*Supporting Information*

# Palladium-Catalyzed Dehydrogenative Coupling of Terminal Alkynes with Secondary Phosphine Oxides

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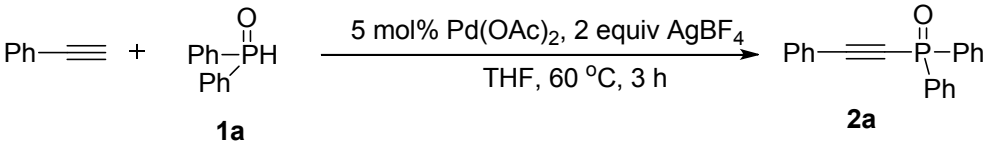
## *General information*

Reactions for the synthesis of metal intermediates were conducted in a glove box ($O_2$<0.1 ppm, $H_2O$<0.1 ppm). All other reactions were carried out in oven-dried Schlenk tubes under $N_2$ atmosphere. Dry solvents were obtained by purification according to standard methods. Reagents were used as received unless otherwise noted. $^1$H NMR, $^{13}$C NMR and $^{31}$P NMR data were obtained on a Bruker-400 spectrometer (400 MHz for $^1$H, 100 MHz for $^{13}$C, and 162 MHz for $^{31}$P NMR spectroscopy). Mass spectra were measured on a Shimadzu GCMS-QP2010 Plus spectrometer (EI). HRMS were conducted in the Analytical Center at Hunan University, China.

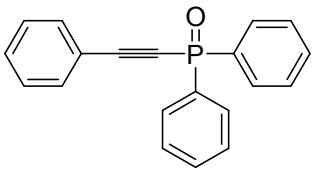
## *General procedure*




Under $N_2$ atmosphere, 0.2 mmol diphenylphosphine oxide, 0.2 mmol phenylacetylene, 5 mol% $Pd(OAc)_2$, 0.4 mmol $AgBF_4$ and 0.5 mL THF were charged into a 10 mL schlenck tube, and the mixture was stirred at 60 °C for 3 h. Then 1 mL $Et_3N$ was added. After removal of the volatiles, the residues were passed through a short silica chromatography (particle size 37–54 μm, pether/ethyl acetate as eluent) to afford analytically pure

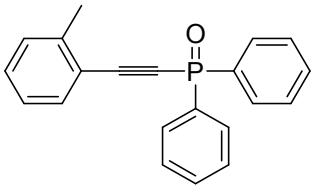
alkynylphosphorus compounds **2**.

## *Characterization data of 2*



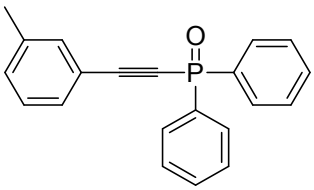
**2a**[1]

Following general procedure (60 °C, 3 h), **2a** was isolated as a yellow solid. $^{1}$H NMR (400 MHz, $CDCl_3$) δ 7.88–7.94 (m, 4H), 7.43–7.61 (m, 9H), 7.38 (t, 2H, $J$ = 7.2 Hz); $^{31}$P NMR (162 MHz, $CDCl_3$) δ 8.34; $^{13}$C NMR (100 MHz, $CDCl_3$) δ 133.06 (d, $J_{P\text{-}C}$ = 121.4 Hz), 132.56 (d, $J_{P\text{-}C}$ = 1.7 Hz), 132.28 (d, $J_{P\text{-}C}$ = 2.7 Hz), 131.00 (d, $J_{P\text{-}C}$ = 11.2 Hz), 130.74, 128.69 (d, $J_{P\text{-}C}$ = 13.4 Hz), 128.60, 119.96 (d, $J_{P\text{-}C}$ = 3.9 Hz), 105.47 (d, $J_{P\text{-}C}$ = 29.8 Hz), 82.88 (d, $J_{P\text{-}C}$ = 169.4 Hz). MS (EI): 302.



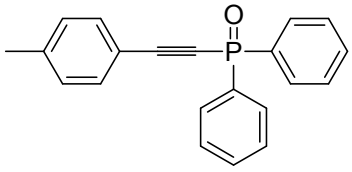
**2b**

Following general procedure (60 °C, 6 h), **2b** was isolated as a white solid. m.p.: 92–93 °C. $^{1}$H NMR (400 MHz, $CDCl_3$) δ 7.89–7.95 (m, 4H), 7.48–7.57 (m, 7H), 7.34 (t, 1H, $J$ = 7.2 Hz), 7.17–7.27 (m, 2H), 2.47 (s, 3H); $^{31}$P NMR (162 MHz, $CDCl_3$) δ 8.26; $^{13}$C NMR (100 MHz, $CDCl_3$) δ 141.89 (d, $J_{P\text{-}C}$ = 1.6 Hz), 133.26 (d, $J_{P\text{-}C}$ = 121.3 Hz), 133.03 (d, $J_{P\text{-}C}$ = 1.9 Hz), 132.22 (d, $J_{P\text{-}C}$ = 2.9 Hz), 130.97 (d, $J_{P\text{-}C}$ = 11.1 Hz), 130.72, 129.82, 128.66 (d, $J_{P\text{-}C}$ = 13.4 Hz), 125.84, 119.83 (d, $J_{P\text{-}C}$ = 3.9 Hz), 104.71 (d, $J_{P\text{-}C}$ = 30.0 Hz), 86.60 (d, $J_{P\text{-}C}$ = 169.5 Hz), 20.73. HRMS: Cal.316.1017, Found 316.1011.



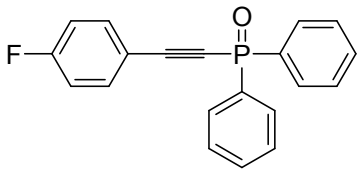
**2c**[2]

Following general procedure (60 °C, 6 h), **2c** was isolated as a white solid. $^{1}$H NMR (400 MHz, $CDCl_3$) δ 7.88–7.93 (m, 4H), 7.47–7.57 (m, 6H), 7.39–7.42 (m, 2H), 7.26–7.27 (m, 2H), 2.35 (s, 3H); $^{31}$P NMR (162 MHz, $CDCl_3$) δ 8.28; $^{13}$C NMR (100 MHz, $CDCl_3$) δ 138.44, 133.19 (d, $J_{P-C}$ = 121.4 Hz), 132.98 (d, $J_{P-C}$ = 1.9 Hz), 132.20 (d, $J_{P-C}$ = 2.9 Hz), 131.64, 130.99 (d, $J_{P-C}$ = 11.1 Hz), 129.69 (d, $J_{P-C}$ = 1.9 Hz), 128.65 (d, $J_{P-C}$ = 13.4 Hz), 128.49, 119.78 (d, $J_{P-C}$ = 4.0 Hz), 105.82 (d, $J_{P-C}$ = 30.0 Hz), 82.51 (d, $J_{P-C}$ = 169.5 Hz), 21.16. MS (EI): 316.



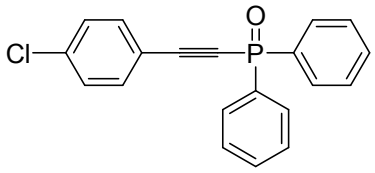
**2d**[2]

Following general procedure (60 °C, 6 h), **2d** was isolated as a white solid. $^{1}$H NMR (400 MHz, $CDCl_3$) δ 7.88–7.93 (m, 4H), 7.47–7.57 (m, 8H), 7.18 (d, 2H, $J$ = 8.0 Hz), 2.38 (s, 3H); $^{31}$P NMR (162 MHz, $CDCl_3$) δ 8.18; $^{13}$C NMR (100 MHz, $CDCl_3$) δ 141.40, 133.17 (d, $J_{P-C}$ = 121.4 Hz), 132.50 (d, $J_{P-C}$ = 1.9 Hz), 132.22 (d, $J_{P-C}$ = 2.9 Hz), 131.00 (d, $J_{P-C}$ = 11.1 Hz), 129.37, 128.66 (d, $J_{P-C}$ = 13.4 Hz), 116.84 (d, $J_{P-C}$ = 4.1 Hz), 106.04 (d, $J_{P-C}$ = 30.3 Hz), 82.21 (d, $J_{P-C}$ = 170.7 Hz), 21.78. MS (EI): 316.



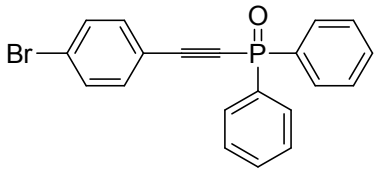
**2g**

Following general procedure (60 °C, 6 h), **2g** was isolated as a white solid. m.p.: 126–127 °C. $^{1}$H NMR (400 MHz, $CDCl_3$) δ 7.87–7.93 (m, 4H), 7.48–7.61 (m, 8H), 7.07 (t, 2H, $J$ = 8.4 Hz); $^{31}$P NMR (162 MHz, $CDCl_3$) δ 8.34; $^{13}$C NMR (100 MHz, $CDCl_3$) δ 163.88 (d, $J_{F-C}$ = 252.2 Hz), 134.82 (dd, $J_{P-C}$ = 1.9 Hz, $J_{F-C}$ = 8.9 Hz), 132.89 (d, $J_{P-C}$ = 121.4 Hz), 132.35 (d, $J_{P-C}$ = 2.9 Hz), 130.97 (d, $J_{P-C}$ = 11.1 Hz), 128.72 (d, $J_{P-C}$ = 13.5 Hz), 116.15 (d, $J_{F-C}$ = 22.3 Hz), 104.31 (d, $J_{P-C}$ = 29.8 Hz), 82.84 (d, $J_{P-C}$ = 168.9 Hz). HRMS: Cal. 320.0766, Found 320.0752.



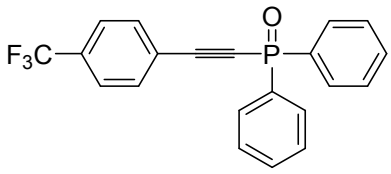
**2h**

Following general procedure (60 °C, 18 h), **2h** was isolated as a white solid. m.p.: 158–159 °C.$^{1}$H NMR (400 MHz, $CDCl_3$) δ 7.87–7.92 (m, 4H), 7.48–7.58 (m, 8H), 7.35 (d, 2H, $J$ = 8.4 Hz); $^{31}$P NMR (162 MHz, $CDCl_3$) δ 8.34; $^{13}$C NMR (100 MHz, $CDCl_3$) δ 137.12, 133.76 (d, $J_{P-C}$ = 1.8 Hz), 132.80 (d, $J_{P-C}$ = 121.6 Hz), 132.37 (d, $J_{P-C}$ = 2.9 Hz), 130.99 (d, $J_{P-C}$ = 11.2 Hz), 129.07, 128.73 (d, $J_{P-C}$ = 13.4 Hz), 118.43 (d, $J_{P-C}$ = 4.0 Hz), 104.05 (d, $J_{P-C}$ = 24.4 Hz), 83.98 (d, $J_{P-C}$ = 166.5 Hz). HRMS: Cal. 336.0471, Found 336.0454.



**2i**[3]

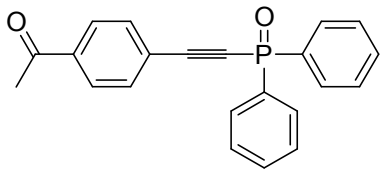
Following general procedure (60 °C, 24 h), **2i** was isolated as a white solid. $^{1}$H NMR (400 MHz, $CDCl_3$) δ 7.87–7.92 (m, 4H), 7.44–7.58 (m, 10H); $^{31}$P NMR (162 MHz, $CDCl_3$) δ 8.35; $^{13}$C NMR (100 MHz, $CDCl_3$) δ 133.86 (d, $J_{P-C}$ = 1.9 Hz), 132.73 (d, $J_{P-C}$ = 121.4 Hz), 132.42 (d, $J_{P-C}$ = 2.9 Hz), 132.00, 130.98 (d, $J_{P-C}$ = 11.2 Hz), 128.75 (d, $J_{P-C}$ = 13.4 Hz), 125.51, 118.84 (d, $J_{P-C}$ = 4.0 Hz), 104.09 (d, $J_{P-C}$ = 29.2 Hz), 84.13 (d, $J_{P-C}$ = 166.3 Hz). MS (EI): 380.



**2j**[3]

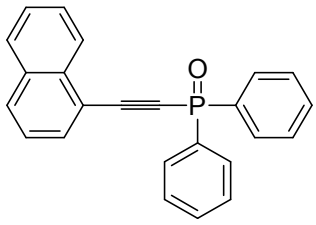
Following general procedure (60 °C, 6 h), **2j** was isolated as a white solid. $^{1}$H NMR (400 MHz, $CDCl_3$) δ 7.87–7.92 (m, 4H), 7.64–7.73 (m, 4H), 7.50–7.66 (m, 6H); $^{31}$P NMR (162 MHz, $CDCl_3$) δ 8.45; $^{13}$C NMR (100 MHz, $CDCl_3$) δ 132.87 (d, $J_{P-C}$ = 1.8 Hz), 132.53 (d, $J_{P-C}$ = 2.9 Hz), 132.49 (d, $J_{P-C}$ = 121.7 Hz), 132.30 (q, $J_{F-C}$ = 33.1 Hz), 131.00 (d, $J_{P-C}$ = 11.1 Hz), 128.79 (d, $J_{P-C}$ = 13.5 Hz), 125.57 (q, $J_{F-C}$ = 3.7 Hz), 123.73 (d, $J_{P-C}$ = 4.0 Hz), 123.49 (q, $J_{F-C}$ = 269.3 Hz), 103.14 (d, $J_{P-C}$ = 29.1 Hz), 85.27 (d, $J_{P-C}$

= 163.5 Hz). MS (EI): 370.



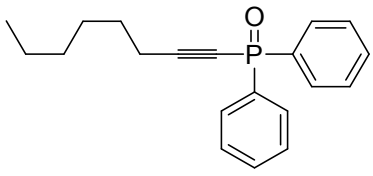
**2k**

Following general procedure (60 °C, 18 h), **2k** was isolated as a white solid. m.p.: 151–152 °C. $^{1}$H NMR (400 MHz, $CDCl_3$) δ 7.96 (d, 2H, $J$ = 8.4 Hz), 7.88–7.93 (m, 4H), 7.69 (d, 2H, $J$ = 8.4 Hz), 7.49–7.60 (m, 6H), 2.62 (s, 3H); $^{31}$P NMR (162 MHz, $CDCl_3$) δ 8.47; $^{13}$C NMR (100 MHz, $CDCl_3$) δ 196.98, 138.12, 132.75 (d, $J_{P-C}$ = 1.8 Hz), 132.62 (d, $J_{P-C}$ = 121.6 Hz), 132.46 (d, $J_{P-C}$ = 2.9 Hz), 131.00 (d, $J_{P-C}$ = 11.2 Hz), 128.76 (d, $J_{P-C}$ = 13.5 Hz), 128.31, 124.47 (d, $J_{P-C}$ = 3.9 Hz), 103.80 (d, $J_{P-C}$ = 28.7 Hz), 85.82 (d, $J_{P-C}$ = 163.9 Hz), 26.70. HRMS: Cal.344.0966, Found 344.0950.



**2l**[2]

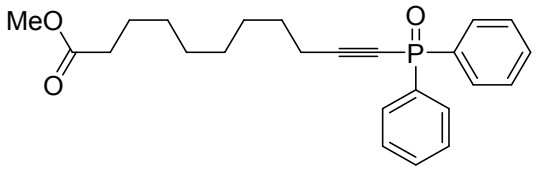
Following general procedure (60 °C, 24 h), **2l** was isolated as an oil. $^{1}$H NMR (400 MHz, $CDCl_3$) δ 8.24 (d, 1H, $J$ = 8.0 Hz), 7.92–8.01 (m, 5H), 7.85 (d, 2H, $J$ = 6.4 Hz), 7.51–7.59 (m, 8H), 7.45 (t, 1H, $J$ = 8.0 Hz); $^{31}$P NMR (162 MHz, $CDCl_3$) δ 8.50; $^{13}$C NMR (100 MHz, $CDCl_3$) δ 133.36 (d, $J_{P-C}$ = 1.3 Hz), 133.13 (d, $J_{P-C}$ = 121.4 Hz ), 132.98, 132.63 (d, $J_{P-C}$ = 2.1 Hz), 132.37 (d, $J_{P-C}$ = 2.9 Hz), 131.43, 131.05 (d, $J_{P-C}$ = 11.2 Hz), 128.78 (d, $J_{P-C}$ = 13.5 Hz), 128.61, 127.78, 126.98, 125.67, 125.09, 117.43 (d, $J_{P-C}$ = 4.0 Hz), 104.09 (d, $J_{P-C}$ = 29.8 Hz), 87.59 (d, $J_{P-C}$ = 168.0 Hz). MS (EI): 352.



**2n**

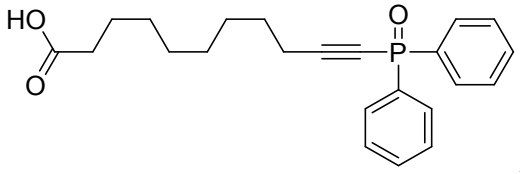
Following general procedure (60 °C, 6 h), **2n** was isolated as a oil. $^{1}$H NMR (400 MHz,

$CDCl_3$) δ 7.81–7.87 (m, 4H), 7.43–7.52 (m, 6H), 2.41–2.46 (m, 2H), 1.58–1.65 (m, 2H), 1.38–1.45 (m, 2H), 1.27–1.29 (m, 4H), 0.87 (t, 3H, $J$ = 6.4 Hz); $^{31}$P NMR (162 MHz, $CDCl_3$) δ 7.56; $^{13}$C NMR (100 MHz, $CDCl_3$) δ 133.38 (d, $J_{P-C}$ = 121.1 Hz), 132.03 (d, $J_{P-C}$ = 2.9 Hz), 130.81 (d, $J_{P-C}$ = 11.2 Hz), 128.51 (d, $J_{P-C}$ = 13.3 Hz), 109.85 (d, $J_{P-C}$ = 30.3 Hz), 74.84 (d, $J_{P-C}$ = 174.2 Hz), 31.11, 28.47, 27.47 (d, $J_{P-C}$ = 1.6 Hz), 22.43, 19.74 (d, $J_{P-C}$ = 3.1 Hz), 13.99. HRMS: Cal. 310.1487, Found 310.1475.




**2o**

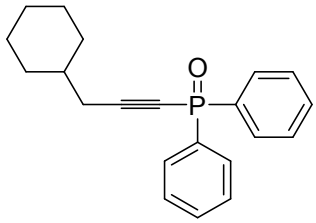
Following general procedure (60 °C, 18 h), **2o** was isolated as a white solid. m.p.: 143–145 °C. $^1$H NMR (400 MHz, $CDCl_3$) δ 7.80–7.85 (m, 4H), 7.44–7.55 (m, 6H), 3.66 (s, 3H), 2.45 (dt, 2H, $J$ = 6.8 Hz, $J_{P-H}$ = 3.6 Hz), 2.29 (t, 2H, $J$ = 7.6 Hz), 1.57–1.66 (m, 4H), 1.38–1.43 (m, 2H), 1.26–1.31 (m, 6H); $^{31}$P NMR (162 MHz, $CDCl_3$) δ 7.54; $^{13}$C NMR (100 MHz, $CDCl_3$) δ 174.27, 133.47 (d, $J_{P-C}$ = 121.1 Hz), 132.03 (d, $J_{P-C}$ = 2.9 Hz), 130.88 (d, $J_{P-C}$ = 11.1 Hz), 128.53 (d, $J_{P-C}$ = 13.4 Hz), 109.72 (d, $J_{P-C}$ = 30.3 Hz), 74.97 (d, $J_{P-C}$ = 173.8 Hz), 51.47, 34.05, 29.71, 29.04 (d, $J_{P-C}$ = 2.1 Hz), 28.79 (d, $J_{P-C}$ = 0.5 Hz), 27.54 (d, $J_{P-C}$ = 1.6 Hz), 24.88, 19.78 (d, $J_{P-C}$ = 3.1 Hz). HRMS: Cal. 396.1854, Found 396.1864.




**2p**

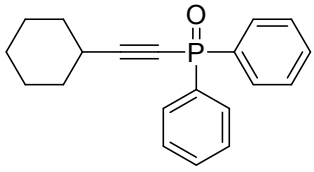
Following general procedure (60 °C, 24 h), **2p** was isolated as a white solid. m.p.: 242–244 °C. $^1$H NMR (400 MHz, $CDCl_3$) δ 7.81–7.86 (m, 4H), 7.47–7.54 (m, 6H), 2.47 (b, 2H), 2.34 (t, 2H, $J$ = 6.8 Hz), 1.63 (b, 3H), 1.26–1.45 (m, 10H); $^{31}$P NMR (162 MHz, $CDCl_3$) δ 8.50; $^{13}$C NMR (100 MHz, $CDCl_3$) δ 177.27, 132.85 (d, $J_{P-C}$ = 123.3 Hz), 132.22 (d, $J_{P-C}$ = 2.9 Hz), 130.95 (d, $J_{P-C}$ = 11.3 Hz), 128.61 (d, $J_{P-C}$ = 13.4 Hz), 110.24 (d, $J_{P-C}$ = 30.9 Hz), 74.63 (d, $J_{P-C}$ = 175.6 Hz), 34.18, 28.29, 28.04, 28.00, 27.92, 27.20 (d, $J_{P-C}$ = 1.3 Hz), 24.51, 19.82 (d, $J_{P-C}$ = 3.0 Hz). HRMS: Cal.382.1698, Found

382.1687.



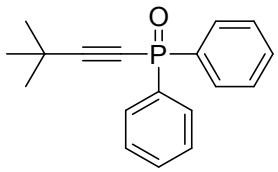
**2q**

Following general procedure (60 $^{o}$C, 24 h), **2q** was isolated as a white solid. m.p.: 81–82 $^{o}$C. $^{1}$H NMR (400 MHz, $CDCl_3$) δ 7.73–7.79 (m, 4H), 7.39–7.47 (m, 6H), 2.28 (b, 2H), 1.75(d, 2H, $J$ = 4.4 Hz), 1.56–1.66 (m, 3H), 0.95–1.22 (m, 6H); $^{31}$P NMR (162 MHz, $CDCl_3$) δ 7.58; $^{13}$C NMR (100 MHz, $CDCl_3$) δ 133.52 (d, $J_{P-C}$ = 121.0 Hz), 132.02 (d, $J_{P-C}$ = 2.8 Hz), 130.87 (d, $J_{P-C}$ = 11.1 Hz), 128.54 (d, $J_{P-C}$ = 23.4 Hz), 108.92 (d, $J_{P-C}$ = 30.5 Hz), 75.73 (d, $J_{P-C}$ = 174.3 Hz), 36.77, 32.73, 27.52 (d, $J_{P-C}$ = 3.0 Hz), 26.02, 25.96. HRMS: Cal. 322.1487, Found 322.1471.



**2r**

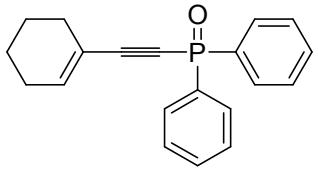
Following general procedure (100 $^{o}$C, 18 h), **2r** was isolated as an oil. $^{1}$H NMR (400 MHz, $CDCl_3$) δ 7.73–7.78 (m, 4H), 7.36–7.46 (m, 6H), 2.54–2.59 (m, 1H), 1.78-1.82 (m, 2H), 1.61–1.66 (m, 2H), 1.45–1.55 (m, 3H), 1.24–1.28 (m, 3H); $^{31}$P NMR (162 MHz, $CDCl_3$) δ 7.67; $^{13}$C NMR (100 MHz, $CDCl_3$) δ 133.56 (d, $J_{P-C}$ = 121.0 Hz), 131.99 (d, $J_{P-C}$ = 2.9 Hz), 130.84 (d, $J_{P-C}$ = 11.1 Hz), 128.53 (d, $J_{P-C}$ = 13.3 Hz), 113.23 (d, $J_{P-C}$ = 29.6 Hz), 74.55 (d, $J_{P-C}$ = 174.2 Hz), 31.45 (d, $J_{P-C}$ = 1.3 Hz), 29.82 (d, $J_{P-C}$ = 3.0 Hz), 25.56, 24.59. HRMS: Cal. 308.1330, Found 308.1314.



**2s**

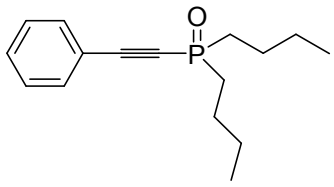
Following general procedure (100 $^{o}$C, 18 h), **2s** was isolated as a white solid. m.p.: 130–

131 °C.$^{1}$H NMR (400 MHz, $CDCl_3$) δ 7.79–7.85 (m, 4H), 7.44–7.54 (m, 6H), 1.34 (s, 9H); $^{31}$P NMR (162 MHz, $CDCl_3$) δ 7.64; $^{13}$C NMR (100 MHz, $CDCl_3$) δ 133.60 (d, $J_{P-C}$ = 121.0 Hz), 131.97 (d, $J_{P-C}$ = 2.9 Hz), 130.83 (d, $J_{P-C}$ = 11.1 Hz), 128.53 (d, $J_{P-C}$ = 13.3 Hz), 116.79 (d, $J_{P-C}$ = 28.7 Hz), 73.08 (d, $J_{P-C}$ = 173.8 Hz), 29.98 (d, $J_{P-C}$ = 1.5 Hz), 28.51 (d, $J_{P-C}$ = 2.8 Hz). HRMS: Cal. 282.1174, Found 282.1157.



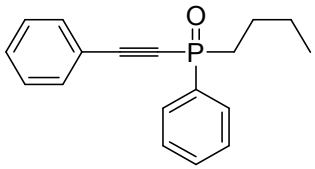
**2t**

Following general procedure (60 °C, 24 h), **2t** was isolated as a white solid. m.p.: 110–111 °C. $^{1}$H NMR (400 MHz, $CDCl_3$) δ 7.85 (b, 4H), 7.46–7.54 (m, 6H), 6.48 (b, 1H), 2.16–2.20 (m, 4H), 1.59–1.67 (m, 4H); $^{31}$P NMR (162 MHz, $CDCl_3$) δ 8.13; $^{13}$C NMR (100 MHz, $CDCl_3$) δ 140.70 (d, $J_{P-C}$ = 12.6 Hz), 132.49 (d, $J_{P-C}$ = 121.2 Hz ), 130.94 (d, $J_{P-C}$ = 2.9 Hz ), 129.90 (d, $J_{P-C}$ = 11.1 Hz), 127.53 (d, $J_{P-C}$ = 14.3 Hz), 117.88 (d, $J_{P-C}$ = 4.2 Hz ), 106.81 (d, $J_{P-C}$ = 30.2 Hz ), 79.08 (d, $J_{P-C}$ = 173.2 Hz ), 26.98 (d, $J_{P-C}$ = 1.0 Hz), 24.88, 20.82, 20.05. HRMS: Cal. 306.1174, Found 306.1166.



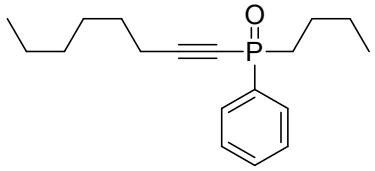
**2u**

Following general procedure (60 °C, 24 h), **2u** was isolated as an oil. $^{1}$H NMR (400 MHz, $CDCl_3$) δ 7.54 (d, 2H, $J$ = 7.6 Hz), 7.35–7.46 (m, 3H), 1.89–2.01 (m, 4H), 1.69–1.77 (m, 4H), 1.45–1.54 (m, 4H), 0.97 (t, 6H, $J$ = 7.2 Hz); $^{31}$P NMR (162 MHz, $CDCl_3$) δ 26.13; $^{13}$C NMR (100 MHz, $CDCl_3$) δ 132.38 (d, $J_{P-C}$ = 1.7 Hz), 130.34, 128.54, 120.24 (d, $J_{P-C}$ = 3.6 Hz ), 102.42 (d, $J_{P-C}$ = 25.1 Hz), 82.94 (d, $J_{P-C}$ = 143.7 Hz), 31.12 (d, $J_{P-C}$ = 79.6 Hz), 24.03 (d, $J_{P-C}$ = 4.1 Hz), 23.95 (d, $J_{P-C}$ = 15.8 Hz), 13.66. HRMS: Cal. 262.1487, Found 262.1472.



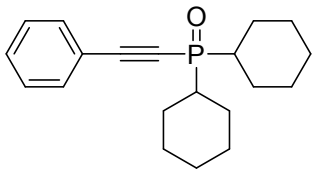
**2v**

Following general procedure (60 °C, 24 h), **2v** was isolated as an oil. $^{1}$H NMR (400 MHz, $CDCl_3$) δ 7.81–7.86 (m, 2H), 7.29–7.51 (m, 8H), 2.02–2.11 (m, 2H), 1.55–1.65 (m, 2H), 1.33–1.42 (m, 2H), 0.84 (t, 3H, $J$ = 8.0 Hz); $^{31}$P NMR (162 MHz, $CDCl_3$) δ 17.01; $^{13}$C NMR (100 MHz, $CDCl_3$) δ 132.49 (d, $J_{P\text{-}C}$ = 1.7 Hz), 132.27 (d, $J_{P\text{-}C}$ = 114.5 Hz ), 132.19 (d, $J_{P\text{-}C}$ = 2.8 Hz ), 130.53 (d, $J_{P\text{-}C}$ = 5.5 Hz), 130.40, 128.70 (d, $J_{P\text{-}C}$ = 12.8 Hz), 128.58, 120.07 (d, $J_{P\text{-}C}$ = 3.8 Hz ), 103.75 (d, $J_{P\text{-}C}$ = 27.5 Hz ), 82.86 (d, $J_{P\text{-}C}$ = 156.0 Hz ), 33.67 (d, $J_{P\text{-}C}$ = 83.7 Hz), 23.90 (d, $J_{P\text{-}C}$ = 2.1 Hz), 23.84 (d, $J_{P\text{-}C}$ = 24.9 Hz), 13.62. HRMS: Cal. 282.1174, Found 282.1157.



**2w**

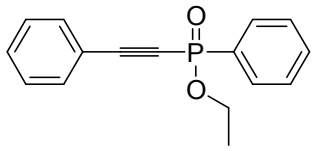
Following general procedure (60 °C, 24 h), **2w** was isolated as an oil. $^{1}$H NMR (400 MHz, $CDCl_3$) δ 7.81–7.86 (m, 2H), 7.49–7.57 (m, 3H), 2.40 (t, 2H, $J$ = 7.2 Hz), 1.97–2.05 (m, 2H), 1.57–1.62 (m, 4H), 1.38-1.43 (m, 4H), 1.30 (b, 4H), 0.89 (t, 6H, $J$ = 6.8 Hz); $^{31}$P NMR (162 MHz, $CDCl_3$) δ 16.38; $^{13}$C NMR (100 MHz, $CDCl_3$) δ 132.59 (d, $J_{P\text{-}C}$ = 114.3 Hz), 131.88 (d, $J_{P\text{-}C}$ = 2.8 Hz ), 130.30 (d, $J_{P\text{-}C}$ = 10.5 Hz ), 128.47 (d, $J_{P\text{-}C}$ = 12.7 Hz), 107.83 (d, $J_{P\text{-}C}$ = 28.1 Hz), 74.69 (d, $J_{P\text{-}C}$ = 161.9 Hz ), 33.67 (d, $J_{P\text{-}C}$ = 84.0 Hz ), 31.10, 28.43, 27.48, 23.85 (d, $J_{P\text{-}C}$ = 9.5 Hz ), 23.73 (d, $J_{P\text{-}C}$ = 22.4 Hz), 22.41, 19.54 (d, $J_{P\text{-}C}$ = 2.9 Hz), 13.94, 13.53. HRMS: Cal. 290.1800, Found 290.1782.



**2x**[4]

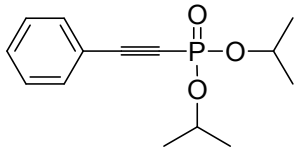
Following general procedure (60 °C, 12 h), **2x** was isolated as a white solid. $^{1}$H NMR (400 MHz, $CDCl_3$) δ 7.54–7.56 (m, 2H), 7.35–7.46 (m, 3H), 2.05–2.08 (m, 2H), 1.86–

1.99 (m, 8H), 1.68–1.76 (m, 2H), 1.49–1.61 (m, 4H), 1.21–1.41 (m, 6H); $^{31}$P NMR (162 MHz, $CDCl_3$) δ 35.75; $^{13}$C NMR (100 MHz, $CDCl_3$) δ 132.44 (d, $J_{P-C}$ = 1.6 Hz), 130.29, 128.52, 120.31 (d, $J_{P-C}$ = 3.5 Hz ), 103.41 (d, $J_{P-C}$ = 21.8 Hz ), 81.02 (d, $J_{P-C}$ = 137.0 Hz), 36.69 (d, $J_{P-C}$ = 78.3 Hz), 26.29 (d, $J_{P-C}$ = 9.5 Hz ), 26.15 (d, $J_{P-C}$ = 9.2 Hz ), 25.82 (d, $J_{P-C}$ = 1.3 Hz ), 25.74 (d, $J_{P-C}$ = 3.2 Hz ), 24.66 (d, $J_{P-C}$ = 3.3 Hz ). MS (EI): 314.



**2y**[1]

Under $N_2$ atmosphere, 0.2 mmol Ph(EtO)P(O)H **1e**, 0.2 mmol phenylacetylene, 5 mol% $Pd(OAc)_2$, 0.4 mmol $AgBF_4$, 0.4 mmol triethylamine and 1 mL THF were charged into a 10 mL schlenk tube, the mixture was stirred at 100 °C for 16 hours. **2y** was isolated as an oil. $^1$H NMR (400 MHz, $CDCl_3$) δ 7.93–7.80 (m, 2H), 7.51–7.56 (m, 5H), 7.42–7.46 (m, 1H), 7.34–7.38 (m, 2H), 4.26–4.35 (m, 2H), 1.44 (t, 3H, $J$ = 11.2 Hz); $^{31}$P NMR (162 MHz, $CDCl_3$) δ 9.74; $^{13}$C NMR (100 MHz, $CDCl_3$) δ 132.84 (d, $J_{P-C}$ = 2.9 Hz), 132.59 (d, $J_{P-C}$ = 1.6 Hz), 131.14 (d $J_{P-C}$ = 11.2 Hz), 131.07 (d, $J_{P-C}$ = 164.6 Hz), 130.68, 128.60 (d, $J_{P-C}$ = 14.8 Hz), 128.56, 119.74 (d, $J_{P-C}$ = 4.3 Hz), 101.59 (d, $J_{P-C}$ = 39.3 Hz), 81.66 (d, $J_{P-C}$ = 214.7 Hz), 62.34 (d, $J_{P-C}$ = 6.3 Hz), 16.40 (d, $J_{P-C}$ = 7.1 Hz). MS (EI): 270.



**2z**[1]

Under $N_2$ atmosphere, 0.2 mmol diisopropylphoshite **1f**, 0.4 mmol phenylacetylene, 5 mol% $Pd(OAc)_2$, 0.4 mmol $AgBF_4$, 0.4 mmol $Et_3N$ and 1 mL THF were charged into a 10 mL schlenk tube, the mixture was stirred at 100 °C for 16 hours. **2z** was isolated as an oil. $^1$H NMR (400 MHz, $CDCl_3$) δ 7.56 (d, 2H, $J$ = 6.8 Hz), 7.45 (t, 1H, $J$ = 6.8 Hz), 7.38 (t, 2H, $J$ = 7.2 Hz), 4.80–4.84 (m, 2H), 1.42 (d, 12H, $J$ = 4.2 Hz); $^{31}$P NMR (162 MHz, $CDCl_3$) δ -8.52; $^{13}$C NMR (100 MHz, $CDCl_3$) δ 132.46 (d, $J_{P-C}$ = 1.3 Hz), 130.50, 128.51, 119.74 (d, $J_{P-C}$ = 5.5 Hz), 98.11 (d, $J_{P-C}$ = 52.6 Hz), 79.74 (d, $J_{P-C}$ = 297.1 Hz), 72.33 (d, $J_{P-C}$ = 5.4 Hz), 23.89 (d, $J_{P-C}$ = 4.5 Hz), 23.61 (d, $J_{P-C}$ = 4.7 Hz). MS (EI): 266.

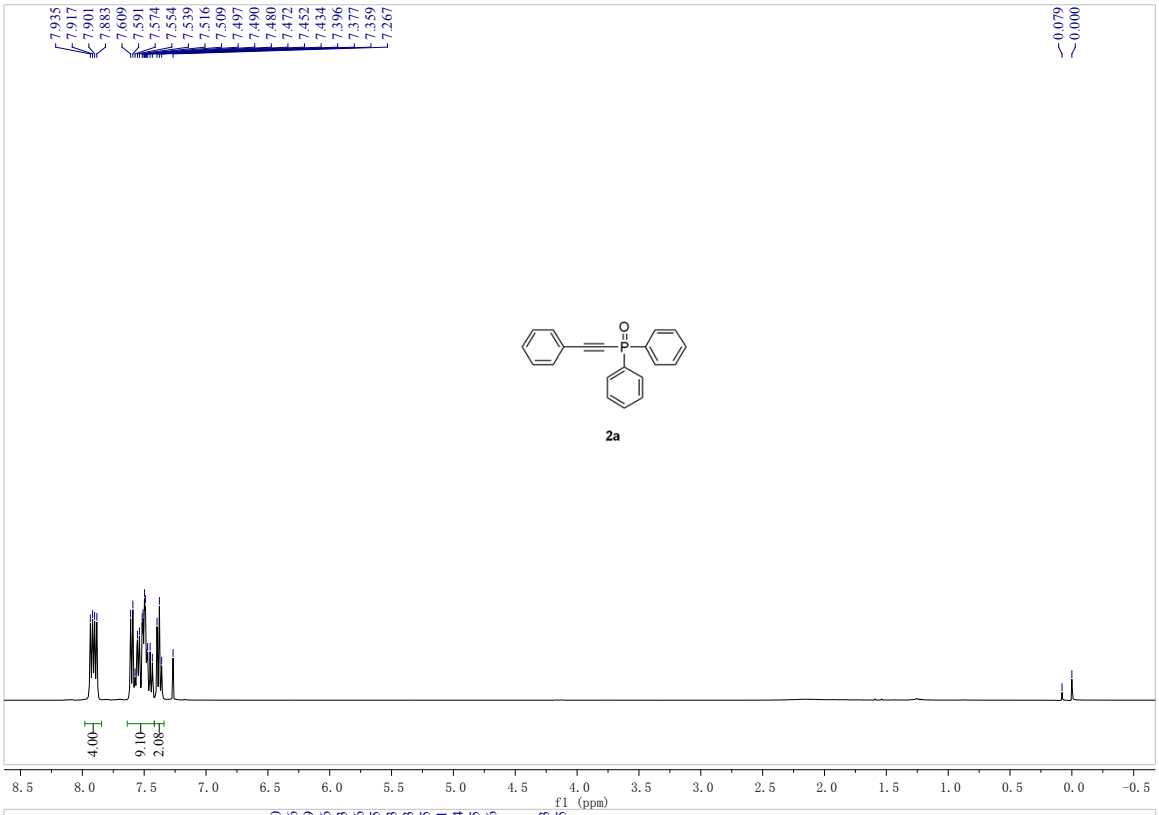
(1) Y. Wang, J. Gan, L. Liu, H. Yuan, Y. Gao, Y. Liu and Y. Zhao, *J. Org. Chem.,* 2014, **79**, 3678.

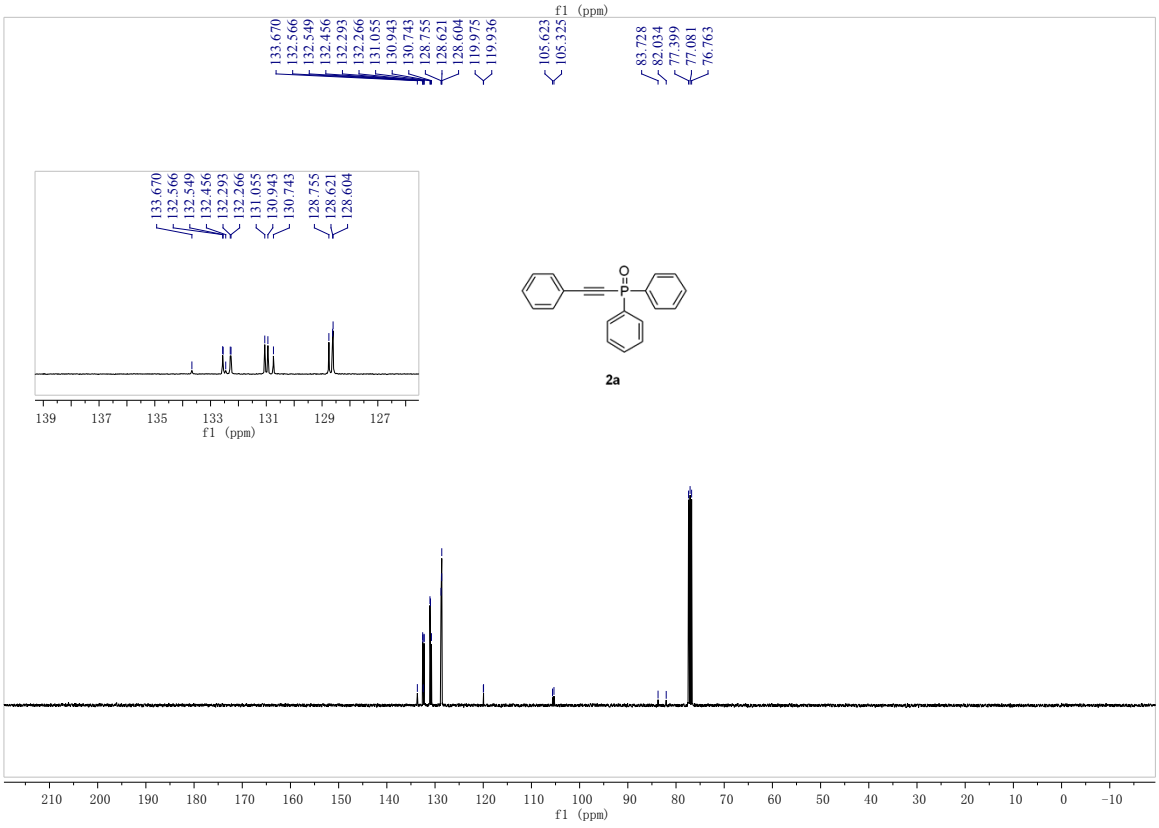
(2) J. Hu, N. Zhao, B. Yang, G. Wang, L.-N. Guo, Y.-M. Liang and S.-D. Yang, *Chem. Eur. J.,* 2011, **17**, 5516.

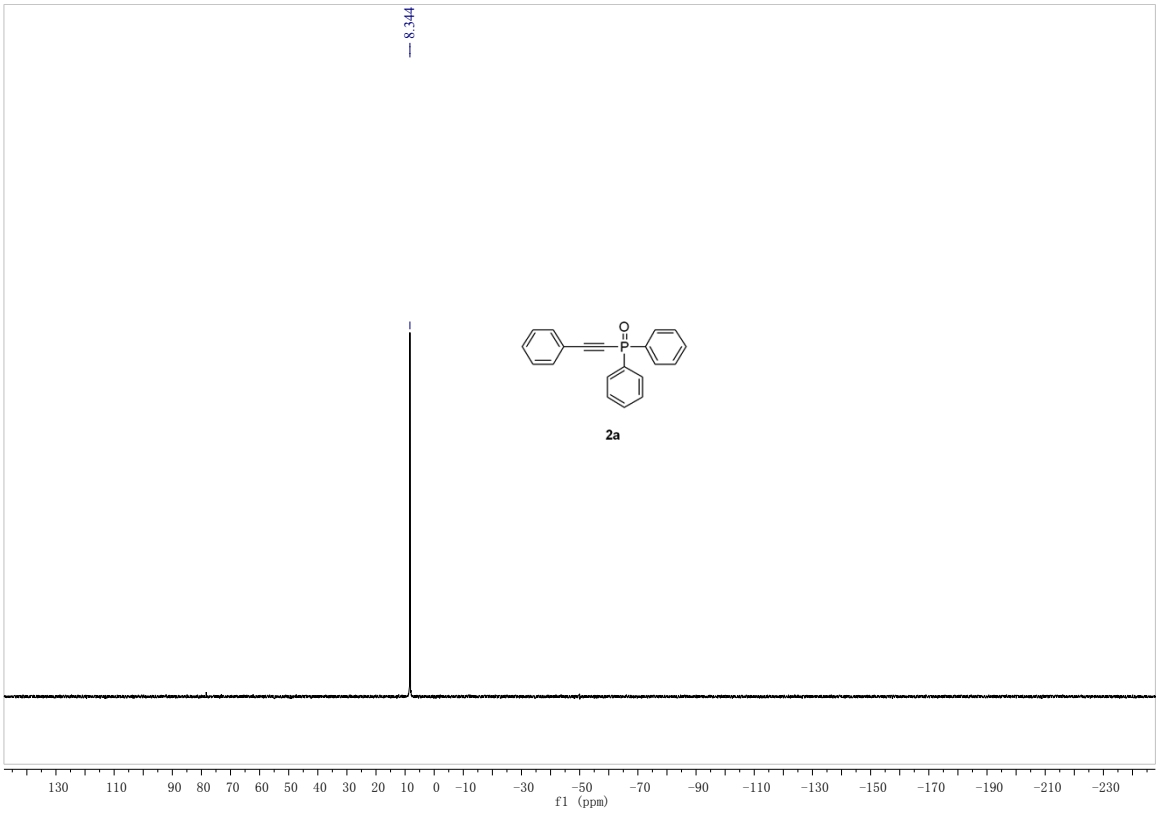
(3) X. Yang, D. Matsuo, Y. Suzuma, J.-K. Fang, F. Xu, A. Orita, J. Otera, S. Kajiyama, N. Koumura and K. Hara, *Synlett*., 2011, **16**, 2402.

(4) S. Doherty, J. G. Knight, C. H. Smyth and G. A. Jorgenson, *Adv. Synth. Catal.*, 2008, **350**, 1808.

## *Copies of $^{1}H$ NMR, $^{31}P$ NMR and $^{13}C$ NMR spectra*

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2a
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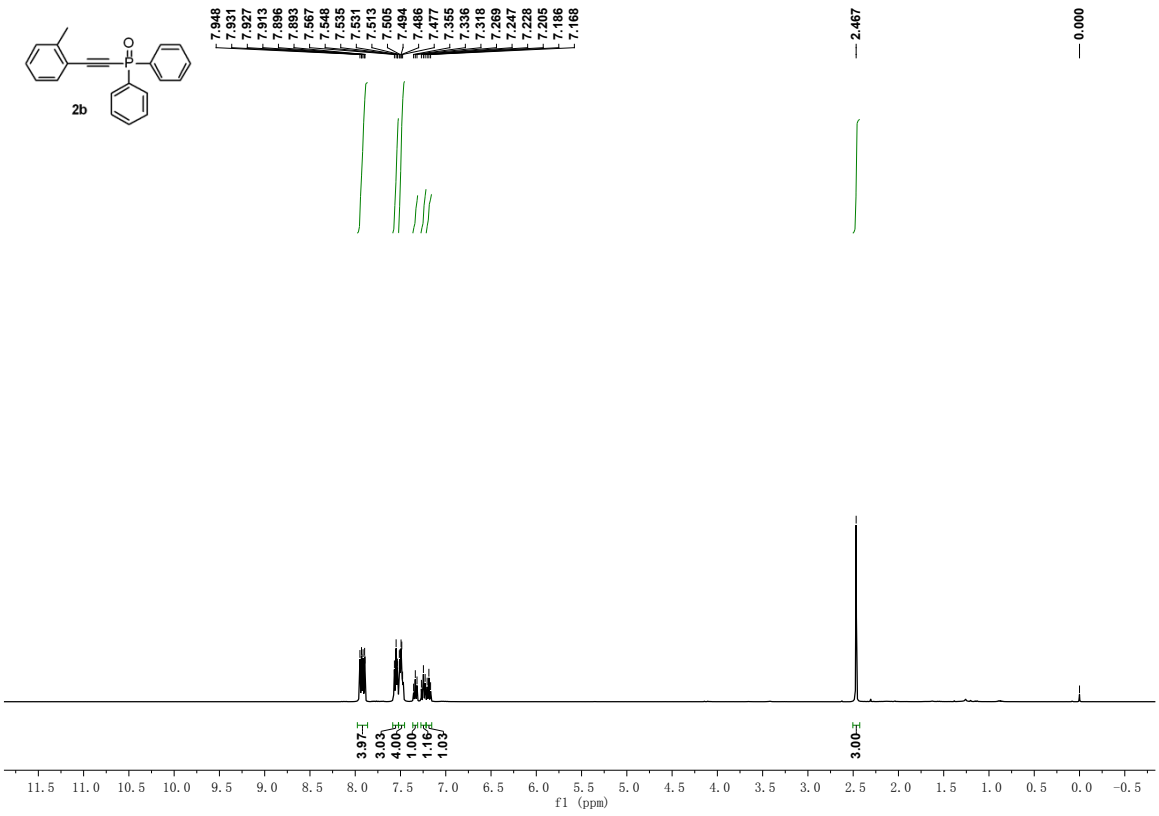
f1 (ppm)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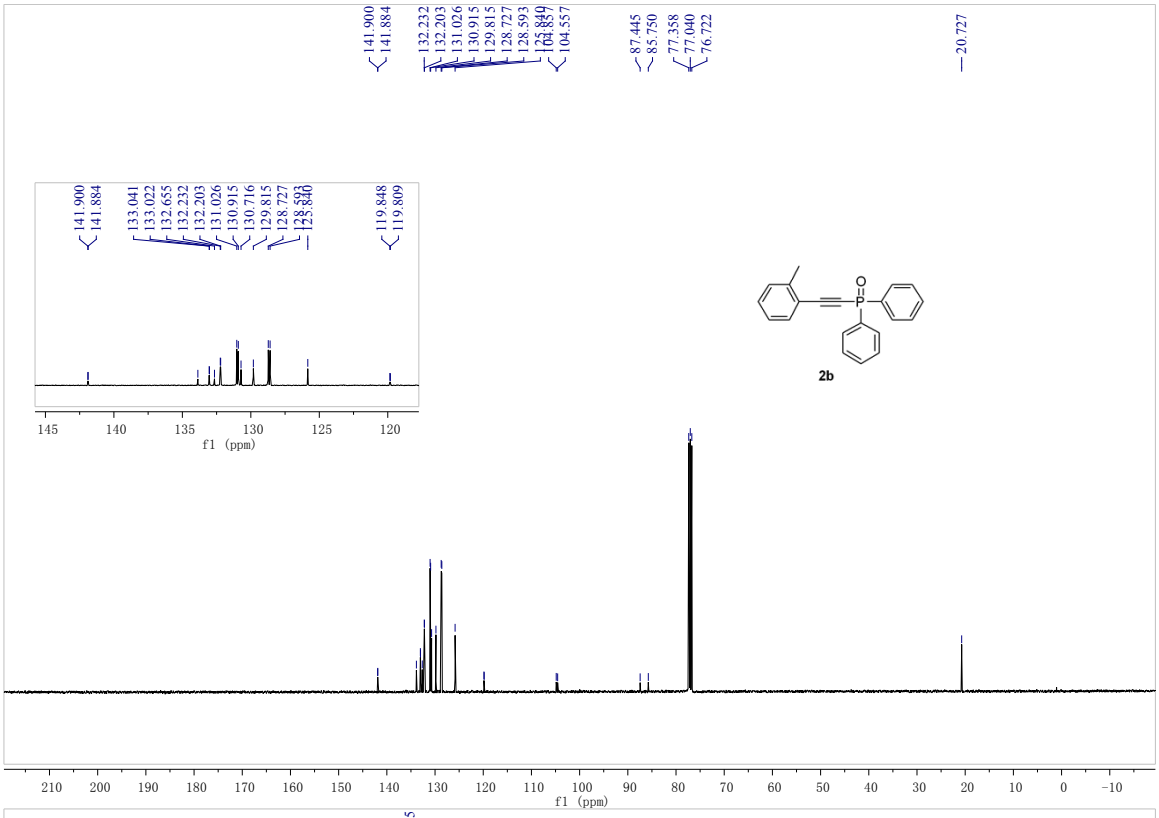
7.931
7.927
7.913
7.896
7.893
7.567
7.548
7.535
7.531
7.513
7.505
7.494
7.486
7.477
7.355
7.336
7.318
7.269
7.247
7.228
7.205
7.186
7.168
2.467
0.000
3.97
3.03
4.00
1.00
1.16
1.03
3.00
11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 −0.5
f1 (ppm)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141.884
132.232
132.203
131.026
130.915
129.815
128.727
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104.557
87.445
85.750
77.358
77.040
76.722
20.727
133.041
133.022
132.655
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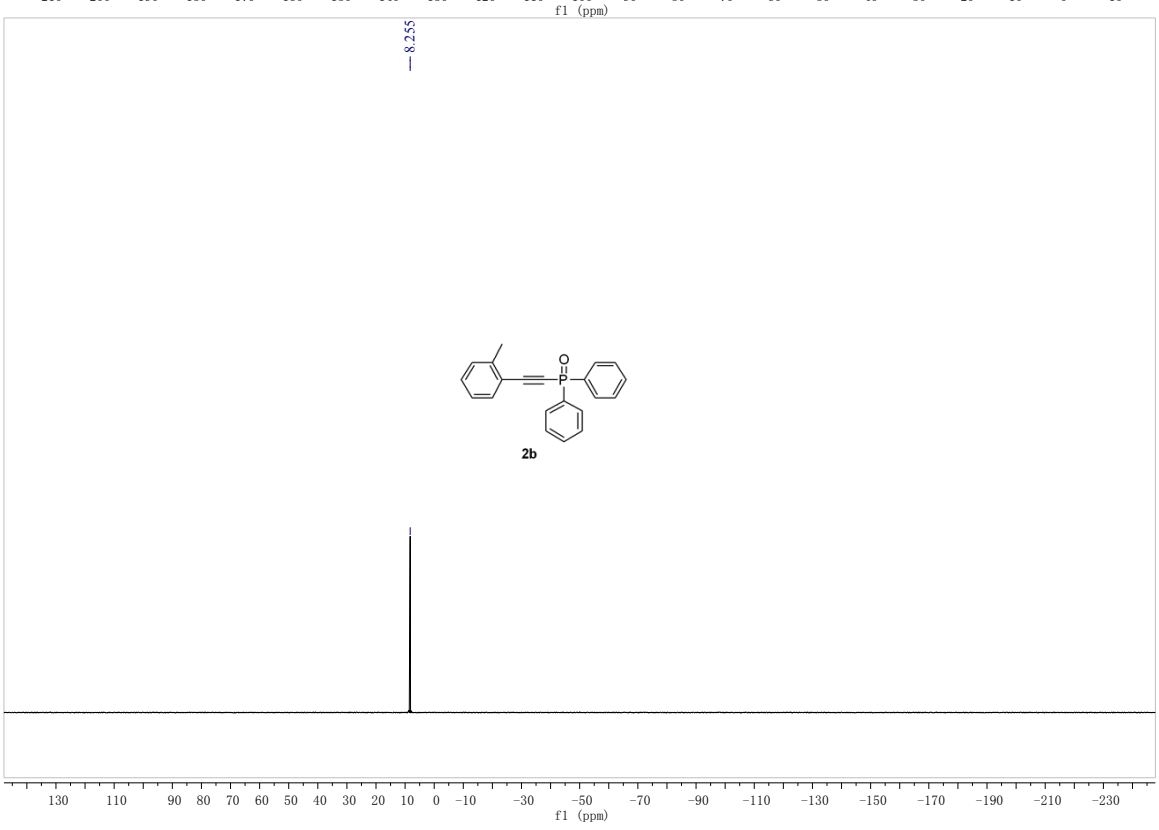
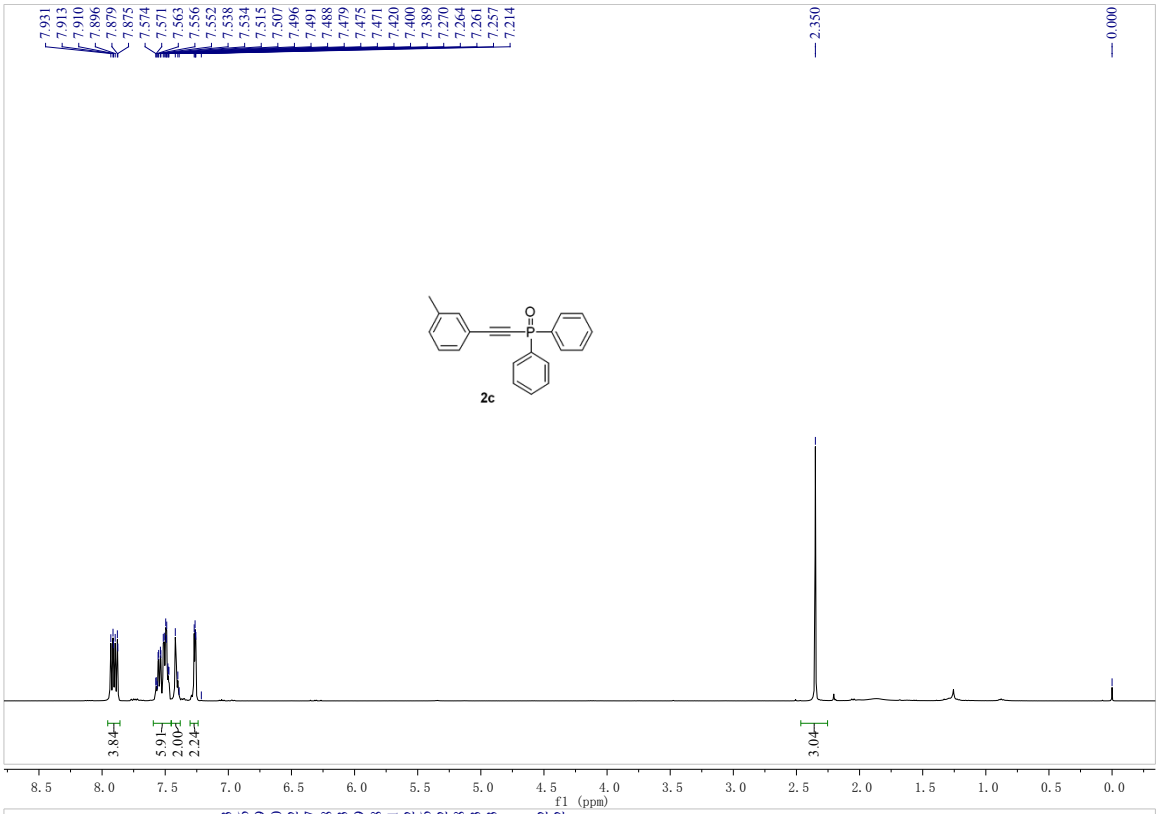
131.026
130.915
130.716
129.815
128.727
119.848
119.809
2b
f1 (ppm)


8.255
2b
f1 (ppm)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7.879
7.875
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7.571
7.563
7.556
7.552
7.538
7.534
7.515
7.507
7.496
7.491
7.488
7.479
7.475
7.471
7.420
7.400
7.389
7.270
7.264
7.261
7.257
7.214
2.350
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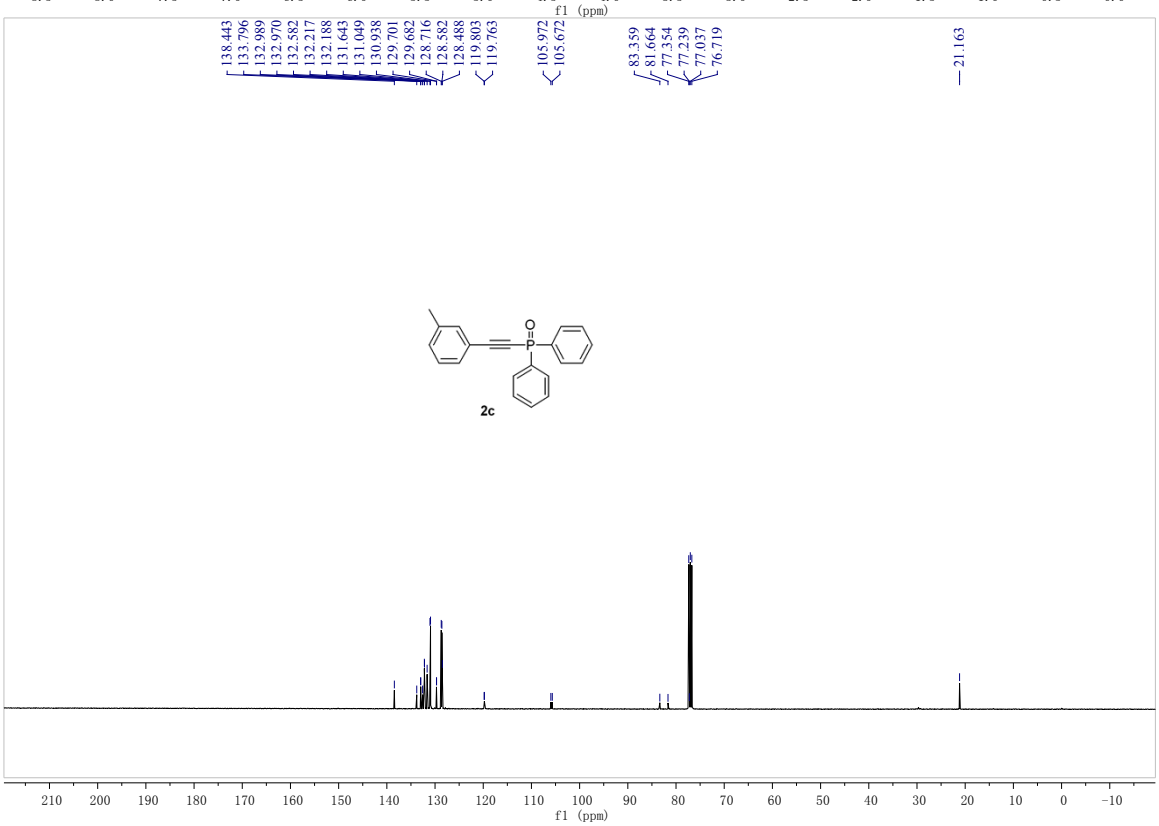
2c
3.84
5.91
2.00
2.24
3.04
f1 (ppm)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128.582
128.488
119.803
119.763
105.972
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77.354
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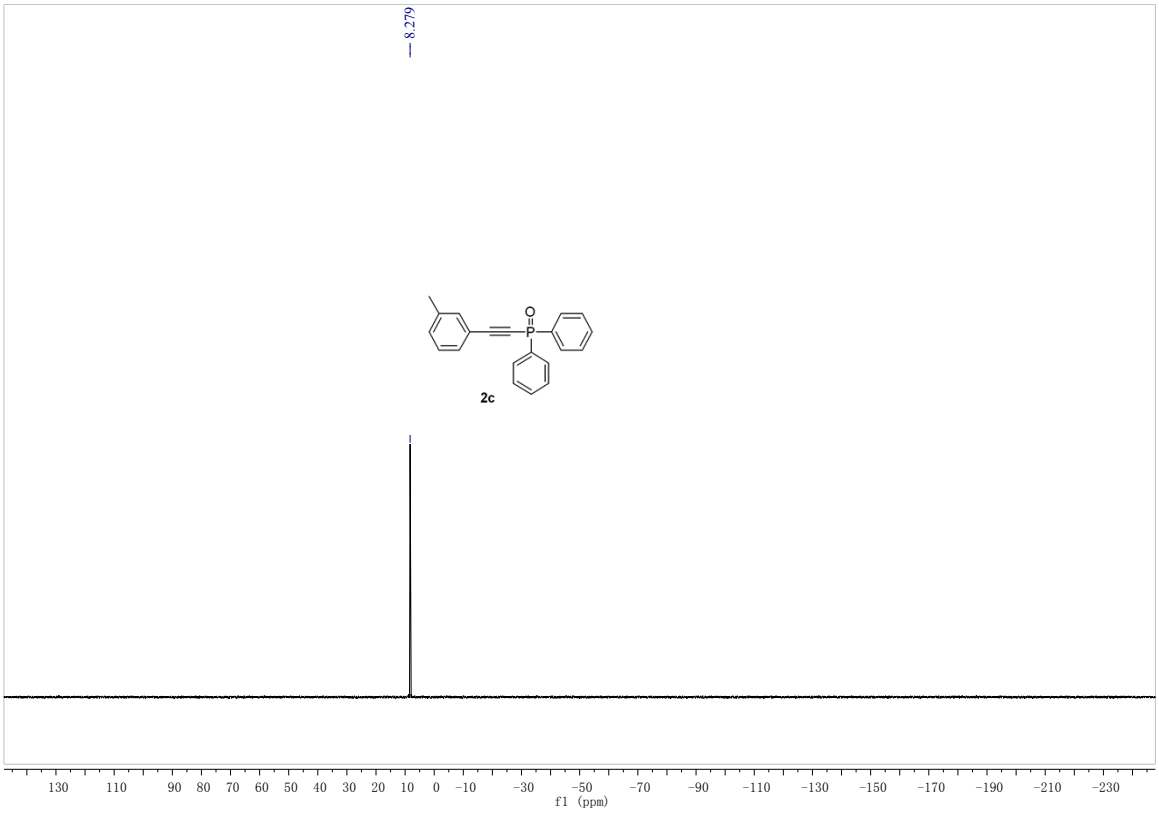
77.037
76.719
21.163
2c
f1 (ppm)


8.279
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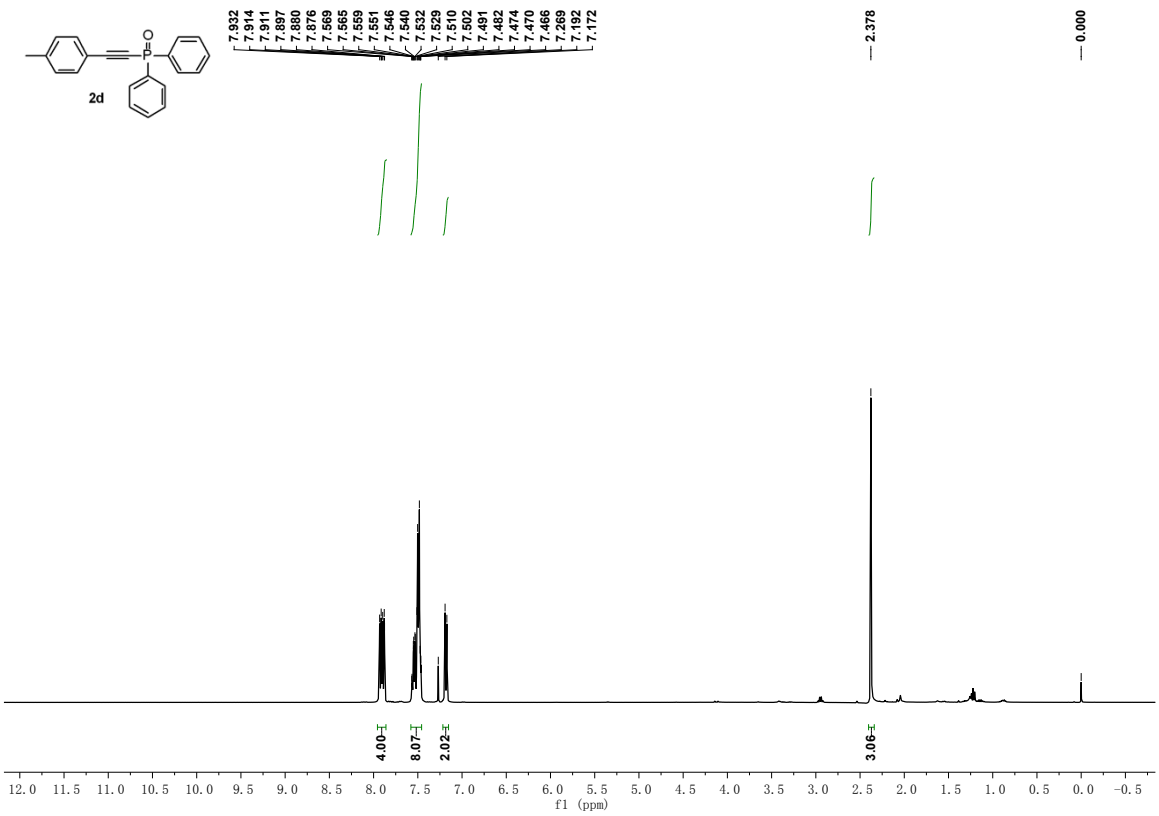
f1 (ppm)


2d
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7.569
7.565
7.559
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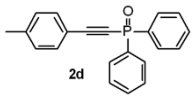
7.532
7.529
7.510
7.502
7.491
7.482
7.474
7.470
7.466
7.269
7.192
7.172
2.378
0.000
4.00
8.07
2.02
3.06
12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)


2d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132.495
131.052
130.941
129.373
128.730
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106.192
105.889
83.064
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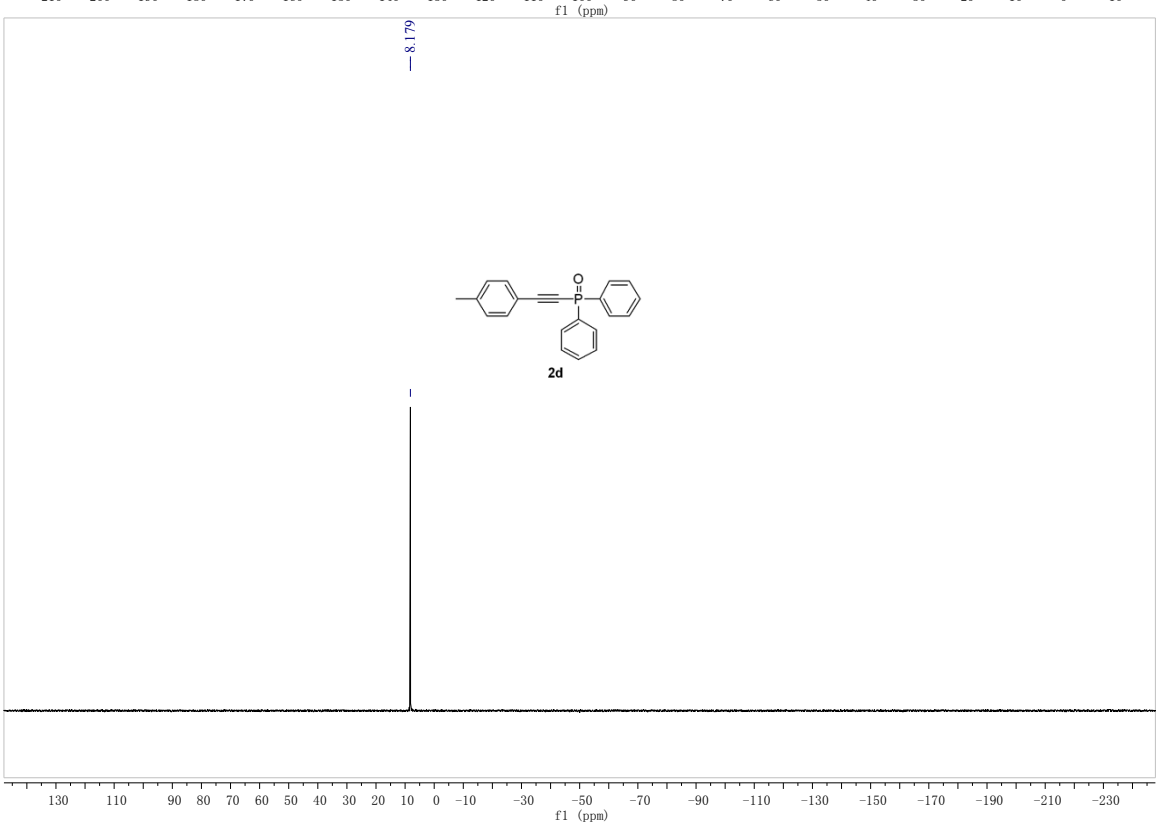
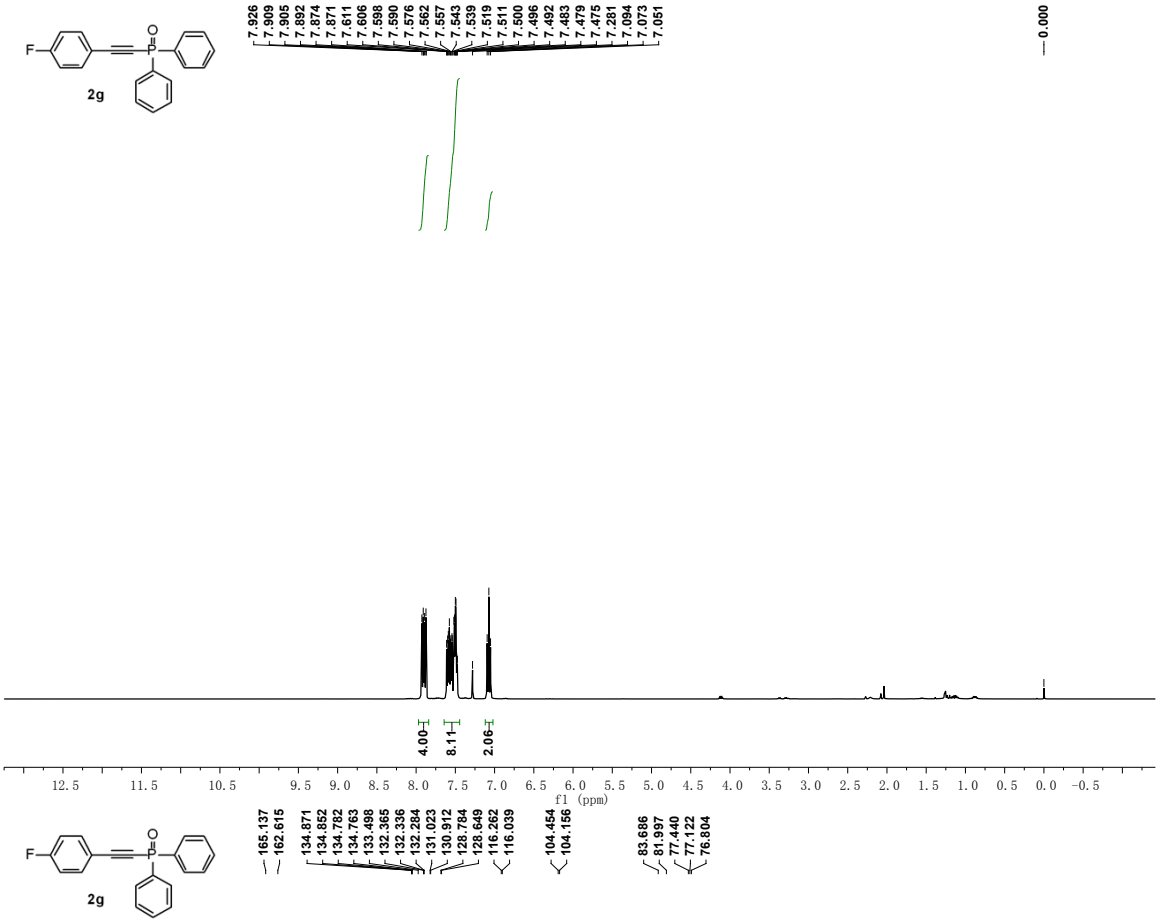
77.414
77.096
76.778
21.777
f1 (ppm)


8.179
2d
f1 (ppm)


F
P
O
2g
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7.909
7.905
7.892
7.874
7.871
7.611
7.606
7.598
7.590
7.576
7.562
7.557
7.543
7.539
7.519
7.511
7.500
7.496
7.492
7.483
7.479
7.475
7.281
7.094
7.073
7.051
0.000
4.00
8.11
2.06
f1 (ppm)
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134.871
134.852
134.782
134.763
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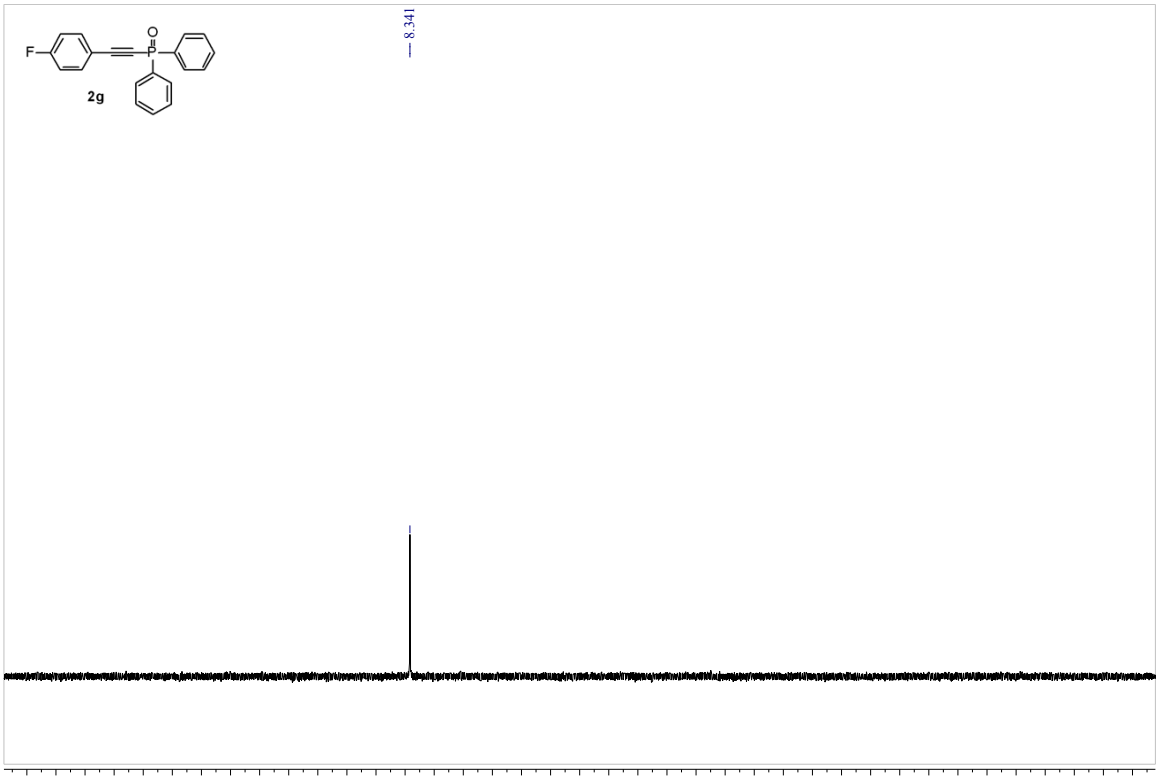
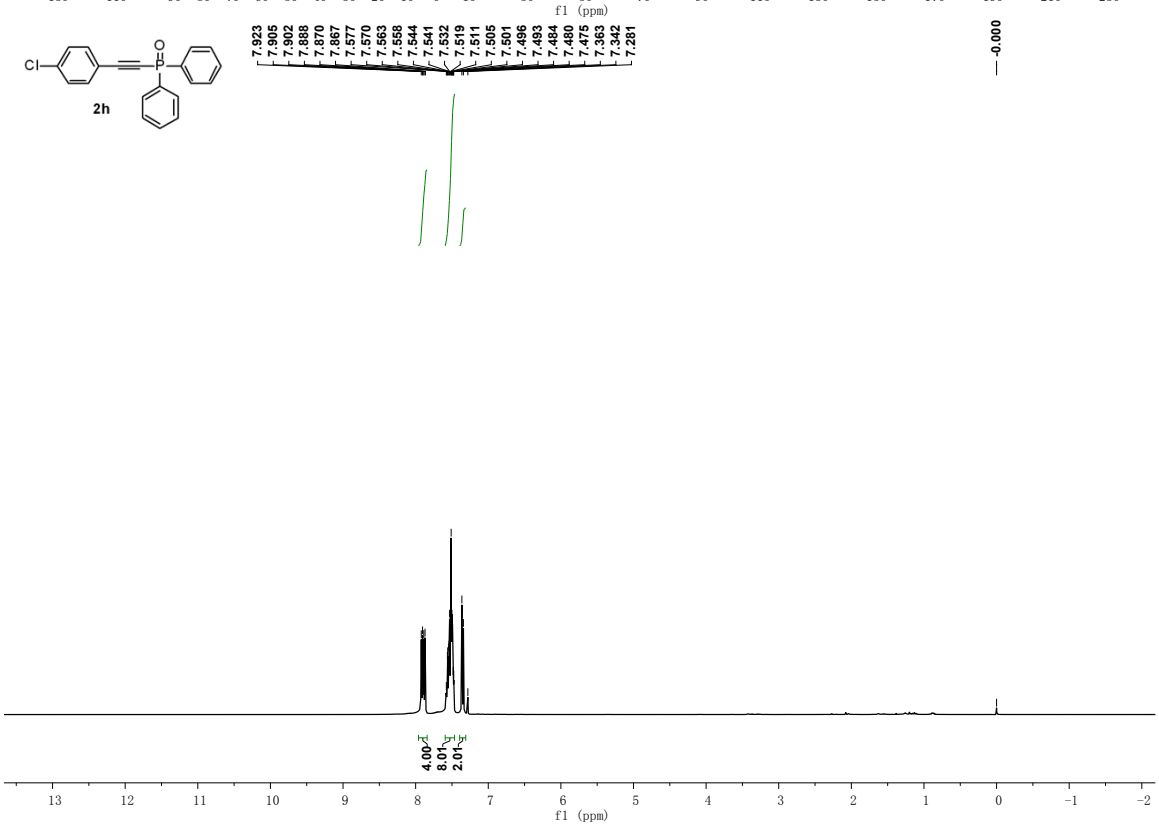
f1 (ppm)


F
2g
8.341
130 110 90 80 70 60 50 40 30 20 10 0 −10 −30 −50 −70 −90 −110 −130 −150 −170 −190 −210 −230
f1 (ppm)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7.563
7.558
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7.532
7.519
7.511
7.505
7.501
7.496
7.493
7.484
7.480
7.475
7.363
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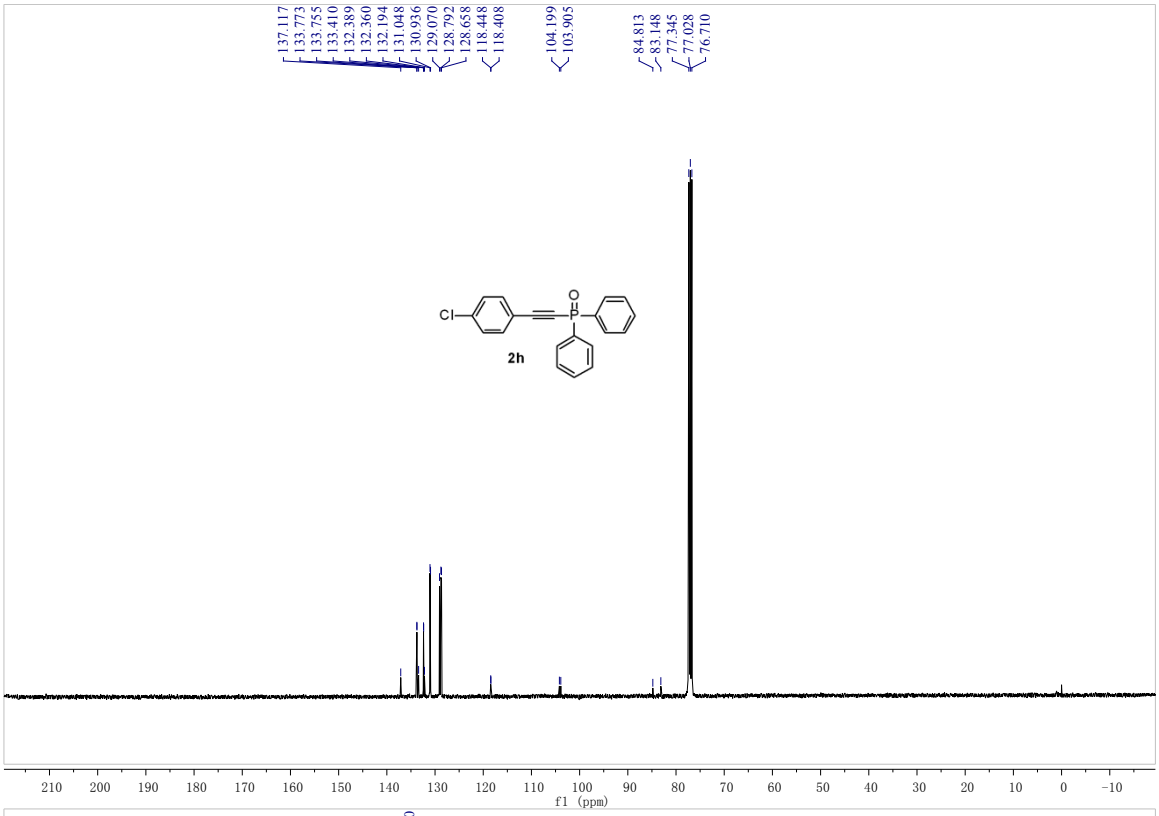
4.00
8.01
2.01
13 12 11 10 9 8 7 6 5 4 3 2 1 0 −1 −2
f1 (ppm)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129.070
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128.658
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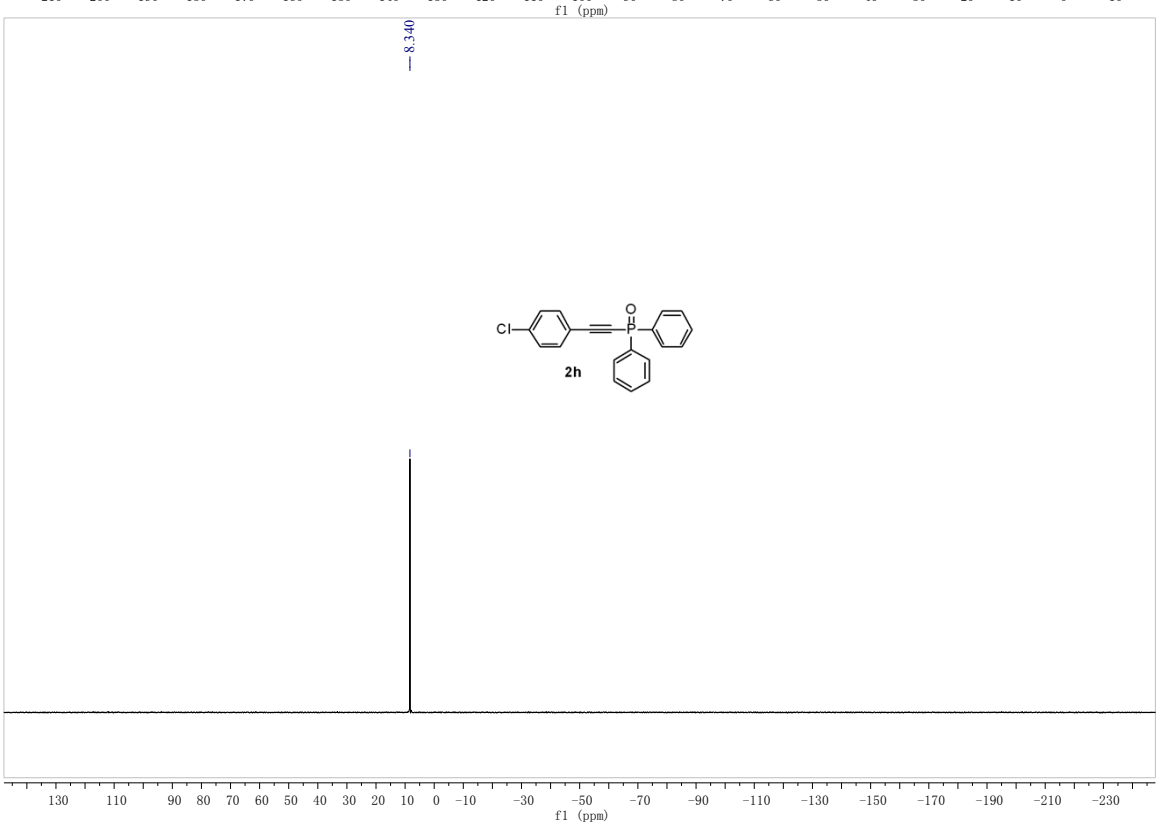
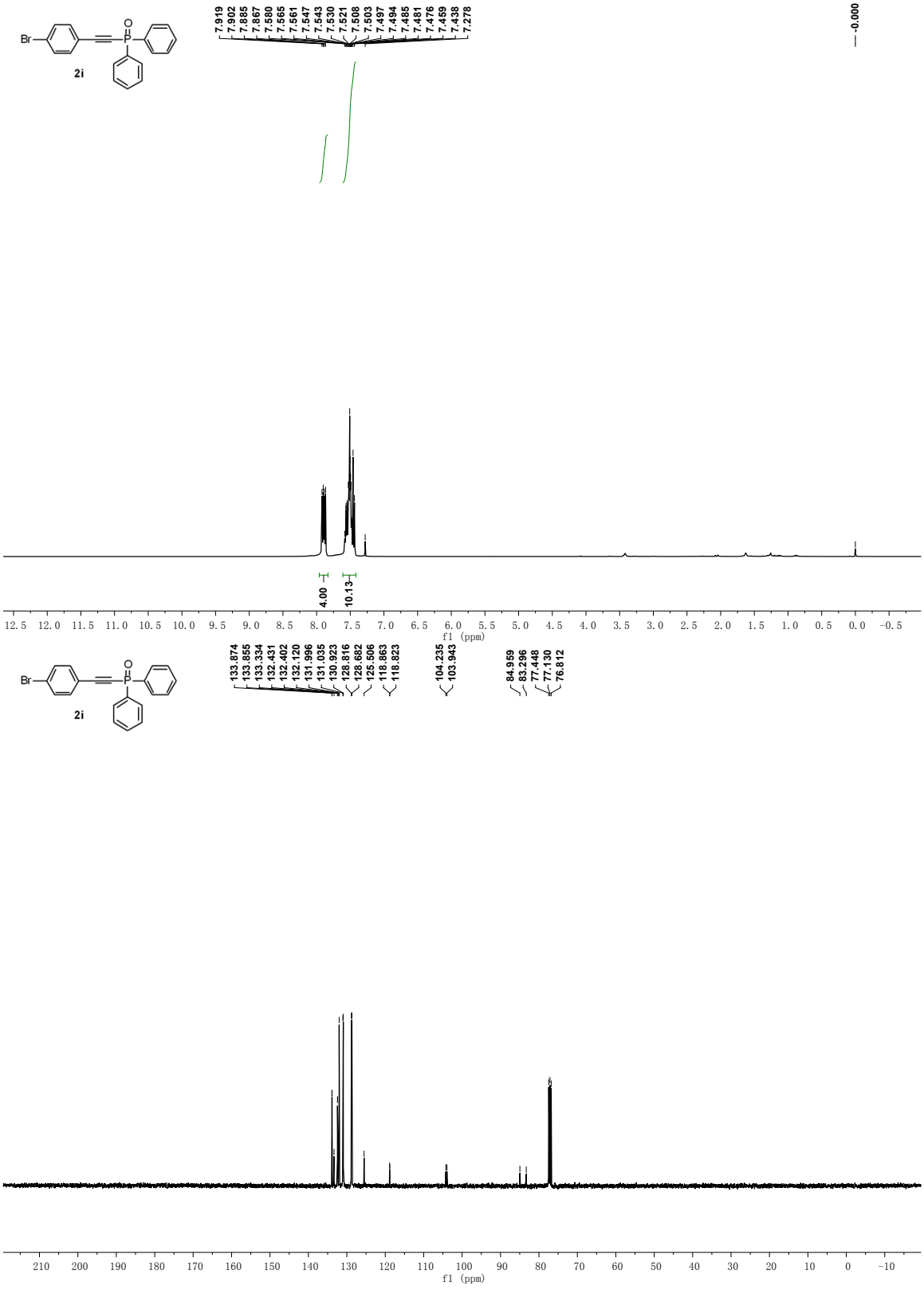
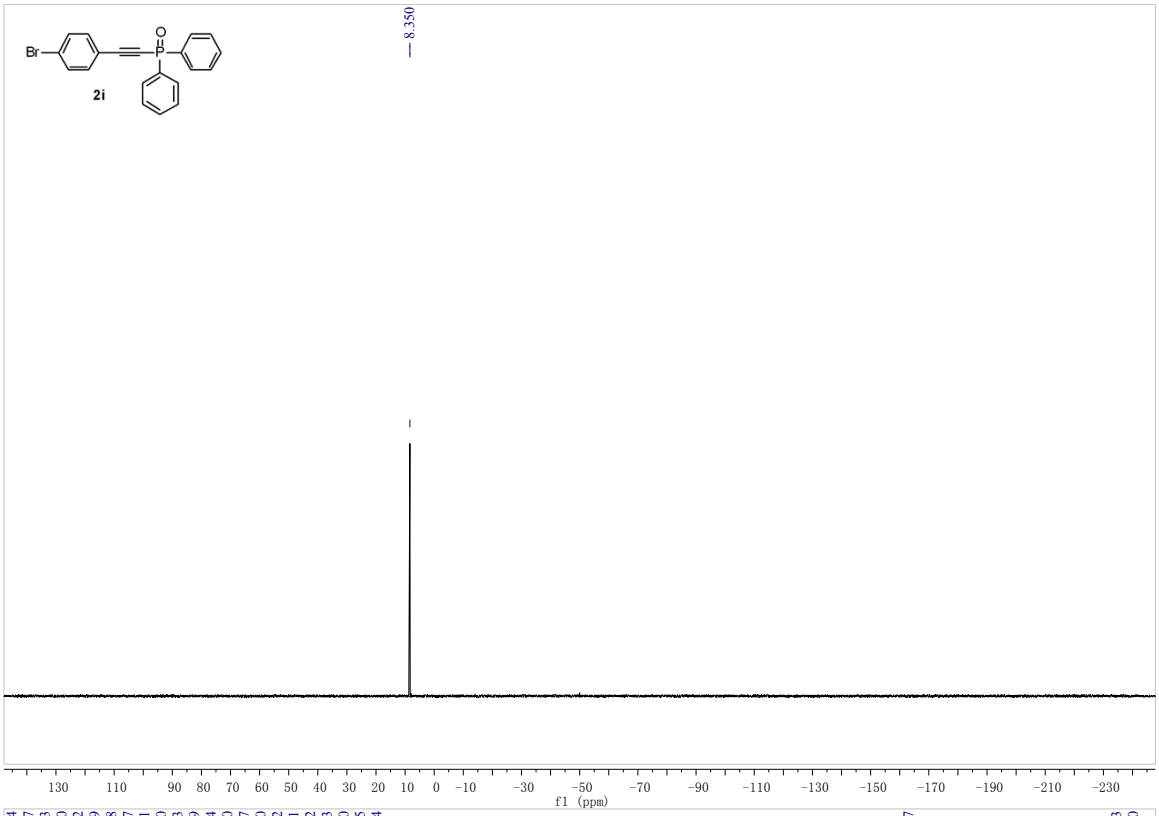
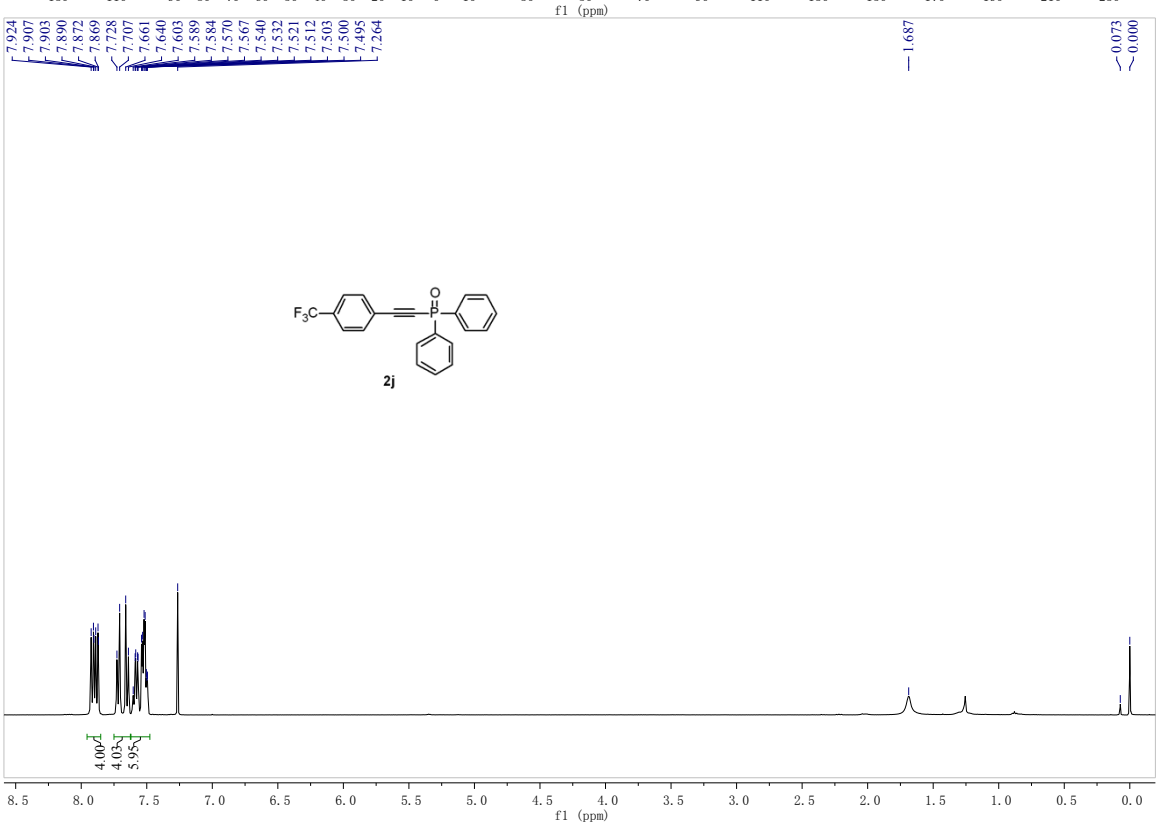
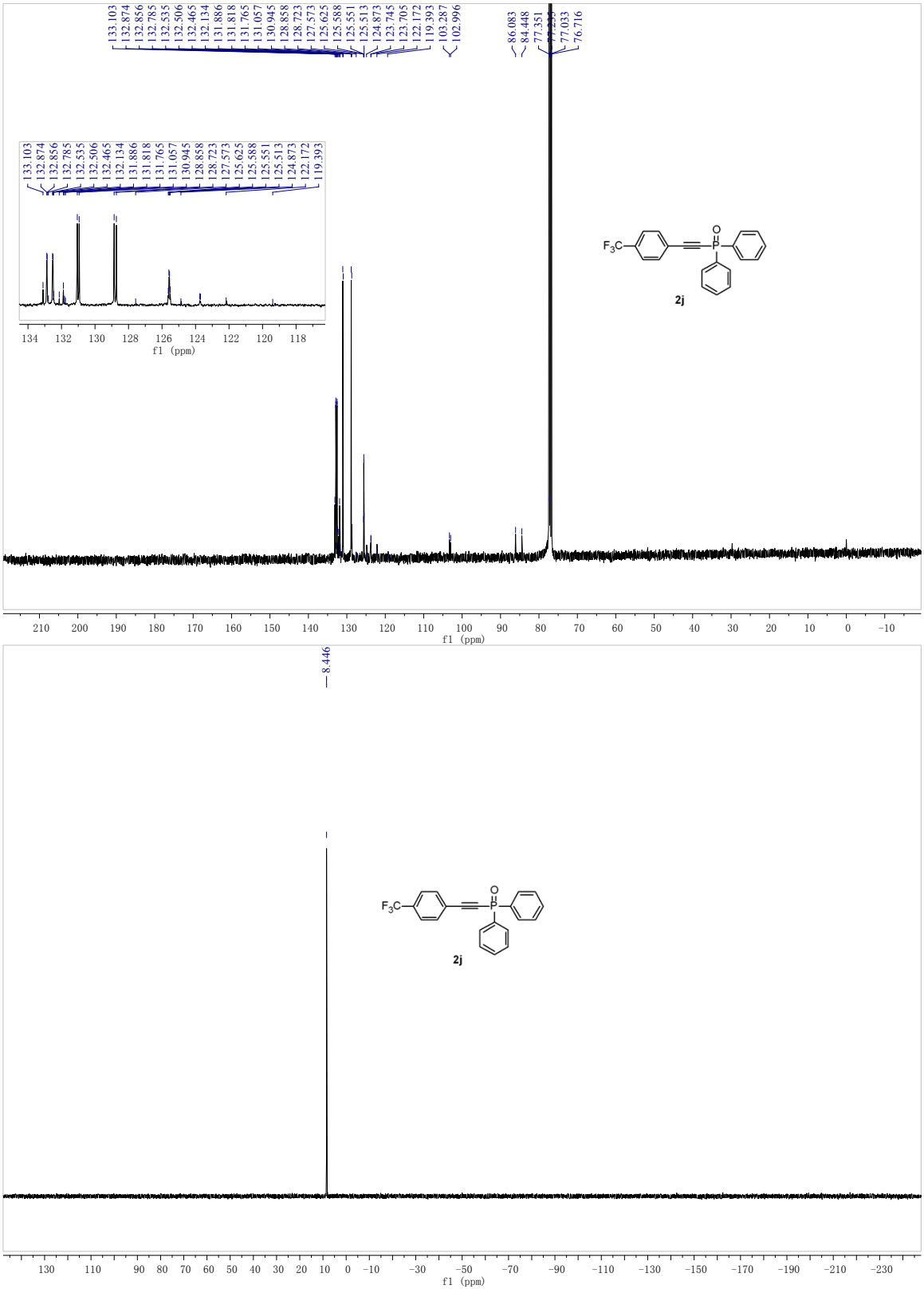
118.408
104.199
103.905
84.813
83.148
77.345
77.028
76.710
Cl
P
O
2h
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

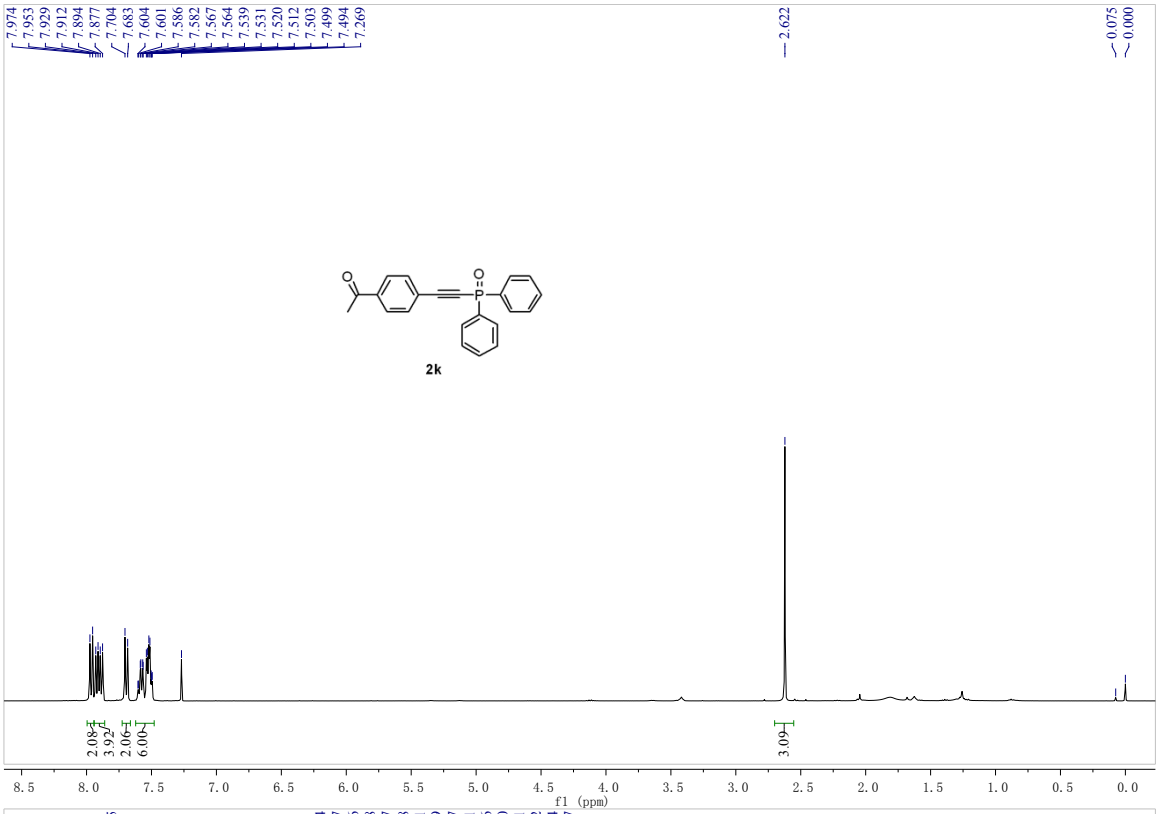

8.340
Cl
P
O
2h
130 110 90 80 70 60 50 40 30 20 10 0 -10 -30 -50 -70 -90 -110 -130 -150 -170 -190 -210 -230
f1 (ppm)

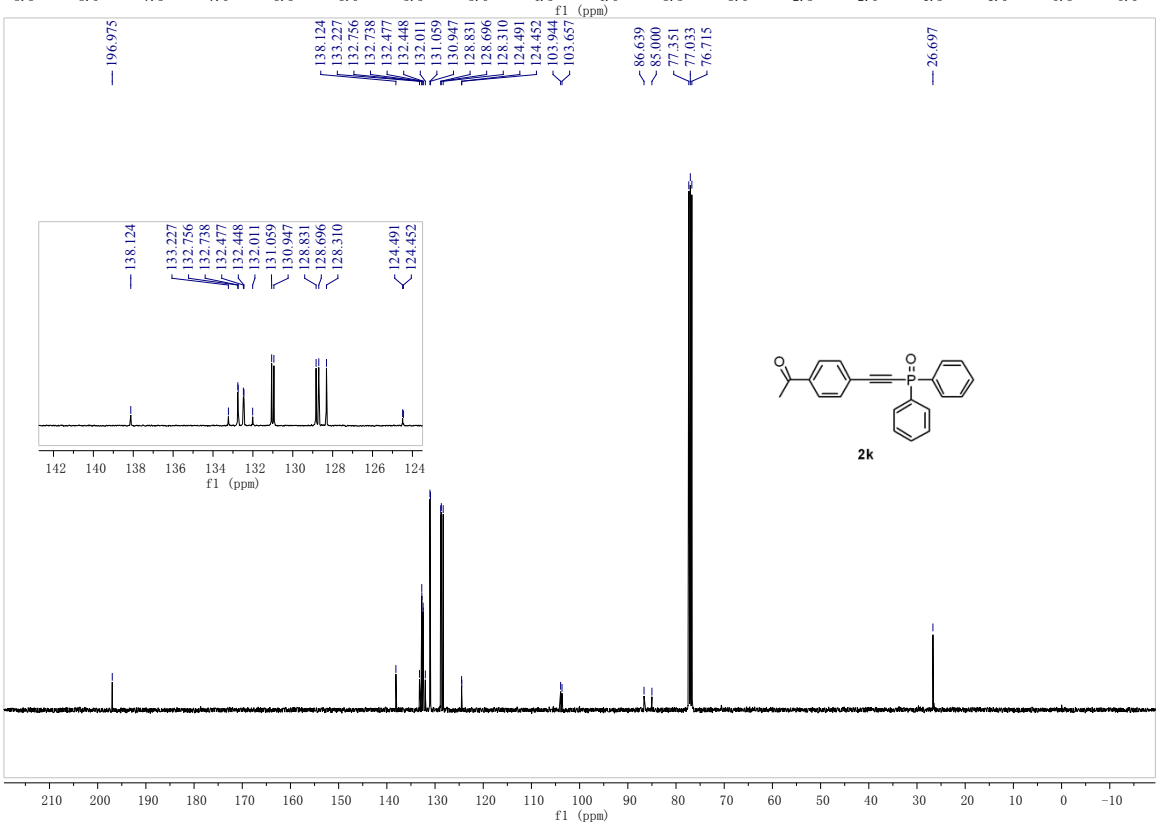

Br
2i
7.919
7.902
7.885
7.867
7.580
7.565
7.561
7.547
7.543
7.530
7.521
7.508
7.503
7.497
7.494
7.485
7.481
7.476
7.459
7.438
7.278
-0.000
4.00
10.13
f1 (ppm)
Br
2i
133.874
133.855
133.334
132.431
132.402
132.120
131.996
131.035
130.923
128.816
128.682
125.506
118.863
118.823
104.235
103.943
84.959
83.296
77.448
77.130
76.812
f1 (ppm)


Br
2i
8.350
130 110 90 80 70 60 50 40 30 20 10 0 -10 -30 -50 -70 -90 -110 -130 -150 -170 -190 -210 -230
f1 (ppm)


7.924
7.907
7.903
7.890
7.872
7.869
7.728
7.707
7.661
7.640
7.603
7.589
7.584
7.570
7.567
7.540
7.532
7.521
7.512
7.503
7.500
7.495
7.264
1.687
0.073
0.000
F3C
2j
4.00
4.03
5.95
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
f1 (ppm)


133.103
132.874
132.856
132.785
132.535
132.506
132.465
132.134
131.886
131.818
131.765
131.057
130.945
128.858
128.723
127.573
125.625
125.588
125.551
125.513
124.873
123.745
123.705
122.172
119.393
103.287
102.996
86.083
84.448
77.351
77.033
76.716
f1 (ppm)
F3C
2j
8.446
f1 (ppm)
F3C
2j


7.974
7.953
7.929
7.912
7.894
7.877
7.704
7.683
7.604
7.601
7.586
7.582
7.567
7.564
7.539
7.531
7.520
7.512
7.503
7.499
7.494
7.269
2.622
0.075
0.000
2k
2.08
3.92
2.06
6.00
3.09
f1 (ppm)


196.975
138.124
133.227
132.756
132.738
132.477
132.448
132.011
131.059
130.947
128.831
128.696
128.310
124.491
124.452
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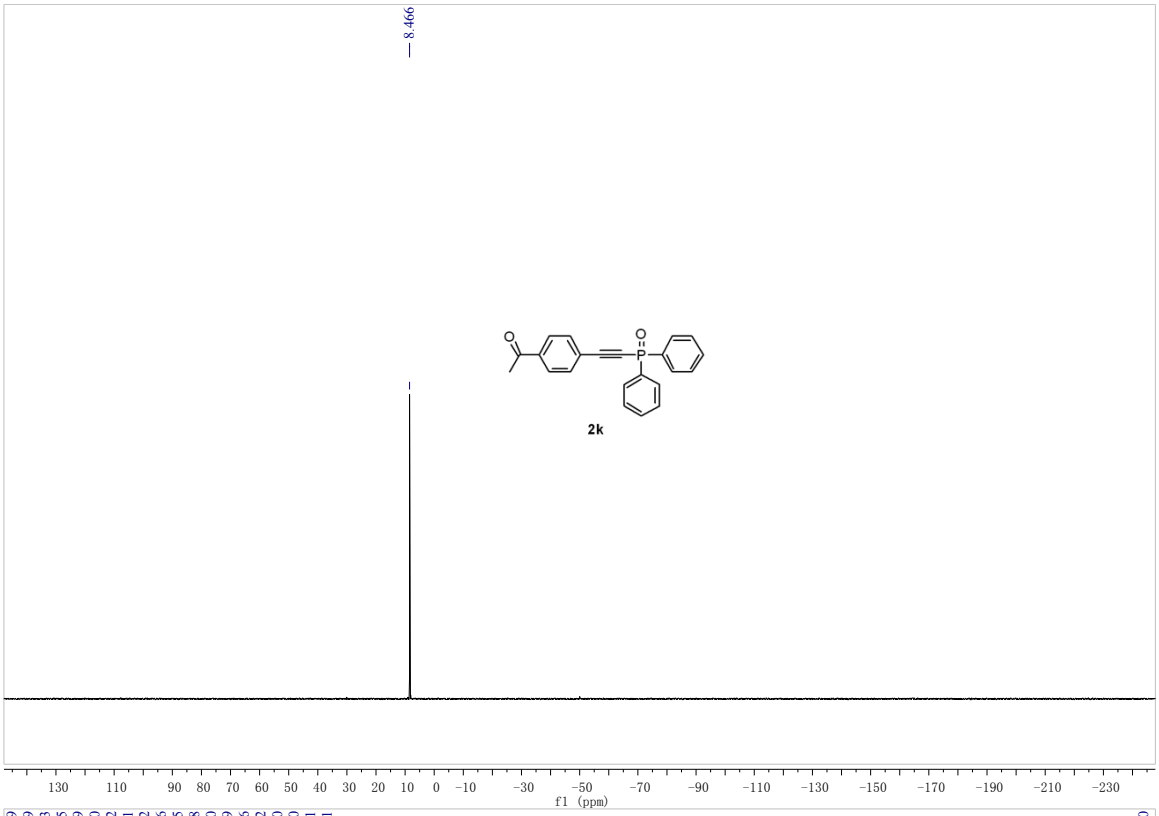
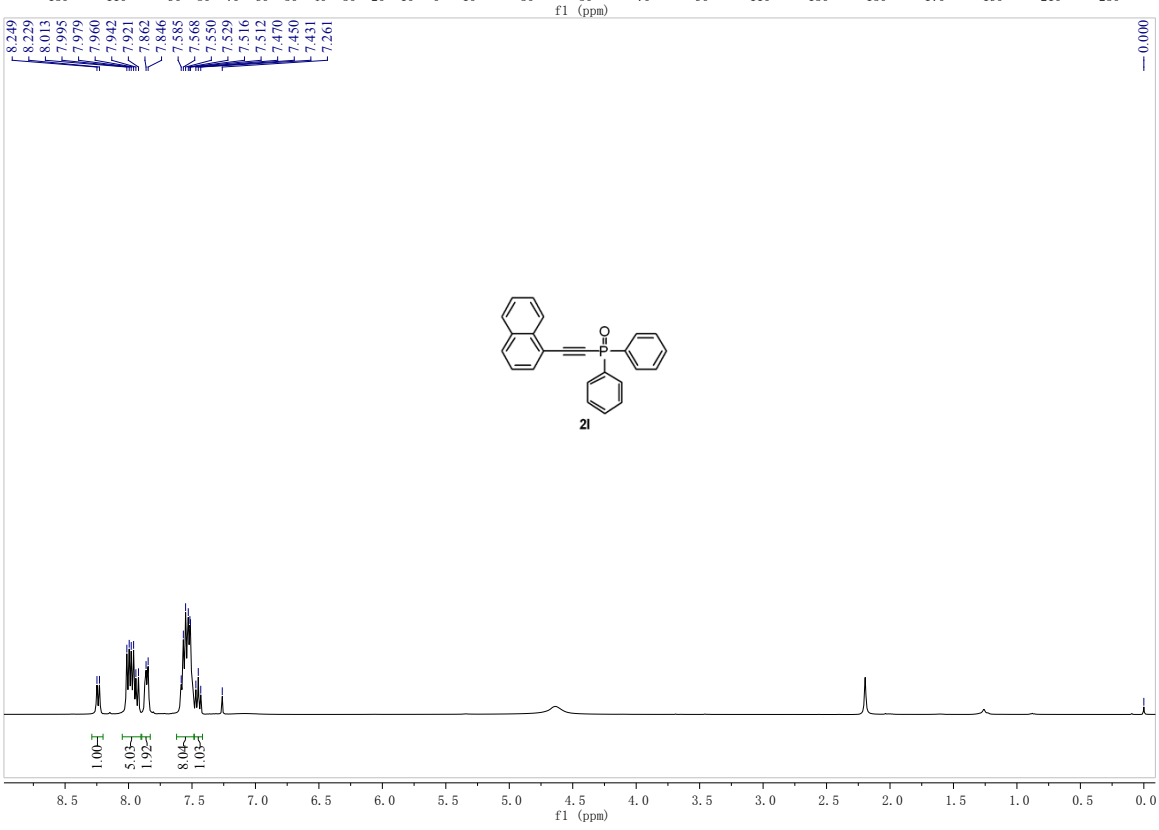
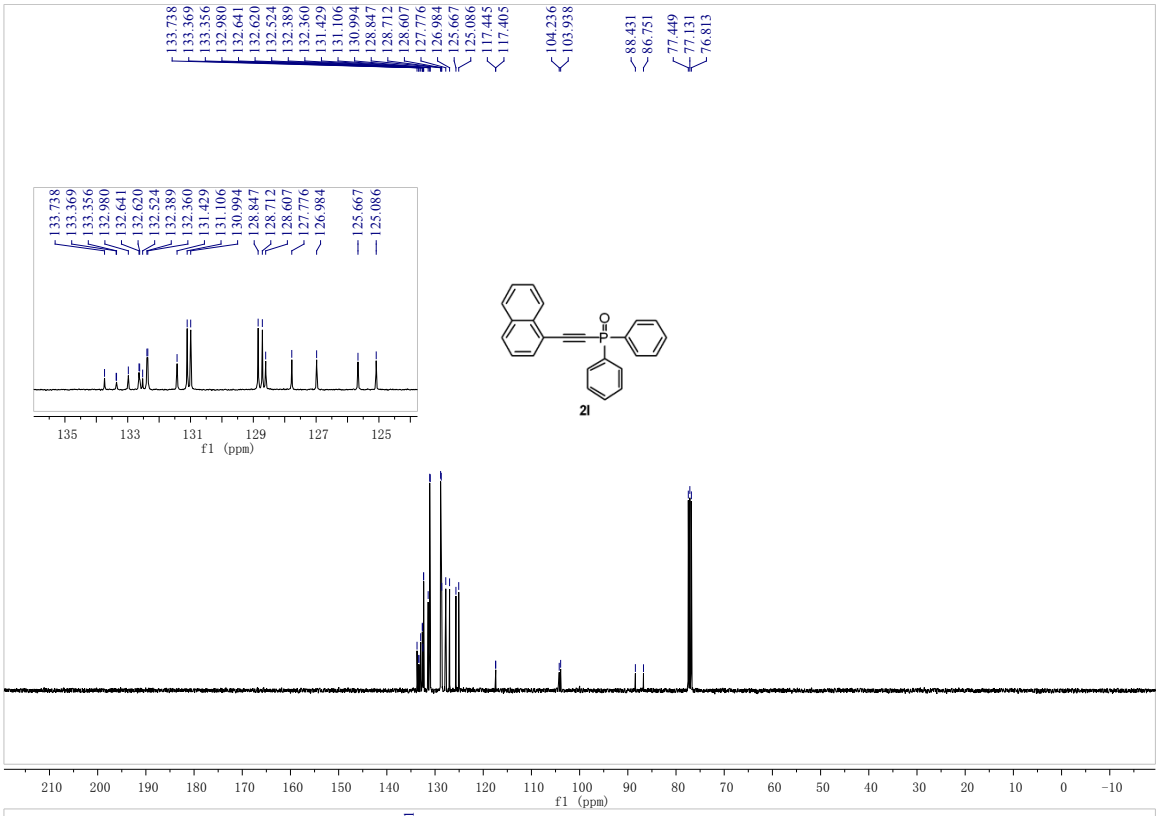
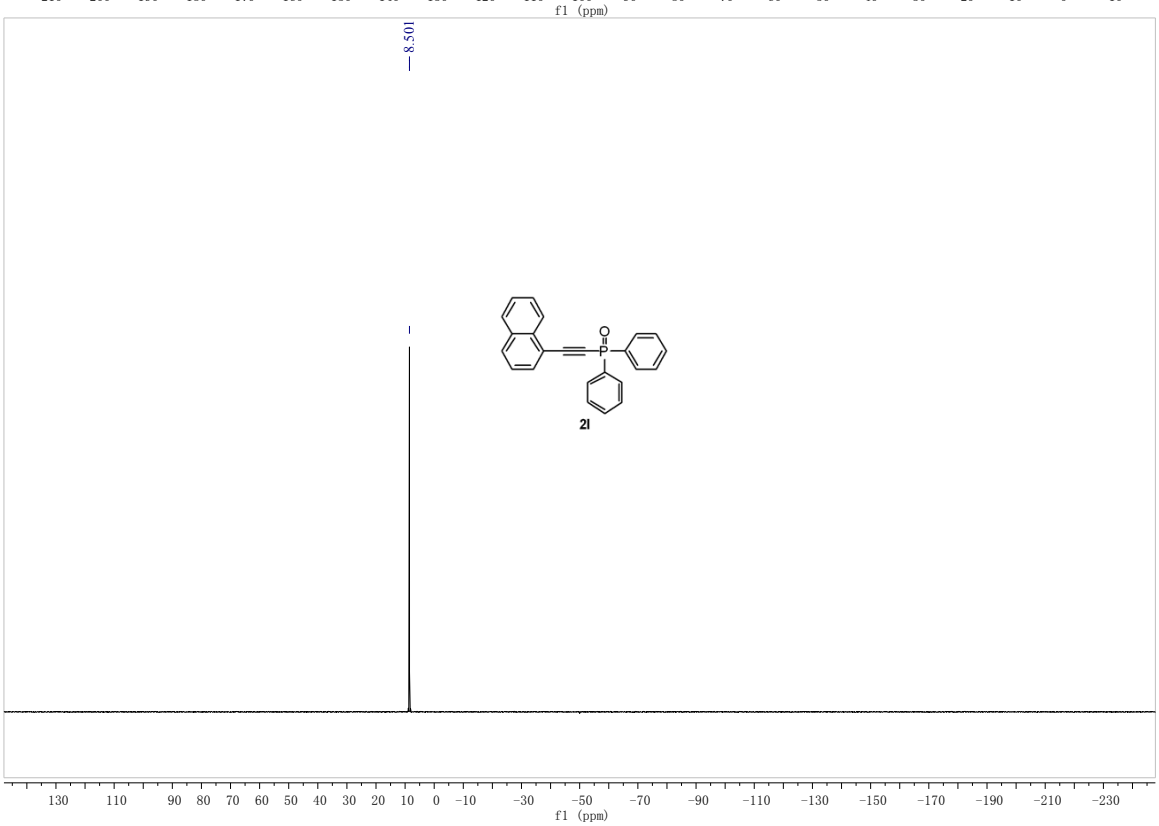
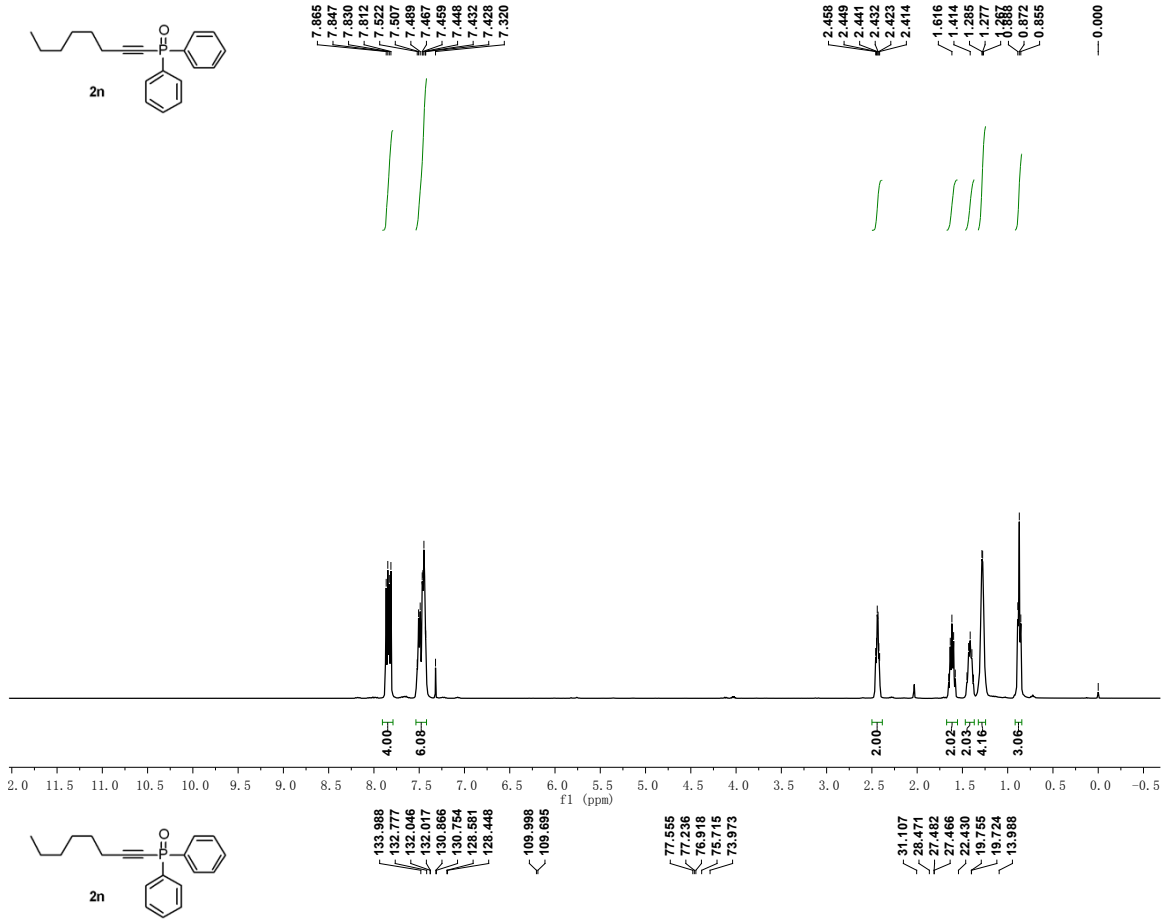
103.657
86.639
85.000
77.351
77.033
76.715
26.697
2k
f1 (ppm)

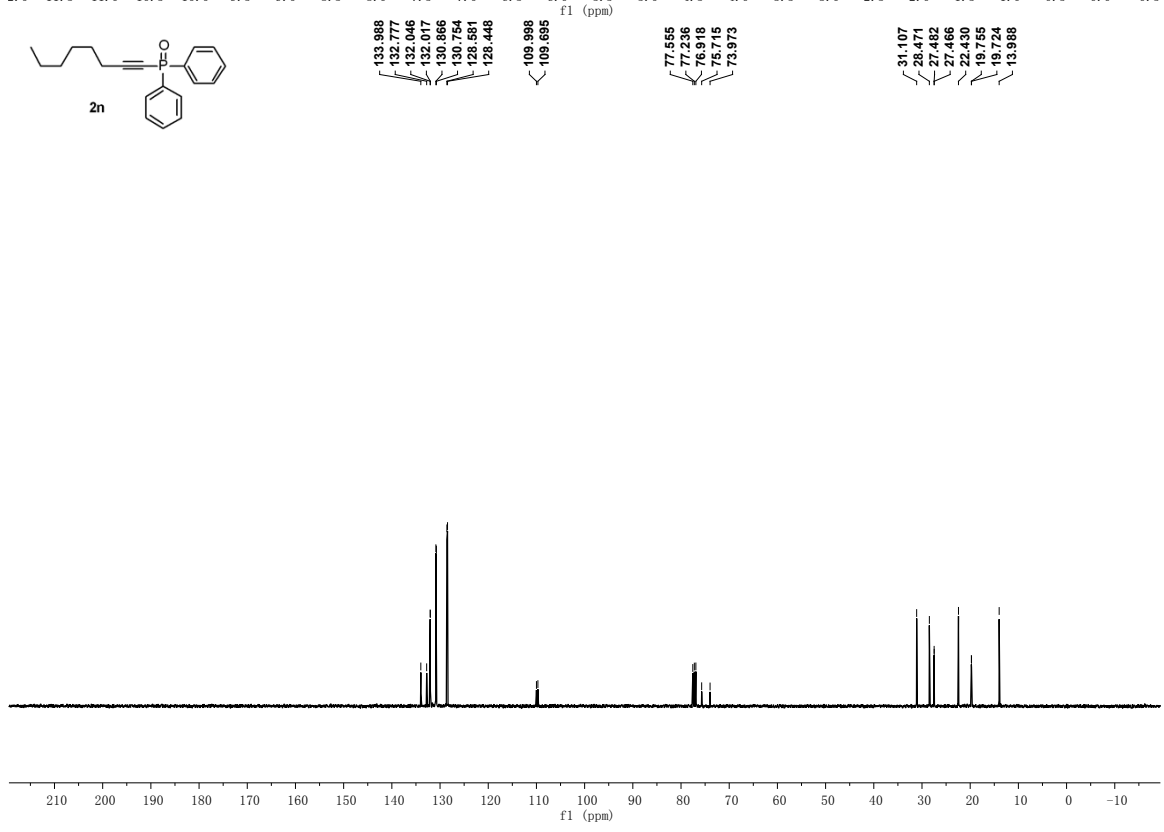

8.466
2k
130 110 90 80 70 60 50 40 30 20 10 0 -10 -30 -50 -70 -90 -110 -130 -150 -170 -190 -210 -230
f1 (ppm)

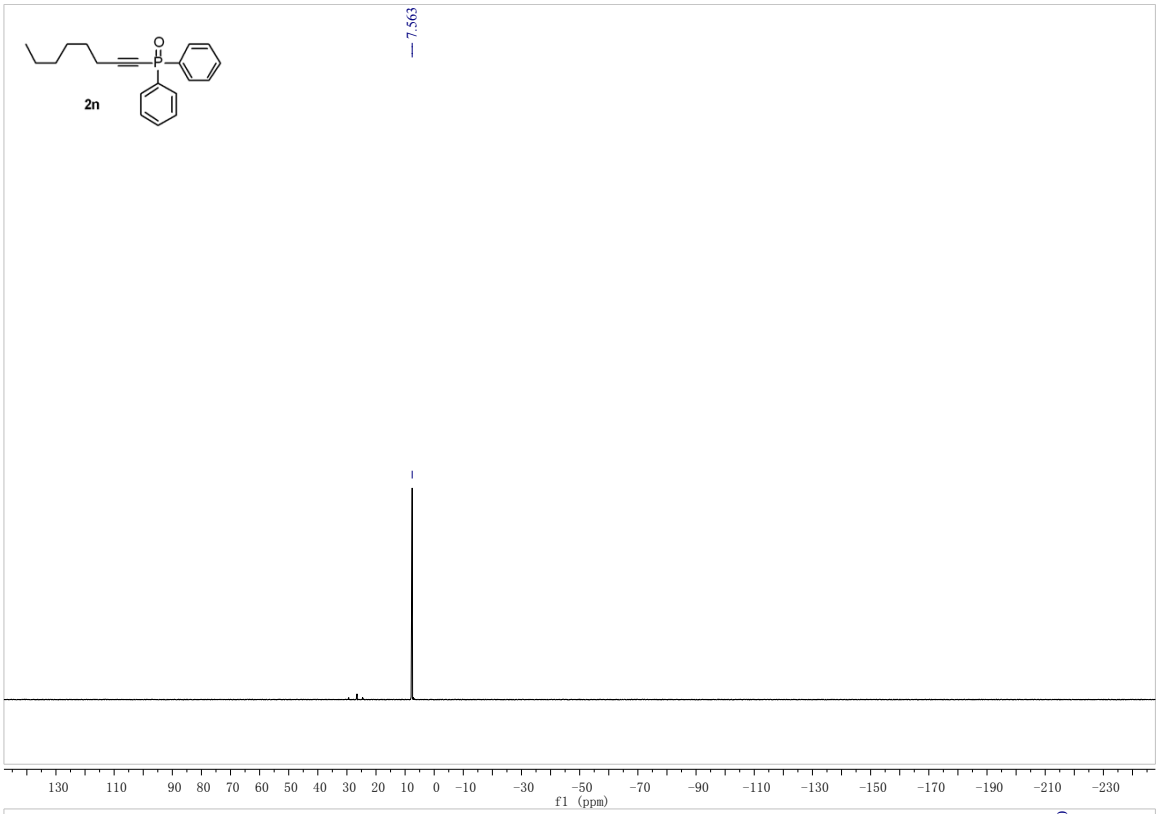

8.249
8.229
8.013
7.995
7.979
7.960
7.942
7.921
7.862
7.846
7.585
7.568
7.550
7.529
7.516
7.512
7.470
7.450
7.431
7.261
0.000
2l
1.00
5.03
1.92
8.04
1.03
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

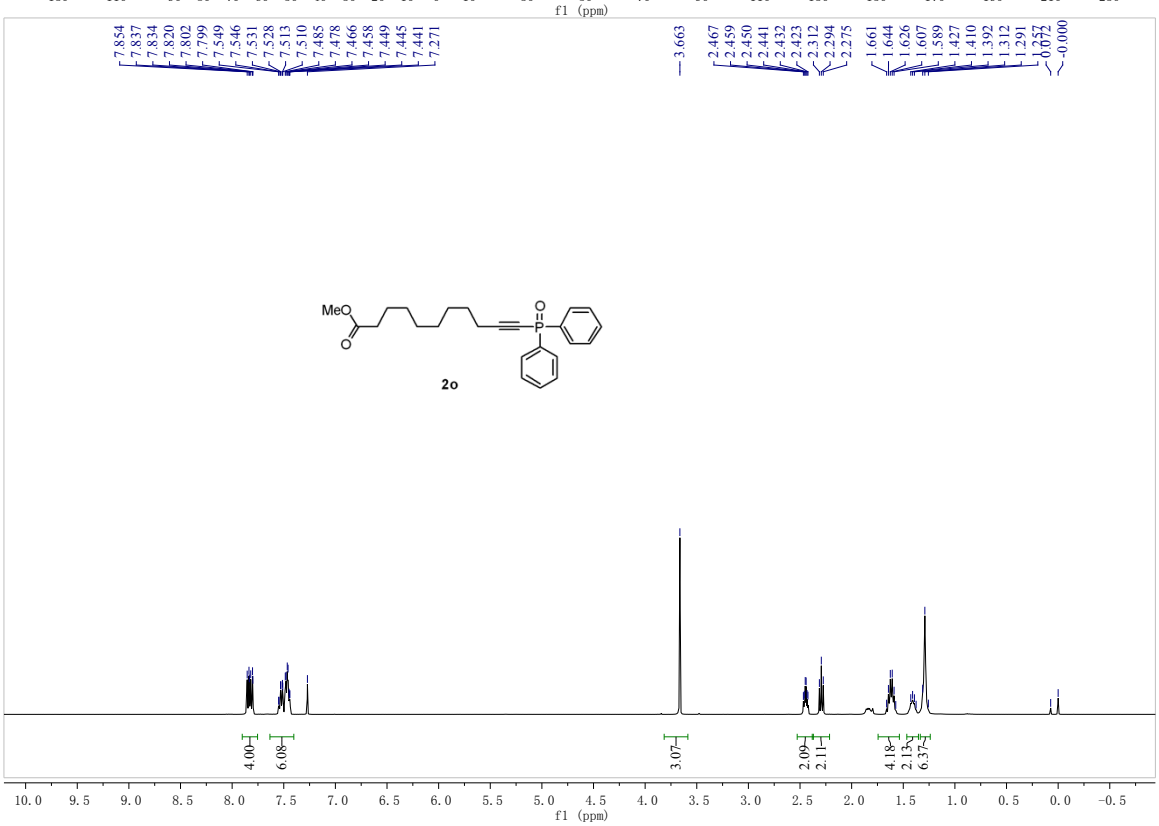

133.738
133.369
133.356
132.980
132.641
132.620
132.524
132.389
132.360
131.429
131.106
130.994
128.847
128.712
128.607
127.776
126.984
125.667
125.086
117.445
117.405
104.236
103.938
88.431
86.751
77.449
77.131
76.813
f1 (ppm)
2l

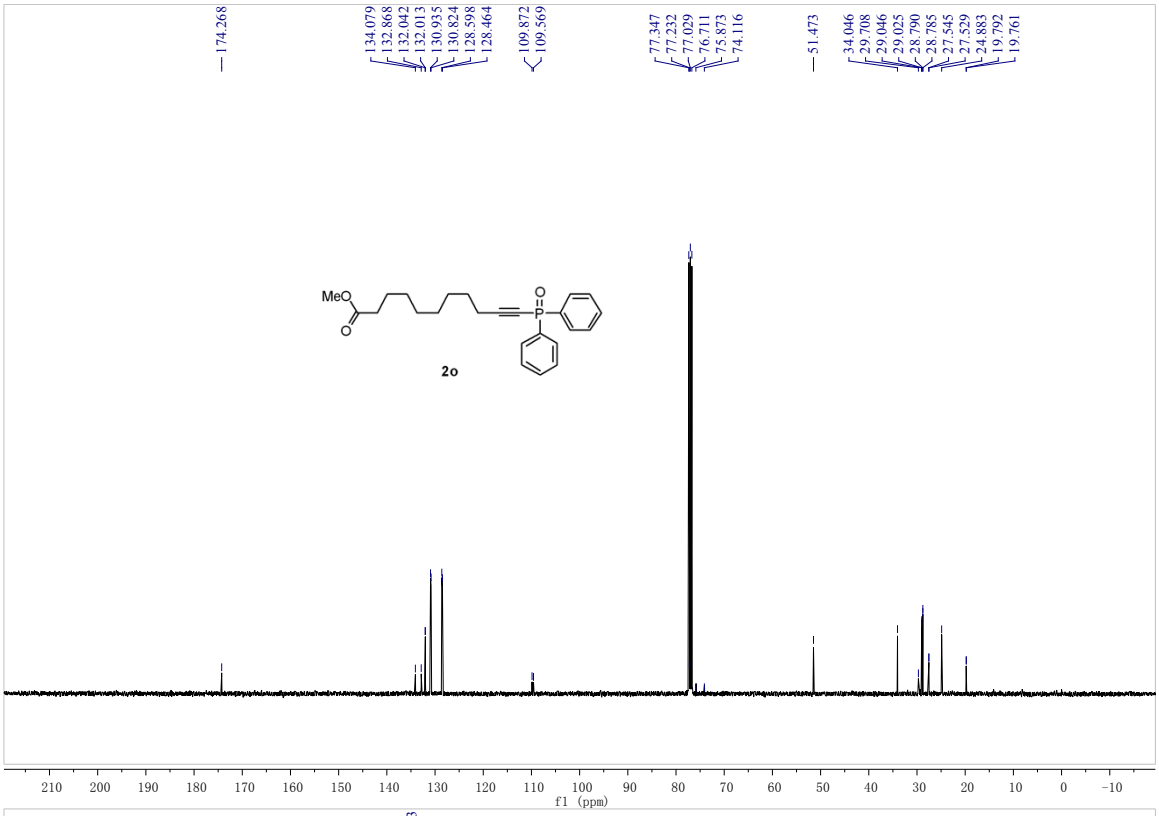

8.501
f1 (ppm)
2l

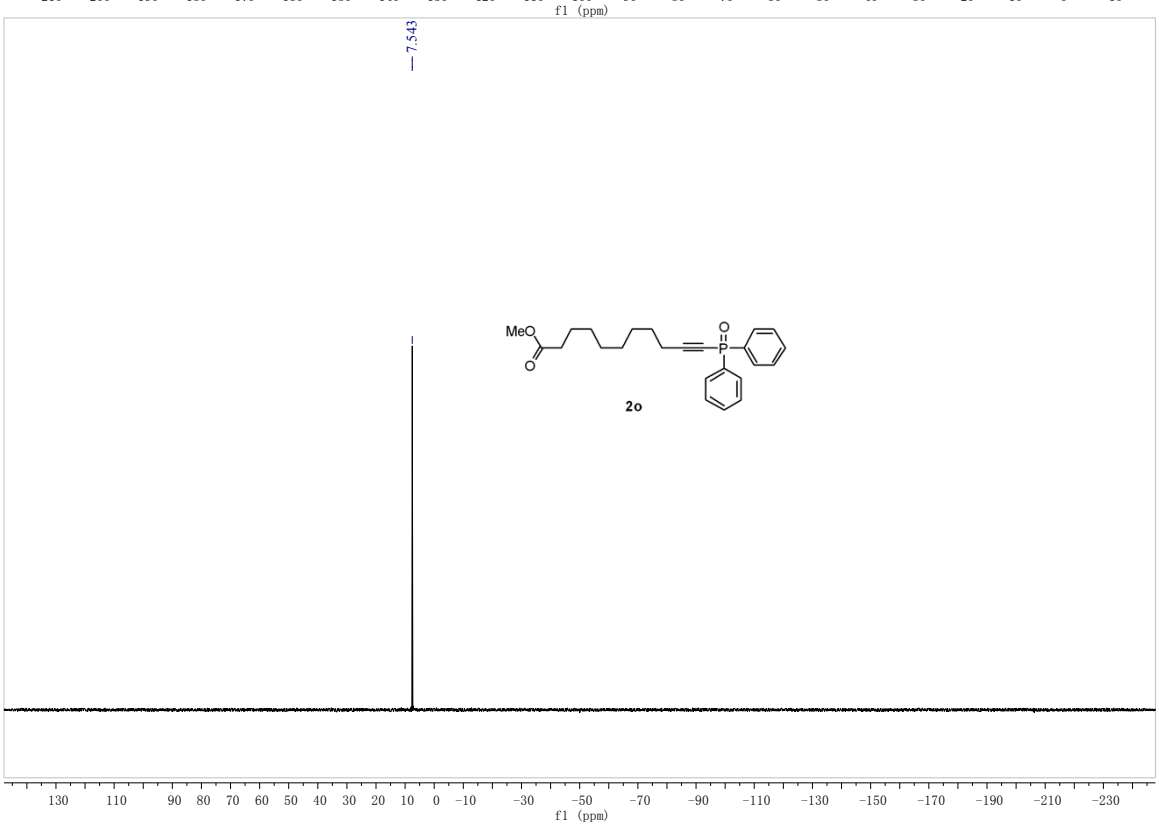

2n
7.865
7.847
7.830
7.812
7.522
7.507
7.489
7.467
7.459
7.448
7.432
7.428
7.320
2.458
2.449
2.441
2.432
2.423
2.414
1.616
1.414
1.285
1.277
0.872
0.855
0.000
4.00
6.08
2.00
2.02
2.03
4.16
3.06
f1 (ppm)

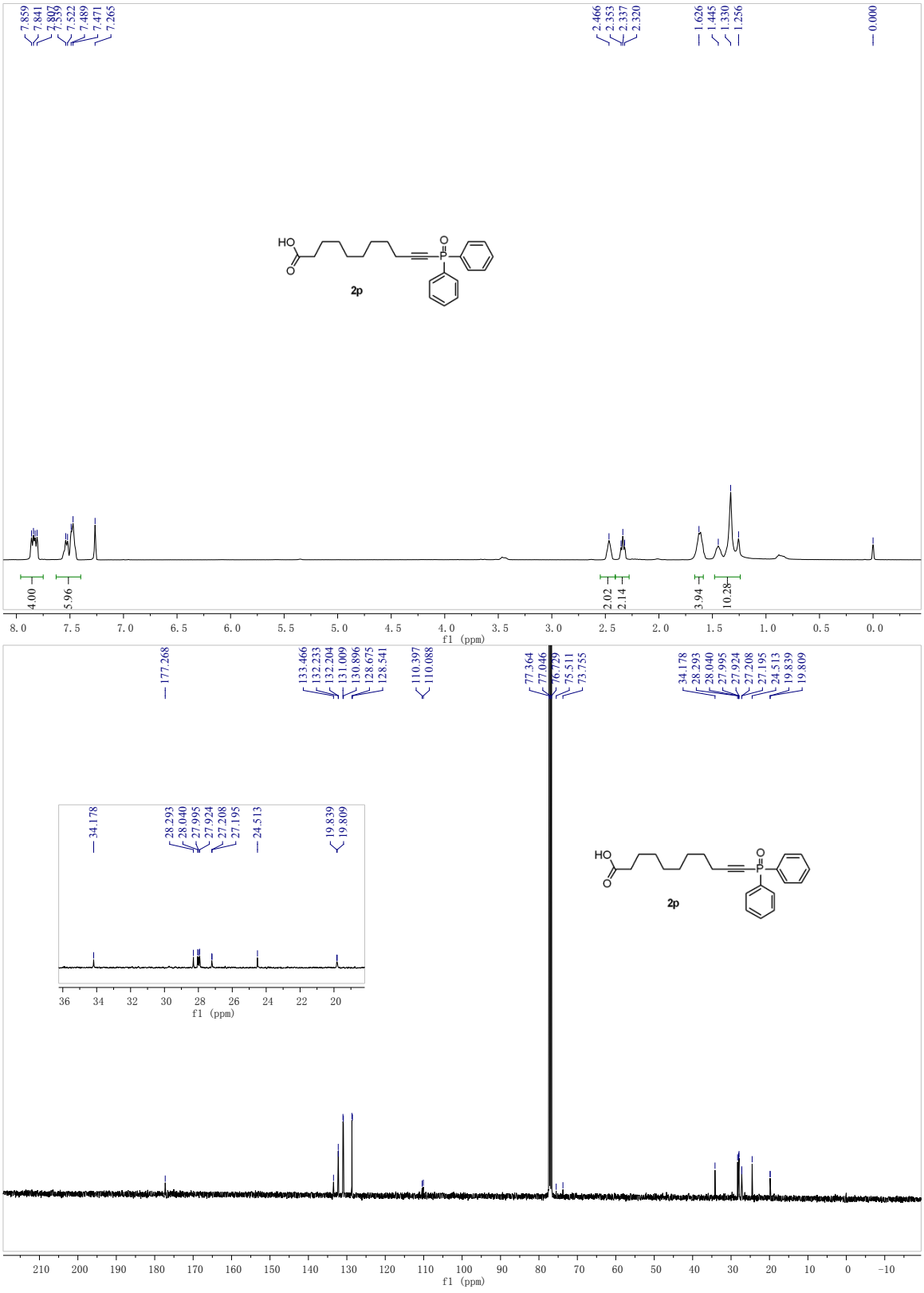

2n
133.988
132.777
132.046
132.017
130.866
130.754
128.581
128.448
109.998
109.695
77.555
77.236
76.918
75.715
73.973
31.107
28.471
27.482
27.466
22.430
19.755
19.724
13.988
f1 (ppm)


2n
7.563
f1 (ppm)


7.854
7.837
7.834
7.820
7.802
7.799
7.549
7.546
7.531
7.528
7.513
7.510
7.485
7.478
7.466
7.458
7.449
7.445
7.441
7.271
3.663
2.467
2.459
2.450
2.441
2.432
2.423
2.312
2.294
2.275
1.661
1.644
1.626
1.607
1.589
1.427
1.410
1.392
1.312
1.291
1.257
0.072
-0.000
MeO
2o
4.00
6.08
3.07
2.09
2.11
4.18
2.13
6.37
f1 (ppm)


174.268
134.079
132.868
132.042
132.013
130.935
130.824
128.598
128.464
109.872
109.569
77.347
77.232
77.029
76.711
75.873
74.116
51.473
34.046
29.708
29.046
29.025
28.790
28.785
27.545
27.529
24.883
19.792
19.761
MeO
O
O
P
2o
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


7.543
MeO
O
O
P
2o
130 110 90 80 70 60 50 40 30 20 10 0 -10 -30 -50 -70 -90 -110 -130 -150 -170 -190 -210 -230
f1 (ppm)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7.539
7.522
7.489
7.471
7.265
2.466
2.353
2.337
2.320
1.626
1.445
1.330
1.256
0.000
HO
O
O
P
2p
4.00
5.96
2.02
2.14
3.94
10.28
f1 (ppm)
177.268
133.466
132.233
132.204
131.009
130.896
128.675
128.541
110.397
110.088
77.364
77.046
76.729
75.511
73.755
34.178
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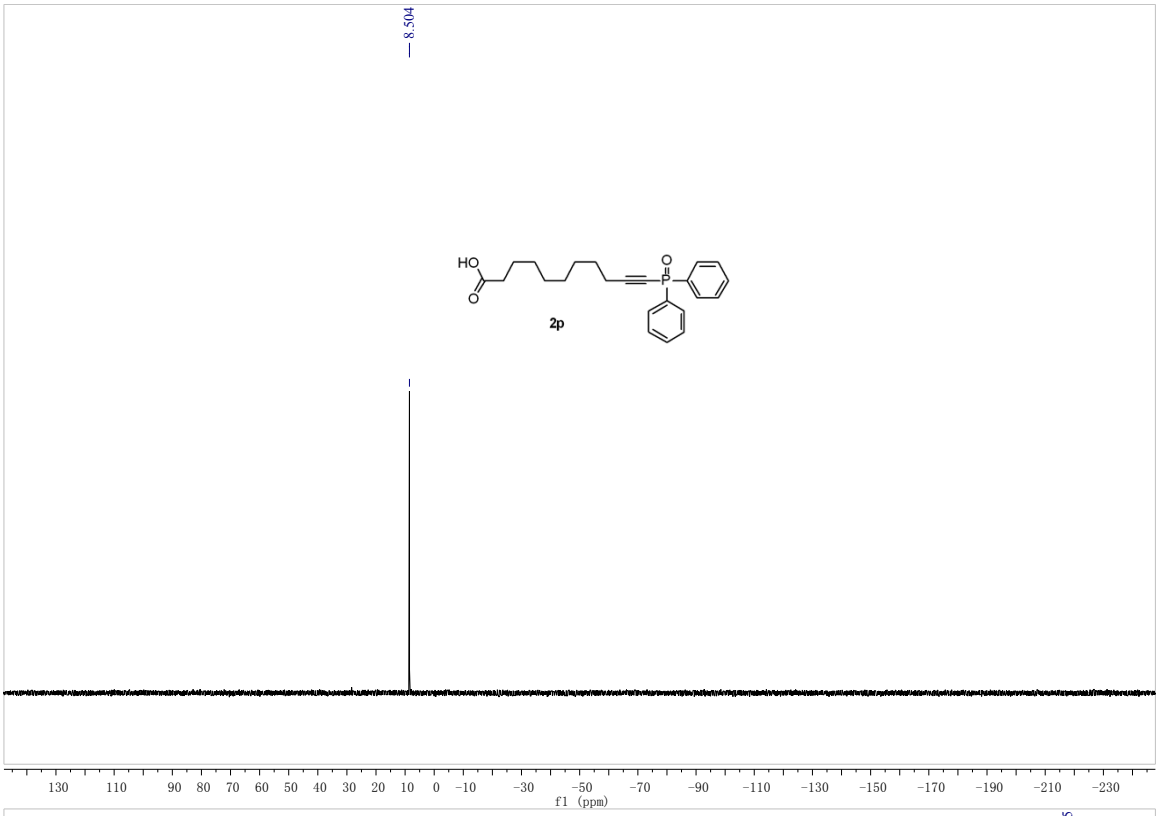
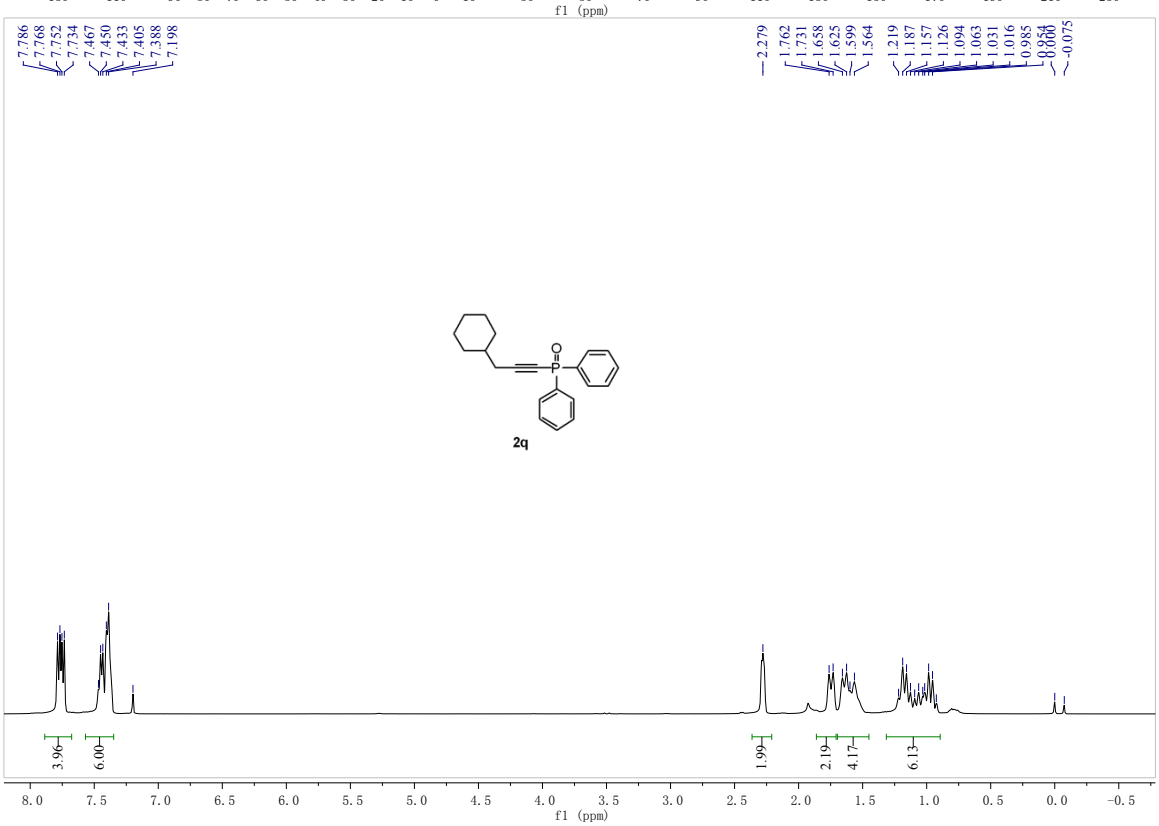
28.040
27.995
27.924
27.208
27.195
24.513
19.839
19.809
f1 (ppm)


8.504
HO
O
O
P
2p
130 110 90 80 70 60 50 40 30 20 10 0 -10 -30 -50 -70 -90 -110 -130 -150 -170 -190 -210 -230
f1 (ppm)


7.786
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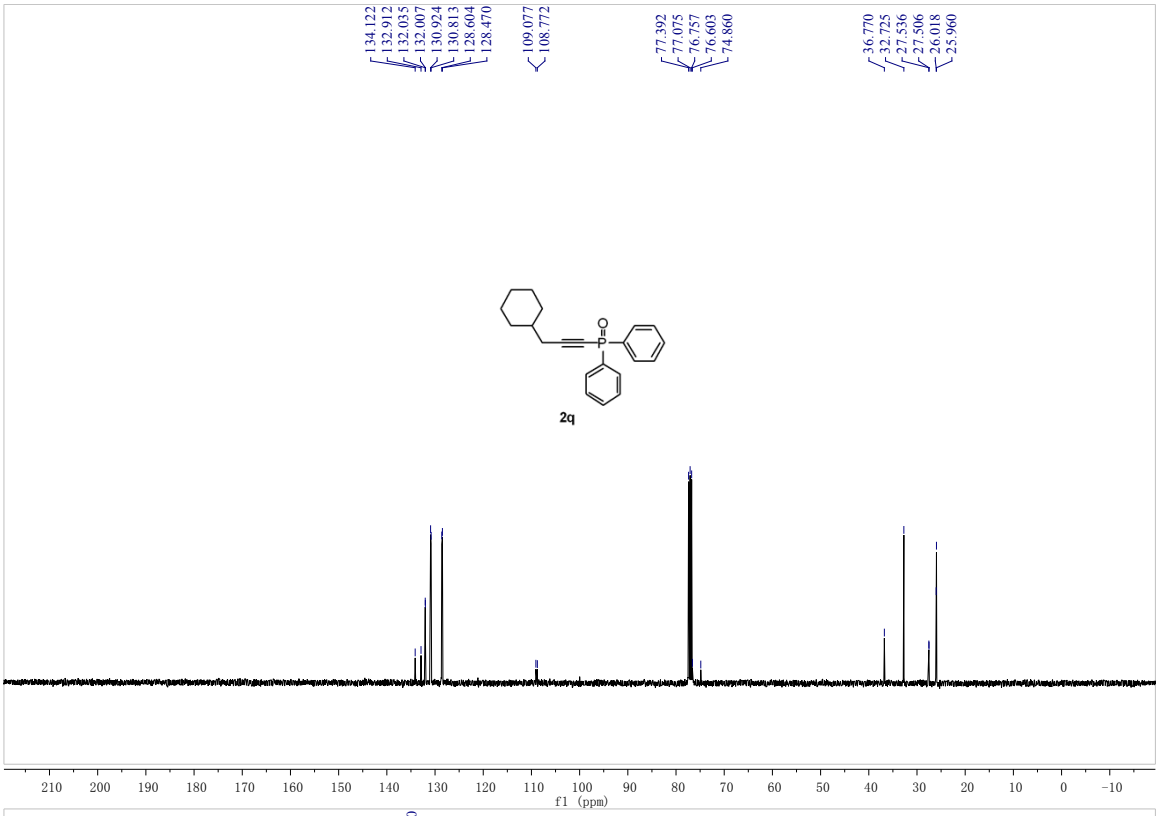
7.752
7.734
7.467
7.450
7.433
7.405
7.388
7.198
2.279
1.762
1.731
1.658
1.625
1.599
1.564
1.219
1.187
1.157
1.126
1.094
1.063
1.031
1.016
0.985
-0.075
O
P
2q
3.96
6.00
1.99
2.19
4.17
6.13
8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)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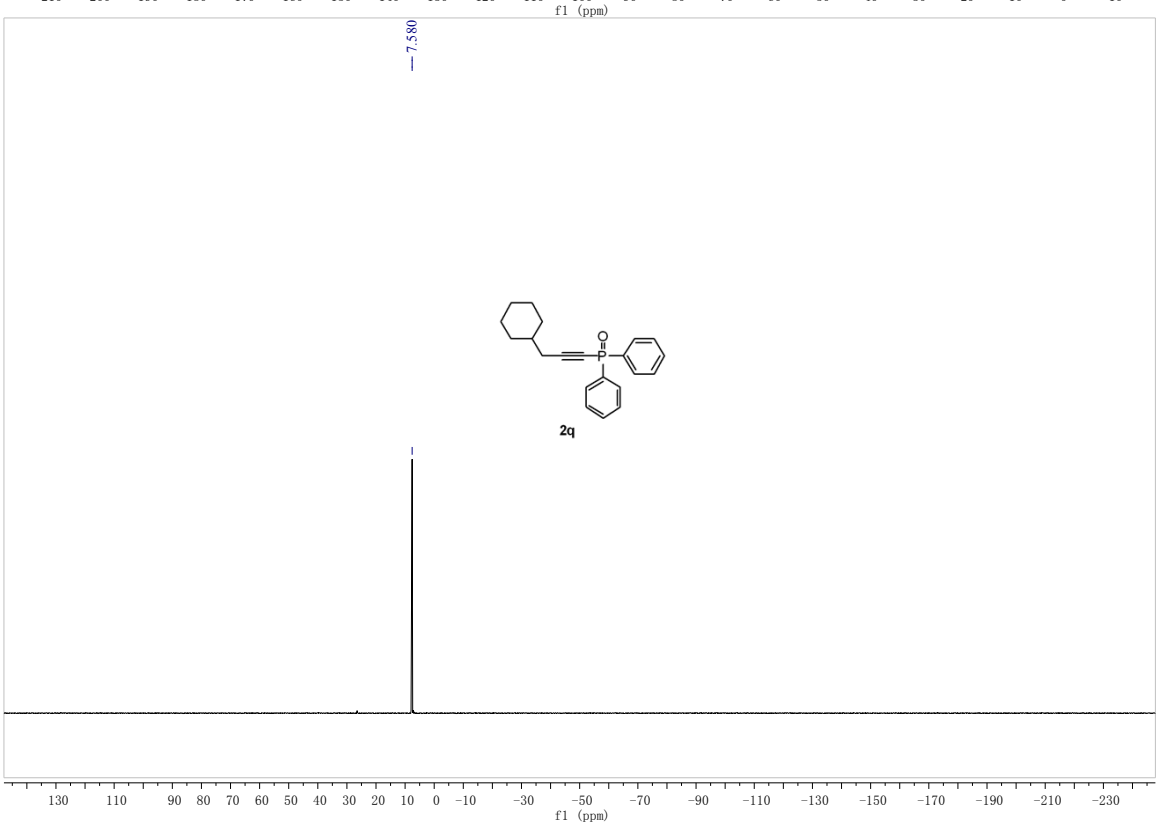
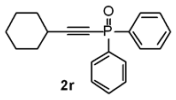
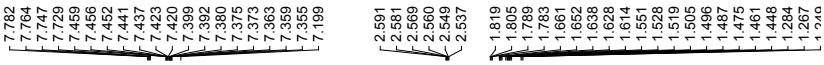
130.813
128.604
128.470
109.077
108.772
77.392
77.075
76.757
76.603
74.860
36.770
32.725
27.536
27.506
26.018
25.960
2q
f1 (ppm)


7.580
2q
f1 (ppm)


2r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7.456
7.452
7.441
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7.420
7.399
7.392
7.380
7.375
7.373
7.363
7.359
7.355
7.199
2.591
2.581
2.569
2.560
2.549
2.537
1.819
1.805
1.789
1.783
1.661
1.652
1.638
1.628
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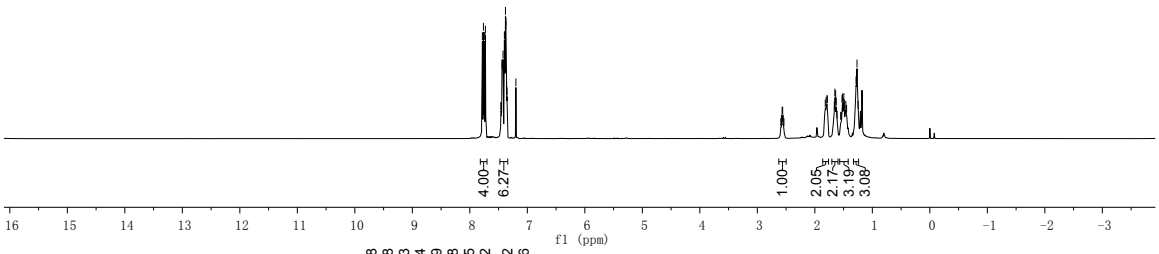
1.448
1.284
1.267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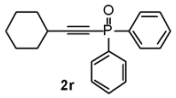
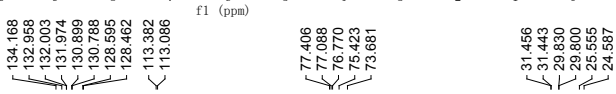
6.27
1.00
2.05
2.17
3.19
3.08
f1 (ppm)


2r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130.899
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128.462
113.382
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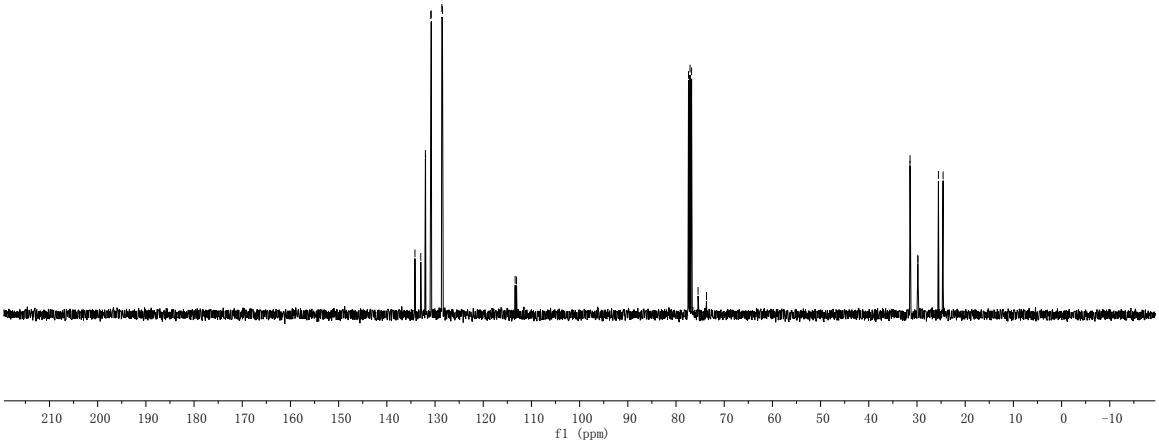
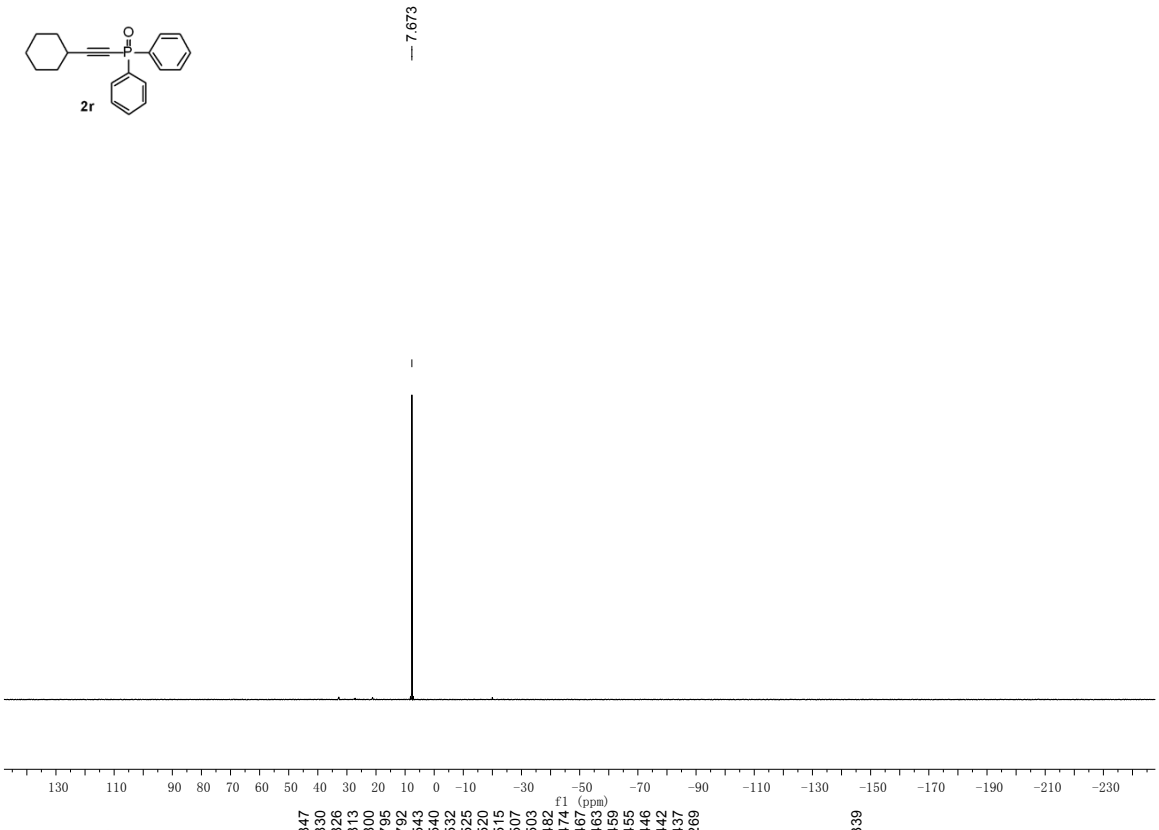
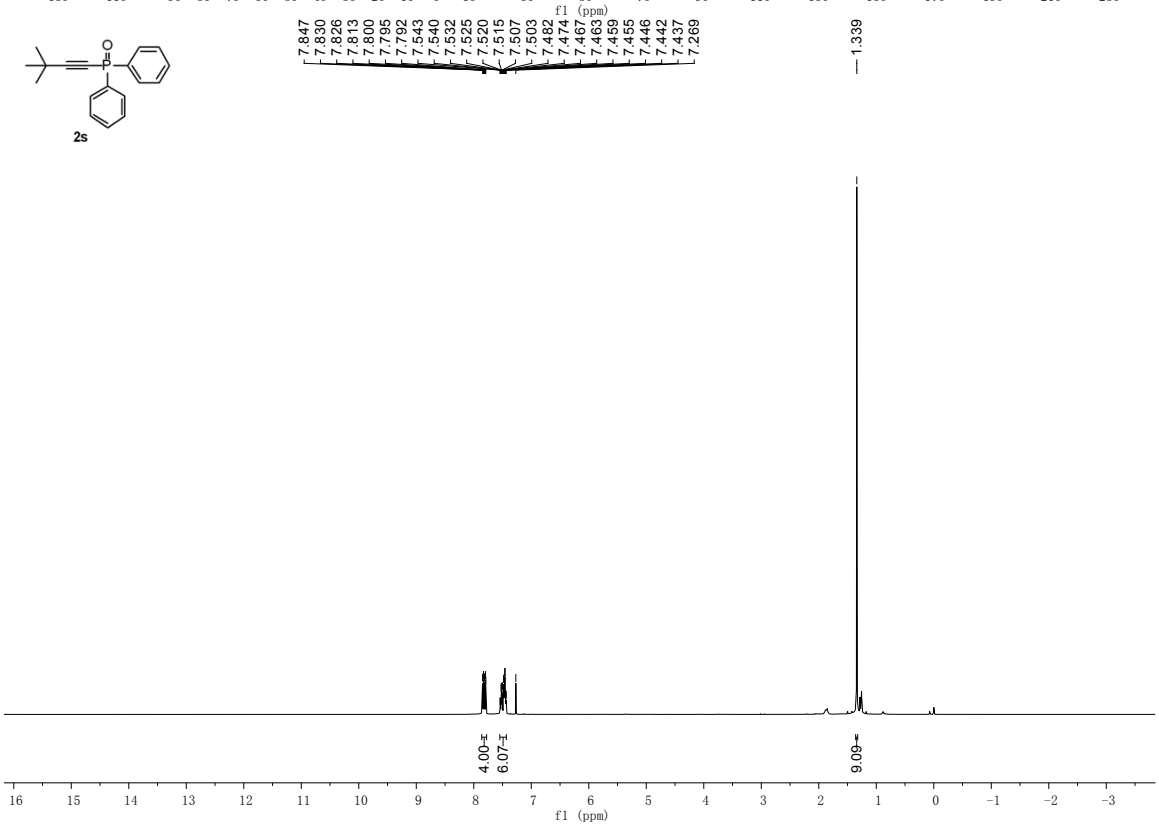
76.770
75.423
73.681
31.456
31.443
29.830
29.800
25.555
24.587


f1 (ppm)


2r
7.673
f1 (ppm)


2s
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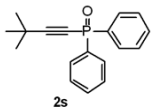
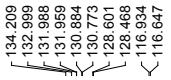
7.800
7.795
7.792
7.543
7.540
7.532
7.525
7.520
7.515
7.507
7.503
7.482
7.474
7.467
7.463
7.459
7.455
7.446
7.442
7.437
7.269
1.339
4.00
6.07
9.09
f1 (ppm)



2s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131.988
131.959
130.884
130.773
128.601
128.468
116.934
116.647


77.370
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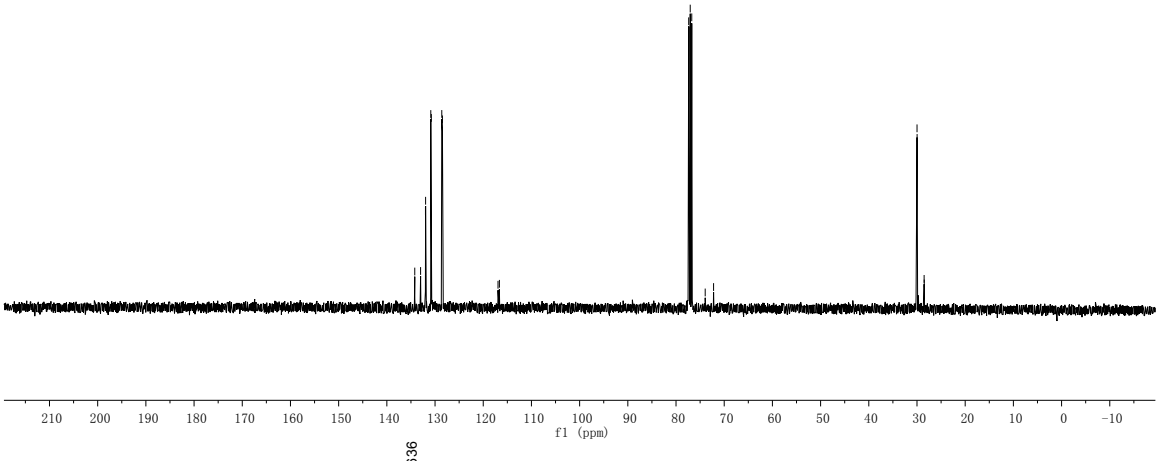
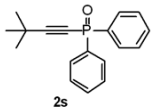
73.945
72.207

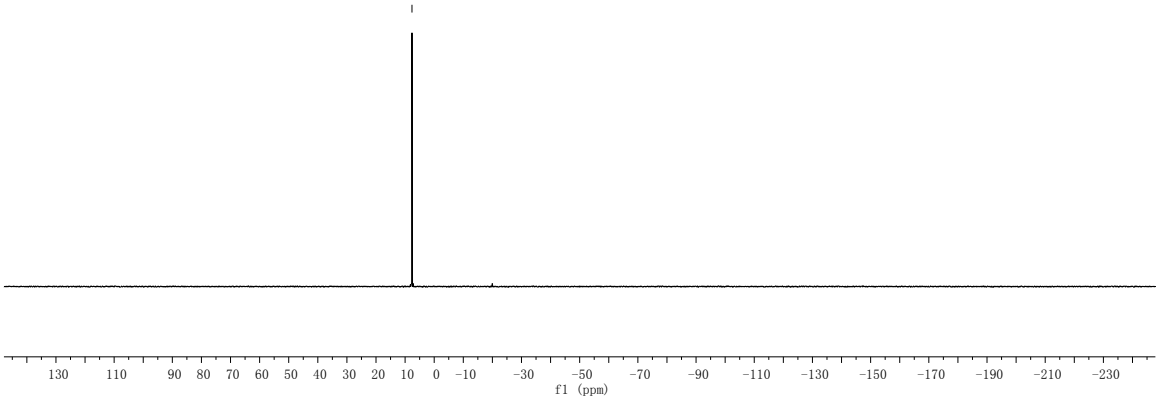

29.992
29.977
28.521
28.493

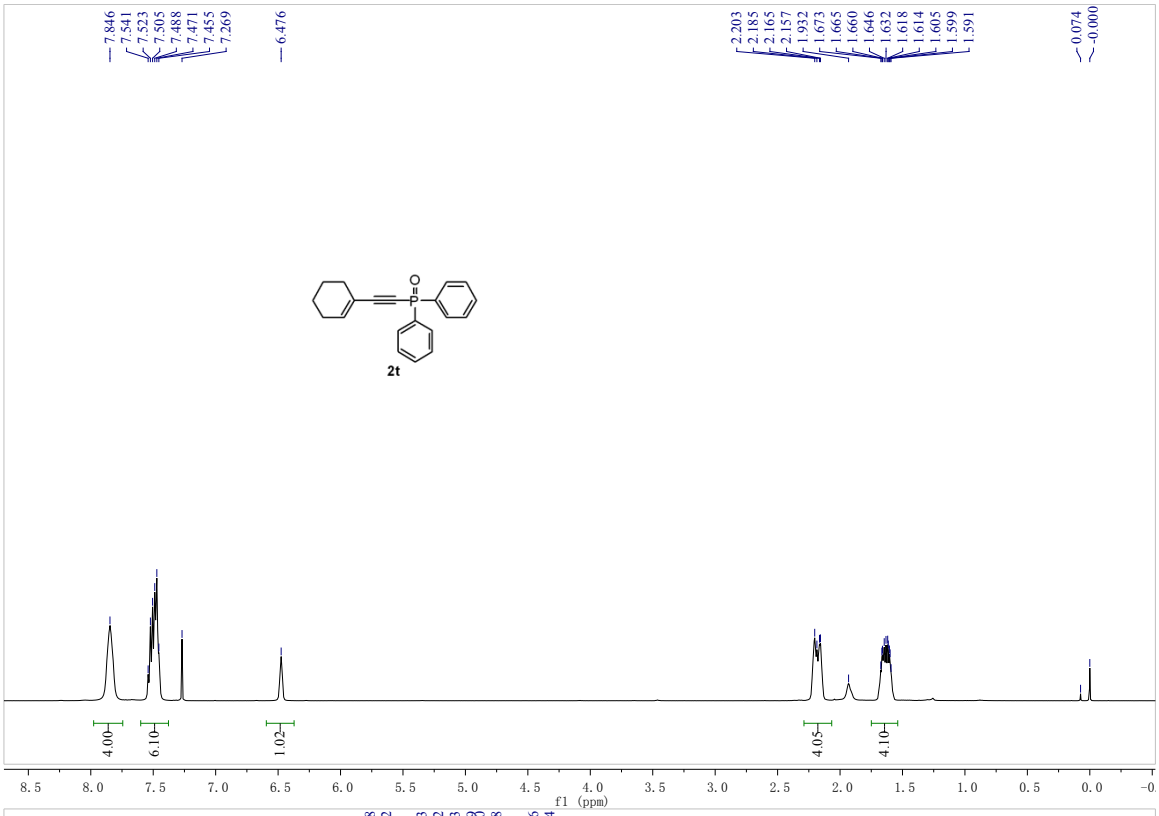

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)



2s


7.636


130 110 90 80 70 60 50 40 30 20 10 0 -10 -30 -50 -70 -90 -110 -130 -150 -170 -190 -210 -230
f1 (ppm)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7.541
7.523
7.505
7.488
7.471
7.455
7.269
6.476
2.203
2.185
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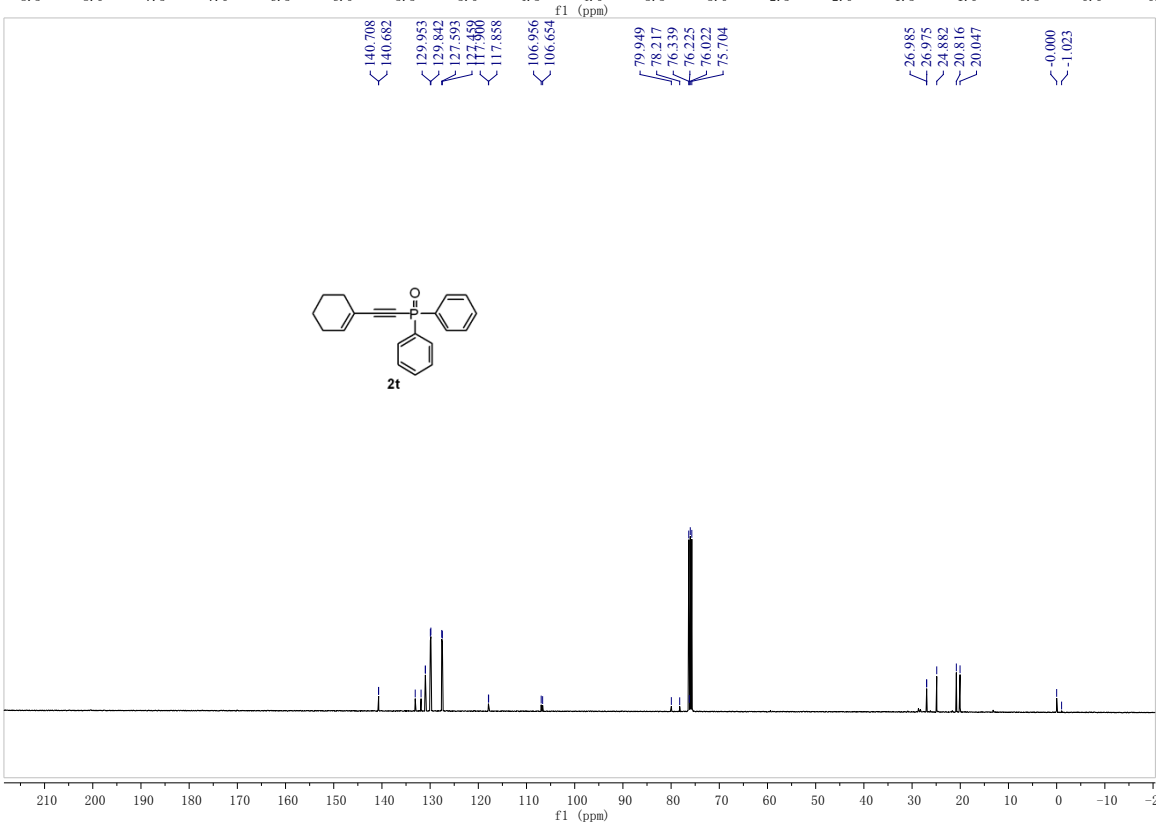
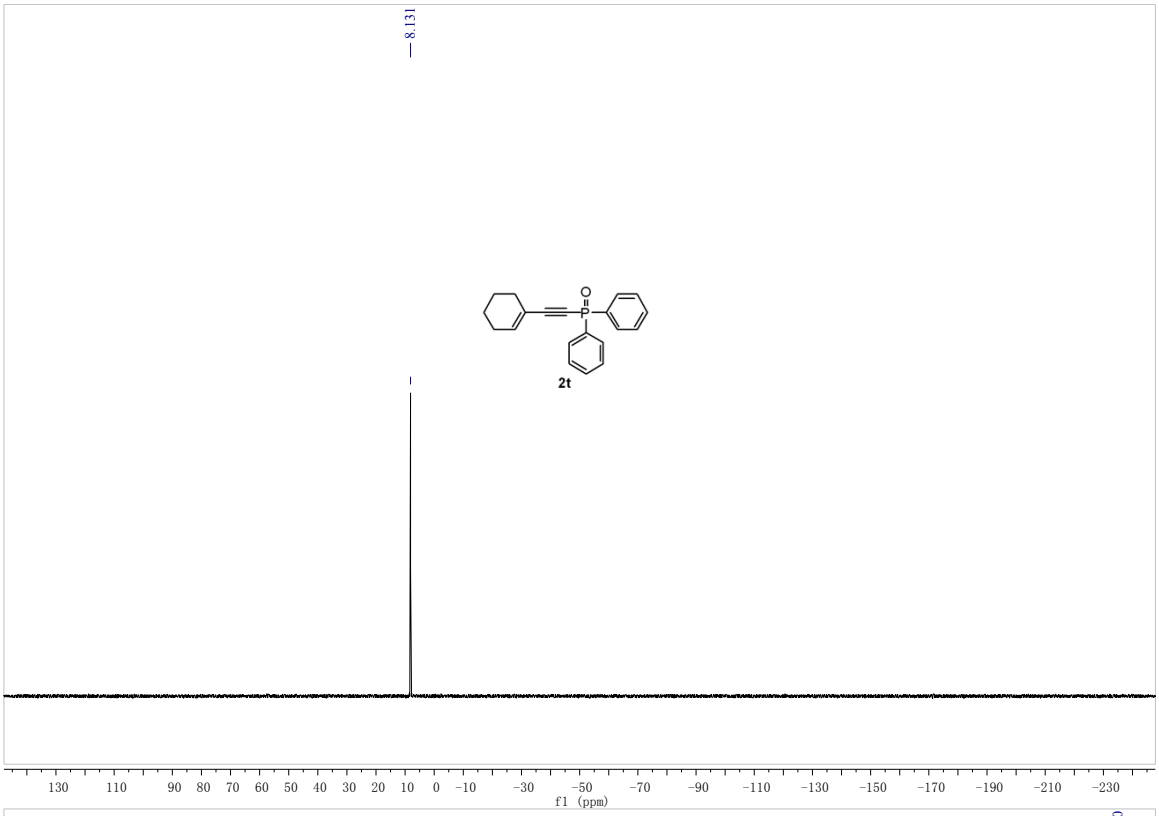
2.157
1.932
1.673
1.665
1.660
1.646
1.632
1.618
1.614
1.605
1.599
1.591
0.074
-0.000
2t
4.00
6.10
1.02
4.05
4.10
f1 (ppm)


140.708
140.682
129.953
129.842
127.593
117.858
106.956
106.654
79.949
78.217
76.339
76.225
76.022
75.704
26.985
26.975
24.882
20.816
20.047
-0.000
-1.023
2t
f1 (ppm)


8.131
2t
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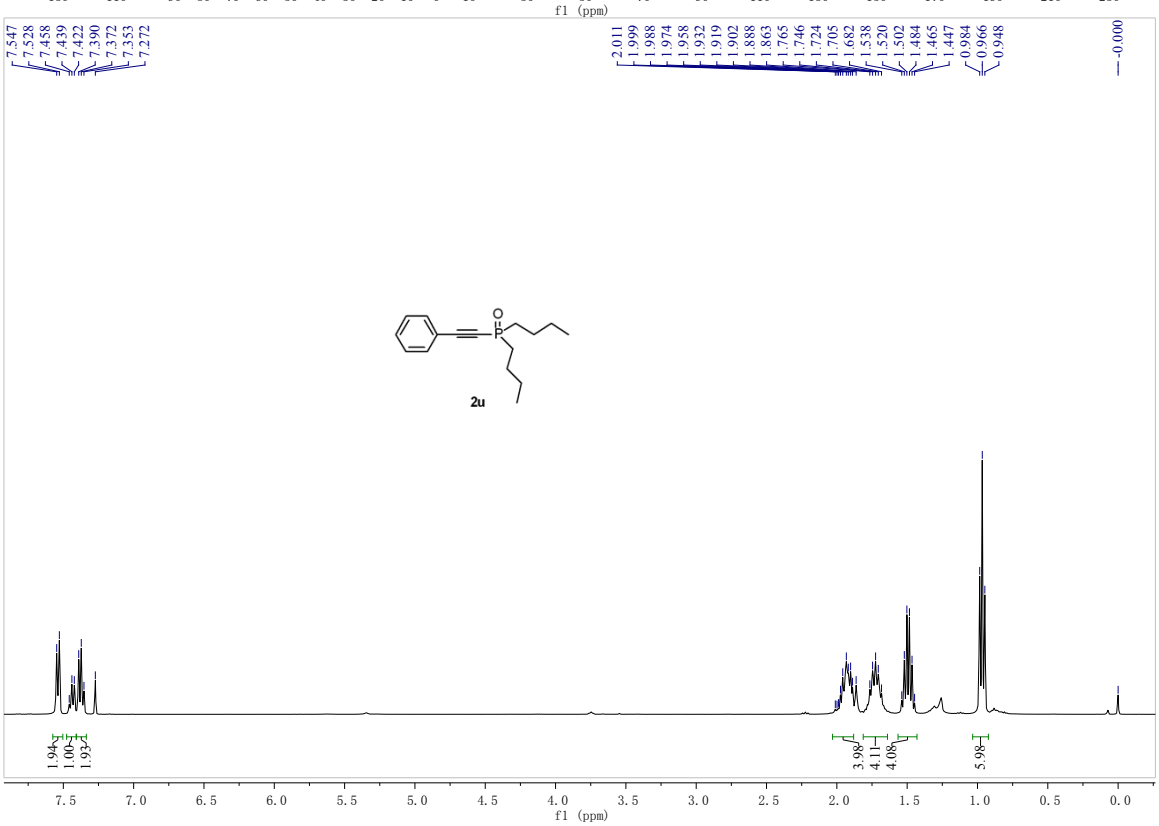
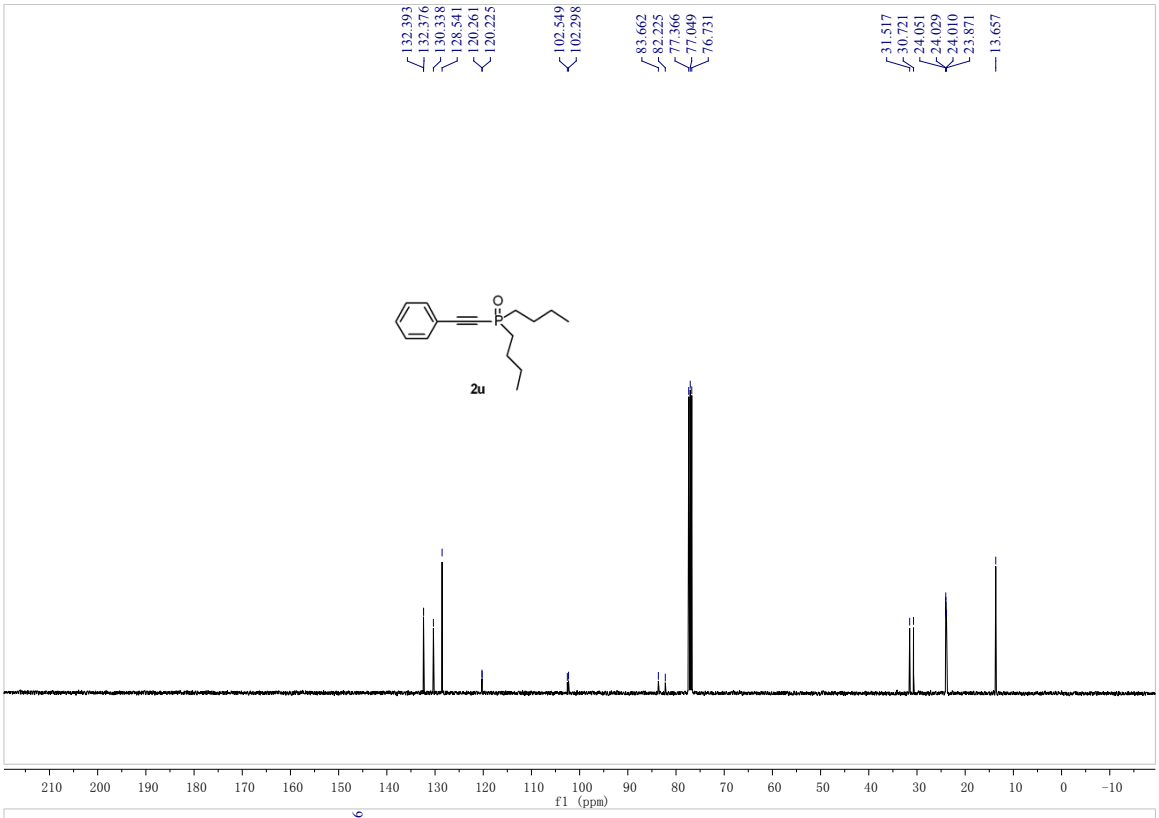
f1 (ppm)


7.547
7.528
7.458
7.439
7.422
7.390
7.372
7.353
7.272
2.011
1.999
1.988
1.974
1.958
1.932
1.919
1.902
1.888
1.863
1.765
1.746
1.724
1.705
1.682
1.538
1.520
1.502
1.484
1.465
1.447
0.984
0.966
0.948
-0.000
2u
1.94
1.00
1.93
3.98
4.11
4.08
5.98
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
f1 (ppm)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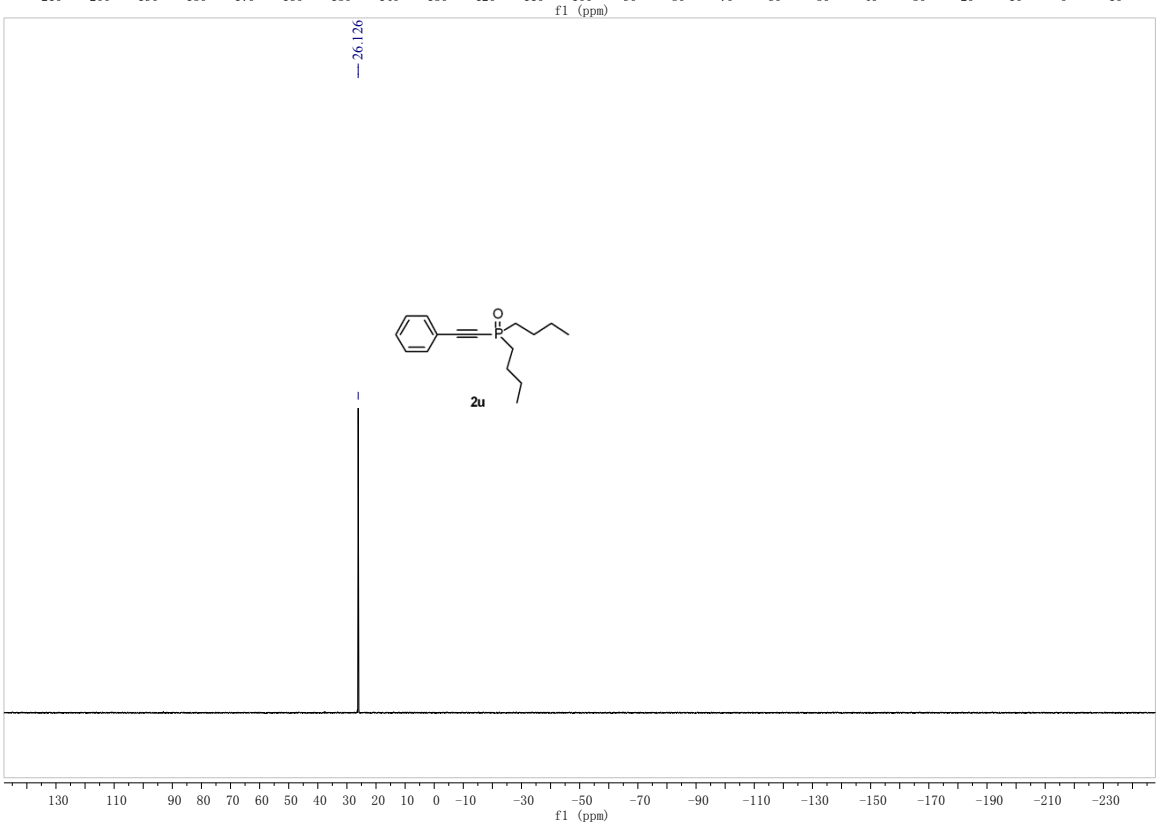
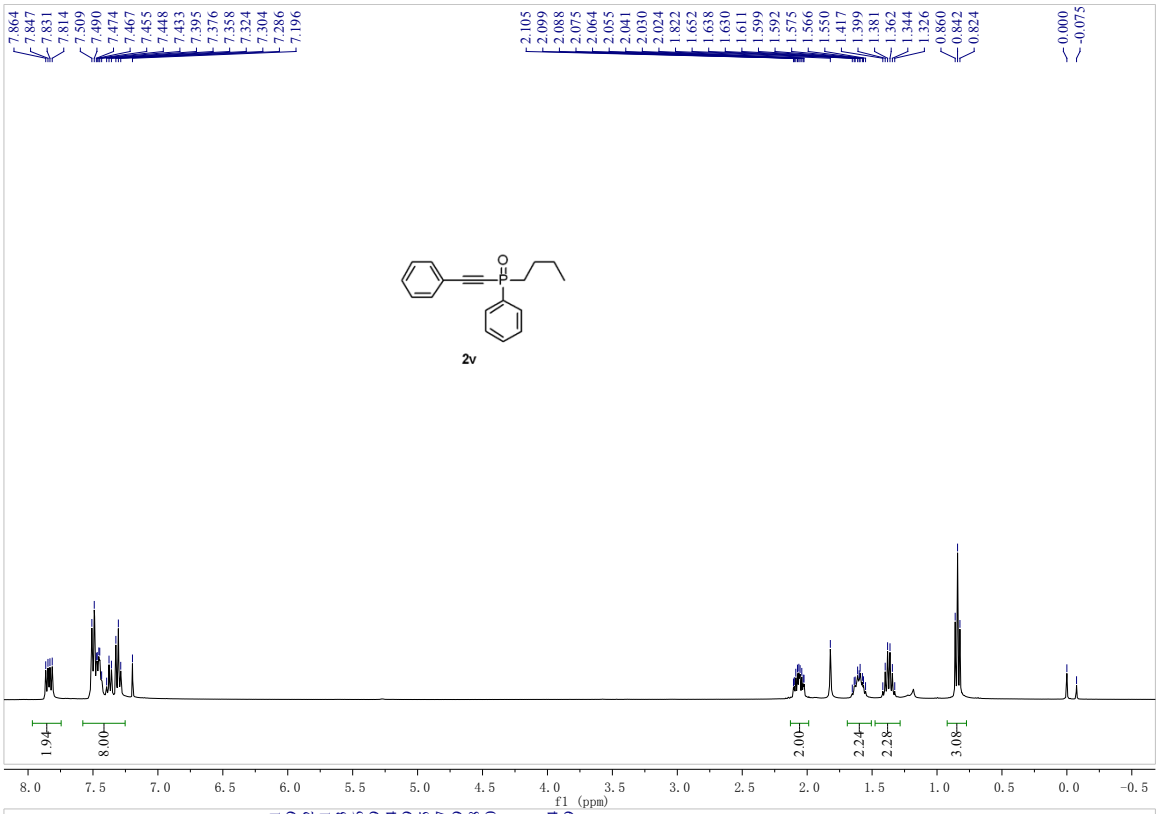
132.376
130.338
128.541
120.261
120.225
102.549
102.298
83.662
82.225
77.366
77.049
76.731
31.517
30.721
24.051
24.029
24.010
23.871
13.657
2u
f1 (ppm)


26.126
2u
f1 (ppm)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7.847
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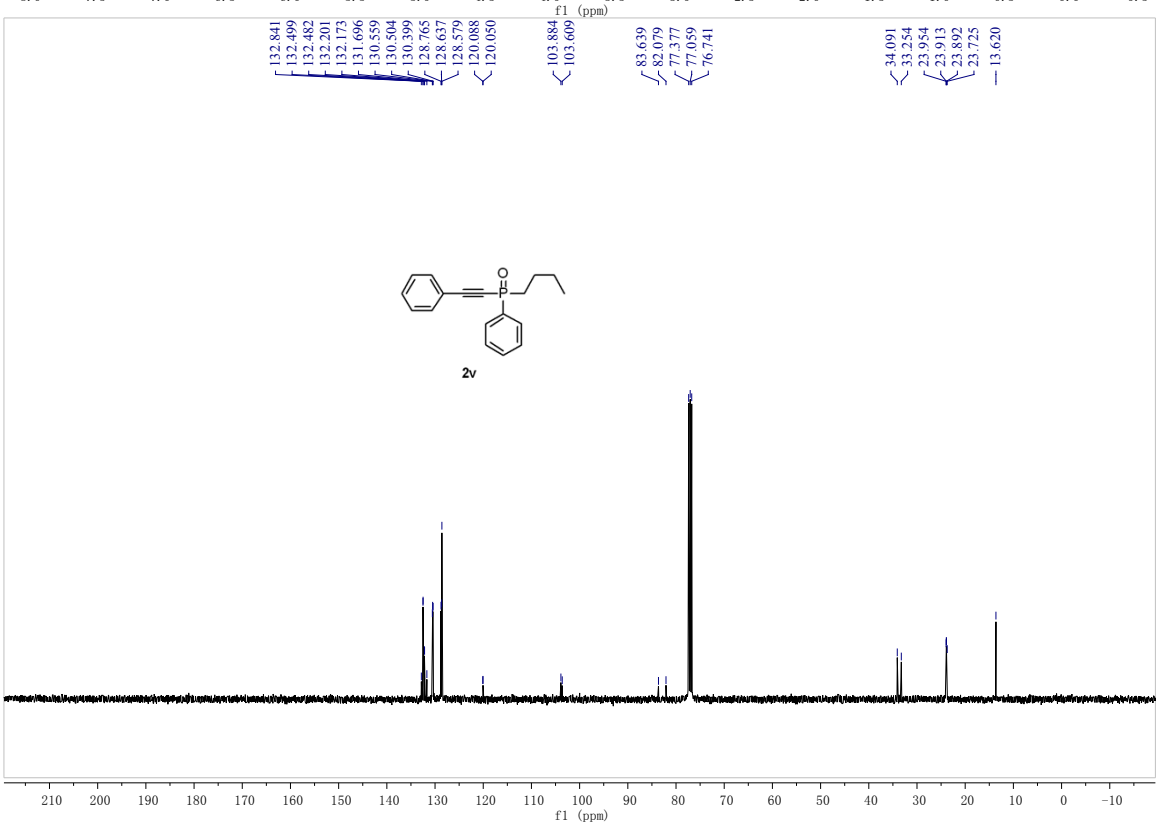
7.814
7.509
7.490
7.474
7.467
7.455
7.448
7.433
7.395
7.376
7.358
7.324
7.304
7.286
7.196
2.105
2.099
2.088
2.075
2.064
2.055
2.041
2.030
2.024
1.822
1.652
1.638
1.630
1.611
1.599
1.592
1.575
1.566
1.550
1.417
1.399
1.381
1.362
1.344
1.326
0.860
0.842
0.824
0.000
-0.075
2v
1.94
8.00
2.00
2.24
2.28
3.08
f1 (ppm)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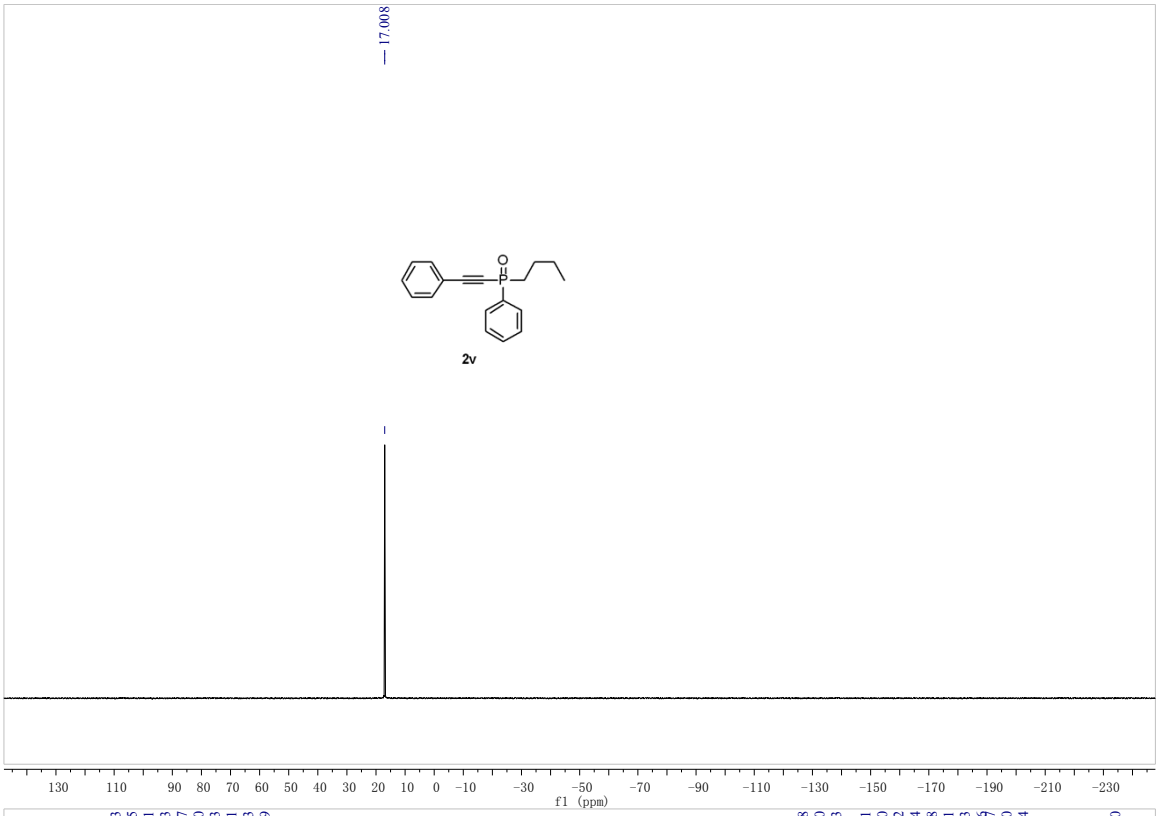
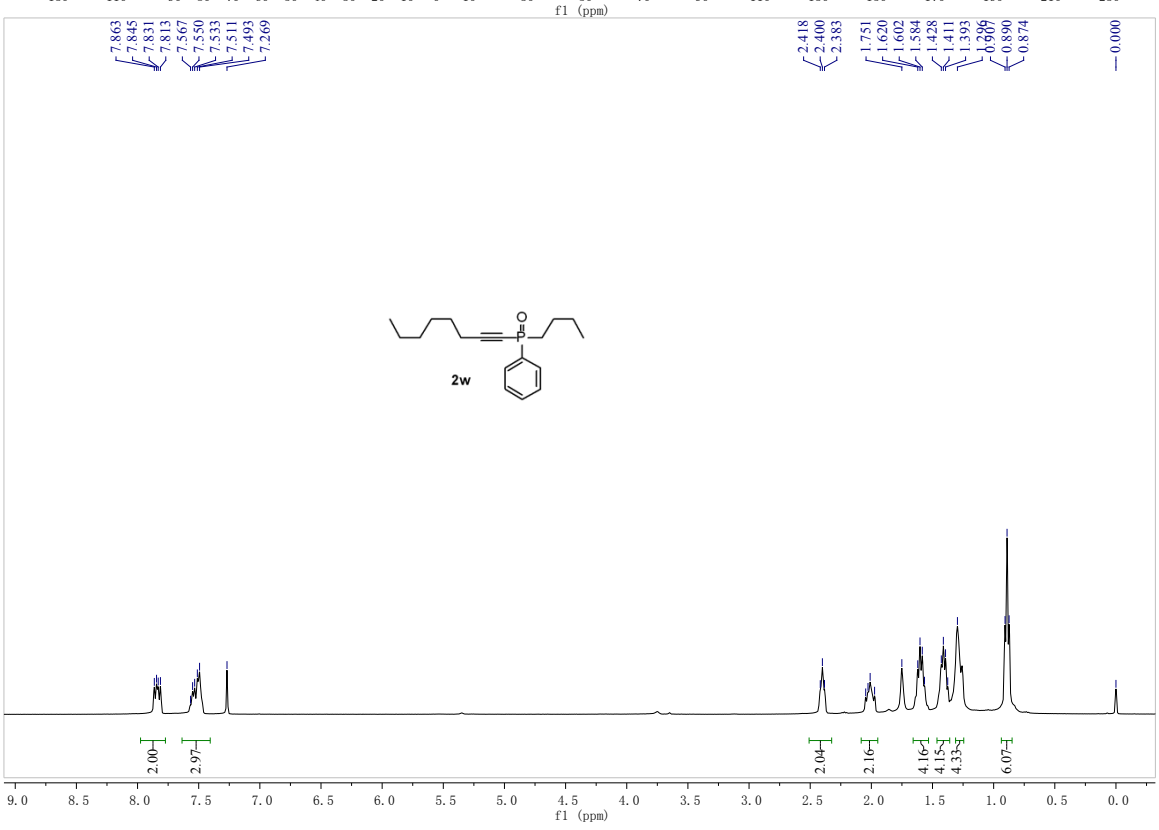
132.499
132.482
132.201
132.173
131.696
130.559
130.504
130.399
128.765
128.637
128.579
120.088
120.050
103.884
103.609
83.639
82.079
77.377
77.059
76.741
34.091
33.254
23.954
23.913
23.892
23.725
13.620
2v
f1 (ppm)


17.008
2v
130 110 90 80 70 60 50 40 30 20 10 0 -10 -30 -50 -70 -90 -110 -130 -150 -170 -190 -210 -230
f1 (ppm)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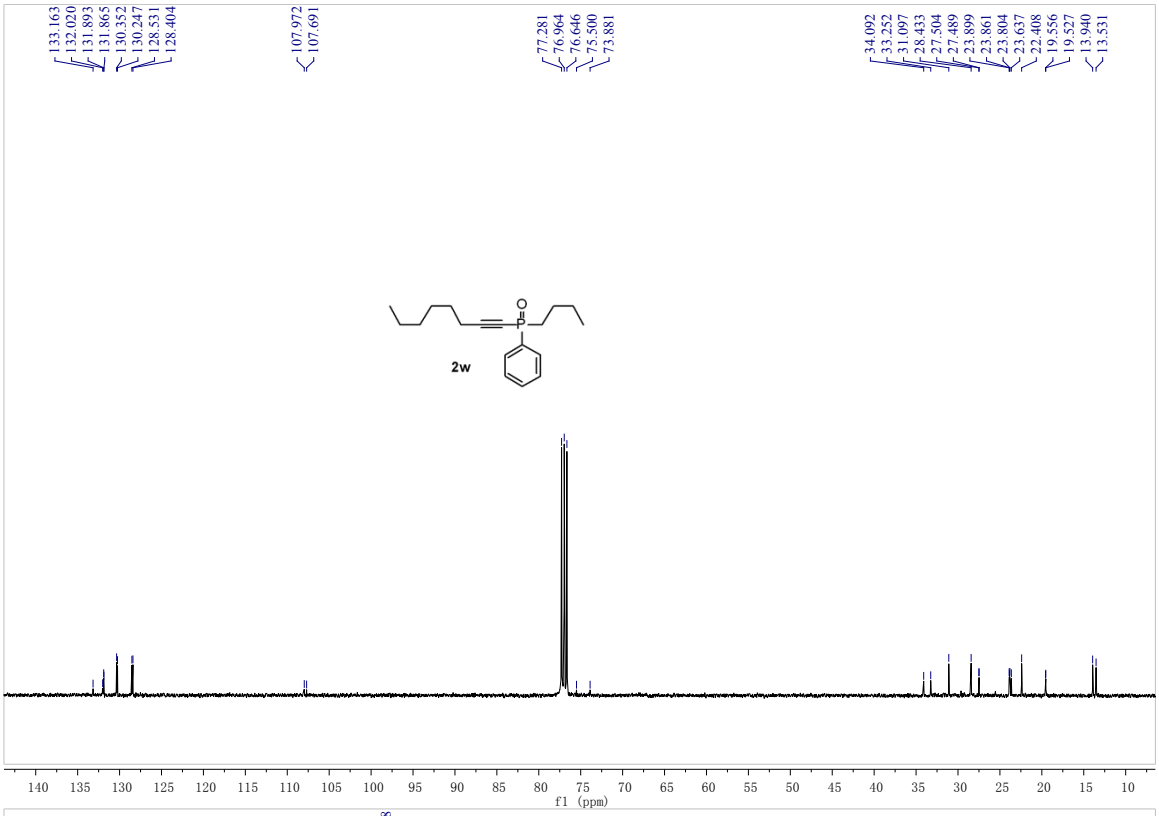
7.845
7.831
7.813
7.567
7.550
7.533
7.511
7.493
7.269
2.418
2.400
2.383
1.751
1.620
1.602
1.584
1.428
1.411
1.393
0.890
0.874
0.000
2w
2.00
2.97
2.04
2.16
4.16
4.15
4.33
6.07
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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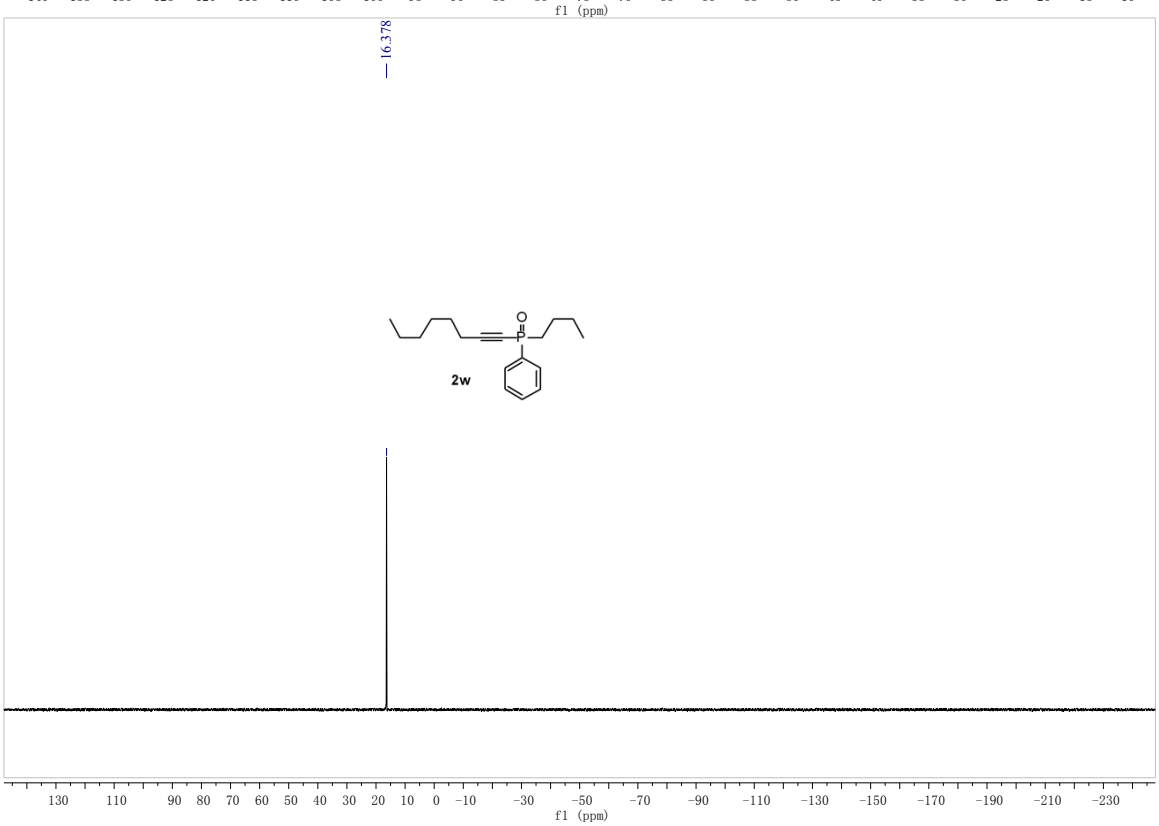
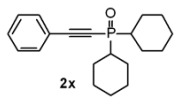
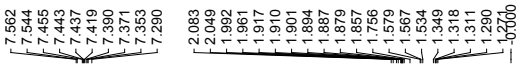
132.020
131.893
131.865
130.352
130.247
128.531
128.404
107.972
107.691
77.281
76.964
76.646
75.500
73.881
34.092
33.252
31.097
28.433
27.504
27.489
23.899
23.861
23.804
23.637
22.408
19.556
19.527
13.940
13.531
2w
f1 (ppm)


16.378
2w
f1 (ppm)


2x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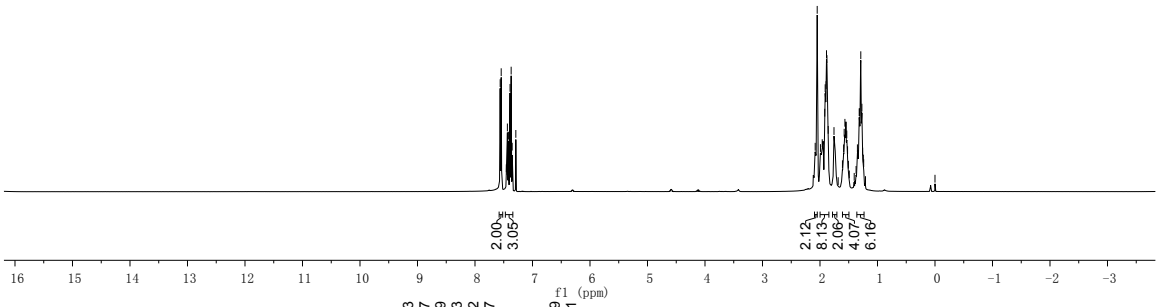
7.455
7.443
7.437
7.419
7.390
7.371
7.353
7.290
2.083
2.049
2.049
1.992
1.961
1.917
1.910
1.901
1.894
1.887
1.879
1.857
1.756
1.579
1.567
1.534
1.349
1.318
1.311
1.290
1.271
0.000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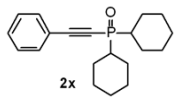
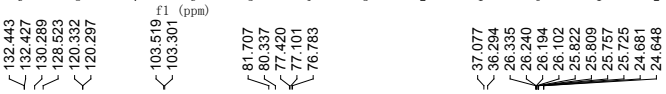
3.05
2.12
8.13
2.06
4.07
6.16
f1 (ppm)


2x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120.297
103.519
103.301
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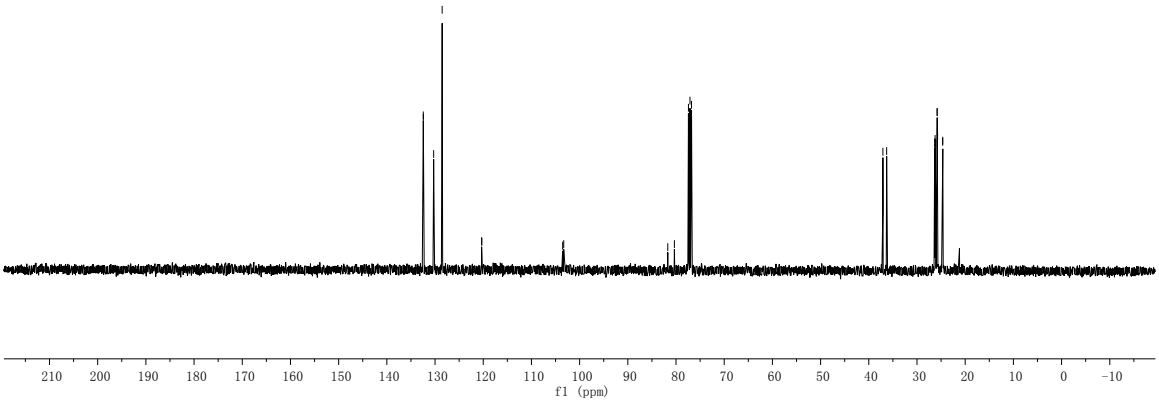
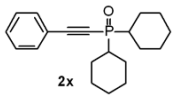
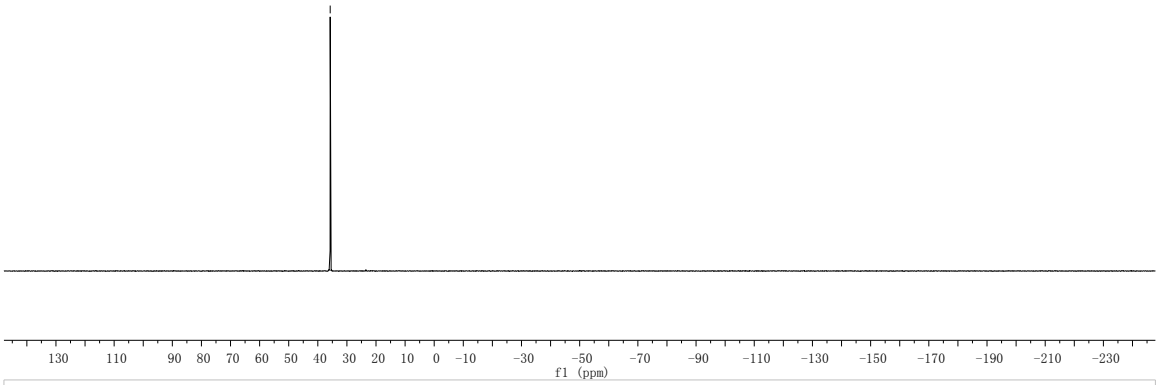
80.337
77.420
77.101
76.783
37.077
36.294
26.335
26.240
26.194
26.102
25.822
25.809
25.757
25.725
24.681
24.648

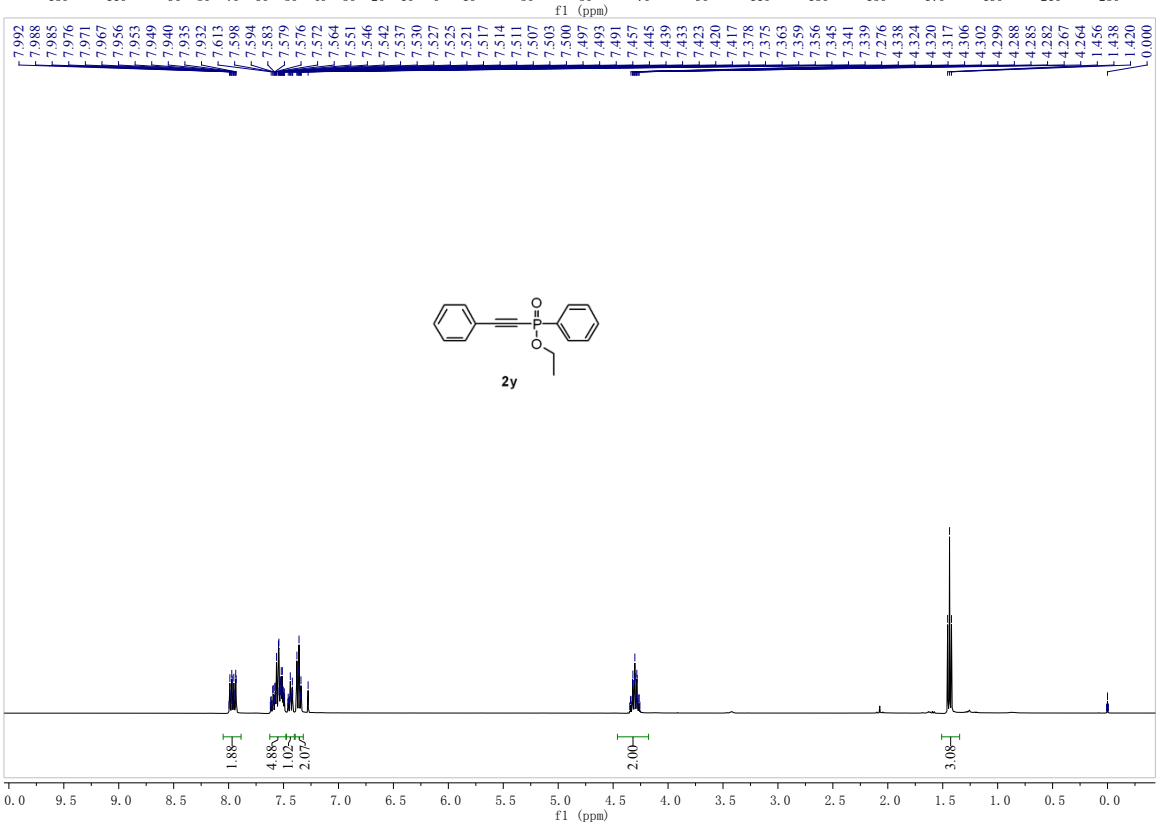

f1 (ppm)



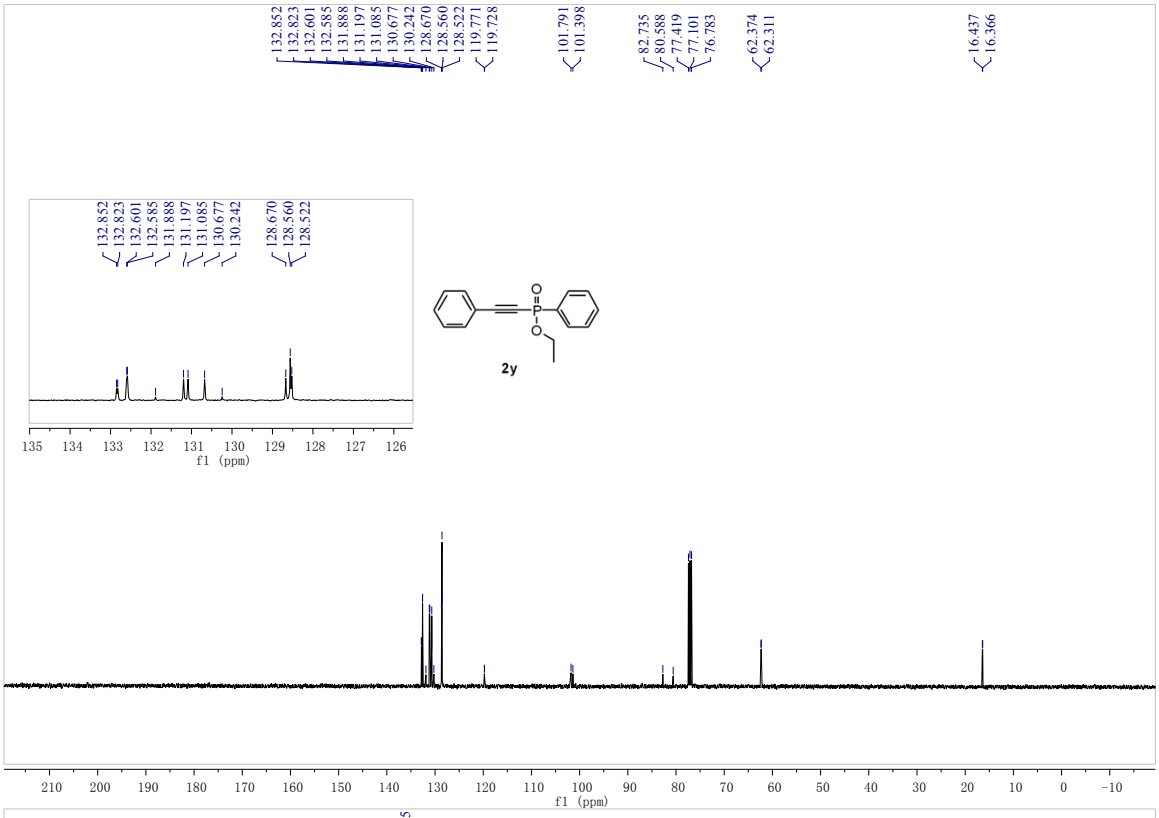
2x


35.745


130 110 90 80 70 60 50 40 30 20 10 0 −10 −30 −50 −70 −90 −110 −130 −150 −170 −190 −210 −230
f1 (ppm)


7.992 7.988 7.985 7.976 7.971 7.967 7.956 7.953 7.949 7.940 7.935 7.932 7.613 7.598 7.594 7.583 7.579 7.576 7.572 7.564 7.551 7.546 7.542 7.537 7.530 7.527 7.525 7.521 7.517 7.514 7.511 7.507 7.503 7.500 7.497 7.493 7.491 7.457 7.445 7.439 7.433 7.423 7.420 7.417 7.378 7.375 7.363 7.359 7.356 7.345 7.341 7.339 7.276 4.338 4.324 4.320 4.317 4.306 4.302 4.299 4.288 4.285 4.282 4.267 4.264 1.456 1.438 1.420 0.000
1.88 4.88 1.02 2.07 2.00 3.08
0.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

2y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128.560
128.522
119.771
119.728
101.791
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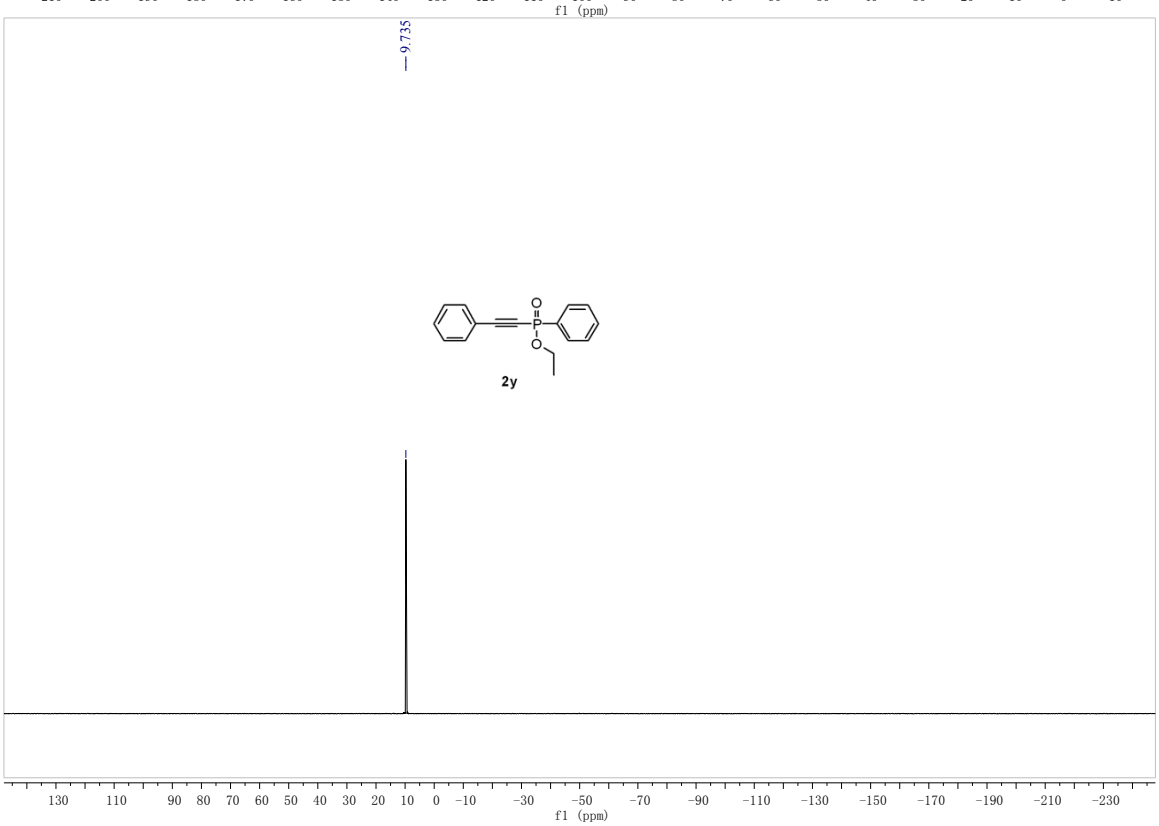
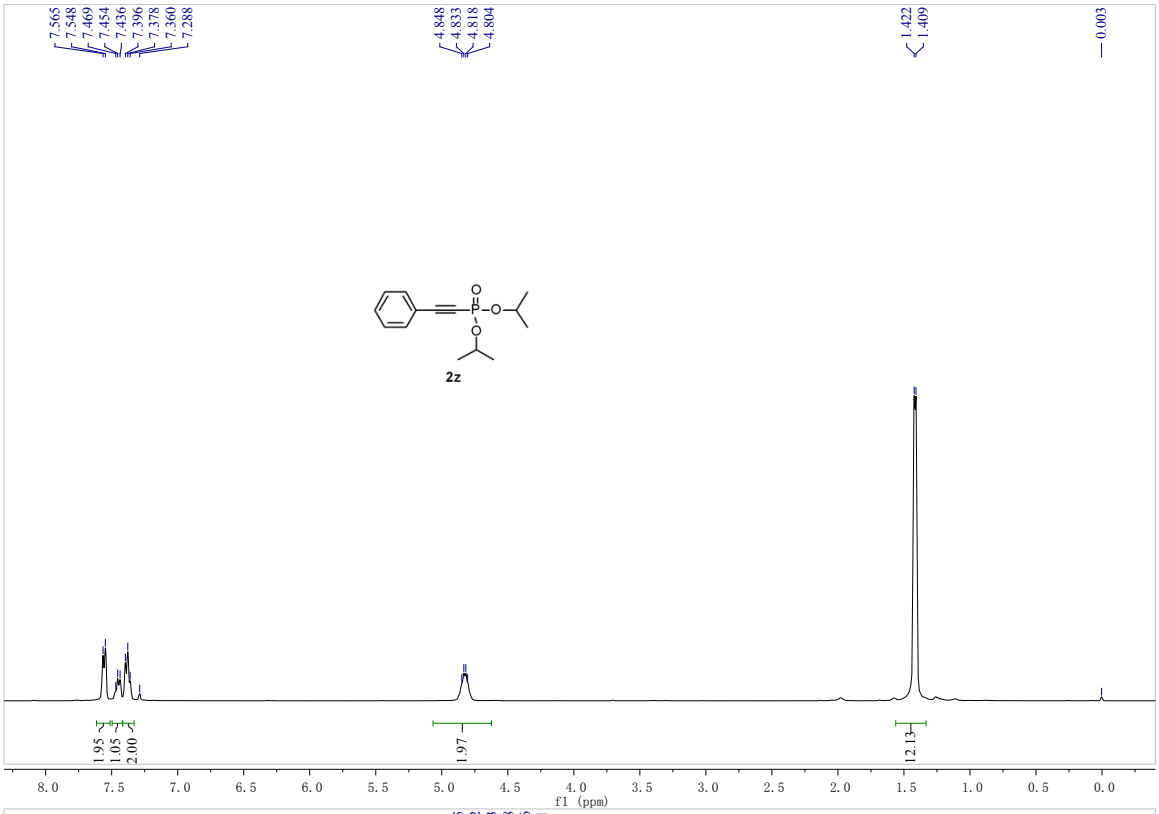
62.311
16.437
16.366
2y
f1 (ppm)


9.735
2y
f1 (ppm)


7.565
7.548
7.469
7.454
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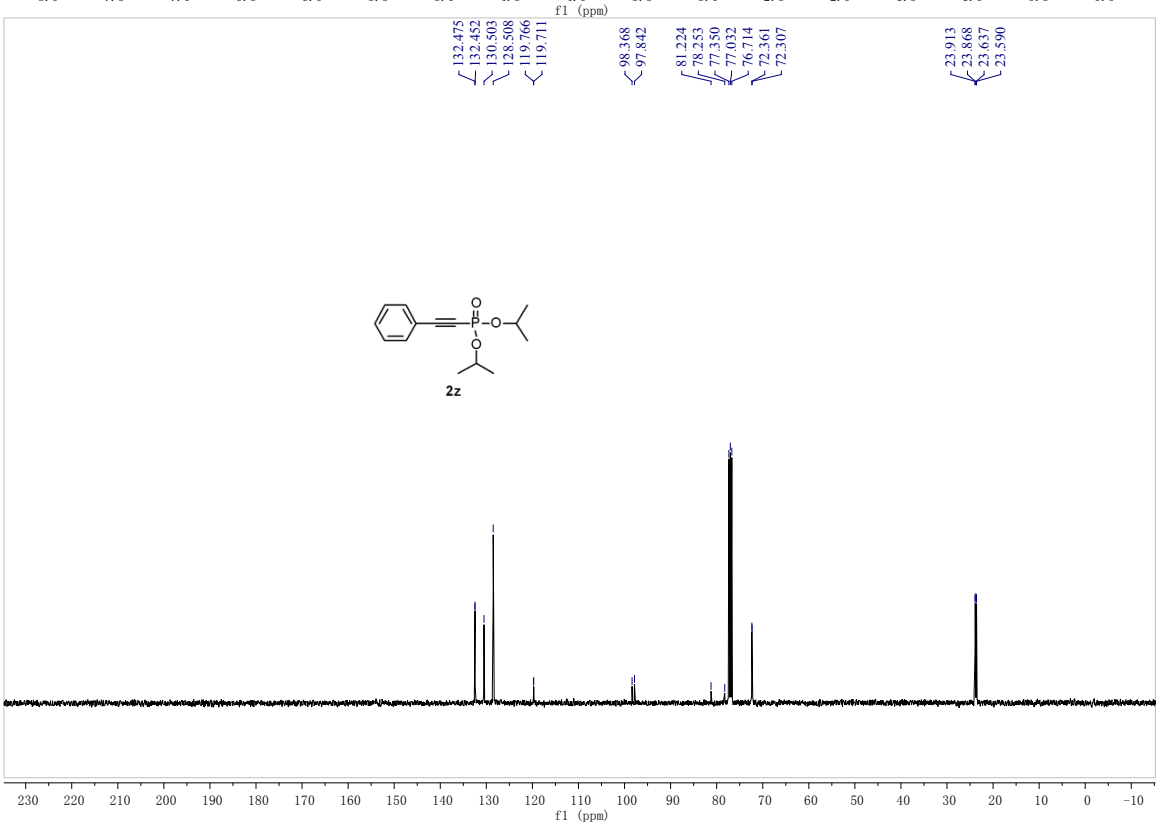
7.396
7.378
7.360
7.288
4.848
4.833
4.818
4.804
1.422
1.409
0.003
2z
1.95
1.05
2.00
1.97
12.13
f1 (ppm)


132.475
132.452
130.503
128.508
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97.842
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78.253
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76.714
72.361
72.307
23.913
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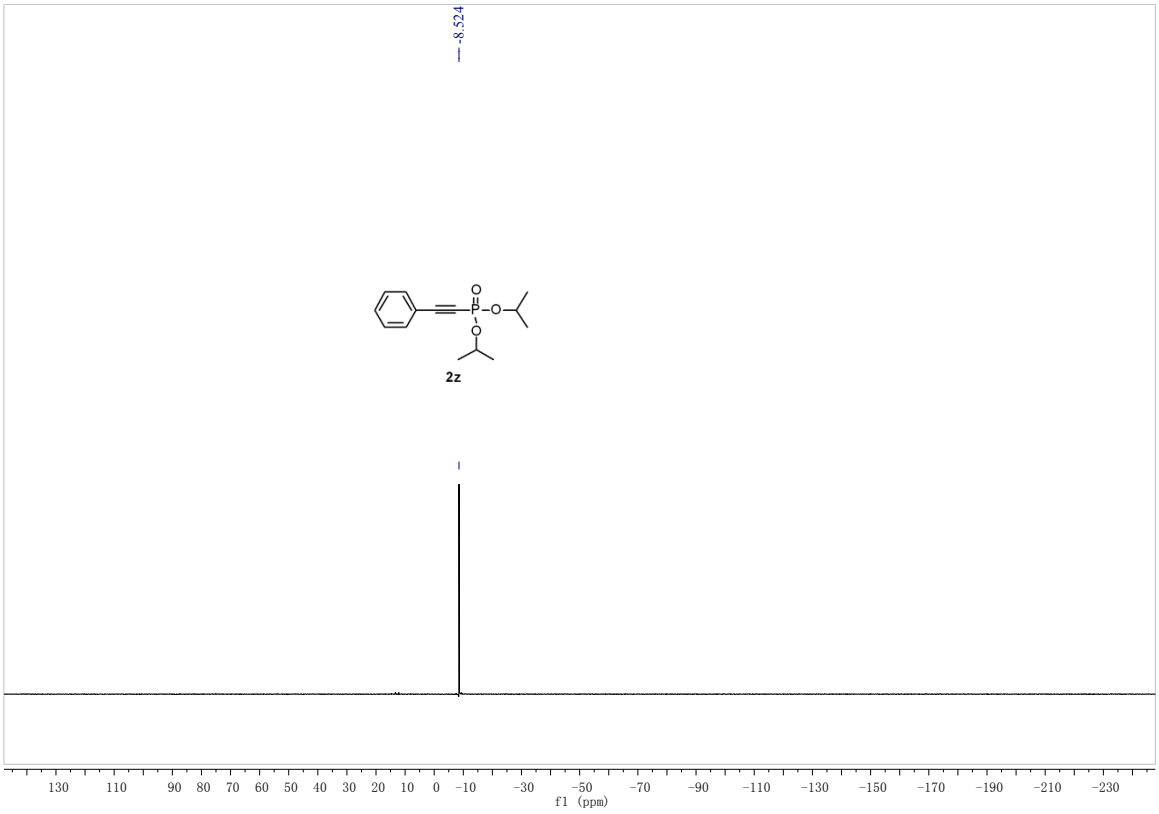
23.637
23.590
2z
f1 (ppm)


-8.524
2z
130 110 90 80 70 60 50 40 30 20 10 0 -10 -30 -50 -70 -90 -110 -130 -150 -170 -190 -210 -230
f1 (ppm)