Supporting Information

Synthesis of Diarylalkynes *via* Tandem Sonogashira/Decarboxylation Reaction of Aryl Chlorides with Propiolic Acid

Xiang Li, Fan Yang* and Yangjie Wu*

The College of Chemistry and Molecular Engineering, Henan Key Laboratory of Chemical Biology and Organic Chemistry, Key Laboratory of Applied Chemistry of Henan Universities, Zhengzhou University, Zhengzhou 450052, People's Republic of China

Fax: (+86)-371-6797-9408. E-mail: yangf@zzu.edu.cn; wyj@zzu.edu.cn

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General Methods. ^{1}H and ^{13}C NMR spectra were recorded with $CDCl_3$ as the solvent and TMS as an internal standard. The cyclopalladated ferrocenylimine were synthesized according to the reported literature.[5b] The other chemicals were bought from commercial sources and used as-received unless otherwise noted.

General Procedure for Synthesis of Symmetric Diarylalkynes via Tandem Sonogashira/Decarboxylation Reaction of Aryl Chlorides with Propiolic Acid.

Under nitrogen atmosphere, propiolic acid (0.4 mmol), aryl chloride (1.0 mmol), DBU (4 equiv), $PdCl_2$ (2 mol%) and Xphos (4 mol%) were added to a 10 mL round-bottomed flask and then 2.0 mL DMSO was added. The mixture was stirred at 120 ^{o}C for 24 h. After the reaction was complete, the mixture was washed with brine and extracted with ethyl acetate for three times. The combined organic layer was dried with anhydrous Na_2SO_4 and evaporated in vacuum. The crude product was purified by flash chromatography on silica gel using hexane or hexane/ethyl acetate as the eluent to give the pure product.

General Procedure for Synthesis of Unsymmetric Diarylalkynes via Tandem Sonogashira/Decarboxylation Reaction of Aryl Chlorides with Propiolic Acid.

Under nitrogen atmosphere, propiolic acid (0.6 mmol), Ar^1Cl (0.4 mmol), Ar^2Cl (0.4 mmol), DBU (4 equiv), $PdCl_2$ (2 mol%) and Xphos (4 mol%) were added to a 10 mL round-bottomed flask and then 2.0 mL DMSO was added. The mixture was stirred at 120 ^{o}C for 24 h. After the reaction was complete, the mixture was washed with brine and extracted with ethyl acetate for three times. The combined organic layer was dried with anhydrous Na_2SO_4 and evaporated in vacuum. The crude product was purified by flash chromatography on silica gel using hexane or hexane/ethyl acetate as the eluent to give the pure product.

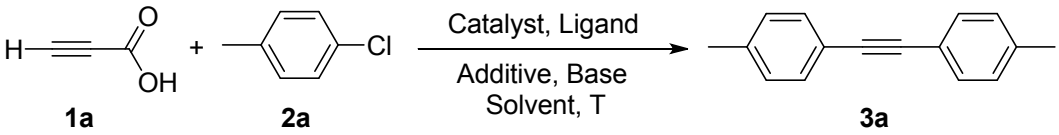
General Procedure for Palladium-catalyzed Decarboxylation Reaction of Aryl Chlorides with Phenylpropiolic Acid.

Under nitrogen atmosphere, Phenylpropiolic acid (0.4 mmol), chlorobenzene (0.5 mmol), DBU (2 equiv), $PdCl_2$ (2 mol%) and Xphos (4 mol%) were added to a 10 mL round-bottomed flask and then 2.0 mL DMSO was added. The mixture was stirred at 120 ^{o}C for 24 h. After the reaction was complete, the mixture was washed with brine and extracted with ethyl acetate for three times. The combined organic layer was dried with anhydrous Na_2SO_4 and evaporated in vacuum. The crude product was purified by flash chromatography on silica gel using hexane as the eluent to give the pure product.

General Procedure for Gram-scale Experiment.

Under nitrogen atmosphere, propiolic acid (16 mmol, 1 mL), 4-chlorotoluene (40 mmol), DBU (4 equiv), $PdCl_2$ (2 mol%) and Xphos (4 mol%) were added to a 250 mL round-bottomed flask and then 80 mL DMSO was added. The mixture was stirred at 120 ^{o}C for 48 h. After the reaction was complete, the mixture was washed with brine and extracted with ethyl acetate for three times. The combined organic layer was dried with anhydrous Na_2SO_4 and evaporated in vacuum. The crude product was purified by flash chromatography on silica gel using hexane as the eluent to give the pure product.

Optimization of the reaction conditions



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

Entry	Catalyst	Ligand	Base	Additive	Solvent	Yield
1	$PdCl_2$	Xphos	DBU	-	DMSO	61
2	$PdCl_2$	Ruphos	DBU	-	DMSO	28
3	$PdCl_2$	Davephos	DBU	-	DMSO	15
4	$PdCl_2$	Johnphos	DBU	-	DMSO	18
5	$PdCl_2$	$^tBu_3P{\cdot}HBF_4$	DBU	-	DMSO	10
6	$PdCl_2$	PPh_3	DBU	-	DMSO	<10
7	$PdCl_2$	PCy_3	DBU	-	DMSO	11
8	$PdCl_2$	Xphos	K_2CO_3	-	DMSO	38
9	$PdCl_2$	Xphos	K_3PO_4	-	DMSO	10
10	$PdCl_2$	Xphos	Cs_2CO_3	-	DMSO	24
11	$PdCl_2$	Xphos	^{t}BuOK	-	DMSO	21
12	$PdCl_2$	Xphos	TBAF	-	DMSO	<5
13	$PdCl_2$	Xphos	DABCO	-	DMSO	<5
14	$PdCl_2$	Xphos	DBU	-	DMF	23
15	$PdCl_2$	Xphos	DBU	-	DMA	21
16	$PdCl_2$	Xphos	DBU	-	NMP	<5
17	$PdCl_2$	Xphos	DBU	-	Toluene	<5
18	$PdCl_2$	Xphos	DBU	-	Dixane	<5
19	$PdCl_2$	Xphos	DBU	-	CH_3CN	<5
20[c]	$PdCl_2$	Xphos	DBU	-	DMSO	53
21[d]	$PdCl_2$	Xphos	DBU	-	DMSO	56
22	$PdCl_2$	Xphos	DBU	KI	DMSO	35
23	$PdCl_2$	Xphos	DBU	NaI	DMSO	28
24	$PdCl_2$	Xphos	DBU	LiCl	DMSO	43
25	$PdCl_2$	Xphos	DBU	TBAF	DMSO	31
26	$PdCl_2$	Xphos	DBU	CuI	DMSO	<5
27	$PdCl_2$	Xphos	DBU	KPF_6	DMSO	36
28	$PdCl_2$	Xphos	DBU	NH_4PF_6	DMSO	49
29	$Pd(OAc)_2$	Xphos	DBU	-	DMSO	18
30[e]	Pd_2dba_3	Xphos	DBU	-	DMSO	33
31	$PdCl_2(PPh_3)_2$	Xphos	DBU	-	DMSO	15

[a] Reaction conditions: propiolic acid **1a** (0.4 mmol), 4-chlorotoluene **2a** (1.0 mmol), catalyst (2 mol%), ligand (4 mol%), base (4 equiv), solvent (2 mL) at 120 °C for 24 h under a nitrogen atmosphere. [b] Isolated yield. [c] At 100 °C. [d] At 140 °C. [e] 1 mol% of Pd_2dba_3 was used.

^{1}H NMR and ^{13}C NMR data of all the products

1,2-Di-*p*-tolylethyne (3a):[1] white solid, mp 132–133 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.39 (s, 6H), 7.18 (d, J = 7.8 Hz, 2H), 7.45 (d, J = 7.8 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 20.5, 87.9, 119.4, 128.1, 130.4, 137.2.

1,2-Di-*m*-tolylethyne (3b):[2] light yellow solid, mp 75–77 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.35 (s, 6H), 7.13 (d, J = 7.5 Hz, 2H), 7.20–7.26 (m, 2H), 7.30–7.37 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 21.3, 89.3, 123.2, 128.3, 128.7, 129.1, 132.2, 138.0.

1,2-Bis(3,4-dimethylphenyl)ethyne (3c): white solid, mp 143–145 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.25 (s, 6H), 2.27 (s, 6H), 7.09 (d, J = 7.8 Hz, 2H), 7.26 (d, J = 7.8 Hz, 2H), 7.30 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 19.6, 19.8, 88.8, 120.8, 129.0, 129.7, 132.6, 136.6, 136.9; HRMS (ESI$^+$) calcd for $C_{18}H_{18}$ $[M+H]^+$: 235.1481, found: 235.1479.

1,2-Di-*o*-tolylethyne (3d):[1] light yellow solid, mp 58–60 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.57 (s, 6H), 7.18–7.23 (m, 2H), 7.24–7.29 (m, 4H), 7.55 (d, J = 7.5 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 21.0, 92.4, 123.4, 125.7, 128.3, 129.5, 131.9, 140.0.

1,2-Bis(2,5-dimethylphenyl)ethyne (3e):[1] white solid, mp 111–113 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.34 (s, 6H), 2.50 (s, 6H), 7.06 (d, J = 7.8 Hz, 2H), 7.14 (d, J = 7.8 Hz, 2H), 7.35 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 20.8, 21.2, 92.5, 123.6, 129.4, 129.8, 132.7, 135.4, 137.3.

1,2-Bis(2,3-dimethylphenyl)ethyne (3f): white solid, mp 142–144 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.33 (s, 6H), 2.51 (s, 6H), 7.06-7.24 (m, 4H), 7.41 (d, J = 7.3 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 18.0, 20.8, 92.8, 124.0, 125.7, 130.2, 130.2, 137.2, 138.7; HRMS (ESI$^+$) calcd for $C_{18}H_{18}$ $[M+H]^+$: 235.1481, found: 235.1481.

1,2-Bis(2,6-dimethylphenyl)ethyne (3g):[1] white solid, mp 114–116 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.57 (s, 12H), 7.07–7.18 (m, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 21.64, 95.8, 123.7, 126.8, 127.7, 140.1.

1,2-Dimesitylethyne (3h):[1] white solid, mp 124–125 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.33 (s, 6H), 2.54 (s, 12H), 6.94 (s, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 21.3, 21.5, 95.3, 120.9, 127.7, 137.5, 139.9.

1,2-Bis(2-vinylphenyl)ethyne (3i):[3] ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.39 (d, J = 11.2 Hz, 2H), 5.85 (d, J = 17.7 Hz, 2H), 7.21–7.36 (m, 6H), 7.54 (d, J = 7.7 Hz, 2H), 7.61 (d, J = 7.7 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 92.3, 115.7, 122.0, 124.7, 127.4, 128.5, 132.4, 135.0, 139.0.

1,2-Bis(3-vinylphenyl)ethyne (3j): ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.29 (d, J = 10.9 Hz, 2H), 5.79 (d, J = 17.4 Hz, 2H), 6.64–6.76 (m, 2H), 7.29–7.43 (m, 6H), 7.59 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 89.2, 114.7, 123.4, 126.1, 128.5, 129.3, 130.8, 136.0, 137.7; HRMS (ESI$^+$) calcd for $C_{18}H_{14}$ $[M+H]^+$: 231.1168, found: 231.1166.

1,2-Bis(4-butylphenyl)ethyne (3k):[2] light yellow solid, mp 107–108 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.89–0.95 (m, 6H), 1.28–1.40 (m, 4H), 1.54–1.64 (m, 4H), 2.53–2.65 (m, 4H), 7.06–7.25 (m, 5H), 7.39–7.45 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 14.0, 22.3, 33.4, 35.6, 89.0, 120.7, 128.5, 131.5, 143.2.

1,2-Bis(4-methoxyphenyl)ethyne (3l):[1] light yellow solid, mp 141–143 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.80 (s, 6H), 6.85 (d, J = 8.6 Hz, 4H), 7.43 (d, J = 8.6 Hz, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 55.3, 88.0, 114.0, 115.8, 132.9, 159.4.

1,2-Bis(4-methoxy-3-methylphenyl)ethyne (3m): light yellow solid, mp 143–145 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.19 (s, 6H), 3.83 (s, 6H), 6.76 (d, J = 8.3 Hz, 2H), 7.26–7.36 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.0, 55.4, 87.9, 109.8, 115.3, 126.8, 130.3, 133.7, 157.7; HRMS (ESI$^+$) calcd for $C_{18}H_{18}O_2$ $[M+H]^+$: 267.1380, found: 267.1354.

3,3'-(Ethyne-1,2-diyl)bis(*N,N*-dimethylaniline) (3n): light yellow solid, mp 84–86 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.96 (s, 12H), 6.68–6.73 (m, 2H), 6.88–6.93 (m, 4H), 7.16–7.23 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 40.6, 89.3, 112.8, 115.5, 120.0, 123.9, 129.0, 150.4; HRMS (ESI$^+$) calcd for $C_{18}H_{20}N_2$ $[M+H]^+$: 265.1699, found:265.1703.

1,2-Diphenylethyne (3o):[4] white solid, mp 59–60 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.34–7.43 (m, 6H), 7.50–7.60 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 89.2, 123.0, 128.0, 128.1, 131.4.

1,2-Di(naphthalen-1-yl)ethyne (3p):[2] light yellow solid, mp 124–125 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.48-7.62 (m, 4H), 7.66 (t, J = 7.5 Hz, 2H), 7.91 (t, J = 7.0 Hz, 6H), 8.61 (d, J = 8.3 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 92.5, 121.1, 125.4, 126.4, 126.5, 127.0, 128.4, 128.9, 130.6, 133.4.

1,2-Bis(4-(trifluoromethyl)phenyl)ethyne (3q):[5] light yellow solid, mp 107–108 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.60–7.67 (m, 8H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 90.3, 124.0 (q, J = 272.6 Hz), 125.5 (q, J = 3.72 Hz), 126.5, 130.6 (q, J = 32.8 Hz), 132.1.

1,2-bis(4-fluorophenyl)ethyne (3r):[6] white solid, mp 89–90 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.54–7.45 (m, 4H), 7.09–7.00 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 86.9, 114.6 (d, J = 21.8 Hz), 118.1 (d, J = 3.0 Hz), 132.4, 130.6 (d, J = 8.0 Hz), 161.5 (d, J = 247.6 Hz).

1-Methoxy-4-(*p*-tolylethynyl)benzene (3t):[7] white solid, mp 118–120 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.37 (s, 3H), 3.83 (s, 3H), 6.88 (d, J = 8.2 Hz, 2H), 7.15 (d, J = 7.6 Hz, 2H), 7.42 (d, J = 7.6 Hz, 2H), 7.47 (d, J = 8.2 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 21.9, 55.7, 88.6, 89.1, 114.4, 116.0, 120.9, 129.5, 131.7, 133.4, 138.4, 159.9.

1-Methoxy-4-(phenylethynyl)benzene (3u):[8] white solid, mp 57–58 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.84 (s, 3H), 6.82–6.92 (m, 2H), 7.30–7.36 (m, 3H), 7.42–7.55 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 55.7, 88.5, 89.8, 114.4, 115.8, 124.0, 128.3, 128.7, 131.9, 133.5, 160.0.

2-((4-Methoxyphenyl)ethynyl)-1,3-dimethylbenzene (3v):[9] light yellow solid, mp 68–70 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.52 (s, 6H), 3.85 (s, 3H), 6.90 (d, J = 8.8 Hz, 2H), 7.05–7.15 (m, 3H), 7.49 (d, J = 8.8 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 21.5, 55.7, 86.2, 98.2, 114.4, 116.4, 123.7, 127.1, 127.8, 133.2, 140.4, 160.0.

Butyl-4-((4-methoxyphenyl)ethynyl)benzene (3w): light yellow solid, mp 40–41 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.94 (t, J = 7.3 Hz, 3H), 1.31-1.42 (m, 2H), 1.55-1.65 (m, 2H), 2.62 0.94 (t, J = 8.0 Hz, 3H), 3.83 (s, 3H), 6.88 (d, J = 8.8 Hz, 2H), 7.16 (d, J = 8.0 Hz, 2H), 7.43 (d, J = 8.0 Hz, 2H), 7.47 (d, J = 8.0 Hz, 2H); ^{13}C NMR (100

MHz, $CDCl_3$) δ 14.3, 22.7, 33.8, 36.0, 55.7, 88.6, 89.1, 114.4, 116.1, 121.1, 128.8, 131.8, 133.4, 143.4, 159.9; HRMS (ESI^+) calcd for $C_{18}H_{20}N_2$ $[M+H]^+$: 265.1592, found: 265.1587.

N,N-dimethyl-3-(p-tolylethynyl)aniline (**3x**): light yellow solid, mp 78–80 ^oC; ^1H NMR (400 MHz, $CDCl_3$) δ 2.37 (s, 3H), 2.97 (s, 6H), 6.69–6.75 (m, 1H), 6.87–6.94 (m, 2H), 7.12–7.25 (m, 3H), 7.40–7.51 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 20.5, 39.5, 87.4, 88.6, 111.7, 114.3, 118.9, 119.3, 122.8, 128.0, 128.0, 130.5, 137.1, 149.3. HRMS (ESI^+) calcd for $C_{17}H_{17}N$ $[M+H]^+$: 236.1434, found: 236.1432.

3-((4-Fluorophenyl)ethynyl)-N,N-dimethylaniline (**3y**): white solid, mp 150–152 ^oC; ^1H NMR (400 MHz, $CDCl_3$) δ 2.97 (s, 6H), 6.69–6.77 (m, 1H), 6.85–6.95 (m, 2H), 7.00–7.10 (m, 2H), 7.17–7.25 (m, 1H), 7.47–7.57 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 39.5, 86.1, 89.0, 111.9, 114.3 (d, J = 24.0 Hz), 118.5 (d, J = 3.1 Hz), 118.8, 122.4, 128.0, 128.9, 132.4 (d, J = 7.9 Hz), 149.3, 161.3 (d, J = 248.1 Hz). HRMS (ESI^+) calcd for $C_{16}H_{14}FN$ $[M+H]^+$: 240.1183, found: 240.1181.

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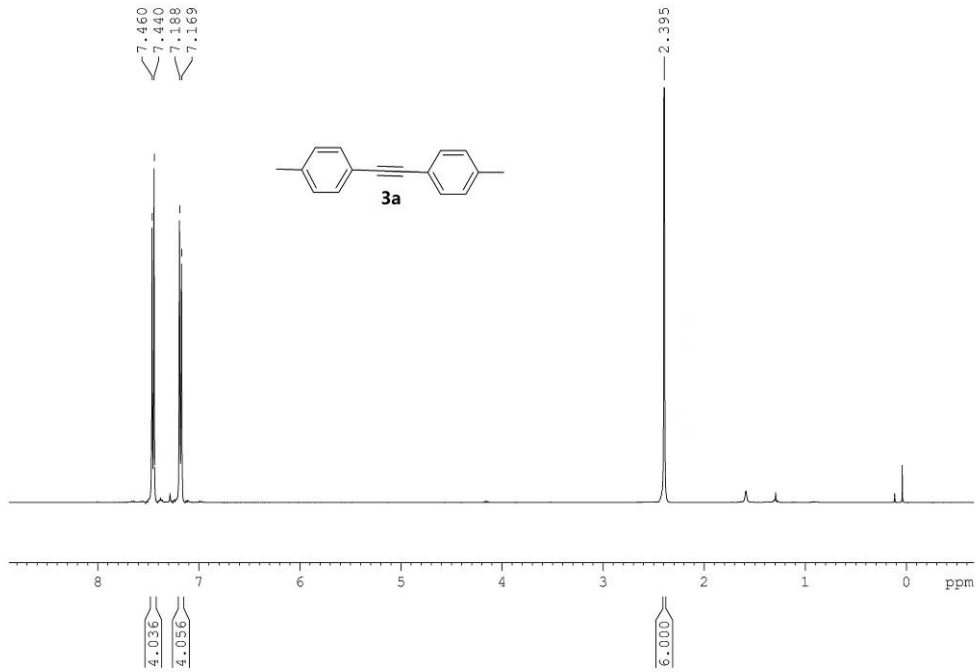
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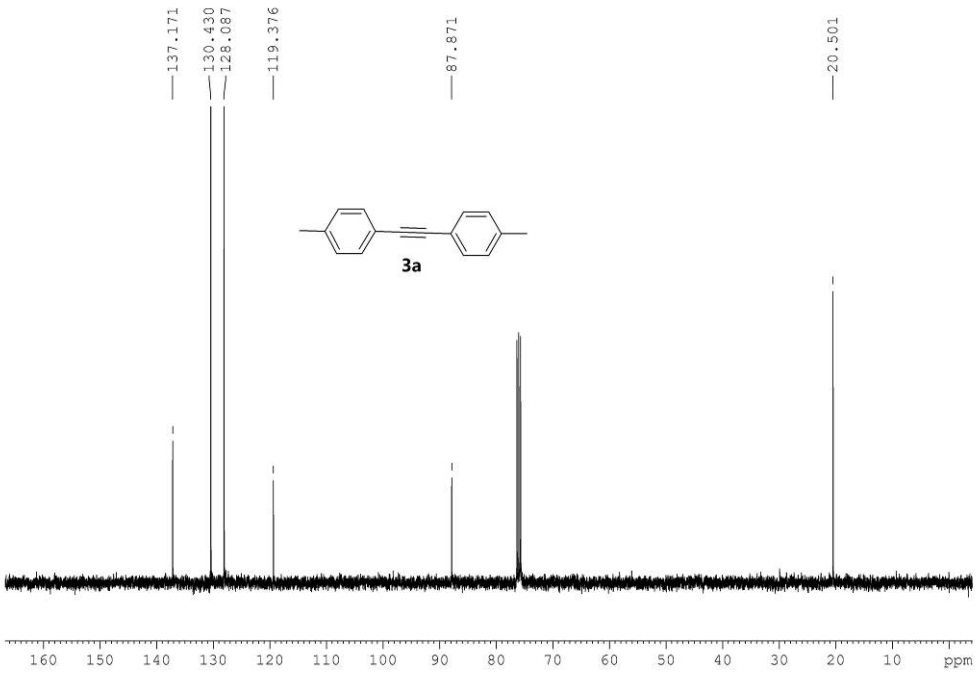
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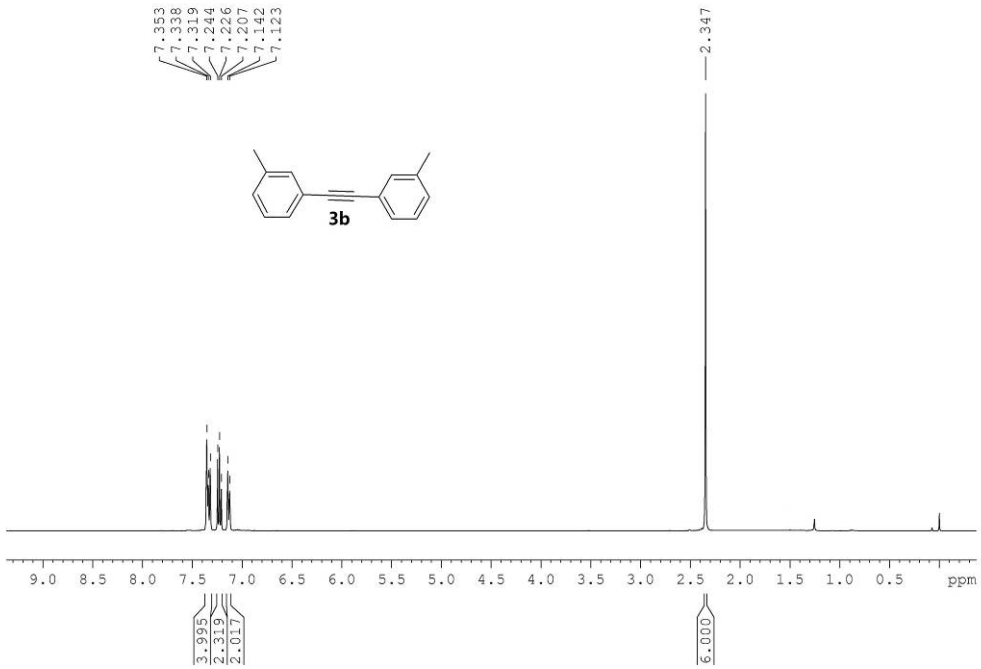
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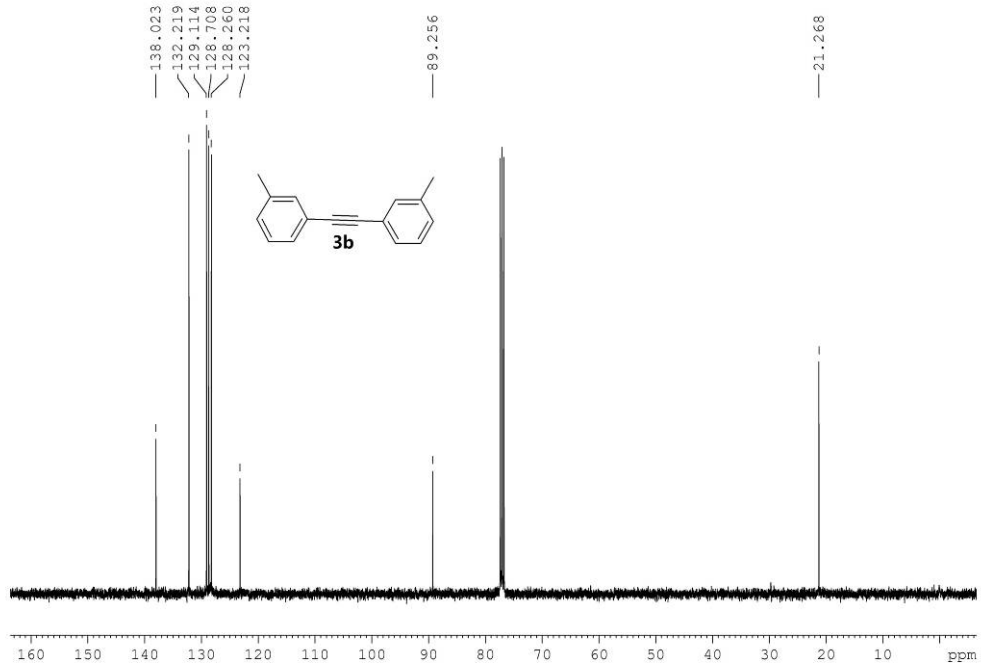
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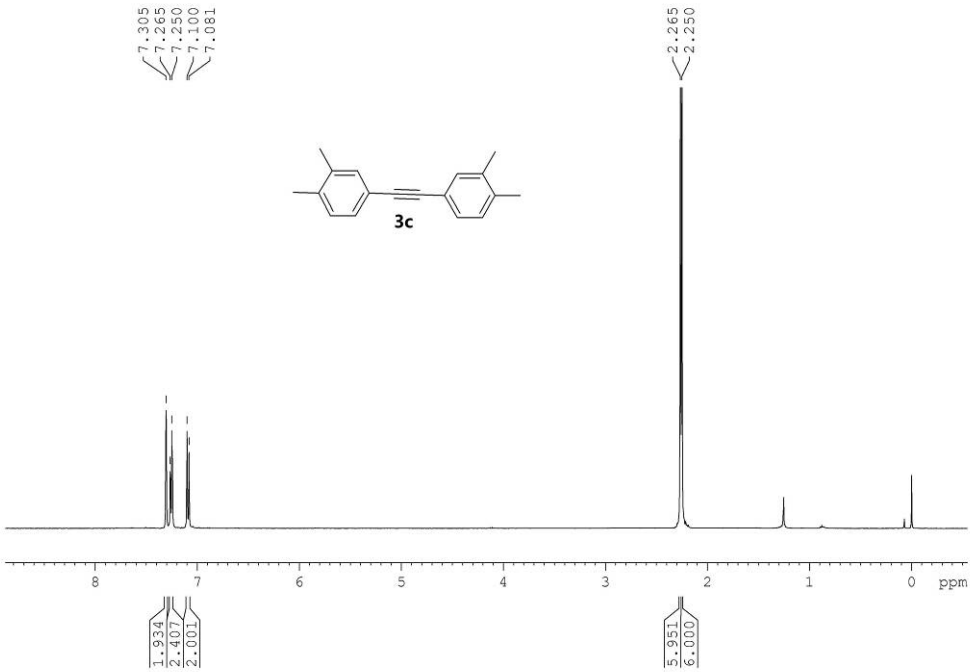
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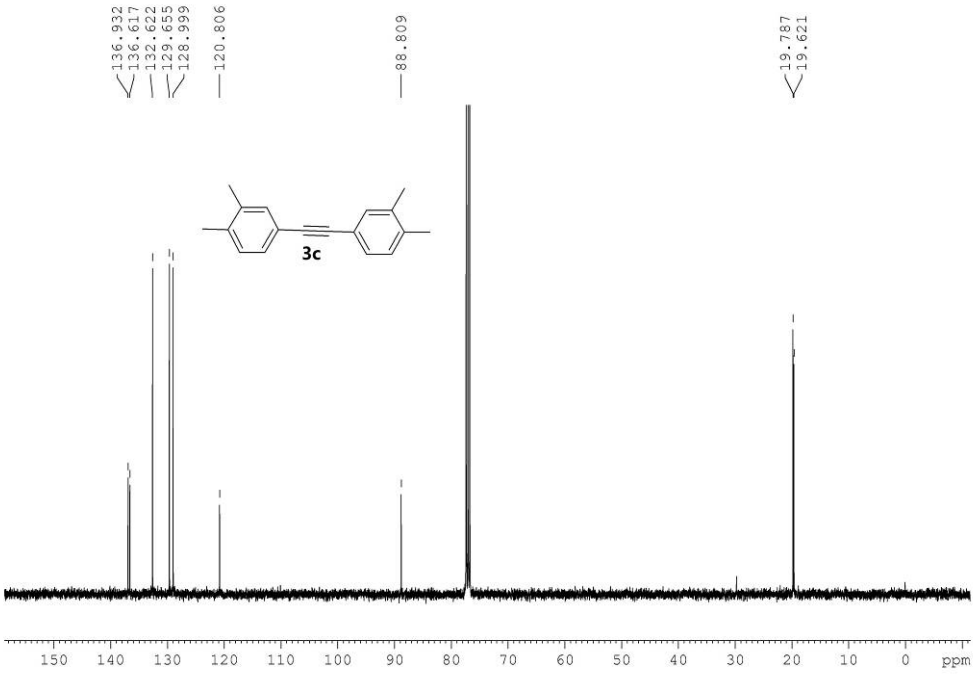
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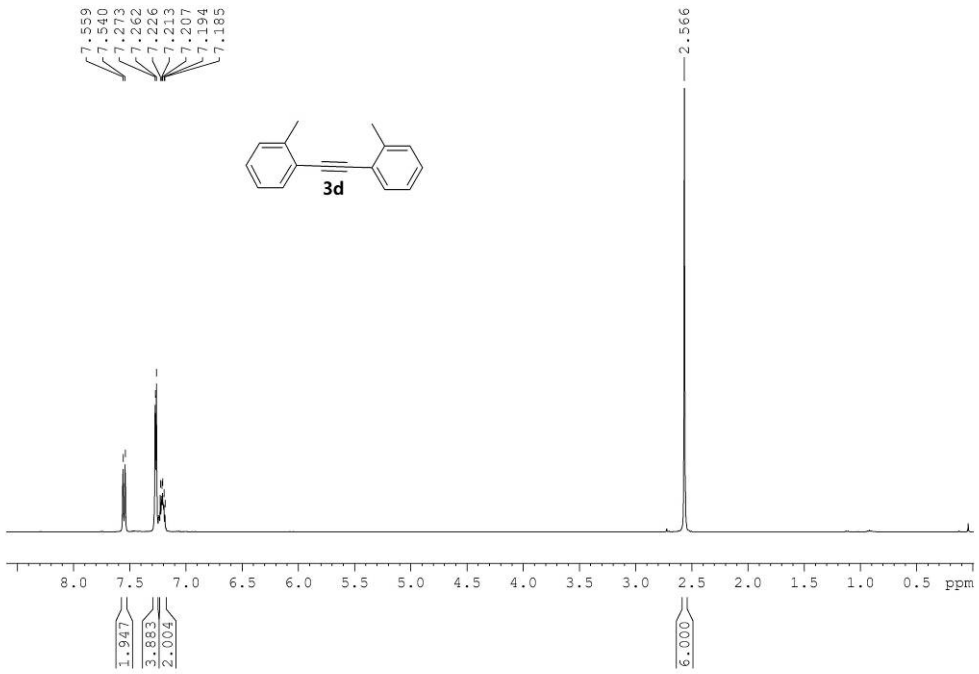
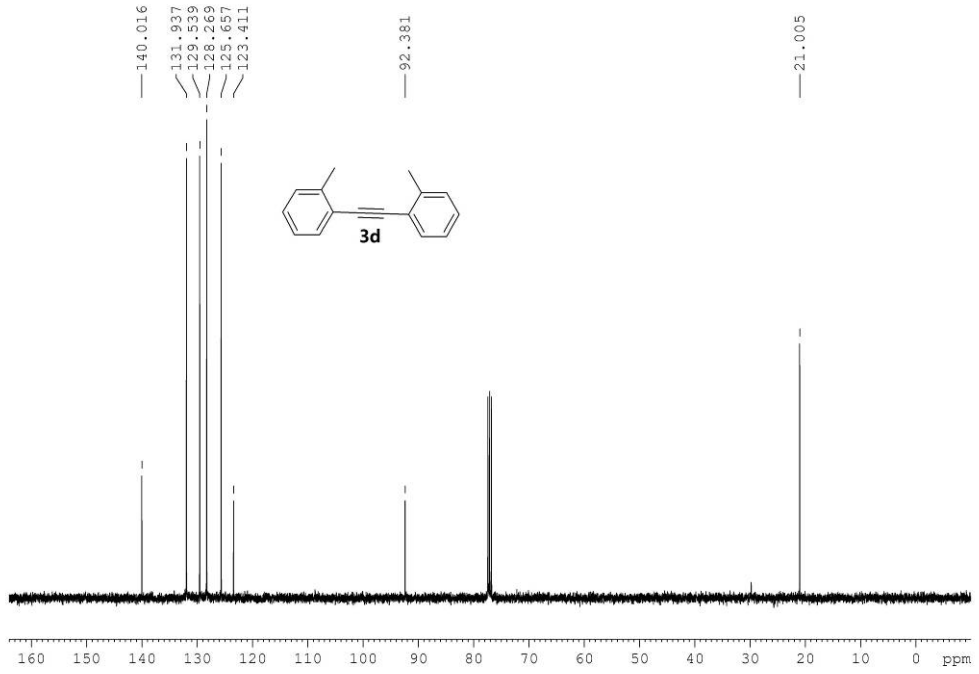
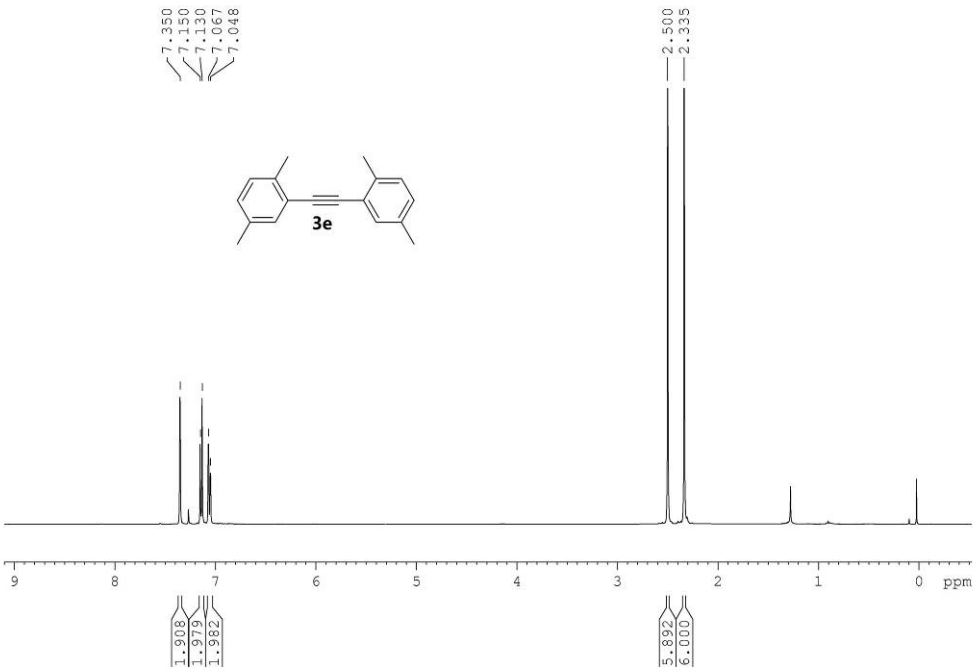
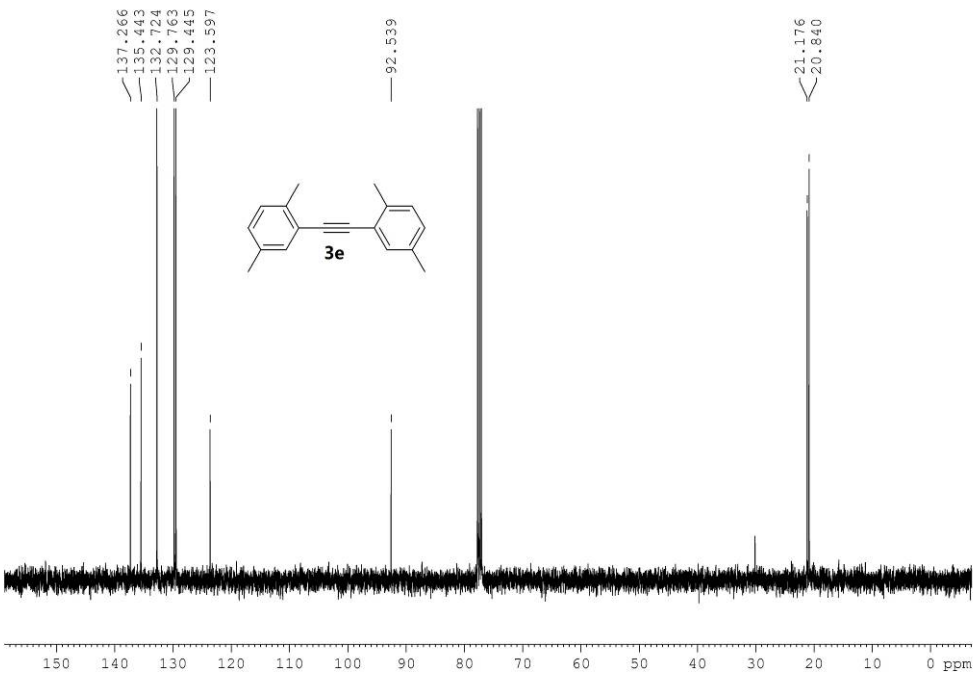
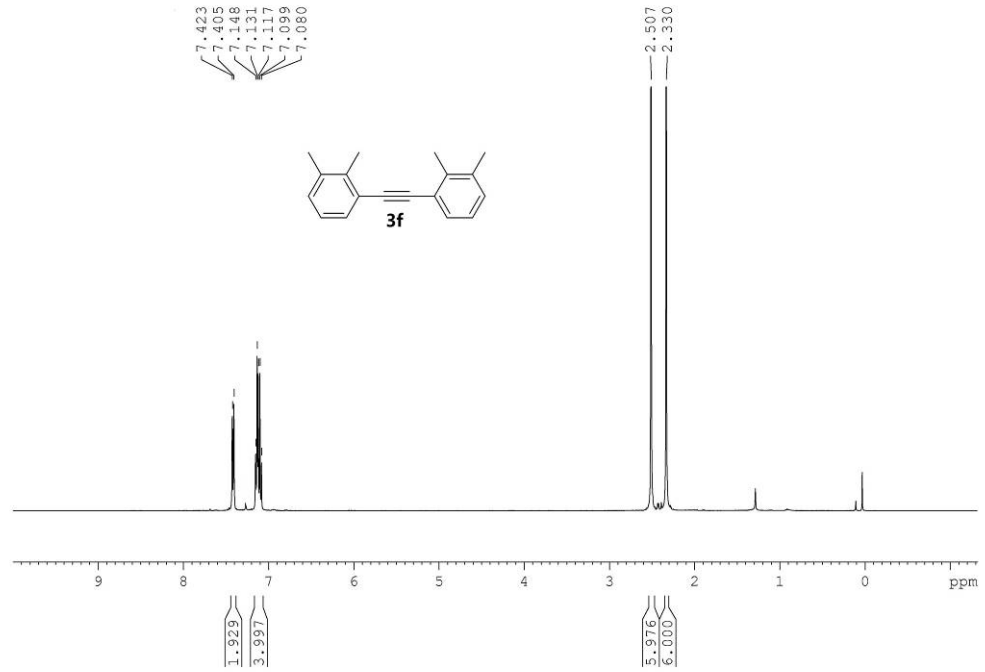
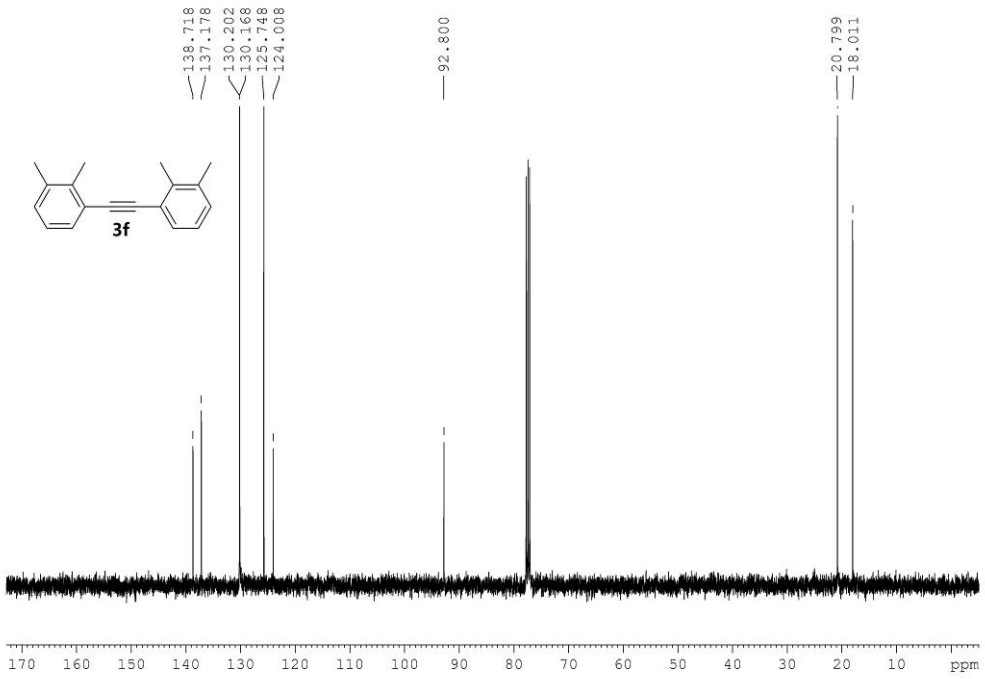

7.559
7.540
7.273
7.262
7.226
7.213
7.207
7.194
7.185
2.566
3d
8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm
1.947
3.883
2.004
6.000

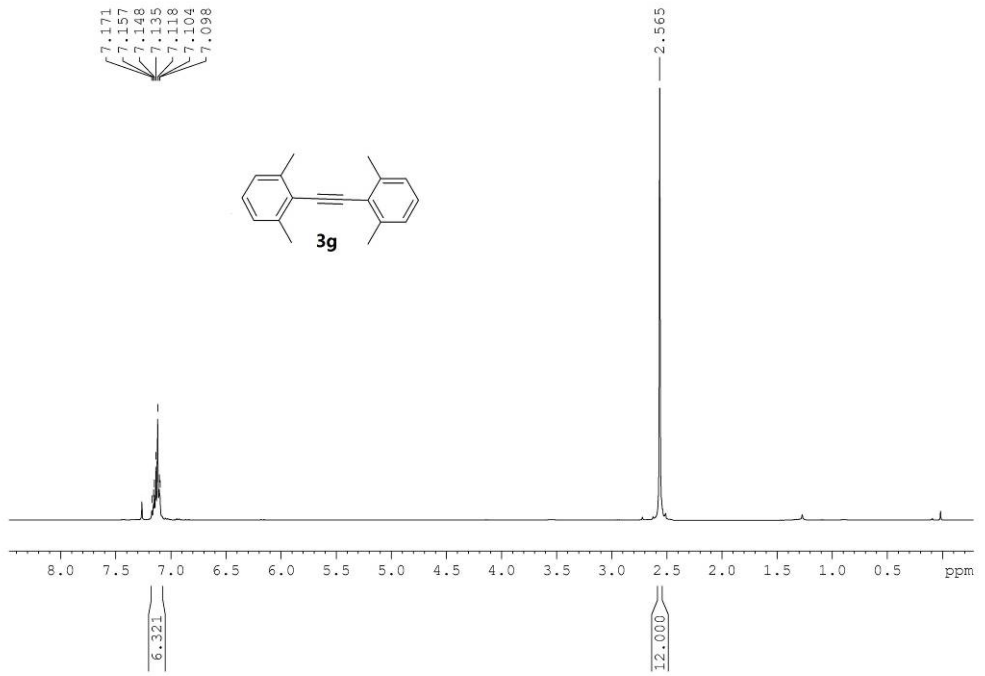

140.016
131.937
129.539
128.269
125.657
123.411
92.381
21.005
3d
160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

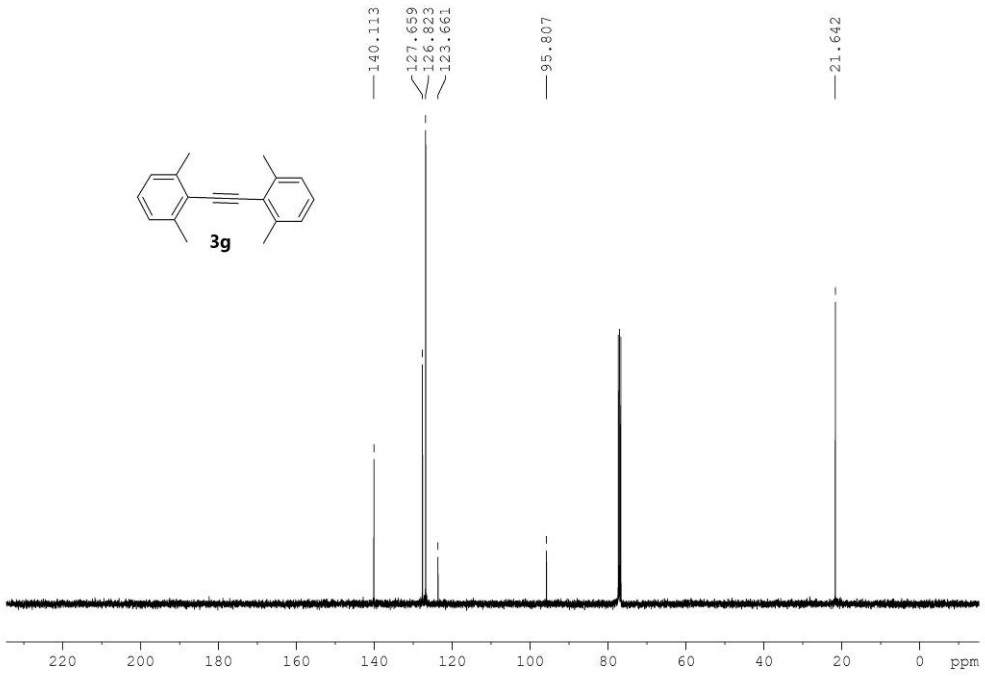

7.350
7.150
7.130
7.067
7.048
2.500
2.335
3e
9
8
7
6
5
4
3
2
1
0 ppm
1.908
1.979
1.982
5.892
6.000

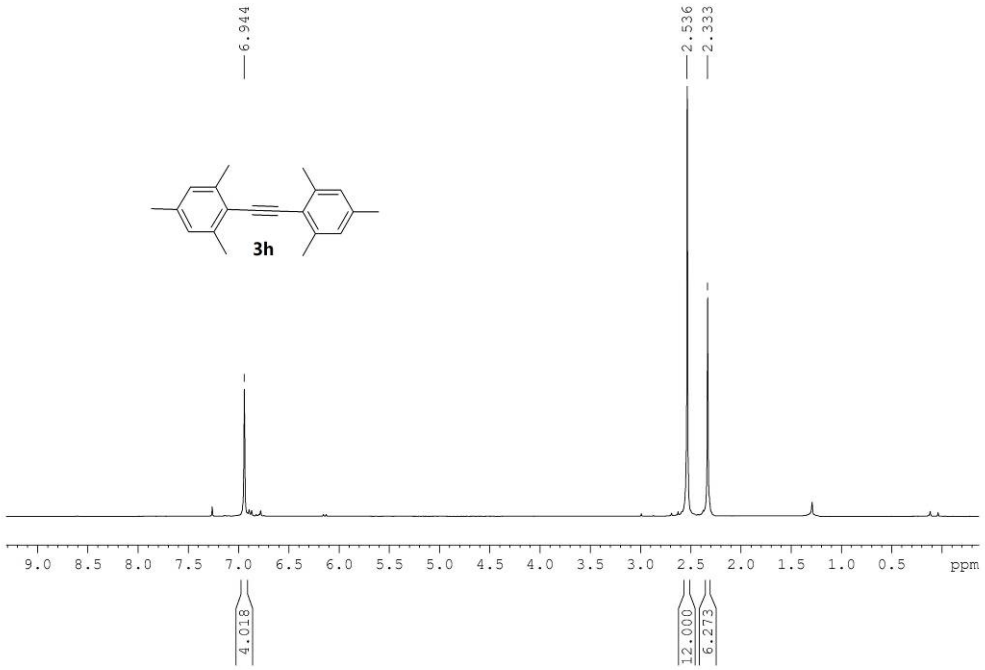

137.266
135.443
132.724
129.763
129.445
123.597
92.539
21.176
20.840
3e
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0 ppm

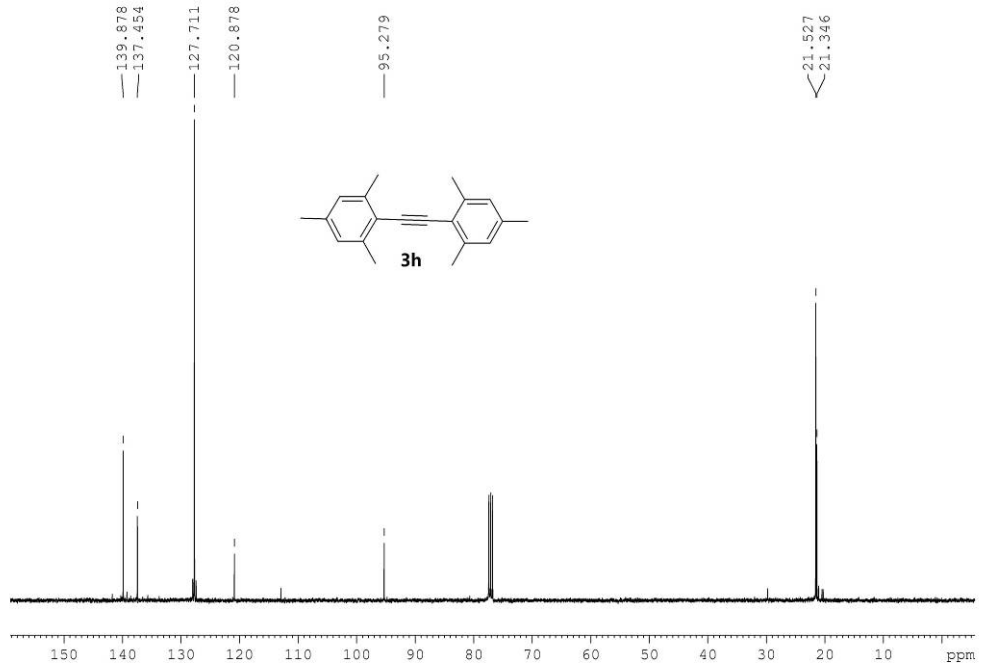

7.423
7.405
7.148
7.131
7.117
7.099
7.080
2.507
2.330
3f
9
8
7
6
5
4
3
2
1
0
ppm
1.929
3.997
5.976
6.000

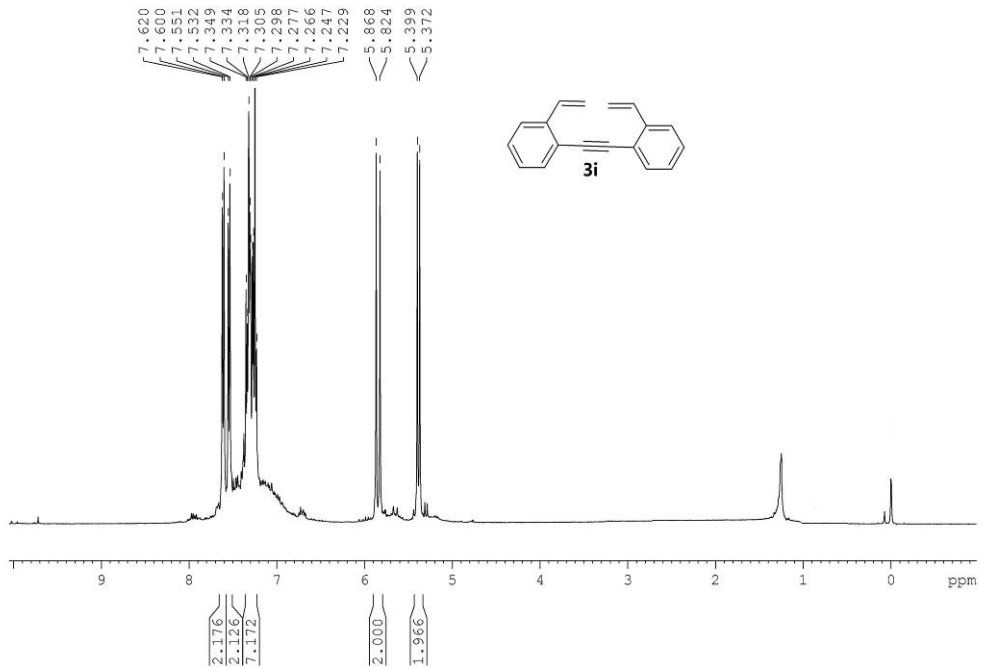

138.718
137.178
130.202
130.168
125.748
124.008
92.800
20.799
18.011
3f
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

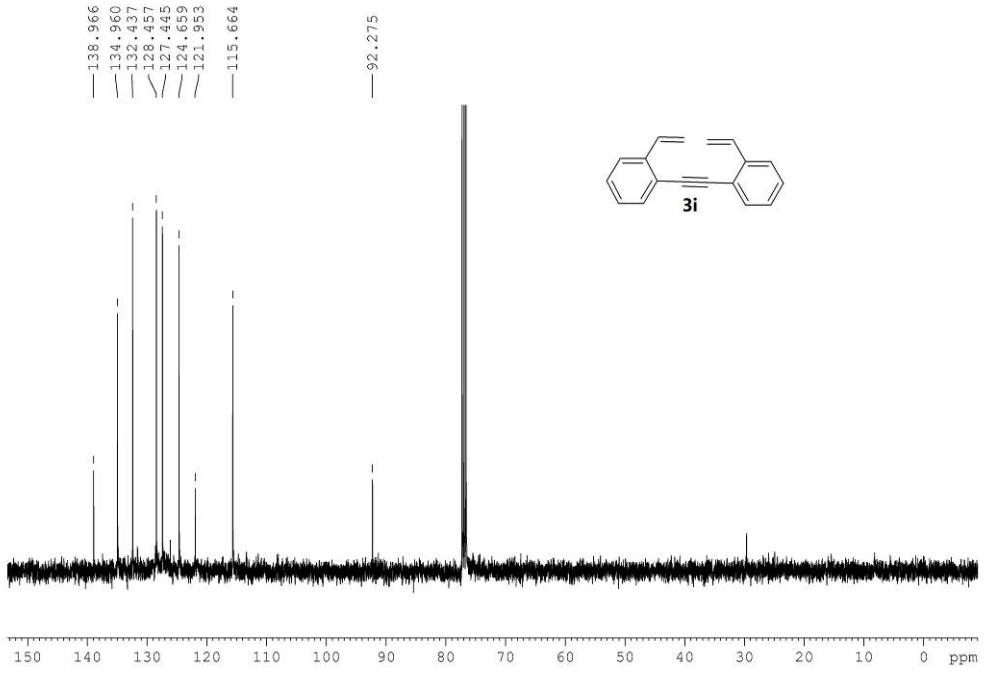

7.171
7.157
7.148
7.135
7.118
7.104
7.098
2.565
3g
8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm
6.321
12.000

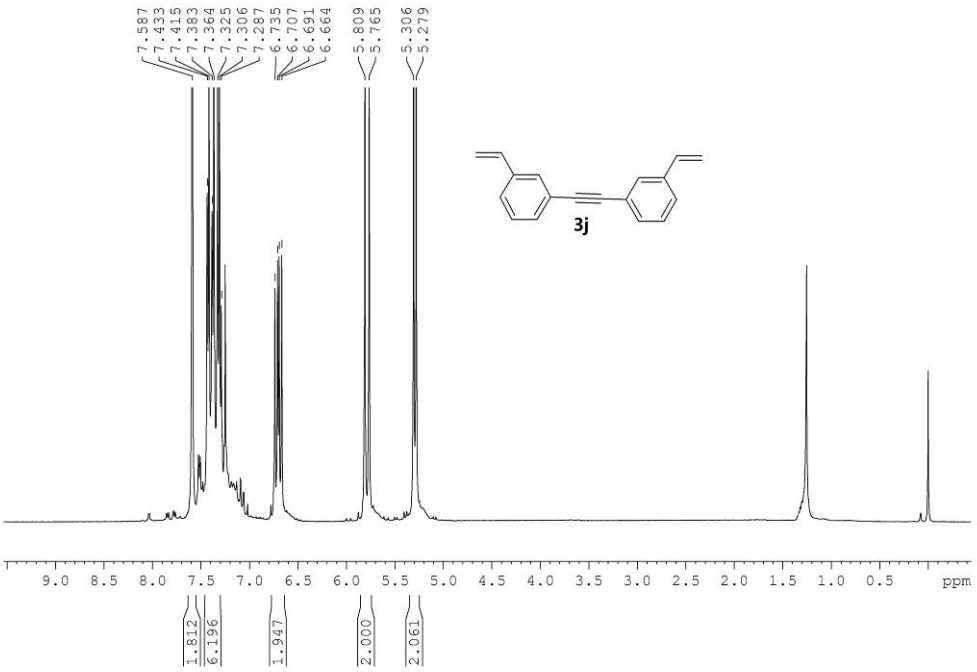

140.113
127.659
126.823
123.661
95.807
21.642
3g
220 200 180 160 140 120 100 80 60 40 20 0 ppm

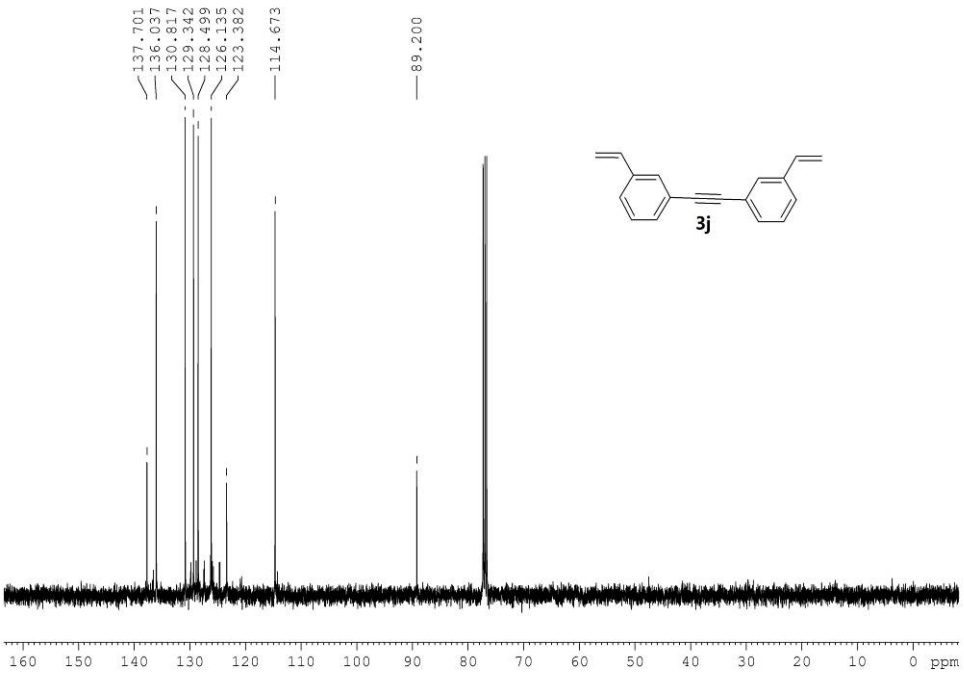

6.944
2.536
2.333
3h
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm
4.018
12.000
6.273

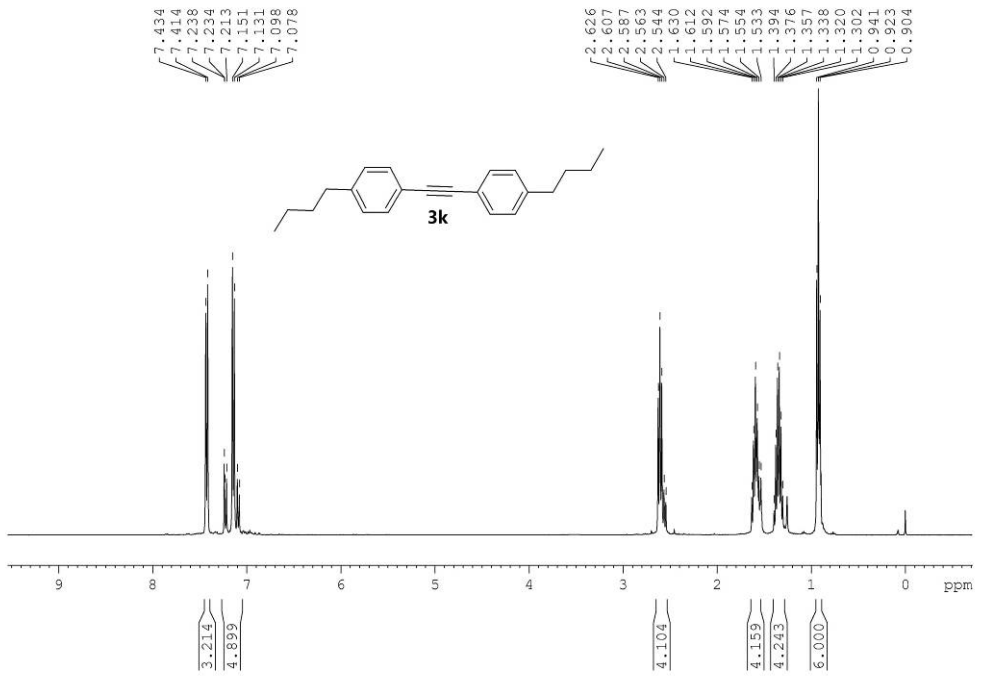

139.878
137.454
127.711
120.878
95.279
21.527
21.346
3h
150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

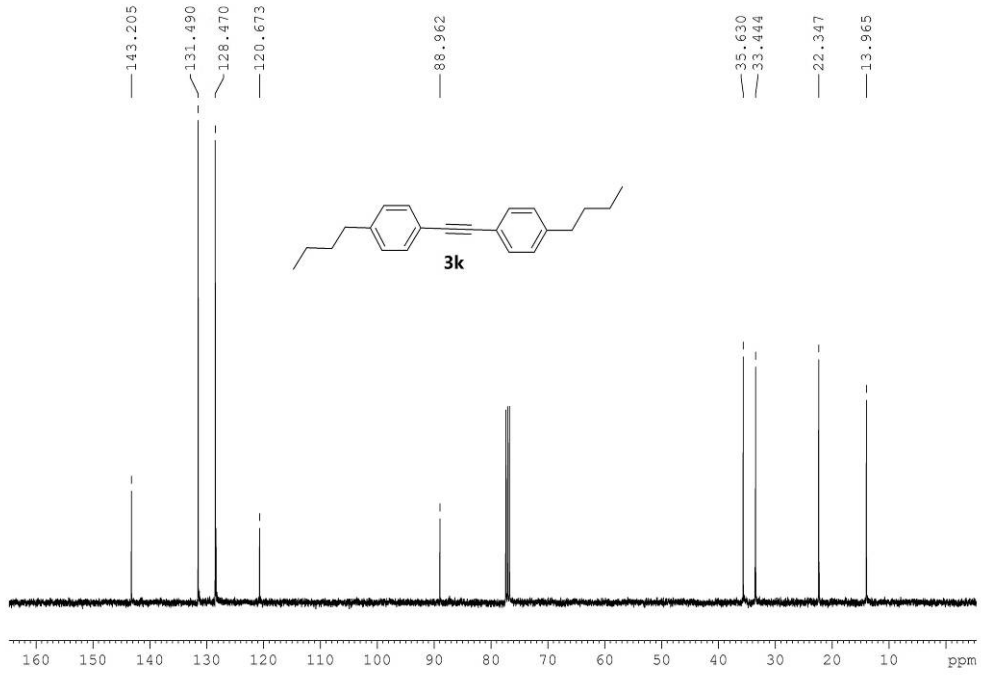

7.620
7.600
7.551
7.532
7.349
7.334
7.318
7.305
7.298
7.277
7.266
7.247
7.229
5.868
5.824
5.399
5.372
3i
9
8
7
6
5
4
3
2
1
0
ppm
2.176
2.126
7.172
2.000
1.966

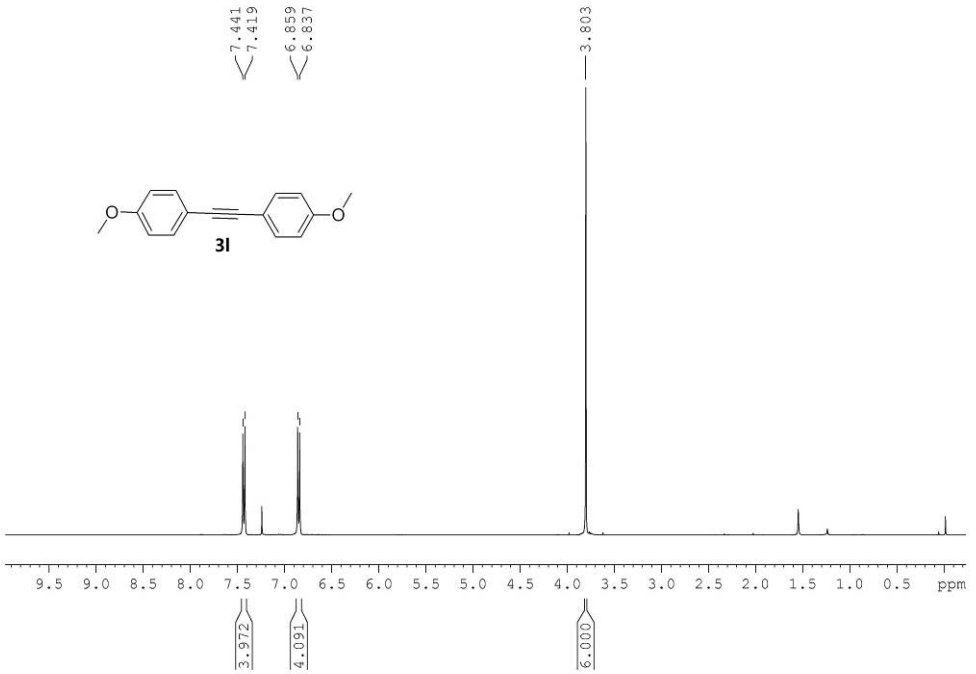

138.966
134.960
132.437
128.457
127.445
124.659
121.953
115.664
92.275
3i
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

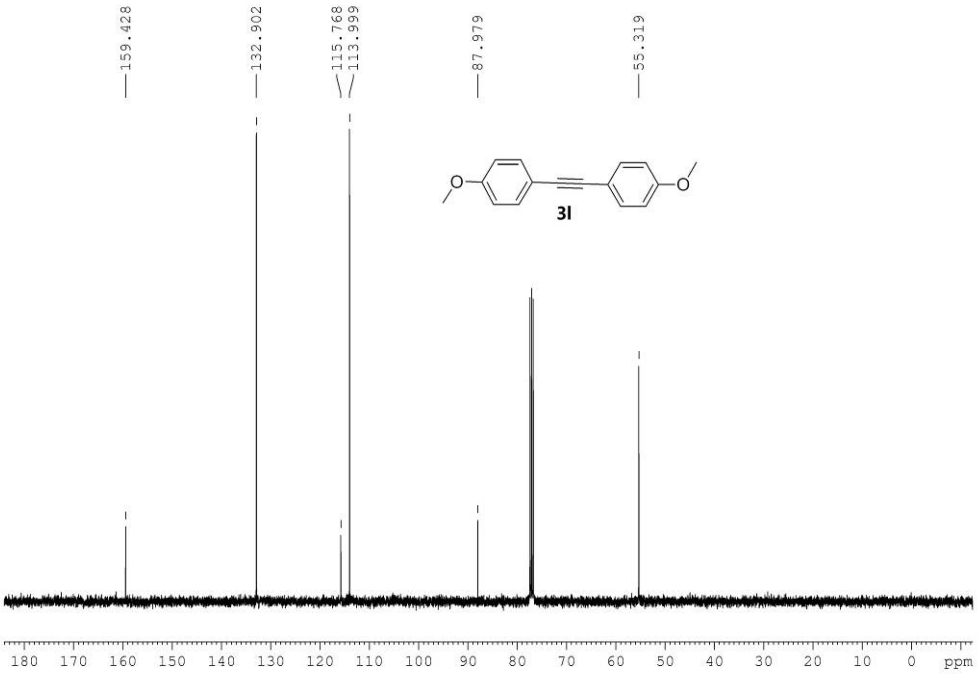

7.587
7.433
7.415
7.383
7.364
7.325
7.306
7.287
6.735
6.707
6.691
6.664
5.809
5.765
5.306
5.279
3j
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm
1.812
6.196
1.947
2.000
2.061

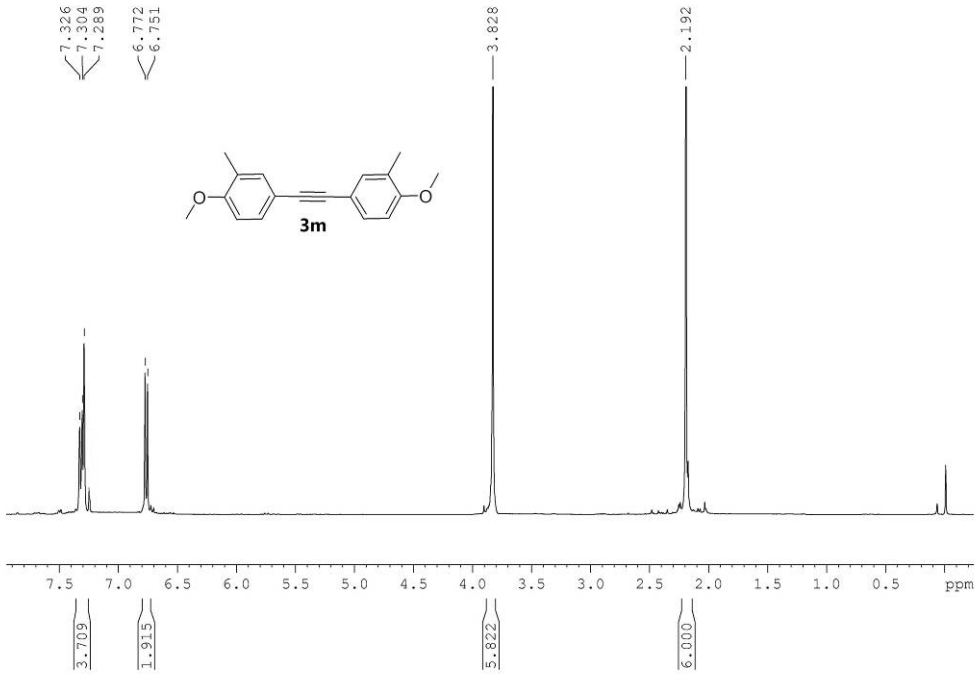

137.701
136.037
130.817
129.342
128.499
126.135
123.382
114.673
89.200
3j
160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

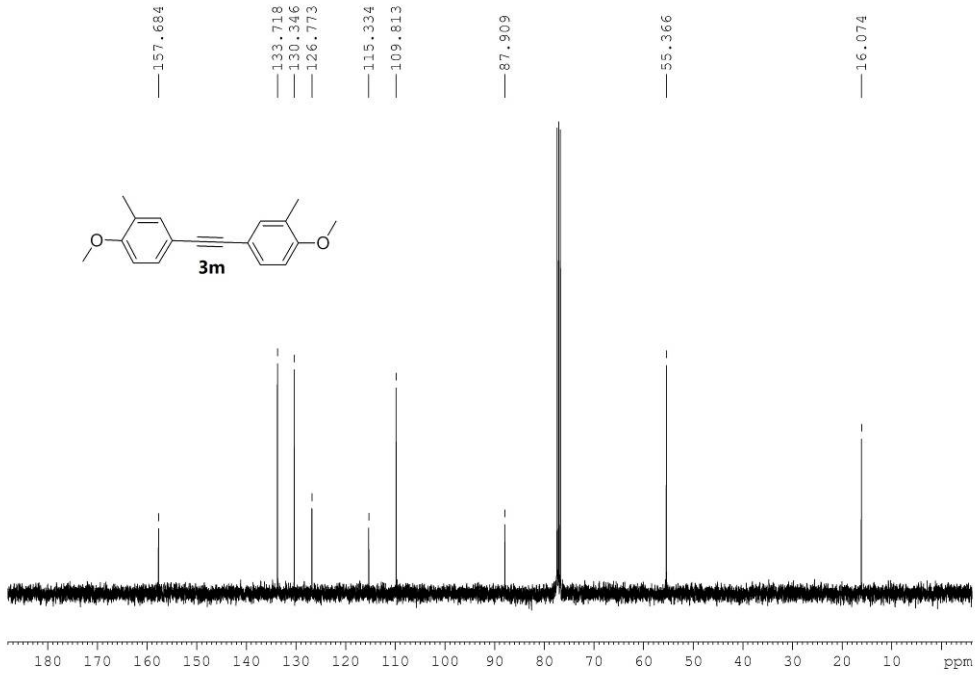

7.434
7.414
7.238
7.234
7.213
7.151
7.131
7.098
7.078
2.626
2.607
2.587
2.563
2.544
1.630
1.612
1.592
1.574
1.554
1.533
1.394
1.376
1.357
1.338
1.320
1.302
0.941
0.923
0.904
3k
9
8
7
6
5
4
3
2
1
0
ppm
3.214
4.899
4.104
4.159
4.243
6.000

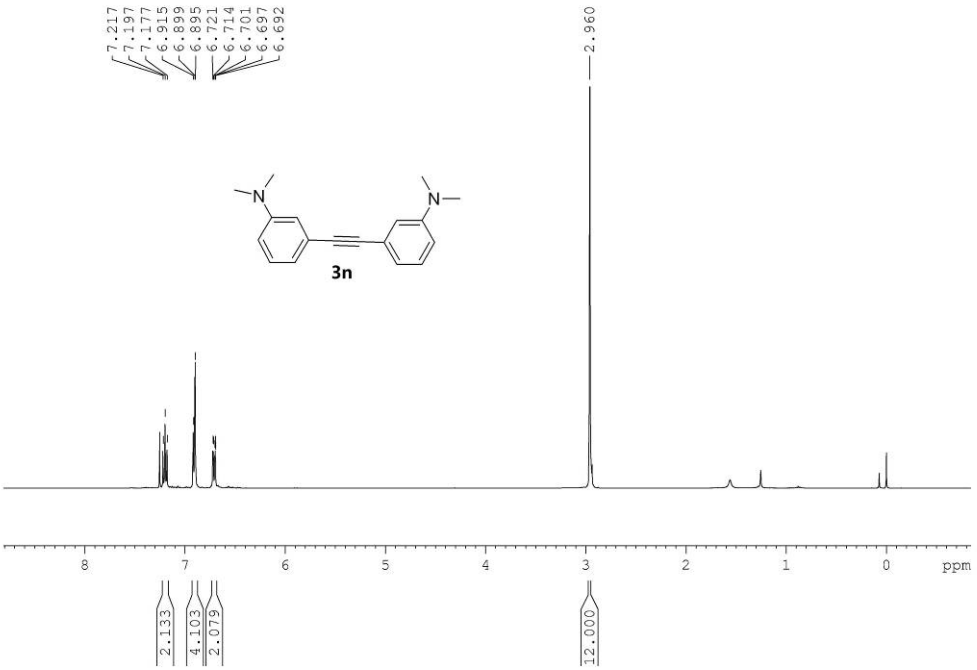

143.205
131.490
128.470
120.673
88.962
35.630
33.444
22.347
13.965
3k
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

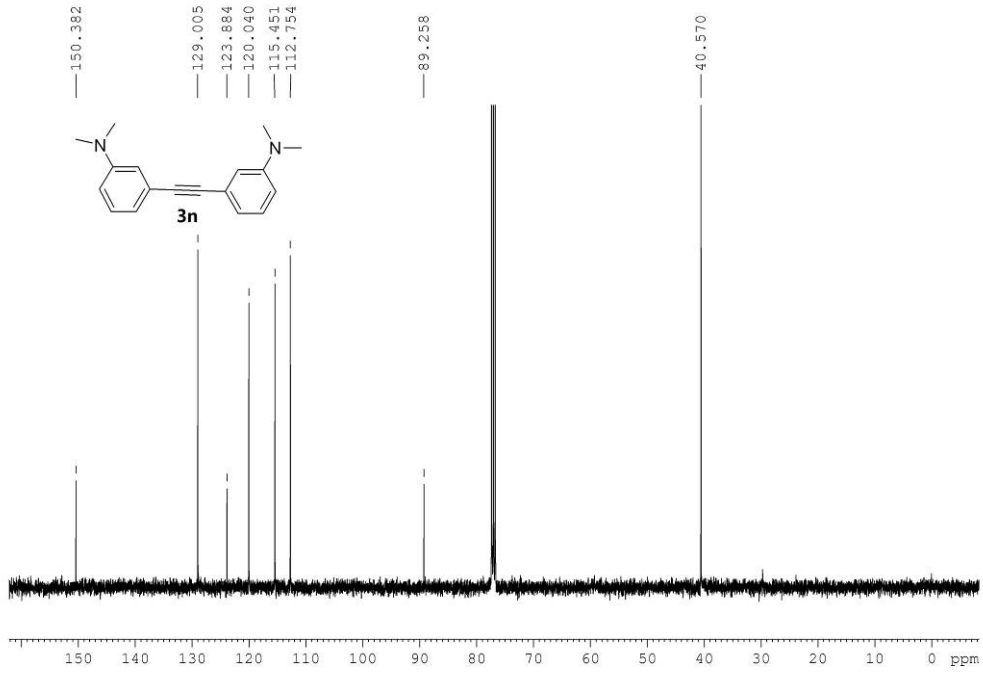

7.441
7.419
6.859
6.837
3.803
3l
9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm
3.972
4.091
6.000

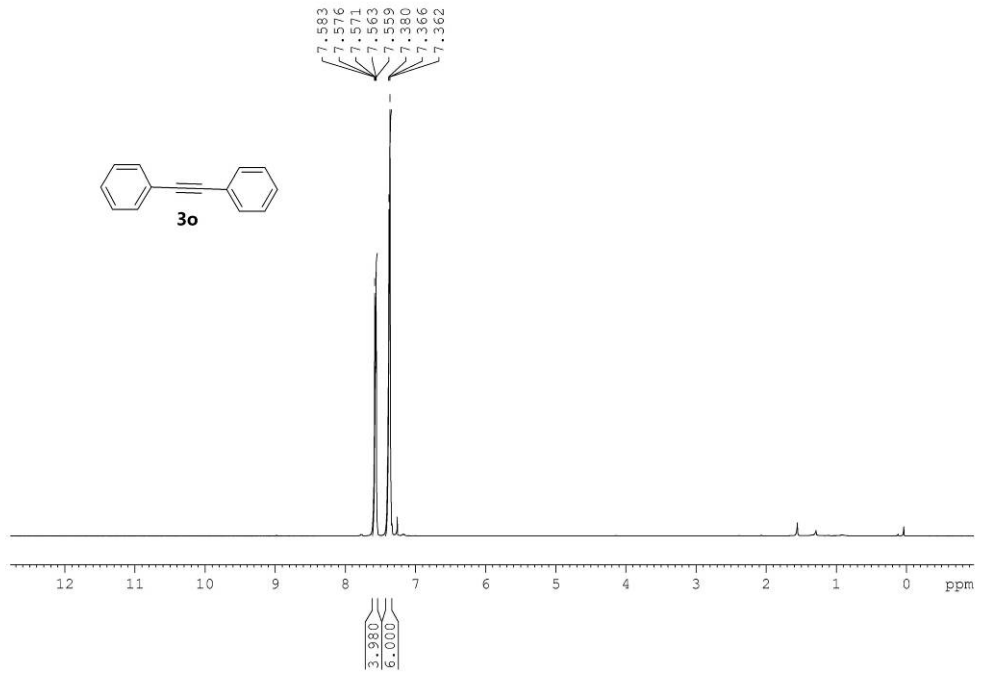

159.428
132.902
115.768
113.999
87.979
55.319
3l
180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

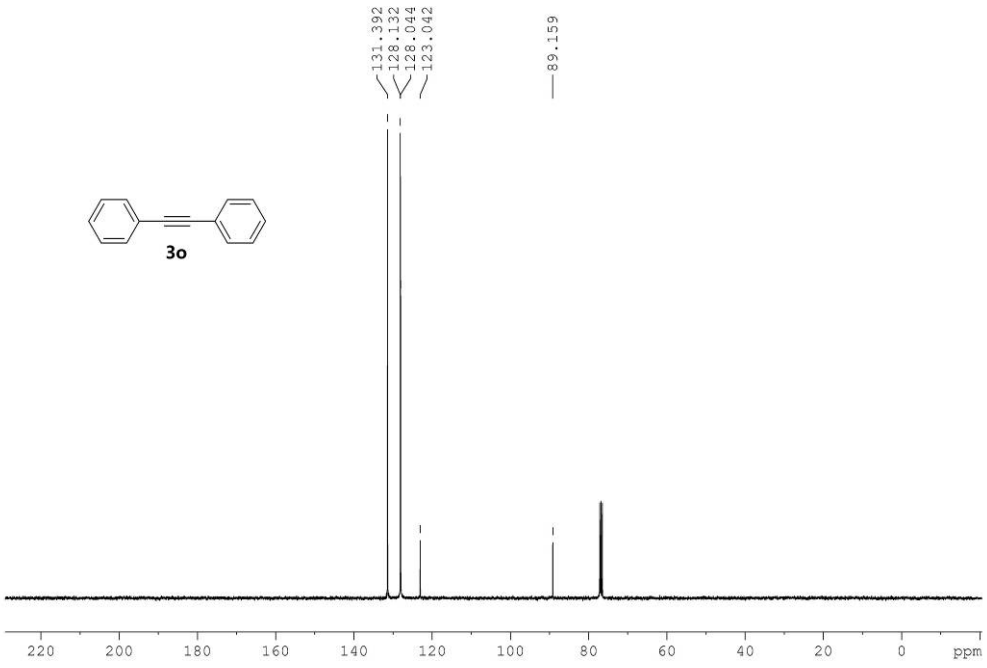

7.326
7.304
7.289
6.772
6.751
3.828
2.192
3m
7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm
3.709
1.915
5.822
6.000

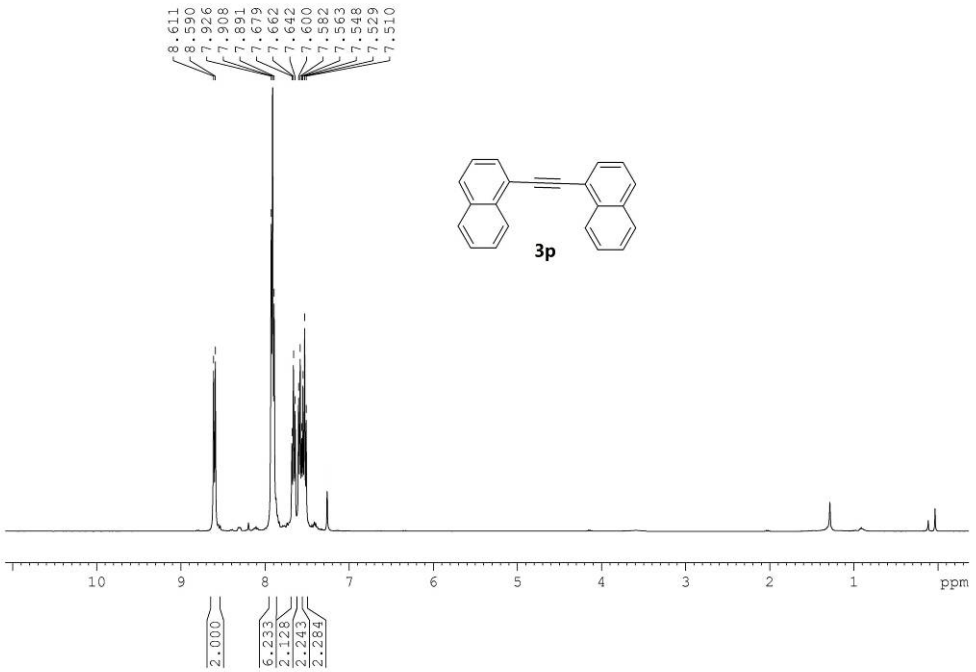

157.684
133.718
130.346
126.773
115.334
109.813
87.909
55.366
16.074
3m
180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

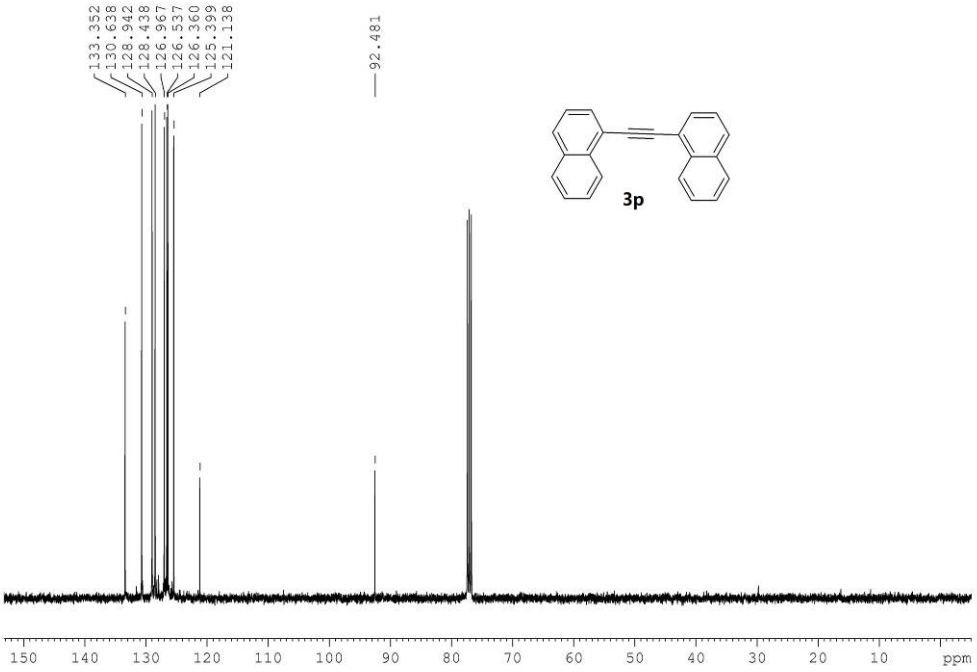

7.217
7.197
7.177
6.915
6.899
6.895
6.721
6.714
6.701
6.697
6.692
2.960
3n
8
7
6
5
4
3
2
1
0
ppm
2.133
4.103
2.079
12.000

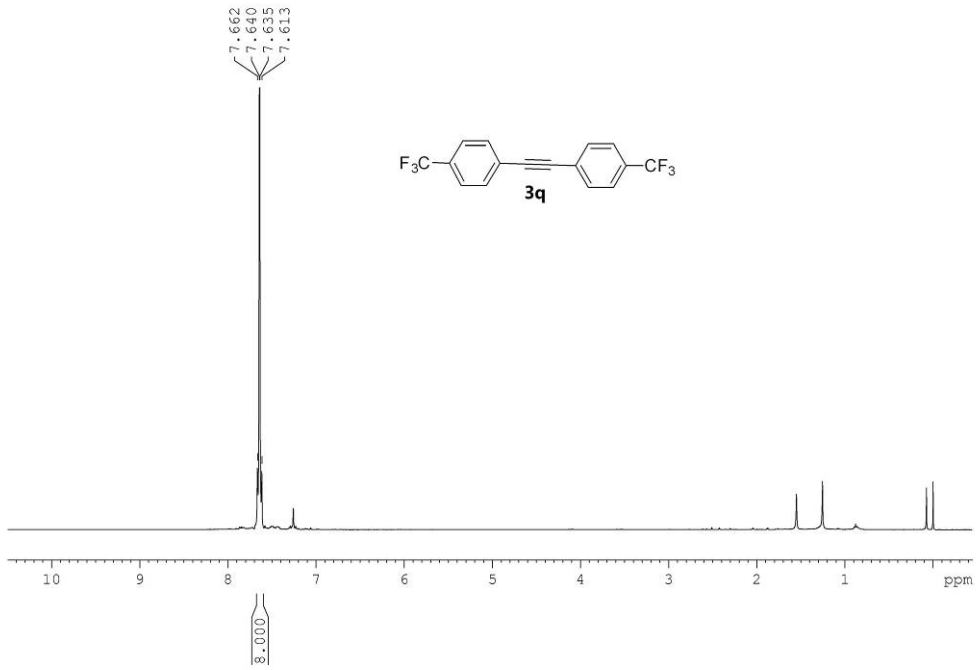

150.382
129.005
123.884
120.040
115.451
112.754
89.258
40.570
3n
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

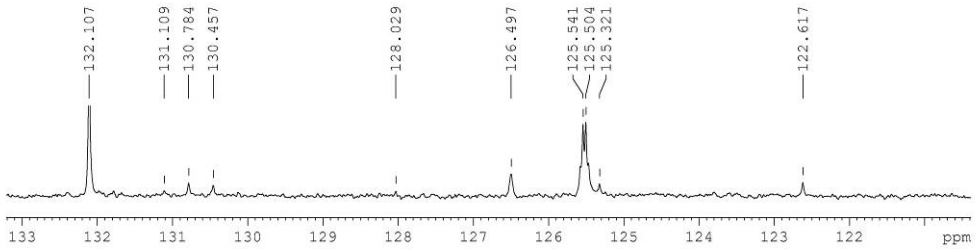

7.583
7.576
7.571
7.563
7.559
7.380
7.366
7.362
3o
12
11
10
9
8
7
6
5
4
3
2
1
0
ppm
3.980
6.000

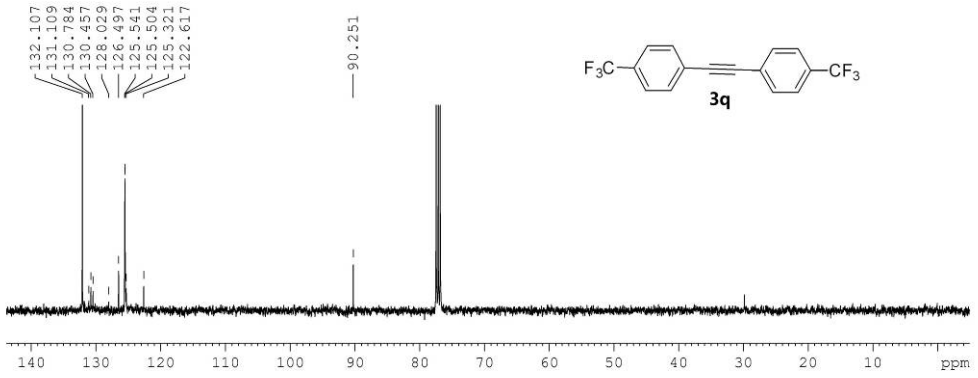

131.392
128.132
128.044
123.042
89.159
3o
220
200
180
160
140
120
100
80
60
40
20
0
ppm

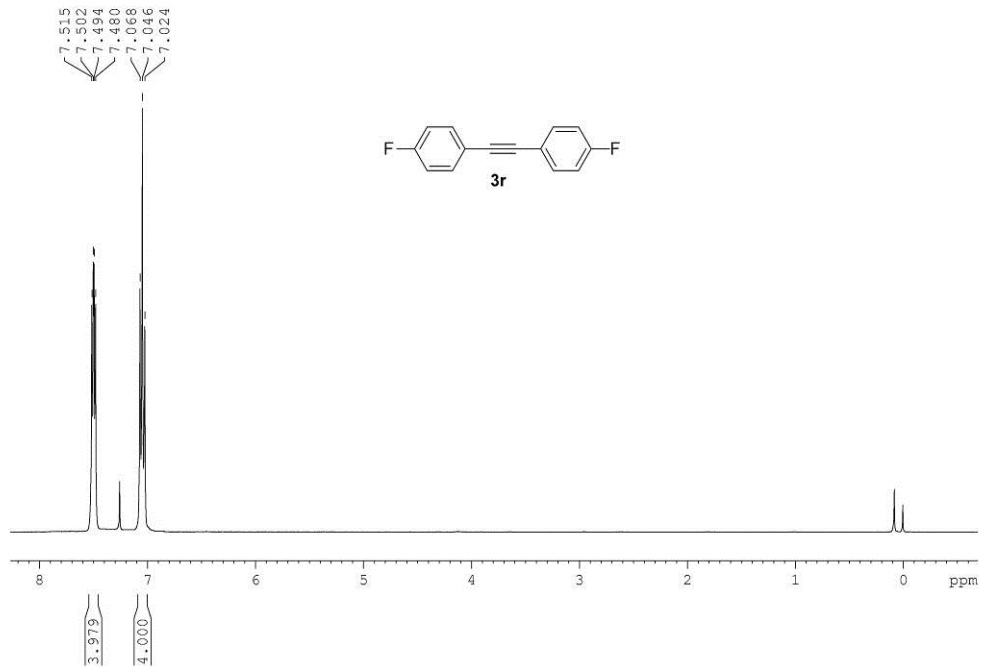

8.611
8.590
7.926
7.908
7.891
7.679
7.662
7.642
7.600
7.582
7.563
7.548
7.529
7.510
3p
10
9
8
7
6
5
4
3
2
1
ppm
2.000
6.233
2.128
2.243
2.284

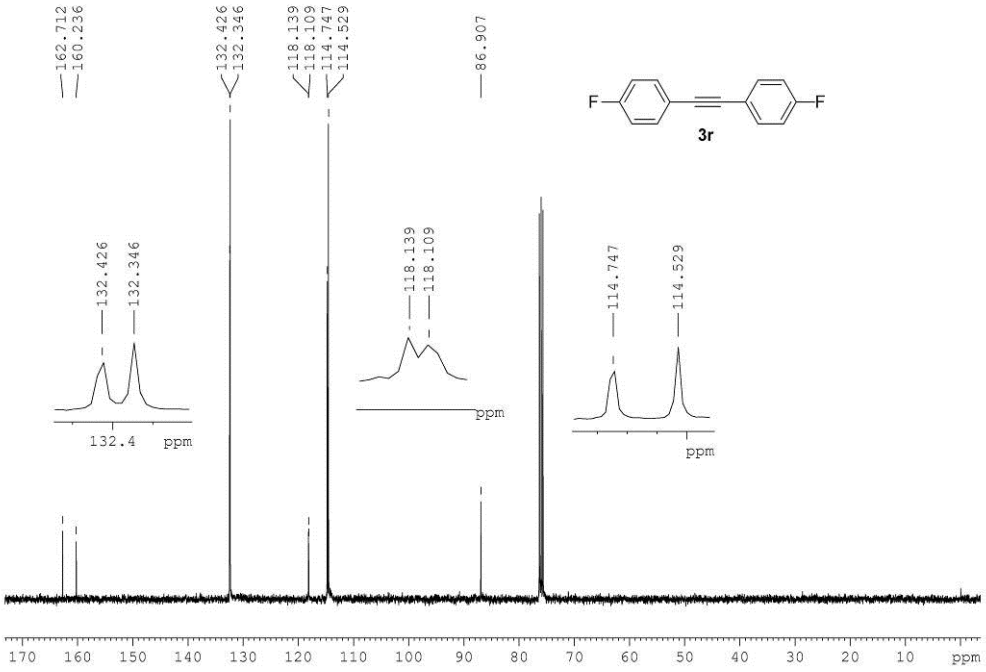

133.352
130.638
128.942
128.438
126.967
126.537
126.360
125.399
121.138
92.481
3p
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

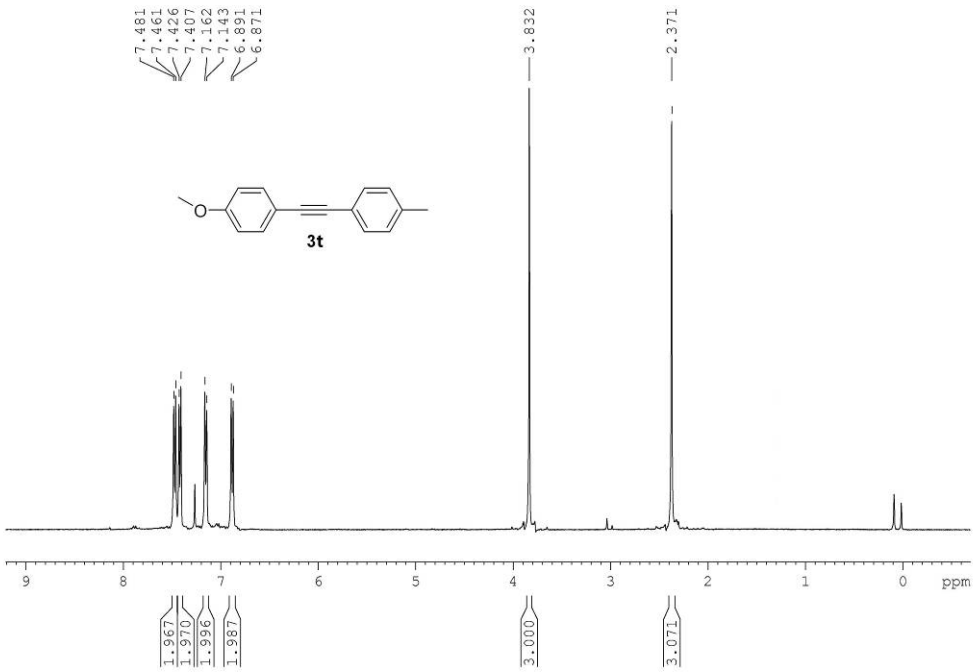

7.662
7.640
7.635
7.613
F3C
CF3
3q
10
9
8
7
6
5
4
3
2
1
ppm
8.000

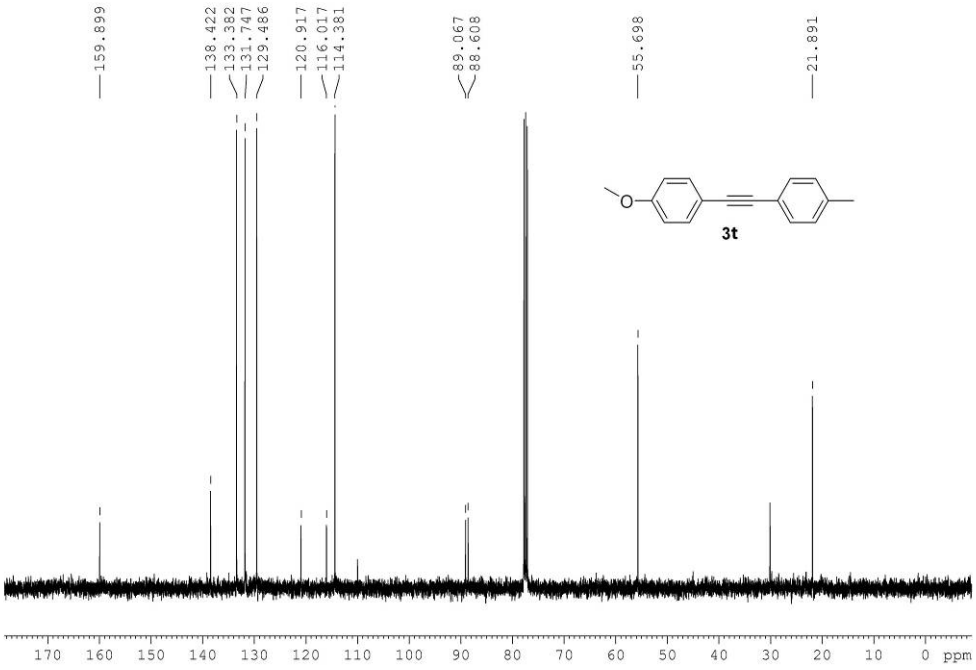

132.107
131.109
130.784
130.457
128.029
126.497
125.541
125.504
125.321
122.617
133
132
131
130
129
128
127
126
125
124
123
122
ppm

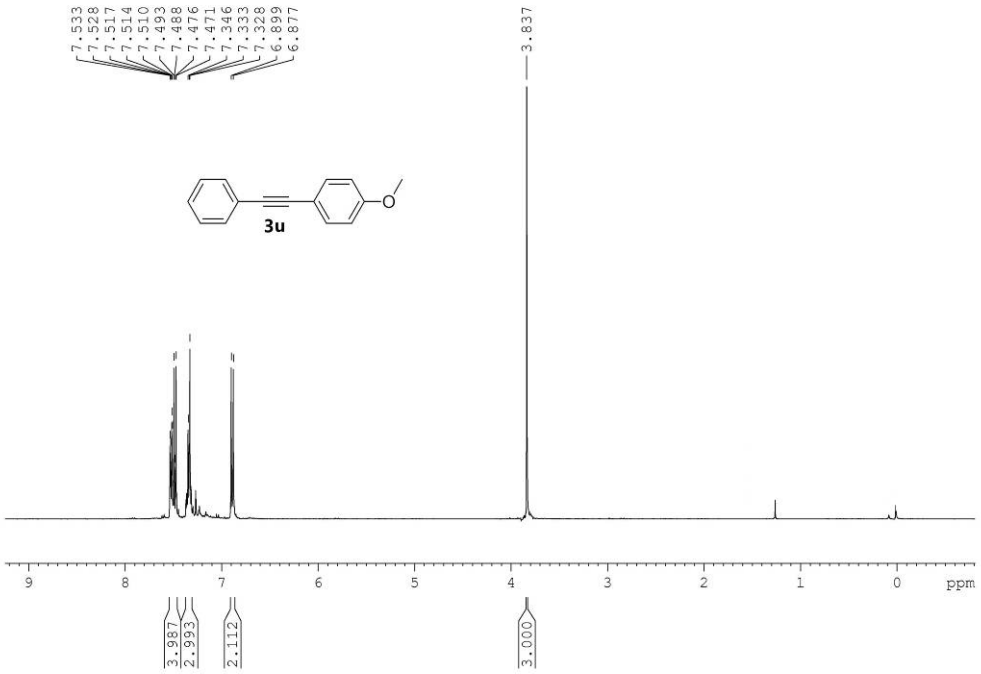

132.107
131.109
130.784
130.457
128.029
126.497
125.541
125.504
125.321
122.617
90.251
F3C
CF3
3q
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

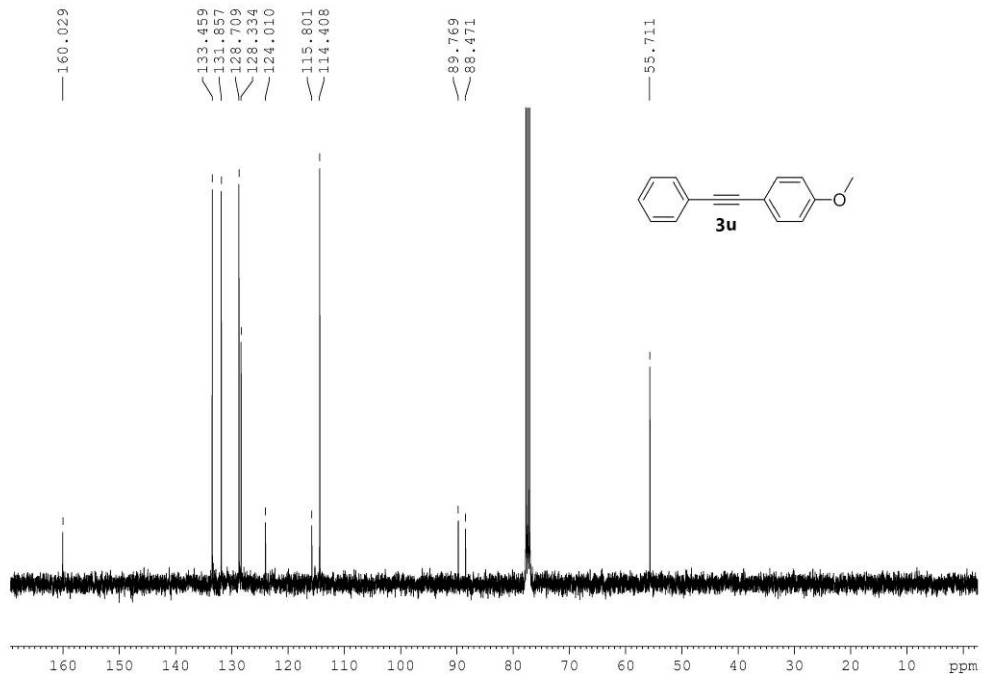

7.515
7.502
7.494
7.480
7.068
7.046
7.024
F
F
3r
8
7
6
5
4
3
2
1
0
ppm
3.979
4.000

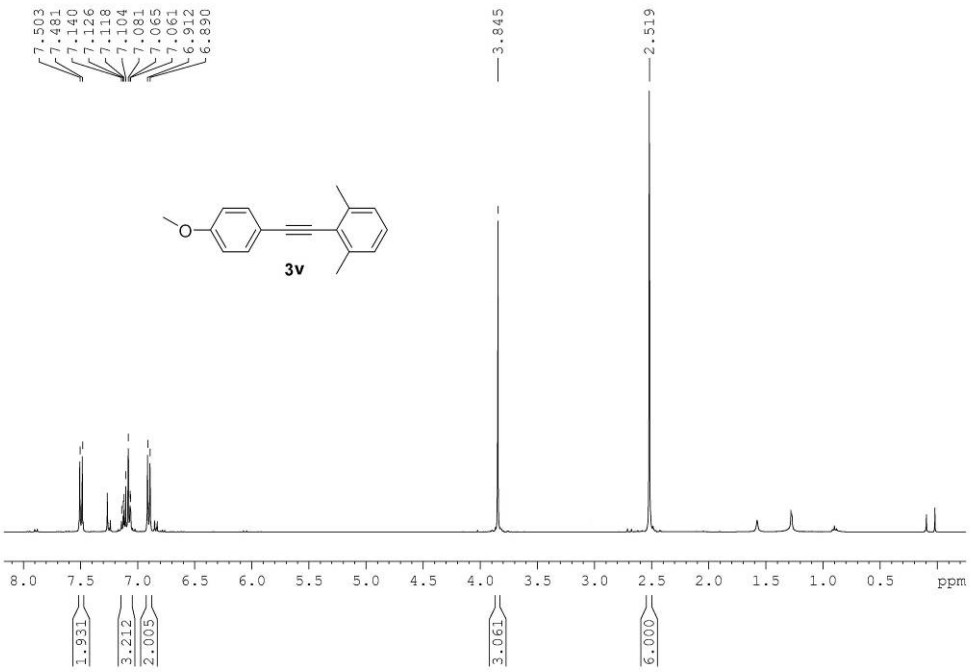

162.712
160.236
132.426
132.346
118.139
118.109
114.747
114.529
86.907
F
F
3r
132.426
132.346
132.4
ppm
118.139
118.109
ppm
114.747
114.529
ppm
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

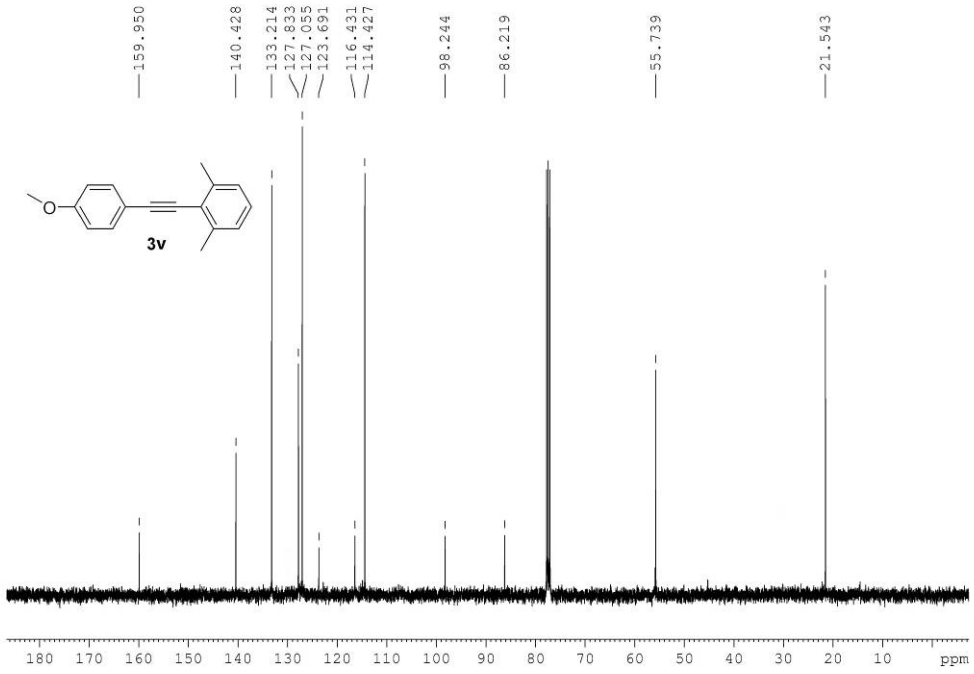

7.481
7.461
7.426
7.407
7.162
7.143
6.891
6.871
3.832
2.371
3t
9
8
7
6
5
4
3
2
1
0
ppm
1.967
1.970
1.996
1.987
3.000
3.071

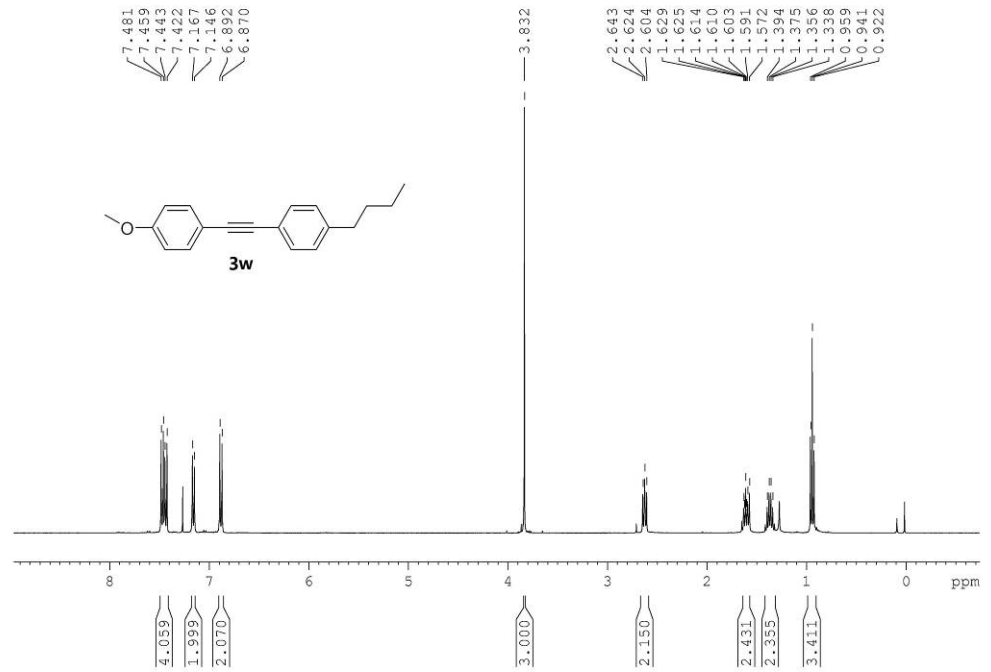

159.899
138.422
133.382
131.747
129.486
120.917
116.017
114.381
89.067
88.608
55.698
21.891
3t
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0 ppm

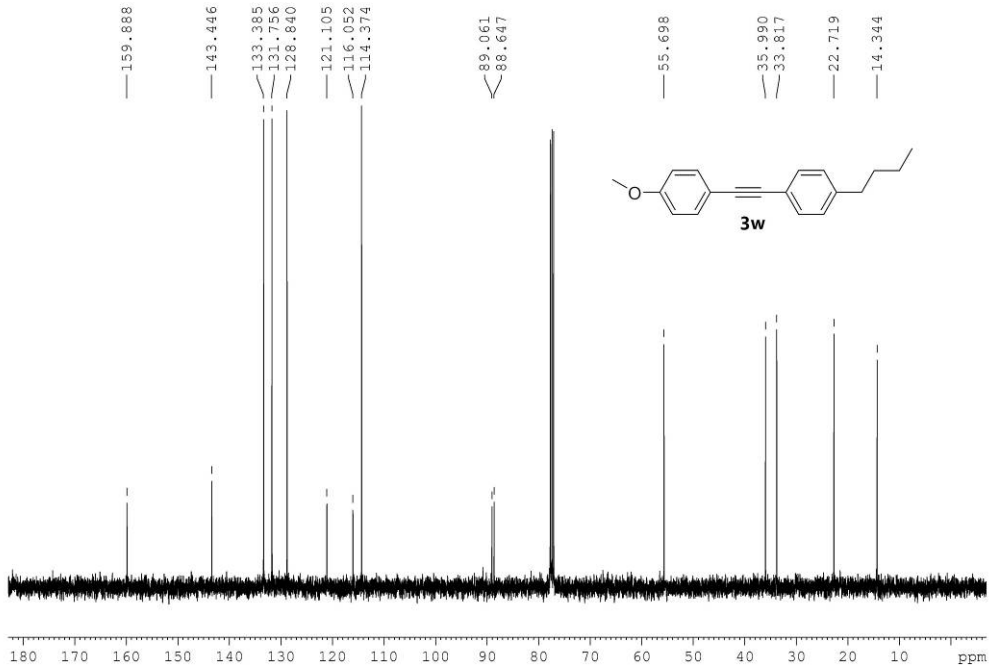

7.533
7.528
7.517
7.514
7.510
7.493
7.488
7.476
7.471
7.346
7.333
7.328
6.899
6.877
3.837
3u
9
8
7
6
5
4
3
2
1
0
ppm
3.987
2.993
2.112
3.000

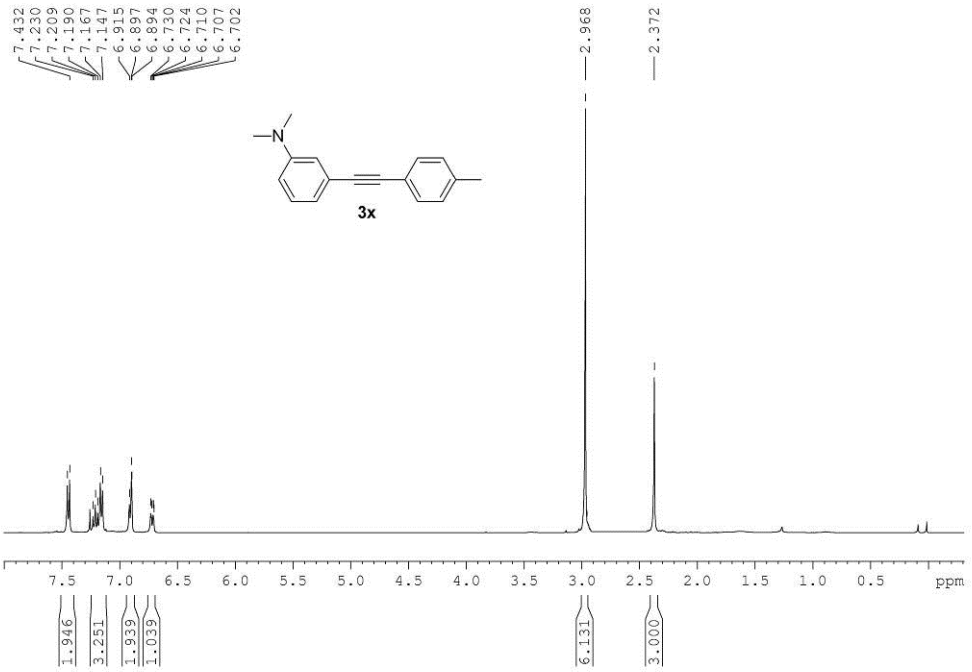

160.029
133.459
131.857
128.709
128.334
124.010
115.801
114.408
89.769
88.471
55.711
3u
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

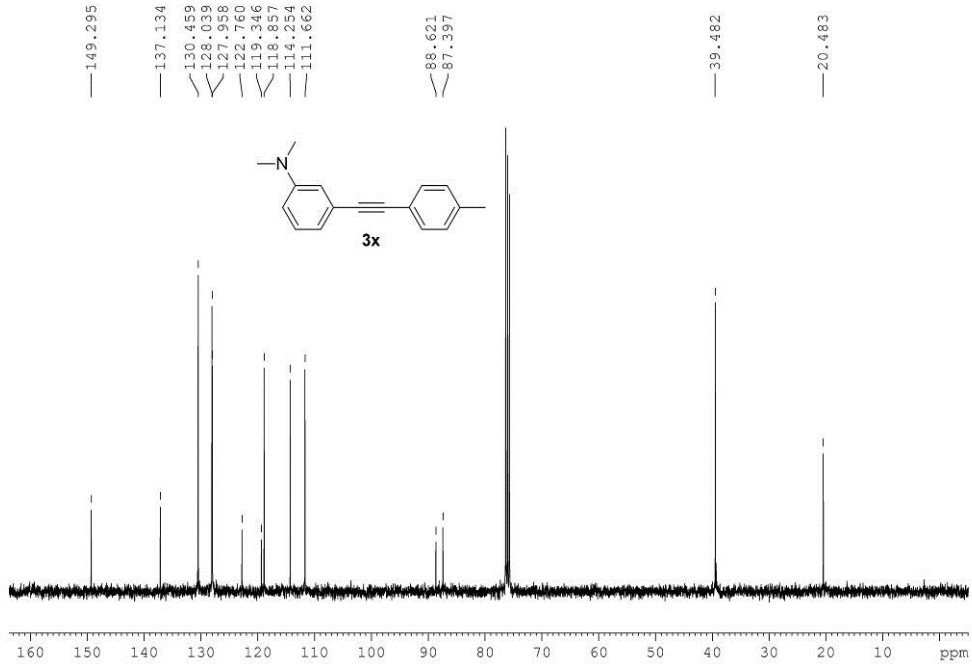

7.503
7.481
7.140
7.126
7.118
7.104
7.081
7.065
7.061
6.912
6.890
3.845
2.519
3v
8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm
1.931
3.212
2.005
3.061
6.000

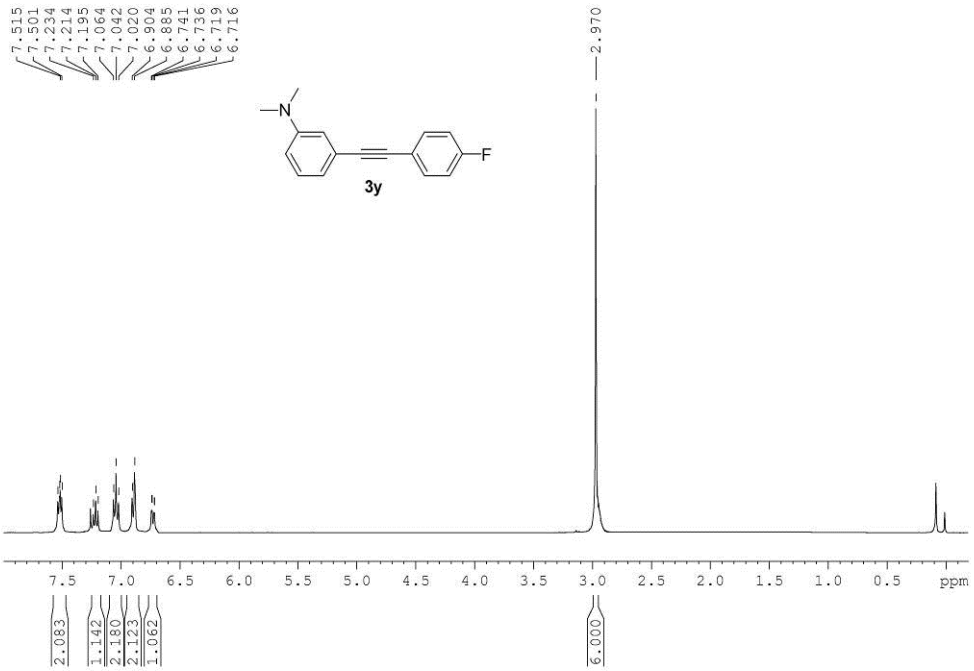

159.950
140.428
133.214
127.833
127.055
123.691
116.431
114.427
98.244
86.219
55.739
21.543
3v
180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

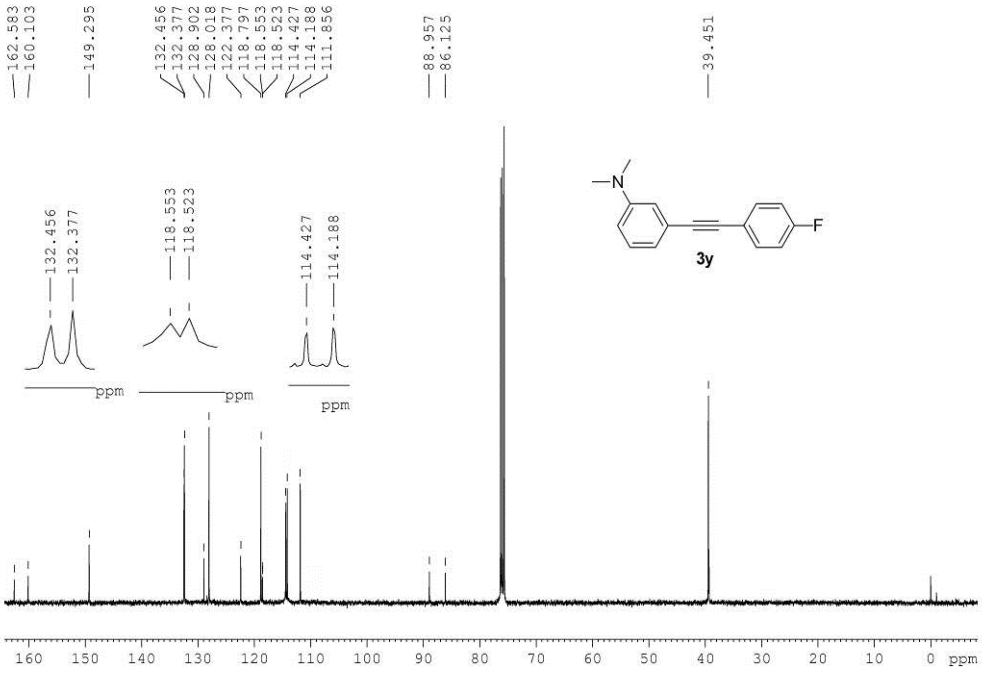

7.481
7.459
7.443
7.422
7.167
7.146
6.892
6.870
3.832
2.643
2.624
2.604
1.629
1.625
1.614
1.610
1.603
1.591
1.572
1.394
1.375
1.356
1.338
0.959
0.941
0.922
3w
ppm
4.059
1.999
2.070
3.000
2.150
2.431
2.355
3.411


159.888
143.446
133.385
131.756
128.840
121.105
116.052
114.374
89.061
88.647
55.698
35.990
33.817
22.719
14.344
3w
ppm


7.432
7.230
7.209
7.190
7.167
7.147
6.915
6.897
6.894
6.730
6.724
6.710
6.707
6.702
2.968
2.372
3x
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
ppm
1.946
3.251
1.939
1.039
6.131
3.000


149.295
137.134
130.459
128.039
127.958
122.760
119.346
118.857
114.254
111.662
88.621
87.397
39.482
20.483
3x
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm


7.515
7.501
7.234
7.214
7.195
7.064
7.042
7.020
6.904
6.885
6.741
6.736
6.719
6.716
2.970
N
F
3y
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
ppm
2.083
1.142
2.180
2.123
1.062
6.000


162.583
160.103
149.295
132.456
132.377
128.902
128.018
122.377
118.797
118.553
118.523
114.427
114.188
111.856
88.957
86.125
39.451
N
F
3y
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm