CHEMISTRY
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Supporting Information

Investigations on Gold-Catalyzed Thioalkyne Activation Toward Facile Synthesis of Ketene Dithioacetals

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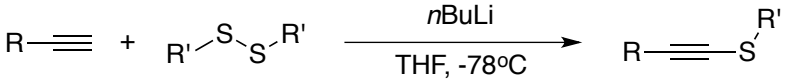
I. General Methods and Materials

All of the reactions dealing with air and/or moisture-sensitive compounds were carried out under an atmosphere of argon using oven/flame-dried glassware and standard syringe/septa techniques. Unless otherwise noted, all commercial reagents and solvents were obtained from the commercial provider and used without further purification. ^{1}H NMR and ^{13}C NMR spectra were recorded on Agilent 400 MHz spectrometers/ Varian 500 MHz spectrometers. Chemical shifts were reported relative to internal tetramethylsilane (δ 0.00 ppm) or $CDCl_3$ (δ 7.26 ppm) for ^{1}H and $CDCl_3$ (δ 77.00 ppm) for ^{13}C. Flash column chromatography was performed on 230-430 mesh silica gel. Analytical thin layer chromatography was performed with precoated glass baked plates (250μ) and visualized by fluorescence and by charring after treatment with potassium permanganate stain. HRMS were recorded on Agilent 6540 LC/QTOF spectrometer.

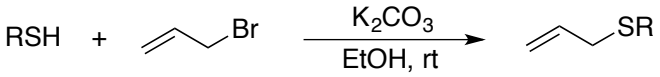
ESI-MS spectra were collected using a Thermo Scientific Orbitrap Q Extractive Plus (Bremen, Germany) in the positive ion mode. The samples were infused with a flow rate of 10 μL/min and sprayed at a high voltage of 5 kV.

1.1 General procedure to synthesize thioalkyne



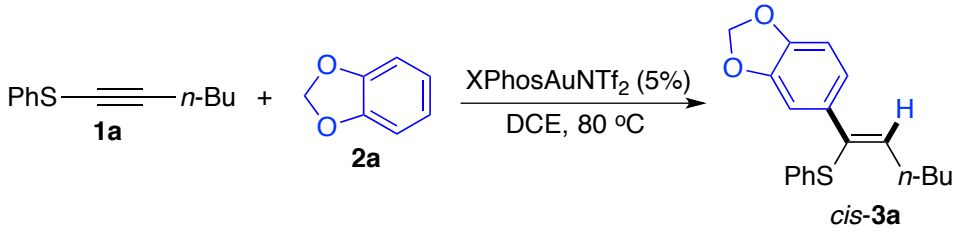
Thioalkynes were prepared according to known literatures. To a THF solution (50 mL) of alkyne (22 mmol, 1.1 eq) was added 9.6 mL *n*-BuLi (2.5 M in hexane, 24 mmol, 1.2 eq) dropwise at -78 ^{o}C. The reaction mixture was allowed to react at -78 ^{o}C for 1 h, then disulfide (20 mmol, 1 eq) in THF (10 mL) was added. The reaction mixture was brought up to RT and stirred for overnight (14 h). The reaction was quenched using sa. K_2CO_3 solution, and organic layers was extracted three time with DCM. The combined organic solution was dried over Na_2SO_4 and concentrated. Crude product was further purified by flash chromatography using pure hexane as elute.

1.2 General procedure to synthesize Allyl phenyl sulfide



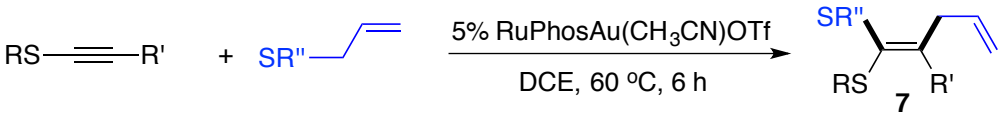
To a EtOH solution (10 mL) of thiol (5 mmol, 1 eq) and allyl bromide (6 mmol, 1.2 eq) was added K_2CO_3 in one portion. The reaction mixture was allowed to react overnight (14 h). The reaction solution was diluted with water and extracted with DCM three times. The combined organic solution was dried over Na_2SO_4 and concentrated. Crude product was further purified by flash chromatography using 100:1 hexane/ethyl acetate as elute.

1.3 General procedure for gold catalyzed C-nucleophile addition to thioalkyne



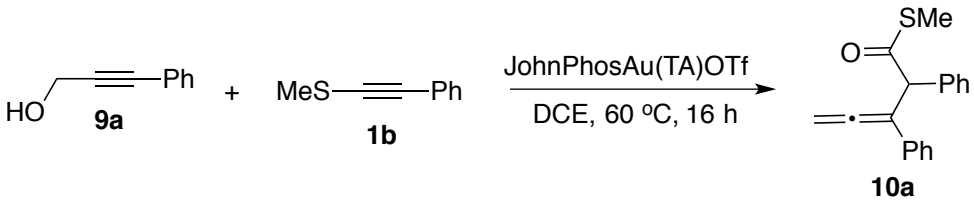
To a DCE solution (1.2 mL) of thioalkyne (0.2 mmol, 1 eq) and benzodioxole (0.6 mmol, 3 eq) was added Au catalyst (0.01 mmol, 0.05 eq) in one portion. The reaction vial was flushed with Argon, and the reaction mixture was allowed to react at 80 °C for 10 h. The reaction solution was filtered through a short pad of silica gel, and concentrated. Crude product was further purified by Flash Chromatography, preparative TLC or HPLC.

1.4 General procedure for gold catalyzed thioether addition to thioalkyne



To a DCE solution (1.2 mL) of alkyne (0.2 mmol, 1 eq) was added thiophenol (0.2 mmol, 1 eq). Catalyst (0.01 mmol, 0.05 eq) was added in one portion if needed. The reaction vial was flushed with Argon, and the reaction mixture was allowed to react at designated temperature for 10 h. The reaction solution was filtered through a short pad of silica gel, and concentrated. Crude product was further purified by Flash Chromatography, preparative TLC or HPLC.

1.5 General procedure for gold catalyzed propargyl alcohol addition to thioalkyne



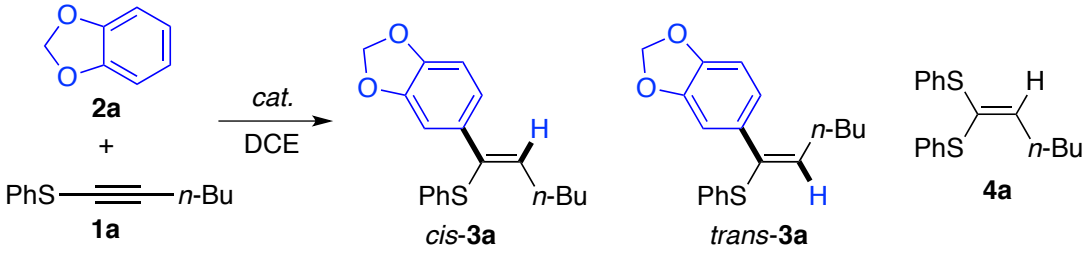
To a DCE solution (1.2 mL) of thioalkyne (0.2 mmol, 1 eq) and thioether (0.24 mmol, 1.2 eq) was added Au catalyst (0.01 mmol, 0.05 eq) in one portion. The reaction vial was flushed with Argon, and the reaction mixture was allowed to react at 60 °C for 6 h. The reaction solution was filtered through a short pad of silica gel, and concentrated. Crude product was further purified by preparative TLC.

1.6 General procedure for competing reaction between alkyne and thioalkyne

To a DCE solution (1.2 mL) of thioalkyne (0.2 mmol, 1 eq), phenylacetylene (0.2 mmol, 1 eq) and propargyl alcohol (0.2 mmol, 1 eq) was added Au catalyst (0.01 mmol, 0.05 eq) in one portion. The reaction vial was flushed with Argon, and the reaction mixture was allowed to react at 80 ^{o}C for 16 h. The reaction solution was filtered through a short pad of silica gel, and concentrated. Crude product was further purified by preparative TLC.

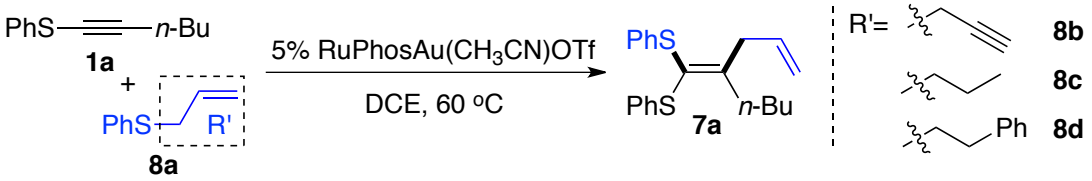
II. Screening Table

2.1 Screening table for gold catalyzed C-nucleophile addition to thioalkyne



Cat. and loading	Temp (°C)	Reaction time	Conv	Yield	cis/trans by dioxole peak
AgOTf+XPhosAuCl (0.05)	60	10 h	59%	31%	3.1:1
$AgNTf_2$ (0.05) + XPhosAuCl(0.05)	80	10 h	84%	59%	4.2:1
PPh_3AuNTf_2(0.05)	80	16 h	80%	52%	6.8:1
JohnPhosAuNTf_2(0.05)	80 °C	10 h	84%	59%	6.0:1
XPhosAuNTf_2(0.05)	80 °C	16 h	70%	64%	7.3:1
XPhosAuNTf_2(0.05), degas	80 °C	10 h	87%	51%	4.7:1
RuPhosAuNTf_2 (0.05)	80 °C	6 h	77%	45%	6.7:1
IPrAuNTf_2 (0.05)	80 °C	16 h	80%	59%	6.1:1
$(ArO)_3PAu$(TA-Ph)OTf (0.05)	80 °C	16 h	<5%	<5%	NA
XPhosAuNTf_2(0.05)	70 °C	10 h	84%	51%	4.4:1
XPhosAuNTf_2 (0.05)	60 °C	16 h	75%	51%	8.3:1
JohnPhosAu(CH_3CN)OTf (0.05)	60 °C	16 h	100%	36%	4.4:1
JohnPhosAu(TA-Me)OTf (0.05)	80 °C	16 h	<5%	<5%	NA
JohnPhosAu(TA-Me)OTf + $Cu(OTf)_2$ (0.05+ 0.01)	60 °C then 80 °C	16 h, 10 h	38%	22%	NA
JohnPhosAu(TA-Me)OTf + $Ga(OTf)_3$ (0.05+ 0.01)	60 °C then 80 °C	16 h, 10h	<5%	<5%	NA
HOTf (0.05)	80 °C	16 h	<5%	<5%	NA
$Cu(OTf)_2$ (0.05)	80 °C	16 h	100%	0%	NA
AgOTf(0.05)	60	6 h	93%	47%	3.3:1
$AgNTf_2$ (0.05)	80	6 h	92%	59%	4.8:1

2.2 General procedure for gold catalyzed thioether addition to thioalkyne



Alternation from above conditions	**1a** convn	yield **7a**
none	>95%	75%
5% $Cu(OTf)_2$ instead of [Au]	>95%	39%
5% AgOTf instead of [Au]	>95%	49%
[Au] = $IPrAuNTf_2$	>95%	60%
R' = *n*-Pr, CH_2CCH, Bn	<5%	<5%
Other catalysts: Pd, Ir, Ru, Rh, Pt, HOTf	<20%	<5%
$CyJohnPhosAu(CH_3CN)OTf$	>95%	65%
$JohnPhosAu(CH_3CN)OTf$	>95%	64%
$XJohnPhosAu(CH_3CN)OTf$	>95%	61%
$PPh_3Au(CH_3CN)OTf$	>95%	67%
$CyJohnPhosAuNTf_2$	46%	29%
CyJohnPhosAu(TA-H)OTf	62%	31%
IPrAu(TA-H)OTf	59%	36%

III. ORTEP Drawing of the Crystal Structures

The X-ray diffraction data for **3d, 6b** and **7p** were measured on Bruker D8 Venture PHOTON 100 CMOS system equipped with a Cu K_α INCOATEC ImuS micro-focus source (λ = 1.54178 Å). The diffraction data for **6a** was measured on Bruker Smart diffractometer with Apex2 detector and CuKα radiation. Indexing was performed using *APEX3* [1] (Difference Vectors method). Data integration and reduction were performed using SaintPlus 6.01 [2]. Absorption correction was performed by multi-scan method implemented in SADABS [3]. Space groups were determined using XPREP implemented in APEX3 [1]. Structures were solved using SHELXT and refined using SHELXL-2016 [4-7] (full-matrix least-squares on F^2) through OLEX2 interface program [8]. All non-hydrogen atoms (except some of disordered) were refined anisotropically. Hydrogen atoms of -CH,-CH2 and -CH3 groups were placed in geometrically calculated positions and were included in the refinement process using riding model with isotropic thermal parameters: Uiso(H) = 1.2(1.5)Ueq(-CH,-CH2, (-CH3)). Crystal data and refinement conditions are shown in Tables 1-4.

Notes: 3d: The structure was refined as inversion twin, which improved weighting scheme parameters and R value. **6a and 6b**: Disordered anions were refined with restraints.

[1] Bruker (2016). *APEX3* (Version 2015.9). Bruker AXS Inc., Madison, Wisconsin, USA.
[2] Bruker (2016) SAINT V8.35A. Data Reduction Software.
[3] Sheldrick, G. M. (1996). *SADABS. Program for Empirical Absorption Correction.* University of Gottingen, Germany.
[4] G.M. Sheldrick (2015) "Crystal structure refinement with SHELXL", Acta Cryst., C71, 3-8
[5] Sheldrick, G.M. (1990) Acta Cryst. A46, 467-473
[6] Sheldrick, G. M. (2008) Acta Cryst. A64, 112-122.
[7] Sheldrick, G. M. (2015) Acta Cryst..A71, 3-8
[8] Dolomanov, O.V.; Bourhis, L.J.; Gildea, R.J.; Howard, J.A.K.; Puschmann, H., OLEX2: A complete structure solution, refinement and analysis program (2009). J. Appl. Cryst., 42, 339-341.

Table 1 Crystal data and structure refinement for 7p.	
Identification code	7p
Empirical formula	$C_{21}H_{22}Cl_2S_2$
Formula weight	409.40
Temperature/K	100.05
Crystal system	monoclinic
Space group	$P2_1/c$
a/Å	6.3457(2)
b/Å	22.0777(6)
c/Å	14.2069(4)
α/°	90
β/°	95.9762(16)
γ/°	90
Volume/Å^3	1979.55(10)
Z	4
ρ_{calc}g/cm^3	1.374
μ/mm^{-1}	4.915
F(000)	856.0
Crystal size/mm^3	0.183 × 0.029 × 0.021
Radiation	CuKα (λ = 1.54178)
2Θ range for data collection/°	7.428 to 155.294
Index ranges	$-8 \le h \le 7$, $-27 \le k \le 27$, $-17 \le l \le 17$
Reflections collected	30613
Independent reflections	4109 [R_{int} = 0.1149, R_{sigma} = 0.0565]
Data/restraints/parameters	4109/0/229
Goodness-of-fit on F^2	1.035
Final R indexes [I>=2σ (I)]	R_1 = 0.0443, wR_2 = 0.0826
Final R indexes [all data]	R_1 = 0.0698, wR_2 = 0.0913
Largest diff. peak/hole / e Å^{-3}	0.32/-0.29

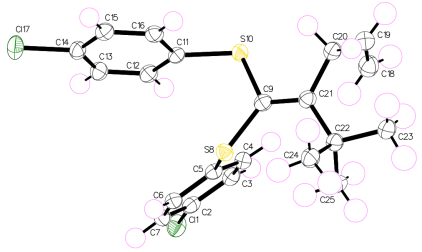


Fig.1. Conformation and numbering scheme of molecule in asymmetric unit of **7p**. Thermal ellipsoids were drawn at 50% probability. CCDC# 1547919

Table 2 Crystal data and structure refinement for 3d.	
Identification code	3d
Empirical formula	$C_{19}H_{20}O_2S$
Formula weight	312.41
Temperature/K	100(2)
Crystal system	monoclinic
Space group	Cc
a/Å	15.0719(4)
b/Å	9.4326(2)
c/Å	11.4784(3)
α/°	90
β/°	92.5702(12)
γ/°	90
Volume/Å^3	1630.21(7)
Z	4
ρ_{calc}g/cm^3	1.273
μ/mm^{-1}	1.791
F(000)	664.0
Crystal size/mm^3	0.305 × 0.097 × 0.09
Radiation	CuKα (λ = 1.54178)
2Θ range for data collection/°	11.068 to 154.112
Index ranges	$-16 \leq h \leq 18$, $-11 \leq k \leq 11$, $-14 \leq l \leq 14$
Reflections collected	11967
Independent reflections	3082 [R_{int} = 0.0363, R_{sigma} = 0.0347]
Data/restraints/parameters	3082/2/203
Goodness-of-fit on F^2	1.099
Final R indexes [I>=2σ (I)]	R_1 = 0.0283, wR_2 = 0.0660
Final R indexes [all data]	R_1 = 0.0300, wR_2 = 0.0671

Largest diff. peak/hole / e $Å^{-3}$	0.17/-0.23
Flack parameter	0.288(19)

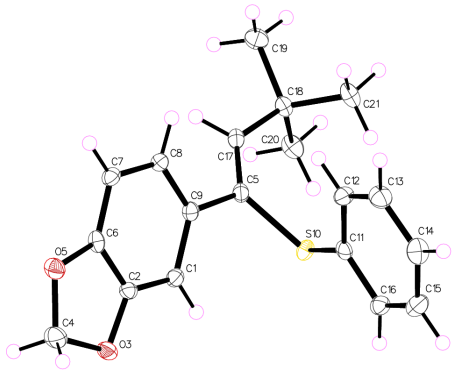


Fig.2. Conformation and numbering scheme of molecule in asymmetric unit of **3d**. Thermal ellipsoids were drawn at 50% probability. CCDC# 1547926

Table 3 Crystal data and structure refinement for 6b.	
Identification code	6b
Empirical formula	$C_{43.5}H_{57}Au_2F_{7.5}N_{1.25}O_5P_2S_{3.5}$
Moiety formula	$C_{41}H_{57}Au_2P_2S$, $1.25(C_2F_6NO_4S_2)$
Formula weight	1387.98
Temperature/K	100.03
Crystal system	triclinic
Space group	P-1
a/Å	12.4159(6)
b/Å	14.0289(7)
c/Å	17.6541(8)
α/°	108.043(2)
β/°	93.939(2)
γ/°	115.751(2)
Volume/Å^3	2558.2(2)
Z	2
ρ_{calc}g/cm^3	1.802
μ/mm^{-1}	13.164
F(000)	1356.0
Crystal size/mm^3	0.21 × 0.15 × 0.03
Radiation	CuKα (λ = 1.54178)
2Θ range for data collection/°	5.42 to 154.864
Index ranges	$-15 \le h \le 15$, $-17 \le k \le 17$, $-22 \le l \le 22$
Reflections collected	28501
Independent reflections	10365 [R_{int} = 0.0621, R_{sigma} = 0.0632]
Data/restraints/parameters	10365/832/833
Goodness-of-fit on F^2	1.038
Final R indexes [I>=2σ (I)]	R_1 = 0.0509, wR_2 = 0.1348
Final R indexes [all data]	R_1 = 0.0616, wR_2 = 0.1418
Largest diff. peak/hole / e Å^{-3}	2.78/-2.64

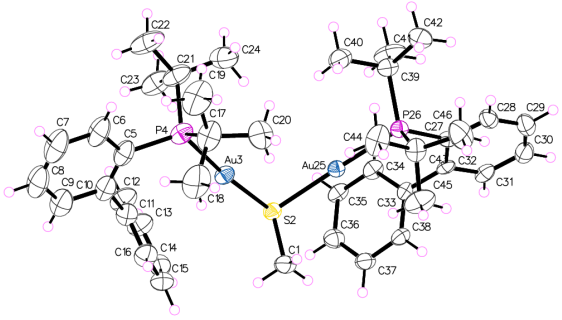


Fig.3. Conformation and numbering scheme of cation in 6b. Disordered anions were omitted for clarity. Thermal ellipsoids were drawn at 50% probability. CCDC#1547929

Table 4 Crystal data and structure refinement for 6a.	
Identification code	6a
Empirical formula	$C_{47.5}H_{59.5}Au_2Cl_{1.5}F_3O_3P_2S_2$
Moiety formula	$C_{46}H_{59}Au_2P_2S$, CF_3O_3S, 0.5($CHCl_3$)
Formula weight	1308.62
Temperature/K	298.15
Crystal system	monoclinic
Space group	$P2_1/n$
a/Å	24.5358(7)
b/Å	13.8415(4)
c/Å	30.5610(9)
α/°	90
β/°	100.8595(17)
γ/°	90
Volume/Å^3	10193.0(5)
Z	8
ρ_{calc}g/cm^3	1.705
μ/mm^{-1}	13.152
F(000)	5128.0
Crystal size/mm^3	0.167 × 0.098 × 0.096
Radiation	CuKα (λ = 1.54178)
2Θ range for data collection/°	4.248 to 142.782
Index ranges	$-29 \le h \le 29$, $-16 \le k \le 15$, $-36 \le l \le 36$
Reflections collected	131865
Independent reflections	19385 [R_{int} = 0.0987, R_{sigma} = 0.0565]
Data/restraints/parameters	19385/321/1185
Goodness-of-fit on F^2	1.006
Final R indexes [I>=2σ (I)]	R_1 = 0.0384, wR_2 = 0.0784
Final R indexes [all data]	R_1 = 0.0705, wR_2 = 0.0910
Largest diff. peak/hole / e Å^{-3}	0.61/-0.79

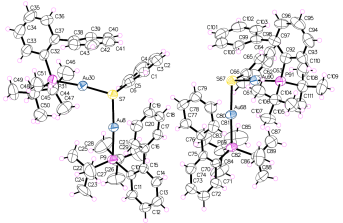
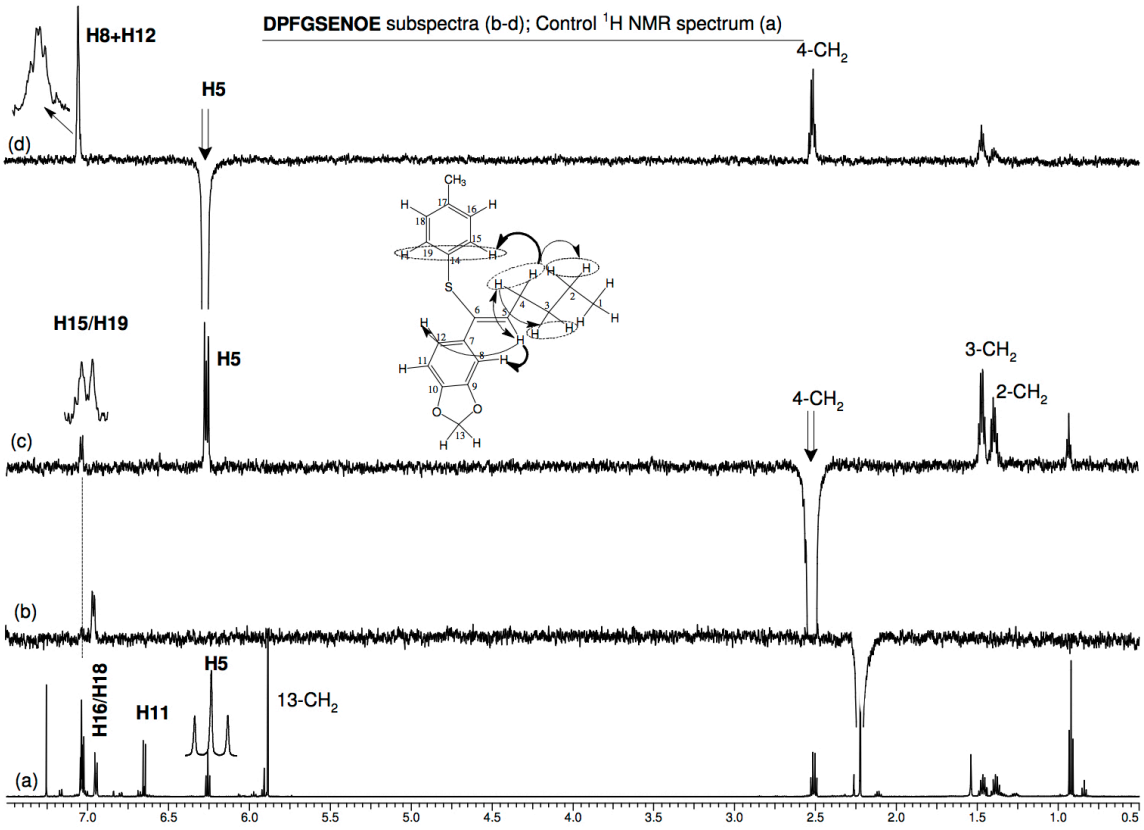


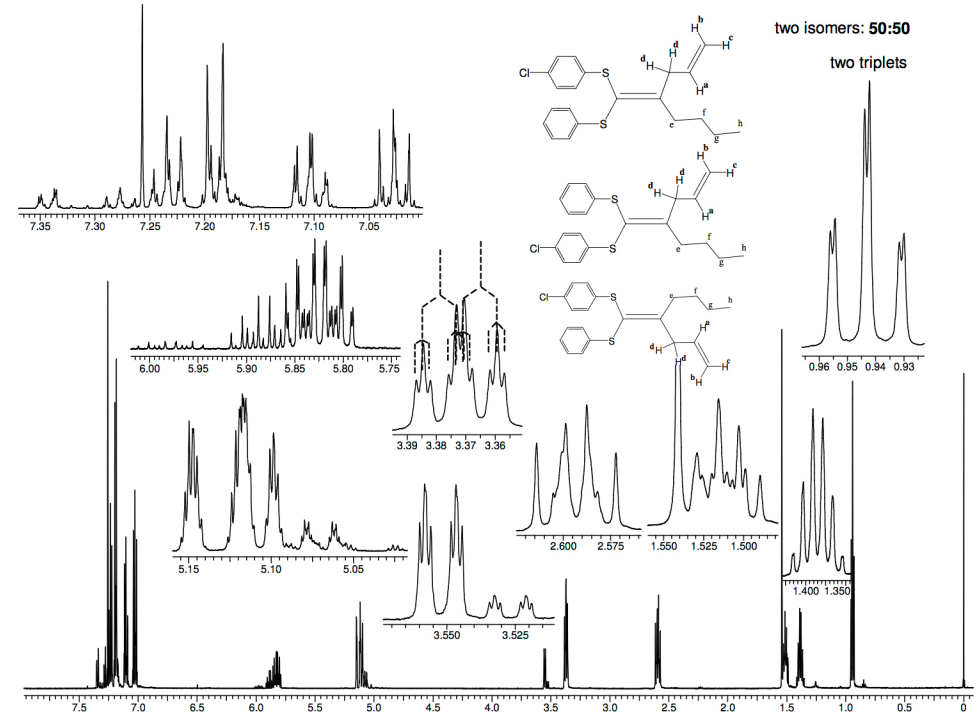
Fig.4. Conformation and numbering scheme of two symmetrically independent cations in 6a. Disordered anions were omitted for clarity. Thermal ellipsoids were drawn at 50% probability. CCDC#1547928

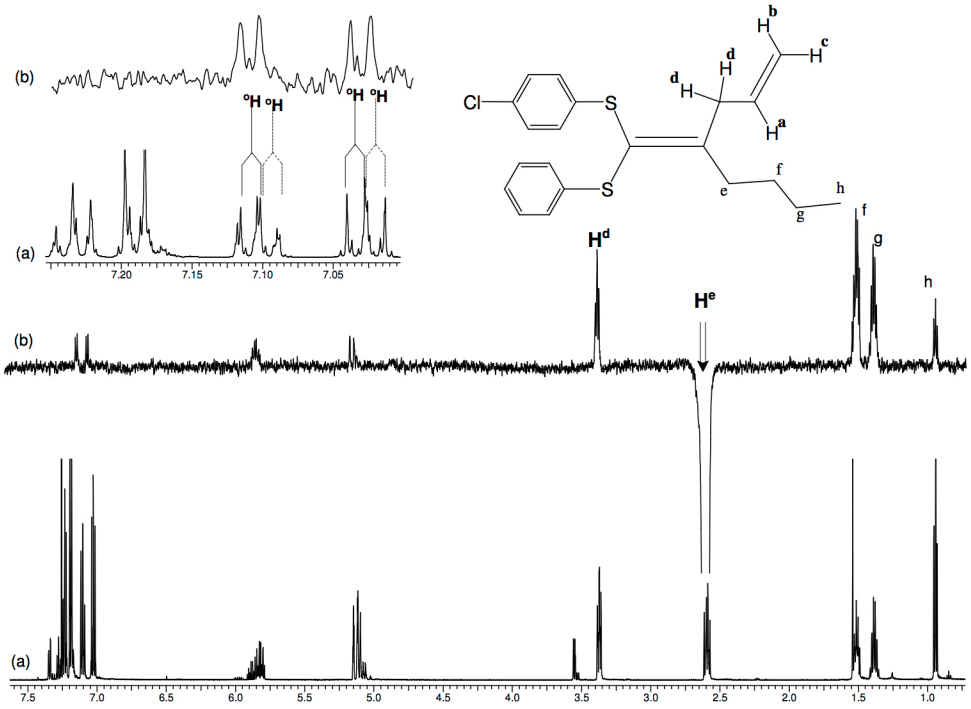
IV. NMR experiment

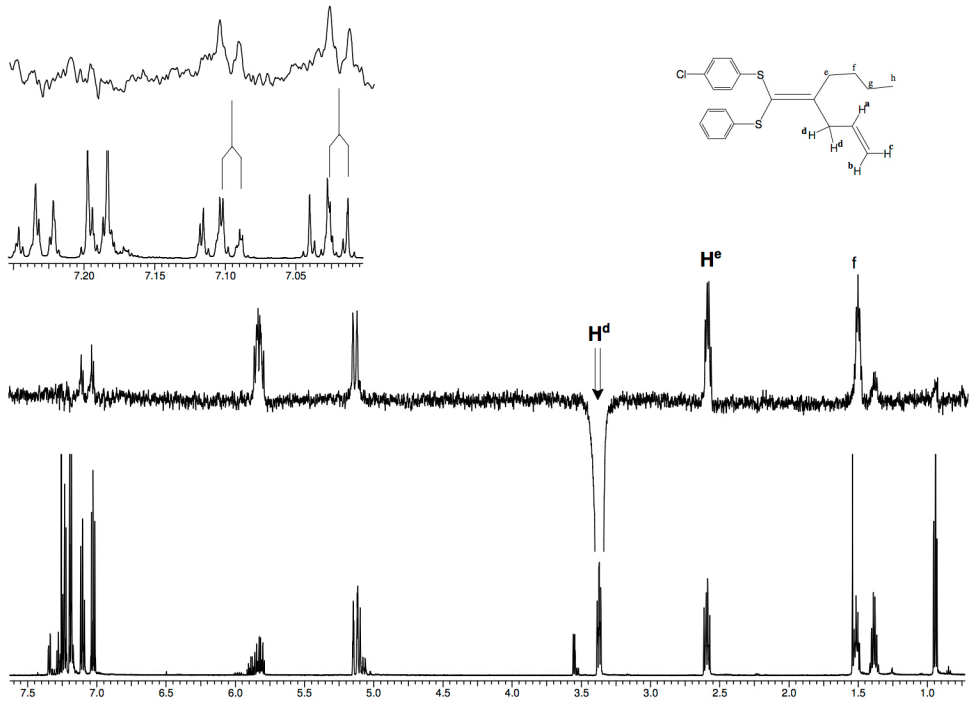
3.1 NOE Study for the conformation analysis of cis-addition product 3c



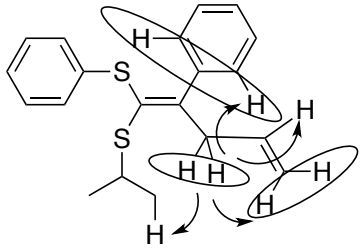
3.2 NOE Study for the conformation analysis of Z/E product 7d



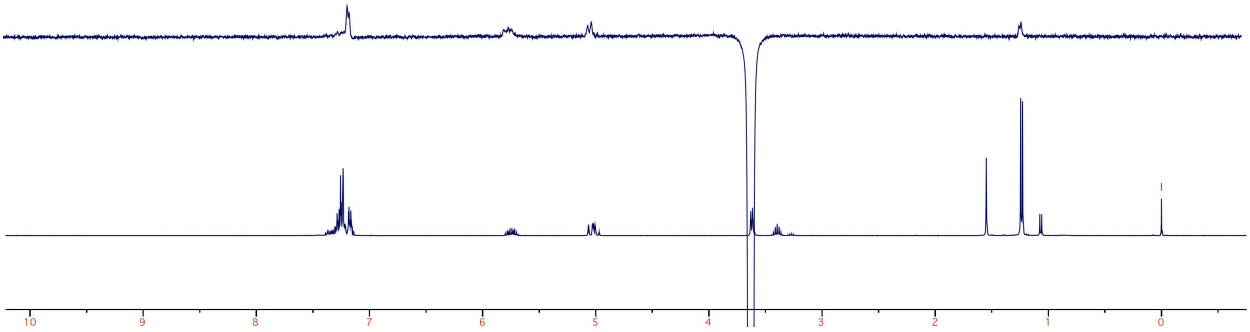


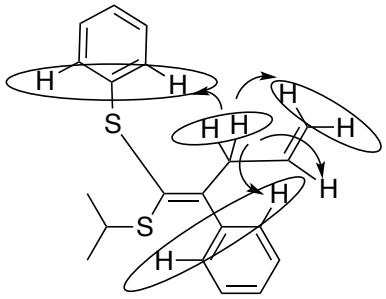

Cl
S
S
e
f
g
h
Ha
Hd
Hd
Hb
Hf
7.20
7.15
7.10
7.05
He
f
Hd
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0

3.2 NOE Study for the conformation analysis of Z/E product 7j

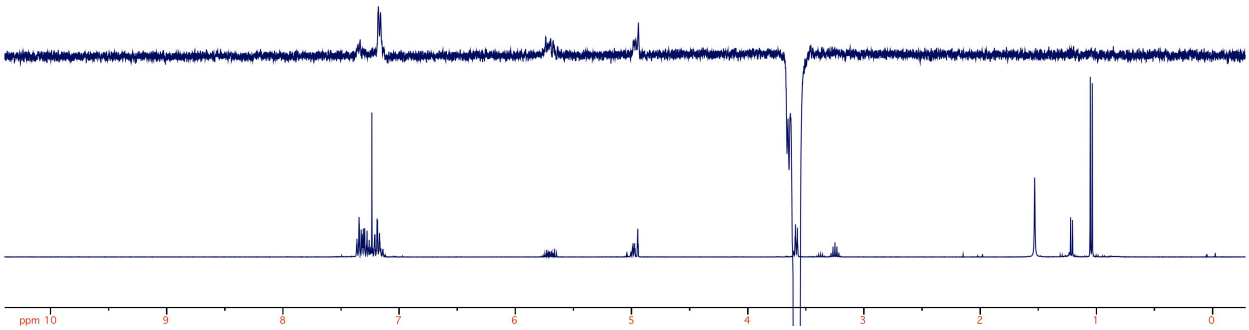


E isomer

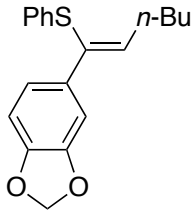




Z isomer



V. Compound Characterization



3a

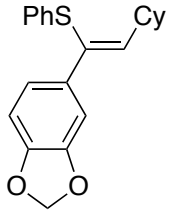
(*Z*)-5-(1-(phenylthio)hex-1-en-1-yl)benzo[*d*][1,3]dioxole

3a was prepared following the General Procedure **1.3** and purified by flash Chromatography (Hexane: Ether= 100:1) as pale yellow oil.

^{1}H-NMR (400 MHz; $CDCl_3$): δ 7.14-7.13 (m, 4H), 7.06-7.02 (m, 3H), 6.65 (d, *J* = 8.6 Hz, 1H), 6.31 (t, *J* = 7.2 Hz, 1H), 5.88 (s, 2H), 2.51 (q, *J* = 7.3 Hz, 2H), 1.49-1.43 (m, 2H), 1.38 (dd, *J* = 15.0, 7.2 Hz, 2H), 0.92 (t, *J* = 7.2 Hz, 3H).

^{13}C-NMR (101 MHz; $CDCl_3$): δ 147.5, 147.0, 139.1, 136.1, 134.9, 132.7, 128.6, 128.0, 125.3, 121.2, 107.9, 101.0, 36.6, 31.5, 30.7, 22.4, 14.0

HRMS *m/z* (ESI) calcd. for $C_{19}H_{21}O_2S^+$ $(M+K)^+$ 351.0821, found 351.0826.



3b

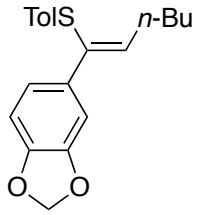
(*Z*)-5-(2-cyclohexyl-1-(phenylthio)vinyl)benzo[*d*][1,3]dioxole

3b was prepared following the General Procedure **1.3** and purified by flash Chromatography (Hexane: Ether= 100:1) as pale yellow oil.

^{1}H-NMR (400 MHz; $CDCl_3$): δ 7.14-7.13 (m, 4H), 7.07-7.02 (m, 3H), 6.65 (d, *J* = 8.6 Hz, 1H), 6.14 (d, *J* = 9.1 Hz, 1H), 5.88 (s, 2H), 2.86 (dt, *J* = 8.6, 3.1 Hz, 1H), 1.75-1.65 (m, 5H), 1.37-1.29 (m, 2H), 1.25-1.16 (m, *J* = 3.8 Hz, 3H).

^{13}C-NMR (101 MHz; $CDCl_3$): δ 147.4, 147.0, 144.7, 136.1, 134.7, 130.7, 128.6, 128.1, 125.3, 121.3, 107.92, 107.80, 101.0, 39.9, 32.8, 25.9, 25.7

HRMS m/z (ESI) calcd. for C21H23O2S+ (M+H)+ 339.1413, found 339.1423.



3c

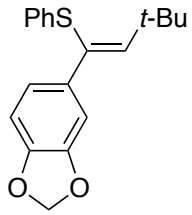
(*Z*)-5-(1-(*p*-tolylthio)hex-1-en-1-yl)benzo[*d*][1,3]dioxole

3c was prepared following the General Procedure **1.3** and purified by flash Chromatography (Hexane: Ether= 100:1) as pale yellow oil.

^{1}H-NMR (400 MHz; $CDCl_3$): δ 7.05-7.02 (m, 4H), 6.95 (d, *J* = 8.0 Hz, 2H), 6.65 (d, *J* = 8.5 Hz, 1H), 6.26 (t, *J* = 7.2 Hz, 1H), 5.88 (s, 2H), 2.51 (q, *J* = 7.2 Hz, 2H), 2.22 (s, 3H), 1.51-1.43 (m, 2H), 1.41-1.34 (m, 2H), 0.92 (t, *J* = 7.2 Hz, 3H).

^{13}C-NMR (101 MHz; $CDCl_3$): δ 147.4, 146.9, 138.57, 138.55, 135.17, 135.07, 133.3, 132.3, 129.4, 128.4, 121.3, 107.97, 107.78, 101.0, 31.6, 30.7, 22.4, 20.9, 14.0

HRMS *m/z* (ESI) calcd. for $C_{21}H_{23}O_2S^+$ $(M+H)^+$ 327.1413, found 327.1417.



3d

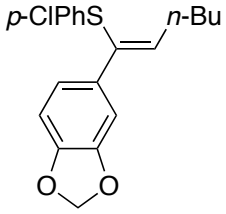
(*Z*)-5-(3,3-dimethyl-1-(phenylthio)but-1-en-1-yl)benzo[*d*][1,3]dioxole

3b was prepared following the General Procedure **1.3** and purified by flash Chromatography (Hexane: Ether= 100:1) as white solid.

^{1}H-NMR (400 MHz; $CDCl_3$): δ 7.12-7.11 (m, 4H), 7.04-6.99 (m, 3H), 6.61 (d, *J* = 8.0 Hz, 1H), 6.28 (s, 1H), 5.85 (s, 2H), 1.35 (s, 9H).

^{13}C-NMR (101 MHz; $CDCl_3$): δ 148.6, 147.3, 146.9, 136.04, 135.85, 132.2, 128.66, 128.52, 125.4, 121.5, 108.3, 107.6, 100.9, 33.9, 30.6

HRMS *m/z* (ESI) calcd. for $C_{19}H_{21}O_2S^+$ $(M+H)^+$ 313.1257, found 313.1267.



3e

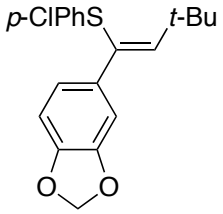
(*Z*)-5-(1-((4-chlorophenyl)thio)hex-1-en-1-yl)benzo[*d*][1,3]dioxole

3e was prepared following the to the General Procedure and purified by flash Chromatography (Hexane: Ether= 100:1) as colorless oil, which contained *E/Z* isomer (6:1) as unrepeatable mixture

^{1}H-NMR (400 MHz; $CDCl_3$): *Z* isomer δ 7.15-7.10 (m, 3H), 7.06-7.02 (m, 3H), 6.67 (d, *J* = 8.7 Hz, 1H), 6.30 (t, *J* = 7.3 Hz, 1H), 5.91 (s, 2H), 2.50 (q, *J* = 7.3 Hz, 2H), 1.48-1.44 (m, 2H), 1.40-1.36 (m, 2H), 0.92 (t, *J* = 7.2 Hz, 3H). *E* isomer: δ 7.15-7.09 (m, 3H), 7.06-7.02 (m, 3H), 6.69 (d, *J* = 1.8 Hz, 1H), 6.12 (t, *J* = 7.5 Hz, 1H), 5.92 (s, 2H), 2.16 (q, *J* = 7.4 Hz, 2H), 1.38-1.35 (m, 2H), 1.29-1.26 (m, 2H), 0.86 (t, *J* = 7.2 Hz, 1H).

^{13}C-NMR (101 MHz; $CDCl_3$): *Z* isomer was detected as major peak δ 147.6, 147.1, 139.3, 134.61, 134.47, 132.5, 131.2, 129.4, 128.8, 121.2, 107.89, 107.81, 101.1, 31.5, 30.7, 22.4, 14.0

HRMS *m/z* (ESI) calcd. for $C_{19}H_{20}ClO_2S^+$ $(M+H)^+$ 347.0867, found 347.0933.



3f

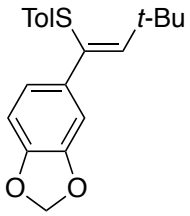
(*Z*)-5-(1-((4-chlorophenyl)thio)-3,3-dimethylbut-1-en-1-yl)benzo[*d*][1,3]dioxole

3f was prepared following the General Procedure **1.3** and purified by flash Chromatography (Hexane: Ether= 100:1) as pale white solid, which contained *E/Z* isomer (5:1) as unrepeatable mixture.

^{1}H-NMR (500 MHz; $CDCl_3$): *Z* isomer: δ 7.09-7.07 (m, 2H), 7.04-7.01 (m, 2H), 6.98-6.95 (m, 2H), 6.66-6.55 (m, 1H), 6.28 (s, 1H), 5.91 (s, 1H), 5.89 (s, 2H), 1.32 (s, 9H). *E* isomer: **^{1}H-NMR** (500 MHz; $CDCl_3$): δ 7.21-7.16 (m, 4H), 6.98-6.95 (m, 2H), 6.66-6.55 (m, 1H), 6.11 (s, 1H), 5.91 (s, 2H), 0.94 (s, 9H).

^{13}C-NMR (101 MHz; $CDCl_3$): *Z* isomer was detected as major peak δ 149.0, 147.4, 147.0, 135.6, 134.4, 133.1, 131.8, 131.3, 129.9, 128.7, 121.5, 108.2, 107.7, 101.0, 33.9, 30.9, 30.6

HRMS *m/z* (ESI) calcd. for $C_{19}H_{20}ClO_2S^+$ $(M+K)^+$ 385.0431, found 385.0435.



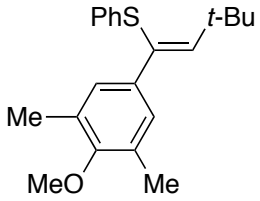
3g

3g was prepared following the General Procedure **1.3** and purified by flash Chromatography (Hexane: Ether= 100:1) as colorless oil.

^{1}H-NMR (400 MHz; $CDCl_3$): δ 6.99-6.89 (m, 6H), 6.58 (d, *J* = 8.2 Hz, 1H), 6.20 (s, 1H), 5.84 (s, 2H), 2.18 (s, 3H), 1.30 (d, *J* = 12.1 Hz, 9H).

^{13}C-NMR (101 MHz; $CDCl_3$): δ 149.0, 147.4, 147.0, 135.6, 134.4, 133.1, 131.8, 131.3, 129.9, 128.7, 121.5, 108.2, 107.7, 101.0, 33.9, 30.9, 30.6

HRMS *m/z* (ESI) calcd. for $C_{19}H_{20}ClO_2S^+$ $(M+K)^+$ 365.0977, found 365.0973.



3h

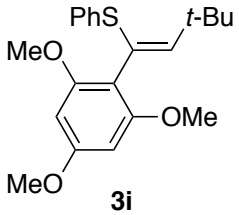
(*Z*)-(1-(4-methoxy-3,5-dimethylphenyl)-3,3-dimethylbut-1-en-1-yl)(phenyl)sulfane

3g was prepared following the General Procedure **1.3** and purified by flash Chromatography (Hexane: Ether= 100:1) as colorless oil.

^{1}H-NMR (400 MHz; $CDCl_3$): δ 7.14-7.11 (m, 6H), 7.02-6.99 (m, 1H), 6.30 (s, 1H), 3.63 (s, 3H), 2.18 (s, 6H), 1.33 (s, 9H)

^{13}C-NMR (101 MHz; $CDCl_3$): δ 156.4, 149.1, 137.0, 136.2, 131.9, 130.1, 128.46, 128.42, 128.1, 125.2, 59.6, 34.0, 30.6, 16.1

HRMS *m/z* (ESI) calcd. for $C_{21}H_{27}OS^+$ $(M+H)^+$ 327.1777, found 327.1770.



3i

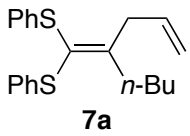
(*Z*)-(3,3-dimethyl-1-(2,4,6-trimethoxyphenyl)but-1-en-1-yl)(phenyl)sulfane

3i was prepared following the General Procedure **1.3** and purified by flash Chromatography (Hexane: Ether= 100:1) as colorless oil.

^{1}H-NMR (500 MHz; $CDCl_3$): δ 7.40-7.39 (m, 2H), 7.17-7.12 (m, 3H), 6.05 (s, 1H), 5.97 (s, 2H), 3.75 (s, 3H), 3.66 (s, 6H), 0.88 (s, 9H).

^{13}C-NMR (101 MHz; $CDCl_3$): δ 160.8, 157.9, 144.8, 135.4, 133.0, 127.9, 126.7, 124.9, 109.6, 90.0, 55.27, 55.15, 34.8, 29.5

HRMS *m/z* (ESI) calcd. for $C_{21}H_{27}O_3S^+$ $(M+H)^+$ 359.1675, found 359.1683.



7a

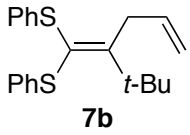
(2-allylhex-1-ene-1,1-diyl)bis(phenylsulfane)

7a was prepared following the General Procedure **1.4** and purified by flash Chromatography (Hexane) as colorless oil.

^{1}H-NMR (400 MHz; $CDCl_3$): δ 7.24-7.10 (m, 10H), 5.83 (ddt, *J* = 16.9, 10.1, 6.7 Hz, 1H), 5.16-5.08 (m, 2H), 3.38 (d, *J* = 6.6 Hz, 2H), 2.60 (t, *J* = 7.9 Hz, 2H), 1.56-1.48 (m, 2H), 1.38 (dq, *J* = 14.7, 7.3 Hz, 2H), 0.94 (t, *J* = 7.3 Hz, 3H).

^{13}C-NMR (101 MHz; $CDCl_3$): δ 157.5, 135.64, 135.64, 135.0, 129.6, 129.4, 128.57, 128.55, 126.20, 126.13, 123.2, 116.6, 40.0, 35.1, 31.0, 22.8, 13.9

HRMS *m/z* (ESI) calcd. for $C_{21}H_{25}S_2^+$ $(M+H)^+$ 341.1392, found 341.1367.



7b

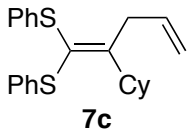
(2-(*tert*-butyl)penta-1,4-diene-1,1-diyl)bis(phenylsulfane)

7b was prepared following the General Procedure **1.4** and purified by flash Chromatography (Hexane) as colorless oil.

1H-NMR (400 MHz; CDCl3): δ 7.32-7.16 (m, 7H), 7.13-7.07 (m, 3H), 5.99-5.89 (m, 1H), 5.18-5.12 (m, 2H), 3.59 (dt, *J* = 5.6, 1.8 Hz, 2H), 1.49 (s, 9H).

^{13}C-NMR (101 MHz; $CDCl_3$): δ 162.4, 136.6, 136.4, 135.8, 129.7, 129.3, 128.49, 128.47, 126.11, 125.97, 125.1, 115.9, 39.8, 38.6, 30.8

HRMS *m/z* (ESI) calcd. for $C_{21}H_{25}S_2^+$ $(M+H)^+$ 341.1392, found 341.1399.



7c

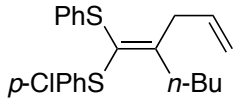
(2-cyclohexylpenta-1,4-diene-1,1-diyl)bis(phenylsulfane)

7c was prepared following the General Procedure **1.4** and purified by flash Chromatography (Hexane) as colorless oil.

^{1}H-NMR (500 MHz; $CDCl_3$): δ 7.25-7.20 (m, 4H), 7.18-7.15 (m, 2H), 7.13-7.12 (m, 2H), 7.09-7.08 (m, 2H), 5.85 (ddt, *J* = 16.9, 10.4, 6.3 Hz, 1H), 5.14-5.07 (m, 2H), 3.40-3.34 (m, 3H), 1.78-1.76 (m, 2H), 1.70-1.64 (m, 3H), 1.45 (qd, *J* = 12.4, 3.0 Hz, 2H), 1.33 (qt, *J* = 12.8, 3.1 Hz, 2H), 1.19 (tt, *J* = 12.8, 3.3 Hz, 1H).

^{13}C-NMR (101 MHz; $CDCl_3$): δ 160.8, 136.3, 135.9, 135.6, 129.60, 129.53, 128.57, 128.54, 126.2, 123.4, 116.2, 45.4, 36.5, 31.6, 26.3, 26.0

HRMS *m/z* (ESI) calcd. for $C_{23}H_{27}S_2^+$ $(M+H)^+$ 367.1549, found 367.1545.



7d Z/E= 1:1

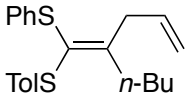
(*Z/E*)-(2-allyl-1-((4-chlorophenyl)thio)hex-1-en-1-yl)(phenyl)sulfane

7d was prepared following the General Procedure **1.4** and purified by flash Chromatography (Hexane) as colorless oil, which contained Z/E isomer (1:1) as an inseparable mixture.

^{1}H-NMR (400 MHz; $CDCl_3$): δ 7.24-7.16 (m, 5H), 7.12-7.08 (m, *J* = 1.2 Hz, 2H), 7.04-7.00 (m, 2H), 5.87-5.77 (m, 1H), 5.15-5.08 (m, 2H), 3.38-3.35 (m, 2H), 2.62-2.56 (m, 2H), 1.55-1.47 (m, 2H), 1.38 (dq, *J* = 14.7, 7.3 Hz, 2H), 0.94 (t, *J* = 7.3 Hz, 3H).

^{13}C-NMR (101 MHz; $CDCl_3$): δ 157.43, 157.38, 135.3, 134.90, 134.85, 134.1, 132.28, 132.21, 131.0, 130.8, 129.7, 129.5, 128.69, 128.68, 128.63, 128.61, 126.38, 126.32, 123.02, 122.96, 116.7, 40.03, 39.99, 35.19, 35.14, 31.0, 22.8, 13.9.

HRMS *m/z* (ESI) calcd. for $C_{21}H_{24}ClS_2^+$ $(M+H)^+$ 375.1002, found 374.0995.



7e Z/E= 1:1

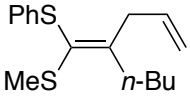
(Z/E)-(2-allyl-1-(*p*-tolylthio)hex-1-en-1-yl)(phenyl)sulfane

7e was prepared following the General Procedure **1.4** and purified by flash Chromatography (Hexane) as colorless oil, which contained Z/E isomer (1:1) as an inseparable mixture.

^{1}H-NMR (400 MHz; $CDCl_3$): δ 7.24-7.21 (m, 2H), 7.17-7.10 (m, 3H), 7.05-7.00 (m, 4H), 5.89-5.77 (m, 1H), 5.16-5.07 (m, 2H), 3.38 (dd, *J* = 13.4, 6.5 Hz, 2H), 2.63-2.57 (m, 2H), 2.30 (s, 3H), 1.55-1.49 (m, 2H), 1.42-1.34 (m, 2H), 0.94 (q, *J* = 7.4 Hz, 3H).

^{13}C-NMR (101 MHz; $CDCl_3$): δ 156.6, 136.41, 136.33, 135.9, 135.1, 131.9, 130.4, 130.1, 129.39, 129.38, 129.1, 128.6, 126.05, 125.99, 123.8, 116.5, 40.04, 39.95, 35.15, 35.06, 31.0, 22.9, 21.1, 14.0

HRMS *m/z* (ESI) calcd. for $C_{22}H_{27}S_2^+$ $(M+H)^+$ 355.1549, found 355.1540.



7f Z/E= 1:1

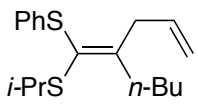
(Z/E)-(2-allyl-1-(methylthio)hex-1-en-1-yl)(phenyl)sulfane

7f was prepared following the General Procedure **1.4** and purified by flash Chromatography (Hexane) as colorless oil, which contained Z/E isomer (1:1) as an inseparable mixture.

1H-NMR (400 MHz; CDCl3): δ 7.29-7.21 (m, 8H), 7.18-7.14 (m, 2H), 5.87-5.80 (m, 1H), 5.78-5.69 (m, 1H), 5.15-5.00 (m, 4H), 3.31-3.26 (m, J = 1.4 Hz, 4H), 2.53-2.48 (m, 4H), 2.20 (s, 3H), 2.19 (s, 3H), 1.51-1.28 (m, 9H), 0.96 (t, J = 7.2 Hz, 3H), 0.89 (t, J = 7.2 Hz, 3H).

^{13}C-NMR (101 MHz; $CDCl_3$): δ 152.94, 152.83, 136.3, 135.4, 135.0, 128.76, 128.74, 127.8, 127.6, 125.68, 125.64, 124.53, 124.33, 116.19, 116.18, 40.2, 39.5, 35.4, 34.6, 30.9, 30.5, 22.87, 22.73, 17.10, 17.05, 13.98, 13.93

HRMS *m/z* (ESI) calcd. for $C_{18}H_{25}S_2^+$ $(M+H)^+$ 305.1392, found 305.1400.



7g Z/E= 1:1

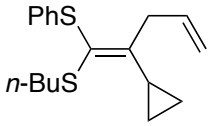
(Z/E)-(2-allyl-1-(isopropylthio)hex-1-en-1-yl)(phenyl)sulfane

7g was prepared following the General Procedure **1.4** and purified by flash Chromatography (Hexane) as colorless oil, which contained Z/E isomer (1:1) as an inseparable mixture.

^{1}H-NMR (400 MHz; $CDCl_3$): δ 7.29-7.21 (m, 8H), 7.20-7.14 (m, 2H), 5.86-5.72 (m, 2H), 5.13-5.02 (m, 4H), 3.37-3.28 (m, 7H), 2.53 (q, *J* = 7.7 Hz, 5H), 1.47-1.31 (m, 8H), 1.18 (d, *J* = 4.5 Hz, 6H), 1.16 (d, *J* = 4.4 Hz, 6H), 0.95 (t, *J* = 7.2 Hz, 3H), 0.90 (t, *J* = 7.2 Hz, 3H).

^{13}C-NMR (101 MHz; $CDCl_3$): δ 155.61, 155.56, 136.28, 136.26, 135.5, 135.3, 128.67, 128.65, 128.4, 128.2, 125.70, 125.64, 123.83, 123.70, 116.13, 116.03, 39.9, 39.7, 37.19, 37.14, 35.00, 34.85, 31.1, 30.9, 22.89, 22.76, 22.67, 14.03, 13.97

HRMS *m/z* (ESI) calcd. for $C_{18}H_{25}S_2^+$ $(M+H)^+$ 305.1392, found 305.1400.



7h Z/E= 1:1

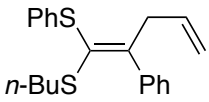
(Z/*E*)-butyl(2-cyclopropyl-1-(phenylthio)penta-1,4-dien-1-yl)sulfane

7h was prepared following the General Procedure **1.4** and purified by flash Chromatography (Hexane) as colorless oil, which contained Z/E isomer (1:1) as an inseparable mixture.

^{1}H-NMR (400 MHz; $CDCl_3$): δ 7.28-7.21 (m, 4H), 7.17-7.13 (m, 1H), 5.83-5.72 (m, 1H), 5.10-4.97 (m, 2H), 2.90 (ddt, *J* = 9.6, 5.8, 1.8 Hz, 2H), 2.71 (dd, *J* = 7.3 Hz, 2H), 2.56-2.47 (m, 1H), 1.52-1.41 (m, 2H), 1.34 (ddt, *J* = 14.9, 10.0, 7.4 Hz, 2H), 0.88-0.81 (m, 4H), 0.74-0.64 (m, 3H).

^{13}C-NMR (101 MHz; $CDCl_3$): δ 153.25, 153.21, 136.7, 136.3, 136.1, 135.6, 128.69, 128.65, 128.2, 127.7, 125.7, 125.5, 123.6, 123.2, 115.8, 115.6, 34.4, 34.0, 33.4, 33.1, 31.82, 31.72, 21.89, 21.79, 16.5, 16.3, 13.67, 13.63, 6.7, 6.5

HRMS *m/z* (ESI) calcd. for $C_{18}H_{25}S_2^+$ $(M+H)^+$ 305.1392, found 305.1400.



7i, Z/E= 2:1

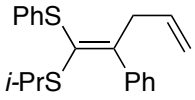
(Z/*E*)-butyl(2-phenyl-1-(phenylthio)penta-1,4-dien-1-yl)sulfane

7i was prepared following the General Procedure **1.4** and purified by flash Chromatography (Hexane) as colorless oil

^{1}H-NMR (500 MHz; $CDCl_3$): Major Z isomer: δ 7.38-7.28 (m, 7H), 7.26-7.20 (m, 3H), 5.75-5.67 (m, 1H), 5.00-4.97 (m, 2H), 3.60 (d, *J* = 6.6 Hz, 2H), 2.56 (t, *J* = 7.4 Hz, 2H), 1.37 (quintet, *J* = 7.4 Hz, 2H), 1.20 (dt, *J* = 14.9, 7.4 Hz, 2H), 0.79 (t, *J* = 7.3 Hz, 3H).

^{13}C-NMR (126 MHz; $CDCl_3$): Major Z isomer: δ 151.0, 141.9, 135.7, 134.7, 128.9, 128.6, 128.4, 128.0, 127.2, 126.1, 116.5, 42.9, 33.2, 31.6, 21.7, 13.6

HRMS *m/z* (ESI) calcd. for $C_{21}H_{25}S_2^+$ $(M+K)^+$ 379.0956, found 370.0953.



7j, Z/E= 1.5:1

7i was prepared following the General Procedure **1.4** and purified by flash Chromatography (Hexane) as colorless oil.

(*Z*)-isopropyl(2-phenyl-1-(phenylthio)penta-1,4-dien-1-yl)sulfane

^{1}H-NMR (500 MHz; $CDCl_3$): δ 7.39-7.28 (m, 7H), 7.23-7.20 (m, 3H), 5.75-5.69 (m, 1H), 5.01-4.97 (m, 2H), 3.61 (t, *J* = 7.6 Hz, 2H), 3.27 (dt, *J* = 13.5, 6.7 Hz, 1H), 1.07 (d, *J* = 6.8 Hz, 6H).

^{13}C-NMR (126 MHz; $CDCl_3$): δ 151.6, 141.9, 135.6, 134.7, 128.90, 128.80, 128.4, 127.9, 127.1, 126.1, 116.5, 42.8, 37.3, 22.7

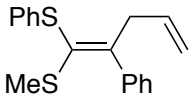
HRMS *m/z* (ESI) calcd. for $C_{20}H_{23}S_2^+$ $(M+H)^+$ 327.1236, found 327.1235.

(*E*)-isopropyl(2-phenyl-1-(phenylthio)penta-1,4-dien-1-yl)sulfane

^{1}H-NMR (500 MHz; $CDCl_3$): δ 7.29-7.23 (m, 7H), 7.17 (dt, *J* = 8.2, 1.9 Hz, 3H), 5.78-5.71 (m, 1H), 5.06-5.01 (m, 2H), 3.62 (d, *J* = 6.6 Hz, 2H), 3.40 (dt, *J* = 13.5, 6.7 Hz, 1H), 1.24 (d, *J* = 6.7 Hz, 6H).

^{13}C-NMR (126 MHz; $CDCl_3$): δ 152.3, 142.3, 136.1, 134.4, 129.3, 128.5, 128.02, 127.86, 127.67, 127.1, 126.0, 116.5, 77.3, 77.0, 76.7, 42.6, 37.3, 22.9

HRMS *m/z* (ESI) calcd. for $C_{20}H_{23}S_2^+$ $(M+H)^+$ 327.1236, found 127.1230.



7k, Z/E= 1.5:1

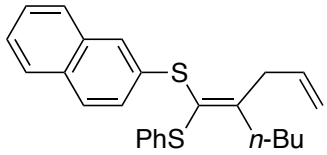
(*Z*/*E*)-methyl(2-phenyl-1-(phenylthio)penta-1,4-dien-1-yl)sulfane

7k was prepared following the General Procedure **1.4** and purified by flash Chromatography (Hexane) as colorless oil, which contained Z/E isomer (1.5:1) as an inseparable mixture.

^{1}H-NMR (500 MHz; $CDCl_3$): δ 7.40-7.17 (m, 10H), 5.80-5.67 (m, 1H), 5.07-4.96 (m, 2H), 3.59 (d, *J* = 6.6 Hz, 2H), 2.25 (s, 1H), 2.09 (s, 2H).

^{13}C-NMR (126 MHz; $CDCl_3$): δ 149.7, 141.5, 135.78, 135.77, 134.6, 130.8, 128.9, 128.68, 128.58, 128.33, 128.25, 128.23, 128.22, 128.09, 128.03, 128.02, 128.01, 128.00, 127.94, 127.93, 127.86, 127.78, 127.4, 127.12, 127.11, 126.06, 125.89, 116.54, 116.53, 42.88, 42.87, 42.86, 42.4, 17.3, 16.8

HRMS *m/z* (ESI) calcd. for $C_{18}H_{19}S_2^+$ $(M+H)^+$ 299.0923, found 299.0917.



7l, Z/E= 1:1

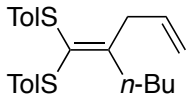
(*Z/E*)-(2-allyl-1-(naphthalen-2-ylthio)hex-1-en-1-yl)(phenyl)sulfane

7l was prepared following the General Procedure **1.4** and purified by flash Chromatography (Hexane) as colorless oil, which contained Z/E isomer (1:1) as an inseparable mixture.

^{1}H-NMR (400 MHz; $CDCl_3$): δ 7.77-7.64 (m, 3H), 7.51 (d, *J* = 6.2 Hz, 1H), 7.45-7.40 (m, 2H), 7.26-7.16 (m, 4H), 7.12-7.09 (m, 2H), 5.92-5.82 (m, 1H), 5.20-5.10 (m, 2H), 3.42 (dd, *J* = 6.5, 1.3 Hz, 2H), 2.65 (t, *J* = 7.9 Hz, 2H), 1.59-1.52 (m, 2H), 1.41 (dt, *J* = 14.6, 7.3 Hz, 2H), 0.95 (q, *J* = 7.8 Hz, 3H).

^{13}C-NMR (126 MHz; $CDCl_3$): δ 157.63, 157.61, 135.62, 135.60, 135.09, 135.05, 133.56, 133.56, 133.07, 133.05, 131.93, 131.90, 129.7, 129.4, 128.59, 128.57, 128.11, 128.10, 128.06, 127.79, 127.67, 127.66, 127.53, 127.34, 127.25, 127.22, 126.29, 126.28, 126.27, 126.20, 125.66, 125.63, 123.12, 123.10, 116.69, 116.67, 40.1, 35.2, 31.1, 22.9, 13.99, 13.97

HRMS *m/z* (ESI) calcd. for $C_{18}H_{19}S_2^+$ $(M+H)^+$ 391.1549, found 391.1542.



7n

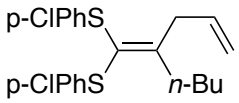
(2-allylhex-1-ene-1,1-diyl)bis(*p*-tolylsulfane)

7n was prepared following the General Procedure **1.4** and purified by flash Chromatography (Hexane) as colorless oil.

^{1}H-NMR (400 MHz; $CDCl_3$): δ 7.03 (q, *J* = 7.1 Hz, 8H), 5.86-5.79 (m, 1H), 5.10 (t, *J* = 13.9 Hz, 2H), 3.38 (d, *J* = 6.5 Hz, 2H), 2.59 (t, *J* = 7.9 Hz, 2H), 2.31 (s, 6H), 1.53-1.47 (m, 2H), 1.38 (q, *J* = 7.3 Hz, 2H), 0.94 (t, *J* = 7.2 Hz, 3H).

^{13}C-NMR (126 MHz; $CDCl_3$): δ 156.0, 136.25, 136.18, 135.3, 132.1, 130.1, 129.9, 129.39, 129.38, 124.4, 116.4, 40.0, 35.1, 31.0, 22.9, 21.1, 14.0

HRMS *m/z* (ESI) calcd. for $C_{23}H_{29}S_2^+$ $(M+H)^+$ 369.1705, found 369.1710.



7o

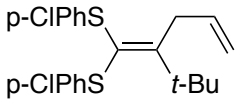
(2-allylhex-1-ene-1,1-diyl)bis((4-chlorophenyl)sulfane)

7o was prepared following the General Procedure **1.4** and purified by flash Chromatography (Hexane) as colorless oil, which contained trace inseparable Allyl 4-chlorophenyl sulfide starting material.

^{1}H-NMR (500 MHz; $CDCl_3$): δ 7.21-7.19 (m, 4H), 7.03-7.00 (m, 4H), 5.87-5.77 (m, *J* = 4.6 Hz, 1H), 5.15-5.06 (m, 2H), 3.36 (d, *J* = 6.6 Hz, 2H), 2.58 (t, *J* = 7.9 Hz, 2H), 1.49 (ddd, *J* = 5.6, 4.5, 4.4 Hz, 2H), 1.38 (q, *J* = 7.4 Hz, 2H), 0.94 (t, *J* = 7.3 Hz, 3H).

^{13}C-NMR (126 MHz; $CDCl_3$): δ 157.6, 134.7, 133.7, 132.48, 132.42, 131.10, 130.90, 128.8, 122.7, 116.9, 40.0, 35.2, 31.0, 22.8, 13.9

HRMS *m/z* (ESI) calcd. for $C_{23}H_{29}S_2^+$ $(M+H)^+$ 409.0613, found 409.0610.



7p

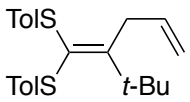
(2-(*tert*-butyl)penta-1,4-diene-1,1-diyl)bis((4-chlorophenyl)sulfane)

7p was prepared following the General Procedure **1.4** and purified by flash Chromatography (Hexane) as white soild.

^{1}H-NMR (500 MHz; $CDCl_3$): δ 7.26-7.18 (m, 5H), 6.98 (dd, *J* = 21.6, 8.5 Hz, 4H), 5.89 (td, *J* = 11.1, 5.9 Hz, 1H), 5.15-5.08 (m, 2H), 3.54 (d, *J* = 5.7 Hz, 2H), 1.44 (s, 10H).

^{13}C-NMR (126 MHz; $CDCl_3$): δ 162.8, 136.3, 134.5, 133.9, 132.4, 132.2, 131.3, 130.6, 128.75, 128.71, 124.5, 116.1, 39.8, 38.6, 30.7

HRMS *m/z* (ESI) calcd. for $C_{23}H_{29}S_2^+$ $(M+K)^+$ 409.0618, found 409.0617.



7q

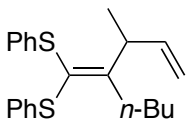
(2-(*tert*-butyl)penta-1,4-diene-1,1-diyl)bis(*p*-tolylsulfane)

7q was prepared following the General Procedure **1.4** and purified by flash Chromatography (Hexane) as white soild.

^{1}H-NMR (500 MHz; $CDCl_3$): δ 7.04 (dt, *J* = 24.0, 8.1 Hz, 6H), 6.95 (d, *J* = 8.1 Hz, 2H), 5.91 (ddd, *J* = 12.0, 9.7, 5.8 Hz, 1H), 5.13-5.09 (m, 2H), 3.57 (dd, *J* = 4.0, 1.7 Hz, 2H), 2.32 (d, *J* = 4.9 Hz, 6H), 1.45 (s, 9H).

^{13}C-NMR (126 MHz; $CDCl_3$): δ 161.2, 136.8, 136.2, 135.9, 133.0, 132.3, 130.2, 129.48, 129.33, 129.31, 126.2, 115.7, 39.7, 38.5, 30.8, 21.12, 21.11

HRMS *m/z* (ESI) calcd. for $C_{23}H_{29}S_2^+$ $(M+H)^+$ 369.1705, found 369.1710.



7r

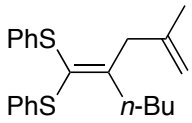
(2-(but-3-en-2-yl)hex-1-ene-1,1-diyl)bis(phenylsulfane)

7r was prepared following the General Procedure **1.4** and purified by flash Chromatography (Hexane) as colorless oil, which contained trace inseparable **4a** byproduct.

^{1}H-NMR (500 MHz; $CDCl_3$): δ 7.26-7.22 (m, 5H), 7.19-7.16 (m, 2H), 7.12-7.10 (m, 3H), 5.94-5.87 (m, 1H), 5.11-5.07 (m, 2H), 4.28 (quintet, *J* = 6.6 Hz, 1H), 2.44 (dd, *J* = 9.0, 6.2 Hz, 2H), 1.58-1.51 (m, 2H), 1.43-1.35 (m, 2H), 1.24 (d, *J* = 7.0 Hz, 3H), 0.93 (t, *J* = 7.2 Hz, 3H).

^{13}C-NMR (126 MHz; $CDCl_3$): δ 162.6, 140.6, 136.0, 135.7, 131.2, 130.2, 129.7, 128.9, 128.63, 128.59, 126.2, 126.0, 114.5, 43.3, 33.1, 32.2, 23.3, 18.1, 13.8

HRMS *m/z* (ESI) calcd. for $C_{23}H_{29}S_2^+$ $(M+H)^+$ 355.1549, found 355.1540.



7s

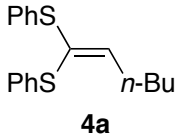
(2-(2-methylallyl)hex-1-ene-1,1-diyl)bis(phenylsulfane)

7s was prepared following the General Procedure **1.4** and purified by flash Chromatography (Hexane) as colorless oil.

^{1}H-NMR (500 MHz; $CDCl_3$): δ 7.26-7.22 (m, 5H), 7.19-7.16 (m, 2H), 7.14-7.09 (m, 3H), 4.87 (s, 1H), 4.76 (s, 1H), 3.37 (s, 2H), 2.60-2.57 (m, 2H), 1.78 (s, 3H), 1.55-1.50 (m, 2H), 1.39 (dd, *J* = 14.8, 7.4 Hz, 2H), 0.94 (t, *J* = 7.3 Hz, 3H).

^{13}C-NMR (126 MHz; $CDCl_3$): δ 157.2, 143.1, 135.70, 135.69, 129.9, 129.5, 128.6, 126.27, 126.17, 124.1, 112.1, 43.5, 34.9, 31.3, 22.92, 22.80, 14.0

HRMS *m/z* (ESI) calcd. for $C_{23}H_{29}S_2^+$ $(M+H)^+$ 355.1549, found 355.1544.



4a

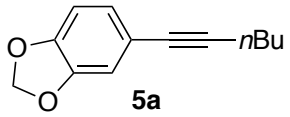
Hex-1-ene-1,1-diylbis(phenylsulfane)

4a was separated as byproduct following the General Procedure **1.3** and purified by flash Chromatography (Hexane) as colorless oil.

^{1}H-NMR (400 MHz; $CDCl_3$): δ 7.27-7.19 (m, 10H), 6.39 (t, *J* = 7.4 Hz, 1H), 2.44 (q, *J* = 7.3 Hz, 2H), 1.45-1.33 (m, 5H), 0.91 (t, *J* = 7.2 Hz, 3H).

^{13}C-NMR (101 MHz; $CDCl_3$): δ 145.0, 134.47, 134.43, 131.2, 130.2, 128.78, 128.64, 128.51, 127.2, 126.6, 31.20, 31.03, 22.4, 13.9

HRMS *m/z* (ESI) calcd. for $C_{18}H_{21}S_2^+$ $(M+H)^+$ 301.1085, found 355.1088.



5a

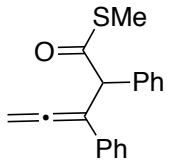
5-(hex-1-yn-1-yl)benzo[*d*][1,3]dioxole

5a was separated as byproduct following the General Procedure **1.3** and purified by flash Chromatography (Hexane) as colorless oil.

^{1}H-NMR (400 MHz; $CDCl_3$): δ 7.56 (dd, *J* = 8.2, 1.6 Hz, 1H), 7.44 (d, *J* = 1.6 Hz, 1H), 6.84 (d, *J* = 8.2 Hz, 1H), 6.03 (s, 2H), 2.87 (t, *J* = 7.5 Hz, 2H), 1.73-1.70 (m, 2H), 1.35 (dt, *J* = 6.7, 3.6 Hz, 4H), 0.91 (dd, *J* = 8.9, 4.7 Hz, 3H).

^{13}C-NMR (101 MHz; $CDCl_3$): δ 198.6, 151.5, 148.1, 132.0, 124.2, 107.89, 107.77, 101.7, 38.3, 31.5, 24.3, 22.5, 13.9.

HRMS *m/z* (ESI) calcd. for $C_{13}H_{15}O_2^+$ $(M+H)^+$ 203.1067, found 203.1001.



10a

S-methyl 2,3-diphenylpenta-3,4-dienethioate

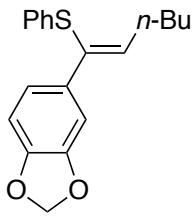
10a was separated following the General Procedure **1.5** and purified by flash Chromatography (Hexane) as colorless oil.

^{1}H-NMR (400 MHz; $CDCl_3$): δ 7.40-7.23 (m, 10H), 7.19-7.16 (m, 1H), 5.22-5.10 (m, 2H), 5.02 (t, *J* = 2.5 Hz, 1H), 2.28 (s, 3H).

^{13}C-NMR (101 MHz; $CDCl_3$): δ 209.8, 198.2, 136.5, 135.1, 129.10, 129.10, 128.47, 128.46, 128.44, 127.8, 127.0, 126.22, 126.22, 104.6, 80.7, 60.5, 12.1

HRMS *m/z* (ESI) calcd. for $C_{18}H_{17}OS^+$ $(M+H)^+$ 281.0995, found 280.0862.

VI. NMR Spectra Data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O
O

3a


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2.521
2.503
2.484
1.490
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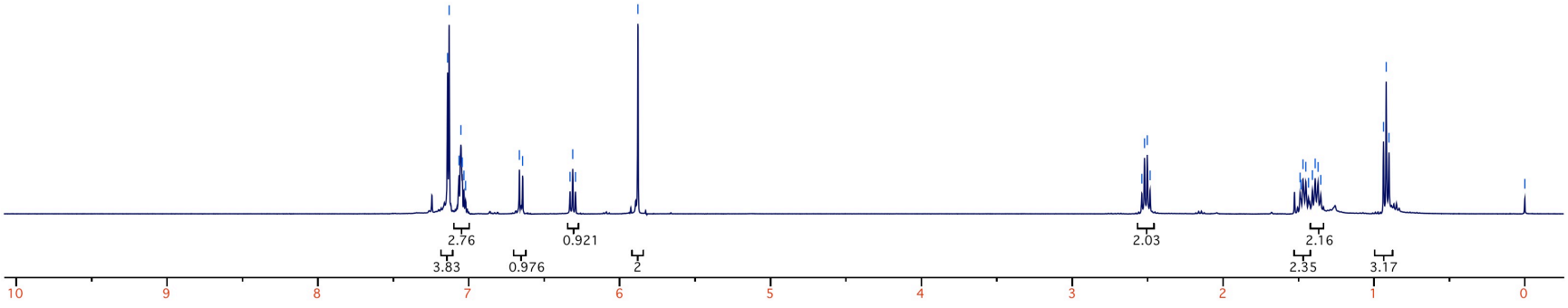
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4
3
2
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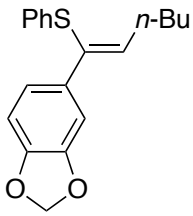
PhS
n-Bu
O
O

3a


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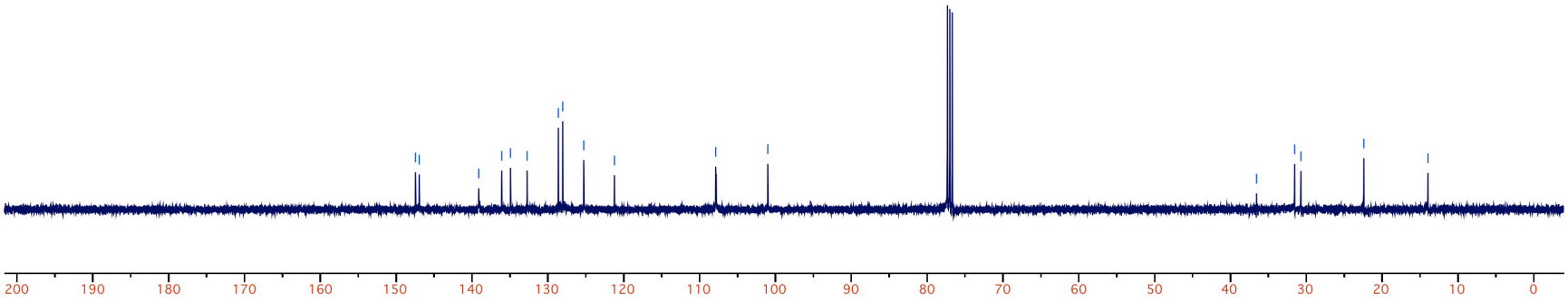
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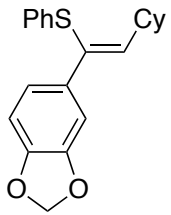
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Cy
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3b


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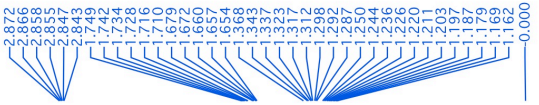
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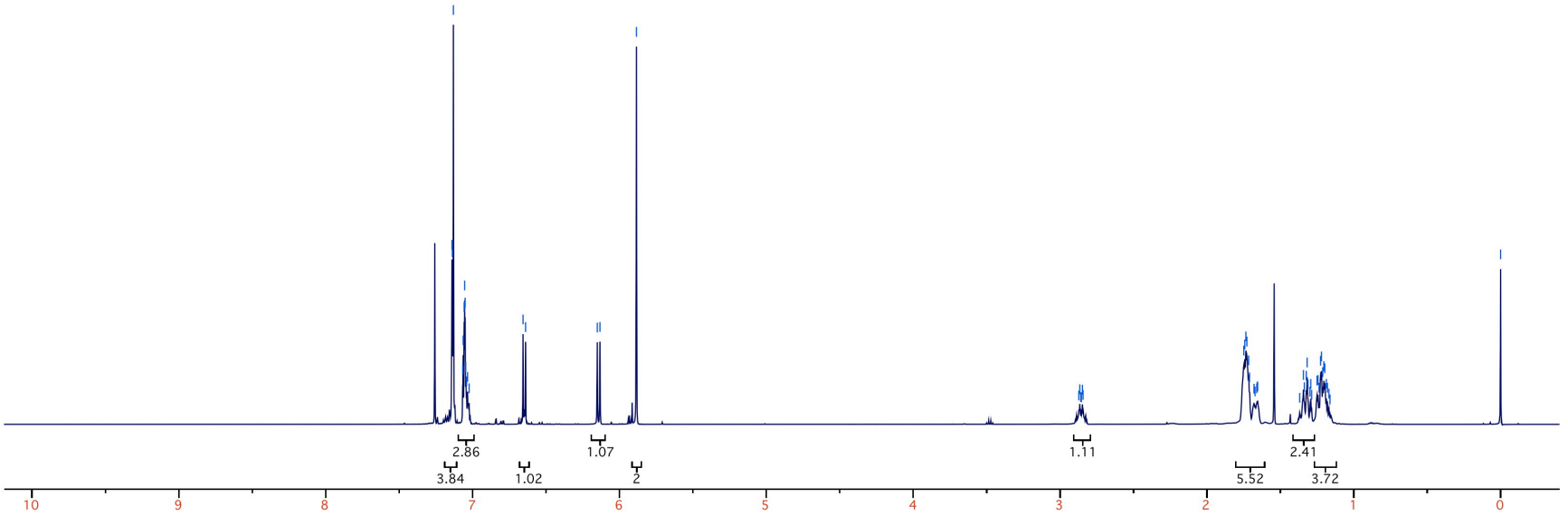
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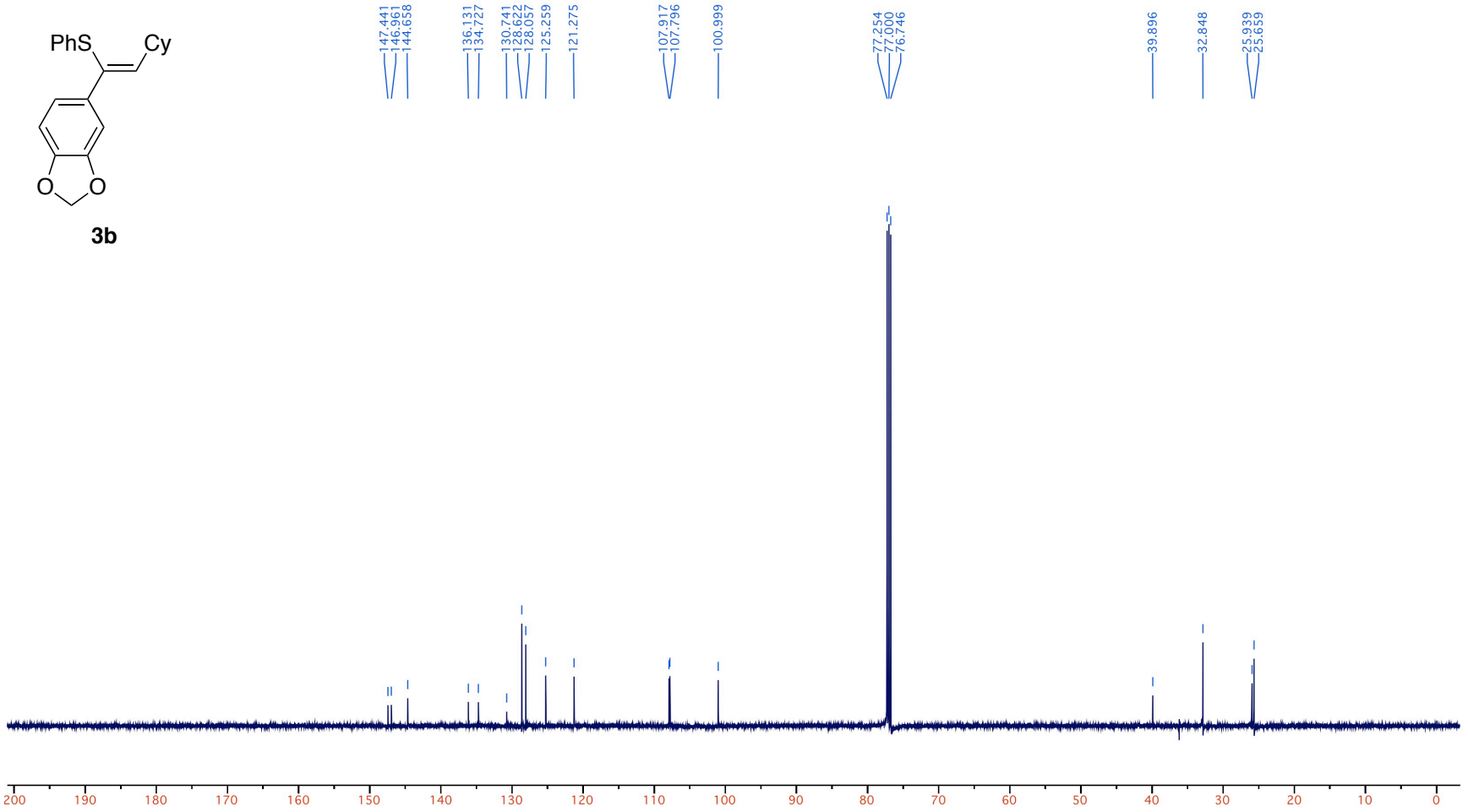
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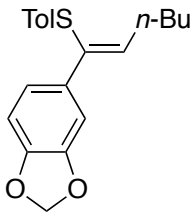
TolS
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O

3c

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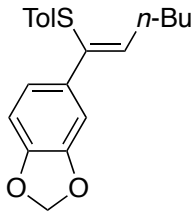
TolS
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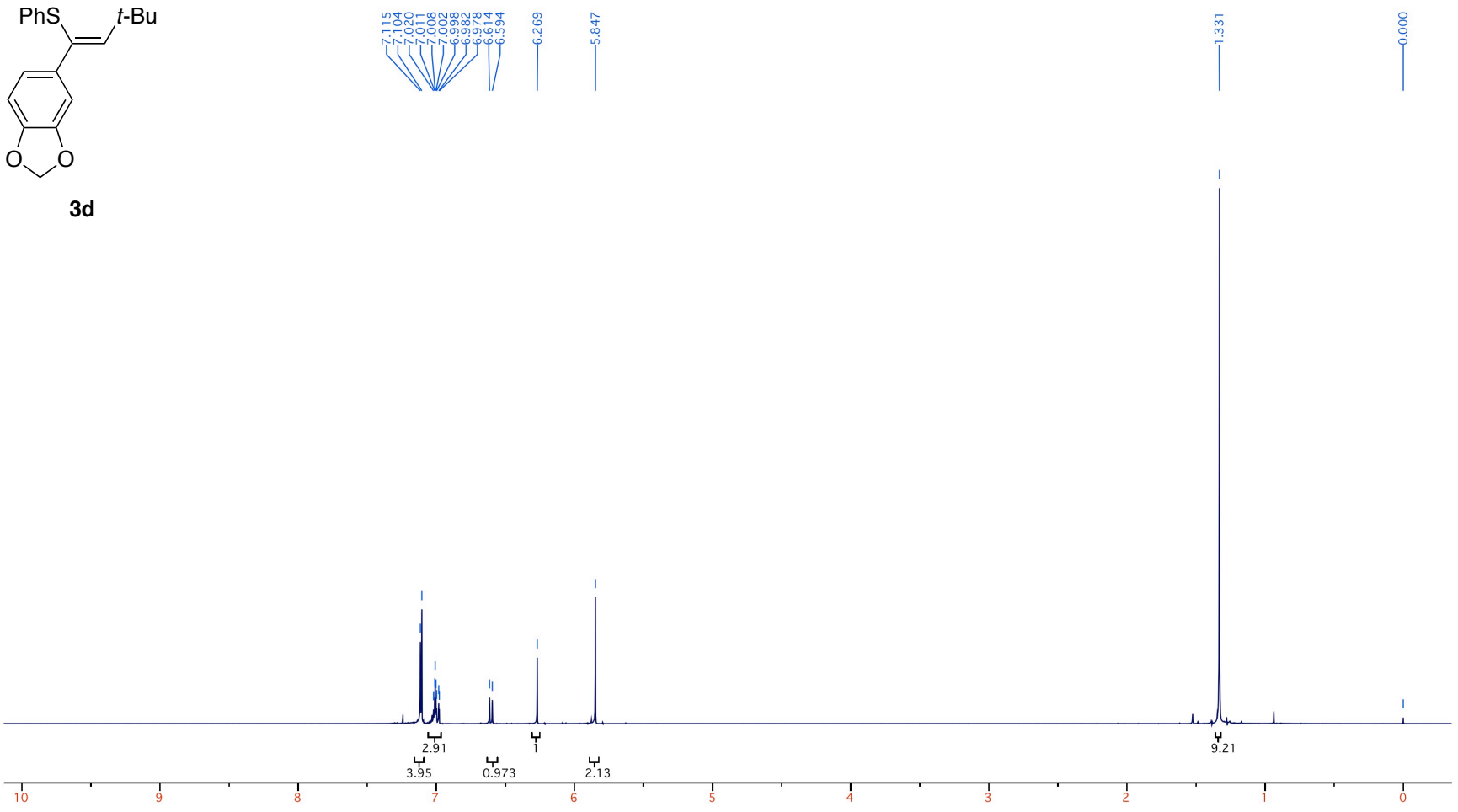
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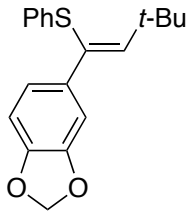
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3d

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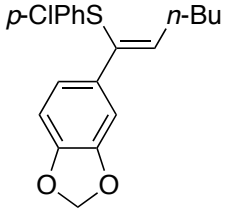
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n-Bu
O
O

3e

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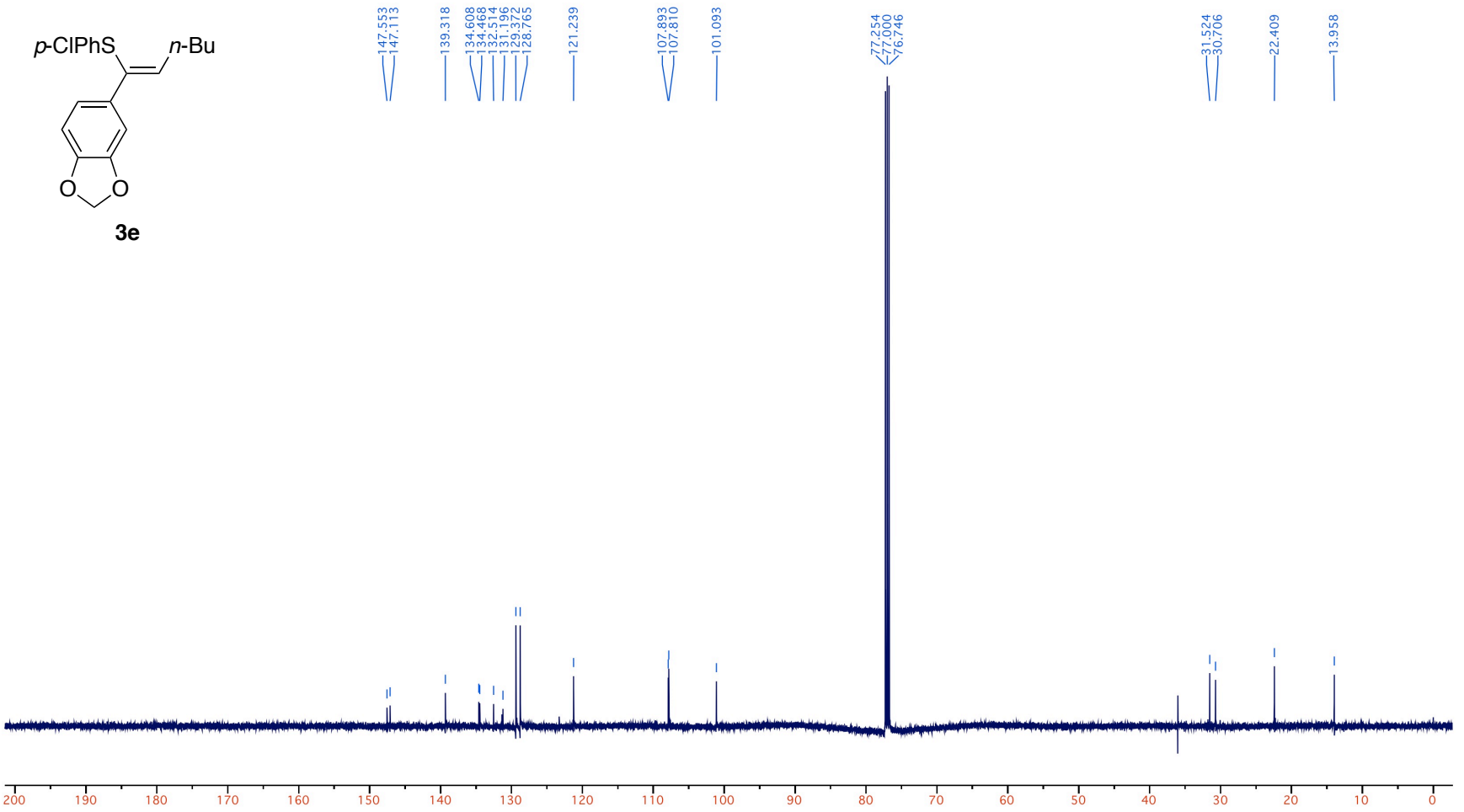
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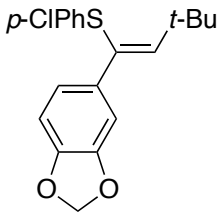
p-ClPhS
t-Bu
O
O

3f

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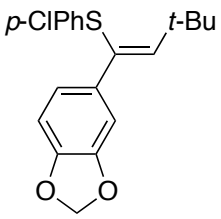
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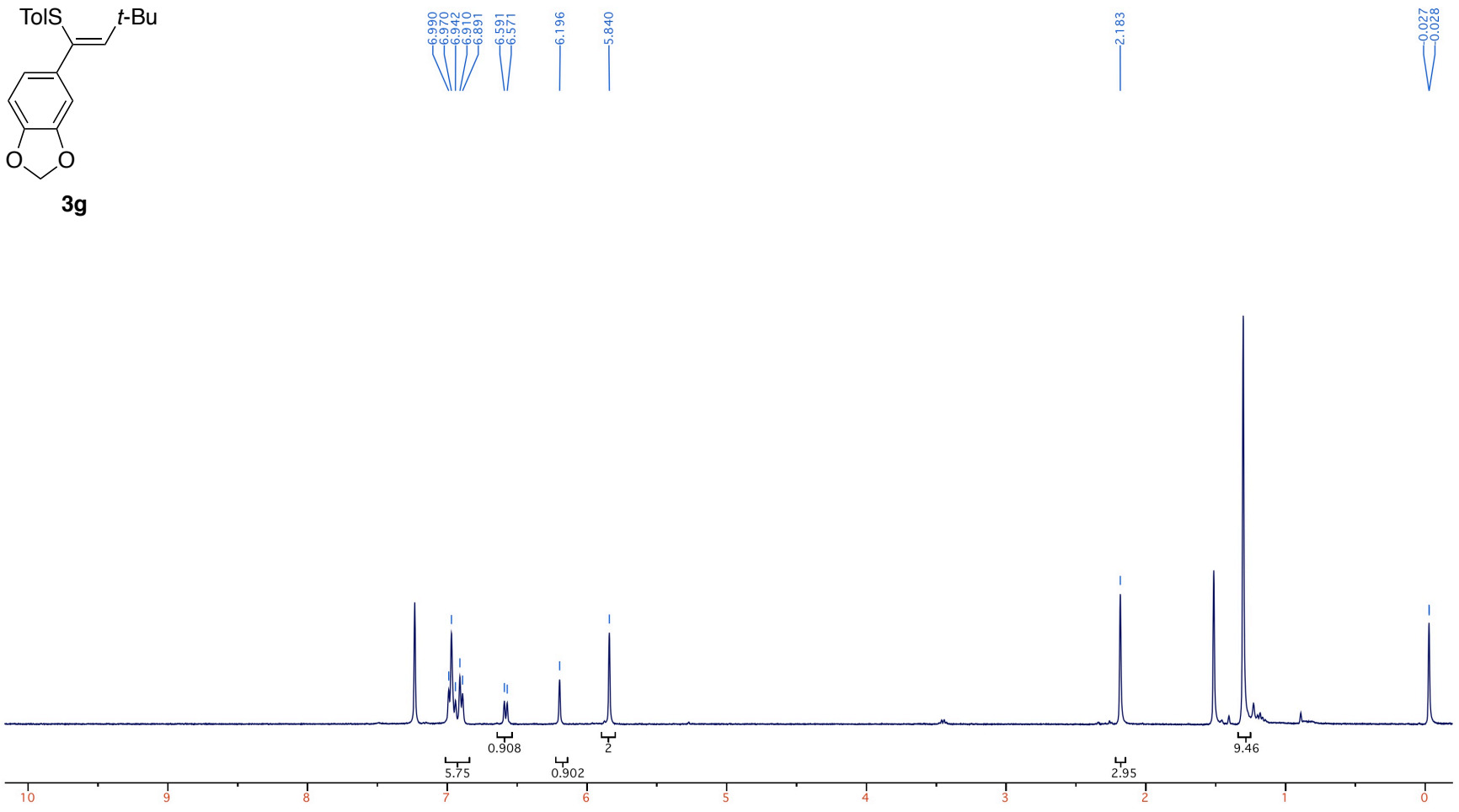
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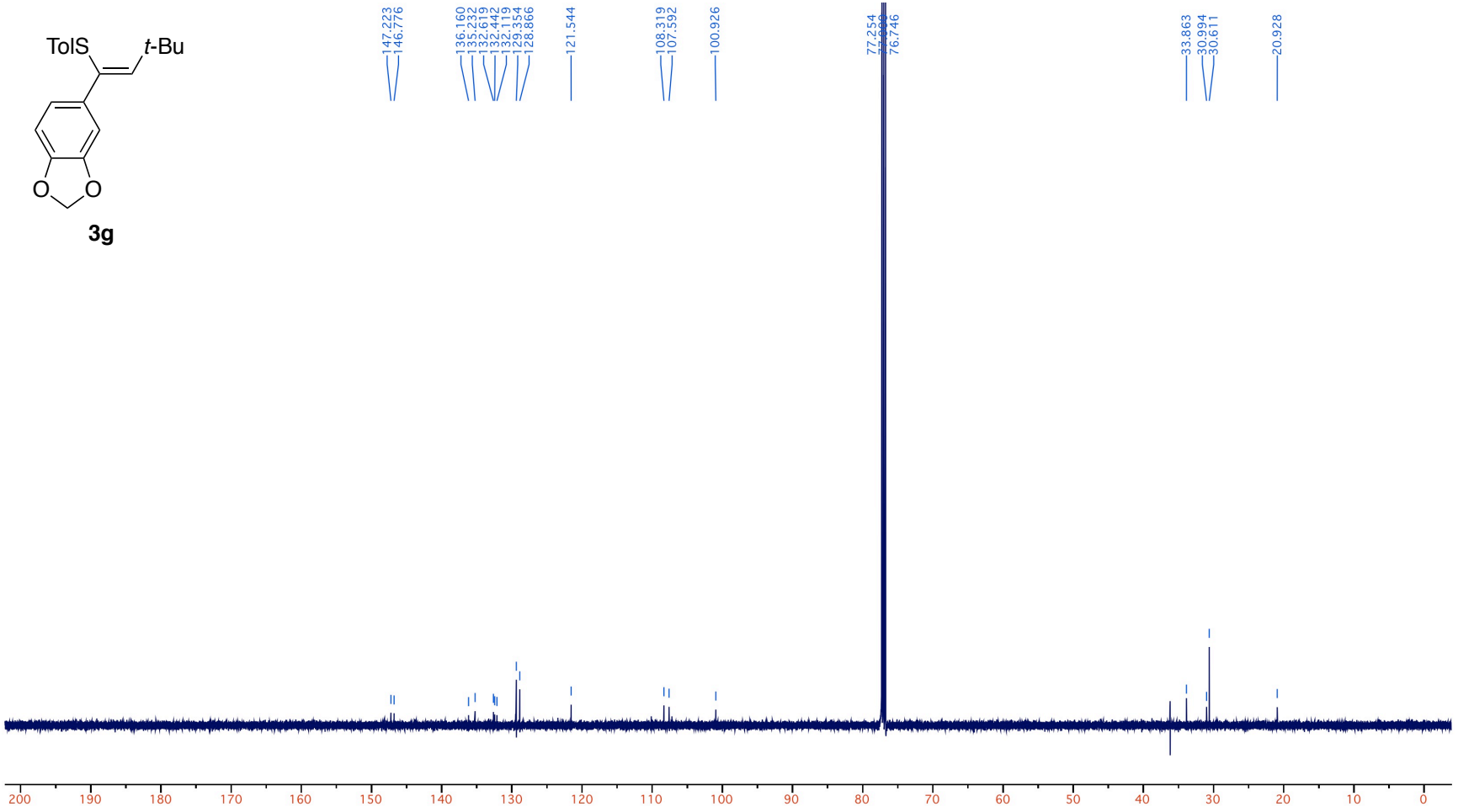
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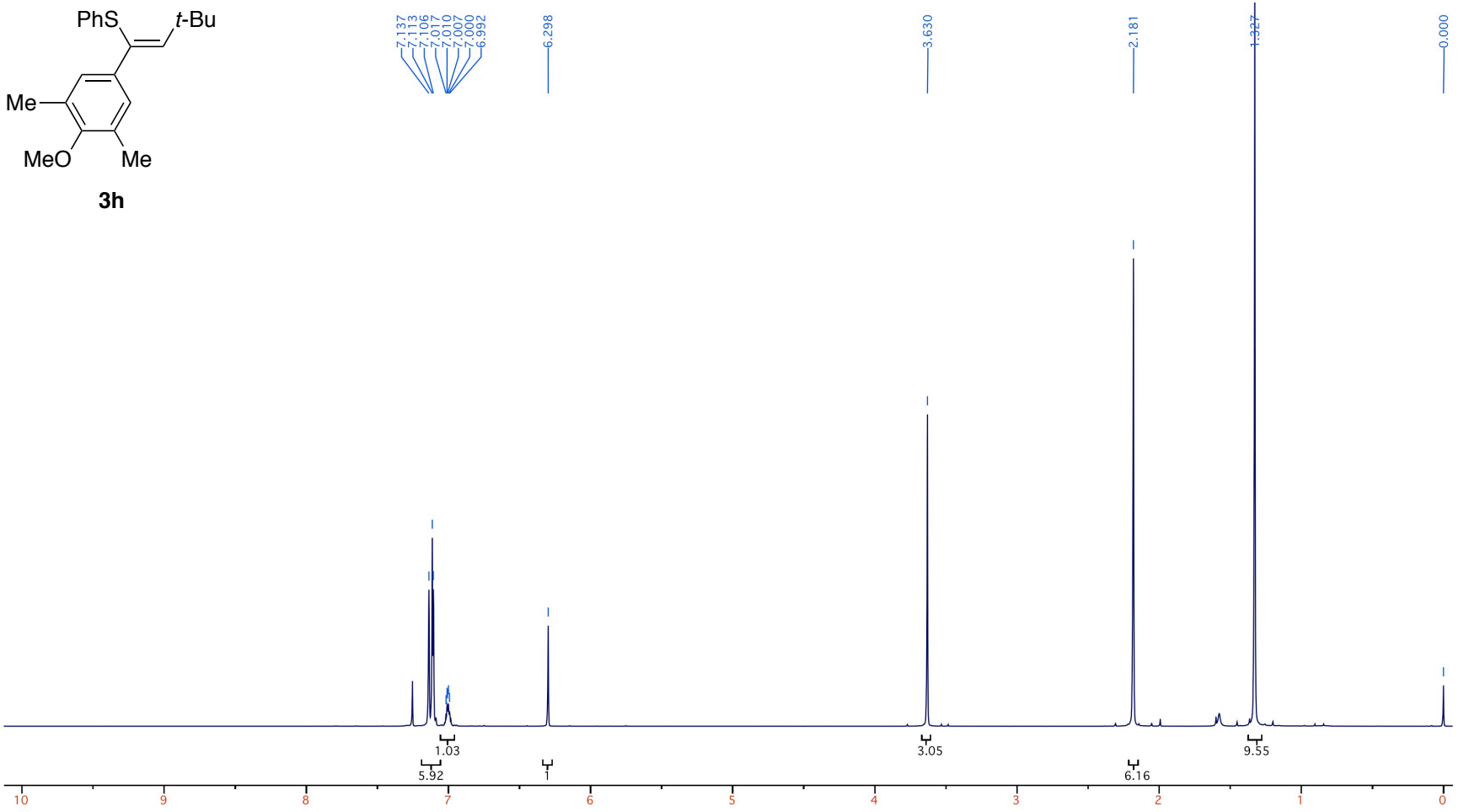
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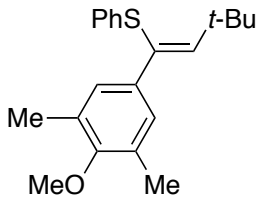
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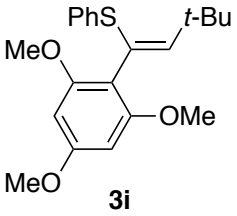
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t-Bu
MeO
OMe
MeO

3i


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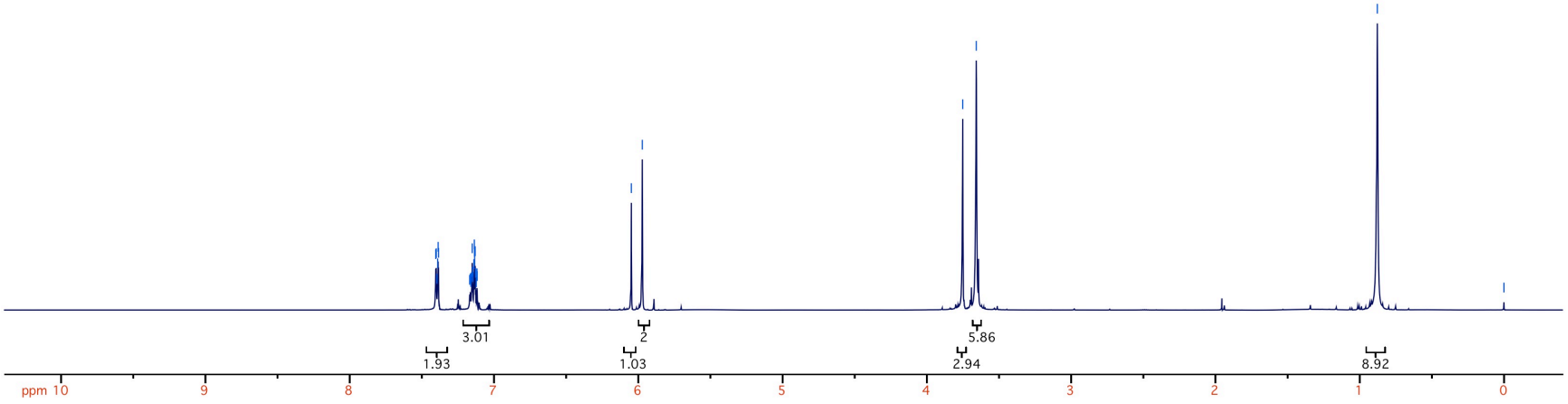
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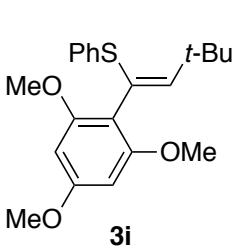
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OMe
MeO

3i

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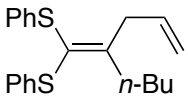
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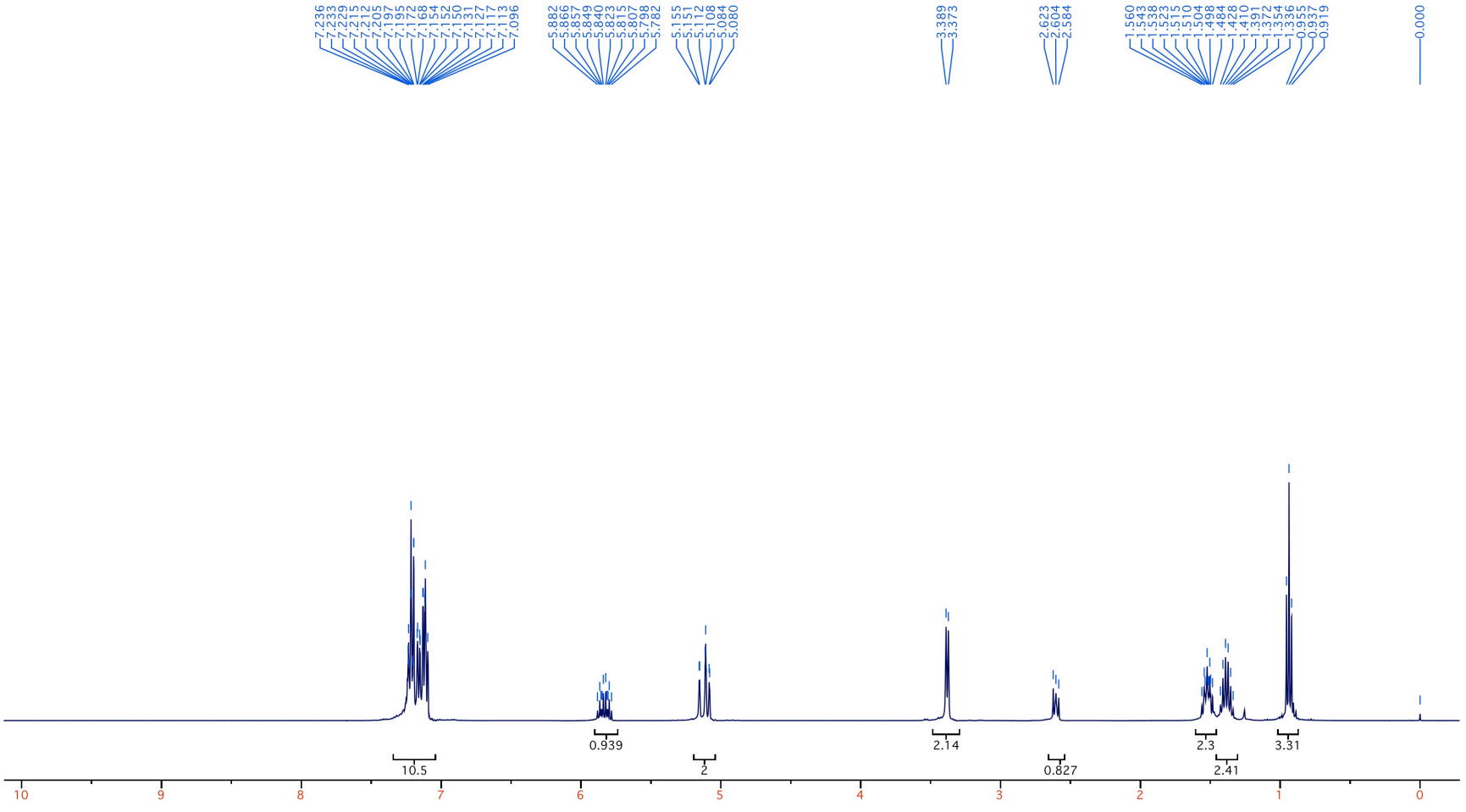
PhS
n-Bu

7a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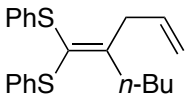
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PhS
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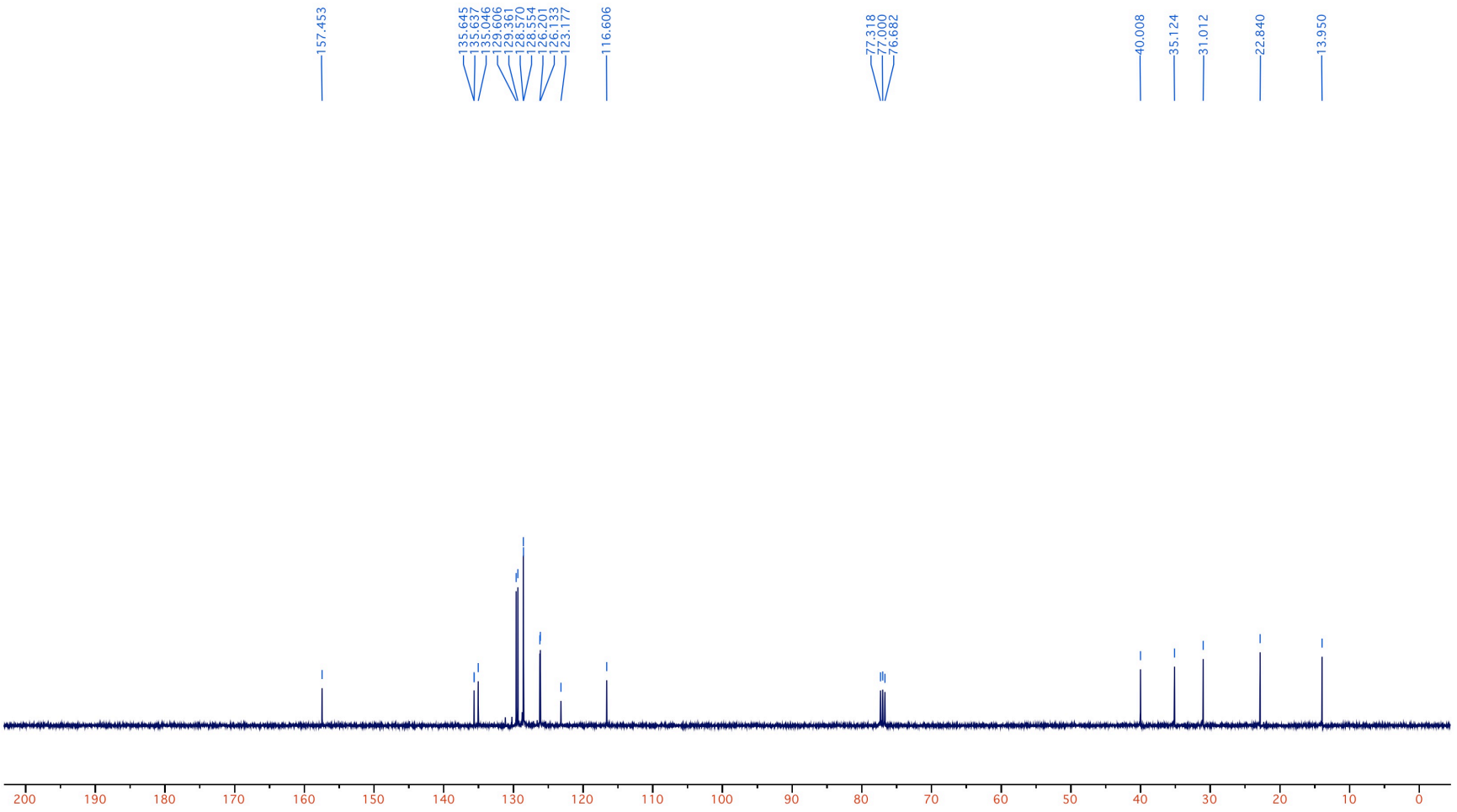
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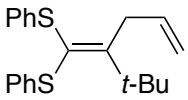
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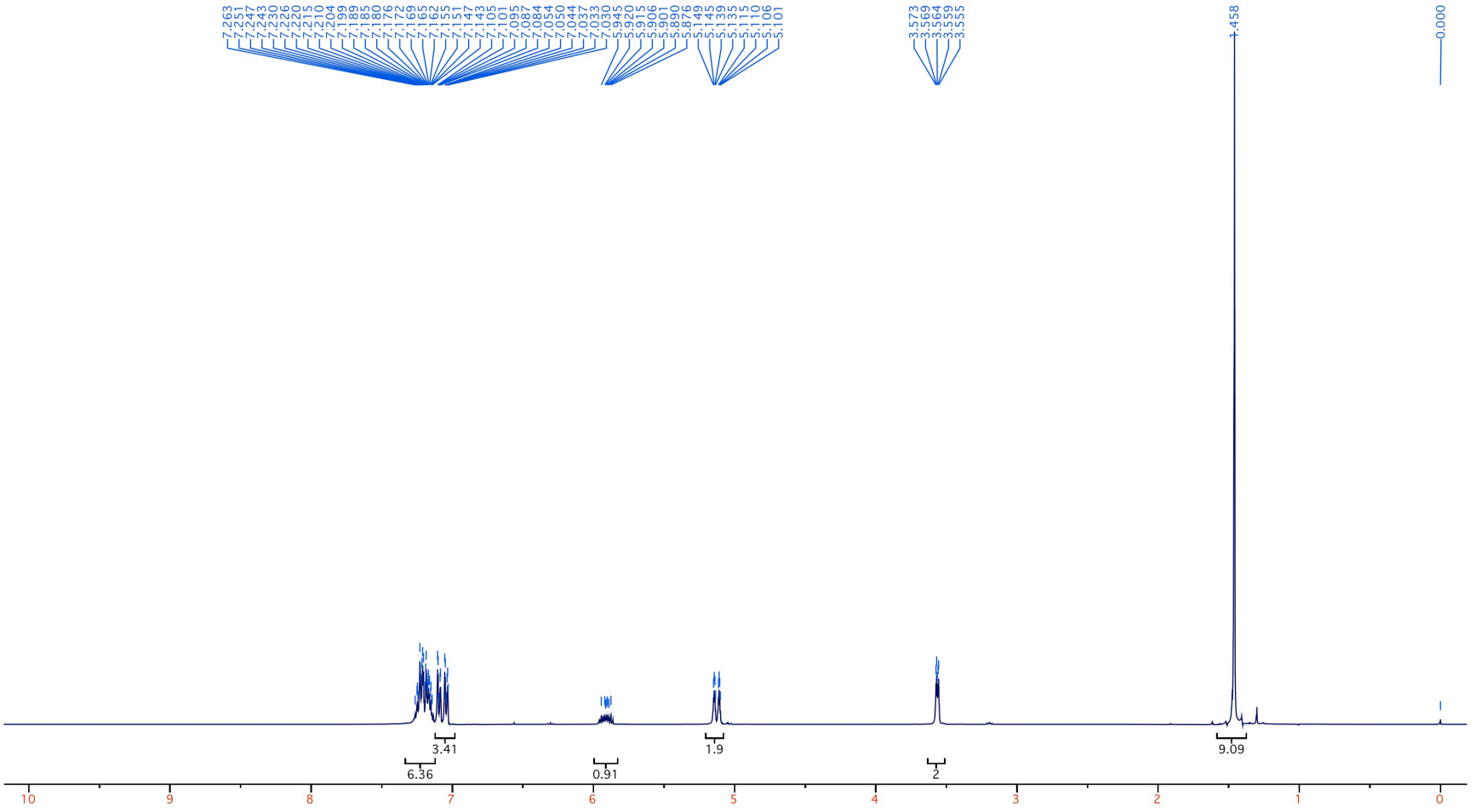
PhS
t-Bu

7b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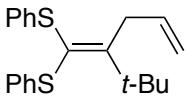
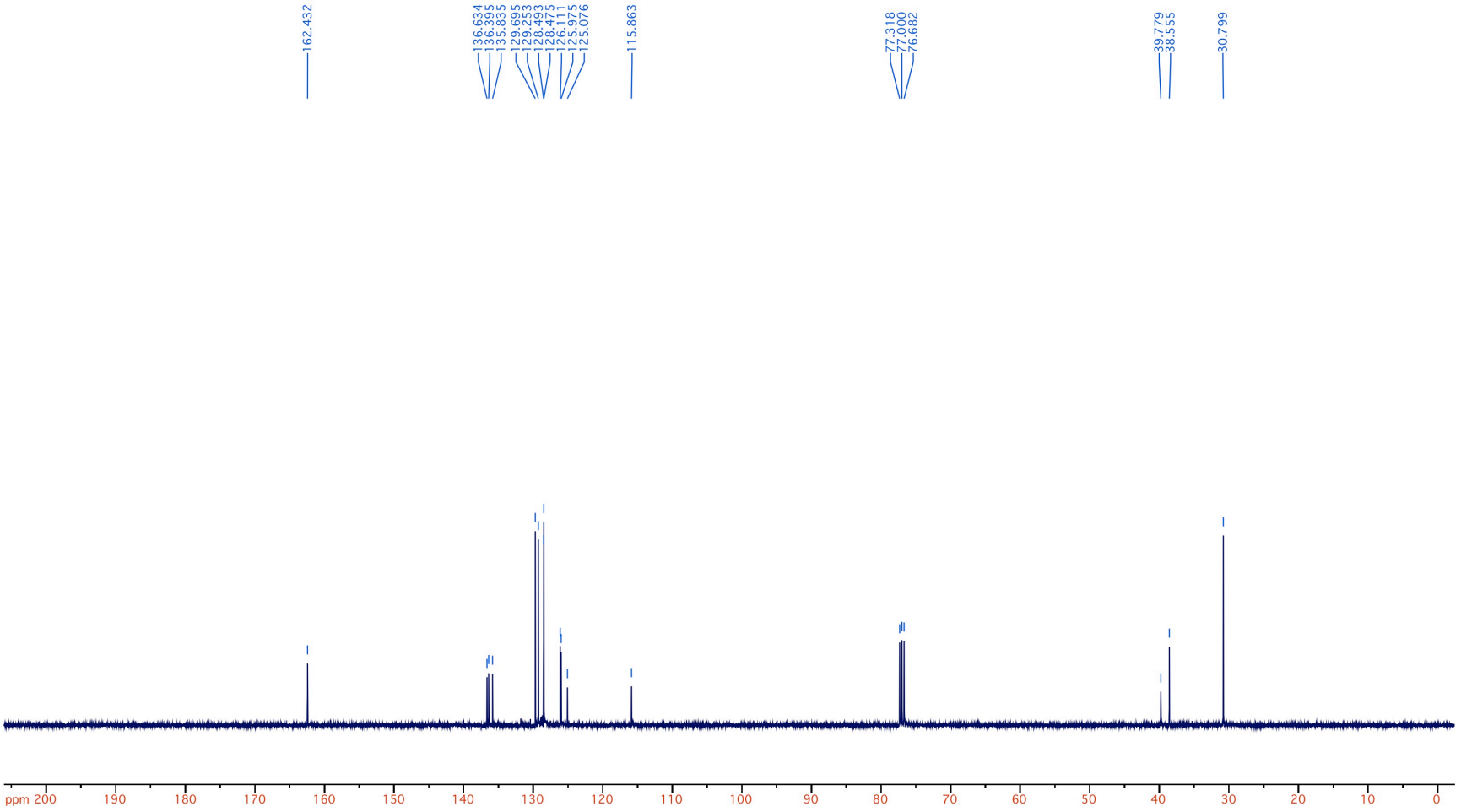

PhS
PhS
t-Bu

7b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135.635
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129.253
128.493
128.475
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125.975
125.076
115.863
77.318
77.000
76.682
39.779
38.555
30.799
ppm 200
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150
140
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110
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90
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70
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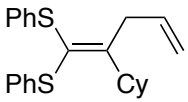
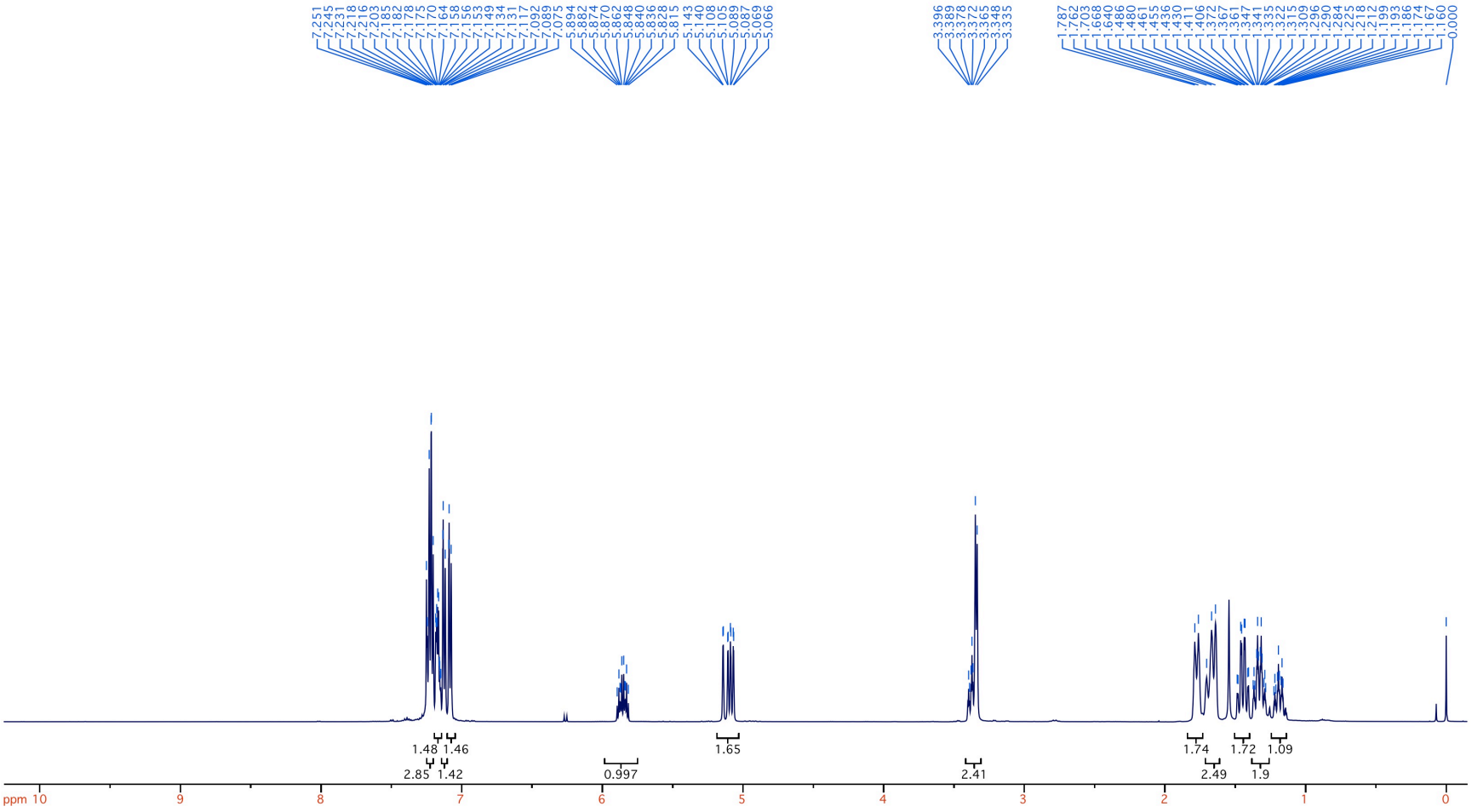
30
20
10
0


PhS
PhS
Cy

7c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7.231
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7.216
7.203
7.185
7.182
7.178
7.175
7.170
7.164
7.158
7.156
7.153
7.149
7.134
7.131
7.117
7.092
7.089
7.075
5.894
5.882
5.874
5.870
5.862
5.848
5.840
5.836
5.828
5.815
5.143
5.140
5.108
5.105
5.089
5.087
5.069
5.066
3.396
3.389
3.378
3.372
3.365
3.348
3.335
1.787
1.762
1.703
1.668
1.640
1.486
1.480
1.461
1.455
1.436
1.430
1.411
1.406
1.372
1.367
1.361
1.347
1.341
1.335
1.322
1.315
1.309
1.296
1.290
1.284
1.225
1.218
1.212
1.199
1.193
1.186
1.174
1.167
1.160
0.000
1.48
1.46
2.85
1.42
0.997
1.65
2.41
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2.49
1.72
1.9
1.09
ppm 10
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4
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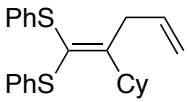
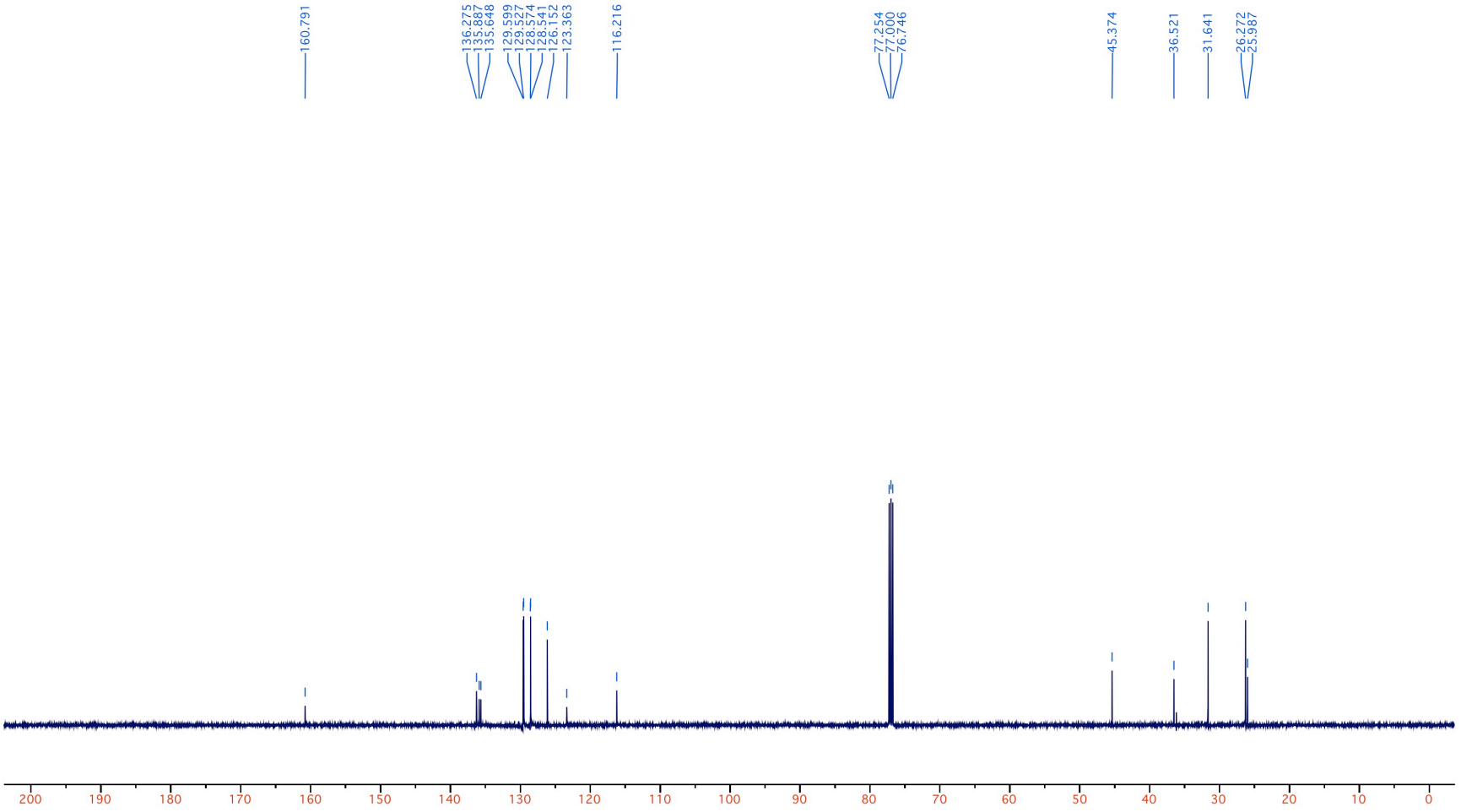

PhS
PhS
Cy

7c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129.599
129.527
128.574
128.541
126.152
123.363
116.216
77.254
77.000
76.746
45.374
36.521
31.641
26.272
25.987
200
190
180
170
160
150
140
130
120
110
100
90
80
70
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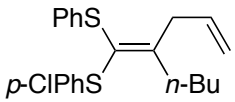
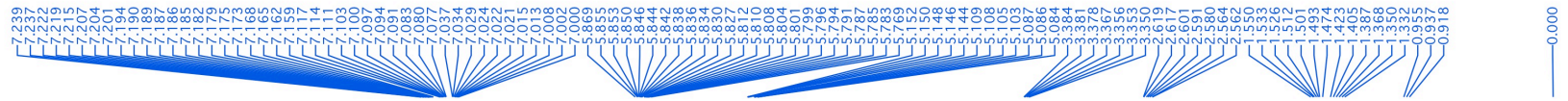
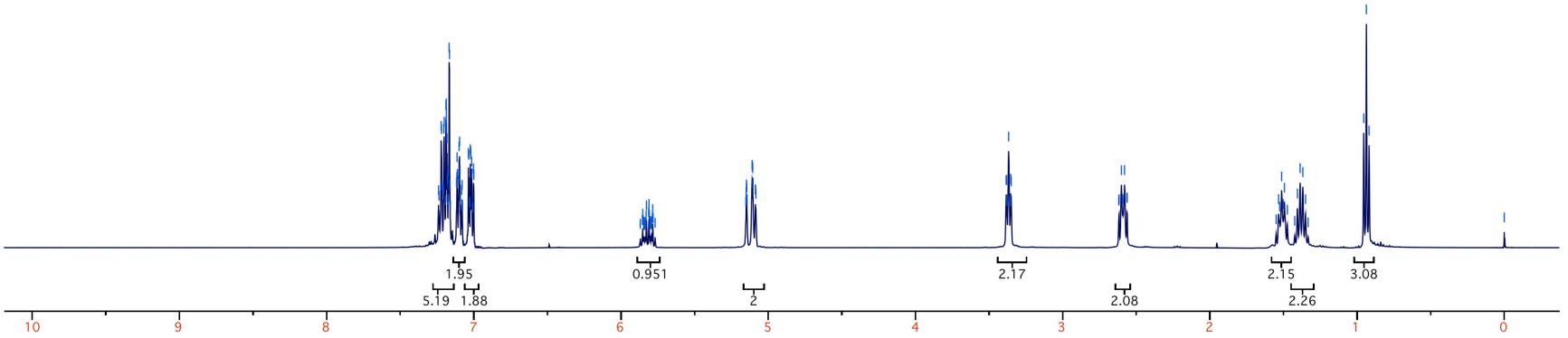
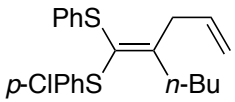

PhS
p-ClPhS
n-Bu

7d Z/E= 1:1

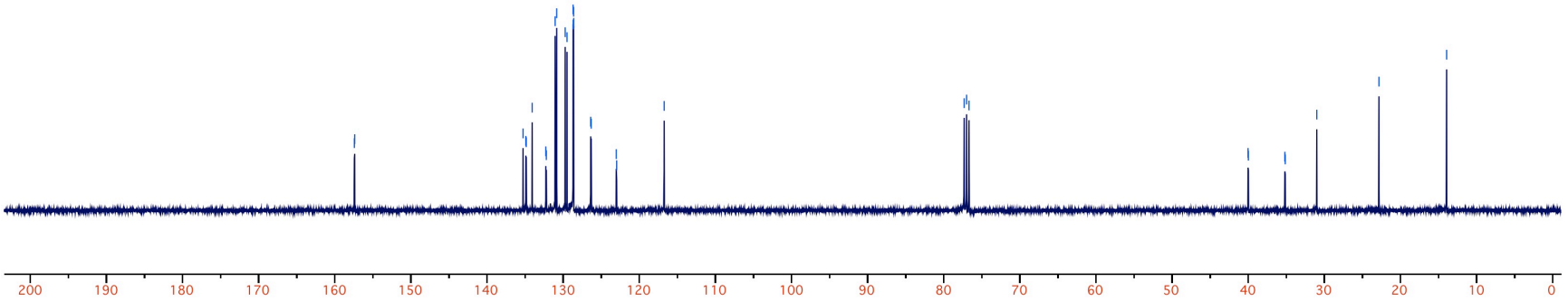



1.95
5.19
1.88
0.951
2
2.17
2.08
2.15
2.26
3.08
10
9
8
7
6
5
4
3
2
1
0


PhS
p-ClPhS
n-Bu

7d Z/E= 1:1


157.425
157.380
135.268
134.899
134.851
134.069
132.276
132.210
131.047
130.846
129.729
129.489
128.689
128.678
128.626
128.610
126.380
126.315
123.020
122.965
116.728
77.318
77.000
76.682
40.026
39.985
35.191
35.141
30.994
22.829
13.938


200
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180
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160
150
140
130
120
110
100
90
80
70
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50
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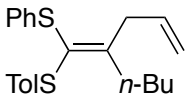
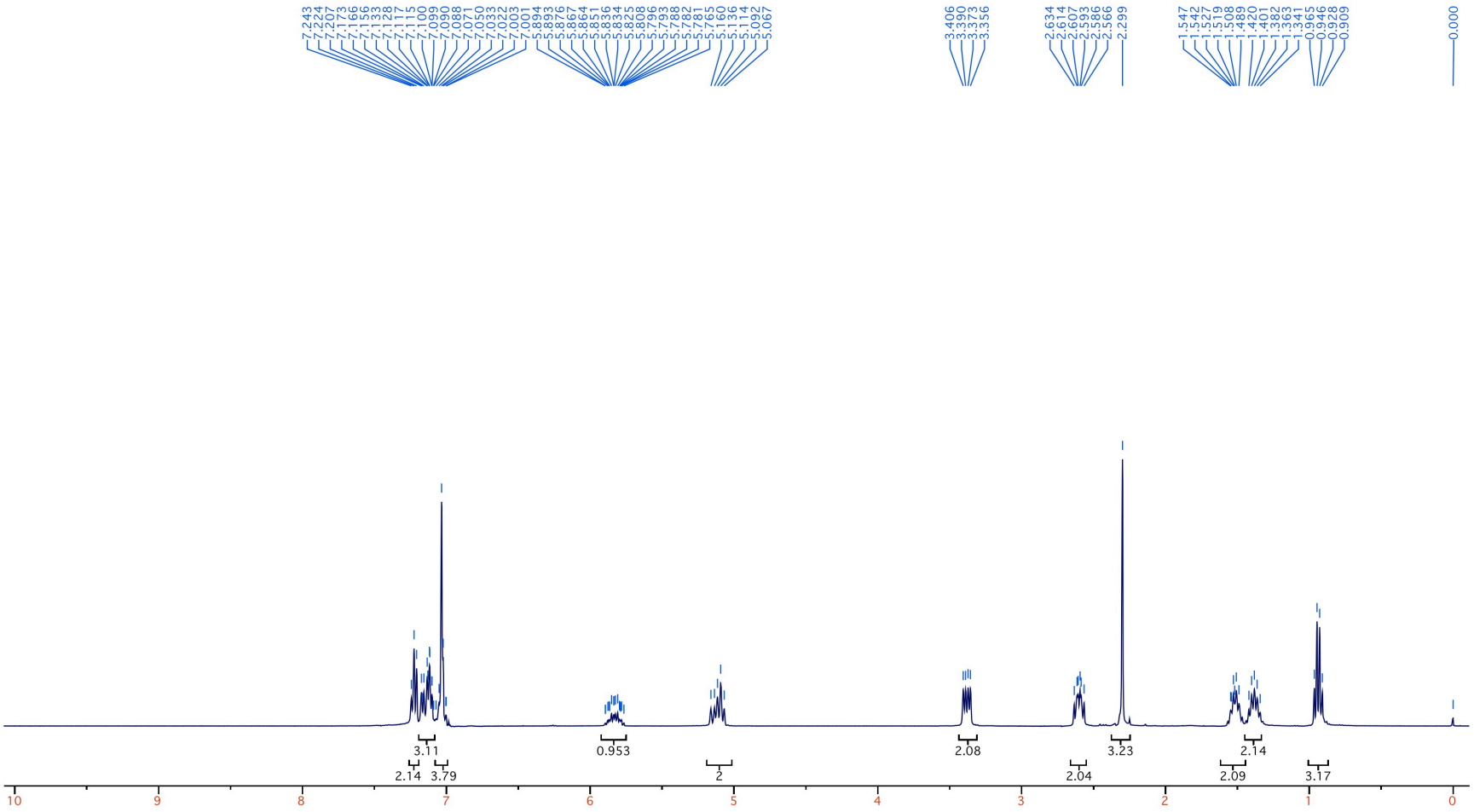
30
20
10
0


PhS
TolS
n-Bu

7e Z/E= 1:1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7.156
7.133
7.128
7.117
7.115
7.100
7.093
7.090
7.088
7.071
7.050
7.033
7.022
7.003
7.001
5.894
5.893
5.876
5.867
5.864
5.851
5.836
5.834
5.825
5.808
5.796
5.793
5.788
5.782
5.781
5.765
5.160
5.136
5.114
5.092
5.067
3.406
3.390
3.373
3.356
2.634
2.614
2.607
2.593
2.586
2.566
2.299
1.547
1.542
1.527
1.519
1.508
1.489
1.420
1.401
1.382
1.363
1.341
0.965
0.946
0.928
0.909
0.000
3.11
2.14
3.79
0.953
2
2.08
2.04
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2.14
2.09
3.17
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8
7
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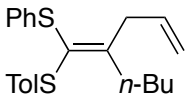
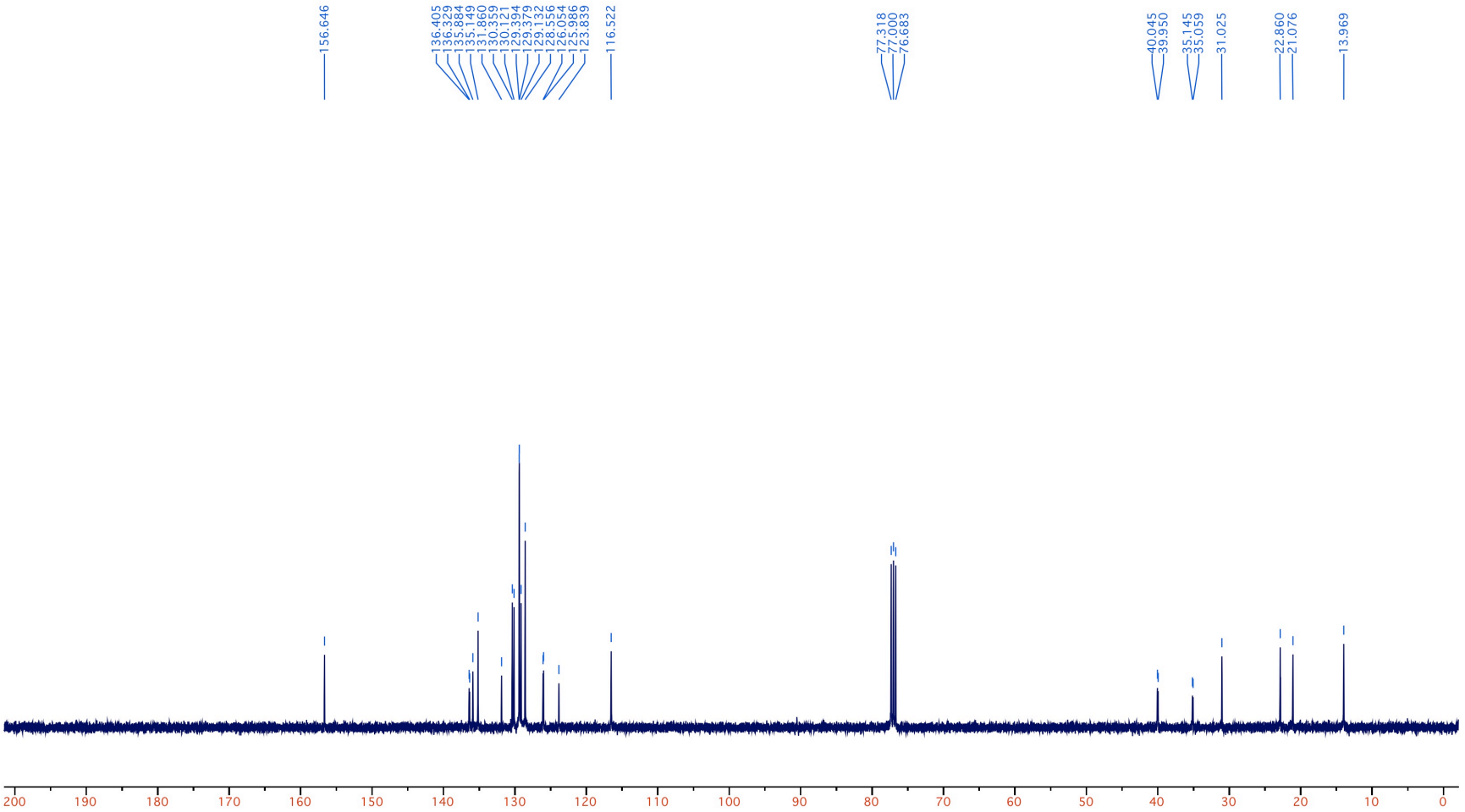
4
3
2
1
0


PhS
TolS
n-Bu

7e Z/E= 1:1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131.860
130.359
130.121
129.394
129.379
129.132
128.556
126.054
125.986
123.839
116.522
77.318
77.000
76.683
40.045
39.950
35.145
35.059
31.025
22.860
21.076
13.969
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150
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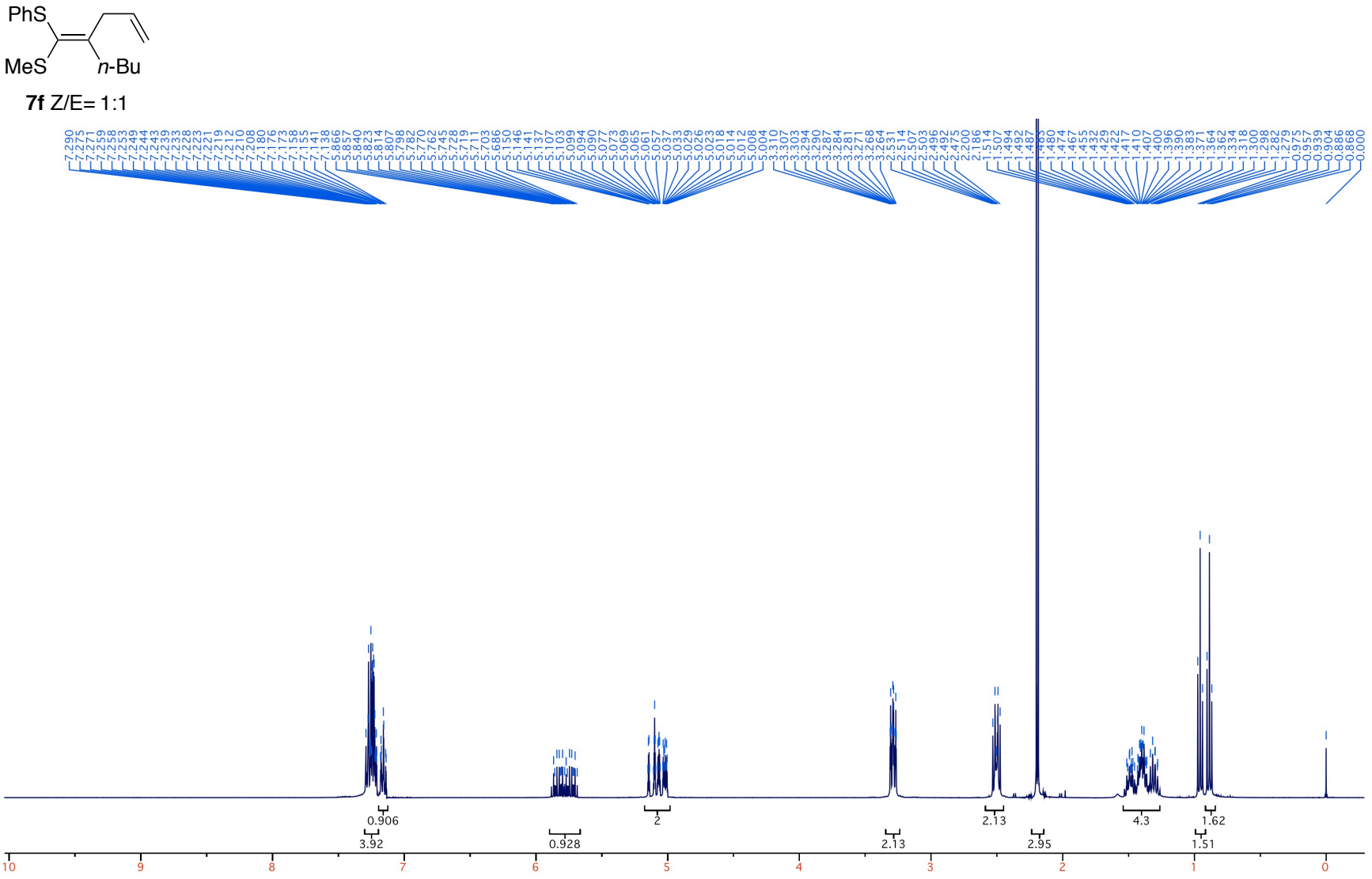
10
0


PhS
MeS
n-Bu
7f Z/E= 1:1
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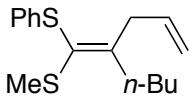
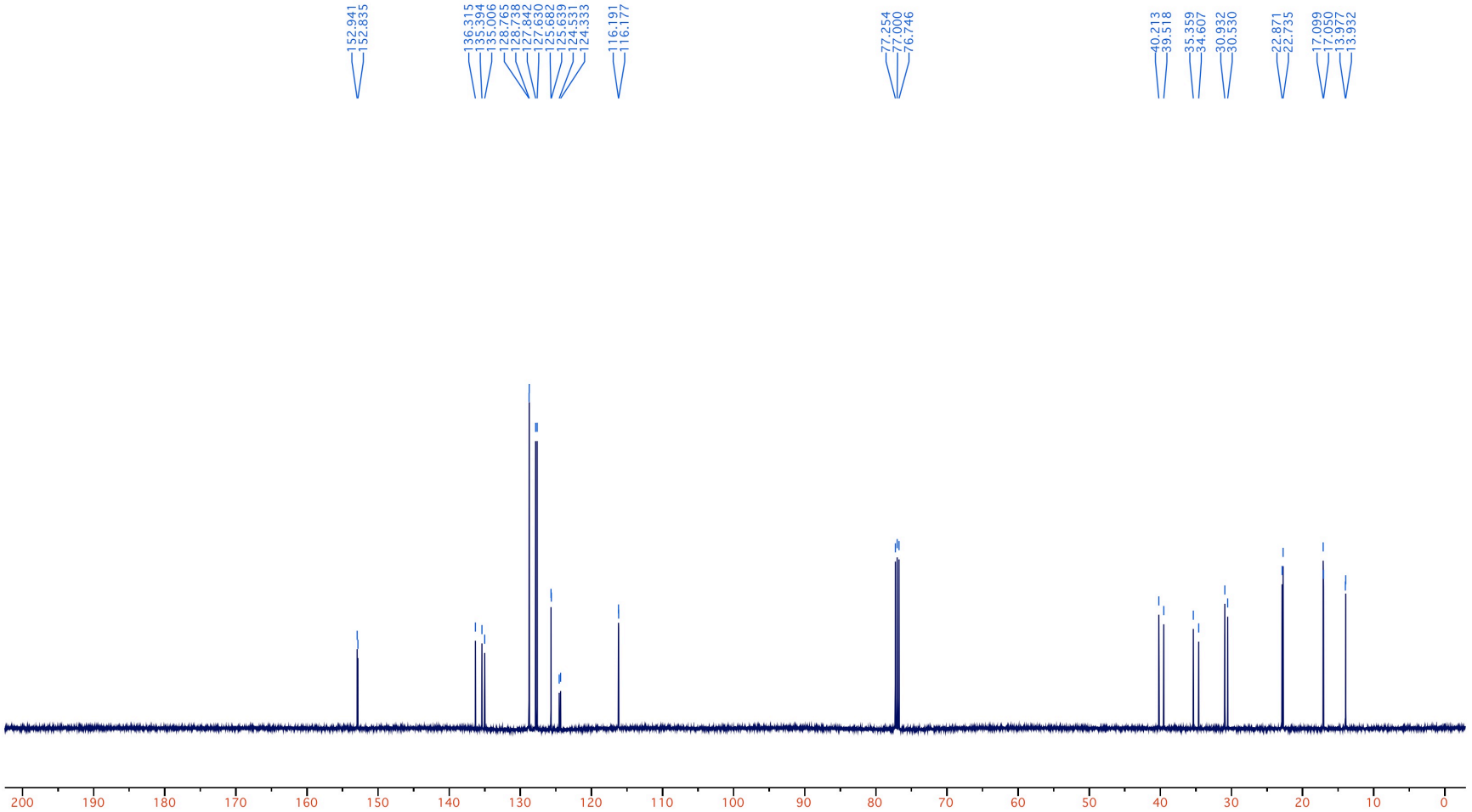
3.92
0.928
2
2.13
2.13
2.95
4.3
1.62
1.51


PhS
MeS
n-Bu

7f Z/E= 1:1


152.941
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136.315
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128.765
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127.842
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125.682
125.639
124.531
124.333
116.191
116.177
77.254
77.000
76.746
40.213
39.518
35.359
34.607
30.932
30.530
22.871
22.735
17.099
17.050
13.977
13.932
200
190
180
170
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150
140
130
120
110
100
90
80
70
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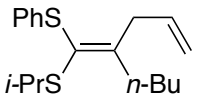
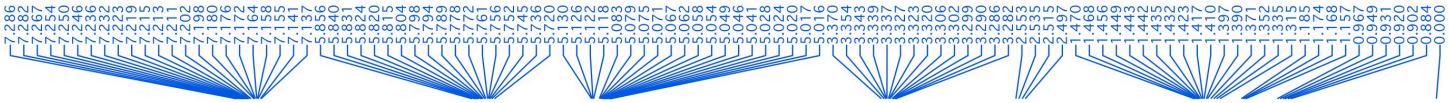
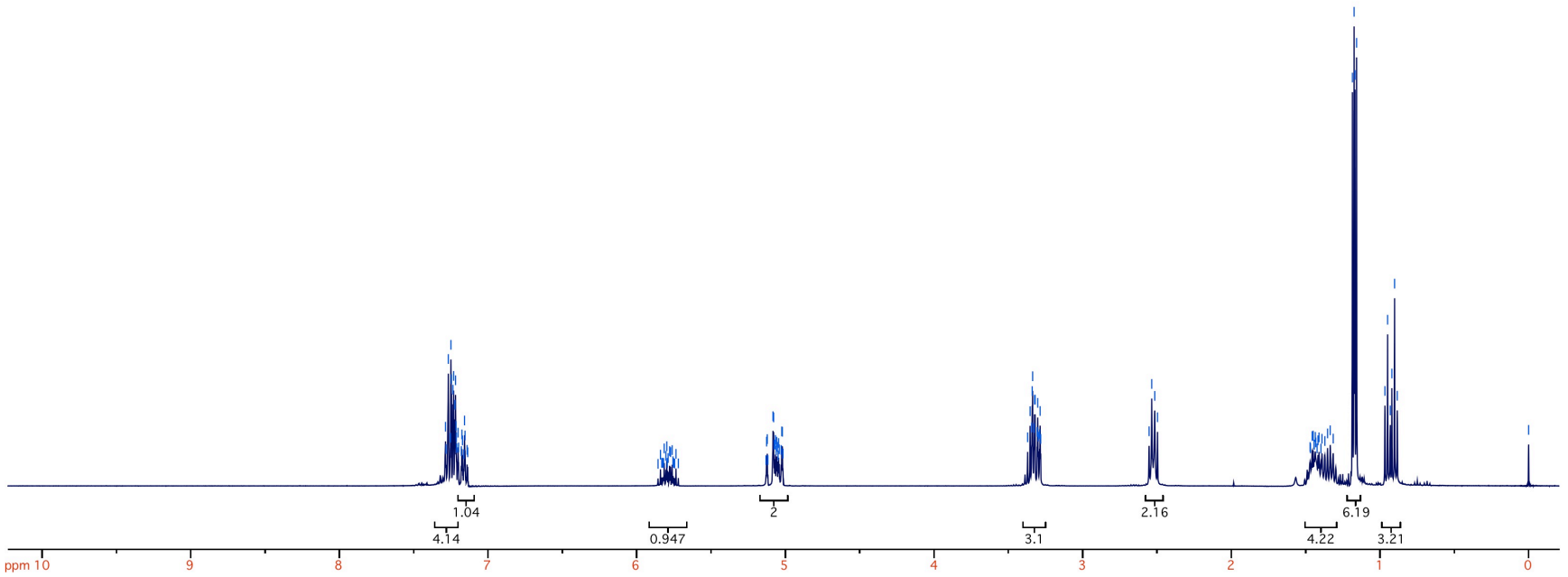
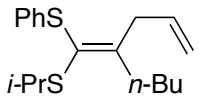
40
30
20
10
0


PhS
i-PrS
n-Bu

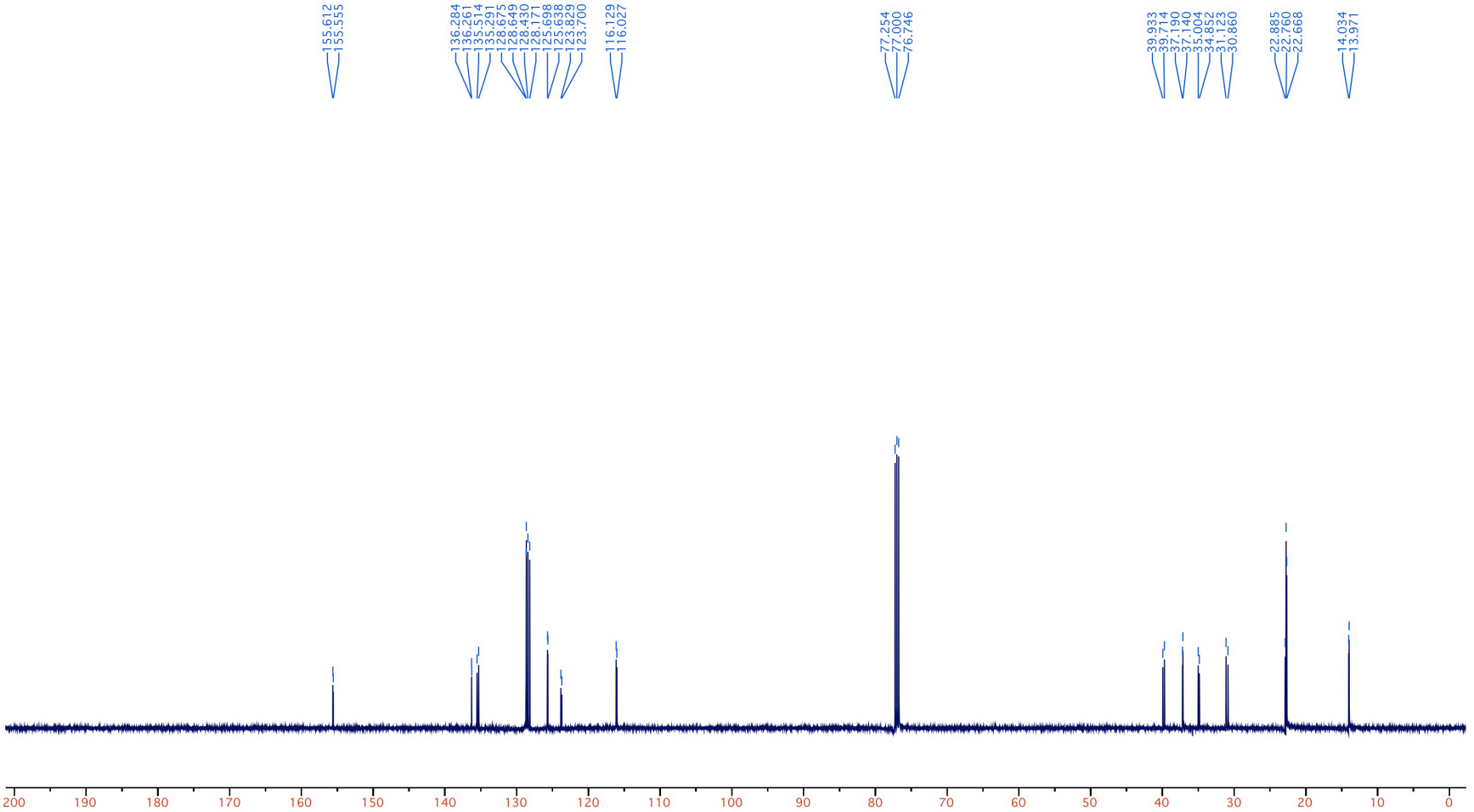
7g Z/E= 1:1




1.04
2
2.16
6.19
4.14
0.947
3.1
4.22
3.21
ppm 10
9
8
7
6
5
4
3
2
1
0


PhS
i-PrS
n-Bu

7g Z/E= 1:1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136.261
135.514
135.291
128.675
128.649
128.430
128.171
125.698
125.638
123.829
123.700
116.129
116.027
77.254
77.000
76.746
39.933
39.714
37.190
37.140
35.004
34.852
31.123
30.860
22.885
22.760
22.668
14.034
13.971
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150
140
130
120
110
100
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70
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30
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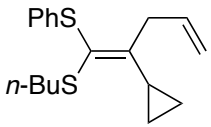
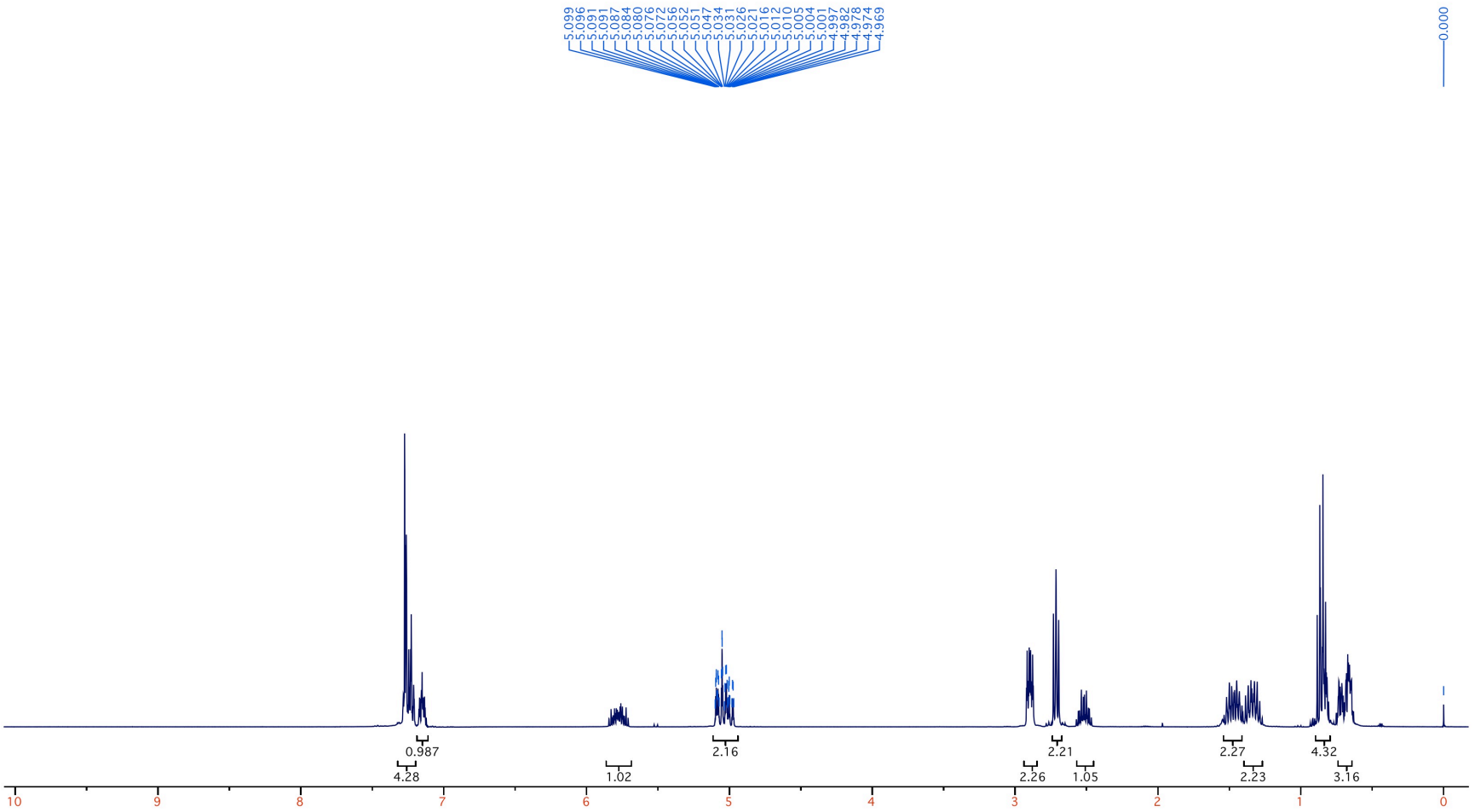

PhS
n-BuS

7h Z/E= 1:1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5.091
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5.084
5.080
5.076
5.072
5.056
5.052
5.051
5.047
5.034
5.031
5.026
5.021
5.016
5.012
5.010
5.005
5.004
5.001
4.997
4.982
4.978
4.974
4.969
0.000
0.987
4.28
1.02
2.16
2.21
2.26
1.05
2.27
2.23
4.32
3.16
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8
7
6
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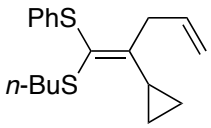
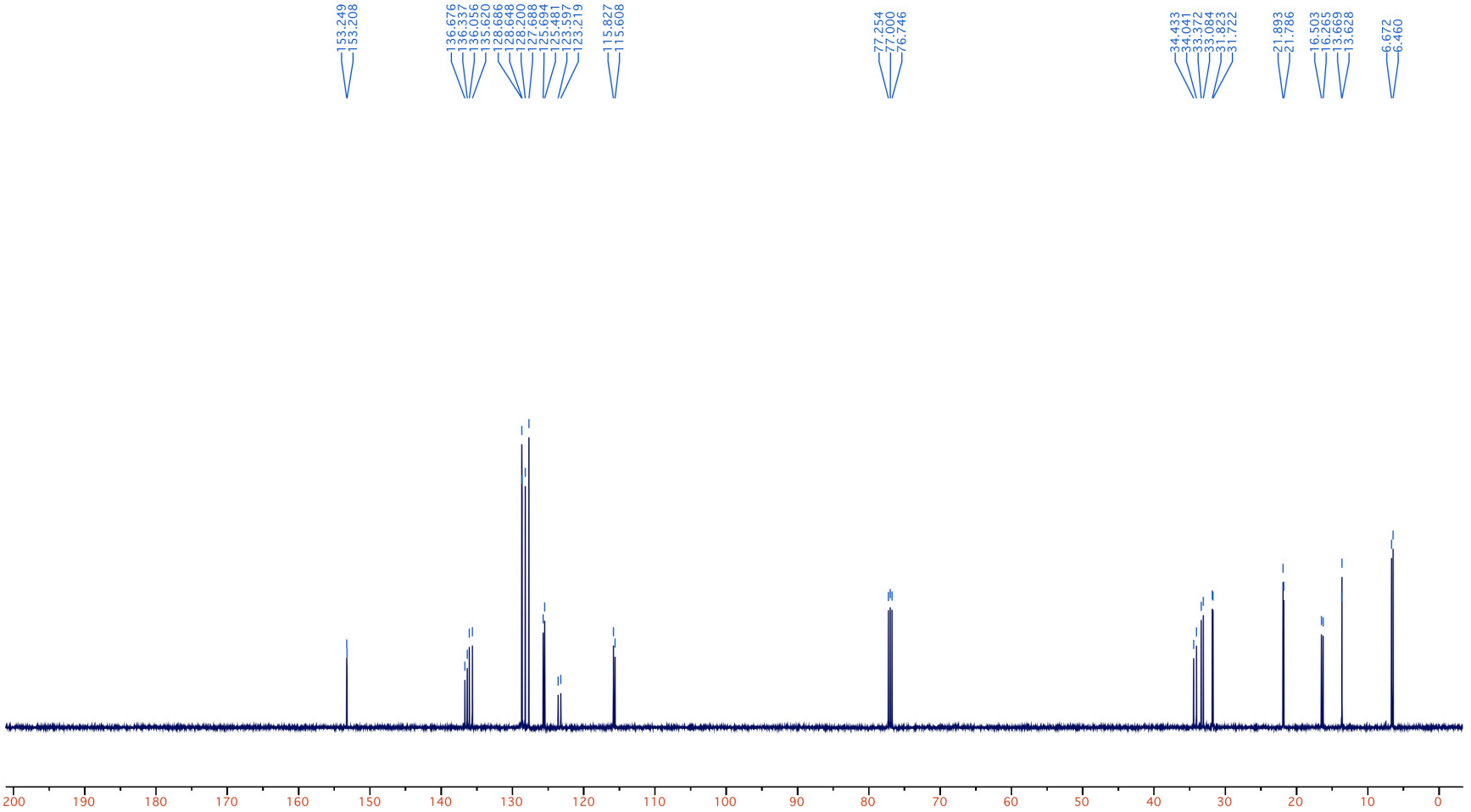
4
3
2
1
0


PhS
n-BuS

7h Z/E= 1:1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153.208
136.676
136.337
136.056
135.620
128.686
128.648
128.200
127.688
125.694
125.481
123.597
123.219
115.827
115.608
77.254
77.000
76.746
34.433
34.041
33.372
33.084
31.823
31.722
21.993
21.786
16.503
16.265
13.669
13.628
6.672
6.460
200
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150
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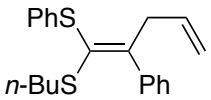
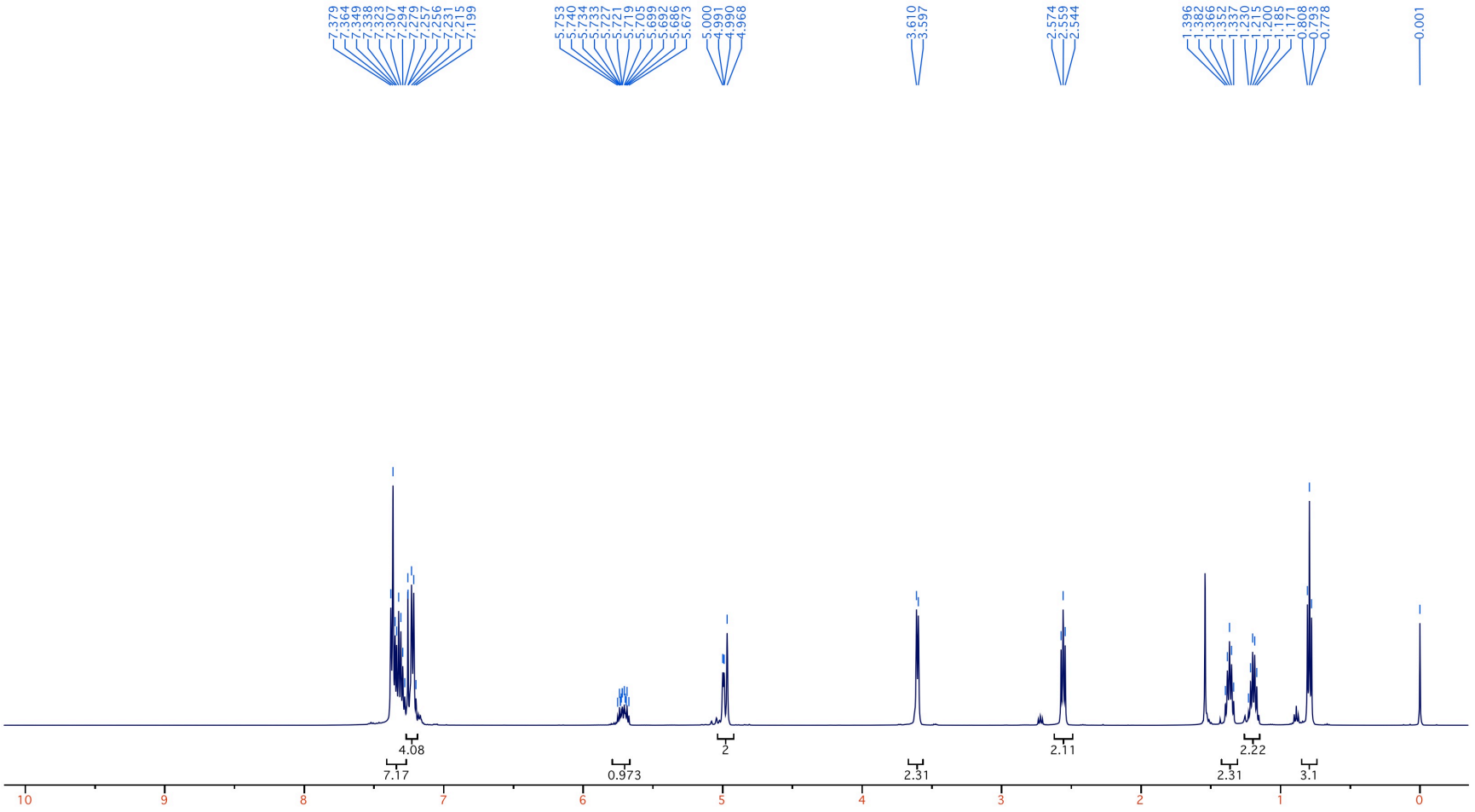

PhS
n-BuS
Ph

7i, Z/E= 2:1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7.256
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7.199
5.753
5.740
5.734
5.733
5.727
5.721
5.719
5.705
5.699
5.692
5.686
5.673
5.000
4.991
4.990
4.968
3.610
3.597
2.574
2.559
2.544
1.396
1.382
1.366
1.352
1.337
1.310
1.215
1.200
1.185
1.171
0.808
0.793
0.778
0.001
4.08
7.17
0.973
2
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2.31
2.22
3.1
10
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7
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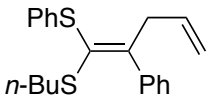
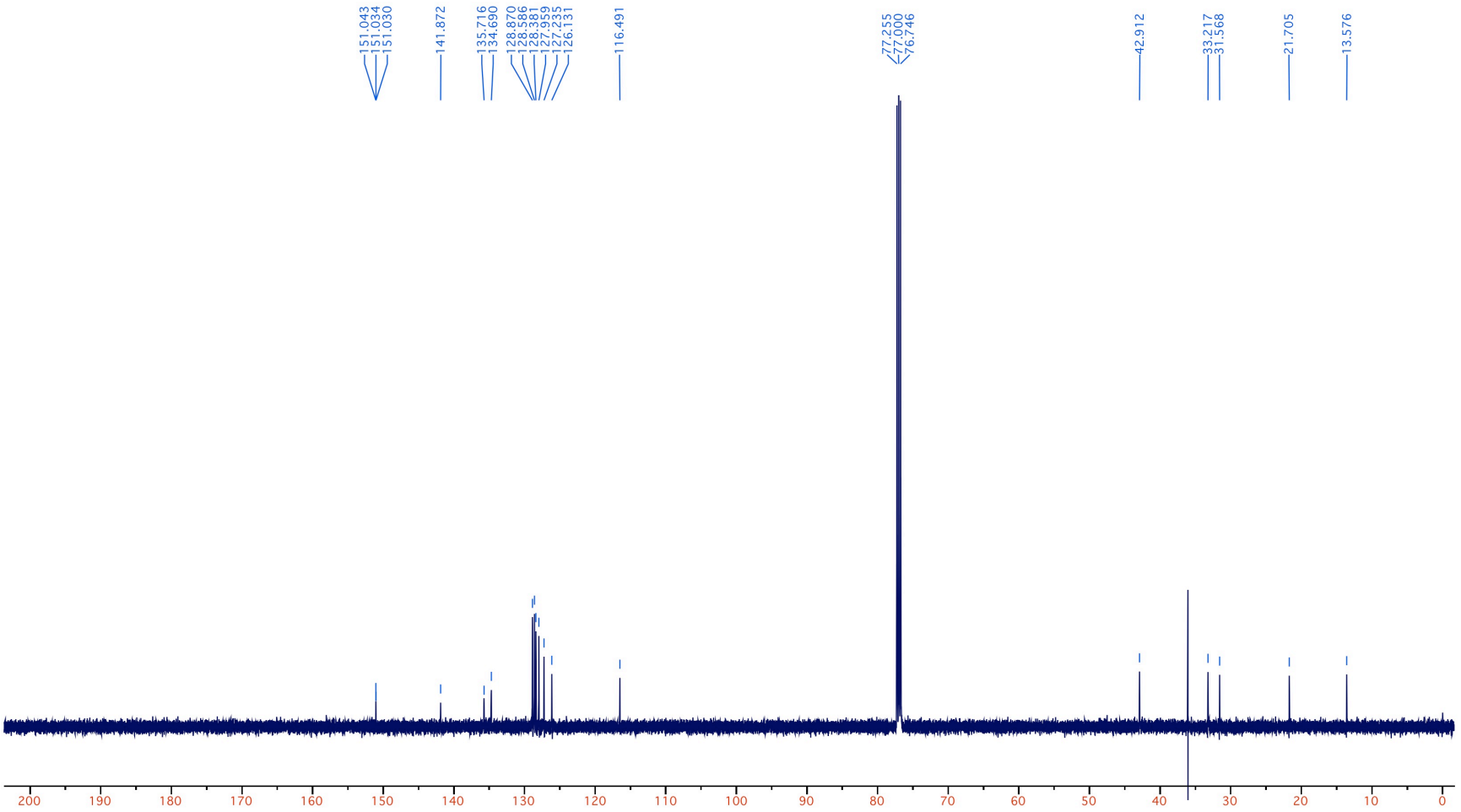
2
1
0


PhS
n-BuS
Ph

7i, Z/E= 2:1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127.959
127.235
126.131
116.491
77.255
77.000
76.746
42.912
33.217
31.568
21.705
13.576
200
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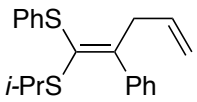
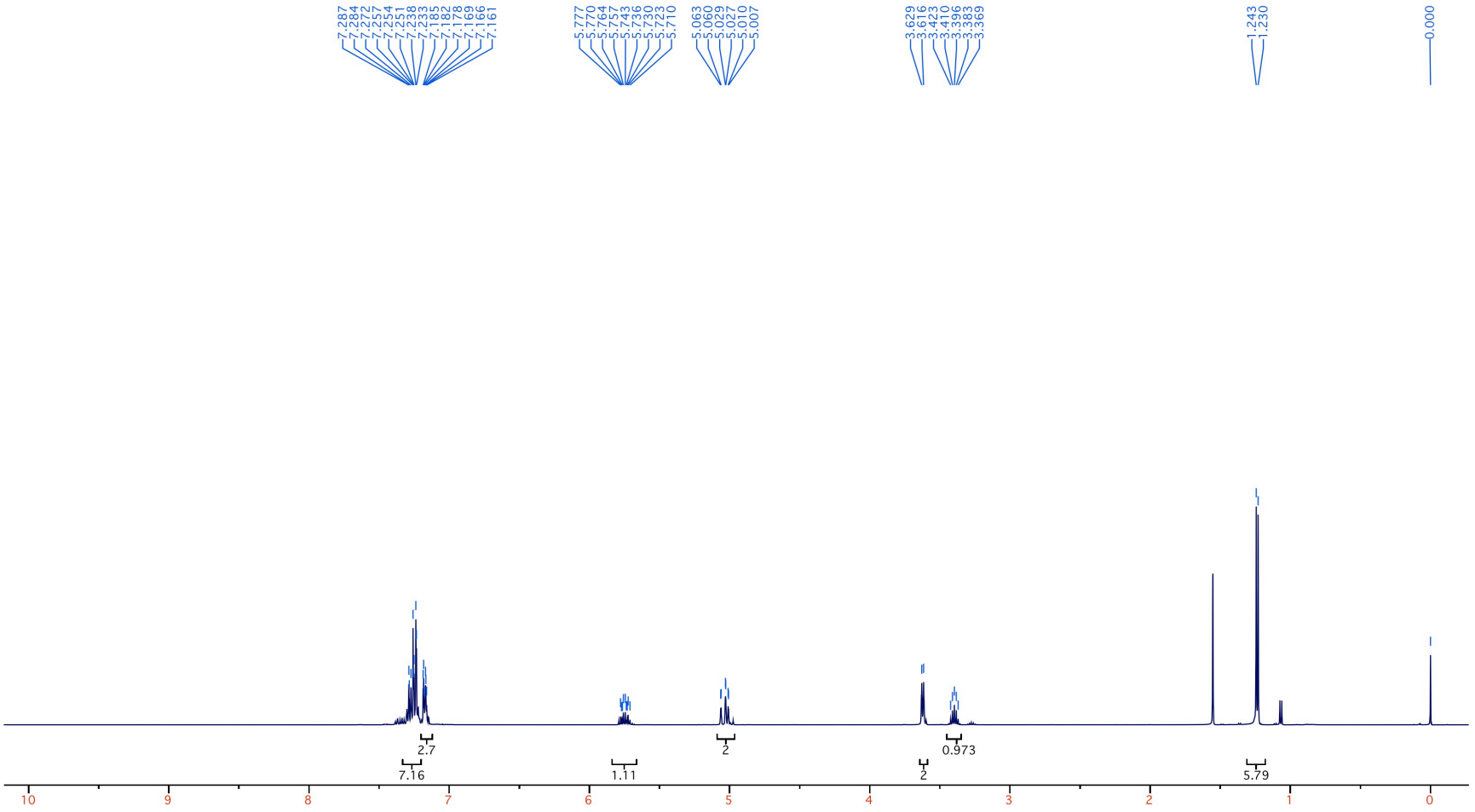

PhS
i-PrS
Ph

7j, E isomer


7.287
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7.251
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7.178
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7.166
7.161
5.777
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5.764
5.757
5.743
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5.723
5.710
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5.060
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5.027
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5.007
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3.423
3.410
3.396
3.383
3.369
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1.230
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5.79
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5
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3
2
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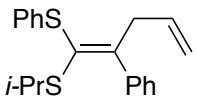
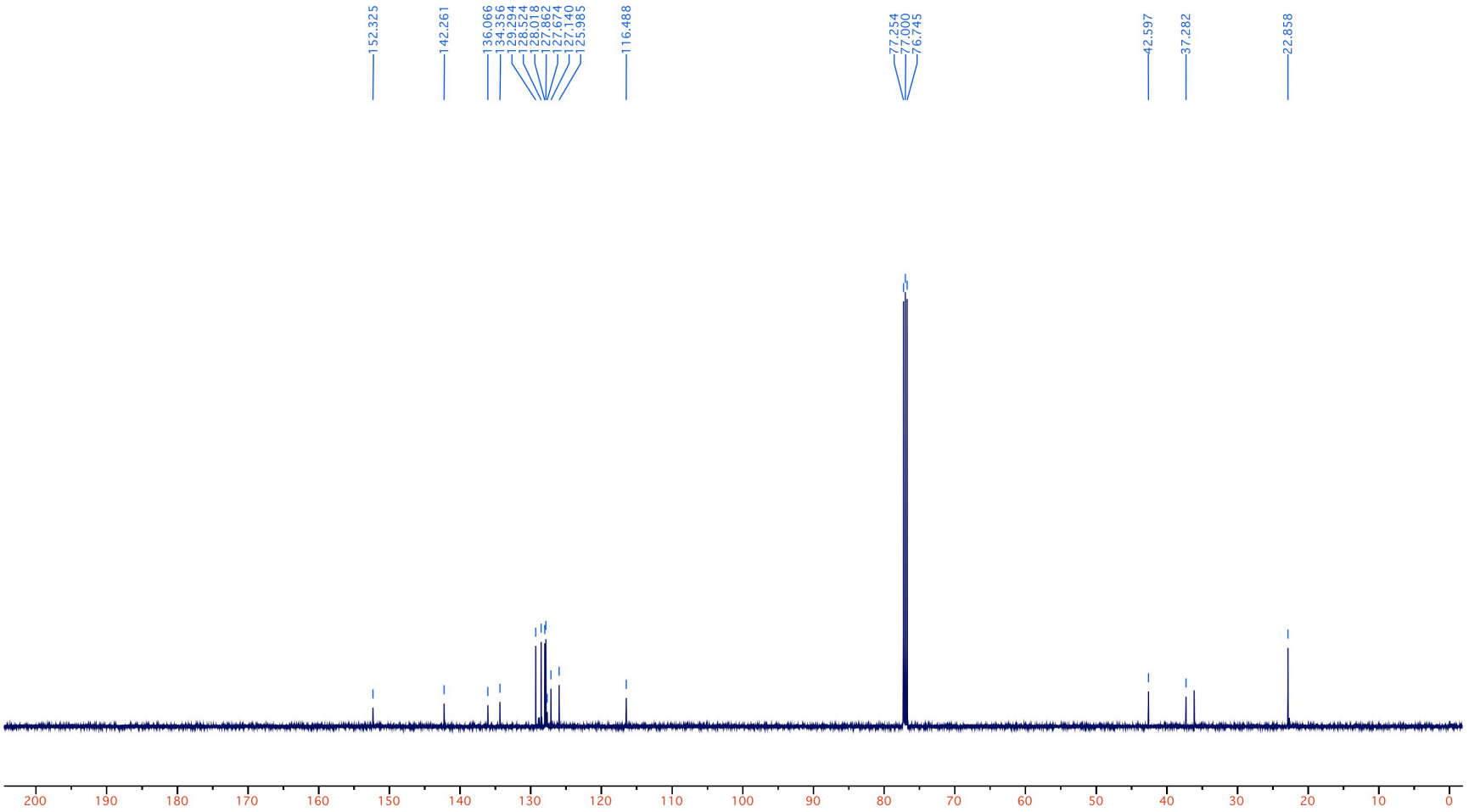

PhS
i-PrS
Ph

7j, E isomer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136.066
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128.524
128.018
127.862
127.674
127.140
125.985
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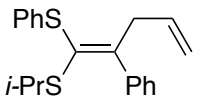
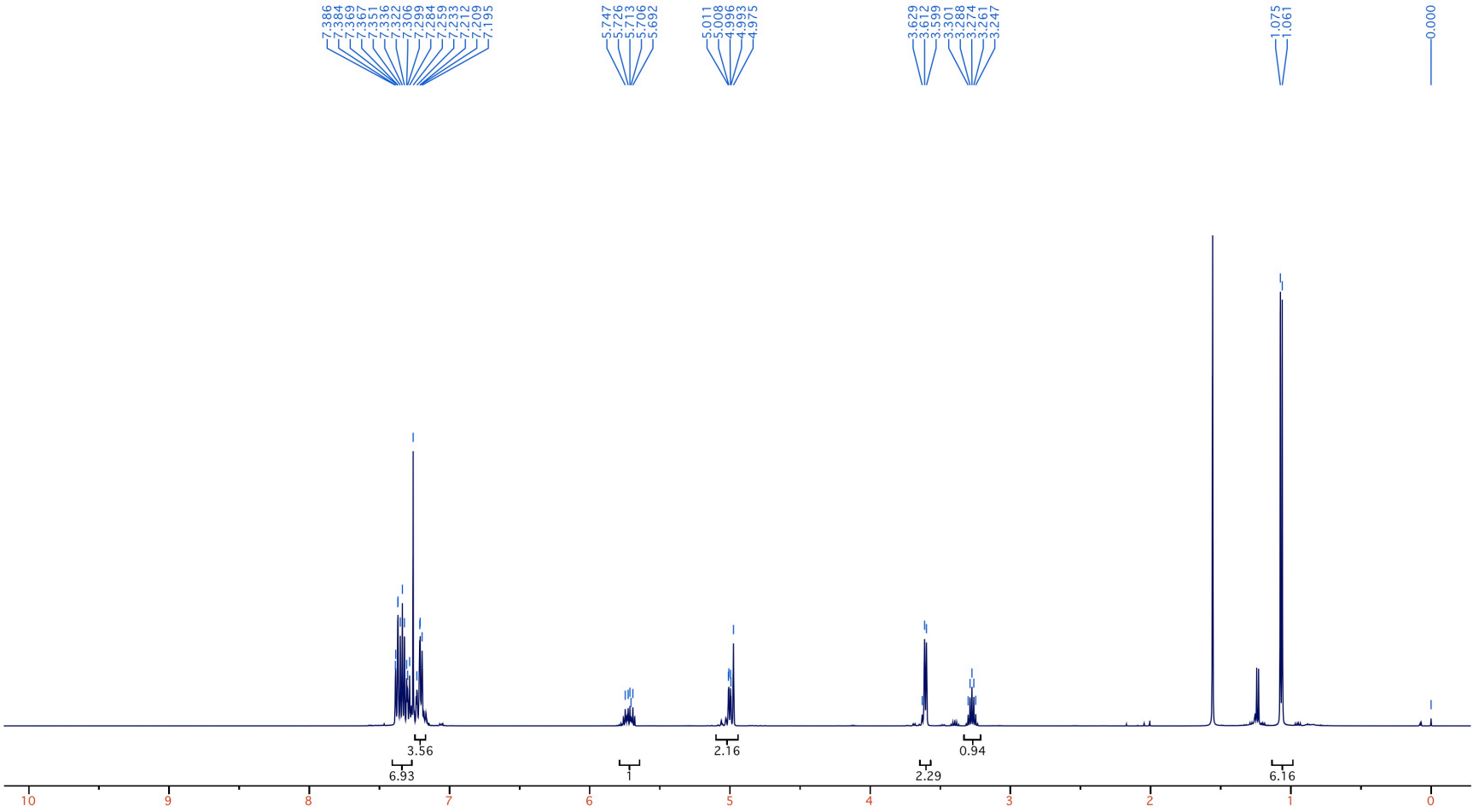
77.254
77.000
76.745
42.597
37.282
22.858
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0


PhS
i-PrS
Ph

7j, Z isomer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7.367
7.351
7.336
7.322
7.306
7.299
7.284
7.259
7.233
7.212
7.209
7.195
5.747
5.726
5.713
5.706
5.692
5.011
5.008
4.996
4.993
4.975
3.629
3.612
3.599
3.591
3.288
3.274
3.261
3.247
1.075
1.061
0.000
3.56
6.93
1
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0.94
2.29
6.16
10
9
8
7
6
5
4
3
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1
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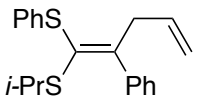
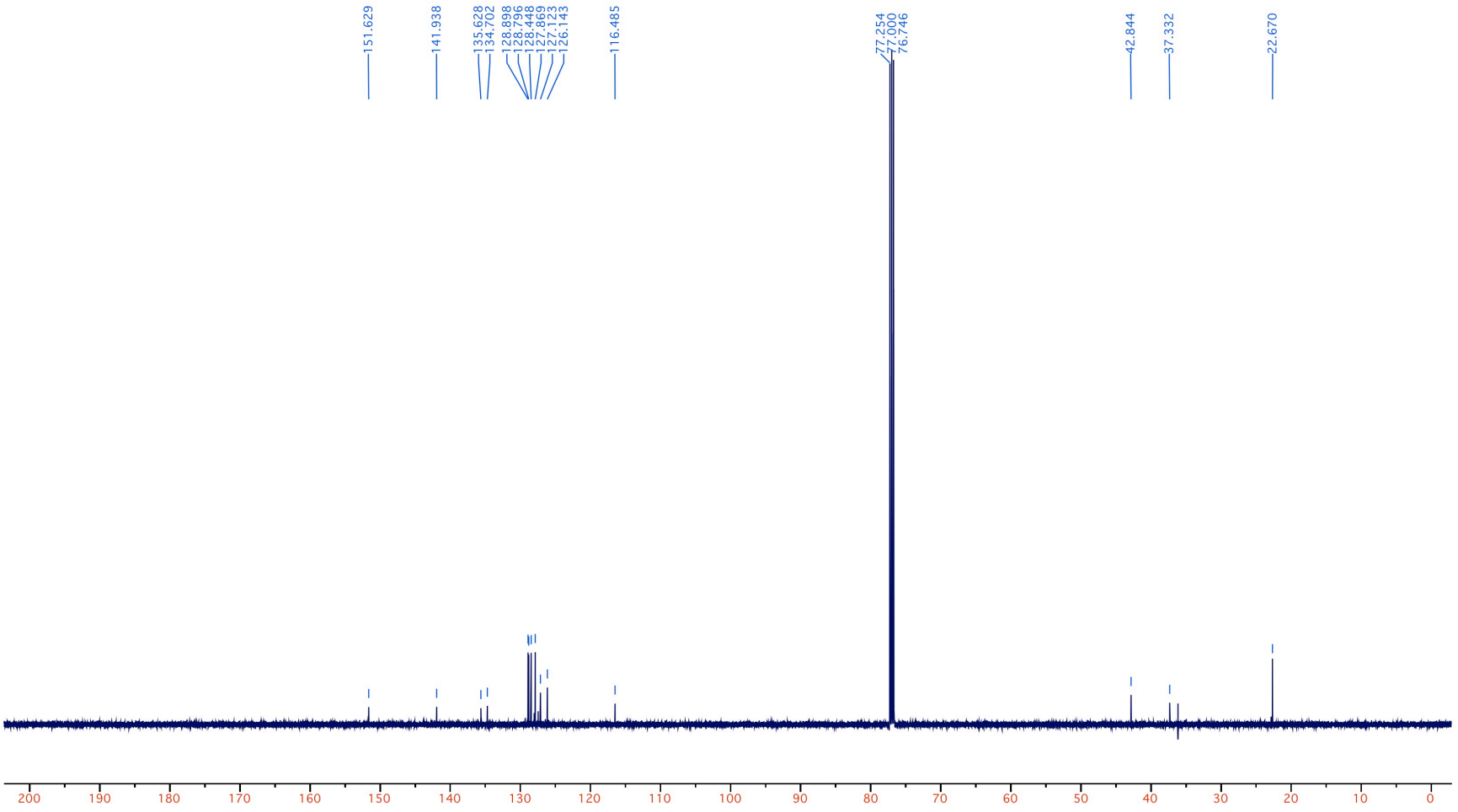

PhS
i-PrS
Ph

7j, Z isomer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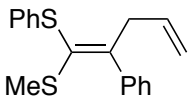
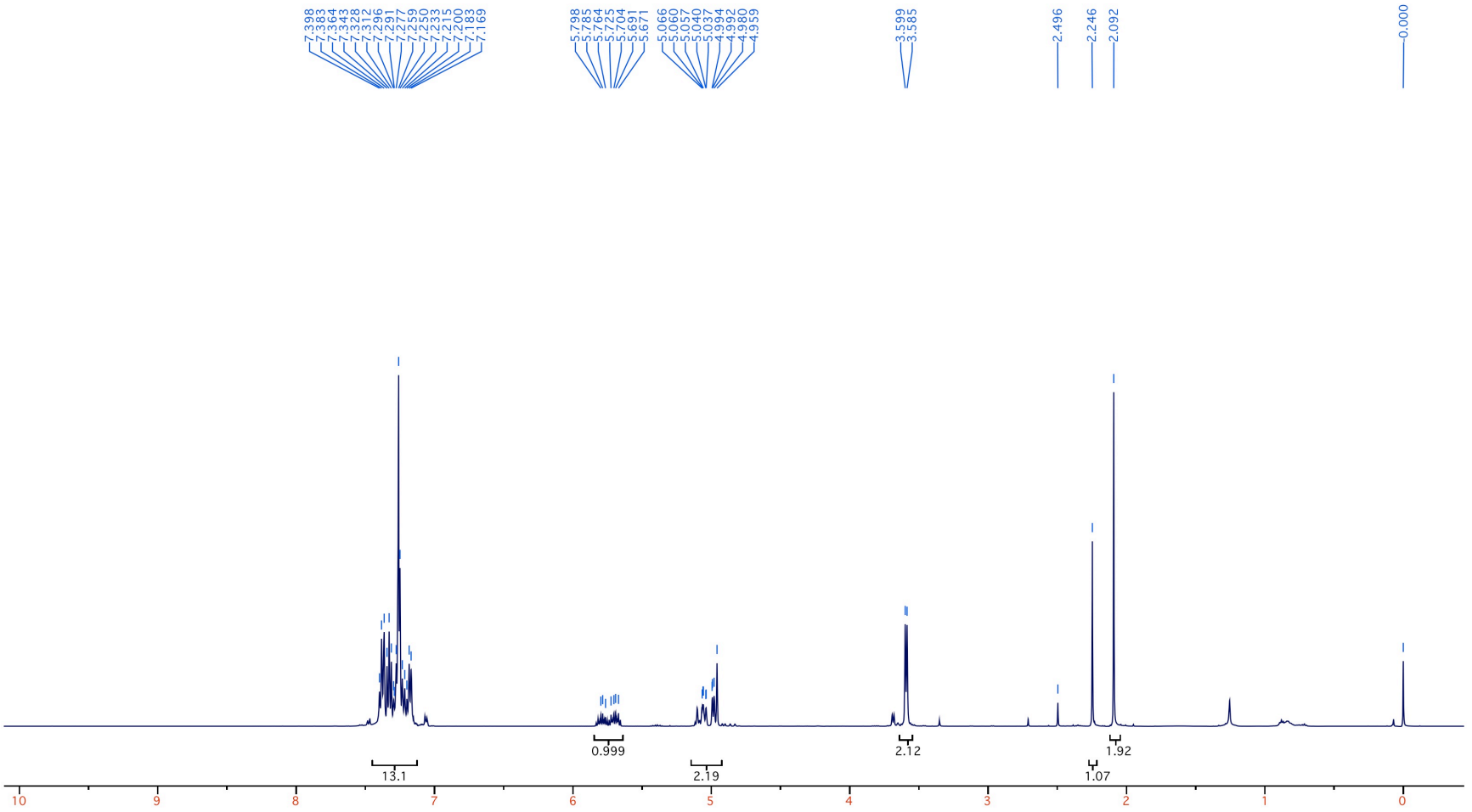
135.628
134.702
128.898
128.796
128.448
127.869
127.123
126.143
116.485
77.254
77.000
76.746
42.844
37.332
22.670
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0


PhS
MeS
Ph

7k, Z/E= 1.5:1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7.383
7.364
7.343
7.328
7.312
7.296
7.291
7.277
7.259
7.250
7.233
7.215
7.200
7.183
7.169
5.798
5.785
5.764
5.725
5.704
5.691
5.671
5.066
5.060
5.057
5.040
5.037
4.994
4.992
4.980
4.959
3.599
3.585
2.496
2.246
2.092
0.000
13.1
0.999
2.19
2.12
1.07
1.92
10
9
8
7
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2
1
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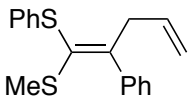
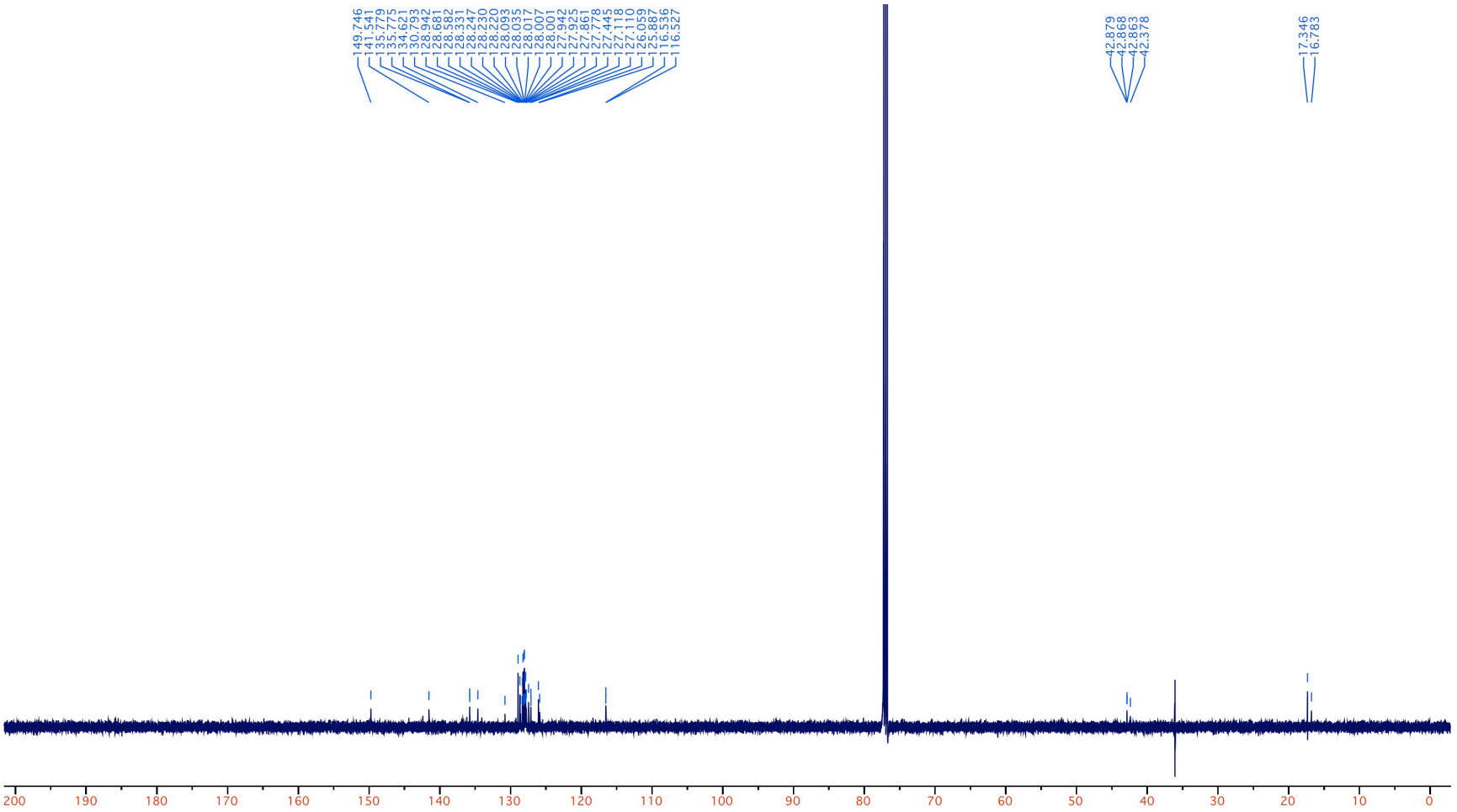

PhS
MeS
Ph

7k, Z/E= 1.5:1


149.746
141.541
135.779
135.775
134.621
130.793
128.942
128.681
128.582
128.331
128.247
128.230
128.220
128.093
128.035
128.017
128.007
128.001
127.942
127.925
127.861
127.778
127.445
127.118
127.110
126.059
125.887
116.536
116.527
42.879
42.868
42.863
42.378
17.346
16.783
200
190
180
170
160
150
140
130
120
110
100
90
80
70
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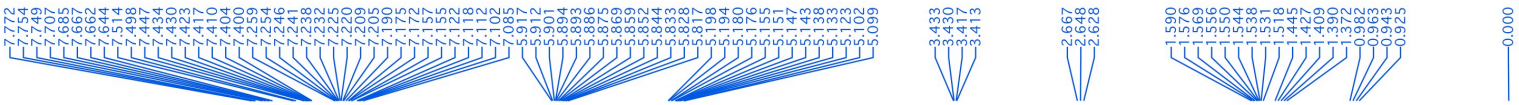
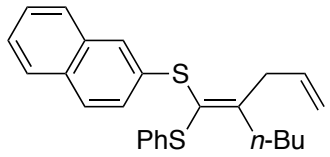
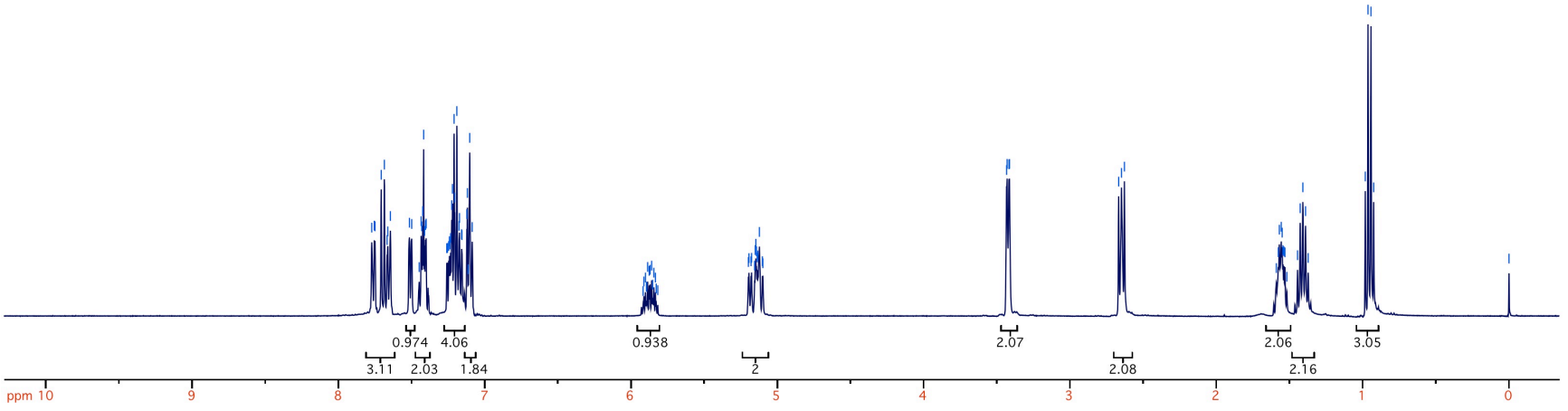
40
30
20
10
0




S
PhS
n-Bu

7l, Z/E= 1:1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4.06
0.938
2.07
2.06
3.05
3.11
2.03
1.84
2
2.08
2.16
ppm 10
9
8
7
6
5
4
3
2
1
0


157.632
157.607
135.616
135.605
135.089
133.047
133.563
133.556
133.066
133.055
131.932
131.904
129.662
129.415
128.588
128.573
128.111
128.099
128.065
127.789
127.665
127.660
127.534
127.336
127.252
127.222
126.288
126.278
126.266
126.197
125.658
125.634
123.116
123.097
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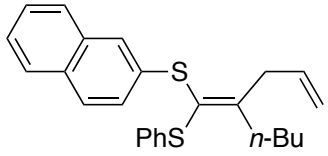
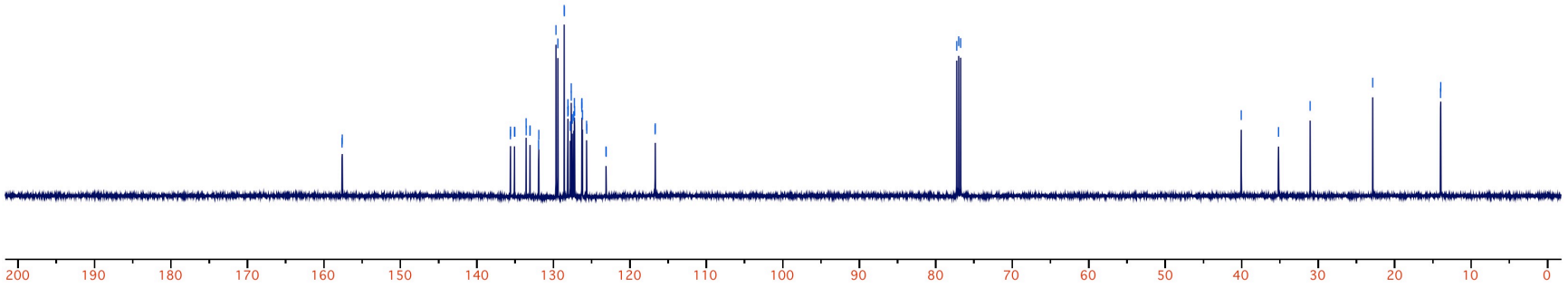
77.254
77.000
76.746
40.057
35.184
31.052
22.868
13.993
13.970


S
PhS
n-Bu

7l, Z/E= 1:1


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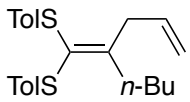
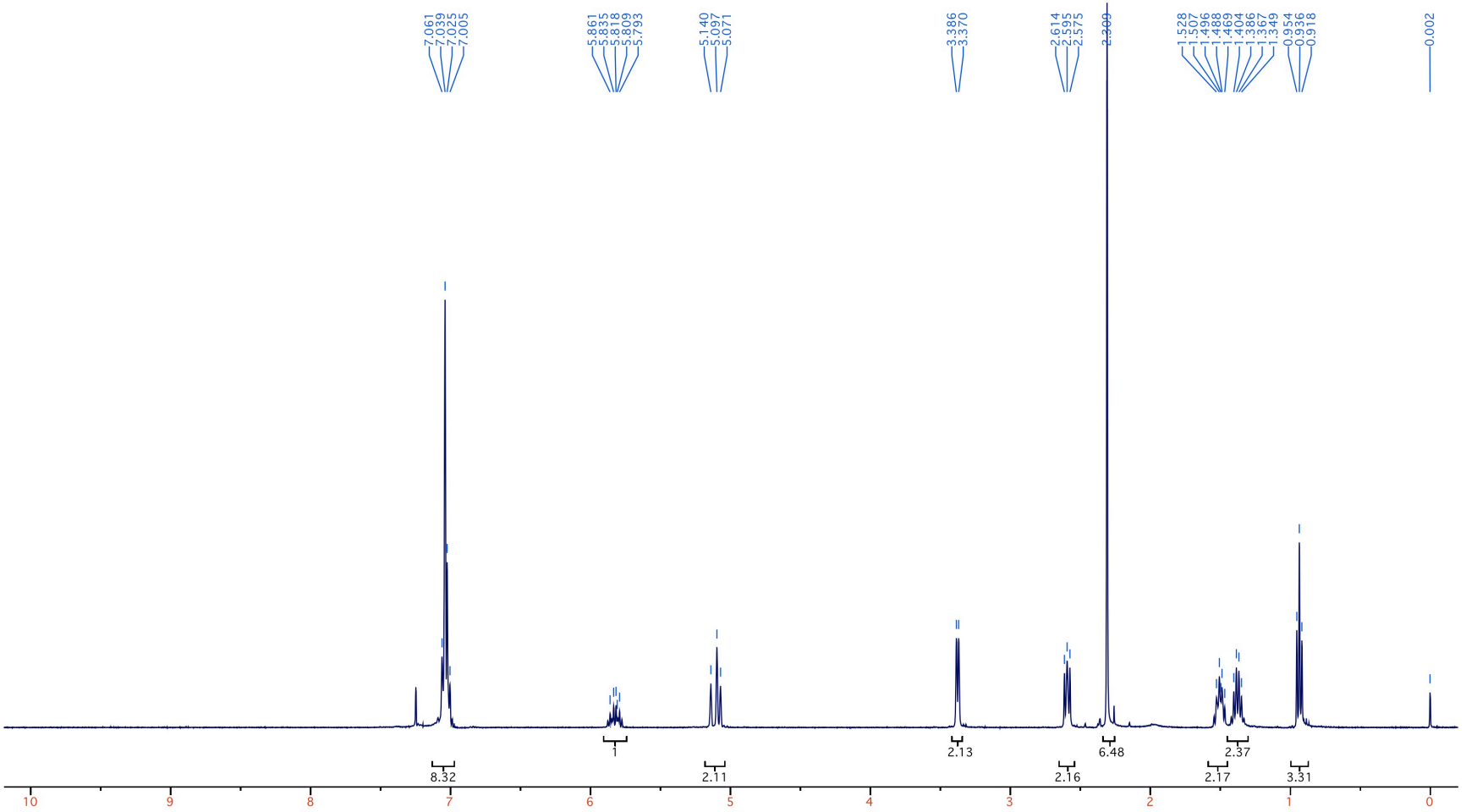
40
30
20
10
0


TolS
TolS
n-Bu

7n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7.039
7.025
7.005
5.861
5.835
5.818
5.809
5.793
5.140
5.097
5.071
3.386
3.370
2.614
2.595
2.575
2.399
1.528
1.507
1.496
1.488
1.469
1.404
1.386
1.367
1.349
0.954
0.936
0.918
0.002
1
2.13
6.48
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8.32
2.11
2.16
2.17
3.31
10
9
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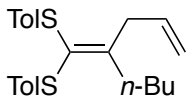
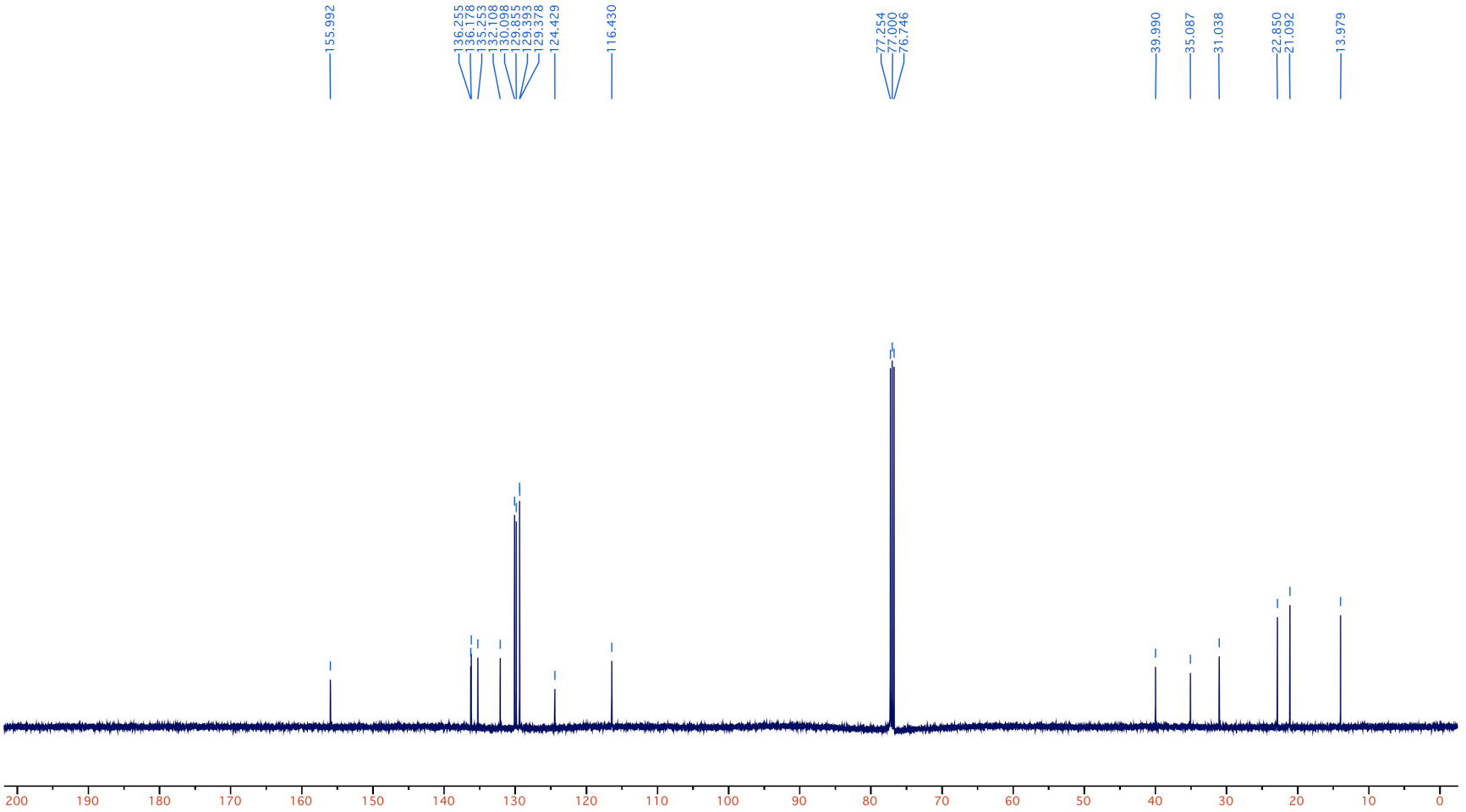
7
6
5
4
3
2
1
0


TolS
TolS
n-Bu

7n


155.992
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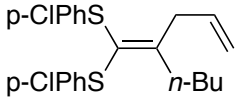
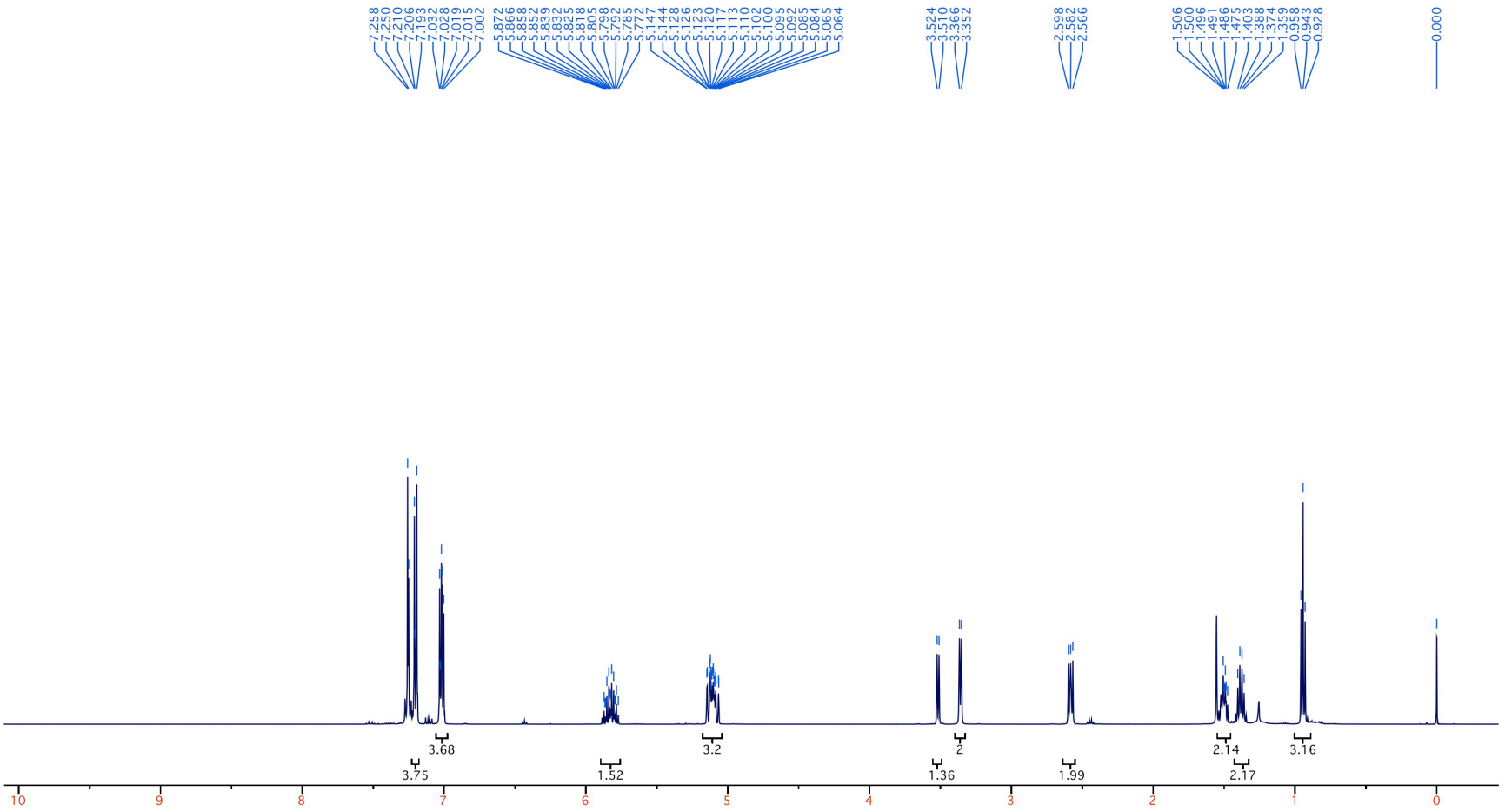
136.178
135.253
132.108
130.098
129.855
129.393
129.378
124.429
116.430
77.254
77.000
76.746
39.990
35.087
31.038
22.850
21.092
13.979
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0


p-ClPhS
p-ClPhS
n-Bu

7o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7.250
7.210
7.206
7.193
7.032
7.028
7.019
7.015
7.002
5.872
5.866
5.858
5.852
5.839
5.832
5.825
5.818
5.805
5.798
5.792
5.785
5.772
5.147
5.144
5.128
5.126
5.123
5.120
5.117
5.113
5.110
5.102
5.100
5.095
5.092
5.085
5.084
5.065
5.064
3.524
3.510
3.366
3.332
2.598
2.582
2.566
1.506
1.500
1.496
1.491
1.486
1.475
1.403
1.388
1.374
1.359
0.938
0.933
0.928
0.000
3.68
3.2
2
2.14
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1.36
1.99
2.17
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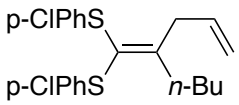
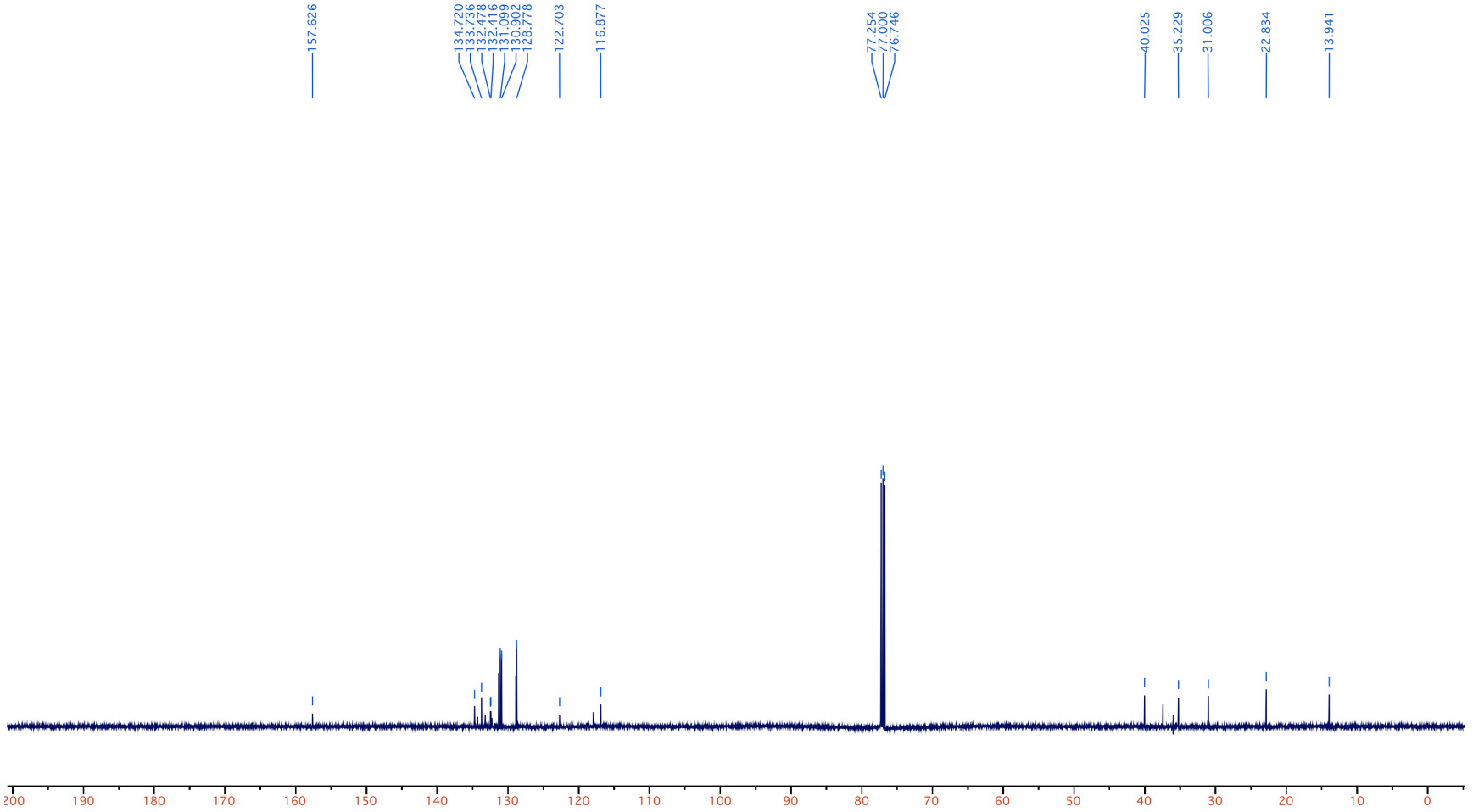

p-ClPhS
p-ClPhS
n-Bu

7o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132.416
131.099
130.902
128.778
122.703
116.877
77.254
77.000
76.746
40.025
35.229
31.006
22.834
13.941
200
190
180
170
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150
140
130
120
110
100
90
80
70
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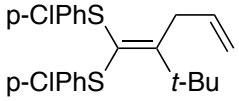
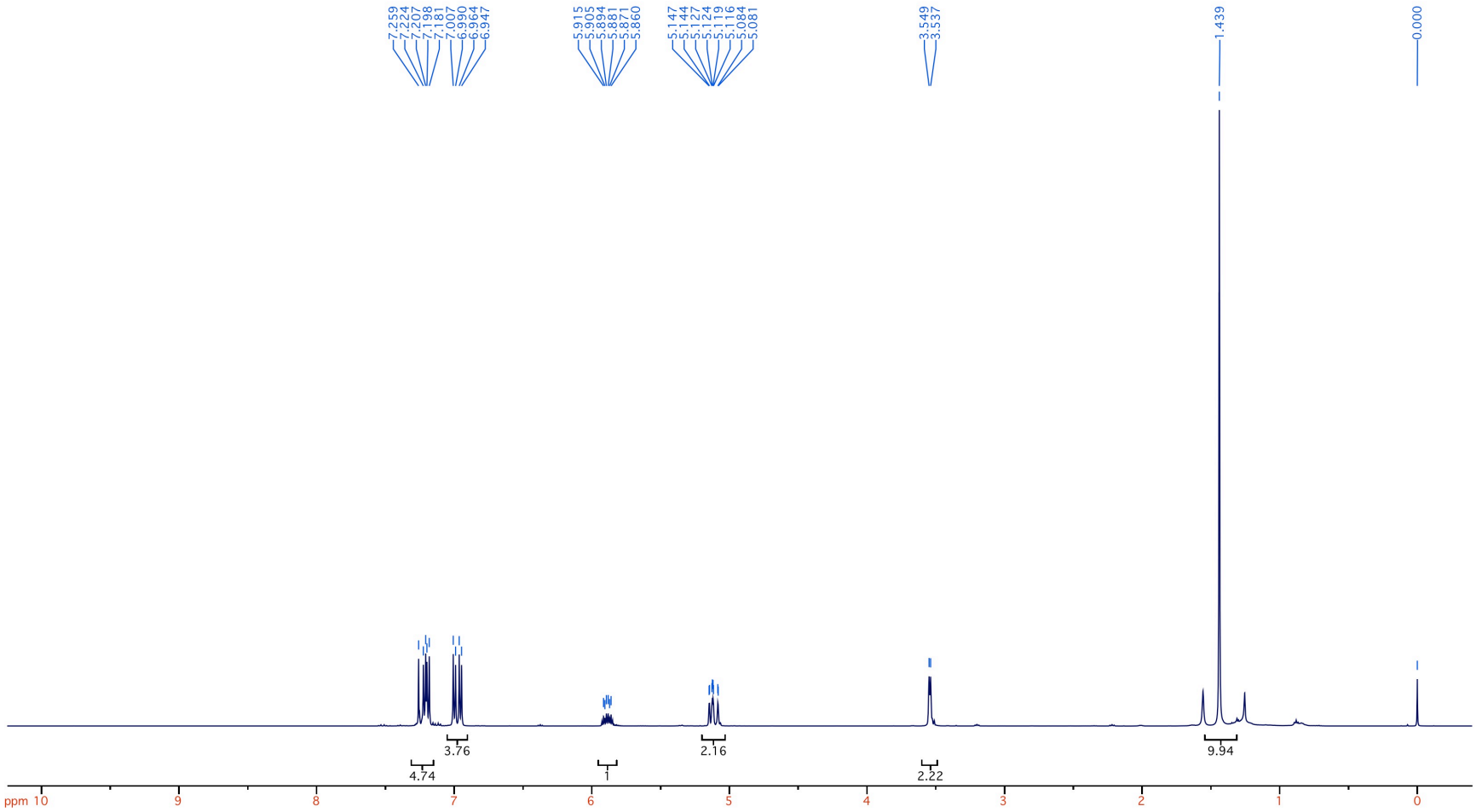
20
10
0


p-ClPhS
p-ClPhS
t-Bu

7p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7.224
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7.198
7.181
7.007
6.990
6.964
6.947
5.915
5.905
5.894
5.881
5.871
5.860
5.147
5.144
5.127
5.124
5.119
5.116
5.084
5.081
3.549
3.537
1.439
0.000
4.74
3.76
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2.16
2.22
9.94
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7
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1
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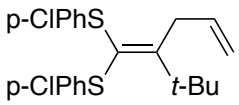
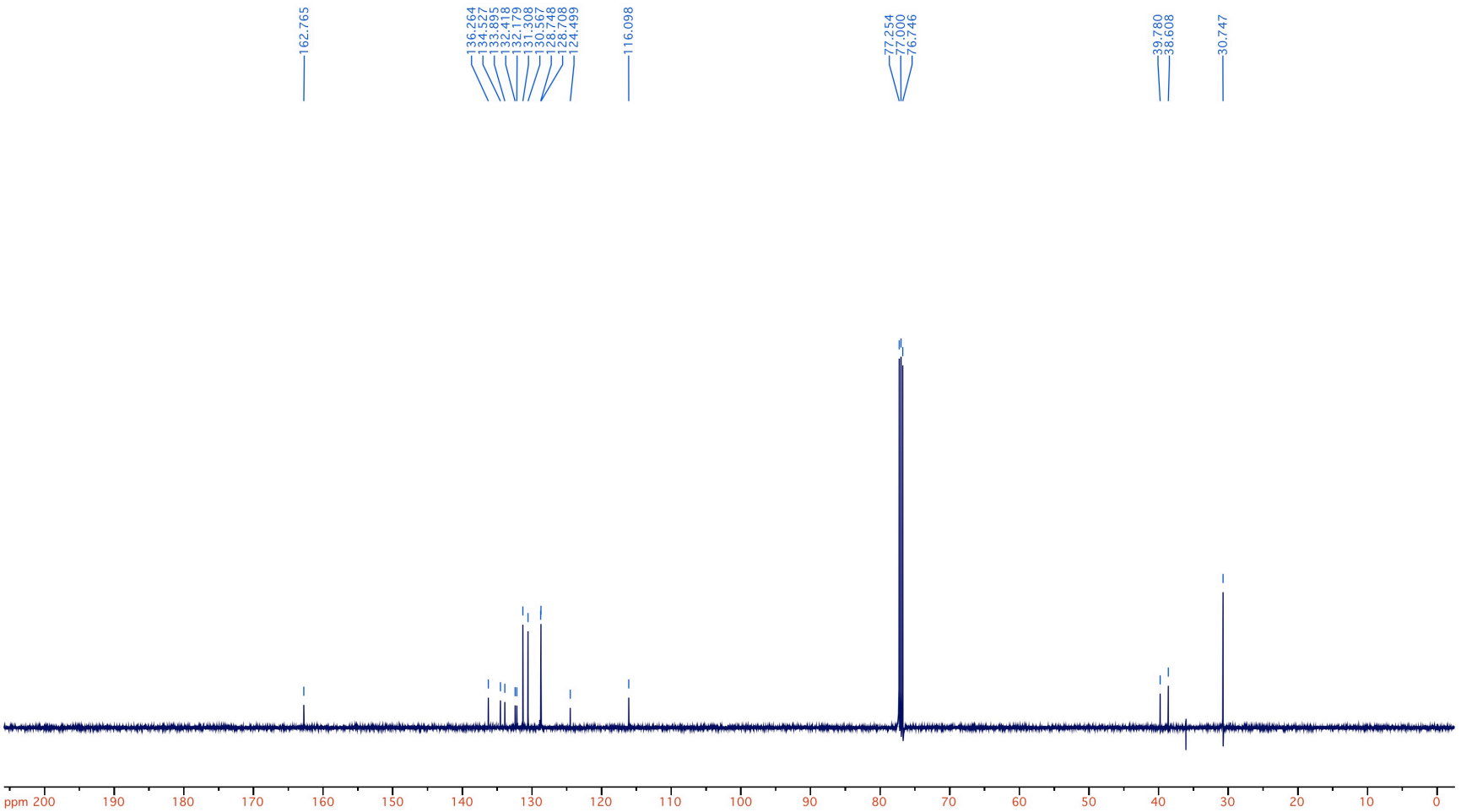

p-ClPhS
p-ClPhS
t-Bu

7p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134.527
133.895
132.418
132.179
131.308
130.567
128.748
128.708
124.499
116.098
77.254
77.000
76.746
39.780
38.608
30.747
ppm 200
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180
170
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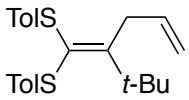
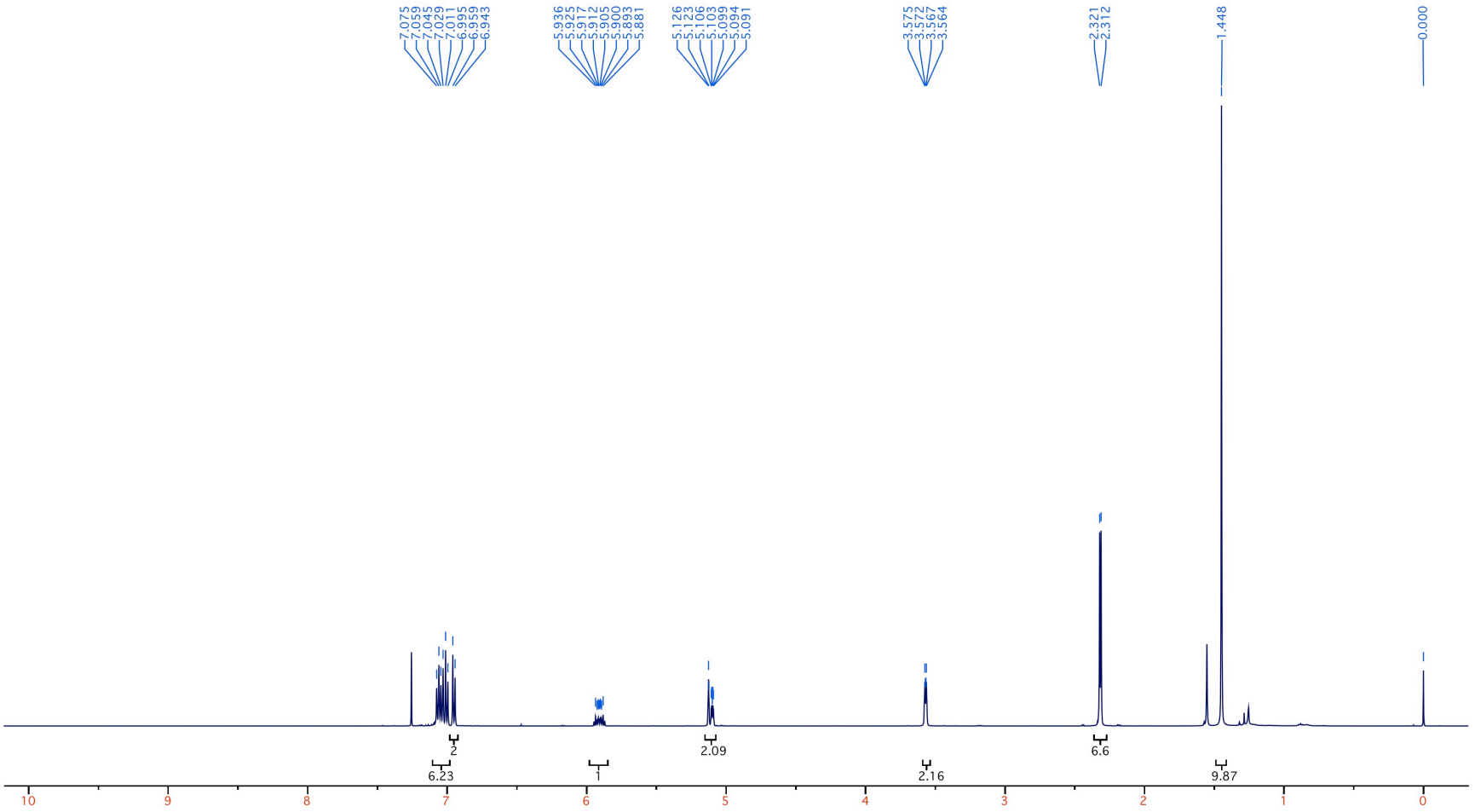
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0


TolS
TolS
t-Bu

7q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7.045
7.029
7.011
6.995
6.959
6.943
5.936
5.925
5.917
5.912
5.905
5.900
5.893
5.881
5.126
5.123
5.106
5.103
5.099
5.094
5.091
3.575
3.572
3.567
3.564
2.321
2.312
1.448
0.000
2
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1
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2.16
6.6
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7
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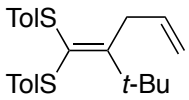
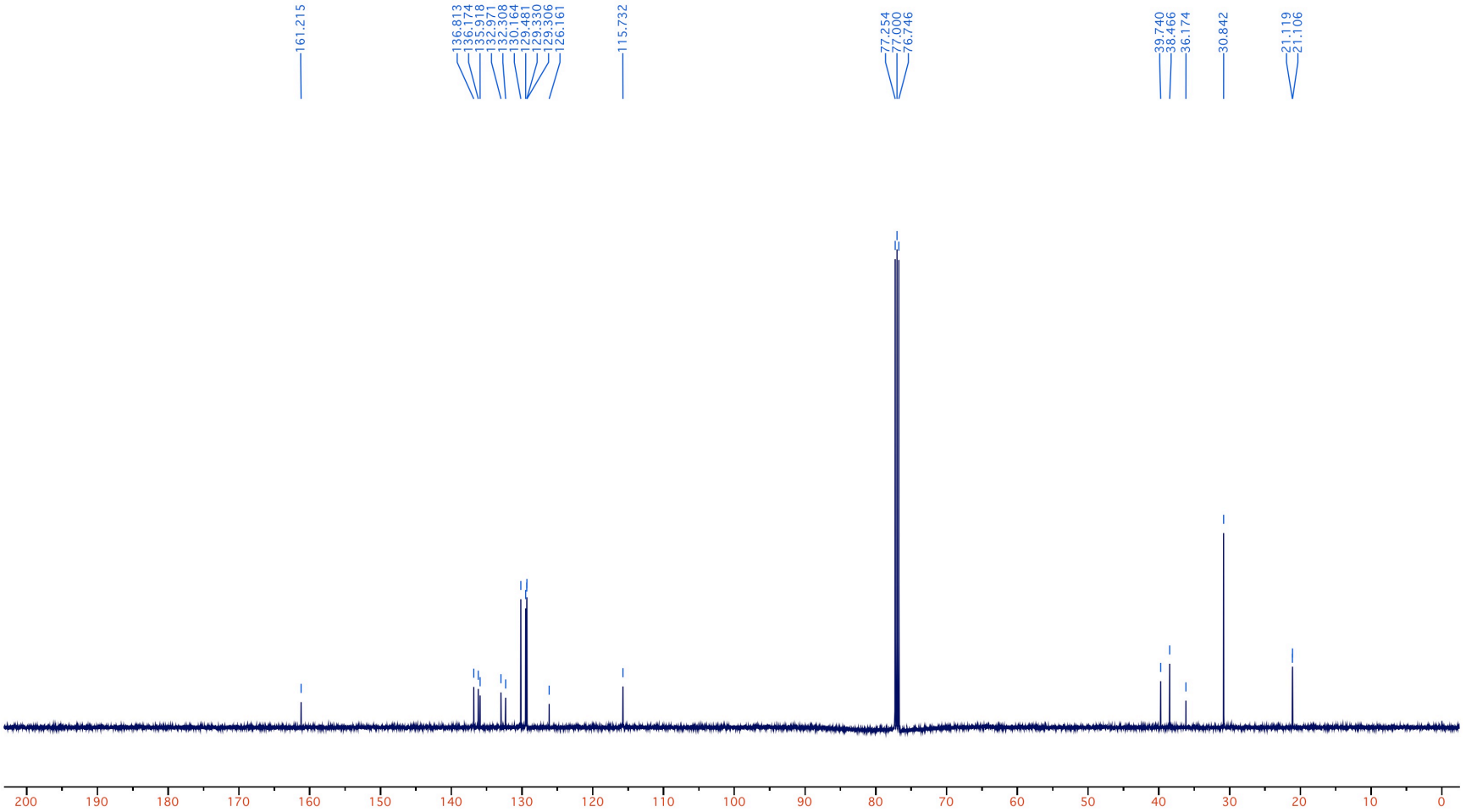
1
0


TolS
TolS
t-Bu

7q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132.971
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130.164
130.081
129.330
129.306
126.161
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77.254
77.000
76.746
39.740
38.466
36.174
30.842
21.119
21.106
200
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180
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150
140
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120
110
100
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70
60
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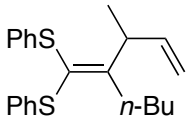
20
10
0


PhS
PhS
n-Bu

7r


7.255
7.235
7.220
7.192
7.178
7.164
7.118
7.102
5.939
5.927
5.919
5.907
5.904
5.894
5.892
5.884
5.872
5.108
5.095
5.075
5.073
4.291
4.278
4.265
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2.443
2.438
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1.585
1.582
1.574
1.569
1.566
1.560
1.547
1.533
1.526
1.519
1.512
1.432
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1.347
1.246
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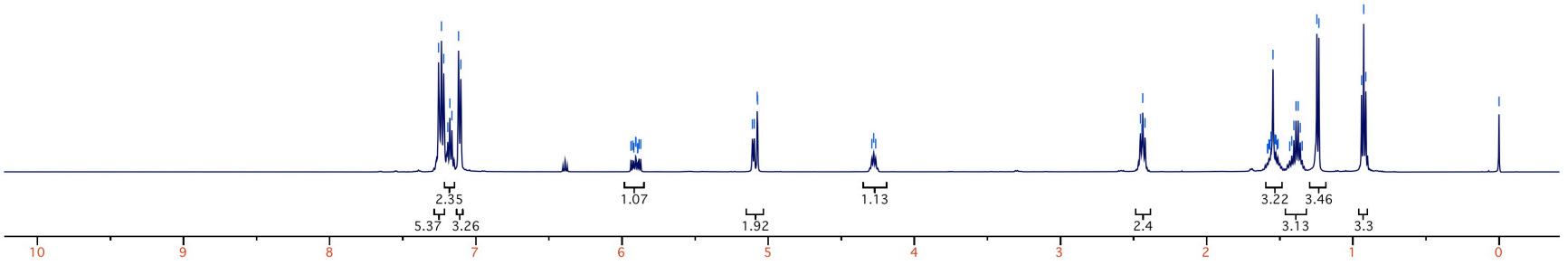
0.912
0.000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1.07
1.92
1.13
2.4
3.22
3.13
3.46
3.3
10
9
8
7
6
5
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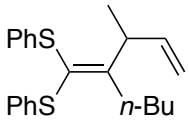
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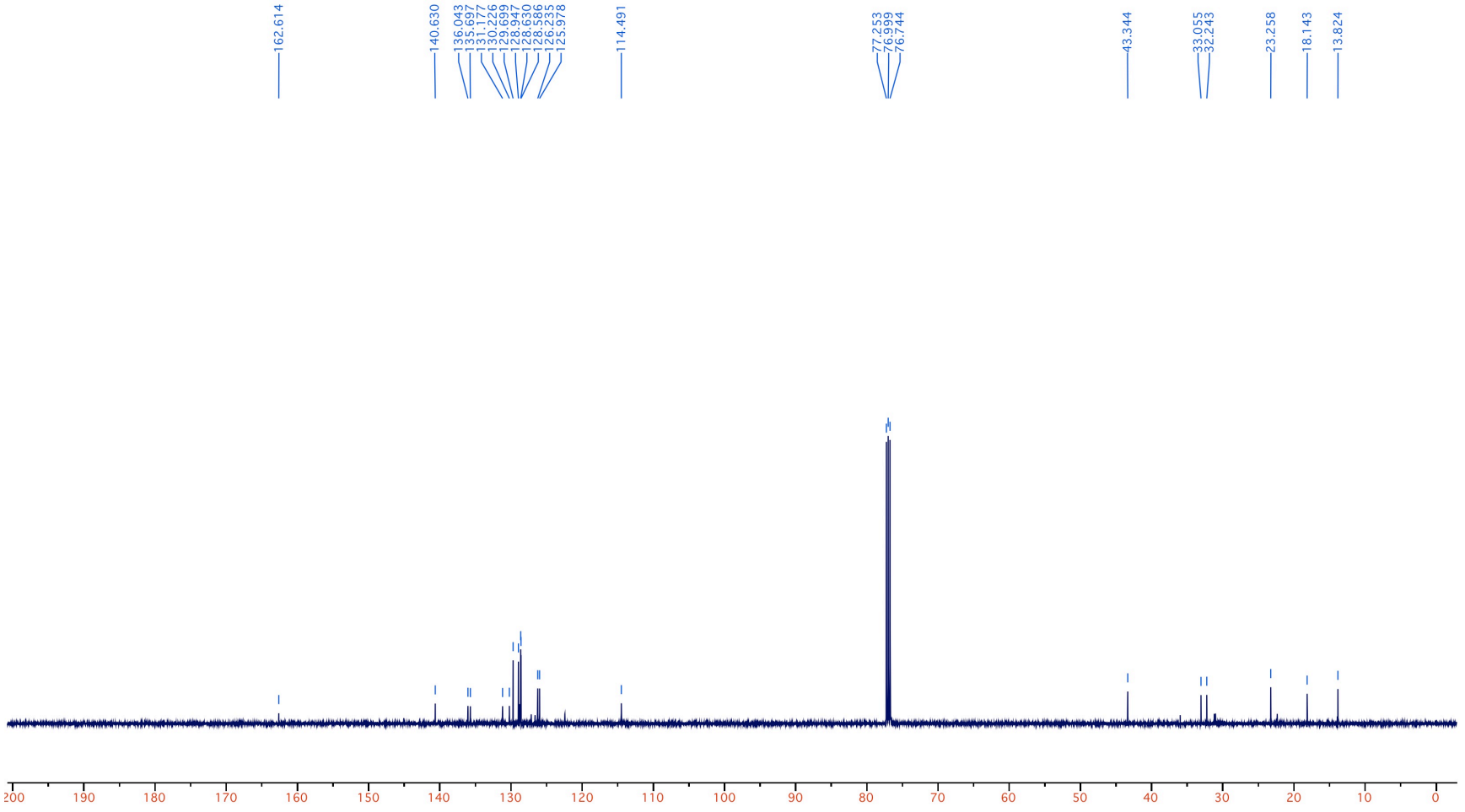
7r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77.253
76.999
76.744
43.344
33.055
32.243
23.258
18.143
13.824
200
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150
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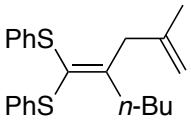
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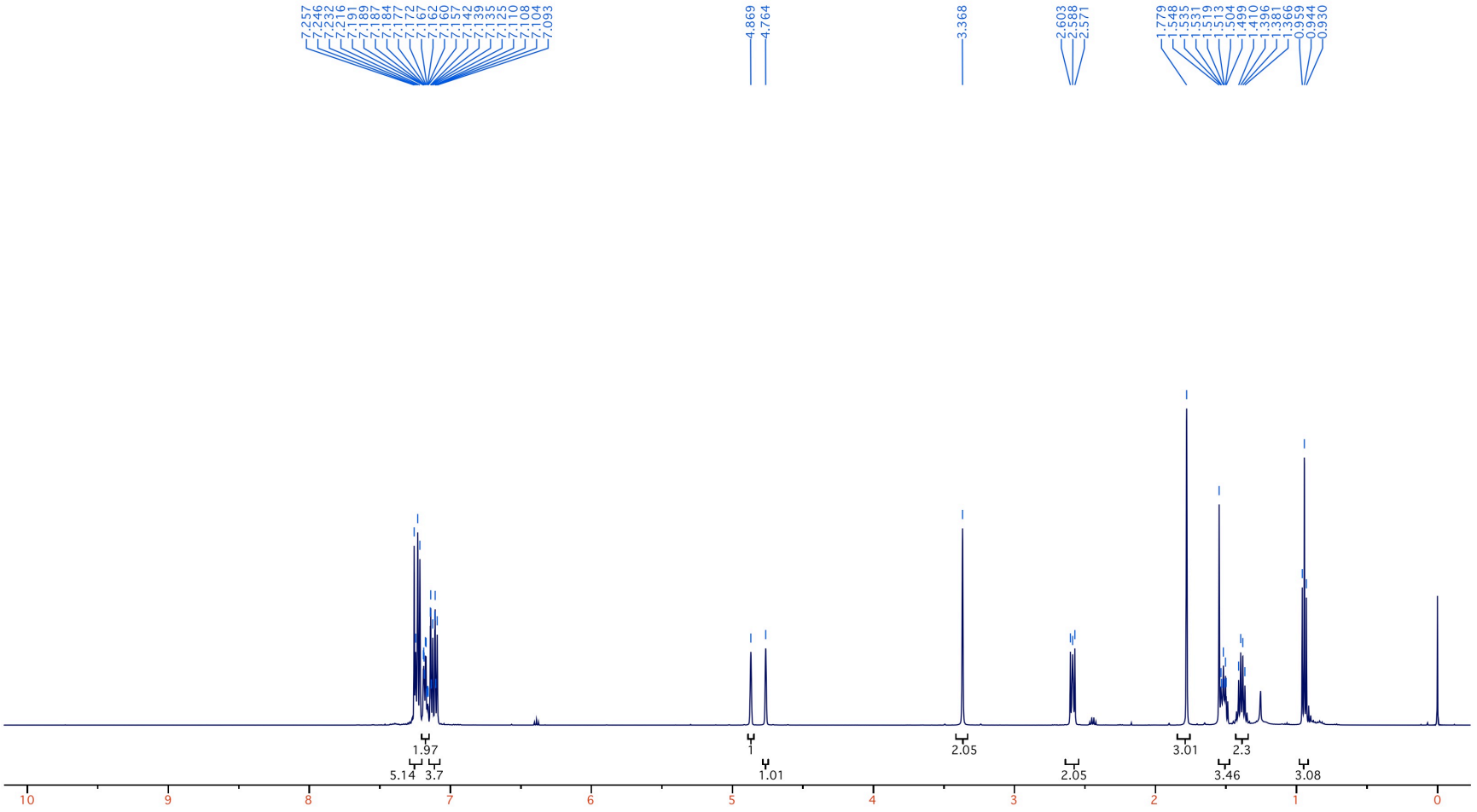
7s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7.184
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7.160
7.157
7.142
7.139
7.135
7.125
7.110
7.108
7.104
7.093
4.869
4.764
3.368
2.603
2.588
2.571
1.779
1.548
1.535
1.531
1.519
1.513
1.504
1.499
1.410
1.396
1.381
1.366
0.959
0.944
0.930
1.97
5.14
3.7
1
1.01
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3.08
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7
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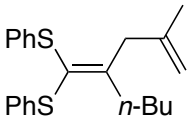
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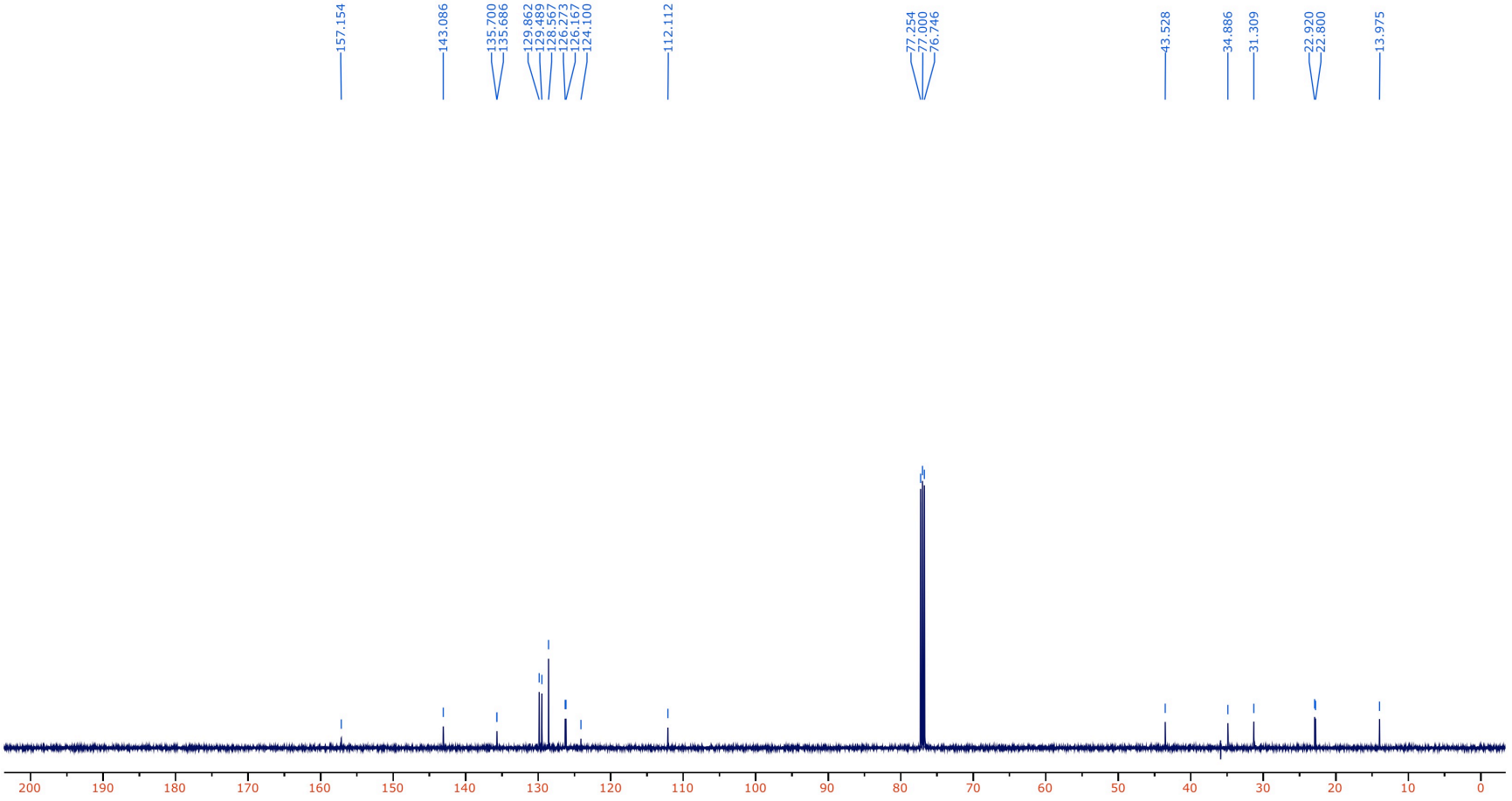
PhS
n-Bu

7s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126.273
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124.100
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77.000
76.746
43.528
34.886
31.309
22.920
22.800
13.975
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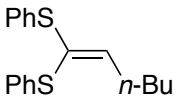
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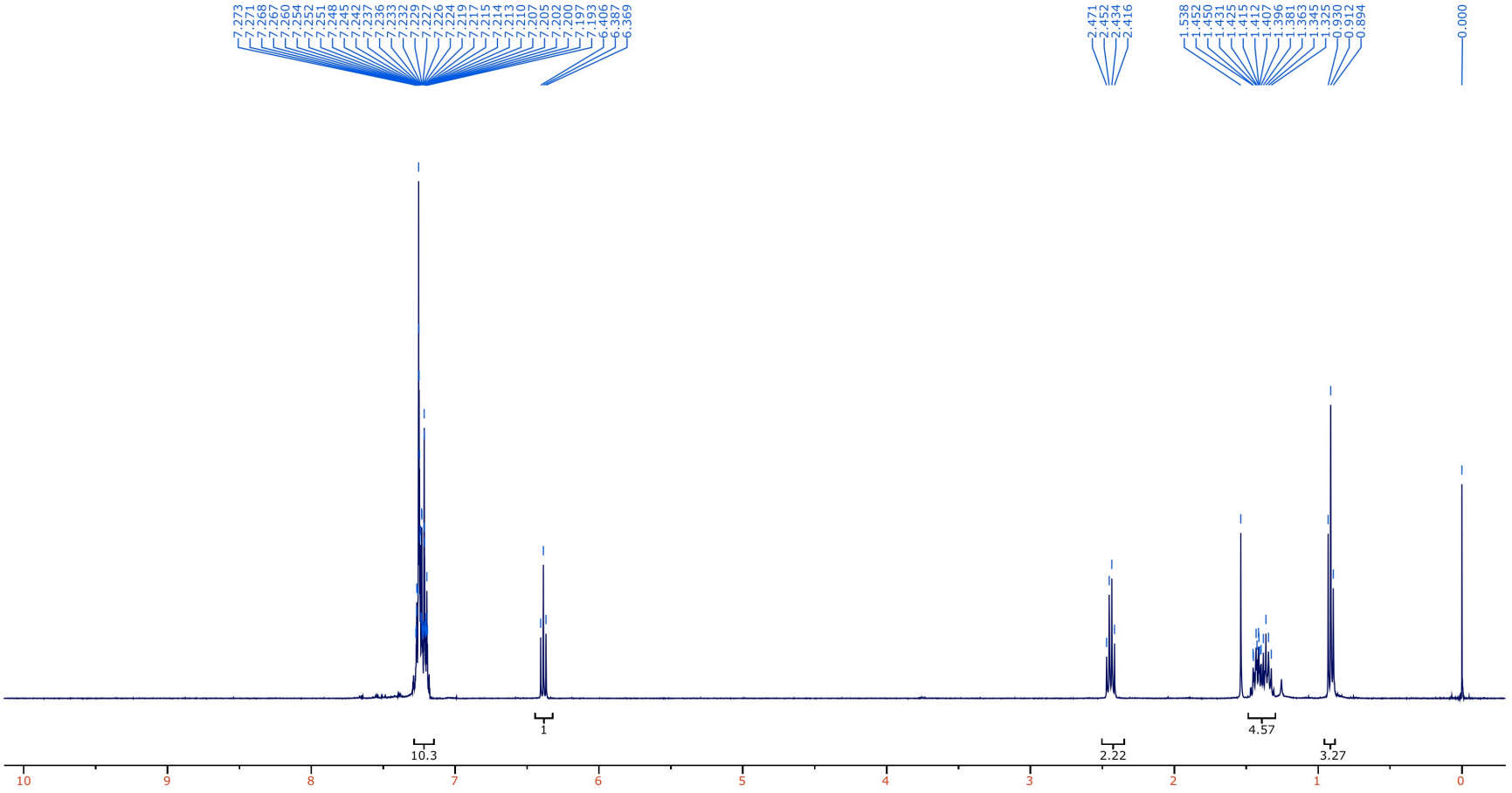
PhS
n-Bu

4a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7.237
7.236
7.233
7.232
7.229
7.227
7.226
7.224
7.219
7.217
7.215
7.214
7.213
7.210
7.207
7.205
7.202
7.200
7.197
7.193
6.406
6.387
6.369
2.471
2.452
2.434
2.416
1.538
1.452
1.450
1.431
1.425
1.415
1.412
1.407
1.396
1.381
1.363
1.345
1.325
0.910
0.912
0.894
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2.22
4.57
3.27
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8
7
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1
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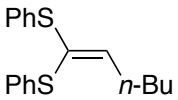
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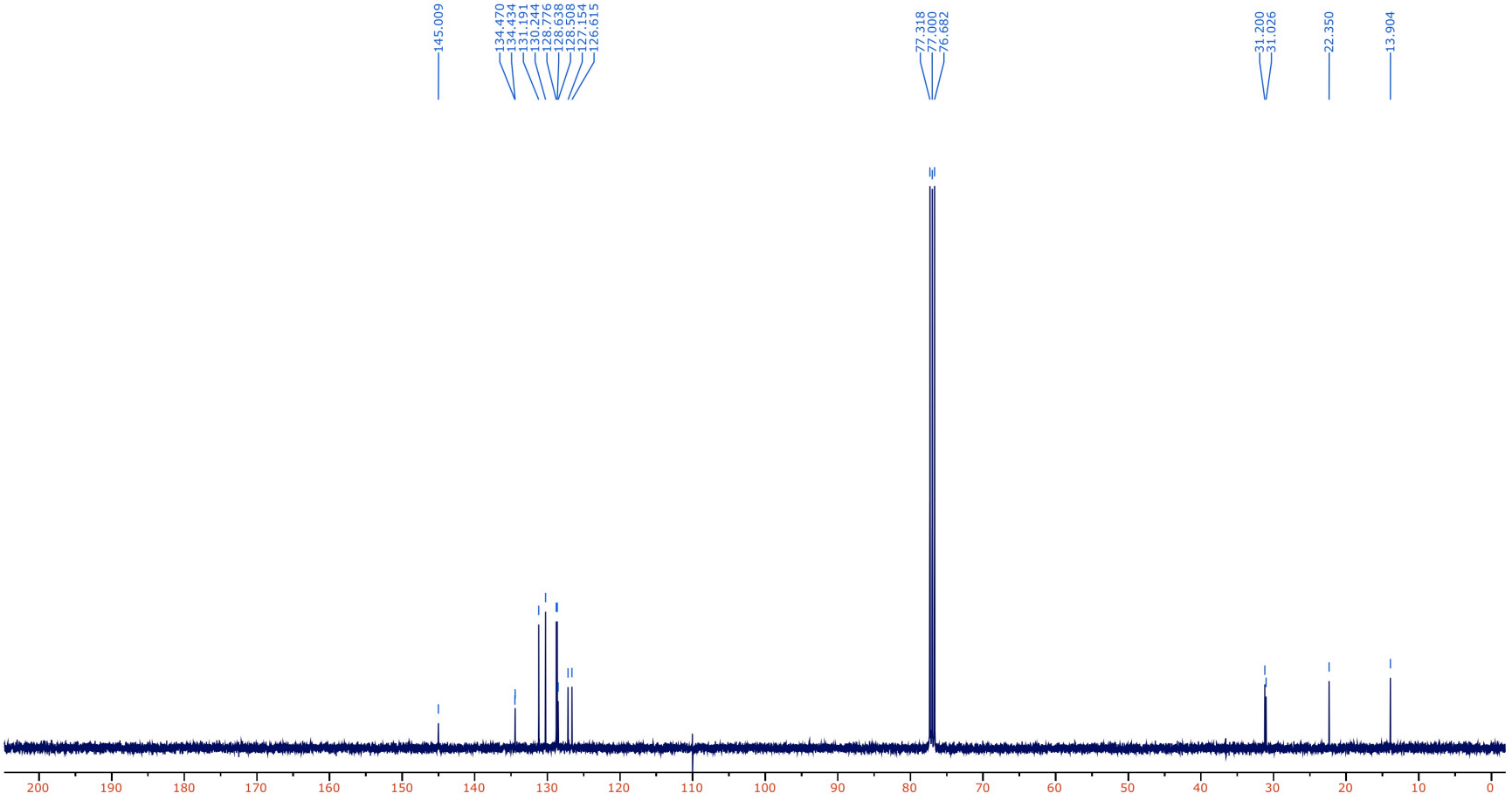
PhS
n-Bu

4a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128.508
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126.615
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77.000
76.682
31.200
31.026
22.350
13.904
200
190
180
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150
140
130
120
110
100
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70
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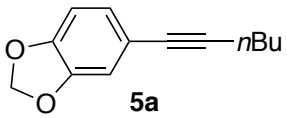
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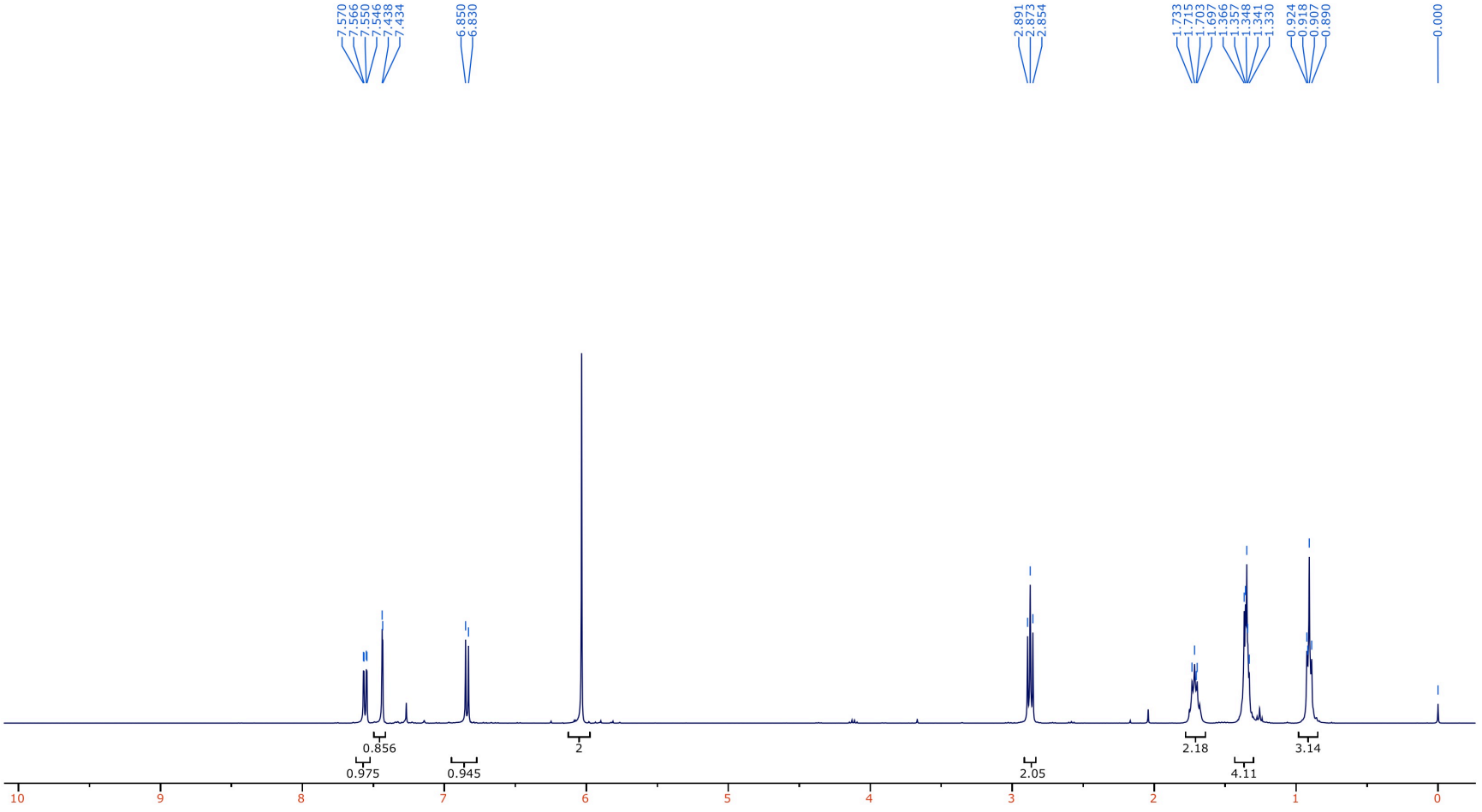
nBu

5a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7.434
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6.830
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2.873
2.854
1.733
1.715
1.703
1.697
1.366
1.357
1.348
1.341
1.330
0.924
0.918
0.907
0.890
0.000
0.856
0.975
0.945
2
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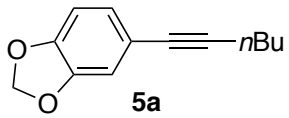
2.18
4.11
3.14
10
9
8
7
6
5
4
3
2
1
0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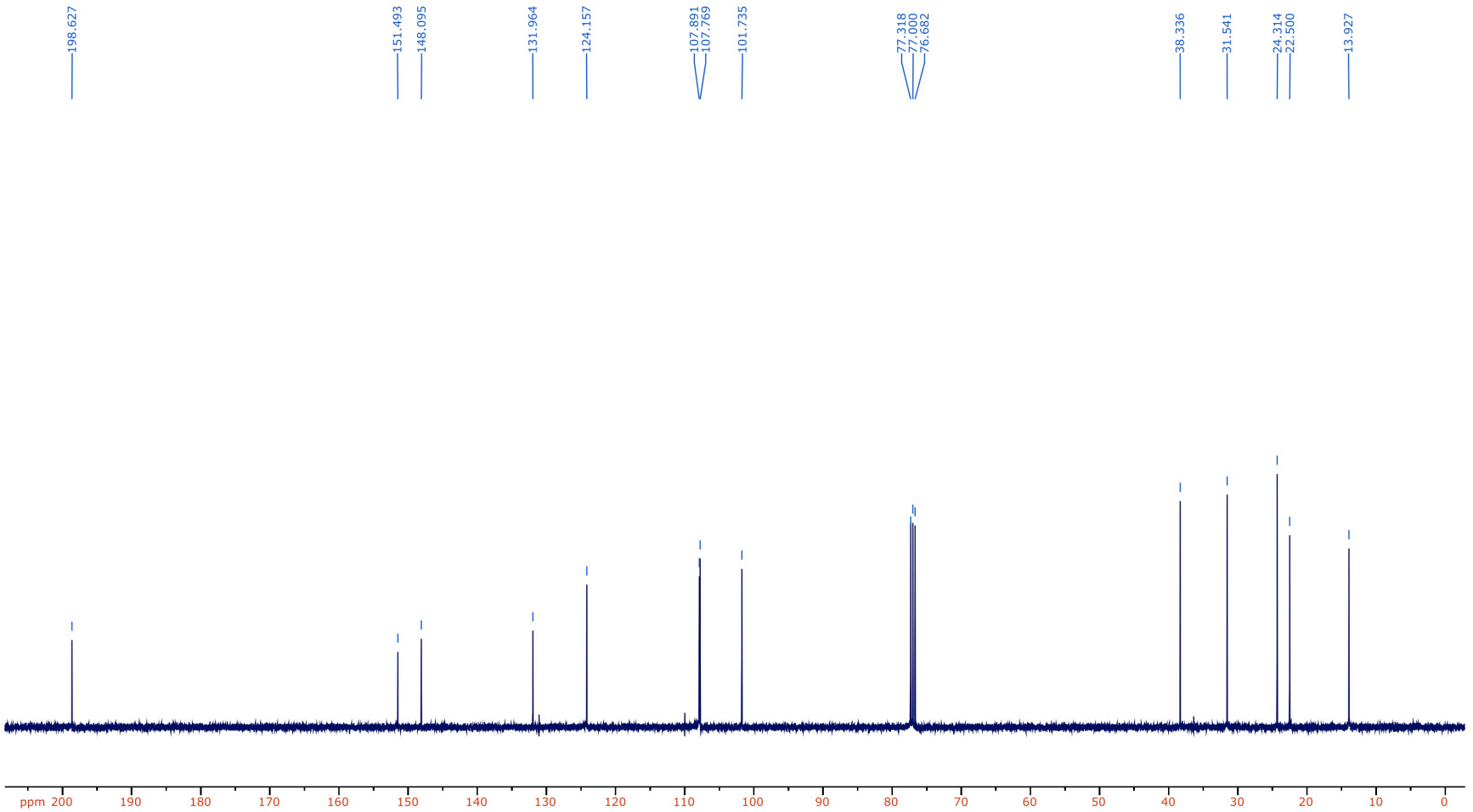
5a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107.891
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101.735
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77.000
76.682
38.336
31.541
24.314
22.500
13.927
ppm 200
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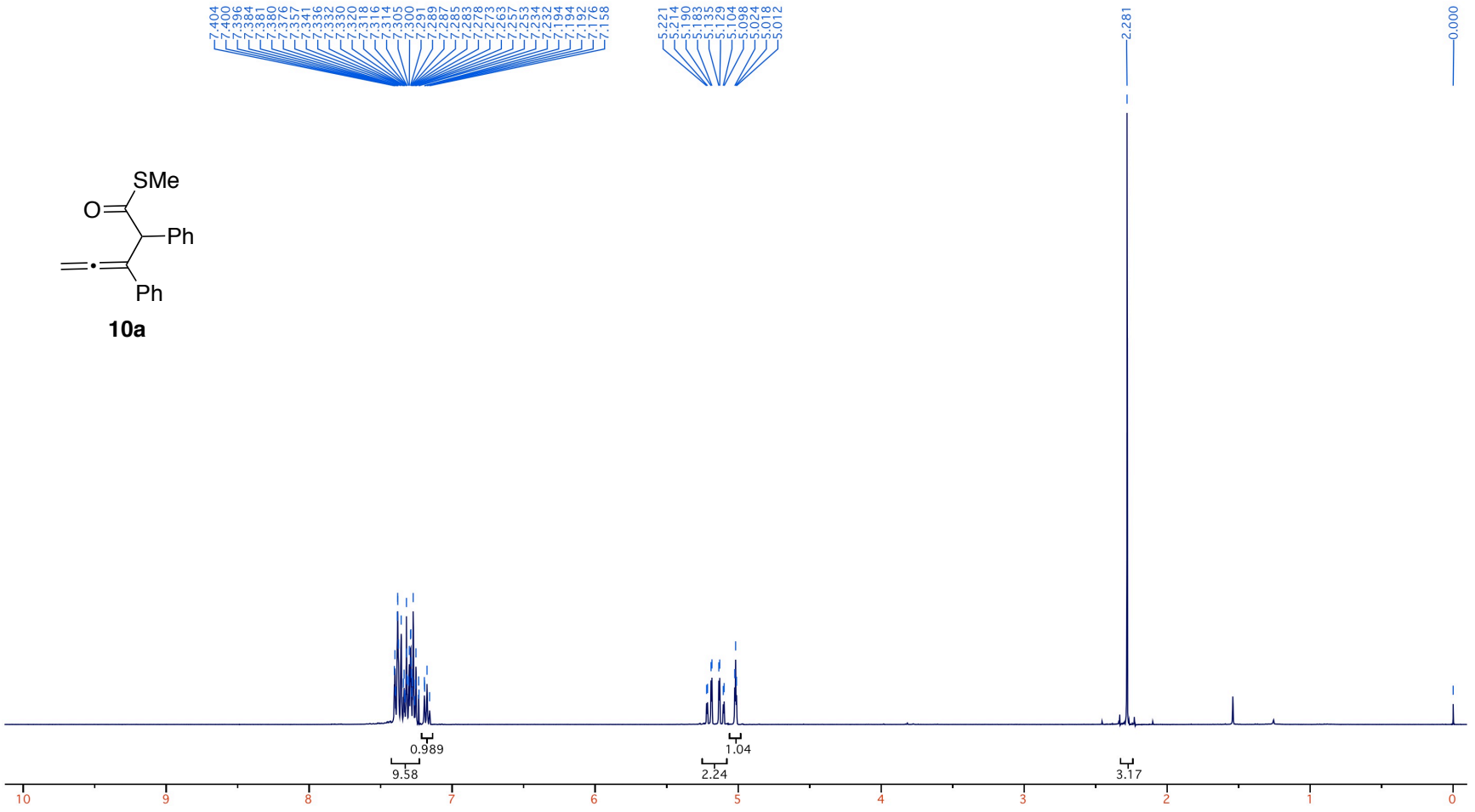
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0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7.380
7.376
7.357
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7.336
7.332
7.330
7.320
7.318
7.316
7.314
7.305
7.300
7.291
7.289
7.287
7.285
7.283
7.278
7.273
7.263
7.257
7.253
7.234
7.232
7.194
7.194
7.192
7.176
7.158
5.221
5.214
5.190
5.183
5.135
5.129
5.104
5.098
5.024
5.018
5.012
2.281
0.000
SMe
O
Ph
Ph
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2.24
3.17
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9
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7
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5
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3
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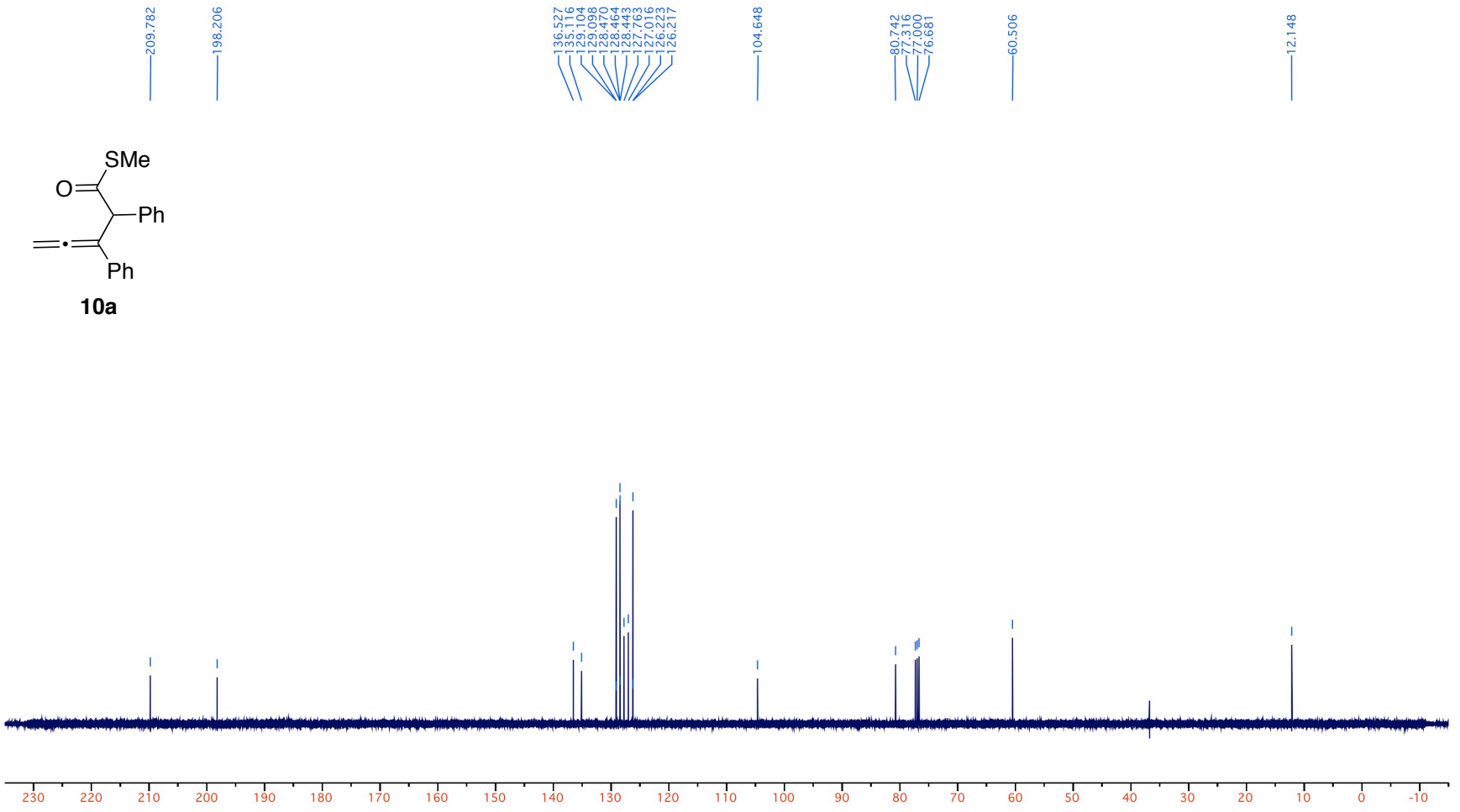
1
0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127.016
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126.217
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77.000
76.681
60.506
12.148
SMe
O
Ph
Ph
230
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10

10a