Supporting Information

Cu-Based Ternary Deep Eutectic Solvents for Homo- and Cross-Coupling Reactions of Terminal Alkynes

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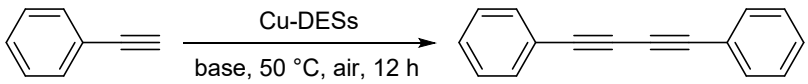
1. General information

All reactions were carried out using oven-dried schlenk tube (25 mL) and magnetic stirring (the speed is 1000 rpm) under air unless otherwise stated. All commercially available compounds were purchased from J&K, Alfa, Energy, TCI or Aladdin. TLC was carried out on SiO_2 (silica gel 60 F254, Merck), and the spots were located with UV light (254 nm). Flash chromatography was carried out on SiO_2 (silica gel 60, 200-300 mesh). ^1H and ^{13}C NMR spectra were recorded on a Bruker Avance II-400 spectrometer (400 MHz for ^1H, 101 MHz for ^{13}C). $CDCl_3$ and TMS were used as a solvent and an internal standard, respectively. The chemical shifts were reported in ppm downfield (δ) from TMS, the coupling constants *J* are given in Hz. The peak patterns were indicated as follows: s, singlet; d, doublet; t, triplet; m, multiplet; q, quartet. IR spectra were recorded on a NEXUS FT-IR spectrometer. Raman spectra were recorded on a DXR Raman Microscope spectrometer.

2. Procedure for optimization studies

Table S1 **Optimization for the homo-coupling reaction[a].**



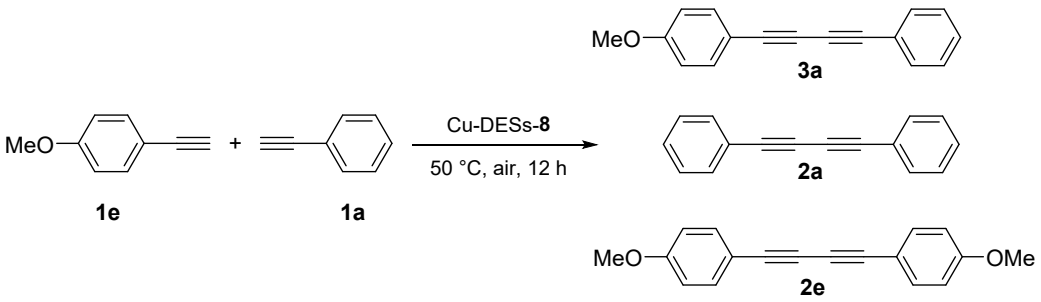
1a **2a**

Entry	DESs name	Base (equiv.)	Yield (%) [b]
1	Cu-DESs-**1**	-	3
2	Cu-DESs-**2**	-	81
3	Cu-DESs-**3**	-	99
4	Cu-DESs-**4**	-	Trace
5	Cu-DESs-**5**	-	40
6	Cu-DESs-**6**	-	53
7	Cu-DESs-**7**	-	Trace
8	Cu-DESs-**3**	DBU (2)	39
9	Cu-DESs-**3**	Na_2CO_3 (2)	11
10	Cu-DESs-**3**	K_2CO_3 (2)	46
11	Cu-DESs-**8**	-	99
12	Cu-DESs-**9**	-	84

13[c]	Cu-DESs-**8**	-	90
14[d]	Cu-DESs-**8**	-	79
15[e]	Cu-DESs-**8**	-	99
16[f]	Cu-DESs-**8**	-	82
17[g]	Cu-DESs-**8**	-	86
18[h]	Cu-DESs-**8**	-	6
19[i]	-	-	43

[a] The reaction was carried out using **1a** (0.3 mmol) in Cu-DESs (0.6 mL) at 50 ℃ for 12 h in air. [b] Isolated yields. [c] Temperature is 40 ℃. [d] Temperature is 30 ℃. [e] Reaction time is 8 h. [f] Reaction time is 5 h. [g] Under O_2 atmosphere, reaction time is 5 h. [h] Under N_2 atmosphere, reaction time is 8 h. [i] The reaction was carried out using 0.6 mL EG, 0.15 mmol $Cu(OAc)_2$, and 0.3 mmol ChCl for 8 h.

Table S2 **Optimization for the cross-coupling reaction[a].**

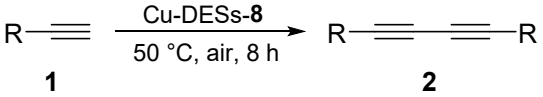


Entry	**1e** (mmol)	**1a** (mmol)	**3a** Yield (%) [b]	**2a** Yield (%) [c]	**2e** Yield (%) [d]
1	0.1	0.1	41	53	43
2	0.1	0.2	54	65	36
3	0.1	0.5	66	74	28
4[e]	0.1	0.5	82	81	13

[a] The reaction was carried out using Cu-DESs-**8** (0.6 mL) at 50 ℃ for 12 h in air; isolated yield. [b] Yields based on **1e**. [c] Yields based on **1a**. [d] Yields based on **1e**. [e] Temperature is 70 ℃.

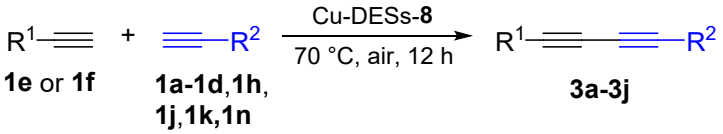
3. Experimental procedures

3.1 .General procedure for the synthesis of symmetric 1,3-diynes



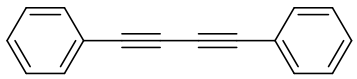
A dry schlenk tube (25 mL) with a magnetic rotor was charged with **1 (**0.3 mmol) and Cu-DESs-**8** (0.6 mL). The mixture was stirred at 50 ℃ for 8 h in air. After the reaction completed, the reaction mixture was extracted with petroleum ether (3×5 mL). The combined organic layer was dried over Na_2SO_4, concentrated under reduced pressure to afford the desired products **2**. [**2i** and **2j** were purified by flash column chromatography on silica gel (petroleum ether/methylene dichloride =30:1)].

3.2 General procedure for the synthesis of unsymmetrical 1,3-diynes.



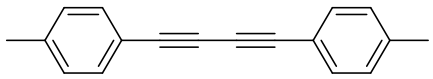
A dry schlenk tube (25 mL) with a magnetic rotor was charged with **1e**/**1f** (0.1 mmol), **1a-1d**/**1h**/**1j**/**1k**/**1n** (0.5 mmol) and Cu-DESs-**8** (0.6 mL). The mixture was stirred at 70 ℃ for 12 h in air. After the reaction completed, the reaction mixture was extracted with petroleum ether (3×5 mL). The combined organic layer was dried over Na_2SO_4, concentrated under reduced pressure. The residue was purified by flash column chromatography on silica gel (petroleum ether/methylene dichloride =40:1)] to afford **3a-3j**.

4. Characterization of products



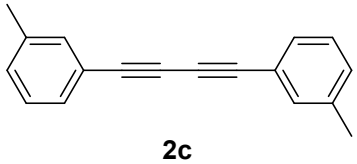
2a

1,4-diphenyl buta-1,3-diyne (2a)[1]: White solid; mp 85-86 ℃; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.59-7.56 (m, 4 H), 7.41-7.35 (m, 6 H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 132.5, 129.2, 128.4, 121.8, 81.6, 74.0.



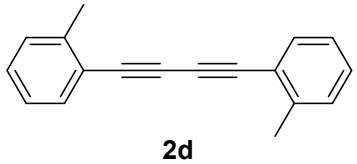
2b

1,4-bis(p-methylphenyl)buta-1,3-diyne (2b)[1]: White solid; mp 178-180 ℃; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.43 (d, J = 8.4 Hz, 4 H), 7.16 (d, J = 8.0 Hz, 4 H), 2.37 (s, 6 H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 139.5, 132.4, 129.2, 118.8, 81.6, 73.5, 21.6.



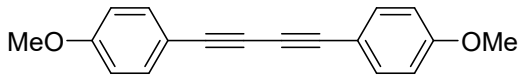
2c

1,4-bis(m-methylphenyl)buta-1,3-diyne (2c)[1]: White solid; mp 70-71 ℃; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.33-7.31 (m, 4 H), 7.22-7.15 (m, 4 H), 2.32 (s, 6 H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 138.2, 133.0, 130.2, 129.7, 128.4, 121.7, 81.7, 73.8, 21.2.



2d

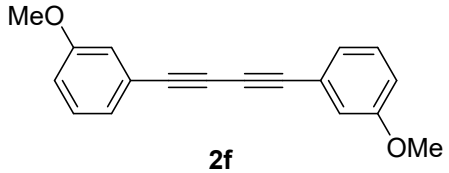
1,4-bis(o-methylphenyl)buta-1,3-diyne (2d)[2]: White solid; mp 72-73 ℃; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.50 (d, J = 7.6 Hz, 2 H), 7.27-7.20 (m, 4 H), 7.15 (t, J = 7.4 Hz, 2 H), 2.49 (s, 6 H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 141.7, 132.9, 129.6, 129.1, 125.7, 121.8, 81.2, 77.6, 20.8.



2e

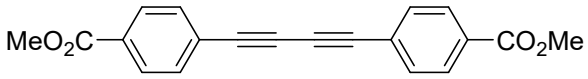
1,4-bis(p-methoxyphenyl)buta-1,3-diyne (2e)[1]: White solid; mp 139-140 ℃; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.46 (d, J = 8.8 Hz, 4 H), 6.85 (d, J = 8.8 Hz, 4 H), 3.82

(s, 6 H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 160.3, 134.1, 114.2, 114.0, 81.3, 73.0, 55.3.



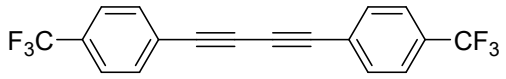
2f

1,4-bis(m-methoxyphenyl)buta-1,3-diyne (2f)[3]: White solid; mp 96-97 °C; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.24 (d, J = 8.0 Hz, 2 H), 7.12 (d, J = 8.0 Hz, 2 H), 7.04 (s, 2 H), 6.92 (d, J = 8.0 Hz, 2 H), 3.79 (s, 6 H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 159.4, 129.6, 125.1, 122.7, 117.2, 116.1, 81.6, 73.7, 55.3.



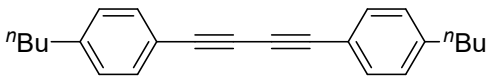
2g

1,4-bis(p-carbomethoxyphenyl)buta-1,3-diyne (2g)[4]: White solid; mp 189-191 °C; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 8.02 (d, J = 8.4 Hz, 4 H), 7.59 (d, J = 8.4 Hz, 4 H), 3.93 (s, 6 H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 166.3, 132.5, 130.6, 129.6, 126.1, 81.9, 76.3, 52.4.



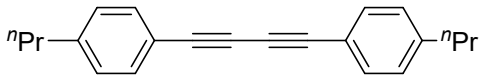
2h

1,4-bis(p-trifluoromethyl)buta-1,3-diyne (2h)[2]: Yellow solid; mp 169-170 °C; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.66-7.60 (m, 8 H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 132.8, 131.1 (q, J = 32.3 Hz), 125.5 (q, J = 4.0 Hz), 125.3, 123.7 (q, J = 272.7 Hz), 81.0, 75.6.



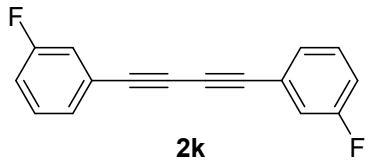
2i

1,4-bis(4-n-butylphenyl)buta-1,3-diyne (2i)[5]: Yellow solid; mp 111-113 °C; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.44 (d, J = 8.0 Hz, 4 H), 7.15 (d, J = 8.0 Hz, 4 H), 2.62 (t, J = 7.6 Hz, 4 H), 1.63-1.56 (m, 4 H), 1.40-1.31(m, 4 H), 0.93 (t, J = 7.4 Hz, 6 H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 144.5, 132.4, 128.6, 119.0, 81.6, 73.5, 35.7, 33.3, 22.3, 13.9.



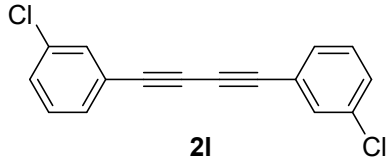
2j

1,4-bis(4-n-propylphenyl)buta-1,3-diyne (2j)[1]: Yellow solid; mp 105-107 ℃; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.44 (d, J = 8.0 Hz, 4 H), 7.14 (d, J = 8.0 Hz, 4 H), 2.59 (t, J = 7.6 Hz, 4 H), 1.67-1.61 (m, 4 H), 0.94 (t, J = 7.4 Hz, 4 H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 144.3, 132.4, 128.6, 119.1, 81.6, 73.5, 38.1, 24.3, 13.8.



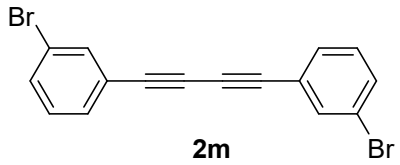
2k

1,4-bis(3-fluorophenyl)buta-1,3-diyne (2k)[6]: White solid; mp 118-120 ℃; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.31-7.29 (m, 4 H), 7.21 (d, J = 7.2 Hz, 2 H), 7.11-7.06 (m, 2 H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 162.3 (d, J = 242.4 Hz), 130.1 (d, J = 9.1 Hz), 128.5 (d, J = 4.0 Hz), 123.4 (d, J = 10.1 Hz), 119.2 (d, J = 23.2 Hz), 116.9 (d, J = 21.2 Hz), 80.7 (d, J = 3.0 Hz), 74.5.



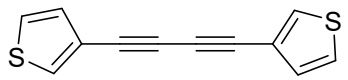
2l

1,4-bis(3-chlorophenyl)buta-1,3-diyne (2l) [6]: White solid; mp 74-76 ℃; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.50-7.49 (m, 2 H), 7.41-7.39 (m, 2 H), 7.35 (ddd, J = 8.0, 2.4, 1.2 Hz, 2 H), 7.29-7.25 (m, 2 H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 134.4, 132.3, 130.7, 129.7, 123.3, 80.6, 74.7.



2m

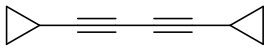
1,4-bis(3-bromophenyl)buta-1,3-diyne (2m)[7]: White solid; mp 95-97 ℃; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.67-7.66 (m, 2 H), 7.51 (ddd, J = 8.0, 2.0, 1.2 Hz, 2 H), 7.46-7.44 (m, 2 H), 7.23-7.20 (m, 2 H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 135.2, 132.6, 131.1, 129.9, 123.6, 122.3, 80.5, 74.8.



2n

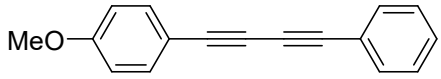
1,4-bis(3-thienyl)buta-1,3-diyne (2n)[5]: White solid; mp 110-112 ℃; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.59 (dd, J = 3.2, 1.2 Hz, 2 H), 7.28 (dd, J = 5.2, 3.0 Hz, 2 H), 7.17 (dd, J = 4.8, 1.2 Hz, 2 H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 131.2, 130.2, 125.6, 120.9,

76.6, 73.6.



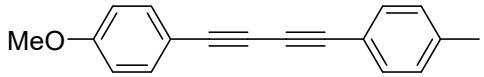
2o

1,4-dicyclopropylbuta-1,3-diyne (2o)[2]: Colorless oil; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 1.31-1.25 (m, 2 H), 0.79-0.71 (m, 8 H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 80.1, 60.8, 8.7, 0.1.



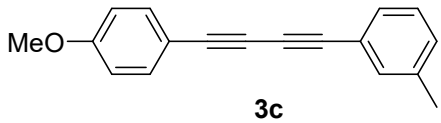
3a

1-methoxy-4-(phenylbuta-1,3-diyn-1-yl) benzene (3a)[1]: White solid; mp 97-98 ℃; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.52 (d, J = 7.6 Hz, 2 H), 7.47 (d, J = 8.8 Hz, 2 H), 7.37-7.31 (m, 3 H), 6.86 (d, J = 8.4 Hz, 2 H), 3.83 (s, 3 H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 160.4, 134.2, 132.5, 129.0, 128.4, 122.0, 114.2, 113.7, 81.8, 81.0, 74.2, 72.8, 55.4.



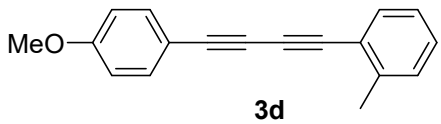
3b

1-((4-methoxyphenyl)buta-1,3-diynyl)-4-methylbenzene (3b)[1]: White solid; mp 141-143 ℃; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.47 (d, J = 8.8 Hz, 2 H), 7.41 (d, J = 8.4 Hz, 2 H), 7.14 (d, J = 8.4 Hz, 2 H), 6.86 (d, J = 8.8 Hz, 2 H), 3.82 (s, 3 H), 2.37 (s, 3 H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 160.3, 139.4, 134.1, 132.4, 129.2, 118.9, 114.2, 113.9, 81.5, 81.3, 73.6, 72.9, 55.4, 21.6.



3c

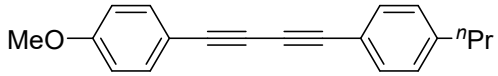
1-(4-methoxyphenyl)-4-(*m*-toluenyl)buta-1,3-diyne (3c)[1]: White solid; mp 63-64 ℃; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.47 (d, J = 8.8 Hz, 2 H), 7.34-7.31 (m, 2 H), 7.24-7.16 (m, 2 H), 6.86 (d, J = 8.8 Hz, 2 H), 3.82 (s, 3 H), 2.33 (s, 3 H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 160.4, 138.2, 134.1, 133.0, 130.0, 129.6, 128.3, 121.8, 114.2, 113.8, 81.6, 81.3, 73.8, 72.8, 55.4, 21.2.



3d

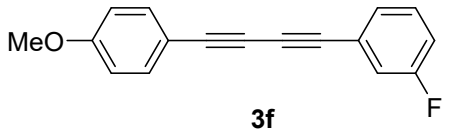
1-(4-methoxyphenyl)-4-(*o*-toluenyl)buta -1,3-diyne (3d)[8]: White solid; mp 62-64 ℃;

^{1}H NMR (400 MHz, $CDCl_3$): δ 7.48 (d, J = 8.0 Hz, 3 H), 7.27-7.13 (m, 3 H), 6.86 (d, J = 8.0 Hz, 2 H), 3.83 (s, 3 H), 2.49 (s, 3 H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 160.3, 141.6, 134.1, 132.9, 129.6, 129.0, 125.7, 121.8, 114.2, 113.8, 82.3, 80.1, 77.7, 72.8, 55.4, 20.8.



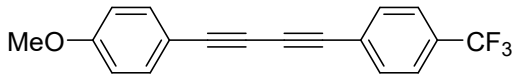
3e

1-Propyl-4-((4-methoxyphenyl)buta-1,3-diynyl)benzene (3e)[1]: Yellow solid; mp 90-92 °C; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.48-7.42 (m, 4 H), 7.14 (d, J = 7.6 Hz, 2 H), 6.86 (d, J = 8.4 Hz, 2 H), 3.83 (s, 3 H), 2.59 (t, J = 7.6 Hz, 2 H), 1.66-1.61 (m, 2 H), 0.94 (t, J = 7.6 Hz, 3 H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 160.3, 144.2, 134.1, 132.4, 128.6, 119.1, 114.2, 113.9, 81.5, 81.4, 73.5, 72.9, 55.4, 38.1, 24.3, 13.8.



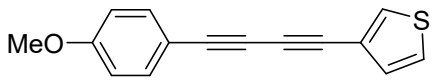
3f

1-fluoro-3-((4-methoxyphenyl)buta-1,3-diyn-1-yl)benzene (3f)[9]: Yellow solid; mp 61-62 °C; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.48 (d, J = 8.8 Hz, 2 H), 7.31-7.30 (m, 2 H), 7.20 (d, J = 8.8 Hz, 1 H), 7.09-7.04 (m, 1 H), 6.87 (d, J = 8.4 Hz, 2 H), 3.83 (s, 3 H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 162.3 (d, J = 245.8 Hz) 160.5, 134.2, 130.1 (d, J = 8.1 Hz), 128.4 (d, J = 3.0 Hz), 123.9 (d, J = 9.1 Hz), 119.2, 119.0, 116.4, 114.2, 113.4, 82.5, 79.6, 75.1, 72.4, 55.4.



3g

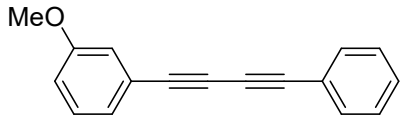
1-(4-methoxyphenyl)-4-(4-trifluorophenyl)buta-1,3-diyne (3g)[1]: Yellow solid; mp 142-143 °C; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.63-7.57 (m, 4 H), 7.49 (d, J = 8.8 Hz, 2 H), 6.87 (d, J = 8.8 Hz, 2 H), 3.83 (s, 3 H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 160.7, 134.3, 132.6, 130.6 (q, J = 33.3 Hz), 126.0, 125.4 (q, J = 4.0 Hz), 123.8 (q, J = 272.7 Hz), 114.3, 113.3, 83.2, 79.3, 76.6, 72.3, 55.4.



3h

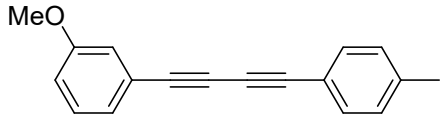
3-((4-methoxyphenyl)buta-1,3-diyn-1-yl)thiophene (3h)[8]: Yellow solid; mp 84-86 °C; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.57 (dd, J = 3.2, 1.2 Hz, 1 H), 7.46 (d, J = 9.2 Hz,

2 H), 7.27 (dd, J = 4.8, 2.8 Hz, 1 H), 7.17 (dd, J = 5.2, 1.2 Hz, 1 H), 6.85 (d, J = 9.2 Hz, 2 H), 3.82 (s, 3 H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 160.4, 134.1, 131.0, 130.2, 125.5, 121.1, 114.2, 113.7, 81.6, 76.2, 73.8, 72.7, 55.4.



3i

1-methoxy-3-(phenylbuta-1,3-diyn-1-yl)benzene (3i)[9]: White solid; mp 61-62 ℃; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.54-7.52 (m, 2 H), 7.38-7.31 (m, 3 H), 7.26-7.22 (m, 1 H), 7.13 (d, J = 7.6 Hz, 1 H), 7.05 (s, 1 H), 6.94-6.92 (m, 1 H); 3.81 (s, 3 H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 159.3, 132.5, 129.6, 129.2, 128.5, 125.1, 122.8, 121.8, 117.1, 116.1, 81.6, 81.5, 73.9, 73.7, 55.3.



3j

1-methoxy-3-(p-tolylbuta-1,3-diyn-1-yl)benzene (3j)[9]: White solid; mp 76-78 ℃; **^{1}H NMR** (400 MHz, $CDCl_3$): δ 7.42 (d, J = 8.0 Hz, 2 H), 7.23 (d, J = 8.0 Hz, 1 H), 7.15-7.11 (m, 3 H), 7.04 (s, 1 H), 6.92 (ddd, J = 8.0, 2.4, 1.2 Hz, 1 H), 3.80 (s, 3 H), 2.37 (s, 3 H); **^{13}C NMR** (101 MHz, $CDCl_3$): δ 159.3, 139.7, 132.5, 129.5, 129.3, 125.1, 122.9, 118.7, 117.1, 116.0, 81.9, 81.2, 73.9, 73.3, 55.3, 21.6.

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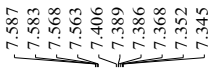
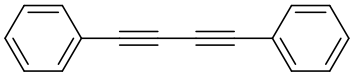
6. NMR Spectra

^{1}H NMR, 400 MHz, $CDCl_3$





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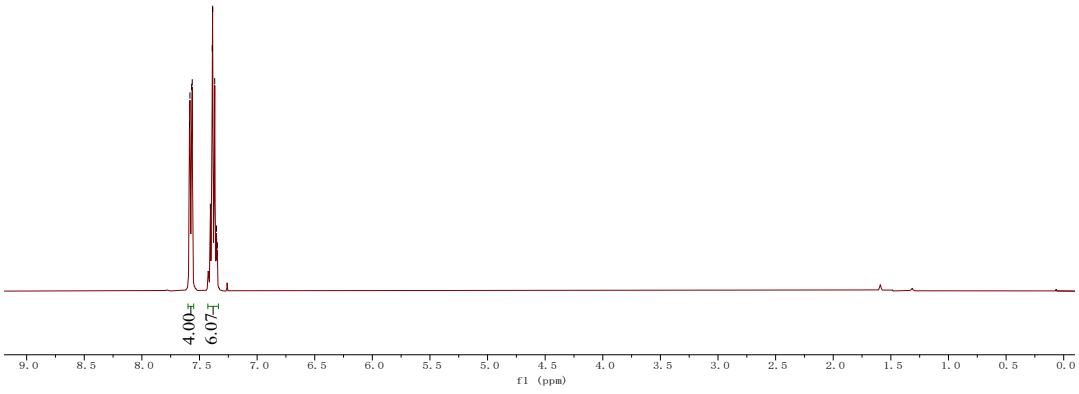
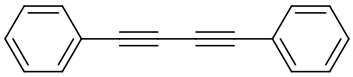


^{13}C NMR, 101 MHz, $CDCl_3$



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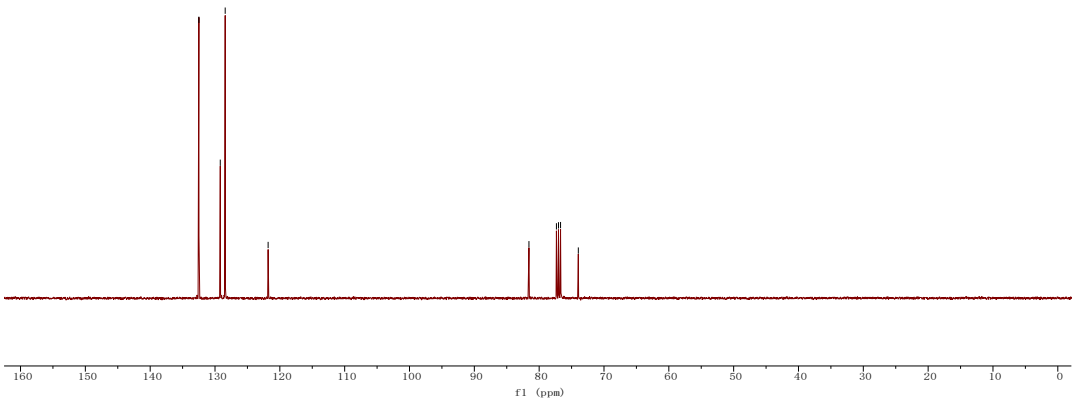
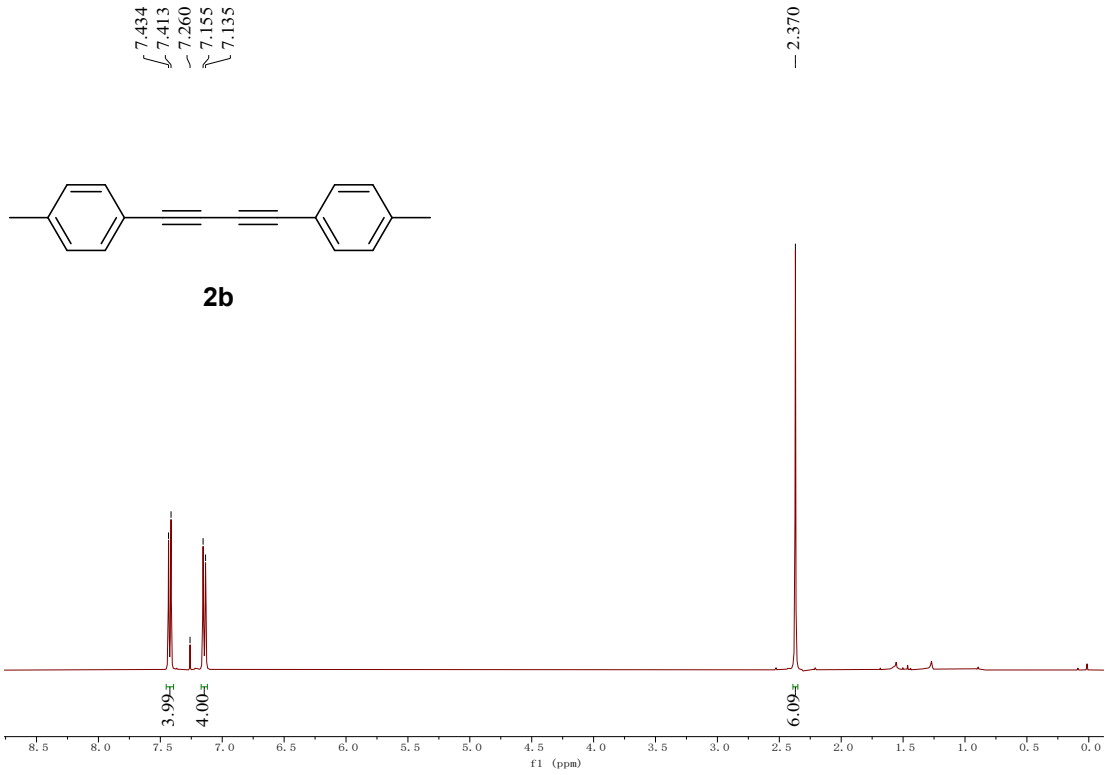


^{1}H NMR, 400 MHz, $CDCl_3$



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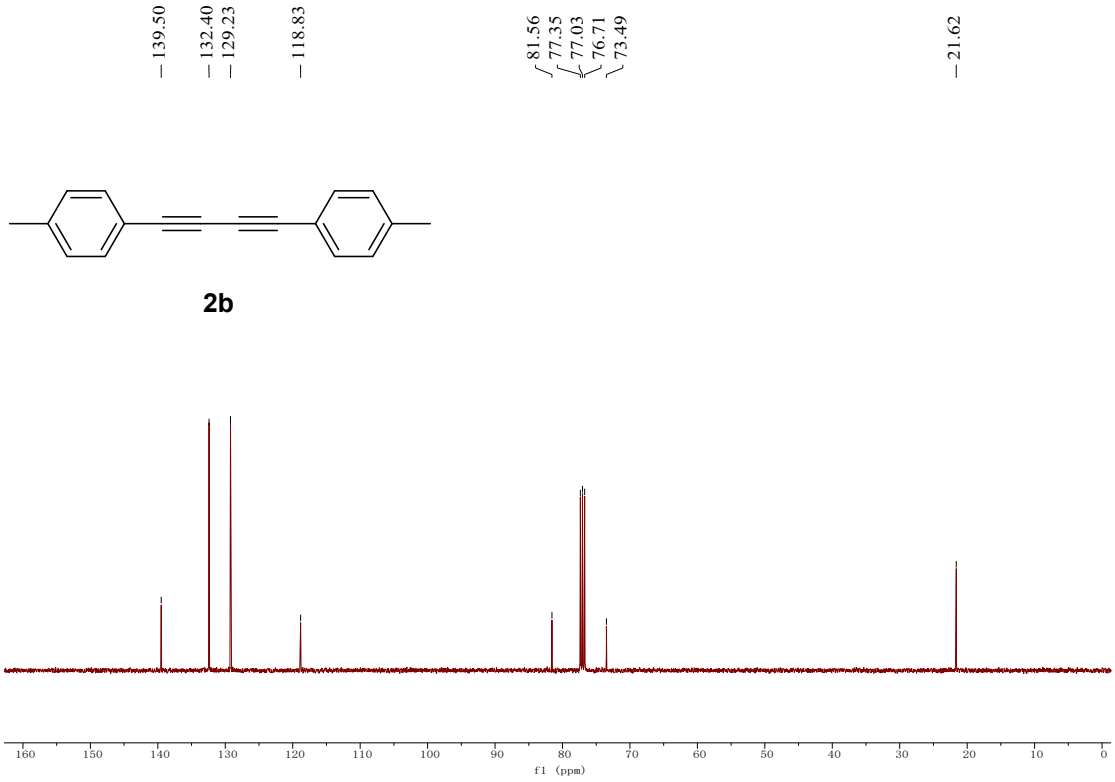

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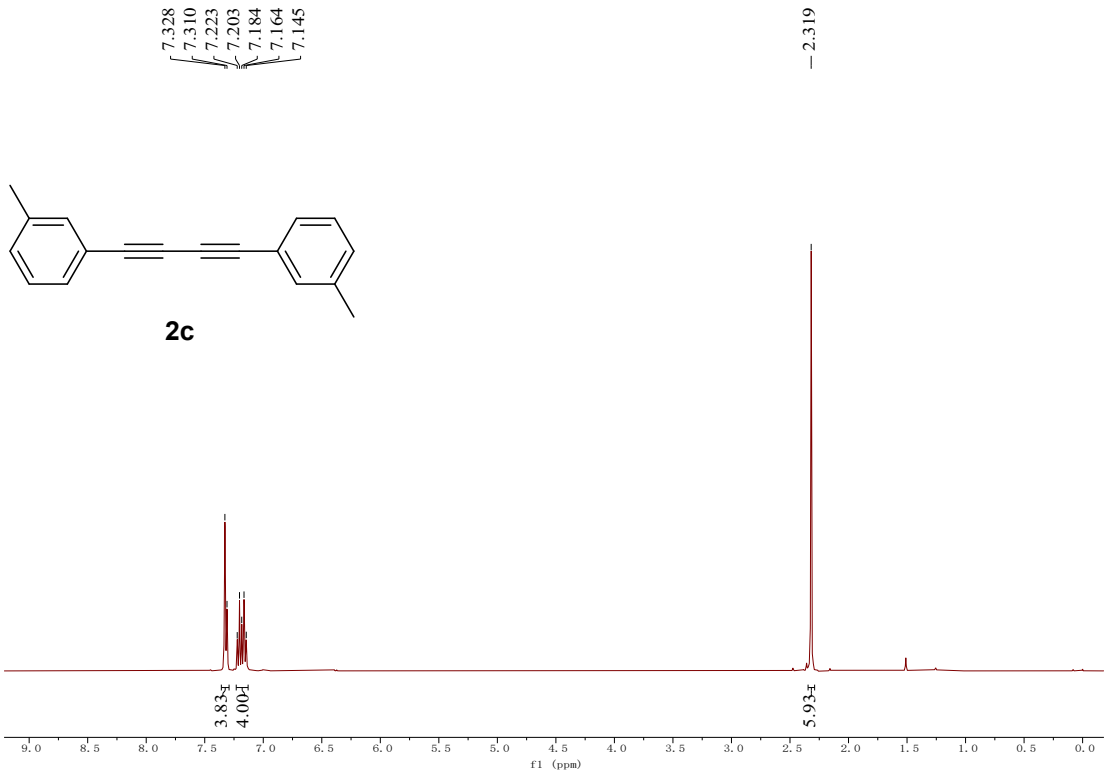

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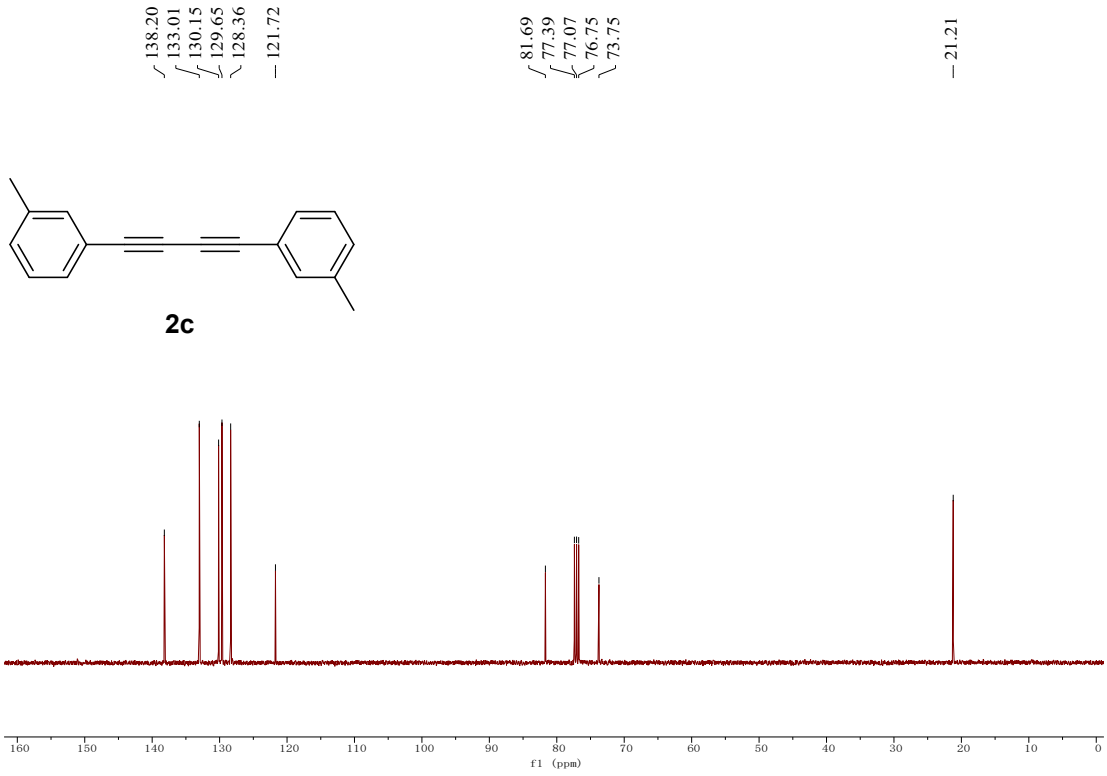

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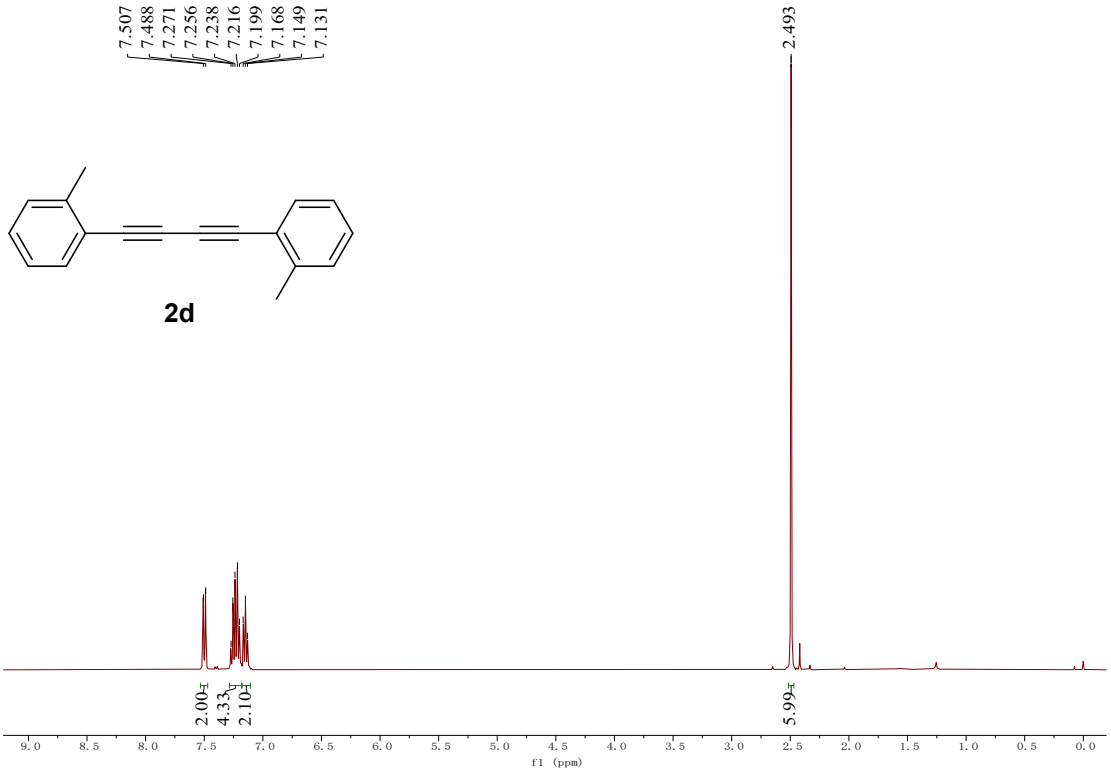

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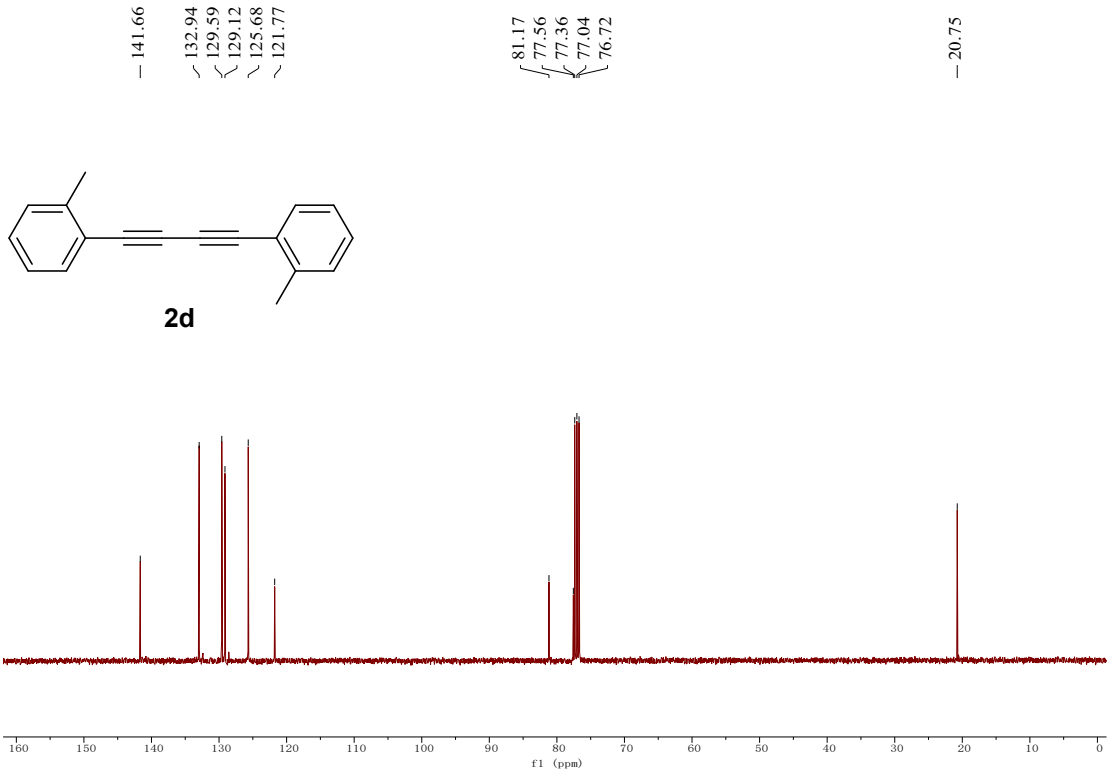

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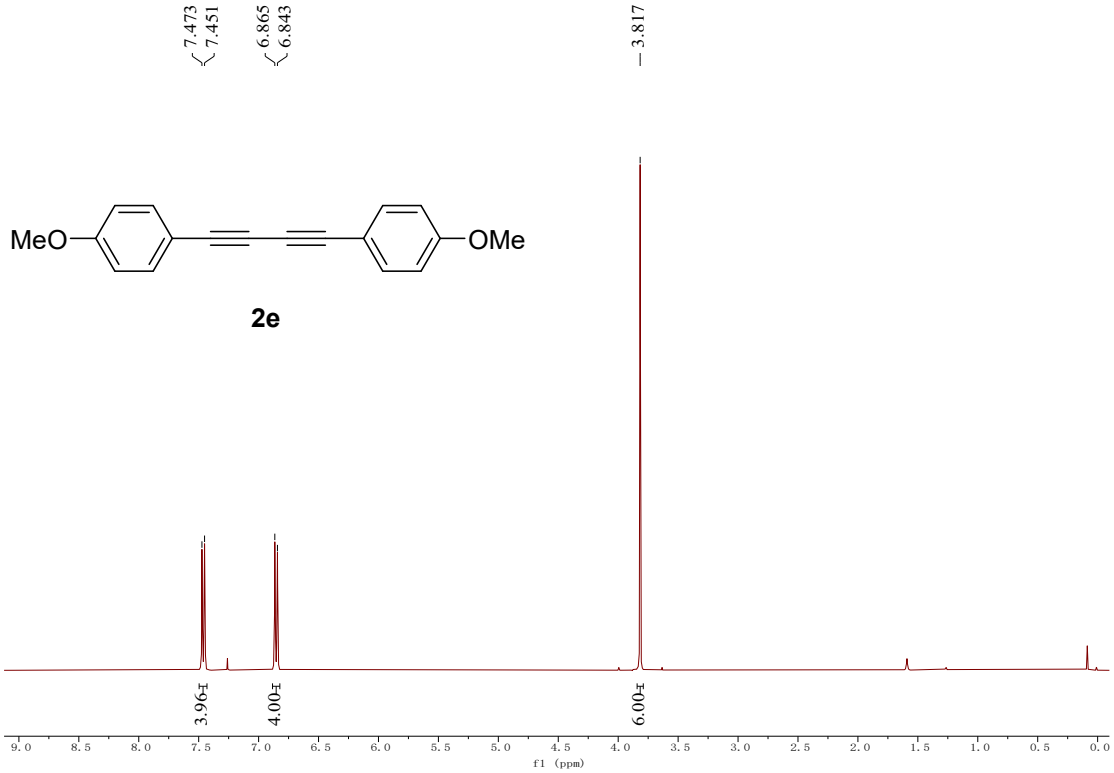

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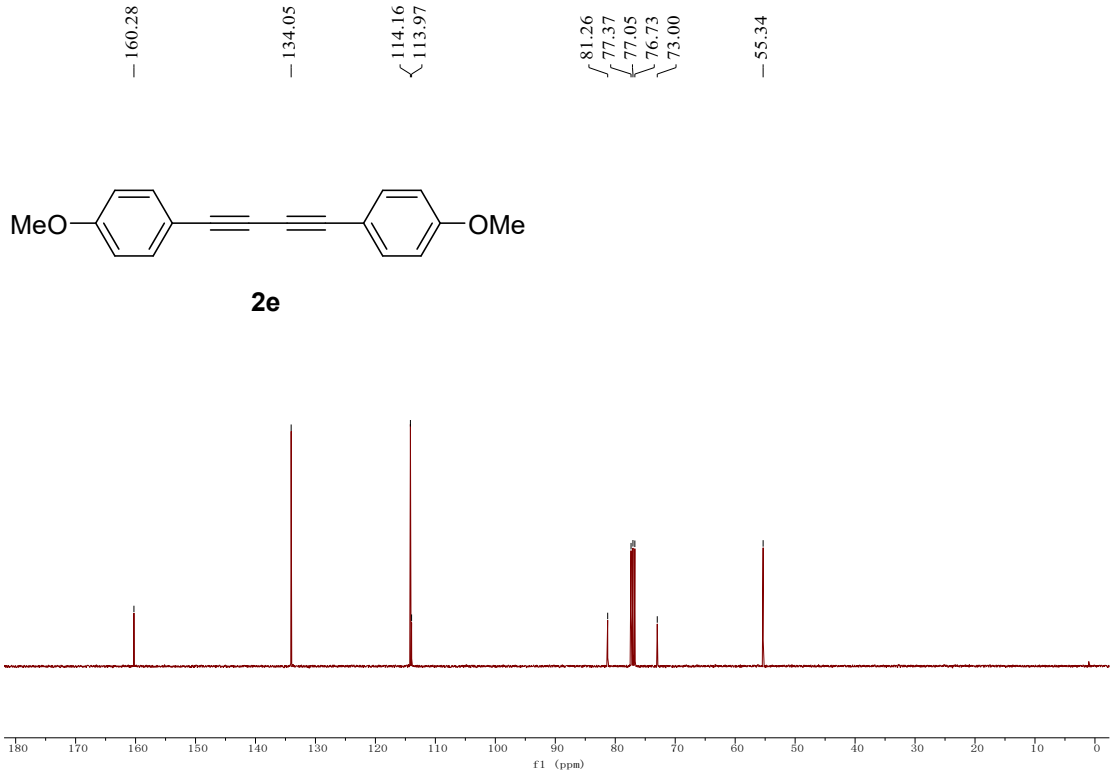

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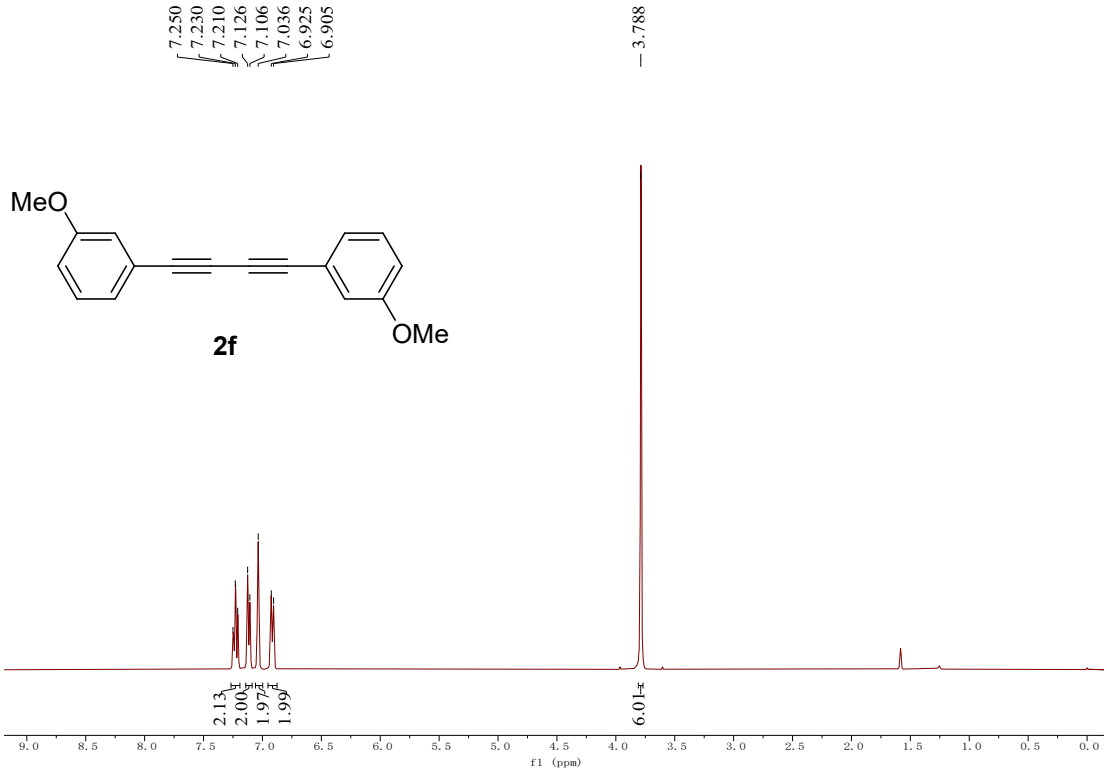

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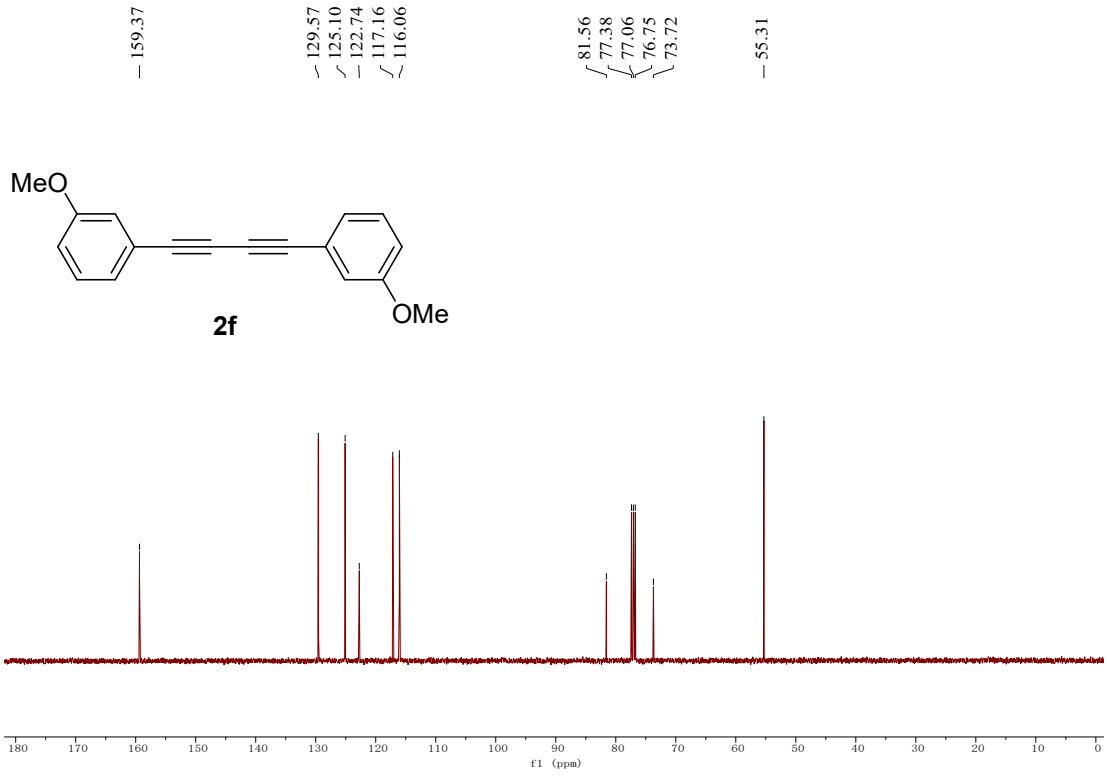

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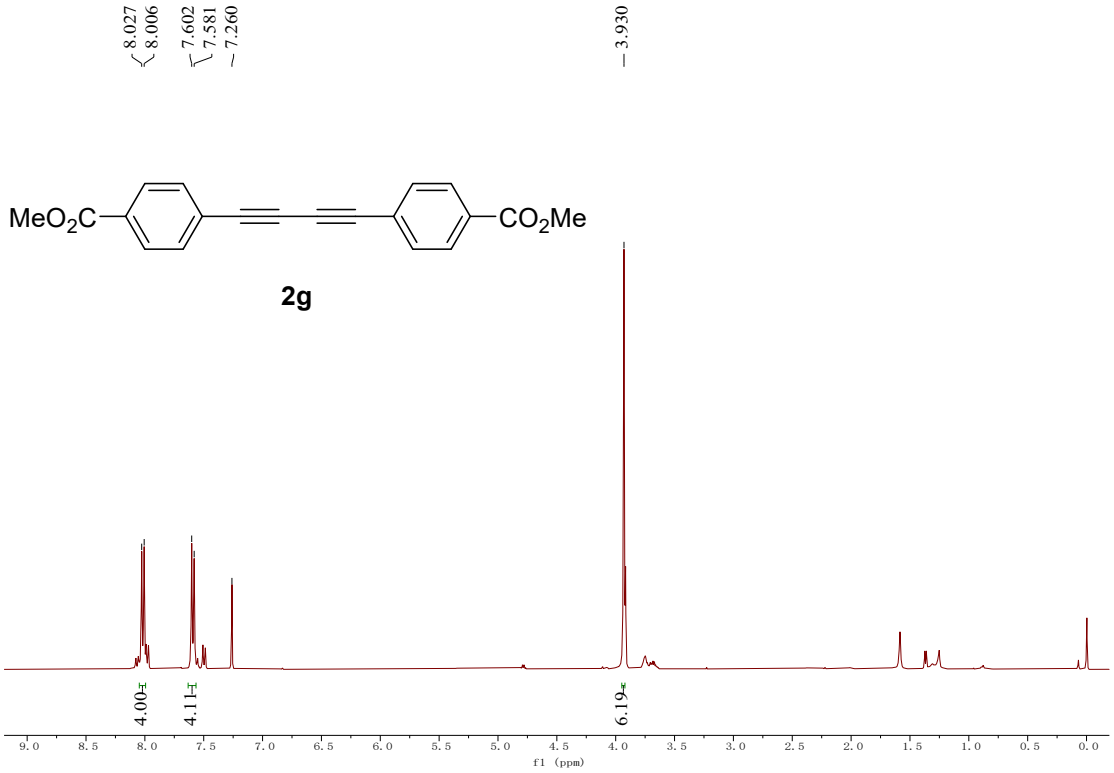

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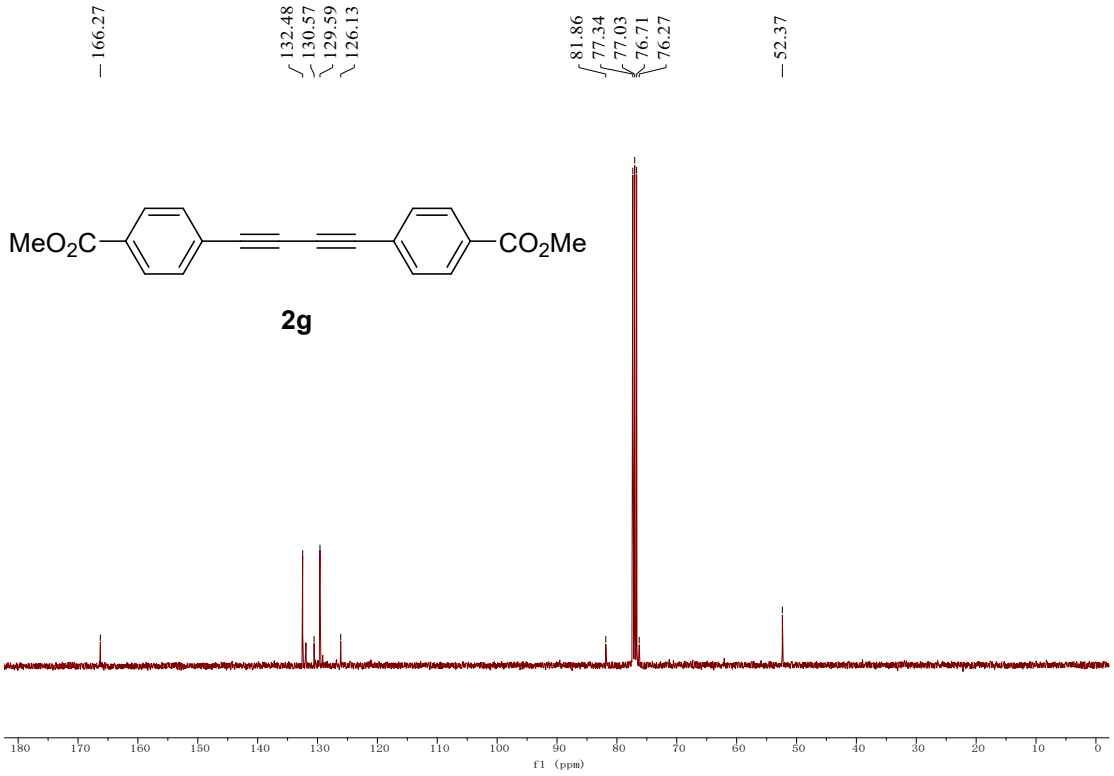

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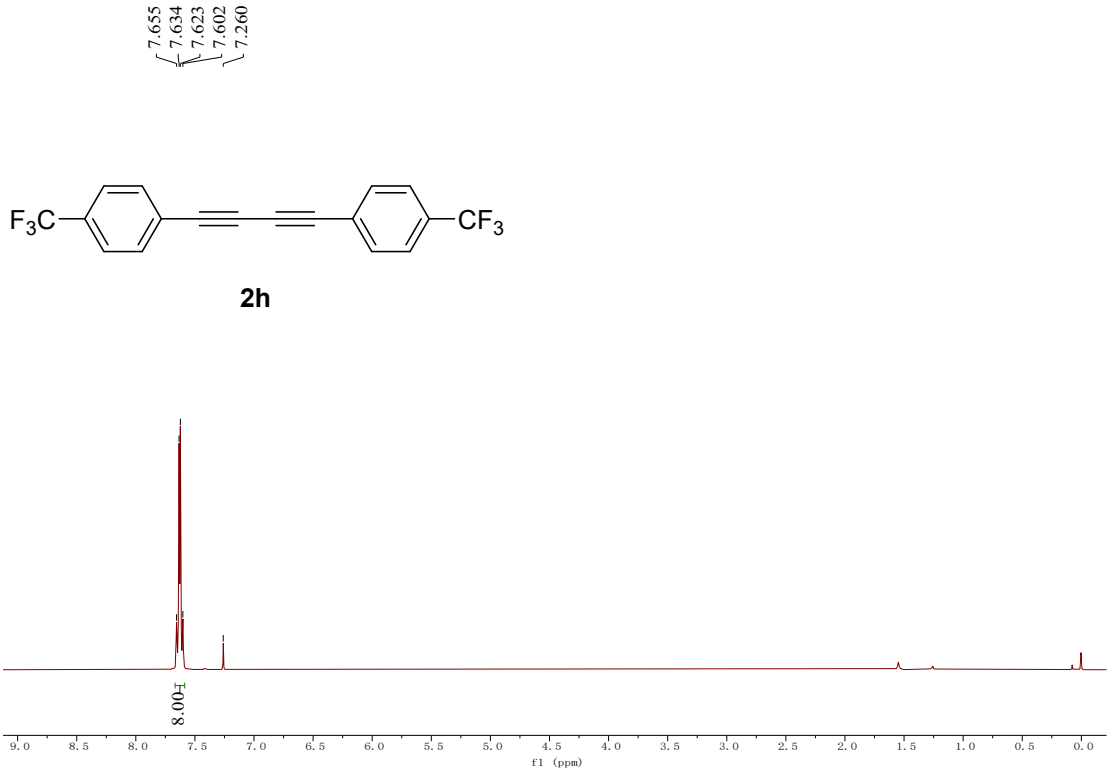

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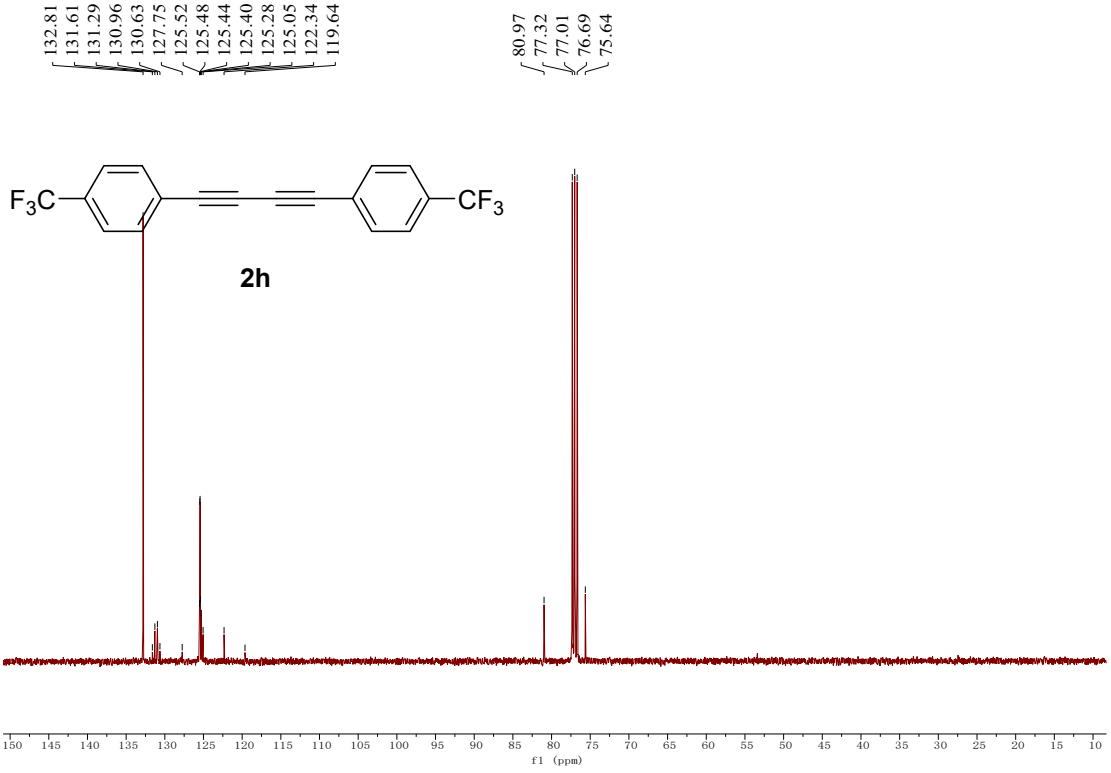

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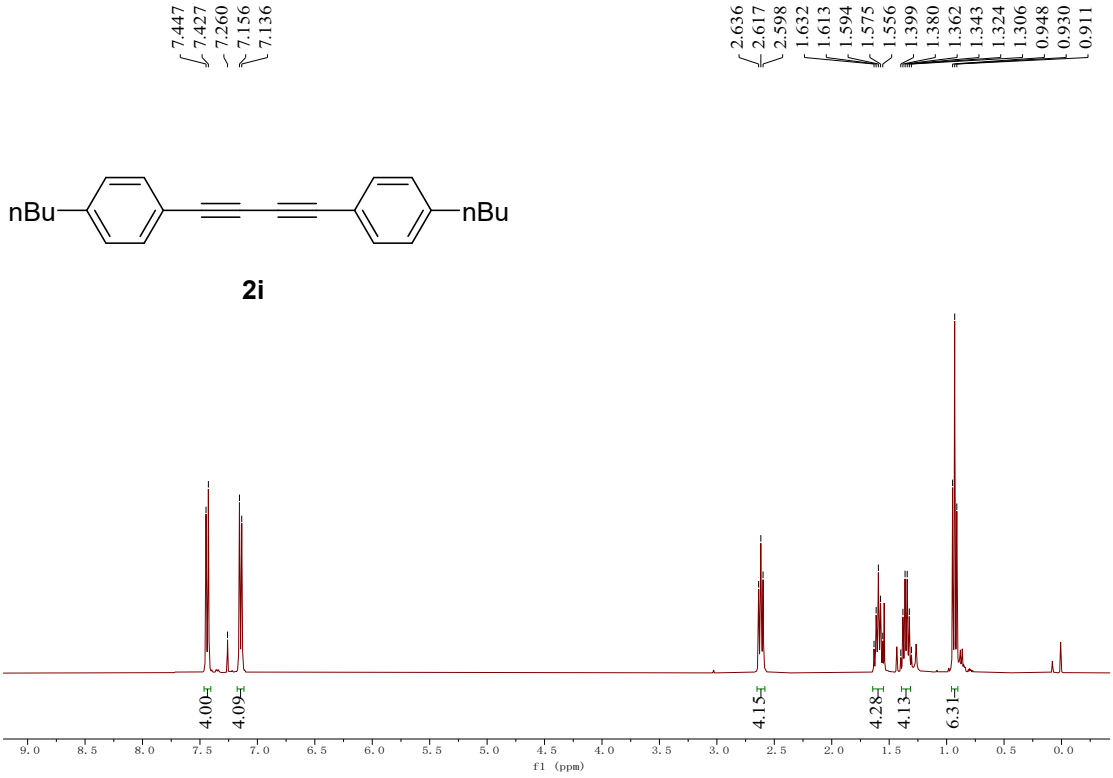

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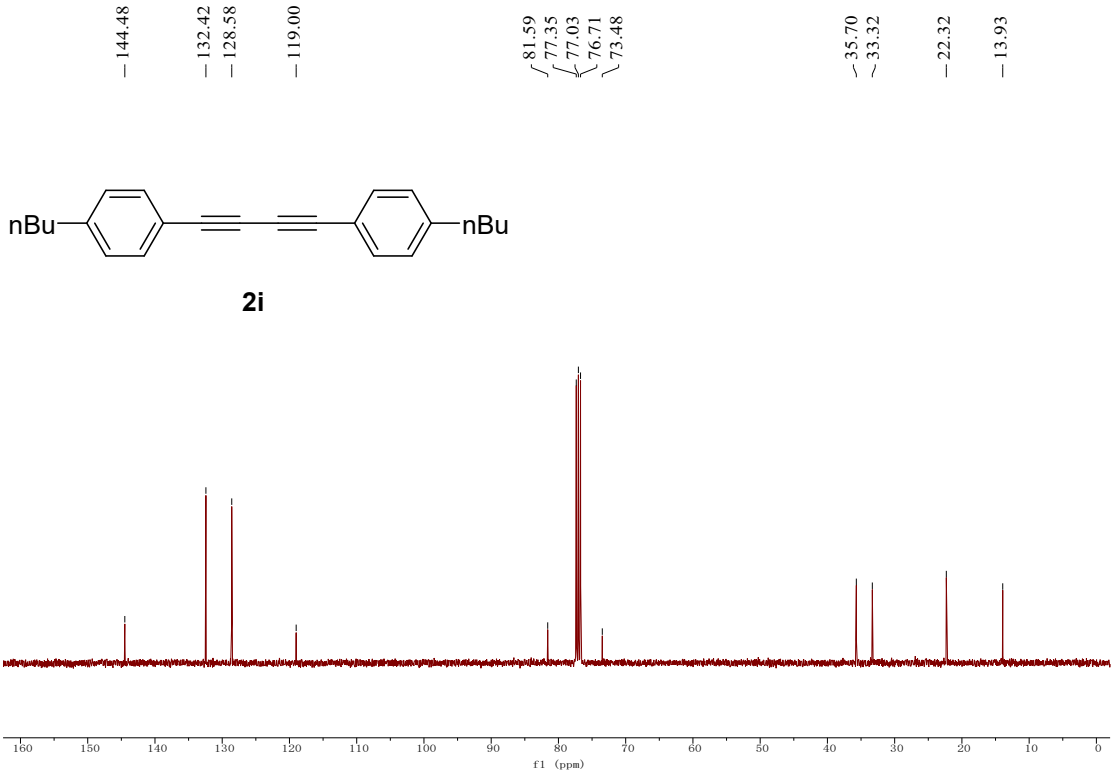

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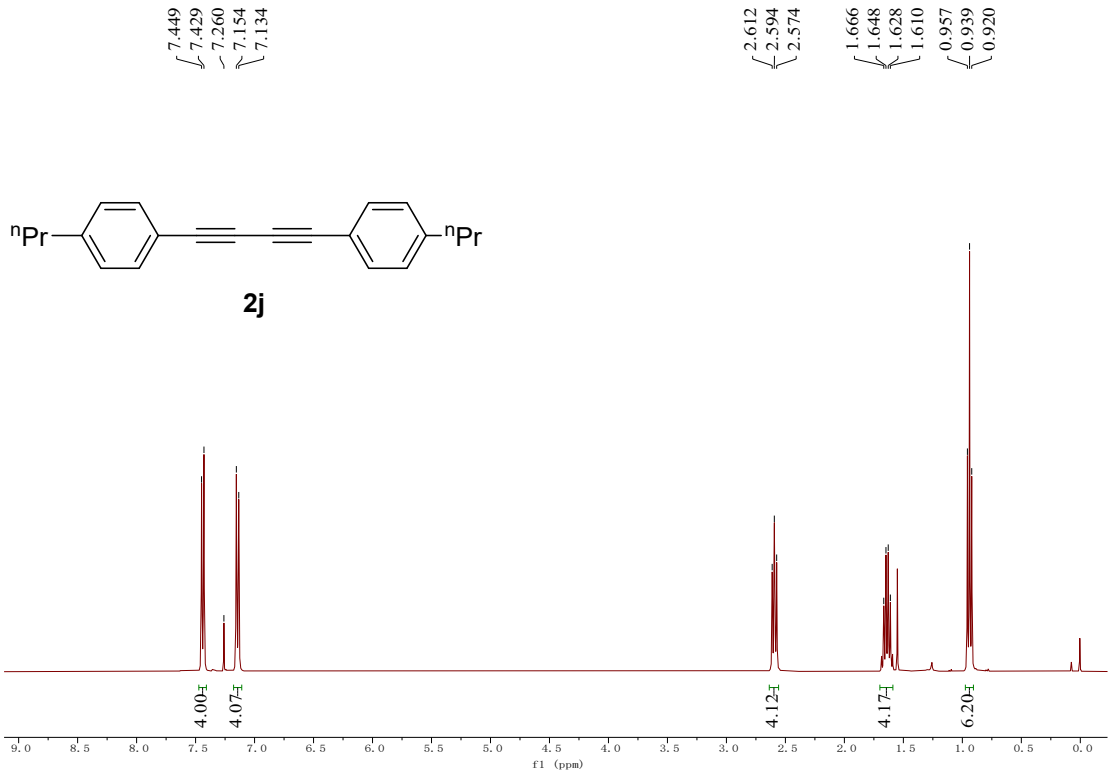

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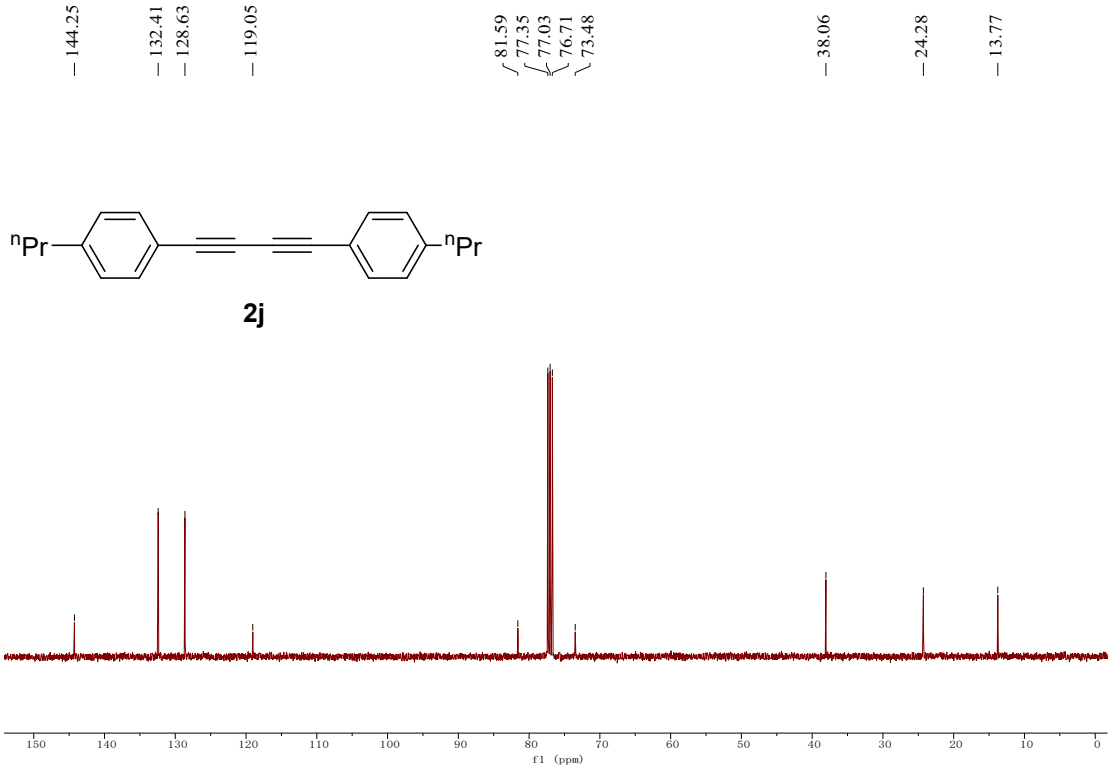

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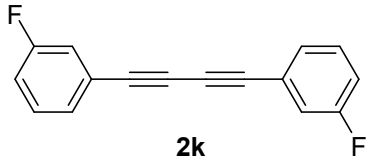

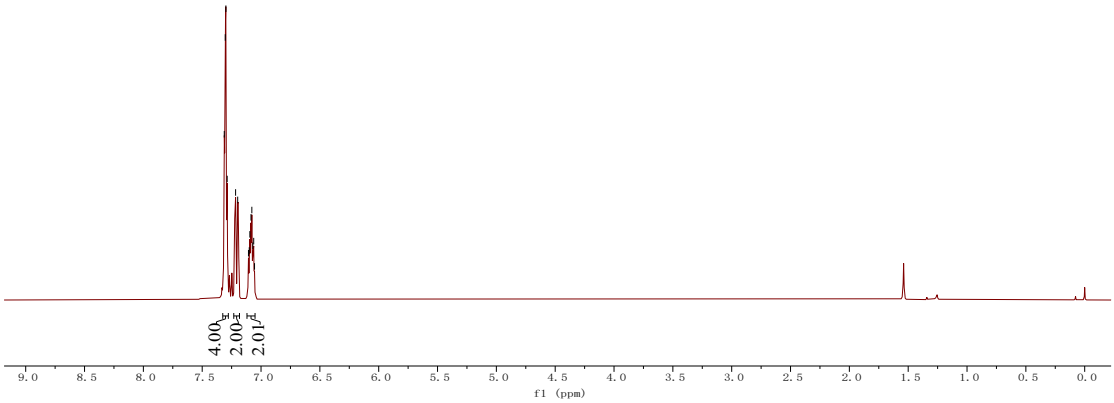

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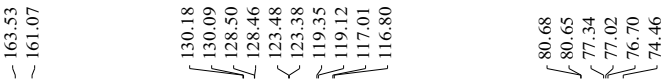

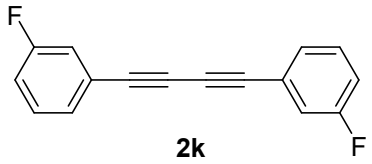

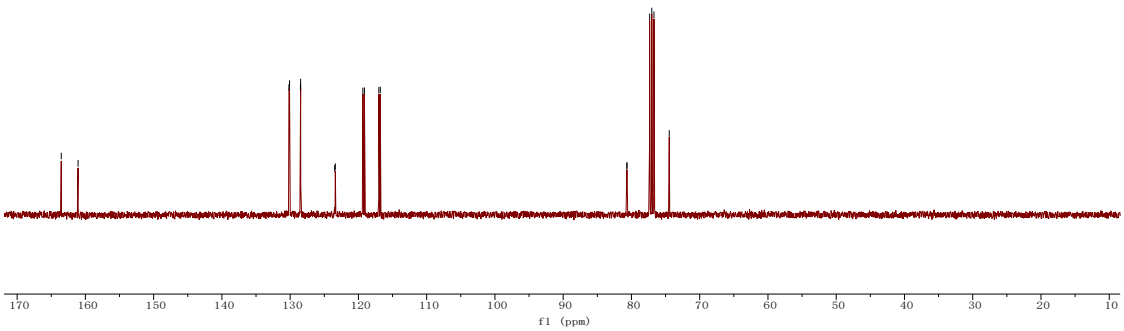

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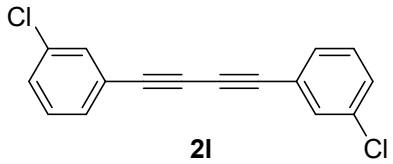

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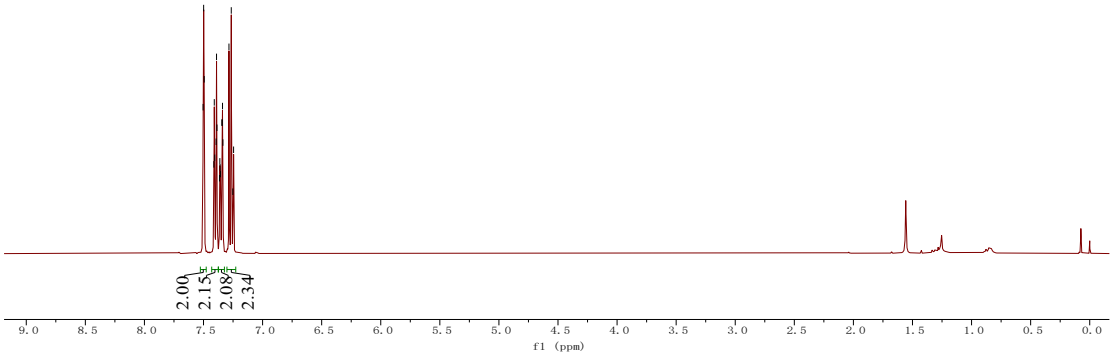

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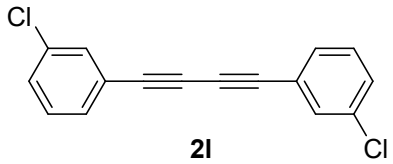

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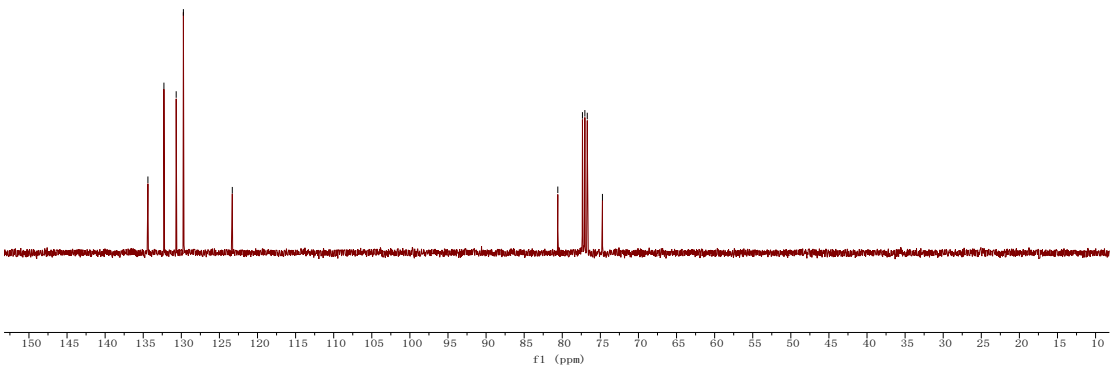

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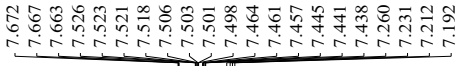

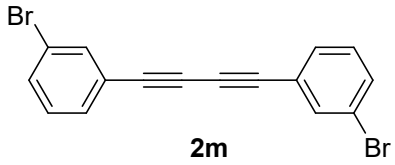

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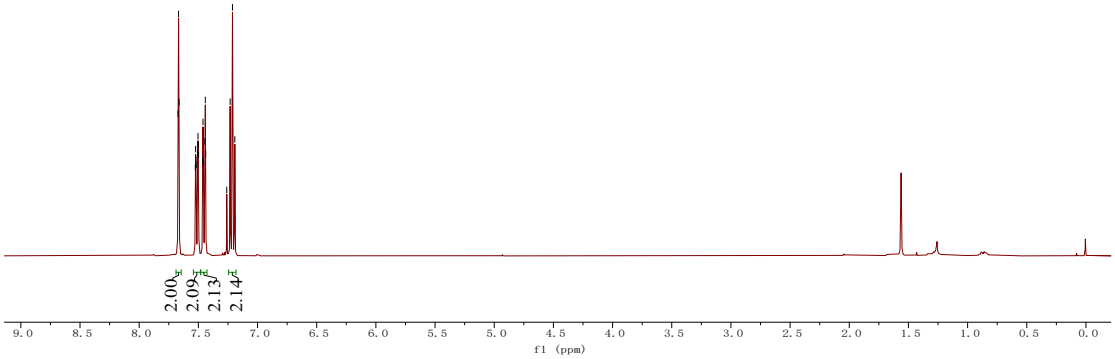

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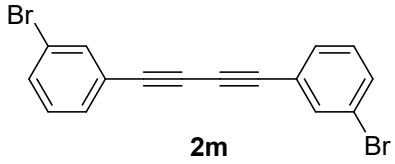

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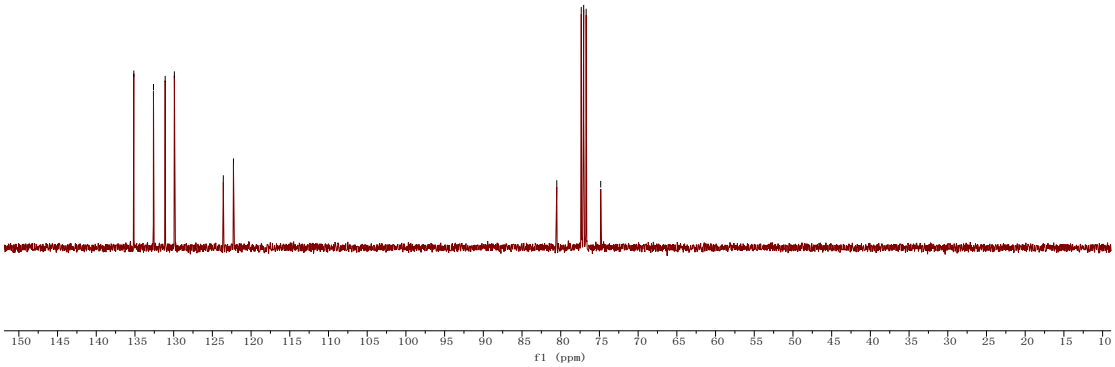
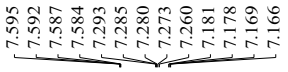
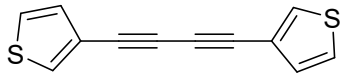
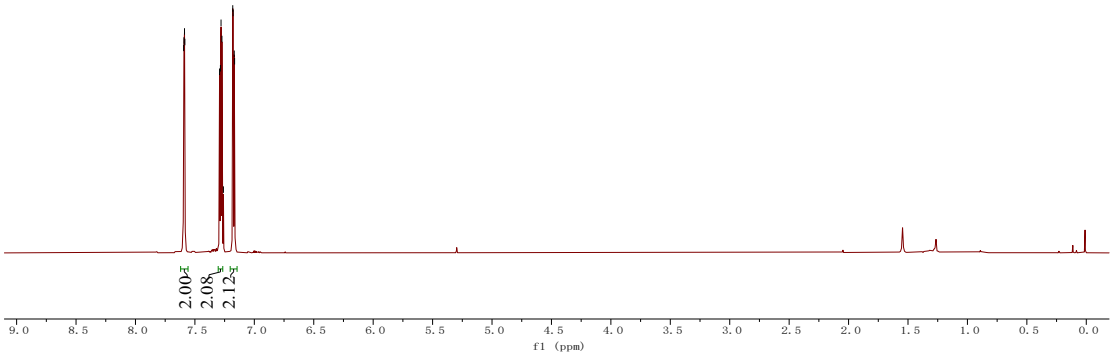


^{1}H NMR, 400 MHz, $CDCl_3$

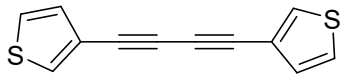




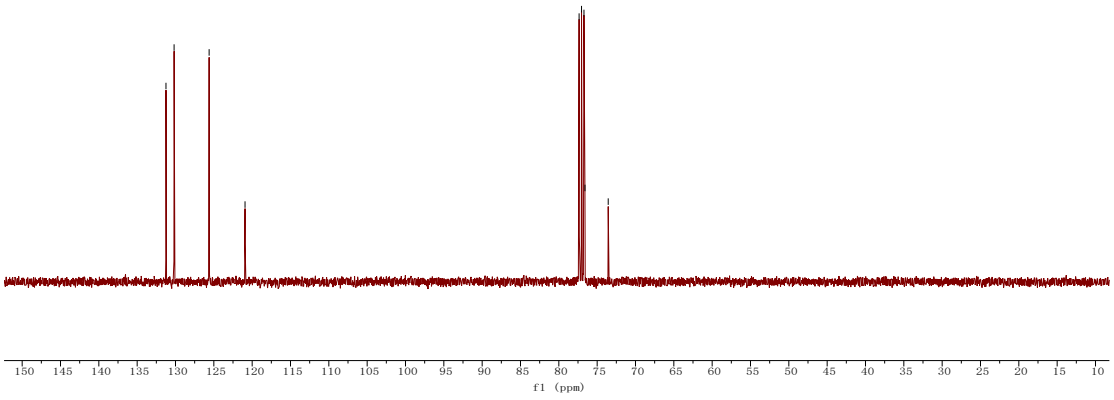
2n



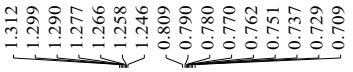
^{13}C NMR, 101 MHz, $CDCl_3$

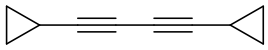


2n

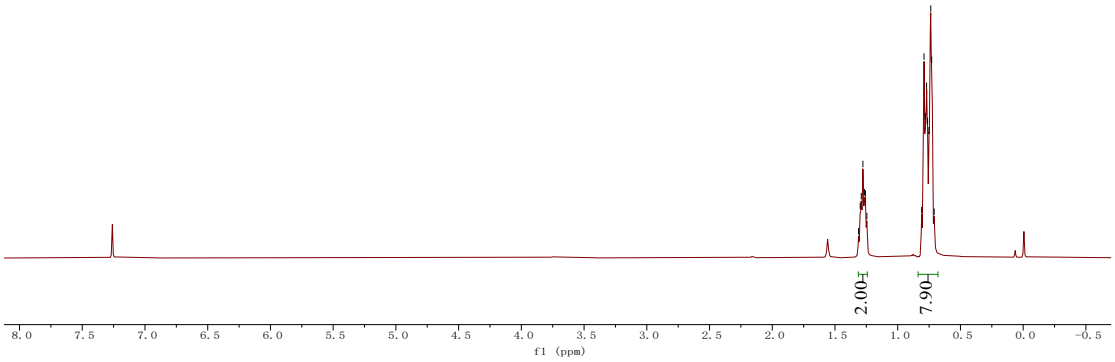


^{1}H NMR, 400 MHz, $CDCl_3$

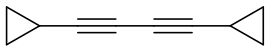




2o



^{13}C NMR, 101 MHz, $CDCl_3$



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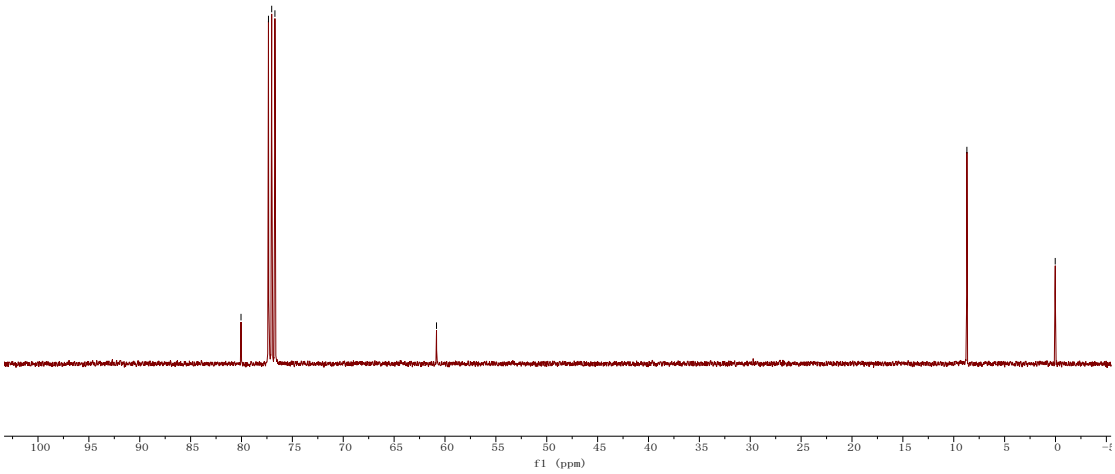
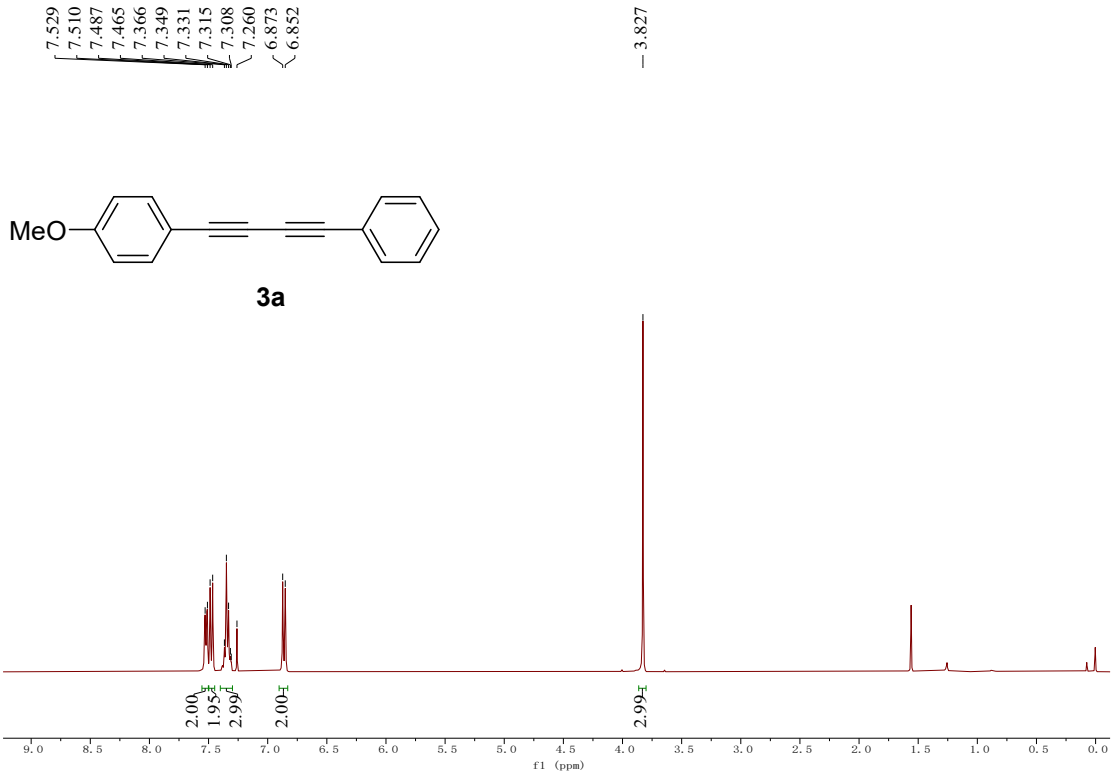
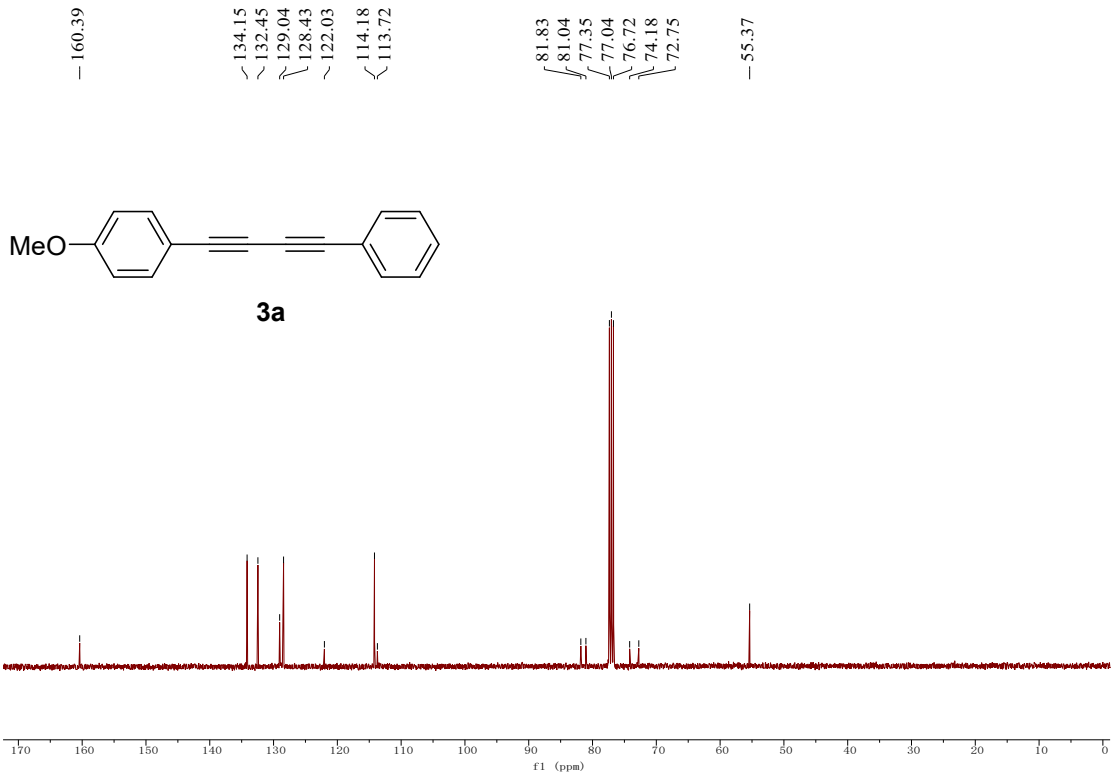


^{1}H NMR, 400 MHz, $CDCl_3$



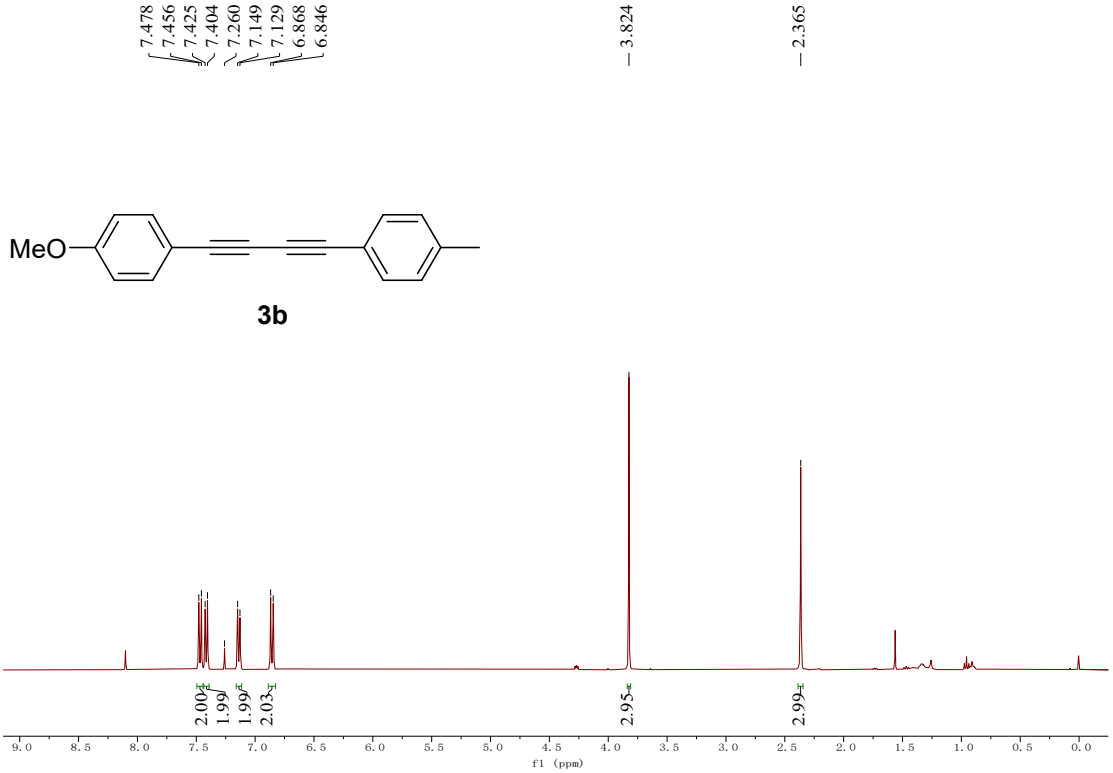
3a

^{13}C NMR, 101 MHz, $CDCl_3$

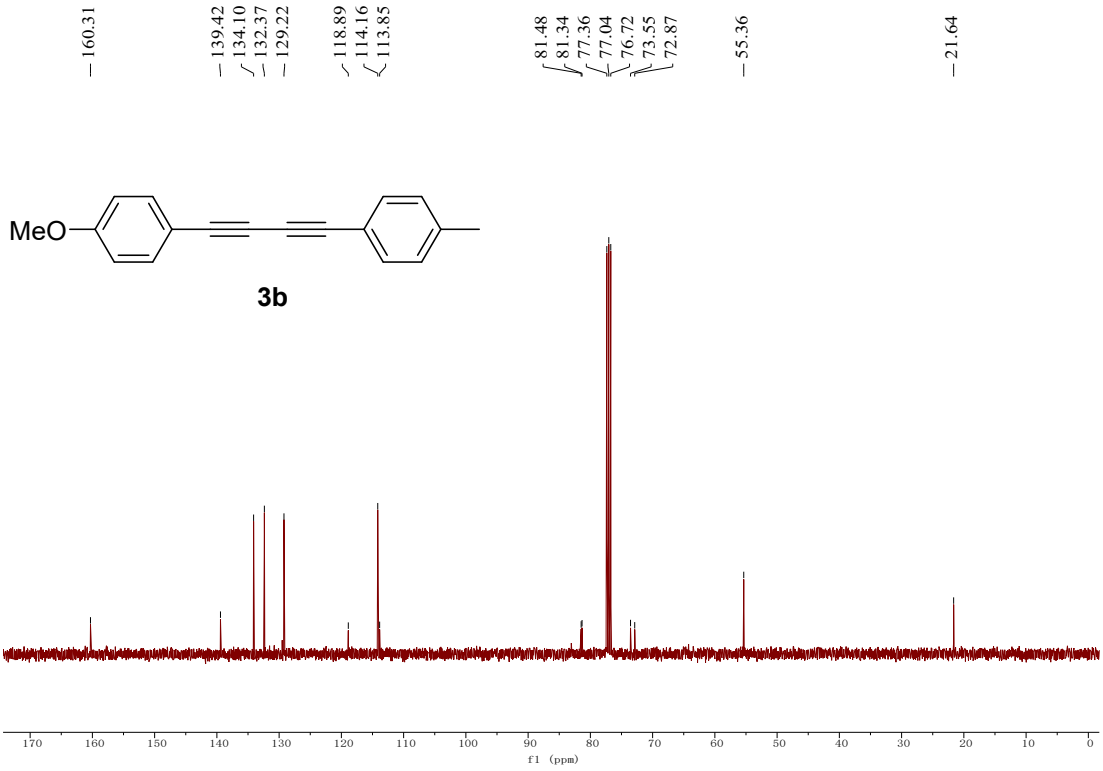


3a

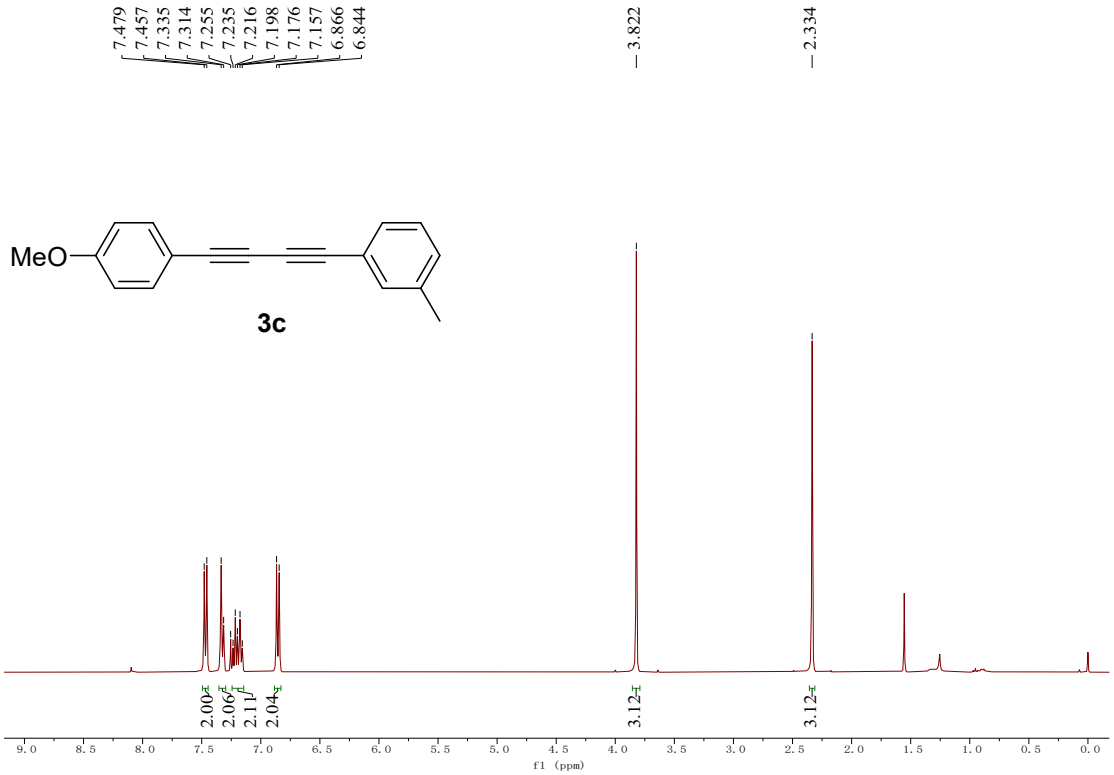
^{1}H NMR, 400 MHz, $CDCl_3$



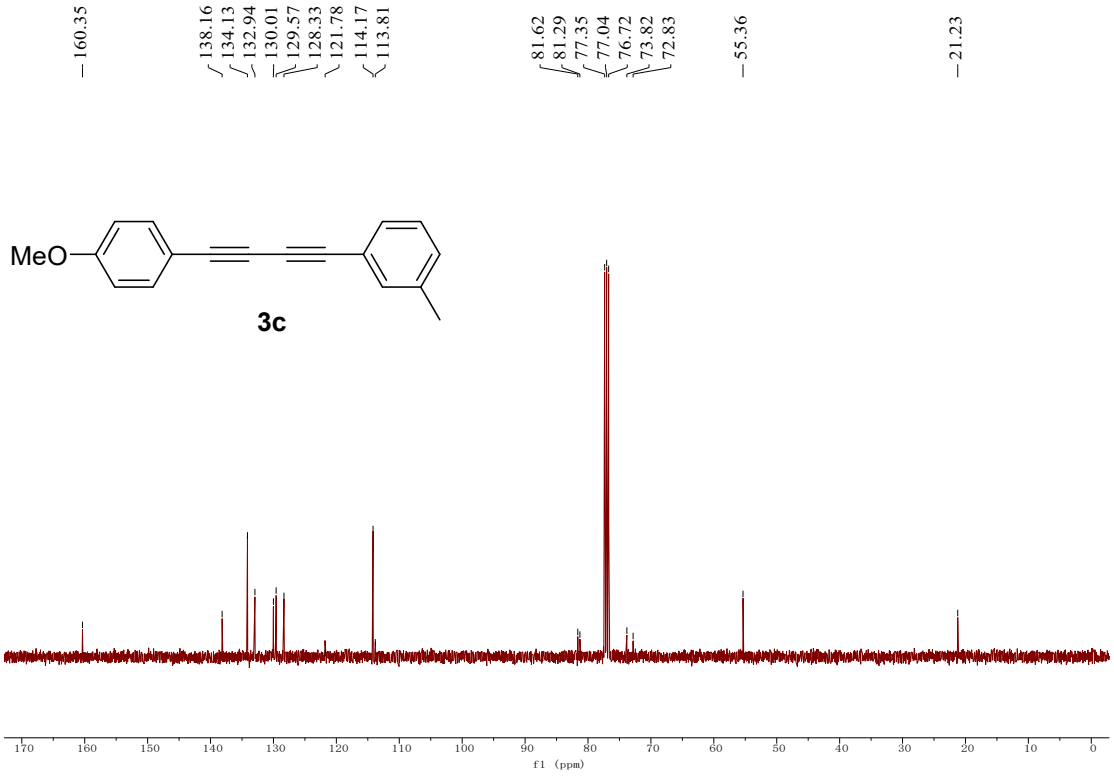
^{13}C NMR, 101 MHz, $CDCl_3$



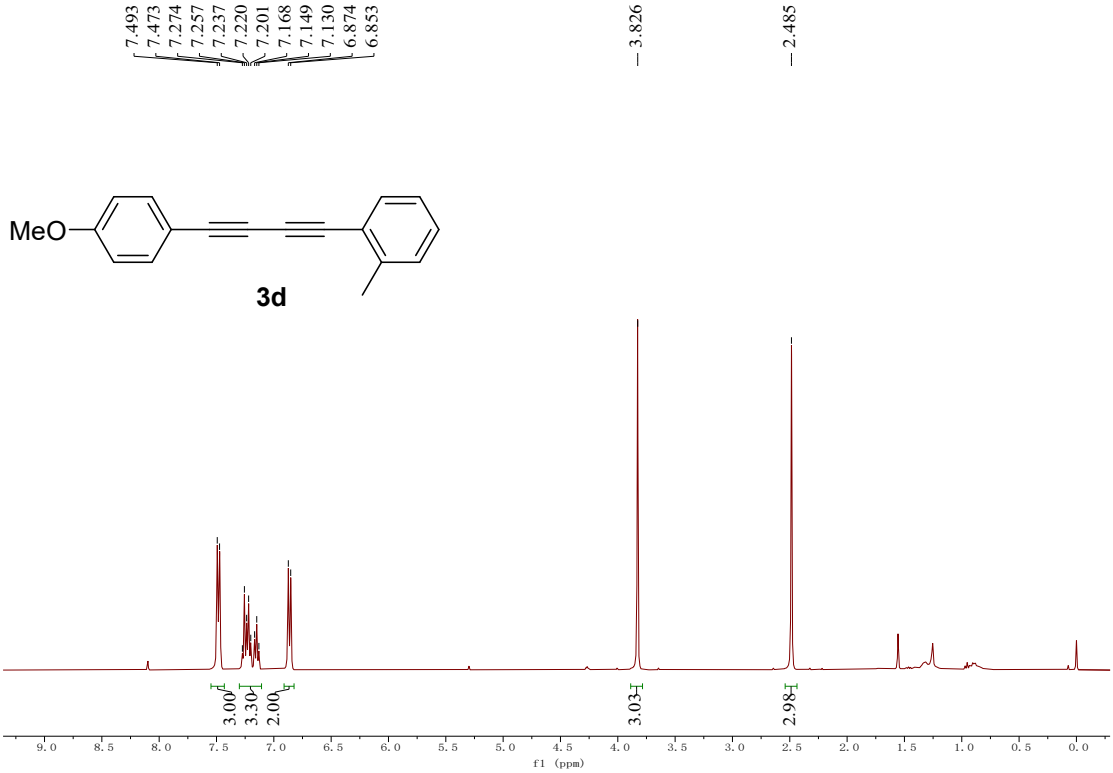
^{1}H NMR, 400 MHz, $CDCl_3$



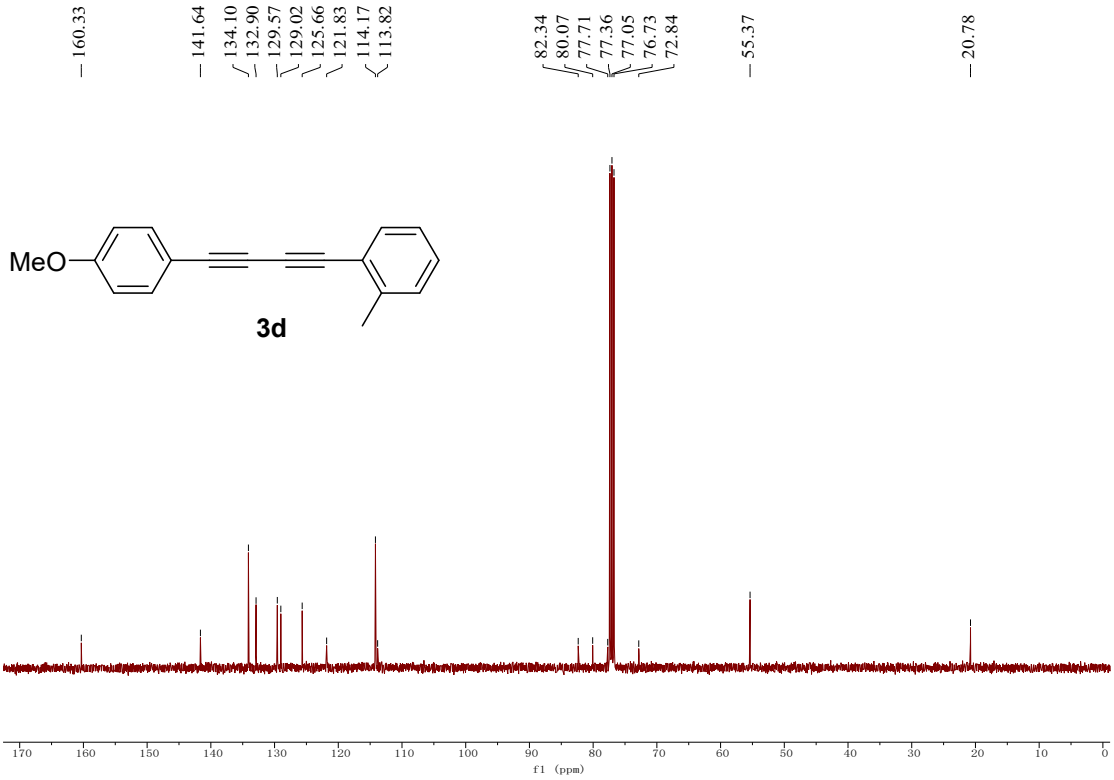
^{13}C NMR, 101 MHz, $CDCl_3$



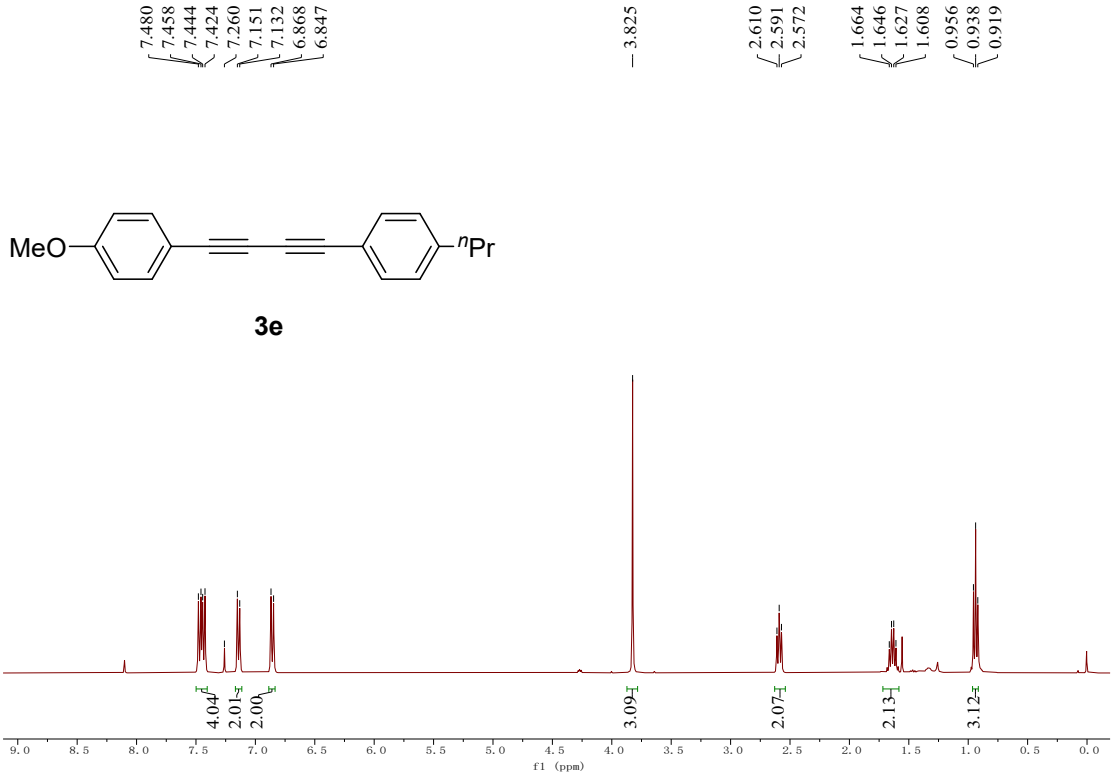
^{1}H NMR, 400 MHz, $CDCl_3$



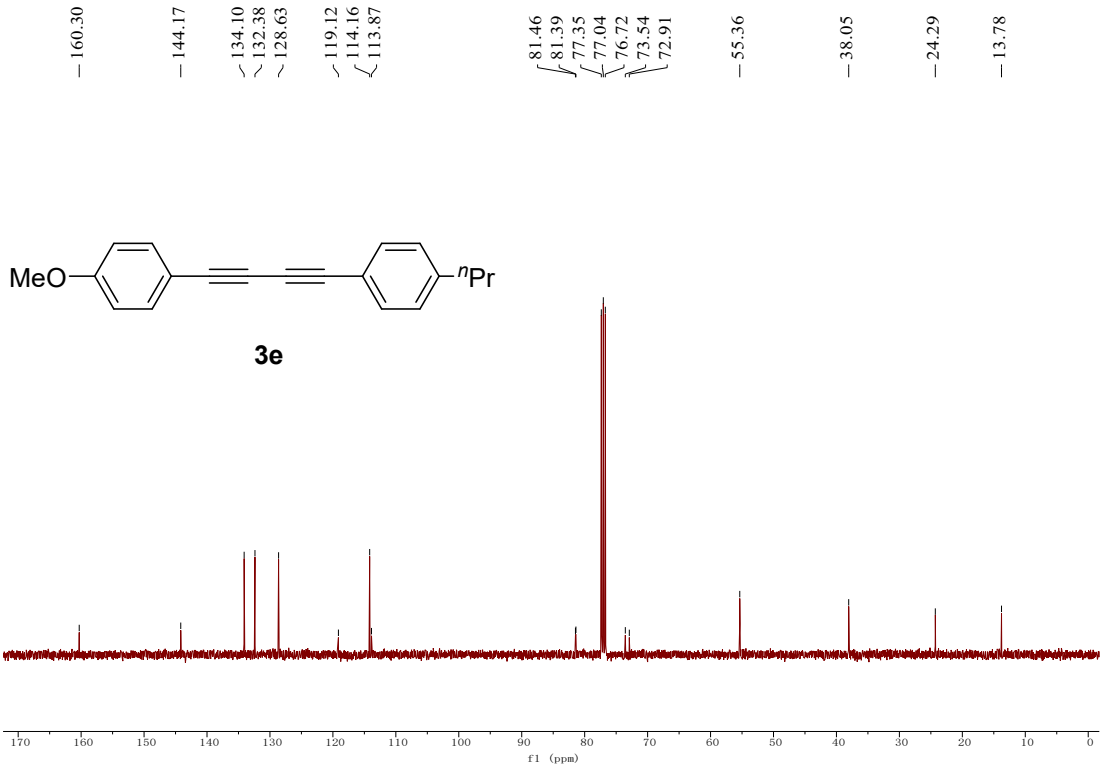
^{13}C NMR, 101 MHz, $CDCl_3$



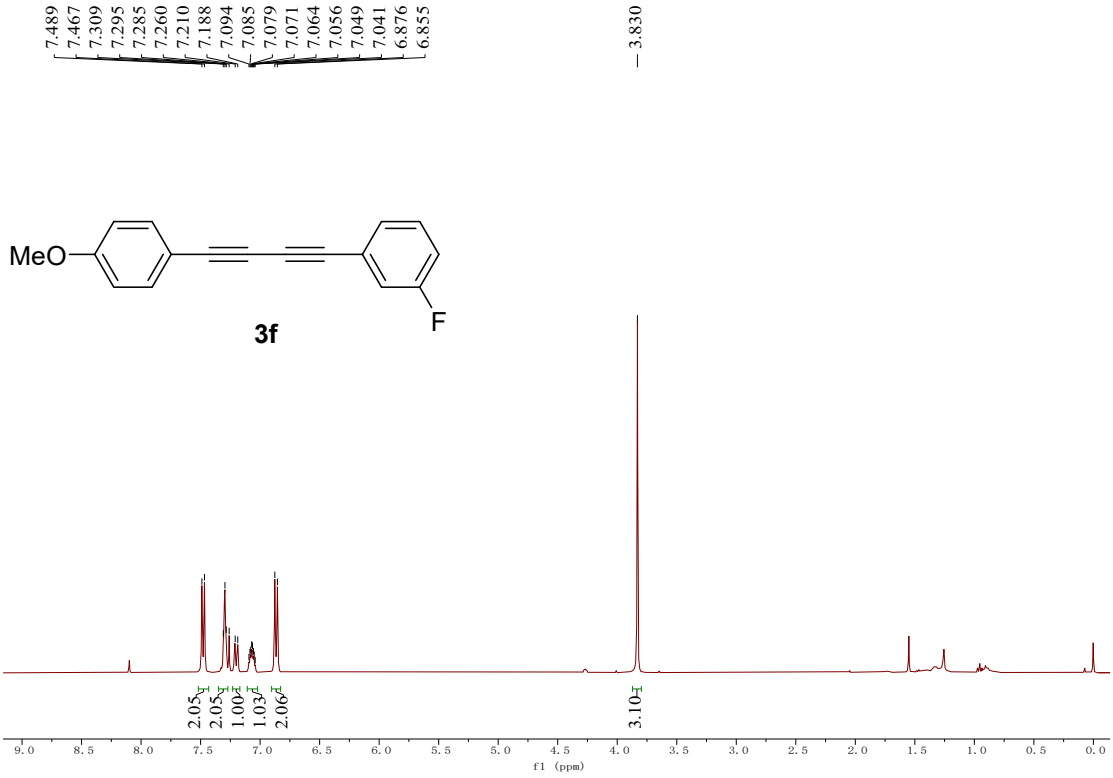
^{1}H NMR, 400 MHz, $CDCl_3$



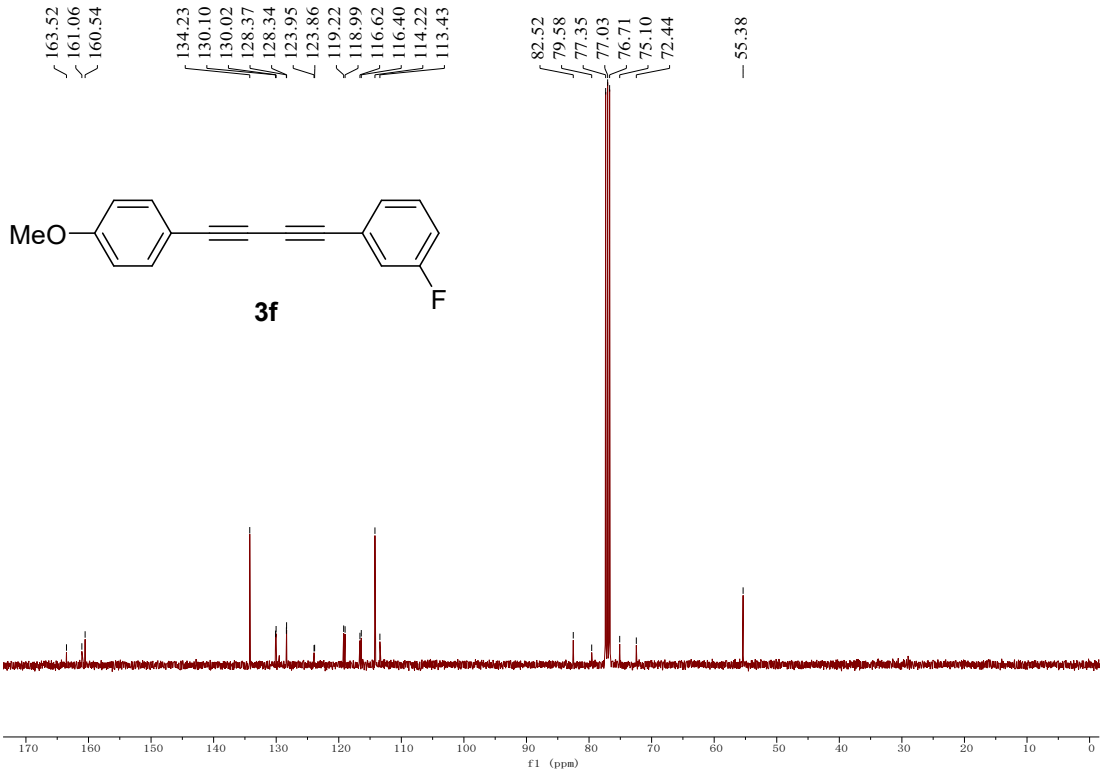
^{13}C NMR, 101 MHz, $CDCl_3$



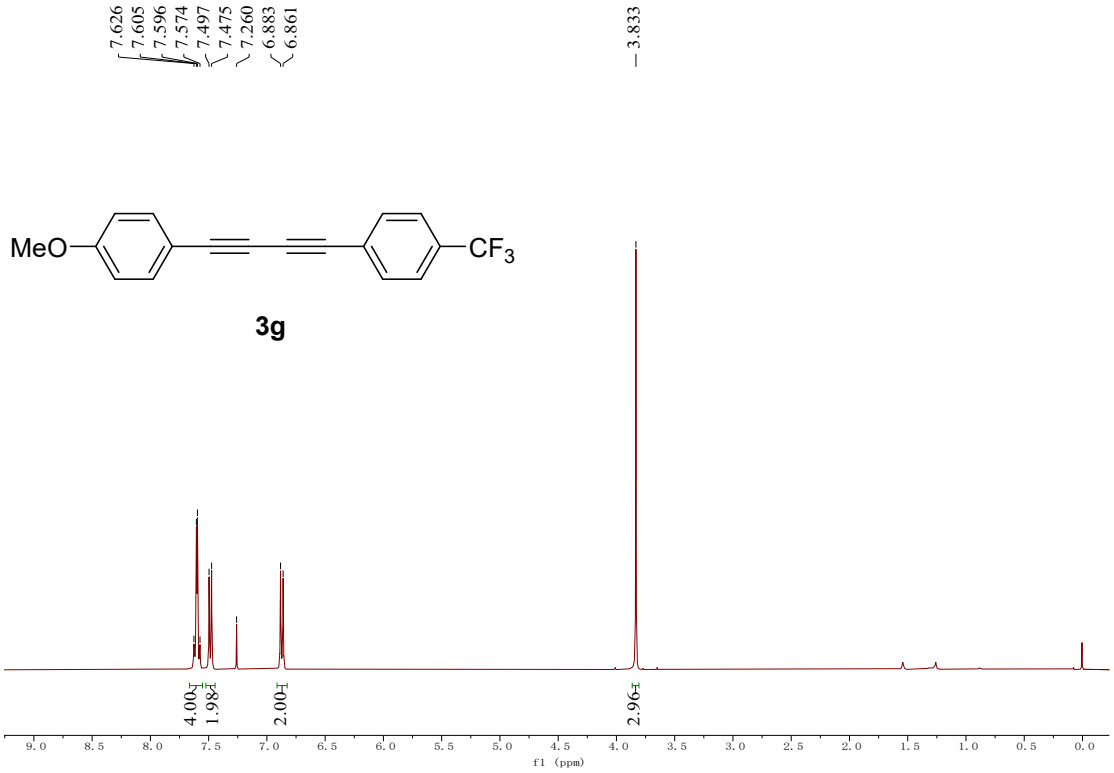
^{1}H NMR, 400 MHz, $CDCl_3$



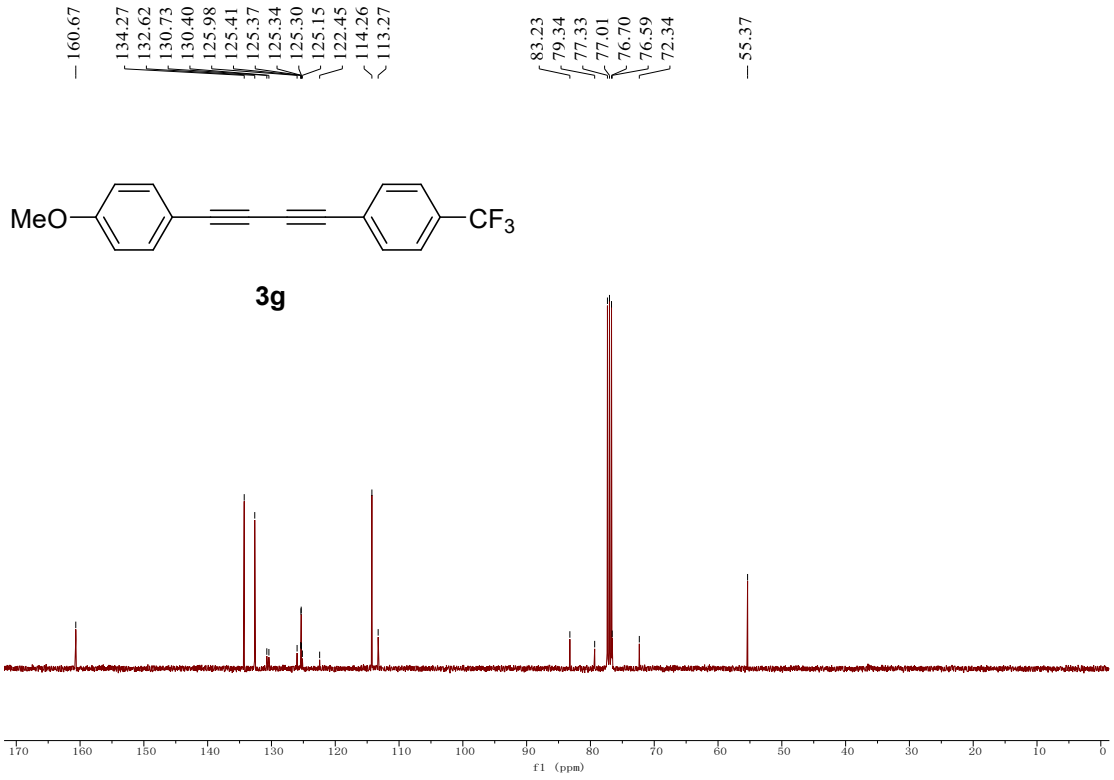
^{13}C NMR, 101 MHz, $CDCl_3$



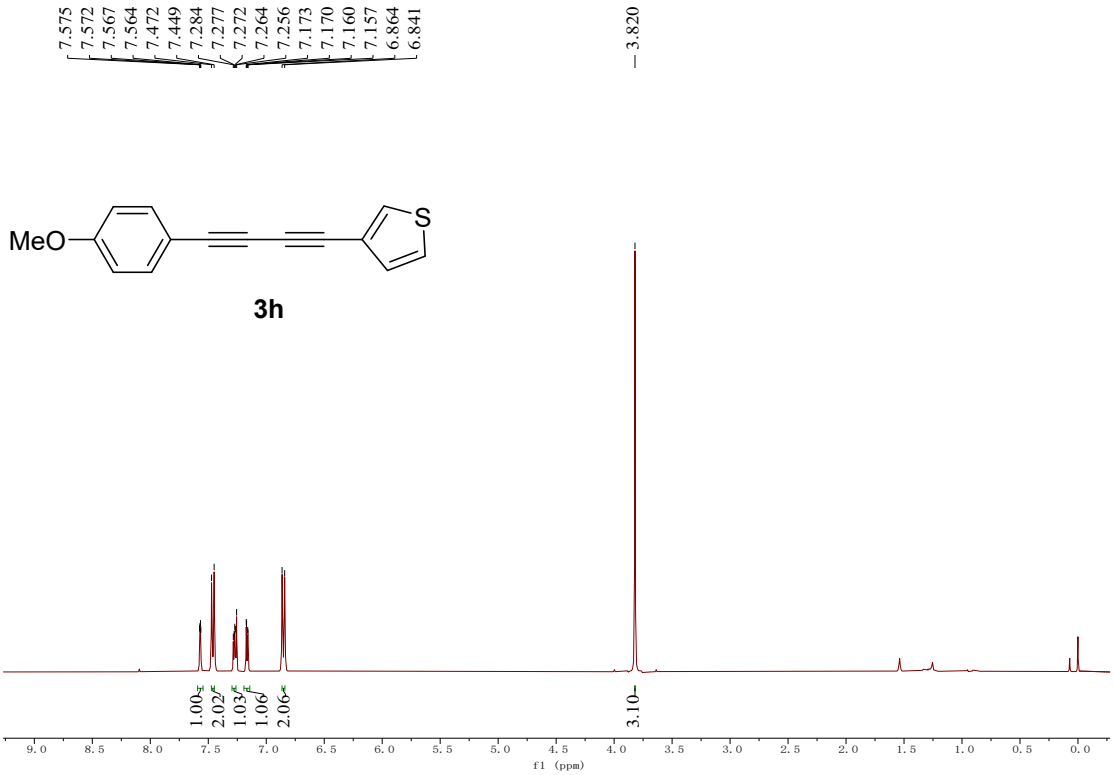
^{1}H NMR, 400 MHz, $CDCl_3$



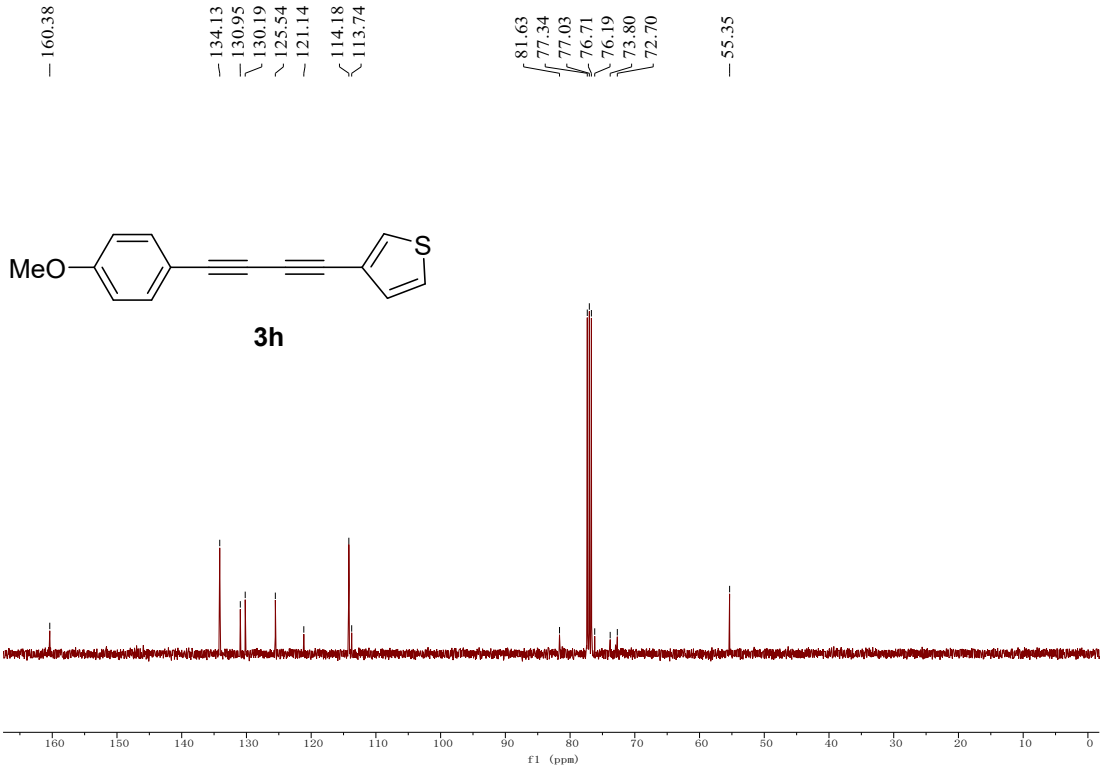
^{13}C NMR, 101 MHz, $CDCl_3$



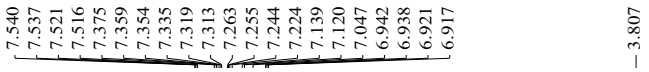
^{1}H NMR, 400 MHz, $CDCl_3$

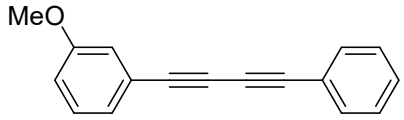


^{13}C NMR, 101 MHz, $CDCl_3$



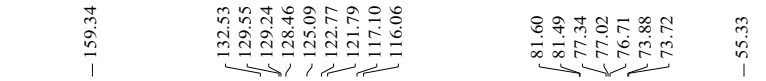
^{1}H NMR, 400 MHz, $CDCl_3$

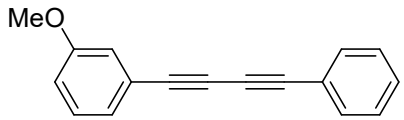




3i

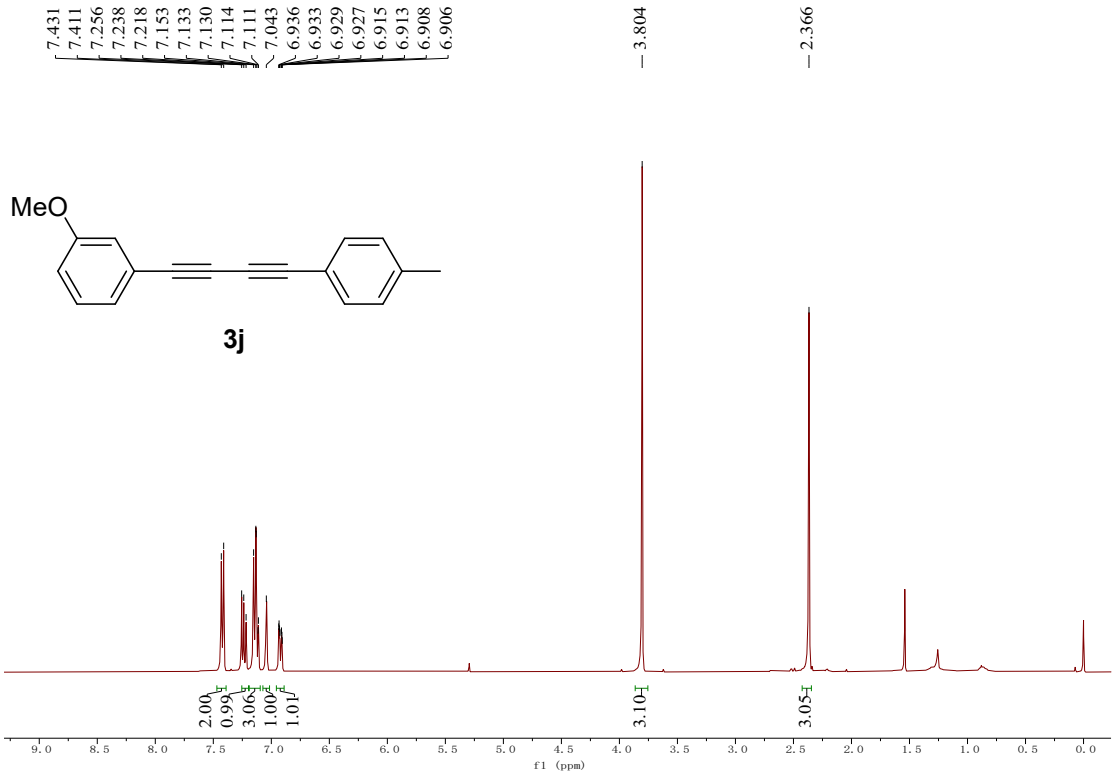
^{13}C NMR, 101 MHz, $CDCl_3$





3i

^{1}H NMR, 400 MHz, $CDCl_3$



^{13}C NMR, 101 MHz, $CDCl_3$