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Supporting information for

Efficient Heterogeneous Hydroboration of Alkynes: Enhancing the Catalytic Activity by Cu(0) Incorporated $CuFe_2O_4$ Nanoparticles

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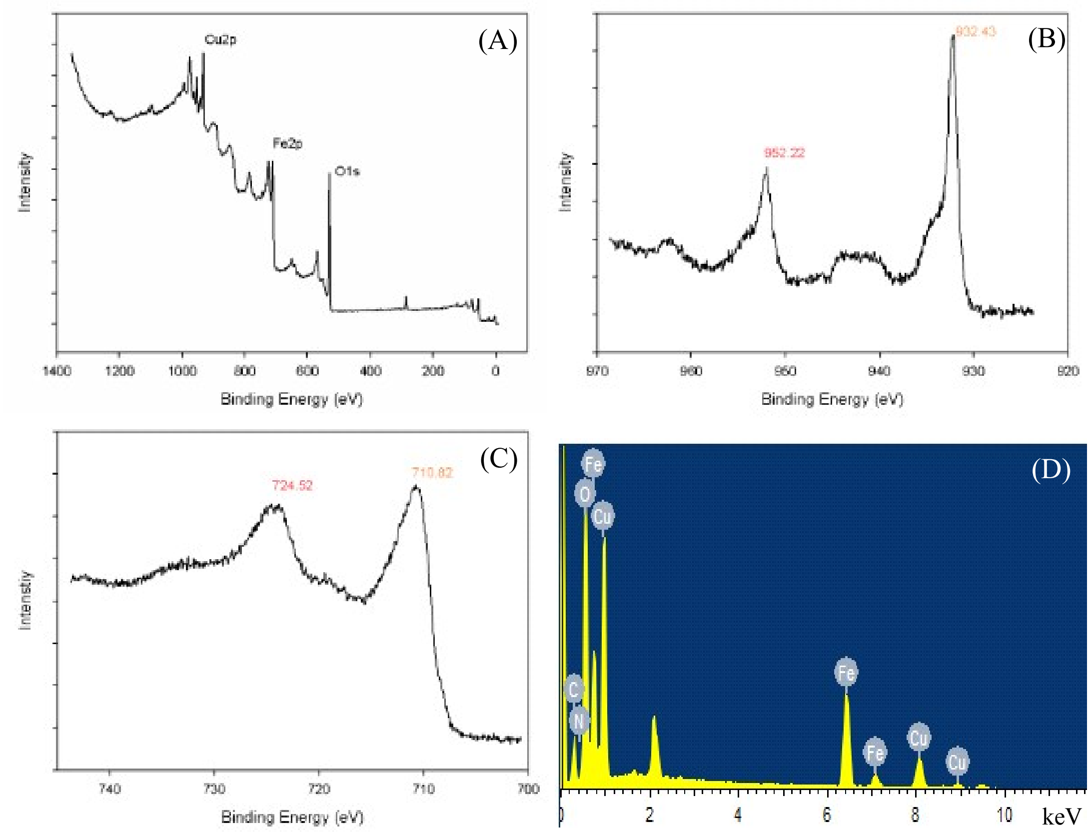
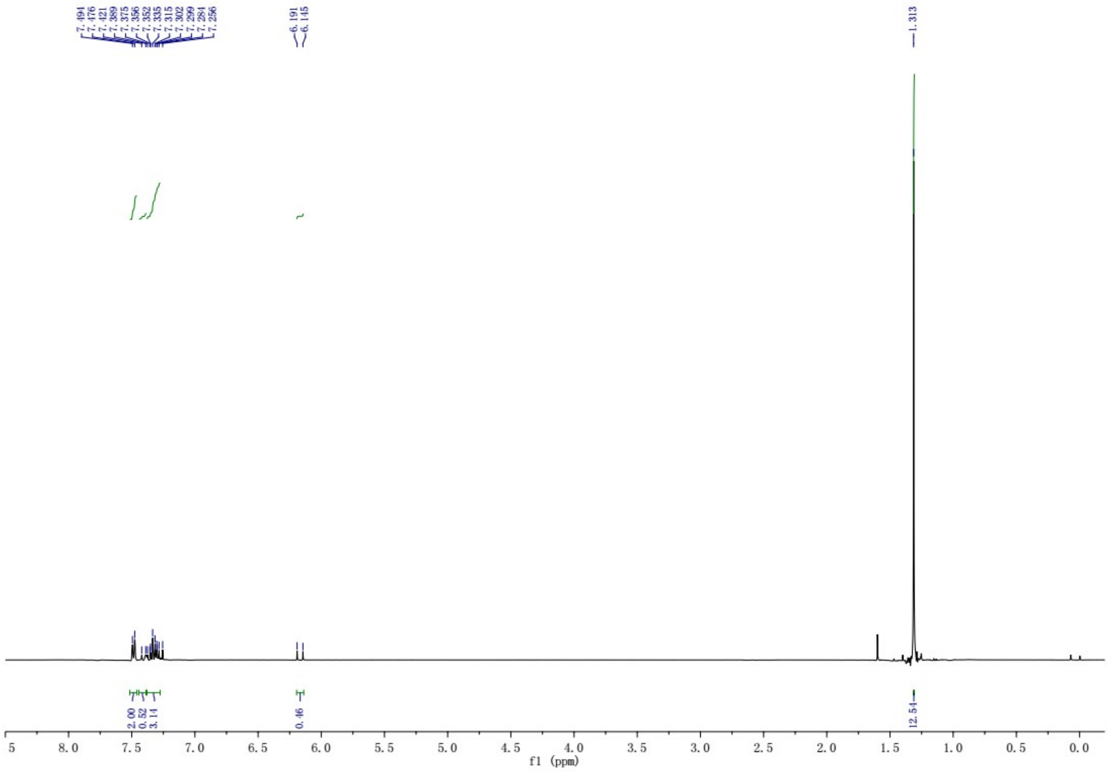


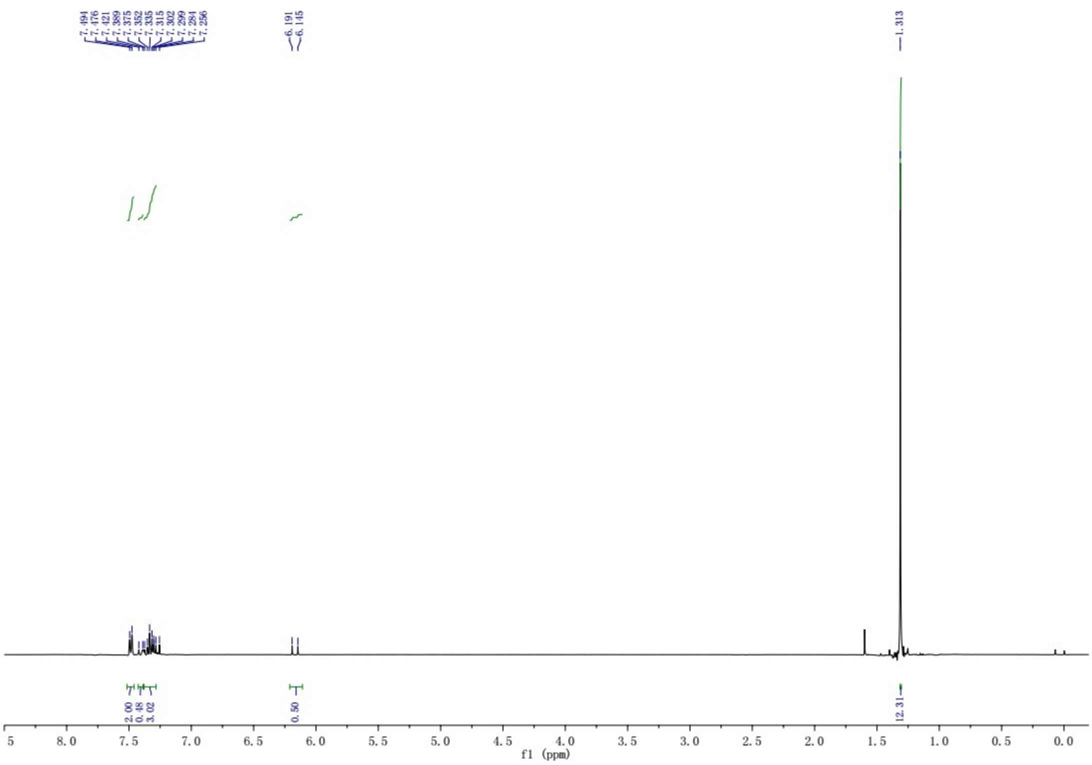
Fig. S1. The XPS spectrum of Cu-$CuFe_2O_4$ MNPs: (A) survey, (B) Cu 2p, (C) Fe 2p and SEM-EDS of Cu-$CuFe_2O_4$ MNPs (D).

2. The ^{1}H NMR spectrum of deuterium-labeling experiments

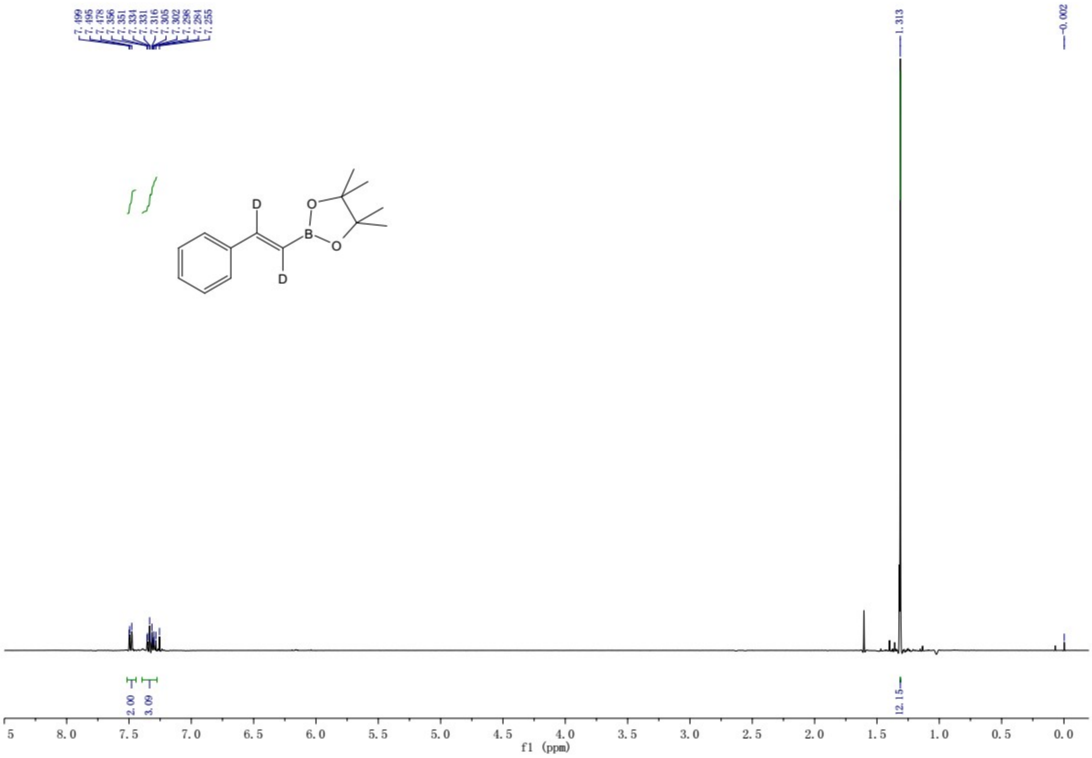
2.1 The hydroboration reaction of phenylacetylene with B_2Pin_2 in methanol-d_4



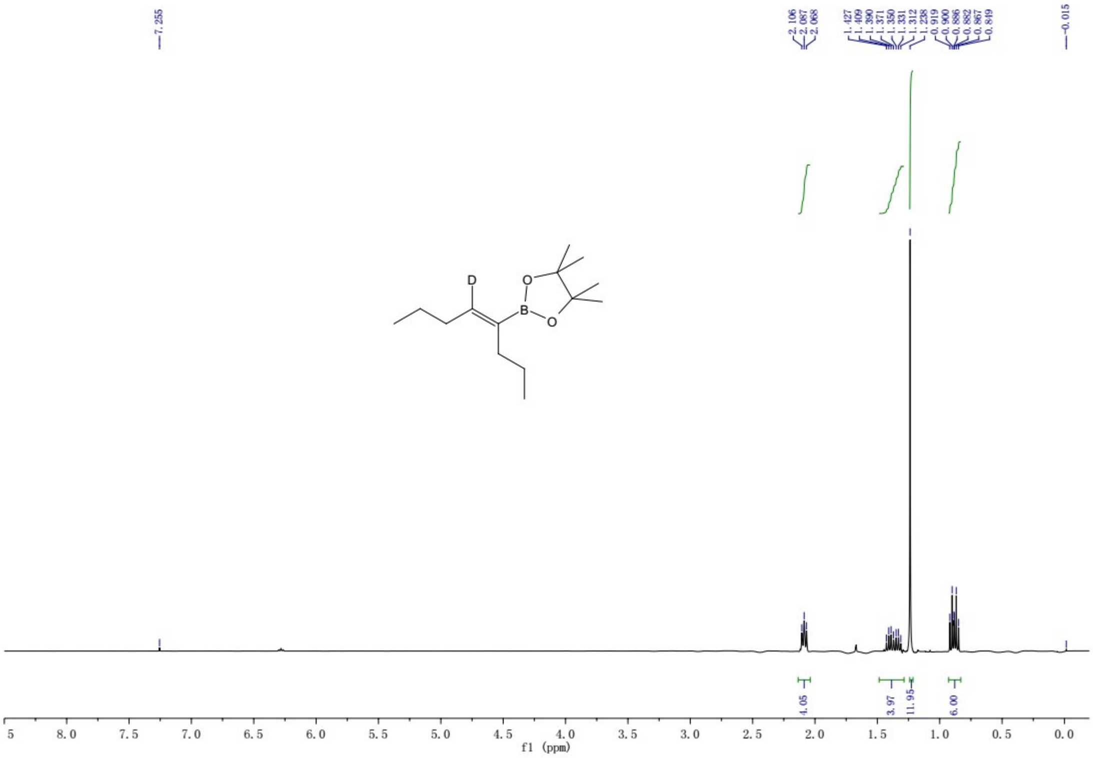
2.2 The hydroboration reaction of phenylacetylene-d_1 with B_2Pin_2 in methanol



2.3 The hydroboration reaction of phenylacetylene-d_1 with B_2Pin_2 in methanol- d_4



2.4 The hydroboration reaction of oct-4-yne with B_2Pin_2 in methanol- d_4



3. Photographs of before reaction and after reaction of B_2Pin_2 and phenylacetylene

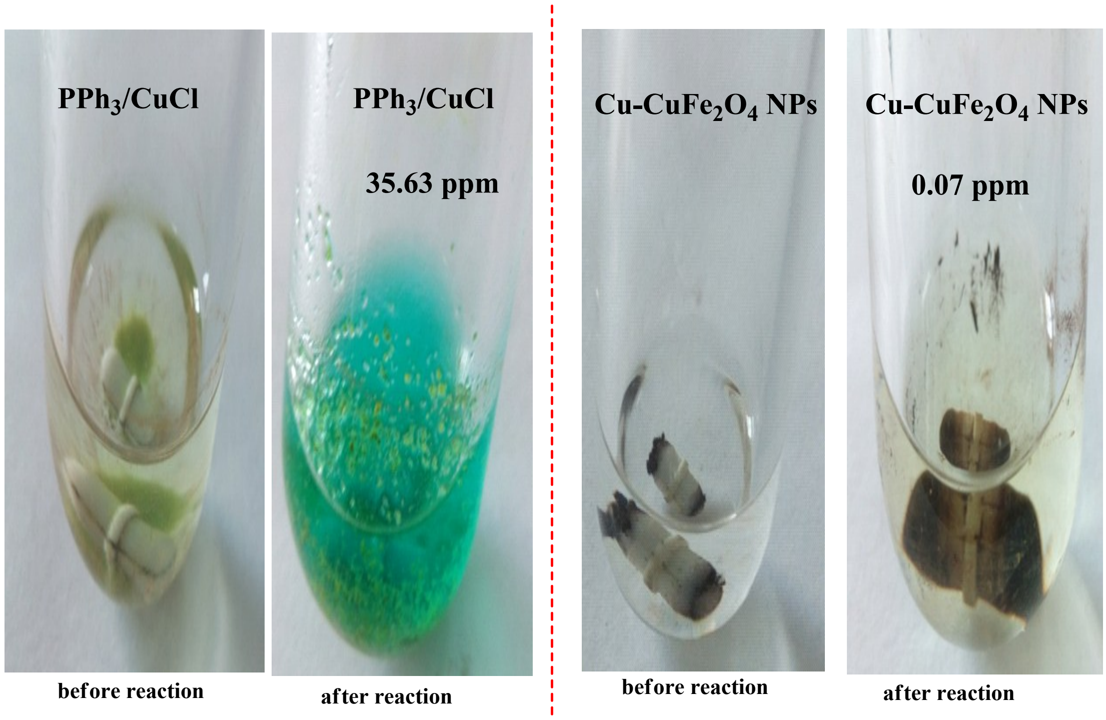


Fig. S2. Left two are CuCl/PPh_3 system, and the right two are Cu-$CuFe_2O_4$ NPs catalytic system.

4. TEM images of Cu-$CuFe_2O_4$ NPs before and after reaction

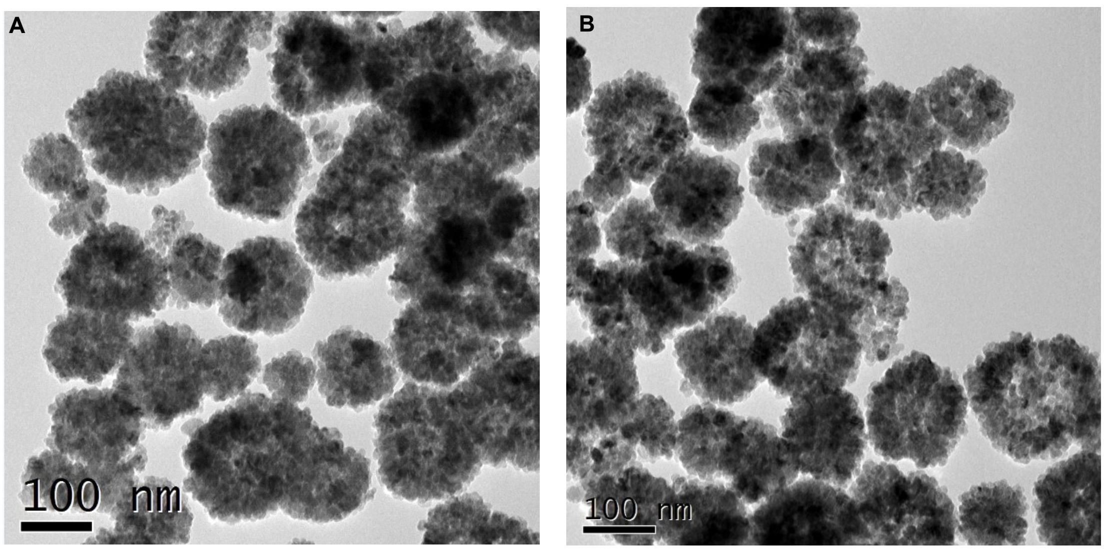


Fig. S3. TEM images of Cu-$CuFe_2O_4$ NPs: (A) before reaction and (B) after reused six times.

5. The photographs of reusability of Cu-$CuFe_2O_4$ catalyst

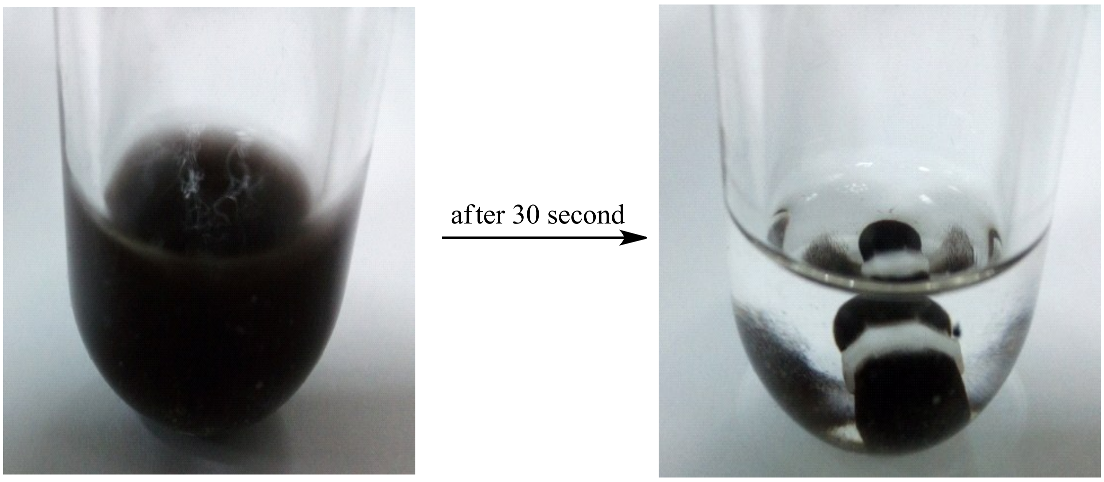


Fig. S4. The reusability of $Cu\text{-}CuFe_2O_4$ catalyst in the hydroboration of alkynes

6. PXRD of $Cu\text{-}CuFe_2O_4$ catalyst after reused six times.

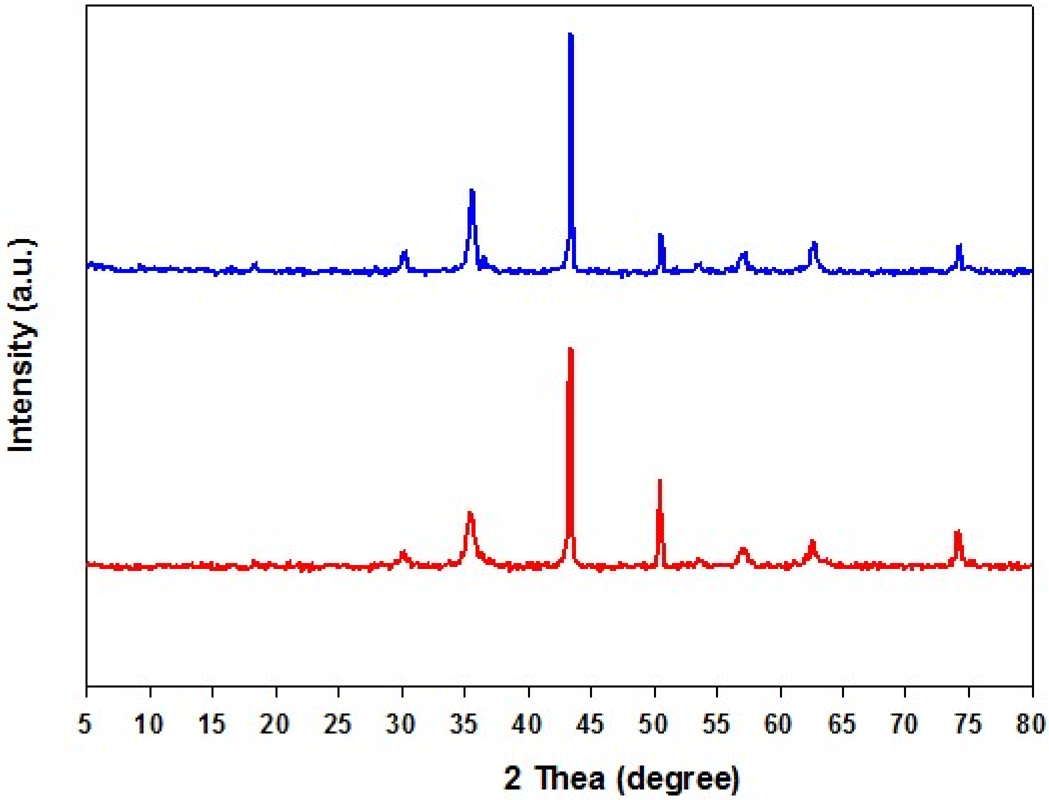


Fig. S5. X-ray powder diffractogram of the synthesized $Cu\text{-}CuFe_2O_4$ nanoparticles (red line) and after reused six times (blue line).

7. Analytic data of the obtained compounds:

(E)-4,4,5,5-tetramethyl-2-styryl-1,3,2-dioxaborolane (2a)[1]: Colorless oil, yield 95%. ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.477-7.496 (m, 2H), 7.470 (d, J = 18.8 Hz, 1H), 7.285-7.351 (m, 3H), 6.168 (d, J = 18.4 Hz, 1H), 1.312 (s, 12H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 149.50, 137.41, 128.89, 128.56, 127.04, 83.35, 24.81. GC-MS: M^+ m/z 230.2.

(E)-4,4,5,5-tetramethyl-2-(4-methylstyryl)-1,3,2-dioxaborolane (2b)[2]: Colorless oil, yield 90%. ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.345-7.392 (m, 3H), 7.127-7.147 (m, 2H), 6.100 (d, J = 18.4 Hz, 1H), 2.239 (s, 3H), 1.306 (s, 12H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 149.45, 138.96, 134.57, 129.27, 127.00, 83.27, 24.80, 21.34. GC-MS: M^+ m/z 244.2.

(E)-4,4,5,5-tetramethyl-2-(3-methylstyryl)-1,3,2-dioxaborolane (2c)[1]: Colorless oil, yield 91%. ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.369 (d, J = 18.4 Hz, 1H), 7.202-7.297 (m, 3H), 7.096-7.115 (m, 1H), 6.147 (d, J = 18.4 Hz, 1H), 2.342 (s, 3H), 1.309 (s, 12H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 149.65, 138.07, 137.40, 129.70, 128.44, 127.76, 124.22, 83.30, 24.80, 21.40. GC-MS: M^+ m/z 244.2.

(E)-2-(4-ethylstyryl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (2d)[2]: Colorless oil, yield 90%. ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.356-7.421 (m, 3H), 7.155-7.175 (m, 2H), 6.117 (d, J = 18.4 Hz, 1H), 2.638 (q, J = 7.6 Hz, 2H), 1.309 (s, 12H), 1.226 (t, J = 7.6 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 149.49, 145.30, 134.99, 128.08, 127.08, 83.26, 28.69, 24.81, 15.41. GC-MS: M^+ m/z 258.2.

(E)-4,4,5,5-tetramethyl-2-(4-propylstyryl)-1,3,2-dioxaborolane (2e): Colorless oil, yield 92%. ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.358-7.415 (m, 3H), 7.132-7.152 (m, 2H), 6.119 (d, J = 18.4 Hz, 1H), 2.553-2.591 (m, 2H), 1.583-1.676 (m, 2H), 1.309 (s, 12H), 0.931 (t, J = 7.6 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 149.52, 143.77, 134.99, 128.68, 126.99, 83.25, 37.85, 24.80, 24.40, 13.82. GC-MS: M^+ m/z 272.2.

(E)-2-(4-butylstyryl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (2f): Colorless oil, yield 92%. ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.350-7.409 (m, 3H), 7.132-7.152 (m, 2H), 6.109 (d, J = 18.4 Hz, 1H), 2.594 (d, J = 7.6 Hz, 2H), 1.546-1.621 (m, 2H), 1.305-1.369 (m, 14H), 0.915 (t, J = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 149.51, 144.01, 135.00, 128.63, 127.00, 83.26, 35.46, 33.47, 24.80, 22.34, 13.95. GC-MS: M^+ m/z 286.2.

(E)-2-(4-hexylstyryl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (2g)[1]: Colorless oil, yield 89%. ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.870 (d, *J* = 8.4 Hz, 1H), 7.352-7.409 (m, 3H), 7.249-7.269 (m, 1H), 7.130-7.150 (m, 1H), 6.110 (d, *J* = 18.4 Hz, 1H), 2.652 (t, *J* = 8.0 Hz, 1H), 2.578 (t, *J* = 5.6 Hz, 3H), 1.599-1.627 (m, 2H), 1.306-1.316 (m, 14H), 0.883 (dt, *J* = 6.8, 3.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 149.51, 148.83, 144.05, 134.94, 128.59, 127.00, 83.25, 35.75, 31.48, 26.56, 24.80, 22.53, 14.03. GC-MS: M^+ m/z 300.2.

(E)-2-(4-methoxystyryl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (2h)[2]: Colorless oil, yield 90%. ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.419-7.441 (m, 2H), 7.344 (d, *J* = 18.8 Hz, 2H), 6.859 (d, *J* = 8.8 Hz, 1H), 6.009 (d, *J* = 18.4 Hz, 1H), 3.806 (s, 3H), 1.301 (s, 12H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 160.24, 149.04, 130.27, 128.45, 113.93, 83.21, 55.27, 24.80. GC-MS: M^+ m/z 260.2.

(E)-2-(4-ethoxystyryl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (2i)[1]: Colorless oil, yield 91%. ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.398-7.427 (m, 2H), 7.341 (d, *J* = 19.2 Hz, 2H), 6.842 (d, *J* = 8.8 Hz, 1H), 5.999 (d, *J* = 18.4 Hz, 1H), 4.000-4.053 (m, 2H), 1.402 (d, *J* = 6.8 Hz, 3H), 1.300 (s, 12H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 159.66, 149.12, 130.16, 128.45, 114.43, 83.18, 63.42, 24.80, 14.80. GC-MS: M^+ m/z 274.2.

(E)-2-(4-chlorostyryl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (2j)[1]: white solid, yield 85%. ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.349-7.408 (m, 3H), 7.281-7.302 (m, 2H), 6.124 (d, *J* = 18.4 Hz, 1H), 1.302 (s, 12H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 148.00, 135.86, 134.58, 128.77, 128.21, 83.44, 24.80. GC-MS: M^+ m/z 264.1.

(E)-2-(4-fluorostyryl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (2k)[1]: Colorless oil, yield 92%. ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.433-7.469 (m, 2H), 7.345 (d, *J* = 18.4 Hz, 1H), 7.014 (d, *J* = 8.4 Hz, 1H), 6.066 (d, *J* = 18.8 Hz, 1H), 1.304 (s, 12H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 164.34, 161.89, 148.14, 133.64, 128.73, 128.64, 115.65, 115.43, 83.38, 24.79. GC-MS: M^+ m/z 248.1.

(E)-4-(2-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)vinyl)aniline(2l): light yellow solid, yield 84%. ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.278-7.324 (m, 3H), 6.618

(d, J = 8.4 Hz, 1H), 5.930 (d, J = 18.4 Hz, 1H), 3.806 (s, 2H), 1.294 (s, 12H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 149.56, 147.33, 128.56, 128.18, 114.82, 83.08, 24.80. GC-MS: M^+ m/z 245.1.

(E)-2-(2-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)vinyl)pyridine (2m)[1]: Colorless oil, yield 94%. ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.585 (d, J = 4.4 Hz, 1H), 7.617-7.659 (m, 1H), 7.374-7.460 (m, 2H), 7.145-7.176 (m, 1H), 6.613 (d, J = 18.4 Hz, 1H), 1.290 (s, 12H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 155.36, 149.66, 148.68, 136.49, 123.08, 122.23, 83.46, 24.77. GC-MS: M^+ m/z 231.1.

(E)-4,4,5,5-tetramethyl-2-(2-(thiophen-2-yl)vinyl)-1,3,2-dioxaborolane (2n): Colorless oil, yield 87%. ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.464 (d, J = 18.0 Hz, 1H), 7.230 (d, J = 5.2 Hz, 1H), 7.071 (d, J = 3.2 Hz, 1H), 6.975 (dd, J = 3.6, 2.4 Hz, 1H), 5.907 (d, J = 18.0 Hz, 1H), 1.290 (s, 12H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 143.89, 141.79, 127.71, 127.61, 126.29, 83.34, 24.78. GC-MS: M^+ m/z 236.1.

(E)-4,4,5,5-tetramethyl-2-(2-(thiophen-3-yl)vinyl)-1,3,2-dioxaborolane (2o)[1]: Colorless oil, yield 90%. ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.373 (d, J = 18.4 Hz, 1H), 7.283-7.297 (m, 2H), 7.245-7.256 (m, 1H), 5.937 (d, J = 18.4 Hz, 1H), 1.295 (s, 12H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 143.13, 132.27, 126.11, 124.99, 124.88, 83.34, 24.79. GC-MS: M^+ m/z 236.1.

(E)-1-phenyl-3-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)prop-2-en-1-ol (2p): Colorless oil, yield 92%. ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.540-7.558 (m, 1H), 7.373 7.269-7.388 (m, 5H), 5.937 (dd, J = 18.0, 5.2 Hz, 1H), 5.738 (dd, J = 18.0, 1.2 Hz, 1H), 5.229 (dd, J = 5.6, 1.6 Hz, 1H), 1.246 (s, 12H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 153.62, 141.90, 128.67, 128.56, 127.79, 126.59, 126.47, 83.38, 76.11, 24.77. GC-MS: M^+ m/z 260.2.

(E)-2-methyl-4-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)but-3-en-2-ol (2q)[1]: Colorless oil, yield 91%. ^{1}H NMR (400 MHz, $CDCl_3$) δ: 6.706 (d, J = 18.0 Hz, 1H), 5.597 (d, J = 18.0 Hz, 1H), 1.594 (s, 1H), 1.300 (s, 6H), 1.262 (s, 12H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 159.76, 104.95, 83.28, 71.80, 29.10, 24.76. GC-MS: M^+ m/z 212.1.

(E)-4-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)but-3-en-1-ol (2r)[1]: Colorless oil, yield 90%. ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.544-7.621 (m, 1H), 5.541 (dd, *J* = 18.0, 1.2 Hz, 1H), 3.705 (t, *J* = 6.4 Hz, 2H), 2.417 (q, *J* = 6.4 Hz, 2H), 1.691 (s, 1H), 1.246 (s, 12H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 150.02, 105.17, 83.19, 61.20, 39.06, 24.75. GC-MS: M^+ m/z 198.1.

(E)-2-(3,3-dimethylbut-1-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (2s)[1]: Colorless oil, yield 87%. ^{1}H NMR (400 MHz, $CDCl_3$) δ: 6.625 (d, *J* = 18.4 Hz, 1H), 5.336 (d, *J* = 18.8 Hz, 1H), 1.258 (s, 12H), 1.003 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 164.40, 82.98, 35.00, 28.76, 24.78. GC-MS: M^+ m/z 210.2.

(E)-2-(2-cyclopropylvinyl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (2t)[1]: Colorless oil, yield 87%. ^{1}H NMR (400 MHz, $CDCl_3$) δ: 6.045 (dd, *J* = 16.6, 9.2 Hz, 1H), 5.470 (d, *J* = 18.0 Hz, 1H), 1.466-1.529 (m, 1H), 1.231 (s, 12H), 0.760-0.807 (m, 2H), 0.504-0.532 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 158.58, 125.20, 82.88, 24.72, 17.03, 7.87. GC-MS: M^+ m/z 194.1.

(E)-2-(hex-1-en-1-yl)-4,4,5,5-tetramethyl-1,3,2-dioxaborolane (2u)[3]: Colorless oil, yield 95%. ^{1}H NMR (400 MHz, $CDCl_3$) δ: 6.615 (dt, *J* = 16.6, 6.4 Hz, 1H), 5.404 (d, *J* = 18.0 Hz, 1H), 2.105-2.158 (m, 2H), 1.296-1.401 (m, 4H), 1.246 (s, 12H), 0.867 (t, *J* = 7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 154.79, 128.64, 82.94, 35.49, 30.32, 24.75, 22.23, 13.90. GC-MS: M^+ m/z 210.2.

(E)-4,4,5,5-tetramethyl-2-(oct-1-en-1-yl)-1,3,2-dioxaborolane (2v)[1]: Colorless oil, yield 94%. ^{1}H NMR (400 MHz, $CDCl_3$) δ: 6.623 (dt, *J* = 18.0, 6.4 Hz, 1H), 5.404 (d, *J* = 18.0 Hz, 1H), 2.104-2.140 (m, 2H), 1.376-1.490 (m, 2H), 1.230-1.281 (m, 18H), 0.844-0.878 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 154.86, 128.65, 82.95, 35.84, 31.71, 28.91, 28.17, 24.76, 24.72, 22.59, 14.10. GC-MS: M^+ m/z 223.2.

(E)-4,4,5,5-tetramethyl-2-(oct-4-en-4-yl)-1,3,2-dioxaborolane (2w)[3]: Colorless oil, yield 95%. ^{1}H NMR (400 MHz, $CDCl_3$) δ: 6.261-6.296 (m, 1H), 2.059-2.114 (m, 4H), 1.308-1.424 (m, 4H), 1.233 (s, 12H), 0.845-0.914 (m, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 145.96, 82.87, 30.54, 24.69, 23.28, 22.38, 14.08, 14.03. GC-MS: M^+ m/z 223.2.

(E)-4,4,5,5-tetramethyl-2-(1-phenylprop-1-en-2-yl)-1,3,2-dioxaborolane (2x)[1]: Colorless oil, yield 90%. ^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.297-7.393 (m, 3H), 7.217-

7.254 (m, 2H), 7.143-7.162 (m, 1H), 1.990 (s, 3H), 1.313 (s, 12H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 142.34, 137.90, 129.39, 128.01, 127.07, 83.50, 24.84, 24.73, 15.90. GC-MS: M^+ m/z 244.2.

(E)-ethyl 3-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)acrylate (2y)[3]: Colorless oil, yield 70%. ^1H NMR (400 MHz, $CDCl_3$) δ: 6.738 (d, J = 18.0 Hz, 1H), 6.593 (d, J = 18.0 Hz, 1H), 4.177 (q, J = 7.2 Hz, 2H), 1.251 (s, 12H), 1.192-1.210(m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 174.88, 138.70, 125.91, 83.15, 60.56, 24.78, 24.70, 24.43, 14.15. GC-MS: M^+ m/z 226.1.

(E)-methyl 3-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)acrylate (2z): Colorless oil, yield 75%. ^1H NMR (400 MHz, $CDCl_3$) δ: 6.761 (d, J = 18.4 Hz, 1H), 6.610 (d, J = 18.4 Hz, 1H), 3.744 (s, 3H), 1.269(s, 12H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 166.33, 138.70, 138.15, 84.03, 51.77, 24.71. HRMS *m/z* (ESI): Calcd for $C_{10}H_{17}BO_4Na$ ($[M+Na]^+$): 235.1112, Found 235.1110.

(Z)-N-methyl-N-styrylmethanesulfonamide (3a): White solid, yield 95% (Z:E=3:1). ^1H NMR (400 MHz, $CDCl_3$) δ: 7.292-7.404 (m, 5H), 6.333 (d, J=8.8 Hz, 1H), 6.055 (d, J=8.8 Hz, 1H),2.932 (s, 3H), 2.892 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 134.69, 129.00, 128.33, 127.72, 126.97, 120.64, 36.59, 36.21. HRMS *m/z* (ESI): Calcd for $C_{10}H_{13}O_2SNNa$ ($[M+Na]^+$): 234.0559, Found 234.0558.

1,3-diphenylpropan-1-one (3b): Colorless oil, yield 92%. ^1H NMR (400 MHz, $CDCl_3$) δ: 7.952-7.973 (m, 2H), 7.541-7.578 (m, 1H), 7.435-7.474 (m, 2H), 7.210-7.324 (m, 5H), 3.331 (t, J=7.6 Hz, 2H), 3.073 (t, J=7.6 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 199.23, 141.27, 136.80, 133.07, 128.60, 128.52, 128.42, 128.03, 127,16, 126.12, 40.46, 30.11. HRMS *m/z* (ESI): Calcd for $C_{15}H_{14}ONa$ ($[M+Na]^+$): 233.0937, Found 233.0935.

(5S)-2-methyl-5-(prop-1-en-2-yl)-3-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)cyclohexanone (3c): white solid, yield 94%. Colorless oil, yield 95%. ^1H NMR (400 MHz, $CDCl_3$) δ: 4.644-4.699 (m, 2H), 2.532-2.592 (m, 1H), 2.408-2.423 (m, 2H), 2.374-2.389 (m, 1H), 1.952-2.216 (m, 1H), 1.664-1.791 (m, 5H), 1.158-1.204 (m, 12H), 1.029-1.046 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 212.08, 147.90, 109.43, 83.38, 46.13, 45.83, 44.36, 32.41, 24.81, 24.77, 24.57, 20.69, 13.91. HRMS *m/z* (ESI):

Calcd for $C_{16}H_{27}O_3BNa$ ($[M+Na]^+$): 301.1945, Found 301.1944.

Ethyl 3-(4,4,5,5-tetramethyl-1,3,2-dioxaborolan-2-yl)but-3-enoate (3d): Colorless oil, yield 95%. ^1H NMR (400 MHz, $CDCl_3$) δ: 5.882 (s, 1H), 5.672 (s, 1H), 4.112 (q, *J*=7.2 Hz, 2H), 3.155 (s, 2H), 1.251 (s, 12H), 1.215-1.235 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ: 172.16, 131.75, 83.67, 60.42, 40.66, 24.67, 14.21. HRMS *m/z* (ESI): Calcd for $C_{12}H_{21}O_4BNa$ ($[M+Na]^+$): 263.1425, Found 263.1422.

8. References

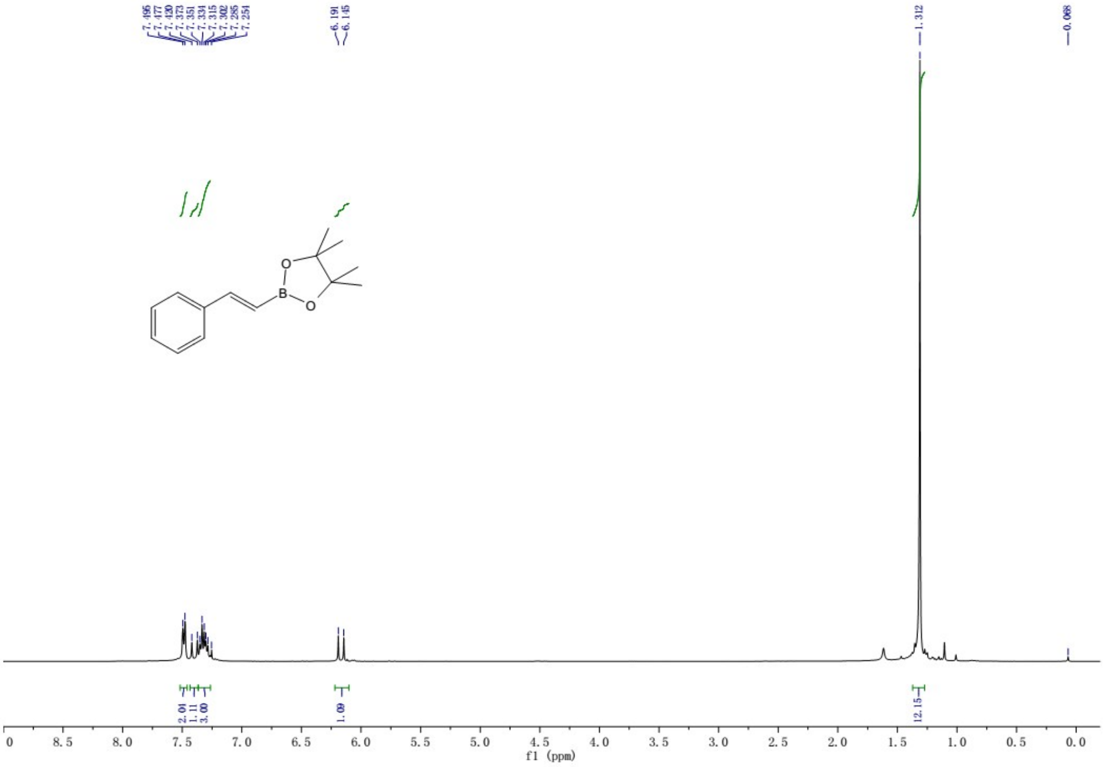
[1] J. Zhao, Z. Niu, H. Fu and Y. Li, *Chem. Commun.*, 2014, **50**, 2058.

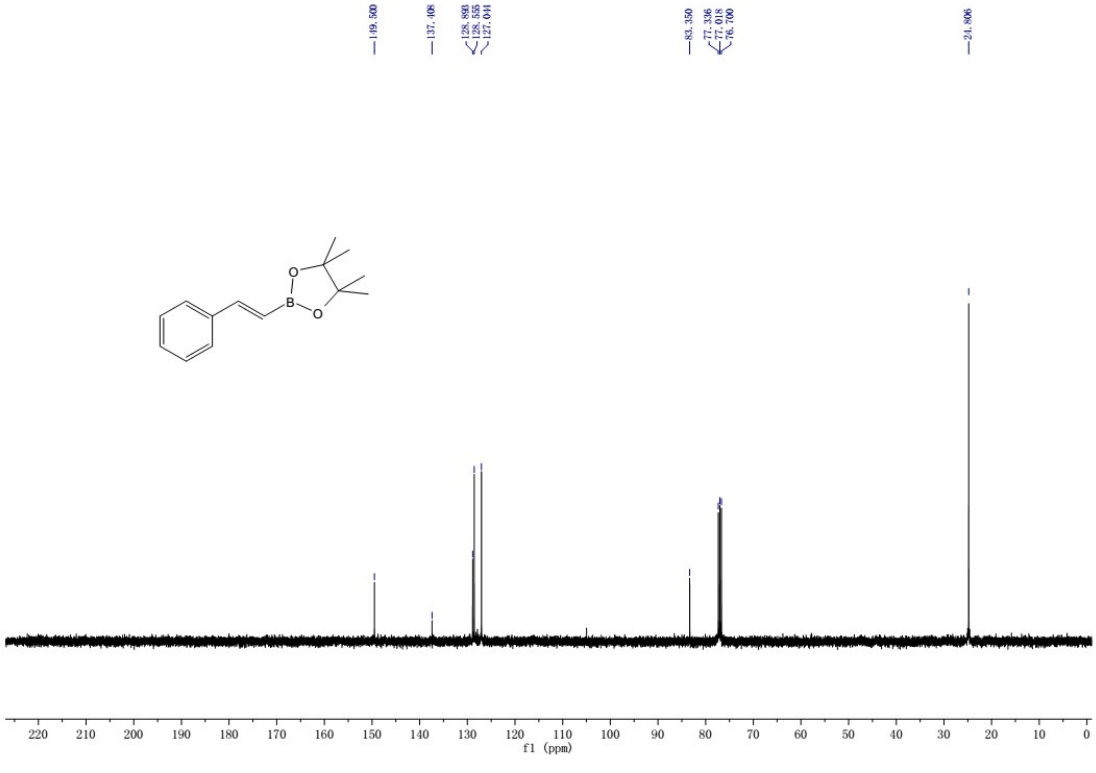
[2] B. Mohan and K. H. Park, *Appl. Catal. A Gen.*, 2016, **519**, 78.

[3] J.-E. Lee, J. Kwon, and J. Yun, *Chem. Commun.*, 2008, 733.

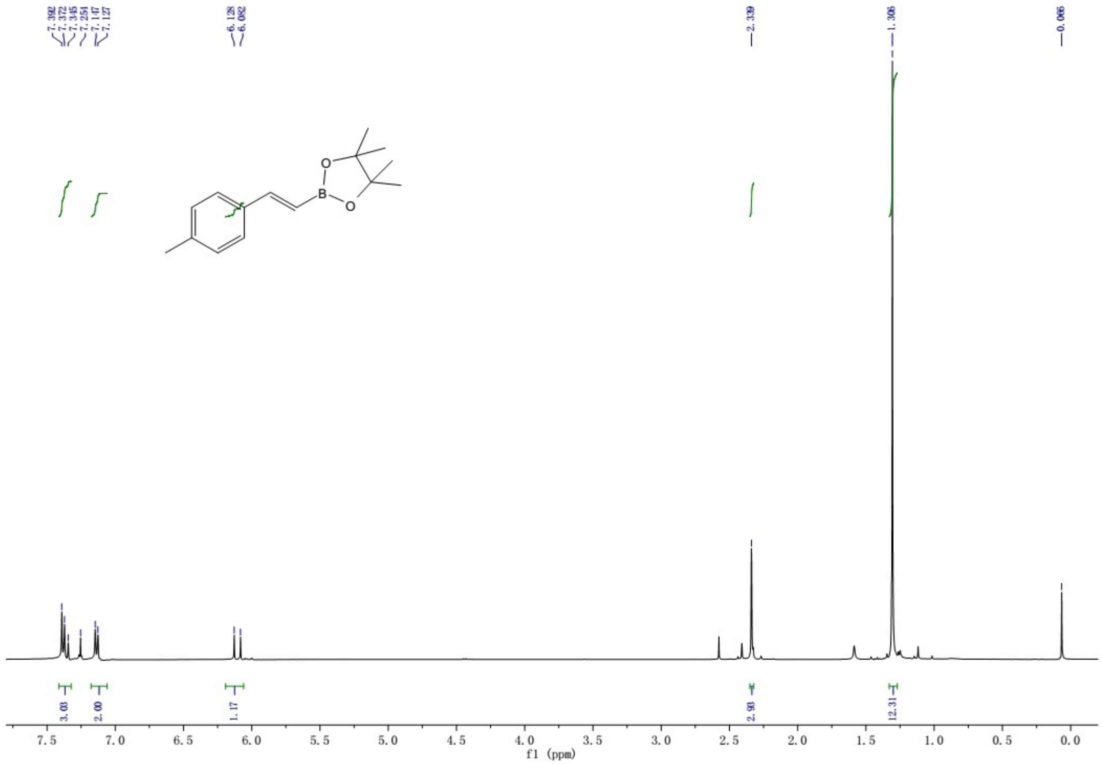
9. ^{1}H-NMR and ^{13}C-NMR spectra of the obtained compounds

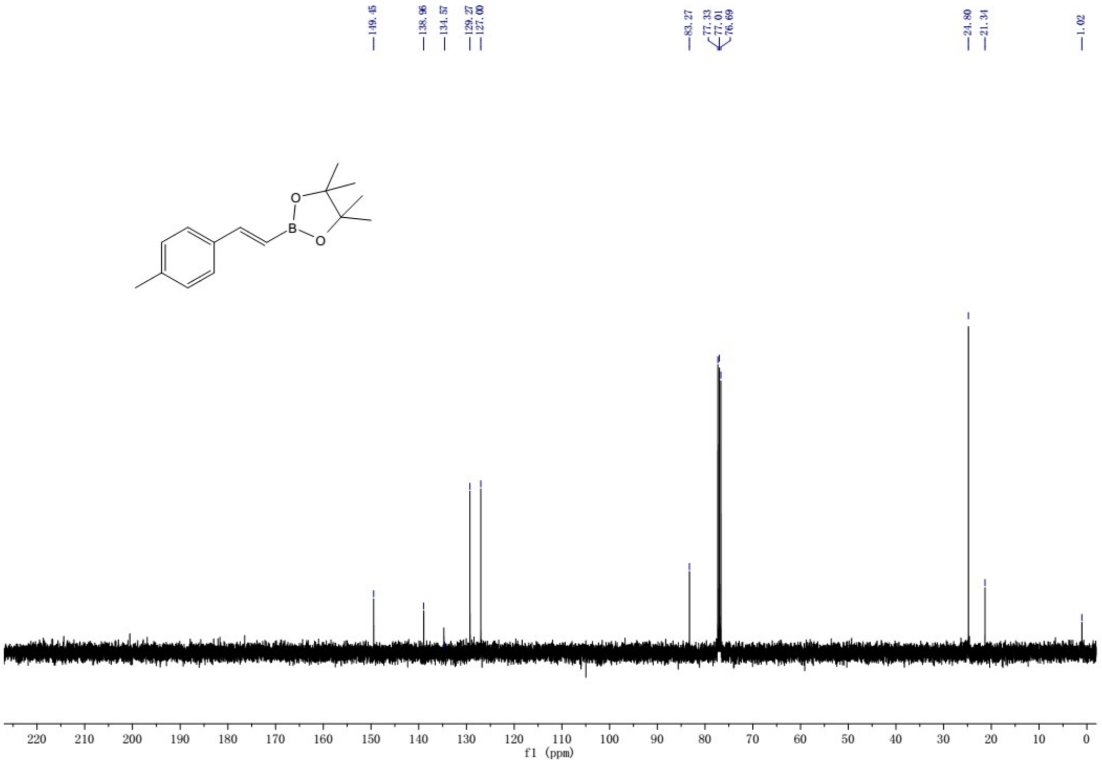
2a



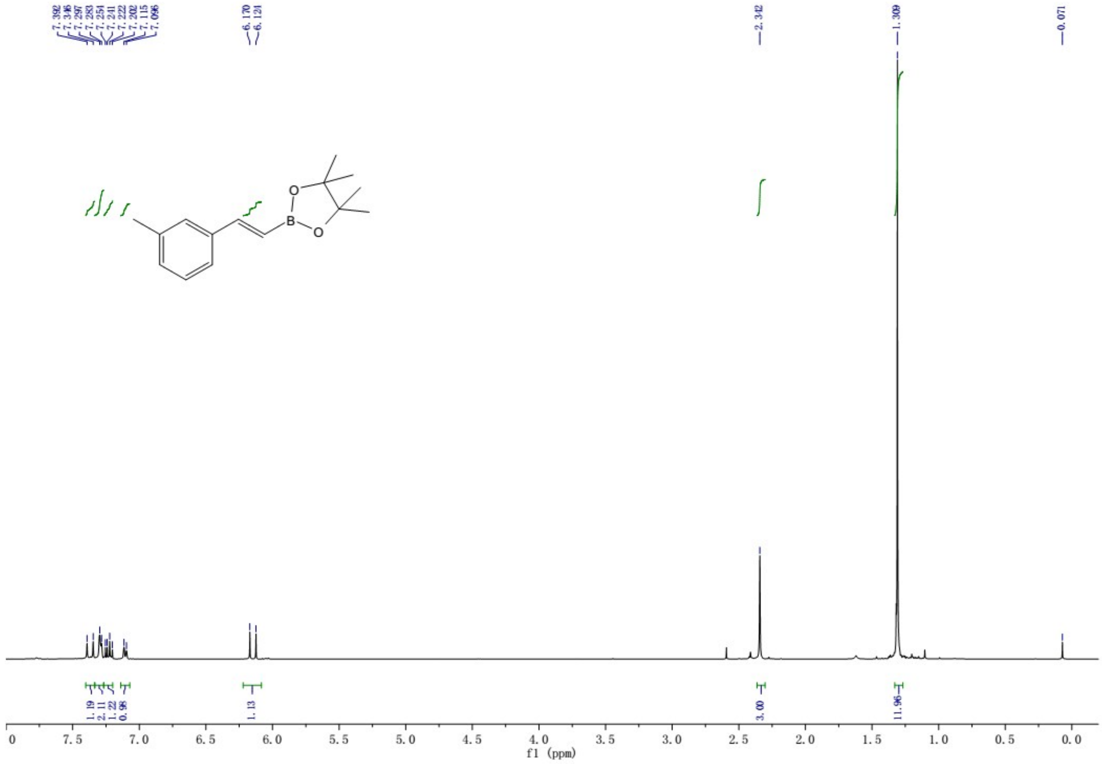


2b





2c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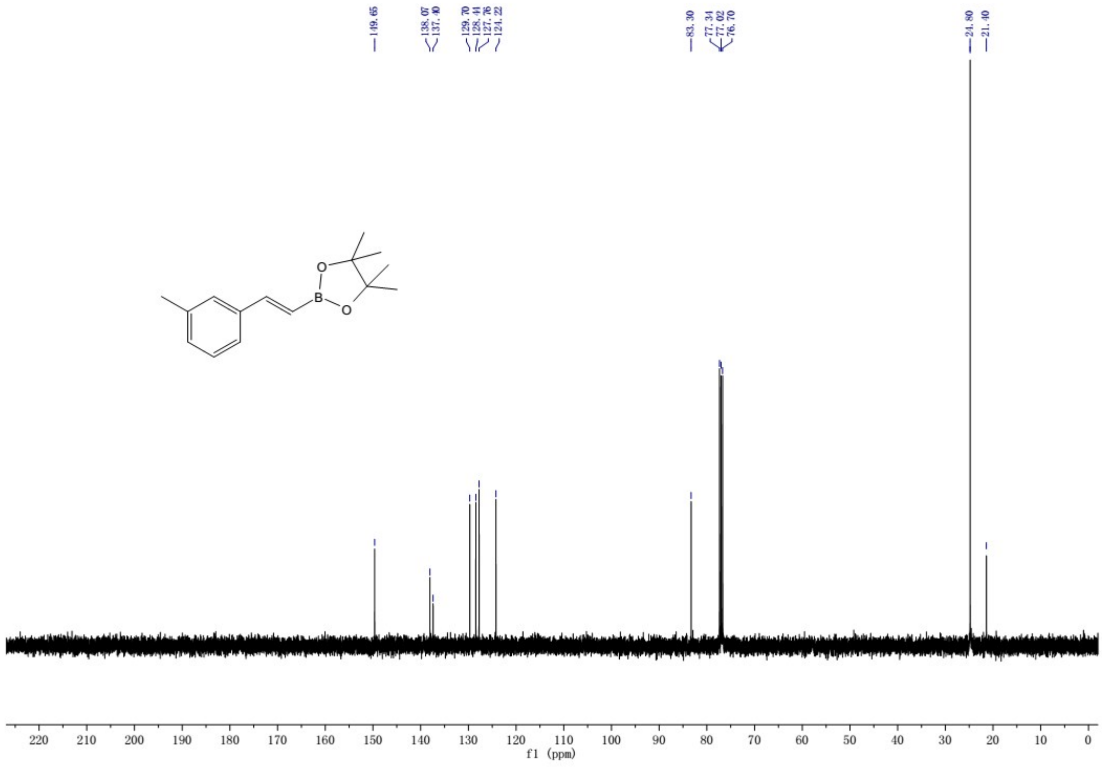
7.346
7.297
7.283
7.254
7.231
7.222
7.202
7.115
7.096
6.170
6.124
2.342
1.309
0.071
1.19
2.11
1.22
0.98
1.13
3.00
11.96
f1 (ppm)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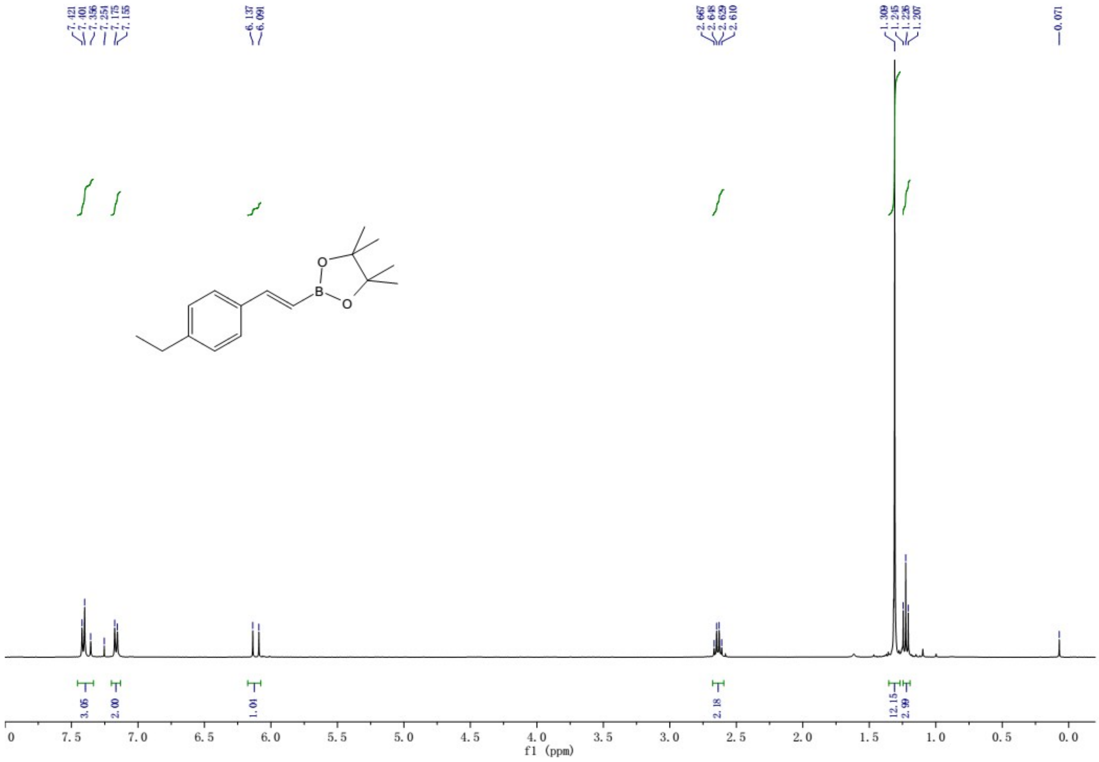
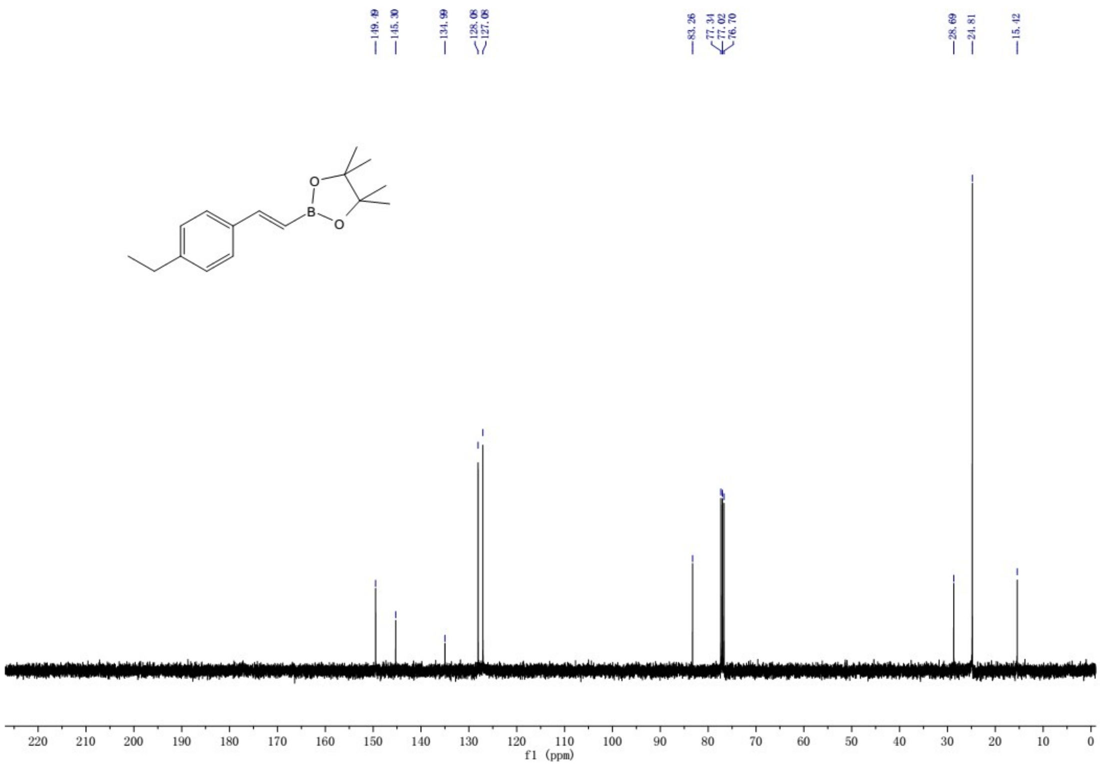
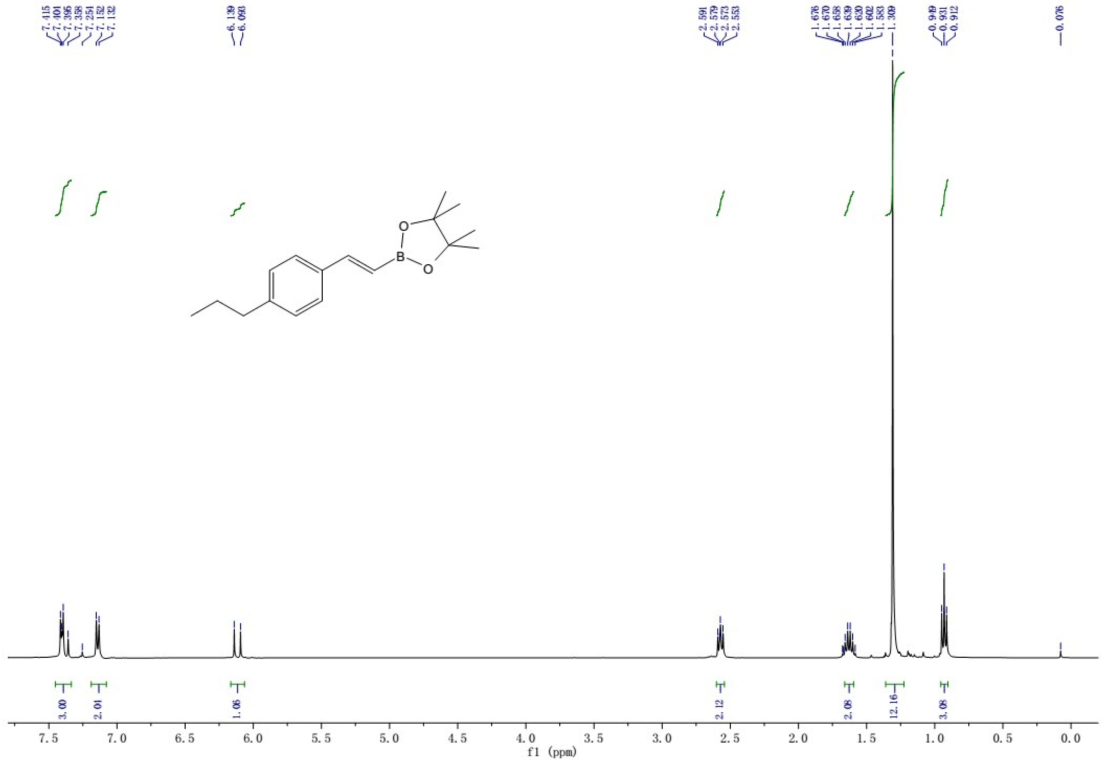
138.07
137.90
129.70
128.44
127.76
124.22
83.30
77.34
77.02
76.70
24.80
21.40
f1 (ppm)

2d





2e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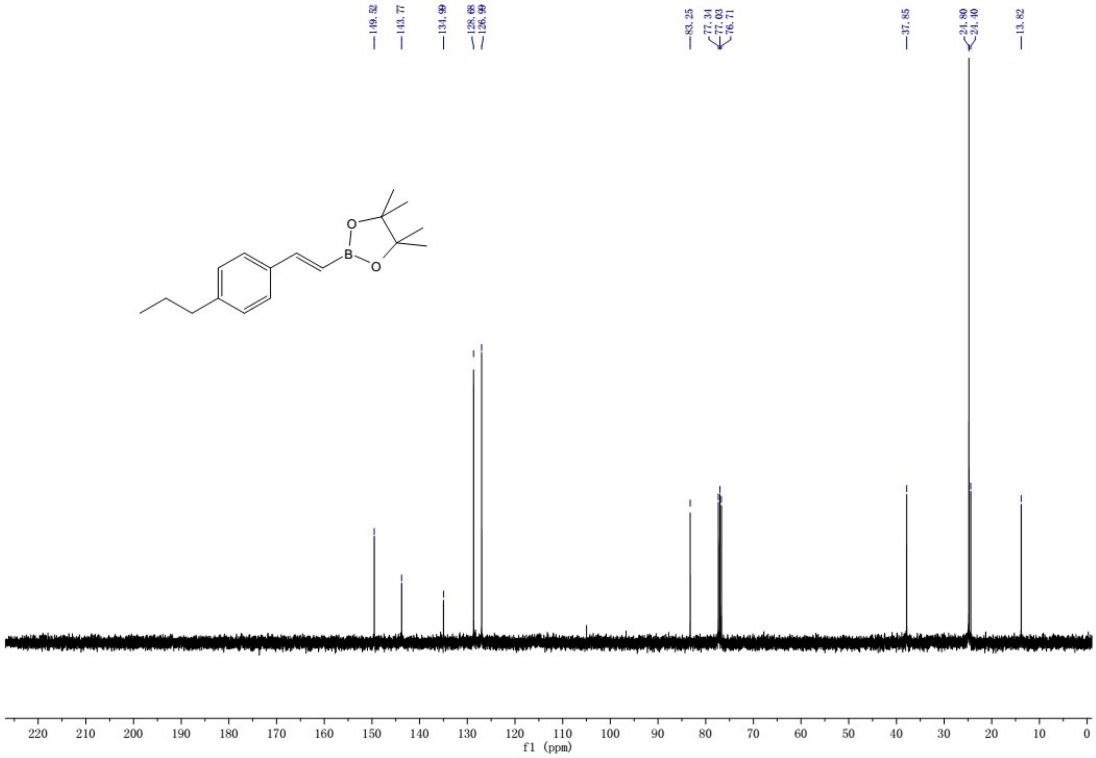
7.401
7.396
7.358
7.251
7.152
7.132
6.139
6.093
2.591
2.579
2.573
2.553
1.676
1.670
1.658
1.639
1.620
1.602
1.583
1.309
0.949
0.931
0.912
0.076
3.00
2.01
1.06
2.12
2.08
12.16
3.08
f1 (ppm)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143.77
134.99
128.68
126.99
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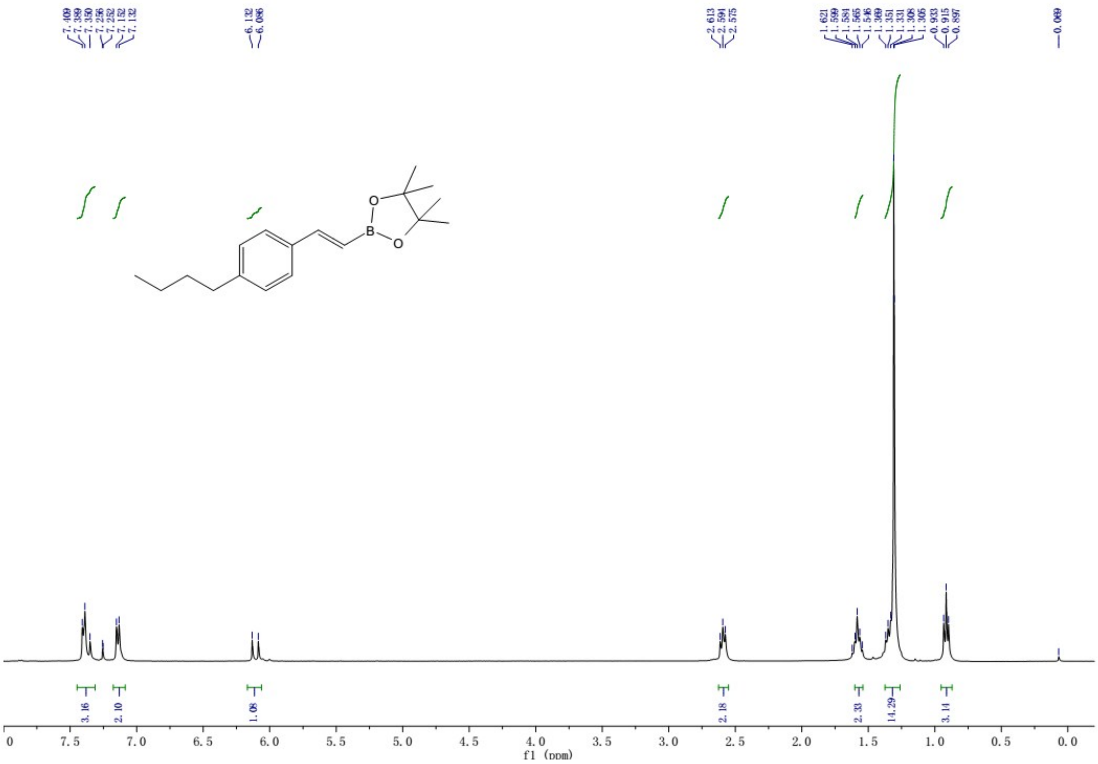
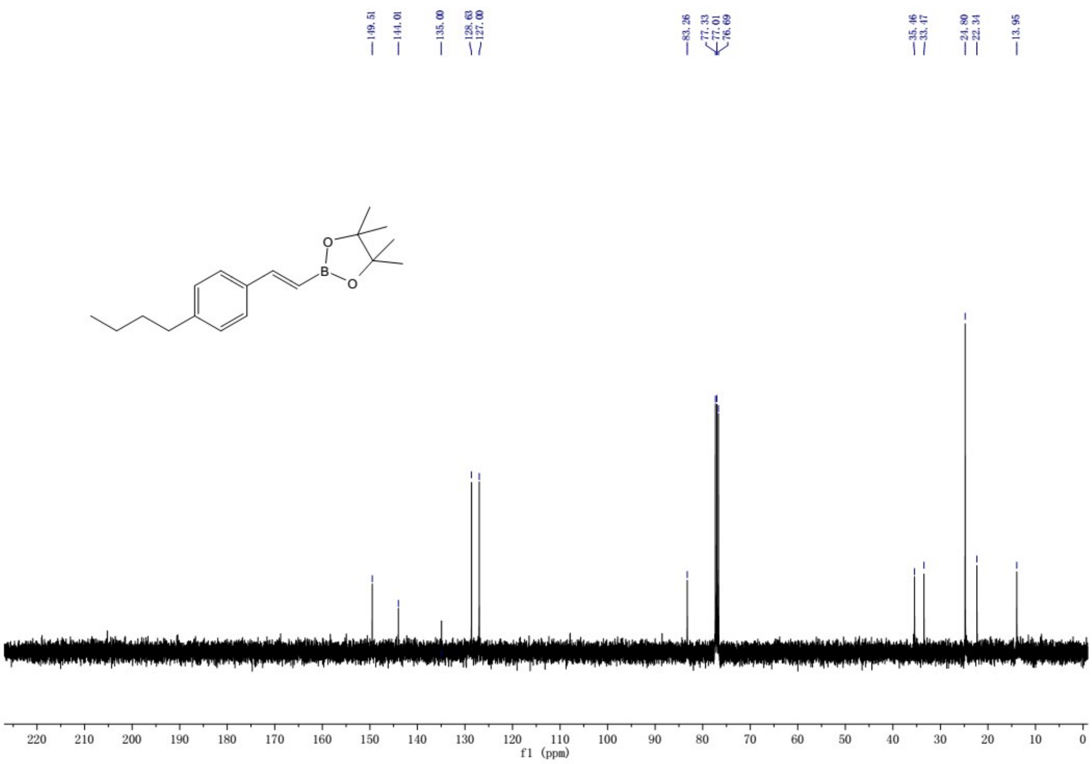
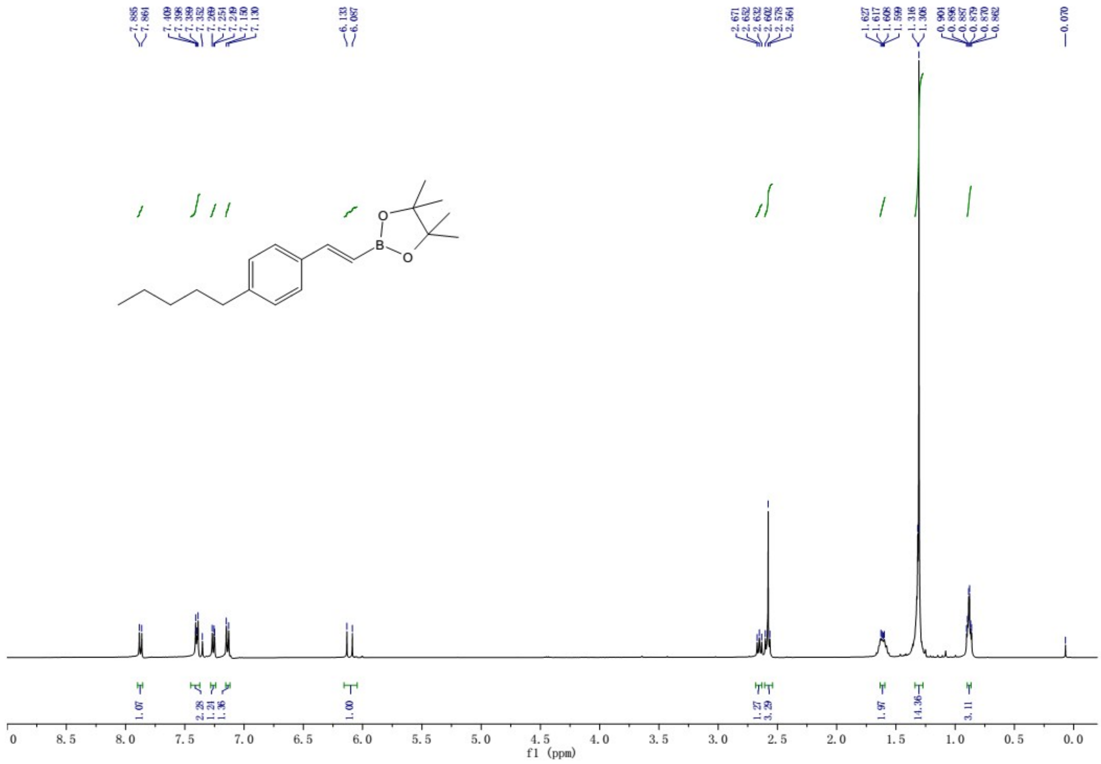
77.34
77.03
76.71
37.85
24.80
24.40
13.82
f1 (ppm)

2f





2g



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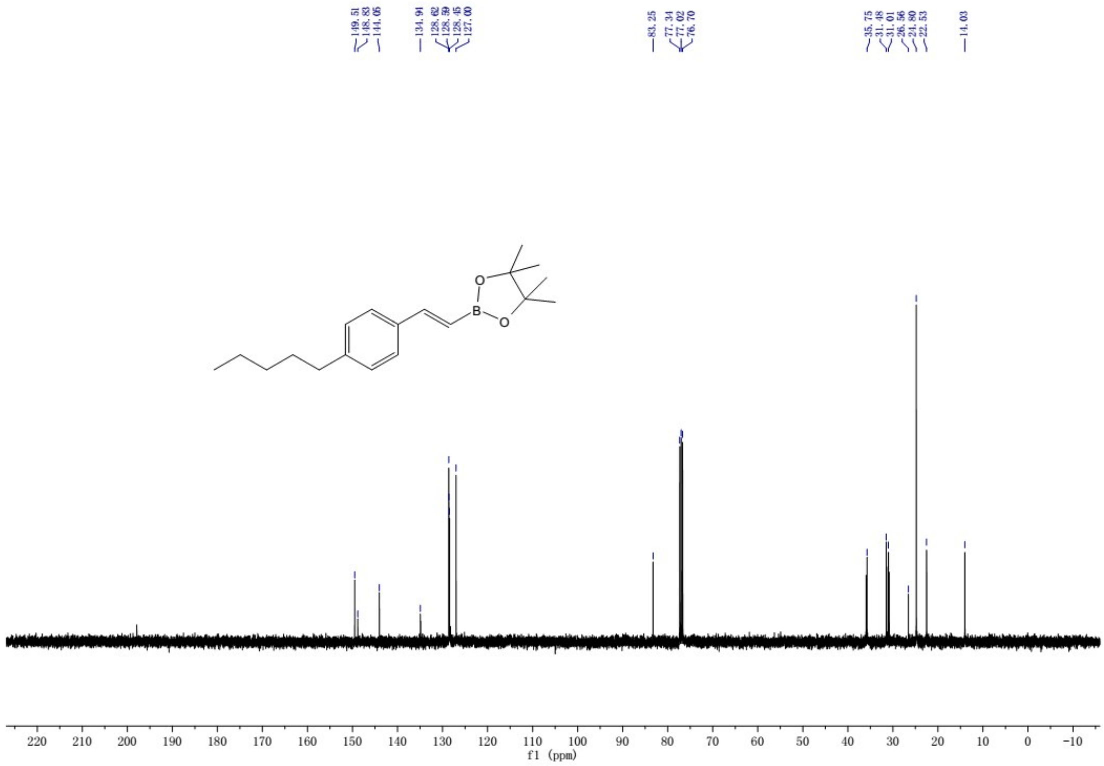
7.861
7.409
7.398
7.389
7.352
7.269
7.254
7.249
7.150
7.130
6.133
6.087
2.671
2.652
2.632
2.602
2.578
2.564
1.627
1.617
1.608
1.599
1.316
1.306
0.901
0.896
0.887
0.879
0.870
0.862
0.070
O
B
O
1.07
2.28
1.21
1.36
1.00
1.27
3.29
1.97
14.36
3.11
f1 (ppm)



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134.91
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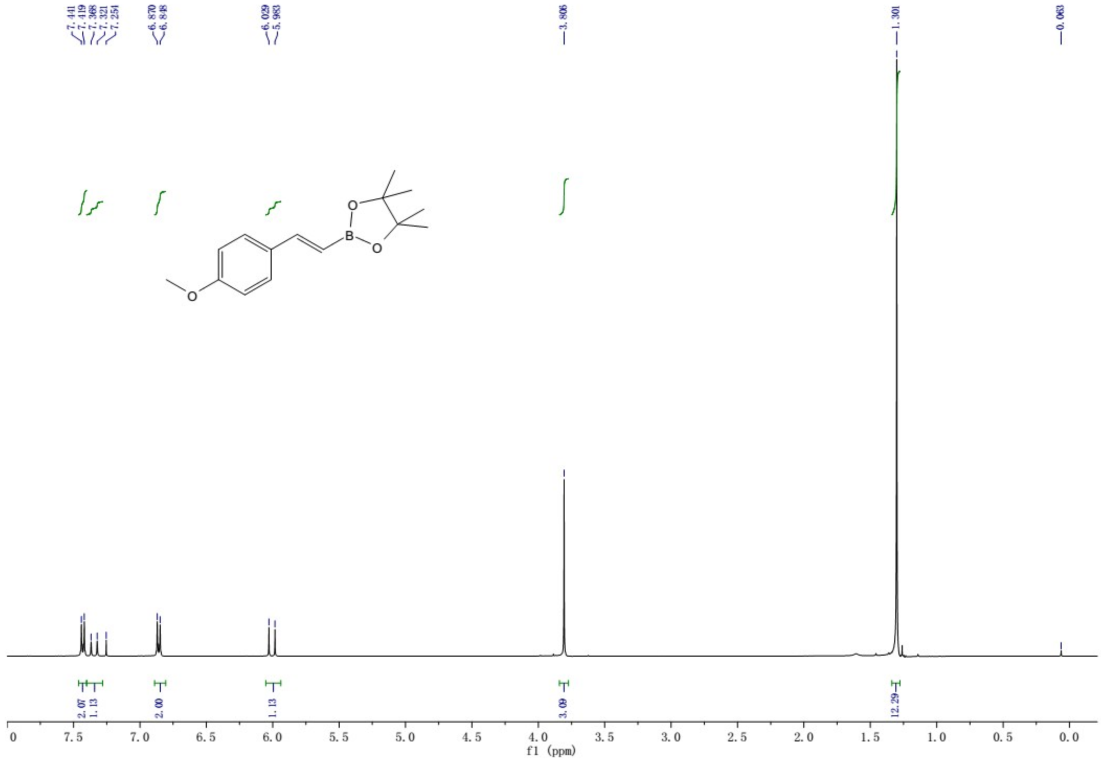
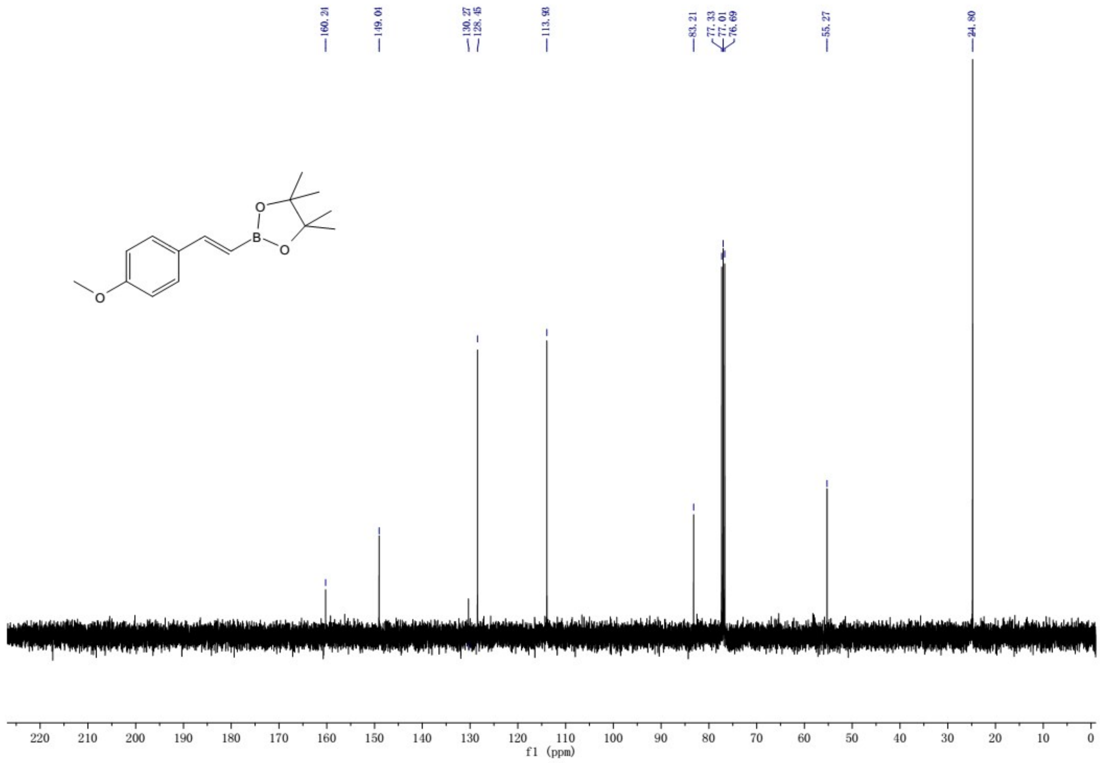
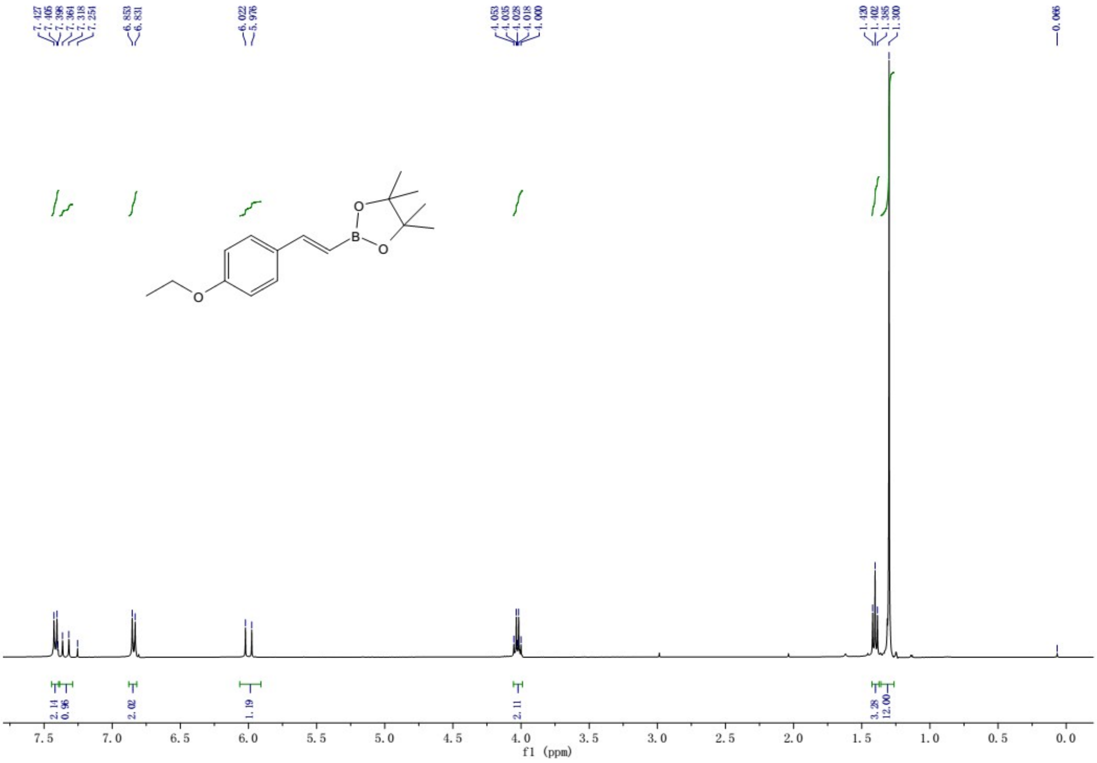
128.59
128.45
127.00
83.25
77.34
77.02
76.70
35.75
31.48
31.01
26.56
24.80
22.53
14.03
O
B
O
f1 (ppm)

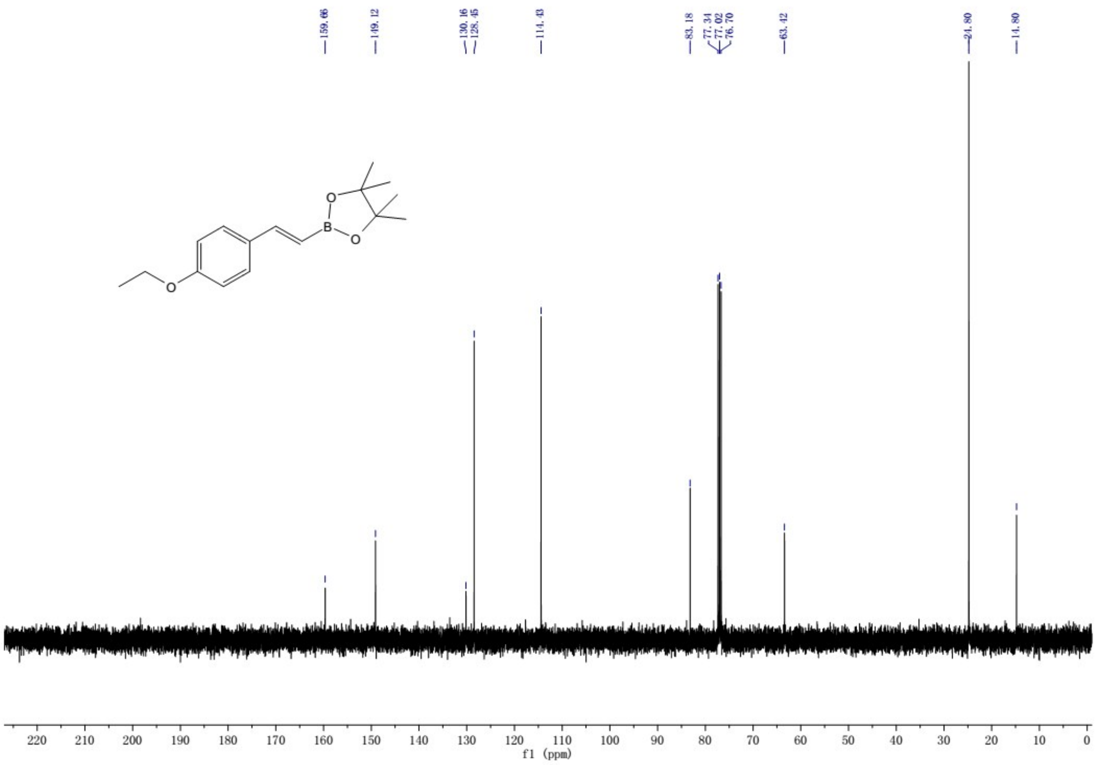
2h





2i





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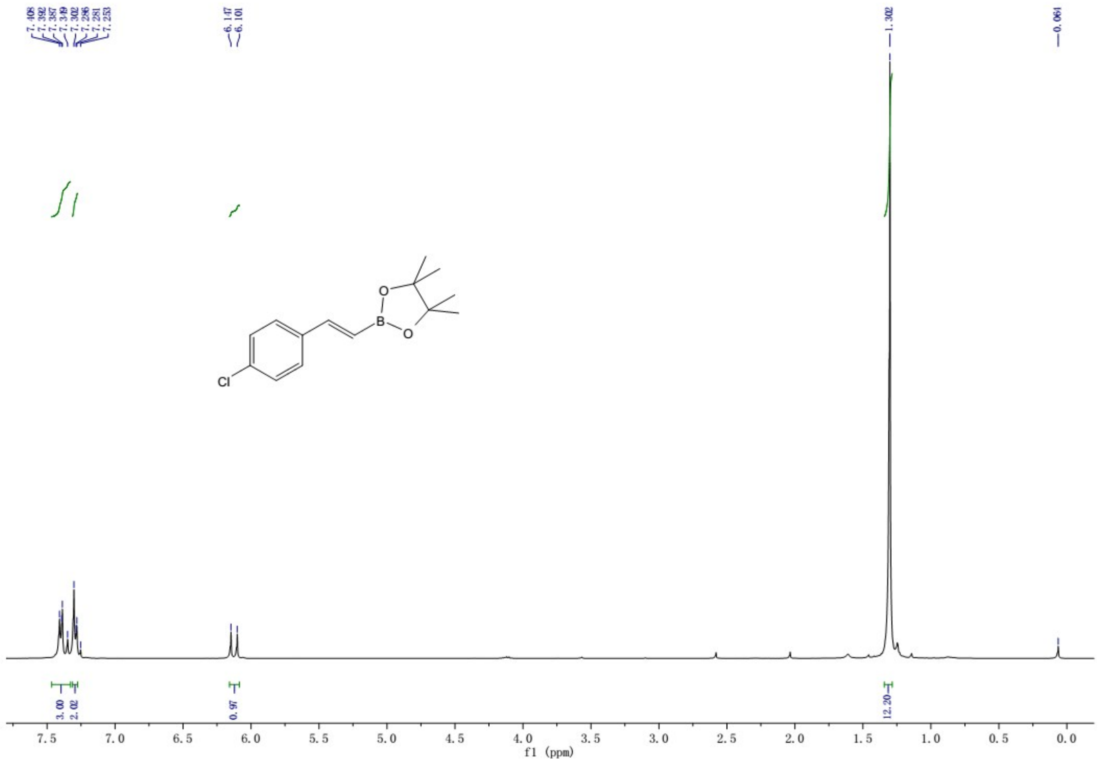

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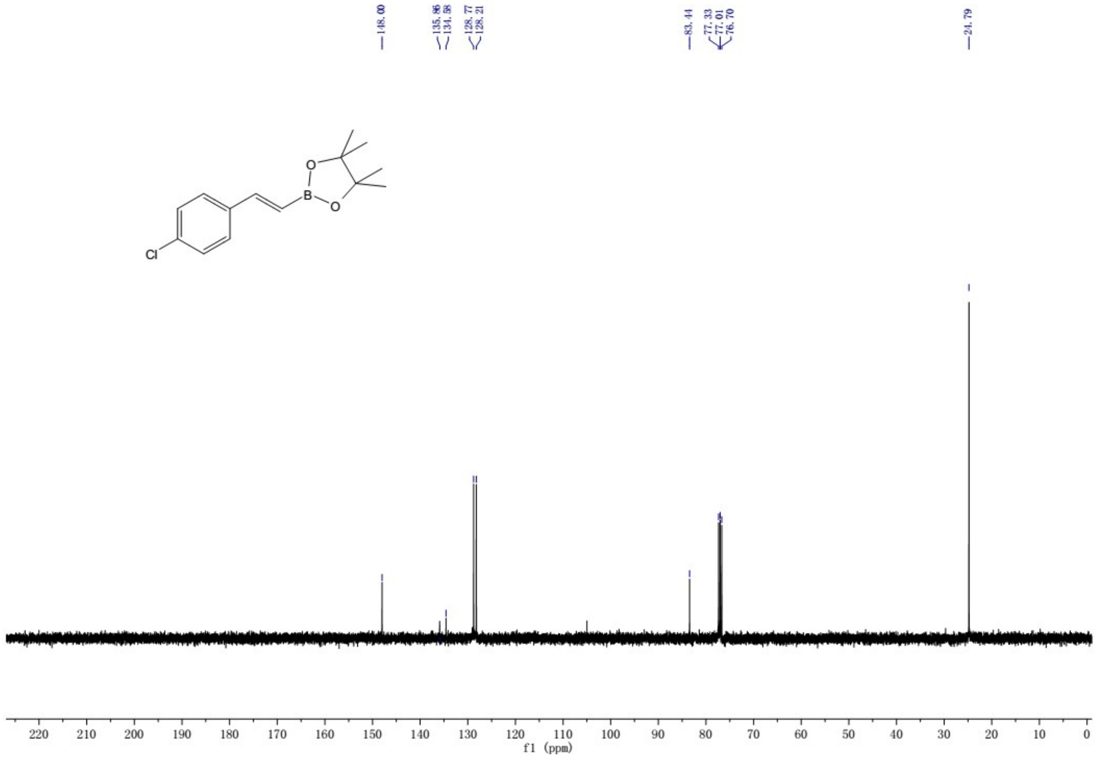
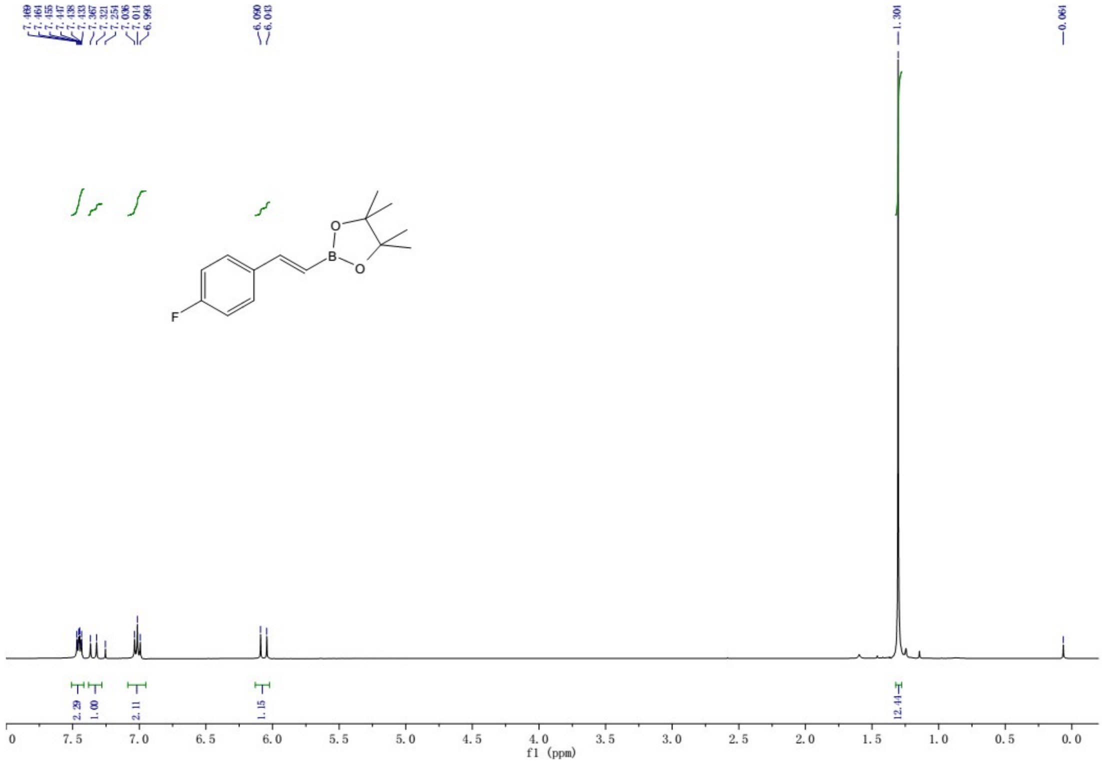
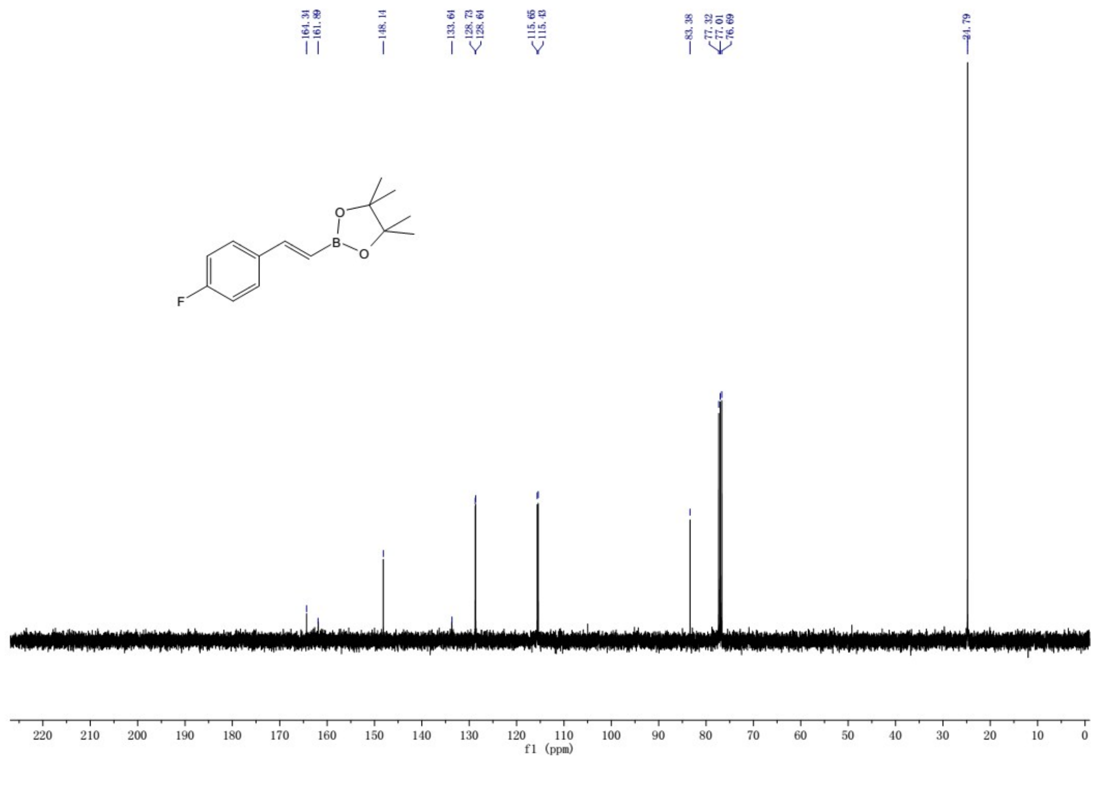
7.387
7.349
7.302
7.286
7.281
7.253
6.147
6.101
1.302
0.064
Cl
B
O
O
3.00
2.02
0.97
12.20
7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)



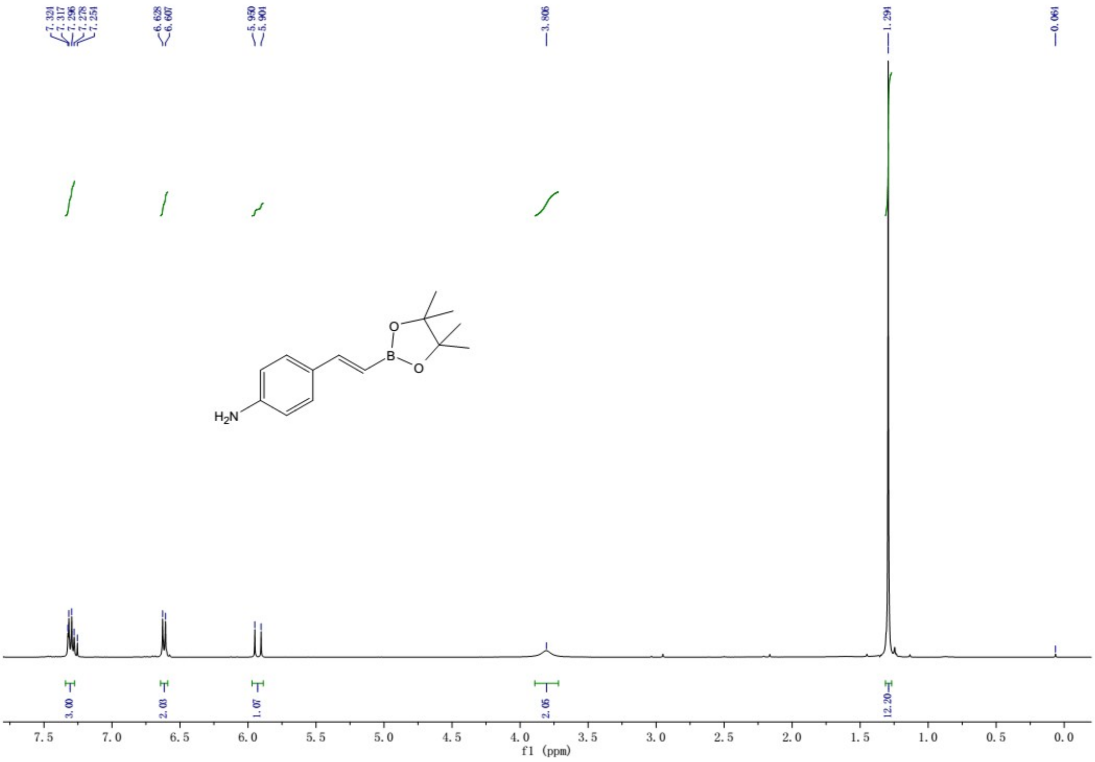
148.00
135.86
134.58
128.77
128.21
83.44
77.33
77.01
76.70
24.79
Cl
B
O
O
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

2k





2l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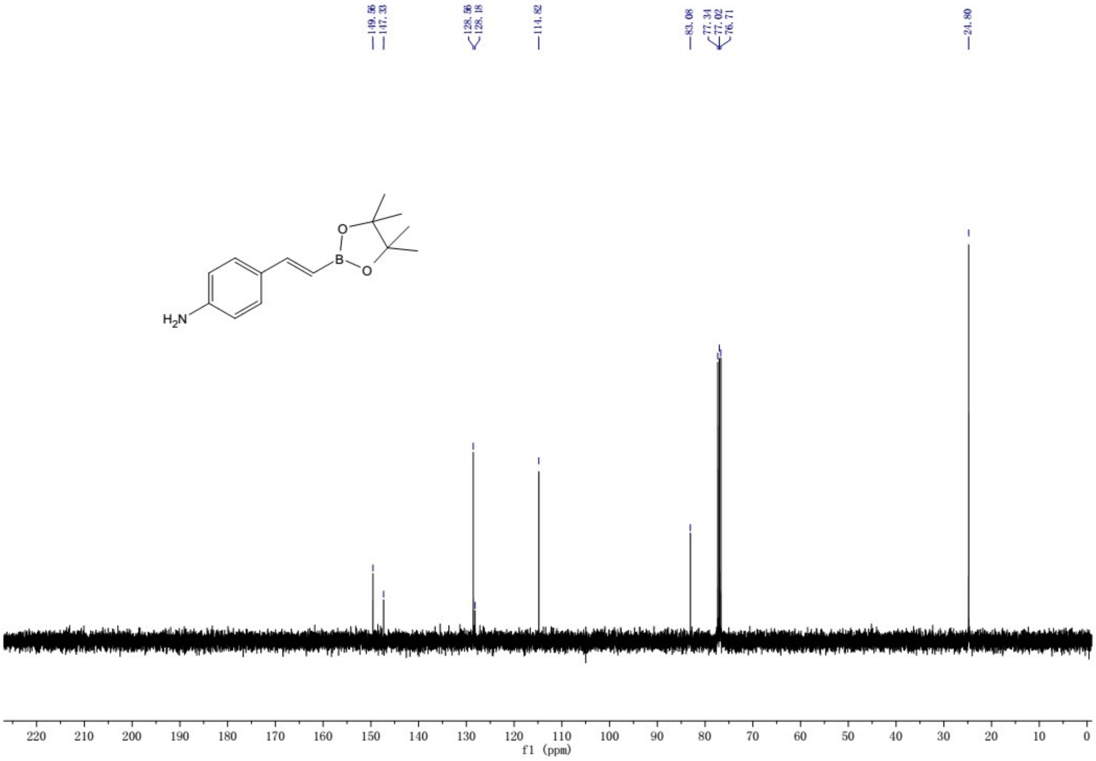
5.950
5.901
3.806
1.294
0.061
H2N
B
O
O
3.00
2.03
1.07
2.05
12.20
7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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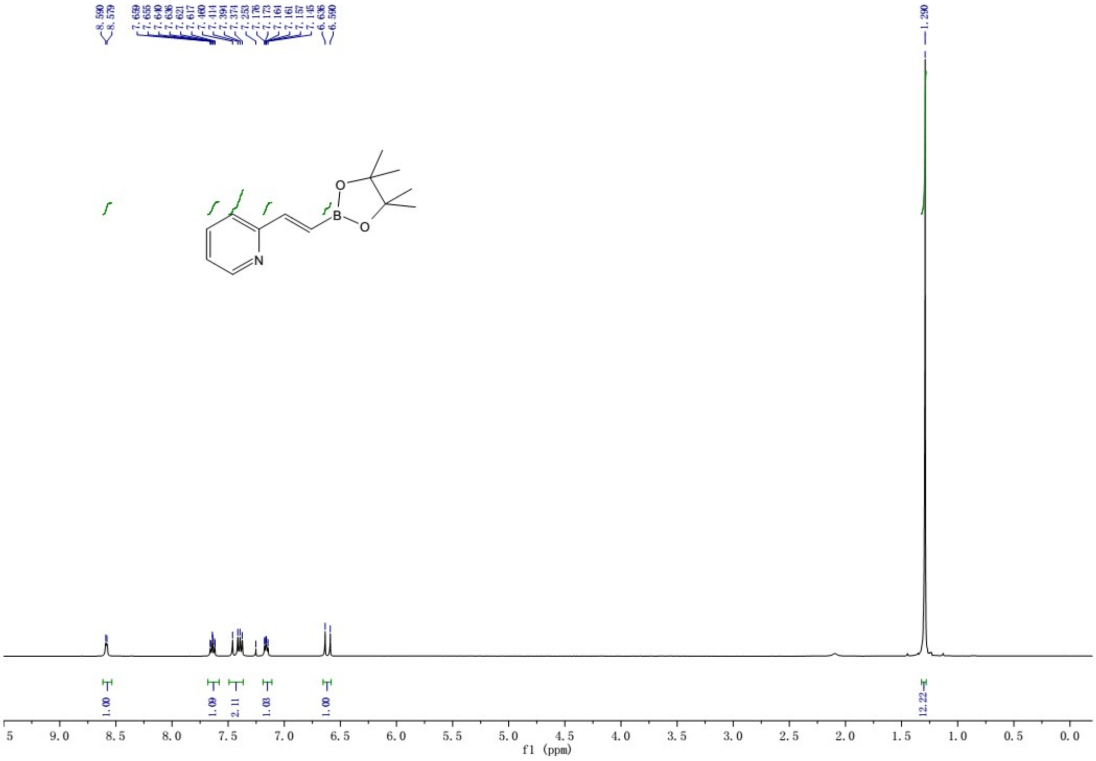
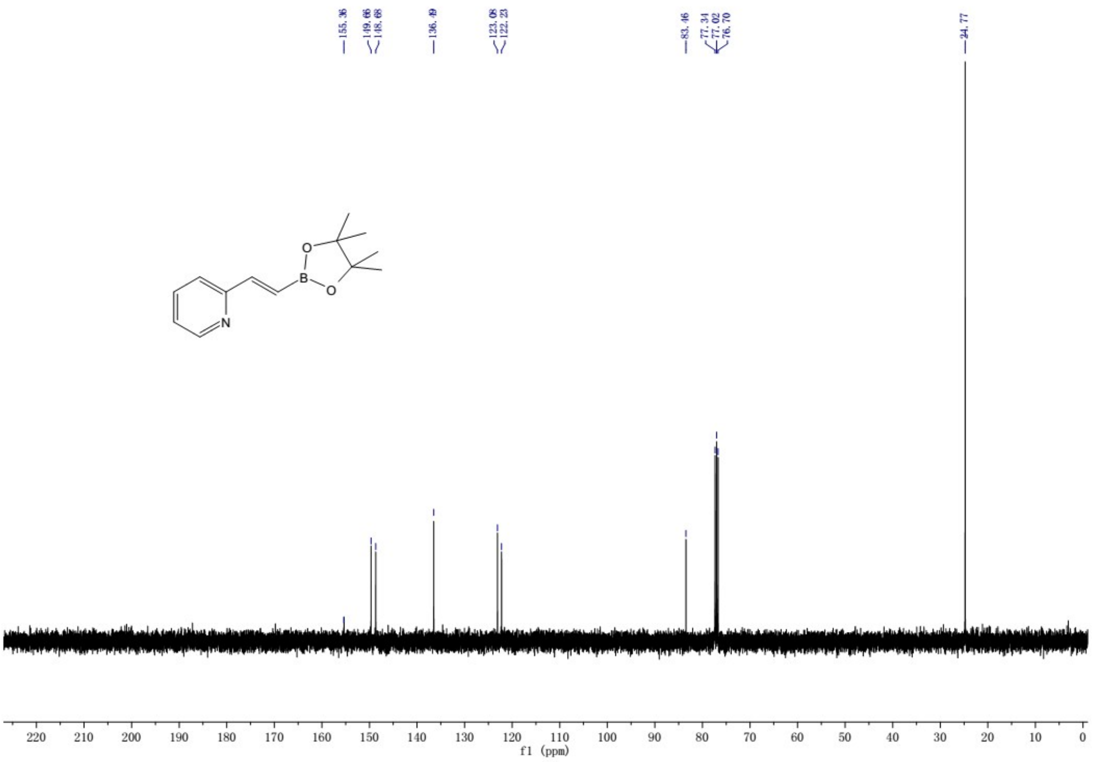
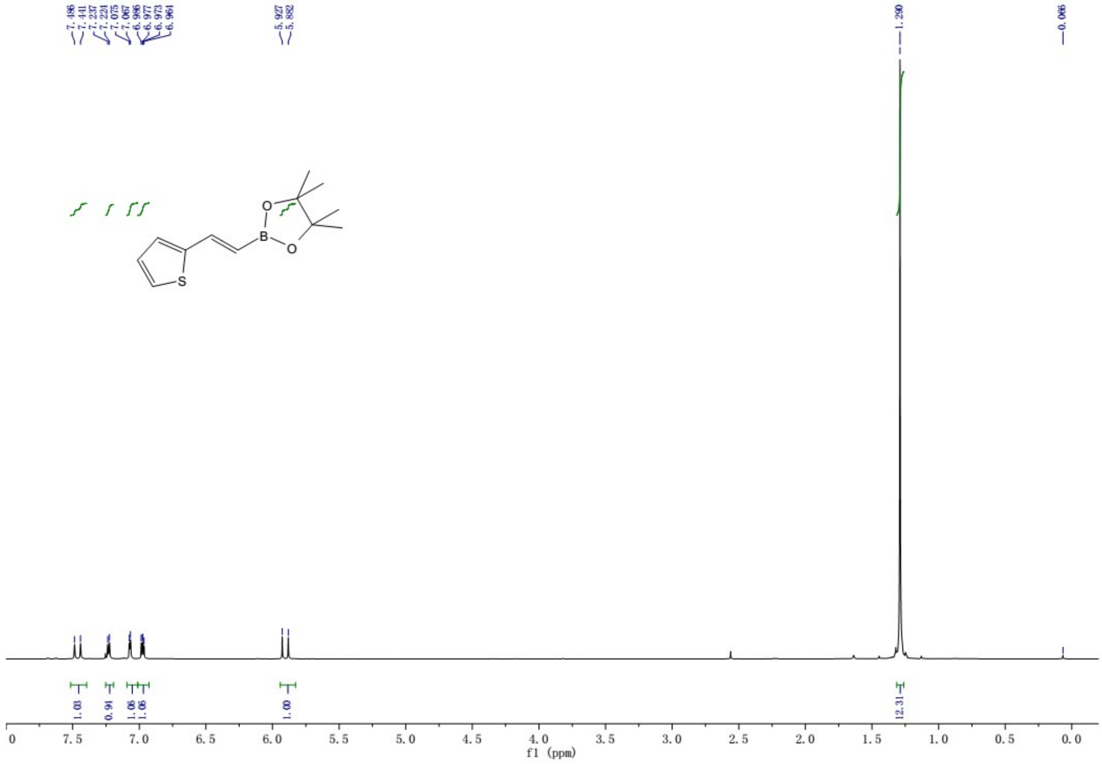
128.56
128.18
114.82
83.08
77.34
77.02
76.71
24.80
H2N
B
O
O
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

2m





2n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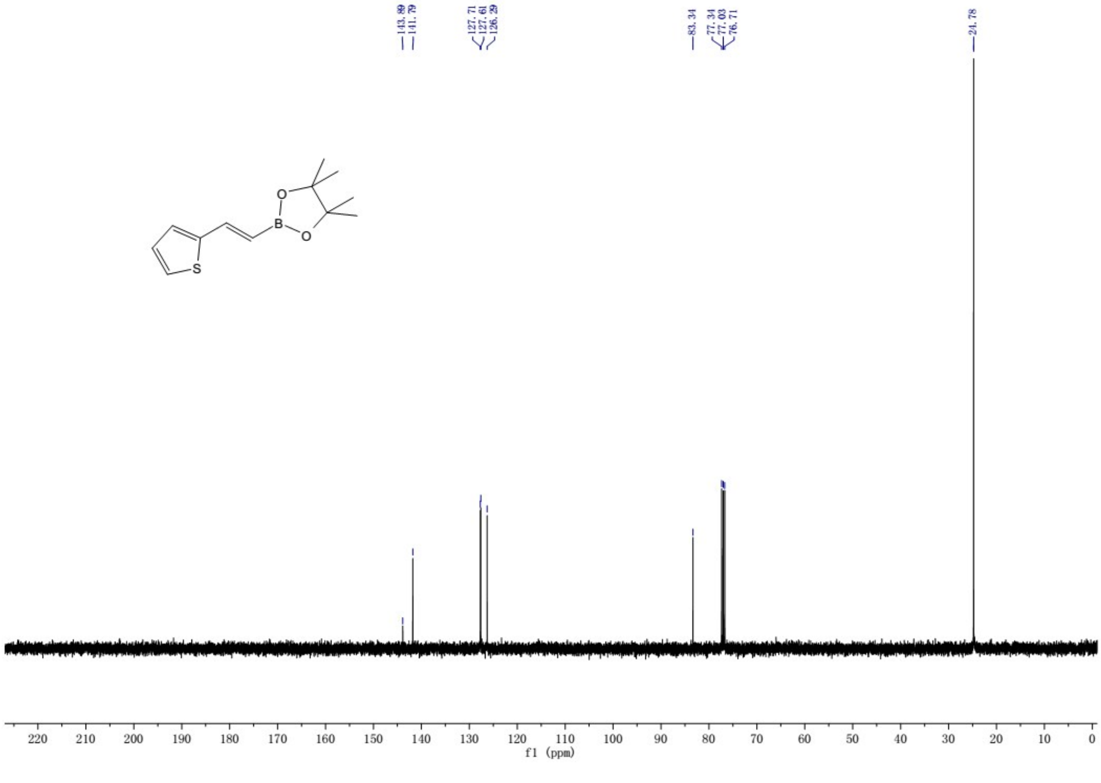
7.067
6.986
6.977
6.973
6.961
5.927
5.882
1.290
0.066
O
B
O
S
1.03
0.91
1.06
1.06
1.00
12.31
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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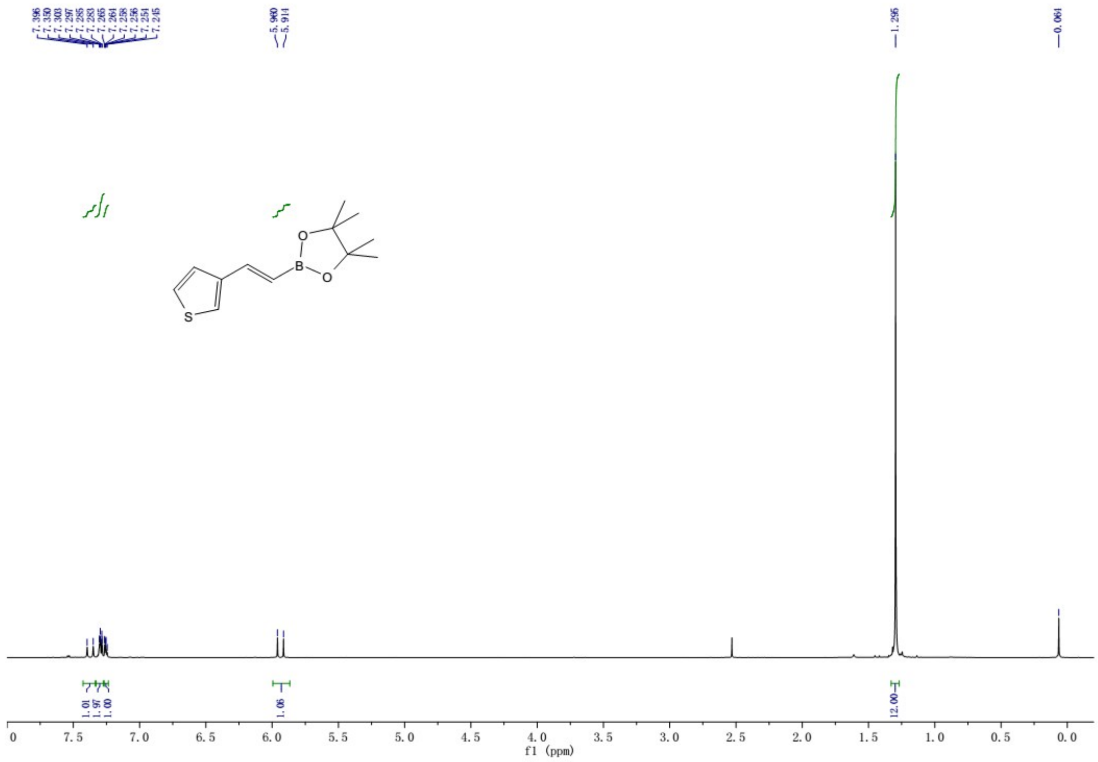
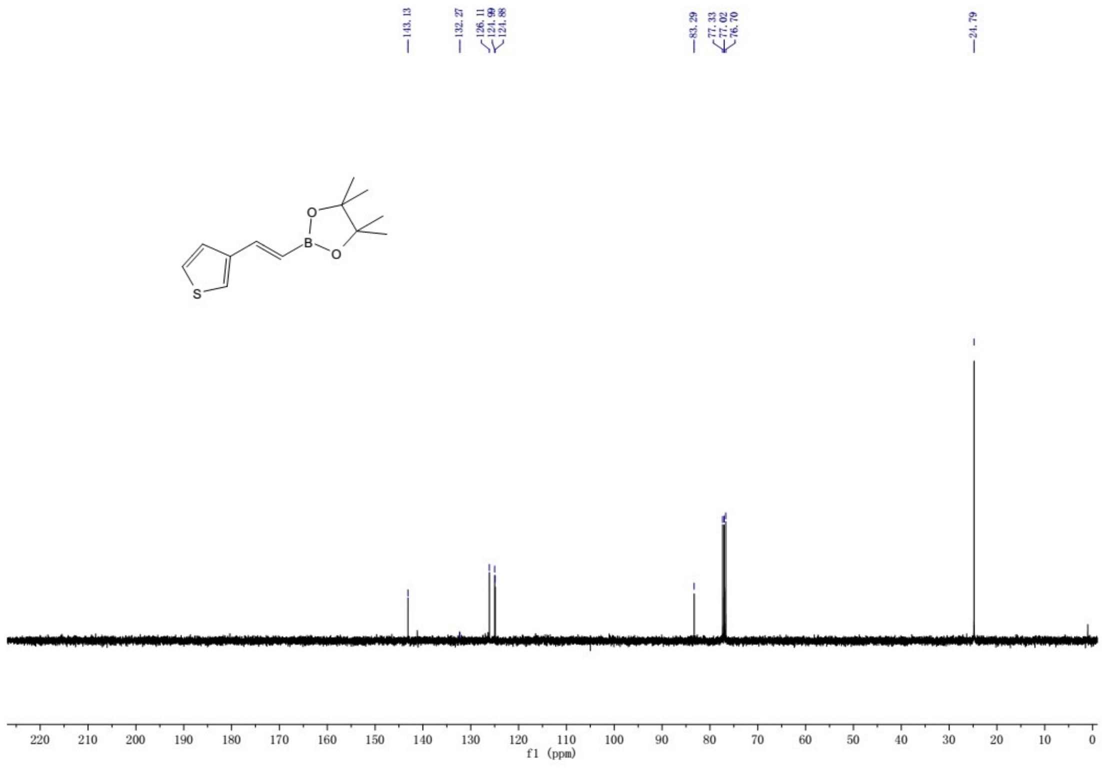
141.79
127.71
127.61
126.29
83.34
77.34
77.03
76.71
24.78
O
B
O
S
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

2o





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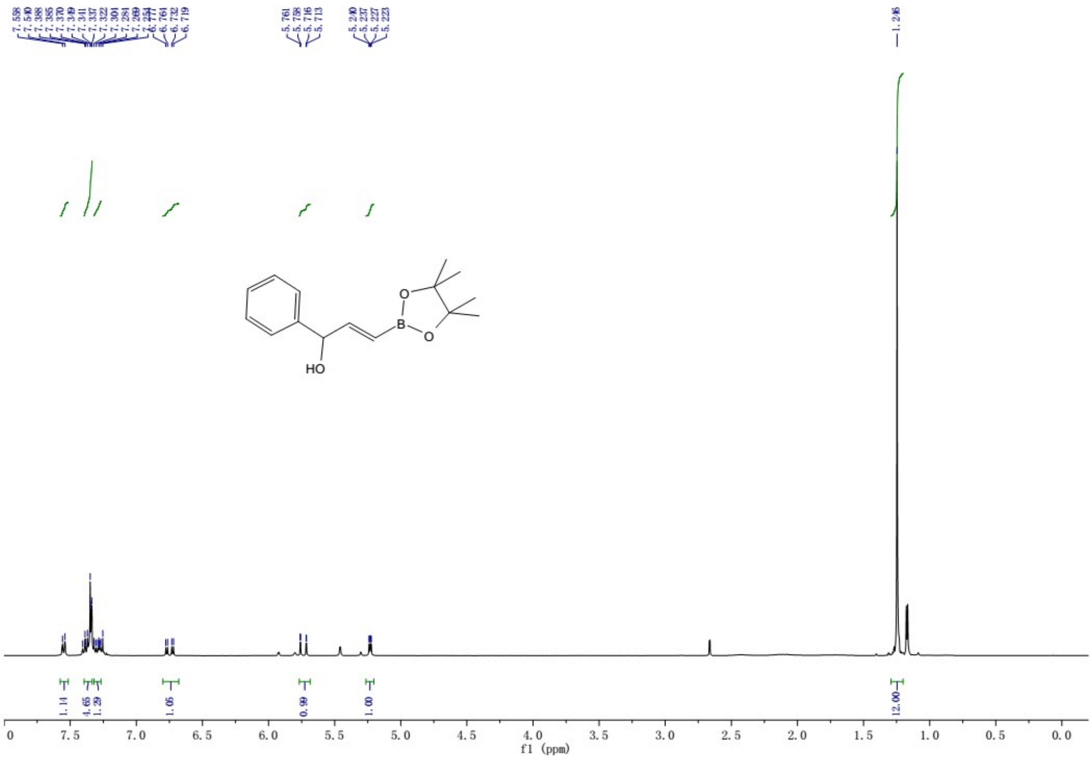
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7.337
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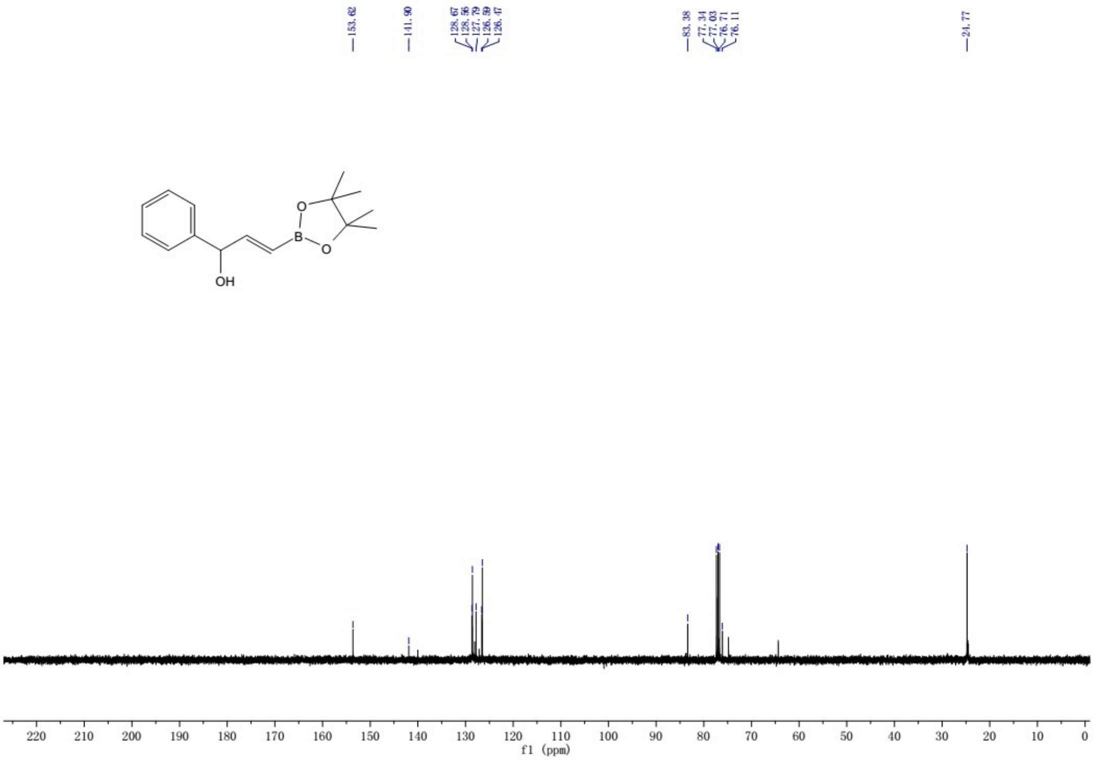
7.289
7.254
6.777
6.761
6.732
6.719
5.761
5.758
5.716
5.713
5.240
5.237
5.227
5.223
1.246
O
B
O
HO
1.14
4.65
1.29
1.05
0.99
1.00
12.00
f1 (ppm)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127.79
126.59
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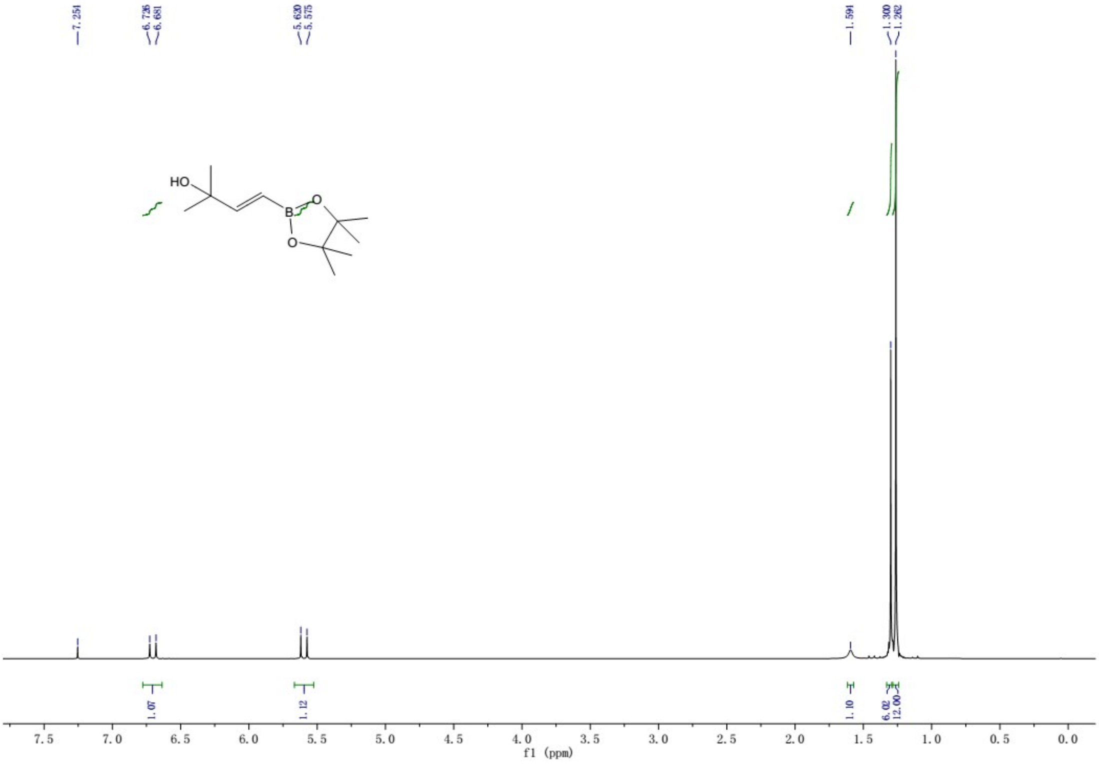
83.38
77.34
77.03
76.71
76.11
24.77
O
B
O
OH
f1 (ppm)

2q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5.575
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1.300
1.262
HO
B
O
O
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1.12
1.10
6.02
12.00
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
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2.5
2.0
1.5
1.0
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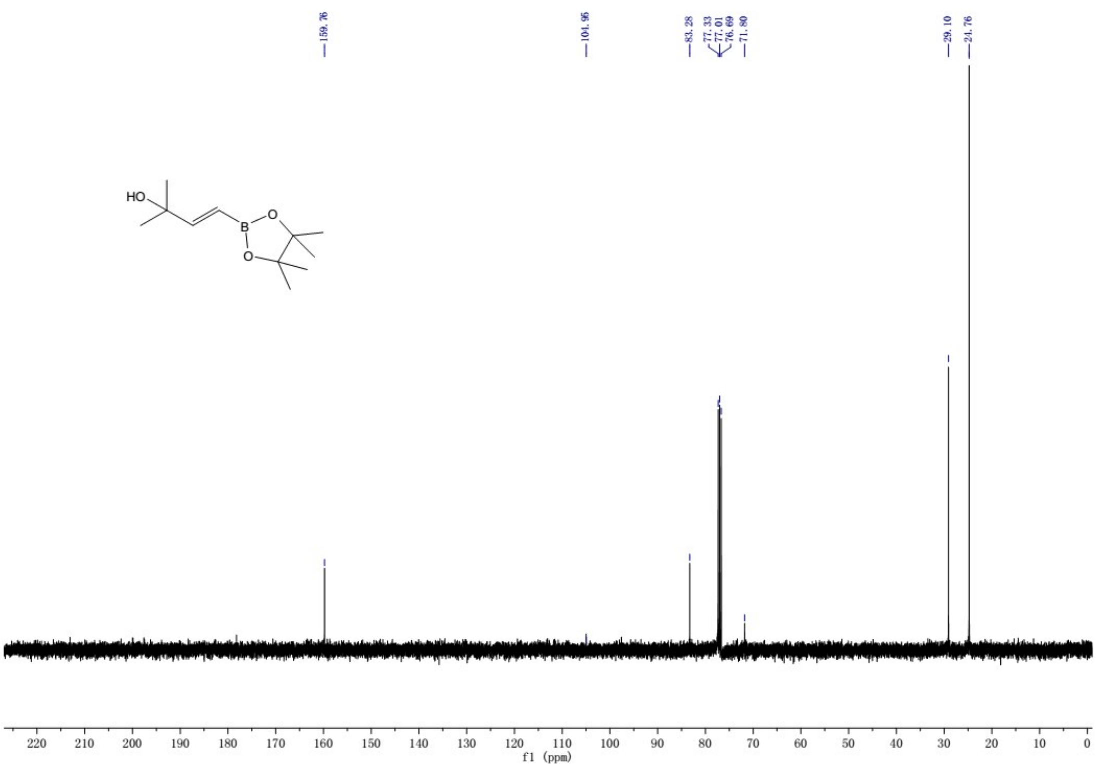
0.0
f1 (ppm)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76.69
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29.10
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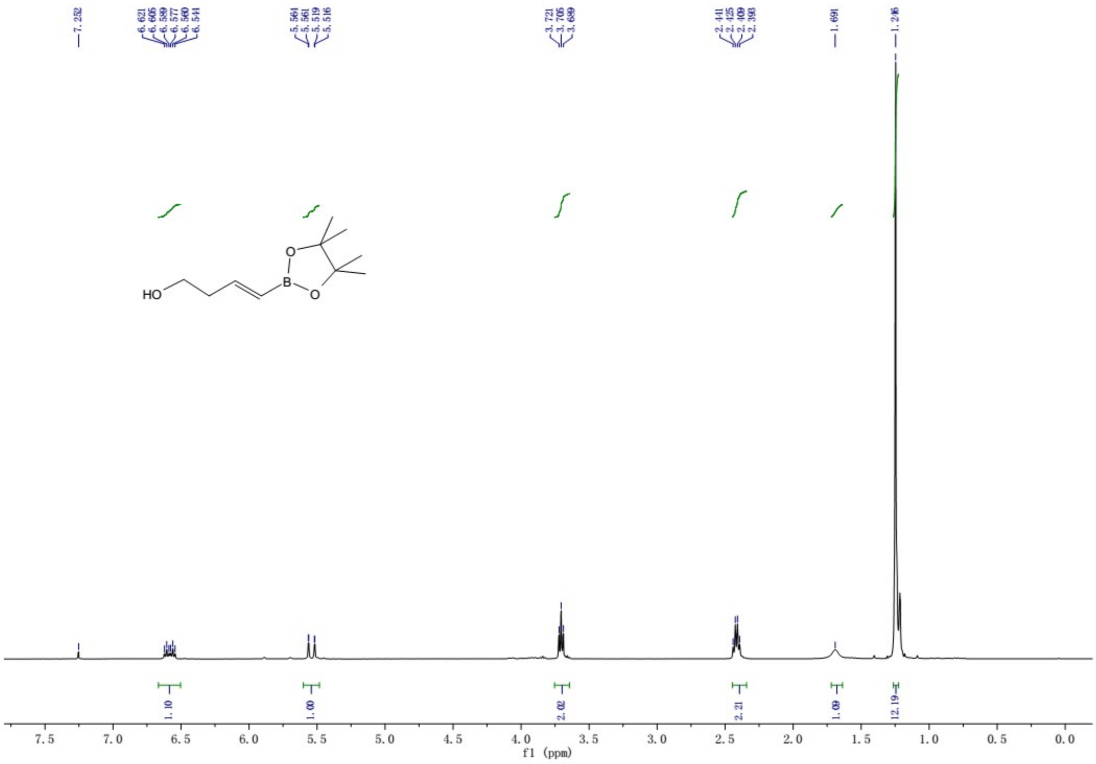
B
O
O
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

2r



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5.564 5.561 5.519 5.516
3.721 3.705 3.689
2.441 2.425 2.409 2.393
1.691
1.246
HO
B
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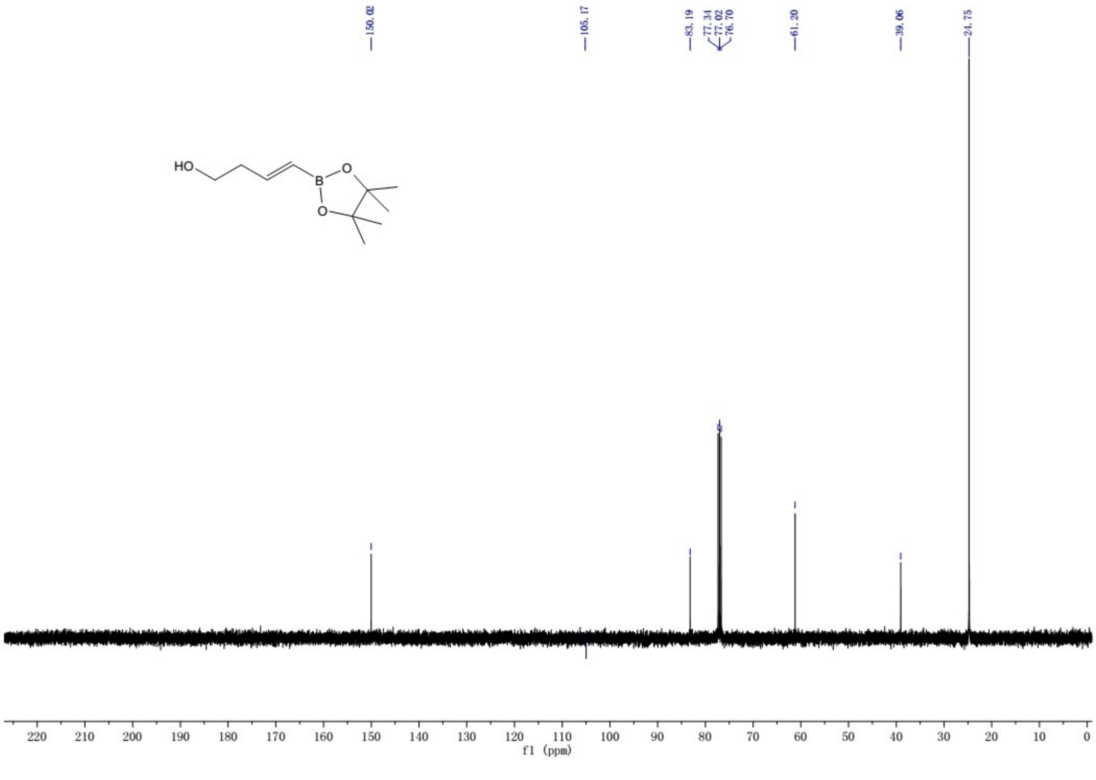
1.10
1.00
2.02
2.21
1.09
12.19
f1 (ppm)



150.02
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77.34 77.02 76.70
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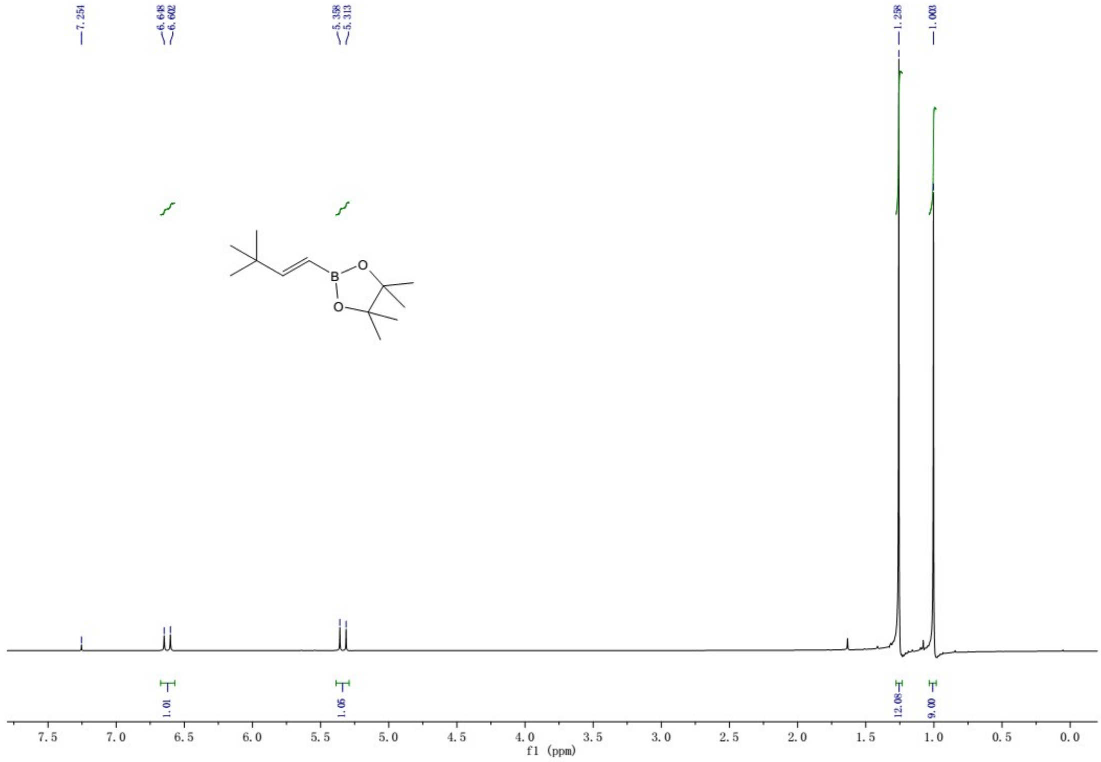
39.06
24.75
HO
B
O
O
f1 (ppm)

2s



7.254
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5.358
5.313
1.258
1.003
B
O
O
1.01
1.05
12.08
9.00
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
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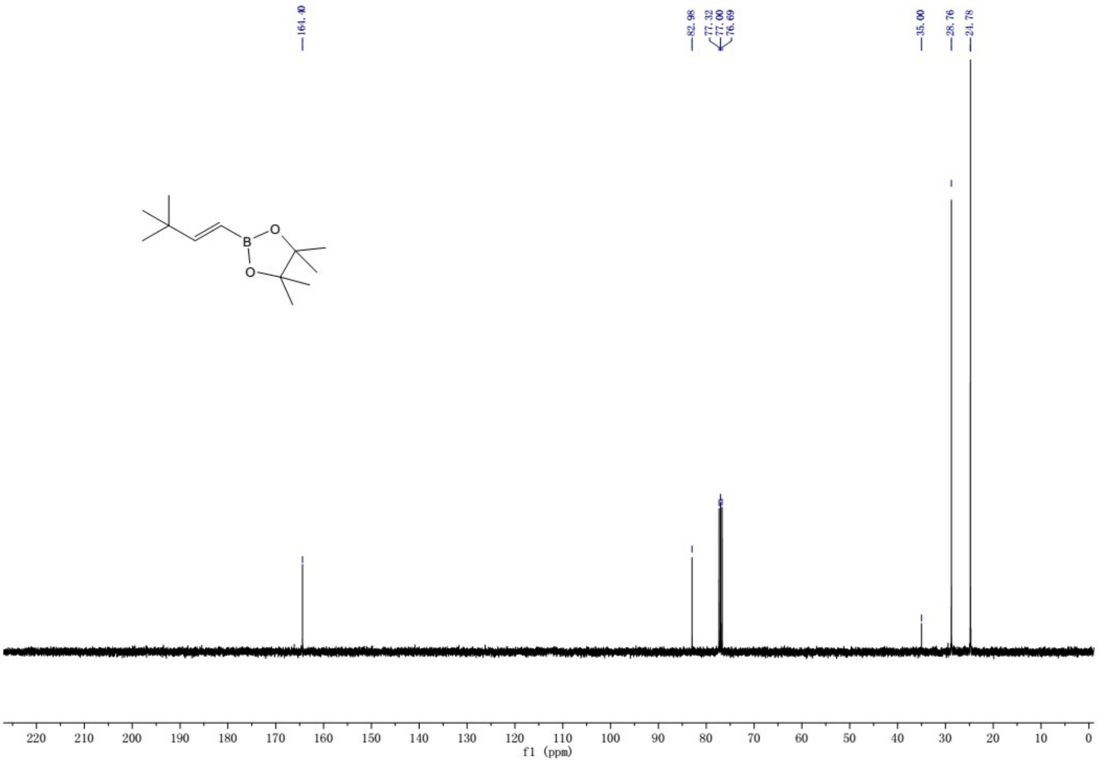
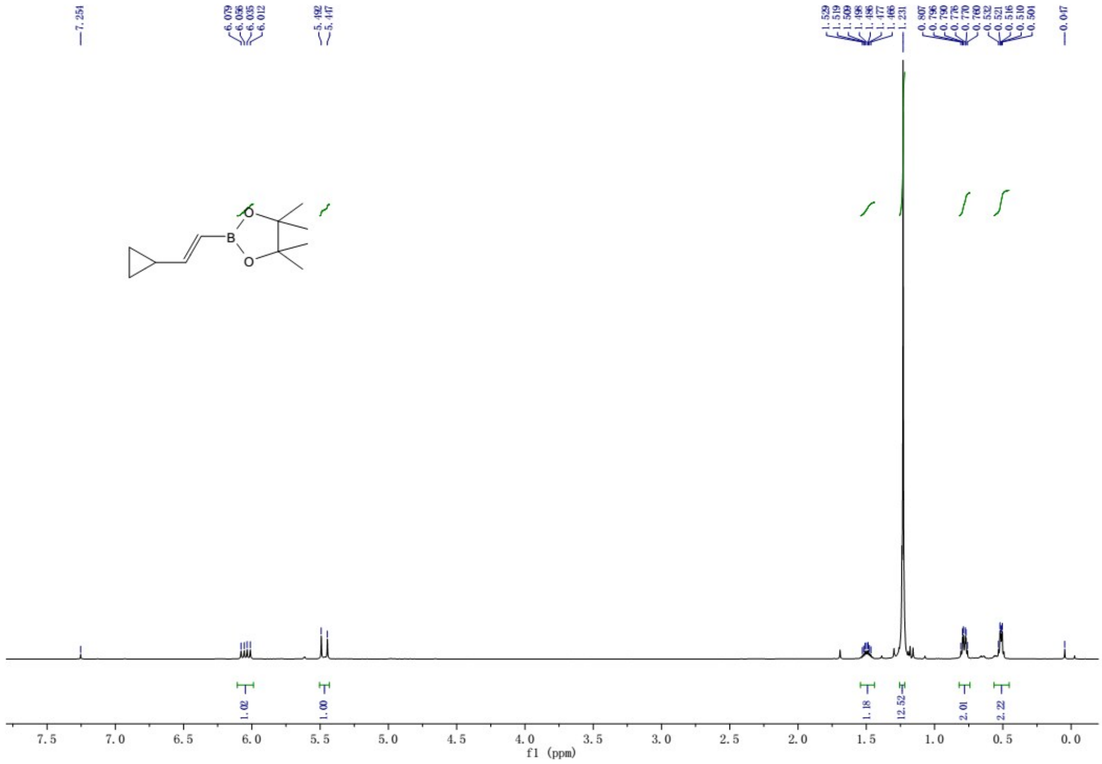
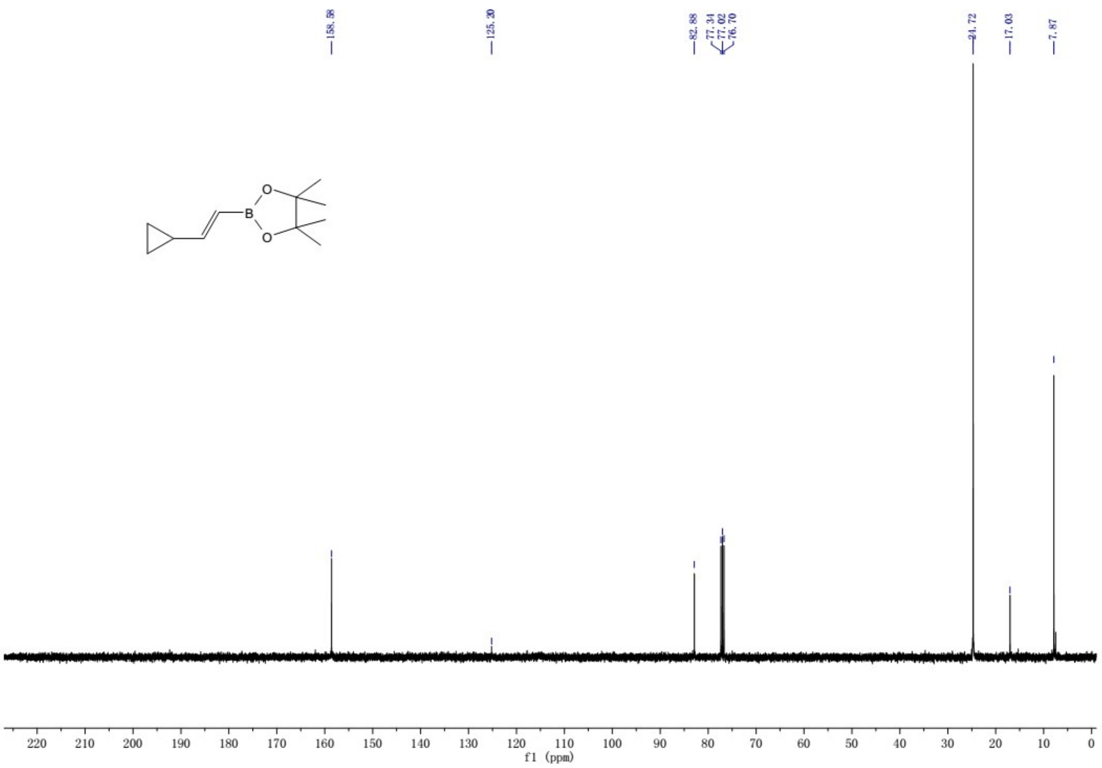
0.0
f1 (ppm)



164.40
82.98
77.32
77.00
76.69
35.00
28.76
24.78
B
O
O
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

2t





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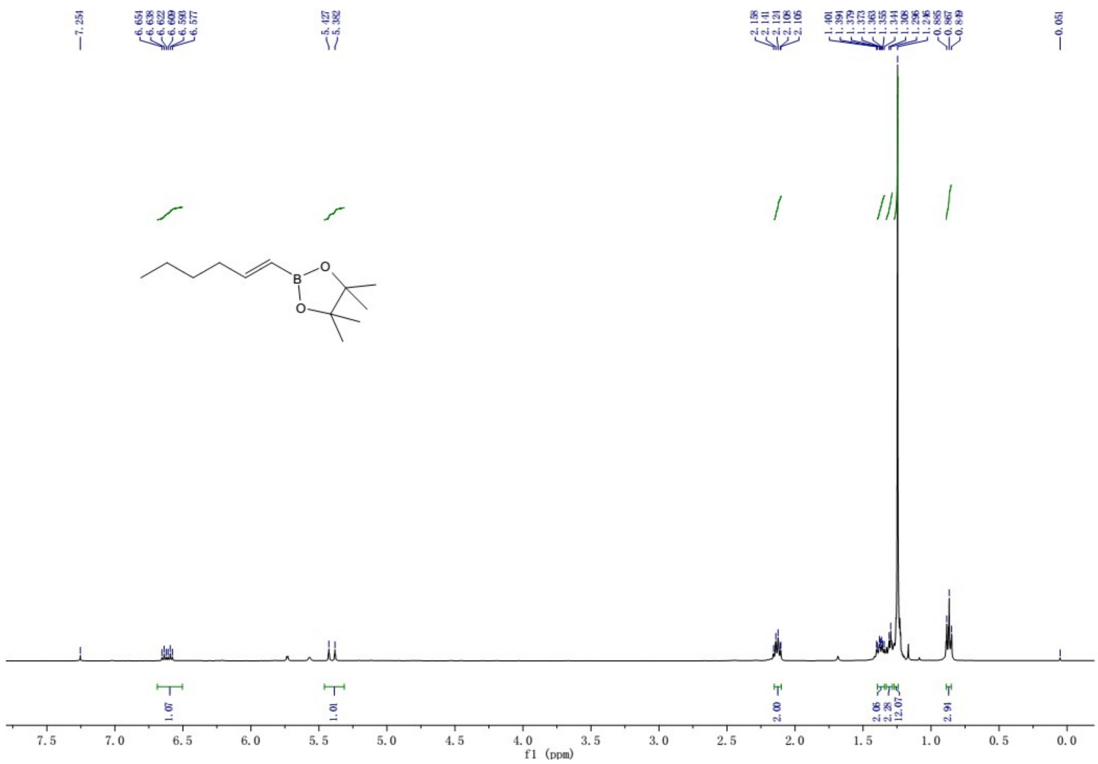

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6.577
5.427
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2.141
2.121
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2.105
1.401
1.394
1.379
1.373
1.363
1.355
1.344
1.308
1.296
1.246
0.885
0.867
0.849
0.051
1.07
1.01
2.00
2.06
2.28
12.07
2.91
7.5
7.0
6.5
6.0
5.5
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3.5
3.0
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1.0
0.5
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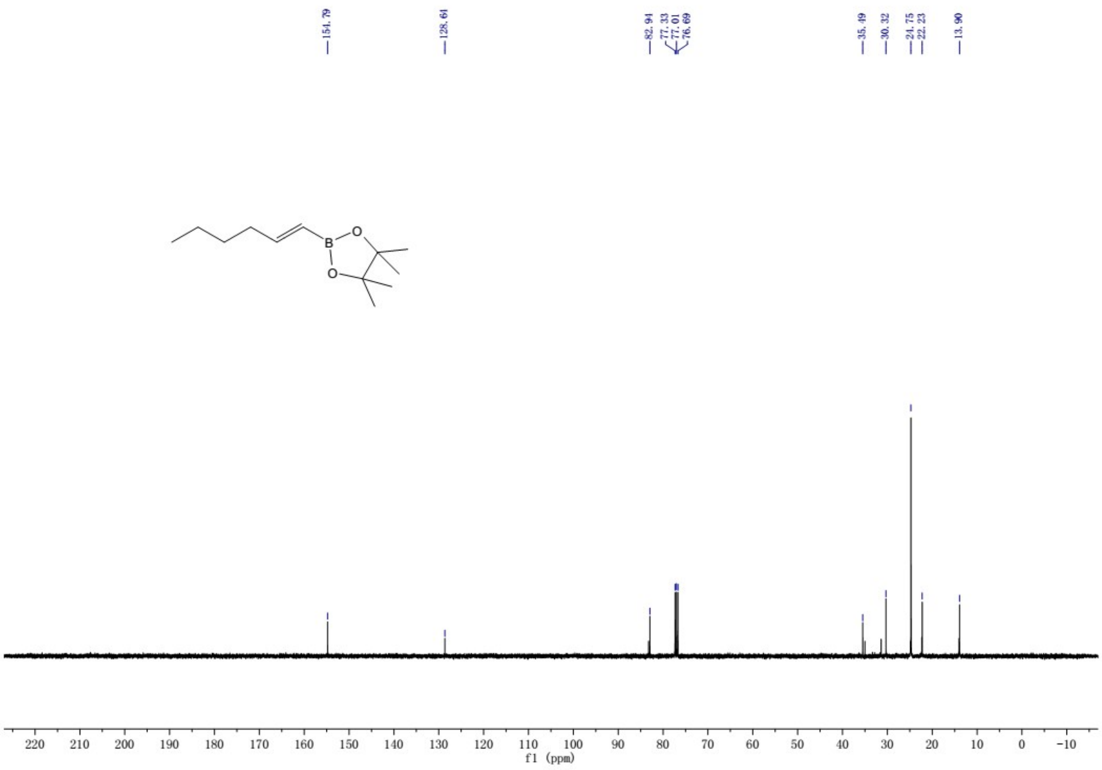
f1 (ppm)



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76.69
35.49
30.32
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22.23
13.90
220
210
200
190
180
170
160
150
140
130
120
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60
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40
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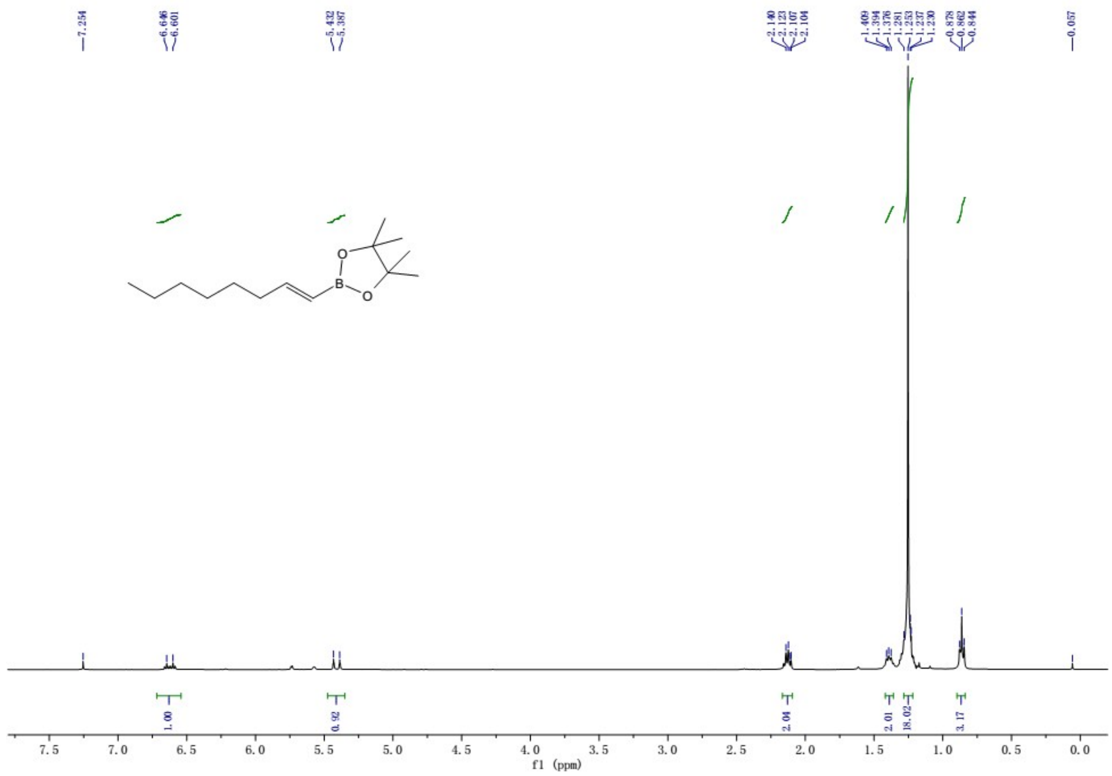
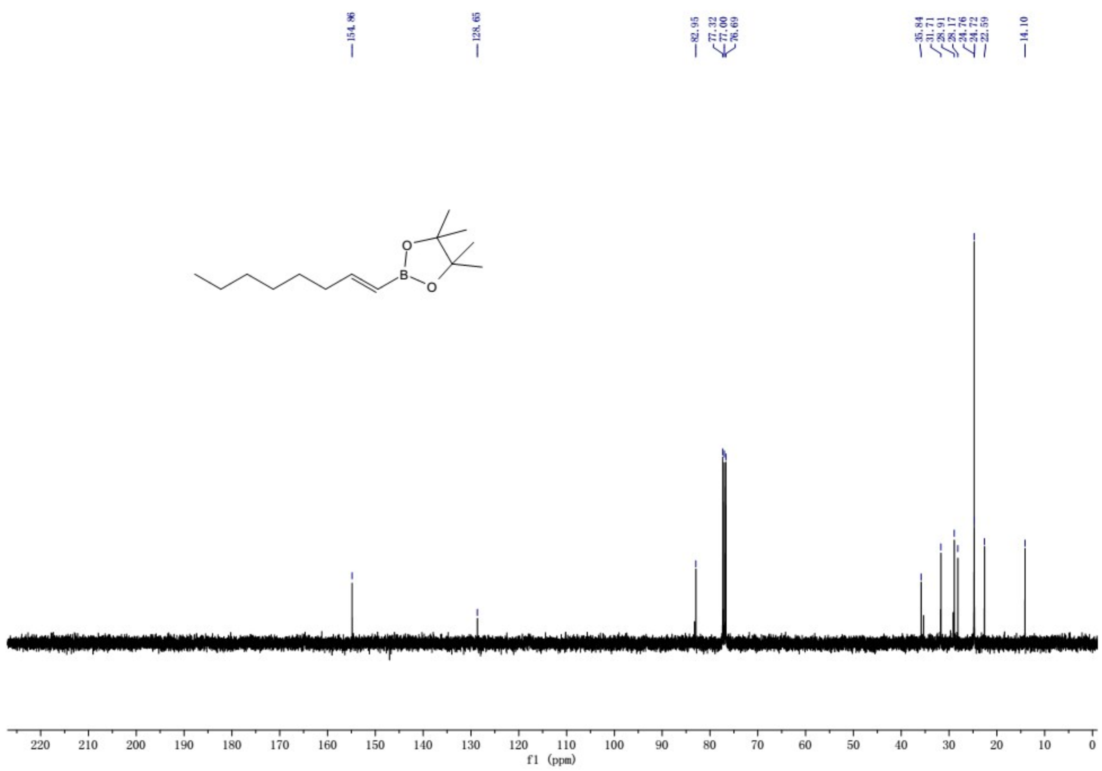
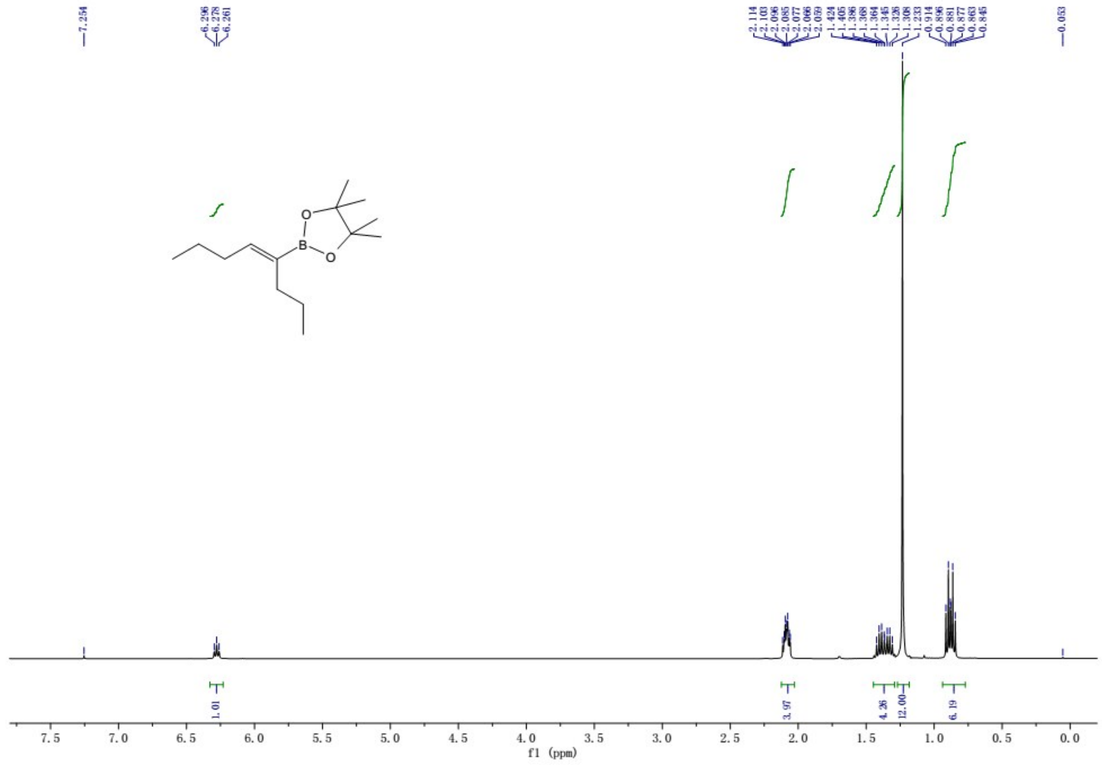
20
10
0
-10
f1 (ppm)

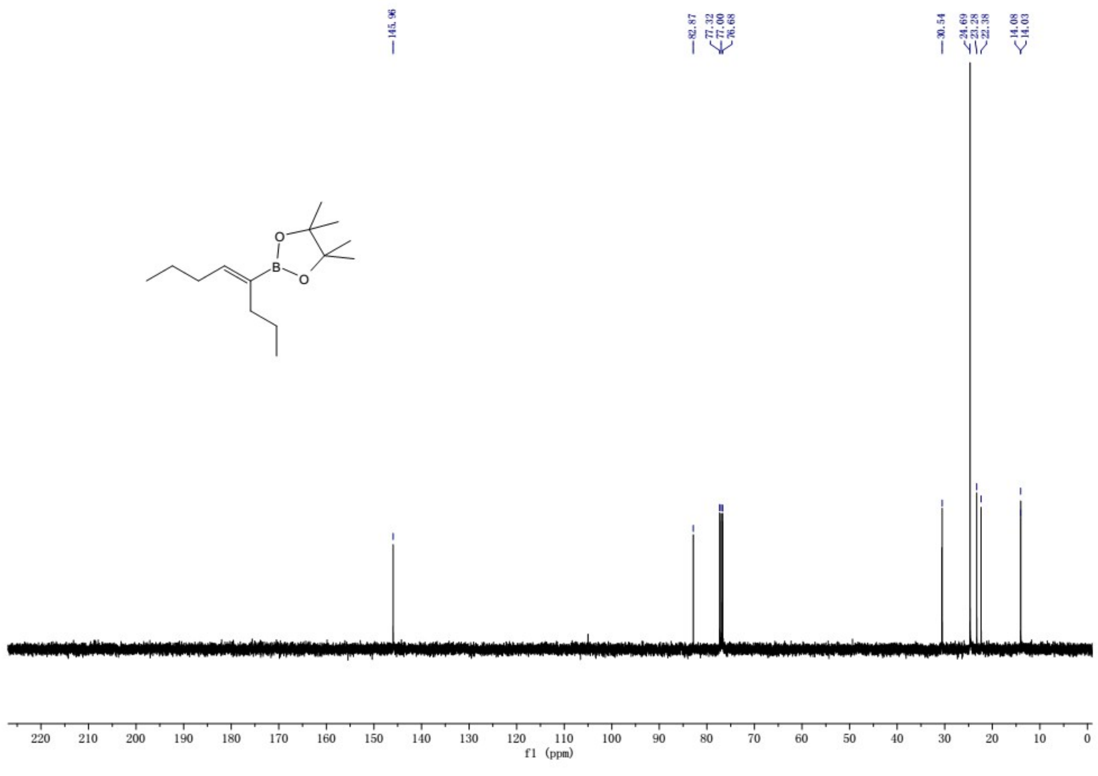
2v



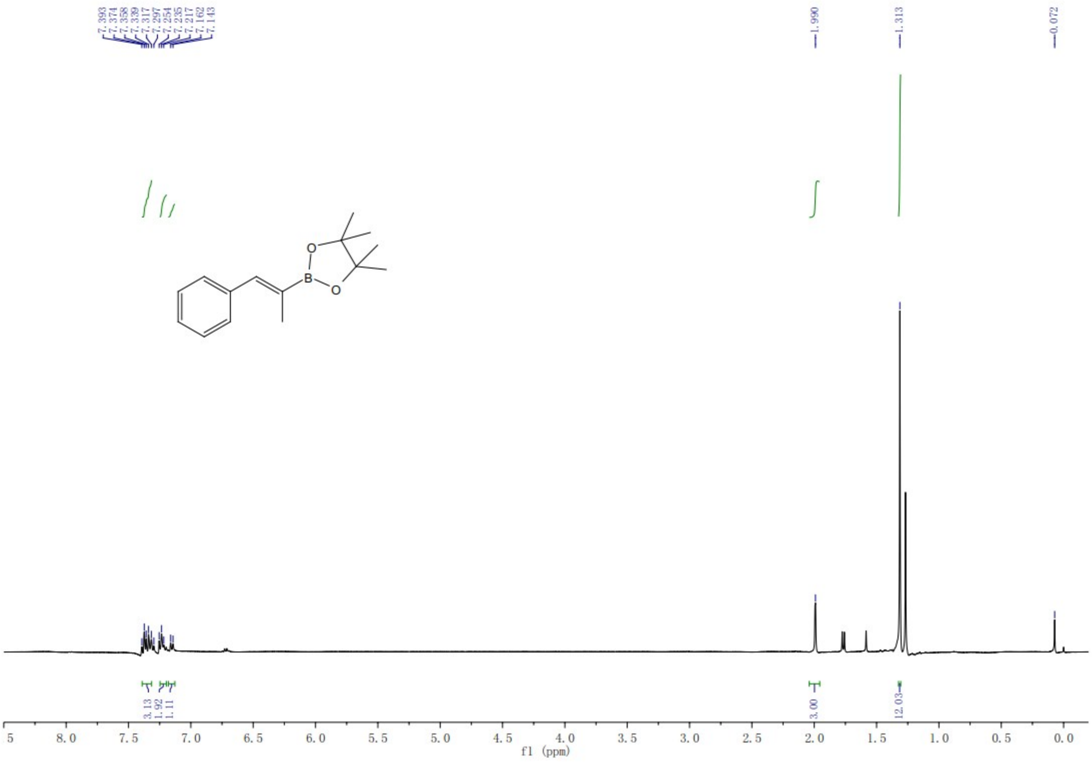


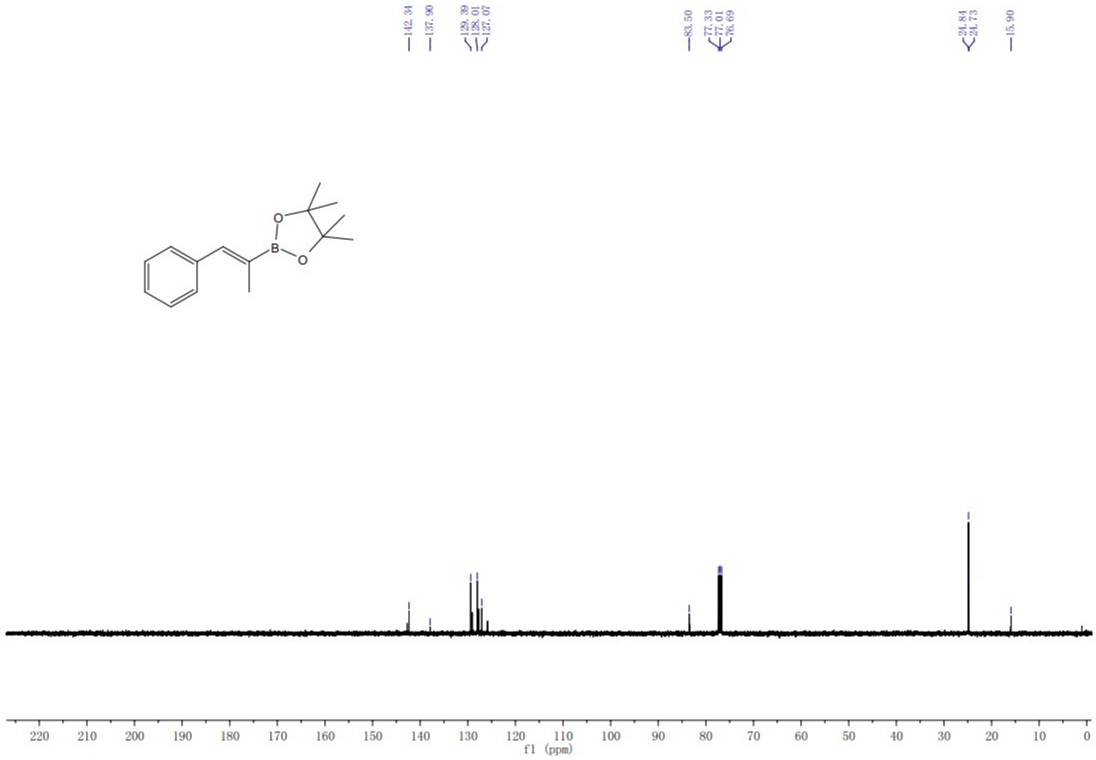
2w



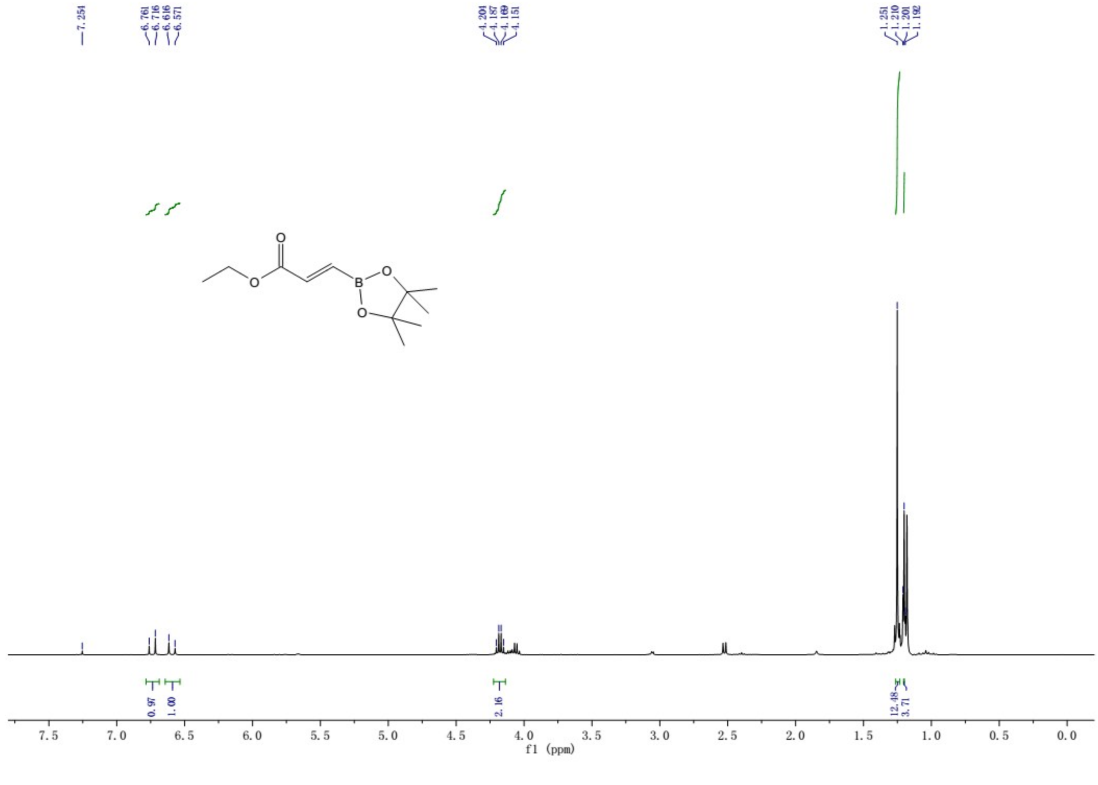


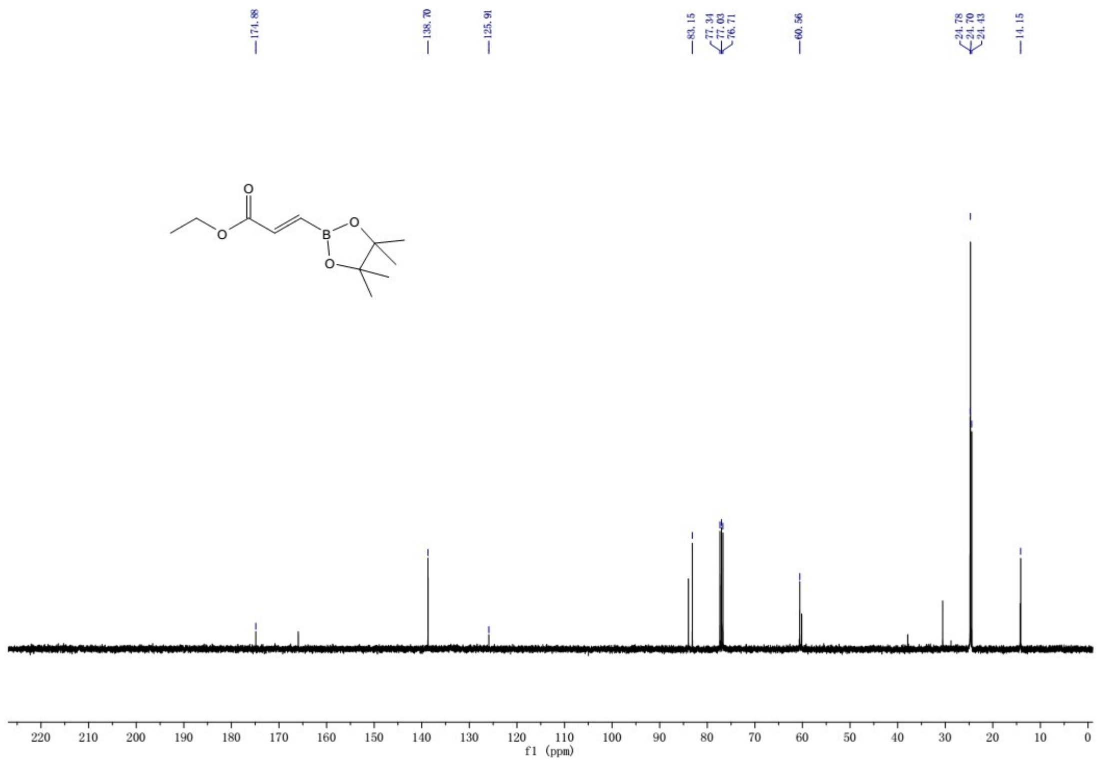
2x


7.393
7.374
7.358
7.339
7.317
7.297
7.254
7.235
7.217
7.162
7.143
1.990
1.313
0.072
3.13
1.92
1.11
3.00
12.03
f1 (ppm)

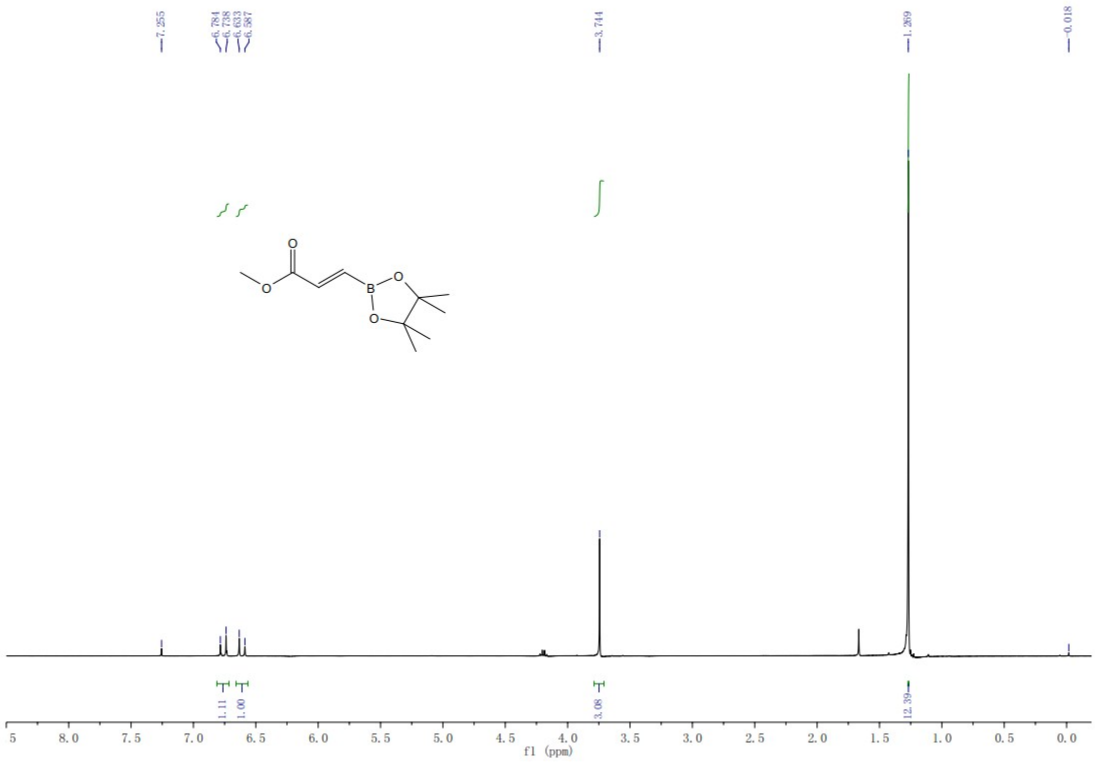

142.34
137.90
129.39
128.01
127.07
83.50
77.33
77.01
76.69
24.84
24.73
15.90
f1 (ppm)

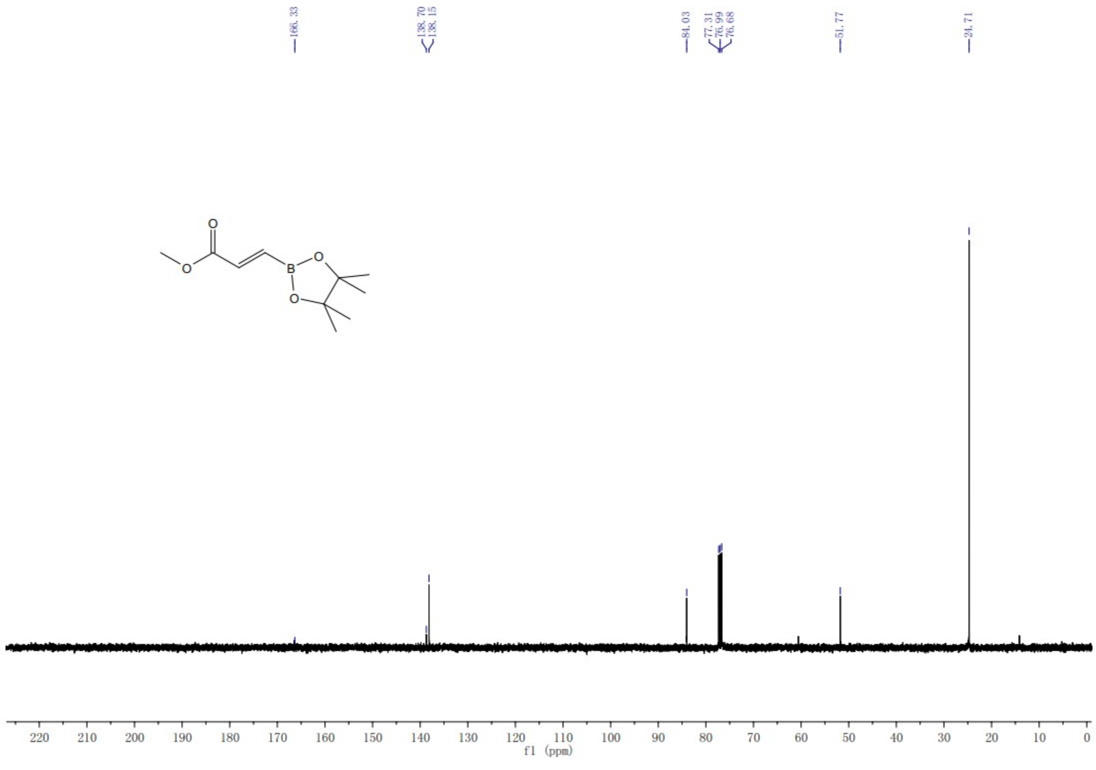
2y



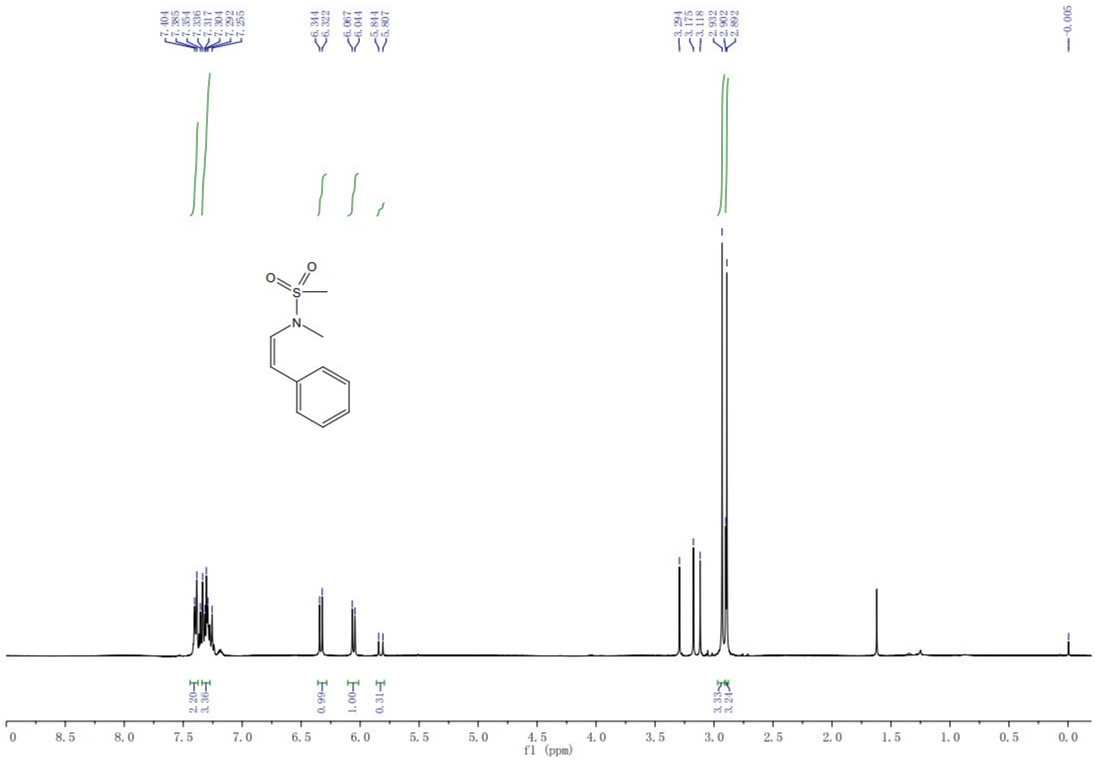


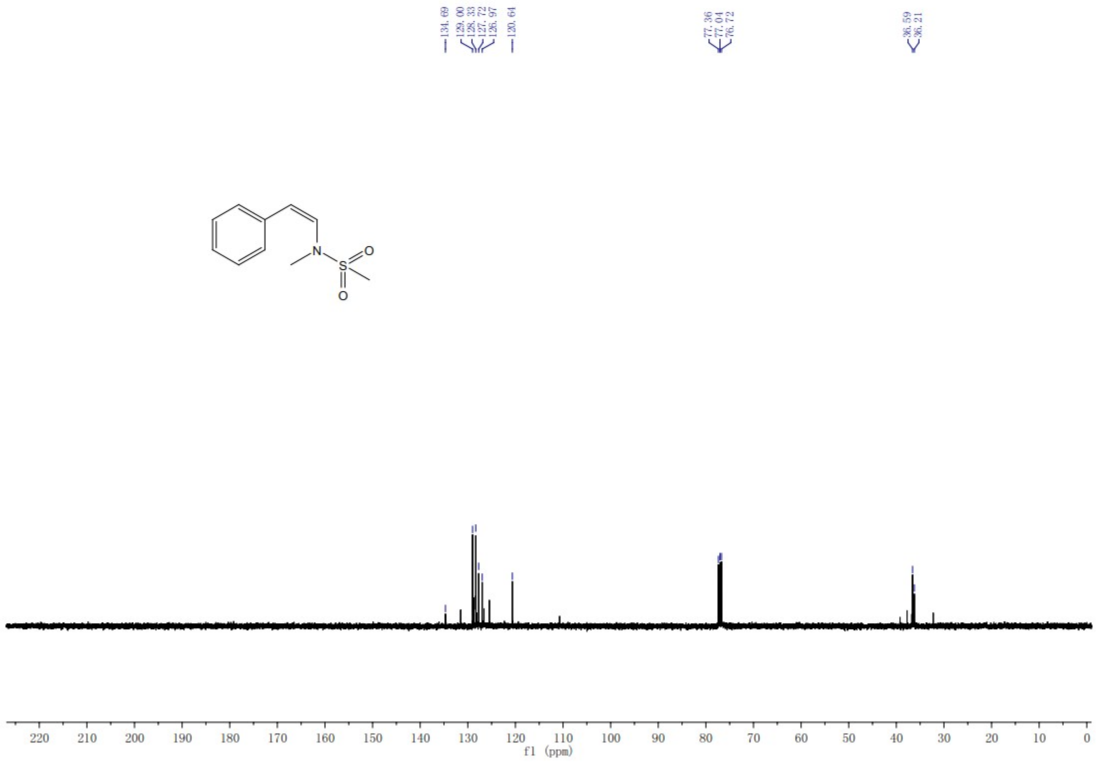
2z


7.255
6.784
6.738
6.633
6.587
3.744
1.269
0.018
1.11
1.00
3.08
12.39
f1 (ppm)

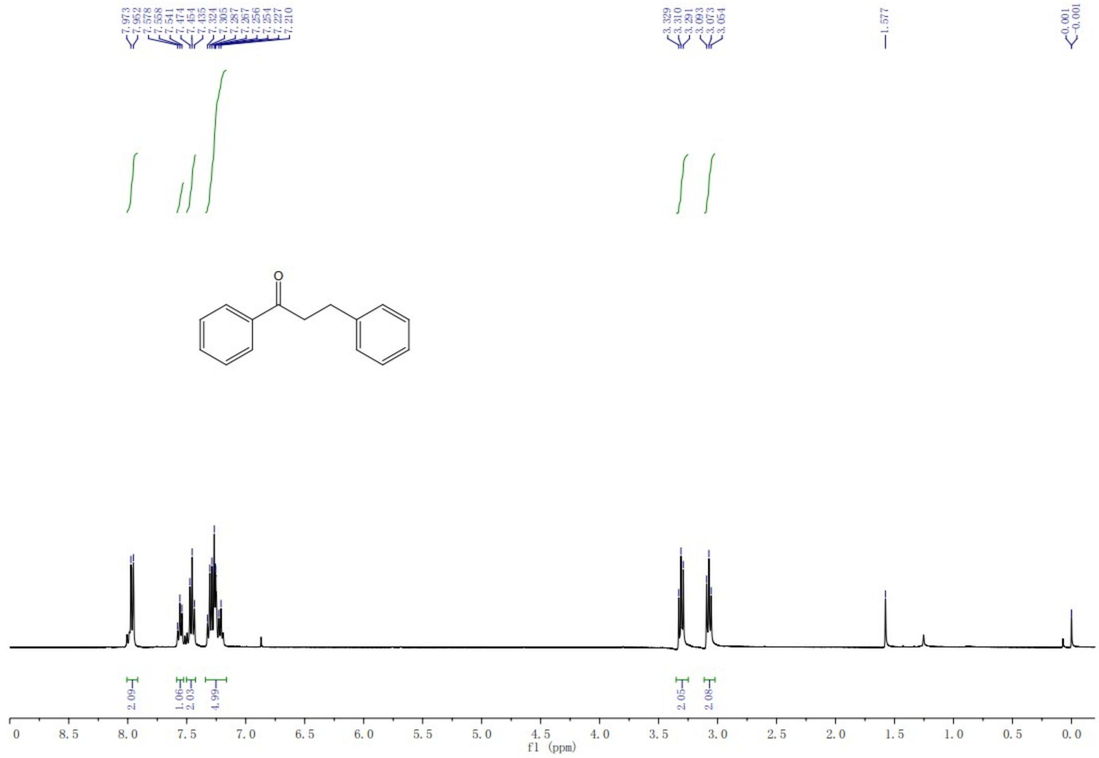

166.33
138.70
138.15
84.03
77.31
76.99
76.68
51.77
24.71
f1 (ppm)

3a





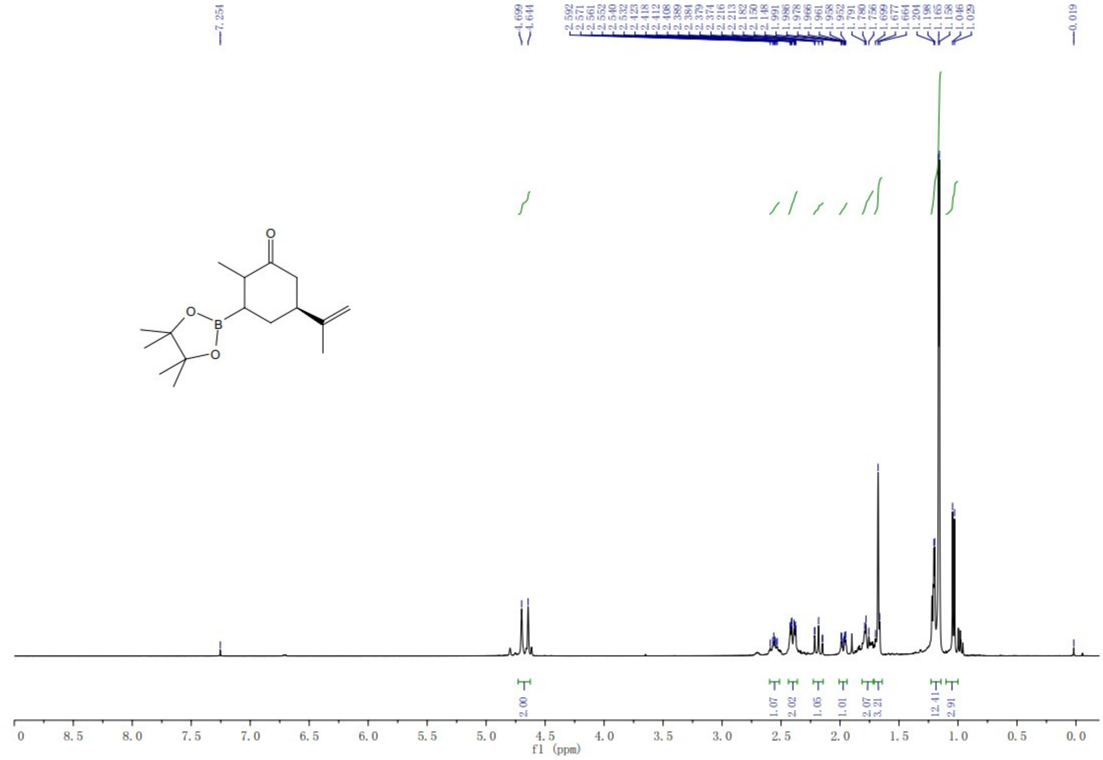
3b

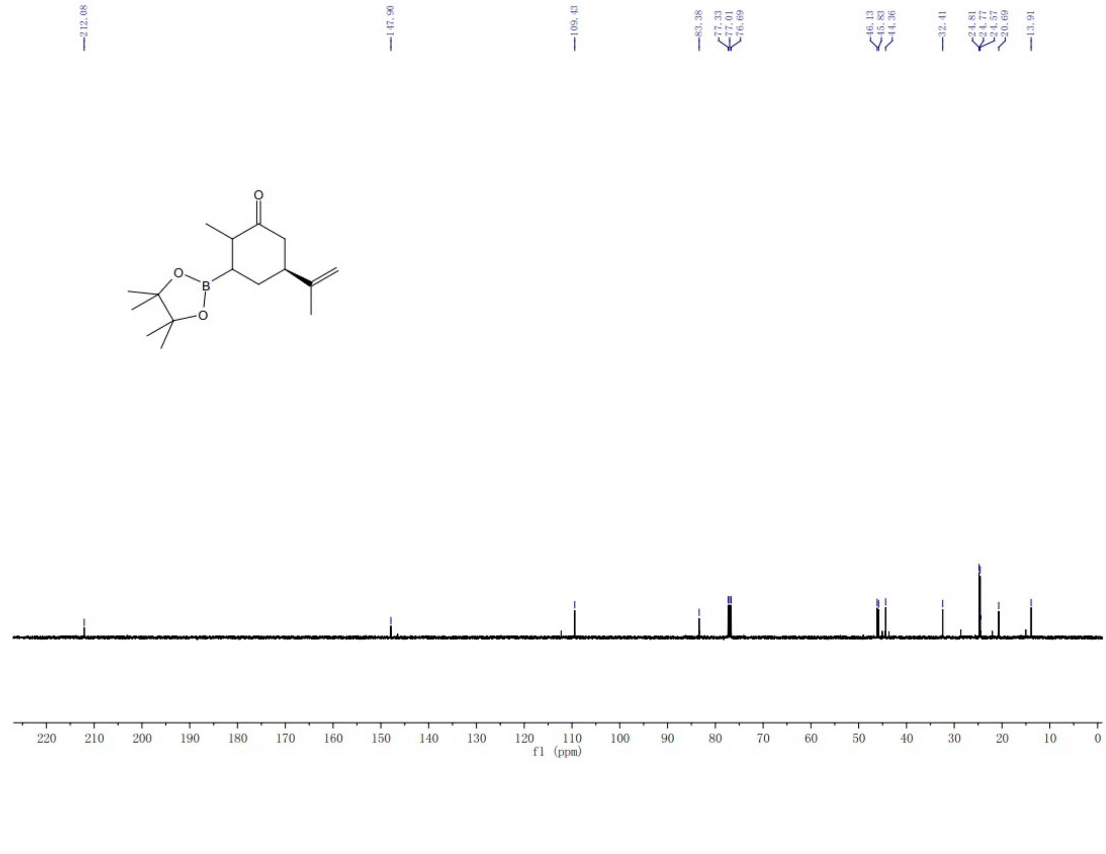


7.973
7.952
7.578
7.558
7.541
7.474
7.454
7.435
7.324
7.305
7.287
7.267
7.256
7.254
7.227
7.210
3.329
3.310
3.291
3.093
3.073
3.054
1.577
0.001
-0.001
O
2.09
1.06
2.03
4.99
2.05
2.08
f1 (ppm)

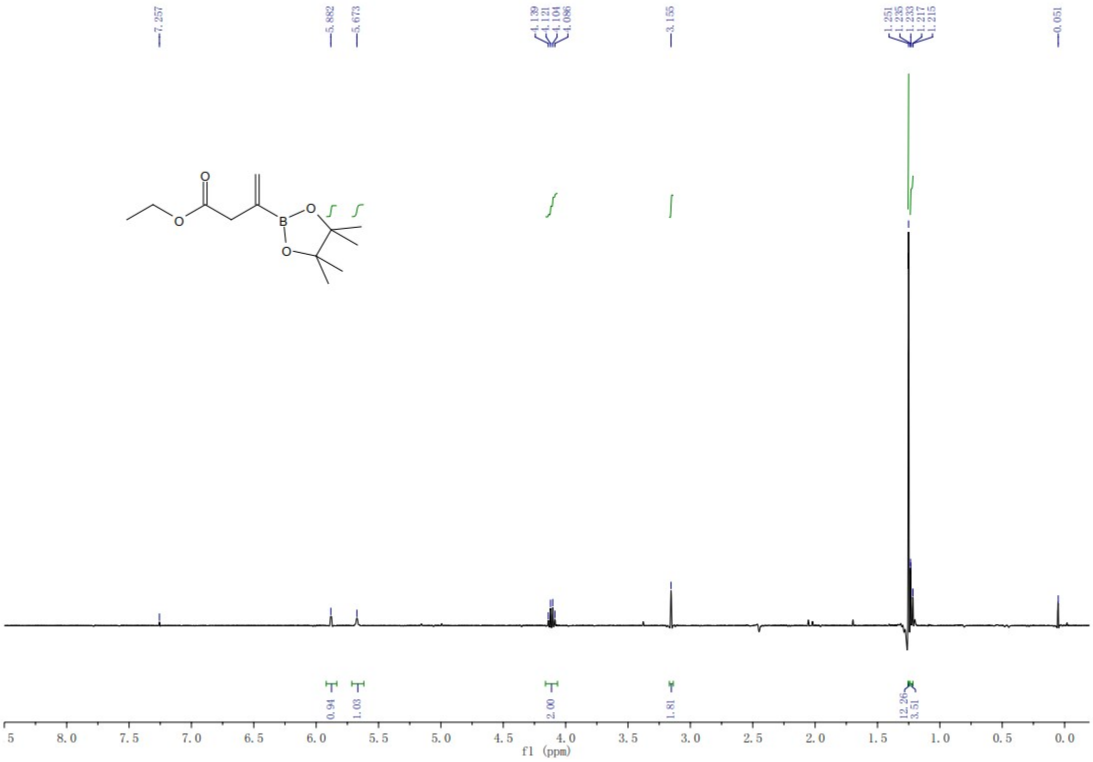
199.23
141.27
136.80
133.07
128.60
128.52
128.42
128.03
127.16
126.12
40.46
30.11
O
f1 (ppm)

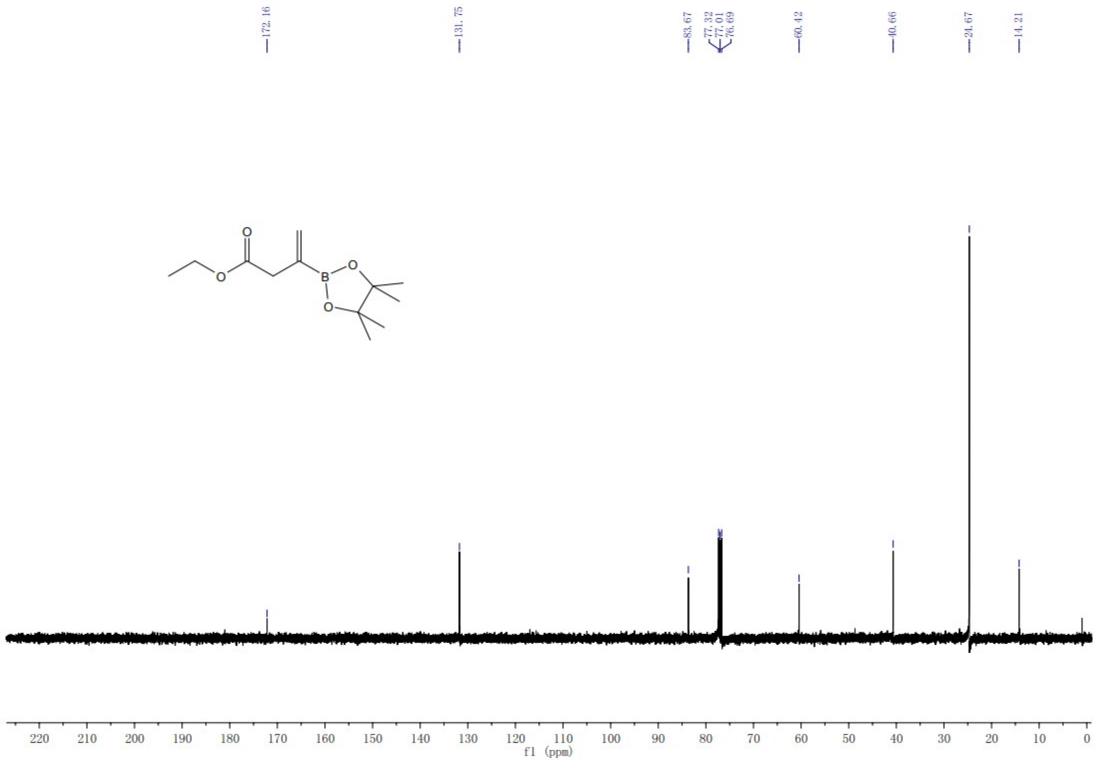
3c


7.254
4.699
4.644
2.592
2.571
2.561
2.552
2.540
2.532
2.423
2.418
2.412
2.408
2.389
2.384
2.379
2.374
2.216
2.213
2.182
2.150
2.148
1.991
1.986
1.978
1.966
1.961
1.958
1.952
1.791
1.780
1.756
1.699
1.677
1.664
1.204
1.198
1.165
1.158
1.046
1.029
0.019
2.00
1.07
2.02
1.05
1.01
2.07
3.21
12.41
2.91
f1 (ppm)


212.08
147.90
109.43
83.38
77.33
77.01
76.69
46.13
45.83
44.36
32.41
24.81
24.77
24.57
20.69
13.91
f1 (ppm)

3d


7.257
5.882
5.673
4.139
4.121
4.104
4.086
3.155
1.251
1.235
1.233
1.217
1.215
0.051
O
O
B
O
O
0.94
1.03
2.00
1.81
12.26
3.51
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)


172.16
131.75
83.67
77.32
77.01
76.69
60.42
40.66
24.67
14.21
O
O
B
O
O
220
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)