Supporting Information

Copper(II)-catalyzed cascade Csp^2–P/C–C bond formation to construct benzo[d]thiazol-2-ylphosphonates

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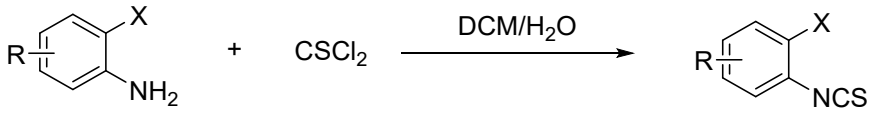
1. Experimental Section

1.1. General Information

All reagents, ligands, and metal catalysts were purchased from commercial suppliers without further purification, and commercially available solvents were purified before use. All nuclear magnetic resonance (NMR) spectra were recorded on Bruker ADVANCE 400 spectrometer. (^{1}H NMR at 400 MHz and ^{13}C NMR at 100 MHz). NMR spectra are reported in parts per million (ppm) from internal tetramethylsilane on the δ scale. Thin layer chromatography plates were visualized by exposure to ultraviolet light with 254 nm and 365 nm of wavelength. HPTLC Silica gel 60 GF254 were used for thin layer chromatography (TLC) and column chromatography was performed in 300-400 mesh silica gels.

1.2. General procedure for the synthesis of 1

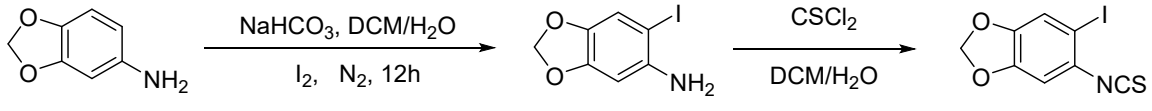


5 1

X= Cl, Br, I

Add **5** (1.0 equiv.) and $CSCl_2$ (1.5 equiv.) in DCM/H_2O (30mL, 3:7) for 3h, at room temperature. After completion of reaction as indicated by TLC, the mixture was washed by DCM, then the liquid was separated, and the organic layer was combined. Then the organic layer was dried by anhydrous Na_2SO_4 and concentrated in vacuo. The crude product was purified by column chromatography on 300-400 mesh silica gels (ethyl acetate/petroleum ether, 1:20) to get desired product **1**.[1]

1.3. General procedure for the synthesis of 1n



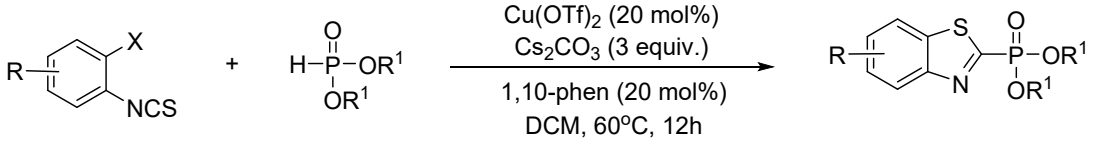
4 5n 1n

In a 150 mL round bottom flask equipped with a magnetic stirring bar, **4**(685mg, 5.0mmol) and $NaHCO_3$ (1.26g, 15.0mmol) was added. Then, DCM/H_2O (33mL, 2:1)

was added into the reaction. Nitrogen was bubbled through the mixture for 15 min while stirring. Then, Iodine (1.27g, 5mmol) was transferred to the reaction vessel and the mixture was stirred under nitrogen gas for a night. When the reaction completed (indicated by TLC), the mixture was separated and the aqueous phase was extracted with DCM (50 mL). The combined organic layers were washed with $Na_2S_2O_3$ (25 mL, aq./H_2O, 1:3), and dried over anhydrous Na_2SO_4, filtered and concentrated. The mixture was purified by flash column chromatography (EtOAc/petroleum ether, 1:3) to obtain a brown solid **5n** (986mg, 75%yield).[2]

A mixture of **5n** (788mg, 3.0mmol), and $CSCl_2$(517mg, 4.5mmol), DCM/H_2O (30mL, 3:7) was stirred at room temperature for 3h. Then, the crude was extracted with DCM, and dried over anhydrous Na_2SO_4 and concentrated in vacuo. The crude product was purified by column chromatography on 300-400 mesh silica gels (ethyl acetate/petroleum ether, 1:20) to get **1n.**[1]

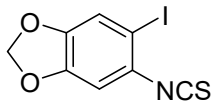
1.4 General procedure for the synthesis of 3



1 2 3

In a schlenk sealed tube equipped with a stirrer, **1** (0.20 mmol, 1.0 equiv.) and **2** (0.4mmol, 2.0 equiv.), $Cu(OTf)_2$ (20 mol%), 1,10-phen (20 mol%), $CsCO_3$ (0.6 mmol, 3 equiv.) and DCM (2mL) were added. Place the sealed tube in an oil bath which is preheated to 60 °C. The mixture was stirred for 12h. Then, the mixture was concentrated in vacuo, and purified by column chromatography on silica gels (ethyl acetate/ petroleum ether, 4:5) to get **3**.

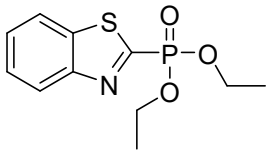
2. ^{1}H and ^{13}C data of the compound 1n



5-iodo-6-isothiocyanatobenzo[d][1,3]dioxole (1n)

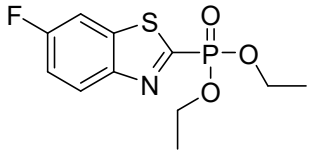
^{1}H NMR (400 MHz, CDCl3) δ 7.15 (s, 1H), 6.76 (s, 1H), 6.02 (s, 2H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 148.8, 147.5, 128.4, 117.8, 107.3, 102.6, 83.3. HRMS calcd for $C_8H_4INO_2S^+$ ($M + H^+$): 305.9080, Found: 305.9082.

3. ^{1}H, ^{13}C and ^{31}P data of the compounds 3



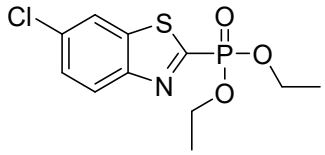
diethyl benzo[d]thiazol-2-ylphosphonate (3aa)[3]

Yield: 85%; light yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.25 (d, J = 7.9 Hz, 1H), 8.02 (d, J = 8.1 Hz, 1H), 7.56 (dt, J = 14.9, 7.1 Hz, 2H), 4.42 - 4.26 (m, 4H), 1.40 (t, J = 7.1 Hz, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.1 (d, J_{C-P} =237.0 Hz), 154.6 (d, J = 29.0 Hz), 136.4, 127.0, 126.9, 124.9, 122.0, 64.1 (d, J_{C-P} = 5.9 Hz), 16.3 (d, J_{C-P} = 6.3 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ 3.96.



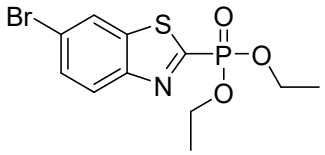
diethyl (6-fluorobenzo[d]thiazol-2-yl)phosphonate (3ba)

Yield: 42%; yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.20 (dd, J = 9.0, 4.8 Hz, 1H), 7.68 (dd, J = 8.0, 2.4 Hz, 1H), 7.33 (td, J = 8.9, 2.5 Hz, 1H), 4.42 - 4.25 (m, 4H), 1.41 (t, J = 7.1 Hz, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 161.5 (d, $^{1}J_F$ = 247.0 Hz), 159.9 (d, J_{C-P}=238.0 Hz), 151.3 (d, $^{2}J_F$ = 29.0 Hz), 137.6 (d, $^{3}J_F$ = 12.0 Hz), 126.1 (d, $^{3}J_F$ = 10.0 Hz), 116.1 (d, $^{2}J_F$ = 25.0 Hz), 107.9 (d, $^{2}J_F$ = 26.0 Hz), 64.2 (d, J_{C-P} = 5.9 Hz), 16.2 (d, J_{C-P} = 6.2 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ 3.39. ^{19}F NMR (376 MHz, $CDCl_3$) δ -112.66. HRMS calcd for $C_{11}H_{13}FNO_3PS^+$ ($M + H^+$): 290.0411, Found: 290.0412.



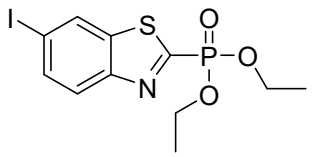
diethyl (6-chlorobenzo[d]thiazol-2-yl)phosphonate (3ca)[3]

Yield: 54%; yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.15 (d, J = 8.8 Hz, 1H), 7.99 (d, J = 1.7 Hz, 1H), 7.54 (dd, J = 8.8, 1.9 Hz, 1H), 4.42 - 4.21 (m, 4H), 1.41 (t, J = 7.1 Hz, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.7 (d, $J_{C\text{-}P}$=237.0 Hz), 153.0 (d, J=29.0 Hz), 137.5, 133.3, 127.8, 125.6, 121.5, 64.2 (d, $J_{C\text{-}P}$ = 5.9 Hz), 16.3 (d, $J_{C\text{-}P}$ = 6.2 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ 3.31.



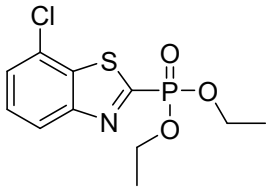
diethyl (6-bromobenzo[d]thiazol-2-yl)phosphonate (3da)[3]

Yield: 57%; yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.07 (d, J = 1.5 Hz, 1H), 8.00 (d, J = 8.8 Hz, 1H), 7.59 (dd, J = 8.8, 1.7 Hz, 1H), 4.32 - 4.19 (m, 4H), 1.32 (t, J = 7.1 Hz, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.8 (d, $J_{C\text{-}P}$ = 237.0 Hz), 153.4 (d, J=28.0 Hz), 138.0, 130.5, 125.9, 124.5, 121.1, 64.2 (d, $J_{C\text{-}P}$ = 6.0 Hz), 16.3 (d, $J_{C\text{-}P}$ = 6.2 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ 3.25.



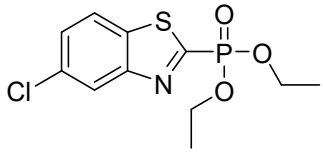
diethyl (6-iodobenzo[d]thiazol-2-yl)phosphonate (3ea)

Yield: 42%; yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.36 (s, 1H), 7.96 (d, J = 8.7 Hz, 1H), 7.85 (d, J = 8.7 Hz, 1H), 4.41 - 4.25 (m, 4H), 1.40 (t, J = 7.1 Hz, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.8 (d, $J_{C\text{-}P}$ =237.0 Hz), 153.9 (d, J=28.0 Hz), 138.4, 136.1, 130.5, 126.2, 92.2, 64.3 (d, $J_{C\text{-}P}$ = 6.0 Hz), 16.3 (d, $J_{C\text{-}P}$ = 6.2 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ 3.23. HRMS calcd for $C_{11}H_{13}INO_3PS^+$ ($M + H^+$): 397.9471, Found: 397.9470.



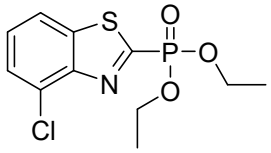
diethyl (7-chlorobenzo[d]thiazol-2-yl)phosphonate (3fa)

Yield: 17%; orange oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.14 (dd, J = 6.6, 2.5 Hz, 1H), 7.57 - 7.51 (m, 2H), 4.41 - 4.29 (m, 4H), 1.42 (t, J = 7.1 Hz, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 161.2 (d, $J_{C\text{-}P}$ = 236.0 Hz), 155.1 (d, J=28.0 Hz), 136.8, 127.9, 127.3, 126.6, 123.2, 64.4 (d, $J_{C\text{-}P}$ = 5.9 Hz), 16.3 (d, $J_{C\text{-}P}$ = 6.2 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ 3.23. HRMS calcd for $C_{11}H_{13}ClNO_3PS^+$ (M + H^+): 306.0115, Found: 306.0113.



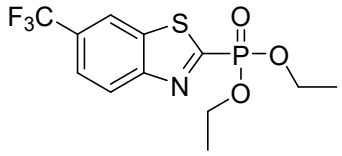
diethyl (5-chlorobenzo[d]thiazol-2-yl)phosphonate (3ga)[4]

Yield: 63%; yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.22 (d, J = 1.6 Hz, 1H), 7.93 (d, J = 8.6 Hz, 1H), 7.50 (d, J = 8.6 Hz, 1H), 4.42 - 4.26 (m, 4H), 1.41 (t, J = 7.1 Hz, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 162.3 (d, $J_{C\text{-}P}$=236.0 Hz), 155.3 (d, J=28.0 Hz), 134.6, 133.0, 127.6, 124.5, 122.7, 64.3 (d, $J_{C\text{-}P}$ = 6.0 Hz), 16.3 (d, $J_{C\text{-}P}$ = 6.2 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ 3.16.



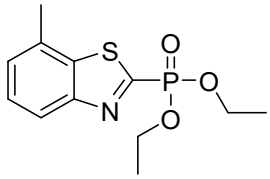
diethyl (4-chlorobenzo[d]thiazol-2-yl)phosphonate (3ha)

Yield: 55%; yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.23 (d, J = 1.8 Hz, 1H), 7.93 (d, J = 8.6 Hz, 1H), 7.51 (dd, J = 8.6, 1.1 Hz, 1H), 4.42 - 4.25 (m, 4H), 1.41 (t, J = 7.1 Hz, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 162.2 (d, $J_{C\text{-}P}$ = 236.0 Hz), 155.3 (d, J = 28.0 Hz), 134.6, 133.0, 127.7, 124.5, 122.7, 64.3 (d, $J_{C\text{-}P}$ = 6.0 Hz), 16.3 (d, $J_{C\text{-}P}$ = 6.3 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ 3.19. HRMS calcd for $C_{11}H_{13}ClNO_3PS^+$ (M + H^+): 306.0115, Found: 306.0117.



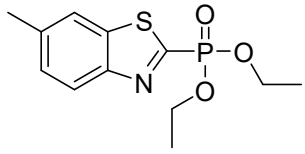
diethyl (6-(trifluoromethyl)benzo[d]thiazol-2-yl)phosphonate (3ia)

Yield: 51%; yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.35 (d, J = 9.9 Hz, 2H), 7.82 (dd, J = 8.7, 1.2 Hz, 1H), 4.44 - 4.28 (m, 4H), 1.42 (t, J = 7.1 Hz, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 163.9 (d, $J_{C\text{-}P}$ = 235 Hz), 156.3 (d, $^{2}J_{CF}$ = 27 Hz), 136.4 (d, $^{4}J_{CF}$ = 2 Hz), 129.1 (dd, $^{4}J_{CF}$ = 3.3 Hz), 125.5, 123.8 (d, $^{4}J_{CF}$ = 3 Hz), 122.5, 119.8 (d, $^{4}J_{CF}$ = 5 Hz), 64.4 (d, $J_{C\text{-}P}$ = 6.0 Hz), 16.3 (d, $J_{C\text{-}P}$ = 6.2 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ 2.86. HRMS calcd for $C_{12}H_{13}F_3NO_3PS^+$ (M + H^+): 340.0379, Found: 340.0378.



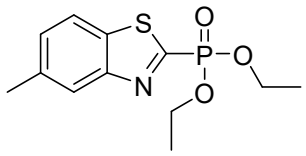
diethyl (7-methylbenzo[d]thiazol-2-yl)phosphonate (3ja)

Yield: 85%; yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.08 (d, J = 8.3 Hz, 1H), 7.49 (t, J = 7.8 Hz, 1H), 7.31 (d, J = 7.2 Hz, 1H), 4.42 - 4.26 (m, 4H), 2.62 (s, 3H), 1.41 (t, J = 7.1 Hz, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.4 (d, $J_{C\text{-}P}$ = 237.0 Hz), 154.5 (d, J=28.0 Hz), 137.1, 132.1, 127.1, 126.9, 122.3, 64.0 (d, $J_{C\text{-}P}$ = 5.9 Hz), 21.4, 16.3 (d, $J_{C\text{-}P}$ = 6.2 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ 4.13. HRMS calcd for $C_{12}H_{16}NO_3PS^+$ (M + H^+): 286.0661, Found: 286.0662.



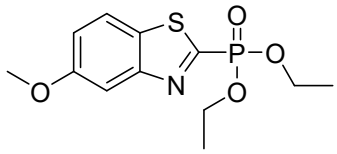
diethyl (6-methylbenzo[d]thiazol-2-yl)phosphonate (3ka)[3]

Yield: 88%; yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.08 (d, J = 8.4 Hz, 1H), 7.75 (s, 1H), 7.35 (d, J = 8.4 Hz, 1H), 4.37 - 4.21 (m, 4H), 2.49 (s, 3H), 1.36 (t, J = 7.1 Hz, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.7 (d, $J_{C\text{-}P}$ = 236.0 Hz), 152.8 (d, J=29.0 Hz), 137.5, 136.7, 128.6, 124.3, 121.4, 64.0 (d, $J_{C\text{-}P}$ = 5.9 Hz), 21.6, 16.2 (d, $J_{C\text{-}P}$ = 6.2 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ 4.26.



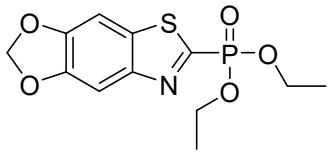
diethyl (5-methylbenzo[d]thiazol-2-yl)phosphonate (3la)[4]

Yield: 70%; yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.04 (s, 1H), 7.87 (d, J = 8.2 Hz, 1H), 7.35 (d, J = 8.2 Hz, 1H), 4.42 - 4.24 (m, 4H), 2.53 (s, 3H), 1.40 (t, J = 7.1 Hz, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.9 (d, J_{C-P} = 238.0 Hz), 155.1 (d, J = 28.0 Hz), 137.1, 133.5, 128.9, 124.6, 121.4, 64.0 (d, J_{C-P} = 5.9 Hz), 21.4, 16.3 (d, J_{C-P} = 6.3 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ 4.19.



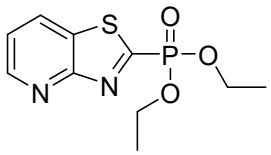
diethyl (5-methoxybenzo[d]thiazol-2-yl)phosphonate (3ma)[5]

Yield: 73%; yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.85 (d, J = 8.9 Hz, 1H), 7.68 (d, J = 2.0 Hz, 1H), 7.18 (d, J = 8.9 Hz, 1H), 4.42 - 4.25 (m, 4H), 3.90 (s, 3H), 1.41 (t, J = 7.1 Hz, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.7 (d, J_{C-P} = 237.0 Hz), 156.0 (d, J=28.0 Hz), 128.5, 122.1, 118.2, 106.0, 64.0 (d, J_{C-P} = 5.9 Hz), 55.6, 16.3 (d, J_{C-P} = 6.3 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ 4.02.



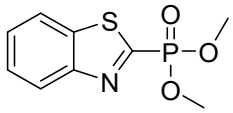
diethyl [1,3]dioxolo[4',5':4,5]benzo[1,2-d]thiazol-6-ylphosphonate(3na)

Yield: 64%; yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.56 (s, 1H), 7.30 (s, 1H), 6.11 (s, 2H), 4.39 - 4.22 (m, 4H), 1.39 (t, J = 7.1 Hz, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 157.2 (d, J_{C-P} = 241.0 Hz), 150.2 (d, J = 28.0 Hz), 148.8, 130.8, 103.3, 102.3, 99.7, 63.9 (d, J_{C-P} = 5.9 Hz), 16.2 (d, J_{C-P} = 6.3 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ 4.21. HRMS calcd for $C_{12}H_{14}NO_5PS^+$ ($M + H^+$): 316.0403, Found: 316.0400.



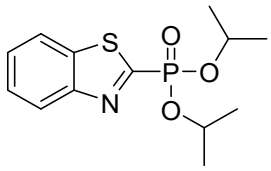
diethyl thiazolo[4,5-b]pyridin-2-ylphosphonate (3oa)

Yield: 58%; yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.89 (d, J = 4.4 Hz, 1H), 8.45 (dd, J = 8.1, 1.5 Hz, 1H), 7.50 (dd, J = 8.1, 4.5 Hz, 1H), 4.47 - 4.31 (m, 4H), 1.42 (t, J = 7.1 Hz, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 164.6 (d, J_{C-P} = 31.0 Hz), 164.1 (d, J=235.0 Hz), 149.5, 131.5, 129.9, 121.4, 64.7 (d, J_{C-P} = 6.3 Hz), 16.2 (d, J_{C-P} = 6.4 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ 2.26. HRMS calcd for $C_{10}H_{13}N_2O_3PS^+$ (M + H^+): 273.0457, Found: 273.0456.



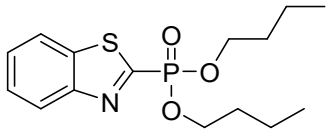
dimethyl benzo[d]thiazol-2-ylphosphonate (3ab)[6]

Yield: 49%; yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.17 (d, J = 8.2 Hz, 1H), 7.94 (d, J = 7.8 Hz, 1H), 7.49 (dt, J = 15.0, 7.2 Hz, 2H), 3.88 (d, J = 11.3 Hz, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 158.6 (d, J_{C-P} = 239.0 Hz), 154.5 (d, J = 29.0 Hz), 136.4, 127.2, 127.0, 124.9, 122.0, 54.2 (d, J_{C-P} = 6.0 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ 6.67.



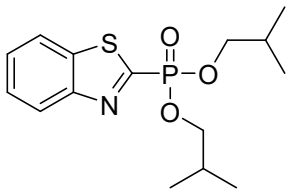
diisopropyl benzo[d]thiazol-2-ylphosphonate (3ac)[3]

Yield: 51%; white solid; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.24 (d, J = 8.1 Hz, 1H), 8.00 (d, J = 7.9 Hz, 1H), 7.54 (dt, J = 14.9, 7.2 Hz, 2H), 4.98 - 4.88 (m, 2H), 1.43 (d, J = 6.2 Hz, 6H), 1.35 (d, J = 6.2 Hz, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 161.5 (d, J_{C-P} = 240.0 Hz), 154.6 (d, J = 29.0 Hz), 136.4, 126.8, 126.7, 124.9, 121.9, 73.2 (d, J_{C-P} = 6.0 Hz), 24.0 (d, J_{C-P} = 4.1 Hz), 23.8 (d, J_{C-P} = 4.9 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ 1.92.



dibutyl benzo[d]thiazol-2-ylphosphonate (3ad)[7]

Yield: 90%; yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.25 (d, *J* = 8.1 Hz, 1H), 8.01 (d, *J* = 7.9 Hz, 1H), 7.54 (dt, *J* = 15.0, 7.2 Hz, 2H), 4.35 - 4.19 (m, 4H), 1.78 - 1.67 (m, 4H), 1.49 - 1.37 (m, 4H), 0.92 (t, *J* = 7.4 Hz, 6H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 160.0 (d, J_{C-P} = 237.0 Hz), 154.6 (d, *J* = 28.0 Hz), 136.3, 126.8, 124.9, 121.9, 67.7 (d, J_{C-P} = 6.2 Hz), 32.3 (d, J_{C-P} = 6.3 Hz), 18.6, 13.4. ^{31}P NMR (162 MHz, $CDCl_3$) δ 4.12.



diisobutyl benzo[d]thiazol-2-ylphosphonate (3ae)

Yield: 84%; yellow oil; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.16 (d, *J* = 7.9 Hz, 1H), 7.91 (d, *J* = 8.1 Hz, 1H), 7.51 - 7.39 (m, 2H), 4.01 - 3.87 (m, 4H), 1.94 (dp, *J* = 13.4, 6.7 Hz, 2H), 0.87 (dd, *J* = 6.7, 1.7 Hz, 12H). ^{13}C NMR (100 MHz, $CDCl_3$) δ 159.8 (d, J_{C-P} = 239.0 Hz), 154.5 (d, *J* = 29.0 Hz), 136.3, 127.0, 126.8, 124.9, 121.9, 73.7 (d, J_{C-P} = 6.6 Hz), 29.1 (d, J_{C-P} = 6.5 Hz), 18.6. ^{31}P NMR (162 MHz, $CDCl_3$) δ 3.95. HRMS calcd for $C_{15}H_{22}NO_3PS^+$ ($M + H^+$): 328.1131, Found: 328.1133.

4. References

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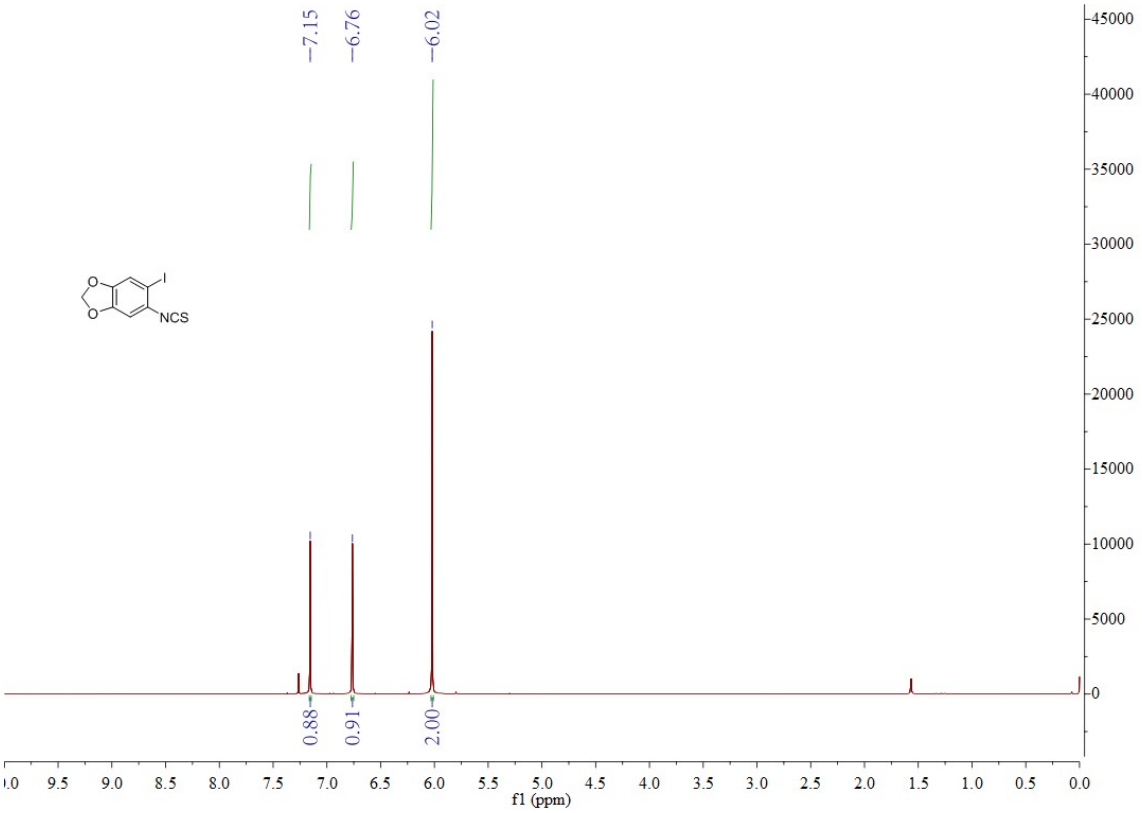
5. Copies of ^{1}H, ^{13}C, and ^{31}P NMR Spectra

1n ^{1}H NMR



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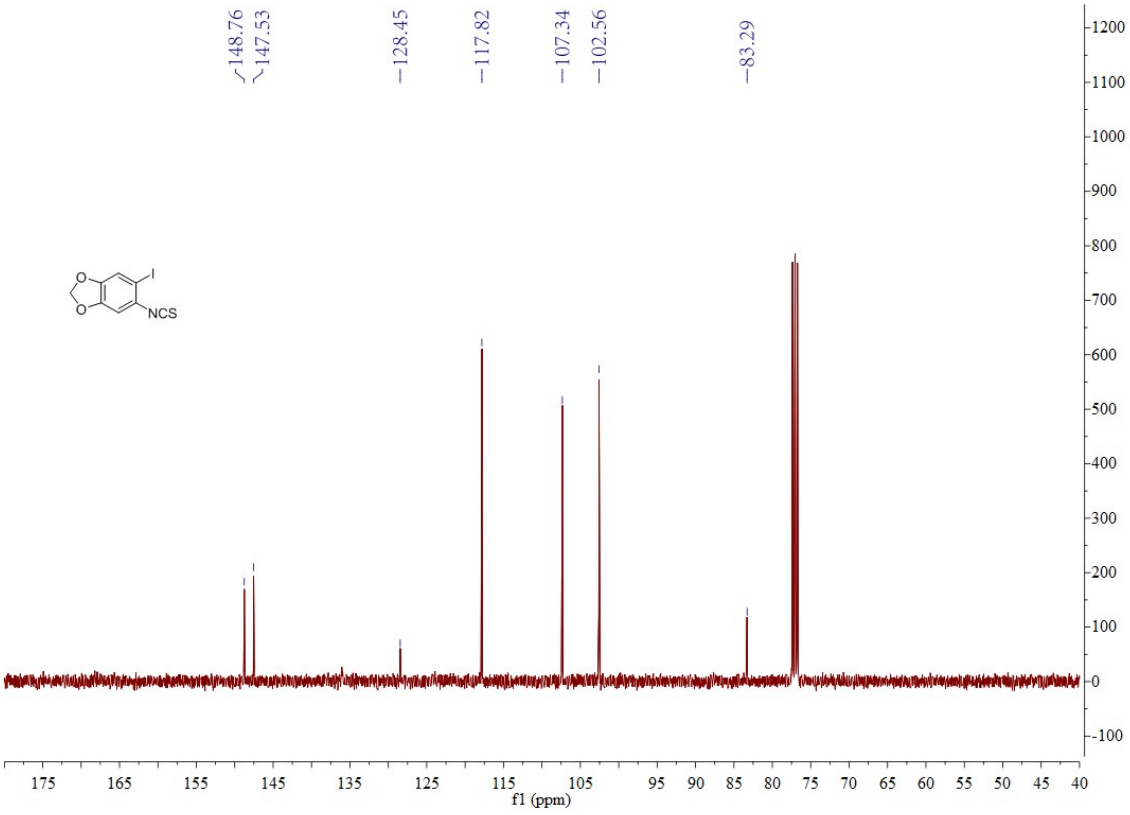
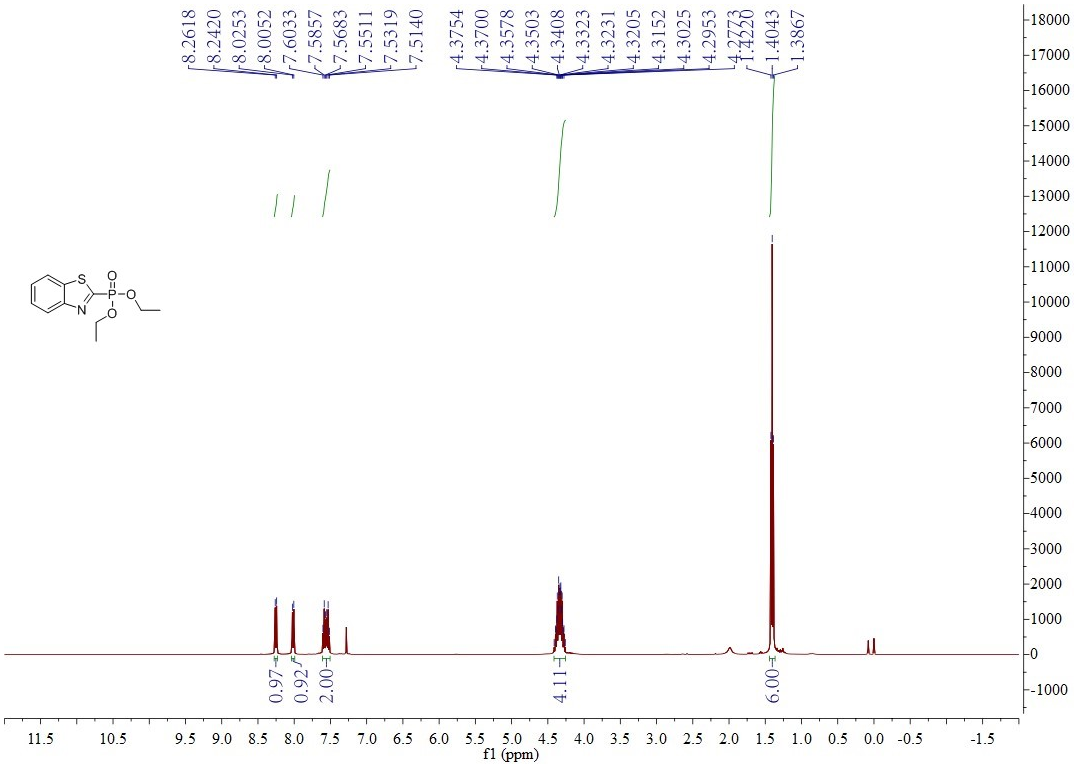


3aa ^{1}H NMR



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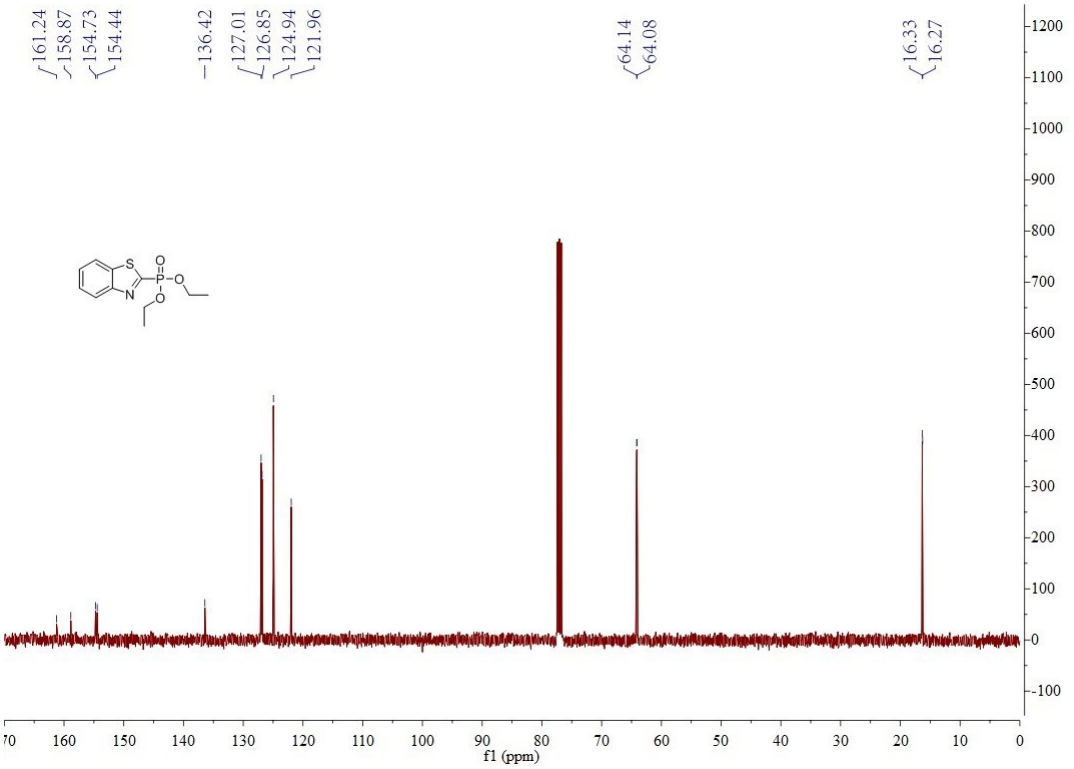

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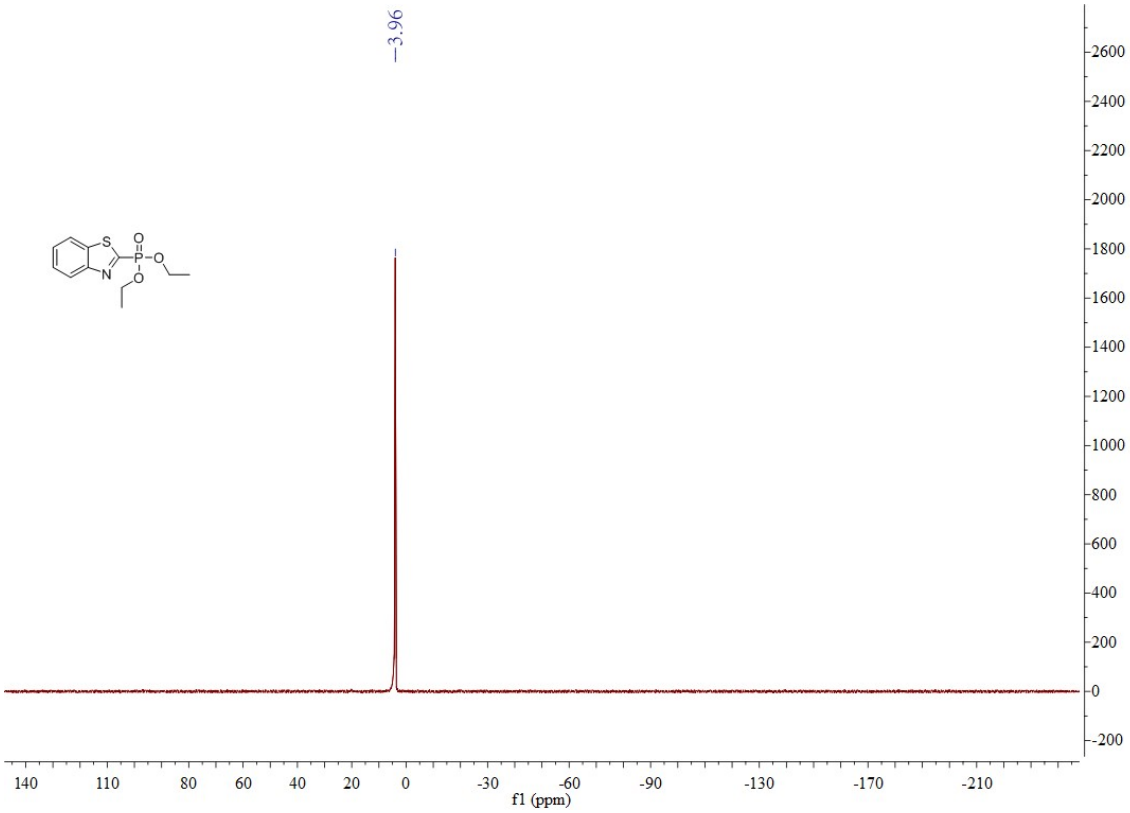

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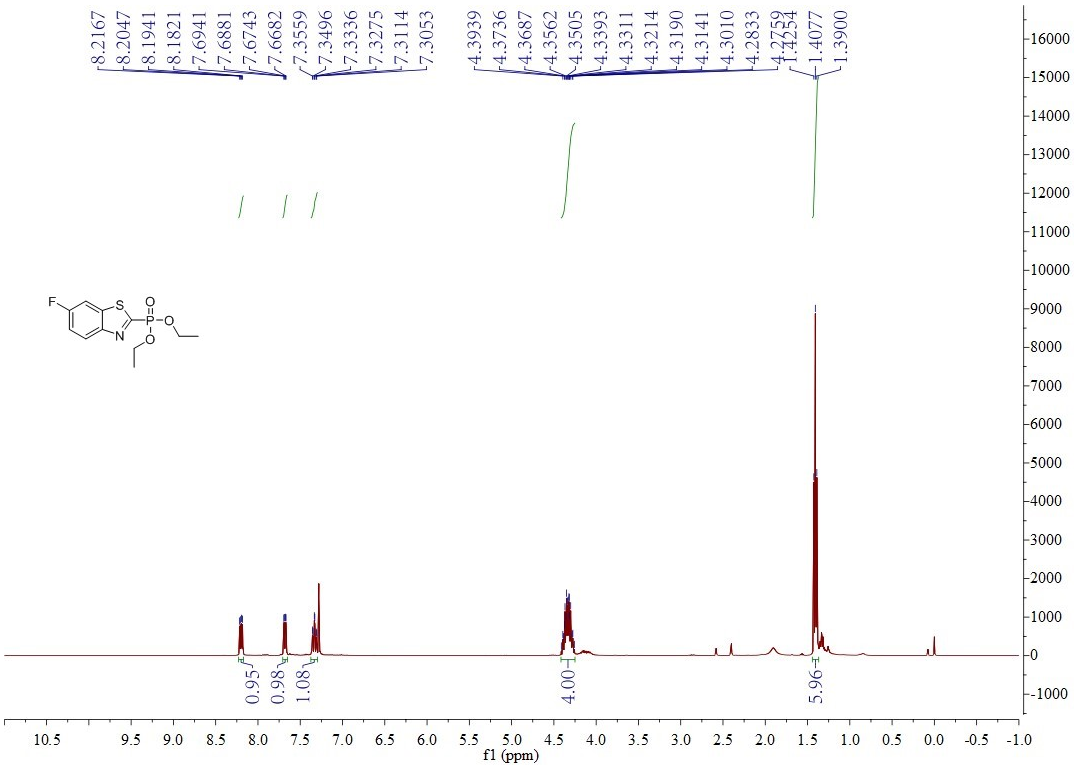

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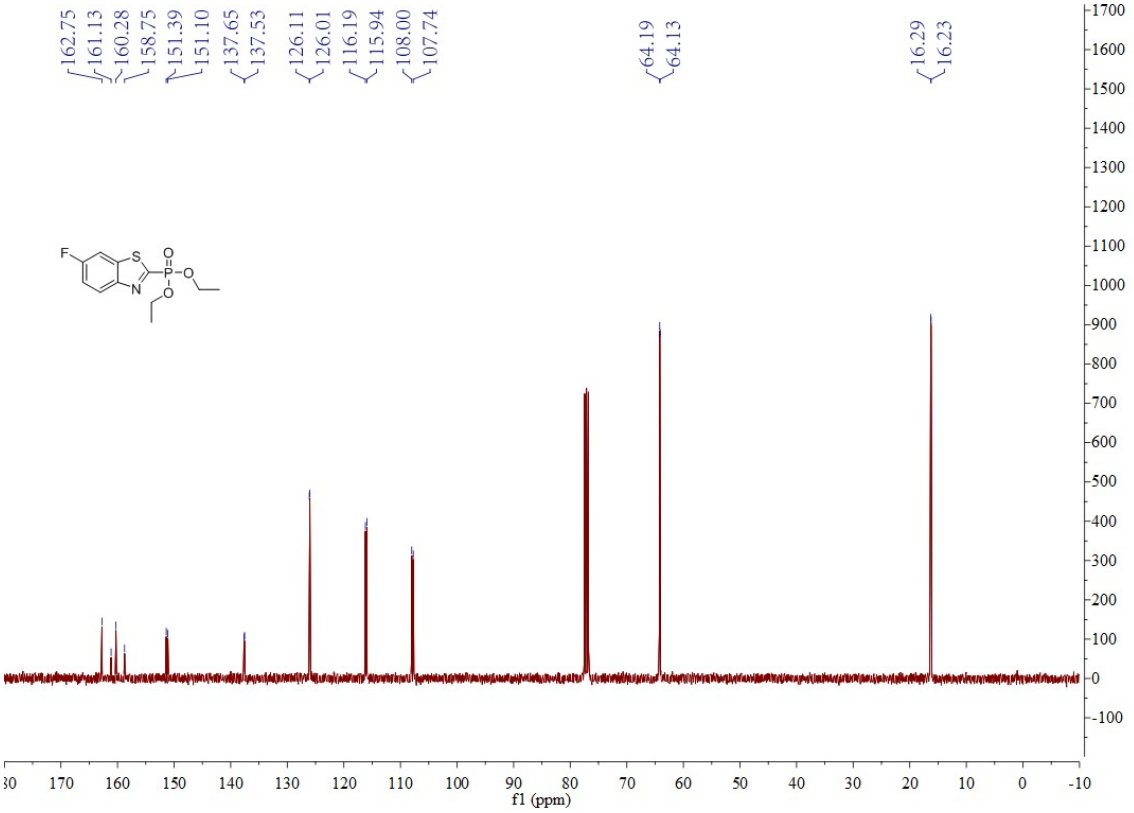

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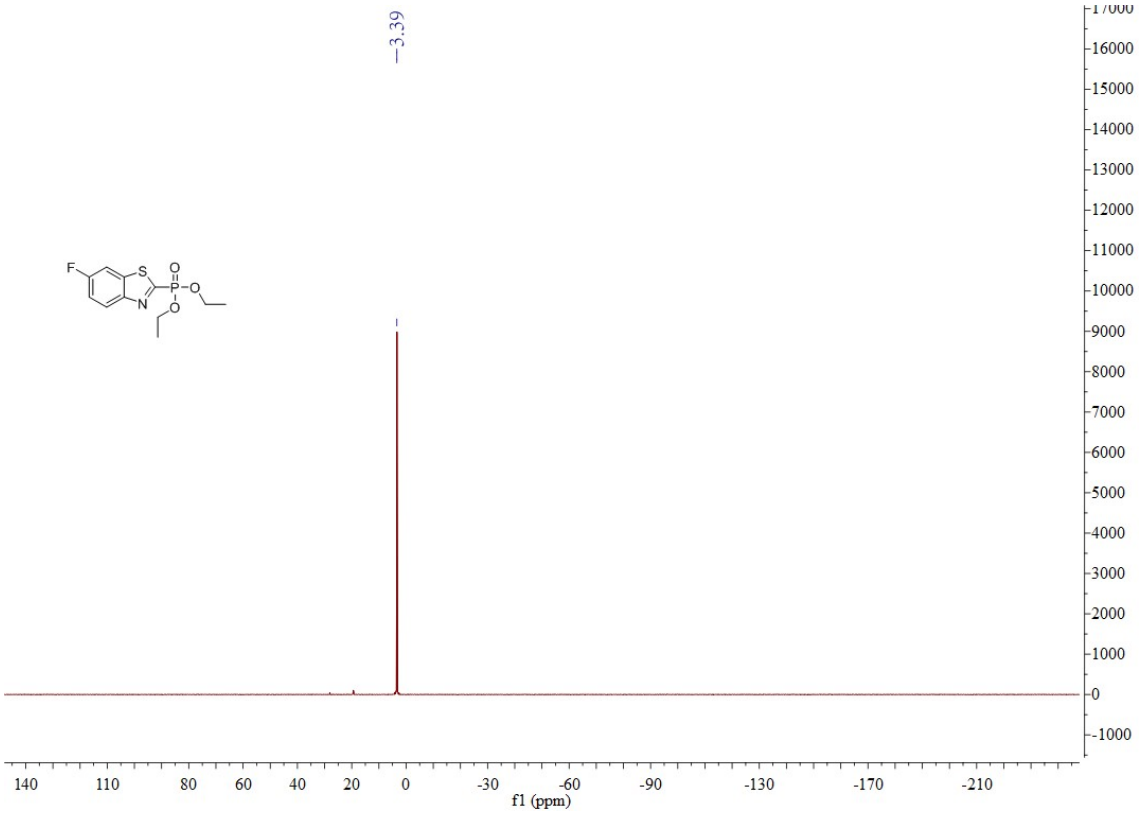

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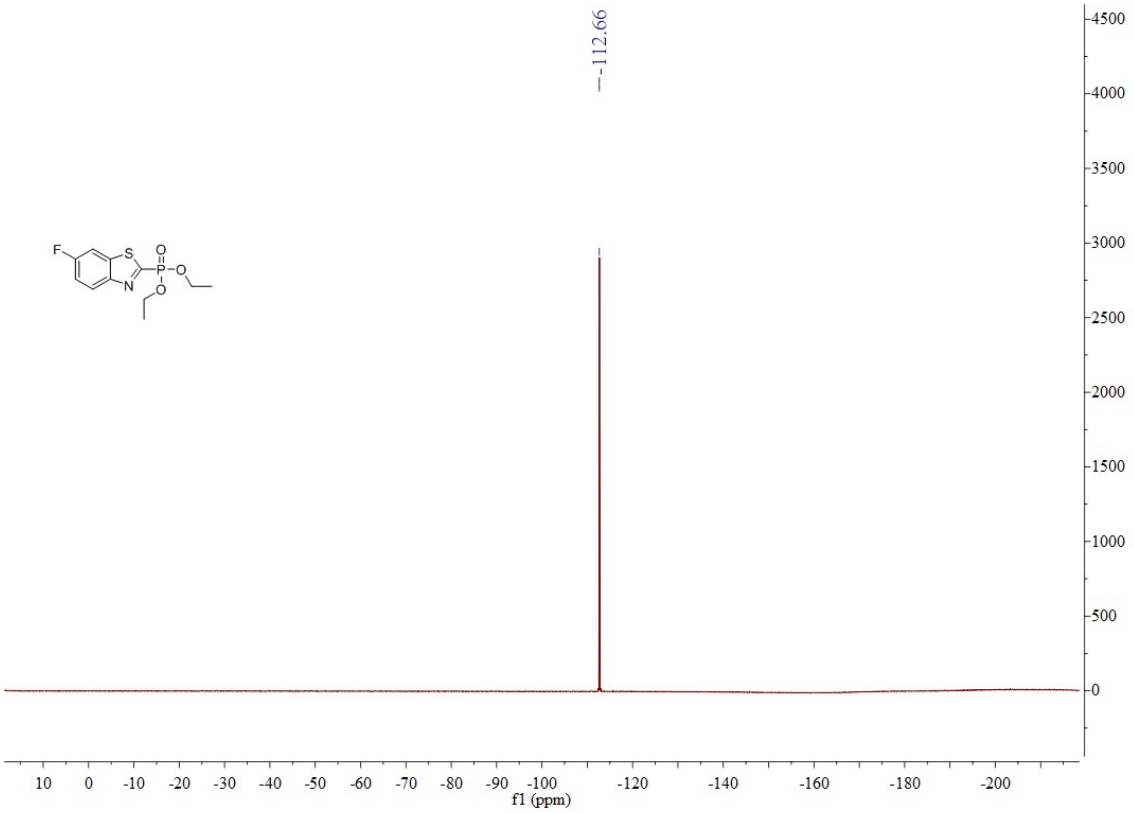

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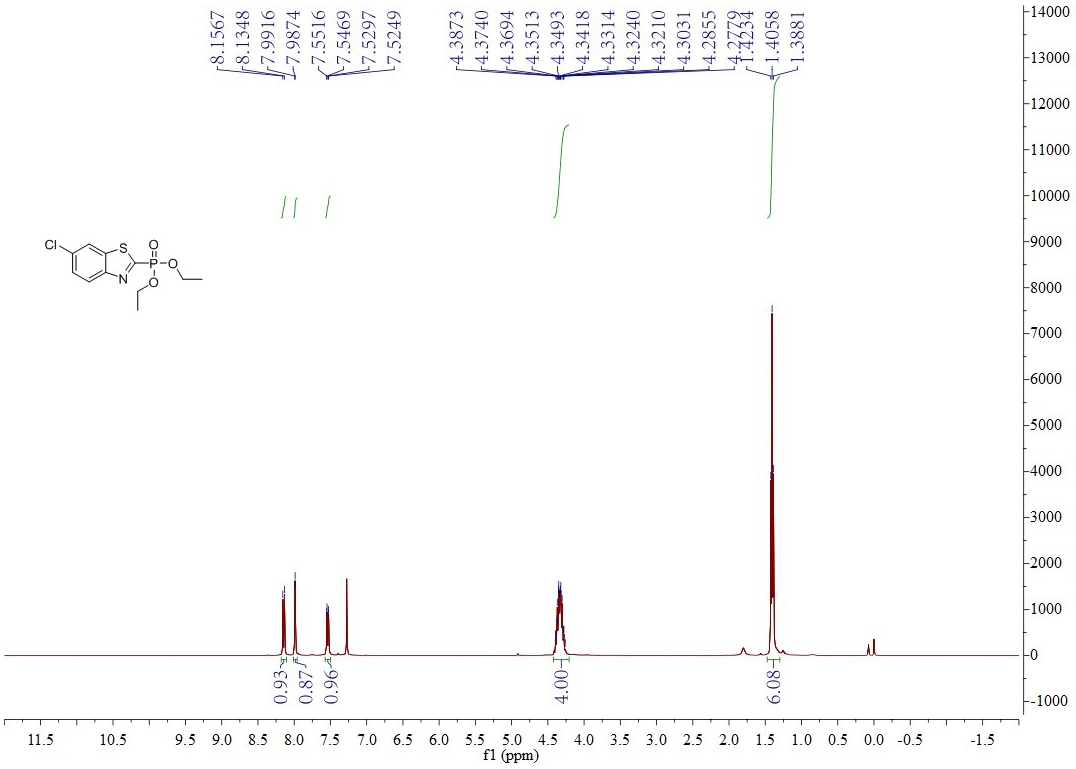

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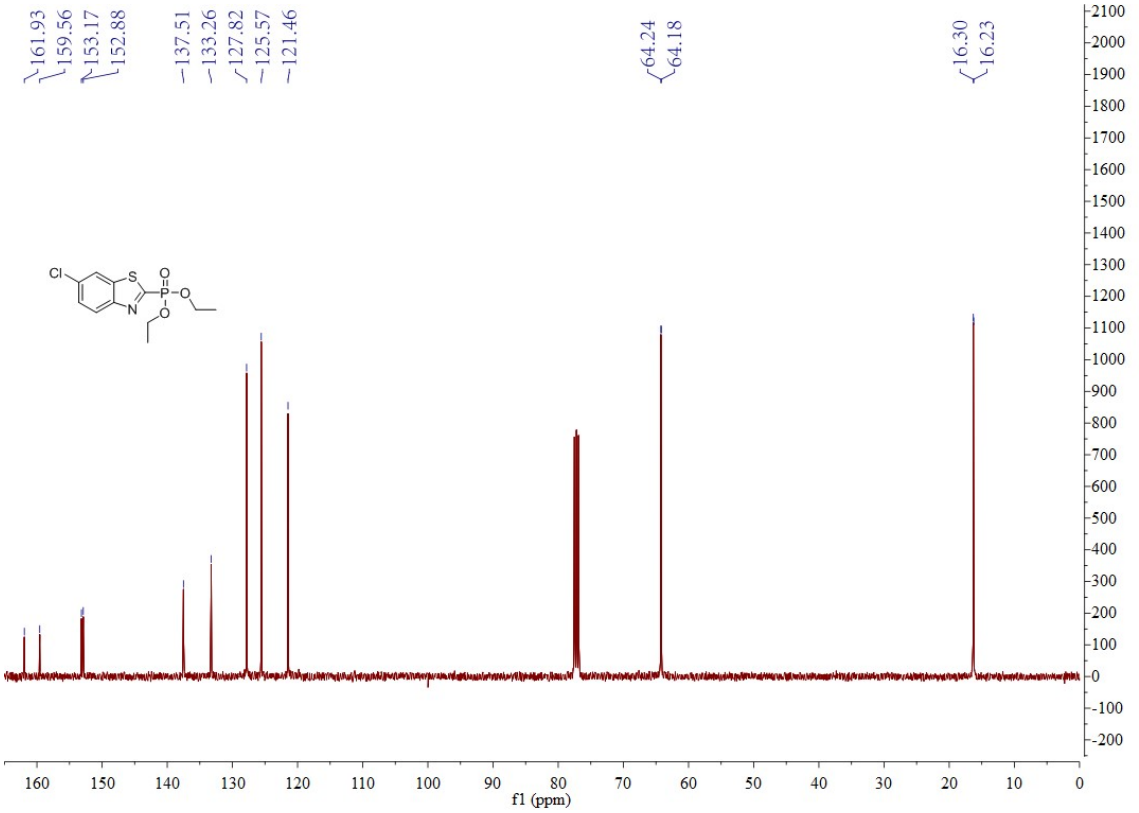

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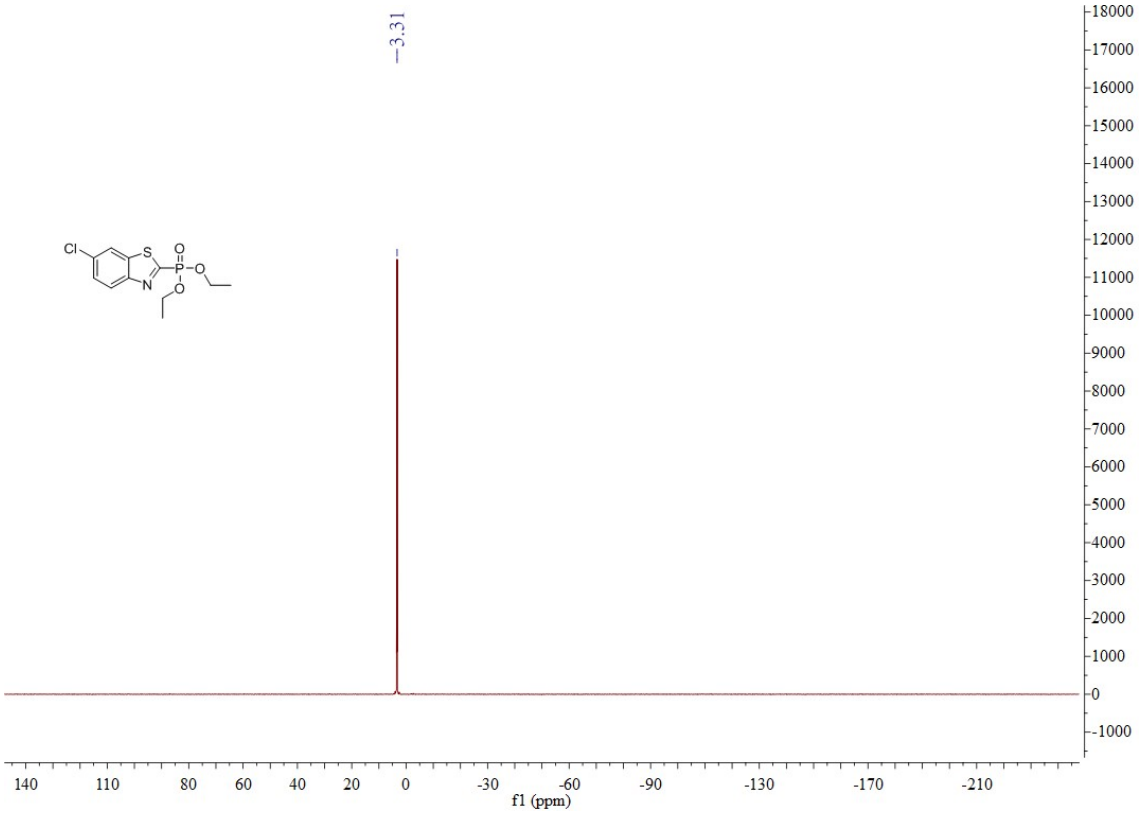

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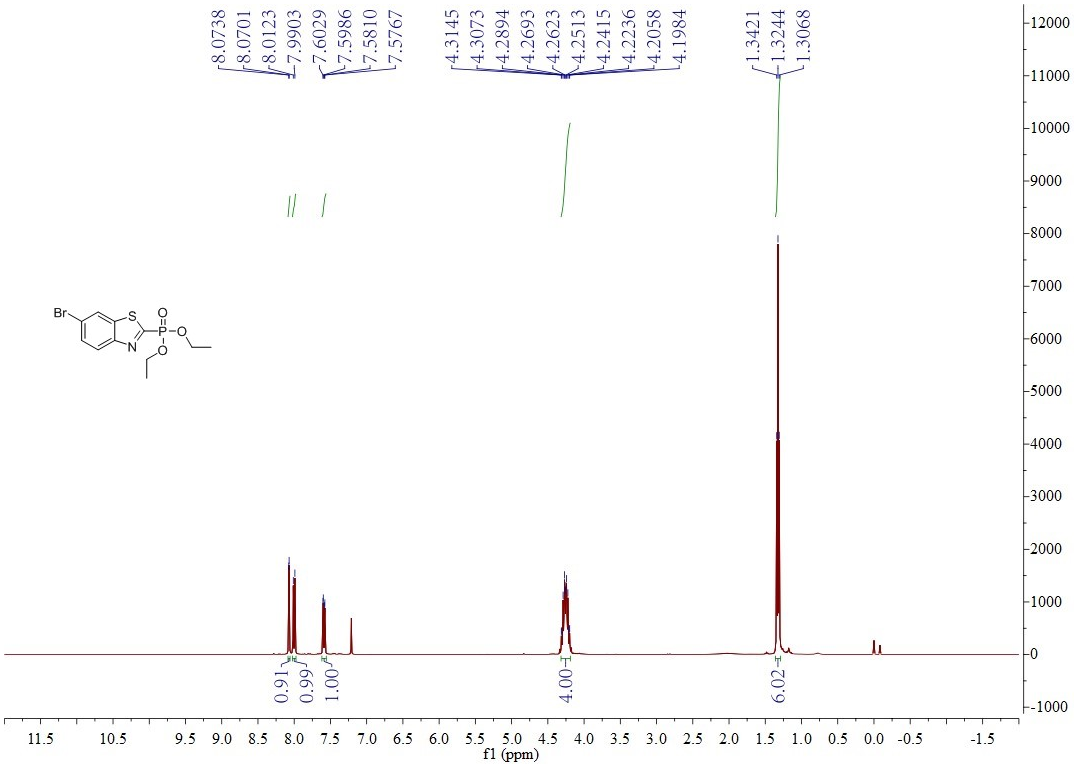

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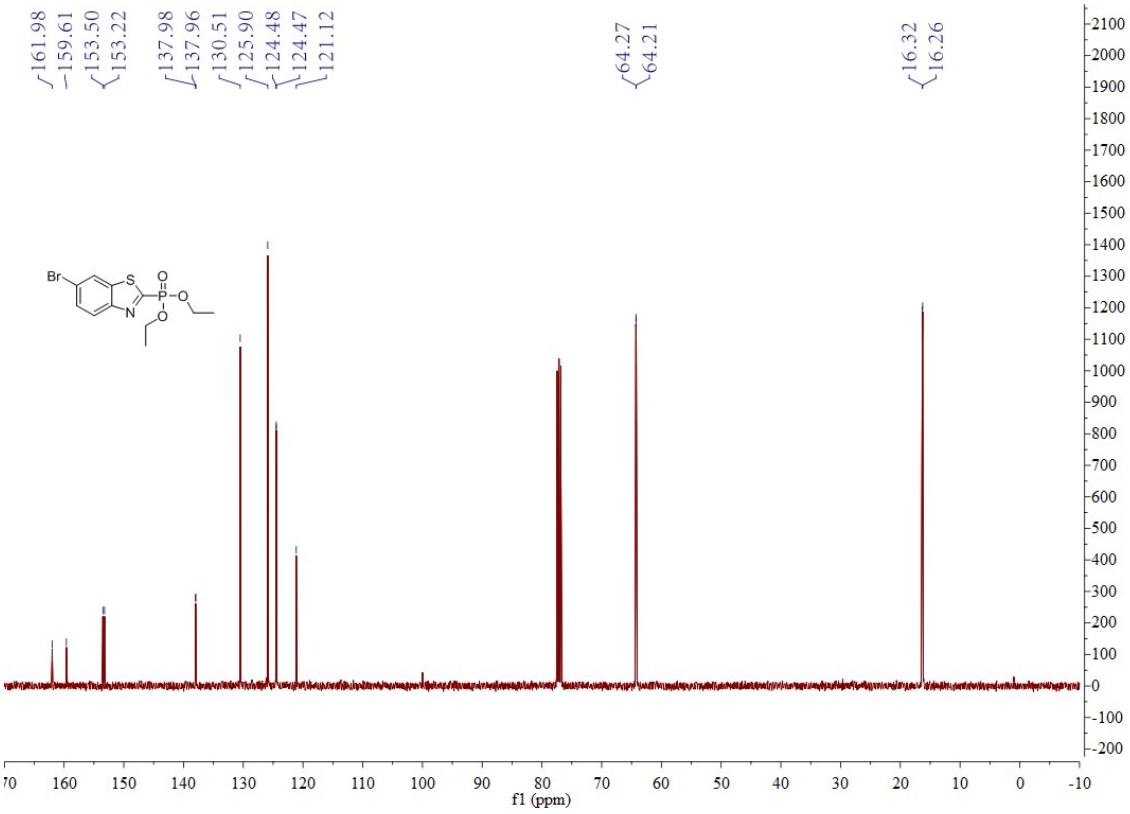

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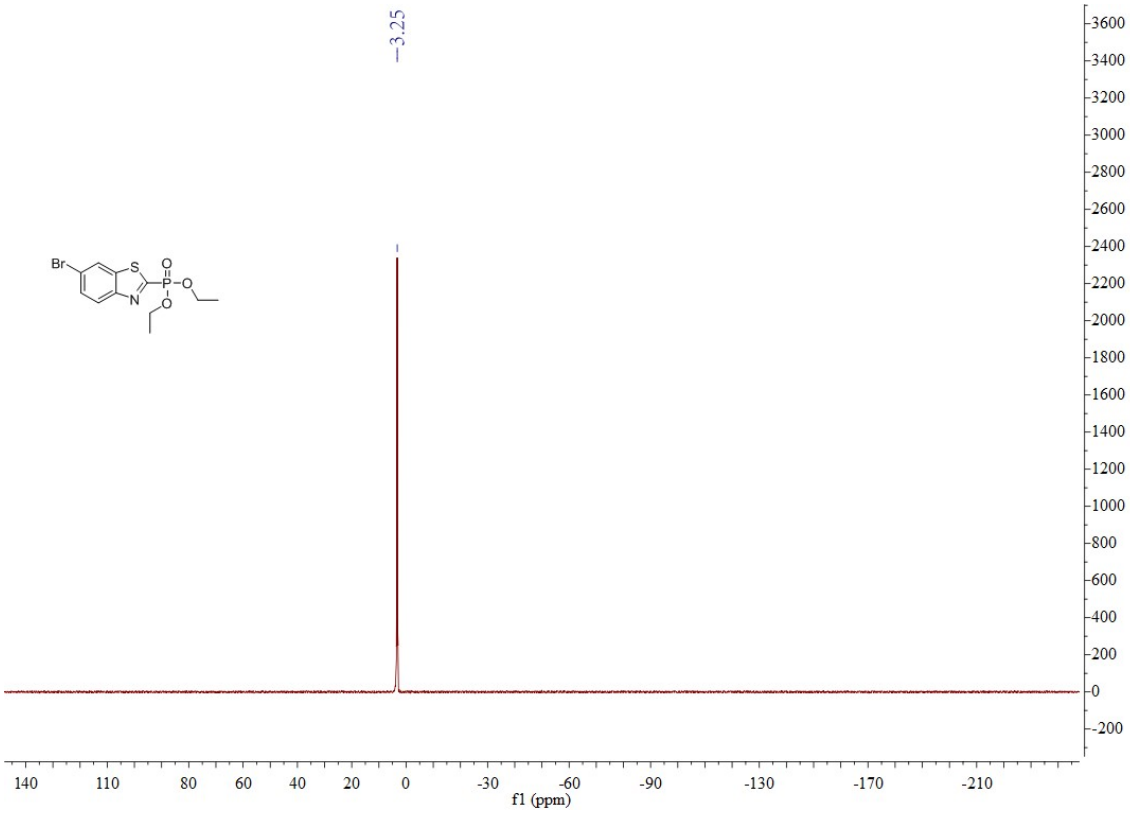

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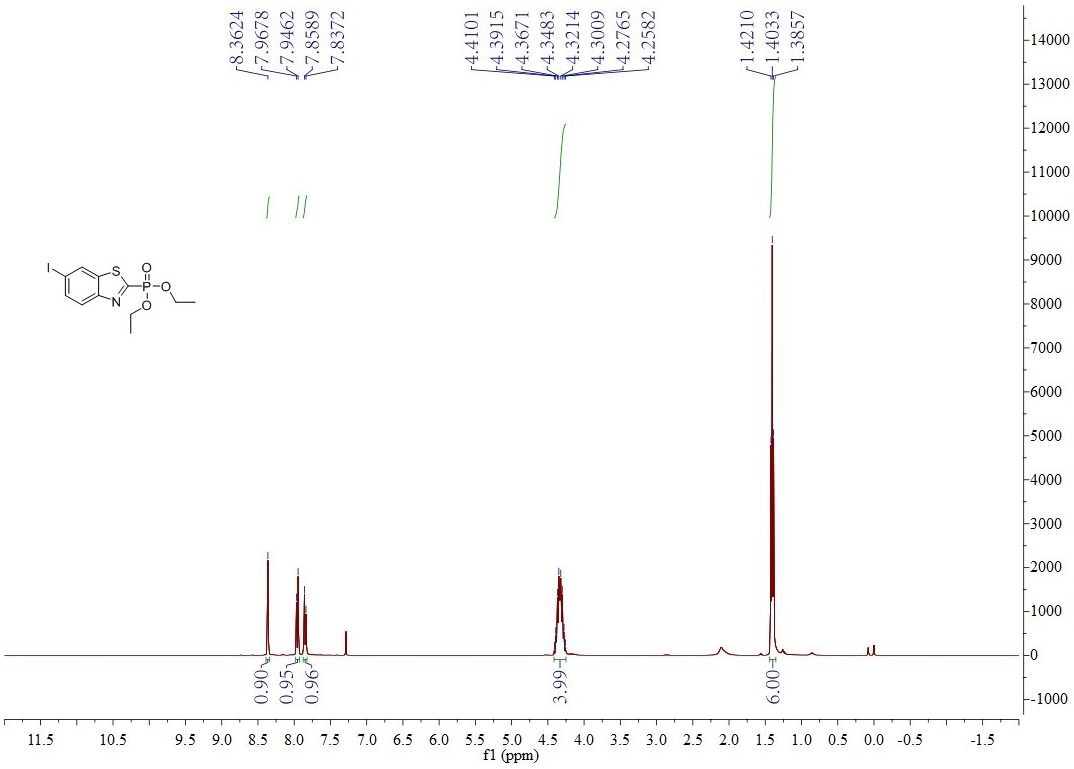

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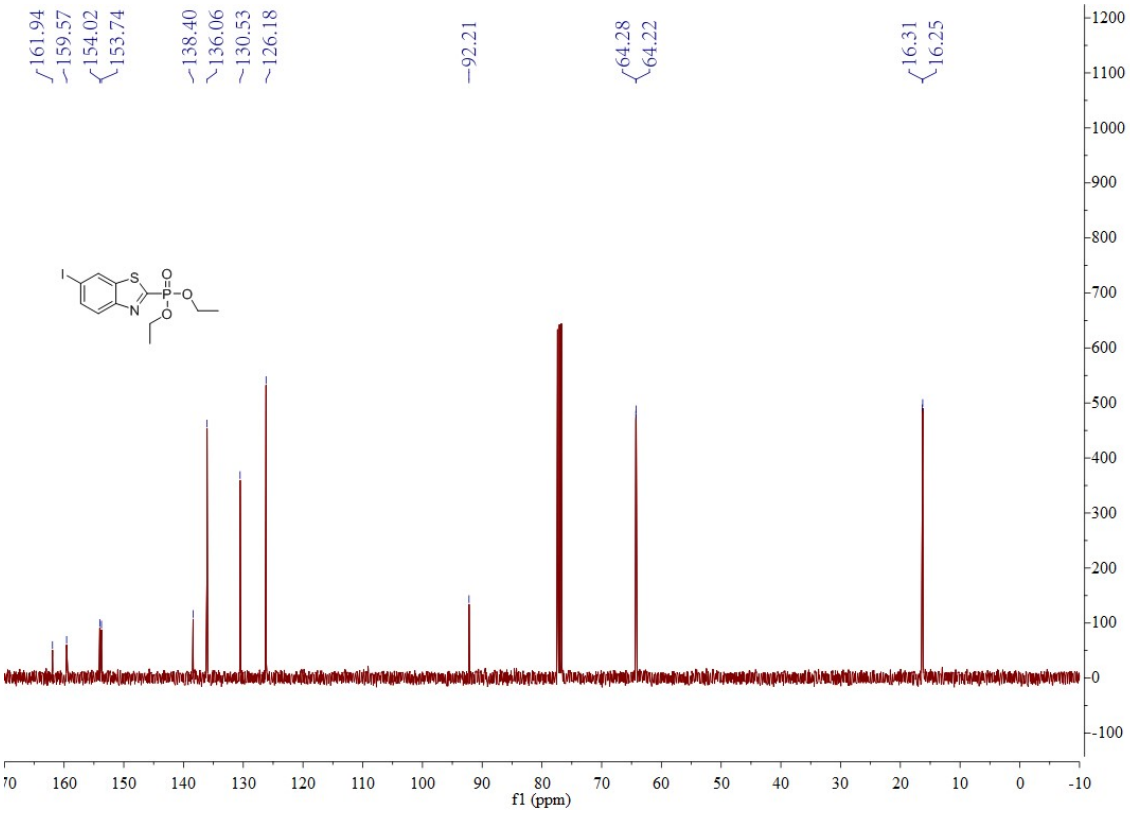

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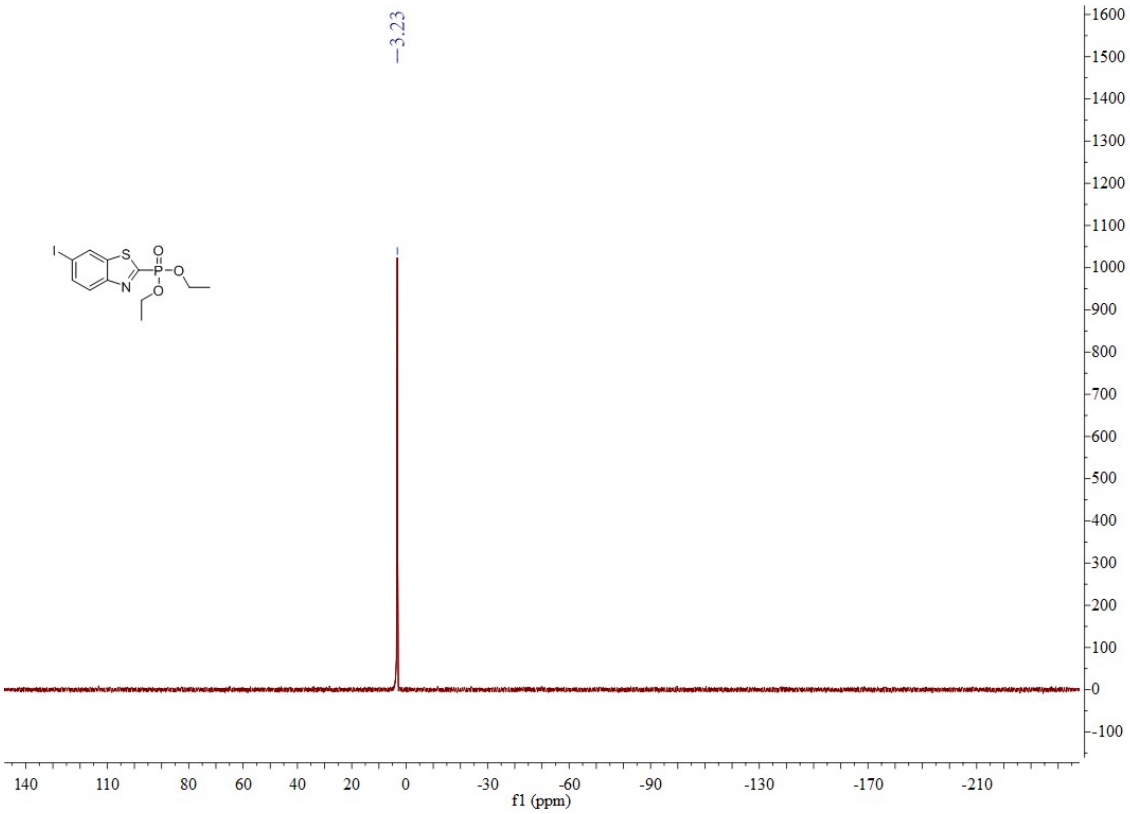

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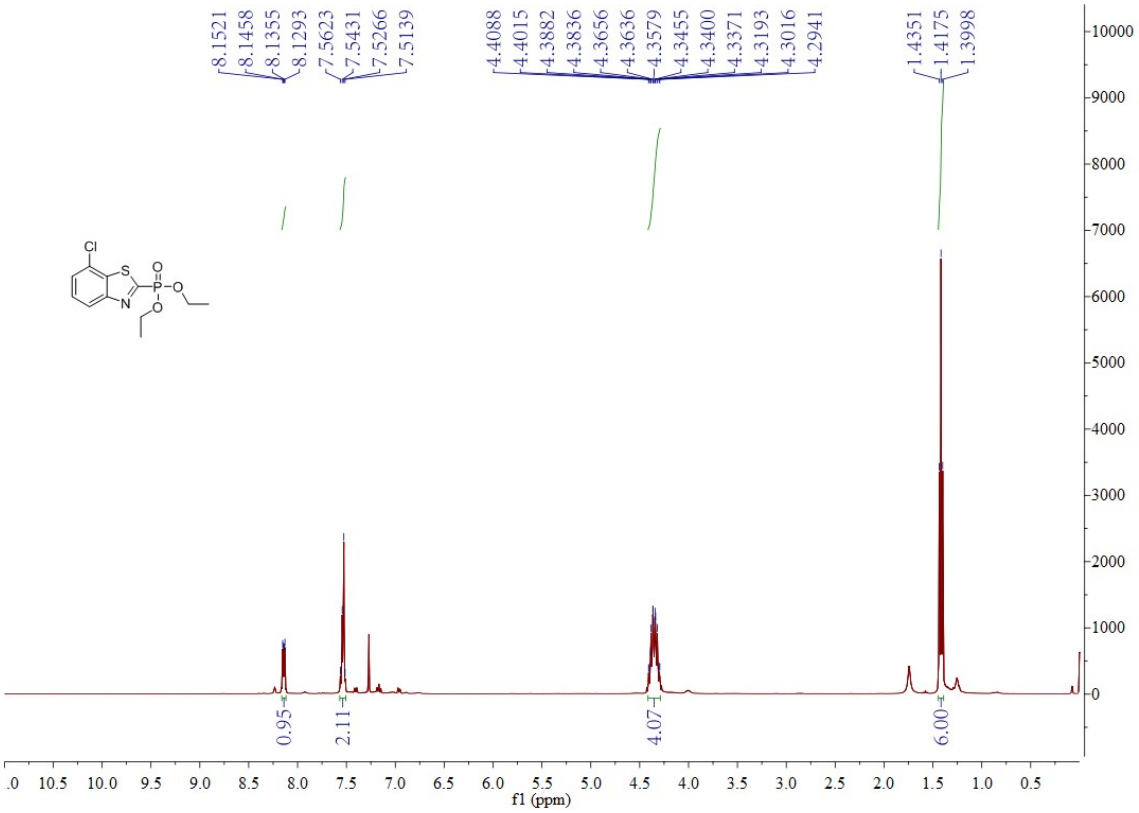

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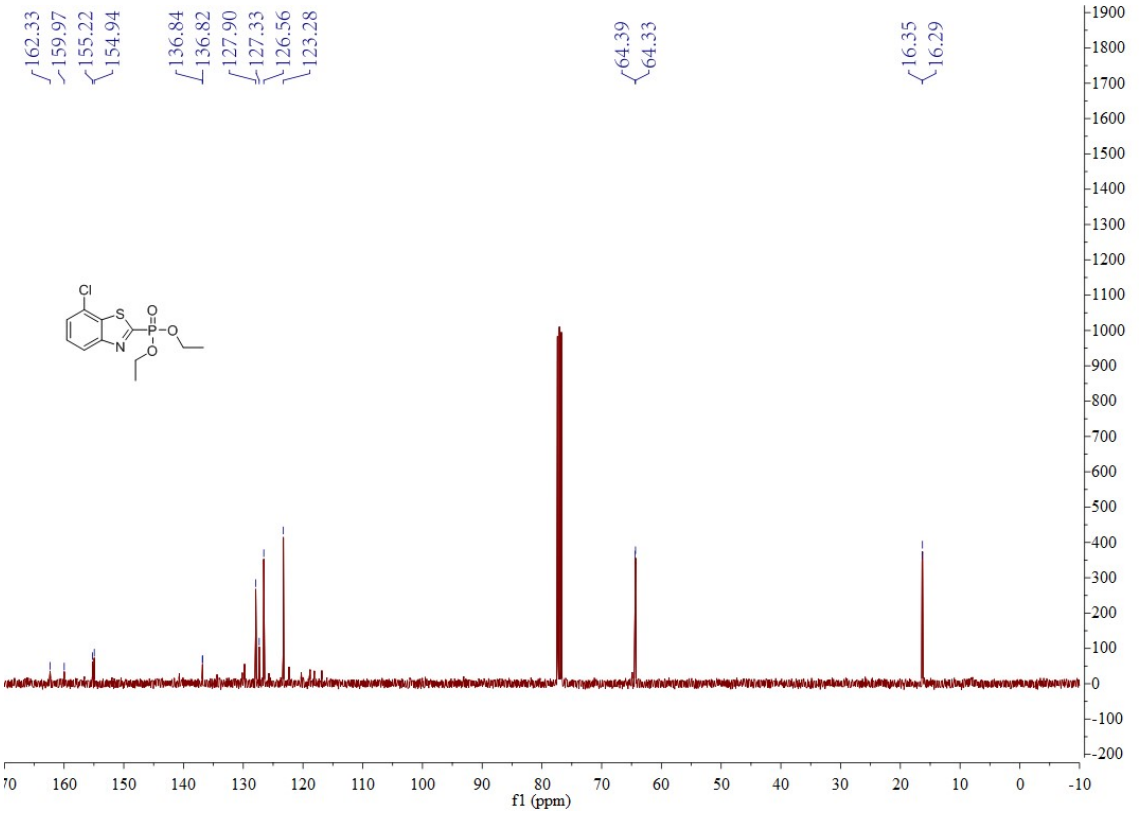

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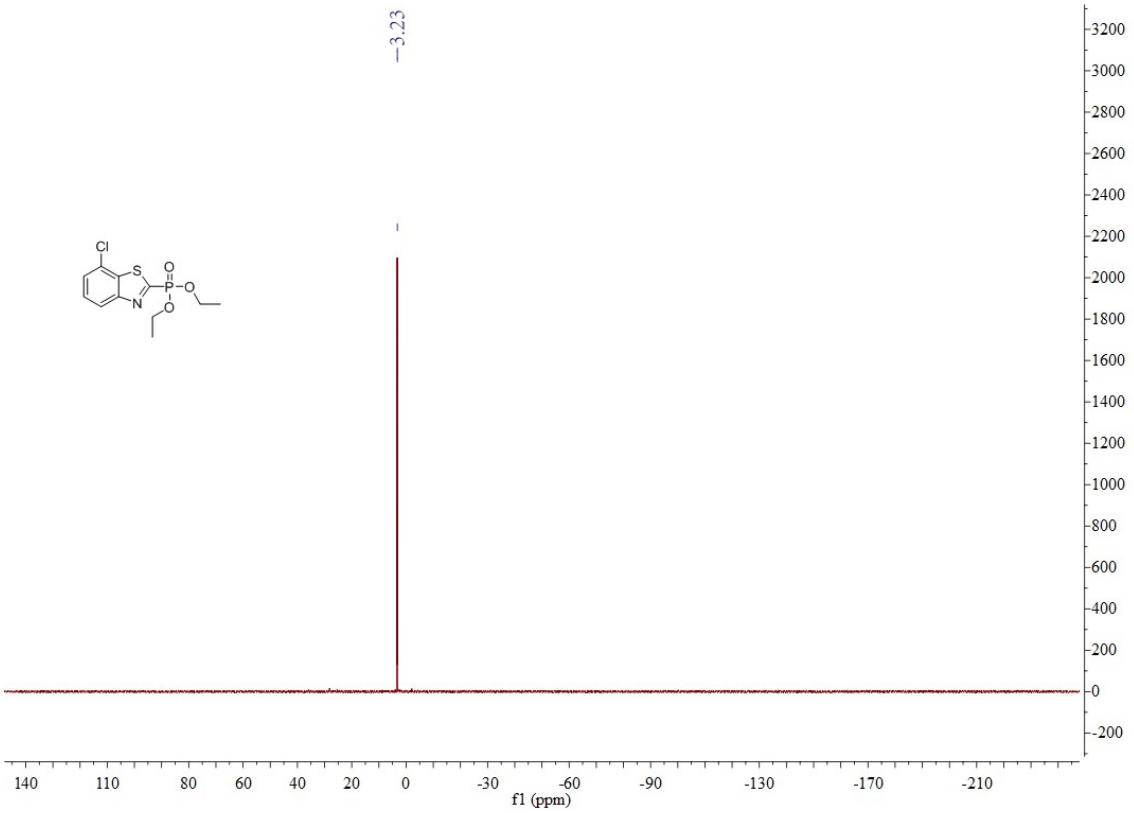

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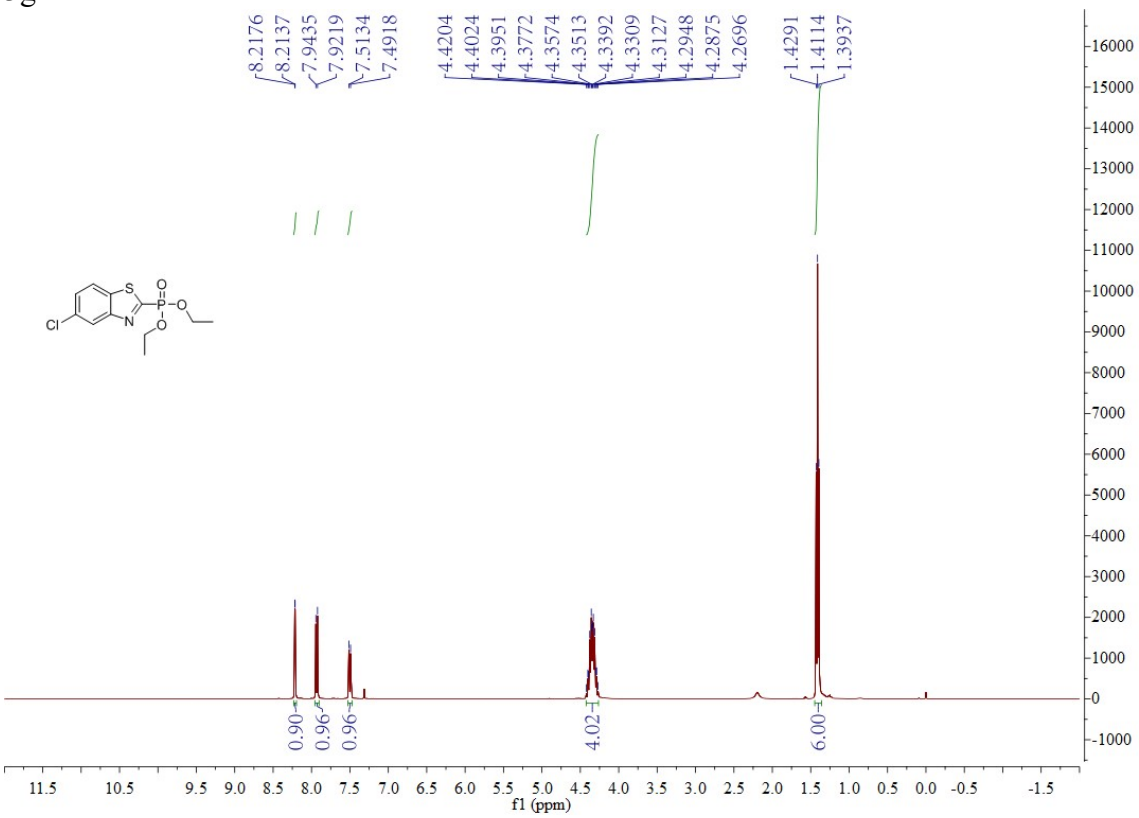

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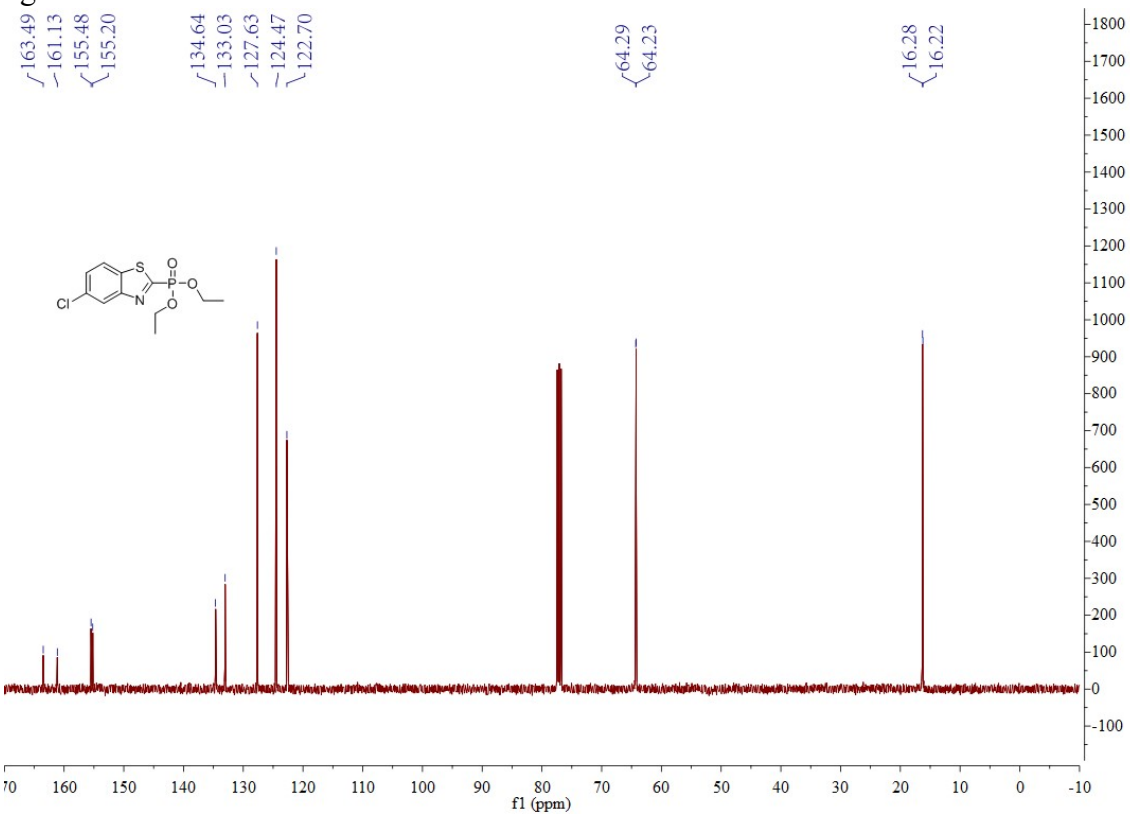

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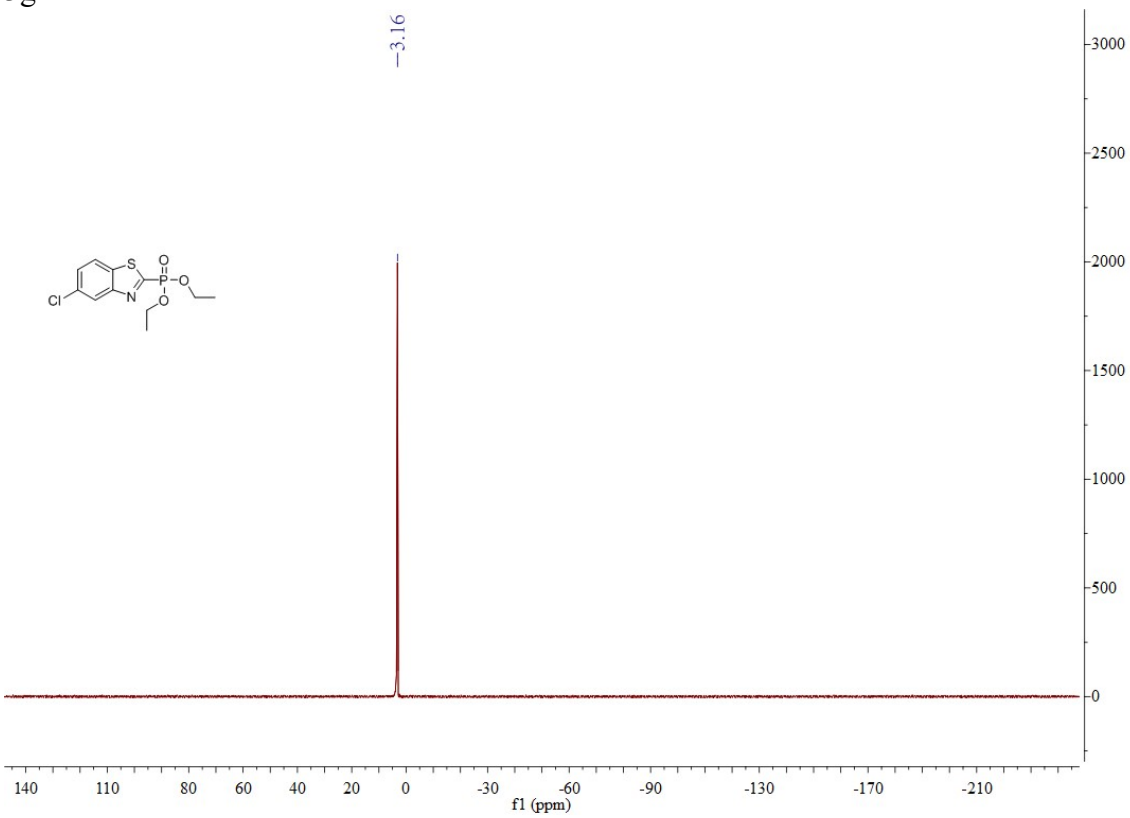

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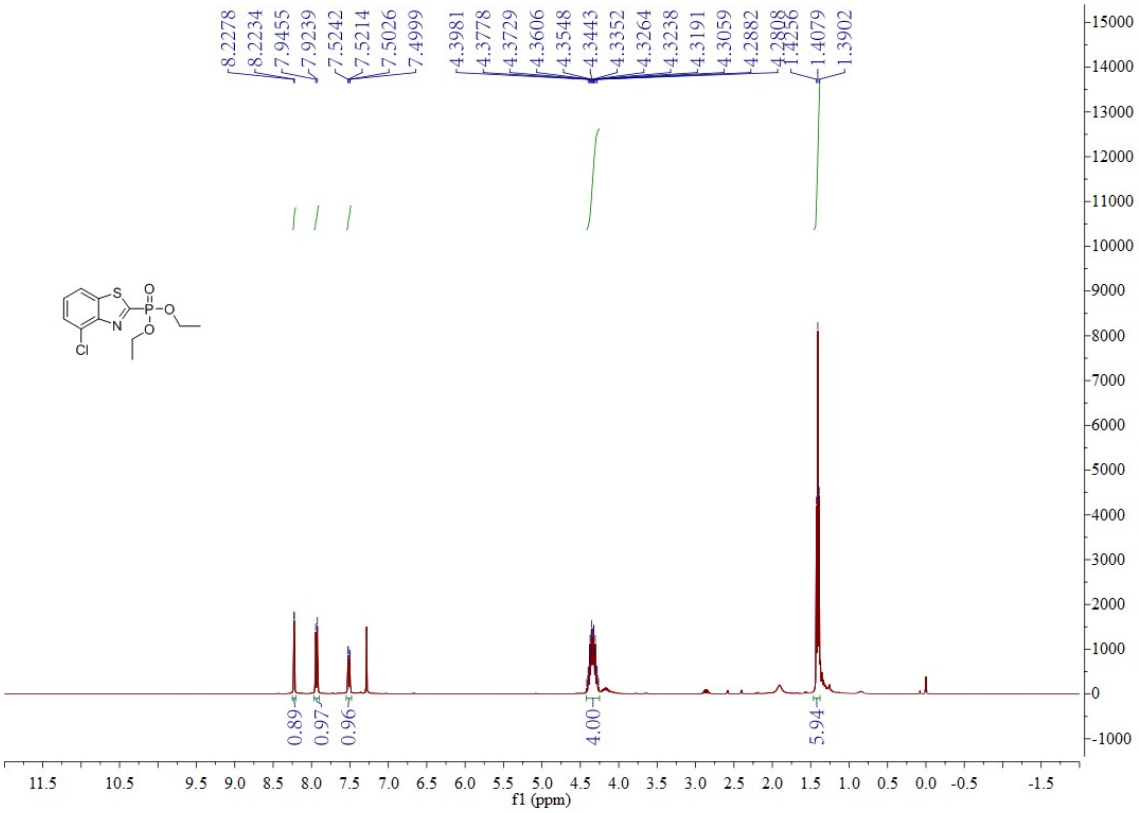

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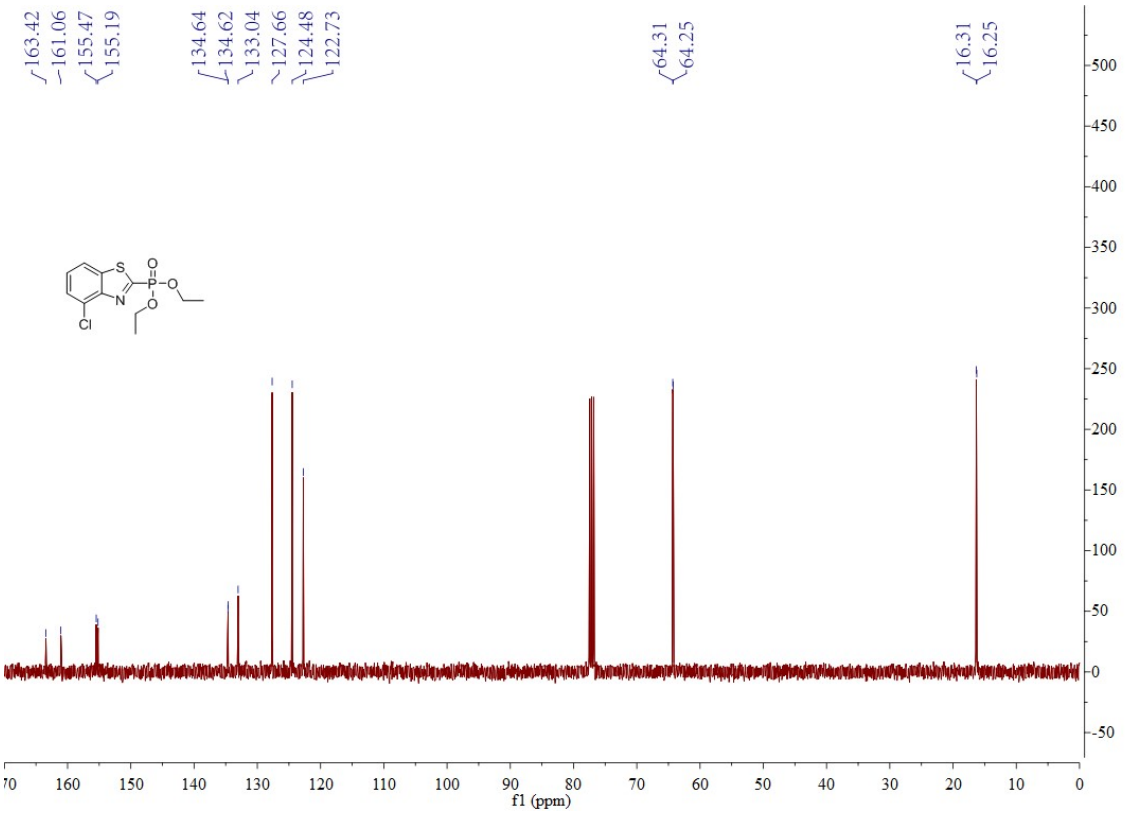

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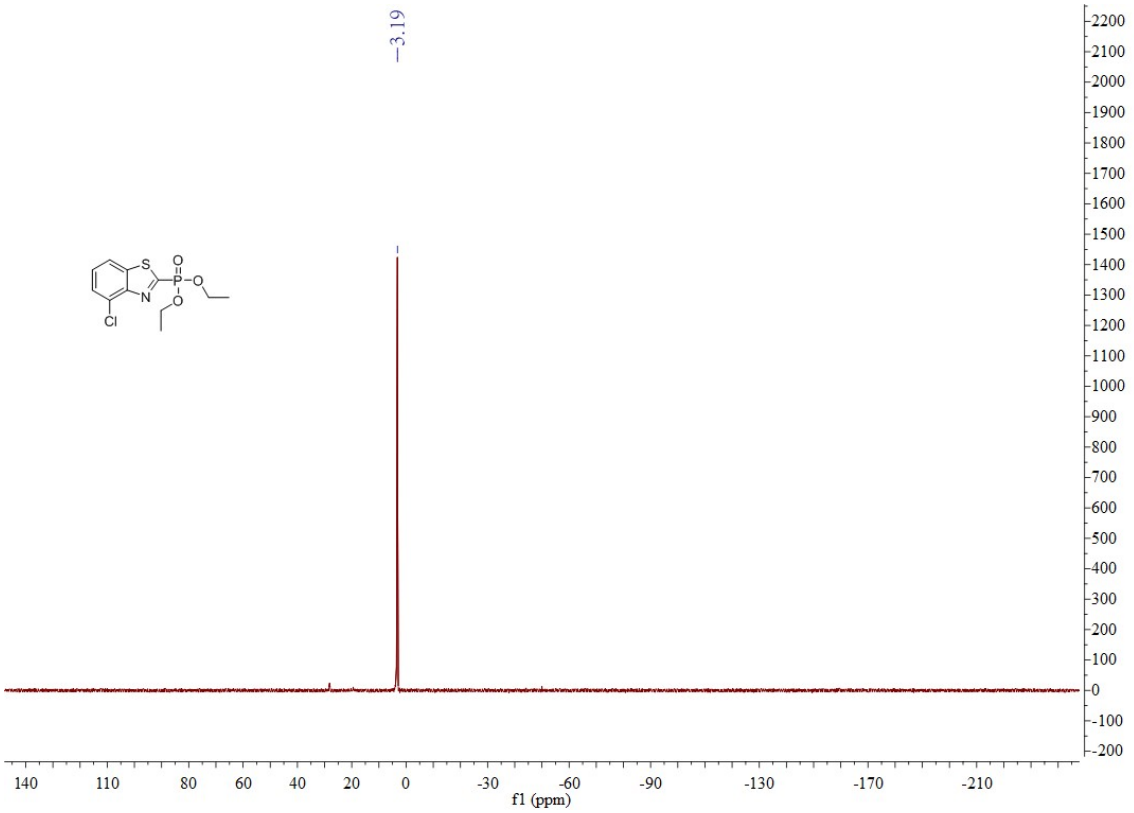

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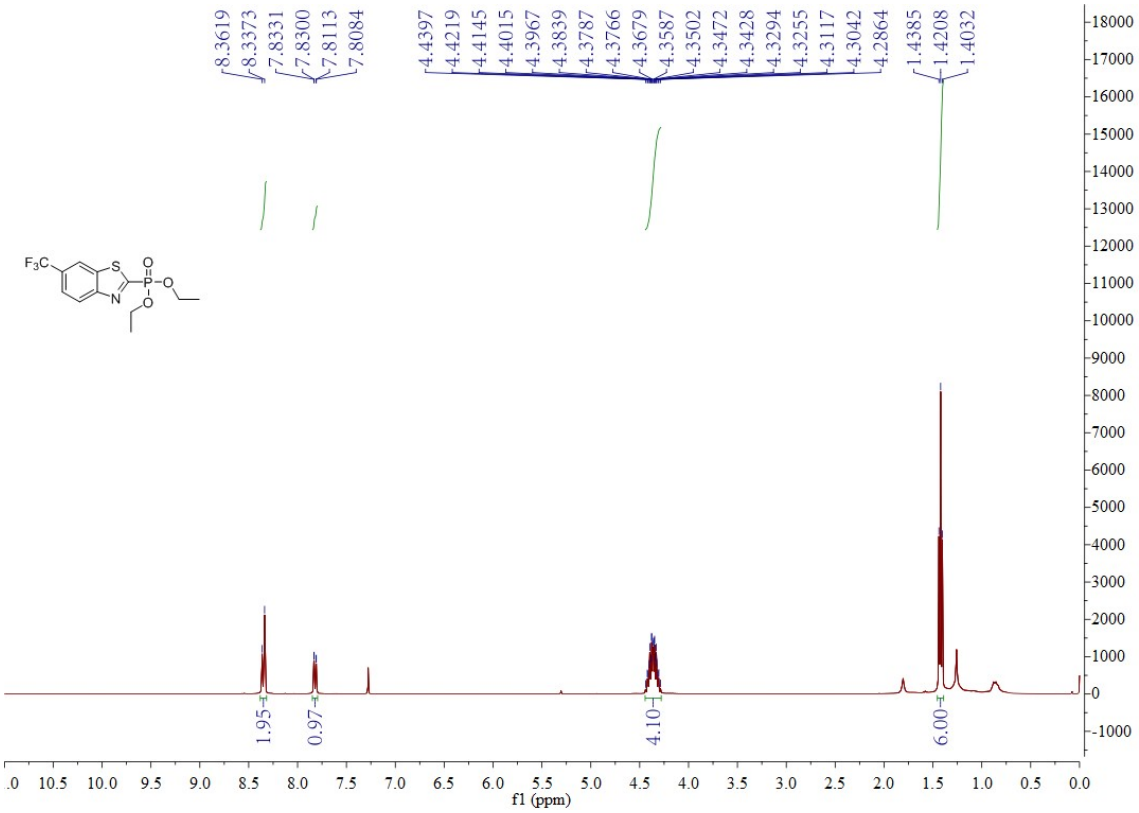

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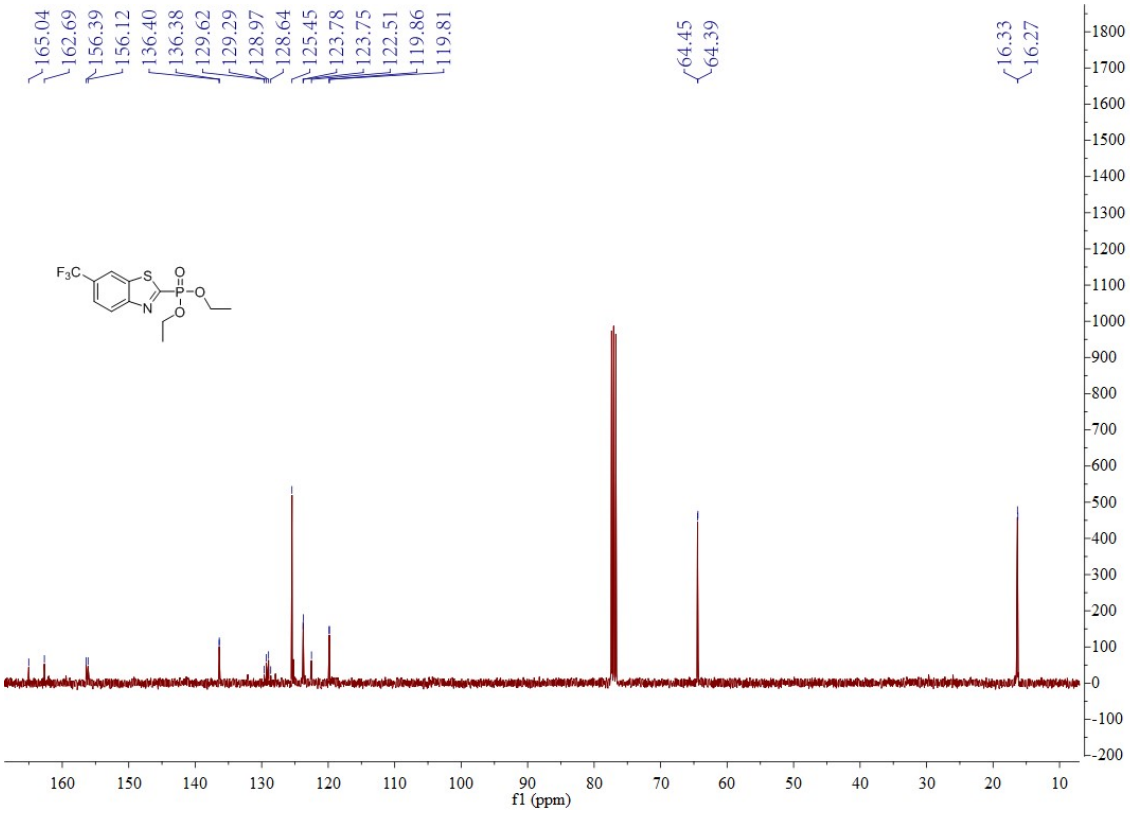

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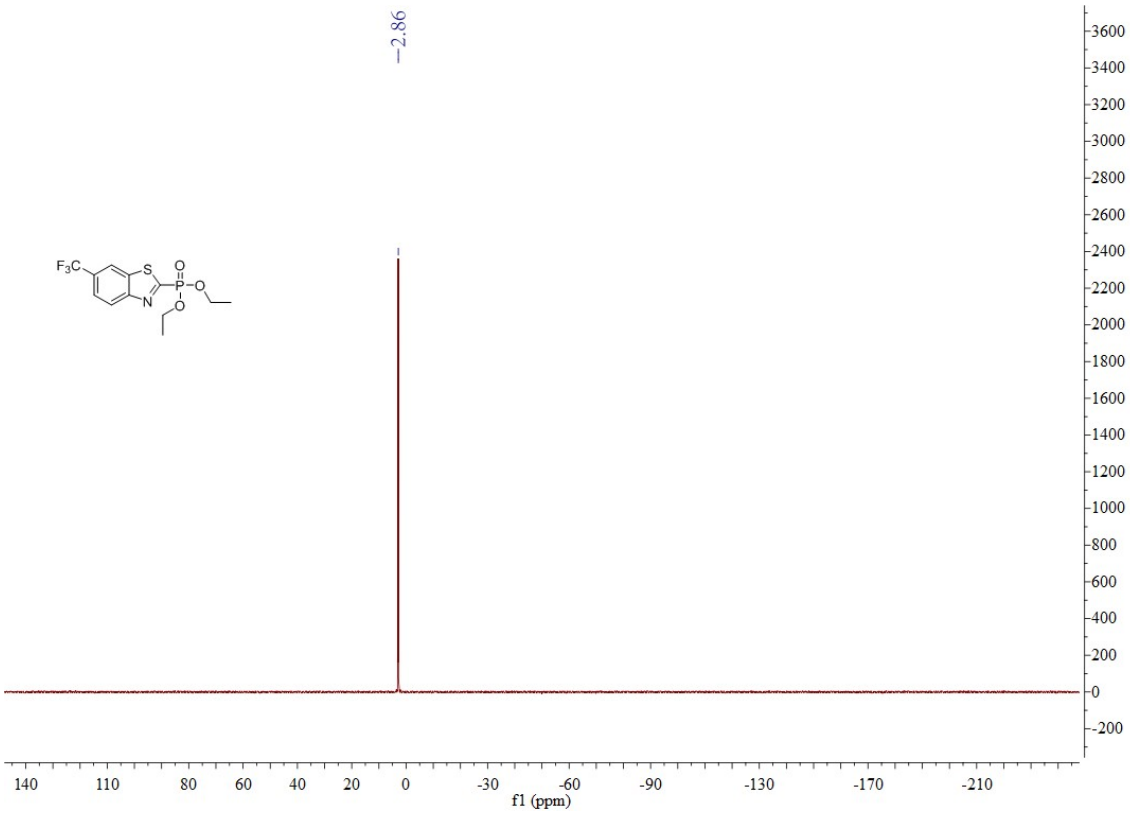

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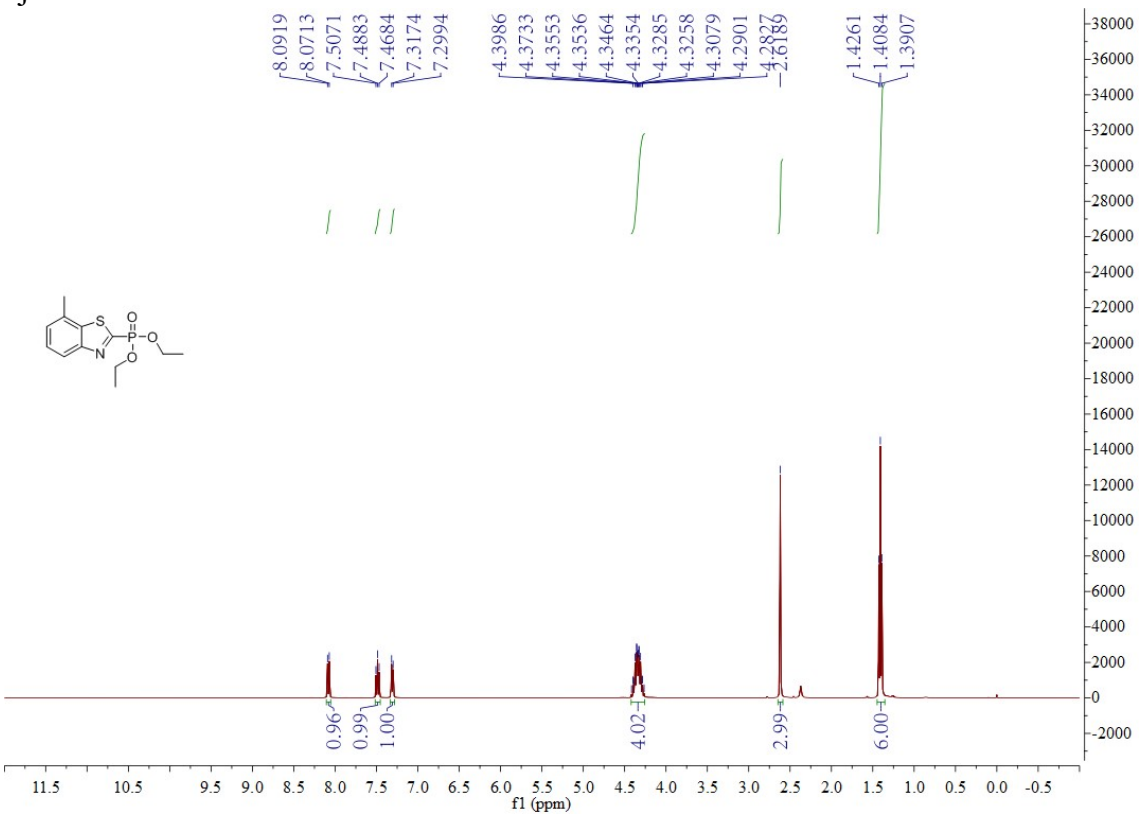

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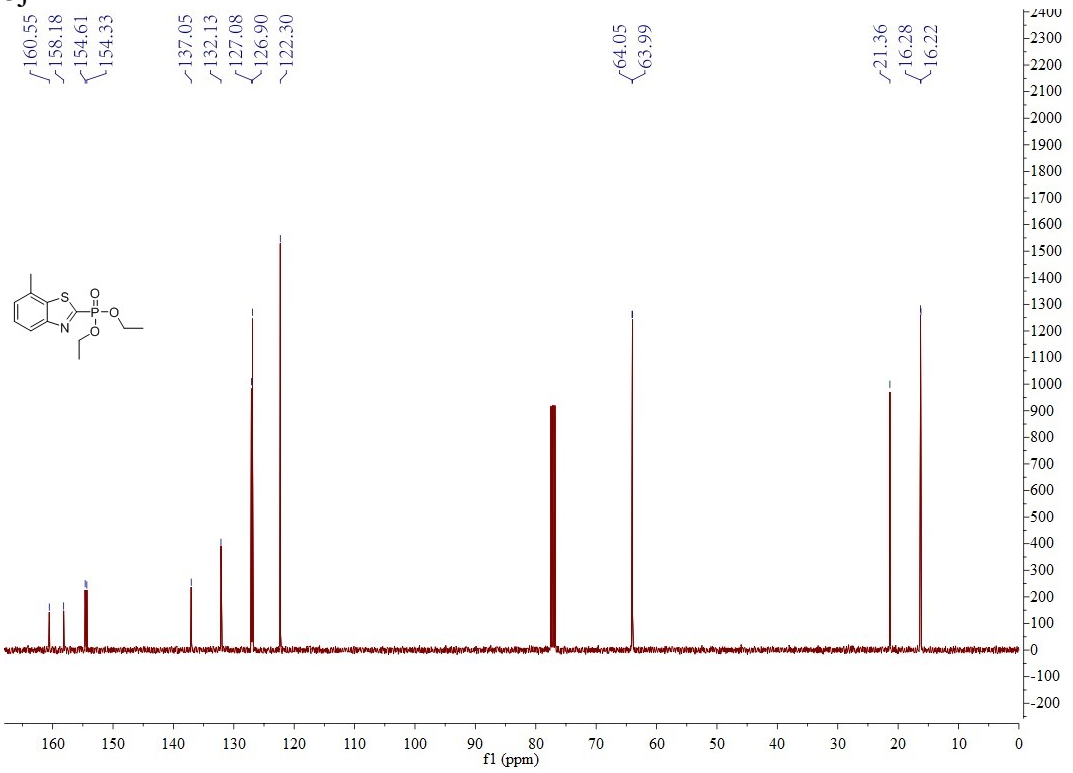

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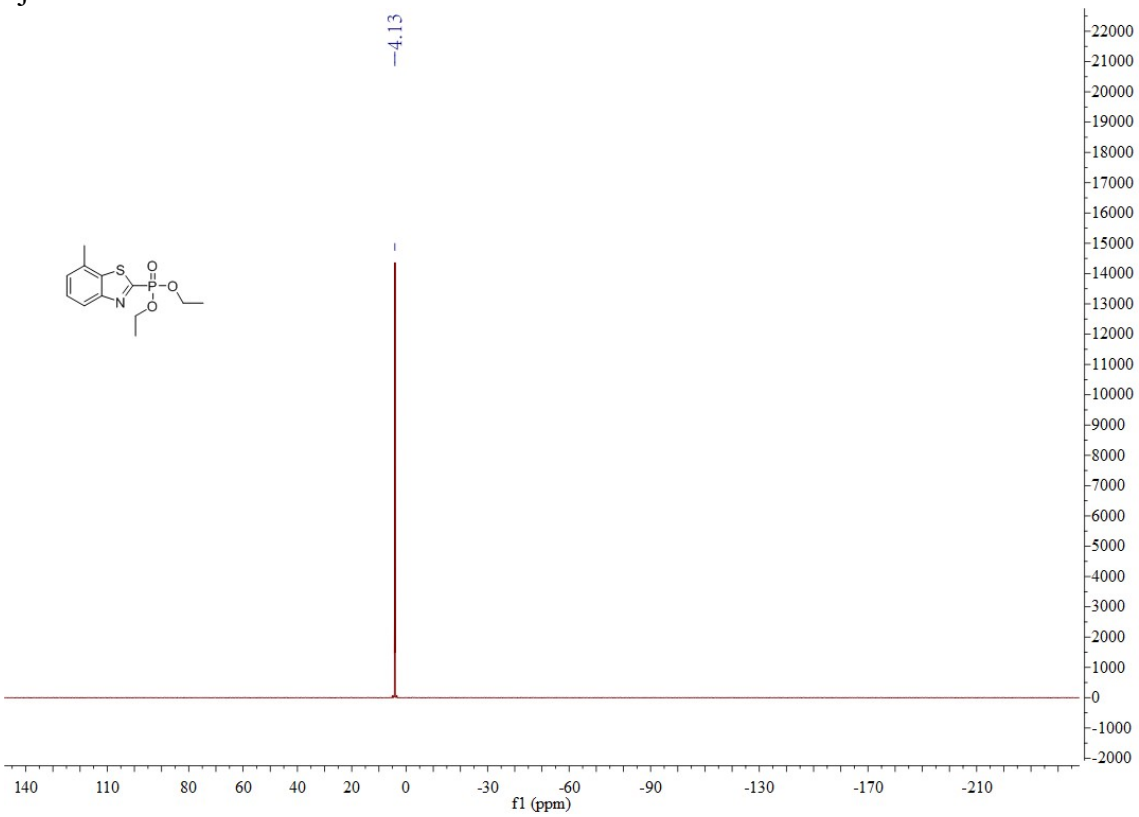

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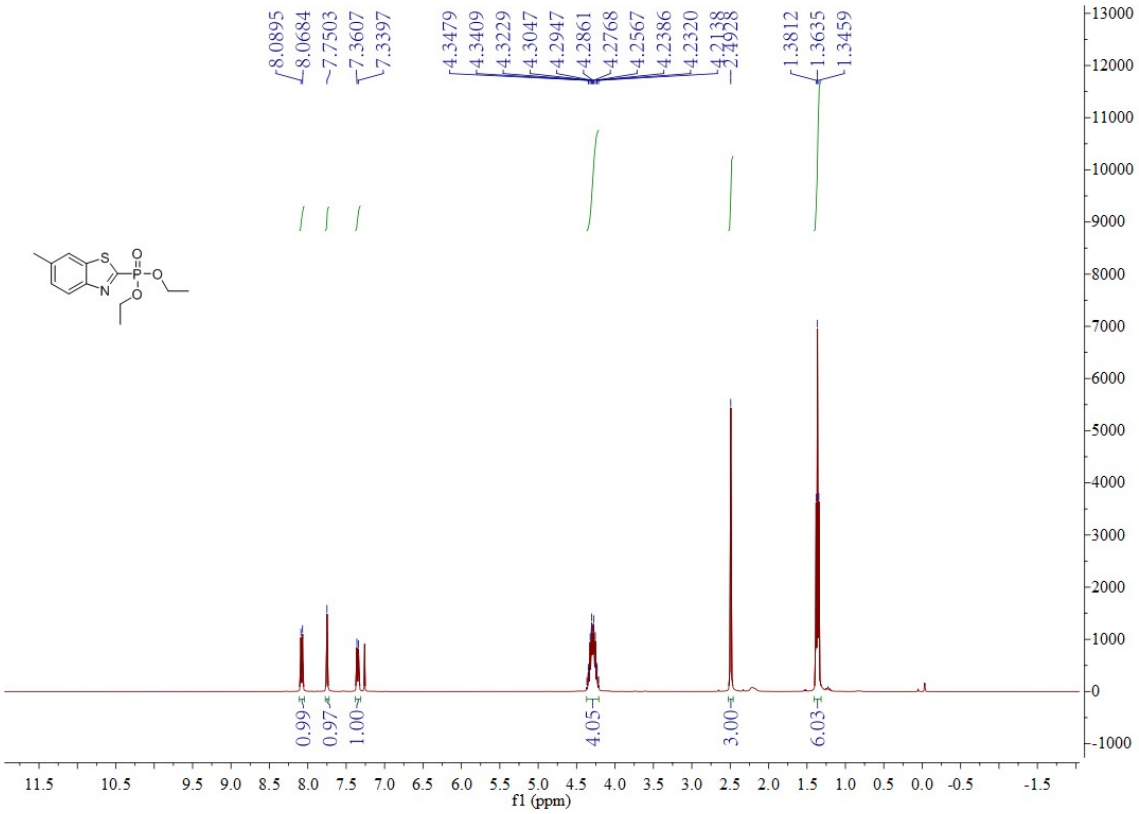

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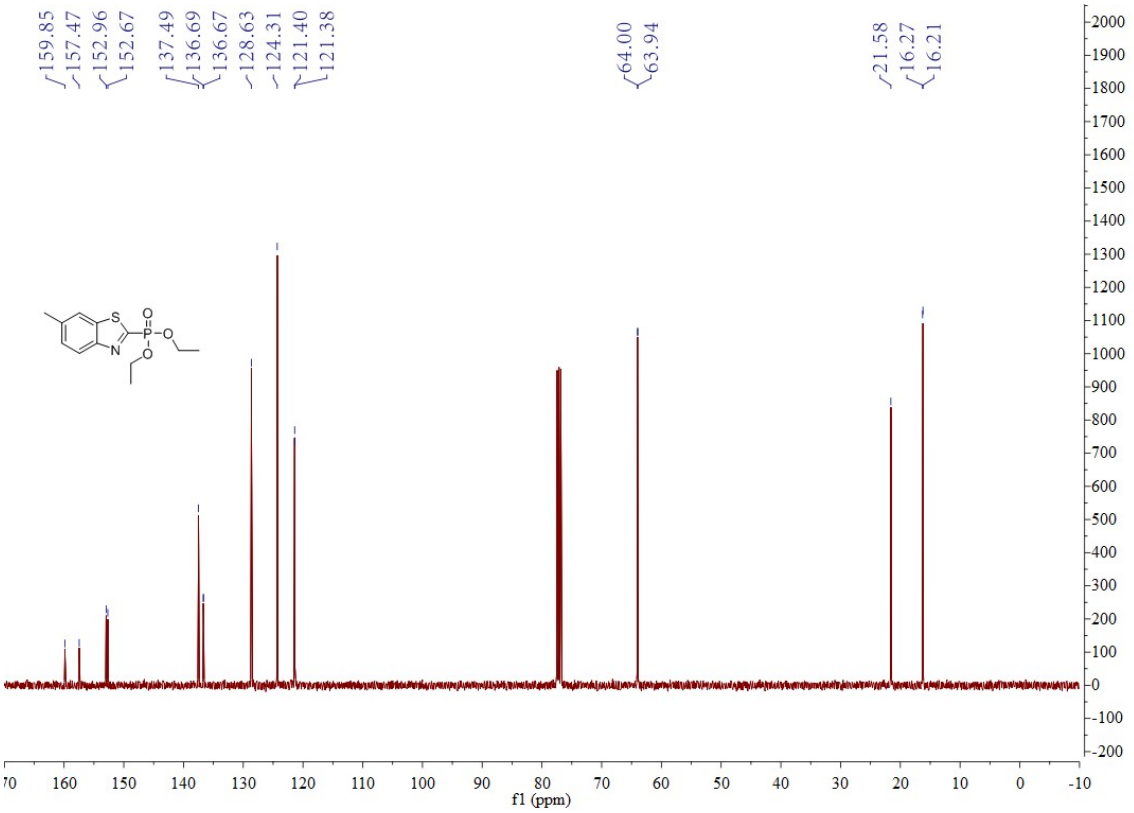

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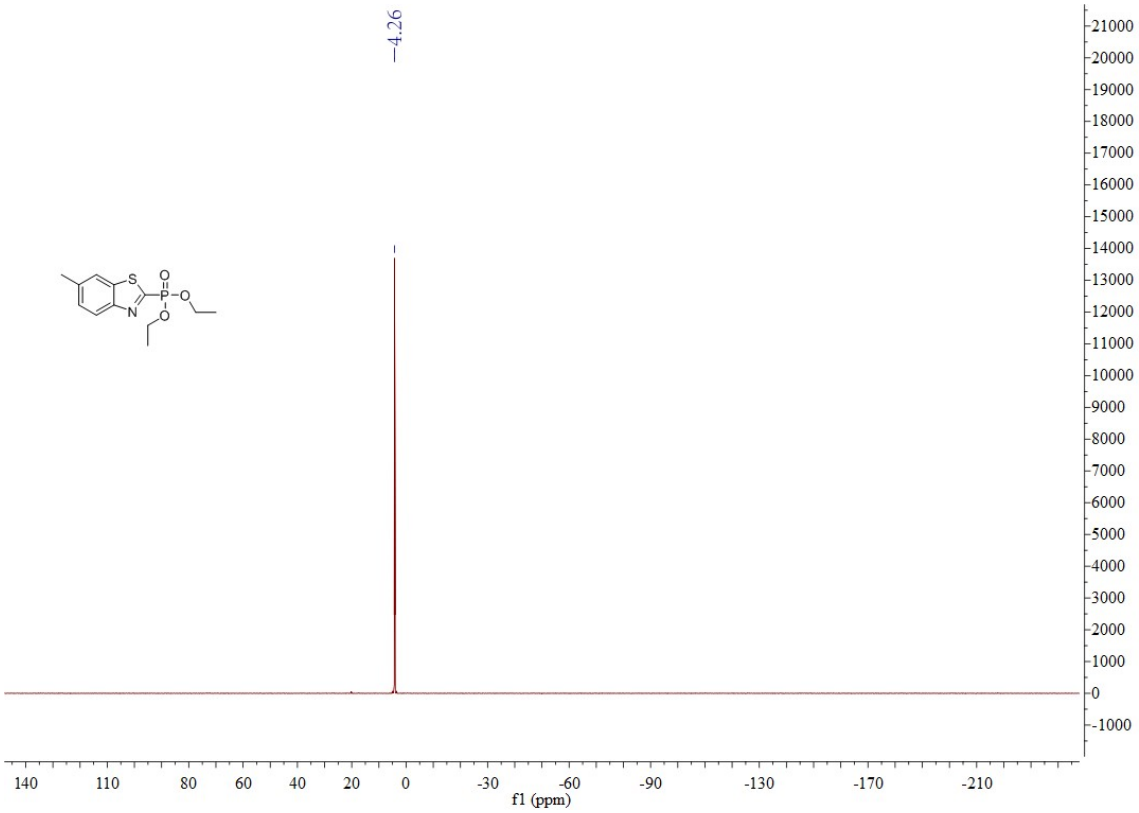

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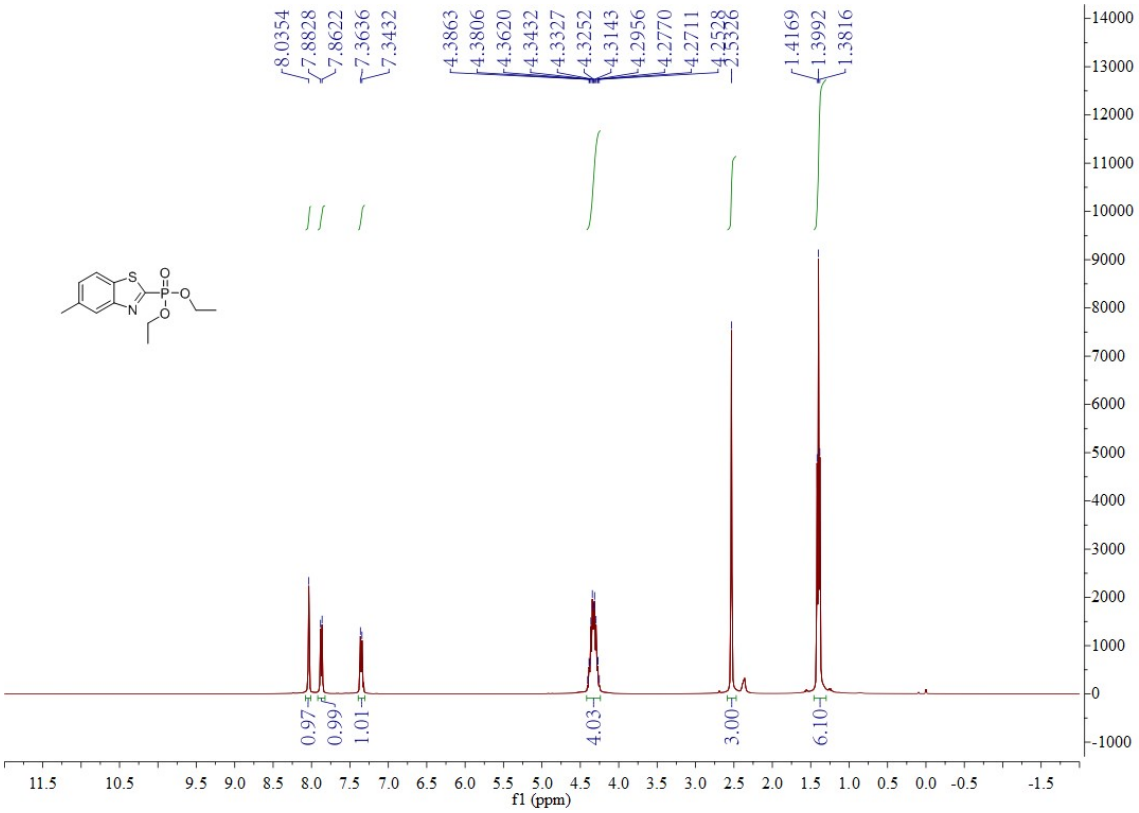

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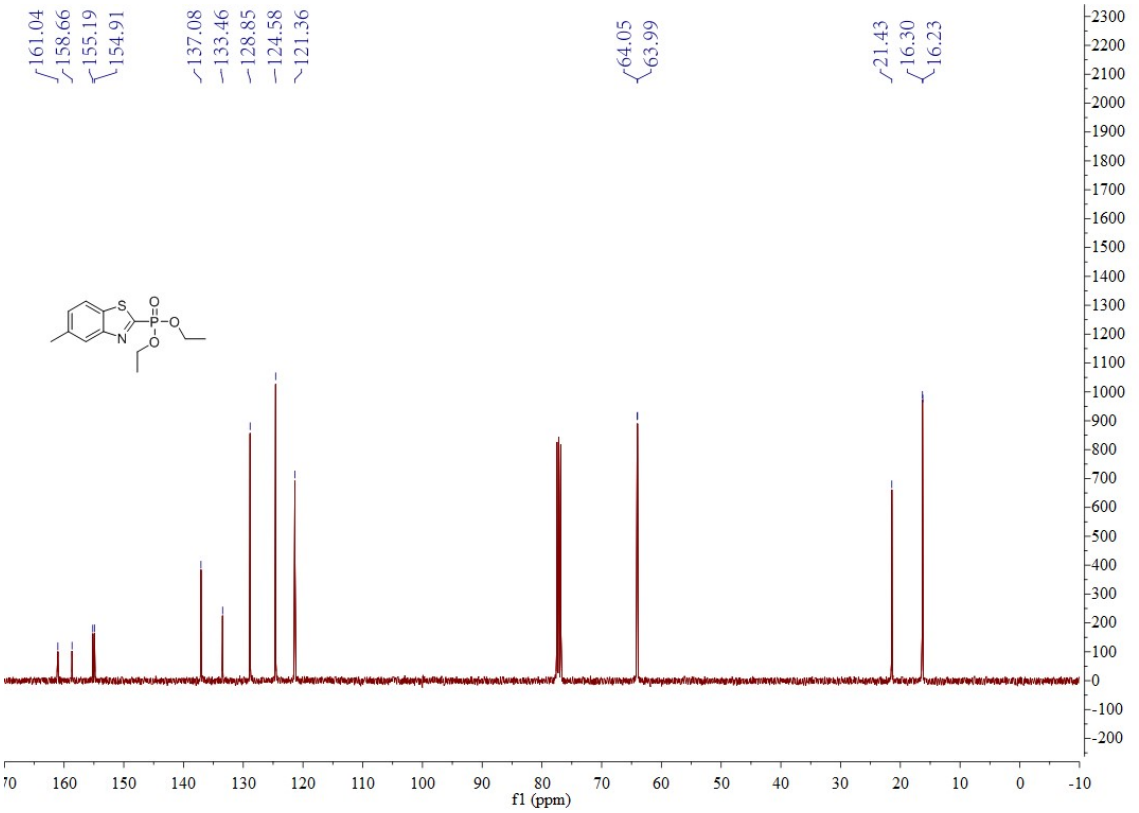

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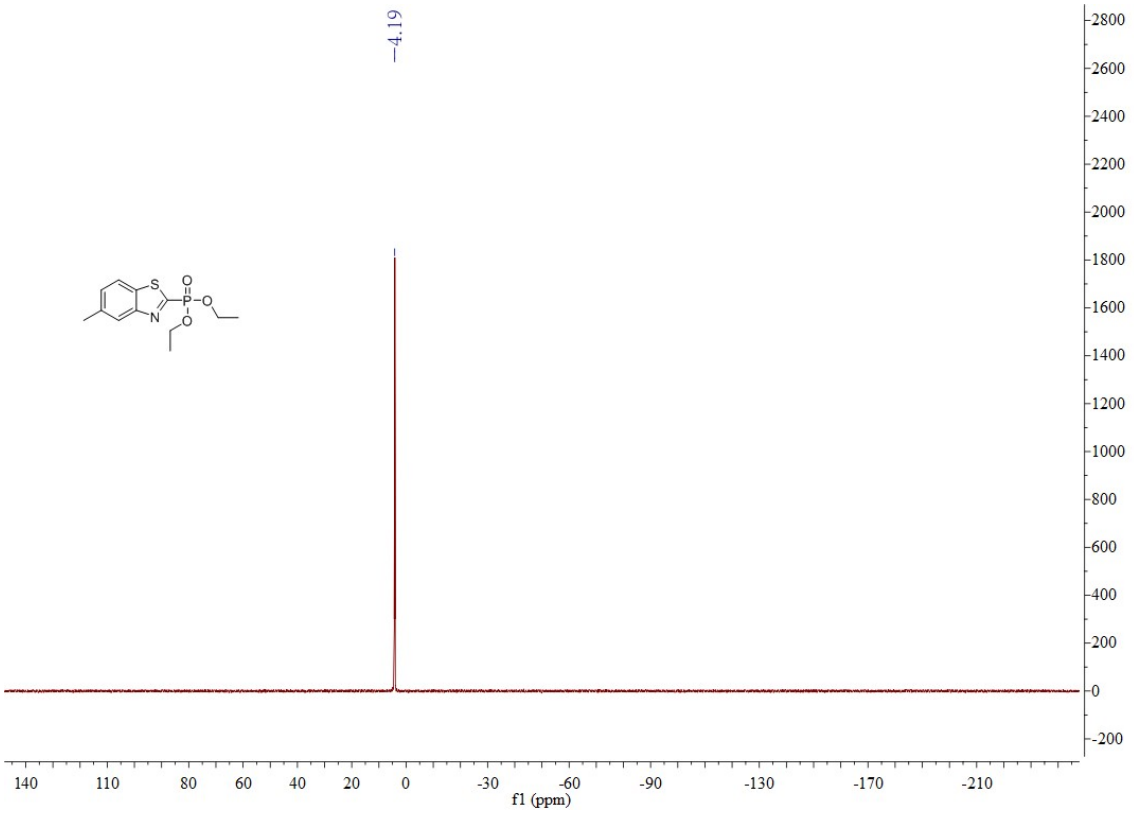

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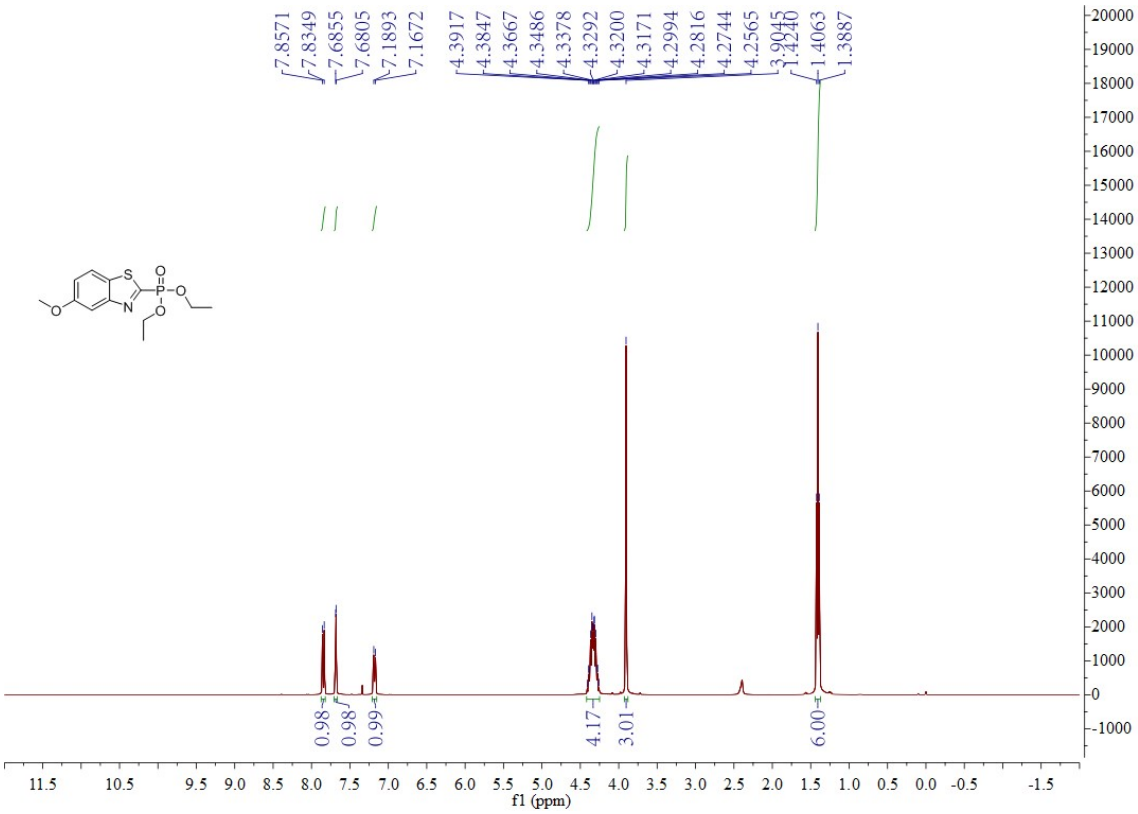

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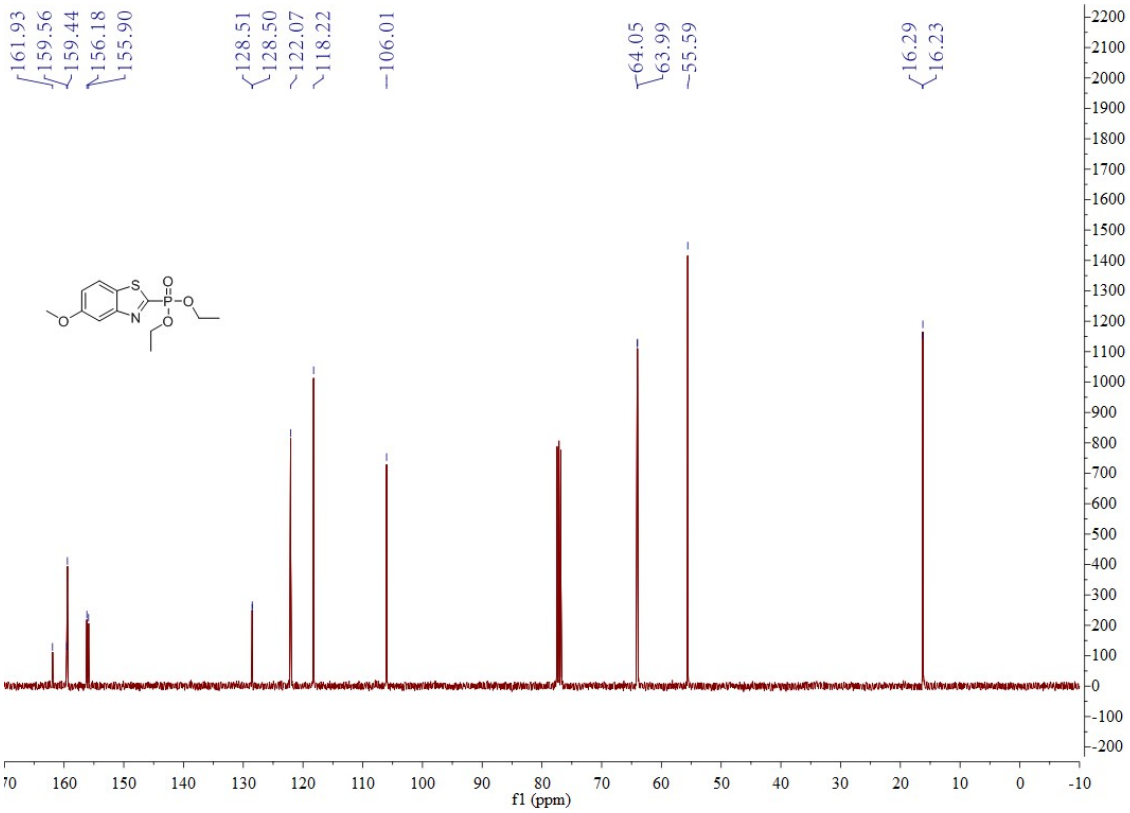
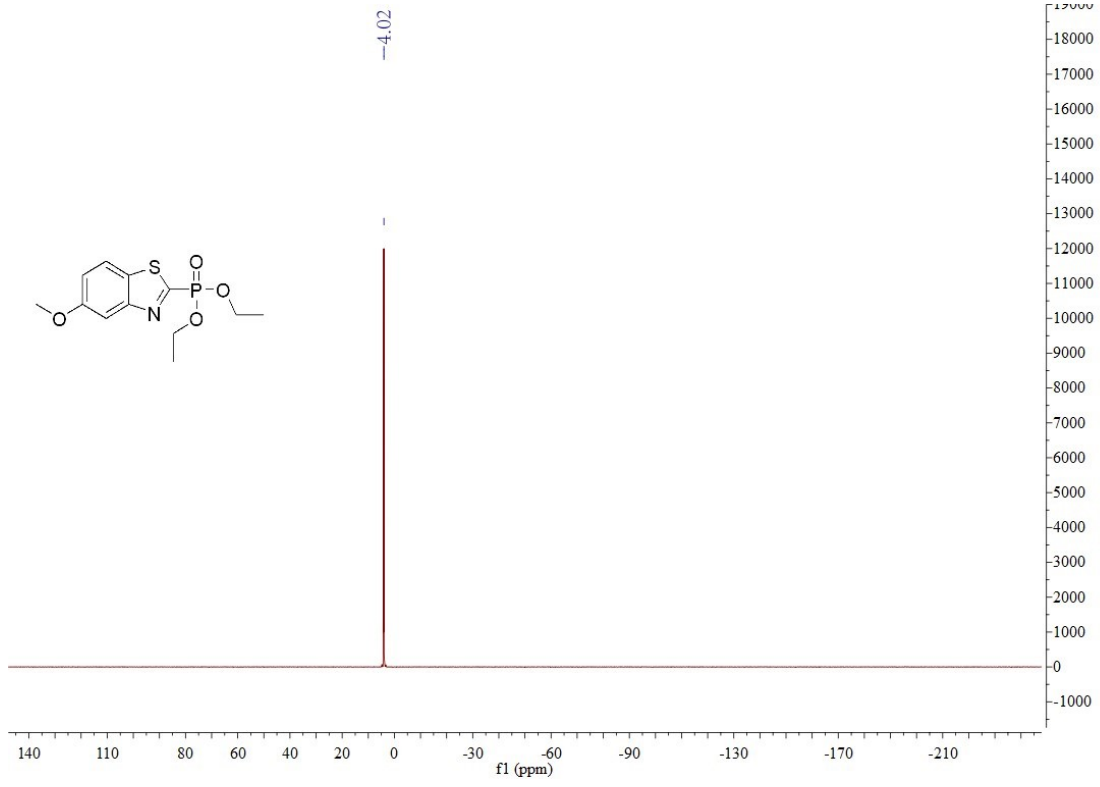
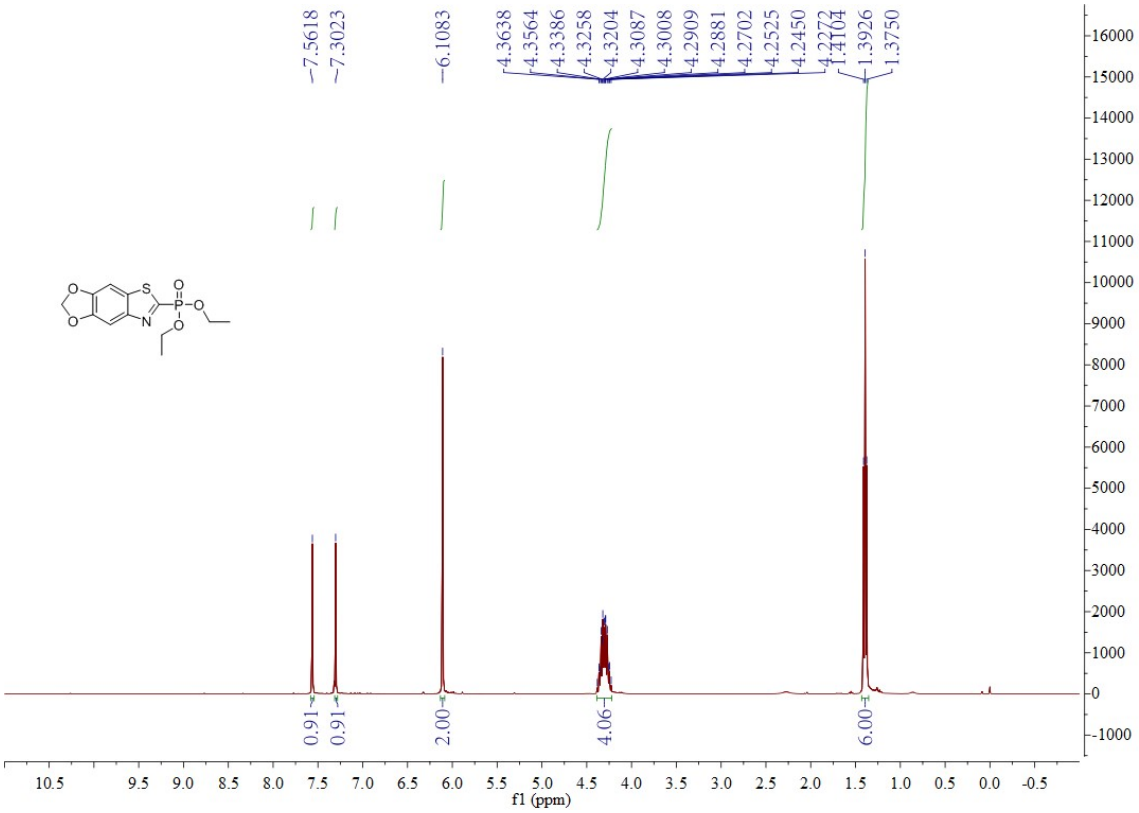


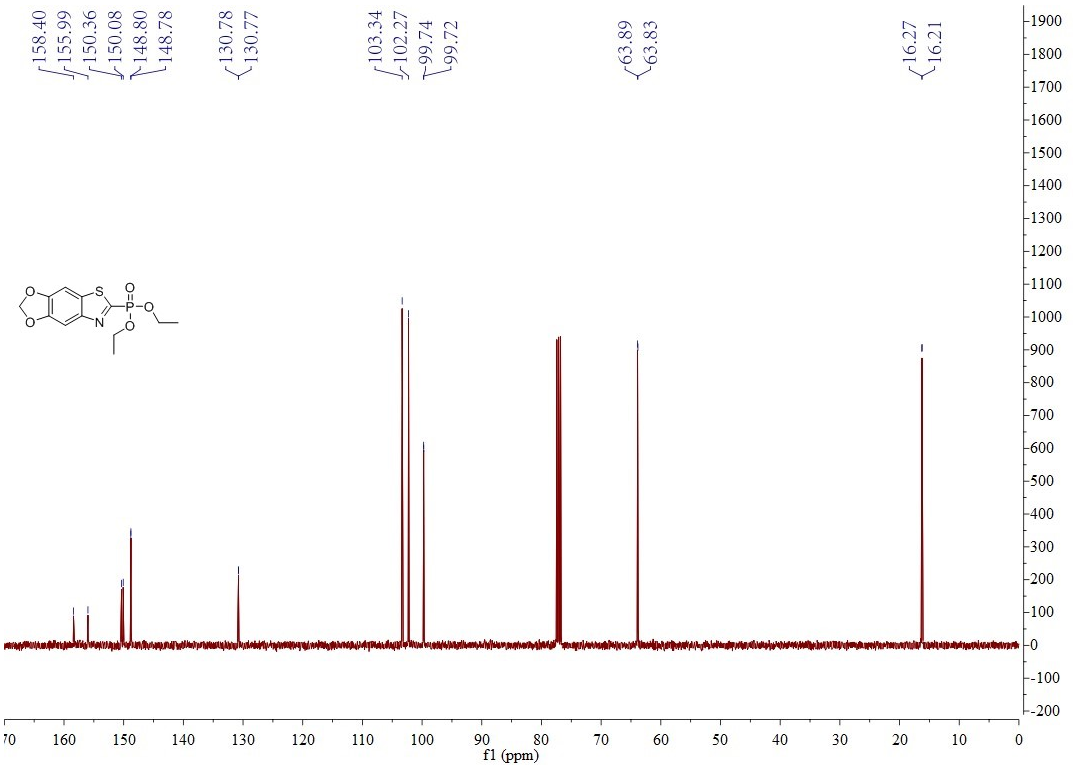
3ma ^{31}P NMR



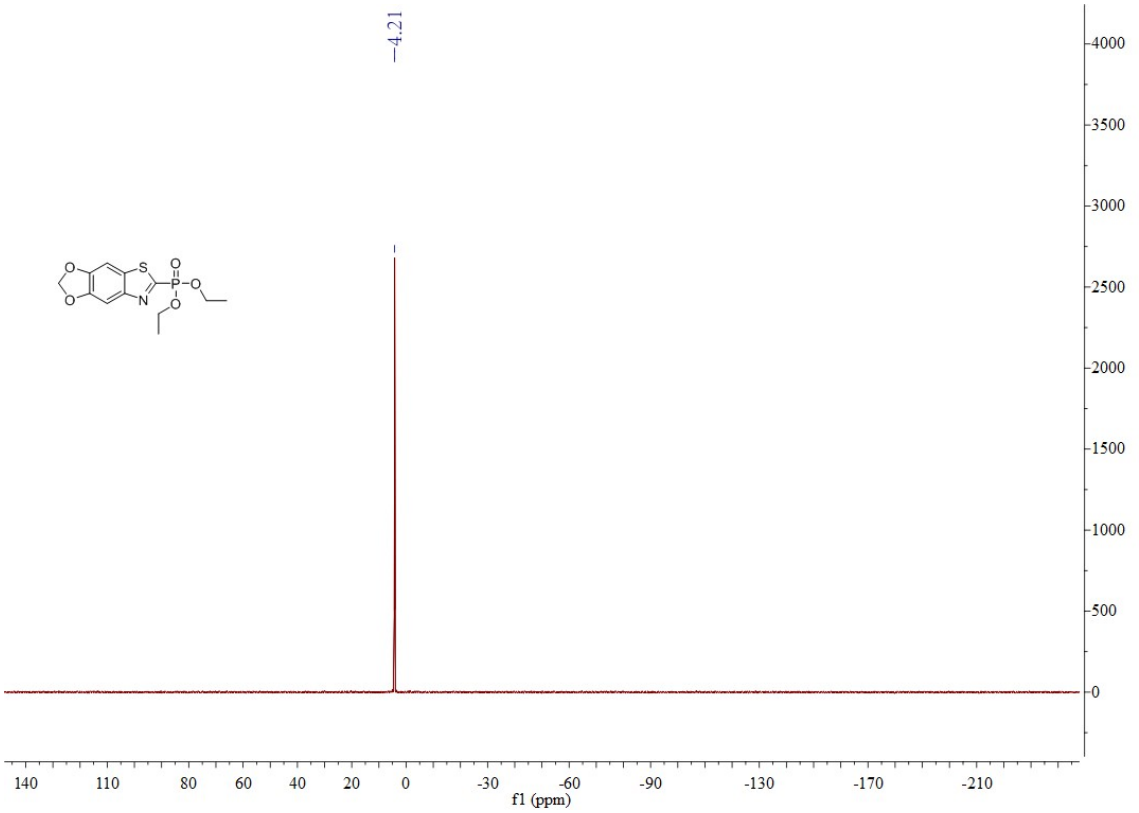
3na ^{1}H NMR



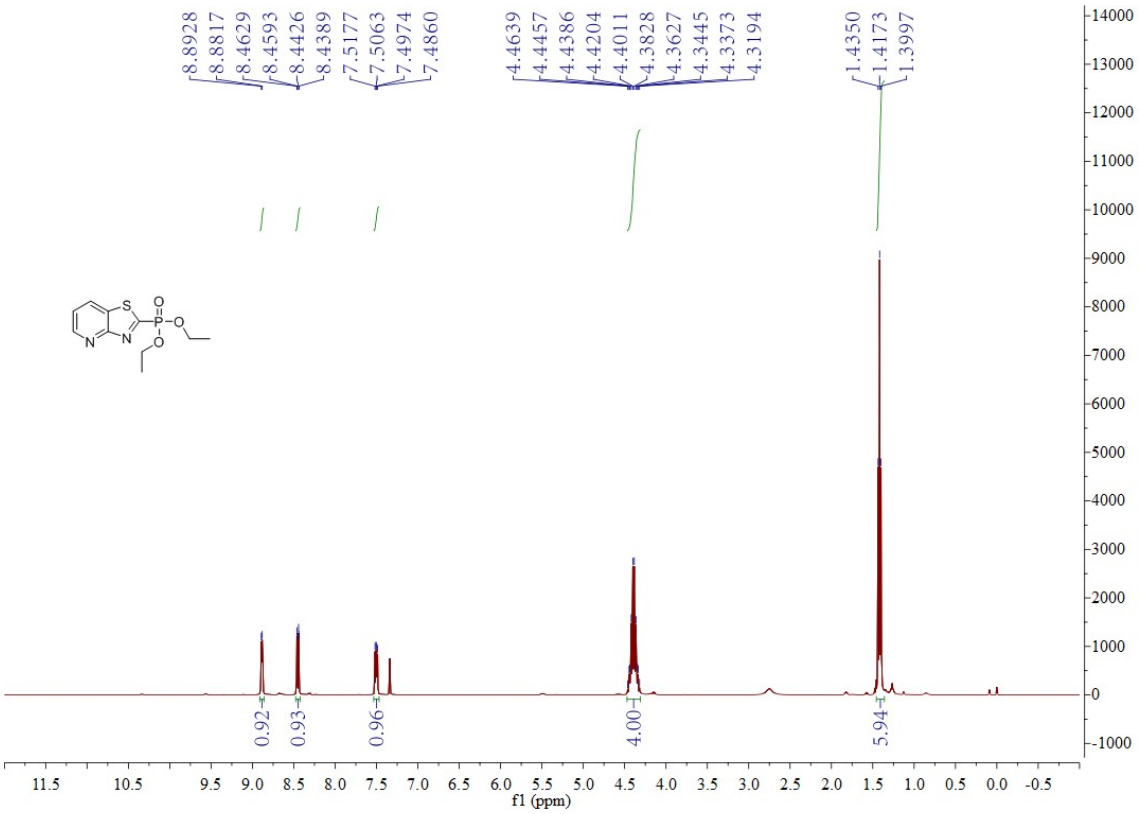
3na ^{13}C NMR



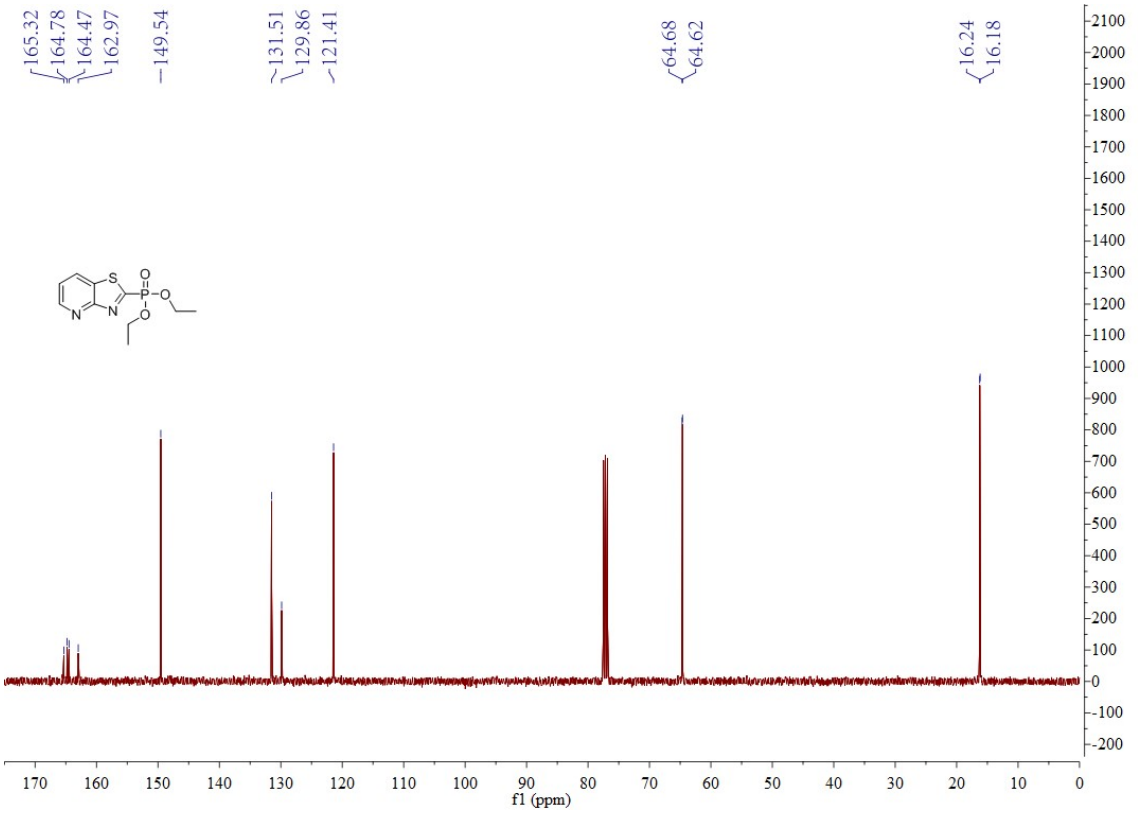
3na ^{31}P NMR



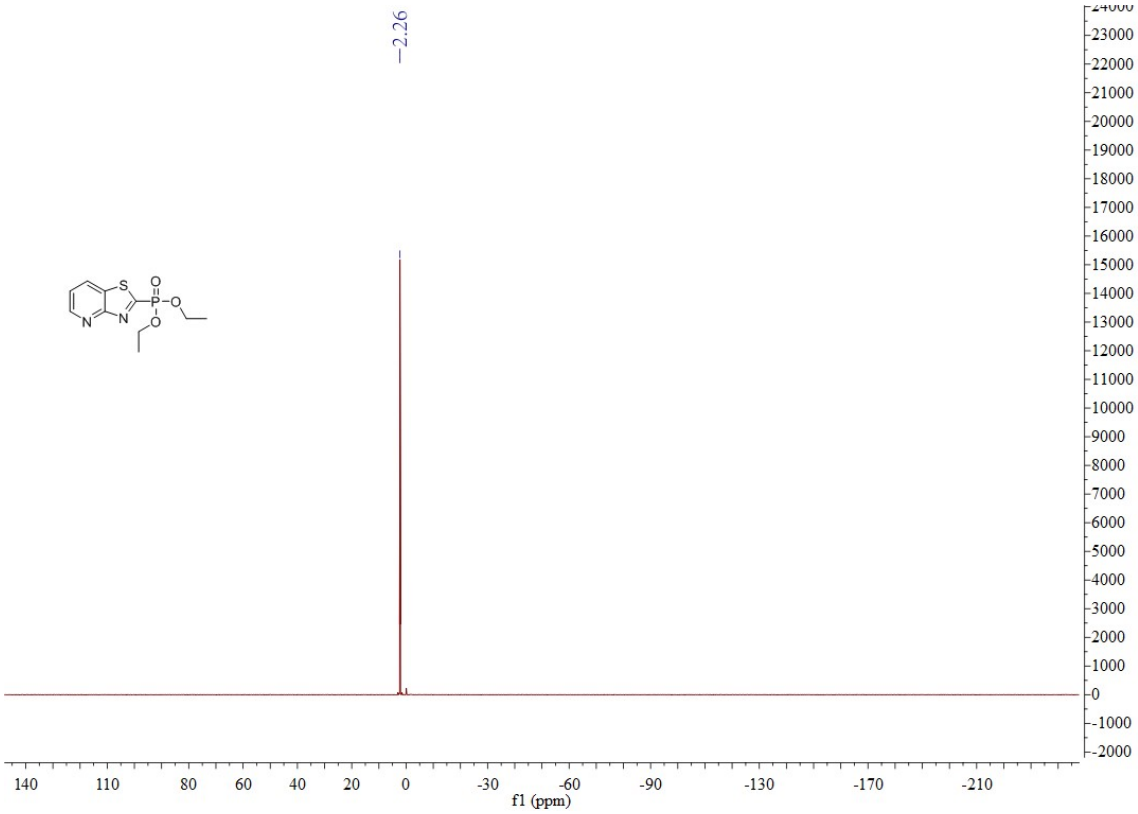
3oa ^{1}H NMR



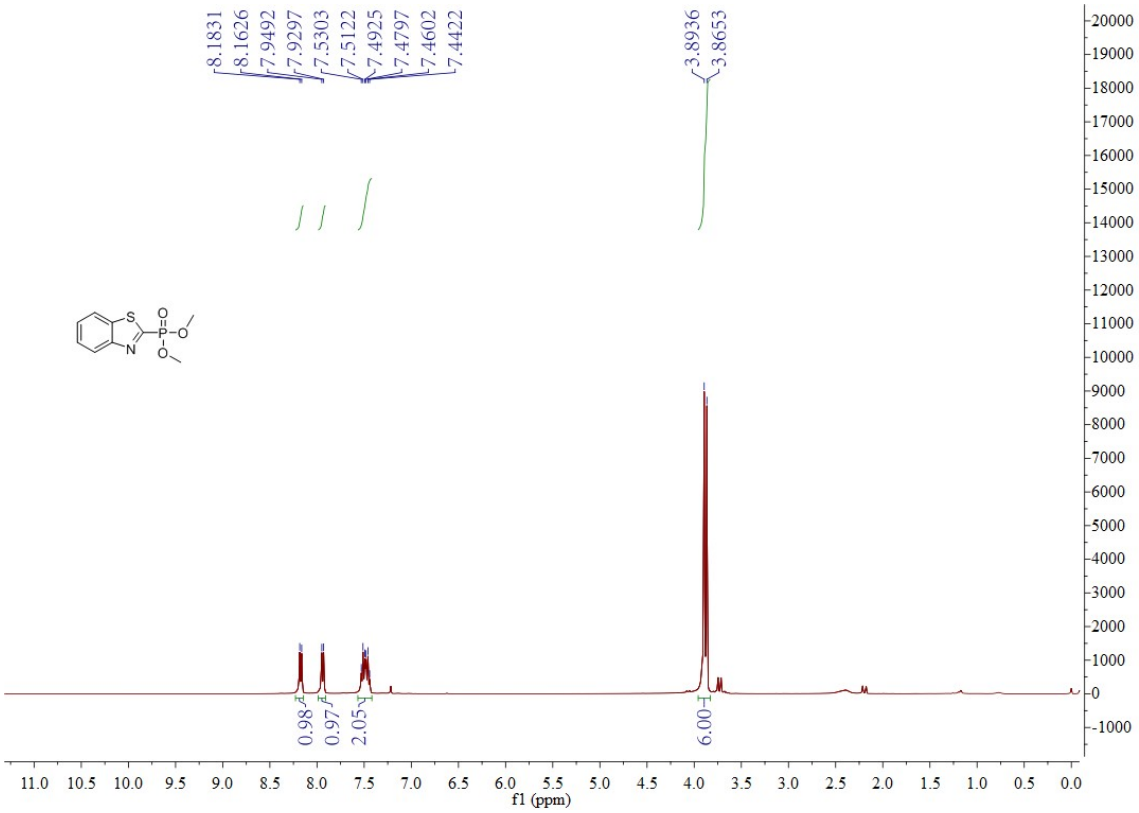
3oa ^{13}C NMR



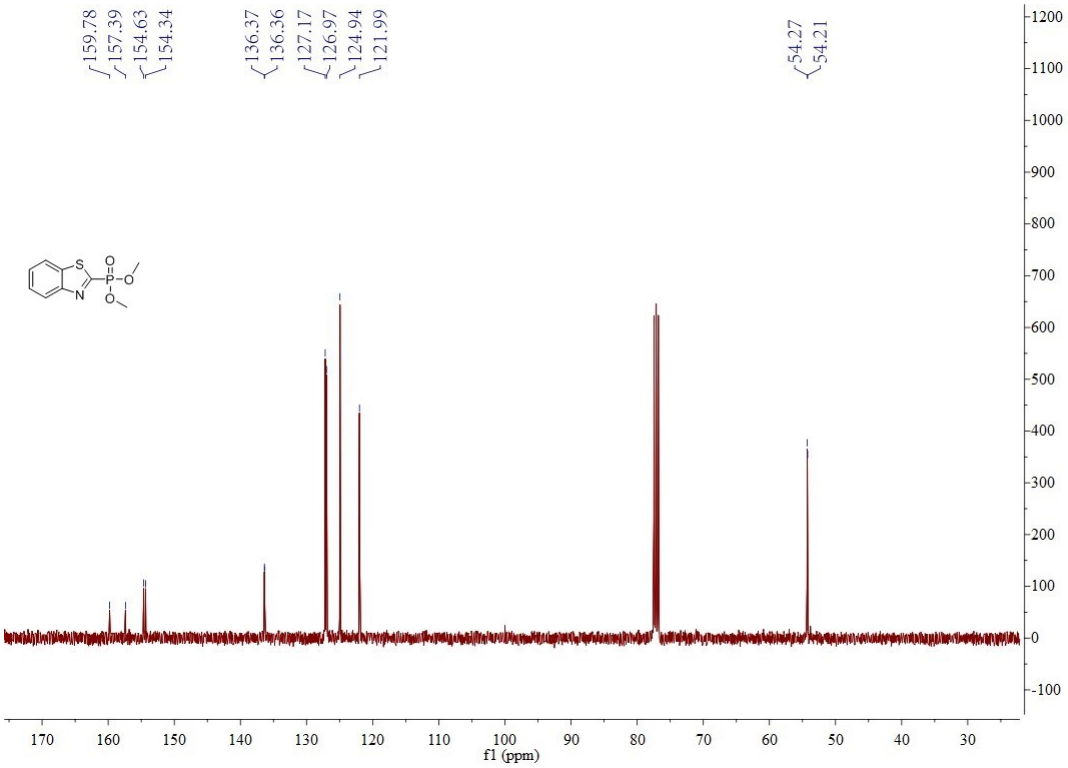
3oa ^{31}P NMR



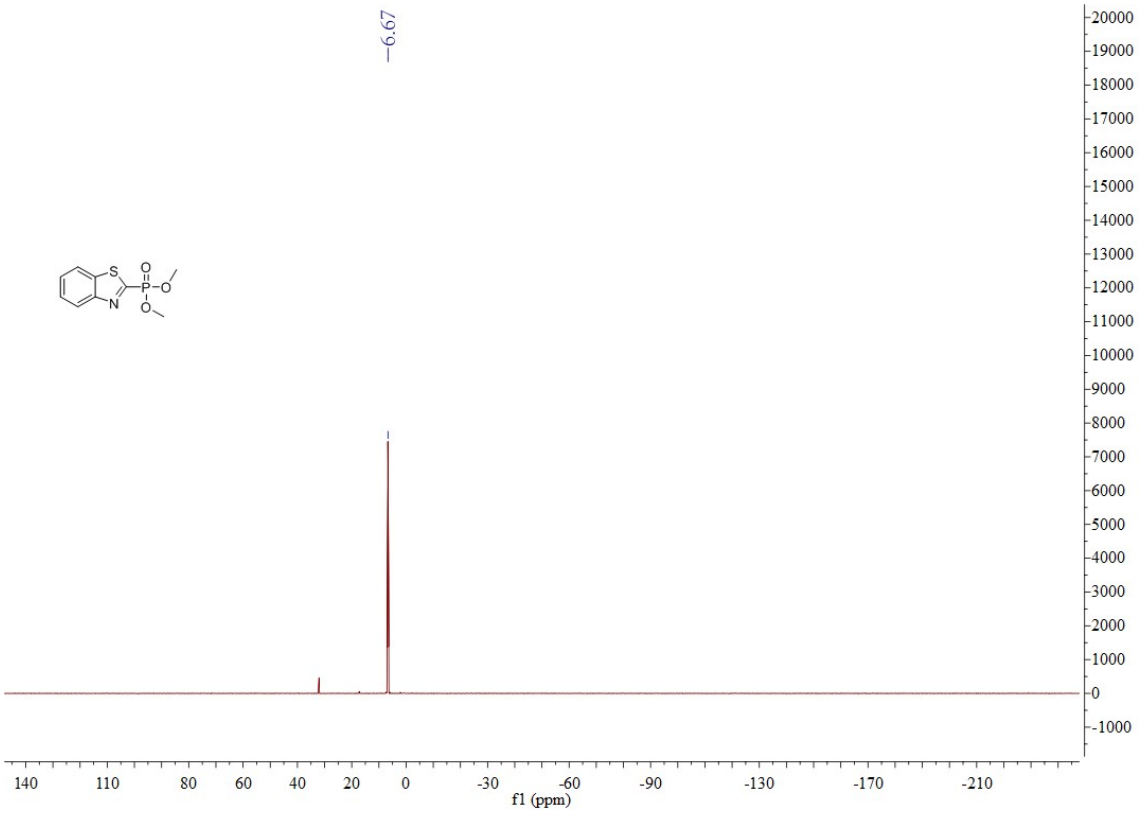
3ab ^{1}H NMR



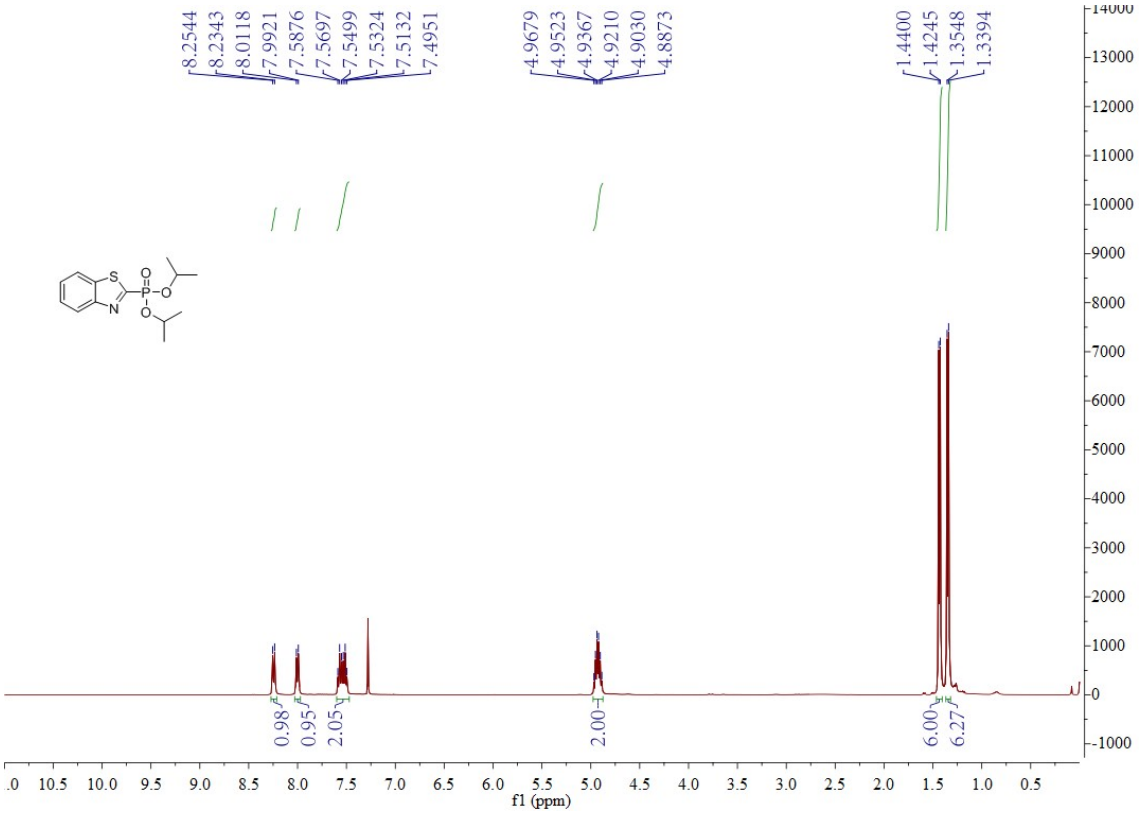
3ab ^{13}C NMR



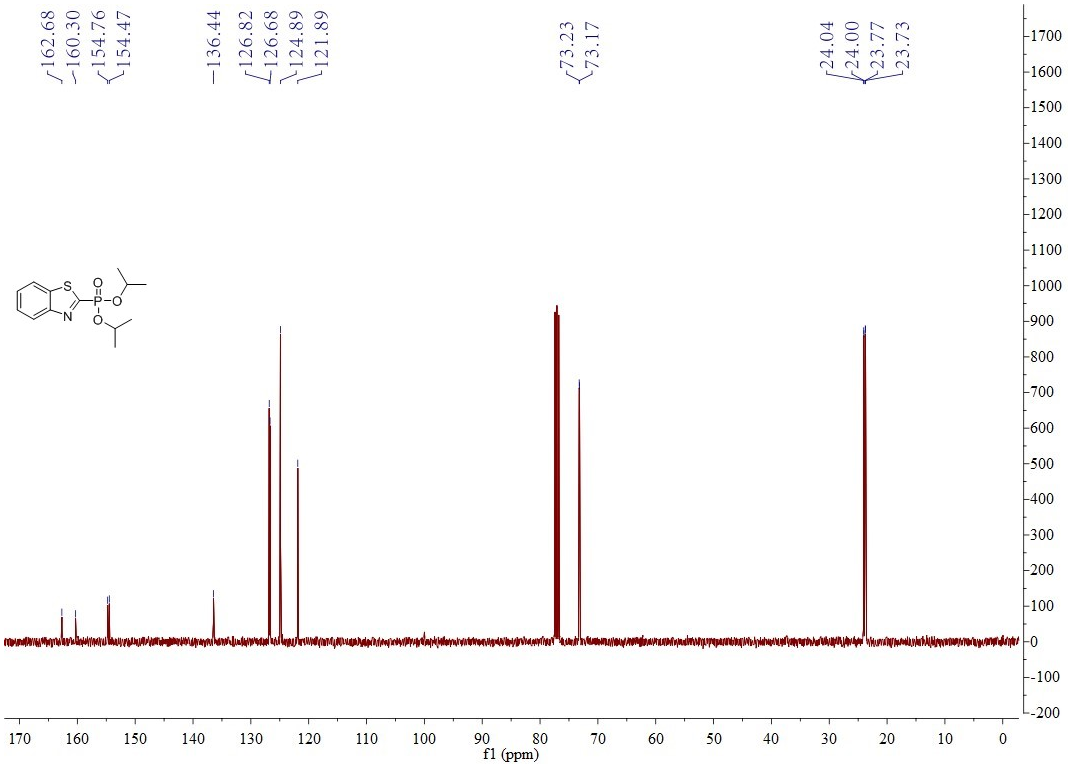
3ab ^{31}P NMR



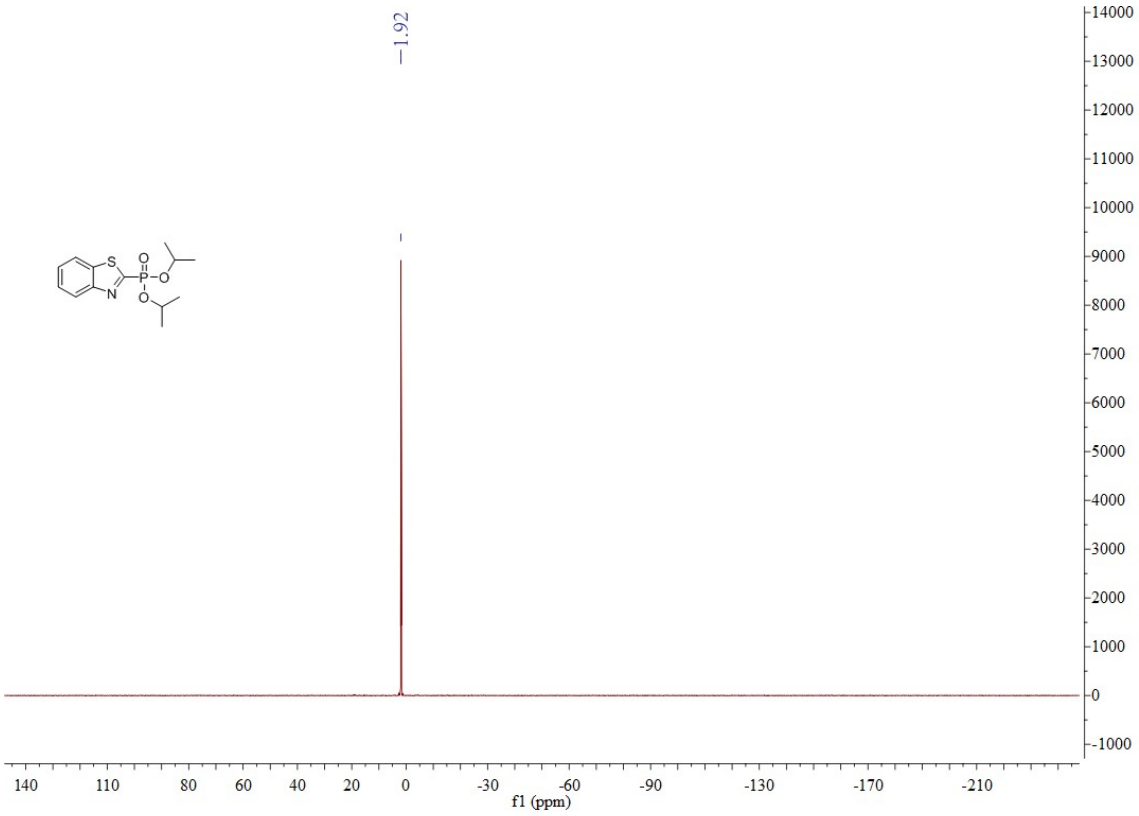
3ac ^{1}H NMR



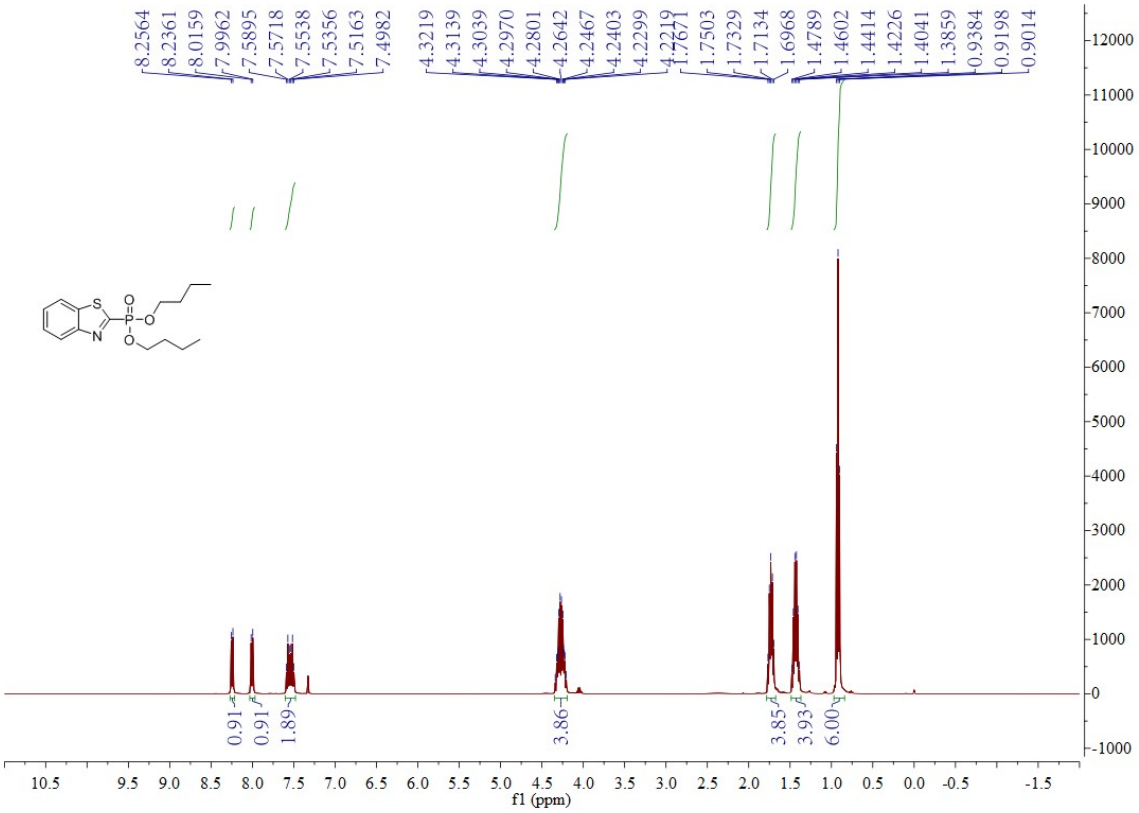
3ac ^{13}C NMR



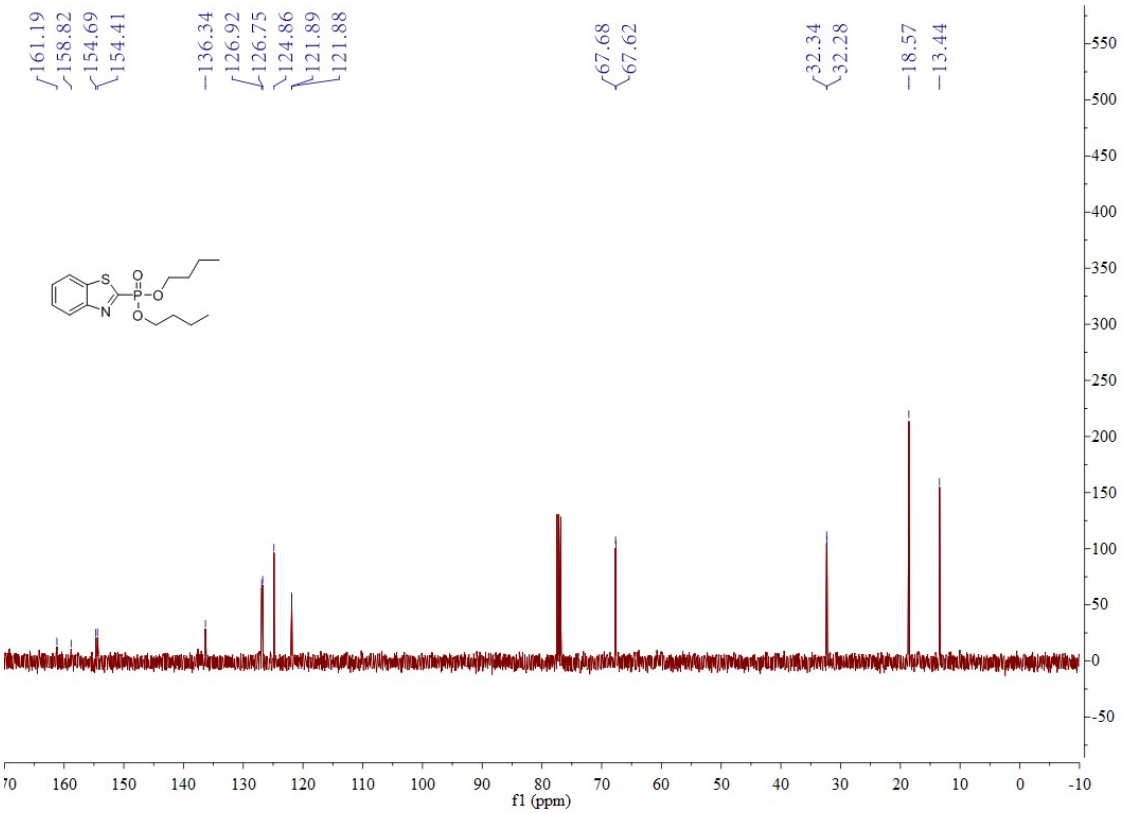
3ac ^{31}P NMR



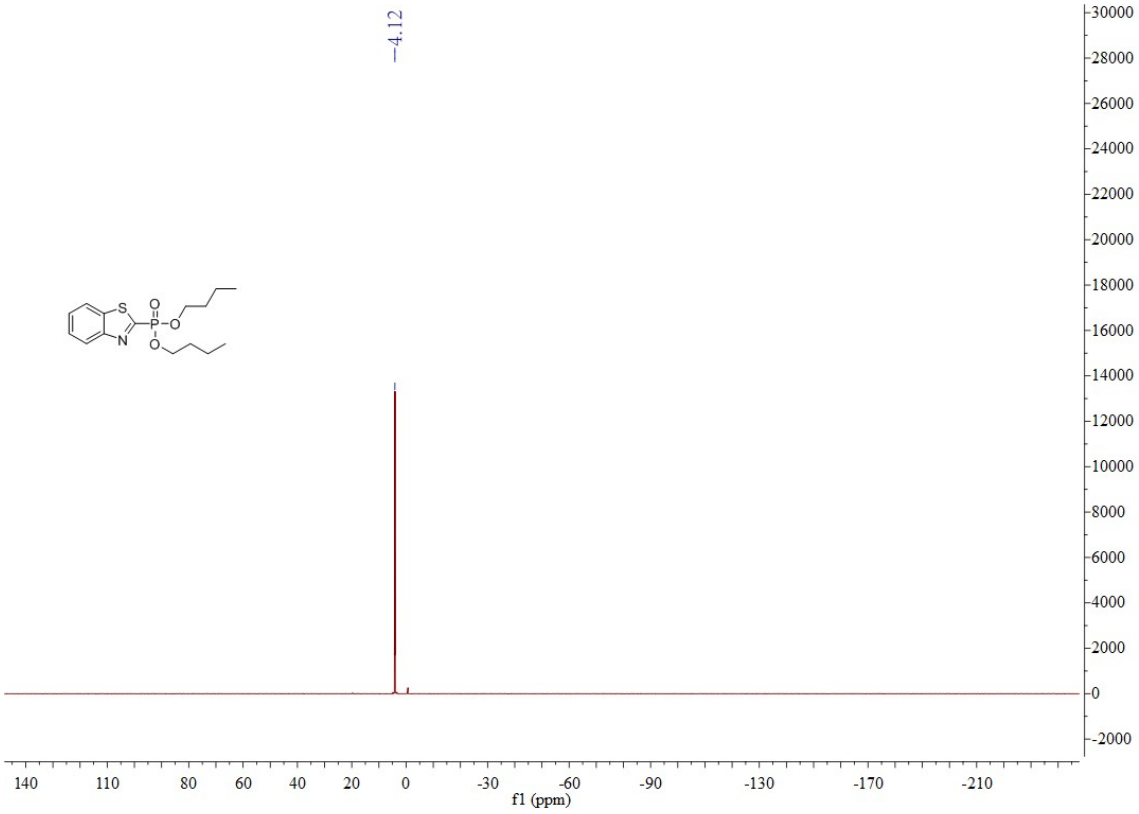
3ad ^{1}H NMR



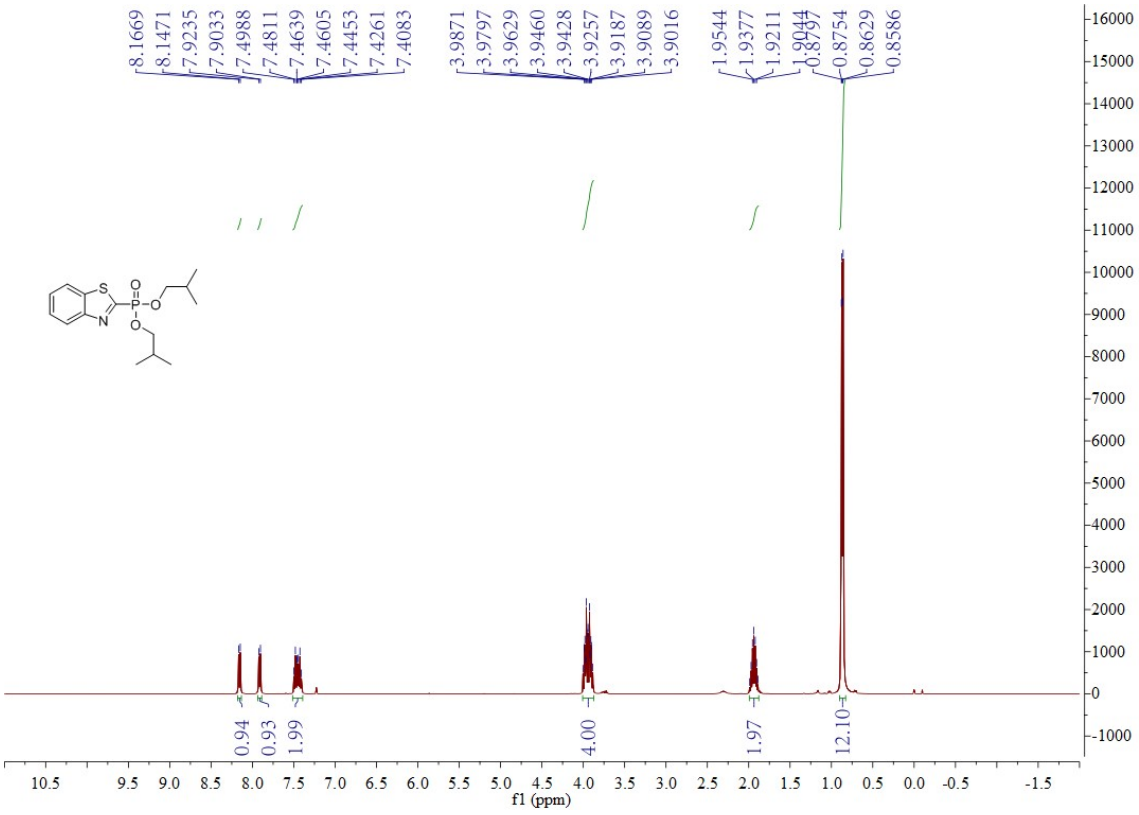
3ad ^{13}C NMR



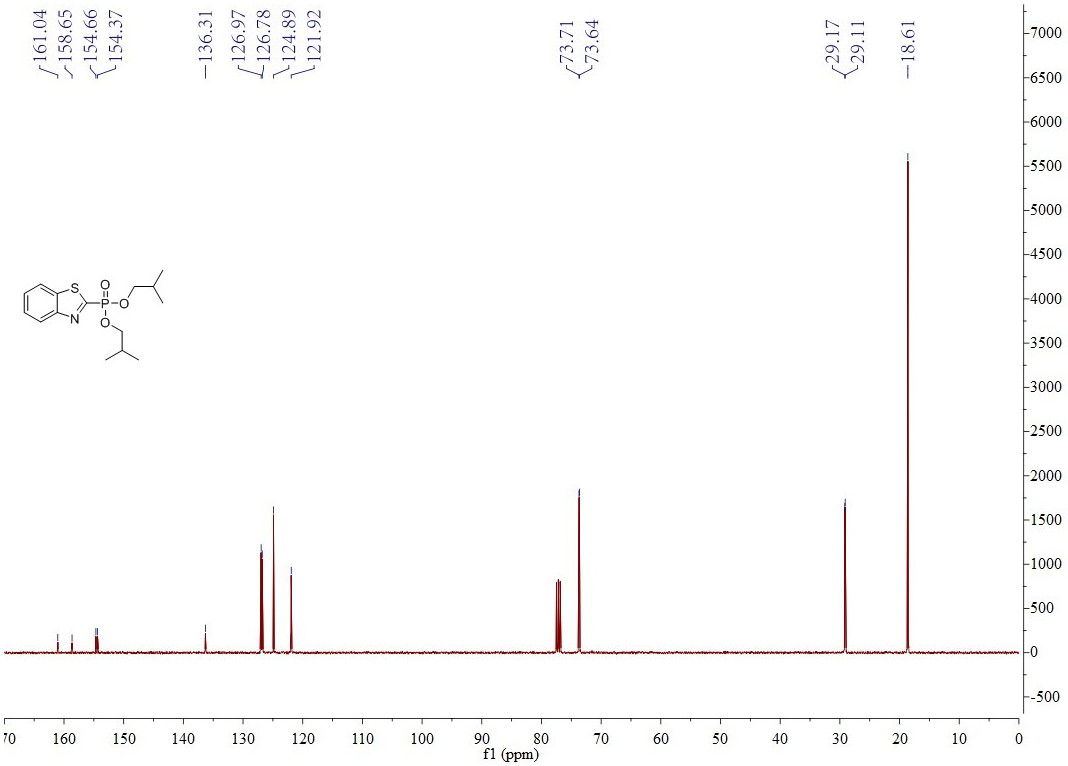
3ad ^{31}P NMR



3ae ^{1}H NMR



3ae ^{13}C NMR



3ae ^{31}P NMR