Supplementary Information

Nickel-Catalyzed Regiodivergent Sulfonylarylation of 1,3-Enynes to Access Allenes and Dienes

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Table of Contents

1. General Information

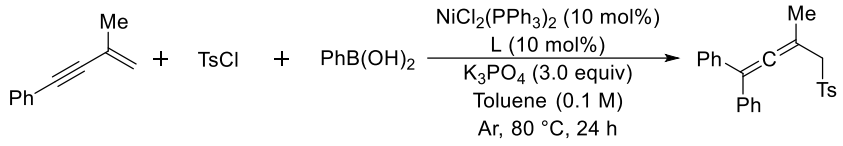
Unless otherwise noted, commercially available reagents were purchased from commercial suppliers (such as Innochem, Alfa Aesar, J&K Chemical, Energy Chemical, Bidepharm and Adamas) and used as received without further purification. Solvents were generally dried over 4 Å molecular sieves (water <50ppm, resealable bottle). Purification of products was performed by flash chromatography (FC) using silica gel or preparative thin layer chromatography. ^{1}H and ^{13}C NMR spectra were recorded on a Bruker AVANCE III spectrometer (400 MHz and 101 MHz, respectively). Chemical shifts are reported parts per million (ppm) referenced to $CDCl_3$ (δ = 7.26 ppm), tetramethylsilane (TMS, δ = 0.00 ppm) for ^{1}H NMR and $CDCl_3$ (δ = 77.0 ppm) for ^{13}C NMR. Multiplicities are given as s (singlet), d (doublet), t (triplet), dd (doublet of doublets), td (triplet of doublets) or m (multiplet). High-resolution mass spectra (HRMS) were obtained using a Q-TOF instrument equipped with an ESI source. Data collection for crystal structure was performed on a Bruker APEXII diffractometer.

2. Experimental Section

2.1 Optimization of reaction conditions

The oven-dried Schlenk sealed tube (15 mL) containing a stirring bar was charged with 1,3-enyne substrate, arylboronic acid, sulfonyl chloride, Ni-catalyst, ligand, base and slovent under argon atmosphere. Then the tube was placed into a preheated oil bath with stirring for 24 h. Upon completion of the reaction, the crude reaction mixture was diluted with DCM, and filtrated. After the solvent was concentrated under reduced pressure, the crude ^{1}H NMR spectrum was taken using CH_2Br_2 as internal standard. Yield was determined by ^{1}H NMR with CH_2Br_2 as internal standard.

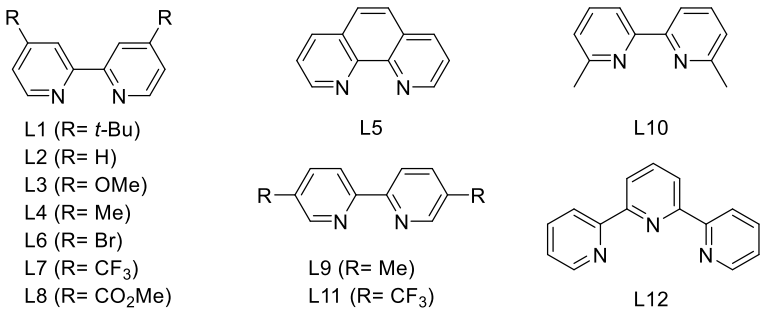
2.1.1 Ligand screening



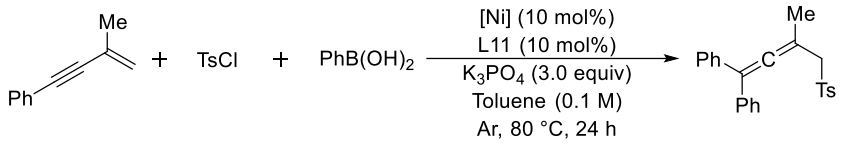
1a **2a** **3a** **4**

Entry	Ligand	Yield
1	L1	21%
2	L2	4%
3	L3	4%
4	L4	Trace
5	L5	Trace
6	L6	20%
7	L7	25%
8	L8	21%
9	L9	Trace
10	L10	N.D.
11	L11	25%
12	L12	Trace

Reaction conditions: 1,3-enyne (0.1 mmol, 1.0 equiv), arylboronic acids (0.2 mmol, 2.0 equiv), sulfonyl chlorides (0.2 mmol, 2.0 equiv), Ni-catalyst (10 mol%), ligand (10 mol%), base (0.3 mmol, 3.0 equiv) and solvent (1.0 mL), Ar, 80 °C, 24 h.



2.1.2 Ni-catalyst screening

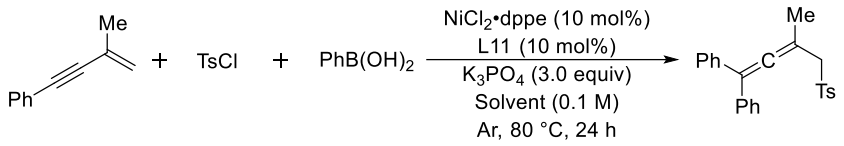


1a **2a** **3a** **4**

Entry	[Ni]	Yield
1	$NiBr_2(PPh_3)_2$	30%
2	$NiCl_2$·dppe	38%
3	$NiCl_2$·dppp	34%
4	$NiCl_2$·dppf	24%
5	$NiCl_2(Py)_4$	14%
6	$NiCl_2$·DME	26%
7	$Ni(OTf)_2$	33%
8	$Ni(COD)_2$	37%
9	$Ni(NO_3)_2$·$6H_2O$	16%

Reaction conditions: 1,3-enyne (0.1 mmol, 1.0 equiv), arylboronic acids (0.2 mmol, 2.0 equiv), sulfonyl chlorides (0.2 mmol, 2.0 equiv), Ni-catalyst (10 mol%), ligand (10 mol%), base (0.3 mmol, 3.0 equiv) and solvent (1.0 mL), Ar, 80 °C, 24 h.

2.1.3 Solvent screening

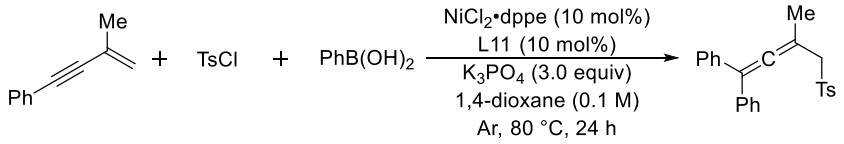


1a **2a** **3a** **4**

Entry	Solvent	Yield
1	1,4-Dioxane	46%
2	DCE	35%
3	DMF	N.D.
4	MeCN	N.D.
5	Acetone	N.D.
6	Xylene	35%
7	Mesitylene	30%
8	THF	N.D.
9	DME	N.D.
10	Tetrahydropyran	N.D.

Reaction conditions: 1,3-enyne (0.1 mmol, 1.0 equiv), arylboronic acids (0.2 mmol, 2.0 equiv), sulfonyl chlorides (0.2 mmol, 2.0 equiv), Ni-catalyst (10 mol%), ligand (10 mol%), base (0.3 mmol, 3.0 equiv) and solvent (1.0 mL), Ar, 80 °C, 24 h.

2.1.4 Relative ratios screening

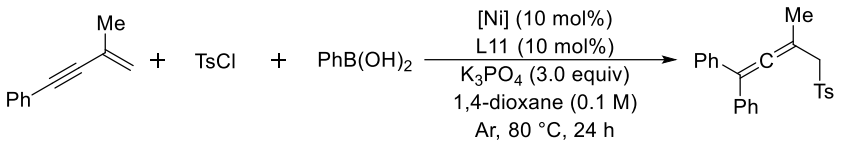


1a **2a** **3a** **4**

Entry	1a(mmol)	2a(mmol)	3a(mmol)	Yield
1	0.1	0.1	0.1	11%
2	0.1	0.15	0.15	26%
3	0.1	0.25	0.25	52%
4	0.1	0.3	0.3	52%
5	0.1	0.2	0.3	51%
6	0.1	0.3	0.2	24%
7	0.2	0.1	0.2	31%
8	0.2	0.2	0.1	15%

Reaction conditions: 1,3-enyne, arylboronic acids, sulfonyl chlorides, Ni-catalyst (10 mol%), ligand (10 mol%), base (0.3 mmol, 3.0 equiv) and solvent (1.0 mL), Ar, 80 °C, 24 h.

2.1.5 Ni-catalyst screening

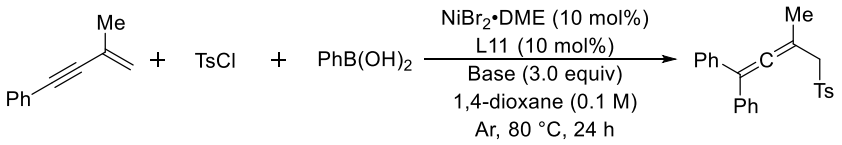


1a **2a** **3a** **4**

Entry	[Ni]	Yield
1	$NiCl_2(PPh_3)_2$	51%
2	$NiBr_2(PPh_3)_2$	40%
3	$NiCl_2$·dppe	58%
4	$NiCl_2$·dppp	31%
5	$NiCl_2$·dppf	48%
6	$NiCl_2(PCy_3)_2$	44%
7	$NiCl_2(Py)_4$	20%
8	$Ni(PPh_3)_4$	53%
9	$Ni(OTf)_2$	57%
10	$Ni(COD)_2$	51%
11	$NiCl_2$·DME	50%
12	$NiBr_2$·DME	62%
13	$NiBr_2$·diglyme	45%
14	$Ni(acac)_2$	trace
15	NiF_2	N.D.
16	$NiCl_2$	14%
17	NiI_2	50%
18	$Ni(NO_3)_2$·$6H_2O$	41%
19	$Ni(PO_4)_2$·$8H_2O$	N.D.

Reaction conditions: 1,3-enyne (0.1 mmol, 1.0 equiv), arylboronic acids (0.25 mmol, 2.5 equiv), sulfonyl chlorides (0.25 mmol, 2.5 equiv), Ni-catalyst (10 mol%), ligand (10 mol%), base (0.3 mmol, 3.0 equiv) and solvent (1.0 mL), Ar, 80 °C, 24 h.

2.1.6 Base screening

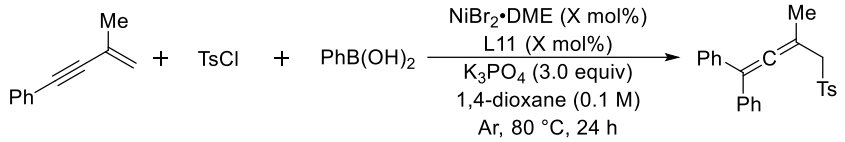


1a **2a** **3a** **4**

Entry	Base	Yield
1	K_2CO_3	57%
2	K_2HPO_4	35%
3	*t*-BuOK	16
4	AcOK	N.D.
5	$KHCO_3$	N.D.
6	Na_3PO_4	40%
7	Na_2CO_3	31%
8	Cs_2CO_3	N.D.

Reaction conditions: 1,3-enyne (0.1 mmol, 1.0 equiv), arylboronic acids (0.25 mmol, 2.5 equiv), sulfonyl chlorides (0.25 mmol, 2.5 equiv), Ni-catalyst (10 mol%), ligand (10 mol%), base (0.3 mmol, 3.0 equiv) and solvent (1.0 mL), Ar, 80 °C, 24 h.

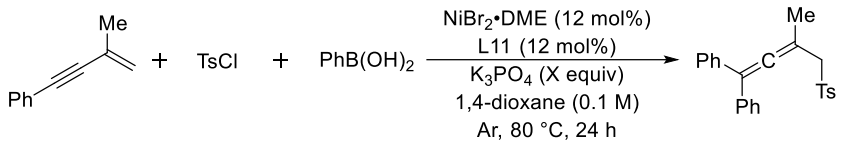
2.1.7 Relative ratios screening



1a **2a** **3a** **4**

Entry	$NiBr_2$•DME	L11	Yield
1	5.0%	7.5%	46%
2	10%	15%	44%
3	10%	20%	36%
4	12%	12%	69%
5	12%	15%	56%
6	15%	15%	65%
7	15%	20%	63%

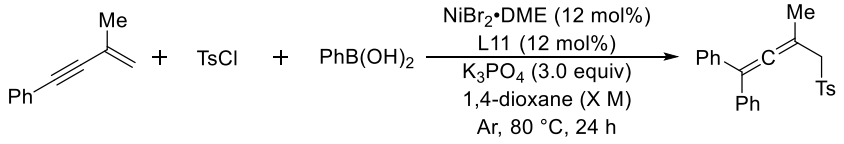
Reaction conditions: 1,3-enyne (0.1 mmol, 1.0 equiv), arylboronic acids (0.25 mmol, 2.5 equiv), sulfonyl chlorides (0.25 mmol, 2.5 equiv), Ni-catalyst, ligand, base (0.3 mmol, 3.0 equiv) and solvent (1.0 mL), Ar, 80 °C, 24 h.



1a **2a** **3a** **4**

Entry	K_3PO_4(eq)	Yield
1	1.5	55%
2	2.0	65%
3	2.5	66%
4	3.5	57%
5	4.0	50%

Reaction conditions: 1,3-enyne (0.1 mmol, 1.0 equiv), arylboronic acids (0.25 mmol, 2.5 equiv), sulfonyl chlorides (0.25 mmol, 2.5 equiv), Ni-catalyst (12 mol%), ligand (12 mol%), base and solvent (1.0 mL), Ar, 80 °C, 24 h.

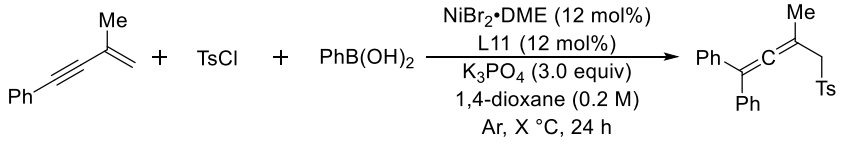


1a **2a** **3a** **4**

Entry	1,4-dioxane(mL)	Yield
1	0.5	82%
2	1.5	69%
3	2.0	69%

Reaction conditions: 1,3-enyne (0.1 mmol, 1.0 equiv), arylboronic acids (0.25 mmol, 2.5 equiv), sulfonyl chlorides (0.25 mmol, 2.5 equiv), Ni-catalyst (12 mol%), ligand (12 mol%), base (0.3 mmol, 3.0 equiv) and solvent, Ar, 80 °C, 24 h.

2.1.8 Temperature screening

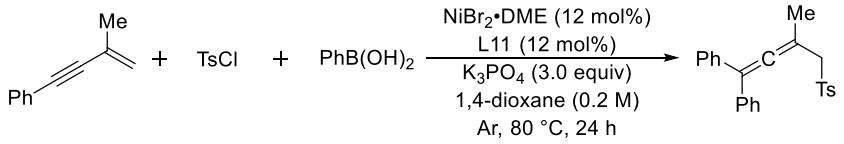


1a **2a** **3a** **4**

Entry	T(°C)	Yield
1	40	38%
2	50	63%
3	60	71%
4	70	75%
5	90	58%
6	100	53%

Reaction conditions: 1,3-enyne (0.1 mmol, 1.0 equiv), arylboronic acids (0.25 mmol, 2.5 equiv), sulfonyl chlorides (0.25 mmol, 2.5 equiv), Ni-catalyst (12 mol%), ligand (12 mol%), base (0.3 mmol, 3.0 equiv) and solvent (0.5 mL), Ar, 24 h.

2.1.9 Control reactions

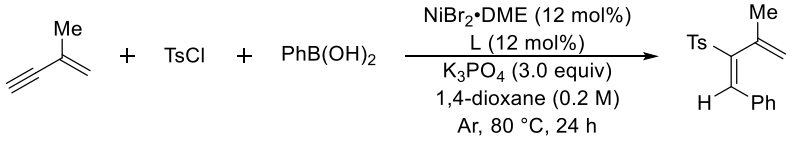


1a **2a** **3a** **4**

Entry		Yield
1	Without [Ni]	N.D.
2	Without ligand	N.D.
3	Without base	N.D.

Reaction conditions: 1,3-enyne (0.1 mmol, 1.0 equiv), arylboronic acids (0.25 mmol, 2.5 equiv), sulfonyl chlorides (0.25 mmol, 2.5 equiv), Ni-catalyst (12 mol%), ligand (12 mol%), base (0.3 mmol, 3.0 equiv) and solvent (0.5 mL), Ar, 80 °C, 24 h.

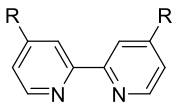
2.1.10 Ligand screening



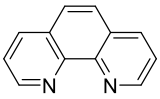
1a' **2a** **3a** **50**

Entry	Ligand	Yield
1	L1	33%
2	L2	Trace
3	L3	Trace
4	L4	N.D.
5	L5	Trace
6	L6	16%
7	L7	55%
8	L8	26%
9	L9	5%
10	L10	N.D.
11	L11	60%
12	L12	N.D.

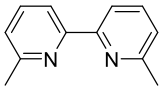
Reaction conditions: 1,3-enyne (0.1 mmol, 1.0 equiv), arylboronic acids (0.25 mmol, 2.5 equiv), sulfonyl chlorides (0.25 mmol, 2.5 equiv), Ni-catalyst (12 mol%), ligand (12 mol%), base (0.3 mmol, 3.0 equiv) and solvent (0.5 mL), Ar, 80 °C, 24 h.



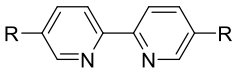
L1 (R= *t*-Bu)
L2 (R= H)
L3 (R= OMe)
L4 (R= Me)
L6 (R= Br)
L7 (R= CF_3)
L8 (R= CO_2Me)



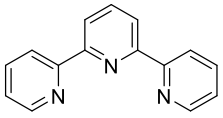
L5



L10



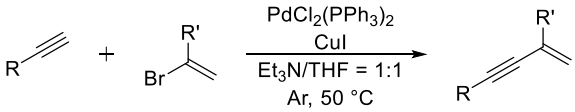
L9 (R= Me)
L11 (R= CF_3)



L12

2.2 General procedures for synthesis of substrates

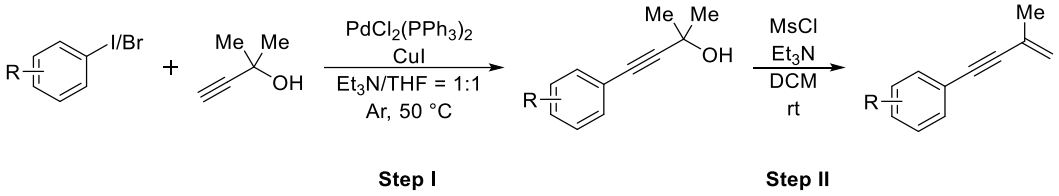
2.2.1 General procedure A



The oven-dried Schlenk flask containing a stirring bar was charged with $PdCl_2(PPh_3)_2$ (2.0 mmol%) and CuI (5.0 mmol%). The mixture was evacuated and back-filled with Ar for 3 times. Dry THF and Et_3N was respectively added under a stream of argon, and the substituted alkyne (1.0 equiv) and substituted 2-Bromopropene (1.2 equiv) was successively added carefully at room temperature. Then, the reaction mixture was stirred and heated to 50 °C under argon atmosphere. After completion (monitored by TLC), the reaction was cooled to room temperature and diluted with ethyl acetate and washed with brine. The

organic layer was dried over anhydrous Na_2SO_4 and filtrated. After the solvent was concentrated under reduced pressure, the crude product was purified by flash silica gel column chromatography (PE) to afford the desired products.[1]

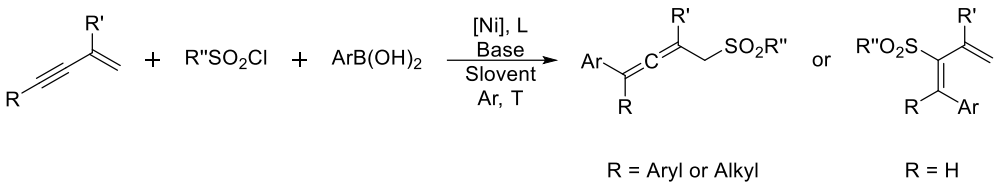
2.2.2 General procedure B



Step I: The oven-dried Schlenk flask containing a stirring bar was charged with $PdCl_2(PPh_3)_2$ (2.0 mmol%) and CuI (5.0 mmol%). The mixture was evacuated and back-filled with Ar for 3 times. Dry THF and Et_3N was respectively added under a stream of argon, and the substituted aryl halides (1.0 equiv) and 2-methyl-3-butyn-2-ol (1.2 equiv) was added carefully at room temperature. Then, the reaction mixture was stirred and heated to 50 °C under argon atmosphere. After completion (monitored by TLC), the reaction was cooled to room temperature and diluted with ethyl acetate and washed with brine. The organic layer was dried over anhydrous Na_2SO_4 and filtrated. After the solvent was concentrated under reduced pressure, the crude product was purified by flash silica gel column chromatography (PE:EA=5:1-1:1) to afford the desired products.

Step II: The resulting propargyl alcohol (1.0 equiv) was dissolved in DCM, and the mixture was cooled to 0 °C. After Et_3N (5.0 equiv) was added to this solution, methylsulfonyl chloride (2.0 equiv) was added carefully at 0 °C. Then, the reaction mixture was stirred at room temperature. After completion (monitored by TLC), the reaction was diluted with dichloromethane and washed with brine. The organic layer was dried over anhydrous Na_2SO_4 and filtrated. After the solvent was concentrated under reduced pressure, the crude product was purified by flash silica gel column chromatography (PE:EA=100:1-10:1) to afford the desired products.[2]

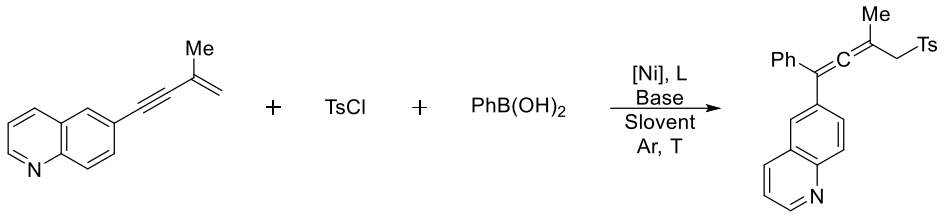
2.3 General procedures for synthesis of products



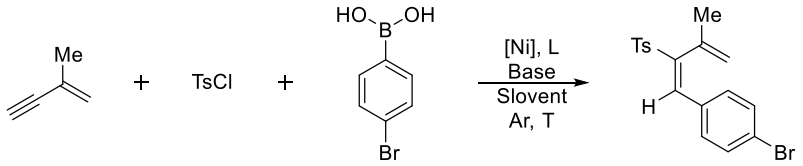
The oven-dried Schlenk sealed tube (15 mL) containing a stirring bar was charged with 1,3-enyne

substrates (0.1 mmol, 1.0 equiv), arylboronic acids (0.25 mmol, 2.5 equiv), sulfonyl chlorides (0.25 mmol, 2.5 equiv), $NiBr_2$•DME (12 mol%), 5,5'-Bis(trifluoromethyl)-2,2'-bipyridine (12 mol%), K_3PO_4 (0.3 mmol, 3.0 equiv) and 1,4-dioxane (0.5 mL) under argon atmosphere. Then the tube was placed into a preheated oil bath at 80 °C with stirring for 24 h. Upon completion of the reaction, the crude reaction mixture was diluted with DCM, and filtrated. After the solvent was concentrated under reduced pressure, the crude ^1H NMR spectrum was taken using CH_2Br_2 as internal standard. The resulting residue was purified by flash silica gel column chromatography or preparative thin layer chromatography to give the desired products.

2.4 Large-scale experiments



The oven-dried Schlenk sealed tube (100 mL) containing a stirring bar was charged with 1,3-enyne substrates (3.0 mmol, 1.0 equiv), arylboronic acids (7.5 mmol, 2.5 equiv), sulfonyl chlorides (7.5 mmol, 2.5 equiv), $NiBr_2$•DME (12 mol%), 5,5'-Bis(trifluoromethyl)-2,2'-bipyridine (12 mol%), K_3PO_4 (9 mmol, 3.0 equiv) and 1,4-dioxane (15 mL) under argon atmosphere. Then the tube was placed into a preheated oil bath at 80 °C with stirring for 24 h. Upon completion of the reaction, the crude reaction mixture was diluted with DCM, and filtrated. After the solvent was concentrated under reduced pressure, the resulting residue was purified by flash silica gel column chromatography (PE:EA=5:1-1:1) to give the desired products in 68%.

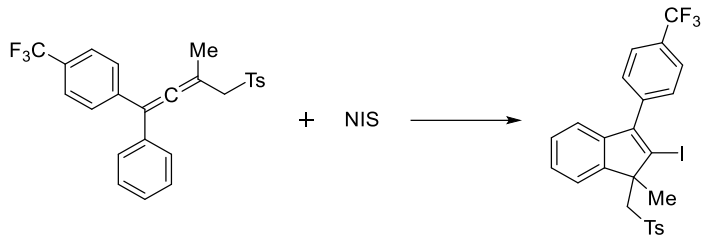


The oven-dried Schlenk sealed tube (100 mL) containing a stirring bar was charged with 1,3-enyne substrates (5.0 mmol, 1.0 equiv), arylboronic acids (12.5 mmol, 2.5 equiv), sulfonyl chlorides (12.5 mmol, 2.5 equiv), $NiBr_2$•DME (12 mol%), 5,5'-Bis(trifluoromethyl)-2,2'-bipyridine (12 mol%), K_3PO_4 (15 mmol, 3.0 equiv) and 1,4-dioxane (25 mL) under argon atmosphere. Then the tube was placed into a preheated oil bath at 80 °C with stirring for 24 h. Upon completion of the reaction, the crude reaction

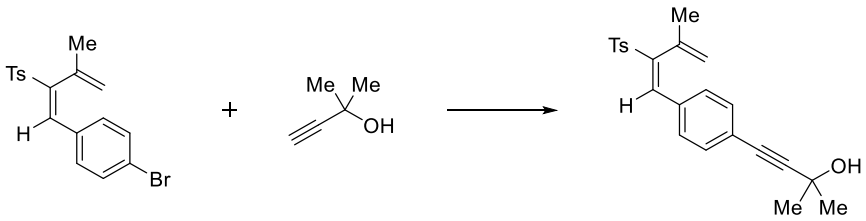
mixture was diluted with DCM, and filtrated. After the solvent was concentrated under reduced pressure, the resulting residue was purified by flash silica gel column chromatography (PE:EA=20:1-10:1) to give the desired products in 60%.

2.5 Synthetic application

2.5.1 Synthetic transformations

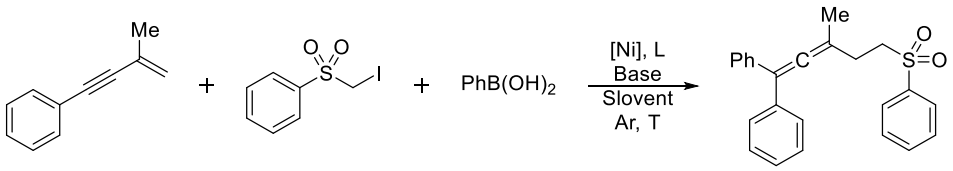


The oven-dried Schlenk sealed tube (15 mL) containing a stirring bar was charged with **26** substrate (0.1 mmol, 1.0 equiv), NIS (0.2 mmol, 2.0 equiv), and $MeNO_2$ (1.5 mL) under air atmosphere. Then, the reaction mixture was stirred at room temperature for 30 min. After completion (monitored by TLC), the solvent was concentrated under reduced pressure. The crude product was purified by flash silica gel column chromatography (PE:EA=15:1-10:1) to afford the desired products.[3]



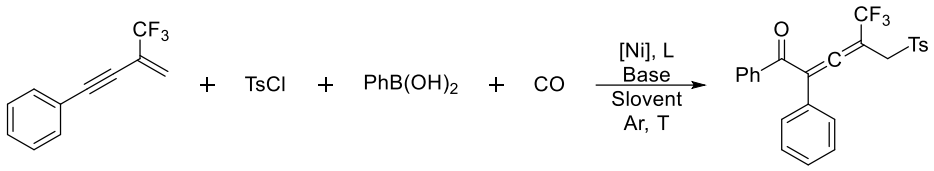
The oven-dried Schlenk flask containing a stirring bar was charged with **54** substrate (0.1 mmol, 1.0 equiv), $Pd(OAc)_2$ (2.0 mmol%), PPh_3 (2.0 mmol%) and CuI (5.0 mmol%). The mixture was evacuated and back-filled with Ar for 3 times. Dry Et_3N was added under a stream of argon, and 2-methyl-3-butyn-2-ol (1.2 equiv) was added carefully at room temperature. Then, the reaction mixture was stirred and heated to 50 °C under argon atmosphere. After completion (monitored by TLC), the reaction was cooled to room temperature and diluted with ethyl acetate and washed with brine. The organic layer was dried over anhydrous Na_2SO_4 and filtrated. After the solvent was concentrated under reduced pressure, the crude product was purified by flash silica gel column chromatography (PE:EA=5:1-1:1) to afford the desired products.[4]

2.5.2 Utilization of another type of radical precursor



The oven-dried Schlenk sealed tube (15 mL) containing a stirring bar was charged with 1,3-enyne substrates (0.1 mmol, 1.0 equiv), arylboronic acids (0.25 mmol, 2.5 equiv), ((iodomethyl)sulfonyl)benzene (0.25 mmol, 2.5 equiv), $NiBr_2$•DME (12 mol%), 5,5'-Bis(trifluoromethyl)-2,2'-bipyridine (12 mol%), K_3PO_4 (0.3 mmol, 3.0 equiv) and 1,4-dioxane (0.5 mL) under argon atmosphere. Then the tube was placed into a preheated oil bath at 80 °C with stirring for 24 h. Upon completion of the reaction, the crude reaction mixture was diluted with DCM, and filtrated. After the solvent was concentrated under reduced pressure, the crude ^{1}H NMR spectrum was taken using CH_2Br_2 as internal standard. The resulting residue was purified by flash silica gel column chromatography (PE:EA=20:1-10:1) to give the desired products.

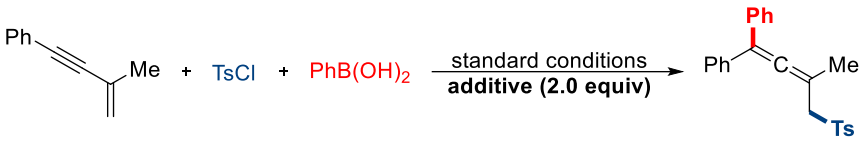
2.5.3 Utilization of CO



The oven-dried Schlenk sealed tube (15 mL) containing a stirring bar was charged with 1,3-enyne substrates (0.1 mmol, 1.0 equiv), arylboronic acids (0.25 mmol, 2.5 equiv), sulfonyl chlorides (0.25 mmol, 2.5 equiv), $NiBr_2$•DME (12 mol%), 5,5'-Bis(trifluoromethyl)-2,2'-bipyridine (12 mol%), K_3PO_4 (0.3 mmol, 3.0 equiv) and 1,4-dioxane (0.5 mL) under argon atmosphere. The mixture was evacuated and back-filled with CO (1atm) for 3 times. Then the tube was placed into a preheated oil bath at 80 °C with stirring for 24 h. Upon completion of the reaction, the crude reaction mixture was diluted with DCM, and filtrated. After the solvent was concentrated under reduced pressure, the crude ^{1}H NMR spectrum was taken using CH_2Br_2 as internal standard. The resulting residue was purified by preparative thin layer chromatography (PE:EA=20:1-10:1) to give the desired products.

2.6 Mechanistic Studies

2.6.1 Radical inhibition experiments

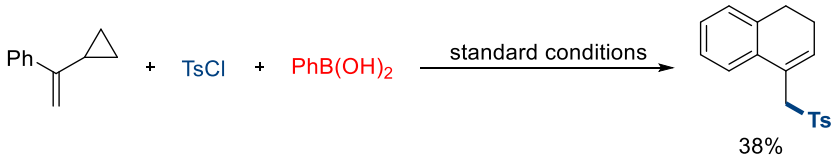


The oven-dried Schlenk sealed tube (15 mL) containing a stirring bar was charged with **TEMPO** (0.2 mmol, 2.0 equiv) 1,3-enyne substrates (0.1 mmol, 1.0 equiv), arylboronic acids (0.25 mmol, 2.5 equiv), sulfonyl chlorides (0.25 mmol, 2.5 equiv), $NiBr_2$•DME (12 mol%), 5,5'-Bis(trifluoromethyl)-2,2'-bipyridine (12 mol%), K_3PO_4 (0.3 mmol, 3.0 equiv) and 1,4-dioxane (0.5 mL) under argon atmosphere. Then the tube was placed into a preheated oil bath at 80 °C with stirring for 24 h. Upon completion of the reaction, the crude reaction mixture was diluted with DCM, and filtrated. After the solvent was concentrated under reduced pressure, the crude ^1H NMR spectrum was taken using CH_2Br_2 as internal standard. No expected product was observed.

The oven-dried Schlenk sealed tube (15 mL) containing a stirring bar was charged with **1,1-diphenylethylene** (0.2 mmol, 2.0 equiv) 1,3-enyne substrates (0.1 mmol, 1.0 equiv), arylboronic acids (0.25 mmol, 2.5 equiv), sulfonyl chlorides (0.25 mmol, 2.5 equiv), $NiBr_2$•DME (12 mol%), 5,5'-Bis(trifluoromethyl)-2,2'-bipyridine (12 mol%), K_3PO_4 (0.3 mmol, 3.0 equiv) and 1,4-dioxane (0.5 mL) under argon atmosphere. Then the tube was placed into a preheated oil bath at 80 °C with stirring for 24 h. Upon completion of the reaction, the crude reaction mixture was diluted with DCM, and filtrated. After the solvent was concentrated under reduced pressure, the crude ^1H NMR spectrum was taken using CH_2Br_2 as internal standard. The resulting residue was purified by preparative thin layer chromatography to give the desired products in 20% yield. Fortunately, **78** product was detected in 30% yield.

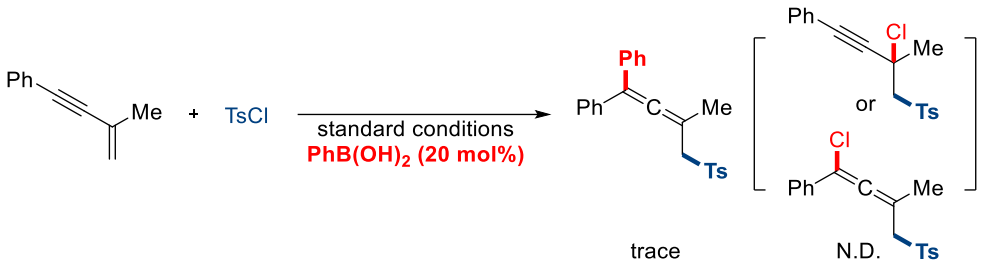
The oven-dried Schlenk sealed tube (15 mL) containing a stirring bar was charged with 1,3-enyne substrates (0.1 mmol, 1.0 equiv), arylboronic acids (0.25 mmol, 2.5 equiv), sulfonyl chlorides (0.25 mmol, 2.5 equiv), $NiBr_2$•DME (12 mol%), 5,5'-Bis(trifluoromethyl)-2,2'-bipyridine (12 mol%), K_3PO_4 (0.3 mmol, 3.0 equiv) and 1,4-dioxane (0.5 mL) under **air** atmosphere. Then the tube was placed into a preheated oil bath at 80 °C with stirring for 24 h. Upon completion of the reaction, the crude reaction mixture was diluted with DCM, and filtrated. After the solvent was concentrated under reduced pressure, the crude ^1H NMR spectrum was taken using CH_2Br_2 as internal standard. No expected product was observed.

2.6.2 Radical clock experiment



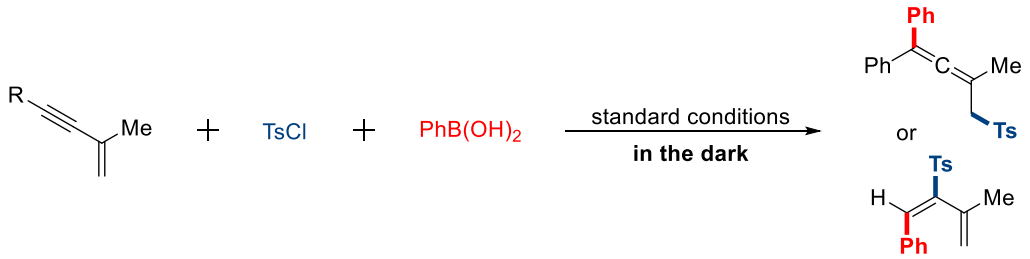
The oven-dried Schlenk sealed tube (15 mL) containing a stirring bar was charged with (1-cyclopropylvinyl)benzene (0.1 mmol, 1.0 equiv), arylboronic acids (0.25 mmol, 2.5 equiv), sulfonyl chlorides (0.25 mmol, 2.5 equiv), $NiBr_2$•DME (12 mol%), 5,5'-Bis(trifluoromethyl)-2,2'-bipyridine (12 mol%), K_3PO_4 (0.3 mmol, 3.0 equiv) and 1,4-dioxane (0.5 mL) under argon atmosphere. Then the tube was placed into a preheated oil bath at 80 °C with stirring for 24 h. Upon completion of the reaction, the crude reaction mixture was diluted with DCM, and filtrated. After the solvent was concentrated under reduced pressure, the crude ^1H NMR spectrum was taken using CH_2Br_2 as internal standard. The resulting residue was purified by preparative thin layer chromatography to give the **79** product in 38% yield.

2.6.3 Probe for putative intermediates



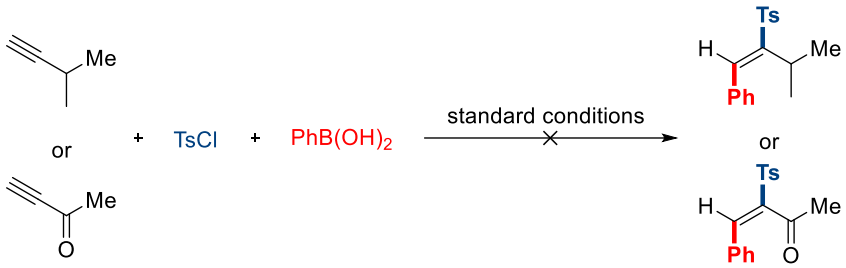
The oven-dried Schlenk sealed tube (15 mL) containing a stirring bar was charged with 1,3-enyne substrates (0.1 mmol, 1.0 equiv), **arylboronic acids (20 mol%)**, sulfonyl chlorides (0.25 mmol, 2.5 equiv), $NiBr_2$•DME (12 mol%), 5,5'-Bis(trifluoromethyl)-2,2'-bipyridine (12 mol%), K_3PO_4 (0.3 mmol, 3.0 equiv) and 1,4-dioxane (0.5 mL) under argon atmosphere. Then the tube was placed into a preheated oil bath at 80 °C with stirring for 24 h. Upon completion of the reaction, the crude reaction mixture was diluted with DCM, and filtrated. After the solvent was concentrated under reduced pressure, the crude ^1H NMR spectrum was taken using CH_2Br_2 as internal standard. The resulting residue was purified by preparative thin layer chromatography to give the desired products in 5% yield.

2.6.4 Control experiments in the dark:



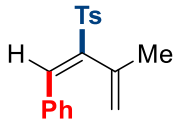
The oven-dried Schlenk sealed tube (15 mL) containing a stirring bar was charged with 1,3-enyne substrates (0.1 mmol, 1.0 equiv), arylboronic acids (0.25 mmol, 2.5 equiv), sulfonyl chlorides (0.25 mmol, 2.5 equiv), $NiBr_2$•DME (12 mol%), 5,5'-Bis(trifluoromethyl)-2,2'-bipyridine (12 mol%), K_3PO_4 (0.3 mmol, 3.0 equiv) and 1,4-dioxane (0.5 mL) under argon atmosphere. Then the tube was placed into a preheated oil bath at 80 °C with stirring for 24 h **in the dark.** Upon completion of the reaction, the crude reaction mixture was diluted with DCM, and filtrated. After the solvent was concentrated under reduced pressure, the crude ^{1}H NMR spectrum was taken using CH_2Br_2 as internal standard. The resulting residue was purified by preparative thin layer chromatography to give the desired products.

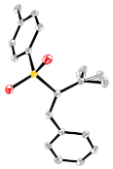
2.6.5 Control experiments with other terminal alkynes:



The oven-dried Schlenk sealed tube (15 mL) containing a stirring bar was charged with terminal alkynes substrates (0.1 mmol, 1.0 equiv), arylboronic acids (0.25 mmol, 2.5 equiv), sulfonyl chlorides (0.25 mmol, 2.5 equiv), $NiBr_2$•DME (12 mol%), 5,5'-Bis(trifluoromethyl)-2,2'-bipyridine (12 mol%), K_3PO_4 (0.3 mmol, 3.0 equiv) and 1,4-dioxane (0.5 mL) under argon atmosphere. Then the tube was placed into a preheated oil bath at 80 °C with stirring for 24 h. Upon completion of the reaction, the crude reaction mixture was diluted with DCM, and filtrated. The solvent was concentrated under reduced pressure and no expected product was observed.

3. X-Ray Crystallographic Spectrum





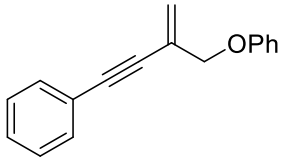
The CCDC number of this compound is **2344342**.

Table 1. Crystal data and structure refinement for **50.**

Identification code	50
Empirical formula	$C_{18}H_{18}O_2S$
Formula weight	298.38
Temperature/K	150.00(10)
Crystal system	Triclinic
Space group	P-1
a/Å	9.12295(12)
b/Å	9.29509(14)
c/Å	10.32066(17)
α/°	66.4462(15)
β/°	78.6780(13)
γ/°	73.4692(12)
Volume/Å^3	765.70(2)
Z	2
ρcalcg/cm^3	1.294
μ/mm^{-1}	1.883
F(000)	316.0
Crystal size/mm^3	0.12 × 0.07 × 0.06
Radiation	Cu Kα (λ = 1.54184)
Theta range for data collection/°	9.39 to 133.18
Index ranges	-10 ≤ h ≤ 10, -11 ≤ k ≤ 11, -12 ≤ l ≤ 12
Reflections collected	12187
Independent reflections	2674 [Rint = 0.0281, Rsigma = 0.0175]
Data/restraints/parameters	2674/61/212
Goodness-of-fit on F^2	1.052
Final R indexes [I>=2σ (I)]	R1 = 0.0313, wR2 = 0.0855
Final R indexes [all data]	R1 = 0.0317, wR2 = 0.0859
Largest diff. peak/hole / e Å^{-3}	0.32/-0.33

4. Characterization of unknown substrates and products

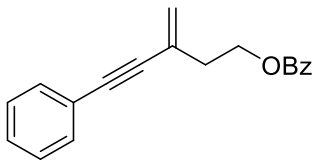
4.1 Characterization of unknown substrates



((2-methylene-4-phenylbut-3-yn-1-yl)oxy)benzene

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.41 – 7.35 (m, 2H), 7.27 – 7.18 (m, 5H), 6.93 – 6.85 (m, 3H), 5.61 (q, *J* = 1.7 Hz, 1H), 5.59 (q, *J* = 1.5 Hz, 1H), 4.58 – 4.52 (m, 2H).

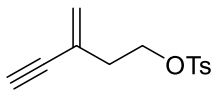
^{13}C NMR (101 MHz, $CDCl_3$): δ 158.2, 131.6, 129.4, 128.5, 128.3, 127.0, 122.7, 122.1, 121.1, 114.9, 90.7, 86.8, 69.4.



3-methylene-5-phenylpent-4-yn-1-yl benzoate

^{1}H NMR (400 MHz, $CDCl_3$): δ 8.08 – 8.03 (m, 2H), 7.57 – 7.51 (m, 1H), 7.45 – 7.38 (m, 4H), 7.34 – 7.27 (m, 3H), 5.56 (d, *J* = 1.6 Hz, 1H), 5.45 (d, *J* = 1.7 Hz, 1H), 4.57 (t, *J* = 6.5 Hz, 2H), 2.72 (t, *J* = 6.5 Hz, 2H).

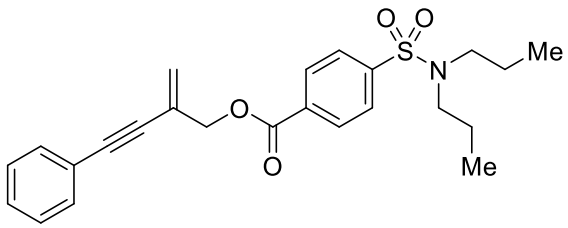
^{13}C NMR (101 MHz, $CDCl_3$): δ 166.4, 132.8, 131.5, 130.1, 129.5, 128.3, 128.2, 128.2, 127.6, 123.4, 122.8, 89.8, 88.8, 63.1, 36.5.



3-methylenepent-4-yn-1-yl 4-methylbenzenesulfonate

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.79 (d, *J* = 8.3 Hz, 2H), 7.34 (d, *J* = 8.1 Hz, 2H), 5.48 (s, 1H), 5.35 (s, 1H), 4.20 (t, *J* = 6.5 Hz, 2H), 2.83 (s, 1H), 2.49 (t, *J* = 6.6 Hz, 2H), 2.45 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 144.7, 133.0, 129.7, 127.9, 125.8, 125.0, 82.3, 78.1, 67.8, 36.3, 21.6.

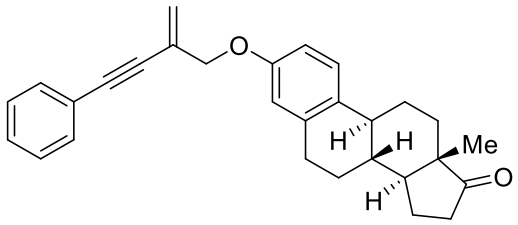


2-methylene-4-phenylbut-3-yn-1-yl 4-(N,N-dipropylsulfamoyl)benzoate

^{1}H NMR (400 MHz, $CDCl_3$): δ 8.23 (d, *J* = 8.5 Hz, 2H), 7.89 (d, *J* = 8.5 Hz, 2H), 7.47 – 7.40 (m, 2H), 7.36 – 7.29 (m, 3H), 5.72 – 5.69 (m, 1H), 5.68 – 5.65 (m, 1H), 4.96 (s, 2H), 3.14 – 3.06 (m, 4H), 1.60 – 1.48 (m, 4H), 0.87 (t, *J* = 7.4 Hz, 6H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 164.6, 144.3, 133.1, 131.6, 130.3, 128.6, 128.3, 127.0, 126.1, 123.2,

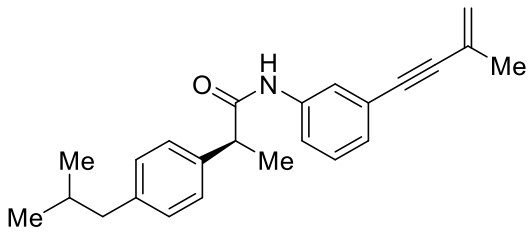
122.4, 90.9, 86.4, 66.6, 49.8, 21.9, 11.1.



(8R,9S,13S,14S)-13-methyl-3-((2-methylene-4-phenylbut-3-yn-1-yl)oxy)-6,7,8,9,11,12,13,14,15,16-decahydro-17H-cyclopenta[a]phenanthren-17-one

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.50 – 7.42 (m, 2H), 7.36 – 7.28 (m, 3H), 7.21 (d, *J* = 8.6 Hz, 1H), 6.78 (dd, *J* = 8.9, 2.7 Hz, 1H), 6.71 (d, *J* = 2.7 Hz, 1H), 5.70 (t, *J* = 1.7 Hz, 1H), 5.66 (t, *J* = 1.6 Hz, 1H), 4.60 (d, *J* = 1.8 Hz, 2H), 2.94 – 2.85 (m, 2H), 2.55 – 2.44 (m, 1H), 2.43 – 2.35 (m, 1H), 2.25 (td, *J* = 10.7, 3.9 Hz, 1H), 2.16 – 1.93 (m, 4H), 1.62 – 1.42 (m, 6H), 0.90 (s, 3H).

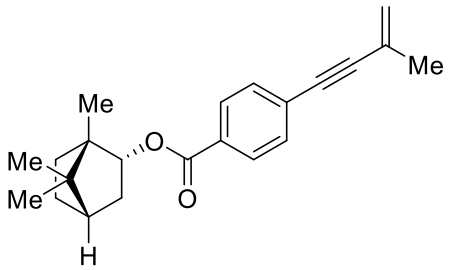
^{13}C NMR (101 MHz, $CDCl_3$): δ 156.2, 137.7, 132.4, 131.6, 128.4, 128.3, 127.0, 126.3, 122.6, 121.9, 114.8, 112.4, 90.6, 86.8, 69.4, 50.3, 47.9, 43.9, 38.2, 35.8, 31.5, 29.6, 26.4, 25.8, 21.5, 13.8.



(S)-2-(4-isobutylphenyl)-N-(3-(3-methylbut-3-en-1-yn-1-yl)phenyl)propanamide

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.52 (t, *J* = 1.9 Hz, 1H), 7.40 (dt, *J* = 8.2, 1.6 Hz, 1H), 7.24 (d, *J* = 7.9 Hz, 2H), 7.21 – 7.11 (m, 5H), 5.38 – 5.34 (m, 1H), 5.30 – 5.25 (m, 1H), 3.68 (q, *J* = 7.1 Hz, 1H), 2.47 (d, *J* = 7.2 Hz, 2H), 1.95 (s, 3H), 1.90 – 1.81 (m, 1H), 1.57 (d, *J* = 7.2 Hz, 3H), 0.91 (d, *J* = 6.6 Hz, 6H).

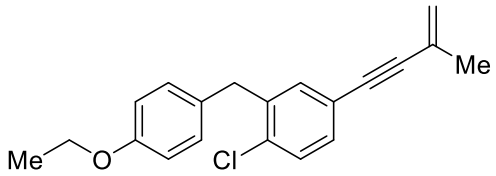
^{13}C NMR (101 MHz, $CDCl_3$): δ 172.7, 141.1, 137.8, 137.8, 129.8, 128.8, 127.3, 127.2, 126.6, 123.8, 122.5, 122.1, 119.5, 90.7, 87.8, 47.6, 45.0, 30.1, 23.4, 22.3, 18.4.



(1S,2R,4S)-1,7,7-trimethylbicyclo[2.2.1]heptan-2-yl 4-(3-methylbut-3-en-1-yn-1-yl)benzoate

^{1}H NMR (400 MHz, $CDCl_3$): δ 8.00 (d, *J* = 8.4 Hz, 2H), 7.50 (d, *J* = 8.4 Hz, 2H), 5.45 (s, 1H), 5.36 (s, 1H), 5.15 – 5.07 (m, 1H), 2.55 – 2.41 (m, 1H), 2.18 – 2.07 (m, 1H), 2.01 (s, 3H), 1.86 – 1.77 (m, 1H), 1.74 (t, *J* = 4.5 Hz, 1H), 1.46 – 1.36 (m, 1H), 1.36 – 1.27 (m, 1H), 1.12 (dd, *J* = 13.8, 3.5 Hz, 1H), 0.97 (s, 3H), 0.91 (s, 6H).

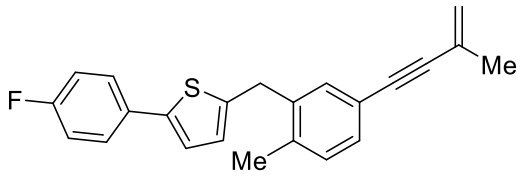
^{13}C NMR (101 MHz, $CDCl_3$): δ 166.2, 131.4, 130.0, 129.3, 127.8, 126.5, 123.0, 93.3, 87.6, 80.7, 49.1, 47.9, 44.9, 36.8, 28.1, 27.4, 23.3, 19.7, 18.9, 13.6.



1-chloro-2-(4-ethoxybenzyl)-4-(3-methylbut-3-en-1-yn-1-yl)benzene

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.32 – 7.27 (m, 1H), 7.25 – 7.19 (m, 2H), 7.09 (d, *J* = 8.7 Hz, 2H), 6.82 (d, *J* = 8.6 Hz, 2H), 5.39 – 5.35 (m, 1H), 5.30 – 5.27 (m, 1H), 4.04 – 3.96 (m, 4H), 1.95 (s, 3H), 1.39 (t, *J* = 7.0 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 157.5, 139.3, 134.2, 133.8, 130.8, 130.6, 129.9, 129.5, 126.6, 122.3, 122.0, 114.5, 91.2, 87.4, 63.4, 38.2, 23.4, 14.9.



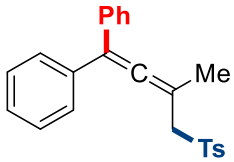
2-(4-fluorophenyl)-5-(2-methyl-5-(3-methylbut-3-en-1-yn-1-yl)benzyl)thiophene

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.48 – 7.43 (m, 2H), 7.31 (s, 1H), 7.26 (dd, *J* = 7.8, 1.8 Hz, 1H), 7.11 (d, *J* = 7.8 Hz, 1H), 7.04 – 6.98 (m, 3H), 6.65 (d, *J* = 3.6 Hz, 1H), 5.39 – 5.35 (m, 1H), 5.28 – 5.25 (m, 1H), 4.07 (s, 2H), 2.30 (s, 3H), 1.97 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 162.0 (d, *J* = 247.7 Hz), 142.8, 141.6, 138.2, 136.8, 132.5, 130.7 (d, *J* = 3.4 Hz), 130.5, 130.1, 127.1 (d, *J* = 7.9 Hz), 126.9, 126.0, 122.6, 121.7, 121.0, 115.7 (d, *J* = 22.0 Hz), 90.1, 88.4, 33.9, 23.5, 19.4.

^{19}F NMR (376 MHz, $CDCl_3$): δ -115.08.

4.2 Characterization of products



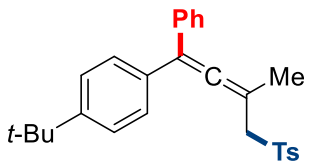
(3-methyl-4-tosylbuta-1,2-diene-1,1-diyl)dibenzene (4)

Colorless oil, 27.5 mg, **73%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.67 (d, *J* = 8.4 Hz, 2H), 7.30 – 7.23 (m, 6H), 7.14 – 7.04 (m, 4H), 3.92 (s, 2H), 2.32 (s, 3H), 2.06 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.5, 144.3, 136.1, 135.3, 129.6, 128.5, 128.2, 128.1, 127.4, 110.1, 92.8, 61.4, 21.6, 19.2.

HRMS (m/z, ESI-TOF): Calcd for $C_{24}H_{22}SO_2Na^+$ [M+Na^+] 397.1233, found 397.1241.



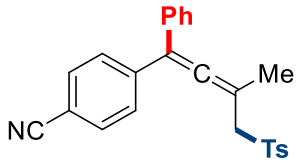
1-(tert-butyl)-4-(3-methyl-1-phenyl-4-tosylbuta-1,2-dien-1-yl)benzene (5)

Colorless oil, 30.5mg, **71%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.69 (d, *J* = 8.0 Hz, 2H), 7.30 (d, *J* = 8.2 Hz, 2H), 7.28 – 7.22 (m, 3H), 7.15 – 7.02 (m, 6H), 3.91 (s, 2H), 2.34 (s, 3H), 2.05 (s, 3H), 1.33 (s, 9H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.5, 150.4, 144.3, 136.3, 135.5, 133.0, 129.6, 128.7, 128.2, 128.1, 127.3, 125.1, 109.9, 92.6, 61.6, 34.5, 31.3, 21.6, 19.3.

HRMS (m/z, ESI-TOF): Calcd for $C_{28}H_{30}SO_2Na^+$ [M+Na$^+$] 453.1859, found 453.1852.



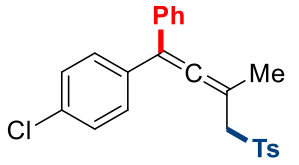
4-(3-methyl-1-phenyl-4-tosylbuta-1,2-dien-1-yl)benzonitrile (6)

Colorless oil, 29.5mg, **74%** yield. (PE/EtOAc = 10/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.70 (d, *J* = 7.9 Hz, 2H), 7.55 (d, *J* = 8.1 Hz, 2H), 7.37 – 7.24 (m, 5H), 7.20 – 7.05 (m, 4H), 3.93 (d, *J* = 4.9 Hz, 2H), 2.36 (s, 3H), 2.06 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.9, 144.5, 141.2, 135.4, 134.8, 131.9, 129.6, 128.9, 128.5, 128.4, 127.9, 127.8, 118.7, 110.6, 109.2, 93.9, 60.8, 21.5, 19.0.

HRMS (m/z, ESI-TOF): Calcd for $C_{25}H_{21}NSO_2Na^+$ [M+Na$^+$] 422.1185, found 422.1184.



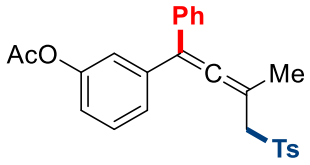
1-chloro-4-(3-methyl-1-phenyl-4-tosylbuta-1,2-dien-1-yl)benzene (7)

Colorless oil, 28.5mg, **70%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.67 (d, *J* = 7.9 Hz, 2H), 7.33 – 7.25 (m, 3H), 7.22 (d, *J* = 8.4 Hz, 2H), 7.14 – 7.07 (m, 4H), 7.04 (d, *J* = 8.2 Hz, 2H), 3.98 – 3.86 (m, 2H), 2.34 (s, 3H), 2.05 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.4, 144.5, 135.7, 135.3, 134.7, 133.1, 129.8, 129.6, 128.4, 128.3, 128.3, 128.0, 127.6, 109.2, 93.2, 61.3, 21.6, 19.1.

HRMS (m/z, ESI-TOF): Calcd for $C_{24}H_{21}ClSO_2Na^+$ [M+Na$^+$] 431.0843, found 431.0848.



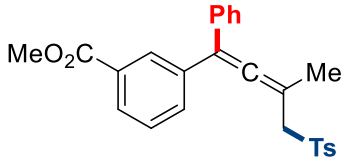
3-(3-methyl-1-phenyl-4-tosylbuta-1,2-dien-1-yl)phenyl acetate (8)

Colorless oil, 29.7mg, **69%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.66 (d, *J* = 8.0 Hz, 2H), 7.31 – 7.23 (m, 4H), 7.15 – 7.05 (m, 4H), 6.99 (dt, *J* = 7.8, 2.2 Hz, 2H), 6.91 (t, *J* = 2.0 Hz, 1H), 3.92 (s, 2H), 2.31 (s, 3H), 2.26 (s, 3H), 2.04 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.4, 169.2, 150.5, 144.3, 137.8, 135.6, 135.2, 129.5, 129.0, 128.5, 128.2, 127.9, 127.4, 125.9, 121.5, 120.6, 109.4, 93.1, 61.2, 21.5, 21.0, 19.1.

HRMS (m/z, ESI-TOF): Calcd for $C_{26}H_{24}SO_4Na^+$ [M+Na$^+$] 455.1288, found 455.1288.



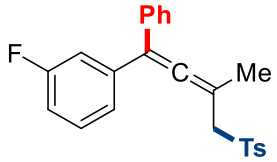
methyl 3-(3-methyl-1-phenyl-4-tosylbuta-1,2-dien-1-yl)benzoate (9)

Colorless oil, 32.4mg, **75%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.95 (d, *J* = 6.4 Hz, 1H), 7.83 (s, 1H), 7.67 (d, *J* = 7.9 Hz, 2H), 7.40 – 7.32 (m, 2H), 7.32 – 7.22 (m, 3H), 7.15 – 7.01 (m, 4H), 3.95 (s, 2H), 3.89 (s, 3H), 2.28 (s, 3H), 2.06 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.5, 166.7, 144.3, 136.7, 135.6, 135.2, 133.0, 130.2, 129.5, 129.4, 128.4, 128.3, 127.9, 127.5, 109.4, 93.2, 61.2, 52.0, 21.5, 19.1.

HRMS (m/z, ESI-TOF): Calcd for $C_{26}H_{24}SO_4Na^+$ [M+Na^+] 455.1288, found 455.1289.



1-fluoro-3-(3-methyl-1-phenyl-4-tosylbuta-1,2-dien-1-yl)benzene (10)

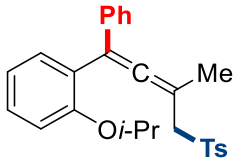
Colorless oil, 30.0mg, **76%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.68 (d, *J* = 7.9 Hz, 2H), 7.33 – 7.17 (m, 4H), 7.16 – 7.05 (m, 4H), 7.00 – 6.87 (m, 2H), 6.80 (d, *J* = 10.0 Hz, 1H), 3.93 (d, *J* = 2.7 Hz, 2H), 2.32 (s, 3H), 2.06 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.4, 162.6 (d, *J* = 246.5 Hz), 144.5, 138.6 (d, *J* = 7.5 Hz), 135.4 (d, *J* = 32.2 Hz), 129.6, 129.6, 129.6, 128.5, 128.3, 128.0, 127.6, 124.2 (d, *J* = 2.9 Hz), 115.3 (d, *J* = 22.2 Hz), 114.2 (d, *J* = 21.4 Hz), 109.3 (d, *J* = 2.4 Hz), 93.3, 61.2, 21.5, 19.1.

^{19}F NMR (376 MHz, $CDCl_3$): δ -112.99.

HRMS (m/z, ESI-TOF): Calcd for $C_{24}H_{21}FSO_2Na^+$ [M+Na^+] 415.1138, found 415.1154.



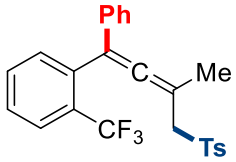
1-isopropoxy-2-(3-methyl-1-phenyl-4-tosylbuta-1,2-dien-1-yl)benzene (11)

Colorless oil, 24.0mg, **55%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.65 (d, *J* = 8.1 Hz, 2H), 7.25 (td, *J* = 7.6, 7.1, 1.9 Hz, 1H), 7.19 – 7.13 (m, 3H), 7.02 (d, *J* = 8.1 Hz, 2H), 6.99 – 6.91 (m, 3H), 6.86 (dd, *J* = 8.0, 4.9 Hz, 2H), 4.43 – 4.33 (m, 1H), 3.97 (d, *J* = 13.9 Hz, 1H), 3.87 (d, *J* = 13.9 Hz, 1H), 2.29 (s, 3H), 2.03 (s, 3H), 1.06 (dd, *J* = 6.0, 2.3 Hz, 6H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.4, 155.3, 144.1, 136.9, 135.2, 131.4, 129.5, 128.7, 128.0, 127.8, 127.2, 126.6, 126.2, 120.2, 113.8, 106.1, 91.5, 70.1, 61.6, 21.9, 21.8, 21.6, 18.8.

HRMS (m/z, ESI-TOF): Calcd for $C_{27}H_{28}SO_3Na^+$ [M+Na^+] 455.1651, found 455.1663.



1-(3-methyl-1-phenyl-4-tosylbuta-1,2-dien-1-yl)-2-(trifluoromethyl)benzene (12)

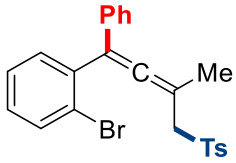
Colorless oil, 19.7mg, **45%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.69 (d, *J* = 7.6 Hz, 1H), 7.64 (d, *J* = 8.2 Hz, 2H), 7.53 – 7.41 (m, 2H), 7.22 – 7.12 (m, 4H), 7.05 (d, *J* = 7.9 Hz, 2H), 6.91 – 6.81 (m, 2H), 3.95 (d, *J* = 13.9 Hz, 1H), 3.83 (d, *J* = 13.9 Hz, 1H), 2.30 (s, 3H), 2.01 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 205.4, 144.3, 136.1, 135.1, 134.6 (q, *J* = 2.0 Hz), 132.2, 131.6, 129.5, 129.0 (q, *J* = 30.3 Hz), 128.1, 128.1, 127.7, 127.1, 126.9, 126.2 (q, *J* = 5.1 Hz), 123.8 (q, *J* = 275.2 Hz), 106.0, 93.9, 61.1, 21.6, 18.5.

^{19}F NMR (376 MHz, $CDCl_3$): δ -59.29.

HRMS (m/z, ESI-TOF): Calcd for $C_{25}H_{21}F_3SO_2Na^+$ [M+Na^+] 465.1107, found 465.1120.



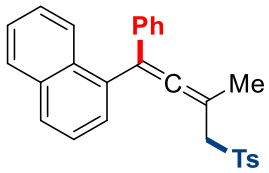
1-bromo-2-(3-methyl-1-phenyl-4-tosylbuta-1,2-dien-1-yl)benzene (13)

Colorless oil, 27.6mg, **61%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.65 (d, *J* = 7.9 Hz, 2H), 7.56 (d, *J* = 7.9 Hz, 1H), 7.30 – 7.23 (m, 1H), 7.23 – 7.14 (m, 4H), 7.10 (d, *J* = 7.4 Hz, 1H), 7.04 (d, *J* = 8.0 Hz, 2H), 6.96 – 6.86 (m, 2H), 4.02 (d, *J* = 13.9 Hz, 1H), 3.88 (d, *J* = 13.9 Hz, 1H), 2.29 (s, 3H), 2.07 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 206.2, 144.2, 136.8, 135.3, 134.9, 132.8, 131.6, 129.5, 129.0, 128.2, 128.0, 127.2, 127.1, 126.9, 124.0, 108.3, 93.7, 60.9, 21.6, 18.4.

HRMS (m/z, ESI-TOF): Calcd for $C_{24}H_{21}BrSO_2Na^+$ [M+Na^+] 475.0338, found 475.0358.



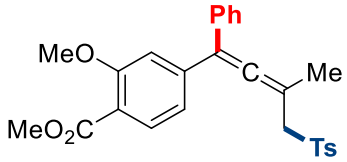
1-(3-methyl-1-phenyl-4-tosylbuta-1,2-dien-1-yl)naphthalene (14)

Colorless oil, 22.4mg, **53%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.83 (dd, *J* = 11.7, 8.2 Hz, 2H), 7.60 (d, *J* = 8.5 Hz, 1H), 7.54 (d, *J* = 8.3 Hz, 2H), 7.47 – 7.39 (m, 2H), 7.33 – 7.27 (m, 1H), 7.23 (dd, *J* = 7.2, 1.3 Hz, 1H), 7.19 – 7.11 (m, 3H), 7.01 – 6.93 (m, 2H), 6.80 (d, *J* = 8.0 Hz, 2H), 3.98 – 3.85 (m, 2H), 2.15 (s, 3H), 2.08 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.0, 144.1, 136.4, 134.9, 133.6, 133.5, 131.7, 129.2, 128.3, 128.2, 128.0, 127.9, 127.5, 127.1, 127.1, 125.9, 125.8, 125.8, 125.4, 107.3, 92.5, 61.5, 21.5, 18.8.

HRMS (m/z, ESI-TOF): Calcd for $C_{28}H_{24}SO_2Na^+$ [M+Na^+] 447.1389, found 447.1405.



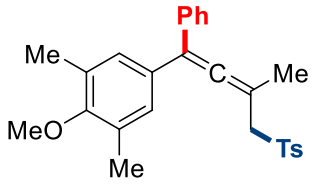
methyl 2-methoxy-4-(3-methyl-1-phenyl-4-tosylbuta-1,2-dien-1-yl)benzoate (15)

Colorless oil, 34.3mg, **74%** yield. (PE/EtOAc = 15/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.77 – 7.64 (m, 3H), 7.35 – 7.24 (m, 3H), 7.20 – 7.09 (m, 4H), 6.99 (s, 1H), 6.72 (d, *J* = 8.0 Hz, 1H), 4.02 – 3.81 (m, 8H), 2.34 (s, 3H), 2.05 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.7, 166.2, 159.1, 144.5, 141.8, 135.4, 135.4, 131.4, 129.6, 128.4, 128.3, 127.9, 127.6, 120.2, 118.6, 112.2, 109.7, 93.2, 61.0, 56.0, 51.9, 21.4, 19.1.

HRMS (m/z, ESI-TOF): Calcd for $C_{27}H_{26}SO_5Na^+$ [M+Na$^+$] 485.1393, found 485.1400.



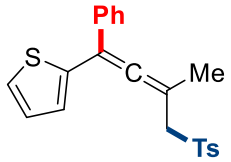
2-methoxy-1,3-dimethyl-5-(3-methyl-1-phenyl-4-tosylbuta-1,2-dien-1-yl)benzene (16)

Colorless oil, 17.3mg, **40%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.67 (d, *J* = 7.9 Hz, 2H), 7.31 – 7.23 (m, 3H), 7.13 – 7.01 (m, 4H), 6.84 (s, 2H), 3.92 (d, *J* = 3.4 Hz, 2H), 3.73 (s, 3H), 2.31 (s, 3H), 2.25 (s, 6H), 2.03 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.4, 156.4, 144.3, 136.4, 135.4, 131.4, 130.6, 129.5, 129.0, 128.6, 128.1, 128.0, 127.2, 109.8, 92.2, 61.6, 59.6, 21.6, 19.4, 16.1.

HRMS (m/z, ESI-TOF): Calcd for $C_{27}H_{28}SO_3Na^+$ [M+Na$^+$] 455.1651, found 455.1657.



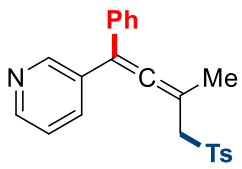
2-(3-methyl-1-phenyl-4-tosylbuta-1,2-dien-1-yl)thiophene (17)

Colorless oil, 18.5mg, **49%** yield. (PE/EtOAc = 10/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.67 (d, *J* = 8.1 Hz, 2H), 7.32 – 7.26 (m, 3H), 7.24 – 7.18 (m, 3H), 7.08 (d, *J* = 7.9 Hz, 2H), 6.94 (dd, *J* = 5.1, 3.6 Hz, 1H), 6.79 (dd, *J* = 3.6, 1.2 Hz, 1H), 3.97 – 3.85 (m, 2H), 2.33 (s, 3H), 2.05 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.0, 144.4, 139.4, 135.7, 135.3, 129.6, 128.3, 128.2, 128.1, 127.8, 127.3, 126.4, 125.4, 104.9, 93.4, 61.3, 21.6, 19.2.

HRMS (m/z, ESI-TOF): Calcd for $C_{22}H_{20}S_2O_2Na^+$ [M+Na$^+$] 403.0797, found 403.0802.



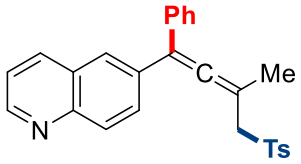
3-(3-methyl-1-phenyl-4-tosylbuta-1,2-dien-1-yl)pyridine (18)

Colorless oil, 23.0mg, **61%** yield. (PE/EtOAc = 5/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 8.52 (dd, *J* = 4.8, 1.6 Hz, 1H), 8.38 (d, *J* = 2.3 Hz, 1H), 7.68 (d, *J* = 8.0 Hz, 2H), 7.47 (dt, *J* = 8.0, 2.0 Hz, 1H), 7.32 – 7.27 (m, 3H), 7.22 (dd, *J* = 7.9, 4.8 Hz, 1H), 7.16 – 7.06 (m, 4H), 3.93 (d, *J* = 1.6 Hz, 2H), 2.33 (s, 3H), 2.06 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.5, 149.3, 148.1, 144.5, 135.8, 135.1, 134.9, 132.2, 129.6, 128.4, 128.2, 127.9, 127.7, 123.1, 107.2, 93.7, 61.0, 21.6, 19.1.

HRMS (m/z, ESI-TOF): Calcd for $C_{23}H_{21}NSO_2H^+$ [M+H$^+$] 376.1366, found 376.1375.



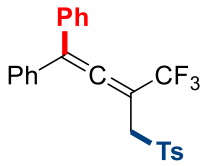
6-(3-methyl-1-phenyl-4-tosylbuta-1,2-dien-1-yl)quinolone (19)

Colorless oil, 32.5mg, **76%** yield. (PE/EtOAc = 3/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 8.89 (dd, *J* = 4.1, 1.9 Hz, 1H), 8.06 (d, *J* = 8.3 Hz, 1H), 8.00 (d, *J* = 8.8 Hz, 1H), 7.67 (d, *J* = 7.9 Hz, 2H), 7.59 (d, *J* = 2.0 Hz, 1H), 7.48 (dd, *J* = 8.8, 2.0 Hz, 1H), 7.42 – 7.36 (m, 1H), 7.35 – 7.29 (m, 3H), 7.23 – 7.14 (m, 2H), 6.98 (d, *J* = 7.9 Hz, 2H), 4.07 – 3.91 (m, 2H), 2.16 (s, 3H), 2.11 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 208.0, 150.3, 147.5, 144.4, 135.9, 135.7, 135.1, 134.4, 130.1, 129.5, 129.2, 128.5, 128.3, 128.0, 127.9, 127.6, 127.0, 121.3, 109.7, 93.3, 61.2, 21.3, 19.1.

HRMS (m/z, ESI-TOF): Calcd for $C_{33}H_{27}NSO_3Na^+$ [M+Na$^+$] 540.1604, found 540.1616.



(4,4,4-trifluoro-3-(tosylmethyl)buta-1,2-diene-1,1-diyl)dibenzene (20)

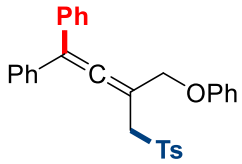
Colorless oil, 21.4mg, **50%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.60 (d, *J* = 8.0 Hz, 2H), 7.42 – 7.33 (m, 6H), 7.33 – 7.25 (m, 4H), 7.08 (d, *J* = 8.0 Hz, 2H), 4.06 (s, 2H), 2.32 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 208.3 (q, *J* = 3.6 Hz), 144.9, 134.8, 133.4, 129.7, 128.9, 128.6, 128.3, 122.4 (q, *J* = 276.2 Hz), 118.9, 91.6 (q, *J* = 37.2 Hz), 54.1, 21.6.

^{19}F NMR (376 MHz, $CDCl_3$): δ -62.35.

HRMS (m/z, ESI-TOF): Calcd for $C_{24}H_{19}F_3SO_2Na^+$ [M+Na$^+$] 451.0950, found 451.0945.



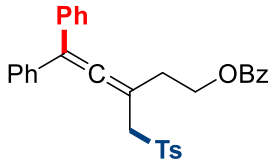
(4-phenoxy-3-(tosylmethyl)buta-1,2-diene-1,1-diyl)dibenzene (21)

Colorless oil, 33.5mg, **72%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.64 (d, *J* = 8.1 Hz, 2H), 7.31 – 7.22 (m, 6H), 7.17 – 7.08 (m, 6H), 7.00 (d, *J* = 8.0 Hz, 2H), 6.90 – 6.79 (m, 3H), 4.81 (s, 2H), 4.05 (s, 2H), 2.26 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.6, 157.8, 144.4, 135.2, 135.0, 129.6, 129.3, 128.7, 128.2, 128.0, 127.7, 121.1, 115.0, 113.1, 94.2, 67.5, 56.6, 21.5.

HRMS (m/z, ESI-TOF): Calcd for $C_{30}H_{26}SO_3Na^+$ [M+Na^+] 489.1495, found 489.1515.



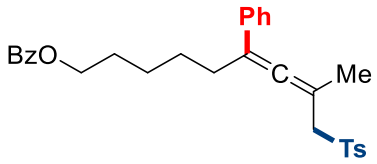
5,5-diphenyl-3-(tosylmethyl)penta-3,4-dien-1-yl benzoate (22)

Colorless oil, 32.8mg, **64%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.80 (d, *J* = 6.8 Hz, 2H), 7.66 (d, *J* = 8.3 Hz, 2H), 7.48 (t, *J* = 7.4 Hz, 1H), 7.30 (t, *J* = 7.8 Hz, 2H), 7.22 – 7.12 (m, 6H), 7.12 – 7.06 (m, 4H), 7.02 (d, *J* = 8.1 Hz, 2H), 4.52 (t, *J* = 6.0 Hz, 2H), 4.03 (s, 2H), 2.89 (t, *J* = 6.0 Hz, 2H), 2.28 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 206.9, 166.3, 144.4, 135.5, 135.1, 132.6, 129.8, 129.6, 129.4, 128.4, 128.1, 128.1, 127.9, 127.4, 112.3, 94.2, 62.2, 60.1, 31.6, 21.5.

HRMS (m/z, ESI-TOF): Calcd for $C_{32}H_{28}SO_4Na^+$ [M+Na^+] 531.1601, found 531.1598.



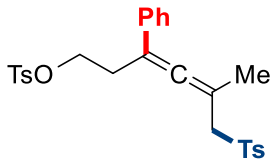
8-methyl-6-phenyl-9-tosylnona-6,7-dien-1-yl benzoate (23)

Colorless oil, 16.9mg, **35%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 8.04 (d, *J* = 7.7 Hz, 2H), 7.76 (d, *J* = 7.9 Hz, 2H), 7.60 – 7.51 (m, 1H), 7.44 (t, *J* = 7.6 Hz, 2H), 7.29 – 7.18 (m, 5H), 7.14 (d, *J* = 7.5 Hz, 2H), 4.31 (t, *J* = 6.6 Hz, 2H), 3.83 (s, 2H), 2.39 (s, 3H), 2.34 – 2.24 (m, 1H), 2.24 – 2.14 (m, 1H), 1.95 (s, 3H), 1.82 – 1.71 (m, 2H), 1.49 – 1.39 (m, 4H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 206.4, 166.6, 144.5, 135.9, 135.9, 132.9, 130.3, 129.7, 129.5, 128.3, 128.3, 128.2, 126.9, 126.3, 106.0, 92.1, 64.9, 61.7, 30.0, 28.5, 27.4, 25.8, 21.6, 19.0.

HRMS (m/z, ESI-TOF): Calcd for $C_{30}H_{32}SO_4Na^+$ [M+Na^+] 511.1914, found 511.1917.



5-methyl-3-phenyl-6-tosylhexa-3,4-dien-1-yl 4-methylbenzenesulfonate (24)

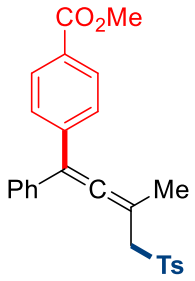
Colorless oil, 12.5mg, **25%** yield. (PE/EtOAc = 15/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.76 (d, *J* = 8.0 Hz, 4H), 7.34 – 7.25 (m, 5H), 7.24 – 7.20 (m, 2H), 7.11 – 7.05 (m, 2H), 4.14 – 4.03 (m, 2H), 3.86 – 3.73 (m, 2H), 2.67 – 2.54 (m, 2H), 2.43 (d, *J* = 6.4 Hz, 6H), 1.91 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 206.4, 144.8, 144.8, 135.8, 134.8, 132.8, 129.8, 129.8, 128.4, 128.2,

127.8, 127.3, 126.1, 101.4, 93.9, 68.2, 61.3, 29.7, 21.7, 21.6, 19.0.

HRMS (m/z, ESI-TOF): Calcd for $C_{27}H_{28}S_2O_5Na^+$ [M+Na^+] 519.1270, found 519.1261.



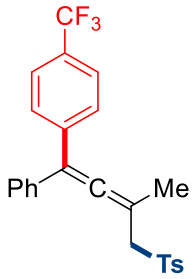
methyl 4-(3-methyl-1-phenyl-4-tosylbuta-1,2-dien-1-yl)benzoate (25)

Colorless oil, 35.9mg, **83%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.93 (d, *J* = 8.5 Hz, 2H), 7.68 (d, *J* = 8.2 Hz, 2H), 7.32 – 7.27 (m, 3H), 7.16 (d, *J* = 8.4 Hz, 2H), 7.14 – 7.07 (m, 4H), 3.95 (d, *J* = 3.1 Hz, 2H), 3.92 (s, 3H), 2.33 (s, 3H), 2.07 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.8, 166.6, 144.5, 141.0, 135.4, 135.2, 129.6, 129.4, 128.8, 128.3, 128.0, 127.6, 109.6, 93.4, 61.1, 52.0, 21.5, 18.9.

HRMS (m/z, ESI-TOF): Calcd for $C_{26}H_{24}SO_4Na^+$ [M+Na^+] 455.1288, found 455.1304.



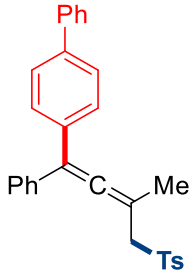
1-methyl-4-((2-methyl-4-phenyl-4-(4-(trifluoromethyl)phenyl)buta-2,3-dien-1-yl)sulfonyl)benzene (26) Colorless oil, 28.3mg, **64%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.69 (d, *J* = 8.0 Hz, 2H), 7.52 (d, *J* = 8.1 Hz, 2H), 7.34 – 7.27 (m, 3H), 7.24 (d, *J* = 7.9 Hz, 2H), 7.16 – 7.05 (m, 4H), 4.02 – 3.86 (m, 2H), 2.33 (s, 3H), 2.07 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.7, 144.6, 140.1 (q, *J* = 1.5 Hz), 135.4, 135.4, 129.7, 129.3 (q, *J* = 32.4 Hz), 128.8, 128.5, 128.4, 128.1, 127.8, 125.1 (q, *J* = 3.8 Hz), 124.7 (q, *J* = 272.9 Hz), 109.3, 93.6, 61.1, 21.5, 19.1.

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

HRMS (m/z, ESI-TOF): Calcd for $C_{25}H_{21}F_3SO_2Na^+$ [M+Na^+] 465.1107, found 465.1093.



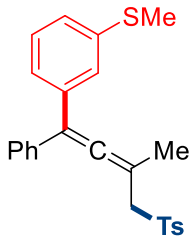
4-(3-methyl-1-phenyl-4-tosylbuta-1,2-dien-1-yl)-1,1'-biphenyl (27)

Colorless oil, 28.0mg, **62%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.69 (d, *J* = 7.9 Hz, 2H), 7.59 (d, *J* = 7.0 Hz, 2H), 7.51 (d, *J* = 8.2 Hz, 2H), 7.44 (t, *J* = 7.5 Hz, 2H), 7.35 (d, *J* = 7.4 Hz, 1H), 7.33 – 7.25 (m, 3H), 7.23 – 7.13 (m, 4H), 7.08 (d, *J* = 8.0 Hz, 2H), 3.94 (s, 2H), 2.29 (s, 3H), 2.07 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.6, 144.4, 140.5, 140.2, 136.1, 135.4, 135.1, 129.6, 128.9, 128.8, 128.6, 128.3, 128.1, 127.4, 127.4, 126.9, 126.8, 109.9, 92.9, 61.4, 21.6, 19.2.

HRMS (m/z, ESI-TOF): Calcd for $C_{30}H_{26}SO_2Na^+$ [M+Na^+] 473.1546, found 473.1569.



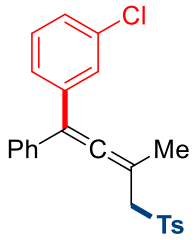
methyl(3-(3-methyl-1-phenyl-4-tosylbuta-1,2-dien-1-yl)phenyl)sulfane (28)

Colorless oil, 24.0mg, **57%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.67 (d, *J* = 7.9 Hz, 2H), 7.31 – 7.23 (m, 3H), 7.22 – 7.05 (m, 7H), 6.88 (dt, *J* = 7.4, 1.7 Hz, 1H), 3.92 (d, *J* = 2.4 Hz, 2H), 2.45 (s, 3H), 2.32 (s, 3H), 2.04 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.4, 144.4, 138.5, 136.9, 135.8, 135.3, 129.6, 128.6, 128.5, 128.2, 128.0, 127.4, 126.4, 125.3, 125.3, 109.8, 92.9, 61.3, 21.6, 19.2, 15.6.

HRMS (m/z, ESI-TOF): Calcd for $C_{25}H_{24}S_2O_2Na^+$ [M+Na^+] 443.1110, found 443.1125.



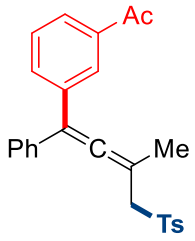
1-chloro-3-(3-methyl-1-phenyl-4-tosylbuta-1,2-dien-1-yl)benzene (29)

Colorless oil, 29.0mg, **71%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.66 (d, *J* = 8.3 Hz, 2H), 7.31 – 7.26 (m, 3H), 7.25 – 7.17 (m, 2H), 7.14 – 7.06 (m, 5H), 7.02 (dt, *J* = 7.2, 1.6 Hz, 1H), 3.92 (d, *J* = 3.9 Hz, 2H), 2.31 (s, 3H), 2.05 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.4, 144.4, 138.2, 135.5, 135.2, 134.1, 129.6, 129.4, 128.4, 128.4, 128.0, 127.6, 127.4, 126.8, 109.2, 93.4, 61.2, 21.6, 19.2.

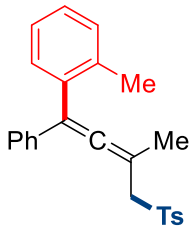
HRMS (m/z, ESI-TOF): Calcd for $C_{24}H_{21}ClSO_2H^+$ [M+H^+] 409.1024, found 409.1023.



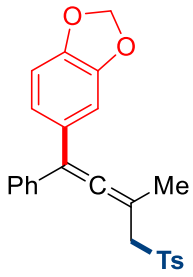
1-(3-(3-methyl-1-phenyl-4-tosylbuta-1,2-dien-1-yl)phenyl)ethan-1-one (30)

Colorless oil, 30.8mg, **74%** yield. (PE/EtOAc = 20/1)

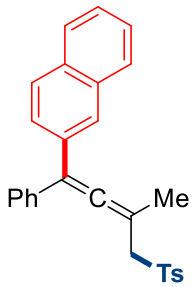
^{1}H NMR (400 MHz, $CDCl_3$): δ 7.91 – 7.84 (m, 2H), 7.69 (d, *J* = 8.1 Hz, 2H), 7.42 – 7.35 (m, 2H), 7.33 – 7.27 (m, 3H), 7.16 – 7.08 (m, 4H), 3.93 (d, *J* = 5.4 Hz, 2H), 2.59 (s, 3H), 2.32 (s, 3H), 2.05 (s, 3H).
^{13}C NMR (101 MHz, $CDCl_3$): δ 207.6, 198.0, 144.4, 137.2, 136.9, 135.6, 135.5, 133.1, 129.6, 128.5, 128.5, 128.4, 128.0, 127.6, 127.2, 109.6, 93.2, 61.2, 26.7, 21.5, 19.3.
HRMS (m/z, ESI-TOF): Calcd for $C_{26}H_{24}SO_3Na^+$ [M+Na^+] 439.1338, found 439.1353.



1-methyl-2-(3-methyl-1-phenyl-4-tosylbuta-1,2-dien-1-yl)benzene (31)
Colorless oil, 7.5mg, **19%** yield. (PE/EtOAc = 20/1)
^{1}H NMR (400 MHz, $CDCl_3$): δ 7.63 (d, *J* = 8.3 Hz, 2H), 7.27 – 7.24 (m, 1H), 7.23 – 7.17 (m, 4H), 7.16 – 7.13 (m, 1H), 7.04 (d, *J* = 8.0 Hz, 2H), 6.99 (dd, *J* = 7.8, 1.4 Hz, 1H), 6.96 – 6.91 (m, 2H), 3.89 (d, *J* = 4.0 Hz, 2H), 2.33 (s, 3H), 2.04 (s, 3H), 1.98 (s, 3H).
^{13}C NMR (101 MHz, $CDCl_3$): δ 206.2, 144.3, 136.5, 136.1, 135.3, 135.1, 130.2, 130.1, 129.6, 128.3, 128.1, 127.7, 127.1, 127.0, 125.8, 108.1, 92.3, 61.6, 21.7, 20.0, 18.8.
HRMS (m/z, ESI-TOF): Calcd for $C_{25}H_{24}SO_2Na^+$ [M+Na^+] 411.1389, found 411.1395.



5-(3-methyl-1-phenyl-4-tosylbuta-1,2-dien-1-yl)benzo[d][1,3]dioxole (32)
Colorless oil, 26.3mg, **63%** yield. (PE/EtOAc = 20/1)
^{1}H NMR (400 MHz, $CDCl_3$): δ 7.68 (d, *J* = 8.3 Hz, 2H), 7.29 – 7.24 (m, 3H), 7.15 – 7.06 (m, 4H), 6.71 (dd, *J* = 7.8, 0.8 Hz, 1H), 6.62 – 6.56 (m, 2H), 5.95 (q, *J* = 1.4 Hz, 2H), 3.91 (d, *J* = 1.2 Hz, 2H), 2.34 (s, 3H), 2.03 (s, 3H).
^{13}C NMR (101 MHz, $CDCl_3$): δ 207.2, 147.5, 147.0, 144.4, 136.3, 135.4, 130.0, 129.6, 128.6, 128.2, 128.1, 127.4, 122.2, 109.9, 108.9, 108.0, 101.1, 92.6, 61.5, 21.6, 19.2.
HRMS (m/z, ESI-TOF): Calcd for $C_{25}H_{22}SO_4Na^+$ [M+Na^+] 441.1131, found 441.1142.



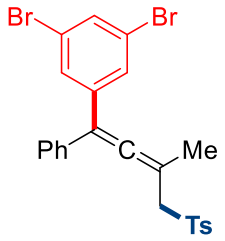
2-(3-methyl-1-phenyl-4-tosylbuta-1,2-dien-1-yl)naphthalene (33)

Colorless oil, 27.3mg, **64%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.84 – 7.78 (m, 1H), 7.72 (d, *J* = 8.3 Hz, 2H), 7.65 (d, *J* = 7.9 Hz, 2H), 7.56 (s, 1H), 7.49 – 7.42 (m, 2H), 7.33 – 7.27 (m, 3H), 7.24 (dd, *J* = 8.5, 1.8 Hz, 1H), 7.17 (dd, *J* = 6.6, 3.0 Hz, 2H), 6.92 (d, *J* = 7.9 Hz, 2H), 3.96 (d, *J* = 4.3 Hz, 2H), 2.10 (d, *J* = 1.8 Hz, 6H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.9, 144.3, 136.1, 135.2, 133.5, 133.2, 132.6, 129.5, 128.6, 128.3, 128.0, 127.8, 127.5, 127.5, 127.4, 126.7, 126.2, 126.0, 110.2, 92.9, 61.4, 21.3, 19.2.

HRMS (m/z, ESI-TOF): Calcd for $C_{28}H_{24}SO_2Na^+$ [M+Na^+] 447.1389, found 447.1395.



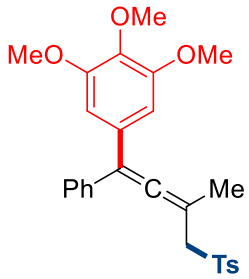
1,3-dibromo-5-(3-methyl-1-phenyl-4-tosylbuta-1,2-dien-1-yl)benzene (34)

Colorless oil, 37.8mg, **71%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.66 (d, *J* = 8.0 Hz, 2H), 7.55 (s, 1H), 7.34 – 7.27 (m, 3H), 7.24 (d, *J* = 1.8 Hz, 2H), 7.14 – 7.05 (m, 4H), 4.01 – 3.85 (m, 2H), 2.32 (s, 3H), 2.03 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.4, 144.5, 140.2, 135.2, 134.9, 132.8, 130.1, 129.6, 128.5, 128.3, 127.9, 127.9, 122.7, 108.3, 94.0, 61.0, 21.6, 19.2.

HRMS (m/z, ESI-TOF): Calcd for $C_{24}H_{20}Br_2SO_2Na^+$ [M+Na^+] 552.9443, found 552.9426.



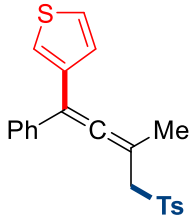
1,2,3-trimethoxy-5-(3-methyl-1-phenyl-4-tosylbuta-1,2-dien-1-yl)benzene (35)

Colorless oil, 26.4mg, **57%** yield. (PE/EtOAc = 10/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.71 (d, *J* = 8.3 Hz, 2H), 7.33 – 7.26 (m, 3H), 7.19 (dd, *J* = 7.6, 2.0 Hz, 2H), 7.16 (d, *J* = 8.0 Hz, 2H), 6.57 (s, 2H), 3.97 – 3.91 (m, 2H), 3.88 (s, 3H), 3.81 (s, 6H), 2.36 (s, 3H), 2.01 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.4, 153.0, 144.6, 137.4, 136.1, 135.9, 131.6, 129.6, 128.6, 128.2, 127.9, 127.5, 110.3, 105.9, 92.4, 61.5, 60.8, 56.1, 21.5, 19.5.

HRMS (m/z, ESI-TOF): Calcd for $C_{27}H_{28}SO_5Na^+$ [M+Na^+] 487.1550, found 487.1551.



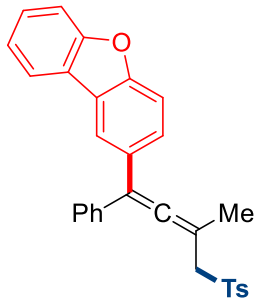
3-(3-methyl-1-phenyl-4-tosylbuta-1,2-dien-1-yl)thiophene (36)

Colorless oil, 25.2mg, **66%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.70 (d, *J* = 8.4 Hz, 2H), 7.32 – 7.26 (m, 3H), 7.24 (dd, *J* = 5.0, 3.0 Hz, 1H), 7.21 – 7.17 (m, 2H), 7.14 (d, *J* = 8.0 Hz, 2H), 6.94 (dd, *J* = 3.0, 1.3 Hz, 1H), 6.90 (dt, *J* = 5.0, 1.1 Hz, 1H), 3.90 (d, *J* = 2.8 Hz, 2H), 2.36 (s, 3H), 2.04 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.5, 144.5, 136.7, 136.1, 135.5, 129.7, 128.3, 128.2, 128.1, 127.9, 127.5, 125.3, 123.0, 105.5, 92.4, 61.5, 21.6, 19.2.

HRMS (m/z, ESI-TOF): Calcd for $C_{22}H_{20}S_2O_2H^+$ [M+H$^+$] 381.0977, found 381.0985.



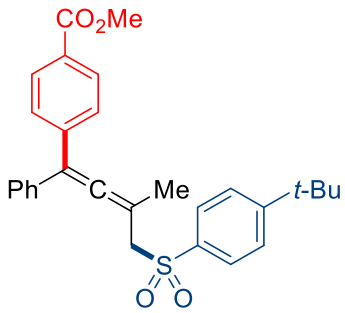
2-(3-methyl-1-phenyl-4-tosylbuta-1,2-dien-1-yl)dibenzo[b,d]furan (37)

Colorless oil, 29.4mg, **63%** yield. (PE/EtOAc = 15/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.89 (d, *J* = 7.6 Hz, 1H), 7.75 (s, 1H), 7.67 (d, *J* = 7.9 Hz, 2H), 7.56 (d, *J* = 8.2 Hz, 1H), 7.46 (d, *J* = 8.3 Hz, 2H), 7.36 – 7.26 (m, 4H), 7.24 – 7.15 (m, 3H), 6.98 (d, *J* = 7.9 Hz, 2H), 4.05 – 3.90 (m, 2H), 2.10 (d, *J* = 10.0 Hz, 6H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.6, 156.5, 155.5, 144.3, 136.5, 135.4, 131.0, 129.5, 128.5, 128.3, 128.0, 127.5, 127.3, 124.3, 123.9, 122.8, 120.8, 120.7, 111.6, 111.3, 110.1, 92.7, 61.6, 21.3, 19.3.

HRMS (m/z, ESI-TOF): Calcd for $C_{30}H_{24}SO_3Na^+$ [M+Na$^+$] 487.1338, found 487.1340.



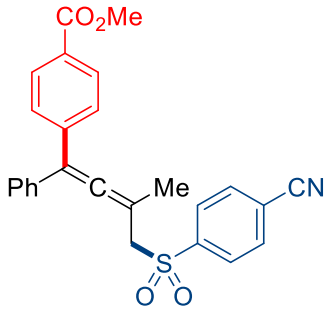
methyl 4-(4-((4-(tert-butyl)phenyl)sulfonyl)-3-methyl-1-phenylbuta-1,2-dien-1-yl)benzoate (38)

Colorless oil, 32.3mg, **68%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.97 (d, *J* = 8.5 Hz, 2H), 7.76 (d, *J* = 8.5 Hz, 2H), 7.36 (d, *J* = 8.6 Hz, 2H), 7.34 – 7.28 (m, 5H), 7.25 – 7.21 (m, 2H), 3.94 (d, *J* = 3.0 Hz, 2H), 3.91 (s, 3H), 2.07 (s, 3H), 1.27 (s, 9H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.9, 166.7, 157.5, 141.1, 135.9, 135.5, 129.6, 128.9, 128.6, 128.4, 127.9, 127.7, 126.0, 109.8, 93.3, 61.2, 52.0, 35.1, 30.9, 19.5.

HRMS (m/z, ESI-TOF): Calcd for $C_{29}H_{30}SO_4Na^+$ [M+Na$^+$] 497.1757, found 497.1753.



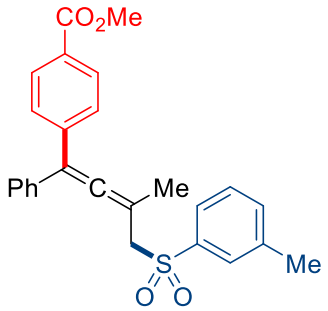
methyl 4-(4-((4-cyanophenyl)sulfonyl)-3-methyl-1-phenylbuta-1,2-dien-1-yl)benzoate (39)

Colorless oil, 25.8mg, **58%** yield. (PE/EtOAc = 5/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.96 (d, *J* = 8.1 Hz, 2H), 7.83 (d, *J* = 8.1 Hz, 2H), 7.41 (d, *J* = 8.1 Hz, 2H), 7.38 – 7.30 (m, 3H), 7.14 (d, *J* = 8.1 Hz, 2H), 7.06 – 6.99 (m, 2H), 4.09 – 3.99 (m, 2H), 3.93 (s, 3H), 2.12 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.8, 166.5, 141.7, 140.5, 135.1, 132.4, 129.6, 129.4, 128.6, 128.5, 128.5, 128.2, 128.2, 117.1, 116.9, 110.1, 92.8, 60.9, 52.1, 19.0.

HRMS (m/z, ESI-TOF): Calcd for $C_{26}H_{21}NSO_4Na^+$ [M+Na^+] 466.1083, found 466.1092.



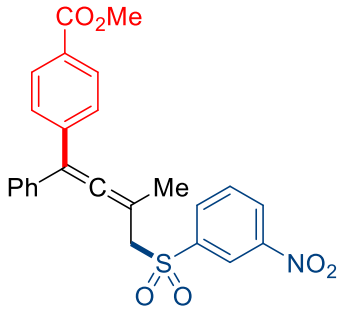
methyl 4-(3-methyl-1-phenyl-4-(m-tolylsulfonyl)buta-1,2-dien-1-yl)benzoate (40)

Colorless oil, 32.1mg, **74%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.93 (d, *J* = 8.1 Hz, 2H), 7.68 – 7.60 (m, 2H), 7.33 – 7.26 (m, 4H), 7.24 (d, *J* = 7.6 Hz, 1H), 7.18 (d, *J* = 8.1 Hz, 2H), 7.14 – 7.07 (m, 2H), 3.96 (d, *J* = 3.1 Hz, 2H), 3.92 (s, 3H), 2.31 (s, 3H), 2.07 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.9, 166.7, 141.0, 139.3, 138.3, 135.4, 134.4, 129.5, 128.9, 128.9, 128.4, 128.4, 128.3, 128.1, 127.6, 125.2, 109.6, 93.3, 61.1, 52.0, 21.1, 18.9.

HRMS (m/z, ESI-TOF): Calcd for $C_{26}H_{24}SO_4Na^+$ [M+Na^+] 455.1288, found 455.1289.



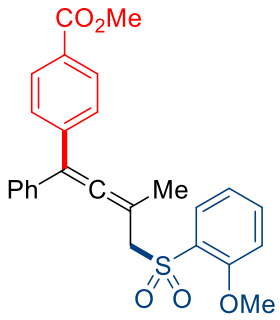
methyl 4-(3-methyl-4-((3-nitrophenyl)sulfonyl)-1-phenylbuta-1,2-dien-1-yl)benzoate (41)

Colorless oil, 18.7mg, **40%** yield. (PE/EtOAc = 10/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 8.59 (t, *J* = 2.0 Hz, 1H), 8.12 – 8.02 (m, 2H), 7.90 (d, *J* = 8.4 Hz, 2H), 7.37 (t, *J* = 8.0 Hz, 1H), 7.31 – 7.22 (m, 3H), 7.11 (d, *J* = 8.5 Hz, 2H), 7.02 – 6.96 (m, 2H), 4.09 (d, *J* = 2.3 Hz, 2H), 3.94 (s, 3H), 2.14 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 208.0, 166.6, 147.7, 140.5, 139.9, 135.0, 133.3, 130.1, 129.6, 129.3, 128.5, 128.4, 128.2, 128.0, 127.9, 123.2, 110.1, 92.9, 61.0, 52.2, 18.9.

HRMS (m/z, ESI-TOF): Calcd for $C_{25}H_{21}NSO_6Na^+$ [M+Na^+] 486.0982, found 486.0982.

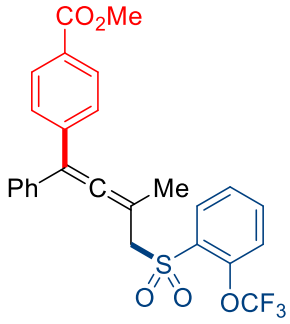


methyl 4-(4-((2-methoxyphenyl)sulfonyl)-3-methyl-1-phenylbuta-1,2-dien-1-yl)benzoate (42) Colorless oil, 35.0mg, **78%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.90 (d, *J* = 8.4 Hz, 2H), 7.86 (dd, *J* = 7.9, 1.8 Hz, 1H), 7.33 – 7.24 (m, 4H), 7.14 (d, *J* = 8.4 Hz, 2H), 7.09 (dd, *J* = 6.6, 3.0 Hz, 2H), 6.90 (t, *J* = 7.5 Hz, 1H), 6.63 (d, *J* = 8.4 Hz, 1H), 4.31 (d, *J* = 13.8 Hz, 1H), 4.20 (d, *J* = 14.0 Hz, 1H), 3.92 (s, 3H), 3.77 (s, 3H), 2.04 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.8, 166.6, 156.7, 141.1, 135.5, 130.1, 129.5, 128.7, 128.4, 128.4, 128.2, 127.5, 125.8, 120.4, 111.8, 109.4, 93.7, 59.2, 55.9, 52.0, 18.9.

HRMS (m/z, ESI-TOF): Calcd for $C_{26}H_{24}SO_5Na^+$ [M+Na^+] 471.1237, found 471.1245.



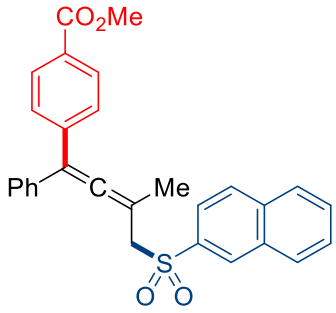
methyl 4-(3-methyl-1-phenyl-4-((2-(trifluoromethoxy)phenyl)sulfonyl)buta-1,2-dien-1-yl)benzoate (43) Colorless oil, 26.0mg, **52%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.95 – 7.88 (m, 3H), 7.36 – 7.30 (m, 1H), 7.30 – 7.26 (m, 3H), 7.19 – 7.11 (m, 3H), 7.11 – 7.06 (m, 2H), 7.04 (dt, *J* = 8.4, 1.6 Hz, 1H), 4.25 – 4.13 (m, 2H), 3.93 (s, 3H), 2.07 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.8, 166.7, 146.4 (q, *J* = 1.7 Hz), 140.9, 135.4, 135.3, 131.1, 129.8, 129.6, 129.0, 128.5, 128.5, 128.3, 127.7, 126.3, 120.1 (q, *J* = 262.6 Hz), 119.2 (q, *J* = 2.2 Hz), 110.0, 93.0, 60.2, 52.1, 19.2.

^{19}F NMR (376 MHz, $CDCl_3$): δ -56.18.

HRMS (m/z, ESI-TOF): Calcd for $C_{26}H_{21}F_3SO_5Na^+$ [M+Na^+] 525.0954, found 525.0971.



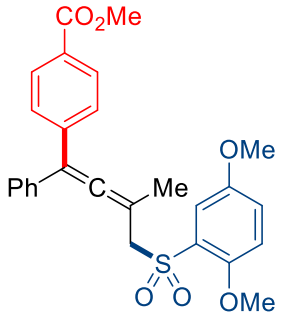
methyl 4-(3-methyl-4-(naphthalen-2-ylsulfonyl)-1-phenylbuta-1,2-dien-1-yl)benzoate (44)

Colorless oil, 31.5mg, **67%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 8.41 (s, 1H), 7.85 (d, *J* = 8.1 Hz, 1H), 7.82 – 7.71 (m, 3H), 7.68 – 7.59 (m, 3H), 7.59 – 7.53 (m, 1H), 7.19 – 7.08 (m, 3H), 6.98 (dd, *J* = 8.1, 6.1 Hz, 4H), 4.15 – 4.00 (m, 2H), 3.91 (s, 3H), 2.11 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 208.0, 166.6, 140.7, 135.3, 135.2, 135.2, 132.0, 130.0, 129.5, 129.5, 129.4, 129.2, 128.9, 128.4, 128.2, 128.1, 127.8, 127.6, 122.6, 109.7, 93.5, 61.1, 52.1, 19.1.

HRMS (m/z, ESI-TOF): Calcd for $C_{29}H_{24}SO_4Na^+$ [M+Na$^+$] 491.1288, found 491.1297.



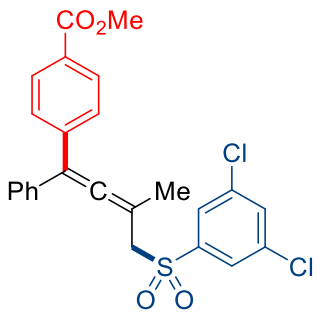
methyl 4-(4-((2,5-dimethoxyphenyl)sulfonyl)-3-methyl-1-phenylbuta-1,2-dien-1-yl)benzoate (45)

Colorless oil, 38.5mg, **80%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.90 (d, *J* = 8.3 Hz, 2H), 7.38 (d, *J* = 3.2 Hz, 1H), 7.31 – 7.25 (m, 3H), 7.14 (d, *J* = 8.3 Hz, 2H), 7.09 (dd, *J* = 6.7, 3.0 Hz, 2H), 6.77 (dd, *J* = 9.0, 3.2 Hz, 1H), 6.56 (d, *J* = 9.0 Hz, 1H), 4.35 (d, *J* = 13.9 Hz, 1H), 4.20 (d, *J* = 13.9 Hz, 1H), 3.93 (s, 3H), 3.75 (s, 3H), 3.73 (s, 3H), 2.06 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.9, 166.7, 153.0, 150.7, 141.0, 135.5, 129.5, 128.8, 128.4, 128.4, 128.2, 127.6, 126.3, 121.2, 114.2, 113.4, 109.5, 93.6, 58.9, 56.5, 55.6, 52.0, 19.1.

HRMS (m/z, ESI-TOF): Calcd for $C_{27}H_{26}SO_6Na^+$ [M+Na$^+$] 501.1342, found 501.1340.



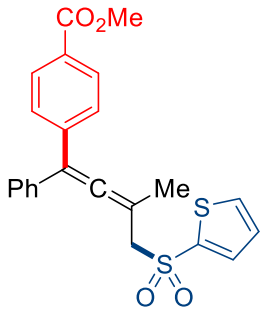
methyl 4-(4-((3,5-dichlorophenyl)sulfonyl)-3-methyl-1-phenylbuta-1,2-dien-1-yl)benzoate (46)

Colorless oil, 24.8mg, **51%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.97 (d, *J* = 8.0 Hz, 2H), 7.66 (d, *J* = 1.9 Hz, 2H), 7.36 – 7.28 (m, 3H), 7.23 (t, *J* = 1.9 Hz, 1H), 7.17 (d, *J* = 8.1 Hz, 2H), 7.11 – 7.04 (m, 2H), 4.02 (s, 2H), 3.93 (s, 3H), 2.10 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 208.1, 166.6, 140.9, 140.6, 135.9, 135.0, 133.6, 129.7, 129.2, 128.5, 128.3, 128.2, 127.9, 126.2, 110.0, 92.7, 61.0, 52.1, 18.8.

HRMS (m/z, ESI-TOF): Calcd for $C_{25}H_{20}Cl_2SO_4Na^+$ [M+Na^+] 509.0352, found 509.0346.



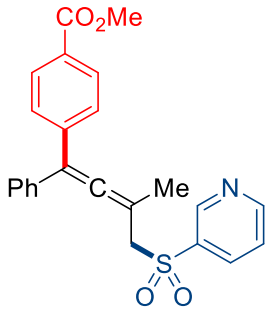
methyl 4-(3-methyl-1-phenyl-4-(thiophen-2-ylsulfonyl)buta-1,2-dien-1-yl)benzoate (47)

Colorless oil, 21.2mg, **50%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.96 (d, *J* = 8.0 Hz, 2H), 7.56 (d, *J* = 3.7 Hz, 1H), 7.51 (d, *J* = 5.0 Hz, 1H), 7.32 (d, *J* = 6.7 Hz, 3H), 7.23 (d, *J* = 8.1 Hz, 2H), 7.15 (dd, *J* = 7.3, 2.2 Hz, 2H), 6.88 (t, *J* = 4.4 Hz, 1H), 4.07 – 4.01 (m, 2H), 3.92 (s, 3H), 2.09 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 208.0, 166.7, 141.0, 139.0, 135.5, 134.5, 134.1, 129.6, 129.0, 128.6, 128.5, 127.8, 127.7, 109.9, 93.4, 62.8, 52.1, 19.0.

HRMS (m/z, ESI-TOF): Calcd for $C_{23}H_{20}S_2O_4Na^+$ [M+Na^+] 447.0695, found 447.0696.



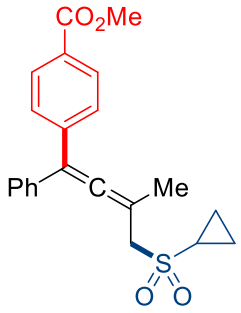
methyl 4-(3-methyl-1-phenyl-4-(pyridin-3-ylsulfonyl)buta-1,2-dien-1-yl)benzoate (48)

Colorless oil, 23.8mg, **57%** yield. (PE/EtOAc = 5/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 9.03 (d, *J* = 2.3 Hz, 1H), 8.59 (dd, *J* = 4.9, 1.6 Hz, 1H), 8.00 (dt, *J* = 8.1, 2.0 Hz, 1H), 7.95 (d, *J* = 8.4 Hz, 2H), 7.34 – 7.29 (m, 3H), 7.17 (d, *J* = 8.4 Hz, 2H), 7.11 – 7.04 (m, 3H), 4.03 (s, 2H), 3.93 (s, 3H), 2.11 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.9, 166.6, 154.0, 148.8, 140.6, 135.7, 135.1, 134.6, 129.6, 129.2, 128.5, 128.5, 128.3, 127.9, 123.3, 110.1, 92.9, 61.6, 52.1, 19.1.

HRMS (m/z, ESI-TOF): Calcd for $C_{24}H_{21}NSO_4Na^+$ [M+Na^+] 442.1083, found 442.1092.



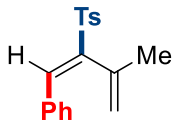
methyl 4-(4-(cyclopropylsulfonyl)-3-methyl-1-phenylbuta-1,2-dien-1-yl)benzoate (49)

Colorless oil, 22.9mg, **60%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, CDCl$_3$): δ 8.01 (d, *J* = 8.0 Hz, 2H), 7.42 (d, *J* = 8.1 Hz, 2H), 7.39 – 7.28 (m, 5H), 3.92 (s, 3H), 3.83 (s, 2H), 2.28 – 2.11 (m, 4H), 1.11 (td, *J* = 4.8, 2.4 Hz, 2H), 0.67 (dd, *J* = 8.1, 2.4 Hz, 2H).

^{13}C NMR (101 MHz, CDCl$_3$): δ 208.0, 166.6, 140.9, 135.4, 129.7, 129.2, 128.6, 128.5, 128.3, 127.9, 109.9, 93.6, 58.5, 52.1, 28.9, 19.1, 4.8, 4.8.

HRMS (m/z, ESI-TOF): Calcd for $C_{22}H_{22}SO_4Na^+$ [M+Na$^+$] 405.1131, found 405.1143.



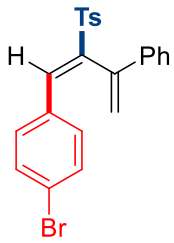
(*E*)-1-methyl-4-((3-methyl-1-phenylbuta-1,3-dien-2-yl)sulfonyl)benzene (50)

White solid, 15.1mg, **51%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, CDCl$_3$): δ 7.77 (d, *J* = 8.0 Hz, 2H), 7.71 (s, 1H), 7.63 – 7.57 (m, 2H), 7.40 – 7.33 (m, 3H), 7.30 (d, *J* = 8.0 Hz, 2H), 5.26 (s, 1H), 4.81 (s, 1H), 2.42 (s, 3H), 1.78 (s, 3H).

^{13}C NMR (101 MHz, CDCl$_3$): δ 144.1, 142.3, 136.5, 135.7, 135.7, 133.0, 130.0, 130.0, 129.4, 128.8, 128.6, 121.9, 22.6, 21.6.

HRMS (m/z, ESI-TOF): Calcd for $C_{18}H_{18}SO_2Na^+$ [M+Na$^+$] 321.0920, found 321.0914.



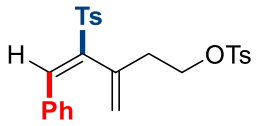
(*E*)-1-bromo-4-(3-phenyl-2-tosylbuta-1,3-dien-1-yl)benzene (51)

White solid, 17.0mg, **39%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, CDCl$_3$): δ 7.93 (s, 1H), 7.65 (d, *J* = 7.9 Hz, 2H), 7.41 (d, *J* = 8.4 Hz, 2H), 7.36 (d, *J* = 8.4 Hz, 2H), 7.25 – 7.20 (m, 2H), 7.20 – 7.11 (m, 5H), 5.89 (s, 1H), 5.12 (s, 1H), 2.34 (s, 3H).

^{13}C NMR (101 MHz, CDCl$_3$): δ 144.2, 141.7, 139.3, 137.0, 136.2, 135.4, 131.8, 131.7, 131.5, 129.3, 129.0, 128.4, 128.3, 126.1, 124.7, 120.7, 21.5.

HRMS (m/z, ESI-TOF): Calcd for $C_{23}H_{19}BrSO_2Na^+$ [M+Na$^+$] 461.0181, found 461.0201.



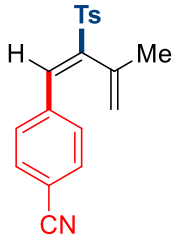
(*E*)-3-methylene-5-phenyl-4-tosylpent-4-en-1-yl 4-methylbenzenesulfonate (52)

White solid, 19.3mg, **40%** yield. (PE/EtOAc = 15/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.76 – 7.64 (m, 5H), 7.56 (d, *J* = 6.8 Hz, 2H), 7.39 – 7.25 (m, 7H), 5.31 (s, 1H), 4.89 (s, 1H), 4.02 (t, *J* = 6.5 Hz, 2H), 2.50 – 2.39 (m, 8H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 144.8, 144.5, 140.9, 137.2, 135.4, 135.1, 132.7, 132.4, 130.4, 130.1, 129.8, 129.5, 128.8, 128.7, 127.7, 122.9, 67.2, 34.6, 21.6.

HRMS (m/z, ESI-TOF): Calcd for $C_{26}H_{26}S_2O_5Na^+$ [M+Na^+] 505.1114, found 505.1111.



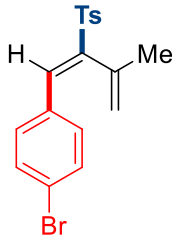
(*E*)-4-(3-methyl-2-tosylbuta-1,3-dien-1-yl)benzonitrile (53)

White solid, 19.2mg, **59%** yield. (PE/EtOAc = 8/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.76 (d, *J* = 7.9 Hz, 2H), 7.73 – 7.61 (m, 5H), 7.33 (d, *J* = 7.9 Hz, 2H), 5.30 (s, 1H), 4.82 (s, 1H), 2.44 (s, 3H), 1.75 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 146.0, 144.6, 137.4, 135.7, 134.8, 133.1, 132.3, 130.1, 129.5, 129.0, 122.6, 118.2, 113.1, 22.6, 21.6.

HRMS (m/z, ESI-TOF): Calcd for $C_{19}H_{17}NSO_2Na^+$ [M+Na^+] 346.0872, found 346.0876.



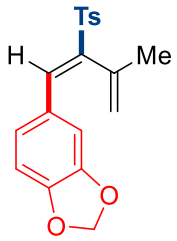
(*E*)-1-bromo-4-(3-methyl-2-tosylbuta-1,3-dien-1-yl)benzene (54)

White solid, 24.4mg, **65%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.76 (d, *J* = 8.0 Hz, 2H), 7.64 (s, 1H), 7.52 – 7.43 (m, 4H), 7.31 (d, *J* = 7.9 Hz, 2H), 5.27 (s, 1H), 4.80 (s, 1H), 2.43 (s, 3H), 1.75 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 144.3, 143.0, 136.2, 135.3, 134.2, 131.9, 131.9, 131.3, 129.4, 128.9, 124.4, 122.2, 22.6, 21.6.

HRMS (m/z, ESI-TOF): Calcd for $C_{18}H_{17}BrSO_2Na^+$ [M+Na^+] 399.0025, found 399.0021.



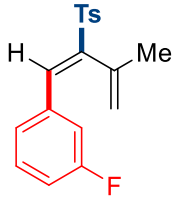
(*E*)-5-(3-methyl-2-tosylbuta-1,3-dien-1-yl)benzo[d][1,3]dioxole (55)

White solid, 16.9mg, **49%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.75 (d, *J* = 7.9 Hz, 2H), 7.61 (s, 1H), 7.29 (d, *J* = 8.0 Hz, 2H), 7.18 (s, 1H), 7.09 (d, *J* = 7.7 Hz, 1H), 6.81 (d, *J* = 8.1 Hz, 1H), 5.99 (s, 2H), 5.26 (s, 1H), 4.78 (s, 1H), 2.42 (s, 3H), 1.78 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 149.2, 147.9, 144.0, 139.8, 136.6, 135.8, 135.3, 129.3, 128.7, 127.0, 126.5, 122.0, 108.6, 108.4, 101.5, 22.6, 21.6.

HRMS (m/z, ESI-TOF): Calcd for $C_{19}H_{18}SO_4Na^+$ [M+Na$^+$] 365.0818, found 365.0819.



(*E*)-1-fluoro-3-(3-methyl-2-tosylbuta-1,3-dien-1-yl)benzene (56)

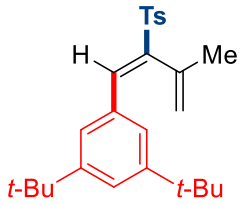
White solid, 17.5mg, **55%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.76 (d, *J* = 8.3 Hz, 2H), 7.67 (s, 1H), 7.40 – 7.28 (m, 5H), 7.12 – 7.02 (m, 1H), 5.28 (s, 1H), 4.81 (s, 1H), 2.43 (s, 3H), 1.77 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 162.6 (d, *J* = 247.3 Hz), 144.3, 143.7, 136.1, 135.3, 135.0 (d, *J* = 7.9 Hz), 134.1 (d, *J* = 2.7 Hz), 130.2 (d, *J* = 8.4 Hz), 129.4, 128.9, 126.1 (d, *J* = 2.6 Hz), 122.2, 116.9 (d, *J* = 21.4 Hz), 116.0 (d, *J* = 22.6 Hz), 22.6, 21.6.

^{19}F NMR (376 MHz, $CDCl_3$): δ -112.19.

HRMS (m/z, ESI-TOF): Calcd for $C_{18}H_{17}FSO_2Na^+$ [M+Na$^+$] 339.0825, found 339.0826.



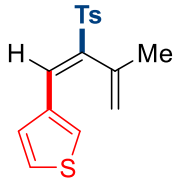
(*E*)-1,3-di-tert-butyl-5-(3-methyl-2-tosylbuta-1,3-dien-1-yl)benzene (57)

White solid, 18.1mg, **44%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.77 (d, *J* = 8.0 Hz, 2H), 7.74 (s, 1H), 7.51 (d, *J* = 1.8 Hz, 2H), 7.43 (s, 1H), 7.30 (d, *J* = 7.9 Hz, 2H), 5.28 (s, 1H), 4.75 (s, 1H), 2.43 (s, 3H), 1.83 (s, 3H), 1.30 (s, 18H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 151.1, 144.0, 140.8, 137.4, 136.9, 135.9, 132.1, 129.4, 128.8, 124.8, 124.4, 121.2, 34.9, 31.3, 22.7, 21.6.

HRMS (m/z, ESI-TOF): Calcd for $C_{26}H_{34}SO_2Na^+$ [M+Na$^+$] 433.2172, found 433.2167.



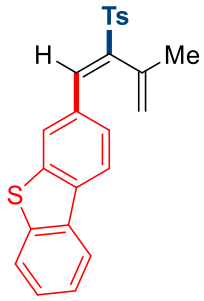
(*E*)-3-(3-methyl-2-tosylbuta-1,3-dien-1-yl)thiophene (58)

White solid, 10.2mg, **33%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.75 (d, *J* = 8.3 Hz, 2H), 7.71 (s, 1H), 7.66 (dd, *J* = 3.1, 1.3 Hz, 1H), 7.35 (dd, *J* = 5.1, 1.3 Hz, 1H), 7.33 – 7.27 (m, 3H), 5.26 (s, 1H), 4.70 (s, 1H), 2.43 (s, 3H), 1.85 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 144.1, 140.5, 137.0, 135.8, 134.8, 129.7, 129.6, 129.4, 128.8, 127.6, 126.3, 121.7, 22.7, 21.6.

HRMS (m/z, ESI-TOF): Calcd for $C_{16}H_{16}S_2O_2Na^+$ [M+Na^+] 327.0484, found 327.0478.



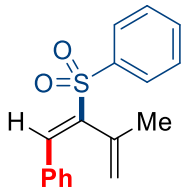
(*E*)-3-(3-methyl-2-tosylbuta-1,3-dien-1-yl)dibenzo[b,d]thiophene (59)

White solid, 15.8mg, **39%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 8.21 – 8.04 (m, 3H), 7.90 – 7.83 (m, 2H), 7.79 (d, *J* = 8.0 Hz, 2H), 7.71 (d, *J* = 8.3 Hz, 1H), 7.53 – 7.44 (m, 2H), 7.31 (d, *J* = 8.0 Hz, 2H), 5.34 (s, 1H), 4.89 (s, 1H), 2.43 (s, 3H), 1.81 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 144.2, 142.4, 140.3, 139.7, 136.7, 136.6, 135.6, 135.3, 134.7, 131.5, 129.4, 128.9, 127.4, 126.1, 124.6, 124.4, 122.9, 122.3, 122.0, 121.6, 22.7, 21.6.

HRMS (m/z, ESI-TOF): Calcd for $C_{24}H_{20}S_2O_2Na^+$ [M+Na^+] 427.0797, found 427.0792.



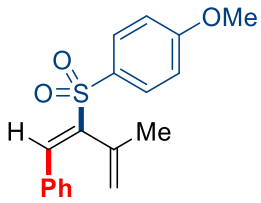
(*E*)-((3-methyl-1-phenylbuta-1,3-dien-2-yl)sulfonyl)benzene (60)

White solid, 12.8mg, **45%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.90 (d, *J* = 7.3 Hz, 2H), 7.74 (s, 1H), 7.66 – 7.56 (m, 3H), 7.51 (t, *J* = 7.6 Hz, 2H), 7.41 – 7.33 (m, 3H), 5.26 (s, 1H), 4.79 (s, 1H), 1.78 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 141.9, 138.6, 136.5, 136.1, 133.2, 132.9, 130.2, 130.0, 128.8, 128.7, 128.7, 122.0, 22.6.

HRMS (m/z, ESI-TOF): Calcd for $C_{17}H_{16}SO_2Na^+$ [M+Na^+] 307.0763, found 307.0766.



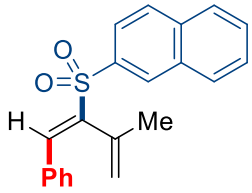
(*E*)-1-methoxy-4-((3-methyl-1-phenylbuta-1,3-dien-2-yl)sulfonyl)benzene (61)

White solid, 12.8mg, **41%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.81 (d, *J* = 8.9 Hz, 2H), 7.69 (s, 1H), 7.63 – 7.57 (m, 2H), 7.40 – 7.32 (m, 3H), 6.97 (d, *J* = 8.9 Hz, 2H), 5.27 (s, 1H), 4.81 (s, 1H), 3.87 (s, 3H), 1.78 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 163.3, 142.4, 136.7, 135.2, 133.0, 131.0, 130.1, 130.0, 130.0, 128.6, 121.8, 113.9, 55.6, 22.7.

HRMS (m/z, ESI-TOF): Calcd for $C_{18}H_{18}SO_3Na^+$ [M+Na$^+$] 337.0869, found 337.0866.



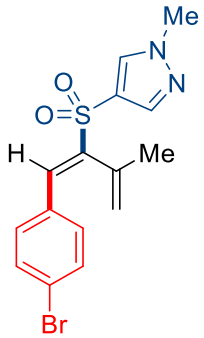
(*E*)-2-((3-methyl-1-phenylbuta-1,3-dien-2-yl)sulfonyl)naphthalene (62)

White solid, 15.6mg, **47%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 8.49 (s, 1H), 8.00 – 7.88 (m, 3H), 7.86 – 7.80 (m, 2H), 7.68 – 7.58 (m, 4H), 7.40 – 7.33 (m, 3H), 5.23 (s, 1H), 4.76 (s, 1H), 1.79 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 141.8, 136.5, 136.4, 135.5, 135.0, 132.9, 131.9, 130.6, 130.2, 130.1, 129.4, 129.0, 129.0, 128.7, 127.9, 127.5, 123.5, 122.0, 22.7.

HRMS (m/z, ESI-TOF): Calcd for $C_{21}H_{18}SO_2Na^+$ [M+Na$^+$] 357.0920, found 357.0915.



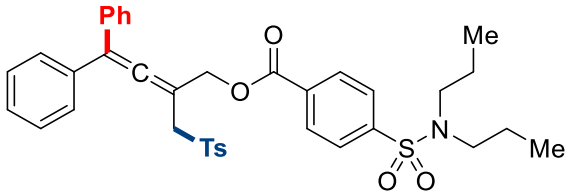
(*E*)-4-((1-(4-bromophenyl)-3-methylbuta-1,3-dien-2-yl)sulfonyl)-1-methyl-1H-pyrazole (63)

White solid, 19.1mg, **52%** yield. (PE/EtOAc = 10/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.83 (s, 1H), 7.76 (s, 1H), 7.57 (s, 1H), 7.53 – 7.43 (m, 4H), 5.39 (s, 1H), 5.01 (s, 1H), 3.96 (s, 3H), 1.85 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 143.5, 140.1, 136.4, 133.5, 133.3, 131.9, 131.7, 131.3, 124.4, 122.2, 120.7, 39.6, 22.8.

HRMS (m/z, ESI-TOF): Calcd for $C_{15}H_{15}BrN_2SO_2Na^+$ [M+Na$^+$] 388.9930, found 388.9938.



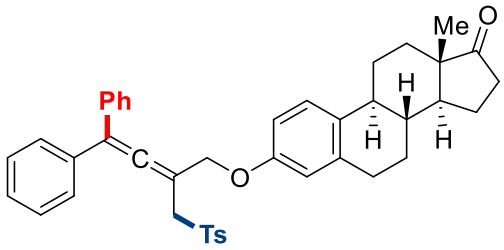
4,4-diphenyl-2-(tosylmethyl)buta-2,3-dien-1-yl 4-(N,N-dipropylsulfamoyl)benzoate (64)

Colorless oil, 43.4mg, **66%** yield. (PE/EtOAc = 10/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 8.05 (d, *J* = 8.1 Hz, 2H), 7.80 (d, *J* = 8.1 Hz, 2H), 7.70 (d, *J* = 7.9 Hz, 2H), 7.33 – 7.20 (m, 6H), 7.17 – 7.02 (m, 6H), 5.15 (s, 2H), 4.11 (s, 2H), 3.08 (t, *J* = 7.7 Hz, 4H), 2.31 (s, 3H), 1.61 – 1.45 (m, 4H), 0.85 (t, *J* = 7.4 Hz, 6H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.4, 164.4, 144.6, 144.1, 134.8, 134.7, 132.8, 130.1, 129.6, 128.4, 128.2, 128.0, 127.8, 126.7, 113.9, 93.6, 64.1, 57.7, 49.7, 21.7, 21.5, 11.0.

HRMS (m/z, ESI-TOF): Calcd for $C_{37}H_{39}NS_2O_6Na^+$ [M+Na$^+$] 680.2111, found 680.2091.



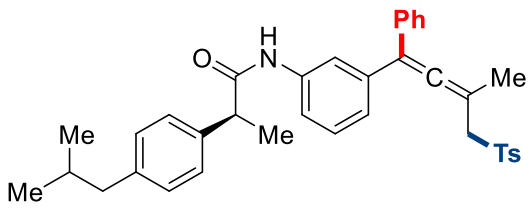
(8R,9S,13S,14S)-3-((4,4-diphenyl-2-(tosylmethyl)buta-2,3-dien-1-yl)oxy)-13-methyl-6,7,8,9,11,12,13,14,15,16-decahydro-17H-cyclopenta[a]phenanthren-17-one (65)

Colorless oil, 32.7mg, **51%** yield. (PE/EtOAc = 10/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.65 (d, *J* = 7.9 Hz, 2H), 7.33 – 7.25 (m, 6H), 7.16 – 7.08 (m, 4H), 7.07 – 6.99 (m, 3H), 6.65 (dd, *J* = 8.6, 2.7 Hz, 1H), 6.55 (d, *J* = 2.7 Hz, 1H), 4.82 (s, 2H), 4.05 (s, 2H), 2.75 – 2.55 (m, 2H), 2.53 – 2.44 (m, 1H), 2.35 – 2.25 (m, 4H), 2.19 – 2.14 (m, 1H), 2.13 – 1.99 (m, 2H), 1.97 – 1.87 (m, 2H), 1.67 – 1.56 (m, 1H), 1.53 – 1.43 (m, 4H), 1.37 – 1.29 (m, 1H), 0.90 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.5, 155.7, 144.4, 137.6, 135.1, 135.1, 135.1, 132.3, 129.5, 128.7, 128.2, 128.0, 127.7, 126.2, 114.7, 113.1, 112.8, 94.2, 67.3, 56.5, 50.2, 47.9, 43.8, 38.1, 35.8, 31.4, 29.3, 26.4, 25.7, 21.6, 21.5, 13.7.

HRMS (m/z, ESI-TOF): Calcd for $C_{42}H_{42}SO_4Na^+$ [M+Na$^+$] 665.2696, found 665.2678.

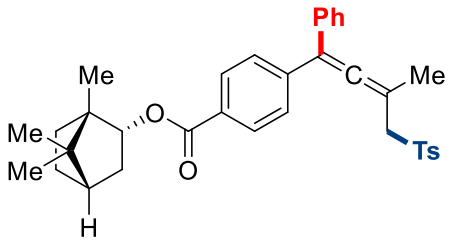


(2S)-2-(4-isobutylphenyl)-N-(3-(3-methyl-1-phenyl-4-tosylbuta-1,2-dien-1-yl)phenyl)propanamide (66) White solid, 42.4mg, **73%** yield. (PE/EtOAc = 8/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.67 – 7.58 (m, 3H), 7.48 (s, 1H), 7.28 – 7.21 (m, 5H), 7.20 – 7.14 (m, 2H), 7.13 – 7.04 (m, 4H), 7.02 (d, *J* = 8.1 Hz, 2H), 6.80 (d, *J* = 7.5 Hz, 1H), 3.88 (d, *J* = 1.9 Hz, 2H), 3.69 – 3.61 (m, 1H), 2.41 (dd, *J* = 7.2, 1.8 Hz, 2H), 2.26 (s, 3H), 1.99 (d, *J* = 3.2 Hz, 3H), 1.86 – 1.77 (m, 1H), 1.53 (d, *J* = 7.1 Hz, 3H), 0.87 (d, *J* = 6.6 Hz, 6H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.5, 172.6, 144.4, 140.7, 138.2, 138.0, 138.0, 136.8, 136.8, 135.8, 135.7, 135.1, 129.5, 129.5, 128.6, 128.4, 128.1, 127.9, 127.9, 127.3, 127.2, 124.2, 119.6, 118.8, 109.8, 92.6, 61.3, 61.3, 47.4, 44.8, 30.0, 22.2, 21.5, 19.1, 19.0, 18.5.

HRMS (m/z, ESI-TOF): Calcd for $C_{37}H_{39}NSO_3Na^+$ [M+Na^+] 600.2543, found 600.2556.

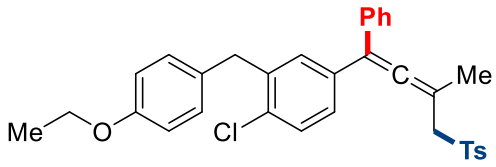


(1S,2R,4S)-1,7,7-trimethylbicyclo[2.2.1]heptan-2-yl 4-(3-methyl-1-phenyl-4-tosylbuta-1,2-dien-1-yl)benzoate (67) Colorless oil, 35.7mg, **64%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.96 (d, *J* = 8.0 Hz, 2H), 7.70 (d, *J* = 7.9 Hz, 2H), 7.33 – 7.25 (m, 3H), 7.21 – 7.07 (m, 6H), 5.13 (d, *J* = 9.8 Hz, 1H), 4.04 – 3.87 (m, 2H), 2.56 – 2.44 (m, 1H), 2.34 (s, 3H), 2.20 – 2.04 (m, 4H), 1.89 – 1.78 (m, 1H), 1.77 – 1.70 (m, 1H), 1.48 – 1.37 (m, 1H), 1.36 – 1.26 (m, 1H), 1.12 (dd, *J* = 13.9, 3.5 Hz, 1H), 0.98 (s, 3H), 0.92 (s, 6H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.8, 166.4, 144.4, 140.8, 135.4, 135.1, 129.6, 129.6, 129.4, 128.5, 128.4, 128.3, 128.0, 127.6, 109.6, 93.4, 80.4, 61.1, 49.0, 47.8, 44.8, 36.8, 28.0, 27.3, 21.6, 19.6, 19.0, 18.8, 13.5.

HRMS (m/z, ESI-TOF): Calcd for $C_{35}H_{38}SO_4Na^+$ [M+Na^+] 577.2383, found 577.2387.

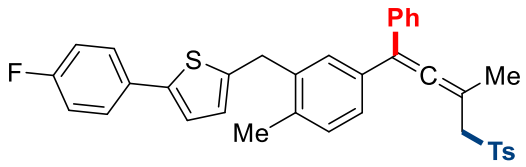


1-chloro-2-(4-ethoxybenzyl)-4-(3-methyl-1-phenyl-4-tosylbuta-1,2-dien-1-yl)benzene (68) Colorless oil, 21.1mg, **39%** yield. (PE/EtOAc = 10/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.63 (d, *J* = 7.9 Hz, 2H), 7.29 – 7.20 (m, 4H), 7.14 – 6.99 (m, 7H), 6.88 (d, *J* = 8.4 Hz, 1H), 6.81 (d, *J* = 8.2 Hz, 2H), 4.03 – 3.93 (m, 4H), 3.86 (d, *J* = 3.0 Hz, 2H), 2.30 (s, 3H), 1.98 (s, 3H), 1.38 (t, *J* = 7.0 Hz, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.5, 157.4, 144.4, 139.0, 135.6, 135.3, 134.9, 133.1, 131.1, 129.8, 129.5, 129.2, 128.4, 128.2, 128.0, 127.6, 127.5, 114.4, 109.3, 93.1, 63.3, 61.2, 38.3, 21.6, 19.1, 14.8.

HRMS (m/z, ESI-TOF): Calcd for $C_{33}H_{31}ClSO_3Na^+$ [M+Na^+] 565.1575, found 565.1586.



2-(4-fluorophenyl)-5-(2-methyl-5-(3-methyl-1-phenyl-4-tosylbuta-1,2-dien-1-yl)benzyl)thiophene (69) Colorless oil, 14.6mg, **25%** yield. (PE/EtOAc = 10/1)

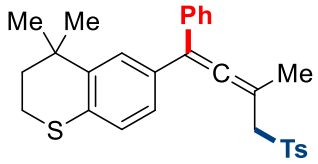
^{1}H NMR (400 MHz, $CDCl_3$): δ 7.67 (d, *J* = 8.0 Hz, 2H), 7.50 – 7.43 (m, 2H), 7.28 – 7.23 (m, 3H), 7.14

– 6.99 (m, 9H), 6.93 (dd, *J* = 7.7, 1.9 Hz, 1H), 6.67 (d, *J* = 3.6 Hz, 1H), 4.08 (s, 2H), 3.89 (d, *J* = 3.9 Hz, 2H), 2.32 (d, *J* = 9.0 Hz, 6H), 2.01 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.6, 162.0 (d, *J* = 247.7 Hz), 144.3, 143.1, 141.5, 138.2, 136.1, 135.7, 135.4, 134.0, 130.7 (d, *J* = 3.3 Hz), 130.4, 129.7, 129.6, 128.6, 128.2, 128.1, 127.3, 127.1, 127.0 (d, *J* = 8.0 Hz), 126.0, 122.6, 115.7 (d, *J* = 21.9 Hz), 109.9, 92.6, 61.5, 34.1, 21.6, 19.2, 19.2.

^{19}F NMR (376 MHz, $CDCl_3$): δ -115.03.

HRMS (m/z, ESI-TOF): Calcd for $C_{36}H_{31}FS_2O_2Na^+$ [M+Na^+] 601.1642, found 601.1626.



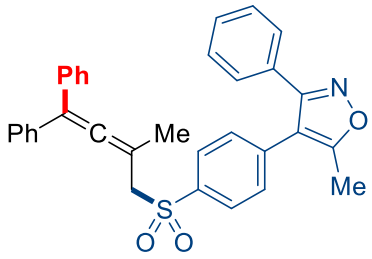
4,4-dimethyl-6-(3-methyl-1-phenyl-4-tosylbuta-1,2-dien-1-yl)thiochromane (70)

Colorless oil, 16.9mg, **35%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.68 (d, *J* = 7.9 Hz, 2H), 7.29 – 7.23 (m, 4H), 7.16 – 7.06 (m, 4H), 6.98 (d, *J* = 8.2 Hz, 1H), 6.74 (dd, *J* = 8.2, 2.0 Hz, 1H), 3.91 (d, *J* = 2.4 Hz, 2H), 3.07 – 2.99 (m, 2H), 2.36 (s, 3H), 2.04 (s, 3H), 1.99 – 1.93 (m, 2H), 1.28 (d, *J* = 5.1 Hz, 6H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.5, 144.4, 141.8, 136.1, 135.5, 131.6, 131.2, 129.6, 128.5, 128.2, 128.1, 127.4, 126.9, 126.3, 126.3, 110.1, 92.6, 61.5, 37.6, 33.0, 30.1, 30.1, 23.1, 21.7, 19.4.

HRMS (m/z, ESI-TOF): Calcd for $C_{29}H_{30}S_2O_2Na^+$ [M+Na^+] 497.1579, found 497.1567.



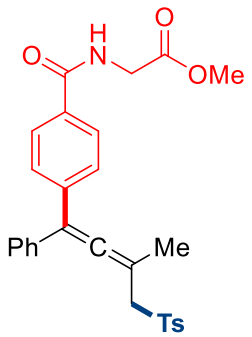
5-methyl-4-(4-((2-methyl-4,4-diphenylbuta-2,3-dien-1-yl)sulfonyl)phenyl)-3-phenylisoxazole (71)

Colorless oil, 22.9mg, **44%** yield. (PE/EtOAc = 8/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.80 (d, *J* = 8.5 Hz, 2H), 7.37 – 7.20 (m, 16H), 7.10 (d, *J* = 8.4 Hz, 2H), 3.95 (s, 2H), 2.40 (s, 3H), 2.05 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.5, 167.2, 160.9, 137.7, 136.0, 136.0, 130.0, 129.6, 128.6, 128.6, 128.5, 128.3, 128.3, 127.5, 114.2, 110.5, 92.4, 61.5, 19.7, 11.8.

HRMS (m/z, ESI-TOF): Calcd for $C_{33}H_{27}NSO_3Na^+$ [M+Na^+] 540.1604, found 540.1616.



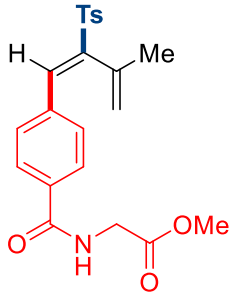
methyl (4-(3-methyl-1-phenyl-4-tosylbuta-1,2-dien-1-yl)benzoyl)glycinate (72)

White solid, 36.3mg, **74%** yield. (PE/EtOAc = 5/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.74 (d, *J* = 8.0 Hz, 2H), 7.67 (d, *J* = 7.9 Hz, 2H), 7.32 – 7.25 (m, 4H), 7.17 (d, *J* = 8.0 Hz, 3H), 7.10 (d, *J* = 7.4 Hz, 5H), 4.22 (d, *J* = 5.3 Hz, 2H), 4.00 – 3.87 (m, 2H), 3.76 (s, 3H), 2.33 (s, 3H), 2.05 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 207.7, 170.3, 166.9, 144.6, 139.7, 135.4, 135.0, 132.3, 129.6, 128.5, 128.4, 128.3, 127.9, 127.6, 127.0, 109.5, 93.2, 61.0, 52.2, 41.5, 21.5, 19.0.

HRMS (m/z, ESI-TOF): Calcd for $C_{28}H_{27}NSO_5Na^+$ [M+Na^+] 512.1502, found 512.1506.



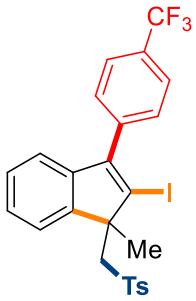
methyl (*E*)-(4-(3-methyl-2-tosylbuta-1,3-dien-1-yl)benzoyl)glycinate (73)

White solid, 8.2mg, **20%** yield. (PE/EtOAc = 8/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.80 (d, *J* = 8.2 Hz, 2H), 7.77 (d, *J* = 8.0 Hz, 2H), 7.72 (s, 1H), 7.66 (d, *J* = 8.2 Hz, 2H), 7.32 (d, *J* = 7.9 Hz, 2H), 6.72 (t, *J* = 5.0 Hz, 1H), 5.28 (s, 1H), 4.83 (s, 1H), 4.25 (d, *J* = 5.0 Hz, 2H), 3.81 (s, 3H), 2.44 (s, 3H), 1.75 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 170.3, 166.5, 144.4, 136.4, 136.2, 135.2, 134.6, 134.2, 130.0, 129.5, 129.0, 127.4, 122.3, 52.5, 41.7, 22.7, 21.6.

HRMS (m/z, ESI-TOF): Calcd for $C_{22}H_{23}NSO_5Na^+$ [M+Na^+] 436.1189, found 436.1183.



2-iodo-1-methyl-1-(tosylmethyl)-3-(4-(trifluoromethyl)phenyl)-1H-indene (74)

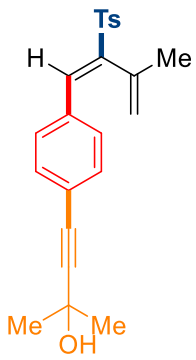
White solid, 49.8mg, **88%** yield. (PE/EtOAc = 8/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.75 (d, *J* = 8.0 Hz, 2H), 7.60 (d, *J* = 8.0 Hz, 2H), 7.31 (d, *J* = 8.4 Hz, 2H), 7.16 (d, *J* = 7.5 Hz, 2H), 7.12 – 7.02 (m, 3H), 6.96 (td, *J* = 7.4, 1.2 Hz, 1H), 3.76 (q, *J* = 14.8 Hz, 2H), 2.35 (s, 3H), 1.34 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 146.6, 146.2, 144.0, 142.4, 138.8 (q, *J* = 1.8 Hz), 137.0, 130.2 (q, *J* = 32.7 Hz), 129.4, 127.7, 127.4, 125.7, 125.4 (q, *J* = 3.8 Hz), 123.5, 124.1 (q, *J* = 273.1 Hz), 120.1, 112.9, 62.3, 54.4, 26.5, 21.5.

^{19}F NMR (376 MHz, $CDCl_3$): δ -62.50.

HRMS (m/z, ESI-TOF): Calcd for $C_{25}H_{20}F_3ISO_2Na^+$ [M+Na^+] 591.0073, found 591.0073.



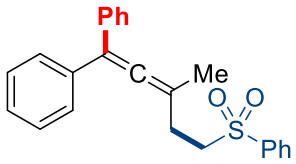
(*E*)-2-methyl-4-(4-(3-methyl-2-tosylbuta-1,3-dien-1-yl)phenyl)but-3-yn-2-ol (75)

White solid, 35.0mg, **92%** yield. (PE/EtOAc = 5/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.76 (d, *J* = 8.0 Hz, 2H), 7.66 (s, 1H), 7.52 (d, *J* = 8.1 Hz, 2H), 7.38 (d, *J* = 8.1 Hz, 2H), 7.30 (d, *J* = 8.0 Hz, 2H), 5.26 (s, 1H), 4.81 (s, 1H), 2.42 (s, 3H), 2.24 (s, 1H), 1.74 (s, 3H), 1.61 (s, 6H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 144.2, 143.0, 136.4, 135.5, 134.7, 132.8, 131.8, 129.7, 129.4, 128.9, 124.5, 122.1, 96.0, 81.5, 65.6, 31.4, 31.0, 22.6, 21.6.

HRMS (m/z, ESI-TOF): Calcd for $C_{23}H_{24}SO_3Na^+$ [M+Na$^+$] 403.1338, found 403.1345.



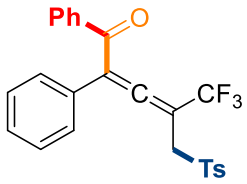
(3-methyl-5-(phenylsulfonyl)penta-1,2-diene-1,1-diyl)dibenzene (76)

Colorless oil, 17.4mg, **46%** yield. (PE/EtOAc = 20/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.93 – 7.86 (m, 2H), 7.66 (t, *J* = 7.4 Hz, 1H), 7.55 (t, *J* = 7.7 Hz, 2H), 7.36 – 7.21 (m, 10H), 3.34 – 3.22 (m, 2H), 2.56 – 2.45 (m, 2H), 1.87 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 201.8, 138.6, 136.9, 133.8, 129.3, 128.3, 128.3, 128.1, 127.3, 111.3, 100.3, 54.2, 27.2, 19.3.

HRMS (m/z, ESI-TOF): Calcd for $C_{24}H_{22}SO_2Na^+$ [M+Na$^+$] 397.1233, found 397.1233.



5,5,5-trifluoro-1,2-diphenyl-4-(tosylmethyl)penta-2,3-dien-1-one (77)

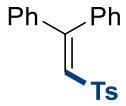
Colorless oil, 9.5mg, **21%** yield. (PE/EtOAc = 15/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.95 (d, *J* = 7.7 Hz, 2H), 7.65 (t, *J* = 7.4 Hz, 1H), 7.55 – 7.47 (m, 4H), 7.45 – 7.35 (m, 5H), 7.13 (d, *J* = 7.9 Hz, 2H), 3.94 (s, 2H), 2.37 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 209.3 (q, *J* = 3.5 Hz), 189.6, 145.3, 136.8, 134.6, 134.2, 130.0, 129.8, 129.7, 129.5, 129.0, 128.8, 128.3, 128.3, 121.9 (q, *J* = 276.5 Hz), 115.8, 94.5 (q, *J* = 37.5 Hz), 53.6, 21.7.

^{19}F NMR (376 MHz, $CDCl_3$): δ -62.15.

HRMS (m/z, ESI-TOF): Calcd for $C_{25}H_{19}F_3SO_3Na^+$ [M+Na$^+$] 479.0899, found 479.0902.



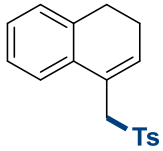
(2-tosylethene-1,1-diyl)dibenzene (78)

Colorless oil, 10.0mg, **30%** yield. (PE/EtOAc = 15/1)

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.47 (d, *J* = 8.3 Hz, 2H), 7.40 – 7.34 (m, 2H), 7.33 – 7.27 (m, 4H), 7.22 – 7.18 (m, 2H), 7.15 (d, *J* = 8.1 Hz, 2H), 7.12 – 7.07 (m, 2H), 6.99 (s, 1H), 2.38 (s, 3H).

^{13}C NMR (101 MHz, $CDCl_3$): δ 154.7, 143.7, 139.2, 138.5, 135.5, 130.2, 129.7, 129.3, 128.9, 128.8, 128.5, 128.2, 127.8, 127.7, 21.5.

HRMS (m/z, ESI-TOF): Calcd for $C_{21}H_{18}SO_2Na^+$ [M+Na^+] 357.0920, found 357.0922.



4-(tosylmethyl)-1,2-dihydronaphthalene (79)

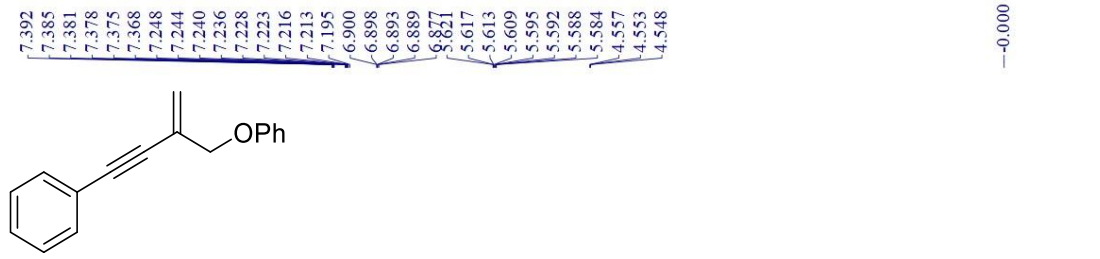
Colorless oil, 11.4mg, **38%** yield. (PE/EtOAc = 20/1)

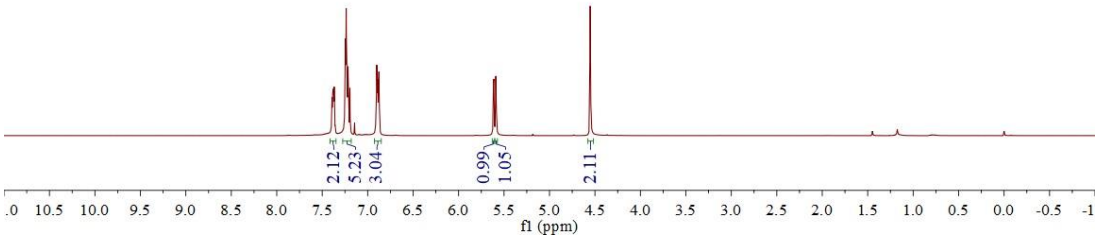
^{1}H NMR (400 MHz, $CDCl_3$): δ 7.67 (d, *J* = 8.0 Hz, 2H), 7.22 (d, *J* = 8.0 Hz, 2H), 7.17 – 7.05 (m, 4H), 5.90 (t, *J* = 4.7 Hz, 1H), 4.20 (s, 2H), 2.69 (t, *J* = 8.1 Hz, 2H), 2.38 (s, 3H), 2.28 – 2.17 (m, 2H).

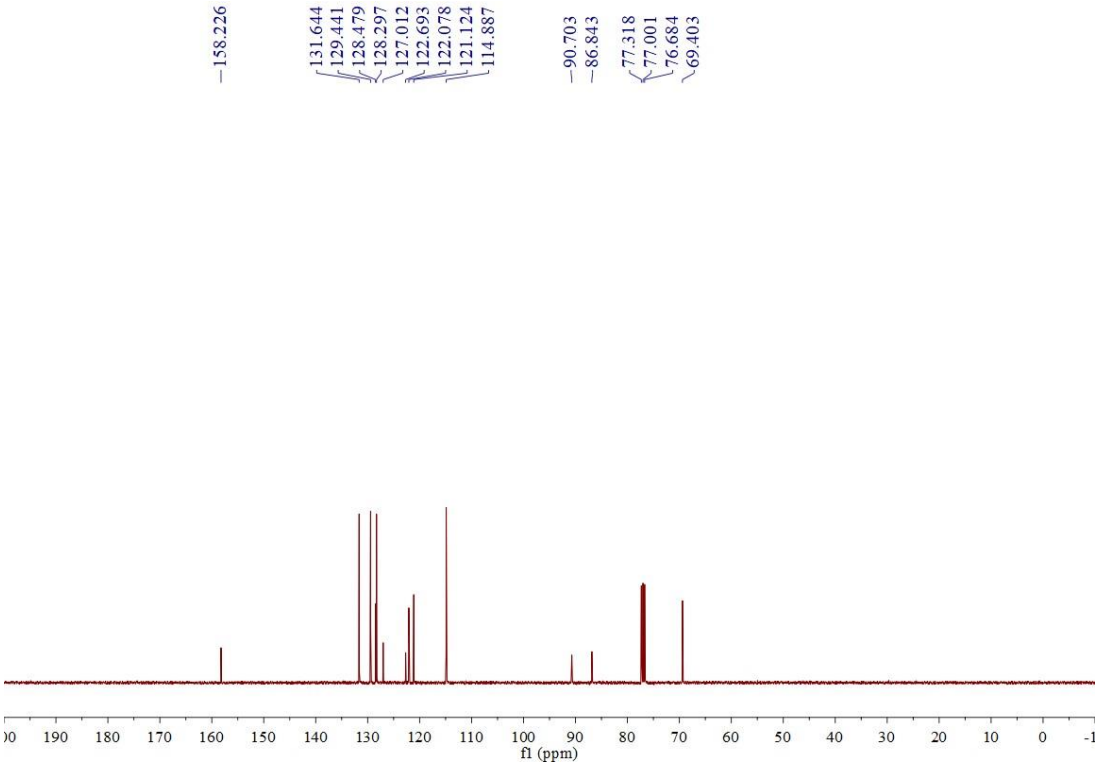
^{13}C NMR (101 MHz, $CDCl_3$): δ 144.5, 135.9, 135.3, 134.8, 132.6, 129.4, 128.7, 127.5, 127.2, 126.3, 125.8, 123.1, 59.9, 27.7, 23.3, 21.5.

HRMS (m/z, ESI-TOF): Calcd for $C_{18}H_{18}SO_2Na^+$ [M+Na^+] 321.0920, found 321.0925.

5. NMR Spectra of Compounds





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7.516
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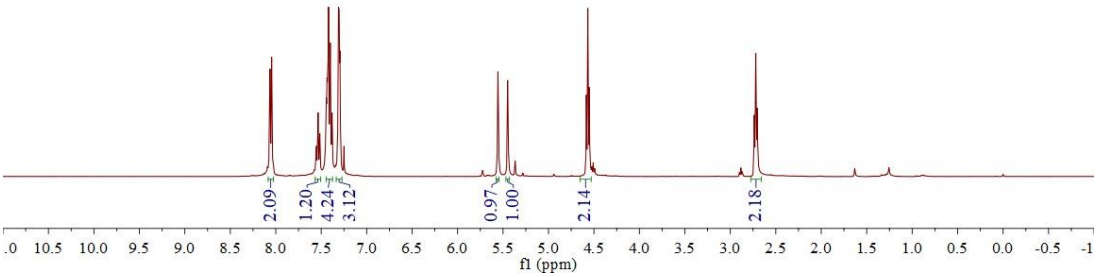
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4.24
3.12
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1.00
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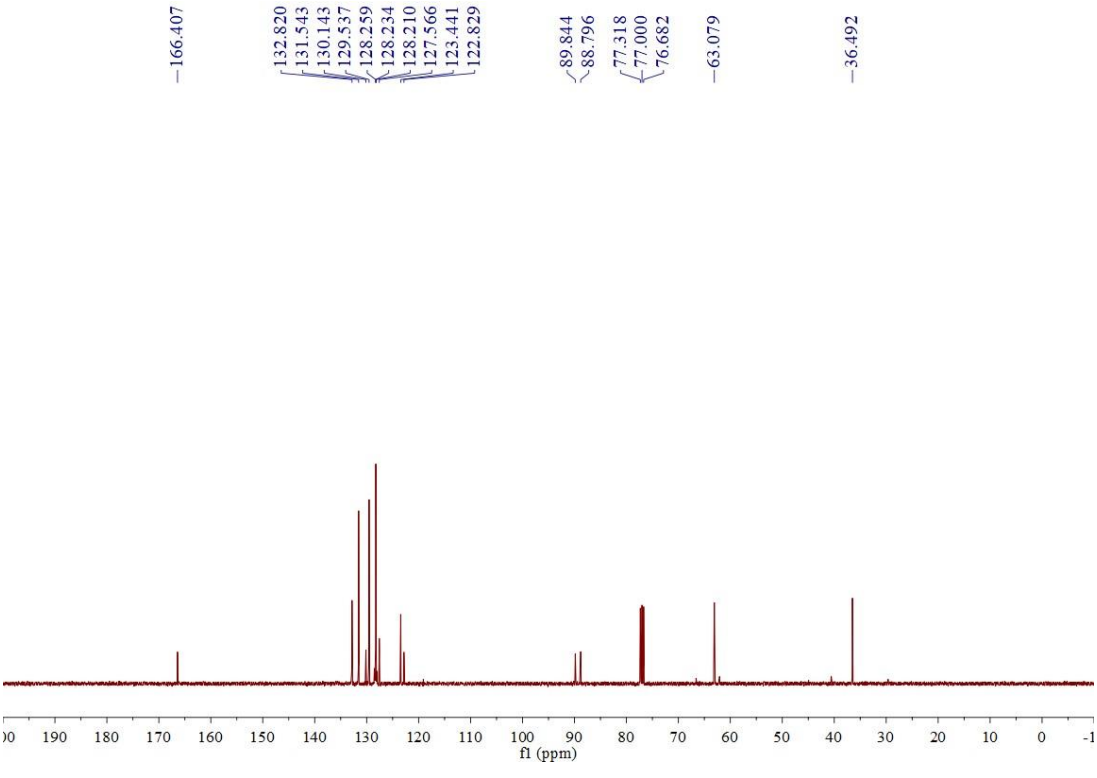
2.18
f1 (ppm)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128.234
128.210
127.566
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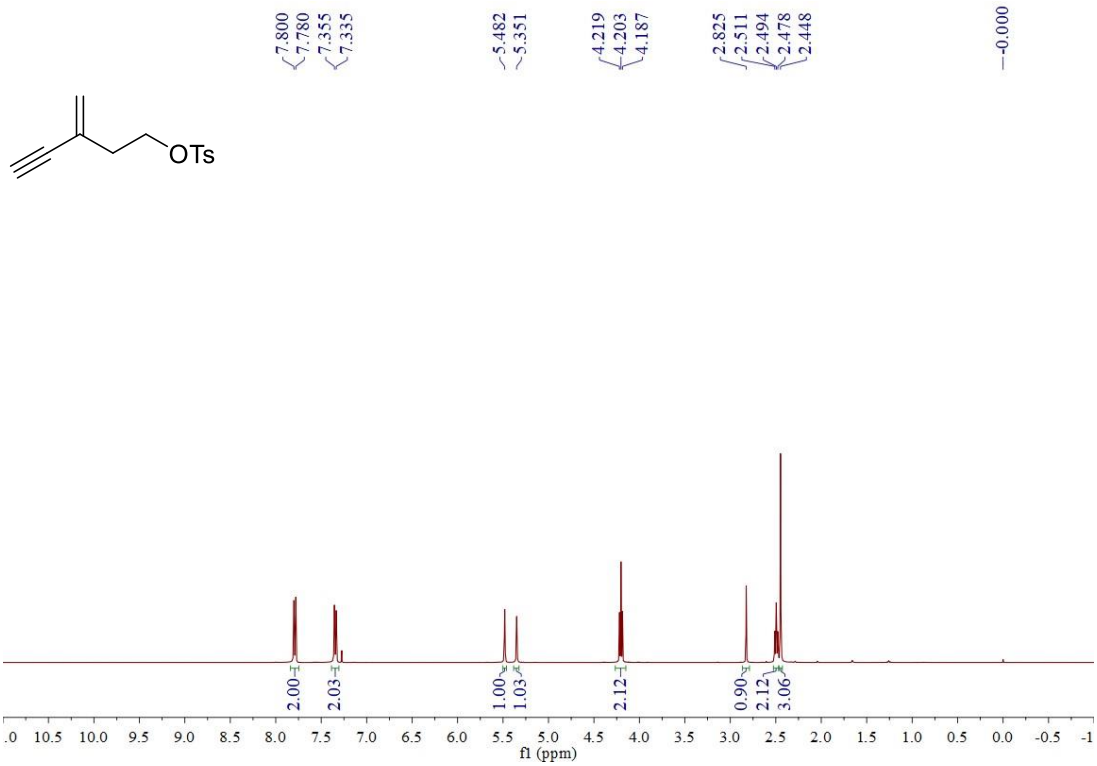
122.829
89.844
88.796
77.318
77.000
76.682
63.079
36.492
f1 (ppm)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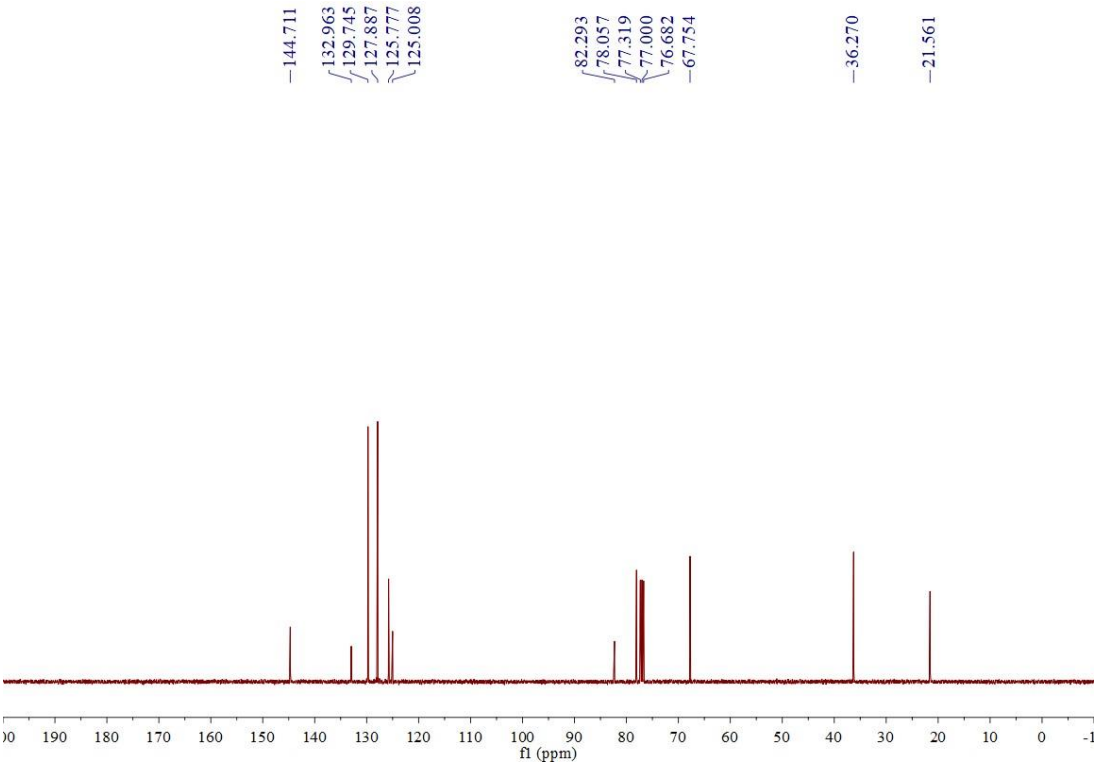
7.780
7.355
7.335
5.482
5.351
4.219
4.203
4.187
2.825
2.511
2.494
2.478
2.448
-0.000
OTs
2.00
2.03
1.00
1.03
2.12
0.90
2.12
3.06
f1 (ppm)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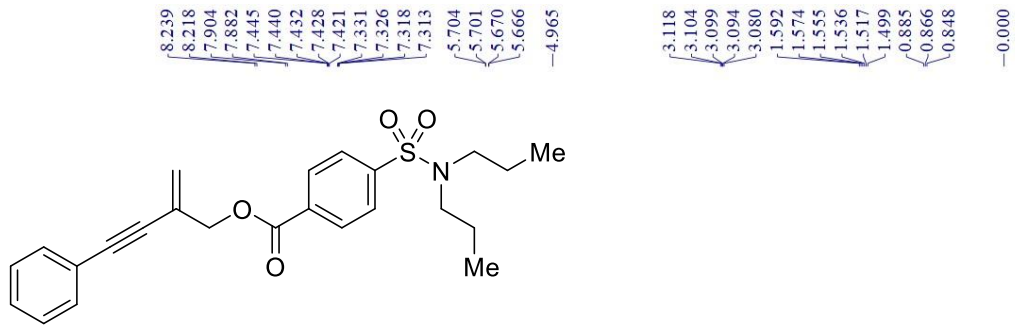
78.057
77.319
77.000
76.682
67.754
36.270
21.561
f1 (ppm)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7.428
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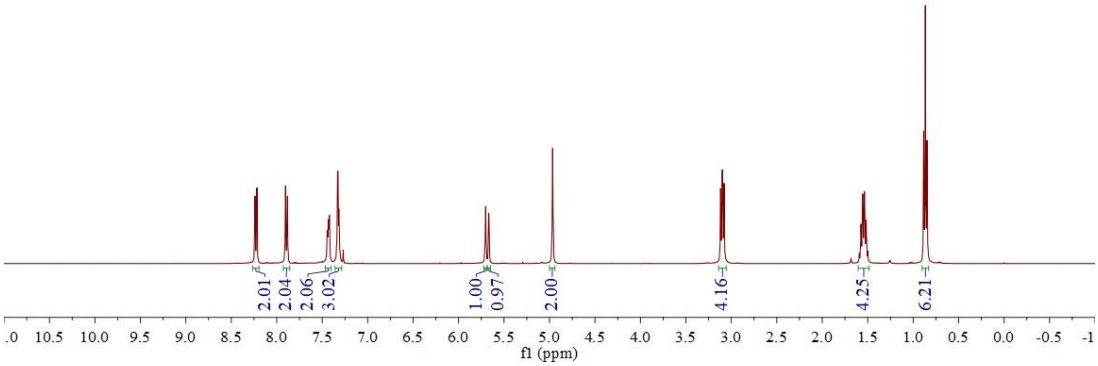
7.326
7.318
7.313
5.704
5.701
5.670
5.666
4.965
3.118
3.104
3.099
3.094
3.080
1.592
1.574
1.555
1.536
1.517
1.499
0.885
0.866
0.848
0.000
O
O
S
N
Me
Me
O
O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2.04
2.06
3.02
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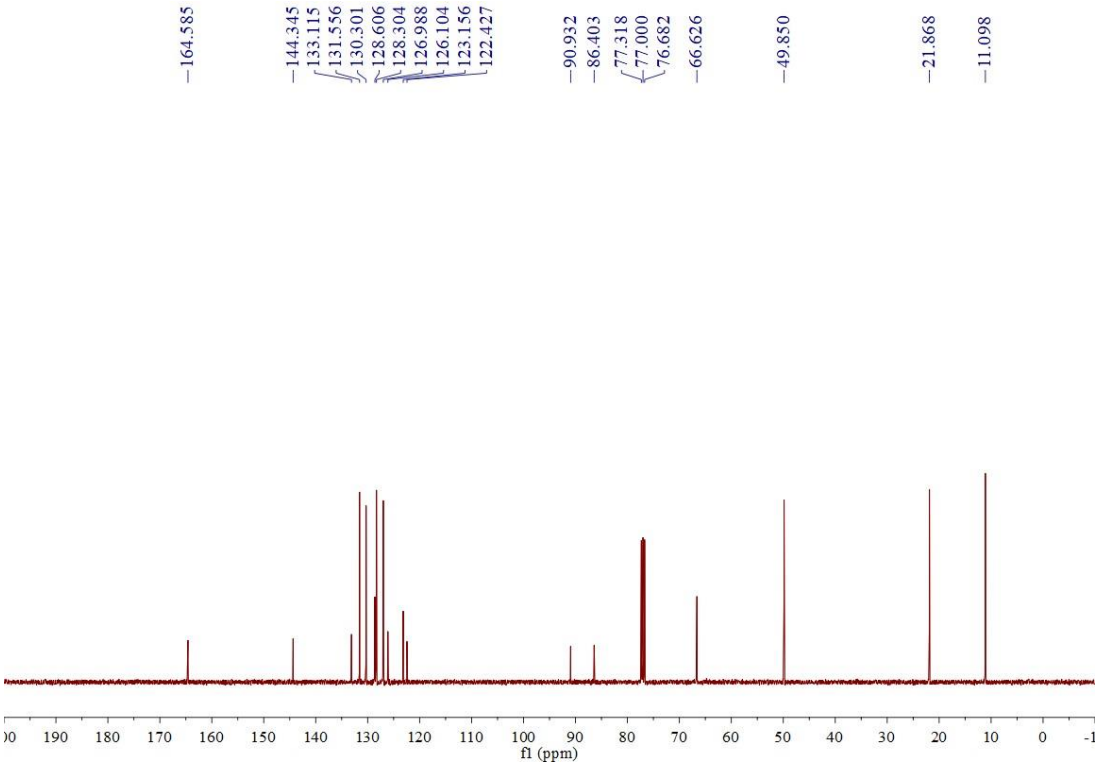
0.97
2.00
4.16
4.25
6.21
f1 (ppm)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130.301
128.606
128.304
126.988
126.104
123.156
122.427
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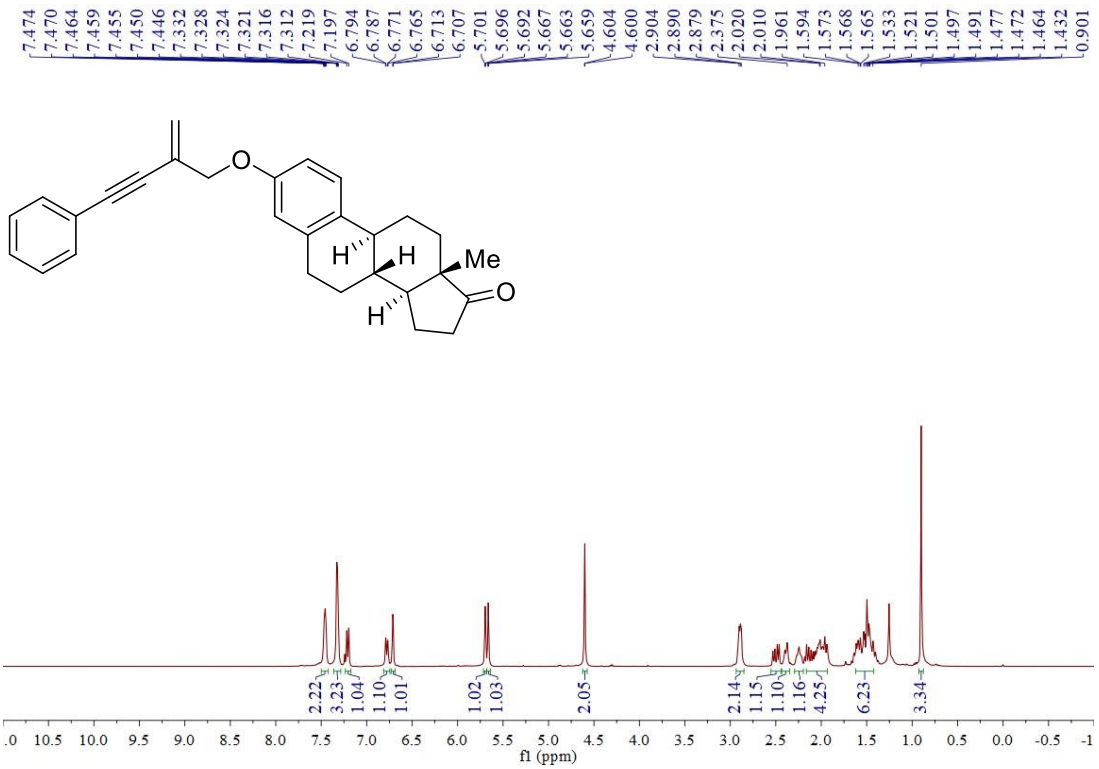
86.403
77.318
77.000
76.682
66.626
49.850
21.868
11.098
f1 (ppm)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7.459
7.455
7.450
7.446
7.332
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7.324
7.321
7.316
7.312
7.219
7.197
6.794
6.787
6.771
6.765
6.713
6.707
5.701
5.696
5.692
5.667
5.663
5.659
4.604
4.600
2.904
2.890
2.879
2.375
2.020
2.010
1.961
1.594
1.573
1.568
1.565
1.533
1.521
1.501
1.497
1.491
1.477
1.472
1.464
1.432
0.901
O
H
H
Me
O
H
2.22
3.23
1.04
1.10
1.01
1.02
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2.05
2.14
1.15
1.10
1.16
4.25
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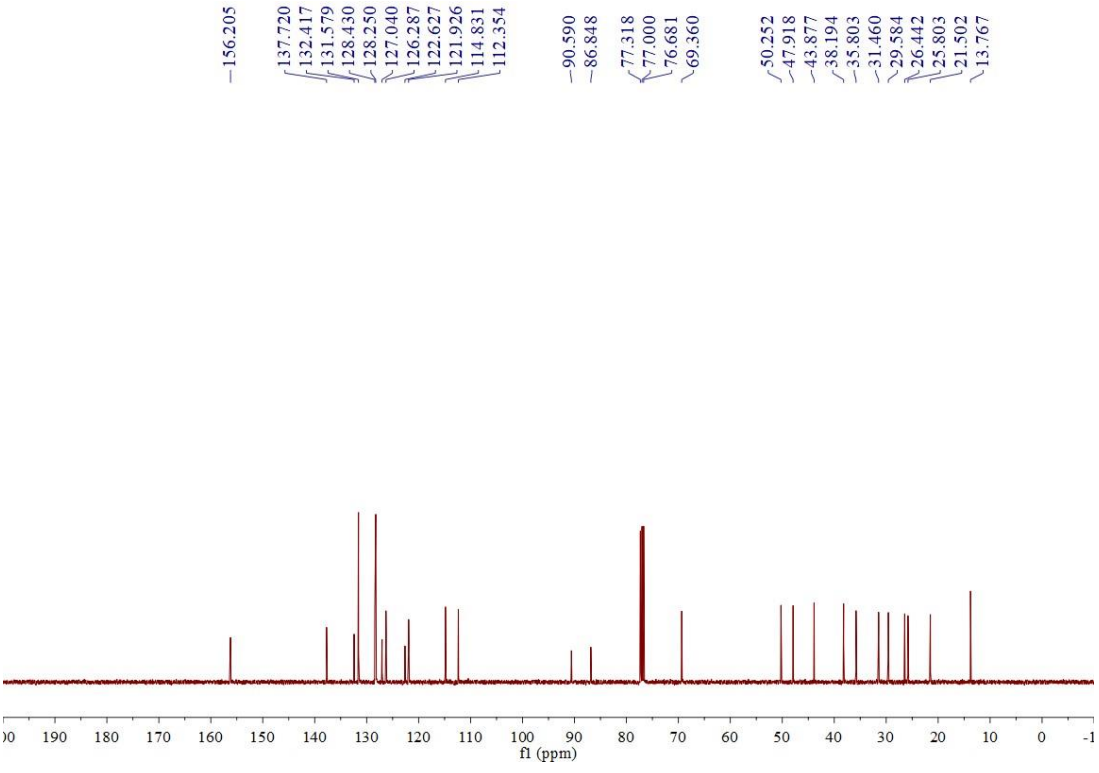
3.34
f1 (ppm)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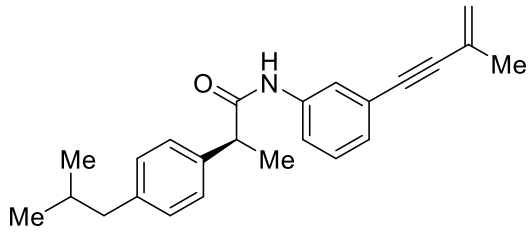
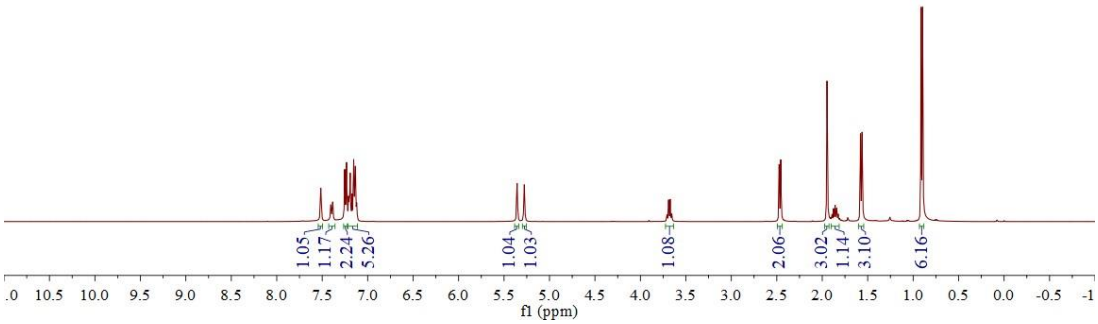
132.417
131.579
128.430
128.250
127.040
126.287
122.627
121.926
114.831
112.354
90.590
86.848
77.318
77.000
76.681
69.360
50.252
47.918
43.877
38.194
35.803
31.460
29.584
26.442
25.803
21.502
13.767
f1 (ppm)


7.520
7.515
7.511
7.406
7.401
7.389
7.385
7.381
7.252
7.233
7.211
7.201
7.192
7.172
7.154
7.143
7.139
7.135
7.124
5.358
5.356
5.353
5.286
5.282
5.277
5.273
5.269
3.708
3.690
3.672
3.655
2.474
2.456
1.948
1.892
1.875
1.858
1.841
1.824
1.580
1.562
0.913
0.897
-0.000


H
N
O
Me
Me
Me
Me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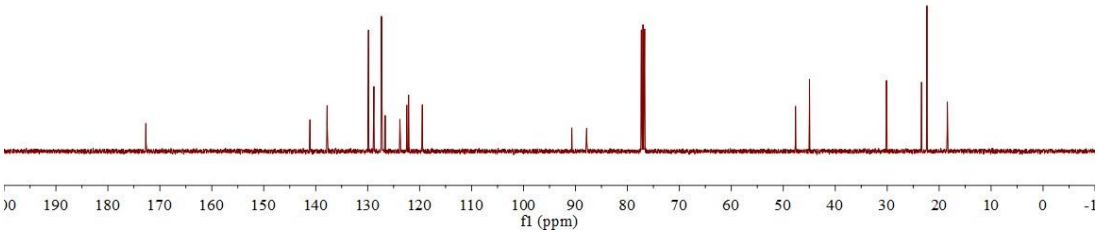
1.17
2.24
5.26
1.04
1.03
1.08
2.06
3.02
1.14
3.10
6.16
f1 (ppm)


172.692
141.104
137.829
137.799
129.845
128.797
127.339
127.249
126.630
123.800
122.473
122.127
119.481
90.715
87.843
77.318
77.000
76.682
47.647
44.957
30.135
23.388
22.350
18.426


f1 (ppm)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5.452
5.358
5.128
5.123
5.120
5.114
5.104
5.098
5.095
5.090
2.481
2.471
2.461
2.448
2.142
2.130
2.120
2.110
2.097
2.086
2.006
1.815
1.805
1.795
1.785
1.775
1.753
1.741
1.730
1.421
1.412
1.406
1.347
1.336
1.323
1.316
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1.305
1.293
1.282
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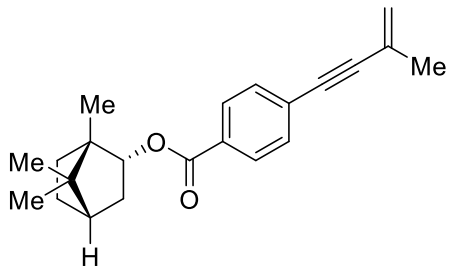
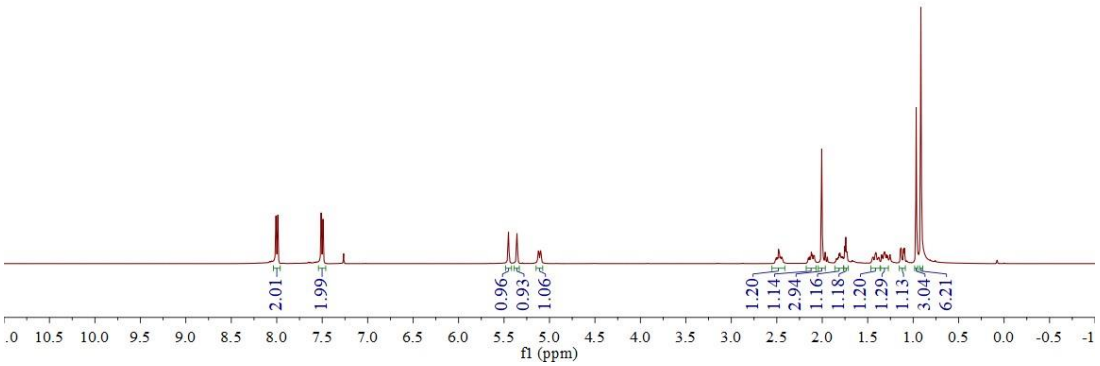
1.132
1.106
1.097
0.967
0.914


Me
Me
Me
O
O
H
Me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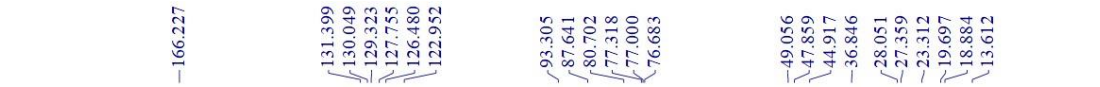
0.93
1.06
1.20
1.14
2.94
1.16
1.18
1.20
1.29
1.13
3.04
6.21
f1 (ppm)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129.323
127.755
126.480
122.952
93.305
87.641
80.702
77.318
77.000
76.683
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47.859
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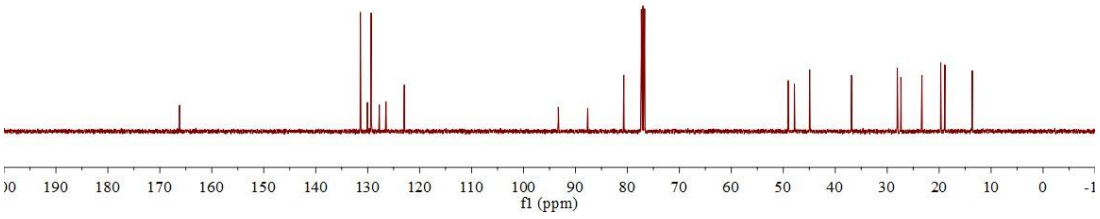
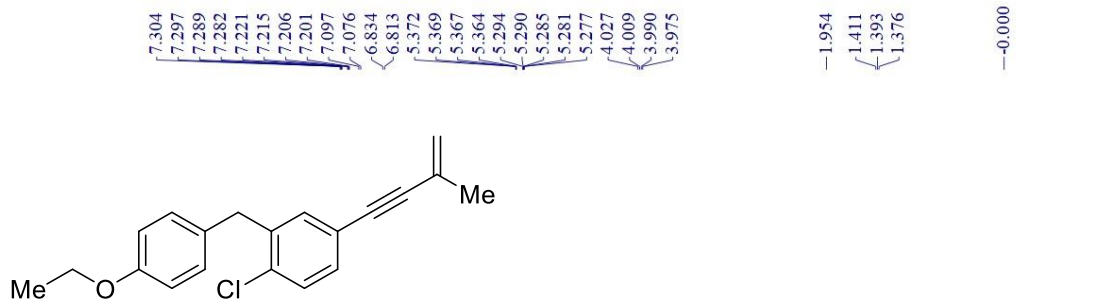
36.846
28.051
27.359
23.312
19.697
18.884
13.612


f1 (ppm)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7.221
7.215
7.206
7.201
7.097
7.076
6.834
6.813
5.372
5.369
5.367
5.364
5.294
5.290
5.285
5.281
5.277
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4.009
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3.975
1.954
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1.393
1.376
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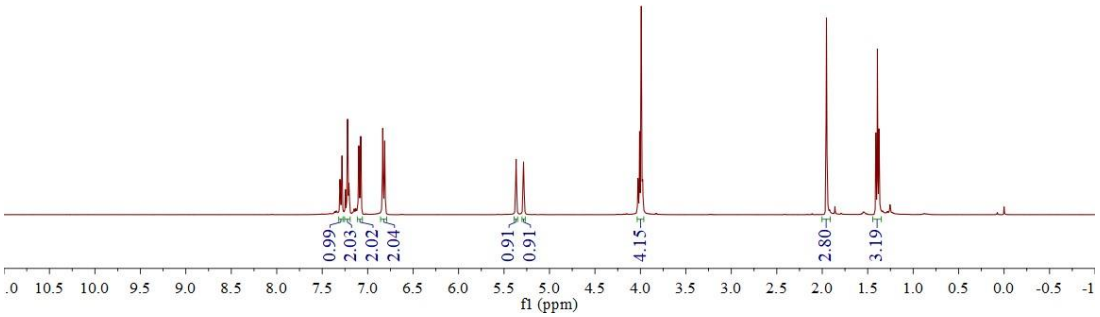
Me
Me
O
Cl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2.04
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0.91
4.15
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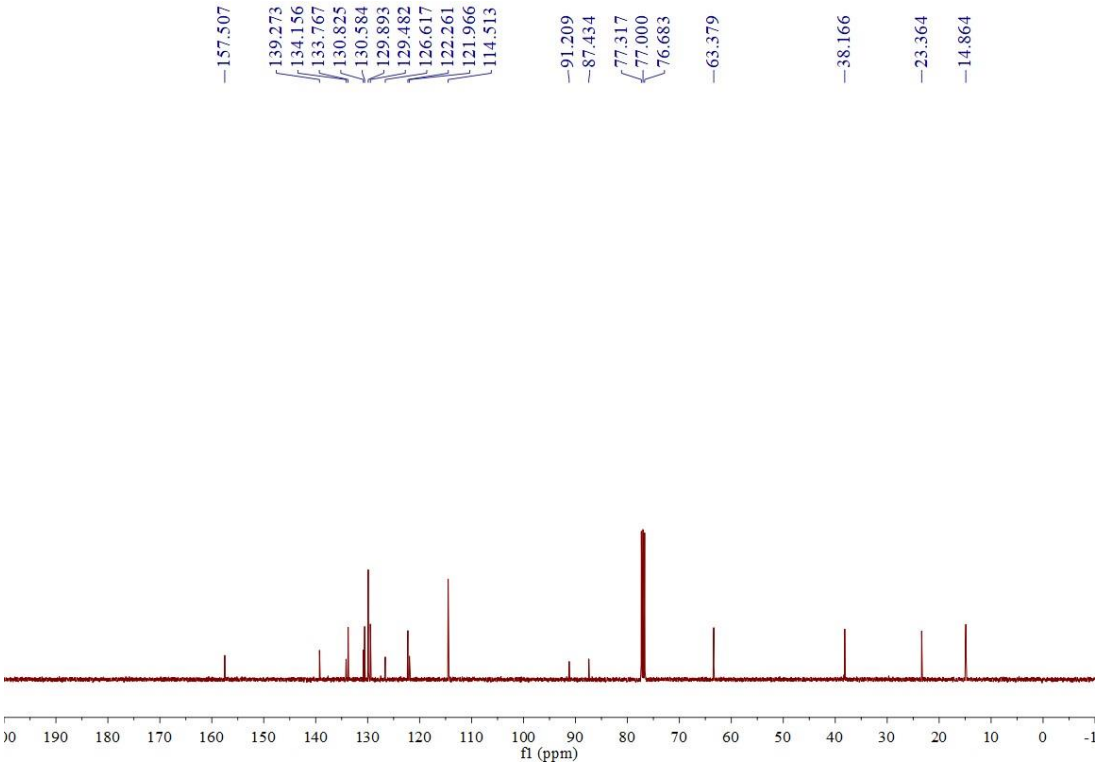
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139.273
134.156
133.767
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130.584
129.893
129.482
126.617
122.261
121.966
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87.434
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77.000
76.683
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38.166
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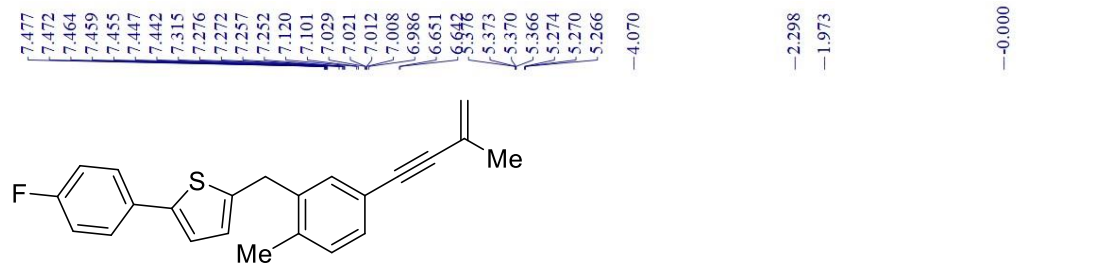
14.864
f1 (ppm)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7.447
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7.276
7.272
7.257
7.252
7.120
7.101
7.029
7.021
7.012
7.008
6.986
6.651
6.642
5.378
5.373
5.370
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5.270
5.266
4.070
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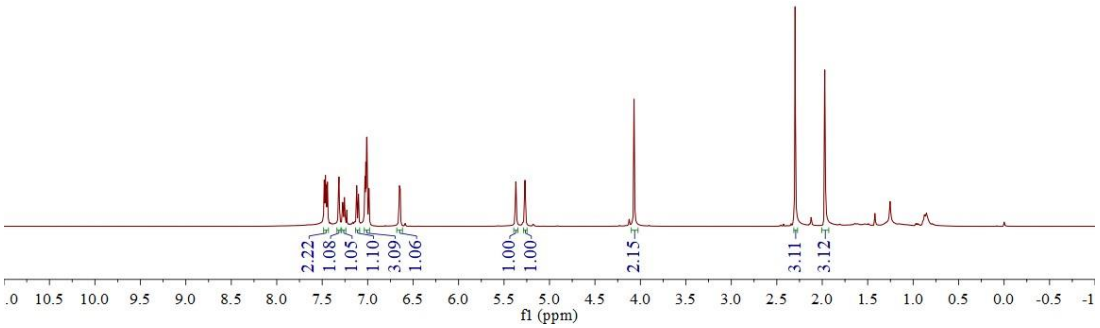
1.973
0.000
F
S
Me
Me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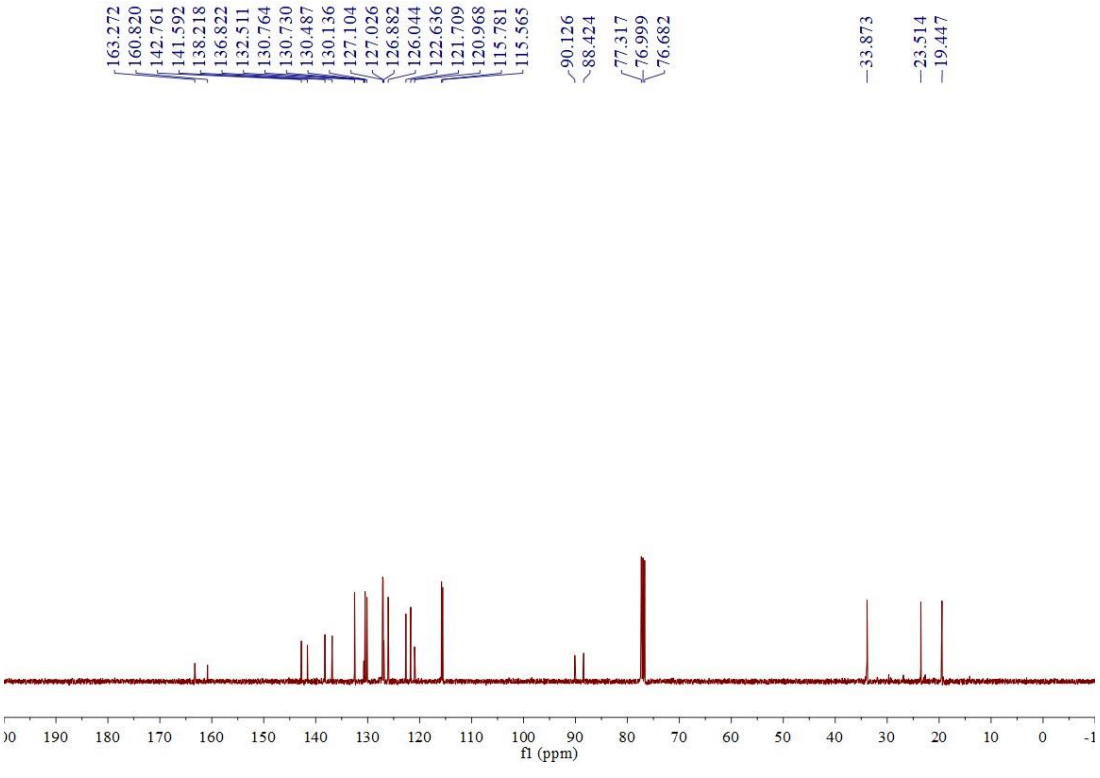
1.05
1.10
3.09
1.06
1.00
1.00
2.15
3.11
3.12
f1 (ppm)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160.820
142.761
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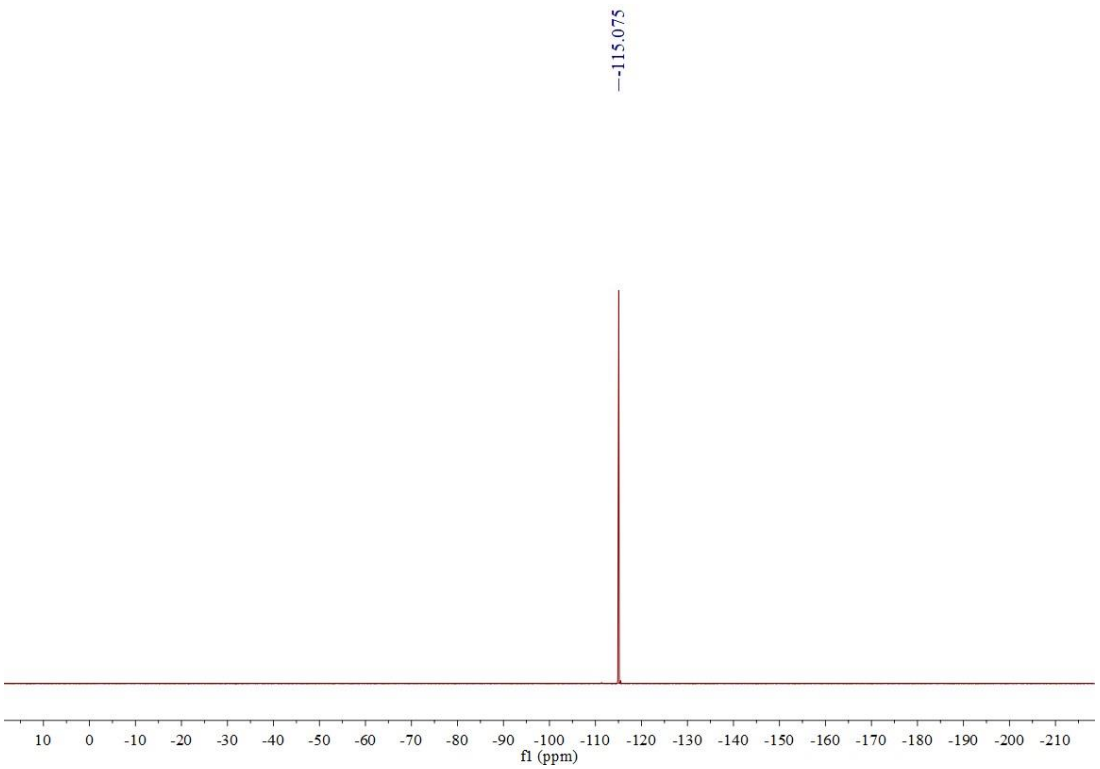
138.218
136.822
132.511
130.764
130.730
130.487
130.136
127.104
127.026
126.882
126.044
122.636
121.709
120.968
115.781
115.565
90.126
88.424
77.317
76.999
76.682
33.873
23.514
19.447
f1 (ppm)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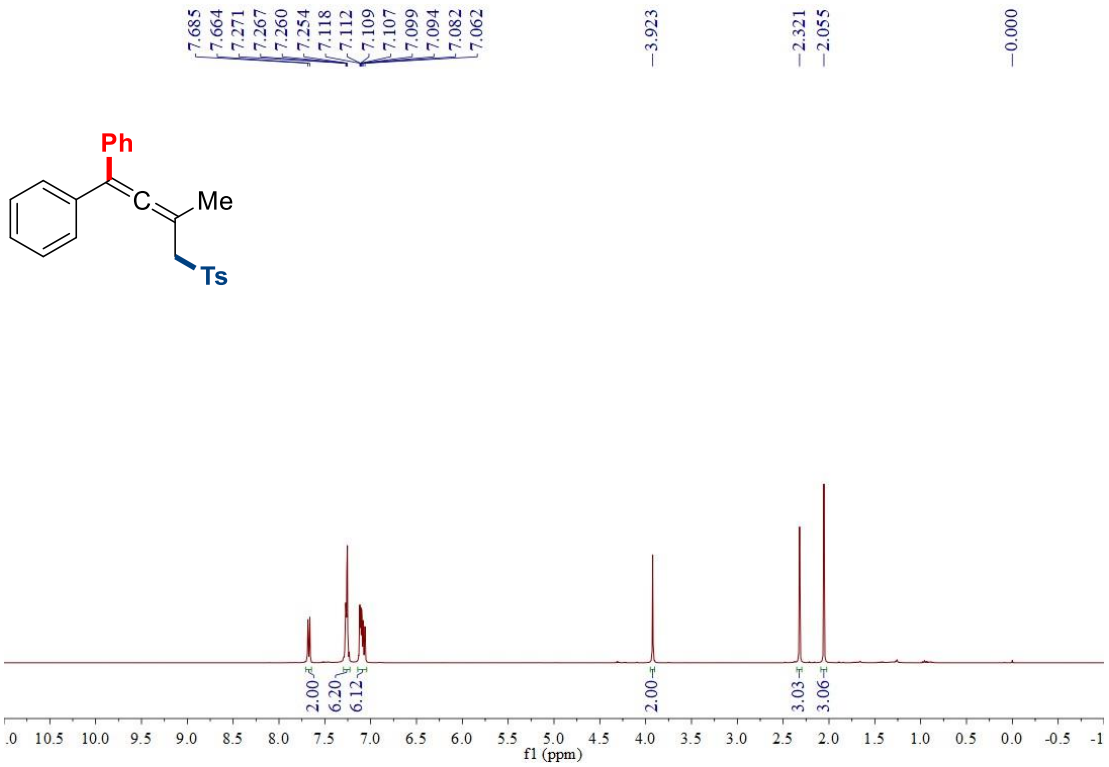
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)

4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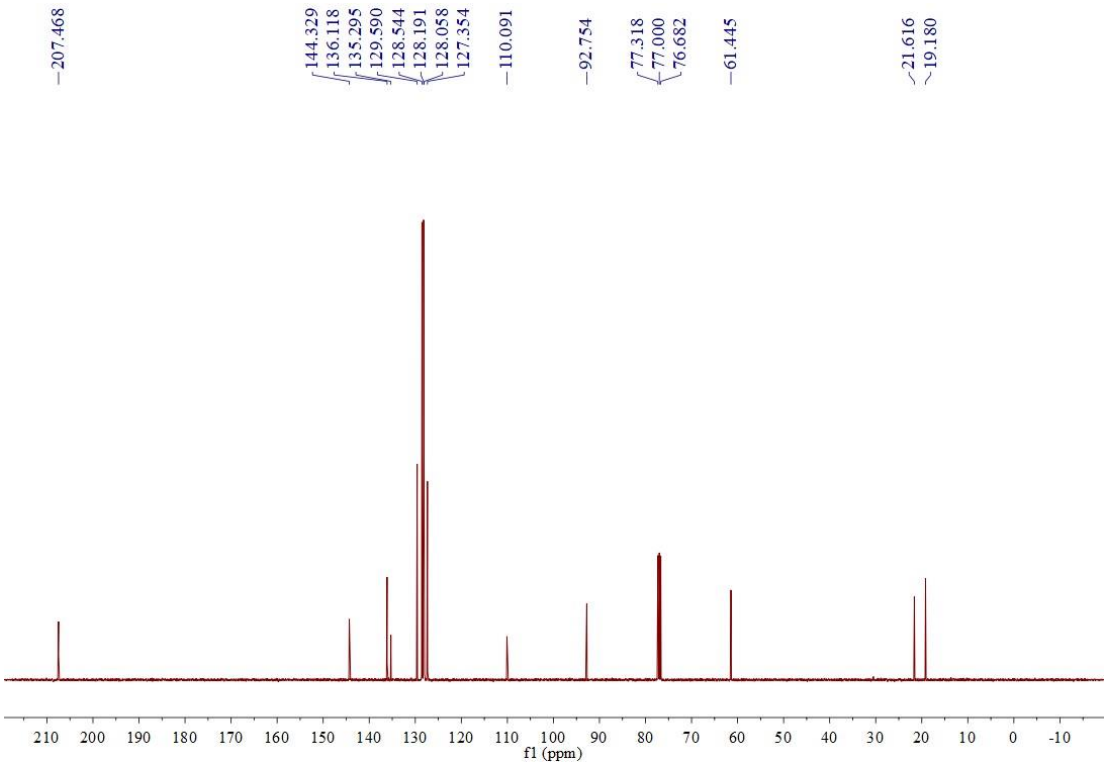
7.254
7.118
7.112
7.109
7.107
7.099
7.094
7.082
7.062
3.923
2.321
2.055
0.000
Ph
C
Me
Ts
2.00
6.20
6.12
2.00
3.03
3.06
f1 (ppm)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135.295
129.590
128.544
128.191
128.058
127.354
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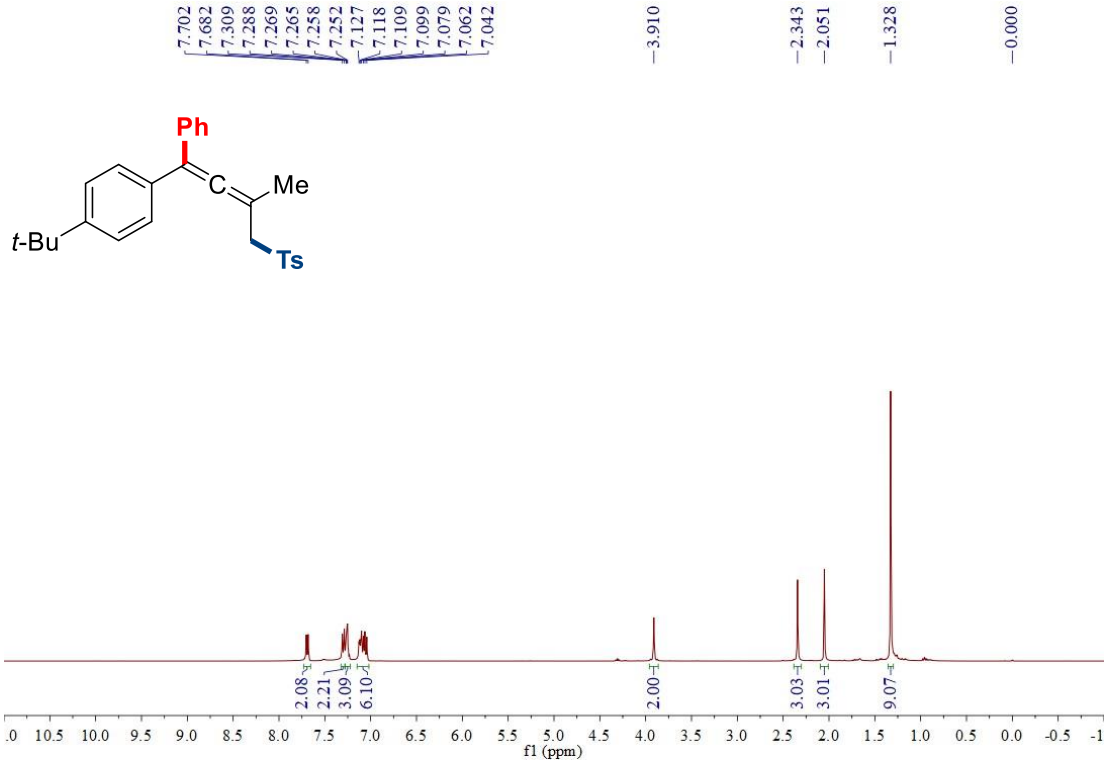
92.754
77.318
77.000
76.682
61.445
21.616
19.180
f1 (ppm)

5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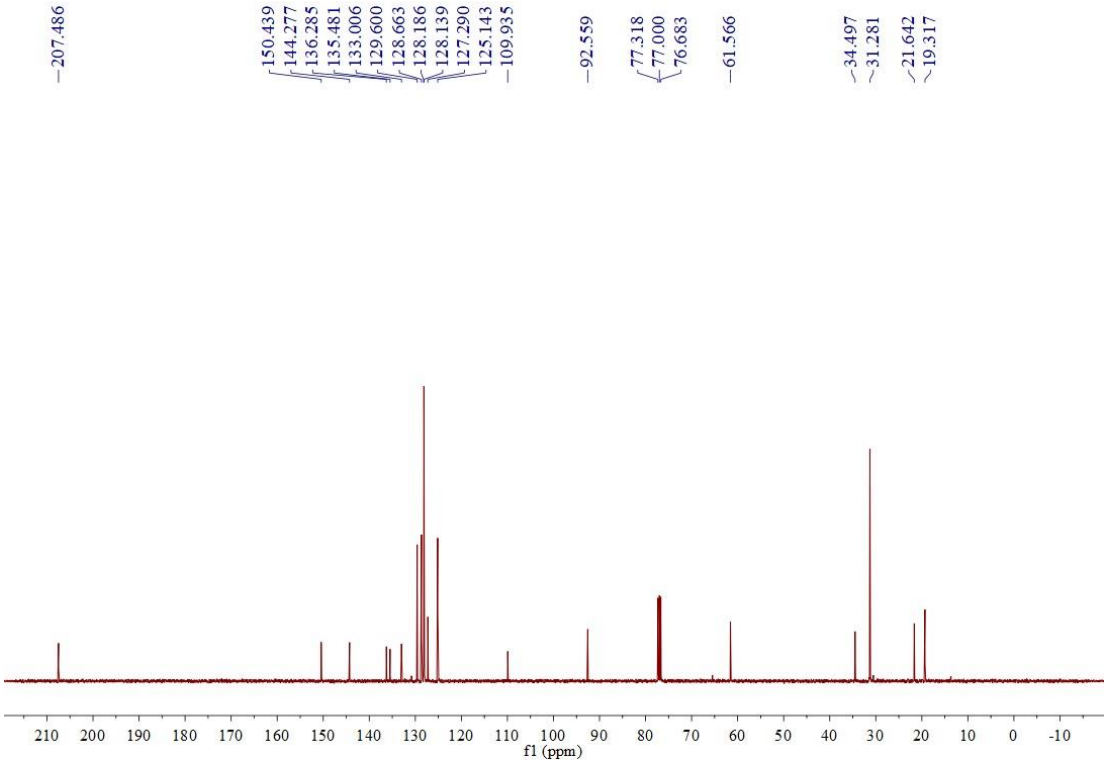
7.265
7.258
7.252
7.127
7.118
7.109
7.099
7.079
7.062
7.042
3.910
2.343
2.051
1.328
0.000
Ph
C
Me
t-Bu
Ts
2.08
2.21
3.09
6.10
2.00
3.03
3.01
9.07
f1 (ppm)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144.277
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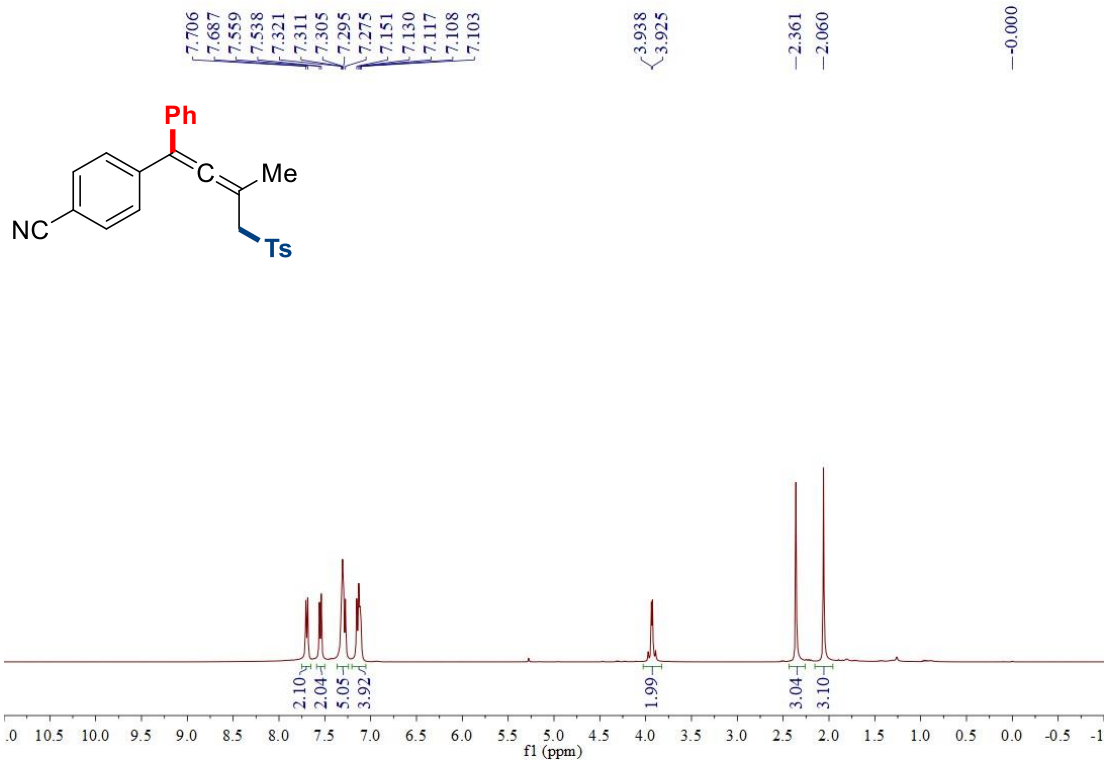
135.481
133.006
129.600
128.663
128.186
128.139
127.290
125.143
109.935
92.559
77.318
77.000
76.683
61.566
34.497
31.281
21.642
19.317
f1 (ppm)

6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7.321
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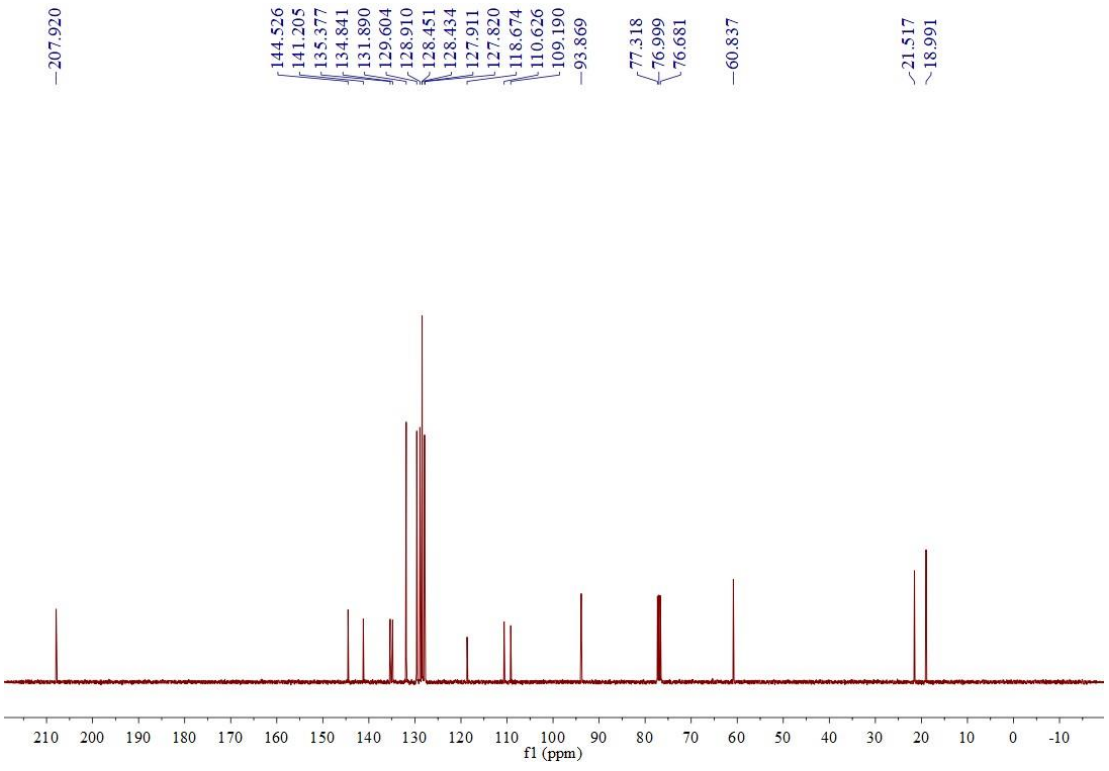
7.305
7.295
7.275
7.151
7.130
7.117
7.108
7.103
3.938
3.925
2.361
2.060
0.000
Ph
C
Me
NC
Ts
2.10
2.04
5.05
3.92
1.99
3.04
3.10
f1 (ppm)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129.604
128.910
128.451
128.434
127.911
127.820
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110.626
109.190
93.869
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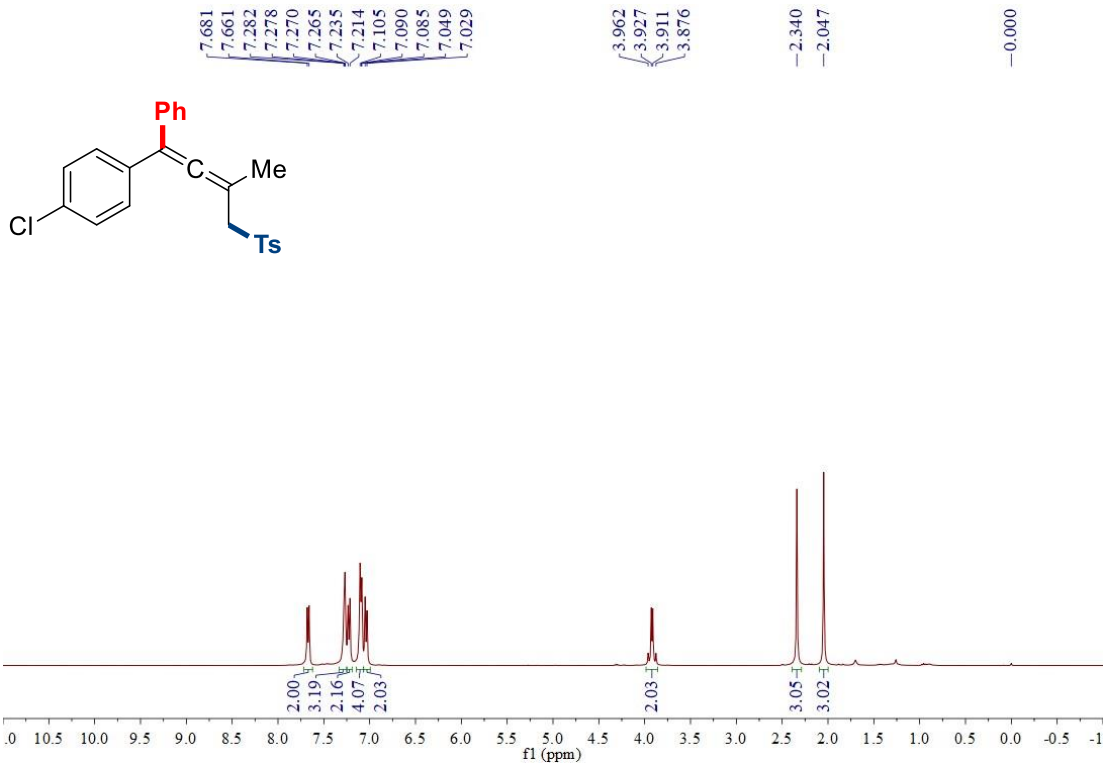
76.681
60.837
21.517
18.991
f1 (ppm)

7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7.270
7.265
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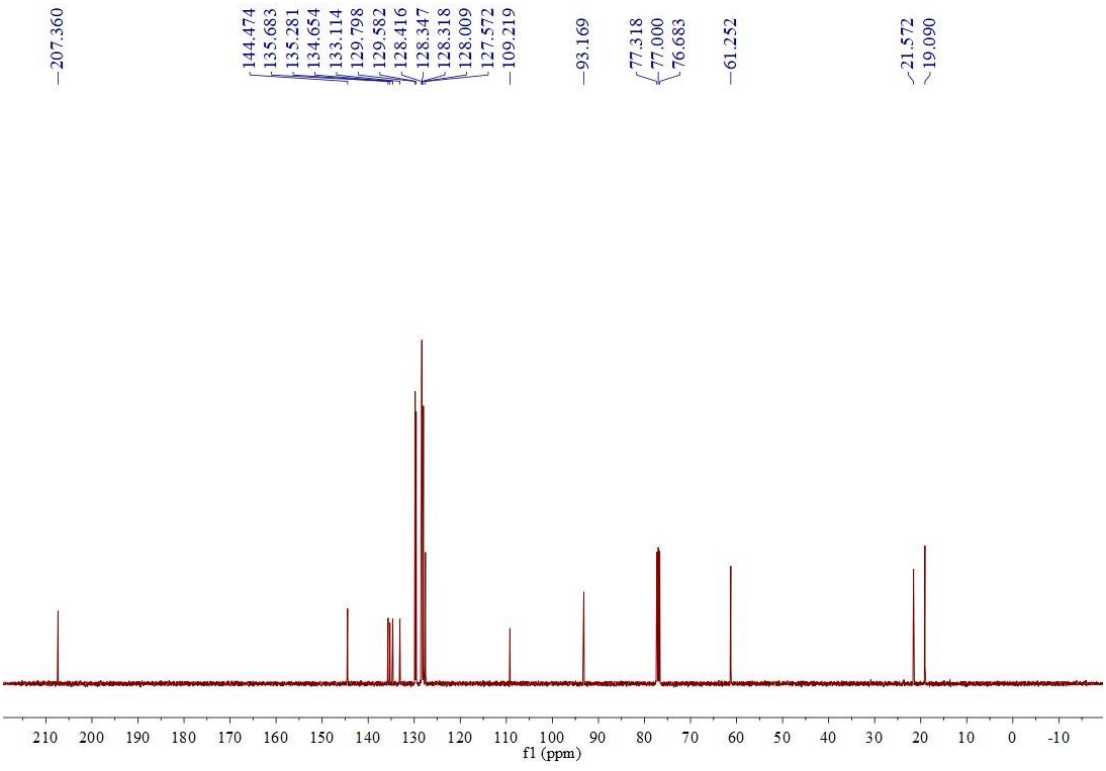
7.214
7.105
7.090
7.085
7.049
7.029
3.962
3.927
3.911
3.876
2.340
2.047
0.000
Ph
C
Me
Cl
Ts
2.00
3.19
2.16
4.07
2.03
2.03
3.05
3.02
f1 (ppm)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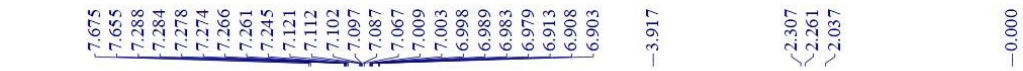
128.318
128.009
127.572
109.219
93.169
77.318
77.000
76.683
61.252
21.572
19.090
f1 (ppm)

8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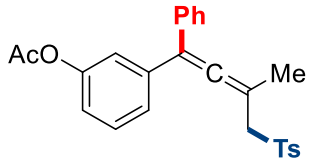
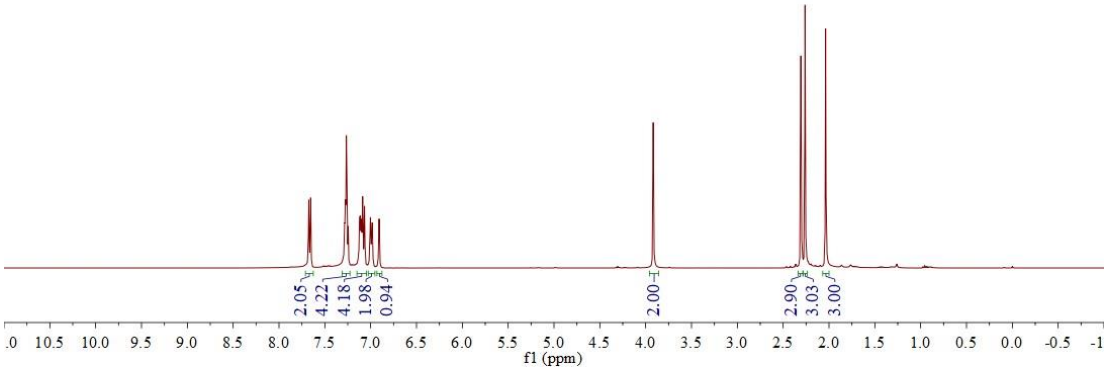
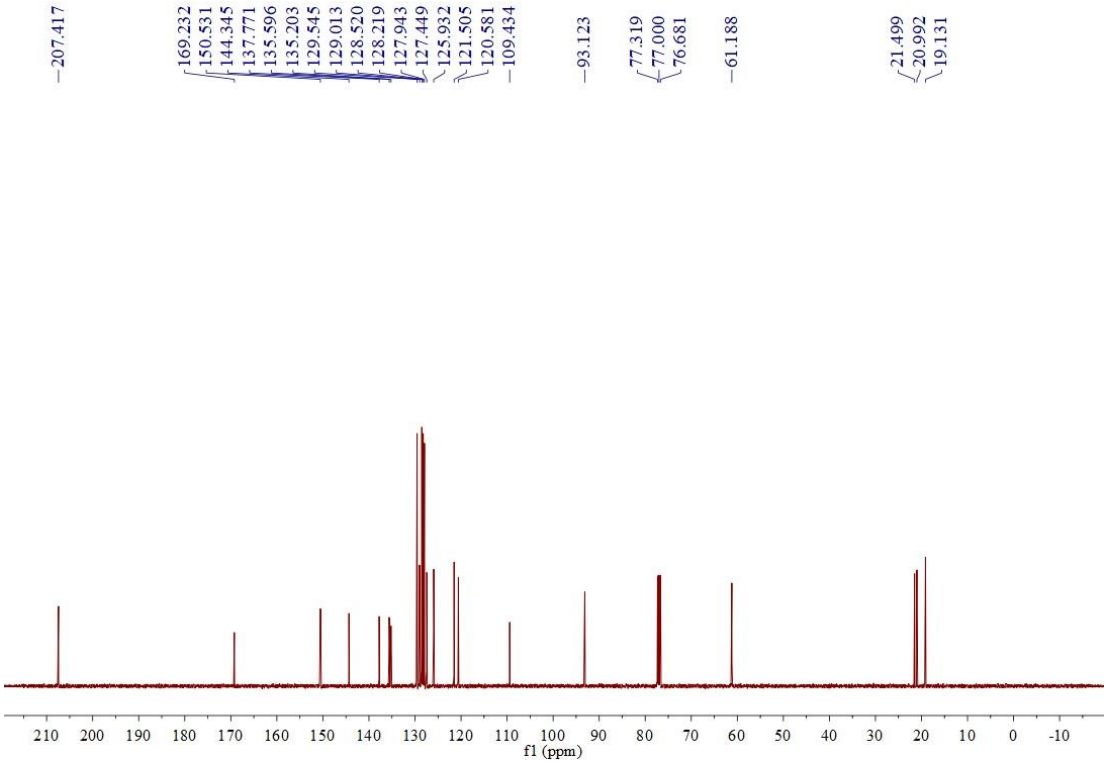
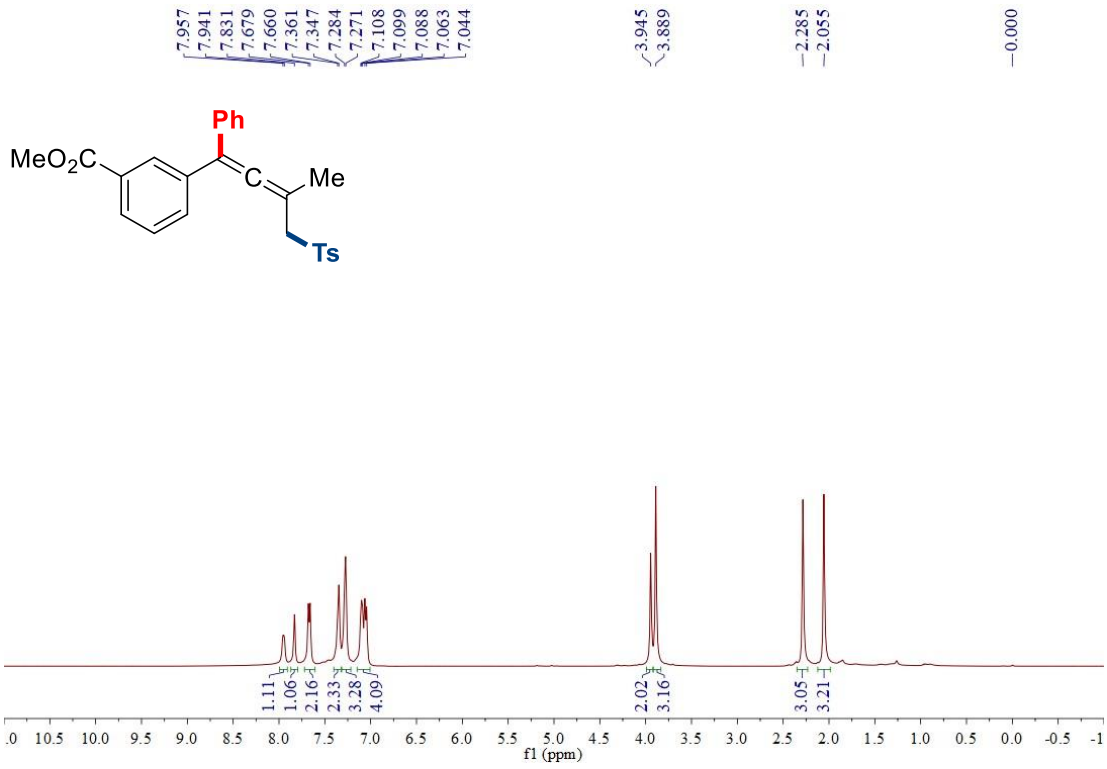
7.655
7.288
7.284
7.278
7.274
7.266
7.261
7.245
7.121
7.112
7.102
7.097
7.087
7.067
7.009
7.003
6.998
6.989
6.983
6.979
6.913
6.908
6.903
3.917
2.307
2.261
2.037
0.000

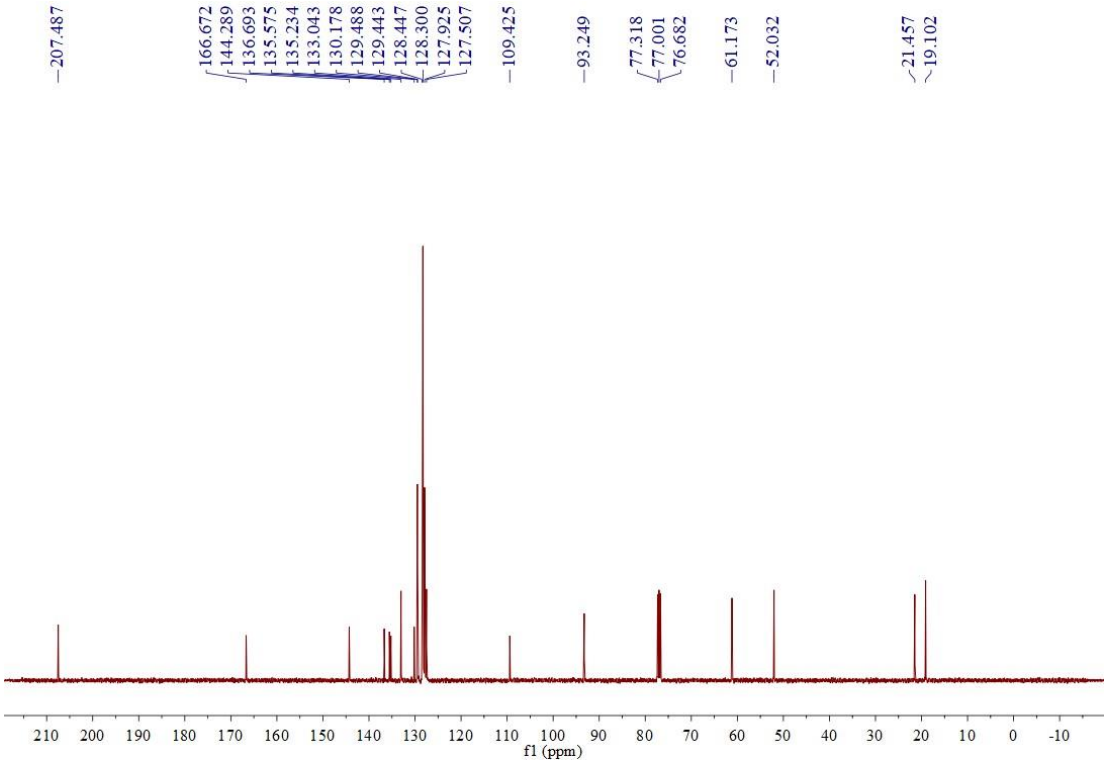

Ph
AcO
C
Me
Ts


2.05
4.22
4.18
1.98
0.94
2.00
2.90
3.03
3.00
f1 (ppm)

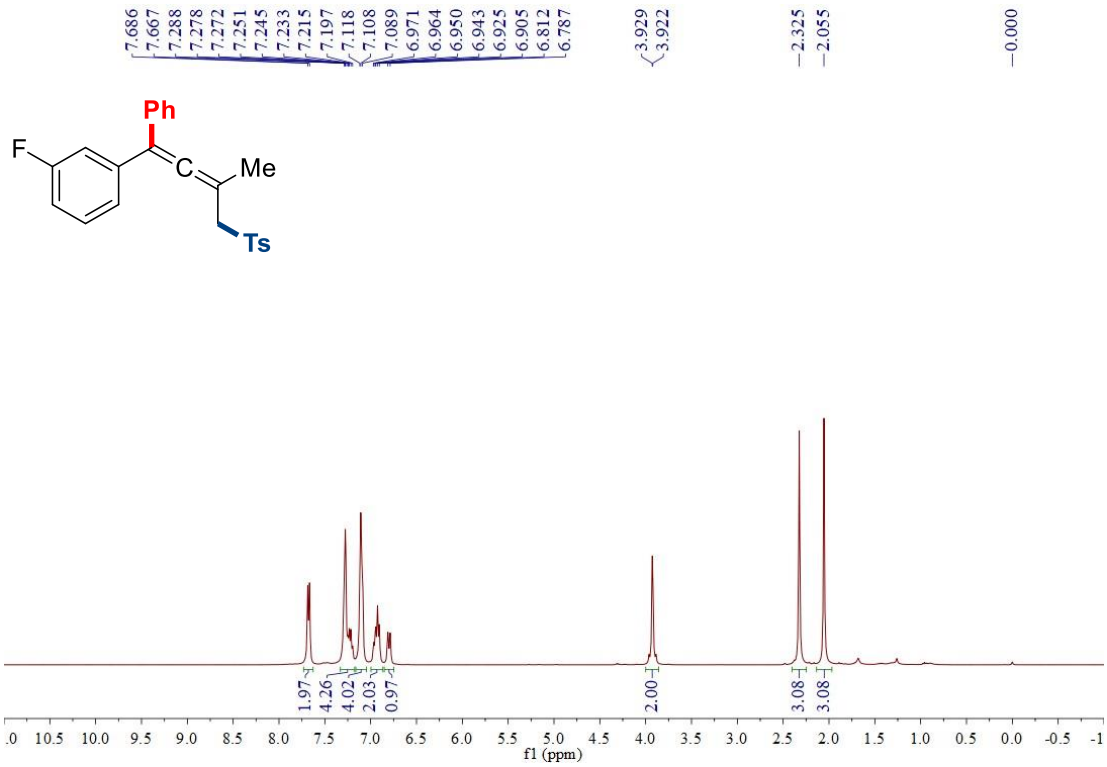

207.417
169.232
150.531
144.345
137.771
135.596
135.203
129.545
129.013
128.520
128.219
127.943
127.449
125.932
121.505
120.581
109.434
93.123
77.319
77.000
76.681
61.188
21.499
20.992
19.131
f1 (ppm)

9


7.957
7.941
7.831
7.679
7.660
7.361
7.347
7.284
7.271
7.108
7.099
7.088
7.063
7.044
3.945
3.889
2.285
2.055
0.000
Ph
MeO2C
C
Me
Ts
1.11
1.06
2.16
2.33
3.28
4.09
2.02
3.16
3.05
3.21
f1 (ppm)


207.487
166.672
144.289
136.693
135.575
135.234
133.043
130.178
129.488
129.443
128.447
128.300
127.925
127.507
109.425
93.249
77.318
77.001
76.682
61.173
52.032
21.457
19.102
f1 (ppm)

10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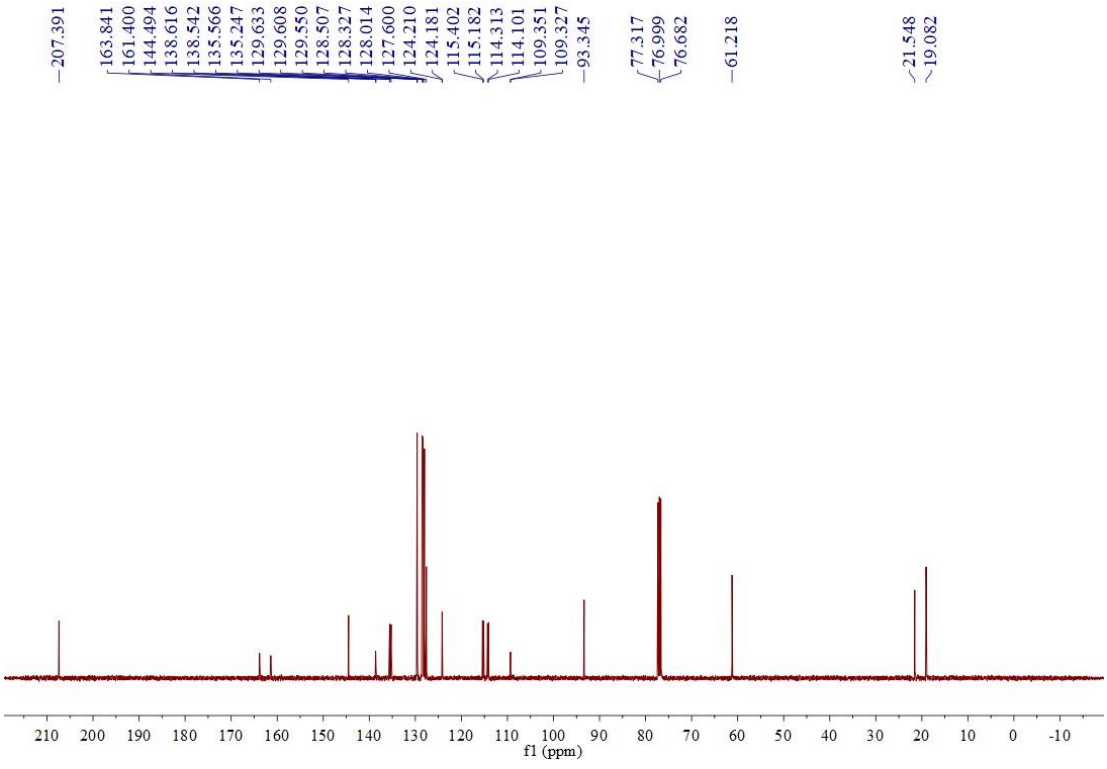
7.667
7.288
7.278
7.272
7.251
7.245
7.233
7.215
7.197
7.118
7.108
7.089
6.971
6.964
6.950
6.943
6.925
6.905
6.812
6.787
3.929
3.922
2.325
2.055
0.000
Ph
F
C
Me
Ts
1.97
4.26
4.02
2.03
0.97
2.00
3.08
3.08
f1 (ppm)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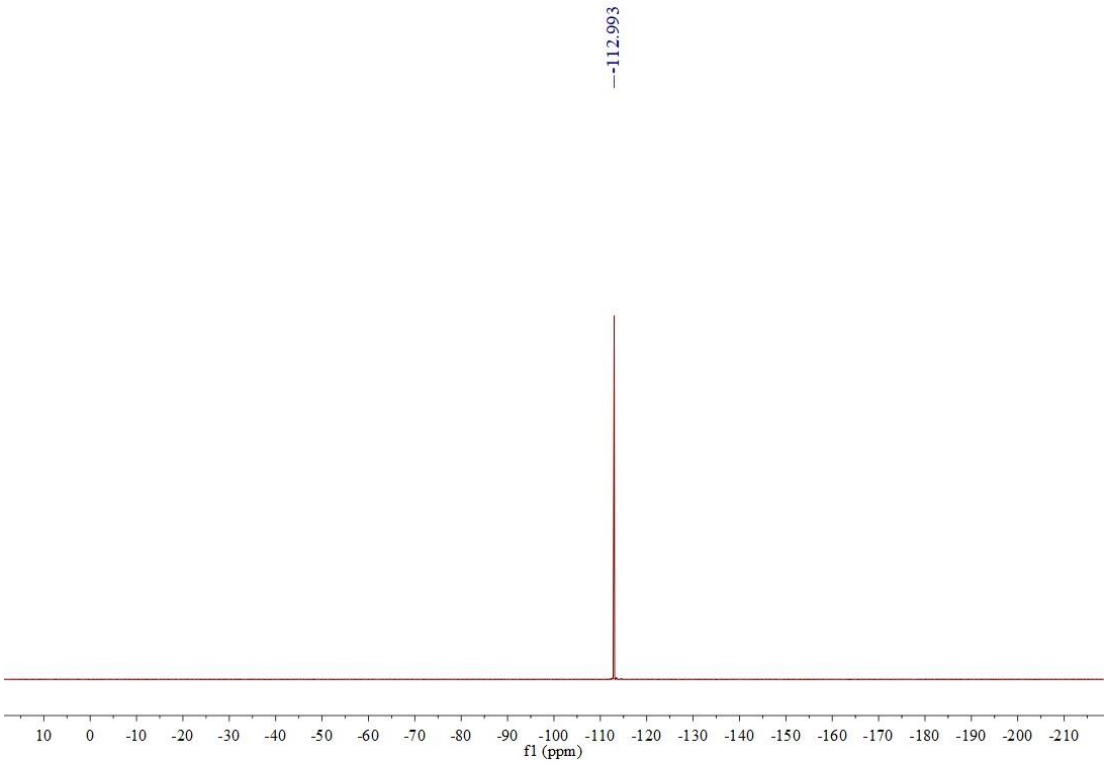
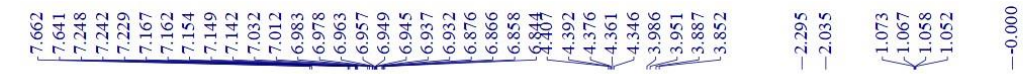
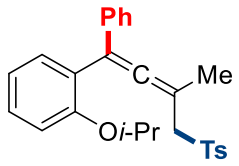
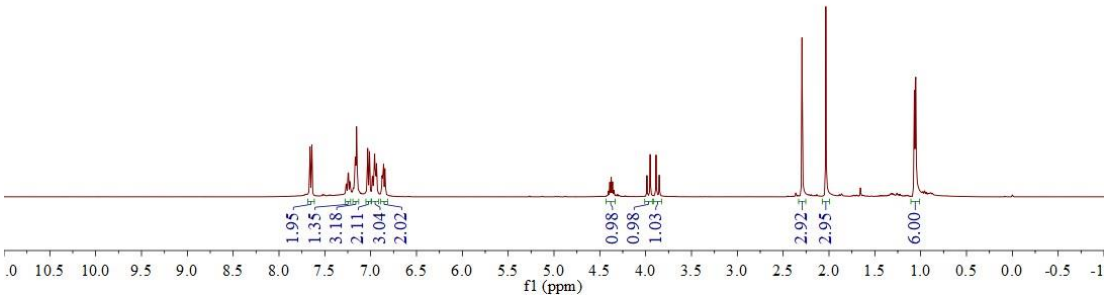
163.841
161.400
144.494
138.616
138.542
135.566
135.247
129.633
129.608
129.550
128.507
128.327
128.014
127.600
124.210
124.181
115.402
115.182
114.313
114.101
109.351
109.327
93.345
77.317
76.999
76.682
61.218
21.548
19.082
f1 (ppm)

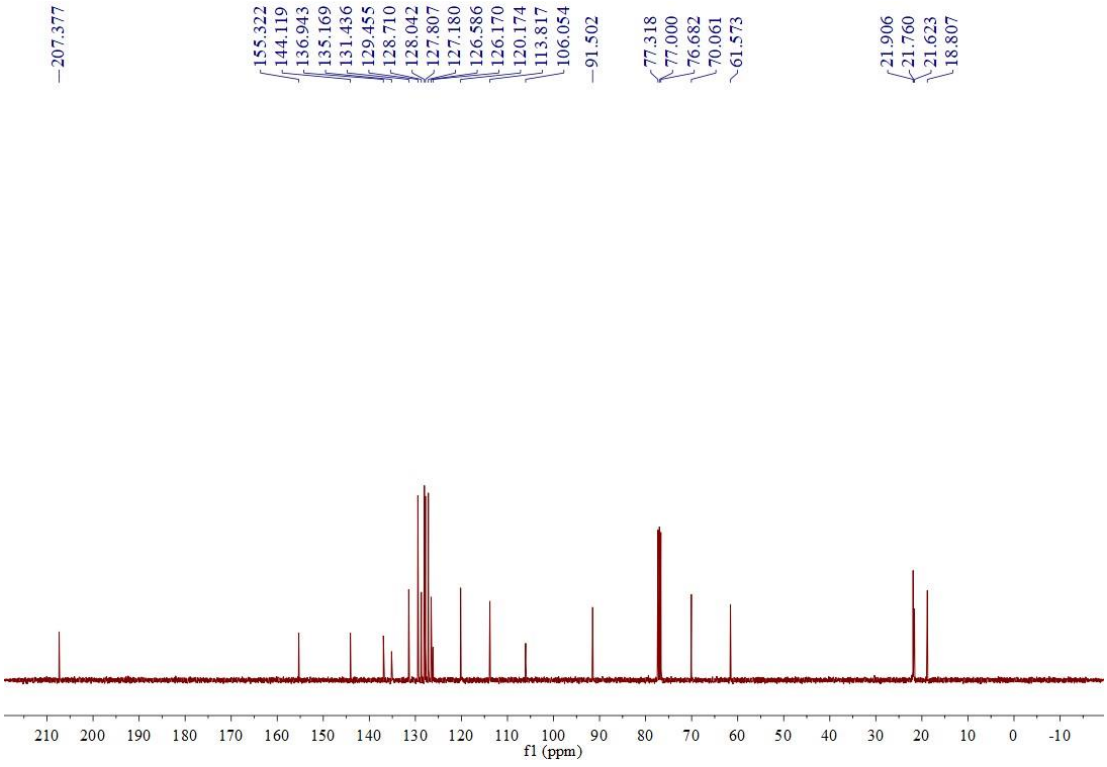

-112.993
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)

11

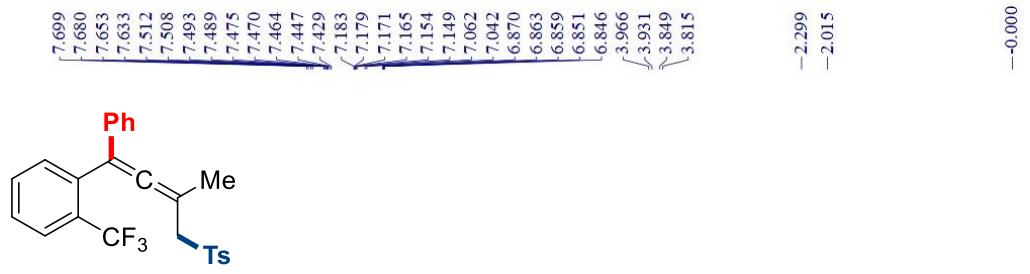

7.662
7.641
7.248
7.242
7.229
7.167
7.162
7.154
7.149
7.142
7.032
7.012
6.983
6.978
6.963
6.957
6.949
6.945
6.937
6.932
6.876
6.866
6.858
6.844
6.407
4.392
4.376
4.361
4.346
3.986
3.951
3.887
3.852
2.295
2.035
1.073
1.067
1.058
1.052
0.000


Ph
C
Me
Oi-Pr
Ts

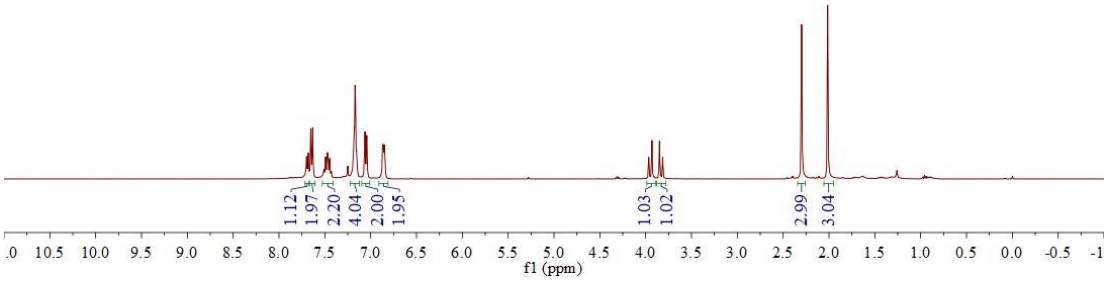

1.95
1.35
3.18
2.11
3.04
2.02
0.98
0.98
1.03
2.92
2.95
6.00
f1 (ppm)

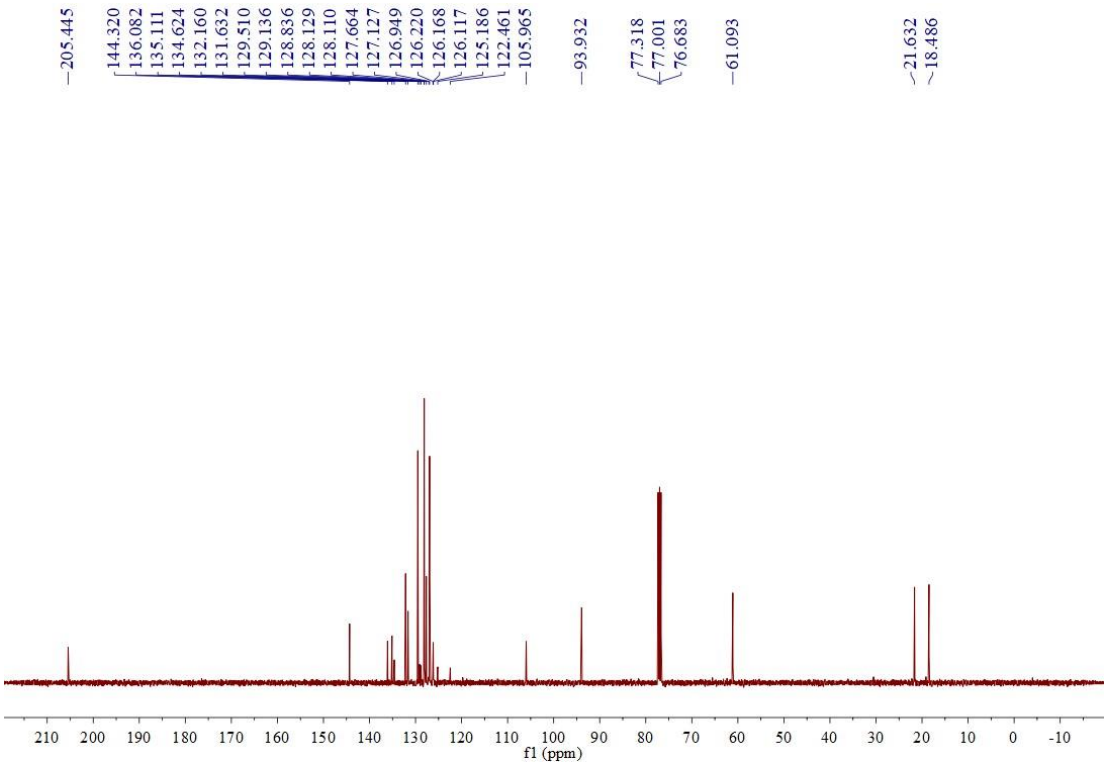

207.377
155.322
144.119
136.943
135.169
131.436
129.455
128.710
128.042
127.807
127.180
126.586
126.170
120.174
113.817
106.054
91.502
77.318
77.000
76.682
70.061
61.573
21.906
21.760
21.623
18.807
f1 (ppm)

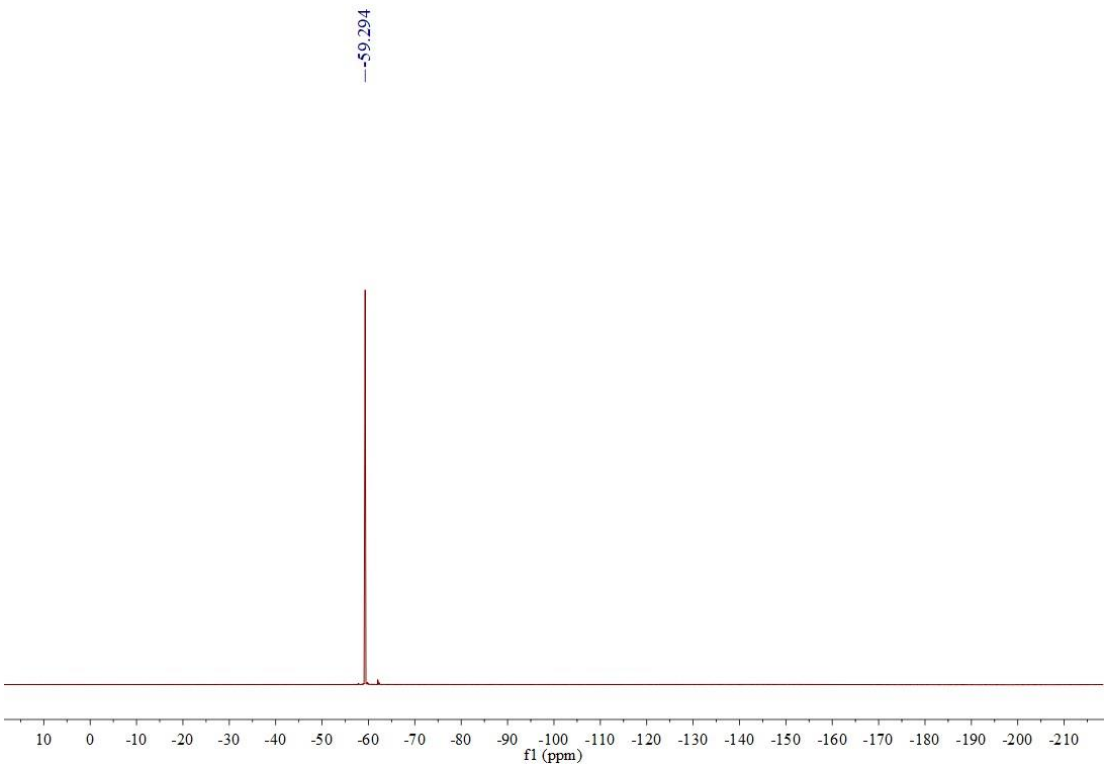
12


7.699
7.680
7.653
7.633
7.512
7.508
7.493
7.489
7.475
7.470
7.464
7.447
7.429
7.183
7.179
7.171
7.165
7.154
7.149
7.062
7.042
6.870
6.863
6.859
6.851
6.846
3.966
3.931
3.849
3.815
2.299
2.015
0.000

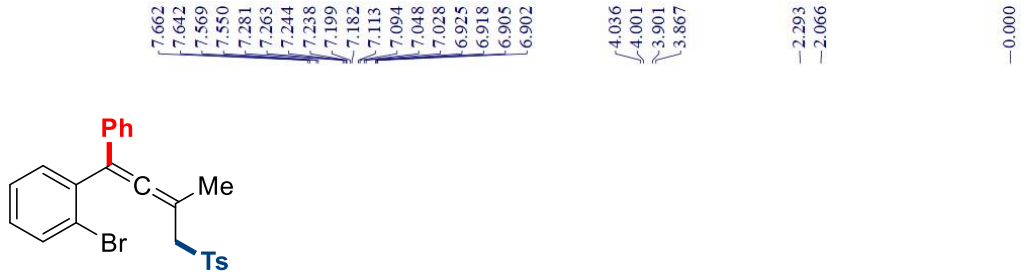
Ph
C
Me
CF3
Ts


1.12
1.97
2.20
4.04
2.00
1.95
1.03
1.02
2.99
3.04
f1 (ppm)

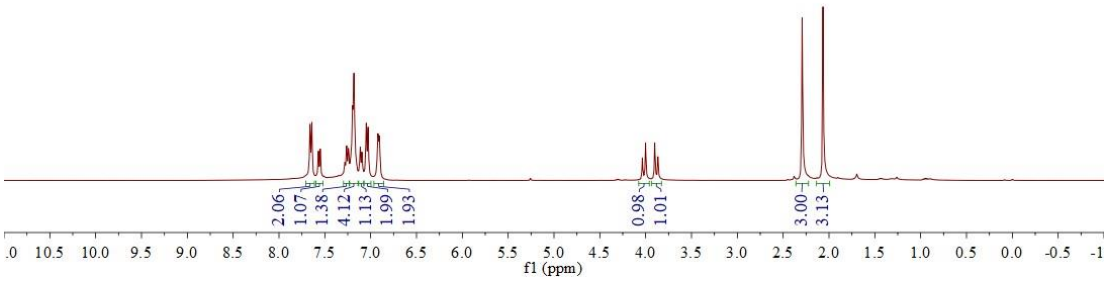

205.445
144.320
136.082
135.111
134.624
132.160
131.632
129.510
129.136
128.836
128.129
128.110
127.664
127.127
126.949
126.220
126.168
126.117
125.186
122.461
105.965
93.932
77.318
77.001
76.683
61.093
21.632
18.486
f1 (ppm)

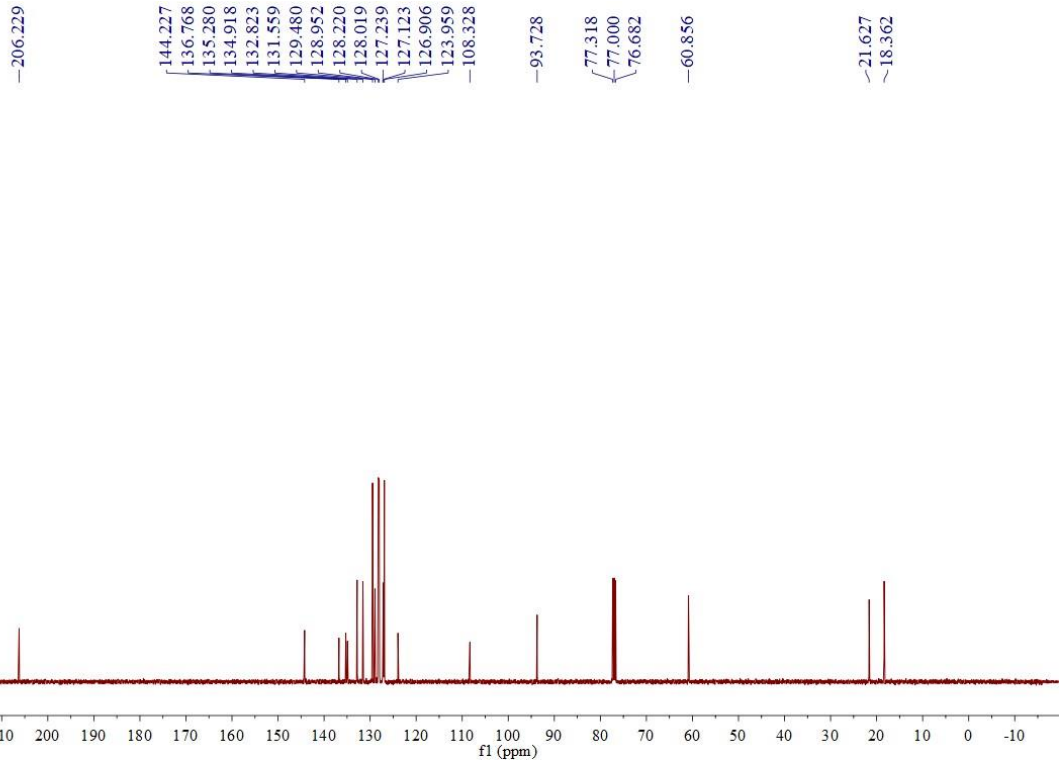

-59.294
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)

13


7.662
7.642
7.569
7.550
7.281
7.263
7.244
7.238
7.199
7.182
7.113
7.094
7.048
7.028
6.925
6.918
6.905
6.902
4.036
4.001
3.901
3.867
2.293
2.066
0.000

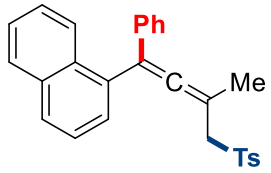
Ph
C
Me
Br
Ts

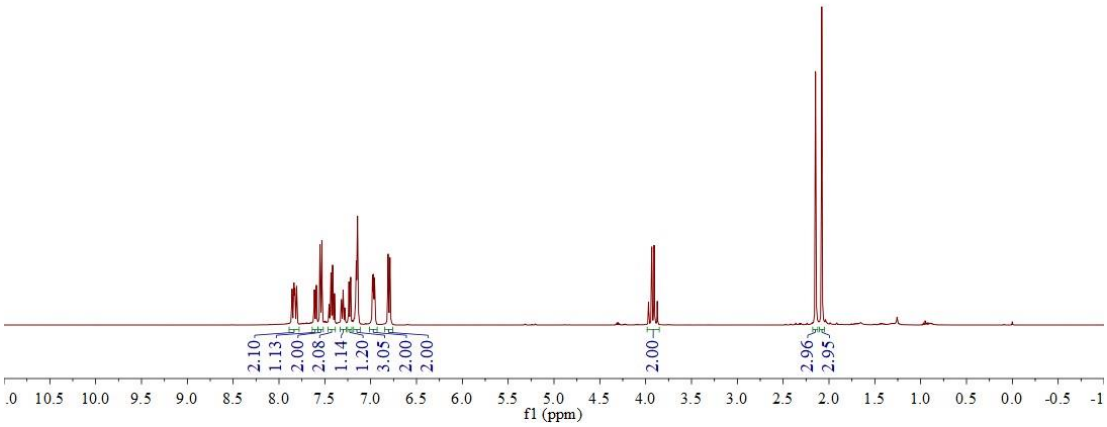

2.06
1.07
1.38
4.12
1.13
1.99
1.93
0.98
1.01
3.00
3.13
f1 (ppm)


206.229
144.227
136.768
135.280
134.918
132.823
131.559
129.480
128.952
128.220
128.019
127.239
127.123
126.906
123.959
108.328
93.728
77.318
77.000
76.682
60.856
21.627
18.362
f1 (ppm)

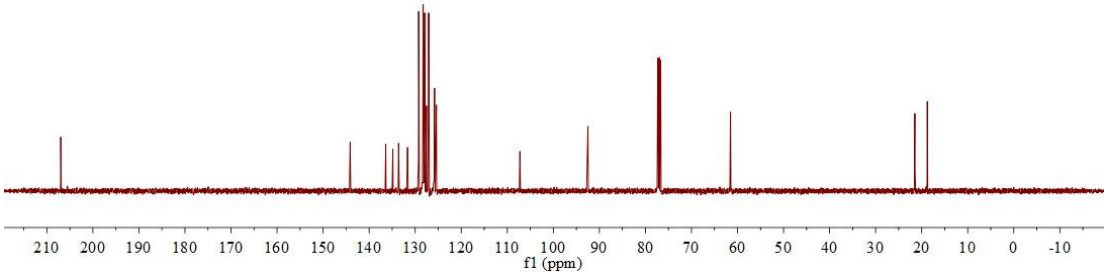
14


7.857
7.837
7.828
7.807
7.613
7.592
7.553
7.532
7.456
7.453
7.439
7.436
7.433
7.419
7.415
7.412
7.395
7.322
7.318
7.305
7.301
7.297
7.239
7.236
7.222
7.218
7.170
7.166
7.161
7.157
7.149
7.143
7.134
6.980
6.972
6.969
6.961
6.955
6.809
6.789
3.968
3.934
3.908
3.873
2.147
0.079
0.000

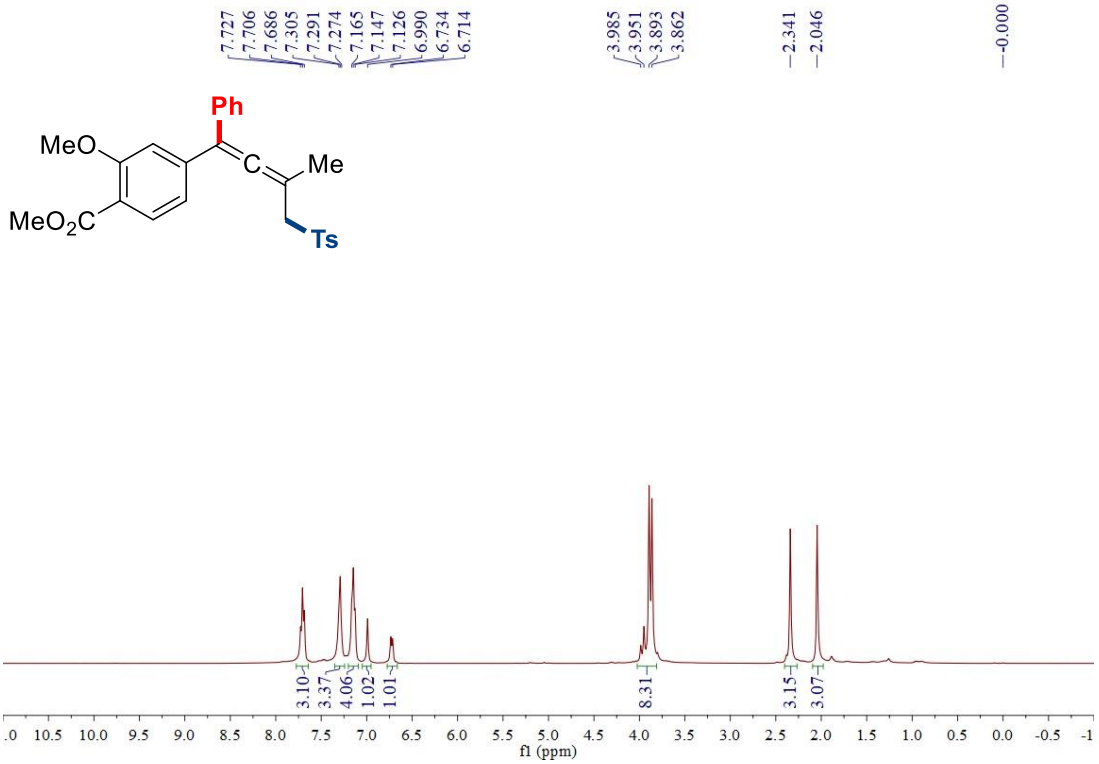

Ph
C
Me
Ts


2.10
1.13
2.00
2.08
1.14
1.20
3.05
2.00
2.00
2.00
2.96
2.95
.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1
f1 (ppm)

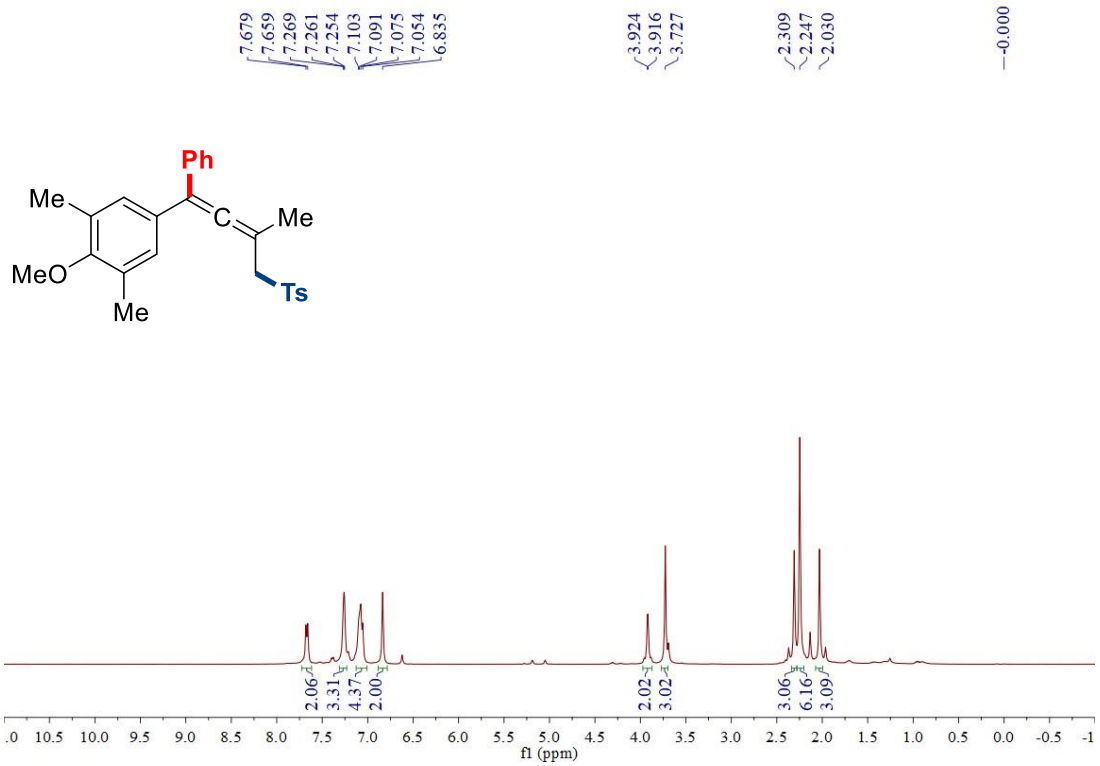

206.975
144.123
136.392
134.857
133.599
133.512
131.653
129.247
128.266
128.185
128.018
127.927
127.542
127.118
127.069
125.924
125.797
125.769
125.385
107.258
92.475
77.317
76.999
76.682
61.514
21.479
18.777

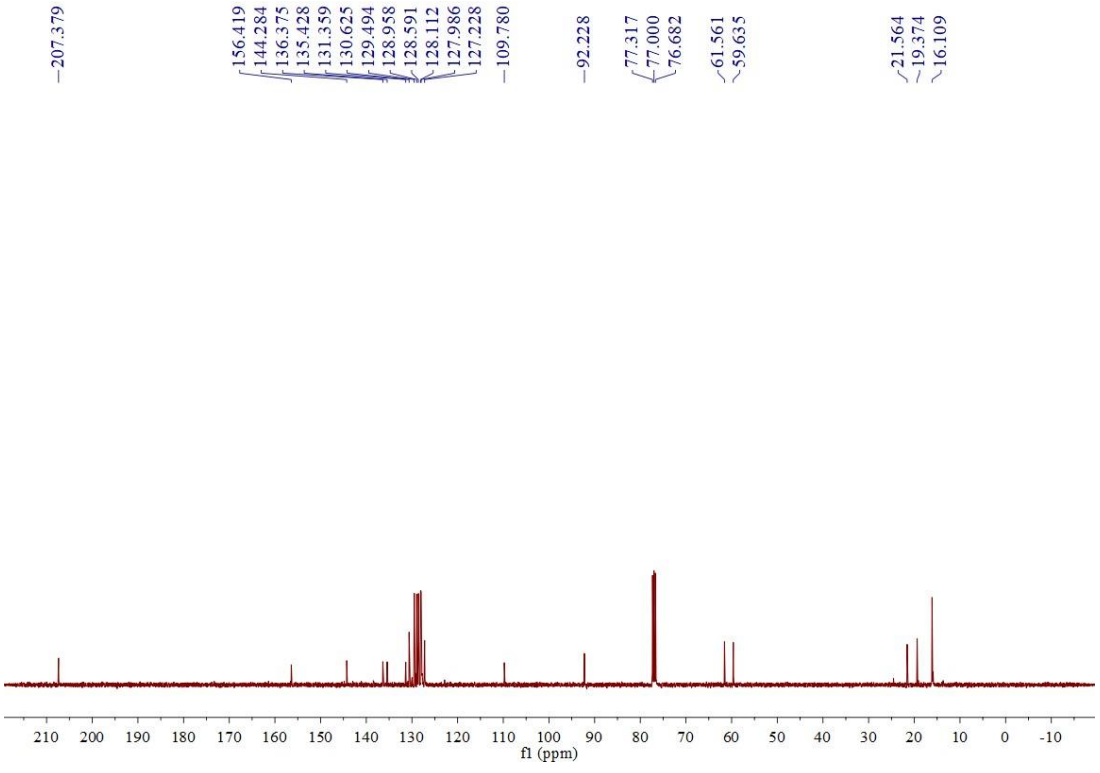

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

15


7.727
7.706
7.686
7.305
7.291
7.274
7.165
7.147
7.126
6.990
6.734
6.714
3.985
3.951
3.893
3.862
2.341
2.046
0.000
Ph
MeO
C
Me
MeO2C
Ts
3.10
3.37
4.06
1.02
1.01
8.31
3.15
3.07
f1 (ppm)
207.691
166.229
159.065
144.549
141.816
135.448
135.377
131.429
129.582
128.439
128.281
127.873
127.609
120.206
118.557
112.250
109.679
93.180
77.319
77.000
76.682
61.046
56.006
51.854
21.420
19.149
f1 (ppm)

16


7.679
7.659
7.269
7.261
7.254
7.103
7.091
7.075
7.054
6.835
3.924
3.916
3.727
2.309
2.247
2.030
-0.000
Ph
Me
C
Me
MeO
Ts
Me
2.06
3.31
4.37
2.00
2.02
3.02
3.06
6.16
3.09
f1 (ppm)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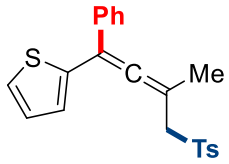
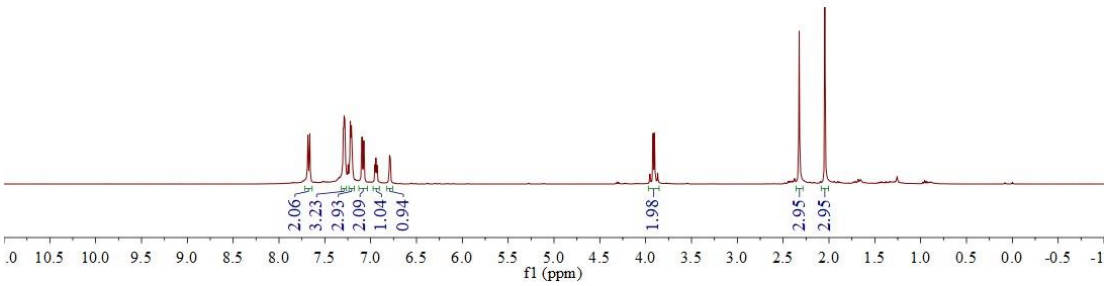
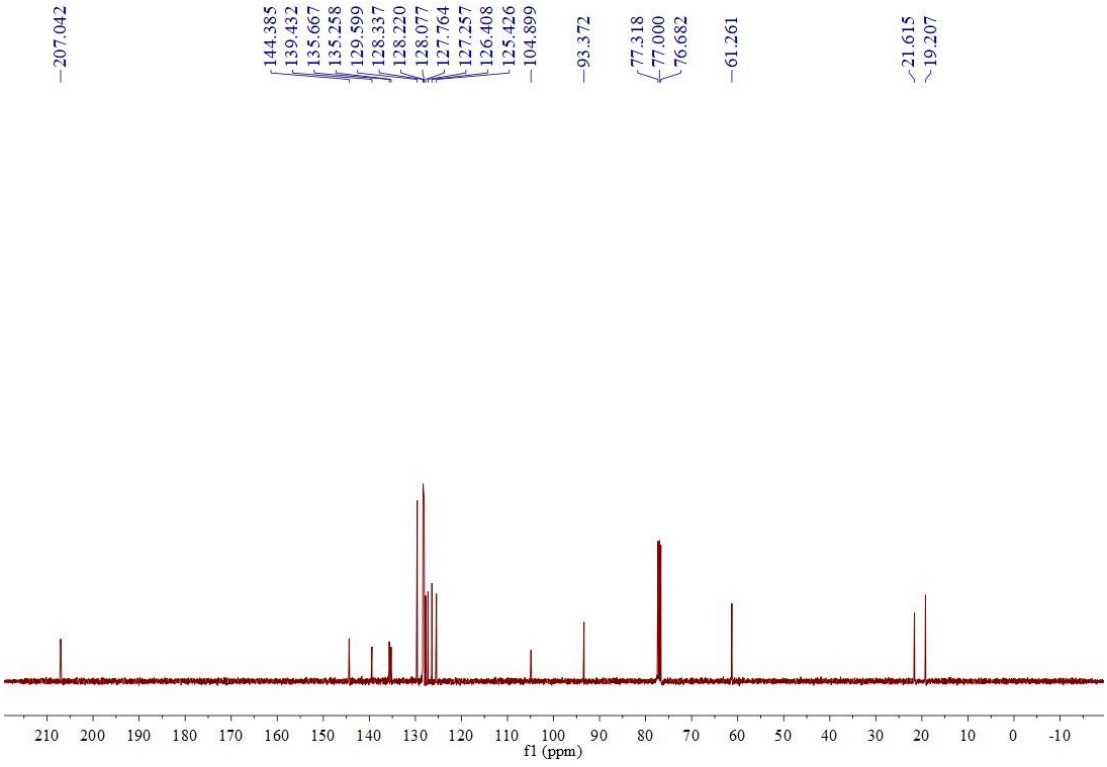
144.284
136.375
135.428
131.359
130.625
129.494
128.958
128.591
128.112
127.986
127.228
109.780
92.228
77.317
77.000
76.682
61.561
59.635
21.564
19.374
16.109
f1 (ppm)

17


7.685
7.665
7.298
7.290
7.282
7.222
7.216
7.211
7.207
7.198
7.094
7.075
6.952
6.943
6.939
6.930
6.795
6.792
6.786
6.783
3.954
3.919
3.903
3.868
2.325
2.046
0.000


Ph
S
C
Me
Ts

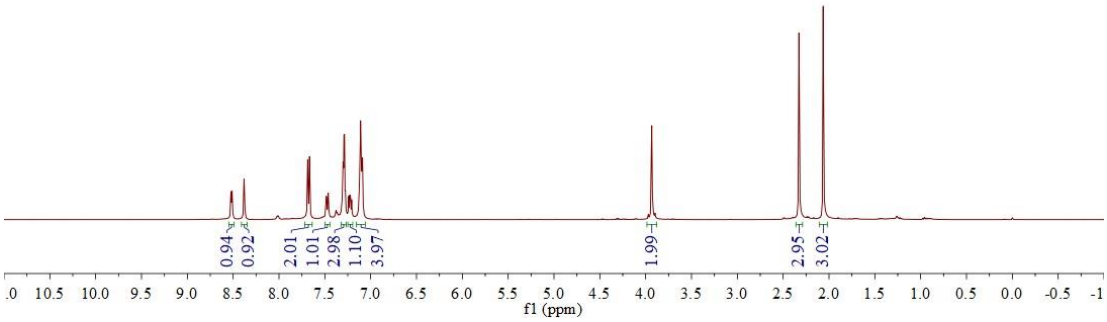

2.06
3.23
2.93
2.09
1.04
0.94
1.98
2.95
2.95
f1 (ppm)

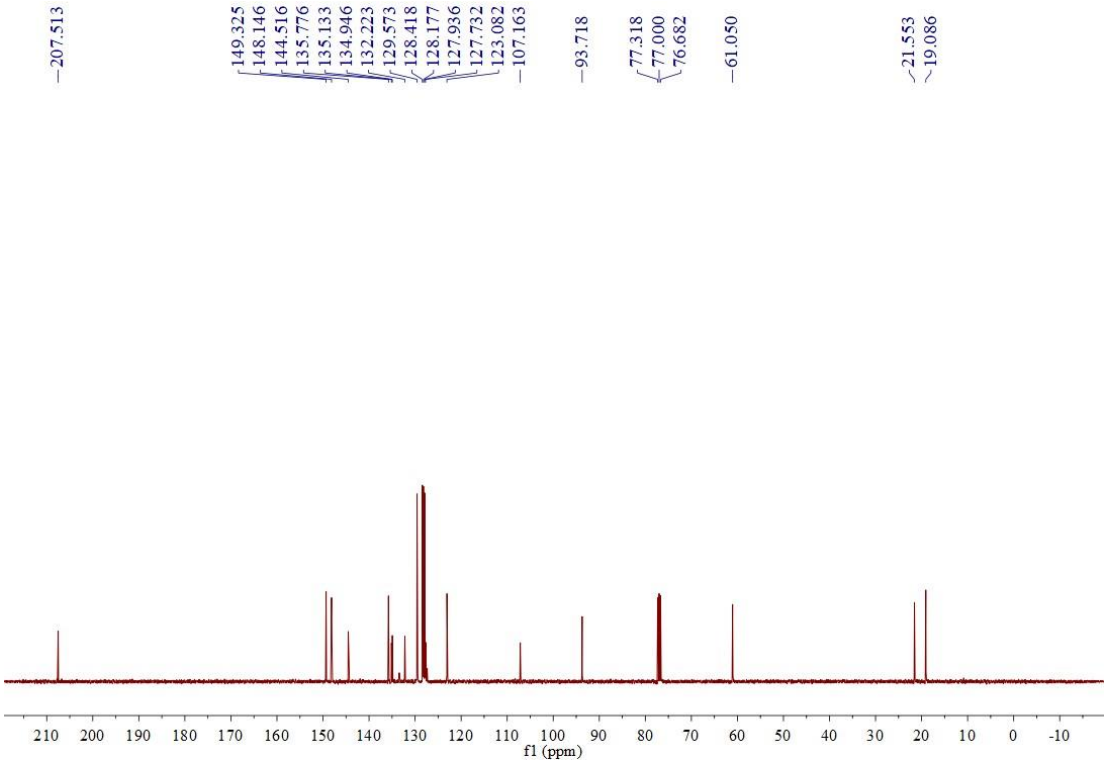

207.042
144.385
139.432
135.667
135.258
129.599
128.337
128.220
128.077
127.764
127.257
126.408
125.426
104.899
93.372
77.318
77.000
76.682
61.261
21.615
19.207
f1 (ppm)

18

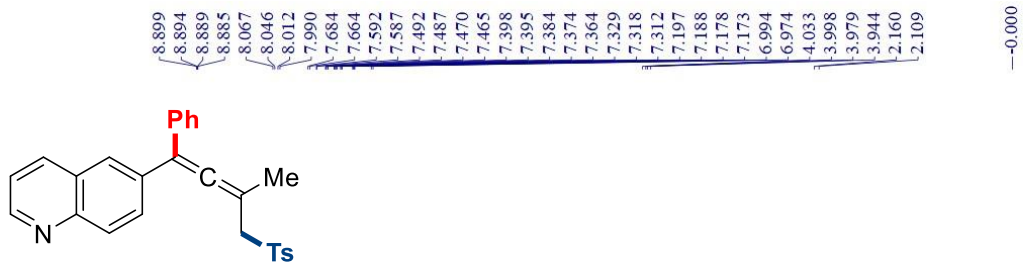

8.525
8.521
8.513
8.509
8.382
8.376
7.687
7.667
7.488
7.483
7.478
7.468
7.463
7.458
7.303
7.299
7.291
7.285
7.276
7.239
7.227
7.220
7.208
7.121
7.110
7.102
7.096
7.089
3.936
3.932
2.328
2.063
0.000

Ph
N
C
Me
Ts


0.94
0.92
2.01
1.01
2.98
1.10
3.97
1.99
2.95
3.02
f1 (ppm)


207.513
149.325
148.146
144.516
135.776
135.133
134.946
132.223
129.573
128.418
128.177
127.936
127.732
123.082
107.163
93.718
77.318
77.000
76.682
61.050
21.553
19.086
f1 (ppm)

19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8.889
8.885
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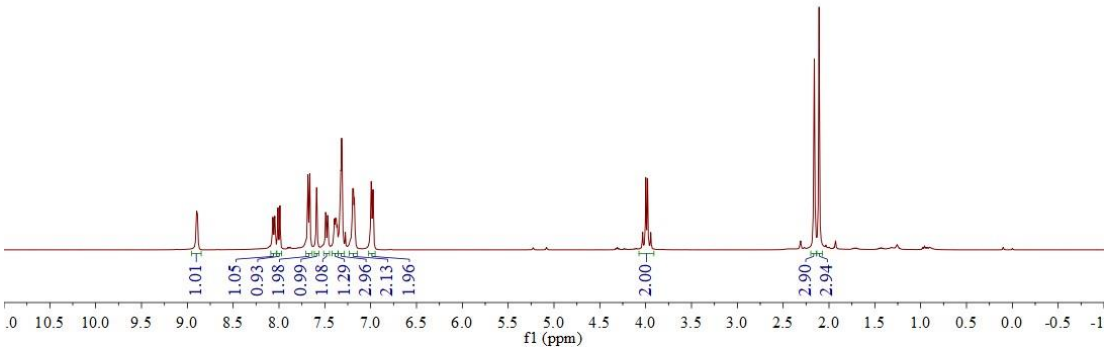
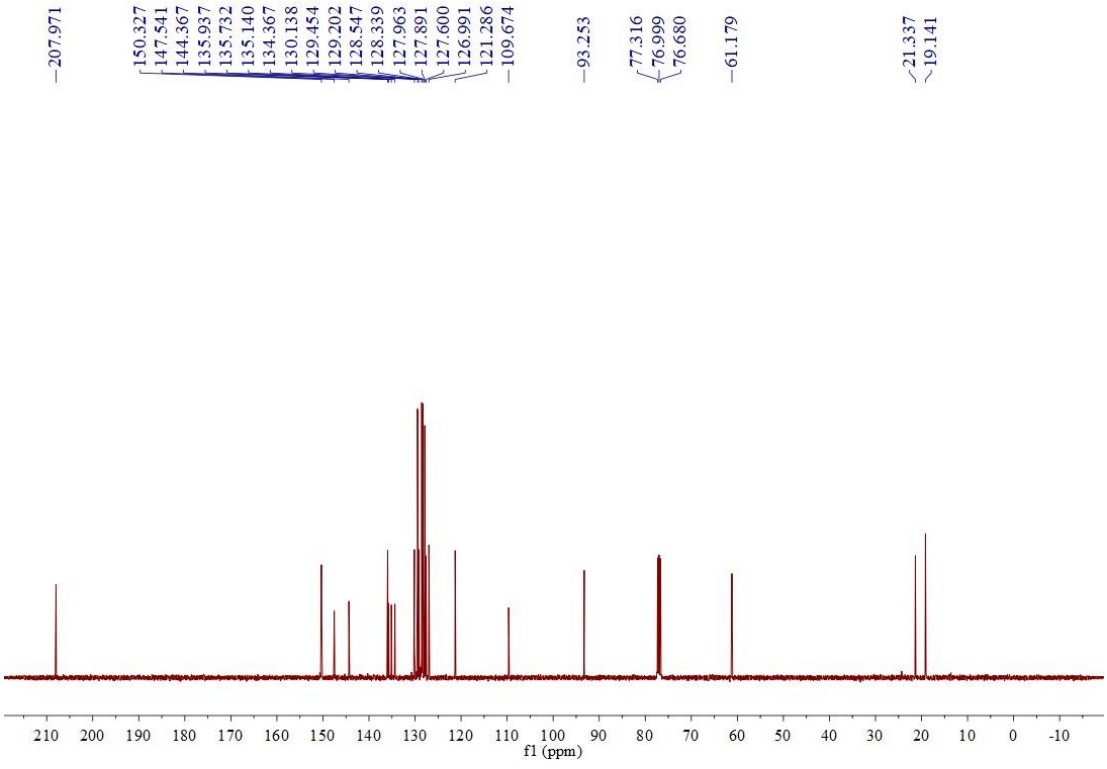
8.046
8.012
7.990
7.684
7.664
7.592
7.587
7.492
7.487
7.470
7.465
7.398
7.395
7.384
7.374
7.364
7.329
7.318
7.312
7.197
7.188
7.178
7.173
6.994
6.974
4.033
3.998
3.979
3.944
2.160
2.109
0.000
Ph
C
Me
N
Ts


1.01
1.05
0.93
1.98
0.99
1.08
1.29
2.96
2.13
1.96
2.00
2.90
2.94
f1 (ppm)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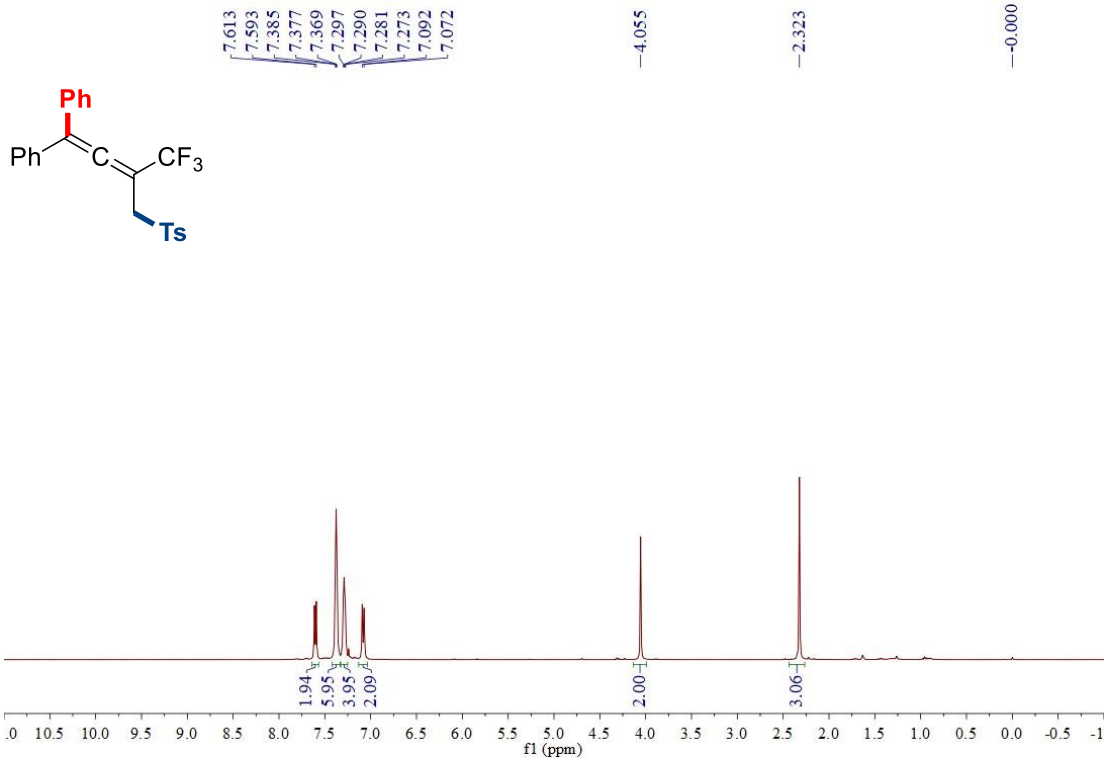
150.327
147.541
144.367
135.937
135.732
135.140
134.367
130.138
129.454
129.202
128.547
128.339
127.963
127.891
127.600
126.991
121.286
109.674
93.253
77.316
76.999
76.680
61.179
21.337
19.141
f1 (ppm)

20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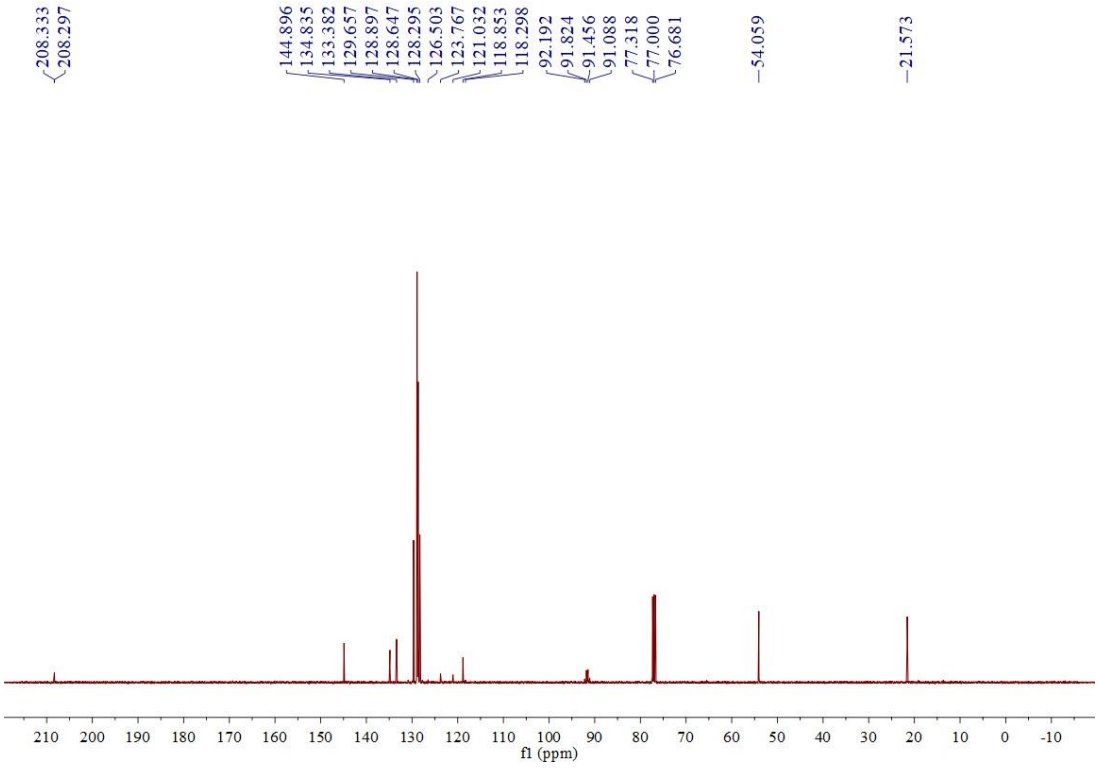
7.593
7.385
7.377
7.369
7.297
7.290
7.281
7.273
7.092
7.072
4.055
2.323
0.000
Ph
Ph
C
CF3
Ts
1.94
5.95
3.95
2.09
2.00
3.06
f1 (ppm)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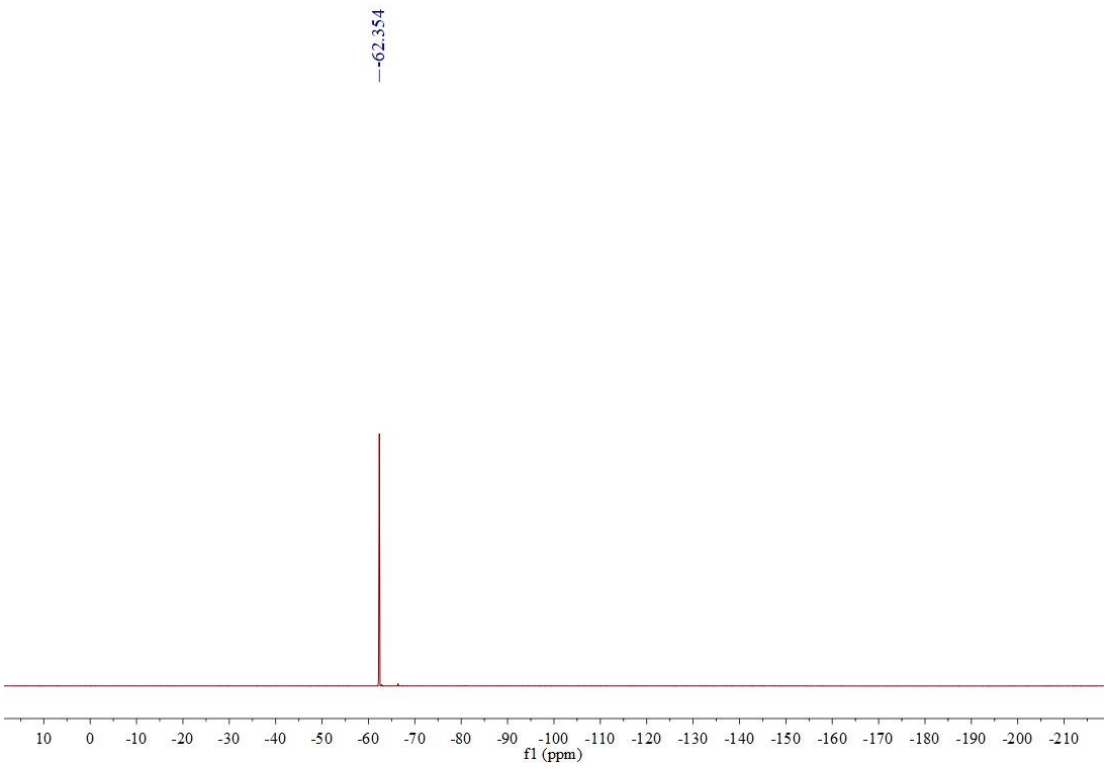
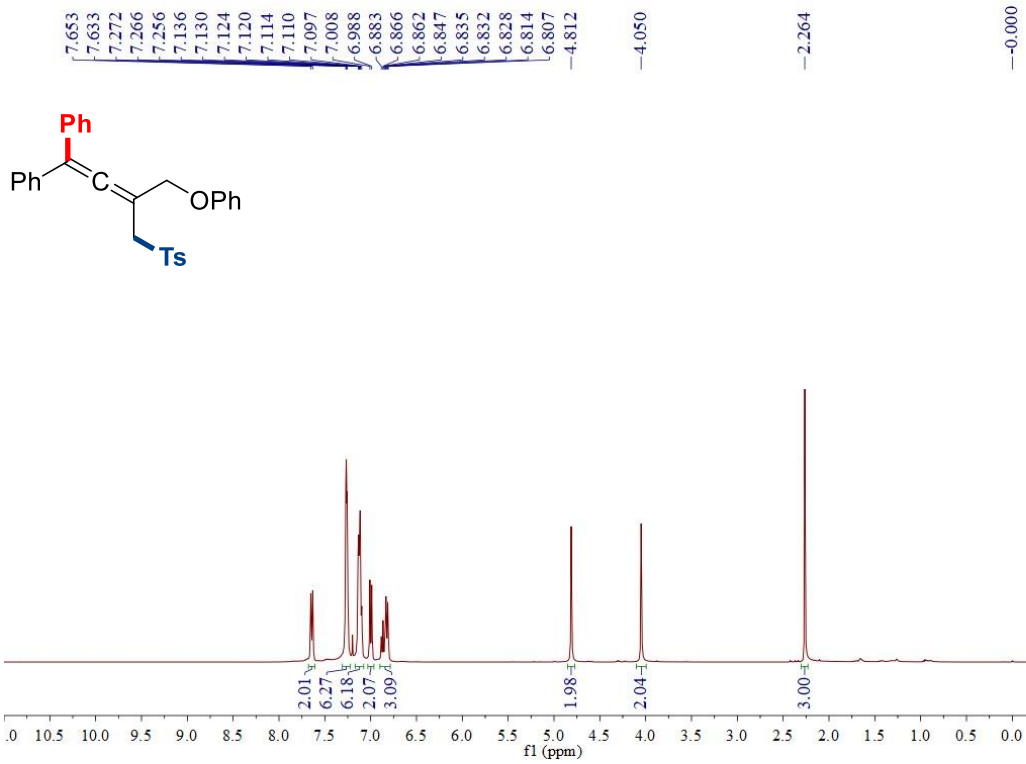
208.297
144.896
134.835
133.382
129.657
128.897
128.647
128.295
126.503
123.767
121.032
118.853
118.298
92.192
91.824
91.456
91.088
77.318
77.000
76.681
54.059
21.573
f1 (ppm)


-62.354
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)

21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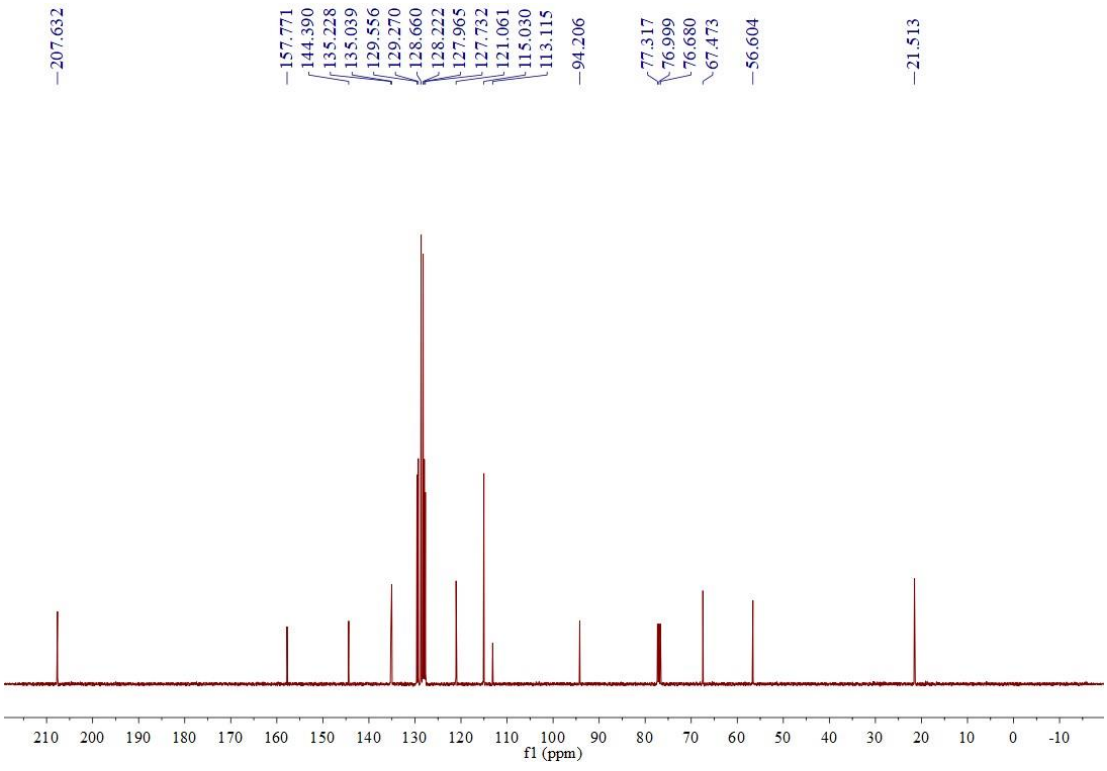
7.633
7.272
7.266
7.256
7.136
7.130
7.124
7.120
7.114
7.110
7.097
7.008
6.988
6.883
6.866
6.862
6.847
6.835
6.832
6.828
6.814
6.807
4.812
4.050
2.264
0.000
Ph
Ph
C
OPh
Ts
2.01
6.27
6.18
2.07
3.09
1.98
2.04
3.00
f1 (ppm)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144.390
135.228
135.039
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129.270
128.660
128.222
127.965
127.732
121.061
115.030
113.115
94.206
77.317
76.999
76.680
67.473
56.604
21.513
f1 (ppm)

22


7.807
7.790
7.674
7.653
7.483
7.464
7.317
7.298
7.278
7.213
7.195
7.188
7.183
7.179
7.175
7.171
7.163
7.156
7.146
7.140
7.135
7.099
7.095
7.091
7.080
7.075
7.029
7.009
4.535
4.519
4.504
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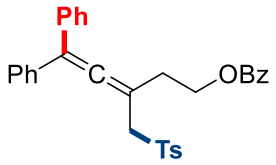
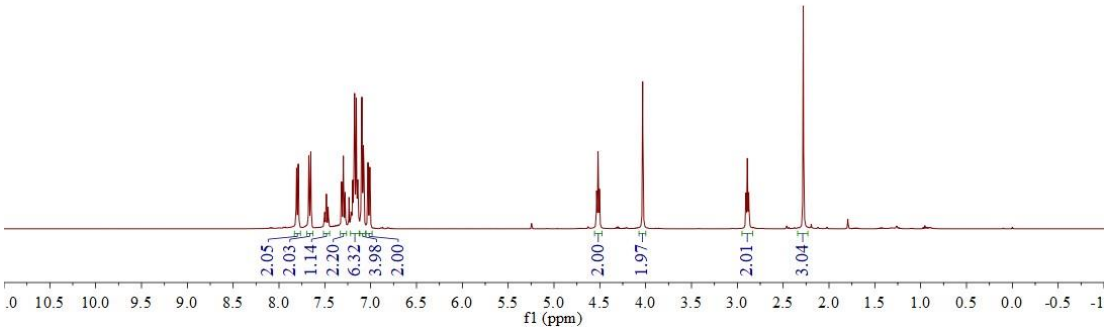
2.876
2.281
0.000


Ph
Ph
C
OBz
Ts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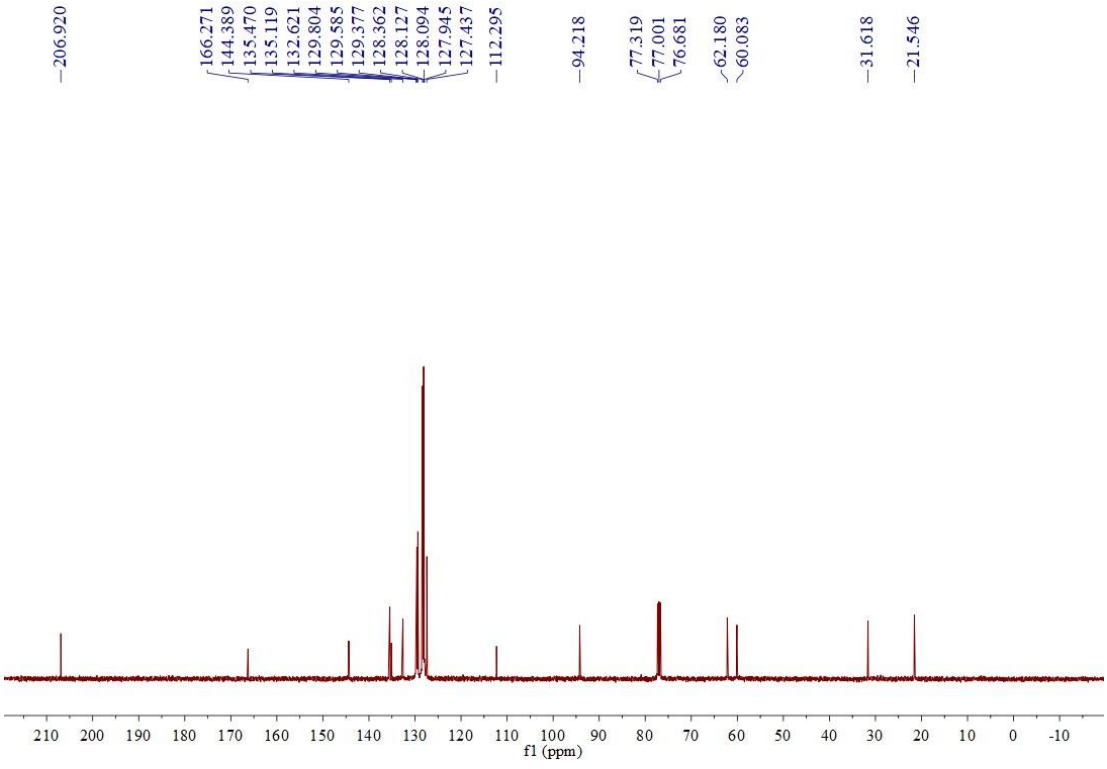
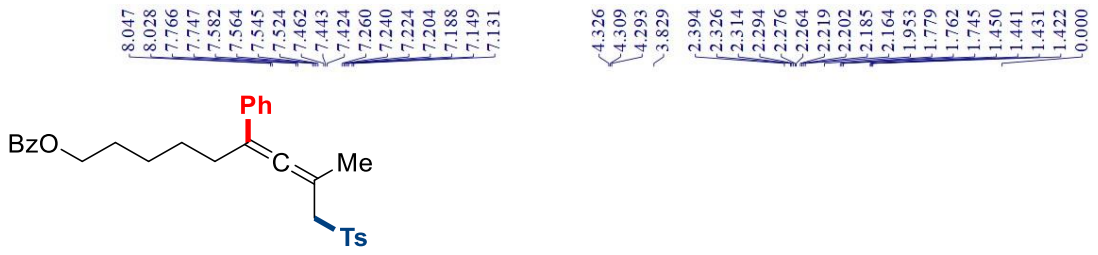
2.03
1.14
2.20
6.32
3.98
2.00
2.00
1.97
2.01
3.04
f1 (ppm)


206.920
166.271
144.389
135.470
135.119
132.621
129.804
129.585
129.377
128.362
128.127
128.094
127.945
127.437
112.295
94.218
77.319
77.001
76.681
62.180
60.083
31.618
21.546
f1 (ppm)

23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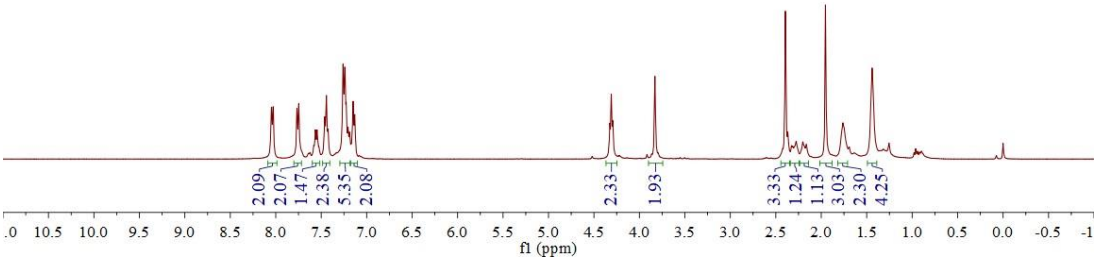
8.028
7.766
7.747
7.582
7.564
7.545
7.524
7.462
7.443
7.424
7.260
7.240
7.224
7.204
7.188
7.149
7.131
4.326
4.309
4.293
3.829
2.394
2.326
2.314
2.294
2.276
2.264
2.219
2.202
2.185
2.164
1.953
1.779
1.762
1.745
1.450
1.441
1.431
1.422
0.000
Ph
BzO
C
Me
Ts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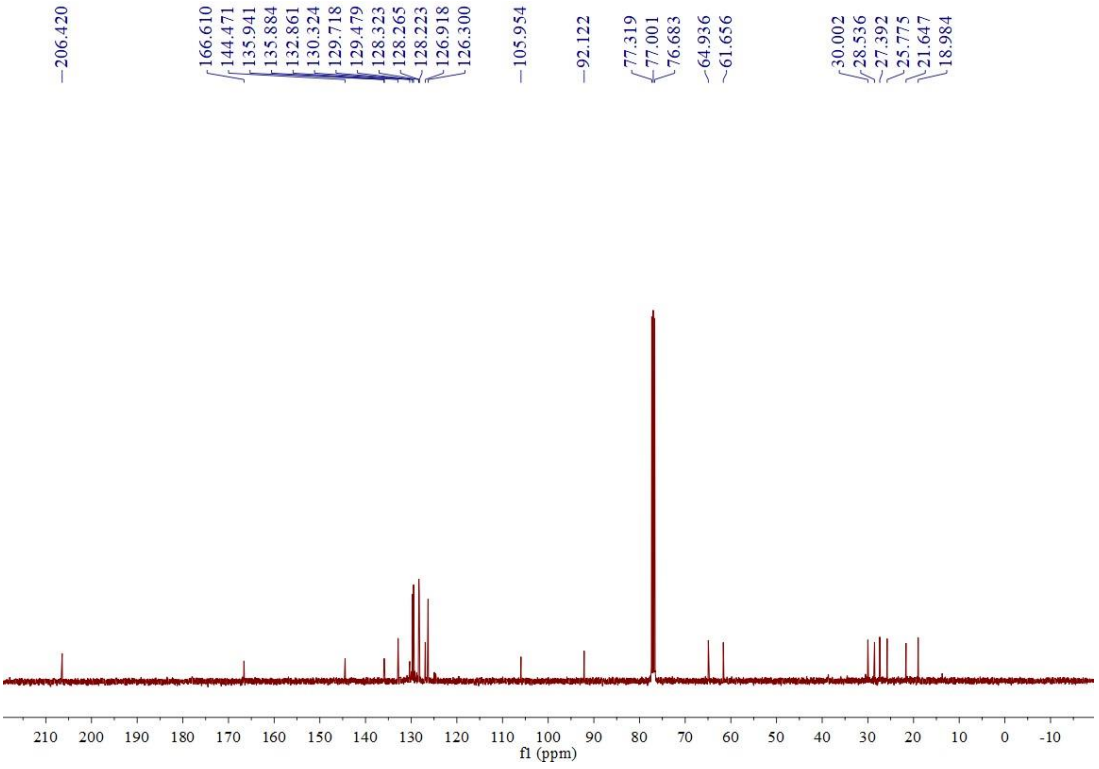
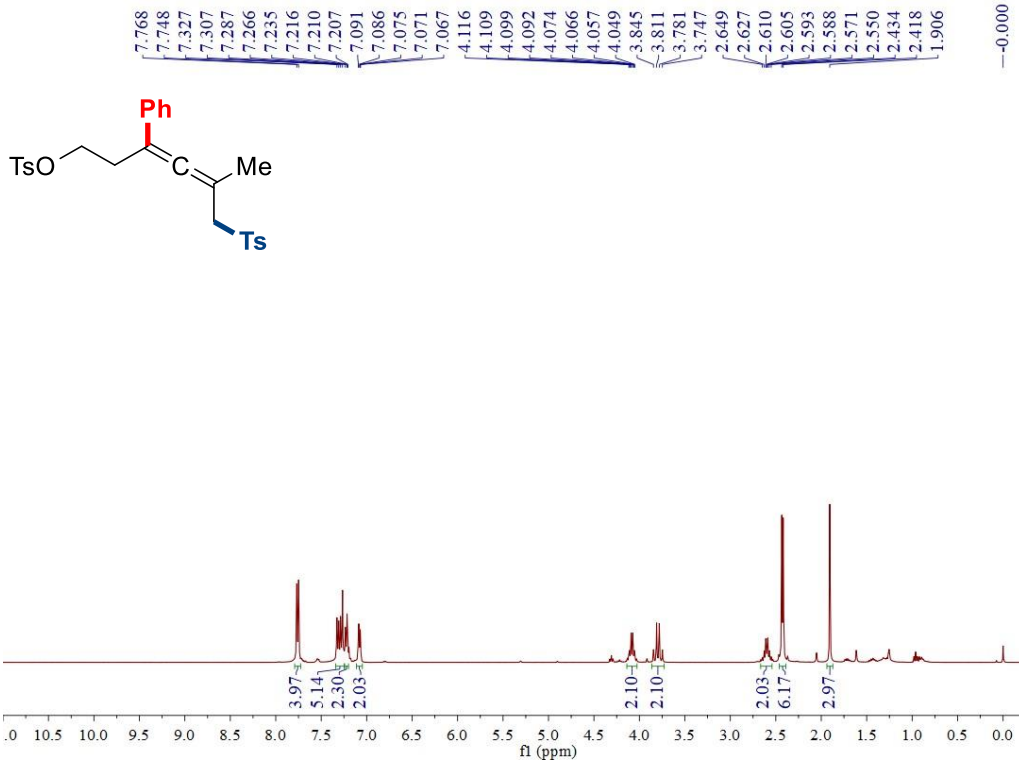
2.07
1.47
2.38
5.35
2.08
2.33
1.93
3.33
1.24
1.13
3.03
2.30
4.25
f1 (ppm)


206.420
166.610
144.471
135.941
135.884
132.861
130.324
129.718
129.479
128.323
128.265
128.223
126.918
126.300
105.954
92.122
77.319
77.001
76.683
64.936
61.656
30.002
28.536
27.392
25.775
21.647
18.984
f1 (ppm)

24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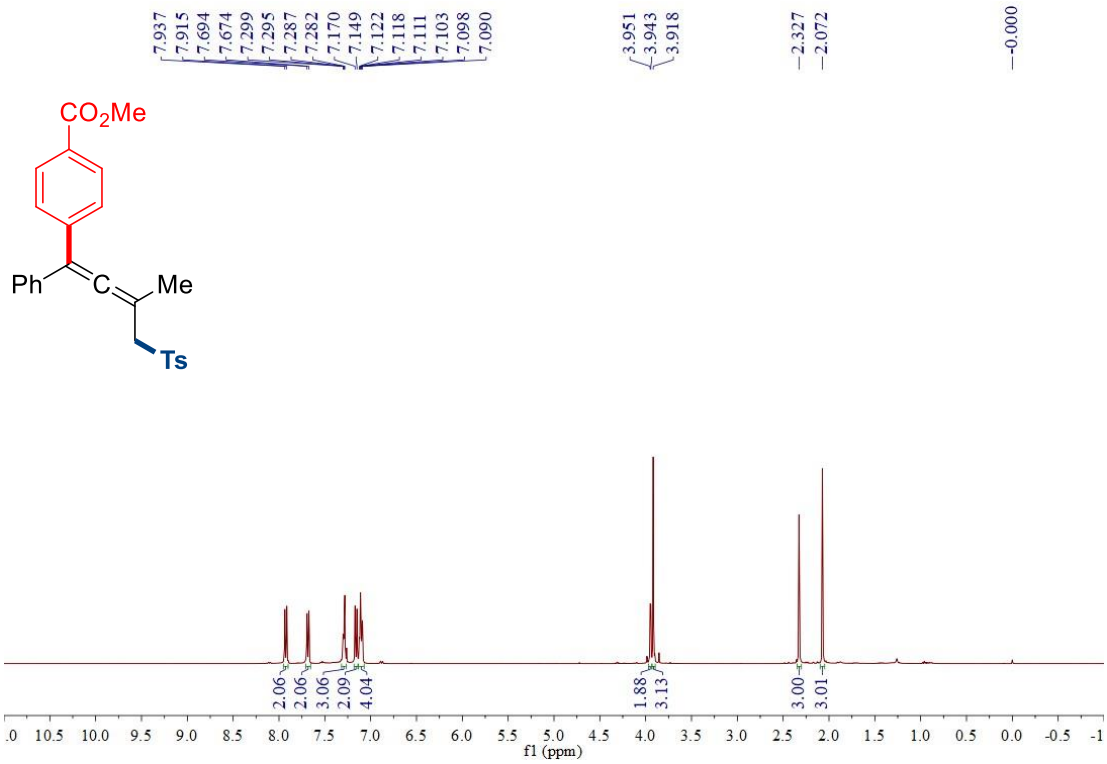
7.327
7.307
7.287
7.266
7.235
7.216
7.210
7.207
7.091
7.086
7.075
7.071
7.067
4.116
4.109
4.099
4.092
4.074
4.066
4.057
4.049
3.845
3.811
3.781
3.747
2.649
2.627
2.610
2.605
2.593
2.588
2.571
2.550
2.434
2.418
1.906
-0.000
Ph
TsO
C
Me
Ts
3.97
5.14
2.30
2.03
2.10
2.10
2.03
6.17
2.97
f1 (ppm)
206.391
144.799
144.773
135.804
134.760
132.844
129.841
129.822
128.420
128.200
127.831
127.290
126.051
101.440
93.902
77.318
77.000
76.682
68.178
61.252
29.655
21.661
21.638
18.963
f1 (ppm)

25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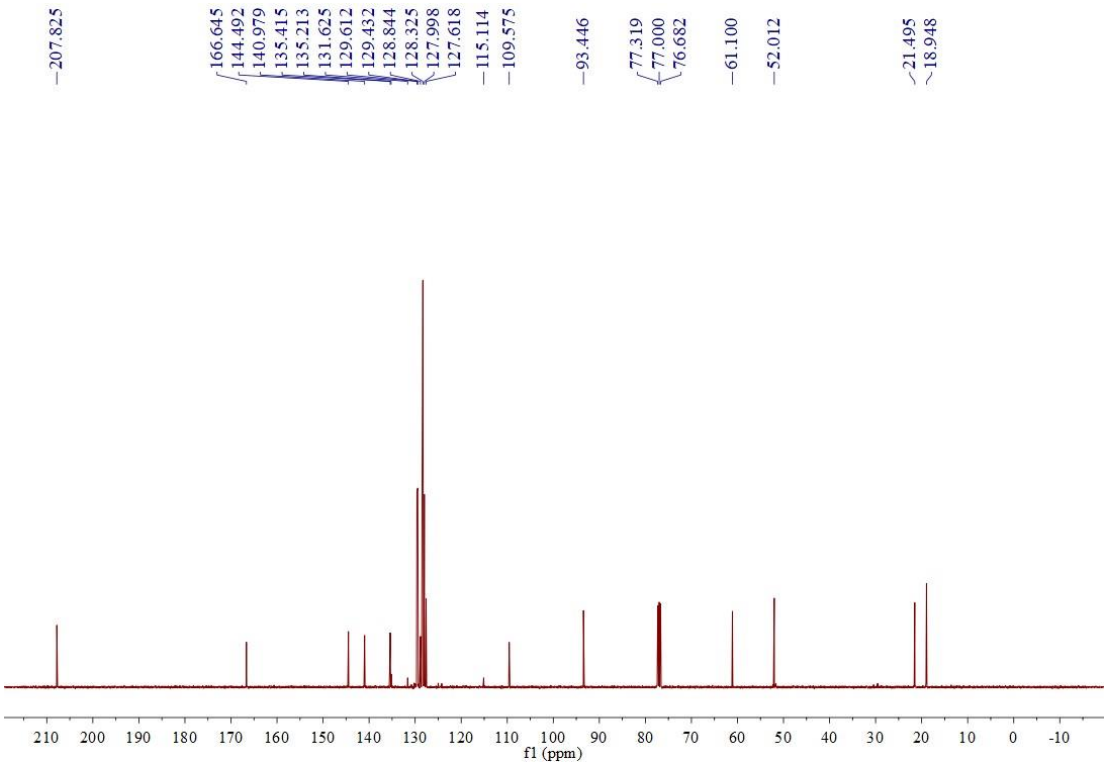
7.694
7.674
7.299
7.295
7.287
7.282
7.170
7.149
7.122
7.118
7.111
7.103
7.098
7.090
3.951
3.943
3.918
2.327
2.072
0.000
CO2Me
Ph
C
Me
Ts
2.06
2.06
3.06
2.09
4.04
1.88
3.13
3.00
3.01
f1 (ppm)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135.415
135.213
131.625
129.612
129.432
128.844
128.325
127.998
127.618
115.114
109.575
93.446
77.319
77.000
76.682
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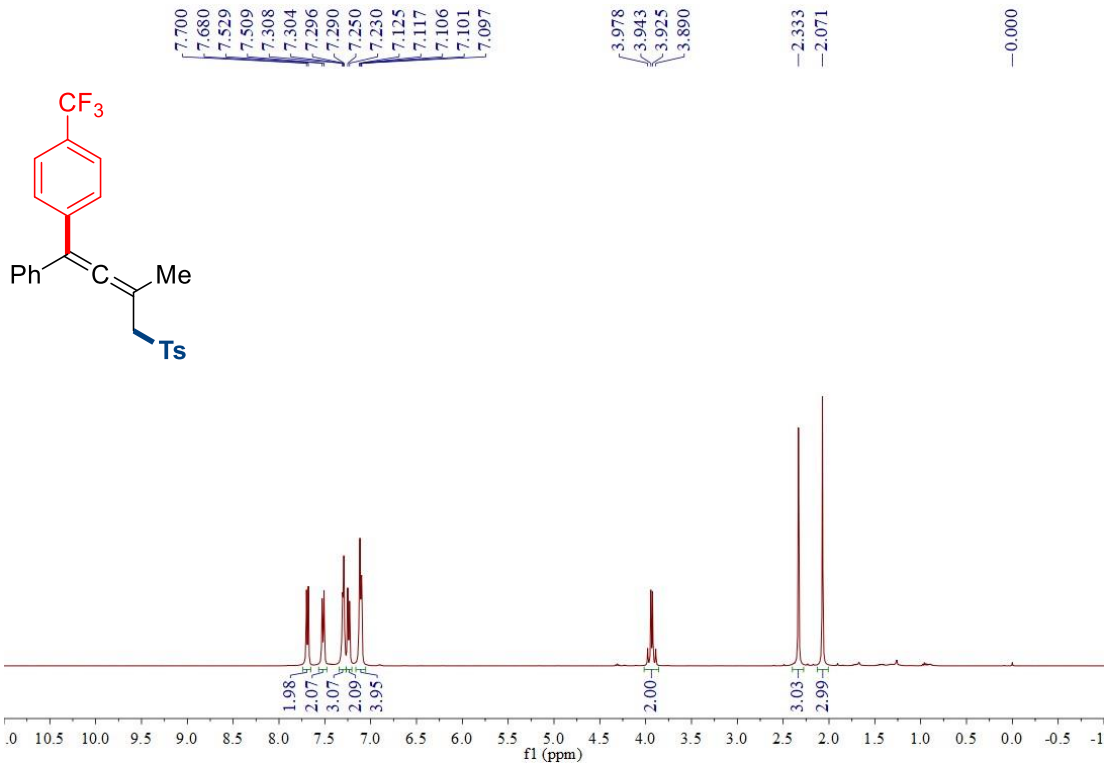
52.012
21.495
18.948
f1 (ppm)

26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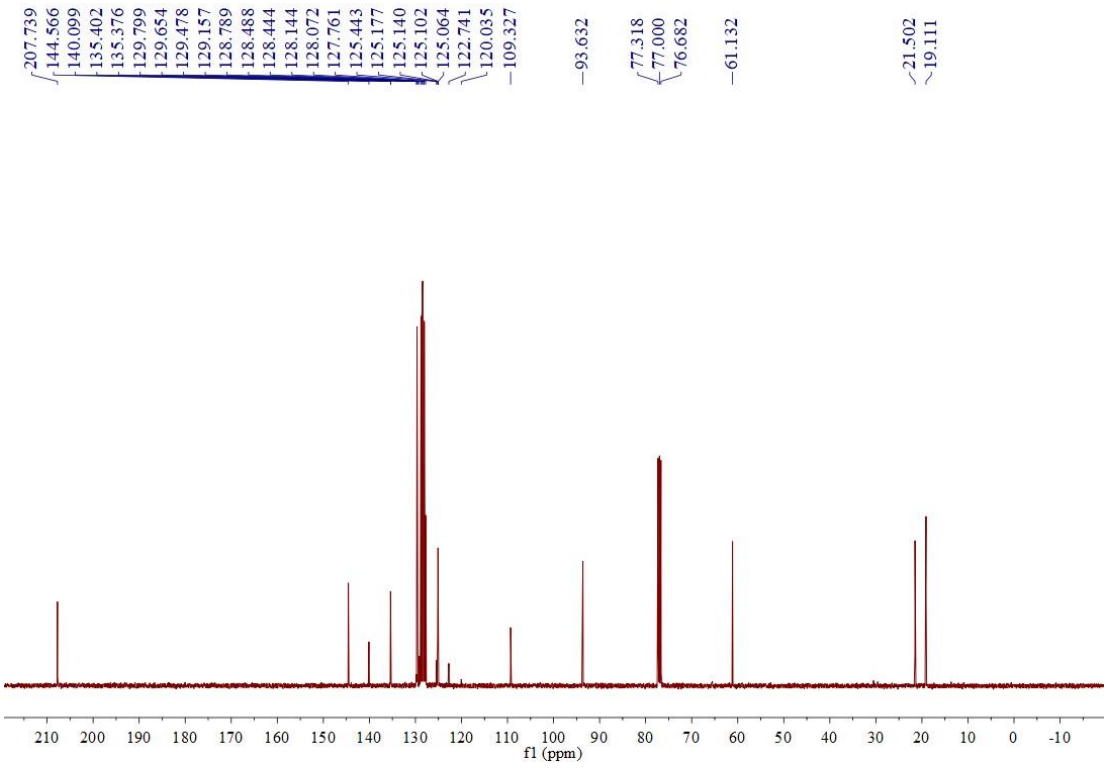
7.529
7.509
7.308
7.304
7.296
7.290
7.250
7.230
7.125
7.117
7.106
7.101
7.097
3.978
3.943
3.925
3.890
2.333
2.071
0.000
CF3
Ph
C
Me
Ts
1.98
2.07
3.07
2.09
3.95
2.00
3.03
2.99
f1 (ppm)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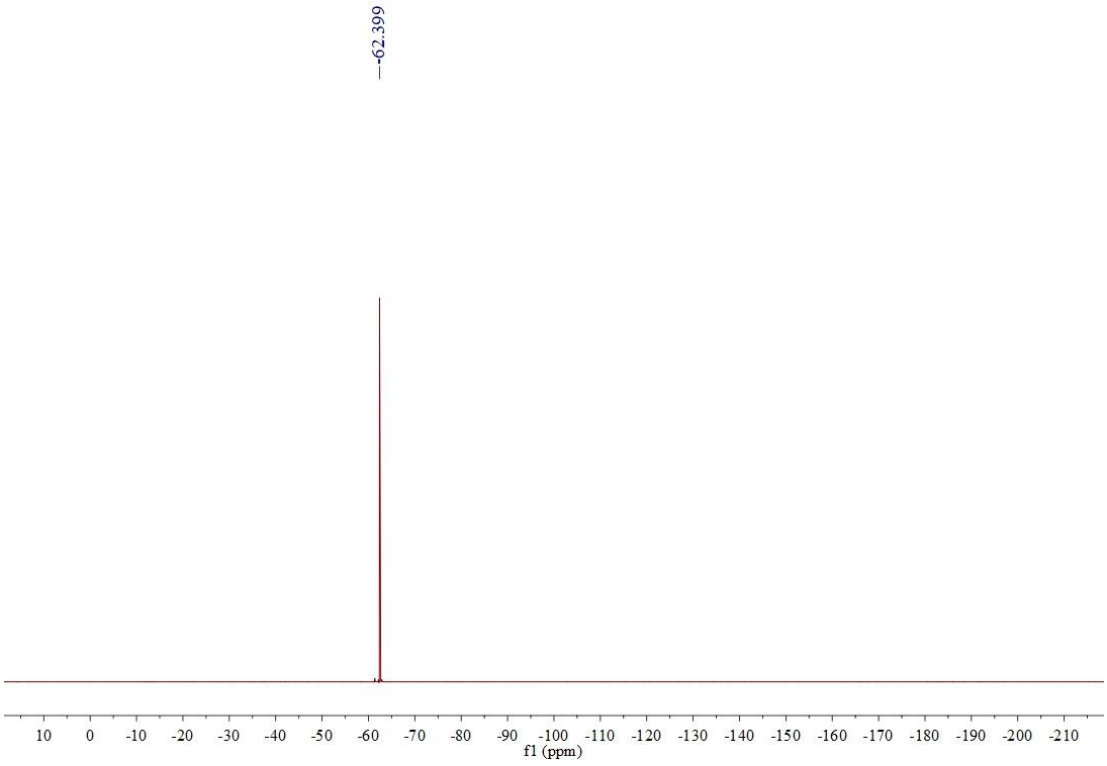
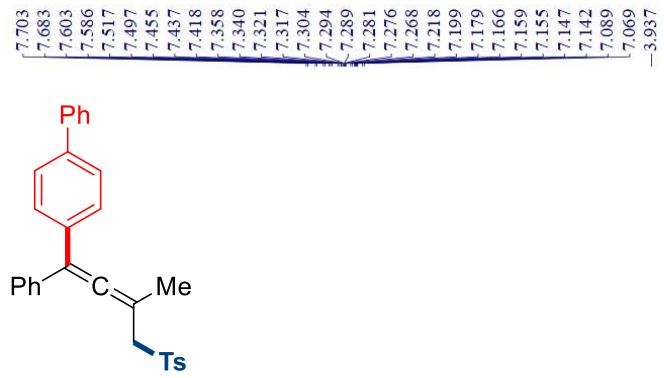
135.402
135.376
129.799
129.654
129.478
129.157
128.789
128.488
128.444
128.144
128.072
127.761
125.443
125.177
125.140
125.102
125.064
122.741
120.035
109.327
93.632
77.318
77.000
76.682
61.132
21.502
19.111
f1 (ppm)


-62.399
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)

27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7.683
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7.586
7.517
7.497
7.455
7.437
7.418
7.358
7.340
7.321
7.317
7.304
7.294
7.289
7.281
7.276
7.268
7.218
7.199
7.179
7.166
7.159
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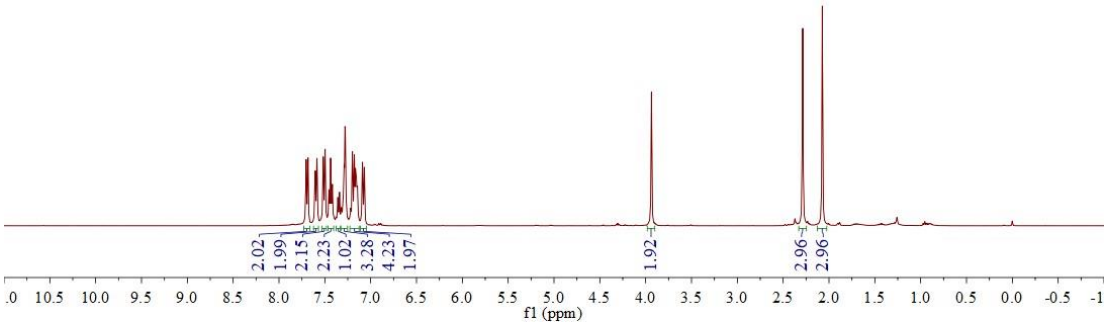
7.089
7.069
3.937
2.287
2.073
0.000

Ph
Ph
C
Me
Ts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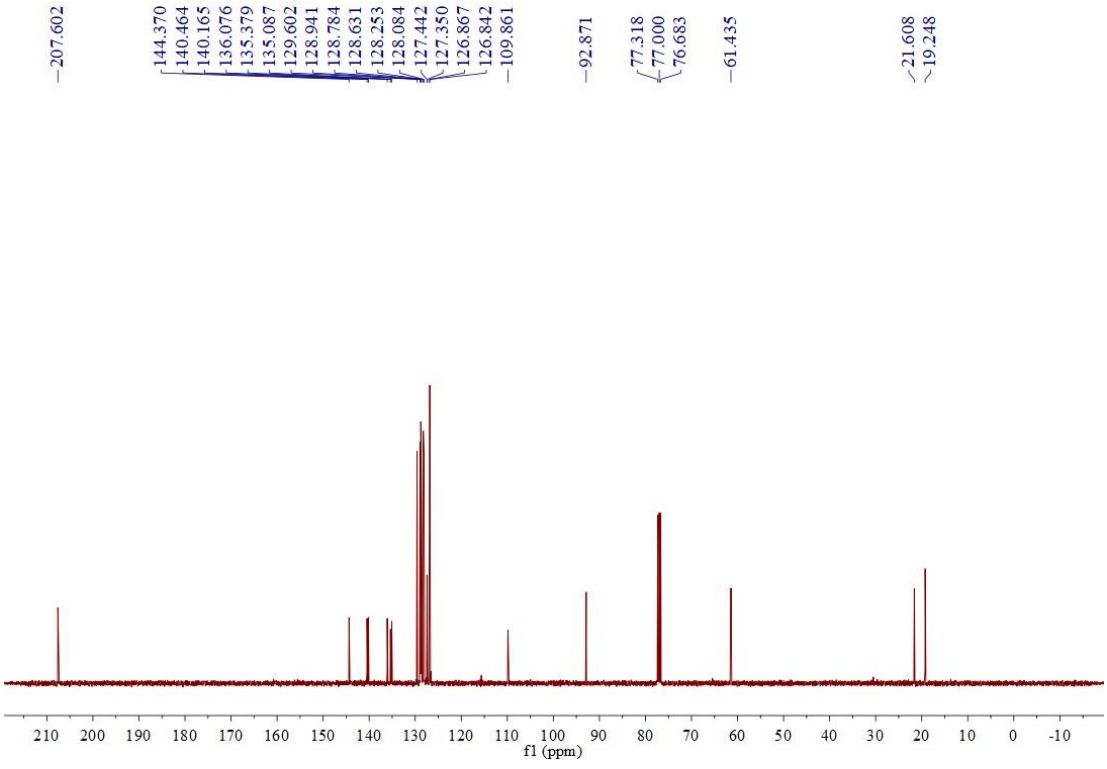
1.99
2.15
2.23
1.02
3.28
4.23
1.97
1.92
2.96
2.96
f1 (ppm)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144.370
140.464
140.165
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135.379
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129.602
128.941
128.784
128.631
128.253
128.084
127.442
127.350
126.867
126.842
109.861
92.871
77.318
77.000
76.683
61.435
21.608
19.248
f1 (ppm)

28


7.678
7.658
7.276
7.272
7.263
7.258
7.211
7.192
7.173
7.163
7.159
7.154
7.144
7.139
7.135
7.117
7.107
7.097
7.093
7.080
7.075
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6.874
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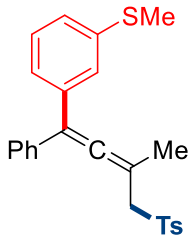
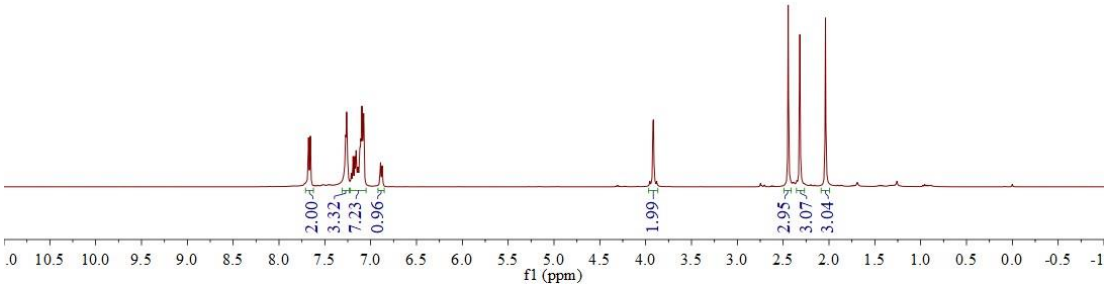
0.000


SMe
Ph
C
Me
Ts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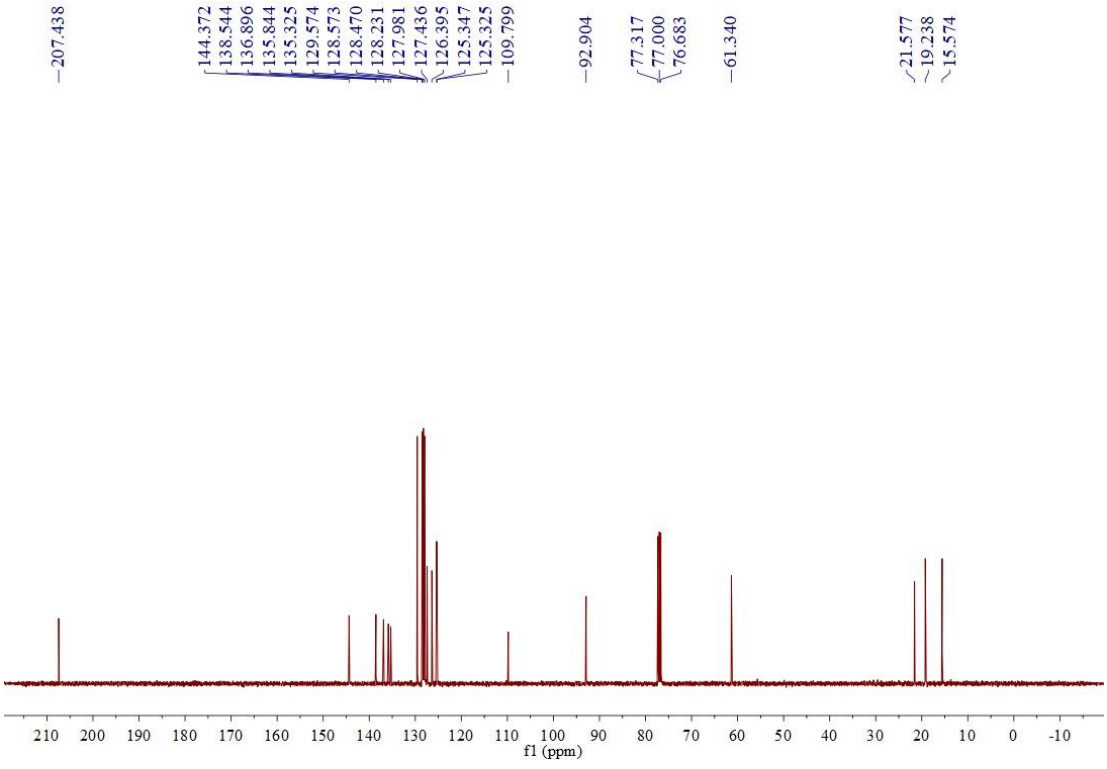
2.95
3.07
3.04
f1 (ppm)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135.325
129.574
128.573
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128.231
127.981
127.436
126.395
125.347
125.325
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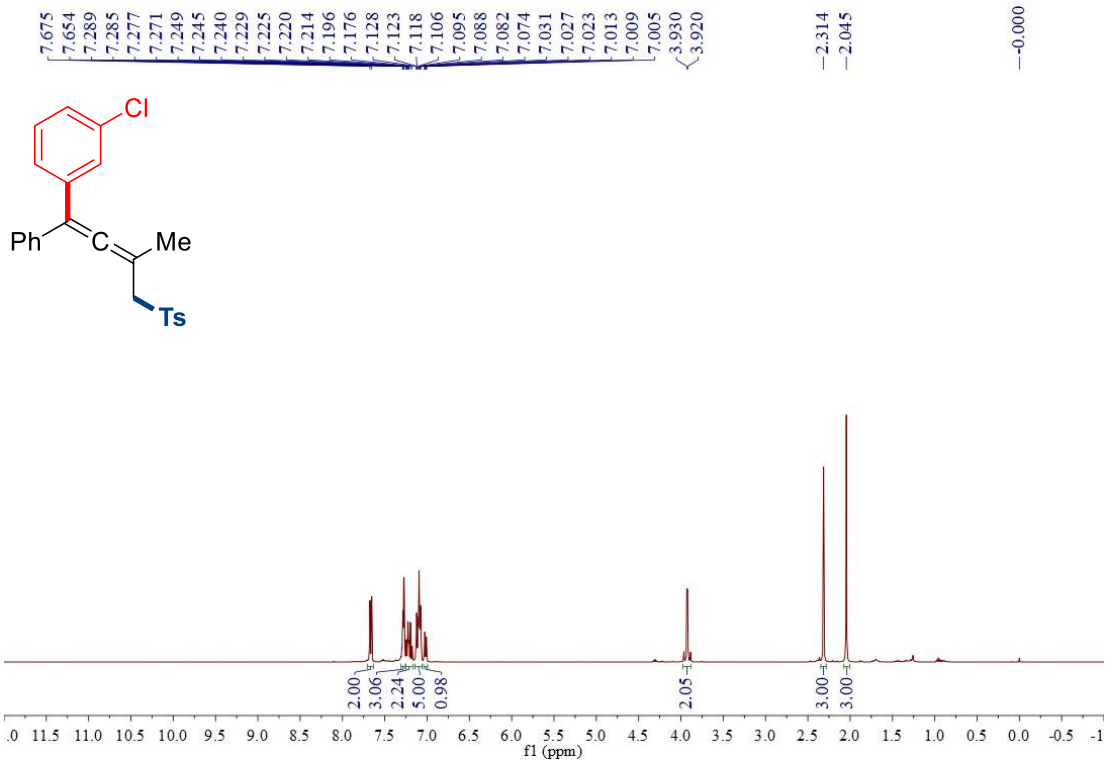
92.904
77.317
77.000
76.683
61.340
21.577
19.238
15.574
f1 (ppm)

29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7.249
7.245
7.240
7.229
7.225
7.220
7.214
7.196
7.176
7.128
7.123
7.118
7.106
7.095
7.088
7.082
7.074
7.031
7.027
7.023
7.013
7.009
7.005
3.930
3.920
2.314
2.045
0.000
Cl
Ph
C
Me
Ts
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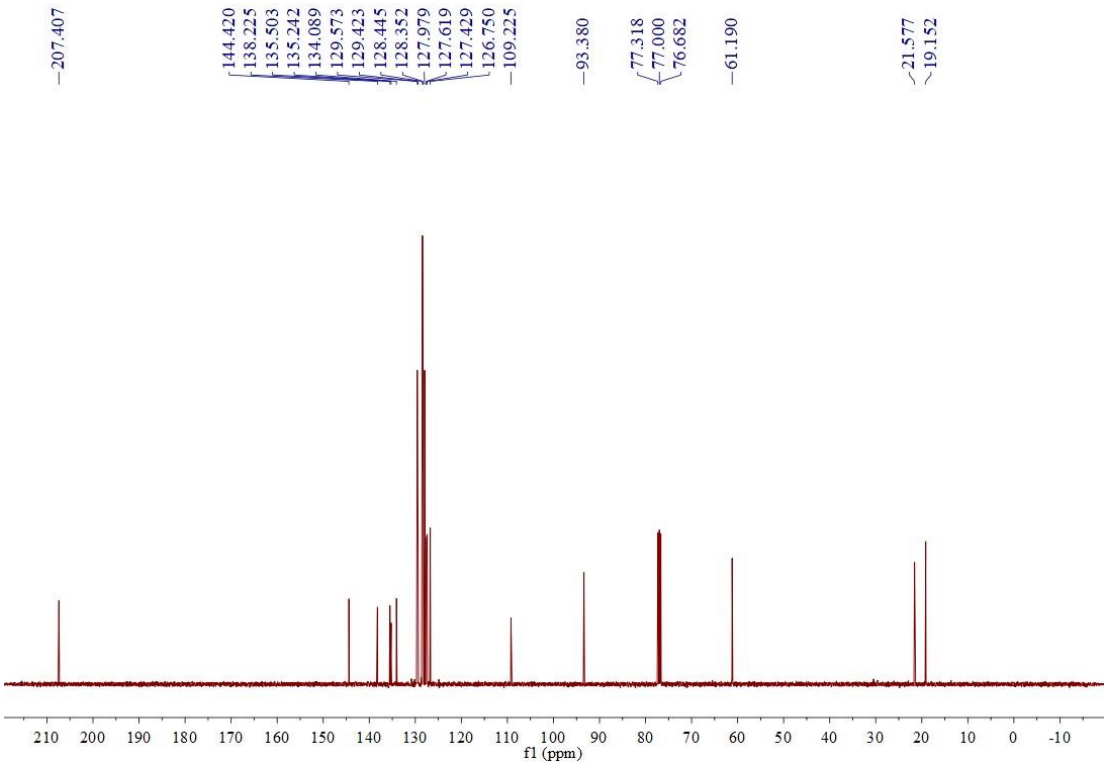
3.06
2.24
5.00
0.98
2.05
3.00
3.00
f1 (ppm)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129.423
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128.352
127.979
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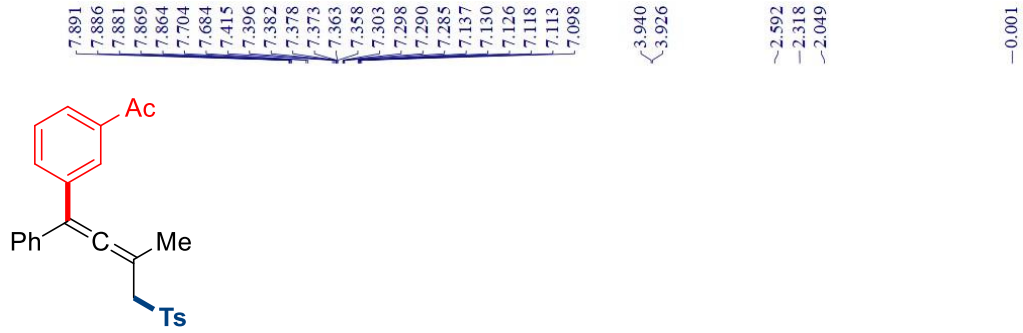
76.682
61.190
21.577
19.152
f1 (ppm)

30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7.704
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7.415
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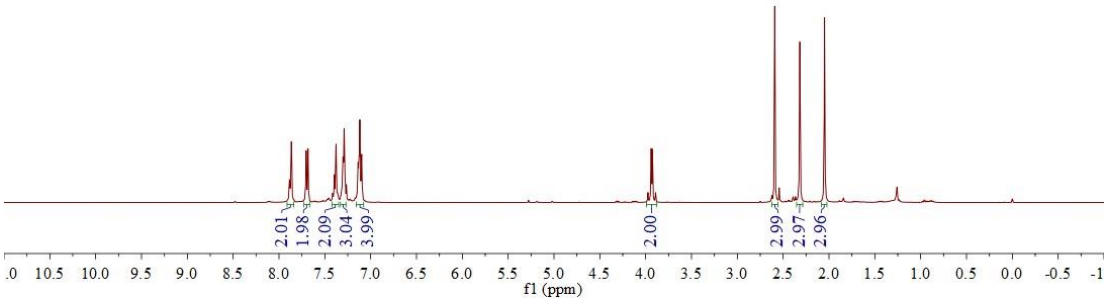
7.378
7.373
7.363
7.358
7.303
7.298
7.290
7.285
7.137
7.130
7.126
7.118
7.113
7.098
3.940
3.926
2.592
2.318
2.049
0.001
Ac
Ph
C
Me
Ts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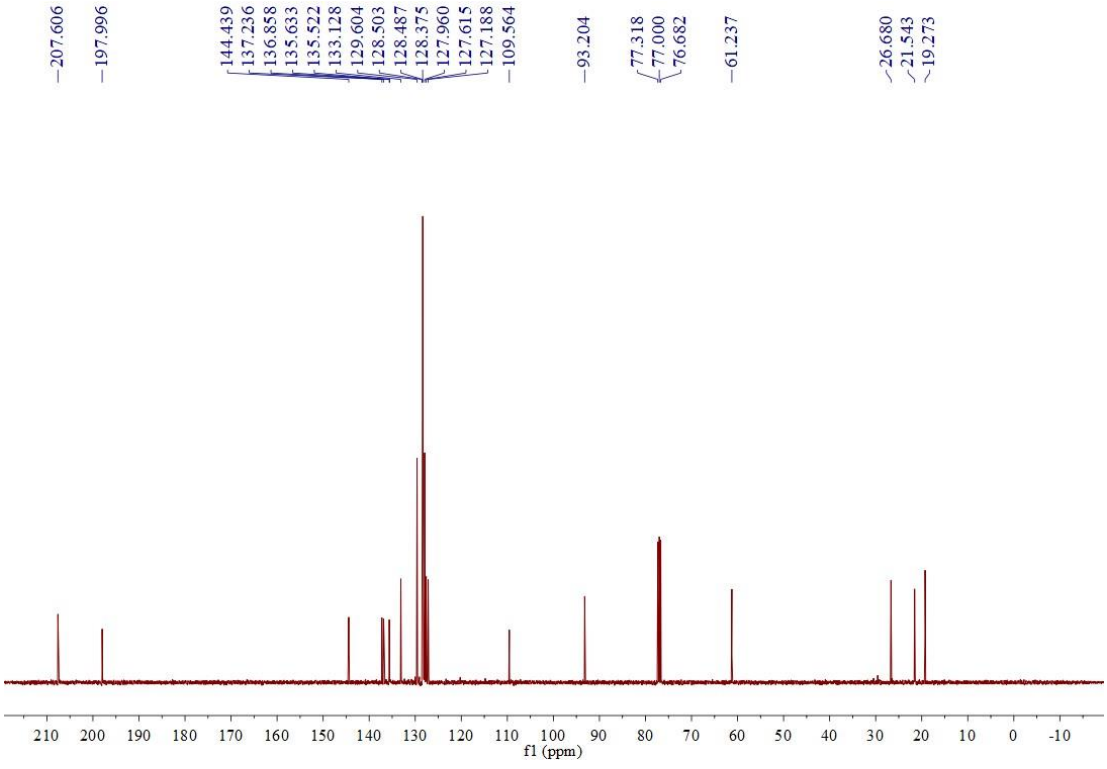
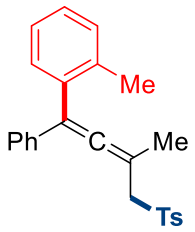
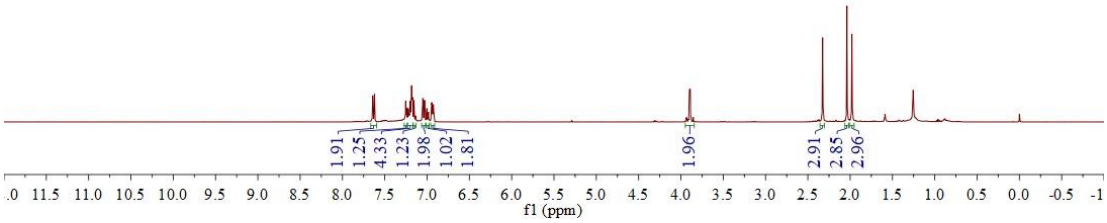
1.98
2.09
3.04
3.99
2.00
2.99
2.97
2.96
f1 (ppm)

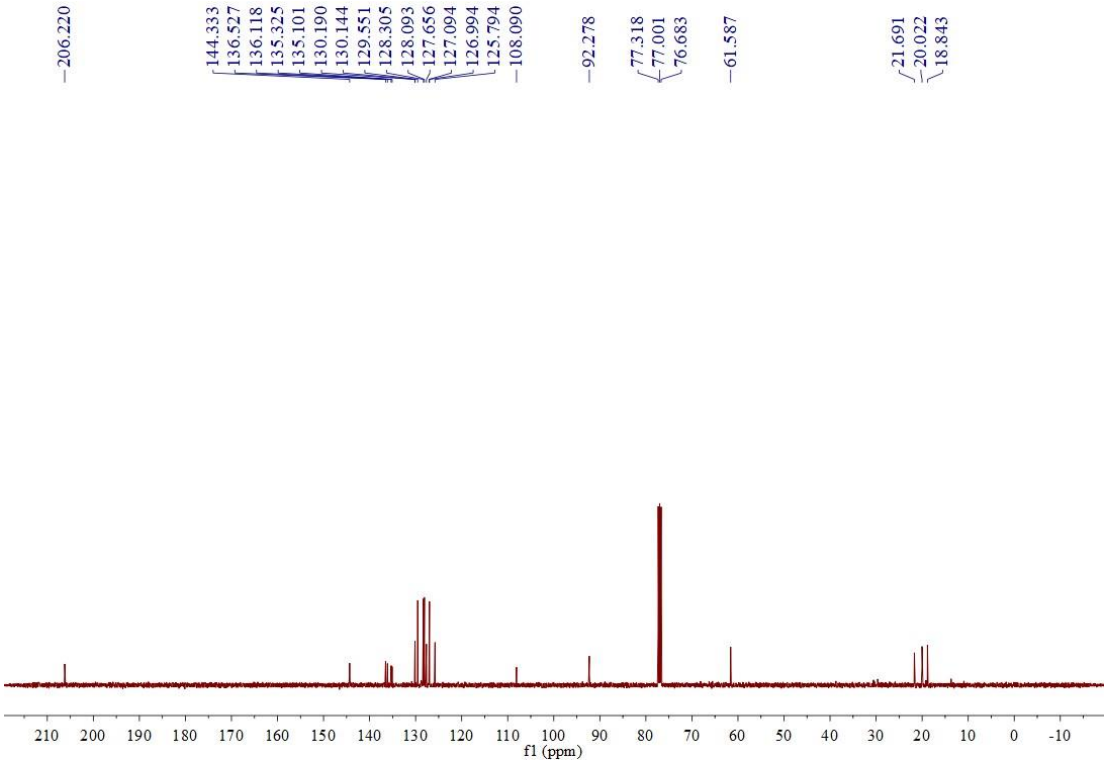

207.606
197.996
144.439
137.236
136.858
135.633
135.522
133.128
129.604
128.503
128.487
128.375
127.960
127.615
127.188
109.564
93.204
77.318
77.000
76.682
61.237
26.680
21.543
19.273
f1 (ppm)

31


7.642
7.621
7.253
7.247
7.242
7.226
7.223
7.200
7.196
7.190
7.187
7.184
7.182
7.178
7.174
7.171
7.155
7.050
7.030
7.007
7.003
6.987
6.983
6.946
6.940
6.935
6.933
6.930
6.926
6.822
3.899
3.889
2.326
2.038
1.979
0.000

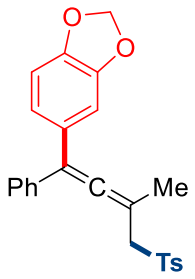

Me
Ph
C
Me
Ts

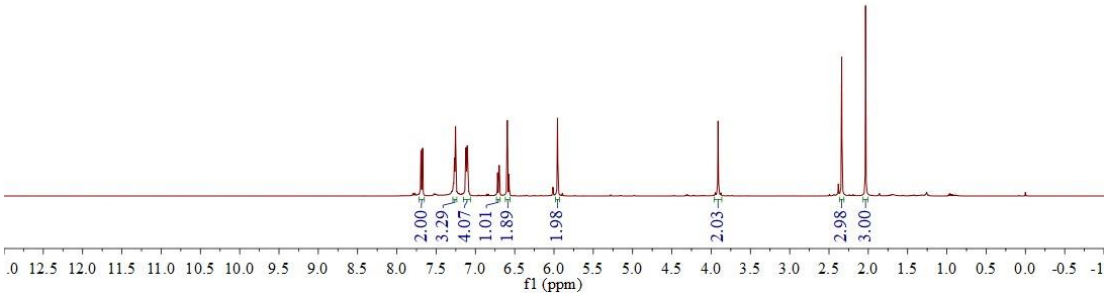

1.91
1.25
4.33
1.23
1.98
1.02
1.81
1.96
2.91
2.85
2.96
f1 (ppm)


206.220
144.333
136.527
136.118
135.325
135.101
130.190
130.144
129.551
128.305
128.093
127.656
127.094
126.994
125.794
108.090
92.278
77.318
77.001
76.683
61.587
21.691
20.022
18.843
f1 (ppm)

32


7.693
7.672
7.271
7.266
7.259
7.253
7.251
7.122
7.116
7.114
7.111
7.108
7.105
7.102
7.097
7.092
6.718
6.716
6.699
6.696
6.598
6.595
6.575
6.570
5.958
5.956
5.953
5.949
3.913
3.910
2.338
2.034
0.000


O
O
Ph
C
Me
Ts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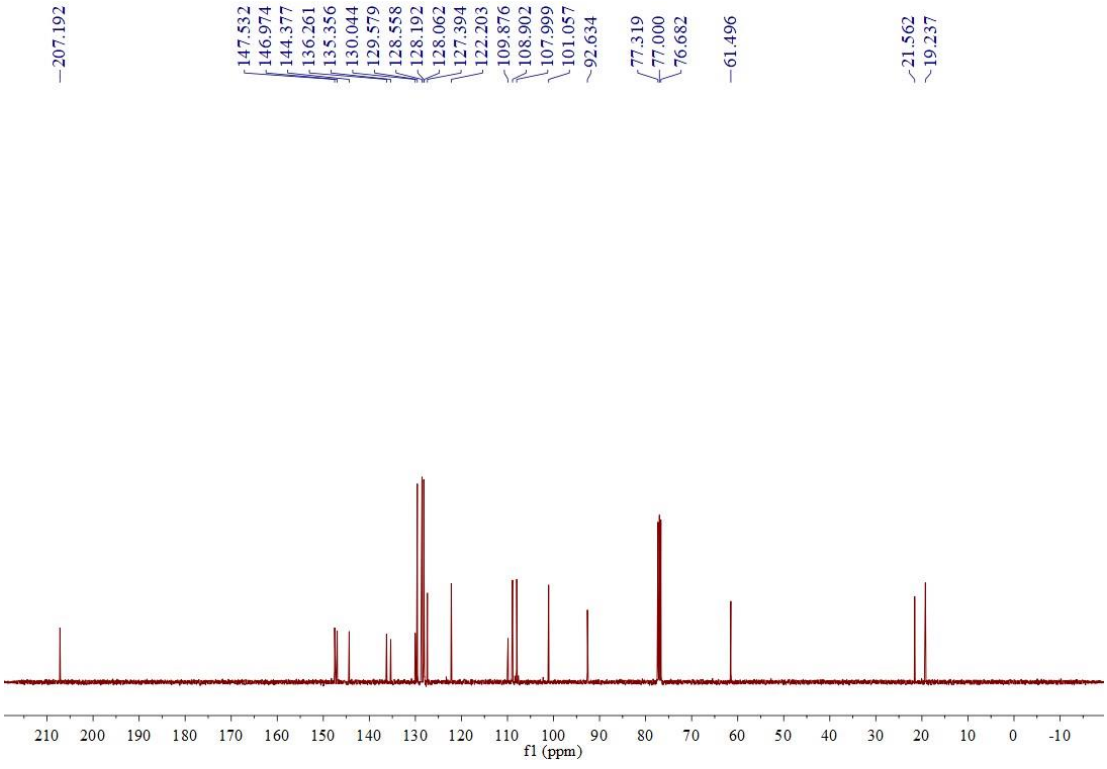
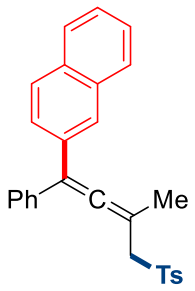
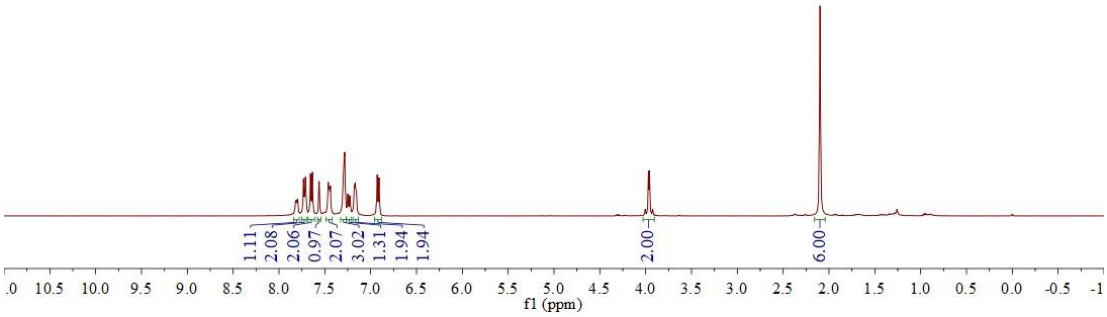
3.29
4.07
1.01
1.89
1.98
2.03
2.98
3.00
f1 (ppm)


207.192
147.532
146.974
144.377
136.261
135.356
130.044
129.579
128.558
128.192
128.062
127.394
122.203
109.876
108.902
107.999
101.057
92.634
77.319
77.000
76.682
61.496
21.562
19.237
f1 (ppm)

33


7.820
7.810
7.797
7.732
7.712
7.656
7.636
7.562
7.463
7.457
7.453
7.449
7.445
7.439
7.299
7.295
7.287
7.281
7.252
7.248
7.231
7.226
7.179
7.169
7.160
7.155
6.928
6.909
3.969
3.959
2.101
2.096
0.000


Ph
C
Me
Ts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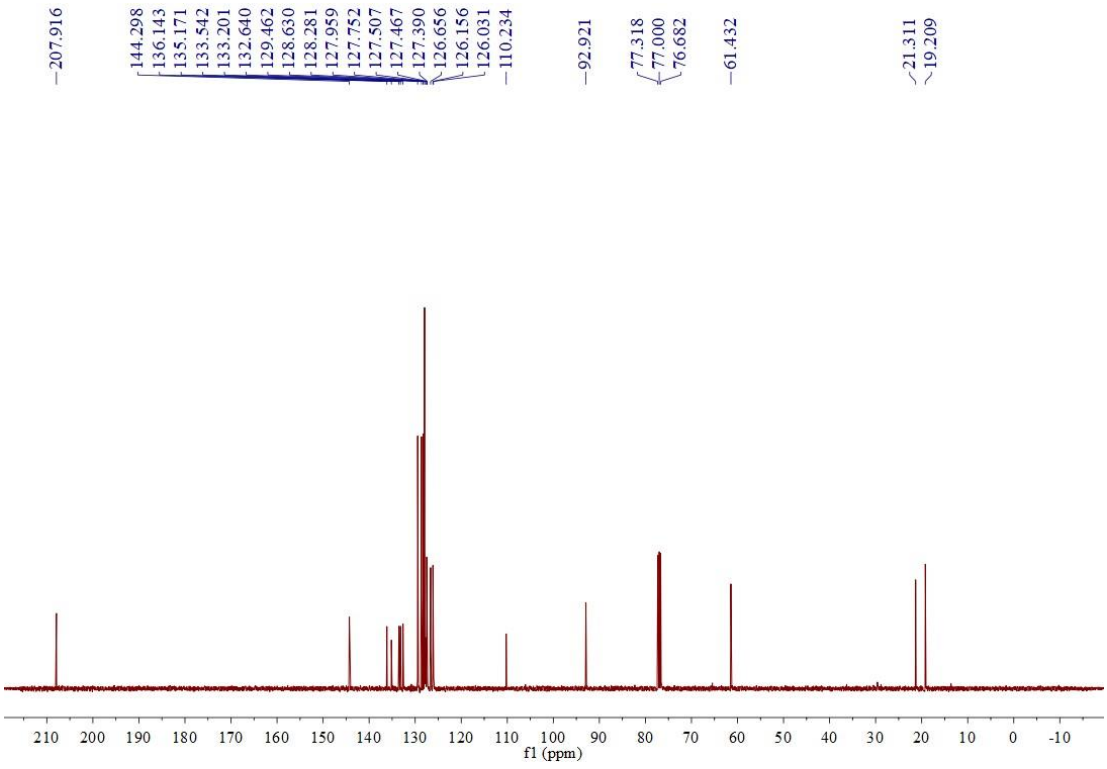
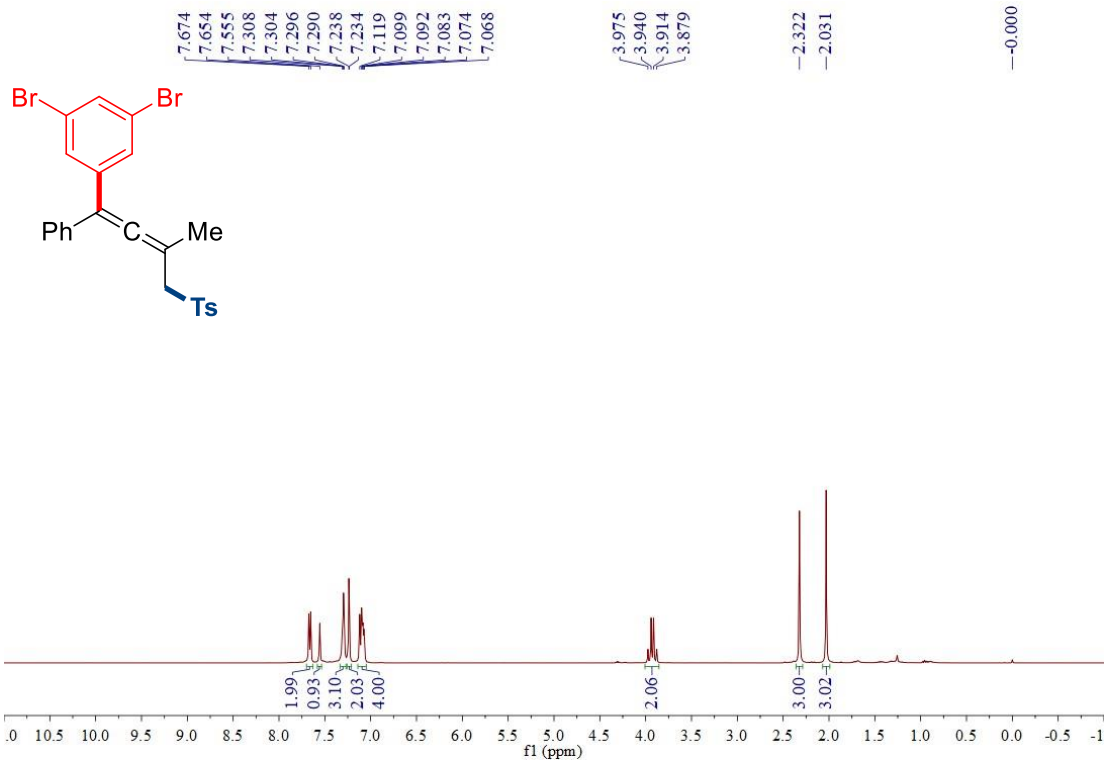
2.08
2.06
0.97
2.07
3.02
1.31
1.94
1.94
2.00
6.00
f1 (ppm)


207.916
144.298
136.143
135.171
133.542
133.201
132.640
129.462
128.630
128.281
127.959
127.752
127.507
127.467
127.390
126.656
126.156
126.031
110.234
92.921
77.318
77.000
76.682
61.432
21.311
19.209
f1 (ppm)

34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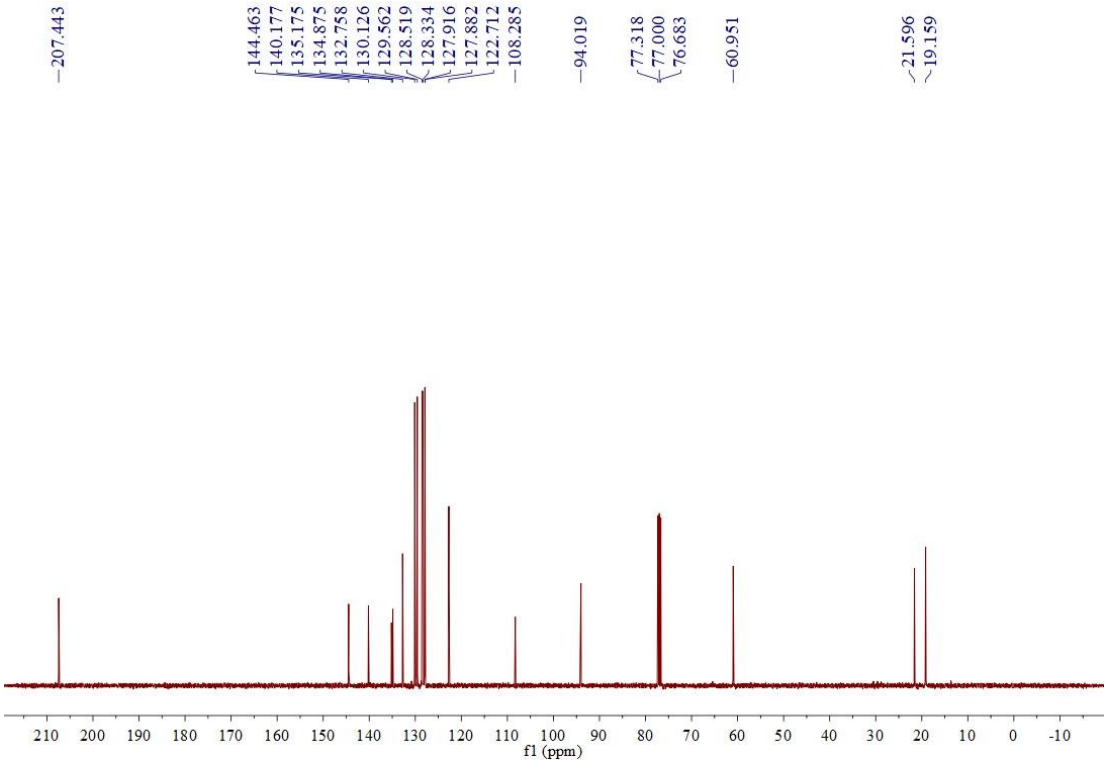
7.654
7.555
7.308
7.304
7.296
7.290
7.238
7.234
7.119
7.099
7.092
7.083
7.074
7.068
3.975
3.940
3.914
3.879
2.322
2.031
0.000
Br
Br
Ph
C
Me
Ts
1.99
0.93
3.10
2.03
4.00
2.06
3.00
3.02
f1 (ppm)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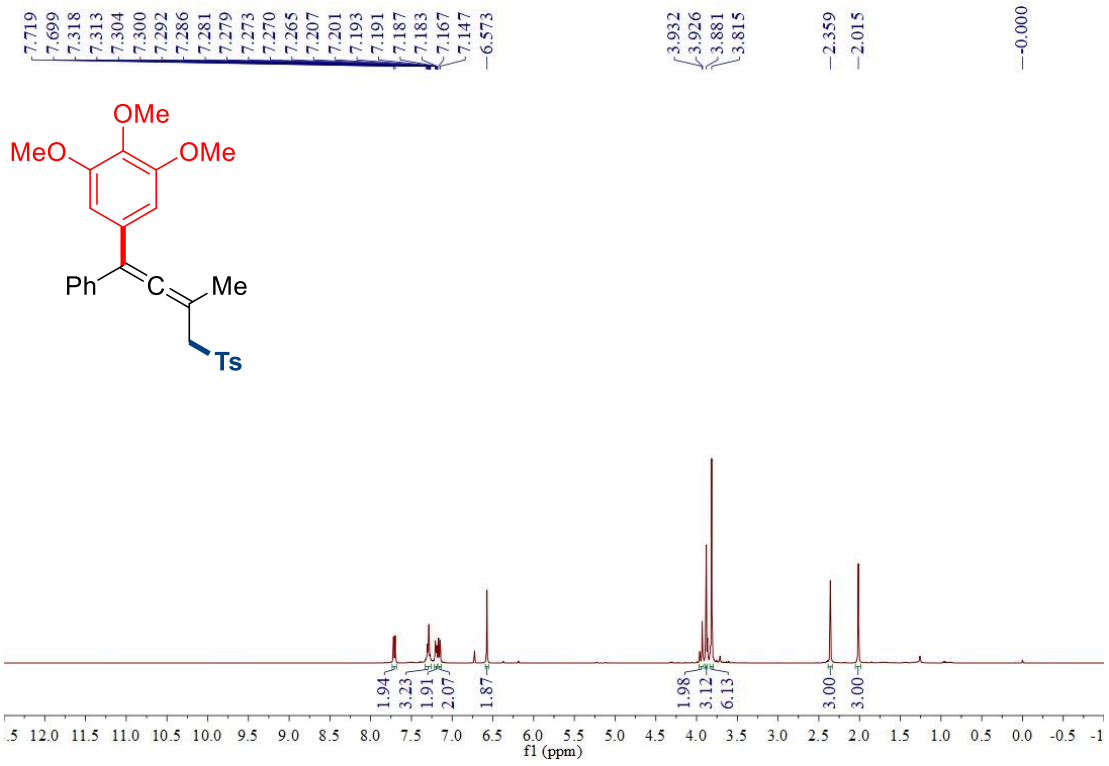
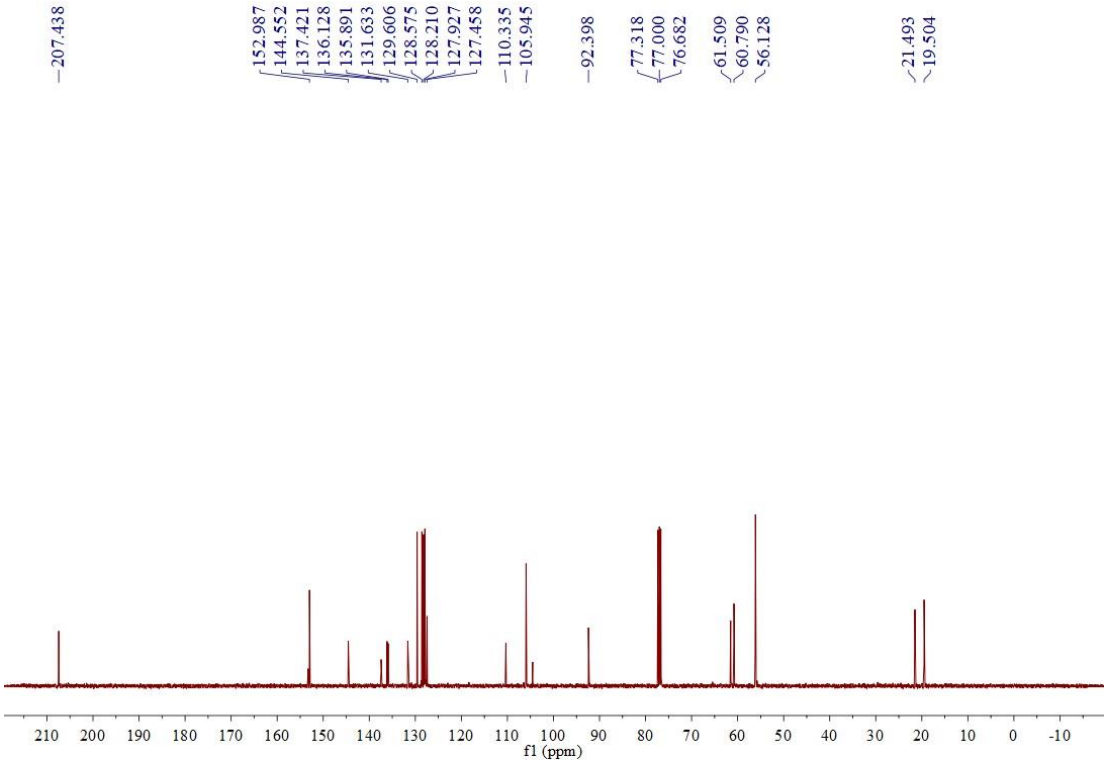
144.463
140.177
135.175
134.875
132.758
130.126
129.562
128.519
128.334
127.916
127.882
122.712
108.285
94.019
77.318
77.000
76.683
60.951
21.596
19.159
f1 (ppm)

35


7.719
7.699
7.318
7.313
7.304
7.300
7.292
7.286
7.281
7.279
7.273
7.270
7.265
7.207
7.201
7.193
7.191
7.187
7.183
7.167
7.147
6.573
3.932
3.926
3.881
3.815
2.359
2.015
0.000
OMe
MeO
OMe
Ph
C
Me
Ts
1.94
3.23
1.91
2.07
1.87
1.98
3.12
6.13
3.00
3.00
f1 (ppm)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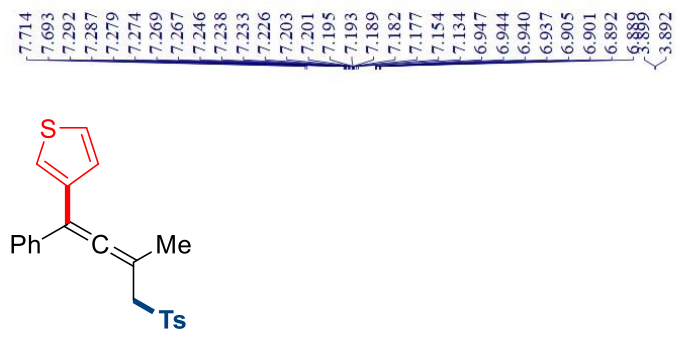
144.552
137.421
136.128
135.891
131.633
129.606
128.575
128.210
127.927
127.458
110.335
105.945
92.398
77.318
77.000
76.682
61.509
60.790
56.128
21.493
19.504
f1 (ppm)

36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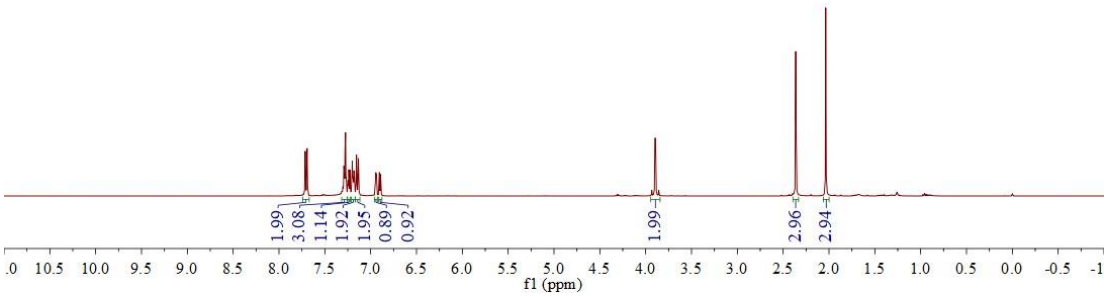
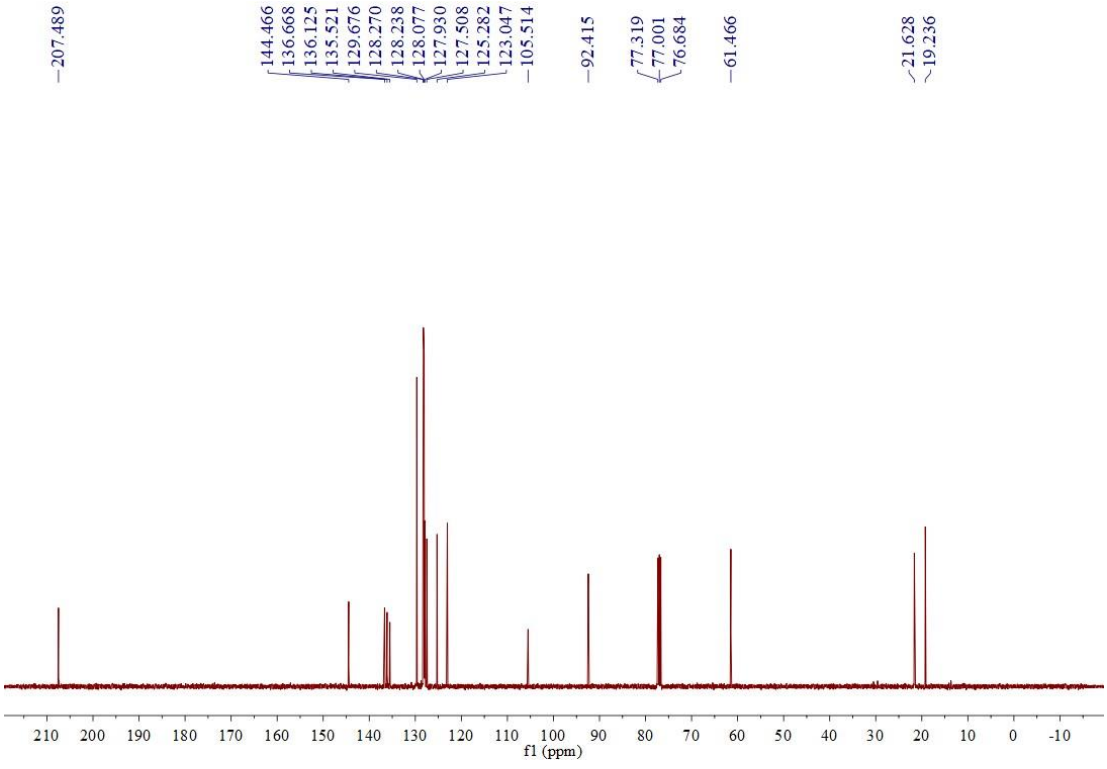
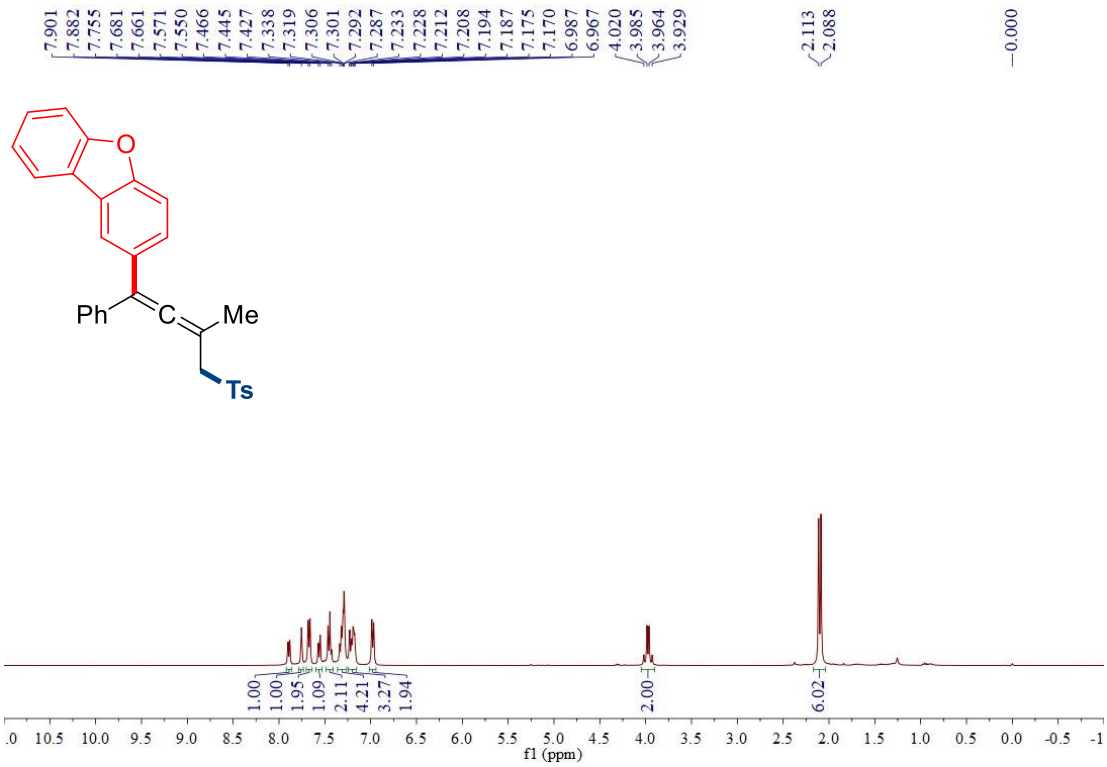
7.693
7.292
7.287
7.279
7.274
7.269
7.267
7.246
7.238
7.233
7.226
7.203
7.201
7.195
7.193
7.189
7.182
7.177
7.154
7.134
6.947
6.944
6.940
6.937
6.905
6.901
6.892
3.892
2.363
2.036
0.000

S
Ph
C
Me
Ts


1.99
3.08
1.14
1.92
1.95
0.89
0.92
1.99
2.96
2.94
f1 (ppm)


207.489
144.466
136.668
136.125
135.521
129.676
128.270
128.238
128.077
127.930
127.508
125.282
123.047
105.514
92.415
77.319
77.001
76.684
61.466
21.628
19.236
f1 (ppm)

37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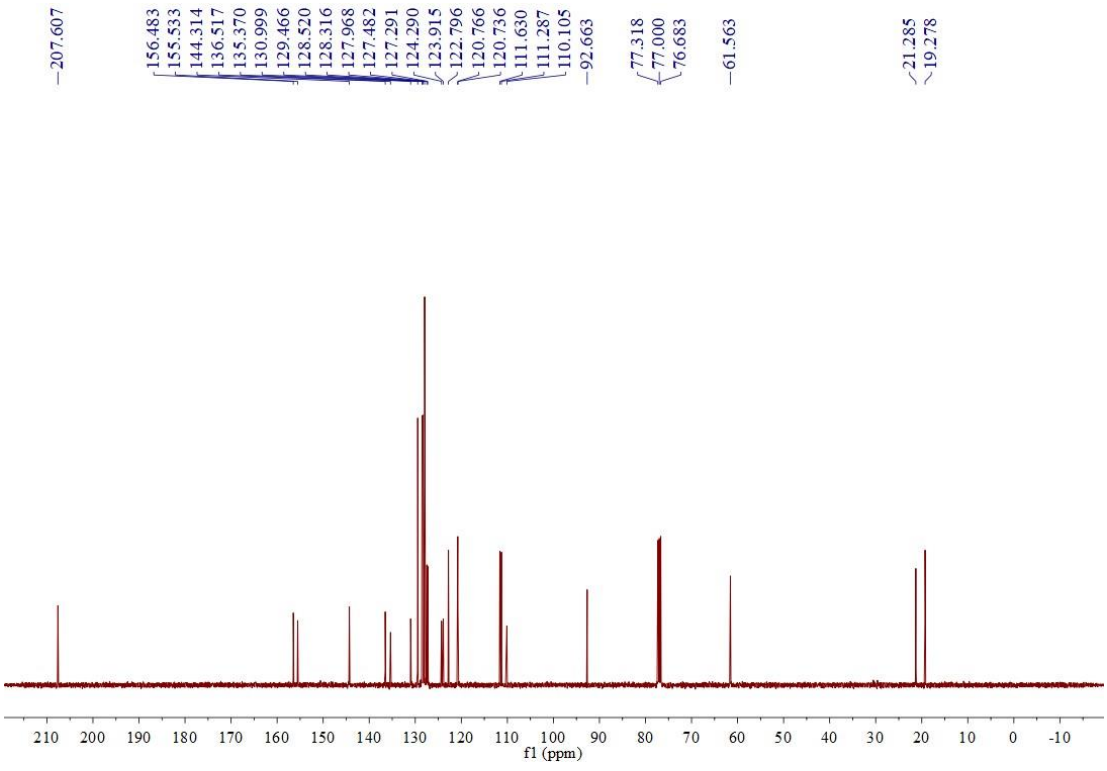
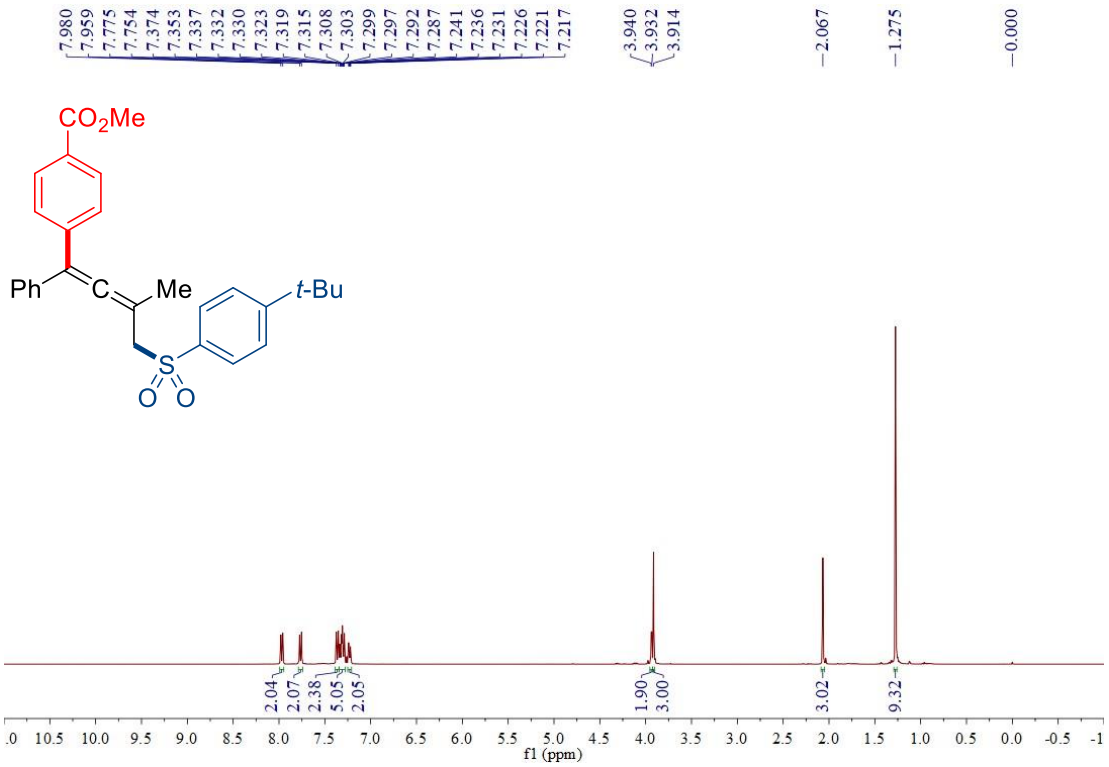
7.571
7.550
7.466
7.445
7.427
7.338
7.319
7.306
7.301
7.292
7.287
7.233
7.228
7.212
7.208
7.194
7.187
7.175
7.170
6.987
6.967
4.020
3.985
3.964
3.929
2.113
2.088
0.000
O
Ph
C
Me
Ts
1.00
1.00
1.95
1.09
2.11
4.21
3.27
1.94
2.00
6.02
f1 (ppm)


207.607
156.483
155.533
144.314
136.517
135.370
130.999
129.466
128.520
128.316
127.968
127.482
127.291
124.290
123.915
122.796
120.766
120.736
111.630
111.287
110.105
92.663
77.318
77.000
76.683
61.563
21.285
19.278
f1 (ppm)

38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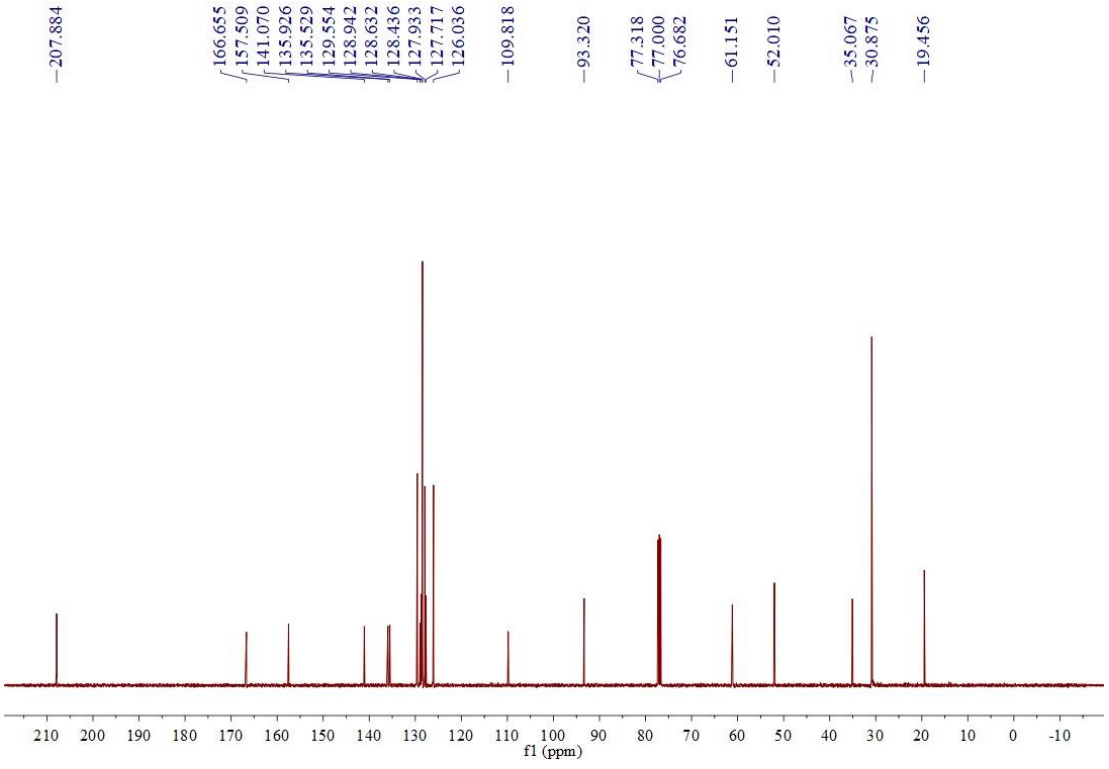
7.754
7.374
7.353
7.337
7.332
7.330
7.323
7.319
7.315
7.308
7.303
7.299
7.297
7.292
7.287
7.241
7.236
7.231
7.226
7.221
7.217
3.940
3.932
3.914
2.067
1.275
0.000
CO2Me
Ph
C
Me
t-Bu
S
O
O
2.04
2.07
2.38
5.05
2.05
1.90
3.00
3.02
9.32
f1 (ppm)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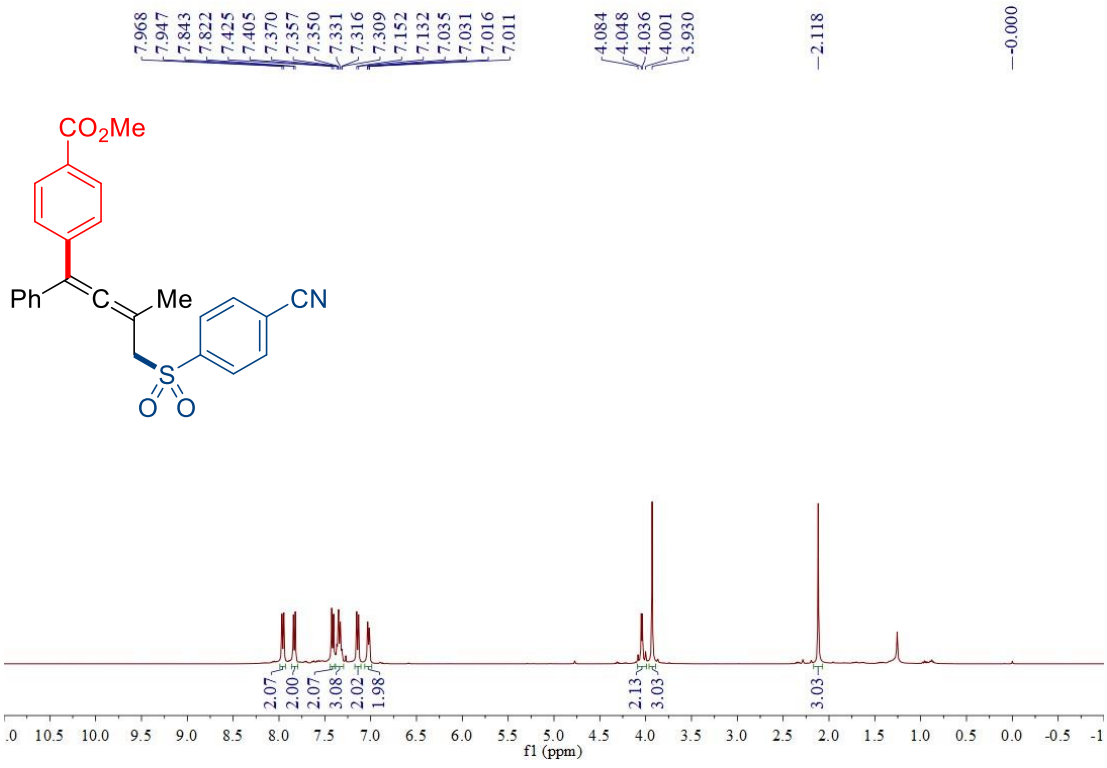
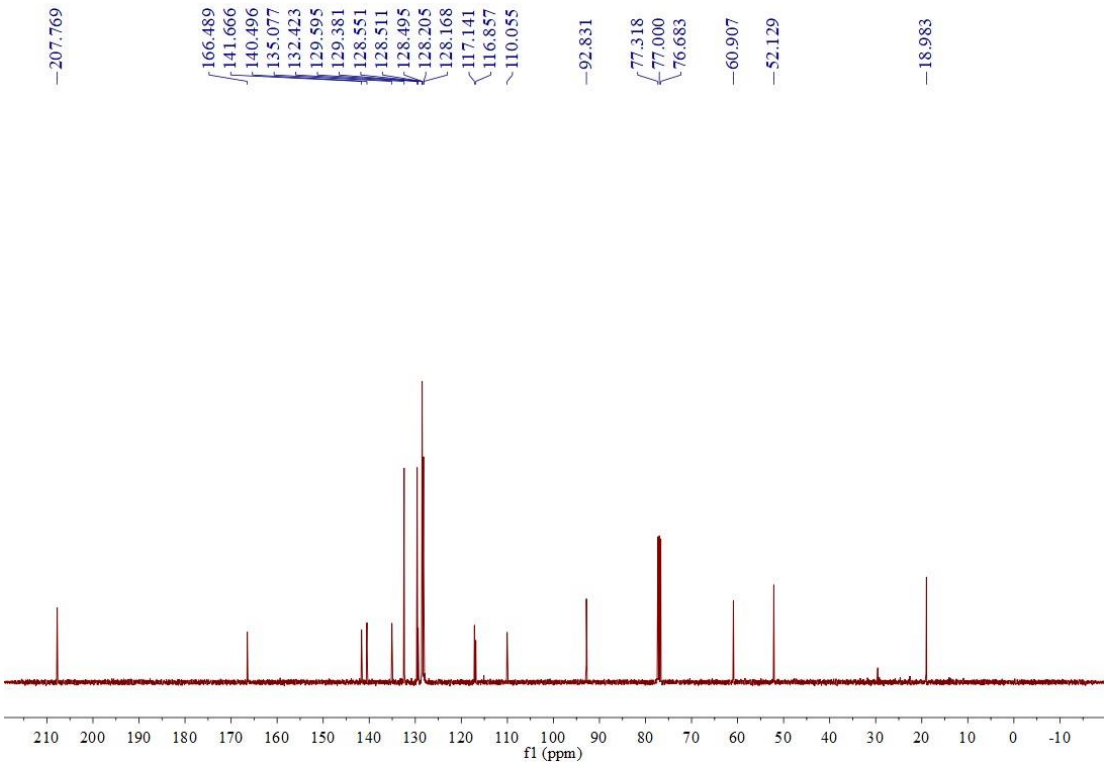
166.655
157.509
141.070
135.926
135.529
129.554
128.942
128.632
128.436
127.933
127.717
126.036
109.818
93.320
77.318
77.000
76.682
61.151
52.010
35.067
30.875
19.456
f1 (ppm)

39


7.968
7.947
7.843
7.822
7.425
7.405
7.370
7.357
7.350
7.331
7.316
7.309
7.152
7.132
7.035
7.031
7.016
7.011
4.084
4.048
4.036
4.001
3.930
2.118
0.000
CO2Me
Ph
C
Me
CN
S
O
O
2.07
2.00
2.07
3.08
2.02
1.98
2.13
3.03
3.03
f1 (ppm)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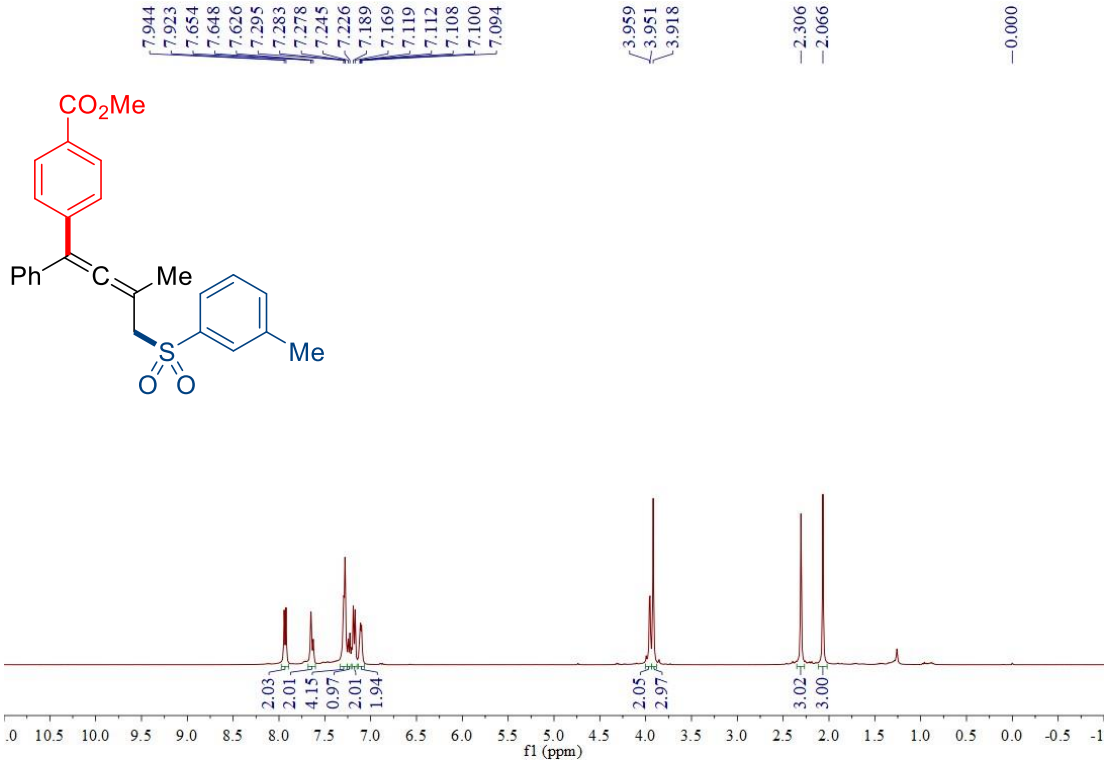
140.496
135.077
132.423
129.595
129.381
128.551
128.511
128.495
128.205
128.168
117.141
116.857
110.055
92.831
77.318
77.000
76.683
60.907
52.129
18.983
f1 (ppm)

40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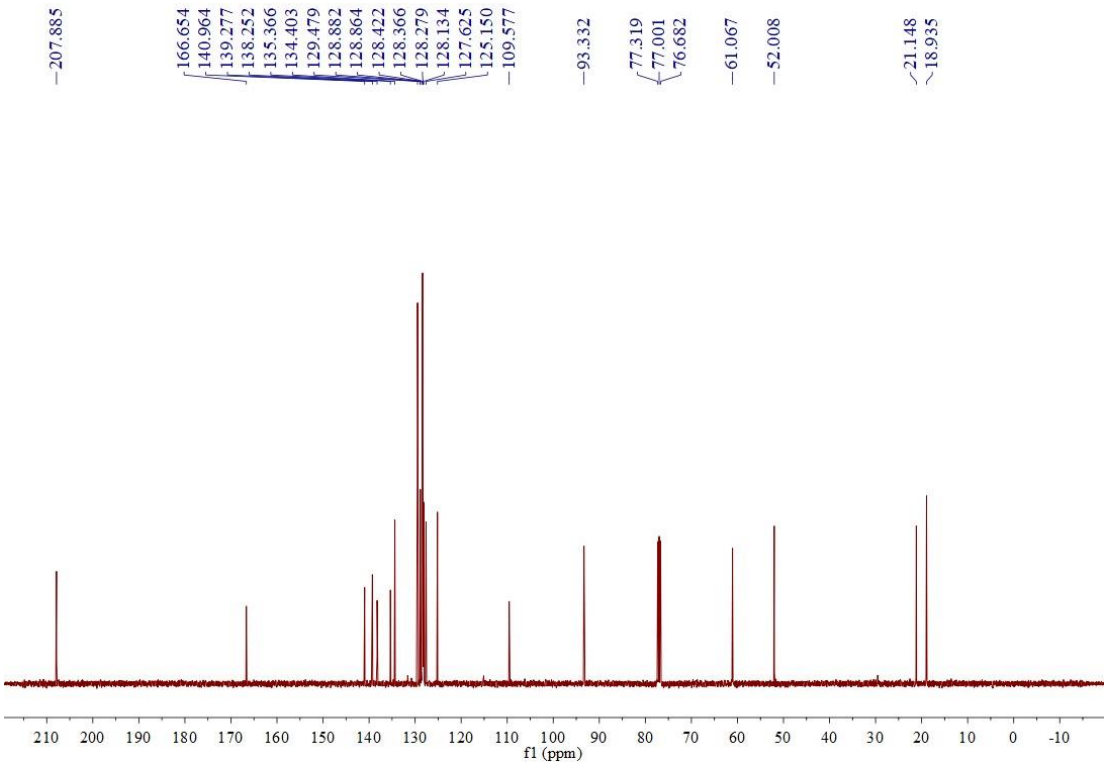
7.295
7.283
7.278
7.245
7.226
7.189
7.169
7.119
7.112
7.108
7.100
7.094
3.959
3.951
3.918
2.306
2.066
0.000
CO2Me
Ph
C
Me
S
O
O
Me
2.03
2.01
4.15
0.97
2.01
1.94
2.05
2.97
3.02
3.00
f1 (ppm)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134.403
129.479
128.882
128.864
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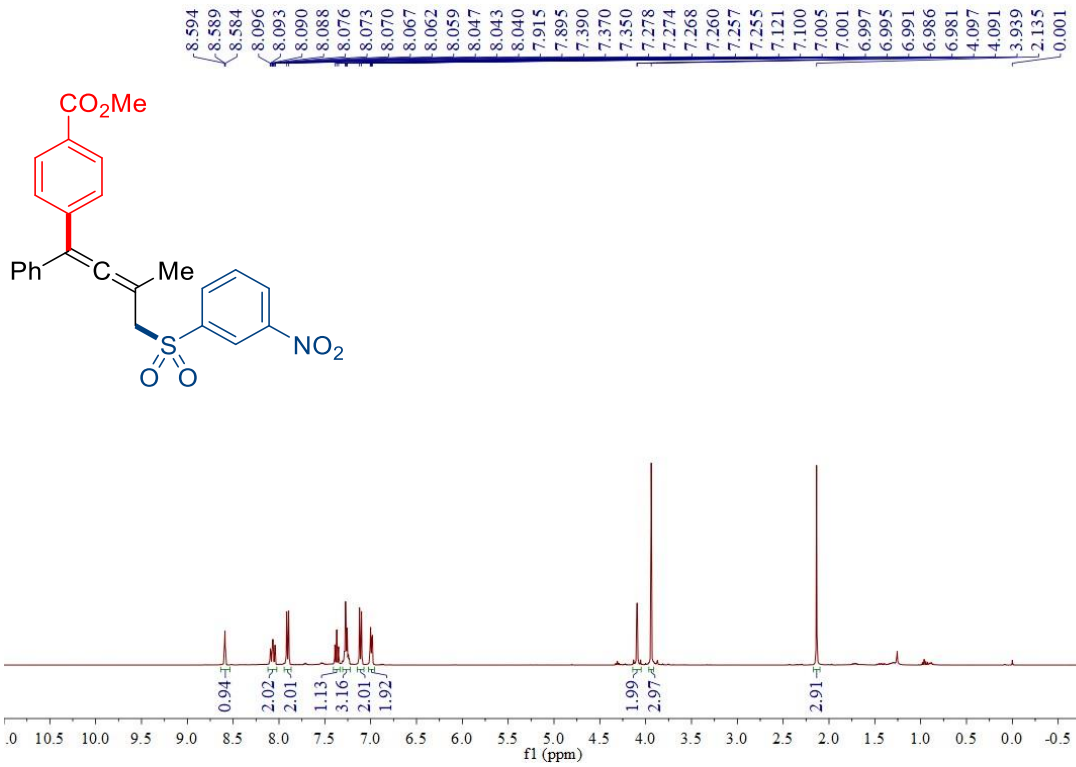
128.366
128.279
128.134
127.625
125.150
109.577
93.332
77.319
77.001
76.682
61.067
52.008
21.148
18.935
f1 (ppm)

41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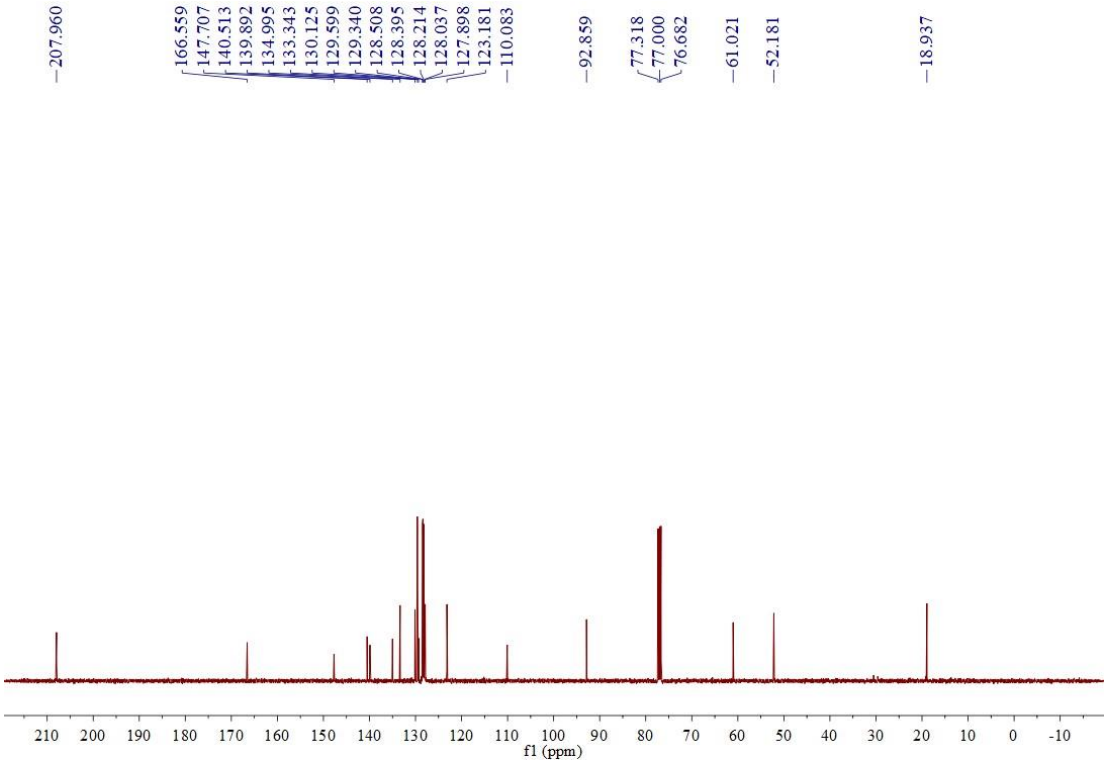
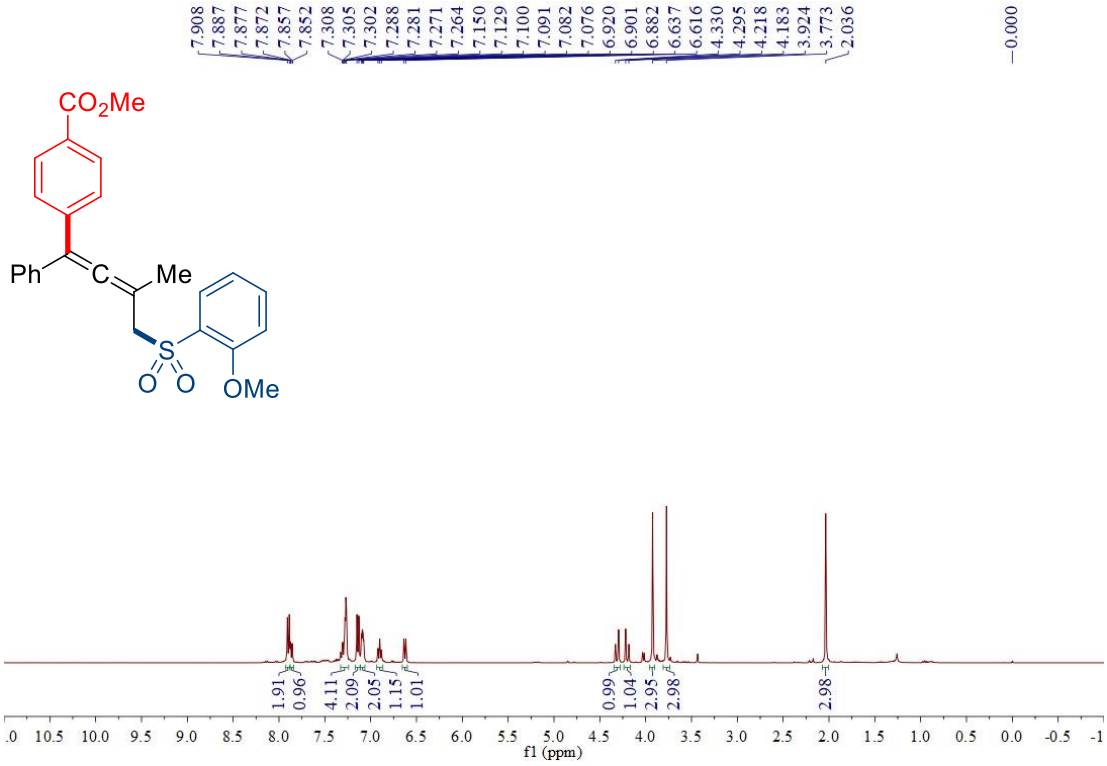
8.090
8.088
8.076
8.073
8.070
8.067
8.062
8.059
8.047
8.043
8.040
7.915
7.895
7.390
7.370
7.350
7.278
7.274
7.268
7.260
7.257
7.255
7.121
7.100
7.005
7.001
6.997
6.995
6.991
6.986
6.981
4.097
4.091
3.939
2.135
0.001
CO2Me
Ph
C
Me
S
O
O
NO2
0.94
2.02
2.01
1.13
3.16
2.01
1.92
1.99
2.97
2.91
f1 (ppm)


207.960
166.559
147.707
140.513
139.892
134.995
133.343
130.125
129.599
129.340
128.508
128.395
128.214
128.037
127.898
123.181
110.083
92.859
77.318
77.000
76.682
61.021
52.181
18.937
f1 (ppm)

42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7.857
7.852
7.308
7.305
7.302
7.288
7.281
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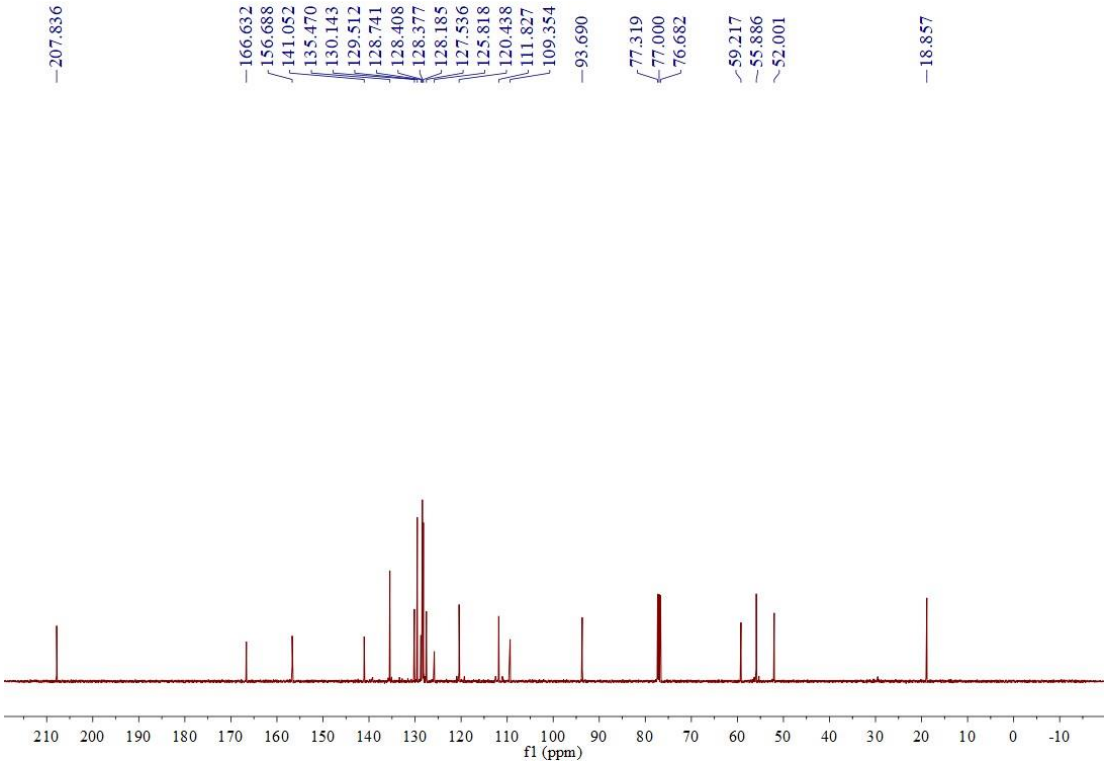
7.264
7.150
7.129
7.100
7.091
7.082
7.076
6.920
6.901
6.882
6.637
6.616
4.330
4.295
4.218
4.183
3.924
3.773
2.036
0.000
CO2Me
Ph
C
Me
S
O
O
OMe
1.91
0.96
4.11
2.09
2.05
1.15
1.01
0.99
1.04
2.95
2.98
2.98
f1 (ppm)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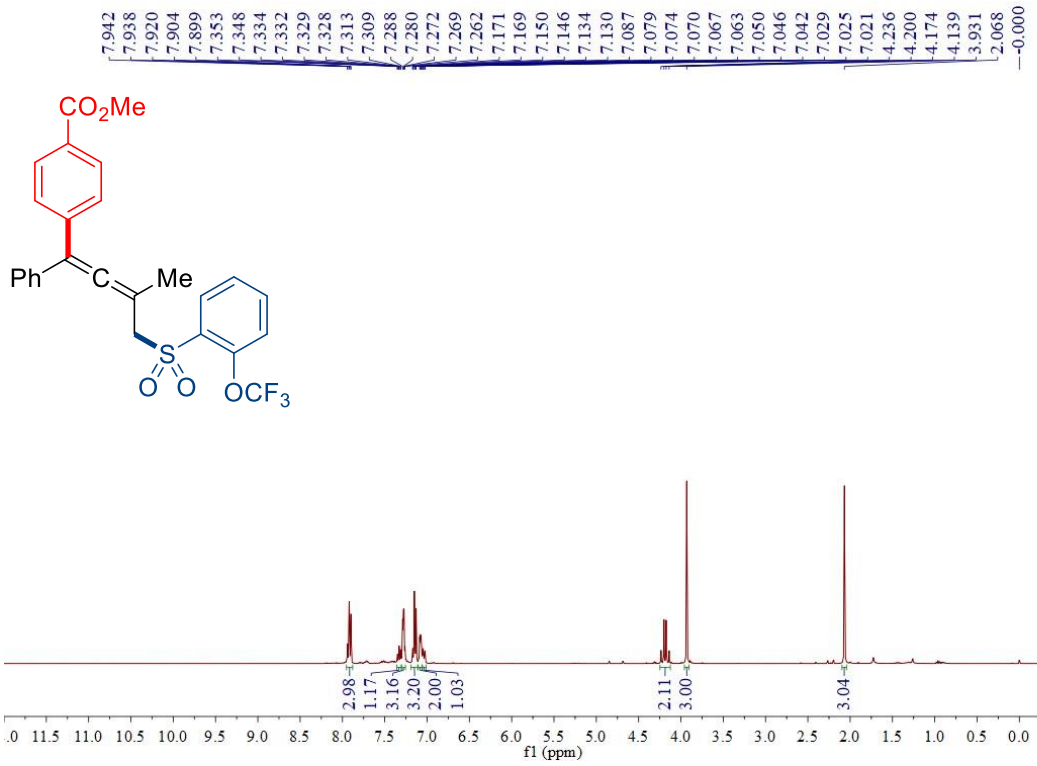
166.632
156.688
141.052
135.470
130.143
129.512
128.741
128.408
128.377
128.185
127.536
125.818
120.438
111.827
109.354
93.690
77.319
77.000
76.682
59.217
55.886
52.001
18.857
f1 (ppm)

43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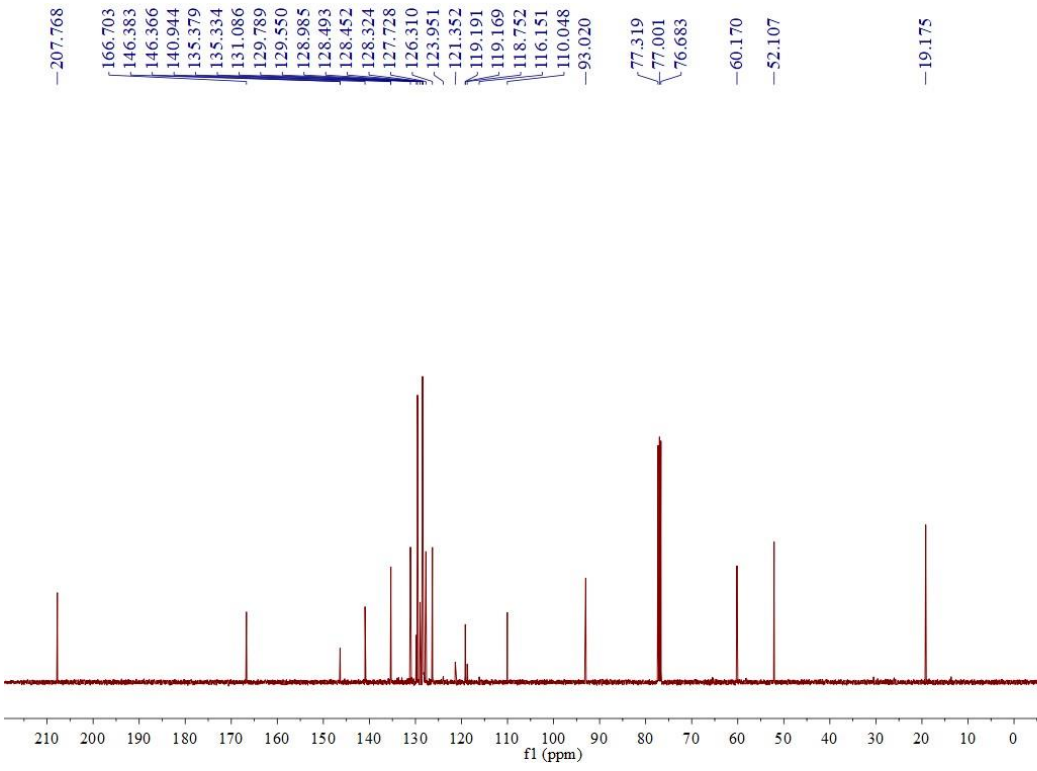
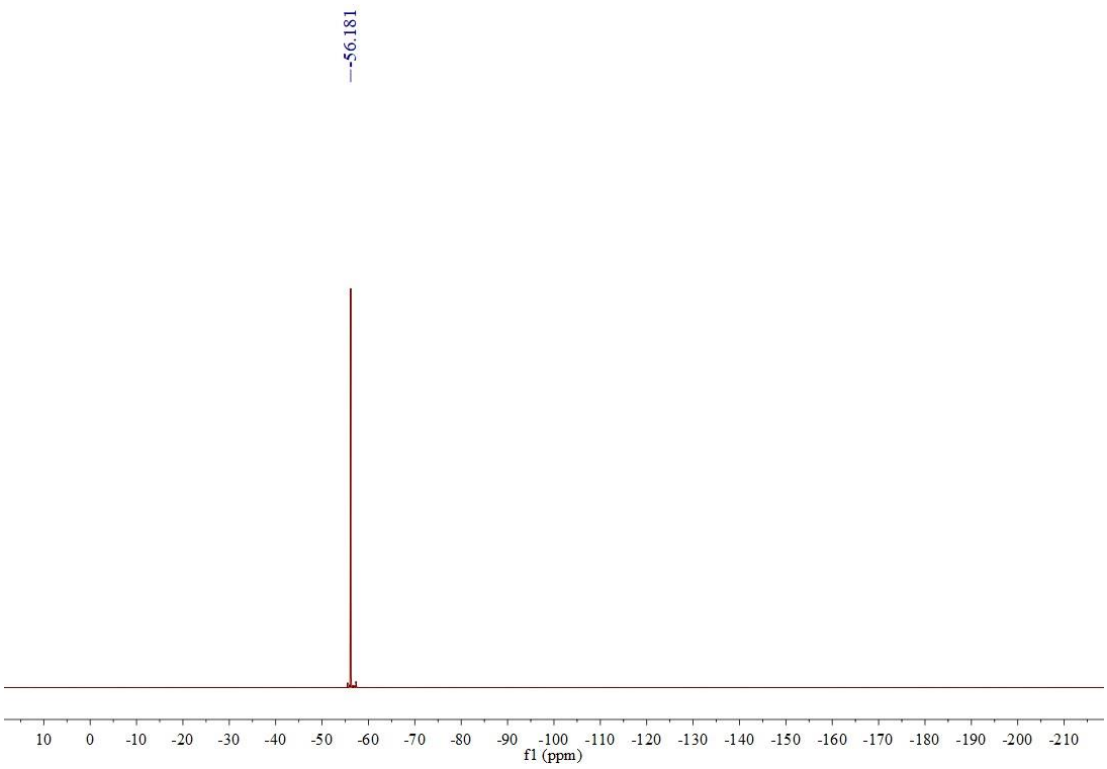
7.920
7.904
7.899
7.353
7.348
7.334
7.332
7.329
7.328
7.313
7.309
7.288
7.280
7.272
7.269
7.262
7.171
7.169
7.150
7.146
7.134
7.130
7.087
7.079
7.074
7.070
7.067
7.063
7.050
7.046
7.042
7.029
7.025
7.021
4.236
4.200
4.174
4.139
3.931
2.068
-0.000
CO2Me
Ph
C
Me
S
O
O
OCF3
2.98
1.17
3.16
3.20
2.00
1.03
2.11
3.00
3.04
f1 (ppm)


207.768
166.703
146.383
146.366
140.944
135.379
135.334
131.086
129.789
129.550
128.985
128.493
128.452
128.324
127.728
126.310
123.951
121.352
119.191
119.169
118.752
116.151
110.048
93.020
77.319
77.001
76.683
60.170
52.107
19.175
f1 (ppm)


-56.181
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)

44


8.411
7.856
7.835
7.801
7.781
7.753
7.748
7.743
7.722
7.647
7.626
7.607
7.604
7.583
7.580
7.562
7.545
7.542
7.184
7.180
7.173
7.165
7.159
7.151
7.148
7.144
7.129
7.115
7.110
7.094
7.089
6.994
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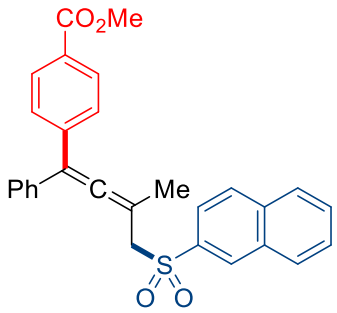
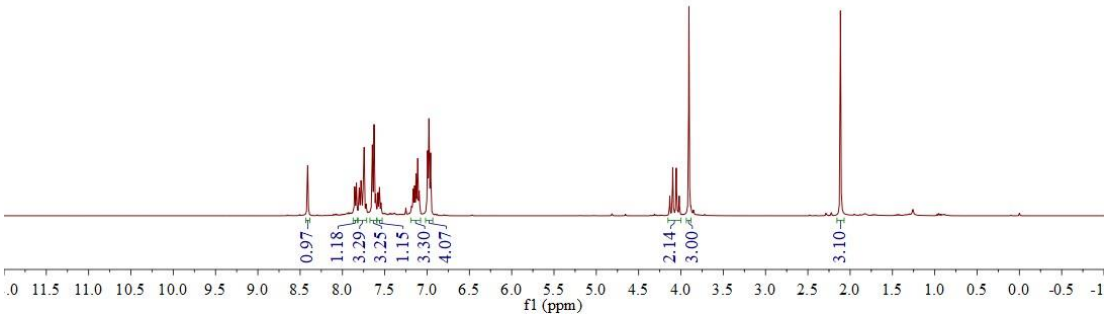
6.973
6.958
4.132
4.097
4.055
4.020
3.905
2.115
0.000


CO2Me
Ph
C
Me
S
O
O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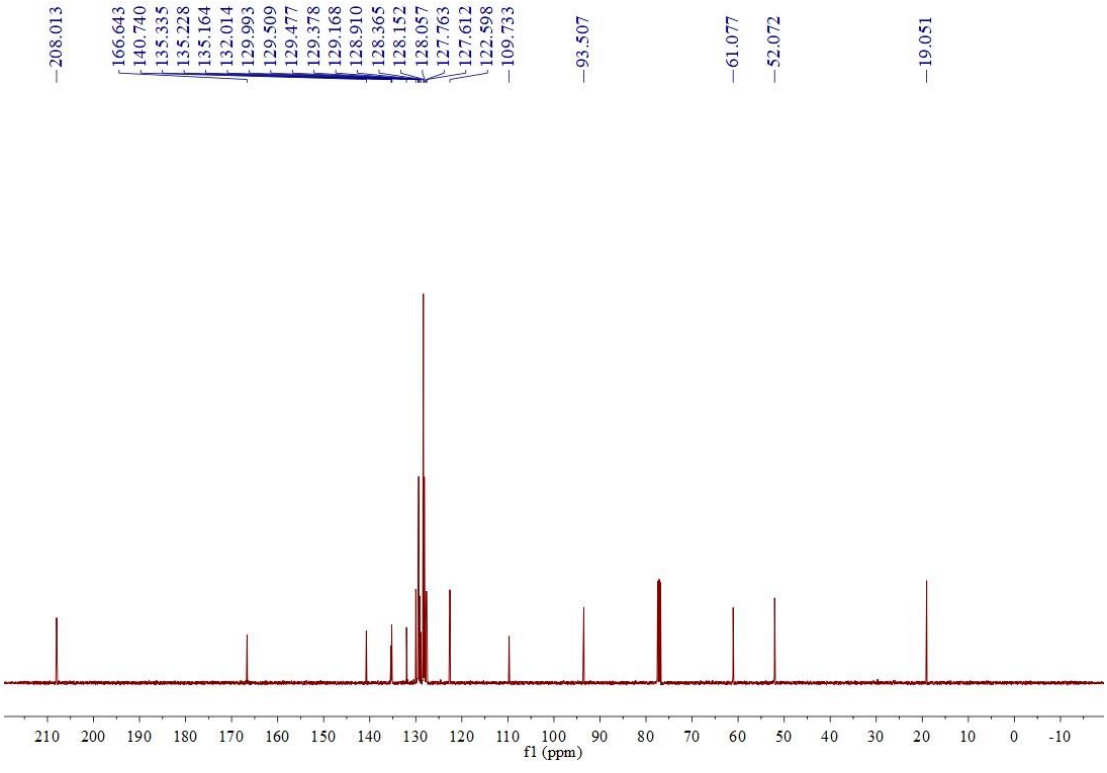
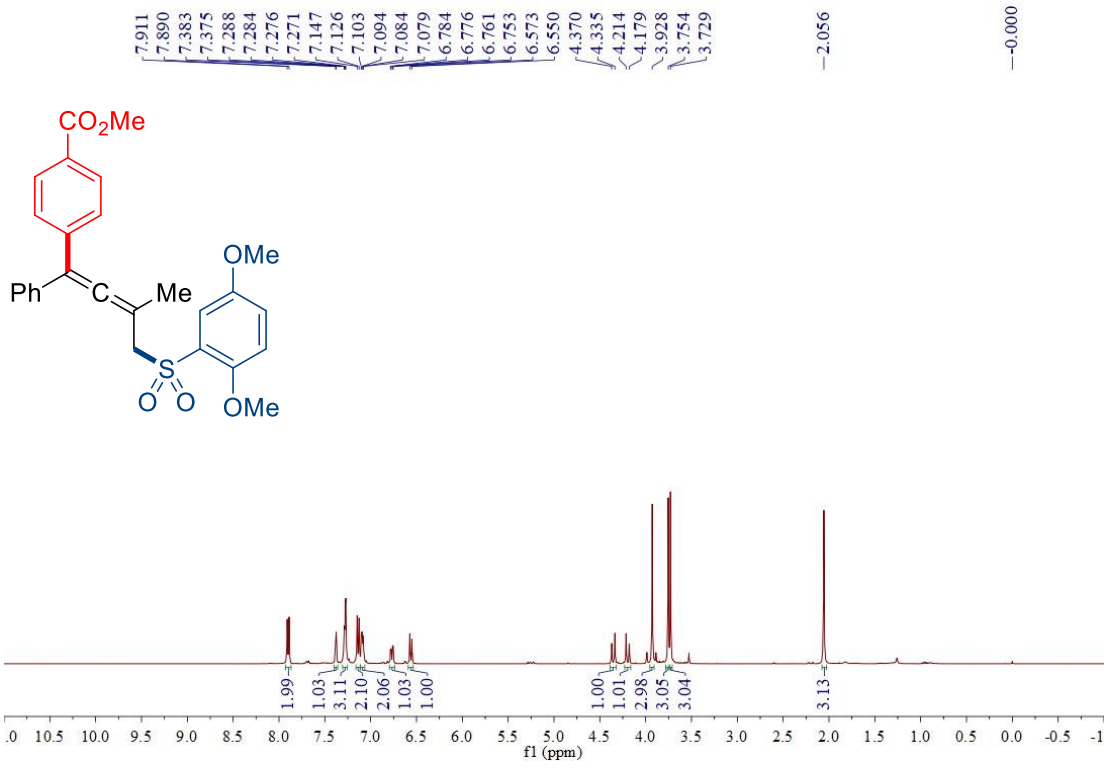
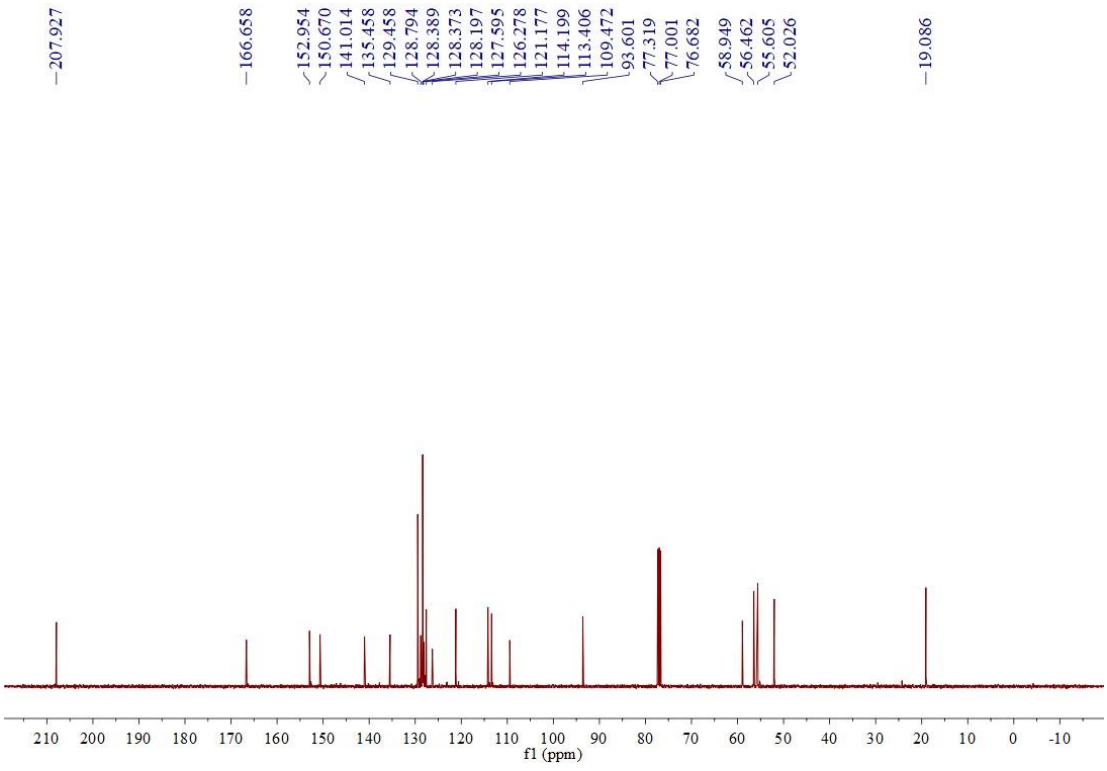
1.18
3.29
3.25
1.15
3.30
4.07
2.14
3.00
3.10
f1 (ppm)

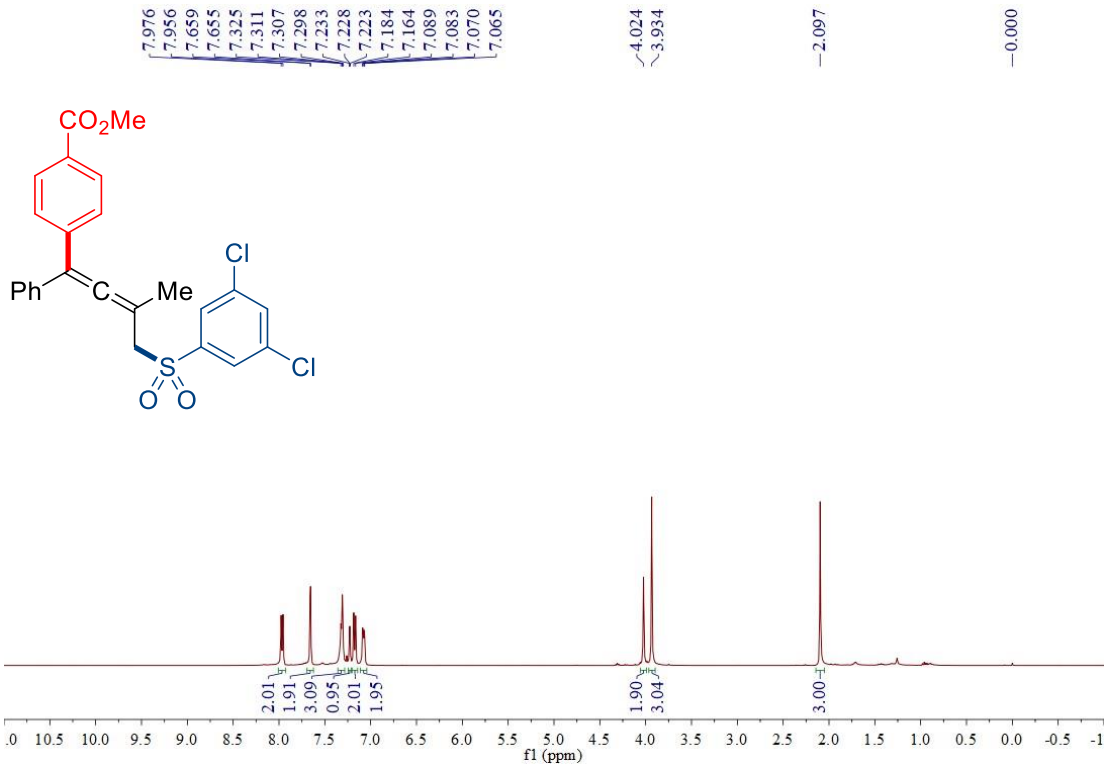

208.013
166.643
140.740
135.335
135.228
135.164
132.014
129.993
129.509
129.477
129.378
129.168
128.910
128.365
128.152
128.057
127.763
127.612
122.598
109.733
93.507
61.077
52.072
19.051
f1 (ppm)

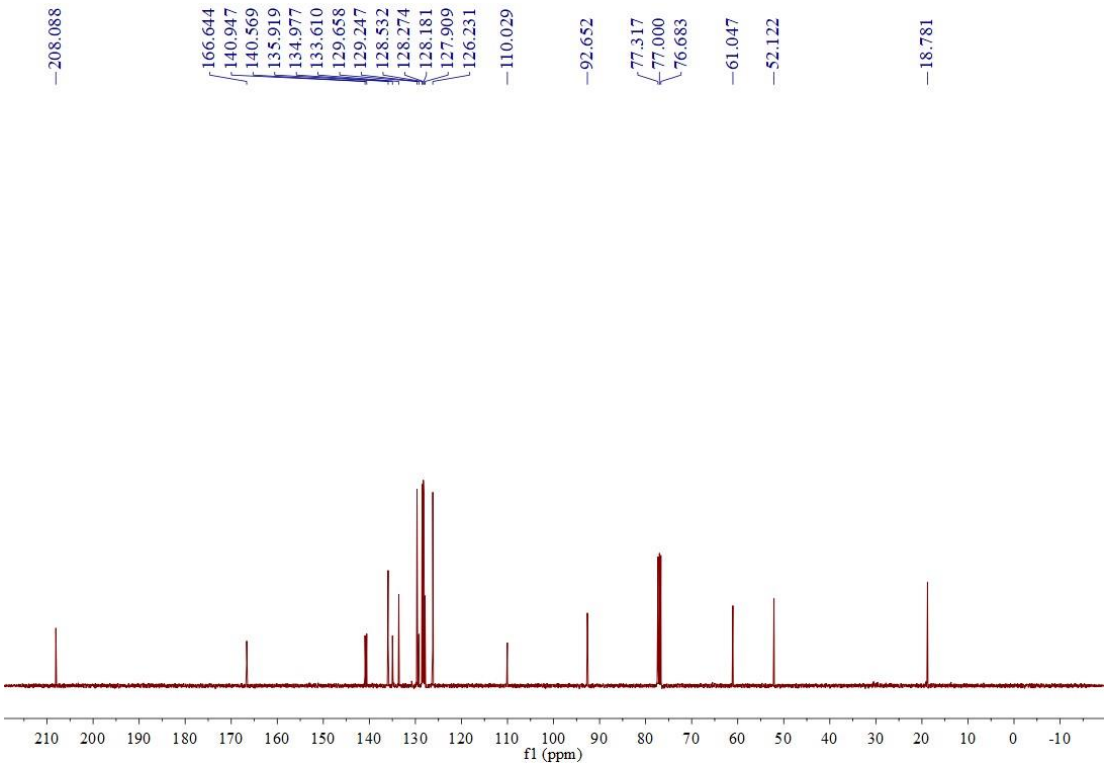
45


7.911
7.890
7.383
7.375
7.288
7.284
7.276
7.271
7.147
7.126
7.103
7.094
7.084
7.079
6.784
6.776
6.761
6.753
6.573
6.550
4.370
4.335
4.214
4.179
3.928
3.754
3.729
2.056
0.000
CO2Me
OMe
Ph
C
Me
S
O
O
OMe
1.99
1.03
3.11
2.10
2.06
1.03
1.00
1.00
1.01
2.98
3.05
3.04
3.13
f1 (ppm)

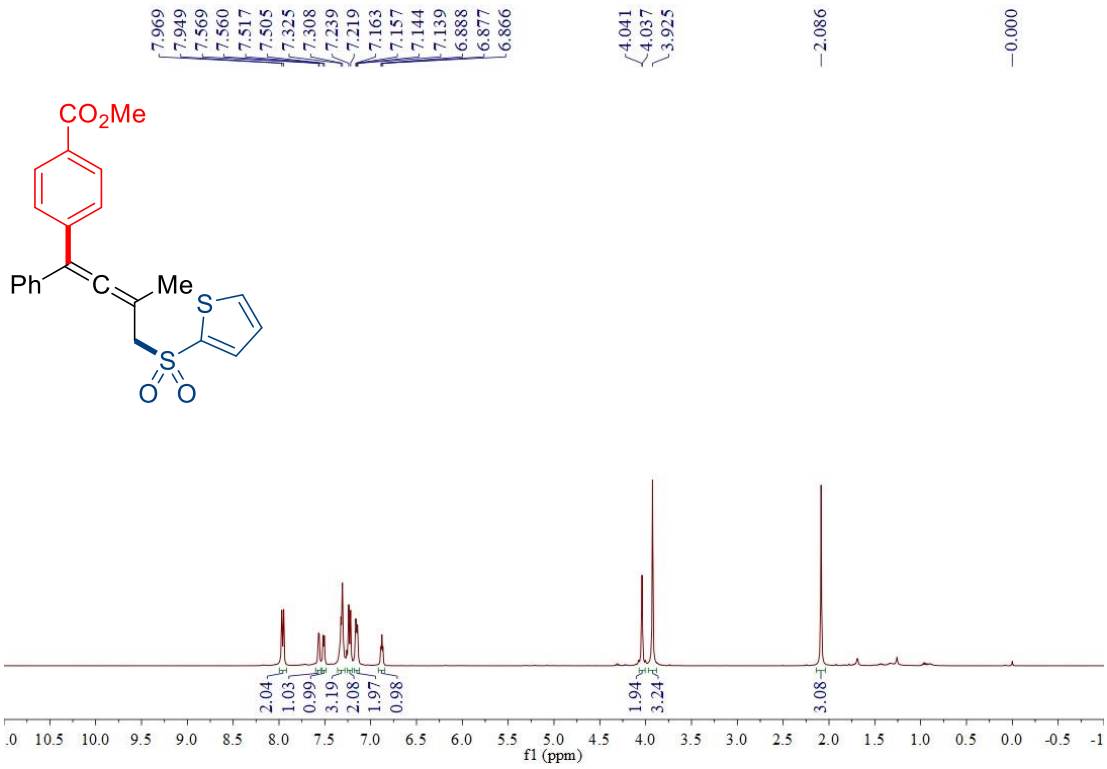

207.927
166.658
152.954
150.670
141.014
135.458
129.458
128.794
128.389
128.373
128.197
127.595
126.278
121.177
114.199
113.406
109.472
93.601
77.319
77.001
76.682
58.949
56.462
55.605
52.026
19.086
f1 (ppm)

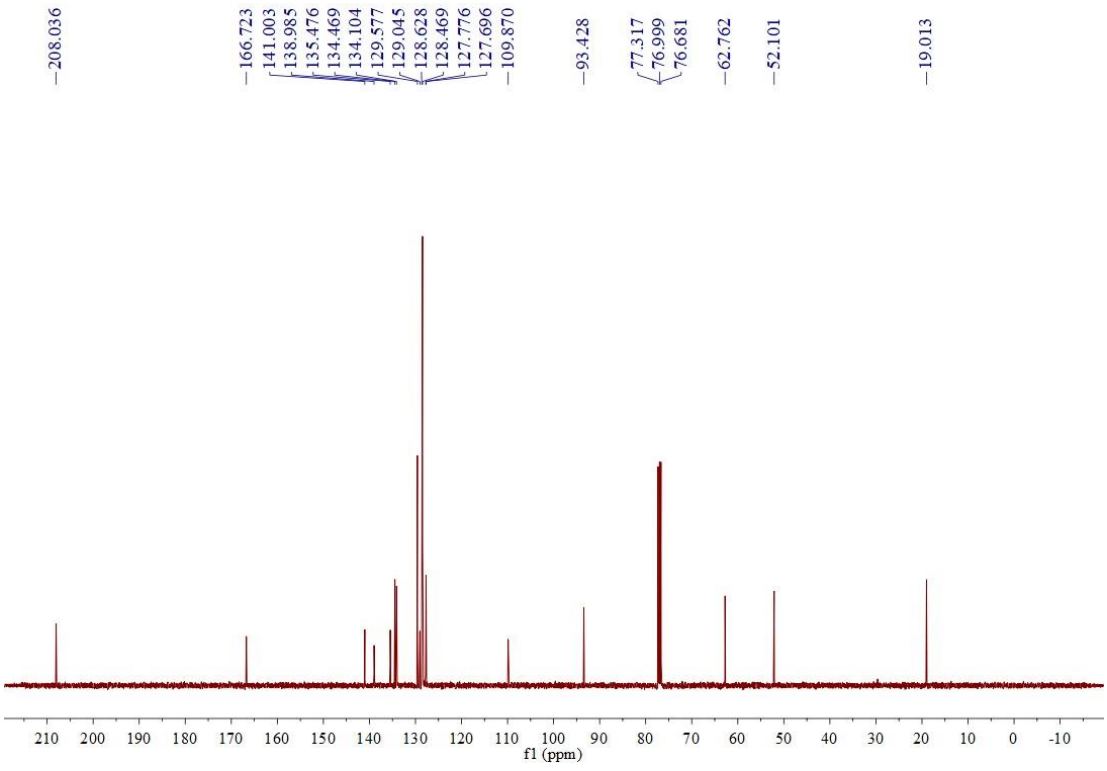
46


7.976
7.956
7.659
7.655
7.325
7.311
7.307
7.298
7.233
7.228
7.223
7.184
7.164
7.089
7.083
7.070
7.065
4.024
3.934
2.097
0.000
CO2Me
Ph
C
Me
Cl
Cl
S
O
O
2.01
1.91
3.09
0.95
2.01
1.95
1.90
3.04
3.00
f1 (ppm)


208.088
166.644
140.947
140.569
135.919
134.977
133.610
129.658
129.247
128.532
128.274
128.181
127.909
126.231
110.029
92.652
77.317
77.000
76.683
61.047
52.122
18.781
f1 (ppm)

47


7.969
7.949
7.569
7.560
7.517
7.505
7.325
7.308
7.239
7.219
7.163
7.157
7.144
7.139
6.888
6.877
6.866
4.041
4.037
3.925
2.086
0.000
CO2Me
Ph
C
Me
S
S
O
O
2.04
1.03
0.99
3.19
2.08
1.97
0.98
1.94
3.24
3.08
f1 (ppm)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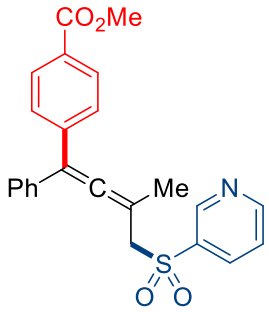
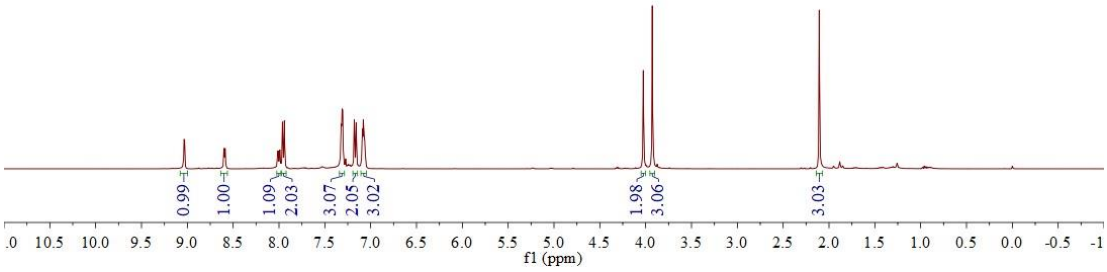
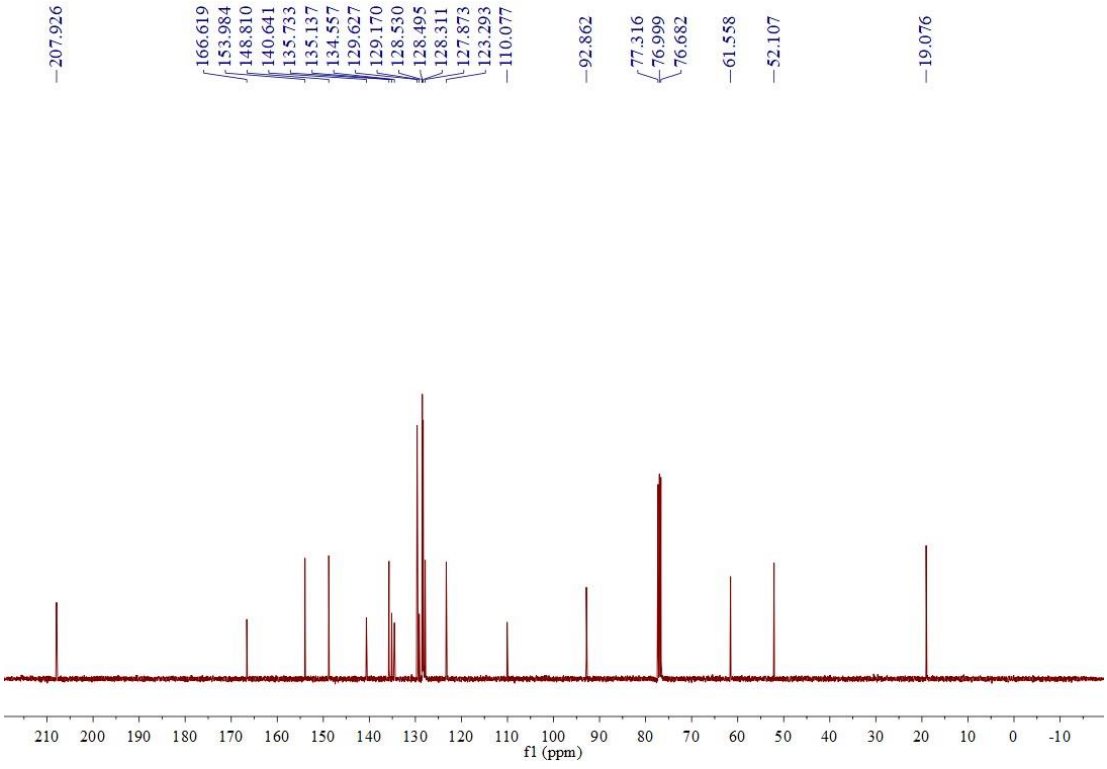
166.723
141.003
138.985
135.476
134.469
134.104
129.577
129.045
128.628
128.469
127.776
127.696
109.870
93.428
77.317
76.999
76.681
62.762
52.101
19.013
f1 (ppm)

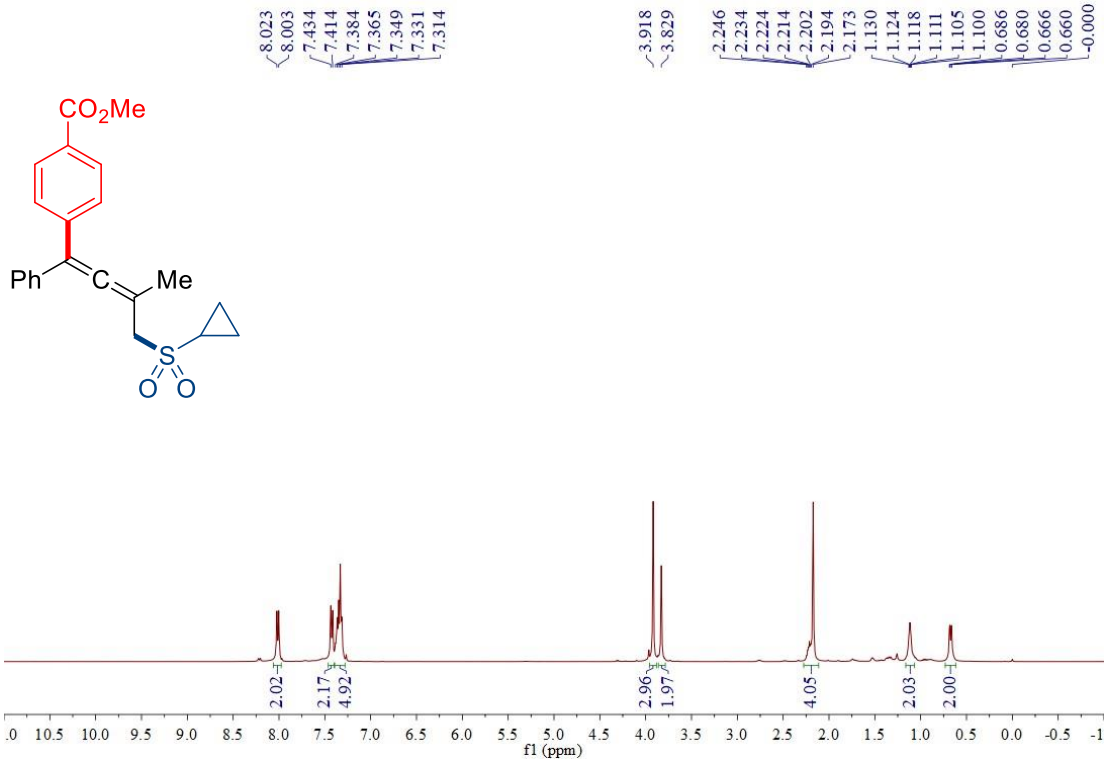
48

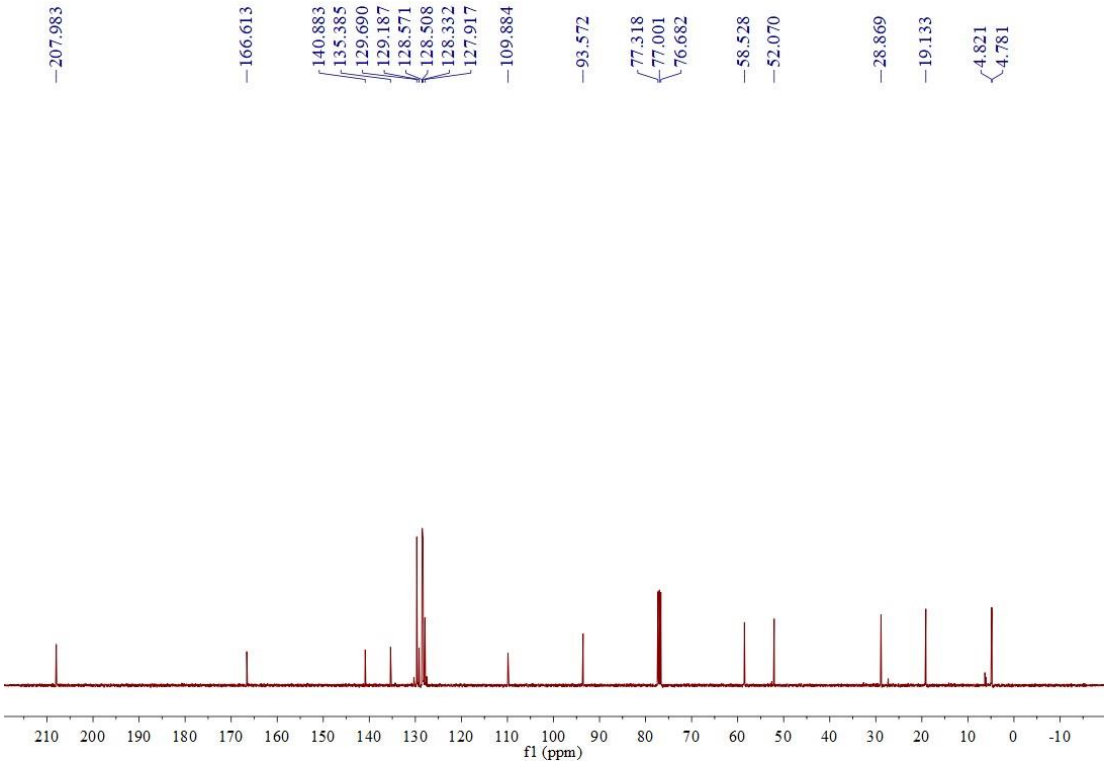

9.036
9.030
8.600
8.596
8.588
8.584
8.016
8.011
8.006
7.996
7.991
7.986
7.962
7.941
7.320
7.311
7.304
7.178
7.157
7.092
7.089
7.080
7.071
7.065
7.059
4.026
3.928
2.106
0.000


CO2Me
Ph
C
Me
N
S
O
O


0.99
1.00
1.09
2.03
3.07
2.05
3.02
1.98
3.06
3.03
f1 (ppm)


207.926
166.619
153.984
148.810
140.641
135.733
135.137
134.557
129.627
129.170
128.530
128.495
128.311
127.873
123.293
110.077
92.862
77.316
76.999
76.682
61.558
52.107
19.076
f1 (ppm)


8.023
8.003
7.434
7.414
7.384
7.365
7.349
7.331
7.314
3.918
3.829
2.246
2.234
2.224
2.214
2.202
2.194
2.173
1.130
1.124
1.118
1.111
1.105
1.100
0.686
0.680
0.666
0.660
-0.000
CO2Me
Ph
C
Me
S
O
O
2.02
2.17
4.92
2.96
1.97
4.05
2.03
2.00
f1 (ppm)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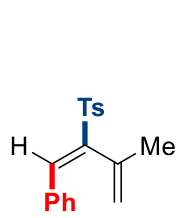
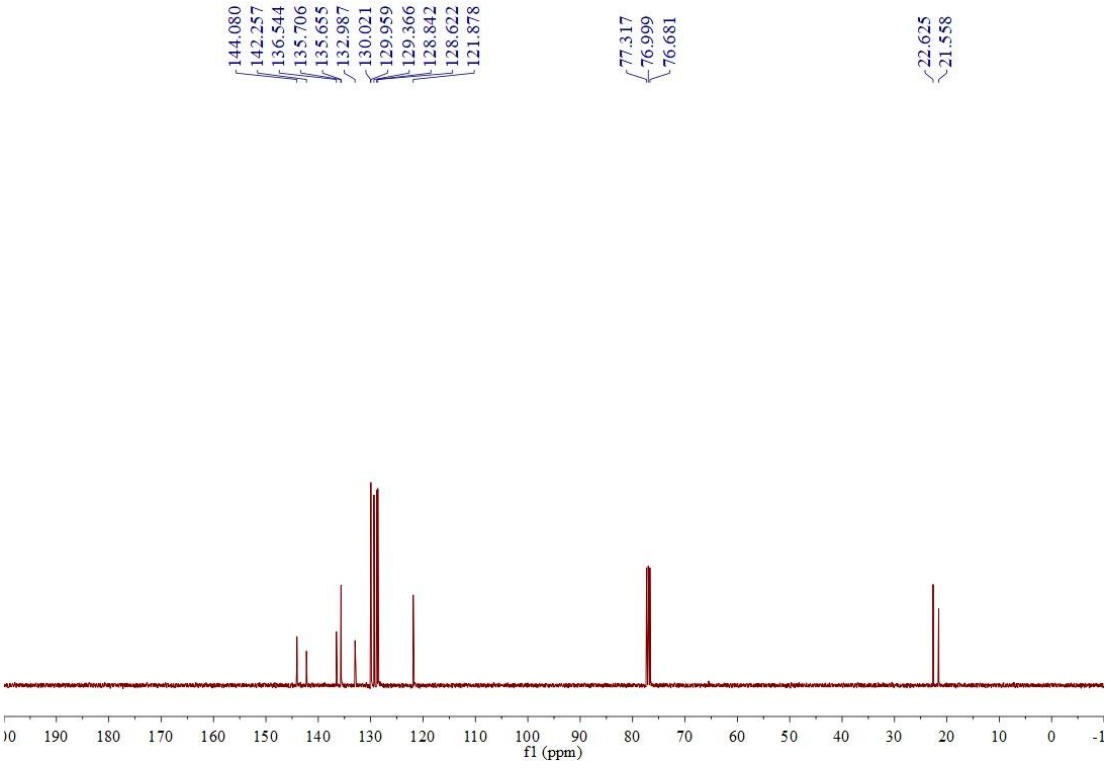
140.883
135.385
129.690
129.187
128.571
128.508
128.332
127.917
109.884
93.572
77.318
77.001
76.682
58.528
52.070
28.869
19.133
4.821
4.781
f1 (ppm)

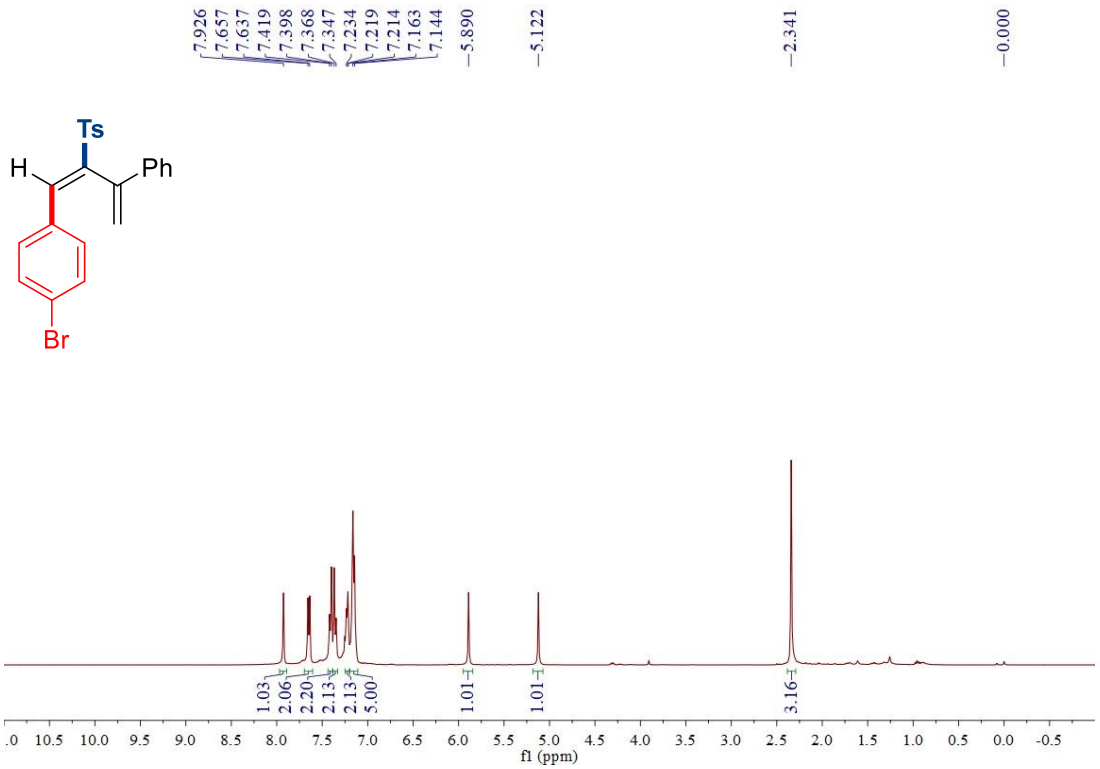
50

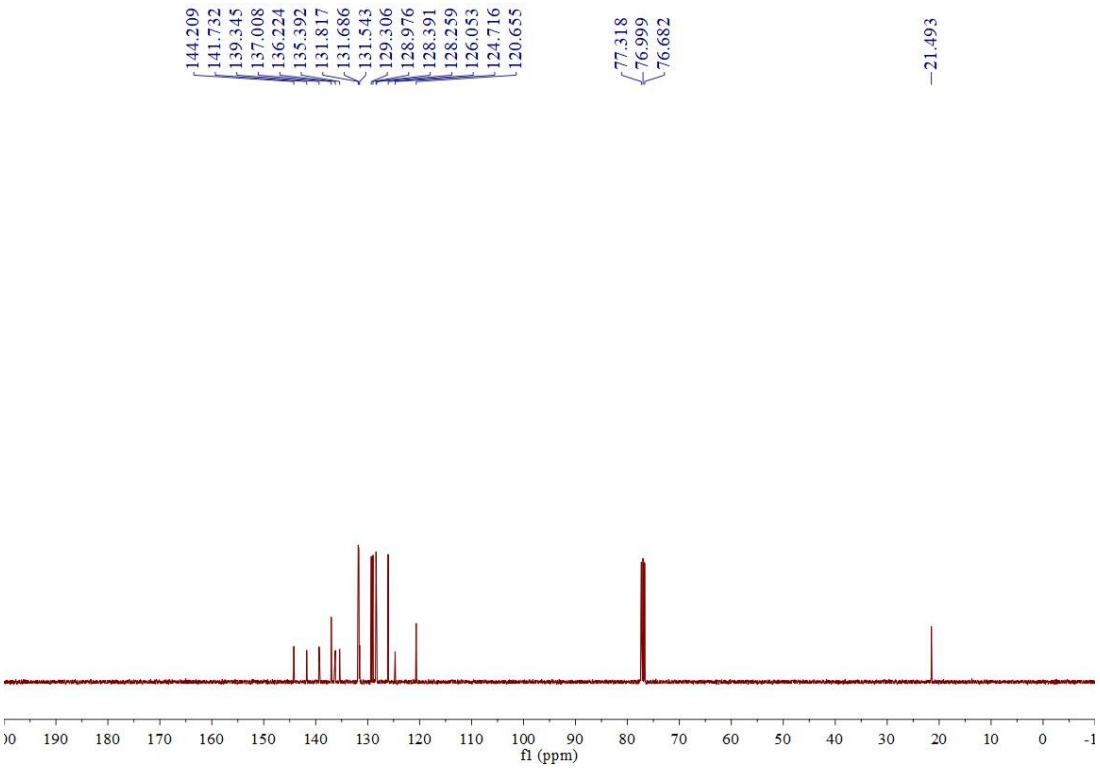

Ts
H
Me
Ph

7.776
7.756
7.712
7.612
7.606
7.597
7.588
7.362
7.355
7.346
7.306
7.286
5.261
4.805
2.421
1.775
0.000
2.00
1.01
1.98
3.04
1.93
0.98
0.97
3.00
3.02
f1 (ppm)


144.080
142.257
136.544
135.706
135.655
132.987
130.021
129.959
129.366
128.842
128.622
121.878
77.317
76.999
76.681
22.625
21.558
f1 (ppm)

51


7.926
7.657
7.637
7.419
7.398
7.368
7.347
7.234
7.219
7.214
7.163
7.144
5.890
5.122
2.341
0.000
Ts
H
Ph
Br
1.03
2.06
2.20
2.13
2.13
5.00
1.01
1.01
3.16
fl (ppm)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141.732
139.345
137.008
136.224
135.392
131.817
131.686
131.543
129.306
128.976
128.391
128.259
126.053
124.716
120.655
77.318
76.999
76.682
21.493
fl (ppm)


7.735
7.711
7.691
7.680
7.660
7.571
7.554
7.374
7.356
7.337
7.320
7.309
7.301
7.288
7.280
7.265
5.306
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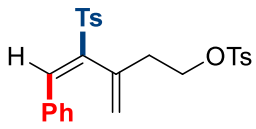
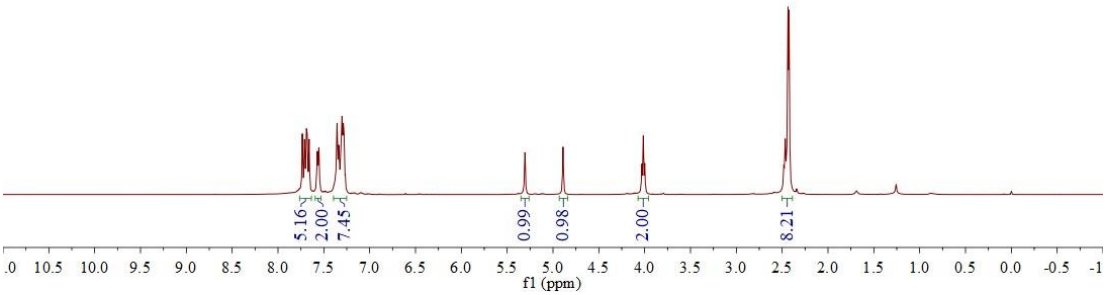
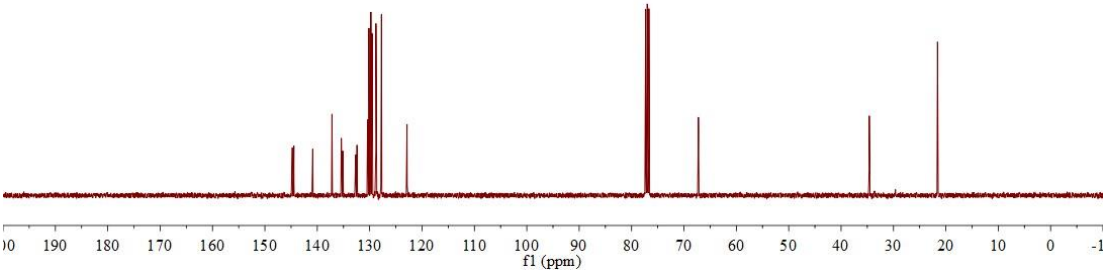
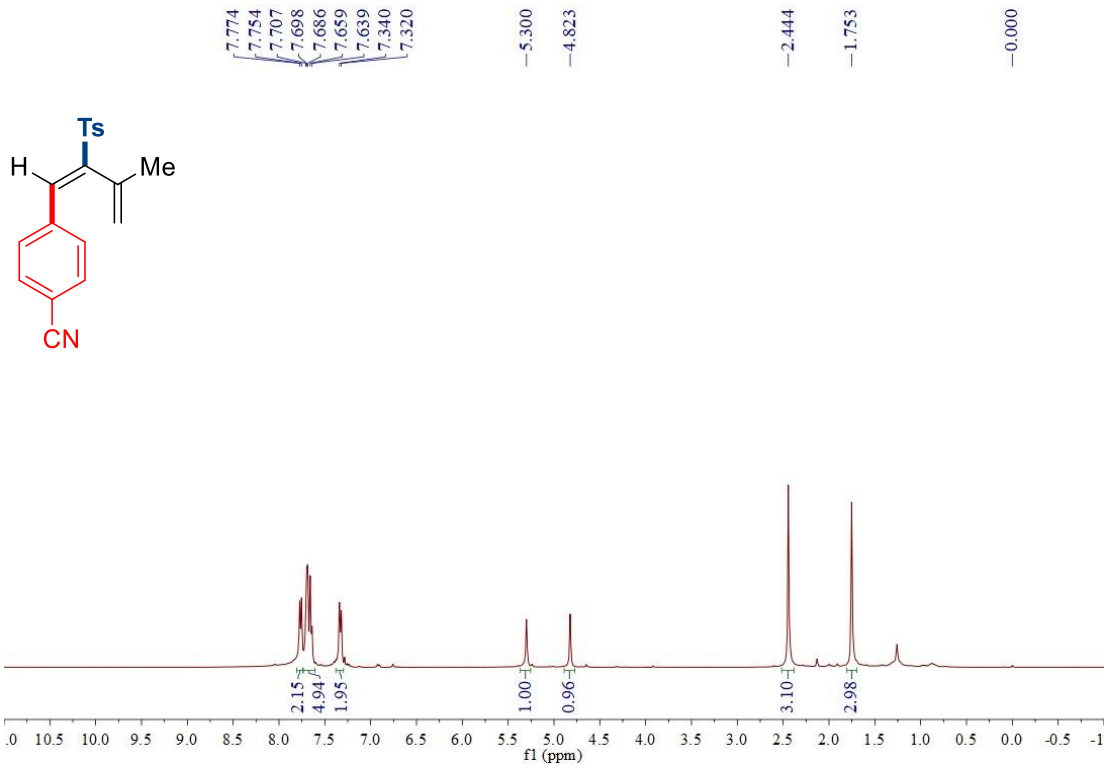
2.467
2.451
2.436
2.425
0.000


Ts
H
OTs
Ph


5.16
2.00
7.45
0.99
0.98
2.00
8.21
f1 (ppm)


144.762
144.465
140.864
137.194
135.408
135.135
132.682
132.413
130.406
130.136
129.765
129.534
128.799
128.718
127.745
122.864
77.317
77.000
76.682
67.239
34.612
21.588


f1 (ppm)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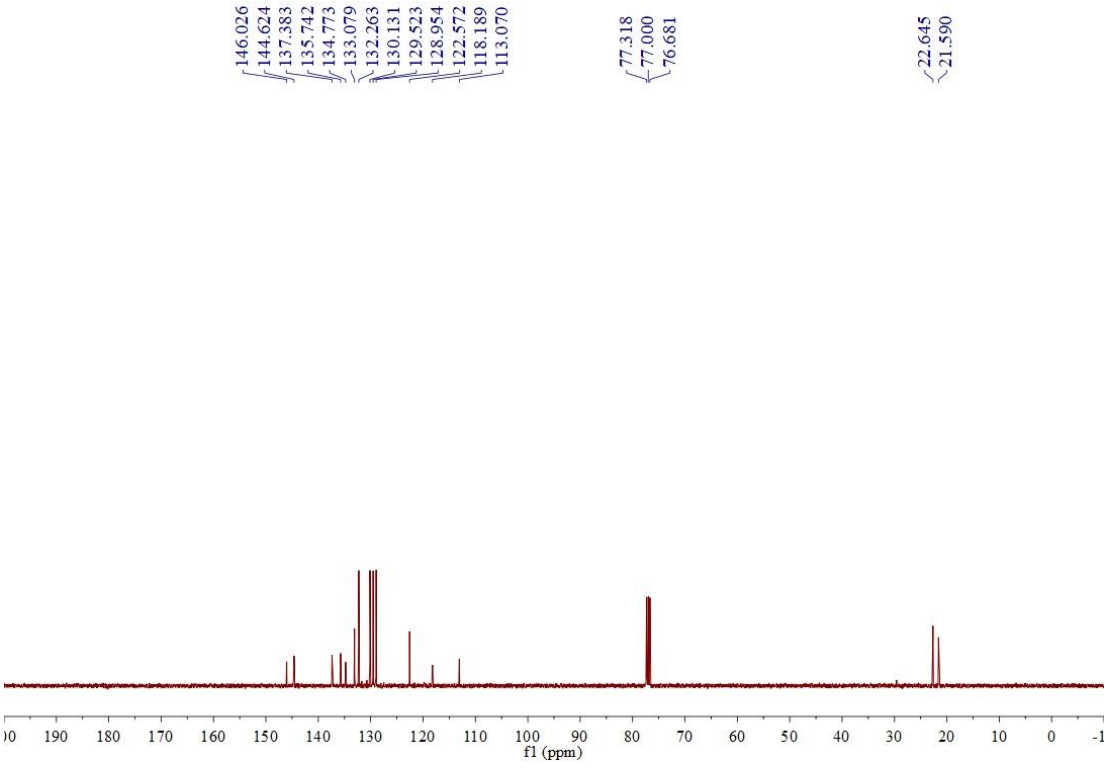
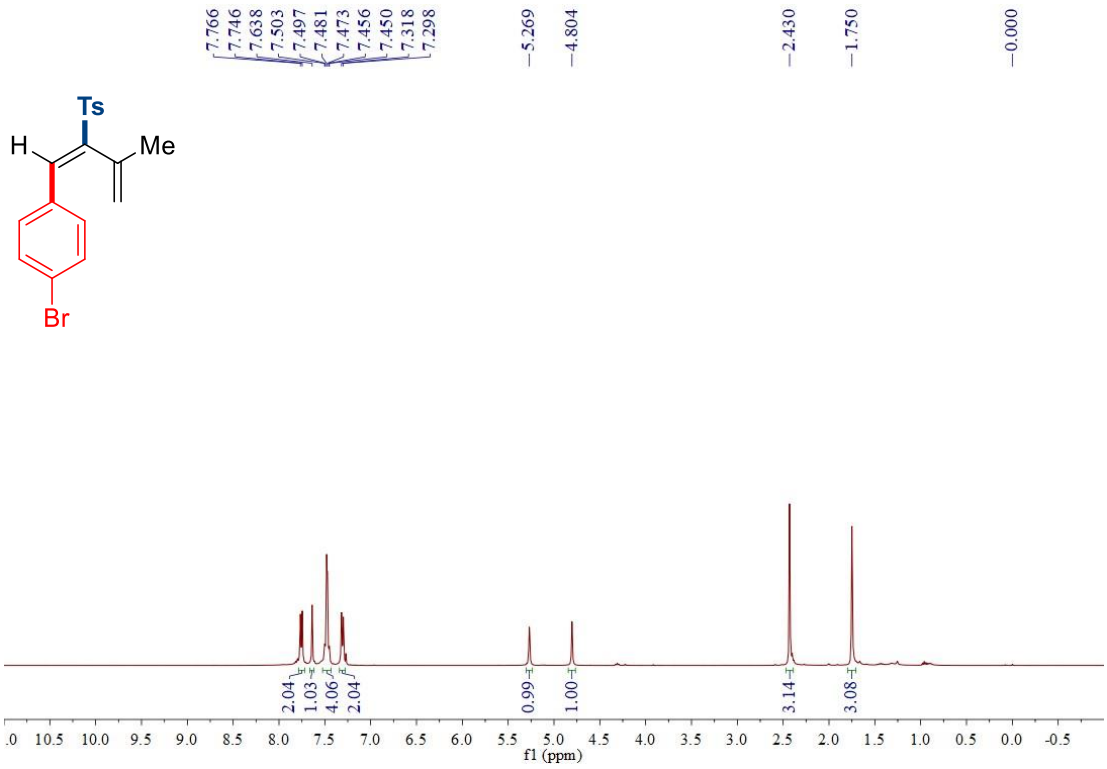
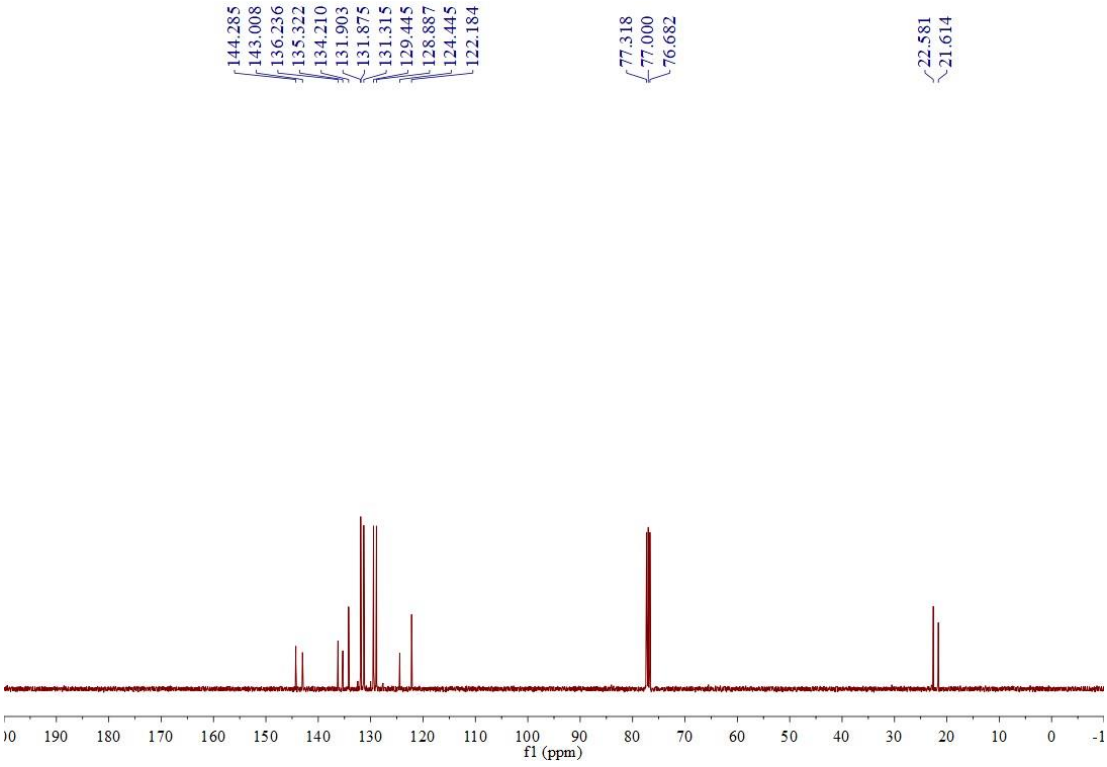
7.686
7.659
7.639
7.340
7.320
5.300
4.823
2.444
1.753
0.000
Ts
H
Me
CN
2.15
4.94
1.95
1.00
0.96
3.10
2.98
f1 (ppm)

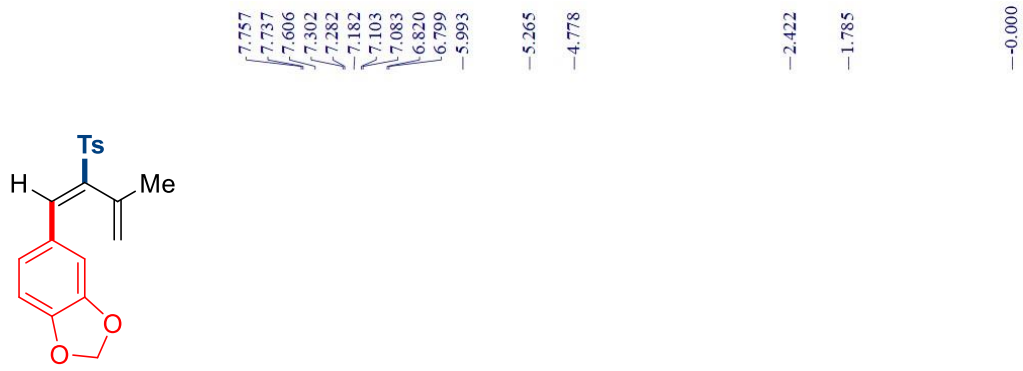

146.026
144.624
137.383
135.742
134.773
133.079
132.263
130.131
129.523
128.954
122.572
118.189
113.070
77.318
77.000
76.681
22.645
21.590
f1 (ppm)

54

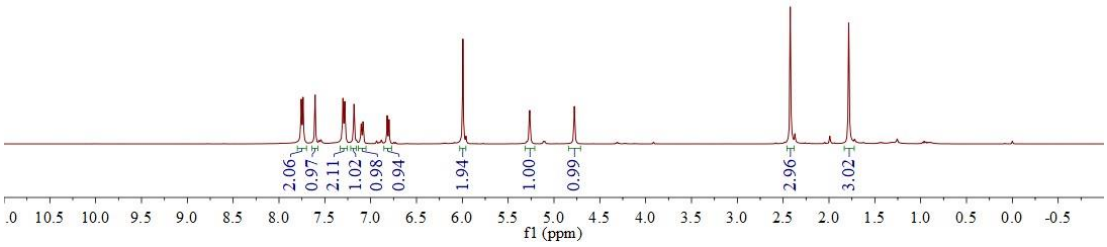

7.766
7.746
7.638
7.503
7.497
7.481
7.473
7.456
7.450
7.318
7.298
5.269
4.804
2.430
1.750
0.000
Ts
H
Me
Br
2.04
1.03
4.06
2.04
0.99
1.00
3.14
3.08
f1 (ppm)


144.285
143.008
136.236
135.322
134.210
131.903
131.875
131.315
129.445
128.887
124.445
122.184
77.318
77.000
76.682
22.581
21.614
f1 (ppm)

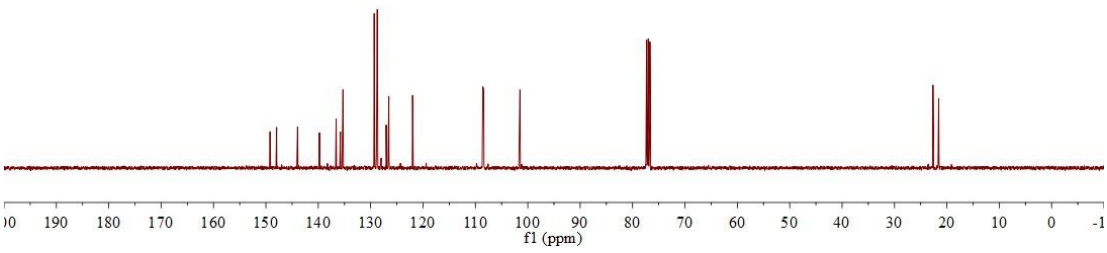
55

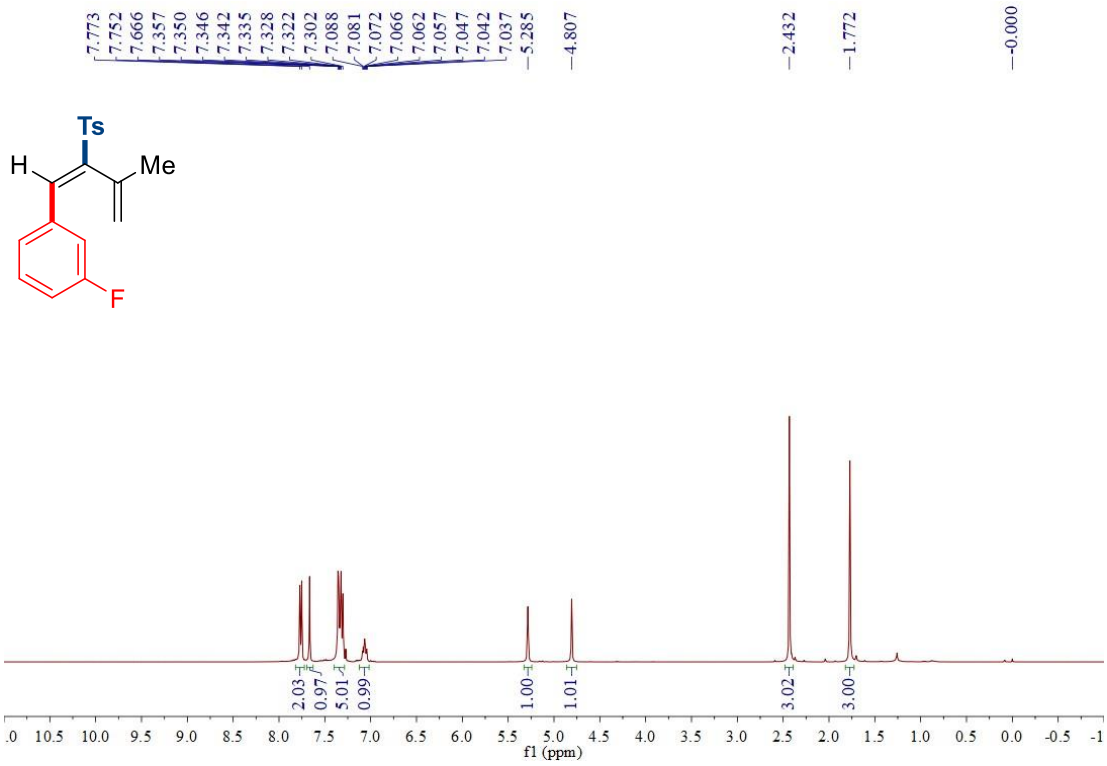

7.757
7.737
7.606
7.302
7.282
7.182
7.103
7.083
6.820
6.799
5.993
5.265
4.778
2.422
1.785
0.000

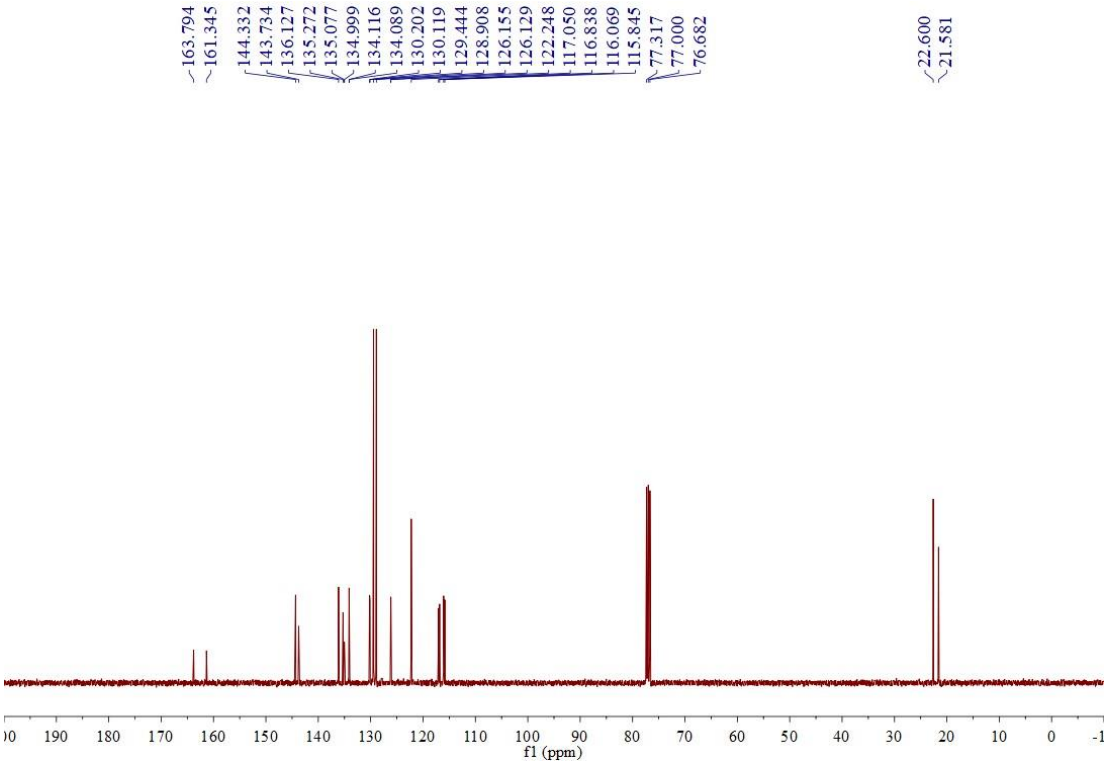
Ts
H
Me
O
O

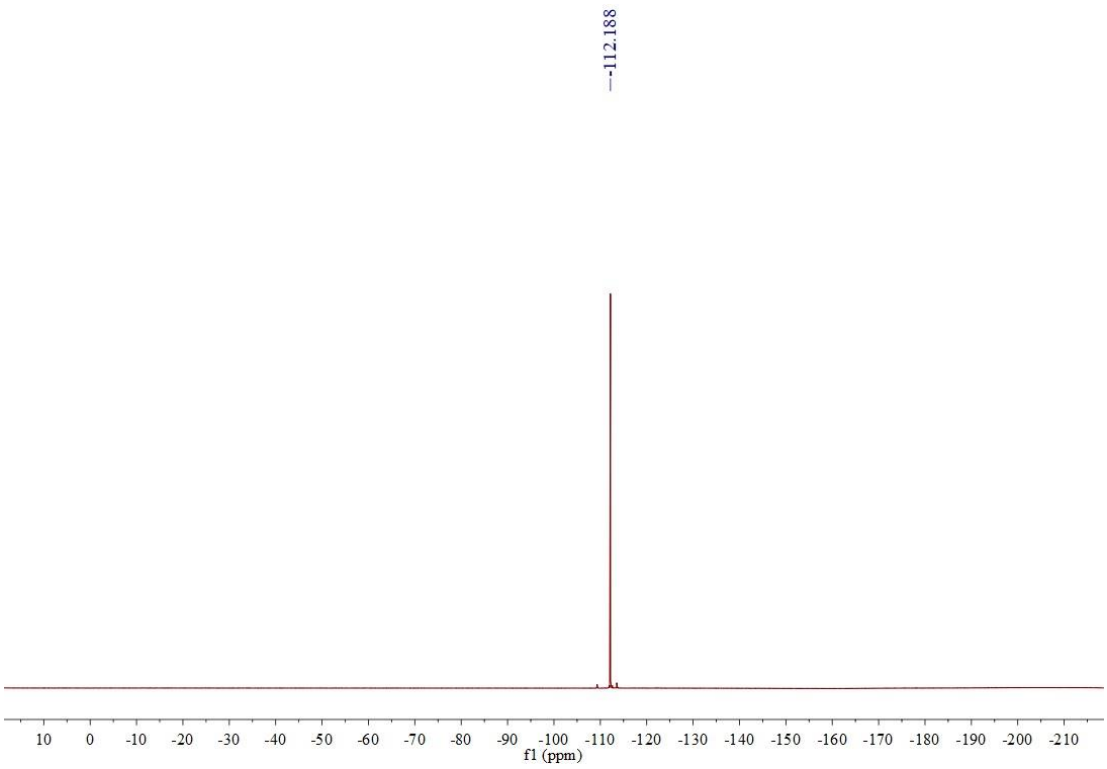

2.06
0.97
2.11
1.02
0.98
0.94
1.94
1.00
0.99
2.96
3.02
f1 (ppm)


149.212
147.949
143.952
139.772
136.585
135.771
135.278
129.324
128.737
127.036
126.531
121.991
108.573
108.423
101.494
77.317
76.999
76.681
22.644
21.560

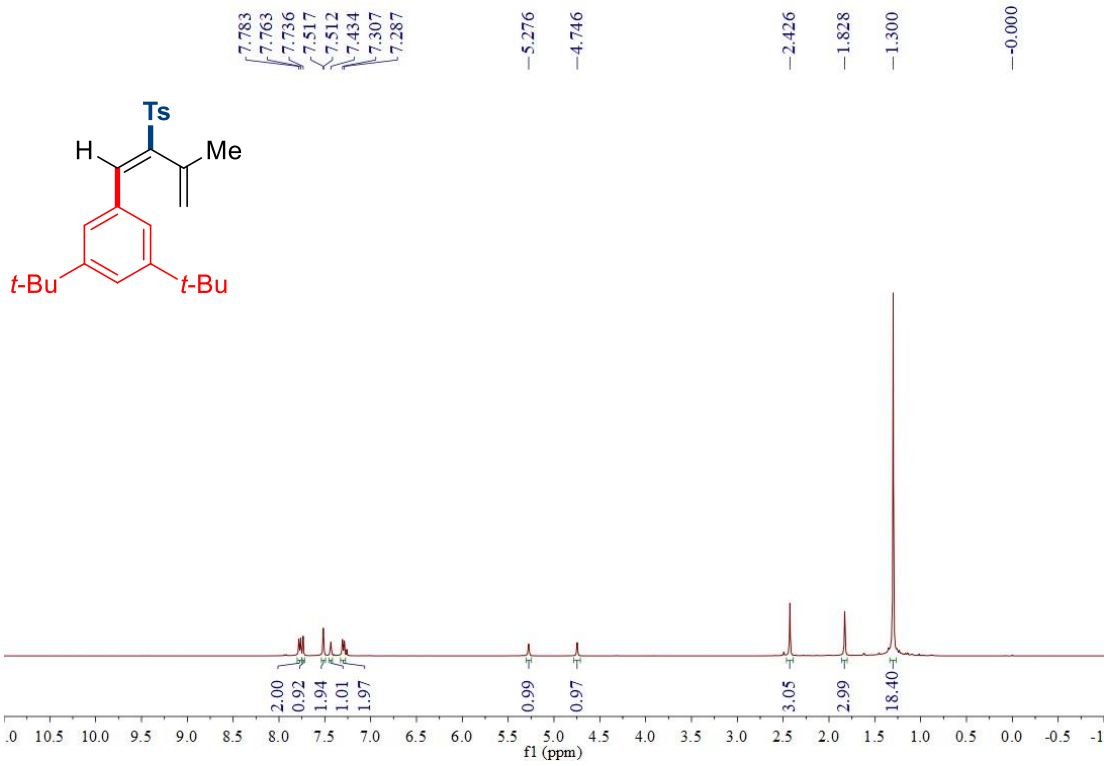

f1 (ppm)

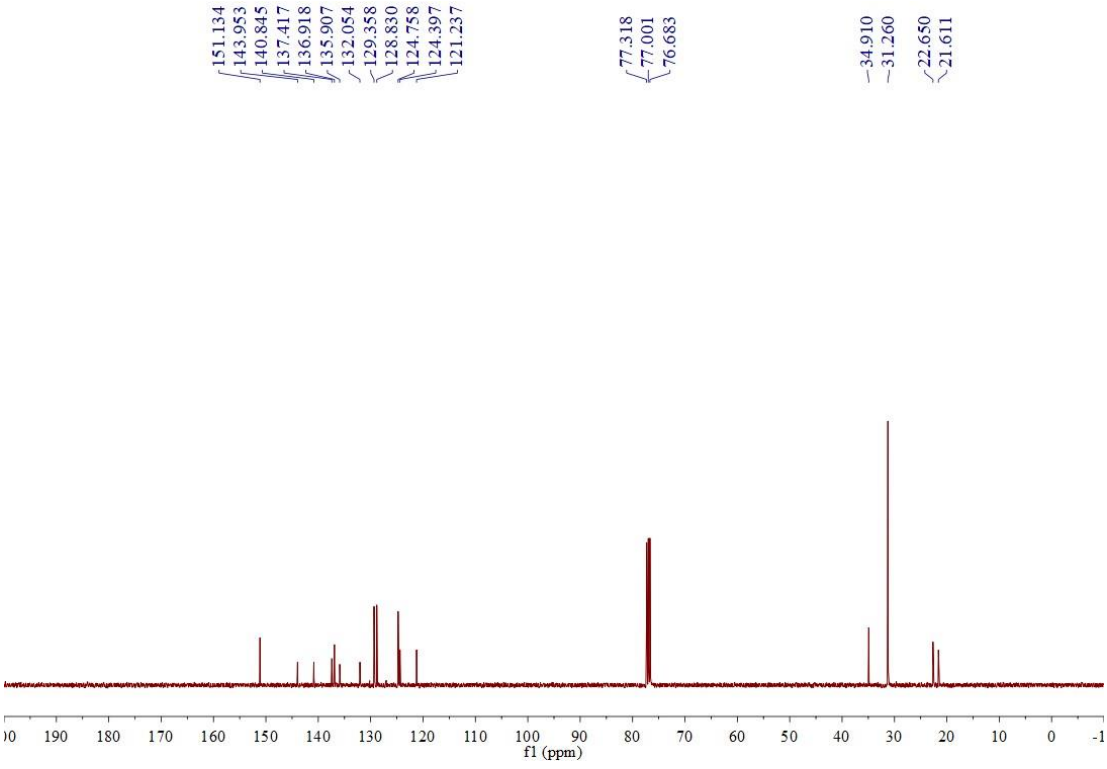

7.773
7.752
7.666
7.357
7.350
7.346
7.342
7.335
7.328
7.322
7.302
7.088
7.081
7.072
7.066
7.062
7.057
7.047
7.042
7.037
5.285
4.807
2.432
1.772
0.000
Ts
H
Me
F
2.03
0.97
5.01
0.99
1.00
1.01
3.02
3.00
f1 (ppm)


163.794
161.345
144.332
143.734
136.127
135.272
135.077
134.999
134.116
134.089
130.202
130.119
129.444
128.908
126.155
126.129
122.248
117.050
116.838
116.069
115.845
77.317
77.000
76.682
22.600
21.581
f1 (ppm)

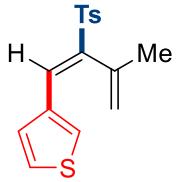

-112.188
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)

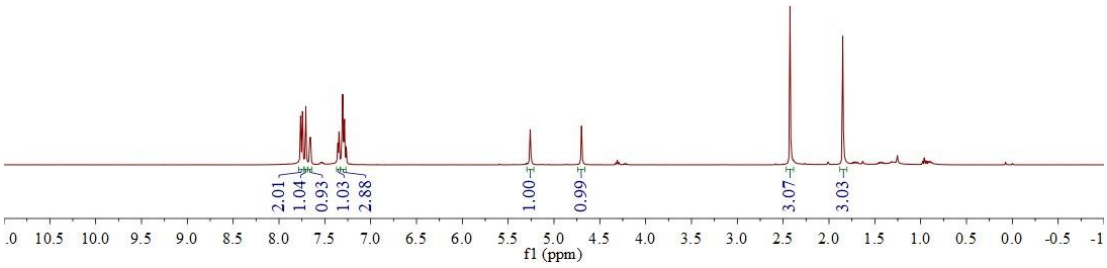
57


7.783
7.763
7.736
7.517
7.512
7.434
7.307
7.287
5.276
4.746
2.426
1.828
1.300
0.000
Ts
H
Me
t-Bu
t-Bu
2.00
0.92
1.94
1.01
1.97
0.99
0.97
3.05
2.99
18.40
f1 (ppm)

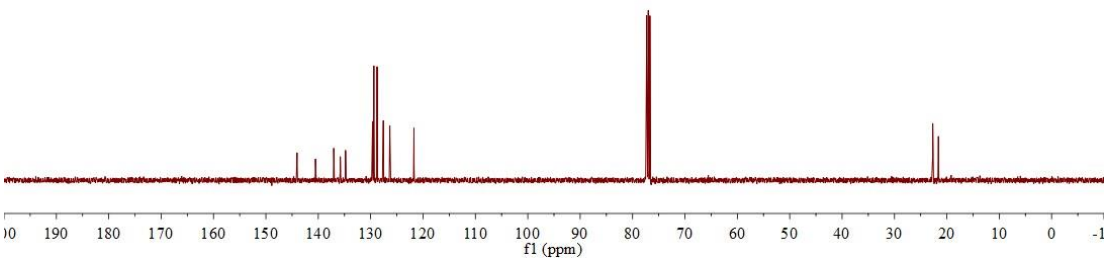

151.134
143.953
140.845
137.417
136.918
135.907
132.054
129.358
128.830
124.758
124.397
121.237
77.318
77.001
76.683
34.910
31.260
22.650
21.611
f1 (ppm)


7.764
7.744
7.708
7.666
7.663
7.658
7.655
7.361
7.357
7.348
7.345
7.312
7.305
7.300
7.292
7.285
5.260
4.700
2.425
1.850
0.000

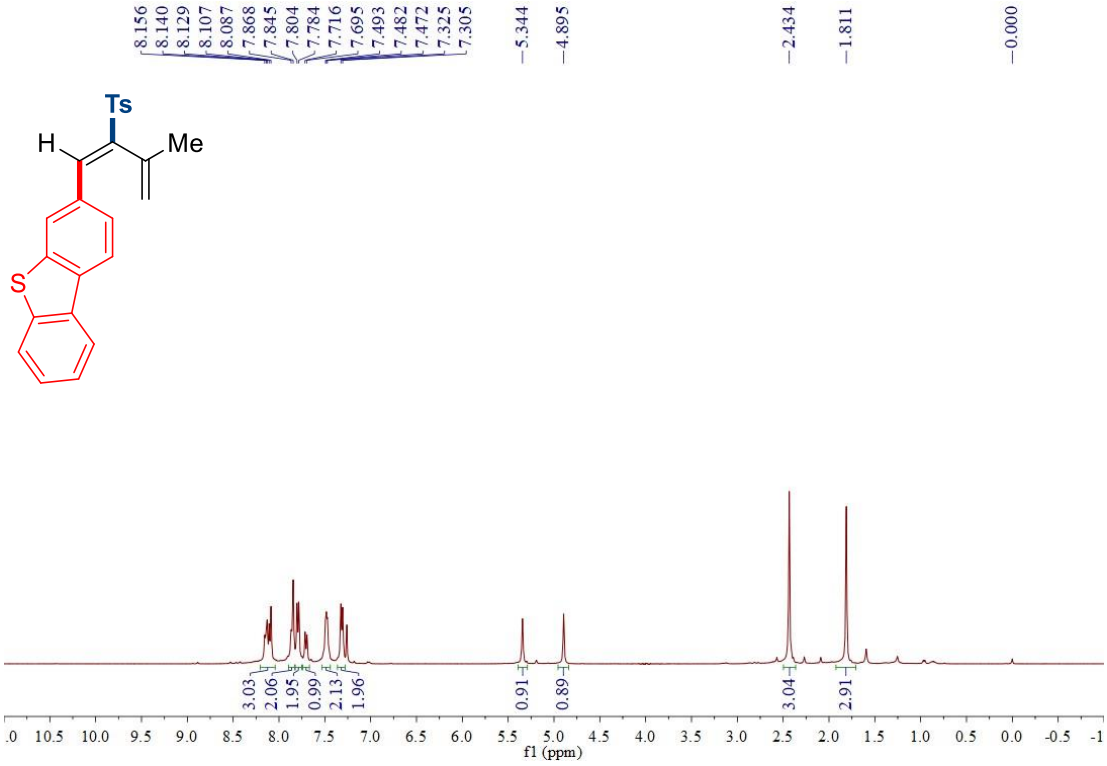

Ts
H
Me
S

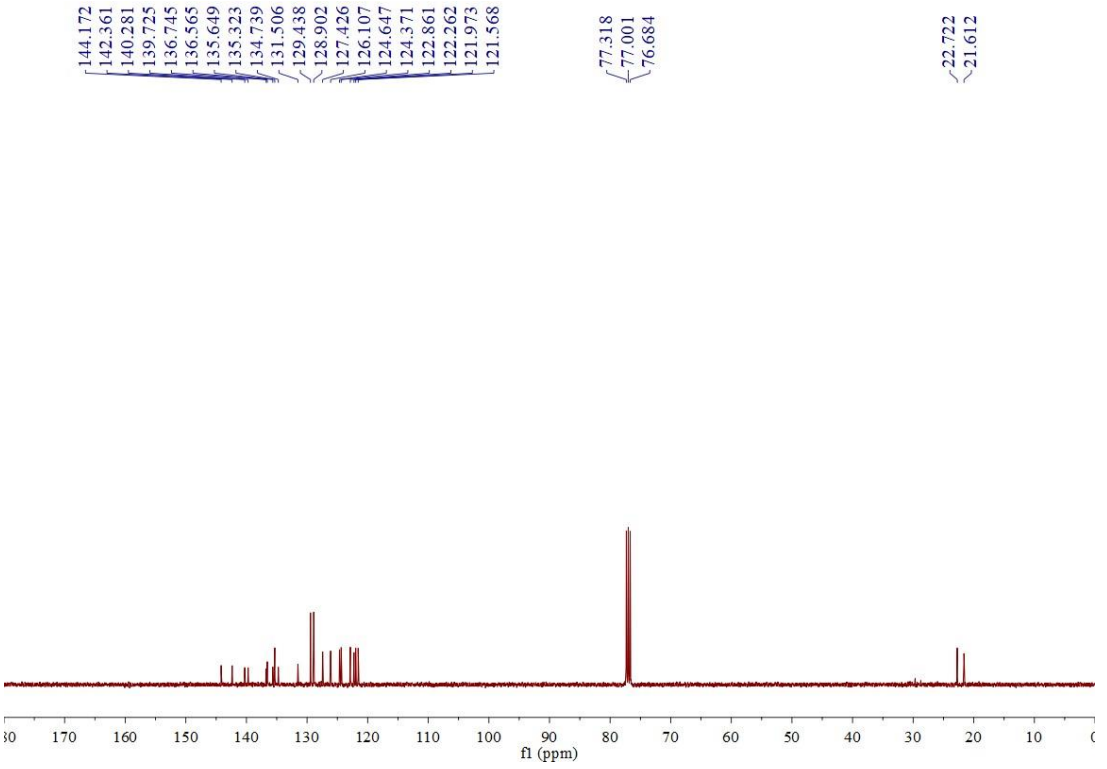

2.01
1.04
0.93
1.03
2.88
1.00
0.99
3.07
3.03
f1 (ppm)


144.054
140.537
137.049
135.795
134.788
129.748
129.640
129.384
128.774
127.583
126.347
121.730
77.317
76.999
76.682
22.690
21.610

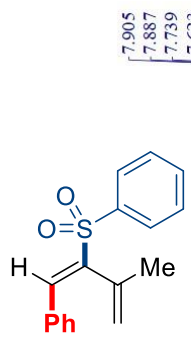

f1 (ppm)

59

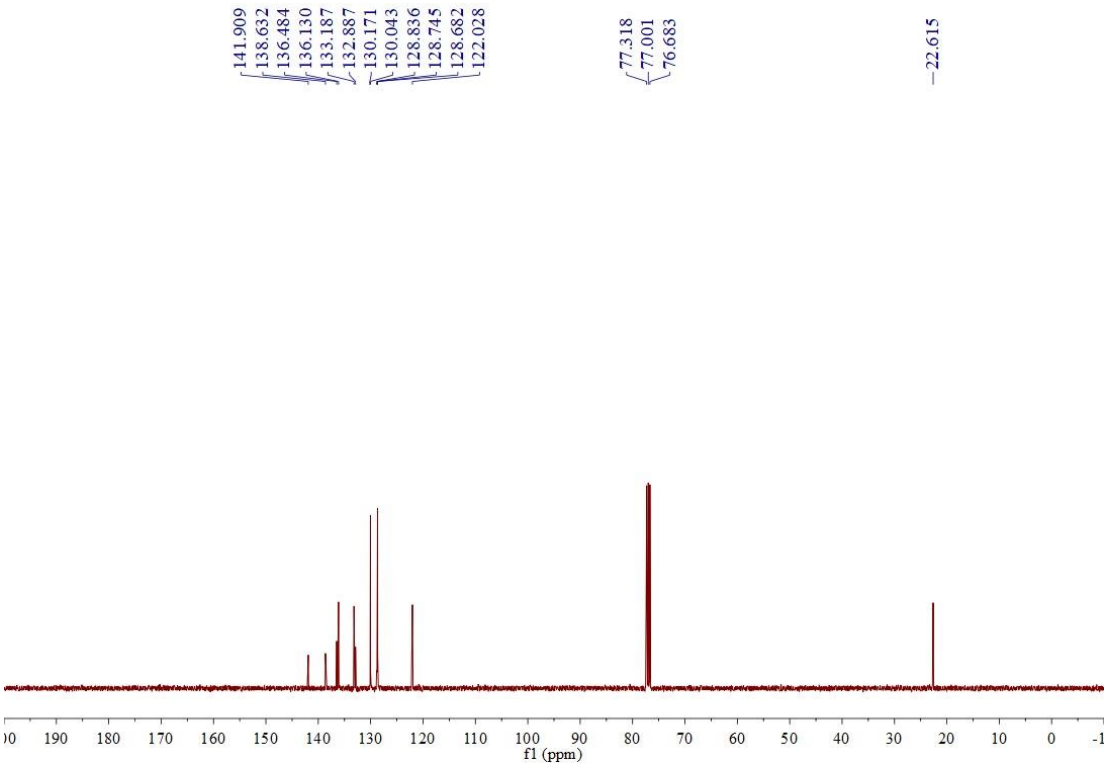

8.156
8.140
8.129
8.107
8.087
7.868
7.845
7.804
7.784
7.716
7.695
7.493
7.482
7.472
7.325
7.305
5.344
4.895
2.434
1.811
0.000
Ts
H
Me
S
3.03
2.06
1.95
0.99
2.13
1.96
0.91
0.89
3.04
2.91
f1 (ppm)


144.172
142.361
140.281
139.725
136.745
136.565
135.649
135.323
134.739
131.506
129.438
128.902
127.426
126.107
124.647
124.371
122.861
122.262
121.973
121.568
77.318
77.001
76.684
22.722
21.612
f1 (ppm)

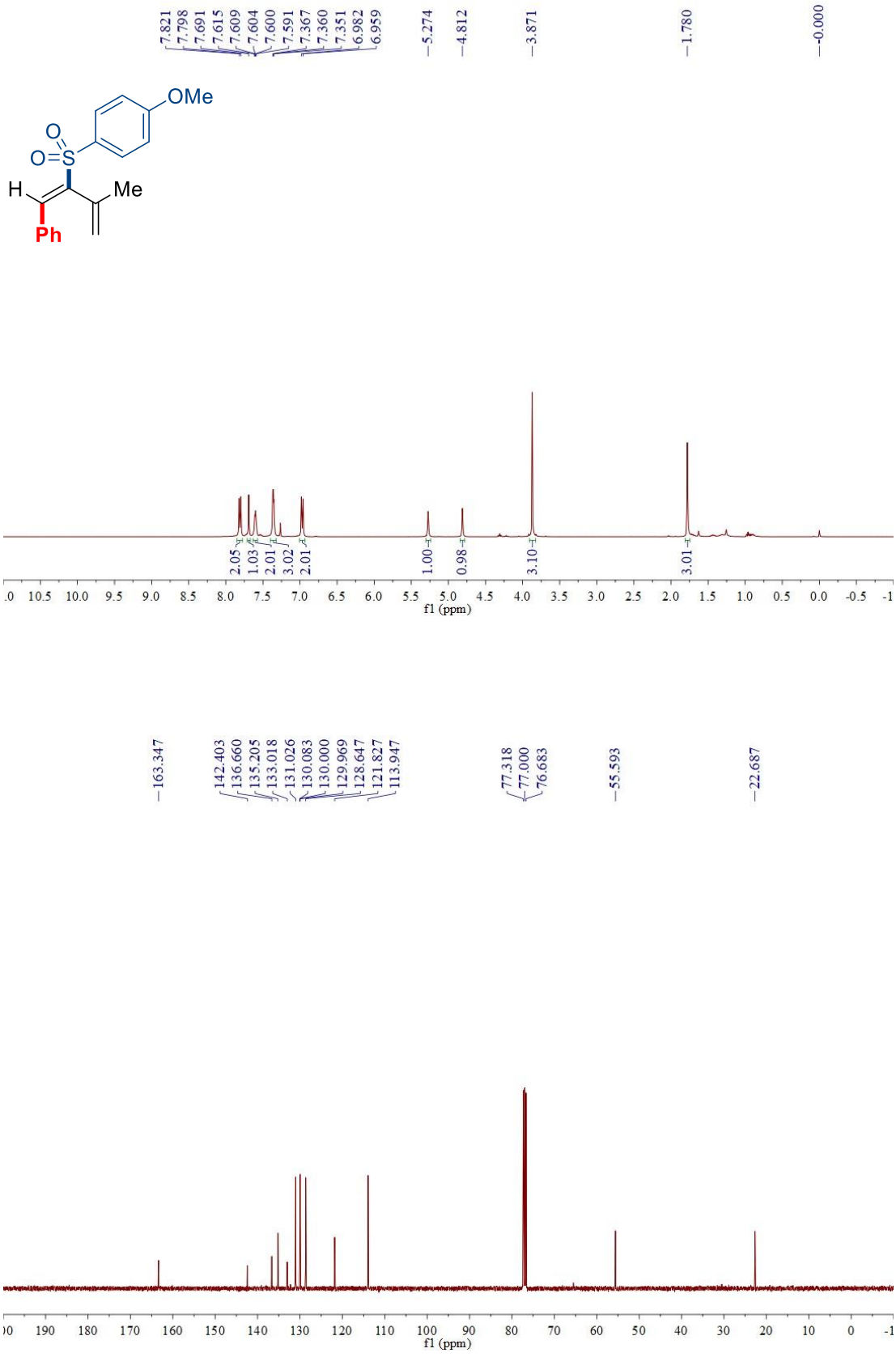
60


O
O=S
H
Me
Ph

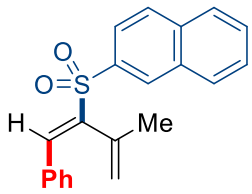
7.905
7.887
7.739
7.623
7.618
7.608
7.599
7.585
7.581
7.578
7.530
7.511
7.492
7.383
7.373
7.367
7.357
7.348
5.263
4.786
1.777
0.000
1.94
1.00
3.15
2.03
2.99
0.99
1.00
3.09
f1 (ppm)

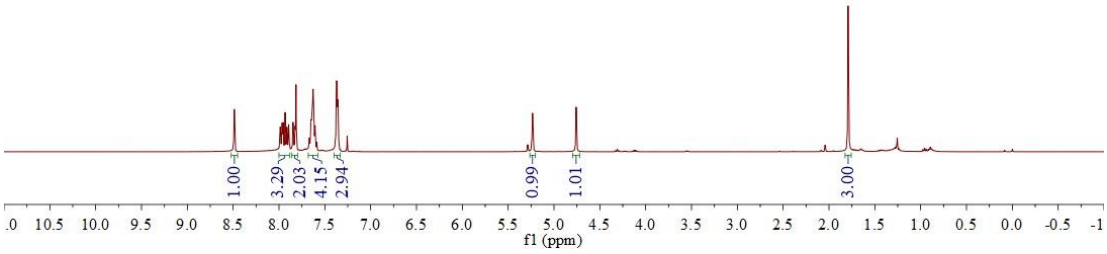

141.909
138.632
136.484
136.130
133.187
132.887
130.171
130.043
128.836
128.745
128.682
122.028
77.318
77.001
76.683
22.615
f1 (ppm)

61


7.821
7.798
7.691
7.615
7.609
7.604
7.600
7.591
7.367
7.360
7.351
6.982
6.959
5.274
4.812
3.871
1.780
0.000
OMe
O
O=S
H
Me
Ph
2.05
1.03
2.01
3.02
2.01
1.00
0.98
3.10
3.01
f1 (ppm)
163.347
142.403
136.660
135.205
133.018
131.026
130.083
130.000
129.969
128.647
121.827
113.947
77.318
77.000
76.683
55.593
22.687
f1 (ppm)


8.488
7.986
7.966
7.955
7.933
7.914
7.894
7.849
7.844
7.827
7.823
7.814
7.672
7.668
7.654
7.651
7.644
7.636
7.629
7.623
7.619
7.607
7.604
7.590
7.587
7.374
7.367
7.358
5.234
4.758
1.791
0.000

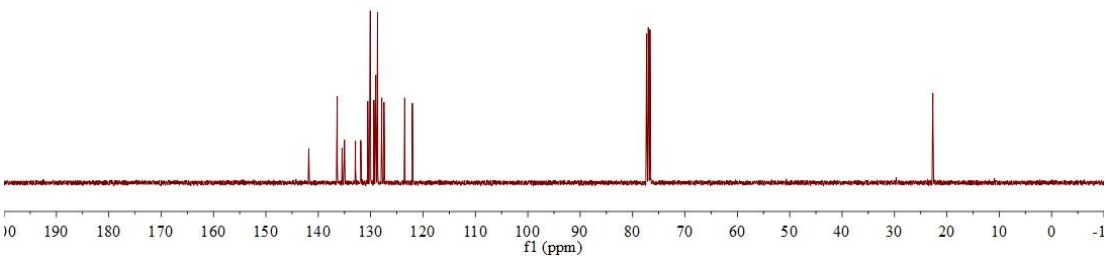

O
O=S
H
Me
Ph


1.00
3.29
2.03
4.15
2.94
0.99
1.01
3.00
f1 (ppm)

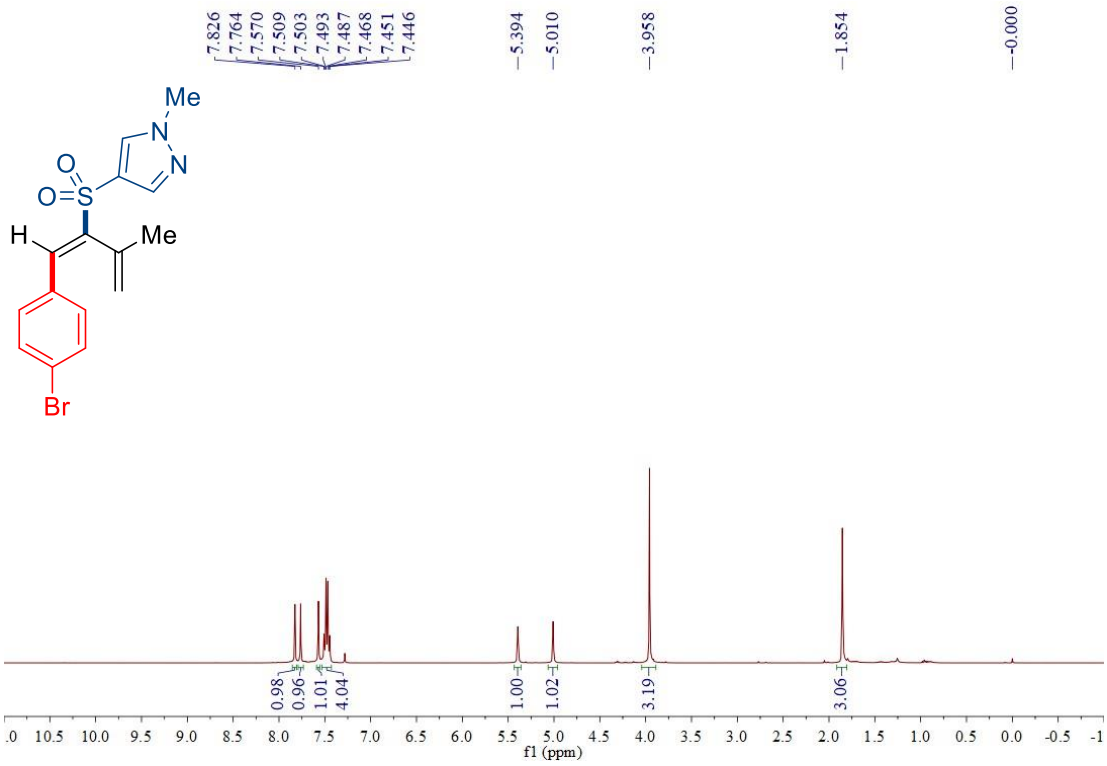

141.811
136.504
136.381
135.459
135.012
132.900
131.894
130.557
130.193
130.069
129.376
129.048
129.033
128.686
127.880
127.464
123.496
122.042

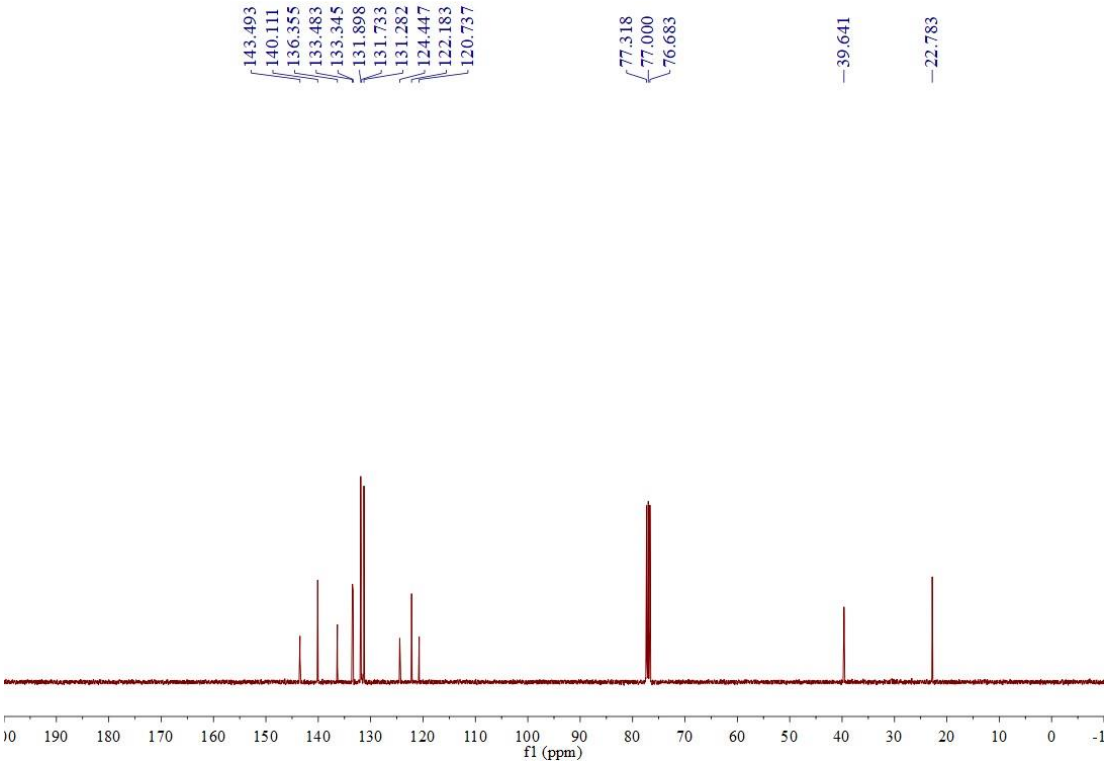

77.318
77.001
76.683


22.679

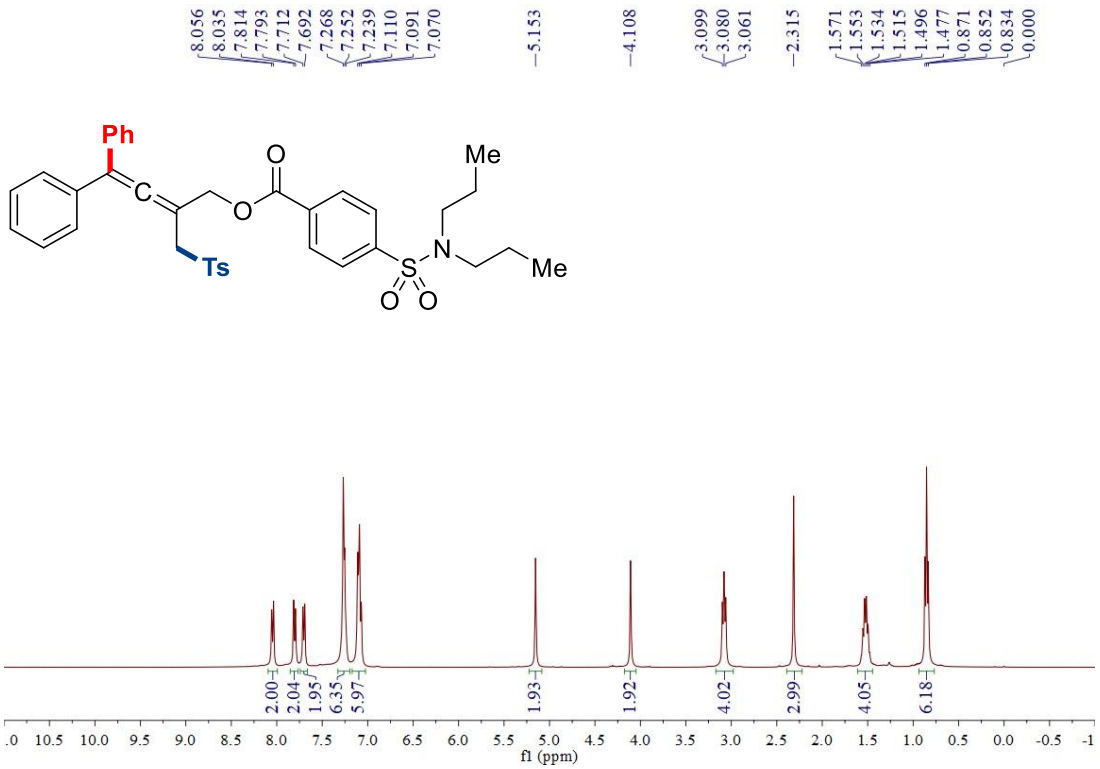

f1 (ppm)

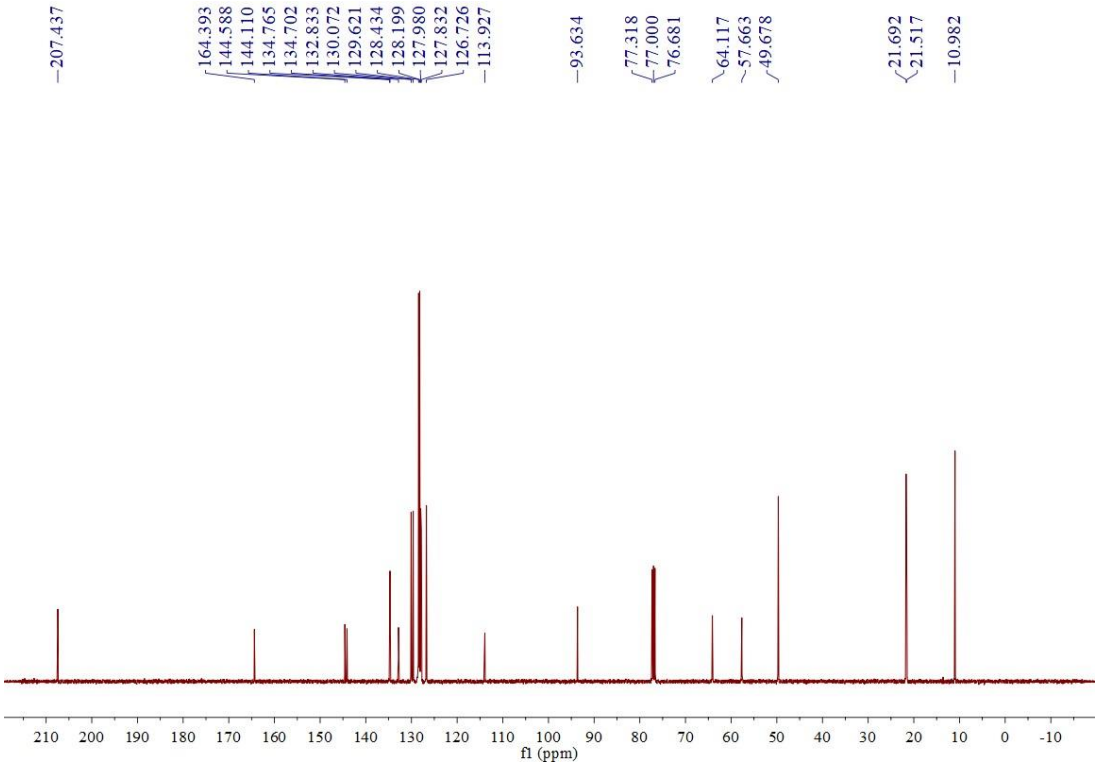
63


7.826
7.764
7.570
7.509
7.503
7.493
7.487
7.468
7.451
7.446
5.394
5.010
3.958
1.854
0.000
Me
N
N
O
O=S
H
Me
Br
0.98
0.96
1.01
4.04
1.00
1.02
3.19
3.06
f1 (ppm)

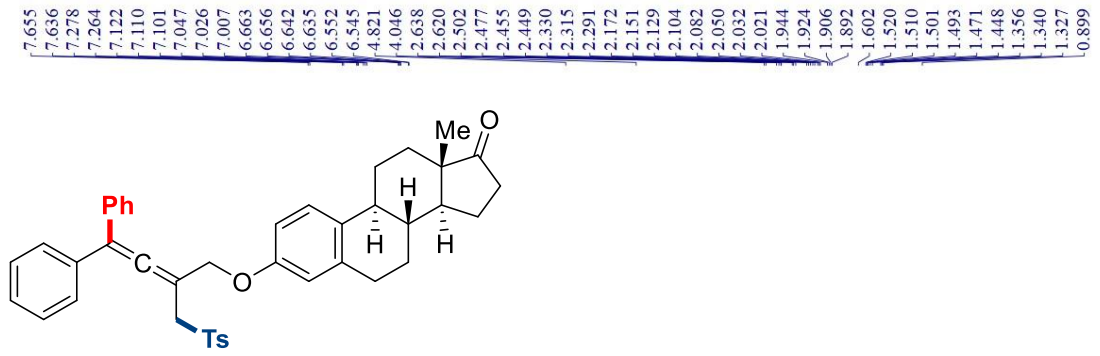

143.493
140.111
136.355
133.483
133.345
131.898
131.733
131.282
124.447
122.183
120.737
77.318
77.000
76.683
39.641
22.783
f1 (ppm)

64

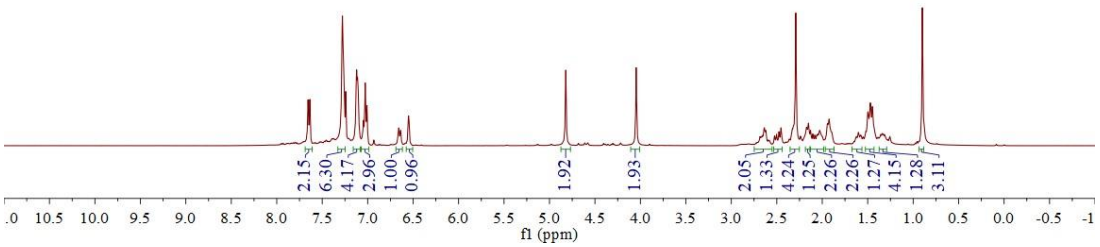

8.056
8.035
7.814
7.793
7.712
7.692
7.268
7.252
7.239
7.110
7.091
7.070
5.153
4.108
3.099
3.080
3.061
2.315
1.571
1.553
1.534
1.515
1.496
1.477
0.871
0.852
0.834
0.000
Ph
C
O
O
Ts
Me
N
Me
S
O
O
2.00
2.04
1.95
6.35
5.97
1.93
1.92
4.02
2.99
4.05
6.18
f1 (ppm)

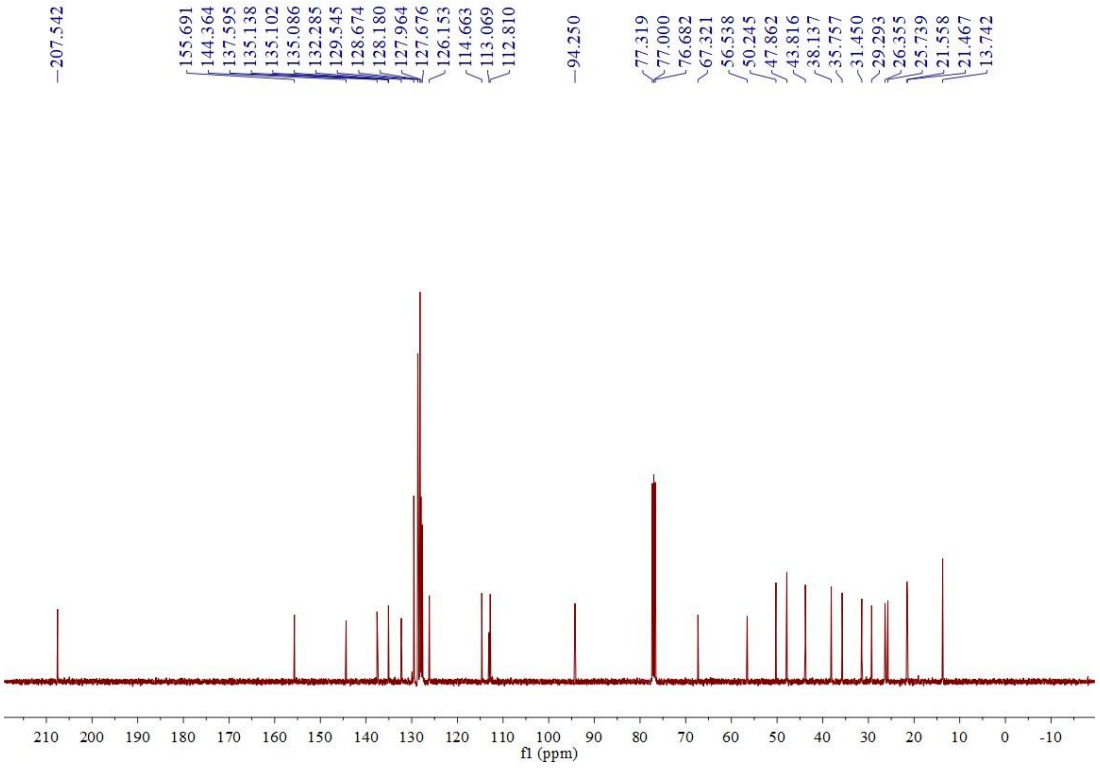

207.437
164.393
144.588
144.110
134.765
134.702
132.833
130.072
129.621
128.434
128.199
127.980
127.832
126.726
113.927
93.634
77.318
77.000
76.681
64.117
57.663
49.678
21.692
21.517
10.982
f1 (ppm)

65


7.655
7.636
7.278
7.264
7.122
7.110
7.101
7.047
7.026
7.007
6.663
6.656
6.642
6.635
6.552
6.545
4.821
4.046
2.638
2.620
2.502
2.477
2.455
2.449
2.330
2.315
2.291
2.172
2.151
2.129
2.104
2.082
2.050
2.032
2.021
1.944
1.924
1.906
1.892
1.602
1.520
1.510
1.501
1.493
1.471
1.448
1.356
1.340
1.327
0.899

Me
O
H
H
H
Ph
C
O
Ts


2.15
6.30
4.17
2.96
1.00
0.96
1.92
1.93
2.05
1.33
4.24
1.25
2.26
2.26
1.27
4.15
1.28
3.11
f1 (ppm)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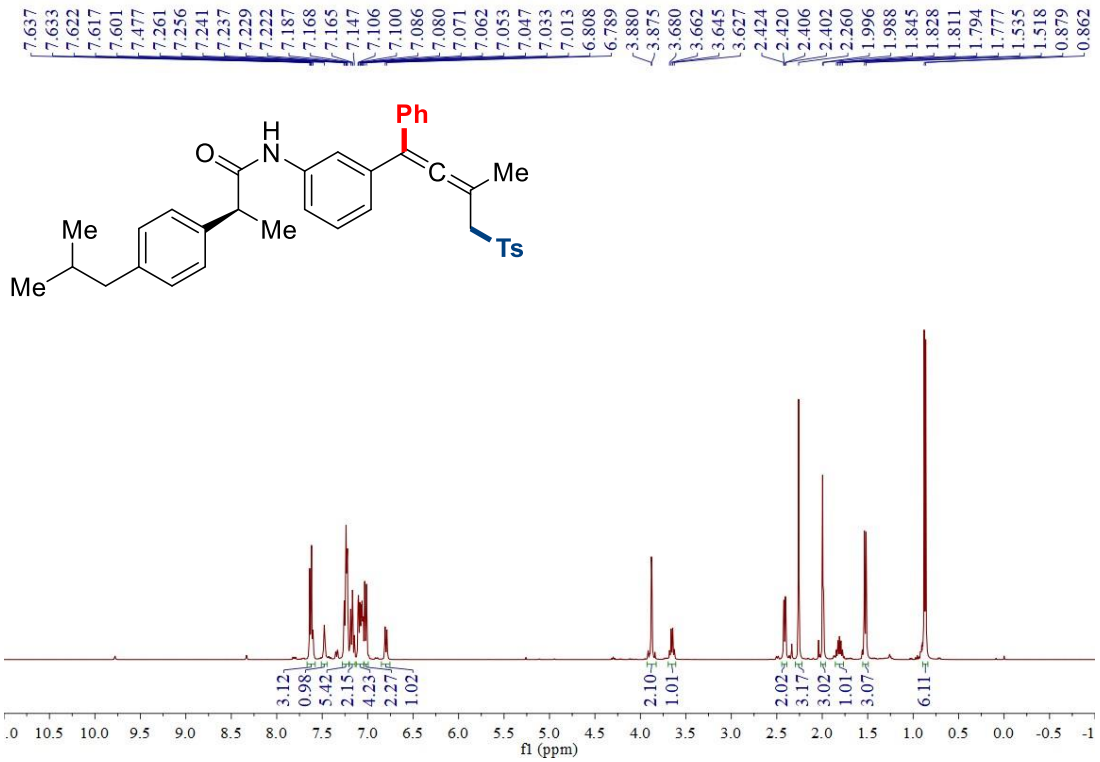
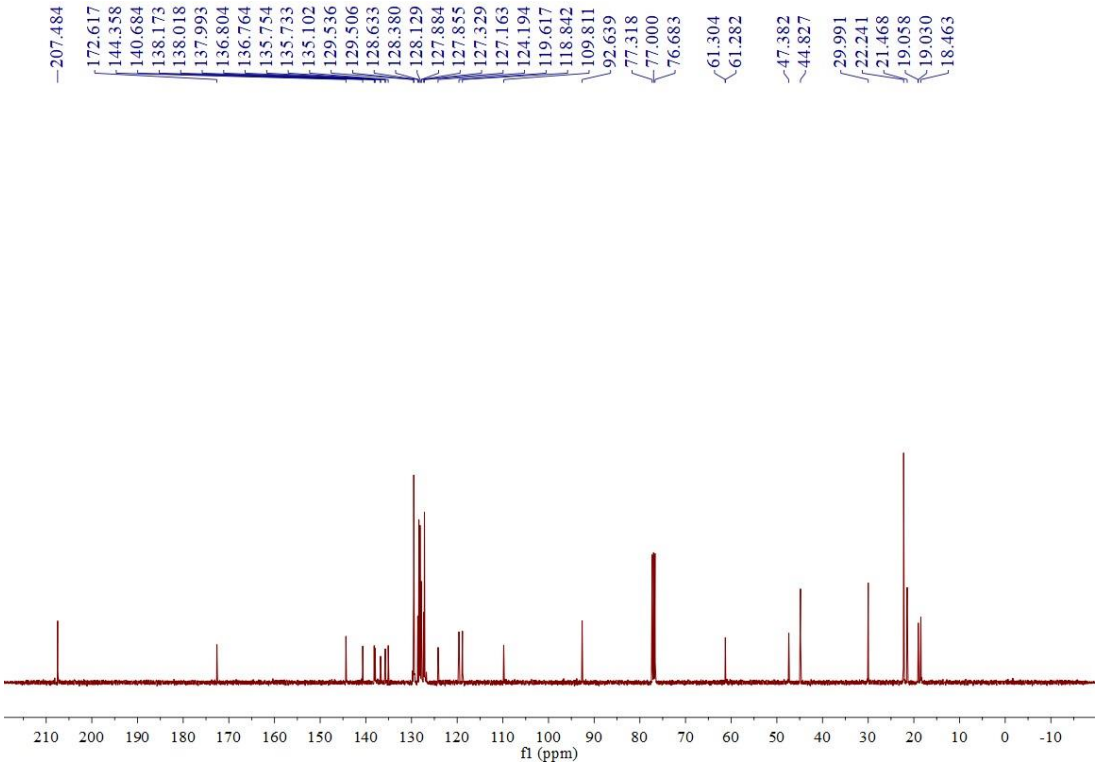
155.691
144.364
137.595
135.138
135.102
135.086
132.285
129.545
128.674
128.180
127.964
127.676
126.153
114.663
113.069
112.810
94.250
77.319
77.000
76.682
67.321
56.538
50.245
47.862
43.816
38.137
35.757
31.450
29.293
26.355
25.739
21.558
21.467
13.742
f1 (ppm)

66


7.637
7.633
7.622
7.617
7.601
7.477
7.261
7.256
7.241
7.237
7.229
7.222
7.187
7.168
7.165
7.147
7.106
7.100
7.086
7.080
7.071
7.062
7.053
7.047
7.033
7.013
6.808
6.789
3.880
3.875
3.680
3.662
3.645
3.627
2.424
2.420
2.406
2.402
2.260
1.996
1.988
1.845
1.828
1.811
1.794
1.777
1.535
1.518
0.879
0.862
Ph
H
N
O
C
Me
Me
Me
Me
Ts
3.12
0.98
5.42
2.15
4.23
2.27
1.02
2.10
1.01
2.02
3.17
3.02
1.01
3.07
6.11
f1 (ppm)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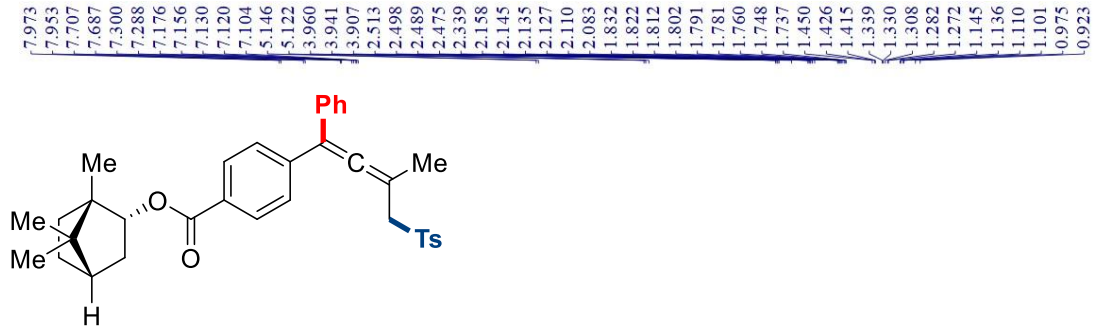
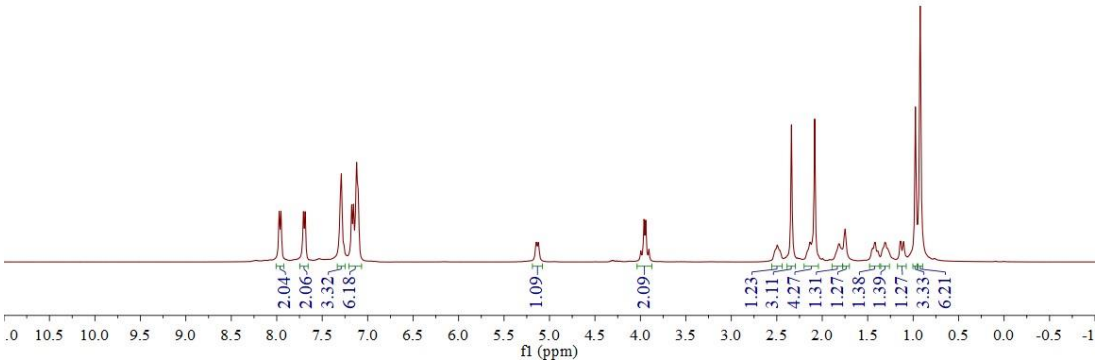
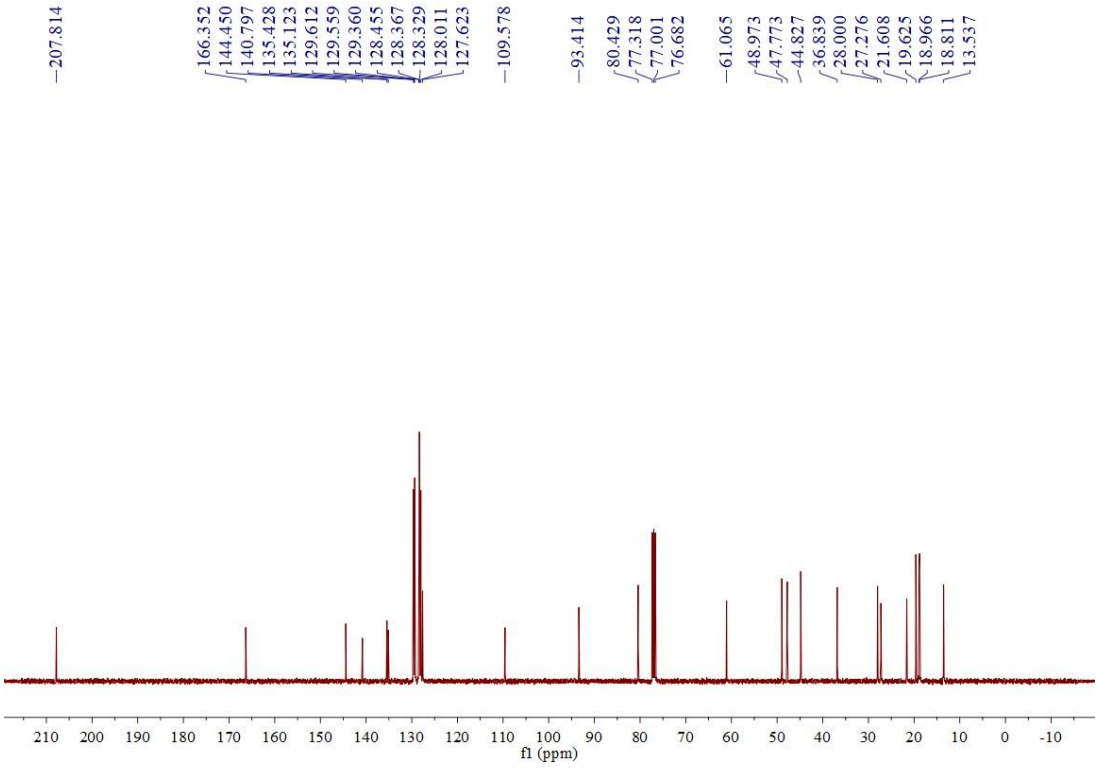
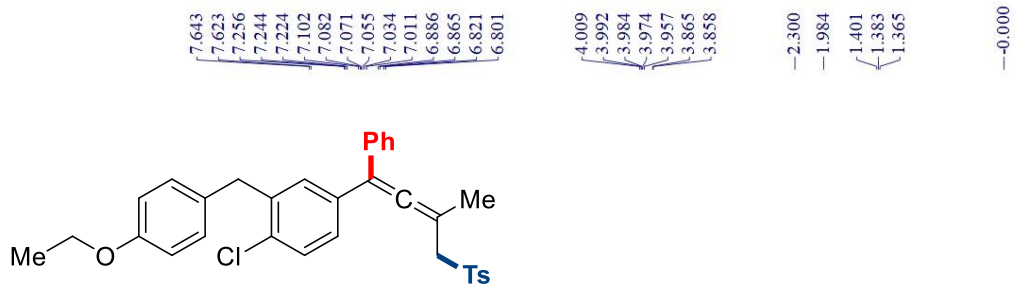
140.684
138.173
138.018
137.993
136.804
136.764
135.754
135.733
135.102
129.536
129.506
128.633
128.380
128.129
127.884
127.855
127.329
127.163
124.194
119.617
118.842
109.811
92.639
77.318
77.000
76.683
61.304
61.282
47.382
44.827
29.991
22.241
21.468
19.058
19.030
18.463
f1 (ppm)


Ph
Me
C
Me
Me
O
Ts
Me
O
H

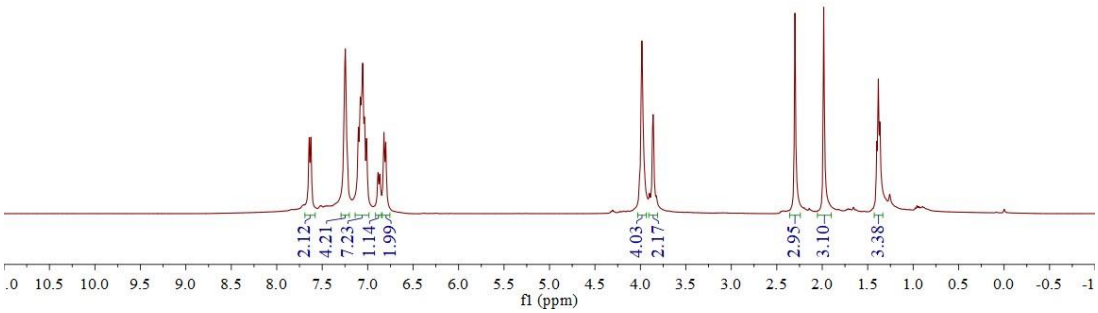

2.04
2.06
3.32
6.18
1.09
2.09
1.23
3.11
4.27
1.31
1.27
1.38
1.39
1.27
3.33
6.21
f1 (ppm)


207.814
166.352
144.450
140.797
135.428
135.123
129.612
129.559
129.360
128.455
128.367
128.329
128.011
127.623
109.578
93.414
80.429
77.318
77.001
76.682
61.065
48.973
47.773
44.827
36.839
28.000
27.276
21.608
19.625
18.966
18.811
13.537
f1 (ppm)

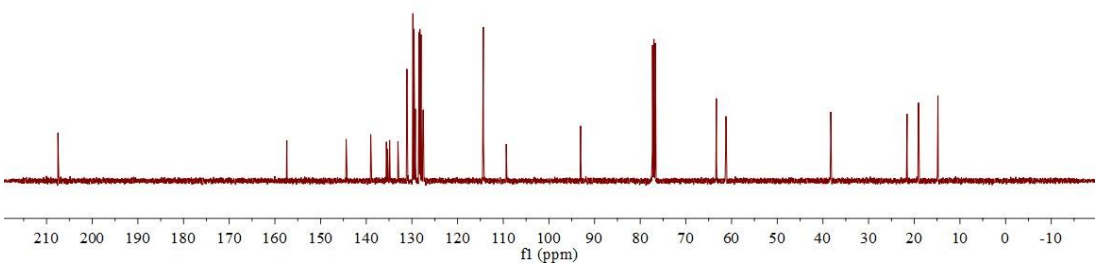
68


7.643
7.623
7.256
7.244
7.224
7.102
7.082
7.071
7.055
7.034
7.011
6.886
6.865
6.821
6.801
4.009
3.992
3.984
3.974
3.957
3.865
3.858
2.300
1.984
1.401
1.383
1.365
-0.000

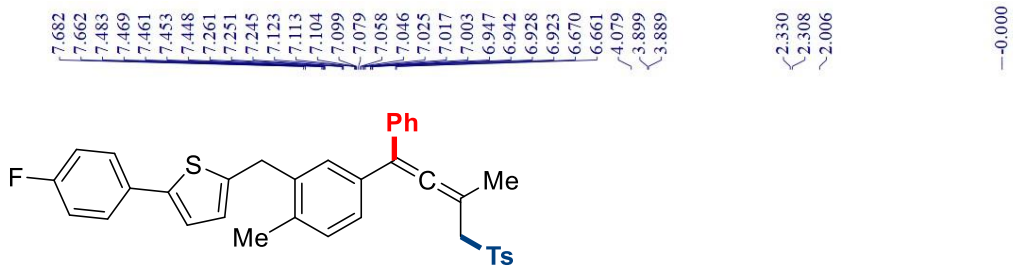
Ph
C
Me
Me
O
Cl
Ts


2.12
4.21
7.23
1.14
1.99
4.03
2.17
2.95
3.10
3.38
.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5 -1
f1 (ppm)

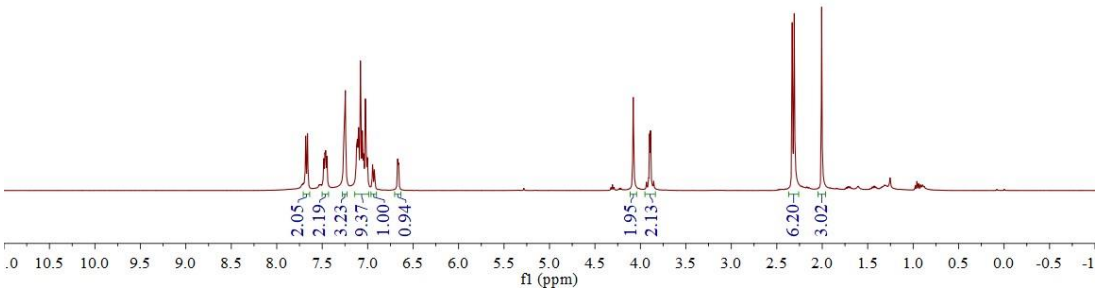

207.504
157.389
144.396
139.019
135.590
135.322
134.870
133.054
131.080
129.779
129.535
129.240
128.423
128.246
127.992
127.591
127.495
114.360
109.347
93.061
77.318
77.001
76.682
63.318
61.222
38.276
21.567
19.068
14.814


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

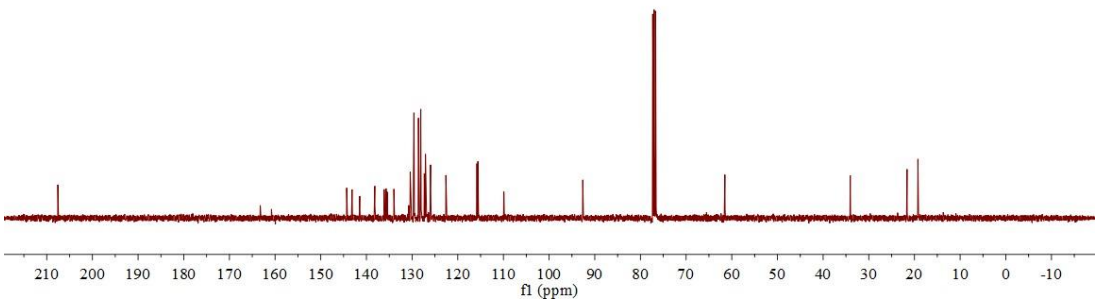
69

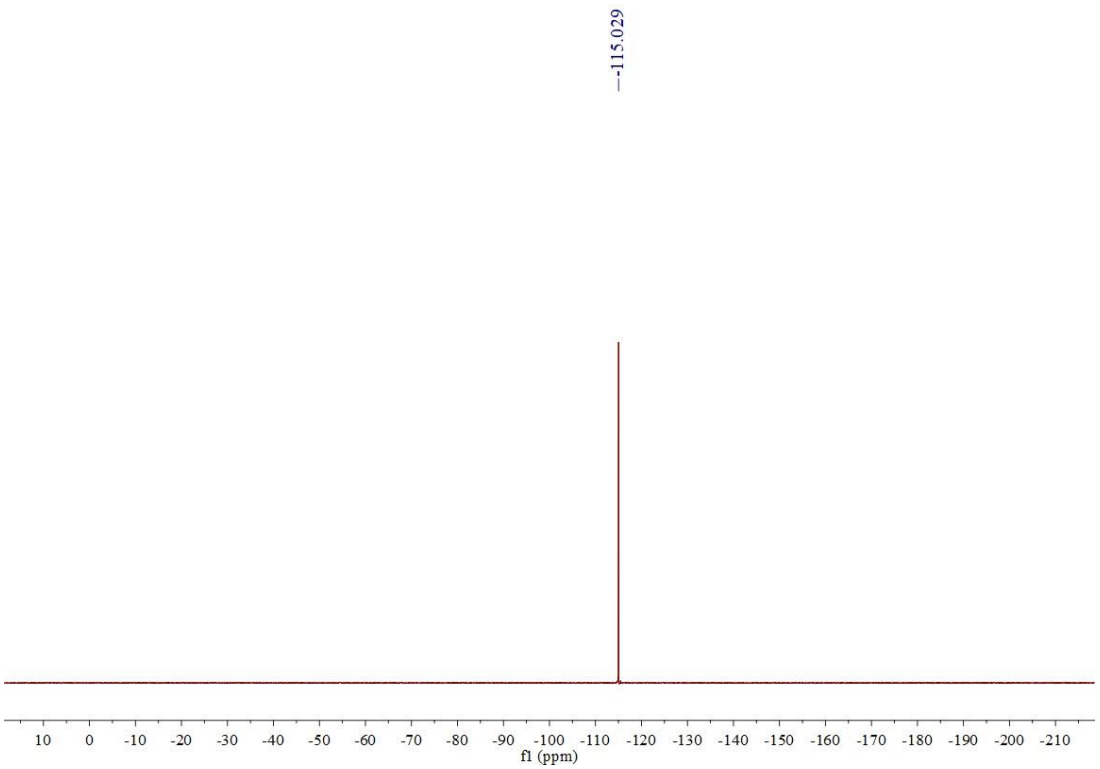

7.682
7.662
7.483
7.469
7.461
7.453
7.448
7.261
7.251
7.245
7.123
7.113
7.104
7.099
7.079
7.058
7.046
7.025
7.017
7.003
6.947
6.942
6.928
6.923
6.670
6.661
4.079
3.899
3.889
2.330
2.308
2.006
-0.000

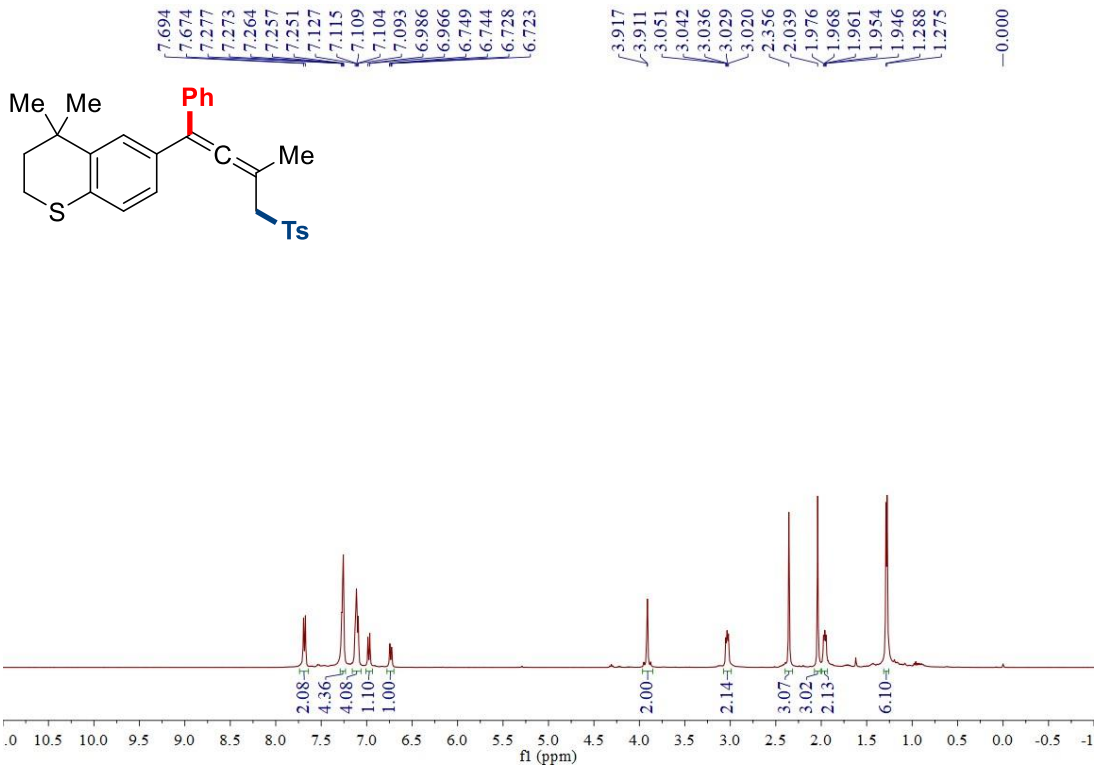
Ph
F
S
C
Me
Me
Ts

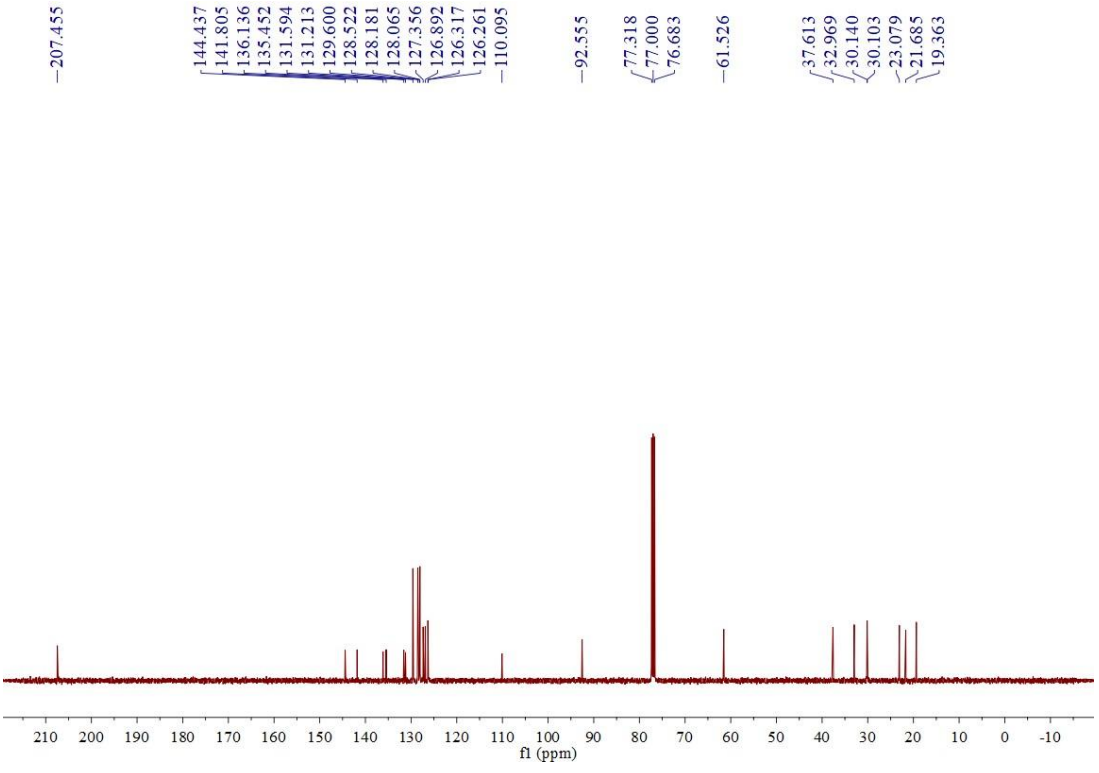

2.05
2.19
3.23
9.37
1.00
0.94
1.95
2.13
6.20
3.02
f1 (ppm)


207.563
163.246
160.794
144.322
143.148
141.464
138.164
136.116
135.693
135.433
133.980
130.723
130.411
129.703
129.596
128.613
128.170
128.101
127.329
127.134
127.073
126.994
125.961
122.606
115.803
115.586
109.907
92.627
77.318
77.000
76.682
61.507
34.058
21.621
19.242
19.206

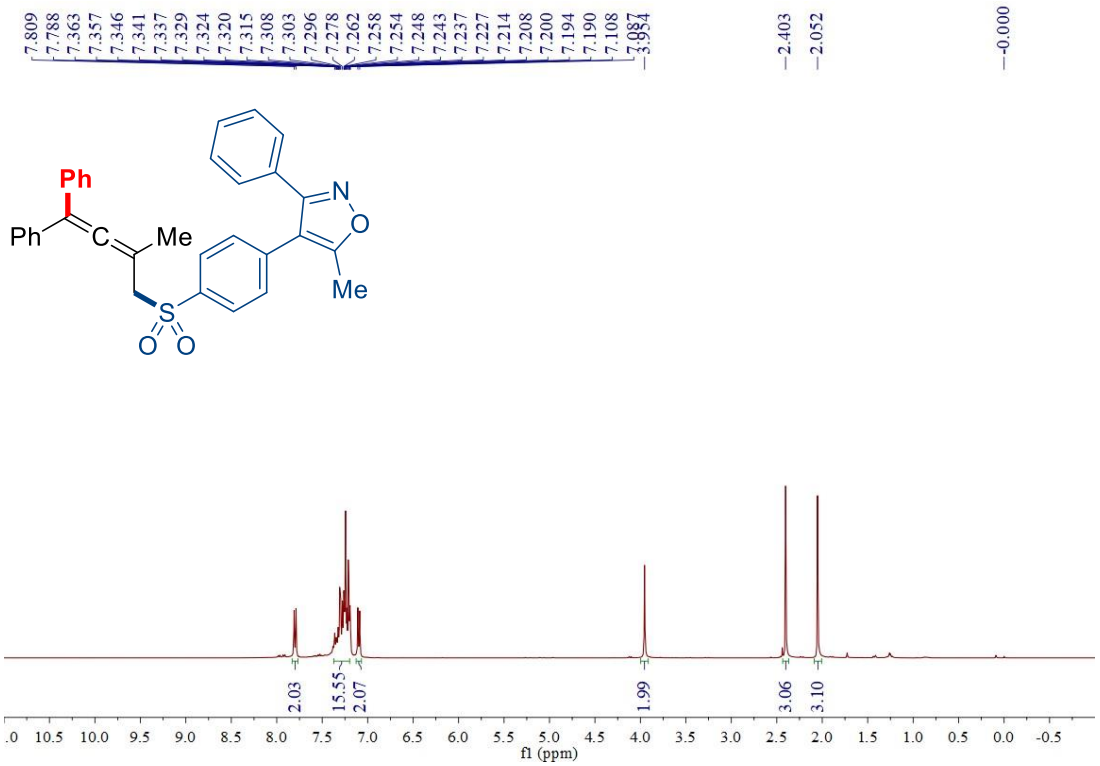

f1 (ppm)

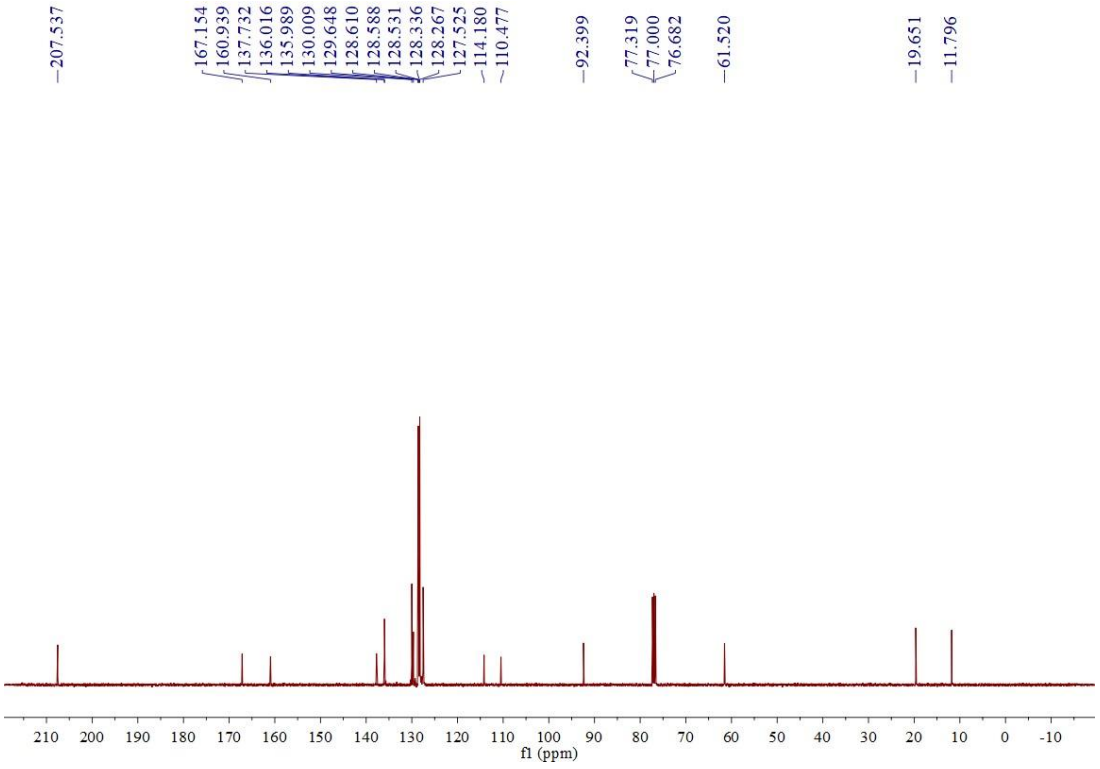

-115.029
10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200 -210
f1 (ppm)


7.694
7.674
7.277
7.273
7.264
7.257
7.251
7.127
7.115
7.109
7.104
7.093
6.986
6.966
6.749
6.744
6.728
6.723
3.917
3.911
3.051
3.042
3.036
3.029
3.020
2.356
2.039
1.976
1.968
1.961
1.954
1.946
1.288
1.275
0.000
Me
Me
Ph
C
Me
S
Ts
2.08
4.36
4.08
1.10
1.00
2.00
2.14
3.07
3.02
2.13
6.10
f1 (ppm)

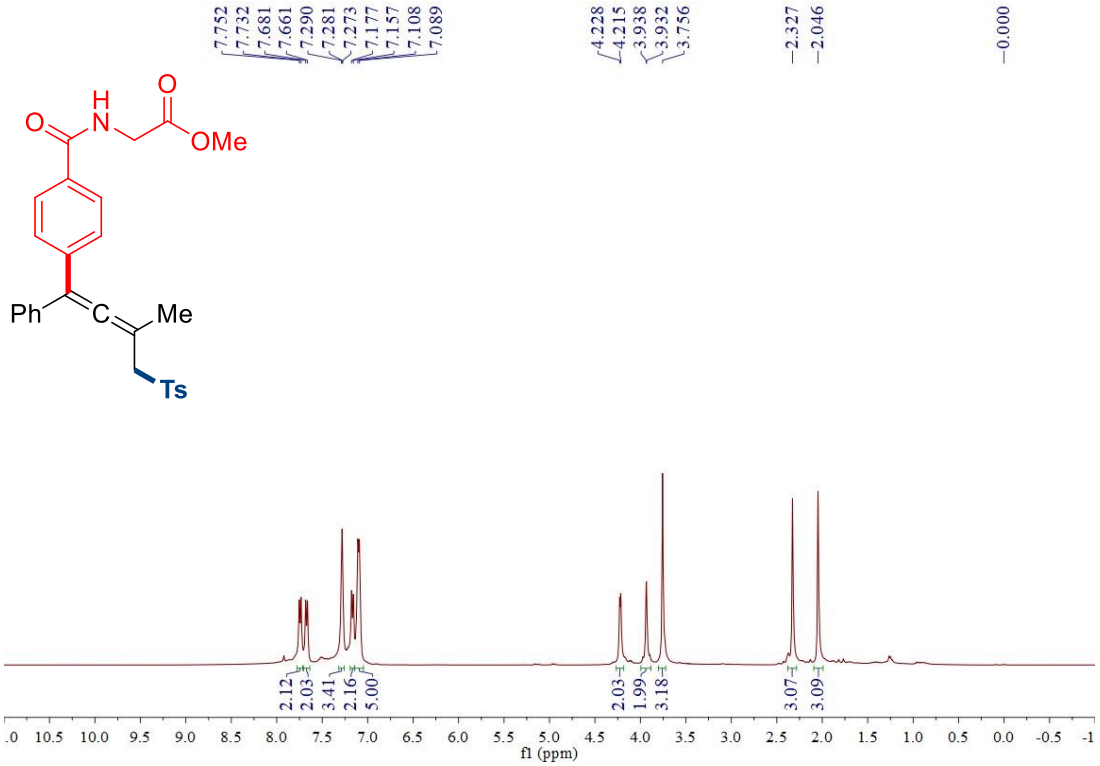

207.455
144.437
141.805
136.136
135.452
131.594
131.213
129.600
128.522
128.181
128.065
127.356
126.892
126.317
126.261
110.095
92.555
77.318
77.000
76.683
61.526
37.613
32.969
30.140
30.103
23.079
21.685
19.363
f1 (ppm)

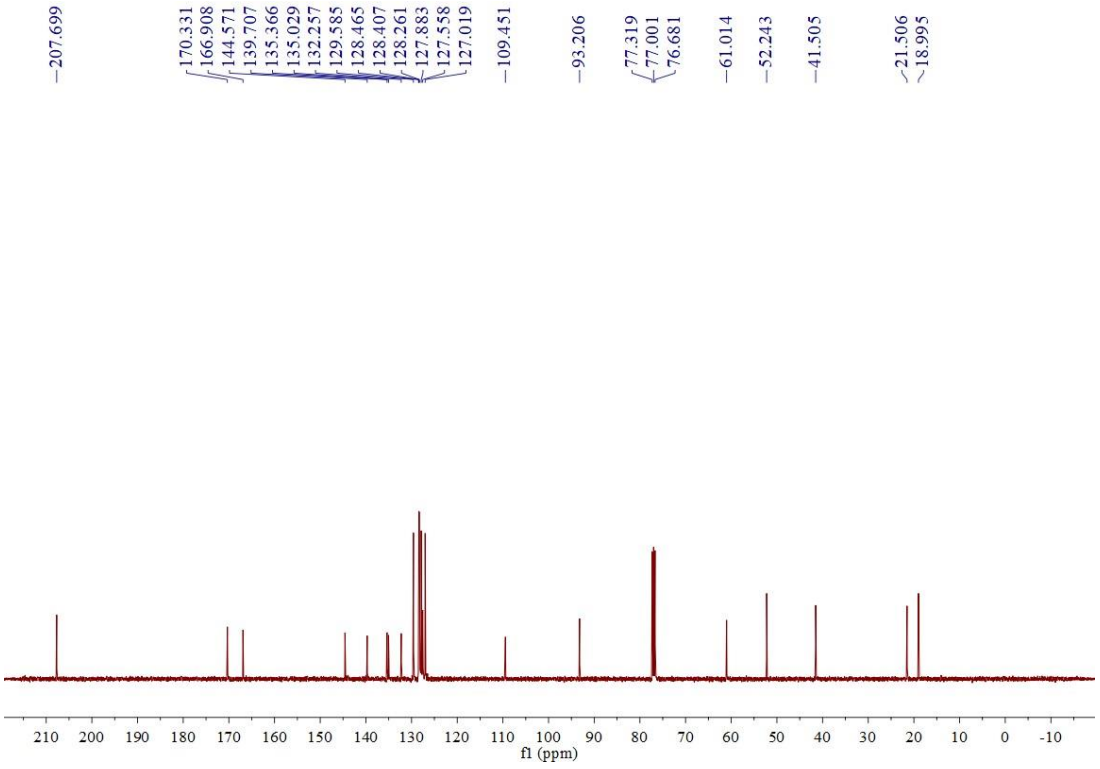
71

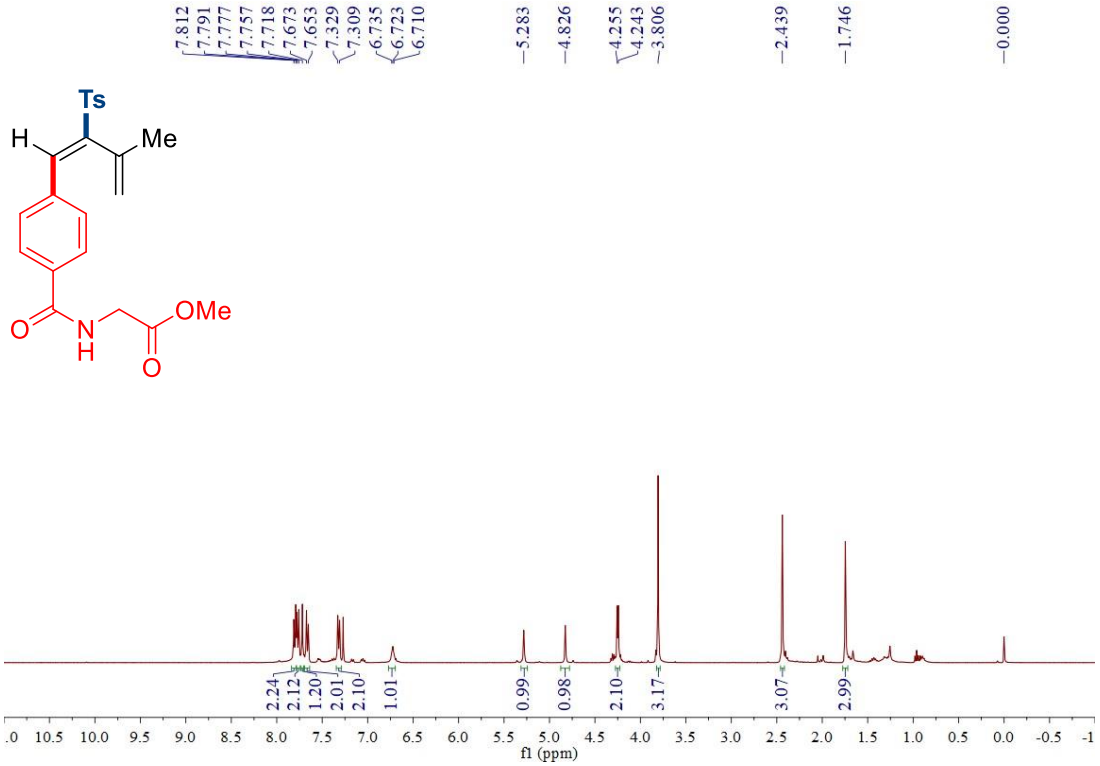

7.809
7.788
7.363
7.357
7.346
7.341
7.337
7.329
7.324
7.320
7.315
7.308
7.303
7.296
7.278
7.262
7.258
7.254
7.248
7.243
7.237
7.227
7.214
7.208
7.200
7.194
7.190
7.108
7.087
3.954
2.403
2.052
0.000
Ph
Ph
C
Me
N
O
Me
S
O
O
2.03
15.55
2.07
1.99
3.06
3.10
f1 (ppm)

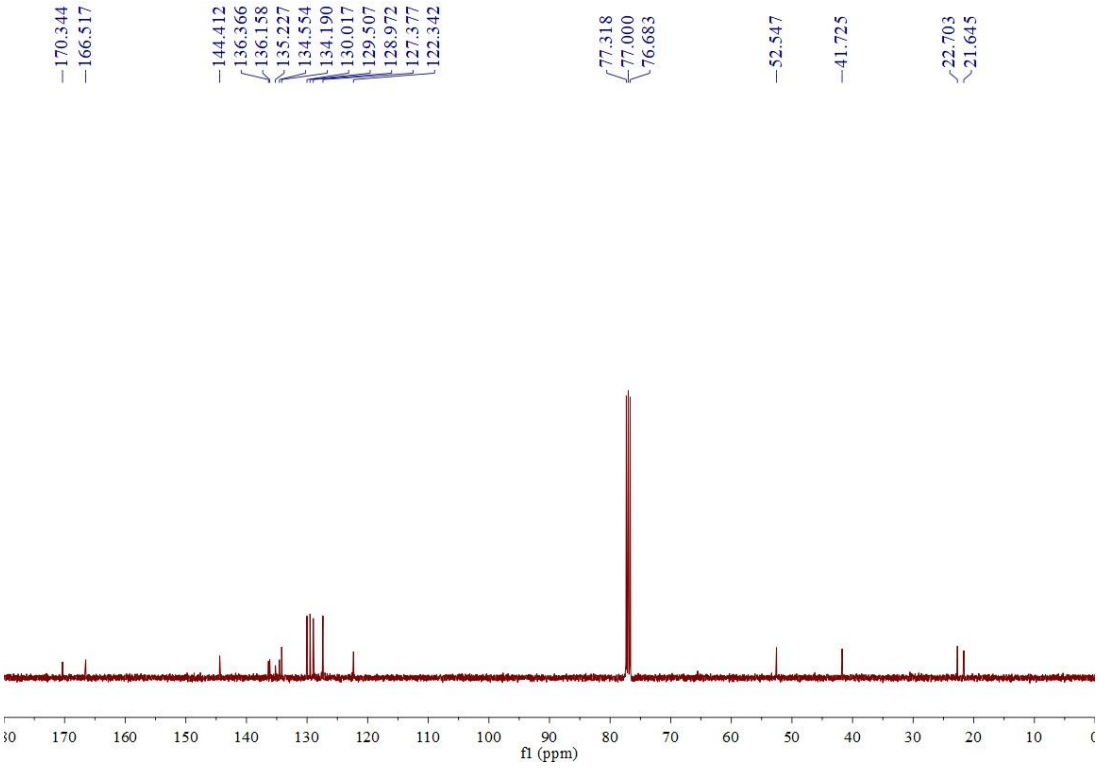

207.537
167.154
160.939
137.732
136.016
135.989
130.009
129.648
128.610
128.588
128.531
128.336
128.267
127.525
114.180
110.477
92.399
77.319
77.000
76.682
61.520
19.651
11.796
f1 (ppm)

72

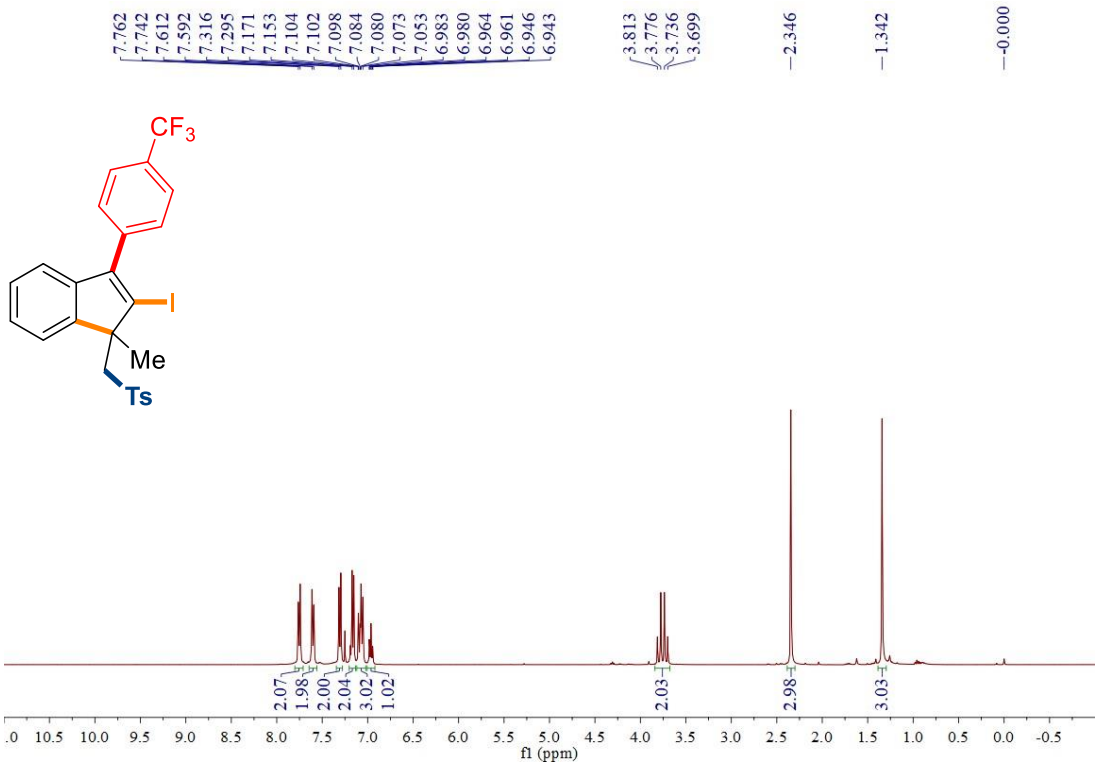

7.752
7.732
7.681
7.661
7.290
7.281
7.273
7.177
7.157
7.108
7.089
4.228
4.215
3.938
3.932
3.756
2.327
2.046
0.000
O
H
N
O
OMe
Ph
C
Me
Ts
2.12
2.03
3.41
2.16
5.00
2.03
1.99
3.18
3.07
3.09
fl (ppm)

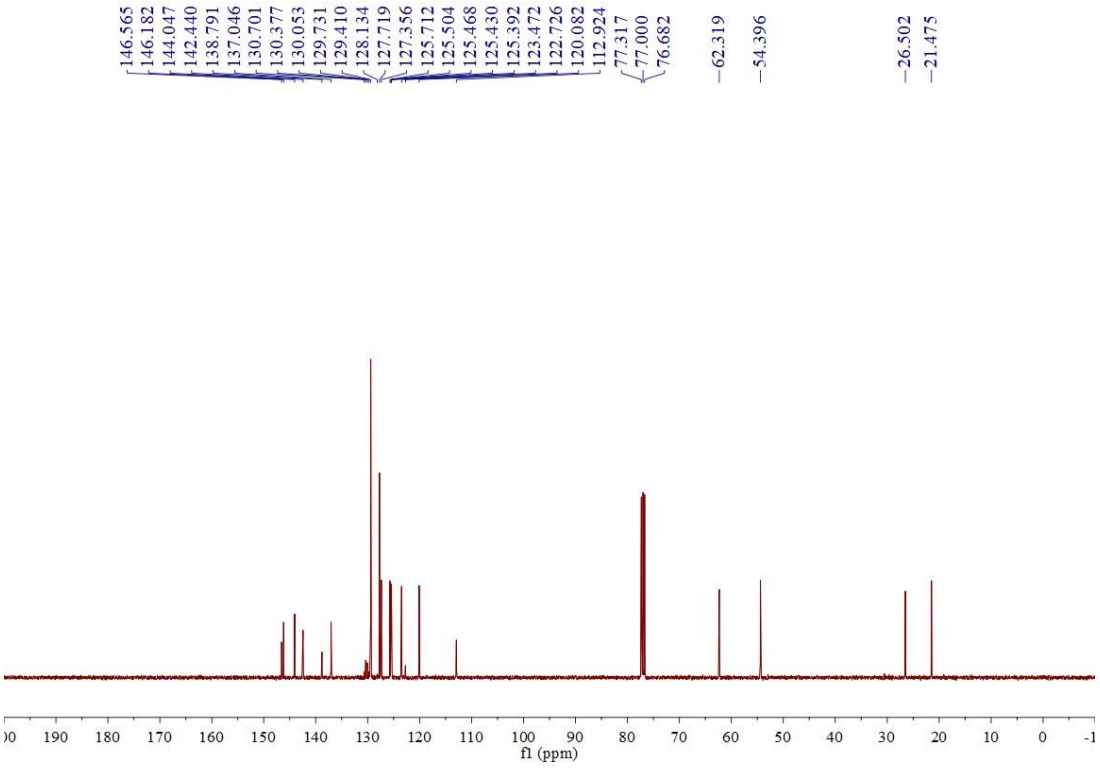

207.699
170.331
166.908
144.571
139.707
135.366
135.029
132.257
129.585
128.465
128.407
128.261
127.883
127.558
127.019
109.451
93.206
77.319
77.001
76.681
61.014
52.243
41.505
21.506
18.995
fl (ppm)

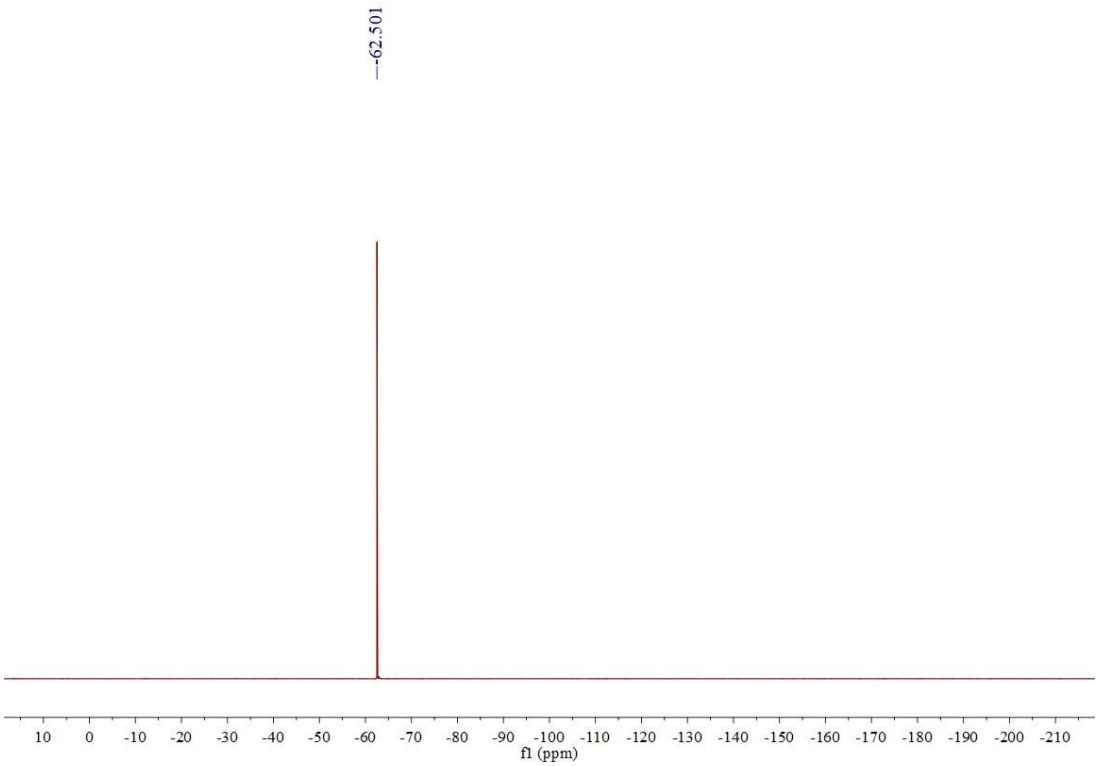

7.812
7.791
7.777
7.757
7.718
7.673
7.653
7.329
7.309
6.735
6.723
6.710
5.283
4.826
4.255
4.243
3.806
2.439
1.746
0.000
Ts
H
Me
O
N
H
OMe
O
2.24
2.12
1.20
2.01
2.10
1.01
0.99
0.98
2.10
3.17
3.07
2.99
f1 (ppm)


170.344
166.517
144.412
136.366
136.158
135.227
134.554
134.190
130.017
129.507
128.972
127.377
122.342
77.318
77.000
76.683
52.547
41.725
22.703
21.645
f1 (ppm)

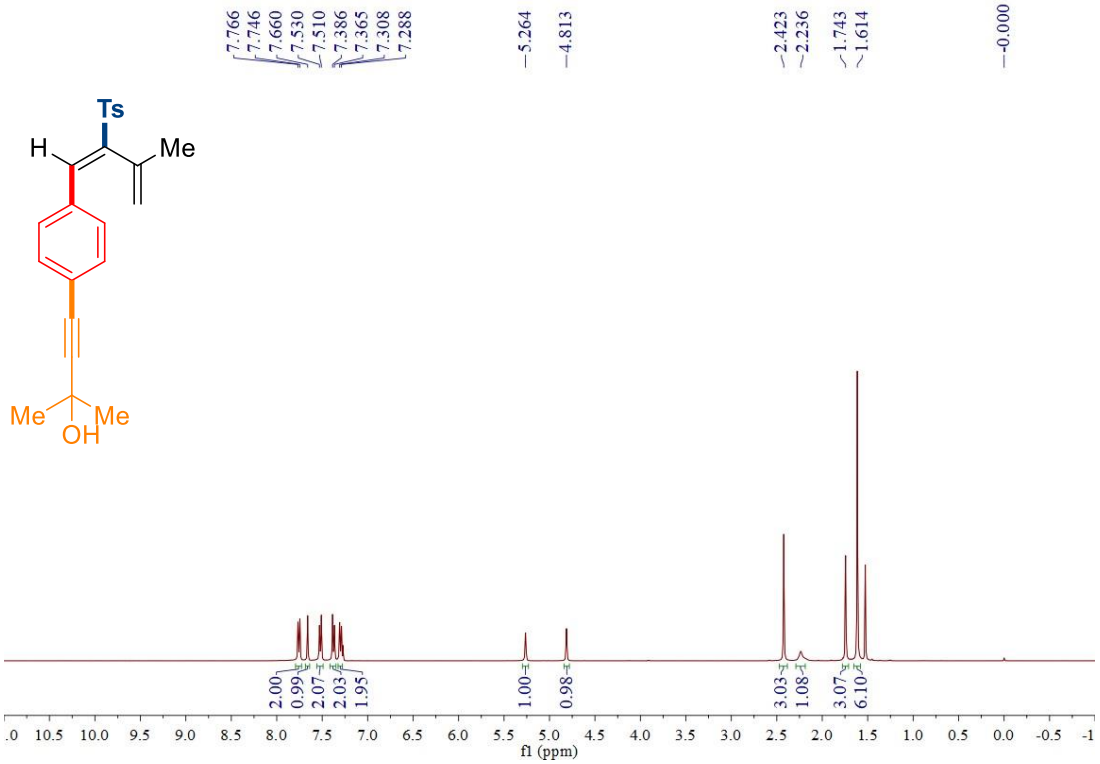
74

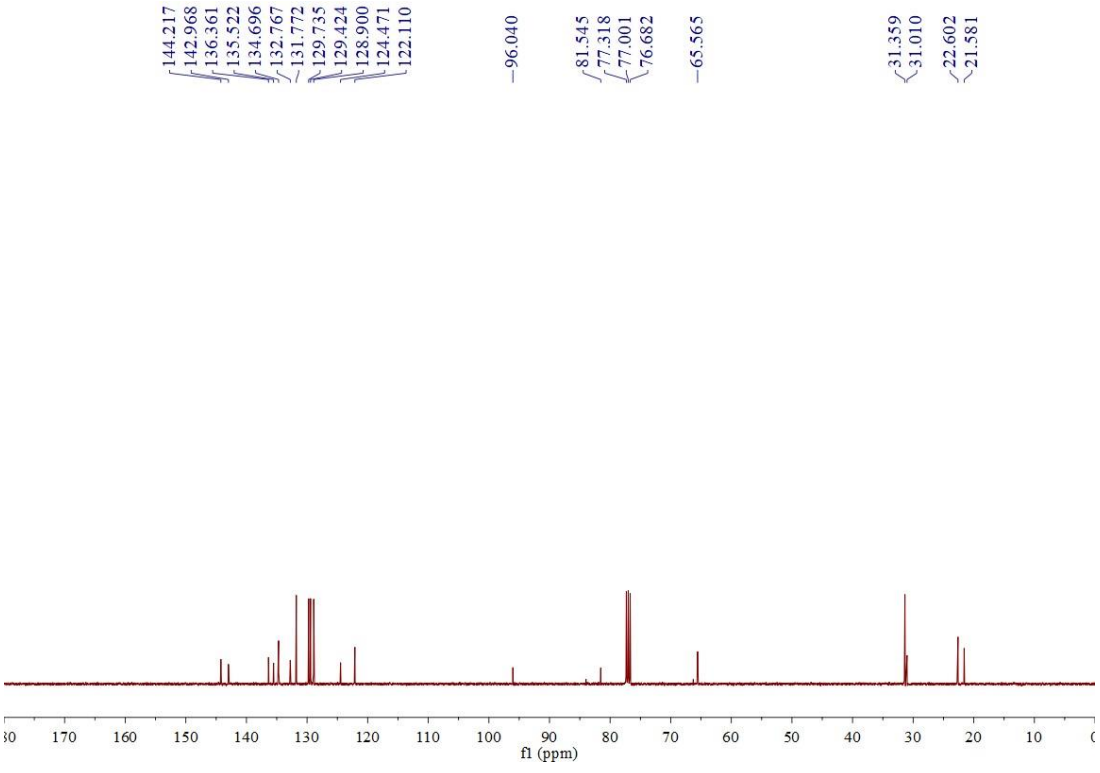

7.762
7.742
7.612
7.592
7.316
7.295
7.171
7.153
7.104
7.102
7.098
7.084
7.080
7.073
7.053
6.983
6.980
6.964
6.961
6.946
6.943
3.813
3.776
3.736
3.699
2.346
1.342
0.000
CF3
I
Me
Ts
2.07
1.98
2.00
2.04
3.02
1.02
2.03
2.98
3.03
f1 (ppm)


146.565
146.182
144.047
142.440
138.791
137.046
130.701
130.377
130.053
129.731
129.410
128.134
127.719
127.356
125.712
125.504
125.468
125.430
125.392
123.472
122.726
120.082
112.924
77.317
77.000
76.682
62.319
54.396
26.502
21.475
f1 (ppm)


-62.501
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)

75


7.766
7.746
7.660
7.530
7.510
7.386
7.365
7.308
7.288
5.264
4.813
2.423
2.236
1.743
1.614
0.000
Ts
H
Me
Me
Me
OH
2.00
0.99
2.07
2.03
1.95
1.00
0.98
3.03
1.08
3.07
6.10
f1 (ppm)


144.217
142.968
136.361
135.522
134.696
132.767
131.772
129.735
129.424
128.900
124.471
122.110
96.040
81.545
77.318
77.001
76.682
65.565
31.359
31.010
22.602
21.581
f1 (ppm)


7.899
7.893
7.881
7.877
7.675
7.657
7.638
7.573
7.553
7.534
7.347
7.342
7.338
7.326
7.321
7.307
7.294
7.289
7.285
7.279
7.272
7.264
7.256
7.252
7.240
7.235
7.232
3.298
3.290
3.286
3.278
3.269
3.265
3.257
2.520
2.510
2.499
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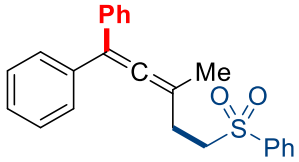
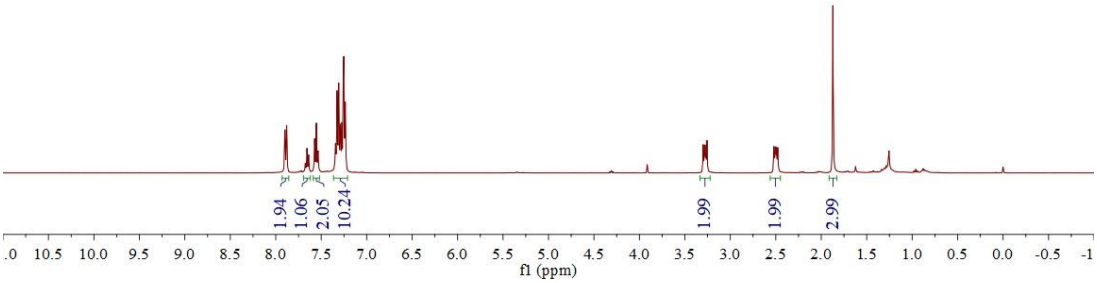
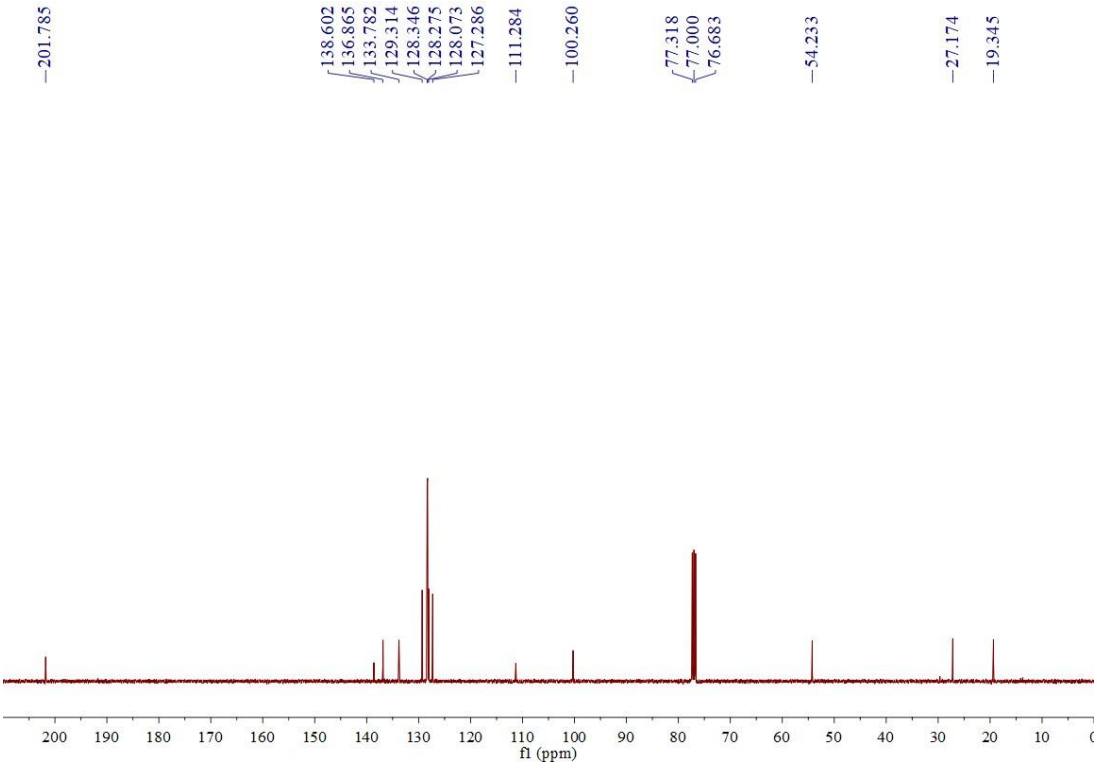
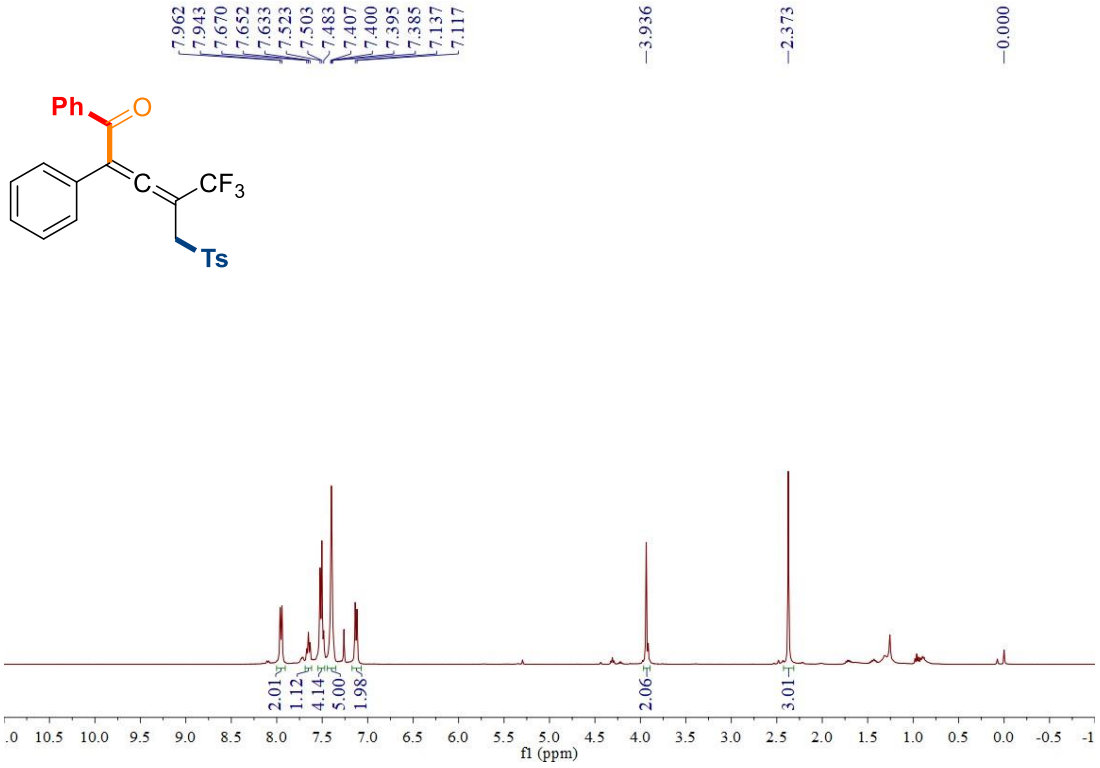
2.479
1.872
0.000

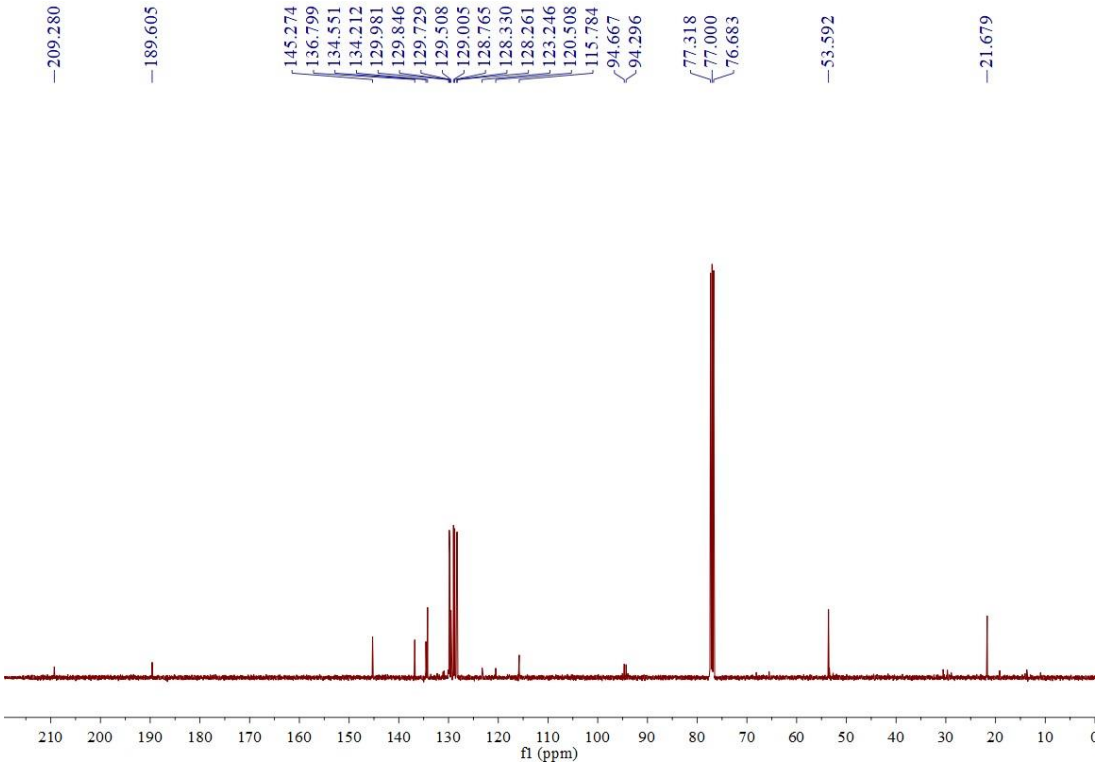

Ph
C
Me
O
O
S
Ph

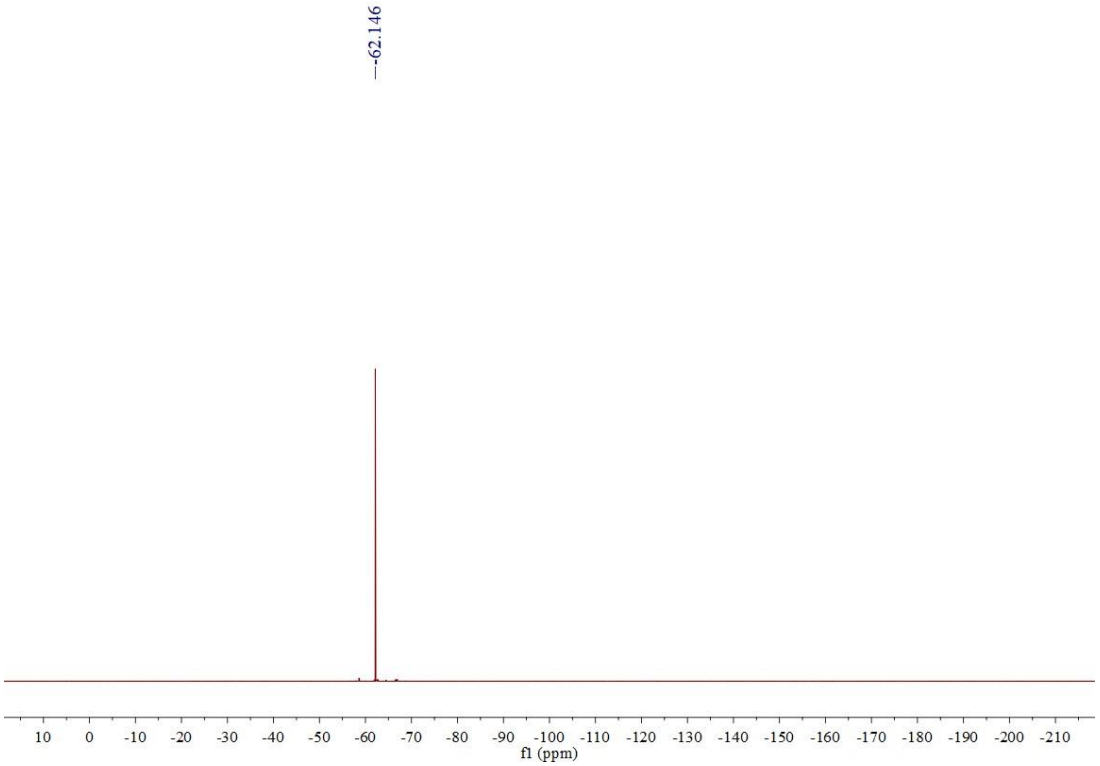

1.94
1.06
2.05
10.24
1.99
1.99
2.99
fl (ppm)


201.785
138.602
136.865
133.782
129.314
128.346
128.275
128.073
127.286
111.284
100.260
77.318
77.000
76.683
54.233
27.174
19.345
fl (ppm)

77

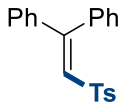

7.962
7.943
7.670
7.652
7.633
7.523
7.503
7.483
7.407
7.400
7.395
7.385
7.137
7.117
3.936
2.373
0.000
Ph
O
C
CF3
Ts
2.01
1.12
4.14
5.00
1.98
2.06
3.01
fl (ppm)

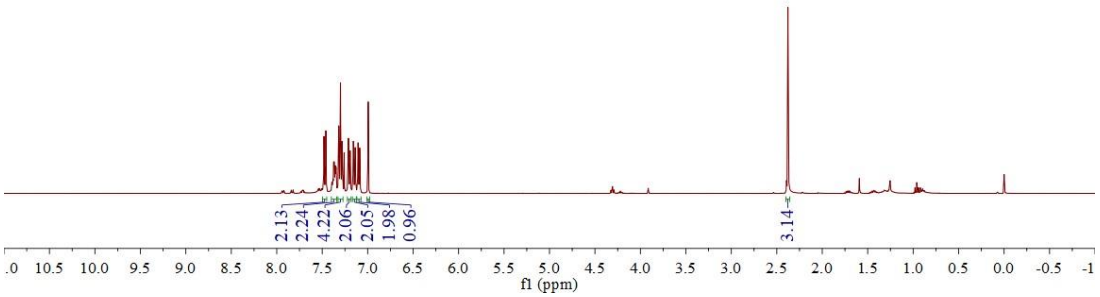

209.280
189.605
145.274
136.799
134.551
134.212
129.981
129.846
129.729
129.508
129.005
128.765
128.330
128.261
123.246
120.508
115.784
94.667
94.296
77.318
77.000
76.683
53.592
21.679
fl (ppm)


-62.146
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)

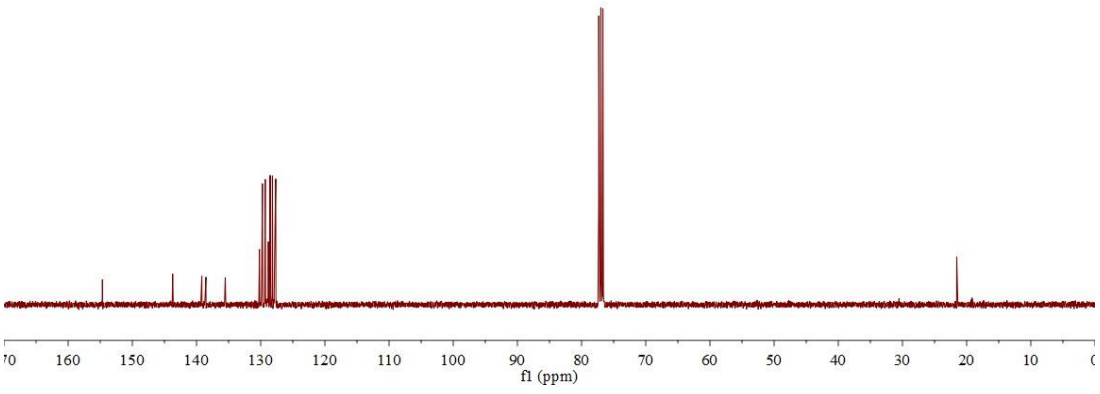
78


7.480
7.459
7.397
7.394
7.390
7.387
7.384
7.381
7.375
7.369
7.366
7.360
7.357
7.352
7.348
7.344
7.319
7.315
7.303
7.299
7.286
7.281
7.278
7.213
7.211
7.207
7.193
7.189
7.157
7.137
7.108
7.105
7.101
7.088
7.084
6.994
2.378
-0.000

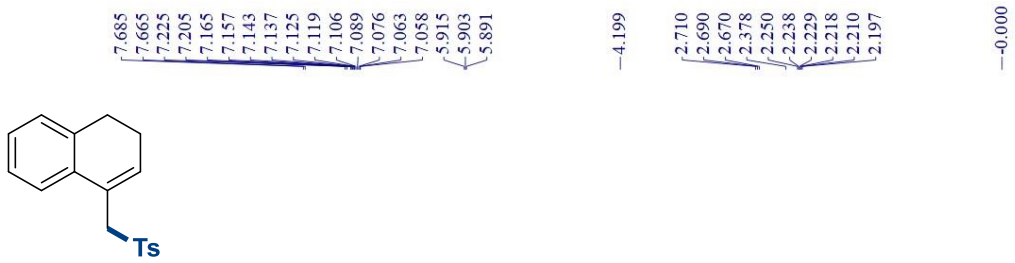

Ph
Ph
Ts

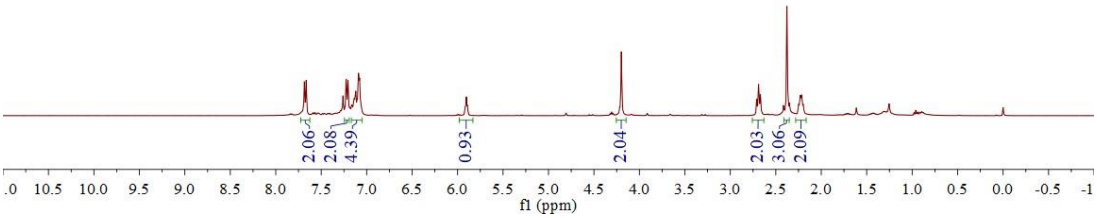

2.13
2.24
4.22
2.06
2.05
1.98
0.96
3.14
f1 (ppm)

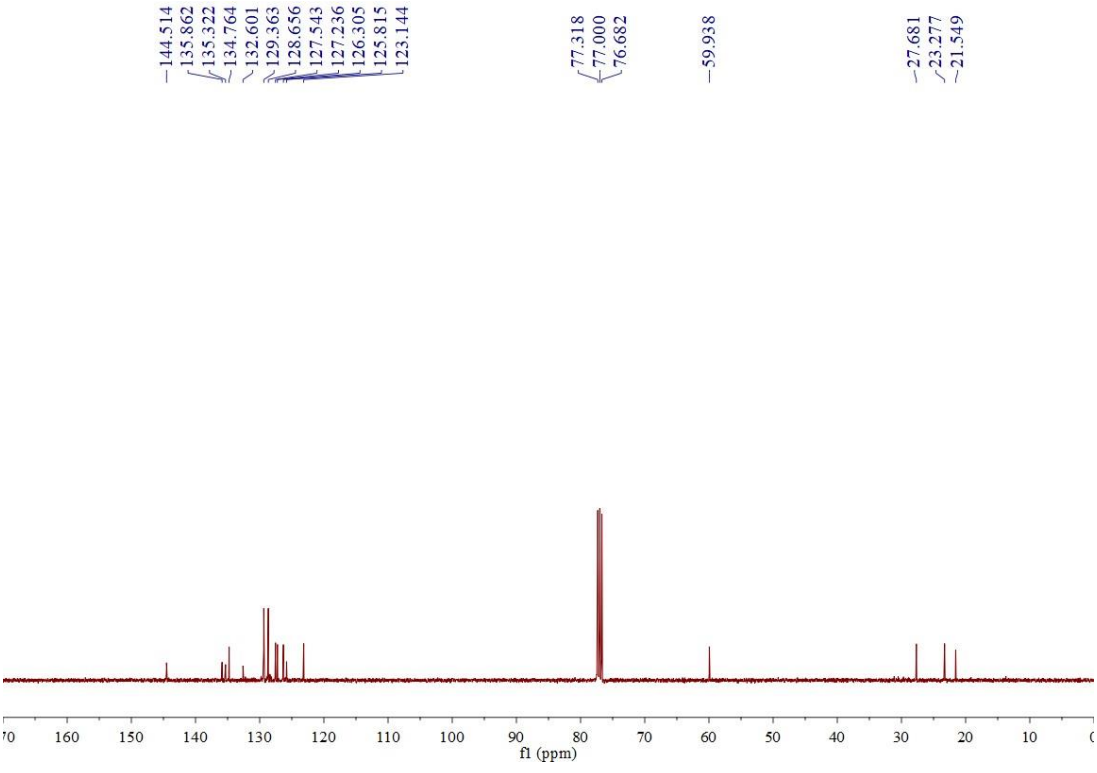

154.661
143.712
139.174
138.528
135.522
130.192
129.728
129.289
128.902
128.803
128.530
128.169
127.766
127.652
77.318
77.000
76.683
21.546


f1 (ppm)

79


7.685
7.665
7.225
7.205
7.165
7.157
7.143
7.137
7.125
7.119
7.106
7.089
7.076
7.063
7.058
5.915
5.903
5.891
4.199
2.710
2.690
2.670
2.378
2.250
2.238
2.229
2.218
2.210
2.197
0.000
Ts


2.06
2.08
4.39
0.93
2.04
2.03
3.06
2.09
f1 (ppm)


144.514
135.862
135.322
134.764
132.601
129.363
128.656
127.543
127.236
126.305
125.815
123.144
77.318
77.000
76.682
59.938
27.681
23.277
21.549
f1 (ppm)

6. References

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