Electronic Supplementary Material (ESI) for Chemical Communications

γ-Alkynylation of Ketones *via* Pd-catalyzed C-C Bond Cleavage

*Asraa Ziadi, Arkatiz Correa and Ruben Martin**

Institute of Chemical Research of Catalonia (ICIQ)
Av. Països Catalans, 16
Tarragona, 43007 (Spain)
FAX: (+34) 977 920 222
E-mail: rmartinromo@iciq.es

Supporting Information

General Considerations

Reagents. All reactions were set up in the air (with no use of a glovebox) unless otherwise noted and carried out under an argon atmosphere in resalable screw-cap test tubes. $Pd(OAc)_2$ was a gift from Johnson Matthey. SPhos and Xantphos were purchased by Strem and used as received. Powdered Na*t*BuO and Cs_2CO_3 was purchased from Acros Organics and Alfa Aesar. The bulk of inorganic bases was stored under nitrogen in a nitrogen atmosphere glovebox. Small portions (~ 5 g) were removed from the glovebox in glass vials, stored in the air in a desiccator filled with anhydrous calcium sulfate, and weighed in the air. Dry toluene was taken from the SPS (innovative technology, Newburyport, MA). *Tert*-cyclobutanols (**1a-m**) were all prepared according to standard literature procedures in multigram scale[1,2] 1-Haloalkynes were all synthesized following reported protocols.[3] All other reagents were purchased from commercial sources and used as received. Flash chromatography was performed with EM Science silica gel 60 (230-400 mesh).

Analytical methods. ^{1}H NMR and ^{13}C NMR spectra and melting points (where applicable) are included for all compounds. ^{1}H and ^{13}C NMR spectra were recorded on a Bruker 400 MHz and a Bruker 500 MHz at 20 ^{o}C. All ^{1}H NMR spectra are reported in parts per million (ppm) downfield of TMS and were measured relative to the signals for $CHCl_3$ (7.27 ppm). All ^{13}C NMR spectra were reported in ppm relative to residual $CHCl_3$ (77 ppm) and were obtained with ^{1}H decoupling. Coupling constants, *J*, are reported in hertz. Melting points were measured using open glass capillaries in a Büchi B540 apparatus. Infrared spectra were recorded on a Bruker Tensor 27. Mass spectra were recorded on a Waters LCT Premier spectrometer. Gas chromatographic analyses were performed on Hewlett-Packard 6890 gas chromatography instrument with a FID detector using 25m x 0.20 mm capillary column with cross-linked methyl siloxane as the stationary phase. Chiral High Performance Liquid Chromatography analyses were performed on Agilent Technologies 1260 Infinity HPLC instrument with a UV detector using 4.6 mm Ø x 350 mmL ChiralPak IA column with amylose tris(3,5-dimethylpehnylcarbamate) on a 20 µm silica-gel from Daicel Chemical Ind., LTD.

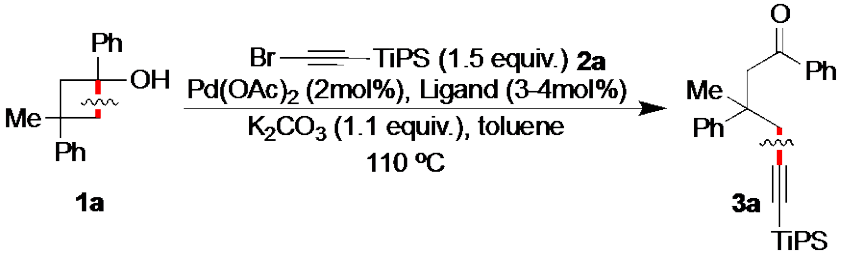
The yields reported in Table 1 and Table 2 refer to isolated yields and represent an average of at least two independent runs. The procedures described in this section are representative.

Optimization details

[1] L. R. Krepski, A. Hassner. *J. Org. Chem.*, 1978, **43**, 2879.
[2] B. D. Johnston, E. Czyzewska, A. C. Oehlschlager, *J. Org. Chem.*, 1987, **52**, 3693.
[3] Z. Chen, H. Jiang, Y. Li and C. Qi, *Chem. Commun.*, 2010, **46**, 8049.

1. *Screening of the reaction conditions for the coupling of (bromoethynyl) triisopropylsilane.*

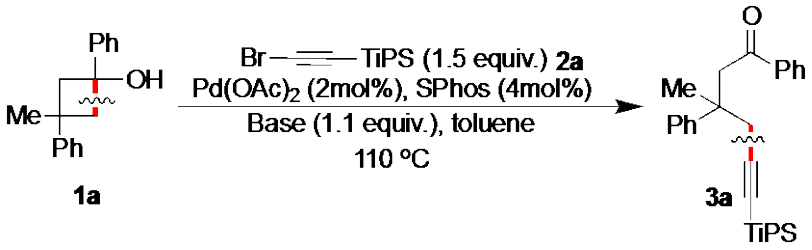
Table 1. Screening of ligands.[a]



Entry	Ligands	GCyield (%)[b]
1	Bu_2Pt⌒$PtBu_2$	2
2	PCy3	68
3	XPhos	32
4	SPhos	99
5	Cy_2P⌒PCy_2	10
6	Cy_2P⌒PCy_2	54
7	PtBu3	40

[a] Cyclobutanol (0.25 mmol), Acetylene (1.5 equiv.), $Pd(OAc)_2$ (2 mol%), SPhos (4 mol%), Cs_2CO_3 (1.1 equiv.), Toluene (0.13 M) at 110 ºC. [b] Yields were determined by GC analysis using dodecane as internal standard.

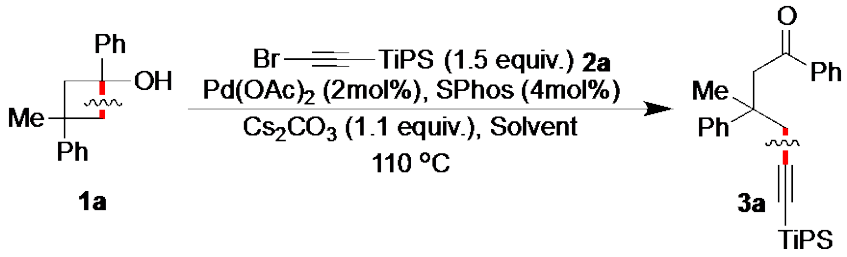
Table 2. Optimization of bases.[a]



Entry	Base	GCyield (%)[b]
1	NatBuO	78
2	Cs2CO3	97
3	NaOMe	65
4	CsHCO3	56

[a] Cyclobutanol (0.25 mmol), Acetylene (1.5 equiv.), $Pd(OAc)_2$ (2 mol%), SPhos (4 mol%), Cs_2CO_3 (1.1 equiv.), Toluene (0.13 M) at 110 ºC. [b] Yields were determined by GC analysis using dodecane as internal standard.

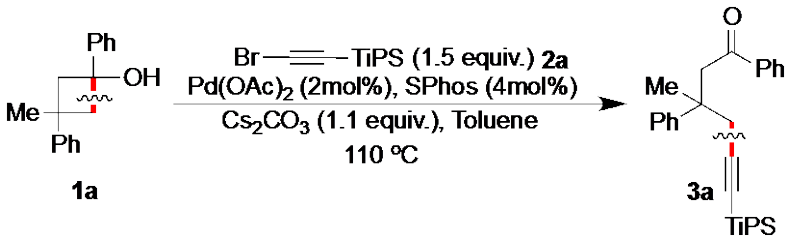
Table 2. Optimization of solvents.[a]



Entry	Solvent	GCyield (%)[b]
1	Cyclopentylmethyl ether	20
2	a,a,a-trifluorotoluene	32
3	Methylcyclohexane	39
4	1,2-dimethoxyethane	78
5	Toluene	99

[a] Cyclobutanol (0.25 mmol), Acetylene (1.5 equiv.), $Pd(OAc)_2$ (2 mol%), SPhos (4 mol%), Cs_2CO_3 (1.1 equiv.), Toluene (0.13 M) at 110 ºC. [b] Yields were determined by GC analysis using dodecane as internal standard.

Table 4. Blank experiments.[a]

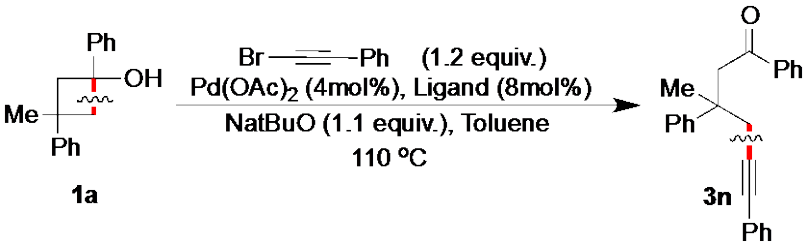


Entry	Conditions			Yield(%)[b]
	$Pd(OAc)_2$	SPhos	Cs_2CO_3	
1	3	3	3	100
2	3	3	7	0
3	7	3	3	0
4	3	7	3	0
5	3	7	7	0
6	7	3	7	0
7	7	7	3	0
8	7	7	7	0

[a] Cyclobutanol (0.25 mmol), Acetylene (1.3 equiv.), $Pd(OAc)_2$ (2 mol%), SPhos (4 mol%), Cs_2CO_3 (1.1 equiv.), Toluene (0.13 M) at 110 ºC. [b] Yields were determined by GC analysis using dodecane as internal standard.

2. *Screening of the reaction conditions for the coupling of bromoethynyl benzene*

Table 1. Screening of ligands.



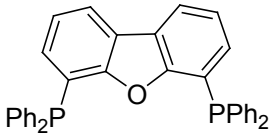
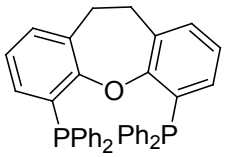
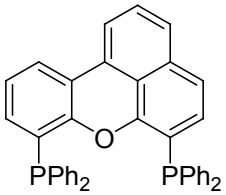
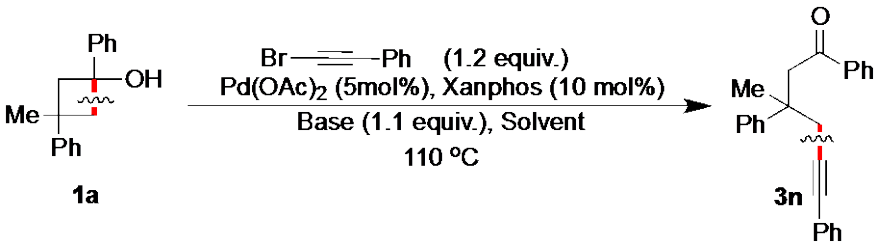
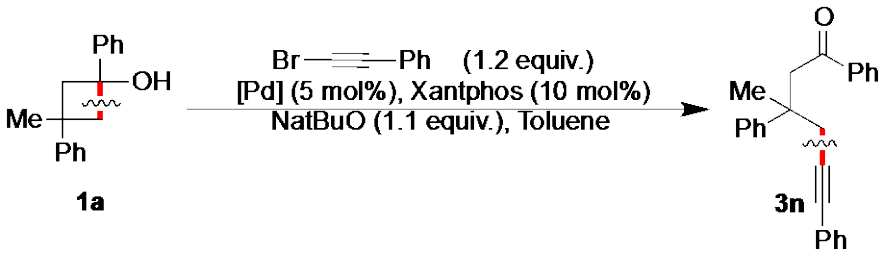
Entry	Ligand	GCyield (%)
1	SPhos	0
2	DPEphos	0
3	dppm	0
4	dppe	0
5	dppp	0
6	dppf	0
7	(rac)-BINAP	0
8	$(Bu^t)_2P$ $P(^tBu)_2$	0
9	Cy_2P PCy_2	0
10	Ph_2P PPh_2	0
11	Xantphos	60
12		0
13		60
14		52

Table 2. Screening of bases and solvents



Entry	Base	Solvent	GCyield (%)
1	Cs_2CO_3	Toluene	17
2	NaOtBu	Toluene	60
3	KOtBu	Toluene	7
4	CsOAc	Toluene	0
5	KOH	Toluene	0
6	NaOtBu	Dioxane	28

Table 3. Screening of palladium sources and temperature



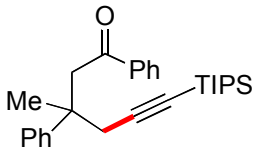
Entry	[Pd]	T (ºC)	GCyield (%)
1	$Pd(OAc)_2$	110	60
2	$Pd(OCOCF_3)_2$	110	0
3	$PdCl_2$	110	37
4	$PdBr_2$	110	37
5	$PdCl_2(PhCN)_2$	110	42
6	$[Pd(2\text{-methylallyl})Cl]_2$	110	62
7	$[Pd(1\text{-methylallyl})Cl]_2$	110	50
8	$[Pd(1\text{-phenylallyl})Cl]_2$	110	60
9[a]	$[Pd(2\text{-methylallyl})Cl]_2$	110	72 (71)[b]
10[a]	$[Pd(2\text{-methylallyl})Cl]_2$	80	78 (75)[b]

[a] 2.0 equivalents of 1-bromophenylacetylene were used. [b]Isolated yield

Synthesis of γ-alkynylated ketones via Pd-catalyzed C-C bond-cleavage

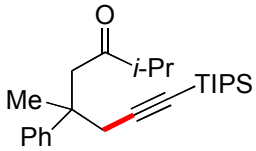
General procedure A (Table 1). An oven-dried screw-cap test tube containing a stirring bar was charged with the corresponding *tert*-cyclobutanol (0.35 mmol, 1.0 equiv.), SPhos (6.7 mg, 4.0 mol%), $Pd(OAc)_2$ (1.6 mg, 2.0 mol%) and Cs_2CO_3 (125.0 mg, 0.39 mmol, 1.10 equiv.). The test tube was evacuated and back-filled with dry argon (this sequence was repeated three times). **2a** (0.42 mmol) and toluene (2 mL) were added. The mixture was then stirred in a pre-heated oil bath (110 ^oC) for 14 h. The mixture was then allowed to reach room temperature, diluted with EtOAc (5 mL) and filtered through a Celite® plug, eluting with additional EtOAc (10 mL). The filtrate was concentrated and purified by column chromatography on silica gel (eluting with hexanes/ethyl acetate mixtures).

General procedure B (Table 2). An oven-dried screw-cap test tube containing a stirring bar was charged with the corresponding *tert*-cyclobutanol (0.50 mmol, 1.0 equiv.), $[PdCl(2\text{-methylallyl})]_2$ (0.0125 mmol, 2.5 mol%, 4.9 mg) and Xantphos (0.05 mmol, 10 mol%, 29 mg). Next the tube was introduced in the glovebox to weigh anhydrous NaOtBu (0.6 mmol, 1.1 equiv, 53 mg). The test tube was evacuated and back-filled with dry argon (this sequence was repeated three times). The corresponding 1-bromoalkyne (1.0 mmol, 2.0 equiv.) and toluene (1mL) were subsequently added by syringe. The mixture was then stirred in a pre-heated oil bath (80 ^oC) for 14 h. The mixture was then allowed to reach room temperature, diluted with EtOAc (5 mL) and filtered through a Celite® plug, eluting with additional EtOAc (10 mL). The filtrate was concentrated and purified by column chromatography on silica gel (eluting with hexanes/dichloromethane mixtures).



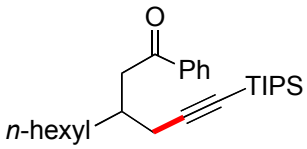
3a

3-methyl-1,3-diphenyl-6-(triisopropylsilyl)hex-5-yn-1-one (Table 1, 3a). Following general procedure A, 3-methyl-1,3-diphenylcyclobutanol (**1a**, 83 mg, 0.35 mmol) and **2a** (119.0 mg, 0.45 mmol) were used. Column chromatography: silica gel, (hexanes/EtOAc, 15:1, R_f=0.60). Yellowish oil; yield: 134 mg (92% yield). ^{1}H-NMR: (400 MHz, $CDCl_3$) δ 7.87 (dd, *J* = 1.34 Hz; 8.32 Hz, 2H), 7.53-7.49 (m, 1H), 7.39-7.37 (m, 4H), 7.29-7.25 (m, 2H), 7.19-7.14 (m, 1H), 3.62 (d, *J* = 16.93 Hz, 1H), 3.52 (d, *J* = 16.89 Hz, 1H), 2.94 (d, *J* = 16.75 Hz, 1H), 2.81 (d, *J* = 16.74 Hz, 1H), 1.63 (s, 3H), 1.10 (s, 3H), 0.99 (s, 18H). ^{13}C-NMR: (101 MHz, $CDCl_3$) δ 198.1, 146.5, 137.9, 132.7, 128.1, 127.9, 126.1, 125.7, 106.1, 83.3, 47.7, 40.3, 33.3, 26.3, 18.6, 11.3, 11.3. IR (neat, cm^{-1}): 2981, 1786, 1761, 1698, 1446, 1220, 1010, 823, 690, 553. HRMS *calcd* for $[C_{28}H_{38}OSi+Na]$ 441.2590, *found* 441.2591.



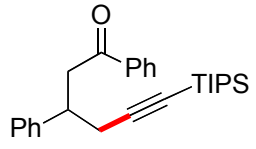
3b

2,5-dimethyl-5-phenyl-8-(triisopropylsilyl)oct-7-yn-3-one (Table 1, 3b). Following general procedure A, 1-isopropyl-3-methyl-3-phenylcyclobutanol (**1b,** 72 mg, 0.35 mmol) and **2a** (119.0 mg, 0.45 mmol) were used. Column chromatography: silica gel, (hexanes/EtOAc, 15:1, R_f=0.60). Brownish oil; yield: 112 mg (83% yield). ^{1}H-NMR: (300 MHz, $CDCl_3$) δ 7.39-7.14 (m, 5H), 3.00 (dd, *J* = 16.59 Hz; 15.94 Hz, 2H), 2.75 (dd, *J* = 16.70 Hz; 21.90 Hz, 2H), 2.36 (p, *J* = 6.91 Hz, 1H), 1.55 (s, 3H), 1.26-0.93 (m, 27H). ^{13}C-NMR: (75 MHz, $CDCl_3$) δ 212.9, 146.3, 128.1, 126.0, 125.7, 106.2, 83.1, 50.0, 41.8, 40.1, 32.9, 25.9, 18.6, 17.9, 11.3. IR (neat, cm^{-1}): 2989, 1872, 1811, 1791, 1762, 1544, 1452, 1324, 1241, 1128, 1003, 935, 785, 682, 453. HRMS *calcd* for [$C_{25}H_{40}$OSi+Na] 407.2746, *found* 407.2748.



3c

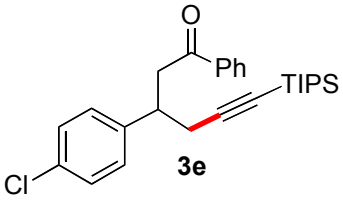
1-phenyl-3-(3-(triisopropylsilyl)prop-2-yn-1-yl)nonan-1-one (Table 1, 3c). Following general procedure A, 3-hexyl-1-phenylcyclobutanol (**1c,** 81 mg, 0.35 mmol) and **2a** (119.0 mg, 0.45 mmol) were used. Column chromatography: silica gel, (hexanes/EtOAc, 15:1, R_f=0.70). Brownish oil; yield: 127 mg (88% yield). ^{1}H-NMR: (400 MHz, $CDCl_3$) δ 7.86 (dd, *J*=1.38 Hz; 8.40 Hz, 1H), 7.55-7.19 (m, 4H), 2.90 (m, 2H), 2.76 (dd, *J* = 6.56 Hz; 13.45 Hz, 1H), 2.60 (dd, *J* = 7.47 Hz; 13.44 Hz, 1H), 2.49-2.38 (m, 1H), 1.39-1.25 (m, 13H), 0.91-0.87 (m, 21H). ^{13}C NMR (75 MHz, $CDCl_3$) ? 200.40, 140.63, 132.81, 129.37, 128.26, 77.38, 77.06, 76.74, 42.60, 40.51, 36.46, 33.92, 31.82, 29.49, 26.79, 22.65, 18.77, 14.11, 11.26. IR (neat, cm^{-1}): 2982, 1782, 1752, 1680, 1562, 1476, 13442, 1118, 1063, 834, 742, 493. HRMS *calcd* for [$C_{27}H_{44}$OSi+Na] 435.3059, *found* 435.3057.



3d

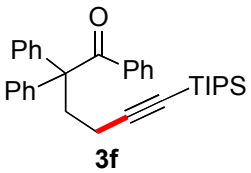
1,3-diphenyl-6-(triisopropylsilyl)hex-5-yn-1-one (Table 1, 3d). Following general procedure A, 1,3-diphenylcyclobutanol (**1d,** 79 mg, 0.35 mmol) and **2a** (119.0 mg, 0.45 mmol) were used. Column chromatography: silica gel, (hexanes/EtOAc, 15:1, R_f=0.80).

Yellowish oil; yield: 110 mg (78% yield). ^{1}H-NMR: (300 MHz, $CDCl_3$) δ 8.01-7.92 (m, 2H), 7.57-7.25 (m, 8H), 3.70-3.62 (m, 2H), 3.48-3.21 (m, 1H), 2.73-2.60 (m, 2H), 1.09-1.00 (m, 21H). ^{13}C-NMR: (75 MHz, $CDCl_3$) δ 198.2, 148.3, 136.5, 133.0, 128.5, 128.4, 128.0, 127.5, 126.5, 106.8, 87.0, 47.2, 31.3, 26.9, 18.6, 11.3. IR (neat, cm^{-1}): 3414, 3295, 2961, 2941, 2920, 2889, 2863, 2164, 1687, 1597, 1462, 1215, 991, 572, 436. HRMS *calcd* for [$C_{27}H_{36}OSi$+Na] 427.2433, *found* 427.2422.



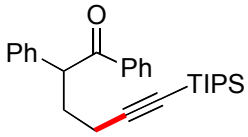
3e

3-(4-chlorophenyl)-1-phenyl-6-(triisopropylsilyl)hex-5-yn-1-one (Table 1, 3e). Following general procedure A, 3-(4-chlorophenyl)-1-phenylcyclobutanol (**1e,** 91 mg, 0.35 mmol) and **2a** (119.0 mg, 0.45 mmol) were used. Column chromatography: silica gel, (hexanes/EtOAc, 15:1, R_f=0.70). Yellowish oil; yield: 120 mg (78% yield). ^{1}H-NMR: (300 MHz, $CDCl_3$) δ 7.95-7.93 (m, 2H), 7.56-7.23 (m, 7H), 3.68-3.59 (m, 2H), 3.37-3.30 (m, 1H), 2.71-2.57 (m, 2H), 1.03-1.01 (m, 21H). ^{13}C NMR (75 MHz, $CDCl_3$) δ 198.1, 142.0, 136.9, 133.1, 132.3, 128.9, 128.8, 128.6, 128.5, 128.2, 127.9, 127.8, 105.7, 83.4, 43.2, 38.9, 26.9, 18.5, 11.2. IR (neat, cm^{-1}): 3004, 1750, 1712, 1438, 1418, 1358, 1220, 1091, 901, 785, 529, 418. HRMS *calcd* for [$C_{27}H_{35}OClSi$+Na] 461.2043, *found* 461.2041.



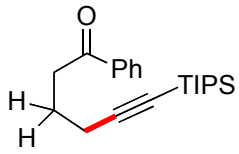
3f

1,2,2-triphenyl-6-(triisopropylsilyl)hex-5-yn-1-one (Table 1, 3f). Following general procedure A, 1,3,3-triphenylcyclobutanol (**1f,** 105 mg, 0.35 mmol) and **2a** (119.0 mg, 0.45 mmol) were used. Column chromatography: silica gel, (hexanes/EtOAc, 15:1, R_f=0.60). Yellowish oil; yield: 128 mg (82% yield). ^{1}H-NMR: (300 MHz, $CDCl_3$) δ 7.38-7.20 (m, 15H), 2.27 (t, *J* = 6.29 Hz, 2H), 2.14 (t, *J* = 6.34 Hz, 2H), 1.07-1.05 (m, 21H). ^{13}C-NMR: (75 MHz, $CDCl_3$) δ 198.0, 142.1, 135.8, 134.0, 129.7, 127.6, 126.9, 126.6, 125.2, 99.7, 85.7, 59.2, 35.5, 21.0, 18.3, 12.9. IR (neat, cm^{-1}): 3065, 1897, 1762, 1684, 1542, 1436, 1345, 1214, 1120, 1006, 746, 691, 553. HRMS *calcd* for [$C_{33}H_{40}OSi$+Na] 503.2746, *found* 503.2744.



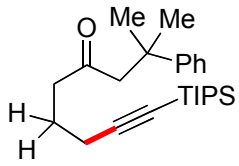
3g

1,2-diphenyl-6-(triisopropylsilyl)hex-5-yn-1-one (Table 1, 3g). Following general procedure A, 1,2-diphenylcyclobutanol (**1g,** 79 mg, 0.35 mmol) and **2a** (119.0 mg, 0.45 mmol) were used. Column chromatography: silica gel, (hexanes/EtOAc, 15:1, R_f=0.60). Yellowish oil; yield: 97 mg (69% yield). ^{1}H-NMR: (300 MHz, $CDCl_3$) δ 7.99-7.96 (m, 2H), 7.50-4.93 (m, 8H), 4.96 (t, *J* = 7.09 Hz, 1H), 2.36-2.00 (m, 2H), 1.97 (p, *J* = 6.98 Hz, 4H), 1.09-0.86 (m, 21H). ^{13}C-NMR: (75 MHz, $CDCl_3$) δ 199.6, 153.2, 138.9, 132.9, 129.0, 128.7, 128.4, 128.3, 127.2, 108.0, 92.8, 51.7, 32.6, 18.7, 17.8, 11.3. IR (neat, cm^{-1}): 3450, 3050 2889, 2863, 1762, 1715, 1681, 1562, 1436, 1276, 1214, 1003, 798, 612, 540. HRMS *calcd* for [$C_{27}H_{36}OSi$+Na] 427.2433, *found* 427.2429.



3h

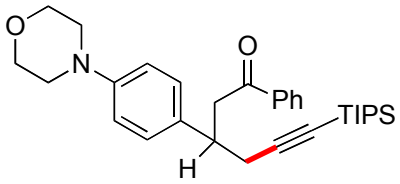
1-phenyl-6-(triisopropylsilyl)hex-5-yn-1-one (Table 1, 3h). Following general procedure A, 1- phenylcyclobutanol (**1h,** 52 mg, 0.35 mmol) and **2a** (119.0 mg, 0.45 mmol) were used. Column chromatography: silica gel, (hexanes/EtOAc, 15:1, R_f=0.70). Brownish oil; yield: 94 mg (82% yield). ^{1}H-NMR: (400 MHz, $CDCl_3$) δ 7.98 (m, 2H), 7.56 (m, 1H), 7.46 (m, 2H), 3.16 (t, *J* = 7.29 Hz, 2H), 2.40 (t, *J* = 6.73 Hz, 2H), 1.97 (p, *J* = 6.98 Hz, 2H), 1.11-0.99 (m, 21H). ^{13}C-NMR: (101 MHz, $CDCl_3$) δ 199.7, 137.0, 133.0, 128.5, 128.0, 108.0, 81.3, 37.1, 23.2, 19.4, 18.6, 11.3. IR (neat, cm^{-1}): 3002, 1789, 1659, 1465, 1240, 1093, 896, 690, 542. HRMS *calcd* for [$C_{21}H_{32}OSi$+Na] 351.2120, *found* 351.2118.



3i

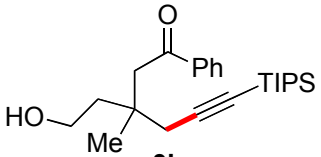
1,2,2-triphenyl-6-(triisopropylsilyl)hex-5-yn-1-one (Table 1, 3i). Following general procedure A, 1-(2-methyl-2-phenylpropyl)cyclobutanol (**1i,** 72 mg, 0.35 mmol) and **2a** (119.0 mg, 0.45 mmol) were used. Column chromatography: silica gel, (hexanes/EtOAc, 15:1, R_f=0.60). Orange oil; yield: 116 mg (86% yield). ^{1}H-NMR: (300 MHz, $CDCl_3$) δ 7.37-7.16 (m, 5H), 2.72 (s, 2H), 2.25 (t, *J* = 7.16 Hz, 2H), 2.12 (t, *J* =

6.88 Hz, 2H), 1.61-1.56 (m, 2H), 1.43 (s, 6H), 1.06-1.04 (m, 21H). ^{13}C-NMR: (75 MHz, $CDCl_3$) δ209.4, 148.3, 128.2, 125.9, 125.4, 108.1, 89.3, 56.0, 43.0, 37.4, 28.9, 22.5, 19.1, 18.6, 11.3. IR (neat, cm^{-1}): 3014, 1785, 1654, 1346, 1284, 1245, 1093, 897, 657, 540, 433. HRMS *calcd* for [$C_{25}H_{40}OSi$+Na] 407.2746, *found* 407.2748.



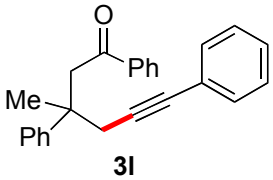
3j

3-(4-morpholinophenyl)-1-phenyl-6-(triisopropylsilyl)hex-5-yn-1-one (Table 1, 3j). Following general procedure A, 3-(4-morpholinophenyl)-1-phenylcyclobutanol (**1j,** 108 mg, 0.35 mmol) and **2a** (119.0 mg, 0.45 mmol) were used. Column chromatography: silica gel, (hexanes/EtOAc, 15:1, R_f=0.60). Yellowish solid; yield: 125 mg (82% yield). ^{1}H-NMR: (300 MHz, $CDCl_3$) δ 7.94-7.92 (m, 2H), 7.55-7.40 (m, 3H), 7.29-7.23 (m, 4H), 4.15-3.85 (m, 4H), 3.68-3.58 (m, 2H), 3.36-3.30 (m, 1H), 2.99-2.94 (m, 4H), 2.70-2.56 (m, 2H), 1.02-1.01 (m, 21H). ^{13}C NMR (75 MHz, $CDCl_3$) δ198.1, 144.7, 137.9, 136.9, 133.2, 128.8, 128.6, 127.2, 115.6, 105.8, 91.6, 65.9, 49.8, 45.9, 29.8, 29.6, 18.6, 11.3. IR (neat, cm^{-1}): 3009, 1752, 1720, 1437,1420, 1368, 1240, 1191, 930, 840, 532, 419. HRMS *calcd* for [$C_{31}H_{43}NO_2Si$+Na] 512.2961, *found* 512.2958.



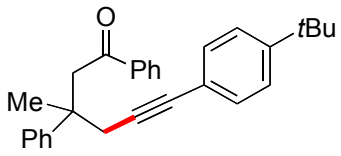
3k

3-(2-hydroxyethyl)-3-methyl-1-phenyl-6-(triisopropylsilyl)hex-5-yn-1-one (Table 1, 3k). Following general procedure A, 3-(2-hydroxyethyl)-3-methyl-1-phenylcyclobutanol (**1k,** 72 mg, 0.35 mmol) and **2a** (119.0 mg, 0.45 mmol) were used. Column chromatography: silica gel, (hexanes/EtOAc, 15:1, R_f=0.30). Yellowish solid; yield: 55 mg (41% yield). ^{1}H-NMR: (300 MHz, $CDCl_3$) δ 7.96-7.93 (m, 2H), 7.57-7.26 (m, 3H), 4.17 (t, *J* = 6.87 Hz, 1H), 3.27-3.26 (bs, 1H), 3.11 (s, 1H), 2.81-2.46 (m, 3H), 1.95-1.91 (m, 2H), 1.09-0.97 (m, 24H). ^{13}C NMR (75 MHz, $CDCl_3$) δ 198.9, 135.8, 132.9, 128.5, 127.9, 99.8, 88.6, 56.6, 48.5, 44.5, 30.9, 23.6, 20.7, 18.6, 11.3. IR (neat, cm^{-1}): 3003, 1750, 1712, 1438, 1418, 1358, 1220, 1091, 901, 785, 529. HRMS *calcd* for [$C_{24}H_{38}O_2Si$+Na] 409.2539, *found* 409.2536.



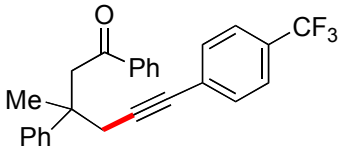
3l

3-Methyl-1,3,6-triphenyl-5-hexyn-1-one (Table 2, 3l). Following the general procedure B, using **1a** (0.50 mmol, 119 mg) and 1-bromophenylacetylene (1.0 mmol, 181 mg) provided 127 mg (75% yield) of the corresponding product as a brown oil. Column chromatography: silica gel, (hexanes/CH_2Cl_2, 8:2). ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.99-7.96 (m, 2H), 7.60-7.56 (m, 1H), 7.53-7.44 (m, 4H), 7.42-7.38 (m, 4H), 7.33-7.26 (m, 4H), 3.69 (dd, *J* = 48, 20 Hz, 2H), 3.11 (dd, *J* = 58, 20Hz, 2H), 1.78 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 13C NMR (100 MHz, CDCl3) δ 198.4, 146.4, 137.8, 132.7, 131.4, 128.4, 128.1, 127.9, 127.6, 126.1, 125.6, 123.6, 112.8, 87.6, 83.3, 47.5, 40.6, 32.7, 26.3. IR (neat, cm^{-1}): 1681, 1578, 1496, 1444, 1352, 1180, 1029, 1008, 934, 887, 699, 602, 544. HRMS *calcd.* for ($C_{25}H_{22}O$+Na): 316.1568, *found* 316.1563.



3m

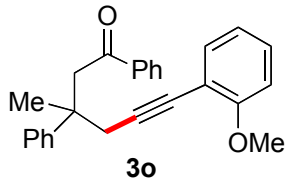
6-(4-(Tert-butyl)phenyl)-3-methyl-1,3-diphenyl-5-hexyn-1-one (Table 2, 3m). Following the general procedure B, using **1a** (0.50 mmol, 119 mg) and 1-bromo-4-tert-butylphenylacetylene (1.0 mmol, 237 mg) provided 114 mg (58% yield) of the corresponding product as a brown oil. Column chromatography: silica gel, (hexanes/CH_2Cl_2, 8:2). ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.94-7.92 (m, 2H), 7.55-7.53 (m, 1H), 7.48-7.42 (m, 4H), 7.37-7.23 (m, 7H), 3.64 (dd, *J* = 48, 20 Hz, 2H), 3.04 (dd, *J* = 56, 20 Hz, 2H), 1.72 (s, 3H), 1.32 (s, 9H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 198.3, 150.8, 146.6, 137.9, 132.7, 131.2, 128.4, 128.1, 127.9, 126.1, 125.7, 125.1, 120.7, 86.9, 83.3, 47.6, 40.6, 34.6, 32.9, 31.1, 26.3. IR (neat, cm^{-1}): 1692, 1671, 1596, 1497, 1406, 1361, 1352, 1267, 1179, 1108, 1002, 922, 798, 664. HRMS *calcd.* for ($C_{29}H_{30}O$+Na): 417.2189, *found* 417.2201.



3n

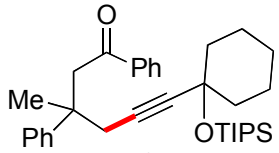
3-Methyl-1,3-diphenyl-6-(4-(trifluoromethyl)phenyl)-5-hexyn-1-one (Table 2, 3n). Following the general procedure B, using **1a** (0.30 mmol, 71.4 mg) and 1-(bromoethynyl)-4-(trifluoromethyl)benzene (0.6 mmol, 149 mg) provided 45 mg (37% yield) of the corresponding product as a brown oil. Column chromatography: silica gel, (hexanes/CH_2Cl_2, 8:2). ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.93-7.91 (m, 2H), 7.58-7.51 (m, 3H), 7.47-7.33 (m, 8H), 7.26-7.22 (m, 1H), 3.63 (dd, *J* = 40, 20 Hz, 2H), 3.10 (dd, *J* = 52, 20 Hz, 2H), 1.72 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 198.2, 146.3, 137.8, 132.9,

131.7, 129.3 (d, *J* = 40 Hz), 128.5, 128.3, 127.9, 127.3, 126.3, 125.7, 125.0 (m), 90.6, 82.2, 47.7, 40.6, 32.5, 26.4. IR (neat, cm^{-1}): 1691, 1597, 1165, 1065, 1002, 751, 688, 664, 596. HRMS *calcd.* for ($C_{26}H_{21}F_3O$+Na): 429.1437, *found* 429.1424.



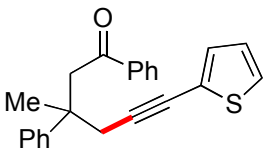
3o

6-(2-Methoxyphenyl)-3-methyl-1,3-diphenyl-5-hexyn-1-one (Table 2, 3o). Following the general procedure B, using **1a** (0.50 mmol, 119 mg) and 1-(bromoethynyl)-2-methoxybenzene (1.0 mmol, 211 mg) provided 73 mg (41% yield) of the corresponding product as a brown oil. Column chromatography: silica gel, (hexanes/CH_2Cl_2, 8:2). ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.97-7.95 (m, 2H), 7.56-7.41 (m, 5H), 7.36-7.21 (m, 5H), 6.91-6.85 (m, 2H), 3.80 (s, 3H), 3.75 (dd, *J* = 52, 20 Hz, 2H), 3.08 (dd, *J* = 60, 20 Hz, 2H), 1.73 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 198.3, 160.0, 146.6, 137.9, 133.2, 132.6, 128.9, 128.3, 128.1, 127.9, 125.9, 125.7, 120.3, 112.9, 110.5, 91.9, 79.5, 55.59, 47.5, 40.5, 33.5, 26.2. IR (neat, cm^{-1}): 1688, 1595, 1491, 1376, 1291, 1179, 1072, 1002, 946, 880, 664, 604. HRMS *calcd.* for ($C_{26}H_{24}O_2$+Na): 391.1669, *found* 391.1676.



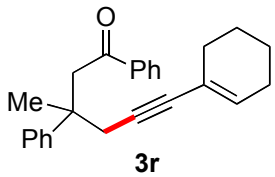
3p

3-Methyl-1,3-diphenyl-6-(1-((triisopropylsilyl)oxy)cyclohexyl)-5-hexyn-1-one (Table 2, 3p). Following the general procedure B, using **1a** (0.30 mmol, 71.4 mg) and 1-(bromoethynyl)cyclohexyl)oxy)triisopropylsilane (0.6 mmol, 187 mg) provided 99 mg (64% yield) of the corresponding product as a colorless oil. Column chromatography: silica gel, (hexanes/CH_2Cl_2, 1:1). ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.91-7.89 (m, 2H), 7.56-7.52 (m, 1H), 7.45-7.40 (m, 4H), 7.33-7.28 (m, 2H), 7.22-7.18 (m, 1H), 3.55 (dd, *J* = 44, 20 Hz, 2H), 2.89 (dd, *J* = 56, 20 Hz, 2H), 1.87-1.76 (m, 2H), 1.66 (s, 3H), 1.62-1.55 (m, 4H), 1.41-1.06 (m, 26H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 198.0, 146.5, 137.8, 132.7, 128.4, 128.1, 127.8, 126.0, 125.7, 87.4, 82.2, 77.3, 76.7, 69.2, 47.9, 41.6, 40.3, 32.1, 26.2, 25.3, 23.1, 18.4, 13.1. IR (neat, cm^{-1}): 2940, 2289, 1694, 1461, 1446, 1105, 1054, 881, 750, 697, 687, 637. HRMS *calcd.* for ($C_{34}H_{48}O_2Si$+Na): 539.3316, *found* 539.3321.



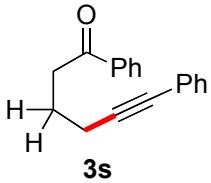
3q

3-Methyl-1,3-diphenyl-6-(3-thienyl)-5-hexyn-1-one (Table 2, 3q). Following the general procedure B, using **1a** (0.50 mmol, 119 mg) and 3-(bromoethynyl)thiophene (2.0 mmol, 374 mg) provided 104 mg (61% yield) of the corresponding product as a yellow oil. Column chromatography: silica gel, (hexanes/CH_2Cl_2, 1:1). ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.94-7.91 (m, 2H), 7.57-7.53 (m, 1H), 7.46-7.44 (m, 4H), 7.37-7.33 (m, 2H), 7.29-7.28 (m, 1H), 7.25-7.21 (m, 2H), 7.01 (dd, *J* = 5.0, 1.2 Hz, 1H), 3.63 (dd, *J* = 44, 20 Hz, 2H), 3.04 (dd, *J* = 56, 20 Hz, 2H), 1.72 (s, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 198.3, 146.5, 137.9, 132.7, 129.9, 128.4, 128.2, 127.9, 127.9, 127.7, 126.1, 125.7, 124.9, 122.6, 87.2, 78.3, 47.6, 40.6, 32.7, 26.4. IR (neat, cm^{-1}): 1688, 1596, 1520, 1495, 1375, 1215, 1179, 1119, 858, 751, 688, 641, 568. HRMS *calcd.* for ($C_{23}H_{20}OS$+Na): 367.1127, *found* 367.1132.



3r

6-(1-Cyclohexenyl)-3-methyl-1,3-diphenyl-5-hexyn-1-one (Table 2, 3r). Following the general procedure B, using **1a** (0.30 mmol, 71.4 mg) and 1-(bromoethynyl)cyclohex-1-ene (0.6 mmol, 110 mg) provided 36 mg (35% yield) of the corresponding product as a colorless oil. Column chromatography: silica gel, (hexanes/CH_2Cl_2, 7:3). ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.92-7.89 (m, 2H), 7.56-7.52 (m, 1H), 7.45-7.39 (m, 3H), 7.22-7.18 (m, 1H), 5.98-5.96 (m, 1H), 3.57 (dd, *J* = 48, 20 Hz, 2H), 2.90 (dd, *J* = 64, 20 Hz, 2H), 2.07-2.03 (m, 5H), 1.65 (s, 3H), 1.64-1.55 (m, 3H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 198.3, 146.6, 137.9, 133.4, 132.7, 128.6, 128.4, 128.3, 128.2, 128.1, 128.0, 127.9, 126.0, 125.8, 125.7, 120.8, 85.2, 84.6, 47.5, 40.5, 32.9, 29.4, 26.2, 25.5, 22.3, 21.5. IR (neat, cm^{-1}): 2285, 1691, 1596, 1446, 1354, 1179, 1029, 946, 799, 697, 689, 663. HRMS *calcd.* for ($C_{25}H_{26}O$+Na): 365.1876, *found* 365.1862.

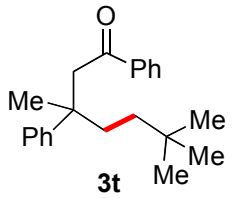


3s

1,6-Diphenyl-5-hexyn-1-one (Table 2, 3s).[4] Following the general procedure B, using **1h** (0.50 mmol, 74.1 mg) and 1-bromophenylacetylene (1.0 mmol, 181 mg) provided 57 mg (46% yield) of the corresponding product as an orange oil. Column chromatography: silica gel, (hexanes/CH_2Cl_2, 1:1). ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.04-8.02 (m, 2H), 7.59-7.57 (m, 1H), 7.51-7.47 (m, 1H), 7.43-7.40 (m, 1H), 7.30-7.28 (m,

[4] Crandall, J. K.; Ayers, T. A. *Organometallics* **1992**, *11*, 473-477.

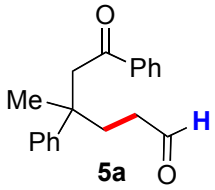
2H), 3.21 (t, *J* = 7Hz, 2H), 2.59 (t, *J* = 7 Hz, 2H), 2.13-2.06 (m, 2H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 199.7, 136.9, 133.0, 131.5, 128.6, 128.2, 128.1, 127.7, 123.8, 89.3, 81.5, 37.3, 23.2, 18.9.



3t

3,6,6-trimethyl-1,3-diphenylheptan-1-one (3t). Following the general procedure A, using **1a** (0.35 mmol, 83 mg), NatBuO (1.10 equiv), Dicyclohexylphosphinobutane (4 mol%) and neopentyliodide (0.46 mmol, 61 µL) provided 268 mg (87% yield) of the corresponding product as colorless oil. Column chromatography: silica gel, (hexanes/EtOAc, 15:1). ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.81 (dd, *J* = 8.5 Hz; 1.3 Hz, 1H), 7.47-7.14 (m, 8H), 3.32 (dd, *J* = 15.6 Hz; 53.2 Hz, 1H), 1.90 (td, *J* = 12.9, 4.3 Hz, 1H), 1.74 (td, *J* = 12.9, 4.7 Hz, 1H), 1.51 (s, 3H), 1.06 (td, *J* = 12.8, 4.6 Hz, 1H), 0.81 (s, 9H). ^{13}C NMR (75 MHz, $CDCl_3$) δ 199.1, 147.2, 138.4, 132.5, 128.3, 128.0, 127.9, 126.1, 125.6, 77.4, 77.0, 76.6, 50.3, 40.5, 37.7, 37.5, 30.1, 29.3, 24.4. IR (neat, cm^{-1}): 2285, 1691, 1596, 1446, 1354, 1179, 1029, 946, 799, 697, 689, 663. MS (m/z): 308.2

Synthetic Application Profile (Table 3)

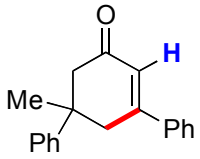


5a

4-methyl-6-oxo-4,6-diphenylhexanal (5a). Following reported procedure[5], borane monohydrate (1.0 M in THF) was charged in a flask under Ar. Cyclohexene (61µL, 0.60 mmol) was added dropwise at 0 °C and the mixture was stirred for 1h. 3-methyl-1,3-diphenylhex-5-yn-1-one (**4a,** 80 mg, 0.30 mmol) in THF was added to the mixture (which turned to clear yellow almost immediately) and the mixture was stirred at room temperature for an additional hour. Thereafter, sodium perborate monohydrate (90 mg, 0.90 mmol) and water (0.3mL) were added and the mixture was stirred at room temperature overnight (the mixture turned colorless). The product was obtained as a

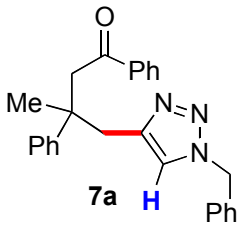
[5] G. W. Kabalka, S. Yu, N.-S. Li, *Can. J. Chem.*, 1998, **76**, 800.

colorless oil after column chromatography (Hexanes:EtOAc; 15:1, R_f=0.4) in 58% yield (50 mg). ^{1}H-NMR: (400 MHz, $CDCl_3$) δ 9.93 (s, 1H), 7.90-7.87 (m, 2H), 7.54-7.20 (m, 8H), 3.56 (dd, *J* = 16.92 Hz; 13.51 Hz, 2H), 2.87 (ddd, *J* = 2.66 Hz; 16.64 Hz; 30.09 Hz, 2H), 2.02 (s, 2H), 1.64 (s, 3H). ^{13}C NMR (75 MHz, $CDCl_3$) δ 208.6, 198.2, 146.2, 137.8, 132.8, 128.4, 128.2, 127.9, 126.2, 125.6, 47.5, 40.0, 34.2, 31.6, 26.2. IR (neat, cm^{-1}): 3005, 2928, 1781, 1658, 1547, 1475, 1312, 1103, 937, 781, 435. HRMS *calcd* for [$C_{19}H_{20}O_2$ + Na] 303.1361, *found* 303.1382



6a

1'-methyl-1',6'-dihydro-[1,1':3',1''-terphenyl]-5'(2'*H*)-one (6a). Following reported procedure[6], $AuCl_3$ (4.5 mg, 5mol%) and AgOTf (11.6 mg, 15mol%) were charged in a schlenk inside of a glovebox. Toluene (1.5mL) and 3-methyl-1,3-diphenylhex-5-yn-1-one (**4a,** 80 mg, 0.30 mmol) were added under Ar and the mixture was stirred at room temperature outside of the glovebox overnight. The product was obtained as a yellowish oil after column chromatography (Hexanes:EtOAc; 15:1, R_f=0.4) in 99% yield (78mg). ^{1}H-NMR: (300 MHz, $CDCl_3$) δ 7.55-7.26 (m, 10H), 6.39 (s, 1H), 3.33-3.27 (m, 1H), 3.07-2.98 (m, 2H), 2.73-2.68 (m, 1H), 1.48 (s, 3H). ^{13}C NMR (75 MHz, $CDCl_3$) δ 202.1, 152.7, 145.2, 137.4, 130.0, 128.8, 128.6, 127.2, 126.5, 126.2, 125.4, 61.3, 49.8, 29.6, 25.5. IR (neat, cm^{-1}): 2929, 1782, 1701, 1396, 1452, 1214, 1102, 1008, 835, 780, 653. HRMS *calcd* for [$C_{19}H_{18}O$+Na] 285.1255, *found* 285.1259

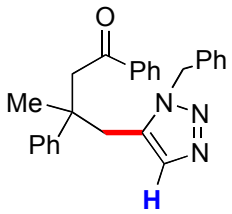


7a

1,2,2-triphenyl-6-(triisopropylsilyl)hex-5-yn-1-one (7a). 3-methyl-1,3-diphenylhex-5-yn-1-one (**4a,** 77 mg, 0.29 mmol) was mixed with sodium ascorbate (12 mg, 0.06 mmol), $CuSO_4$ (1.45 mg, 0.006 mmol) and benzyl azide (36 µL) in tBuOH/H_2O (1:1; 3 mL). The mixture was stirred at room temperature for 48h. The product was obtained as a thick yellowish oil after column chromatography (Hexanes:EtOAc; 1:1) in 96% yield (110 mg). ^{1}H-NMR: (300 MHz, $CDCl_3$) δ 7.87-7.84 (m, 2H), 7.50-7.05 (m, 13H), 6.49 (bs, 1H), 5.34 (s, 2H), 3.65-3.14 (m, 4H), 1.56 (s, 3H). ^{13}C NMR (75 MHz, $CDCl_3$) δ 198.2, 146.2, 137.8, 134.7, 132.6, 128.8, 128.3, 128.3, 127.9, 127.8, 127.6, 125.9,

[6] T. Jin, Y. Yamamoto, *Org. Lett.*, 2007, **9**, 5259.

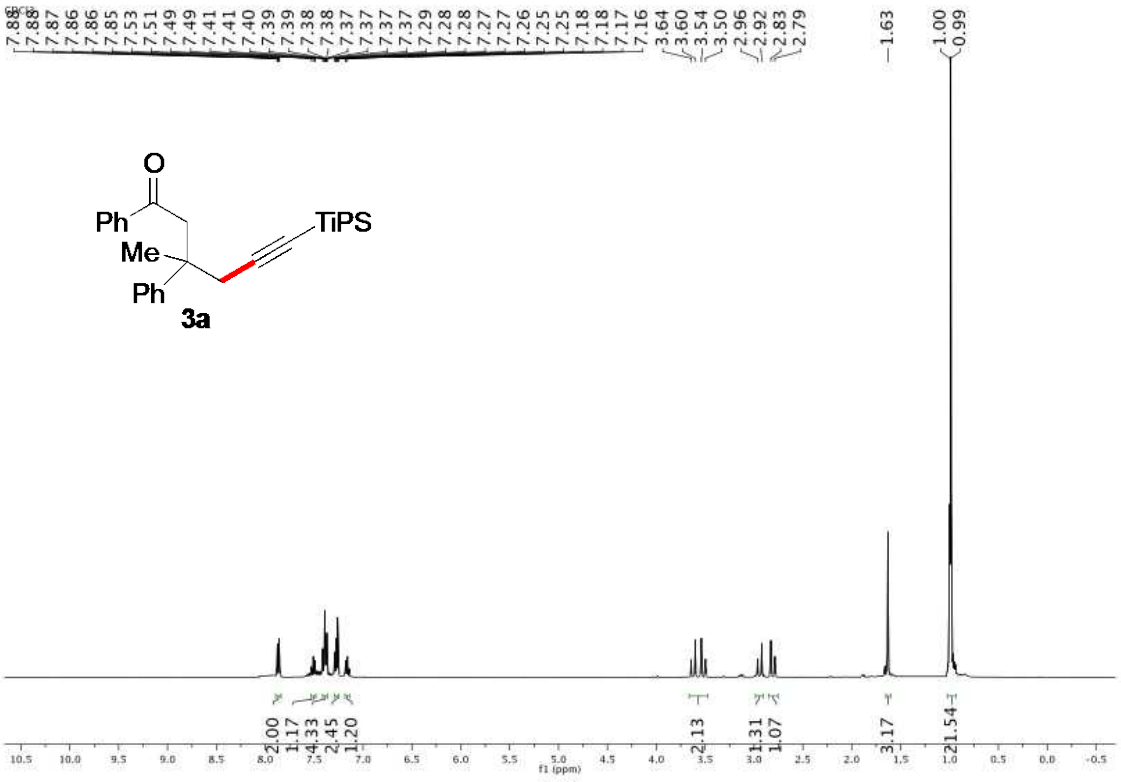
125.8, 53.7, 48.1, 40.8, 39.7, 24.9. IR (neat, cm^{-1}): 3004, 1750,1712, 1438, 1419, 1357, 1220, 1091, 902, 784, 529, 426.

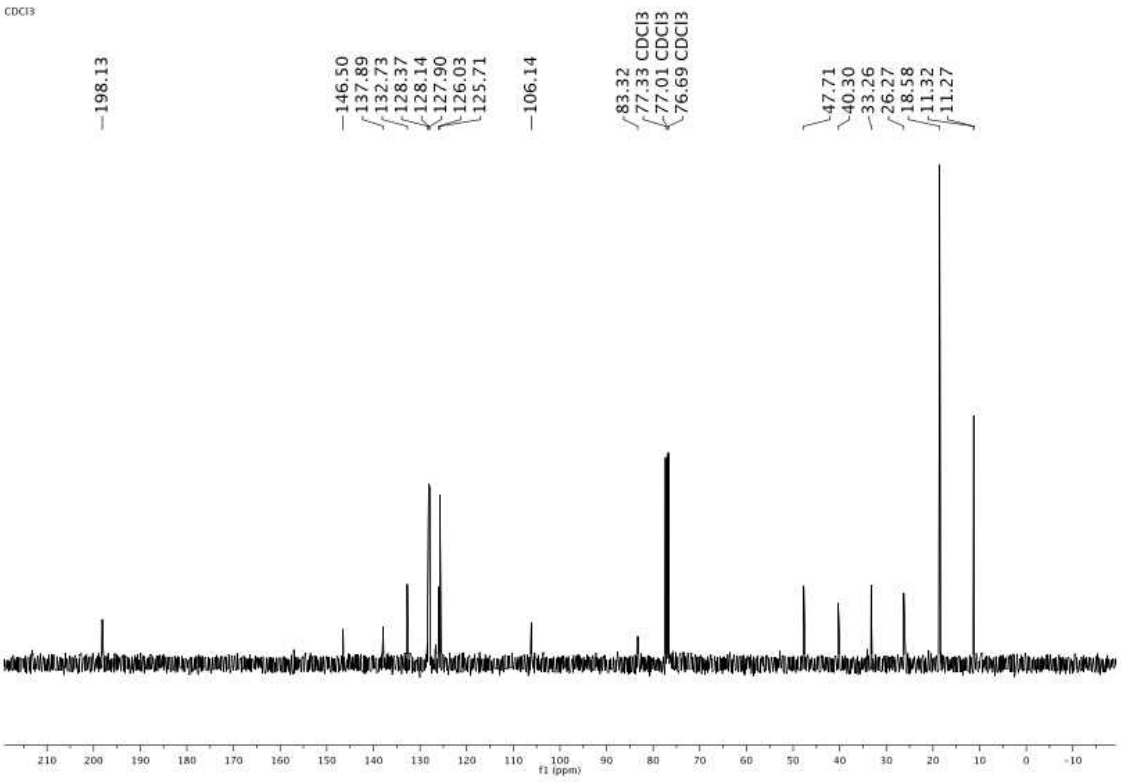


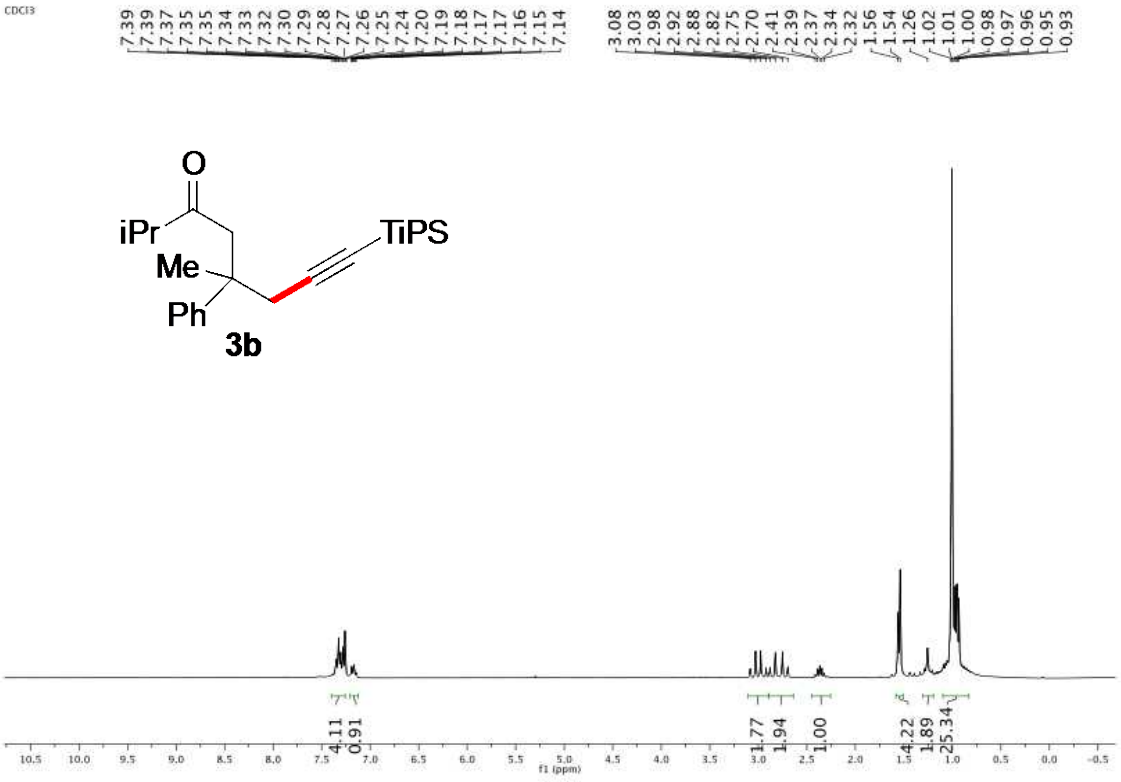
8a

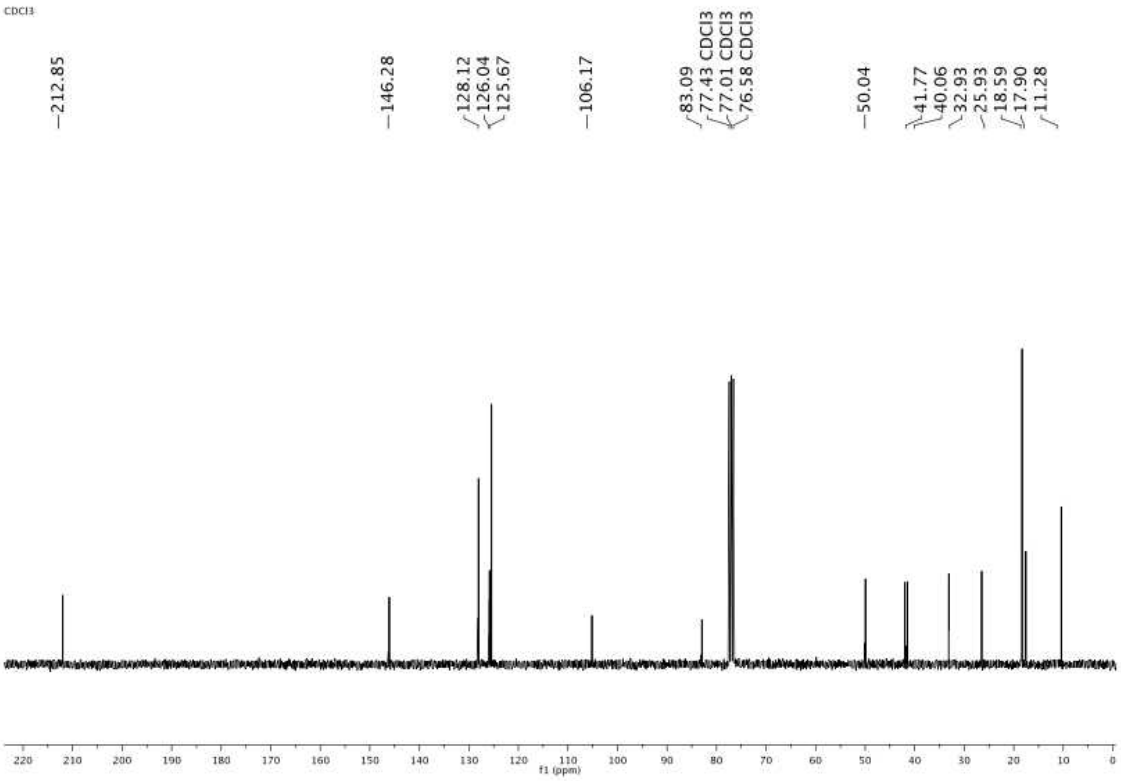
1,2,2-triphenyl-6-(triisopropylsilyl)hex-5-yn-1-one (8a). To a schlenk charged with 3-methyl-1,3-diphenylhex-5-yn-1-one (**4a,** 100 mg, 0.38 mmol) was added Cp*RuCODCl (2.9 mg, 2mol%) under Argon atmospheres. Toluene was then added (3 mL) as the solvent. After stirring at room temperature for 30 minutes, a solution of benzyl azide (47 µL) in toluene (0.20 mL) was added to the flask. The mixture was stirred at room temperature for 14 h. The solvent was evaporated and the product was obtained after column chromatography (Hexanes:EtOAc; 1:1) as a colorless oil in 85% yield (127 mg). ^{1}H-NMR: (300 MHz, $CDCl_3$) δ 7.87-7.84 (m, 2H), 7.55-7.20 (m, 11H), 7.06-6.98 (m, 3H), 5.09 (dd, *J* = 15.69 Hz; 37.12 Hz 2H), 3.56-3.50 (dd, *J* = 16.48 Hz, 1H), 3.25-3.10 (m, 3H), 1.46 (s, 3H). ^{13}C NMR (75 MHz, $CDCl_3$) δ 198.3, 145.5, 137.7, 135.2, 134.2, 133.6, 133.1, 128.8, 128.6, 128.5, 128.0, 127.8, 126.9, 126.8, 125.7, 51.0, 47.2, 40.9, 35.4, 24.5. IR (neat, cm^{-1}): 3003, 1750, 1712, 1438, 1418, 1358, 1220, 1091, 901, 785. 529, 438.

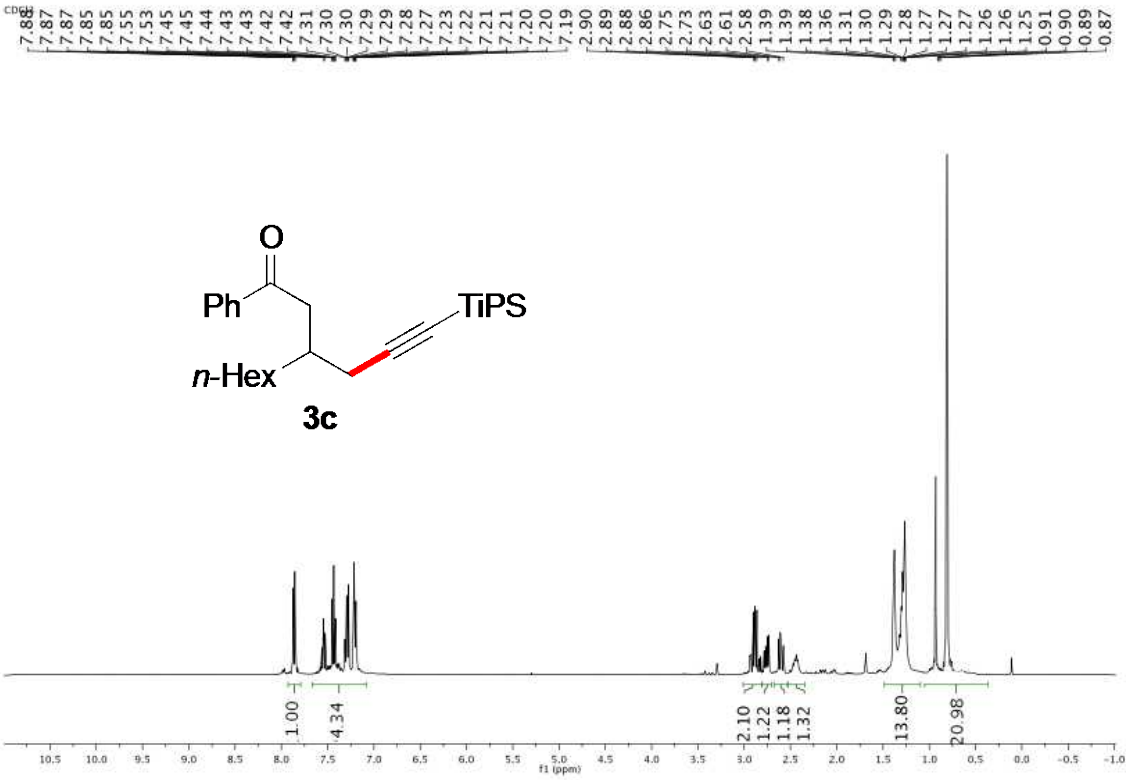
^{1}H-NMR and ^{13}C-NMR Spectra

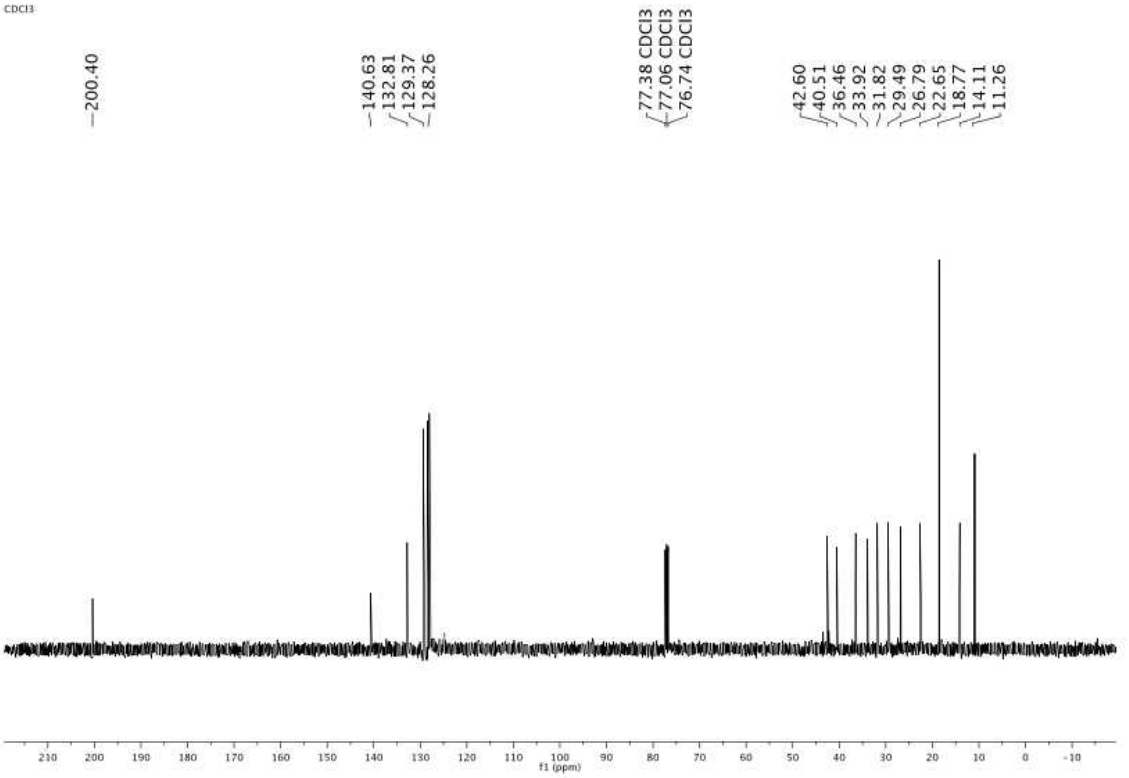

7.88
7.87
7.86
7.85
7.53
7.51
7.49
7.41
7.40
7.39
7.38
7.37
7.29
7.28
7.27
7.26
7.25
7.18
7.17
7.16
3.64
3.60
3.54
3.50
2.96
2.92
2.83
2.79
1.63
1.00
0.99
O
Ph
Me
Ph
TiPS
3a
2.00
1.17
4.33
2.45
1.20
2.13
1.31
1.07
3.17
21.54
f1 (ppm)

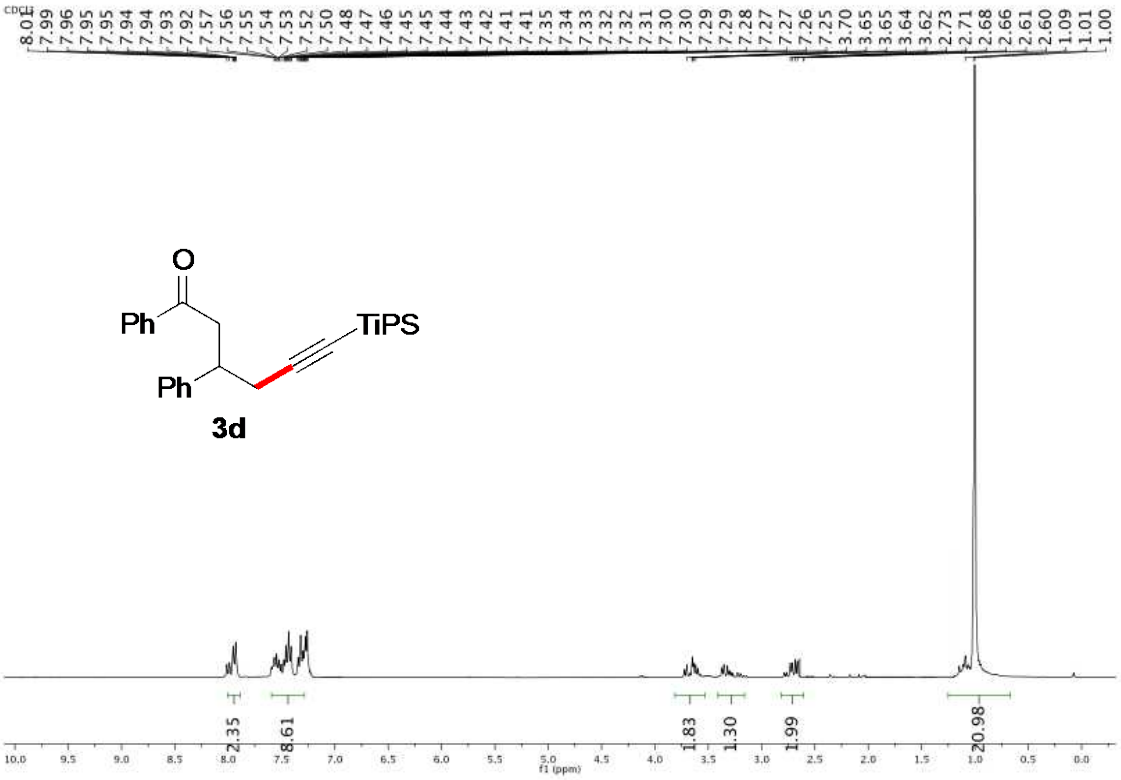

CDCl3
198.13
146.50
137.89
132.73
128.37
128.14
127.90
126.03
125.71
106.14
83.32
77.33 CDCl3
77.01 CDCl3
76.69 CDCl3
47.71
40.30
33.26
26.27
18.58
11.32
11.27
f1 (ppm)

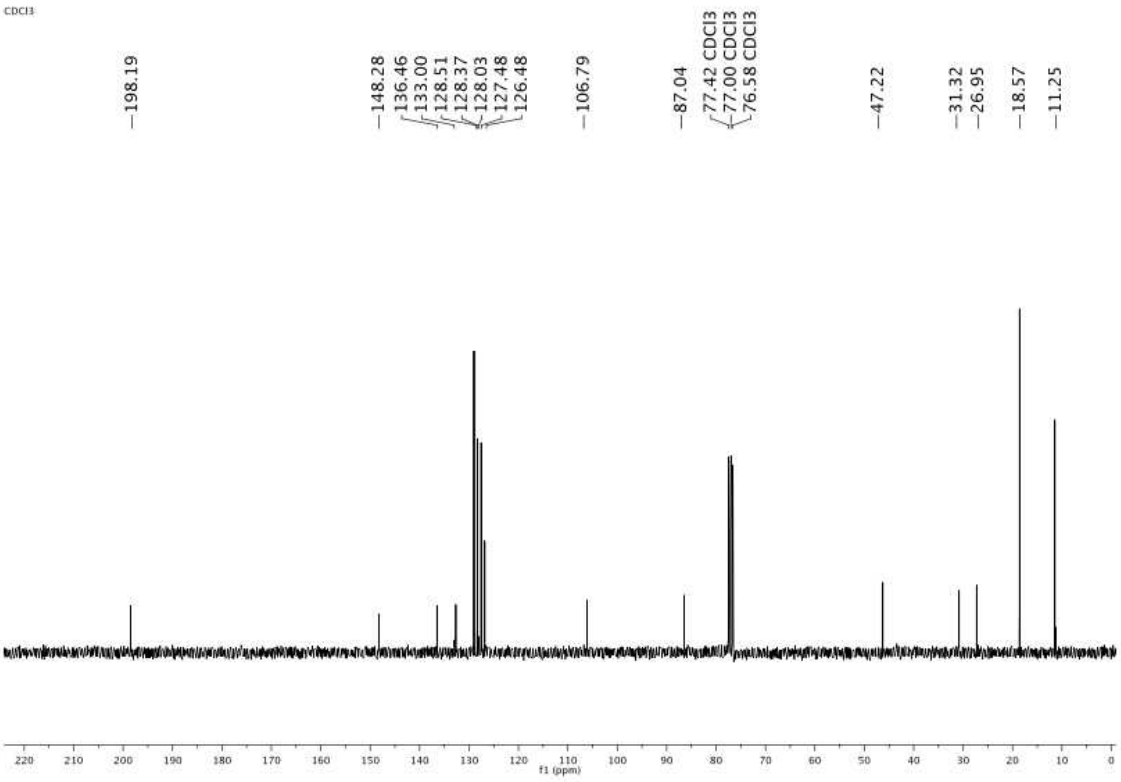

CDCl3
7.39 7.39 7.37 7.35 7.35 7.34 7.33 7.32 7.30 7.29 7.28 7.27 7.26 7.25 7.24 7.20 7.19 7.18 7.17 7.17 7.16 7.15 7.14
3.08 3.03 2.98 2.92 2.88 2.82 2.75 2.70 2.41 2.39 2.37 2.34 2.32 1.56 1.54 1.26 1.02 1.01 1.00 0.98 0.97 0.96 0.95 0.93
O
iPr
Me
Ph
TiPS
3b
4.11 0.91 1.77 1.94 1.00 4.22 1.89 25.34
f1 (ppm)

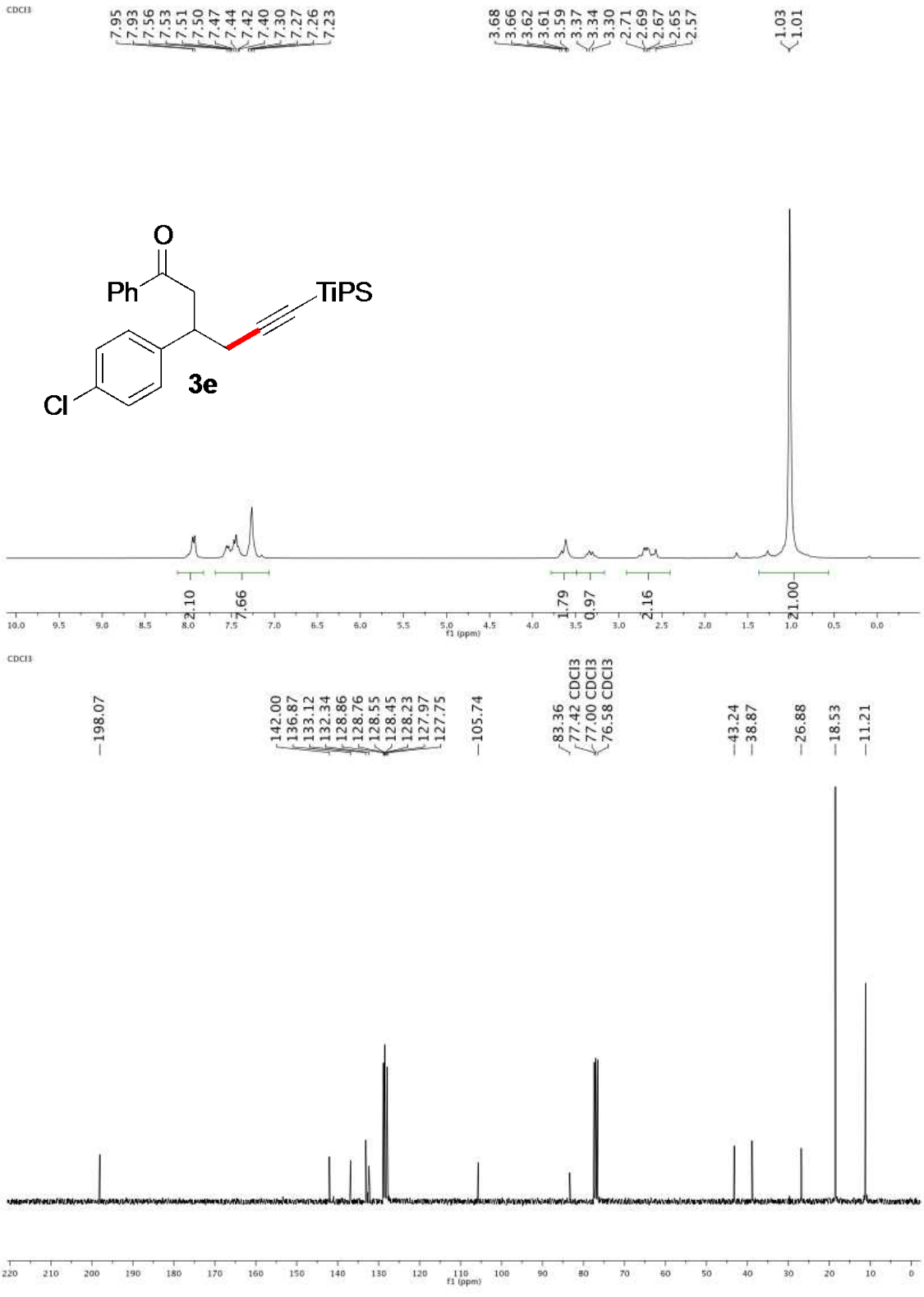

CDCl3
212.85
146.28
128.12 126.04 125.67
106.17
83.09 77.43 CDCl3 77.01 CDCl3 76.58 CDCl3
50.04
41.77 40.06 32.93 25.93 18.59 17.90 11.28
f1 (ppm)

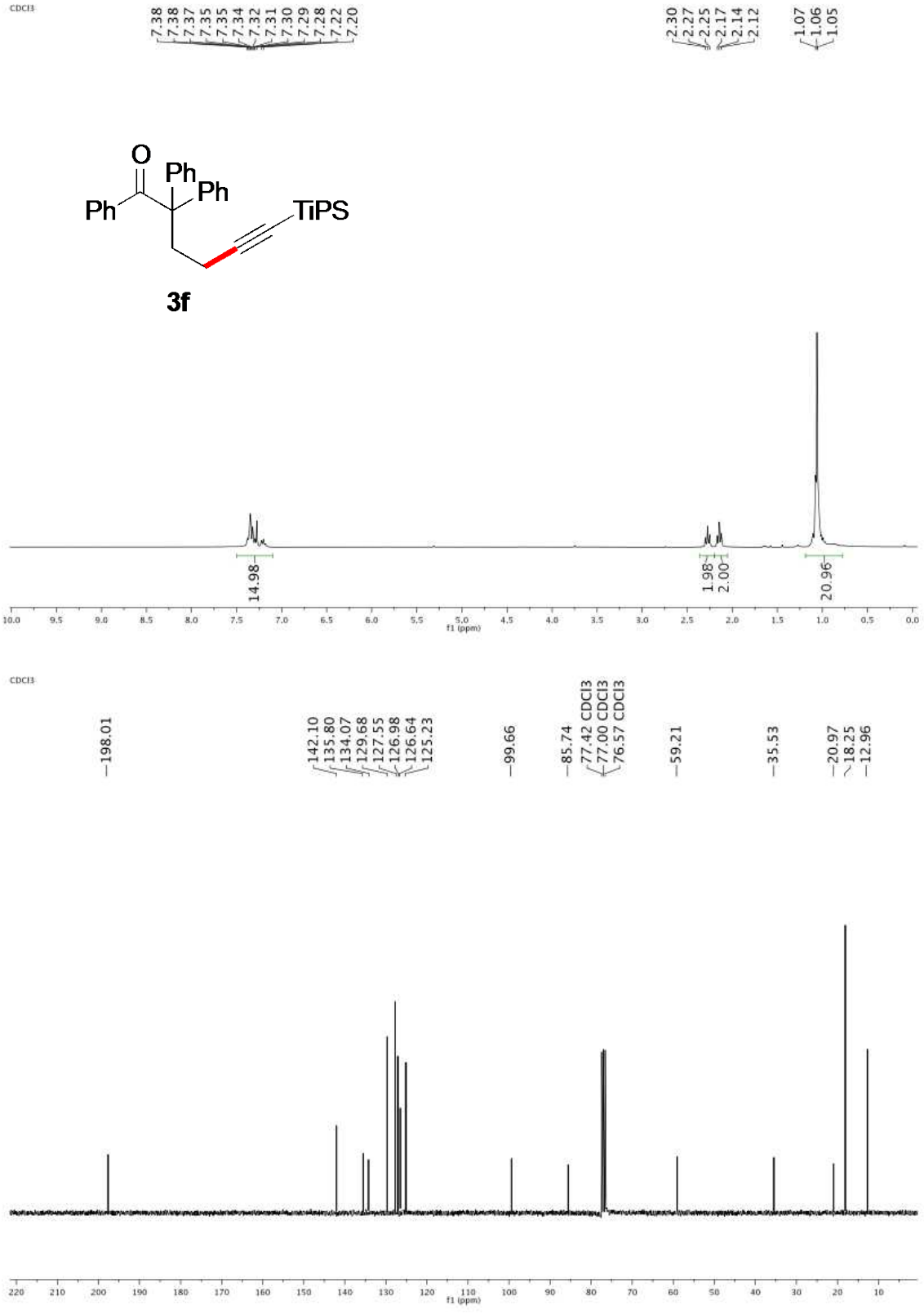

CDCl3
7.88
7.87
7.87
7.85
7.85
7.55
7.53
7.45
7.45
7.44
7.43
7.43
7.42
7.42
7.31
7.30
7.30
7.29
7.29
7.28
7.27
7.23
7.22
7.21
7.21
7.20
7.20
7.19
2.90
2.89
2.88
2.86
2.75
2.73
2.63
2.61
2.58
1.39
1.39
1.38
1.36
1.31
1.30
1.29
1.28
1.27
1.27
1.27
1.26
1.26
1.25
0.91
0.90
0.89
0.87
O
Ph
TiPS
n-Hex
3c
1.00
4.34
2.10
1.22
1.18
1.32
13.80
20.98
f1 (ppm)

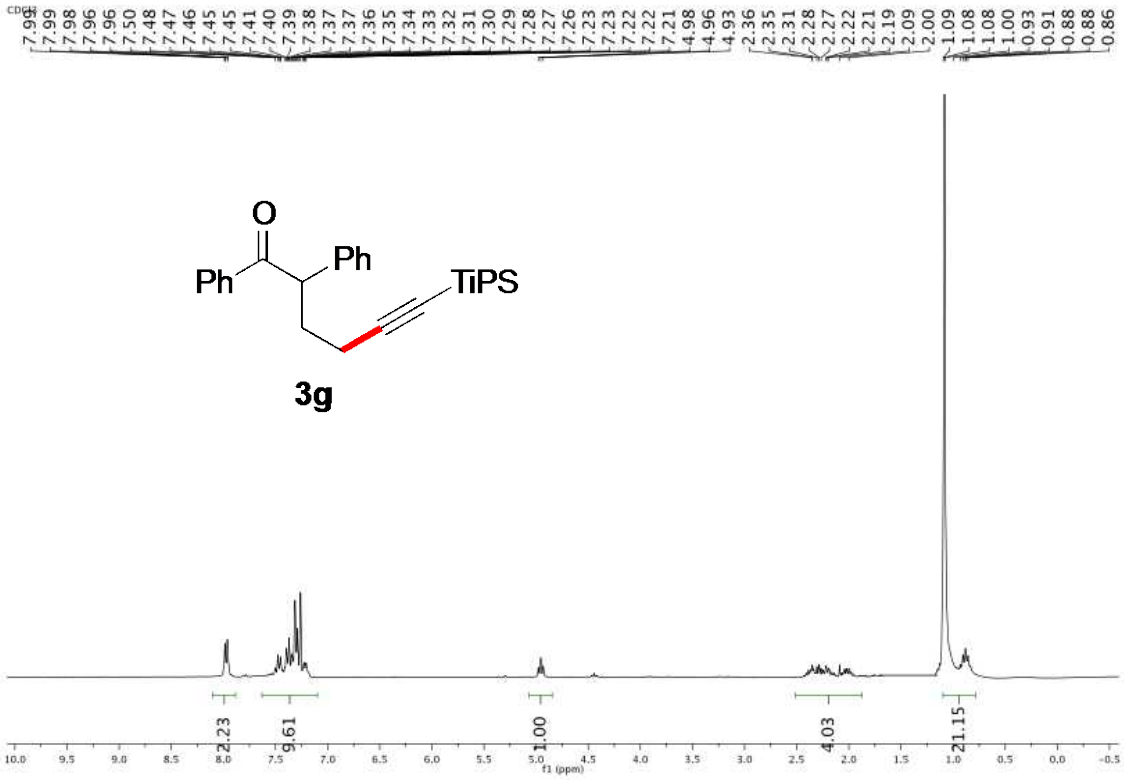

CDCl3
200.40
140.63
132.81
129.37
128.26
77.38 CDCl3
77.06 CDCl3
76.74 CDCl3
42.60
40.51
36.46
33.92
31.82
29.49
26.79
22.65
18.77
14.11
11.26
f1 (ppm)

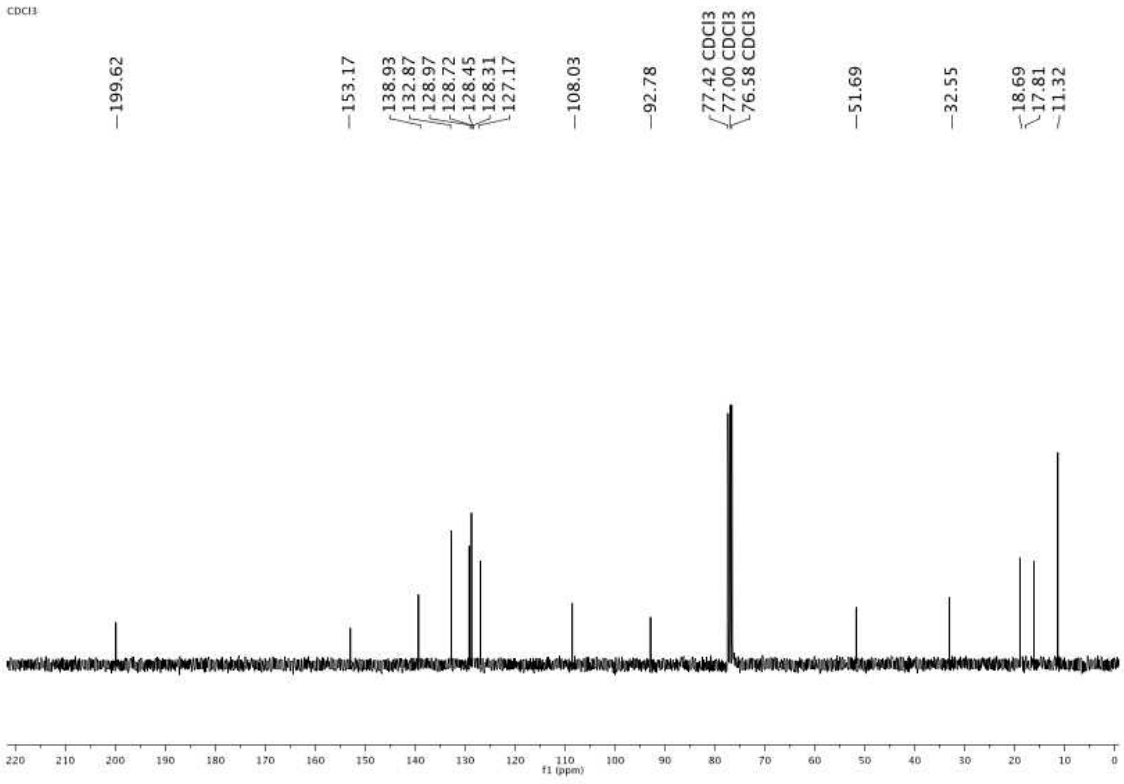

CDCl3
8.01
7.99
7.96
7.95
7.95
7.94
7.94
7.93
7.92
7.57
7.56
7.55
7.54
7.53
7.52
7.50
7.48
7.47
7.46
7.45
7.45
7.44
7.43
7.42
7.41
7.41
7.35
7.34
7.33
7.32
7.32
7.31
7.30
7.30
7.29
7.29
7.28
7.27
7.27
7.26
7.25
3.70
3.65
3.65
3.64
3.62
2.73
2.71
2.68
2.66
2.61
2.60
1.09
1.01
1.00
O
Ph
TiPS
Ph
3d
2.35
8.61
1.83
1.30
1.99
20.98
f1 (ppm)

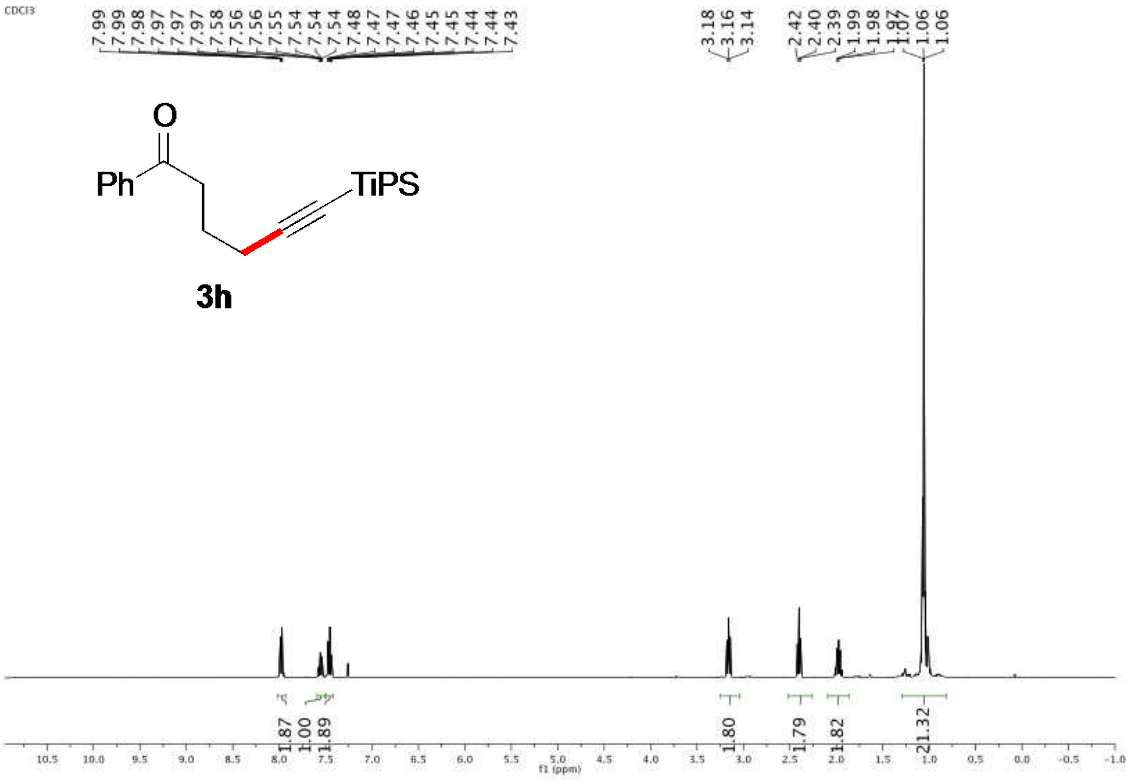

CDCl3
198.19
148.28
136.46
133.00
128.51
128.37
128.03
127.48
126.48
106.79
87.04
77.42 CDCl3
77.00 CDCl3
76.58 CDCl3
47.22
31.32
26.95
18.57
11.25
f1 (ppm)

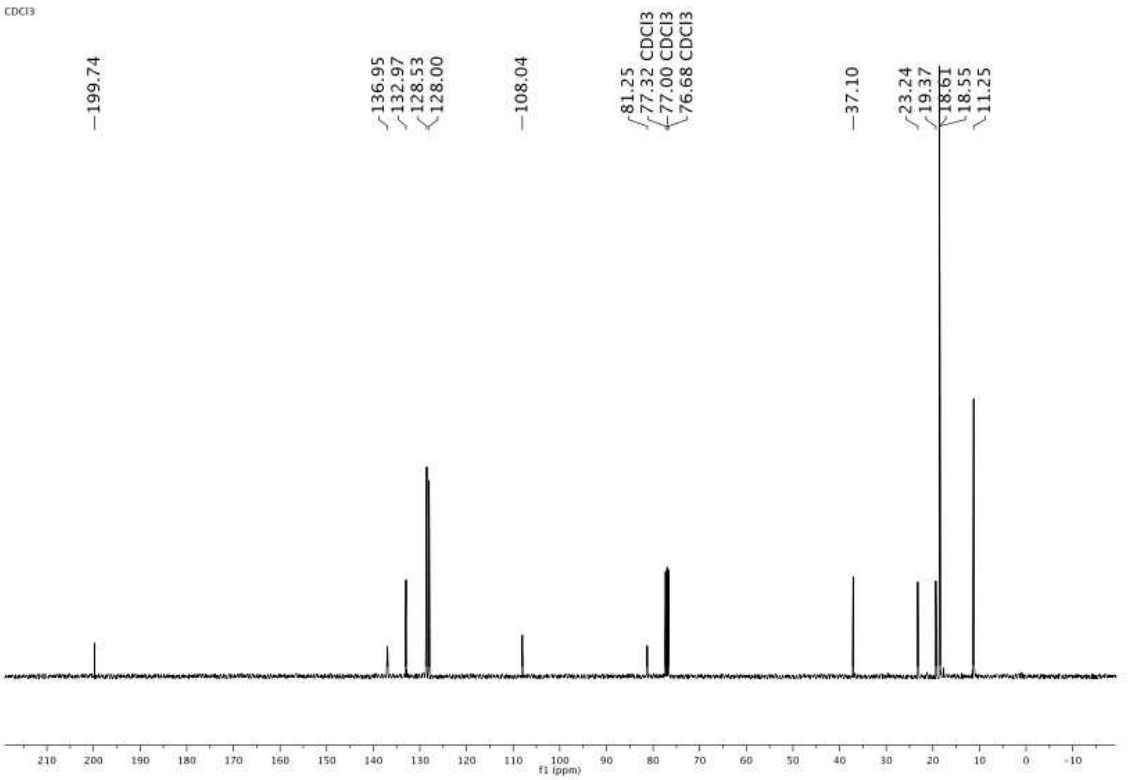

CDCl3
7.95
7.93
7.56
7.53
7.51
7.50
7.47
7.44
7.42
7.40
7.30
7.27
7.26
7.23
3.68
3.66
3.62
3.61
3.59
3.37
3.34
3.30
2.71
2.69
2.67
2.65
2.57
1.03
1.01
O
Ph
TiPS
Cl
3e
2.10
7.66
1.79
0.97
2.16
21.00
f1 (ppm)
CDCl3
198.07
142.00
136.87
133.12
132.34
128.86
128.76
128.55
128.45
128.23
127.97
127.75
105.74
83.36
77.42 CDCl3
77.00 CDCl3
76.58 CDCl3
43.24
38.87
26.88
18.53
11.21
f1 (ppm)

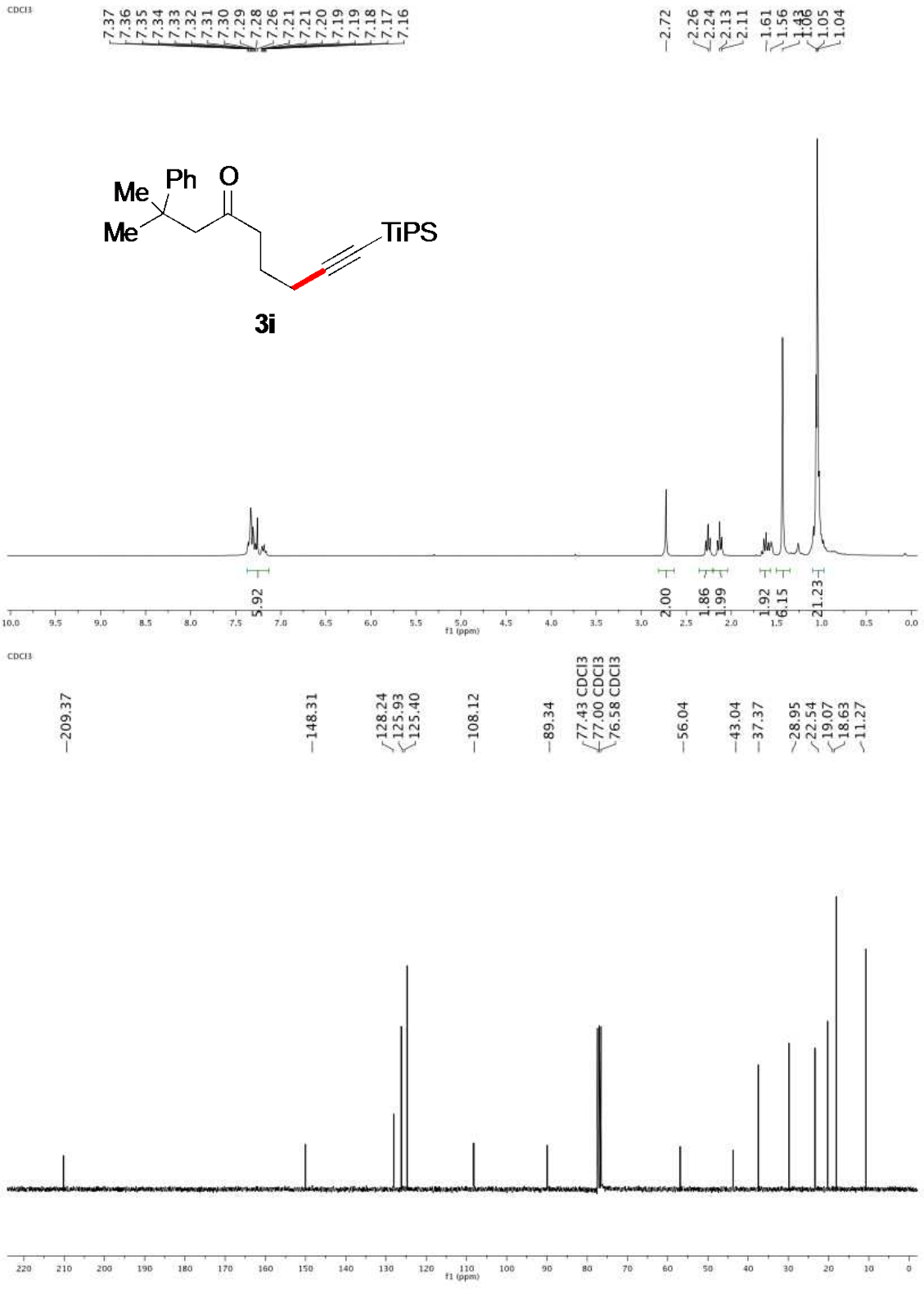

CDCl3
7.38
7.38
7.37
7.35
7.35
7.34
7.32
7.31
7.30
7.29
7.28
7.22
7.20
2.30
2.27
2.25
2.17
2.14
2.12
1.07
1.06
1.05
O
Ph
Ph
Ph
TiPS
3f
14.98
1.98
2.00
20.96
f1 (ppm)
CDCl3
198.01
142.10
135.80
134.07
129.68
127.55
126.98
126.64
125.23
99.66
85.74
77.42 CDCl3
77.00 CDCl3
76.57 CDCl3
59.21
35.53
20.97
18.25
12.96
f1 (ppm)

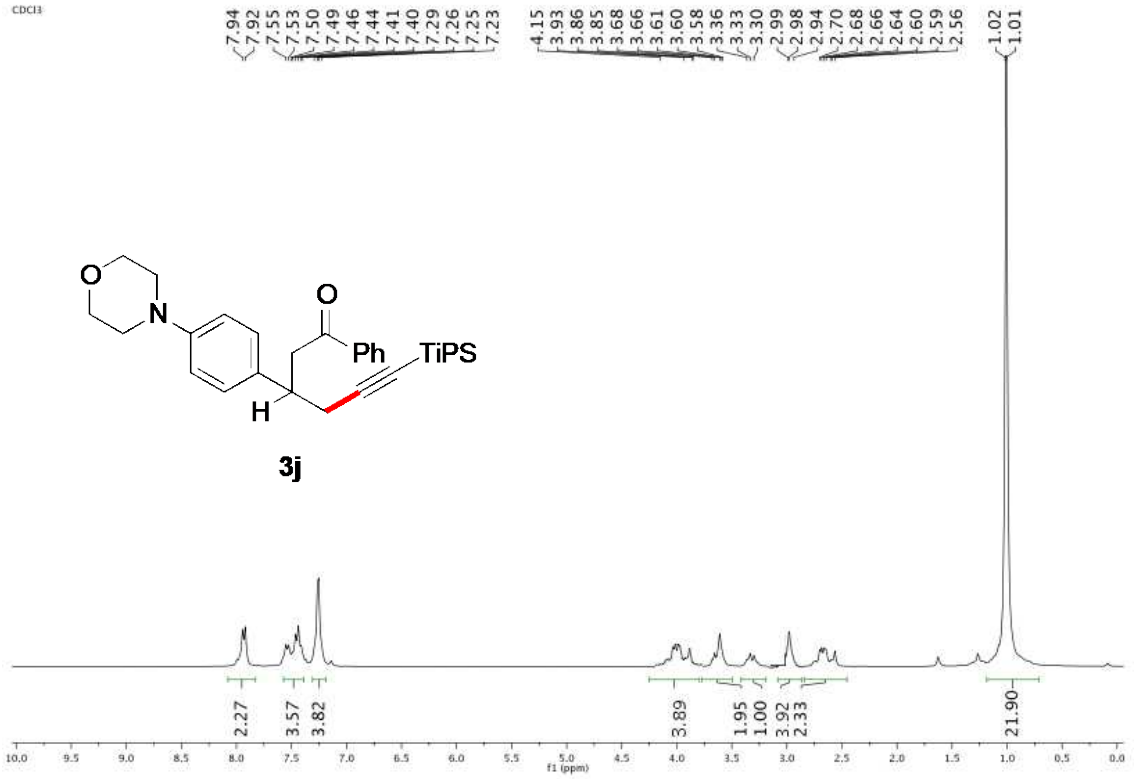

CDCl3
7.99 7.98 7.96 7.50 7.48 7.47 7.46 7.45 7.41 7.40 7.39 7.38 7.37 7.36 7.35 7.34 7.33 7.32 7.31 7.30 7.29 7.28 7.27 7.26 7.23 7.22 7.21 4.98 4.96 4.93 2.36 2.35 2.31 2.28 2.27 2.22 2.21 2.19 2.09 2.00 1.09 1.08 1.08 1.00 0.93 0.91 0.88 0.88 0.86
O
Ph
Ph
TiPS
3g
2.23
9.61
1.00
4.03
21.15
f1 (ppm)


CDCl3
199.62
153.17
138.93
132.87
128.97
128.72
128.45
128.31
127.17
108.03
92.78
77.42 CDCl3
77.00 CDCl3
76.58 CDCl3
51.69
32.55
18.69
17.81
11.32
f1 (ppm)

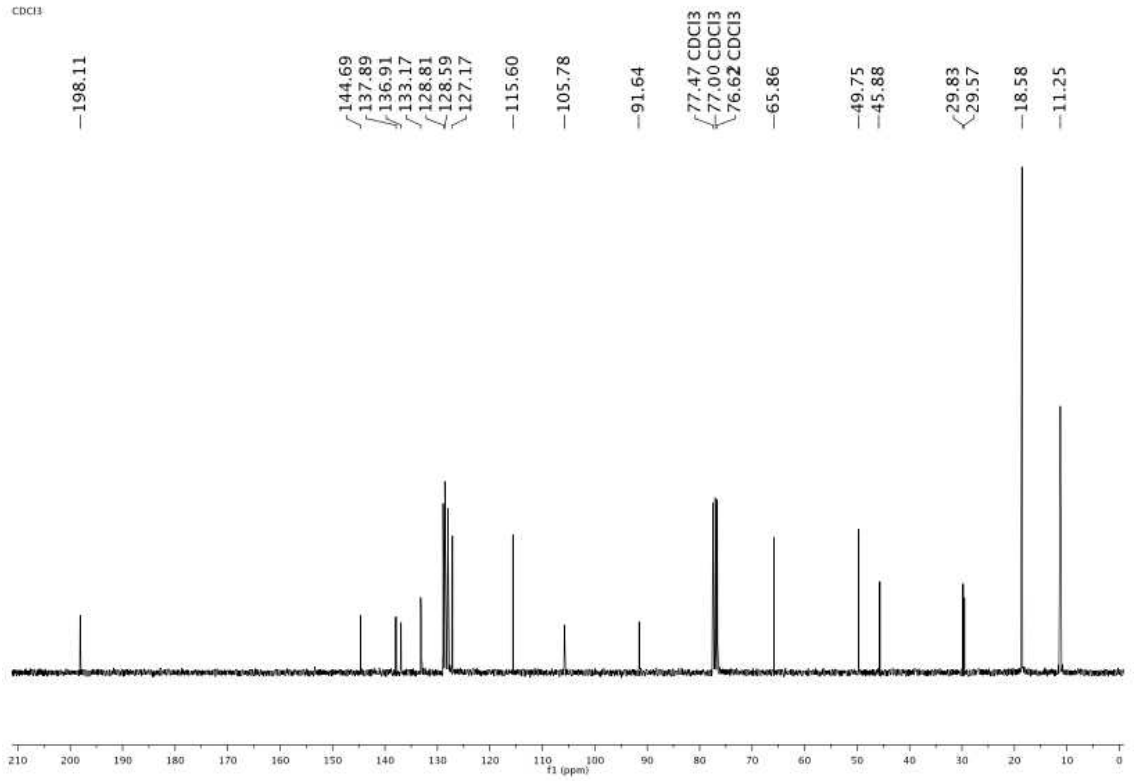

CDCl3
7.99
7.99
7.98
7.97
7.97
7.97
7.58
7.56
7.56
7.55
7.54
7.54
7.54
7.48
7.47
7.47
7.46
7.45
7.45
7.44
7.44
7.43
3.18
3.16
3.14
2.42
2.40
2.39
1.99
1.98
1.07
1.06
1.06
O
Ph
TiPS
3h
1.87
1.00
1.89
1.80
1.79
1.82
21.32
f1 (ppm)

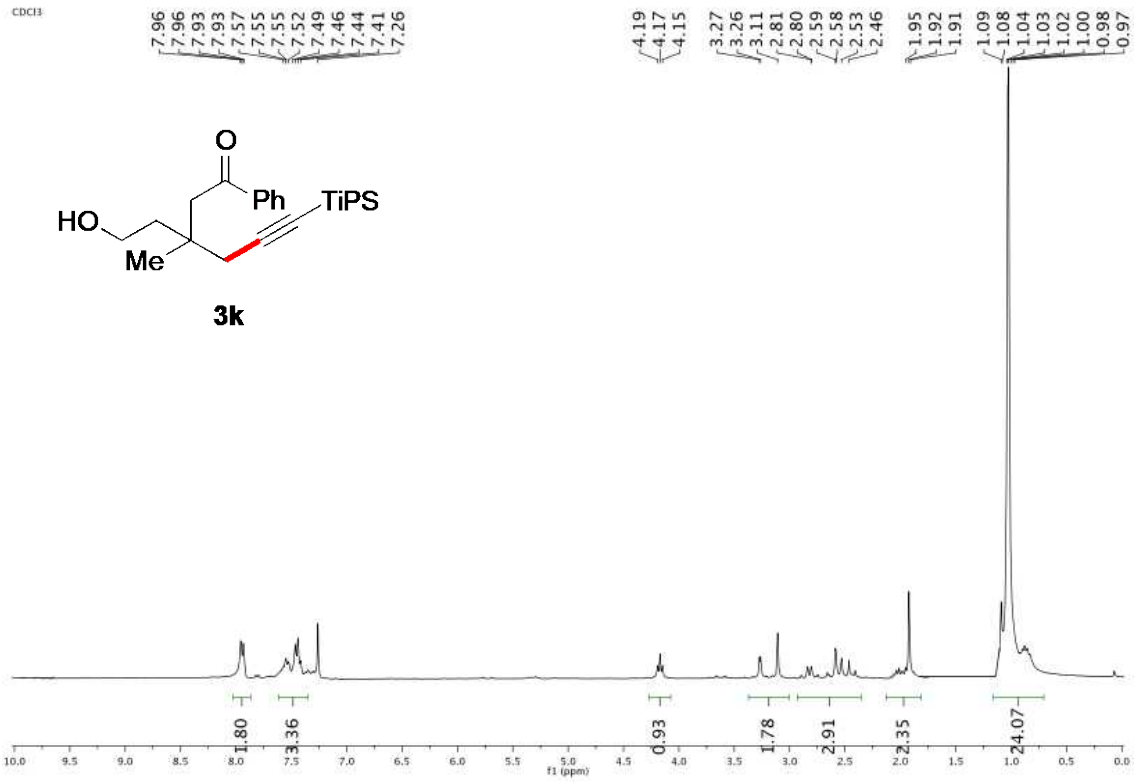

CDCl3
199.74
136.95
132.97
128.53
128.00
108.04
81.25
77.32 CDCl3
77.00 CDCl3
76.68 CDCl3
37.10
23.24
19.37
18.61
18.55
11.25
f1 (ppm)


CDCl3
7.37
7.36
7.35
7.34
7.33
7.32
7.31
7.30
7.29
7.28
7.26
7.21
7.21
7.20
7.19
7.19
7.18
7.17
7.16
2.72
2.26
2.24
2.13
2.11
1.61
1.56
1.43
1.06
1.05
1.04
Me
Ph
O
Me
TiPS
3i
5.92
2.00
1.86
1.99
1.92
6.15
21.23
f1 (ppm)
CDCl3
209.37
148.31
128.24
125.93
125.40
108.12
89.34
77.43 CDCl3
77.00 CDCl3
76.58 CDCl3
56.04
43.04
37.37
28.95
22.54
19.07
18.63
11.27
f1 (ppm)

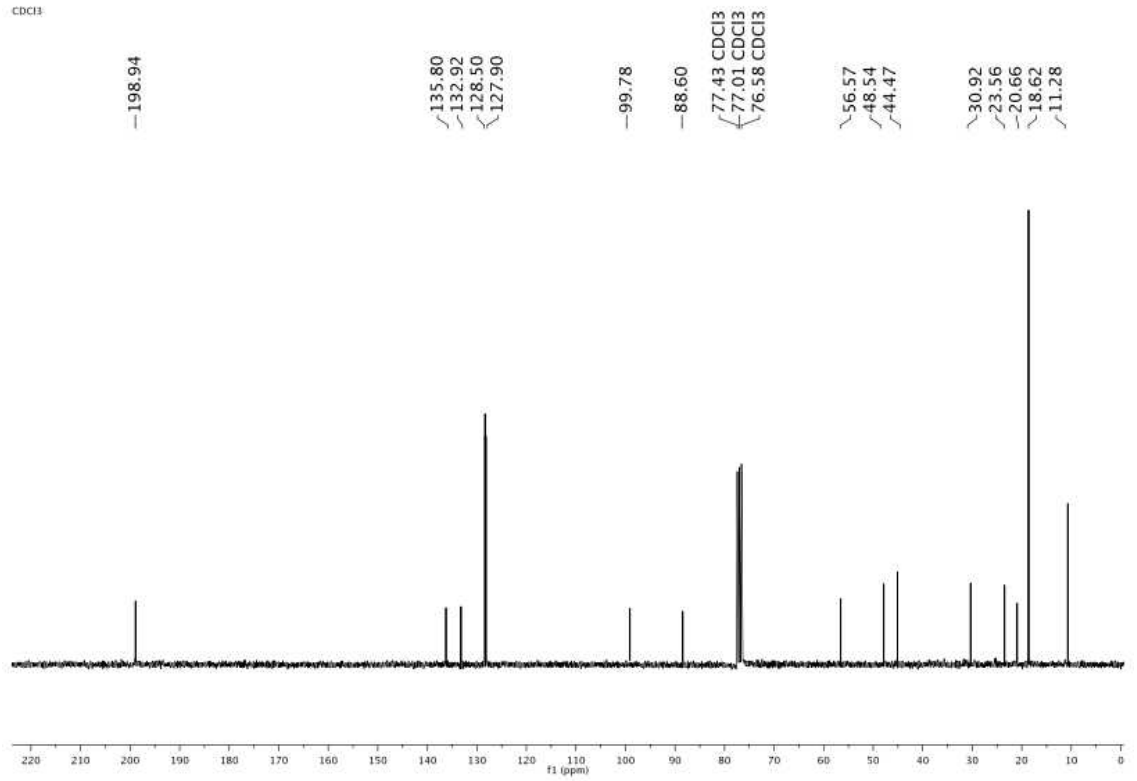

CDCl3
7.94
7.92
7.55
7.53
7.50
7.49
7.46
7.44
7.41
7.40
7.29
7.26
7.25
7.23
4.15
3.93
3.86
3.85
3.68
3.66
3.61
3.60
3.58
3.36
3.33
3.30
2.99
2.98
2.94
2.70
2.68
2.66
2.64
2.60
2.59
2.56
1.02
1.01
O
N
O
Ph
TiPS
H
2.27
3.57
3.82
3.89
1.95
1.00
3.92
2.33
21.90
f1 (ppm)

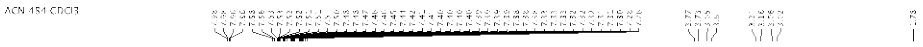
3j

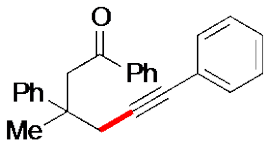

CDCl3
198.11
144.69
137.89
136.91
133.17
128.81
128.59
127.17
115.60
105.78
91.64
77.47 CDCl3
77.00 CDCl3
76.62 CDCl3
65.86
49.75
45.88
29.83
29.57
18.58
11.25
f1 (ppm)


CDCl3
7.96
7.96
7.93
7.93
7.57
7.55
7.55
7.52
7.49
7.46
7.44
7.41
7.26
4.19
4.17
4.15
3.27
3.26
3.11
2.81
2.80
2.59
2.58
2.53
2.46
1.95
1.92
1.91
1.09
1.08
1.04
1.03
1.02
1.00
0.98
0.97
O
Ph
TiPS
HO
Me
1.80
3.36
0.93
1.78
2.91
2.35
24.07
f1 (ppm)

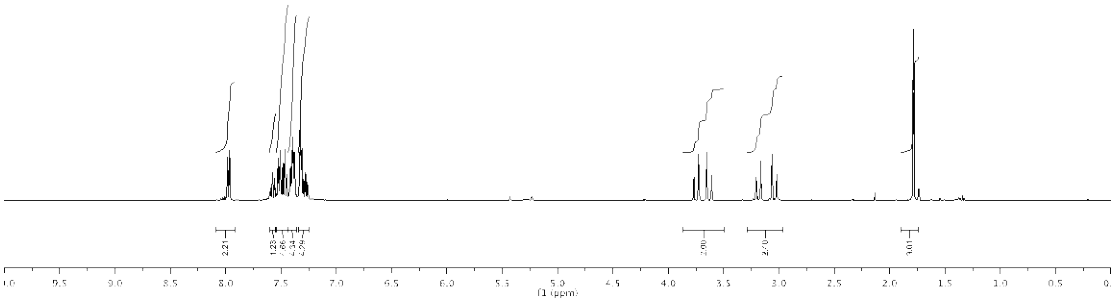
3k

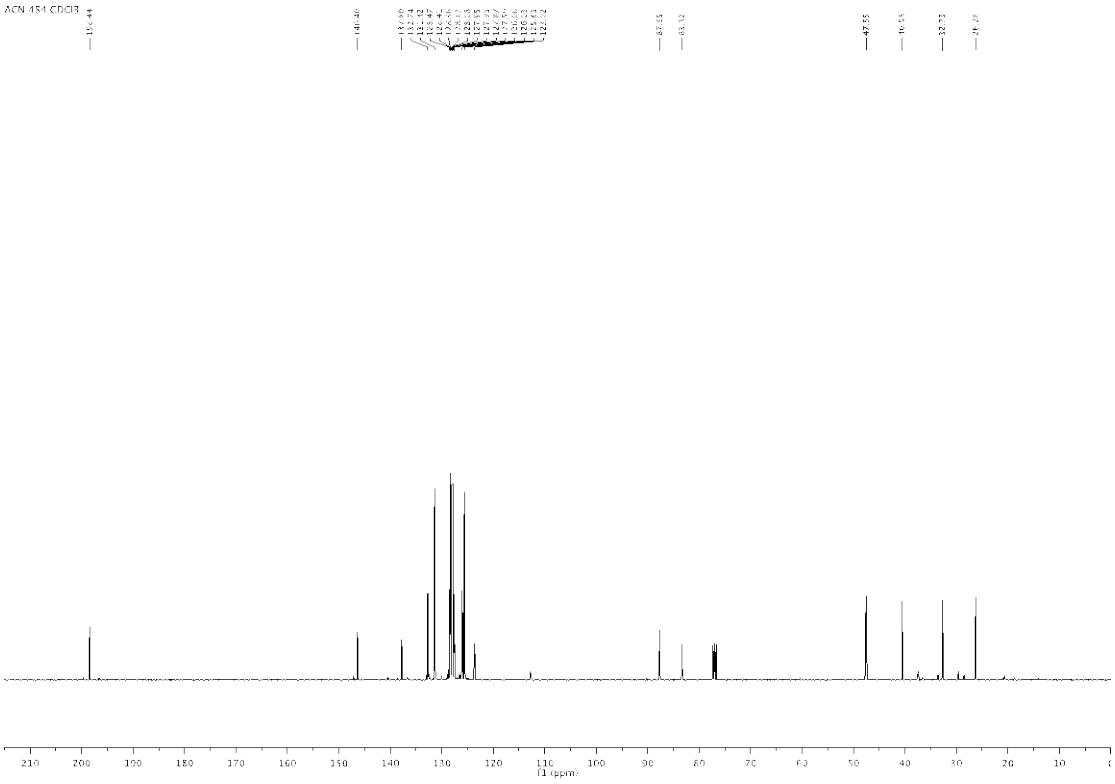

CDCl3
198.94
135.80
132.92
128.50
127.90
99.78
88.60
77.43 CDCl3
77.01 CDCl3
76.58 CDCl3
56.57
48.54
44.47
30.92
23.56
20.66
18.62
11.28
f1 (ppm)

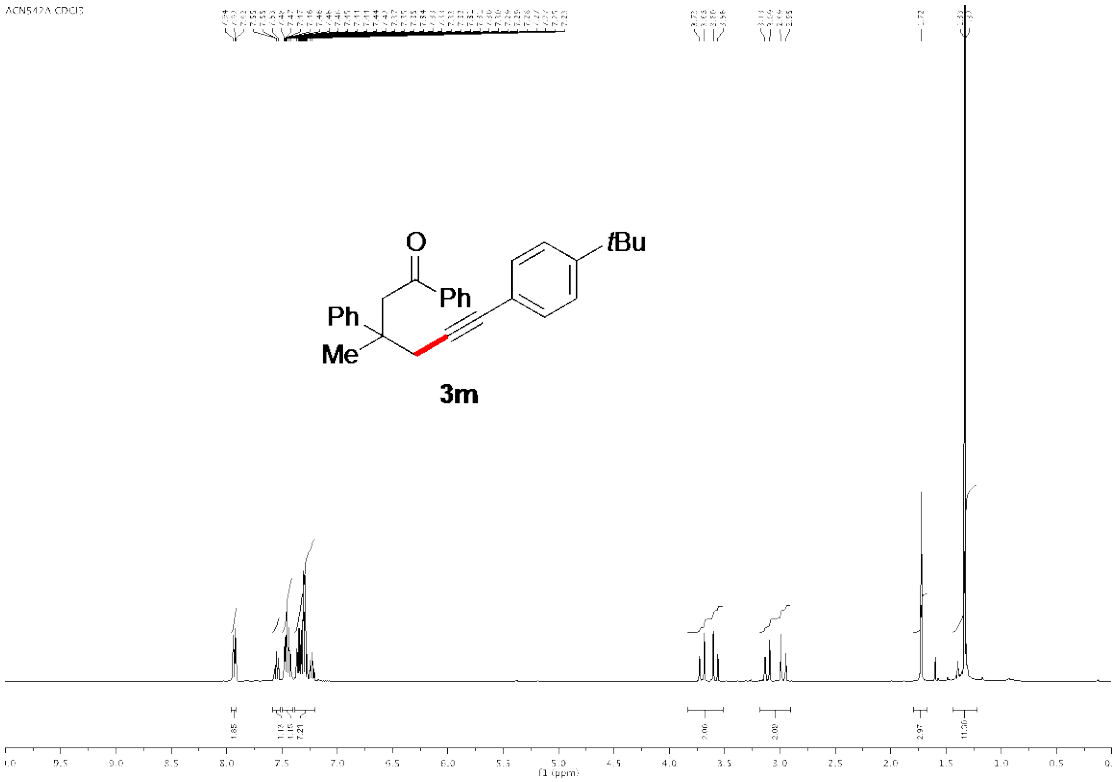




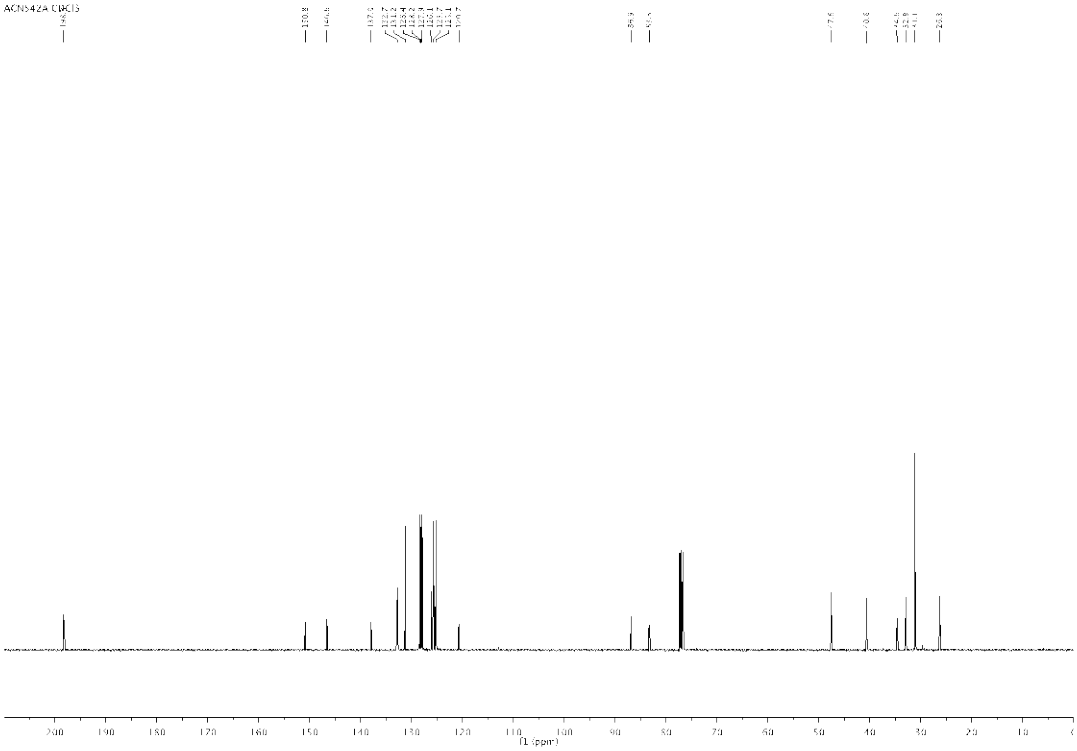
3l

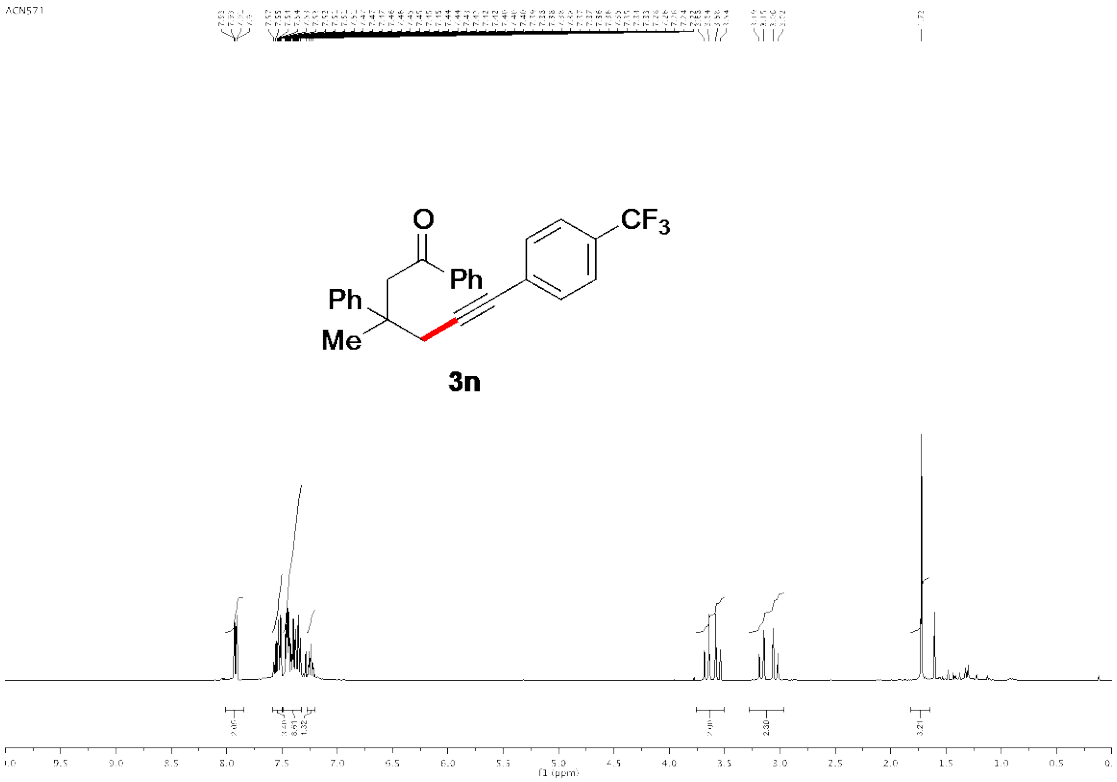


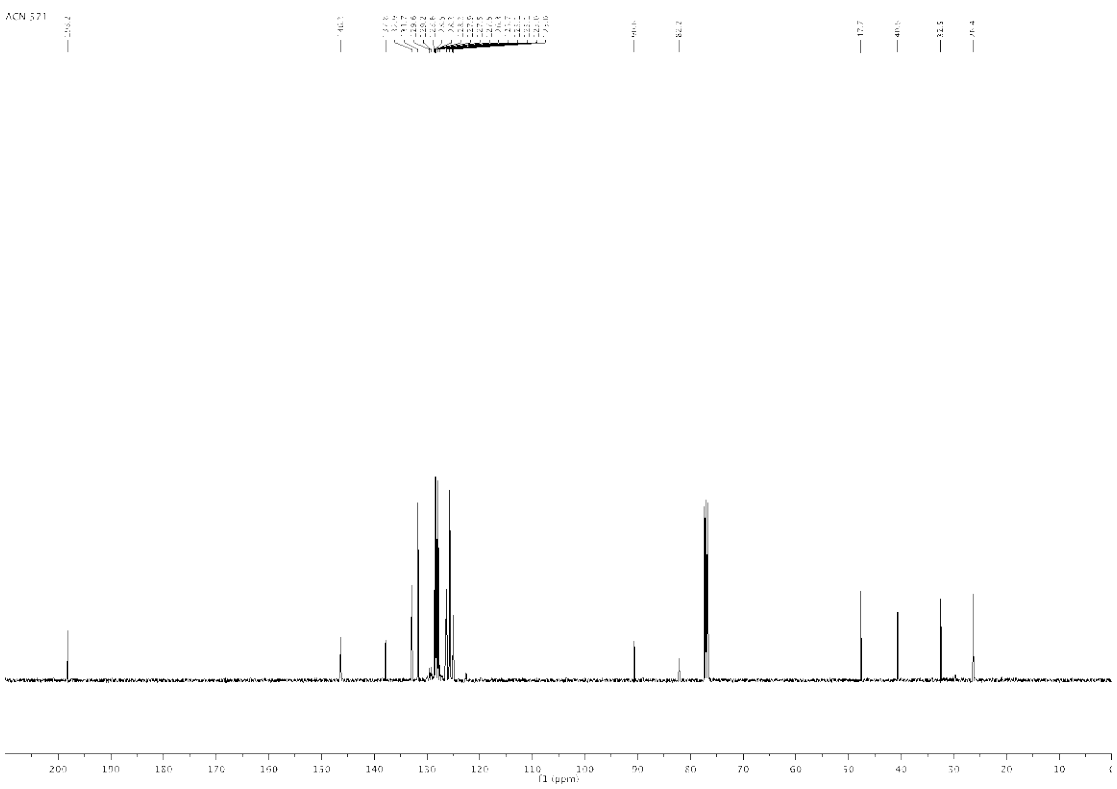


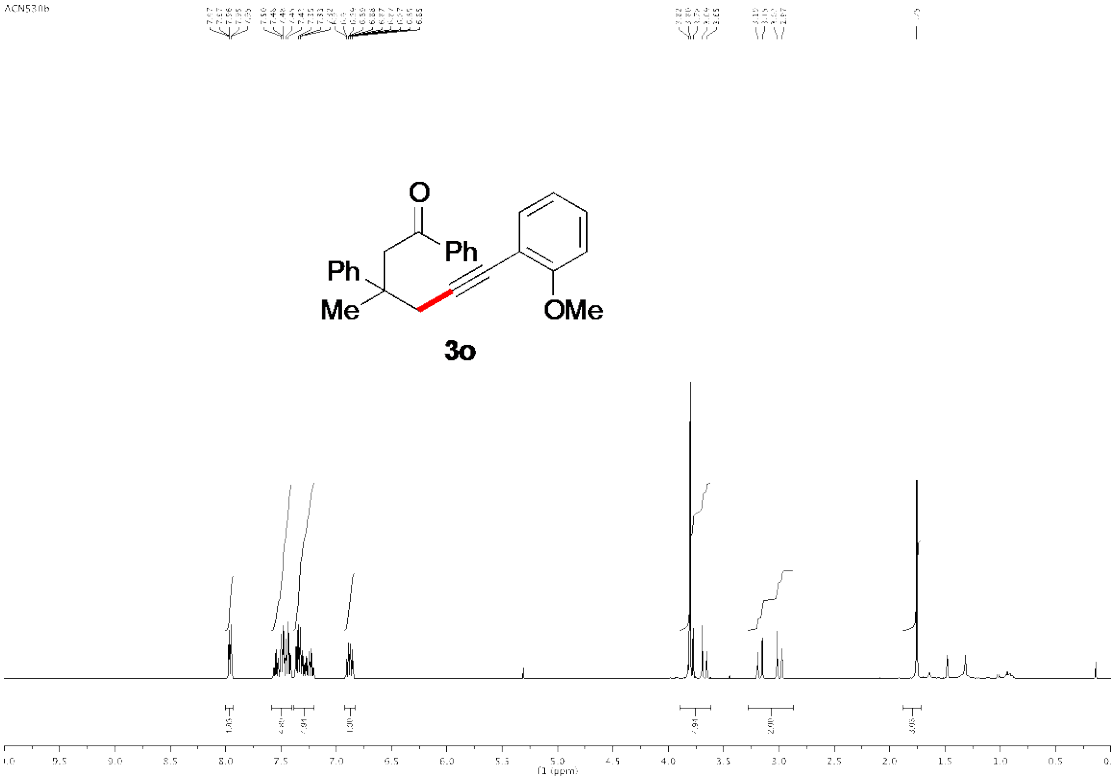


3m

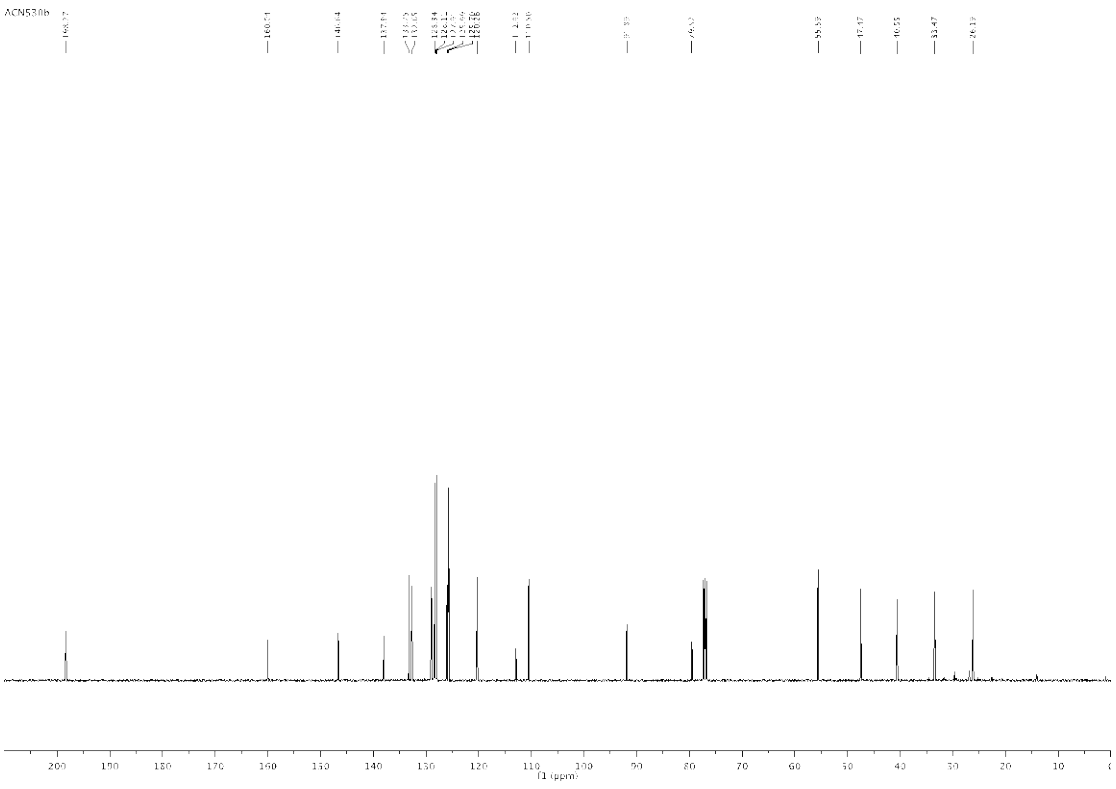


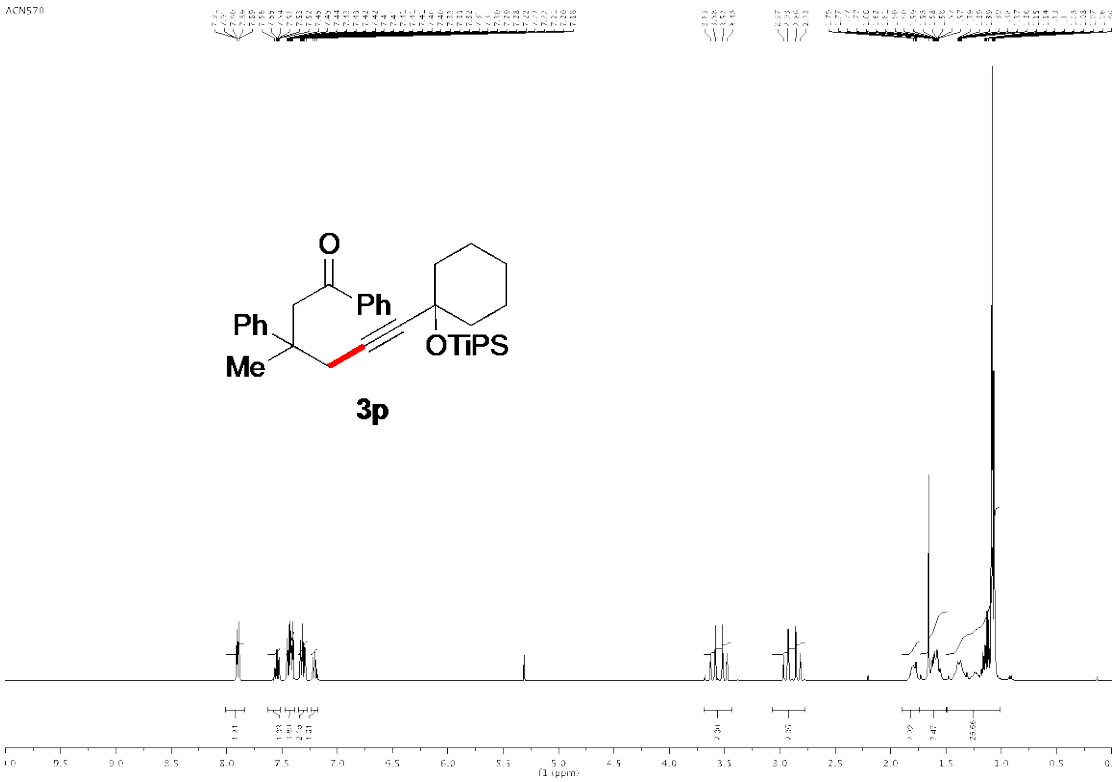

ACN571
O
Ph
Ph
Me
CF3
3n

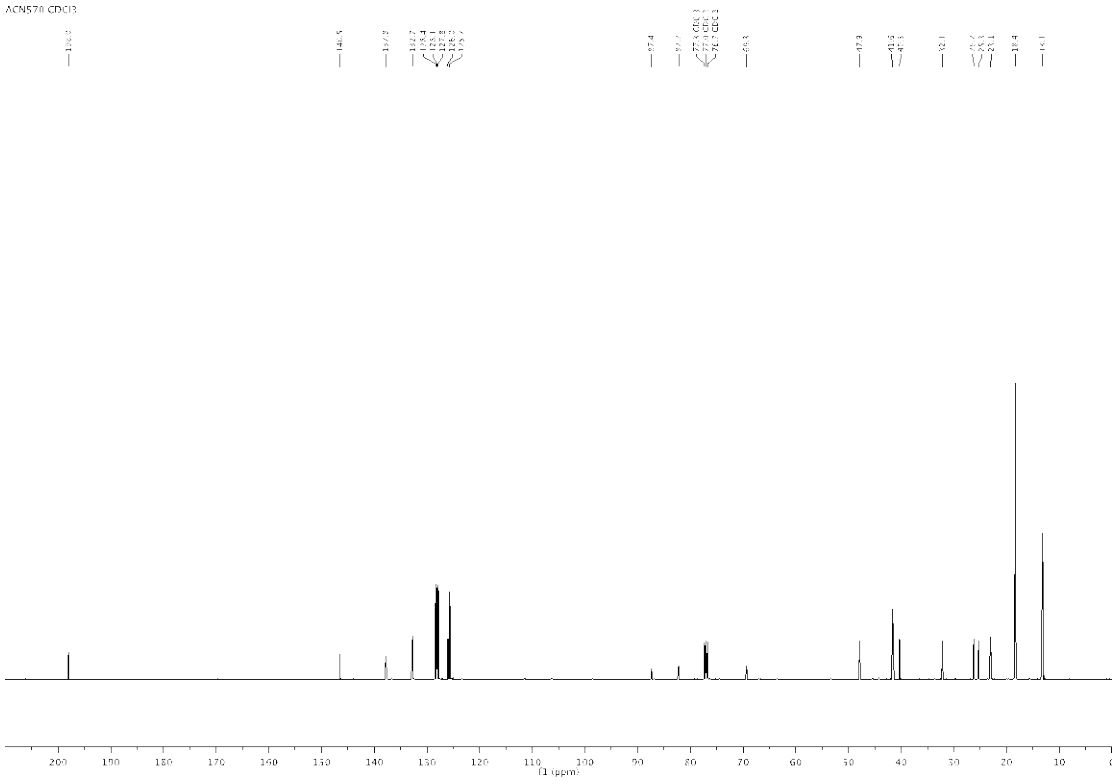

ACN 571



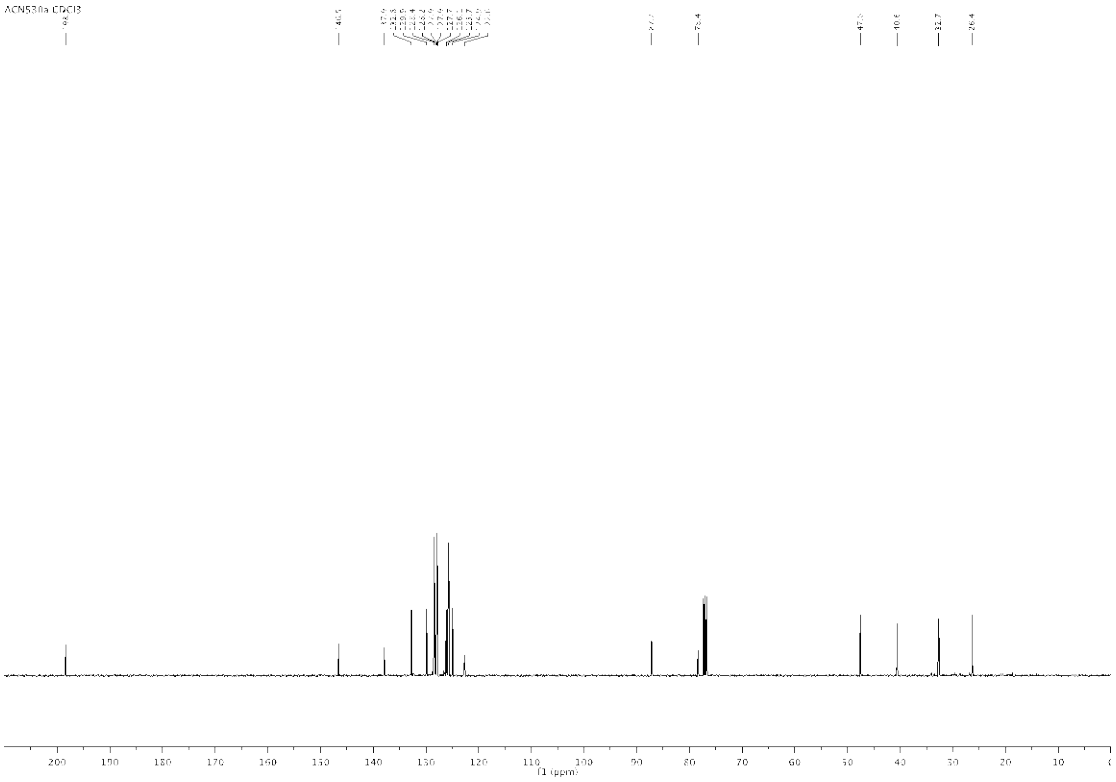
3o

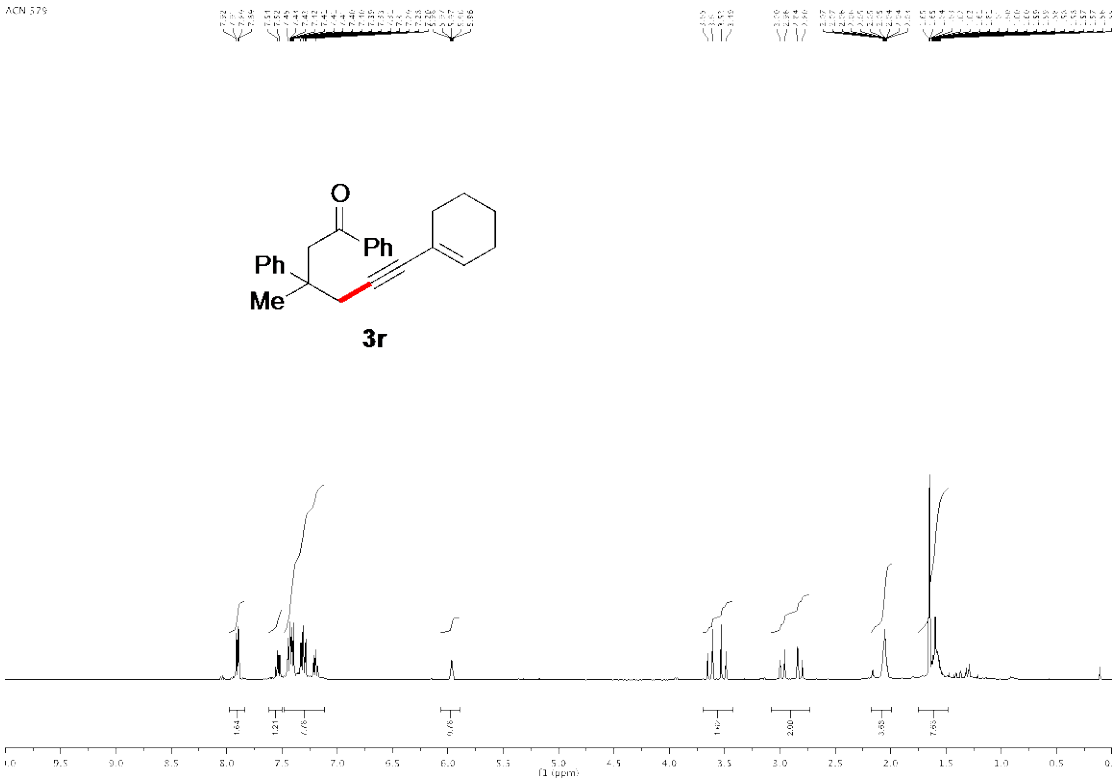


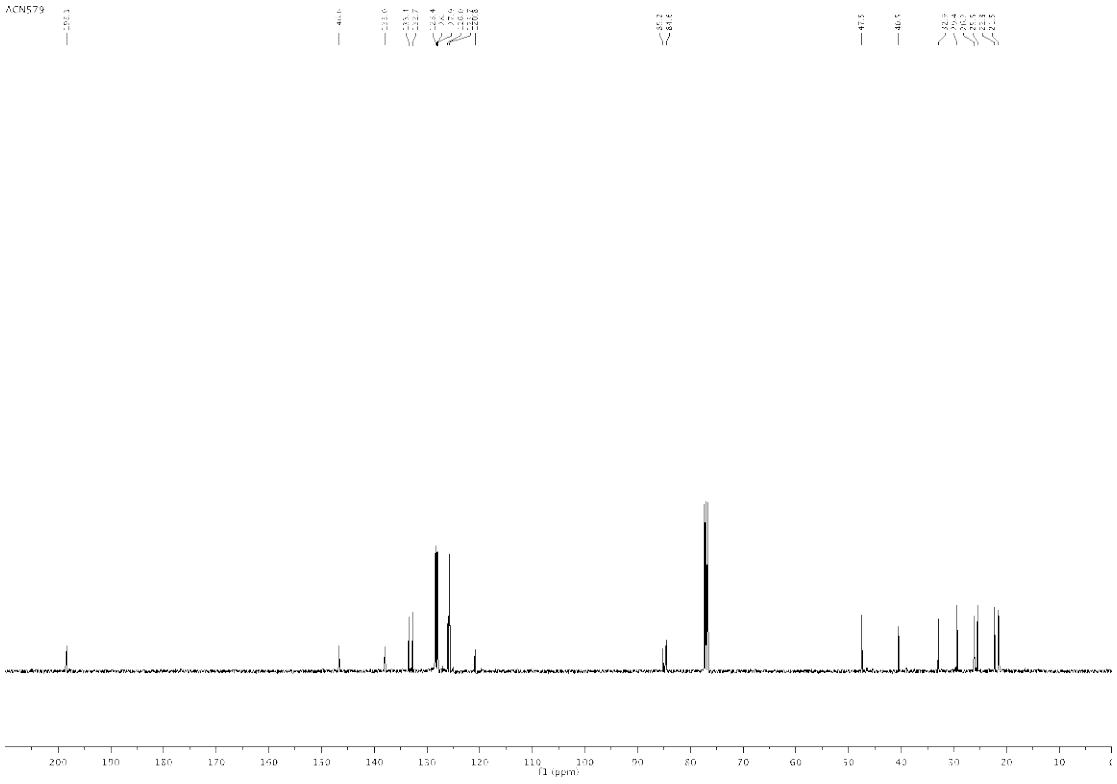

ACN578
O
Ph
Ph
Me
OTiPS
3p
f1 (ppm)

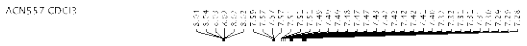

ACN578 CDCl3
f1 (ppm)

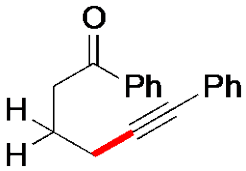
3q



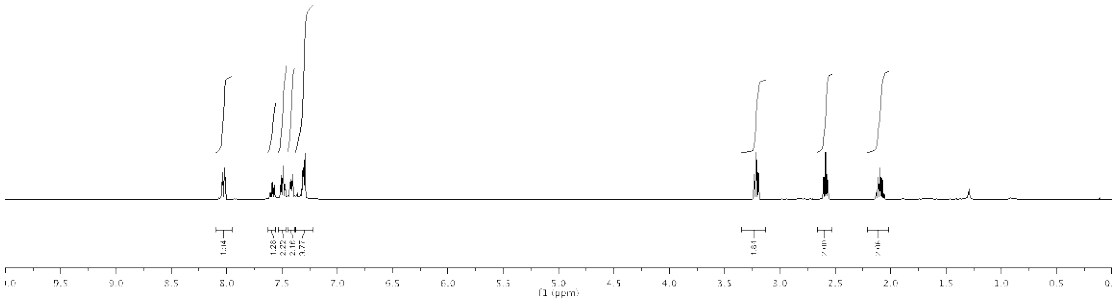

ACN 579
O
Ph
Ph
Me
3r
f1 (ppm)

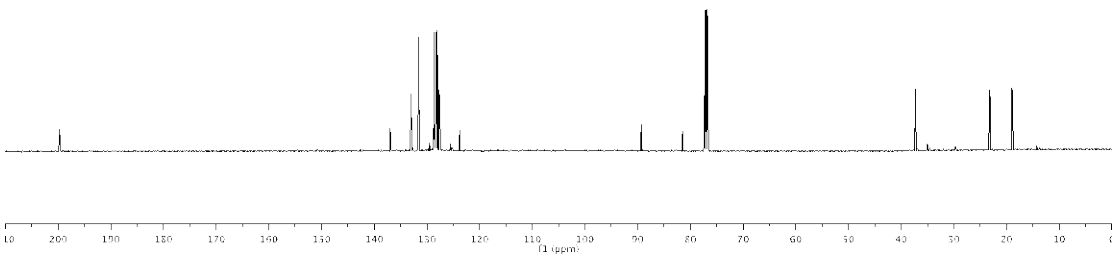

ACN579
f1 (ppm)

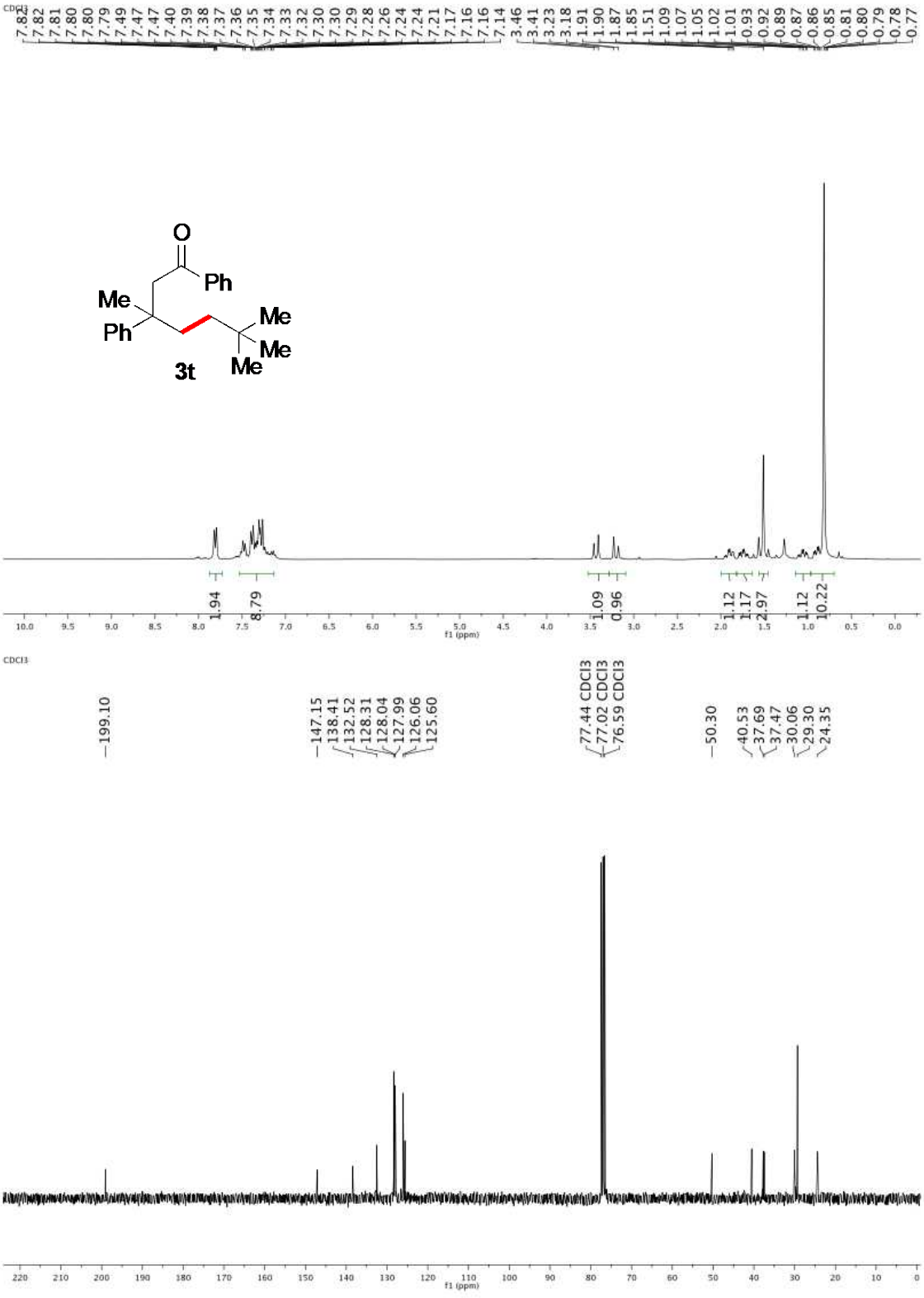


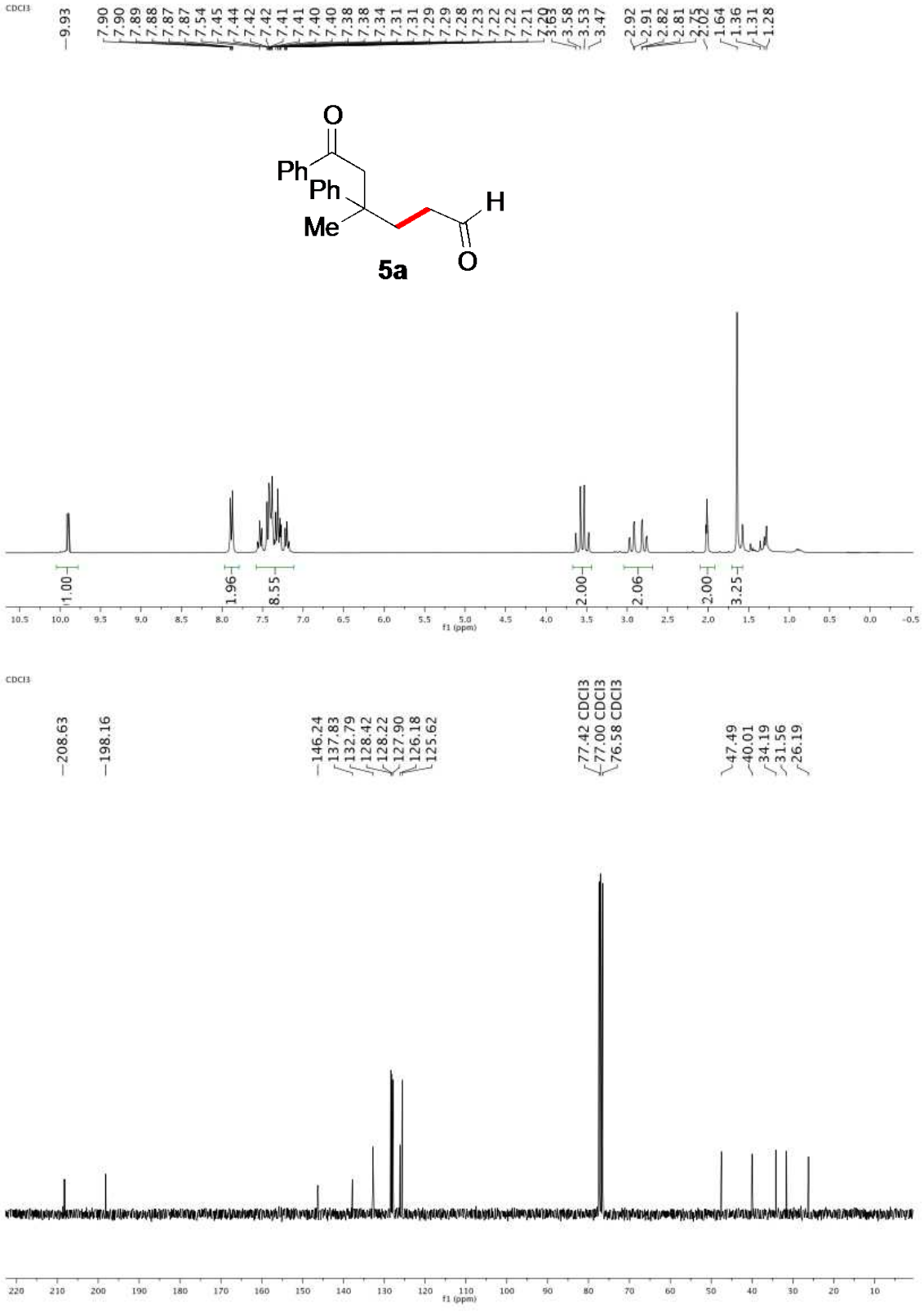


3s

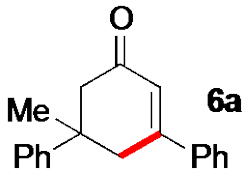




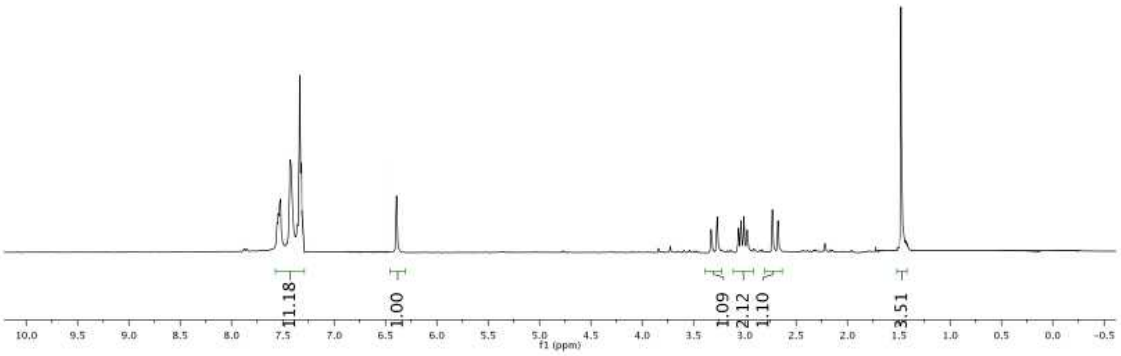

7.82 7.82 7.81 7.80 7.80 7.79 7.49 7.47 7.47 7.40 7.39 7.38 7.37 7.36 7.35 7.34 7.33 7.32 7.30 7.30 7.29 7.28 7.26 7.24 7.24 7.21 7.17 7.16 7.16 7.14 3.46 3.41 3.23 3.18 1.91 1.90 1.87 1.85 1.51 1.09 1.07 1.05 1.02 1.01 0.93 0.92 0.89 0.87 0.86 0.85 0.81 0.80 0.79 0.78 0.77
O
Ph
Me
Ph
Me
Me
Me
3t
1.94 8.79 1.09 0.96 1.12 1.17 2.97 1.12 10.22
f1 (ppm)
CDCl3
199.10
147.15 138.41 132.52 128.31 128.04 127.99 126.06 125.60
77.44 CDCl3 77.02 CDCl3 76.59 CDCl3
50.30
40.53 37.69 37.47 30.06 29.30 24.35
f1 (ppm)

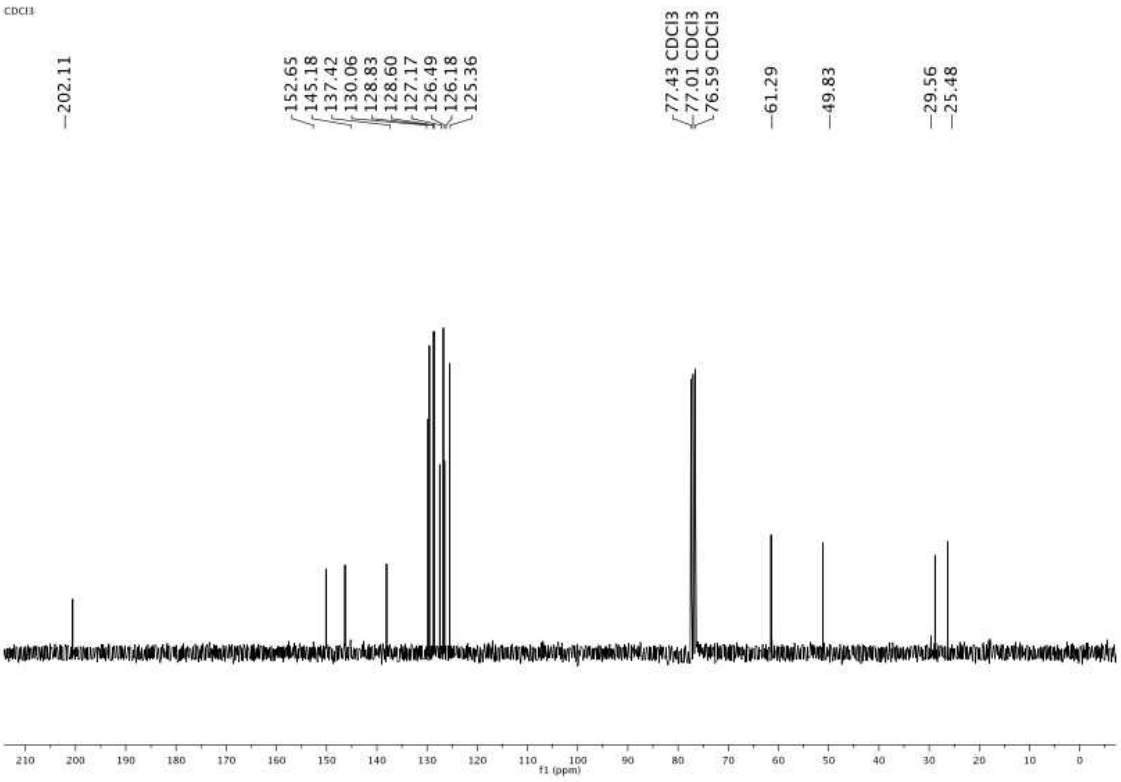

CDCl3
9.93
7.90
7.90
7.89
7.88
7.87
7.87
7.54
7.45
7.44
7.42
7.42
7.41
7.41
7.40
7.40
7.38
7.38
7.34
7.31
7.31
7.29
7.29
7.28
7.23
7.22
7.22
7.21
7.20
3.59
3.58
3.53
3.47
2.92
2.91
2.82
2.81
2.75
2.02
1.64
1.36
1.31
1.28
O
Ph
Ph
Me
H
O
5a
1.00
1.96
8.55
2.00
2.06
2.00
3.25
f1 (ppm)
CDCl3
208.63
198.16
146.24
137.83
132.79
128.42
128.22
127.90
126.18
125.62
77.42 CDCl3
77.00 CDCl3
76.58 CDCl3
47.49
40.01
34.19
31.56
26.19
f1 (ppm)


CDCl3
7.55
7.54
7.54
7.54
7.53
7.52
7.44
7.43
7.42
7.41
7.40
7.40
7.36
7.34
7.33
7.32
7.31
7.26
6.39
6.39
3.33
3.33
3.32
3.27
3.27
3.27
3.07
3.06
3.04
3.03
3.01
3.01
2.98
2.98
2.73
2.68
1.48

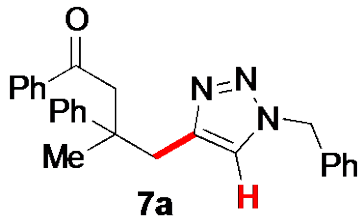

O
Me
Ph
Ph

6a

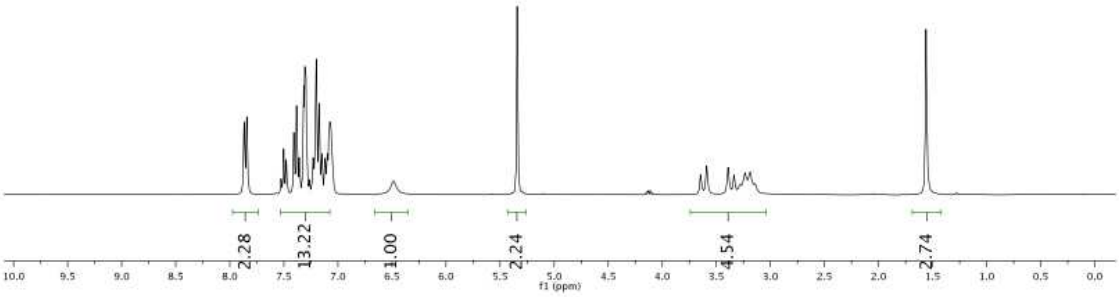

11.18
1.00
1.09
2.12
1.10
3.51
f1 (ppm)

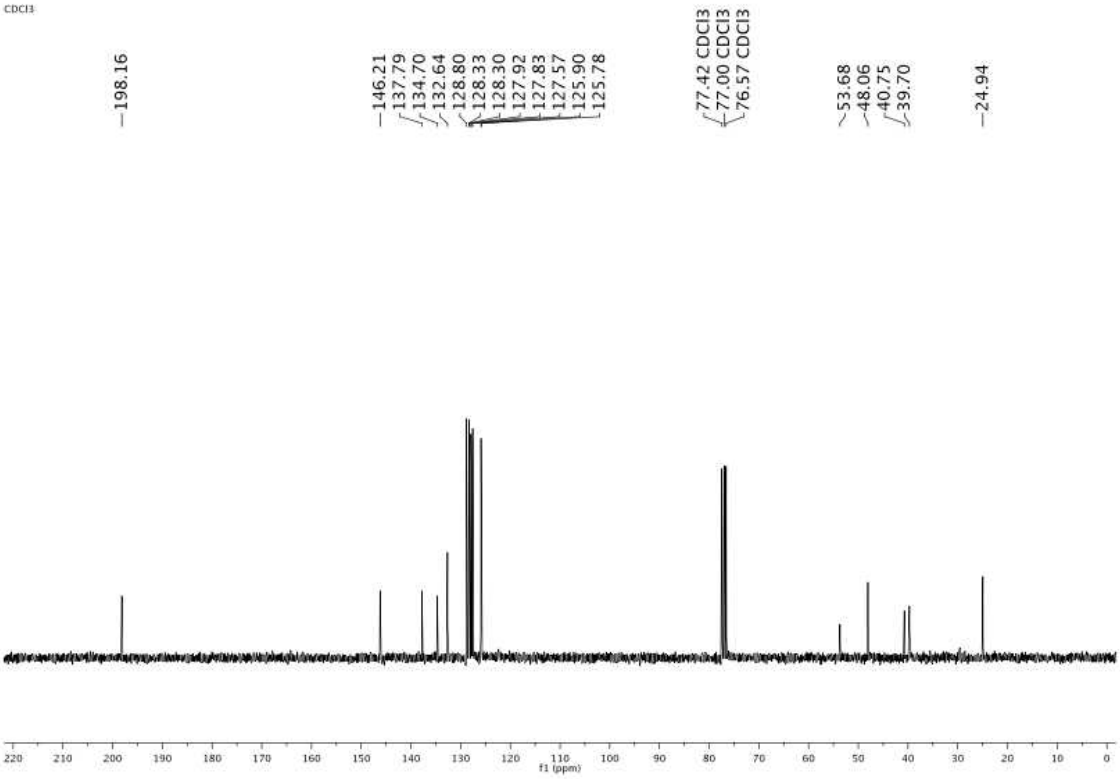

CDCl3
202.11
152.65
145.18
137.42
130.06
128.83
128.60
127.17
126.49
126.18
125.36
77.43 CDCl3
77.01 CDCl3
76.59 CDCl3
61.29
49.83
29.56
25.48
f1 (ppm)

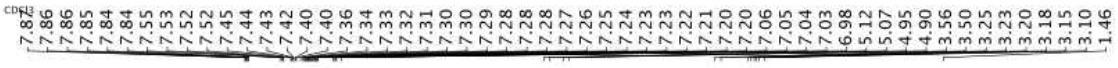

CDCl3
7.87
7.84
7.84
7.50
7.41
7.38
7.36
7.32
7.31
7.30
7.29
7.23
7.21
7.20
7.20
7.17
7.17
7.15
7.12
7.10
7.08
7.08
7.07
7.06
5.94
3.65
3.59
3.39
3.34
3.28
3.24
3.19
3.15
3.14
1.56

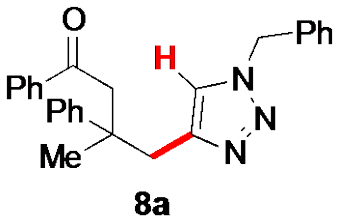

O
Ph
Ph
Me
N
N
N
Ph
H

7a

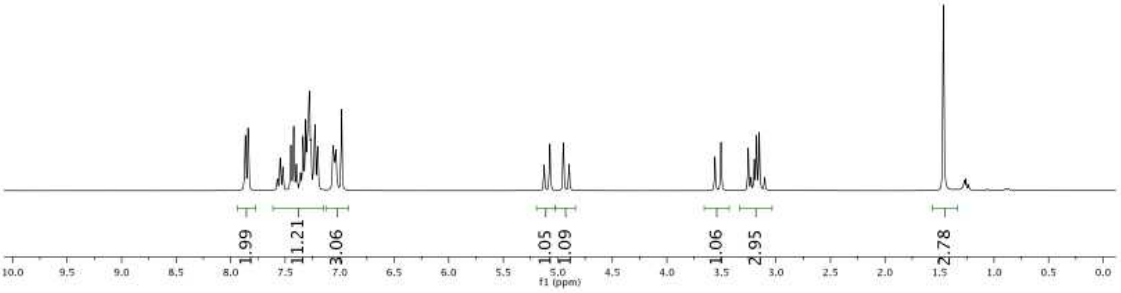

2.28
13.22
1.00
2.24
4.54
2.74
f1 (ppm)

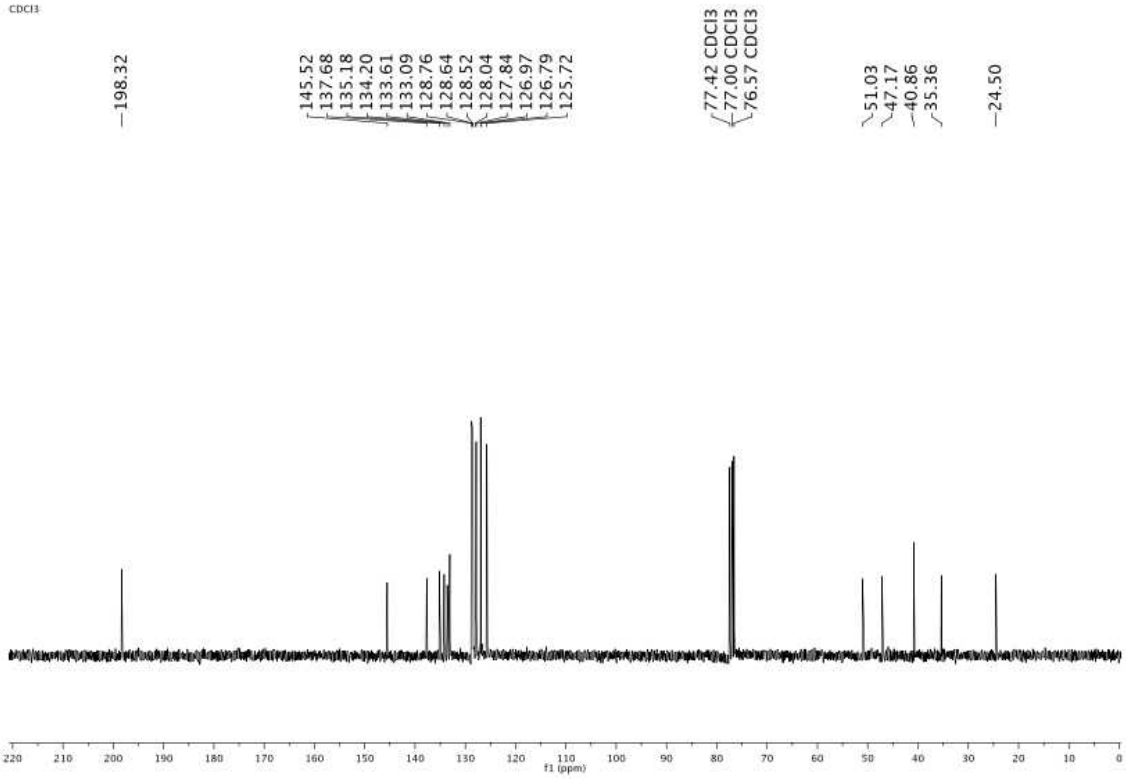

CDCl3
198.16
146.21
137.79
134.70
132.64
128.80
128.33
128.30
127.92
127.83
127.57
125.90
125.78
77.42 CDCl3
77.00 CDCl3
76.57 CDCl3
53.68
48.06
40.75
39.70
24.94
f1 (ppm)


CDCl3
7.87 7.86 7.86 7.85 7.84 7.84 7.55 7.53 7.52 7.52 7.45 7.44 7.43 7.42 7.40 7.40 7.36 7.34 7.33 7.32 7.31 7.30 7.30 7.29 7.28 7.28 7.28 7.27 7.26 7.25 7.24 7.23 7.23 7.22 7.21 7.20 7.20 7.06 7.05 7.04 7.03 6.98 5.12 5.07 4.95 4.90 3.56 3.50 3.25 3.23 3.20 3.18 3.15 3.10 1.46


O
Ph
Ph
Me
H
N
N
N
Ph

8a

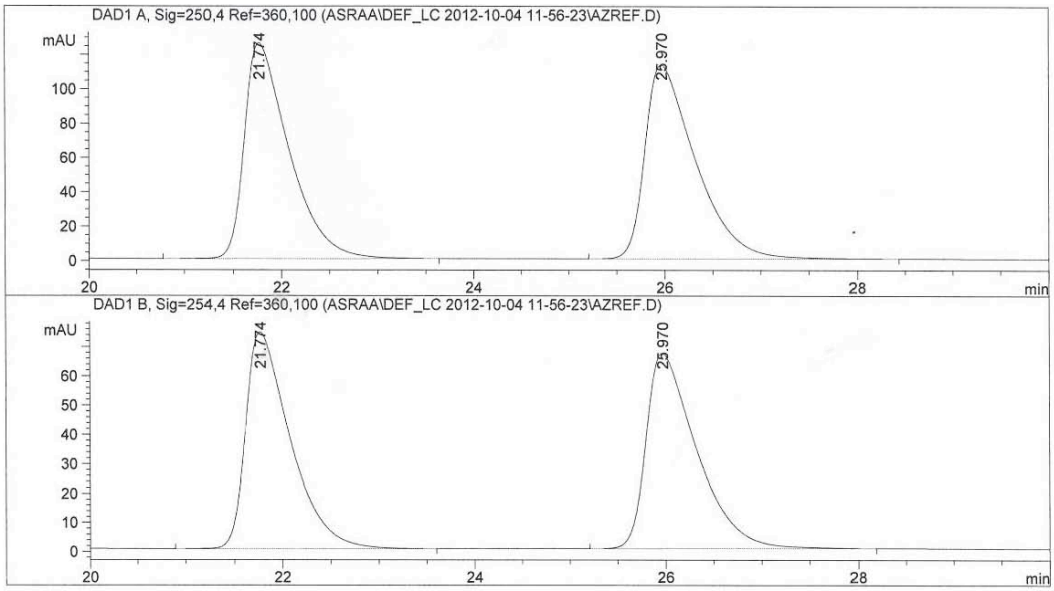

1.99
11.21
3.06
1.05
1.09
1.06
2.95
2.78
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


CDCl3
198.32
145.52
137.68
135.18
134.20
133.61
133.09
128.76
128.64
128.52
128.04
127.84
126.97
126.79
125.72
77.42 CDCl3
77.00 CDCl3
76.57 CDCl3
51.03
47.17
40.86
35.36
24.50
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

Scheme 2: Enantioselective γ-Alkynylation of Ketones

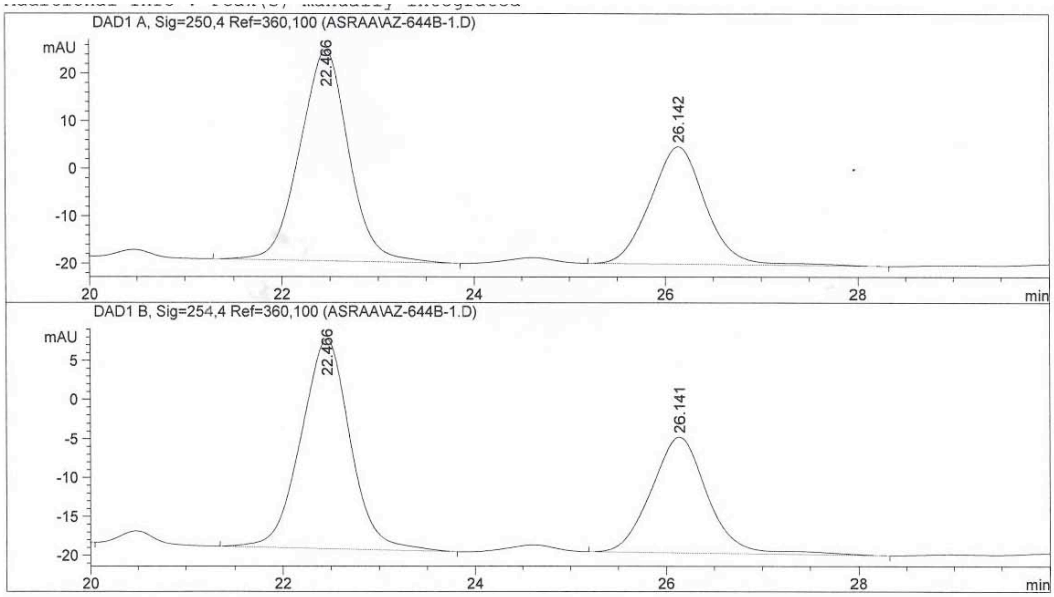
Chiral High Performance Liquid Chromatography analyses were performed on Agilent Technologies 1260 Infinity HPLC instrument with a UV detector using 4.6 mm Ø x 350 mmL ChiralPak IA column with amylose tris(3,5-dimethylpehnylcarbamate) on a 20 µm silica-gel from Daicel Chemical Ind., LTD. 5 µL injection of a pure sample in a 95:5 hexanes:dichloromethane mixtures was used (254 nm wavelength).

Racemic mixture:




```
=====================================================================
                      Area Percent Report
=====================================================================

Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: DAD1 A, Sig=250,4 Ref=360,100

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [mAU*s]     [mAU]       %
----|-------|----|-------|----------|----------|--------|
   1  21.774 BB    0.4765 4057.14941  125.72383  49.5078
   2  25.970 BB    0.5352 4137.81445  112.99350  50.4922

Totals :                  8194.96387  238.71733
```

using (R)-DTBM-SegPhos




```
=====================================================================
                    Area Percent Report
=====================================================================

Sorted By             :      Signal
Multiplier:                   :      1.0000
Dilution:                     :      1.0000
Use Multiplier & Dilution Factor with ISTDs


Signal 1: DAD1 A, Sig=250,4 Ref=360,100

Peak RetTime Type  Width     Area      Height     Area
  #   [min]        [min]   [mAU*s]     [mAU]       %
----|-------|----|-------|----------|----------|--------|
   1  22.466 BB    0.5227 1566.95044   44.50860  61.2271
   2  26.142 BB    0.5896  992.29144   24.75761  38.7729

Totals :                  2559.24188   69.26621
```