Supporting Information

Palladium-Catalyzed Oxidative Deacetonative Coupling of 4-Aryl-2-methyl-3-butyn-2-ols with H-phosphonates

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Diisopropyl (phenylethynyl)phosphonate (**3a**):[1] colorless oil; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.56-7.52 (m, 2H), 7.47-7.43 (m, 1H), 7.39-7.34 (m, 2H), 4.89-4.75 (m, 2H), 1.41 (d, J = 6.2 Hz, 6H), 1.40 (d, J = 6.2 Hz, 6H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 131.7 (d, $J_{C\text{-}P}$ = 2.4 Hz), 129.7, 127.7, 119.0 (d, $J_{C\text{-}P}$ = 5.5 Hz), 97.3 (d, $J_{C\text{-}P}$ = 52.5 Hz), 79.0 (d, $J_{C\text{-}P}$ = 296.5 Hz), 71.5 (d, $J_{C\text{-}P}$ = 5.6 Hz), 23.1 (d, $J_{C\text{-}P}$ = 4.5 Hz), 22.8 (d, $J_{C\text{-}P}$ = 4.8 Hz); ^{31}P NMR ($CDCl_3$, 163 MHz): δ -8.14.

Diethyl (phenylethynyl)phosphonate (**3b**):[1] colorless oil; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.60-7.54 (m, 2H), 7.49-7.43 (m, 1H), 7.42-7.35 (m, 2H), 4.28-4.19 (m, 4H), 1.41 (t, J = 7.1 Hz, 6H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 131.8 (d, $J_{C\text{-}P}$ = 2.5 Hz), 129.9, 127.7, 118.7 (d, $J_{C\text{-}P}$ = 5.6 Hz), 98.3 (d, $J_{C\text{-}P}$ = 52.8 Hz), 77.5 (d, $J_{C\text{-}P}$ = 305.4 Hz), 62.4 (d, $J_{C\text{-}P}$ = 5.5 Hz), 15.3 (d, $J_{C\text{-}P}$ = 7.0 Hz); ^{31}P NMR ($CDCl_3$, 163 MHz): δ -5.57.

Dibutyl (phenylethynyl)phosphonate (**3c**):[1] colorless oil; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.57 (d, J = 7.2 Hz, 2H), 7.50-7.44 (m, 1H), 7.42-7.35 (m, 2H), 4.20-4.10 (m, 4H), 1.79-1.69 (m, 4H), 1.53-1.41 (m, 4H), 0.96 (t, J = 7.4 Hz, 6H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 131.8 (d, $J_{C\text{-}P}$ = 2.4 Hz), 129.8, 127.7, 118.8 (d, $J_{C\text{-}P}$ = 5.7 Hz), 98.2 (d, $J_{C\text{-}P}$ = 52.4 Hz), 77.5 (d, $J_{C\text{-}P}$ = 297.6 Hz), 66.1 (d, $J_{C\text{-}P}$ = 5.8 Hz), 31.4 (d, $J_{C\text{-}P}$ = 7.1 Hz), 17.9, 12.7; ^{31}P NMR ($CDCl_3$, 163 MHz): δ -5.15.

Diethyl ((3-methoxyphenyl)ethynyl)phosphonate (**3d**): colorless oil; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.26-7.20 (m, 1H), 7.14-7.08 (m, 1H), 7.01 (s, 1H), 6.99-6.90 (m, 1H), 4.25-4.12 (m, 4H), 3.75 (s, 3H), 1.35 (t, J = 7.0 Hz, 6H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 158.3, 128.7, 124.1 (d, $J_{C\text{-}P}$ = 2.4 Hz), 119.4 (d, $J_{C\text{-}P}$ = 5.6 Hz), 116.5, 116.2 (d, $J_{C\text{-}P}$ = 2.3 Hz), 98.0 (d, $J_{C\text{-}P}$ = 52.6 Hz), 77.1 (d, $J_{C\text{-}P}$ = 297.8 Hz), 62.3 (d, $J_{C\text{-}P}$ = 5.4 Hz), 54.4, 15.1 (d, $J_{C\text{-}P}$ = 6.9 Hz); ^{31}P NMR ($CDCl_3$, 163 MHz): δ -5.63; HRMS (ESI$^+$) calcd for $C_{13}H_{17}O_4P$ $[M+H]^+$: 269.0937, found: 269.0937.

Diethyl (naphthalen-1-ylethynyl)phosphonate (**3e**): colorless oil; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.23 (d, J = 8.3 Hz, 1H), 7.91 (d, J = 8.3 Hz, 1H), 7.84 (d, J = 8.1 Hz, 1H), 7.79 (d, J = 7.1 Hz, 1H), 7.61-7.49 (m, 2H), 7.42 (t, J = 7.9 Hz, 1H), 4.34-4.18 (m, 4H), 1.40 (t, J = 7.1 Hz, 6H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 132.3, 132.0, 131.7 (d, $J_{C\text{-}P}$ = 2.7 Hz), 130.4, 127.6, 126.7, 126.0, 124.6, 124.0, 116.1 (d, $J_{C\text{-}P}$ = 5.6 Hz), 96.5 (d, $J_{C\text{-}P}$ = 52.3 Hz), 82.1 (d, $J_{C\text{-}P}$ = 296.9 Hz), 62.3 (d, $J_{C\text{-}P}$ = 5.4 Hz), 15.2 (d, $J_{C\text{-}P}$ = 6.9 Hz); ^{31}P NMR ($CDCl_3$, 163 MHz): δ -5.57; HRMS (ESI$^+$) calcd for $C_{16}H_{17}O_3P$ $[M+H]^+$: 289.0988, found: 289.0988.

Dibutyl (naphthalen-1-ylethynyl)phosphonate (**3f**): colorless oil; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.25 (d, J = 8.2 Hz, 1H), 7.91 (d, J = 8.2 Hz, 1H), 7.85 (d, J = 8.0 Hz, 1H), 7.79 (d, J = 7.1 Hz, 1H), 7.61-7.50 (m, 2H), 7.43 (t, J = 7.7 Hz, 1H), 4.25-4.14 (m, 4H), 1.78-1.69 (m, 4H), 1.52-1.40 (m, 4H), 0.93 (t, J = 7.3 Hz, 6H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 132.4, 132.0, 131.7 (d, $J_{C\text{-}P}$ = 2.7 Hz), 130.3, 127.6, 126.7, 126.0, 124.6, 124.0, 116.2 (d, $J_{C\text{-}P}$ = 5.5 Hz), 96.5 (d, $J_{C\text{-}P}$ = 52.1 Hz), 82.1 (d, $J_{C\text{-}P}$ = 296.5 Hz), 66.0 (d, $J_{C\text{-}P}$ = 5.8 Hz), 31.3 (d, $J_{C\text{-}P}$ = 7.0 Hz), 17.8, 12.6; ^{31}P NMR

($CDCl_3$, 163 MHz): δ -5.18; HRMS (ESI^+) calcd for $C_{20}H_{25}O_3P$ $[M+H]^+$: 345.1614, found: 345.1615.

Diisopropyl (*p*-tolylethynyl)phosphonate (**3g**):[2] colorless oil; ^1H NMR ($CDCl_3$, 400 MHz): δ 7.38 (d, J = 8.0 Hz, 2H), 7.11 (d, J = 8.0 Hz, 2H), 4.82-4.69 (m, 2H), 2.32 (s, 3H), 1.35 (d, J = 6.1 Hz, 6H), 1.34 (d, J = 6.1 Hz, 6H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 140.3, 131.6 (d, $J_{C\text{-}P}$ = 2.4 Hz), 128.5, 115.9 (d, $J_{C\text{-}P}$ = 5.6 Hz), 97.8 (d, $J_{C\text{-}P}$ = 52.8 Hz), 78.4 (d, $J_{C\text{-}P}$ = 297.8 Hz), 71.4 (d, $J_{C\text{-}P}$ = 5.5 Hz), 23.1 (d, $J_{C\text{-}P}$ = 4.5 Hz), 22.8 (d, $J_{C\text{-}P}$ = 4.8 Hz), 20.8. ^{31}P NMR ($CDCl_3$, 163 MHz): δ -7.85.

Diisopropyl (*m*-tolylethynyl)phosphonate (**3h**): colorless oil; ^1H NMR ($CDCl_3$, 400 MHz): δ 7.37-7.30 (m, 2H), 7.25-7.19 (m, 2H), 4.85-4.71 (m, 2H), 2.33 (s, 3H), 1.39 (d, J = 6.0 Hz, 12H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 137.4, 131.9 (d, $J_{C\text{-}P}$ = 2.5 Hz), 130.5, 128.6 (d, $J_{C\text{-}P}$ = 2.5 Hz), 127.5, 118.6 (d, $J_{C\text{-}P}$ = 5.5 Hz), 97.5 (d, $J_{C\text{-}P}$ = 52.6 Hz), 78.5 (d, $J_{C\text{-}P}$ = 297.2 Hz), 71.3 (d, $J_{C\text{-}P}$ = 5.5 Hz), 22.9 (d, $J_{C\text{-}P}$ = 4.5 Hz), 22.7 (d, $J_{C\text{-}P}$ = 4.8 Hz), 20.2; ^{31}P NMR ($CDCl_3$, 163 MHz): δ -8.03; HRMS (ESI^+) calcd for $C_{15}H_{21}O_3P$ $[M+H]^+$: 281.1301, found: 281.1303.

Diisopropyl ((3,4-dimethylphenyl)ethynyl)phosphonate (**3i**): colorless oil; ^1H NMR ($CDCl_3$, 400 MHz): δ 7.34-7.24 (m, 2H), 7.14-1.07 (d, J = 7.6 Hz, 1H), 4.91-4.66 (m, 2H), 2.27 (s, 3H), 2.24 (s, 3H), 1.39 (d, J = 6.1 Hz, 6H), 1.38 (d, J = 6.1 Hz, 6H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 139.1, 136.2, 132.6 (d, $J_{C\text{-}P}$ = 2.4 Hz), 129.2 (d, $J_{C\text{-}P}$ = 2.4 Hz), 129.0, 116.2 (d, $J_{C\text{-}P}$ = 5.6 Hz), 98.1 (d, $J_{C\text{-}P}$ = 52.9 Hz), 78.1 (d, $J_{C\text{-}P}$ = 298.1 Hz), 71.4 (d, $J_{C\text{-}P}$ = 5.5 Hz), 23.1 (d, $J_{C\text{-}P}$ = 4.5 Hz), 22.8 (d, $J_{C\text{-}P}$ = 4.8 Hz), 19.1, 18.7; ^{31}P NMR ($CDCl_3$, 163 MHz): δ -7.71; HRMS (ESI^+) calcd for $C_{16}H_{23}O_3P$ $[M+H]^+$: 295.1458, found: 295.1458.

Diisopropyl ((3,5-dimethylphenyl)ethynyl)phosphonate (**3j**): colorless oil; ^1H NMR ($CDCl_3$, 400 MHz): δ 7.15 (s, 2H), 7.05 (s, 1H), 4.84-4.72 (m, 2H), 2.29 (s, 6H), 1.39 (d, J = 6.1 Hz, 12H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 137.3, 131.5, 129.1 (d, $J_{C\text{-}P}$ = 2.4 Hz), 118.5 (q, $J_{C\text{-}P}$ = 5.5 Hz), 97.8 (d, $J_{C\text{-}P}$ = 52.7 Hz), 78.1 (d, $J_{C\text{-}P}$ = 297.1 Hz), 71.2 (d, $J_{C\text{-}P}$ = 5.5 Hz), 22.9 (d, $J_{C\text{-}P}$ = 4.5 Hz), 22.7 (d, $J_{C\text{-}P}$ = 4.8 Hz); ^{31}P NMR ($CDCl_3$, 163 MHz): δ -7.92; HRMS (ESI^+) calcd for $C_{16}H_{23}O_3P$ $[M+H]^+$: 295.1458, found: 295.1460.

Diisopropyl ((4-butylphenyl)ethynyl)phosphonate (**3k**): colorless oil; ^1H NMR ($CDCl_3$, 400 MHz): δ 7.44 (d, J = 8.0 Hz, 2H), 7.16 (d, J = 8.0 Hz, 1H), 4.85-4.72 (m, 2H), 2.61 (t, J = 7.6 Hz, 2H), 1.57 (q, J = 7.6 Hz, 2H), 1.39 (d, J = 6.0 Hz, 12H), 1.35-1.27 (m, 2H), 0.90 (t, J = 7.6 Hz, 3H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 145.2, 131.7 (d, $J_{C\text{-}P}$ = 2.3 Hz), 127.8, 116.1 (d, $J_{C\text{-}P}$ = 5.6 Hz), 97.9 (d, $J_{C\text{-}P}$ = 52.8 Hz), 78.4 (d, $J_{C\text{-}P}$ = 297.6 Hz), 71.4 (d, $J_{C\text{-}P}$ = 5.5 Hz), 34.9, 32.4, 23.1 (d, $J_{C\text{-}P}$ = 4.5 Hz), 22.8 (d, $J_{C\text{-}P}$ = 4.8 Hz), 21.4, 13.1; ^{31}P NMR ($CDCl_3$, 163 MHz): δ -7.82; HRMS (ESI^+) calcd for $C_{18}H_{27}O_3P$ $[M+H]^+$: 323.1771, found: 323.1772.

Diisopropyl ((3-methoxyphenyl)ethynyl)phosphonate (**3l**): colorless oil; ^1H NMR ($CDCl_3$, 400 MHz): δ 7.21 (t, J = 8.0 Hz, 1H), 7.08 (d, J = 7.6 Hz, 1H), 6.99 (s, 1H),

6.96-6.90 (m, 1H), 4.82-4.68 (m, 2H), 3.74 (s, 3H), 1.35 (d, J = 6.0 Hz, 6H), 1.34 (d, J = 6.0 Hz, 6H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 158.5, 128.9, 124.1 (d, $J_{C\text{-}P}$ = 2.4 Hz), 119.9 (d, $J_{C\text{-}P}$ = 5.6 Hz), 116.4, 116.3 (d, $J_{C\text{-}P}$ = 2.3 Hz), 97.2 (d, $J_{C\text{-}P}$ = 52.4 Hz), 78.8 (d, $J_{C\text{-}P}$ = 296.4 Hz), 71.5 (d, $J_{C\text{-}P}$ = 5.5 Hz), 54.5, 23.1 (d, $J_{C\text{-}P}$ = 4.5 Hz), 22.8 (d, $J_{C\text{-}P}$ = 4.8 Hz); ^{31}P NMR ($CDCl_3$, 163 MHz): δ -8.21; HRMS (ESI$^+$) calcd for $C_{15}H_{21}O_4P$ [M+H]$^+$: 297.1250, found: 297.1255.

Diisopropyl (naphthalen-1-ylethynyl)phosphonate (**3m**):[2] colorless oil; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.28 (d, J = 8.3 Hz, 1H), 7.94 (d, J = 8.3 Hz, 1H), 7.87 (d, J = 8.0 Hz, 1H), 7.81 (d, J = 7.1 Hz, 1H), 7.65-7.51 (m, 2H), 7.45 (t, J = 7.8 Hz, 1H), 4.95-4.82 (m, 2H), 1.47-1.42 (m, 12H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 132.4 (d, $J_{C\text{-}P}$ = 2.1 Hz), 132.0, 131.5 (d, $J_{C\text{-}P}$ = 2.7 Hz), 130.2, 127.6, 126.7, 126.0, 124.6, 124.1, 116.4 (d, $J_{C\text{-}P}$ = 5.6 Hz), 95.6 (d, $J_{C\text{-}P}$ = 52.2 Hz), 83.6 (d, $J_{C\text{-}P}$ = 295.2 Hz), 71.5 (d, $J_{C\text{-}P}$ = 5.6 Hz), 23.0 (d, $J_{C\text{-}P}$ = 4.5 Hz), 22.8 (d, $J_{C\text{-}P}$ = 4.9 Hz); ^{31}P NMR ($CDCl_3$, 163 MHz): δ -8.18.

Diisopropyl ((4-cyanophenyl)ethynyl)phosphonate (**3n**): colorless oil; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.68-7.58 (m, 4H), 4.88-4.70 (m, 2H), 1.39 (d, J = 6.1 Hz, 12H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 132.0 (d, $J_{C\text{-}P}$ = 2.4 Hz), 131.2, 127.5 (d, $J_{C\text{-}P}$ = 12.1 Hz), 116.8, 112.9, 94.1 (d, $J_{C\text{-}P}$ = 51.4 Hz), 83.0 (d, $J_{C\text{-}P}$ = 292.7 Hz), 71.8 (d, $J_{C\text{-}P}$ = 5.6 Hz), 22.9 (d, $J_{C\text{-}P}$ = 4.5 Hz), 22.6 (t, $J_{C\text{-}P}$ = 4.6 Hz); ^{31}P NMR ($CDCl_3$, 163 MHz): δ -9.41; HRMS (ESI$^+$) calcd for $C_{15}H_{18}NO_3P$ [M+H]$^+$: 292.1097, found: 292.1096.

Diisopropyl ((4-nitrophenyl)ethynyl)phosphonate (**3o**): colorless oil; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.21 (d, J = 8.5 Hz, 2H), 7.69 (d, J = 8.5 Hz, 2H), 4.88-4.74 (m, 2H), 1.39 (d, J = 6.0 Hz, 6H), 1.38 (d, J = 6.0 Hz, 6H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 147.4, 132.4 (d, $J_{C\text{-}P}$ = 2.4 Hz), 125.4 (d, $J_{C\text{-}P}$ = 5.7 Hz), 122.8, 93.7 (d, $J_{C\text{-}P}$ = 51.3 Hz), 83.6 (d, $J_{C\text{-}P}$ = 291.1 Hz), 71.9 (d, $J_{C\text{-}P}$ = 5.6 Hz), 22.9 (d, $J_{C\text{-}P}$ = 4.6 Hz), 22.6 (t, $J_{C\text{-}P}$ = 5.3 Hz); ^{31}P NMR ($CDCl_3$, 163 MHz): δ -9.55; HRMS (ESI$^+$) calcd for $C_{14}H_{18}NO_5P$ [M+H]$^+$: 312.0995, found: 312.0994.

Diisopropyl ((4-acetylphenyl)ethynyl)phosphonate (**3p**):[2] colorless oil; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.93 (d, J = 8.2 Hz, 2H), 7.62 (d, J = 8.2 Hz, 1H), 4.90-4.74 (m, 2H), 2.60 (s, 3H), 1.40 (d, J = 6.4 Hz, 6H), 1.39 (d, J = 6.0 Hz, 6H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 196.0, 137.0, 131.7 (d, $J_{C\text{-}P}$ = 2.3 Hz), 127.3, 123.4 (d, $J_{C\text{-}P}$ = 5.5 Hz), 95.5 (d, $J_{C\text{-}P}$ = 51.9 Hz), 81.6 (d, $J_{C\text{-}P}$ = 294.0 Hz), 71.6 (d, $J_{C\text{-}P}$ = 5.6 Hz), 25.7, 22.9 (d, $J_{C\text{-}P}$ = 4.5 Hz), 22.7 (d, $J_{C\text{-}P}$ = 4.7 Hz); ^{31}P NMR ($CDCl_3$, 163 MHz): δ -8.87.

Diisopropyl ((4-fluorophenyl)ethynyl)phosphonate (**3q**):[2] colorless oil; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.55-7.49 (m, 2H), 7.10-7.02 (m, 2H), 4.87-4.71 (m, 2H), 1.39 (d, J = 6.1 Hz, 12H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 163.8 (d, $J_{C\text{-}F}$ = 251.8 Hz), 134.8 (dd, $J_{C\text{-}P}$ = 2.4 Hz, $J_{C\text{-}F}$ = 8.8 Hz), 116.1 (d, $J_{C\text{-}F}$ = 22.3 Hz), 115.9 (d, $J_{C\text{-}P}$ = 3.7 Hz), 97.0 (d, $J_{C\text{-}P}$ = 52.8 Hz), 79.8 (d, $J_{C\text{-}P}$ = 297.2 Hz), 72.4 (d, $J_{C\text{-}P}$ = 5.5 Hz), 23.9 (d, $J_{C\text{-}P}$ = 4.6 Hz), 23.7 (d, $J_{C\text{-}P}$ = 4.9 Hz); ^{31}P NMR ($CDCl_3$, 163 MHz): δ -8.28.

Diisopropyl ((4-chlorophenyl)ethynyl)phosphonate (**3r**): colorless oil; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.44 (d, J = 8.4 Hz, 2H), 7.31 (d, J = 8.4 Hz, 2H), 4.84-4.70 (m, 2H), 1.37 (d, J = 6.1 Hz, 12H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 135.9, 132.7 (d, $J_{C\text{-}P}$ = 2.4 Hz), 128.0, 117.3 (d, $J_{C\text{-}P}$ = 5.7 Hz), 95.7 (d, $J_{C\text{-}P}$ = 52.4 Hz), 80.0 (d, $J_{C\text{-}P}$ = 296.8 Hz), 71.5 (d, $J_{C\text{-}P}$ = 5.6 Hz), 22.9 (d, $J_{C\text{-}P}$ = 4.5 Hz), 22.6 (d, $J_{C\text{-}P}$ = 4.8 Hz); ^{31}P NMR ($CDCl_3$, 163 MHz): δ -8.53; HRMS (ESI$^+$) calcd for $C_{14}H_{18}ClO_3P$ [M+H]$^+$: 301.0755, found: 301.0755.

Diisopropyl ((4-(trifluoromethyl)phenyl)ethynyl)phosphonate (**3s**):[2] colorless oil; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.68-7.60 (m, 4H), 4.87-4.74 (m, 2H), 1.40 (d, J = 6.0 Hz, 6H), 1.39 (d, J = 6.4 Hz, 6H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 132.8 (d, $J_{C\text{-}P}$ = 2.3 Hz), 132.2 (q, $J_{C\text{-}F}$ = 33.0 Hz), 125.6 (q, $J_{C\text{-}F}$ = 3.7 Hz), 123.7 (d, $J_{C\text{-}P}$ = 5.3 Hz), 123.5 (q, $J_{C\text{-}F}$ = 270.9 Hz), 95.8 (d, $J_{C\text{-}P}$ = 51.7 Hz), 82.4 (d, $J_{C\text{-}P}$ = 293.6 Hz), 72.7 (d, $J_{C\text{-}P}$ = 5.6 Hz), 23.9 (d, $J_{C\text{-}P}$ = 4.5 Hz), 23.7 (d, $J_{C\text{-}P}$ = 4.8 Hz); ^{31}P NMR ($CDCl_3$, 163 MHz): δ -9.03.

Methyl 4-((diisopropoxyphosphoryl)ethynyl)benzoate (**3t**): colorless oil; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.04 (d, J = 8.4 Hz, 2H), 7.62 (d, J = 8.4 Hz, 1H), 4.88-4.76 (m, 2H), 3.94 (s, 3H), 1.42 (d, J = 6.2 Hz, 6H), 1.41 (d, J = 6.2 Hz, 6H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 166.1, 132.5 (d, $J_{C\text{-}P}$ = 2.3 Hz), 131.7, 129.6, 124.3 (d, $J_{C\text{-}P}$ = 5.4 Hz), 96.7 (d, $J_{C\text{-}P}$ = 52.0 Hz), 82.5 (d, $J_{C\text{-}P}$ = 294.6 Hz), 72.7 (d, $J_{C\text{-}P}$ = 5.5 Hz), 52.5, 23.9 (d, $J_{C\text{-}P}$ = 4.6 Hz), 23.7 (t, $J_{C\text{-}P}$ = 4.7 Hz); ^{31}P NMR ($CDCl_3$, 163 MHz): δ -9.26; HRMS (ESI$^+$) calcd for $C_{16}H_{22}O_5P$ [M+H]$^+$: 325.1199, found: 325.1203.

Diisopropyl ((2-aminophenyl)ethynyl)phosphonate (**3u**): colorless oil; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.32 (d, J = 7.6 Hz, 1H), 7.22-7.10 (m, 1H), 6.71-6.65 (m, 2H), 4.85-4.77 (m, 2H), 4.41 (s, 2H), 1.40 (d, J = 6.2 Hz, 12H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 150.0, 133.0 (d, $J_{C\text{-}P}$ = 2.3 Hz), 132.1, 117.7, 114.7, 103.5 (d, $J_{C\text{-}P}$ = 5.5 Hz), 96.3 (d, $J_{C\text{-}P}$ = 52.5 Hz), 85.0 (d, $J_{C\text{-}P}$ = 296.7 Hz), 72.4 (d, $J_{C\text{-}P}$ = 5.5 Hz), 24.0 (d, $J_{C\text{-}P}$ = 4.5 Hz), 23.7 (d, $J_{C\text{-}P}$ = 4.9 Hz); ^{31}P NMR ($CDCl_3$, 163 MHz): δ -8.29; HRMS (ESI$^+$) calcd for $C_{14}H_{21}NO_3P$ [M+H]$^+$: 282.1254, found: 282.1256.

Diisopropyl ((4-vinylphenyl)ethynyl)phosphonate (**3v**): colorless oil; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.50 (d, J = 8.2 Hz, 2H), 7.40 (d, J = 8.2 Hz, 2H), 6.71 (dd, J = 17.6 Hz, 10.9 Hz, 1H), 5.82 (d, J = 17.6 Hz, 1H), 5.37 (d, J = 10.8 Hz, 1H), 4.86-4.77 (m, 2H), 1.41 (d, J = 6.2 Hz, 6H), 1.40 (d, J = 6.2 Hz, 6H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 139.7, 135.9, 132.8 (d, $J_{C\text{-}P}$ = 2.4 Hz), 126.3, 118.9 (d, $J_{C\text{-}P}$ = 5.7 Hz),116.3, 98.3 (d, $J_{C\text{-}P}$ = 52.7 Hz), 80.4 (d, $J_{C\text{-}P}$ = 297.4 Hz), 72.4 (d, $J_{C\text{-}P}$ = 5.6 Hz), 24.0 (d, $J_{C\text{-}P}$ = 4.5 Hz), 23.7 (d, $J_{C\text{-}P}$ = 4.8 Hz). ^{31}P NMR ($CDCl_3$, 163 MHz): δ -8.49; HRMS (ESI$^+$) calcd for $C_{16}H_{22}O_3P$ [M+H]$^+$: 293.1301, found: 293.1306.

Diisopropyl (benzo[b]thiophen-6-ylethynyl)phosphonate (**3x**): colorless oil; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.00 (s, 1H), 7.83 (d, J = 8.3 Hz, 1H), 7.55-7.41 (m, 2H), 7.34-7.28 (m, 1H), 4.90-4.74 (m, 2H), 1.44-1.37 (m, 12H); ^{13}C NMR ($CDCl_3$, 100

MHz): δ 140.8, 138.4, 127.2 (d, $J_{C\text{-}P}$ = 2.5 Hz), 127.2, 126.3 (d, $J_{C\text{-}P}$ = 2.2 Hz), 122.7, 121.8, 114.6 (d, $J_{C\text{-}P}$ = 5.6 Hz), 97.8 (d, $J_{C\text{-}P}$ = 52.8 Hz), 78.5 (d, $J_{C\text{-}P}$ = 297.2 Hz), 71.3 (d, $J_{C\text{-}P}$ = 5.5 Hz), 23.0 (d, $J_{C\text{-}P}$ = 4.5 Hz), 22.7 (d, $J_{C\text{-}P}$ = 4.9 Hz); ^{31}P NMR ($CDCl_3$, 163 MHz): δ -7.99; HRMS (ESI^+) calcd for $C_{16}H_{19}O_3PS$ $[M+H]^+$: 323.0865, found: 323.0866.

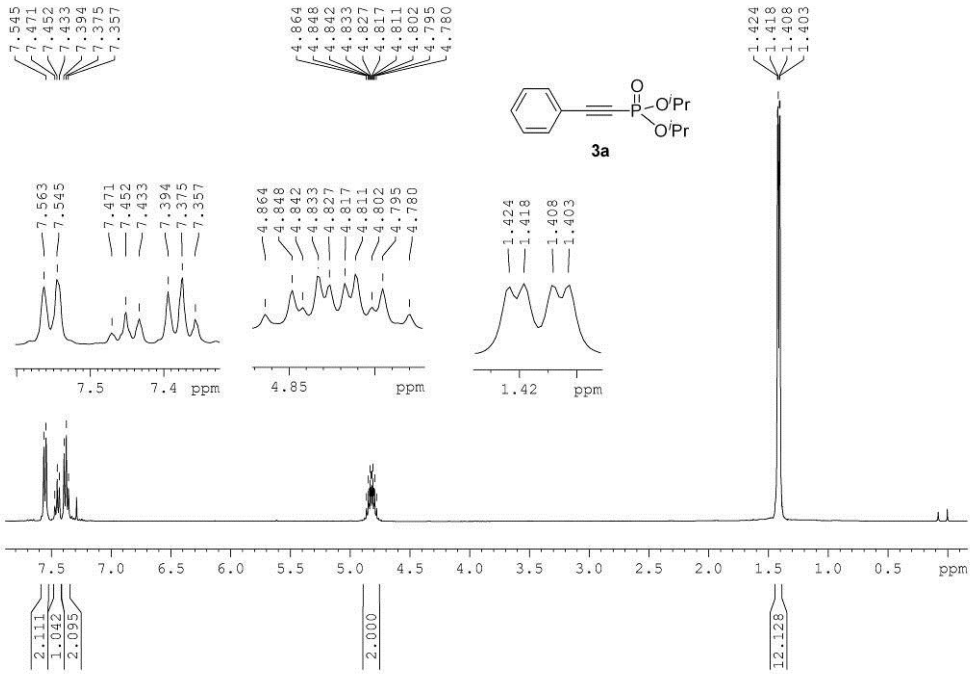
Diisopropyl ((5-methylthiophen-2-yl)ethynyl)phosphonate (**3y**): colorless oil; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.15 (d, J = 3.6 Hz, 1H), 6.61 (d, J = 3.6 Hz, 1H), 4.80-4.64 (m, 2H), 2.42 (s, 3H), 1.31 (d, J = 6.2 Hz, 12H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 144.7, 135.1, 124.8, 116.1, 91.3 (d, $J_{C\text{-}P}$ = 53.5 Hz), 82.1 (d, $J_{C\text{-}P}$ = 298.0 Hz), 71.3 (d, $J_{C\text{-}P}$ = 5.5 Hz), 22.9 (d, $J_{C\text{-}P}$ = 4.5 Hz), 22.6 (d, $J_{C\text{-}P}$ = 4.9 Hz), 14.5; ^{31}P NMR ($CDCl_3$, 163 MHz): δ -8.04; HRMS (ESI^+) calcd for $C_{13}H_{19}O_3PS$ $[M+H]^+$: 287.0865, found: 287.0865.

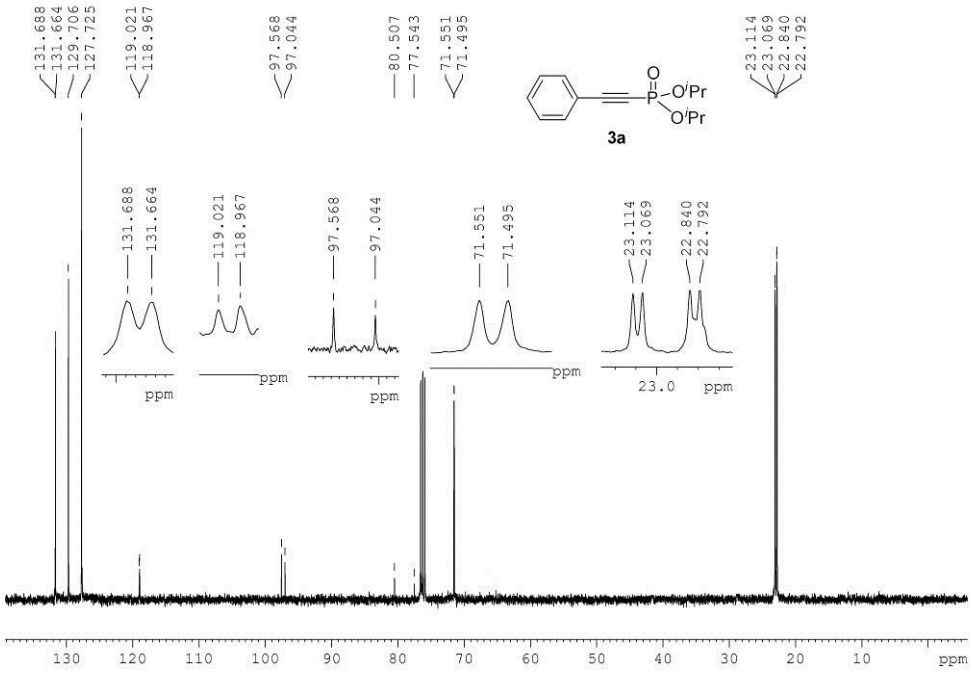
Diisopropyl (isoquinolin-4-ylethynyl)phosphonate (**3z**): colorless oil; ^{1}H NMR ($CDCl_3$, 400 MHz): δ 9.22 (s, 1H), 8.72 (s, 1H), 8.13 (d, J = 8.2 Hz, 1H), 7.98 (d, J = 8.2 Hz, 1H), 7.78 (t, J = 7.6 Hz, 1H), 7.64 (t, J = 7.6 Hz, 1H), 4.87-4.78 (m, 2H), 1.38 (m, 12H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 154.0, 148.1 (d, $J_{C\text{-}P}$ = 2.7 Hz), 135.6, 128.6, 128.3, 124.6, 112.9, 93.4 (d, $J_{C\text{-}P}$ = 52.1 Hz), 87.4 (d, $J_{C\text{-}P}$ = 293.4 Hz), 72.8 (d, $J_{C\text{-}P}$ = 5.5 Hz), 24.0 (d, $J_{C\text{-}P}$ = 4.5 Hz), 23.8 (d, $J_{C\text{-}P}$ = 4.8 Hz); ^{31}P NMR ($CDCl_3$, 163 MHz): δ -9.46; HRMS (ESI^+) calcd for $C_{17}H_{21}NO_3P$ $[M+H]^+$: 318.1254, found: 318.1258.

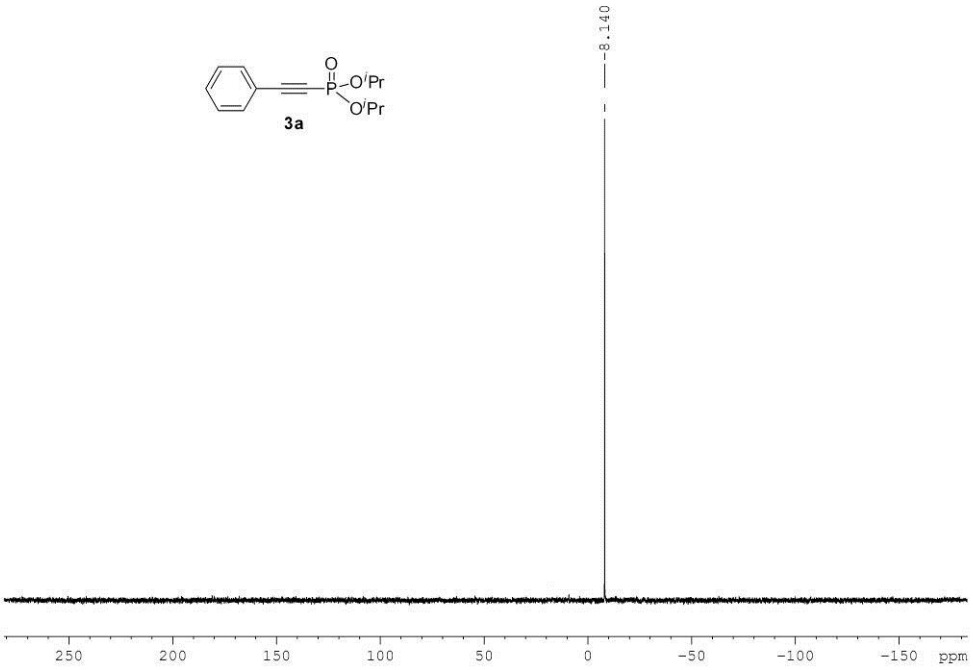
References:

1. Gao, Y.; Wang, G.; Chen, L.; Xu, P.; Zhao, Y., Zhou, Y.; Han, L.-B. *J. Am. Chem. Soc.* **2009**, *131*, 7956.
2. X. Li, F. Yang, Y.-J. Wu and Y.-S. Wu, *Org. Lett.,* 2014, **16**, 992.

Copies of ^{1}H NMR, ^{13}C NMR and ^{31}P NMR spectra for all the products



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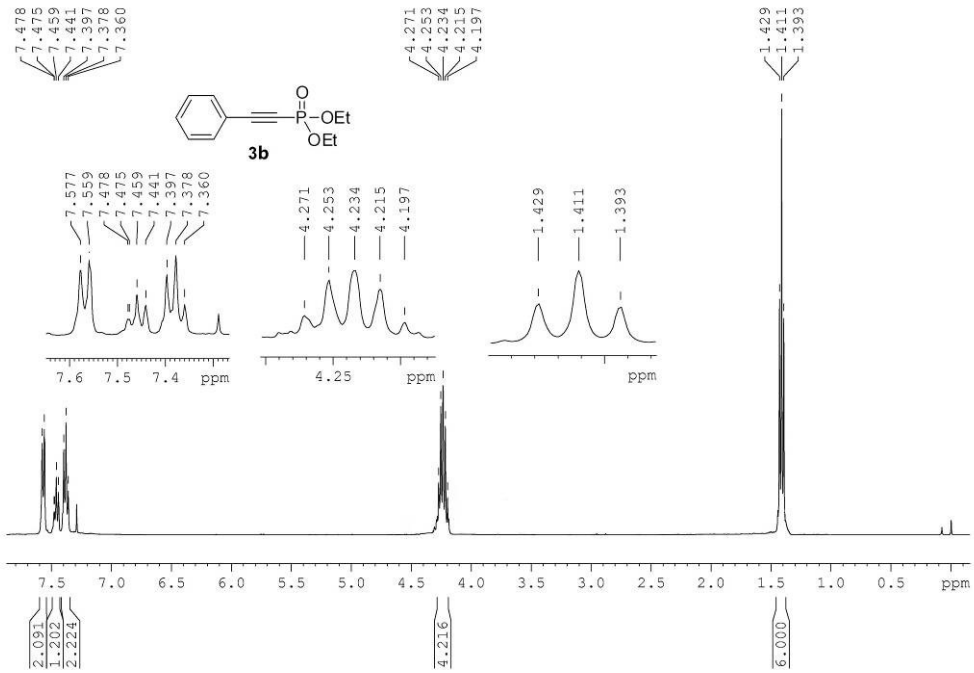
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1.411
1.393
3b
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7.6
7.5
7.4
ppm
4.25
ppm
ppm
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6.5
6.0
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5.0
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4.0
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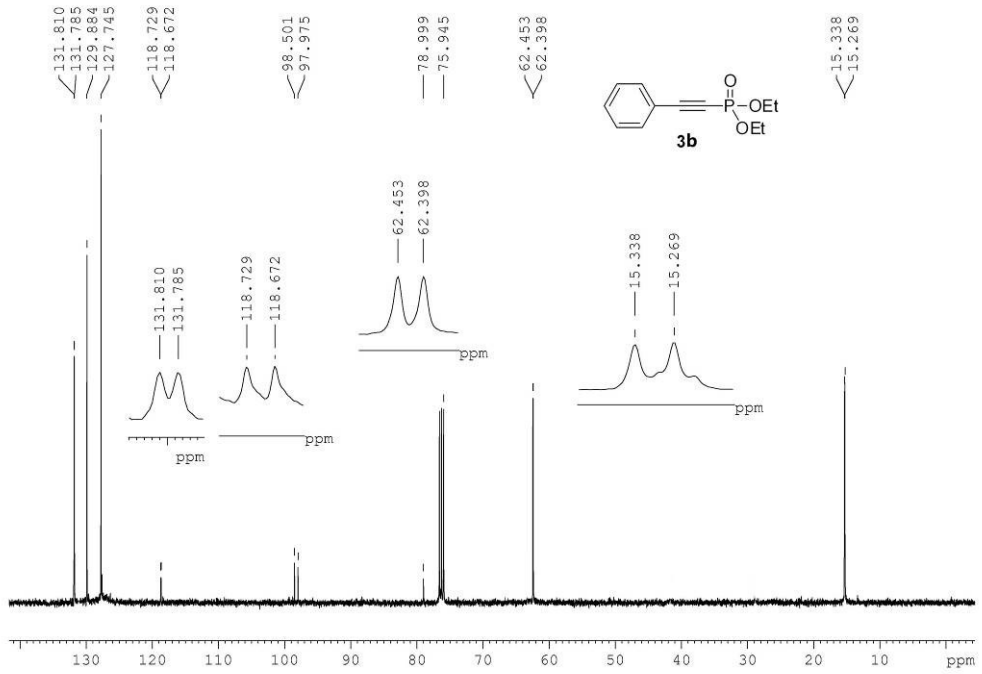
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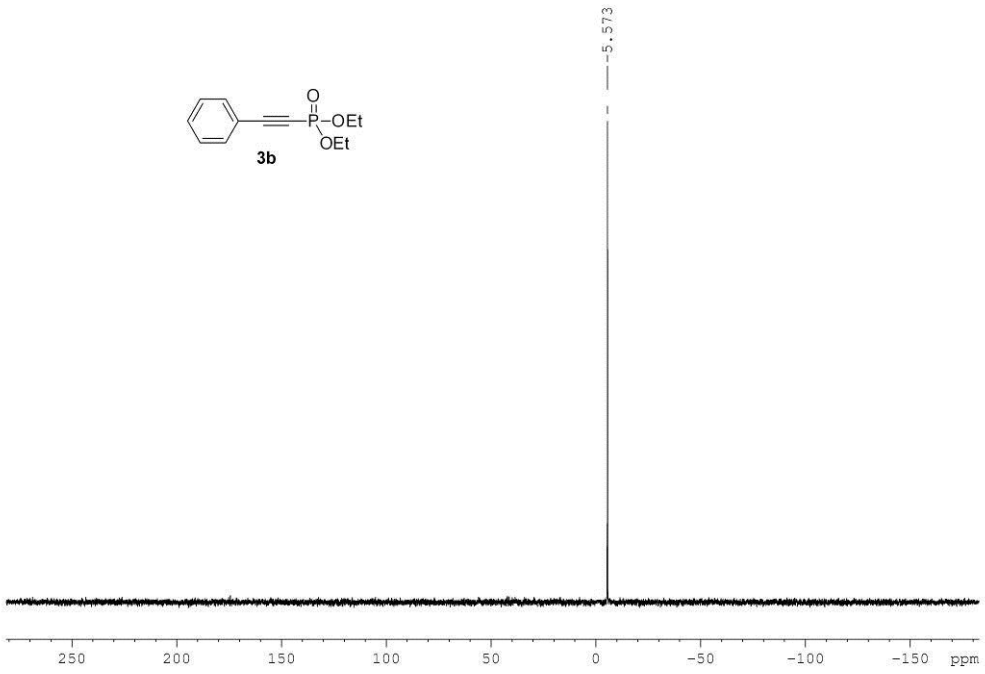
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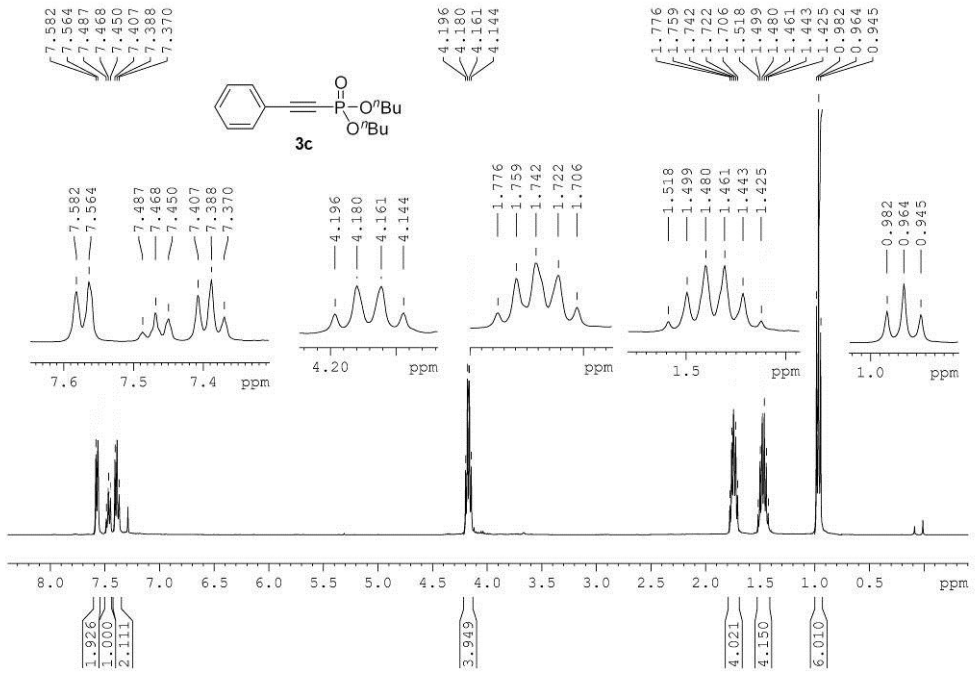
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1.742
1.722
1.706
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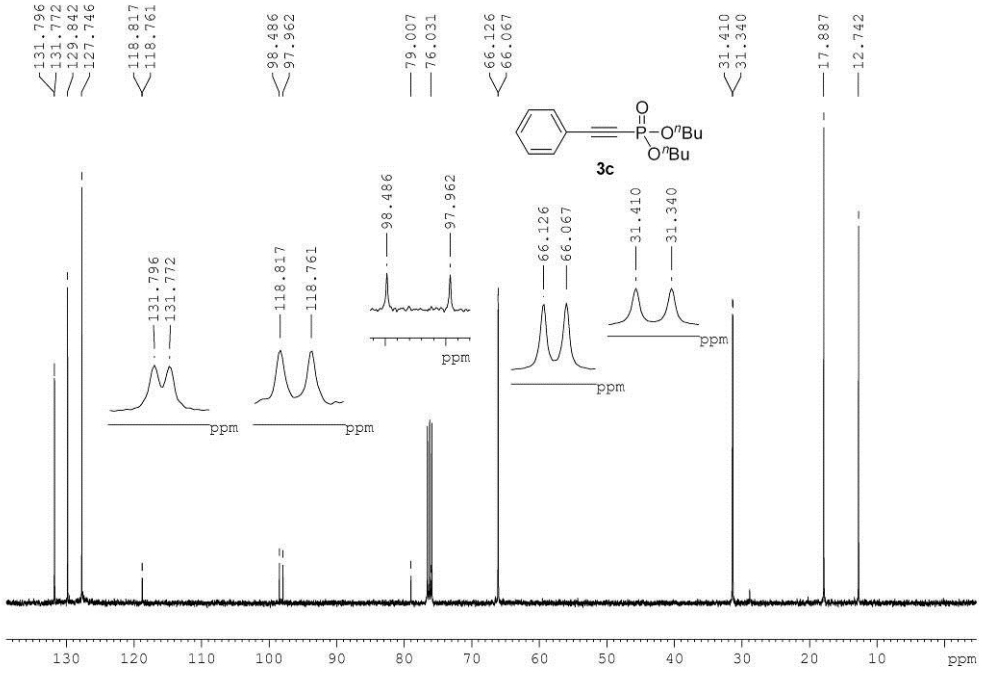
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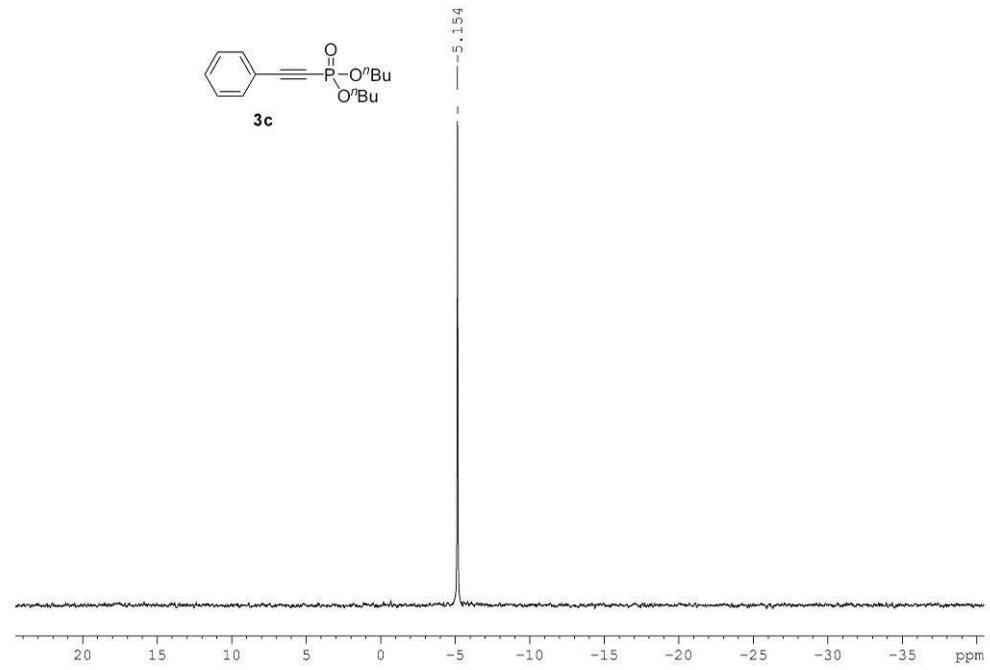
3c
ppm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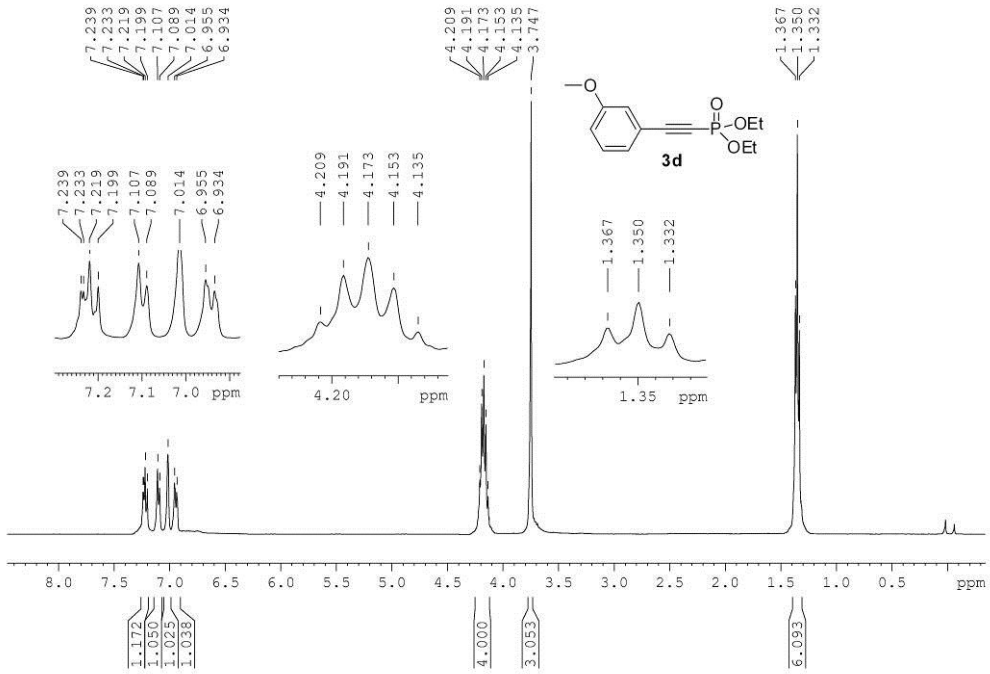
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1.332
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4.20 ppm
1.35 ppm
8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm
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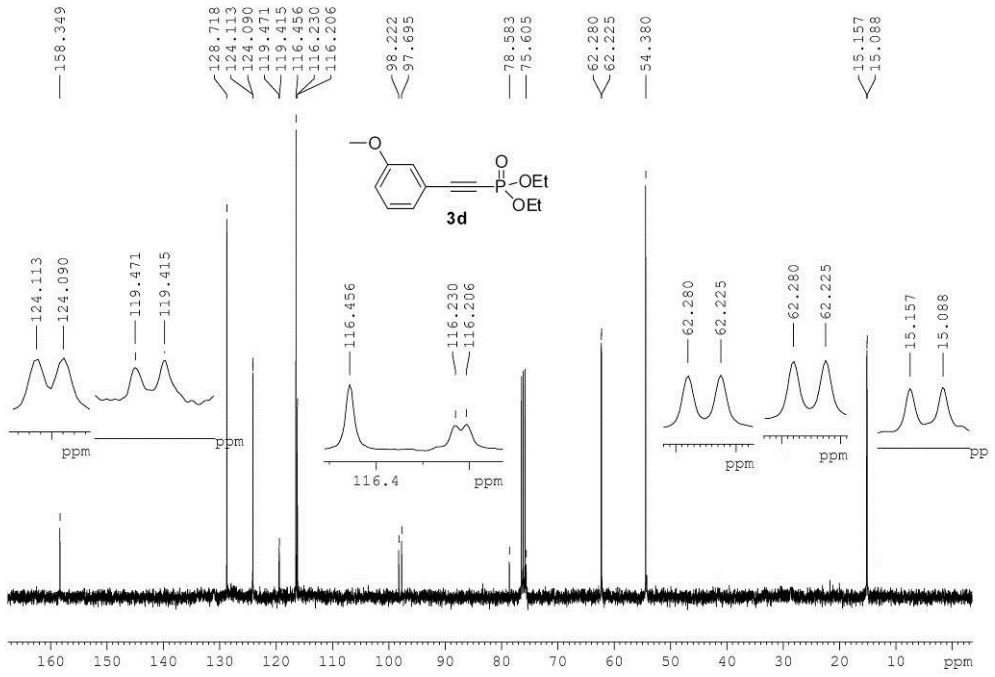
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62.225
54.380
15.157
15.088
3d
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124.090
119.471
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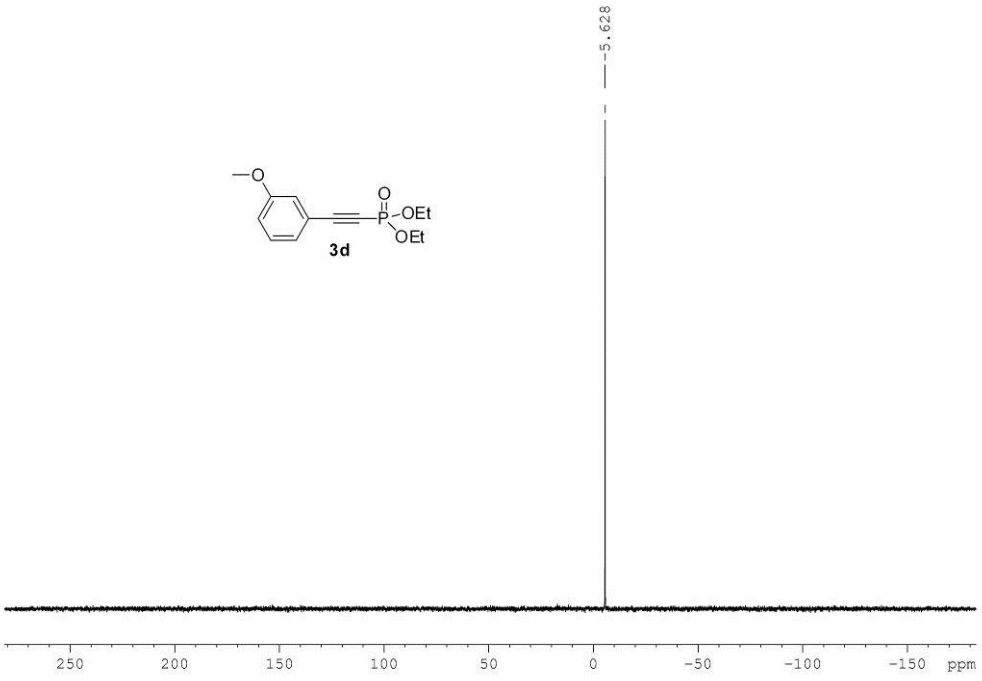
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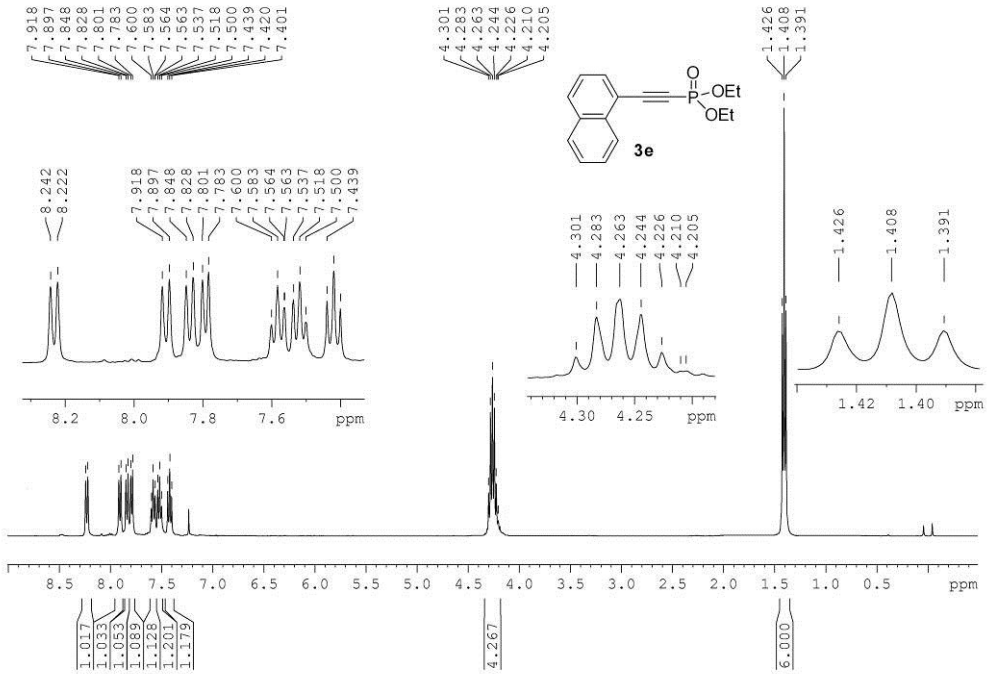
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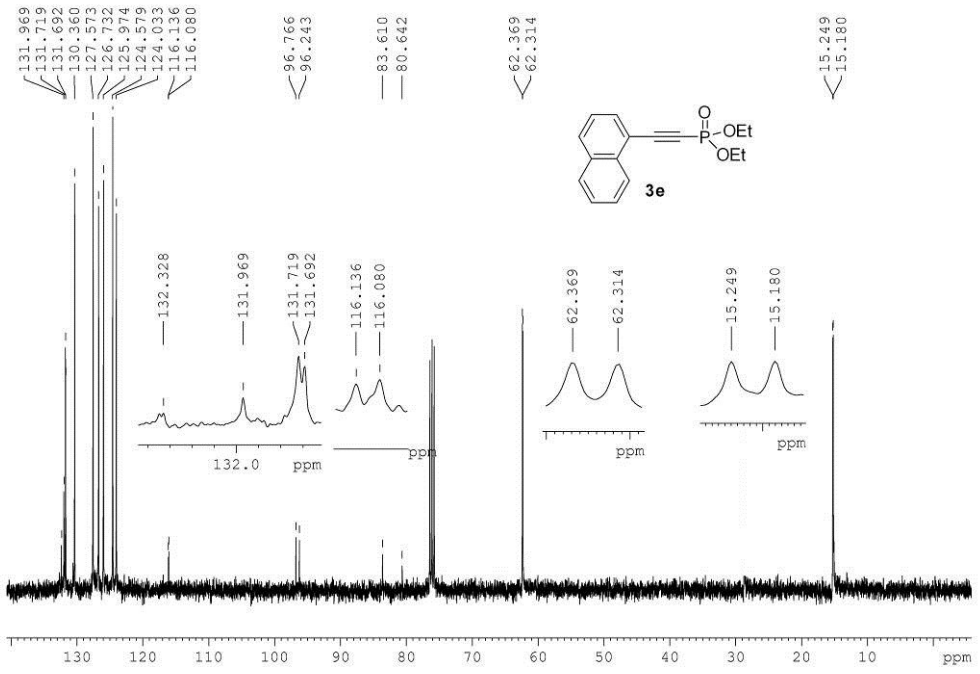
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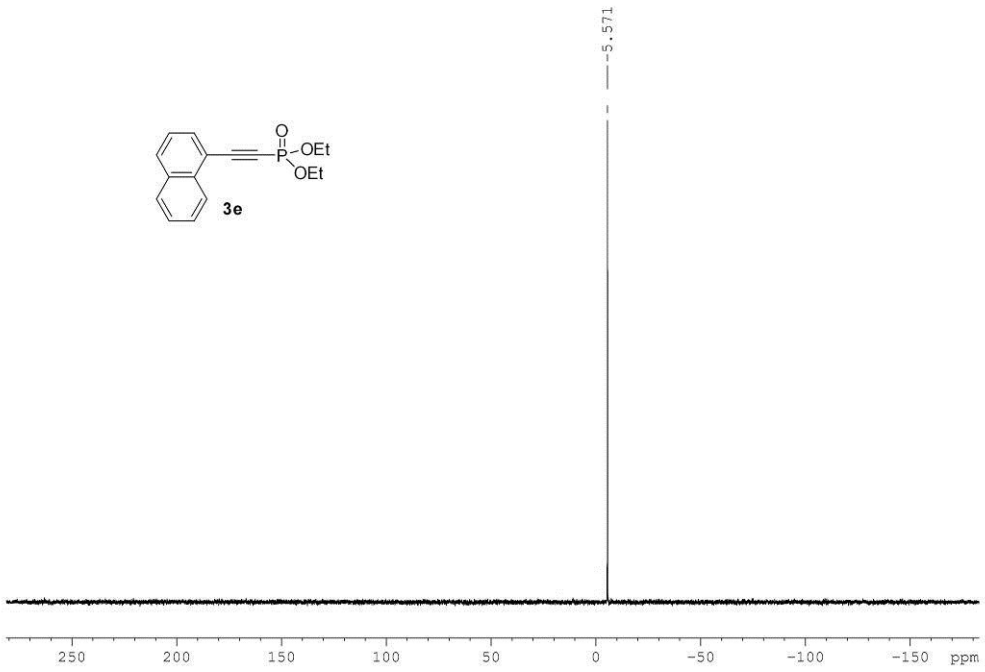
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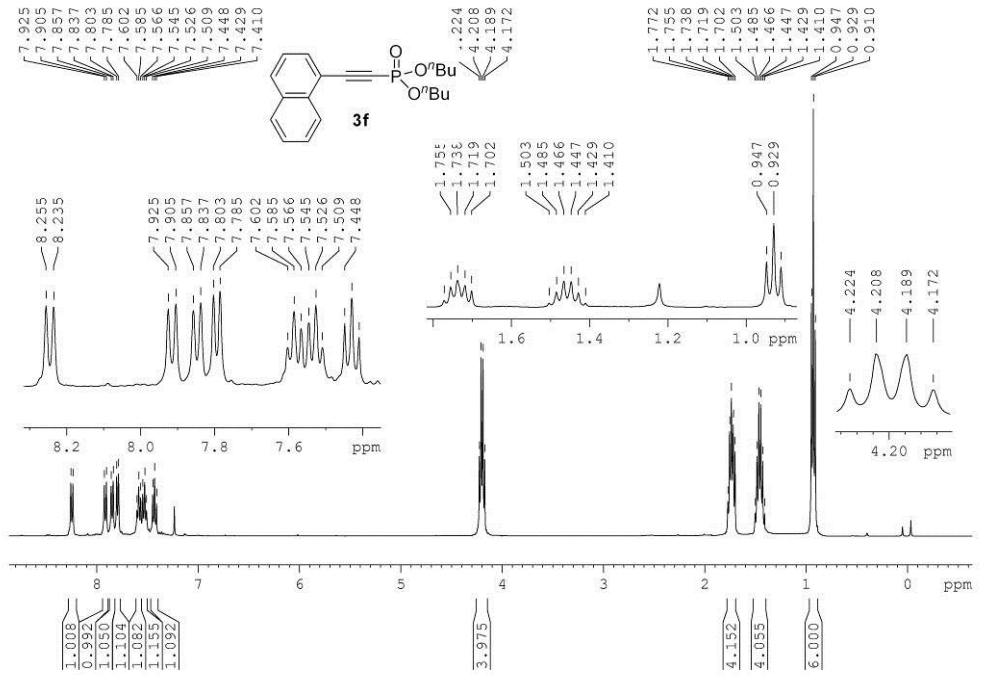
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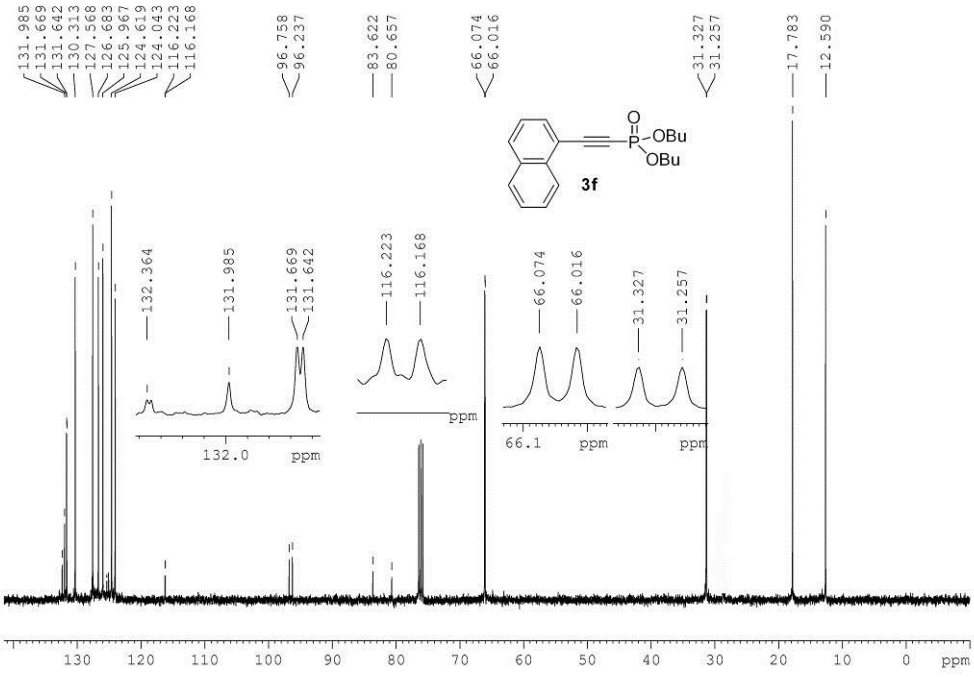
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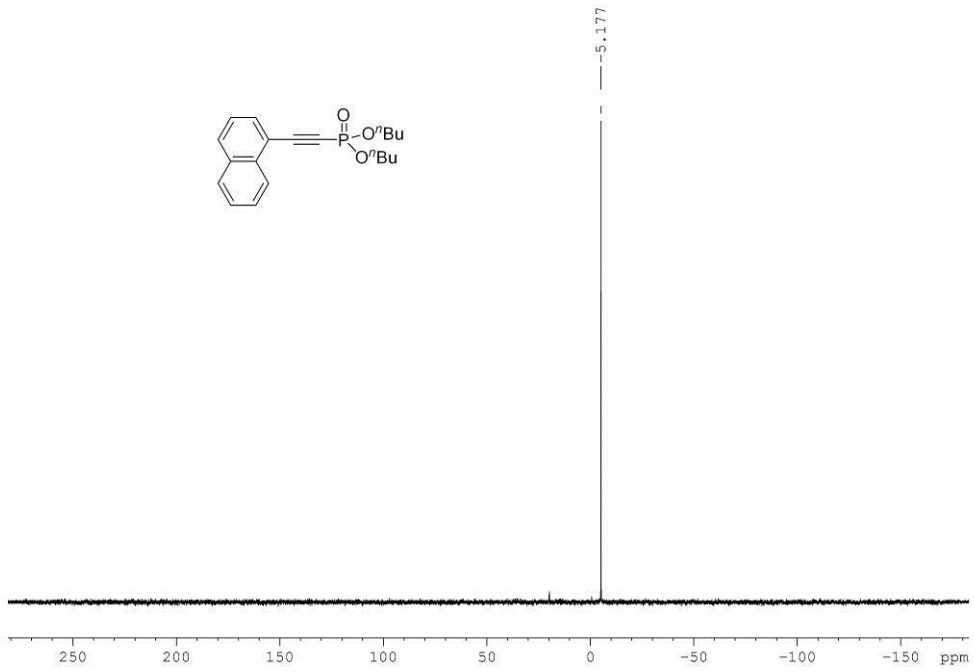
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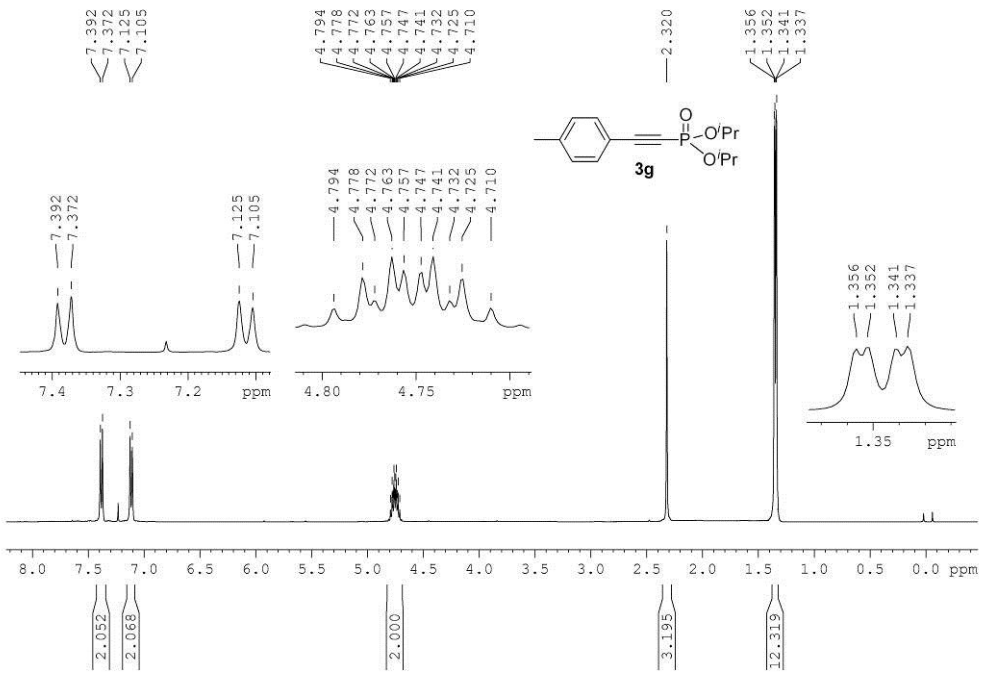
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O^{i}Pr
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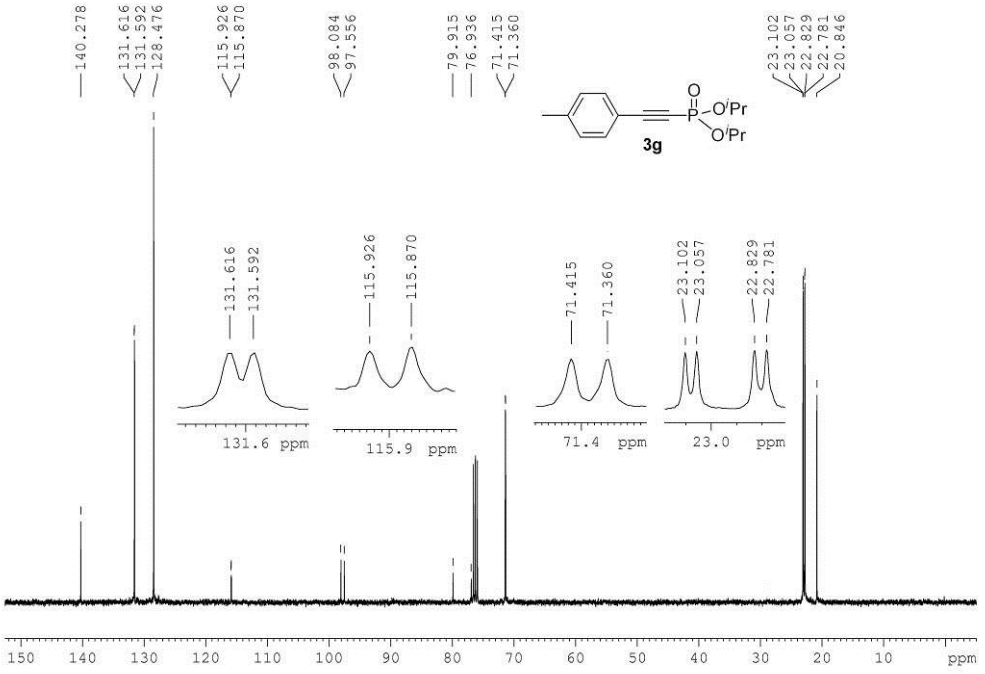
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P
O^{i}Pr
O^{i}Pr
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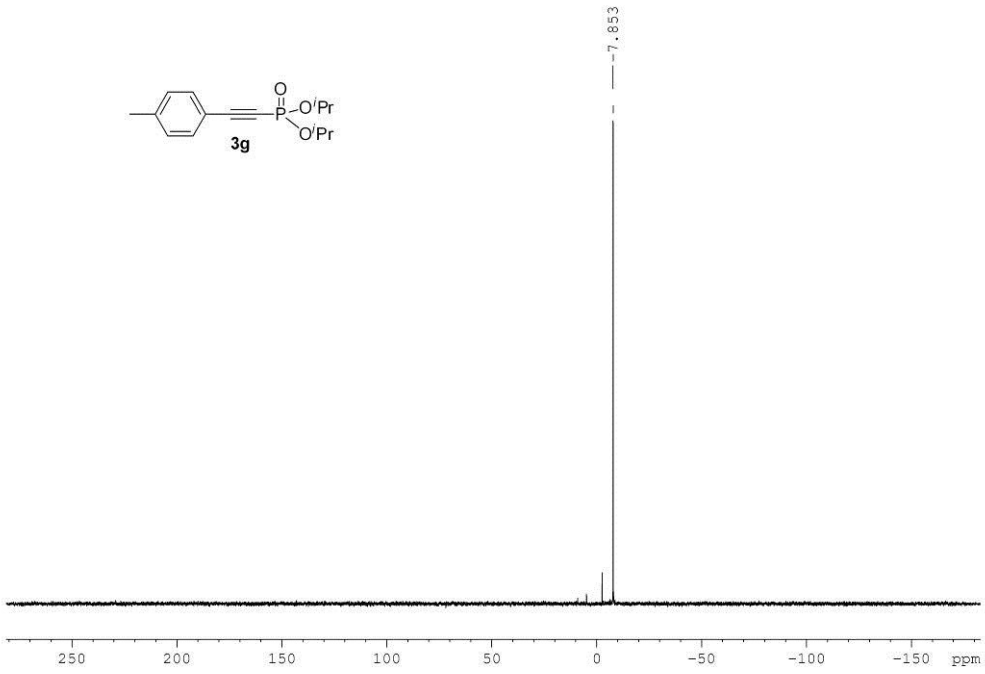
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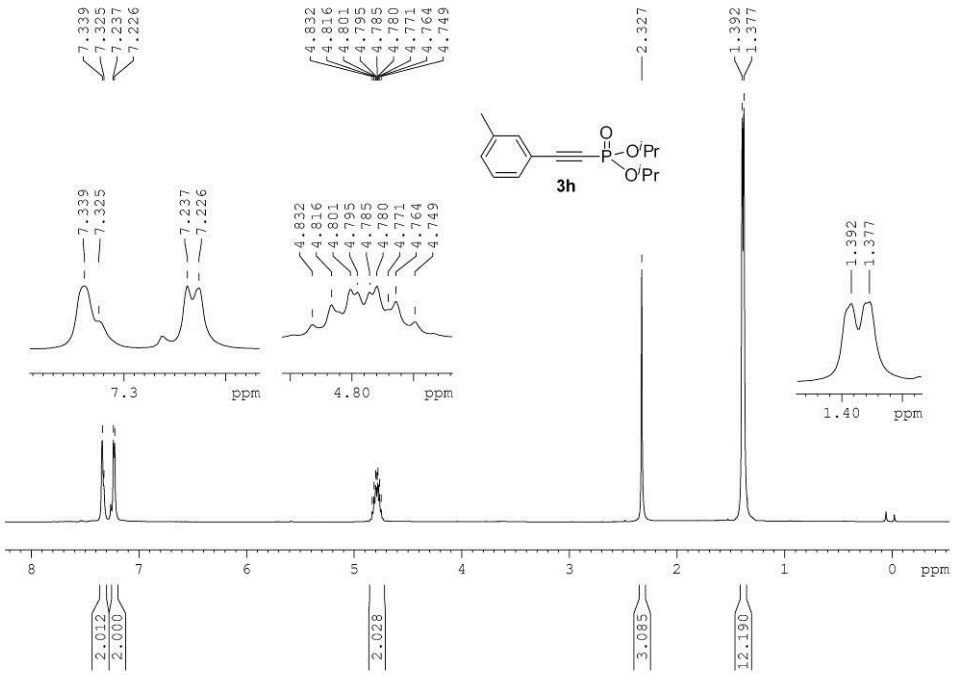
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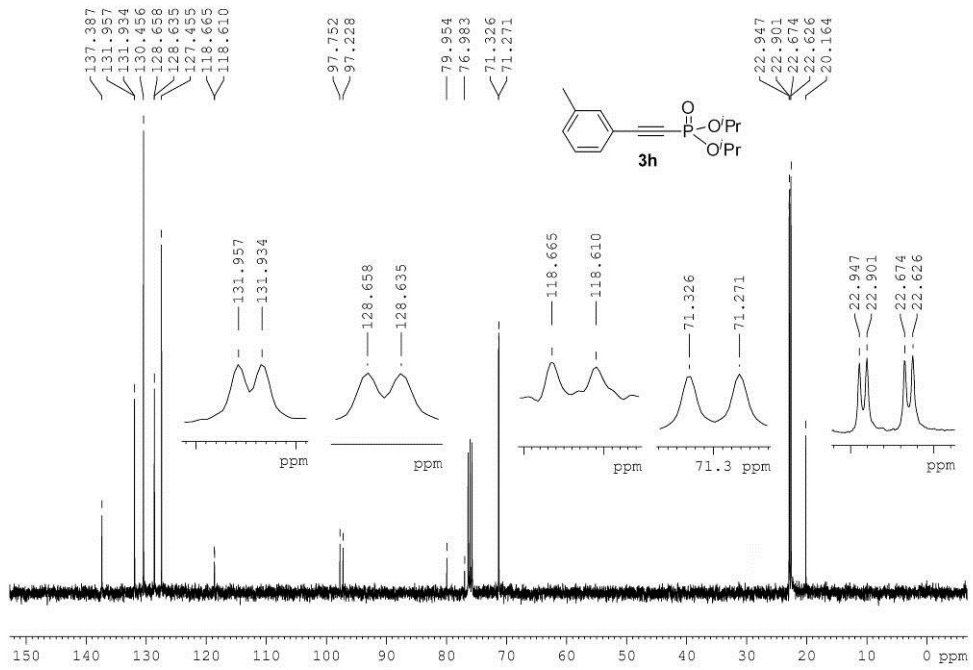
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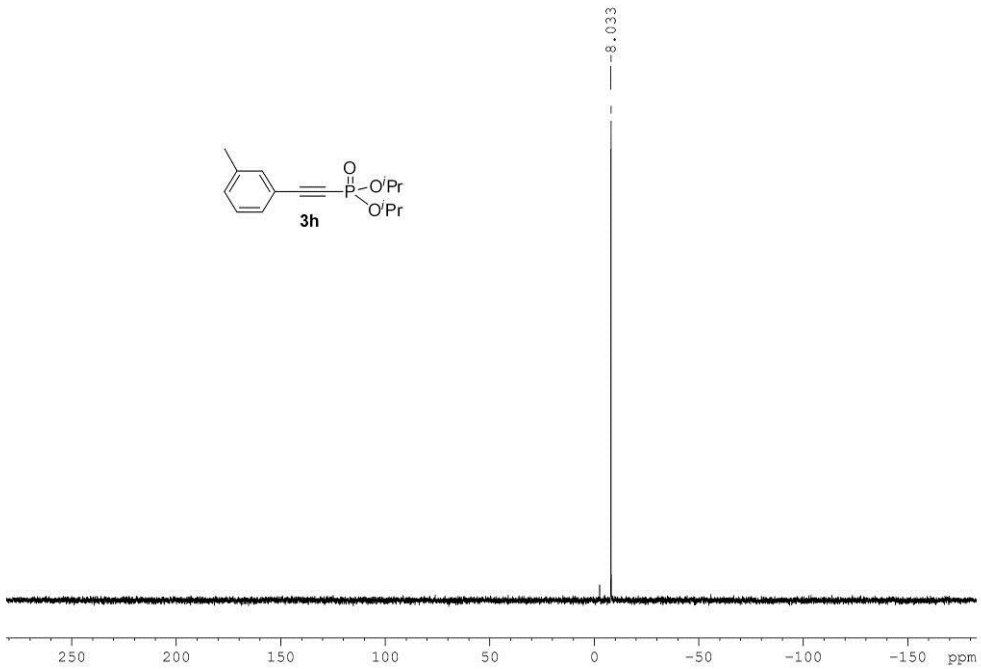
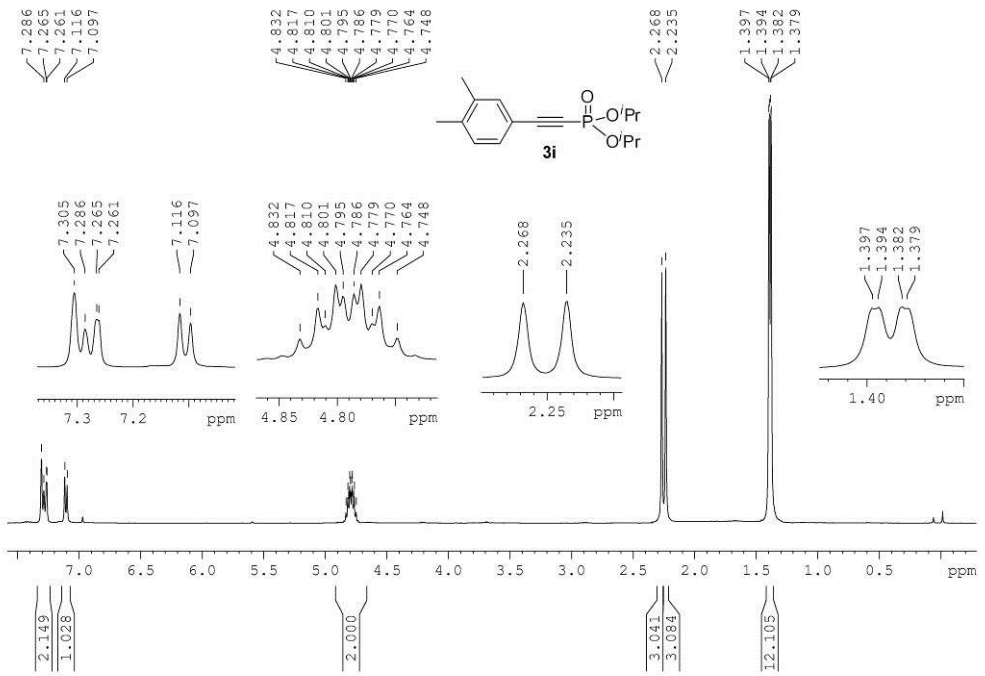
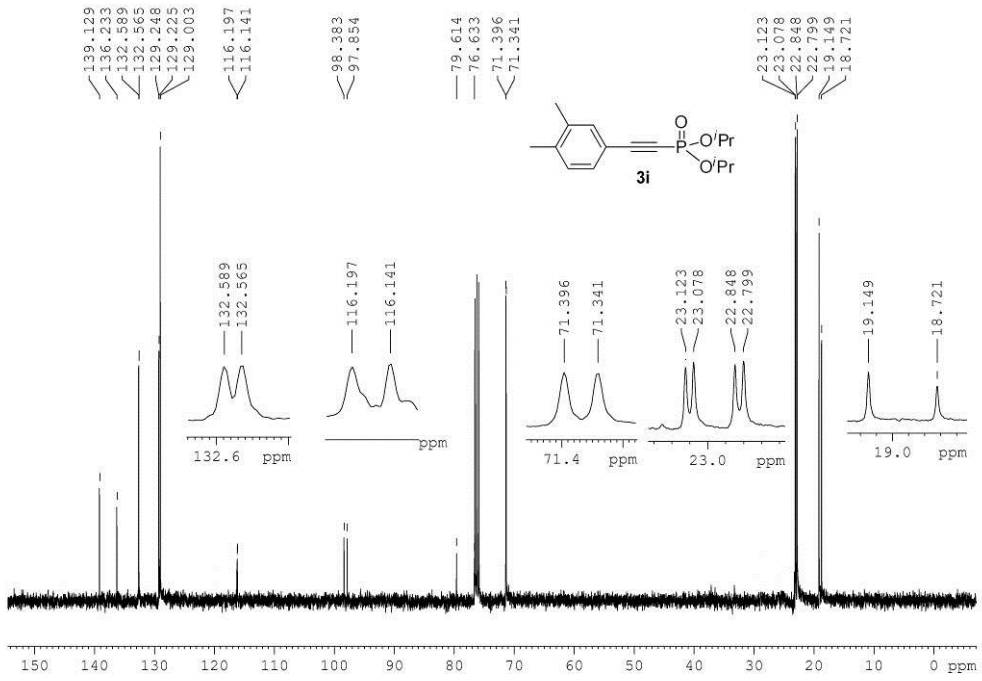
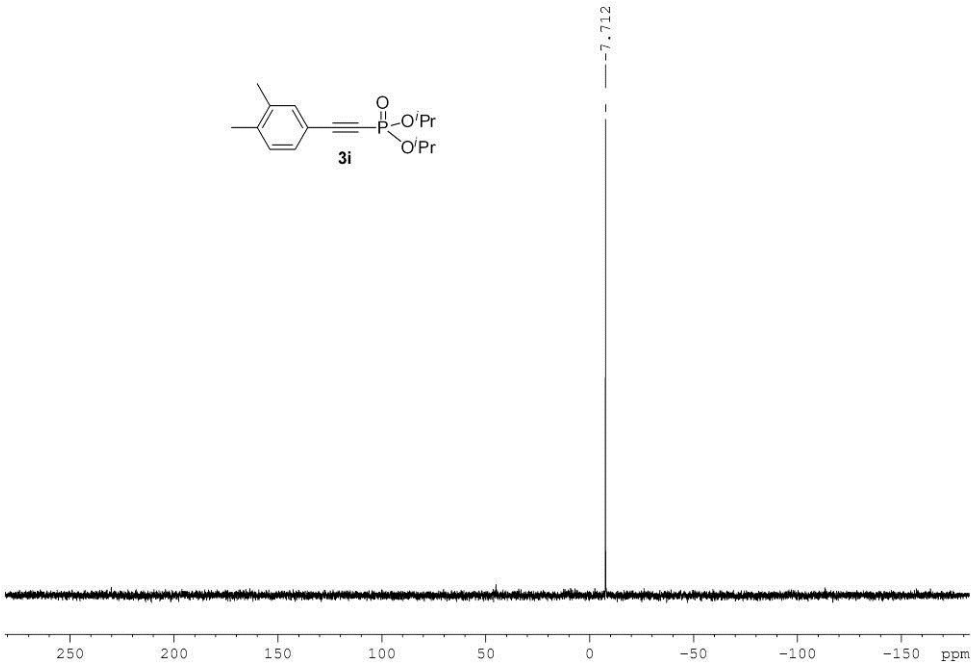
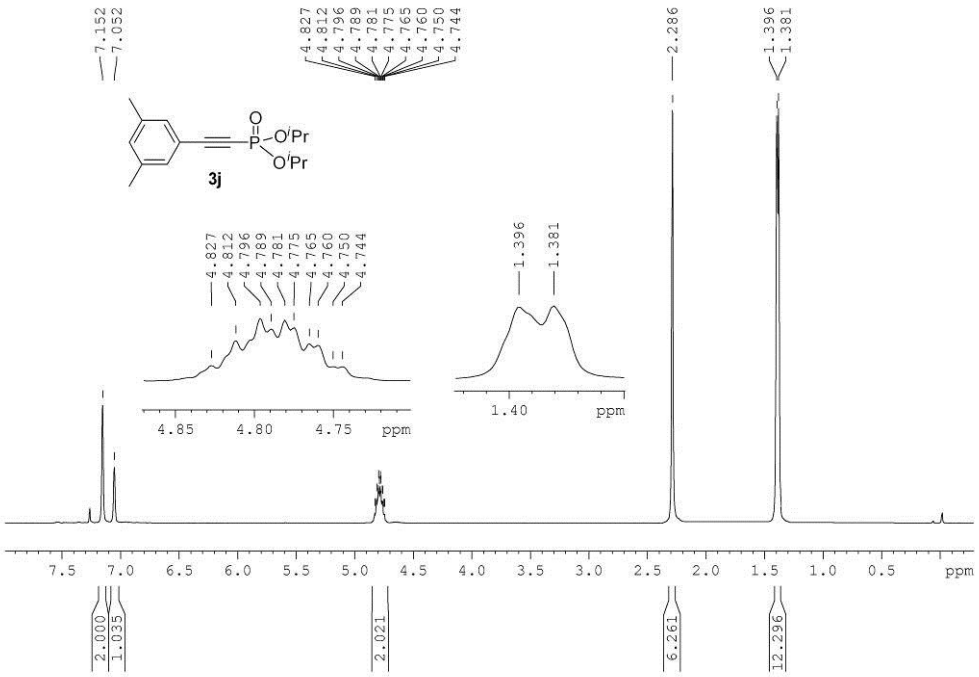
97.752
97.228
79.954
76.983
71.326
71.271
22.947
22.901
22.674
22.626
20.164
3h
131.957
131.934
128.658
128.635
118.665
118.610
71.326
71.271
22.947
22.901
22.674
22.626
ppm
71.3 ppm
150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

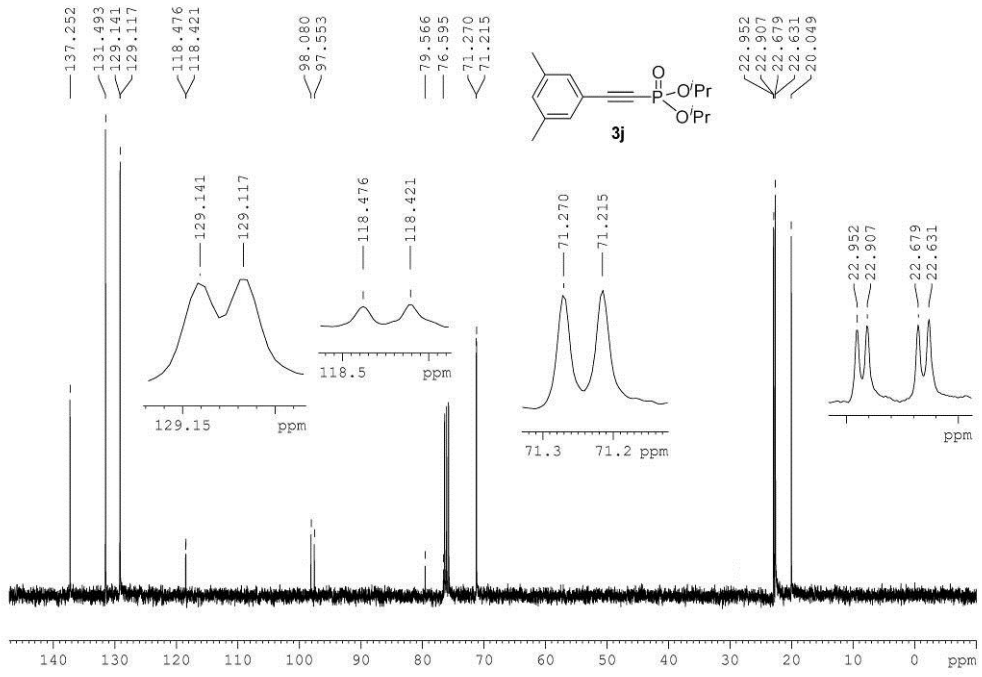

-8.033
3h
250 200 150 100 50 0 -50 -100 -150 ppm

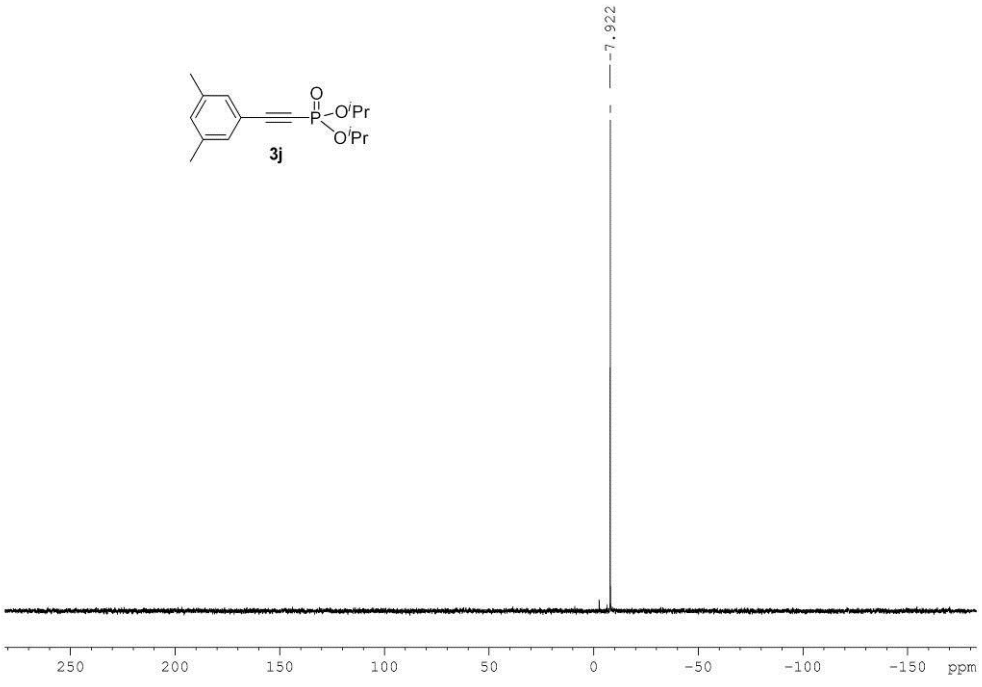

7.286
7.265
7.261
7.116
7.097
4.832
4.817
4.810
4.801
4.795
4.786
4.779
4.770
4.764
4.748
2.268
2.235
1.397
1.394
1.382
1.379
3i
7.3
7.2
ppm
4.85
4.80
ppm
2.25
ppm
1.40
ppm
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
ppm
2.149
1.028
2.000
3.041
3.084
12.105

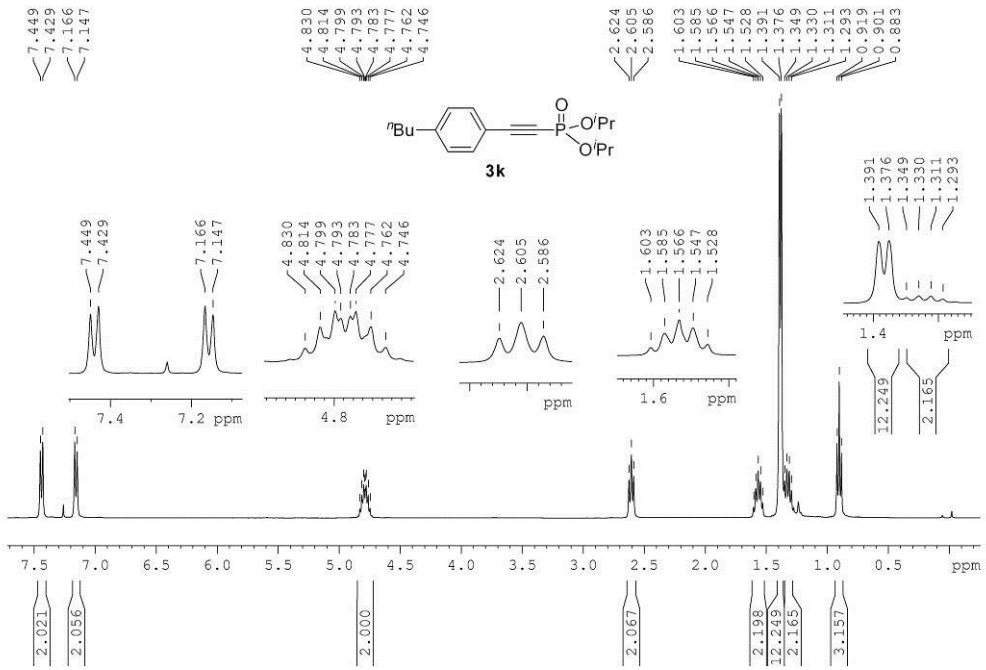

139.129
136.233
132.589
132.565
129.248
129.225
129.003
116.197
116.141
98.383
97.854
79.614
76.633
71.396
71.341
23.123
23.078
22.848
22.799
19.149
18.721
3i
132.6
ppm
ppm
71.4
ppm
23.0
ppm
19.0
ppm
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0 ppm

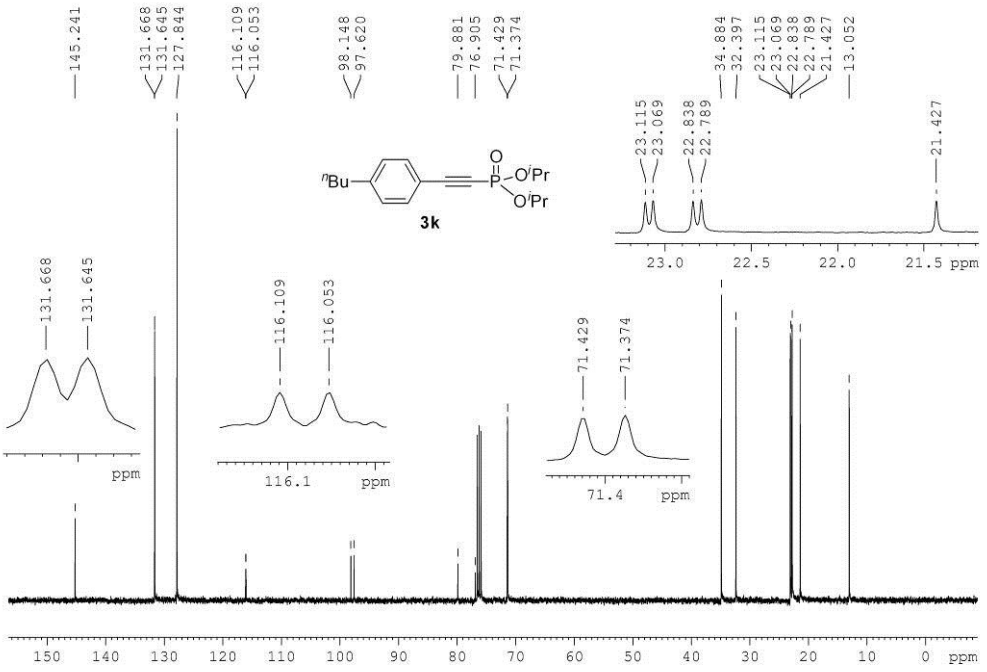

7.712
3i
250
200
150
100
50
0
-50
-100
-150
ppm

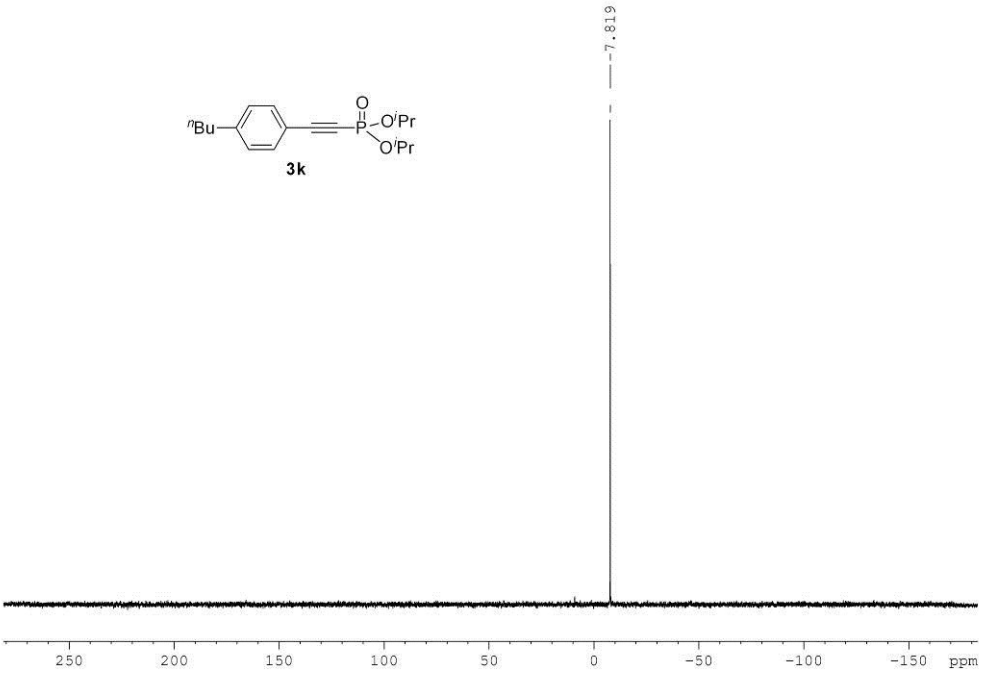

7.152
7.052
4.827
4.812
4.796
4.789
4.781
4.775
4.765
4.760
4.750
4.744
2.286
1.396
1.381
3j
4.85
4.80
4.75
ppm
1.40
ppm
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
ppm
2.000
1.035
2.021
6.261
12.296


137.252
131.493
129.141
129.117
118.476
118.421
98.080
97.553
79.566
76.595
71.270
71.215
22.952
22.907
22.679
22.631
20.049
3j
129.15 ppm
118.5 ppm
71.3 71.2 ppm
ppm
140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

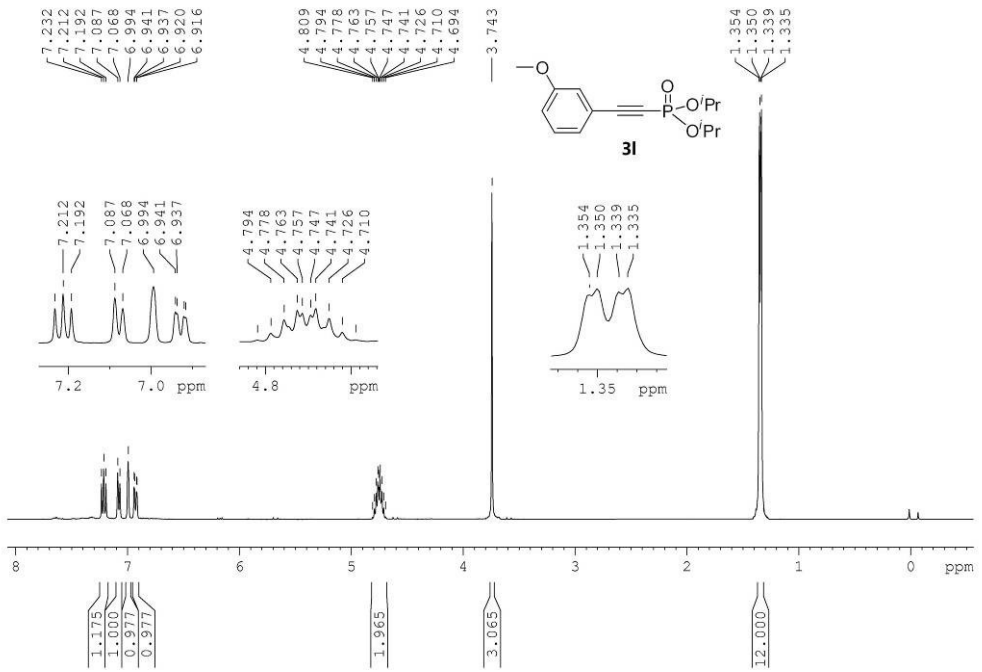

7.922
3j
250 200 150 100 50 0 -50 -100 -150 ppm


7.449
7.429
7.166
7.147
4.830
4.814
4.799
4.793
4.783
4.777
4.762
4.746
2.624
2.605
2.586
1.603
1.585
1.566
1.547
1.528
1.391
1.376
1.349
1.330
1.311
1.293
0.919
0.901
0.883
nBu
O
P
O^iPr
O^iPr
3k
12.249
2.165
7.4
7.2 ppm
4.8
ppm
1.6
1.4
2.021
2.056
2.000
2.067
2.198
3.157
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

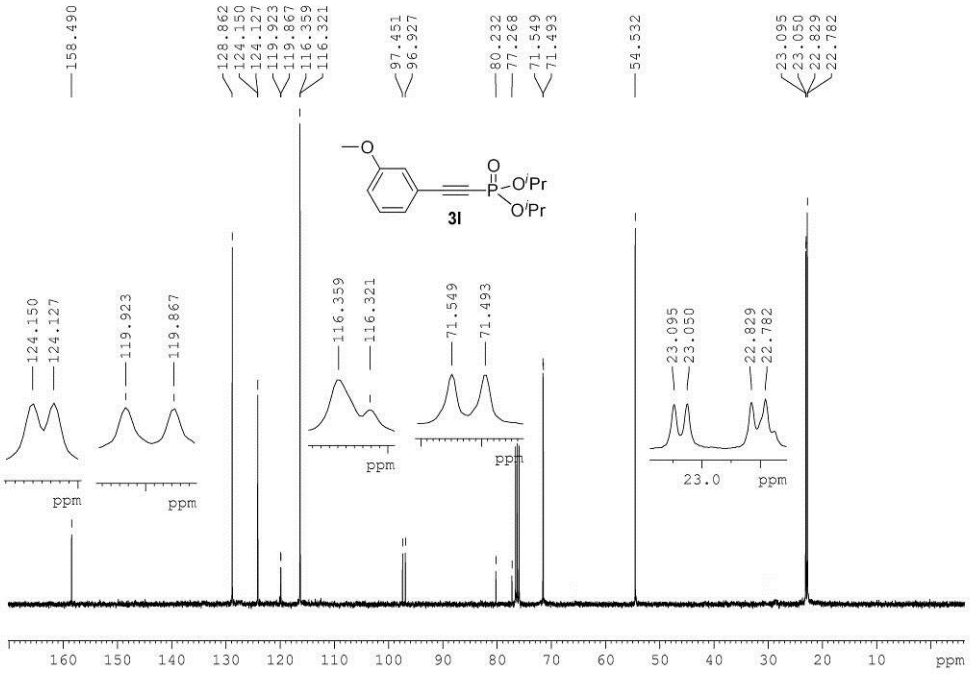

145.241
131.668
131.645
127.844
116.109
116.053
98.148
97.620
79.881
76.905
71.429
71.374
34.884
32.397
23.115
23.069
22.838
22.789
21.427
13.052
nBu
O
P
O^iPr
O^iPr
3k
131.668
131.645
ppm
116.109
116.053
116.1
ppm
71.429
71.374
71.4
ppm
23.0
22.5
22.0
21.5 ppm
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

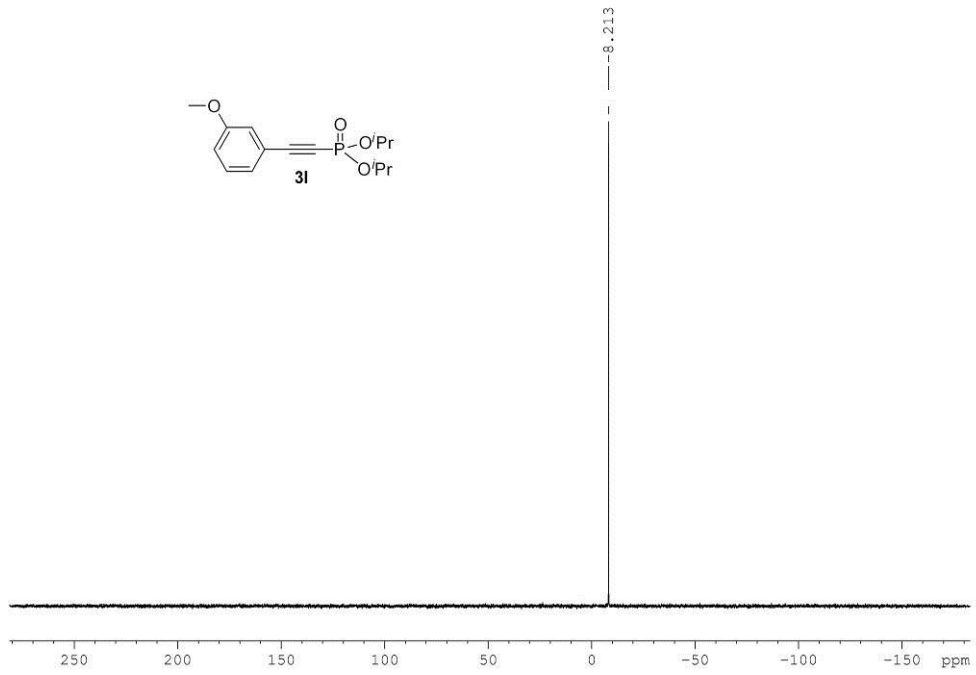

7.819
250
200
150
100
50
0
-50
-100
-150
ppm

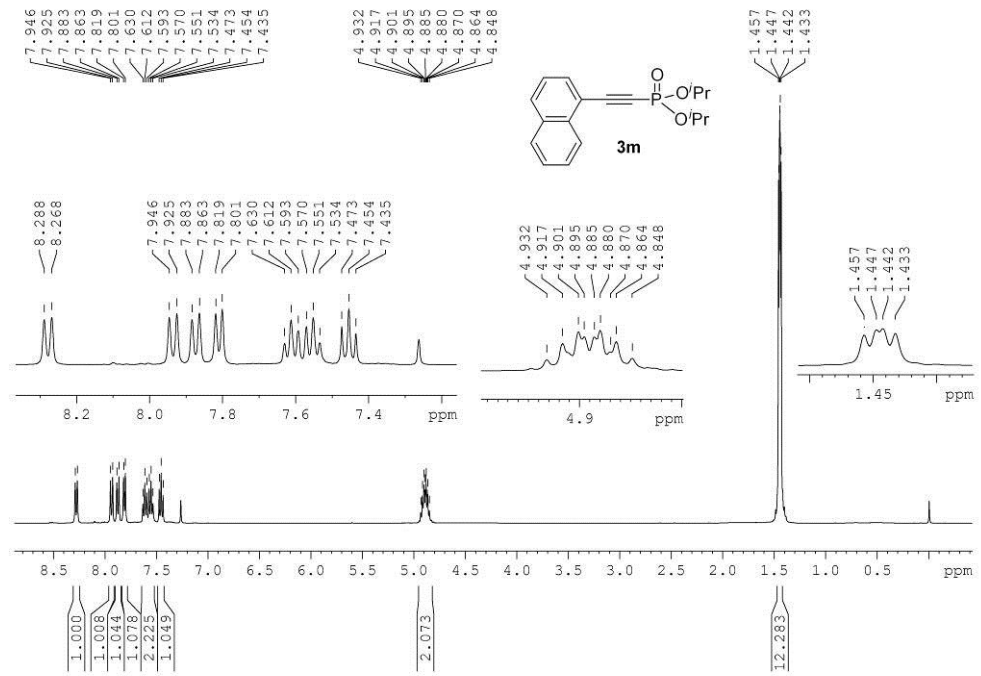
3k

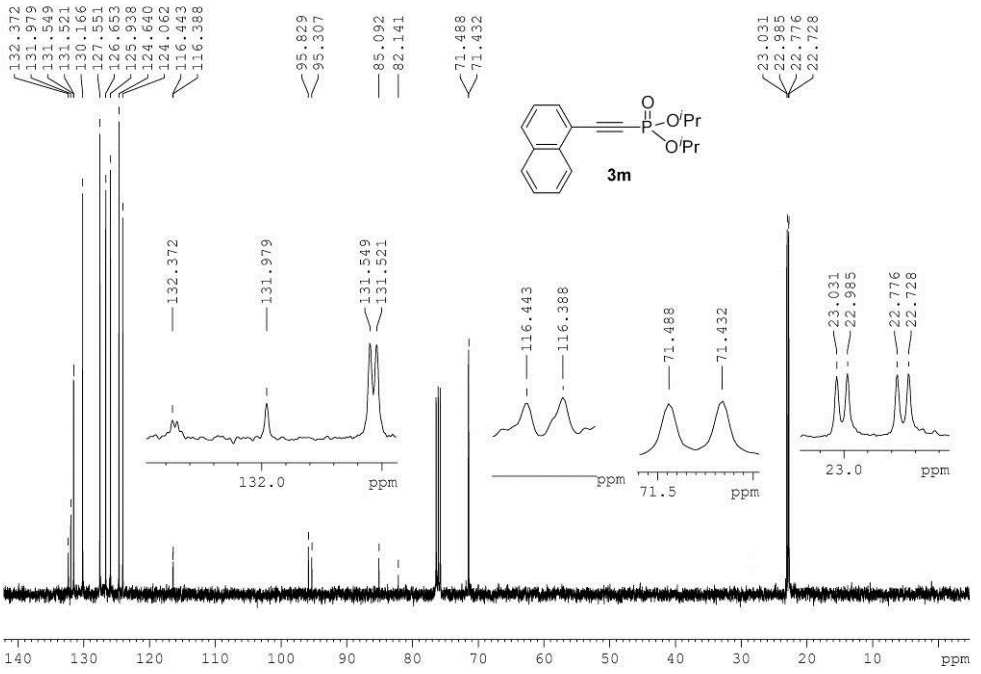

7.232
7.212
7.192
7.087
7.068
6.994
6.941
6.937
6.920
6.916
4.809
4.794
4.778
4.763
4.757
4.747
4.741
4.726
4.710
4.694
3.743
1.354
1.350
1.339
1.335
7.2
7.0 ppm
4.8
ppm
1.35 ppm
8
7
6
5
4
3
2
1
0
ppm
1.175
1.000
0.977
0.977
1.965
3.065
12.000

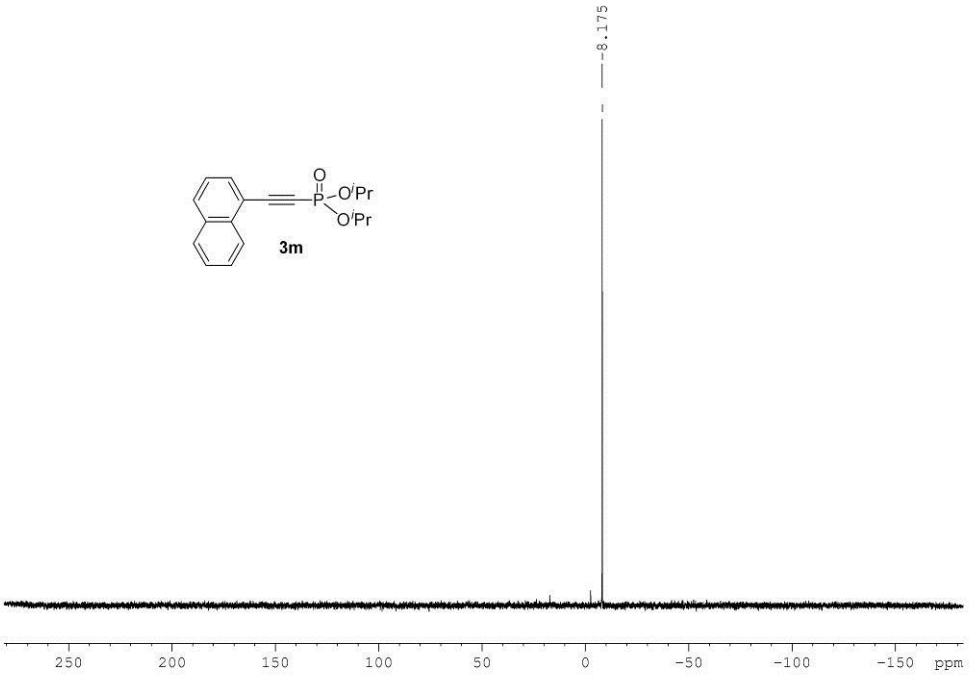
3l

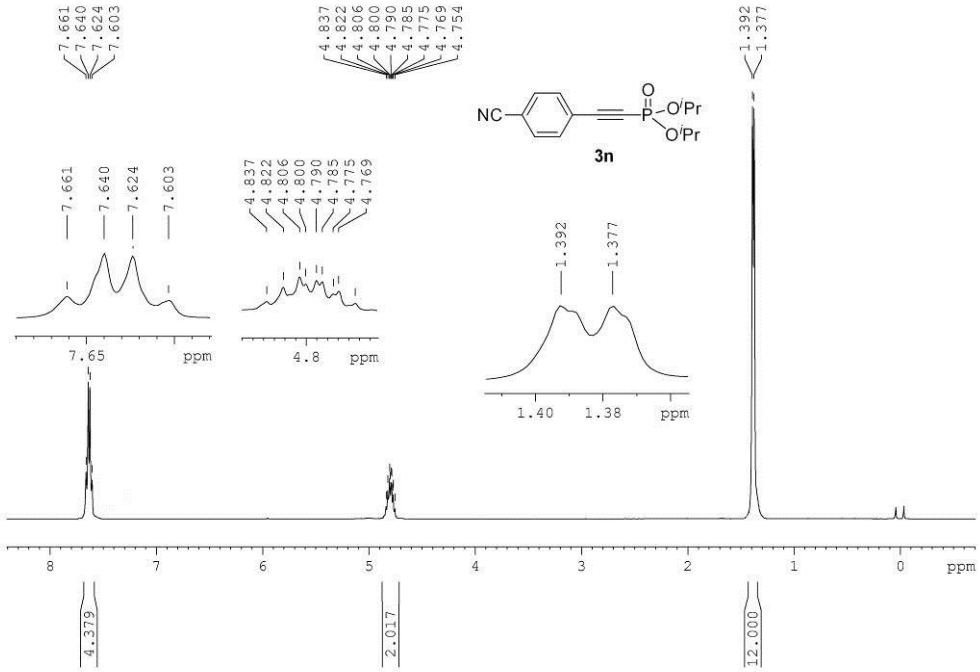

158.490
128.862
124.150
124.127
119.923
119.867
116.359
116.321
97.451
96.927
80.232
77.268
71.549
71.493
54.532
23.095
23.050
22.829
22.782
3l
ppm

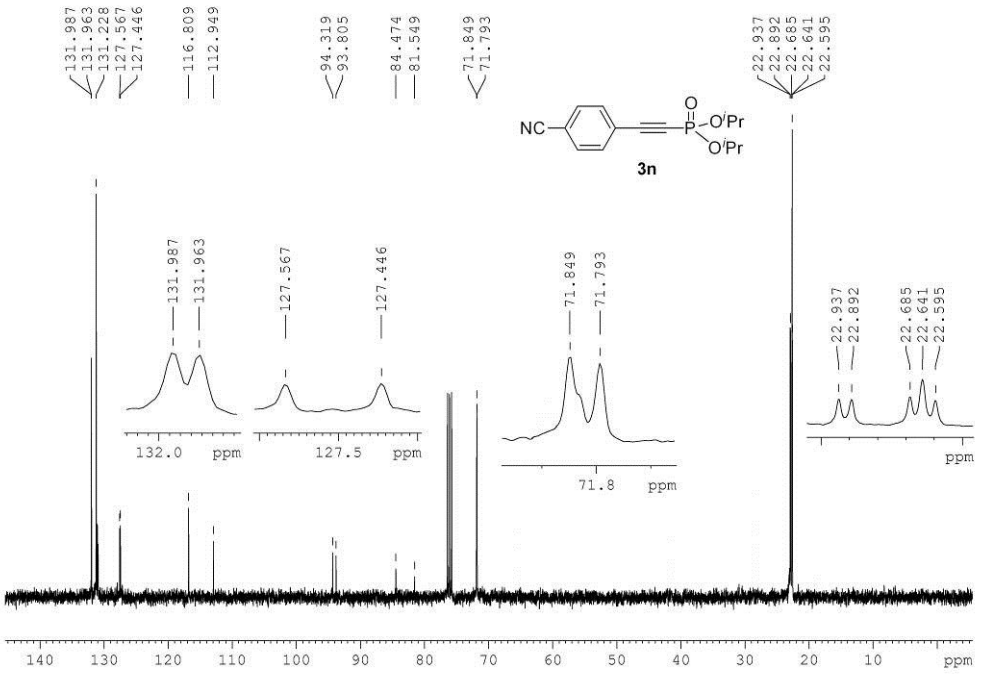

-8.213
3l
ppm

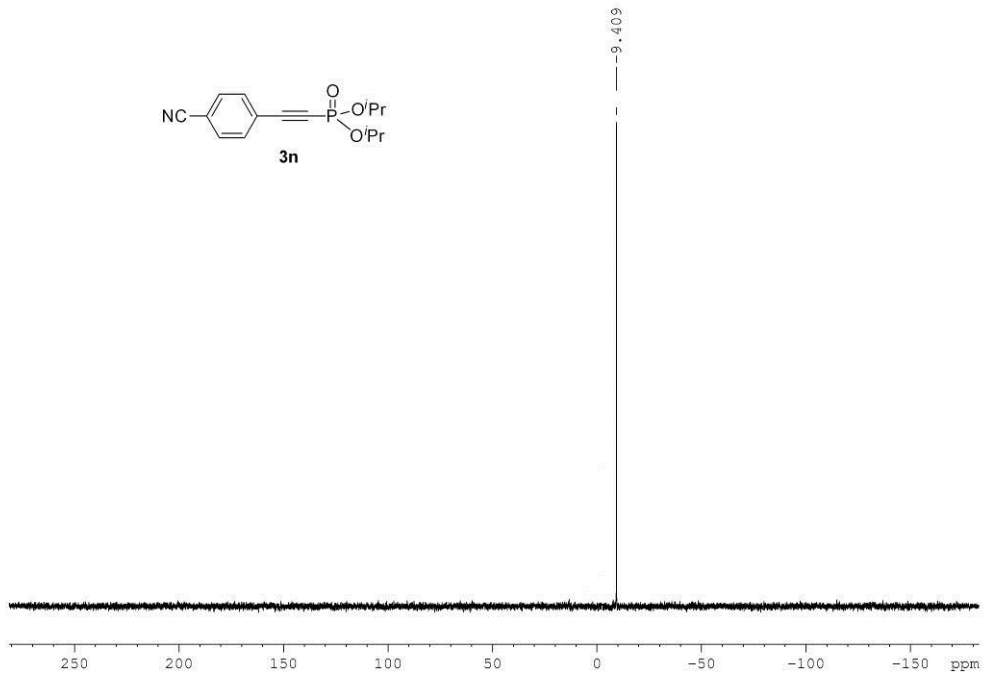

7.946
7.925
7.883
7.863
7.819
7.801
7.630
7.612
7.593
7.570
7.551
7.534
7.473
7.454
7.435
4.932
4.917
4.901
4.895
4.885
4.880
4.870
4.864
4.848
1.457
1.447
1.442
1.433
O
P
O^{i}Pr
O^{i}Pr
3m
8.288
8.268
8.2
8.0
7.8
7.6
7.4
ppm
4.9
ppm
1.45
ppm
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
ppm
1.000
1.008
1.044
1.078
2.225
1.049
2.073
12.283

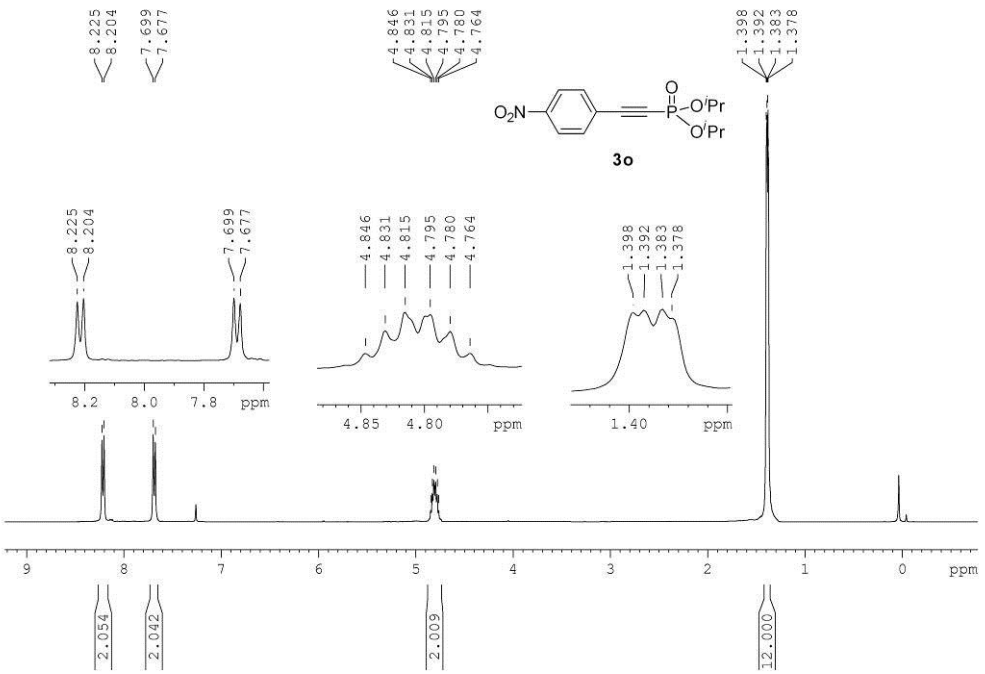

132.372
131.979
131.549
131.521
130.166
127.551
126.653
125.938
124.640
124.062
116.443
116.388
95.829
95.307
85.092
82.141
71.488
71.432
23.031
22.985
22.776
22.728
O
P
O^{i}Pr
O^{i}Pr
3m
132.0
ppm
ppm
71.5
ppm
23.0
ppm
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

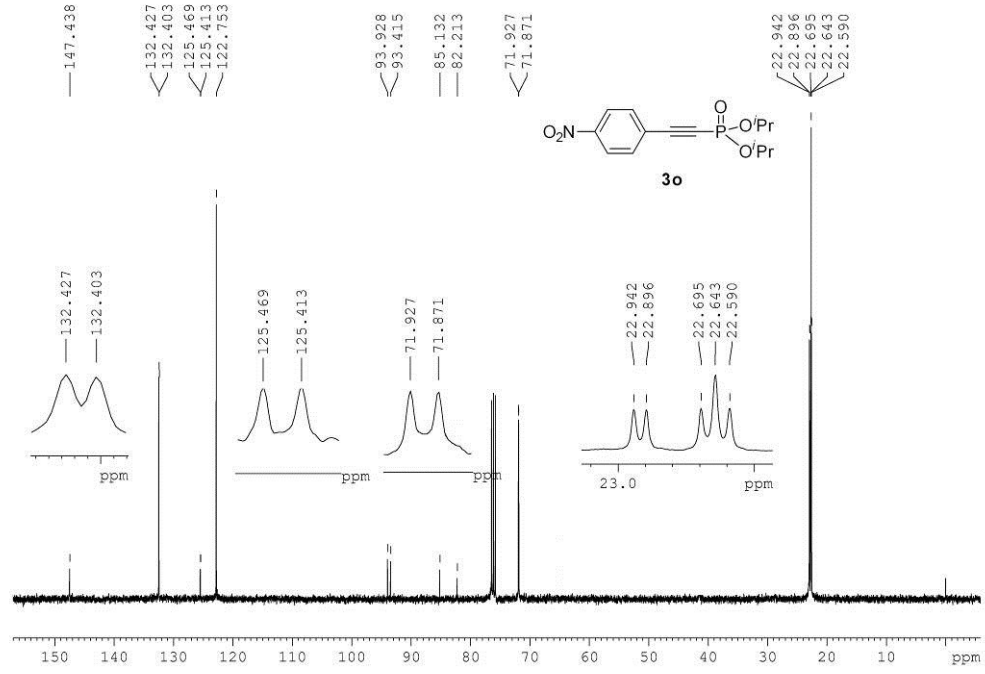

8.175
O
P
O^{i}Pr
O^{i}Pr
3m
250
200
150
100
50
0
-50
-100
-150
ppm

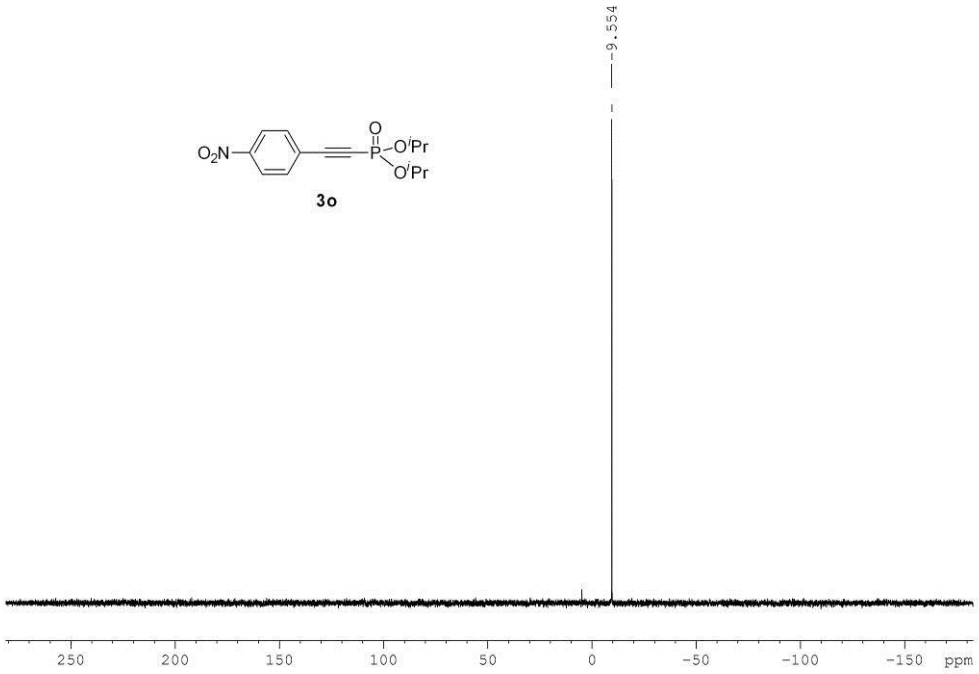

7.661
7.640
7.624
7.603
4.837
4.822
4.806
4.800
4.790
4.785
4.775
4.769
4.754
1.392
1.377
NC
O
P
O^{i}Pr
O^{i}Pr
3n
7.65
ppm
4.8
ppm
1.40
1.38
ppm
8
7
6
5
4
3
2
1
0
ppm
4.379
2.017
12.000


131.987
131.963
131.228
127.567
127.446
116.809
112.949
94.319
93.805
84.474
81.549
71.849
71.793
22.937
22.892
22.685
22.641
22.595
NC
O
P
O^{i}Pr
O^{i}Pr
3n
132.0 ppm
127.5 ppm
71.8 ppm
ppm
140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

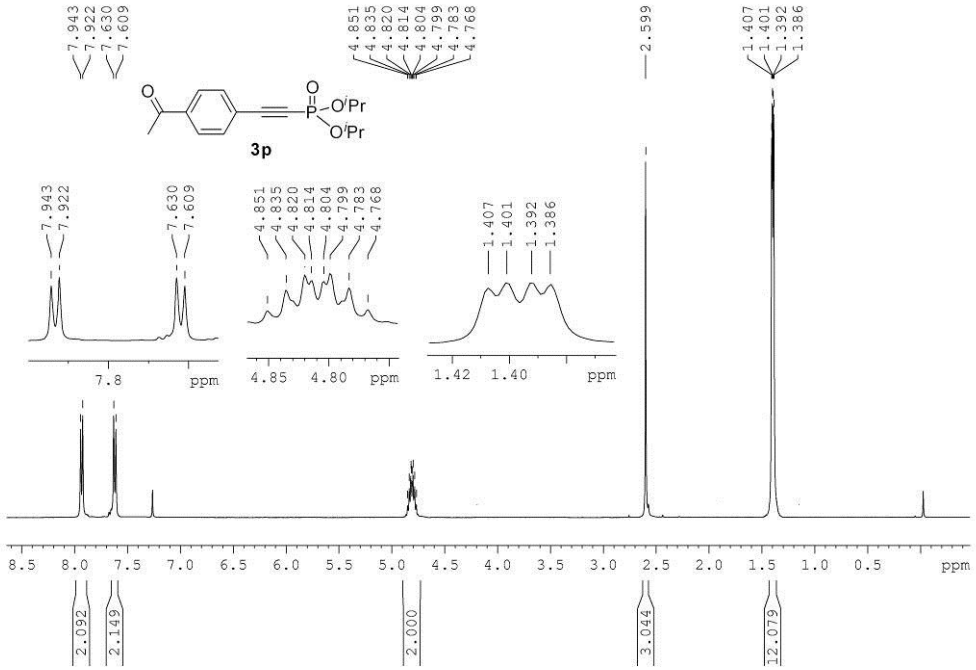

-9.409
NC
O
P
O^{i}Pr
O^{i}Pr
3n
250 200 150 100 50 0 -50 -100 -150 ppm


8.225
8.204
7.699
7.677
4.846
4.831
4.815
4.795
4.780
4.764
1.398
1.392
1.383
1.378
O2N
O
P
O'Pr
O'Pr
3o
8.2
8.0
7.8
ppm
4.85
4.80
ppm
1.40
ppm
9
8
7
6
5
4
3
2
1
0
ppm
2.054
2.042
2.009
12.000

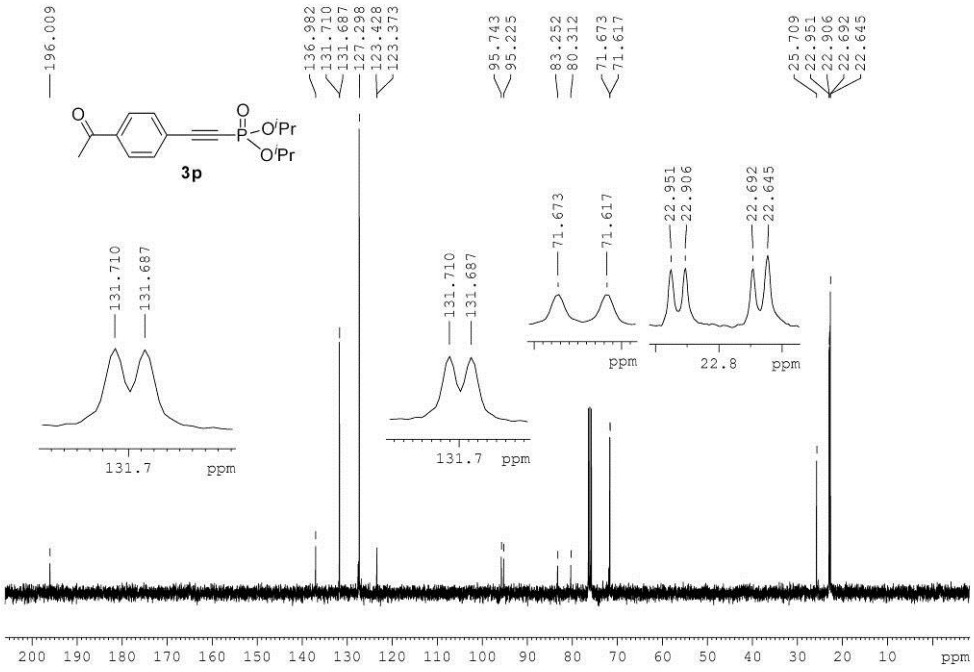

147.438
132.427
132.403
125.469
125.413
122.753
93.928
93.415
85.132
82.213
71.927
71.871
22.942
22.896
22.695
22.643
22.590
O2N
O
P
O'Pr
O'Pr
3o
ppm
23.0
ppm
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

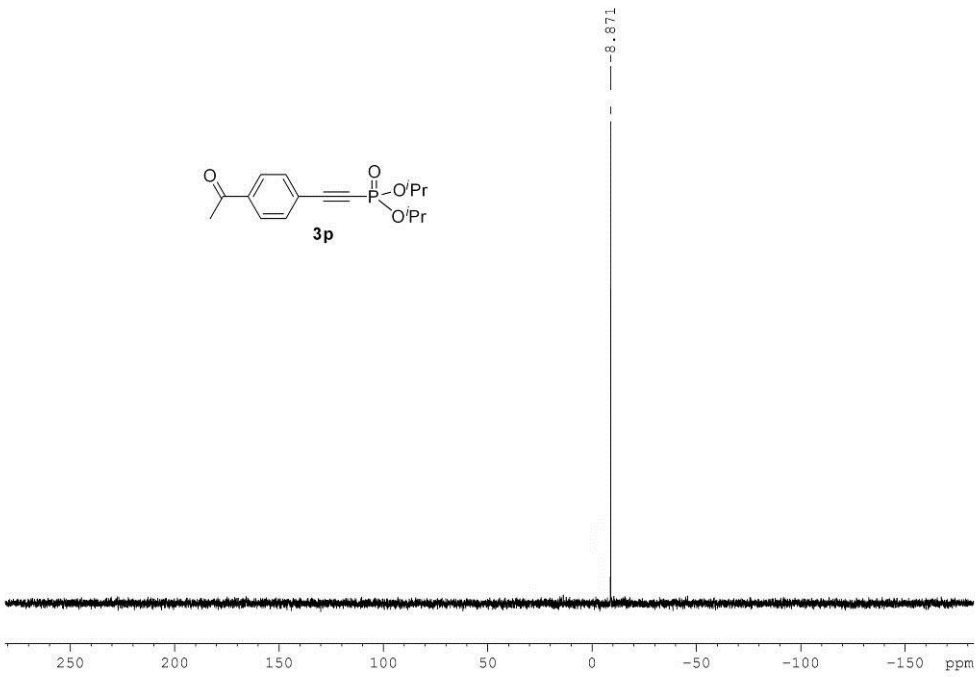

-9.554
250
200
150
100
50
0
-50
-100
-150
ppm

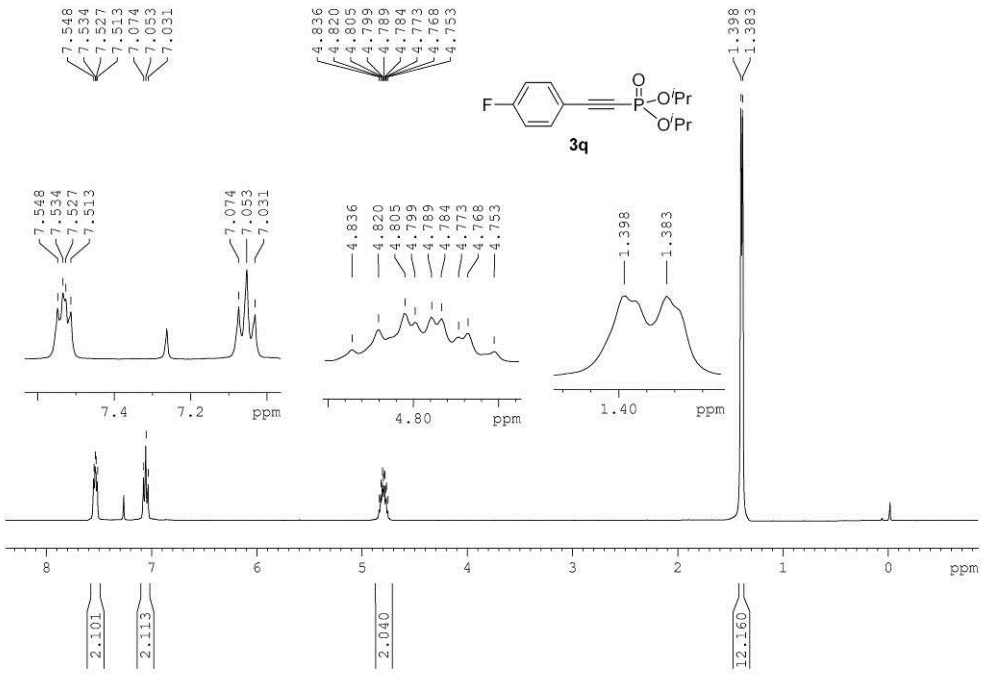
3o

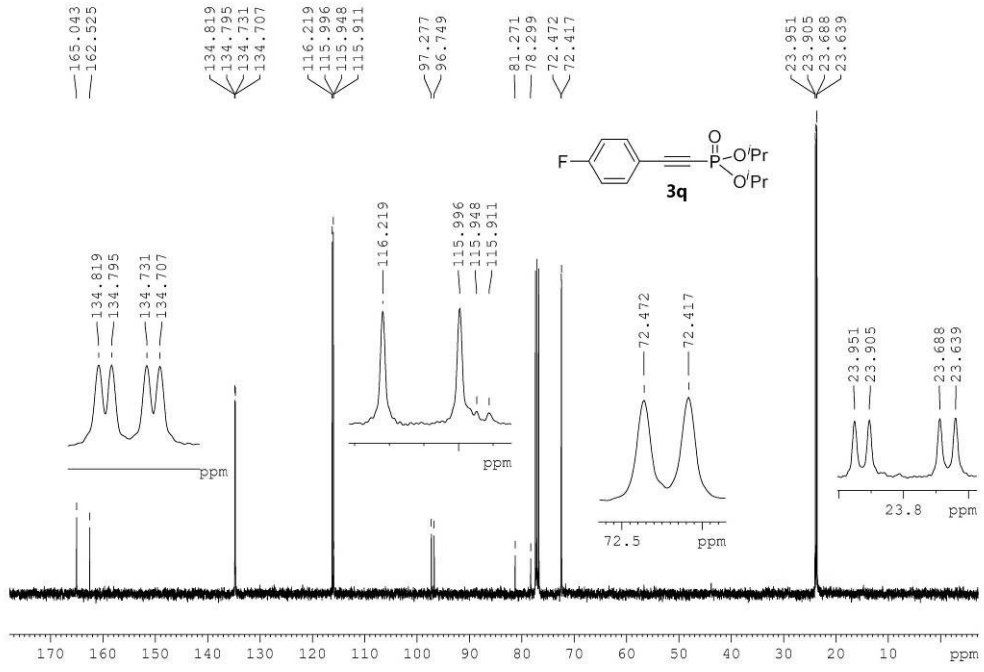

7.943
7.922
7.630
7.609
4.851
4.835
4.820
4.814
4.804
4.799
4.783
4.768
2.599
1.407
1.401
1.392
1.386
7.8
ppm
4.85
4.80
ppm
1.42
1.40
ppm
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
ppm
2.092
2.149
2.000
3.044
12.079

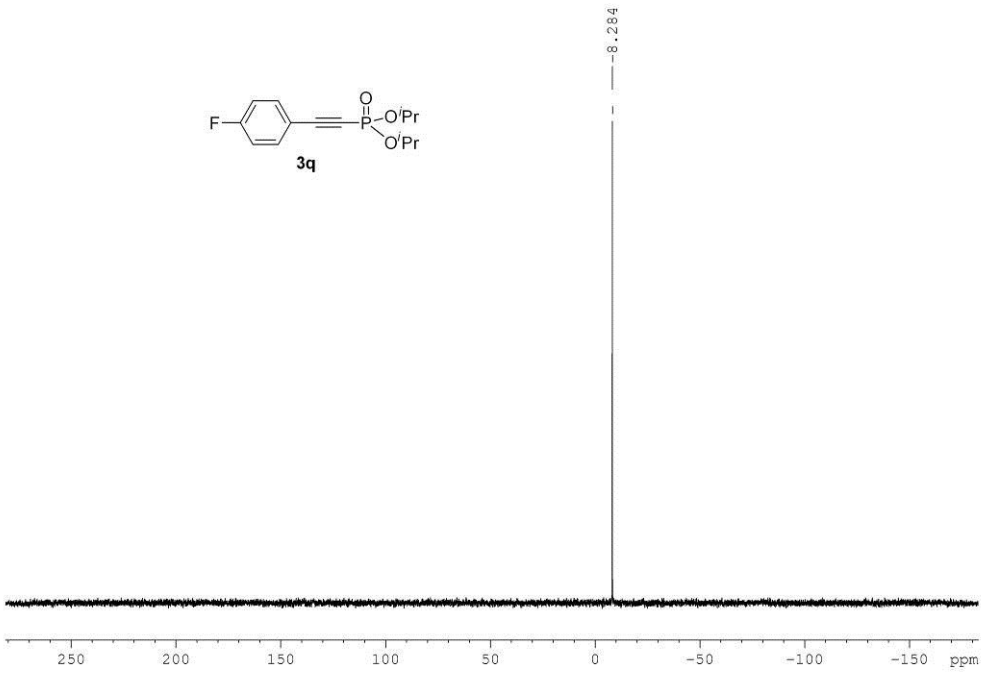
3p

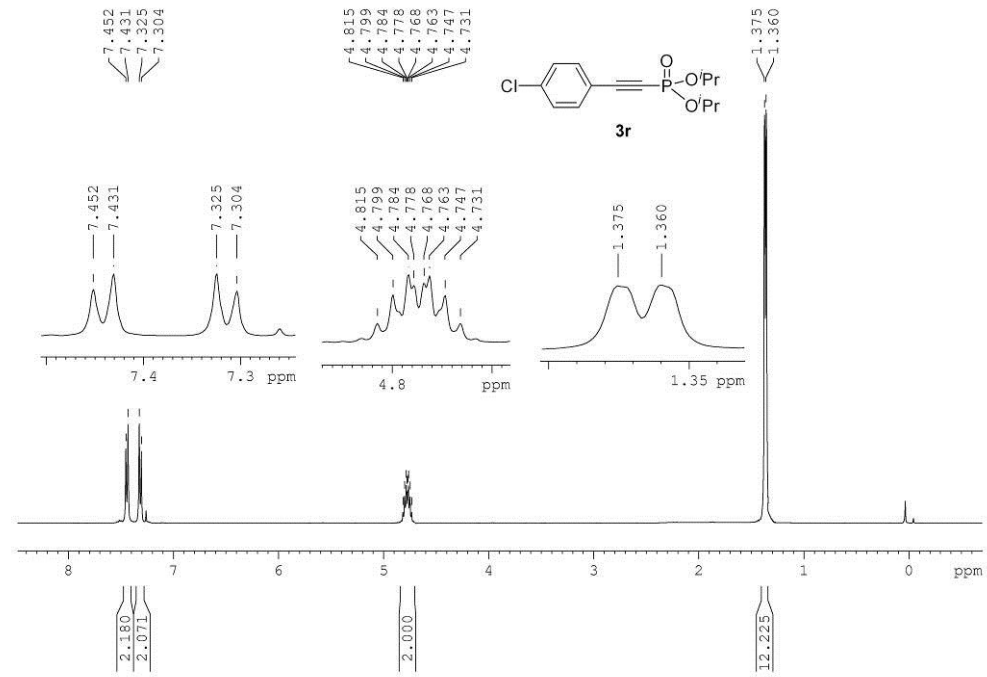

196.009
136.982
131.710
131.687
127.298
123.428
123.373
95.743
95.225
83.252
80.312
71.673
71.617
25.709
22.951
22.906
22.692
22.645
3p
131.710
131.687
131.7 ppm
131.710
131.687
131.7 ppm
71.673
71.617
ppm
22.951
22.906
22.692
22.645
22.8 ppm
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

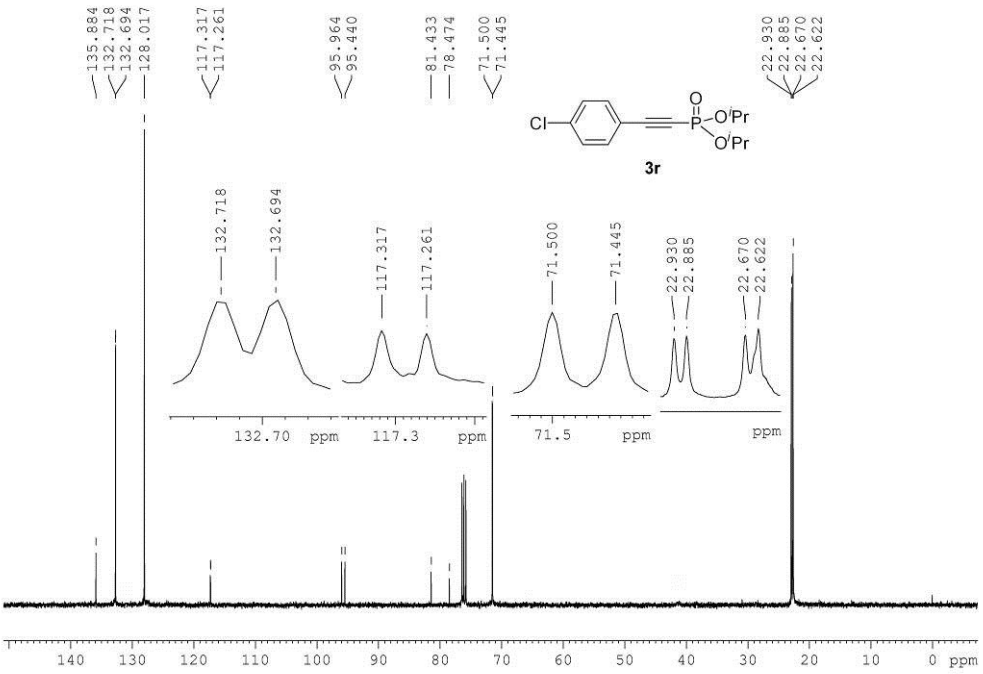

-8.871
3p
250 200 150 100 50 0 -50 -100 -150 ppm

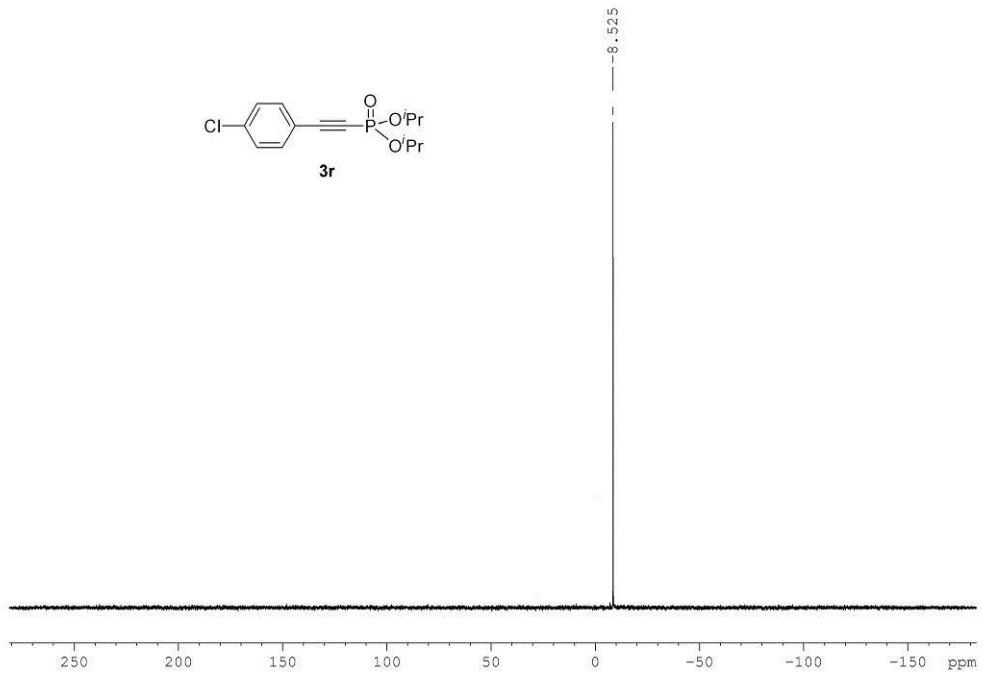

7.548
7.534
7.527
7.513
7.074
7.053
7.031
4.836
4.820
4.805
4.799
4.789
4.784
4.773
4.768
4.753
1.398
1.383
F
O
P
O^{i}Pr
O^{i}Pr
3q
7.4
7.2
ppm
4.80
ppm
1.40
ppm
8
7
6
5
4
3
2
1
0
ppm
2.101
2.113
2.040
12.160

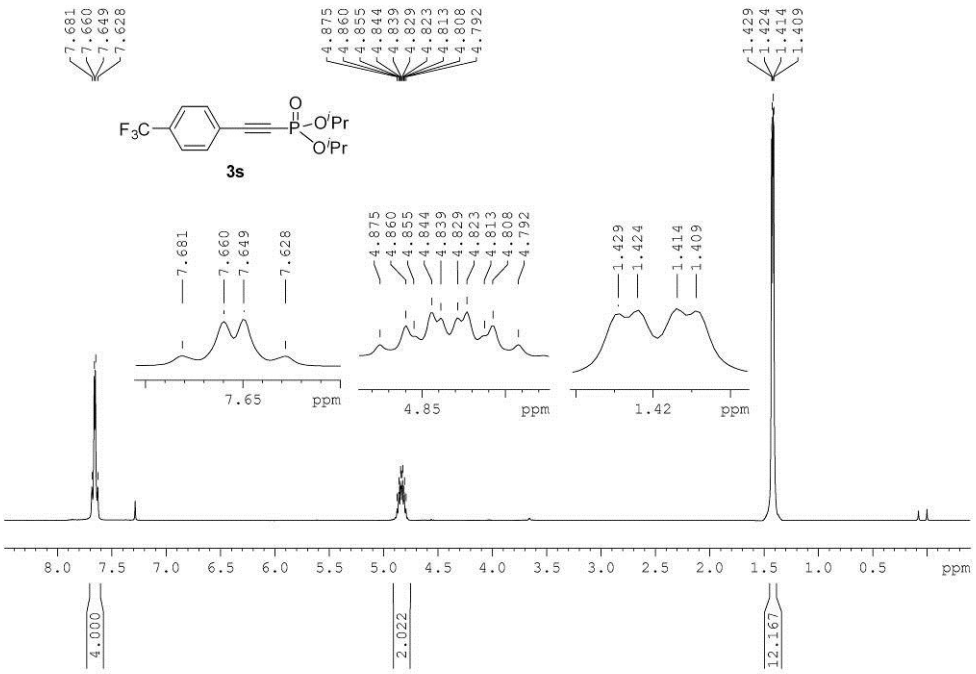

165.043
162.525
134.819
134.795
134.731
134.707
116.219
115.996
115.948
115.911
97.277
96.749
81.271
78.299
72.472
72.417
23.951
23.905
23.688
23.639
F
O
P
O^{i}Pr
O^{i}Pr
3q
ppm
72.5
ppm
23.8
ppm
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

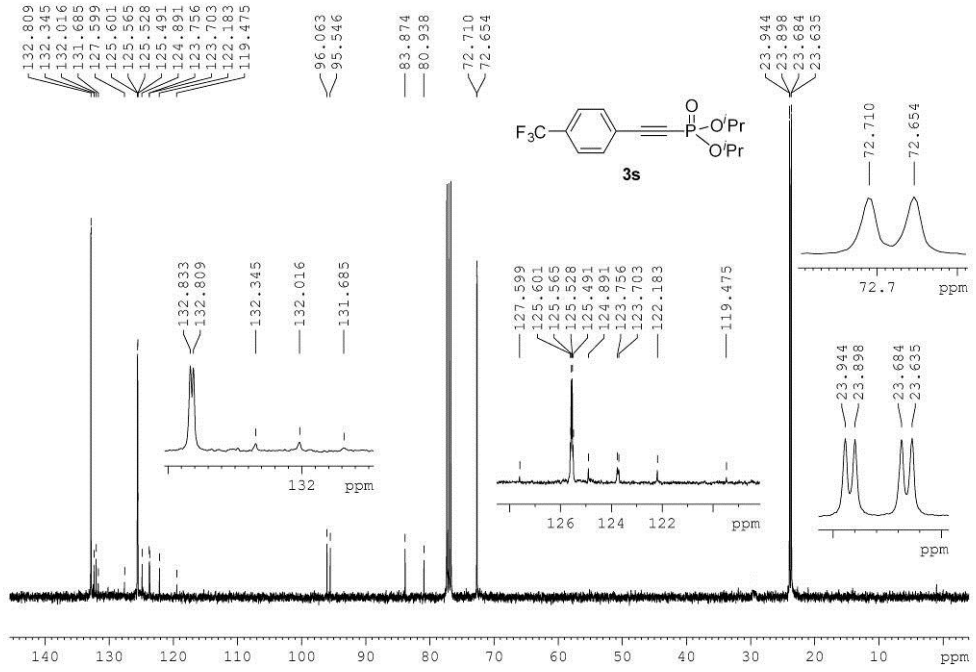

8.284
F
O
P
O^{i}Pr
O^{i}Pr
3q
250
200
150
100
50
0
-50
-100
-150
ppm

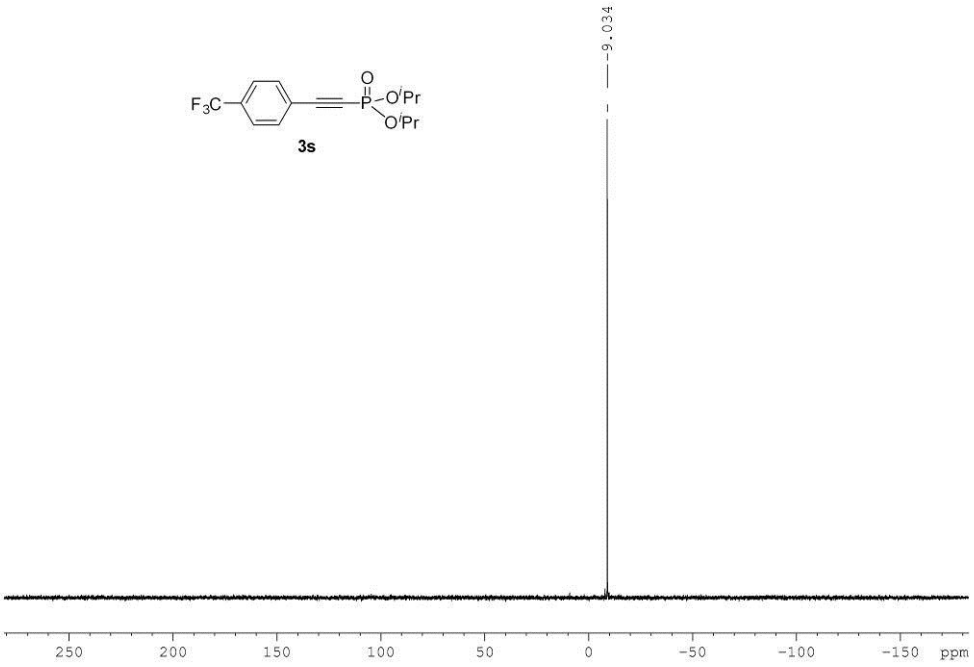

7.452
7.431
7.325
7.304
4.815
4.799
4.784
4.778
4.768
4.763
4.747
4.731
1.375
1.360
Cl
O
P
O^{i}Pr
O^{i}Pr
3r
7.4
7.3
ppm
4.8
ppm
1.35 ppm
8
7
6
5
4
3
2
1
0
ppm
2.180
2.071
2.000
12.225

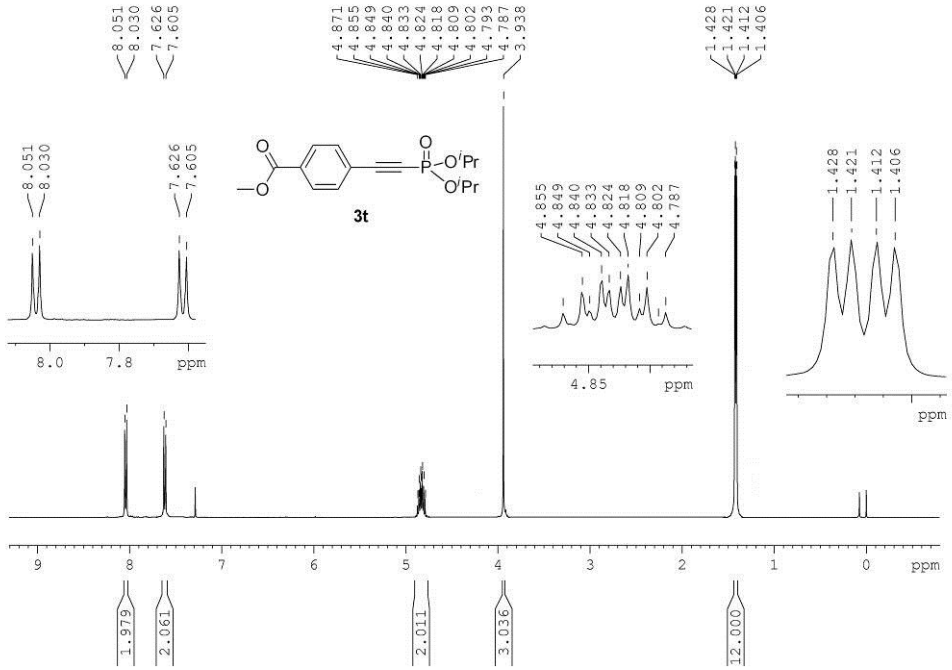

135.884
132.718
132.694
128.017
117.317
117.261
95.964
95.440
81.433
78.474
71.500
71.445
22.930
22.885
22.670
22.622
Cl
O
P
O^{i}Pr
O^{i}Pr
3r
132.718
132.694
117.317
117.261
71.500
71.445
22.930
22.885
22.670
22.622
132.70 ppm
117.3 ppm
71.5 ppm
ppm
140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 ppm

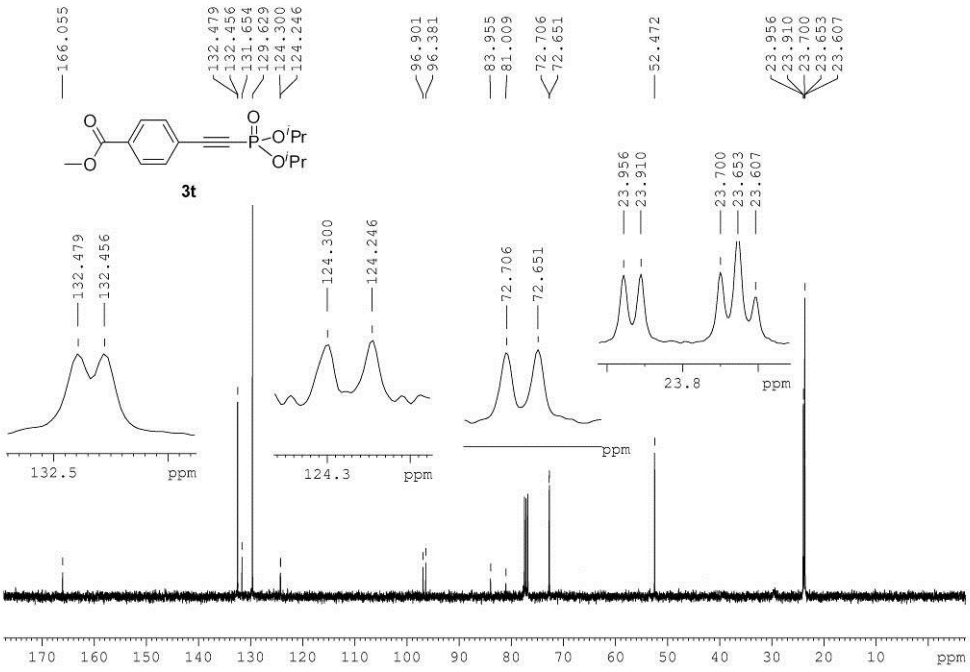

Cl
O
P
O^{i}Pr
O^{i}Pr
3r
-8.525
250 200 150 100 50 0 -50 -100 -150 ppm

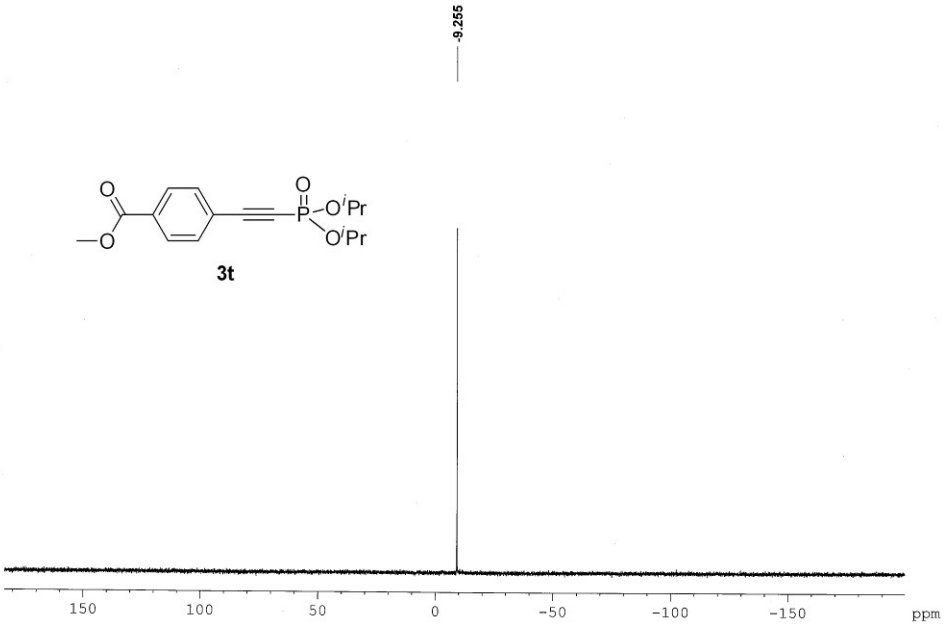

7.681
7.660
7.649
7.628
4.875
4.860
4.855
4.844
4.839
4.829
4.823
4.813
4.808
4.792
1.429
1.424
1.414
1.409
F3C
O
O^iPr
O^iPr
3s
7.65 ppm
4.85 ppm
1.42 ppm
8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 ppm
4.000
2.022
12.167

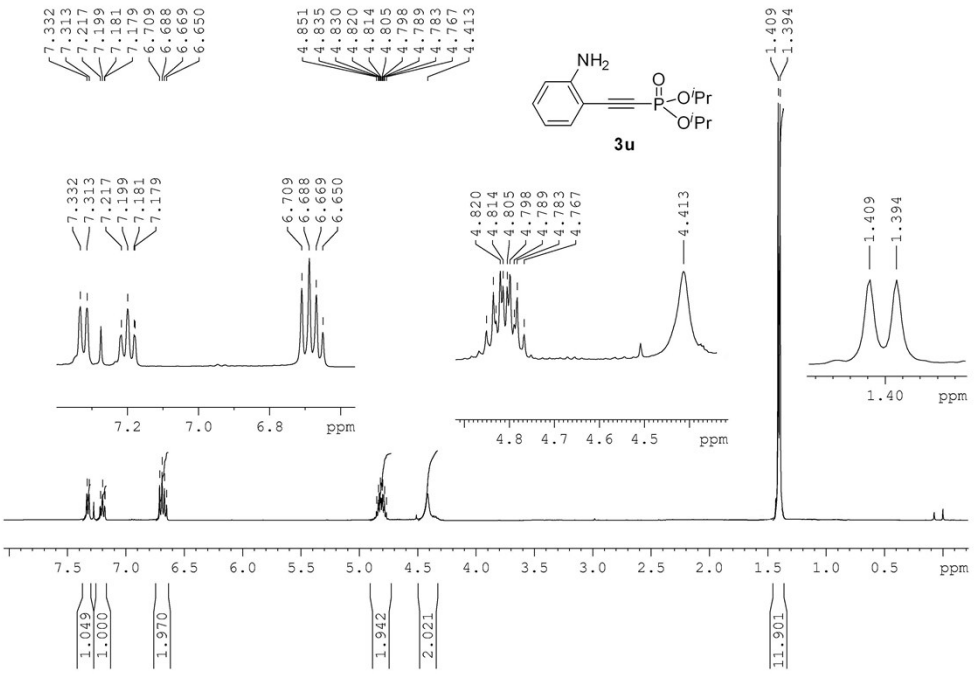

132.809
132.345
132.016
131.685
127.599
125.601
125.565
125.528
125.491
124.891
123.756
123.703
122.183
119.475
96.063
95.546
83.874
80.938
72.710
72.654
23.944
23.898
23.684
23.635
F3C
O
O^iPr
O^iPr
3s
132 ppm
126 124 122 ppm
72.7 ppm
ppm
140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

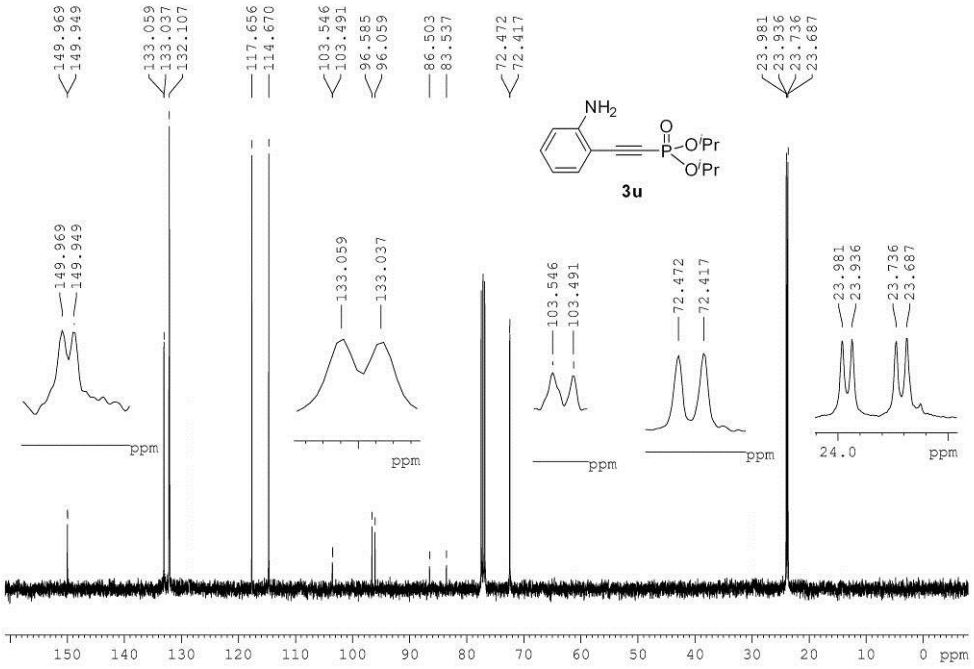

3s
9.034
250
200
150
100
50
0
-50
-100
-150
ppm

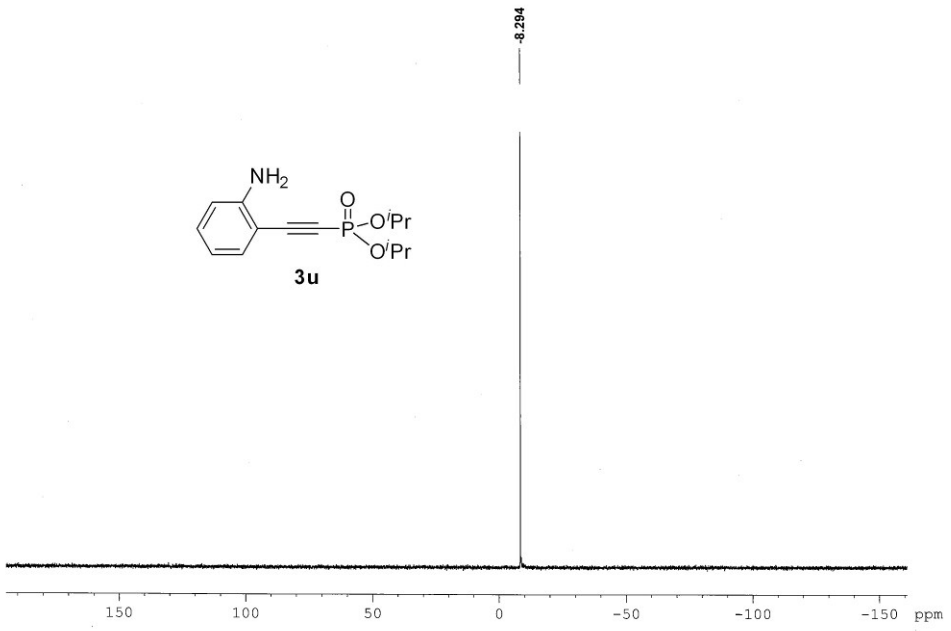

8.051
8.030
7.626
7.605
4.871
4.855
4.849
4.840
4.833
4.824
4.818
4.809
4.802
4.793
4.787
3.938
1.428
1.421
1.412
1.406
3t
8.0
7.8
ppm
4.85
ppm
ppm
9
8
7
6
5
4
3
2
1
0
ppm
1.979
2.061
2.011
3.036
12.000

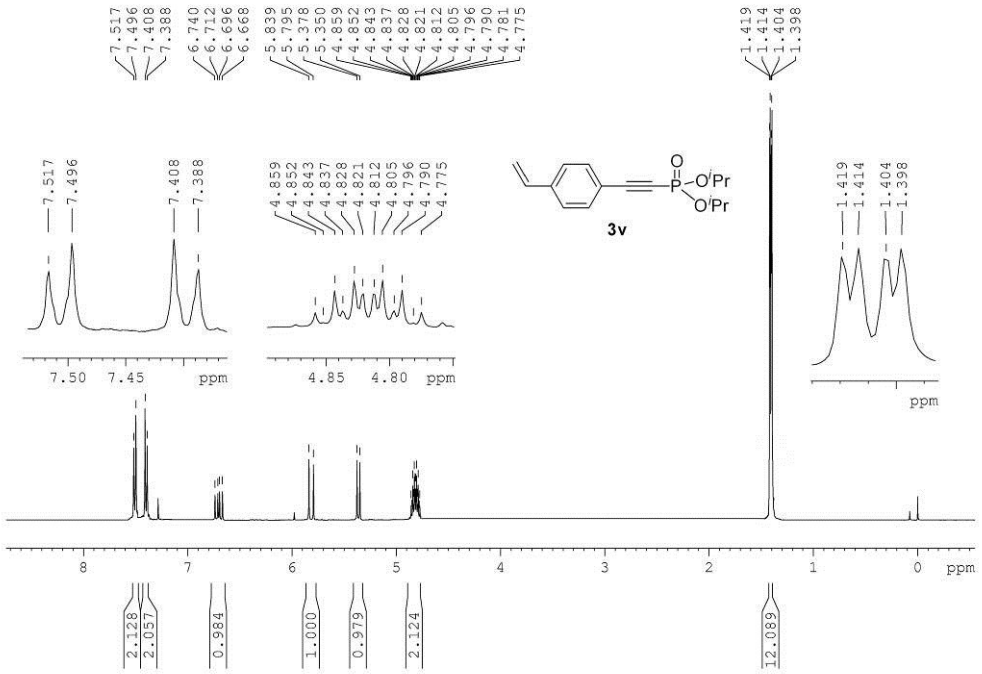

166.055
132.479
132.456
131.654
129.629
124.300
124.246
96.901
96.381
83.955
81.009
72.706
72.651
52.472
23.956
23.910
23.700
23.653
23.607
3t
132.5
ppm
124.3
ppm
23.8
ppm
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

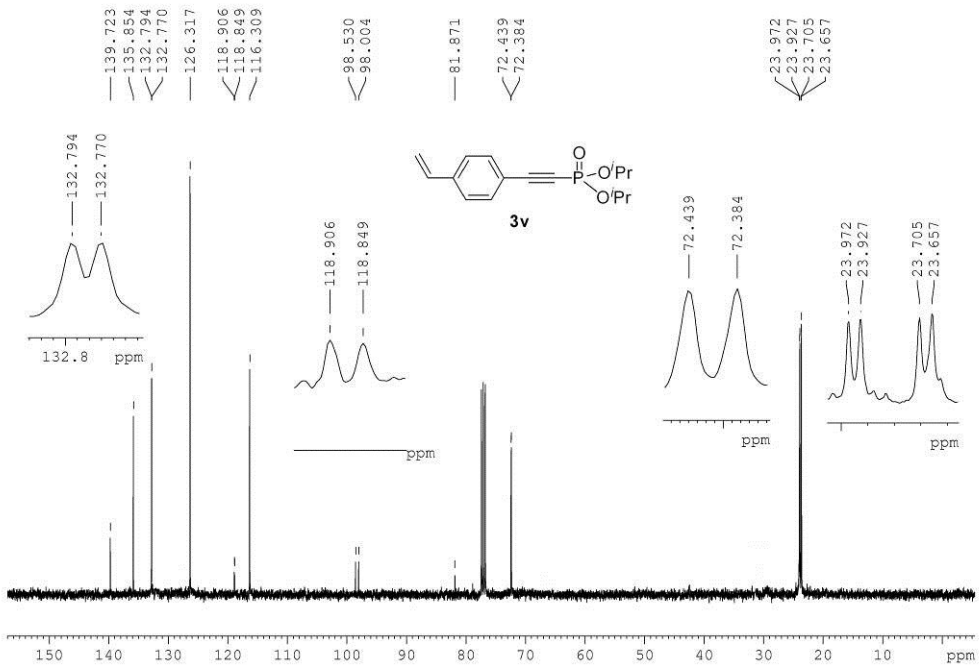

-9.255
3t
150 100 50 0 -50 -100 -150 ppm

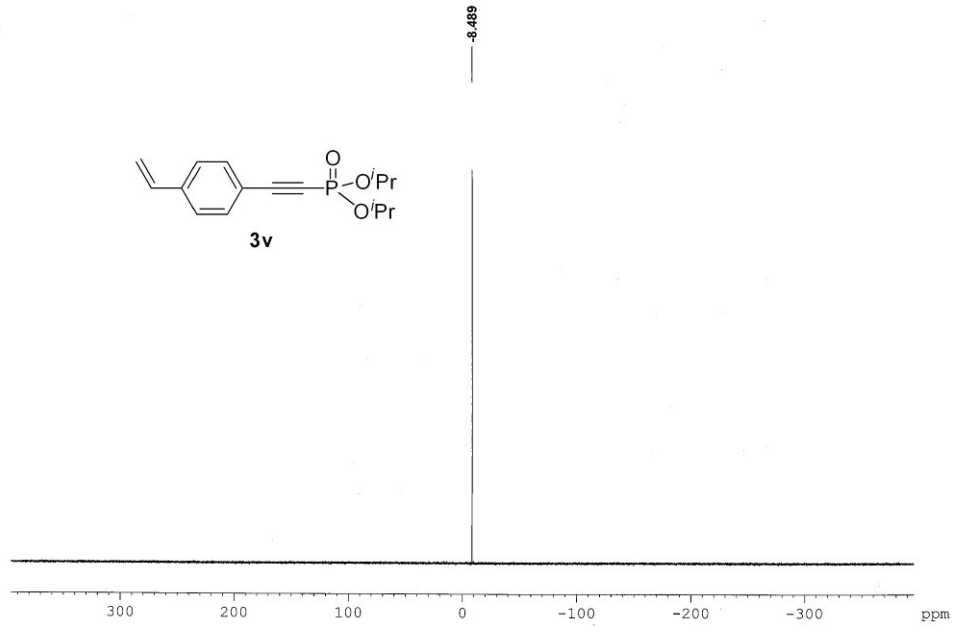

7.332
7.313
7.217
7.199
7.181
7.179
6.709
6.688
6.669
6.650
4.851
4.835
4.830
4.820
4.814
4.805
4.798
4.789
4.783
4.767
4.413
1.409
1.394
NH2
O
P
O'Pr
O'Pr
3u
7.2
7.0
6.8
ppm
4.8
4.7
4.6
4.5
ppm
1.40
ppm
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
ppm
1.049
1.000
1.970
1.942
2.021
11.901

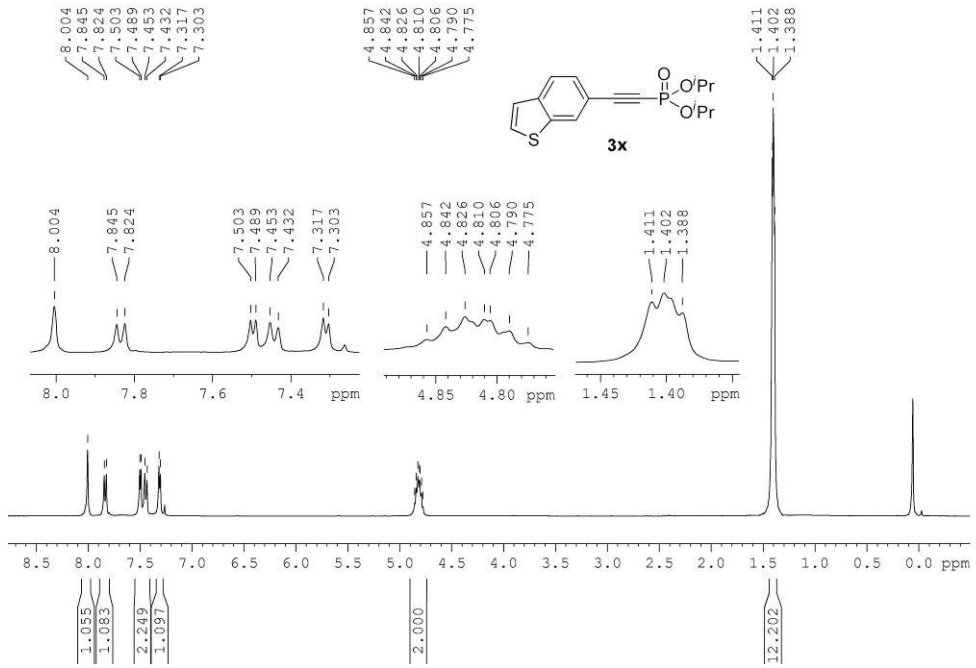

149.969
149.949
133.059
133.037
132.107
117.656
114.670
103.546
103.491
96.585
96.059
86.503
83.537
72.472
72.417
23.981
23.936
23.736
23.687
NH2
O
P
O'Pr
O'Pr
3u
ppm
24.0
ppm
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0 ppm

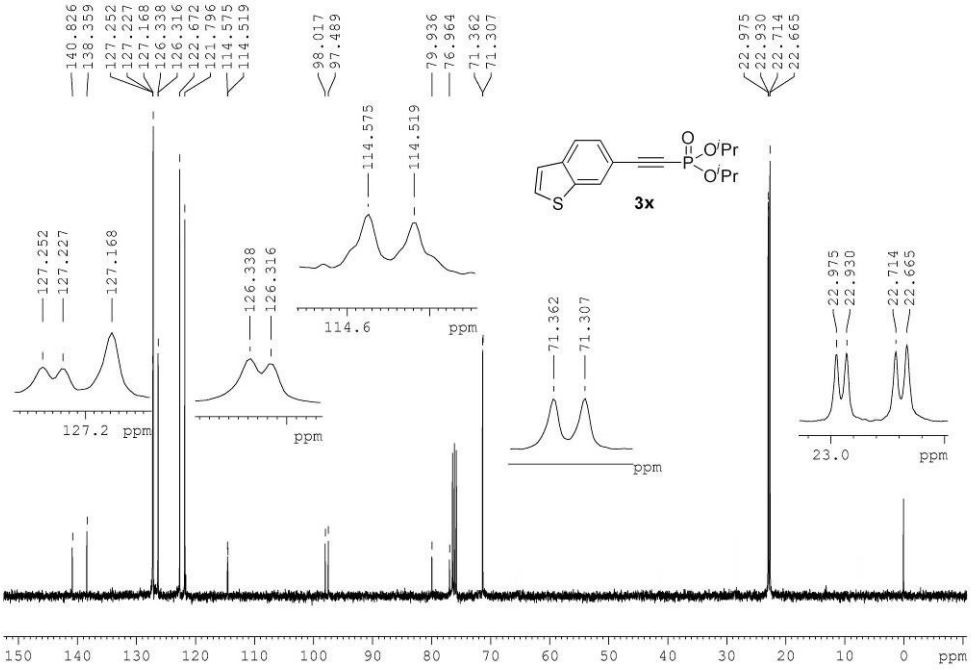

-8.294
NH2
O
P
O^{i}Pr
O^{i}Pr
3u
150
100
50
0
-50
-100
-150
ppm

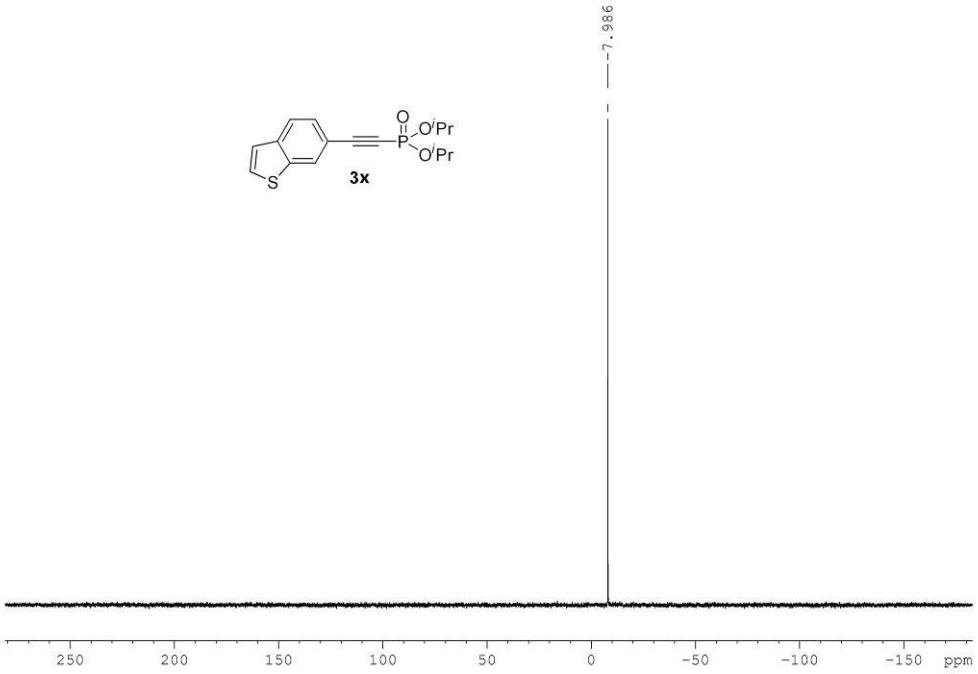

7.517
7.496
7.408
7.388
6.740
6.712
6.696
6.668
5.839
5.795
5.378
5.350
4.859
4.852
4.843
4.837
4.828
4.821
4.812
4.805
4.796
4.790
4.775
1.419
1.414
1.404
1.398
O
P
O^{i}Pr
O^{i}Pr
3v
7.50
7.45
ppm
4.85
4.80
ppm
ppm
8
7
6
5
4
3
2
1
0
ppm
2.128
2.057
0.984
1.000
0.979
2.124
12.089

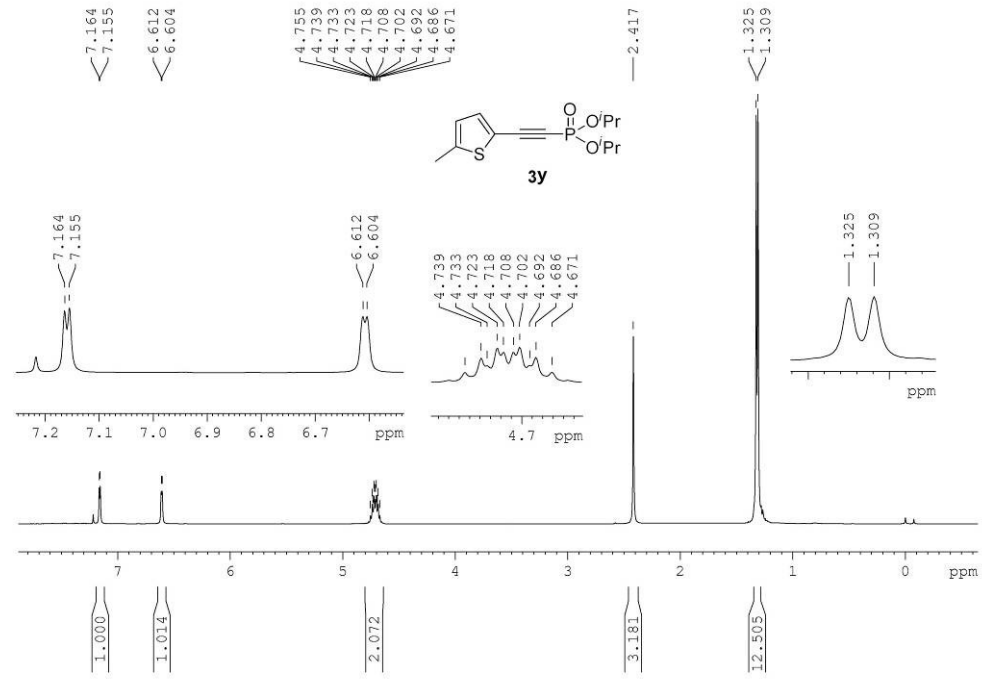

139.723
135.854
132.794
132.770
126.317
118.906
118.849
116.309
98.530
98.004
81.871
72.439
72.384
23.972
23.927
23.705
23.657
132.794
132.770
132.8
ppm
118.906
118.849
ppm
72.439
72.384
ppm
23.972
23.927
23.705
23.657
ppm
O
P
O^{i}Pr
O^{i}Pr
3v
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

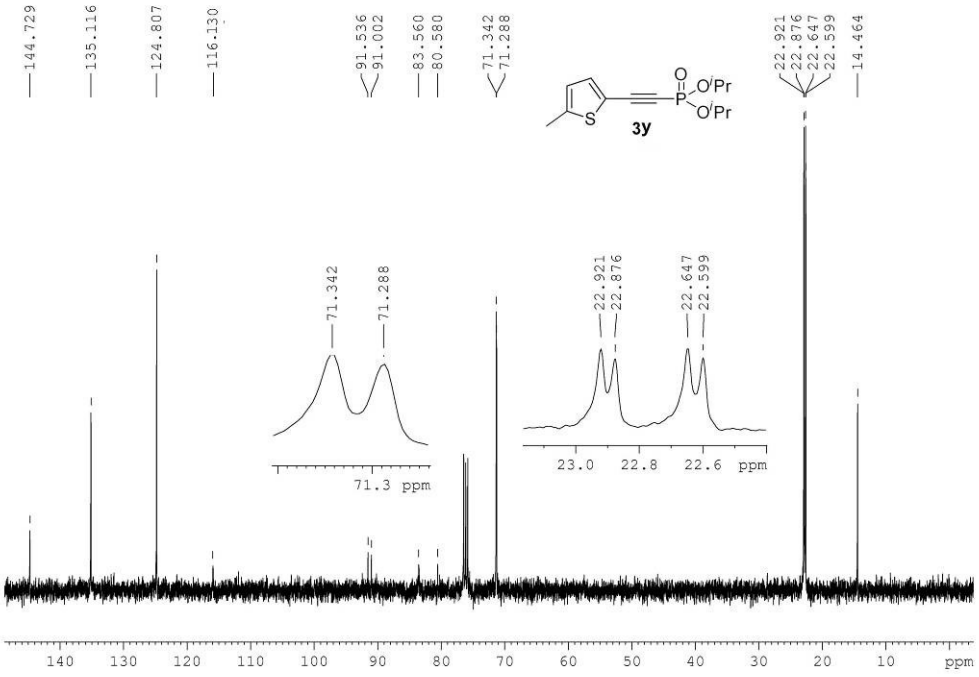

-8.489
O
P
O^{i}Pr
O^{i}Pr
3v
300
200
100
0
-100
-200
-300
ppm

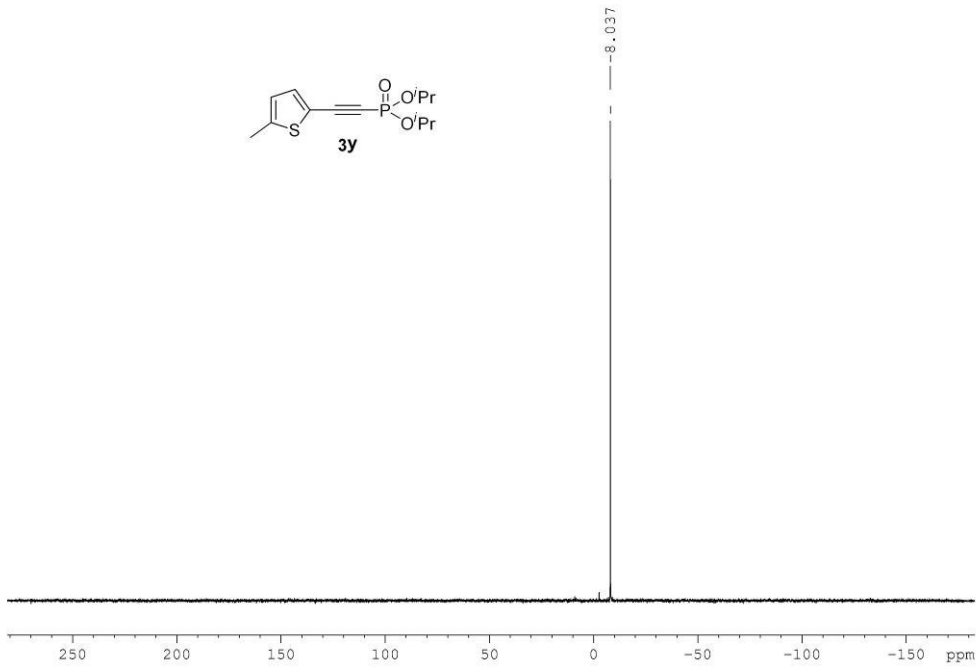

8.004
7.845
7.824
7.503
7.489
7.453
7.432
7.317
7.303
4.857
4.842
4.826
4.810
4.806
4.790
4.775
1.411
1.402
1.388
O
O^{i}Pr
P
O^{i}Pr
S
3x
8.0
7.8
7.6
7.4
ppm
4.85
4.80
ppm
1.45
1.40
ppm
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0 ppm
1.055
1.083
2.249
1.097
2.000
12.202

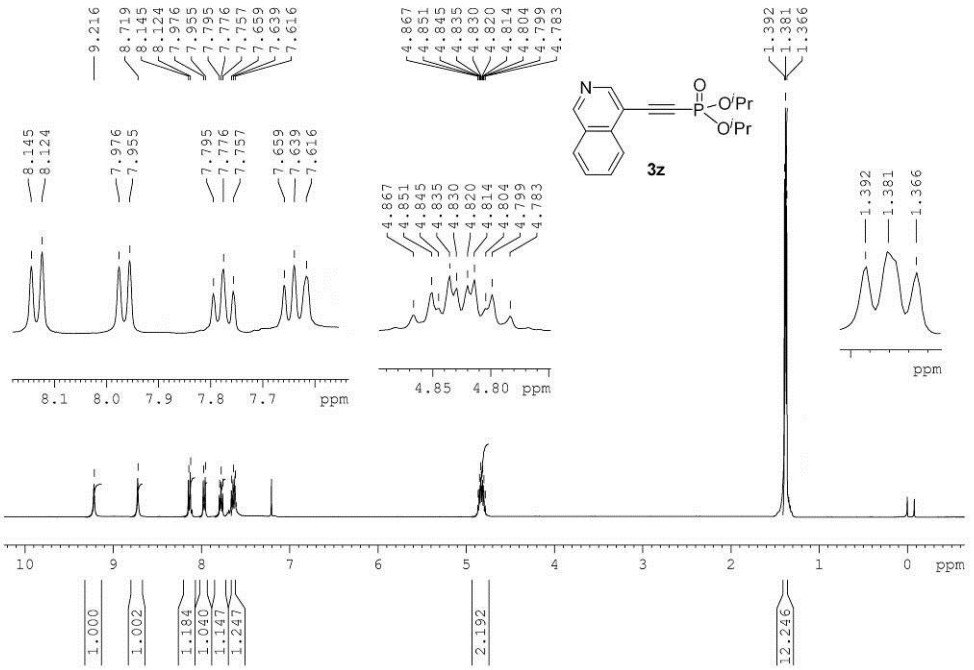

140.826
138.359
127.252
127.227
127.168
126.338
126.316
122.672
121.796
114.575
114.519
98.017
97.489
79.936
76.964
71.362
71.307
22.975
22.930
22.714
22.665
O
O^{i}Pr
P
O^{i}Pr
S
3x
127.2
ppm
114.6
ppm
23.0
ppm
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
ppm

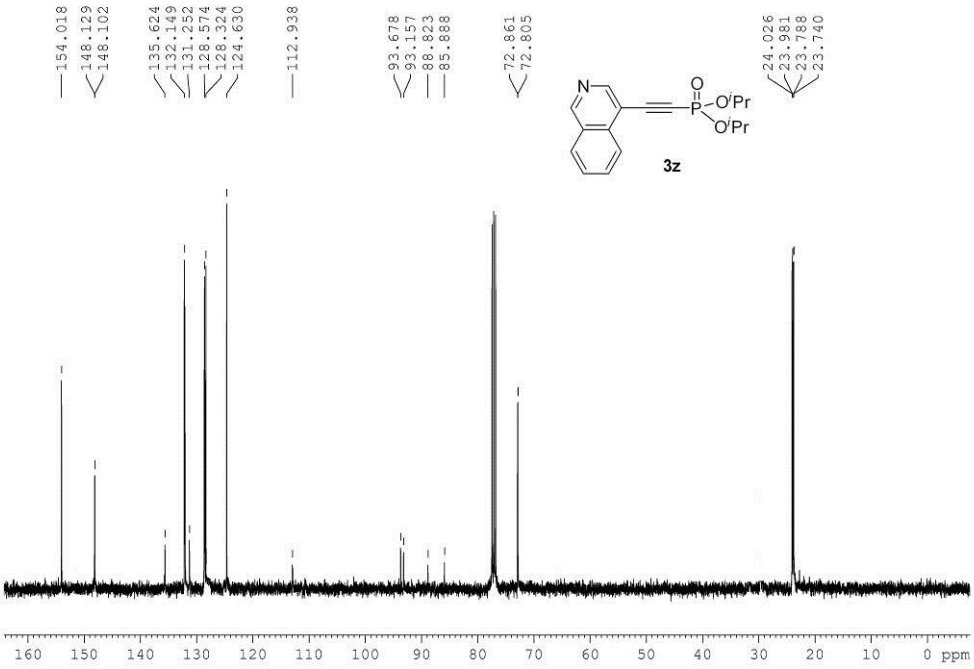

7.986
3x
250
200
150
100
50
0
-50
-100
-150
ppm

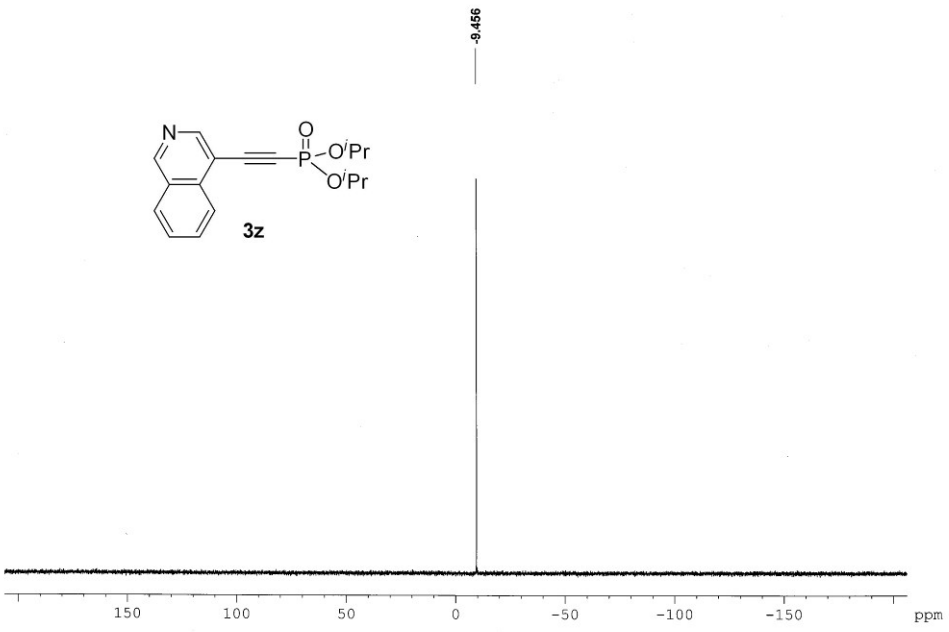

7.164
7.155
6.612
6.604
4.755
4.739
4.733
4.723
4.718
4.708
4.702
4.692
4.686
4.671
2.417
1.325
1.309
3y
7.2
7.1
7.0
6.9
6.8
6.7
4.7
ppm
1.000
1.014
2.072
3.181
12.505


144.729
135.116
124.807
116.130
91.536
91.002
83.560
80.580
71.342
71.288
22.921
22.876
22.647
22.599
14.464
O
P
O^{i}Pr
O^{i}Pr
S
3y
71.342
71.288
71.3 ppm
22.921
22.876
22.647
22.599
23.0
22.8
22.6 ppm
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm


-8.037
O
P
O^{i}Pr
O^{i}Pr
S
3y
250
200
150
100
50
0
-50
-100
-150
ppm


9.216
8.719
8.145
8.124
7.976
7.955
7.795
7.776
7.757
7.659
7.639
7.616
4.867
4.851
4.845
4.835
4.830
4.820
4.814
4.804
4.799
4.783
1.392
1.381
1.366
3z
ppm
1.000
1.002
1.184
1.040
1.147
1.247
2.192
12.246


154.018
148.129
148.102
135.624
132.149
131.252
128.574
128.324
124.630
112.938
93.678
93.157
88.823
85.888
72.861
72.805
24.026
23.981
23.788
23.740
3z
ppm


-9.456
N
O
P
O^{i}Pr
O^{i}Pr
3z
150
100
50
0
-50
-100
-150
ppm