Supporting Information

$NaIO_4$/air-Initiated Phosphorylation of Alcohols with H-phosphine Oxides for the Construction of P(O)-O Bonds in Water

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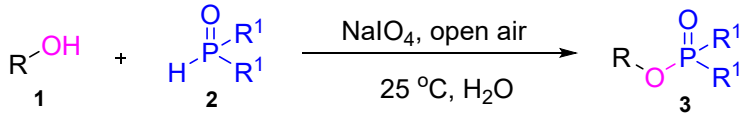
1. General Information

Unless otherwise stated, commercially available reagents including dry solvents were used without additional purification. Petroleum ether refers to the petroleum fraction b.p. 60-90 °C. All reactions were carried out in oven-dried thick-walled glassware. Flash chromatography was performed using the indicated solvent system on silica gel standard grade (200-300 mesh). ^{1}H NMR spectra were recorded in DMSO-d_6 on a Bruker 400 (400 MHz) spectrometer. ^{13}C NMR spectra were recorded in DMSO-d_6 on a Bruker 400 (101 MHz) spectrometer. ^{31}P NMR spectra were recorded in DMSO-d_6 on a Bruker 400 (243 MHz) spectrometer. Chemical shifts were reported relative to DMSO-d_6 (δ 2.50 ppm) for ^{1}H NMR and DMSO-d_6 (δ 39.52 ppm) for ^{13}C NMR. High-resolution mass spectra (HRMS) were recorded on a Q-Exactive Orbitrap mass spectrometer (Thermo, CA).

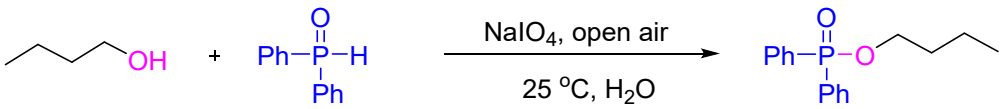
2. Experimental Section

1) General procedure for the synthesis of compound 3



To a solution of alcohols **1** (0.5 ml) and diarylphosphine oxide **2** (101 mg, 0.5 mmol) in water (2 mL) was added $NaIO_4$ (215 mg, 1 mmol) under air, the reaction mixture was stirred at 25 °C for 6 h. After completion of reaction, the solution of 20% $NaHCO_3$ was added into the mixture, and then the solution was extracted three times with EA (3 × 20 mL). The combined organic phase was concentrated and purified by flash chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) to afford diarylphosphinate **3**. The structures of isolated products were identified by NMR and HRMS.

2) Large-Scale Synthesis

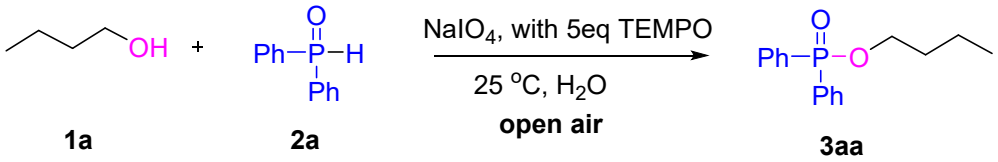


1a (5 ml) **2a (5 mmol)** **3aa, 1.07 g, 78%**

To a solution of alcohols **1a** (5 ml) and diarylphosphine oxide **2a** (1.01 g, 5 mmol)

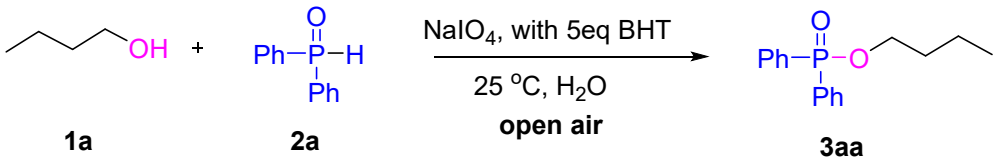
in water (20 mL) was added $NaIO_4$ (2.15 g, 10 mmol) under air, the reaction mixture was stirred at 25 °C for 6 h. After completion of reaction, the solution of 20% $NaHCO_3$ was added into the mixture, and then the solution was extracted three times with EA (3 × 50 mL). The combined organic phase was concentrated and purified by flash chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) to afford diarylphosphinate **3aa** with the yield of 78%.

3) Mechanistic Studies



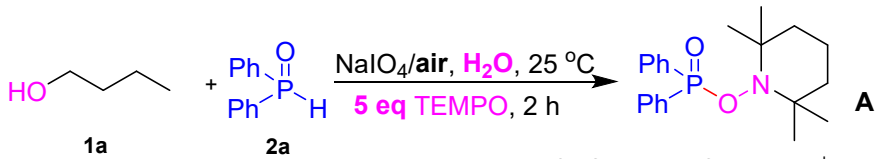
1a **2a** **3aa**

To a solution of alcohols **1a** (0.5 ml) and diarylphosphine oxide **2a** (101 mg, 0.5 mmol) and TEMPO (391 mg, 2.5 mmol) in water (2 mL) was added $NaIO_4$ (215 mg, 1 mmol) under air, the reaction mixture was stirred at 25 °C for 6 h. After completion of reaction, the solution of 20% $NaHCO_3$ was added into the mixture, and then the solution was extracted three times with EA (3 × 20 mL). The combined organic phase was concentrated and purified by flash chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) to afford diarylphosphinate **3aa** with the yield of 12%.



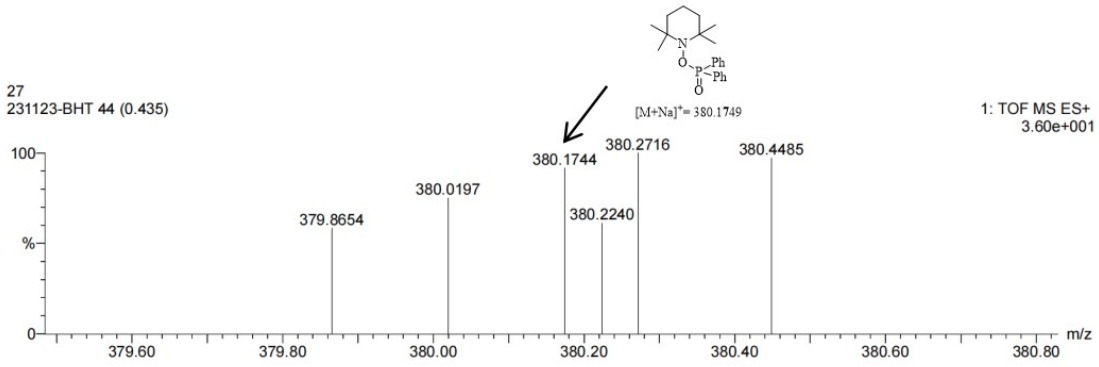
1a **2a** **3aa**

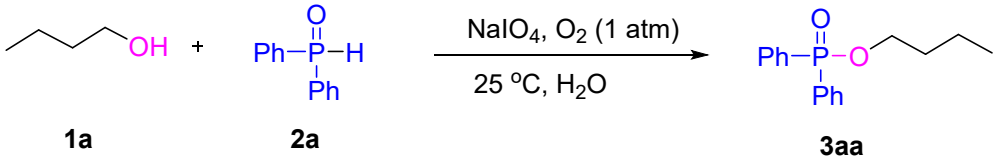
To a solution of alcohols **1a** (0.5 ml) and diarylphosphine oxide **2a** (101 mg, 0.5 mmol) and BHT (551 mg, 2.5 mmol) in water (2 mL) was added $NaIO_4$ (215 mg, 1 mmol) under air, the reaction mixture was stirred at 25 °C for 6 h. After completion of reaction, the solution of 20% $NaHCO_3$ was added into the mixture, and then the solution was extracted three times with EA (3 × 20 mL). The combined organic phase was concentrated and purified by flash chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) to afford diarylphosphinate **3aa** with the yield of 18%.



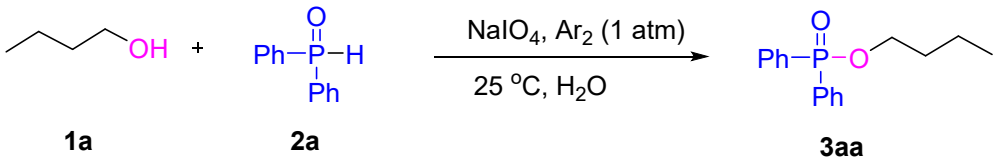
calcd for $C_{21}H_{28}NNaO_2P$ $[M+Na]^+$: 380.1749
found $[M+Na]^+$: 380.1744

To a solution of alcohols **1a** (0.5 ml) and diarylphosphine oxide **2a** (101 mg, 0.5 mmol) and TEMPO (391 mg, 2.5 mmol) in water (2 mL) was added $NaIO_4$ (215 mg, 1 mmol) under air, the reaction mixture was stirred at 25 °C for 2 h, and then analyzed by LC-HRMS to capture the intermediates. The intermediate A was found at 380.1744 of m/s, which was consistent with the molecular ion peak of $[M+Na]^+$.





To a solution of alcohols **1a** (0.5 ml) and diarylphosphine oxide **2a** (101 mg, 0.5 mmol) in water (2 mL) was added $NaIO_4$ (215 mg, 1 mmol) under O_2 atmosphere (1 atm), the reaction mixture was stirred at 25 °C for 6 h. After completion of reaction, the solution of 20% $NaHCO_3$ was added into the mixture, and then the solution was extracted three times with EA (3 × 20 mL). The combined organic phase was concentrated and purified by flash chromatography on silica gel (petroleum ether/ethyl acetate = 10:1) to afford diarylphosphinate **3aa** with the yield of 89%.

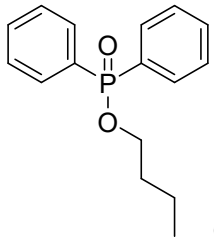


1a **2a** **3aa**

To a solution of alcohols **1a** (0.5 ml) and diarylphosphine oxide **2a** (101 mg, 0.5 mmol) in water (2 mL) was added $NaIO_4$ (215 mg, 1 mmol) under argon atmosphere (1 atm), the reaction mixture was stirred at 25 °C for 6 h. After completion of reaction, the solution of 20% $NaHCO_3$ was added into the mixture, and then the solution was extracted three times with EA (3 × 20 mL). The combined organic phase was concentrated and no product of diarylphosphinate **3aa** was found.

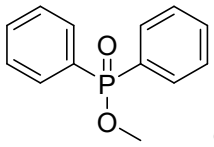
3. NMR data of products 3

Butyl Diphenylphosphinate (3aa)



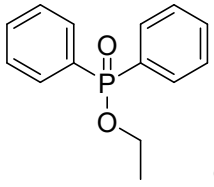
Colorless oil (116 mg, 85%): ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.80 – 7.74 (m, 4H), 7.61 – 7.56 (m, 2H), 7.55 – 7.50 (m, 4H), 3.91 (q, 6.4 Hz, 2H), 1.65 – 1.58 (m, 2H), 1.41 – 1.32 (m, 2H), 0.85 (t, J = 7.4 Hz, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 132.49 (d, J = 2.8 Hz),132.00 (d, J = 135.4 Hz), 131.44 (d, J = 10.1 Hz),129.03 (d, J = 13.0 Hz), 64.36 (d, J = 6.0 Hz), 32.21 (d, J = 6.4 Hz), 18.56, 13.64; ^{31}P NMR (243 MHz, DMSO-d_6) δ 30.29. HRMS (ESI) calcd for $C_{16}H_{19}O_2P$ $[M+H]^+$: 275.1195, found 275.1197.

Methyl Diphenylphosphinate (3ab)



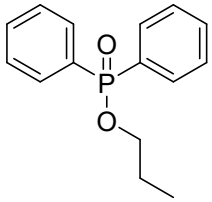
Colorless oil (103 mg, 89%): ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.79 – 7.74 (m, 4H), 7.63 – 7.59 (m, 2H), 7.56 – 7.51 (m, 4H), 3.65 (d, J = 11.2 Hz, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 132.65 (d, J = 2.8 Hz), 131.55 (d, J = 10.1 Hz), 131.44 (d, J = 135.8 Hz), 129.13 (d, J = 12.5 Hz), 51.61 (d, J = 5.9 Hz); ^{31}P NMR (243 MHz, DMSO-d_6) δ 31.66. HRMS (ESI) calcd for $C_{13}H_{13}O_2P$ $[M+H]^+$: 233.0726, found 233.0722

Ethyl Diphenylphosphinate (3ac)



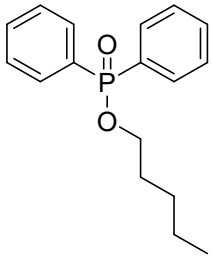
Colorless oil (103 mg, 84%): ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.80 – 7.74 (m, 4H), 7.62 – 7.57 (m, 2H), 7.55 – 7.50 (m, 4H), δ 4.02 – 3.95 (m, 2H), 1.27 (t, J = 7.0 Hz, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 132.48 (d, J = 2.8 Hz), 132.03 (d, J = 135.4 Hz), 131.45 (d, J = 9.7 Hz), 129.01 (d, J = 12.6 Hz), 60.99 (d, J = 5.8 Hz), 16.53 (d, J = 6.0 Hz); ^{31}P NMR (243 MHz, DMSO-d_6) δ 30.18. HRMS (ESI) calcd for $C_{14}H_{15}O_2P$ $[M+H]^+$: 247.0882, found 247.0881.

Propyl Diphenylphosphinate (3ad)



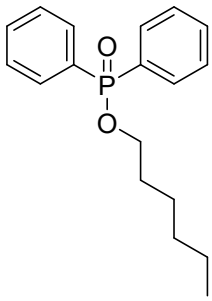
Colorless oil (114 mg, 88%): ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.80 – 7.74 (m, 4H), 7.61 – 7.56 (m, 2H), 7.55 – 7.50 (m, 4H), 3.87 (q, J = 6.7 Hz, 2H), 1.69 – 1.61 (m, 2H), 0.90 (t, J = 7.4 Hz, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 132.49 (d, J = 2.9 Hz), 132.01 (d, J = 135.3 Hz), 131.45 (d, J = 9.8 Hz), 129.03 (d, J = 12.9 Hz), 66.24 (d, J = 5.9 Hz), 23.63 (d, J = 6.5 Hz), 10.30; ^{31}P NMR (243 MHz, DMSO-d_6) δ 29.69. HRMS (ESI) calcd for $C_{15}H_{17}O_2P$ $[M+H]^+$: 261.1039, found 261.1035.

Pentyl Diphenylphosphinate (3ae)



Colorless oil (128 mg, 89%): ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.79 – 7.71 (m, 4H), 7.61 – 7.50 (m, 6H), 3.90 (q, 6.5 Hz, 4H), 1.67 – 1.60 (m, 2H), 1.36 – 1.21 (m, 2H), 0.83 (t, J = 7.1 Hz, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 133.98 (d, J = 3.1 Hz), 132.32 (d, J = 10.2 Hz), 131.76 (d, J = 137.1 Hz), 130.19 (d, J = 12.9 Hz), 66.35 (d, J = 6.4 Hz), 30.56 (d, J = 6.1 Hz), 28.29, 22.66, 14.87. ^{31}P NMR (243 MHz, DMSO-d_6) δ 31.77. HRMS (ESI) calcd for $C_{17}H_{21}O_2P$ $[M+H]^+$: 289.1352, found 289.1353.

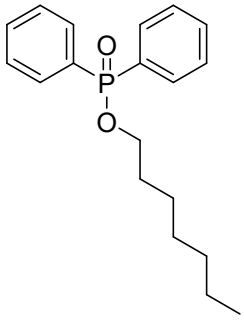
Octyl diphenylphosphinate (3af)



Colorless oil (125 mg, 83%): ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.78 – 7.73 (m, 4H), 7.61 – 7.49 (m, 6H), 3.90 (q, J = 6.7 Hz, 2H), 1.66 – 1.59 (m, 2H),

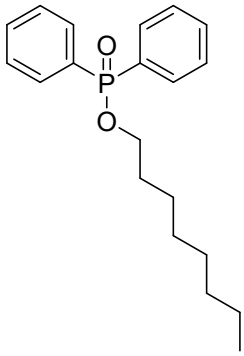
1.36 – 1.28 (m, 2H), 1.28 – 1.16 (m, 4H), 0.82 (t, J = 6.8 Hz, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 132.24 (d, J = 3.3 Hz), 131.80 (d, J = 135.1 Hz), 131.21 (d, J = 9.7 Hz), 128.78 (d, J = 12.5 Hz), 64.44 (d, J = 5.9 Hz), 30.70, 29.88 (d, J = 6.0 Hz), 24.71, 21.94, 13.83; ^{31}P NMR (243 MHz, DMSO-d_6) δ 29.45. HRMS (ESI) calcd for $C_{18}H_{23}O_2P$ [M+H]$^+$: 303.1508, found 303.1508.

Heptyl Diphenylphosphinate (3ag)



Colorless oil (122 mg, 77%): ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.78 – 7.73 (m, 4H), 7.61 – 7.49 (m, 6H), 3.90 (q, J = 6.7 Hz, 2H), 1.66 – 1.59 (m, 2H), 1.36 – 1.29 (m, 2H), 1.25 – 1.15 (m, 6H), 0.86 – 0.79 (m, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 132.71 (d, J = 2.8 Hz), 132.27 (d, J = 135.5 Hz), 131.67 (d, J = 10.1 Hz), 129.25 (d, J = 12.8 Hz), 64.90 (d, J = 5.9 Hz), 31.57, 30.38 (d, J = 6.0 Hz), 28.63, 25.48, 22.47, 14.36; ^{31}P NMR (243 MHz, DMSO-d_6) δ 29.45. HRMS (ESI) calcd for $C_{19}H_{25}O_2P$ [M+H]$^+$: 317.1665, found 317.1665.

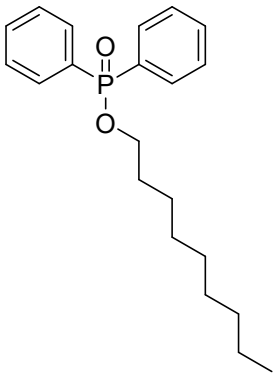
Hexyl Diphenylphosphinate (3ah)



Colorless oil (130 mg, 79%): ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.78 – 7.73 (m, 4H), 7.61 – 7.49 (m, 6H), 3.90 (q, J = 6.7 Hz, 2H), 1.66 – 1.59 (m, 2H), 1.36 – 1.28 (m, 2H), 1.25 – 1.17 (m, 8H), 0.83 (t, J = 6.8 Hz, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 132.44 (d, J = 2.4 Hz), 132.01 (d, J = 133.5 Hz), 131.41 (d, J = 9.7 Hz), 128.98 (d, J = 12.5 Hz), 64.63 (d, J = 5.9 Hz), 31.39, 30.11 (d, J = 6.4 Hz),

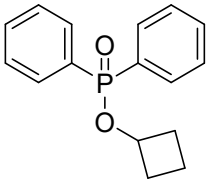
28.70 (d, J = 8.7 Hz), 25.25, 22.25, 14.12; ^{31}P NMR (243 MHz, DMSO-d_6) δ 29.44. HRMS (ESI) calcd for $C_{20}H_{27}O_2P$ [M+H]$^+$: 331.1821, found 331.1824.

Nonyl Diphenylphosphinate (3ai)



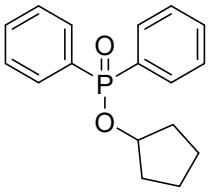
Colorless oil (133 mg, 77%): ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.78 – 7.72 (m, 4H), 7.62 – 7.57 (m, 2H), 7.54 – 7.50 (m, 4H), 3.90 (q, J = 6.7 Hz, 2H), 1.66 – 1.60 (m, 2H), 1.35 – 1.29 (m, 2H), 1.27 – 1.22 (m, 10H), 0.84 (t, J = 6.7 Hz, 3H); ^{13}C NMR (101 MHz, Chloroform-d) δ 132.27 (d, J = 2.9 Hz), 131.80 (d, J = 135.2 Hz), 131.21 (d, J = 10.1 Hz), 128.80 (d, J = 12.9 Hz), 64.45 (d, J = 5.9 Hz), 31.24, 29.89 (d, J = 6.0 Hz), 28.82, 28.54 (d, J = 12.3 Hz), 25.03, 22.09, 13.94; HRMS (ESI) calcd for $C_{21}H_{29}O_2P$ [M+H]$^+$: 345.1978, found 345.1978.

Cyclobutyl Diphenylphosphinate (3aj)



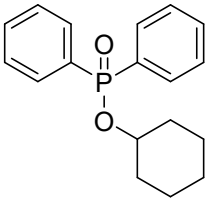
Colorless oil (71 mg, 52%): ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.78 – 7.72 (m, 4H), 7.61 – 7.56 (m, 2H), 7.55 – 7.49 (m, 4H), 4.68 – 4.58 (m, 1H), 2.21 – 2.06 (m, 4H), 1.69 – 1.60 (m, 1H), 1.48 – 1.34 (m, 1H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 132.53 (d, J = 2.9 Hz), 132.21 (d, J = 135.3 Hz), 131.46 (d, J = 9.7 Hz), 129.00 (d, J = 12.5 Hz), 68.83 (d, J = 7.3 Hz), 32.08 (d, J = 4.5 Hz), 12.61; ^{31}P NMR (243 MHz, DMSO-d_6) δ 28.93. HRMS (ESI) calcd for $C_{16}H_{17}O_2P$ [M+H]$^+$: 273.1039, found 273.1036.

Cyclopentyl Diphenylphosphinate (3ak)



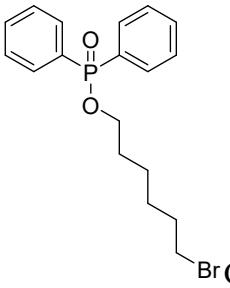
Colorless oil (83 mg, 58%): ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.78 – 7.72 (m, 4H), 7.61 – 7.56 (m, 2H), 7.54 – 7.49 (m, 4H), 4.75 – 4.69 (m, 1H), 1.86 – 1.67 (m, 6H), 1.58 – 1.48 (m, 2H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 132.57 (d, J = 135.8 Hz), 132.37 (d, J = 2.8 Hz), 131.44 (d, J = 10.1 Hz), 128.97 (d, J = 12.9 Hz), 78.48 (d, J = 6.0 Hz), 33.99 (d, J = 4.3 Hz), 22.85; ^{31}P NMR (243 MHz, DMSO-d_6) δ 28.43. HRMS (ESI) calcd for $C_{17}H_{19}O_2P$ [M+H]$^+$: 287.1195, found 287.1192.

Cyclohexyl Diphenylphosphinate (3al)



Colorless oil (84 mg, 56%): ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.79 – 7.73 (m, 4H), 7.61 – 7.56 (m, 2H), 7.54 – 7.49 (m, 4H), 4.29 – 4.21 (m, 1H), 1.83 – 1.77 (m, 2H), 1.70 – 1.62 (m, 2H), 1.58 – 1.50 (m, 2H), 1.44 – 1.37 (m, 1H), 1.28 – 1.23 (m, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 132.75 (d, J = 135.8 Hz), 132.42 (d, J = 2.8 Hz), 131.42 (d, J = 10.1 Hz), 128.99 (d, J = 12.5 Hz), 74.42 (d, J = 6.0 Hz), 33.50 (d, J = 3.9 Hz), 24.92, 23.11; ^{31}P NMR (243 MHz, DMSO-d_6) δ 28.62. HRMS (ESI) calcd for $C_{18}H_{21}O_2P$ [M+H]$^+$: 301.1352, found 301.1353.

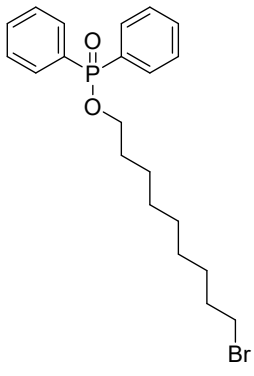
6-bromohexyl diphenylphosphinate (3am)



Colorless oil (153 mg, 81%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.84 – 7.73 (m, 4H), 7.54 – 7.47 (m, 2H), 7.46 – 7.38 (m, 4H), 4.00 (q, J = 6.5 Hz, 2H), 3.36 (t, J = 6.7 Hz, 2H), 1.87 – 1.77 (m, 2H), 1.78 – 1.67 (m, 2H), 1.46 – 1.35 (m, 4H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 132.18, 132.16, 131.67, 131.57, 130.85, 128.63, 128.50, 64.77 (d, J = 5.9 Hz), 33.76, 32.58, 30.36 (d, J = 6.6 Hz), 27.69, 24.87. ^{31}P NMR (162

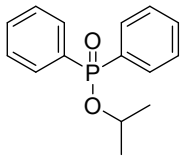
MHz, $CDCl_3$) δ 31.35. HRMS (ESI) calcd for $C_{18}H_{22}BrNaO_2P$ $[M+Na]^+$: 403.0433, found 403.0437.

6-bromohexyl diphenylphosphinate (3an)



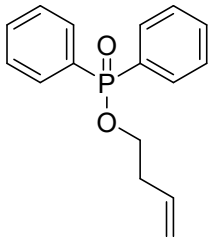
Colorless oil (136 mg, 65%): ^1H NMR (400 MHz, $CDCl_3$) δ 7.82 – 7.74 (m, 4H), 7.52 – 7.46 (m, 2H), 7.45 – 7.39 (m, 4H), 3.99 (q, *J* = 6.7 Hz, 2H), 3.37 (t, *J* = 6.8 Hz, 2H), 1.86 – 1.76 (m, 2H), 1.74 – 1.65 (m, 2H), 1.41 – 1.32 (m, 4H), 1.30 – 1.22 (m, 6H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 132.31, 132.13, 132.10, 131.68, 131.58, 130.95, 128.60, 128.46, 65.00 (d, *J* = 6.1 Hz), 34.05, 32.77, 30.51 (d, *J* = 6.7 Hz), 29.26, 29.01, 28.64, 28.10, 25.56. ^{31}P NMR (162 MHz, $CDCl_3$) δ 31.17. HRMS (ESI) calcd for $C_{21}H_{29}BrO_2P$ $[M+H]^+$: 423.1083, found 423.1086.

Isopropyl diphenylphosphinate (3ao)



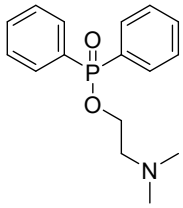
Colorless oil (58 mg, 45%): ^1H NMR (400 MHz, $CDCl_3$) δ 7.84 – 7.76 (m, 4H), 7.53 – 7.46 (m, 2H), 7.46 – 7.38 (m, 4H), 4.66 (td, *J* = 12.6, 6.2 Hz, 1H), 1.33 (d, *J* = 6.2 Hz, 6H). ^{13}C NMR (101 MHz, $cdcl_3$) δ 132.96, 132.06, 131.84, 131.65, 131.55, 128.38, 128.23, 70.25 (dd, *J* = 11.9, 6.1 Hz), 24.31 (dd, *J* = 14.2, 4.3 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ 29.88. HRMS (ESI) calcd for $C_{15}H_{18}O_2P$ $[M+H]^+$: 261.1039, found 261.1036.

But-3-en-1-yl Diphenylphosphinate (3ap)



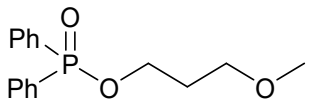
Colorless oil (34 mg, 25%): ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.79 – 7.73 (m, 4H), 7.62 – 7.57 (m, 2H), 7.56 – 7.50 (m, 4H), 5.87 – 5.77 (m, 1H), 5.16 – 5.15 (m, 1H), 5.12 – 5.06 (m, 1H), 4.00 – 3.94 (m, 2H), 2.44 – 2.39 (m, 2H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 134.53, 132.53 (d, J = 2.5 Hz), 131.85 (d, J = 134.0 Hz), 131.45 (d, J = 10.1 Hz), 129.03 (d, J = 12.9 Hz), 117.70, 63.79 (d, J = 5.8 Hz)；^{31}P NMR (243 MHz, DMSO-d_6) δ 30.06. HRMS (ESI) calcd for $C_{16}H_{17}O_2P$ $[M+H]^+$: 273.1039, found 273.1031.

2-(dimethylamino)ethyl diphenylphosphinate (3aq)



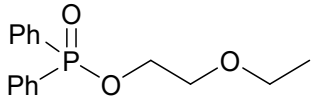
Colorless oil (49 mg, 34%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86 – 7.78 (m, 4H), 7.54 – 7.48 (m, 2H), 7.48 – 7.40 (m, 4H), 4.15 – 4.07 (m, 2H), 2.68 (t, J = 5.9 Hz, 2H), 2.27 (s, 6H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 132.22, 132.10, 131.71, 131.60, 128.68 (d, J = 13.1 Hz), 128.41 (d, J = 13.4 Hz), 62.57, 59.08, 45.62. ^{31}P NMR (162 MHz, $CDCl_3$) δ 32.34. HRMS (ESI) calcd for $C_{16}H_{21}NO_2P$ $[M+H]^+$: 290.1304, found 290.1301.

3-methoxypropyl diphenylphosphinate (3ar)



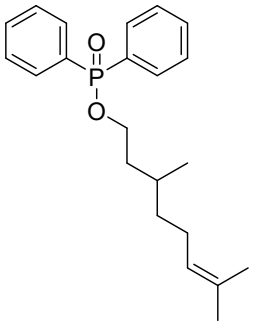
Colorless oil (96 mg, 66%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.82 – 7.73 (m, 1H), 7.52 – 7.45 (m, 1H), 7.45 – 7.38 (m, 1H), 4.09 (q, J = 6.4 Hz, 1H), 3.48 (t, J = 6.1 Hz, 1H), 3.28 (s, 1H), 1.96 (p, J = 6.2 Hz, 1H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 132.33, 132.07, 131.91, 131.63, 131.53, 130.55, 128.69 (d, J = 12.4 Hz), 128.41 (d, J = 13.5 Hz), 68.64, 62.16 (d, J = 5.9 Hz), 58.65 (d, J = 18.1 Hz), 30.75 (d, J = 6.6 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ 31.72. HRMS (ESI) calcd for $C_{16}H_{20}O_3P$ $[M+H]^+$: 291.1145, found 291.1142.

2-ethoxyethyl diphenylphosphinate (3av)



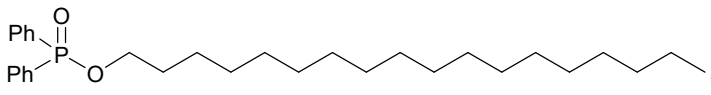
Colorless oil (106 mg, 73%): ^{1}H NMR (400 MHz, cdcl$_3$) δ 7.88 – 7.77 (m, 4H), 7.54 – 7.47 (m, 2H), 7.46 – 7.38 (m, 4H), 4.20 – 4.12 (m, 2H), 3.67 (t, *J* = 4.8 Hz, 2H), 3.48 (q, *J* = 7.0 Hz, 2H), 1.17 (t, *J* = 7.0 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 132.35, 132.11, 131.76, 131.64, 130.45, 128.45, 128.31, 69.58 (d, *J* = 6.7 Hz), 66.57, 64.06 (d, *J* = 6.0 Hz), 15.12 (d, *J* = 13.5 Hz). ^{31}P NMR (162 MHz, $CDCl_3$) δ 32.60. HRMS (ESI) calcd for $C_{16}H_{20}O_3P$ $[M+H]^+$: 291.1145, found 291.1141.

3,7-dimethyloct-6-en-1-yl diphenylphosphinate (3aw)



Colorless oil (94 mg, 53%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.83 – 7.75 (m, 4H), 7.53 – 7.47 (m, 2H), 7.46 – 7.39 (m, 4H), 5.04 (t, *J* = 7.0 Hz, 1H), 4.11 – 3.99 (m, 2H), 2.00 – 1.87 (m, 2H), 1.80 – 1.71 (m, 1H), 1.65 (s, 3H), 1.63 – 1.58 (m, 1H), 1.56 (s, 3H), 1.53 – 1.44 (m, 1H), 1.29 – 1.25 (m, 1H), 1.19 – 1.09 (m, 1H), 0.86 (d, *J* = 6.6 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 132.24, 132.13, 132.11, 131.68, 131.58, 131.33, 130.88, 128.59, 128.46, 124.54, 63.40 (d, *J* = 6.0 Hz), 37.42 (d, *J* = 6.6 Hz), 36.90, 29.06, 25.72, 25.33, 19.33, 17.66. ^{31}P NMR (162 MHz, $CDCl_3$) δ 31.31. HRMS (ESI) calcd for $C_{22}H_{30}O_2P$ $[M+H]^+$: 357.1978, found 357.1982.

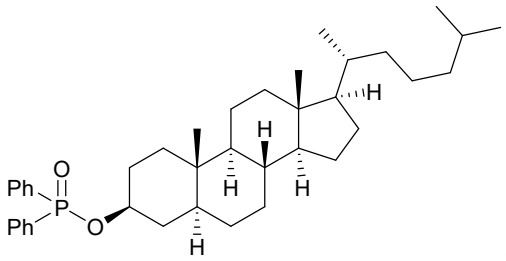
Octadecyl diphenylphosphinate (3ay)



Colorless oil (190 mg, 81%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86 – 7.75 (m, 4H), 7.55 – 7.47 (m, 2H), 7.47 – 7.40 (m, 4H), 4.01 (q, *J* = 6.4 Hz, 2H), 1.76 – 1.61 (m, 3H), 1.43 – 1.16 (m, 28H), 0.86 (t, *J* = 6.4 Hz, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 132.40, 132.07 (d, *J* = 2.7 Hz), 131.70, 131.60, 131.04, 128.57, 128.44, 65.06 (d, *J* = 6.0 Hz), 31.94, 30.59, 30.53,

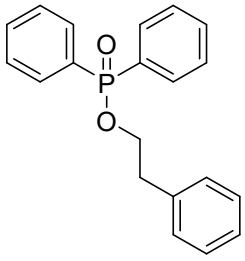
29.71, 29.58, 29.51, 29.37, 29.16, 25.63, 22.70, 14.13. ^{31}P NMR (162 MHz, $CDCl_3$) δ 31.15. HRMS (ESI) calcd for $C_{30}H_{48}O_2P$ $[M+H]^+$: 471.3386, found 471.3389.

(3S,5S,8R,9S,10S,13R,14S,17R)-10,13-dimethyl-17-((R)-6-methylheptan-2-yl)hexadecahydro-1H-cyclopenta[a]phenanthren-3-yl diphenylphosphin- ate (3az)



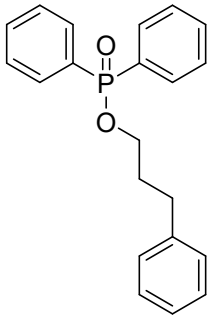
Colorless oil (94 mg, 53%): ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.86 – 7.74 (m, 4H), 7.52 – 7.46 (m, 2H), 7.46 – 7.37 (m, 4H), 4.37 – 4.24 (m, 1H), 1.95 – 1.38 (m, 14H), 1.35 – 1.16 (m, 11H), 1.13 – 0.92 (m, 9H), 0.84 (d, J = 6.6 Hz, 6H), 0.80 (s, 3H), 0.61 (s, 3H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 133.23, 131.93 (d, J = 1.9 Hz), 131.86, 131.71, 131.65, 131.61, 131.55, 128.48, 128.35, 76.19 (d, J = 6.4 Hz), 56.39, 56.25, 54.15, 44.71, 42.58, 39.96, 39.52, 36.85, 36.62, 36.16, 35.79, 35.44, 35.28, 31.95, 30.09 (d, J = 3.7 Hz), 29.72, 28.50, 28.23, 28.01, 24.19, 23.83, 22.82, 22.57, 21.19, 18.66, 12.27, 12.06. ^{31}P NMR (162 MHz, $CDCl_3$) δ 29.95. HRMS (ESI) calcd for $C_{39}H_{57}NaO_2P$ $[M+Na]^+$: 611.3988, found 611.3992.

Phenethyl Diphenylphosphinate (3bc)



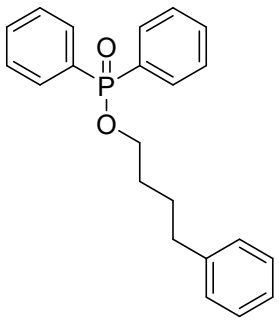
Colorless oil (81 mg, 50%): ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.67 – 7.61 (m, 4H), 7.60 – 7.54 (m, 2H), 7.50 – 7.45 (m, 4H), 7.33 – 7.29 (m, 2H), 7.26 – 7.22 (m, 3H), 4.10 (q, J = 6.6 Hz, 2H), 2.97 (t, J = 6.5 Hz, 2H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 138.06, 132.55 (d, J = 2.9 Hz), 131.74 (d, J = 135.5 Hz), 131.42 (d, J = 9.9 Hz), 129.30, 129.02 ,128.70(d, J = 4.9 Hz), 126.73, 65.40 (d, J = 5.9 Hz), 36.43 (d, J = 6.7 Hz); ^{31}P NMR (243 MHz, DMSO-d_6) δ 29.96. HRMS (ESI) calcd for $C_{20}H_{19}O_2P$ $[M+H]^+$: 323.1195, found 323.1197.

3-phenylpropyl Diphenylphosphinate (3bd)



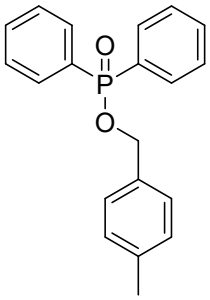
Colorless oil (82 mg, 49%): ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.81 – 7.74 (m, 4H), 7.62 – 7.57 (m, 2H), 7.55 – 7.49 (m, 4H), 7.28 – 7.23 (m, 2H), 7.21 – 7.14 (m, 2H), 3.94 – 3.89 (m, 2H), 2.68 (t, J = 8.5 Hz, 2H), 2.00 – 1.92 (m, 2H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 141.29, 131.92 (d, J = 135.6 Hz), 132.52 , 131.44, 129.05 (d, J = 12.9 Hz), 128.56, 128.32, 126.10, 125.94, 64.06 (d, J = 5.9 Hz), 31.85 (d, J = 6.4 Hz), 31.38; ^{31}P NMR (243 MHz, DMSO-d_6) δ 29.86. HRMS (ESI) calcd for $C_{21}H_{21}O_2P$ $[M+H]^+$: 337.1352, found 337.1354.

4-phenylbutyl Diphenylphosphinate (3be)



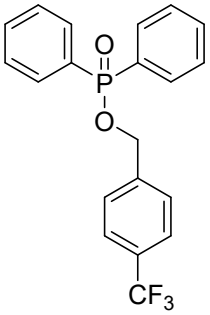
Colorless oil (138 mg, 79%): ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.78 – 7.73 (m, 4H), 7.60 – 7.47 (m, 6H), 7.27 – 7.23 (m, 2H), 7.17 – 7.14 (m, 2H), 3.96 – 3.91 (m, 2H), 2.57 – 2.53 (m, 2H), 1.67 – 1.62 (m, 4H);^{13}C NMR (101 MHz, DMSO-d_6) δ 141.84, 132.25 (d, J = 2.9 Hz), 131.78 (d, J = 135.2 Hz), 131.26, 131.16, 128.79 (d, J = 12.9 Hz), 128.28, 128.25, 125.70, 64.28 (d, J = 6.2 Hz), 34.53, 29.53 (d, J = 6.4 Hz), 26.95; ^{31}P NMR (243 MHz, DMSO-d_6) δ 29.54. HRMS (ESI) calcd for $C_{21}H_{21}O_2P$ $[M+H]^+$: 337.1352, found 337.1353.

4-methylbenzyl diphenylphosphinate (3bf)



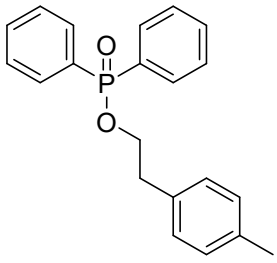
Colorless oil (92 mg, 57%): ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.81 – 7.75 (m, 4H), 7.62 – 7.58 (m, 2H), 7.56 – 7.50 (m, 4H), 7.29 (d, J = 8.20 Hz, 2H), 7.18 (d, J = 7.8 Hz, 2H), 4.94 (d, J = 7.5 Hz, 2H), 2.29 (s, 1H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 137.69, 133.59 (d, J = 6.1 Hz), 132.58 (d, J = 2.8 Hz), 131.55 (d, J = 135.1 Hz), 131.40 (d, J = 10.2 Hz), 129.17, 129.03 (d, J = 13.0 Hz), 128.02, 65.83 (d, J = 5.7 Hz), 20.89; ^{31}P NMR (243 MHz, DMSO-d_6) δ 30.52. HRMS (ESI) calcd for $C_{20}H_{18}O_2P$ $[M+H]^+$: 322.1123, found 322.1124.

4-(Trifluoromethyl)benzyl Diphenylphosphinate (3bg)



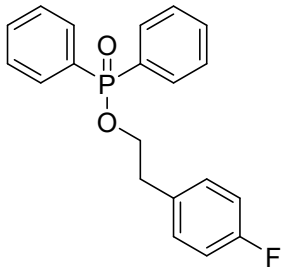
Colorless oil (111 mg, 59%): ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.86 – 7.80 (m, 4H), 7.74 – 7.72 (m, 2H), 7.66 – 7.58 (m, 4H), 7.56 – 7.51 (m, 4H), 5.12 (d, J = 7.9 Hz, 2H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 141.60 (d, J = 6.5 Hz), 132.74 (d, J = 2.9 Hz), 131.53 (d, J = 10.1 Hz), 131.47 (d, J = 135.3 Hz), 129.13 (d, J = 13.0 Hz), 128.27, 125.55 (q, J = 3.9 Hz), 123.05, 65.07 (d, J = 5.2 Hz); ^{31}P NMR (243 MHz, DMSO-d_6) δ 31.66. HRMS (ESI) calcd for $C_{20}H_{16}F_3O_2P$ $[M+H]^+$: 377.0913, found 377.0912.

4-methylphenethyl Diphenylphosphinate (3bh)



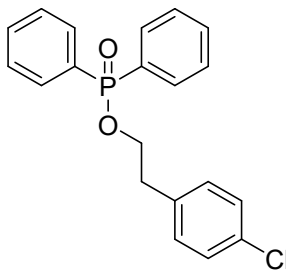
Colorless oil (84 mg, 50%): ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.66 – 7.55 (m, 6H), 7.50 – 7.45 (m, 4H), 7.13 – 7.09 (m, 4H), 4.06 (q, J = 6.6 Hz, 2H), 2.92 (t, J = 6.6 Hz, 2H), 2.27 (s, 3H);^{13}C NMR (101 MHz, DMSO-d_6) δ 135.53, 134.69, 132.35 (d, J = 2.7 Hz), 131.54 (d, J = 135.2 Hz), 131.23 (d, J = 10.1 Hz), 128.98, 128.96, 128.83 (d, J = 13.0 Hz), 65.32 (d, J = 5.9 Hz), 35.84 (d, J = 6.7 Hz), 31.17; ^{31}P NMR (243 MHz, DMSO-d_6) δ 30.62. HRMS (ESI) calcd for $C_{21}H_{21}O_2P$ $[M+H]^+$: 337.1351, found 337.1351.

4-fluorophenethyl Diphenylphosphinate (3bi)



Colorless oil (80 mg, 47%): ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.68 – 7.62 (m, 4H), 7.58 – 7.54 (m, 2H), 7.50 – 7.45 (m, 4H), 7.30 – 7.24 (m, 2H), 7.14 – 7.08 (m, 2H), 4.09 (q, J = 6.5 Hz, 2H), 2.96 (t, J = 6.4 Hz, 2H);^{13}C NMR (101 MHz, DMSO-d_6) δ 161.14 (d, J = 242.0 Hz), 134.04 (d, J = 3.3 Hz), 132.35 (d, J = 2.8 Hz), 131.50 (d, J = 135.2 Hz), 131.21 (d, J = 10.1 Hz), 130.91 (d, J = 8.0 Hz), 128.82 (d, J = 12.9 Hz), 115.07 (d, J = 21.1 Hz), 65.15 (d, J = 5.9 Hz), 35.34 (d, J = 7.0 Hz); ^{31}P NMR (243 MHz, DMSO-d_6) δ 30.31; HRMS (ESI) calcd for $C_{20}H_{18}FO_2P$ $[M+H]^+$: 341.1101, found 341.1104.

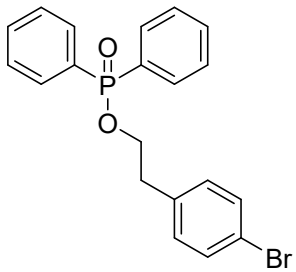
4-chlorophenethyl Diphenylphosphinate (3bj)



Colorless oil (93 mg, 52%): ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.81 – 7.75 (m, 4H), 7.62 – 7.50 (m, 6H), 7.31 – 7.28 (m, 2H), 7.19 – 7.17 (m, 2H),

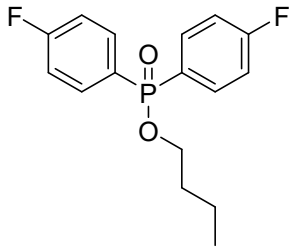
4.94 (d, J = 7.5 Hz, 2H), 2.29 (s, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 136.97, 132.31, 132.30 (d, J = 2.5 Hz), 131.47 (d, J = 135.3 Hz), 131.17 (d, J = 9.8 Hz), 130.93, 128.77 (d, J = 12.6 Hz), 128.27,64.91 (d, J = 5.8 Hz), 35.44 (d, J = 6.7 Hz); ^{31}P NMR (243 MHz, DMSO-d_6) δ 30.63. HRMS (ESI) calcd for $C_{20}H_{18}ClO_2P$ $[M+H]^+$: 357.0806, found 357.0808.

4-bromophenethyl Diphenylphosphinate (3bk)



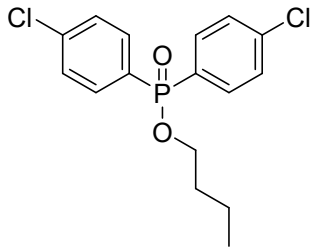
Colorless oil (122 mg, 61%): ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.65 – 7.55 (m, 6H), 7.50 – 7.45 (m, 6H), 7.24 – 7.20 (m, 2H), 4.10 (q, J = 6.4 Hz, 2H), 2.95 (t, J = 6.3 Hz, 2H);^{13}C NMR (101 MHz, DMSO-d_6) δ 137.49, 132.38 (d, J = 2.8 Hz), 131.45 (d, J = 135.3 Hz), 131.40, 131.20 (d, J = 10.2 Hz), 130.78, 128.84 (d, J = 13.0 Hz), 119.67, 64.91 (d, J = 6.0 Hz), 35.51 (d, J = 6.7 Hz); ^{31}P NMR (243 MHz, DMSO-d_6) δ 30.63. HRMS (ESI) calcd for $C_{20}H_{18}BrO_2P$ $[M+H]^+$: 401.0301, found 401.0304.

Butyl bis(4-fluorophenyl)phosphinate (3ca)



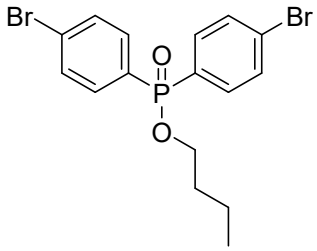
Colorless oil (116 mg, 75%):^{1}H NMR (400 MHz, DMSO-d_6) δ 7.86 – 7.78 (m, 4H), 7.40 – 7.33 (m, 4H), 3.91 (q, J = 7.4, 6.3 Hz, 2H), 1.64 – 1.57 (m, 2H), 1.40 – 1.28 (m, 2H), 0.83 (t, J = 7.4 Hz, 3H);^{13}C NMR (101 MHz, DMSO-d_6) δ 164.59 (dd, J = 251.0, 3.4 Hz), 134.24 (dd, J = 11.5, 8.9 Hz), 127.95 (dd, J = 139.9, 3.3 Hz), 116.20 (dd, J = 21.6, 13.9 Hz), 64.45 (d, J = 5.9 Hz), 31.98 (d, J = 6.3 Hz), 18.35, 13.42; ^{31}P NMR (243 MHz, DMSO-d_6) δ 28.79; HRMS (ESI) calcd for $C_{16}H_{17}F_2O_2P$ $[M+H]^+$: 311.1007, found 311.1006.

Butyl bis(4-chlorophenyl)phosphinate (3cb)



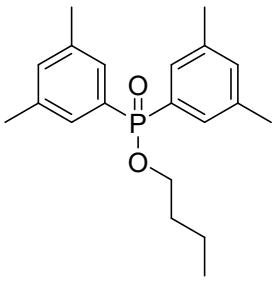
Colorless oil (130 mg, 76%): ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.79 – 7.73 (m, 4H), 7.62 – 7.58 (m, 4H), 3.92 (q, J = 7.5, 6.4 Hz, 2H), 1.65 – 1.58 (m, 2H), 1.40 – 1.31 (m, 2H), 0.84 (t, J = 7.4 Hz, 3H);^{13}C NMR (101 MHz, DMSO-d_6) δ 137.75 (d, J = 3.6 Hz), 133.24 (d, J = 11.0 Hz), 130.22 (d, J = 138.1 Hz), 129.15 (d, J = 13.6 Hz), 64.68 (d, J = 6.1 Hz), 31.96 (d, J = 6.4 Hz), 18.33, 13.44; ^{31}P NMR (243 MHz, DMSO-d_6) δ 28.29. HRMS (ESI) calcd for $C_{16}H_{17}Cl_2O_2P$ $[M+H]^+$: 343.0416, found 343.0417.

Butyl bis(4-bromophenyl)phosphinate (3cc)



Colorless oil (159 mg, 74%): ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.75 – 7.73 (m, 4H), 7.70 – 7.65 (m, 4H), 3.92 (q, J = 6.7 Hz, 2H), 1.64 – 1.57 (m, 2H), 1.39 – 1.30 (m, 2H), 0.83 (t, J = 7.4 Hz, 3H);^{13}C NMR (101 MHz, DMSO-d_6) δ 133.29 (d, J = 10.9 Hz), 132.05 (d, J = 13.1 Hz), 130.55 (d, J = 138.0 Hz), 126.80 (d, J = 3.6 Hz), 64.67 (d, J = 5.9 Hz), 31.96 (d, J = 6.3 Hz), 18.32, 13.43;^{31}P NMR (243 MHz, DMSO-d_6) δ 28.60. HRMS (ESI) calcd for $C_{16}H_{17}Br_2O_2P$ $[M+H]^+$: 430.9406, found 430.9408.

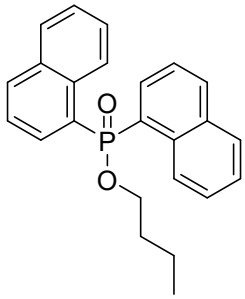
Butyl bis(3,5-dimethylphenyl)phosphinate (3cd)



Colorless oil (122 mg, 74%): ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.81 – 7.76 (m, 2H), 7.52 – 7.47 (m, 2H), 7.40 – 7.34 (m, 2H), 7.29 – 7.26 (m, 2H), 3.90 (q, J = 6.5 Hz, 2H), 2.25 (t, J = 1.4 Hz, 1H), 1.67 – 1.60 (m, 2H), 1.42 – 1.27 (m,

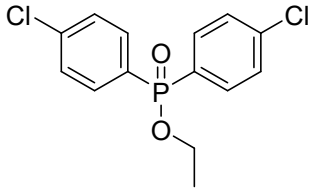
2H), 0.86 (t, J = 7.4 Hz, 3H)^{13}C NMR (101 MHz, DMSO-d_6) δ 140.83 (d, J = 10.9 Hz), 132.89 (d, J = 9.6 Hz), 131.51 (d, J = 12.3 Hz), 130.08 (d, J = 131.3 Hz), 125.85 (d, J = 12.3 Hz), 63.73 (d, J = 5.8 Hz), 32.04 (d, J = 6.5 Hz), 20.58 (d, J = 3.8 Hz), 18.53, 13.49; ^{31}P NMR (243 MHz, DMSO-d_6) δ 30.80. HRMS (ESI) calcd for $C_{20}H_{27}O_2P$ [M+H]$^+$: 331.1821, found 331.1824.

Butyl di(naphthalen-1-yl)phosphinate (3ce)



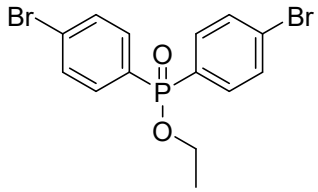
Colorless oil (139 mg, 74%): ^{1}H NMR (600 MHz, DMSO-d_6) δ 8.52 (d, J = 13.9 Hz, 2H), 8.09 (d, J = 8.1 Hz, 2H), 8.03 (dd, J = 8.4, 3.2 Hz, 2H), 7.94 (d, J = 8.0 Hz, 2H), 7.83 – 7.79 (m, 2H), 7.62 – 7.57 (m, 5H), 4.00 (q, J = 6.7 Hz, 2H), 1.68 – 1.63 (m, 2H), 1.42 – 1.33 (m,2H), 0.82 (t, J = 7.4 Hz, 3H); ^{13}C NMR (101 MHz, DMSO-d6) δ 134.46 (d, J = 2.4 Hz), 133.21 (d, J = 9.9 Hz), 132.15 (d, J = 14.6 Hz), 129.74, 129.05, 128.63 (d, J = 3.0 Hz), 128.38, 128.02 (d, J = 150.9 Hz), 127.88, 126.33 (d, J = 10.7 Hz), 64.61 (d, J = 5.9 Hz), 32.17 (d, J = 5.9 Hz), 18.47, 13.56; ^{31}P NMR (243 MHz, DMSO-d_6) δ 29.66. HRMS (ESI) calcd for $C_{24}H_{23}O_2P$ [M+H]$^+$: 375.1508, found 375.1504.

Ethyl bis(4-chlorophenyl)phosphinate (3cf)



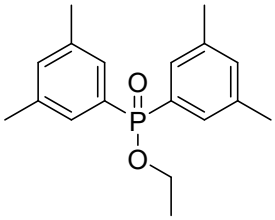
Colorless oil (113 mg, 72%): ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.80 – 7.73 (m, 4H), 7.63 – 7.58 (m, 4H), 4.03 – 3.96 (m, 2H), 1.27 (t, J = 7.0 Hz, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 137.90 (d, J = 3.5 Hz), 133.43 (d, J = 11.3 Hz), 130.46 (d, J = 138.1 Hz), 129.31 (d, J = 13.3 Hz), 61.49 (d, J = 5.8 Hz), 16.49 (d, J = 6.3 Hz); ^{31}P NMR (243 MHz, DMSO-d_6) δ 28.03. HRMS (ESI) calcd for $C_{14}H_{13}Cl_2O_2P$ [M+H]$^+$: 315.0103, found 315.0106.

Ethyl bis(4-bromophenyl)phosphinate (3cg)



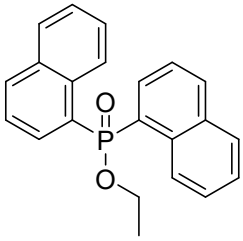
Colorless oil (140 mg, 70%): ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.77 – 7.72 (m, 4H), 7.72 – 7.66 (m, 4H), 4.04 – 3.97 (m, 2H), 1.27 (t, J = 7.0 Hz, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 133.49 (d, J = 10.9 Hz), 132.22 (d, J = 13.6 Hz), 130.80 (d, J = 137.5 Hz), 126.96 (d, J = 3.6 Hz), 61.49 (d, J = 5.8 Hz), 16.49 (d, J = 6.0 Hz); ^{31}P NMR (243 MHz, DMSO-d_6) δ 28.35. HRMS (ESI) calcd for $C_{14}H_{13}Br_2O_2P$ $[M+H]^+$: 402.9093, found 402.9095.

Ethyl bis(3,5-dimethylphenyl)phosphinate (3ch)



Colorless oil (107 mg, 71%): ^{1}H NMR (400 MHz, DMSO-d_6) δ 7.39 – 7.33 (m, 4H), 7.20 (s, 2H), 3.98 – 3.91 (m, 2H), 2.29 (s, 12H), 1.27 (t, J = 7.0 Hz, 3H); ^{13}C NMR (101 MHz, DMSO-d_6) δ 138.23 (d, J = 13.2 Hz), 133.80 (d, J = 3.2 Hz), 132.07 (d, J = 133.8 Hz), 128.91 (d, J = 9.6 Hz), 60.76 (d, J = 5.8 Hz), 21.01, 16.60 (d, J = 6.3 Hz); ^{31}P NMR (243 MHz, DMSO-d_6) δ 30.56. HRMS (ESI) calcd for $C_{18}H_{23}O_2P$ $[M+H]^+$: 303.1508, found 303.1507.

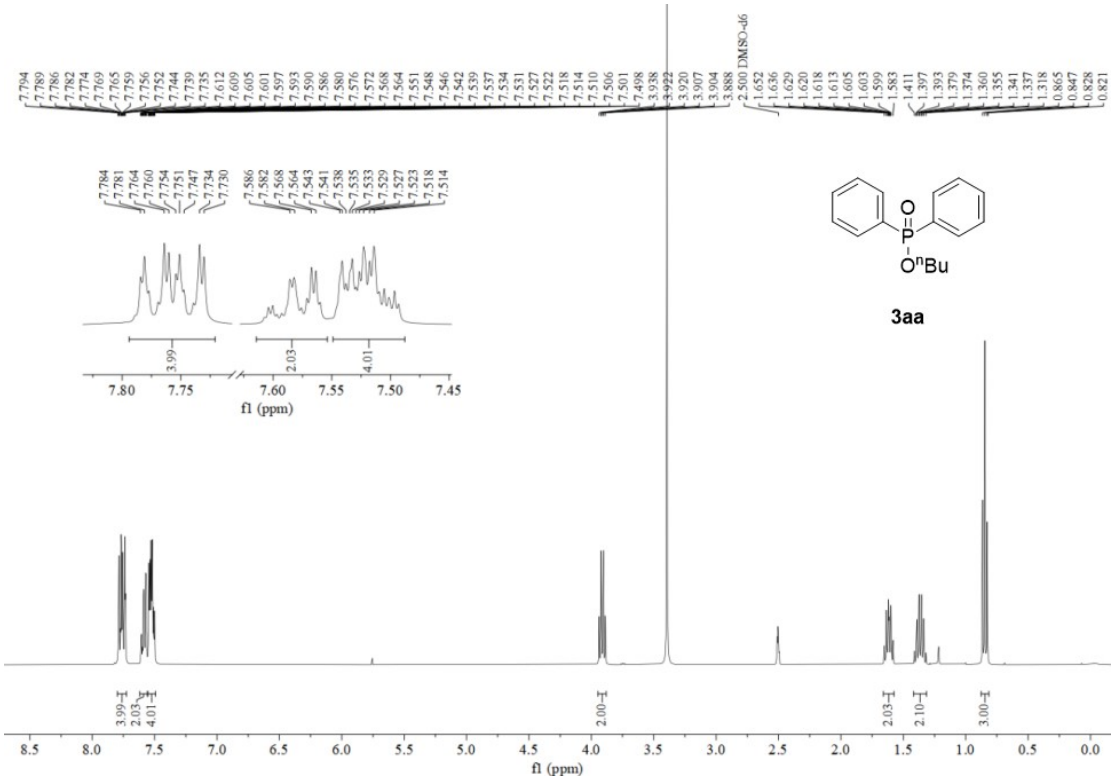
Ethyl di(naphthalen-1-yl)phosphinate (3ci)

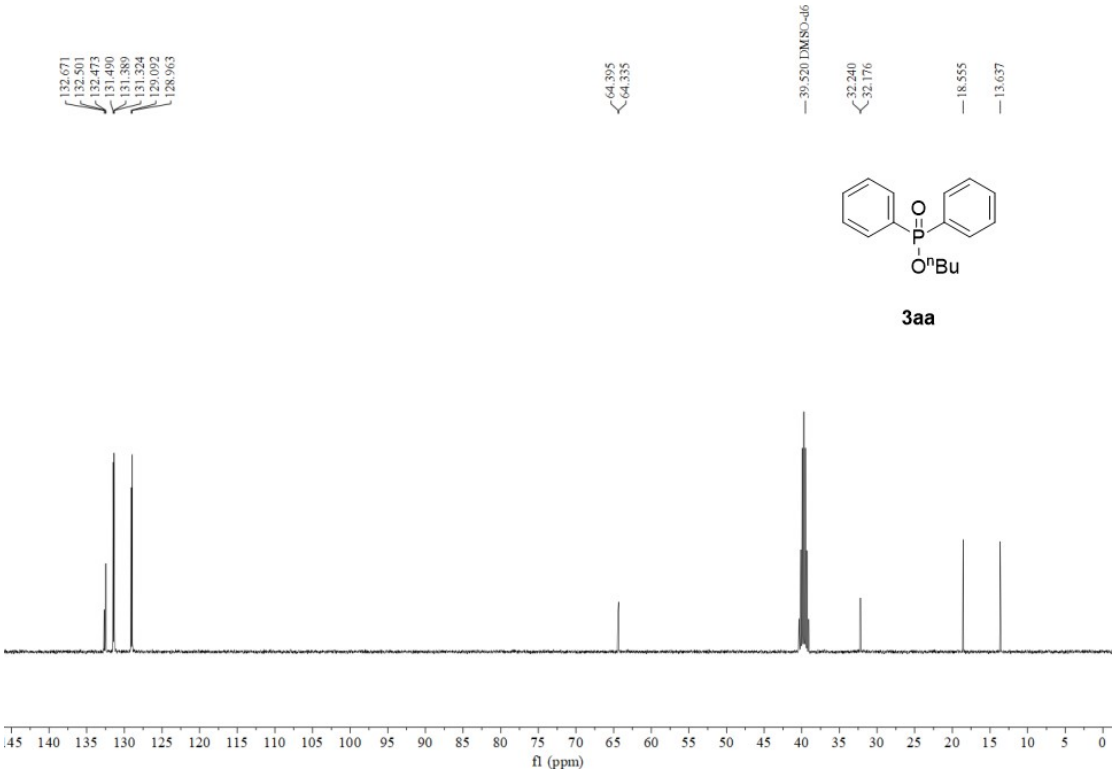


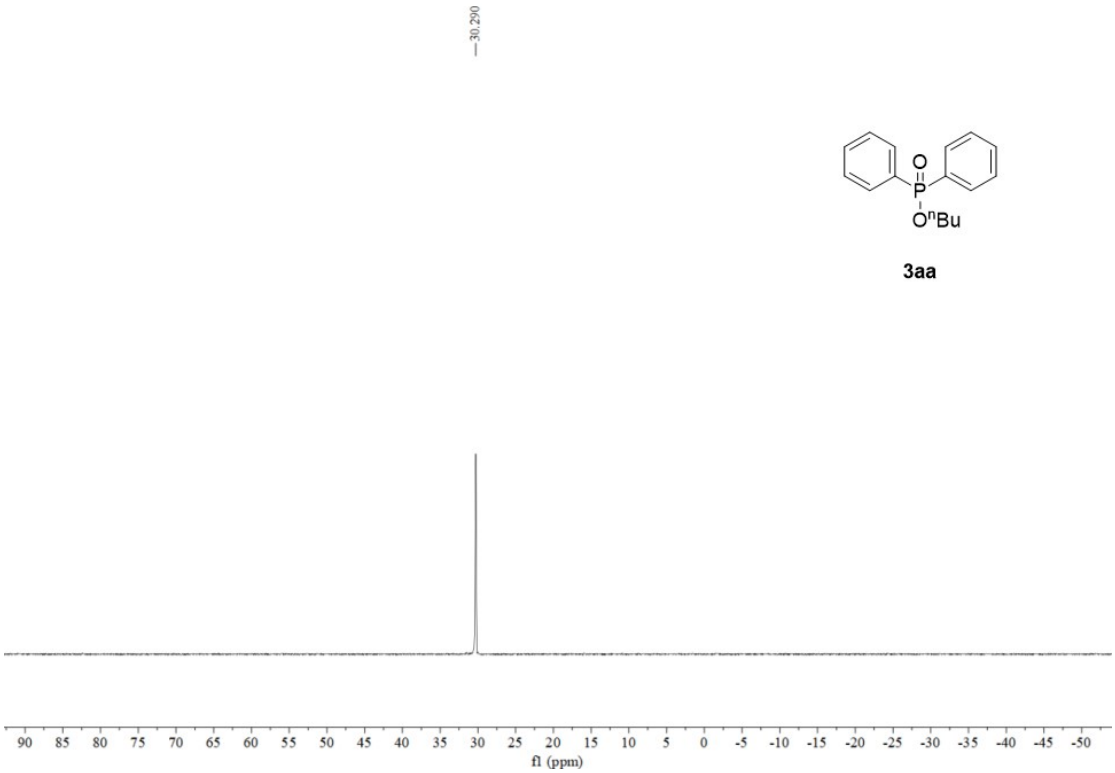
Colorless oil (118 mg, 68%): ^{1}H NMR (600 MHz, DMSO-d_6) δ 8.52 (d, J = 13.9 Hz, 2H), 8.09 (d, J = 8.1 Hz, 2H), 8.03 (dd, J = 8.4, 3.2 Hz, 2H), 7.94 (d, J = 8.0 Hz, 2H), 7.83 – 7.79 (m, 2H), 7.62 – 7.57 (m, 5H), 4.00 (q, J = 6.7 Hz, 2H), 1.68 – 1.63 (m, 2H), 1.42 – 1.33 (m,2H), 0.82 (t, J = 7.4 Hz,3H);^{13}C NMR (101 MHz, DMSO-d6) δ 133.68 (d, J = 3.3 Hz), 133.56, 133.43 (d, J = 10.4 Hz), 132.27 (d, J = 10.5 Hz), 129.24, 127.99 (d, J = 132.0 Hz), 127.53, 126.63, 125.95 (d, J = 4.9 Hz), 125.18 (d, J = 14.5 Hz), 61.32 (d, J = 5.8 Hz), 16.43 (d, J = 6.4 Hz);^{31}P NMR (243

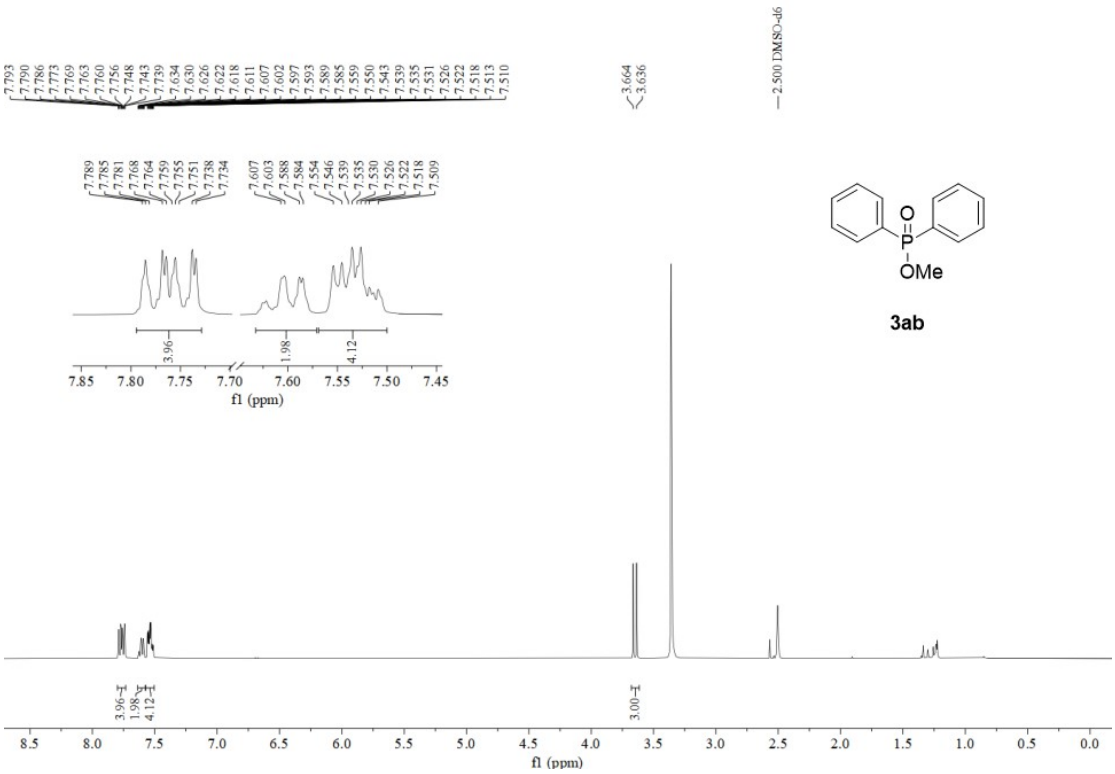
MHz, DMSO-d_6) δ 31.46. HRMS (ESI) calcd for $C_{22}H_{19}O_2P$ $[M+H]^+$: 347.1195, found 347.1198.

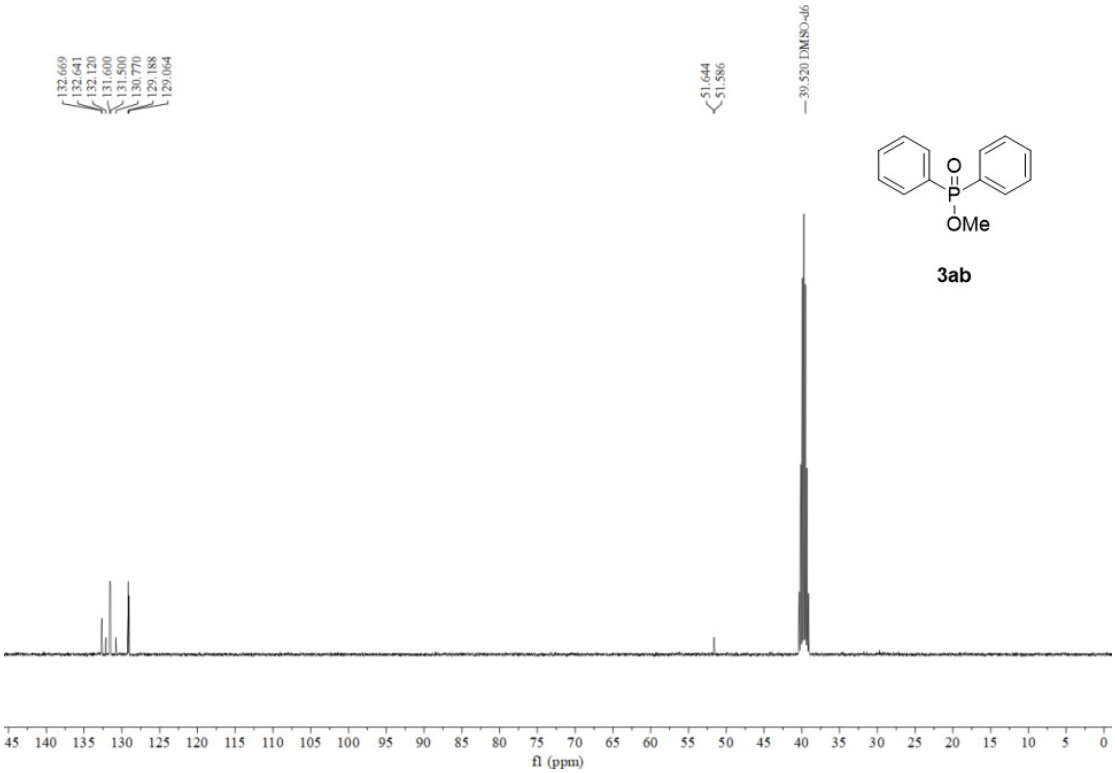
4. NMR Spectra for Products

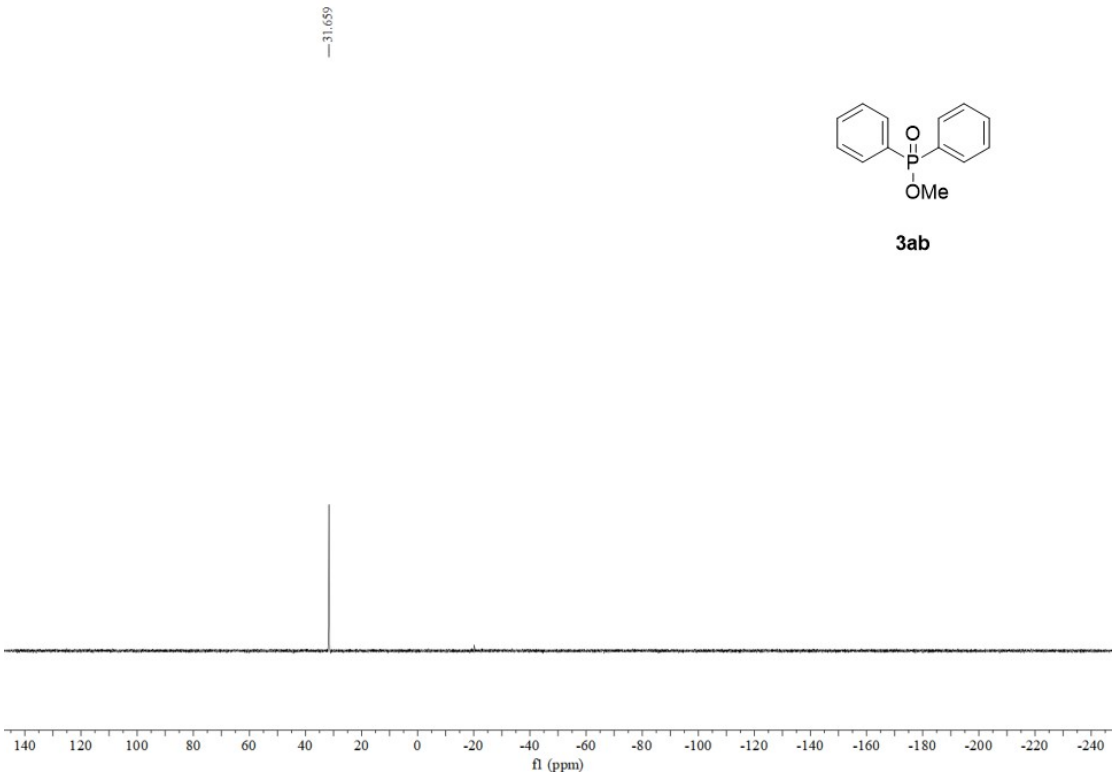


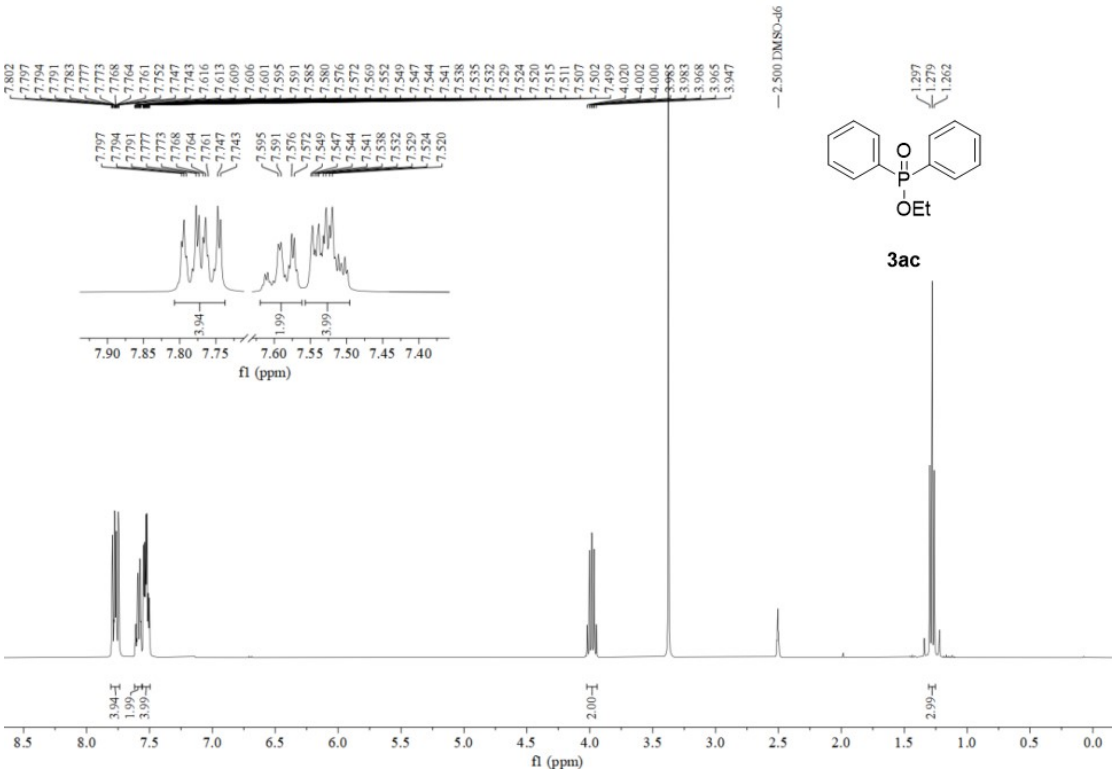


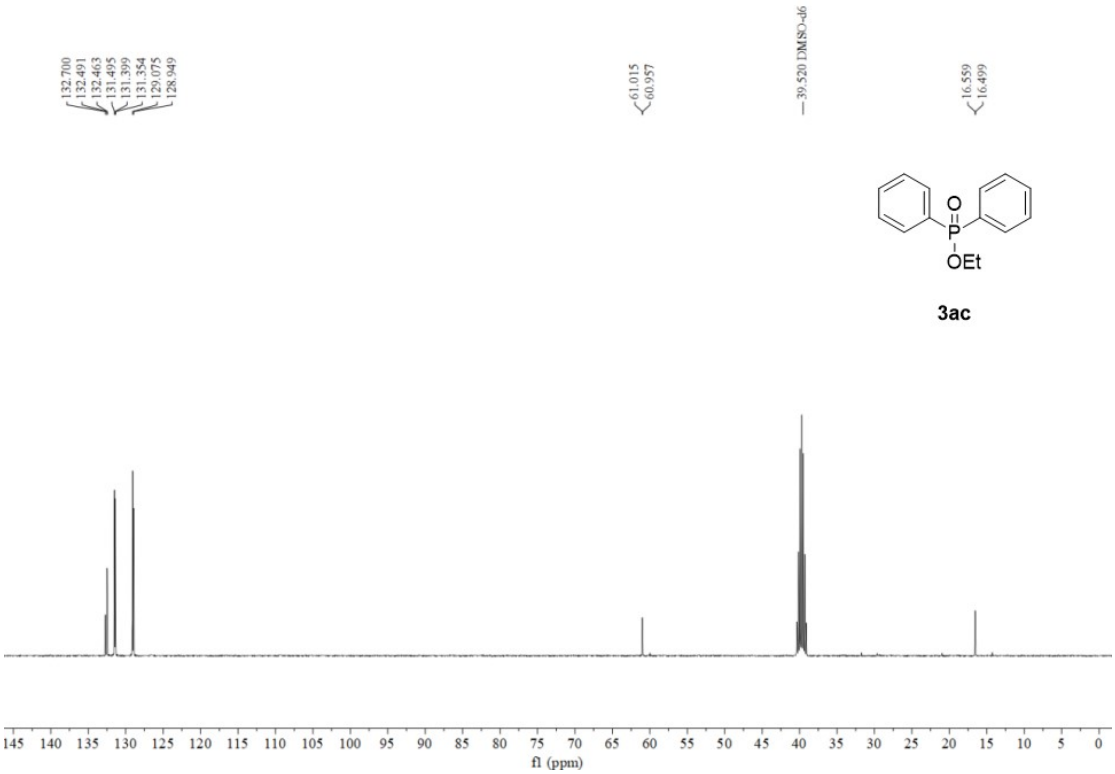

30.290
O
P
O^{n}Bu
3aa
90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0 -5 -10 -15 -20 -25 -30 -35 -40 -45 -50
f1 (ppm)

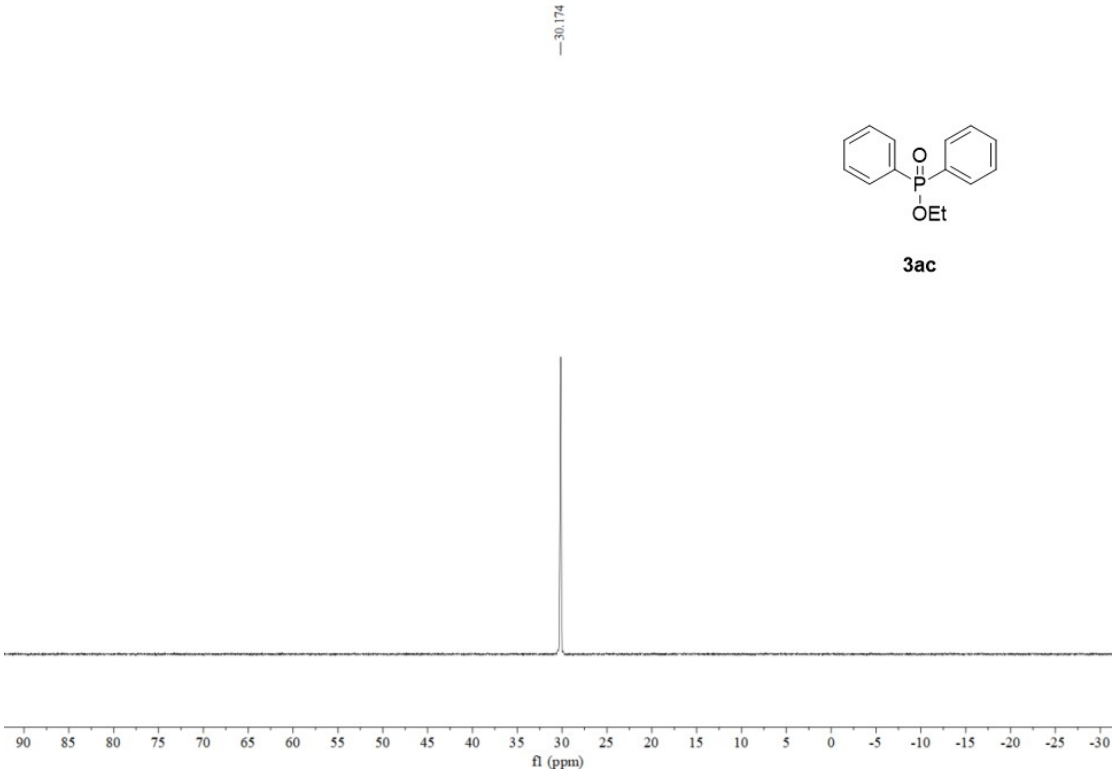

7.793
7.790
7.786
7.773
7.769
7.763
7.760
7.756
7.748
7.743
7.739
7.634
7.630
7.626
7.622
7.618
7.611
7.607
7.602
7.597
7.593
7.589
7.585
7.559
7.550
7.543
7.539
7.535
7.531
7.526
7.522
7.518
7.513
7.510
3.664
3.636
2.500 DMSO-d6
7.789
7.785
7.781
7.768
7.764
7.759
7.755
7.751
7.738
7.734
7.607
7.603
7.588
7.584
7.554
7.546
7.539
7.535
7.530
7.526
7.522
7.518
7.509
O
P
OMe
3ab
3.96
1.98
4.12
7.85 7.80 7.75 7.70 7.60 7.55 7.50 7.45
f1 (ppm)
3.96
1.98
4.12
3.00
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)


132.669
132.641
132.120
131.600
131.500
130.770
129.188
129.064
51.644
51.586
39.520 DMSO-d6
O
P
OMe
3ab
45 140 135 130 125 120 115 110 105 100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0
f1 (ppm)


31.659
O
P
OMe
3ab
140 120 100 80 60 40 20 0 -20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220 -240
f1 (ppm)

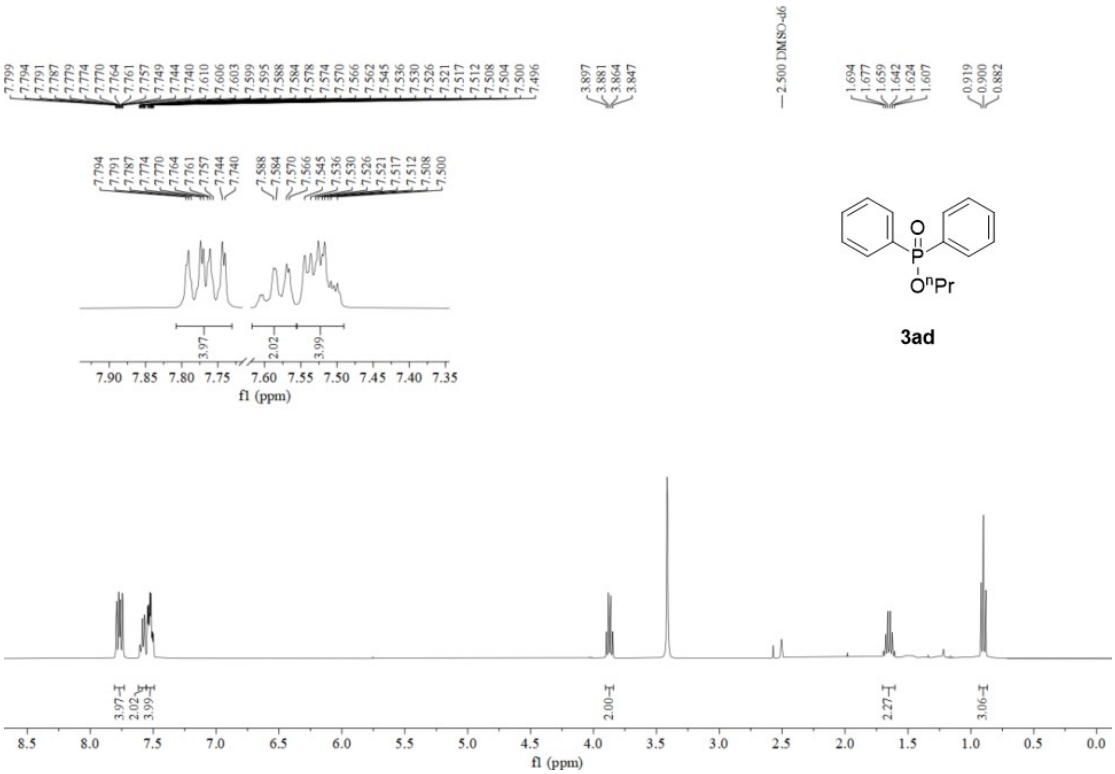

7.802
7.797
7.794
7.791
7.783
7.777
7.773
7.768
7.764
7.761
7.752
7.747
7.743
7.616
7.613
7.609
7.606
7.601
7.595
7.591
7.585
7.580
7.576
7.572
7.569
7.552
7.549
7.547
7.544
7.541
7.538
7.535
7.532
7.529
7.524
7.520
7.515
7.511
7.507
7.502
7.499
4.020
4.002
4.000
3.985
3.983
3.968
3.965
3.947
2.500 DMSO-d6
1.297
1.279
1.262
O
P
OEt
3ac
3.94
1.99
3.99
7.90 7.85 7.80 7.75 7.60 7.55 7.50 7.45 7.40
f1 (ppm)
3.94
1.99
3.99
2.00
2.99
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)


132.700
132.491
132.463
131.495
131.399
131.354
129.075
128.949
61.015
60.957
39.520 DMSO-d6
16.559
16.499
O
P
OEt
3ac
145 140 135 130 125 120 115 110 105 100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0
f1 (ppm)


30.174
90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0 -5 -10 -15 -20 -25 -30
f1 (ppm)

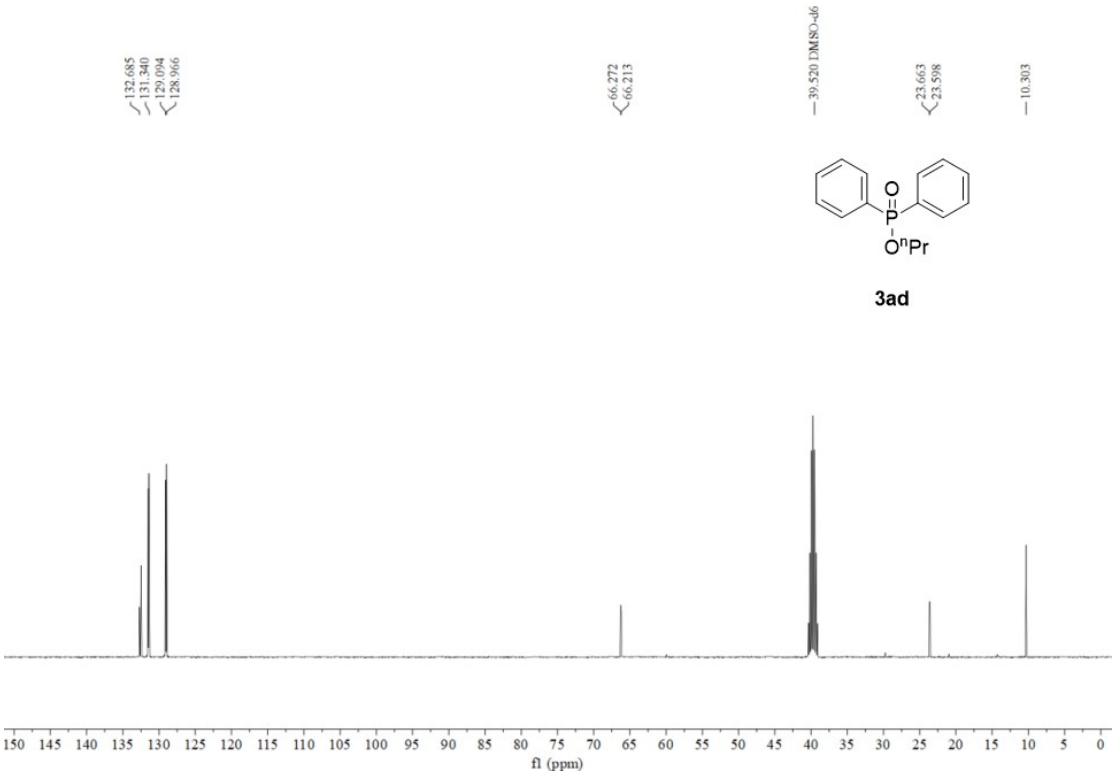
O
P
OEt

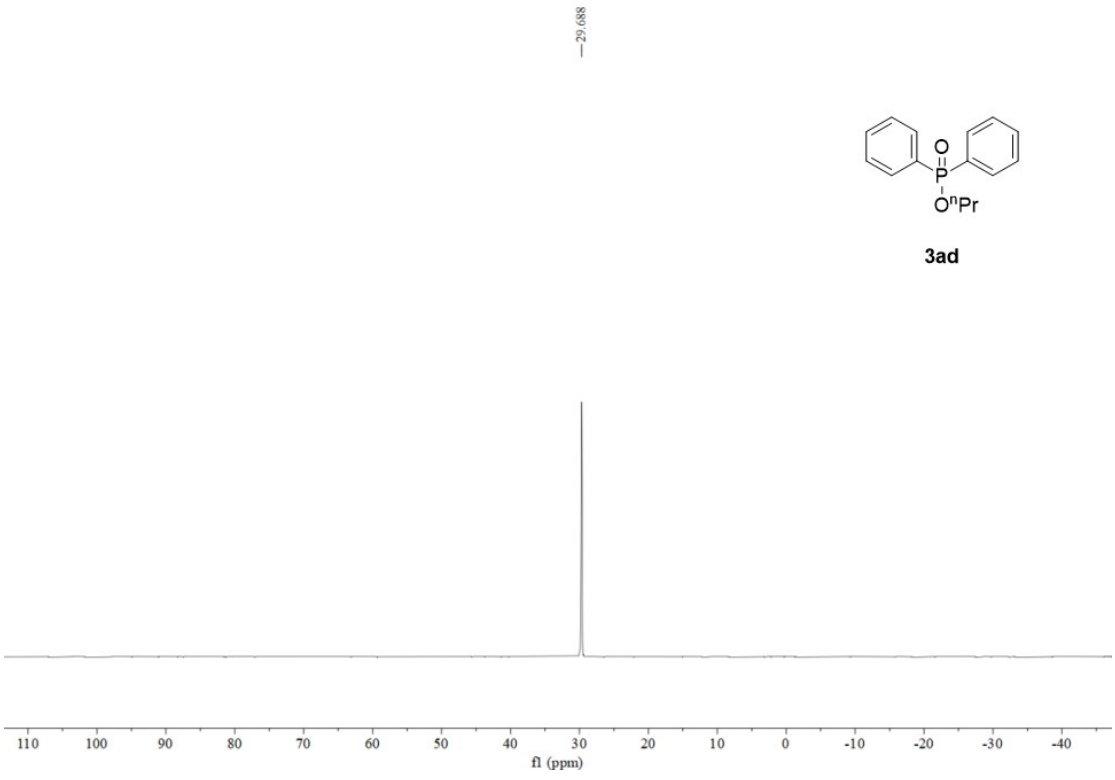
3ac

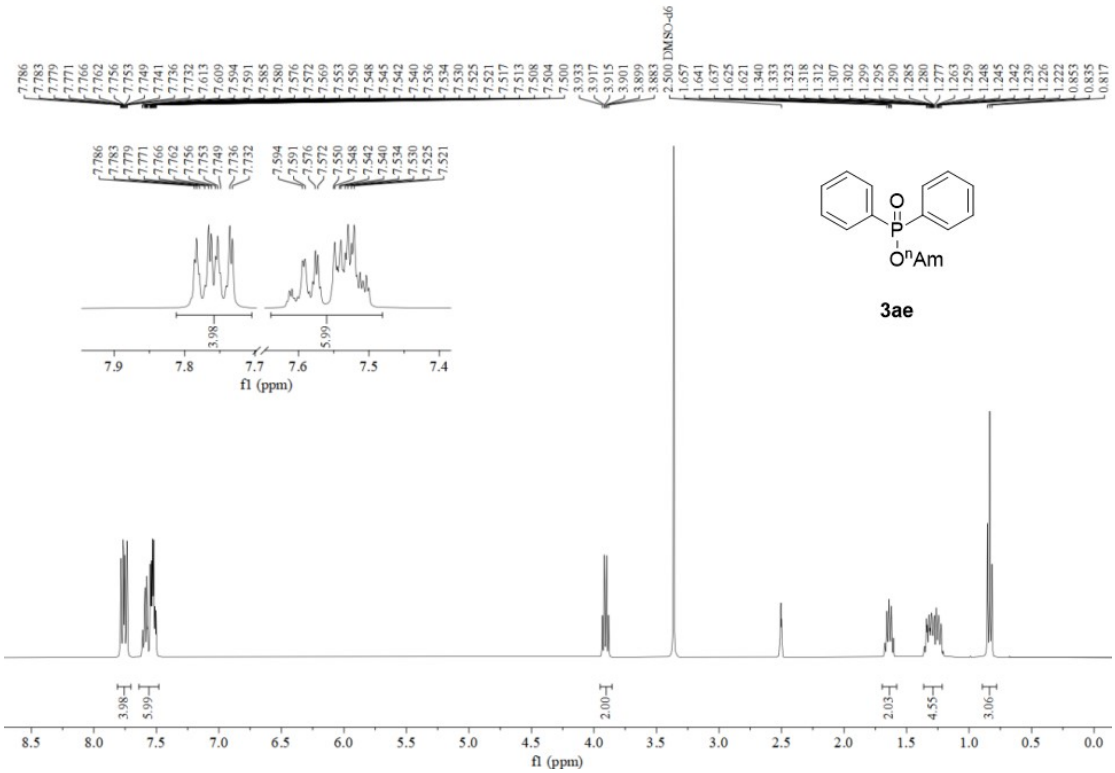

7.799
7.794
7.791
7.787
7.779
7.774
7.770
7.764
7.761
7.757
7.749
7.744
7.740
7.610
7.606
7.603
7.599
7.595
7.588
7.584
7.578
7.574
7.570
7.566
7.562
7.545
7.536
7.530
7.526
7.521
7.517
7.512
7.508
7.504
7.500
7.496
3.897
3.881
3.864
3.847
2.500 DMSO-d6
1.694
1.677
1.659
1.642
1.624
1.607
0.919
0.900
0.882
3.97
2.02
3.99
7.90 7.85 7.80 7.75 7.60 7.55 7.50 7.45 7.40 7.35
f1 (ppm)
3.97
2.02
3.99
2.00
2.27
3.06
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)

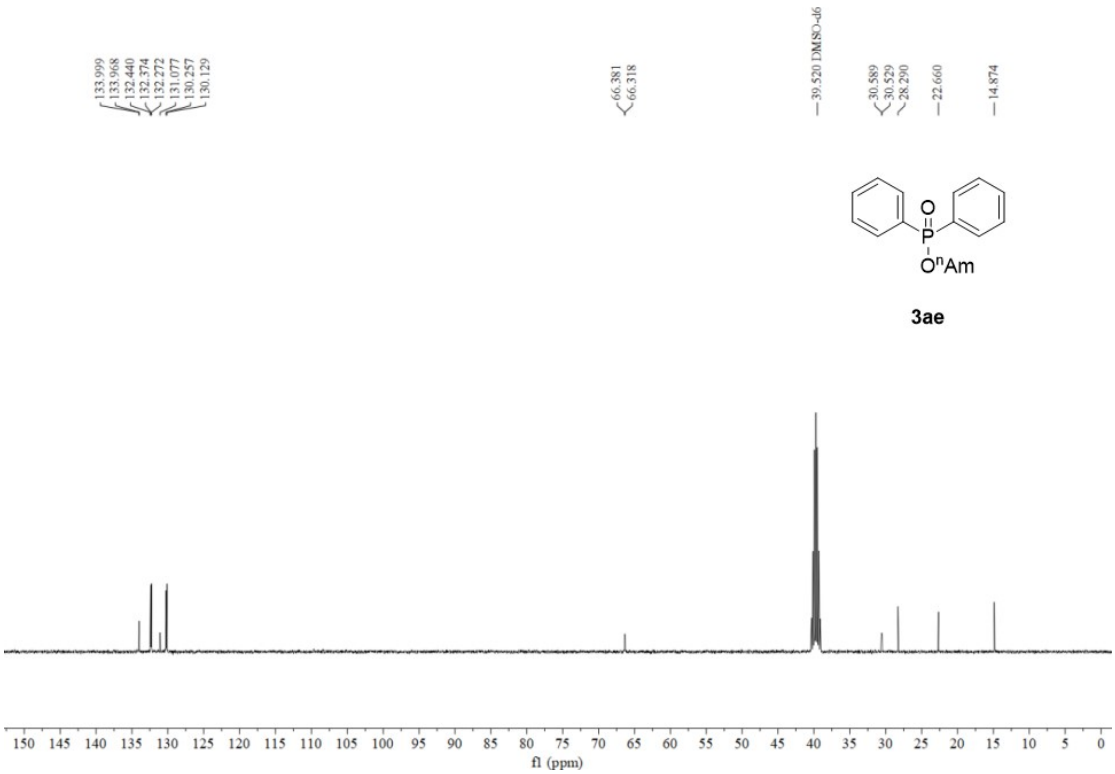
O
P
OnPr

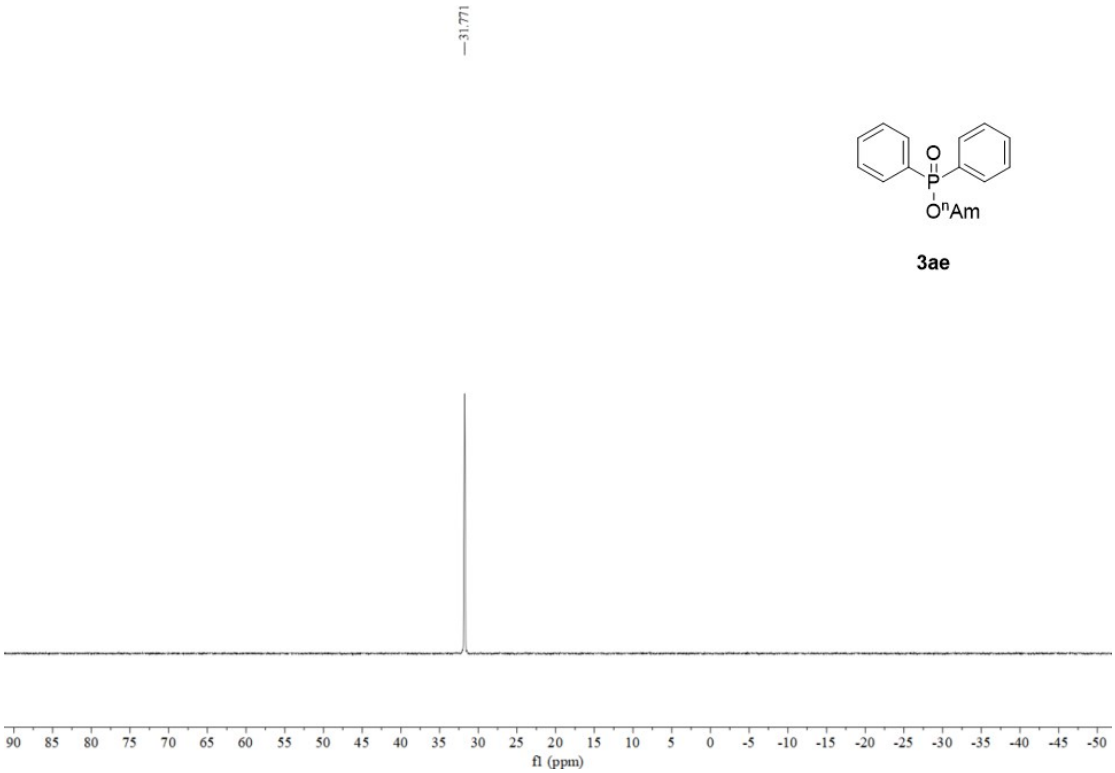
3ad


132.685
131.340
129.094
128.966
66.272
66.213
39.520 DMSO-d6
23.663
23.598
10.303
O
P
OnPr
3ad
150 145 140 135 130 125 120 115 110 105 100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0
f1 (ppm)

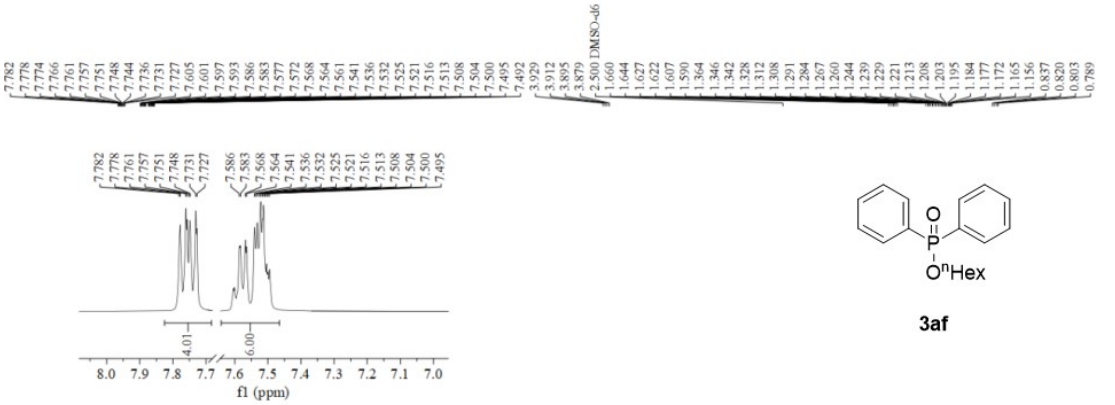

29.688
O
P
OnPr
3ad
110 100 90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40
f1 (ppm)


7.786 7.783 7.779 7.771 7.766 7.762 7.756 7.753 7.749 7.741 7.736 7.732 7.613 7.609 7.594 7.591 7.585 7.580 7.576 7.572 7.569 7.553 7.550 7.548 7.545 7.542 7.540 7.536 7.534 7.530 7.525 7.521 7.517 7.513 7.508 7.504 7.500 3.933 3.917 3.915 3.901 3.899 3.883 2.500 DMSO-d6 1.657 1.641 1.637 1.625 1.621 1.340 1.333 1.323 1.318 1.312 1.307 1.302 1.299 1.295 1.290 1.285 1.280 1.277 1.263 1.259 1.248 1.245 1.242 1.239 1.226 1.222 0.853 0.835 0.817
3.98
5.99
f1 (ppm)
O
P
OnAm
3ae
3.98
5.99
2.00
2.03
4.55
3.06
f1 (ppm)


133.999 133.968 132.440 132.374 132.272 131.077 130.257 130.129
66.381 66.318
39.520 DMSO-d6
30.589 30.529 28.290
22.660
14.874
O
P
OnAm
3ae
f1 (ppm)


31.771
O
P
OnAm
90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0 -5 -10 -15 -20 -25 -30 -35 -40 -45 -50
f1 (ppm)

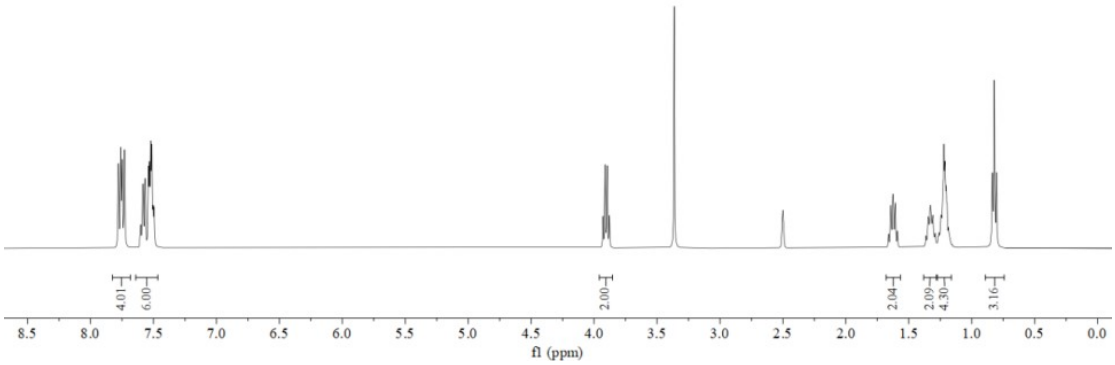
3ae

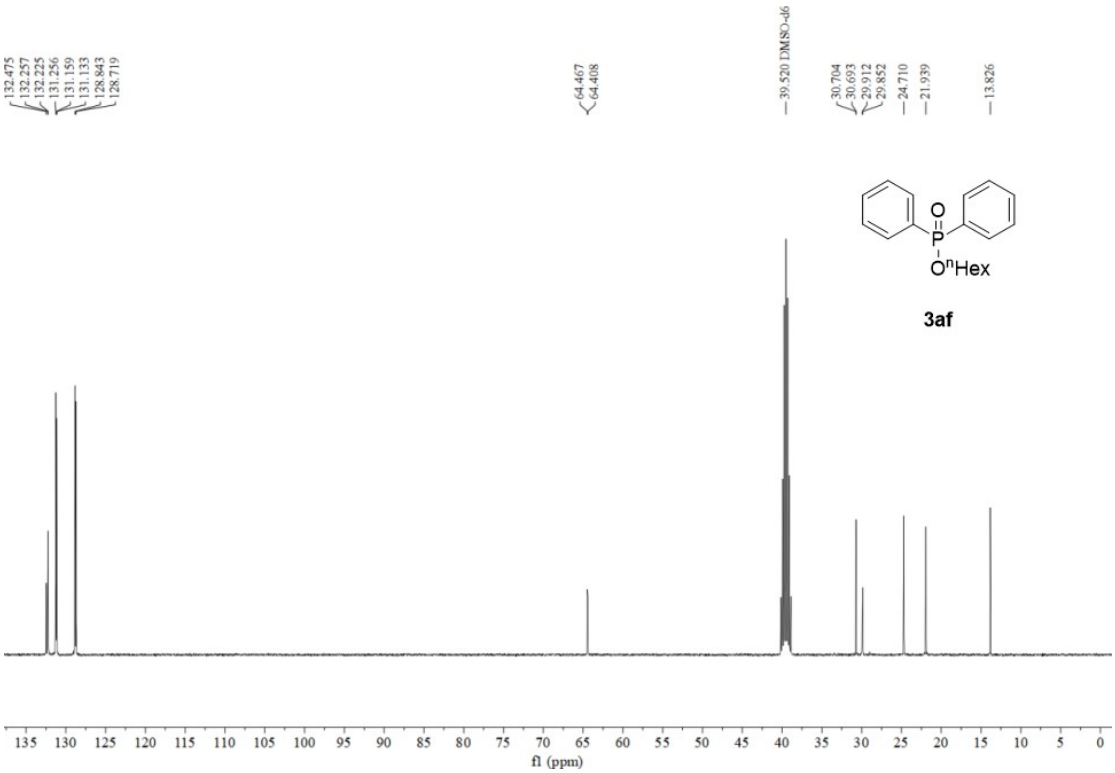

7.782 7.778 7.774 7.766 7.761 7.757 7.751 7.744 7.736 7.731 7.727 7.605 7.601 7.597 7.593 7.586 7.583 7.577 7.572 7.568 7.564 7.561 7.541 7.536 7.532 7.525 7.521 7.516 7.513 7.508 7.504 7.500 7.495 7.492
3.929 3.912 3.895 3.879
2.500 DMSO-d6
1.660 1.644 1.627 1.622 1.607 1.590 1.364 1.346 1.342 1.328 1.312 1.308 1.291 1.284 1.267 1.260 1.244 1.239 1.229 1.221 1.213 1.208 1.203 1.195 1.184 1.177 1.172 1.165 1.156 0.837 0.820 0.803 0.789

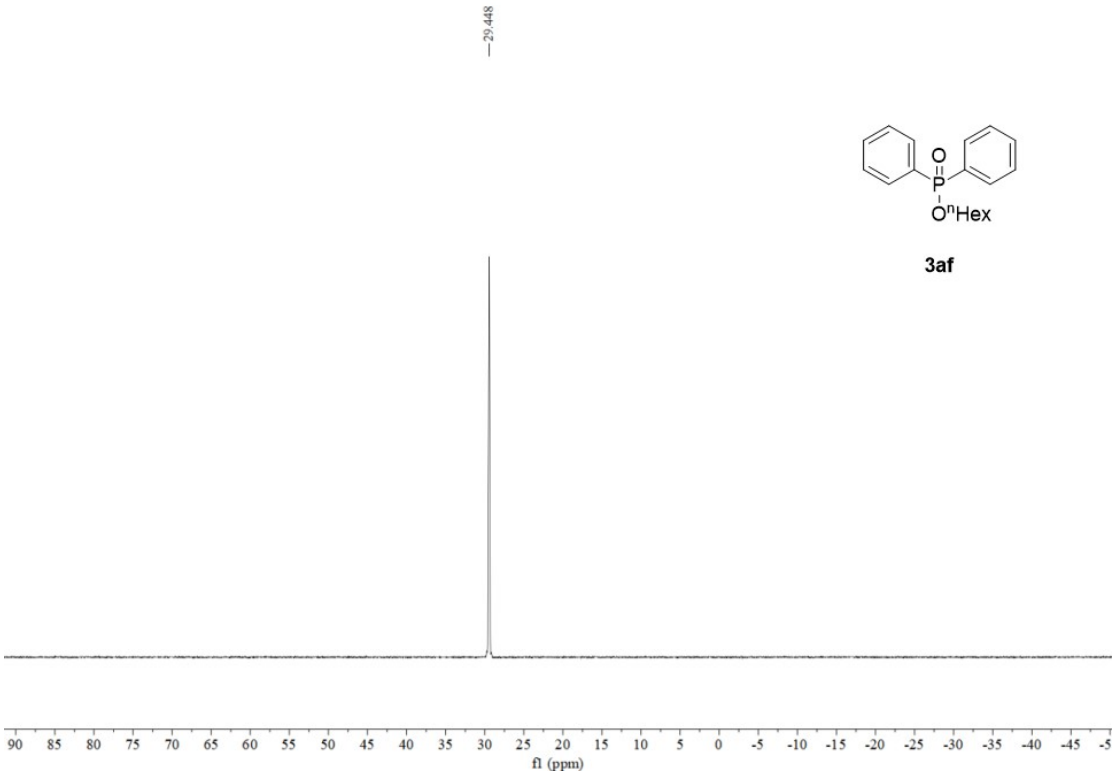
7.782 7.778 7.761 7.757 7.751 7.748 7.731 7.727 7.586 7.583 7.568 7.564 7.541 7.536 7.532 7.525 7.521 7.516 7.513 7.508 7.504 7.500 7.495
4.01
6.00
8.0 7.9 7.8 7.7 7.6 7.5 7.4 7.3 7.2 7.1 7.0
f1 (ppm)

O
P
OnHex

3af


4.01
6.00
2.00
2.04
2.09
4.30
3.16
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)


132.475
132.257
132.225
131.256
131.159
131.133
128.843
128.719
64.467
64.408
39.520 DMSO-d6
30.704
30.693
29.912
29.852
24.710
21.939
13.826
O
P
O
nHex
3af
135 130 125 120 115 110 105 100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0
f1 (ppm)


29.448
O
P
O
nHex
3af
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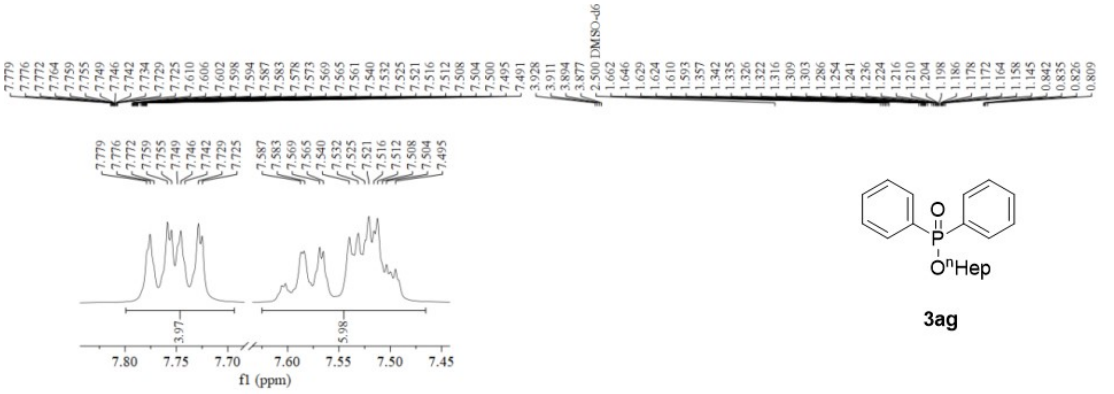
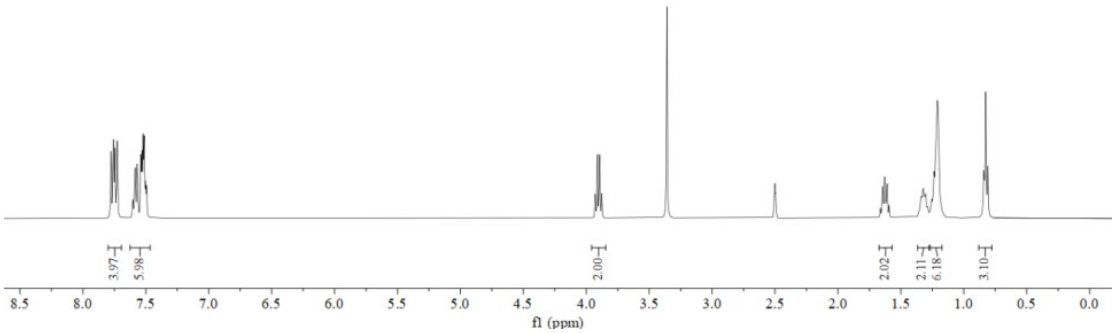
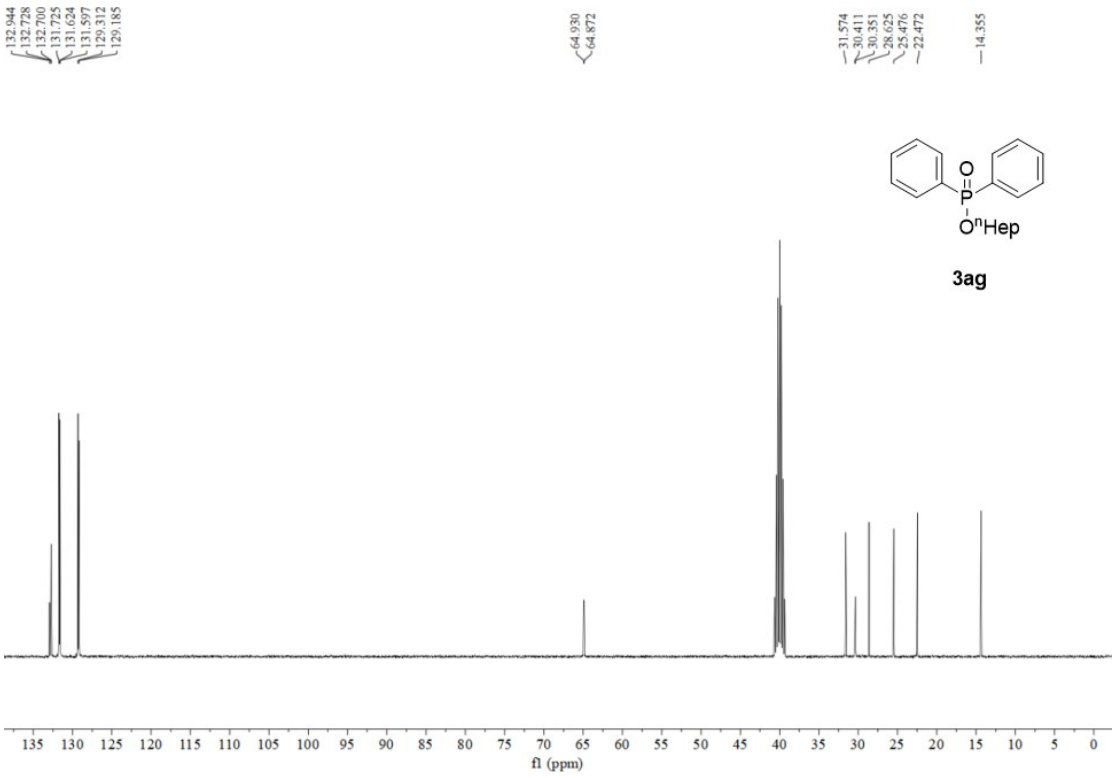
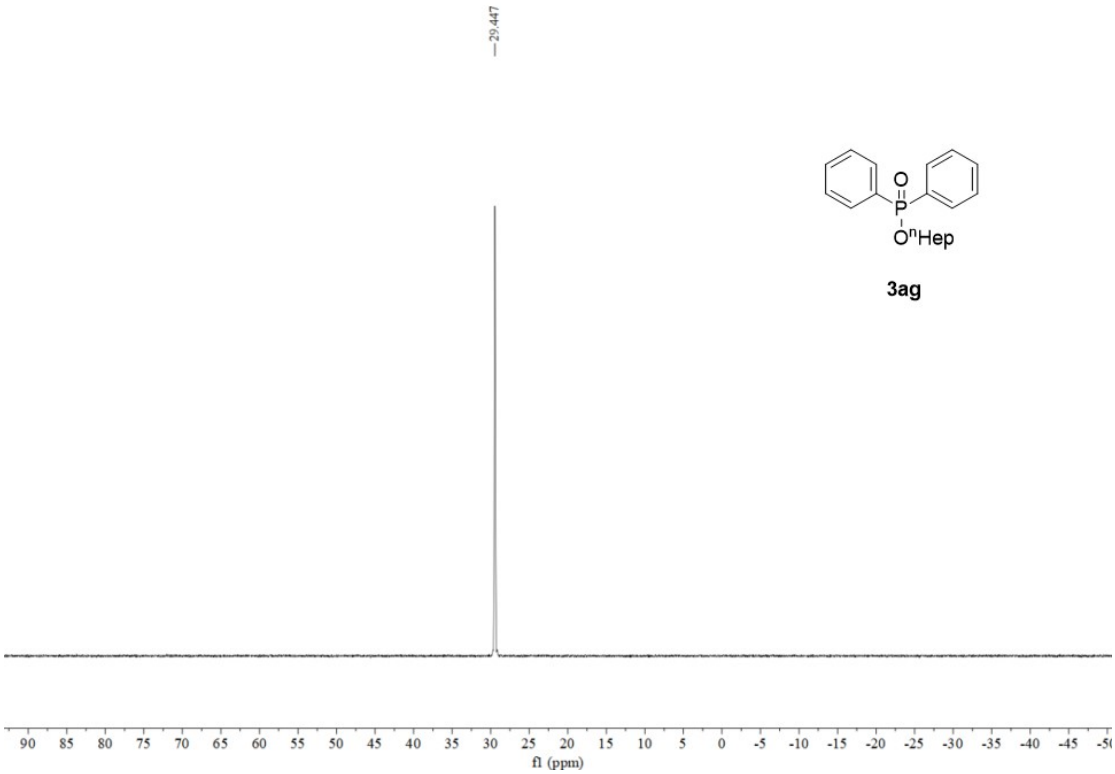
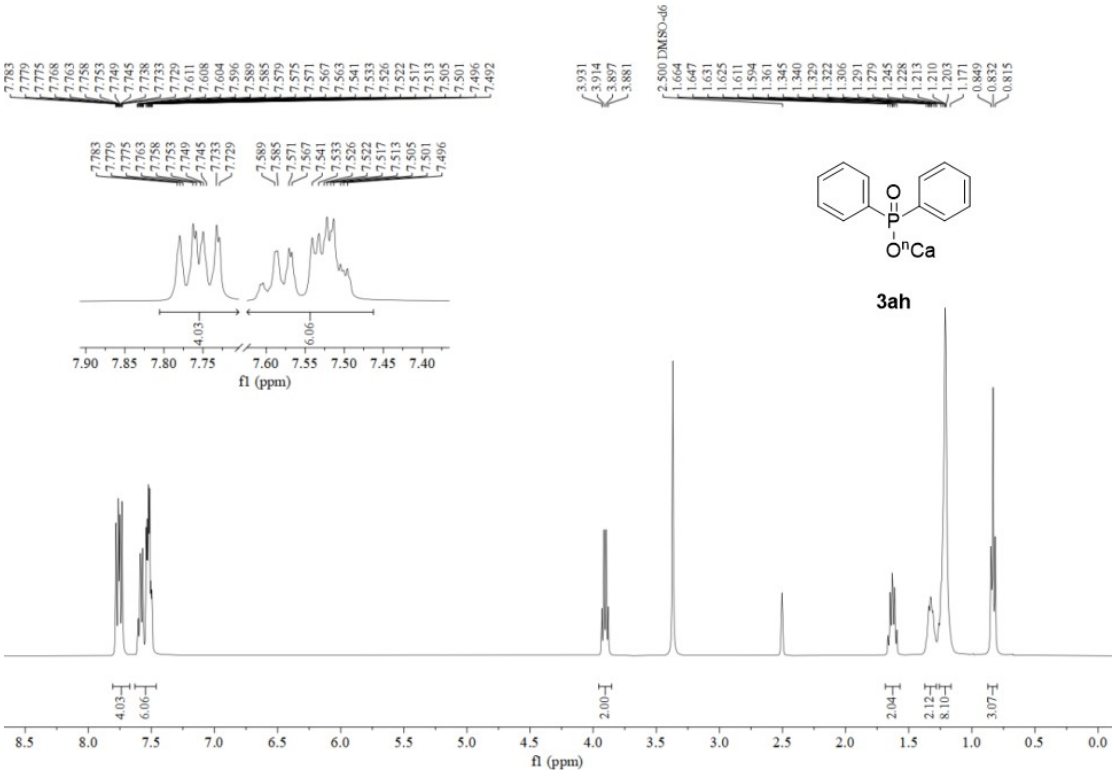
f1 (ppm)

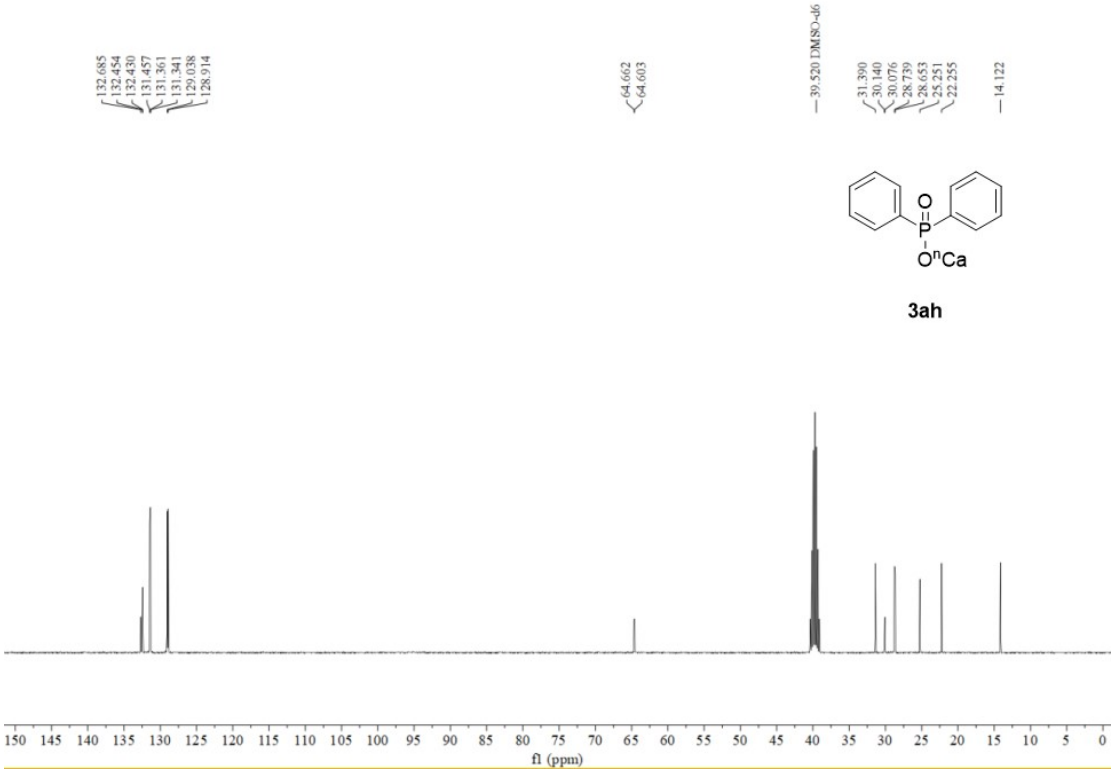

7.779
7.776
7.772
7.764
7.759
7.755
7.749
7.746
7.742
7.734
7.729
7.725
7.610
7.606
7.602
7.598
7.594
7.587
7.583
7.578
7.573
7.569
7.565
7.561
7.540
7.532
7.525
7.521
7.516
7.512
7.508
7.504
7.500
7.495
7.491
3.928
3.911
3.894
3.877
2.500 DMSO-d6
1.662
1.646
1.629
1.624
1.610
1.593
1.357
1.342
1.335
1.326
1.322
1.316
1.309
1.303
1.286
1.254
1.241
1.236
1.224
1.216
1.210
1.204
1.198
1.186
1.178
1.172
1.164
1.158
1.145
0.842
0.835
0.826
0.809
3.97
5.98
7.80
7.75
7.70
7.60
7.55
7.50
7.45
f1 (ppm)
O
P
O
O^nHep
3ag

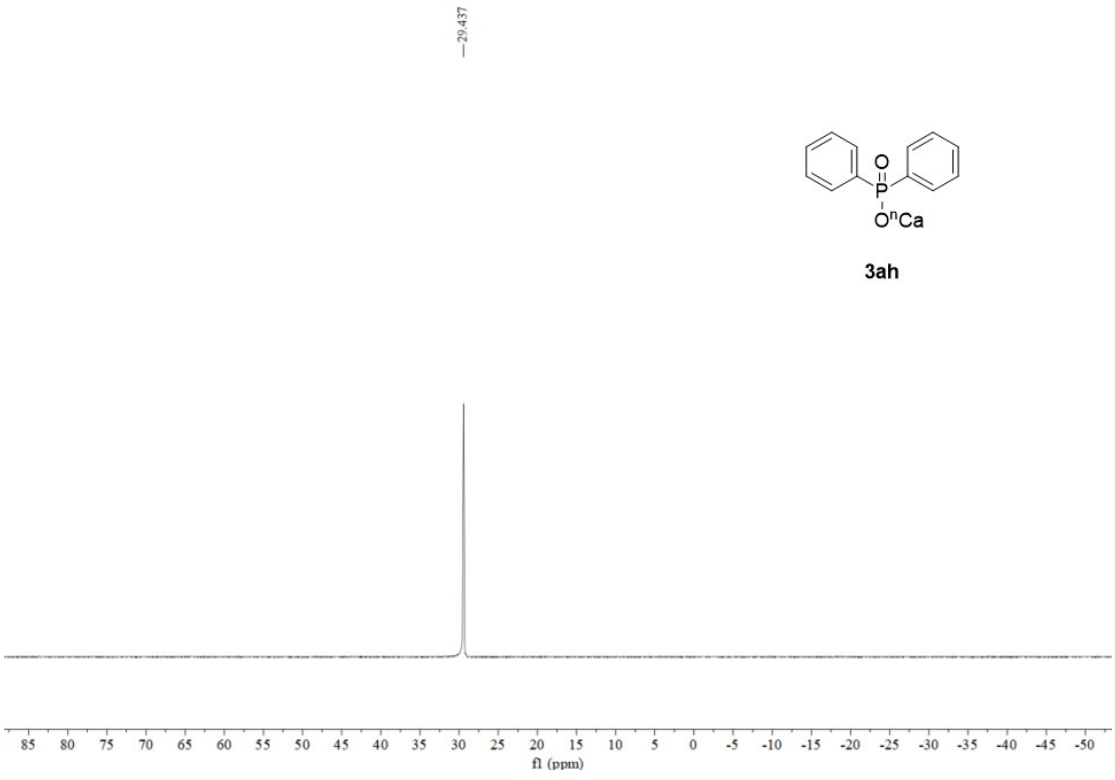

3.97
5.98
2.00
2.02
2.11
6.18
3.10
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

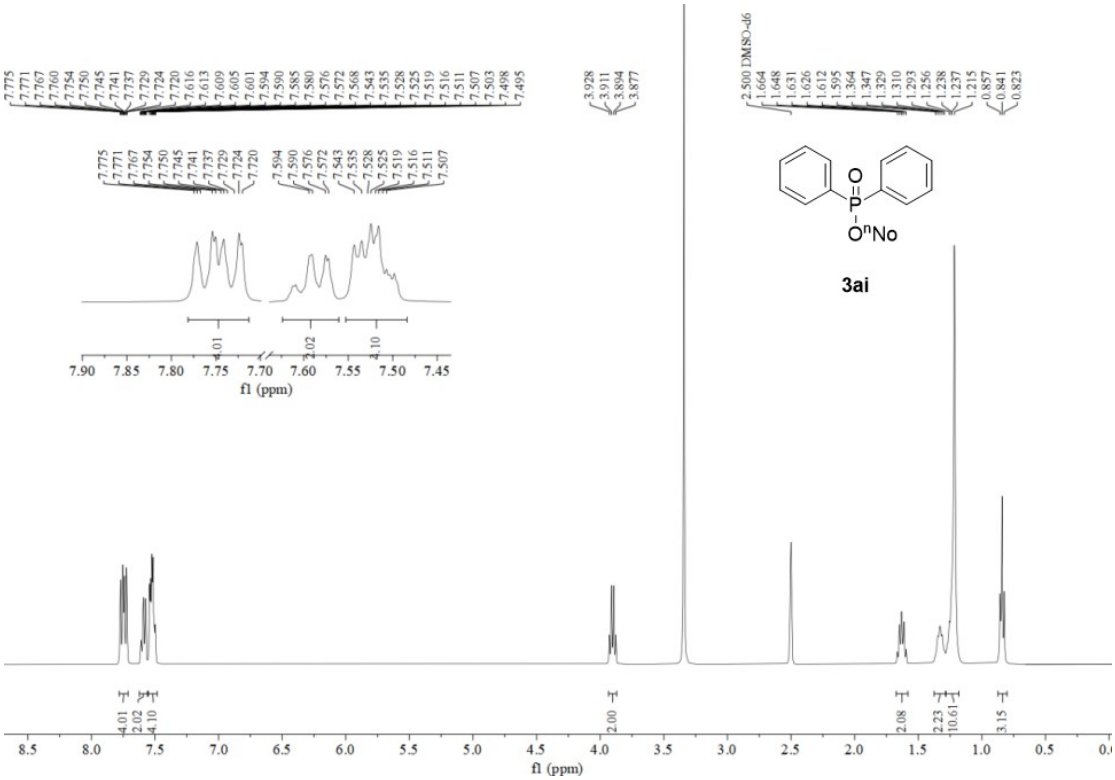

132.944
132.728
132.700
131.725
131.624
131.597
129.312
129.185
64.930
64.872
31.574
30.411
30.351
28.625
25.476
22.472
14.355
O
P
O
O^nHep
3ag
135
130
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
f1 (ppm)

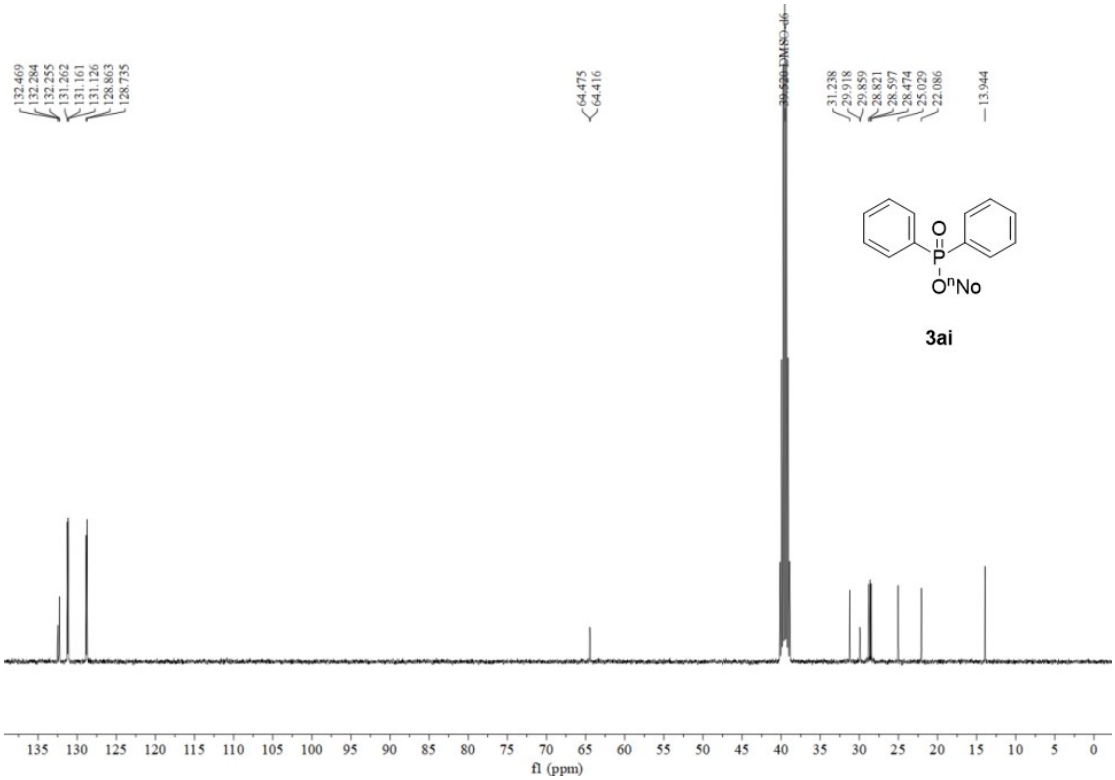

29.447
O
P
O^{n}Hep
3ag
90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0 -5 -10 -15 -20 -25 -30 -35 -40 -45
f1 (ppm)

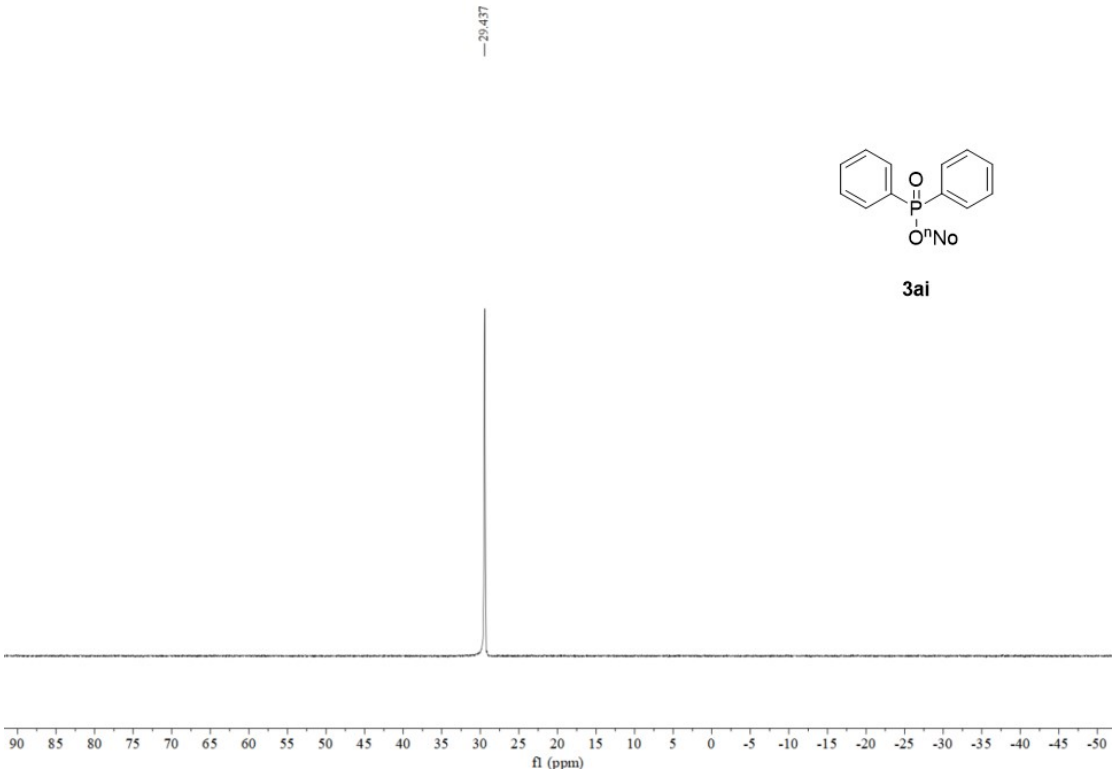

7.783 7.779 7.775 7.768 7.763 7.758 7.753 7.749 7.745 7.738 7.733 7.729 7.611 7.608 7.604 7.596 7.589 7.585 7.579 7.575 7.571 7.567 7.563 7.541 7.533 7.526 7.522 7.517 7.513 7.505 7.501 7.496 7.492
3.931 3.914 3.897 3.881
2.500 DMSO-d6
1.664 1.647 1.631 1.625 1.611 1.594 1.361 1.345 1.340 1.329 1.322 1.306 1.291 1.279 1.245 1.228 1.213 1.210 1.203 1.171 0.849 0.832 0.815
4.03
6.06
2.00
2.04
2.12
8.10
3.07
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)
O
P
O^{n}Ca
3ah

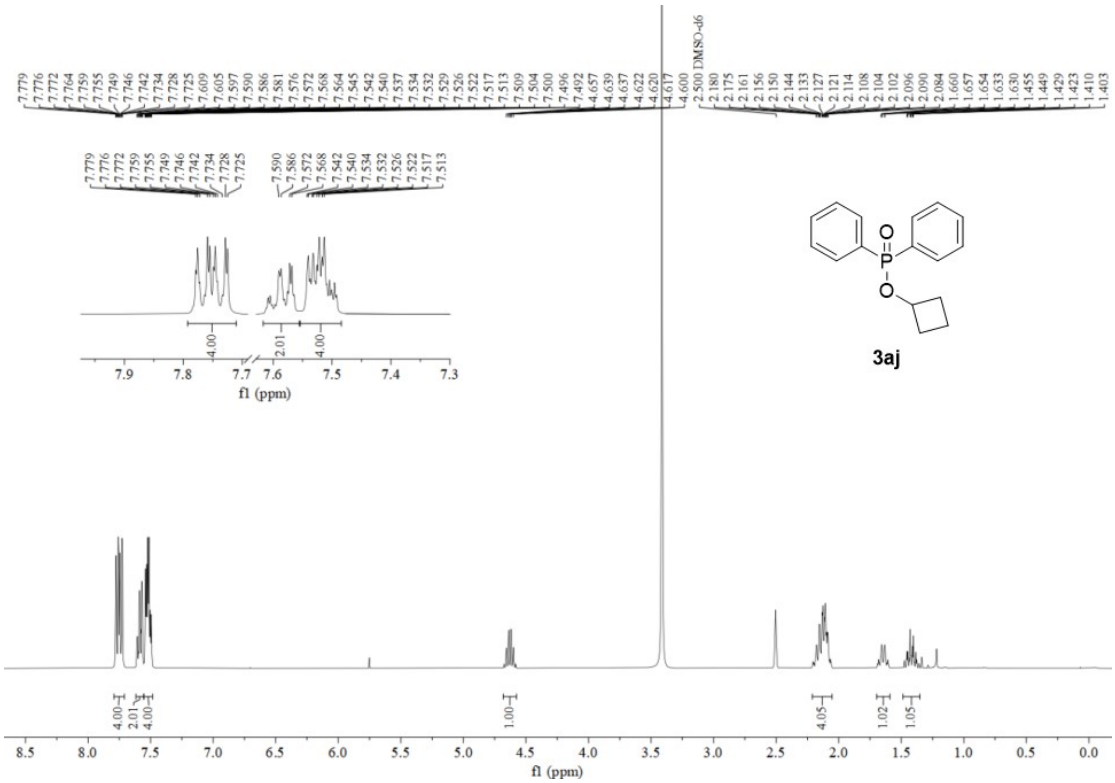

132.685
132.454
132.430
131.457
131.361
131.341
129.038
128.914
64.662
64.603
39.520 DMSO-d6
31.390
30.140
30.076
28.739
28.653
25.251
22.255
14.122
O
P
O
nCa
3ah
150 145 140 135 130 125 120 115 110 105 100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0
f1 (ppm)

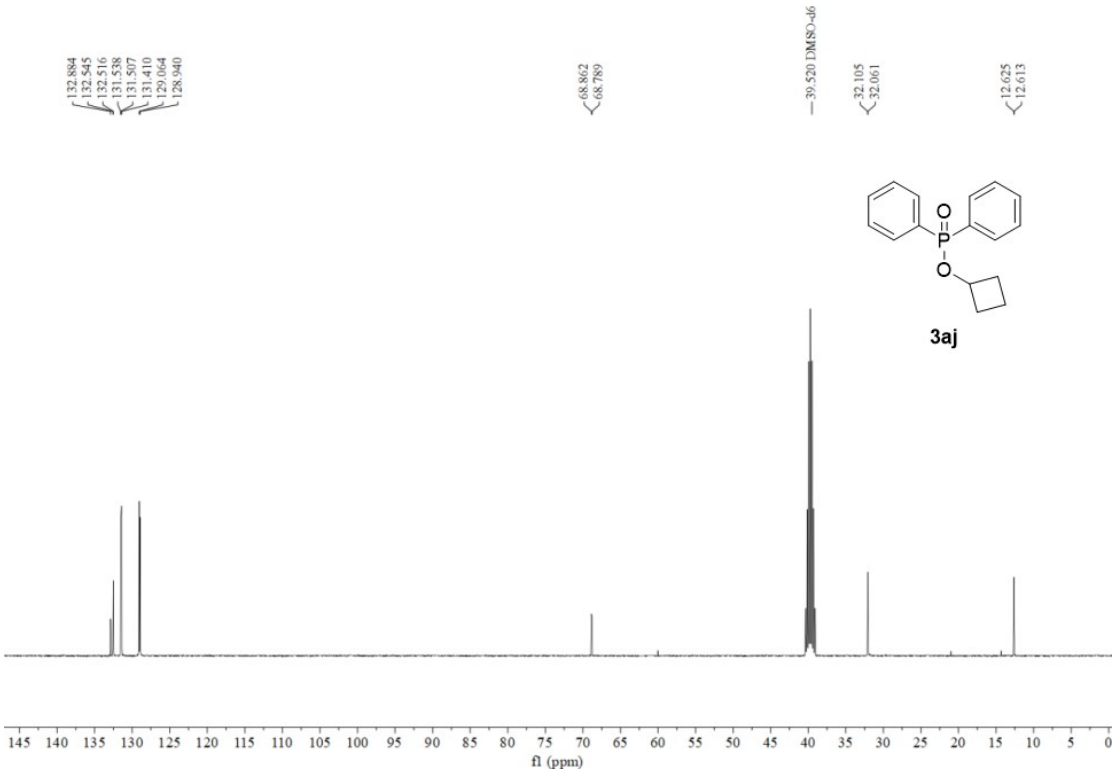

29.437
O
P
O
nCa
3ah
85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0 -5 -10 -15 -20 -25 -30 -35 -40 -45 -50
f1 (ppm)

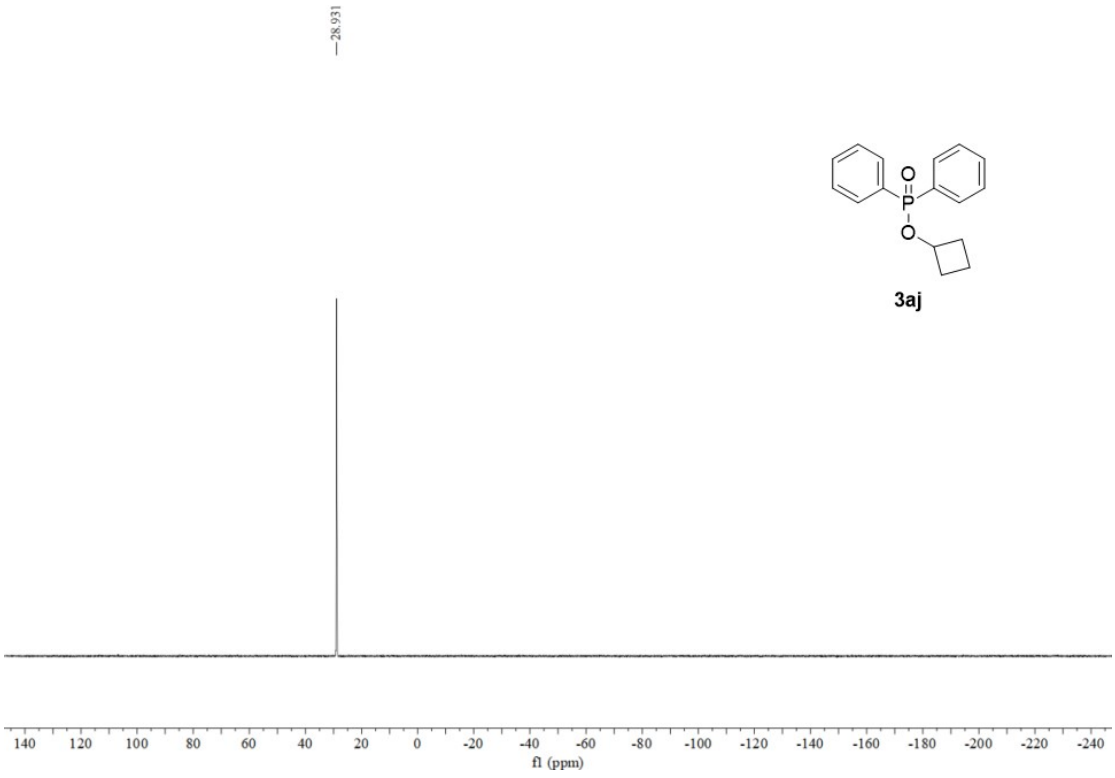

7.775 7.771 7.767 7.760 7.754 7.750 7.745 7.741 7.737 7.729 7.724 7.720 7.616 7.613 7.609 7.605 7.601 7.594 7.590 7.585 7.580 7.576 7.572 7.568 7.543 7.535 7.528 7.525 7.519 7.516 7.511 7.507 7.503 7.498 7.495
3.928 3.911 3.894 3.877
2.500 DMSO-d6
1.664 1.648 1.631 1.626 1.612 1.595 1.364 1.347 1.329 1.310 1.293 1.256 1.238 1.237 1.215 0.857 0.841 0.823
4.01 2.02 4.10 2.00 2.08 2.23 10.61 3.15
fl (ppm)
3ai

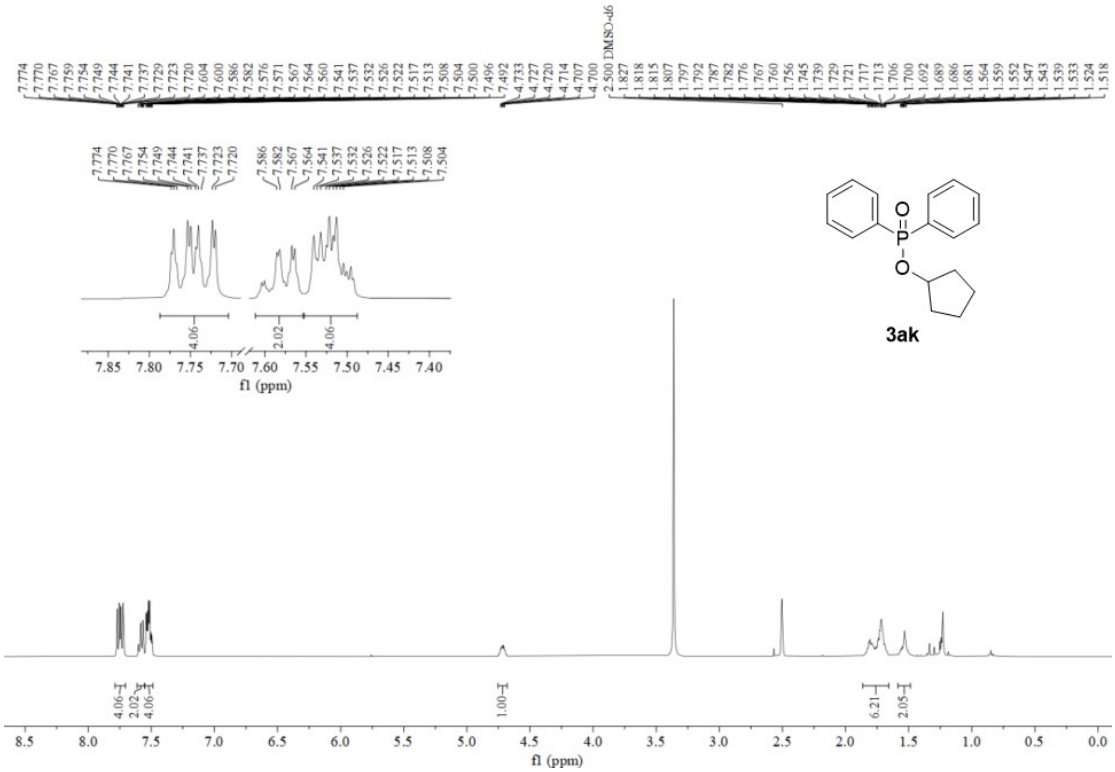

132.469 132.284 132.255 131.262 131.161 131.126 128.863 128.735
64.475 64.416
39.520 DMSO-d6
31.238 29.918 29.859 28.821 28.597 28.474 25.029 22.086 13.944
fl (ppm)
3ai

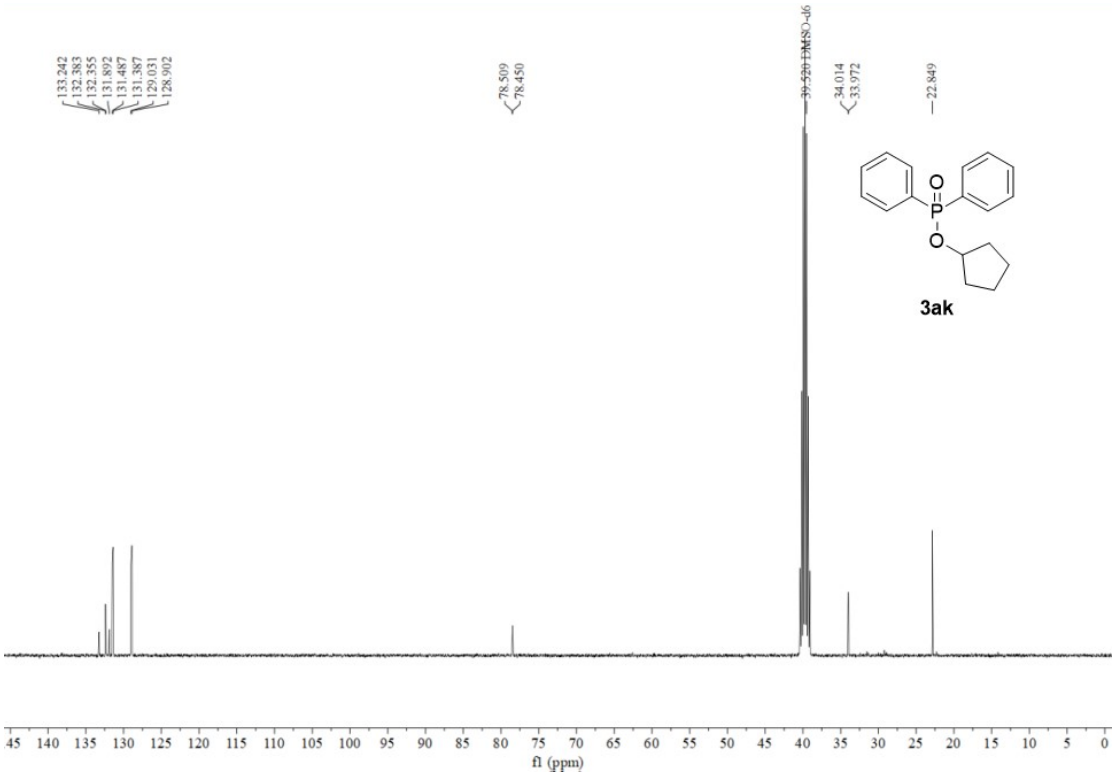

29.437
O
P
O
nNo
3ai
90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0 -5 -10 -15 -20 -25 -30 -35 -40 -45 -50
f1 (ppm)

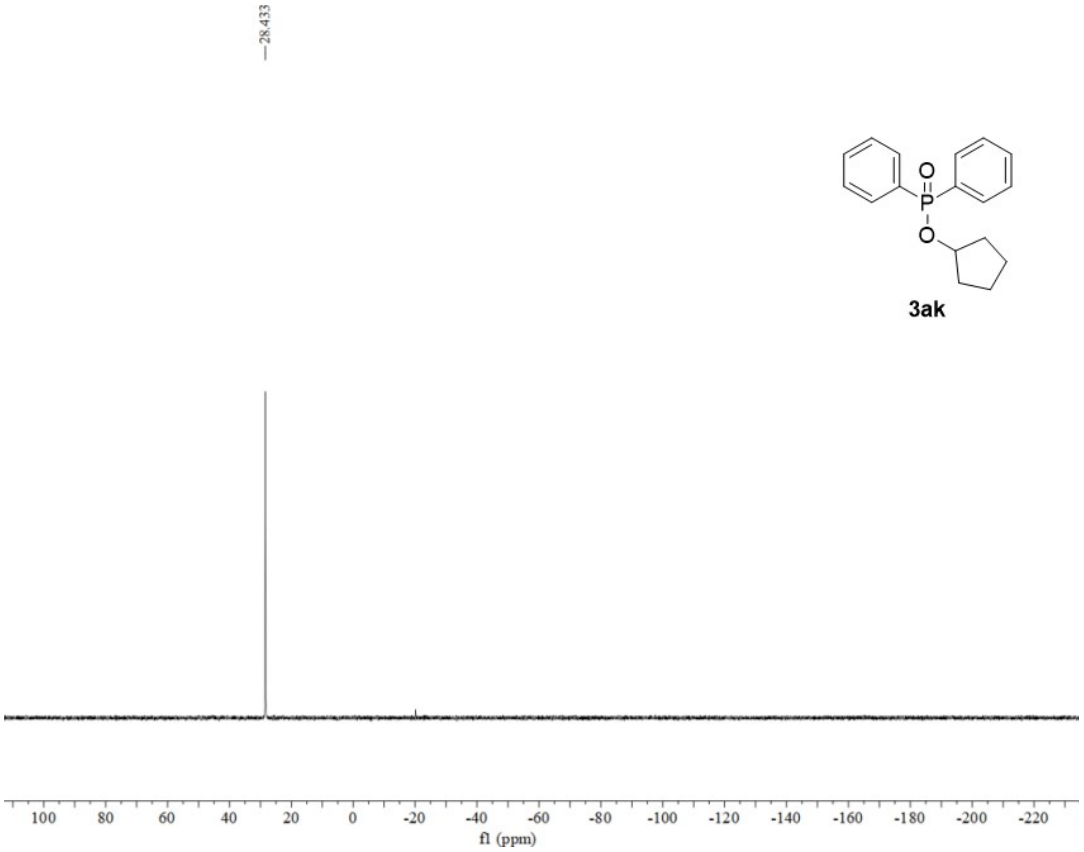

7.779
7.776
7.772
7.764
7.759
7.755
7.749
7.746
7.742
7.734
7.728
7.725
7.609
7.605
7.597
7.590
7.586
7.581
7.576
7.572
7.568
7.564
7.545
7.542
7.540
7.537
7.534
7.532
7.529
7.526
7.522
7.517
7.513
7.509
7.504
7.500
7.496
7.492
4.657
4.639
4.637
4.622
4.620
4.617
4.600
2.500 DMSO-d6
2.180
2.175
2.161
2.156
2.150
2.144
2.133
2.127
2.121
2.114
2.108
2.104
2.102
2.096
2.090
2.084
1.660
1.657
1.654
1.633
1.630
1.455
1.449
1.429
1.423
1.410
1.403
4.00
2.01
4.00
1.00
4.05
1.02
1.05
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)
7.9 7.8 7.7 7.6 7.5 7.4 7.3
f1 (ppm)
O
P
O
3aj


132.884
132.545
132.516
131.538
131.507
131.410
129.064
128.940
68.862
68.789
39.520 DMSO-d6
32.105
32.061
12.625
12.613
O
P
O
3aj
145 140 135 130 125 120 115 110 105 100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0
f1 (ppm)

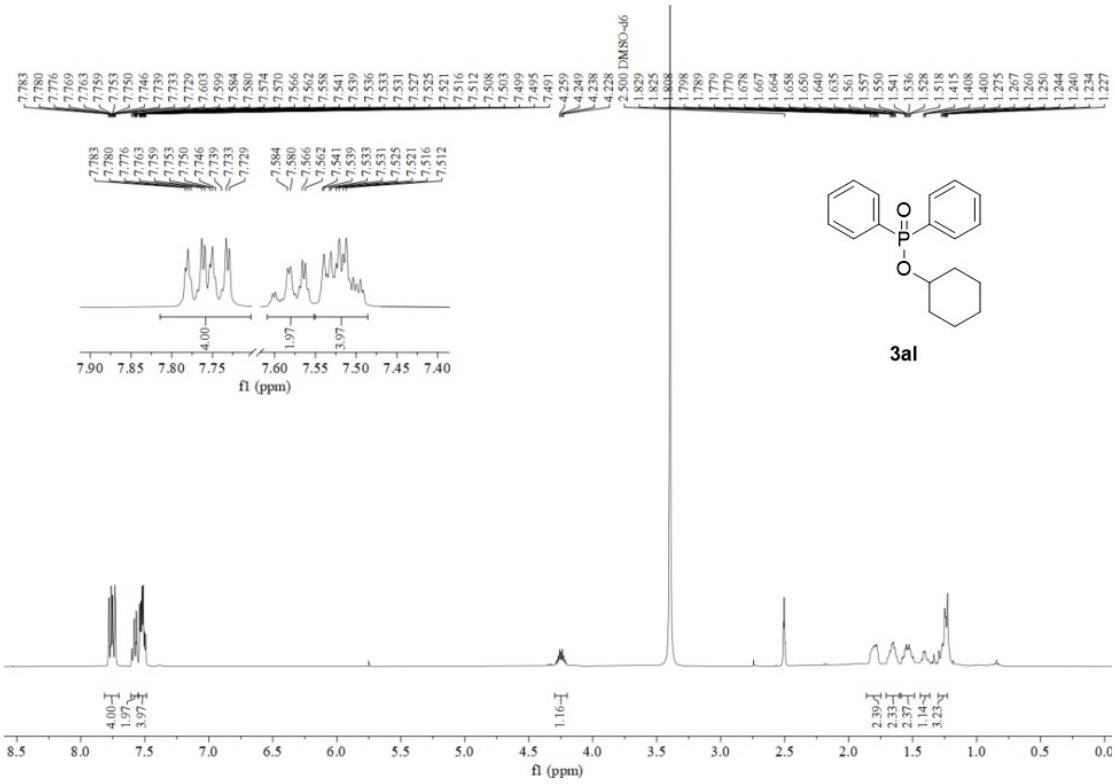

28.931
O
P
O
3aj
140 120 100 80 60 40 20 0 -20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220 -240
f1 (ppm)


DMSO-d6
3ak
f1 (ppm)

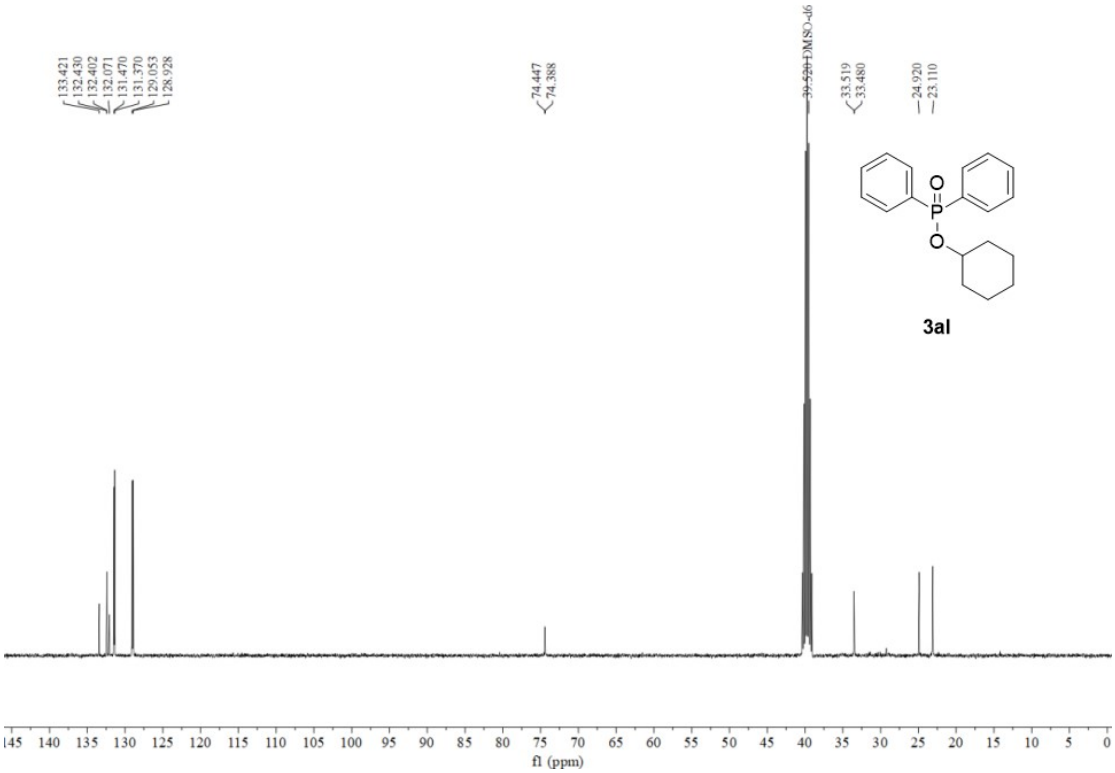

DMSO-d6
3ak
f1 (ppm)

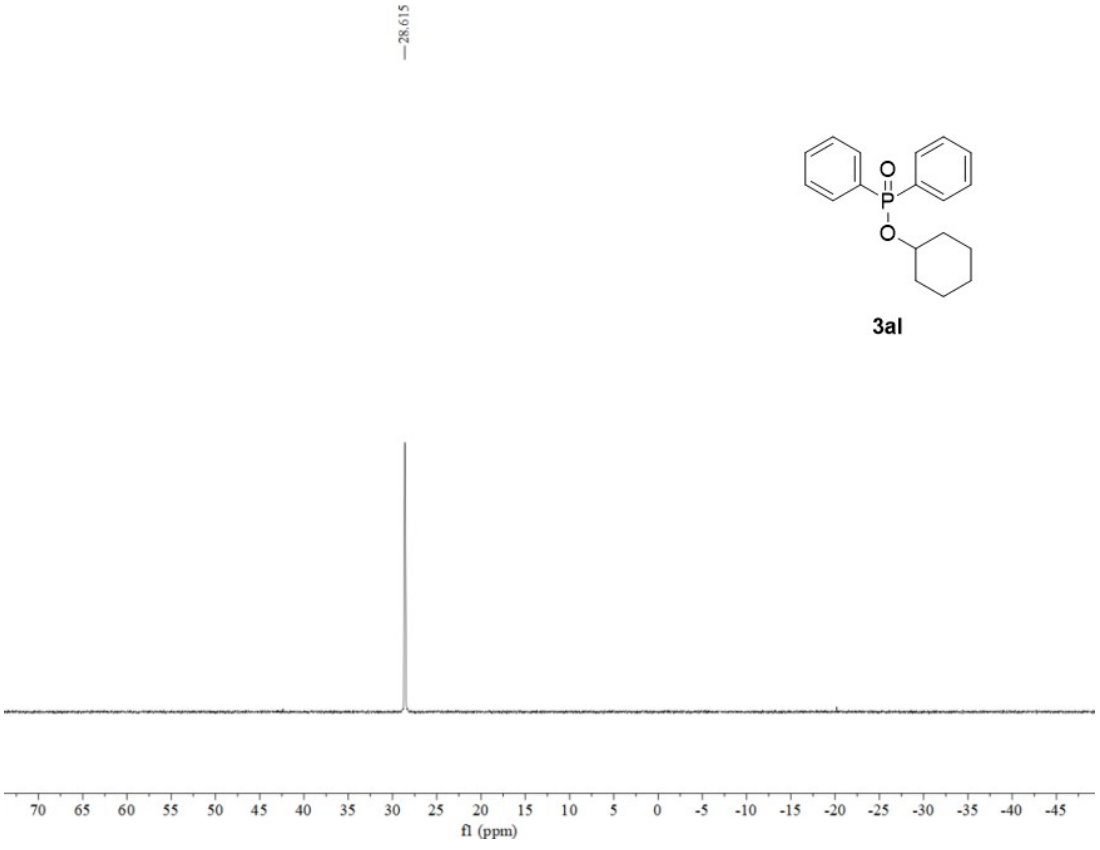

28.433
100 80 60 40 20 0 -20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220
f1 (ppm)

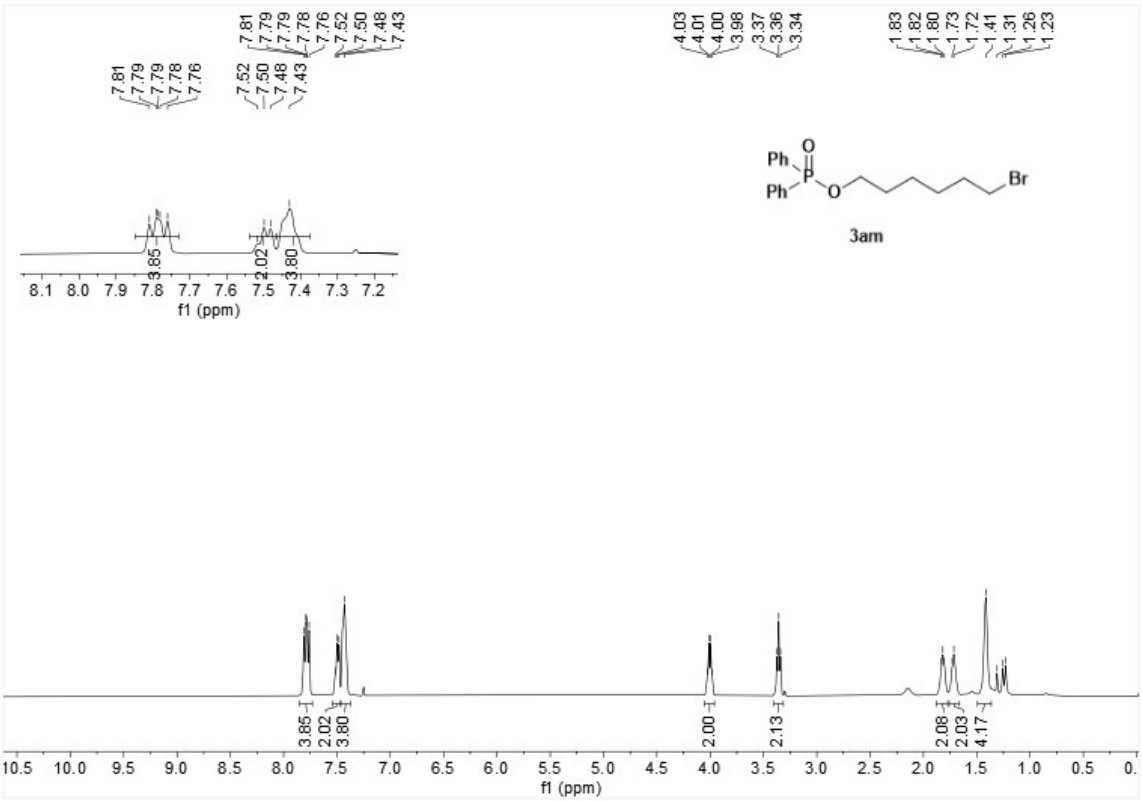
3ak


7.783 7.780 7.776 7.769 7.763 7.759 7.753 7.750 7.746 7.739 7.733 7.729 7.603 7.599 7.584 7.580 7.574 7.570 7.566 7.562 7.558 7.541 7.539 7.536 7.533 7.531 7.527 7.525 7.521 7.516 7.512 7.508 7.503 7.499 7.495 7.491 4.259 4.249 4.238 4.228 2.500 DMSO-d6 1.829 1.825 1.808 1.798 1.789 1.779 1.770 1.678 1.667 1.664 1.658 1.650 1.640 1.635 1.561 1.557 1.550 1.541 1.536 1.528 1.518 1.415 1.408 1.400 1.275 1.267 1.260 1.250 1.244 1.240 1.234 1.227
4.00 1.97 3.97
7.90 7.85 7.80 7.75 7.60 7.55 7.50 7.45 7.40
f1 (ppm)
4.00 1.97 3.97 1.16 2.39 2.33 2.37 1.14 3.23
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)

3al


133.421
132.430
132.402
132.071
131.470
131.370
129.053
128.928
74.447
74.388
39.520
DMSO-d6
33.519
33.480
24.920
23.110
O
P
O
3al
145 140 135 130 125 120 115 110 105 100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0
f1 (ppm)


28.615
O
P
O
3al
70 65 60 55 50 45 40 35 30 25 20 15 10 5 0 -5 -10 -15 -20 -25 -30 -35 -40 -45
f1 (ppm)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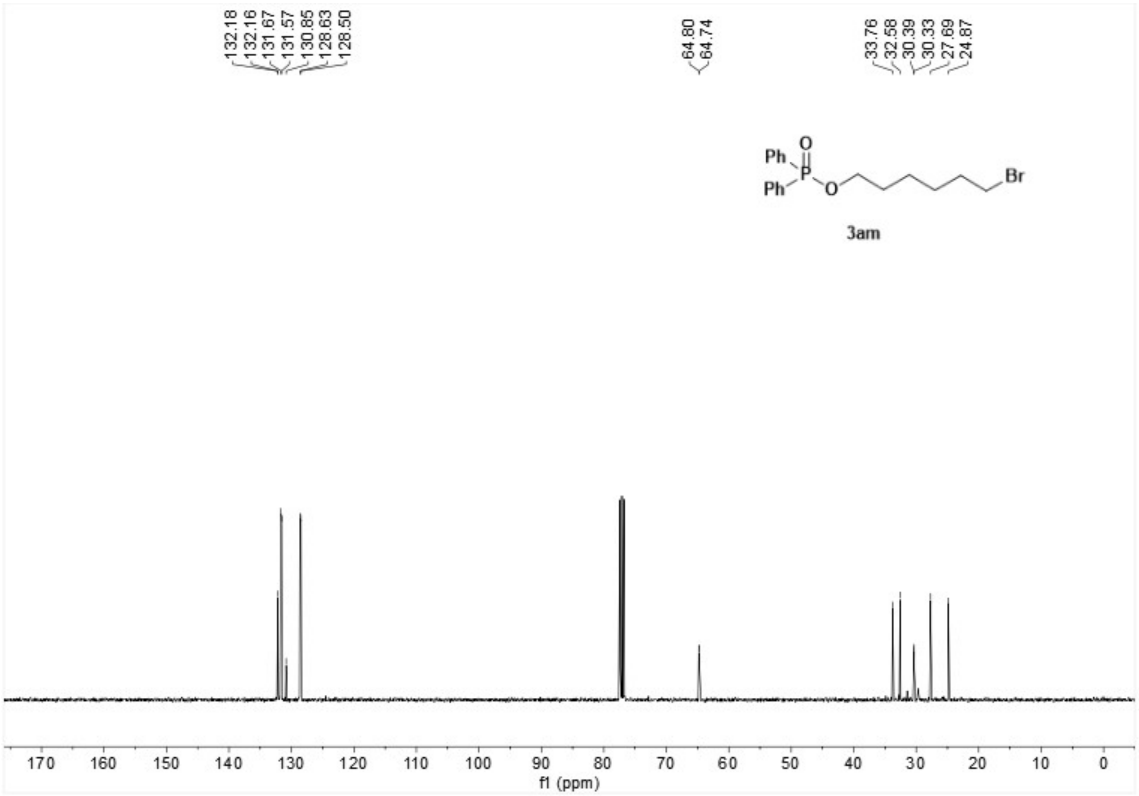
7.79
7.79
7.78
7.76
7.52
7.50
7.48
7.43
4.03
4.01
4.00
3.98
3.37
3.36
3.34
1.83
1.82
1.80
1.73
1.72
1.41
1.31
1.26
1.23
Ph
Ph
O
P
O
Br
3am
3.85
2.02
3.80
2.00
2.13
2.08
2.03
4.17
f1 (ppm)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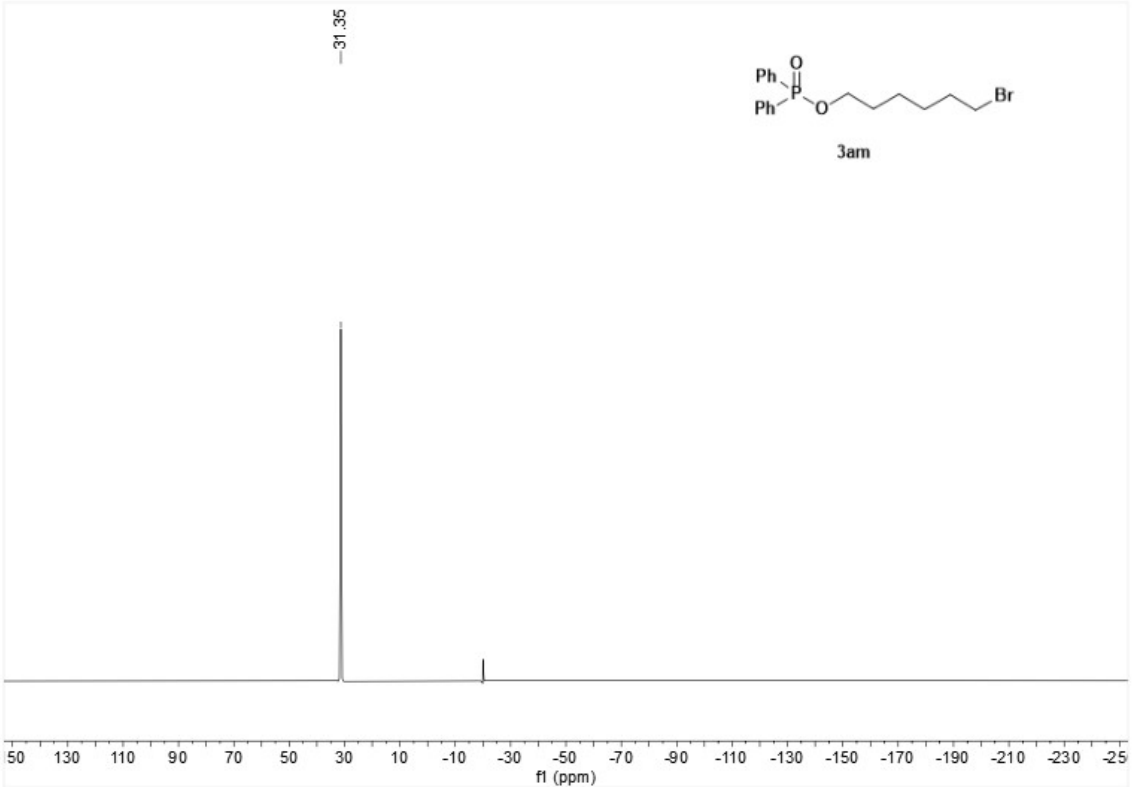
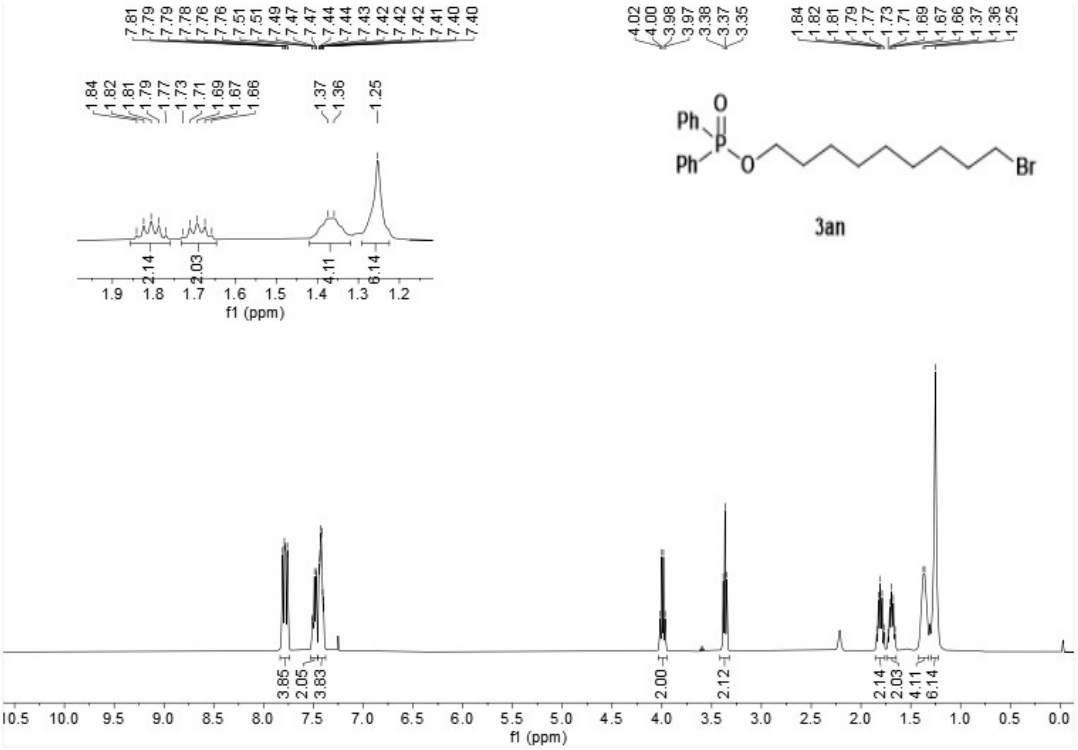
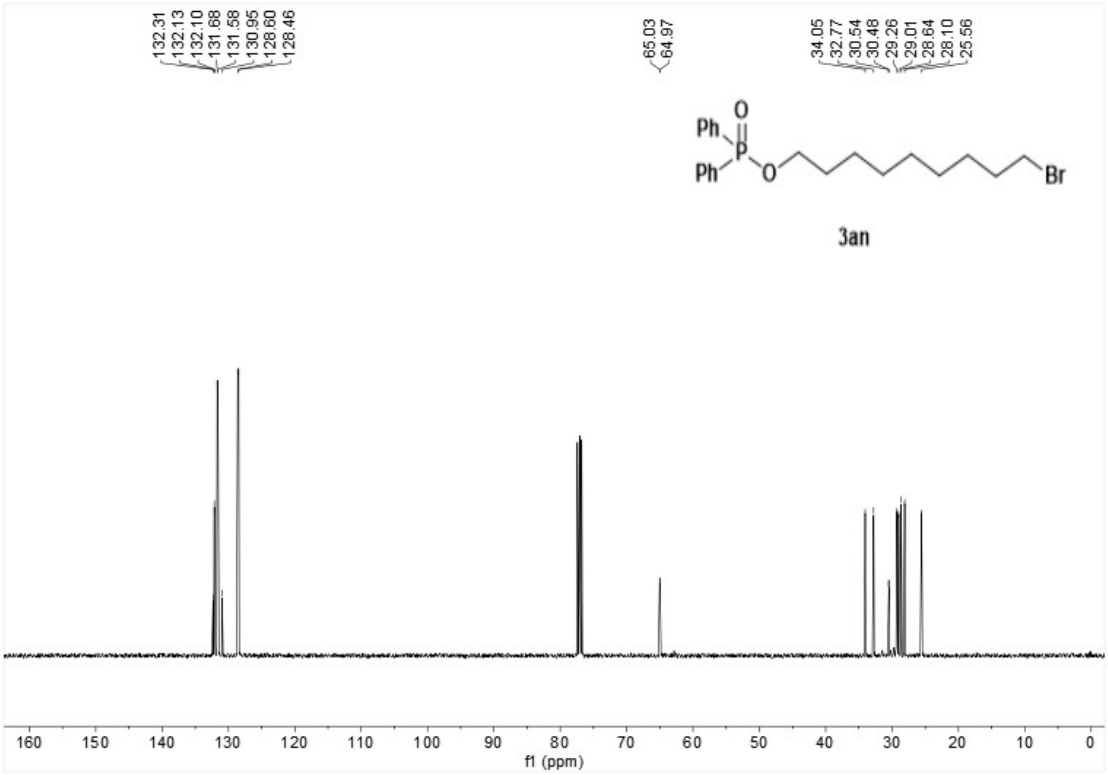
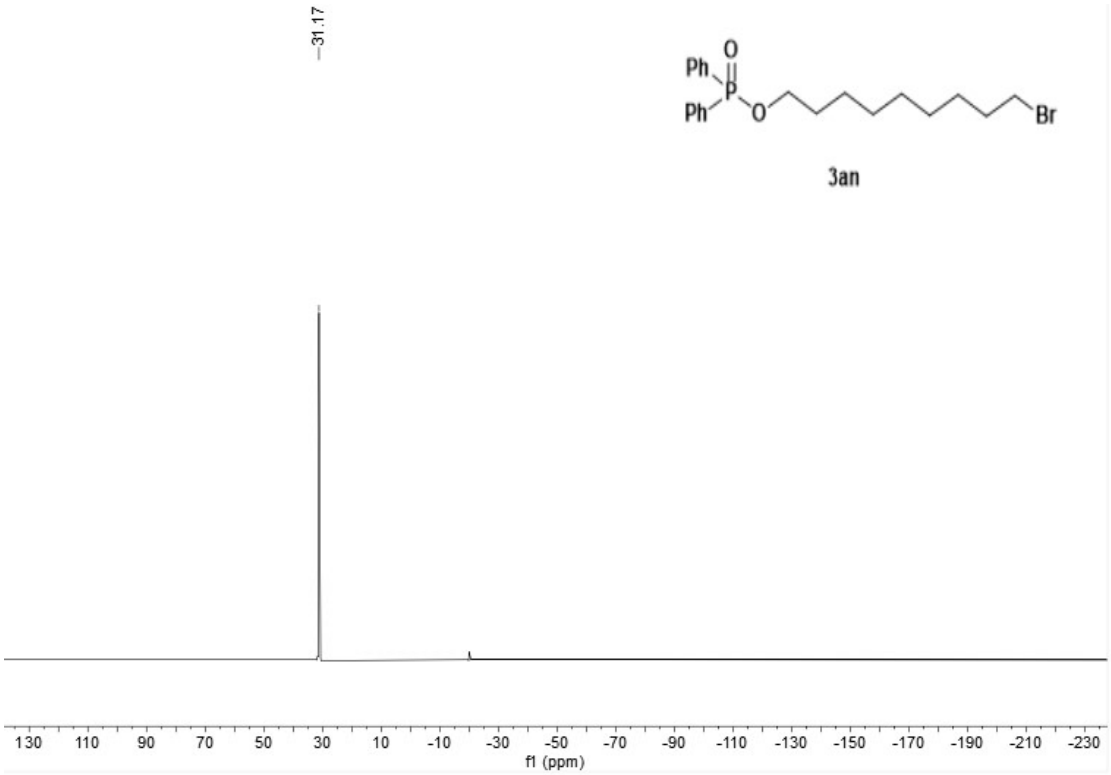
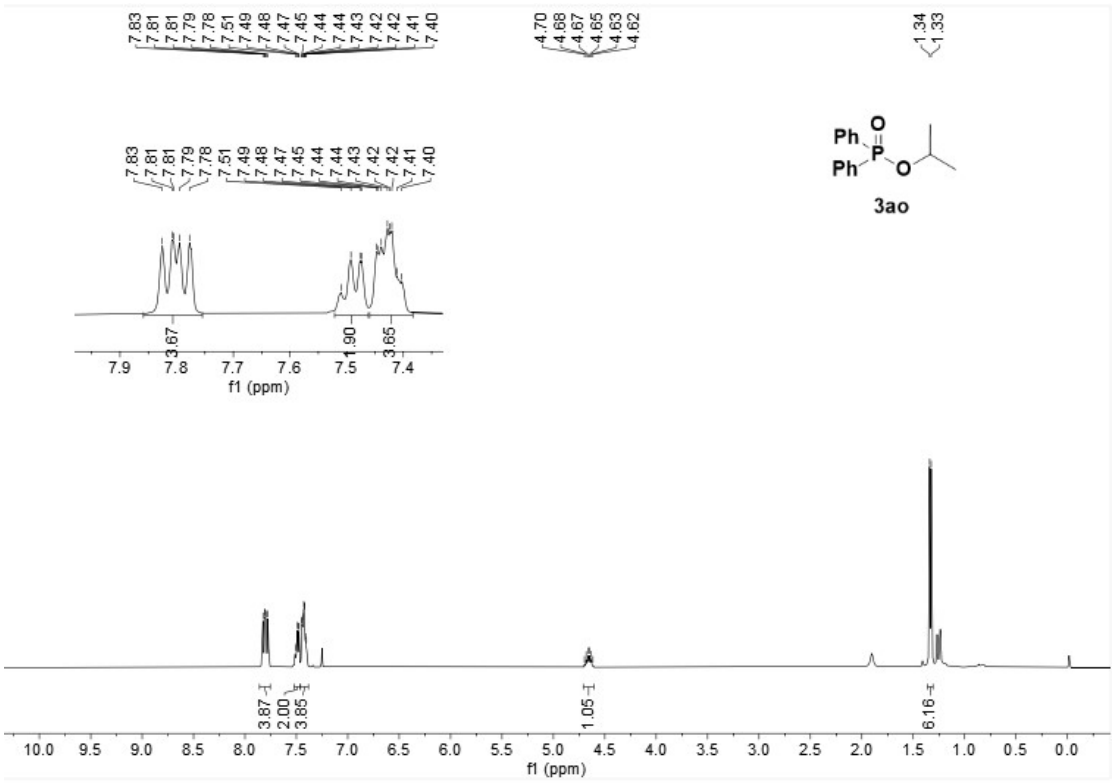
132.16
131.67
131.57
130.85
128.63
128.50
64.80
64.74
33.76
32.58
30.39
30.33
27.69
24.87
Ph
Ph
O
P
O
Br
3am
f1 (ppm)

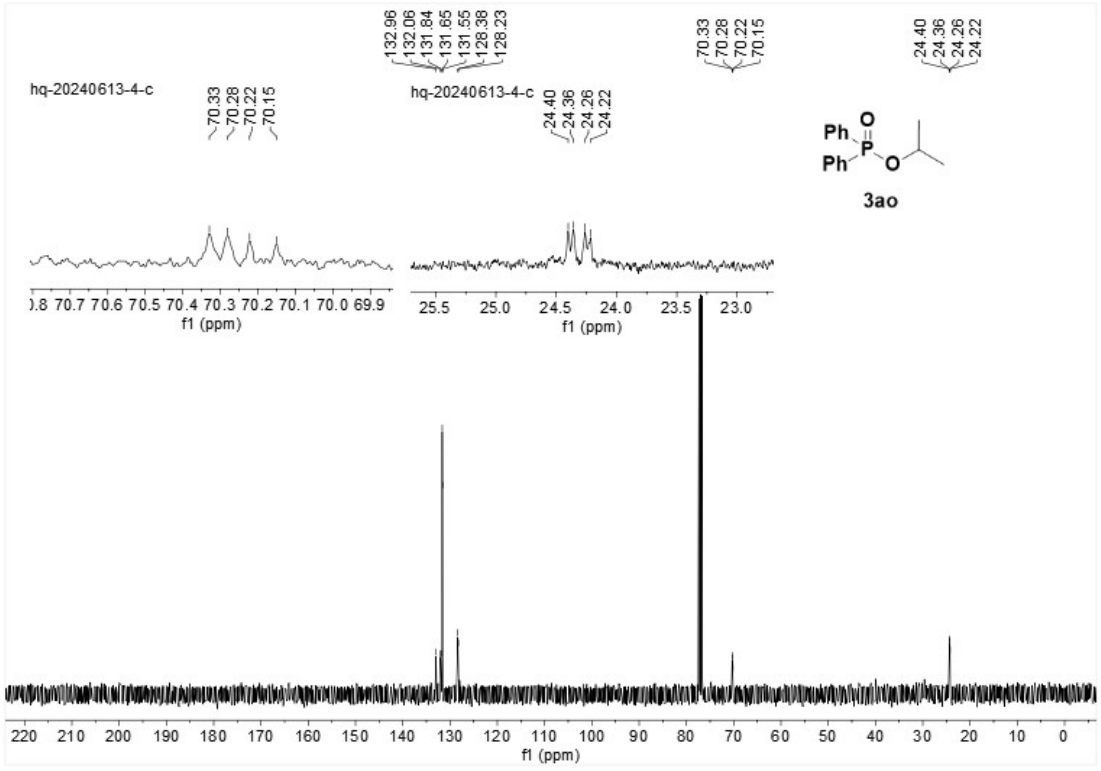

31.35
Ph
Ph
O
P
O
Br
3am
50 130 110 90 70 50 30 10 -10 -30 -50 -70 -90 -110 -130 -150 -170 -190 -210 -230 -25
f1 (ppm)

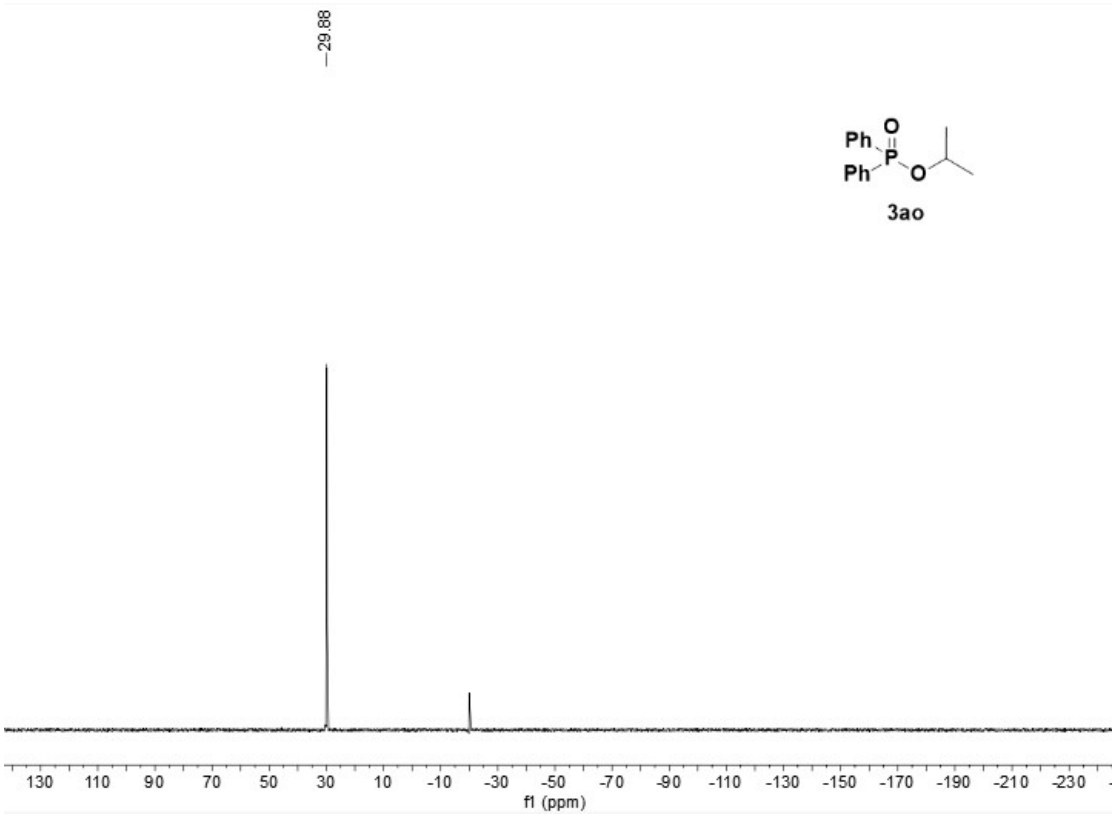

7.81 7.79 7.79 7.78 7.76 7.76 7.51 7.51 7.49 7.47 7.47 7.44 7.44 7.43 7.42 7.42 7.42 7.41 7.40 7.40
4.02 4.00 3.98 3.97 3.38 3.37 3.35
1.84 1.82 1.81 1.79 1.77 1.73 1.71 1.69 1.67 1.66 1.37 1.36 1.25
Ph
Ph
O
P
O
Br
3an
2.14 2.03 4.11 6.14
1.9 1.8 1.7 1.6 1.5 1.4 1.3 1.2
f1 (ppm)
3.85 2.05 3.83 2.00 2.12 2.14 2.03 4.11 6.14
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
f1 (ppm)

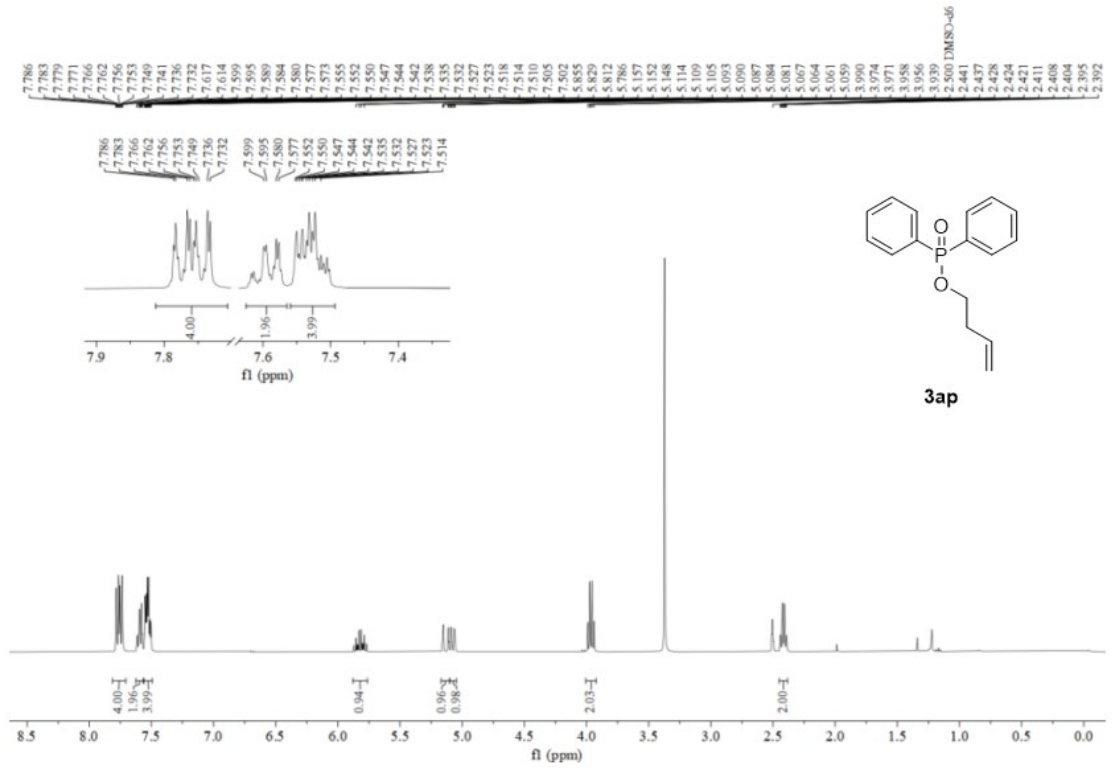

132.31
132.13
132.10
131.68
131.58
130.95
128.60
128.46
65.03
64.97
34.05
32.77
30.54
30.48
29.26
29.01
28.64
28.10
25.56
Ph
O
P
Ph
O
Br
3an
160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

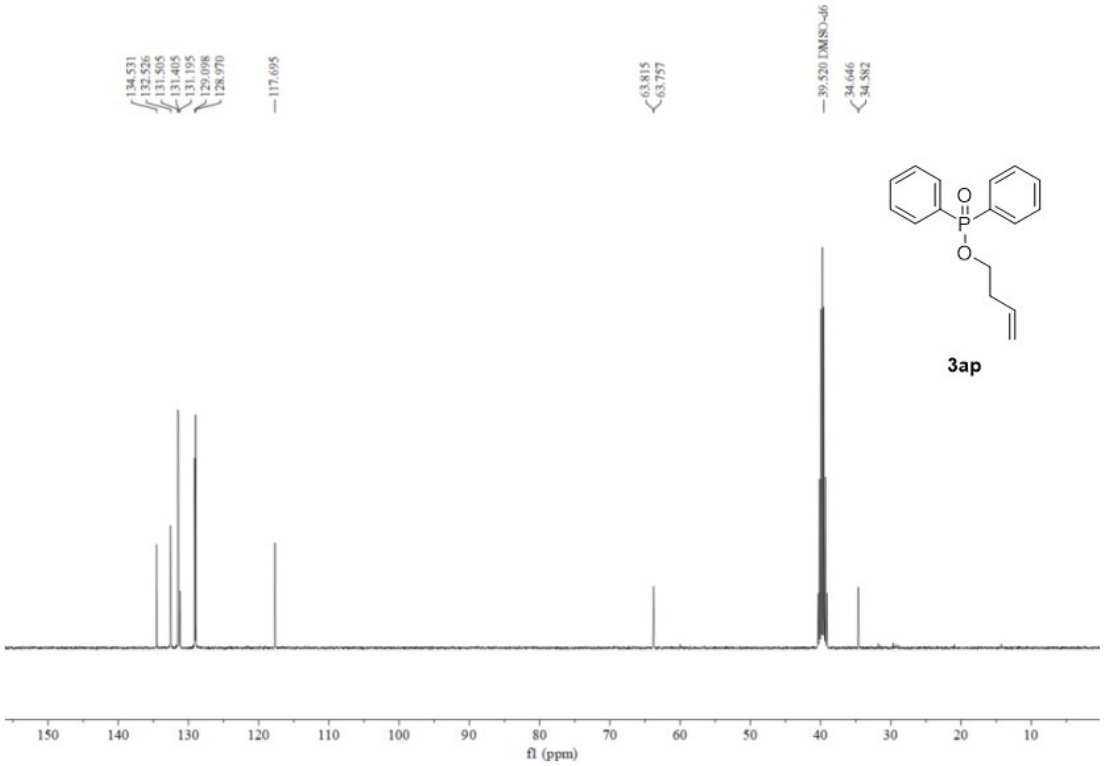

31.17
Ph
O
P
Ph
O
Br
3an
130 110 90 70 50 30 10 -10 -30 -50 -70 -90 -110 -130 -150 -170 -190 -210 -230
f1 (ppm)

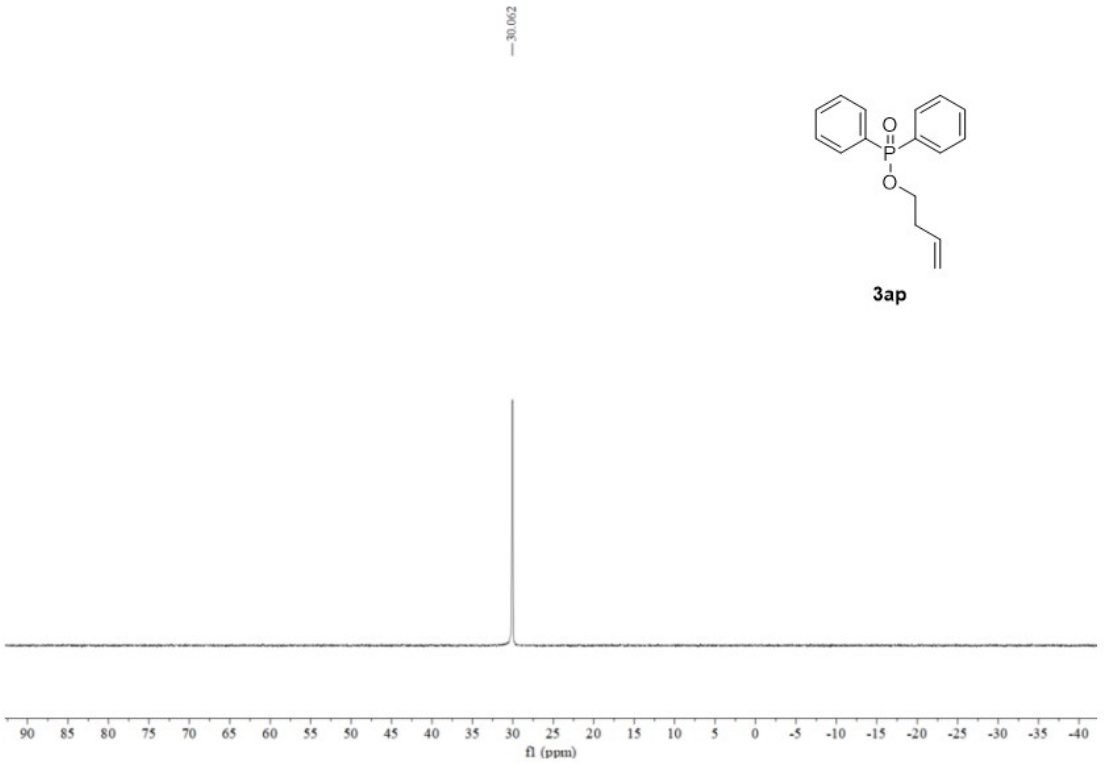

7.83 7.81 7.81 7.79 7.78 7.51 7.49 7.48 7.47 7.45 7.44 7.44 7.43 7.42 7.42 7.41 7.40
4.70 4.68 4.67 4.65 4.63 4.62
1.34 1.33
Ph O P Ph O
3ao
3.67 1.90 3.85
7.9 7.8 7.7 7.6 7.5 7.4
f1 (ppm)
3.87 2.00 3.85 1.05 6.16
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

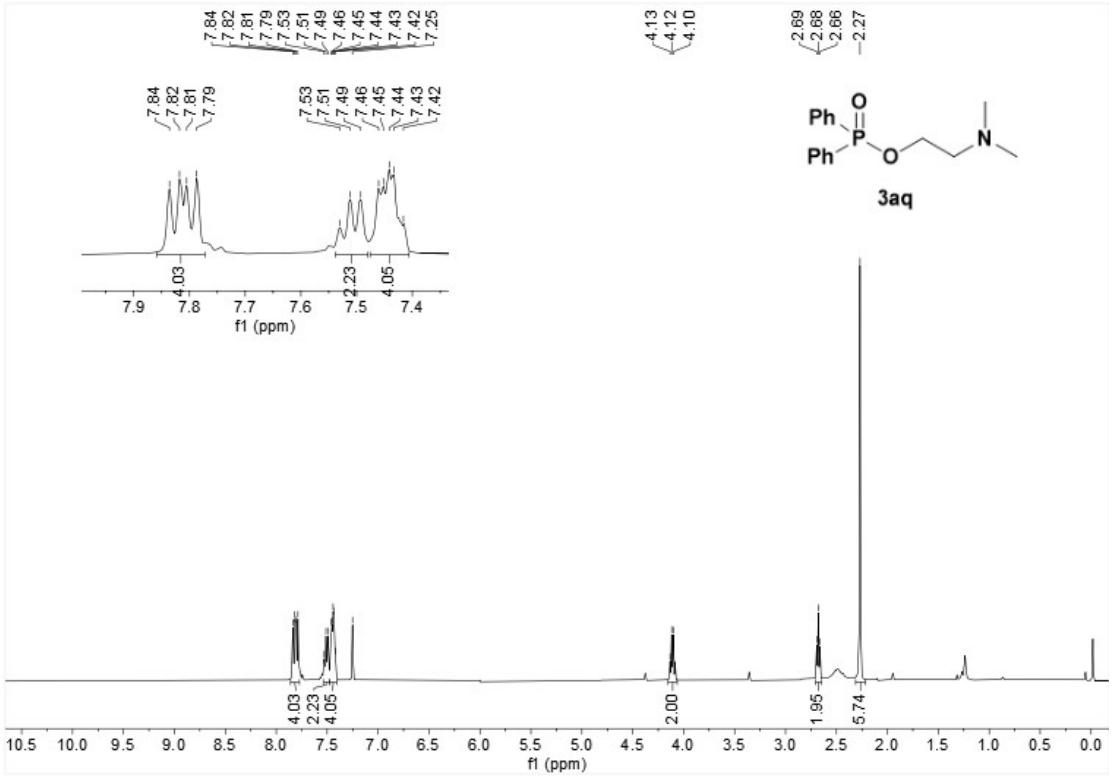

132.96 132.06 131.84 131.65 131.55 128.38 128.23
70.33 70.28 70.22 70.15
24.40 24.36 24.26 24.22
hq-20240613-4-c
hq-20240613-4-c
Ph O P Ph O
3ao
70.8 70.7 70.6 70.5 70.4 70.3 70.2 70.1 70.0 69.9
f1 (ppm)
25.5 25.0 24.5 24.0 23.5 23.0
f1 (ppm)
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

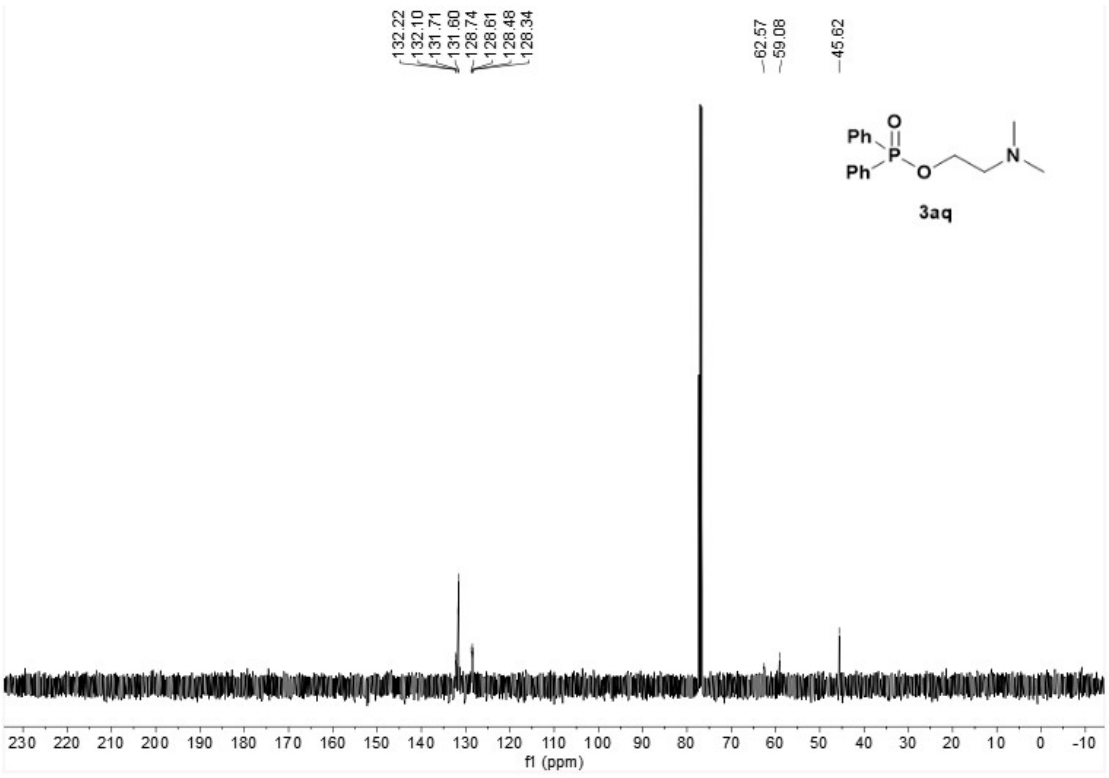

29.88
Ph
O
P
Ph
O
3ao
130 110 90 70 50 30 10 -10 -30 -50 -70 -90 -110 -130 -150 -170 -190 -210 -230
f1 (ppm)

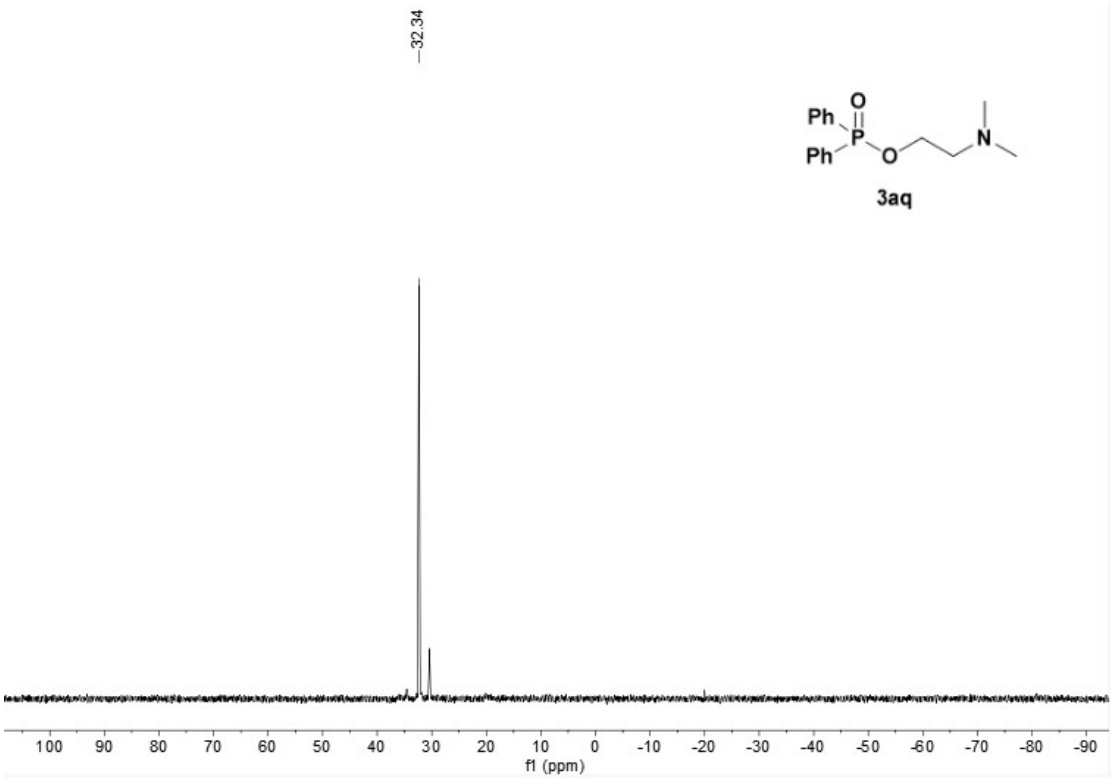

7.786 7.783 7.779 7.771 7.766 7.762 7.756 7.753 7.749 7.741 7.736 7.732 7.617 7.614 7.599 7.595 7.589 7.584 7.580 7.577 7.573 7.555 7.552 7.550 7.547 7.544 7.542 7.538 7.535 7.532 7.527 7.523 7.518 7.514 7.510 7.505 7.502 5.855 5.829 5.812 5.786 5.157 5.152 5.148 5.114 5.109 5.105 5.093 5.090 5.087 5.084 5.081 5.067 5.064 5.061 5.059 3.990 3.974 3.971 3.958 3.956 3.939 2.500 DMSO-d6 2.441 2.437 2.428 2.424 2.421 2.411 2.408 2.404 2.395 2.392
4.00
1.96
3.99
7.9 7.8 7.6 7.5 7.4
f1 (ppm)
O
P
O
3ap
4.00
1.96
3.99
0.94
0.96
0.98
2.03
2.00
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)

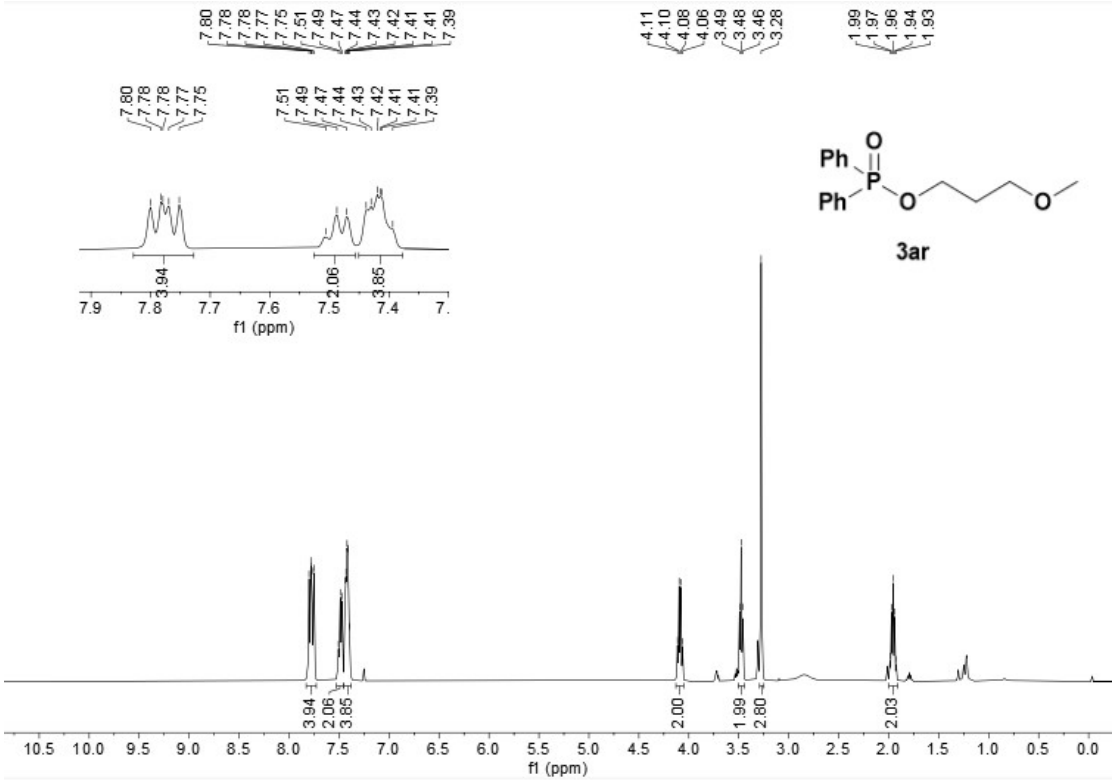

134.531
132.526
131.505
131.405
131.195
129.098
128.970
117.695
63.815
63.757
39.520 DMSO-d6
34.646
34.582
3ap
150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
f1 (ppm)

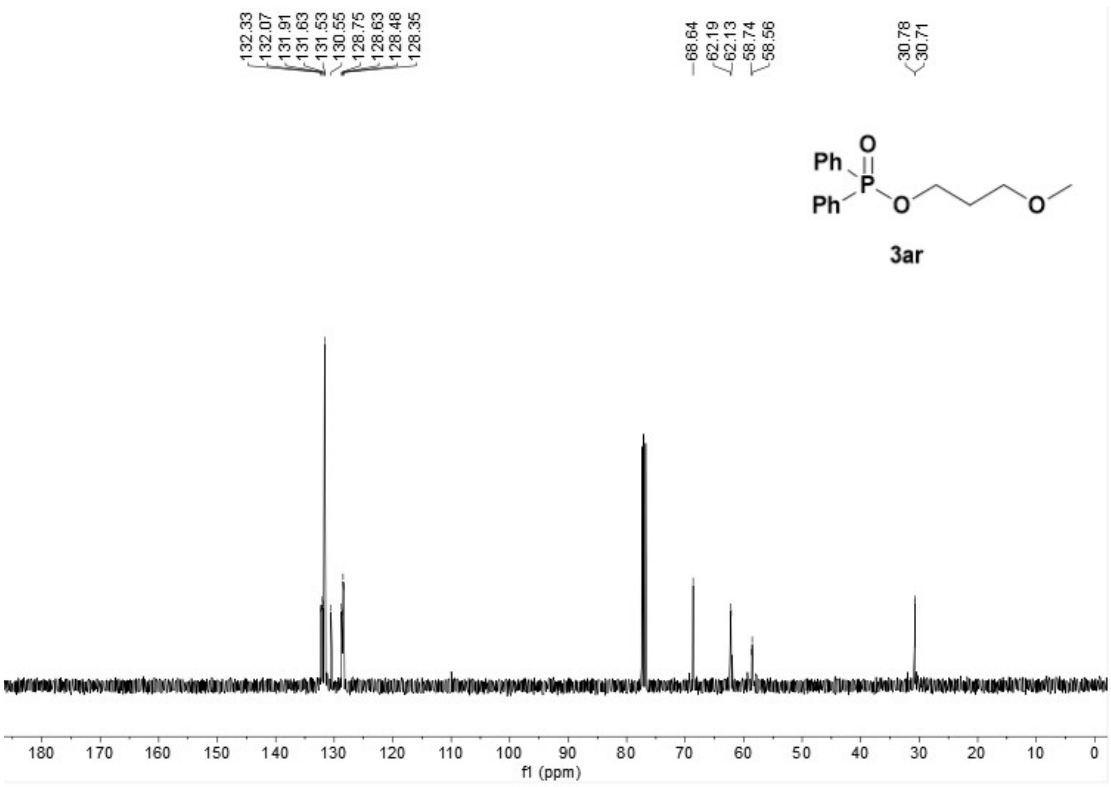

30.062
3ap
90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0 -5 -10 -15 -20 -25 -30 -35 -40
f1 (ppm)

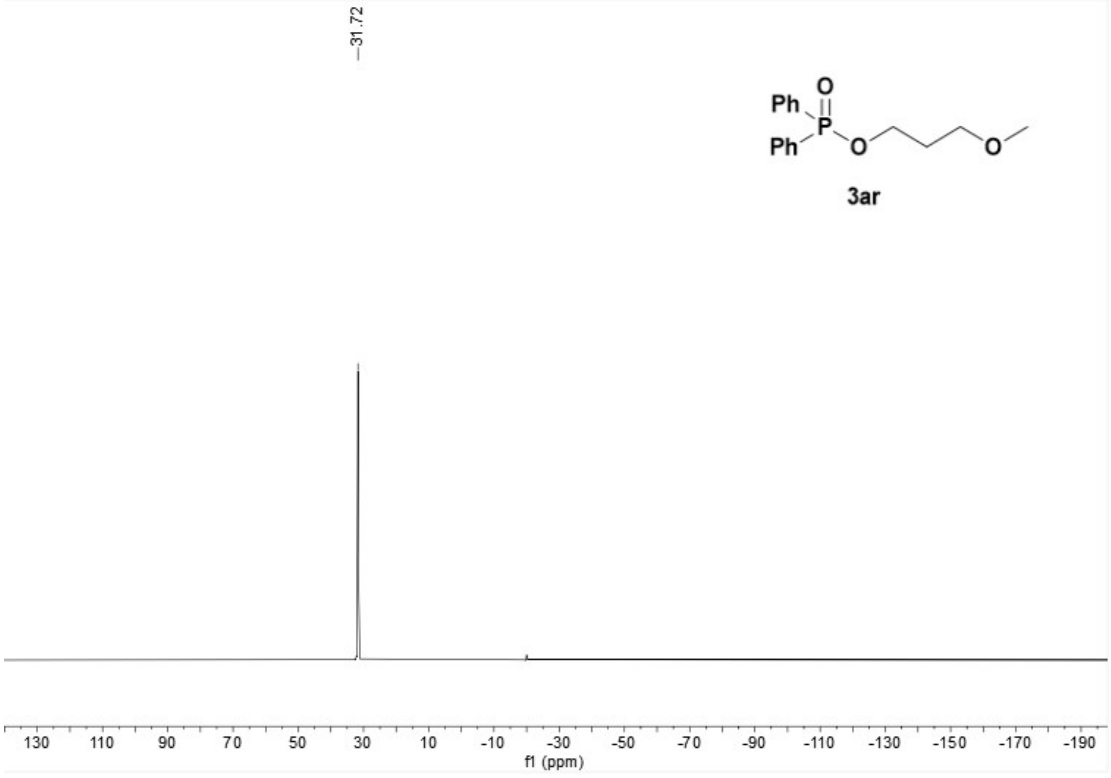

7.84
7.82
7.81
7.79
7.53
7.51
7.49
7.46
7.45
7.44
7.43
7.42
7.25
4.13
4.12
4.10
2.69
2.68
2.66
2.27
Ph
O
P
Ph
O
N
3aq
4.03
2.23
4.05
2.00
1.95
5.74
f1 (ppm)

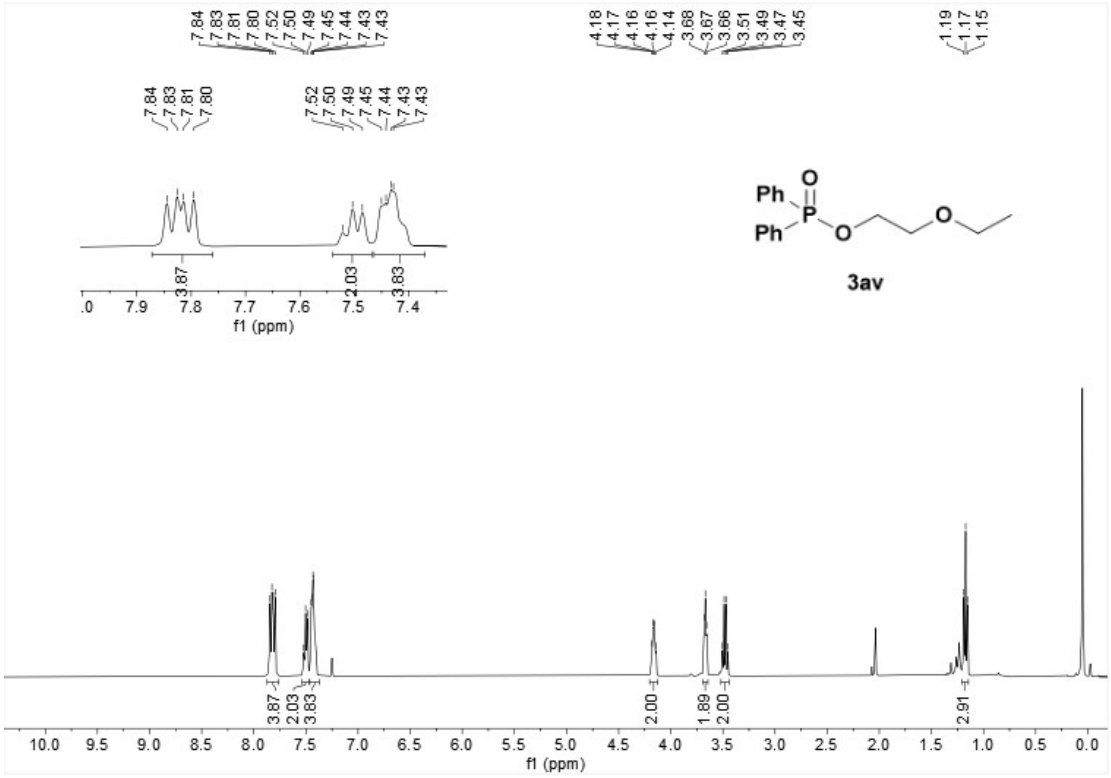

132.22
132.10
131.71
131.60
128.74
128.61
128.48
128.34
62.57
59.08
45.62
Ph
O
P
Ph
O
N
3aq
f1 (ppm)

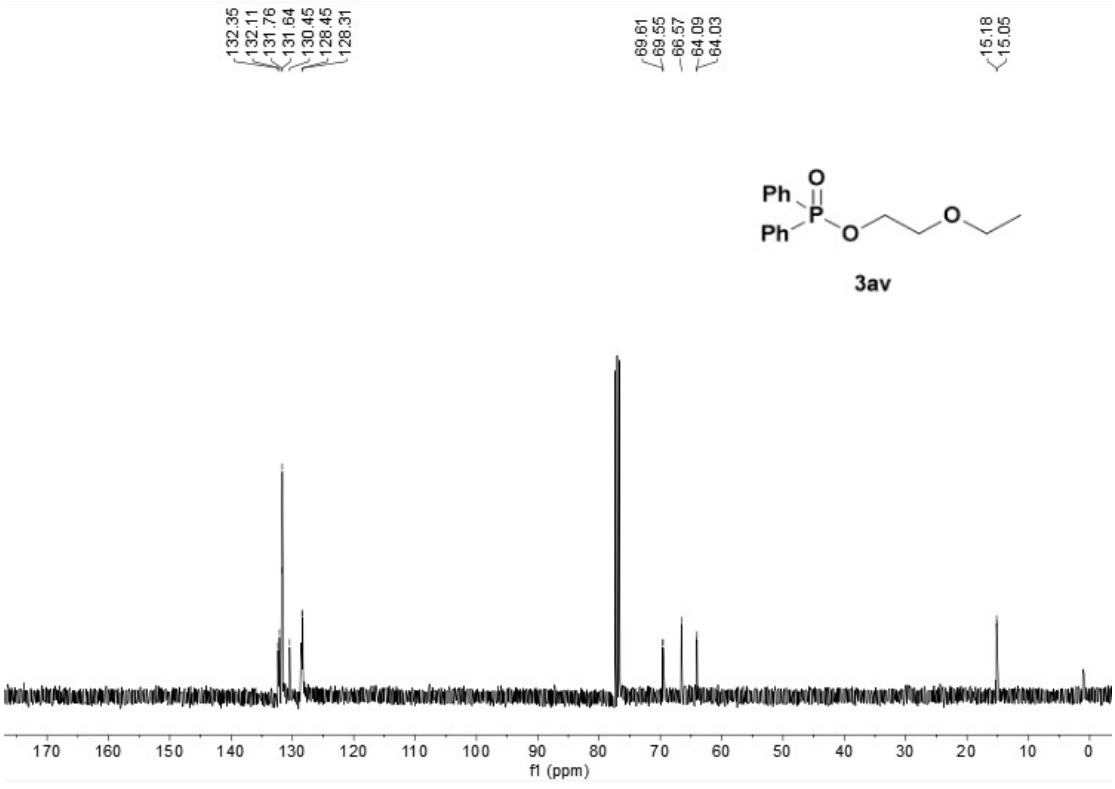

32.34
Ph
Ph
O
P
O
N
3aq
100 90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90
f1 (ppm)

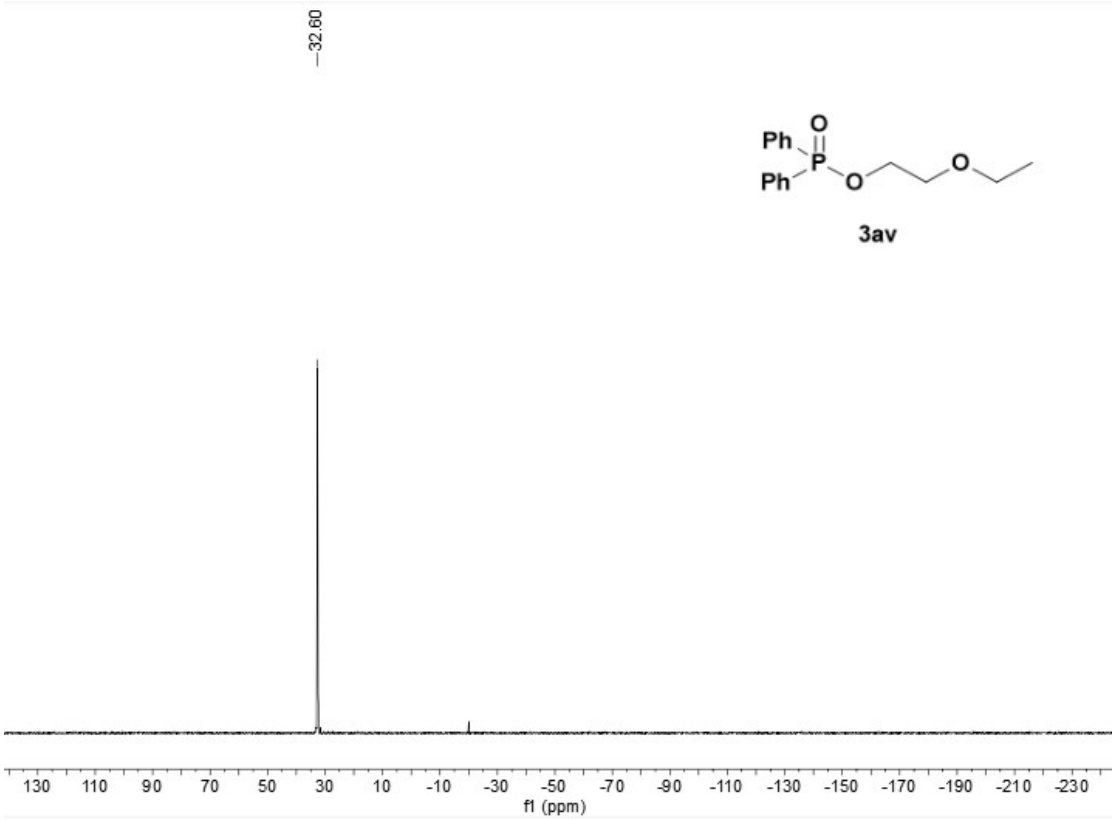

7.80 7.78 7.78 7.77 7.75 7.51 7.49 7.47 7.44 7.43 7.42 7.41 7.41 7.39
4.11 4.10 4.08 4.06 3.49 3.48 3.46 3.28
1.99 1.97 1.96 1.94 1.93
Ph
Ph
O
P
O
O
3ar
3.94 2.06 3.85
2.00 1.99 2.80 2.03
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

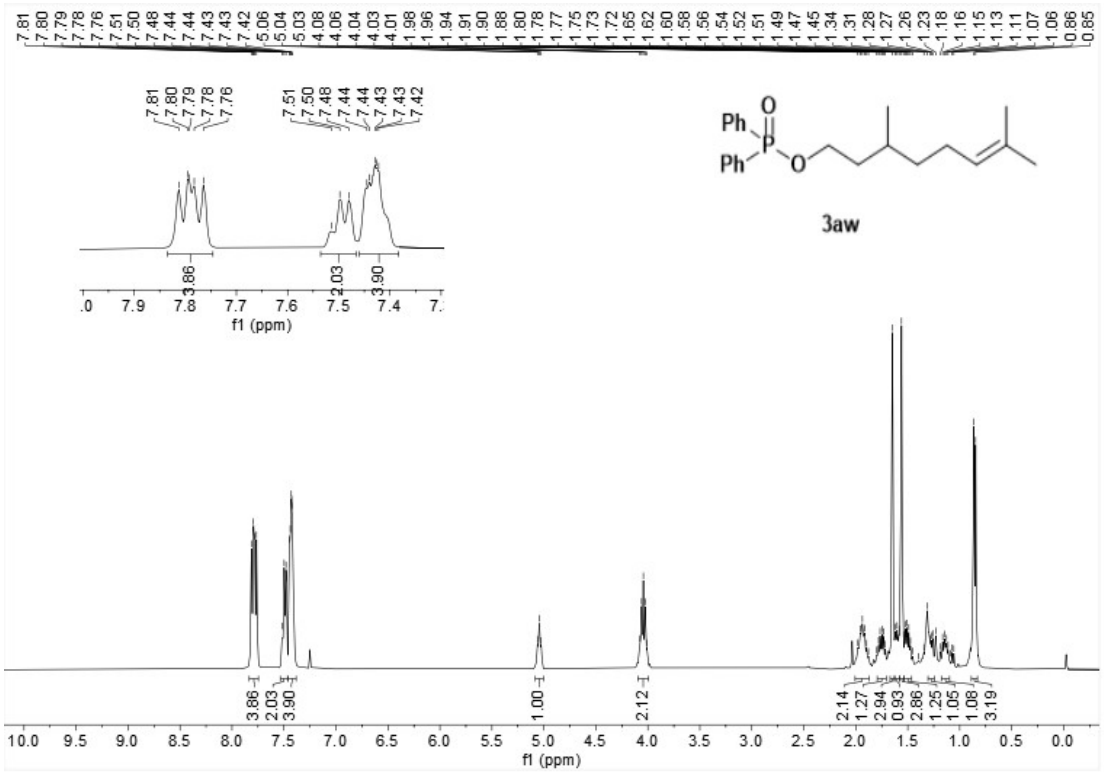

132.33
132.07
131.91
131.63
131.53
130.55
128.75
128.63
128.48
128.35
68.64
62.19
62.13
58.74
58.56
30.78
30.71
Ph
O
P
Ph
O
O
3ar
180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

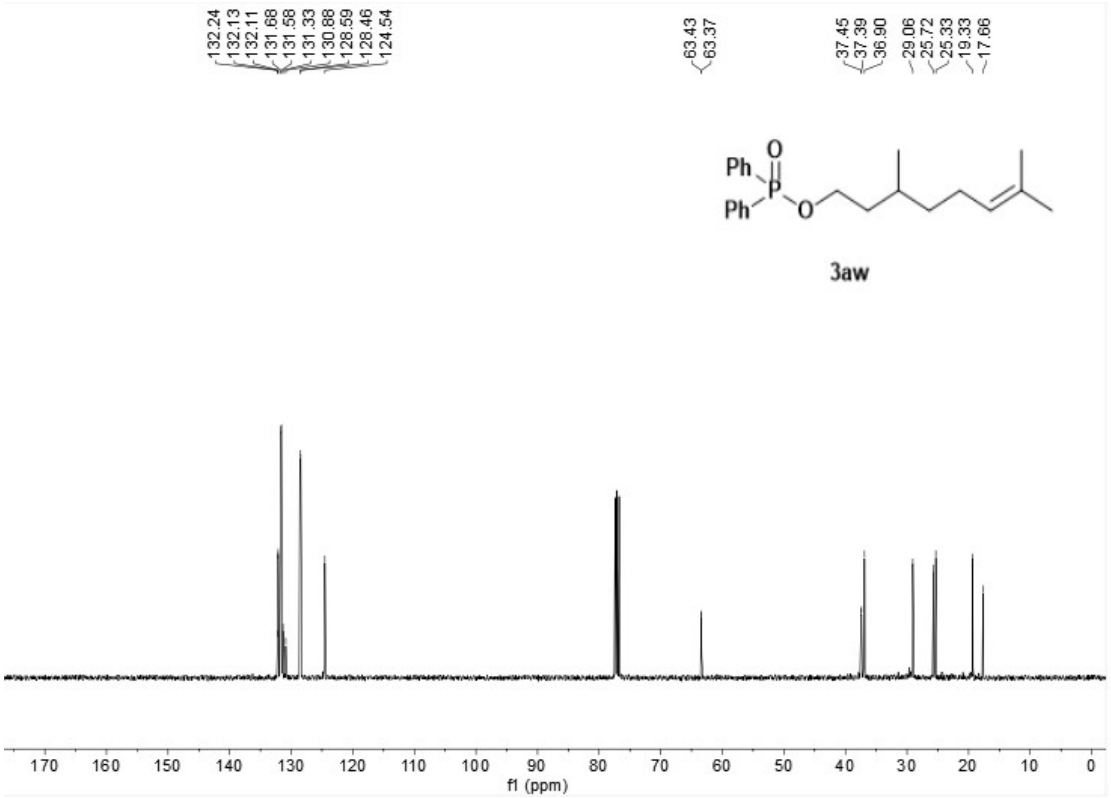

31.72
Ph
O
P
Ph
O
O
3ar
130 110 90 70 50 30 10 -10 -30 -50 -70 -90 -110 -130 -150 -170 -190
f1 (ppm)

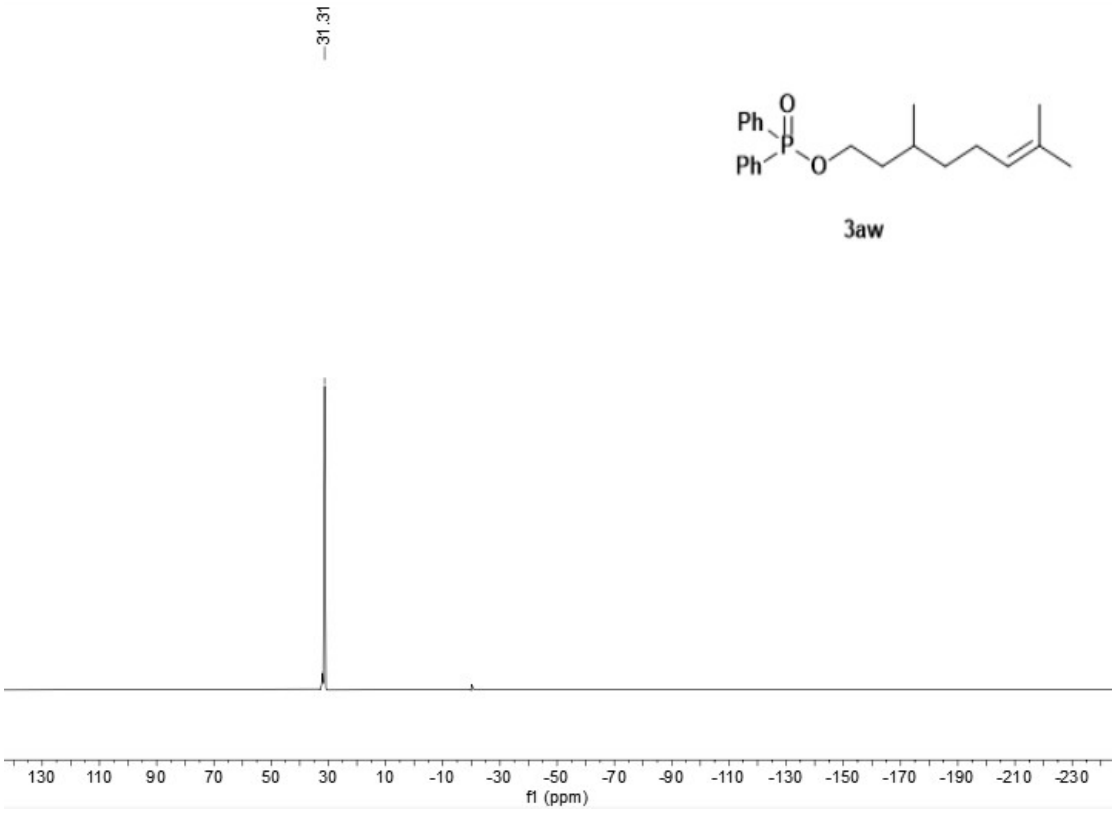

7.84
7.83
7.81
7.80
7.52
7.50
7.49
7.45
7.44
7.43
7.43
4.18
4.17
4.16
4.16
4.14
3.68
3.67
3.66
3.51
3.49
3.47
3.45
1.19
1.17
1.15
3.87
2.03
3.83
f1 (ppm)
Ph
O
P
Ph
O
O
3av
3.87
2.03
3.83
2.00
1.89
2.00
2.91
f1 (ppm)

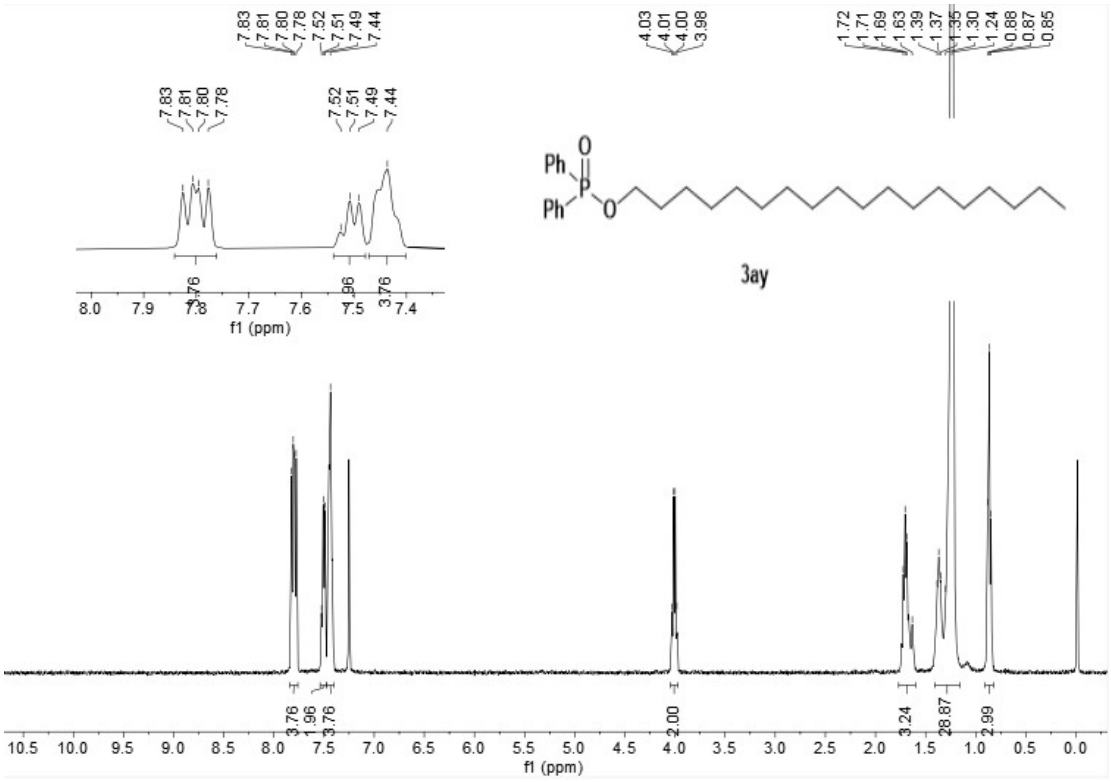

132.35
132.11
131.76
131.64
130.45
128.45
128.31
69.61
69.55
66.57
64.09
64.03
15.18
15.05
Ph
O
P
Ph
O
O
3av
f1 (ppm)

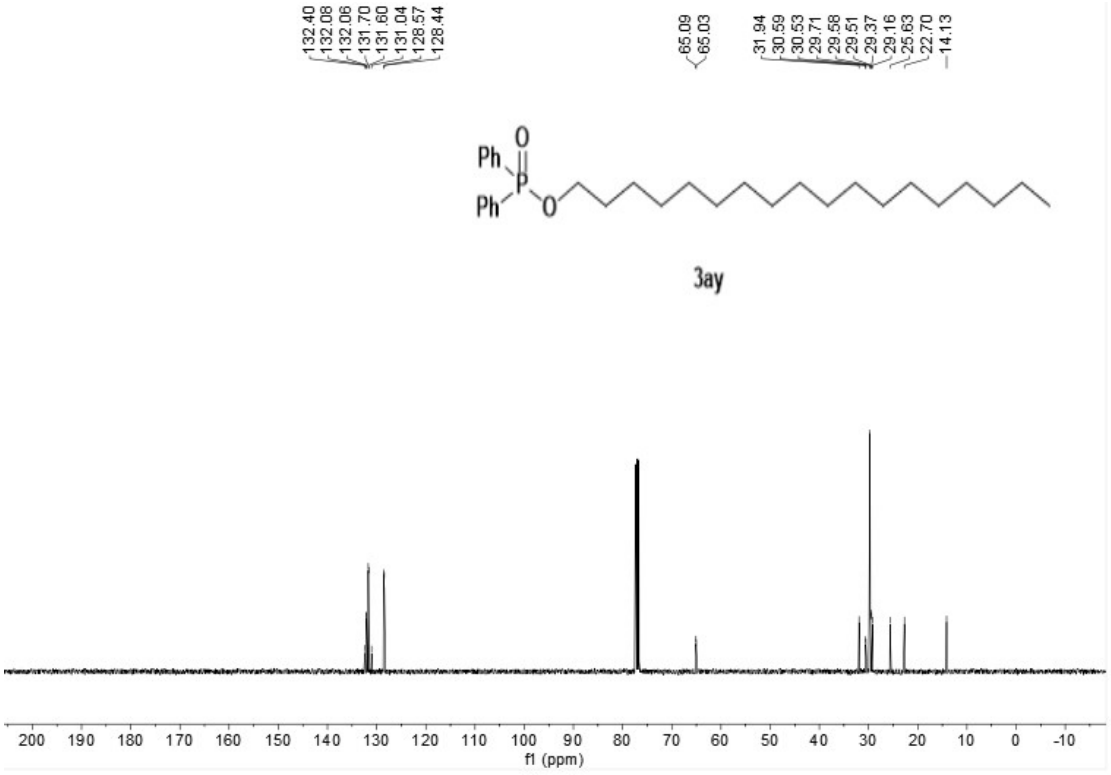

32.60
Ph
Ph
O
P
O
O
3av
f1 (ppm)

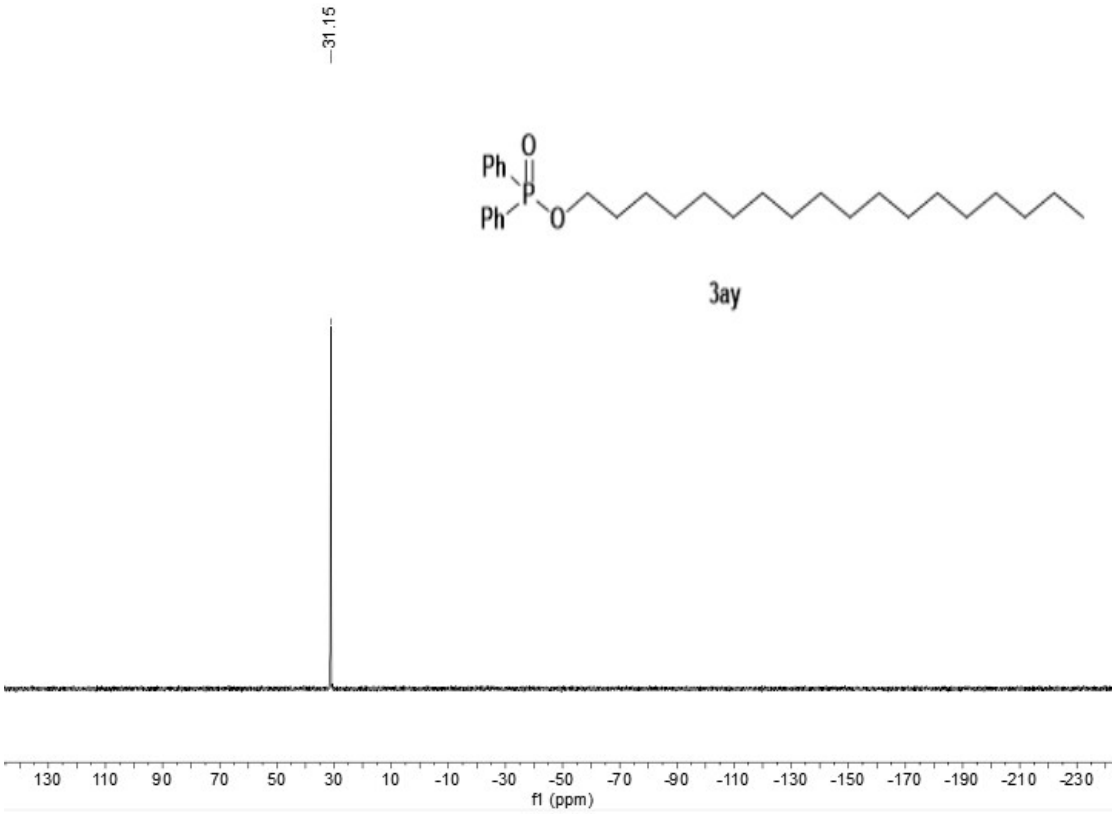

Ph
Ph
O
P
O
3aw
3.86
2.03
3.90
f1 (ppm)
1.00
2.12
f1 (ppm)

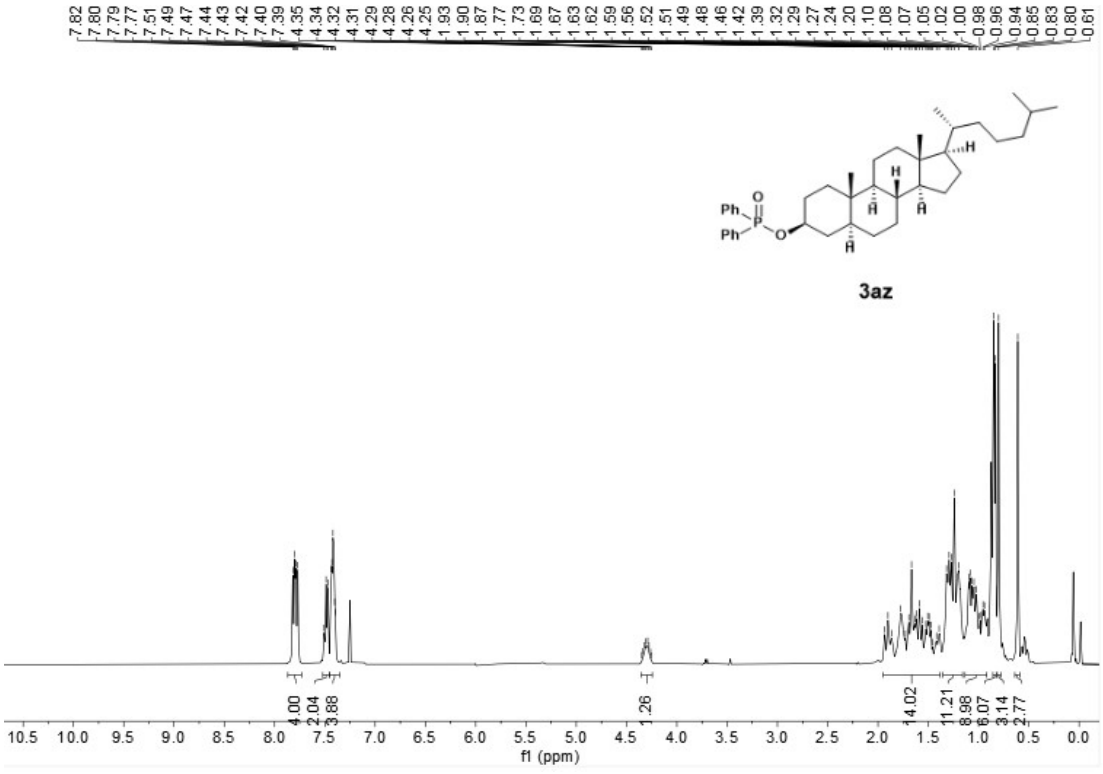

132.24
132.13
132.11
131.68
131.58
131.33
130.88
128.59
128.46
124.54
63.43
63.37
37.45
37.39
36.90
29.06
25.72
25.33
19.33
17.66
Ph
O
P
Ph
O
3aw
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

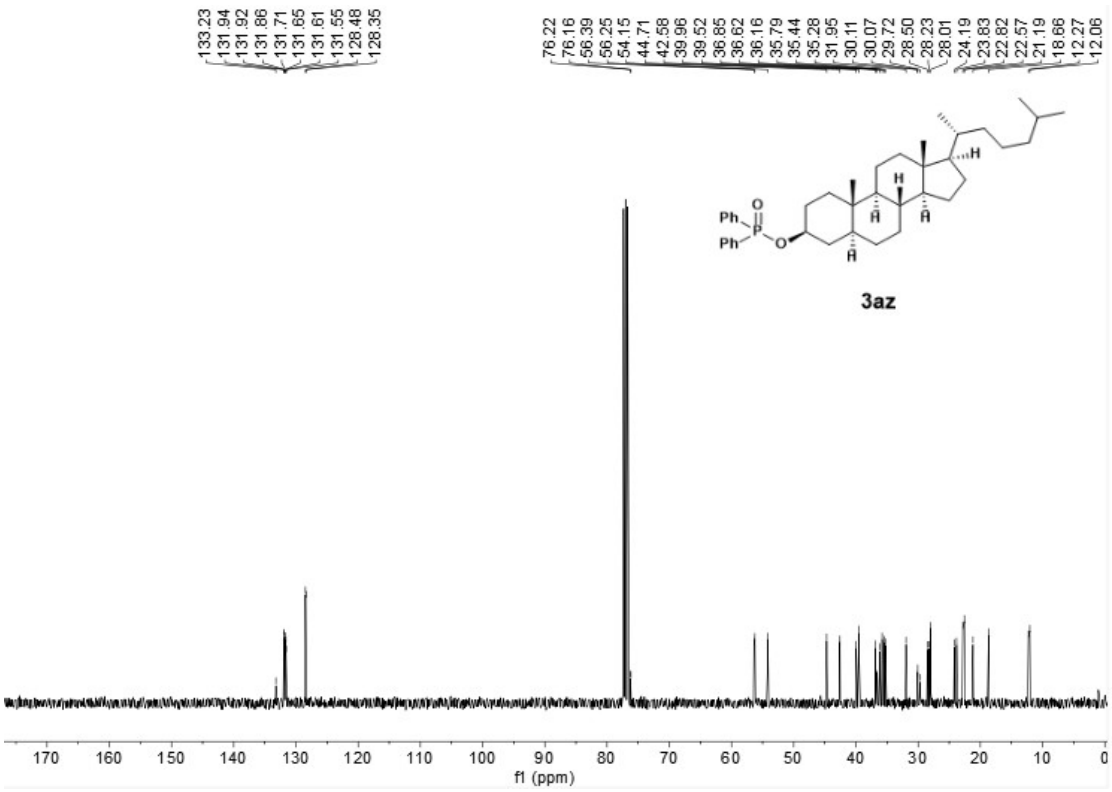

31.31
Ph
O
P
Ph
O
3aw
130 110 90 70 50 30 10 -10 -30 -50 -70 -90 -110 -130 -150 -170 -190 -210 -230
f1 (ppm)


7.83
7.81
7.80
7.78
7.52
7.51
7.49
7.44
4.03
4.01
4.00
3.98
1.72
1.71
1.69
1.63
1.39
1.37
1.30
1.24
0.88
0.87
0.85
Ph
O
P
Ph
O
3ay
3.76
1.96
3.76
2.00
3.24
28.87
2.99
f1 (ppm)


132.40
132.08
132.06
131.70
131.60
131.04
128.57
128.44
65.09
65.03
31.94
30.59
30.53
29.71
29.58
29.51
29.37
29.16
25.63
22.70
14.13
Ph
O
P
Ph
O
3ay
f1 (ppm)


31.15
Ph
O
P
Ph
O
3ay
130 110 90 70 50 30 10 -10 -30 -50 -70 -90 -110 -130 -150 -170 -190 -210 -230
f1 (ppm)


7.82 7.80 7.79 7.77 7.51 7.49 7.47 7.44 7.43 7.42 7.40 7.39 4.35 4.34 4.32 4.31 4.29 4.28 4.26 4.25 1.93 1.90 1.87 1.77 1.73 1.69 1.67 1.63 1.62 1.59 1.56 1.52 1.51 1.49 1.48 1.46 1.42 1.39 1.32 1.29 1.27 1.24 1.20 1.10 1.08 1.07 1.05 1.02 1.00 0.98 0.96 0.94 0.85 0.83 0.80 0.61
Ph
O
P
Ph
O
H
H
H
3az
4.00 2.04 3.88 1.26 14.02 11.21 8.98 6.07 3.14 2.77
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
f1 (ppm)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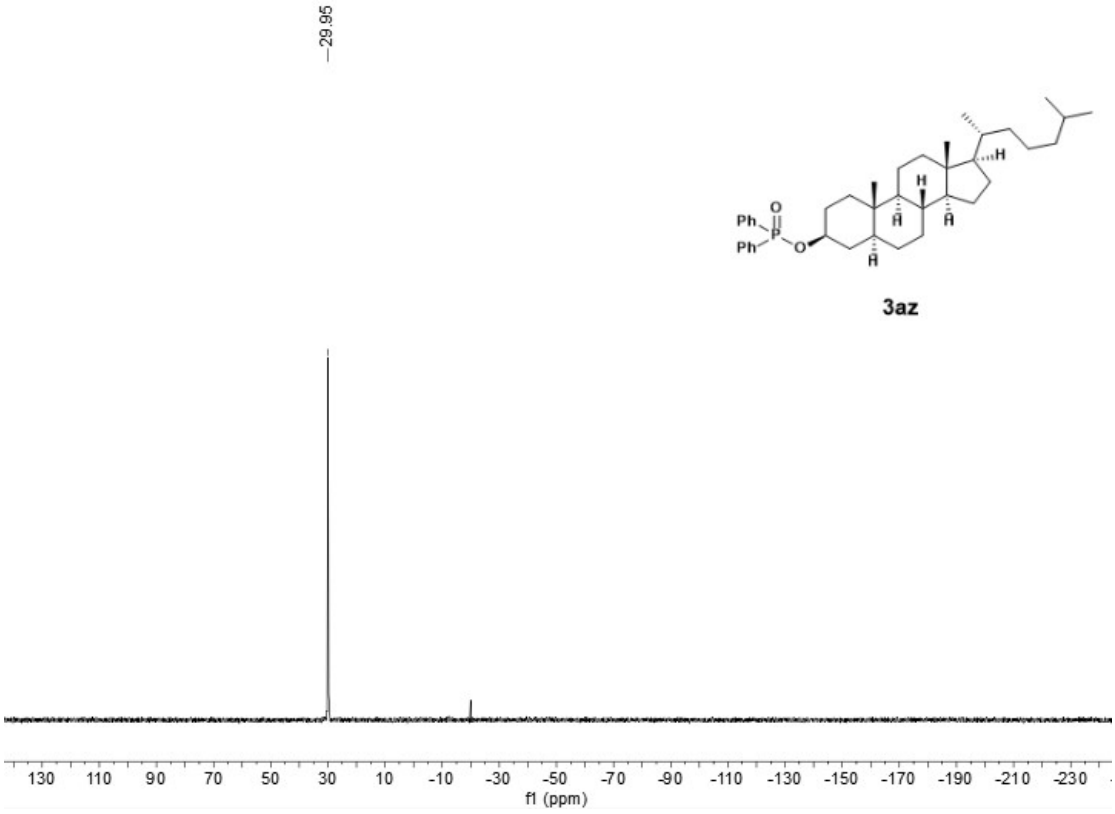
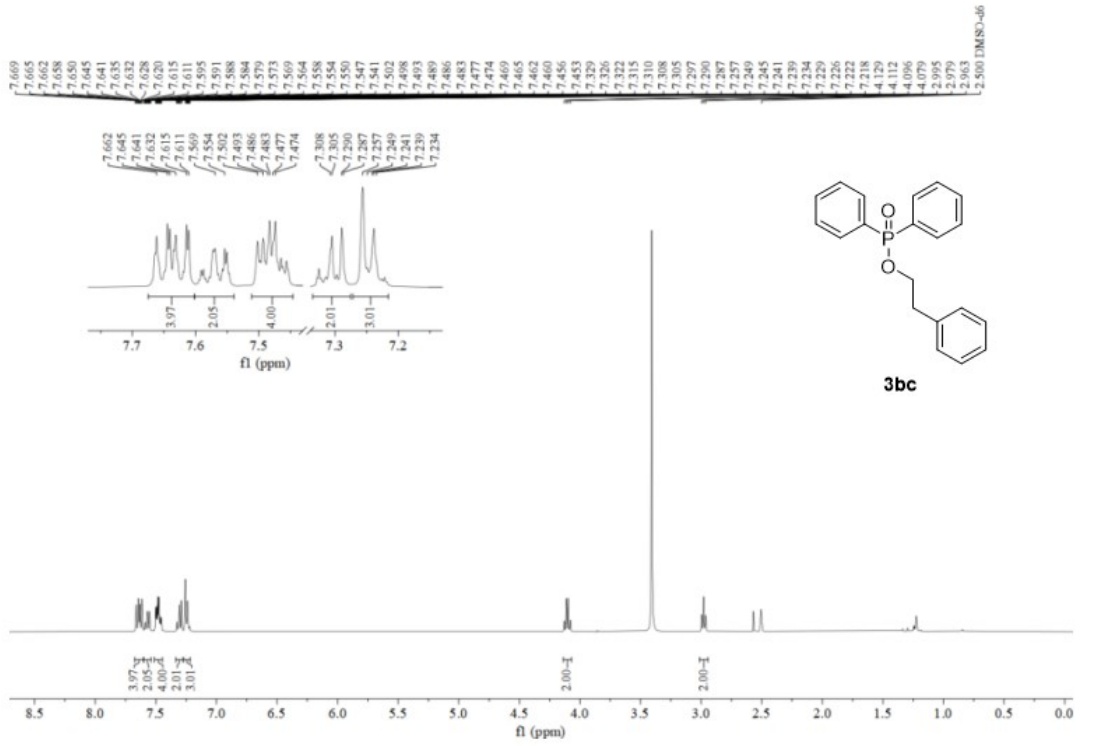
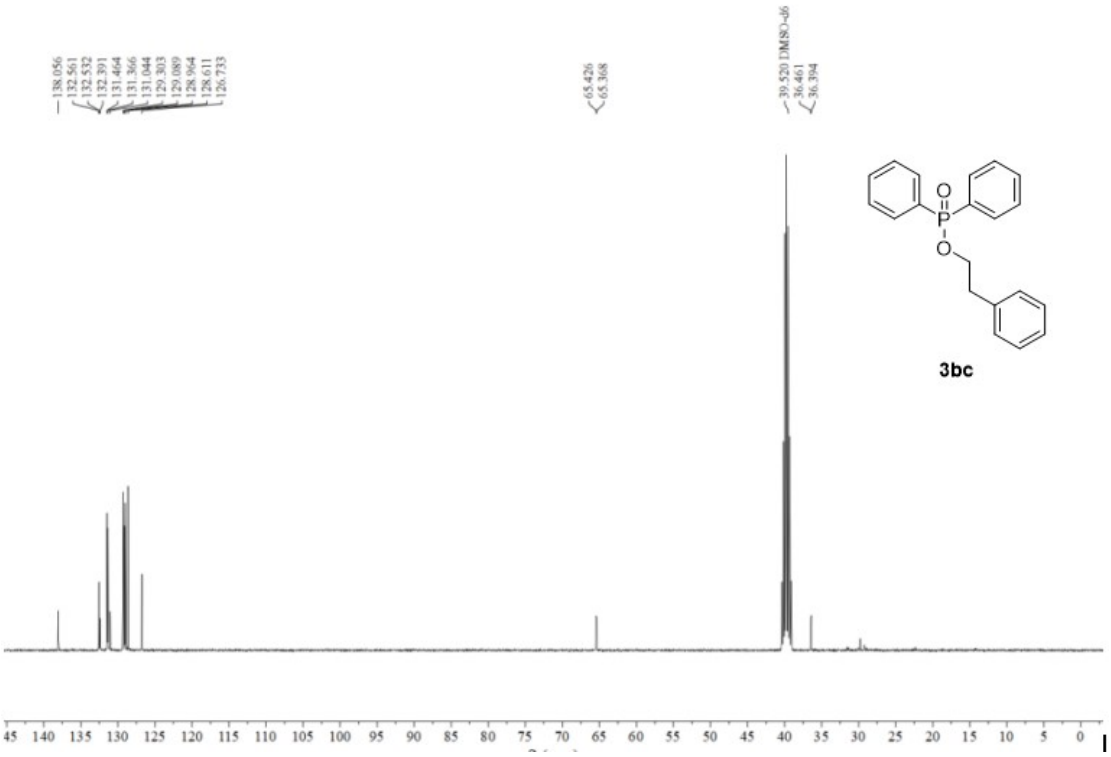
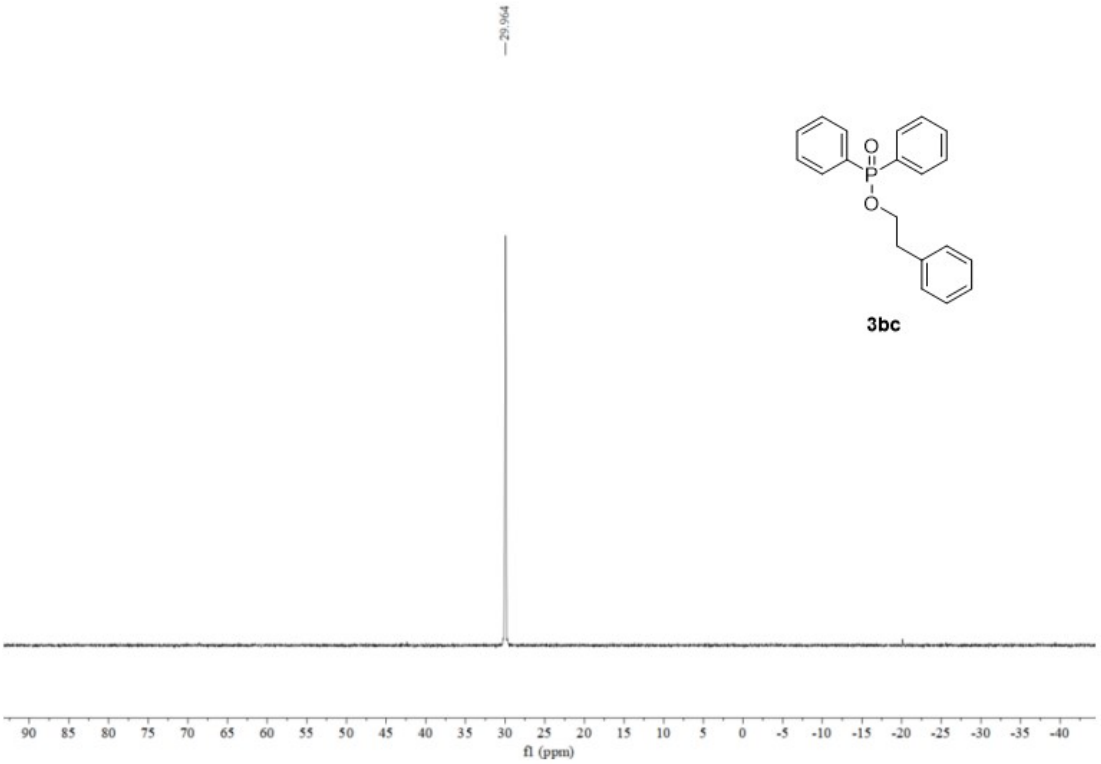
131.94
131.92
131.86
131.71
131.65
131.61
131.55
128.48
128.35
76.22
76.16
56.39
56.25
54.15
44.71
42.58
39.96
39.52
36.85
36.62
36.16
35.79
35.44
35.28
31.95
30.11
30.07
29.72
28.50
28.23
28.01
24.19
23.83
22.82
22.57
21.19
18.66
12.27
12.06
Ph
Ph
O
P
O
H
H
H
H
3az
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

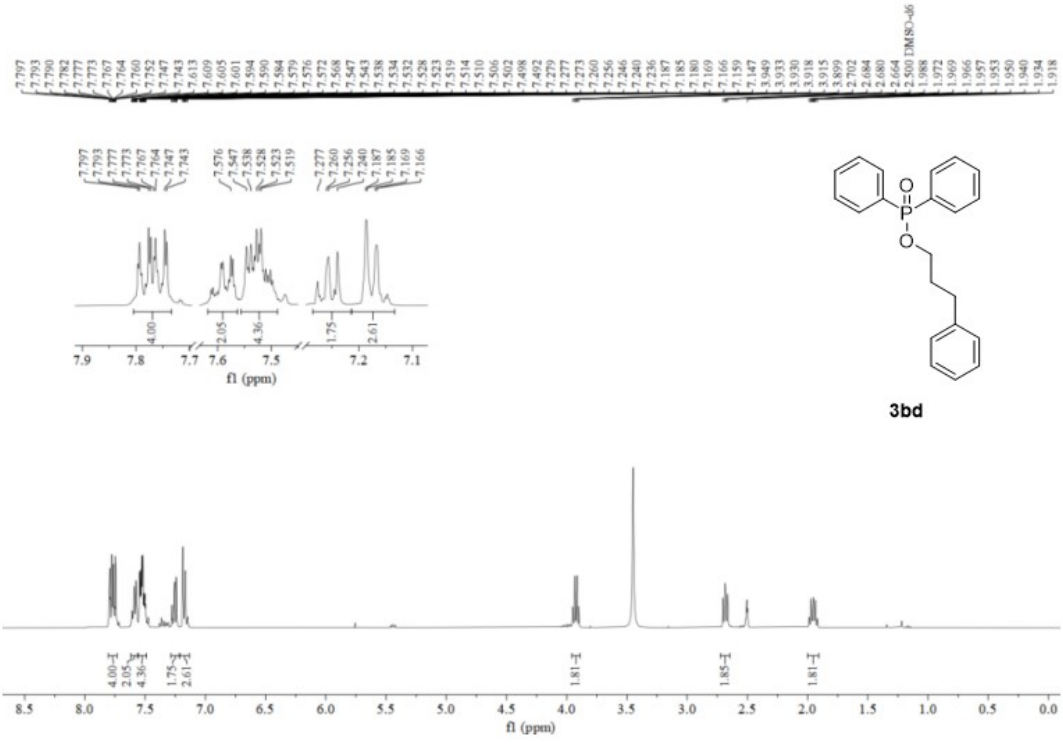

29.95
Ph
Ph
O
P
O
H
H
H
H
3az
130 110 90 70 50 30 10 -10 -30 -50 -70 -90 -110 -130 -150 -170 -190 -210 -230
f1 (ppm)


3bc
fl (ppm)


3bc


29.964
90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0 -5 -10 -15 -20 -25 -30 -35 -40
f1 (ppm)

3bc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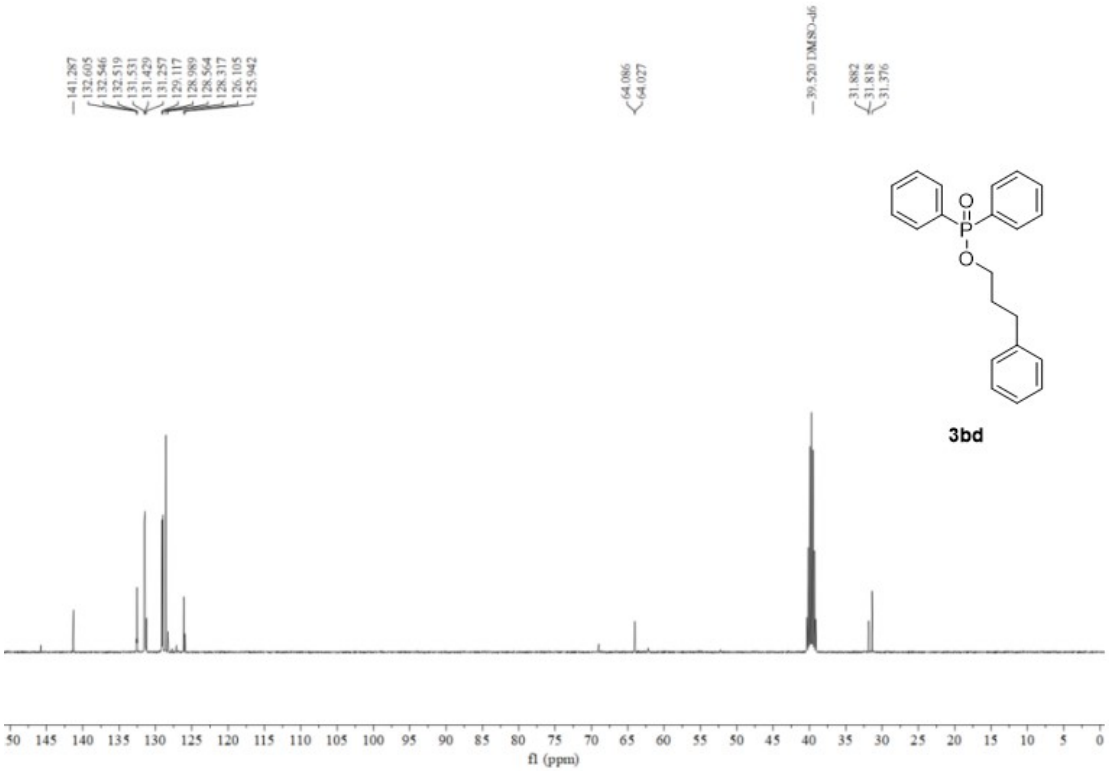
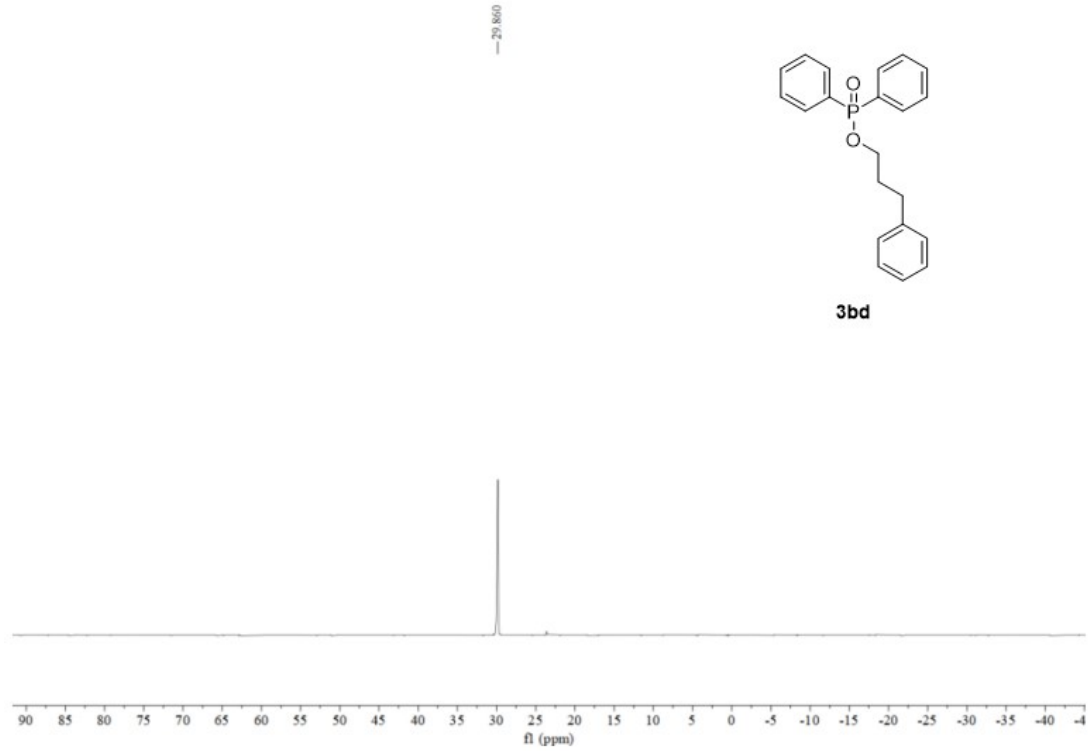
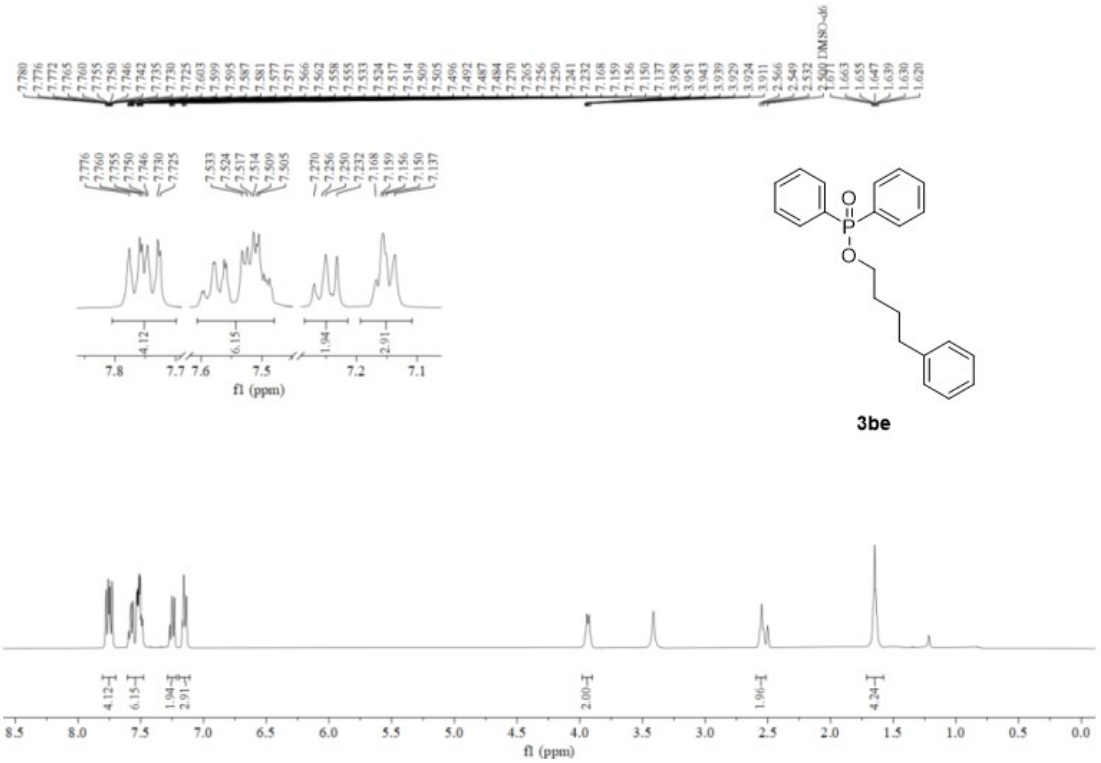
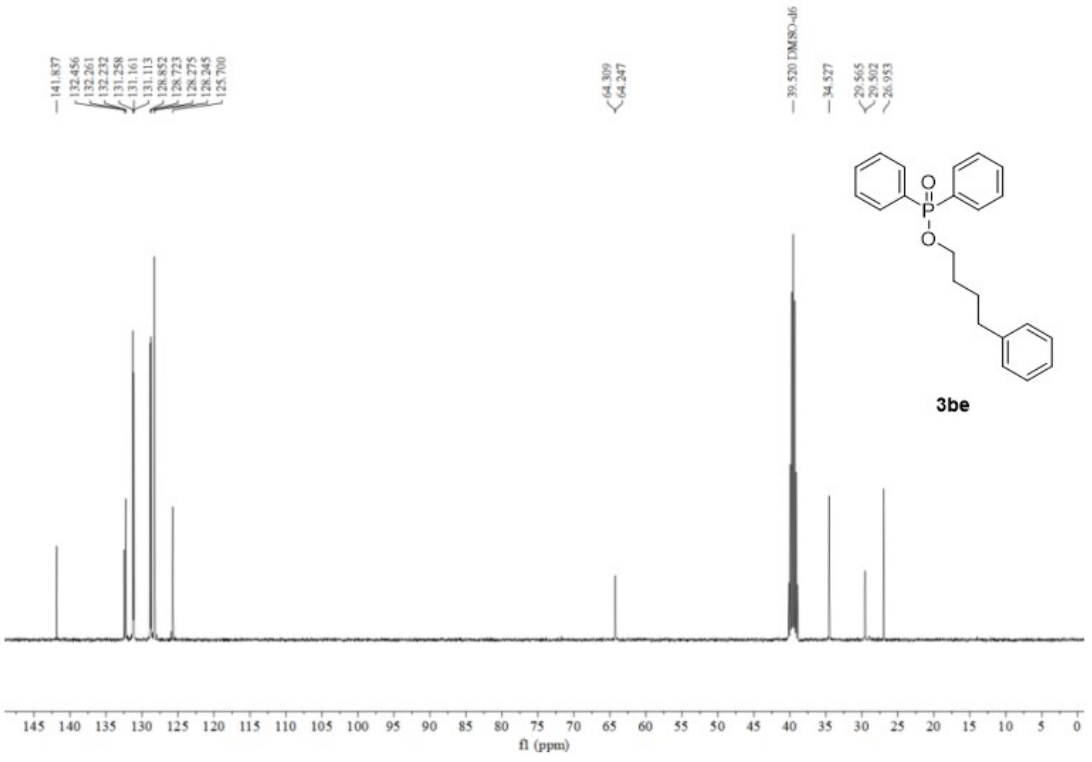
7.790
7.782
7.777
7.773
7.767
7.764
7.760
7.752
7.747
7.743
7.613
7.609
7.605
7.601
7.594
7.590
7.584
7.579
7.576
7.572
7.568
7.547
7.543
7.538
7.534
7.532
7.528
7.523
7.519
7.514
7.510
7.506
7.502
7.498
7.492
7.279
7.277
7.273
7.260
7.256
7.246
7.240
7.236
7.187
7.185
7.180
7.169
7.166
7.159
7.147
3.949
3.933
3.930
3.918
3.915
3.899
2.702
2.684
2.680
2.664
2.500 DMSO-d6
1.988
1.972
1.969
1.966
1.957
1.953
1.950
1.940
1.934
1.918
4.00
2.05
4.36
1.75
2.61
1.81
1.85
1.81
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)

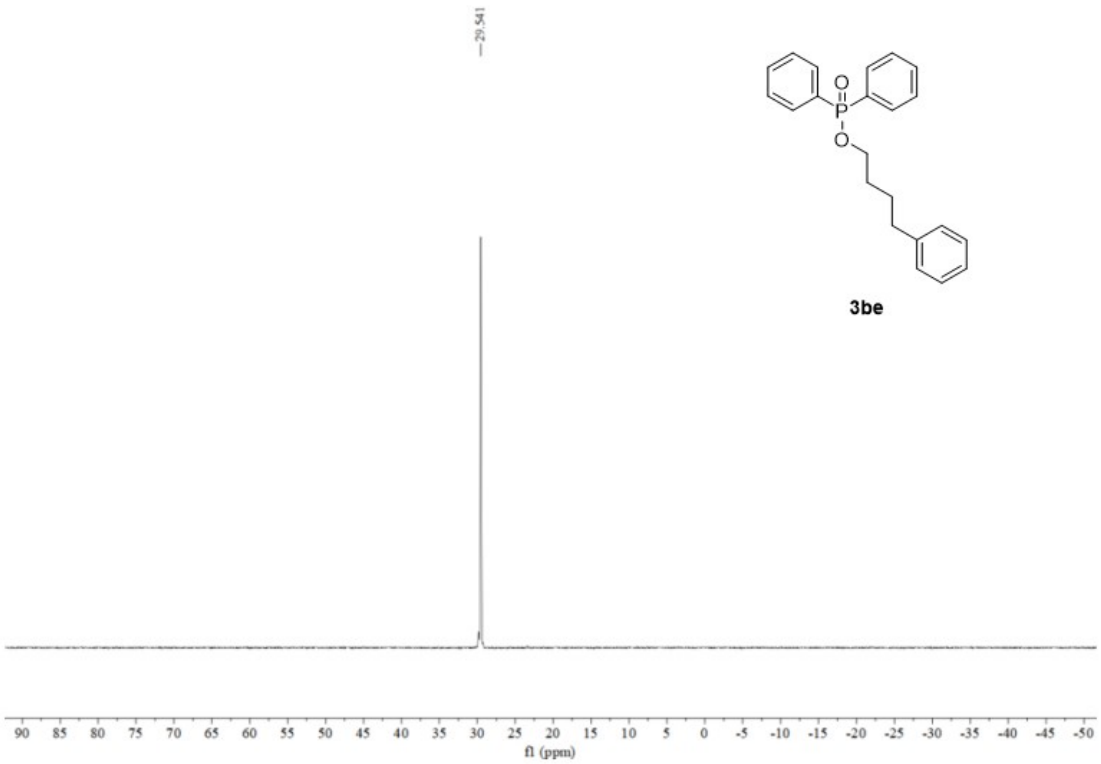
3bd


141.287
132.605
132.546
132.519
131.531
131.429
131.257
129.117
128.989
128.564
128.317
126.105
125.942
64.086
64.027
39.520 DMSO-d6
31.882
31.818
31.376
3bd
50 45 40 35 30 25 20 15 10 5 0
f1 (ppm)

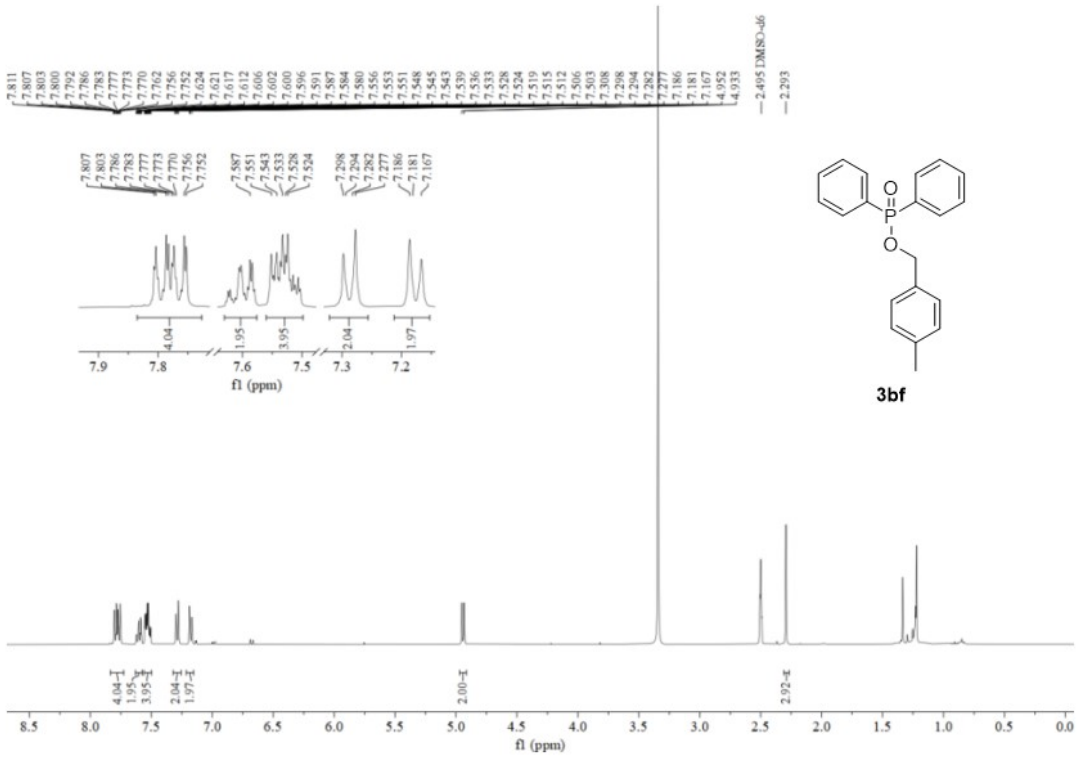

29.860
3bd
90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0 -5 -10 -15 -20 -25 -30 -35 -40 -4
f1 (ppm)


7.780
7.776
7.772
7.765
7.760
7.755
7.750
7.746
7.742
7.735
7.730
7.725
7.603
7.599
7.595
7.587
7.581
7.577
7.571
7.566
7.562
7.558
7.555
7.533
7.524
7.517
7.514
7.509
7.505
7.270
7.256
7.250
7.232
7.168
7.159
7.156
7.150
7.137
3.958
3.951
3.943
3.939
3.929
3.924
3.911
2.566
2.549
2.532
2.500 DMSO-d6
1.663
1.655
1.647
1.639
1.630
1.620
4.12
6.15
1.94
2.91
7.8
7.7
7.6
7.5
7.2
7.1
f1 (ppm)
O
P
O
3be
4.12
6.15
1.94
2.91
2.00
1.96
4.24
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)

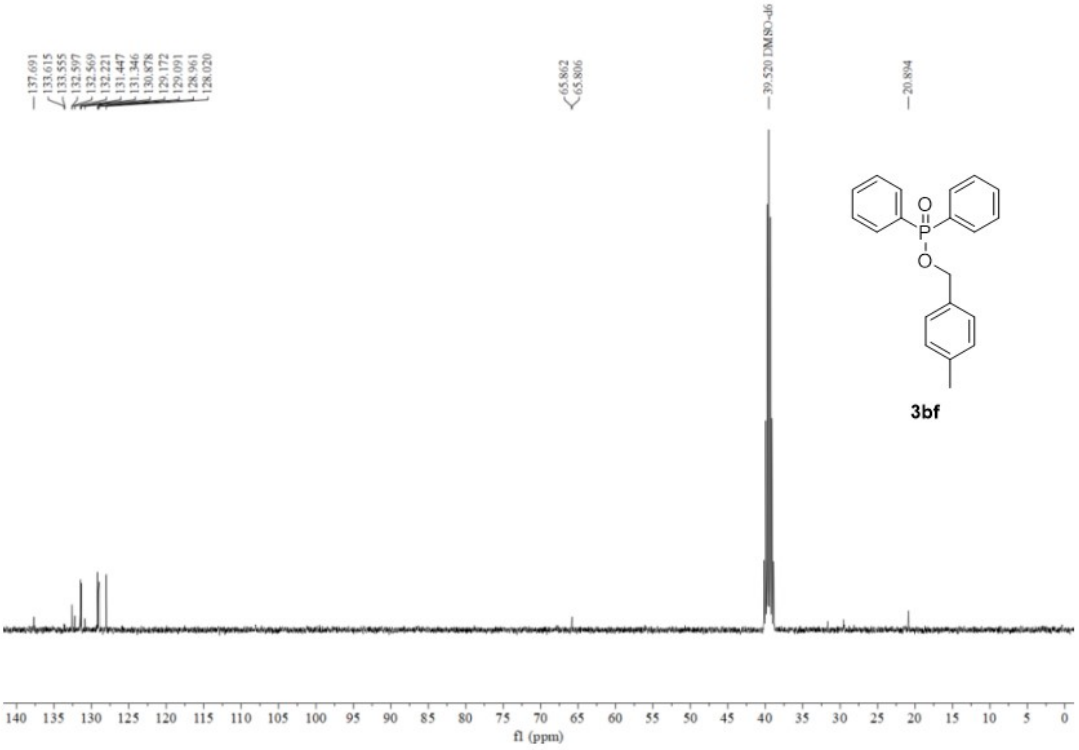

141.837
132.456
132.261
132.232
131.258
131.161
131.113
128.852
128.723
128.275
128.245
125.700
64.309
64.247
39.520 DMSO-d6
34.527
29.565
29.502
26.953
O
P
O
3be
145
140
135
130
125
120
115
110
105
100
95
90
85
80
75
70
65
60
55
50
45
40
35
30
25
20
15
10
5
0
f1 (ppm)

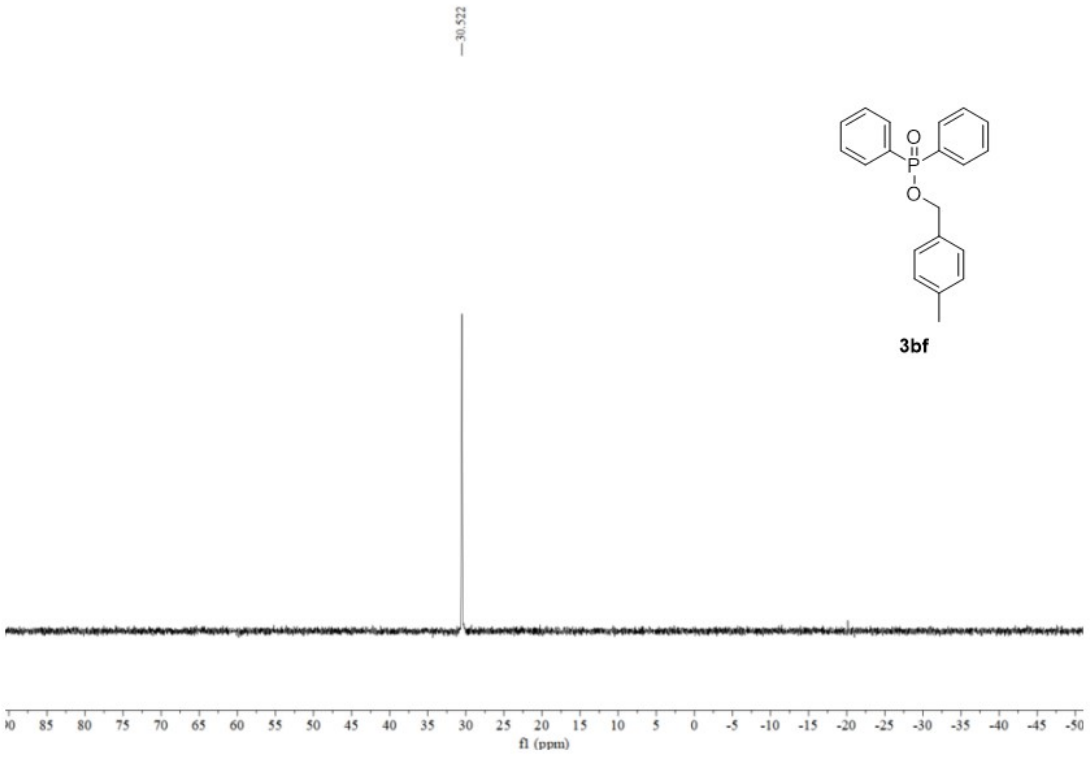

29.541
90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0 -5 -10 -15 -20 -25 -30 -35 -40 -45 -50
f1 (ppm)

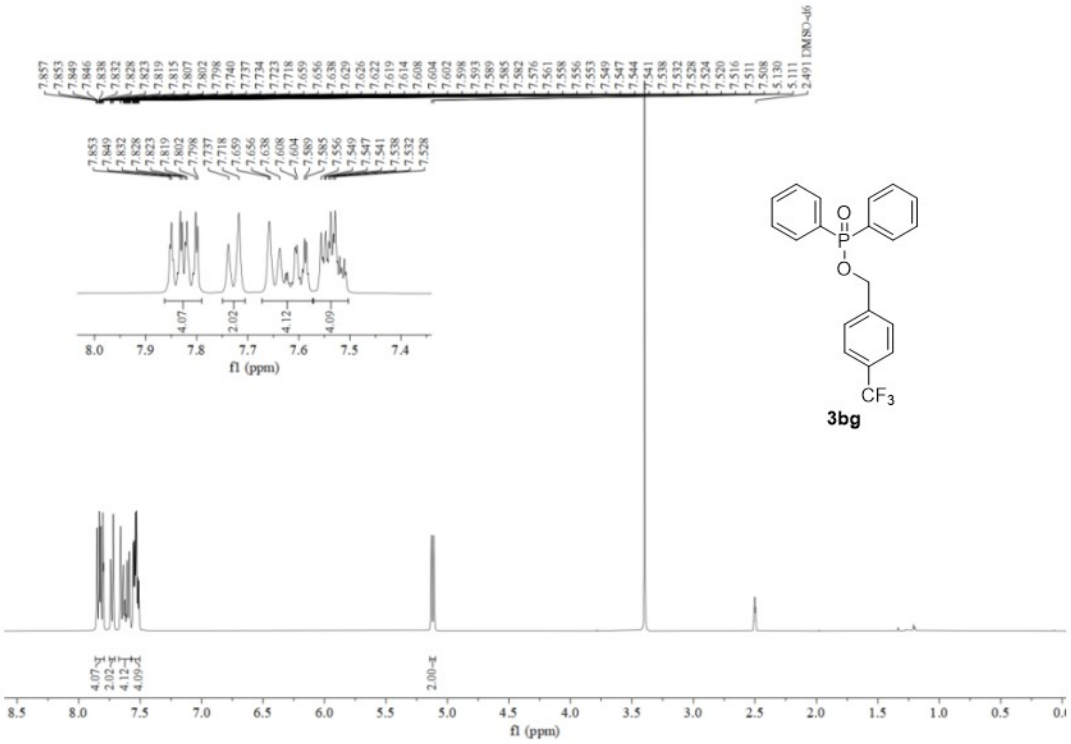
3be

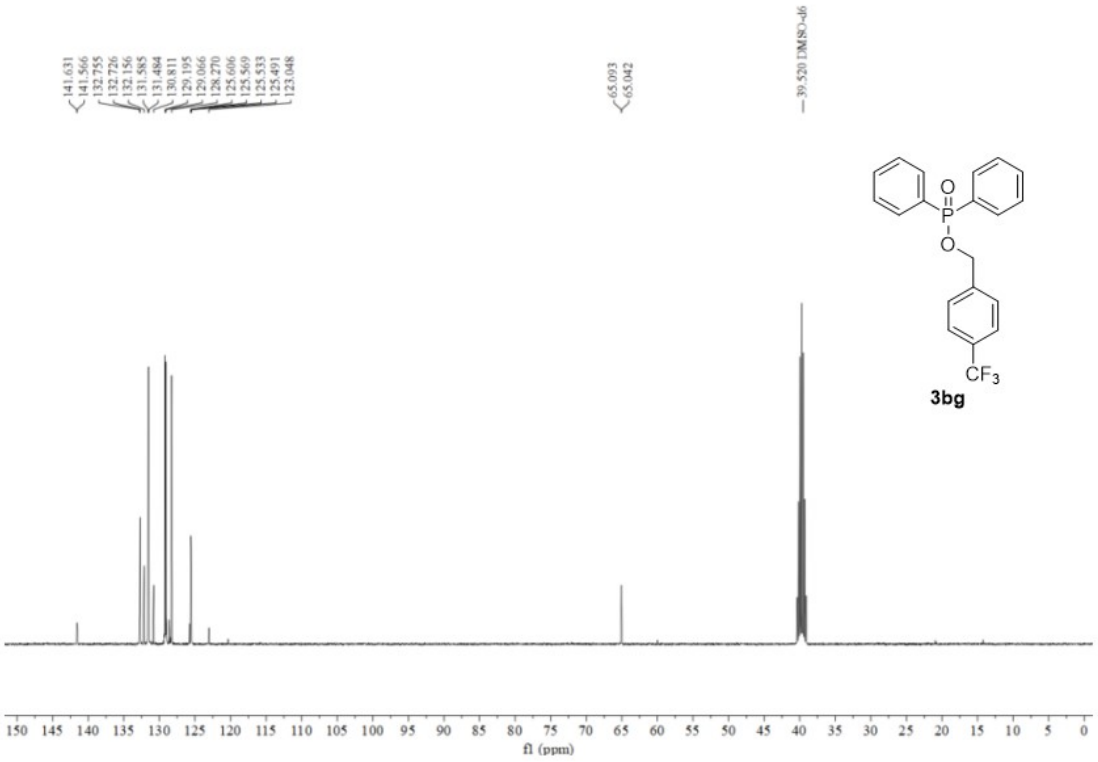

2.495 DMSO-d6
2.293
4.04
1.95
3.95
2.04
1.97
2.00
2.92
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

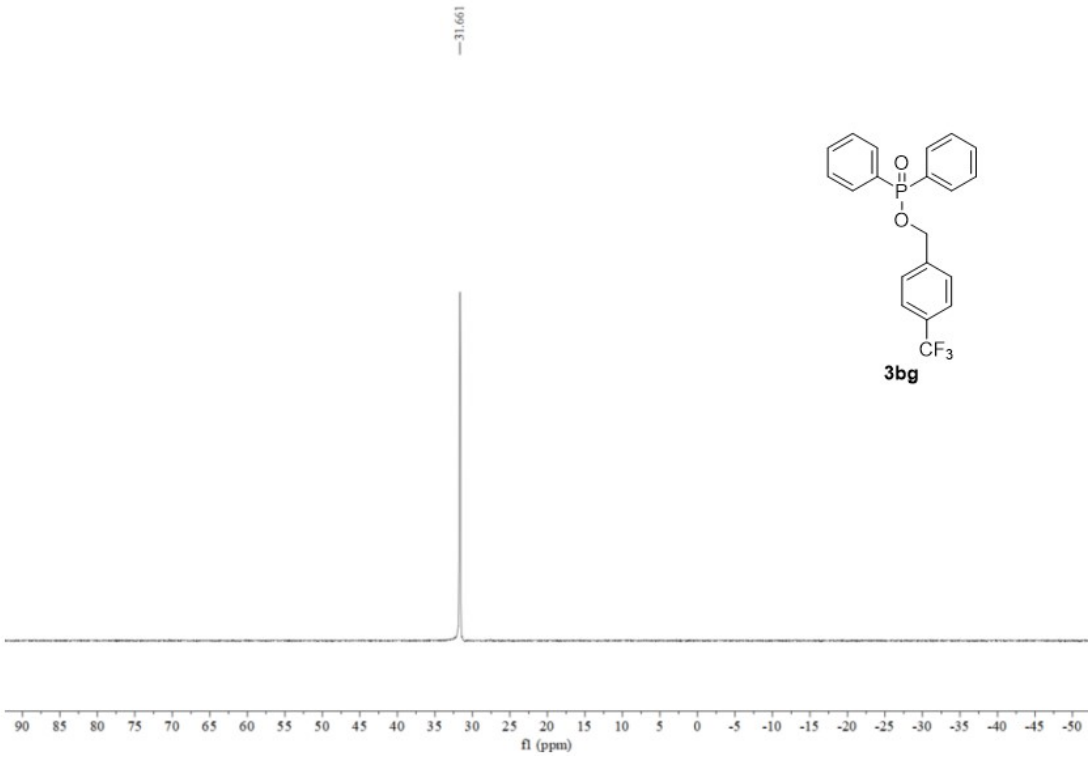
3bf

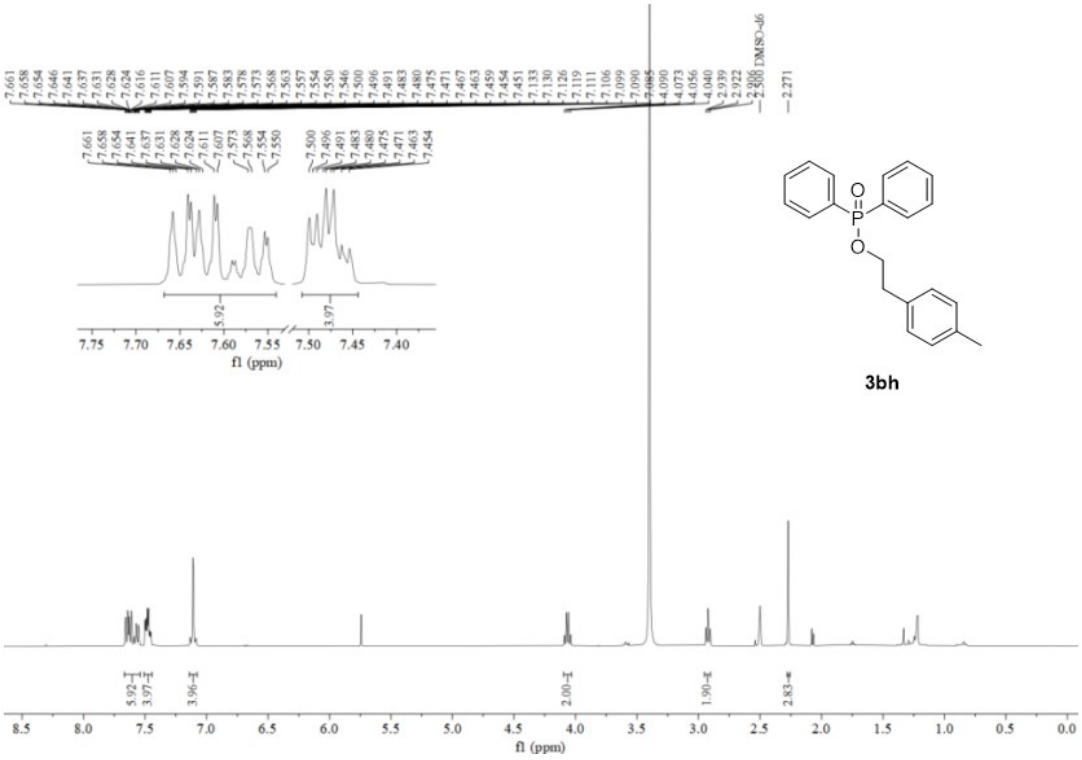

137.691
133.615
133.555
132.597
132.569
132.221
131.447
131.346
130.878
129.172
129.091
128.961
128.020
65.862
65.806
39.520 DMSO-d6
20.894
O
P
O
3bf
140 135 130 125 120 115 110 105 100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0
f1 (ppm)

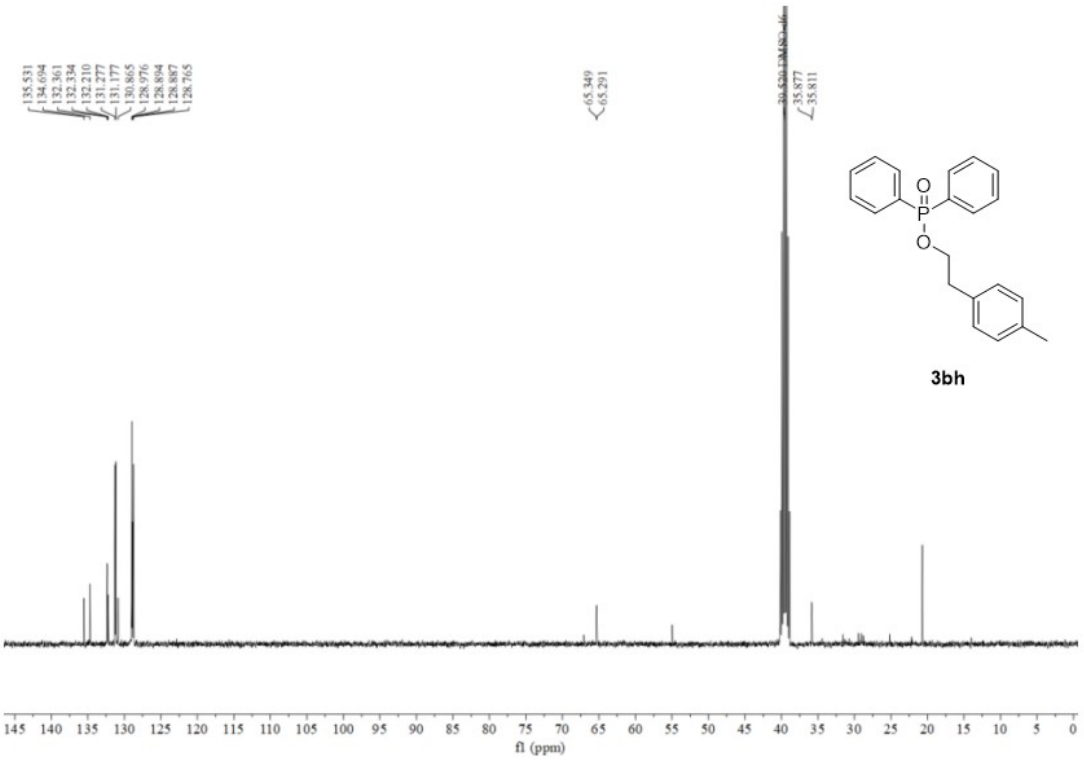

30.522
O
P
O
3bf
90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0 -5 -10 -15 -20 -25 -30 -35 -40 -45 -50
f1 (ppm)

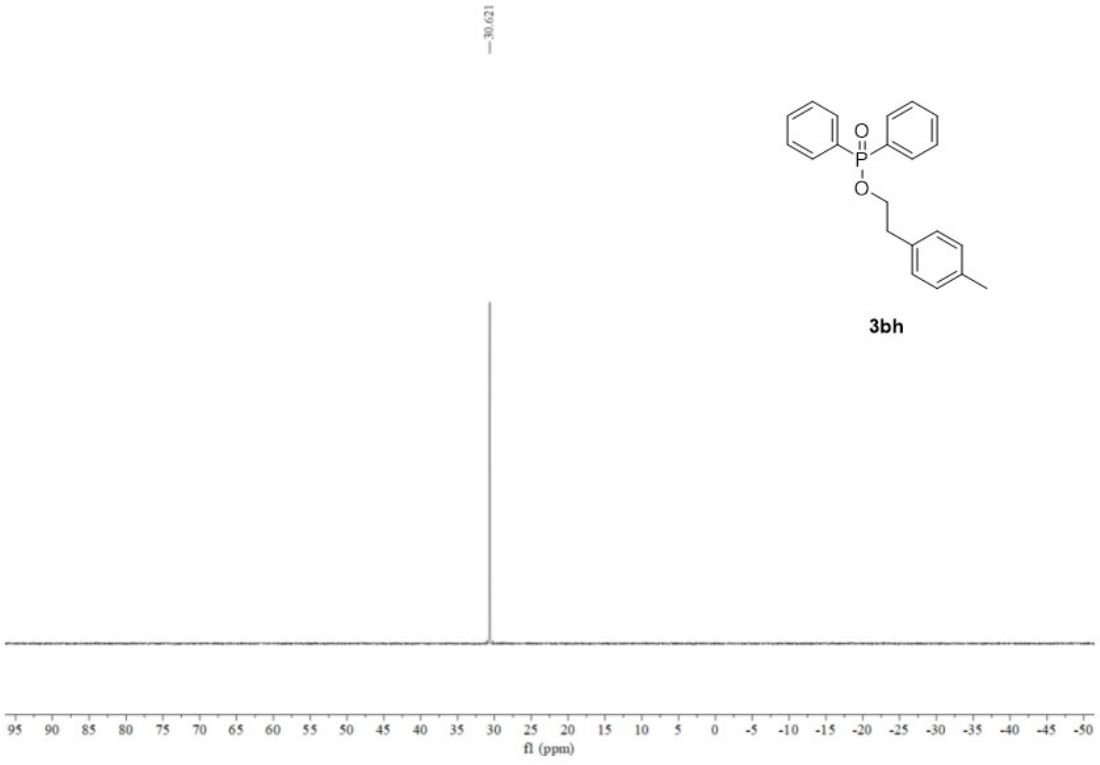

7.857
7.853
7.849
7.846
7.838
7.832
7.828
7.823
7.819
7.815
7.807
7.802
7.798
7.740
7.737
7.734
7.723
7.718
7.659
7.656
7.638
7.622
7.619
7.614
7.608
7.604
7.602
7.598
7.593
7.589
7.585
7.582
7.576
7.561
7.558
7.556
7.553
7.549
7.547
7.544
7.541
7.538
7.532
7.528
7.524
7.520
7.516
7.511
7.508
5.130
5.111
2.491 DMSO-d6
4.07
2.02
4.12
4.09
2.00
f1 (ppm)
3bg

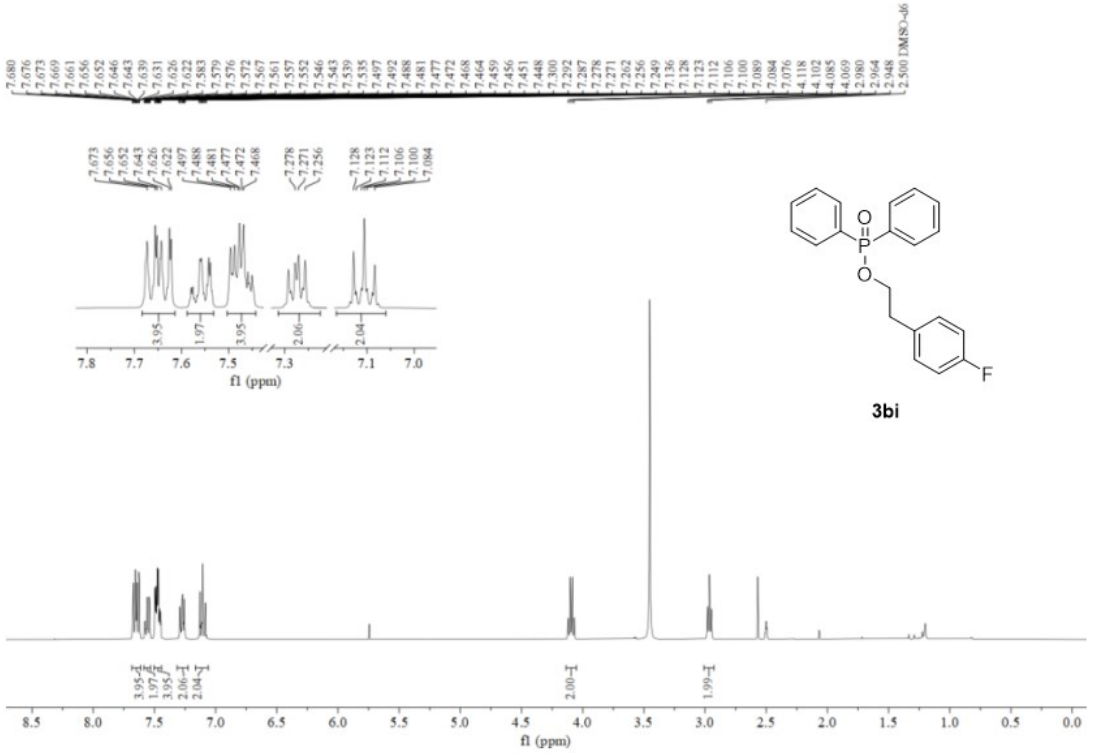

141.631
141.566
132.755
132.726
132.156
131.585
131.484
130.811
129.195
129.066
128.270
125.606
125.569
125.533
125.491
123.048
65.093
65.042
39.520 DMSO-d6
f1 (ppm)
3bg

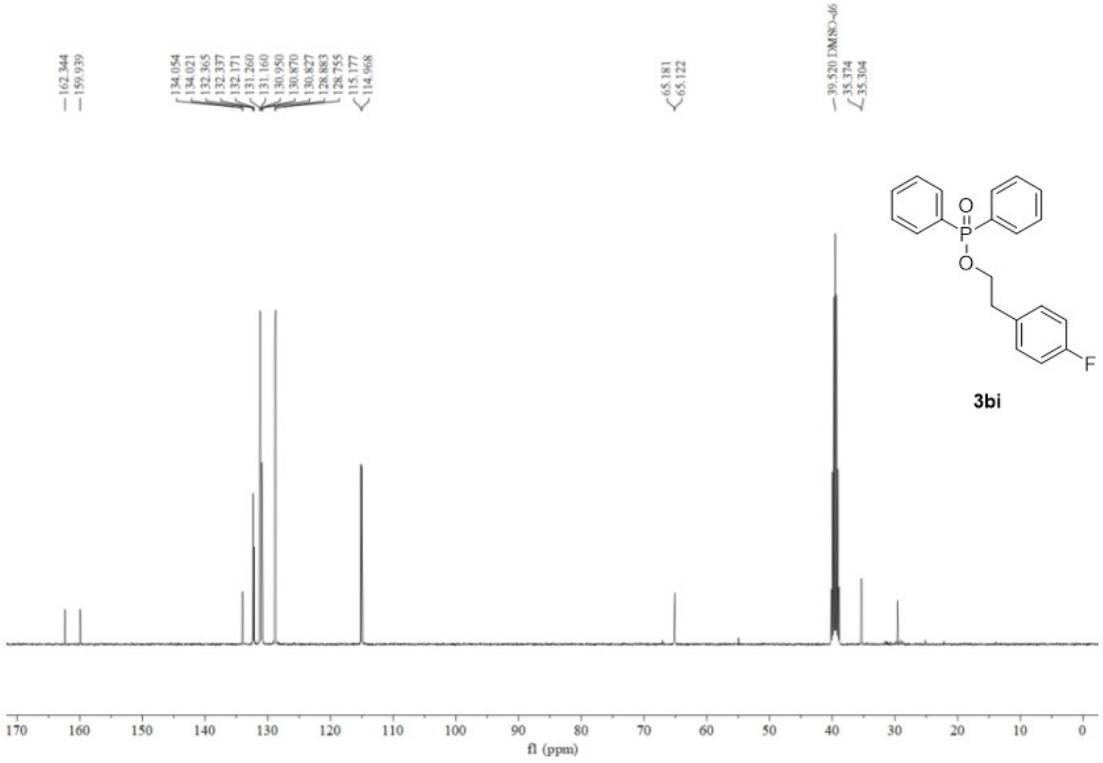

31.661
3bg
90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0 -5 -10 -15 -20 -25 -30 -35 -40 -45 -50
f1 (ppm)

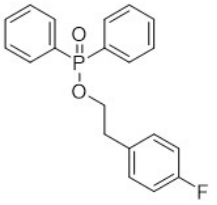

DMSO-d6
3bh
5.92
3.97
7.75 7.70 7.65 7.60 7.55 7.50 7.45 7.40
f1 (ppm)
5.92
3.97
3.96
2.00
1.90
2.83
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


135.531
134.694
132.361
132.334
132.210
131.277
131.177
130.865
128.976
128.894
128.887
128.765
65.349
65.291
35.877
35.811
O
P
O
3bh
145 140 135 130 125 120 115 110 105 100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0
f1 (ppm)

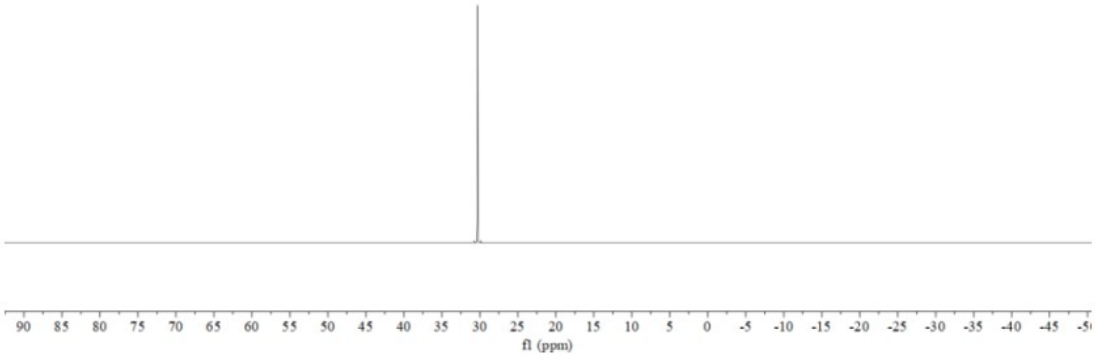

30.621
O
P
O
3bh
95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0 -5 -10 -15 -20 -25 -30 -35 -40 -45 -50
f1 (ppm)

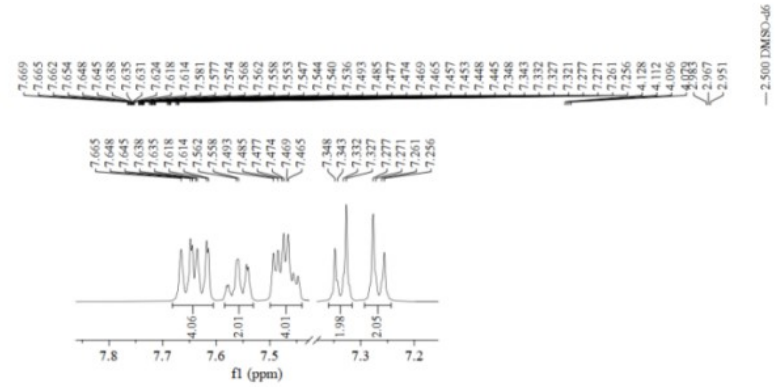

3bi
fl (ppm)

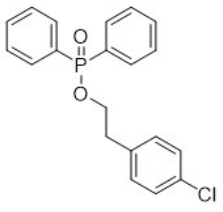

3bi
fl (ppm)



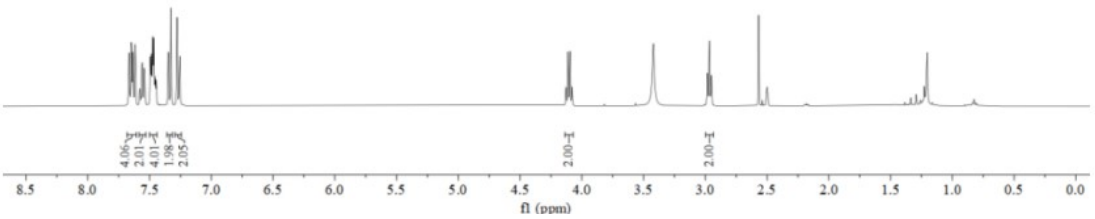
3bi

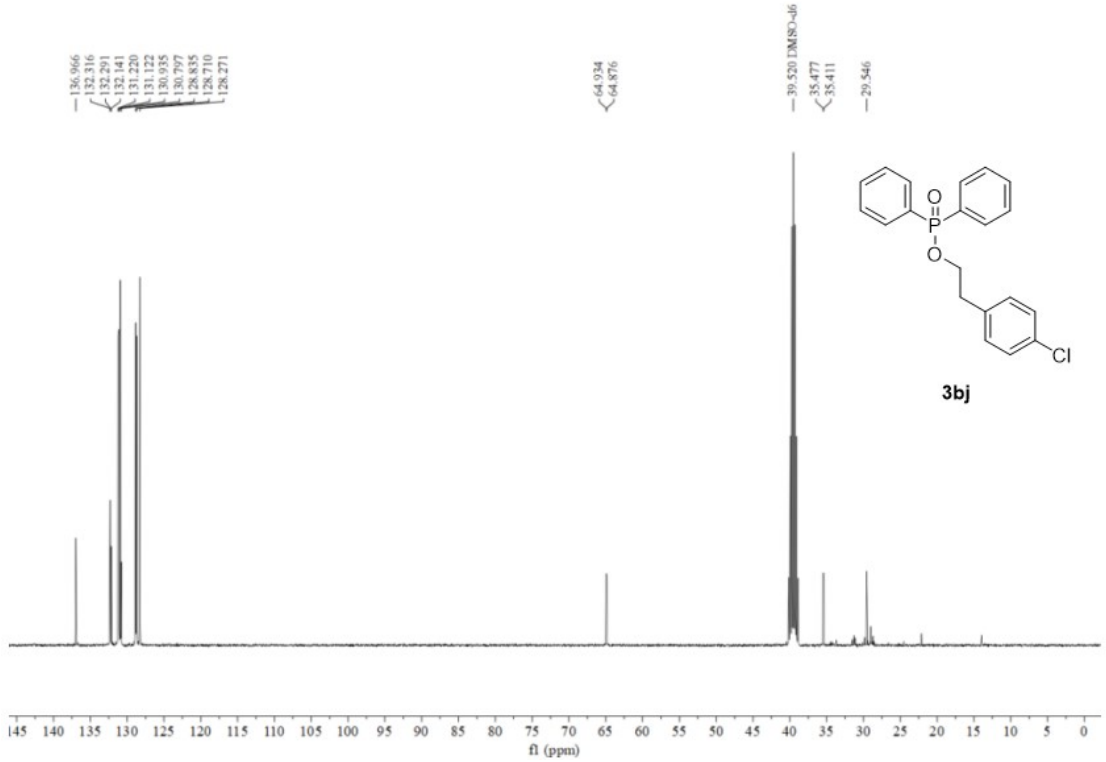






3bj




136.966
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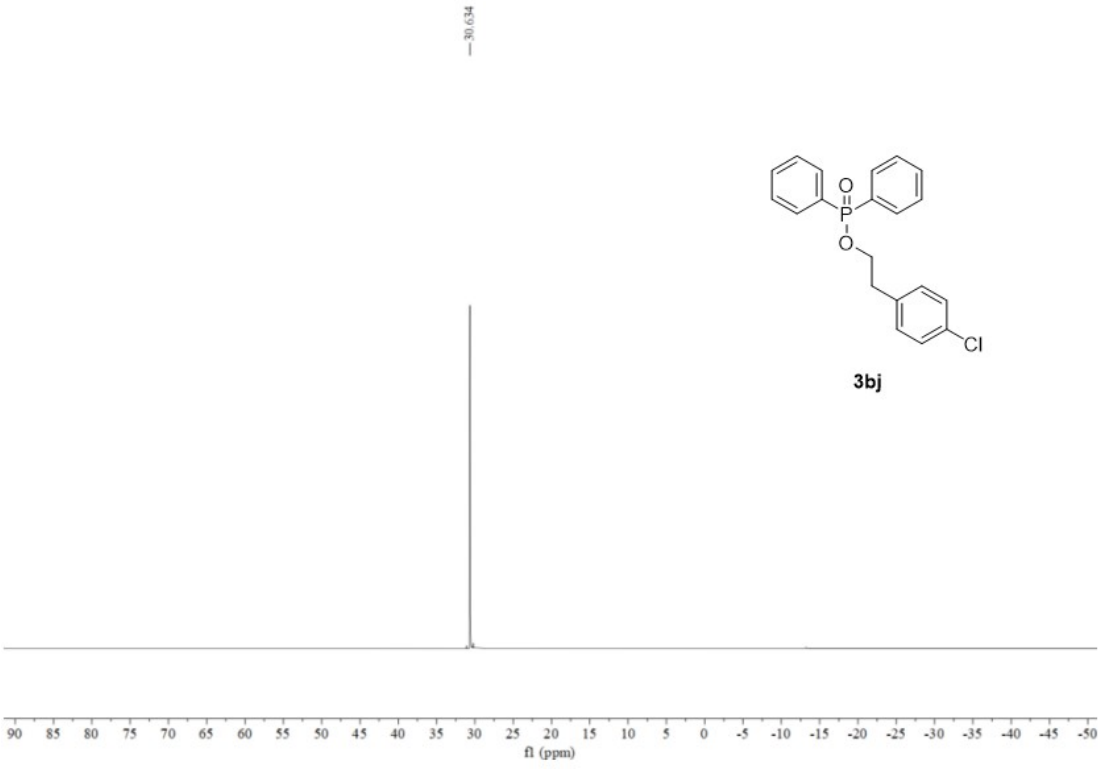
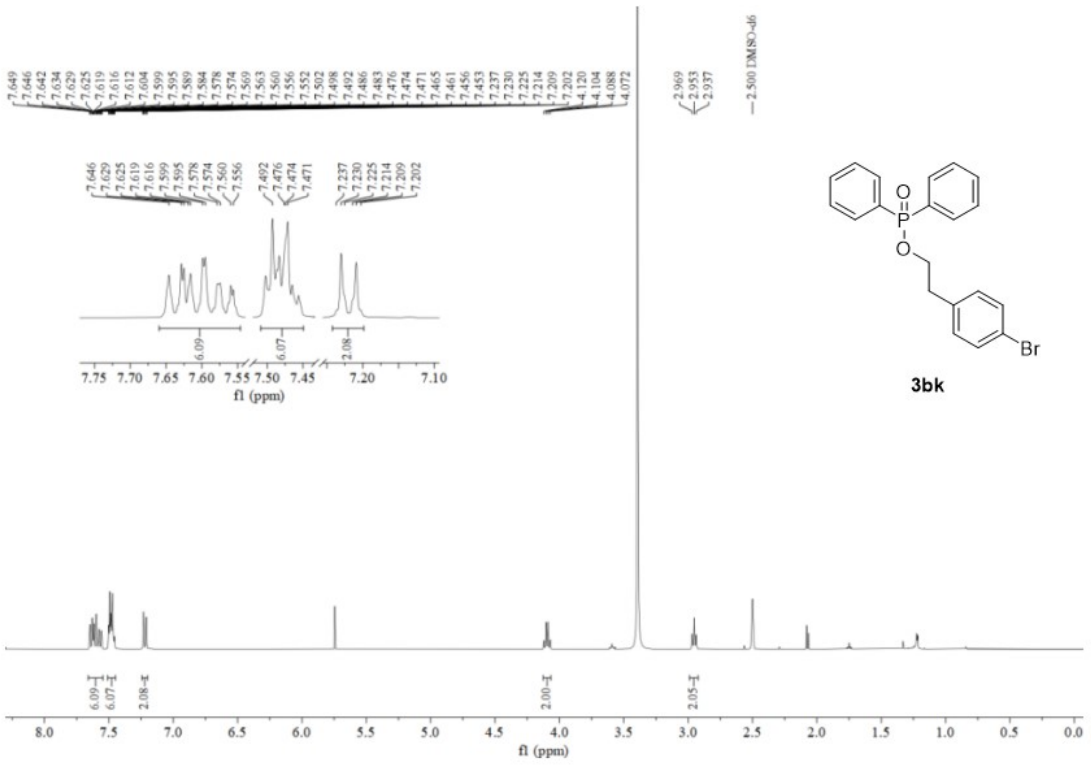
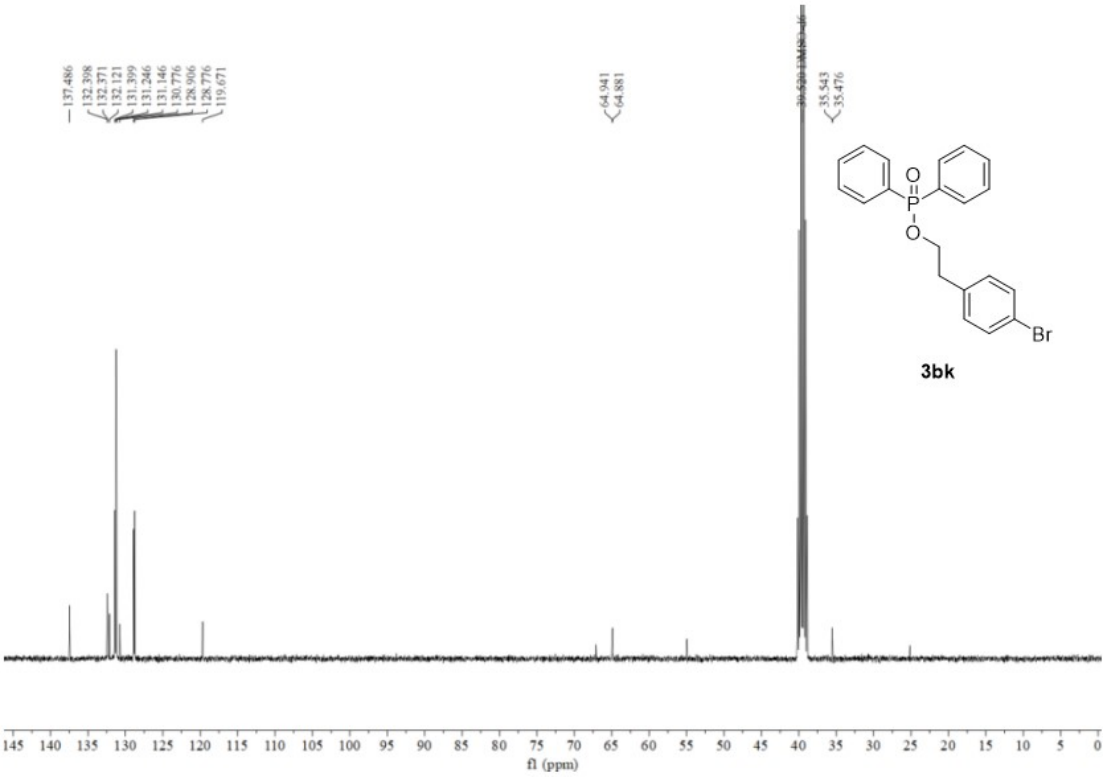
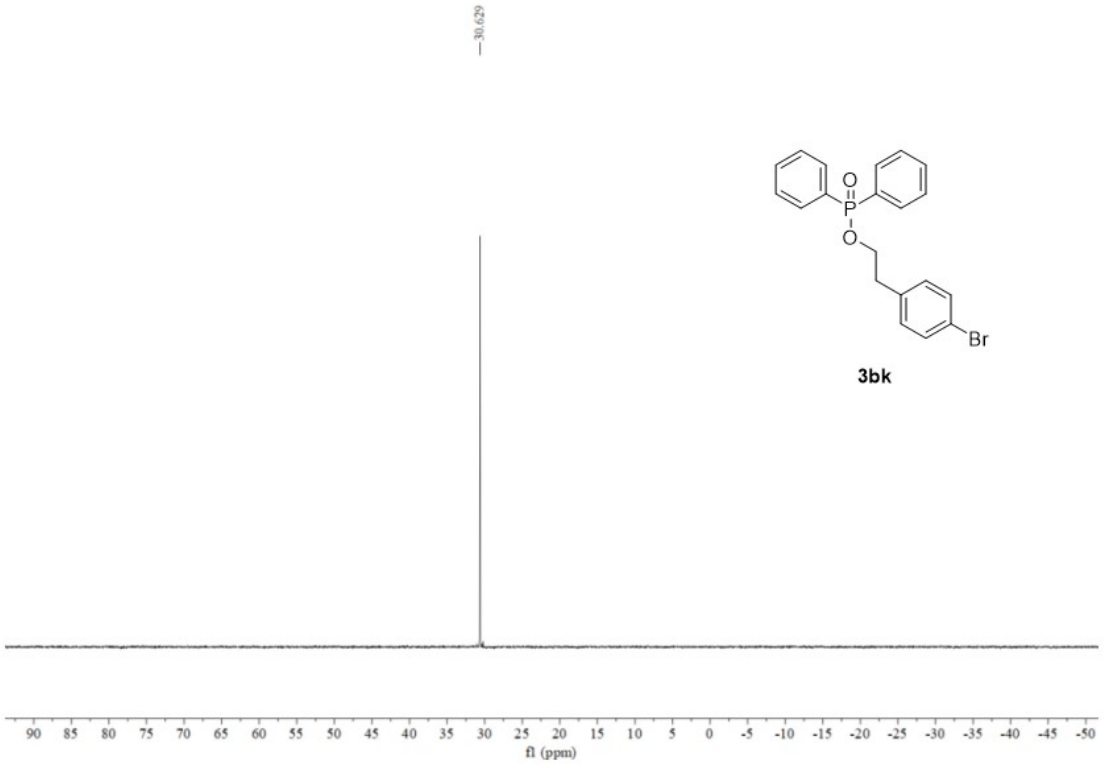
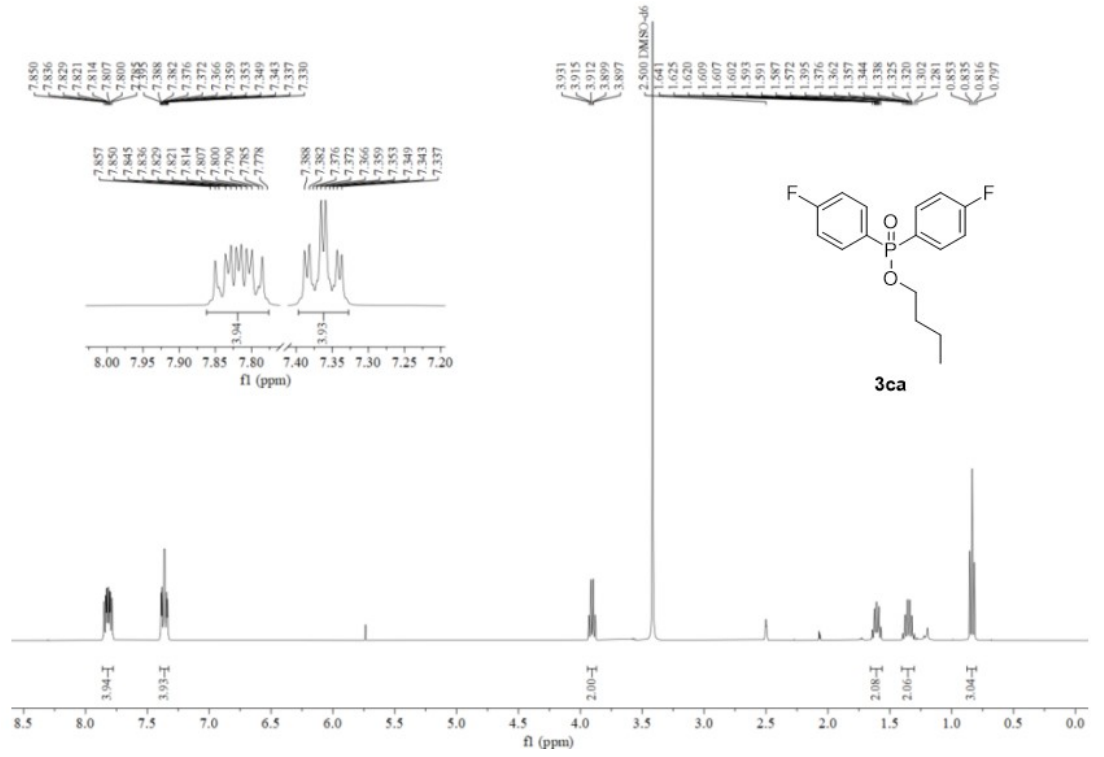
132.291
132.141
131.220
131.122
130.935
130.797
128.835
128.710
128.271
64.934
64.876
39.520 DMSO-d6
35.477
35.411
29.546
O
P
O
Cl
3bj
145 140 135 130 125 120 115 110 105 100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0
f1 (ppm)

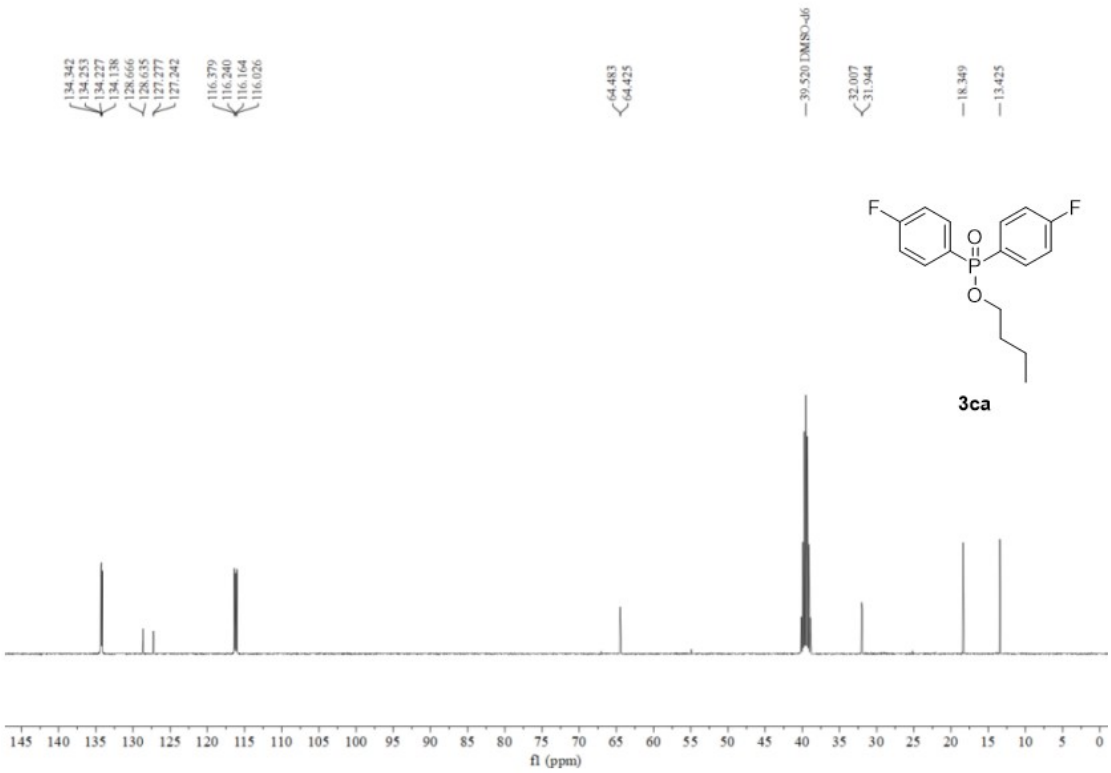

30.634
O
P
O
Cl
3bj
90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0 -5 -10 -15 -20 -25 -30 -35 -40 -45 -50
f1 (ppm)

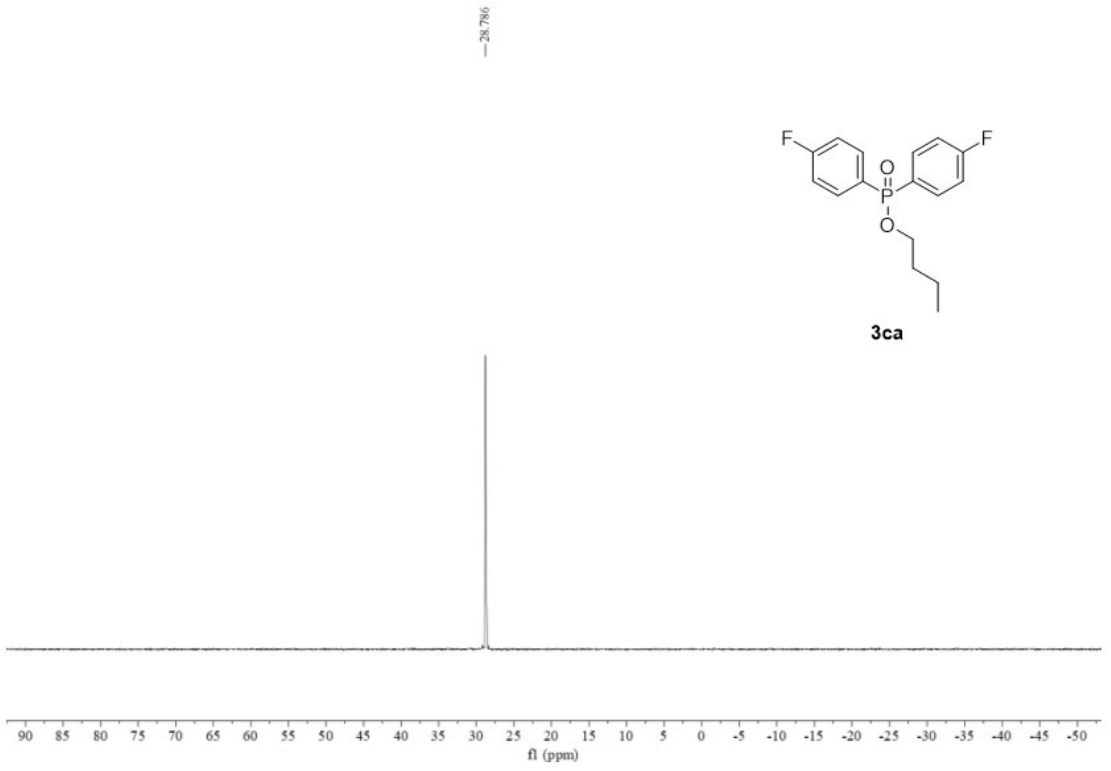

7.649
7.646
7.642
7.634
7.629
7.625
7.619
7.616
7.612
7.604
7.599
7.595
7.589
7.584
7.578
7.574
7.569
7.563
7.560
7.556
7.552
7.502
7.498
7.492
7.486
7.483
7.476
7.474
7.471
7.465
7.461
7.456
7.453
7.237
7.230
7.225
7.214
7.209
7.202
4.120
4.104
4.088
4.072
2.969
2.953
2.937
2.500 (DMSO-d6
6.09
6.07
2.08
2.00
2.05
fl (ppm)
3bk

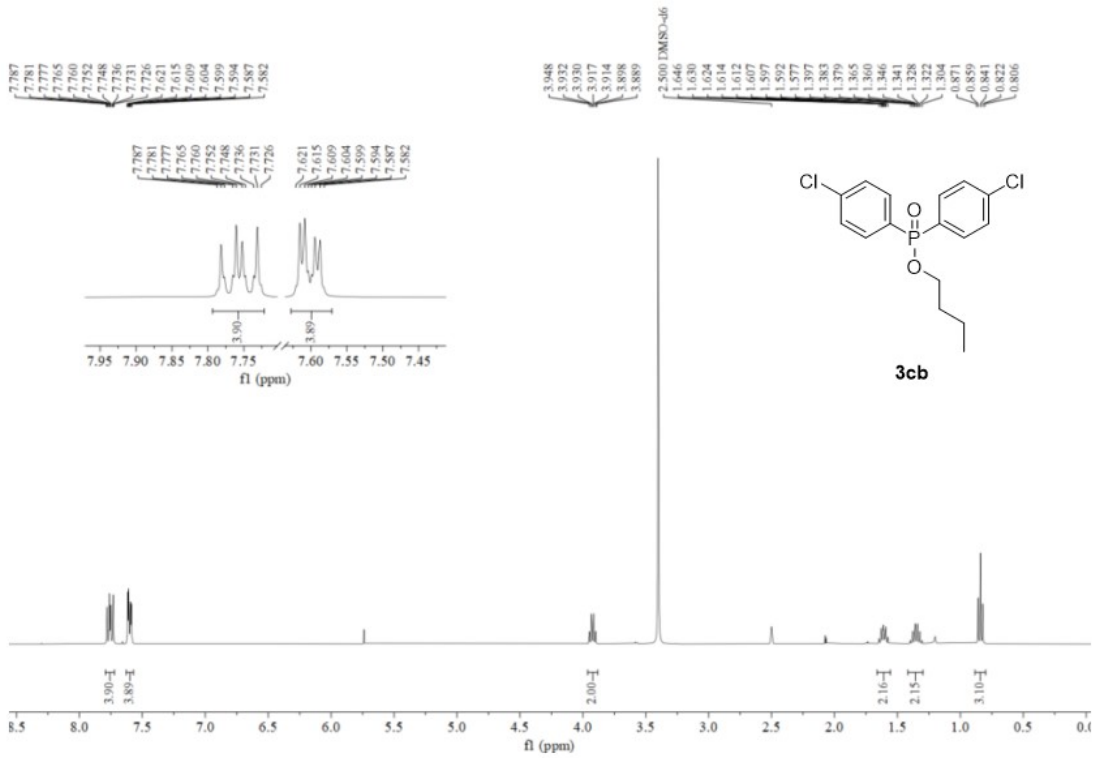

137.486
132.398
132.371
132.121
131.399
131.246
131.146
130.776
128.906
128.776
119.671
64.941
64.881
39.626 (DMSO-d6
35.543
35.476
fl (ppm)
3bk

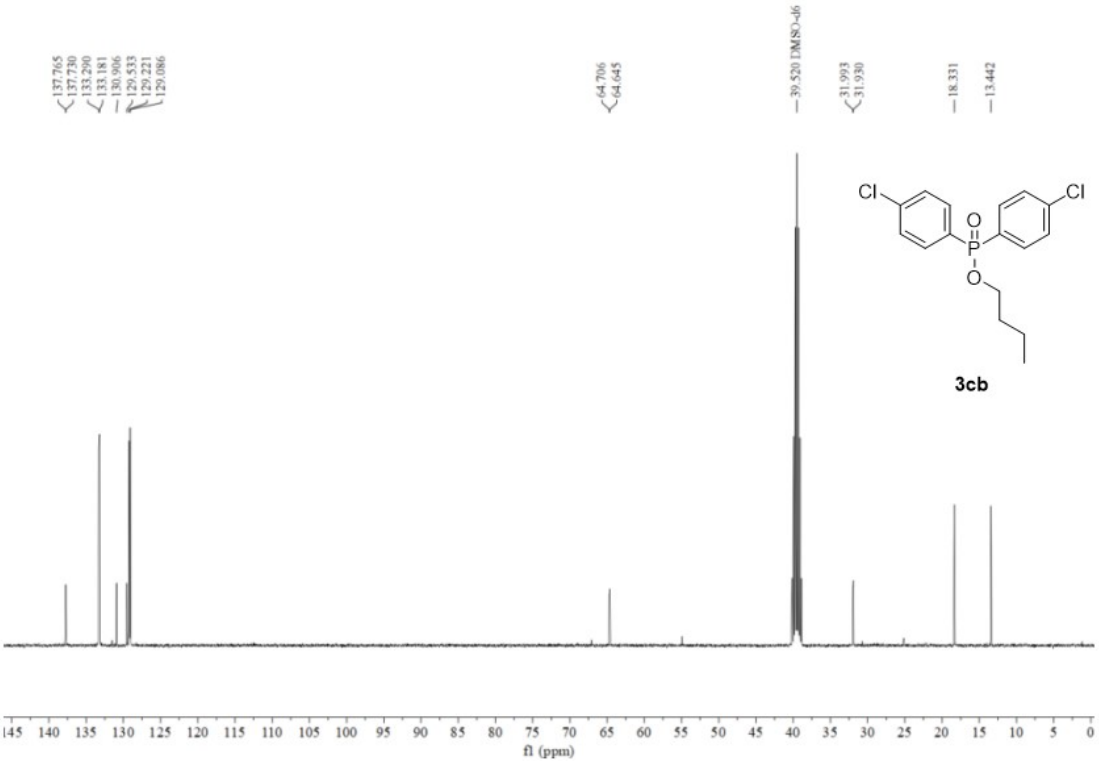

30.629
O
P
O
Br
3bk
90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0 -5 -10 -15 -20 -25 -30 -35 -40 -45 -50
f1 (ppm)

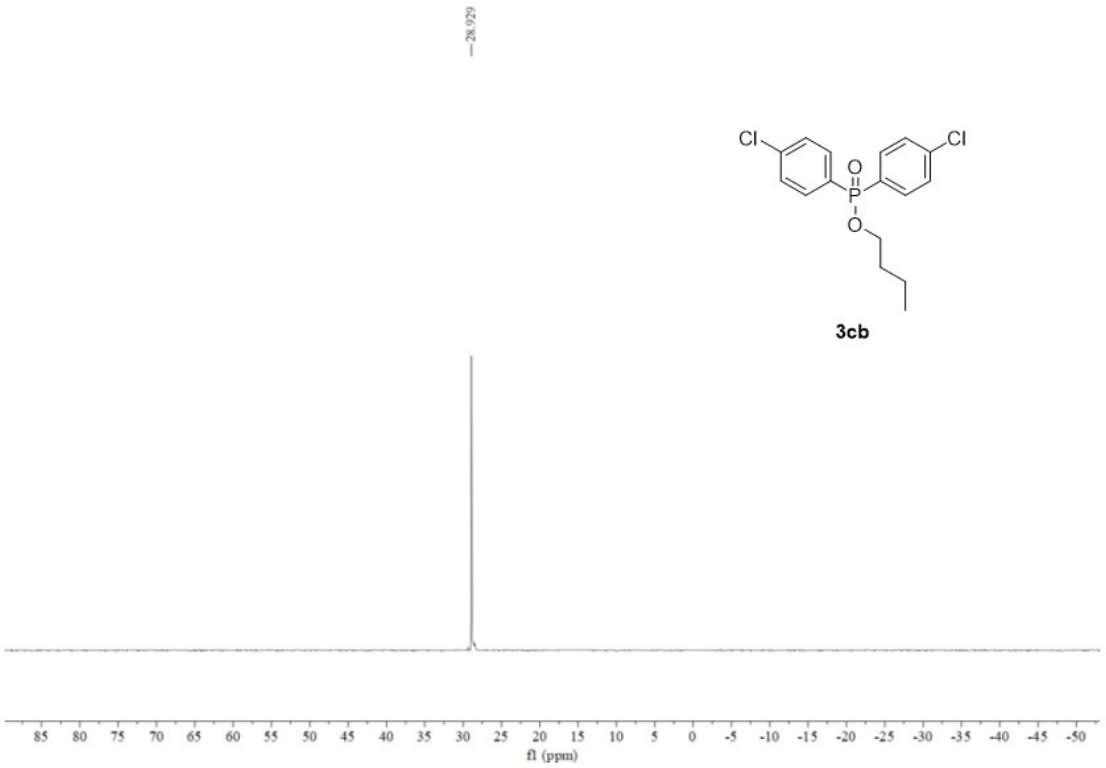

7.850
7.836
7.829
7.821
7.814
7.807
7.800
7.388
7.382
7.376
7.372
7.366
7.359
7.353
7.349
7.343
7.337
7.330
3.931
3.915
3.912
3.899
3.897
2.500 DMSO-d6
1.641
1.625
1.620
1.609
1.607
1.602
1.593
1.591
1.587
1.572
1.395
1.376
1.362
1.357
1.344
1.338
1.325
1.320
1.302
1.281
0.853
0.835
0.816
0.797
7.857
7.850
7.845
7.836
7.829
7.821
7.814
7.807
7.800
7.790
7.785
7.778
7.388
7.382
7.376
7.372
7.366
7.359
7.353
7.349
7.343
7.337
3.94
3.93
8.00 7.95 7.90 7.85 7.80 7.40 7.35 7.30 7.25 7.20
f1 (ppm)
F
F
O
P
O
3ca
3.94
3.93
2.00
2.08
2.06
3.04
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)

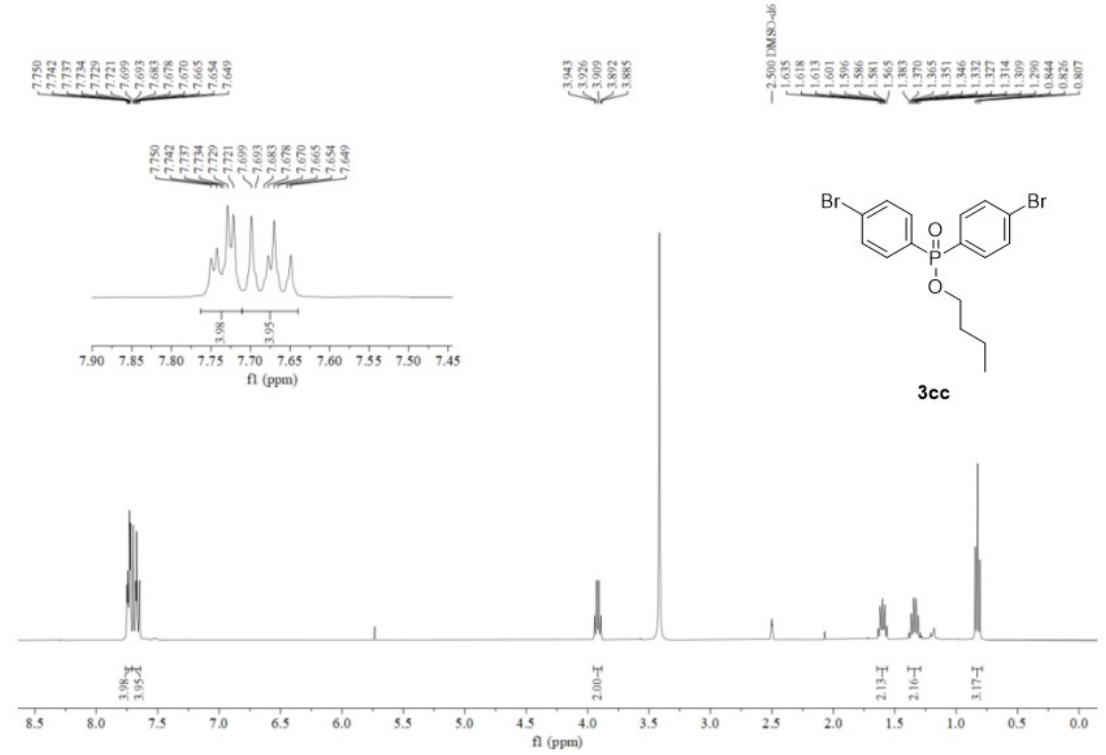

134.342
134.253
134.227
134.138
128.666
128.635
127.277
127.242
116.379
116.240
116.164
116.026
64.483
64.425
39.520 DMSO-d6
32.007
31.944
18.349
13.425
F
F
O
P
O
3ca
145 140 135 130 125 120 115 110 105 100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0
f1 (ppm)

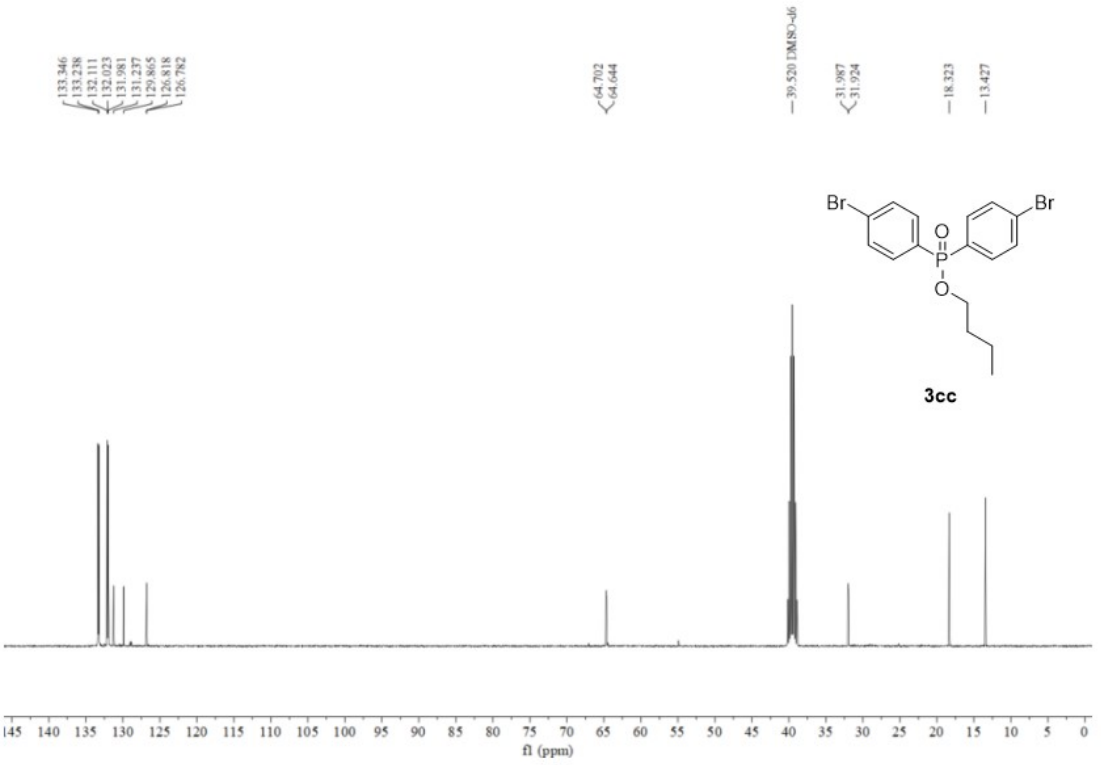

28.786
F
F
O
P
O
3ca
90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0 -5 -10 -15 -20 -25 -30 -35 -40 -45 -50
f1 (ppm)

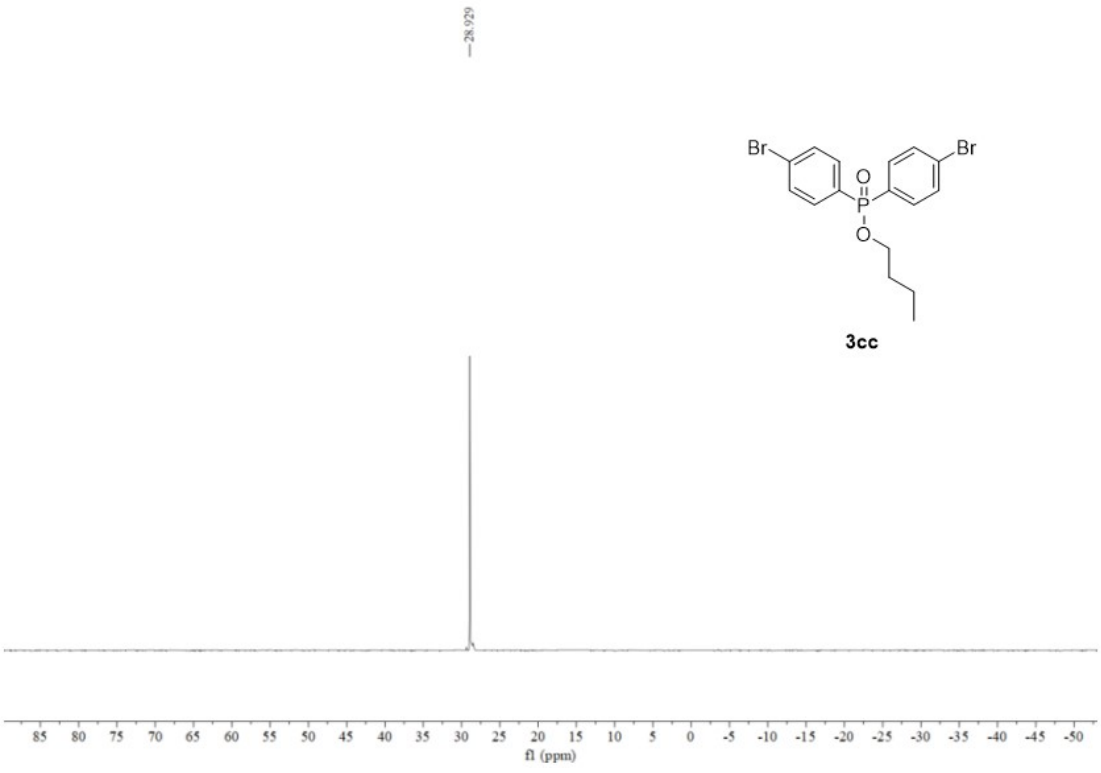

3cb
fl (ppm)

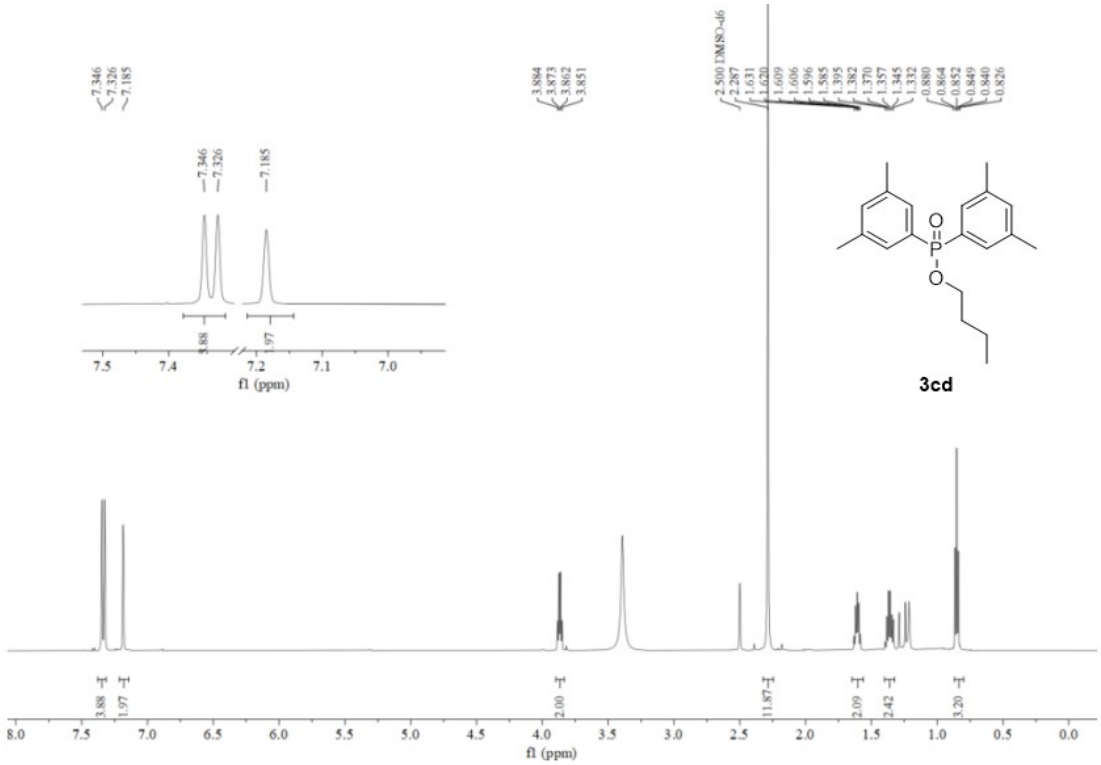

3cb
fl (ppm)

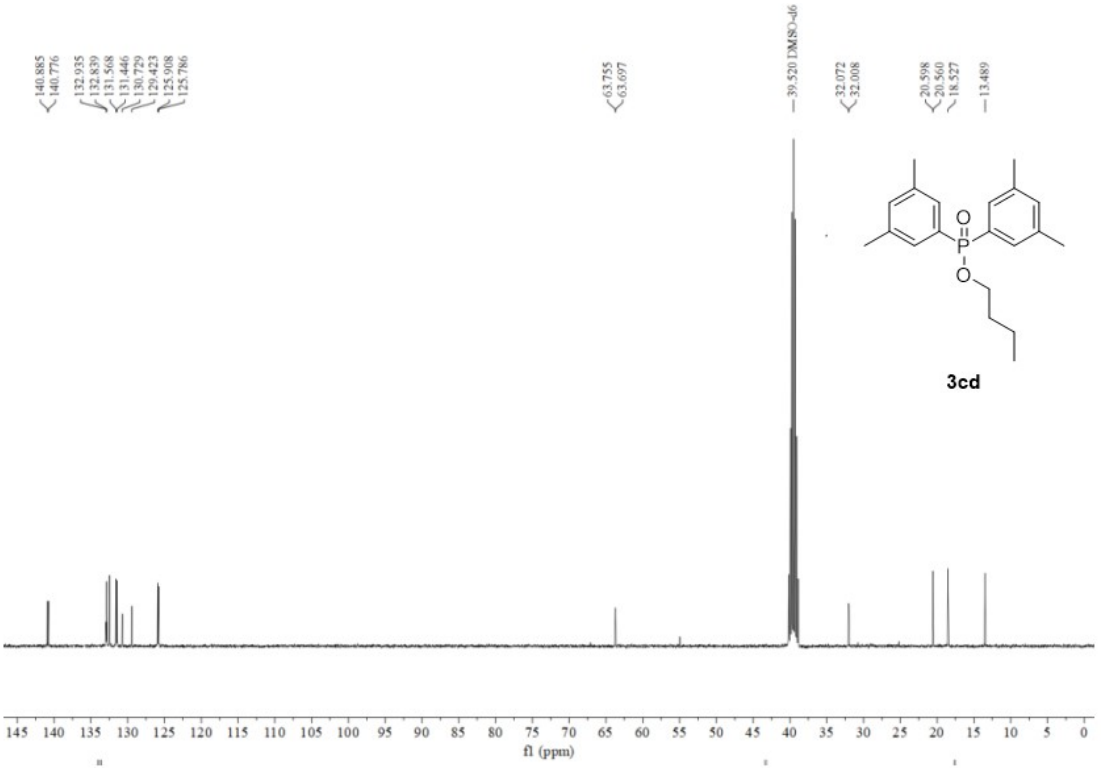

28.929
Cl
Cl
O
P
O
3cb
85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0 -5 -10 -15 -20 -25 -30 -35 -40 -45 -50
f1 (ppm)

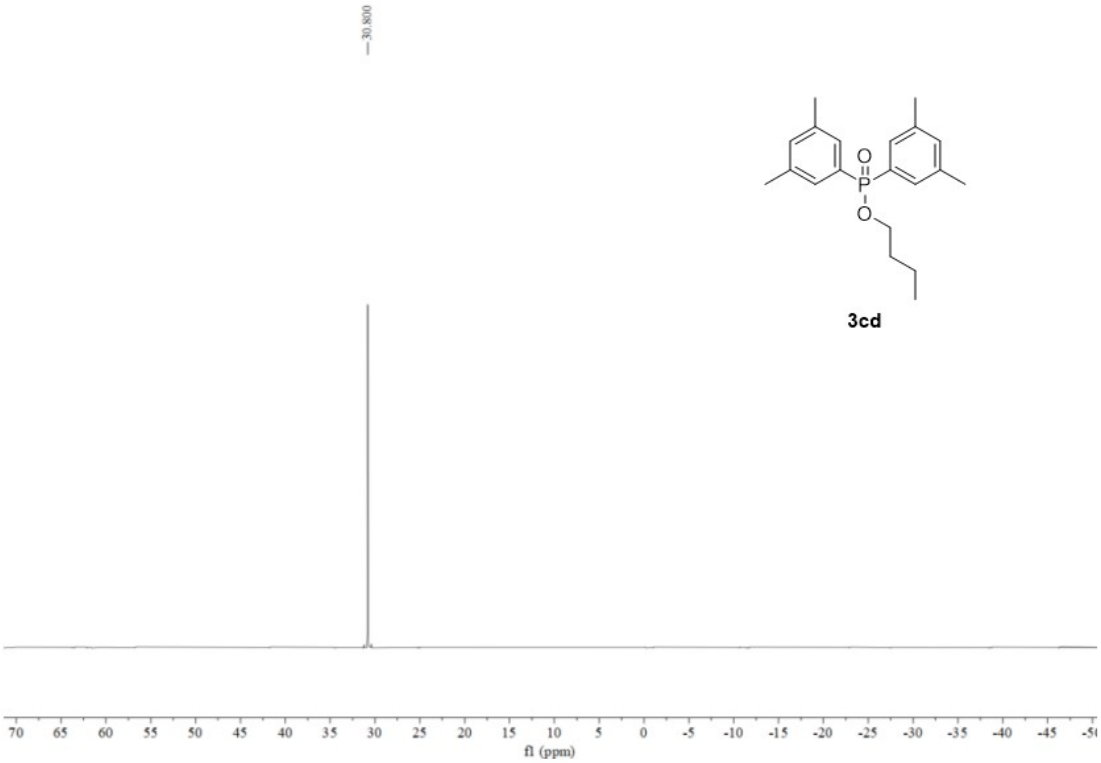

7.750
7.742
7.737
7.734
7.729
7.721
7.699
7.693
7.683
7.678
7.670
7.665
7.654
7.649
3.943
3.926
3.909
3.892
3.885
2.500 DMSO-d6
1.635
1.618
1.613
1.601
1.596
1.586
1.581
1.565
1.383
1.370
1.365
1.351
1.346
1.332
1.327
1.314
1.309
1.290
0.844
0.826
0.807
Br
Br
O
P
O
3cc
3.98
3.95
7.90 7.85 7.80 7.75 7.70 7.65 7.60 7.55 7.50 7.45
f1 (ppm)
3.98
3.95
2.00
2.13
2.16
3.17
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)

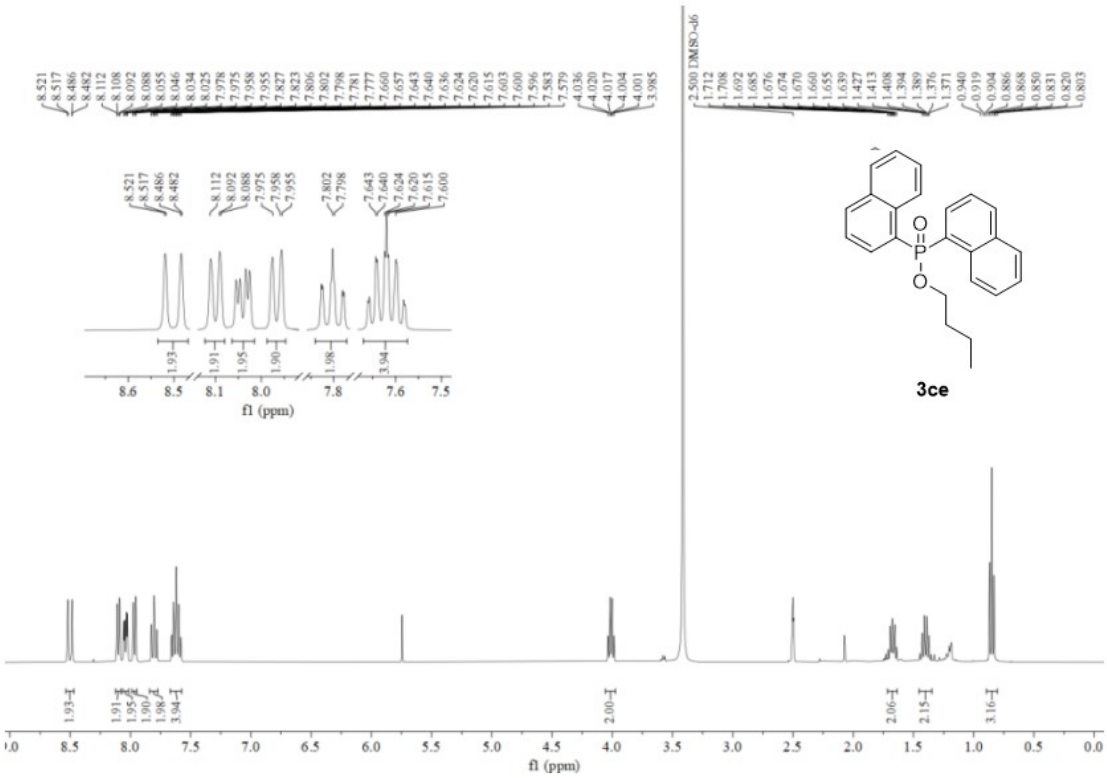

133.346
133.238
132.111
132.023
131.981
131.237
129.865
126.818
126.782
64.702
64.644
39.520 DMSO-d6
31.987
31.924
18.323
13.427
Br
Br
O
P
O
3cc
145 140 135 130 125 120 115 110 105 100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0
f1 (ppm)

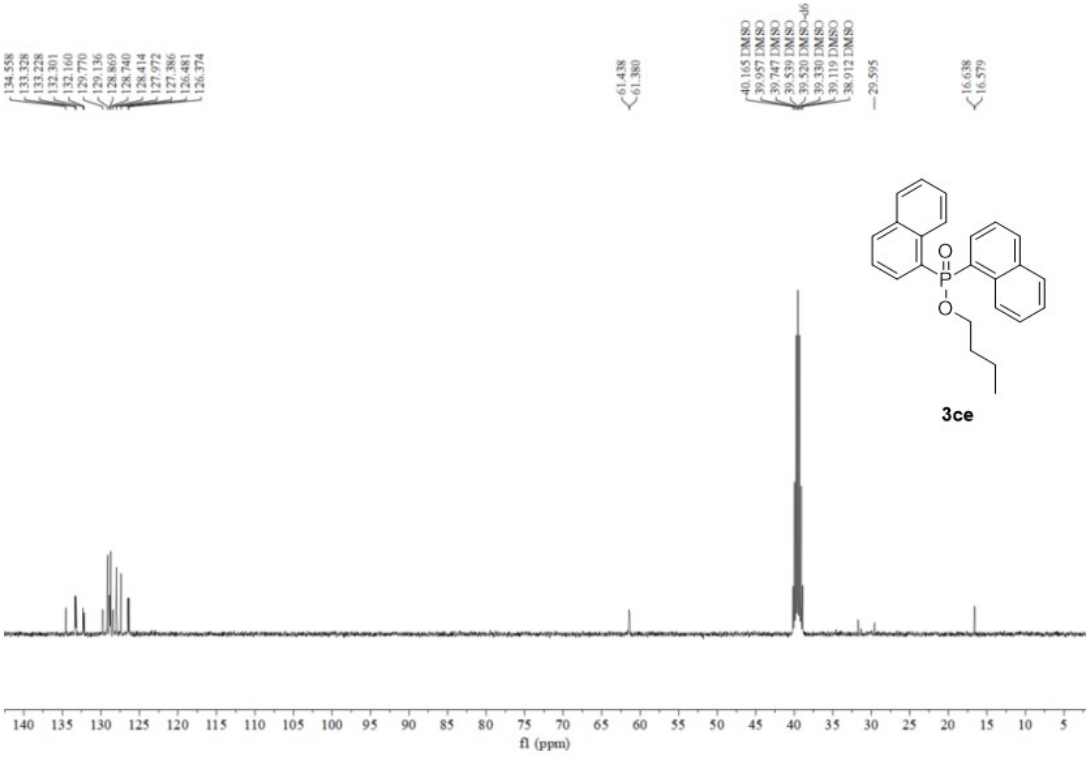

28.929
Br
Br
O
P
O
3cc
85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0 -5 -10 -15 -20 -25 -30 -35 -40 -45 -50
f1 (ppm)

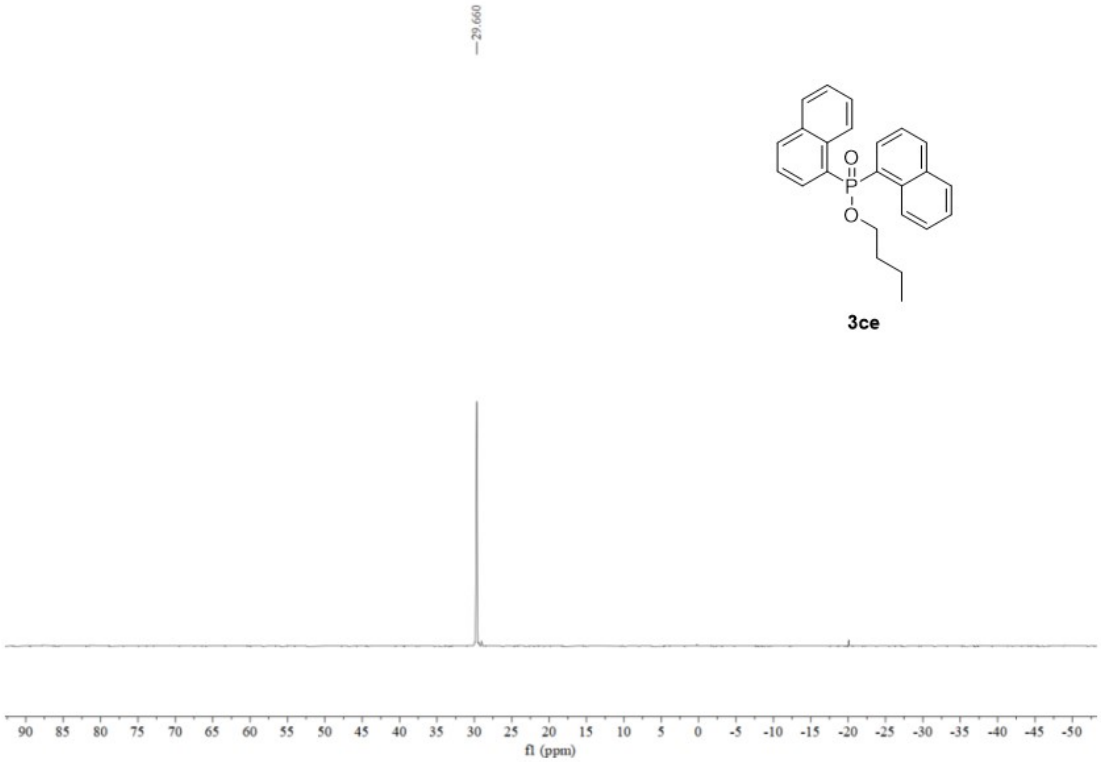

7.346
7.326
7.185
3.884
3.873
3.862
3.851
2.500 (DMSO-d6
2.287
1.631
1.620
1.609
1.606
1.596
1.585
1.395
1.382
1.370
1.357
1.345
1.332
0.880
0.864
0.852
0.849
0.840
0.826
3.88
1.97
2.00
11.87
2.09
2.42
3.20
f1 (ppm)
3cd

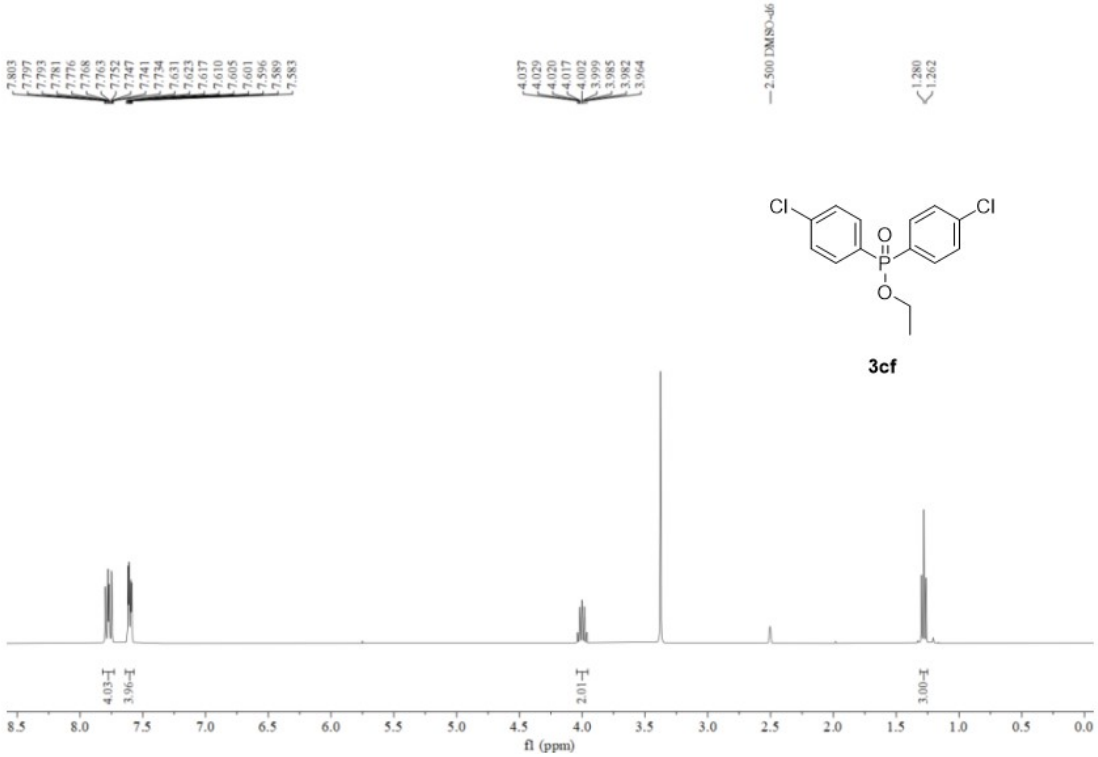

140.885
140.776
132.935
132.839
131.568
131.446
130.729
129.423
125.908
125.786
63.755
63.697
39.520 (DMSO-d6
32.072
32.008
20.598
20.560
18.527
13.489
f1 (ppm)
3cd

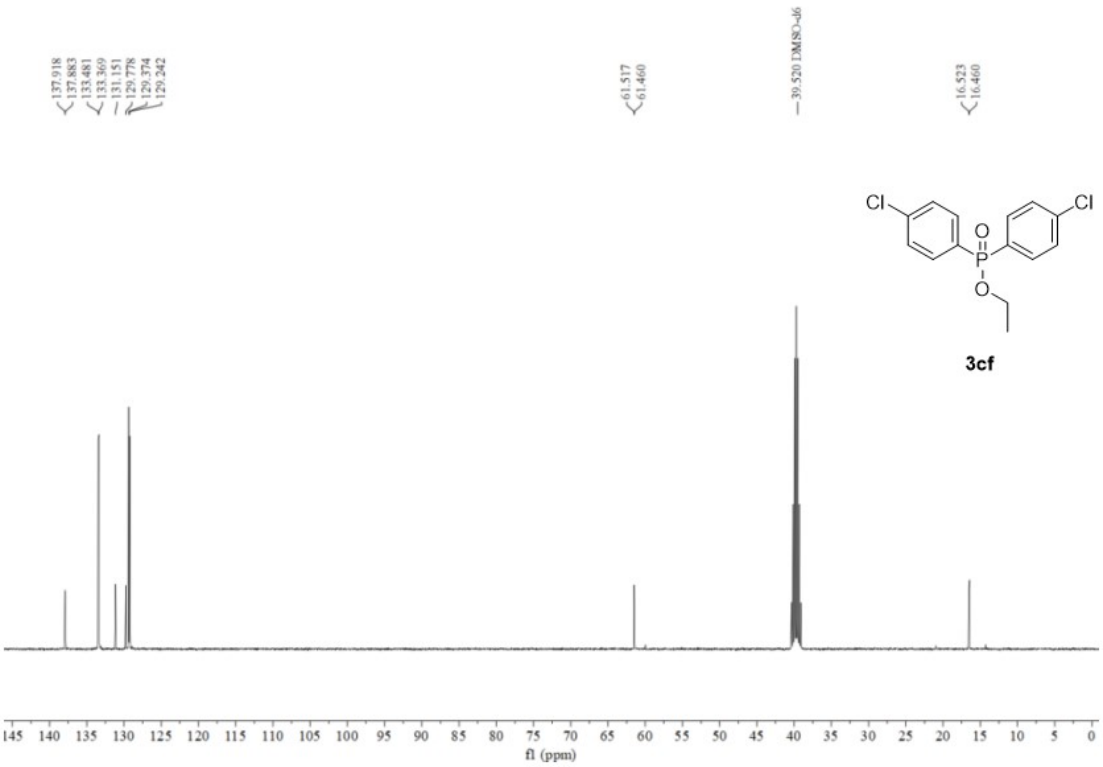

30.800
3cd
70 65 60 55 50 45 40 35 30 25 20 15 10 5 0 -5 -10 -15 -20 -25 -30 -35 -40 -45
f1 (ppm)

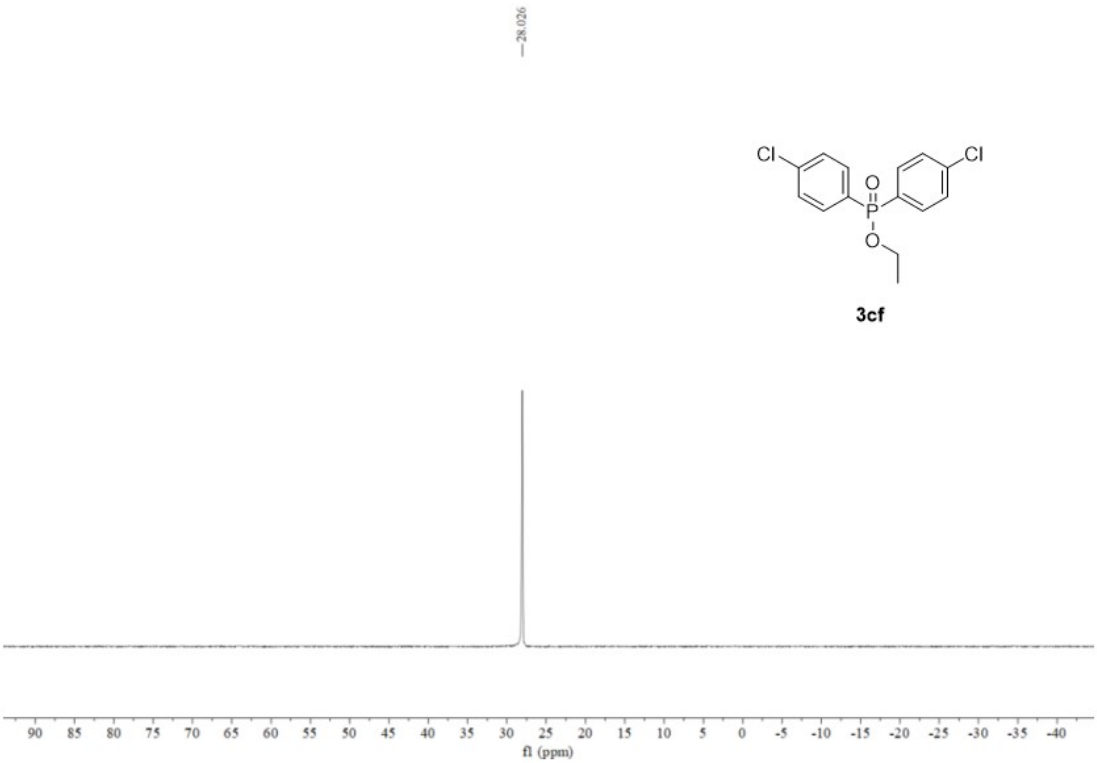

2.500 DMSO-d6
3ce
1.93
1.91
1.95
1.90
1.98
3.94
2.00
2.06
2.15
3.16
f1 (ppm)

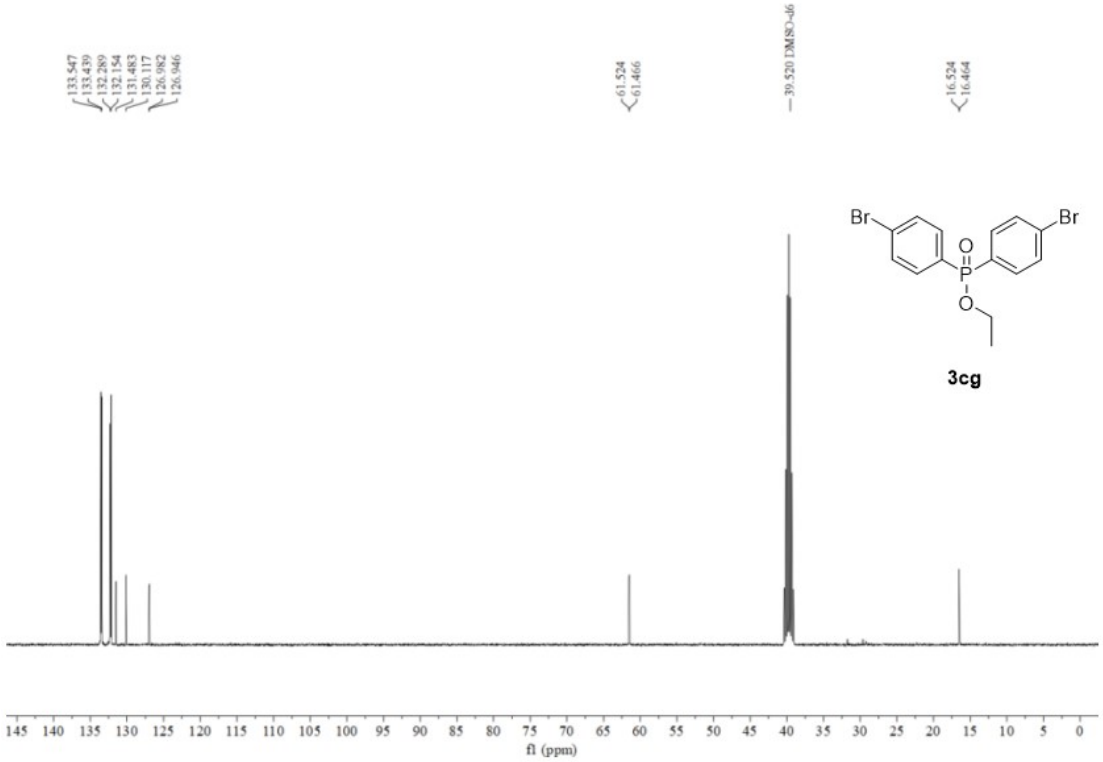

134.558
133.328
133.228
132.301
132.160
129.770
129.136
128.869
128.740
128.414
127.972
127.386
126.481
126.374
61.438
61.380
40.165 DMSO
39.957 DMSO
39.747 DMSO
39.539 DMSO
39.520 DMSO-d6
39.330 DMSO
39.119 DMSO
38.912 DMSO
29.595
16.638
16.579
O
P
O
3ce
140 135 130 125 120 115 110 105 100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5
f1 (ppm)

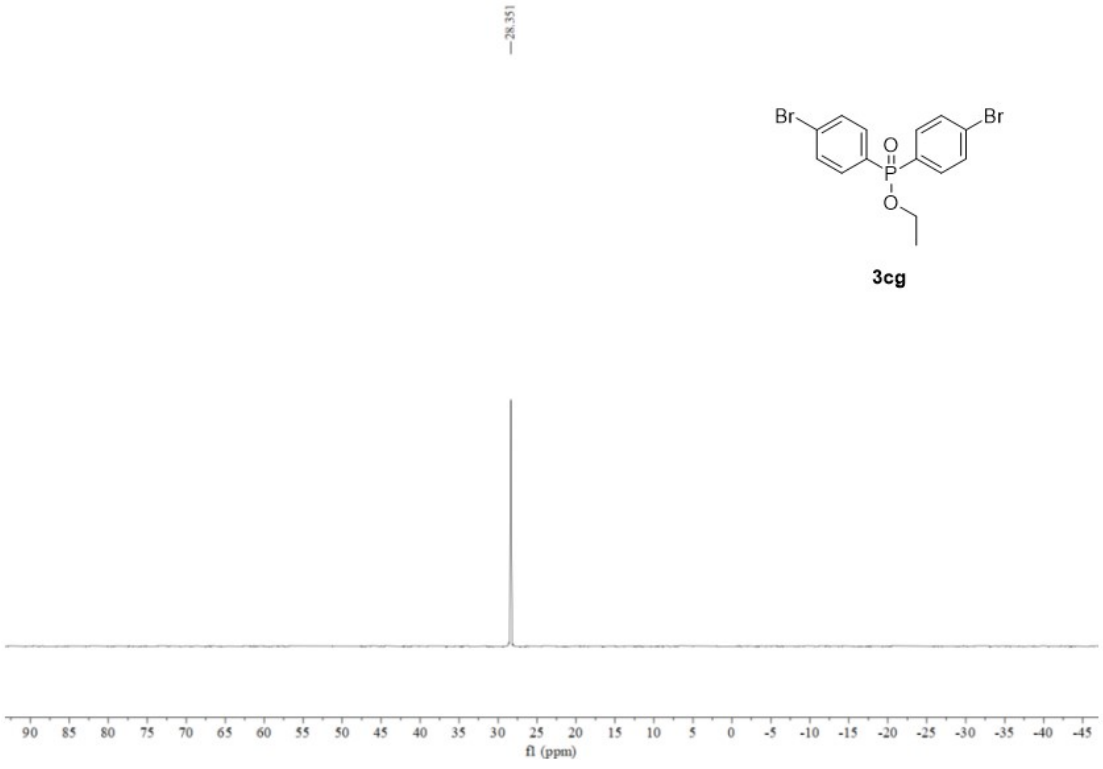

29.660
O
P
O
3ce
90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0 -5 -10 -15 -20 -25 -30 -35 -40 -45 -50
f1 (ppm)

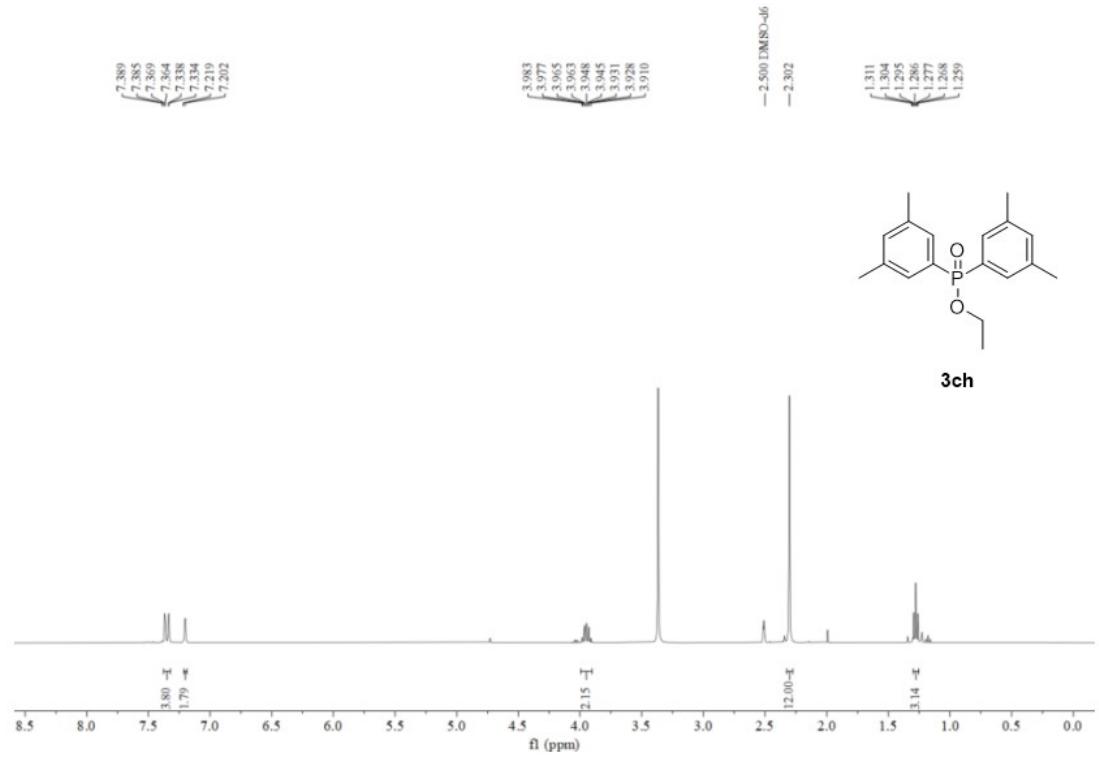

7.803
7.797
7.793
7.781
7.776
7.768
7.763
7.752
7.747
7.741
7.734
7.631
7.623
7.617
7.610
7.605
7.601
7.596
7.589
7.583
4.037
4.029
4.020
4.017
4.002
3.999
3.985
3.982
3.964
2.500 DMSO-d6
1.280
1.262
Cl
Cl
O
P
O
3cf
4.03
3.96
2.01
3.00
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


137.918
137.883
133.481
133.369
131.151
129.778
129.374
129.242
61.517
61.460
39.520 DMSO-d6
16.523
16.460
Cl
Cl
O
P
O
3cf
145 140 135 130 125 120 115 110 105 100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0
f1 (ppm)

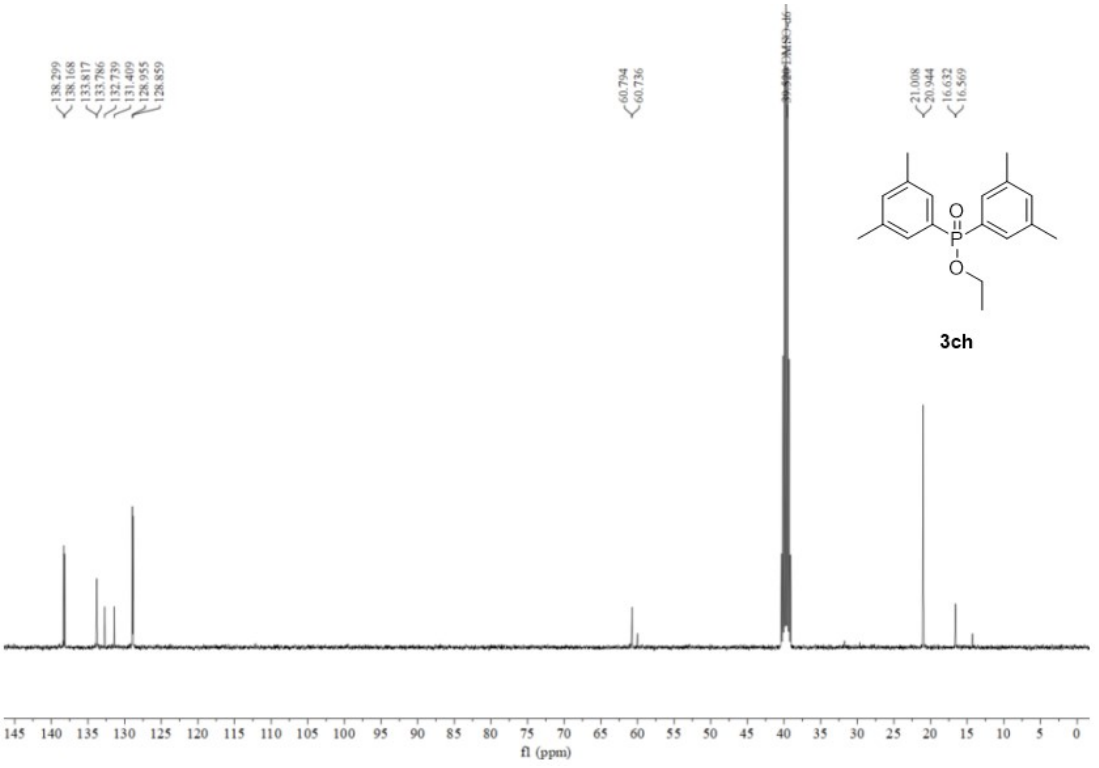

28.026
Cl
Cl
O
P
O
3cf
90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0 -5 -10 -15 -20 -25 -30 -35 -40
f1 (ppm)
7.772
7.767
7.763
7.760
7.755
7.752
7.746
7.739
7.733
7.730
7.722
7.718
7.712
7.701
7.696
7.689
7.684
7.673
7.668
7.663
7.655
4.041
4.023
4.021
4.006
4.003
3.988
3.986
3.968
2.500 DMSO-d6
1.300
1.282
1.265
Br
Br
O
P
O
3cg
3.88
4.02
2.02
3.00
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)


133.547
133.439
132.289
132.154
131.483
130.117
126.982
126.946
61.524
61.466
39.520 DMSO-d6
16.524
16.464
Br
Br
O
P
O
3cg
145 140 135 130 125 120 115 110 105 100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0
f1 (ppm)

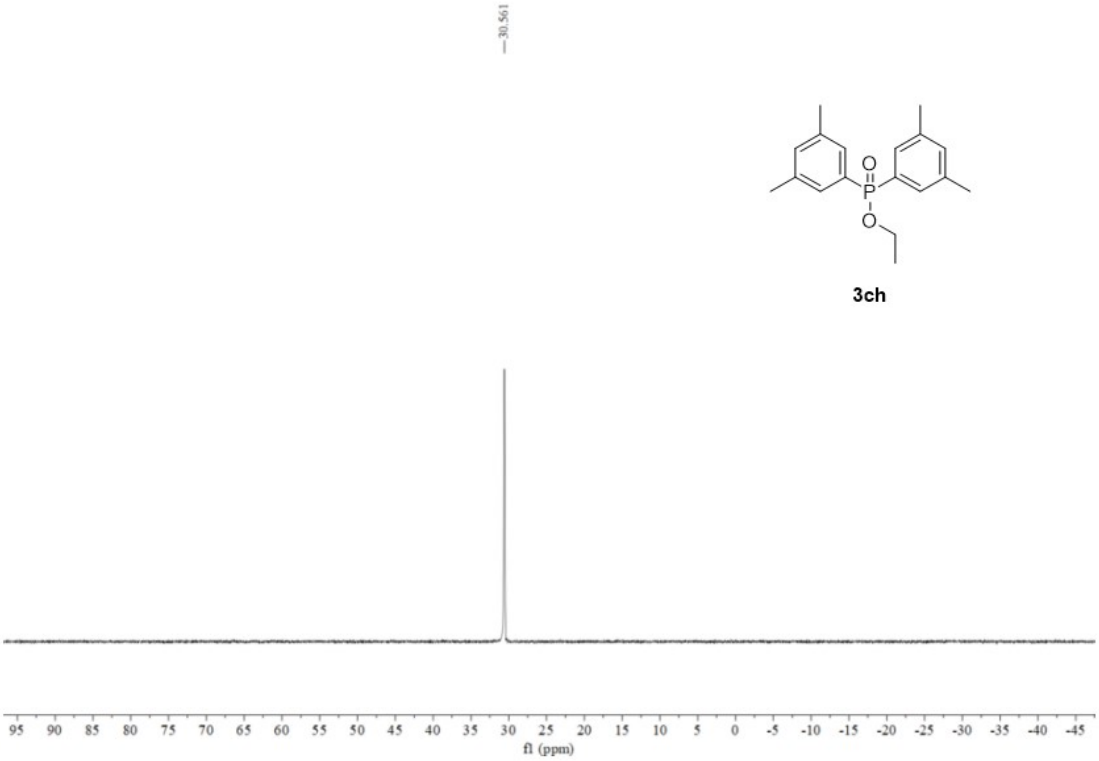

28.351
Br
Br
O
P
O
3cg
90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0 -5 -10 -15 -20 -25 -30 -35 -40 -45
f1 (ppm)


7.389
7.385
7.369
7.364
7.338
7.334
7.219
7.202
3.983
3.977
3.965
3.963
3.948
3.945
3.931
3.928
3.910
2.500 DMSO-d6
2.302
1.311
1.304
1.295
1.286
1.277
1.268
1.259
O
P
O
3.80
1.79
2.15
12.00
3.14
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)

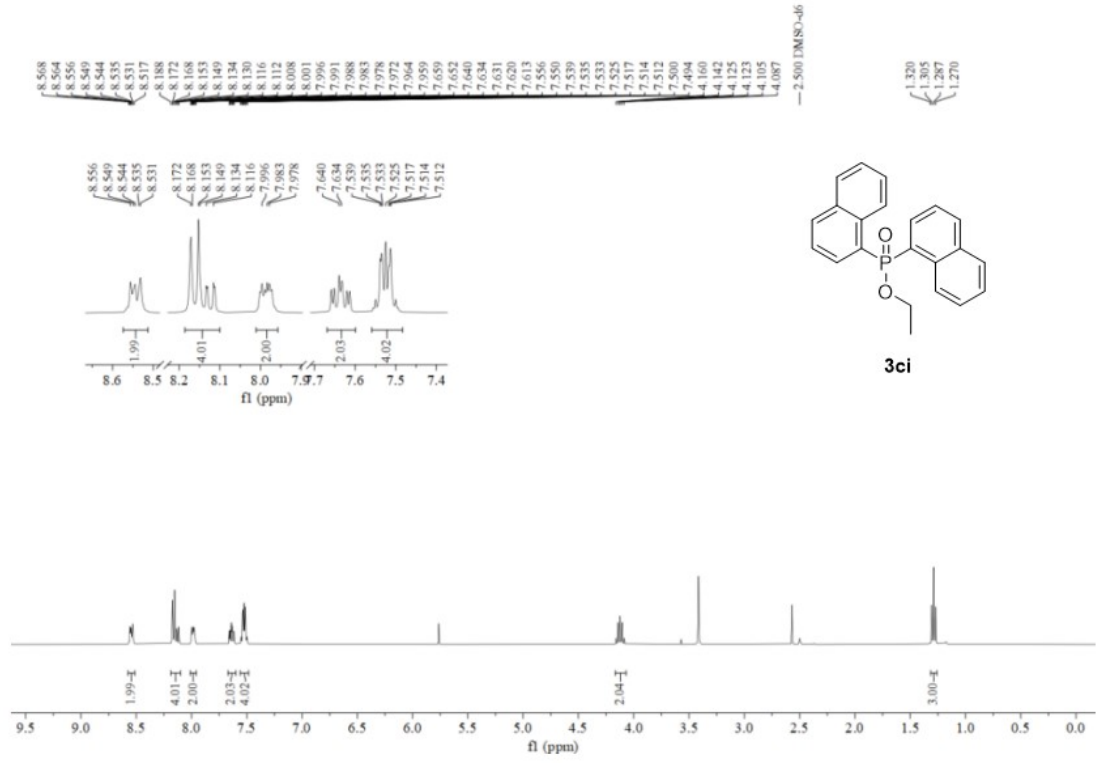
3ch


138.299
138.168
133.817
133.786
132.739
131.409
128.955
128.859
60.794
60.736
21.008
20.944
16.632
16.569
O
P
O
145 140 135 130 125 120 115 110 105 100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0
f1 (ppm)

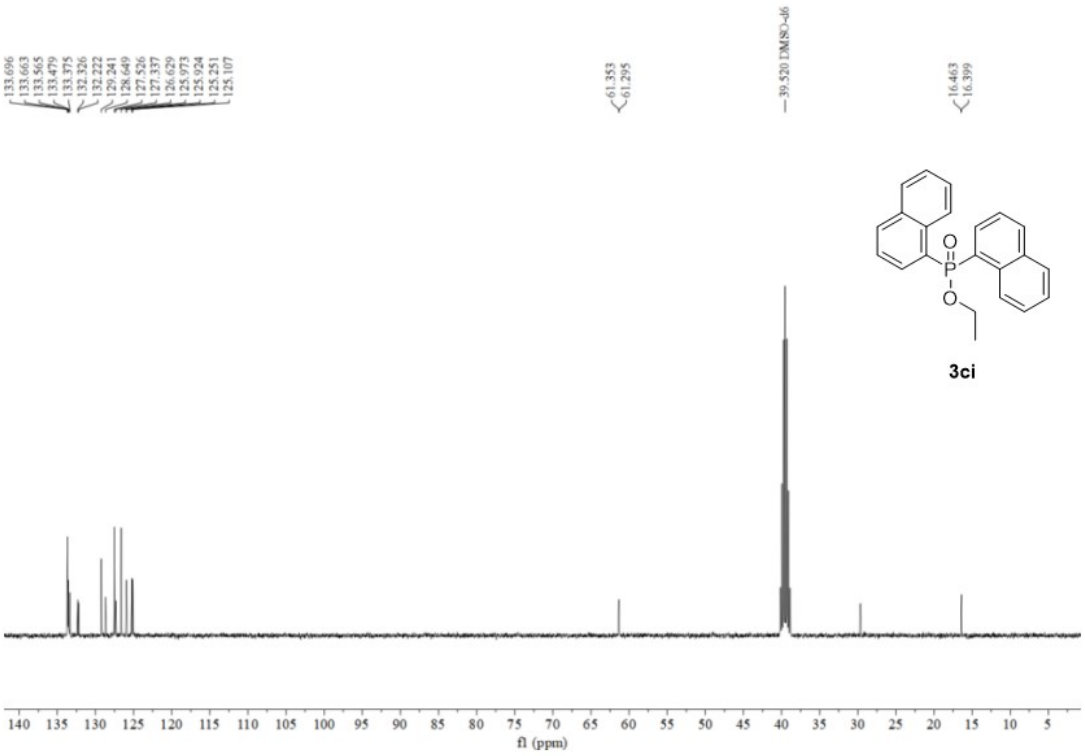
3ch

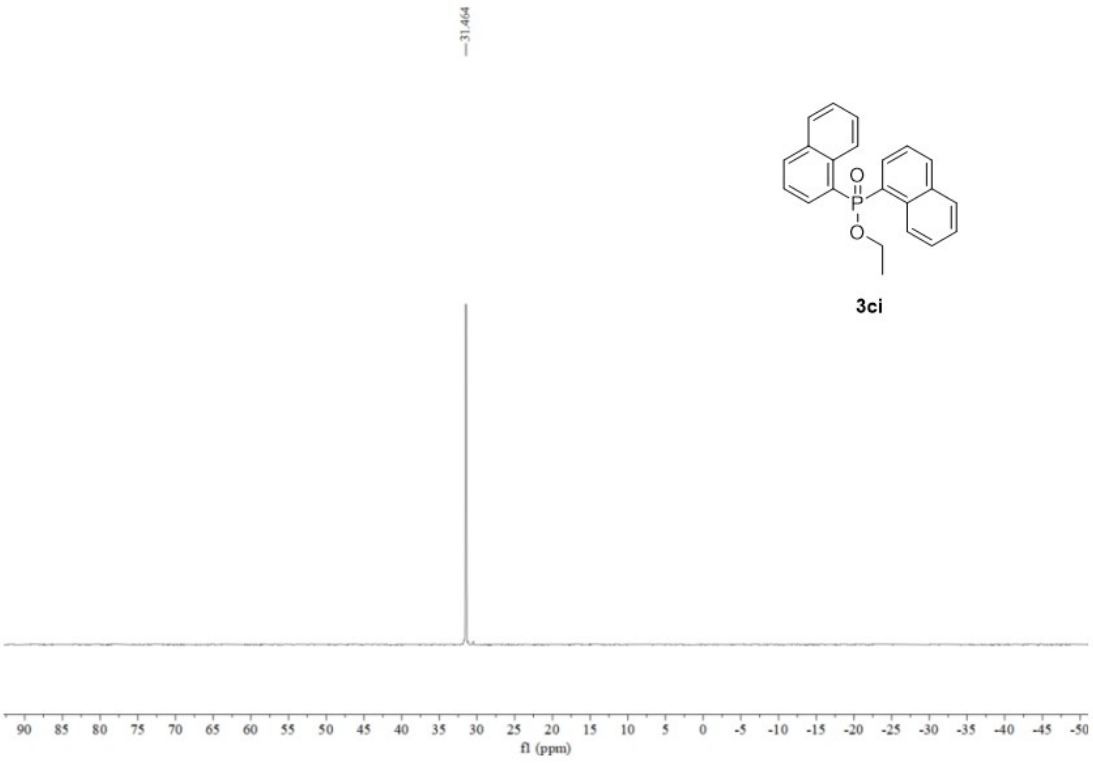

30.561
95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0 -5 -10 -15 -20 -25 -30 -35 -40 -45
f1 (ppm)

3ch


8.568
8.564
8.556
8.549
8.544
8.535
8.531
8.517
8.188
8.172
8.168
8.153
8.149
8.134
8.130
8.116
8.112
8.008
8.001
7.996
7.991
7.988
7.983
7.978
7.972
7.964
7.959
7.659
7.652
7.640
7.634
7.631
7.620
7.613
7.556
7.550
7.539
7.535
7.533
7.525
7.517
7.514
7.512
7.500
7.494
4.160
4.142
4.125
4.123
4.105
4.087
2.500 DMSO-d6
1.320
1.305
1.287
1.270
1.99
4.01
2.00
2.03
4.02
8.6 8.5 8.2 8.1 8.0 7.7 7.6 7.5 7.4
f1 (ppm)
1.99
4.01
2.00
2.03
4.02
2.04
3.00
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)

3ci


133.696
133.663
133.565
133.479
133.375
132.326
132.222
129.241
128.649
127.526
127.337
126.629
125.973
125.924
125.251
125.107
61.353
61.295
39.520 DMSO-d6
16.463
16.399
O
P
O
3ci
140 135 130 125 120 115 110 105 100 95 90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5
f1 (ppm)


31.464
O
P
O
3ci
90 85 80 75 70 65 60 55 50 45 40 35 30 25 20 15 10 5 0 -5 -10 -15 -20 -25 -30 -35 -40 -45 -50
f1 (ppm)