 mmol, 2.0 equiv.), and anhydrous 1,4-dioxane (2.0 mL). Then, alkene (0.30 mmol, 1.5 equiv.), alkyl halide or other radical precursor (0.24 mmol, 1.2 equiv.), and alkyne (0.20 mmol, 1.0 equiv.) were sequentially added into the mixture and the reaction mixture was stirred at room temperature for 12 to 48 h. Upon completion (monitored by TLC), the precipitate was filtered off and washed by CH_2Cl_2. The filtrate was evaporated and the residue was purified by column chromatography on silica gel to afford the desired product.

General procedure B:

Under argon atmosphere, an oven-dried resealable Schlenk tube equipped with a magnetic stir bar was charged with CuOAc (2.45 mg, 0.020 mmol, 10 mol%), **L1** (25 mg, 0.030 mmol, 15 mol%), Cs_2CO_3 (130.4 mg, 0.40 mmol, 2.0 equiv.), and anhydrous 1,4-dioxane (2.0 mL). Then, alkene (0.30 mmol, 1.5 equiv.), alkyl halide or other radical precursor (0.24 mmol, 1.2 equiv.), and alkyne (0.20 mmol, 1.0 equiv.) were sequentially added into the mixture and the reaction mixture was stirred at room temperature for 6 to 48 h. Upon completion (monitored by TLC), the precipitate was filtered off and washed by CH_2Cl_2. The filtrate was evaporated and the residue was purified by column chromatography on silica gel to afford the desired product.

Note: Most of the products are unstable in neat state in air after purification, and should be stored in solvent (CH_2Cl_2 or Et_2O) at –10 °C. Their characterization by NMR, HPLC or HRMS should be done as soon as possible. Meanwhile, the reaction is sensitive to water and air, and thus, Schlenk tubes and the reagents must be dried prior to use. Especially, 1,4-dioxane must be redistilled.

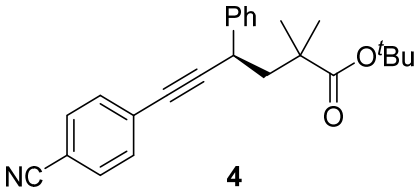


The racemates of products were prepared following the same procedure as described above using CuOAc (2.45 mg, 0.020 mmol, 10 mol%) and $\mathbf{L_{rac}}$ (11.3 mg, 0.030 mmol, 15 mol%) as the catalyst and the ligand, respectively, at room temperature or 80 °C in anhydrous 1,4-dioxane (2.0 mL) for 24 to 72 h. Upon completion (monitored by TLC),

the precipitate was filtered off and washed with CH_2Cl_2. The filtrate was concentrated, and the residue was purified by column chromatography on silica gel to afford the desired product.

Substrates scope of alkene

(*R*)-*tert*-Butyl-6-(4-cyanophenyl)-2,2-dimethyl-4-phenylhex-5-ynoate (4)



4

According to General Procedure **A** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.), 4-ethynylbenzonitrile **2a** (25.4 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **4** as a colorless oil (53.2 mg, 71% yield, 93% ee).

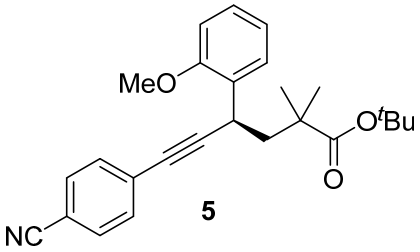
HPLC analysis: Chiralcel IA (*n*-hexane/*i*-PrOH = 97/3, flow rate 0.5 mL/min, λ = 254 nm), t_R (minor) = 12.74 min, t_R (major) = 13.66 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.56 (d, *J* = 8.4 Hz, 2H), 7.48 (d, *J* = 8.4 Hz, 2H), 7.43 – 7.38 (m, 2H), 7.35 (t, *J* = 7.6 Hz, 2H), 7.26 (ddd, *J* = 7.3, 3.9, 1.2 Hz, 1H), 3.92 (dd, *J* = 9.8, 4.3 Hz, 1H), 2.18 (dd, *J* = 13.9, 9.9 Hz, 1H), 2.05 (dd, *J* = 13.9, 4.3 Hz, 1H), 1.42 (s, 9H), 1.34 (s, 3H), 1.24 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 176.5, 142.4, 132.1, 131.9, 128.8, 127.4, 127.0, 118.6, 111.1, 97.2, 82.2, 80.2, 48.3, 43.1, 35.4, 28.1, 26.2, 25.7.

HRMS (ESI) *m/z* calcd. for $C_{25}H_{28}NO_2$ $[M + H]^+$ 374.2115, found 374.2108.

(*S*)-*tert*-Butyl-6-(4-cyanophenyl)-4-(2-methoxyphenyl)-2,2-dimethylhex-5-ynoate (5)



5

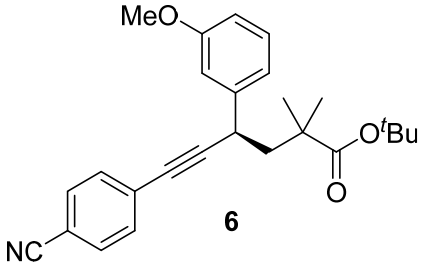
According to General Procedure **A** with 1-methoxy-2-vinylbenzene **1b** (40.3 mg, 0.30 mmol, 1.5 equiv.), 4-ethynylbenzonitrile **2a** (25.4 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **5** as a colorless oil (56.2 mg, 70% yield, 89% ee).

HPLC analysis: Chiralcel ASH (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.5 mL/min, λ = 254 nm), t_R (minor) = 19.85 min, t_R (major) = 23.45 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.63 – 7.53 (m, 3H), 7.54 – 7.47 (m, 2H), 7.26 (m, 1H), 7.10 – 6.96 (m, 1H), 6.90 (d, *J* = 7.9 Hz, 1H), 4.46 (dd, *J* = 9.9, 4.3 Hz, 1H), 3.88 (s,

3H), 2.18 (dd, *J* = 13.8, 9.9 Hz, 1H), 1.97 (dd, *J* = 13.8, 4.4 Hz, 1H), 1.42 (s, 9H), 1.33 (s, 3H), 1.31 (s, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 176.7, 155.7, 132.1, 131.9, 130.6, 129.1, 128.5, 128.1, 120.9, 118.7, 110.9, 110.7, 97.9, 81.1, 79.9, 55.4, 46.2, 42.9, 28.2, 28.0, 26.1, 25.2.
HRMS (ESI) *m/z* calcd. for $C_{26}H_{30}NO_3$ $[M + H]^+$ 404.2220, found 404.2210

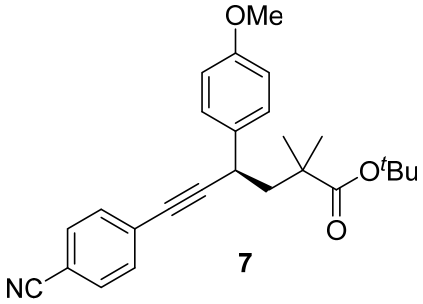
(*R*)-*tert*-Butyl-6-(4-cyanophenyl)-4-(3-methoxyphenyl)-2,2-dimethylhex-5-ynoate (6)



6

According to General Procedure **A** with 1-methoxy-3-vinylbenzene **1c** (40.2 mg, 0.30 mmol, 1.5 equiv.), 4-ethynylbenzonitrile **2a** (25.4 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **6** as a colorless oil (51.1 mg, 63% yield, 95% ee).
HPLC analysis: Chiralcel IA (*n*-hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min, λ = 254 nm), t_R (minor) = 6.65 min, t_R (major) = 7.26 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.56 (d, *J* = 8.4 Hz, 2H), 7.48 (d, *J* = 8.4 Hz, 2H), 7.27 (dd, *J* = 9.0, 6.7 Hz, 1H), 7.07 – 6.92 (m, 2H), 6.80 (dd, *J* = 8.0, 2.3 Hz, 1H), 3.89 (dd, *J* = 9.8, 4.2 Hz, 1H), 3.82 (s, 3H), 2.17 (dd, *J* = 13.9, 9.9 Hz, 1H), 2.05 (dd, *J* = 13.9, 4.3 Hz, 1H), 1.42 (s, 9H), 1.33 (s, 3H), 1.24 (s, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 176.5, 159.9, 144.0, 132.1, 131.9, 129.8, 128.8, 119.7, 118.6, 113.5, 112.0, 111.1, 97.1, 82.2, 80.2, 55.3, 48.2, 43.1, 35.4, 28.1, 26.2, 25.7.
HRMS (ESI) *m/z* calcd. for $C_{26}H_{30}NO_3$ $[M + H]^+$ 404.2220, found 404.2210.

(*R*)-*tert*-Butyl-6-(4-cyanophenyl)-4-(4-methoxyphenyl)-2,2-dimethylhex-5-ynoate (7)

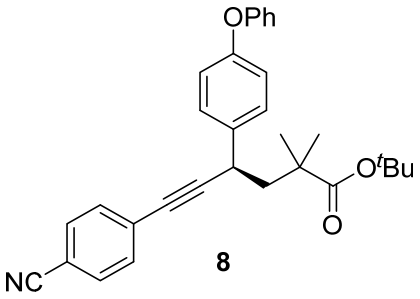


7

According to General Procedure **A** with 1-methoxy-4-vinylbenzene **1d** (40.2 mg, 0.30 mmol, 1.5 equiv.), 4-ethynylbenzonitrile **2a** (25.4 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the

product **7** as a colorless oil (57.9 mg, 72% yield, 91% ee).
HPLC analysis: Chiralcel ADH (*n*-hexane/*i*-PrOH = 96/4, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 9.68 min, t_R (minor) = 11.60 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.56 (d, *J* = 8.3 Hz, 2H), 7.47 (d, *J* = 8.0 Hz, 2H), 7.32 (d, *J* = 8.4 Hz, 2H), 6.88 (d, *J* = 8.4 Hz, 2H), 3.87 (dd, *J* = 9.6, 4.3 Hz, 1H), 3.80 (s, 3H), 2.15 (dd, *J* = 13.7, 9.8 Hz, 1H), 2.03 (dd, *J* = 13.9, 4.3 Hz, 1H), 1.42 (s, 9H), 1.32 (s, 3H), 1.23 (s, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 176.5, 158.6, 134.5, 132.1, 131.9, 128.9, 128.3, 118.6, 114.1, 111.0, 97.6, 82.0, 80.2, 55.3, 48.4, 43.1, 34.6, 28.1, 26.2, 25.7.
HRMS (ESI) *m/z* calcd. for $C_{26}H_{30}NO_3$ $[M + H]^+$ 404.2220, found 404.2210.

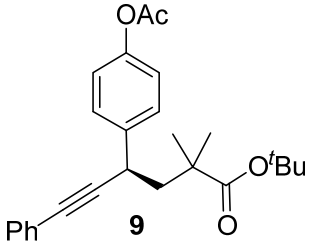
(*R*)-*tert*-Butyl-6-(4-cyanophenyl)-2,2-dimethyl-4-(4-phenoxyphenyl)hex-5-ynoate (8)



8

According to General Procedure **A** with 1-phenoxy-4-vinylbenzene **1e** (58.9 mg, 0.30 mmol, 1.5 equiv.), 4-ethynylbenzonitrile **2a** (25.4 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **8** as a colorless oil (71.6 mg, 77% yield, 94% ee).
HPLC analysis: Chiralcel ADH (*n*-hexane/*i*-PrOH = 97/3, flow rate 0.5 mL/min, λ = 254 nm), t_R (minor) = 20.61 min, t_R (major) = 24.14 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.60 (d, *J* = 7.9 Hz, 2H), 7.51 (d, *J* = 8.0 Hz, 2H), 7.44 – 7.32 (m, 4H), 7.19 – 7.09 (m, 1H), 7.08 – 6.94 (m, 4H), 3.94 (dd, *J* = 9.7, 4.2 Hz, 1H), 2.20 (dd, *J* = 13.9, 9.9 Hz, 1H), 2.09 (dd, *J* = 13.9, 4.2 Hz, 1H), 1.46 (s, 9H), 1.37 (s, 3H), 1.28 (s, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 176.5, 157.2, 156.3, 137.2, 132.1, 131.9, 129.8, 128.7, 128.7, 123.4, 119.02, 118.95, 118.6, 111.1, 97.2, 82.3, 80.3, 48.4, 43.1, 34.8, 28.1, 26.3, 25.7.
HRMS (ESI) *m/z* calcd. for $C_{31}H_{32}NO_3$ $[M + H]^+$ 466.2377, found 466.2368.

(*R*)-*tert*-Butyl-4-(4-acetoxyphenyl)-2,2-dimethyl-6-phenylhex-5-ynoate (9)



9

According to General Procedure **A** with 4-vinylphenyl acetate **1f** (48.6 mg, 0.30 mmol, 1.5 equiv), ethynylbenzene **2b** (20.4 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **9** as a colorless oil (52.2 mg, 64% yield, 98% ee).

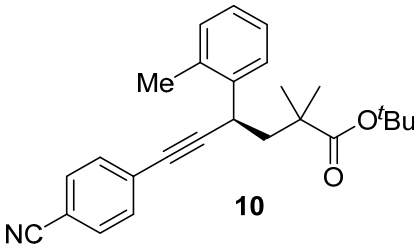
HPLC analysis: Chiralcel AD3 (*n*-hexane/*i*-PrOH = 95/5, flow rate 0.5 mL/min, λ = 254 nm), t_R (major) = 9.88 min, t_R (minor) = 11.84 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.57 (dd, *J* = 7.5, 1.9 Hz, 1H), 7.41 – 7.36 (m, 2H), 7.30 – 7.25 (m, 4H), 7.24 – 7.20 (m, 1H), 7.07 (dd, *J* = 7.7, 1.1 Hz, 1H), 4.09 (dd, *J* = 10.1, 4.2 Hz, 1H), 2.34 (s, 3H), 2.18 (dd, *J* = 13.8, 10.1 Hz, 1H), 1.94 (dd, *J* = 13.8, 4.2 Hz, 1H), 1.40 (s, 9H), 1.34 (s, 3H), 1.27 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$) δ 176.6, 169.4, 147.7, 134.6, 131.5, 129.4, 128.2, 127.8, 127.8, 126.4, 123.7, 123.0, 91.3, 82.8, 80.0, 46.3, 42.9, 30.0, 28.0, 25.9, 25.8, 21.2.

HRMS (ESI) *m/z* calcd. for $C_{26}H_{30}NaO_4$ $[M + Na]^+$ 429.2036, found 429.2035.

(*S*)-*tert*-Butyl-6-(4-cyanophenyl)-2,2-dimethyl-4-(*o*-tolyl)hex-5-ynoate (10)



10

According to General Procedure **A** with 1-methyl-2-vinylbenzene **1g** (35.5 mg, 0.30 mmol, 1.5 equiv.), 4-ethynylbenzonitrile **2a** (25.4 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **10** as a colorless oil (52.5 mg, 68% yield, 86% ee).

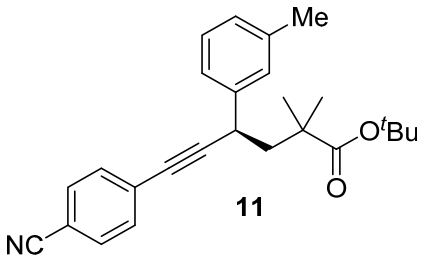
HPLC analysis: Chiralcel ADH (*n*-hexane/*i*-PrOH = 97/3, flow rate 0.5 mL/min, λ = 254 nm), t_R (minor) = 13.16 min, t_R (major) = 14.03 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.58 (d, *J* = 8.1 Hz, 2H), 7.50 (t, *J* = 8.6 Hz, 3H), 7.27 – 7.21 (m, 1H), 7.19 (d, *J* = 4.2 Hz, 2H), 4.16 (dd, *J* = 10.3, 4.1 Hz, 1H), 2.45 (s, 3H), 2.24 (dd, *J* = 13.9, 10.4 Hz, 1H), 1.95 (dd, *J* = 14.0, 4.1 Hz, 1H), 1.44 (s, 9H), 1.37 (s, 3H), 1.31 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 176.6, 140.5, 134.7, 132.1, 131.9, 130.8, 128.9, 127.8, 127.0, 126.6, 118.6, 111.0, 97.4, 81.6, 80.2, 46.3, 43.0, 31.9, 28.0, 26.2, 25.7, 19.4.

HRMS (ESI) *m/z* calcd. for $C_{26}H_{30}NO_2$ $[M + H]^+$ 388.2271, found 388.2261.

(*R*)-*tert*-Butyl-6-(4-cyanophenyl)-2,2-dimethyl-4-(m-tolyl)hex-5-ynoate (11)



11

According to General Procedure **A** with 1-methyl-3-vinylbenzene **1h** (35.5 mg, 0.30 mmol, 1.5 equiv.), 4-ethynylbenzonitrile **2a** (25.4 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **11** as a colorless oil (55.3 mg, 71% yield, 90% ee).

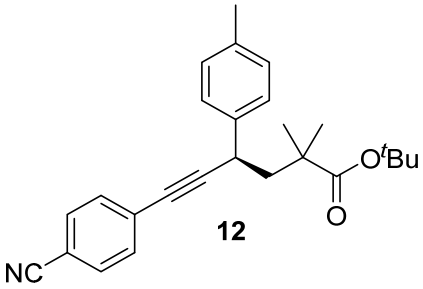
HPLC analysis: Chiralcel ADH (*n*-hexane/*i*-PrOH = 98/2, flow rate 0.5 mL/min, λ = 254 nm), t_R (minor) = 13.97 min, t_R (major) = 15.29 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.56 (d, *J* = 8.2 Hz, 2H), 7.48 (d, *J* = 7.7 Hz, 2H), 7.22 (m, 3H), 7.07 (d, *J* = 7.0 Hz, 1H), 3.88 (dd, *J* = 9.9, 4.1 Hz, 1H), 2.37 (s, 3H), 2.17 (dd, *J* = 13.8, 10.0 Hz, 1H), 2.03 (dd, *J* = 13.9, 3.9 Hz, 1H), 1.42 (s, 9H), 1.34 (s, 3H), 1.24 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 176.6, 142.4, 138.4, 132.1, 131.9, 128.9, 128.7, 128.1, 127.8, 124.4, 118.6, 111.0, 97.4, 82.1, 80.2, 48.3, 43.1, 35.3, 28.1, 26.2, 25.7, 21.5.

HRMS (ESI) *m/z* calcd. for $C_{26}H_{30}NO_2$ $[M + H]^+$ 388.2271, found 388.2261.

(*R*)-*tert*-Butyl-6-(4-cyanophenyl)-2,2-dimethyl-4-(*p*-tolyl)hex-5-ynoate (12)



12

According to General Procedure **A** with 1-methyl-4-vinylbenzene **1i** (35.4 mg, 0.30 mmol, 1.5 equiv.), 4-ethynylbenzonitrile **2a** (25.4 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **12** as a colorless oil (56.1 mg, 72% yield, 92% ee).

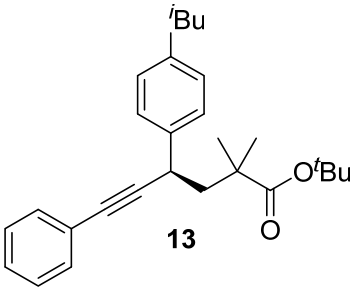
HPLC analysis: Chiralcel ADH (*n*-hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 6.97 min, t_R (minor) = 8.46 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 – 7.57 (m, 2H), 7.52 – 7.48 (m, 2H), 7.32 (d, *J* = 8.1 Hz, 2H), 7.19 (d, *J* = 7.9 Hz, 2H), 3.91 (dd, *J* = 9.8, 4.3 Hz, 1H), 2.37 (s, 3H), 2.19 (dd, *J* = 13.9, 9.8 Hz, 1H), 2.06 (dd, *J* = 13.9, 4.4 Hz, 1H), 1.45 (s, 9H), 1.36 (s, 3H), 1.26 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 176.6, 139.5, 136.6, 132.1, 131.9, 129.4, 128.9, 127.2, 118.6, 111.0, 97.5, 82.0, 80.2, 48.4, 43.1, 35.0, 28.1, 26.2, 25.7, 21.1.

HRMS (ESI) *m/z* calcd. for $C_{26}H_{30}NO_2$ $[M + H]^+$ 388.2271, found 388.2261.

(*R*)-*tert*-Butyl-4-(4-isobutylphenyl)-2,2-dimethyl-6-phenylhex-5-ynoate (13)



13

According to General Procedure **A** with **1j** 1-isobutyl-4-vinylbenzene (48.0 mg, 0.30 mmol, 1.5 equiv.), ethynylbenzene **2b** (20.4 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **13** as a colorless oil (76.9 mg, 95% yield, 96% ee).

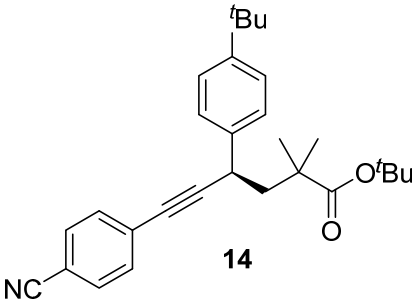
HPLC analysis: Chiralcel ADH (*n*-hexane/*i*-PrOH = 99.5/0.5, flow rate 0.5 mL/min, λ = 254 nm), t_R (major) = 11.96 min, t_R (minor) = 13.58 min.

^{1}H NMR (400 MHz, $CDCl_3$) 7.51 – 7.43 (m, 2H), 7.40 (d, *J* = 7.2 Hz, 2H), 7.36 – 7.29 (m, 3H), 7.16 (d, *J* = 7.6 Hz, 2H), 3.92 (dd, *J* = 9.6, 4.0 Hz, 1H), 2.51 (d, *J* = 7.1 Hz, 2H), 2.18 (dd, *J* = 13.3, 10.3 Hz, 1H), 2.10 (dd, *J* = 13.8, 4.2 Hz, 1H), 1.91 (dp, *J* = 13.4, 6.7 Hz, 1H), 1.49 (s, 9H), 1.42 (s, 3H), 1.29 (s, 3H), 0.96 (d, *J* = 6.6 Hz, 6H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 176.8, 140.5, 140.1, 131.5, 129.4, 128.2, 127.7, 127.2, 124.0, 92.5, 83.5, 80.1, 48.9, 45.1, 43.3, 34.9, 30.3, 28.1, 26.6, 25.4, 22.5.

HRMS (ESI) *m/z* calcd. for $C_{28}H_{37}O_2$ $[M + H]^+$ 405.2788, found 405.2799.

(*R*)-*tert*-Butyl-4-(4-(*tert*-butyl)phenyl)-6-(4-cyanophenyl)-2,2-dimethylhex-5-ynoate (14)



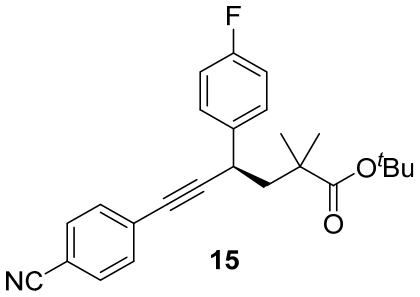
14

According to General Procedure **A** with 1-(*tert*-butyl)-4-vinylbenzene **1k** (48.1 mg, 0.30 mmol, 1.5 equiv.), 4-ethynylbenzonitrile **2a** (25.4 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **14** as a colorless oil (60.6 mg, 71% yield, 95% ee).

HPLC analysis: Chiralcel OD3 (*n*-hexane/*i*-PrOH = 98/2, flow rate 0.5 mL/min, λ = 254 nm), t_R (major) = 10.03 min, t_R (minor) = 11.34 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.56 (d, *J* = 8.3 Hz, 2H), 7.48 (d, *J* = 8.0 Hz, 2H), 7.35 (q, *J* = 8.4 Hz, 4H), 3.89 (dd, *J* = 9.8, 4.3 Hz, 1H), 2.16 (dd, *J* = 13.9, 9.9 Hz, 1H), 2.06 (dd, *J* = 14.0, 4.3 Hz, 1H), 1.41 (s, 9H), 1.34 (s, 3H), 1.32 (s, 9H), 1.24 (s, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 176.5, 149.9, 139.3, 132.1, 131.9, 128.9, 127.0, 125.7, 118.6, 111.0, 97.5, 82.1, 80.2, 48.3, 43.1, 34.9, 34.1, 31.4, 28.1, 26.3, 25.6.
HRMS (ESI) *m/z* calcd. for $C_{29}H_{36}NO_2$ $[M + H]^+$ 430.2741, found 430.2732.

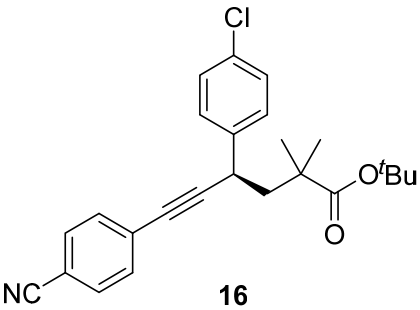
(*R*)-*tert*-Butyl-6-(4-cyanophenyl)-4-(4-fluorophenyl)-2,2-dimethylhex-5-ynoate (15)



15

According to General Procedure **A** with 1-fluoro-4-vinylbenzene **1l** (36.6 mg, 0.30 mmol, 1.5 equiv.), 4-ethynylbenzonitrile **2a** (25.4 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **15** as a colorless oil (64.0 mg, 82% yield, 92% ee).
HPLC analysis: Chiralcel ADH (*n*-hexane/*i*-PrOH = 97/3, flow rate 0.5 mL/min, λ = 254 nm), t_R (major) = 15.70 min, t_R (minor) = 17.02 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.59 (m, 2H), 7.50 (m, 2H), 7.39 (m, 2H), 7.05 (m, 2H), 3.93 (dd, *J* = 9.6, 4.3 Hz, 1H), 2.16 (dd, *J* = 13.8, 9.8 Hz, 1H), 2.05 (dd, *J* = 14.0, 4.2 Hz, 1H), 1.44 (s, 9H), 1.35 (s, 3H), 1.25 (s, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 176.5, 161.8 (d, *J* = 245.4 Hz), 138.1 (d, *J* = 3.2 Hz), 132.0, 131.9, 128.9 (d, *J* = 8.0 Hz), 128.6, 118.6, 115.5 (d, *J* = 21.5 Hz), 111.2, 96.9, 82.4, 80.3, 48.4, 43.1, 34.7, 28.0, 26.3, 25.6.
^{19}F NMR (376 MHz, $CDCl_3$) δ −114.47 – −116.70 (m, 1F).
HRMS (ESI) *m/z* calcd. for $C_{25}H_{27}FNO_2$ $[M + H]^+$ 392.2020, found 392.2011.

(*R*)-*tert*-Butyl-4-(4-chlorophenyl)-6-(4-cyanophenyl)-2,2-dimethylhex-5-ynoate (16)



16

According to General Procedure **A** with 1-chloro-4-vinylbenzene **1m** (41.6 mg, 0.30

mmol, 1.5 equiv.), 4-ethynylbenzonitrile **2a** (25.4 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **16** as a colorless oil (54.0 mg, 66% yield, 90% ee).

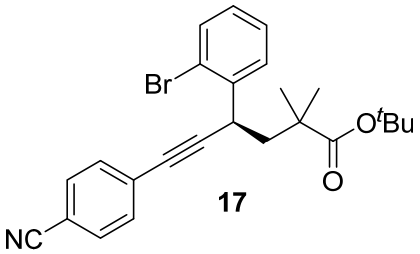
HPLC analysis: Chiralcel ADH (*n*-hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 7.59 min, t_R (minor) = 8.85 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 – 7.58 (m, 2H), 7.51 – 7.47 (m, 2H), 7.39 – 7.30 (m, 4H), 3.92 (dd, *J* = 9.6, 4.4 Hz, 1H), 2.16 (dd, *J* = 13.9, 9.7 Hz, 1H), 2.04 (dd, *J* = 13.9, 4.4 Hz, 1H), 1.44 (s, 9H), 1.35 (s, 3H), 1.25 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 176.4, 140.9, 132.8, 132.1, 132.0, 128.9, 128.8, 128.5, 111.3, 96.5, 82.5, 80.3, 48.2, 43.1, 34.9, 28.0, 26.3, 25.6.

HRMS (ESI) *m/z* calcd. for $C_{25}H_{27}ClNO_2$ $[M + H]^+$ 408.1725, found 408.1713.

(*S*)-*tert*-Butyl-4-(2-bromophenyl)-6-(4-cyanophenyl)-2,2-dimethylhex-5-ynoate (17)



17

According to General Procedure **A** with 1-bromo-2-vinylbenzene **1n** (54.9 mg, 0.30 mmol, 1.5 equiv.), 4-ethynylbenzonitrile **2a** (25.4 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **17** as a colorless oil (68.5 mg, 76% yield, 88% ee).

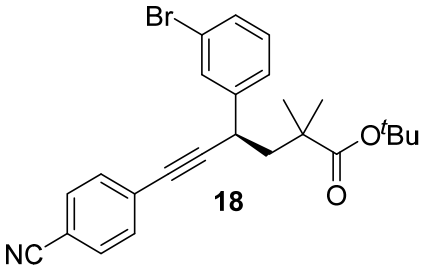
HPLC analysis: Chiralcel ADH (*n*-hexane/*i*-PrOH = 97/3, flow rate 0.5 mL/min, λ = 254 nm), t_R (minor) = 14.28 min, t_R (major) = 15.03 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.66 (d, *J* = 7.8 Hz, 1H), 7.58 (t, *J* = 7.7 Hz, 3H), 7.51 (d, *J* = 7.1 Hz, 2H), 7.36 (t, *J* = 7.5 Hz, 1H), 7.15 (t, *J* = 7.7 Hz, 1H), 4.49 (dd, *J* = 10.2, 4.1 Hz, 1H), 2.35 – 2.12 (m, 1H), 2.04 – 1.91 (m, 1H), 1.41 (s, 9H), 1.36 (s, 3H), 1.33 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 176.5, 141.4, 133.1, 132.1, 131.9, 129.5, 128.7, 128.6, 128.1, 122.92, 118.6, 111.2, 96.0, 82.2, 80.2, 45.7, 42.8, 34.8, 28.0, 26.9, 24.6.

HRMS (ESI) *m/z* calcd. for $C_{25}H_{27}BrNO_2$ $[M + H]^+$ 452.1220, found 452.1209.

(*R*)-*tert*-Butyl-4-(3-bromophenyl)-6-(4-cyanophenyl)-2,2-dimethylhex-5-ynoate (18)



18

According to General Procedure **A** with 1-bromo-3-vinylbenzene **1o** (54.9 mg, 0.30 mmol, 1.5 equiv.), 4-ethynylbenzonitrile **2a** (25.4 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **18** as a colorless oil (64.8 mg, 72% yield, 88% ee).

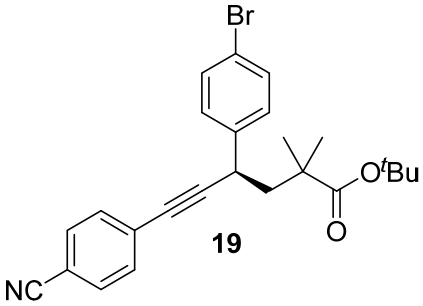
HPLC analysis: Chiralcel ADH (*n*-hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min, λ = 254 nm), t_R (minor) = 6.14 min, t_R (major) = 6.45 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.63 – 7.55 (m, 3H), 7.54 – 7.46 (m, 2H), 7.41 (d, *J* = 7.9 Hz, 1H), 7.36 (d, *J* = 7.8 Hz, 1H), 7.24 (t, *J* = 7.8 Hz, 1H), 3.91 (dd, *J* = 9.7, 4.3 Hz, 1H), 2.16 (dd, *J* = 13.9, 9.8 Hz, 1H), 2.06 (dd, *J* = 13.9, 4.3 Hz, 1H), 1.44 (s, 9H), 1.36 (s, 3H), 1.26 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 176.4, 144.7, 132.1, 132.0, 130.5, 130.3, 130.1, 128.4, 126.1, 122.7, 118.5, 111.3, 96.2, 82.7, 80.4, 48.1, 43.1, 35.1, 28.0, 26.3, 25.6.

HRMS (ESI) *m/z* calcd. for $C_{25}H_{27}BrNO_2$ $[M + H]^+$ 452.1220, found 452.1209.

(*R*)-*tert*-Butyl-4-(4-bromophenyl)-6-(4-cyanophenyl)-2,2-dimethylhex-5-ynoate (19)



19

According to General Procedure **A** with 1-bromo-4-vinylbenzene **1p** (54.9 mg, 0.30 mmol, 1.5 equiv), 4-ethynylbenzonitrile **2a** (25.4 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **19** as a colorless oil (65 mg, 72% yield, 92% ee).

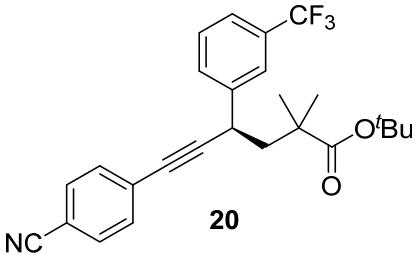
HPLC analysis: Chiralcel ADH (*n*-hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 8.04 min, t_R (minor) = 9.51 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 – 7.56 (m, 2H), 7.51 – 7.46 (m, 4H), 7.32 – 7.31 (m, 1H), 7.33 – 7.27 (m, 1H), 3.91 (dd, *J* = 9.6, 4.4 Hz, 1H), 2.15 (dd, *J* = 13.9, 9.7 Hz, 1H), 2.04 (dd, *J* = 13.9, 4.4 Hz, 1H), 1.43 (s, 9H), 1.35 (s, 3H), 1.25 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 176.4, 141.4, 132.1, 132.0, 131.8, 129.2, 128.5, 120.8, 111.3, 96.4, 82.5, 80.3, 48.1, 43.1, 34.9, 28.0, 26.3, 25.6.

HRMS (ESI) *m/z* calcd. for $C_{25}H_{27}BrNO_2$ $[M + H]^+$ 452.1220, found 452.1207.

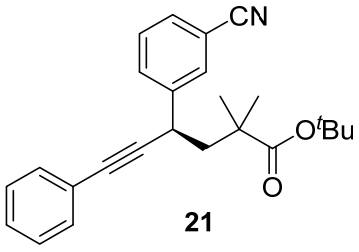
(*R*)-*tert*-Butyl-6-(4-cyanophenyl)-2,2-dimethyl-4-(3-(trifluoromethyl)phenyl)hex-5-ynoate (20)



20

According to General Procedure **A** with 1-(trifluoromethyl)-3-vinylbenzene **1q** (51.6 mg, 0.30 mmol, 1.5 equiv.), 4-ethynylbenzonitrile **2a** (25.4 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **20** as a colorless oil (63.7 mg, 72% yield, 86% ee).
HPLC analysis: Chiralcel OZ3 (*n*-hexane/*i*-PrOH = 98/2, flow rate 0.5 mL/min, λ = 254 nm), t_R (major) = 16.91 min, t_R (minor) = 18.21 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.69 (s, 1H), 7.65 – 7.58 (m, 3H), 7.57 – 7.46 (m, 4H), 4.02 (dd, *J* = 9.8, 4.2 Hz, 1H), 2.19 (dd, *J* = 13.9, 9.8 Hz, 1H), 2.08 (dd, *J* = 13.9, 4.2 Hz, 1H), 1.44 (s, 9H), 1.38 (s, 3H), 1.27 (s, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 176.4, 143.4, 132.1, 132.0, 131.1 (q, *J* = 32.2 Hz), 130.8, 129.3, 128.3, 124.2 (q, *J* = 3.7 Hz), 124.1 (q, *J* = 272.5 Hz), 123.9 (q, *J* = 3.7 Hz), 118.5, 111.4, 95.9, 82.8, 80.5, 48.2, 43.1, 35.3, 28.0, 26.4, 25.6.
^{19}F NMR (376 MHz, $CDCl_3$) δ −62.56 (s, 3F).
HRMS (ESI) *m/z* calcd. for $C_{26}H_{27}F_3NO_2$ $[M + H]^+$ 442.1988, found 442.1979.

(*R*)-*tert*-Butyl-4-(3-cyanophenyl)-2,2-dimethyl-6-phenylhex-5-ynoate (21)

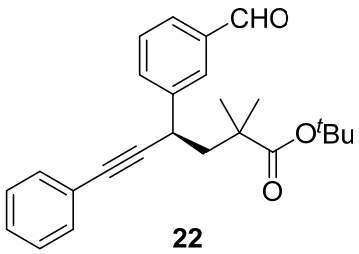


21

According to General Procedure **A** with 3-vinylbenzonitrile **1r** (37.5 mg, 0.30 mmol, 1.5 equiv.), Phenylacetylene **2a** (20.4 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **21** as a colorless oil (61.2 mg, 82% yield, 85% ee).
HPLC analysis: Chiralcel AD3 (*n*-hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 15.01 min, t_R (minor) = 17.43 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.80 (s, 1H), 7.72 (d, *J* = 7.8 Hz, 1H), 7.56 (d, *J* = 7.7 Hz, 1H), 7.50 – 7.40 (m, 3H), 7.37 – 7.29 (m, 3H), 3.97 (dd, *J* = 9.3, 4.5 Hz, 1H), 2.18 – 2.01 (m, 2H), 1.46 (s, 9H), 1.41 (s, 3H), 1.27 (s, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 176.5, 144.7, 132.1, 131.5, 131.1, 130.5, 129.4, 128.3, 128.2, 123.2, 118.9, 112.6, 90.5, 84.6, 80.4, 48.5, 43.2, 35.0, 28.1, 26.8, 25.2.
HRMS (ESI) *m/z* calcd. for $C_{25}H_{28}NO_2$ $[M + H]^+$ 374.2115, found 374.2104.

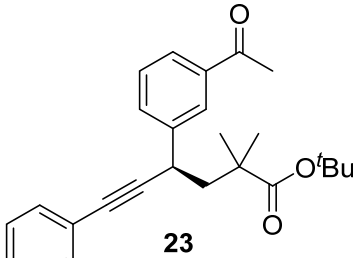
(*R*)-*tert*-Butyl-4-(3-formylphenyl)-2,2-dimethyl-6-phenylhex-5-ynoate (22)



22

According to General Procedure **A** with 3-vinylbenzaldehyde **1s** (31.2 mg, 0.30 mmol, 1.5 equiv.), ethynylbenzene **2b** (20.4 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **22** as a colorless oil (55.2 mg, 74% yield, 88% ee).
HPLC analysis: Chiralcel AY3 (*n*-hexane/*i*-PrOH = 98/2, flow rate 0.5 mL/min, λ = 254 nm), t_R (minor) = 18.24 min, t_R (major) = 21.72 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 10.06 (s, 1H), 8.00 (s, 1H), 7.78 (dd, *J* = 11.6, 7.8 Hz, 2H), 7.54 (t, *J* = 7.6 Hz, 1H), 7.49– 7.39 (m, 2H), 7.36 – 7.26 (m, 3H), 4.03 (dd, *J* = 9.6, 4.2 Hz, 1H), 2.24 – 2.05 (m, 2H), 1.46 (s, 9H), 1.41 (s, 3H), 1.28 (s, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ192.3, 176.6, 144.4, 136.8, 133.7, 131.5, 129.4, 128.6, 128.4, 128.2, 128.0, 123.5, 91.2, 84.2, 80.3, 48.5, 43.2, 35.1, 28.1, 26.6, 25.3.
HRMS (ESI) *m/z* calcd. for $C_{25}H_{28}NaO_3$ $[M + Na]^+$ 399.1931, found 399.1929.

(*R*)-*tert*-Butyl-4-(3-acetylphenyl)-2,2-dimethyl-6-phenylhex-5-ynoate (23)

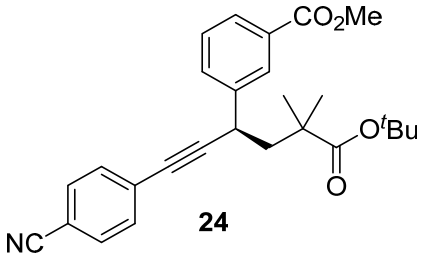


23

According to General Procedure **A** with 1-(3-vinylphenyl)ethan-1-one **1t** (43.8 mg, 0.30 mmol, 1.5 equiv.), ethynylbenzene **2b** (20.4 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **23** as a colorless oil (66.7 mg, 85% yield, 95% ee).
HPLC analysis: Chiralcel AD3 (*n*-hexane/*i*-PrOH = 98/2, flow rate 0.5 mL/min, λ = 254 nm), t_R (major) = 19.05 min, t_R (minor) = 23.55 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.07 (s, 1H), 7.86 (d, *J* = 7.8 Hz, 1H), 7.70 (d, *J* = 7.7 Hz, 1H), 7.51 – 7.40 (m, 3H), 7.34 – 7.26 (m, 3H), 4.00 (dd, *J* = 9.7, 4.2 Hz, 1H), 2.64 (s, 3H), 2.18 (dd, *J* = 13.9, 9.7 Hz, 1H), 2.09 (dd, *J* = 13.9, 4.2 Hz, 1H), 1.46 (s, 9H), 1.41 (s, 3H), 1.28 (s, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 198.0, 176.6, 143.9, 137.5, 132.3, 131.5, 128.9, 128.2, 127.9, 127.3, 126.9, 123.6, 91.5, 84.1, 80.3, 48.5, 43.2, 35.3, 28.1, 26.7, 26.6, 25.4.
HRMS (ESI) *m/z* calcd. for $C_{26}H_{31}NaO_3$ $[M+Na]^+$ 413.2087, found 413.2075.

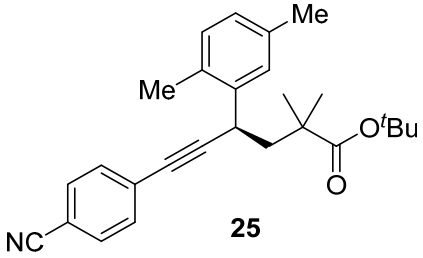
(*R*)-Methyl-3-(6-(*tert*-butoxy)-1-(4-cyanophenyl)-5,5-dimethyl-6-oxohex-1-yn-3-yl)benzoate (24)



24

According to General Procedure **A** with methyl 3-vinylbenzoate **1u** (48.7 mg, 0.30 mmol, 1.5 equiv.), 4-ethynylbenzonitrile **2a** (25.4 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **24** as a colorless oil (45.1 mg, 52% yield, 89% ee).
HPLC analysis: Chiralcel AD3 (*n*-hexane/*i*-PrOH = 95/5, flow rate 0.5 mL/min, λ = 254 nm), t_R (major) = 18.84 min, t_R (minor) = 25.11 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.09 (s, 1H), 7.95 (d, *J* = 7.5 Hz, 1H), 7.63 (d, *J* = 7.7 Hz, 1H), 7.58 (d, *J* = 8.1 Hz, 2H), 7.49 (d, *J* = 8.0 Hz, 2H), 7.44 (t, *J* = 7.7 Hz, 1H), 3.99 (dd, *J* = 9.8, 4.1 Hz, 1H), 3.95 – 3.88 (s, 3H), 2.19 (dd, *J* = 13.8, 10.0 Hz, 1H), 2.06 (dd, *J* = 14.0, 4.0 Hz, 1H), 1.54 – 1.38 (s, 9H), 1.35 (s, 3H), 1.25 (s, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 176.4, 166.9, 142.9, 132.1, 132.0, 130.7, 128.9, 128.6, 128.5, 128.3, 118.6, 111.3, 96.4, 82.6, 80.4, 52.2, 48.1, 43.1, 35.3, 28.0, 26.3, 25.7.
HRMS (ESI) *m/z* calcd. for $C_{27}H_{30}NO_4$ $[M+H]^+$ 432.2169, found 432.2162.

(*S*)-*tert*-Butyl-6-(4-cyanophenyl)-4-(2,5-dimethylphenyl)-2,2-dimethylhex-5-ynoate (25)

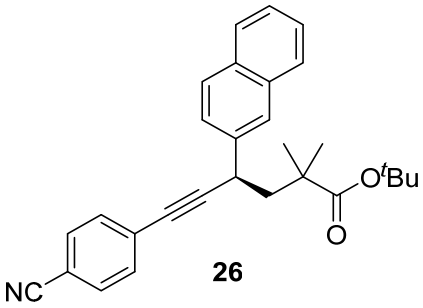


25

According to General Procedure **A** with 1,4-dimethyl-2-vinylbenzene **1v** (39.7 mg, 0.30 mmol, 1.5 equiv.), 4-ethynylbenzonitrile **2a** (25.4 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the

reaction mixture was purified by column chromatography on silica gel to yield the product **25** as a colorless oil (53.2 mg, 66% yield, 87% ee).
HPLC analysis: Chiralcel OD3 (*n*-hexane/*i*-PrOH = 98/2, flow rate 0.5 mL/min, λ = 254 nm), t_R (minor) = 17.04 min, t_R (major) = 19.43 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.55 (d, *J* = 8.4 Hz, 2H), 7.46 (d, *J* = 8.0 Hz, 2H), 7.27 (s, 1H), 7.05 (d, *J* = 7.7 Hz, 1H), 6.97 (d, *J* = 7.7 Hz, 1H), 4.09 (dd, *J* = 10.3, 4.1 Hz, 1H), 2.37 (s, 3H), 2.33 (s, 3H), 2.20 (dd, *J* = 13.9, 10.4 Hz, 1H), 1.90 (dd, *J* = 14.0, 4.1 Hz, 1H), 1.41 (s, 9H), 1.34 (s, 3H), 1.27 (s, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 176.6, 140.2, 136.0, 132.1, 131.9, 131.5, 130.7, 129.0, 128.5, 127.7, 118.7, 111.0, 97.6, 81.5, 80.2, 46.3, 43.0, 31.9, 28.0, 26.2, 25.7, 21.1, 19.0.
HRMS (ESI) *m/z* calcd. for $C_{27}H_{32}NO_2$ $[M + H]^+$ 402.2428, found 402.2417.

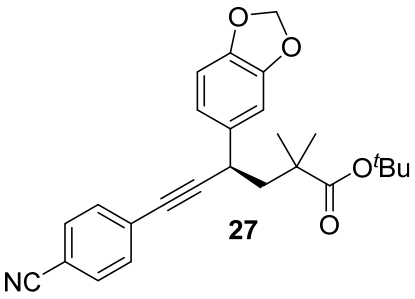
(*R*)-*tert*-Butyl-6-(4-cyanophenyl)-2,2-dimethyl-4-(naphthalen-2-yl)hex-5-ynoate (26)



26

According to General Procedure **A** with 2-vinylnaphthalene **1w** (46.2 mg, 0.30 mmol, 1.5 equiv), 4-ethynylbenzonitrile **2a** (25.4 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **26** as a colorless oil (56.0 mg, 66% yield, 86% ee).
HPLC analysis: Chiralcel ADH (*n*-hexane/*i*-PrOH = 96/4, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 8.99 min, t_R (minor) = 9.70 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.83 (t, *J* = 8.3 Hz, 4H), 7.57 – 7.52 (m, 3H), 7.50 – 7.42 (m, 4H), 4.09 (dd, *J* = 9.6, 4.4 Hz, 1H), 2.26 (dd, *J* = 13.9, 9.6 Hz, 1H), 2.15 (dd, *J* = 14.0, 4.5 Hz, 1H), 1.42 (s, 9H), 1.37 (s, 3H), 1.26 (s, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 176.6, 139.7, 133.5, 132.6, 132.1, 132.0, 128.8, 128.6, 127.8, 127.7, 126.3, 125.9, 125.81, 125.75, 118.6, 111.1, 97.2, 82.5, 80.3, 48.1, 43.2, 35.6, 28.1, 26.3, 25.7.
HRMS (ESI) *m/z* calcd. for $C_{29}H_{30}NO_2$ $[M + H]^+$ 424.2271, found 424.2262.

(*R*)-*tert*-Butyl-4-(benzo[*d*][1,3]dioxol-5-yl)-6-(4-cyanophenyl)-2,2-dimethylhex-5-ynoate (27)



27

According to General Procedure **A** with 5-vinylbenzo[*d*][1,3]dioxole **1x** (44.4 mg, 0.30 mmol, 1.5 equiv.), 4-ethynylbenzonitrile **2a** (25.4 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **27** as a colorless oil (70.8 mg, 85% yield, 87% ee).

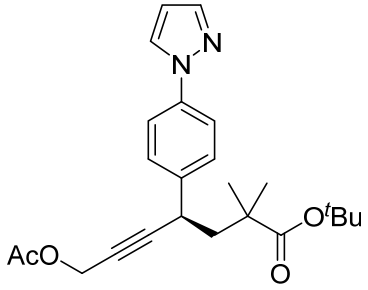
HPLC analysis: Chiralcel IF (*n*-hexane/*i*-PrOH = 98/2, flow rate 0.5 mL/min, λ = 254 nm), t_R (major) = 27.67 min, t_R (minor) = 30.69 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.57 (d, *J* = 8.3 Hz, 2H), 7.48 (d, *J* = 8.4 Hz, 2H), 6.92 (d, *J* = 1.5 Hz, 1H), 6.82 (d, *J* = 1.6 Hz, 1H), 6.77 (d, *J* = 8.0 Hz, 1H), 5.95 (s, 2H), 3.84 (dd, *J* = 9.6, 4.5 Hz, 1H), 2.14 (dd, *J* = 13.9, 9.7 Hz, 1H), 2.02 (dd, *J* = 13.9, 4.5 Hz, 1H), 1.42 (s, 9H), 1.32 (s, 3H), 1.23 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 176.5, 147.9, 146.5, 136.3, 132.1, 131.9, 128.7, 120.4, 118.6, 111.1, 108.3, 107.9, 101.1, 97.2, 82.1, 80.2, 48.4, 43.0, 35.1, 28.0, 26.2, 25.7.

HRMS (ESI) *m/z* calcd. for $C_{26}H_{28}NO_4$ $[M + H]^+$ 418.2013, found 418.2002.

(*R*)-*tert*-Butyl-4-(4-(1*H*-pyrazol-1-yl)phenyl)-7-acetoxy-2,2-dimethylhept-5-ynoate (28)



28

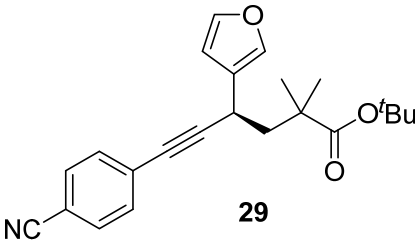
According to General Procedure **A** with 1-(4-vinylphenyl)-1*H*-pyrazole **1y** (51.0 mg, 0.30 mmol, 1.5 equiv.), prop-2-yn-1-yl acetate **2za** (19.6 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **28** as a colorless oil (37.7 mg, 46% yield, 90% ee).

HPLC analysis: Chiralcel OZ3 (*n*-hexane/*i*-PrOH = 95/5, flow rate 0.5 mL/min, λ = 254 nm), t_R (major) = 22.61 min, t_R (minor) = 24.04 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.91 (d, *J* = 2.2 Hz, 1H), 7.73 (s, 1H), 7.66 (d, *J* = 8.5 Hz, 2H), 7.44 (d, *J* = 8.5 Hz, 2H), 6.55 – 6.40 (m, 1H), 4.72 (s, 2H), 3.83 – 3.69 (m, 1H), 2.09 (s, 3H), 2.08 – 1.91 (m, 2H), 1.47 (s, 9H), 1.30 (s, 3H), 1.20 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 176.5, 170.3, 141.0, 140.9, 139.0, 128.4, 126.7, 119.4, 107.6, 89.0, 80.2, 52.7, 48.1, 43.1, 34.2, 28.0, 26.3, 25.4, 20.8.
HRMS (ESI) *m/z* calcd. for $C_{24}H_{31}N_2O_4$ $[M + H]^+$ 411.2278, found 411.2276.

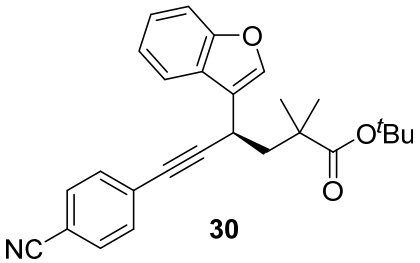
(*S*)-*tert*-butyl -6-(4-cyanophenyl)-4-(furan-3-yl)-2,2-dimethylhex-5-ynoate (29)



29

According to General Procedure **A** with 3-vinylfuran **1z** (28.0 mg, 0.30 mmol, 1.5 equiv.), 4-ethynylbenzonitrile **2a** (25.4 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **29** as a colorless oil (43.4 mg, 60% yield, 85% ee).
HPLC analysis: Chiralcel OZ3 (*n*-hexane/*i*-PrOH = 98/2, flow rate 0.5 mL/min, λ = 254 nm), t_R (major) = 24.03 min, t_R (minor) = 25.61 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.59 (d, *J* = 8.3 Hz, 2H), 7.49 (d, *J* = 8.3 Hz, 2H), 7.44–7.39 (m, 2H), 6.45 (s, 1H), 3.86 (dd, *J* = 7.8, 6.0 Hz, 1H), 2.12 (d, *J* = 2.6 Hz, 1H), 2.11 (s, 1H), 1.43 (s, 9H), 1.34 (s, 3H), 1.27 (s, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 176.5, 143.3, 139.1, 132.1, 131.9, 128.6, 126.3, 118.6, 111.2, 109.8, 96.5, 80.9, 80.2, 46.4, 42.9, 28.0, 26.3, 26.0, 25.5.
HRMS (ESI) *m/z* calcd. for $C_{23}H_{26}NO_3$ $[M + H]^+$ 364.1907, found 364.1899.

(*S*)-*tert*-Butyl-4-(benzofuran-3-yl)-6-(4-cyanophenyl)-2,2-dimethylhex-5-ynoate (30)

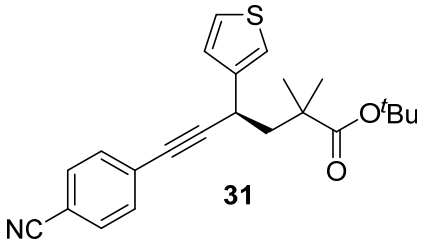


30

According to General Procedure **A** with 3-vinylbenzofuran **1za** (43.2 mg, 0.30 mmol, 1.5 equiv.), 4-ethynylbenzonitrile **2a** (25.4 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **30** as a colorless oil (53.0 mg, 64% yield, 96% ee).
HPLC analysis: Chiralcel OD3 (*n*-hexane/*i*-PrOH = 90/10, flow rate 0.5 mL/min, λ = 254 nm), t_R (minor) = 10.96 min, t_R (major) = 11.35 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.85 – 7.75 (m, 1H), 7.63 – 7.52 (m, 3H), 7.52 – 7.41 (m, 3H), 7.36 – 7.24 (m, 2H), 4.17 (t, *J* = 7.1 Hz, 1H), 2.28 (d, *J* = 7.1 Hz, 2H), 1.38 (m, 12H), 1.29 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 176.4, 155.8, 141.4, 132.1, 132.0 128.5, 126.4, 124.6, 122.6, 121.0, 120.2, 118.6, 111.8, 111.3, 95.6, 81.4, 80.3, 45.0, 42.9, 28.0, 26.3, 25.7, 25.5.
HRMS (ESI) *m/z* calcd. for $C_{27}H_{28}NO_3$ $[M + H]^+$ 414.2064, found 414.2061.

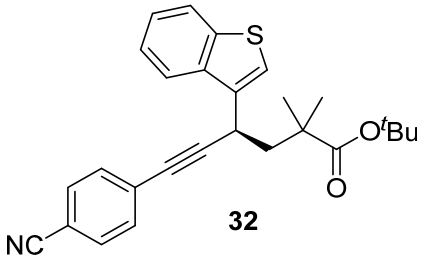
(*S*)-*tert*-Butyl-6-(4-cyanophenyl)-2,2-dimethyl-4-(thiophen-3-yl)hex-5-ynoate (31)



31

According to General Procedure **A** with 3-vinylthiophene **1zb** (33.0 mg, 0.30 mmol, 1.5 equiv.), 4-ethynylbenzonitrile **2a** (25.4 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **31** as a colorless oil (53.3 mg, 70% yield, 92% ee).
HPLC analysis: Chiralcel OZ3 (*n*-hexane/*i*-PrOH = 98/2, flow rate 0.5 mL/min, λ = 254 nm), t_R (major) = 23.88 min, t_R (minor) = 26.22 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.59 (d, *J* = 8.3 Hz, 2H), 7.50 (d, *J* = 8.3 Hz, 2H), 7.32 (dd, *J* = 5.0, 3.0 Hz, 1H), 7.22 (d, *J* = 2.9 Hz, 1H), 7.14 (dd, *J* = 5.0, 1.2 Hz, 1H), 4.04 (dd, *J* = 8.8, 5.1 Hz, 1H), 2.23 – 2.09 (m, 2H), 1.44 (s, 9H), 1.35 (s, 3H), 1.26 (s, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 176.5, 142.4, 132.1, 131.9, 128.7, 126.9, 126.2, 120.9, 118.6, 111.2, 96.9, 81.7, 80.2, 47.2, 43.0, 30.7, 28.1, 26.2, 25.6.
HRMS (ESI) *m/z* calcd. for $C_{23}H_{26}NO_2S$ $[M + H]^+$ 380.1679, found 380.1670.

(*S*)-*tert*-Butyl-4-(benzo[*b*]thiophen-3-yl)-6-(4-cyanophenyl)-2,2-dimethylhex-5-ynoate (32)

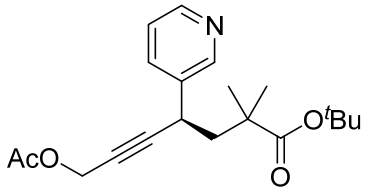


32

According to General Procedure **A** with 3-vinylbenzo[*b*]thiophene **1zc** (48.0 mg, 0.30 mmol, 1.5 equiv.), 4-ethynylbenzonitrile **2a** (25.4 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **32** as a colorless oil (65.7 mg, 77% yield, 92% ee).
HPLC analysis: Chiralcel OZ3 (*n*-hexane/*i*-PrOH = 98/2, flow rate 0.5 mL/min, λ = 254 nm), t_R (major) = 21.15 min, t_R (minor) = 26.49 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.02 (d, *J* = 7.7 Hz, 1H), 7.90 – 7.82 (m, 1H), 7.58 – 7.51 (m, 2H), 7.48–7.45 (m, 1H), 7.45–7.43 (m, 1H), 7.43–7.40 (m, 1H), 7.39 (s, 1H),

7.39 – 7.33 (m, 1H), 4.37 (dd, *J* = 9.9, 4.5 Hz, 1H), 2.32 (dd, *J* = 14.0, 9.9 Hz, 1H), 2.22 (dd, *J* = 14.0, 4.6 Hz, 1H), 1.41 (s, 9H), 1.38 (s, 3H), 1.29 (s, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 176.5, 141.0, 137.2, 135.9, 132.1, 131.9, 128.6, 124.5, 124.1, 123.2, 122.9, 122.2, 118.6, 111.2, 96.0, 82.0, 80.4, 45.2, 42.9, 29.7, 28.1, 26.1, 26.0.
HRMS (ESI) *m/z* calcd. for $C_{27}H_{28}NO_2S$ $[M + H]^+$ 430.1835, found 430.1833.

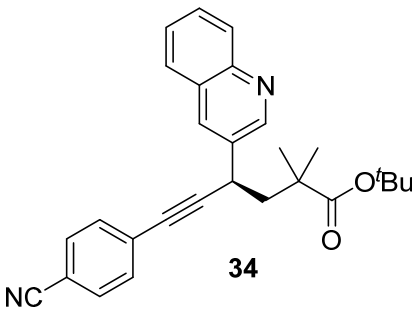
(*S*)-*tert*-Butyl-7-acetoxy-2,2-dimethyl-4-(pyridin-3-yl)hept-5-ynoate (33)



33

According to General Procedure **A** with 3-vinylpyridine **1zd** (31.6 mg, 0.30 mmol, 1.5 equiv.), prop-2-yn-1-yl acetate **2za** (19.6 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **33** as a colorless oil (62.8 mg, 91% yield, 94% ee).
HPLC analysis: Chiralcel AZ3 (*n*-hexane/*i*-PrOH = 95/5, flow rate 0.5 mL/min, λ = 254 nm), t_R (minor) = 42.28 min, t_R (major) = 50.18 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.56 (d, *J* = 1.9 Hz, 1H), 8.50 – 8.42 (m, 1H), 7.75 – 7.60 (m, 1H), 7.23 (dd, *J* = 7.9, 4.8 Hz, 1H), 4.66 (d, *J* = 2.0 Hz, 2H), 3.77 – 67 (m, 1H), 2.05 (s, 3H), 2.04 – 1.90 (m, 2H), 1.42 (s, 9H), 1.27 (s, 3H), 1.16 (s, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 176.3, 170.2, 149.0, 148.2, 138.0, 134.9, 123.5, 88.0, 80.3, 77.7, 52.5, 47.8, 43.0, 32.3, 28.0, 26.4, 25.2, 20.7.
HRMS (ESI) *m/z* calcd. for $C_{20}H_{28}NO_4$ $[M + H]^+$ 346.2013, found 346.2005.

(*S*)-*tert*-Butyl-6-(4-cyanophenyl)-2,2-dimethyl-4-(quinolin-3-yl)hex-5-ynoate (34)

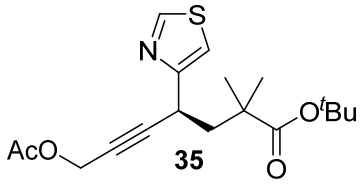


34

According to General Procedure **A** with 3-vinylquinoline **1ze** (46.5 mg, 0.30 mmol, 1.5 equiv.), 4-ethynylbenzonitrile **2a** (25.4 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **34** as a colorless oil (55.5 mg, 65% yield, 85% ee).
HPLC analysis: Chiralcel AD3 (*n*-hexane/*i*-PrOH = 90/10, flow rate 0.5 mL/min, λ = 254 nm), t_R (minor) = 26.20 min, t_R (major) = 29.21 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 9.00 (s, 1H), 8.20 – 8.05 (m, 2H), 7.83 (d, *J* = 8.0 Hz, 1H), 7.75 – 7.66 (m, 1H), 7.58 (m, 3H), 7.51 (d, *J* = 8.3 Hz, 2H), 4.17 (dd, *J* = 9.5, 4.5 Hz, 1H), 2.28 (dd, *J* = 14.0, 9.6 Hz, 1H), 2.19 (dd, *J* = 14.0, 4.5 Hz, 1H), 1.41 (s, 9H), 1.40 (s, 3H), 1.28 (s, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 176.3, 150.6, 147.3, 135.0, 133.7, 132.1, 132.0, 129.4, 129.2, 128.2, 127.9, 127.7, 127.0, 118.5, 111.5, 95.7, 82.3, 80.5, 47.8, 43.1, 33.3, 28.0, 26.4, 25.6.
HRMS (ESI) *m/z* calcd. for $C_{28}H_{29}N_2O_2$ $[M + H]^+$ 425.2224, found 425.2214.

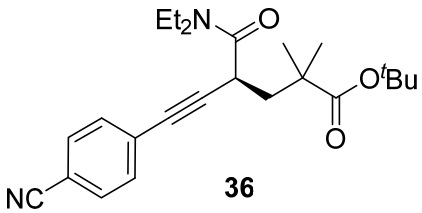
(*S*)-*tert*-Butyl-7-acetoxy-2,2-dimethyl-4-(thiazol-4-yl)hept-5-ynoate (35)



35

According to General Procedure **A** with 4-vinylthiazole **1zf** (33.3 mg, 0.30 mmol, 1.5 equiv.), prop-2-yn-1-yl acetate **2za** (19.6 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **35** as a colorless oil (36.2 mg, 52% yield, 83% ee).
HPLC analysis: Chiralcel AZ3 (*n*-hexane/*i*-PrOH = 95/5, flow rate 0.5 mL/min, λ = 254 nm), t_R (major) = 18.75 min, t_R (minor) = 21.10 min.
^{1}H NMR (400 MHz, $CDCl_3$) 8.77 (s, 1H), 7.28 – 7.24 (m, 1H), 4.74 – 4.67 (m, 2H), 4.10 – 3.97 (m, 1H), 2.27 (dd, *J* = 13.9, 4.4 Hz, 1H), 2.18 – 2.11 (m, 1H), 2.09 (s, 3H), 1.45 (s, 9H), 1.27 (s, 3H), 1.21 (s, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 176.5, 170.3, 157.5, 153.0, 114.3, 87.9, 80.1, 77.2, 52.8, 45.1, 42.7, 31.1, 28.0, 25.8, 25.4, 20.8.
HRMS (ESI) *m/z* calcd. for $C_{18}H_{26}NO_4S$ $[M + H]^+$ 352.1577, found 352.1575.

(*S*)-*tert*-Butyl-6-(4-cyanophenyl)-4-(diethylcarbamoyl)-2,2-dimethylhex-5-ynoate (36)

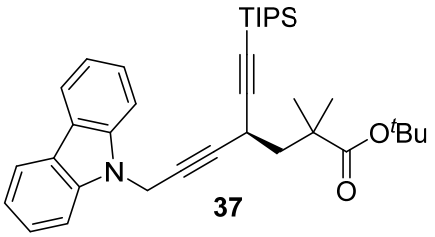


36

According to General Procedure A with *N*,*N*-diethylacrylamide **1zg** (101.6 mg, 0.80 mmol, 4.0 equiv), 4-ethynylbenzonitrile **2a** (25.4 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **36** as a colorless oil (15.7 mg, 20% yield, 81% ee).
HPLC analysis: Chiralcel AZ3 (*n*-hexane/*i*-PrOH = 90/10, flow rate 0.5 mL/min, λ = 254 nm), t_R (major) = 38.01 min, t_R (minor) = 50.23 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.58 (d, *J* = 8.4 Hz, 2H), 7.47 (d, *J* = 8.4 Hz, 2H), 3.73 (t, *J* = 6.1 Hz, 1H), 3.62 – 3.50 (m, 1H), 3.49 – 3.34 (m, 3H), 2.41 (dd, *J* = 14.2, 6.0 Hz, 1H), 2.17 (dd, *J* = 14.2, 6.3 Hz, 1H), 1.45 (s, 9H), 1.32 – 1.26 (m, 6H), 1.20 – 1.12 (m, 6H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 176.7, 168.3, 132.2, 131.9, 128.2, 118.5, 111.4, 93.1, 81.3, 80.3, 42.8, 42.3, 41.5, 41.1, 32.7, 28.0, 26.1, 25.0, 14.4, 12.7.
HRMS (ESI) *m/z* calcd. for $C_{24}H_{32}N_2O_3$ $[M + H]^+$ 397.2486, found 397.2486.

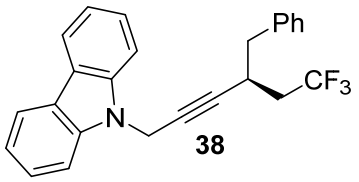
(*S*)-*tert*-butyl-7-(9*H*-carbazol-9-yl)-2,2-dimethyl-4-((triisopropylsilyl)ethynyl)hept-5-ynoate (37)



37

According to General Procedure **A** with but-3-en-1-yn-1-yltriisopropylsilane **1zh** (62.4 mg, 0.3 mmol, 1.5 equiv.), 9-(prop-2-yn-1-yl)-9*H*-carbazole **2v** (41.0 mg, 0.2 mmol, 1.0 equiv.) and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.), after 18 h, the reaction mixture was purified by the column chromatography on silica gel to yield the product **37** as a yellow oil (73.3 mg, 66% yield, 65% ee).
HPLC analysis: Chiralcel IF (hexane/*i*-PrOH = 97/3, flow rate 0.2 mL/min, λ = 254 nm), t_R (minor) = 19.86 min, t_R (major) = 20.67 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 8.19 – 8.09 (m, 2H), 7.56 – 7.46 (m, 4H), 7.32 – 7.26 (m, 2H), 5.05 (d, *J* = 2.0 Hz, 2H), 3.46 – 3.34 (m, 1H), 2.06 (dd, *J* = 13.9, 6.4 Hz, 1H), 1.96 (dd, *J* = 13.9, 6.5 Hz, 1H), 1.41 (s, 9H), 1.19 (s, 3H), 1.16 (s, 3H), 1.10 – 1.02 (m, 21H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 176.3, 140.0, 125.8, 123.2, 120.3, 119.3, 108.9, 106.7, 83.3, 81.7, 80.3, 75.0, 45.7, 42.9, 32.8, 27.9, 26.0, 24.8, 21.2, 18.6, 11.2.
HRMS (ESI) m/z calcd. for $C_{36}H_{49}NO_2Si$ $[M + Na]^+$ 578.3425, found 578.3422.

(*S*)-9-(4-benzyl-6,6,6-trifluorohex-2-yn-1-yl)-9*H*-carbazole (38)



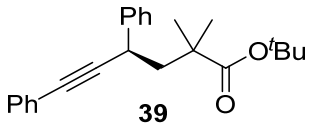
38

According to General Procedure **B** with allylbenzene **1zi** (35.4 mg, 0.3 mmol, 1.5 equiv.), 9-(prop-2-yn-1-yl)-9*H*-carbazole **2v** (41.0 mg, 0.2 mmol, 1.0 equiv.), and **3h** 1-(trifluoromethyl)-1λ^3-benzo[*d*][1,2]iodaoxol-3(1*H*)-one (75.8 mg, 0.24 mmol, 1.2 equiv.), after 60 h, the reaction mixture was purified by the column chromatography on silica gel to yield the product **38** as a white solid (44.4 mg, 69% yield, 20% ee).
HPLC analysis: Chiralcel AD3 (hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 254 nm), t_R (minor) = 9.98 min, t_R (major) = 11.90 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.18 – 8.10 (m, 2H), 7.54 – 7.47 (m, 2H), 7.47 – 7.41 (m, 2H), 7.33 – 7.29 (m, 2H), 7.21 – 7.08 (m, 3H), 7.05 – 6.99 (m, 2H), 5.02 (d, *J* = 2.0 Hz, 2H), 2.95 (tt, *J* = 8.0, 6.3 Hz, 1H), 2.82 – 2.66 (m, 2H), 2.32-2.10 (m, 2H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 140.0, 137.5, 129.3, 128.3, 126.8, 126.1 (q, *J* = 276.0 Hz), 125.9, 123.2, 120.4, 119.4, 108.9, 84.0, 72.3, 40.6, 38.0 (q, *J* = 28.0 Hz), 32.5, 27.7 (q, *J* = 2.9 Hz).
^{19}F NMR (376 MHz, $CDCl_3$) δ –63.93 (t, *J* = 10.5 Hz, 3F).
HRMS (ESI) m/z calcd. for $C_{25}H_{20}F_3N$ $[M + H]^+$ 392.1621, found 392.1618.

Substrates scope of alkyne

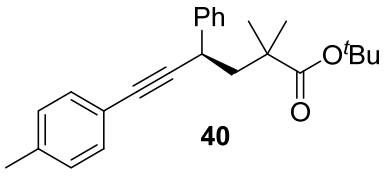
(*R*)-*tert*-Butyl-2,2-dimethyl-4,6-diphenylhex-5-ynoate (39)



39

According to General Procedure **A** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.), ethynylbenzene **2b** (20.4 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **39** as a colorless oil (57.1 mg, 82% yield, 96% ee).
HPLC analysis: Chiralcel IC (*n*-hexane/*i*-PrOH = 99.5/0.5, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 6.24 min, t_R (minor) = 9.71 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.52 – 7.44 (m, 4H), 7.39 (t, *J* = 7.6 Hz, 2H), 7.34 – 7.26 (m, 4H), 3.95 (dd, *J* = 9.6, 4.3 Hz, 1H), 2.19 (dd, *J* = 13.9, 9.7 Hz, 1H), 2.11 (dd, *J* = 13.9, 4.3 Hz, 1H), 1.49 (s, 9H), 1.42 (s, 3H), 1.30 (s, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 176.7, 143.3, 131.5, 128.6, 128.2, 127.8, 127.5, 126.7, 123.9, 92.2, 83.6, 80.1, 48.8, 43.3, 35.3, 28.1, 26.6, 25.4.
HRMS (ESI) *m/z* calcd. for $C_{24}H_{29}O_2$ $[M + H]^+$ 349.2162, found 349.2159.

(*R*)-*tert*-Butyl-2,2-dimethyl-4-phenyl-6-(*p*-tolyl)hex-5-ynoate (40)

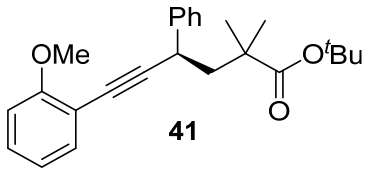


40

According to General Procedure **A** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.), 1-ethynyl-4-methylbenzene **2c** (23.2 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **40** as a colorless oil (49.8 mg, 69% yield, 96% ee).
HPLC analysis: Chiralcel IC (*n*-hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 4.45 min, t_R (minor) = 6.67 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.49 (d, *J* = 7.7 Hz, 2H), 7.37 (dd, *J* = 13.1, 7.3 Hz, 4H),

7.28 (t, *J* = 6.9 Hz, 1H), 7.13 (d, *J* = 7.6 Hz, 2H), 3.93 (dd, *J* = 9.5, 4.0 Hz, 1H), 2.37 (s, 3H), 2.18 (dd, *J* = 13.4, 10.8 Hz, 1H), 2.10 (dd, *J* = 13.8, 3.6 Hz, 1H), 1.48 (s, 9H), 1.41 (s, 3H), 1.29 (s, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 176.8, 143.4, 137.7, 131.4, 128.9, 128.6, 127.5, 126.7, 120.8, 91.4, 83.7, 80.1, 48.8, 43.3, 35.3, 28.1, 26.6, 25.4, 21.5.
HRMS (ESI) *m/z* calcd. for $C_{25}H_{30}NaO_2$ $[M + Na]^+$ 385.2138, found 385.2136.

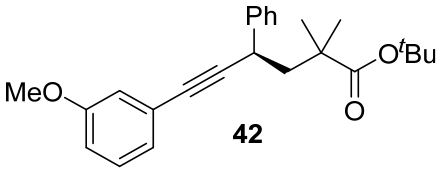
(*R*)-*tert*-Butyl-6-(2-methoxyphenyl)-2,2-dimethyl-4-phenylhex-5-ynoate (41)



41

According to General Procedure **A** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.), 1-ethynyl-2-methoxybenzene **2d** (39.6 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 36 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **41** as a colorless oil (34.2 mg, 45% yield, 95% ee).
HPLC analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.5 mL/min, λ = 254 nm), t_R (major) = 8.60 min, t_R (minor) = 9.42 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.54 (d, *J* = 7.8 Hz, 2H), 7.42 (d, *J* = 7.5 Hz, 1H), 7.37 (t, *J* = 7.3 Hz, 2H), 7.30 – 7.21 (m, 2H), 6.90 (dd, *J* = 16.5, 8.0 Hz, 2H), 3.97 (t, *J* = 6.8 Hz, 1H), 3.88 (s, 3H), 2.15 (d, *J* = 6.9 Hz, 2H), 1.47 (s, 9H), 1.43 (s, 3H), 1.28 (s, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 176.9, 160.2, 143.4, 133.3, 129.1, 128.5, 127.6, 126.6, 120.3, 113.2, 110.7, 96.4, 80.04, 80.02, 55.7, 49.0, 43.3, 35.6, 28.1, 26.9, 24.9.
HRMS (ESI) *m/z* calcd. for $C_{25}H_{30}NaO_3$ $[M + Na]^+$ 401.2087, found 401.2086.

(*R*)-*tert*-Butyl-6-(3-methoxyphenyl)-2,2-dimethyl-4-phenylhex-5-ynoate (42)

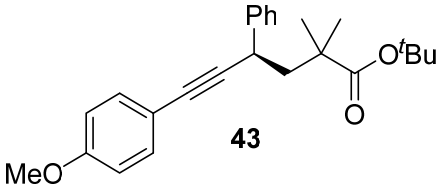


42

According to General Procedure **A** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.), 1-ethynyl-3-methoxybenzene **2e** (39.6 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **42** as a colorless oil (62.7 mg, 83% yield, 95% ee).
HPLC analysis: Chiralcel IC (*n*-hexane/*i*-PrOH = 98/2, flow rate 0.5 mL/min, λ = 254 nm), t_R (major) = 10.01 min, t_R (minor) = 14.21 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.49 (d, *J* = 7.9 Hz, 2H), 7.38 (t, *J* = 7.6 Hz, 2H), 7.28 (dd, *J* = 7.9, 6.8 Hz, 1H), 7.23 (t, *J* = 7.9 Hz, 1H), 7.06 (dd, *J* = 7.6, 0.9 Hz, 1H), 6.99 (d, *J* = 1.1 Hz, 1H), 6.87 (dd, *J* = 8.3, 2.5 Hz, 1H), 3.94 (dd, *J* = 9.6, 4.2 Hz, 1H), 3.82 (s, 3H), 2.19 (dd, *J* = 13.9, 9.6 Hz, 1H), 2.11 (dd, *J* = 13.9, 4.3 Hz, 1H), 1.48 (s, 9H),

1.41 (s, 3H), 1.29 (s, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 176.7, 159.3, 143.2, 129.2, 128.6, 127.5, 126.8, 124.9, 124.1, 116.4, 114.3, 92.1, 83.5, 80.1, 55.3, 48.7, 43.2, 35.3, 28.1, 26.6, 25.4.
HRMS (ESI) *m/z* calcd. for $C_{25}H_{30}NaO_3$ $[M + Na]^+$ 401.2087, found 401.2085.

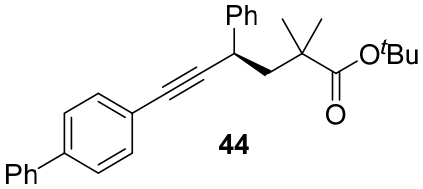
(*R*)-*tert*-Butyl-6-(4-methoxyphenyl)-2,2-dimethyl-4-phenylhex-5-ynoate (43)



43

According to General Procedure **A** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.), 1-ethynyl-4-methoxybenzene **2f** (39.6 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **43** as a colorless oil (62.1 mg, 82% yield, 95% ee).
HPLC analysis: Chiralcel ADH (*n*-hexane/*i*-PrOH = 99 /1, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 6.09 min, t_R (minor) = 6.83 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48 (d, *J* = 7.4 Hz, 2H), 7.42 – 7.35 (m, 4H), 7.31 – 7.25 (m, 1H), 6.88 – 6.79 (m, 2H), 3.92 (dd, *J* = 9.7, 4.3 Hz, 1H), 3.82 (s, 3H), 2.17 (dd, *J* = 13.9, 9.7 Hz, 1H), 2.09 (dd, *J* = 13.9, 4.3 Hz, 1H), 1.48 (s, 9H), 1.41 (s, 3H), 1.29 (s, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 176.8, 159.2, 143.5, 132.9, 128.6, 127.5, 126.7, 116.1, 113.8, 90.6, 83.4, 80.1, 55.3, 48.8, 43.2, 35.3, 28.1, 26.5, 25.4.
HRMS (ESI) *m/z* calcd. for $C_{25}H_{30}NaO_3$ $[M + Na]^+$ 401.2087, found 401.2086.

(*R*)-*tert*-Butyl-6-([1,1'-biphenyl]-4-yl)-2,2-dimethyl-4-phenylhex-5-ynoate (44)

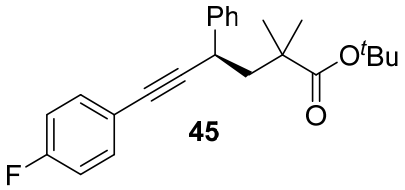


44

According to General Procedure **A** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.), 4-ethynyl-1,1'-biphenyl **2g** (35.6 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **44** as a colorless oil (59.6 mg, 70% yield, 95% ee).
HPLC analysis: Chiralcel IC (*n*-hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 4.94 min, t_R (minor) = 6.59 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.66 – 7.46 (m, 10H), 7.45 – 7.37 (m, 3H), 7.34 – 7.26 (m, 1H), 4.00 (dd, *J* = 9.6, 4.0 Hz, 1H), 2.23 (dd, *J* = 13.8, 9.8 Hz, 1H), 2.15 (dd, *J* = 13.9, 4.2 Hz, 1H), 1.52 (s, 9H), 1.46 (s, 3H), 1.33 (s, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 176.8, 143.3, 140.5, 140.5, 132.0, 128.9, 128.7, 127.6, 127.5, 127.0, 126.9, 126.8, 122.9, 93.0, 83.5, 80.2, 48.8, 43.3, 35.5, 28.1, 26.6, 25.5.

HRMS (ESI) *m/z* calcd. for $C_{30}H_{32}NaO_2$ $[M + Na]^+$ 447.2295, found 447.2293.

(*R*)-*tert*-Butyl-6-(4-fluorophenyl)-2,2-dimethyl-4-phenylhex-5-ynoate (45)



45

According to General Procedure **A** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.), 1-ethynyl-4-fluorobenzene **2h** (24 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **45** as a colorless oil (59.9 mg, 82% yield, 95% ee).

HPLC analysis: Chiralcel IC (*n*-hexane/*i*-PrOH = 99.3/0.7, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 4.65 min, t_R (minor) = 5.80 min.

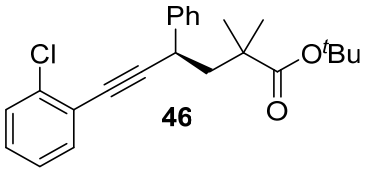
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.50 – 7.34 (m, 6H), 7.28 (t, *J* = 7.3 Hz, 1H), 7.01 (t, *J* = 8.4 Hz, 2H), 3.92 (dd, *J* = 9.8, 4.2 Hz, 1H), 2.19 (dd, *J* = 13.9, 9.9 Hz, 1H), 2.08 (dd, *J* = 13.9, 4.2 Hz, 1H), 1.47 (s, 9H), 1.40 (s, 3H), 1.29 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 176.7, 162.2 (d, *J* = 248.4 Hz), 143.1, 133.3 (d, *J* = 8.2 Hz), 128.7, 127.4, 126.8, 119.9 (d, *J* = 3.5 Hz), 115.4 (d, *J* = 22.0 Hz), 91.8, 82.5, 80.1, 48.6, 43.2, 35.3, 28.1, 26.4, 25.6.

^{19}F NMR (376 MHz, $CDCl_3$) δ −111.86 – −112.06 (m, 1F).

HRMS (ESI) *m/z* calcd. for $C_{24}H_{27}FNaO_2$ $[M + Na]^+$ 389.1887, found 389.1886.

(*R*)-*tert*-Butyl-6-(2-chlorophenyl)-2,2-dimethyl-4-phenylhex-5-ynoate (46)



46

According to General Procedure **A** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.), 1-chloro-2-ethynylbenzene **2i** (27.3 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 24 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **46** as a colorless oil (58.8 mg, 77% yield, 94% ee).

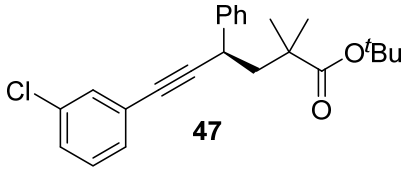
HPLC analysis: Chiralcel IC (*n*-hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 4.31 min, t_R (minor) = 6.19 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.49 (d, *J* = 7.7 Hz, 2H), 7.46 – 7.42 (m, 1H), 7.38 – 7.31 (m, 3H), 7.26 – 7.13 (m, 3H), 3.93 (dd, *J* = 9.5, 4.1 Hz, 1H), 2.16 (dd, *J* = 13.9, 9.6 Hz, 1H), 2.09 (dd, *J* = 13.9, 4.2 Hz, 1H), 1.43 (s, 9H), 1.38 (s, 3H), 1.24 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 176.7, 142.9, 135.9, 133.3, 129.2, 128.7, 128.6, 127.5, 126.8, 126.3, 123.7, 97.7, 80.7, 80.1, 48.8, 43.3, 35.5, 28.0, 26.7, 25.3.

HRMS (ESI) *m/z* calcd. for $C_{24}H_{27}ClNaO_2$ $[M + Na]^+$ 405.1592, found 405.1591.

(*R*)-*tert*-Butyl-6-(3-chlorophenyl)-2,2-dimethyl-4-phenylhex-5-ynoate (47)



47

According to General Procedure **A** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.), 1-chloro-3-ethynylbenzene **2j** (27.3 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **47** as a colorless oil (61.3 mg, 80% yield, 94% ee).

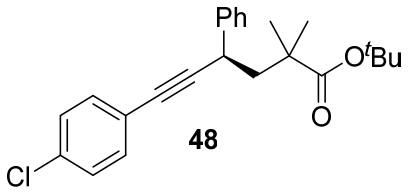
HPLC analysis: Chiralcel IC (*n*-hexane/*i*-PrOH = 99.3/0.7, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 5.81 min, t_R (minor) = 8.20 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48 – 7.43 (m, 3H), 7.38 (t, *J* = 7.5 Hz, 2H), 7.34 – 7.21 (m, 4H), 3.93 (dd, *J* = 9.7, 4.2 Hz, 1H), 2.18 (dd, *J* = 13.9, 9.8 Hz, 1H), 2.10 (dd, *J* = 13.9, 4.3 Hz, 1H), 1.48 (s, 9H), 1.40 (s, 3H), 1.28 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 176.6, 142.9, 134.0, 131.4, 129.7, 129.4, 128.7, 128.0, 127.4, 126.9, 125.6, 93.7, 82.3, 80.2, 48.6, 43.2, 35.3, 28.1, 26.5, 25.5.

HRMS (ESI) *m/z* calcd. for $C_{24}H_{27}ClNaO_2$ $[M + Na]^+$ 405.1592, found 405.1591.

(*R*)-*tert*-Butyl-6-(4-chlorophenyl)-2,2-dimethyl-4-phenylhex-5-ynoate (48)



48

According to General Procedure **A** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.), 1-chloro-4-ethynylbenzene **2k** (27.3 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **48** as a colorless oil (58.9 mg, 77% yield, 95% ee).

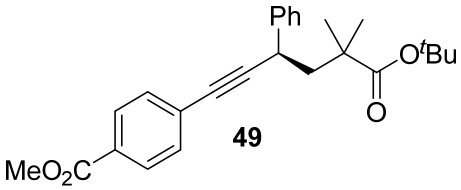
HPLC analysis: Chiralcel IC (*n*-hexane/*i*-PrOH = 99.3/0.7, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 5.88 min, t_R (minor) = 7.66 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.46 (d, *J* = 7.6 Hz, 2H), 7.41 – 7.34 (m, 4H), 7.31 – 7.25 (m, 3H), 3.93 (dd, *J* = 9.8, 4.2 Hz, 1H), 2.19 (dd, *J* = 13.9, 9.9 Hz, 1H), 2.08 (dd, *J* = 13.9, 4.2 Hz, 1H), 1.47 (s, 9H), 1.39 (s, 3H), 1.28 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 176.6, 143.0, 133.7, 132.8, 128.7, 128.5, 127.4, 126.8, 122.4, 93.3, 82.5, 80.1, 48.6, 43.2, 35.3, 28.1, 26.4, 25.6.

HRMS (ESI) *m/z* calcd. for $C_{24}H_{28}ClO_2$ $[M + H]^+$ 383.1772, found 383.1771.

(*R*)-methyl-4-(6-(*tert*-butoxy)-5,5-dimethyl-6-oxo-3-phenylhex-1-yn-1-yl)benzoate (49)



49

According to General Procedure **A** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.), methyl 4-ethynylbenzoate **2l** (25.4 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **49** as a colorless oil (52.9 mg, 65% yield, 94% ee).

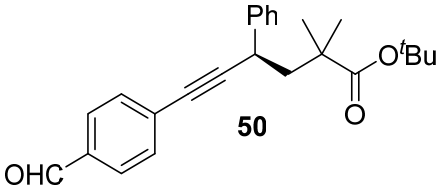
HPLC analysis: Chiralcel IC (*n*-hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 10.27 min, t_R (minor) = 13.62 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.95 (d, *J* = 8.5 Hz, 2H), 7.49 – 7.40 (m, 4H), 7.34 (t, *J* = 7.6 Hz, 2H), 7.28 – 7.21 (m, 1H), 3.94 – 3.87 (m, 4H), 2.17 (dd, *J* = 13.9, 9.8 Hz, 1H), 2.06 (dd, *J* = 13.9, 4.3 Hz, 1H), 1.42 (s, 9H), 1.35 (s, 3H), 1.24 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 176.6, 166.7, 142.8, 131.4, 129.4, 129.1, 128.7, 128.6, 127.4, 126.9, 95.6, 83.0, 80.2, 52.2, 48.5, 43.2, 35.4, 28.1, 26. 3, 25.6.

HRMS (ESI) *m/z* calcd. for $C_{26}H_{30}NaO_4$ $[M + Na]^+$ 429.2036, found 429.2034.

(*R*)-*tert*-Butyl-6-(4-formylphenyl)-2,2-dimethyl-4-phenylhex-5-ynoate (50)



50

According to General Procedure **A** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.), 4-ethynylbenzaldehyde **2m** (26 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **50** as a colorless oil (53.5 mg, 71% yield, 95% ee).

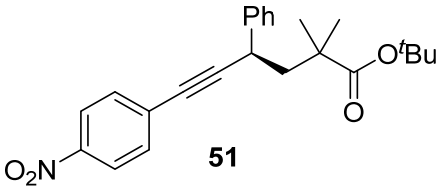
HPLC analysis: Chiralcel IC (*n*-hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 280 nm), t_R (major) = 17.20 min, t_R (minor) = 22.91 min.

^{1}H NMR (600 MHz, $CDCl_3$) δ 9.98 (s, 1H), 7.80 (d, *J* = 7.8 Hz, 2H), 7.55 (d, *J* = 7.9 Hz, 2H), 7.43 (d, *J* = 7.8 Hz, 2H), 7.35 (t, *J* = 7.5 Hz, 2H), 7.26 (t, *J* = 7.3 Hz, 1H), 3.93 (dd, *J* = 9.9, 4.1 Hz, 1H), 2.18 (dd, *J* = 13.9, 10.0 Hz, 1H), 2.06 (dd, *J* = 14.0, 4.1 Hz, 1H), 1.43 (s, 9H), 1.35 (s, 3H), 1.25 (s, 3H).

^{13}C NMR (150 MHz, $CDCl_3$) δ 191.5, 176.6, 142.6, 135.1, 132.1, 130.2, 129.5, 128.7, 127.4, 126.9, 96.9, 82.9, 80.2, 48.4, 43.2, 35.5, 28.1, 26.3, 25.6.

HRMS (ESI) *m/z* calcd. for $C_{25}H_{29}O_3$ $[M + H]^+$ 377.2111, found 377.2112.

(*R*)-*tert*-Butyl-2,2-dimethyl-6-(4-nitrophenyl)-4-phenylhex-5-ynoate (51)



51

According to General Procedure **A** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.), 1-ethynyl-4-nitrobenzene **2n** (29.4 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **51** as a colorless oil (36.3 mg, 46% yield, 93% ee).

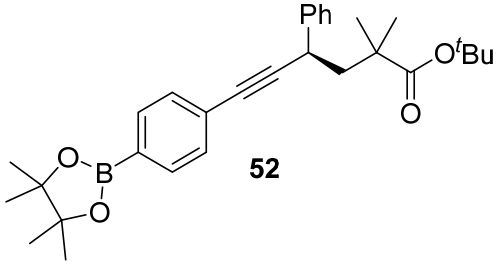
HPLC analysis: Chiralcel IC (*n*-hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 300 nm), t_R (major) = 12.58 min, t_R (minor) = 14.55 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.15 (d, *J* = 8.9 Hz, 2H), 7.54 (d, *J* = 8.9 Hz, 2H), 7.44 – 7.39 (m, 2H), 7.36 (t, *J* = 7.6 Hz, 2H), 7.29 – 7.24 (m, 1H), 3.94 (dd, *J* = 9.8, 4.3 Hz, 1H), 2.20 (dd, *J* = 13.9, 9.9 Hz, 1H), 2.06 (dd, *J* = 14.0, 4.3 Hz, 1H), 1.43 (s, 9H), 1.35 (s, 3H), 1.25 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 176.5, 146.8, 142.3, 132.3, 130.8, 128.8, 127.4, 127.1, 123.5, 98.2, 82.1, 80.3, 48.3, 43.1, 35.5, 28.1, 26.2, 25.8.

HRMS (ESI) *m/z* calcd. for $C_{24}H_{27}NNaO_4$ $[M + Na]^+$ 416.1832, found 416.1833.

(*R*)-*tert*-Butyl-2,2-dimethyl-4-phenyl-6-(4-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)phenyl)hex-5-ynoate (52)



52

According to General Procedure **A** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.), 2-(4-ethynylphenyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane **2o** (45.6 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **52** as a colorless oil (65.7 mg, 69% yield, 96% ee).

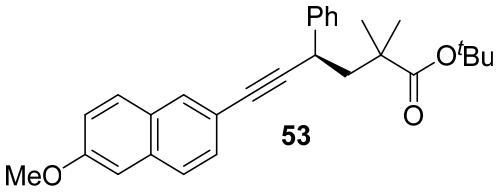
HPLC analysis: Chiralcel IC (*n*-hexane/*i*-PrOH = 99.5/0.5, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 6.90 min, t_R (minor) = 8.17 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.76 (d, *J* = 7.7 Hz, 2H), 7.46 (dd, *J* = 12.1, 7.8 Hz, 4H), 7.38 (t, *J* = 7.4 Hz, 2H), 7.30 – 7.24 (m, 1H), 3.94 (dd, *J* = 9.6, 4.0 Hz, 1H), 2.19 (dd, *J* = 13.7, 9.9 Hz, 1H), 2.09 (dd, *J* = 13.8, 3.9 Hz, 1H), 1.47 (s, 9H), 1.40 (s, 3H), 1.37 (s, 12H), 1.28 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 176.7, 143.1, 134.5, 130.7, 128.7, 127.5, 126.8, 126.7, 93.7, 83.9, 83.8, 80.1, 48.7, 43.2, 35.4, 28.1, 26.5, 25.5, 24.9.

HRMS (ESI) *m/z* calcd. for $C_{30}H_{39}BNaO_4$ $[M + Na]^+$ 497.2834, found 497.2835.

(*R*)-*tert*-Butyl-6-(6-methoxynaphthalen-2-yl)-2,2-dimethyl-4-phenylhex-5-ynoate (53)



53

According to General Procedure **A** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.), 2-ethynyl-6-methoxynaphthalene **2p** (36.4 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **53** as a colorless oil (62.9 mg, 74% yield, 94% ee).

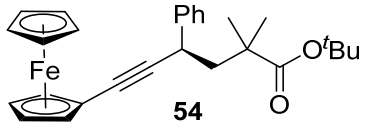
HPLC analysis: Chiralcel IC (*n*-hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 6.63 min, t_R (minor) = 8.99 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.84 (s, 1H), 7.63 (dd, *J* = 11.3, 8.8 Hz, 2H), 7.51 – 7.40 (m, 3H), 7.34 (t, *J* = 7.6 Hz, 2H), 7.27 – 7.20 (m, 1H), 7.12 (dd, *J* = 8.9, 2.4 Hz, 1H), 7.06 (d, *J* = 2.4 Hz, 1H), 3.93 (dd, *J* = 9.7, 4.0 Hz, 1H), 3.87 (s, 3H), 2.18 (dd, *J* = 13.9, 9.8 Hz, 1H), 2.08 (dd, *J* = 13.9, 4.2 Hz, 1H), 1.43 (s, 9H), 1.39 (s, 3H), 1.27 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 176.8, 158.1, 143.4, 133.9, 130.9, 129.2, 128.7, 128.5, 127.5, 126.8, 126.7, 119.3, 118.9, 105.8, 91.8, 84.1, 80.1, 55.3, 48.8, 43.3, 35.5, 28.1, 26.5, 25.5.

HRMS (ESI) *m/z* calcd. for $C_{29}H_{32}NaO_3$ $[M + Na]^+$ 451.2244, found 451.2243.

(*R*)-6-(*tert*-Butyl-2,2-dimethyl-4-phenylhex-5-ynoate)ferrocene (54)



54

According to General Procedure **A** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.), 1-ethynylferrocene **2q** (42 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **54** as a colorless oil (78.6 mg, 86% yield, 94% ee).

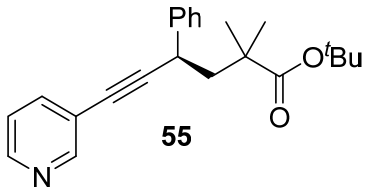
HPLC analysis: Chiralcel ADH (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.5 mL/min, λ = 254 nm), t_R (major) = 7.76 min, t_R (minor) = 8.18 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.49 (d, *J* = 7.4 Hz, 2H), 7.38 (t, *J* = 7.5 Hz, 2H), 7.28 (t, *J* = 7.3 Hz, 1H), 4.43 (s, 2H), 4.24 (s, 5H), 4.19 (s, 2H), 3.83 (dd, *J* = 8.5, 5.0 Hz, 1H), 2.19 – 2.04 (m, 2H), 1.52 (s, 9H), 1.45 (s, 3H), 1.30 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 176.8, 143.7, 128.6, 127.5, 126.6, 88.4, 81.7, 80.1, 71.2, 69.7, 68.3, 66.4, 49.0, 43.4, 35.5, 28.2, 27.1, 25.0.

HRMS (ESI) *m/z* calcd. for $C_{28}H_{32}FeO_2$ $[M]^+$ 456.1746, found 456.1745.

(*R*)-*tert*-Butyl-2,2-dimethyl-4-phenyl-6-(pyridin-3-yl)hex-5-ynoate (55)



55

According to General Procedure **A** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.), 3-ethynylpyridine **2r** (20.6 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **55** as a colorless oil (36.8 mg, 53% yield, 96% ee).

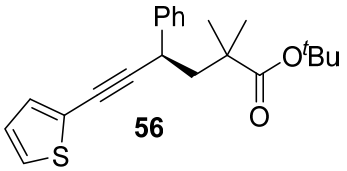
HPLC analysis: Chiralcel IC (*n*-hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 25.53 min, t_R (minor) = 27.43 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.65 (s, 1H), 8.49 (s, 1H), 7.69 (d, *J* = 7.9 Hz, 1H), 7.45 – 7.39 (m, 2H), 7.35 (t, *J* = 7.6 Hz, 2H), 7.28 – 7.24 (m, 1H), 7.24 – 7.17 (m, 1H), 3.91 (dd, *J* = 9.8, 4.3 Hz, 1H), 2.17 (dd, *J* = 13.9, 9.8 Hz, 1H), 2.06 (dd, *J* = 13.9, 4.3 Hz, 1H), 1.43 (s, 9H), 1.35 (s, 3H), 1.24 (s, 3H)

^{13}C NMR (100 MHz, $CDCl_3$) δ 176.6, 152.2, 148.1, 142.7, 138.5, 128.7, 127.4, 126.9, 123.0, 95.9, 80.3, 80.2, 48.4, 43.2, 35.4, 28.1, 26.3, 25.6.

HRMS (ESI) *m/z* calcd. for $C_{23}H_{28}NO_2$ $[M + H]^+$ 350.2115, found 350.2113.

(*R*)-*tert*-Butyl-2,2-dimethyl-4-phenyl-6-(thiophen-2-yl)hex-5-ynoate (56)



56

According to General Procedure **A** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.), 2-ethynylthiophene **2s** (21.6 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **56** as a colorless oil (34.1 mg, 48% yield, 95% ee).

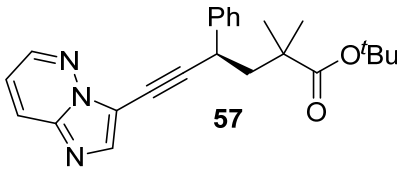
HPLC analysis: Chiralcel IC (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.5 mL/min, λ = 270 nm), t_R (major) = 7.90 min, t_R (minor) = 9.42 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.44 (d, *J* = 7.3 Hz, 2H), 7.36 (t, *J* = 7.6 Hz, 2H), 7.30 – 7.24 (m, 1H), 7.21 (dd, *J* = 5.2, 0.9 Hz, 1H), 7.18 – 7.14 (m, 1H), 6.96 (dd, *J* = 5.1, 3.6 Hz, 1H), 3.93 (dd, *J* = 9.5, 4.3 Hz, 1H), 2.16 (dd, *J* = 13.9, 9.5 Hz, 1H), 2.09 (dd, *J* = 13.9, 4.4 Hz, 1H), 1.47 (s, 9H), 1.37 (s, 3H), 1.25 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 176.6, 142.9, 131.2, 128.7, 127.4, 126.8, 126.8, 126.2, 123.9, 96.2, 80.2, 76.8, 48.5, 43.2, 35.5, 28.1, 26.6, 25.3.

HRMS (ESI) *m/z* calcd. for $C_{22}H_{27}O_2S$ $[M + H]^+$ 355.1726, found 355.1726.

(*R*)-*tert*-Butyl-6-(imidazo[1,2-*b*]pyridazin-3-yl)-2,2-dimethyl-4-phenylhex-5-ynoate (57)



57

According to General Procedure **A** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.), 3-ethynylimidazo[1,2-*b*]pyridazine **2t** (28.6 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **57** as a colorless oil (52.8 mg, 68% yield, 93% ee).

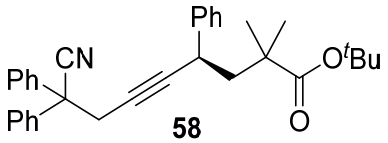
HPLC analysis: Chiralcel OD3 (*n*-hexane/*i*-PrOH = 90/10, flow rate 0.8 mL/min, λ = 254 nm), t_R (major) = 8.28 min, t_R (minor) = 10.19 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.41 (d, *J* = 4.2 Hz, 1H), 7.93 (d, *J* = 9.8 Hz, 2H), 7.51 (d, *J* = 7.4 Hz, 2H), 7.36 (t, *J* = 7.6 Hz, 2H), 7.25 (t, *J* = 7.3 Hz, 1H), 7.05 (dd, *J* = 9.1, 4.4 Hz, 1H), 4.07 (dd, *J* = 9.4, 4.3 Hz, 1H), 2.24 (dd, *J* = 13.9, 9.4 Hz, 1H), 2.16 (dd, *J* = 14.0, 4.3 Hz, 1H), 1.44 (s, 9H), 1.40 (s, 3H), 1.26 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 176.6, 143.6, 142.5, 137.7, 128.7, 127.5, 126.9, 125.7, 117.2, 102.2, 80.2, 70.4, 48.6, 43.3, 35.8, 28.2, 26.7, 25.2.

HRMS (ESI) *m/z* calcd. for $C_{24}H_{28}N_3O_2$ $[M + H]^+$ 390.2176, found 390.2175.

(*R*)-*tert*-Butyl-8-cyano-2,2-dimethyl-4,8,8-triphenyloct-5-ynoate (58)



58

According to General Procedure **A** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.), 2,2-diphenylpent-4-ynenitrile **2u** (46.2 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 24 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **58** as a colorless oil (86.0 mg, 90% yield, 89% ee).

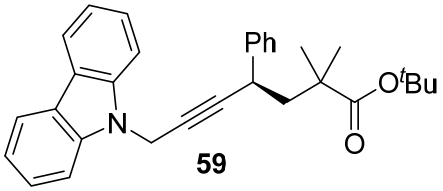
HPLC analysis: Chiralcel ADH (*n*-hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min, λ = 214 nm), t_R (minor) = 7.15 min, t_R (major) = 8.07 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.47 – 7.42 (m, 4H), 7.42 – 7.33 (m, 6H), 7.30 – 7.25 (m, 2H), 7.22 (t, *J* = 6.2 Hz, 3H), 3.59 (dd, *J* = 9.1, 1.8 Hz, 1H), 3.32 (d, *J* = 1.8 Hz, 2H), 1.98 (dd, *J* = 13.9, 4.0 Hz, 1H), 1.90 (dd, *J* = 13.8, 9.4 Hz, 1H), 1.48 (s, 9H), 1.22 (s, 3H), 1.12 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 176.8, 143.1, 139.3, 139.2, 128.9, 128.8, 128.5, 128.2, 128.2, 127.4, 127.3, 127.2, 126.5, 122.0, 87.8, 80.0, 77.6, 51.7, 48.5, 43.2, 34.6, 31.5, 28.1, 26.8, 24.7.

HRMS (ESI) *m/z* calcd. for $C_{33}H_{35}NNaO_2$ $[M + Na]^+$ 500.2560, found 500.2561.

(*R*)-*tert*-Butyl-7-(9*H*-carbazol-9-yl)-2,2-dimethyl-4-phenylhept-5-ynoate (59)



59

According to General Procedure **A** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.), 9-(prop-2-yn-1-yl)-9*H*-carbazole **2v** (41.0 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 24 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **59** as a colorless oil (76.7 mg, 85% yield, 96% ee).

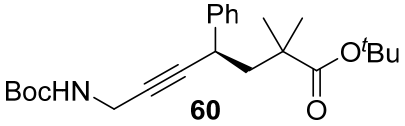
HPLC analysis: Chiralcel ADH (*n*-hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min, λ = 254 nm), t_R (minor) = 5.11 min, t_R (major) = 6.28 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.17 (d, *J* = 7.6 Hz, 2H), 7.62 – 7.47 (m, 4H), 7.38 – 7.39 (m, 6H), 7.29 – 7.22(m, 1H), 5.10 (d, *J* = 1.8 Hz, 2H), 3.73 – 3.64 (m, 1H), 2.01 (d, *J* = 5.3 Hz, 2H), 1.49 (s, 9H), 1.23 (s, 3H), 1.16 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 176.7, 142.8, 140.1, 128.6, 127.4, 126.8, 125.8, 123.3, 120.4, 119.4, 109.1, 86.8, 80.1, 48.3, 43.1, 34.7, 33.0, 28.1, 26.4, 25.2.

HRMS (ESI) *m/z* calcd. for $C_{31}H_{34}NO_2$ $[M + H]^+$ 452.2584, found 452.2584.

(*R*)-*tert*-Butyl-7-((*tert*-butoxycarbonyl)amino)-2,2-dimethyl-4-phenylhept-5-ynoate (60)



60

According to General Procedure **A** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.), *tert*-butyl prop-2-yn-1-ylcarbamate **2w** (31 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 24 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **60** as a colorless oil (76.1 mg, 95% yield, 94% ee).

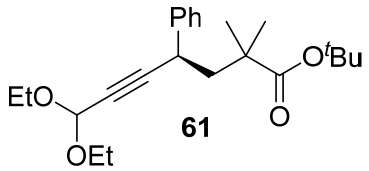
HPLC analysis: Chiralcel IC (*n*-hexane/*i*-PrOH = 97/3, flow rate 1.0 mL/min, λ = 214 nm), t_R (minor) = 19.18 min, t_R (major) = 21.33 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.38 – 7.29 (m, 4H), 7.23 (t, *J* = 6.9 Hz, 1H), 4.81 (s, 1H), 3.92 (s, 2H), 3.71 – 3.63 (m, 1H), 2.08 (dd, *J* = 13.9, 9.9 Hz, 1H), 1.93 (dd, *J* = 13.9, 4.4 Hz, 1H), 1.47 (s, 9H), 1.46 (s, 9H), 1.28 (s, 3H), 1.20 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 176.8, 155.4, 142.9, 128.6, 127.3, 126.7, 85.5, 80.1, 79.7, 79.1, 48.2, 43.0, 34.7, 31.0, 28.4, 28.0, 25.91, 25.85.

HRMS (ESI) *m/z* calcd. for $C_{24}H_{35}NNaO_4$ $[M + Na]^+$ 424.2458, found 424.2458.

(*R*)-*tert*-Butyl-7,7-diethoxy-2,2-dimethyl-4-phenylhept-5-ynoate (61)



61

According to General Procedure **A** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.), 3,3-diethoxyprop-1-yne **2x** (25.6 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 24 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **61** as a colorless oil (57.7 mg, 77% yield, 96% ee).

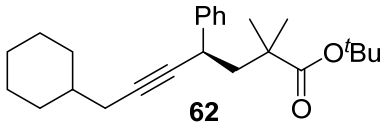
HPLC analysis: Chiralcel ADH (*n*-hexane/*i*-PrOH = 99.3/0.7 flow rate 1.0 mL/min, λ = 214 nm), t_R (major) = 5.82 min, t_R (minor) = 6.57 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.35 (d, *J* = 7.1 Hz, 2H), 7.30 (t, *J* = 7.5 Hz, 2H), 7.21 (t, *J* = 7.2 Hz, 1H), 5.28 (d, *J* = 1.3 Hz, 1H), 3.77 – 3.67 (m, 3H), 3.61 – 3.52 (m, 2H), 2.13 – 1.96 (m, 2H), 1.43 (s, 9H), 1.30 (s, 3H), 1.21 (t, *J* = 7.1 Hz, 6H), 1.16 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 176.5, 142.6, 128.6, 127.5, 126.6, 91.6, 88.3, 80.1, 78.8, 60.73, 60.67, 48.2, 43.1, 34.6, 28.1, 26.7, 25.0, 15.1.

HRMS (ESI) *m/z* calcd. for $C_{23}H_{34}NaO_4$ $[M + Na]^+$ 397.2349, found 397.2348.

(*R*)-*tert*-Butyl-7-cyclohexyl-2,2-dimethyl-4-phenylhept-5-ynoate (62)



62

According to General Procedure **A** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.), prop-2-yn-1-ylcyclo*n*-hexane **2y** (24.4 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 24 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **62** as a colorless oil (53.1 mg, 72% yield, 95% ee).

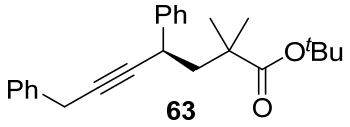
HPLC analysis: Chiralcel OD3 (*n*-hexane/*i*-PrOH = 99.3/0.7, flow rate 1.0 mL/min, λ = 214 nm), t_R (major) = 4.57 min, t_R (minor) = 5.21 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.29 (d, *J* = 7.5 Hz, 2H), 7.22 (t, *J* = 7.6 Hz, 2H), 7.12 (t, *J* = 7.3 Hz, 1H), 3.60 – 3.50 (m, 1H), 2.00 (d, *J* = 2.1 Hz, 1H), 1.99 (d, *J* = 2.1 Hz, 1H), 1.96 – 1.84 (m, 2H), 1.71 (d, *J* = 11.1 Hz, 2H), 1.67 – 1.51 (m, 3H), 1.42 – 1.31 (m, 10H), 1.22 (s, 3H), 1.20 – 1.12 (m, 2H), 1.10 (s, 3H), 1.09 – 0.98 (m, 1H), 0.97 – 0.84 (m, 2H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 176.8, 144.2, 128.4, 127.4, 126.4, 83.1, 82.4, 79.9, 49.0, 43.2, 37.6, 34.8, 32.8, 28.1, 26.9, 26.5, 26.4, 26.2, 25.3.

HRMS (ESI) *m/z* calcd. for $C_{25}H_{36}NaO_2$ $[M + Na]^+$ 391.2608, found 391.2605.

(*R*)-*tert*-Butyl-2,2-dimethyl-4,7-diphenylhept-5-ynoate (63)



63

According to General Procedure **A** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.), prop-2-yn-1-ylbenzene **2z** (23.2 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 24 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **63** as a colorless oil (41.4 mg, 57% yield, 95% ee).

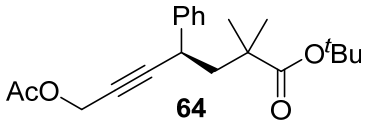
HPLC analysis: Chiralcel ADH (*n*-hexane/*i*-PrOH = 99.3/0.7 flow rate 1.0 mL/min, λ = 214 nm), t_R (minor) = 6.00 min, t_R (major) = 6.49min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.43 (d, *J* = 7.4 Hz, 2H), 7.39 – 7.31 (m, 6H), 7.25 (t, *J* = 7.3 Hz, 2H), 3.78 – 3.71 (m, 1H), 3.65 (d, *J* = 1.8 Hz, 2H), 2.10 (d, *J* = 9.6 Hz, 1H), 2.01 (dd, *J* = 13.9, 4.3 Hz, 1H), 1.48 (s, 9H), 1.33 (s, 3H), 1.22 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 176.8, 143.8, 137.3, 128.5, 128.4, 127.9, 127.4, 126.6, 126.4, 84.7, 80.8, 80.0, 48.7, 43.1, 34.9, 28.1, 26.3, 25.6, 25.4.

HRMS (ESI) *m/z* calcd. for $C_{25}H_{30}NaO_2$ $[M + Na]^+$ 385.2138, found 385.2137.

(*R*)-*tert*-Butyl-7-acetoxy-2,2-dimethyl-4-phenylhept-5-ynoate (64)



64

According to General Procedure **A** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.), prop-2-yn-1-yl acetate **2za** (19.6 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 24 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **64** as a colorless oil (67.9 mg, 99% yield, 94% ee).

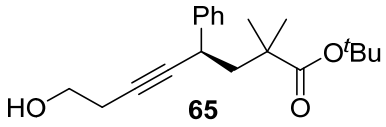
HPLC analysis: Chiralcel IC (*n*-hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min, λ = 214 nm), t_R (minor) = 7.28 min, t_R (major) = 7.77 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.39 – 7.30 (m, 4H), 7.24 (ddd, *J* = 8.4, 3.2, 1.6 Hz, 1H), 4.71 (d, *J* = 2.1 Hz, 2H), 3.73 (dtd, *J* = 6.3, 4.1, 1.9 Hz, 1H), 2.13 – 2.05 (m, 4H), 1.99 (dd, *J* = 13.9, 4.4 Hz, 1H), 1.47 (s, 9H), 1.30 (s, 3H), 1.20 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 176.6, 170.3, 142.6, 128.6, 127.4, 126.8, 89.4, 80.1, 77.0, 52.8, 48.2, 43.1, 34.7, 28.0, 26.3, 25.4, 20.8.

HRMS (ESI) *m/z* calcd. for $C_{21}H_{28}NaO_4$ $[M + Na]^+$ 367.1880, found 367.1879.

(*R*)-*tert*-Butyl-8-hydroxy-2,2-dimethyl-4-phenyloct-5-ynoate (65)



65

According to General Procedure **A** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.),

but-3-yn-1-ol **2zb** (14 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 24 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **65** as a colorless oil (56.9 mg, 90% yield, 97% ee).

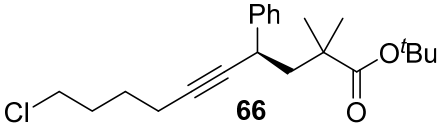
HPLC analysis: Chiralcel IB (*n*-hexane/*i*-PrOH = 99/1, flow rate 1.0 mL/min, λ = 214 nm), t_R (major) = 12.70 min, t_R (minor) = 15.55 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40 – 7.30 (m, 4H), 7.27 – 7.19 (m, 1H), 3.76 – 3.67 (m, 3H), 2.46 (td, *J* = 6.2, 2.2 Hz, 3H), 2.10 (dd, *J* = 13.9, 10.2 Hz, 1H), 1.90 (dd, *J* = 13.9, 4.5 Hz, 1H), 1.49 (s, 9H), 1.30 (s, 3H), 1.23 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 177.0, 143.5, 128.6, 127.3, 126.7, 84.1, 80.2, 80.2, 61.3, 48.4, 43.0, 34.8, 28.1, 26.3, 25.7, 23.5.

HRMS (ESI) *m/z* calcd. for $C_{20}H_{28}NaO_3$ $[M + Na]^+$ 339.1931, found 339.1931.

(*R*)-*tert*-Butyl-10-chloro-2,2-dimethyl-4-phenyldec-5-ynoate (66)



According to General Procedure **A** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.), 6-chlorohex-1-yne **2zc** (23.3 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 36 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **66** as a colorless oil (50.6 mg, 70% yield, 94% ee).

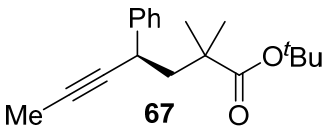
HPLC analysis: Chiralcel OZ3 (*n*-hexane/*i*-PrOH = 99.5/0.5, flow rate 0.5 mL/min, λ = 214 nm), t_R (major) = 8.35 min, t_R (minor) = 8.90 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40 – 7.31 (m, 4H), 7.26 – 7.21 (m, 1H), 3.66 (dtd, *J* = 6.4, 4.2, 2.0 Hz, 1H), 3.58 (t, *J* = 6.6 Hz, 2H), 2.26 (td, *J* = 7.0, 2.2 Hz, 2H), 2.04 (dd, *J* = 13.8, 9.6 Hz, 1H), 1.96 (dd, *J* = 13.8, 4.4 Hz, 1H), 1.93 – 1.86 (m, 2H), 1.74 – 1.66 (m, 2H), 1.48 (s, 9H), 1.32 (s, 3H), 1.21 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 176.8, 143.9, 128.5, 127.3, 126.5, 83.1, 82.5, 79.9, 48.7, 44.6, 43.1, 34.8, 31.7, 28.1, 26.3, 26.0, 25.5, 18.3.

HRMS (ESI) *m/z* calcd. for $C_{22}H_{31}ClNaO_2$ $[M + Na]^+$ 385.1905, found 385.1904.

(*R*)-*tert*-Butyl-2,2-dimethyl-4-phenylhept-5-ynoate (67)

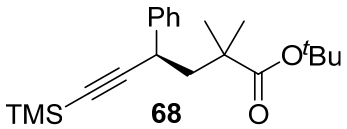


According to General Procedure **A** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.), prop-1-yne **2zd** (0.2 mL, 1 mol/L in THF, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 24 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **67** as a colorless oil (37.9 mg, 66% yield, 95% ee).

HPLC analysis: Chiralcel OD3 (*n*-hexane/*i*-PrOH = 99.3/0.7, flow rate 1.0 mL/min, λ

= 214 nm), t_R (major) = 5.55 min, t_R (minor) = 6.48 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.41 – 7.30 (m, 4H), 7.26 – 7.21 (m, 1H), 3.65 (dtd, *J* = 9.0, 4.5, 2.2 Hz, 1H), 2.10 (dd, *J* = 13.8, 10.0 Hz, 1H), 1.90 (dd, *J* = 13.8, 4.4 Hz, 1H), 1.83 (d, *J* = 2.4 Hz, 3H), 1.48 (s, 9H), 1.29 (s, 3H), 1.22 (s, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 176.8, 143.9, 128.5, 127.4, 126.5, 81.2, 79.9, 78.8, 48.5, 43.0, 34.8, 28.1, 26.0, 25.7, 3.8.
HRMS (ESI) *m/z* calcd. for $C_{19}H_{26}NaO_2$ $[M + Na]^+$ 309.1825, found 309.1824.

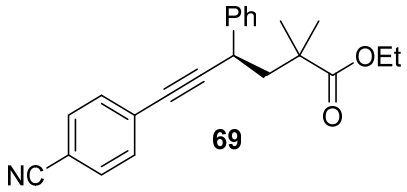
(*R*)-*tert*-Butyl-2,2-dimethyl-4-phenyl-6-(trimethylsilyl)hex-5-ynoate (68)



According to General Procedure **A** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.), ethynyltrimethylsilane **2ze** (19.6 mg, 0.20 mmol, 1.0 equiv.), and *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.) after 24 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **68** as a colorless oil (62.1 mg, 90% yield, 96% ee).
HPLC analysis: Chiralcel OD3 (*n*-hexane/*i*-PrOH = 100/0, flow rate 0.5 mL/min, λ = 214 nm), t_R (major) = 11.06 min, t_R (minor) = 12.14 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.24 – 7.18 (m, 2H), 7.15 (t, *J* = 7.6 Hz, 2H), 7.08 – 7.02 (m, 1H), 3.52 (dd, *J* = 9.4, 4.0 Hz, 1H), 1.88 (dd, *J* = 13.9, 4.0 Hz, 1H), 1.79 (dd, *J* = 13.9, 9.5 Hz, 1H), 1.29 (s, 9H), 1.18 (s, 3H), 1.02 (s, 3H), 0.00 (s, 9H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 176.7, 143.0, 128.5, 127.4, 126.6, 109.3, 87.6, 80.1, 48.9, 43.4, 35.6, 28.1, 27.3, 24.5, 0.0.
HRMS (ESI) *m/z* calcd. for $C_{21}H_{32}NaO_2Si$ $[M + Na]^+$ 367.2064, found 367.2063.

Substrates scope of other radical precursors

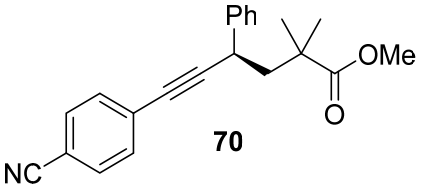
(*R*)-Ethyl-6-(4-cyanophenyl)-2,2-dimethyl-4-phenylhex-5-ynoate (69)



According to General Procedure **A** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.), 4-ethynylbenzonitrile **2a** (25.4 mg, 0.20 mmol, 1.0 equiv.), and ethyl 2-bromo-2-methylpropanoate **3b** (46.8 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **69** as a colorless oil (53.9 mg, 78% yield, 93% ee).
HPLC analysis: Chiralcel IC (*n*-hexane/*i*-PrOH = 96/4, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 17.75 min, t_R (minor) = 21.01 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.56 (d, *J* = 8.3 Hz, 2H), 7.49 (d, *J* = 8.0 Hz, 2H), 7.42 – 7.31 (m, 4H), 7.29 – 7.23 (m, 1H), 4.03 – 3.89 (m, 3H), 2.30 (dd, *J* = 13.8, 10.1 Hz,

1H), 2.00 (dd, *J* = 13.9, 4.7 Hz, 1H), 1.32 (d, *J* = 5.8 Hz, 6H), 1.19 (t, *J* = 7.1 Hz, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 177.2, 141.9, 132.1, 131.9, 128.8, 128.6, 127.4, 127.1, 118.6, 111.2, 96.4, 82.2, 60.5, 48.4, 42.1, 35.3, 26.5, 25.2, 14.1.
HRMS (ESI) *m/z* calcd. for $C_{23}H_{24}NO_2$ $[M + H]^+$ 346.1802, found 346.1802.

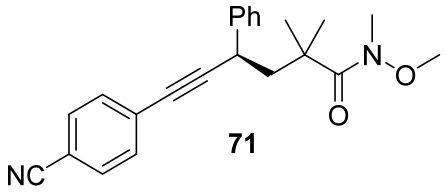
(*R*)-Methyl-6-(4-cyanophenyl)-2,2-dimethyl-4-phenylhex-5-ynoate (70)



70

According to General Procedure **A** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.), 4-ethynylbenzonitrile **2a** (25.4 mg, 0.20 mmol, 1.0 equiv.), and methyl 2-chloro-2-methylpropanoate **3c** (32.8 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **70** as a colorless oil (33.9 mg, 51% yield, 93% ee).
HPLC analysis: Chiralcel IC (*n*-hexane/*i*-PrOH = 98/2, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 21.64 min, t_R (minor) = 24.86 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.60 (d, *J* = 8.4 Hz, 2H), 7.52 (d, *J* = 8.4 Hz, 2H), 7.44 – 7.34 (m, 4H), 7.31 – 7.25 (m, 1H), 3.95 (dd, *J* = 10.0, 4.8 Hz, 1H), 3.55 (s, 3H), 2.34 (dd, *J* = 13.9, 10.1 Hz, 1H), 2.01 (dd, *J* = 13.9, 4.8 Hz, 1H), 1.35 (d, *J* = 1.0 Hz, 6H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 177.7, 141.8, 132.1, 132.0, 128.8, 128.6, 127.4, 127.1, 118.6, 111.2, 96.2, 82.2, 51.8, 48.5, 42.1, 35.3, 26.7, 25.0.
HRMS (ESI) *m/z* calcd. for $C_{22}H_{22}NO_2$ $[M + H]^+$ 332.1645, found 332.1645.

(*R*)-6-(4-Cyanophenyl)-*N*-methoxy-*N*,2,2-trimethyl-4-phenylhex-5-ynamide (71)

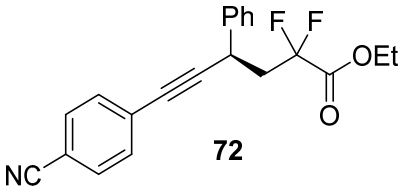


71

According to General Procedure **B** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.), 4-ethynylbenzonitrile **2a** (25.4 mg, 0.20 mmol, 1.0 equiv.), and 2-bromo-*N*-methoxy-*N*,2-dimethylpropanamide **3d** (50.4 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **71** as a colorless oil (53.1 mg, 74% yield, 94% ee).
HPLC analysis: Chiralcel OJH (*n*-hexane/*i*-PrOH = 90/10, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 16.06 min, t_R (minor) = 32.47 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.59 (d, *J* = 8.4 Hz, 2H), 7.52 (d, *J* = 8.4 Hz, 2H), 7.43 (d, *J* = 7.3 Hz, 2H), 7.37 (t, *J* = 7.6 Hz, 2H), 7.30 – 7.24 (m, 1H), 3.98 (dd, *J* = 9.8, 4.4 Hz, 1H), 3.69 (s, 3H), 3.07 (s, 3H), 2.41 (dd, *J* = 13.9, 9.8 Hz, 1H), 2.13 (dd, *J* = 13.9, 4.4 Hz, 1H), 1.43 (s, 3H), 1.37 (s, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 177.5, 142.3, 132.1, 131.9, 128.9, 128.7, 127.5, 127.0, 118.6, 111.0, 97.2, 82.1, 60.5, 48.0, 43.1, 35.2, 33.8, 26.2, 26.1.

HRMS (ESI) *m/z* calcd. for $C_{23}H_{25}N_2O_2$ $[M + H]^+$ 361.1911, found 361.1910.

(*R*)-Ethyl-6-(4-cyanophenyl)-2,2-difluoro-4-phenylhex-5-ynoate (72)



72

According to General Procedure **B** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.), 4-ethynylbenzonitrile **2a** (25.4 mg, 0.20 mmol, 1.0 equiv.), and ethyl 2-bromo-2,2-difluoroacetate **3e** (48.7 mg, 0.24 mmol, 1.2 equiv.) after 48 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **72** as a colorless oil (18.8 mg, 53% yield based on recovered **2a**, 92% ee).

HPLC analysis: Chiralcel AD3 (*n*-hexane/*i*-PrOH = 97/3, flow rate 0.5 mL/min, λ = 254 nm), t_R (minor) = 36.34 min, t_R (major) = 47.91 min.

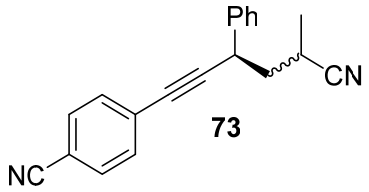
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.61 (d, *J* = 8.4 Hz, 2H), 7.53 (d, *J* = 8.4 Hz, 2H), 7.46 – 7.37 (m, 4H), 7.36 – 7.31 (m, 1H), 4.28 – 4.12 (m, 3H), 2.80 (dtd, *J* = 16.9, 14.6, 9.4 Hz, 1H), 2.62 (qd, *J* = 14.9, 5.3 Hz, 1H), 1.30 (t, *J* = 7.1 Hz, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 163.6 (t, *J* = 32.3 Hz), 139.4, 132.2, 132.0, 129.0, 128.0, 127.8, 127.4, 118.5, 114.8 (dd, *J* = 252.3, 251.1 Hz), 111.6, 93.9, 82.6, 63.1, 42.4 (t, *J* = 23.2 Hz), 32.2 (t, *J* = 5.2 Hz), 13.9.

^{19}F NMR (376 MHz, $CDCl_3$) δ −103.47 (dt, *J* = 265.1, 14.7 Hz, 1F), −105.26 (dt, *J* = 265.1, 16.2 Hz, 1F).

HRMS (ESI) *m/z* calcd. for $C_{21}H_{17}F_2NNaO_2$ $[M + Na]^+$ 376.1120, found 376.1119.

4-((3*R*)-5-Cyano-3-phenylhex-1-yn-1-yl)benzonitrile (73)



73

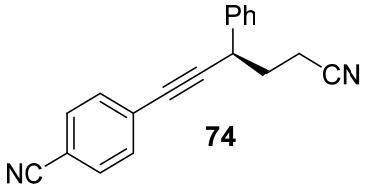
According to General Procedure **B** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.), 4-ethynylbenzonitrile **2a** (25.4 mg, 0.20 mmol, 1.0 equiv.), and 2-chloropropanenitrile **3f** (21.5 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **73** as a colorless oil (diastereomeric mixture, 22.8 mg, 40% yield, 1.3:1.0 dr, 91% ee_1, 94% ee_2).

HPLC analysis: Chiralcel AD3 (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.5 mL/min, λ = 254 nm), t_R ($minor_1$) = 26.40 min, t_R ($minor_2$) = 27.86 min, t_R ($major_1$) = 32.55 min, t_R ($major_2$) = 73.71 min.

^{1}H NMR (400 MHz, $CDCl_3$) (diastereomeric mixture) δ 7.63 (dd, *J* = 8.1, 5.6 Hz, 2H), 7.55 (dd, *J* = 11.3, 8.3 Hz, 2H), 7.45 – 7.38 (m, 4H), 7.37 – 7.31 (m, 1H), 4.19 (dd, *J* = 10.9, 4.7 Hz, 0.58H), 4.06 (dd, *J* = 8.6, 7.1 Hz, 0.42H), 3.10 – 2.97 (m, 0.63H), 2.65 – 2.52 (m, 0.45H), 2.34 (ddd, *J* = 13.6, 9.2, 7.0 Hz, 0.49H), 2.18 – 2.08 (m, 0.74H), 2.06 – 1.94 (m, 1H), 1.44 (s, 0.86H), 1.42 (s, 0.86H), 1.40 (s, 0.65H), 1.38 (s, 0.65H).

^{13}C NMR (100 MHz, $CDCl_3$) (diastereomeric mixture) δ 139.7, 139.2, 132.30, 132.2, 132.0, 132.0, 129.1, 129.0, 128.0, 127.9, 127.8, 127.6, 127.5, 127.2, 122.2, 118.4, 111.7, 111.6, 94.5, 93.7, 83.4, 82.3, 42.6, 41.9, 36.9, 36.4, 24.4, 23.6, 18.3, 17.9.
HRMS (ESI) *m/z* calcd. for $C_{20}H_{17}N_2$ $[M + H]^+$ 285.1386, found 285.1387.

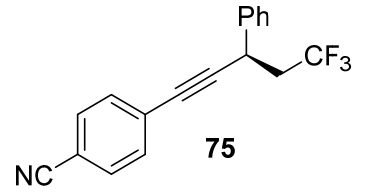
(*R*)-4-(5-Cyano-3-phenylpent-1-yn-1-yl)benzonitrile (74)



74

According to General Procedure **B** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.), 4-ethynylbenzonitrile **2a** (25.4 mg, 0.20 mmol, 1.0 equiv.), and 2-bromoacetonitrile **3g** (28.8 mg, 0.24 mmol, 1.2 equiv.) after 48 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **74** as a colorless oil (18.8 mg, 70% yield based on recovered **2a**, 95% ee).
HPLC analysis: Chiralcel OJH (*n*-hexane/*i*-PrOH = 85/15, flow rate 1.0 mL/min, λ = 254 nm), t_R (major) = 49.59 min, t_R (minor) = 61.27 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.64 – 7.58 (m, 2H), 7.57 – 7.50 (m, 2H), 7.43 – 7.36 (m, 4H), 7.34 – 7.31 (m, 1H), 4.07 (t, *J* = 7.2 Hz, 1H), 2.61 – 2.50 (m, 1H), 2.44 (dt, *J* = 16.9, 6.9 Hz, 1H), 2.24 – 2.16 (m, 2H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 138.9, 132.3, 132.1, 129.1, 127.8, 127.4, 119.0, 118.4, 111.7, 93.6, 83.3, 37.3, 33.4, 15.2.
HRMS (ESI) *m/z* calcd. for $C_{19}H_{15}N_2$ $[M + H]^+$ 271.1230, found 271.1228.

(*R*)-4-(5,5,5-Trifluoro-3-phenylpent-1-yn-1-yl)benzonitrile (75)

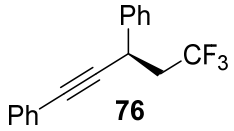


75

According to General Procedure **B** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.), 4-ethynylbenzonitrile **2a** (25.4 mg, 0.20 mmol, 1.0 equiv.), and 1-(trifluoromethyl)-1λ^3-benzo[*d*][1,2]iodaoxol-3(1*H*)-one **3h** (75.8 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **75** as a colorless oil (42.3 mg, 71% yield, 96% ee).
HPLC analysis: Chiralcel AD3 (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.5 mL/min, λ = 254 nm), t_R (minor) = 19.92 min, t_R (major) = 26.54 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.62 (d, *J* = 8.4 Hz, 2H), 7.54 (d, *J* = 8.4 Hz, 2H), 7.48 – 7.40 (m, 4H), 7.39 – 7.32 (m, 1H), 4.26 (dd, *J* = 9.4, 5.2 Hz, 1H), 2.85 – 2.69 (m, 1H), 2.70 – 2.55 (m, 1H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 139.0, 132.2, 132.0, 129.1, 127.93, 127.91, 127.3, 125.6 (q, *J* = 277.9 Hz), 118.5, 111.7, 93.2, 82.72, 41.9 (q, *J* = 27.8 Hz), 32.6 (q, *J* = 3.2 Hz).
^{19}F NMR (376 MHz, $CDCl_3$) δ −64.37 (t, *J* = 10.2 Hz, 3F).

HRMS (ESI) *m/z* calcd. for $C_{18}H_{13}F_3N$ $[M + H]^+$ 300.0995, found 300.0994.

(*R*)-(5,5,5-Trifluoropent-1-yne-1,3-diyl)dibenzene (76)



76

According to General Procedure **B** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.), ethynylbenzene **2a** (20.4 mg, 0.20 mmol, 1.0 equiv.), and 1-(trifluoromethyl)-1λ^3-benzo[*d*][1,2]iodaoxol-3(1*H*)-one **3h** (75.8 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was purified by column chromatography on silica gel to yield the product **76** as a colorless oil (37.8 mg, 69% yield, 98% ee).

HPLC analysis: Chiralcel ADH (*n*-hexane/*i*-PrOH = 100/0, flow rate 0.5 mL/min, λ = 240 nm), t_R (minor) = 14.38 min, t_R (major) = 16.09 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.55 – 7.45 (m, 4H), 7.43 (t, *J* = 7.5 Hz, 2H), 7.38 – 7.30 (m, 4H), 4.25 (dd, *J* = 9.0, 5.4 Hz, 1H), 2.85 – 2.70 (m, 1H), 2.69 – 2.54 (m, 1H).

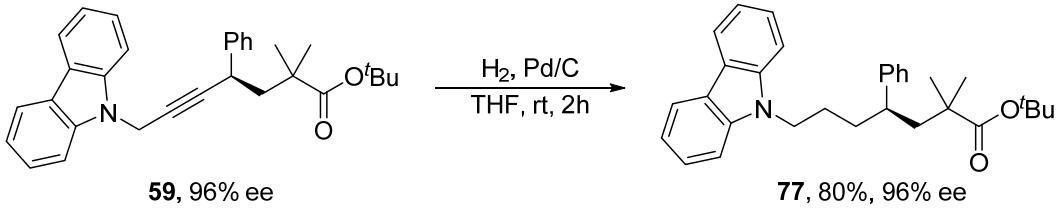
^{13}C NMR (100 MHz, $CDCl_3$) δ 138.7, 130.6, 127.9, 127.23, 127.17, 126.6, 126.3, 124.6 (q, *J* = 277.8 Hz), 122.0, 87.4, 83.1, 41.2 (q, *J* = 27.6 Hz), 31.5 (q, *J* = 3.0 Hz).

^{19}F NMR (376 MHz, $CDCl_3$) δ −64.30 (t, *J* = 10.2 Hz, 3F).

HRMS (ESI) *m/z* calcd. for $C_{17}H_{14}F_3$ $[M + H]^+$ 275.1042, found 275.1040.

Transformations

Synthesis of 77

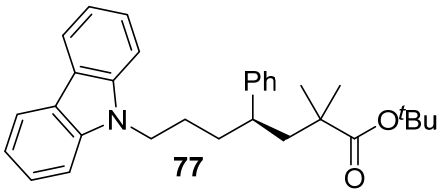


59, 96% ee

77, 80%, 96% ee

To a mixture of Pd/C (10.0 mg, 10% w/w Pd on carbon) in THF (2.0 mL) was added **59** (90.2 mg, 0.20 mmol, 1.0 equiv., 96% ee) under argon atmosphere. Then, the reaction flask was evacuated and refilled with hydrogen through a balloon. The resulting reaction mixture was stirred under the hydrogen atmosphere at room temperature for 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 to afford **77** as a colorless oil (72.9 mg, 80% yield, 96% ee).

(*R*)-*tert*-Butyl-7-(9*H*-carbazol-9-yl)-2,2-dimethyl-4-phenylheptanoate (77)



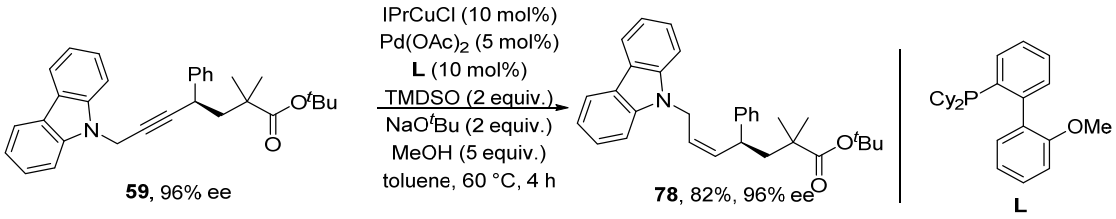
HPLC analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.5 mL/min, λ = 254 nm), t_R (minor) = 18.42 min, t_R (major) = 20.46 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.14 (d, *J* = 7.7 Hz, 2H), 7.52 – 7.43 (m, 2H), 7.36 – 7.12 (m, 9H), 4.30 – 4.14 (m, 2H), 2.63 (tt, *J* = 8.9, 4.5 Hz, 1H), 1.97 (dd, *J* = 14.1, 8.2 Hz, 1H), 1.91 (dd, *J* = 14.1, 4.3 Hz, 1H), 1.84 – 1.58 (m, 4H), 1.35 (s, 9H), 1.09 (s, 3H), 0.97 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 177.1, 145.7, 140.3, 128.5, 128.0, 126.3, 125.6, 122.8, 120.3, 118.7, 108.7, 79.8, 47.3, 43.01, 42.97, 36.3, 27.9, 26.8, 25.4.

HRMS (ESI) *m/z* calcd. for $C_{31}H_{38}NO_2$ $[M + H]^+$ 456.2897, found 456.2896.

Synthesis of 78



59, 96% ee

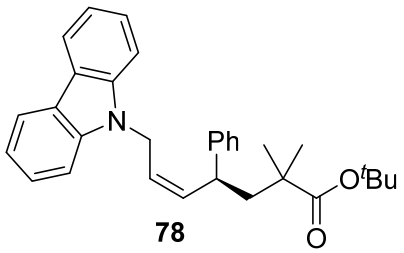
78, 82%, 96% ee

L

To a flamed Schlenk tube charged with a stir bar were added NaO^{t}Bu (38.4 mg, 0.40 mmol, 2.0 equiv.), **59** (90.2 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 (32.0 mg, 1.0 mmol, 5.0 equiv.), and toluene (2.0 mL). The reaction mixture was stirred at 60 °C for 4 h. Upon completion, the reaction mixture was filtered through a short plug of silica gel eluted with EtOAc (3 mL) and purified by column chromatography to afford **78** as a slight yellow oil (74.1 mg, 82% yield, 96% ee).

(*S*, *Z*)-*tert*-Butyl-7-(9*H*-carbazol-9-yl)-2,2-dimethyl-4-phenylhept-5-enoate (78)



78

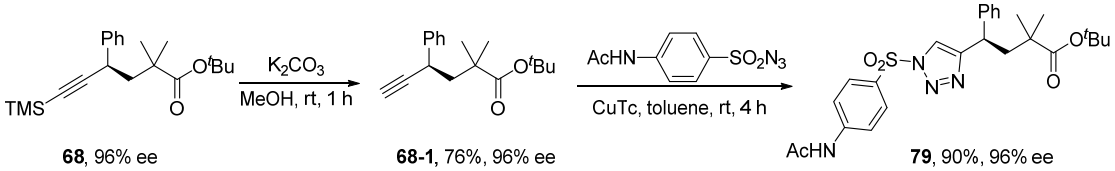
HPLC analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.5 mL/min, λ = 254 nm), t_R (minor) = 14.85 min, t_R (major) = 25.26 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.14 (d, *J* = 7.1 Hz, 2H), 7.52 – 7.32 (m, 7H), 7.32 – 7.11 (m, 4H), 5.99 – 5.81 (m, 1H), 5.47 (dt, *J* = 10.9, 5.6 Hz, 1H), 5.11 (dd, *J* = 16.9, 5.0 Hz, 1H), 4.97 (dd, *J* = 16.9, 6.7 Hz, 1H), 4.01 (dd, *J* = 13.6, 8.7 Hz, 1H), 2.23 (dd, *J* = 13.9, 8.5 Hz, 1H), 2.11 (dd, *J* = 13.9, 4.9 Hz, 1H), 1.54 (s, 9H), 1.32 (s, 3H), 1.27 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 176.9, 145.4, 140.3, 136.7, 128.9, 127.5, 126.5, 125.7, 125.5, 123.0, 120.3, 119.0, 108.9, 80.2, 48.2, 43.0, 41.5, 40.6, 28.2, 27.0, 25.8.

HRMS (ESI) *m/z* calcd. for $C_{31}H_{36}NO_2$ $[M + H]^+$ 454.2741, found 454.2742.

Synthesis of 79

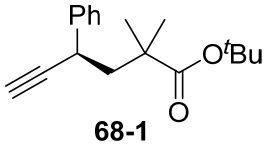


68, 96% ee **68-1**, 76%, 96% ee **79**, 90%, 96% ee

To a solution of **68** (69 mg, 0.20 mmol, 1.0 equiv., 96% ee) in MeOH (2.0 mL) was added K_2CO_3 (55.2 mg, 0.40 mmol, 2.0 equiv.) and the resulting mixture was stirred at room temperature for 1 h. After completion of the reaction (monitored by TLC), the mixture was concentrated under reduced pressure and purified by column chromatography to yield **68-1** as a colorless oil (41.4 mg, 76% yield, 96% ee).

To a solution of the thus-obtained **68-1** in toluene (2.0 mL) were added 4-acetamidobenzenesulfonyl azide (36 mg, 0.15 mmol, 1.0 equiv.) and copper thiophene-2-carboxylate (1.42 mg, 0.0075 mmol, 5.0 mol%) under argon atmosphere. The reaction mixture was stirred under the same conditions for 4 h, and then, was concentrated under reduced pressure. The residue was purified by column chromatography on silica gel to yield the product **79** as a yellow oil (69.3 mg, 90% yield, 96% ee).

(*S*)-*tert*-Butyl-2,2-dimethyl-4-phenylhex-5-ynoate (68-1)



68-1

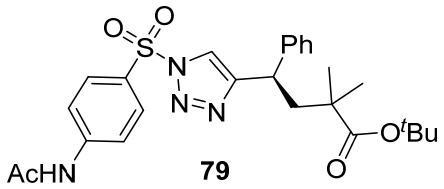
HPLC analysis: Chiralcel OJH (*n*-hexane/*i*-PrOH = 99/1, flow rate 0.4 mL/min, λ = 214 nm), t_R (major) = 11.20 min, t_R (major) = 13.76 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.29 (d, *J* = 7.4 Hz, 2H), 7.23 (t, *J* = 7.6 Hz, 2H), 7.17 – 7.11 (m, 1H), 3.59 (ddd, *J* = 9.8, 4.1, 2.7 Hz, 1H), 2.15 (d, *J* = 2.5 Hz, 1H), 2.06 (dd, *J* = 13.9, 9.9 Hz, 1H), 1.84 (dd, *J* = 13.9, 4.3 Hz, 1H), 1.37 (s, 9H), 1.20 (s, 3H), 1.12 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 176.6, 142.7, 128.6, 127.4, 126.8, 86.4, 80.1, 71.7, 48.1, 43.0, 34.5, 28.0, 26.0, 25.8.

HRMS (ESI) *m/z* calcd. for $C_{18}H_{24}NaO_2$ $[M + Na]^+$ 295.1669, found 295.1669.

(*R*)-*tert*-Butyl-4-(1-((4-acetamidophenyl)sulfonyl)-1*H*-1,2,3-triazol-4-yl)-2,2-dimethyl-4-phenylbutanoate (79)



79

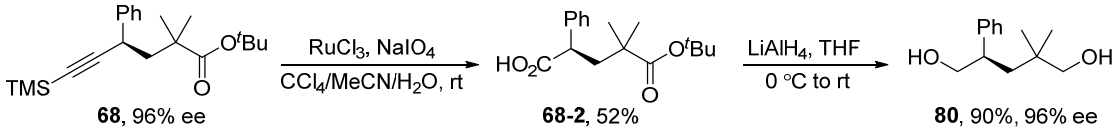
HPLC analysis: Chiralcel ADH (*n*-hexane/*i*-PrOH = 90/10, flow rate 1.0 mL/min, λ = 280 nm), t_R (minor) = 14.18 min, t_R (major) = 17.62 min.

^{1}H NMR (400 MHz, $CDCl_3$) δ 8.41 (s, 1H), 7.89 (d, *J* = 8.9 Hz, 2H), 7.77 (s, 1H), 7.65 (d, *J* = 8.9 Hz, 2H), 7.33 – 7.24 (m, 4H), 7.22 – 7.17 (m, 1H), 4.22 – 4.12 (m, 1H), 2.52 (dd, *J* = 14.2, 5.8 Hz, 1H), 2.31 (dd, *J* = 14.1, 7.5 Hz, 1H), 2.18 (s, 3H), 1.31 (s, 9H), 1.03 (s, 3H), 1.01 (s, 3H).

^{13}C NMR (100 MHz, $CDCl_3$) δ 176.5, 169.3, 152.2, 145.1, 142.8, 130.1, 129.3, 128.9, 128.0, 127.1, 120.8, 119.5, 80.3, 45.5, 43.0, 40.2, 27.9, 26.1, 26.0, 24.7.

HRMS (ESI) *m/z* calcd. for $C_{26}H_{33}N_4O_5S$ $[M + H]^+$ 513.2166, found 513.2169.

Synthesis of 80



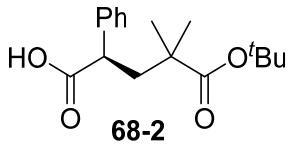
68, 96% ee **68-2**, 52% **80**, 90%, 96% ee

To a mixture of $RuCl_3$ (1.5 mg, 0.010 mmol, 5.0 mol%) and sodium periodate (171.0 mg, 0.80 mmol, 4.0 equiv.) in a mixed solvent of CCl_4 (0.4 mL) and water (0.6 mL) was added a solution of **68** (68.8 mg, 0.20 mmol, 1.0 equiv.) in MeCN (0.4 mL) in one portion. The reaction mixture was stirred at room temperature for 2 h, and then, was concentrated. The residue was purified by column chromatography on silica gel to afford the product **68-2** as a white solid (30.4 mg, 52% yield).

To a solution of **68-2** in anhydrous THF was added $LiAlH_4$ (15.2 mg, 0.40 mmol, 4.0

equiv.) powder slowly at 0 °C. Then it was stirred at room temperature for 4 h. Upon completion (monitored by TLC), the reaction was quenched with wet Na_2SO_4 (0.2 mL water per gram) and filtered, and the solid was washed with THF. The organic phase was concentered and purified with by column chromatography on silica gel to afford the product **80** as a colorless oil (18.7 mg, 90% yield, 96% ee).

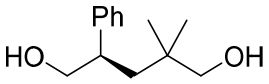
(*R*)-5-(*tert*-Butoxy)-4,4-dimethyl-5-oxo-2-phenylpentanoic acid (68-2)



68-2

^{1}H NMR (400 MHz, $CDCl_3$) δ 7.40 – 7.14 (m, 5H), 3.63 (dd, *J* = 8.0, 4.3 Hz, 1H), 2.50 (dd, *J* = 14.2, 8.1 Hz, 1H), 2.00 (dd, *J* = 14.2, 4.3 Hz, 1H), 1.41 (s, 9H), 1.17 (s, 3H), 1.11 (s, 3H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 180.1, 176.5, 139.7, 128.7, 128.0, 127.4, 80.4, 48.5, 43.1, 43.0, 27.9, 26.0, 24.8.
HRMS (ESI) *m/z* calcd. for $C_{17}H_{24}NaO_4$ $[M + Na]^+$ 315.1567, found 315.1566.

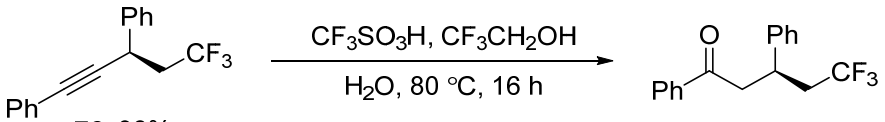
(*R*)-2,2-dimethyl-4-phenylpentane-1,5-diol (80)



80

HPLC analysis: Chiralcel ADH (*n*-hexane/*i*-PrOH = 85/15, flow rate 0.6 mL/min, λ = 214 nm), t_R (major) = 10.60 min, t_R (minor) = 11.51 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.35 – 7.30 (m, 2H), 7.27 – 7.20 (m, 3H), 3.65 (dd, *J* = 7.2, 1.1 Hz, 2H), 3.29 (d, *J* = 11.0 Hz, 1H), 3.16 (d, *J* = 11.0 Hz, 1H), 2.95 – 2.81 (m, 1H), 1.75 (brs, 2H), 1.73 (s, 1H), 1.71 (d, *J* = 1.9 Hz, 1H), 0.82 (s, 6H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 144.1, 128.8, 128.1, 126.8, 71.0, 69.0, 44.4, 40.4, 35.9, 25.1, 24.6.
HRMS (ESI) *m/z* calcd. for $C_{13}H_{20}NaO_2$ $[M + Na]^+$ 231.1356, found 231.1355.

Synthesis of 81

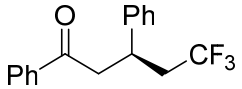


76, 98% ee

81, 78%, 97% ee

To a solution of **76** (38 mg, 0.14 mmol, 1.0 equiv.) in CF_3CH_2OH (0.5 mL) were added CF_3SO_3H (4.2 mg, 0.028 mmol, 0.2 equiv.) and H_2O (5.0 mg, 0.28 mmol, 2.0 equiv.). And the reaction mixture was stirred at 80 °C for 16 h. After evaporation under reduced pressure, the residue was purified with column chromatography on silica gel to yield the product **81** as a colorless oil (31.9 mg, 78% yield, 97% ee).

(*R*)-5,5,5-Trifluoro-1,3-diphenylpentan-1-one (81)



81

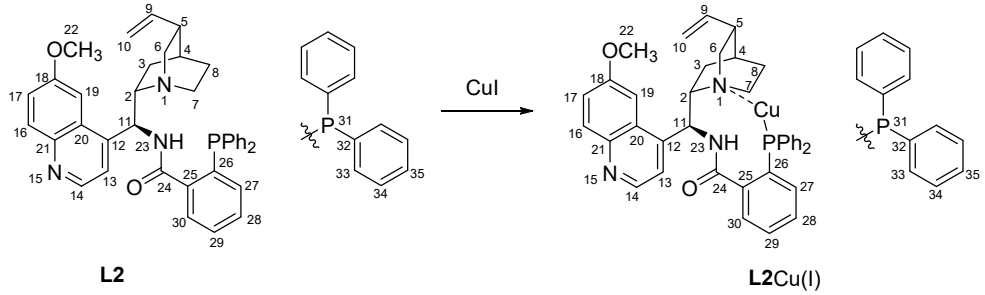
HPLC analysis: Chiralcel ADH (*n*-hexane/*i*-PrOH = 97/3, flow rate 0.5 mL/min, λ = 254 nm), t_R (major) = 17.32 min, t_R (minor) = 25.63 min.
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.92 (d, *J* = 7.4 Hz, 2H), 7.58 (t, *J* = 7.4 Hz, 1H), 7.47 (t, *J* = 7.7 Hz, 2H), 7.39 – 7.22 (m, 5H), 3.86 – 3.74 (m, 1H), 3.51 – 3.21 (m, 2H), 2.76 – 2.60 (m, 1H), 2.60 – 2.43 (m, 1H).
^{13}C NMR (100 MHz, $CDCl_3$) δ 197.5, 142.6, 136.7, 133.3, 128.8, 128.7, 128.0, 127.3, 127.1, 126.4 (q, *J* = 277.7 Hz), 44.7, 39.6 (q, *J* = 27.4 Hz), 35.2 (q, *J* = 2.5 Hz).
^{19}F NMR (376 MHz, $CDCl_3$) δ –63.49 (t, *J* = 10.7 Hz, 3F).
HRMS (ESI) *m/z* calcd. for $C_{17}H_{16}F_3O$ $[M + H]^+$ 293.1148, found 293.1147.

Mechanistic study

Analysis of NMR spectroscopy of ligand L2 and L2Cu^{I}

Experiment for taking the NMR spectroscopy of ligand L2 and L2Cu^{I}

L2 (24.4 mg, 0.04 mmol) was dissolved in $CDCl_3$ (0.5 mL) in an NMR tube to record the ^{1}H NMR, ^{13}C NMR, COSY, HSQC, HMBC of the ligand **L2**.



In an oven-dried vial was added CuI (7.6 mg, 0.04 mmol), **L2** (24.4 mg, 0.04 mmol) and $CDCl_3$ (0.5 mL). The reaction mixture was stirred for 10 min and transferred into an NMR tube to record the ^{1}H NMR, ^{13}C NMR, COSY, HSQC, HMBC of the complex **L2**Cu^{I}.

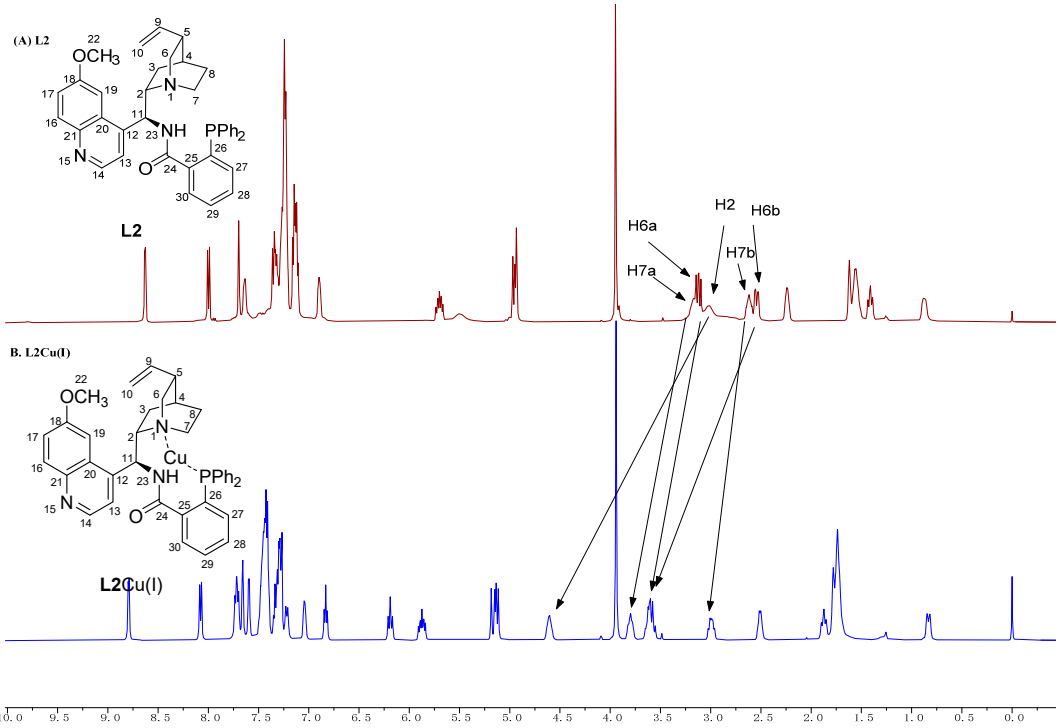


Figure S4. Stacking ^{1}H NMR spectrum of **L2** and **L2**Cu^{I}. (red color: **L2**; blue color: **L2**Cu^{I})

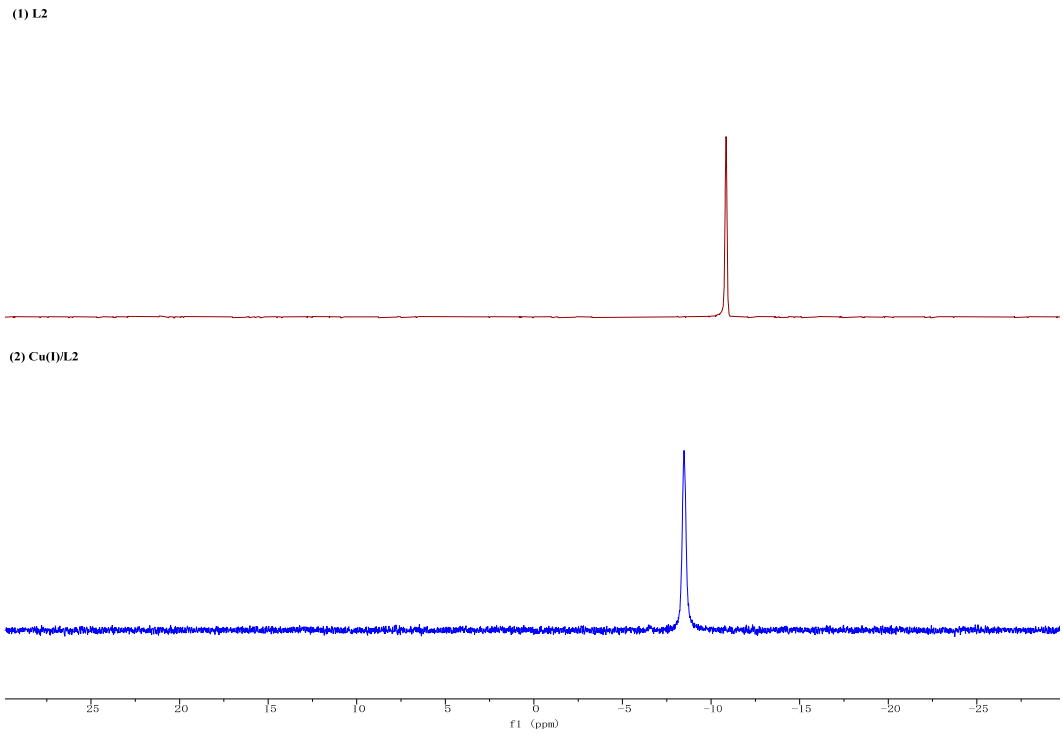


Figure S5. Stacking ^{31}P NMR spectrum of **L2** and **L2**Cu^{I}. (red color: **L2**; blue color: **L2**Cu^{I})

Table S1. The NMR comparison of **L2** and **L2**Cu^{I} complex.

	H-2	**H-3a**	**H-3b**	**H-4**	**H-5**	**H-6a**	**H-6b**	**H-7a**
δ_H **L2**	3.02	1.41	0.87	1.62	2.24	3.12	2.54	3.17
δ_H **L2**Cu^{I}	4.61	1.87	0.83	1.80	2.51	3.63	3.60	3.80
$\Delta\delta_H$	1.59	0.46	-0.04	0.18	0.27	0.51	1.06	0.63

	H-7b	**H-8**	**H-9**	**H-10**	**H-11**	**H-13**	**H-14**	**H-16**
δ_H **L2**	2.62	1.55	5.70	4.95	5.50	~7.30	8.63	8.00
δ_H **L2**Cu^{I}	2.99	~1.70	5.87	5.15	6.19	7.60	8.79	8.08
$\Delta\delta_H$	0.37	0.15	0.17	0.20	0.69	0.30	0.16	0.08

	H-17	**H-19**	**H-22**	**H-23**	**H-27**	**H-28**	**H-29**	**H-30**
δ_H **L2**	~7.4	7.70	3.95	ND	7.64	~7.30	~7.20	6.90
δ_H **L2**Cu^{I}	~7.4	7.66	3.95	7.22	6.83	~7.30	~7.20	7.04
$\Delta\delta_H$	0	-0.04	0	NA	-0.81	0	0	0.14

Cyclic voltammogram (CV) experiments

Cyclic Voltammetry experiments were performed using a CH Instruments Electrochemical Workstation model CHI620E, scan rate = 0. 1V/s, 2 sweep segments, sample interval = 0.001 V. The electrochemical cell was equipped with a glassy carbon disk working electrode (3mm diameter) and a Pt wire counter electrode and the potentials were calibrated with Fc as an internal standard. The samples(0.01M) were prepared under the protection of the N_2 by dissolving them in degassed CH_3CN (0.1 M

Bu_4NPF_6) directly and stirred for 1min, the air sensitive mixture should be tested quickly to avoid forming precipitates or being oxidized.

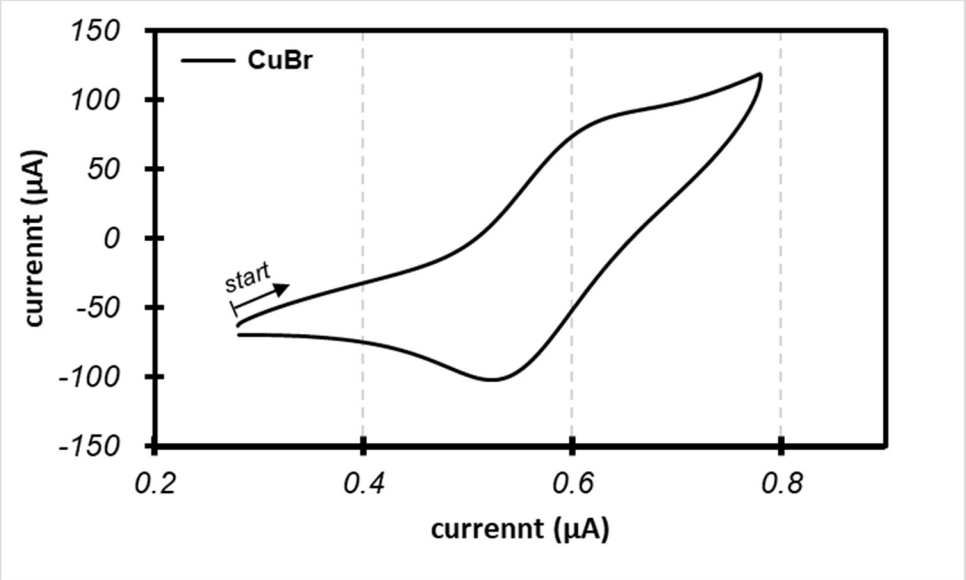


Figure S6. CV of CuBr, calibrated with Fc as an internal standard.

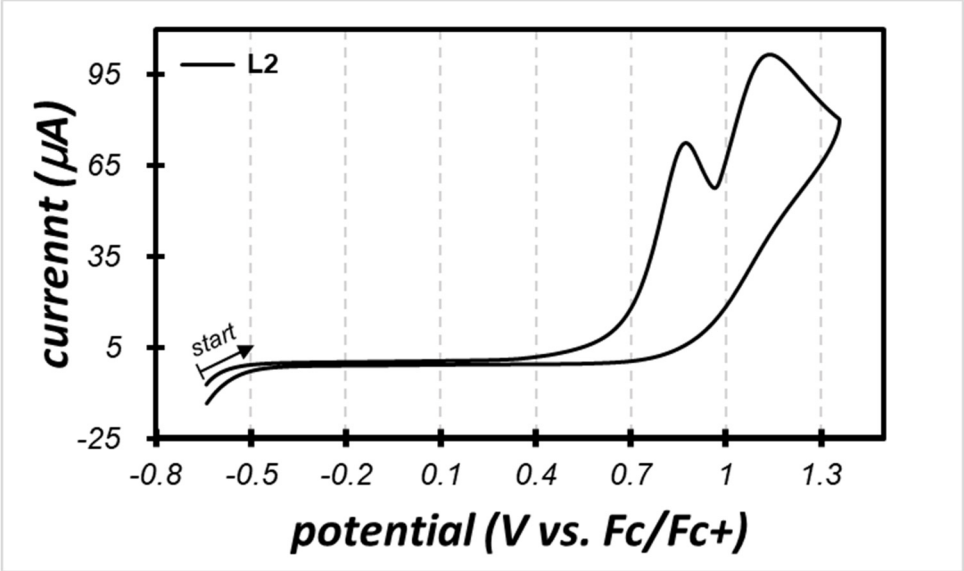


Figure S7. CV of **L2**, calibrated with Fc as an internal standard.

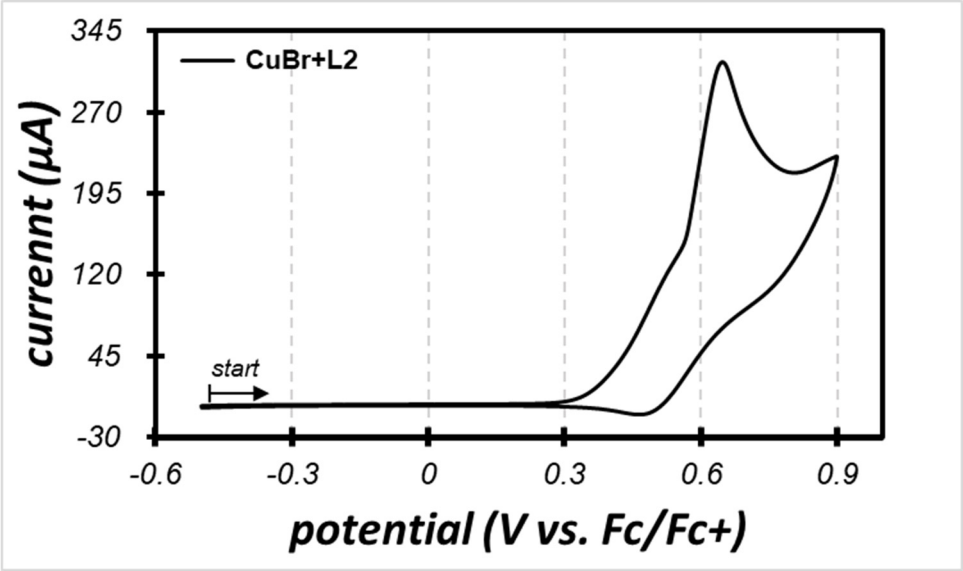


Figure S8. CV of a mixture of **L2** and CuBr in a 1:1 ratio, calibrated with Fc as an internal standard.

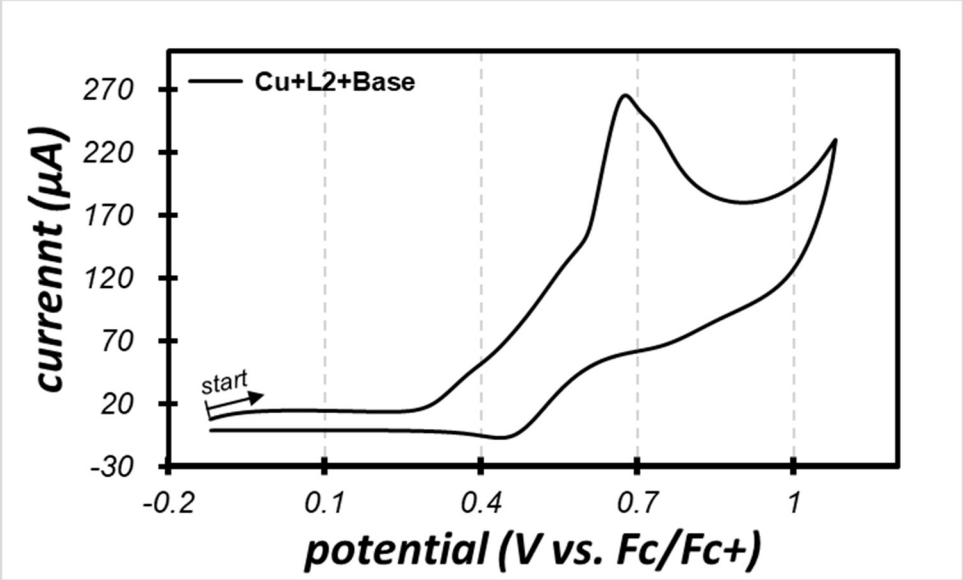


Figure S9. CV of a mixture of **L2**, CuBr and base (Cs_2CO_3) in a 1:1:1 ratio, calibrated with Fc as an internal standard.

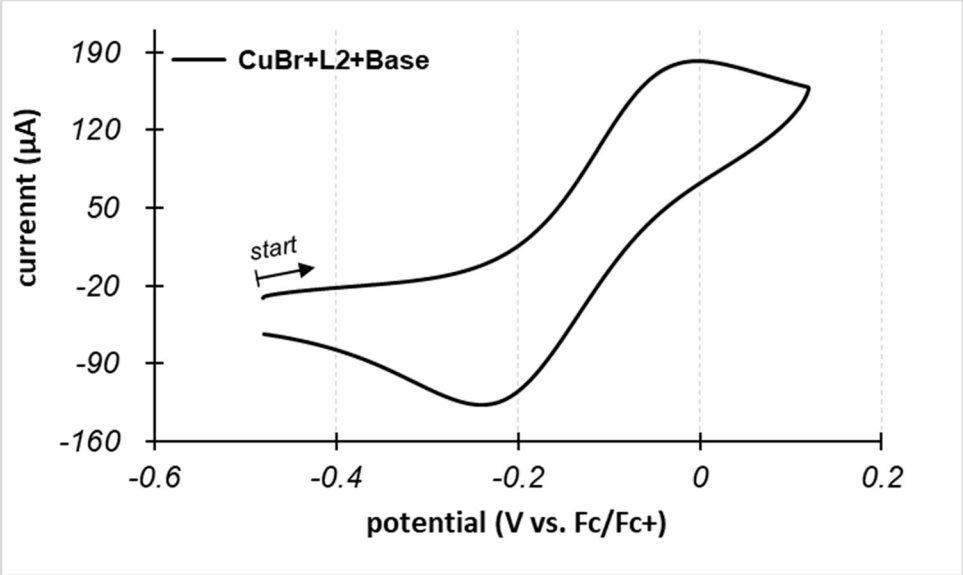


Figure S10. CV of the **L2**Cu from a mixture of **L2**, CuBr and base (Cs_2CO_3) in a 1:1:1 ratio calibrated with Fc as an internal standard.

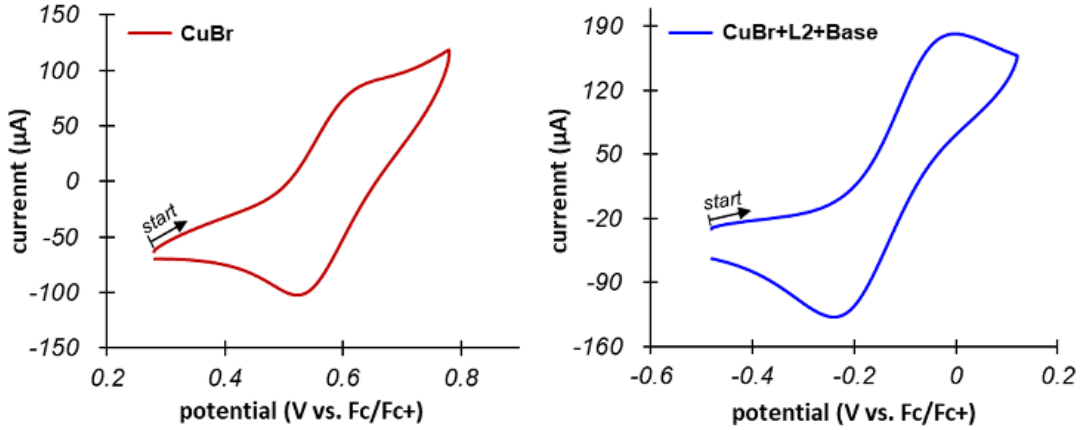


Figure S11. CVs of CuBr and the **L2**CuBr complex, calibrated with Fc as an internal standard.

EPR experiments for detection of the Cu^{II} Species

EPR Experiments for detection of the Cu^{II} intermediate during the reaction.

An oven-dried Schlenk tube was sequentially charged with CuOAc (1.83 mg, 0.015 mmol), **L2** (9.2 mg, 0.015 mmol), Cs_2CO_3 (65 mg, 0.20 mmol). The tube was evacuated and back-filled with argon three times. Then, 1,4-dioxane (4.0 mL) was added and the reaction mixture was stirred for 10 min at 28 °C. Substrates **1l** (15 mg, 0.12 mmol), **3a** (34 mg, 0.15 mmol) and alkyne **2a** (12.7 mg, 0.10 mmol) were added and the reaction mixture was stirred at that temperature for 30 min. An aliquot of the reaction mixture (0.50 mL) was transferred to an EPR tube under an argon atmosphere for X-band EPR measurement at 100 K.

Experiment for independent synthesis of the Cu^{II} intermediate.

An oven-dried round bottom flask was charged with $Cu(OAc)_2$ (1 mg, 0.005 mmol), **L2** (3 mg, 0.005 mmol) and **2a** (1.3 mg, 0.010 mmol). The tube was evacuated and back-filled with argon three times. Then, 1,4-dioxane (1.0 mL) was added and the

reaction mixture was stirred for 30 min at 28 °C. An aliquot of the reaction mixture (0.50 mL) was transferred to an EPR tube for X-band EPR measurement at 100 K.

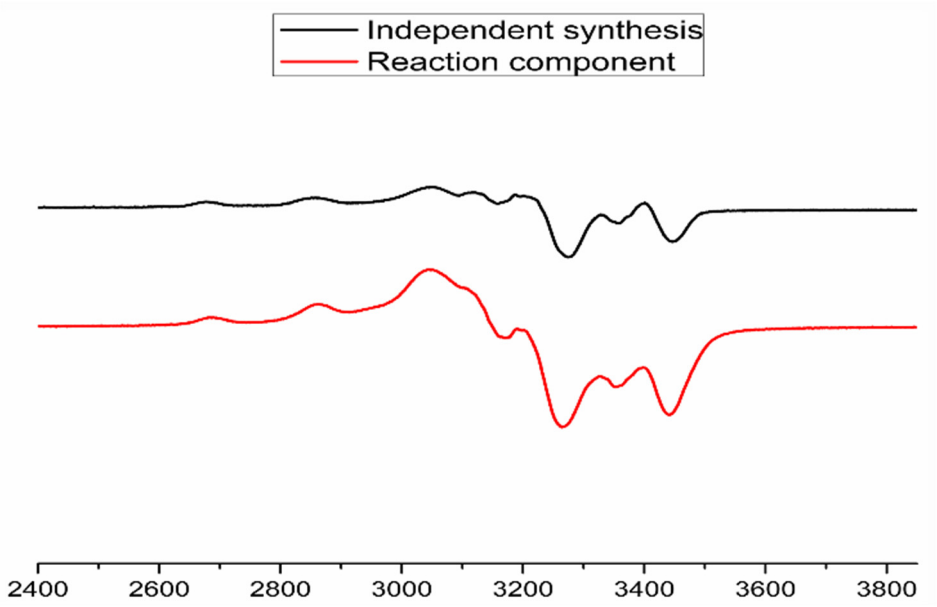
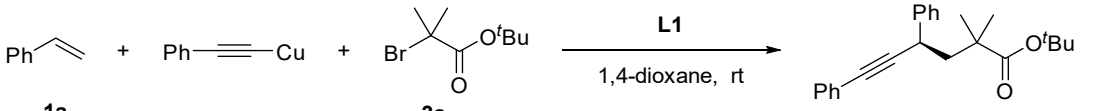


Figure S12. X-band EPR spectrum (9.26 GHz, 100K). black: a mixture of $Cu(OAc)_2$, **L2** and **2a**. red: a reaction component of the standard carboalkynylation reaction.

Control experiments

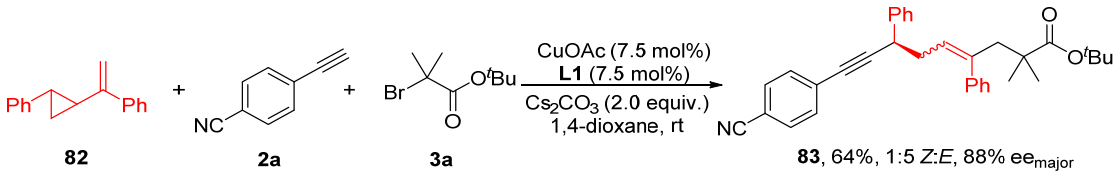
Control experiment with copper phenylacetylide



Under argon atmosphere, an oven-dried resealable Schlenk tube equipped with a magnetic stir bar was charged with styrene **1a** (15.6 mg, 0.15 mmol, 1.5 equiv.), copper phenylacetylide (16.5 mg, 0.10 mmol, 1.0 equiv.), *tert*-butyl 2-bromo-2-methylpropanoate **3a** (26.8 mg, 0.12 mmol, 1.2 equiv.), **L1** (83.6 mg, 0.10 mmol, 1.0 equiv.), and anhydrous 1,4-dioxane (1.0 mL). The resulting reaction mixture was stirred at room temperature for 12 h. Upon completion of the reaction (monitored by TLC), the reaction mixture was filtered and washed by CH_2Cl_2. The filtrate was concentrated and the residue was purified by column chromatography on silica gel to afford **39** (27.9 mg, 80% yield, 96% ee).

The procedure for the reaction without **L1** was the same with that described above except that **L1** was not added. No desired product **37** was observed.

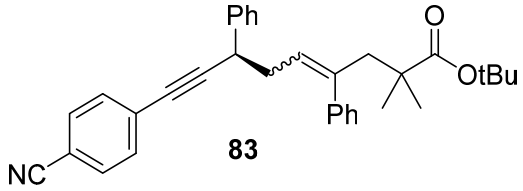
Control experiment with a clock substrate



The substrate **82** was synthesized according to the reported procedure.[10]

Under argon atmosphere, an oven-dried resealable Schlenk tube equipped with a magnetic stir bar was charged with (1-(2-phenylcyclopropyl)vinyl)benzene **82** (66 mg, 0.30 mmol, 1.5 equiv.), 4-ethynylbenzonitrile **2a** (25.4 mg, 0.20 mmol, 1.0 equiv.), *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.), **L1** (12.5 mg, 0.015 mmol, 7.5 mol%), and anhydrous 1,4-dioxane (2.0 mL). The resulting reaction mixture was stirred at room temperature for 12 h. Upon completion of the reaction (monitored by TLC), the reaction mixture was filtered and washed by CH_2Cl_2. The filtrate was concentrated and the residue was purified by column chromatography on silica gel to afford **83** (62.8 mg, 64% yield, *Z*:*E* = 1:5, 88% ee_{major}).

(*R*)-*tert*-Butyl-9-(4-cyanophenyl)-2,2-dimethyl-4,7-diphenylnon-4-en-8-ynoate (83)



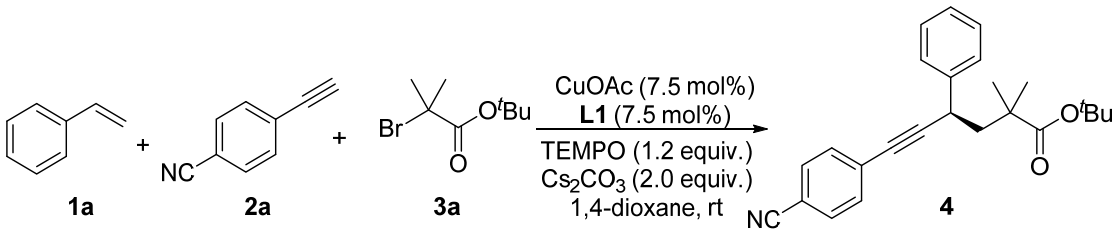
HPLC analysis: Chiralcel ODH (*n*-hexane/*i*-PrOH = 98/2, flow rate 0.5 mL/min, λ = 254 nm), t_R (major) = 18.71 min, t_R (minor) = 21.39 min.

^{1}H NMR (400 MHz, $CDCl_3$) (*Z* and *E* mixture) δ 7.67 – 7.58 (m, 2H), 7.53 (t, *J* = 7.4 Hz, 2H), 7.48 – 7.36 (m, 3H), 7.35 – 7.20 (m, 6.61H), 7.10 – 7.02 (m, 0.36H), 5.78 (t, *J* = 7.3 Hz, 0.83H), 5.63 (t, *J* = 7.3 Hz, 0.17H), 4.01 (t, *J* = 7.1 Hz, 0.81H), 3.89 (t, *J* = 7.0 Hz, 0.16H), 2.86 – 2.44 (m, 4H), 1.30 (s, 7.41H), 1.27 (s, 1.56H), 1.03 (d, *J* = 0.8 Hz, 1.05H), 0.99 (s, 4.91H).

^{13}C NMR (100 MHz, $CDCl_3$) (*Z* and *E* mixture) δ 176.9, 176.6, 144.8, 141.0, 140.7, 140.6, 140.5, 140.3, 132.2, 132.0, 129.5, 128.7, 128.62, 128.59, 128.2, 128.0, 127.57, 127.52, 127.4, 127.2, 127.1, 127.0, 126.8, 126.7, 118.6, 111.2, 111.2, 96.4, 96.2, 82.30, 82.25, 79.9, 79.6, 49.2, 43.6, 43.2, 38.84, 38.77, 38.1, 37.4, 27.79, 27.77, 25.85, 25.82, 25.6.

HRMS (ESI) *m/z* calcd. for $C_{34}H_{36}NO_2$ $[M + H]^+$ 490.2741, found 490.2741.

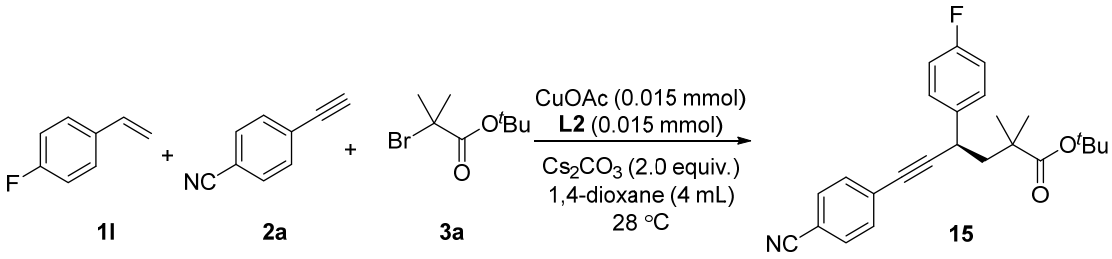
Control experiment with TEMPO



According to General Procedure **A** with styrene **1a** (31.2 mg, 0.30 mmol, 1.5 equiv.), 4-ethynylbenzonitrile **2a** (25.4 mg, 0.20 mmol, 1.0 equiv.), *tert*-butyl 2-bromo-2-methylpropanoate **3a** (53.5 mg, 0.24 mmol, 1.2 equiv.), and 2,2,6,6-tetramethylpiperidinyloxy (TEMPO) (37.4 mg, 0.24 mmol, 1.2 equiv.) after 12 h, the reaction mixture was monitored by TLC. There was no product observed.

Kinetic Studies

Experiment for determining the dependence of reaction rate on the concentration of alkene 1l



A stock solution of 4-bromofluorobenzene (35 mg, 0.20 mmol) in $CDCl_3$ (2 mL) was prepared as the internal standard.

An oven-dried Schlenk tube was sequentially charged with CuOAc (1.83 mg, 0.015 mmol), **L2** (9.2 mg, 0.015 mmol), Cs_2CO_3 (65 mg, 0.20 mmol). The tube was evacuated and back-filled with argon three times. Then, 1,4-dioxane (4.0 mL) was added and the reaction mixture was stirred for 10 min at 28 °C. Substrates **1l** (0.05–0.25 mmol), **3a** (0.30 mL, 1.6 mmol) and alkyne **2a** (127 mg, 1.0 mmol) were added and the reaction mixture was stirred at that temperature. An aliquot of the reaction mixture (0.20 mL) was taken out at a proper time interval. The reaction mixture was filtered through a short pad of silica gel and washed with EtOAc. The filtrate was concentrated and vacuumed to afford the crude residue. The internal standard (100 μL) was added and the sample was analyzed by ^{19}F NMR spectroscopy.

Table S2. The molar concentrations of product **15** ([**15**]/M) with different initial concentrations of alkene ([**1l**]/M) at different time intervals

Time (h)	0.0125 M [**1l**]	0.0250 M [**1l**]	0.0375 M [**1l**]	0.0500 M [**1l**]	0.0625 M [**1l**]
0.167		0.00003	0.00004	0.00018	0.00019
0.333	0.00017	0.00041	0.00056	0.00116	0.00116
0.500		0.00110	0.00124	0.00219	0.00180
0.667	0.00078	0.00176	0.00143	0.00319	0.00322
0.833		0.00220	0.00235	0.00489	0.00481
1.000	0.00171	0.00255	0.00271	0.00495	0.00500
1.333	0.00181				
2.0	0.00230				

Table S3. The k_{in} values at different initial concentrations of alkene (**1l**)

[**1l**] (M)	0.0125	0.0250	0.0375	0.0500	0.0625
k_{in} (Mh^{-1})	0.0013	0.0032	0.0033	0.0062	0.0068

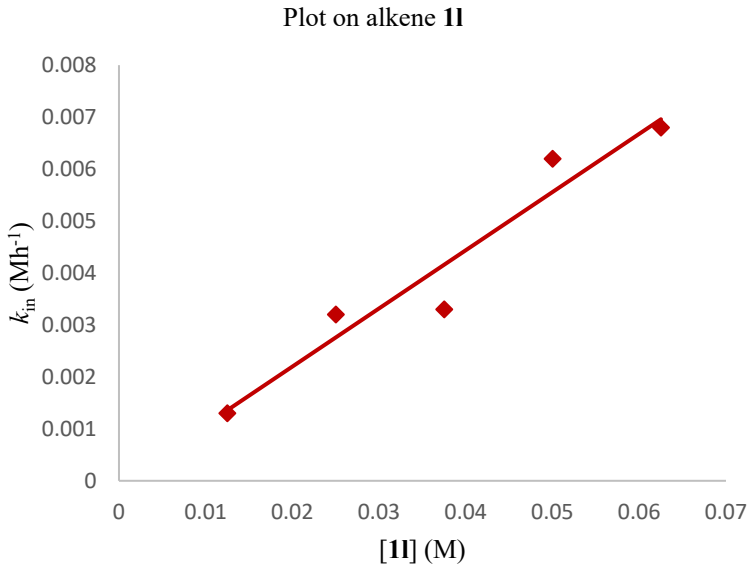
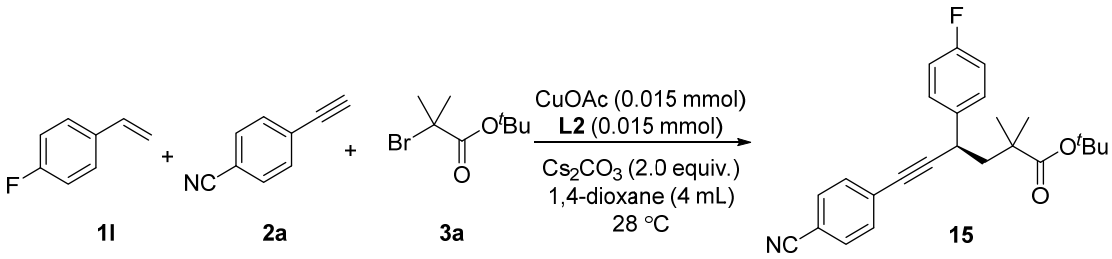


Figure S13. Plot of k_{in} versus [**1l**] from the reactions with 0.0125 M, 0.025 M, 0.0375 M, 0.050 and 0.0625 M of alkene **1l**.

Experiment for determining the dependence of reaction rate on the concentration of alkyne 2a



A stock solution of 4-bromofluorobenzene (35 mg, 0.20 mmol) in $CDCl_3$ (2 mL) was prepared as the internal standard.

An oven-dried Schlenk tube was sequentially charged with CuOAc (1.83 mg, 0.015 mmol), **L2** (9.2 mg, 0.015 mmol), Cs_2CO_3 (65 mg, 0.20 mmol). The tube was evacuated and back-filled with argon three times. Then, 1,4-dioxane (4.0 mL) was added and the reaction mixture was stirred for 10 min at 28 °C. Substrates **1l** (0.20 mL, 1.4 mmol), **3a** (0.30 mL, 1.6 mmol) and alkyne **2a** (0.05–0.30 mmol) were added and the reaction mixture was stirred at that temperature. An aliquot of the reaction mixture (0.3 mL) was

taken out at a proper time interval. The reaction mixture was filtered through a short pad of silica gel and washed with EtOAc. The filtrate was concentrated and vacuumed to afford the crude residue. The internal standard (0.15 mL) was added and the sample was analyzed by ^{19}F NMR spectroscopy.

Table S4. The molar concentrations of product **15** ([**15**]/M) with different initial concentrations of alkyne ([**2a**]/M) at different time intervals

Time (h)	0.0125 M [**2a**]	0.0250 M [**2a**]	0.0375 M [**2a**]	0.0500 M [**2a**]	0.0625 M [**2a**]	0.0750 M [**2a**]
0.167		0.00047	0.00043	0.00043	0.00062	
0.333	0.00041	0.00111	0.00139	0.00173	0.00173	0.00167
0.500		0.00220	0.00242	0.00322	0.00324	
0.667	0.00112	0.00300	0.00347	0.00458	0.00470	0.00432
1.000	0.00176					0.00477
1.333	0.00183					0.00936

Table S5. The k_{in} values at different initial concentrations of alkyne (**2a**)

[**2a**] (M)	0.0125	0.0250	0.0375	0.0500	0.0625	0.0750
k_{in} (Mh^{-1})	0.0020	0.0047	0.0061	0.0078	0.0082	0.0077

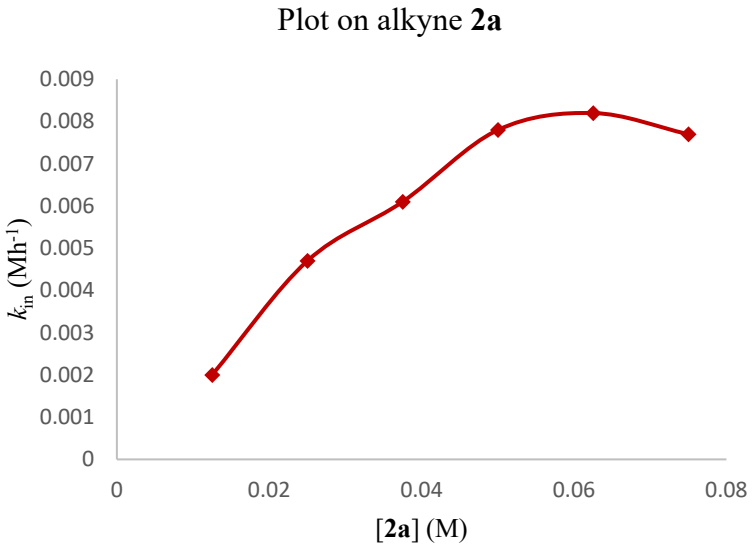
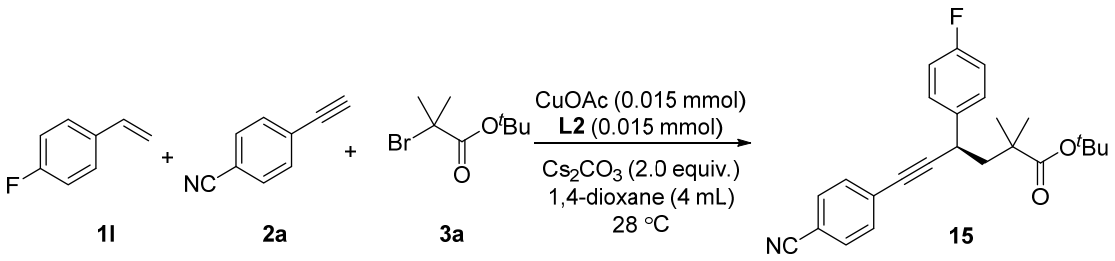


Figure S14. Plot of k_{in} versus [**2a**] from the reactions with 0.0125 M, 0.025 M, 0.0375 M, 0.050 M, 0.0625 M and 0.075 M of alkyne **2a**.

Experiment for determining the dependence of reaction rate on the concentration of the radical precursor 3a



A stock solution of 4-bromofluorobenzene (35 mg, 0.20 mmol) in $CDCl_3$ (2 mL) was prepared as the internal standard.

An oven-dried Schlenk tube was sequentially charged with CuOAc (1.83 mg, 0.015 mmol), **L2** (9.2 mg, 0.015 mmol), Cs_2CO_3 (65 mg, 0.20 mmol). The tube was evacuated and back-filled with argon three times. Then, 1,4-dioxane (4.0 mL) was added and the reaction mixture was stirred for 10 min at 28 °C. Substrates **1l** (0.20 mL, 1.4 mmol), **3a** (0.05–0.25 mmol) and alkyne **2a** (127 mg, 1.0 mmol) were added and the reaction mixture was stirred at that temperature. An aliquot of the reaction mixture (0.20 mL) was taken out at a proper time interval. The reaction mixture was filtered through a short pad of silica gel and washed with EtOAc. The filtrate was concentrated and vacuumed to afford the crude residue. The internal standard (100 μL) was added and the sample was analyzed by ^{19}F NMR spectroscopy.

Table S6. The molar concentrations of product **15** ([**15**]/M) with different initial concentrations of alkene ([**3a**]/M) at different time intervals

Time (h)	0.0125 M [**3a**]
0.133	0.0002675
0.200	0.0009150
0.267	0.0011925
0.333	0.0022575
0.400	0.002850

Time (h)	0.0250 M [**3a**]	0.0375 M [**3a**]	0.0500 M [**3a**]	0.0625 M [**3a**]
0.167	0.00083	0.00056	0.00062	0.00086
0.333	0.00261	0.00251	0.00225	0.00274
0.500	0.00471	0.00582	0.00478	0.00459
0.667	0.00753	0.01030	0.00775	0.00705
0.833	0.01006	0.01018	0.01064	0.01105
1.000	0.01179	0.01144	0.01093	0.01252

Table S7. The k_{in} values at different initial concentrations of radical precursor (**3a**)

[**3a**] (M)	0.0125	0.0250	0.0375	0.0500	0.0625
k_{in} (Mh^{-1})	0.0098	0.0137	0.0140	0.0134	0.0147

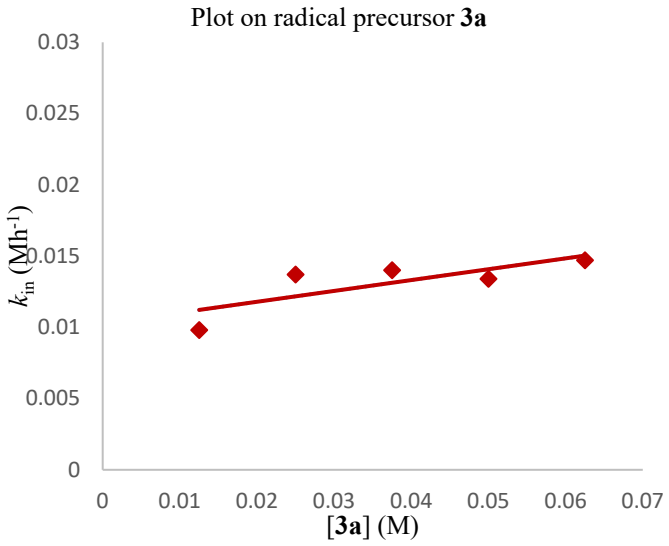
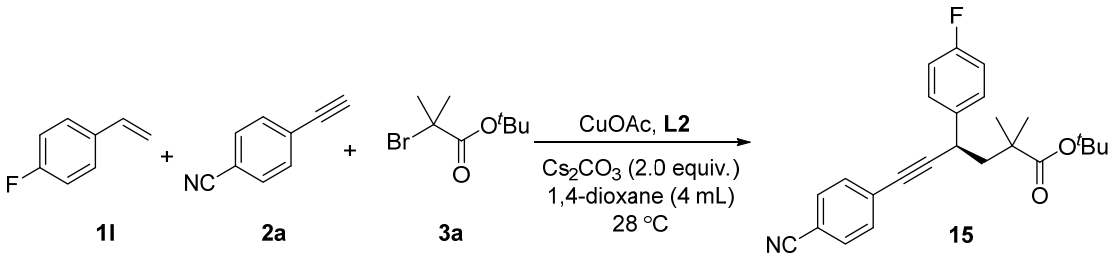


Figure S15. Plot of k_{in} versus [**3a**] from the reactions with 0.0125 M, 0.025 M, 0.0375 M, 0.050 M and 0.0625 M of radical precursor **3a**.

Experiment for determining the dependence of reaction rate on the concentration of catalyst



A stock solution of 4-bromofluorobenzene (35 mg, 0.20 mmol) in $CDCl_3$ (2 mL) was prepared as the internal standard.

An oven-dried Schlenk tube was sequentially charged with CuOAc, **L2** and Cs_2CO_3 (65 mg, 0.20 mmol). The tube was evacuated and back-filled with argon three times. Then, 1,4-dioxane (4.0 mL) was added and the reaction mixture was stirred for 10 min at 28 °C. Substrates **1l** (0.20 mL, 1.4 mmol), **3a** (22 mg, 0.10 mmol) and alkyne **2a** (127 mg, 1.0 mmol) were added and the reaction mixture was stirred at that temperature. An aliquot of the reaction mixture (0.20 mL) was taken out at a proper time interval. The reaction mixture was filtered through a short pad of silica gel and washed with EtOAc. The filtrate was concentrated and vacuumed to afford the crude residue. The internal standard (100 μL) was added and the sample was analyzed by ^{19}F NMR spectroscopy.

Table S8. The molar concentrations of product **15** ([**15**]/M) with different initial concentrations of catalyst (ratio of CuOAc and **L2** is 1:1) at different time intervals

Time (h)	0.00125 M	0.00250 M	0.00375 M
0.167	0.00028	0.00040	0.00083
0.333	0.00078	0.00124	0.00261
0.500	0.00107	0.00304	0.00471
0.667	0.00208	0.00420	0.00753
0.833	0.00241	0.00677	0.01006
1.000	0.00270	0.00717	0.01179

Time (h)	0.00500 M	0.00625 M
0.067	0.00023	0.00047
0.133	0.00112	0.00146
0.200	0.00258	0.00287
0.267	0.00348	0.00426
0.333	0.00434	0.00613
0.400	0.00613	0.00800

Table S9. The k_{in} values at different initial concentrations of catalyst

catalyst (M)	0.00125	0.00250	0.00375	0.00500	0.00625
k_{in} (Mh^{-1})	0.0031	0.0088	0.0137	0.0172	0.0227

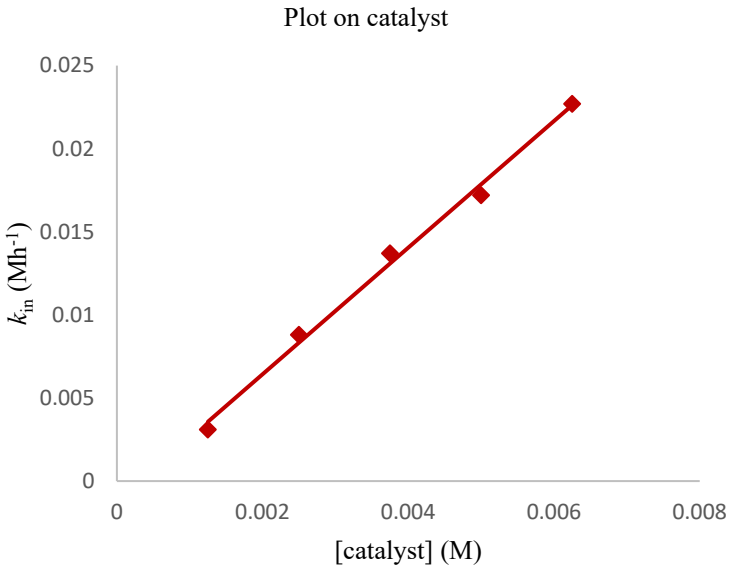
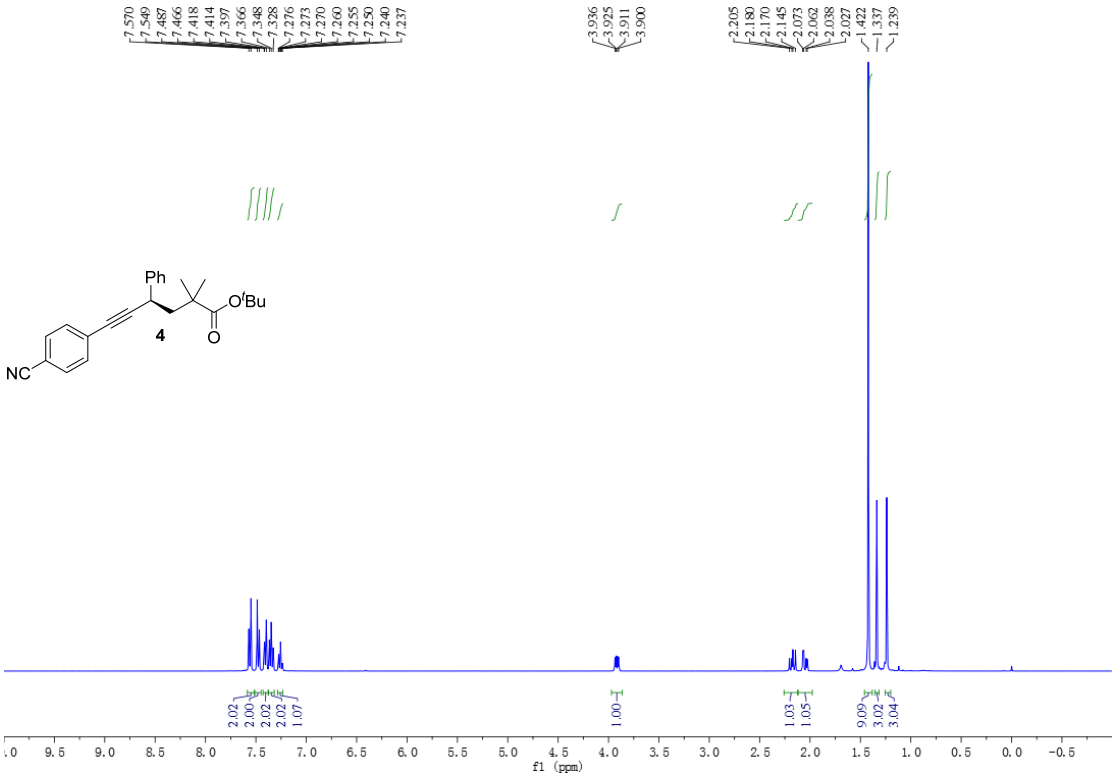


Figure S16. Plot of k_{in} versus catalyst from the reactions with 0.00125 M, 0.0025 M, 0.00375 M, 0.00500 M and 0.00625 M of catalyst.

NMR spectra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7.260
7.255
7.250
7.240
7.237
3.936
3.925
3.911
3.900
2.205
2.180
2.170
2.145
2.073
2.062
2.038
2.027
1.422
1.337
1.239
Ph
O'Bu
4
O
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1.00
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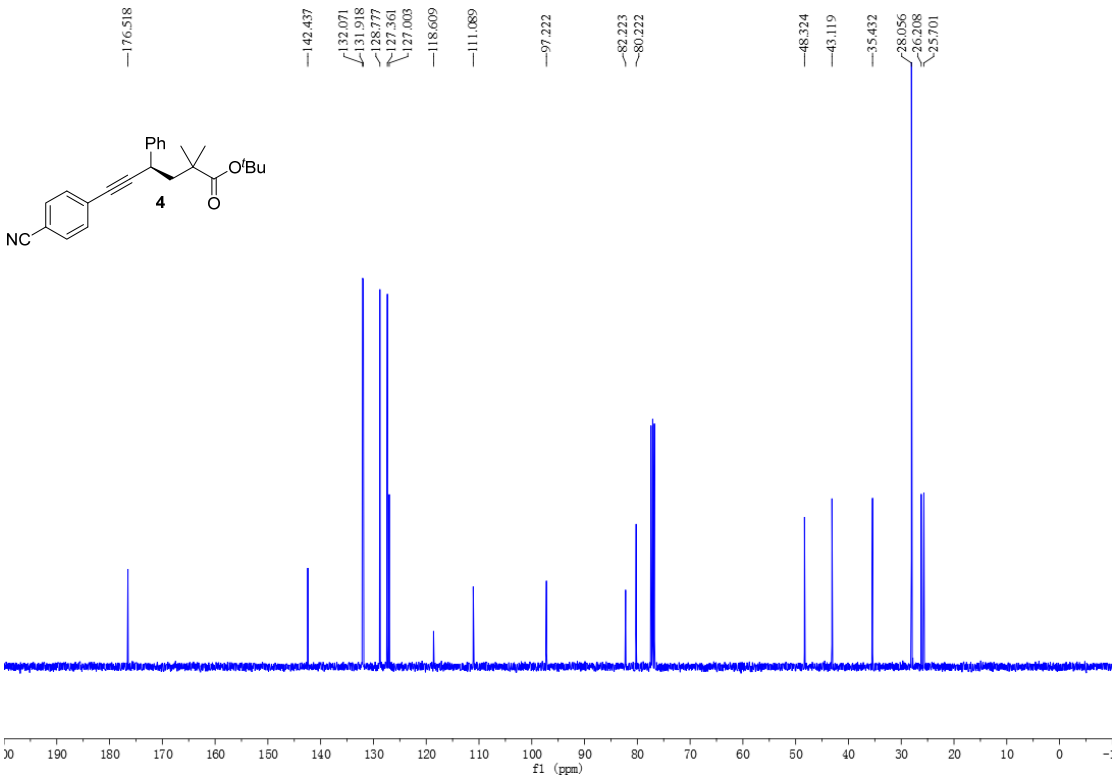
3.04
f1 (ppm)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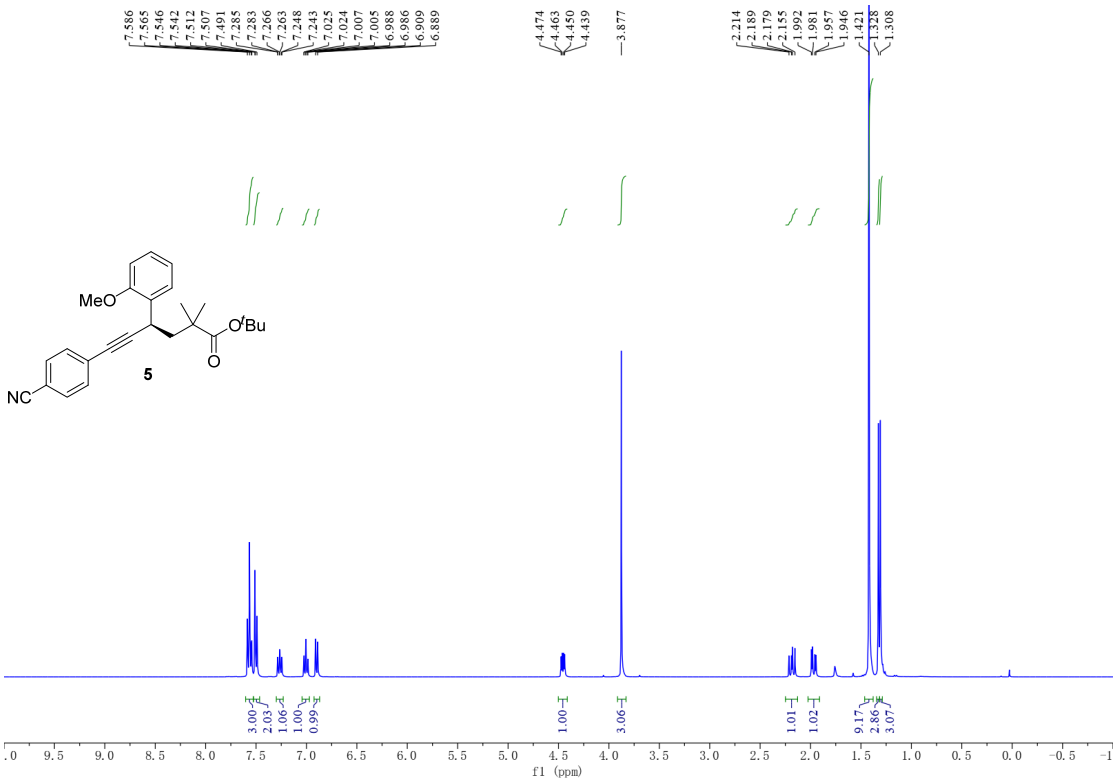
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1.946
1.421
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1.308
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O'Bu
O
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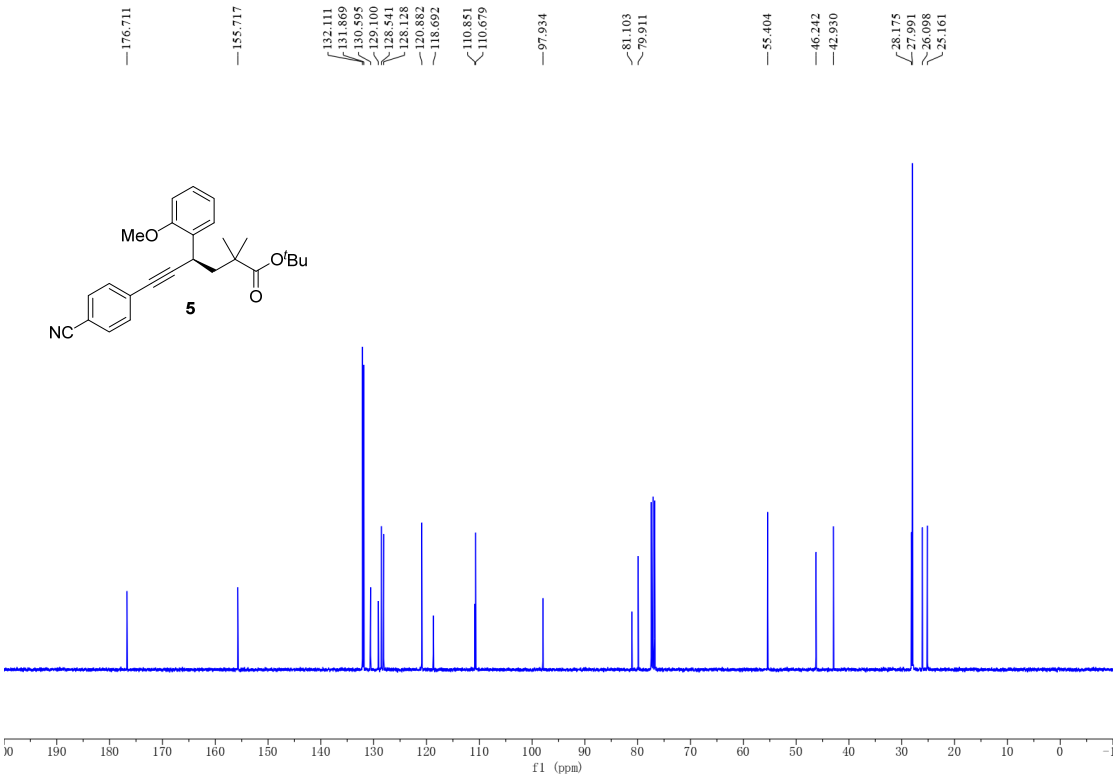
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97.934
81.103
79.911
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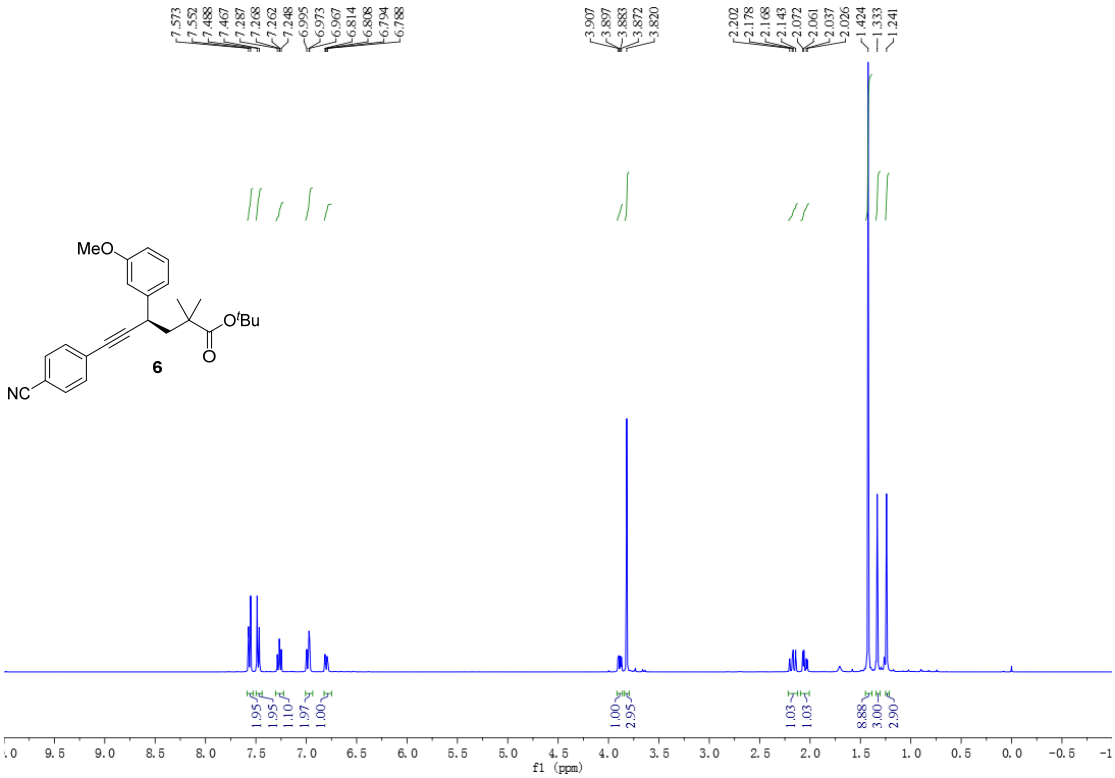
42.930
28.175
27.991
26.098
25.161
MeO
O'Bu
O
NC
5
f1 (ppm)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6.808
6.794
6.788
3.907
3.897
3.883
3.872
3.820
2.202
2.178
2.168
2.143
2.072
2.061
2.037
2.026
1.424
1.333
1.241
MeO
O'Bu
O
6
NC
1.95
1.95
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1.00
2.95
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1.03
8.88
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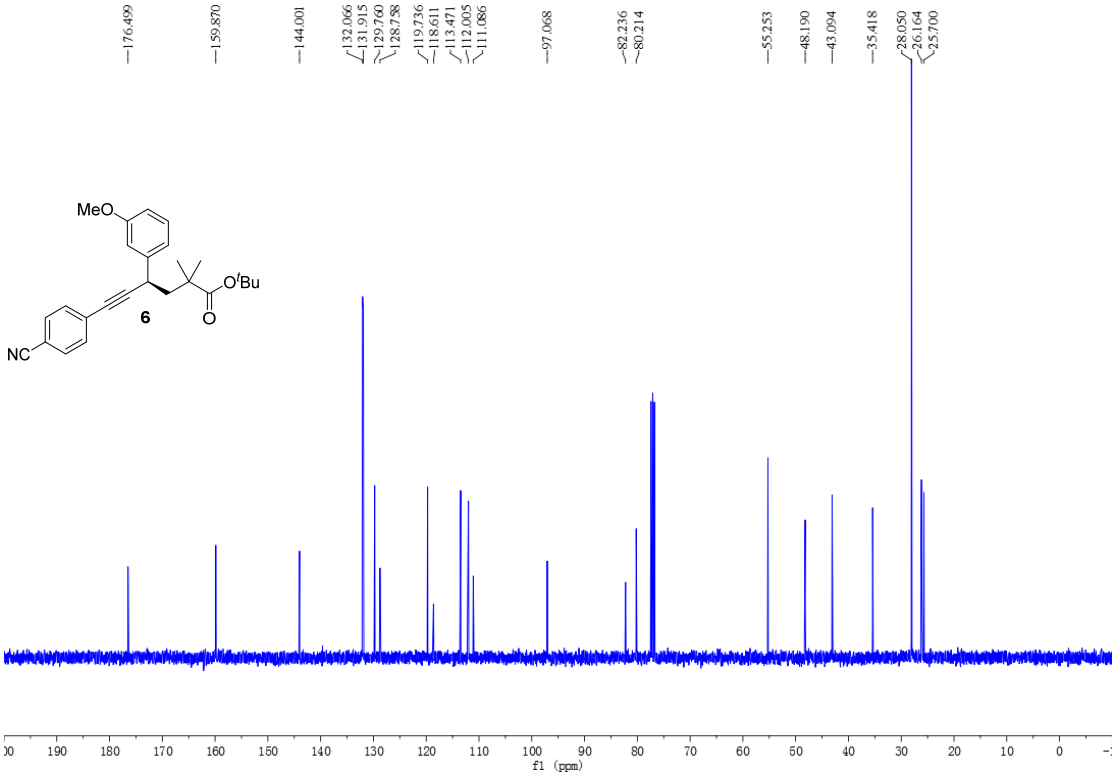
2.90
f1 (ppm)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119.736
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112.005
111.086
97.068
82.236
80.214
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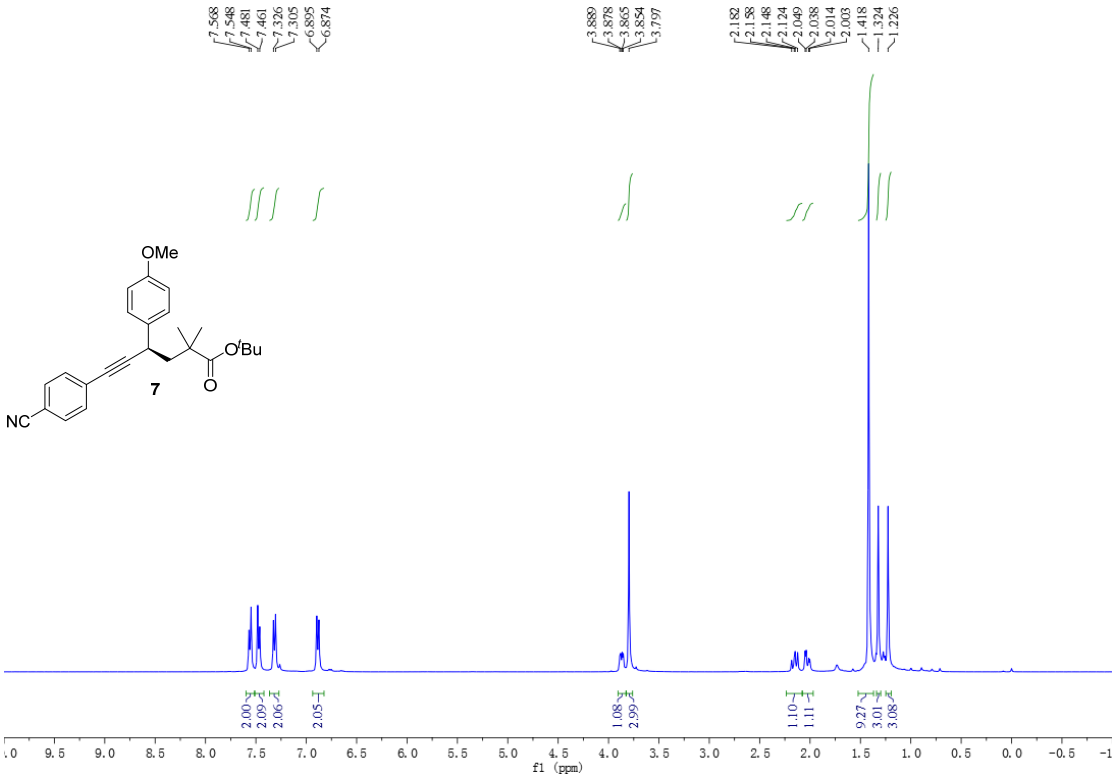
35.418
28.050
26.164
25.700
MeO
O'Bu
O
6
NC
f1 (ppm)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6.874
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3.854
3.797
2.182
2.158
2.148
2.124
2.049
2.038
2.014
2.003
1.418
1.324
1.226
OMe
O'Bu
O
7
NC
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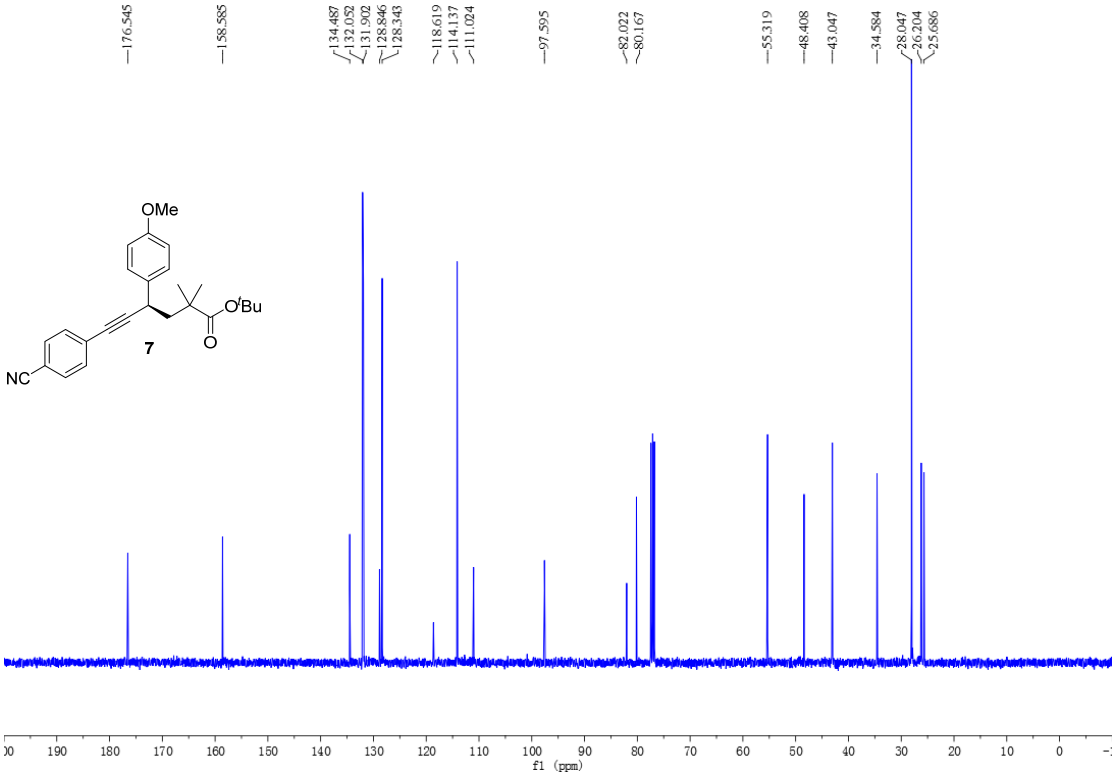
1.08
2.99
1.10
1.11
9.27
3.01
3.08
f1 (ppm)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118.619
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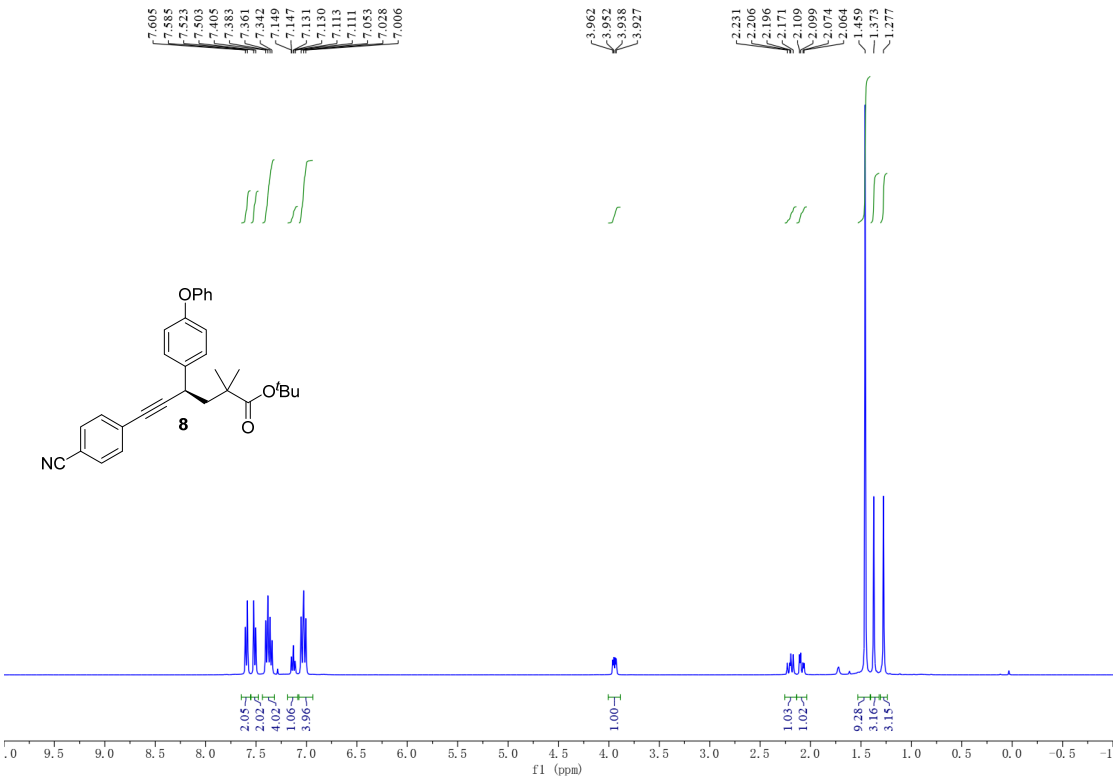
OMe
O'Bu
O
7
NC
f1 (ppm)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7.361
7.342
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7.147
7.131
7.130
7.113
7.111
7.053
7.028
7.006
3.962
3.952
3.938
3.927
2.231
2.206
2.196
2.171
2.109
2.099
2.074
2.064
1.459
1.373
1.277
OPh
O'Bu
O
8
NC
2.05
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1.06
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1.03
1.02
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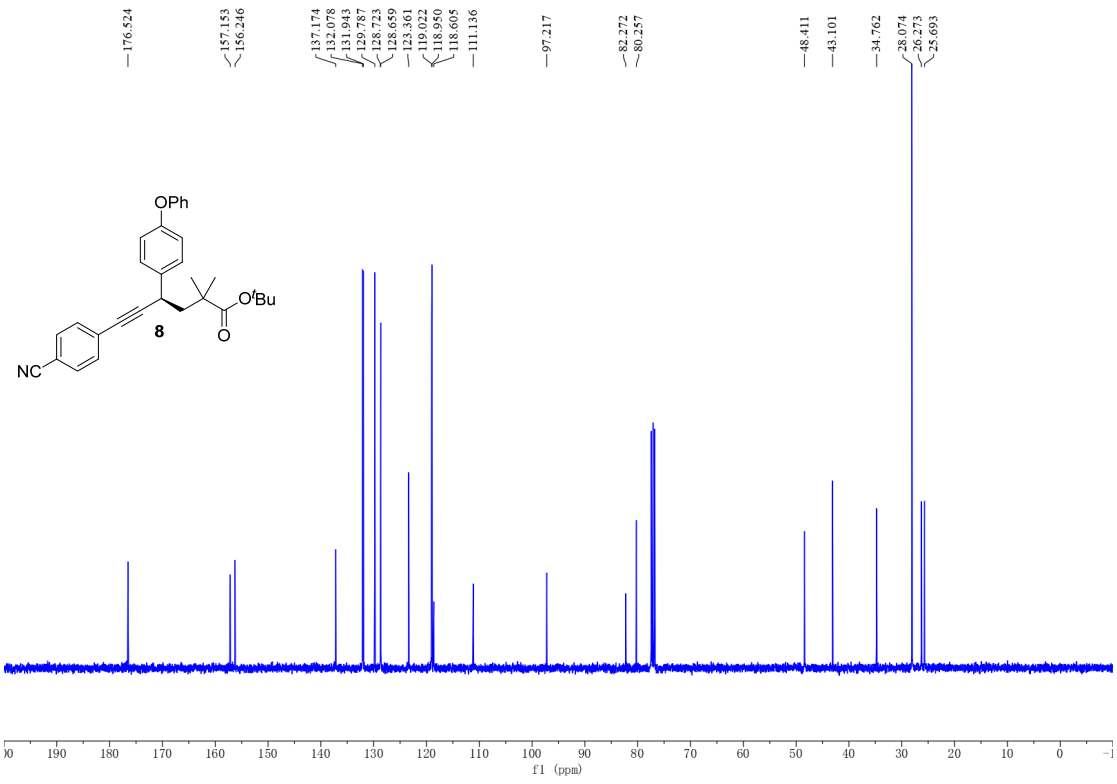
3.15
f1 (ppm)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118.950
118.605
111.136
97.217
82.272
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34.762
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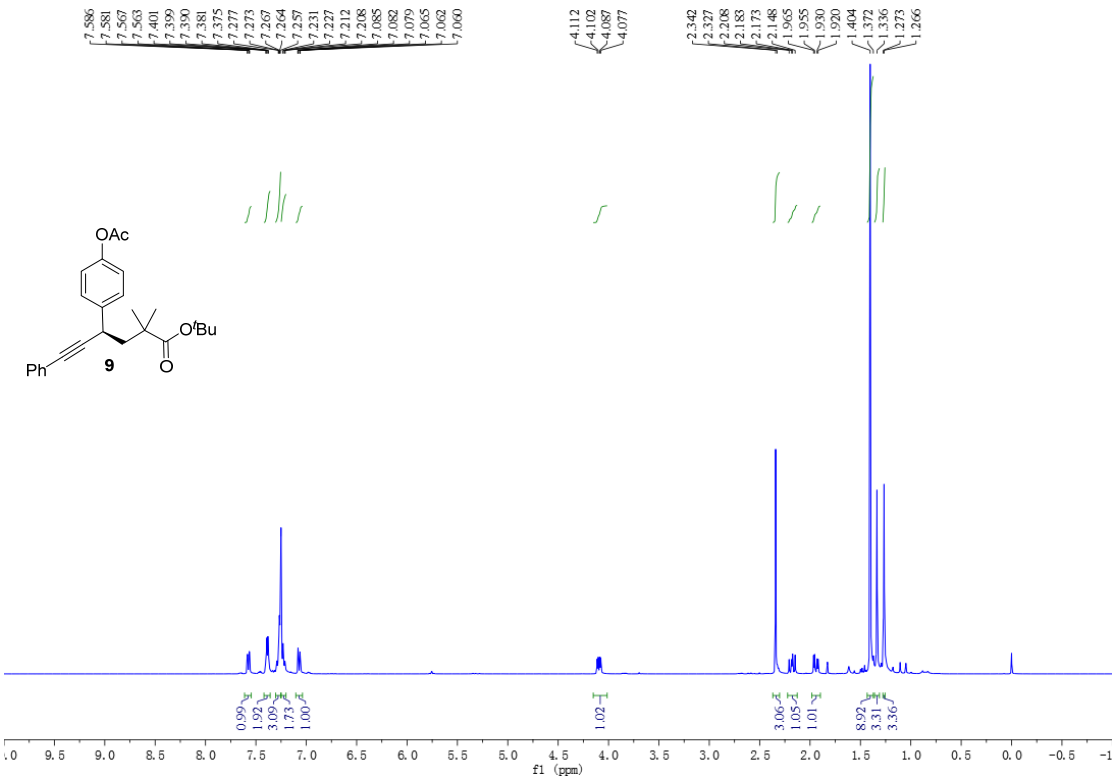
25.693
OPh
O'Bu
O
8
NC
f1 (ppm)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7.381
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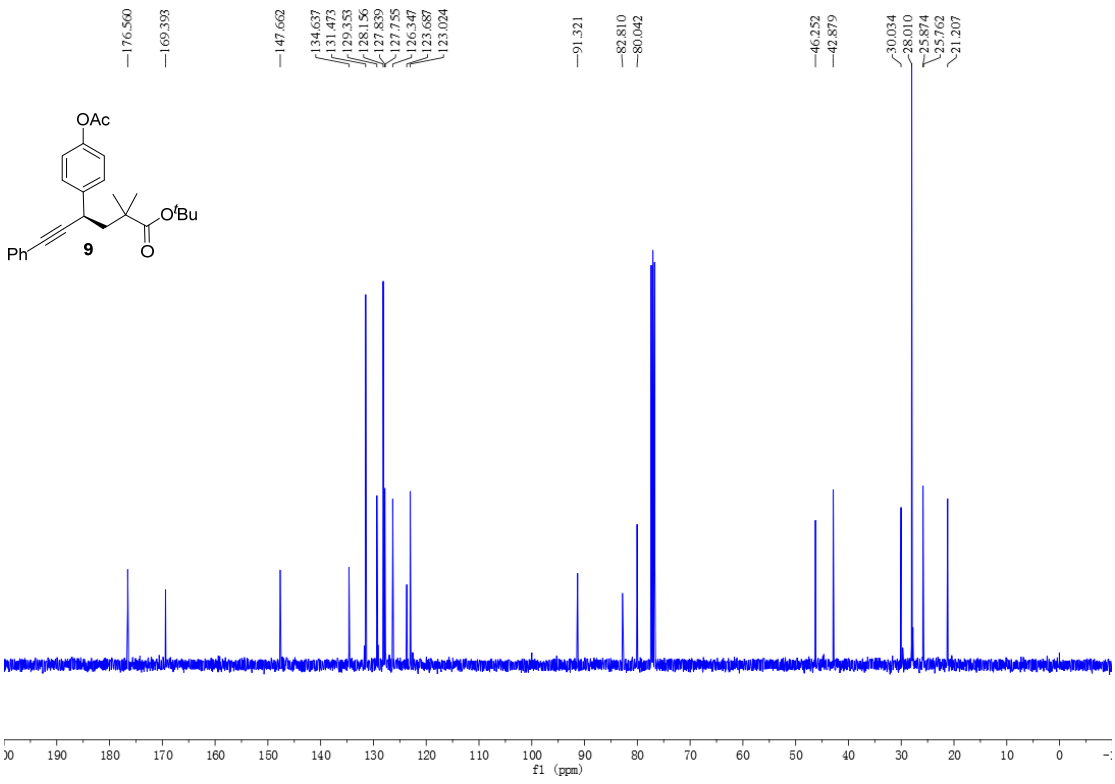
7.264
7.257
7.231
7.227
7.212
7.208
7.085
7.082
7.079
7.065
7.062
7.060
4.112
4.102
4.087
4.077
2.342
2.327
2.208
2.183
2.173
2.148
1.965
1.955
1.930
1.920
1.404
1.372
1.336
1.273
1.266
OAc
O^{t}Bu
Ph
9
O
0.99
1.92
3.09
1.73
1.00
1.02
3.06
1.05
1.01
8.92
3.31
3.36
f1 (ppm)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147.662
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127.839
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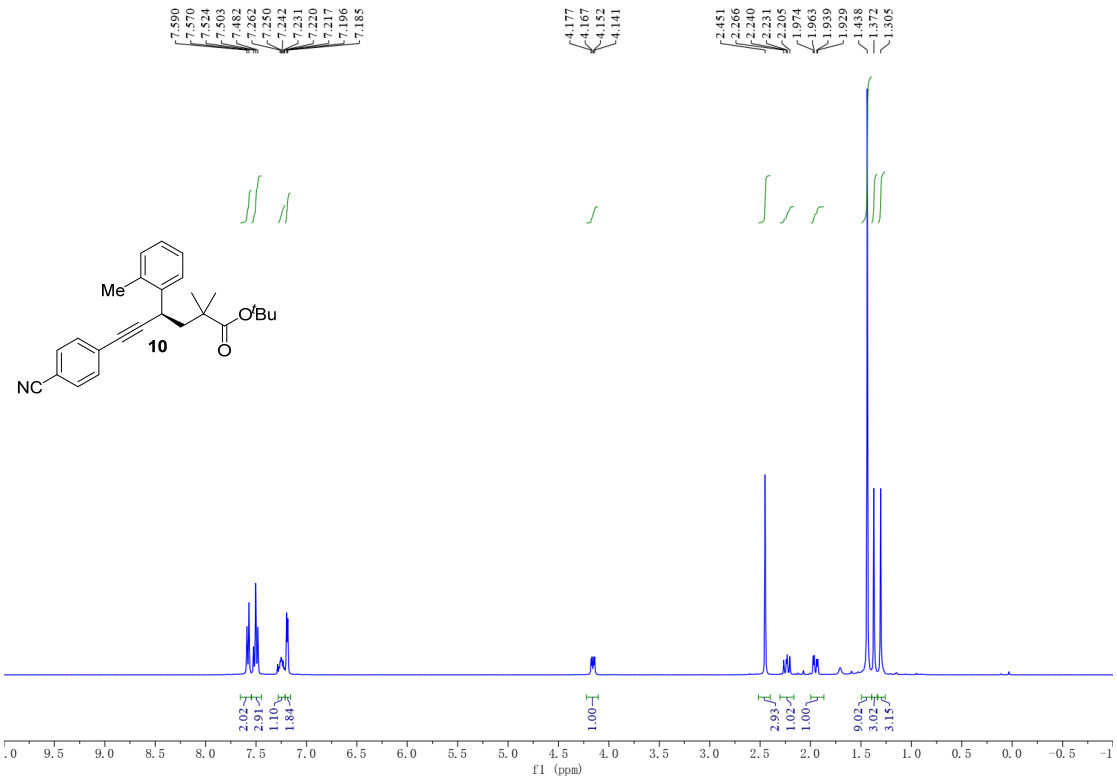
126.347
123.687
123.024
91.321
82.810
80.042
46.252
42.879
30.034
28.010
25.874
25.762
21.207
OAc
O^{t}Bu
Ph
9
O
f1 (ppm)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7.250
7.242
7.231
7.220
7.217
7.196
7.185
4.177
4.167
4.152
4.141
2.451
2.266
2.240
2.231
2.205
1.974
1.963
1.939
1.929
1.438
1.372
1.305
Me
O'Bu
O
10
NC
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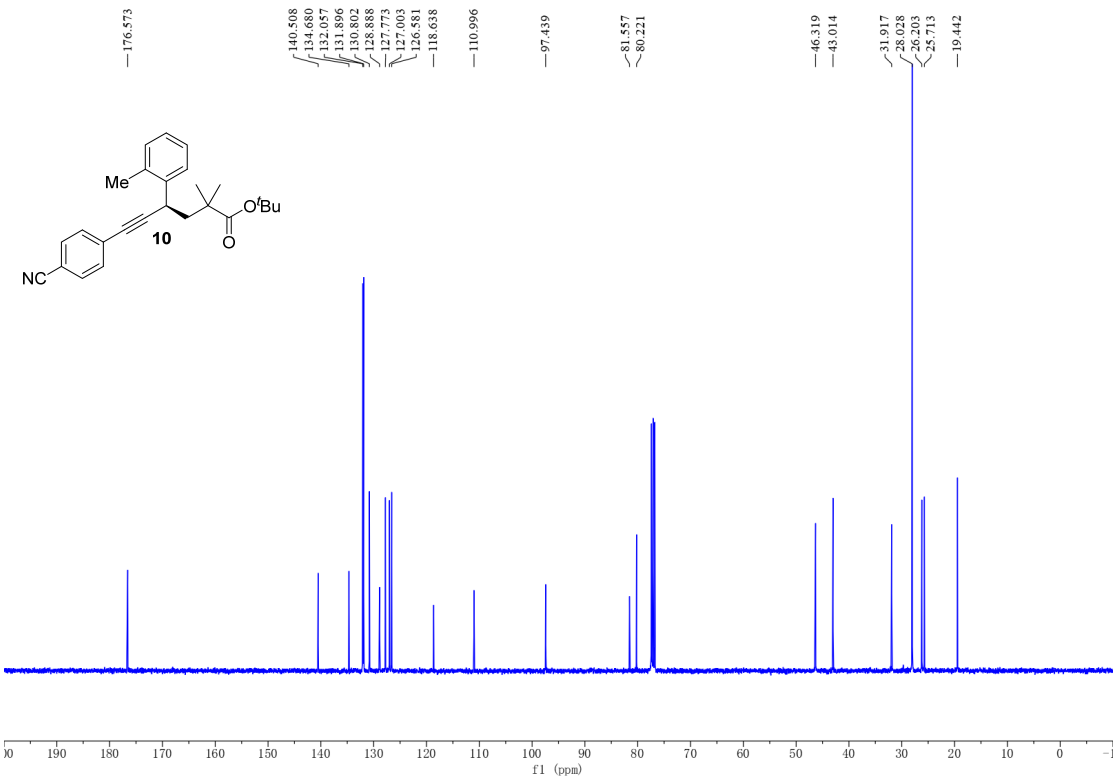
1.84
1.00
2.93
1.02
1.00
9.02
3.02
3.15
f1 (ppm)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127.773
127.003
126.581
118.638
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97.439
81.557
80.221
46.319
43.014
31.917
28.028
26.203
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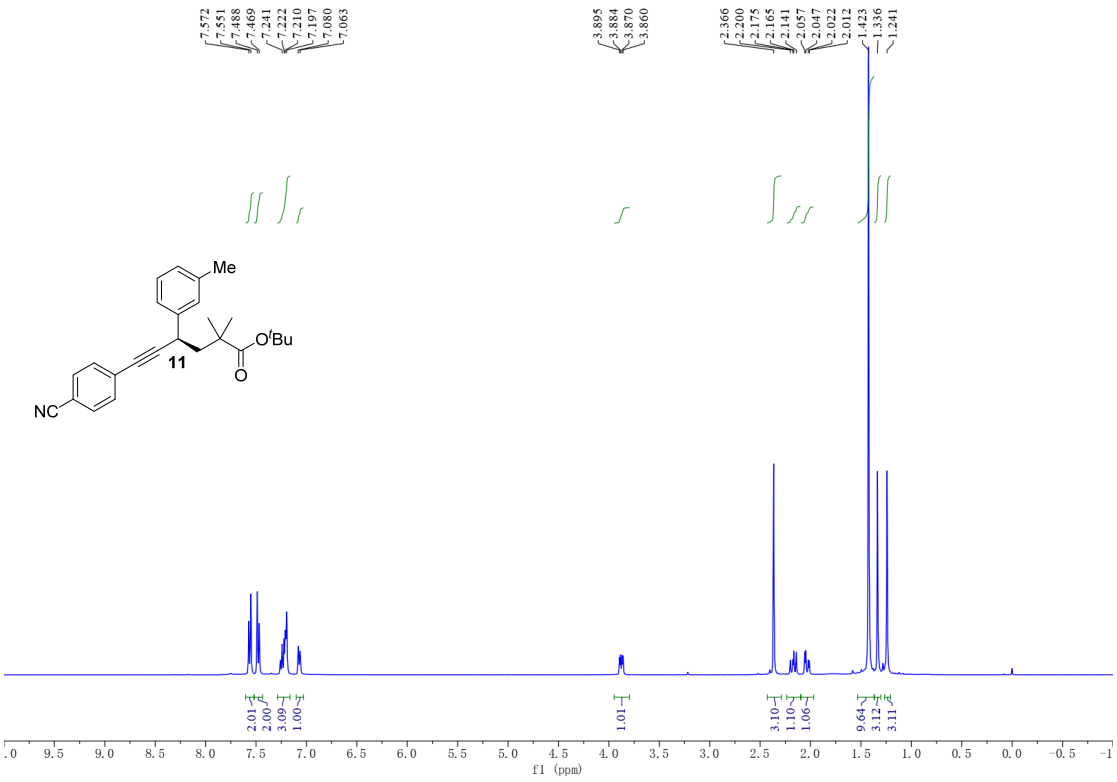
19.442
Me
O'Bu
O
10
NC
f1 (ppm)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7.197
7.080
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3.870
3.860
2.366
2.200
2.175
2.165
2.141
2.057
2.047
2.022
2.012
1.423
1.336
1.241
Me
O'Bu
O
11
NC
2.01
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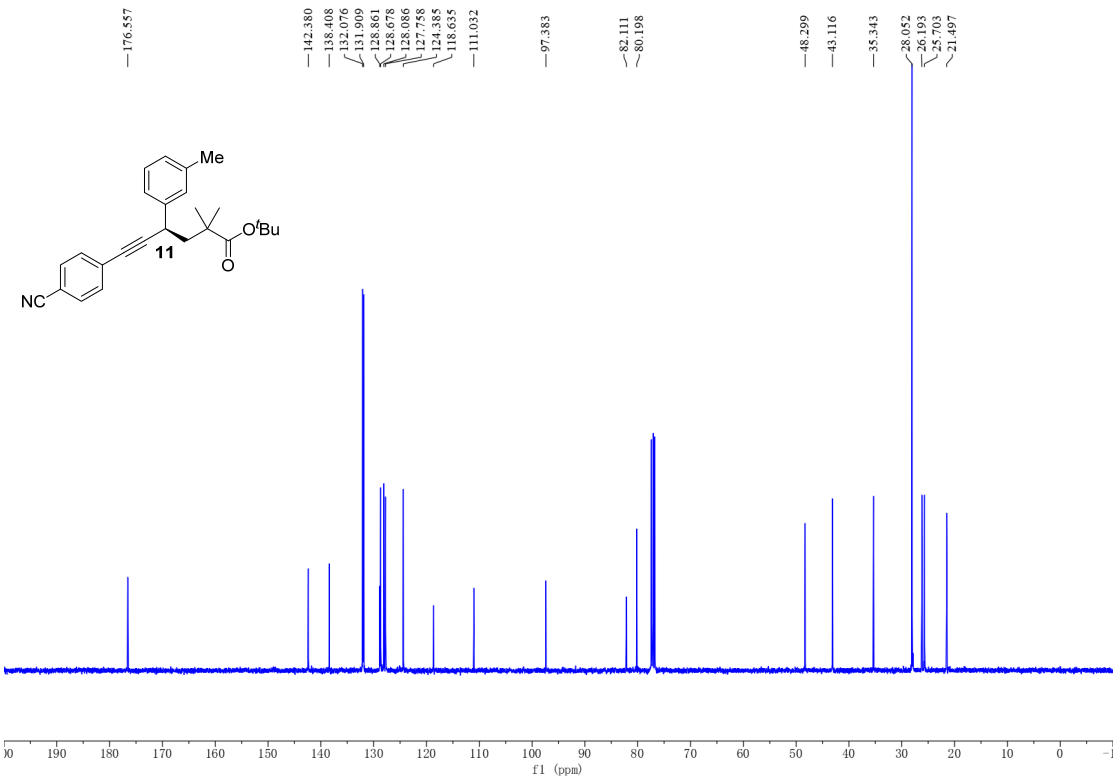
1.06
9.64
3.12
3.11
f1 (ppm)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118.635
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97.383
82.111
80.198
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35.343
28.052
26.193
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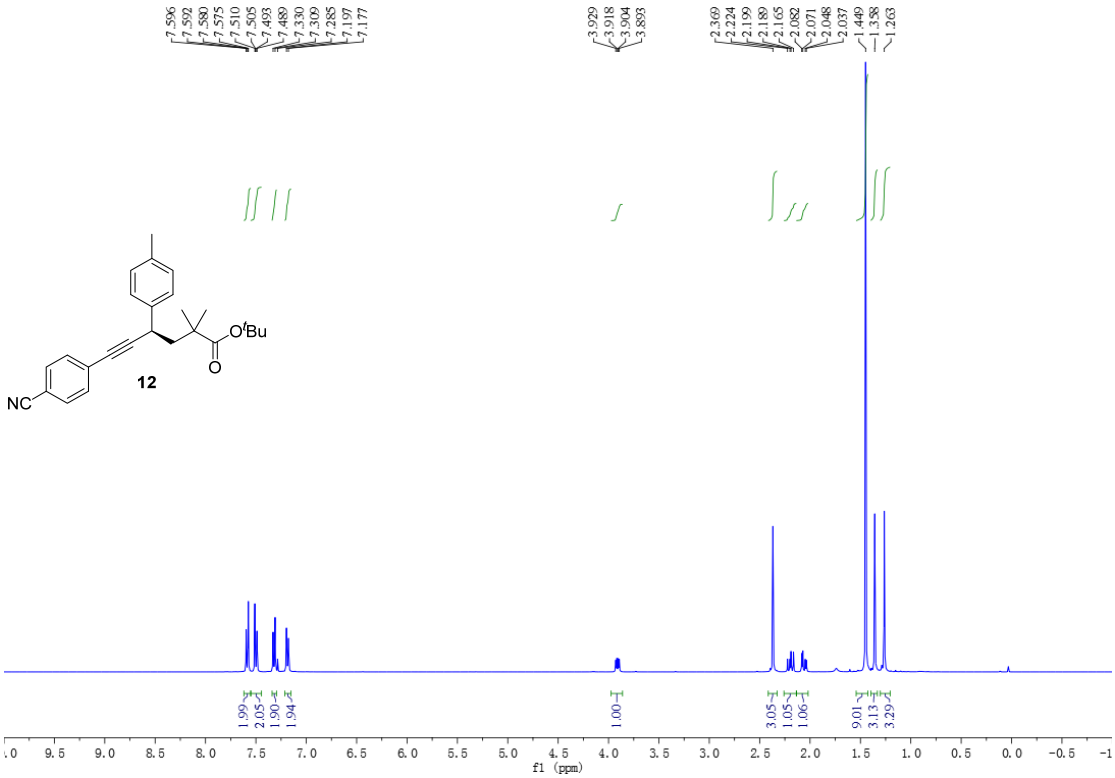
21.497
Me
O'Bu
O
11
NC
f1 (ppm)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7.510
7.505
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7.309
7.285
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3.929
3.918
3.904
3.893
2.369
2.224
2.199
2.189
2.165
2.082
2.071
2.048
2.037
1.449
1.338
1.263
O'Bu
O
12
NC
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1.94
1.00
3.05
1.05
1.06
9.01
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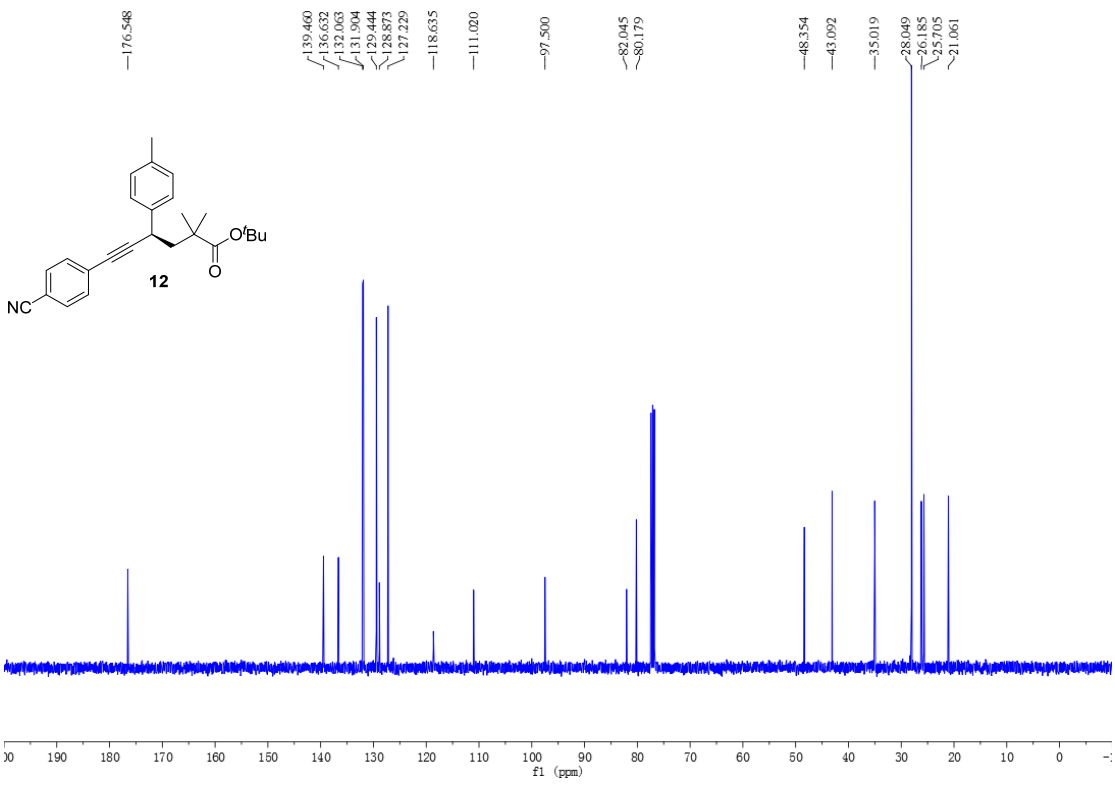
3.29
f1 (ppm)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127.229
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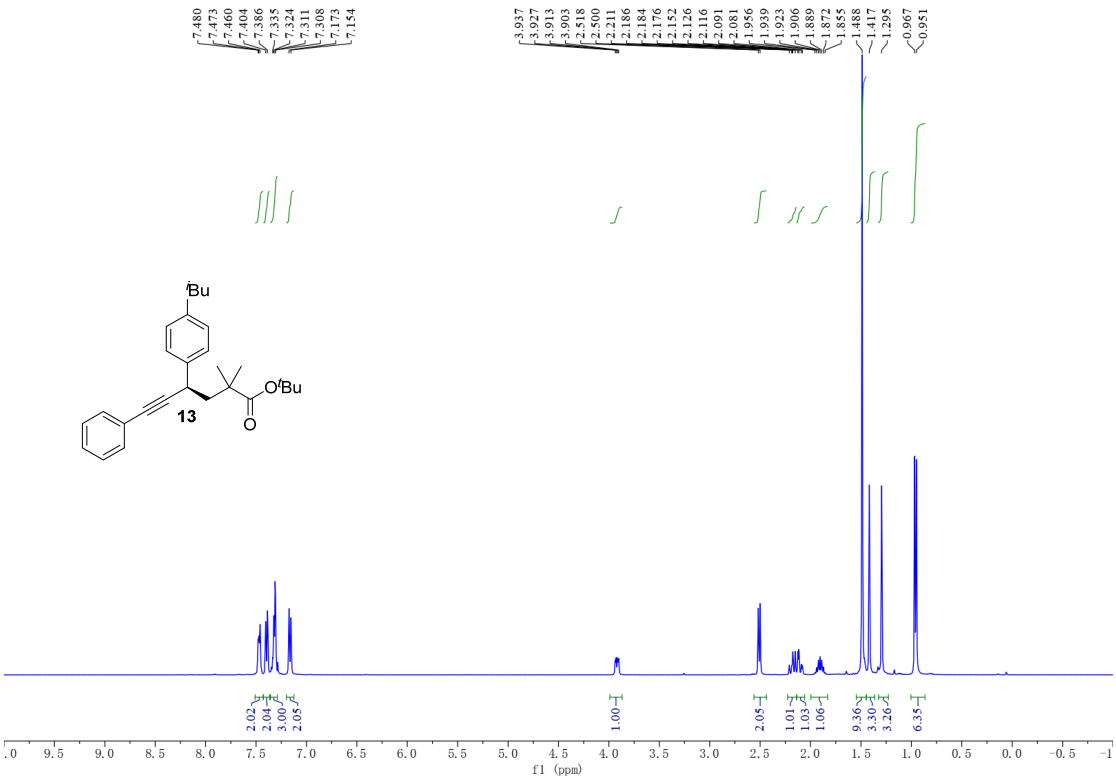
21.061
O'Bu
O
12
NC
f1 (ppm)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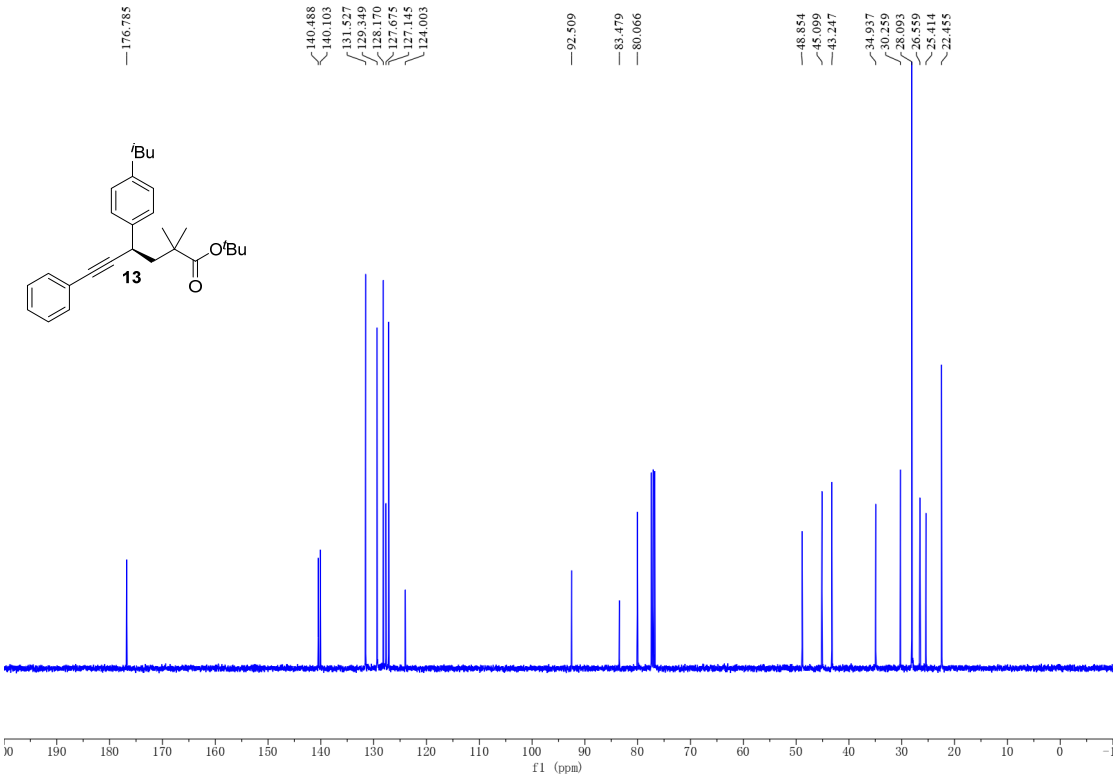
7.324
7.311
7.308
7.173
7.154
3.937
3.927
3.913
3.903
2.518
2.500
2.211
2.186
2.184
2.176
2.152
2.126
2.116
2.091
2.081
1.956
1.939
1.923
1.906
1.889
1.872
1.855
1.488
1.417
1.295
0.967
0.951
tBu
OtBu
O
13
2.02
2.04
3.00
2.05
1.00
2.05
1.01
1.03
1.06
9.36
3.30
3.26
6.35
f1 (ppm)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30.259
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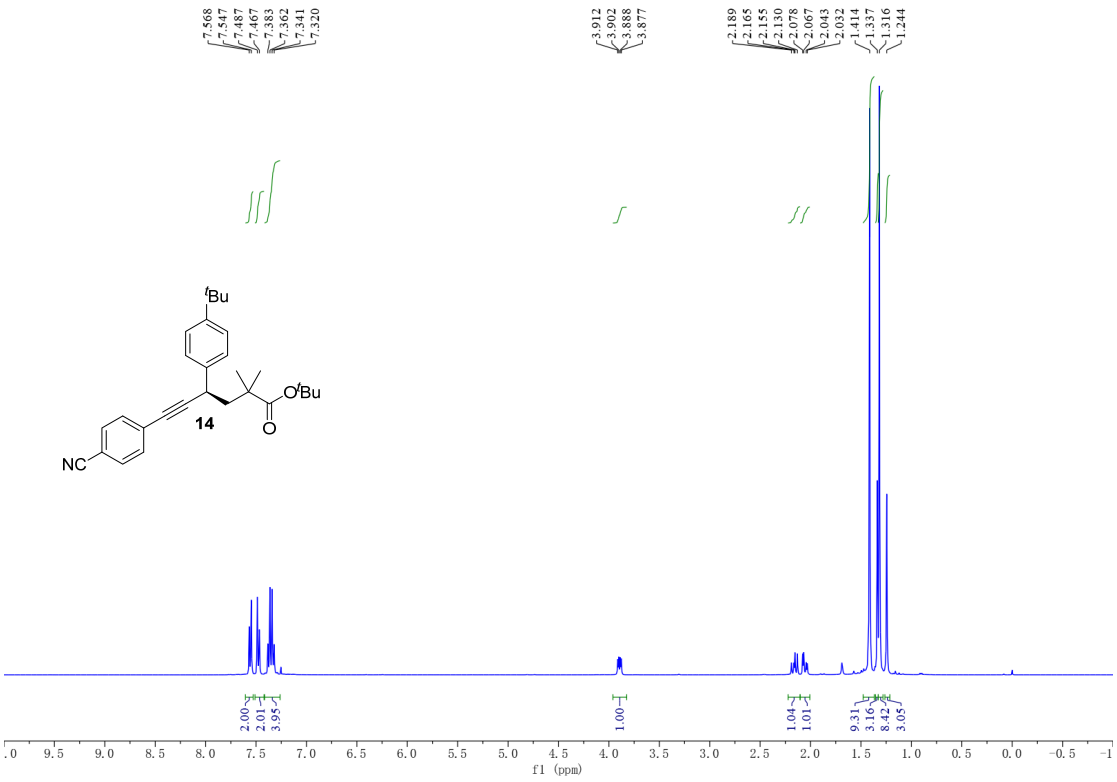
22.455
tBu
OtBu
O
13
f1 (ppm)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2.189
2.165
2.155
2.130
2.078
2.067
2.043
2.032
1.414
1.337
1.316
1.244
tBu
OtBu
O
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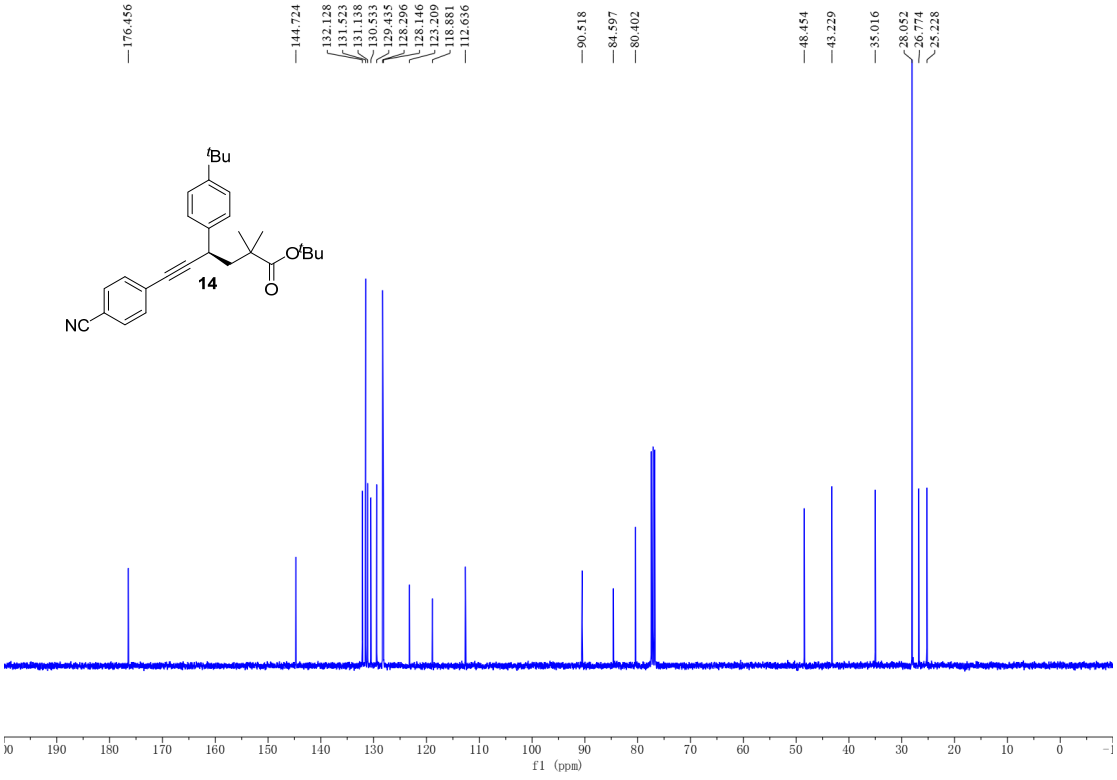
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90.518
84.597
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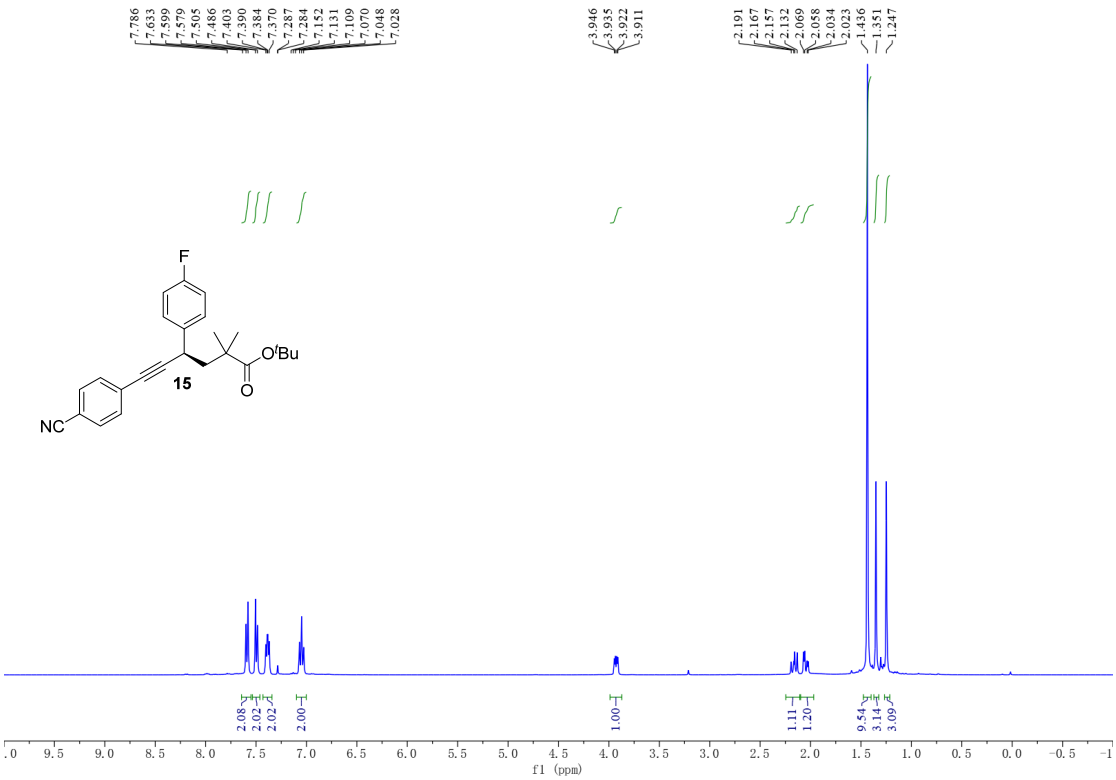
43.229
35.016
28.052
26.774
25.228
tBu
OtBu
O
14
NC
f1 (ppm)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7.284
7.152
7.131
7.109
7.070
7.048
7.028
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3.935
3.922
3.911
2.191
2.167
2.157
2.132
2.069
2.058
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2.023
1.436
1.351
1.247
F
O'Bu
O
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2.02
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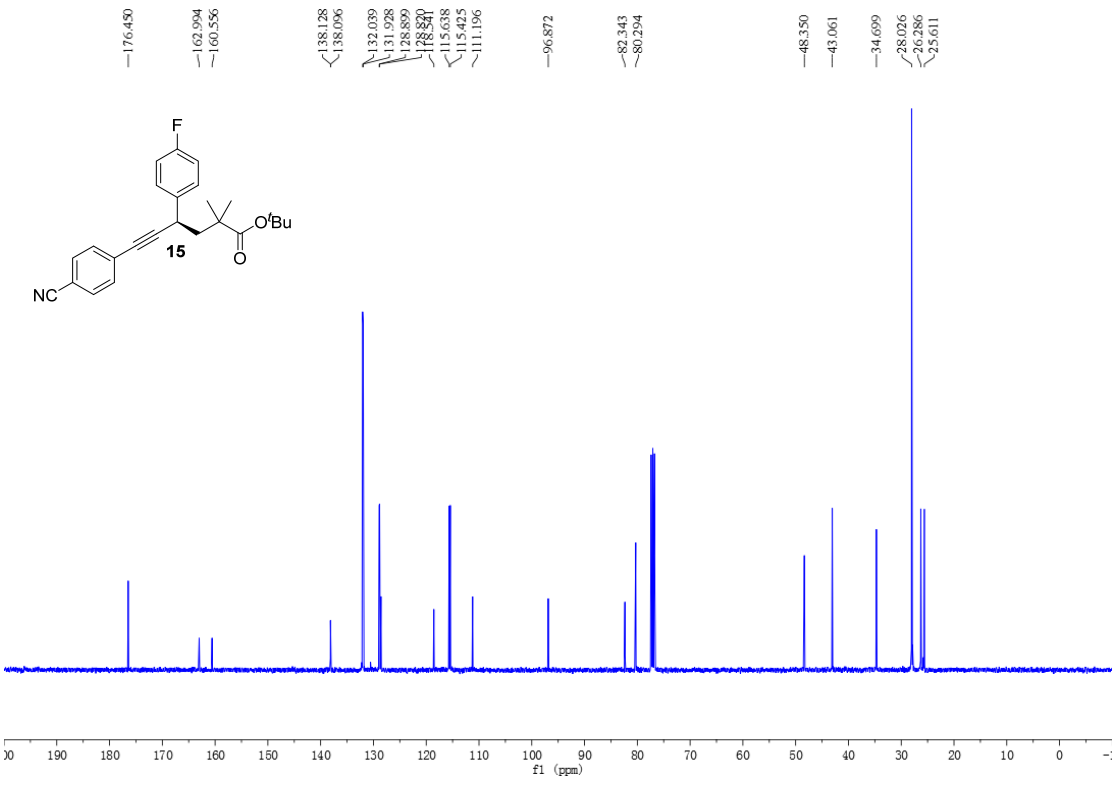
f1 (ppm)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111.196
96.872
82.343
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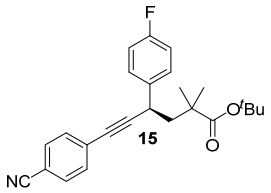
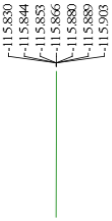
43.061
34.699
28.026
26.286
25.611
F
O'Bu
O
15
NC
f1 (ppm)


F
O
O
NC

15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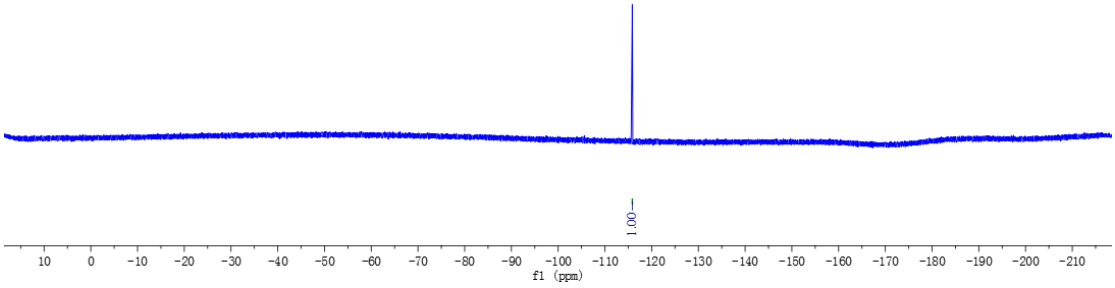
-115.903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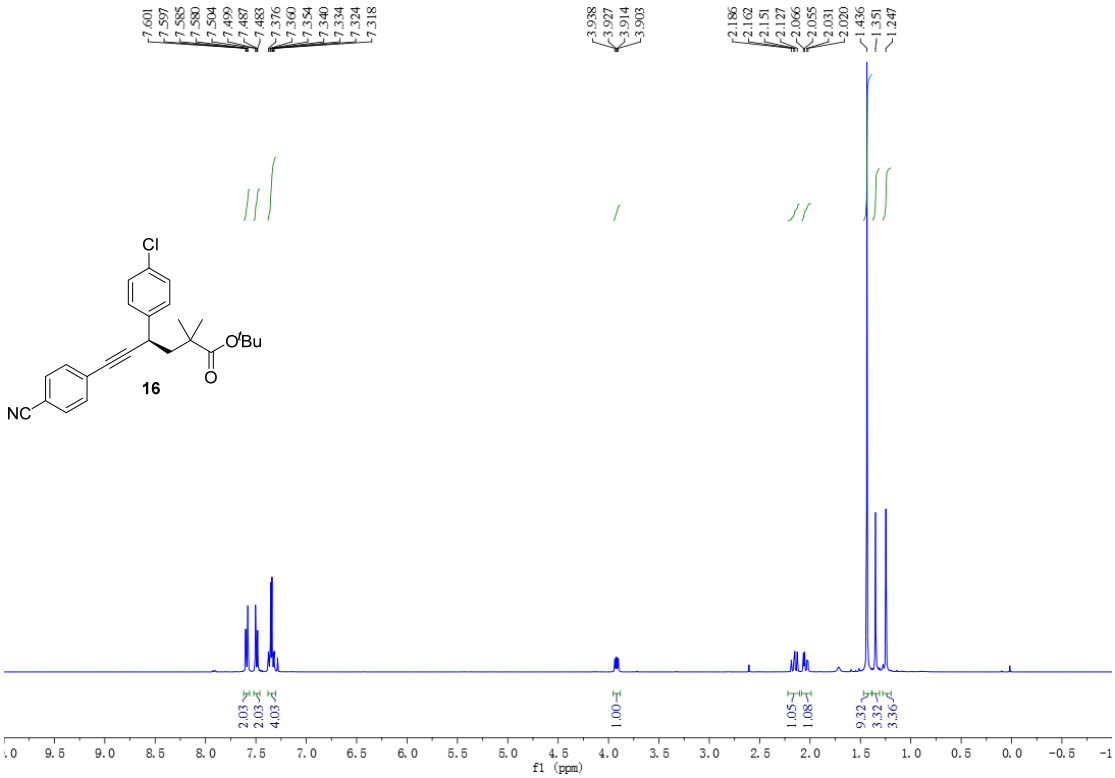
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)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7.334
7.324
7.318
3.938
3.927
3.914
3.903
2.186
2.162
2.151
2.127
2.066
2.055
2.031
2.020
1.436
1.351
1.247
Cl
O'Bu
O
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2.03
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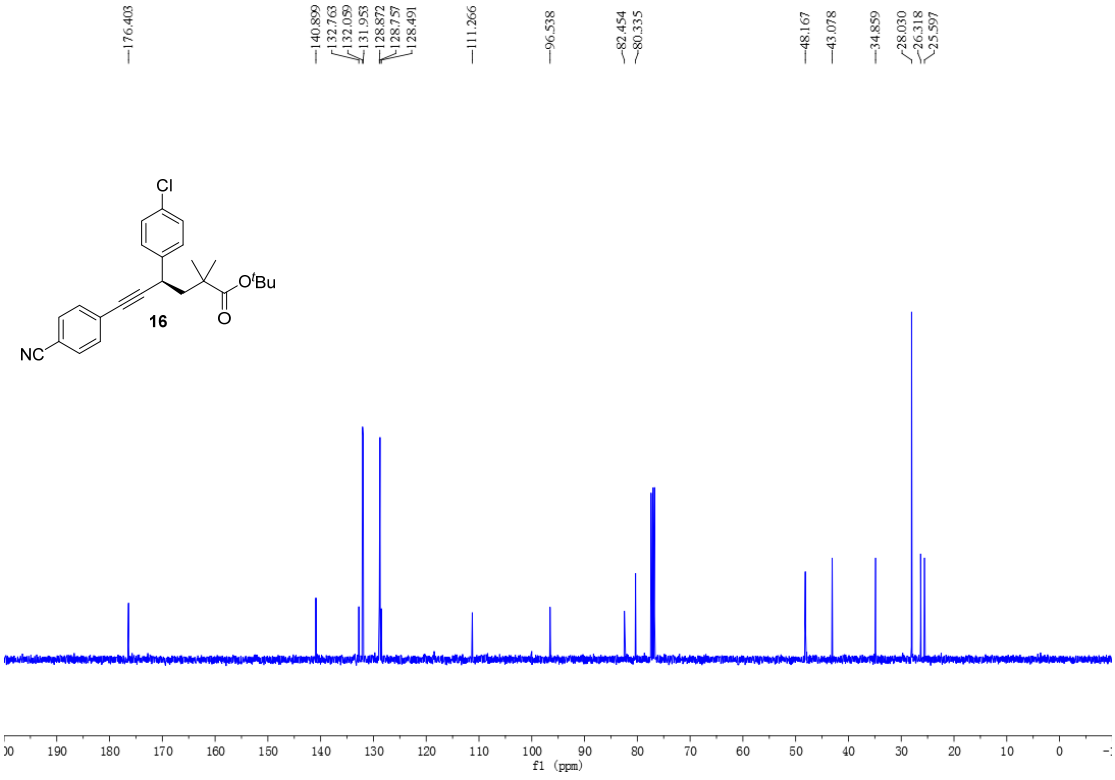
3.36
f1 (ppm)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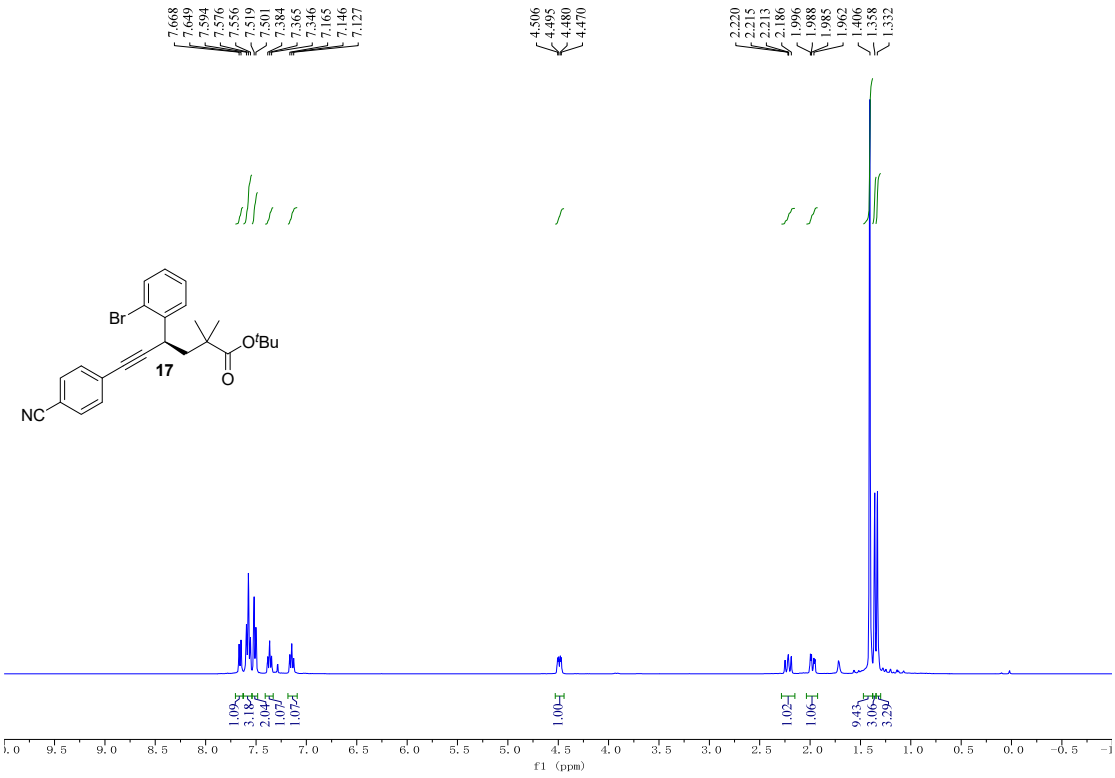
34.859
28.030
26.318
25.597
Cl
O'Bu
O
NC
16
f1 (ppm)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7.127
4.506
4.495
4.480
4.470
2.220
2.215
2.213
2.186
1.996
1.988
1.985
1.962
1.406
1.358
1.332
Br
O^{t}Bu
O
17
NC
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1.07
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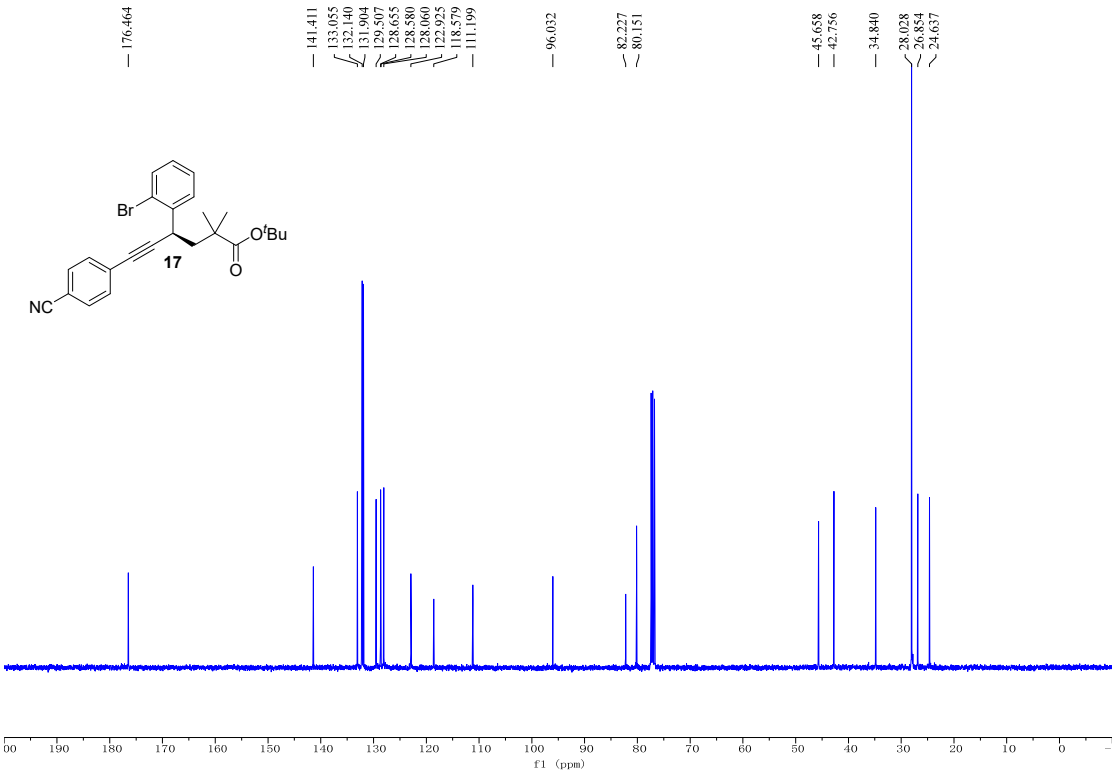
3.29
f1 (ppm)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128.580
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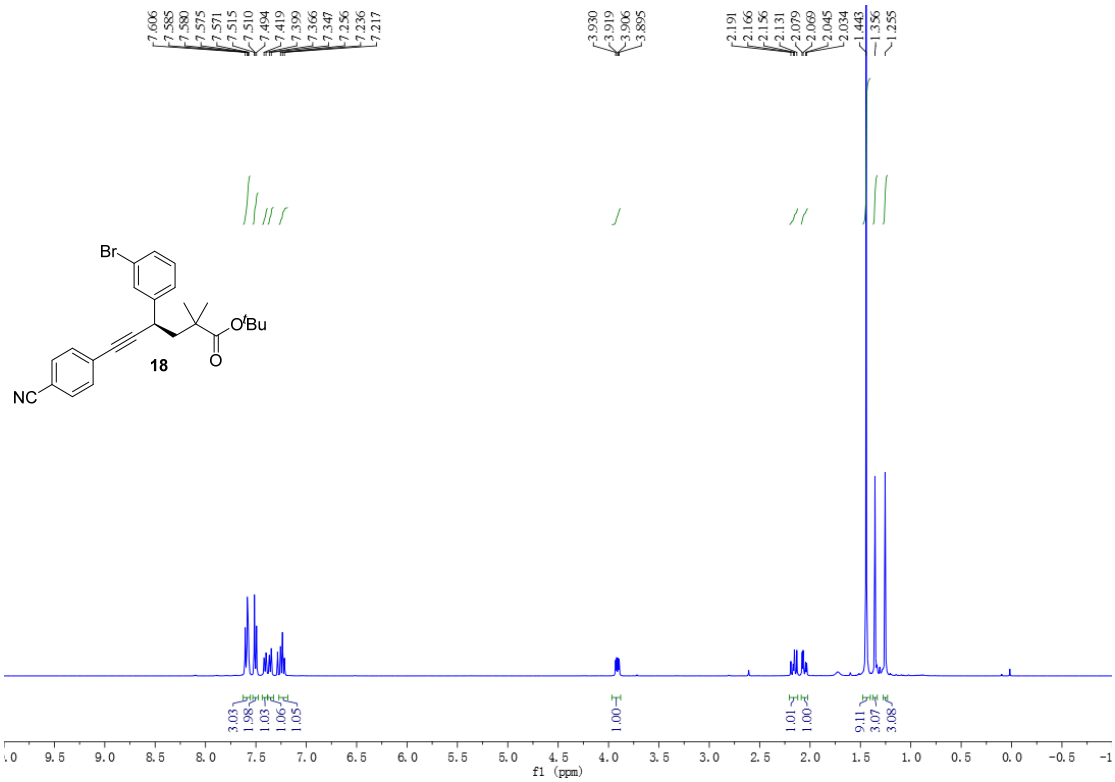
122.925
118.579
111.199
96.032
82.227
80.151
45.658
42.756
34.840
28.028
26.854
24.637
Br
O^{t}Bu
O
17
NC
f1 (ppm)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7.494
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7.347
7.256
7.236
7.217
3.930
3.919
3.906
3.895
2.191
2.166
2.156
2.131
2.079
2.069
2.045
2.034
1.443
1.356
1.255
Br
O'Bu
O
18
NC
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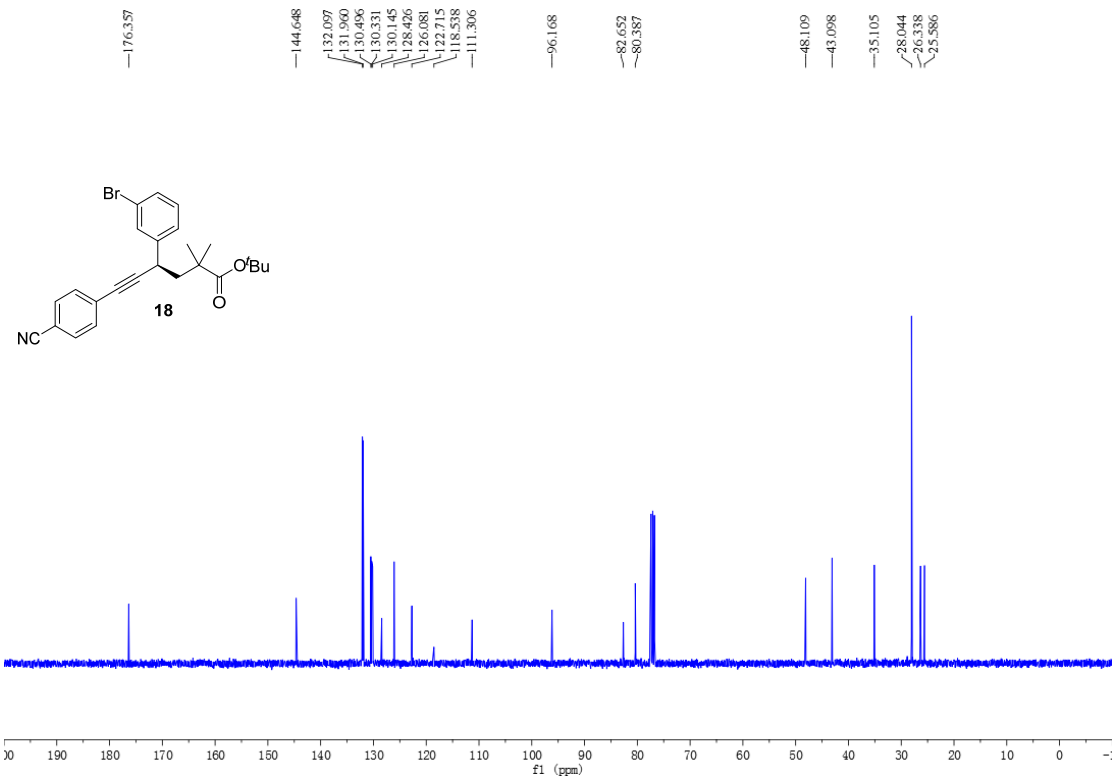
1.03
1.06
1.05
1.00
1.01
1.00
9.11
3.07
3.08
f1 (ppm)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130.145
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126.081
122.715
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96.168
82.652
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43.098
35.105
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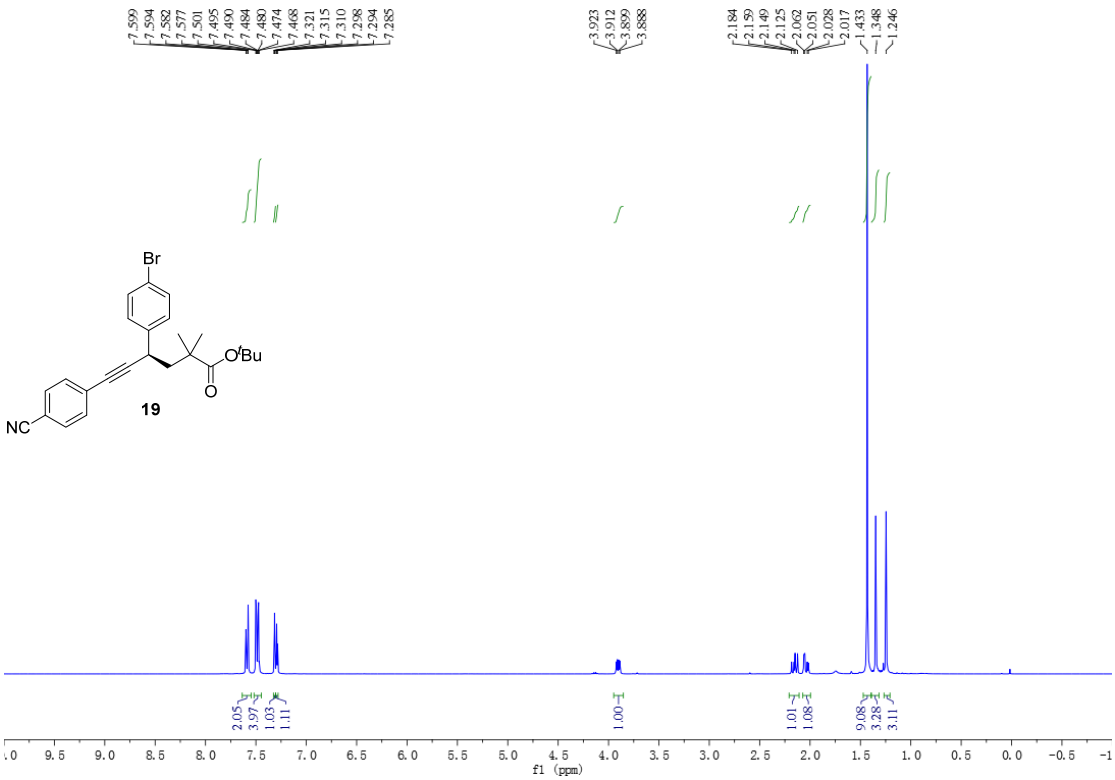
26.338
25.586
Br
O'Bu
O
18
NC
f1 (ppm)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7.310
7.298
7.294
7.285
3.923
3.912
3.899
3.888
2.184
2.159
2.149
2.125
2.062
2.051
2.028
2.017
1.433
1.348
1.246
Br
O'Bu
O
NC
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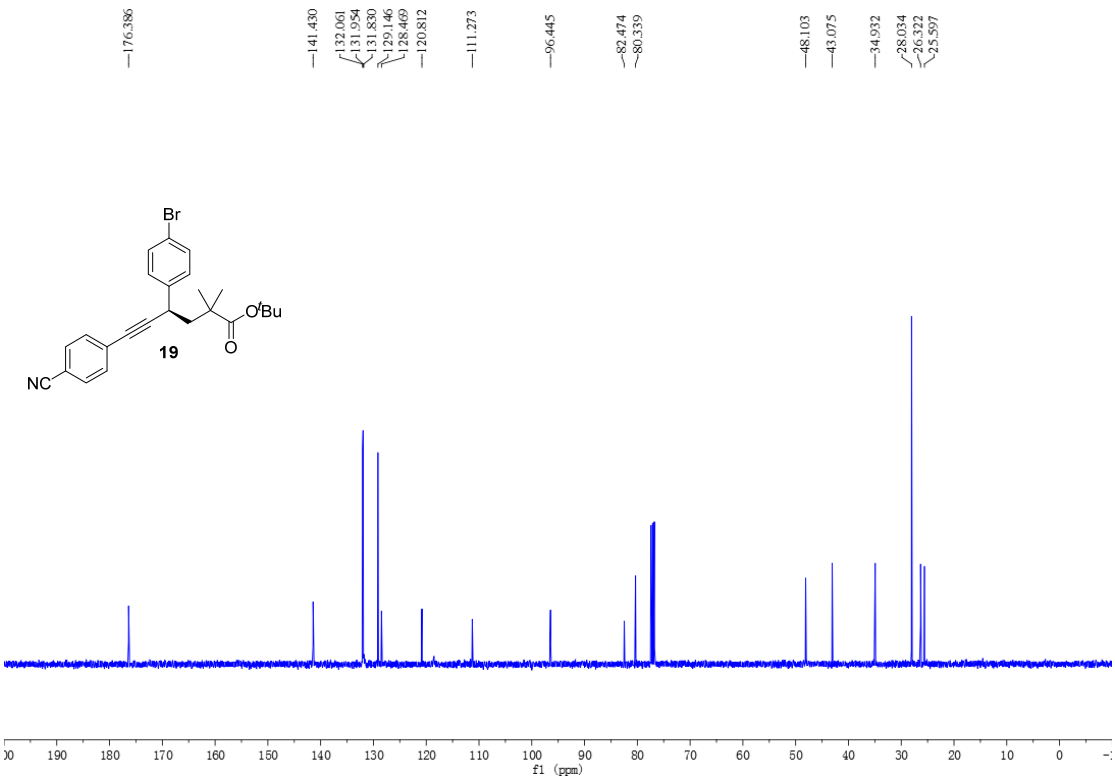
1.00
1.01
1.08
9.08
3.28
3.11
f1 (ppm)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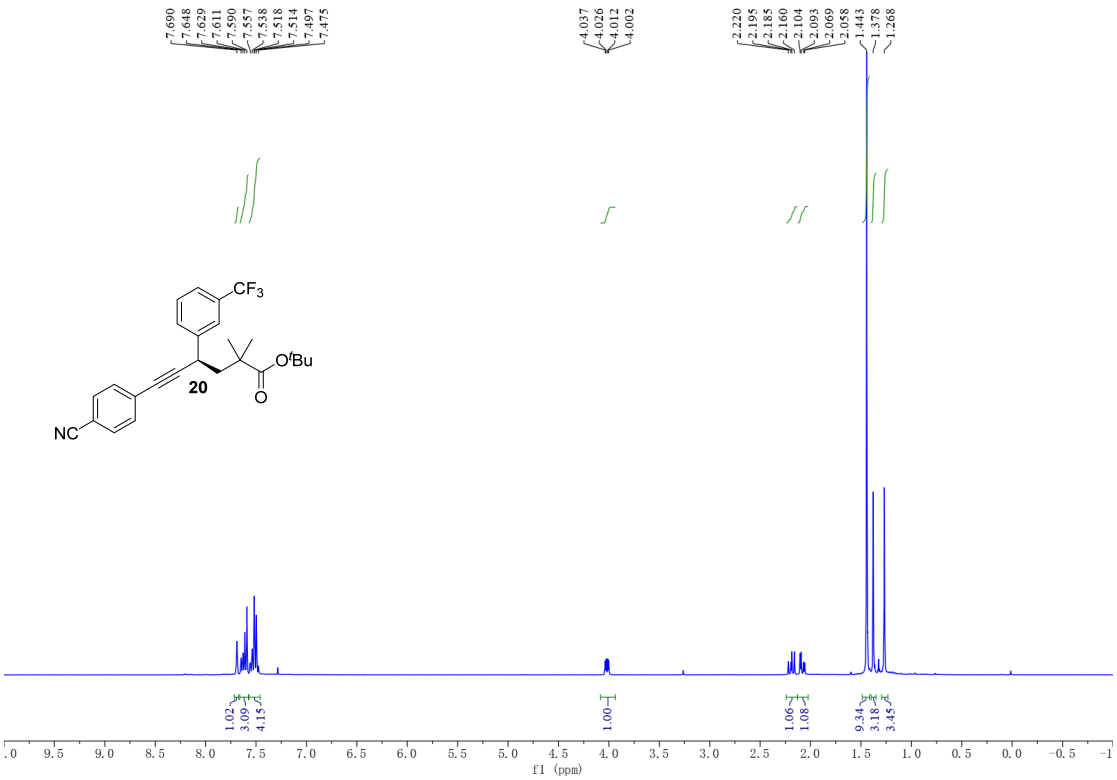
Br
O'Bu
O
NC
19
f1 (ppm)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7.557
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7.518
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4.012
4.002
2.220
2.195
2.185
2.160
2.104
2.093
2.069
2.058
1.443
1.378
1.268
CF3
O'Bu
O
20
NC
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3.09
4.15
1.00
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1.08
9.34
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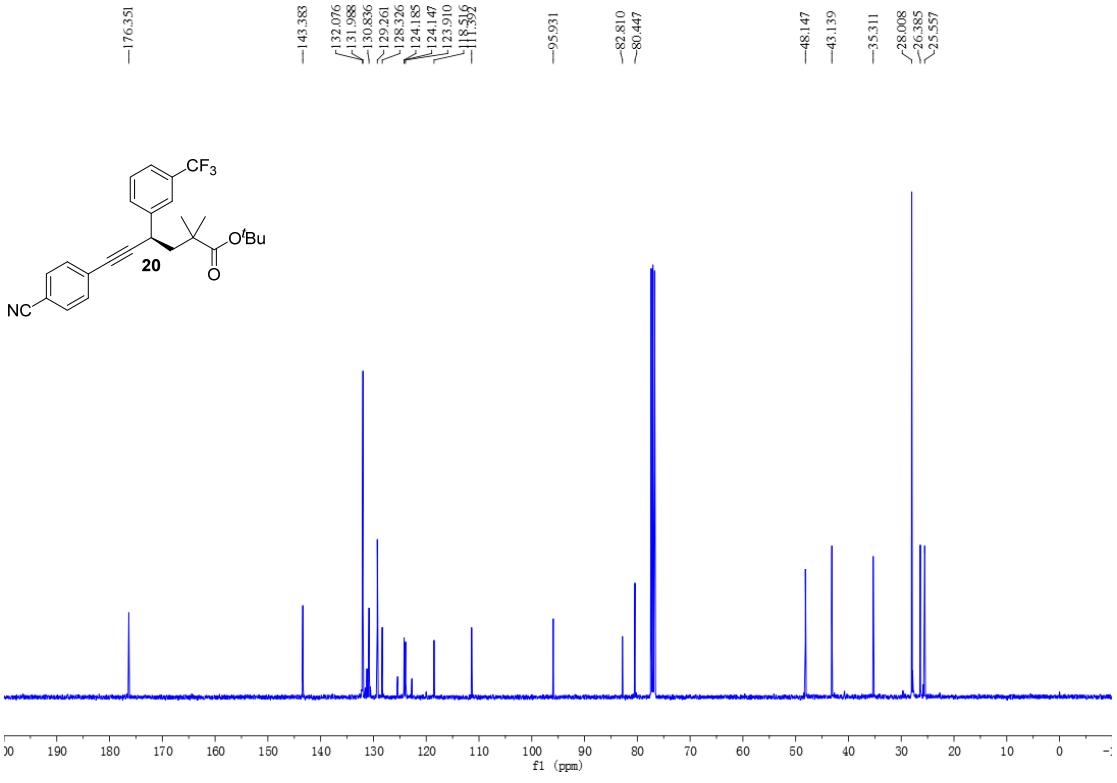
3.45
f1 (ppm)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82.810
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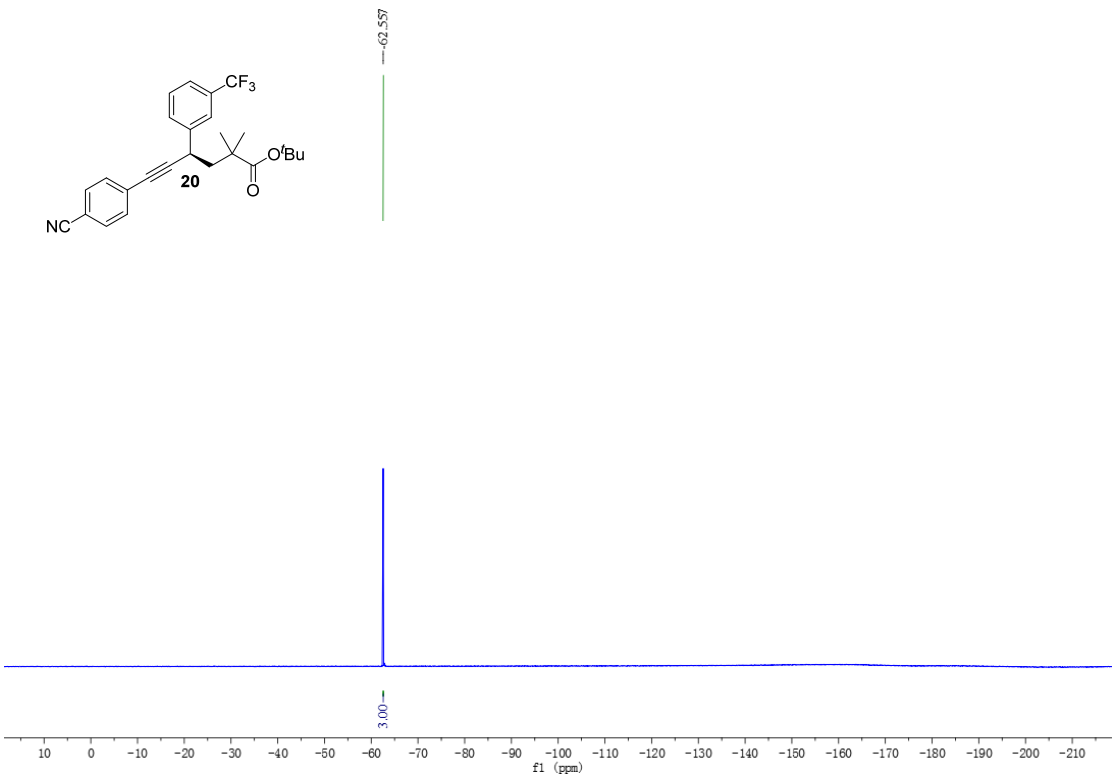
CF3
O'Bu
O
20
NC
f1 (ppm)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O
20
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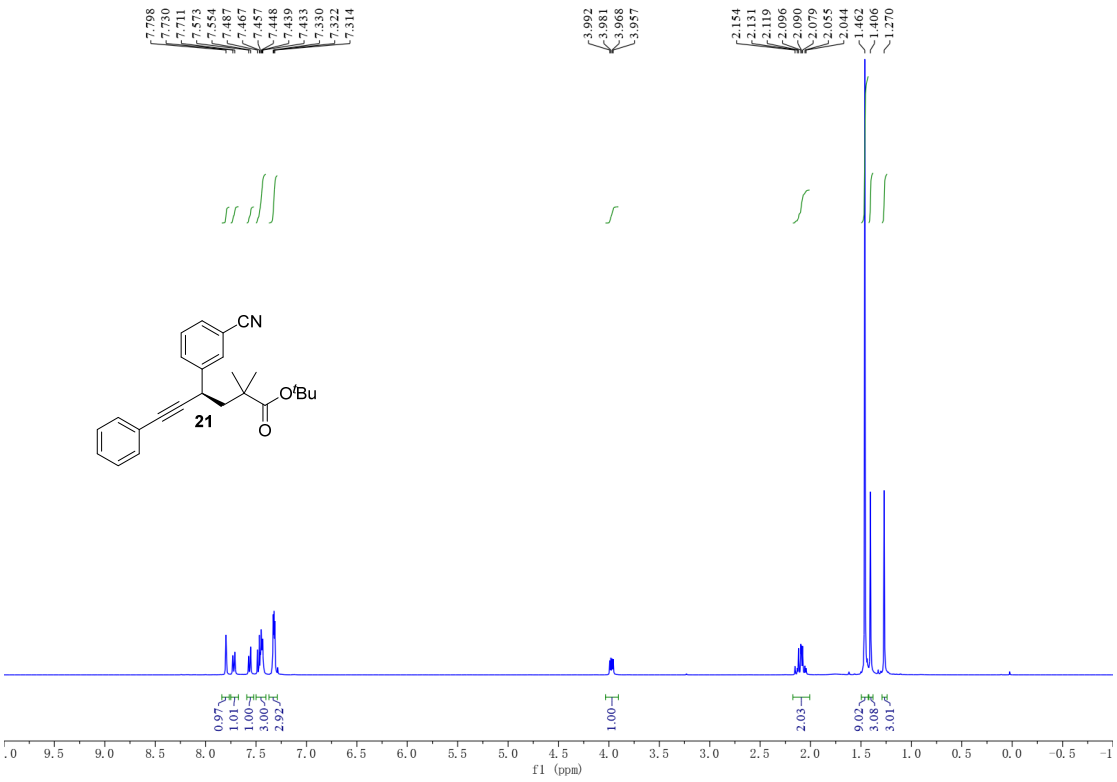
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)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7.439
7.433
7.330
7.322
7.314
3.992
3.981
3.968
3.957
2.154
2.131
2.119
2.096
2.090
2.079
2.055
2.044
1.462
1.406
1.270
CN
O'Bu
O
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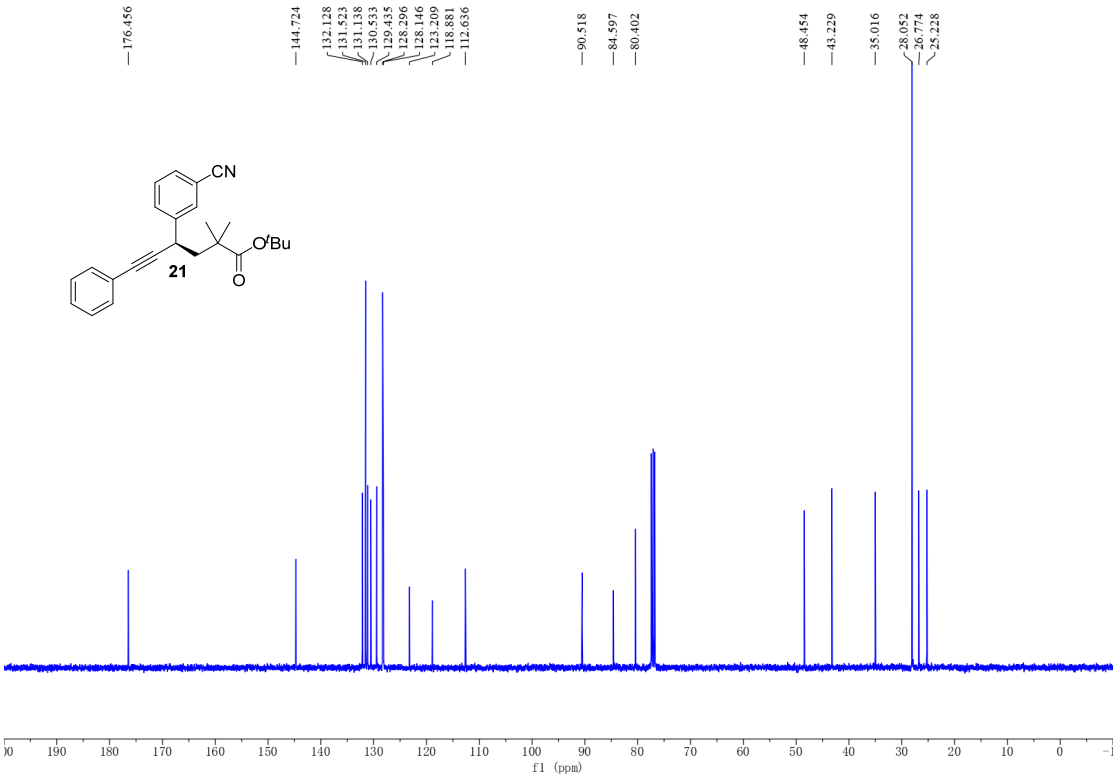
1.00
3.00
2.92
1.00
2.03
9.02
3.08
3.01
f1 (ppm)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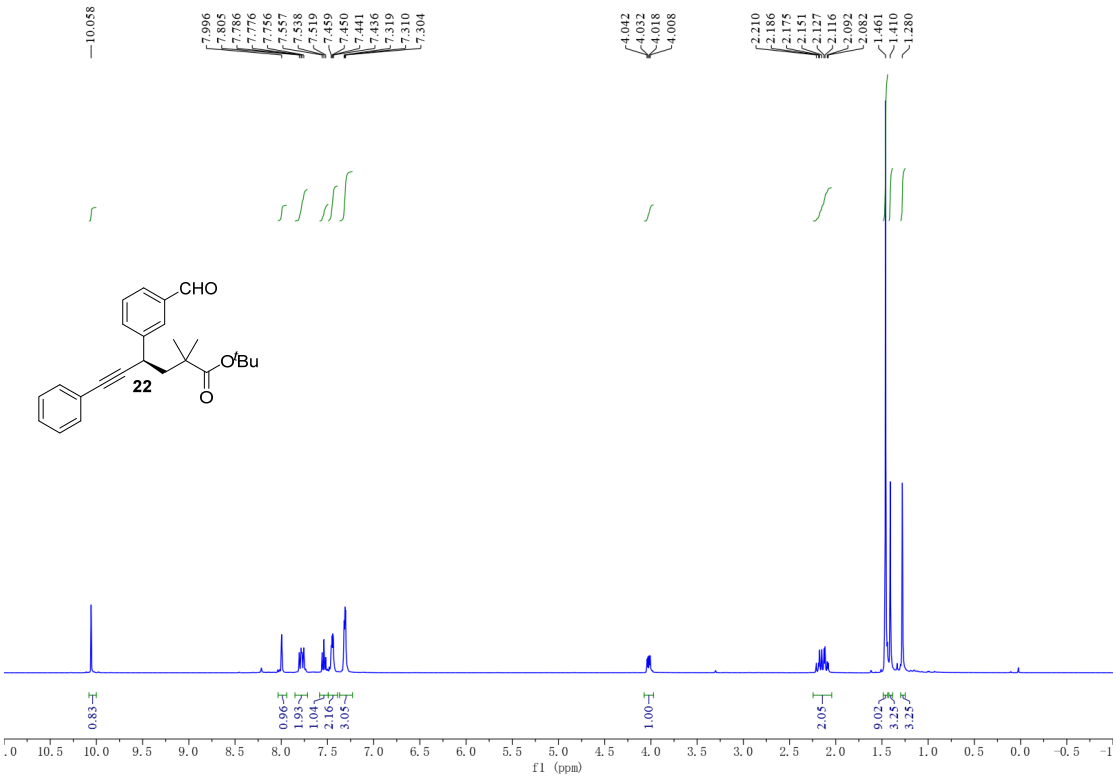
131.523
131.138
130.533
129.435
128.296
128.146
123.209
118.881
112.636
90.518
84.597
80.402
48.454
43.229
35.016
28.052
26.774
25.228
CN
O'Bu
O
21
f1 (ppm)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7.756
7.557
7.538
7.519
7.459
7.450
7.441
7.436
7.319
7.310
7.304
4.042
4.032
4.018
4.008
2.210
2.186
2.175
2.151
2.127
2.116
2.092
2.082
1.461
1.410
1.280
CHO
O'Bu
O
22
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0.96
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1.04
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2.05
9.02
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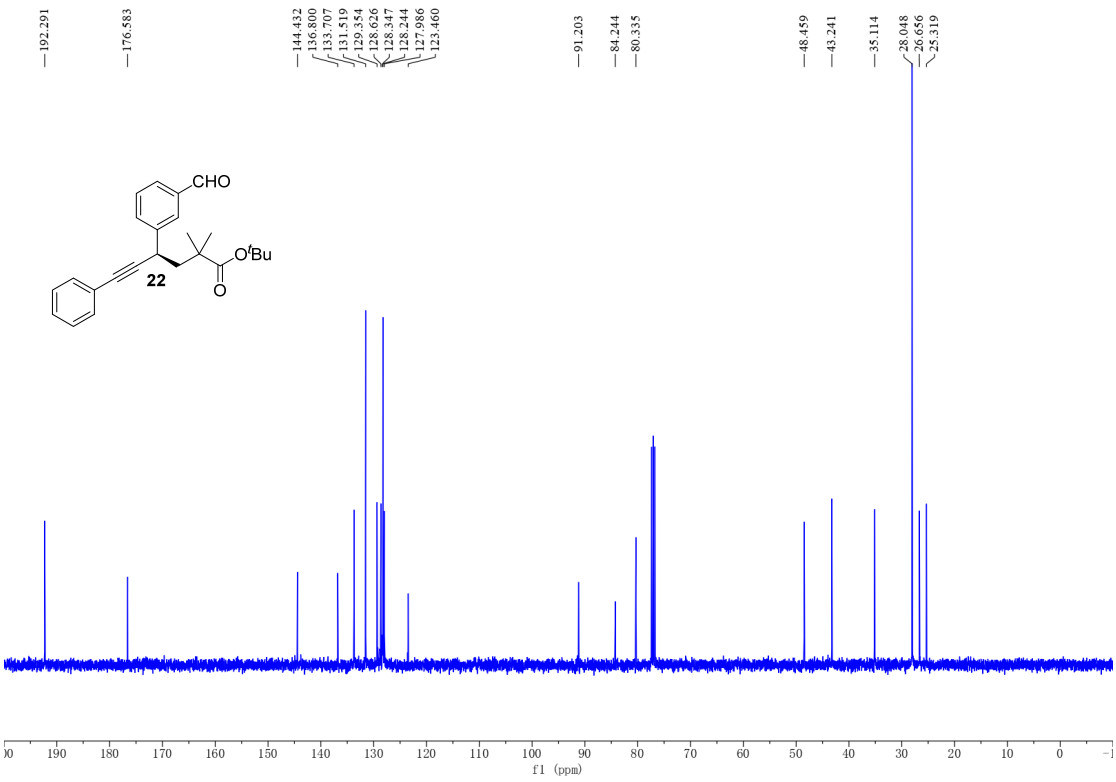
3.25
f1 (ppm)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127.986
123.460
91.203
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43.241
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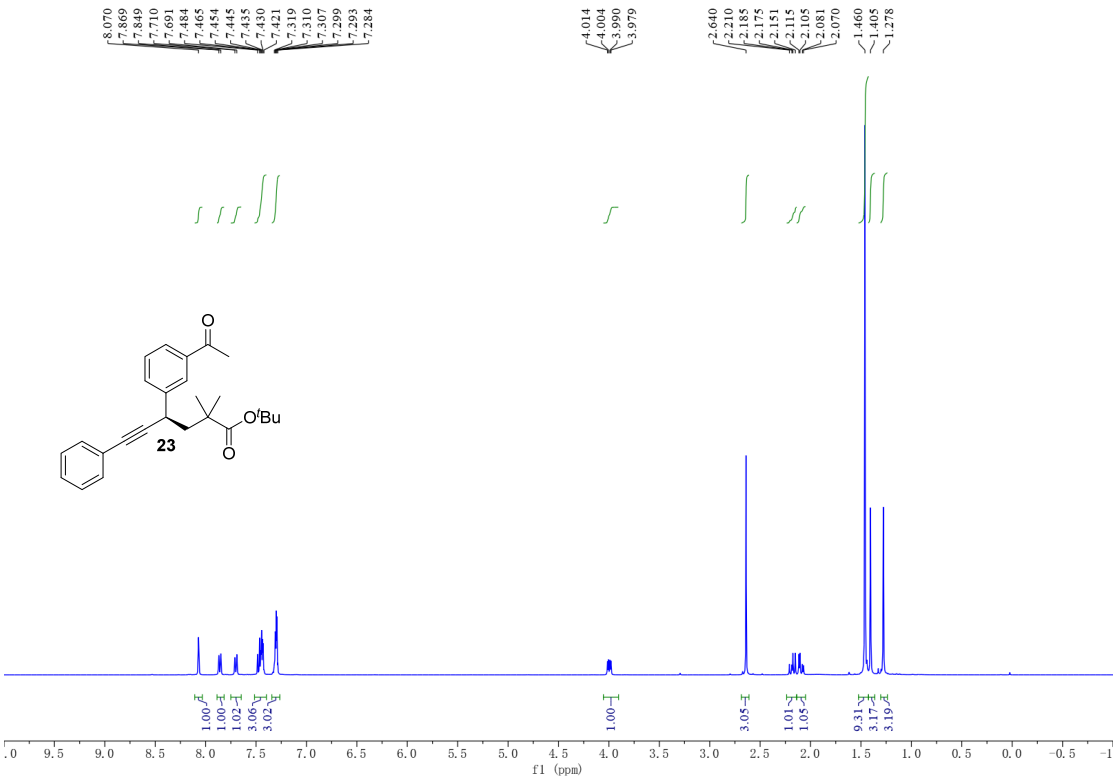
28.048
26.656
25.319
CHO
O'Bu
O
22
f1 (ppm)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7.421
7.319
7.310
7.307
7.299
7.293
7.284
4.014
4.004
3.990
3.979
2.640
2.210
2.185
2.175
2.151
2.115
2.105
2.081
2.070
1.460
1.405
1.278
O
O
O'Bu
23
1.00
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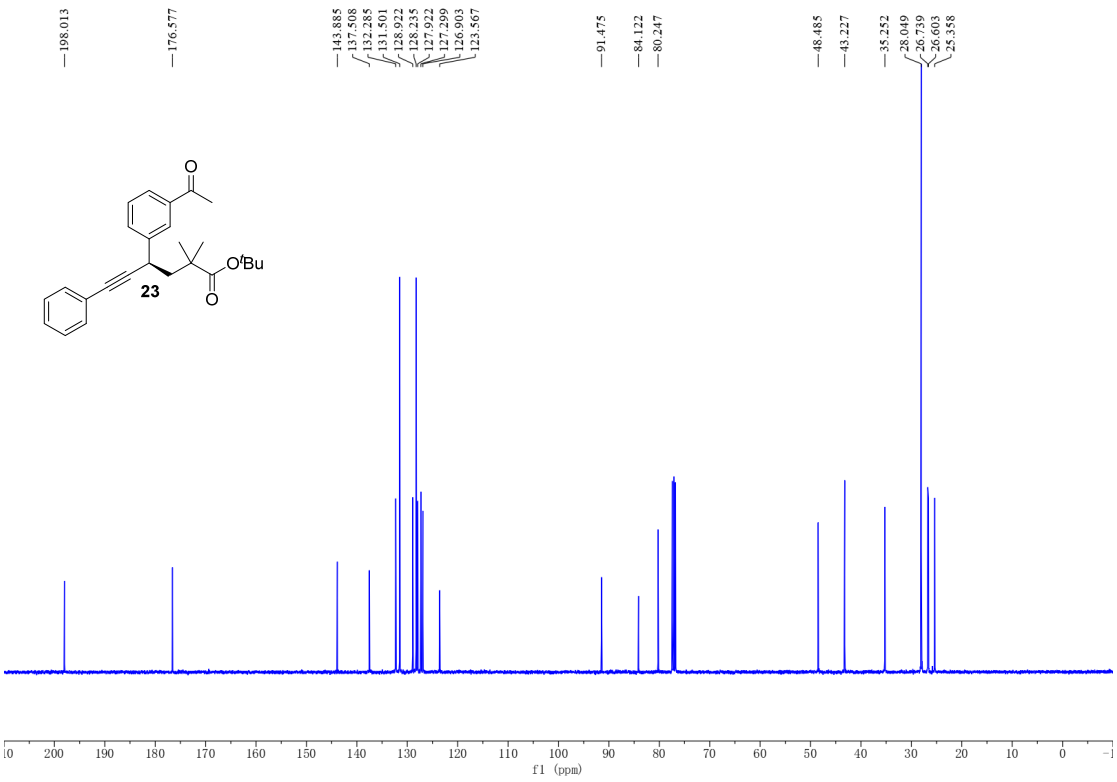
3.19
f1 (ppm)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84.122
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35.252
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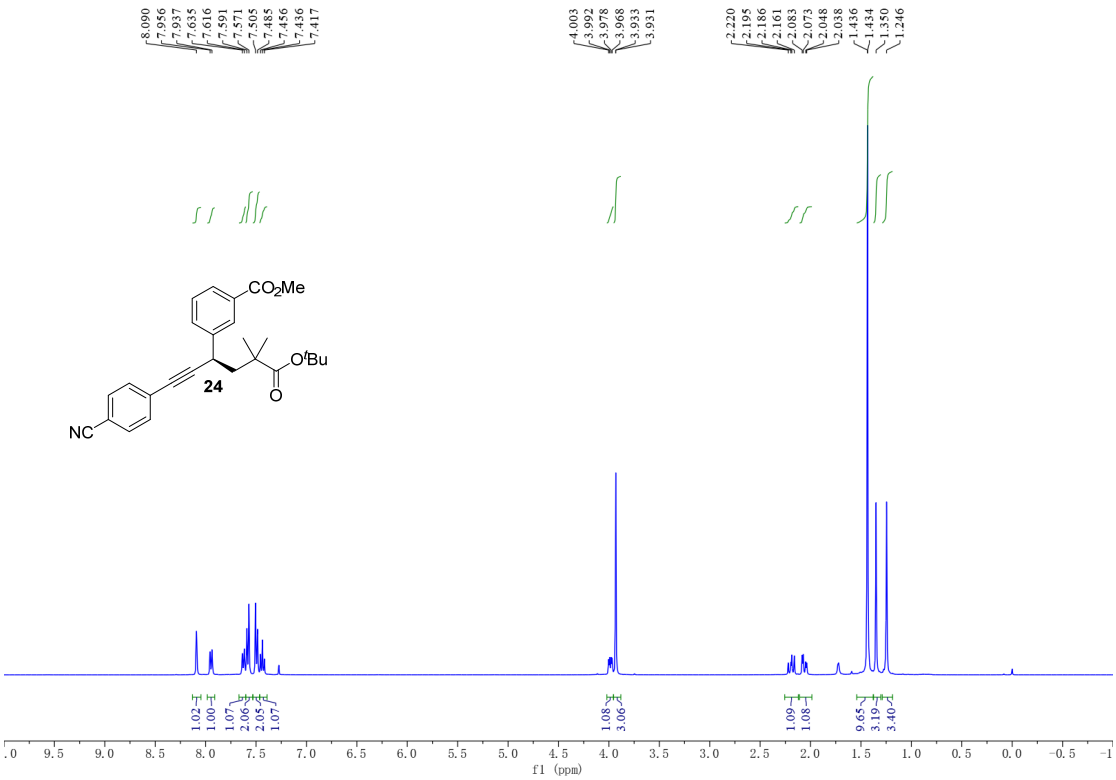
25.358
O
O
O'Bu
23
f1 (ppm)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7.937
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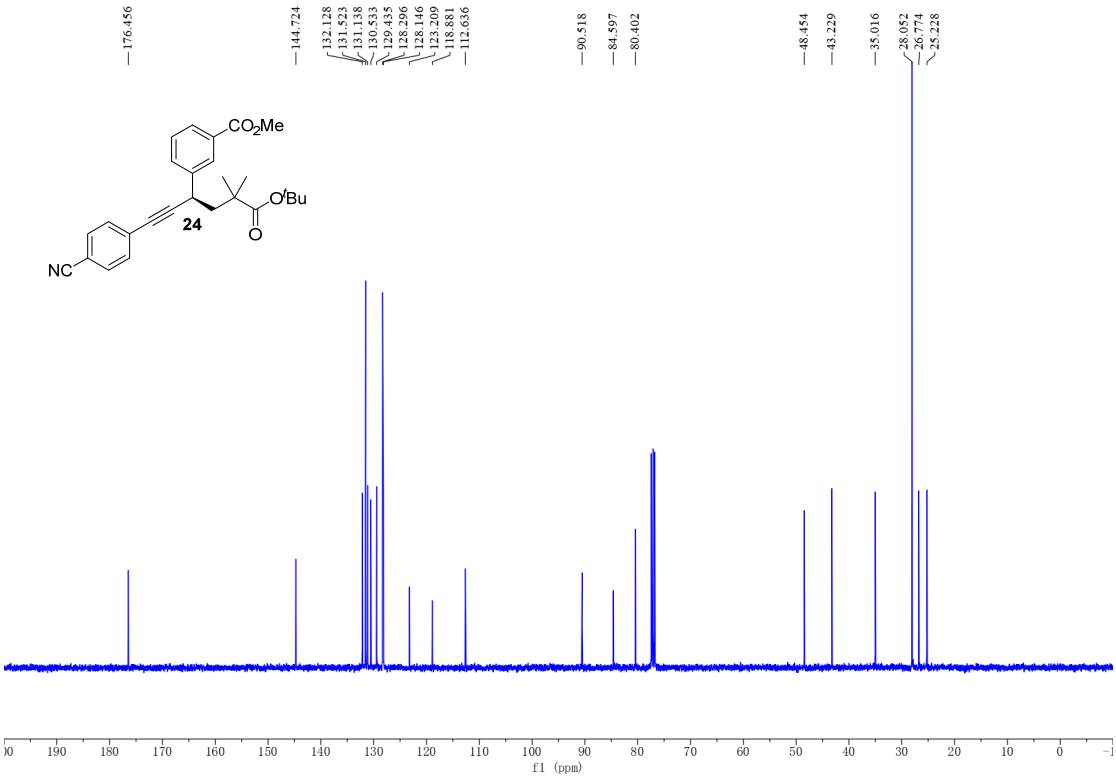
7.436
7.417
4.003
3.992
3.978
3.968
3.933
3.931
2.220
2.195
2.186
2.161
2.083
2.073
2.048
2.038
1.436
1.434
1.350
1.246
CO2Me
O'Bu
O
24
NC
1.02
1.00
1.07
2.06
2.05
1.07
1.08
3.06
1.09
1.08
9.65
3.19
3.40
f1 (ppm)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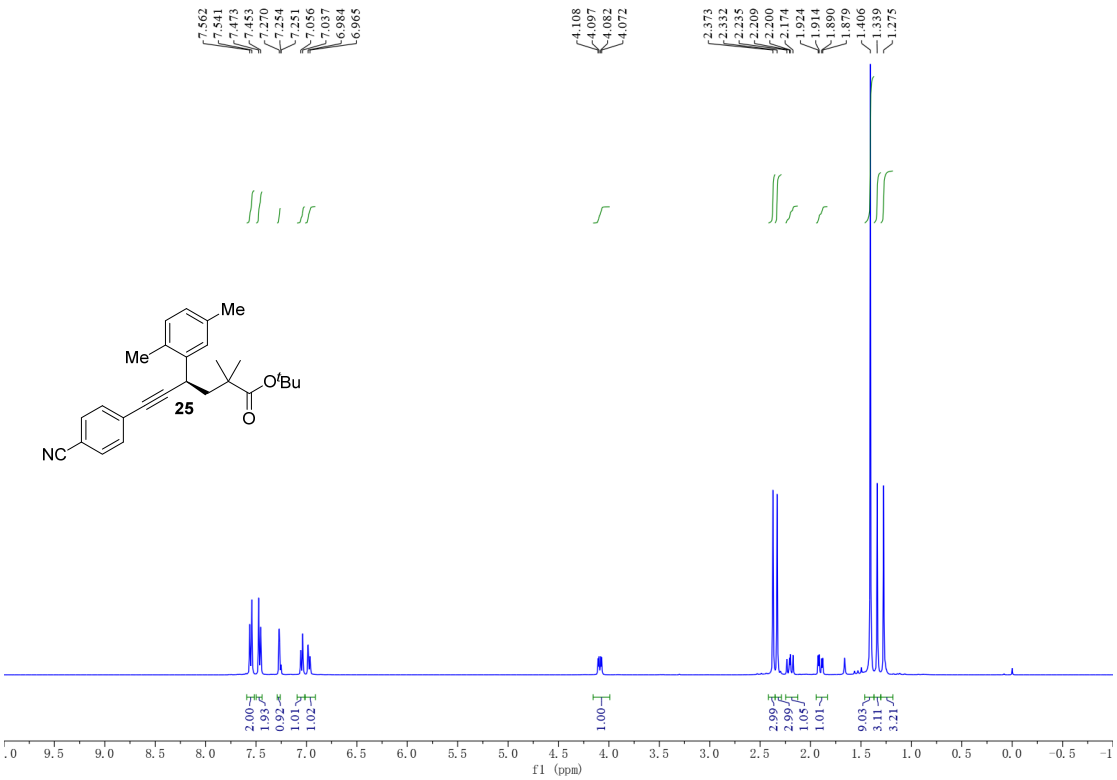
132.128
131.523
131.138
130.533
129.435
128.296
128.146
123.209
118.881
112.636
90.518
84.597
80.402
48.454
43.229
35.016
28.052
26.774
25.228
CO2Me
O'Bu
O
24
NC
f1 (ppm)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4.097
4.082
4.072
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2.332
2.235
2.209
2.200
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1.914
1.890
1.879
1.406
1.339
1.275
Me
Me
O'Bu
O
25
NC
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2.99
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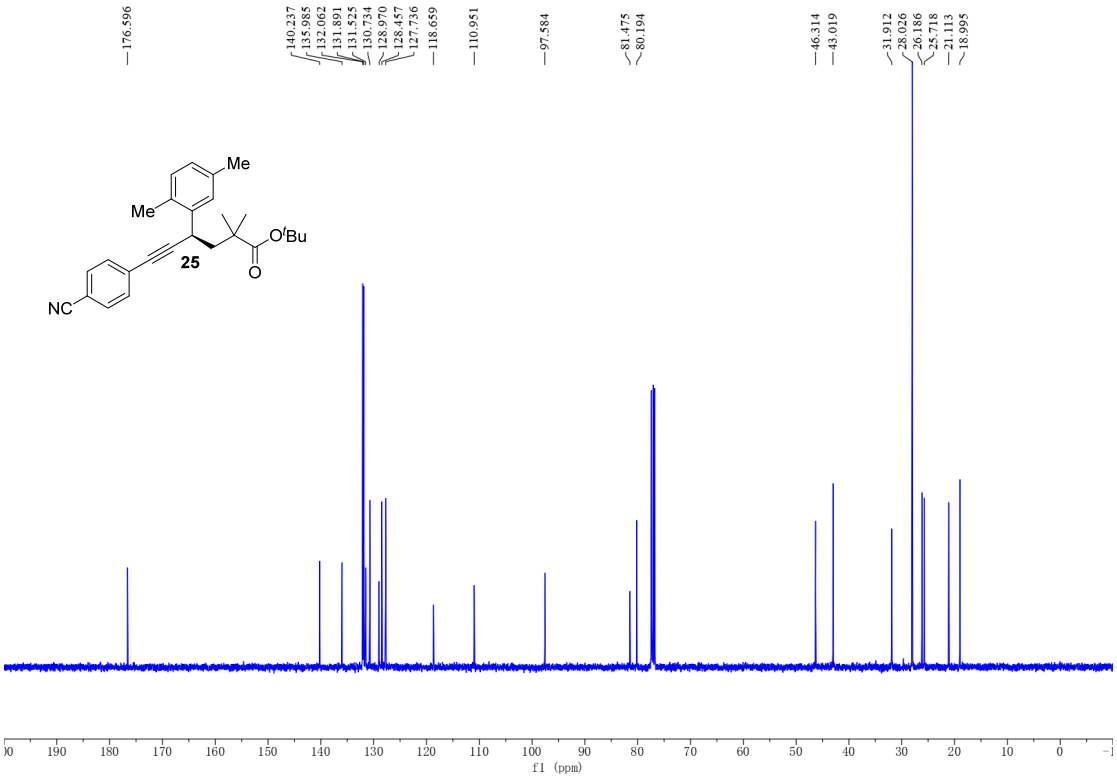
f1 (ppm)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80.194
46.314
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21.113
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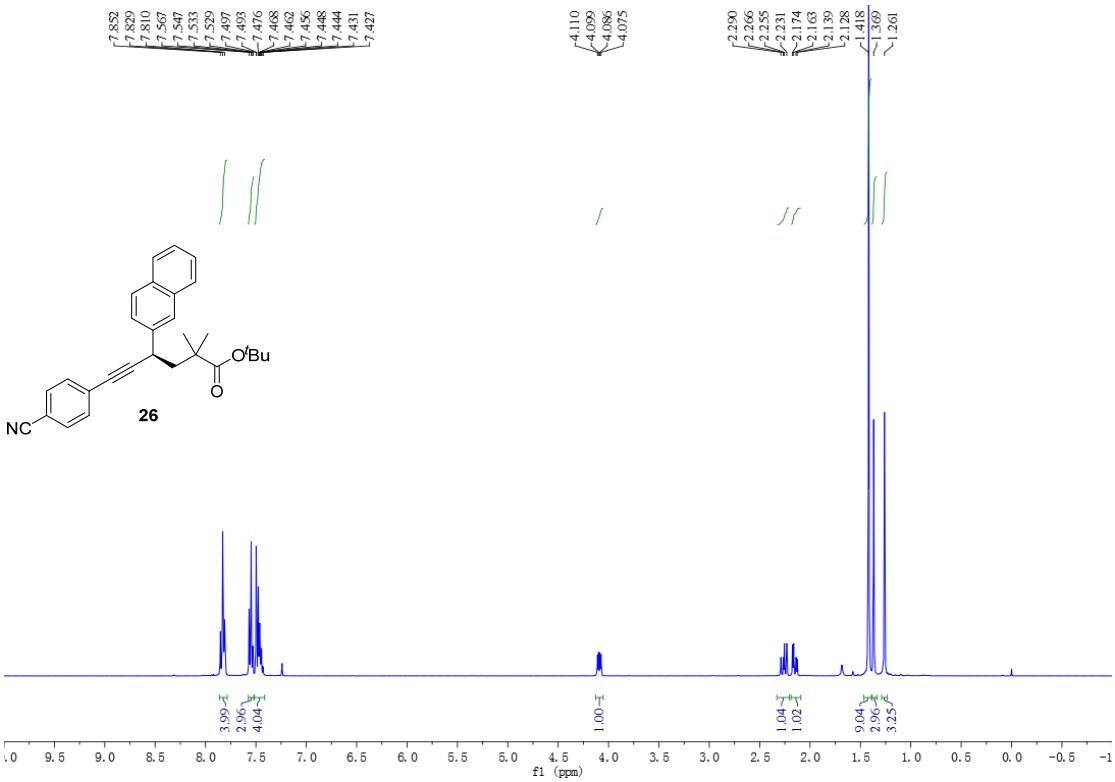
Me
Me
O'Bu
O
25
NC
f1 (ppm)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7.462
7.456
7.448
7.444
7.431
7.427
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4.086
4.075
2.290
2.266
2.255
2.231
2.174
2.163
2.139
2.128
1.418
1.369
1.261
O'Bu
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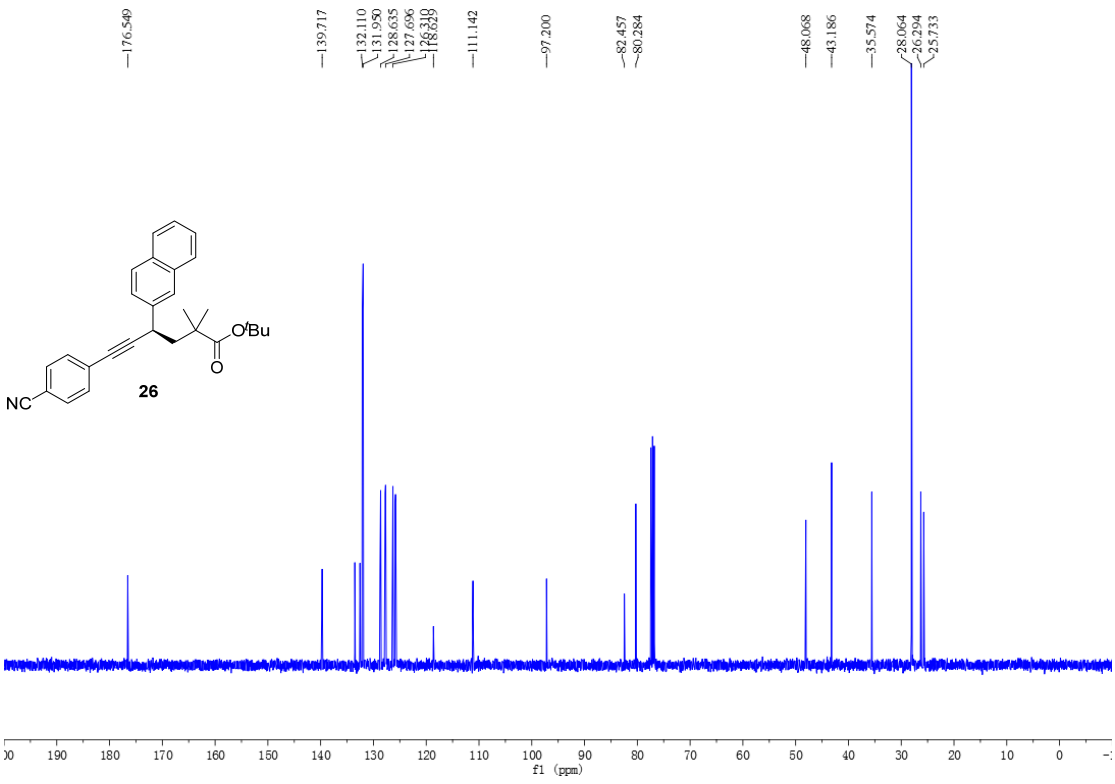
3.25
f1 (ppm)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111.142
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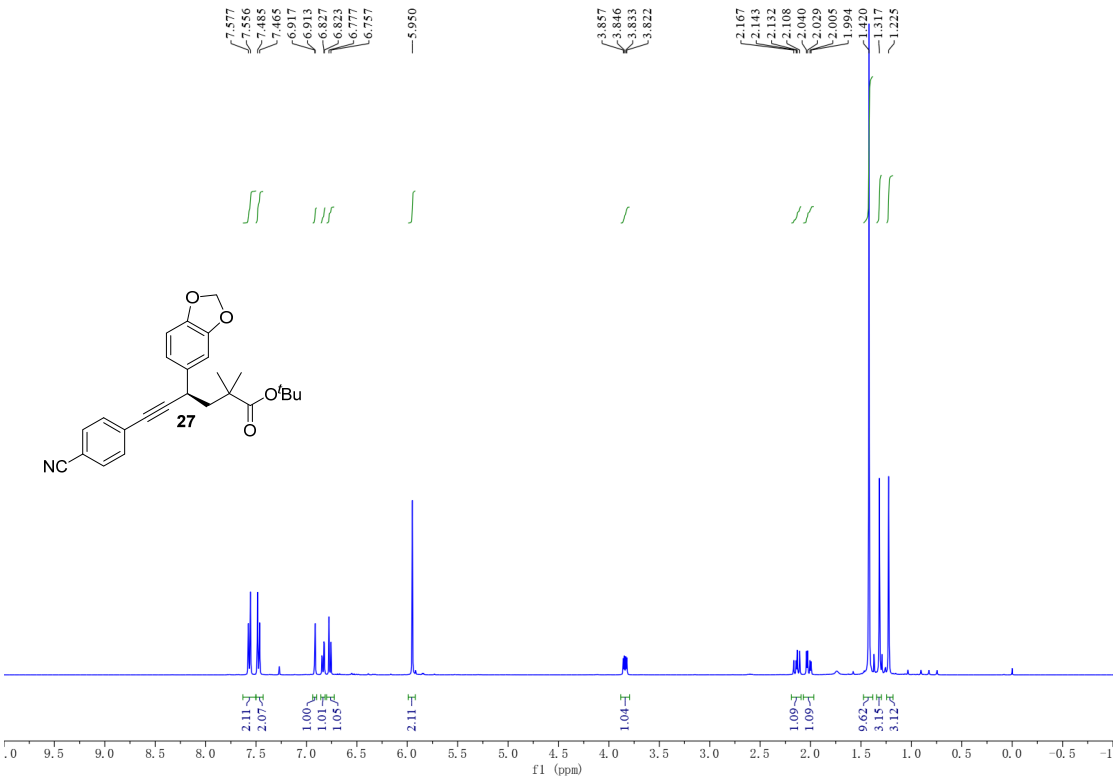
43.186
35.574
28.064
26.294
25.733
O'Bu
O
NC
26
f1 (ppm)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6.823
6.777
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3.846
3.833
3.822
2.167
2.143
2.132
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2.040
2.029
2.005
1.994
1.420
1.317
1.225
O
O
O
O
tBu
27
NC
2.11
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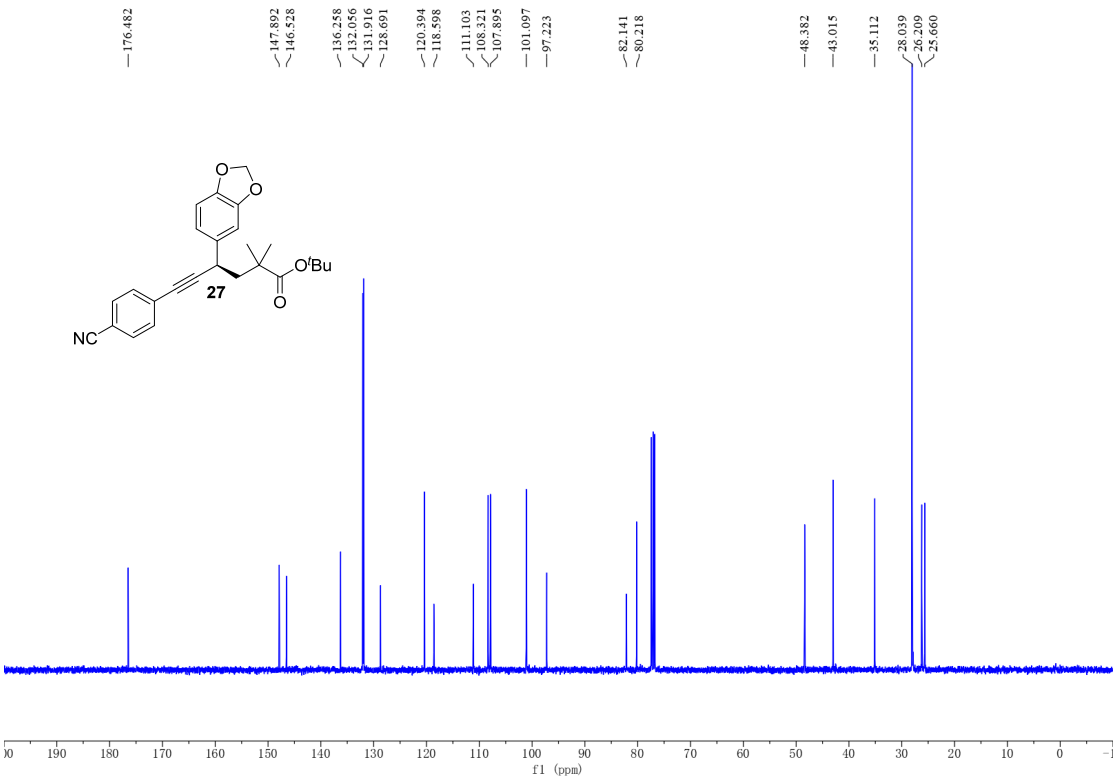
f1 (ppm)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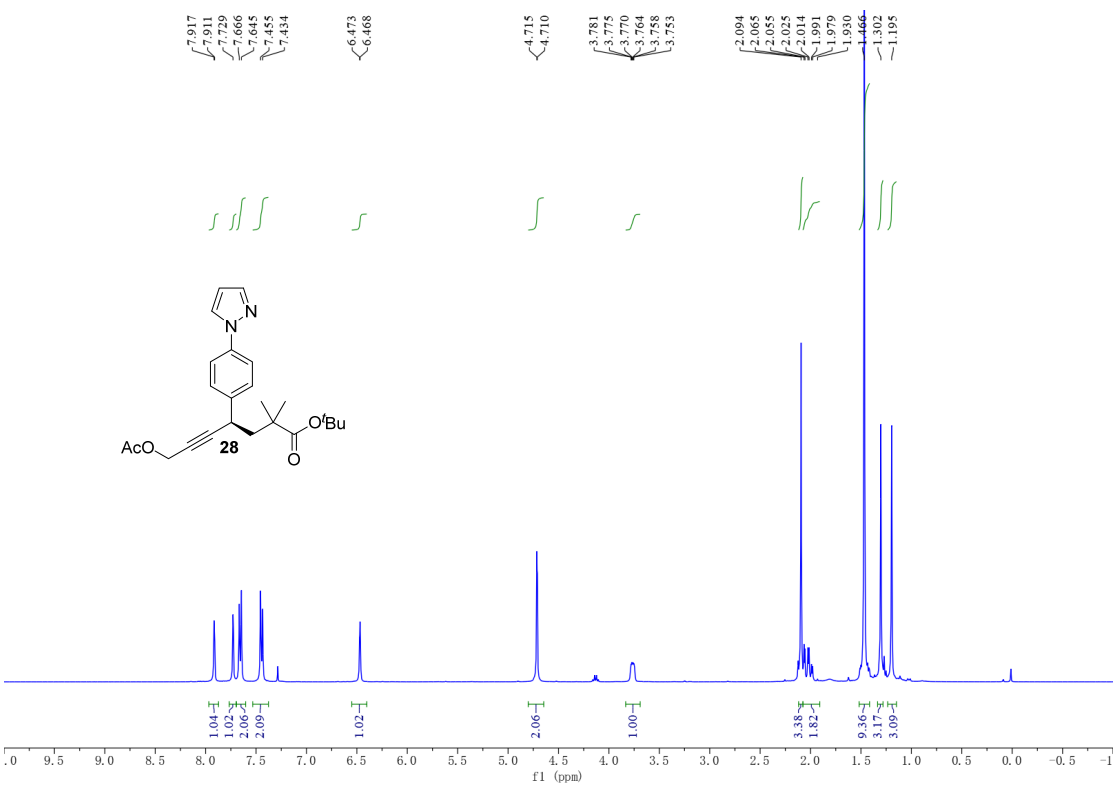
O
O
O
tBu
27
NC
f1 (ppm)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2.025
2.014
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1.979
1.930
1.466
1.302
1.195
AcO
28
O'Bu
O
1.04
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1.02
2.06
1.00
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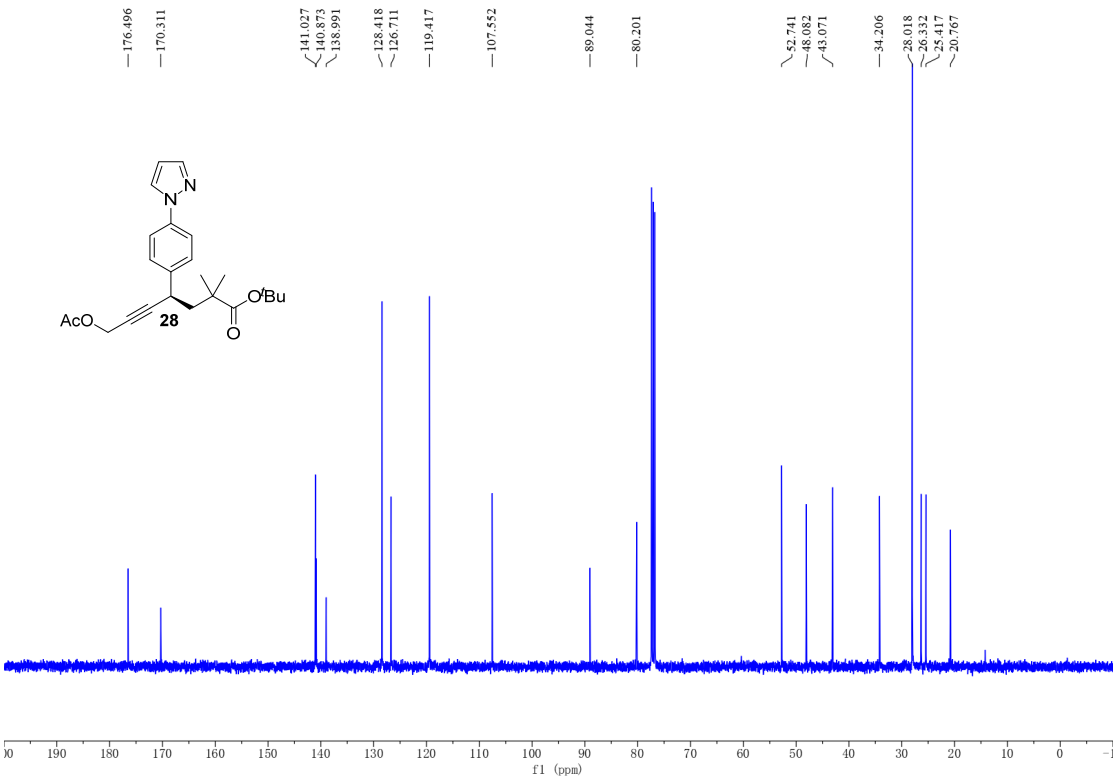
3.09
f1 (ppm)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34.206
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26.332
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AcO
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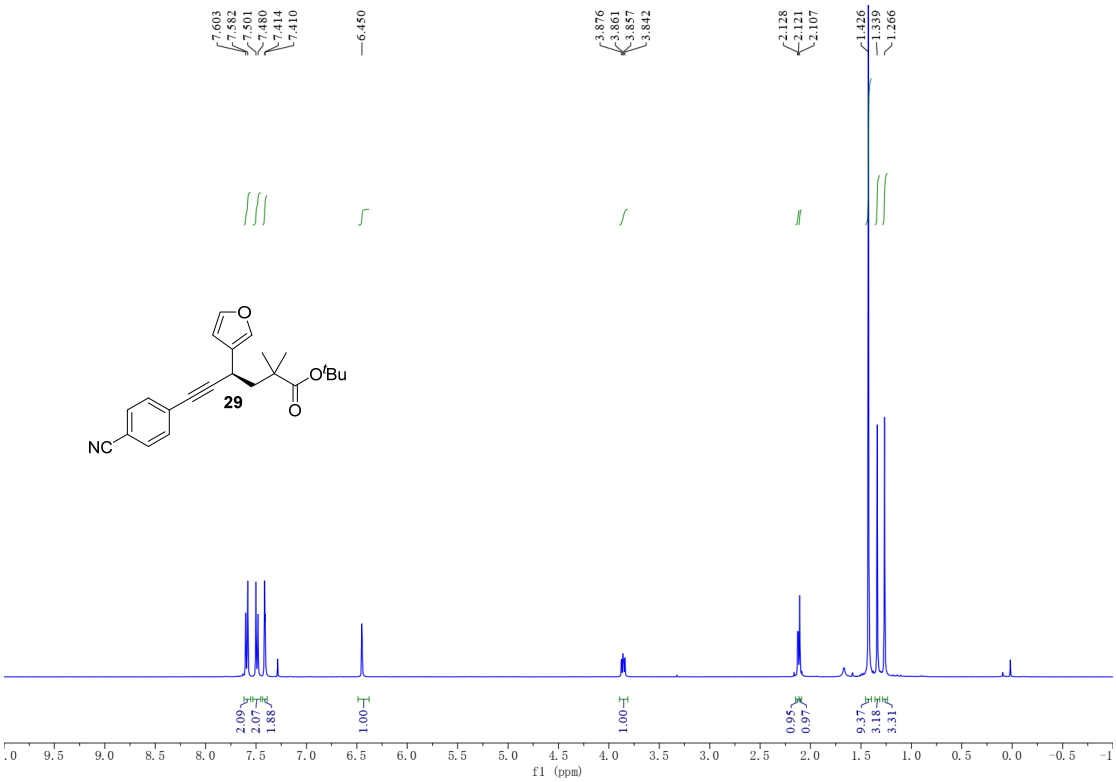
O
f1 (ppm)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2.107
1.426
1.339
1.266
O
O'Bu
O
29
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1.88
1.00
1.00
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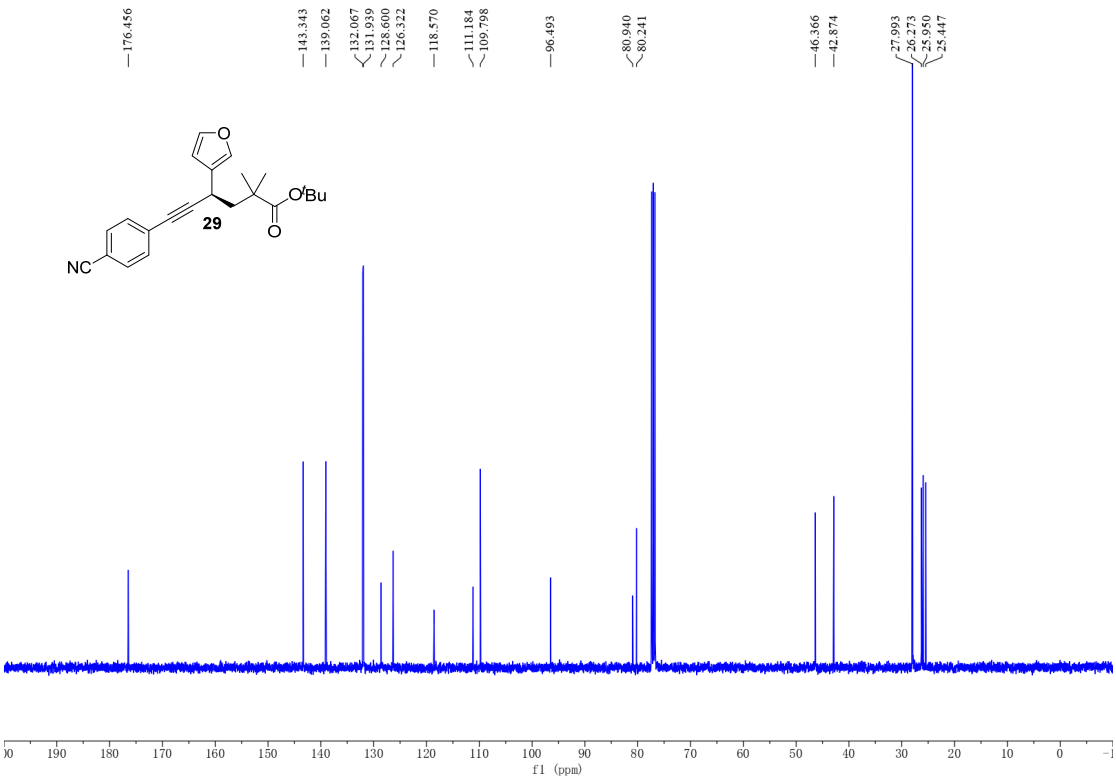
0.97
9.37
3.18
3.31
f1 (ppm)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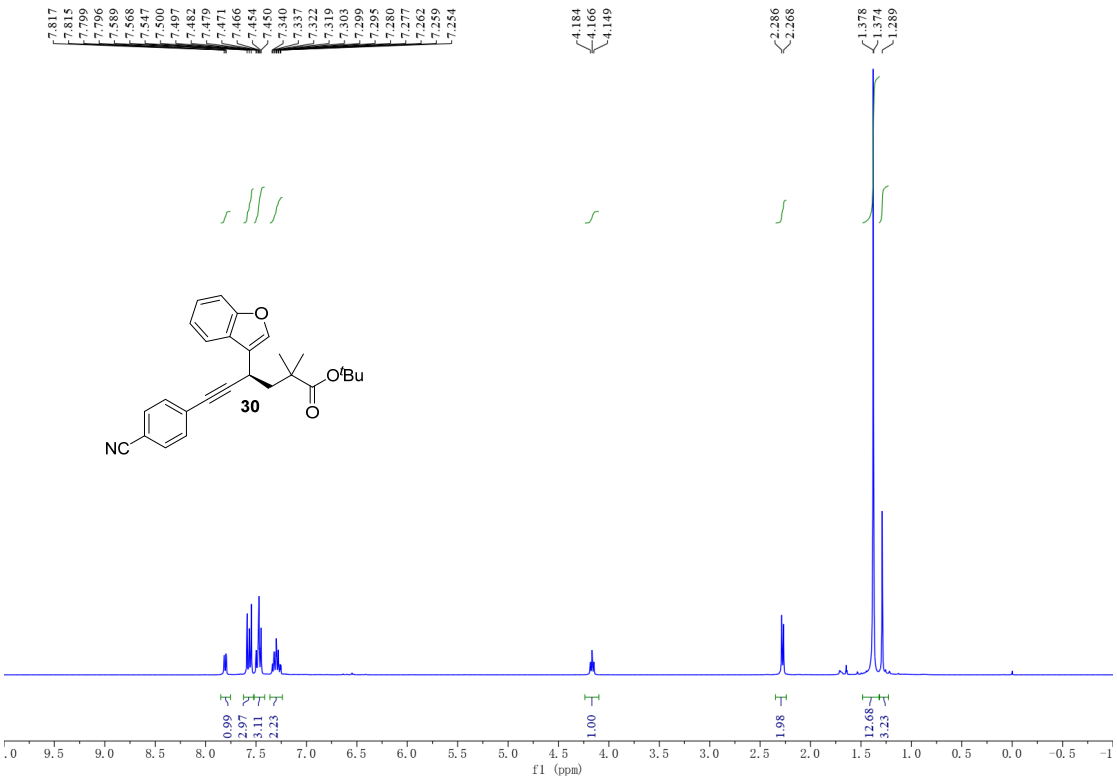
27.993
26.273
25.950
25.447
O
O'Bu
O
29
NC
f1 (ppm)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7.466
7.454
7.450
7.340
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7.319
7.303
7.299
7.295
7.280
7.277
7.262
7.259
7.254
4.184
4.166
4.149
2.286
2.268
1.378
1.374
1.289
O
O
tBu
O
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1.98
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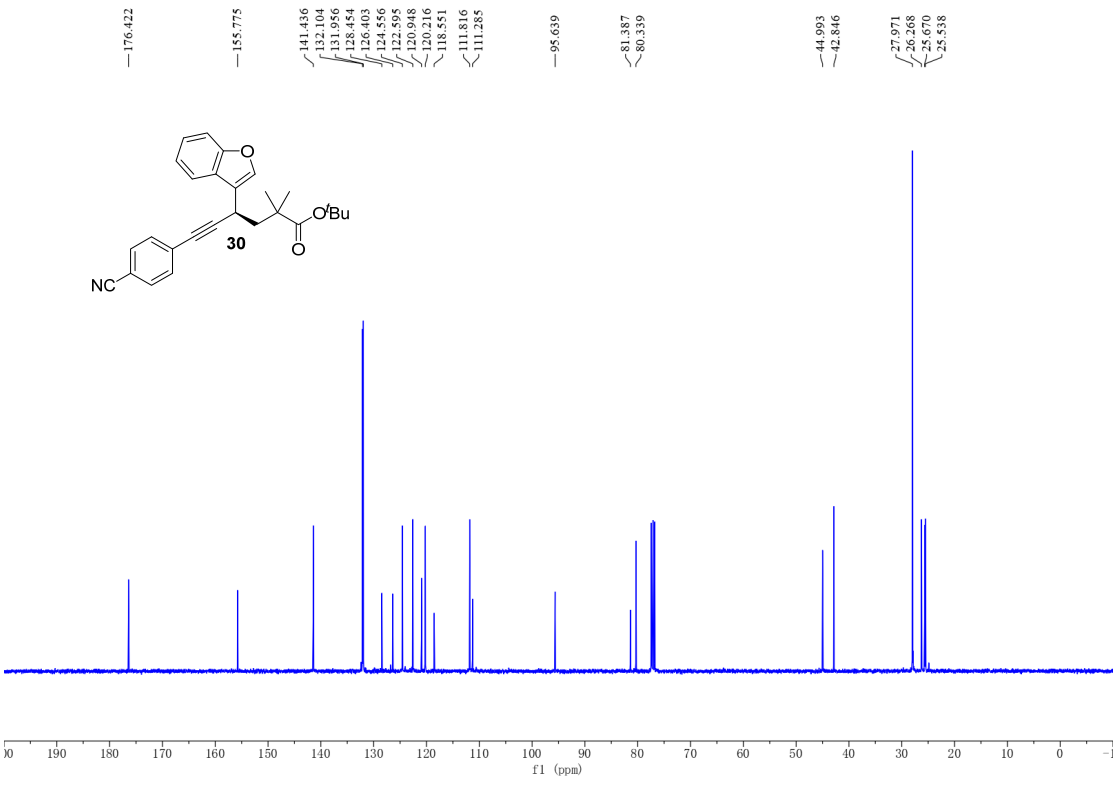
3.23
f1 (ppm)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120.948
120.216
118.551
111.816
111.285
95.639
81.387
80.339
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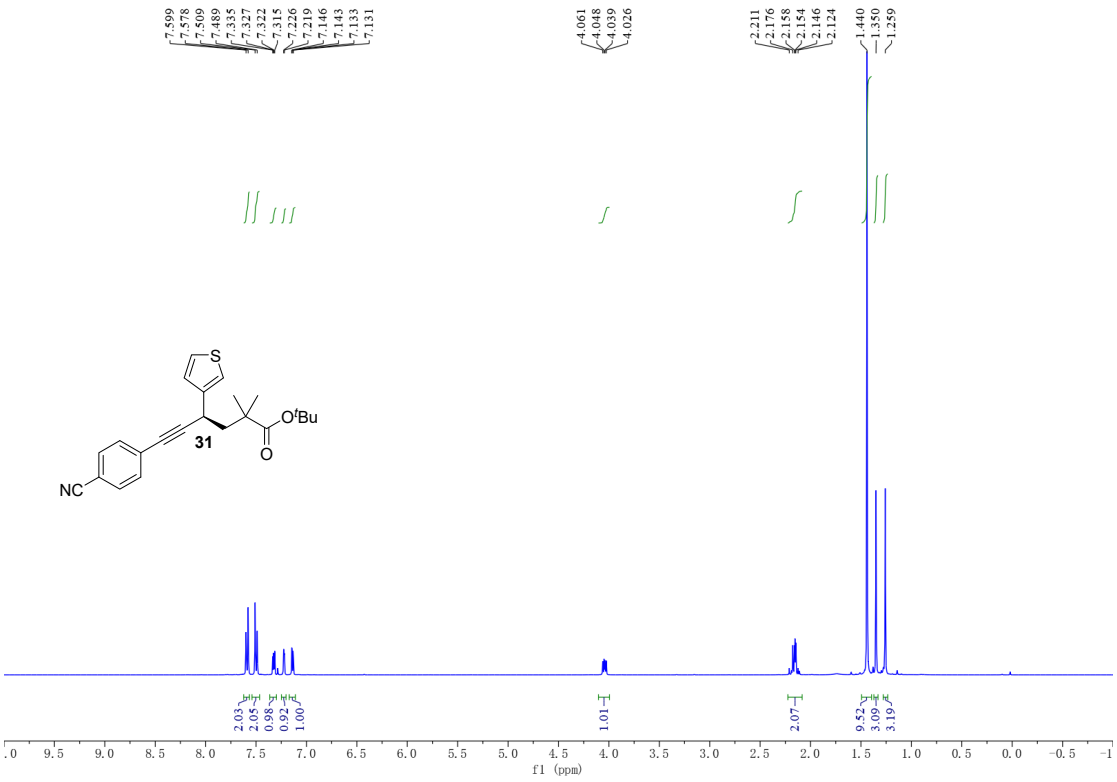
27.971
26.268
25.670
25.538
O
O
tBu
O
30
NC
f1 (ppm)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7.578
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7.322
7.315
7.226
7.219
7.146
7.143
7.133
7.131
4.061
4.048
4.039
4.026
2.211
2.176
2.158
2.154
2.146
2.124
1.440
1.350
1.259
S
O
O
NC
31
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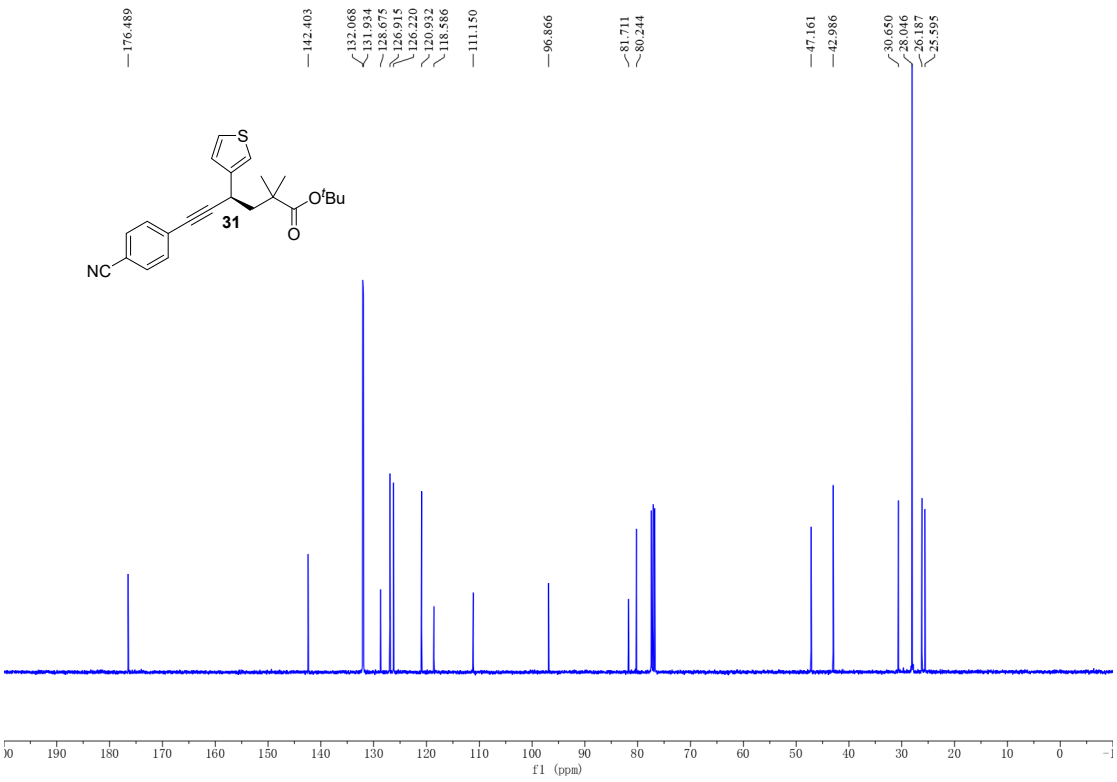
2.05
0.98
0.92
1.00
1.01
2.07
9.52
3.09
3.19
f1 (ppm)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120.932
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111.150
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42.986
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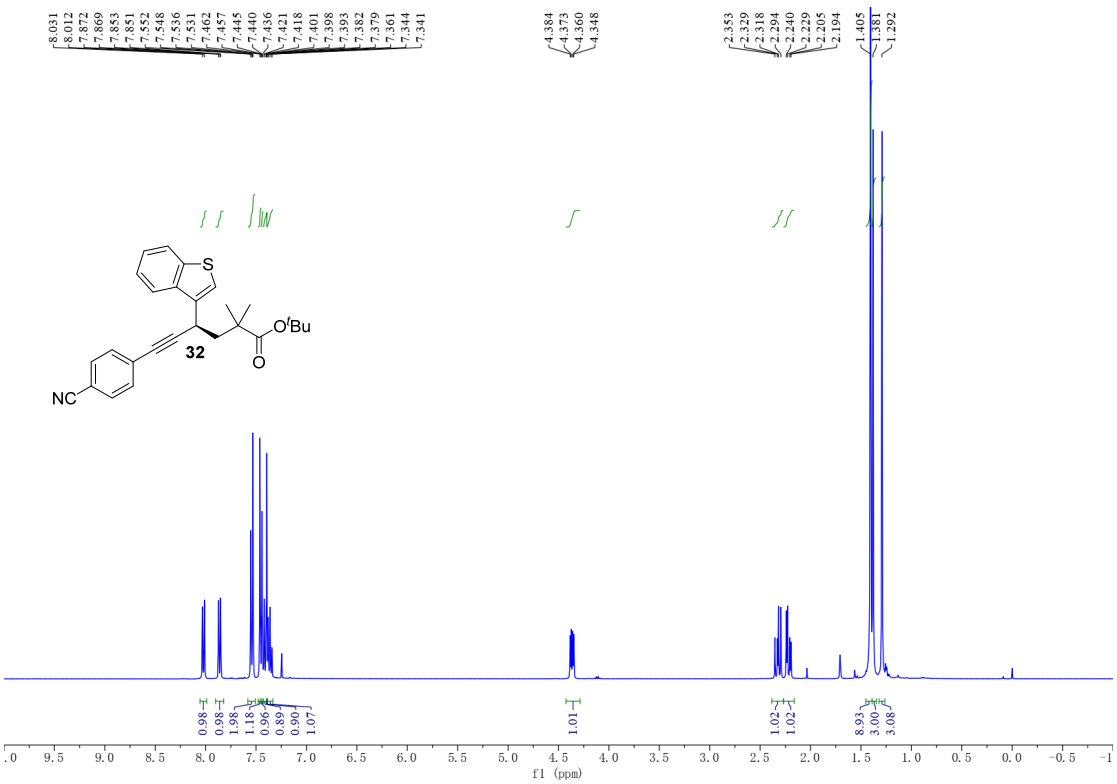
28.046
26.187
25.595
S
O
O
NC
31
f1 (ppm)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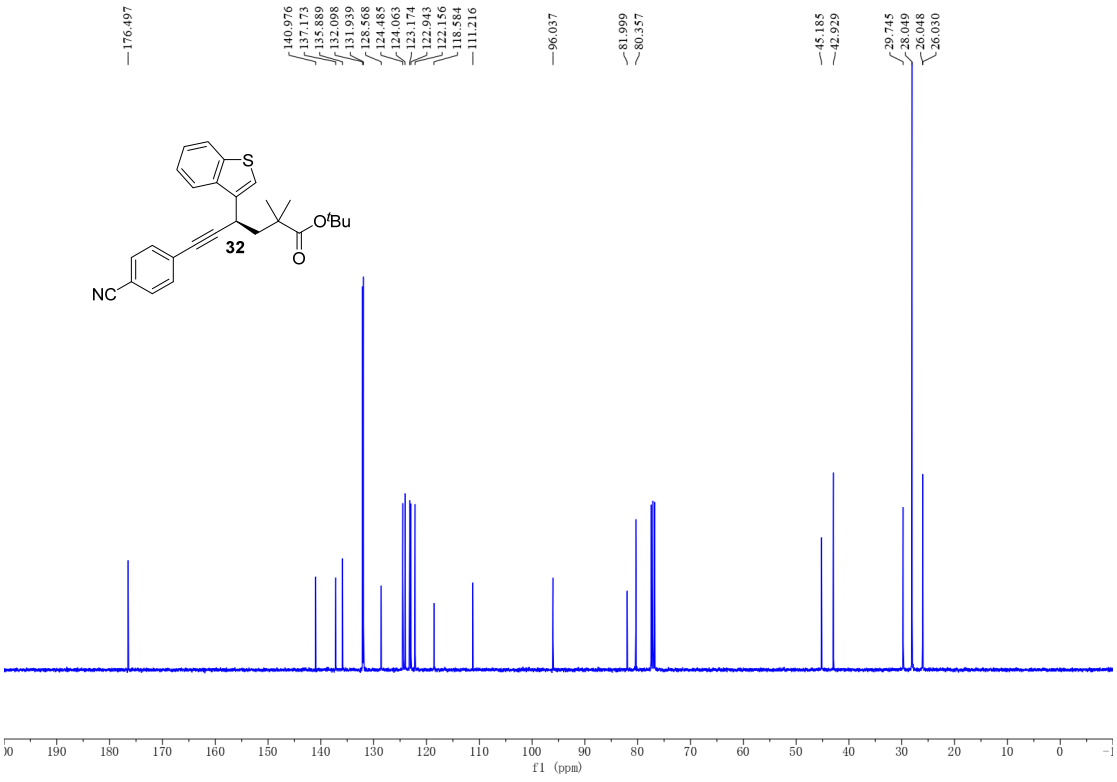
7.536
7.531
7.462
7.457
7.445
7.440
7.436
7.421
7.418
7.401
7.398
7.393
7.382
7.379
7.361
7.344
7.341
4.384
4.373
4.360
4.348
2.353
2.329
2.318
2.294
2.240
2.229
2.205
2.194
1.405
1.381
1.292
S
O'Bu
O
32
NC
0.98
0.98
1.98
1.18
0.96
0.89
0.90
1.07
1.01
1.02
1.02
8.93
3.00
3.08
f1 (ppm)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124.063
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118.584
111.216
96.037
81.999
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42.929
29.745
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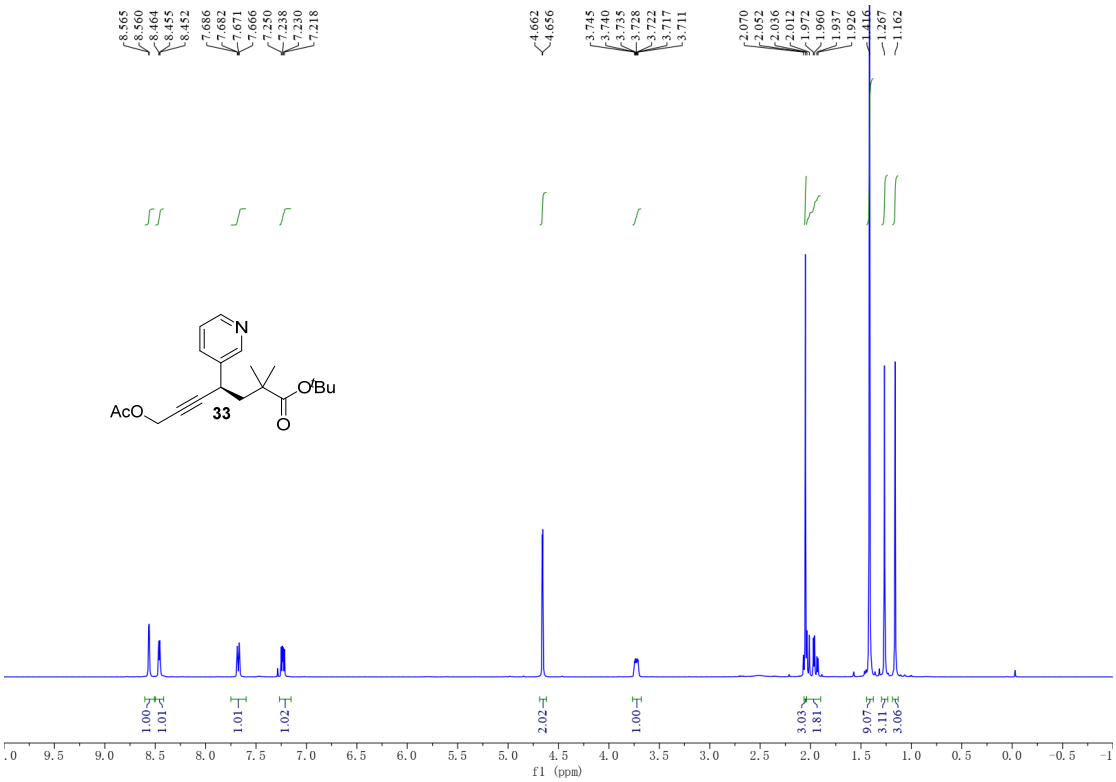
26.048
26.030
S
O'Bu
O
32
NC
f1 (ppm)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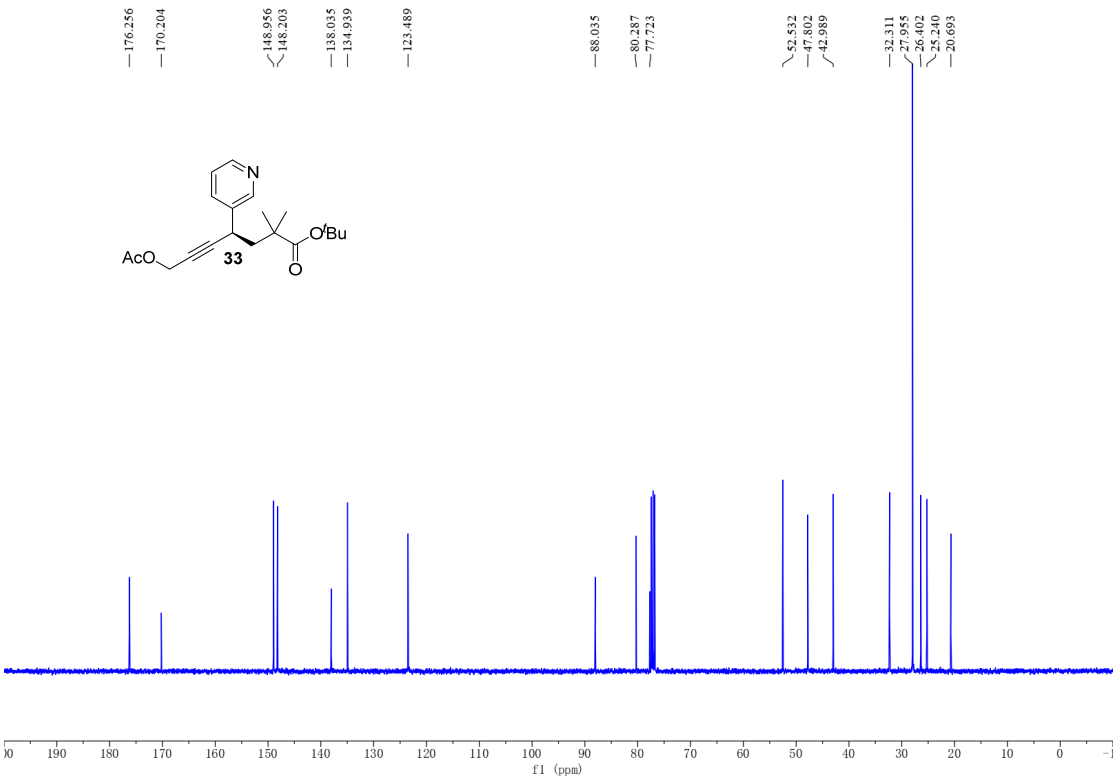
8.455
8.452
7.686
7.682
7.671
7.666
7.250
7.238
7.230
7.218
4.662
4.656
3.745
3.740
3.735
3.728
3.722
3.717
3.711
2.070
2.052
2.036
2.012
1.972
1.960
1.937
1.926
1.416
1.267
1.162
N
AcO
33
O
O'Bu
1.00
1.01
1.01
1.02
2.02
1.00
3.03
1.81
9.07
3.11
3.06
f1 (ppm)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148.956
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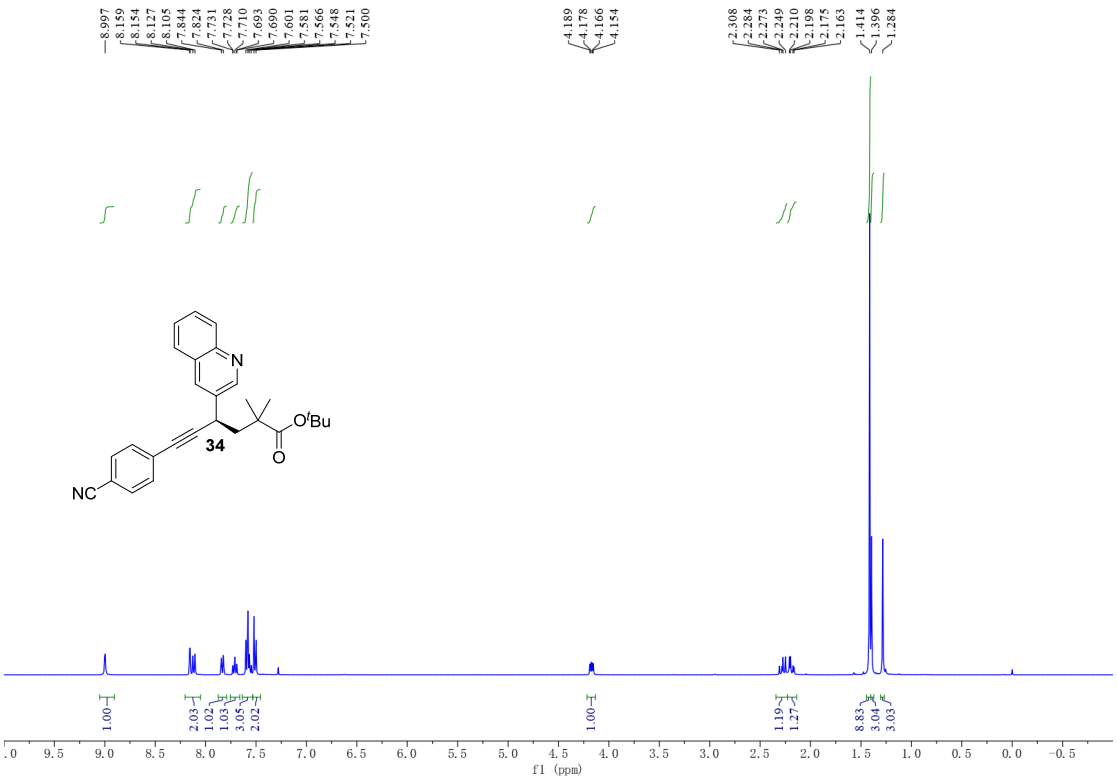
134.939
123.489
88.035
80.287
77.723
52.532
47.802
42.989
32.311
27.955
26.402
25.240
20.693
N
AcO
33
O
O'Bu
f1 (ppm)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8.154
8.127
8.105
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7.824
7.731
7.728
7.710
7.693
7.690
7.601
7.581
7.566
7.548
7.521
7.500
4.189
4.178
4.166
4.154
2.308
2.284
2.273
2.249
2.210
2.198
2.175
2.163
1.414
1.396
1.284
N
O'Bu
O
34
NC
1.00
2.03
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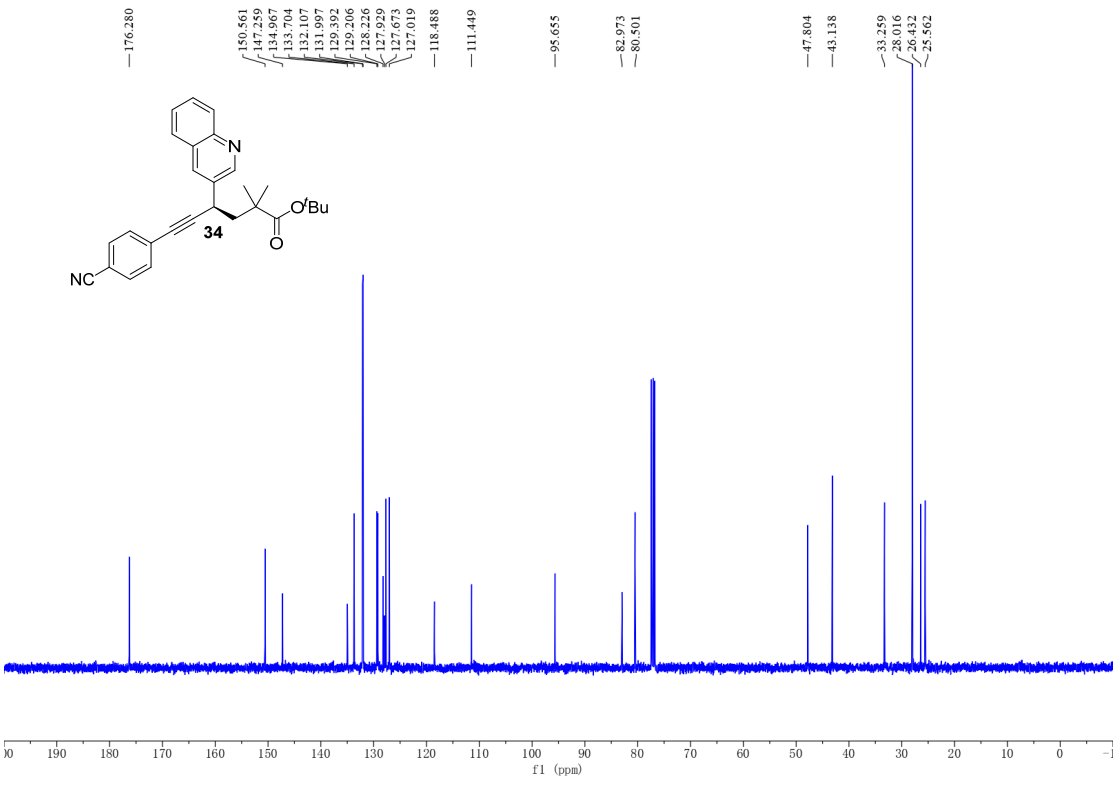
1.03
3.05
2.02
1.00
1.19
1.27
8.83
3.04
3.03
f1 (ppm)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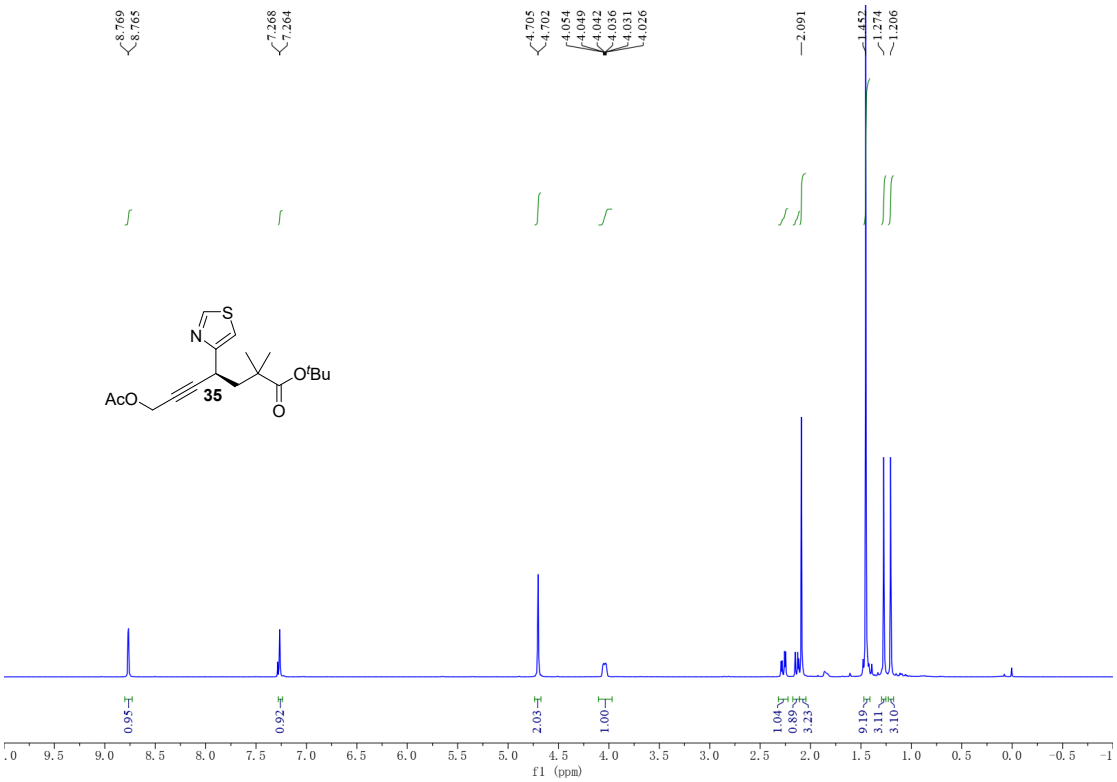
133.704
132.107
131.997
129.392
129.206
128.226
127.929
127.673
127.019
118.488
111.449
95.655
82.973
80.501
47.804
43.138
33.259
28.016
26.432
25.562
N
O'Bu
O
34
NC
f1 (ppm)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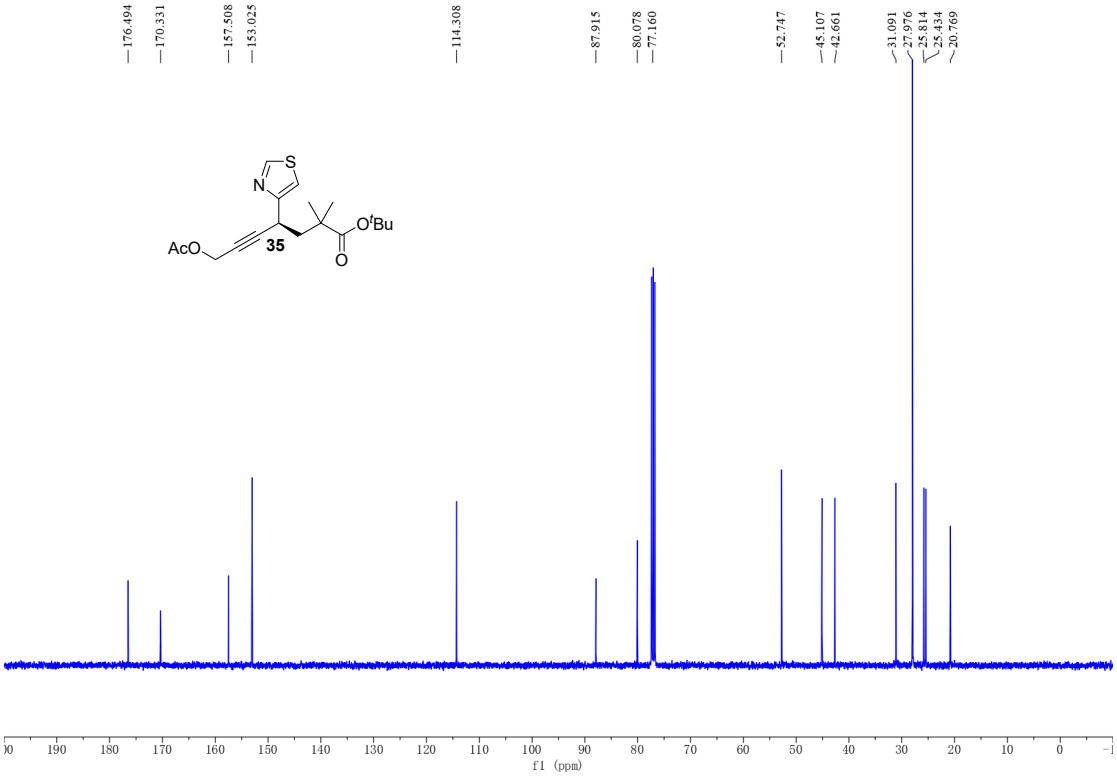
7.268
7.264
4.705
4.702
4.054
4.049
4.042
4.036
4.031
4.026
2.091
1.452
1.274
1.206
S
N
AcO
35
O
O'Bu
0.95
0.92
2.03
1.00
1.04
0.89
3.23
9.19
3.11
3.10
f1 (ppm)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87.915
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77.160
52.747
45.107
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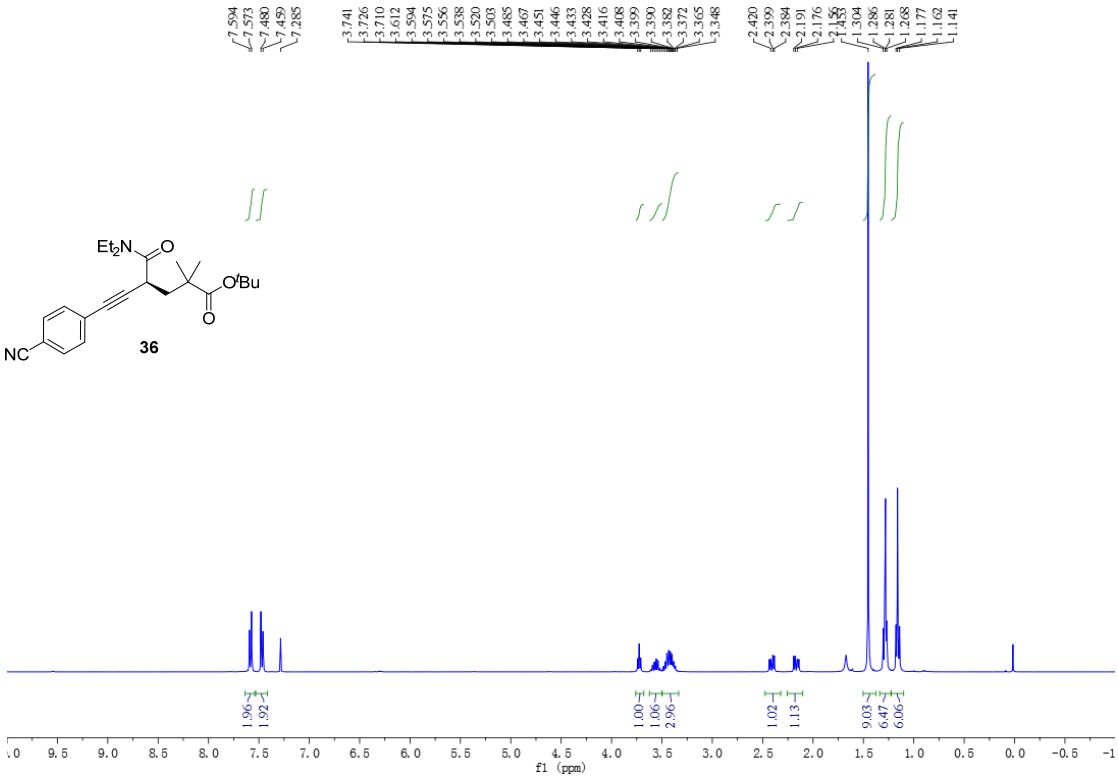
27.976
25.814
25.434
20.769
S
N
AcO
35
O
O'Bu
f1 (ppm)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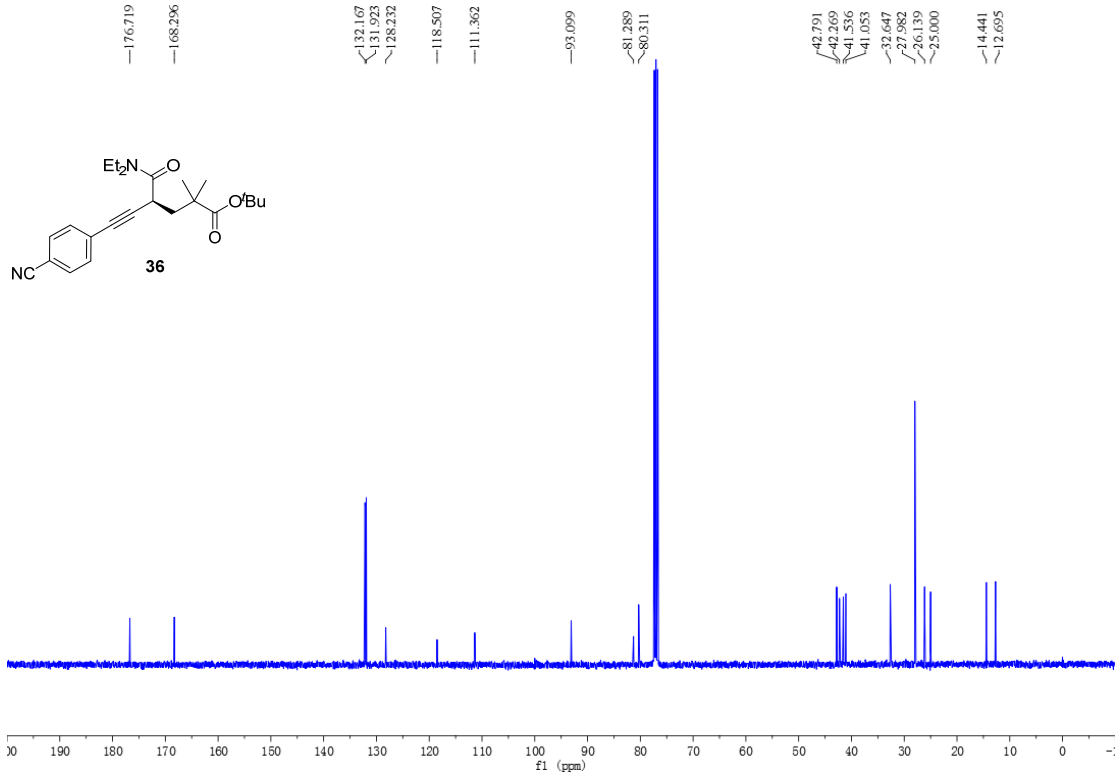
3.556
3.538
3.520
3.503
3.485
3.467
3.451
3.446
3.433
3.428
3.416
3.408
3.399
3.390
3.382
3.372
3.365
3.348
2.420
2.399
2.384
2.191
2.176
1.304
1.286
1.281
1.268
1.177
1.162
1.141
Et2N
O
O
OtBu
O
NC
36
1.96
1.92
1.00
1.06
2.96
1.02
1.13
9.03
6.47
6.06
f1 (ppm)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41.053
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25.000
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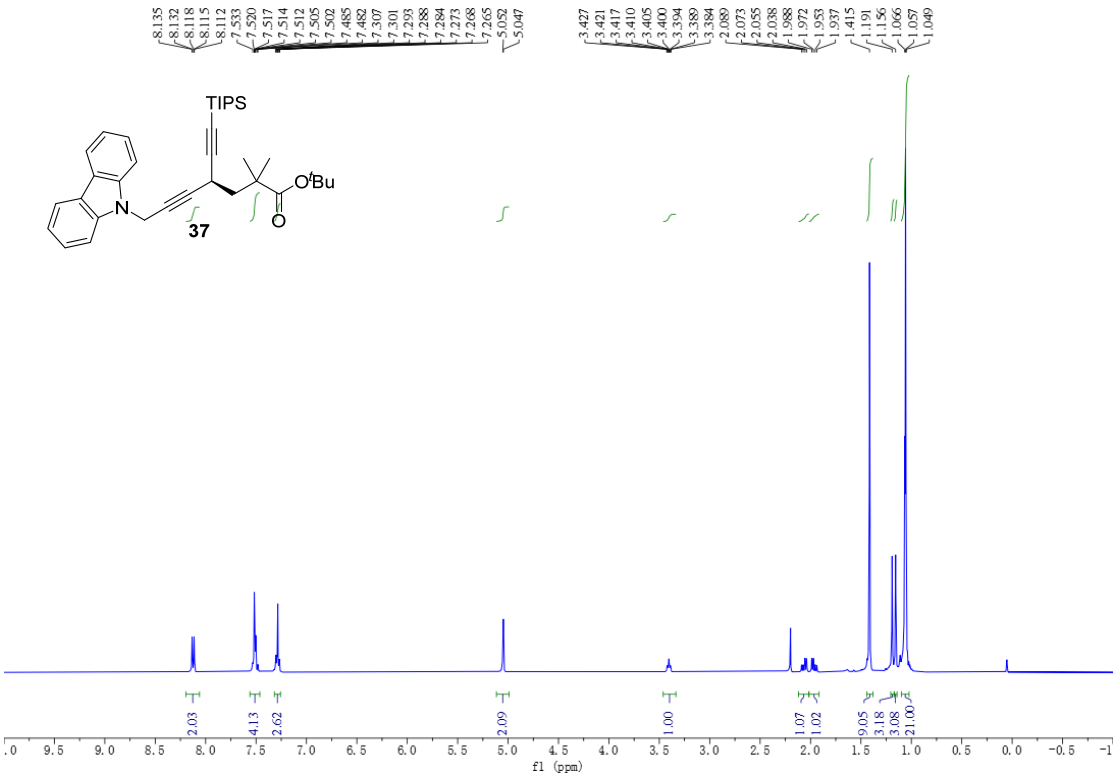
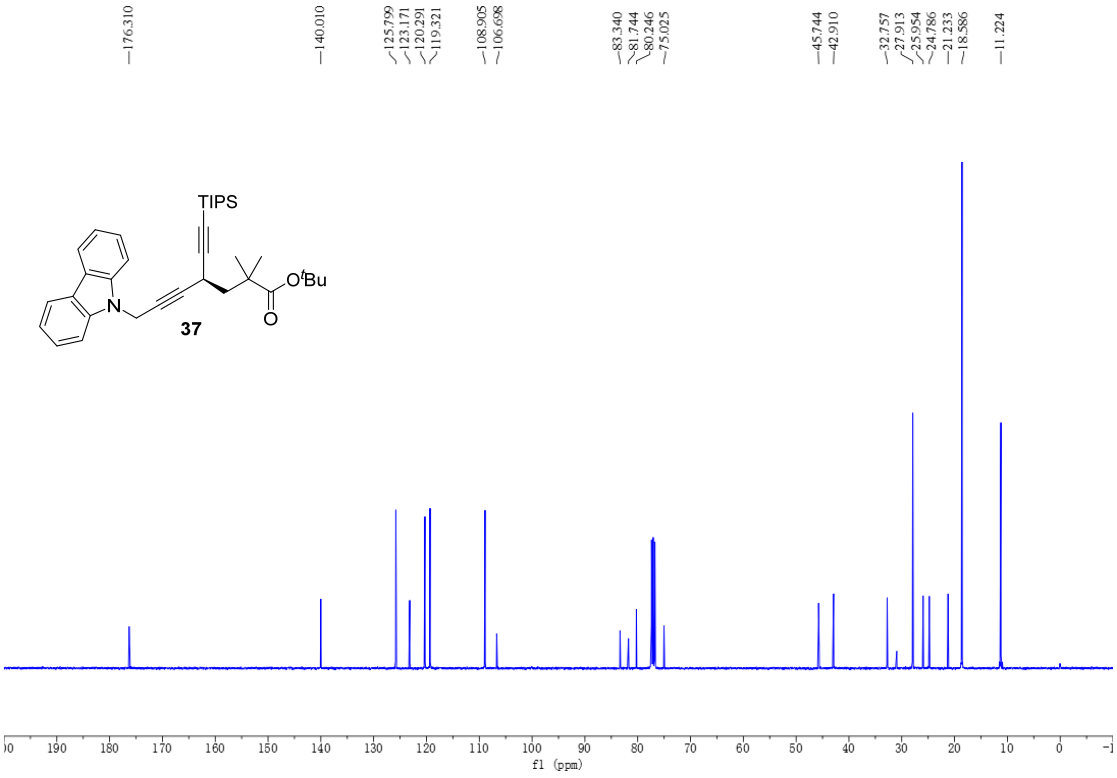
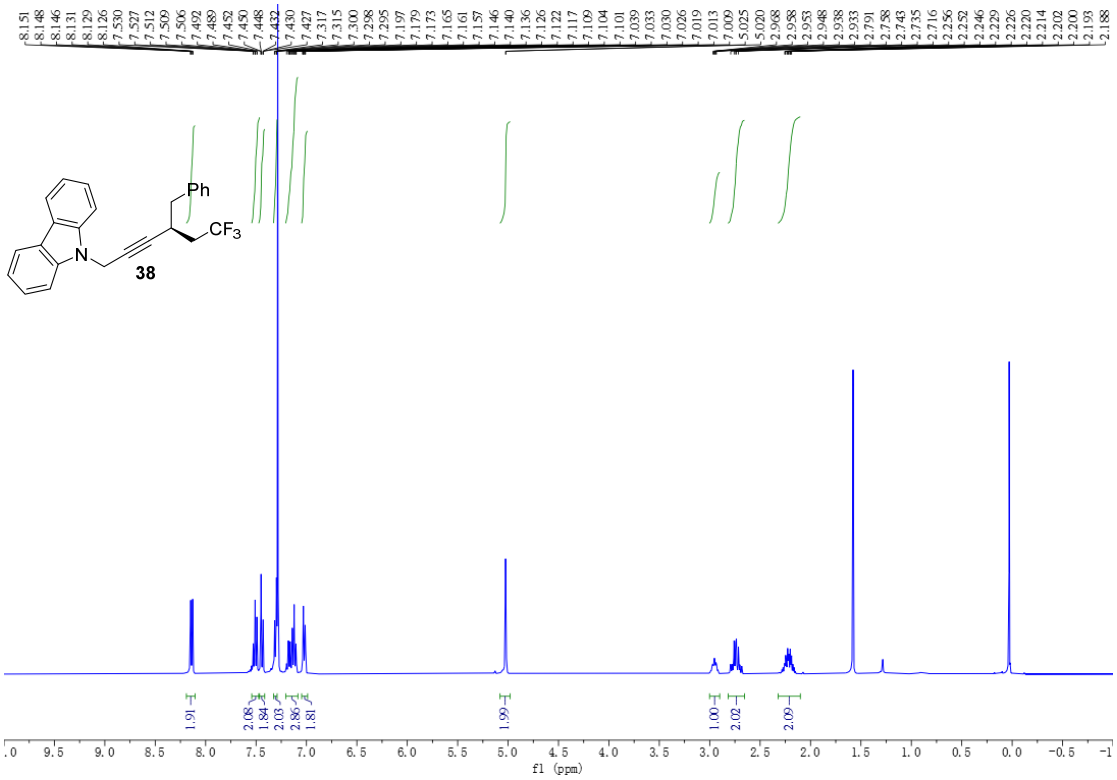
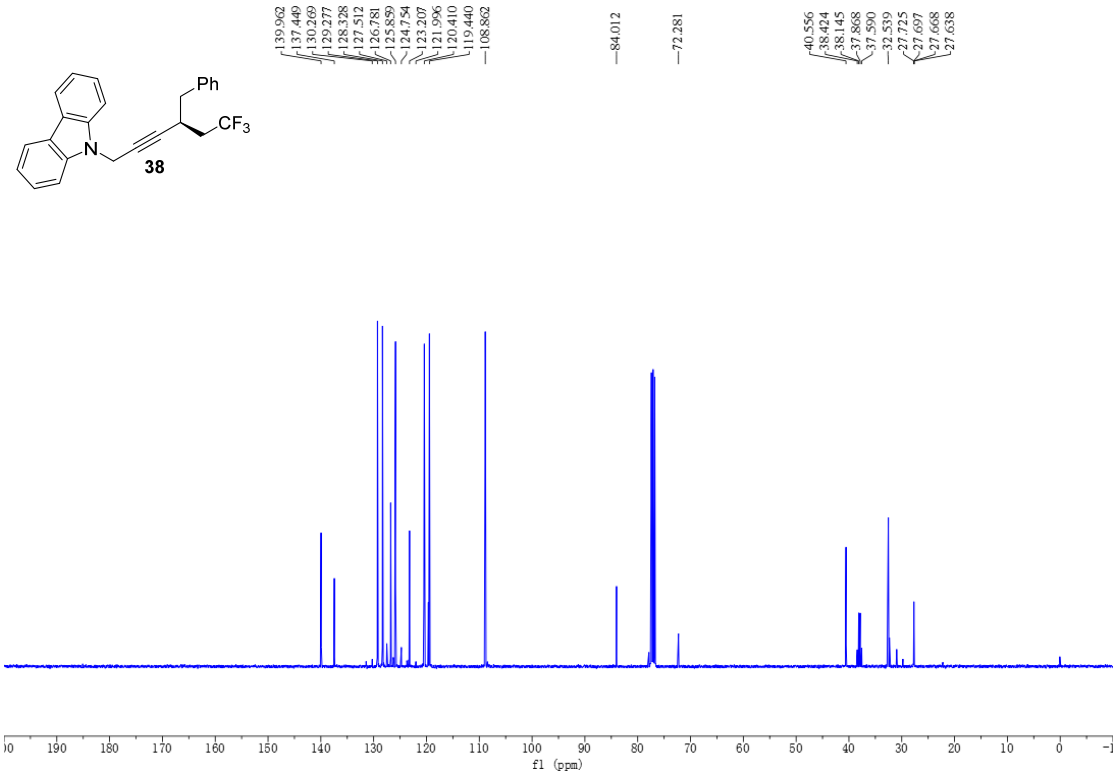
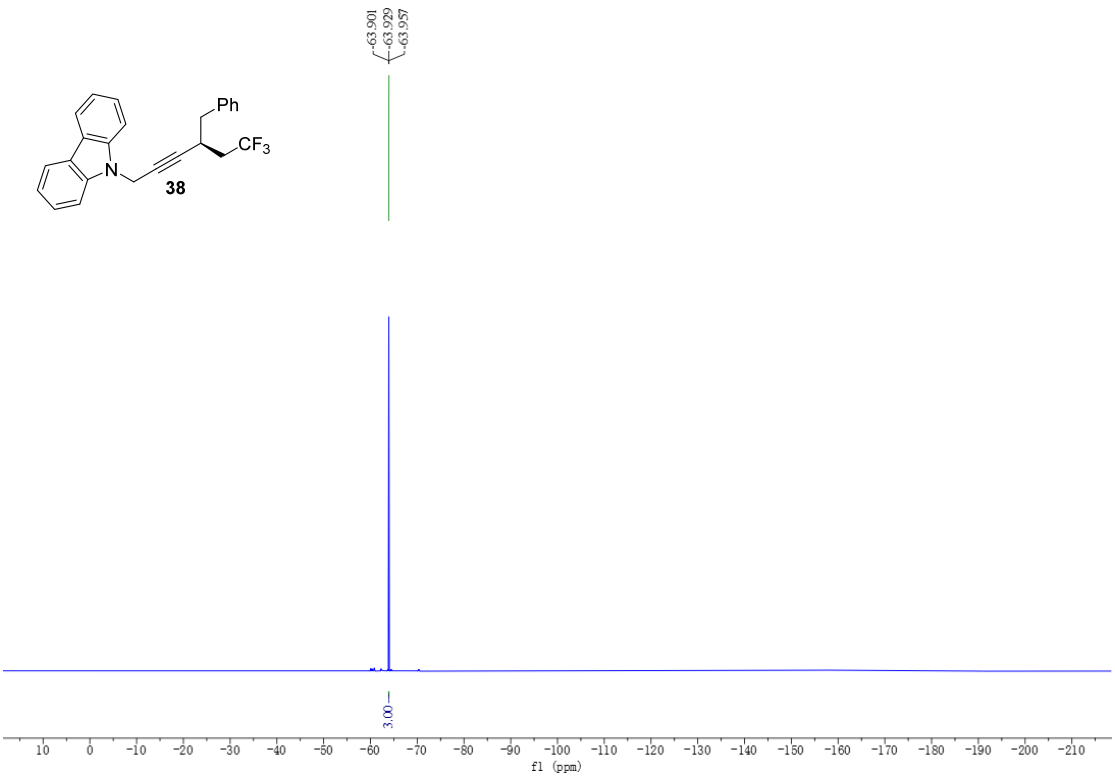
12.695
Et2N
O
O
OtBu
O
NC
36
f1 (ppm)


TIPS
O^{t}Bu
O
N
37
f1 (ppm)


TIPS
O^{t}Bu
O
N
37
f1 (ppm)


Ph
CF3
N
38
f1 (ppm)


Ph
CF3
N
38
f1 (ppm)


-63.901
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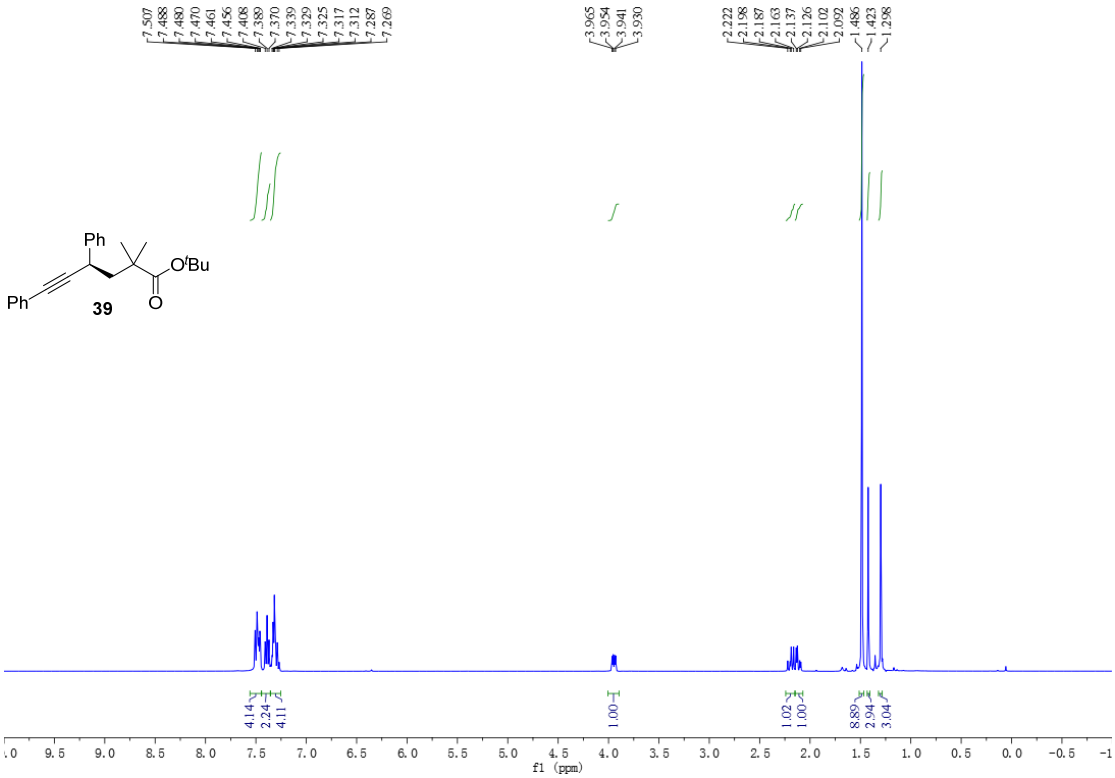
-63.957
Ph
CF3
N
38
3.00
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
f1 (ppm)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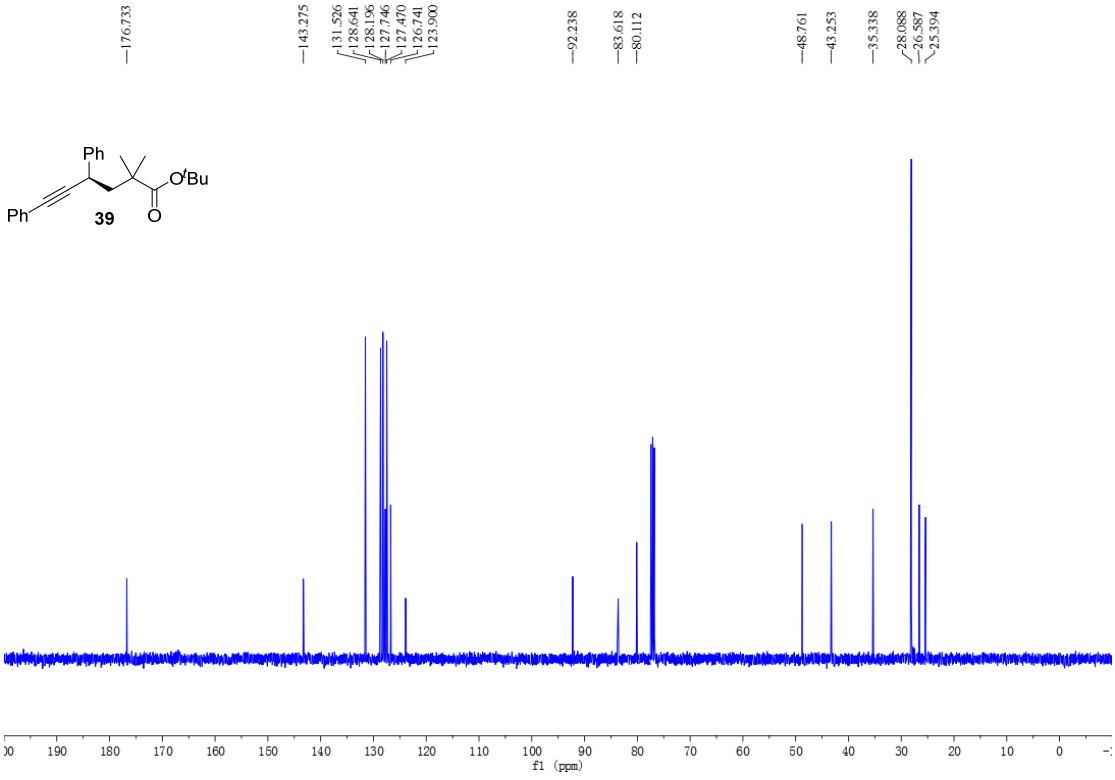
7.325
7.317
7.312
7.287
7.269
3.965
3.954
3.941
3.930
2.222
2.198
2.187
2.163
2.137
2.126
2.102
2.092
1.486
1.423
1.298
Ph
O'Bu
Ph
O
39
4.14
2.24
4.11
1.00
1.02
1.00
8.89
2.94
3.04
f1 (ppm)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128.196
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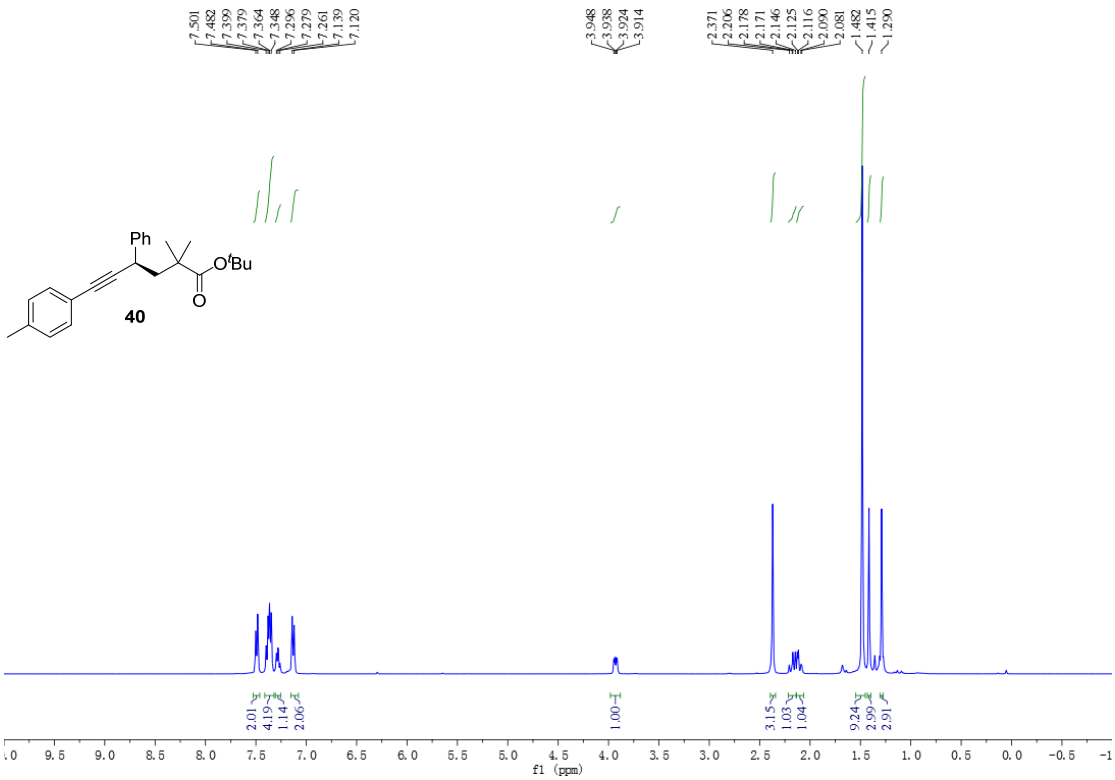
127.470
126.741
123.900
92.238
83.618
80.112
48.761
43.253
35.338
28.088
26.587
25.394
Ph
O'Bu
Ph
O
39
f1 (ppm)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7.296
7.279
7.261
7.139
7.120
3.948
3.938
3.924
3.914
2.371
2.206
2.178
2.171
2.146
2.125
2.116
2.090
2.081
1.482
1.415
1.290
Ph
O'Bu
O
40
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2.06
1.00
3.15
1.03
1.04
9.24
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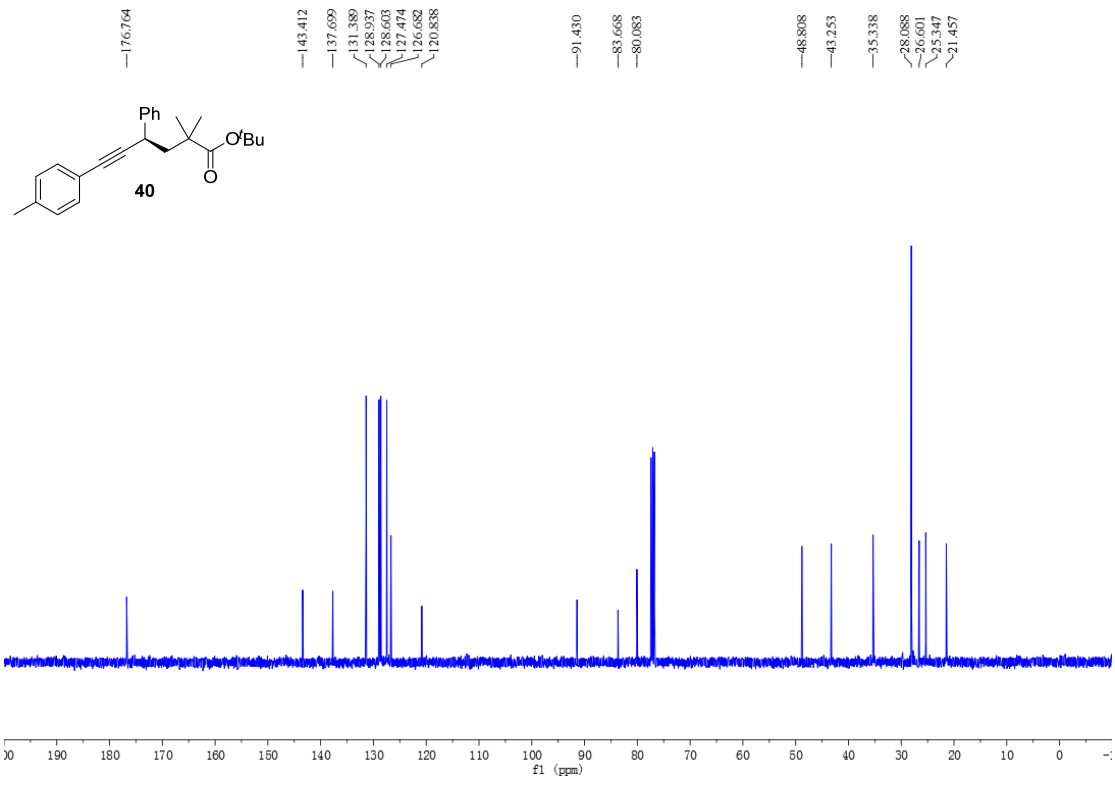
2.91
f1 (ppm)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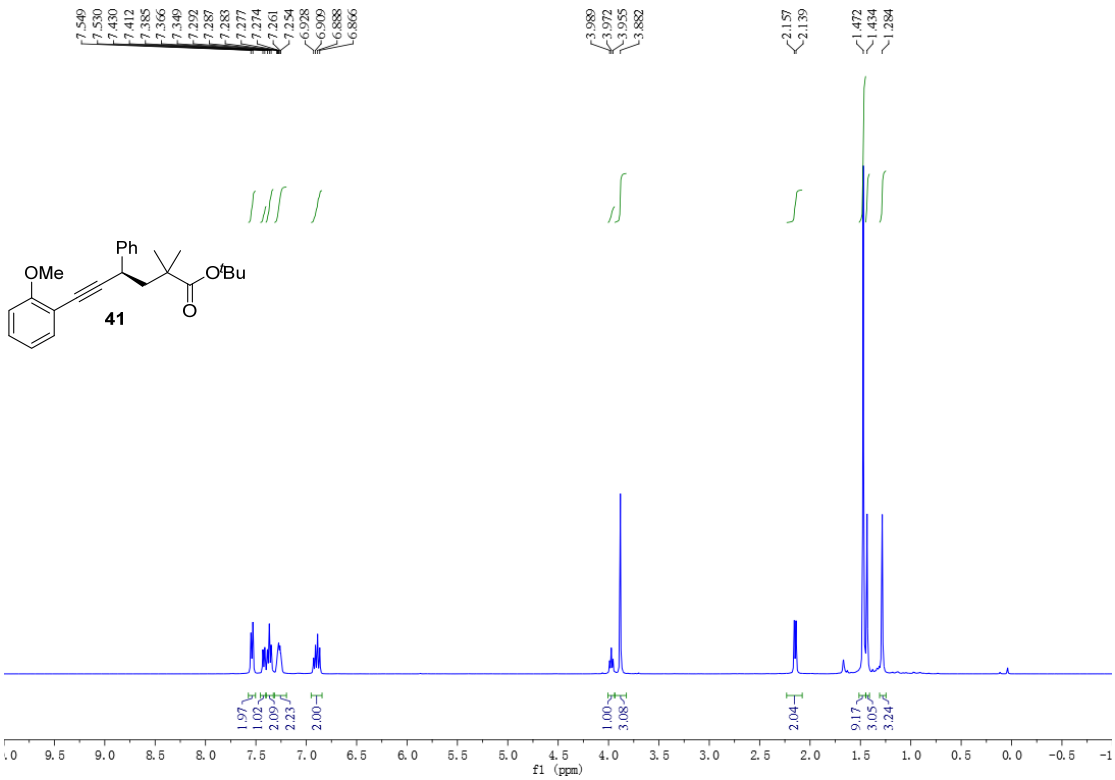
Ph
O'Bu
O
40
f1 (ppm)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7.292
7.287
7.283
7.277
7.274
7.261
7.254
6.928
6.909
6.888
6.866
3.989
3.972
3.955
3.882
2.157
2.139
1.472
1.434
1.284
Ph
OMe
O'Bu
O
41
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1.02
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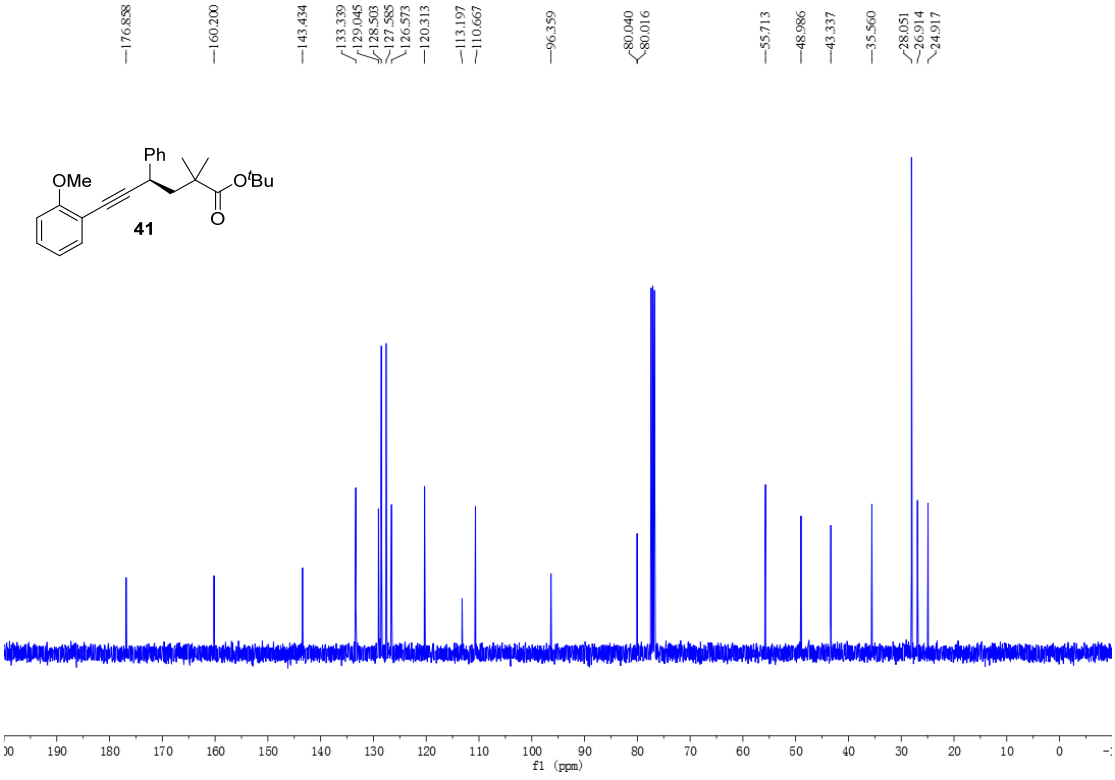
2.23
2.00
1.00
3.08
2.04
9.17
3.05
3.24
f1 (ppm)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110.667
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80.040
80.016
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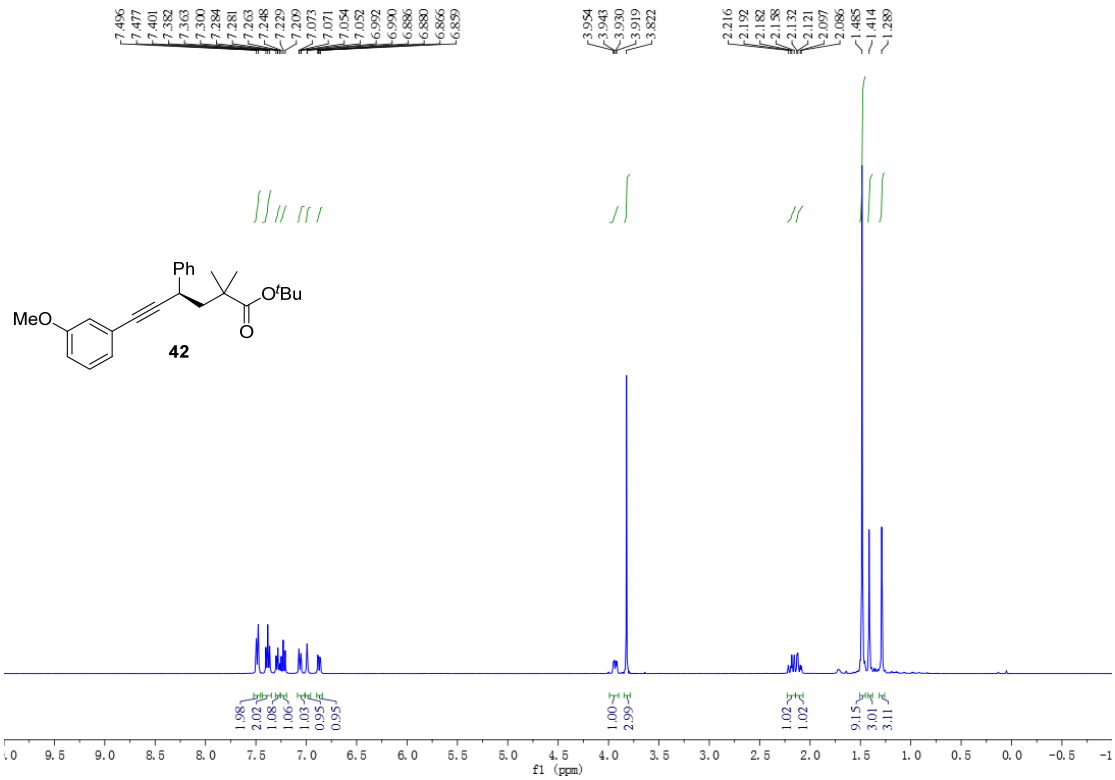
35.560
28.051
26.914
24.917
Ph
OMe
O'Bu
O
41
f1 (ppm)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7.300
7.284
7.281
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7.073
7.071
7.054
7.052
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6.859
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3.919
3.822
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2.192
2.182
2.138
2.132
2.121
2.097
2.086
1.485
1.414
1.289
Ph
MeO
O'Bu
O
42
1.98
2.02
1.08
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2.99
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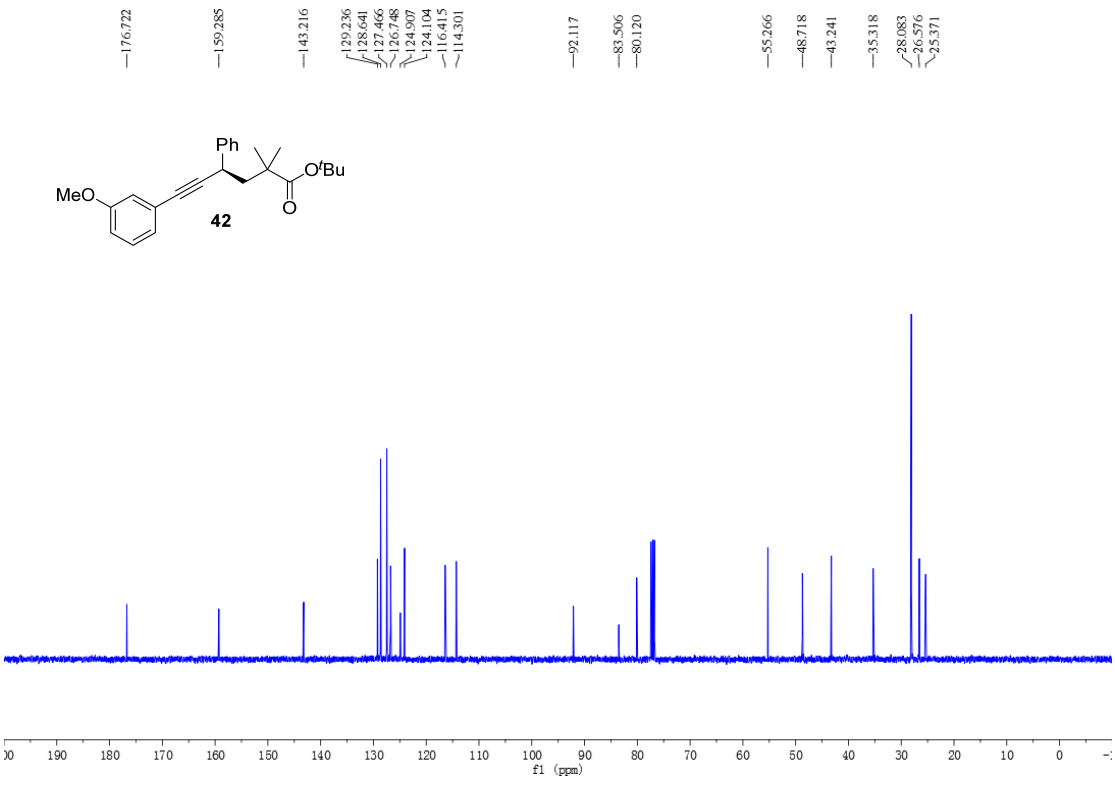
1.02
9.15
3.01
3.11
f1 (ppm)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114.301
92.117
83.506
80.120
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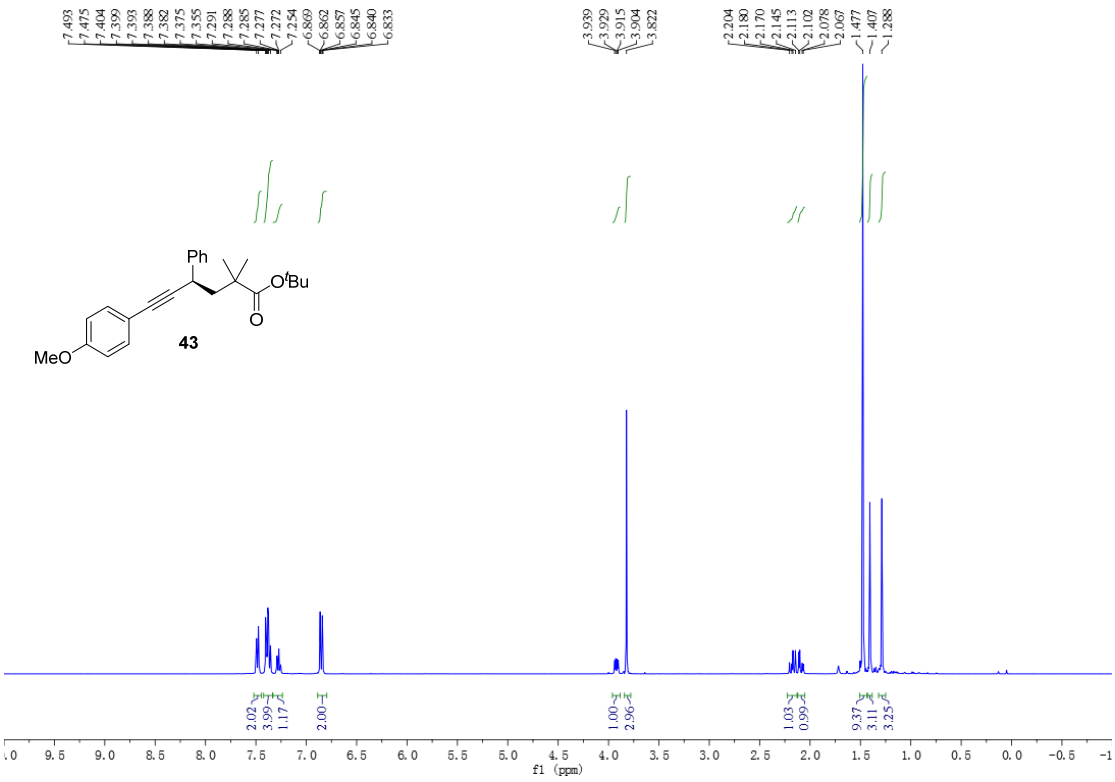
48.718
43.241
35.318
28.083
26.576
25.371
Ph
MeO
O'Bu
O
42
f1 (ppm)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7.272
7.254
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6.862
6.857
6.845
6.840
6.833
3.939
3.929
3.915
3.904
3.822
2.204
2.180
2.170
2.145
2.113
2.102
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1.477
1.407
1.288
Ph
O'Bu
O
MeO
43
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1.00
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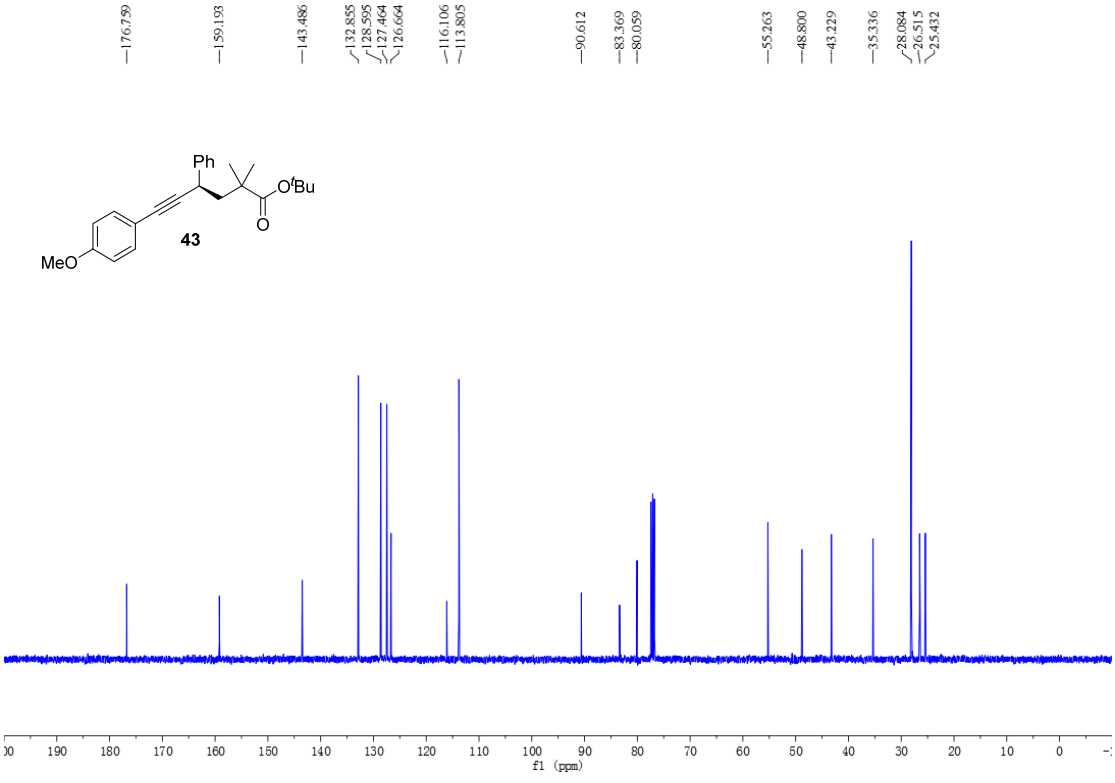
3.25
f1 (ppm)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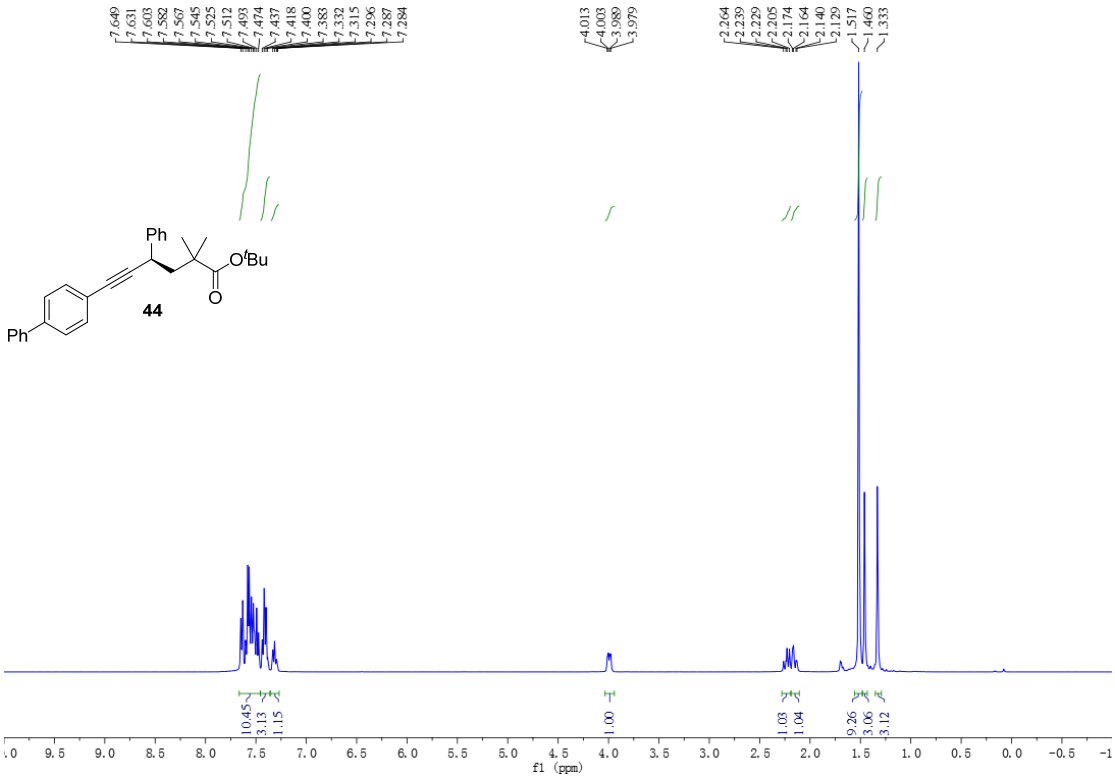
26.515
25.432
Ph
O'Bu
O
MeO
43
f1 (ppm)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7.332
7.315
7.296
7.287
7.284
4.013
4.003
3.980
3.979
2.264
2.239
2.229
2.205
2.174
2.164
2.140
2.129
1.517
1.460
1.333
Ph
O^{t}Bu
O
44
Ph
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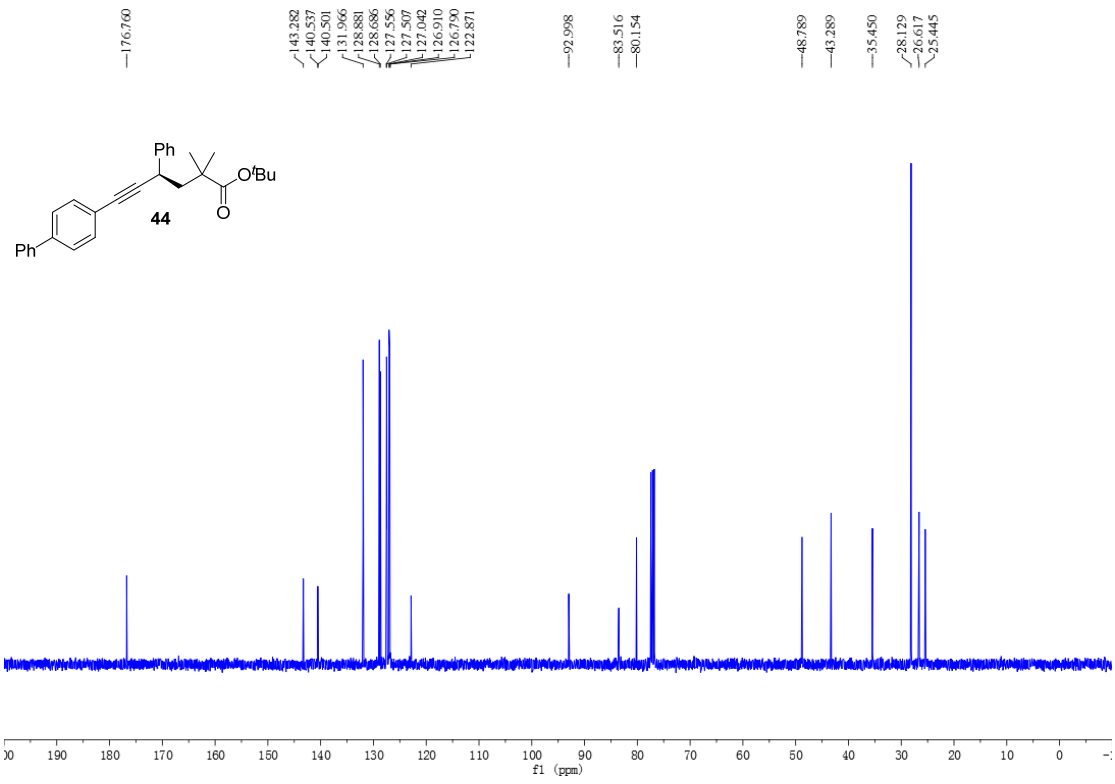
1.15
1.00
1.03
1.04
9.26
3.06
3.12
f1 (ppm)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128.686
127.556
127.507
127.042
126.910
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122.871
92.998
83.516
80.154
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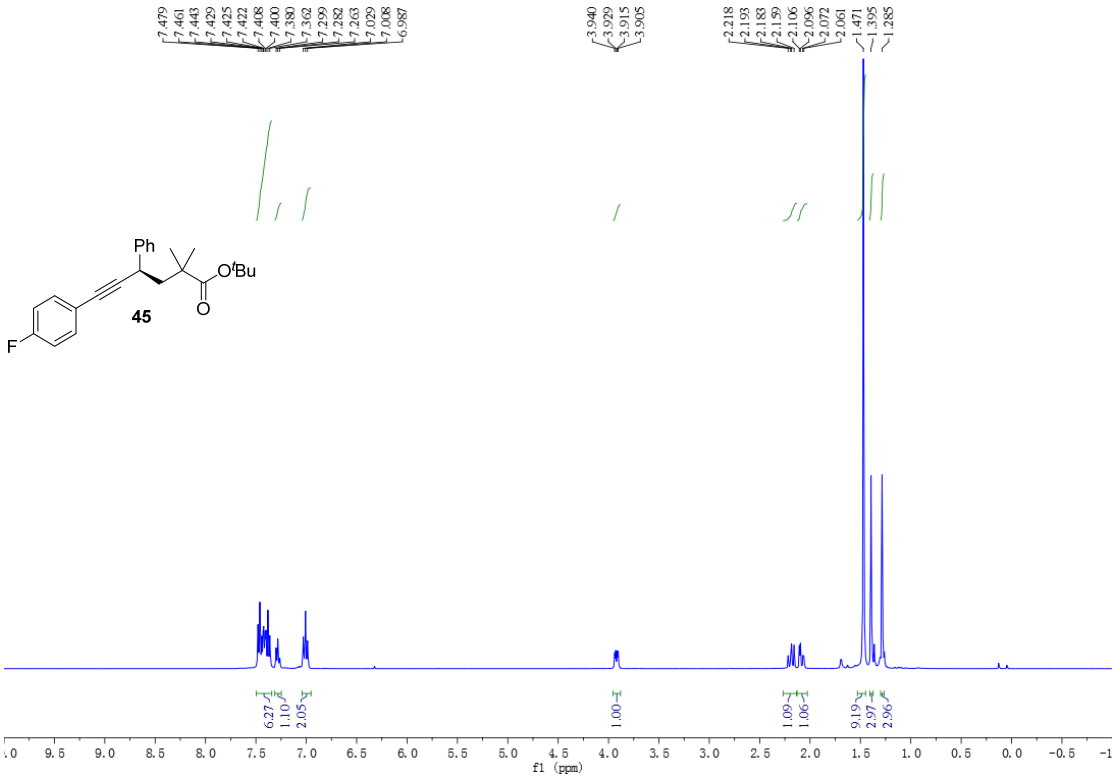
35.450
28.129
26.617
25.445
Ph
O^{t}Bu
O
44
Ph
f1 (ppm)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7.429
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7.408
7.400
7.380
7.362
7.299
7.282
7.263
7.029
7.008
6.987
3.940
3.929
3.915
3.905
2.218
2.193
2.183
2.159
2.106
2.096
2.072
2.061
1.471
1.395
1.285
Ph
O'Bu
O
F
45
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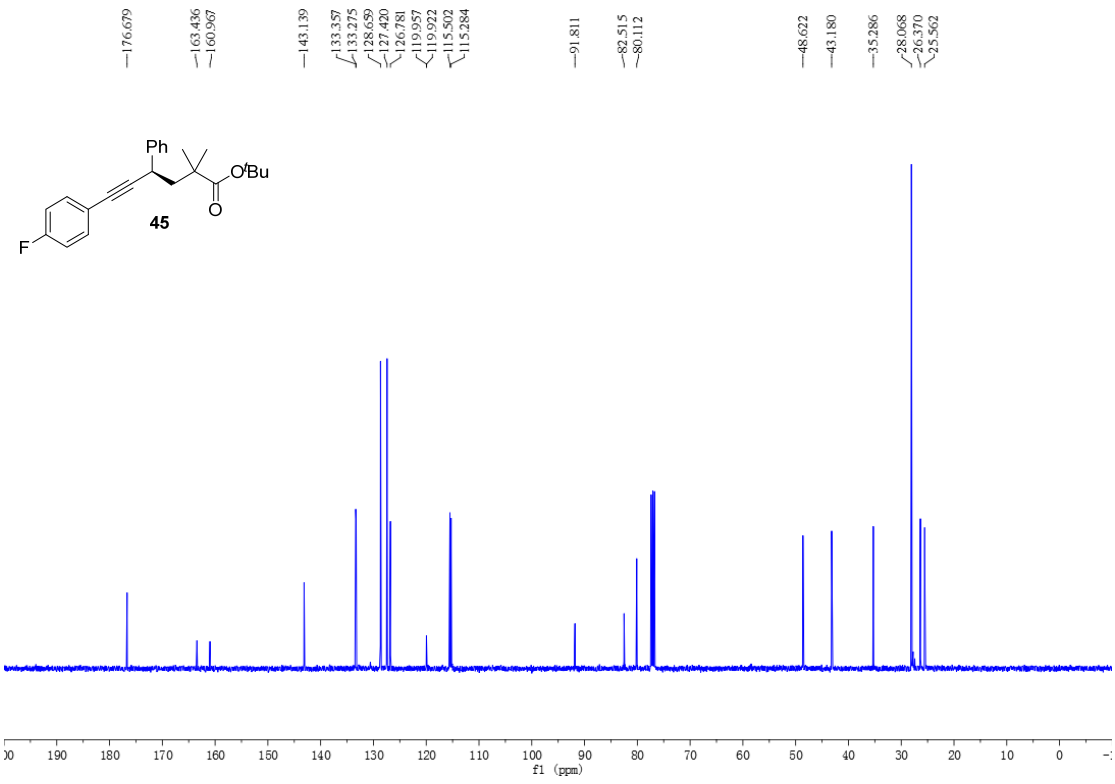
1.10
2.05
1.00
1.09
1.06
9.19
2.97
2.96
f1 (ppm)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133.275
128.659
127.420
126.781
119.957
119.922
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115.284
91.811
82.515
80.112
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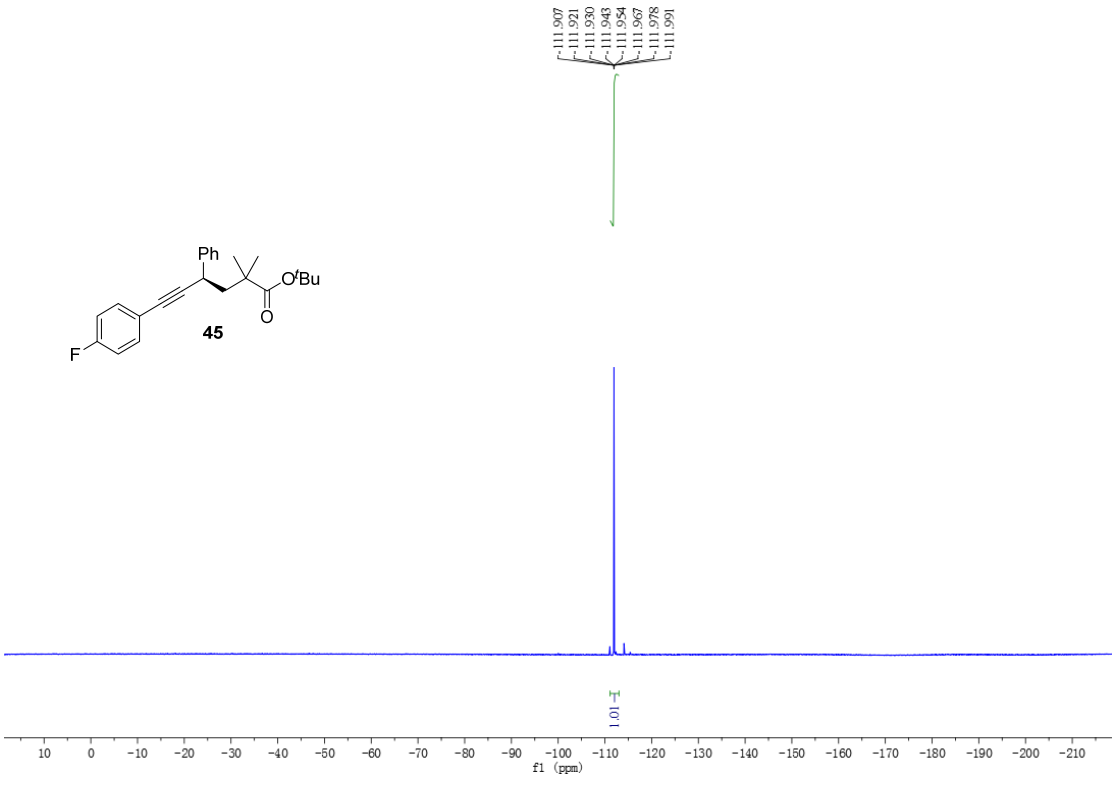
43.180
35.286
28.068
26.370
25.562
Ph
O'Bu
O
F
45
f1 (ppm)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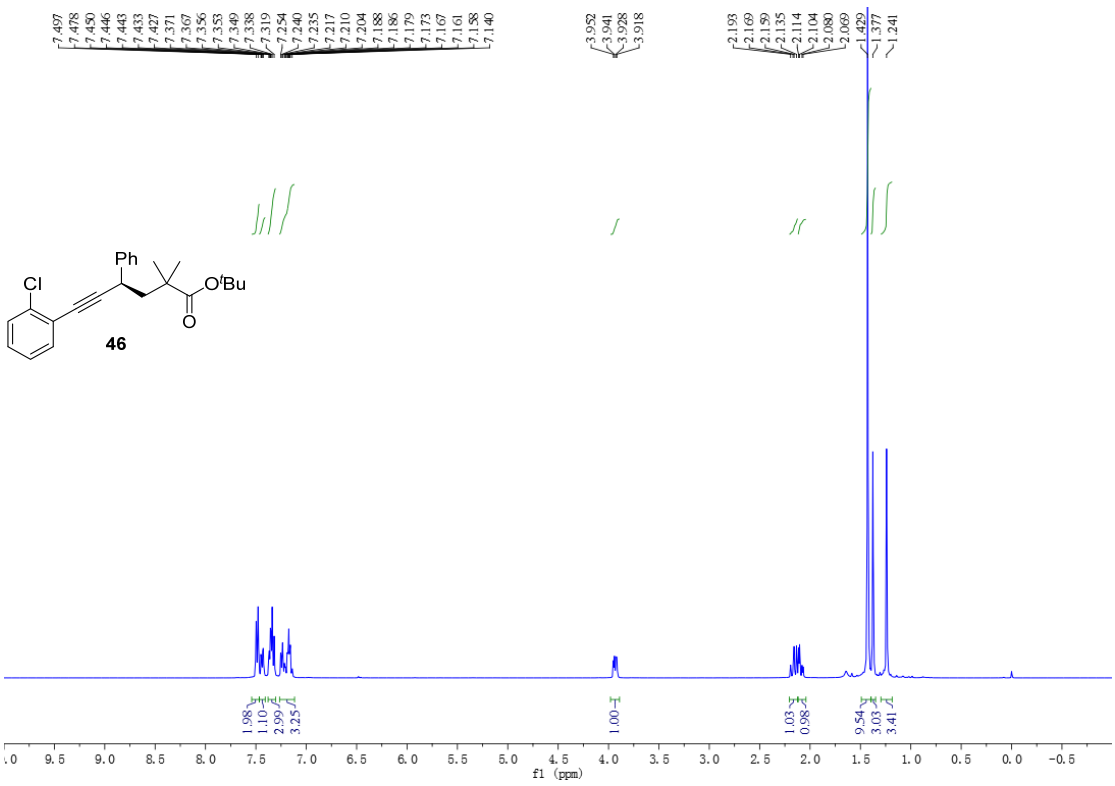
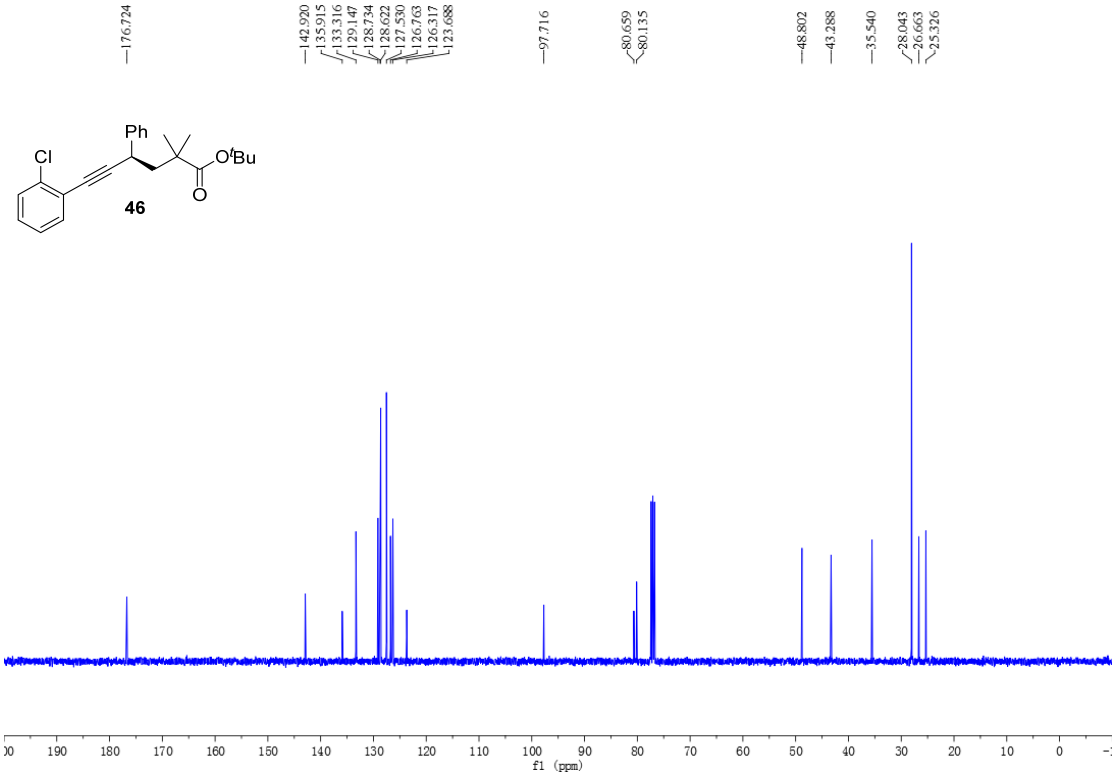
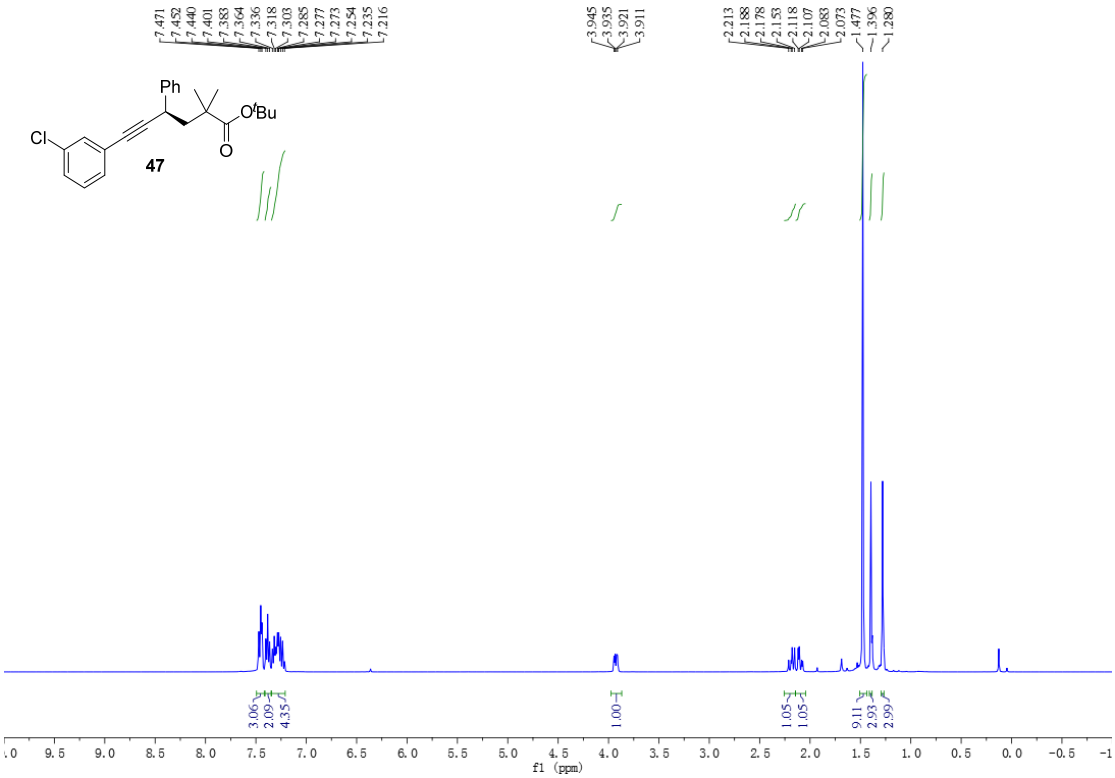
-111.967
-111.978
-111.991
Ph
O^{t}Bu
O
F
45
1.01
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
f1 (ppm)


Cl
Ph
O
O'Bu
46
f1 (ppm)


Cl
Ph
O
O'Bu
46
f1 (ppm)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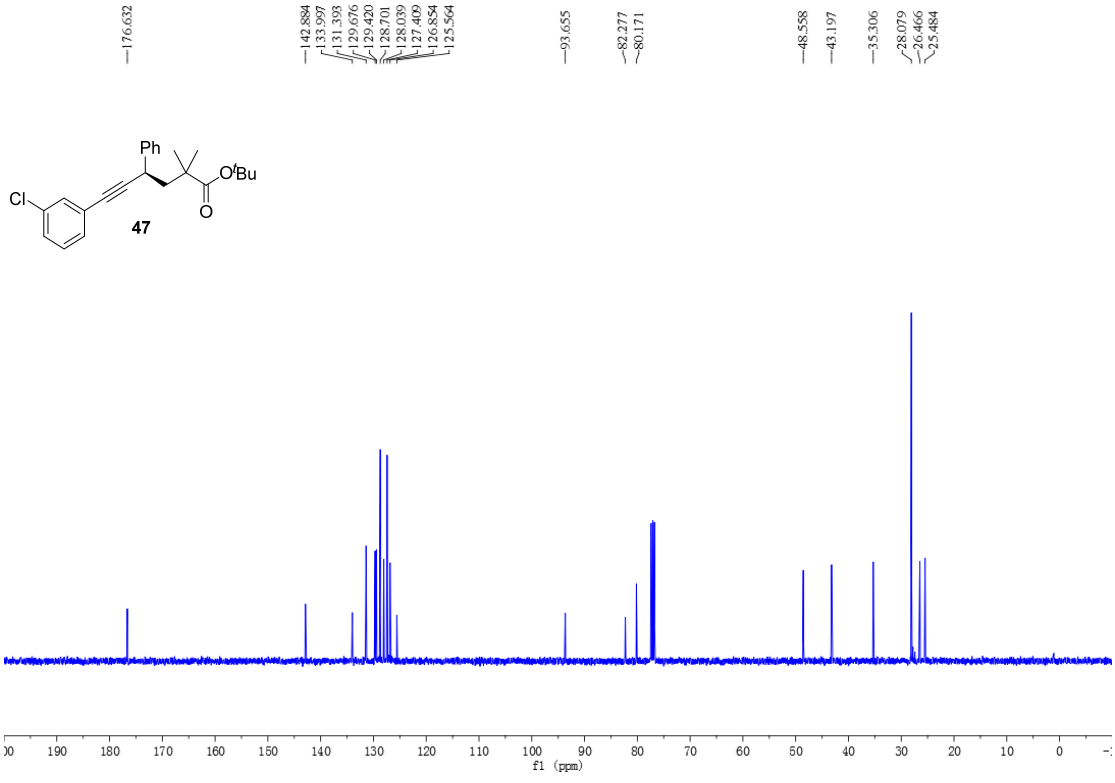
7.401
7.383
7.364
7.336
7.318
7.303
7.285
7.277
7.273
7.254
7.235
7.216
3.945
3.935
3.921
3.911
2.213
2.188
2.178
2.153
2.118
2.107
2.083
2.073
1.477
1.396
1.280
Ph
Cl
O
O'Bu
47
3.06
2.09
4.35
1.00
1.05
1.05
9.11
2.93
2.99
f1 (ppm)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131.393
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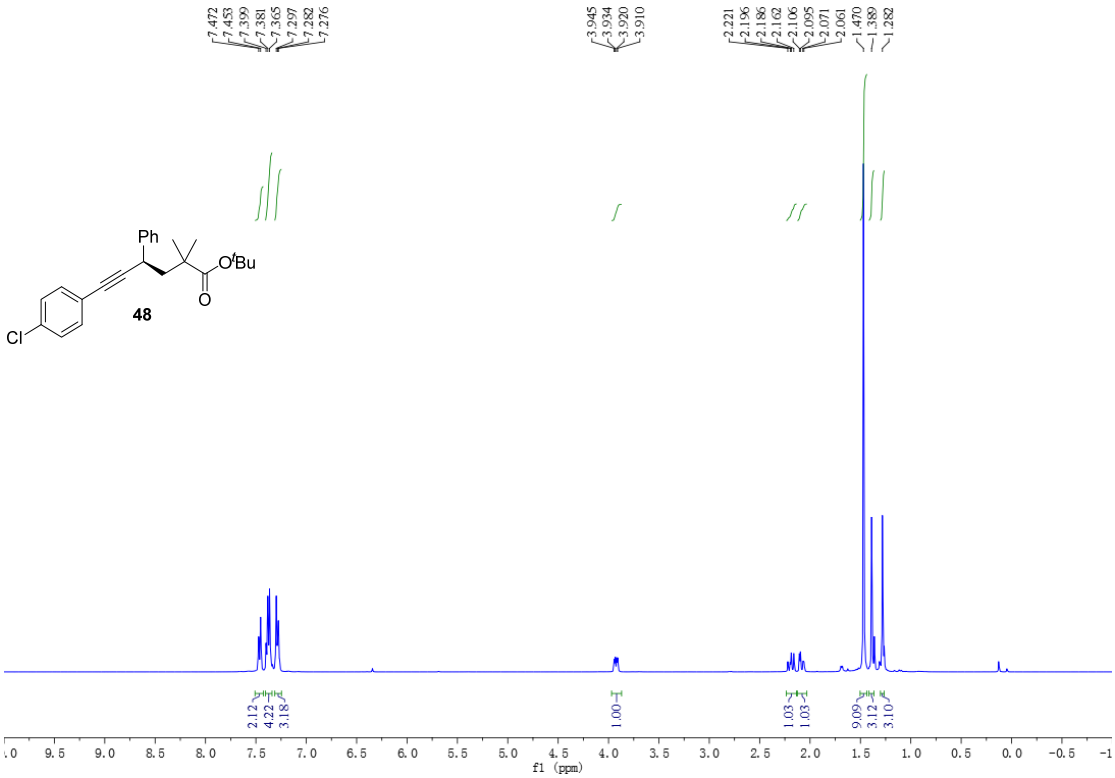
129.420
128.701
128.039
127.409
126.854
125.564
93.655
82.277
80.171
48.558
43.197
35.306
28.079
26.466
25.484
Ph
Cl
O
O'Bu
47
f1 (ppm)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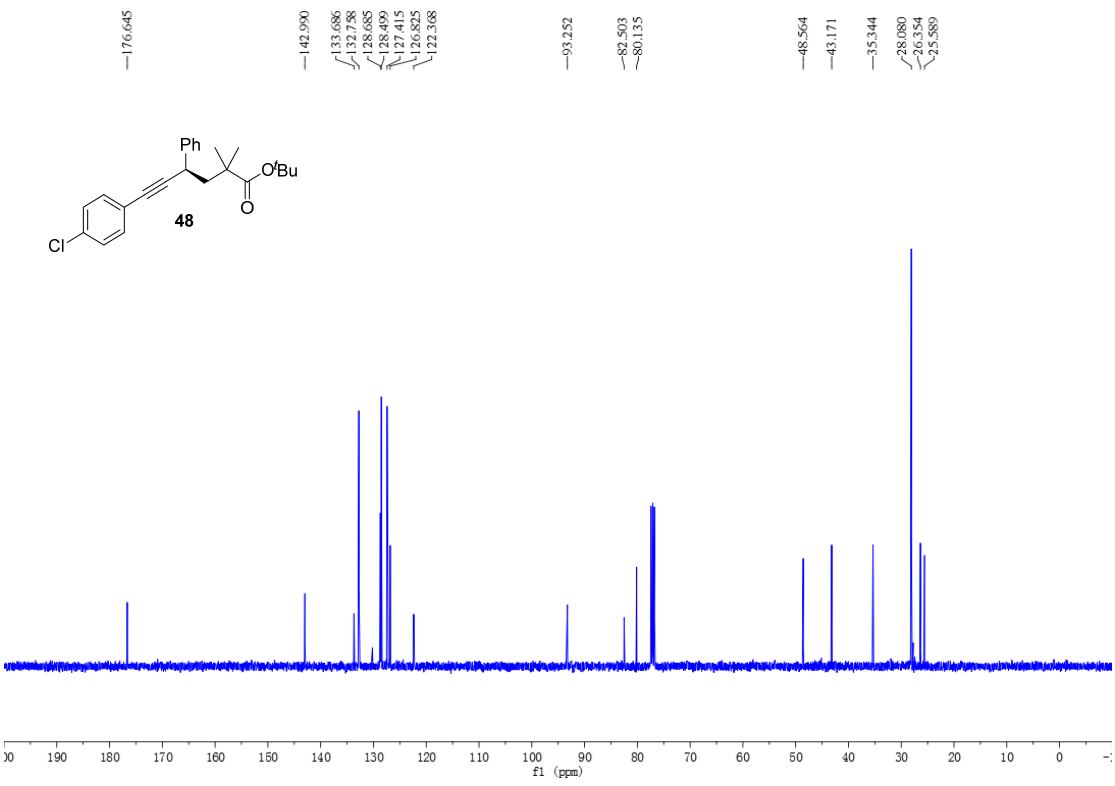
7.453
7.399
7.381
7.365
7.297
7.282
7.276
3.945
3.934
3.920
3.910
2.221
2.196
2.186
2.162
2.106
2.095
2.071
2.061
1.470
1.389
1.282
Ph
O'Bu
O
Cl
48
2.12
4.22
3.18
1.00
1.03
1.03
9.09
3.12
3.10
f1 (ppm)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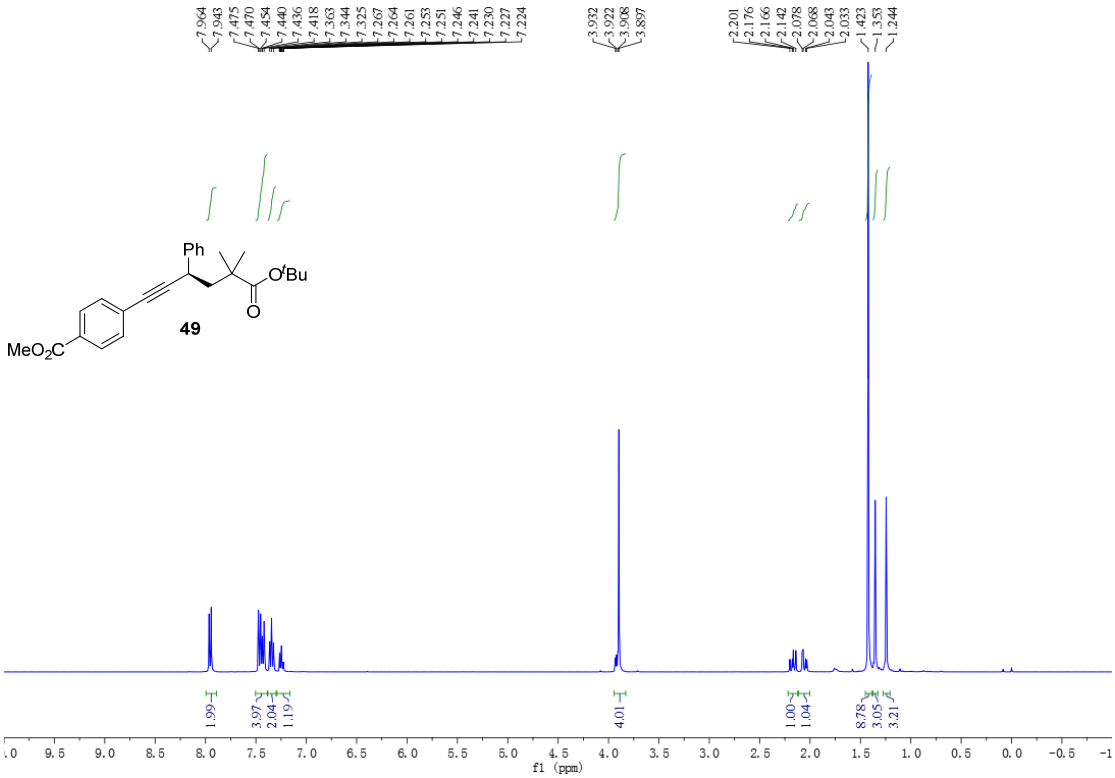
128.499
127.415
126.825
122.368
93.252
82.503
80.135
48.564
43.171
35.344
28.080
26.354
25.589
Ph
O'Bu
O
Cl
48
f1 (ppm)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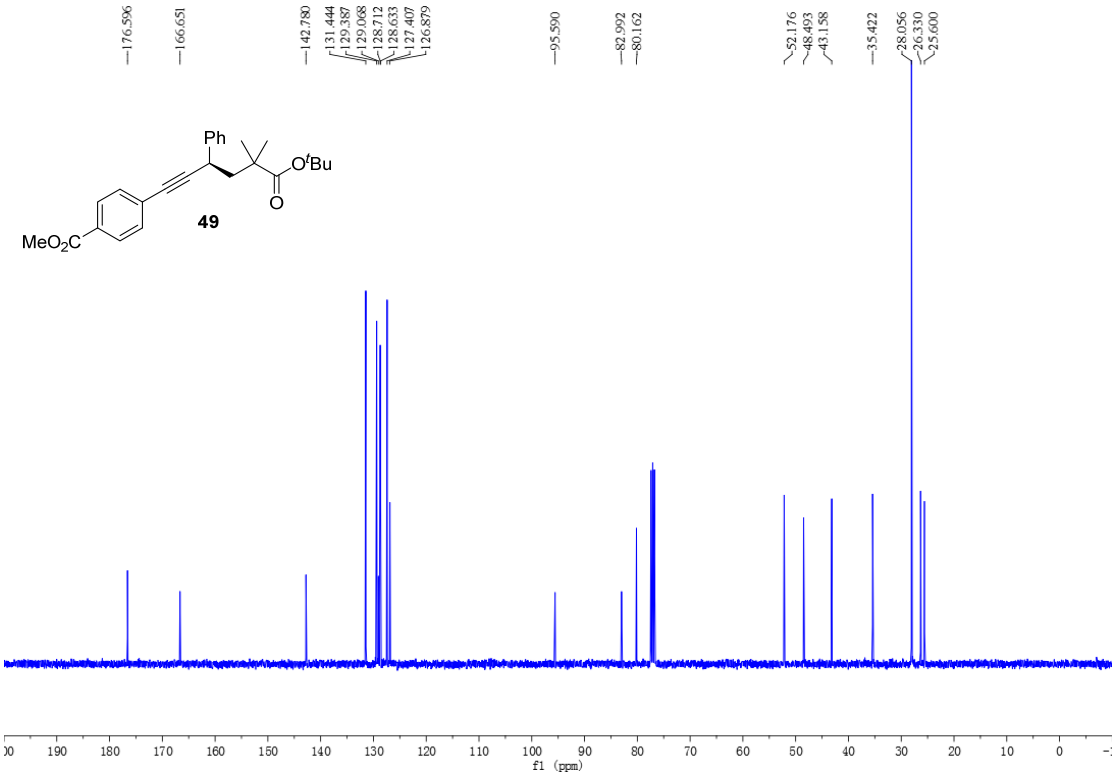
7.418
7.363
7.344
7.325
7.267
7.264
7.261
7.253
7.251
7.246
7.241
7.230
7.227
7.224
3.932
3.922
3.908
3.897
2.201
2.176
2.166
2.142
2.078
2.068
2.043
2.033
1.423
1.353
1.244
Ph
O'Bu
O
MeO2C
49
1.99
3.97
2.04
1.19
4.01
1.00
1.04
8.78
3.05
3.21
f1 (ppm)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142.780
131.444
129.387
129.068
128.712
128.633
127.407
126.879
95.590
82.992
80.162
52.176
48.493
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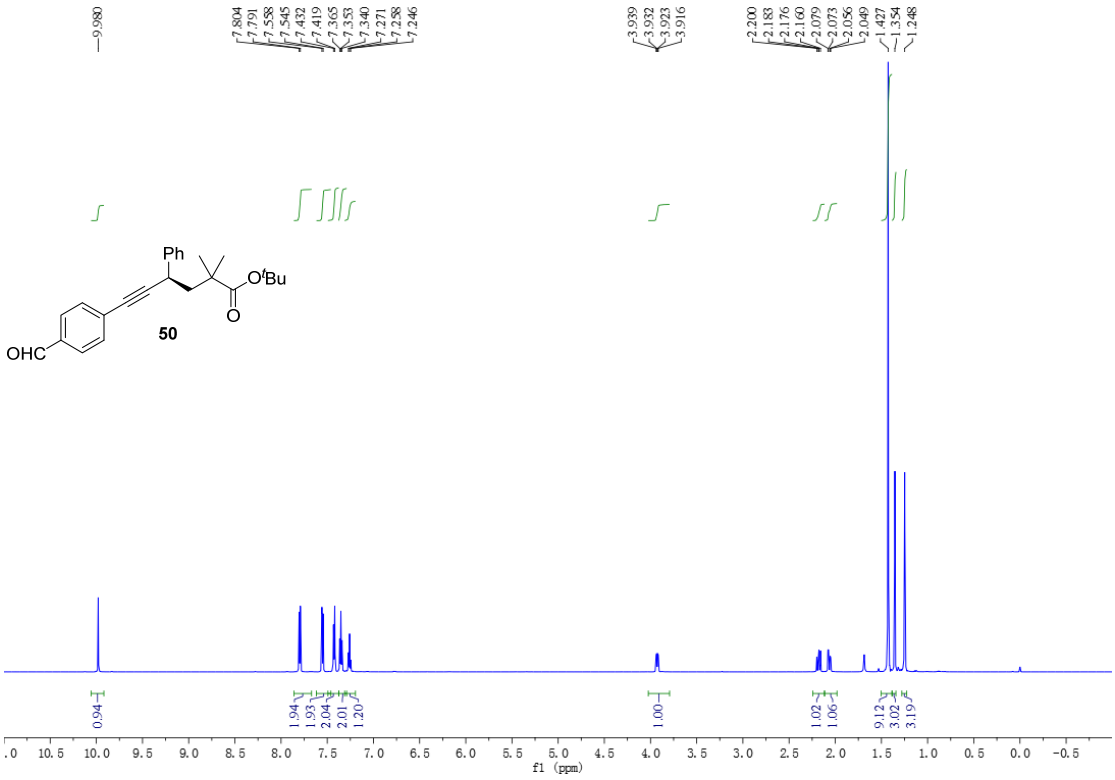
35.422
28.056
26.330
25.600
Ph
O'Bu
O
MeO2C
49
f1 (ppm)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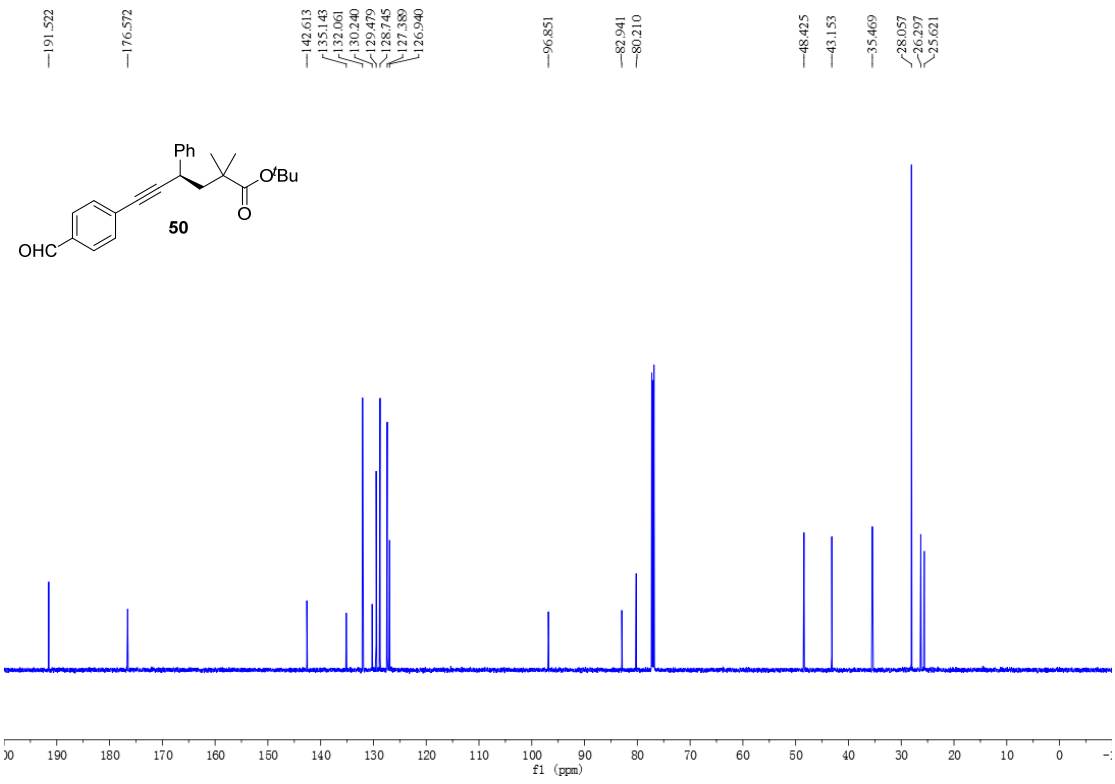
7.804
7.791
7.588
7.545
7.432
7.419
7.365
7.353
7.340
7.271
7.258
7.246
3.939
3.932
3.923
3.916
2.200
2.183
2.176
2.160
2.079
2.073
2.056
2.049
1.427
1.354
1.248
Ph
O'Bu
O
OHC
50
0.94
1.94
1.93
2.04
2.01
1.20
1.00
1.02
1.06
9.12
3.02
3.19
f1 (ppm)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130.240
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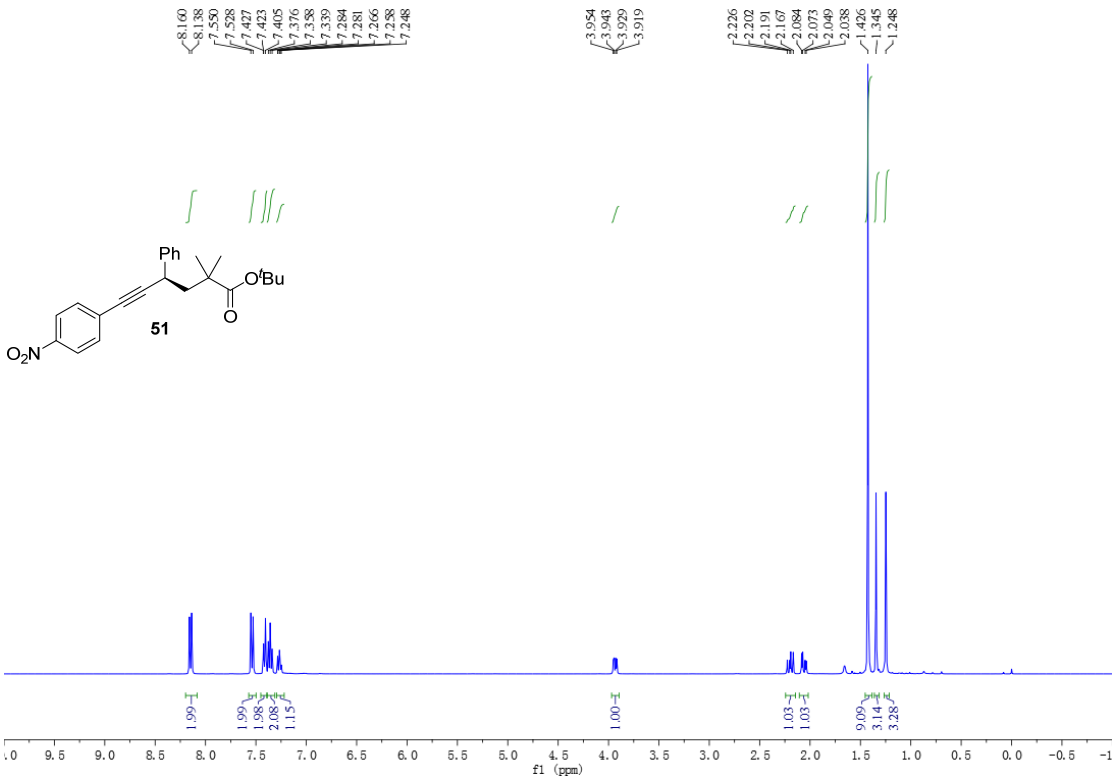
128.745
127.389
126.940
96.851
82.941
80.210
48.425
43.153
35.469
28.057
26.297
25.621
Ph
O'Bu
O
OHC
50
f1 (ppm)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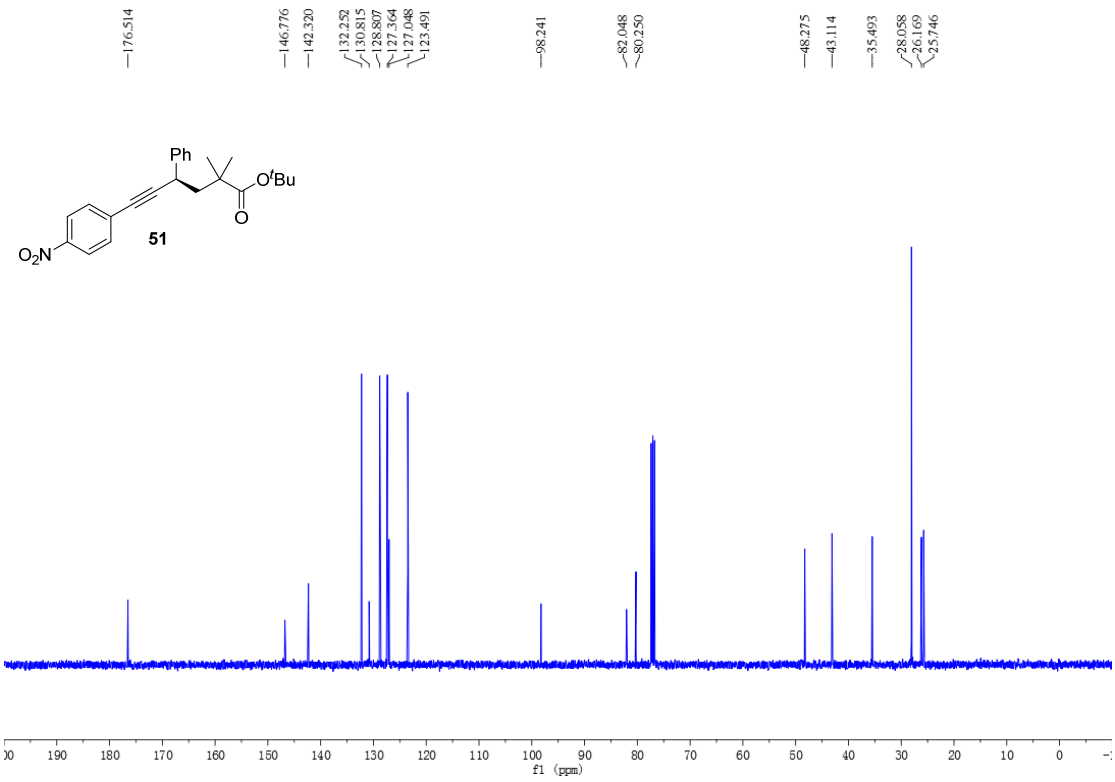
8.138
7.550
7.528
7.427
7.423
7.405
7.376
7.338
7.339
7.284
7.281
7.266
7.258
7.248
3.954
3.943
3.929
3.919
2.226
2.202
2.191
2.167
2.084
2.073
2.049
2.038
1.426
1.345
1.248
Ph
O^{t}Bu
O
O_2N
51
1.99
1.99
1.98
2.08
1.15
1.00
1.03
1.03
9.09
3.14
3.28
f1 (ppm)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142.320
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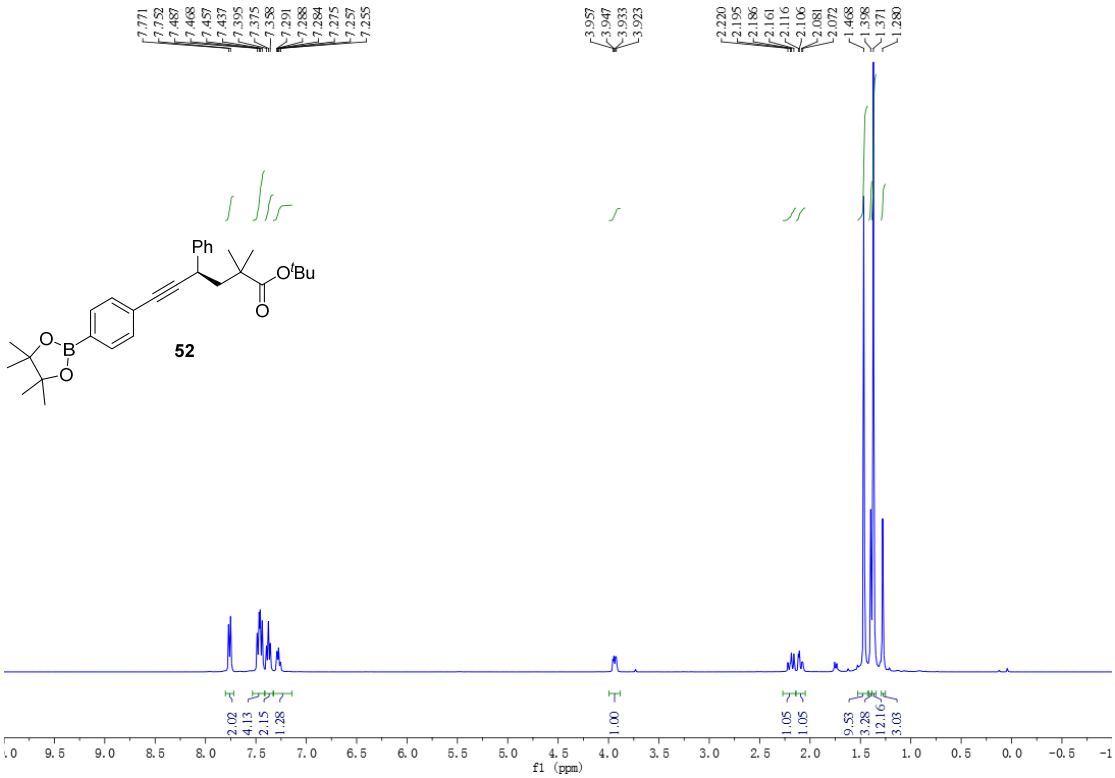
128.807
127.364
127.048
123.491
98.241
82.048
80.250
48.275
43.114
35.493
28.058
26.169
25.746
Ph
O^{t}Bu
O
O_2N
51
f1 (ppm)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7.375
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7.291
7.288
7.284
7.275
7.257
7.255
3.957
3.947
3.933
3.923
2.220
2.195
2.186
2.161
2.116
2.106
2.081
2.072
1.468
1.398
1.371
1.280
Ph
O^{t}Bu
O
B
O
O
52
2.02
4.13
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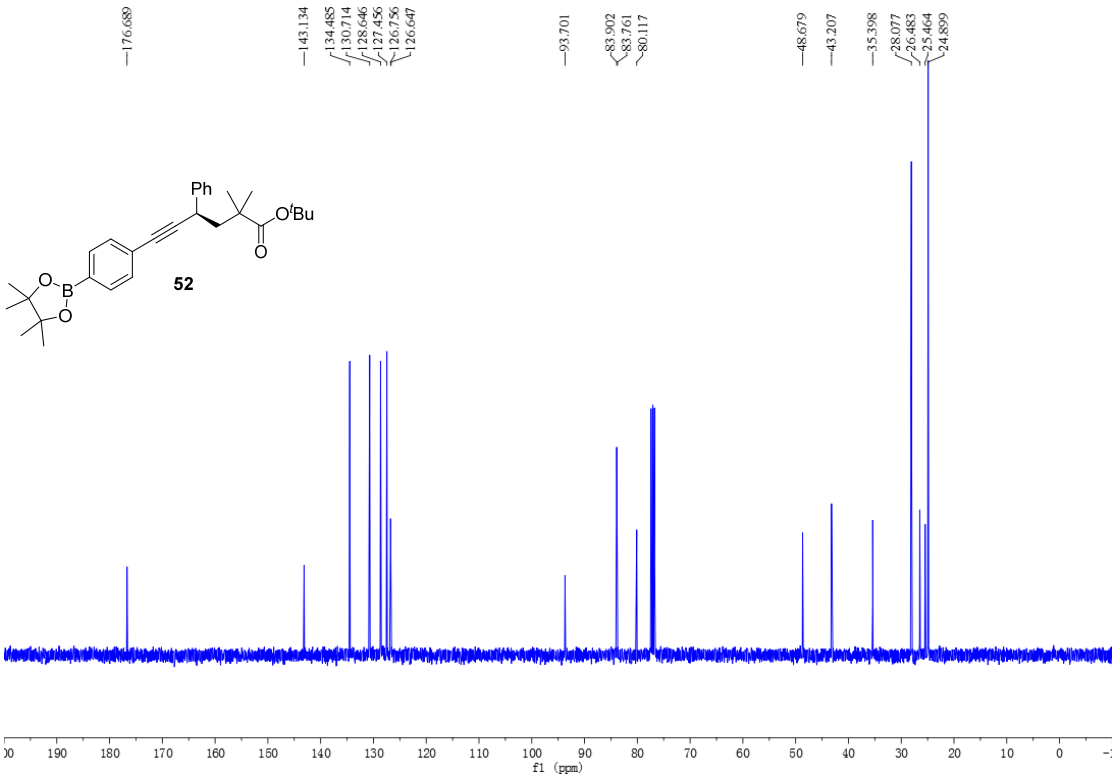
1.28
1.00
1.05
1.05
9.53
3.28
12.16
3.03
f1 (ppm)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126.756
126.647
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83.902
83.761
80.117
48.679
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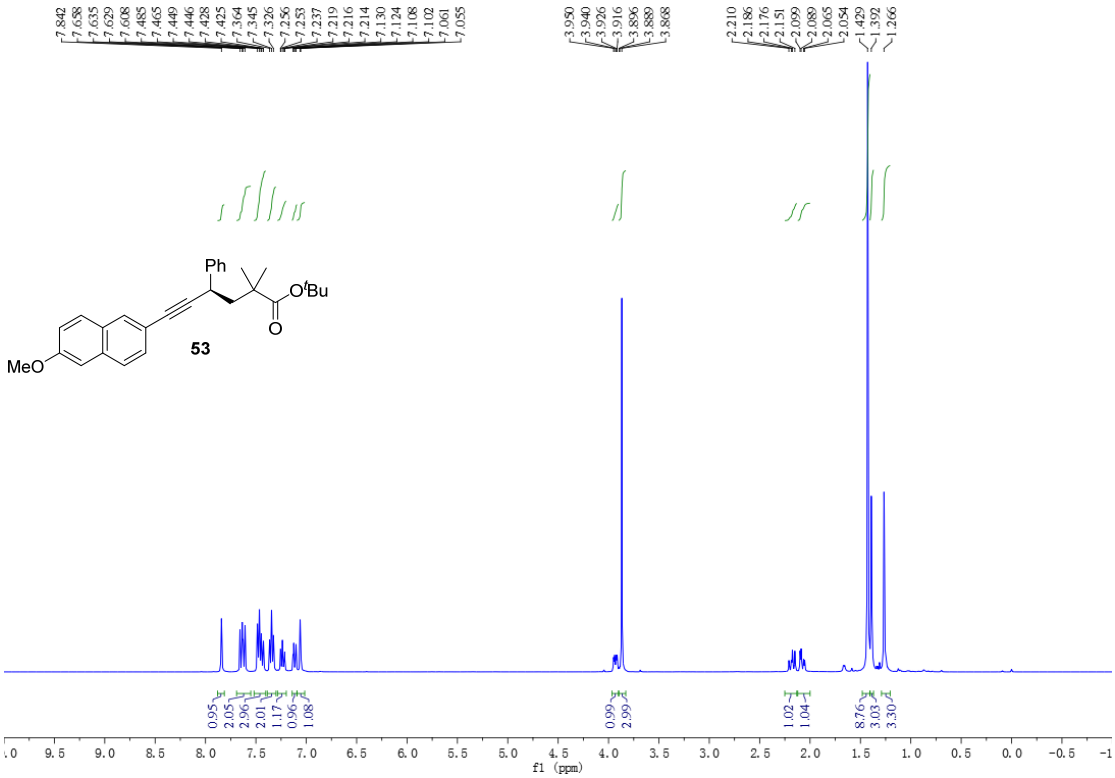
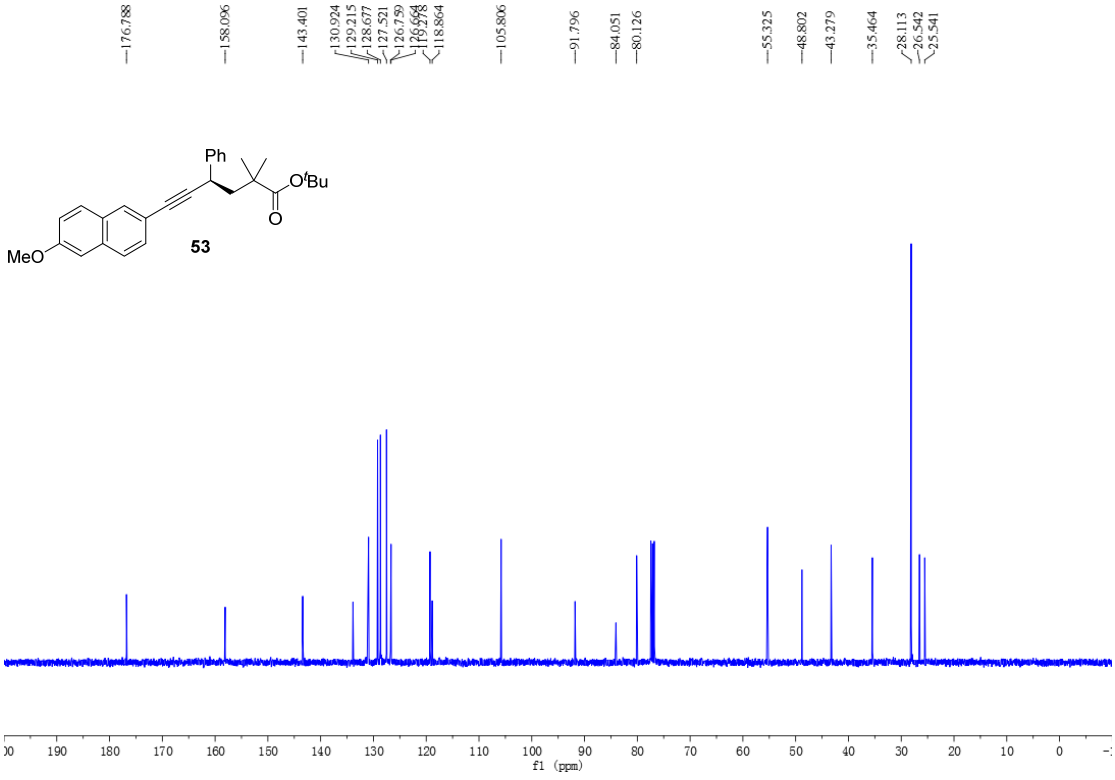
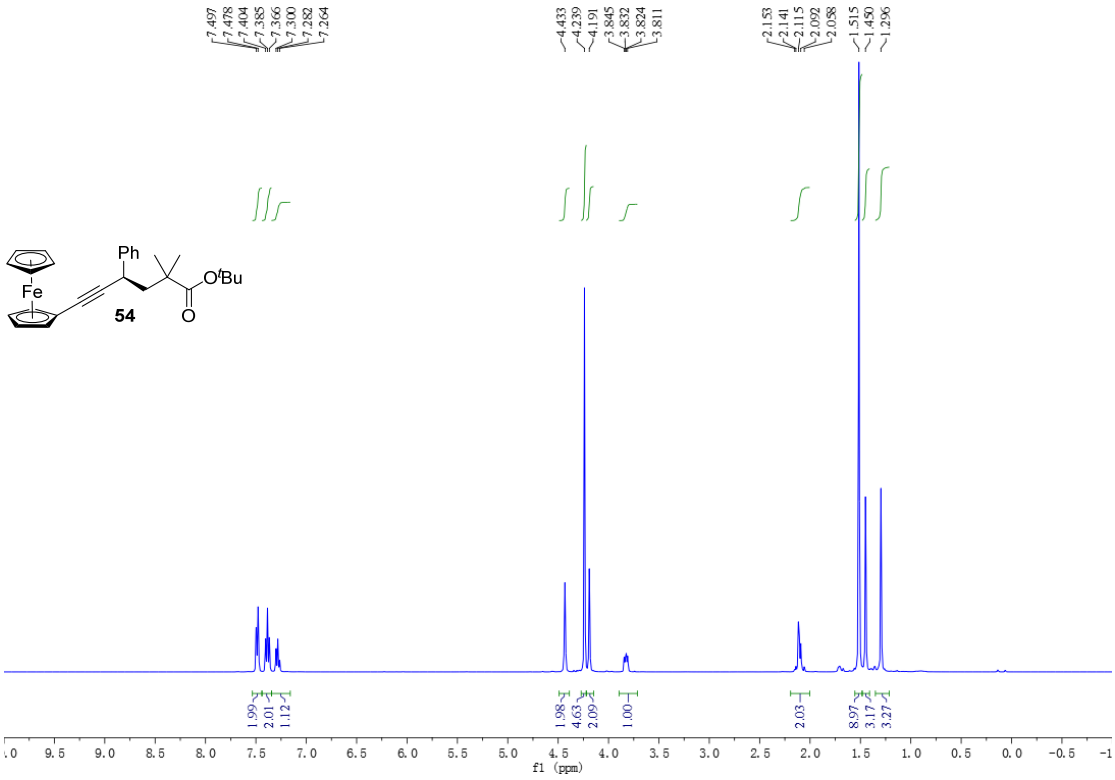
35.398
28.077
26.483
25.464
24.899
Ph
O^{t}Bu
O
B
O
O
52
f1 (ppm)


Ph
O^{t}Bu
O
MeO
53
f1 (ppm)


Ph
O^{t}Bu
O
MeO
53
f1 (ppm)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7.366
7.300
7.282
7.264
4.433
4.239
4.191
3.845
3.832
3.824
3.811
2.153
2.141
2.115
2.092
2.038
1.515
1.450
1.296
Ph
Fe
O'Bu
O
54
1.99
2.01
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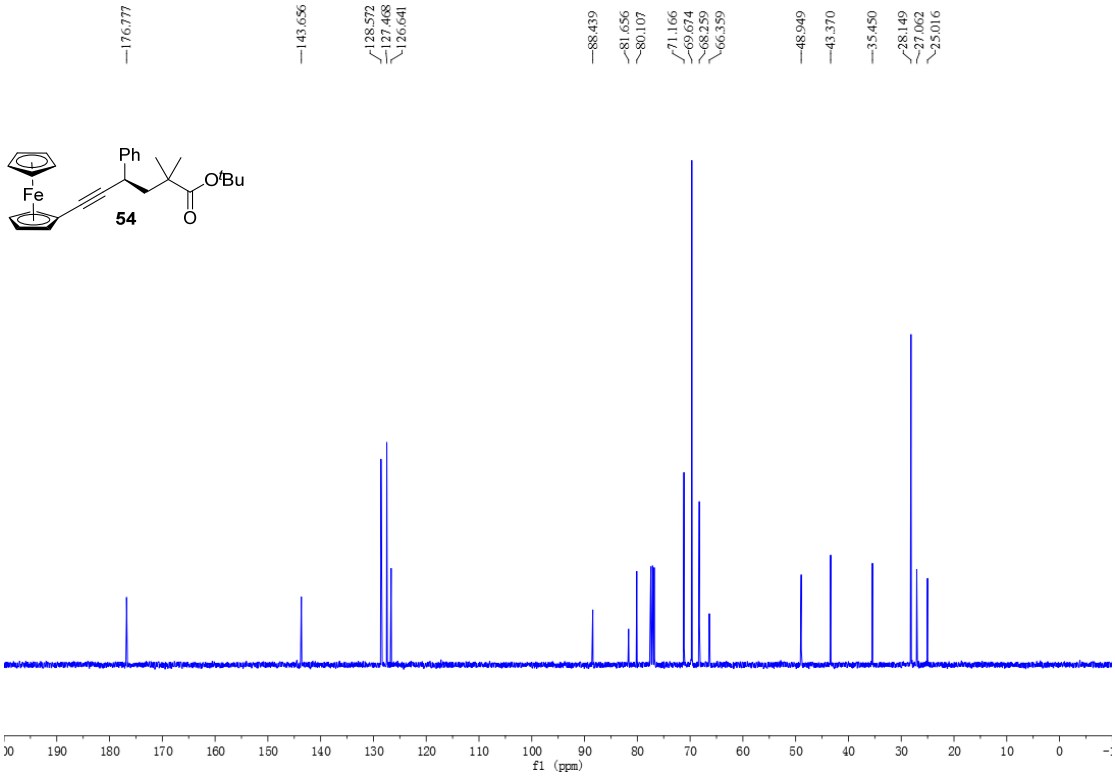
1.98
4.63
2.09
1.00
2.03
8.97
3.17
3.27
f1 (ppm)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81.656
80.107
71.166
69.674
68.259
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43.370
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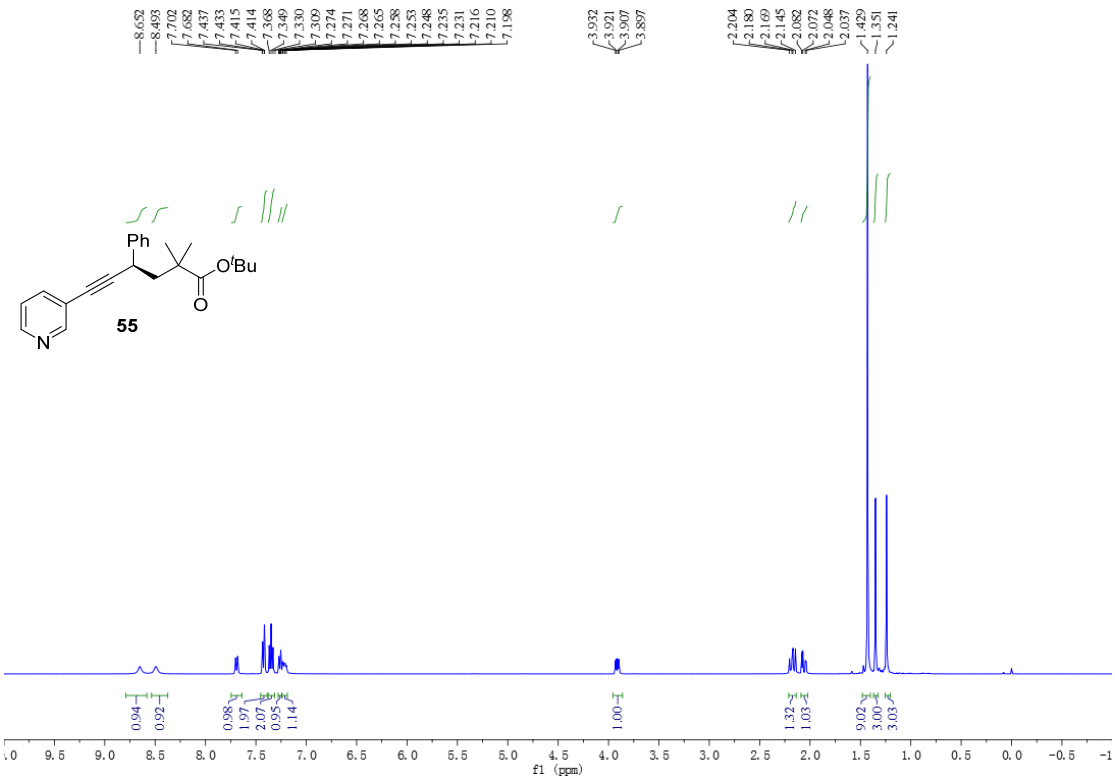
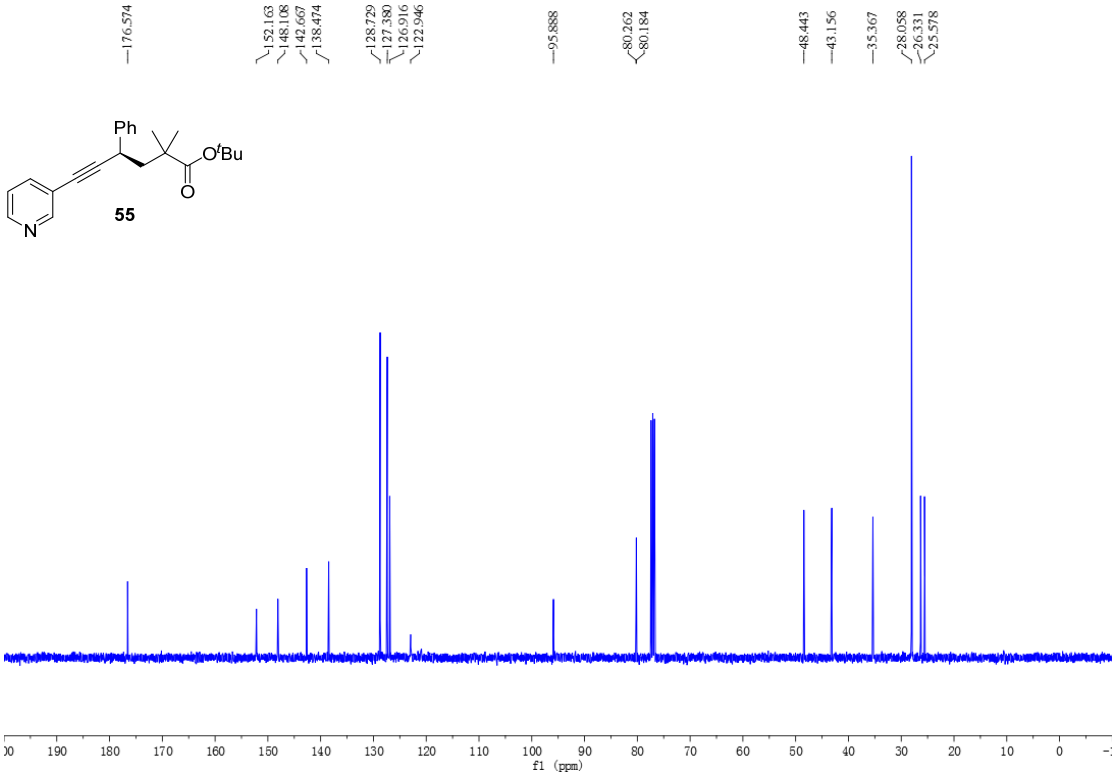
Ph
Fe
O'Bu
O
54
f1 (ppm)


Ph
O^{t}Bu
O
N
55
f1 (ppm)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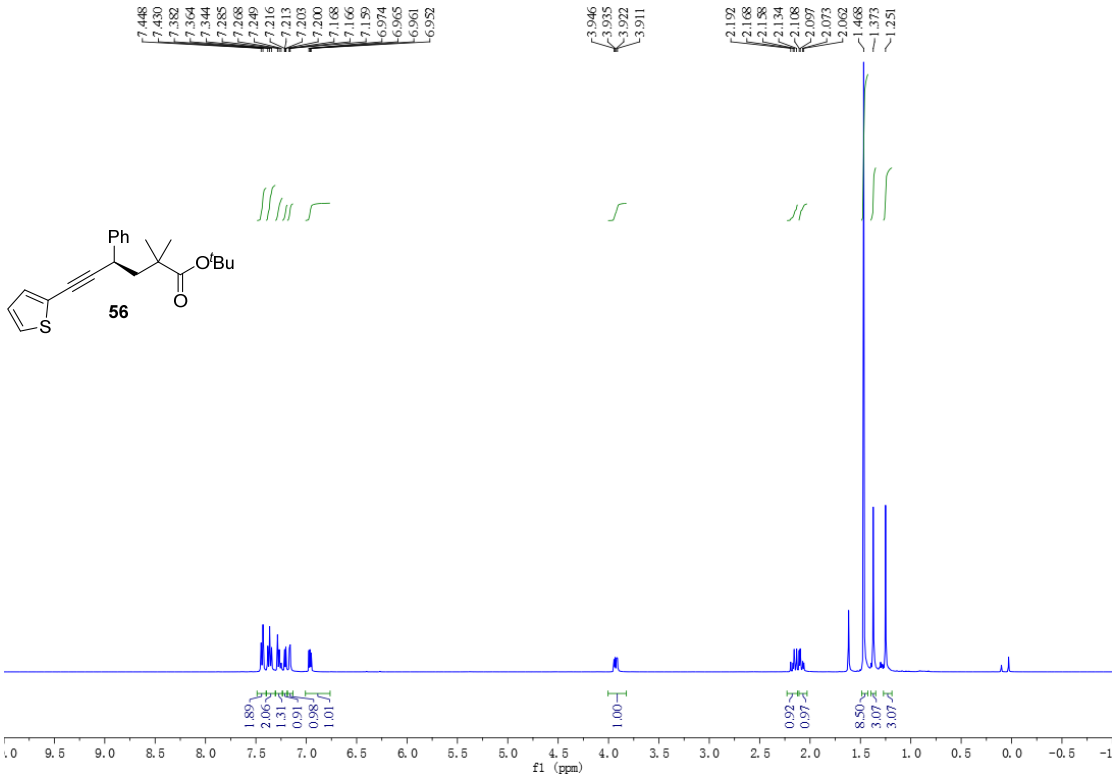
O^{t}Bu
O
N
55
f1 (ppm)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7.249
7.216
7.213
7.203
7.200
7.168
7.166
7.159
6.974
6.965
6.961
6.952
3.946
3.935
3.922
3.911
2.192
2.168
2.158
2.134
2.108
2.097
2.073
2.062
1.468
1.373
1.251
Ph
O^{t}Bu
O
S
56
1.89
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1.31
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0.98
1.01
1.00
0.92
0.97
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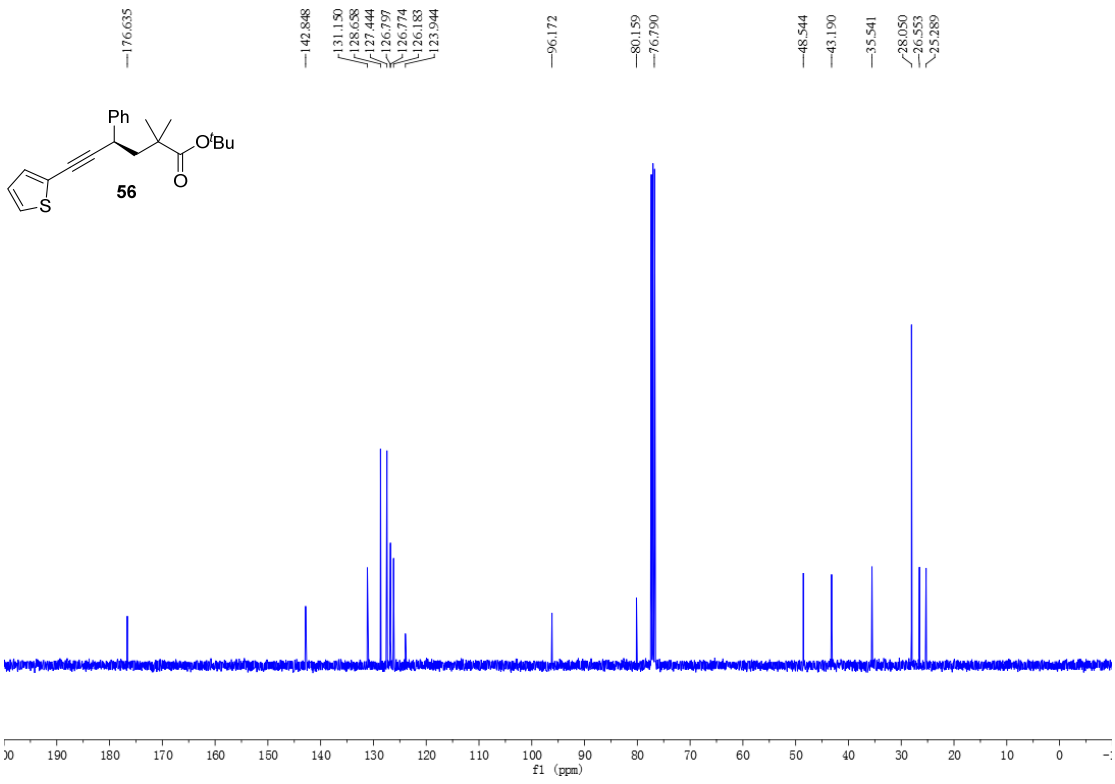
3.07
f1 (ppm)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126.774
126.183
123.944
96.172
80.159
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35.541
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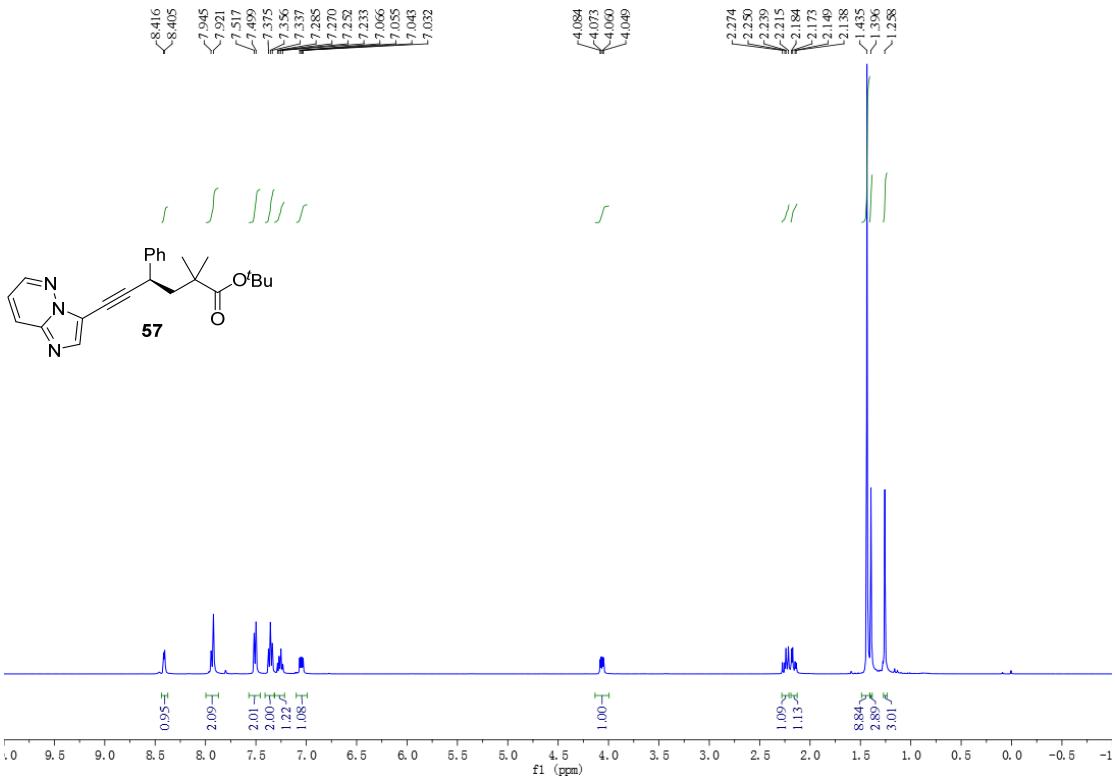
26.553
25.289
Ph
O^{t}Bu
O
S
56
f1 (ppm)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7.252
7.233
7.066
7.055
7.043
7.032
4.084
4.073
4.060
4.049
2.274
2.250
2.239
2.215
2.184
2.173
2.149
2.138
1.435
1.396
1.258
Ph
O'Bu
O
N
N
N
57
0.95
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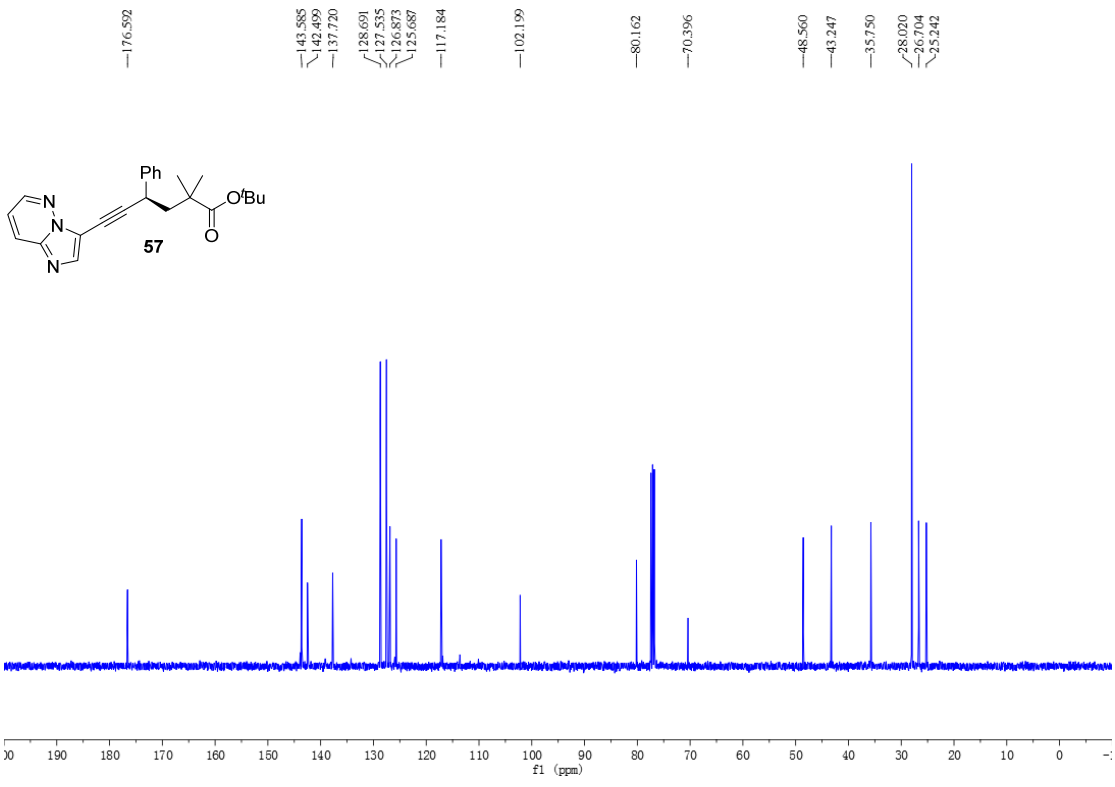
2.00
1.22
1.08
1.00
1.09
1.13
8.84
2.89
3.01
f1 (ppm)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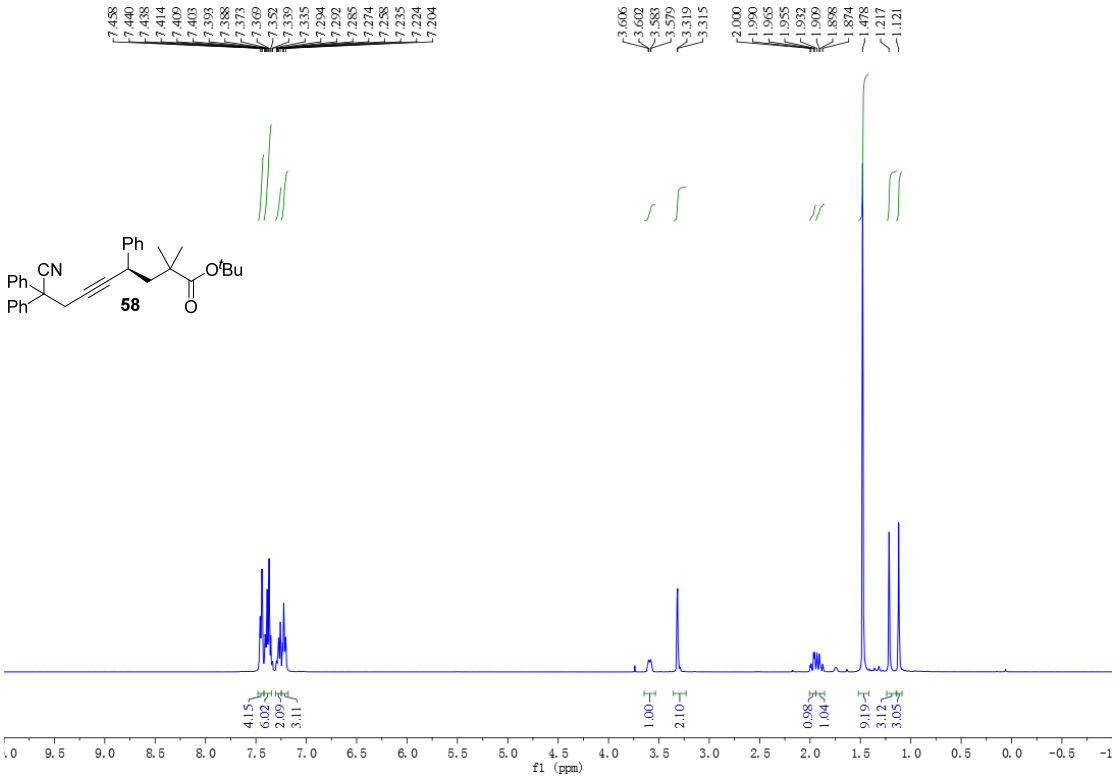
142.499
137.720
128.691
127.535
126.873
125.687
117.184
102.199
80.162
70.396
48.560
43.247
35.750
28.020
26.704
25.242
Ph
O'Bu
O
N
N
N
57
f1 (ppm)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7.438
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7.335
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7.204
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Ph
CN
Ph
O
O
tBu
58
4.15
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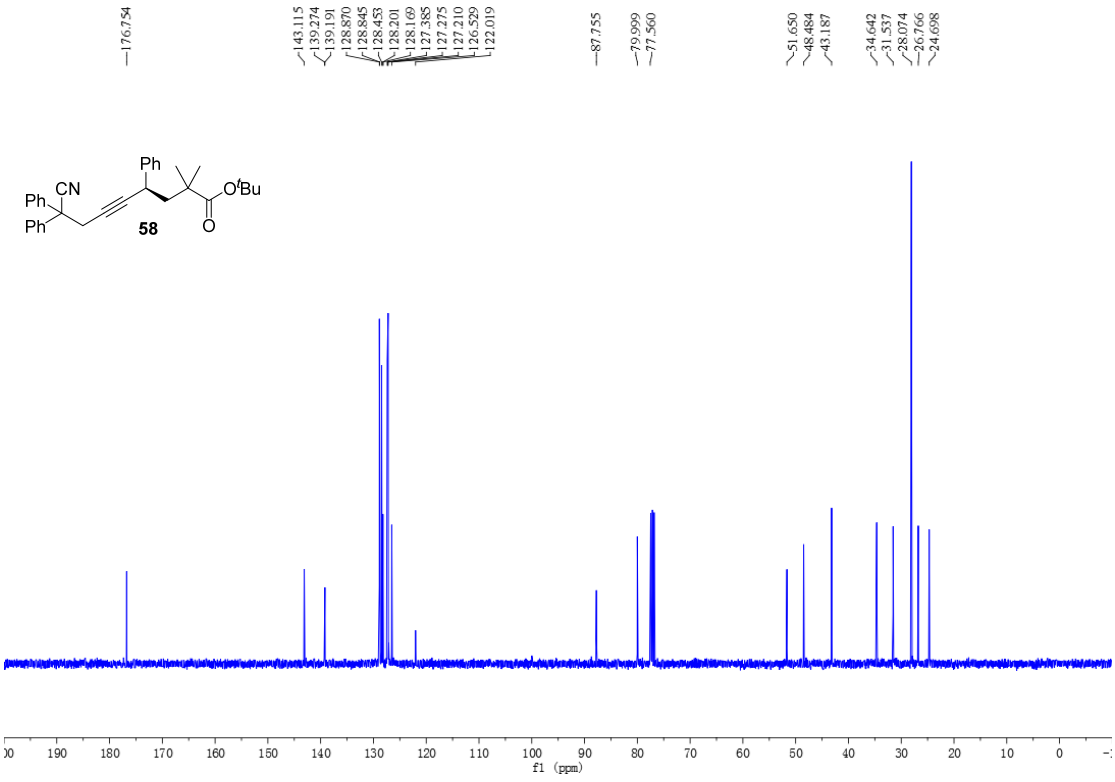
3.11
1.00
2.10
0.98
1.04
9.19
3.12
3.05
f1 (ppm)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139.274
139.191
128.870
128.845
128.453
128.201
128.169
127.385
127.275
127.210
126.529
122.019
87.755
79.999
77.560
51.650
48.484
43.187
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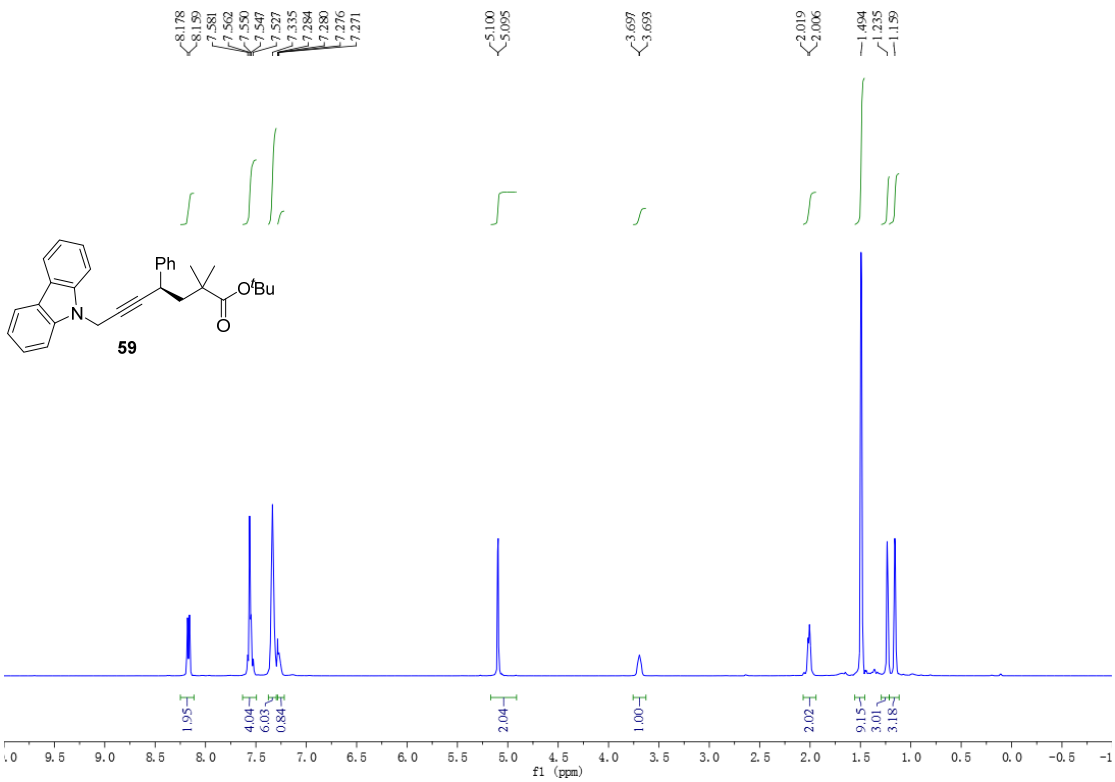
31.537
28.074
26.766
24.698
Ph
CN
Ph
O
O
tBu
58
f1 (ppm)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7.562
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7.547
7.527
7.335
7.284
7.280
7.276
7.271
5.100
5.095
3.697
3.693
2.019
2.006
1.494
1.235
1.159
Ph
O
O'Bu
N
59
1.95
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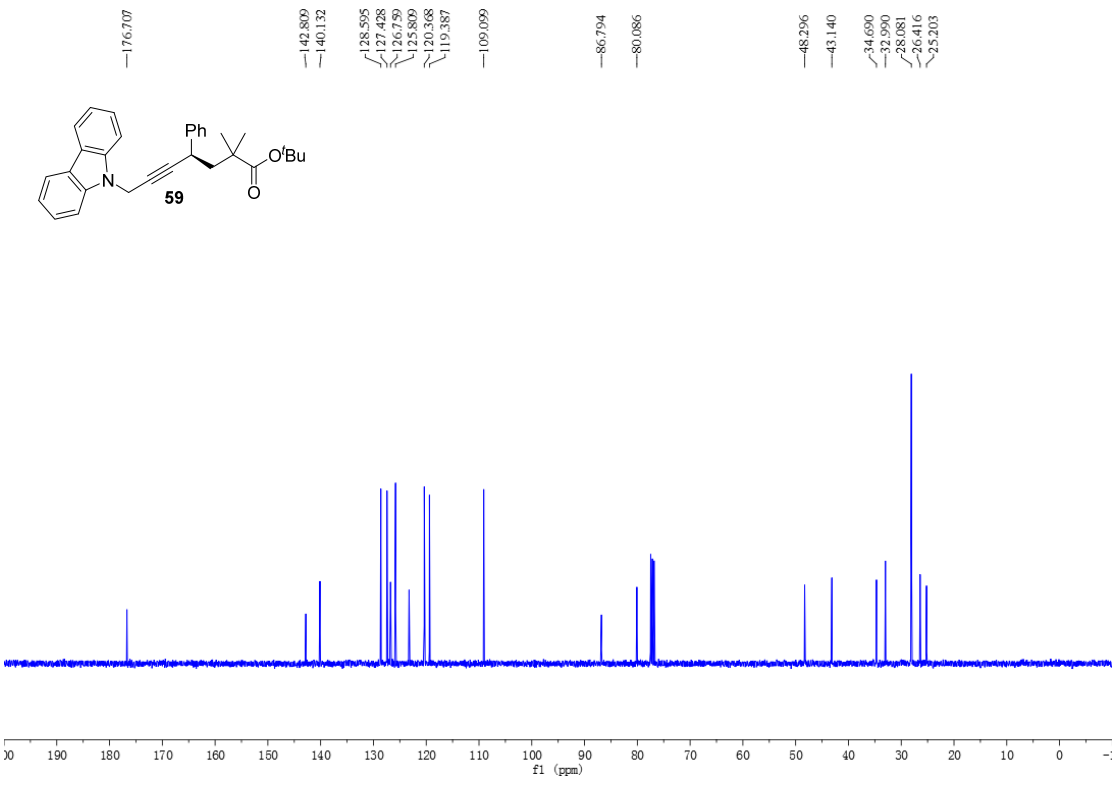
6.03
0.84
2.04
1.00
2.02
9.15
3.01
3.18
f1 (ppm)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120.368
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86.794
80.086
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34.690
32.990
28.081
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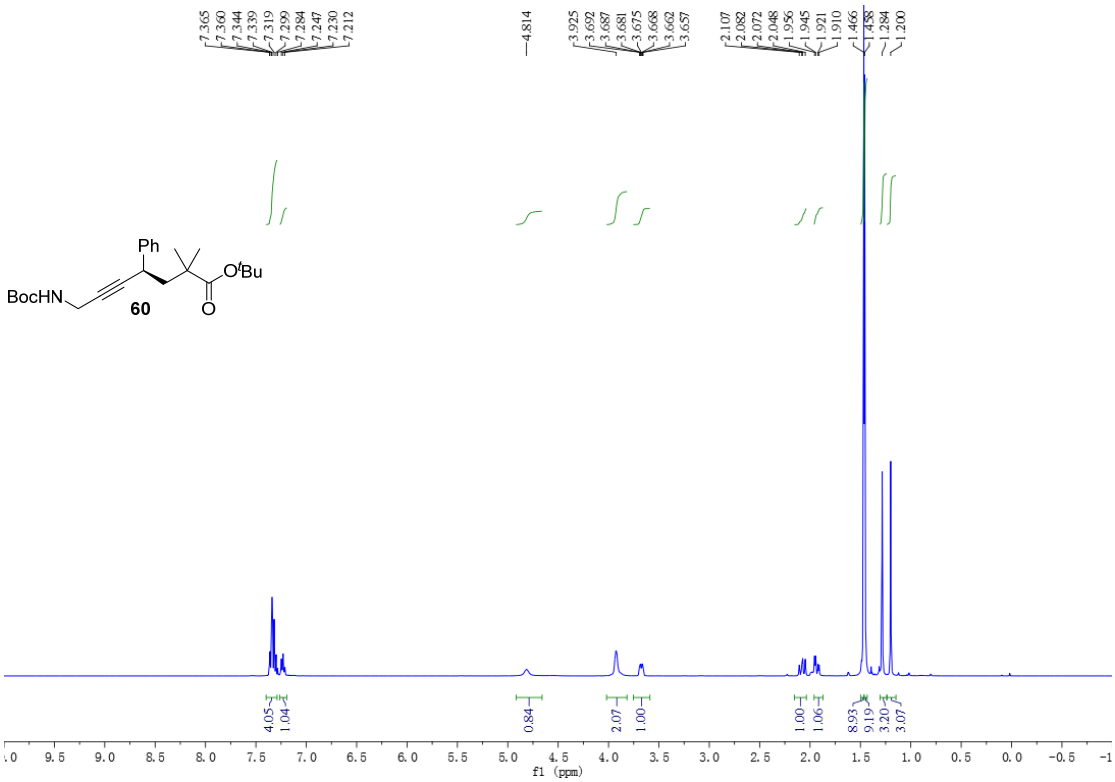
25.203
Ph
O
O'Bu
N
59
f1 (ppm)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7.344
7.339
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7.299
7.284
7.247
7.230
7.212
4.814
3.925
3.692
3.687
3.681
3.675
3.668
3.662
3.657
2.107
2.082
2.072
2.048
1.956
1.945
1.921
1.910
1.466
1.458
1.284
1.200
Ph
BocHN
O^{t}Bu
O
60
4.05
1.04
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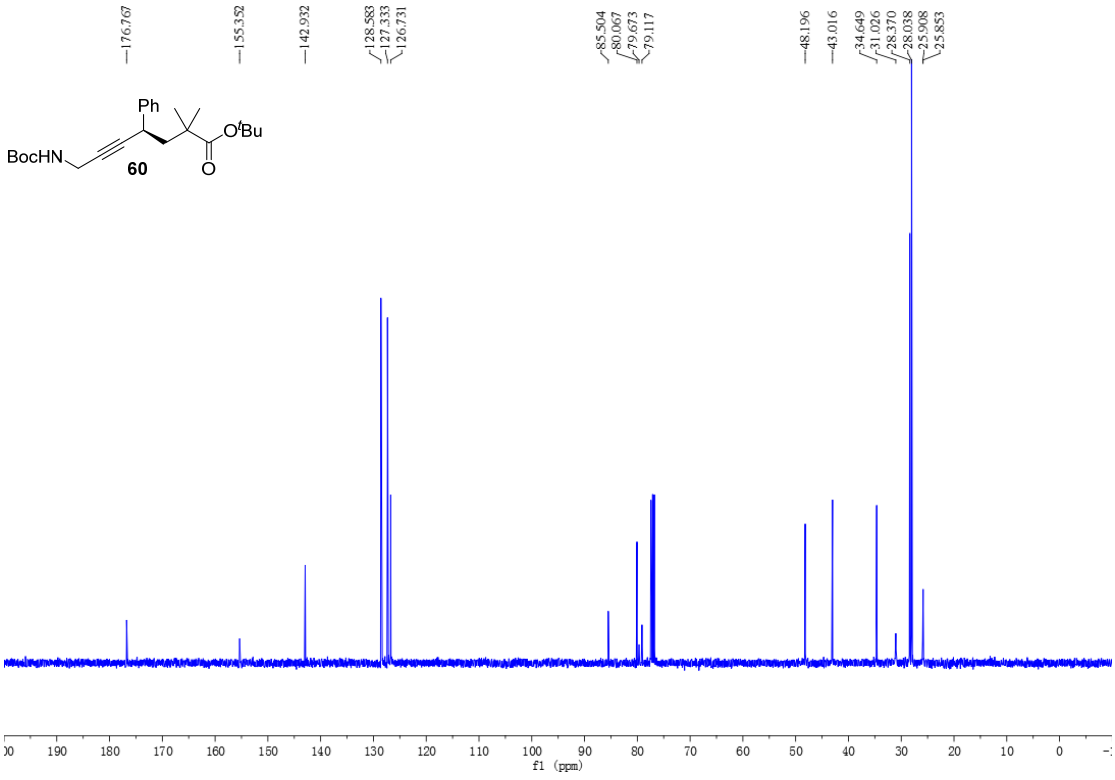
2.07
1.00
1.00
1.06
8.93
9.19
3.20
3.07
f1 (ppm)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85.504
80.067
79.673
79.117
48.196
43.016
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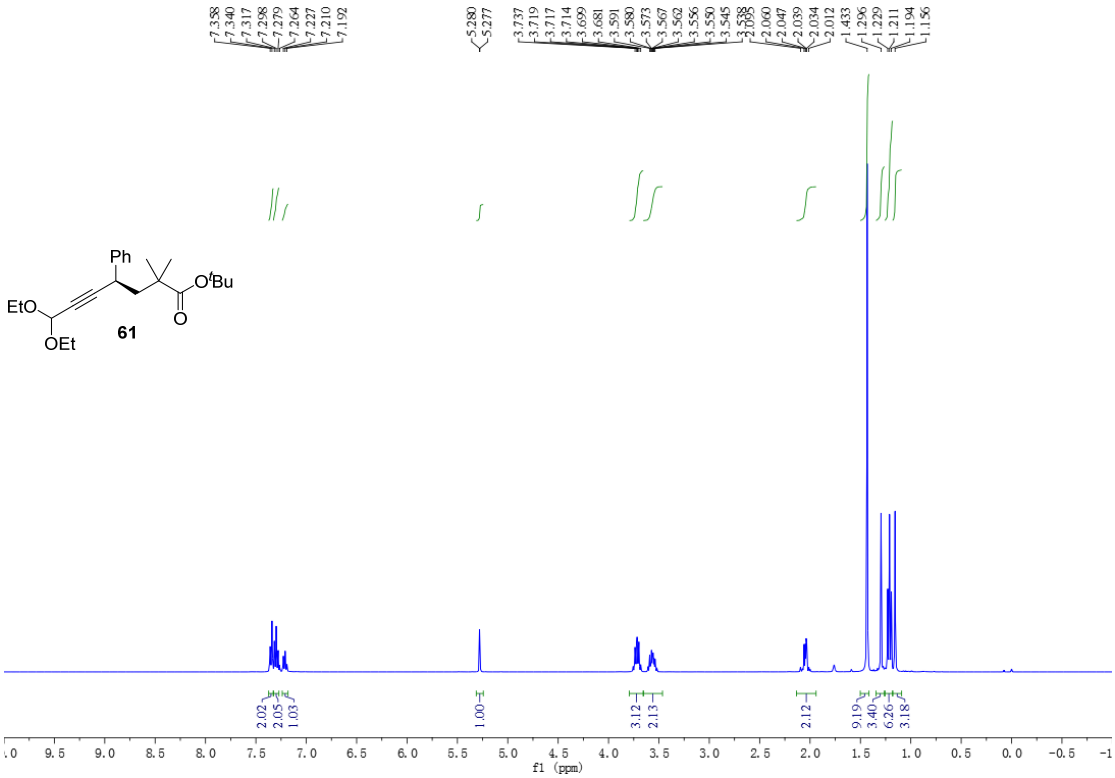
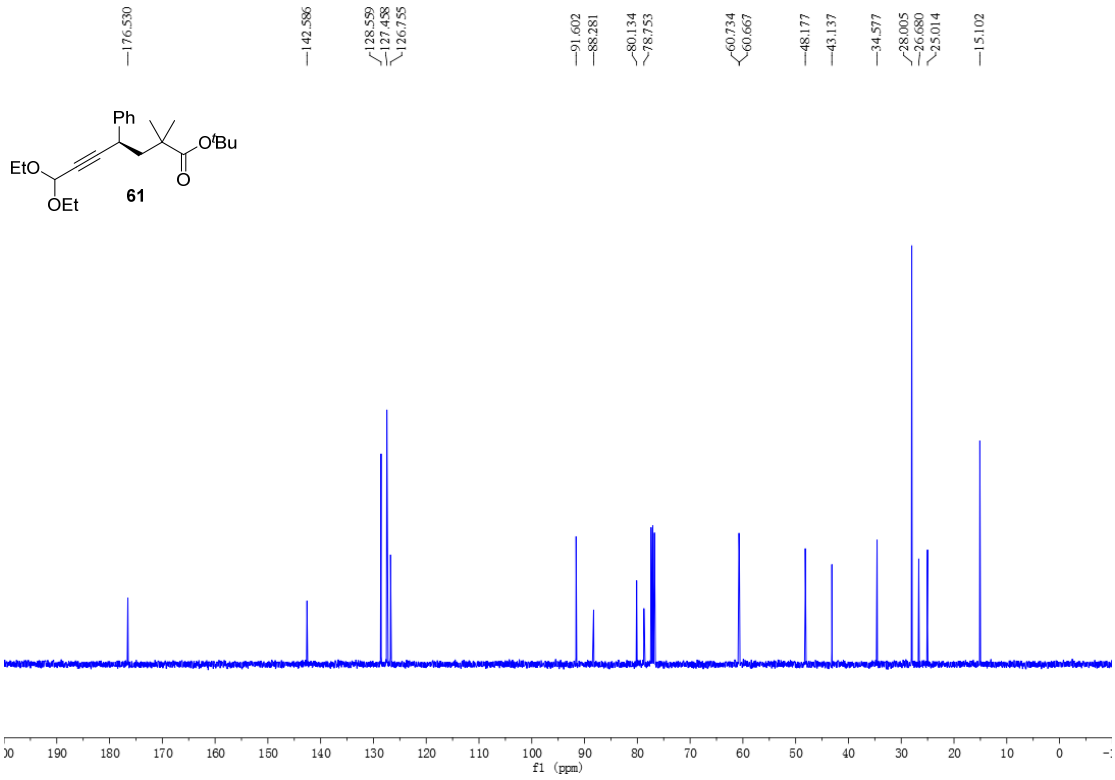
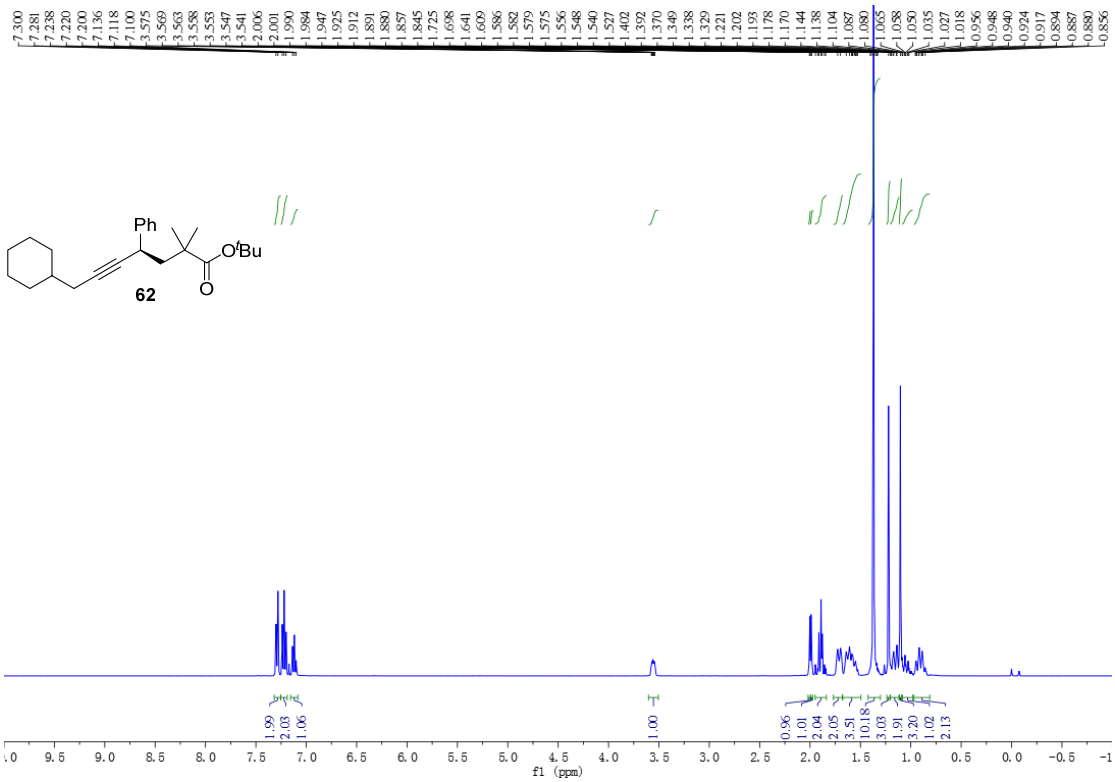
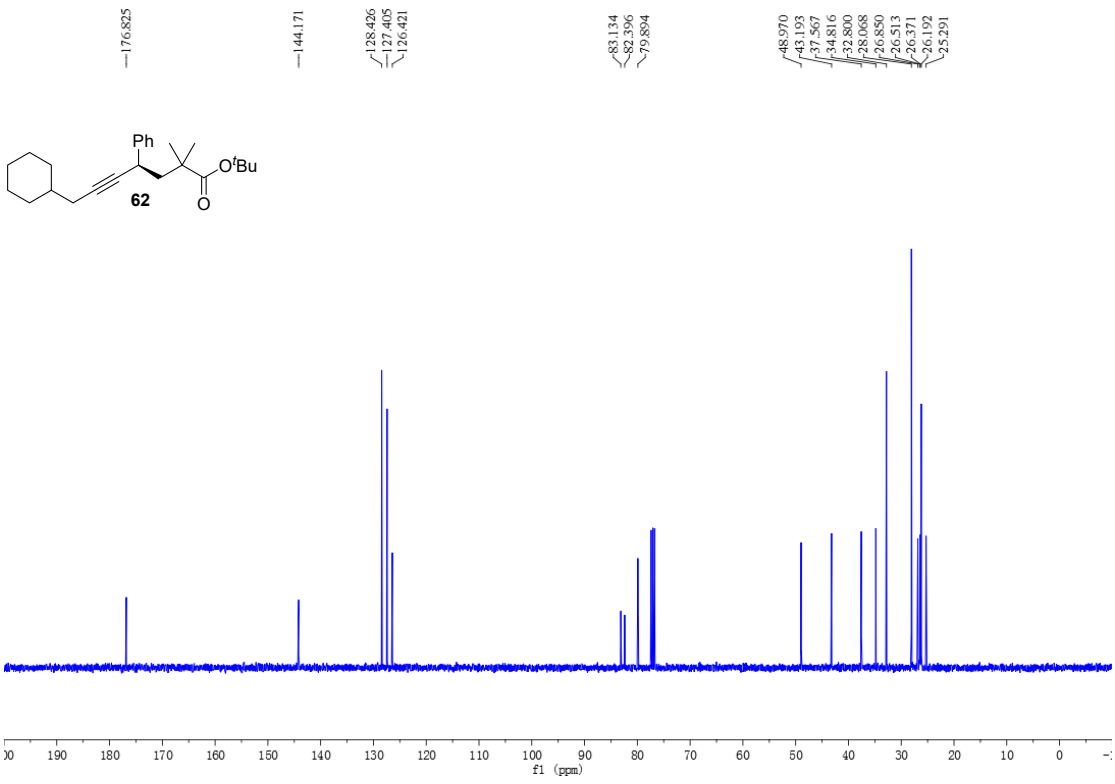
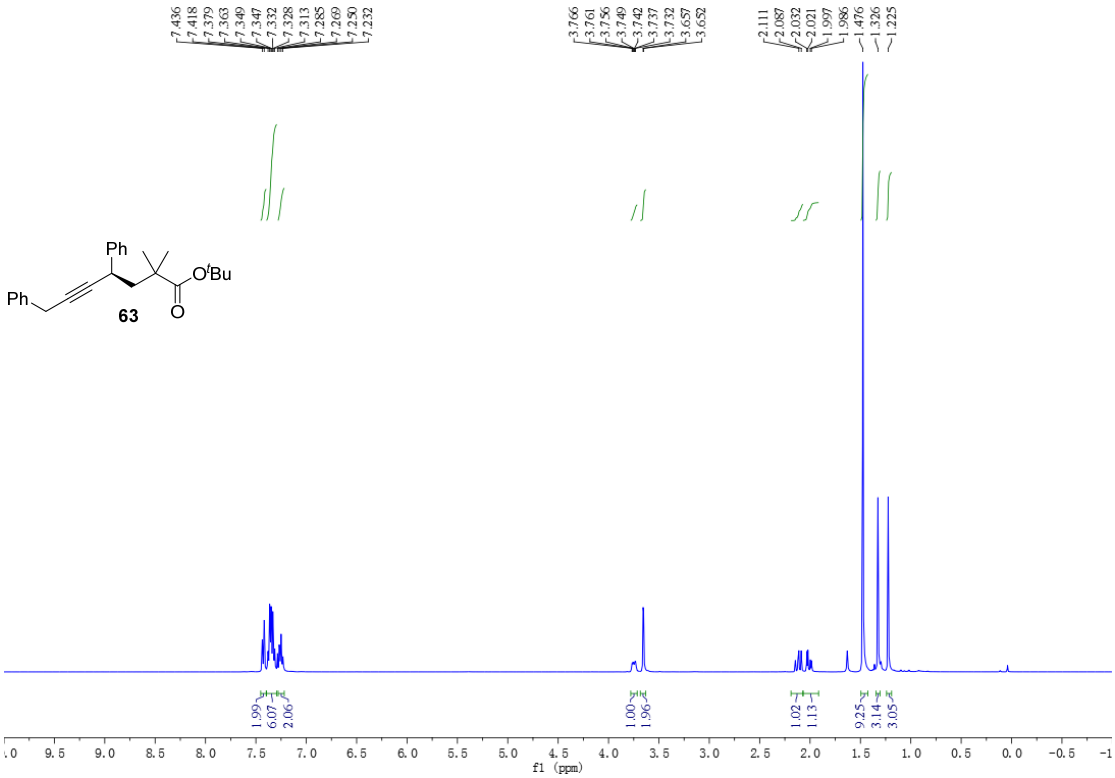
28.370
28.038
25.908
25.853
Ph
BocHN
O^{t}Bu
O
60
f1 (ppm)


Ph
EtO
OEt
O
OtBu
61
f1 (ppm)


Ph
EtO
OEt
O
OtBu
61
f1 (ppm)


Ph
O^{t}Bu
O
62
f1 (ppm)


Ph
O^{t}Bu
O
62
f1 (ppm)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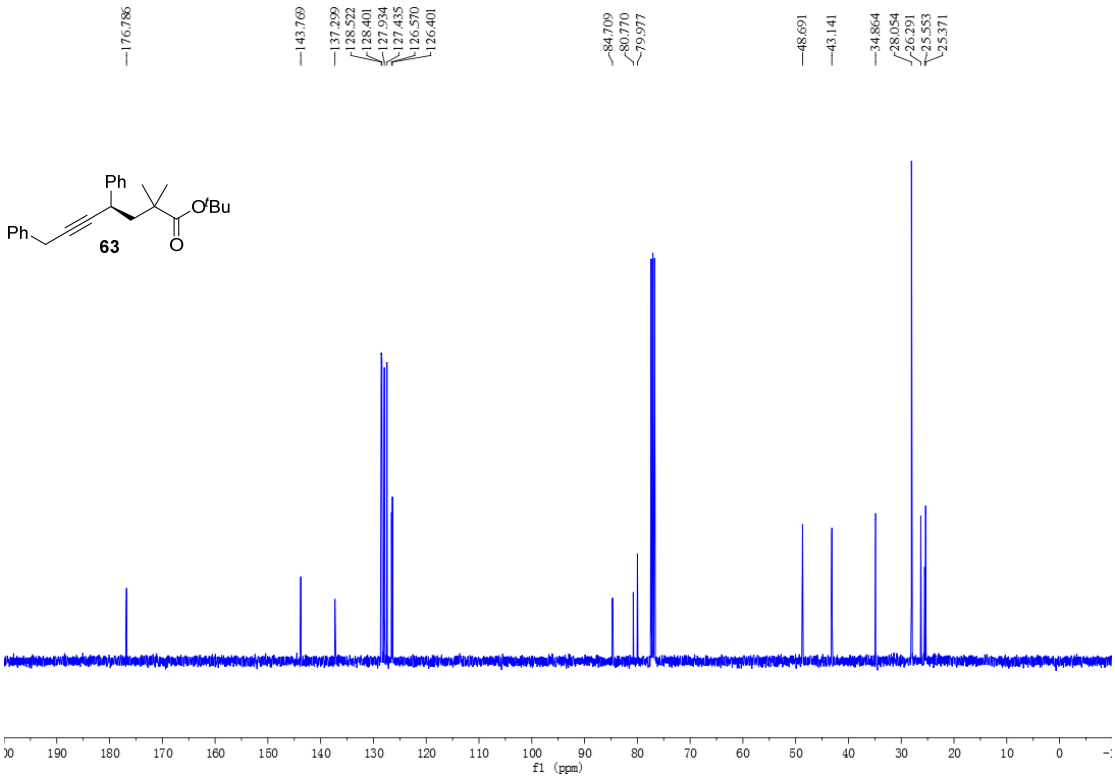
7.379
7.363
7.349
7.347
7.332
7.328
7.313
7.285
7.269
7.250
7.232
3.766
3.761
3.756
3.749
3.742
3.737
3.732
3.657
3.652
2.111
2.087
2.032
2.021
1.997
1.986
1.476
1.326
1.225
Ph
O^{t}Bu
Ph
O
63
1.99
6.07
2.06
1.00
1.96
1.02
1.13
9.25
3.14
3.05
f1 (ppm)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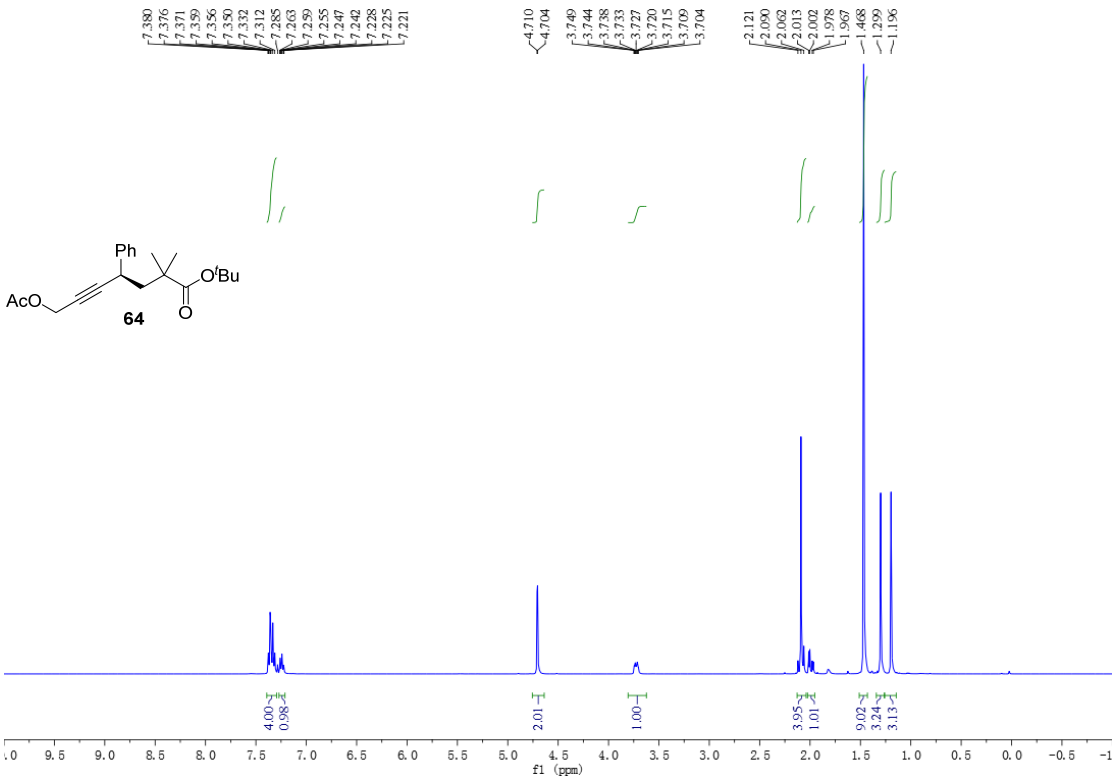
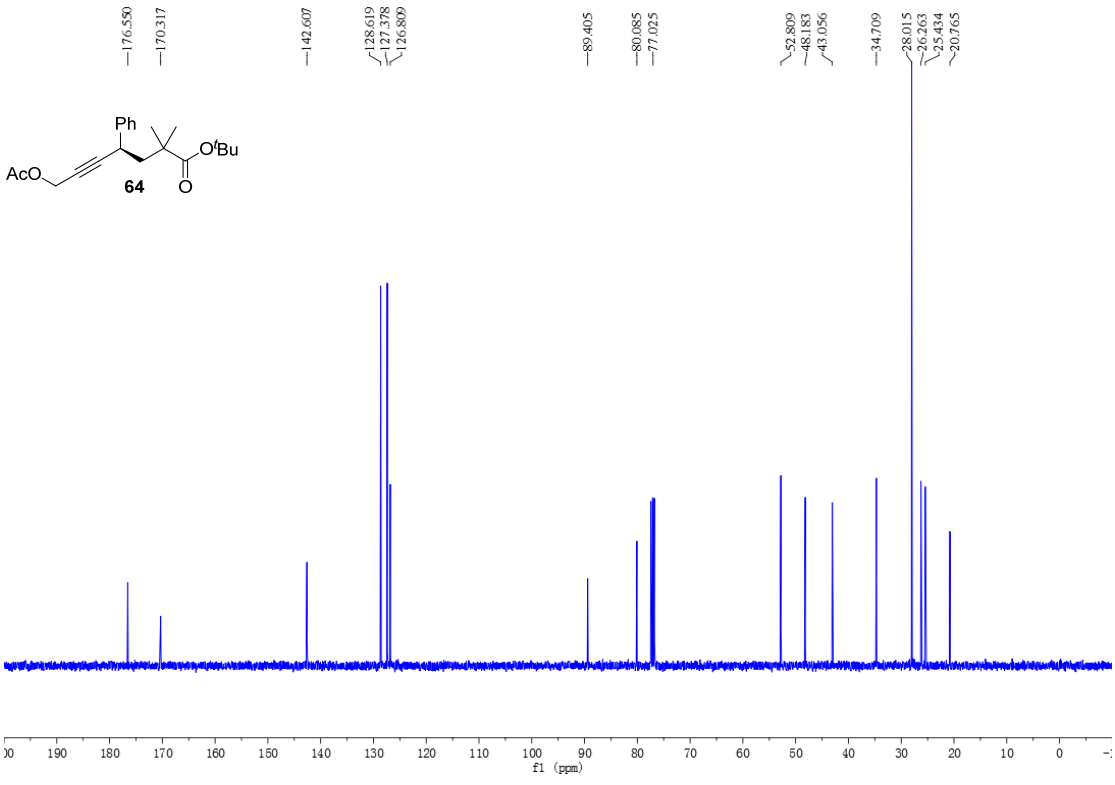
137.299
128.522
128.401
127.934
127.435
126.570
126.401
84.709
80.770
79.977
48.691
43.141
34.864
28.054
26.291
25.553
25.371
Ph
O^{t}Bu
Ph
O
63
f1 (ppm)


7.380
7.376
7.371
7.359
7.356
7.350
7.332
7.312
7.285
7.263
7.259
7.255
7.247
7.242
7.228
7.225
7.221
4.710
4.704
3.749
3.744
3.738
3.733
3.727
3.720
3.715
3.709
3.704
2.121
2.090
2.062
2.013
2.002
1.978
1.967
1.468
1.299
1.196
Ph
AcO
O^{t}Bu
O
64
4.00
0.98
2.01
1.00
3.95
1.01
9.02
3.24
3.13
f1 (ppm)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142.607
128.619
127.378
126.809
89.405
80.085
77.025
52.809
48.183
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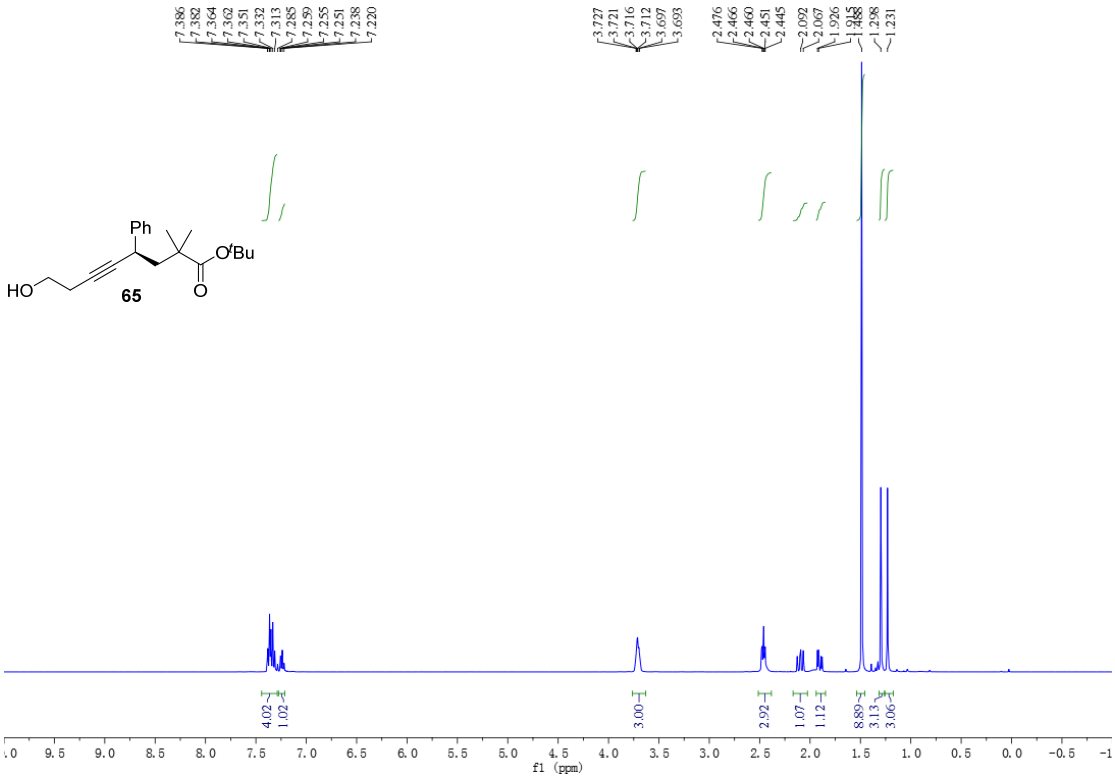
34.709
28.015
26.263
25.434
20.765
Ph
AcO
O^{t}Bu
O
64
f1 (ppm)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7.364
7.362
7.351
7.332
7.313
7.285
7.290
7.255
7.251
7.238
7.220
3.727
3.721
3.716
3.712
3.697
3.693
2.476
2.466
2.460
2.451
2.445
2.092
2.067
1.926
1.298
1.231
Ph
O'Bu
HO
O
65
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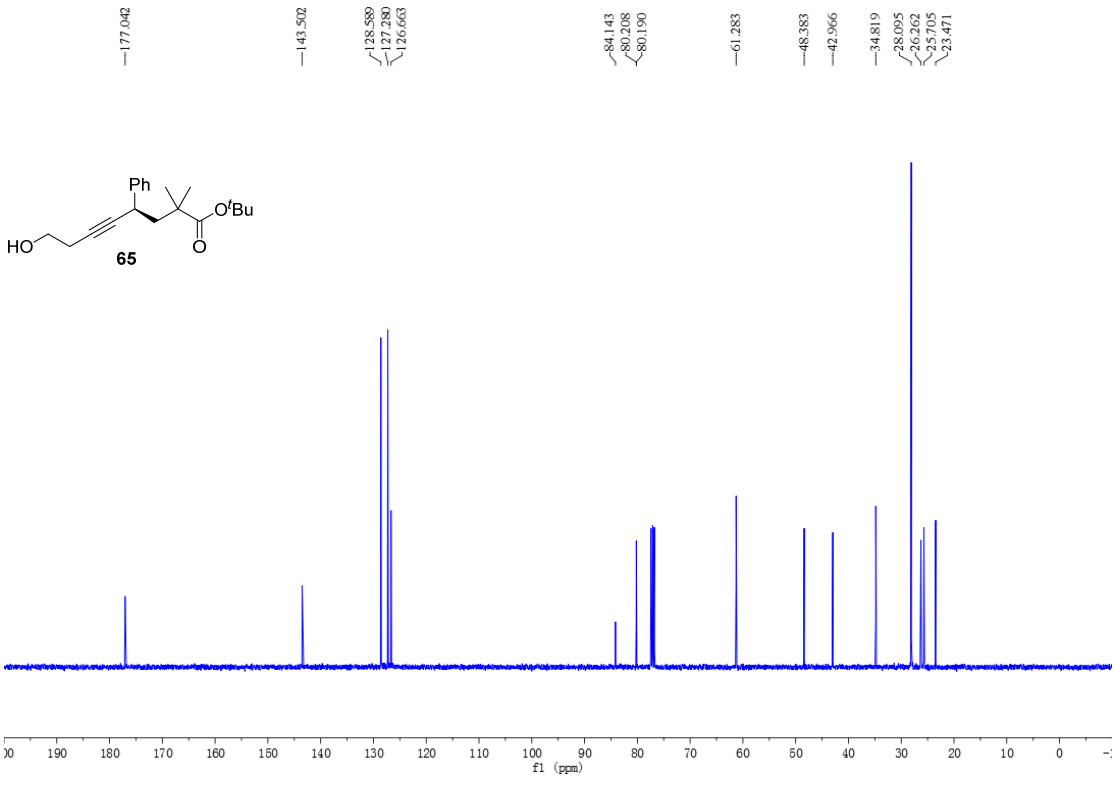
1.02
3.00
2.92
1.07
1.12
8.89
3.13
3.06
f1 (ppm)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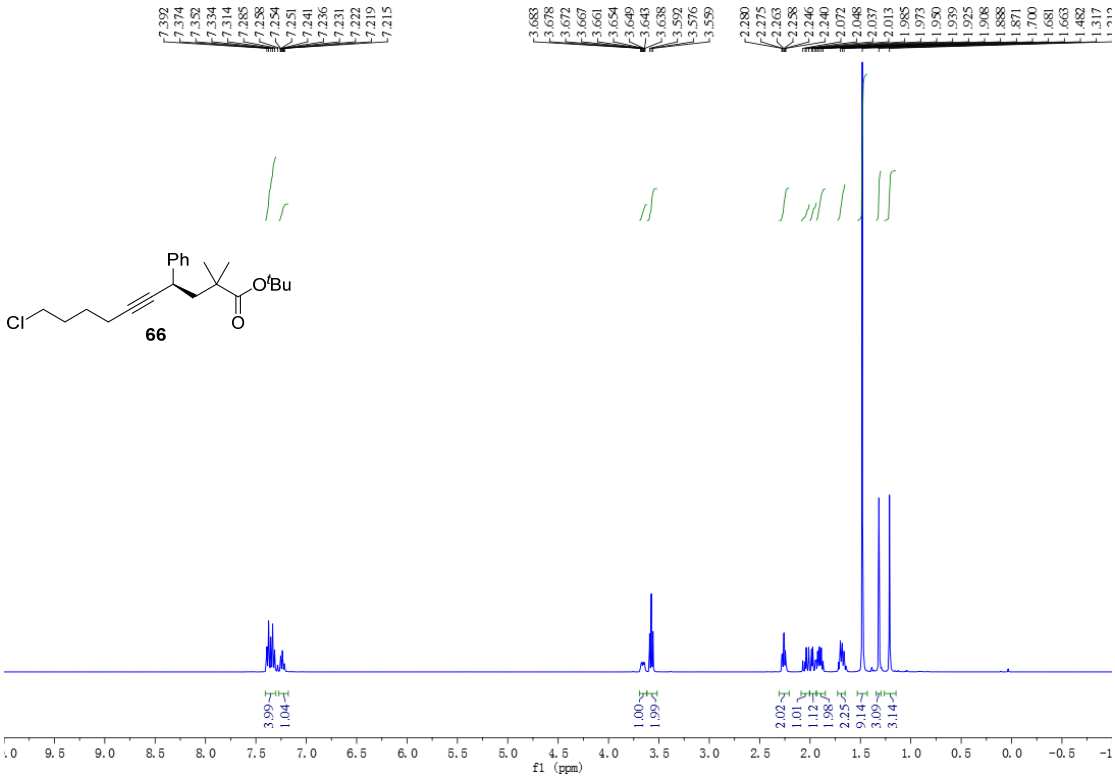
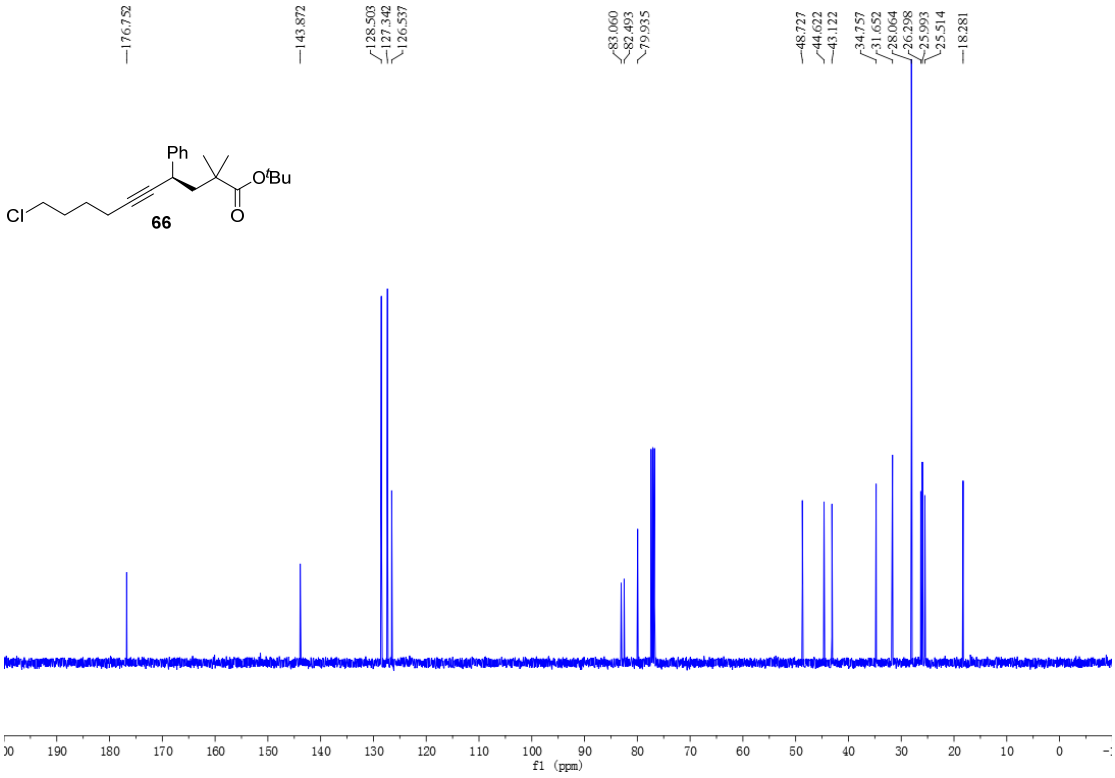
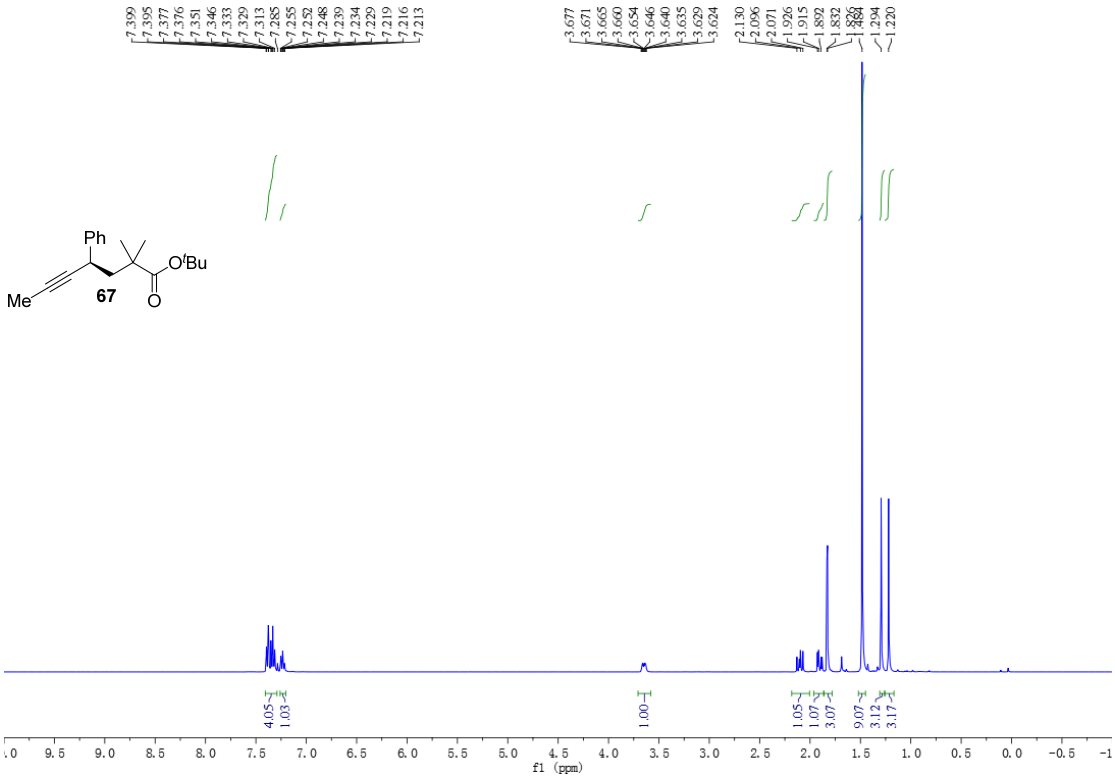
128.589
127.280
126.663
84.143
80.208
80.190
61.283
48.383
42.966
34.819
28.095
26.262
25.705
23.471
Ph
O'Bu
HO
O
65
f1 (ppm)


Ph
O^{t}Bu
O
Cl
66
f1 (ppm)


Ph
O^{t}Bu
O
Cl
66
f1 (ppm)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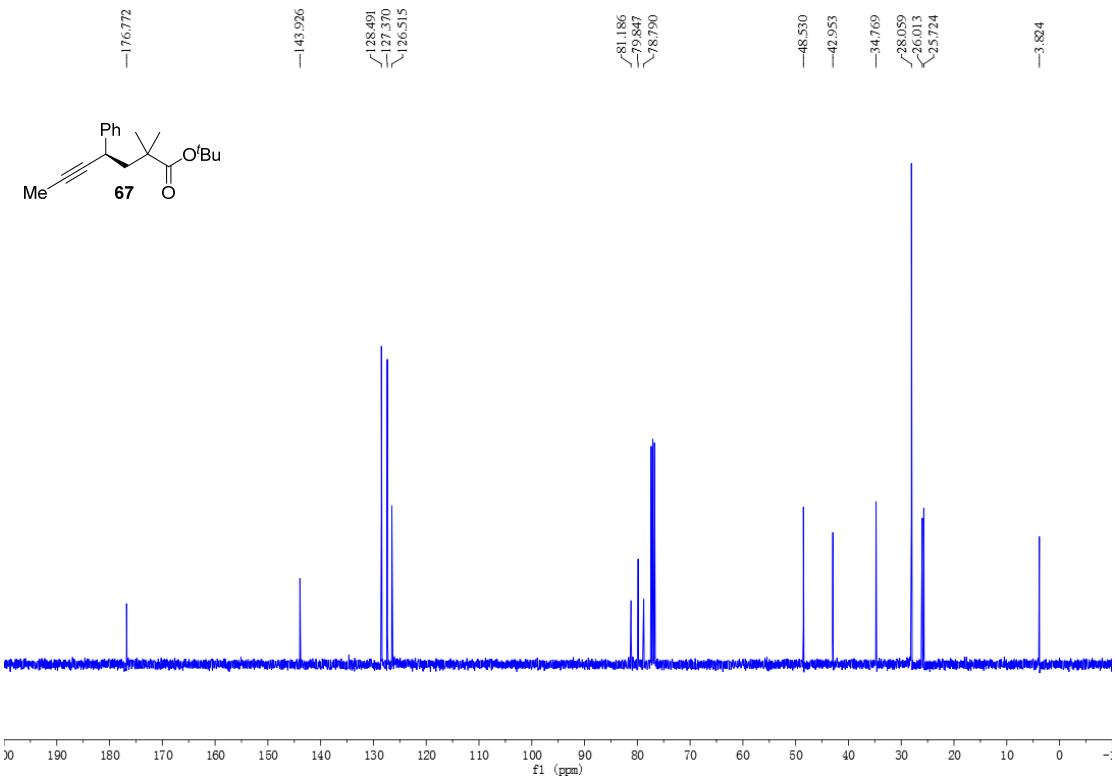
7.285
7.255
7.252
7.248
7.239
7.234
7.229
7.219
7.216
7.213
3.677
3.671
3.665
3.660
3.654
3.646
3.640
3.635
3.629
3.624
2.130
2.096
2.071
1.926
1.915
1.892
1.832
1.825
1.484
1.294
1.220
Ph
O'Bu
Me
67
O
4.05
1.03
1.00
1.05
1.07
3.07
9.07
3.12
3.17
f1 (ppm)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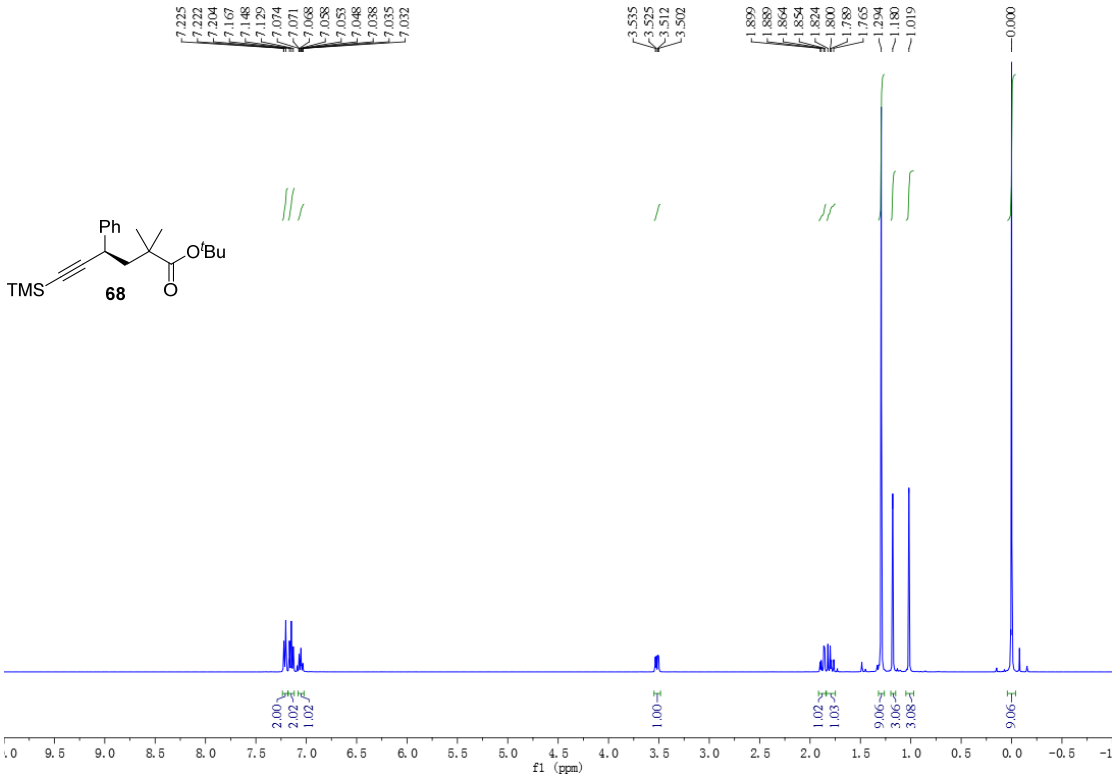
127.370
126.515
81.186
79.847
78.790
48.530
42.953
34.769
28.059
26.013
25.724
3.824
Ph
O'Bu
Me
67
O
f1 (ppm)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7.204
7.167
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7.129
7.074
7.071
7.068
7.038
7.053
7.048
7.038
7.035
7.032
3.535
3.525
3.512
3.502
1.899
1.889
1.864
1.854
1.824
1.800
1.789
1.765
1.294
1.180
1.019
0.000
Ph
O'Bu
TMS
68
O
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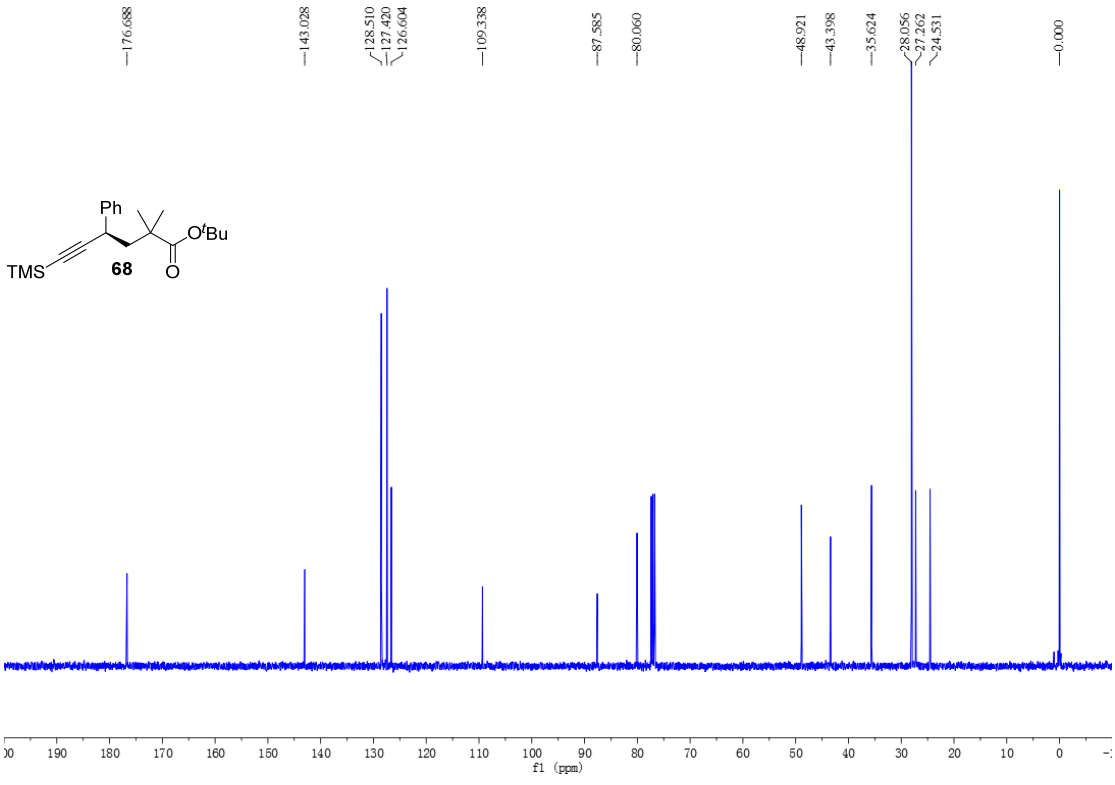
2.02
1.02
1.00
1.02
1.03
9.06
3.06
3.08
9.06
f1 (ppm)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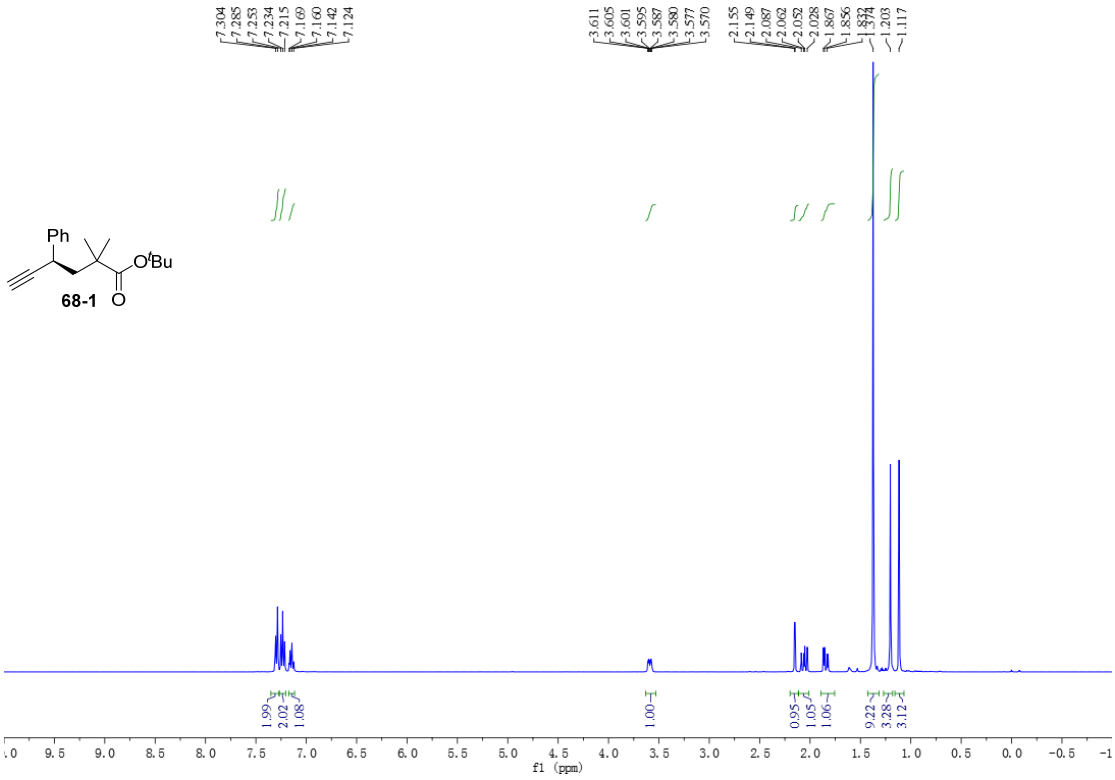
24.531
0.000
Ph
O'Bu
TMS
68
O
f1 (ppm)


Ph
O^{t}Bu
O
68-1
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7.234
7.215
7.169
7.160
7.142
7.124
3.611
3.605
3.601
3.595
3.587
3.580
3.577
3.570
2.155
2.149
2.087
2.062
2.052
2.028
1.867
1.856
1.374
1.203
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2.02
1.08
1.00
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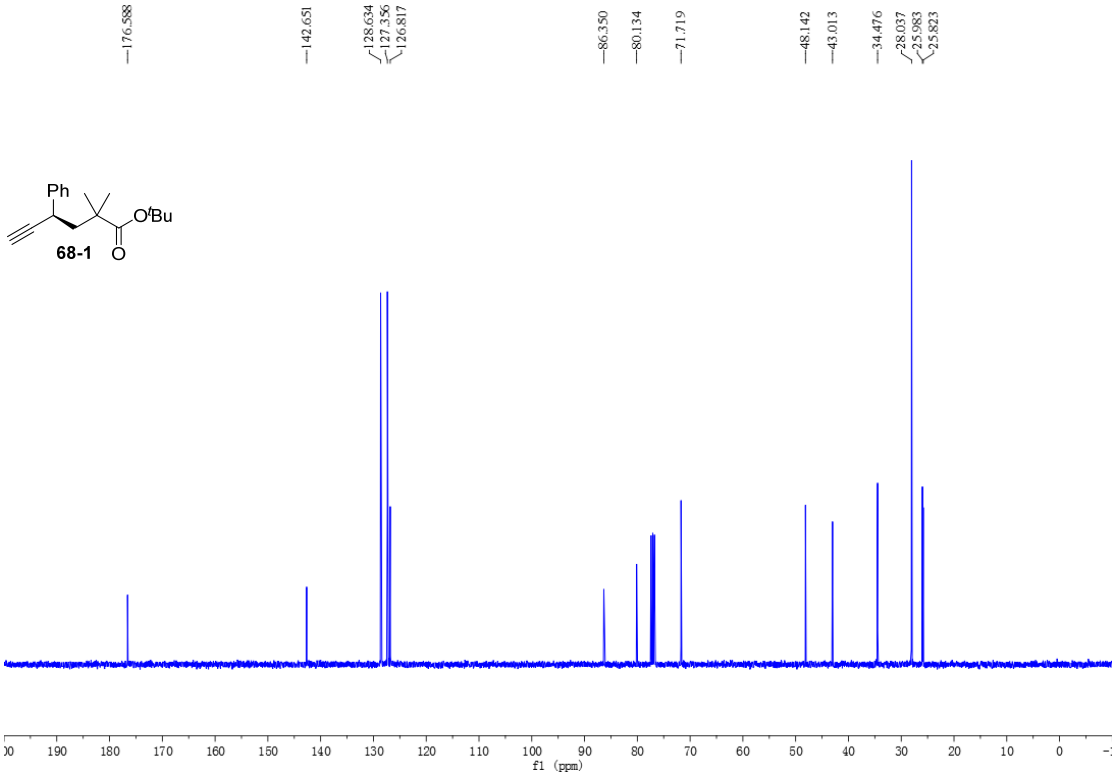
1.05
1.06
9.22
3.28
3.12
f1 (ppm)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O
68-1
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28.037
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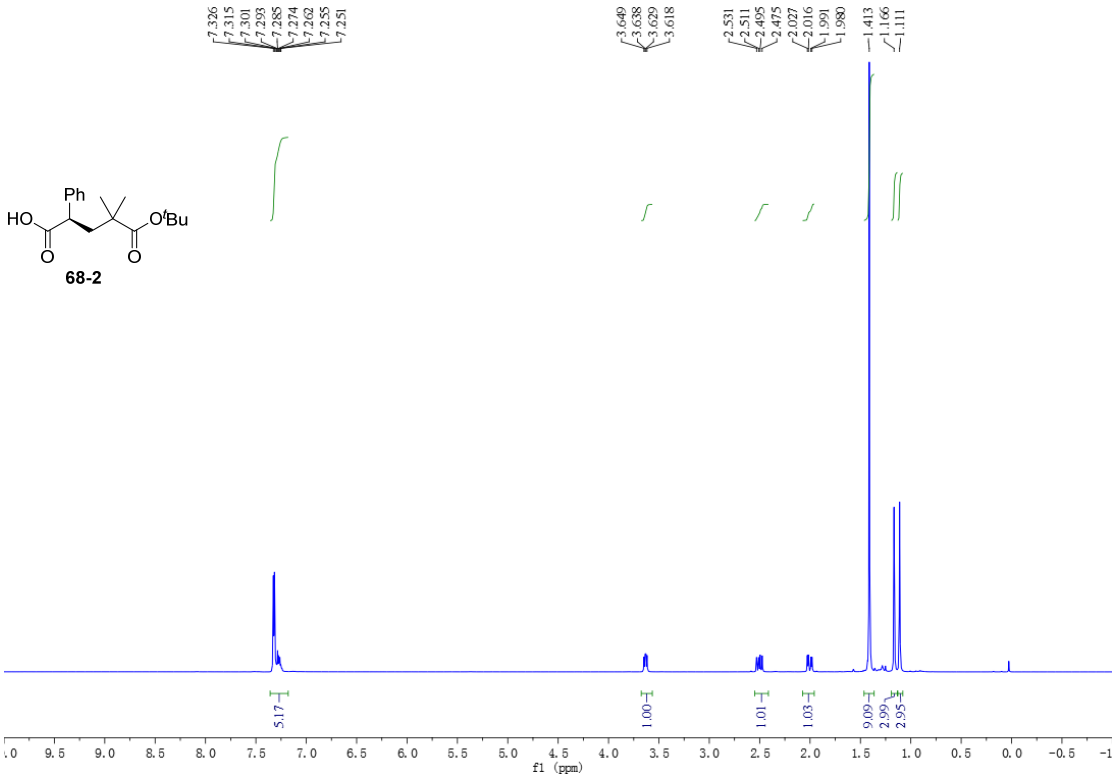
f1 (ppm)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7.285
7.274
7.262
7.255
7.251
3.649
3.638
3.629
3.618
2.531
2.511
2.495
2.475
2.027
2.016
1.991
1.980
1.413
1.166
1.111
Ph
HO
O
O
O
O'Bu
68-2
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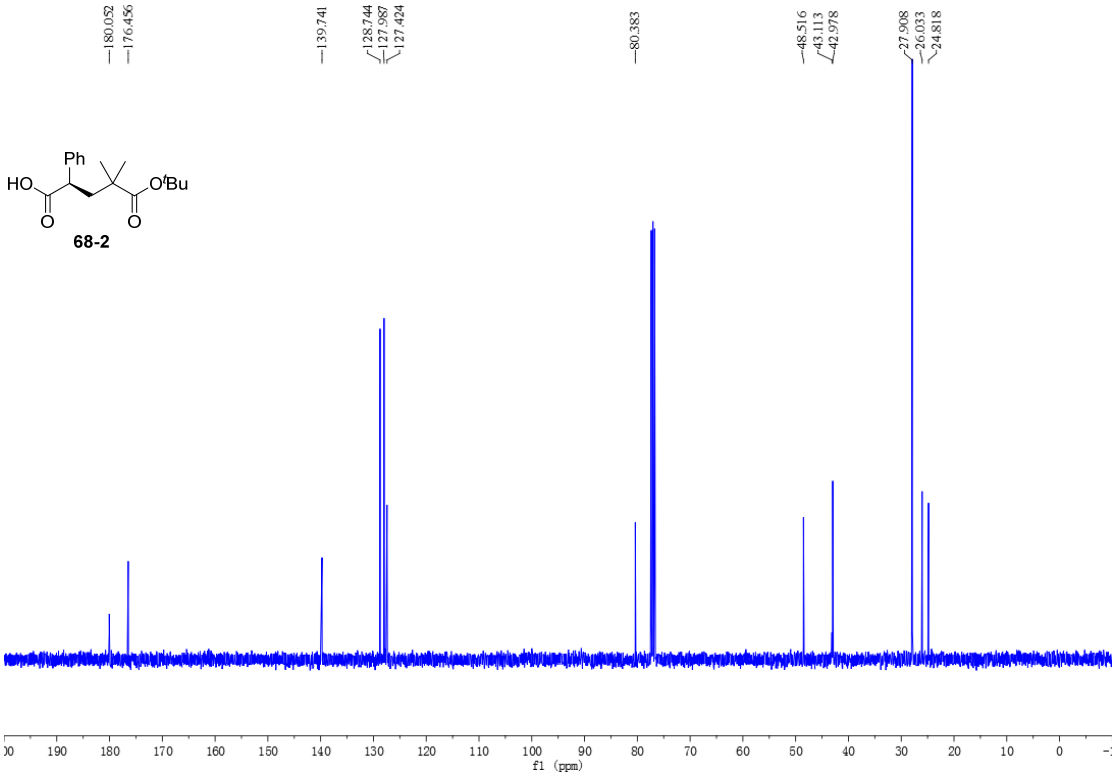
1.01
1.03
9.09
2.99
2.95
f1 (ppm)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127.987
127.424
80.383
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24.818
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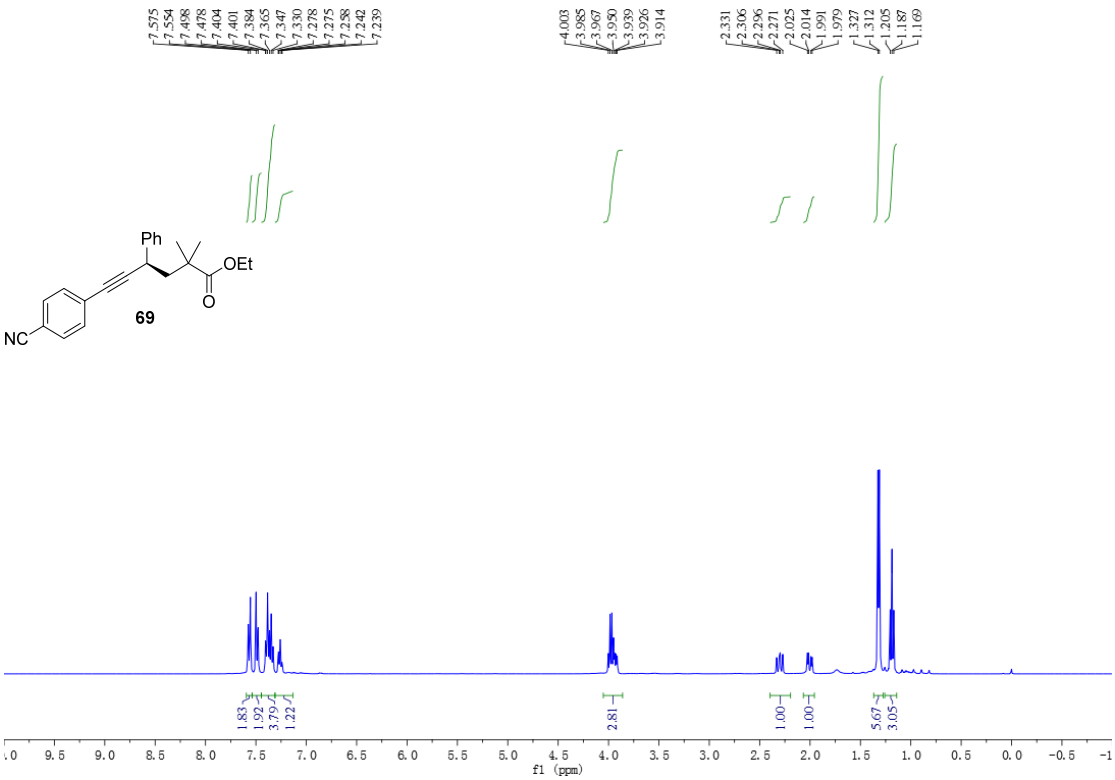
HO
O
O
O
O'Bu
68-2
f1 (ppm)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7.278
7.275
7.258
7.242
7.239
4.003
3.985
3.967
3.950
3.939
3.926
3.914
2.331
2.306
2.296
2.271
2.025
2.014
1.991
1.979
1.327
1.312
1.205
1.187
1.169
Ph
OEt
O
NC
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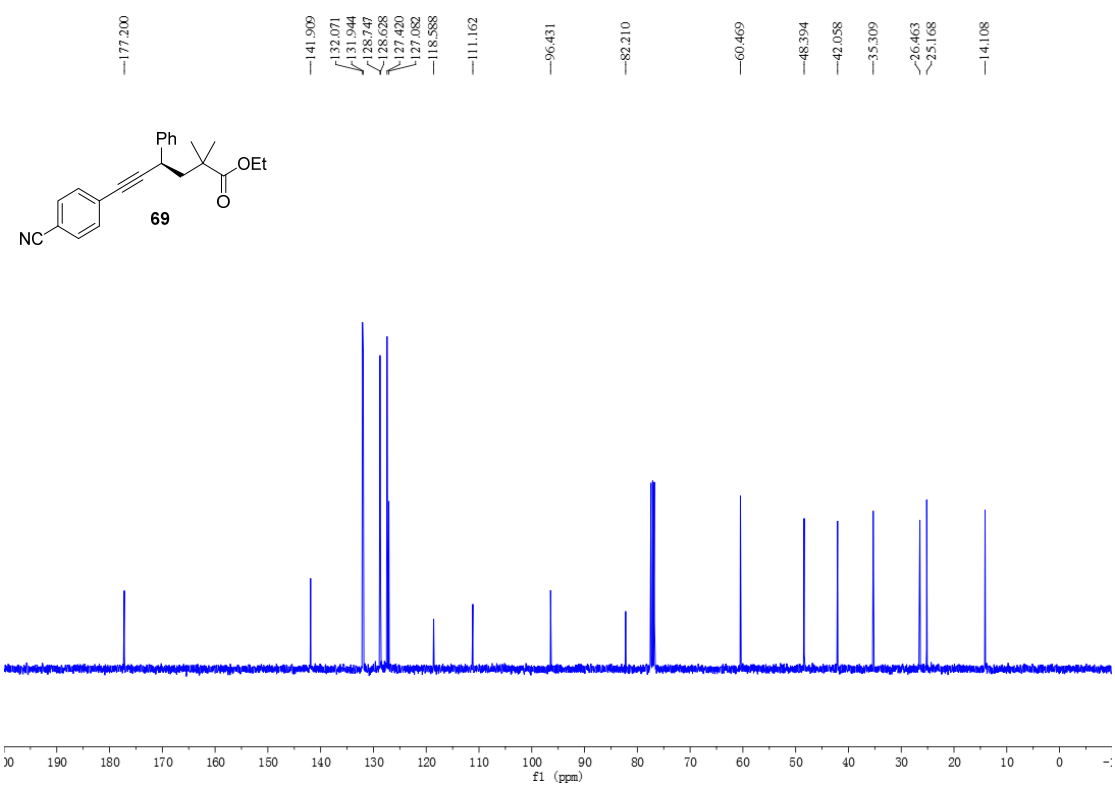
1.00
5.67
3.05
f1 (ppm)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127.420
127.082
118.588
111.162
96.431
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60.469
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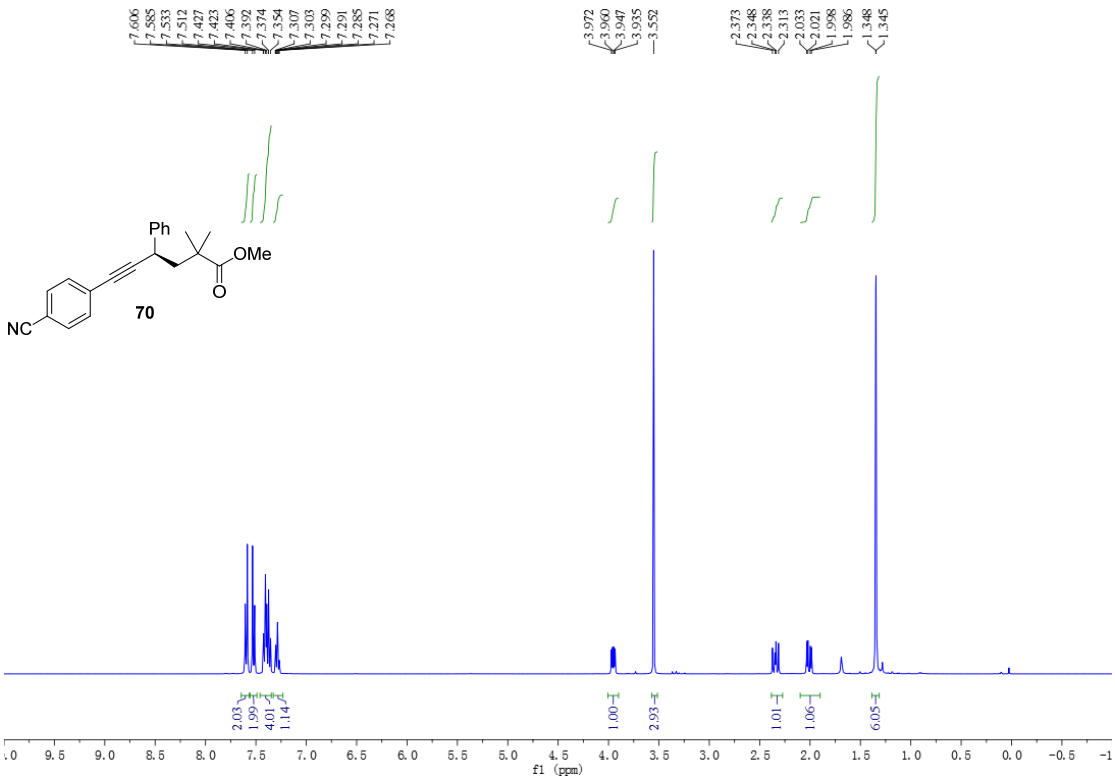
42.058
35.309
26.463
25.168
14.108
Ph
OEt
O
NC
69
f1 (ppm)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7.392
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7.291
7.285
7.271
7.268
3.972
3.960
3.947
3.935
3.552
2.373
2.348
2.338
2.313
2.033
2.021
1.998
1.986
1.348
1.345
Ph
OMe
O
NC
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4.01
1.14
1.00
2.93
1.01
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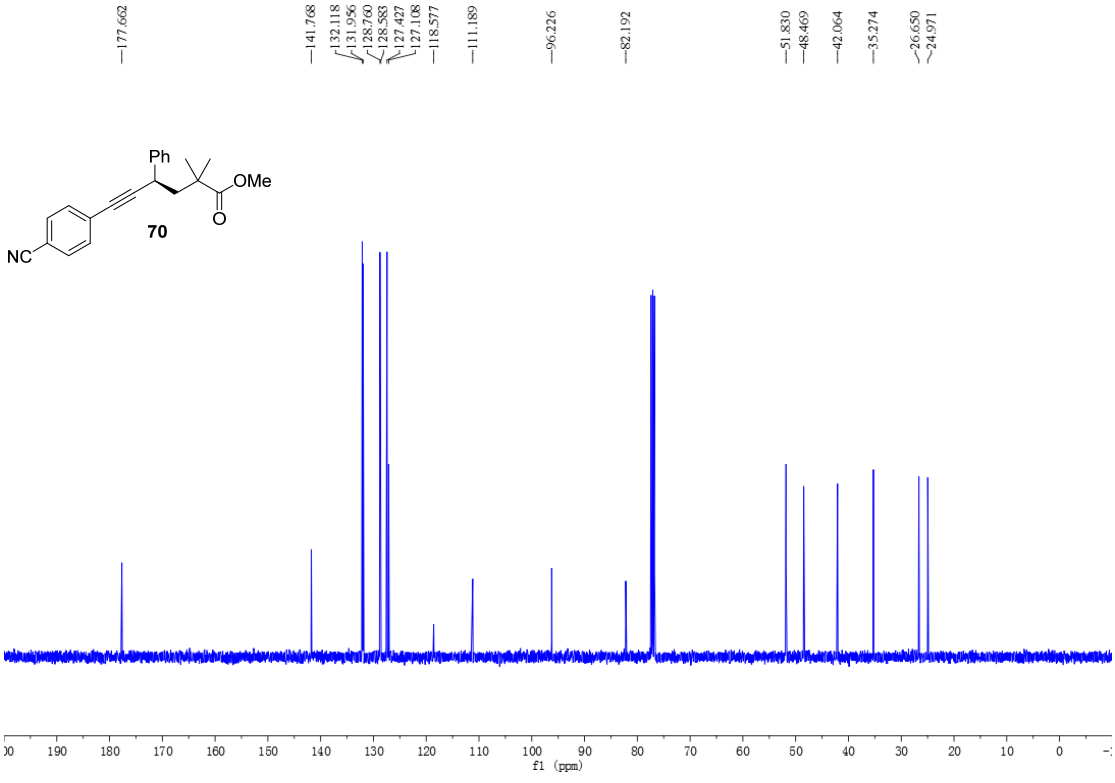
6.05
f1 (ppm)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127.108
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111.189
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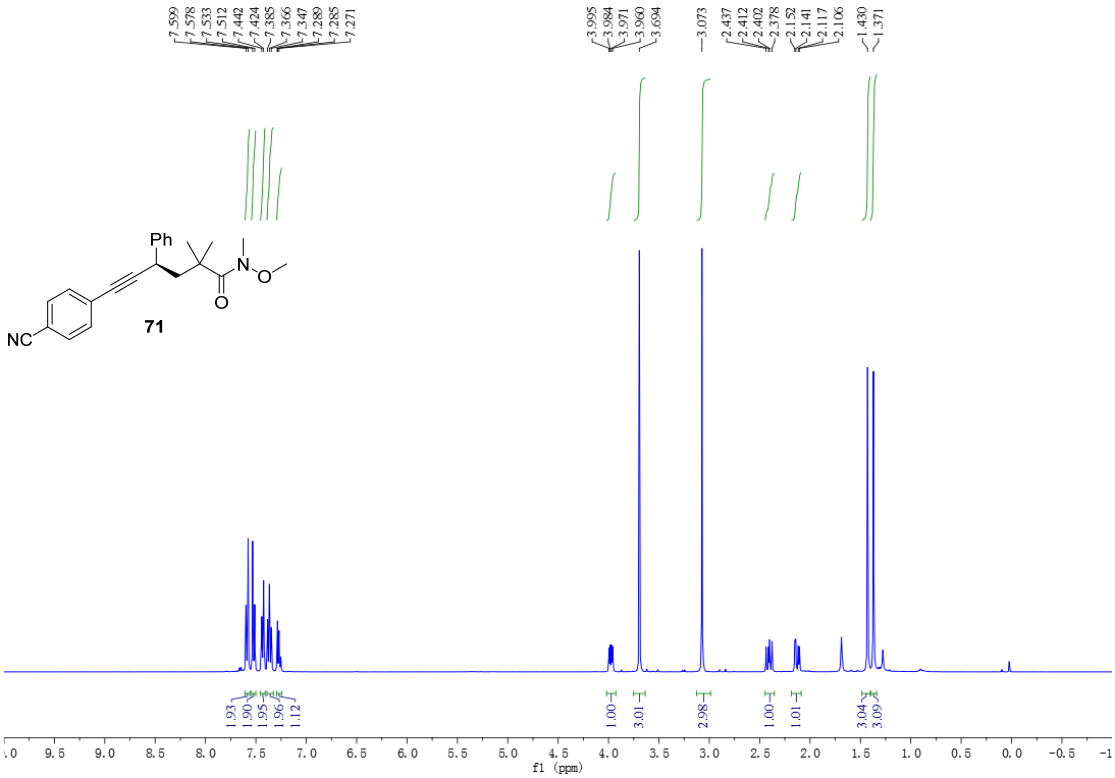
48.469
42.064
35.274
26.650
24.971
Ph
OMe
O
NC
70
f1 (ppm)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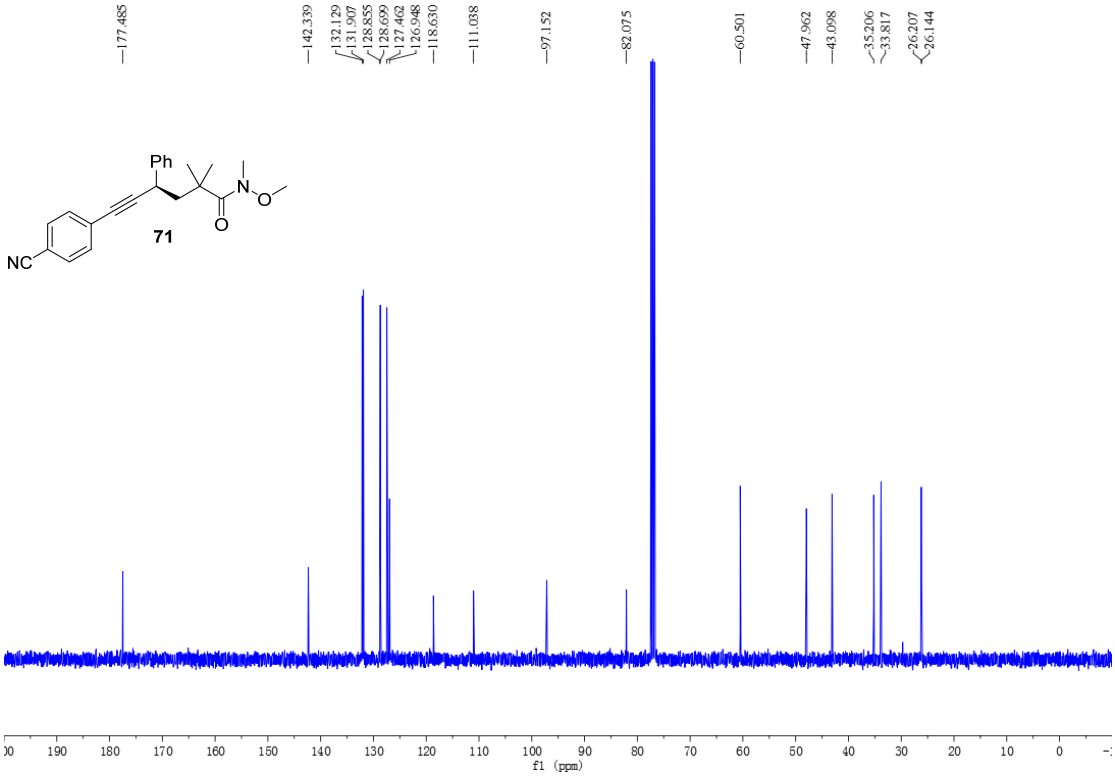
7.385
7.366
7.347
7.289
7.285
7.271
3.995
3.984
3.971
3.960
3.694
3.073
2.437
2.412
2.402
2.378
2.152
2.141
2.117
2.106
1.430
1.371
Ph
N
O
O
NC
71
1.93
1.90
1.95
1.96
1.12
1.00
3.01
2.98
1.00
1.01
3.04
3.09
f1 (ppm)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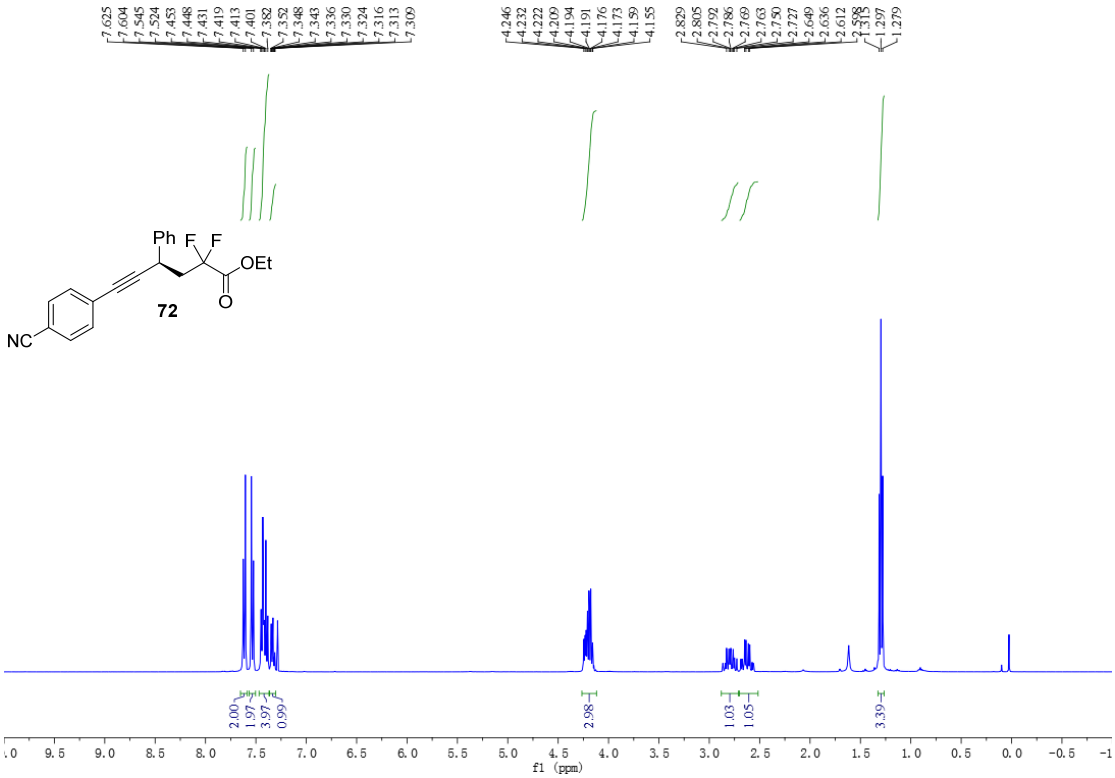
131.907
128.855
128.699
127.462
126.948
118.630
111.038
97.152
82.075
60.501
47.962
43.098
35.206
33.817
26.207
26.144
Ph
N
O
O
NC
71
f1 (ppm)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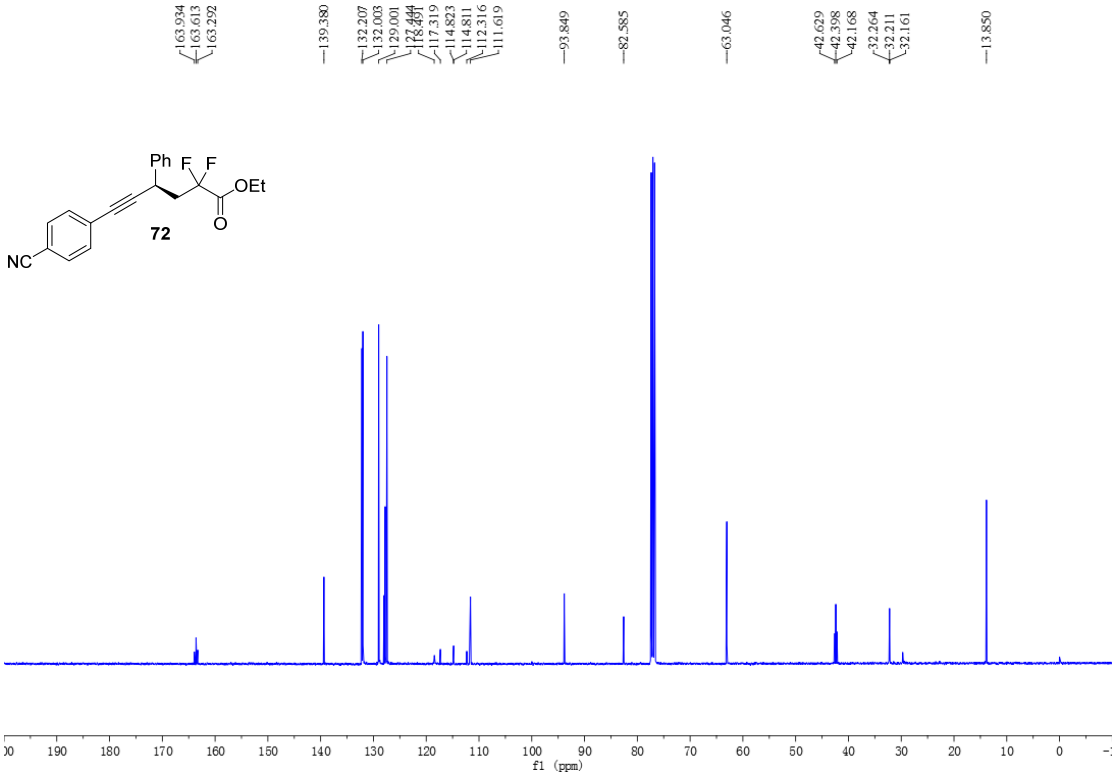
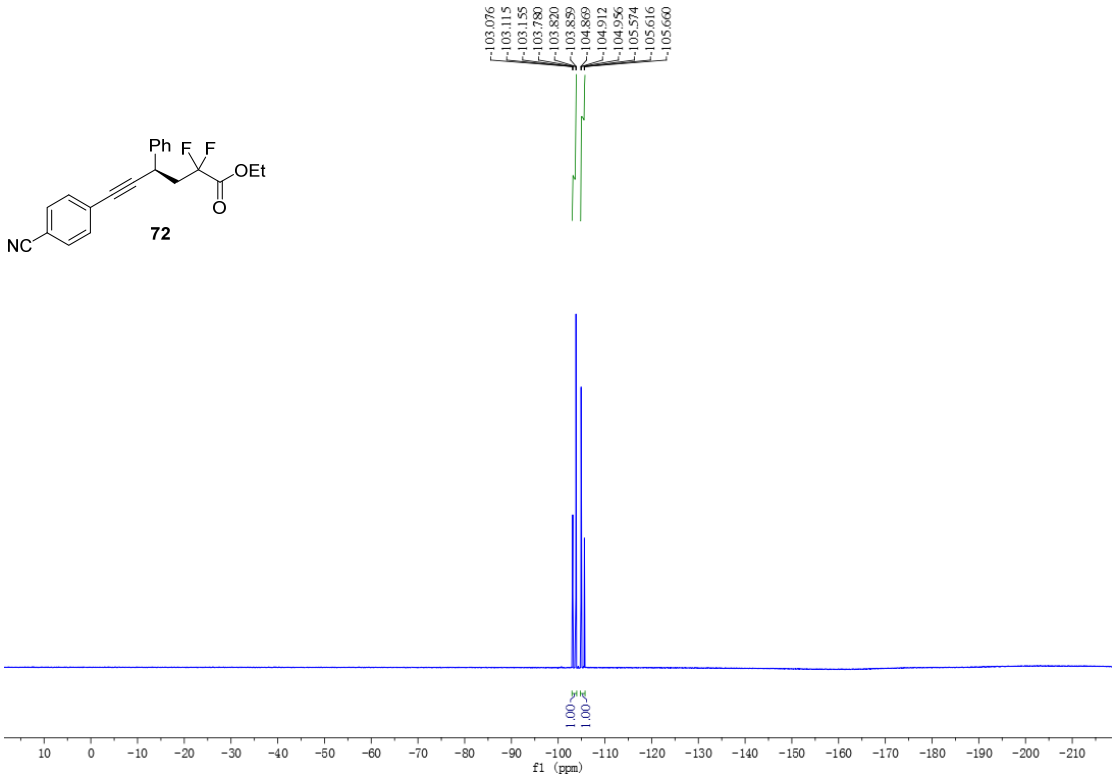
F
F
OEt
O
72
NC
f1 (ppm)


Ph
F
F
OEt
O
72
NC
f1 (ppm)


Ph
F
F
OEt
O
NC
72
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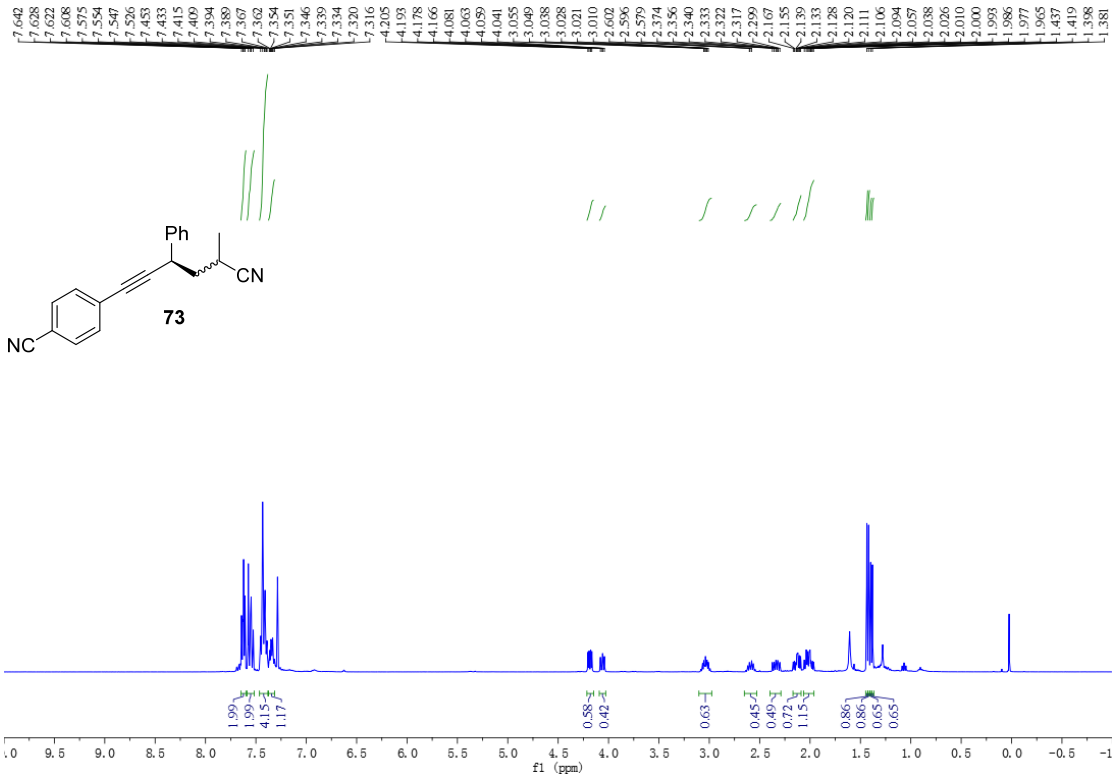
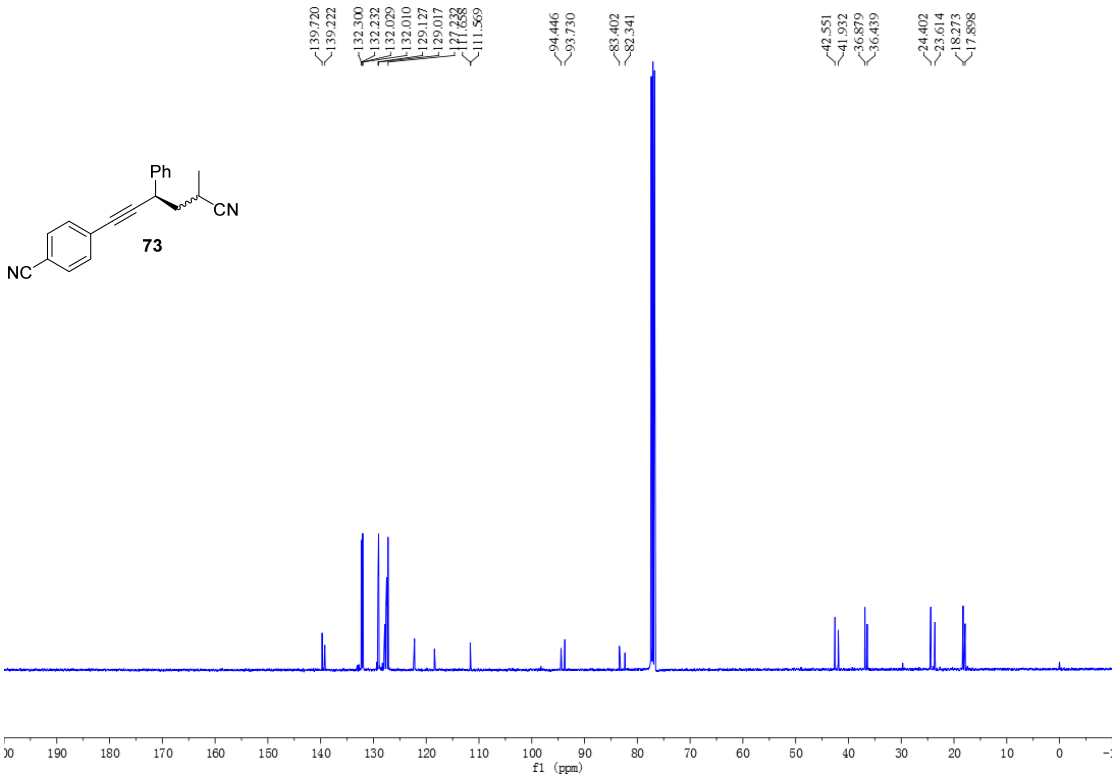
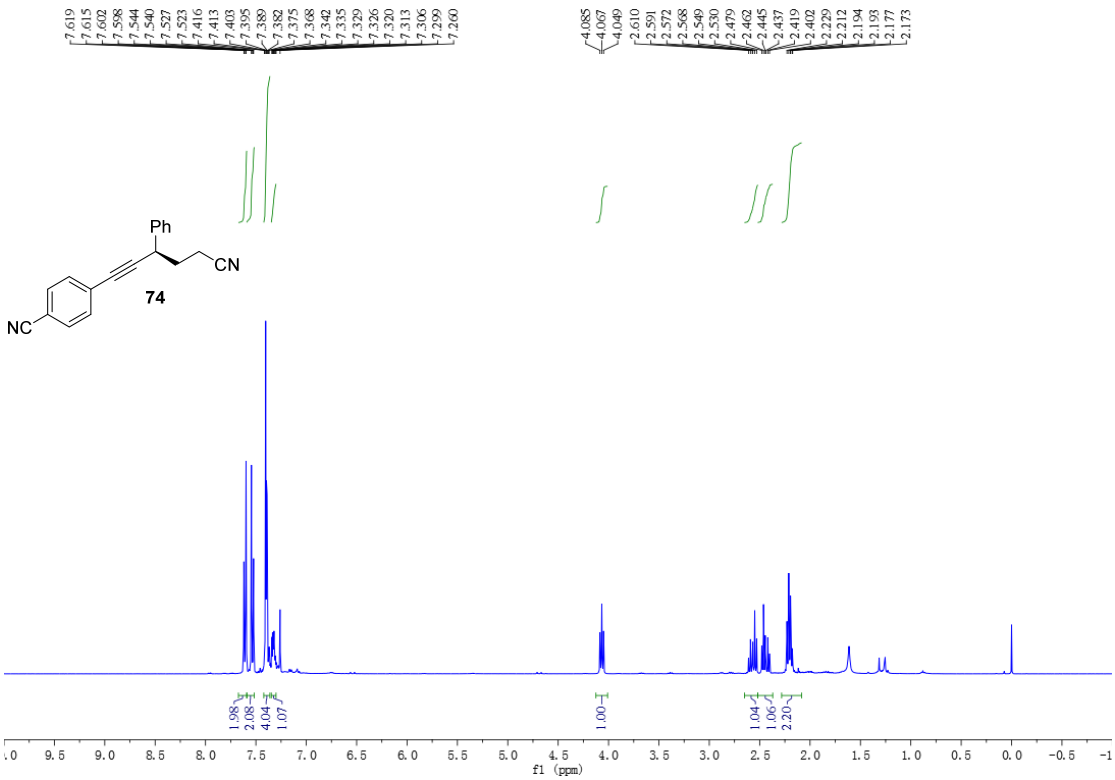
-103.115
-103.155
-103.780
-103.820
-103.859
-104.869
-104.912
-104.956
-105.574
-105.616
-105.660
1.00
1.00
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
f1 (ppm)


Ph
CN
NC
73
f1 (ppm)


Ph
CN
NC
73
f1 (ppm)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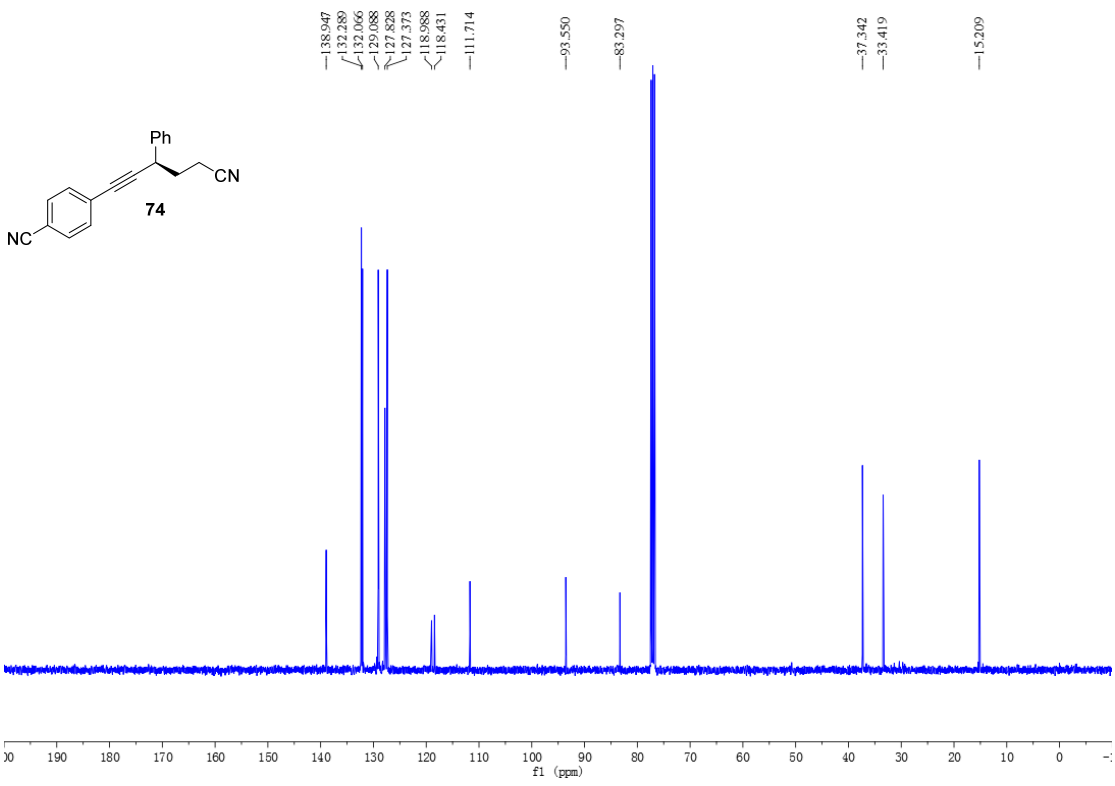
7.615
7.602
7.598
7.544
7.540
7.527
7.523
7.416
7.413
7.403
7.395
7.389
7.382
7.375
7.368
7.342
7.335
7.329
7.326
7.320
7.313
7.306
7.299
7.260
4.085
4.067
4.049
2.610
2.591
2.572
2.568
2.549
2.530
2.479
2.462
2.445
2.437
2.419
2.402
2.229
2.212
2.194
2.193
2.177
2.173
Ph
CN
NC
74
1.98
2.08
4.04
1.07
1.00
1.04
1.06
2.20
f1 (ppm)


138.947
132.289
132.066
129.088
127.828
127.373
118.988
118.431
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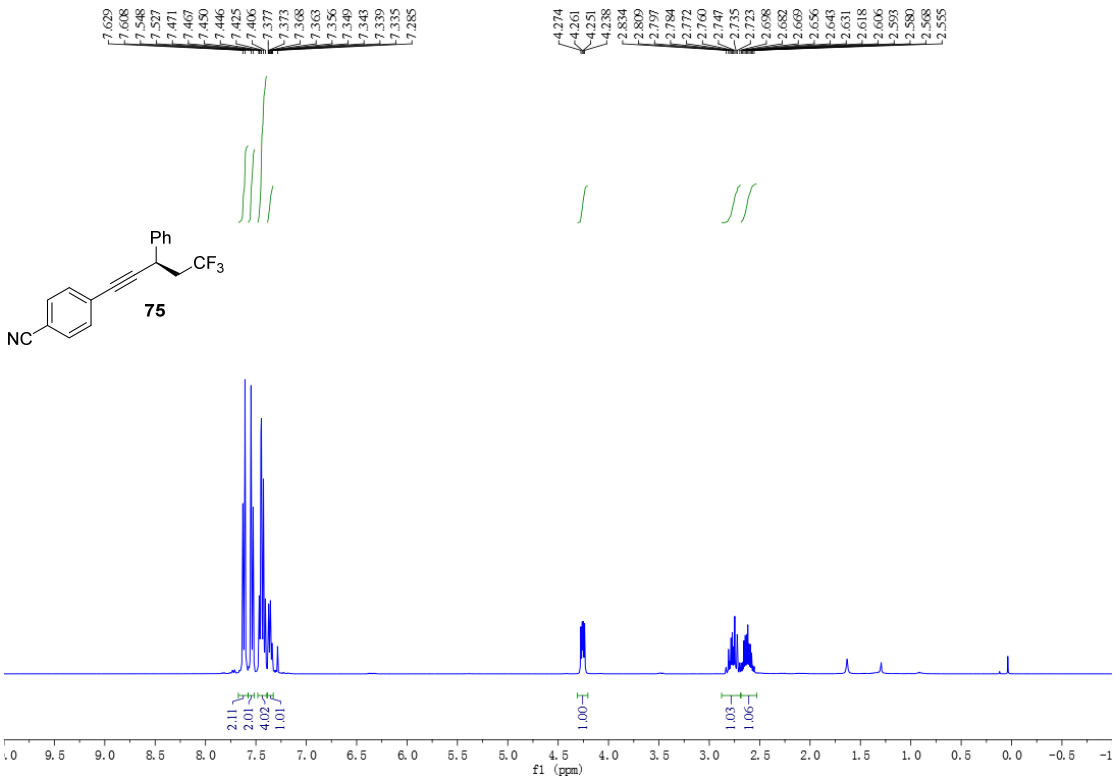
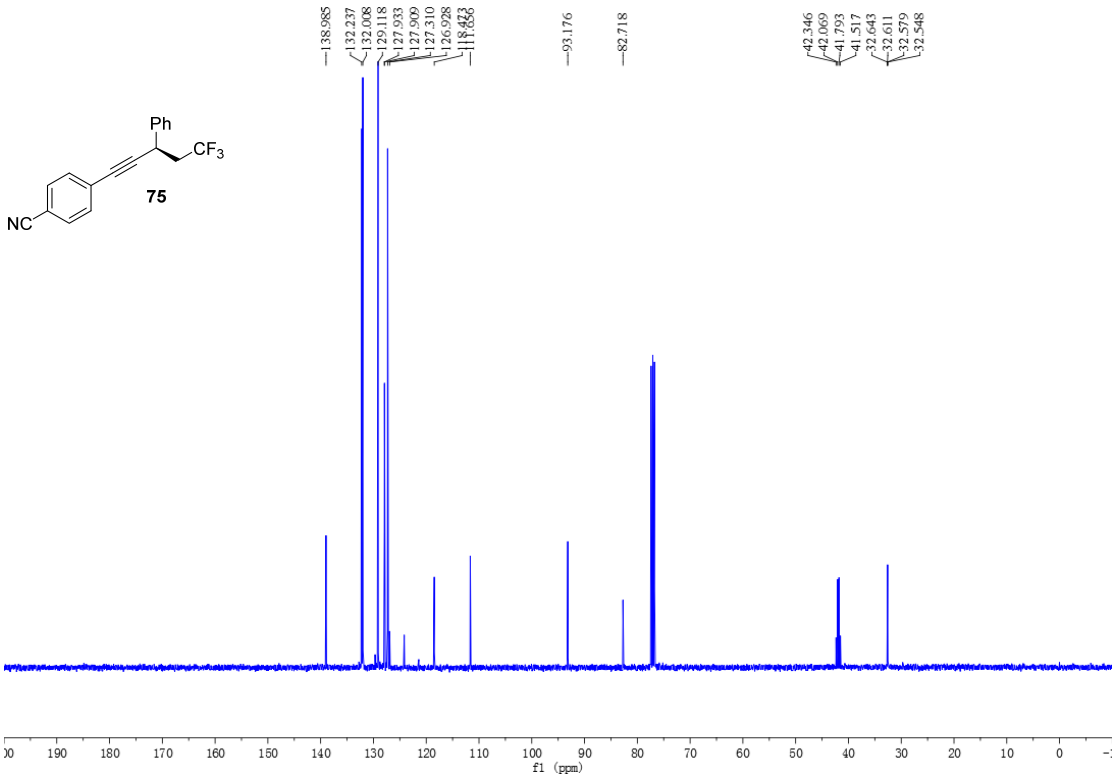
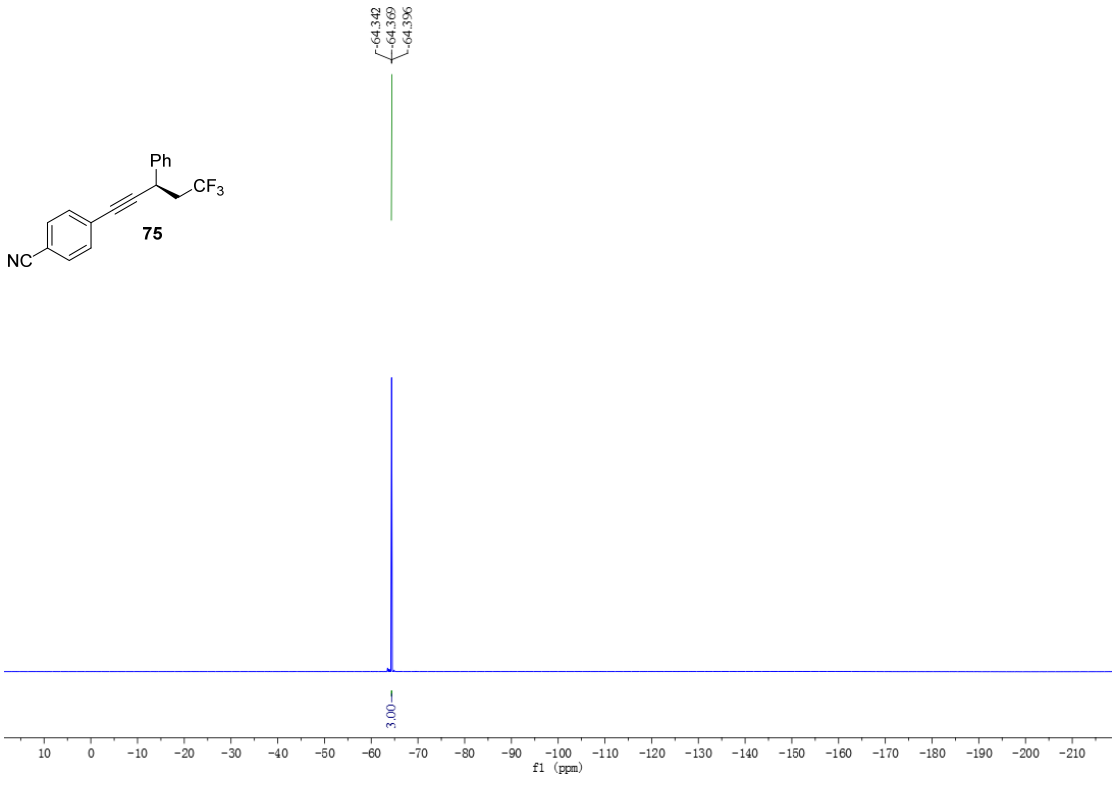
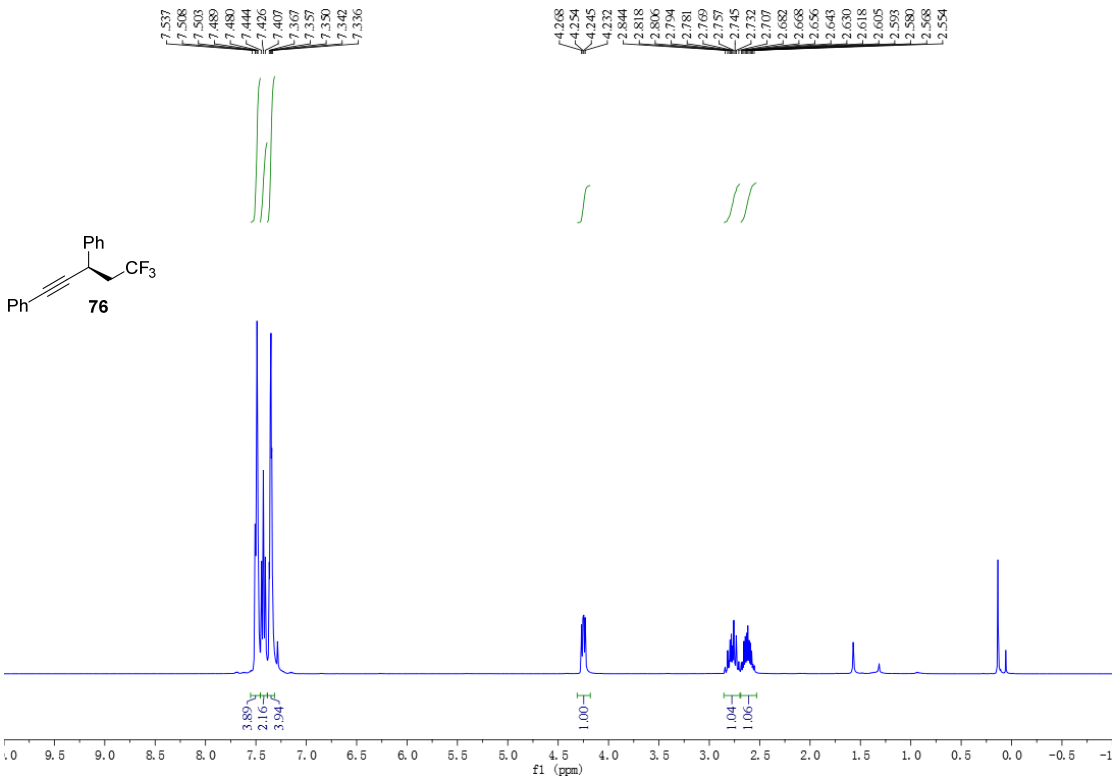
93.550
83.297
37.342
33.419
15.209
Ph
CN
NC
74
f1 (ppm)


7.629
7.608
7.548
7.527
7.471
7.467
7.450
7.446
7.425
7.406
7.377
7.373
7.368
7.363
7.356
7.349
7.343
7.339
7.335
7.285
4.274
4.261
4.251
4.238
2.834
2.809
2.797
2.784
2.772
2.760
2.747
2.735
2.723
2.698
2.682
2.669
2.656
2.643
2.631
2.618
2.606
2.593
2.580
2.568
2.555
Ph
CF3
NC
75
2.11
2.01
4.02
1.01
1.00
1.03
1.06
f1 (ppm)


138.985
132.237
132.008
129.118
127.933
127.909
127.310
126.928
118.473
117.656
93.176
82.718
42.346
42.069
41.793
41.517
32.643
32.611
32.579
32.548
Ph
CF3
NC
75
f1 (ppm)


-64.342
-64.369
-64.396
Ph
CF3
NC
75
3.00
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)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7.508
7.503
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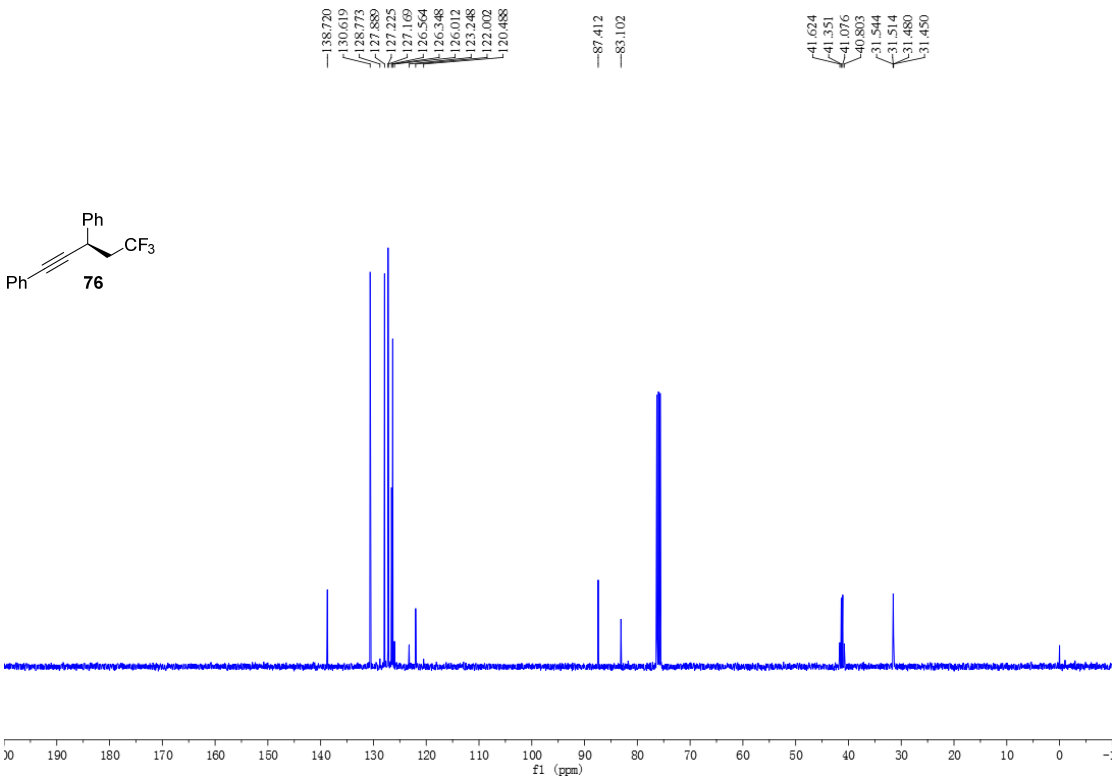
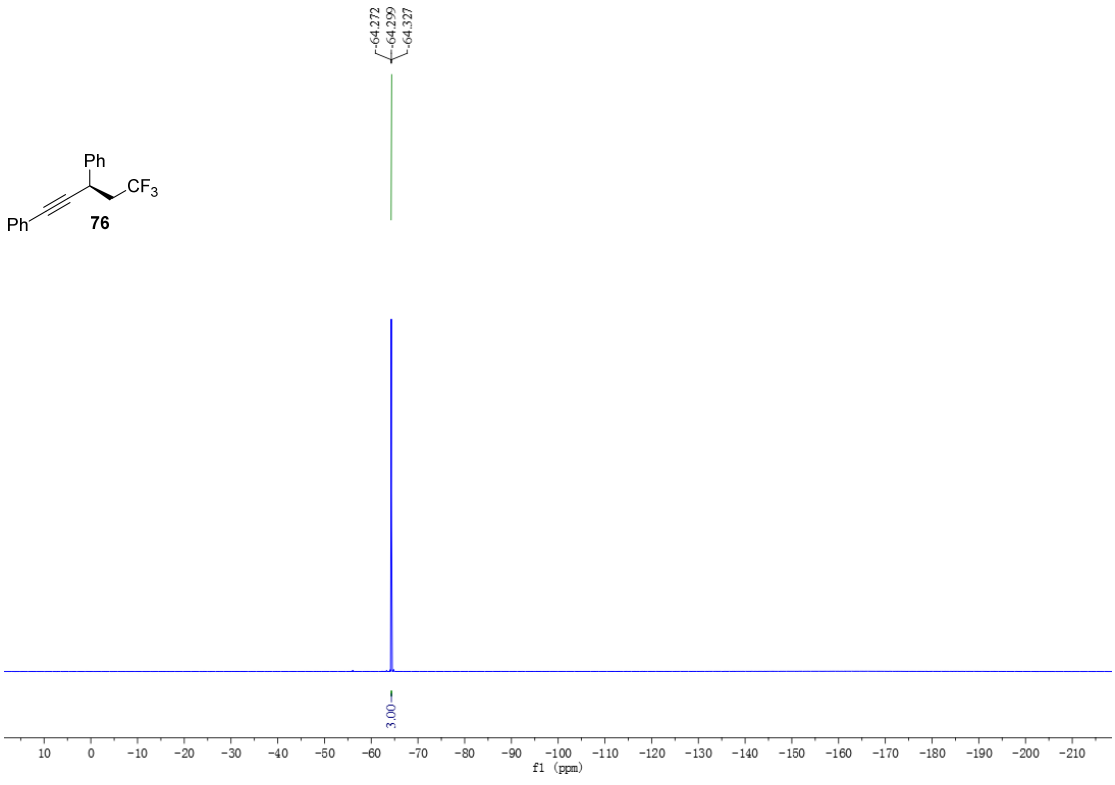
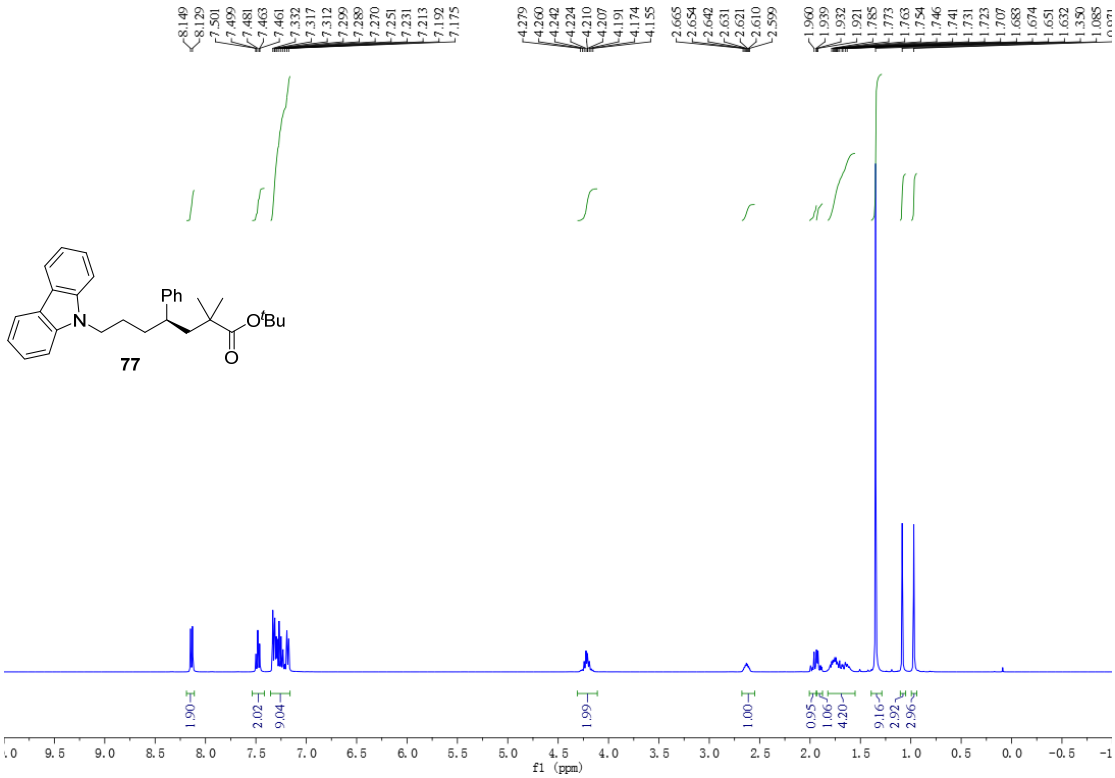
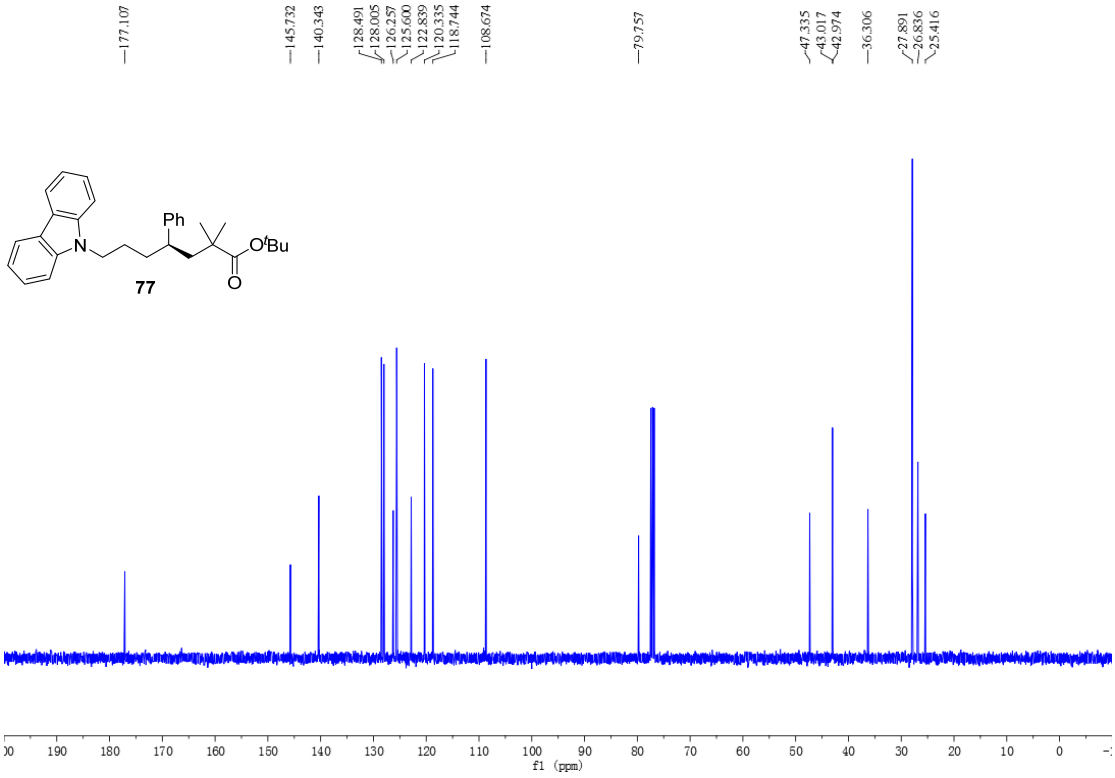
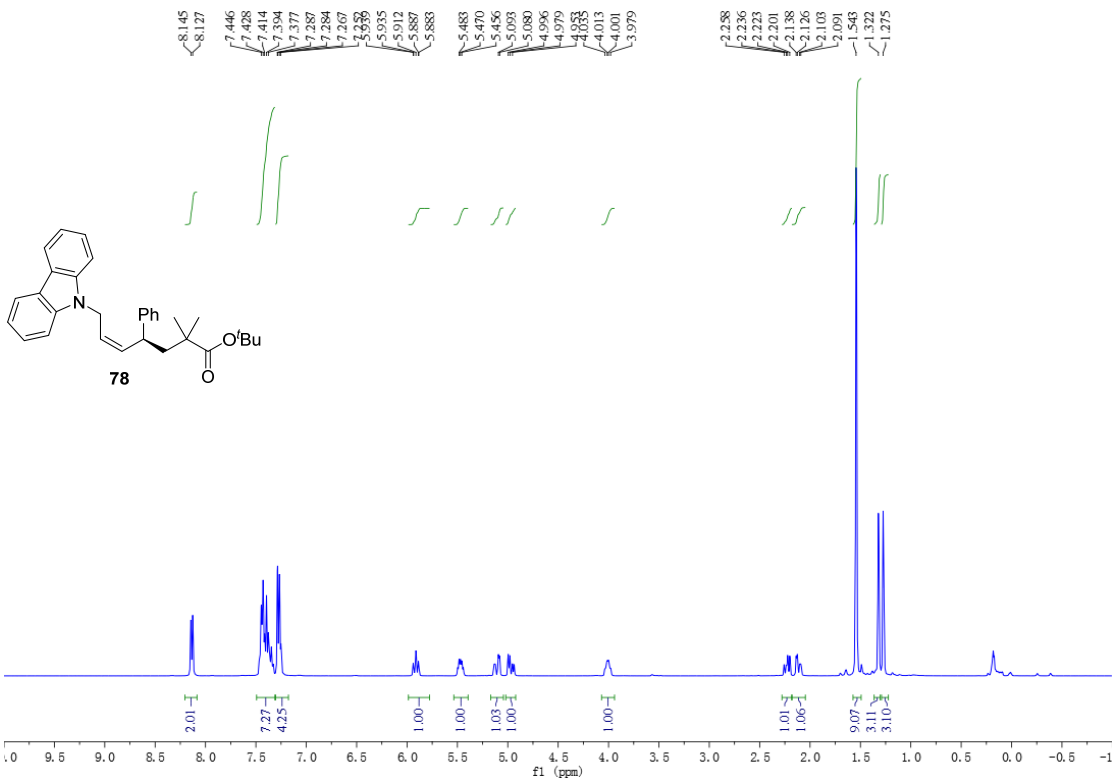
7.480
7.444
7.426
7.407
7.367
7.357
7.350
7.342
7.336
4.268
4.254
4.245
4.232
2.844
2.818
2.806
2.794
2.781
2.769
2.757
2.745
2.732
2.707
2.682
2.668
2.656
2.643
2.630
2.618
2.605
2.593
2.580
2.568
2.554
Ph
CF3
Ph
76
3.89
2.16
3.94
1.00
1.04
1.06
f1 (ppm)


138.720
130.619
128.773
127.889
127.225
127.169
126.564
126.348
126.012
123.248
122.002
120.488
87.412
83.102
41.624
41.351
41.076
40.803
31.544
31.514
31.480
31.450
Ph
CF3
Ph
76
f1 (ppm)


-64.272
-64.299
-64.327
Ph
CF3
Ph
76
3.00
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)


Ph
N
O
O
tBu
77
f1 (ppm)


Ph
N
O
O
tBu
77
f1 (ppm)


8.145
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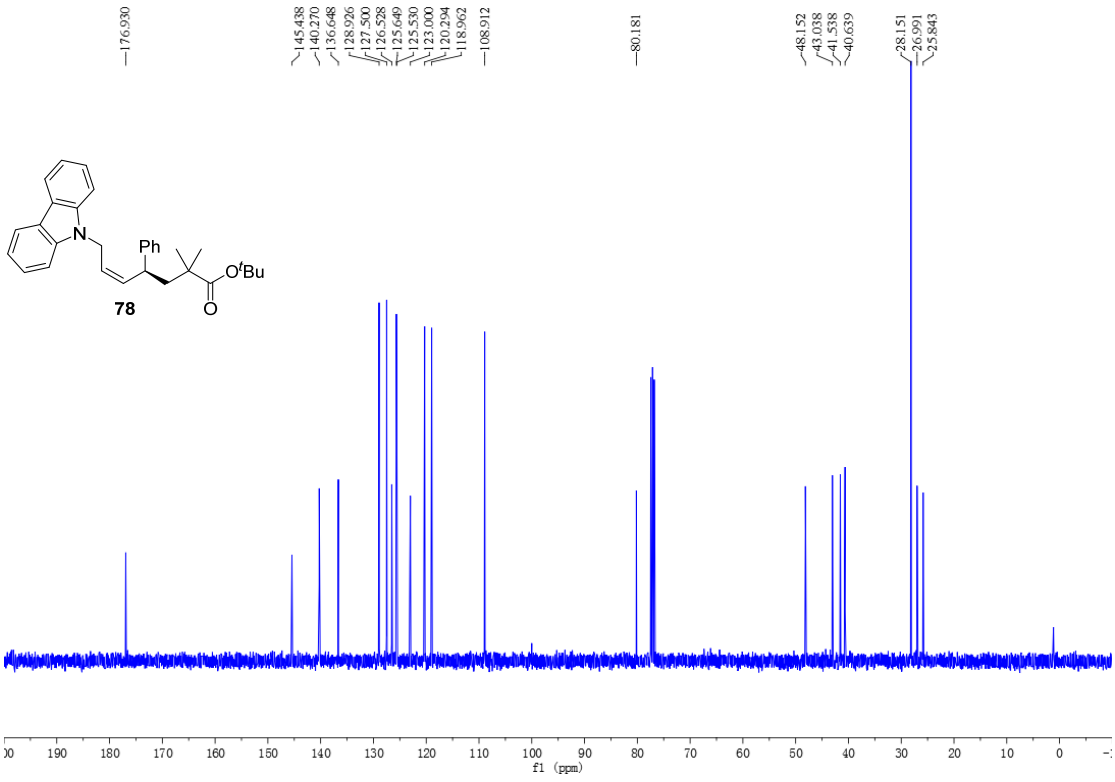
7.428
7.414
7.394
7.377
7.287
7.284
7.267
5.935
5.912
5.887
5.883
5.483
5.470
5.456
5.093
5.080
4.996
4.979
4.033
4.013
4.001
3.979
2.238
2.236
2.223
2.201
2.138
2.126
2.103
2.091
1.543
1.322
1.275
Ph
O'Bu
O
78
2.01
7.27
4.25
1.00
1.00
1.03
1.00
1.00
1.01
1.06
9.07
3.11
3.10
f1 (ppm)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140.270
136.648
128.926
127.500
126.528
125.649
125.530
123.000
120.294
118.962
108.912
80.181
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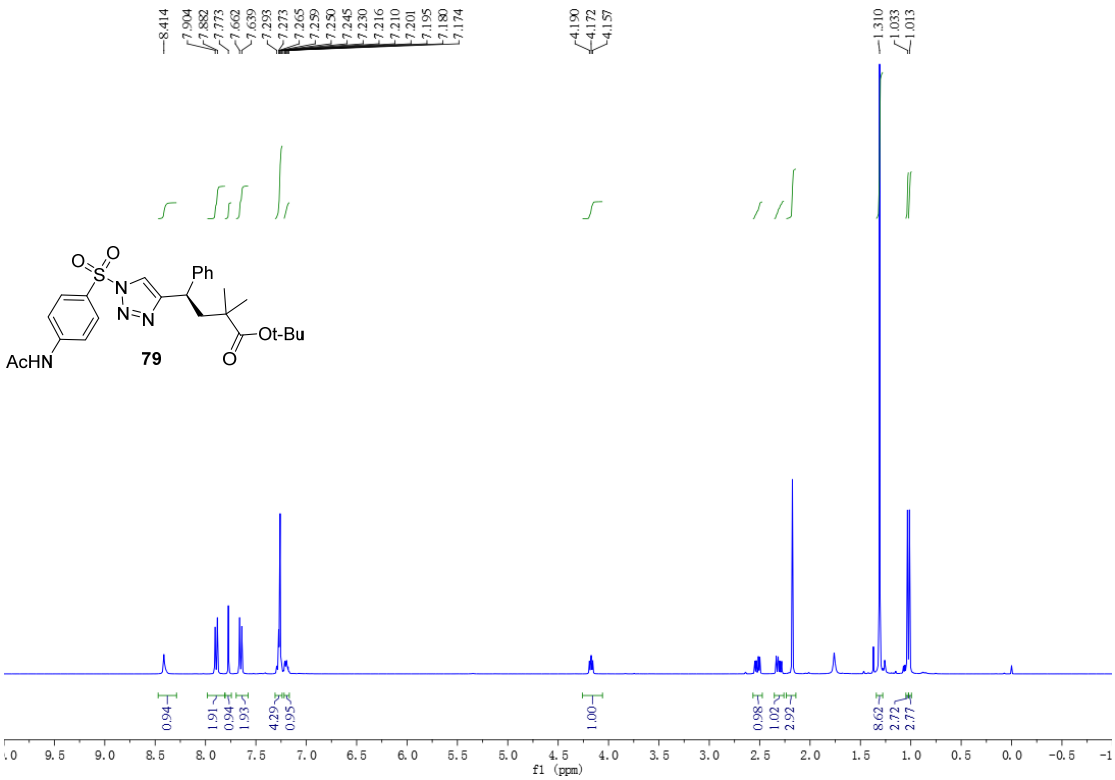
43.038
41.538
40.639
28.151
26.991
25.843
Ph
O'Bu
O
78
f1 (ppm)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7.882
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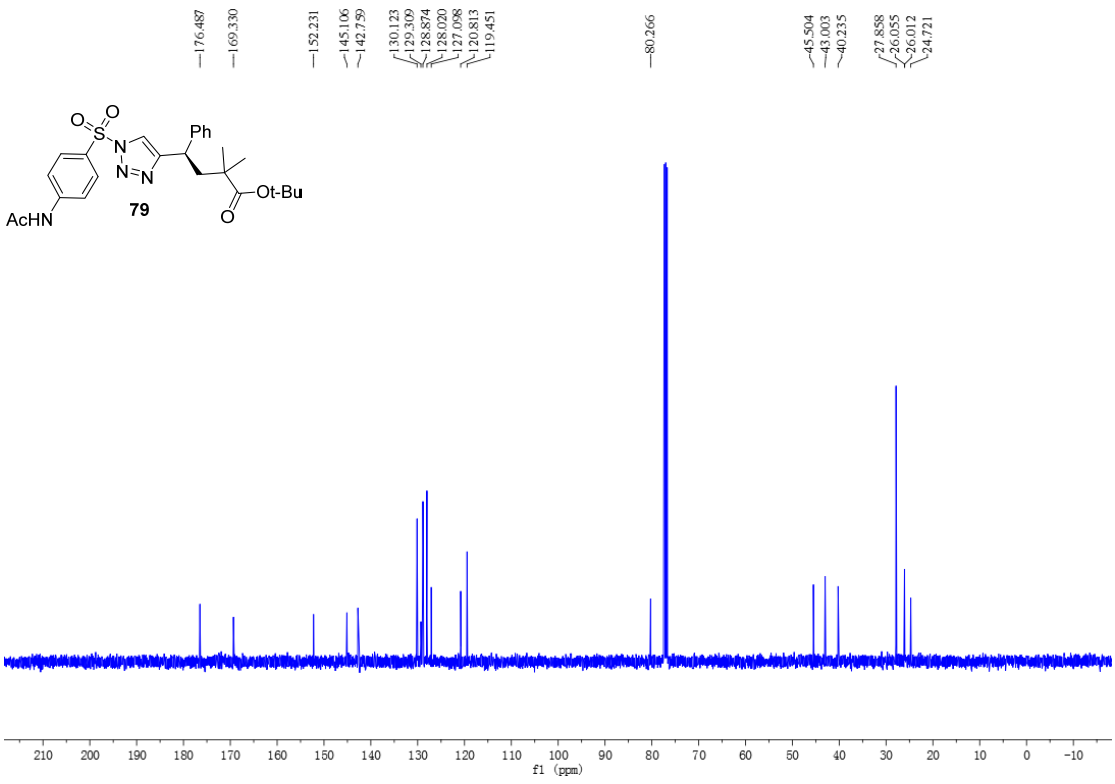
7.662
7.639
7.293
7.273
7.265
7.259
7.250
7.245
7.230
7.216
7.210
7.201
7.195
7.180
7.174
4.190
4.172
4.157
1.310
1.033
1.013
Ph
Ot-Bu
AcHN
79
0.94
1.91
0.94
1.93
4.29
0.95
1.00
0.98
1.02
2.92
8.62
2.72
2.77
f1 (ppm)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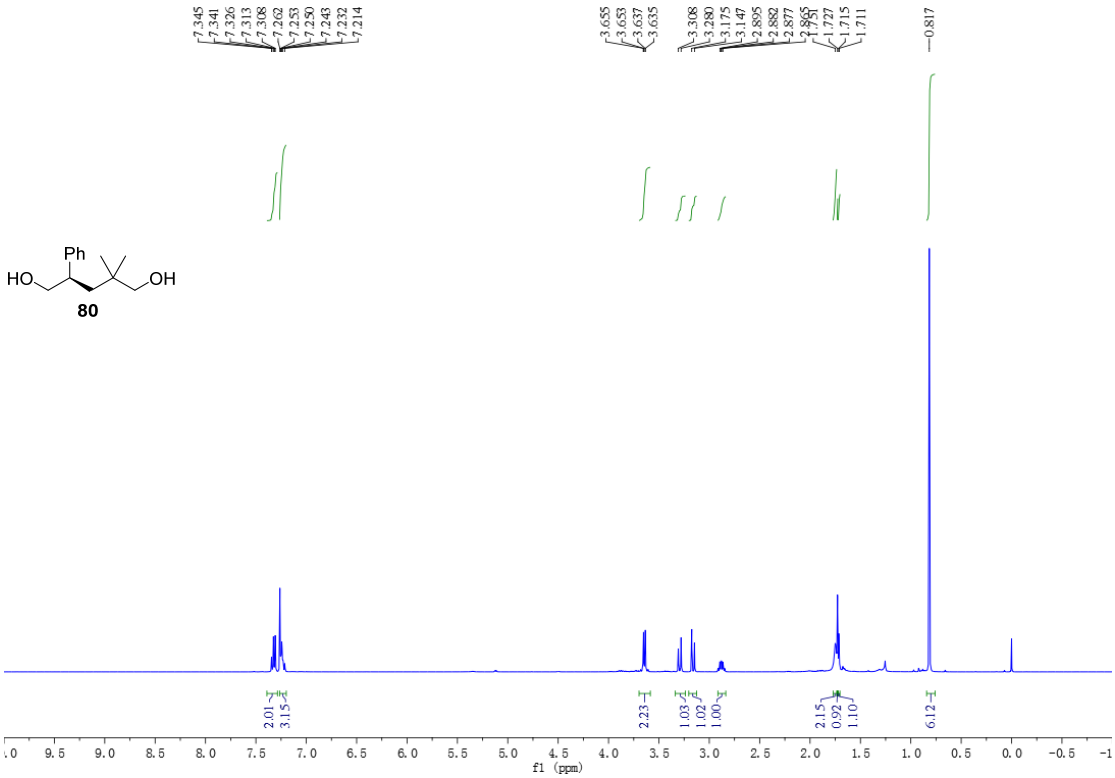
145.106
142.759
130.123
129.309
128.874
128.020
127.098
120.813
119.451
80.266
45.504
43.003
40.235
27.858
26.055
26.012
24.721
Ph
Ot-Bu
AcHN
79
f1 (ppm)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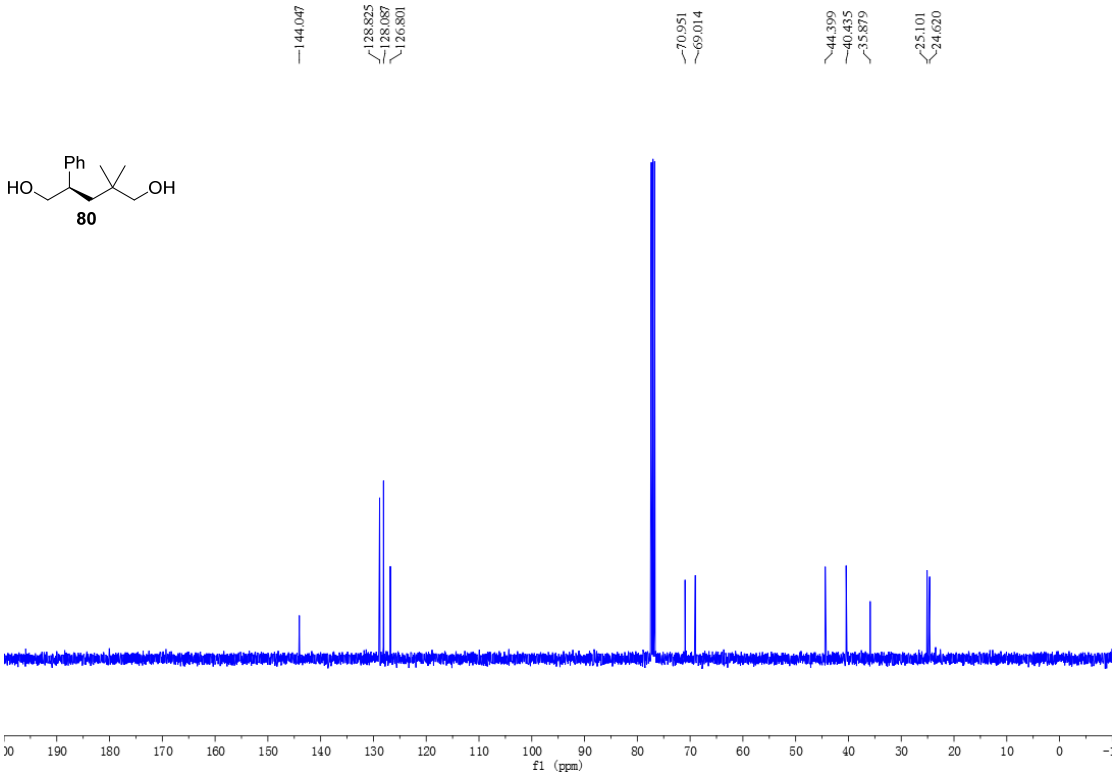
7.313
7.308
7.262
7.253
7.250
7.243
7.232
7.214
3.655
3.653
3.637
3.635
3.308
3.280
3.175
3.147
2.895
2.882
2.877
1.727
1.715
1.711
0.817
Ph
HO
OH
80
2.01
3.15
2.23
1.03
1.02
1.00
2.15
0.92
1.10
6.12
f1 (ppm)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128.825
128.087
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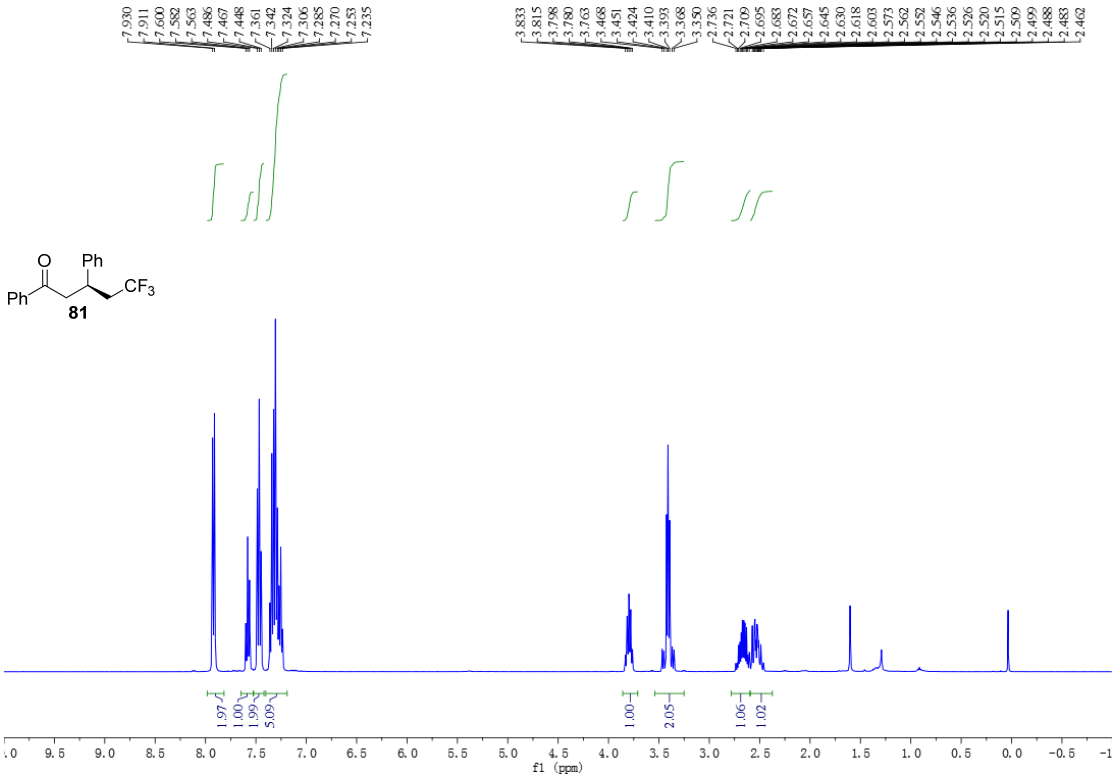
70.951
69.014
44.399
40.435
35.879
25.101
24.620
Ph
HO
OH
80
f1 (ppm)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7.911
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7.582
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7.486
7.467
7.448
7.361
7.342
7.324
7.306
7.285
7.270
7.253
7.235
3.833
3.815
3.798
3.780
3.763
3.468
3.451
3.424
3.410
3.393
3.368
3.350
2.736
2.721
2.709
2.695
2.683
2.672
2.657
2.645
2.630
2.618
2.603
2.573
2.562
2.552
2.546
2.536
2.526
2.520
2.515
2.509
2.499
2.488
2.483
2.462
O
Ph
Ph
CF3
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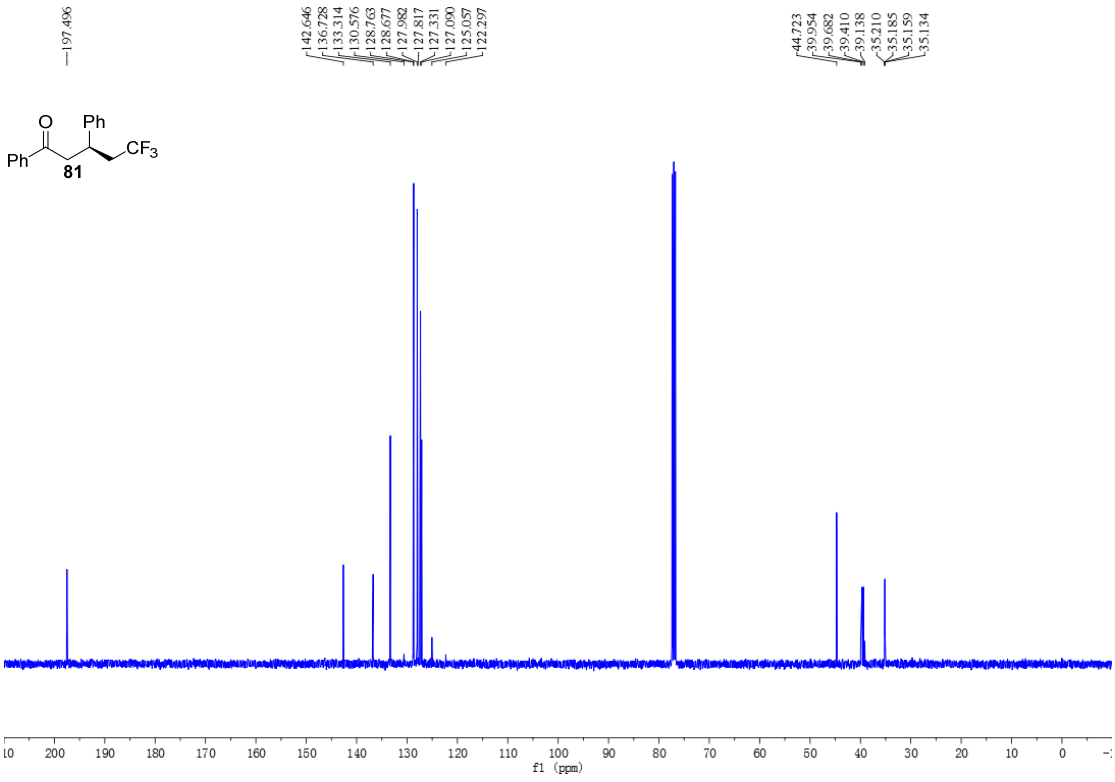
1.99
5.09
1.00
2.05
1.06
1.02
f1 (ppm)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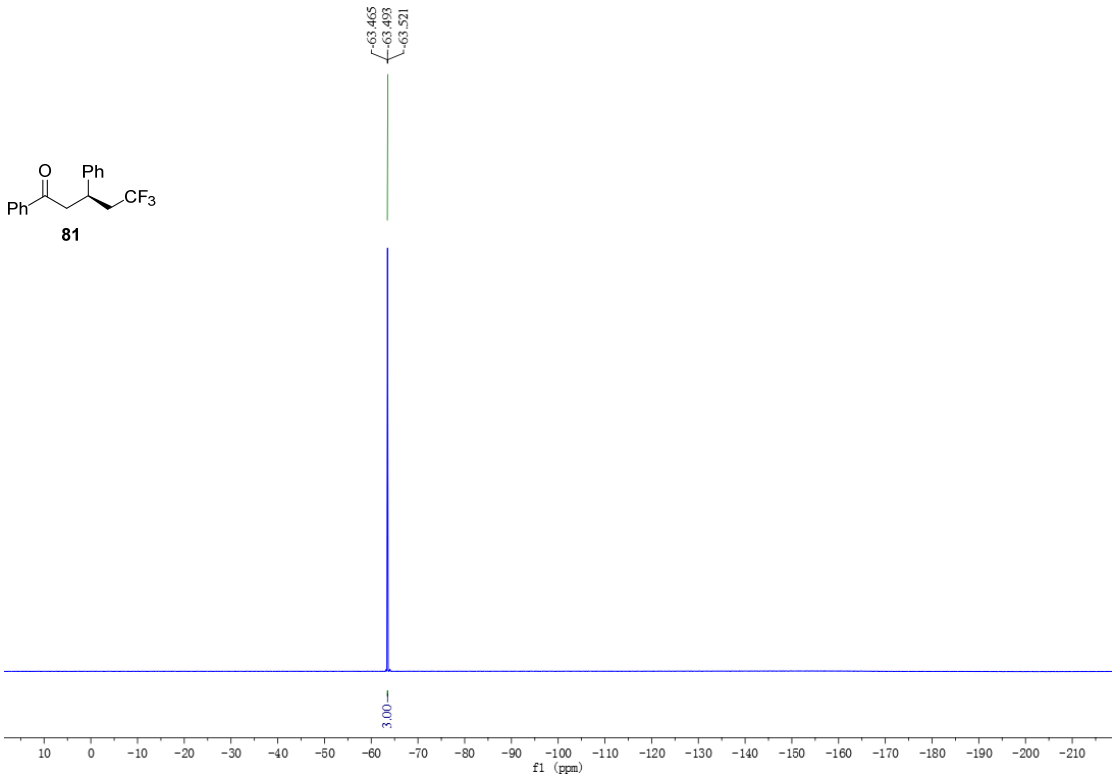
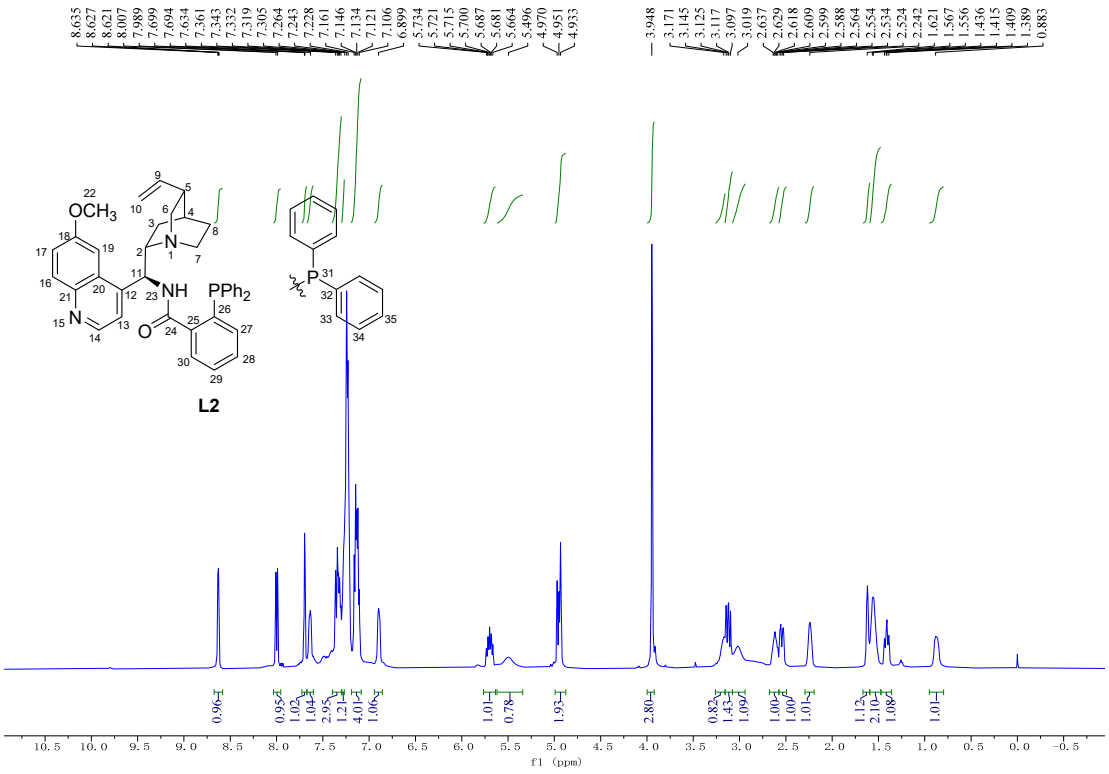
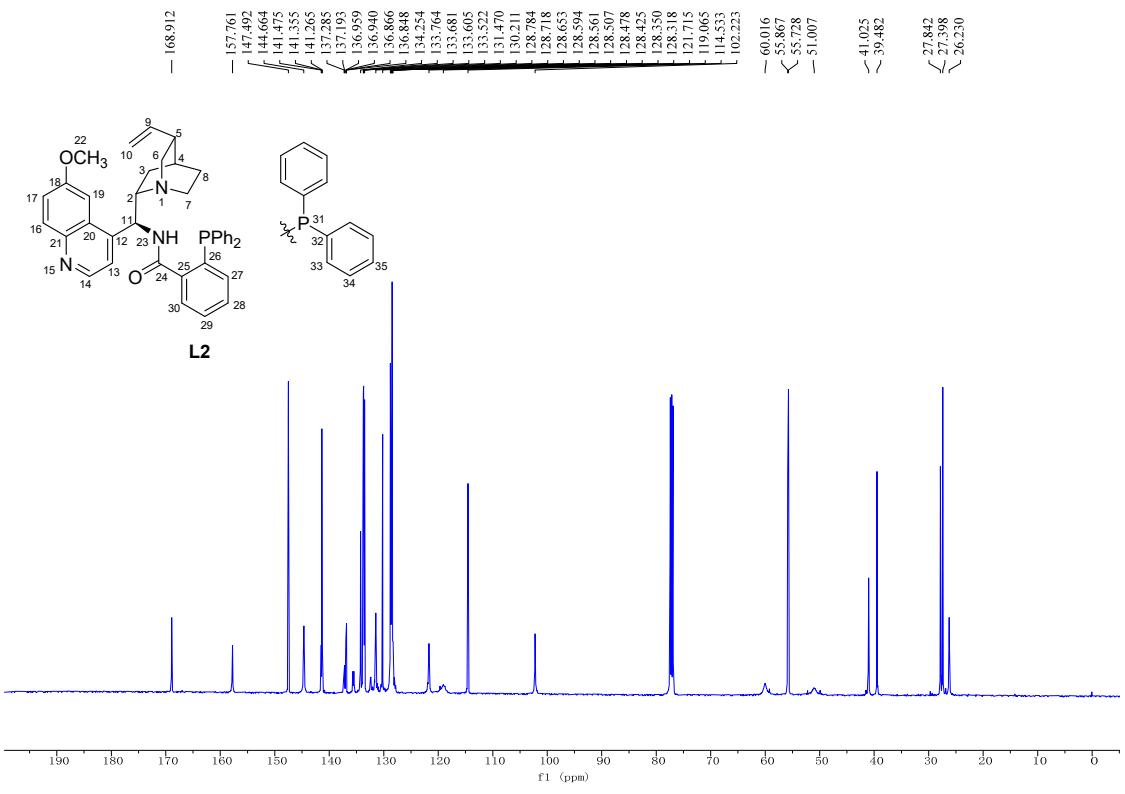
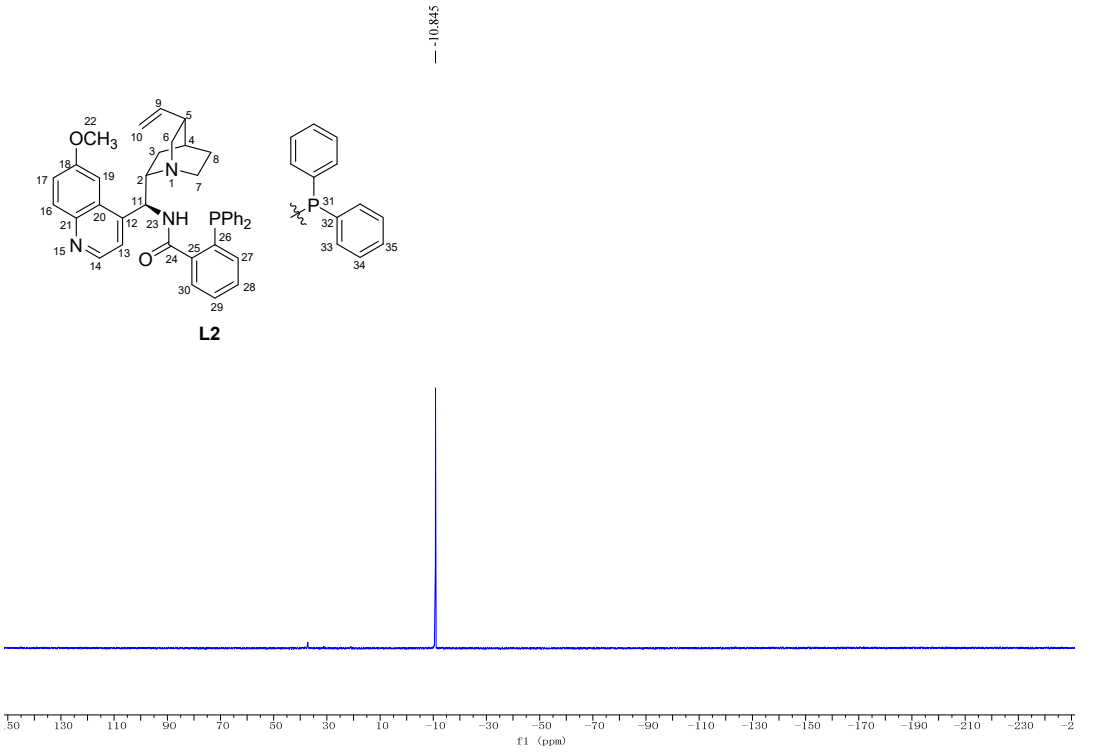
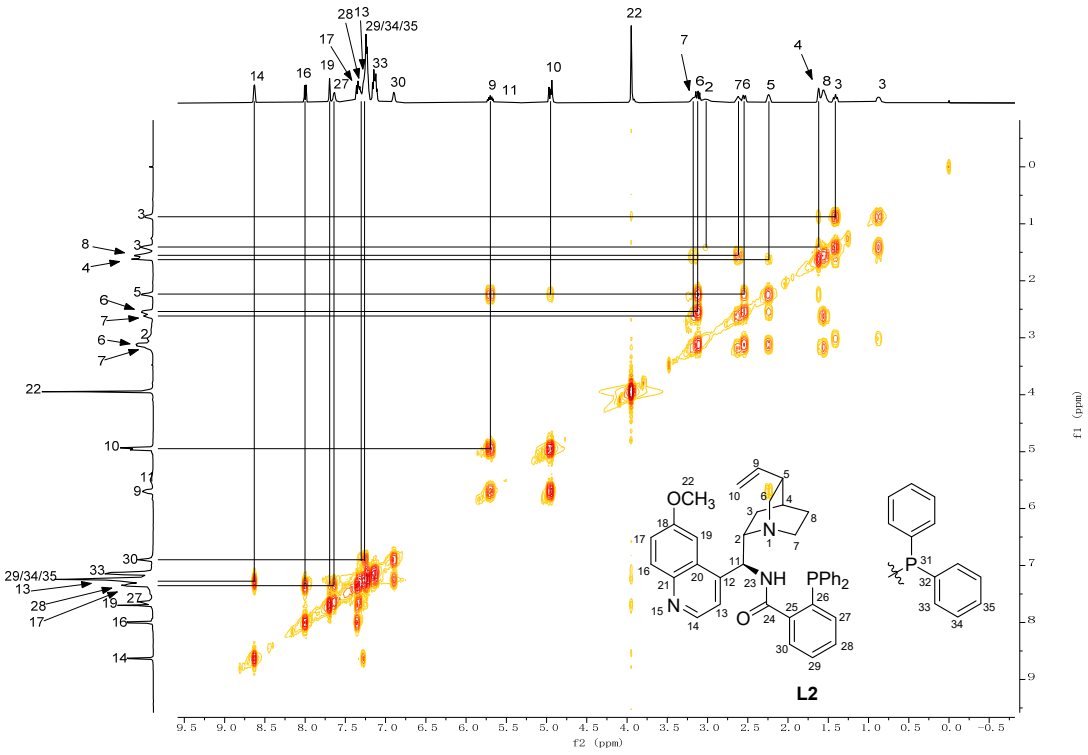
128.763
128.677
127.982
127.817
127.331
127.090
125.057
122.297
44.723
39.954
39.682
39.410
39.138
35.210
35.185
35.159
35.134
O
Ph
Ph
CF3
81
f1 (ppm)

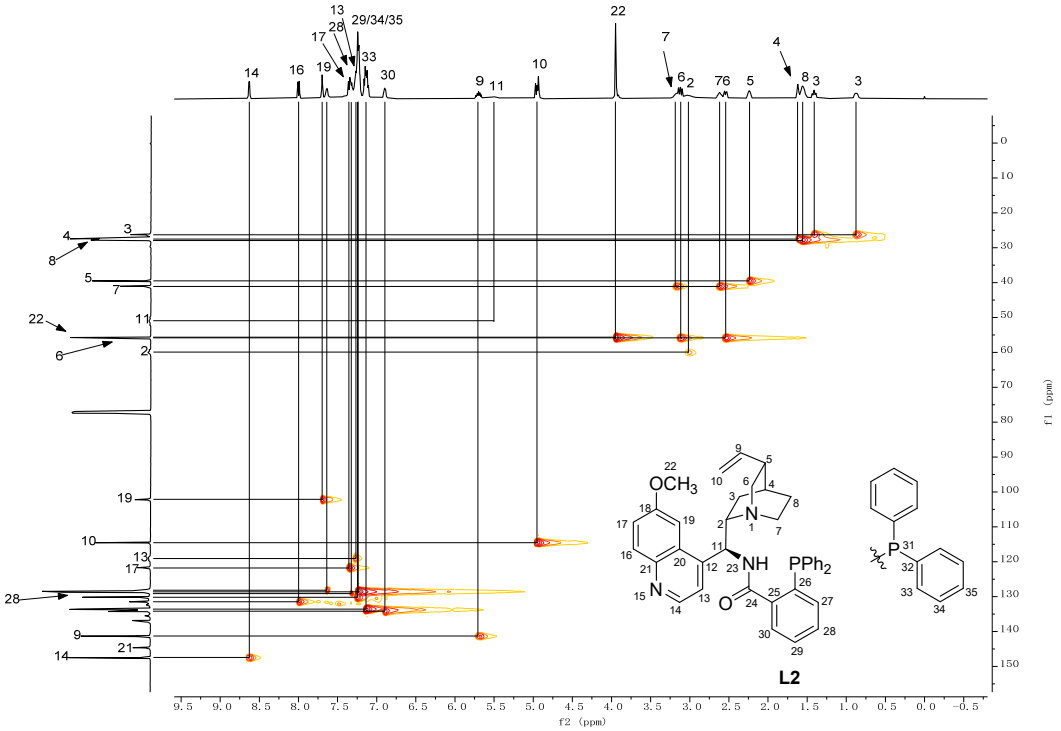

-63.465
-63.493
-63.521
O
Ph
Ph
CF3
81
3.00
10
0
-10
-20
-30
-40
-50
-60
-70
-80
-90
-100
-110
-120
-130
-140
-150
-160
-170
-180
-190
-200
-210
f1 (ppm)

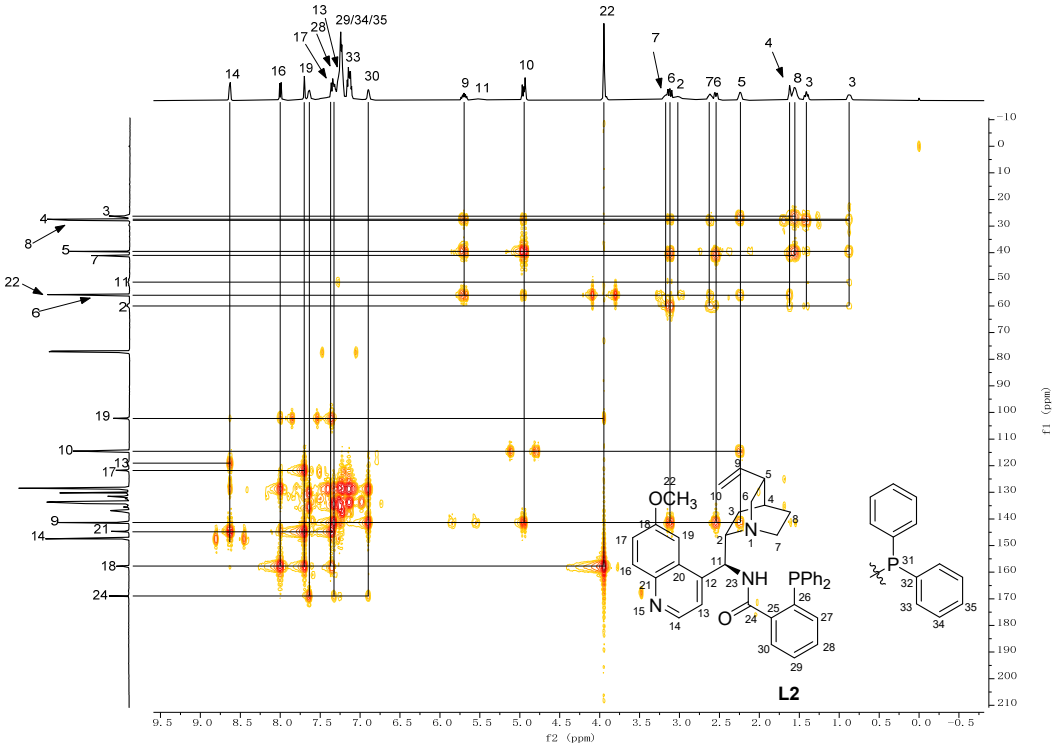

L2
f1 (ppm)

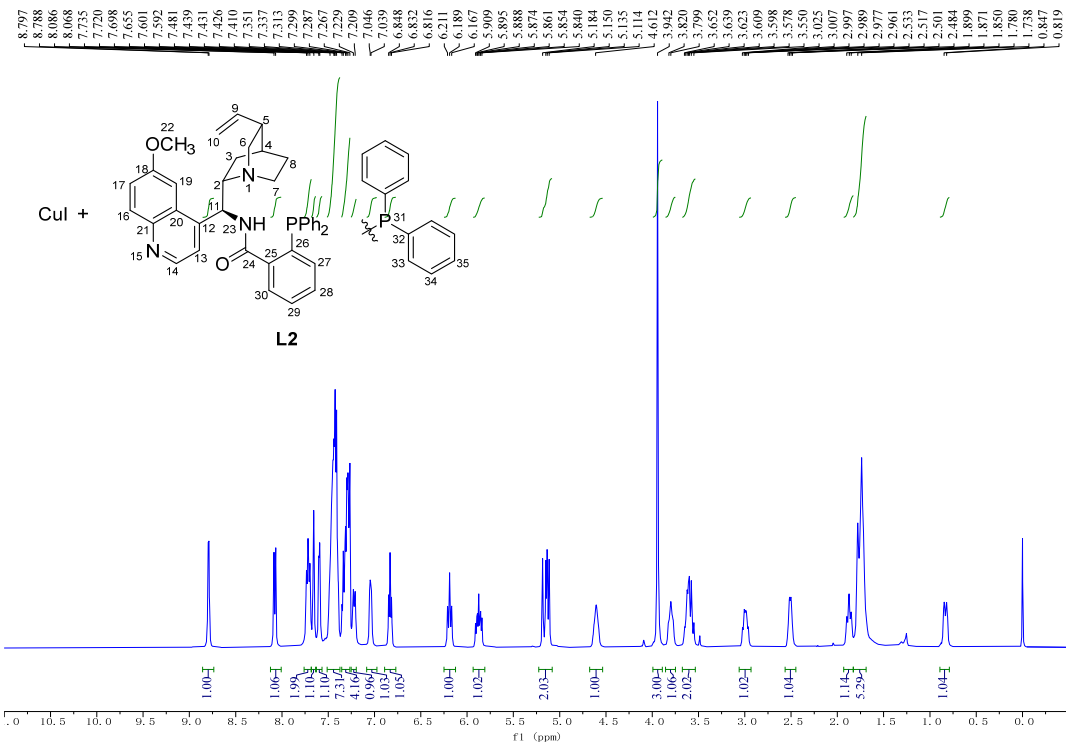

L2
f1 (ppm)

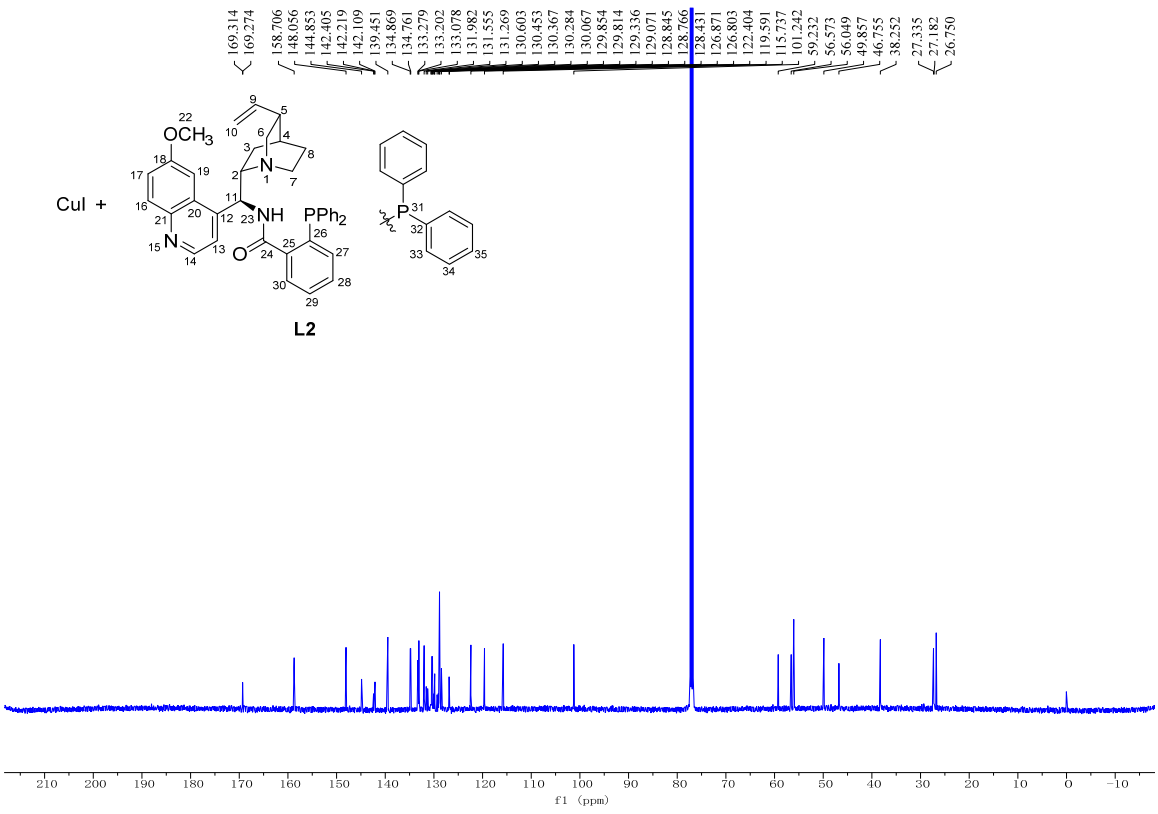

-10.845
L2
f1 (ppm)

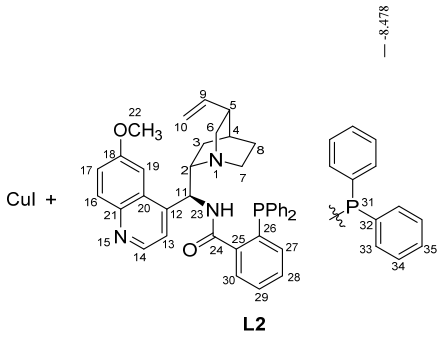

L2
f2 (ppm)
f1 (ppm)

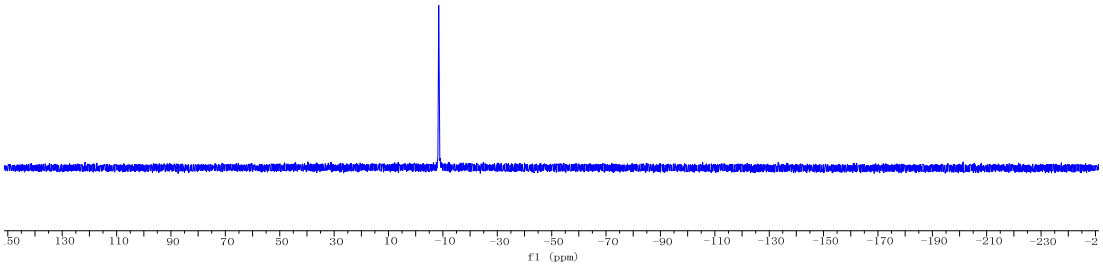

L2
f2 (ppm)
f1 (ppm)

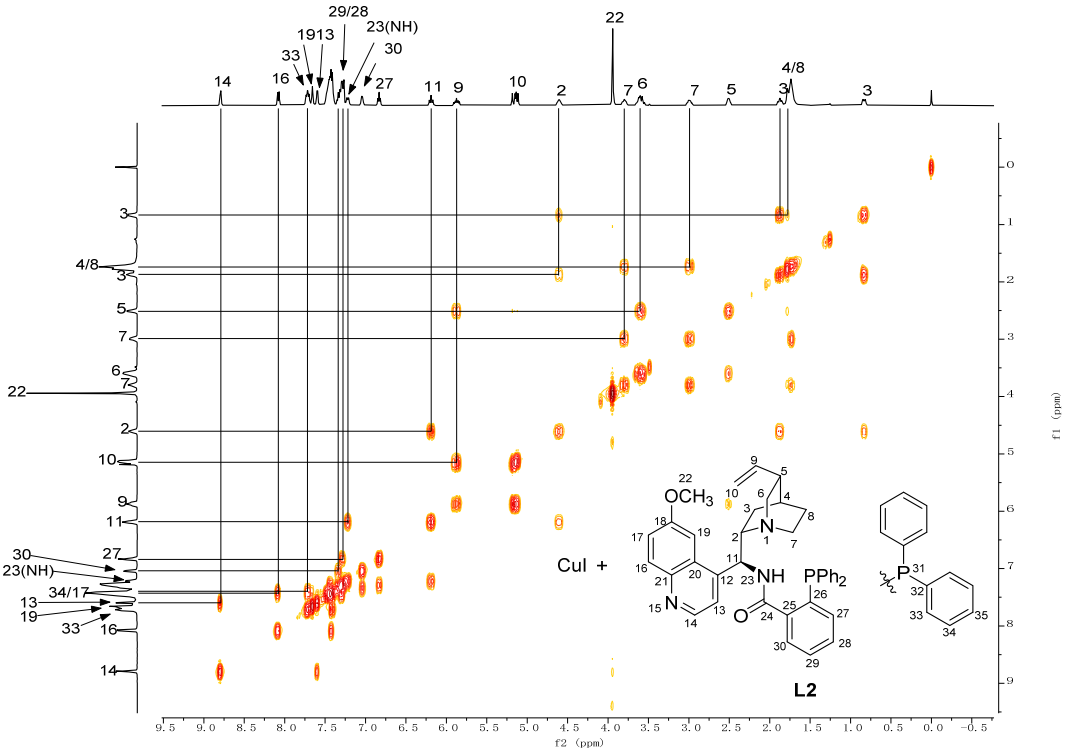

L2
f2 (ppm)
f1 (ppm)

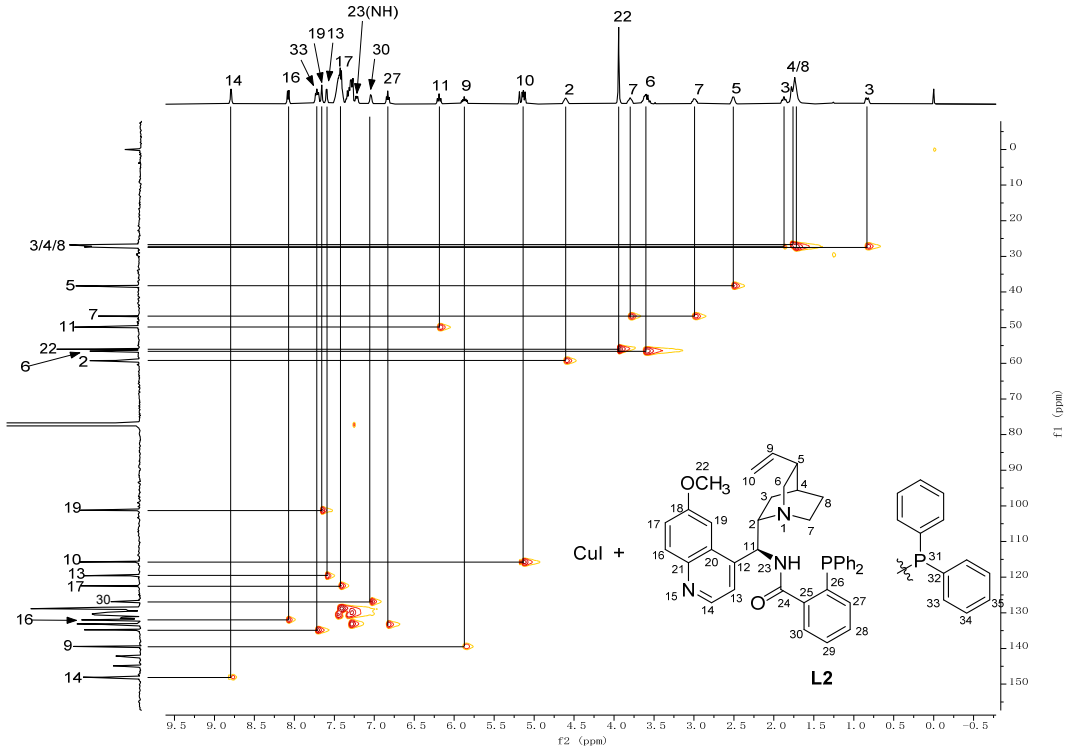

CuI +
L2
f1 (ppm)

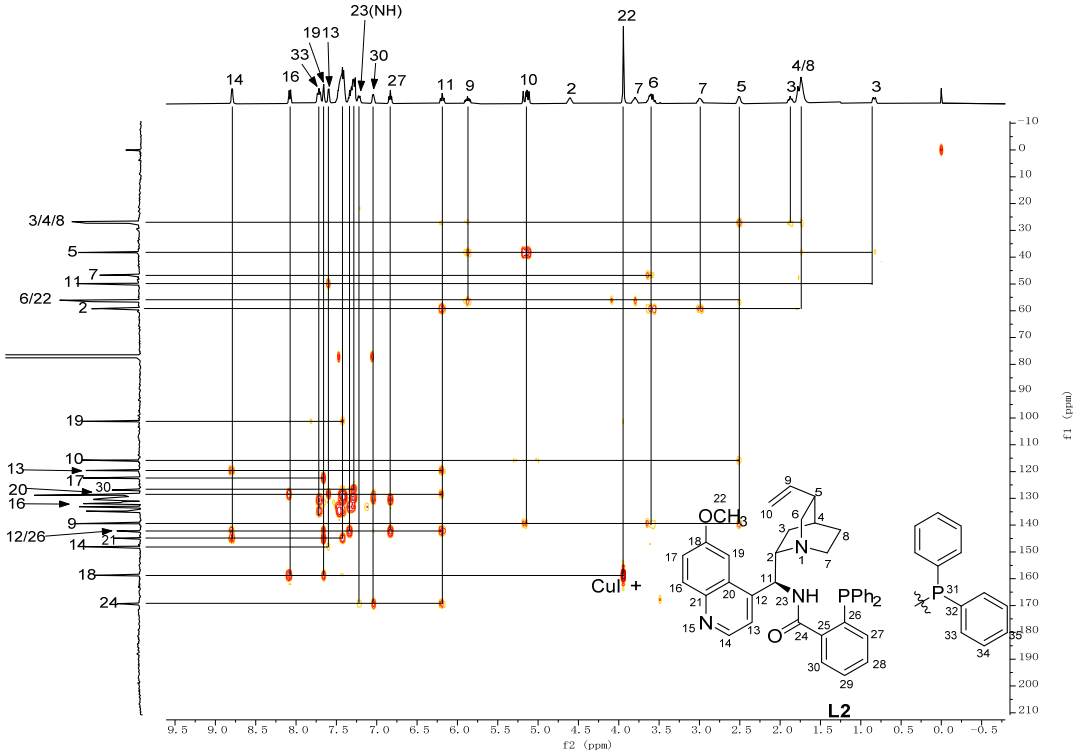

CuI +
L2
f1 (ppm)

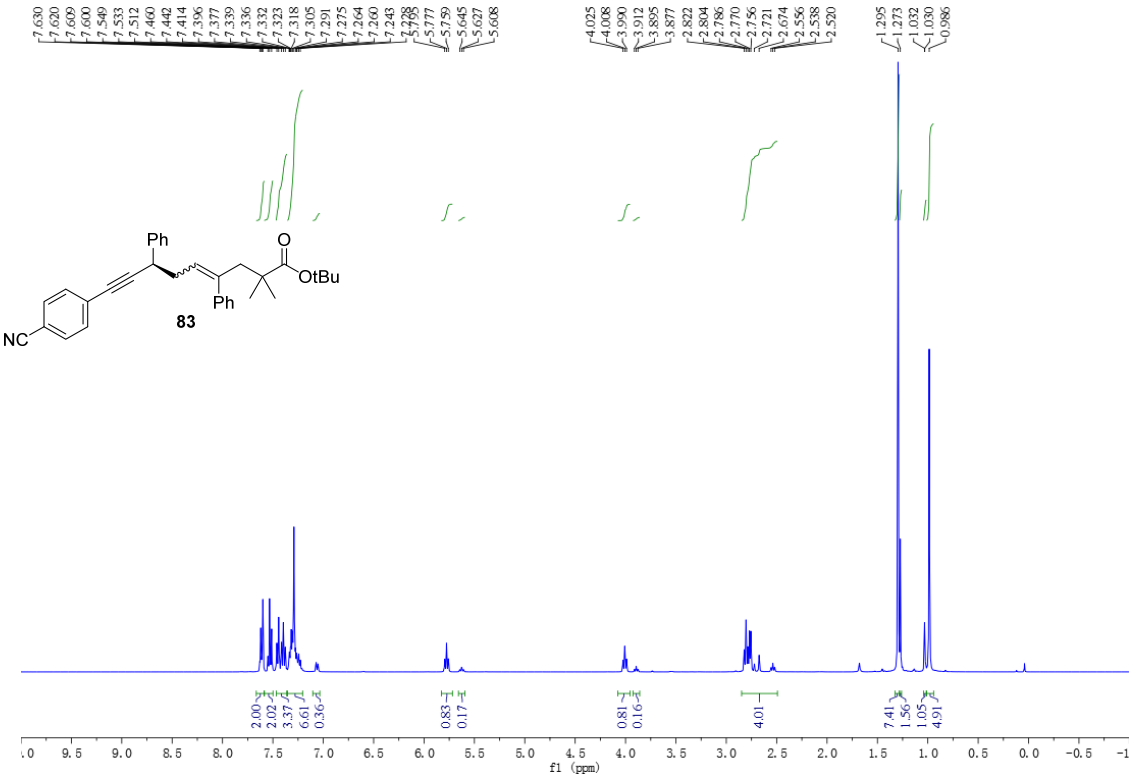

-8.478
CuI +
L2

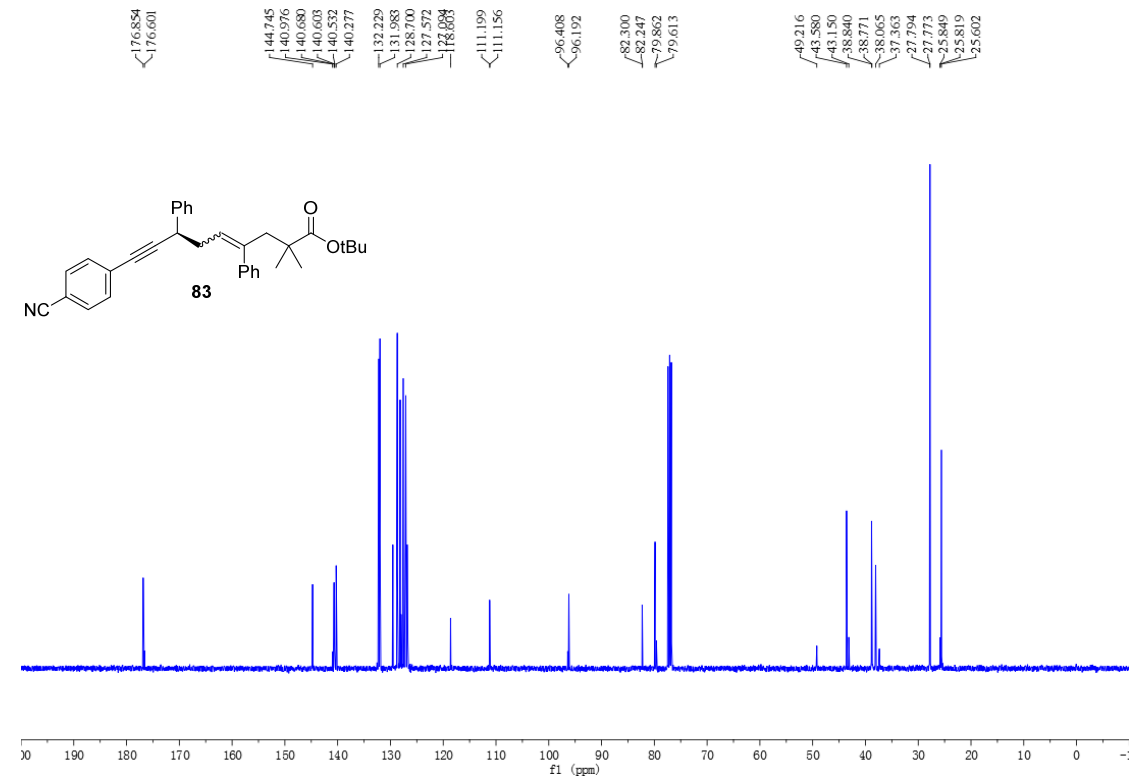

f1 (ppm)


29/28
23(NH)
1913
33
30
22
14
16
27
11
9
10
2
7
6
7
5
4/8
3
CuI +
L2
f2 (ppm)
f1 (ppm)

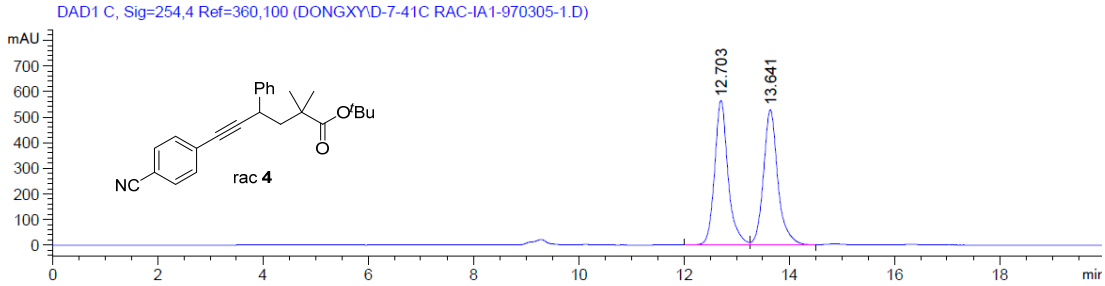

23(NH)
22
19
13
33
30
17
16
14
27
11
9
10
2
7
6
5
4/8
3
3/4/8
5
7
11
22
6
2
19
10
13
17
30
16
9
14
CuI +
OCH3
NH
PPh2
O
N
P
L2
f2 (ppm)
f1 (ppm)


23(NH)
22
19
13
33
30
16
14
27
11
9
10
2
7
6
5
4/8
3
3/4/8
5
7
11
6/22
2
19
10
13
17
20
30
16
9
12/26
14
21
18
24
CuI +
OCH3
NH
PPh2
O
N
P
L2
f2 (ppm)
f1 (ppm)


Ph
O
OtBu
Ph
NC
83
f1 (ppm)

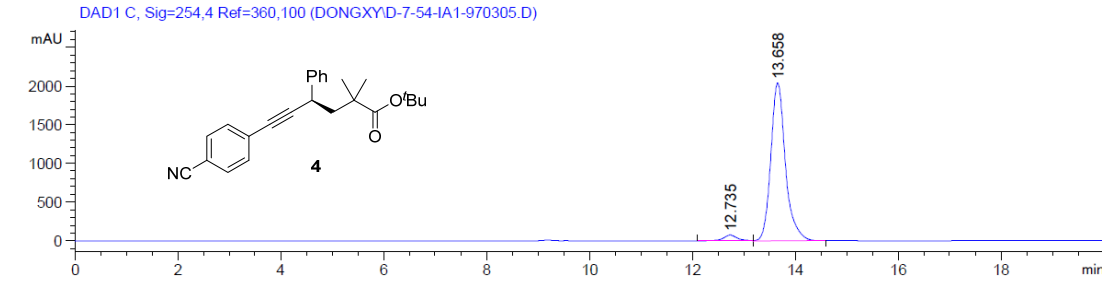

Ph
O
OtBu
Ph
NC
83
f1 (ppm)

HPLC spectra



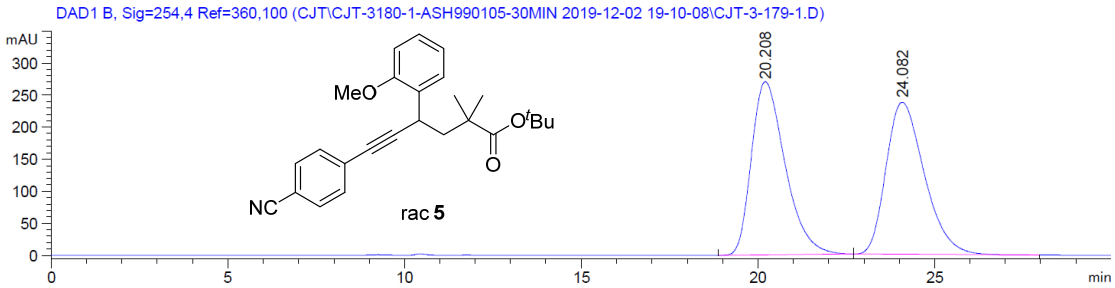
Signal 3: DAD1 C, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.703	BV	0.2645	9986.22168	564.14404	49.9968
2	13.641	VB	0.2829	9987.49707	527.41492	50.0032
Totals :				1.99737e4	1091.55896	



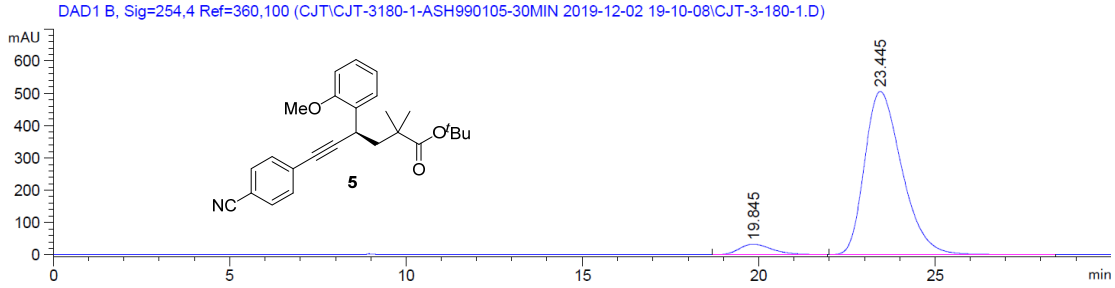
Signal 3: DAD1 C, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.735	BV	0.2786	1418.15674	74.99559	3.4004
2	13.658	VB	0.3006	4.02873e4	2038.65625	96.5996
Totals :				4.17055e4	2113.65184	



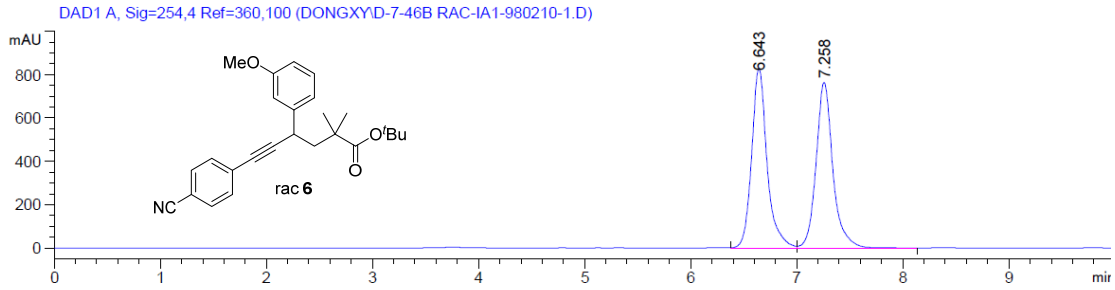
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	20.208	BB	1.0124	1.79216e4	269.99878	50.0190
2	24.082	BB	1.1379	1.79081e4	237.45607	49.9810
Totals :				3.58297e4	507.45485	



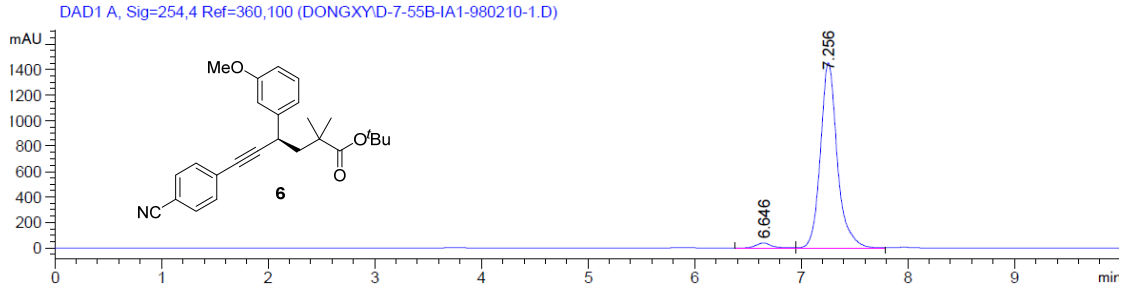
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	19.845	BB	0.9499	2078.49048	32.33758	5.3062
2	23.445	BB	1.1306	3.70929e4	505.21445	94.6938
Totals :				3.91713e4	537.55202	



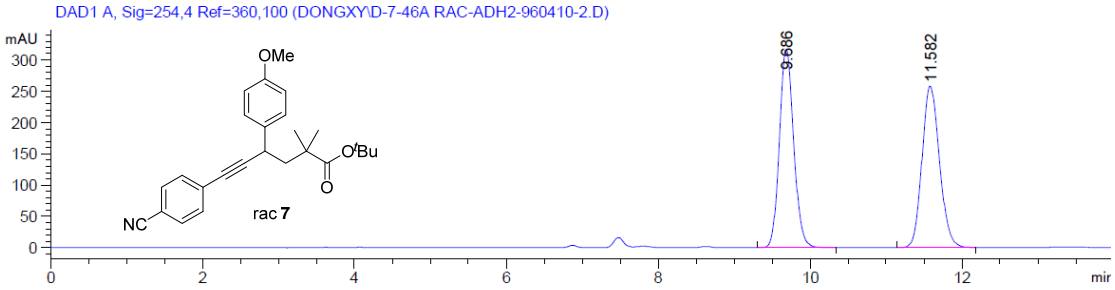
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.643	VV	0.1498	8376.49707	829.37665	49.9982
2	7.258	VB	0.1640	8377.09570	763.55206	50.0018
Totals :				1.67536e4	1592.92871	



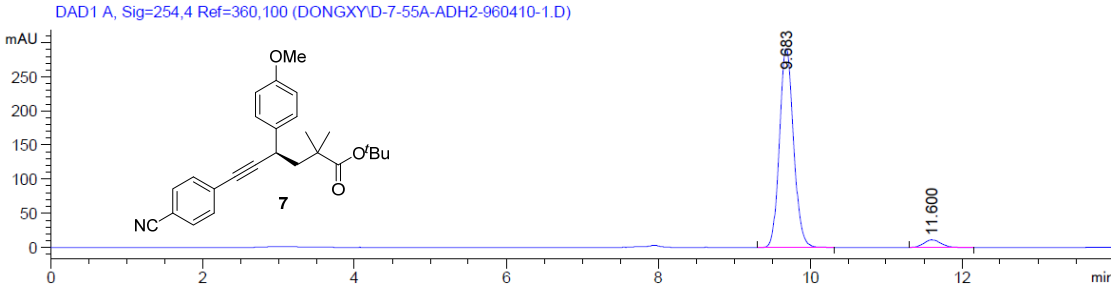
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.646	BV	0.1509	395.26715	38.77490	2.4214
2	7.256	VV	0.1638	1.59284e4	1453.59912	97.5786
Totals :				1.63237e4	1492.37402	



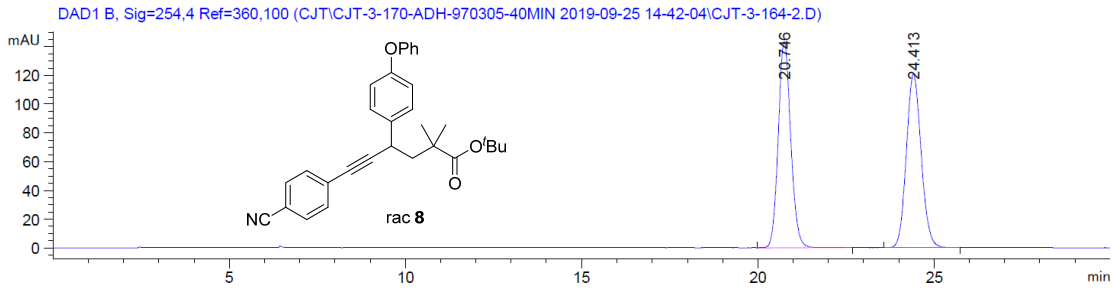
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.686	BB	0.2025	4138.18701	316.54446	50.1024
2	11.582	BB	0.2483	4121.27344	258.11472	49.8976
Totals :				8259.46045	574.65918	



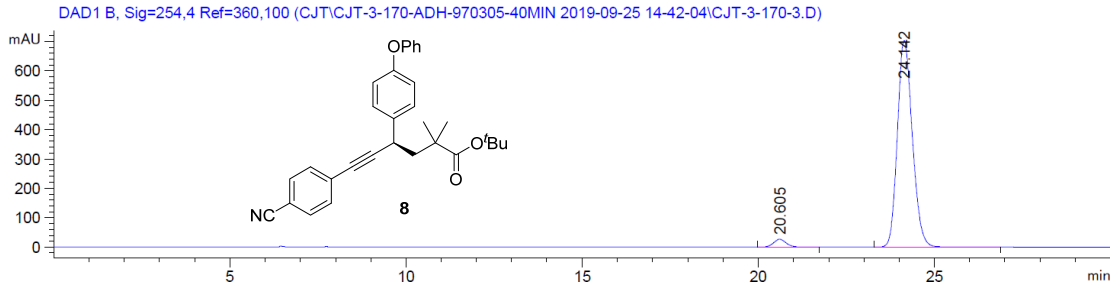
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.683	BB	0.1984	3755.22925	291.31894	95.6361
2	11.600	BB	0.2372	171.35039	10.91465	4.3639
Totals :				3926.57964	302.23359	



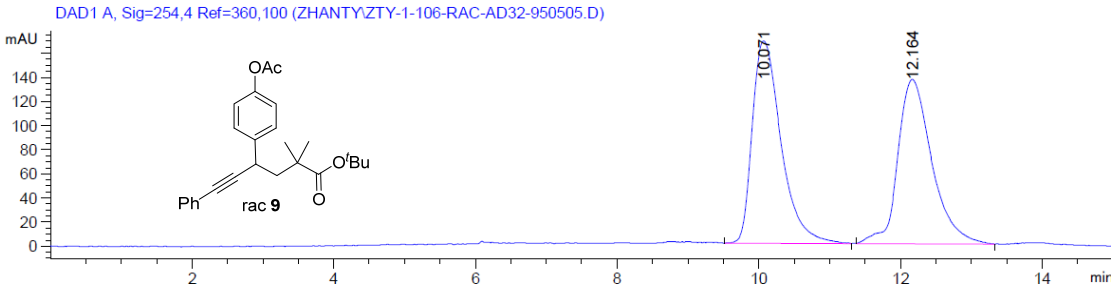
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	20.746	BB	0.3817	3536.30249	143.38103	50.0250
2	24.413	BB	0.4528	3532.76709	120.92850	49.9750
Totals :				7069.06958	264.30952	



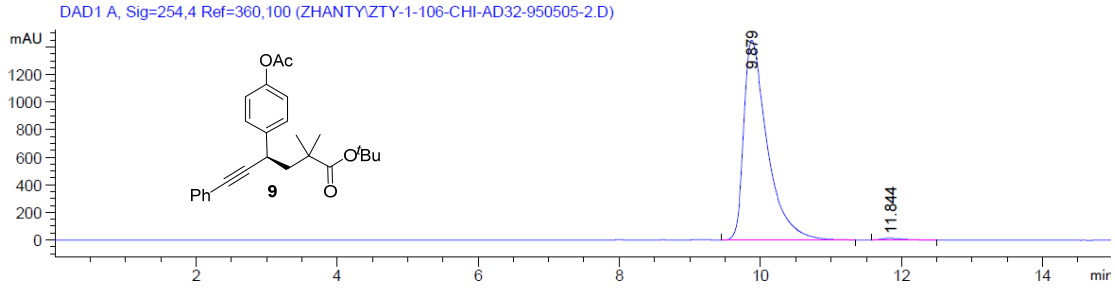
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	20.605	BB	0.3844	652.34644	26.20405	3.0455
2	24.142	BB	0.4589	2.07676e4	702.42078	96.9545
Totals :				2.14200e4	728.62482	



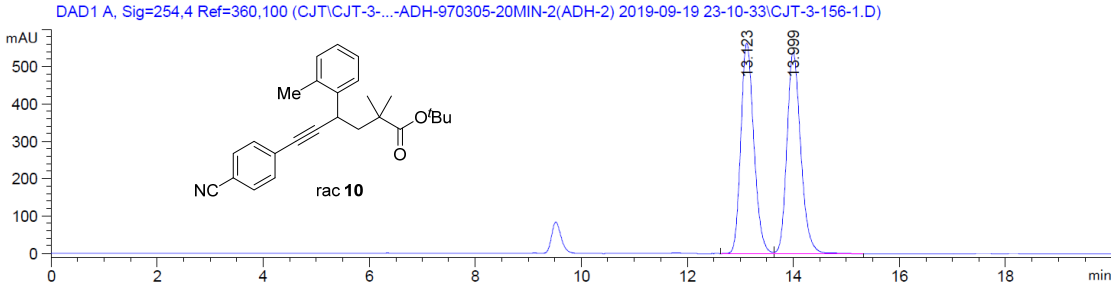
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.071	BB	0.4314	4735.99756	167.71832	50.9421
2	12.164	VV	0.4960	4560.82959	136.42535	49.0579
Totals :				9296.82715	304.14368	



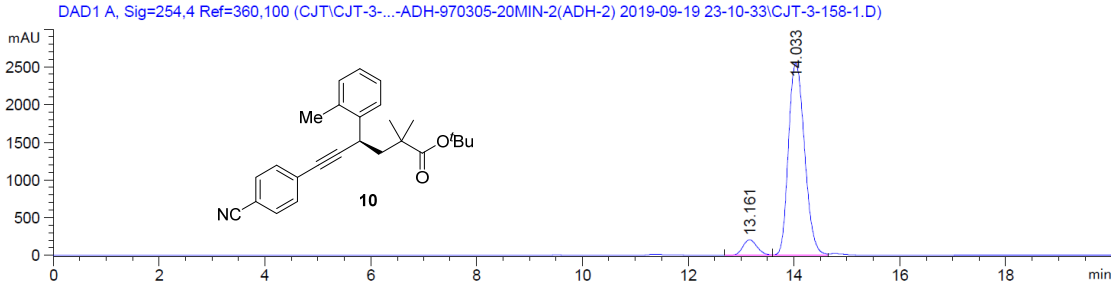
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.879	BV	0.3203	3.35888e4	1449.56494	99.1978
2	11.844	BV	0.2986	271.61356	12.35120	0.8022
Totals :				3.38604e4	1461.91614	



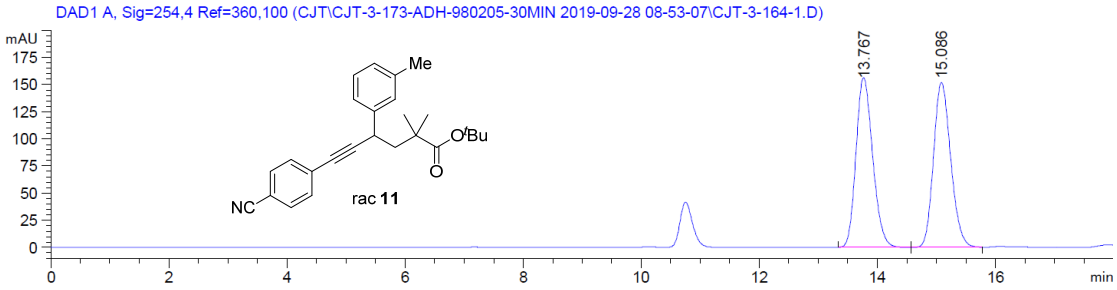
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	13.123	BV	0.2609	9627.07520	564.75964	49.5727
2	13.999	VB	0.2796	9793.02051	539.91400	50.4273
Totals :				1.94201e4	1104.67365	



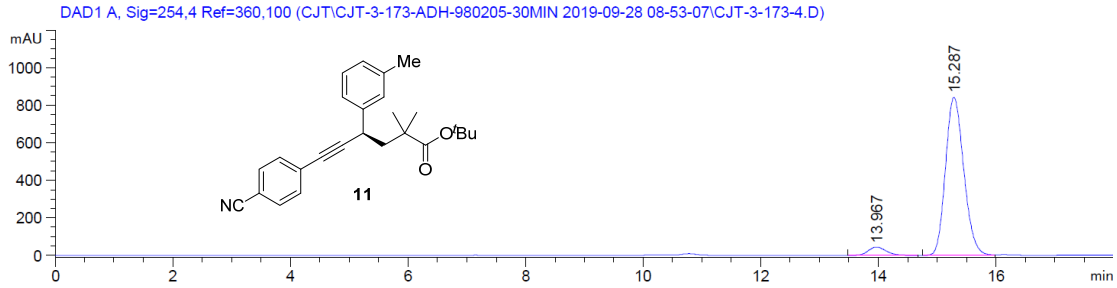
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	13.161	BV	0.2950	3912.18213	206.52402	6.7514
2	14.033	VV	0.3350	5.40337e4	2552.52271	93.2486
Totals :				5.79459e4	2759.04672	



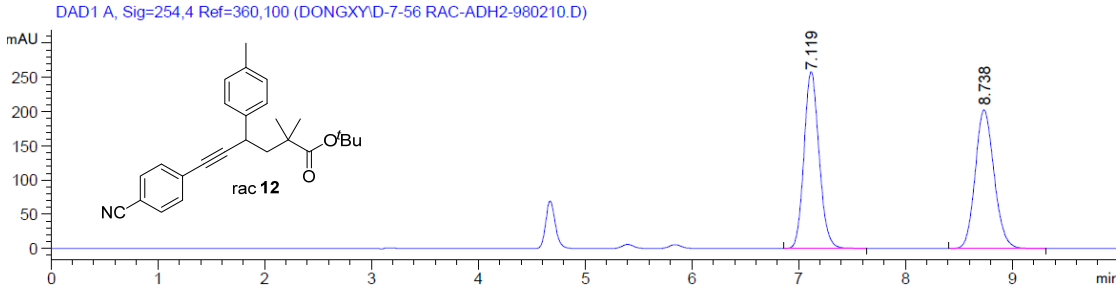
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	13.767	BB	0.3052	3073.79346	156.45981	49.9899
2	15.086	BB	0.3141	3075.03418	151.94891	50.0101
Totals :				6148.82764	308.40872	



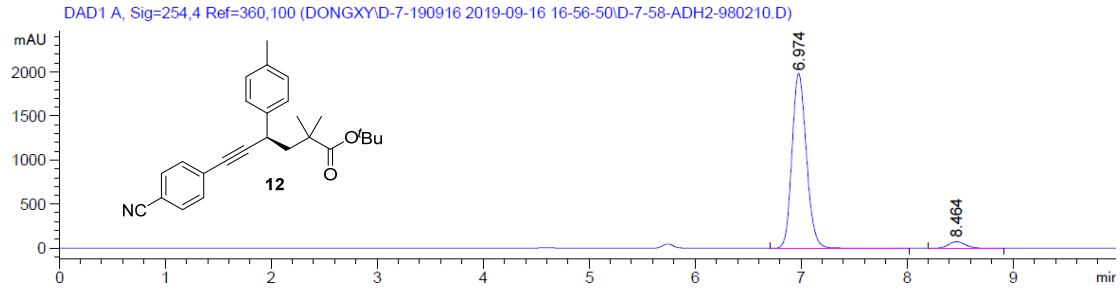
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	13.967	BB	0.3263	922.72131	44.06496	4.8227
2	15.287	BV	0.3362	1.82100e4	842.43402	95.1773
Totals :				1.91327e4	886.49898	



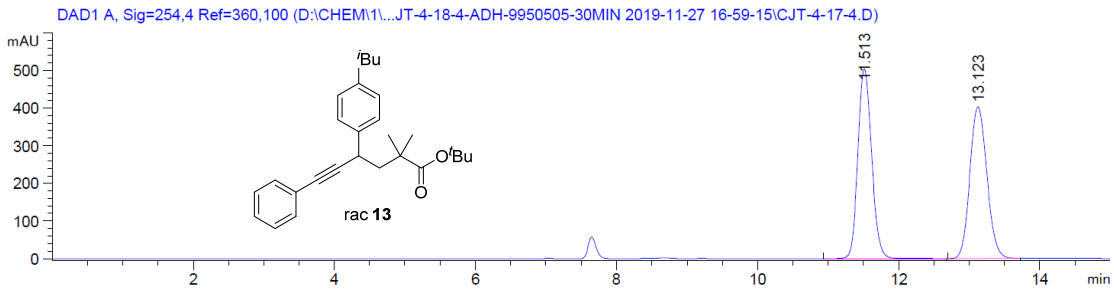
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.119	BB	0.1504	2534.43359	258.52734	50.4786
2	8.738	BB	0.1914	2486.37427	202.34375	49.5214
Totals :				5020.80786	460.87109	



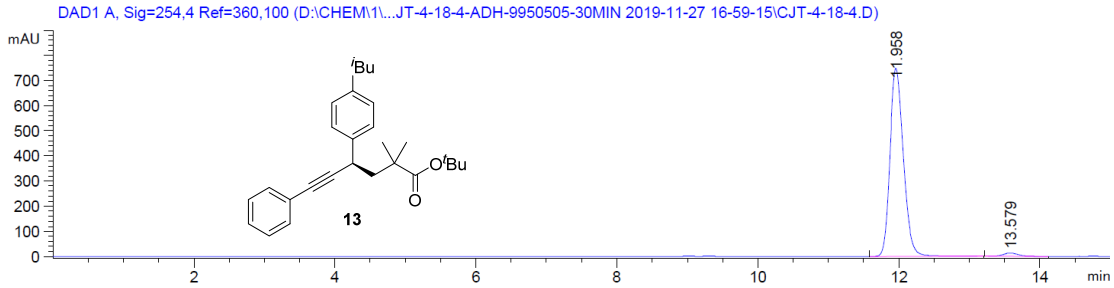
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.974	VB	0.1458	1.87221e4	1989.22314	95.8932
2	8.464	BB	0.1694	801.80139	73.41045	4.1068
Totals :				1.95239e4	2062.63360	



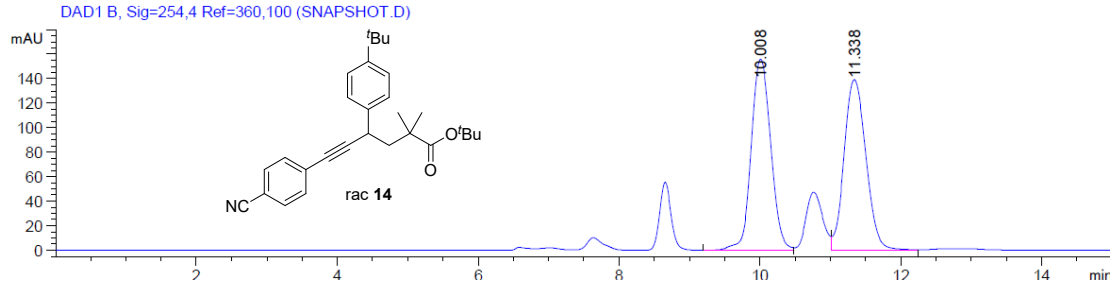
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.513	BB	0.2097	6821.94531	504.73380	50.2615
2	13.123	BB	0.2615	6750.94580	402.82224	49.7385
Totals :				1.35729e4	907.55603	



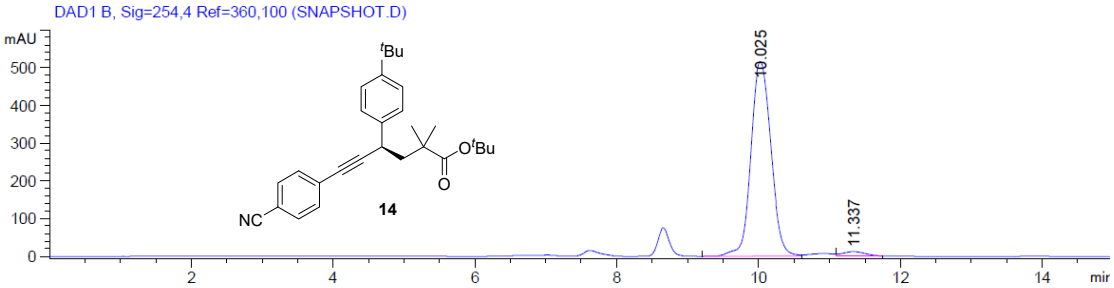
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.958	BB	0.2044	9897.90039	748.00787	98.0719
2	13.579	BB	0.2303	194.58932	13.02612	1.9281
Totals :				1.00925e4	761.03399	



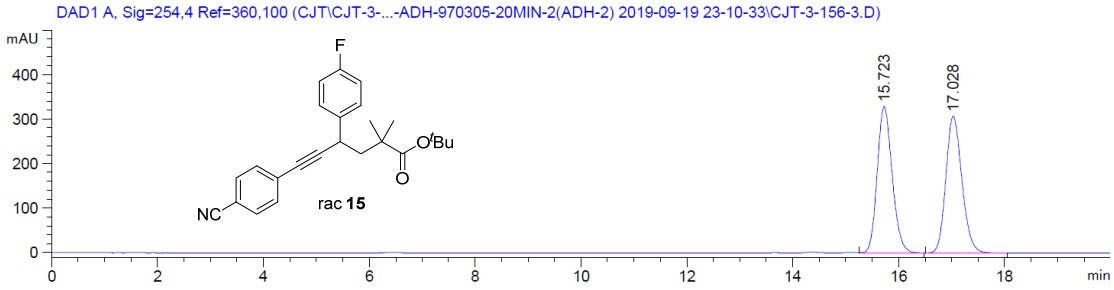
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.008	BV	0.3045	2998.67676	155.84207	50.1583
2	11.338	VB	0.3422	2979.74731	138.91982	49.8417
Totals :				5978.42407	294.76189	



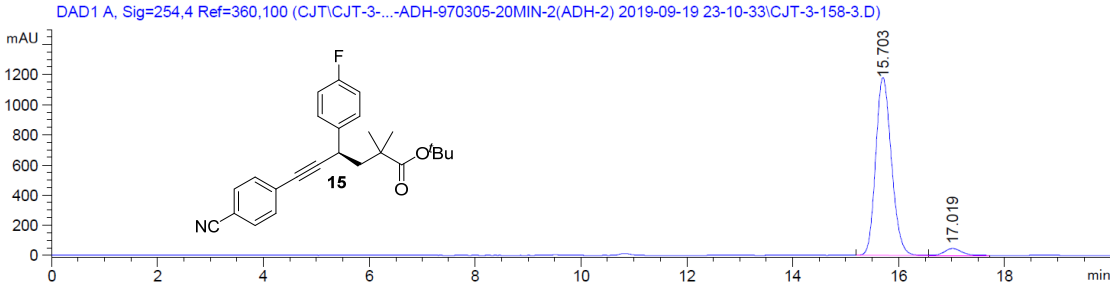
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.025	BV	0.3101	1.00822e4	515.58392	97.6815
2	11.337	VB	0.3320	239.30016	11.25737	2.3185
Totals :				1.03215e4	526.84129	



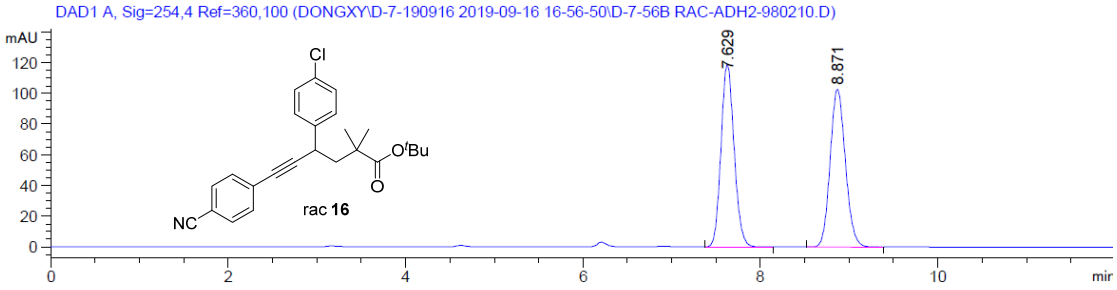
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	15.723	VB	0.3031	6448.95654	328.45575	49.9606
2	17.028	BB	0.3256	6459.11670	306.82410	50.0394
Totals :				1.29081e4	635.27985	



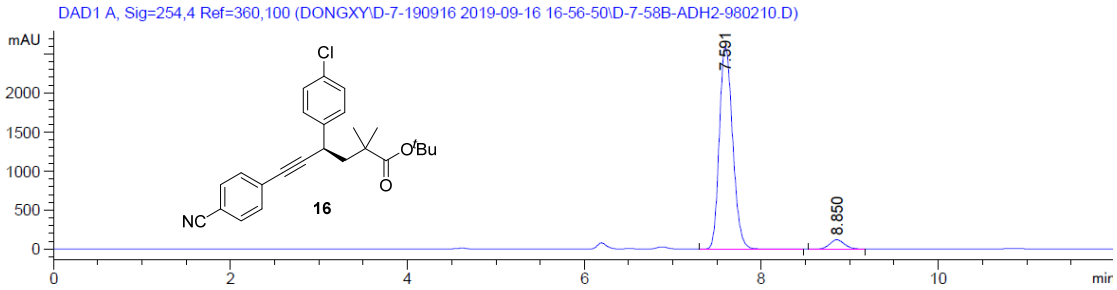
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	15.703	VV	0.3204	2.43501e4	1181.84229	96.0009
2	17.019	VB	0.3464	1014.34229	45.79979	3.9991
Totals :				2.53644e4	1227.64207	



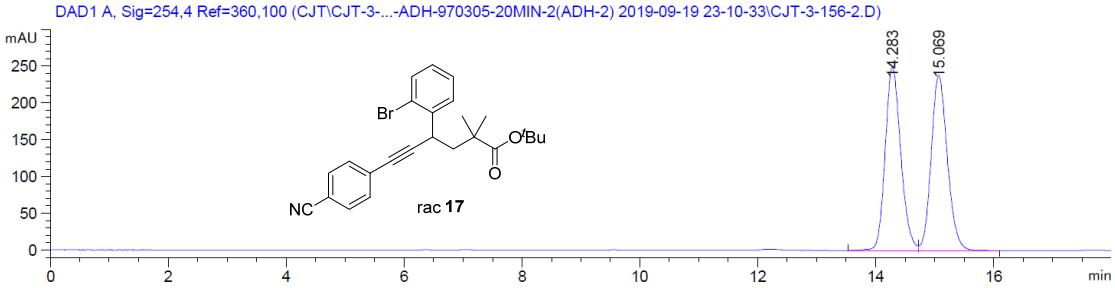
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.629	BB	0.1581	1228.37537	119.35578	49.9708
2	8.871	BB	0.1854	1229.81091	102.91573	50.0292
Totals :				2458.18628	222.27151	



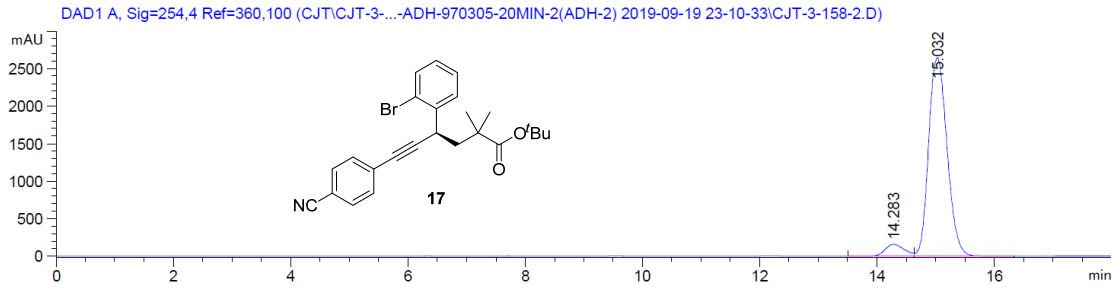
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.591	BB	0.1646	2.72255e4	2591.50342	95.2287
2	8.850	BV	0.1787	1364.10217	118.18421	4.7713
Totals :				2.85896e4	2709.68763	



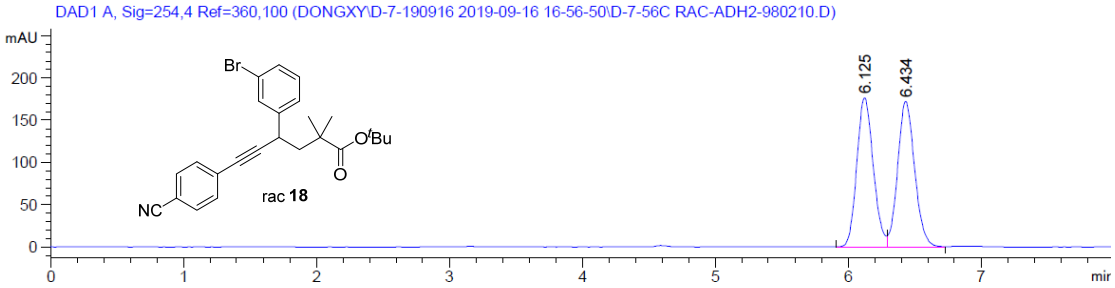
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	14.283	BV	0.2827	4584.15869	249.13396	50.2477
2	15.069	VB	0.2945	4538.95898	238.03766	49.7523
Totals :				9123.11768	487.17162	



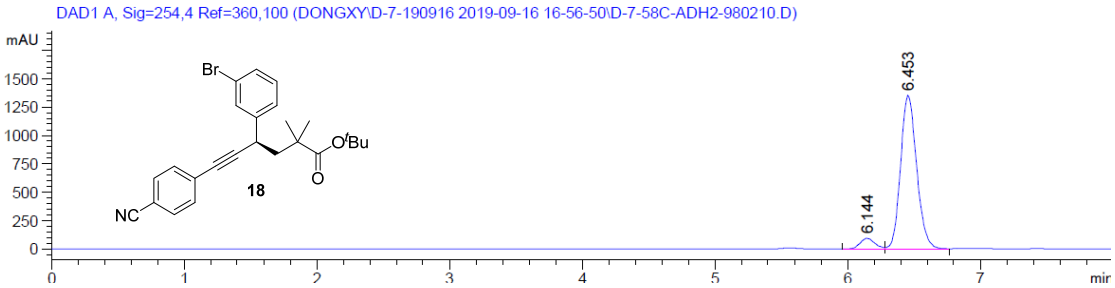
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	14.283	BV	0.3535	3633.41821	158.46327	5.9227
2	15.032	VB	0.3446	5.77138e4	2644.47632	94.0773
Totals :				6.13472e4	2802.93959	



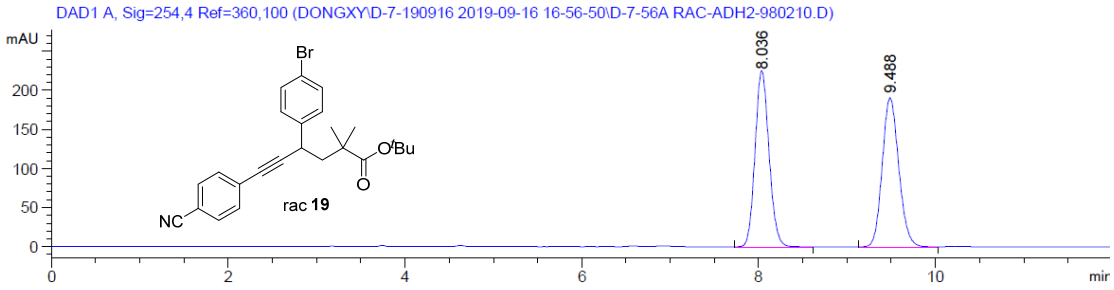
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.125	BV	0.1319	1508.66162	176.21237	49.7119
2	6.434	VB	0.1376	1526.14636	171.90909	50.2881
Totals :				3034.80798	348.12146	



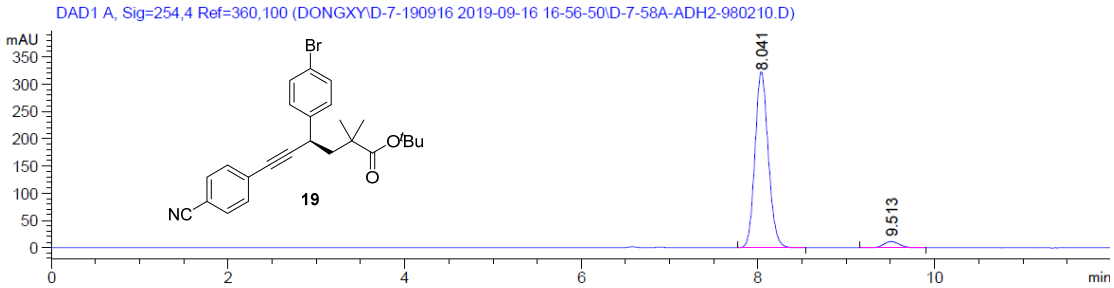
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.144	BV	0.1203	716.04517	92.50546	5.9480
2	6.453	VB	0.1298	1.13223e4	1350.60046	94.0520
Totals :				1.20383e4	1443.10592	



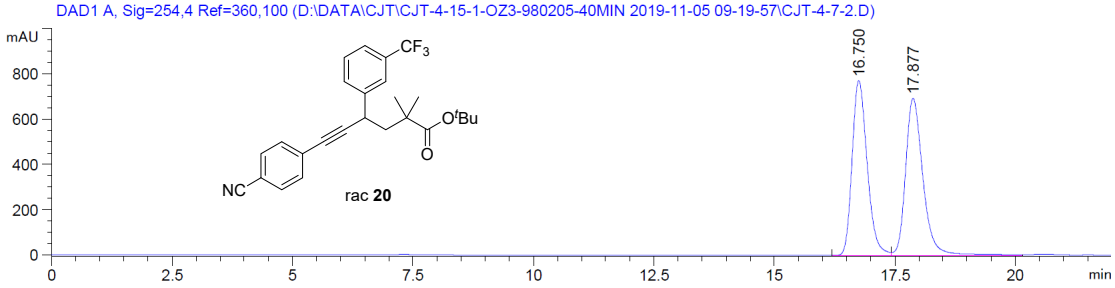
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.036	BB	0.1700	2476.59131	225.69868	49.9545
2	9.488	BB	0.2019	2481.09985	190.61894	50.0455
Totals :				4957.69116	416.31763	



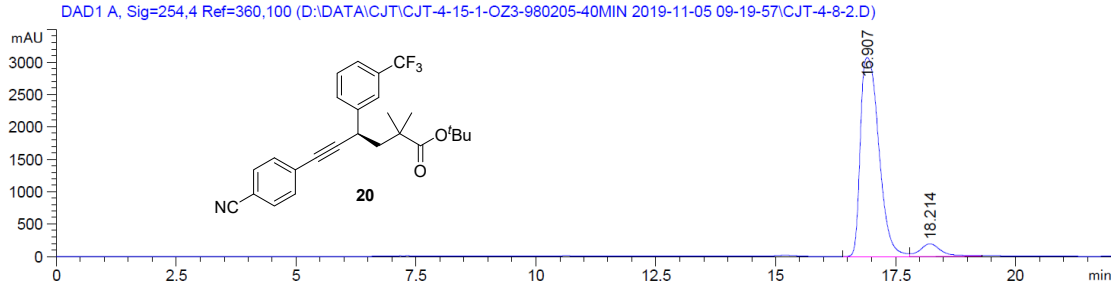
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.041	BB	0.1622	3383.14795	323.10596	95.8819
2	9.513	BB	0.1969	145.30525	11.53650	4.1181
Totals :				3528.45320	334.64245	



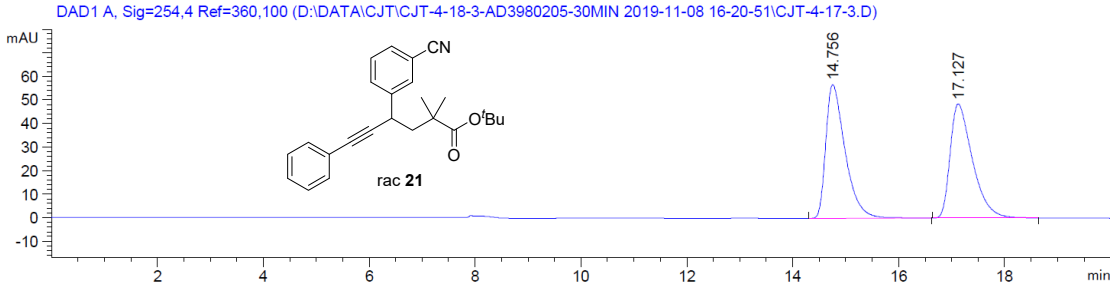
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	16.750	BV	0.3327	1.67234e4	772.07825	49.1200
2	17.877	VV	0.3816	1.73226e4	693.12799	50.8800
Totals :				3.40461e4	1465.20624	



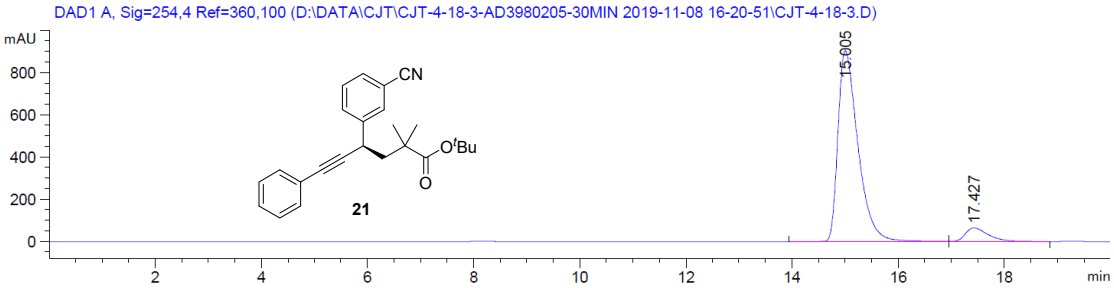
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	16.907	BV	0.4204	8.21386e4	3067.67017	93.2215
2	18.214	VV	0.4606	5972.62012	192.14595	6.7785
Totals :				8.81112e4	3259.81612	



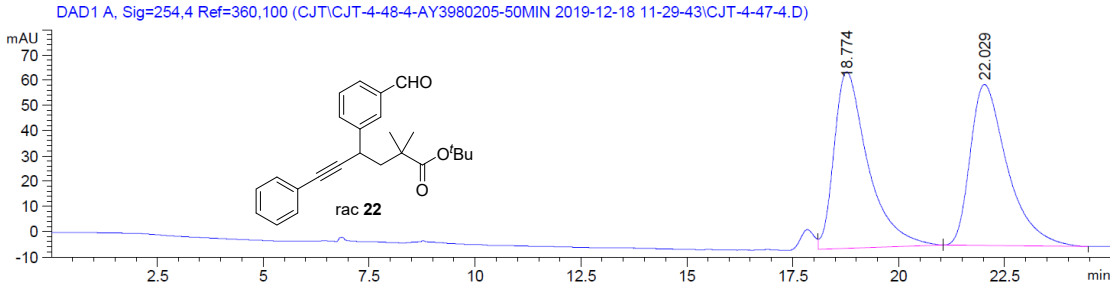
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	14.756	BB	0.3816	1437.55469	56.74049	50.4282
2	17.127	BB	0.4383	1413.14209	48.44251	49.5718
Totals :				2850.69678	105.18300	



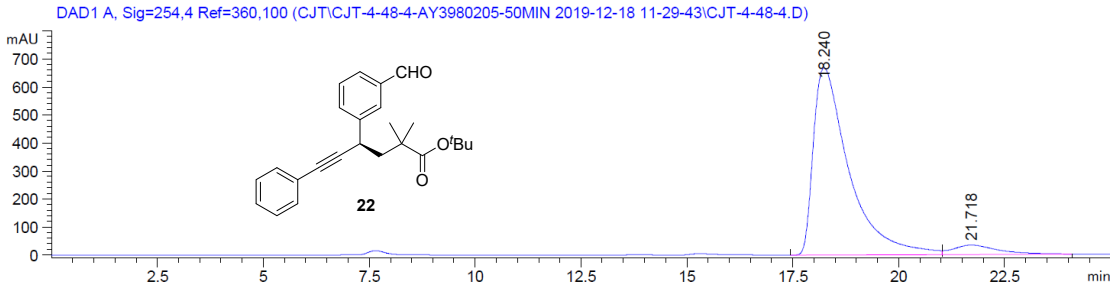
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	15.005	BV	0.4017	2.36423e4	902.31360	92.3043
2	17.427	VV	0.4524	1971.13513	65.24872	7.6957
Totals :				2.56134e4	967.56232	



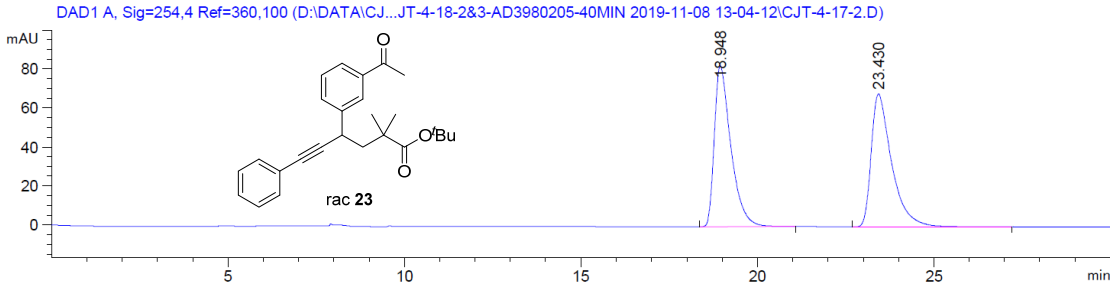
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	18.774	VB	0.8259	3899.42847	70.00223	50.0651
2	22.029	BB	0.9093	3889.28955	63.79278	49.9349
Totals :				7788.71802	133.79501	



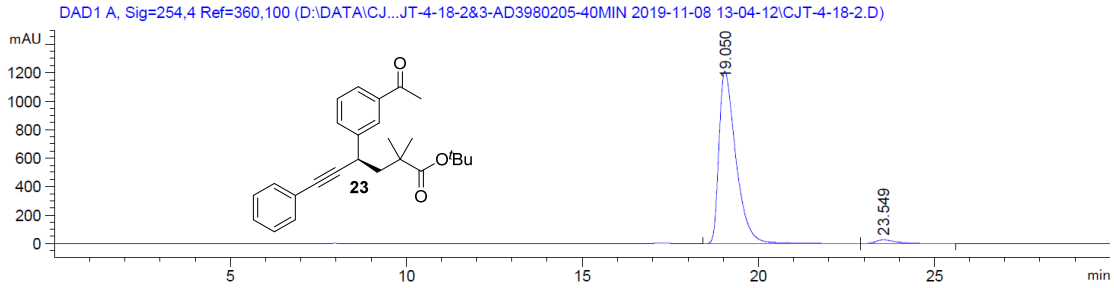
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	18.240	BV	0.8611	3.90897e4	667.63245	94.1917
2	21.718	VB	1.0197	2410.46265	33.41200	5.8083
Totals :				4.15002e4	701.04445	



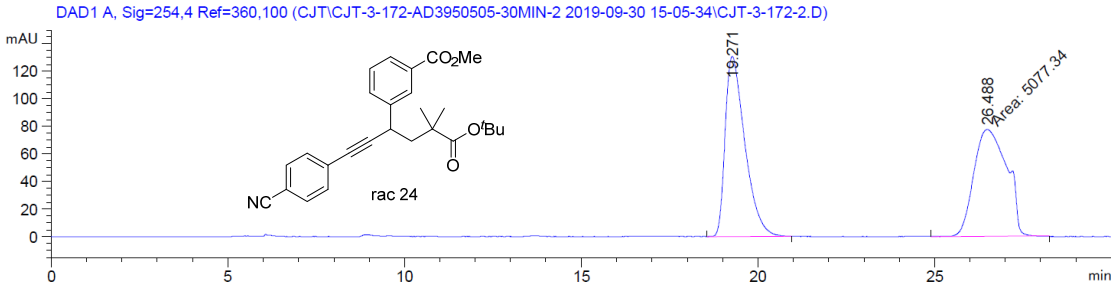
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	18.948	BB	0.4883	2686.54883	82.41031	49.4788
2	23.430	BB	0.5918	2743.15259	68.11906	50.5212
Totals :				5429.70142	150.52937	



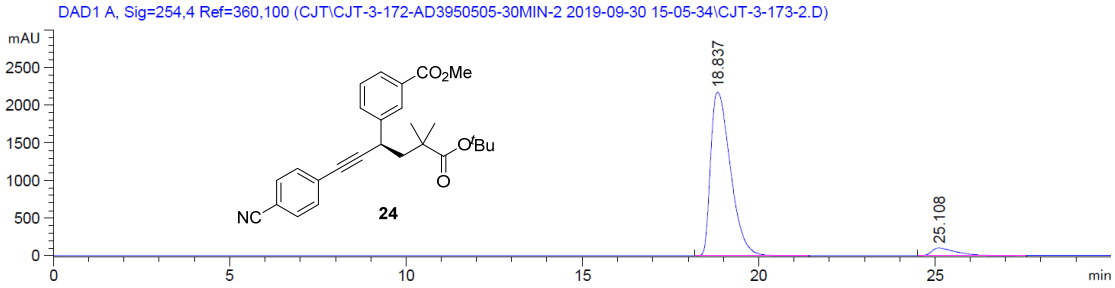
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	19.050	BV	0.4962	4.03757e4	1213.56494	97.5707
2	23.549	VB	0.5735	1005.28259	25.86107	2.4293
Totals :				4.13810e4	1239.42601	



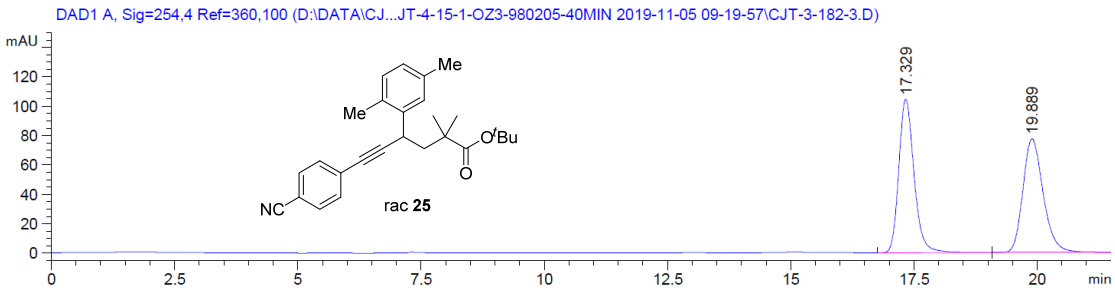
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	19.271	BB	0.5821	5062.56592	130.63191	49.9272
2	26.488	MM	1.0906	5077.33789	77.58896	50.0728
Totals :				1.01399e4	208.22087	



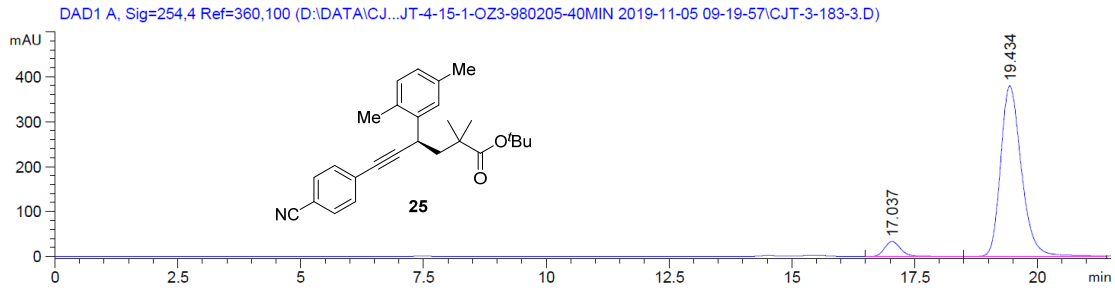
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	18.837	BB	0.6103	8.46240e4	2173.39795	94.5237
2	25.108	BB	0.6877	4902.79053	101.11007	5.4763
Totals :				8.95268e4	2274.50802	



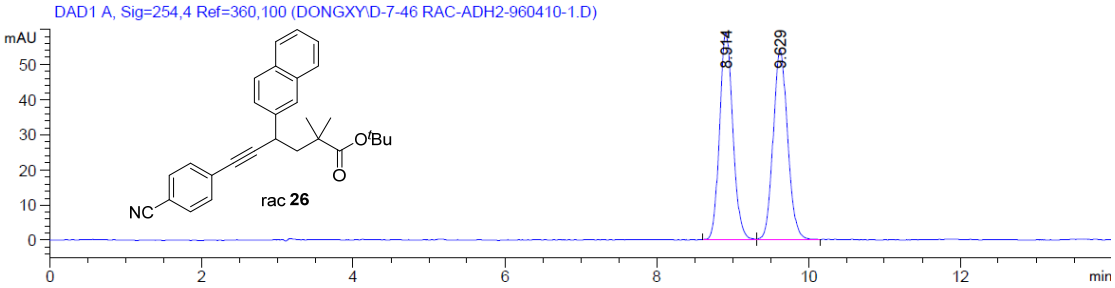
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	17.329	BB	0.3291	2249.07300	104.51752	50.2584
2	19.889	BB	0.4391	2225.94849	77.48733	49.7416
Totals :				4475.02148	182.00484	



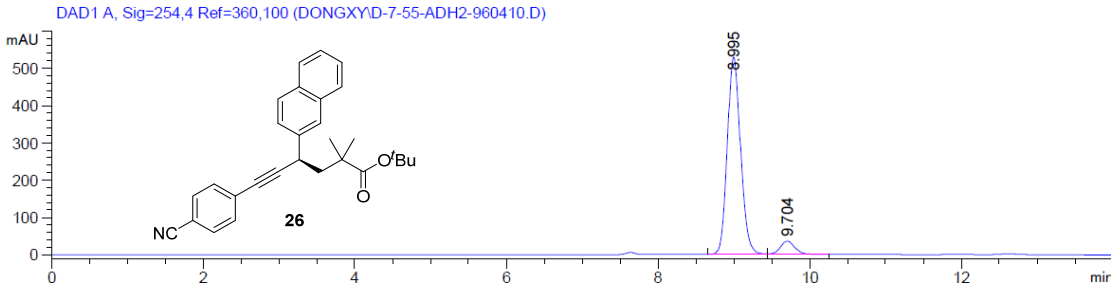
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	17.037	BB	0.3605	781.04919	33.44235	6.5012
2	19.434	BV	0.4509	1.12328e4	379.99142	93.4988
Totals :				1.20139e4	413.43377	



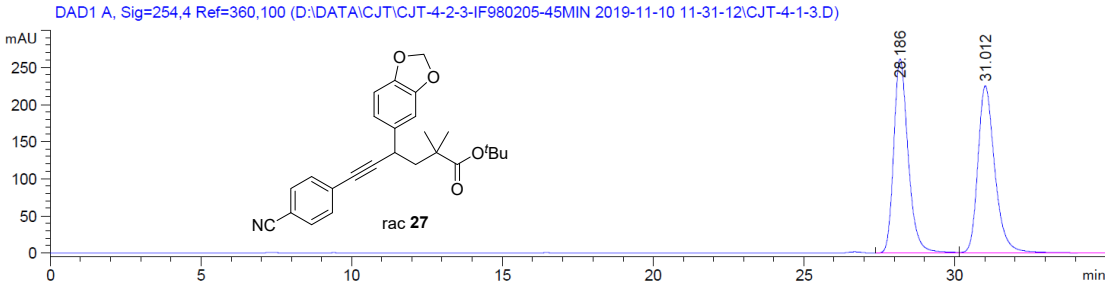
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.914	BV	0.1855	714.00421	58.87333	49.9179
2	9.629	VB	0.2049	716.35333	53.94331	50.0821
Totals :				1430.35754	112.81664	



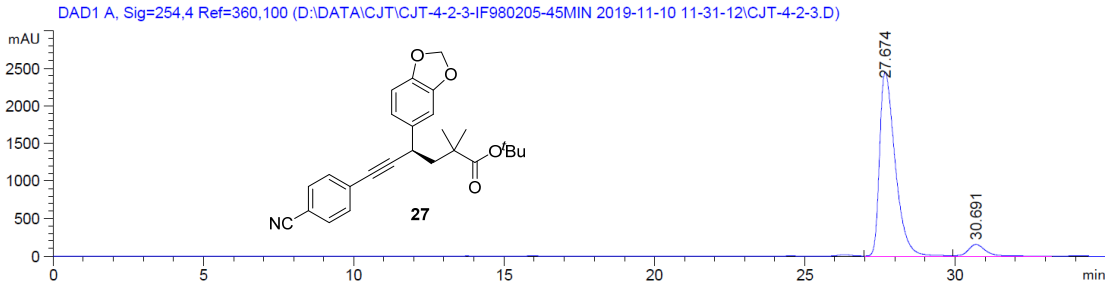
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.995	BV	0.1882	6442.56689	528.52838	93.1701
2	9.704	VB	0.2085	472.27814	35.21478	6.8299
Totals :				6914.84503	563.74316	



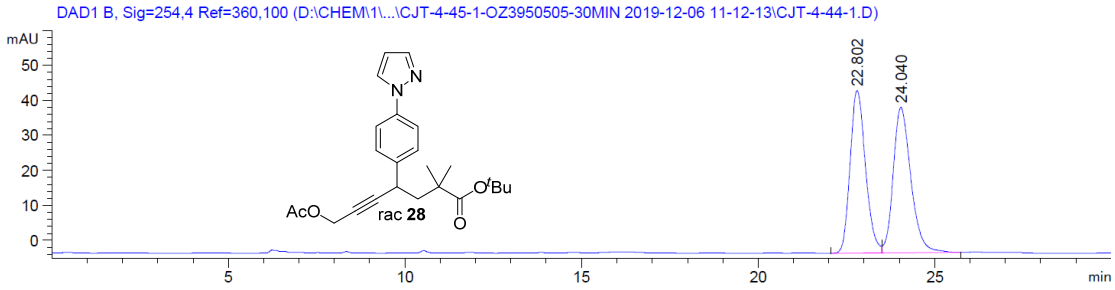
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	28.186	VV	0.5091	8732.04590	261.79999	49.6066
2	31.012	VB	0.5970	8870.55371	225.47795	50.3934
Totals :				1.76026e4	487.27794	



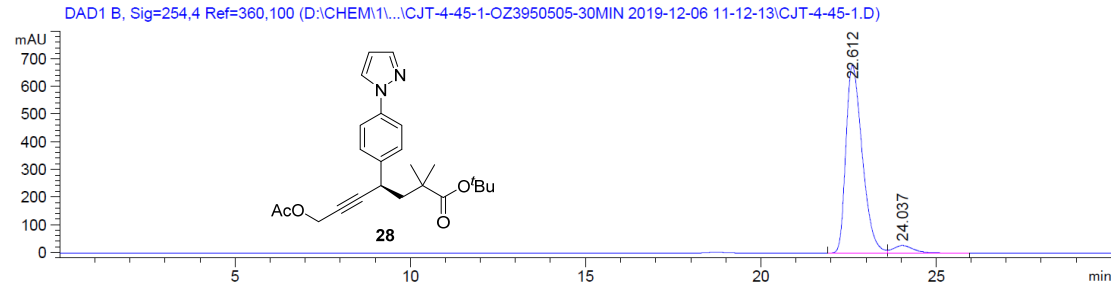
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	27.674	VV	0.5491	8.79661e4	2448.83740	93.5656
2	30.691	VB	0.5886	6049.37012	155.23265	6.4344
Totals :				9.40155e4	2604.07005	



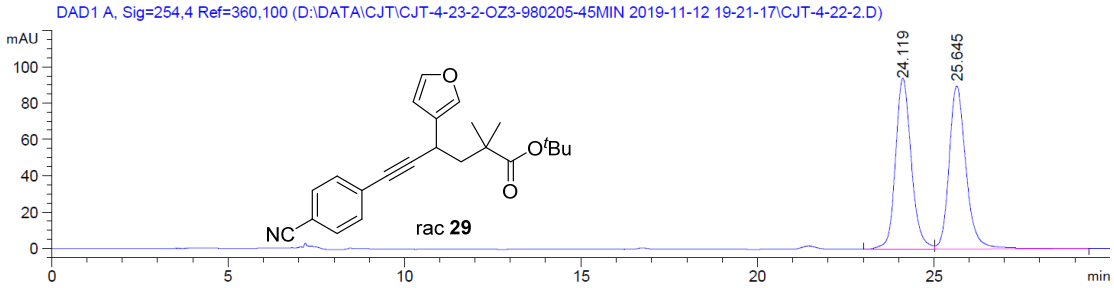
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	22.802	BV	0.4693	1405.36633	46.41291	49.2446
2	24.040	VB	0.5282	1448.48438	41.60647	50.7554
Totals :				2853.85071	88.01938	



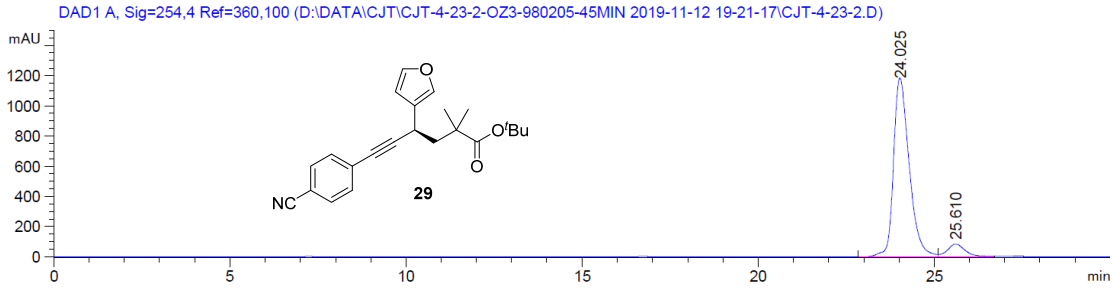
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	22.612	BV	0.5030	2.20600e4	678.99518	95.2638
2	24.037	VB	0.6017	1096.75525	27.24277	4.7362
Totals :				2.31567e4	706.23795	



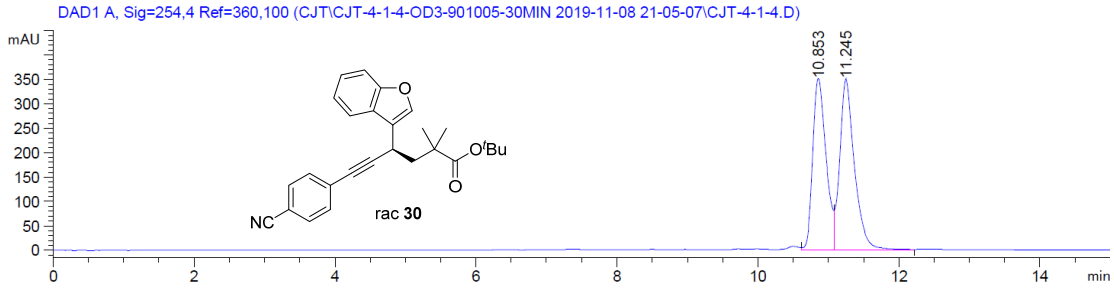
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	24.119	BV	0.4758	2919.05786	94.12176	49.3627
2	25.645	VB	0.5074	2994.42627	89.72096	50.6373
Totals :				5913.48413	183.84272	



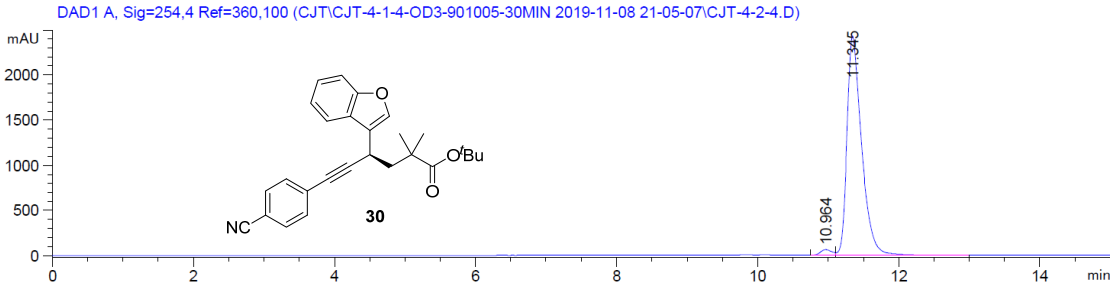
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	24.025	BV	0.4726	3.66365e4	1185.30322	92.3160
2	25.610	VV	0.5382	3049.47363	84.66924	7.6840
Totals :				3.96860e4	1269.97247	



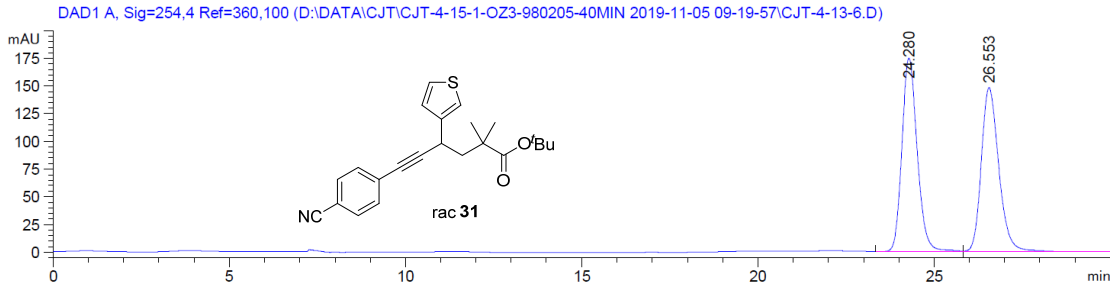
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.853	VV	0.1951	4543.17920	350.85968	47.2434
2	11.245	VB	0.2132	5073.34863	349.86975	52.7566
Totals :				9616.52783	700.72943	



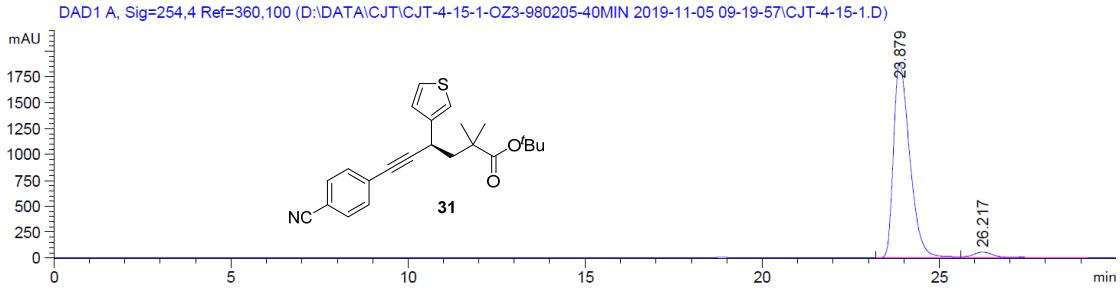
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.964	BV	0.1747	718.91083	63.18927	2.0244
2	11.345	VB	0.2150	3.47939e4	2430.25317	97.9756
Totals :				3.55128e4	2493.44244	



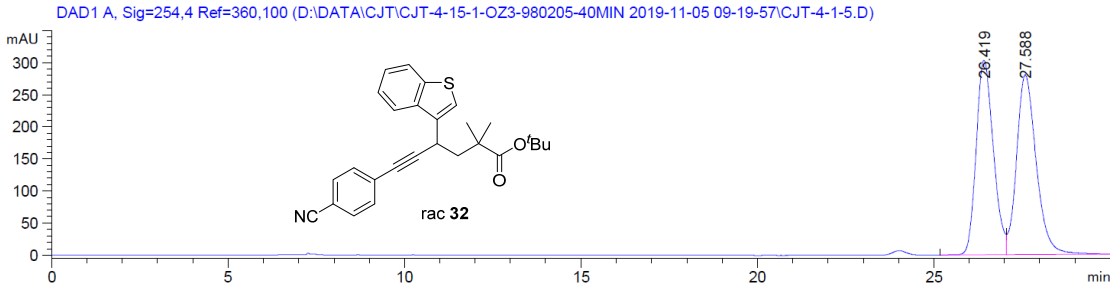
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	24.280	BV	0.4637	5269.39990	174.79636	50.5791
2	26.553	VB	0.5285	5148.74512	148.48883	49.4209
Totals :				1.04181e4	323.28519	



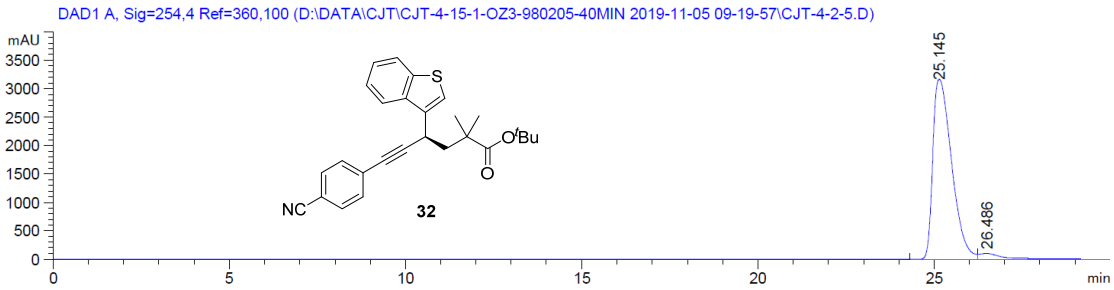
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	23.879	BV	0.4874	6.04618e4	1889.11804	95.8671
2	26.217	VB	0.6547	2606.57178	57.95861	4.1329
Totals :				6.30684e4	1947.07665	



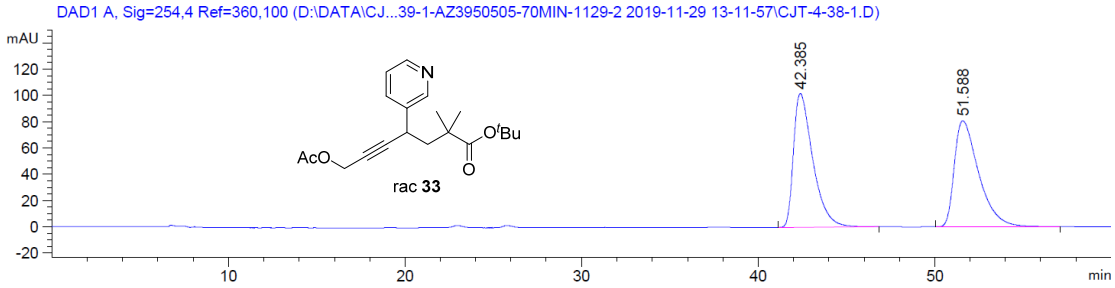
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	26.419	BV	0.5267	1.02680e4	303.47620	48.4640
2	27.588	VB	0.5915	1.09188e4	280.89456	51.5360
Totals :				2.11868e4	584.37076	



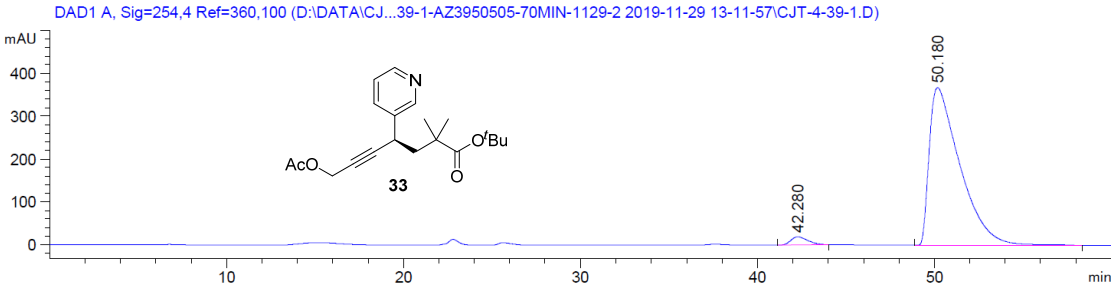
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	25.145	BV	0.5716	1.17148e5	3166.87402	95.7628
2	26.486	VB	0.7031	5183.43701	101.96001	4.2372
Totals :				1.22331e5	3268.83404	



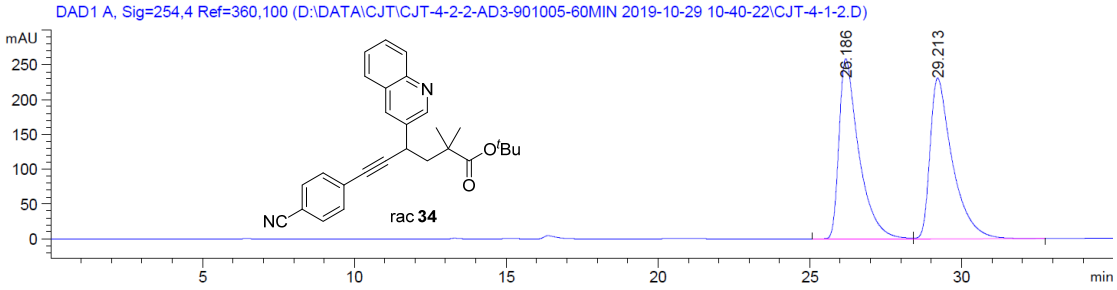
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	42.385	BB	1.1541	7750.16748	101.81424	50.0284
2	51.588	BB	1.4446	7741.35840	80.74204	49.9716
Totals :				1.54915e4	182.55628	



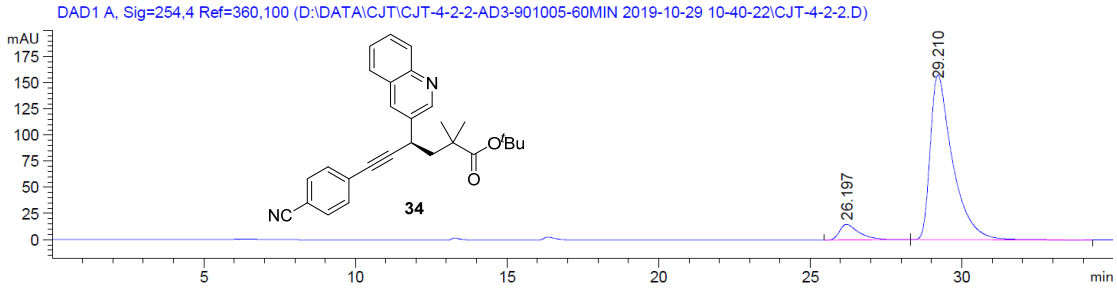
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	42.280	BB	0.9957	1244.65991	18.91478	2.7489
2	50.180	BB	1.7131	4.40335e4	367.19342	97.2511
Totals :				4.52782e4	386.10820	



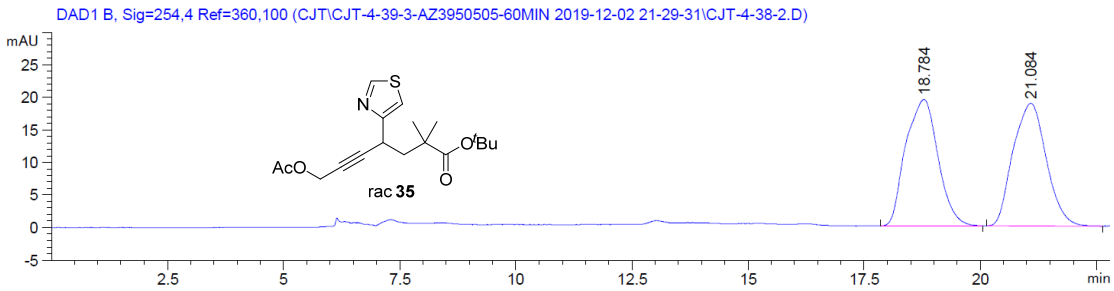
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	26.186	BV	0.6618	1.17463e4	258.66711	49.8264
2	29.213	VB	0.7454	1.18281e4	230.97859	50.1736
Totals :				2.35744e4	489.64571	



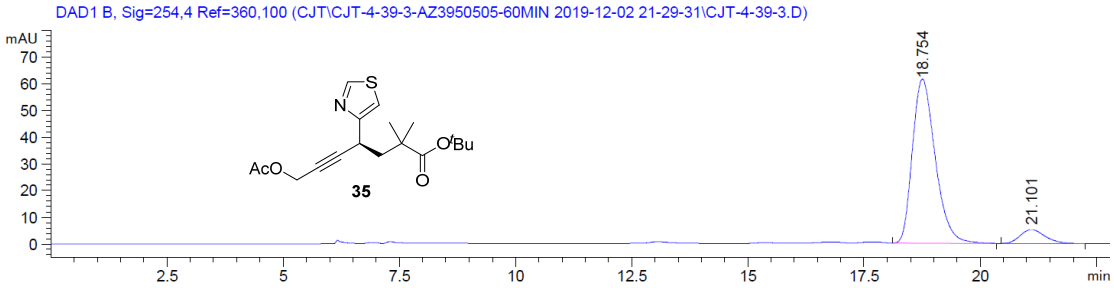
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	26.197	BB	0.6596	669.47949	14.91753	7.6668
2	29.210	BB	0.7473	8062.67285	157.49063	92.3332
Totals :				8732.15234	172.40817	



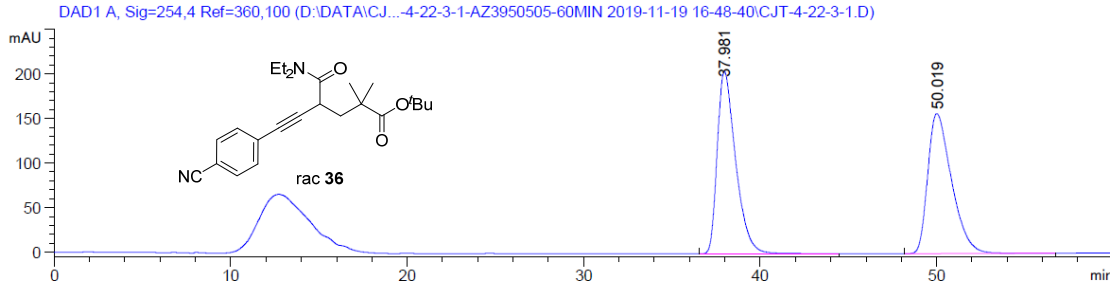
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	18.784	BB	0.6778	941.92542	19.42363	50.0661
2	21.084	BB	0.6979	939.43787	18.83613	49.9339
Totals :				1881.36328	38.25976	



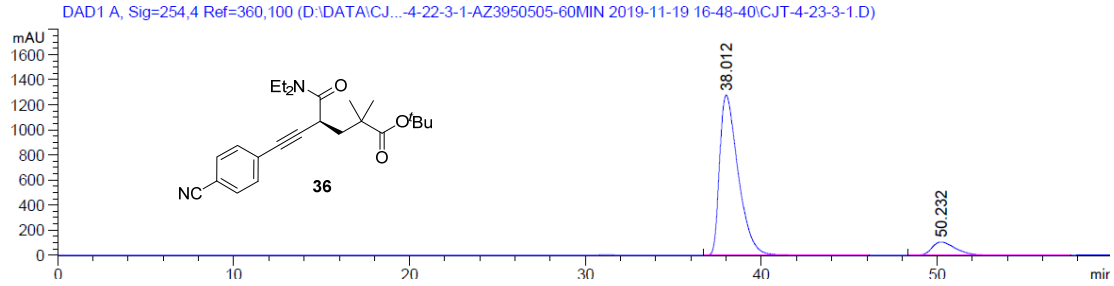
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	18.754	BB	0.5322	2097.30005	61.45028	91.6463
2	21.101	BB	0.5417	191.17317	5.18992	8.3537
Totals :				2288.47322	66.64020	



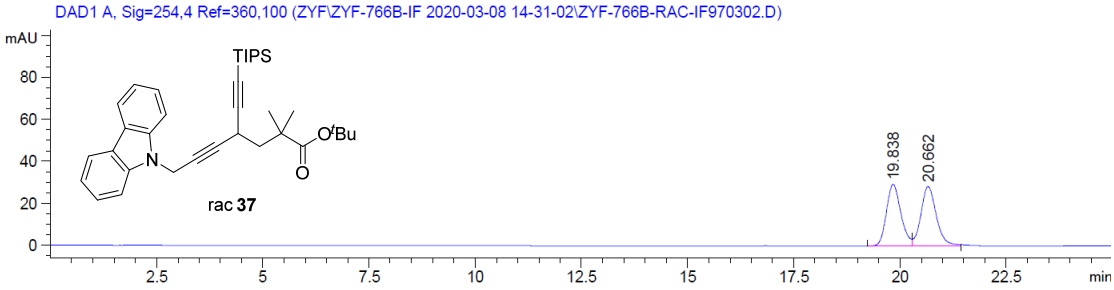
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	37.981	BB	1.0860	1.48438e4	204.69620	50.1848
2	50.019	BB	1.3935	1.47345e4	156.91739	49.8152
Totals :				2.95783e4	361.61359	



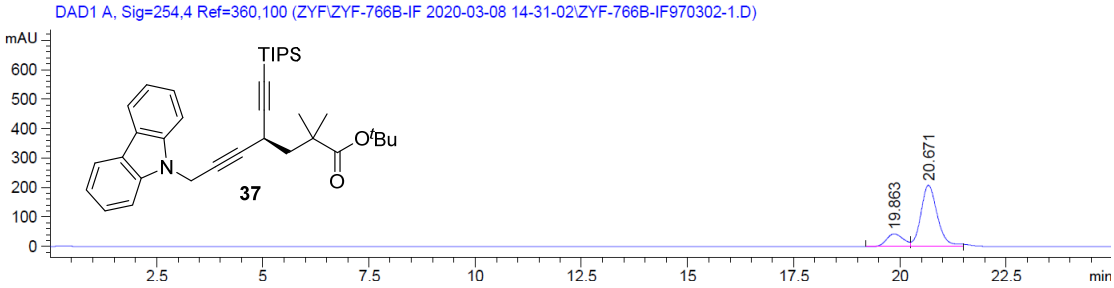
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	38.012	VB	1.1155	9.37797e4	1275.88586	90.4148
2	50.232	BB	1.3903	9941.93848	106.18739	9.5852
Totals :				1.03722e5	1382.07326	



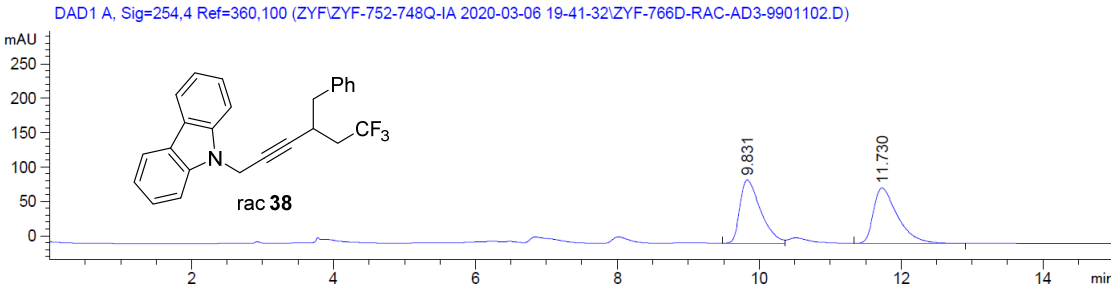
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	19.838	BV	0.3619	694.75287	29.38045	49.2771
2	20.662	MF R	0.4203	715.13733	28.36056	50.7229
Totals :				1409.89020	57.74101	



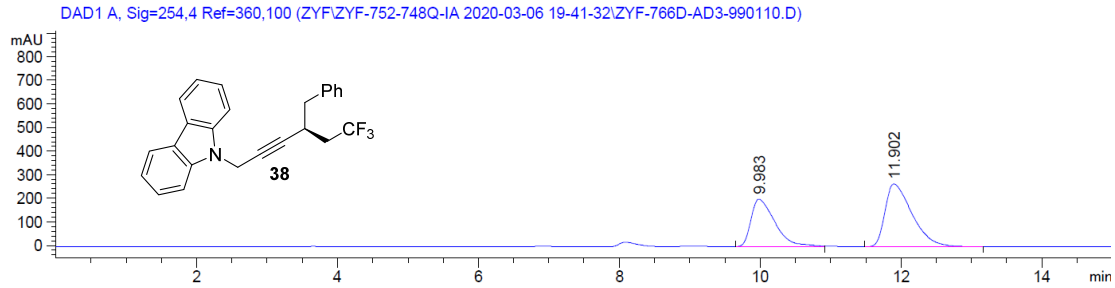
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	19.863	BV	0.4273	1191.67480	43.27234	17.4276
2	20.671	MF R	0.4519	5646.16846	208.21959	82.5724
Totals :				6837.84326	251.49193	



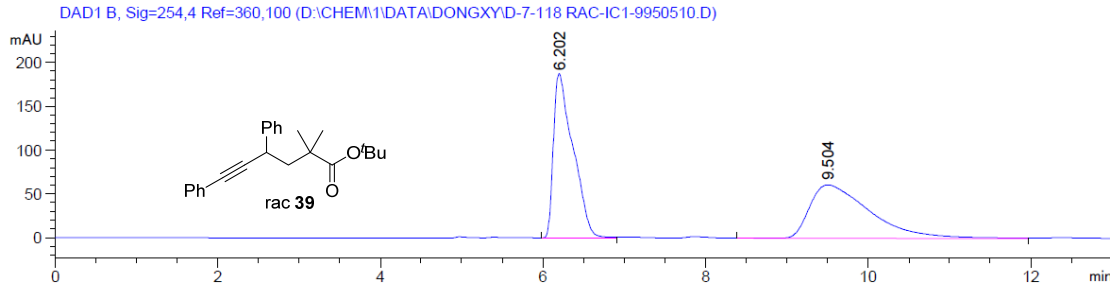
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.831	BV	0.3078	1852.73010	91.65468	49.5967
2	11.730	BB	0.3514	1882.86462	80.35995	50.4033
Totals :				3735.59473	172.01463	



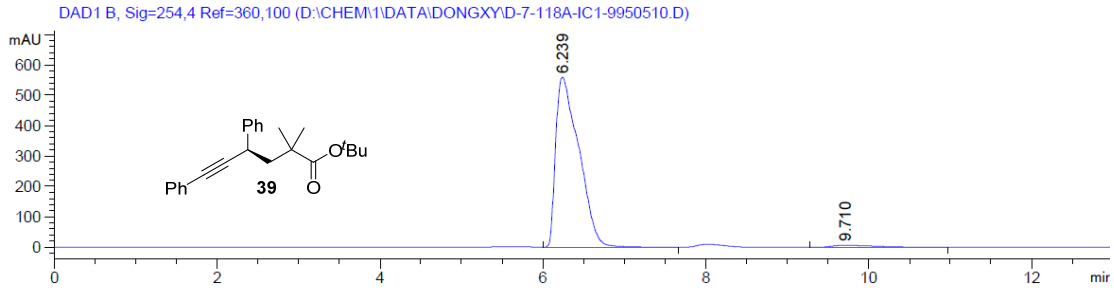
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.983	MM R	0.3927	4753.51270	201.73419	40.2100
2	11.902	BB	0.4165	7068.21826	265.55365	59.7900
Totals :				1.18217e4	467.28784	



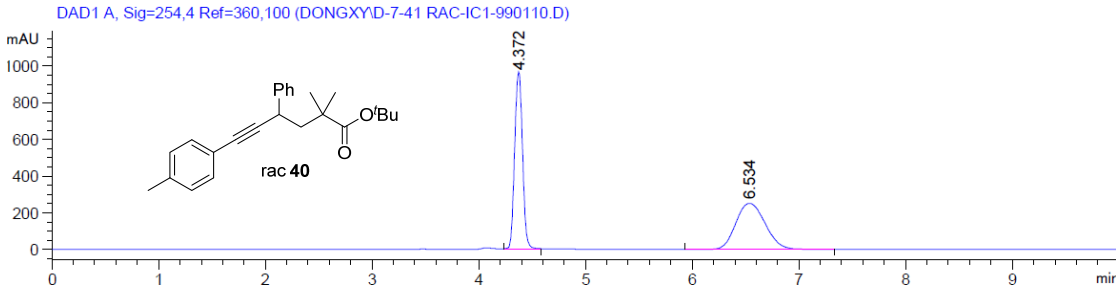
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.202	BV	0.2353	3149.34180	188.10683	50.0656
2	9.504	BV	0.8073	3141.08862	61.14469	49.9344
Totals :				6290.43042	249.25151	



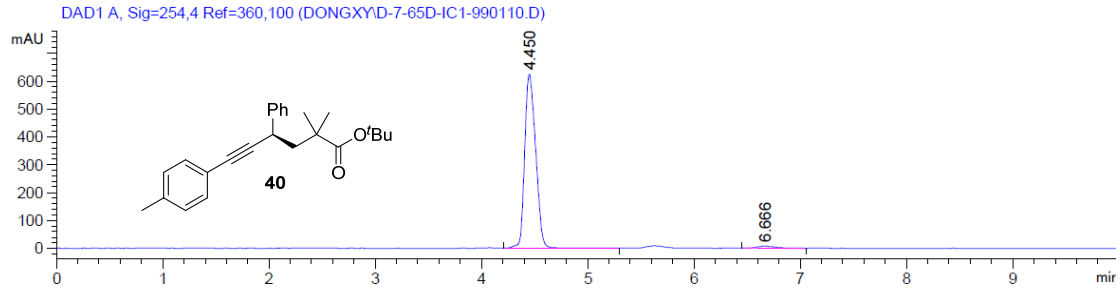
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.239	VB	0.2827	1.10752e4	560.16913	97.9189
2	9.710	MM R	0.5955	235.38094	6.58729	2.0811
Totals :				1.13106e4	566.75642	



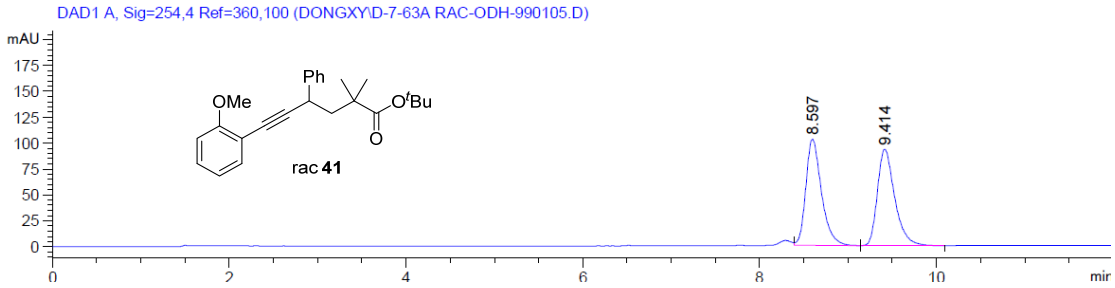
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	4.372	MM R	0.0848	4914.72217	966.10699	50.5425
2	6.534	MM R	0.3188	4809.20996	251.38422	49.4575
Totals :				9723.93213	1217.49121	



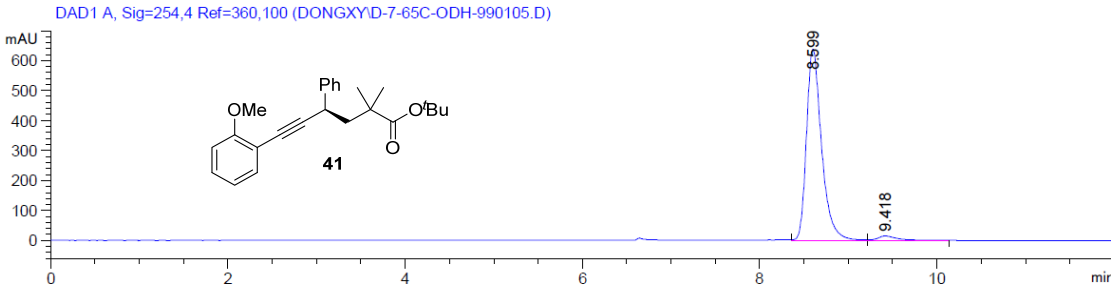
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	4.450	VB	0.1178	4490.42578	625.29132	97.9407
2	6.666	BB	0.1958	94.41592	7.35489	2.0593
Totals :				4584.84171	632.64621	



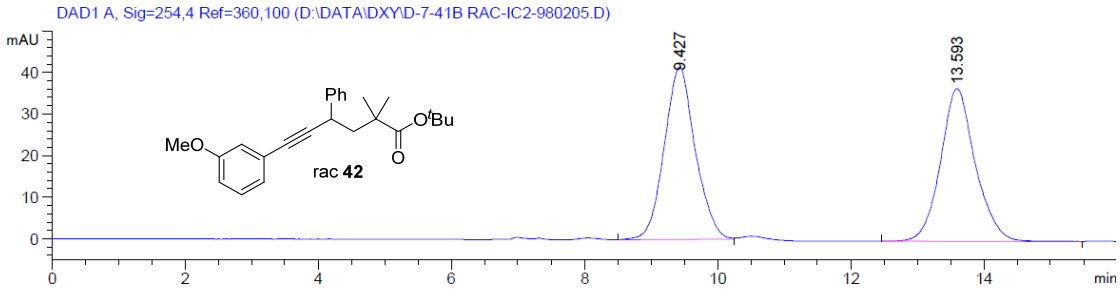
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.597	VB	0.1857	1266.12915	102.80067	50.0310
2	9.414	BB	0.2065	1264.56030	93.09380	49.9690
Totals :				2530.68945	195.89446	



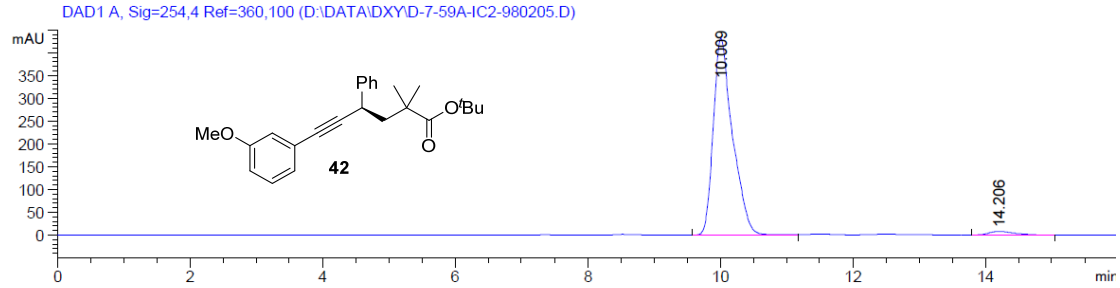
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.599	VV	0.1794	7514.17139	637.98065	97.2802
2	9.418	VB	0.2113	210.08444	14.64723	2.7198
Totals :				7724.25583	652.62788	



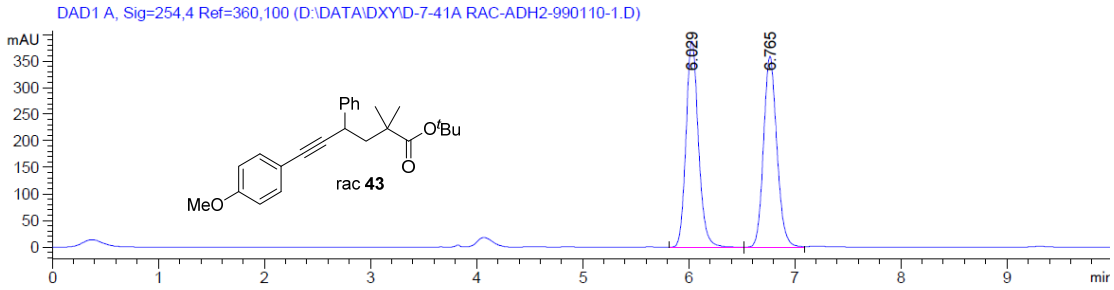
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.427	PM R	0.5393	1340.15222	41.41570	50.0724
2	13.593	VB	0.5357	1336.27417	36.79116	49.9276
Totals :				2676.42639	78.20685	



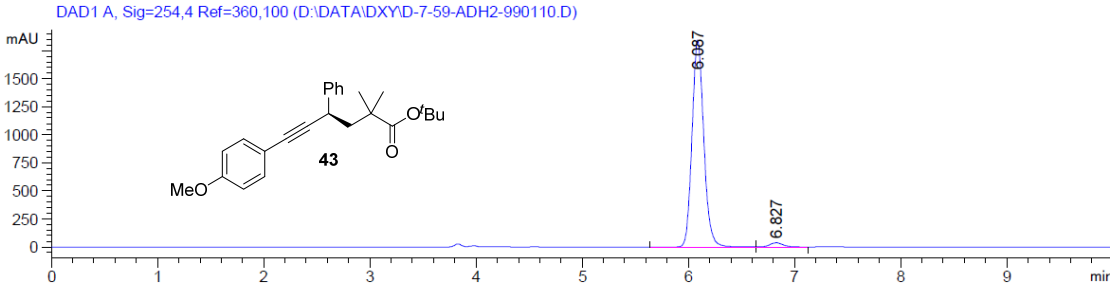
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.009	BV	0.2950	8705.35645	432.26004	97.7066
2	14.206	BB	0.3949	204.33649	7.66687	2.2934
Totals :				8909.69293	439.92692	



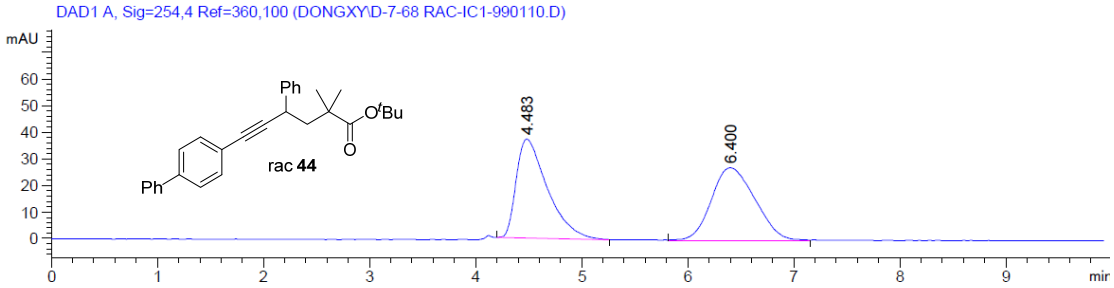
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.029	VB	0.1267	3149.25854	388.15182	50.1868
2	6.765	BV	0.1355	3125.81274	359.19843	49.8132
Totals :				6275.07129	747.35025	



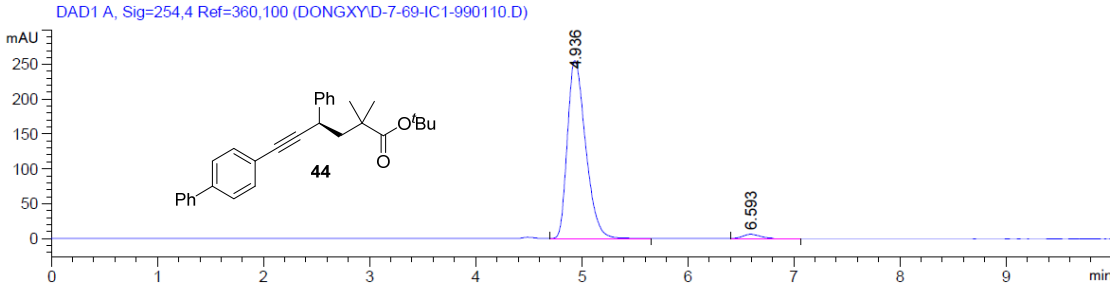
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.087	BV	0.1198	1.41919e4	1844.25476	97.7097
2	6.827	VV	0.1404	332.66104	36.47655	2.2903
Totals :				1.45246e4	1880.73131	



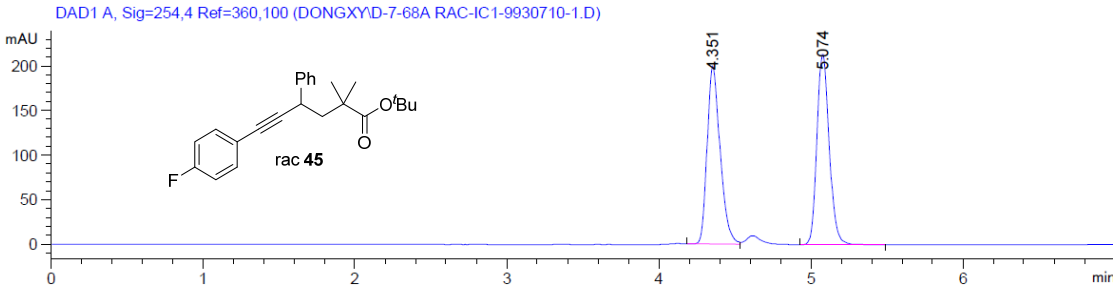
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	4.483	BB	0.3078	756.79382	37.12859	49.5876
2	6.400	BB	0.4100	769.38037	27.19870	50.4124
Totals :				1526.17419	64.32729	



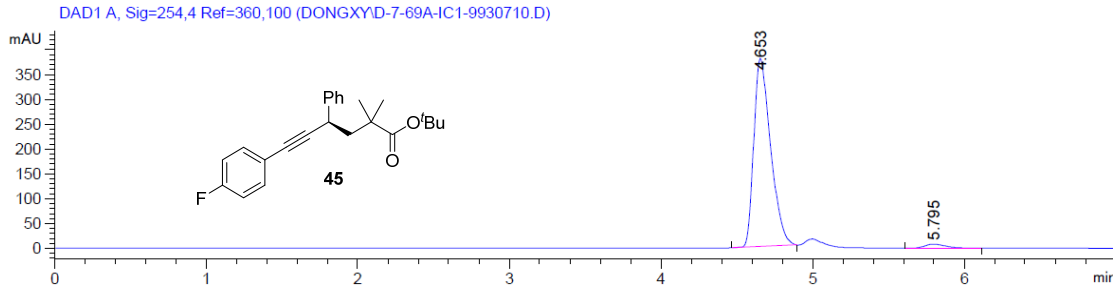
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	4.936	BB	0.1827	3038.54712	255.65346	97.7201
2	6.593	BB	0.1787	70.89193	6.13808	2.2799
Totals :				3109.43905	261.79154	



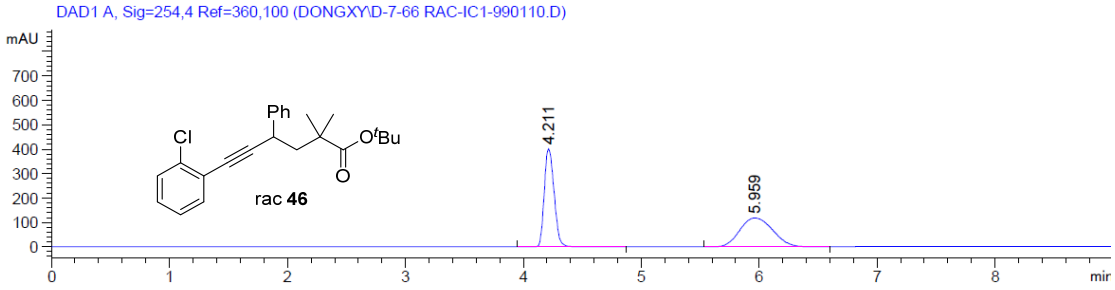
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	4.351	BV	0.0916	1188.51404	199.28923	49.7512
2	5.074	BB	0.0853	1200.40137	214.38448	50.2488
Totals :				2388.91541	413.67371	



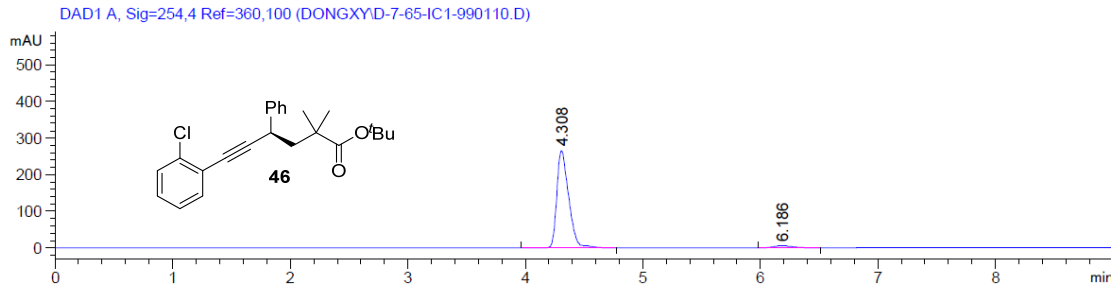
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	4.653	MM R	0.1277	2909.58179	379.59686	97.4694
2	5.795	BB	0.1411	75.54057	8.08003	2.5306
Totals :				2985.12235	387.67689	



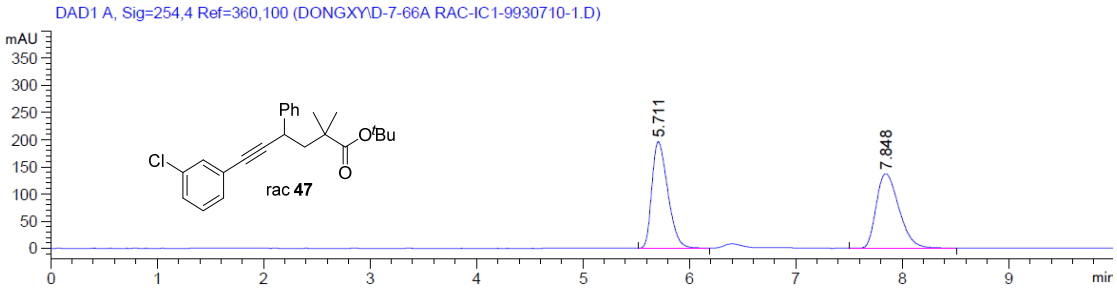
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	4.211	BB	0.0934	2319.35669	401.22198	50.2858
2	5.959	BB	0.3145	2292.99512	118.08895	49.7142
Totals :				4612.35181	519.31094	



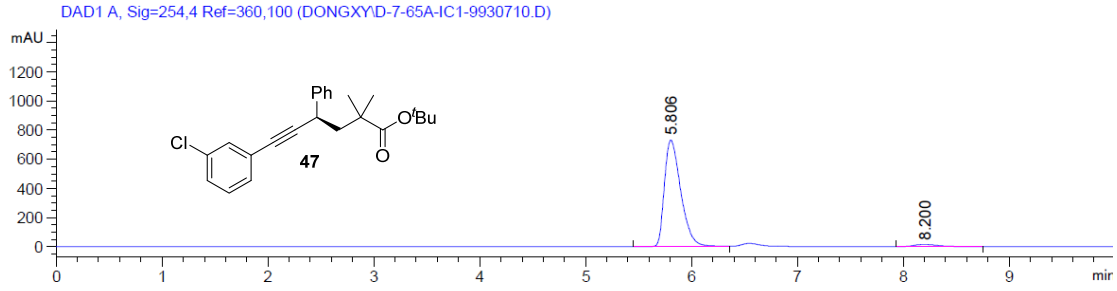
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	4.308	BB	0.1052	1849.19604	265.68259	96.7999
2	6.186	BB	0.1732	61.13306	5.43506	3.2001
Totals :				1910.32911	271.11764	



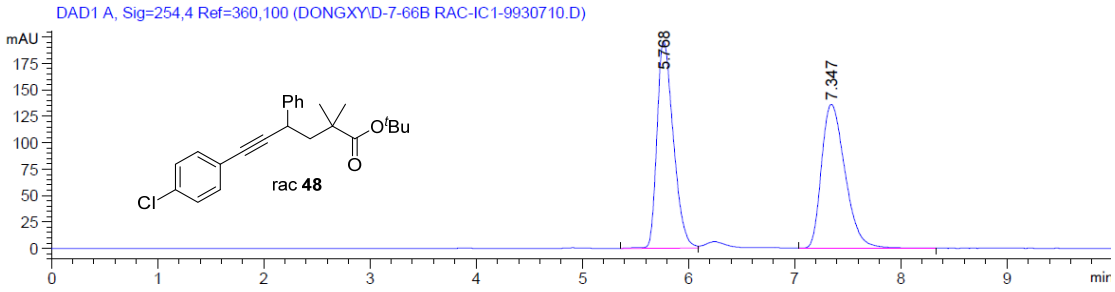
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	5.711	BB	0.1605	2029.38220	196.44568	49.9257
2	7.848	BB	0.2327	2035.42004	137.52225	50.0743
Totals :				4064.80225	333.96793	



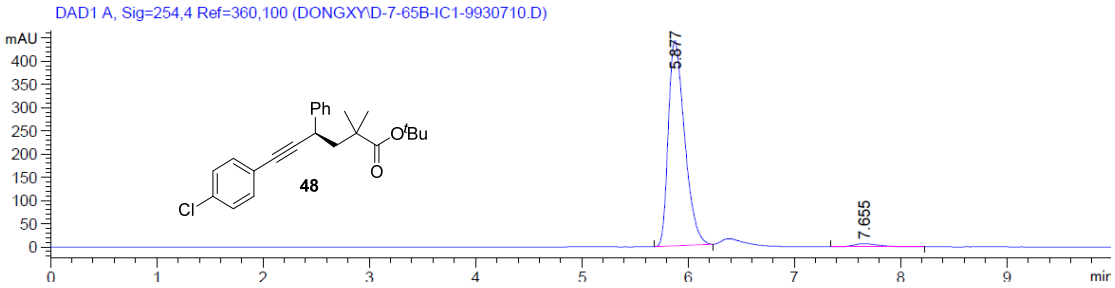
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	5.806	BV	0.1652	7861.32471	732.59369	97.0239
2	8.200	BB	0.2364	241.13655	15.76774	2.9761
Totals :				8102.46126	748.36143	



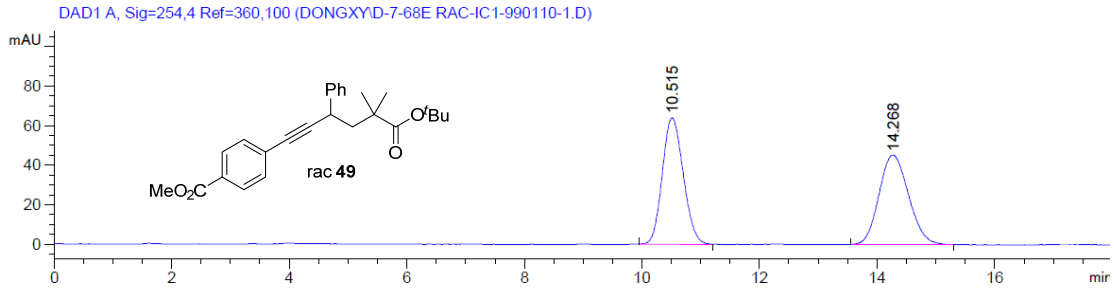
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	5.768	BV	0.1646	2096.00854	196.28316	49.9577
2	7.347	BB	0.2394	2099.55493	136.51146	50.0423
Totals :				4195.56348	332.79462	



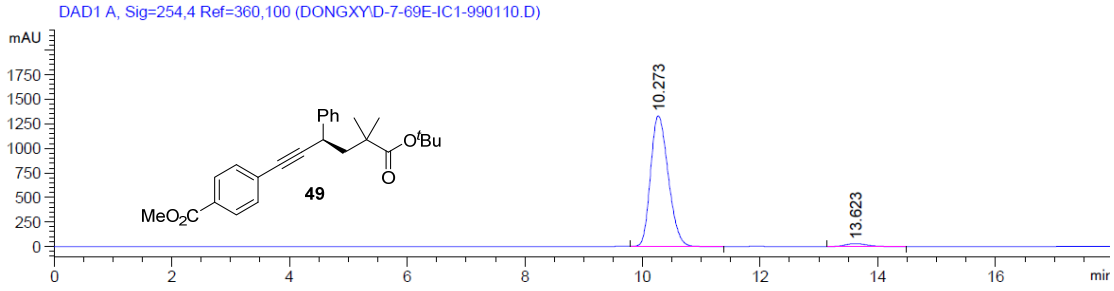
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	5.877	MM R	0.1773	4702.31104	442.00592	97.5933
2	7.655	BB	0.2534	115.96289	6.71721	2.4067
Totals :				4818.27393	448.72313	



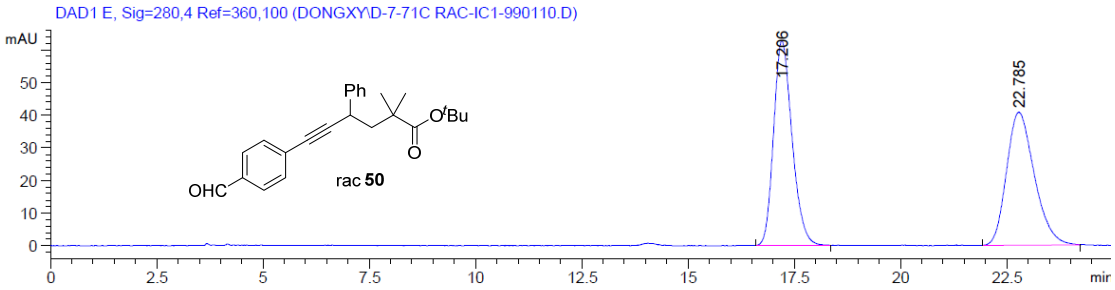
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.515	BB	0.3836	1586.25696	63.89269	50.0502
2	14.268	BB	0.5457	1583.07239	45.30571	49.9498
Totals :				3169.32935	109.19839	



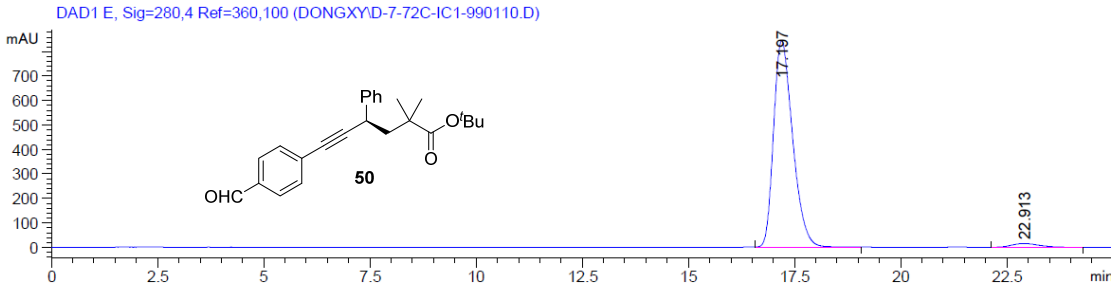
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.273	VB	0.3281	2.78173e4	1329.43298	97.2112
2	13.623	BB	0.3885	798.02722	30.57106	2.7888
Totals :				2.86153e4	1360.00405	



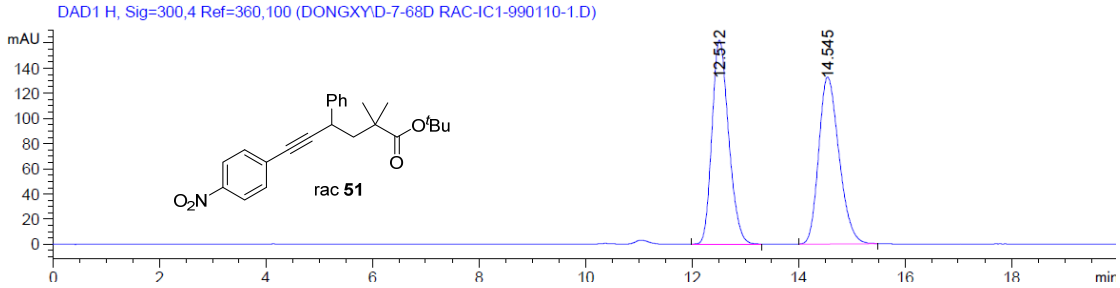
Signal 5: DAD1 E, Sig=280,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	17.206	BB	0.4557	1890.50024	62.71809	50.4911
2	22.785	BB	0.6365	1853.72375	40.77003	49.5089
Totals :				3744.22400	103.48812	



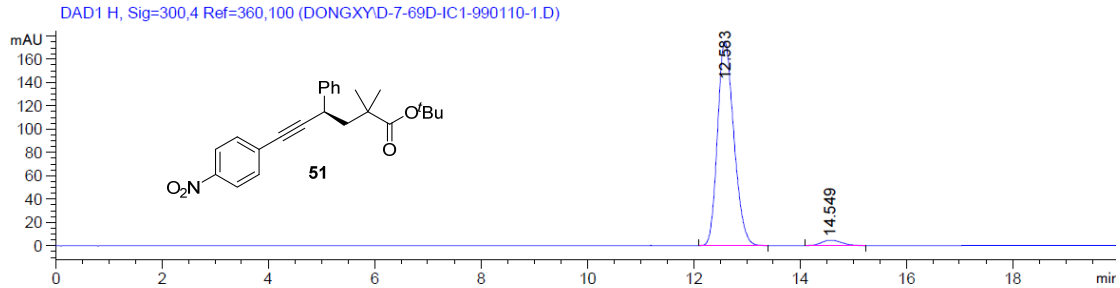
Signal 5: DAD1 E, Sig=280,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	17.197	BB	0.4759	2.63299e4	844.07996	97.3311
2	22.913	BB	0.5470	721.99683	15.86399	2.6689
Totals :				2.70519e4	859.94394	



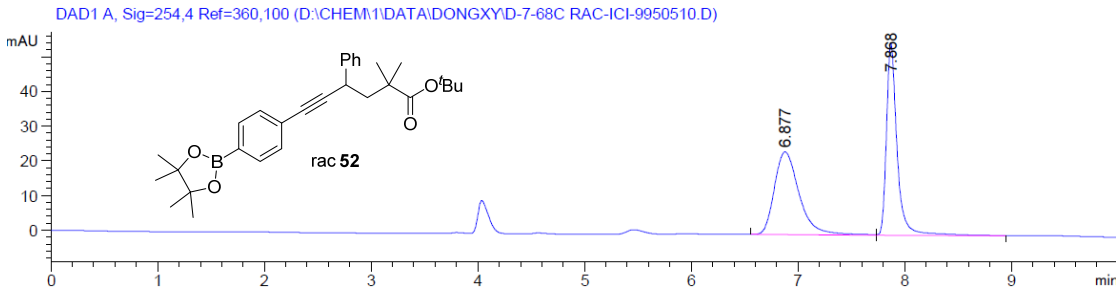
Signal 8: DAD1 H, Sig=300,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.512	BB	0.3339	3527.86963	162.12883	50.0978
2	14.545	BB	0.4109	3514.09961	132.70622	49.9022
Totals :				7041.96924	294.83505	



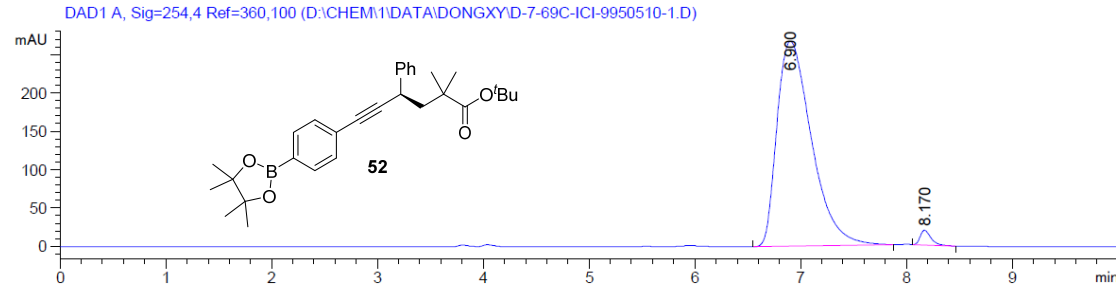
Signal 8: DAD1 H, Sig=300,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.583	BB	0.3290	3746.07715	175.48643	96.7399
2	14.549	BB	0.3364	126.24306	4.71424	3.2601
Totals :				3872.32021	180.20067	



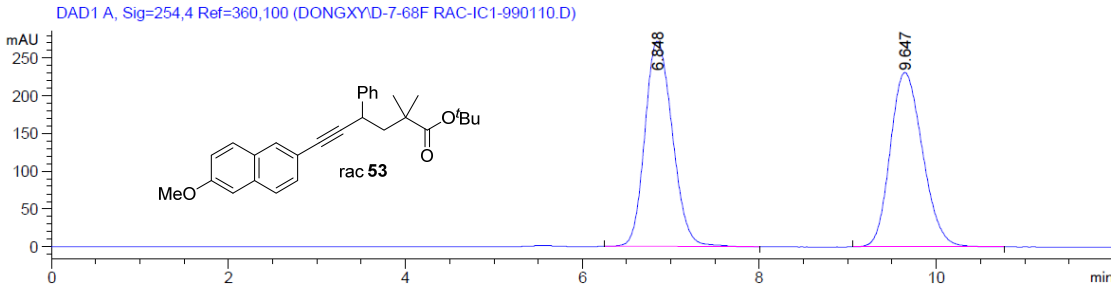
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.877	MF R	0.2693	385.24509	23.84423	49.9686
2	7.868	FM R	0.1151	385.72952	55.86004	50.0314
Totals :				770.97461	79.70428	



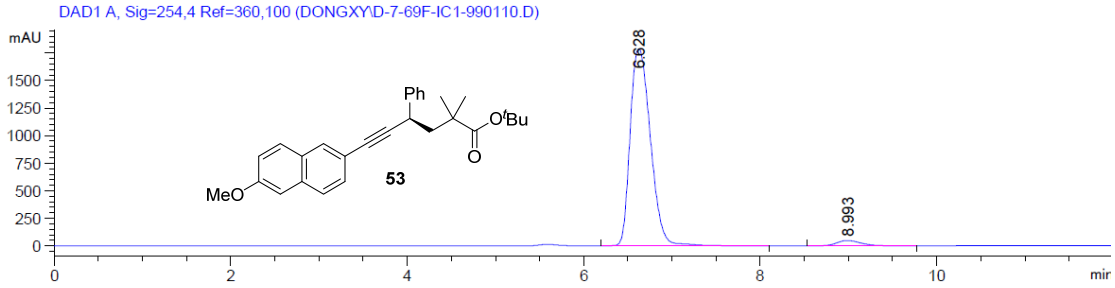
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.900	MM R	0.3778	6059.02344	267.26840	97.8012
2	8.170	MM R	0.1175	136.21985	19.31556	2.1988
Totals :				6195.24329	286.58396	



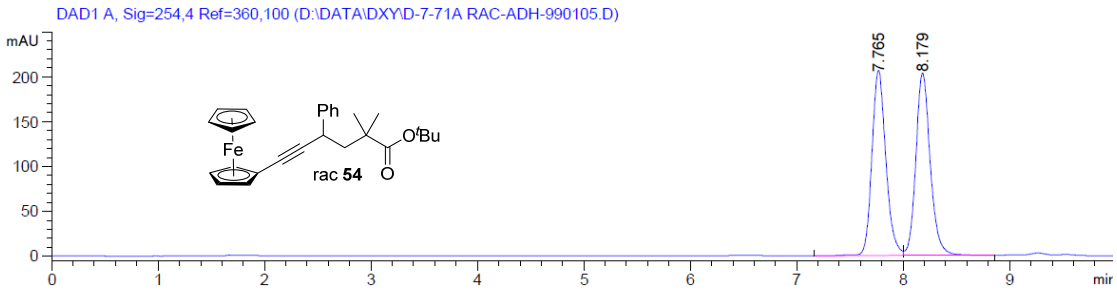
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.848	BB	0.3444	5882.30078	271.88184	50.0957
2	9.647	BB	0.4000	5859.83740	230.99181	49.9043
Totals :				1.17421e4	502.87364	



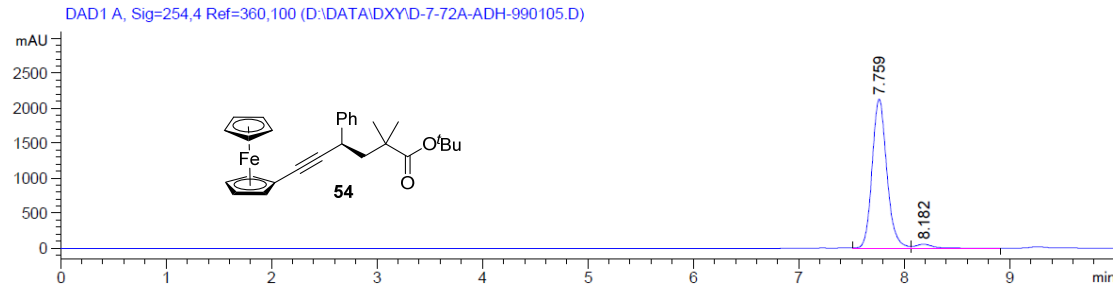
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.628	BB	0.2536	2.84421e4	1787.75195	96.8677
2	8.993	BB	0.2869	919.70154	49.02748	3.1323
Totals :				2.93618e4	1836.77943	



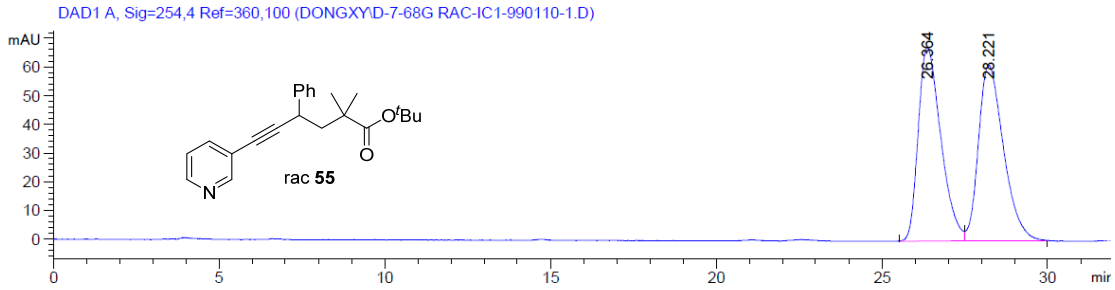
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.765	BV	0.1401	1881.16785	206.88243	49.5946
2	8.179	VB	0.1435	1911.92310	203.71669	50.4054
Totals :				3793.09094	410.59912	



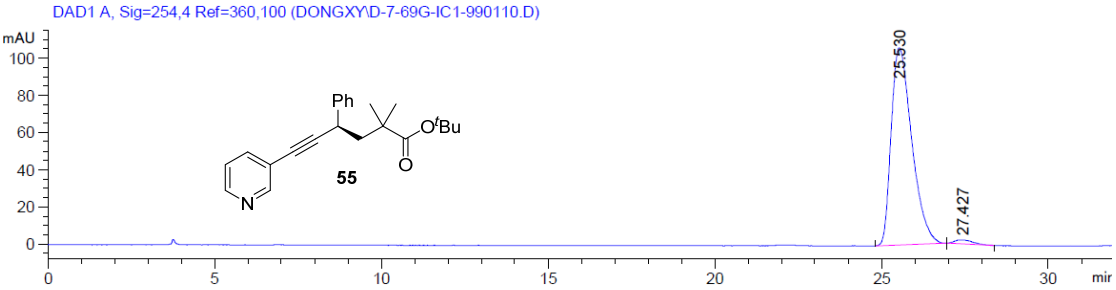
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.759	VV	0.1466	2.05447e4	2128.32544	97.1929
2	8.182	VB	0.1615	593.35657	54.27319	2.8071
Totals :				2.11380e4	2182.59863	



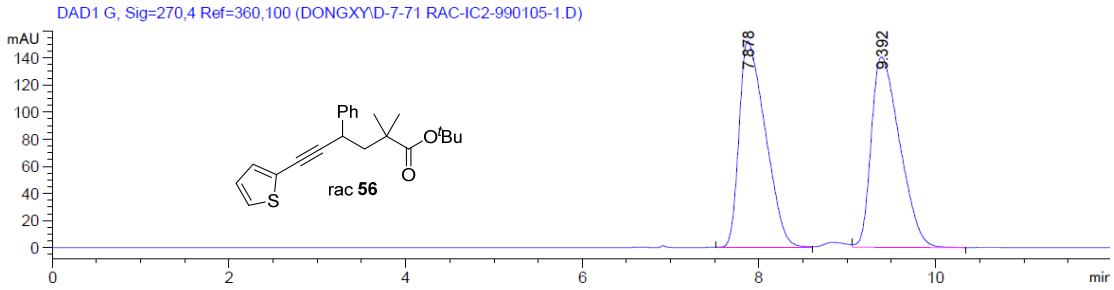
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	26.364	BV	0.7152	3192.59692	67.33228	49.7844
2	28.221	VB	0.7399	3220.24268	61.19516	50.2156
Totals :				6412.83960	128.52745	



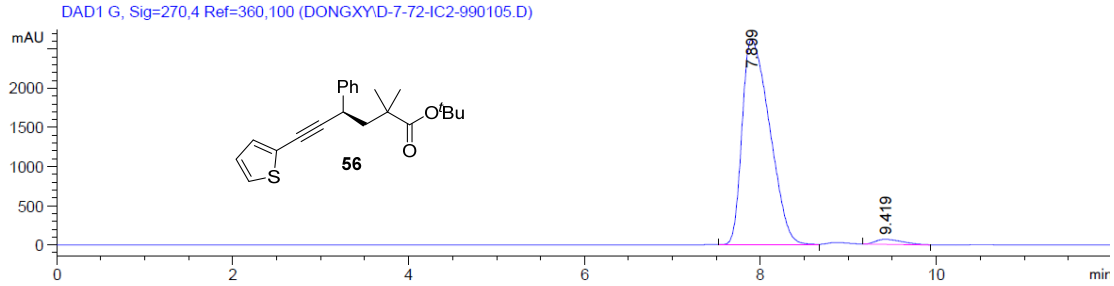
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	25.530	BB	0.6580	4539.26367	105.92168	98.2285
2	27.427	MM R	0.6356	81.86126	2.14651	1.7715
Totals :				4621.12493	108.06819	



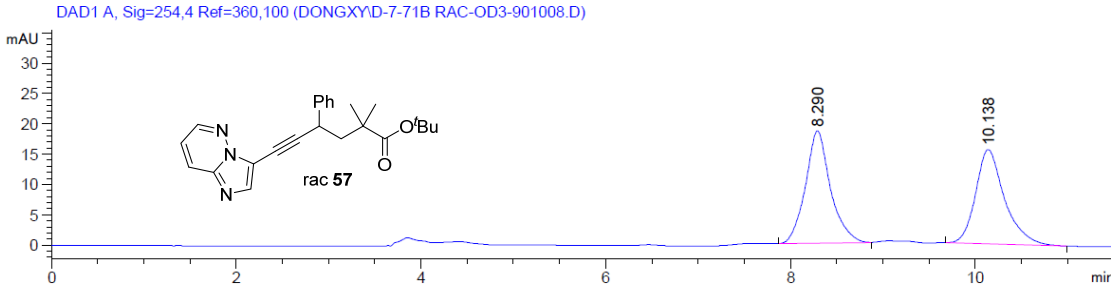
Signal 7: DAD1 G, Sig=270,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.878	BV	0.3206	3138.85400	152.20680	49.9336
2	9.392	VB	0.3456	3147.20752	140.37834	50.0664
Totals :				6286.06152	292.58514	



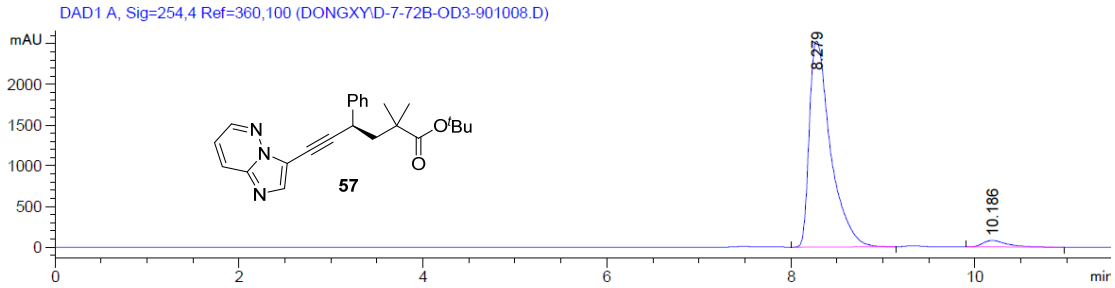
Signal 7: DAD1 G, Sig=270,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.899	MM R	0.3619	5.67590e4	2613.85107	97.6587
2	9.419	MM R	0.3478	1360.75684	65.20293	2.3413
Totals :				5.81197e4	2679.05401	



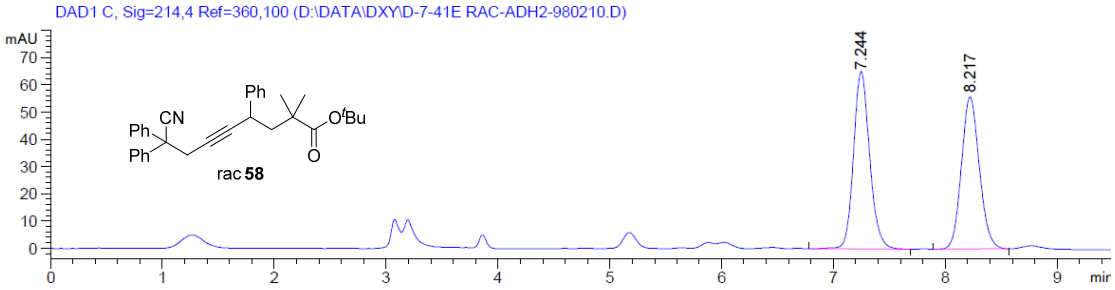
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.290	BB	0.2714	347.67838	18.48835	50.7262
2	10.138	BB	0.3196	337.72354	15.53461	49.2738
Totals :				685.40192	34.02296	



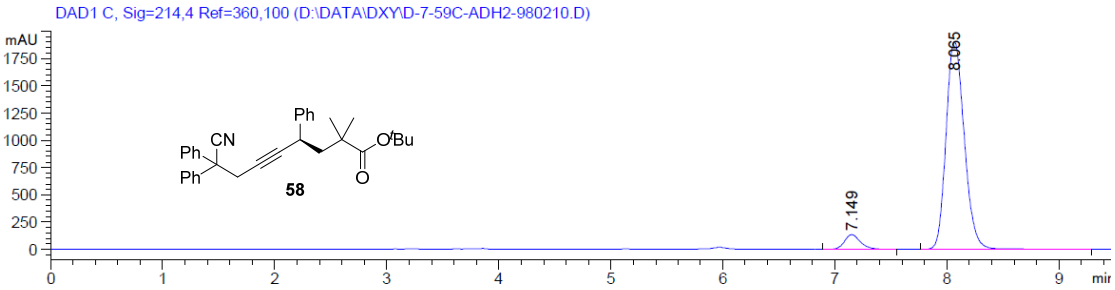
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.279	BV	0.2387	4.04618e4	2527.73828	96.4793
2	10.186	BB	0.2707	1476.53137	81.00645	3.5207
Totals :				4.19383e4	2608.74474	



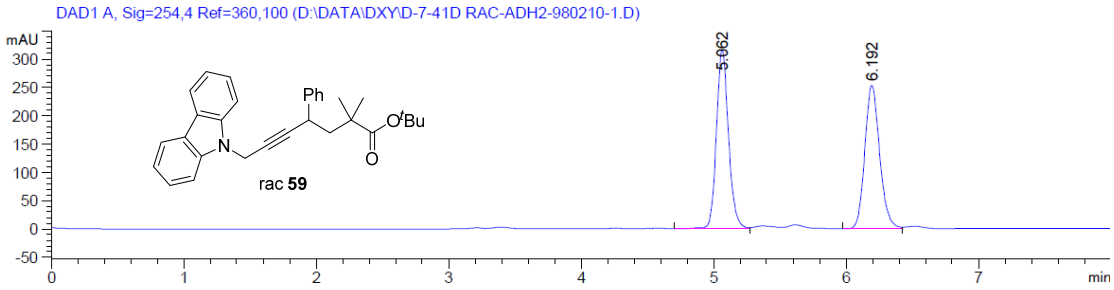
Signal 3: DAD1 C, Sig=214,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.244	BB	0.1553	655.55847	65.20034	51.3881
2	8.217	BB	0.1717	620.14203	55.78038	48.6119
Totals :				1275.70050	120.98072	



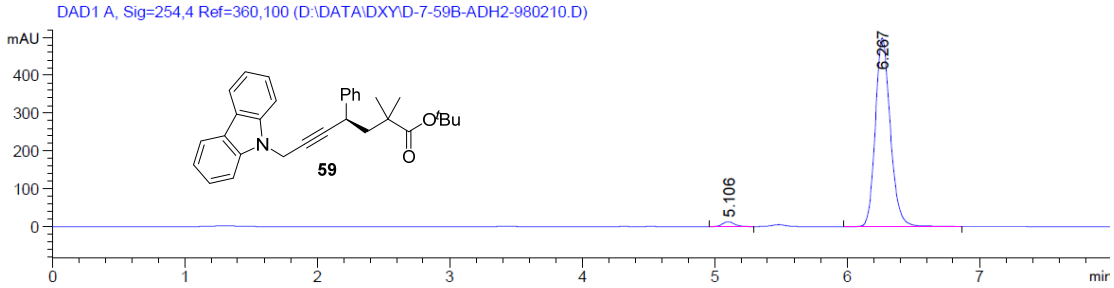
Signal 3: DAD1 C, Sig=214,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.149	BB	0.1499	1301.97253	133.37410	5.7100
2	8.065	BB	0.1757	2.14996e4	1905.12354	94.2900
Totals :				2.28016e4	2038.49763	



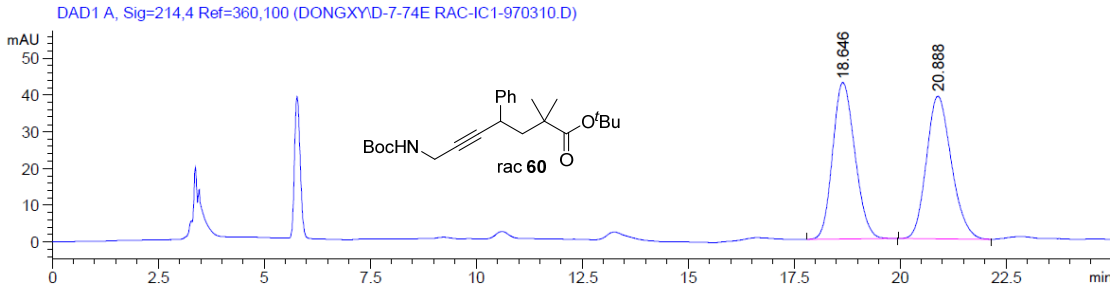
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	5.062	BV	0.0981	2008.43689	316.12735	50.3937
2	6.192	BV	0.1211	1977.05383	253.16180	49.6063
Totals :				3985.49072	569.28915	



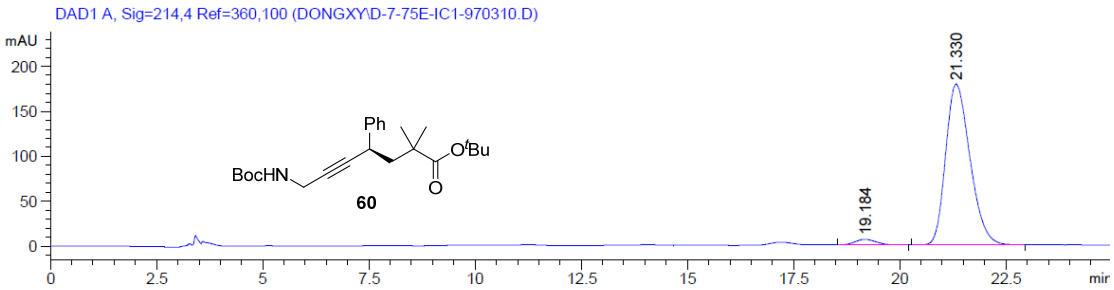
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	5.106	VV	0.0961	80.43413	13.02098	2.0035
2	6.267	BV	0.1220	3934.30713	499.01938	97.9965
Totals :				4014.74126	512.04036	



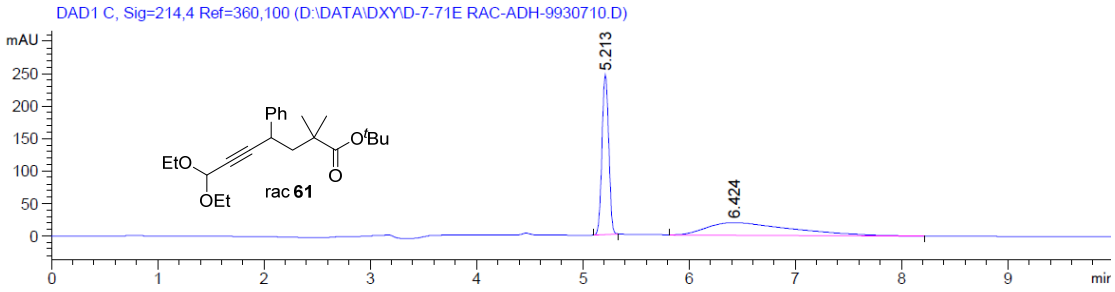
Signal 1: DAD1 A, Sig=214,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	18.646	BB	0.5680	1554.61609	42.57450	49.4216
2	20.888	BB	0.6220	1591.00269	38.83545	50.5784
Totals :				3145.61877	81.40995	



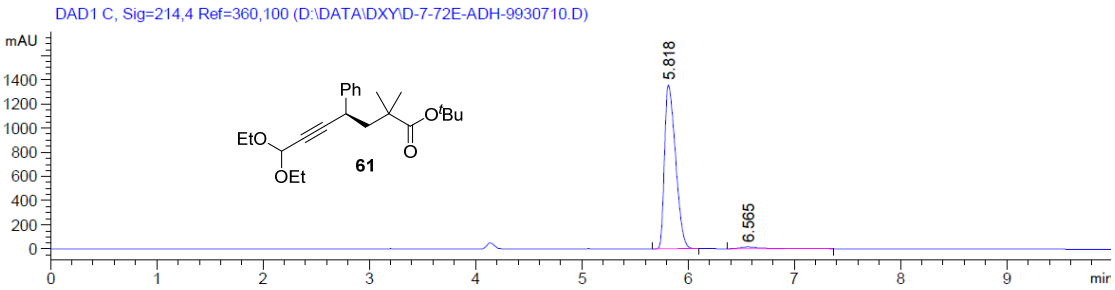
Signal 1: DAD1 A, Sig=214,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	19.184	BB	0.4812	206.54774	6.19099	2.8117
2	21.330	BB	0.6198	7139.35107	178.83075	97.1883
Totals :				7345.89882	185.02174	



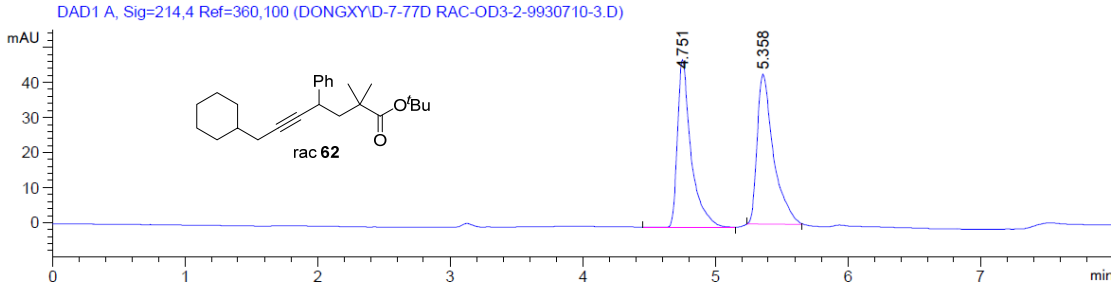
Signal 3: DAD1 C, Sig=214,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	5.213	MM R	0.0731	1083.55103	247.09938	50.5407
2	6.424	BB	0.7832	1060.36792	19.17383	49.4593
Totals :				2143.91895	266.27321	



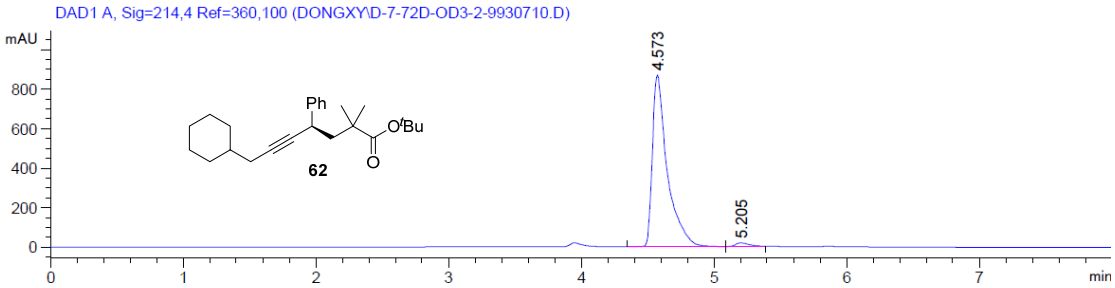
Signal 3: DAD1 C, Sig=214,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	5.818	MM R	0.1204	9809.58203	1357.92017	98.0296
2	6.565	MM R	0.2633	197.17323	12.47970	1.9704
Totals :				1.00068e4	1370.39987	



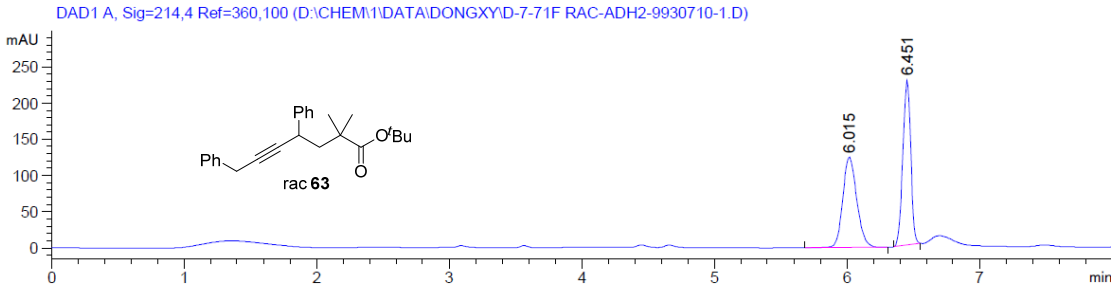
Signal 1: DAD1 A, Sig=214,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	4.751	MM R	0.1201	345.87381	47.98752	48.7034
2	5.358	MM R	0.1420	364.28961	42.74282	51.2966
Totals :				710.16342	90.73034	



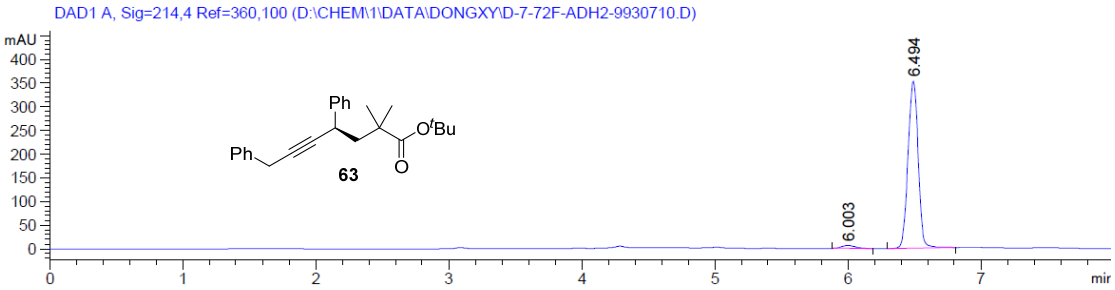
Signal 1: DAD1 A, Sig=214,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	4.573	BV	0.1131	6794.41016	870.11493	97.5879
2	5.205	VV	0.1216	167.94067	20.06841	2.4121
Totals :				6962.35083	890.18334	



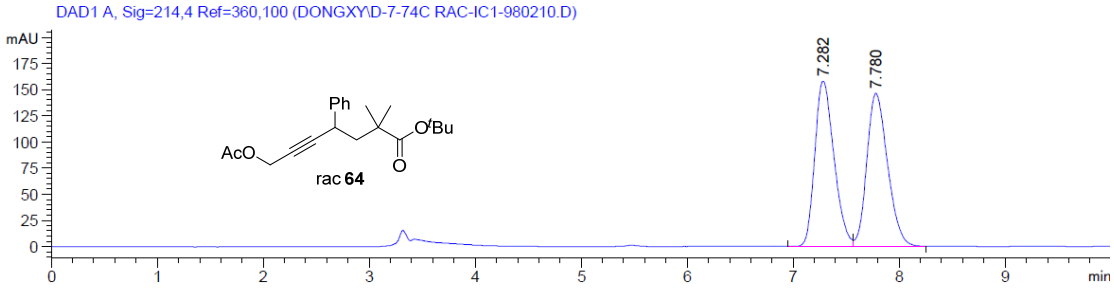
Signal 1: DAD1 A, Sig=214,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.015	BB	0.1134	913.40027	124.72250	49.3037
2	6.451	MM R	0.0688	939.20123	227.45976	50.6963
Totals :				1852.60150	352.18226	



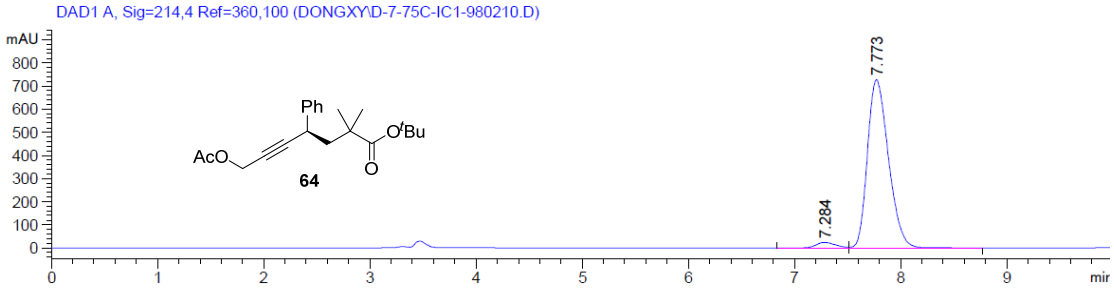
Signal 1: DAD1 A, Sig=214,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	6.003	MM R	0.1244	43.97273	5.89007	2.3082
2	6.494	BB	0.0836	1861.09436	352.44507	97.6918
Totals :				1905.06709	358.33514	



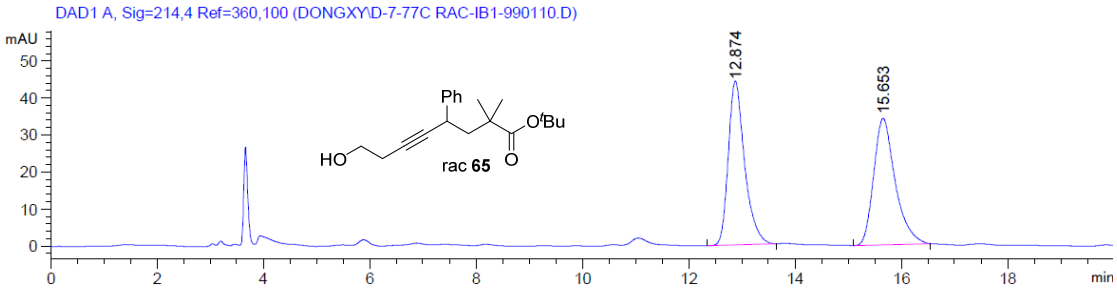
Signal 1: DAD1 A, Sig=214,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.282	BV	0.1942	1980.71033	158.10667	50.0126
2	7.780	VB	0.2101	1979.71606	146.04352	49.9874
Totals :				3960.42639	304.15019	



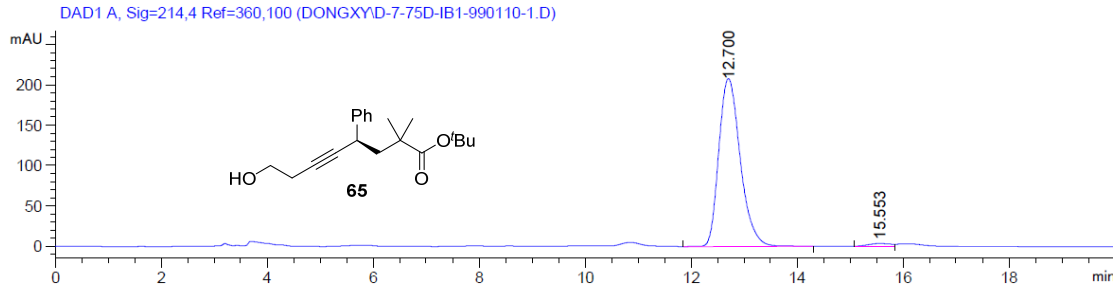
Signal 1: DAD1 A, Sig=214,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	7.284	BV	0.1908	288.00461	23.20487	2.8062
2	7.773	VB	0.2140	9975.31543	727.34558	97.1938
Totals :				1.02633e4	750.55045	



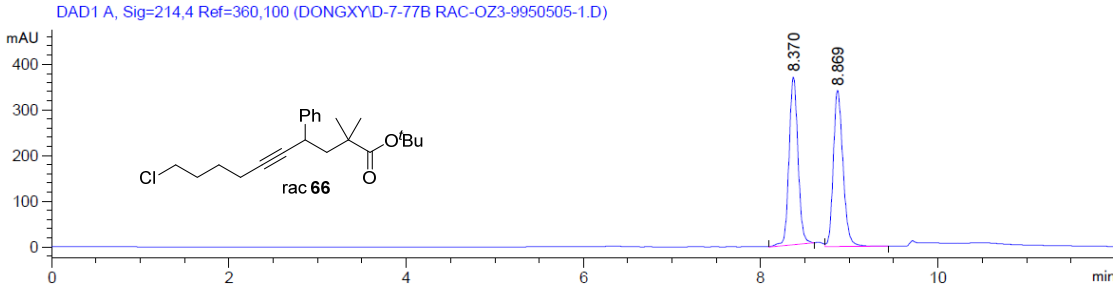
Signal 1: DAD1 A, Sig=214,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.874	BB	0.3205	945.29657	44.37400	49.5588
2	15.653	MM R	0.4689	962.12701	34.20055	50.4412
Totals :				1907.42358	78.57455	



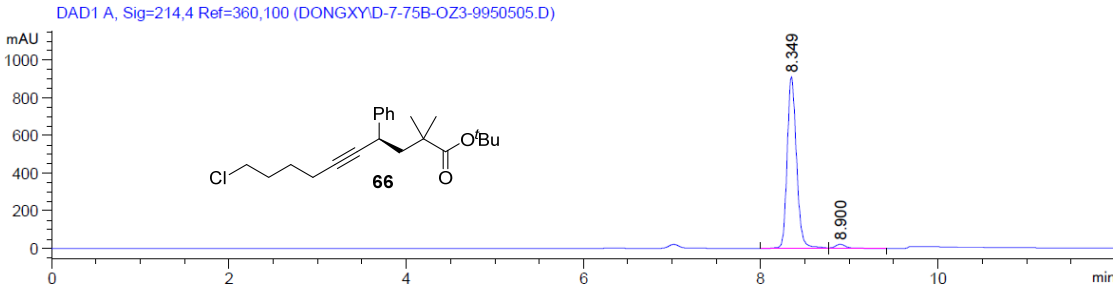
Signal 1: DAD1 A, Sig=214,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	12.700	BB	0.4405	5853.73340	207.89714	98.3271
2	15.553	MM R	0.4851	99.59086	3.42168	1.6729
Totals :				5953.32426	211.31882	



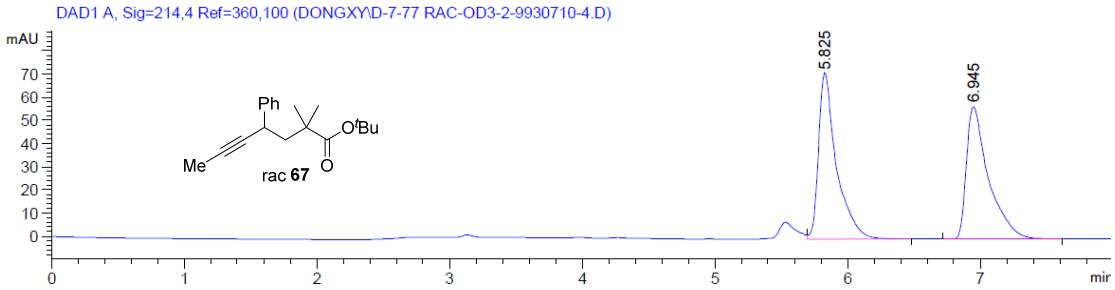
Signal 1: DAD1 A, Sig=214,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.370	MM R	0.1164	2567.30859	367.73059	49.7400
2	8.869	VB	0.1165	2594.14429	342.09372	50.2600
Totals :				5161.45288	709.82431	



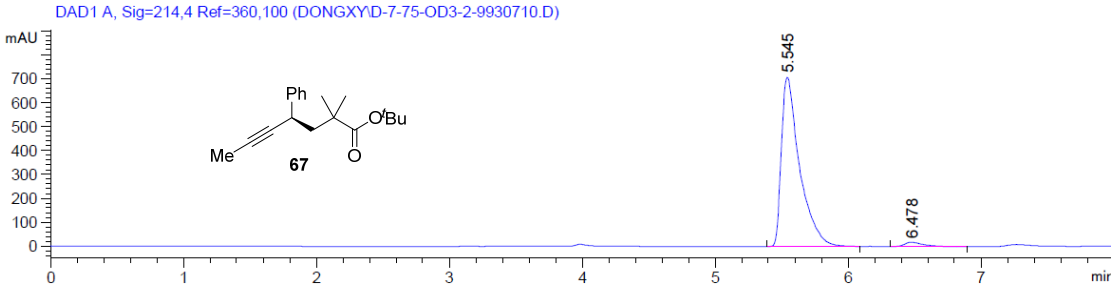
Signal 1: DAD1 A, Sig=214,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	8.349	BV	0.1139	6697.67578	909.37958	97.2002
2	8.900	VB	0.1291	192.92085	22.26547	2.7998
Totals :				6890.59663	931.64505	



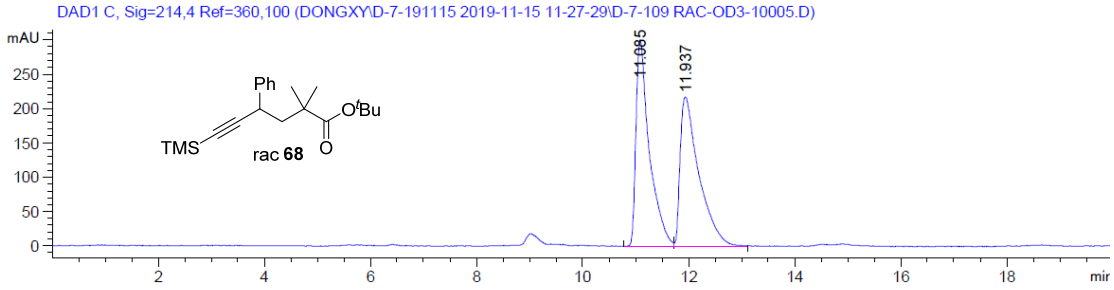
Signal 1: DAD1 A, Sig=214,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	5.825	VB	0.1350	671.90717	71.92393	50.5346
2	6.945	BB	0.1681	657.69202	57.21733	49.4654
Totals :				1329.59918	129.14126	



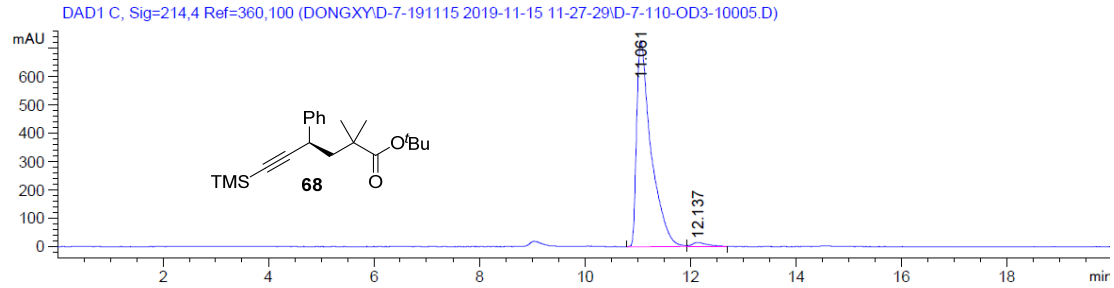
Signal 1: DAD1 A, Sig=214,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	5.545	BB	0.1386	6701.07666	706.94299	97.4670
2	6.478	BB	0.1396	174.14894	18.53441	2.5330
Totals :				6875.22560	725.47740	



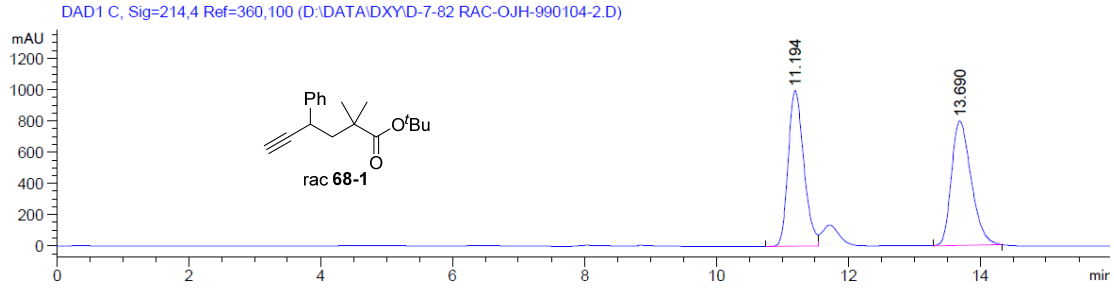
Signal 3: DAD1 C, Sig=214,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.085	BV	0.2523	5272.16260	301.03622	49.6566
2	11.937	VV	0.3523	5345.07666	217.82977	50.3434
Totals :				1.06172e4	518.86600	



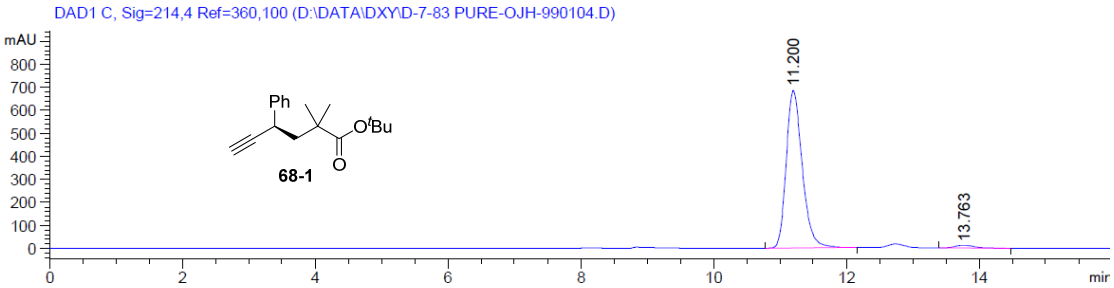
Signal 3: DAD1 C, Sig=214,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.061	BV	0.2739	1.38336e4	727.25342	97.8746
2	12.137	VV	0.2664	300.40100	14.70348	2.1254
Totals :				1.41340e4	741.95690	



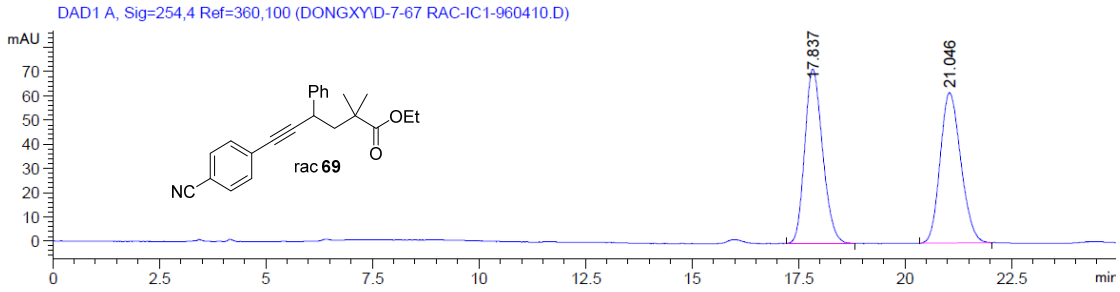
Signal 3: DAD1 C, Sig=214,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.194	BV	0.2560	1.64249e4	997.92523	49.8128
2	13.690	MM R	0.3465	1.65484e4	796.01654	50.1872
Totals :				3.29733e4	1793.94177	



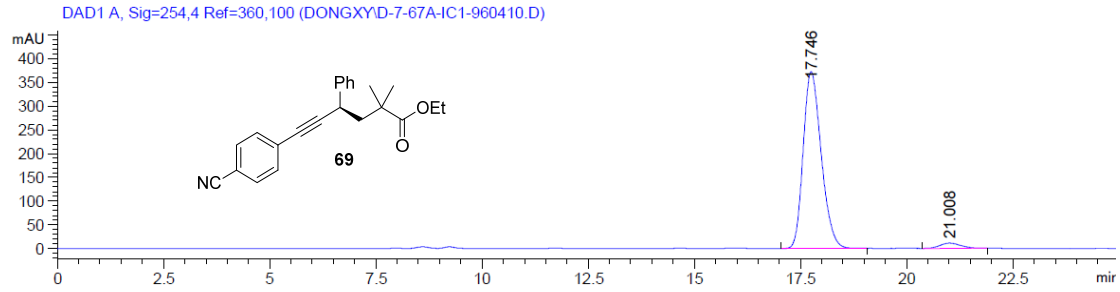
Signal 3: DAD1 C, Sig=214,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	11.200	BB	0.2572	1.14470e4	684.04071	98.0414
2	13.763	BB	0.3176	228.67451	11.23076	1.9586
Totals :				1.16757e4	695.27147	



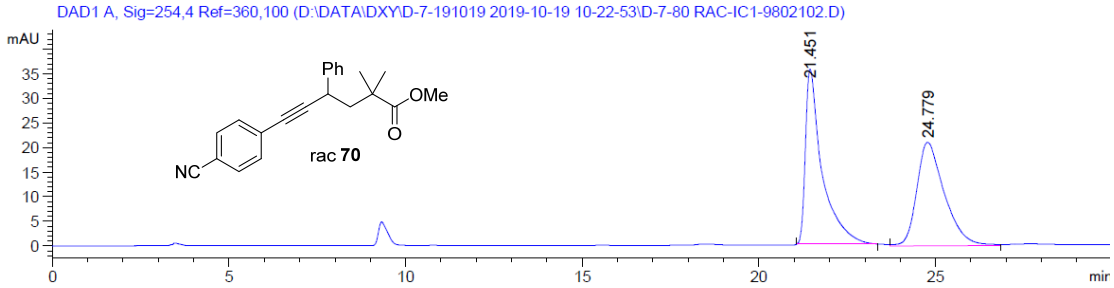
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	17.837	BB	0.4457	2098.60278	72.07382	50.0566
2	21.046	BB	0.5154	2093.85718	62.09042	49.9434
Totals :				4192.45996	134.16424	



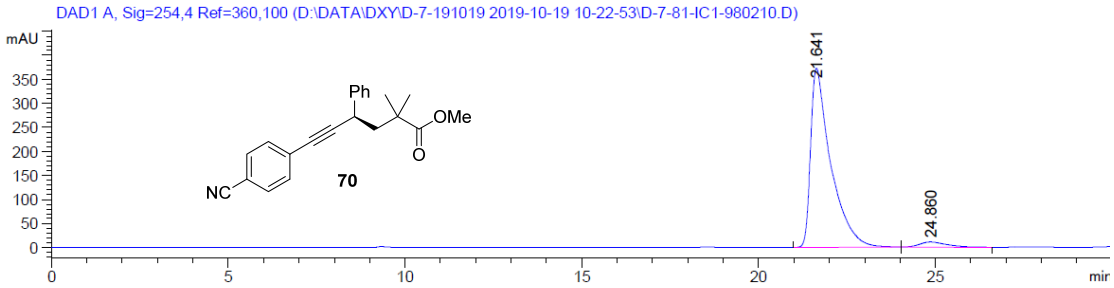
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	17.746	BB	0.4564	1.09902e4	372.29544	96.6405
2	21.008	BB	0.4573	382.05267	11.33355	3.3595
Totals :				1.13723e4	383.62899	



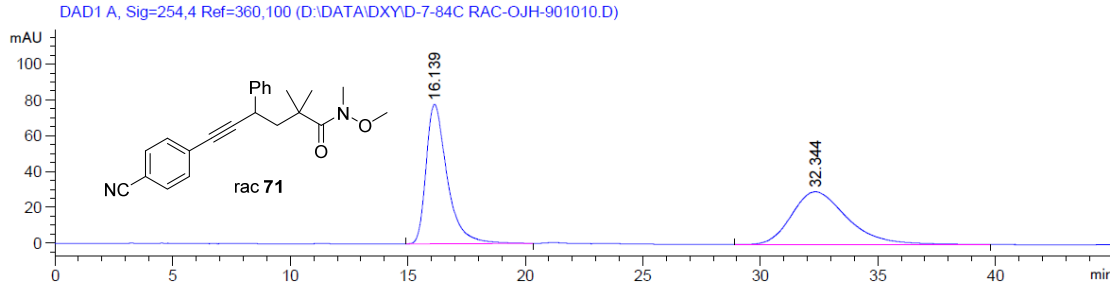
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	21.451	MM R	0.5434	1159.58057	35.56630	50.1926
2	24.779	MM R	0.9105	1150.68372	21.06347	49.8074
Totals :				2310.26428	56.62976	



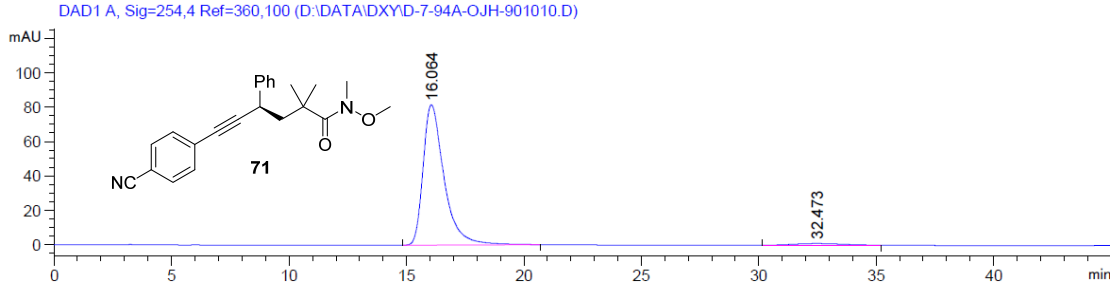
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	21.641	BB	0.5604	1.47110e4	372.77234	96.3564
2	24.860	BB	0.7647	556.28619	10.76901	3.6436
Totals :				1.52673e4	383.54134	



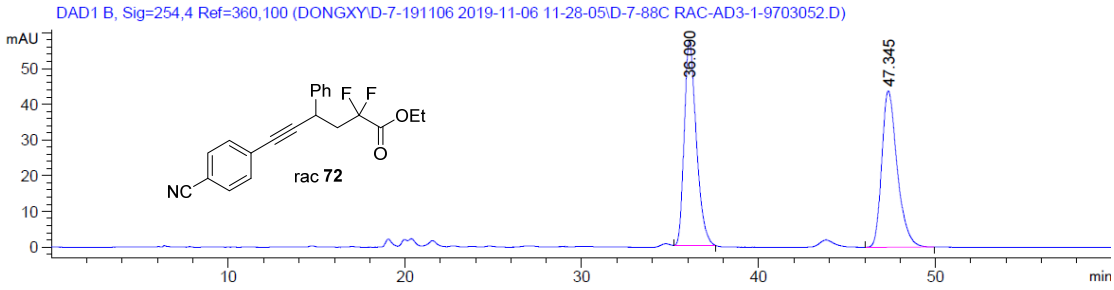
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	16.139	BB	0.9433	4851.99951	77.83559	49.9747
2	32.344	MM R	2.7534	4856.91992	29.39925	50.0253
Totals :				9708.91943	107.23483	



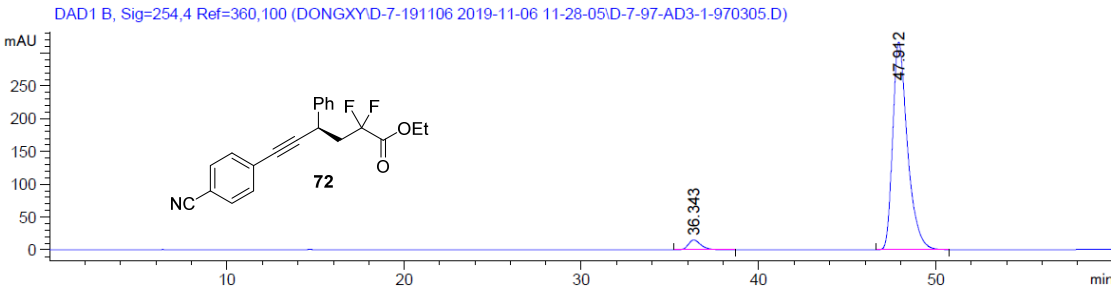
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	16.064	BB	0.9349	5065.50732	81.52888	97.1413
2	32.473	MM R	2.4302	149.07034	1.02233	2.8587
Totals :				5214.57767	82.55121	



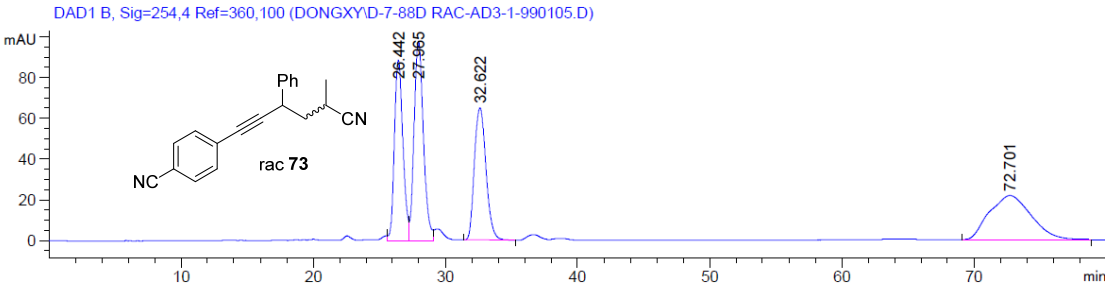
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	36.090	MM R	0.7895	2715.98438	57.33488	50.5562
2	47.345	BB	0.9143	2656.22070	43.75444	49.4438
Totals :				5372.20508	101.08932	



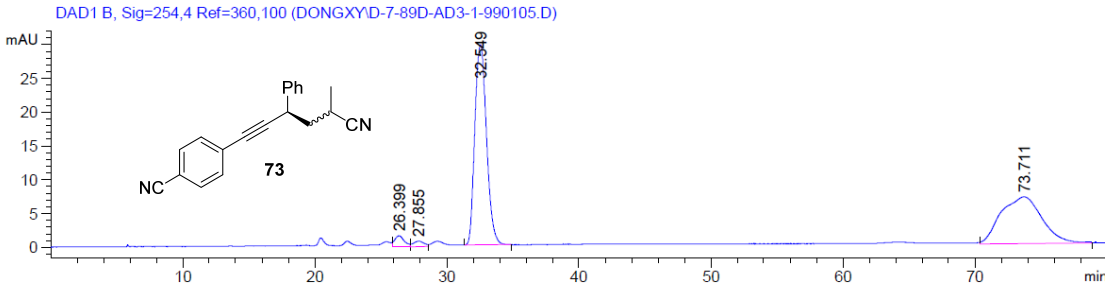
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	36.343	BB	0.7382	731.45221	14.80937	3.8413
2	47.912	BB	0.8706	1.83105e4	316.67783	96.1587
Totals :				1.90420e4	331.48719	



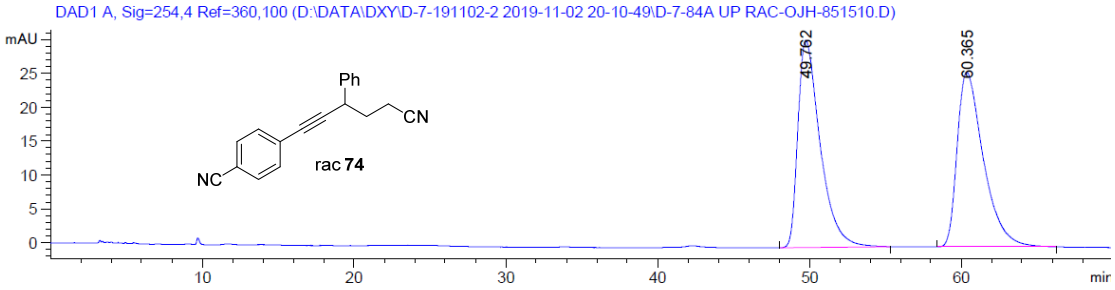
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	26.442	MF R	0.7498	3972.74390	88.30556	22.5920
2	27.965	FM R	0.8227	4820.98682	97.66157	27.4158
3	32.622	BB	0.9617	3949.62598	64.74719	22.4606
4	72.701	MM R	3.6939	4841.35400	21.84377	27.5316
Totals :				1.75847e4	272.55810	



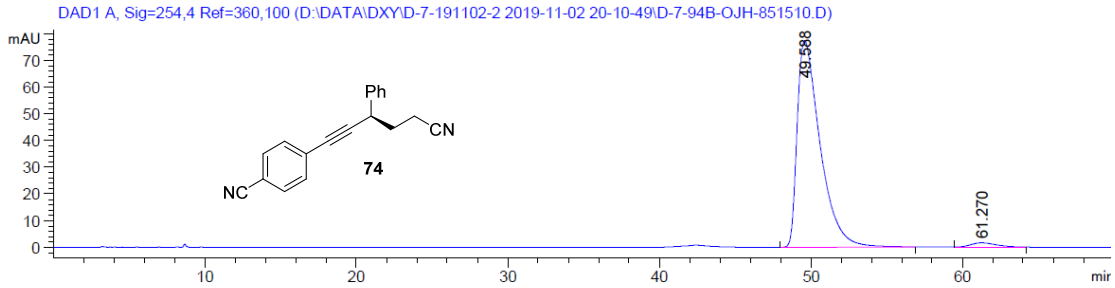
Signal 2: DAD1 B, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	26.399	MM R	0.8570	83.60978	1.62611	2.4258
2	27.855	MM R	0.9583	46.63989	8.11171e-1	1.3532
3	32.549	BB	0.9589	1821.65247	29.64622	52.8518
4	73.711	MM R	3.6009	1494.81494	6.91866	43.3692
Totals :				3446.71708	39.00216	



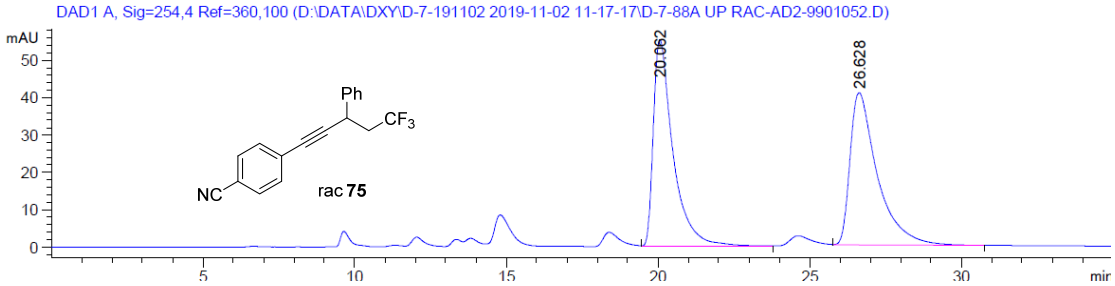
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	49.762	BB	1.4710	3122.11987	30.63352	50.1574
2	60.365	BB	1.7396	3102.52734	25.82574	49.8426
Totals :				6224.64722	56.45926	



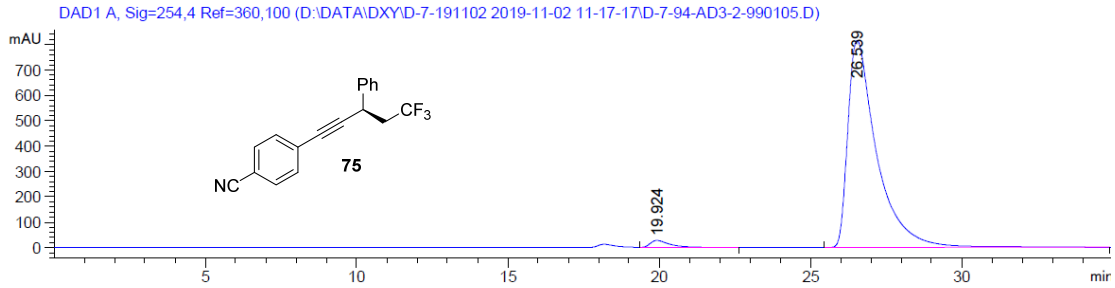
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	49.588	BB	1.5729	8136.13623	77.49374	97.6809
2	61.270	MM R	1.9579	193.16867	1.64433	2.3191
Totals :				8329.30490	79.13808	



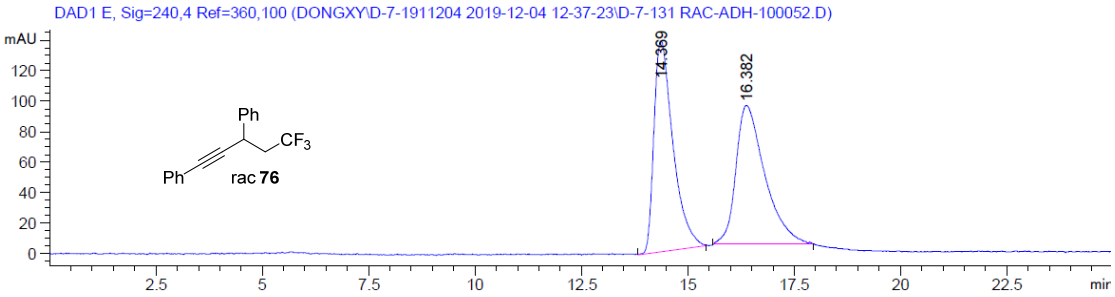
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	20.062	BB	0.6608	2472.86621	55.18290	49.3537
2	26.628	BB	0.9212	2537.63110	40.71278	50.6463
Totals :				5010.49731	95.89569	



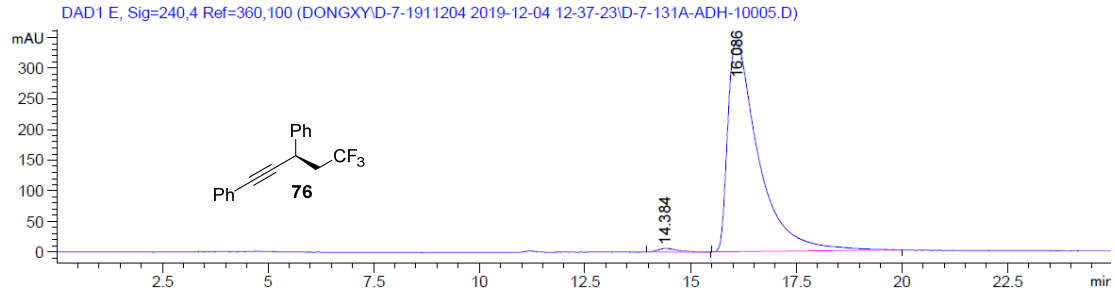
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	19.924	BB	0.6588	1228.36011	27.83800	2.2159
2	26.539	MM R	1.1075	5.42060e4	815.72455	97.7841
Totals :				5.54343e4	843.56255	



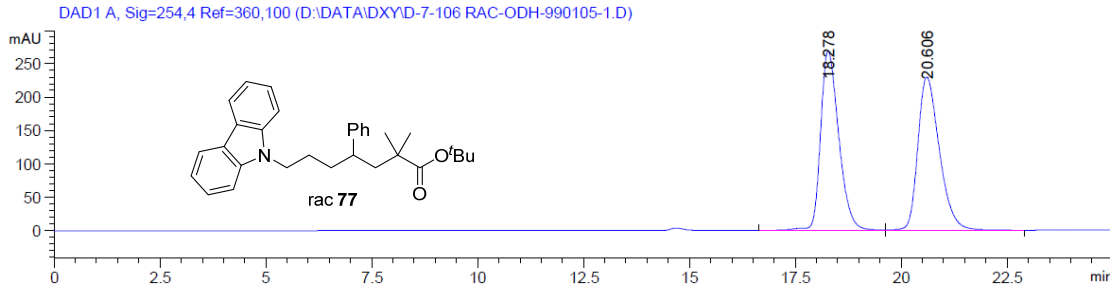
Signal 5: DAD1 E, Sig=240,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	14.369	MM R	0.5201	4320.77100	138.46153	50.1018
2	16.382	MM R	0.7889	4303.21582	90.91515	49.8982
Totals :				8623.98682	229.37668	



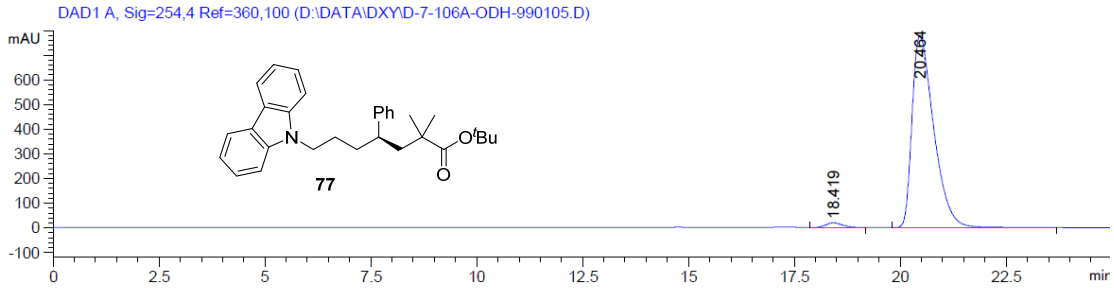
Signal 5: DAD1 E, Sig=240,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	14.384	MM R	0.5750	196.45544	5.69485	1.1221
2	16.086	MM R	0.8381	1.73116e4	344.27591	98.8779
Totals :				1.75080e4	349.97076	



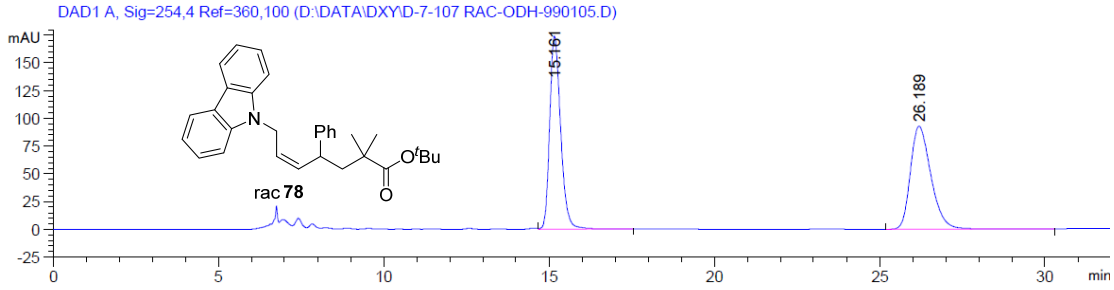
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	18.278	BV	0.4564	8026.73340	268.76758	49.7414
2	20.606	VB	0.5443	8110.20557	229.51840	50.2586
Totals :				1.61369e4	498.28598	



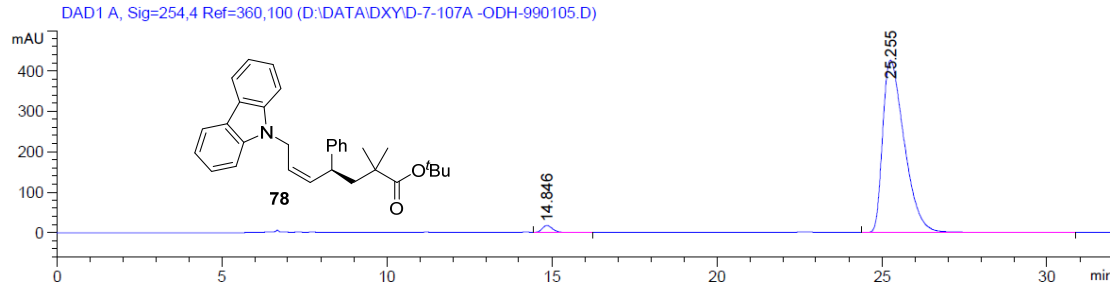
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	18.419	VB	0.4290	528.89917	19.22113	1.8773
2	20.464	BB	0.5423	2.76447e4	778.51514	98.1227
Totals :				2.81736e4	797.73627	



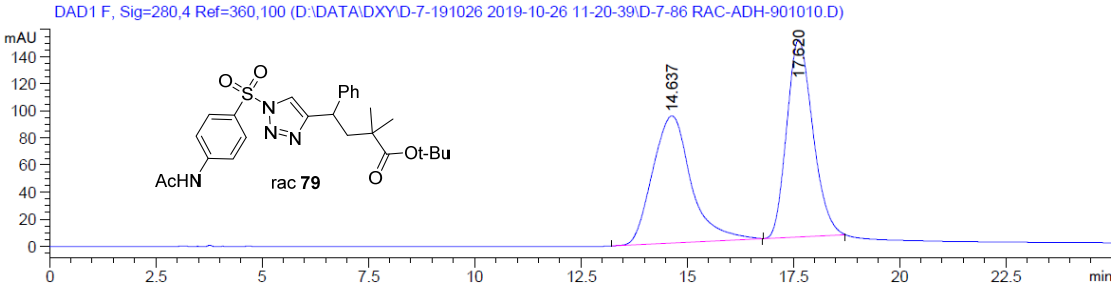
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	15.161	VB	0.3563	3997.34106	173.79562	50.0666
2	26.189	BB	0.6617	3986.71338	92.70757	49.9334
Totals :				7984.05444	266.50319	



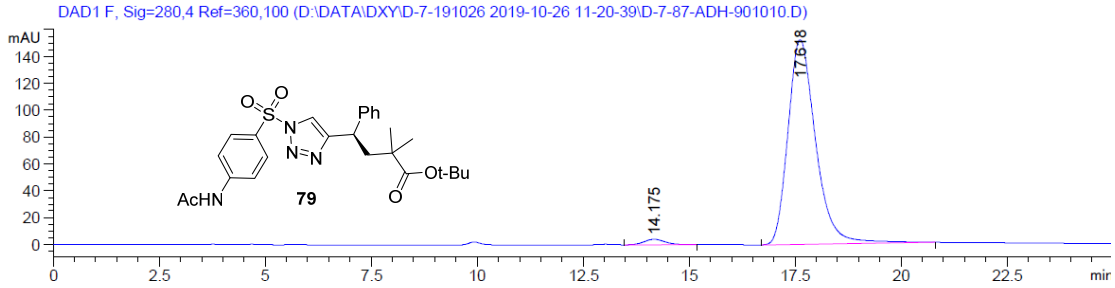
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	14.846	VB	0.3518	391.41522	17.05072	1.9788
2	25.255	BB	0.6989	1.93891e4	426.04935	98.0212
Totals :				1.97805e4	443.10006	



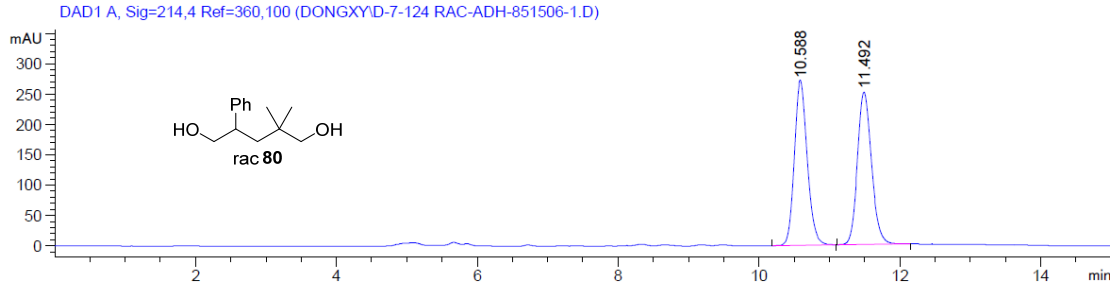
Signal 6: DAD1 F, Sig=280,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	14.637	BB	0.9903	5895.09082	93.66658	48.6286
2	17.620	MM R	0.7128	6227.59229	145.62328	51.3714
Totals :				1.21227e4	239.28986	



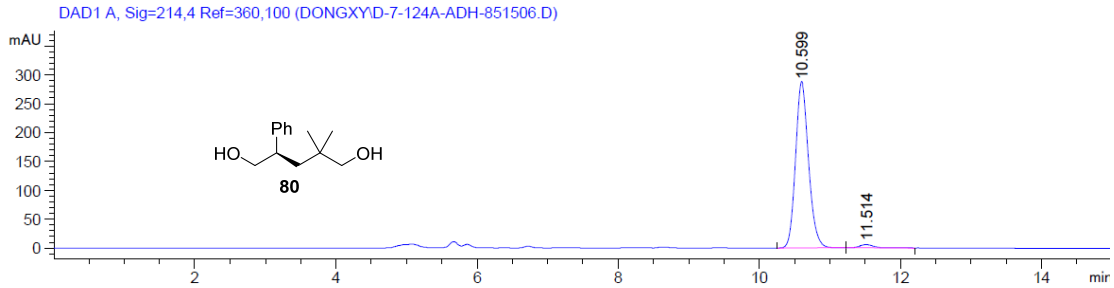
Signal 6: DAD1 F, Sig=280,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	14.175	BB	0.5286	141.67476	4.14668	2.0060
2	17.618	MM R	0.7568	6920.94727	152.40685	97.9940
Totals :				7062.62202	156.55353	



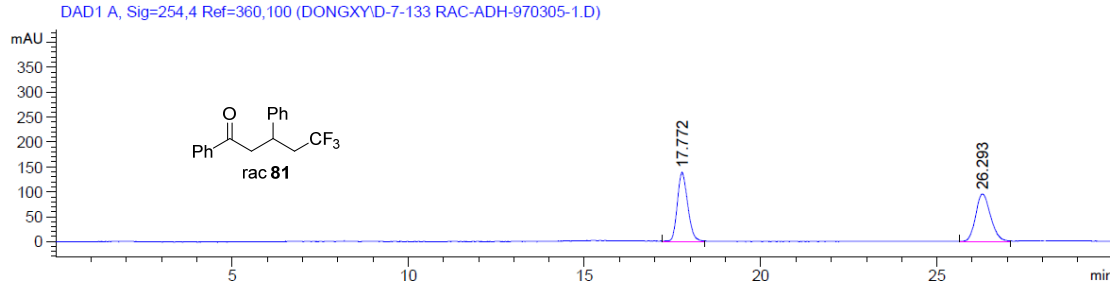
Signal 1: DAD1 A, Sig=214,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.588	BB	0.1961	3457.52783	272.33218	49.8547
2	11.492	BB	0.2136	3477.67480	251.00453	50.1453
Totals :				6935.20264	523.33672	



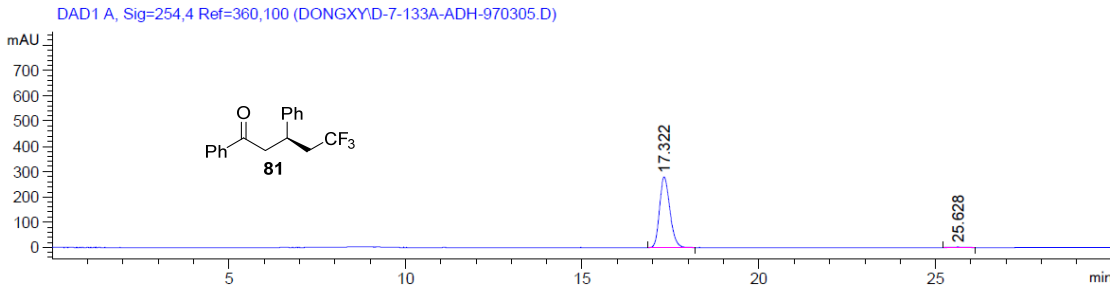
Signal 1: DAD1 A, Sig=214,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	10.599	BB	0.1955	3697.45703	288.56125	98.0243
2	11.514	BB	0.2088	74.52402	5.33948	1.9757
Totals :				3771.98105	293.90073	



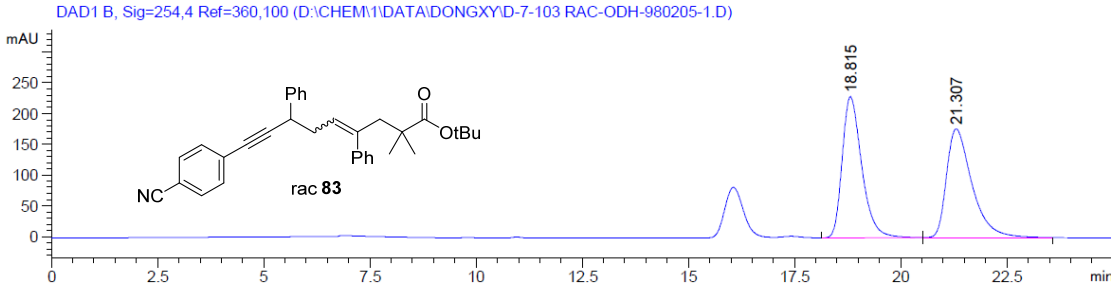
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	17.772	BV	0.3124	2820.82251	138.06364	50.3584
2	26.293	BV	0.4474	2780.67456	95.02544	49.6416
Totals :				5601.49707	233.08909	



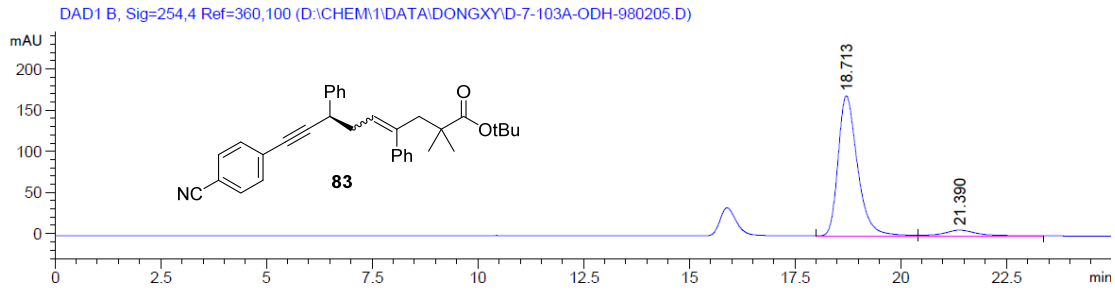
Signal 1: DAD1 A, Sig=254,4 Ref=360,100

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	17.322	VB	0.3152	5689.26611	279.77670	98.6527
2	25.628	VB	0.3523	77.70007	2.60271	1.3473
Totals :				5766.96619	282.37942	



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

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	18.815	MM R	0.5350	7354.45313	229.11613	49.9248
2	21.307	MM R	0.6960	7376.61523	176.63210	50.0752
Totals :				1.47311e4	405.74823	



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

Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	18.713	BV	0.4837	5418.10693	170.07100	93.7927
2	21.390	VB	0.7526	358.57712	7.01265	6.2073
Totals :				5776.68405	177.08365	

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