Electronic Supplementary Information (ESI)

Tunable Synthesis of Chalcophosphinic Amides and Tertiary Phosphinates Using *tert*-Butyl *N*, *N*-Dialkylperoxyamidate

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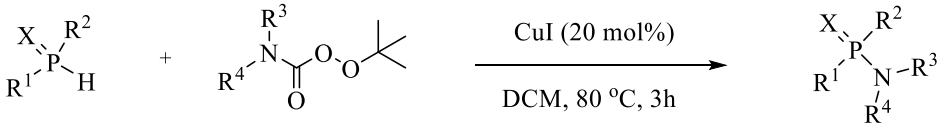
1. General information

Reactions were monitored by using thin-layer chromatography (TLC) on commercial silica gel plates (GF254). Visualization of the developed plates was performed under UV lights (254 nm). Flash column chromatography was performed on silica gel (200-300 mesh). ^{1}H, ^{13}C and ^{31}P NMR spectra were recorded on a Bruker AV300，400 and 500 spectrometer. Chemical shifts (δ) were reported in ppm referenced to the $CDCl_3$ residual peak (δ 7.26) or the DMSO-d_6 residual peak (δ 2.50) for ^{1}H NMR. Chemical shifts of ^{13}C NMR were reported relative to $CDCl_3$ (δ 77.0) or D_6-DMSO (δ 39.5). Chemical shifts of ^{31}P NMR were reported relative to 85% H_3PO_4 (δ = 0). The following abbreviations were used to describe peak splitting patterns when appropriate: br s = broad singlet, s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet. Coupling constant, *J*, was reported in Hertz unit (Hz). Melting points (mp) were taken on a MEL-TEMP® apparatus and were uncorrected. High resolution mass spectra (HRMS) were obtained on an ESI-LC-MS/MS spectrometer.

2. General procedure and product characterization

2.1 General procedure

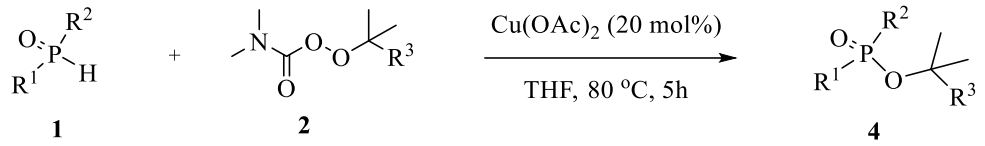
Procedure A: Typical procedure for the synthesis of chalcophosphinic amides **3**.



1 **2** **3**

A 15 mL schlenk tube was charged with a mixture of **1** (0.2 mmol), **2** (0.6 mmol), catalyst (0.04 mmol) in DCM (1.0 mL) and was stirred at 80 °C for 3 h. After the reaction was complete (as determined by TLC analysis), the reaction was cooled to room temperature and EtOAc (20 mL) was added to the solution and washed with brine, dried over Na_2SO_4, concentrated under reduced pressure. The crude product was purified by column chromatography on silica gel (ethanol/hexane = 1:10) to afford the targeted products **3**.

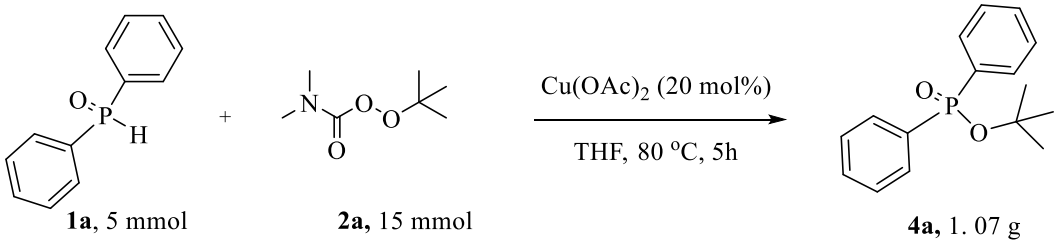
Procedure B: Typical procedure for the synthesis of phosphinates **4**.



A 15 mL schlenk tube was charged with a mixture of **1** (0.2 mmol), **2** (0.6 mmol), catalyst (0.04 mmol) in THF (1.0 mL) and was stirred at 80 °C for 5 h. After the reaction was complete (as determined by TLC analysis), the reaction was cooled to room temperature and EtOAc (20 mL) was added to the solution and washed with brine, dried over Na_2SO_4, concentrated under reduced pressure. The crude product was purified by column chromatography on silica gel (EtOAc/hexane = 1:2) to afford the targeted products **4**.

Procedure C: Gram-scale synthesis of phosphinates **4a**.

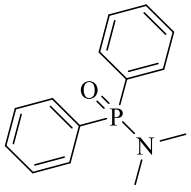
A 100 mL schlenk tube was charged with a mixture of **1a** (5.0 mmol), **2a** (15.0 mmol), catalyst (1.0 mmol) in THF (20.0 mL) and was stirred at 80 °C for 5 h. After the reaction was complete (as determined by TLC analysis), the reaction was cooled to room temperature and EtOAc (100 mL) was added to the solution and washed with brine, dried over Na_2SO_4, concentrated under reduced pressure. The crude product was purified by column chromatography on silica gel (EtOAc/hexane = 1:2) to afford the targeted products **4a** in 78% yield.



1a, 5 mmol **2a,** 15 mmol **4a,** 1. 07 g

2.2 Product Characterization

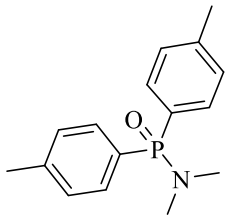
N,N-dimethyl-1,1-diphenylphosphanamine (3a)[1]



Following procedure A, which purified using mixture of ethanol/hexane (1:10) as

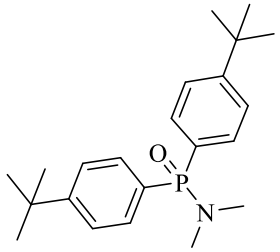
eluent, obtained (39.2 mg, 80% yield) as a white solid; Mp 73-74 ^{o}C. ^{1}H NMR (300 MHz, DMSO): δ 7.82-7.75 (m, 4H), 7.60-7.48 (m, 6H), 2.55 (s, 3H), 2.52 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 132.5, 132.4, 132.3, 131.8, 131.7, 131.2, 128.6, 128.5, 37.2, 37.1; ^{31}P NMR (162 MHz, $CDCl_3$): δ 31.40; HRMS (ESI): Exact mass calcd for $C_{14}H_{16}NOP$ $[M+Na]^+$: 268.0682; Found: 268.0683.

N,N-dimethyl-P-(m-tolyl)-P-(p-tolyl)phosphinic amide (3b)



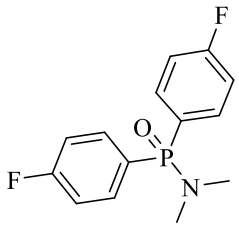
Following procedure A, which purified using mixture of ethanol/hexane (1:10) as eluent, obtained (44.8 mg, 82% yield) as a yellow oil. ^{1}H NMR (500 MHz, $CDCl_3$): δ 7.73 (dd, *J* = 11.5, 8.0, 4H), 7.27-7.24 (m, 4H), 2.65 (s, 3H), 2.63 (s, 3H), 2.37 (s, 6H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 137.9, 137.8, 135.1, 134.0, 133.2, 128.9, 128.8, 31.0, 21.3; ^{31}P NMR (202 MHz, $CDCl_3$): δ 27.18； HRMS (ESI): Exact mass calcd for $C_{16}H_{20}NOP$ $[M+H]^+$: 274.1355; Found: 274.1356.

P,P-bis(4-(tert-butyl)phenyl)-N,N-dimethylphosphinic amide (3c)



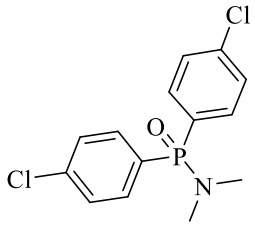
Following procedure A, which purified using mixture of ethanol/hexane (1:10) as eluent, obtained (60.8 mg, 85% yield) as a white solid; Mp 132-134 ^{o}C. White solid. ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.80-7.75 (m, 4H), 7.47-7.44 (m, 4H), 2.67 (s, 3H), 2.64 (s, 3H), 1.31 (s, 18H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 155.0, 132.3, 132.2, 129.4, 128.1, 125.6, 125.4, 37.2, 37.1, 34.9, 31.1; ^{31}P NMR (162 MHz, $CDCl_3$): δ 31.56; HRMS (ESI): Exact mass calcd for $C_{22}H_{32}NOP$ $[M+H]^+$: 358.2294; Found: 358.2293.

P,P-bis(4-fluorophenyl)-N,N-dimethylphosphinic amide (3d)



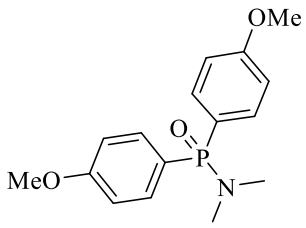
Following procedure A, which purified using mixture of ethanol/hexane (1:10) as eluent, obtained (46.1 mg, 82% yield) as a yellow solid; Mp 88-89 ^{o}C. ^{1}H NMR (300 MHz, DMSO): δ 7.88-7.80 (m, 4H), 7.40-7.33 (m, 4H), 2.54 (s, 6H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 165.1 (d, $^{1}J_{CF}$ = 251.8 Hz), 134.8 (dd, $^{3}J_{CF}$ = 10.3 Hz, $^{3}J_{CF}$ = 8.9 Hz), 127.0, 116.0 (dd, $^{2}J_{CF}$ = 21.1 Hz, $^{2}J_{CF}$ = 13.6 Hz), 37.1; ^{31}P NMR (162 MHz, $CDCl_3$): δ 29.53; ^{19}F NMR (376 MHz, $CDCl_3$) δ -107.03; HRMS (ESI): Exact mass calcd for $C_{14}H_{14}F_2NOP$ $[M+H]^+$: 282.0854; Found: 282.0854.

P,P-bis(4-chlorophenyl)-N,N-dimethylphosphinic amide (3e)



Following procedure A, which purified using mixture of ethanol/hexane (1:10) as eluent, obtained (47.1 mg, 75% yield) as a yellow oil. ^{1}H NMR (300 MHz, DMSO): δ 7.82-7.75 (m, 4H), 7.60 (dd, *J* = 8.7 Hz, 2.4 Hz, 4H), 2.55 (s, 3H), 2.52 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 138.6, 133.8, 133.7, 130.6, 129.3, 129.2, 129.0, 37.1; ^{31}P NMR (162 MHz, $CDCl_3$): δ 29.60; HRMS (ESI): Exact mass calcd for $C_{14}H_{14}Cl_2NOP$ $[M+H]^+$: 314.0263; Found: 314.0266.

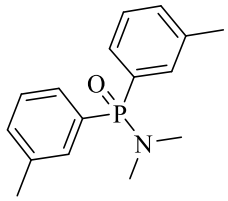
P,P-bis(4-methoxyphenyl)-N,N-dimethylphosphinic amide (3f)



Following procedure A, which purified using mixture of ethanol/hexane (1:10) as eluent, obtained (47.0 mg, 77% yield) as a yellow oil. ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.78-7.71 (m, 4H), 6.94 (d, *J* = 6.6 Hz, 4H), 3.81 (s, 6H), 2.64 (s, 3H), 2.61 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 162.3, 162.2, 134.1, 134.0, 132.9, 132.8, 124.0, 122.7, 114.2, 114.0, 113.5, 113.4, 55.3, 55.1, 37.1, 37.0; ^{31}P NMR (162 MHz, $CDCl_3$): δ

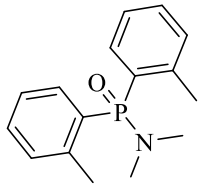
31.60; HRMS (ESI): Exact mass calcd for $C_{16}H_{20}NO_3P$ $[M+H]^+$: 306.1254; Found: 306.1259.

N,N-dimethyl-P,P-di-m-tolylphosphinic amide (3g)



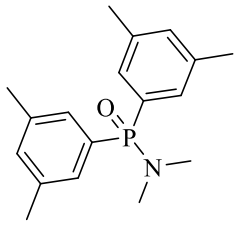
Following procedure A, which purified using mixture of ethanol/hexane (1:10) as eluent, obtained (41.5 mg, 76% yield) as a white solid; Mp 113-114 ^oC. ^1H NMR (300 MHz, $CDCl_3$): δ 7.72 (d, *J* = 12.3 Hz, 2H), 7.62 (t, *J* = 6.9 Hz, 2H), 7.37-7.31 (m, 4H), 2.68 (s, 3H), 2.65 (s, 3H), 2.39 (s, 6H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 138.5, 138.4, 133.0, 132.9, 132.5, 132.3, 131.1, 129.3, 129.2, 128.5, 128.3, 37.2, 21.4; ^{31}P NMR (162 MHz, $CDCl_3$): δ 31.88; HRMS (ESI): Exact mass calcd for $C_{16}H_{20}NOP$ $[M+H]^+$: 274.1355; Found: 274.1358.

N,N-dimethyl-P,P-di-o-tolylphosphinic amide (3h)



Following procedure A, which purified using mixture of ethanol/hexane (1:10) as eluent, obtained (38.8 mg, 71% yield) as a white solid; Mp 110-112 ^oC. ^1H NMR (300 MHz, DMSO): δ 7.50-7.45 (m, 2H), 7.37-7.19 (m, 6H), 2.65 (s, 3H), 2.61 (s, 3H), 2.43 (s, 6H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 143.1, 143.0, 132.7, 132.6, 131.9, 131.8, 131.7, 131.4, 131.3, 130.1, 125.4, 125.3, 36.9, 36.8, 21.5, 21.4; ^{31}P NMR (162 MHz, $CDCl_3$): δ 37.00; HRMS (ESI): Exact mass calcd for $C_{16}H_{20}NOP$ $[M+H]^+$: 274.1355; Found: 274.1351.

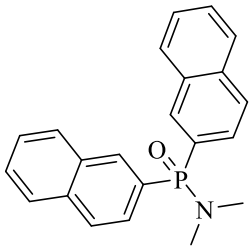
P,P-bis(3,5-dimethylphenyl)-N,N-dimethylphosphinic amide (3i)



Following procedure A, which purified using mixture of ethanol/hexane (1:10) as eluent, obtained (42.2 mg, 70% yield) as a white solid; Mp 117-118 ^oC. ^1H NMR (300

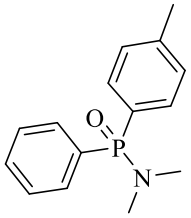
MHz, $CDCl_3$): δ 7.47 (s, 2H), 7.43 (s, 2H), 7.08 (s, 2H), 2.65 (s, 3H), 2.61 (s, 3H), 2.31 (s, 12H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 138.2, 138.1, 133.4, 132.3, 131.0, 129.9, 37.2, 21.3; ^{31}P NMR (162 MHz, $CDCl_3$): δ 32.34; HRMS (ESI): Exact mass calcd for $[M+H]^+$: 302.1668; Found: 302.1662.

N,N-dimethyl-P,P-di(naphthalen-2-yl)phosphinic amide (3j)



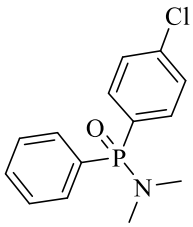
Following procedure A, which purified using mixture of ethanol/hexane (1:10) as eluent, obtained (49.7 mg, 72% yield) as a yellow oil. ^1H NMR (300 MHz, $CDCl_3$): δ 8.58 (d, *J* = 13.5 Hz, 2H), 7.96-7.84 (m, 8H), 7.59-7.53 (m, 4H), 2.78 (s, 3H), 2.75 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 134.8, 134.1, 132.7, 131.8, 129.6, 129.0, 128.8, 128.5, 128.4, 128.1, 127.7, 127.0, 126.9, 126.8, 126.2, 37.3, 37.2, 34.6; ^{31}P NMR (162 MHz, $CDCl_3$): δ 31.34; HRMS (ESI): Exact mass calcd for $C_{22}H_{20}NOP$ $[M+H]^+$: 346.1355; Found: 346.1354.

N,N-dimethyl-P-phenyl-P-(p-tolyl)phosphinic amide (3k)



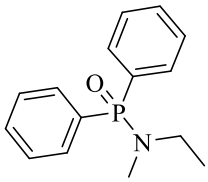
Following procedure A, which purified using mixture of ethanol/hexane (1:10) as eluent, obtained (26.4 mg, 51% yield) as a yellow oil. ^1H NMR (300 MHz, $CDCl_3$): δ 7.87-7.80 (m, 2H), 7.73 (dd, *J* = 11.7 Hz, 8.1 Hz, 2H), 7.47-7.42 (m, 3H), 7.26-7.23 (m, 2H), 2.66 (s, 3H), 2.62 (s, 3H), 2.36 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 142.3, 142.2, 132.7, 132.4, 132.3, 132.2, 131.7, 131.6, 131.4, 129.4, 129.3, 129.0, 128.6, 128.5, 127.7, 37.1, 21.6; ^{31}P NMR (162 MHz, $CDCl_3$): δ 31.81; HRMS (ESI): Exact mass calcd for $C_{15}H_{18}NOP$ $[M+H]^+$: 260.1199; Found: 260.1191.

P-(4-chlorophenyl)-N,N-dimethyl-P-phenylphosphinic amide (3l)



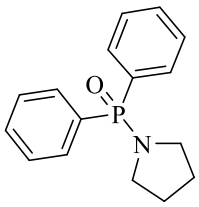
Following procedure A, which purified using mixture of ethanol/hexane (1:10) as eluent, obtained (29.6 mg, 53% yield) as a yellow oil. ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.86-7.76 (m, 4H), 7.51-7.41 (m, 5H), 2.67 (s, 3H), 2.63 (s, 3H) ; ^{13}C NMR (100 MHz, $CDCl_3$): δ 138.4, 133.8, 133.7, 132.3, 132.2, 132.0, 131.1, 130.7, 129.8, 129.0, 128.9, 128.8, 128.7, 37.1; ^{31}P NMR (162 MHz, $CDCl_3$): δ 30.56; HRMS (ESI): Exact mass calcd for $C_{14}H_{15}ClNOP$ $[M+H]^+$: 280.0653; Found: 280.0652.

N-ethyl-N-methyl-P,P-diphenylphosphinic amide (3o)



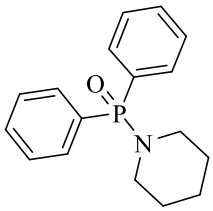
Following procedure A, which purified using mixture of ethanol/hexane (1:10) as eluent, obtained (42.0 mg, 81% yield) as a white solid; Mp 93-94 ^{o}C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.82-7.75 (m, 4H), 7.57-7.48 (m, 6H), 2.90-2.85 (m, 2H), 2.54 (s, 3H), 1.06 (t, *J* =6.9 Hz, 3H) ; ^{13}C NMR (100 MHz, $CDCl_3$): δ 132.8, 132.4, 132.3, 131.7, 131.5, 128.6, 128.5, 43.9, 43.8, 33.3, 33.2, 13.6; ^{31}P NMR (162 MHz, $CDCl_3$): δ 31.23; HRMS (ESI): Exact mass calcd for $C_{15}H_{18}NOP$ $[M+Na]^+$: 282.1018; Found: 282.1017.

diphenyl(pyrrolidin-1-yl)phosphine oxide (3p)



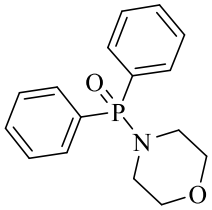
Following procedure A, which purified using mixture of ethanol/hexane (1:10) as eluent, obtained (22.8 mg, 42% yield) as a colorless oil. ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.91-7.84 (m, 4H), 7.44-7.41 (m, 6H), 3.11-3.09 (m, 4H), 1.88-1.83 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 131.2, 131.1, 130.2, 128.0, 127.9, 44.3, 24.3; ^{31}P NMR (162 MHz, $CDCl_3$): δ 21.43; HRMS (ESI): Exact mass calcd for $C_{16}H_{18}NOP$ $[M+H]^+$: 272.1199; Found: 272.1198.

diphenyl(piperidin-1-yl)phosphine oxide (3q)



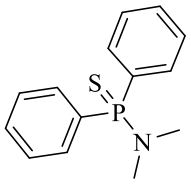
Following procedure A, which purified using mixture of ethanol/hexane (1:10) as eluent, obtained (34.8 mg, 61% yield) as a yellow solid; Mp 103-104 ^{o}C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.92-7.85 (m, 4H), 7.50-7.42 (m, 6H), 3.06-3.00 (m, 4H), 1.61-1.58 (m, 6H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 132.7, 132.4, 132.3, 131.4, 128.6, 128.5, 45.8, 26.3, 26.2, 24.6; ^{31}P NMR (162 MHz, $CDCl_3$): δ 29.06; HRMS (ESI): Exact mass calcd for $C_{17}H_{20}NOP$ $[M+H]^+$: 286.1355; Found: 286.1356.

morpholinodiphenylphosphine oxide (3r)



Following procedure A, which purified using mixture of ethanol/hexane (1:10) as eluent, obtained (31.0 mg, 54% yield) as a yellow oil. ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.92-7.85 (m, 4H), 7.53-7.44 (m, 6H), 3.72 (t, *J* = 4.2 Hz, 4H), 3.11-3.05 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 132.5, 132.4, 132.1, 132.0, 131.4, 130.2, 128.8, 128.7, 67.3, 67.2, 45.0; ^{31}P NMR (162 MHz, $CDCl_3$): δ 29.24; HRMS (ESI): Exact mass calcd for $C_{16}H_{18}NO_2P$ $[M+H]^+$: 288.1148; Found: 288.1149.

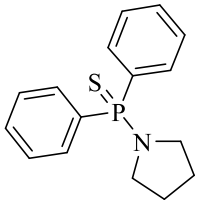
N,N-dimethyl-P,P-diphenylphosphinothioic amide (3s)



Following procedure A, which purified using mixture of ethanol/hexane (1:10) as eluent, obtained (40.8 mg, 78% yield) as a white solid; Mp 78-79 ^{o}C. ^{1}H NMR (300 MHz, DMSO): δ 8.04-7.97 (m, 4H), 7.56-7.53 (m, 6H), 2.42 (s, 3H), 2.38 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 133.3, 132.3, 132.1, 132.0, 131.7, 131.6, 128.5, 128.4, 37.5; ^{31}P NMR (162 MHz, $CDCl_3$): δ 71.13; HRMS (ESI): Exact mass calcd for

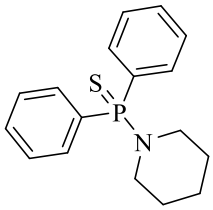
$C_{14}H_{16}NPS$ $[M+NH_4]^+$: 279.1079; Found: 279.1079.

diphenyl(pyrrolidin-1-yl)phosphine sulfide (3t)



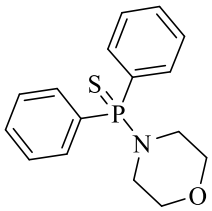
Following procedure A, which purified using mixture of ethanol/hexane (1:10) as eluent, obtained (21.3 mg, 37% yield) as a yellow solid; Mp 92-93 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.12-8.04 (m, 4H), 7.49-7.44 (m, 6H), 3.02 (t, *J* = 2.7 Hz, 4H), 1.92-1.88 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 134.3, 133.3, 132.1, 132.0, 131.5, 128.4, 128.3, 47.3, 47.2, 26.4, 26.3; ^{31}P NMR (162 MHz, $CDCl_3$): δ 65.08; HRMS (ESI): Exact mass calcd for $C_{16}H_{18}NPS$ $[M+H]^+$: 288.0970; Found: 288.0971.

diphenyl(piperidin-1-yl)phosphine sulfide (3u)



Following procedure A, which purified using mixture of ethanol/hexane (1:10) as eluent, obtained (30.7 mg, 51% yield) as a white solid; Mp 77-79 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.12-8.04 (m, 4H), 7.49-7.44 (m, 6H), 2.84 (d, *J* = 3.0 Hz, 4H), 1.63 (s, 6H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 133.4, 132.4, 132.0, 131.9, 131.5, 128.5, 128.4, 46.0, 25.9, 25.8, 24.3; ^{31}P NMR (162 MHz, $CDCl_3$): δ 67.56； HRMS (ESI): Exact mass calcd for $C_{17}H_{20}NPS$ $[M+H]^+$: 302.1127; Found: 302.1121.

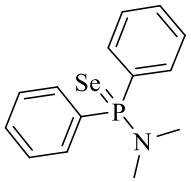
morpholinodiphenylphosphine sulfide (3v)



Following procedure A, which purified using mixture of ethanol/hexane (1:10) as eluent, obtained (27.9 mg, 46% yield) as a white solid; Mp 90-91 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.12-8.04 (m, 4H), 7.52-7.47 (m, 6H), 3.77 (t, *J* = 3.9 Hz, 4H), 2.92-2.87 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 132.3, 132.2, 132.1, 131.9, 131.3,

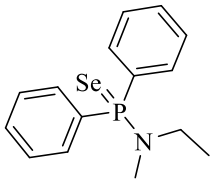
128.7, 128.6, 66.8, 66.7, 45.1; ^{31}P NMR (162 MHz, $CDCl_3$): δ 67.60; HRMS (ESI): Exact mass calcd for $C_{16}H_{18}NOPS$ $[M+H]^+$:304.0847; Found: 304.0851.

N,N-dimethyl-P,P-diphenylphosphinoselenoic amide (3w)



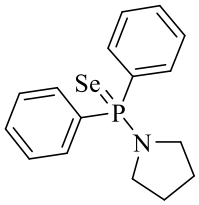
Following procedure A, which purified using mixture of ethanol/hexane (1:10) as eluent, obtained (41.3 mg, 67% yield) as a pink solid; Mp 78-79 ^{o}C. ^{1}H NMR (300 MHz, DMSO): δ 8.08-8.01 (m, 4H), 7.57-7.54 (m, 6H), 2.36 (s, 3H), 2.31 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 132.6, 132.4, 132.3, 131.8, 131.7, 128.5, 128.4, 38.1; ^{31}P NMR (162 MHz, $CDCl_3$): δ 72.82; HRMS (ESI): Exact mass calcd for $C_{14}H_{16}NPSe$ $[M+H]^+$: 310.0258; Found: 310.0259.

N-ethyl-N-methyl-P,P-diphenylphosphinoselenoic amide (3x)



Following procedure A, which purified using mixture of ethanol/hexane (1:10) as eluent, obtained (38.0 mg, 59% yield) as a white solid; Mp 86-87 ^{o}C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.13-8.06 (m, 4H), 7.49-7.42 (m, 6H), 2.87-2.77 (m, 2H), 2.48 (d, *J* = 15.3 Hz, 3H), 1.17 (t, *J* =7.2 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 133.1, 132.3, 132.2, 132.1, 131.7, 128.4, 128.3, 45.0, 34.1, 12.9, 12.8; ^{31}P NMR (162 MHz, $CDCl_3$): δ 71.17; HRMS (ESI): Exact mass calcd for $C_{15}H_{18}NPSe$ $[M+H]^+$: 324.0415; Found: 324.0411.

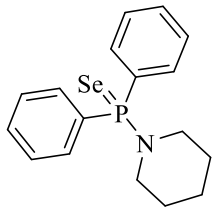
diphenyl(pyrrolidin-1-yl)phosphine selenide (3y)



Following procedure A, which purified using mixture of ethanol/hexane (1:10) as eluent, obtained (27.4 mg, 41% yield) as a yellow solid; Mp 109-110 ^{o}C. ^{1}H NMR (300 MHz, DMSO): δ 8.07-8.00 (m, 4H), 7.56-7.52 (m, 6H), 2.87-2.79 (m, 4H),

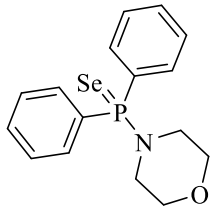
1.85-1.81 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 133.6, 132.7, 132.3, 132.2, 131.7, 128.4, 128.3, 47.9, 26.2, 26.1; ^{31}P NMR (162 MHz, $CDCl_3$): δ 66.42; HRMS (ESI): Exact mass calcd for $C_{16}H_{18}NPSe$ $[M+Na]^+$: 358.0234; Found: 358.0235.

diphenyl(piperidin-1-yl)phosphine selenide (3z)



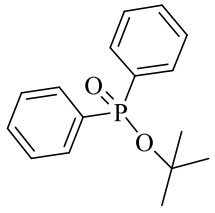
Following procedure A, which purified using mixture of ethanol/hexane (1:10) as eluent, obtained (30.7 mg, 44% yield) as a ywllow solid; Mp 81-82 ^{o}C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.14-8.07 (m, 4H), 7.48-7.42 (m, 6H), 2.77 (t, *J* = 3.9 Hz, 4H), 1.64 (s, 6H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 132.6, 132.3, 132.2, 132.1, 131.7, 128.5, 128.4, 128.3, 46.6, 25.7, 25.6, 24.2; ^{31}P NMR (162 MHz, $CDCl_3$): δ 68.22; HRMS (ESI): Exact mass calcd for $C_{17}H_{20}NPSe$ $[M+H]^+$: 350.0571; Found: 350.0570.

morpholinodiphenylphosphine selenide (3aa)



Following procedure A, which purified using mixture of ethanol/hexane (1:10) as eluent, obtained (35.0 mg, 50% yield) as a brown solid; Mp 113-114 ^{o}C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.14-8.07 (m, 4H), 7.52-7.44 (m, 6H), 3.79 (t, *J* = 4.2 Hz, 4H), 2.86-2.81 (m, 4H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 132.5, 132.4, 132.1, 131.6, 130.6, 128.7, 128.5, 66.6, 66.4, 45.6; ^{31}P NMR (162 MHz, $CDCl_3$): δ 68.61; HRMS (ESI): Exact mass calcd for $C_{16}H_{18}NOPSe$ $[M+H]^+$:352.0291; Found: 352.0296.

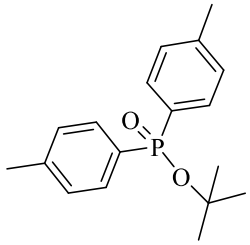
tert-butyl diphenylphosphinate (4a)



Following procedure B, which purified using mixture of EtOAc/hexane (1:2) as eluent,

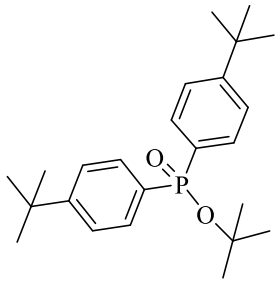
obtained (44.4 mg, 81% yield) as a white solid; Mp 102-103 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.82-7.75 (m, 4H), 7.43-7.35 (m, 6H), 1.49 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 135.4, 134.0, 131.5, 131.4, 131.3, 128.3, 128.2, 83.7, 83.6, 31.0, 30.9; ^{31}P NMR (162 MHz, $CDCl_3$): δ 25.77; HRMS (ESI): Exact mass calcd for $C_{16}H_{19}O_2P$ $[M+Na]^+$: 297.1015; Found: 297.1016.

tert-butyl di-p-tolylphosphinate (4b)



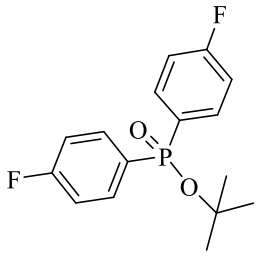
Following procedure B, which purified using mixture of EtOAc/hexane (1:2) as eluent, obtained (52.0 mg, 86% yield) as a white solid; Mp 118-119 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.70-7.63 (m, 4H), 7.21-7.17 (m, 4H), 2.34 (s, 6H), 1.49 (s, 9H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 141.8, 132.5, 131.4, 131.3, 131.1, 129.1, 128.9, 83.2, 31.0, 31.0, 30.9, 21.6; ^{31}P NMR (162 MHz, $CDCl_3$): 26.71; HRMS(ESI): Exact mass calcd for for $C_{18}H_{23}O_2P$ $[M+Na]^+$: 325.1328; Found: 325.1321.

tert-butyl bis(4-(tert-butyl)phenyl)phosphinate (4c)



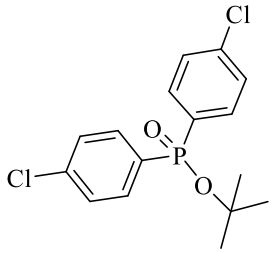
Following procedure B, which purified using mixture of EtOAc/hexane (1:2) as eluent, obtained (63.4 mg, 82% yield) as a white solid; Mp: 144-146 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.76-7.70 (m, 4H), 7.45-7.42 (m, 4H), 1.52 (s, 9H), 1.32 (s, 18H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 154.7, 131.2, 131.1, 131.0, 125.3, 125.2, 83.2, 83.1, 34.9, 31.2, 31.0; ^{31}P NMR (162 MHz, $CDCl_3$): δ 26.66; HRMS (ESI): Exact mass calcd for $C_{24}H_{35}O_2P$ $[M+Na]^+$: 409.2267; Found: 409.2266.

tert-butyl bis(4-fluorophenyl)phosphinate (4d)



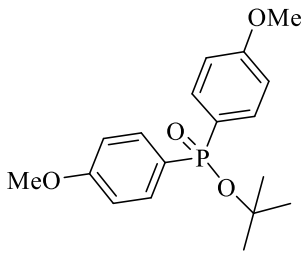
Following procedure B, which purified using mixture of EtOAc/hexane (1:2) as eluent, obtained (47.2 mg, 76% yield) as a white solid; Mp 69-71 ^{o}C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.81-7.72 (m, 4H), 7.12-7.05 (m, 4H), 1.49 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 164.9 (d, J_{CF} = 251.3 Hz), 133.7 (dd, $^{3}J_{CF}$ = 11.5 Hz, $^{3}J_{CF}$ = 8.7 Hz), 131.3, 131.2, 129.9, 129.8, 115.7 (dd, $^{2}J_{CF}$ = 21.3 Hz, $^{2}J_{CF}$ = 14.3 Hz), 84.3, 84.2, 30.9; ^{31}P NMR (162 MHz, $CDCl_3$): δ 23.98; ^{19}F NMR (376 MHz $CDCl_3$): δ -111.11; HRMS (ESI): Exact mass calcd for $C_{16}H_{17}F_2O_2P$ $[M+Na]^+$:333.0934; Found: 333.0931.

tert-butyl bis(4-chlorophenyl)phosphinate (4e)



Following procedure B, which purified using mixture of EtOAc/hexane (1:2) as eluent, obtained (47.4 mg, 69% yield) as a white solid; Mp 79-80 ^{o}C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.74-7.67 (m, 4H), 7.43-7.39 (m, 4H), 1.52 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 138.3, 133.5, 132.7, 132.6 , 132.1, 128.9, 128.7, 84.7, 84.6, 31.0, 30.9; ^{31}P NMR (162 MHz, $CDCl_3$): δ 23.85; HRMS (ESI): Exact mass calcd for $C_{16}H_{17}Cl_2O_2P$ $[M+Na]^+$:365.0235; Found:365.0234.

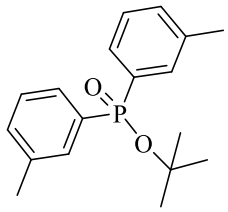
tert-butyl bis(4-methoxyphenyl)phosphinate (4f)



Following procedure B, which purified using mixture of EtOAc/hexane (1:2) as eluent, obtained (55.5 mg, 83% yield) as a white solid; White solid. ^{1}H NMR (300 MHz,

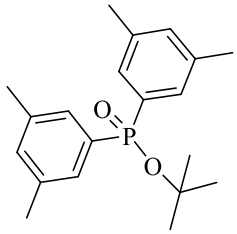
$CDCl_3$): δ 7.64-7.57 (m, 4H), 7.04-7.00 (m, 4H), 3.79 (s, 6H), 1.40 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 162.0, 133.2, 133.1, 127.2, 125.8, 113.8, 113.7, 83.1, 83.0, 55.3, 31.0, 30.9; ^{31}P NMR (162 MHz, $CDCl_3$): δ 26.59; HRMS (ESI): Exact mass calcd for $C_{18}H_{23}O_4P$ $[M+H]^+$: 335.1407; Found: 335.1404.

tert-butyl di-m-tolylphosphinate (4g)



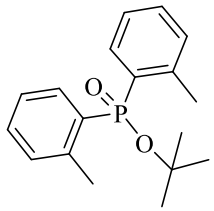
Following procedure B, which purified using mixture of EtOAc/hexane (1:2) as eluent, obtained (46.0 mg, 76% yield) as a white solid; Mp 70-71 ^oC. ^1H NMR (300 MHz, $CDCl_3$): δ 7.64-7.54 (m, 4H), 7.32-7.25 (m, 4H), 2.36 (s, 6H), 1.51 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 138.1, 138.0, 135.3, 134.0, 132.3, 132.2, 131.8, 131.7, 128.5, 128.4, 128.2, 128.1, 83.5, 83.4, 31.0, 30.9, 21.4; ^{31}P NMR (162 MHz, $CDCl_3$): δ 26.49; HRMS (ESI): Exact mass calcd for $C_{18}H_{23}O_2P$ $[M+Na]^+$: 325.1328; Found: 325.1322.

tert-butyl (3,4-dimethylphenyl)(3,5-dimethylphenyl)phosphinate (4h)



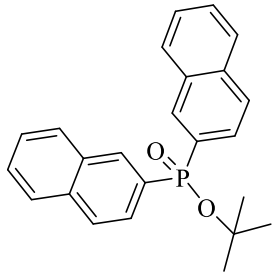
Following procedure B, which purified using mixture of EtOAc/hexane (1:2) as eluent, obtained (39.6 mg, 60% yield) as a white solid; Mp 86-87 ^oC. ^1H NMR (500 MHz, $CDCl_3$): δ 7.43 (s, 2H), 7.39 (s, 2H), 7.09 (s, 2H), 2.33 (s, 12H), 1.52 (s, 9H); ^{13}C NMR (125 MHz, $CDCl_3$): δ 137.8, 137.8, 135.1, 134.0, 133.2, 133.1, 128.9, 128.8, 83.3, 83.2, 31.0, 21.3; ^{31}P NMR (202 MHz, $CDCl_3$): δ 27.18; HRMS (ESI): Exact mass calcd for $C_{20}H_{27}O_2P$ $[M+Na]^+$: 353.1641; Found: 353.1646.

tert-butyl di-o-tolylphosphinate(4i)



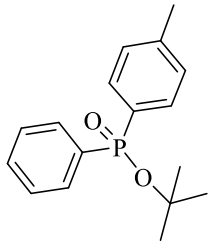
Following procedure B, which purified using mixture of EtOAc/hexane (1:2) as eluent, obtained (40.5 mg, 67% yield) as a white solid; Mp 82-84 ^{o}C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 8.03-7.95 (m, 2H), 7.40-7.34 (m, 2H), 7.30-7.27 (m, 2H), 7.16-7.12 (m, 2H), 2.32 (s, 6H), 1.51 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 141.2, 141.1, 133.5, 133.4, 133.3, 132.1, 131.7, 131.3, 131.2, 125.4, 125.3, 83.9, 83.8, 30.9, 30.8, 21.2; ^{31}P NMR (162 MHz, $CDCl_3$): δ 25.72; HRMS (ESI): Exact mass calcd for $C_{18}H_{23}O_2P$ $[M+Na]^+$: 325.1328; Found: 325.1323.

tert-butyl di(naphthalen-1-yl)phosphinate (4j)



Following procedure B, which purified using mixture of EtOAc/hexane (1:2) as eluent, obtained (57.7 mg, 77% yield) as a white solid; Mp 144-145 ^{o}C. ^{1}H NMR(300 MHz, DMSO): δ 8.44 (d, *J* =14.1 Hz, 2H), 8.10 (d, *J* = 7.2 Hz, 2H), 8.04-7.95 (m, 4H), 7.83-7.76 (m, 2H), 7.64-7.59 (m, 4H), 1.50 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 134.7, 134.6, 133.0, 132.9, 132.6, 132.5, 132.4, 131.1, 129.0, 128.2, 128.0, 127.9, 127.7, 126.7, 126.6, 126.5, 84.0, 83.9, 31.1, 31.0; ^{31}P NMR (162 MHz, $CDCl_3$): δ 25.96; HRMS (EI): Exact mass calcd for $C_{24}H_{23}O_2P$ $[M+Na]^+$: 397.1328; Found: 397.1320.

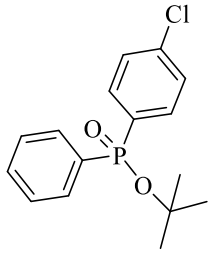
tert-butyl phenyl(p-tolyl)phosphinate (4k)



Following procedure B, which purified using mixture of EtOAc/hexane (1:2) as eluent, obtained (47.3 mg, 82% yield) as a yellow solid; Mp 70-72 ^{o}C. ^{1}H NMR (300 MHz,

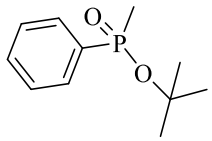
$CDCl_3$): δ 7.82-7.66 (m, 4H), 7.47-7.40 (m, 3H), 7.24-7.22 (m, 2H), 2.38 (s, 3H), 1.52 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 141.9, 135.7, 134.3, 132.2, 131.5, 131.4, 131.3, 131.2, 130.8, 129.1, 129.0, 128.3, 128.2, 83.5, 83.4, 31.0, 30.9, 21.6; ^{31}P NMR (162 MHz, $CDCl_3$): δ 26.26; HRMS (ESI): Exact mass calcd for $C_{17}H_{21}O_2P$ $[M+Na]^+$: 311.1171; Found: 311.1171.

tert-butyl (4-chlorophenyl)(phenyl)phosphinate (4l)



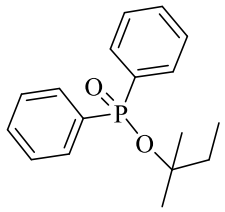
Following procedure B, which purified using mixture of EtOAc/hexane (1:2) as eluent, obtained (45.1 mg, 73% yield) as a white solid; Mp 117-119 °C. ^1H NMR (300 MHz, $CDCl_3$): δ 7.79-7.67 (m, 4H), 7.45-7.34 (m, 5H), 1.49 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 138.1, 138.0, 134.8, 133.9, 133.4, 132.8, 132.7, 132.6, 131.8, 131.7, 131.3, 131.2, 128.7, 128.6, 128.5, 128.4, 84.2, 84.1, 30.9; ^{31}P NMR (162 MHz, $CDCl_3$): δ 24.84; HRMS (ESI): Exact mass calcd for $C_{16}H_{18}ClO_2P$ $[M+H]^+$:309.0987; Found: 309.0989.

tert-butyl methyl(phenyl)phosphinate (4m)



Following procedure B, which purified using mixture of EtOAc/hexane (1:2) as eluent, obtained (19.9 mg, 47% yield) as a colorless oil. ^1H NMR (300 MHz, $CDCl_3$): δ 7.78-7.71 (m, 2H), 7.57-7.51 (m, 3H), 1.56 (d, J = 14.4 Hz, 3H), 1.35 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 135.8, 134.5, 131.6, 130.9, 130.8, 128.4, 128.3, 82.7, 30.8, 19.1, 18.1; ^{31}P NMR (162 MHz, $CDCl_3$): δ 37.15; HRMS (ESI): Exact mass calcd for $C_{11}H_{17}O_2P$ $[M+H]^+$:213.0977; Found: 213.0972.

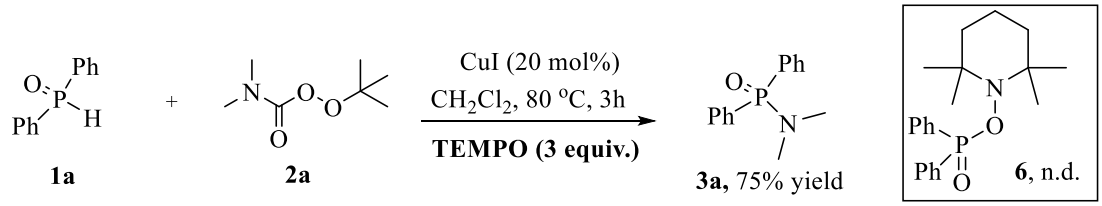
tert-pentyl diphenylphosphinate (4o)



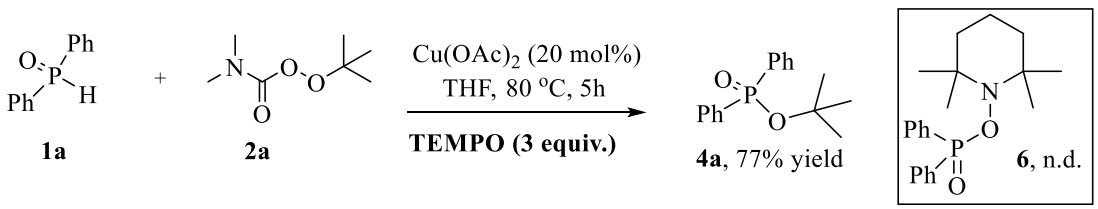
Following procedure B, which purified using mixture of EtOAc/hexane (1:2) as eluent, obtained (34.6 mg, 60% yield) as a white solid; Mp 68-69 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ 7.83-7.76 (m, 4H), 7.49-7.37 (m, 6H), 1.81 (d, *J* = 7.5 Hz, 2H), 1.46 (s, 6H), 0.99 (t, *J* = 7.5 Hz, 3H); ^{13}C NMR (100 MHz, $CDCl_3$): δ 135.5, 134.2, 131.5, 131.4, 131.3, 128.3, 128.2, 86.4, 36.6, 28.1, 8.8; ^{31}P NMR (162 MHz, $CDCl_3$): δ 25.49; HRMS (ESI): Exact mass calcd for $C_{17}H_{21}O_2P$ $[M+Na]^+$: 311.1171; Found: 311.1171.

3. Mechanistic studies

3.1 The radical-trapping experiment



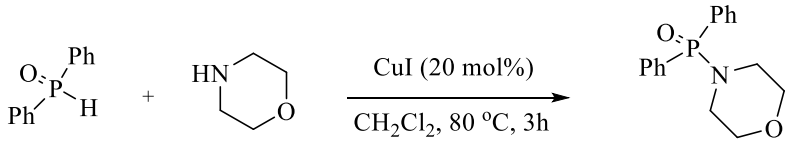
A 15 mL schlenk tube was charged with a mixture of **1a** (0.2 mmol), **2a** (0.6 mmol), TEMPO (0.6 mmol), catalyst (0.04 mmol) in DCM (1.0 mL) and was stirred at 80 °C for 3 h. After the reaction was complete (as determined by TLC analysis), the reaction was cooled to room temperature and EtOAc (20 mL) was added to the solution and washed with brine, dried over Na_2SO_4, concentrated under reduced pressure. The crude product was purified by column chromatography on silica gel (ethanol/hexane = 1:10) to afford the product **3a** in 75% yield.



A15 mL schlenk tube was charged with a mixture of **1a** (0.2 mmol), **2a** (0.6 mmol), TEMPO (0.6 mmol), catalyst (0.04 mmol) in THF (1.0 mL) and was stirred at 80 °C

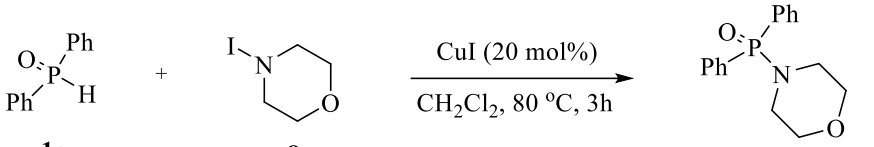
for 5 h. After the reaction was complete (as determined by TLC analysis), the reaction was cooled to room temperature and EtOAc (20 mL) was added to the solution and washed with brine, dried over Na_2SO_4, concentrated under reduced pressure. The crude product was purified by column chromatography on silica gel (EtOAc/hexane = 1:2) to afford the targeted products **4a** in 77% yield.

3.2 Exporing possible reaction pathway



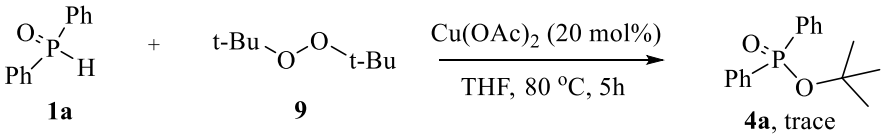
1a **7** **3r,** n.d.

A 15 mL schlenk tube was charged with a mixture of **1a** (0.2 mmol), **7** (0.6 mmol), catalyst (0.04 mmol) in DCM (1.0 mL) and was stirred at 80 °C for 3 h. Then the reaction was monitored by TLC and the targeted product **3r** was not detected.



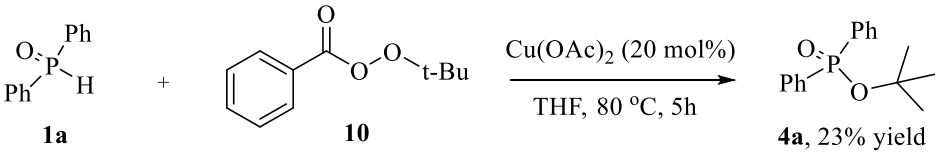
1a **8** **3r,** 64% yield

A 15 mL schlenk tube was charged with a mixture of **1a** (0.2 mmol), **8** (0.6 mmol), catalyst (0.04 mmol) in DCM (1.0 mL) and was stirred at 80 °C for 3 h. After the reaction was complete (as determined by TLC analysis), the reaction was cooled to room temperature and EtOAc (20 mL) was added to the solution and washed with brine, dried over Na_2SO_4, concentrated under reduced pressure. The crude product was purified by column chromatography on silica gel (ethanol/hexane = 1:10) to afford the targeted products **3r** in 64% yield.

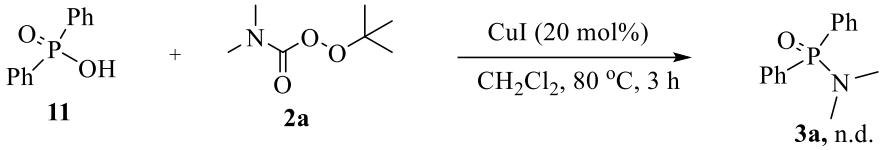


1a **9** **4a**, trace

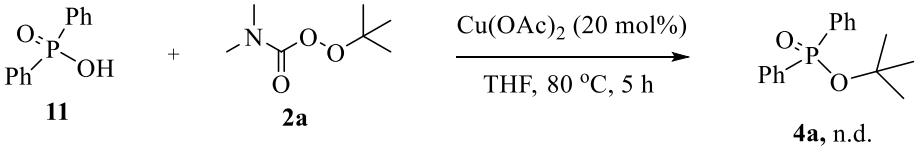
A 15 mL schlenk tube was charged with a mixture of oxidant **1a** (0.2 mmol), **9** (0.6 mmol), catalyst (0.04 mmol) in THF (1.0 mL) and was stirred at 80 °C for 5 h. Then the reaction was monitored by TLC and only trace of **4a** was detected.



A 15 mL schlenk tube was charged with a mixture of oxidant **1a** (0.2 mmol), **10** (0.6 mmol), catalyst (0.04 mmol) in THF (1.0 mL) and was stirred at 80 °C for 5 h. After the reaction was complete (as determined by TLC analysis), the reaction was cooled to room temperature and EtOAc (20 mL) was added to the solution and washed with brine, dried over Na_2SO_4, concentrated under reduced pressure. The crude product was purified by column chromatography on silica gel (EtOAc/hexane = 1:2) to afford the product **4a** in 23% yield.



A 15 mL schlenk tube was charged with a mixture of **11** (0.2 mmol), **2a** (0.6 mmol), catalyst (0.04 mmol) in DCM (1.0 mL) and was stirred at 80 °C for 3 h. Then the reaction was monitored by TLC and the targeted product **3a** was not detected.

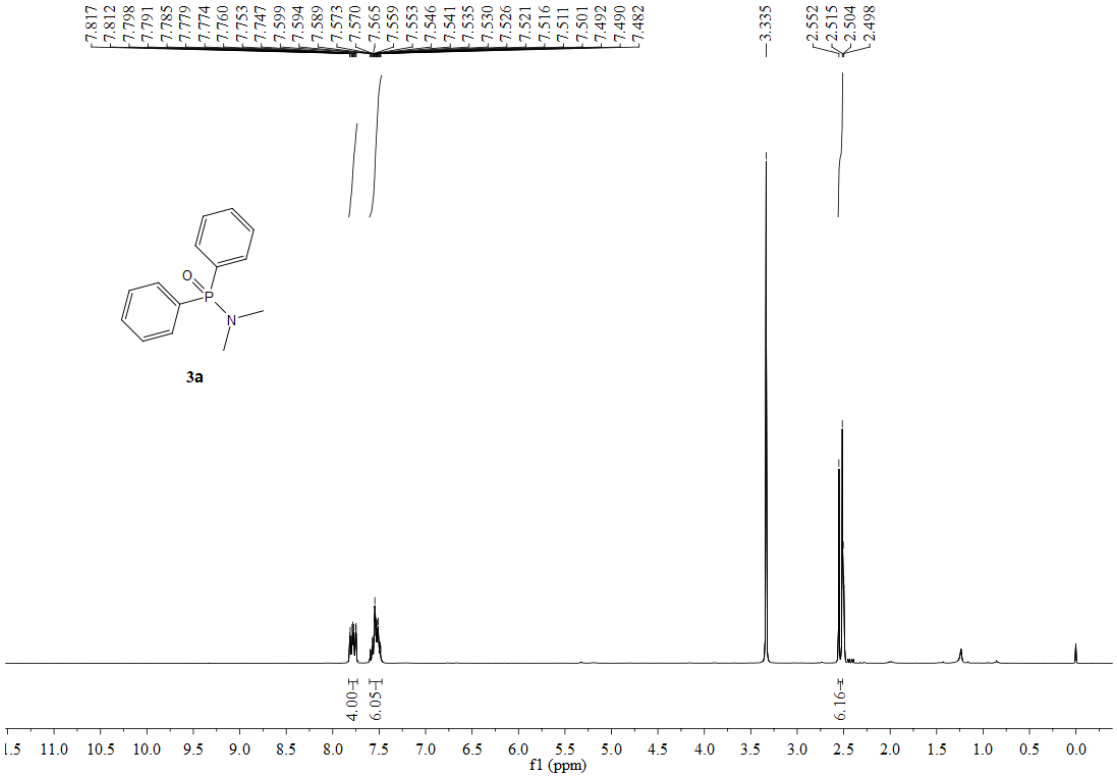


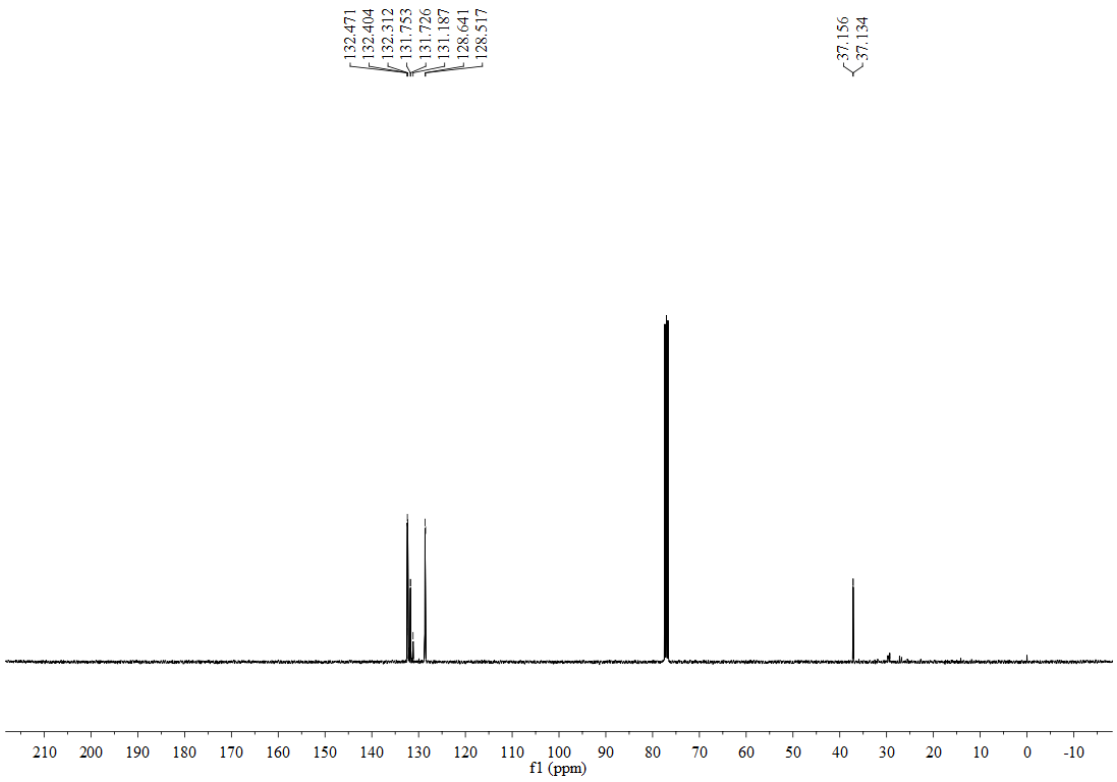
A 15 mL schlenk tube was charged with a mixture of oxidant **11** (0.2 mmol), **2a** (0.6 mmol), catalyst (0.04 mmol) in THF (1.0 mL) and was stirred at 80 °C for 5 h. Then the reaction was monitored by TLC and only trace of **4a** was detected.

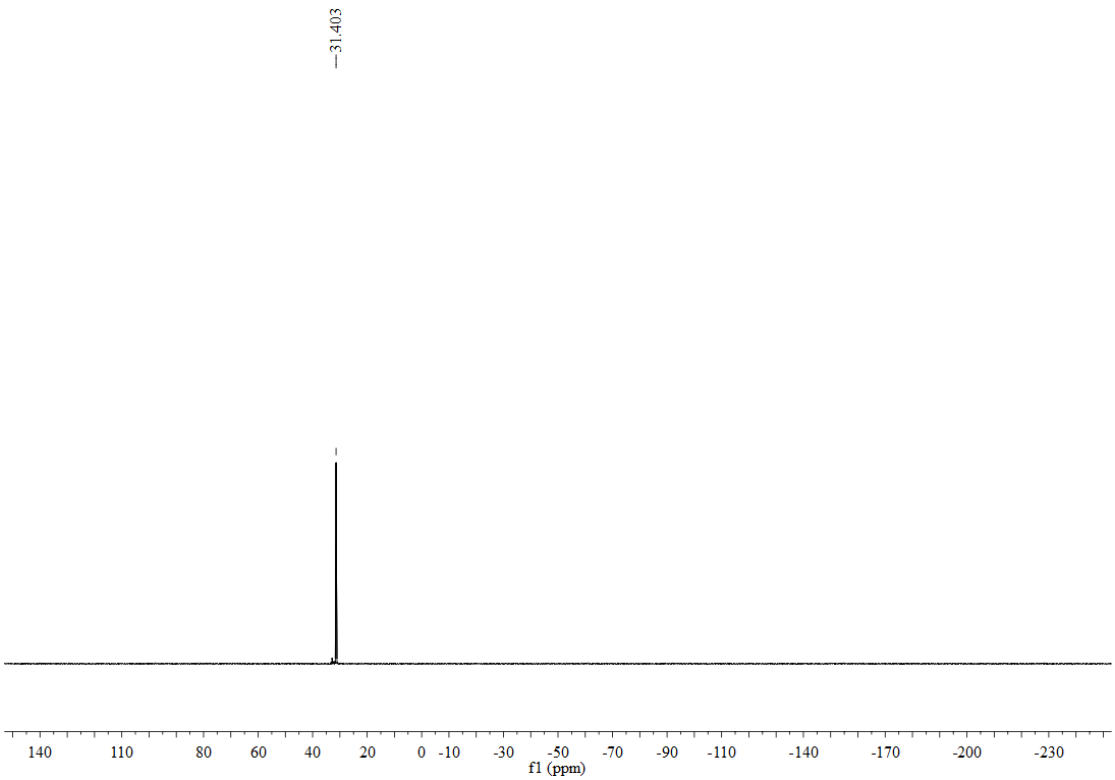
4. References

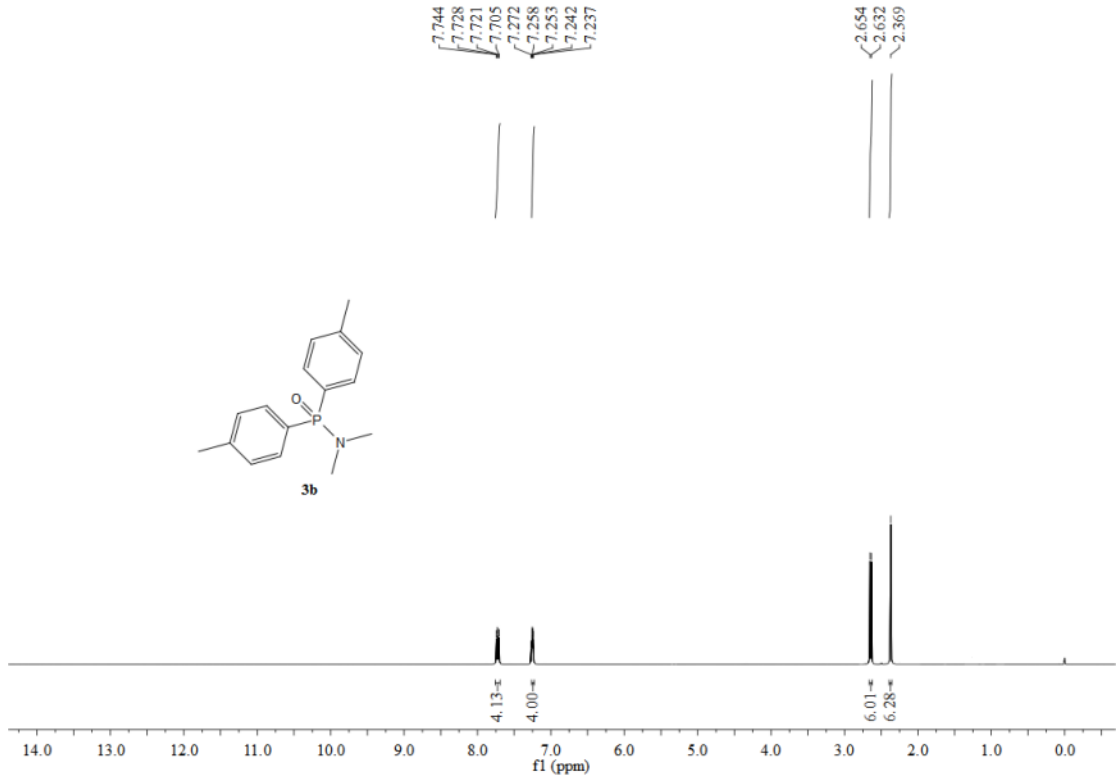
1. (a) Zhu, R.; Pan, C.; Gu, Z. *Org. Lett.* **2015**, *17*, 5862-5865; (b) Wang, Y.; Qian, P.; Su, J.-H.; Li, Y.; Bi, M.; Zha, Z.; Wang, Z. *Green Chem.* **2017**, *19*, 4769-4773; (c) Dong, X.; Wang, R.; Jin, W.; Liu, C. *Org. Lett.* **2020**, *22*, 3062-3066; (d) Tan, C.; Liu, X. Y.; Jia, H. X.; Zhao, X. W.; Chen, J.; Wang, Z. Y.; Tan, J. J. *Chem.-Eur. J.* **2020**, *26*, 881-887; (e) Wu, Y.; Chen, K.; Ge, X.; Ma, P.; Xu, Z.; Lu, H.; Li. G. *Org. Lett.* **2020**, *22*, 6143-6149.

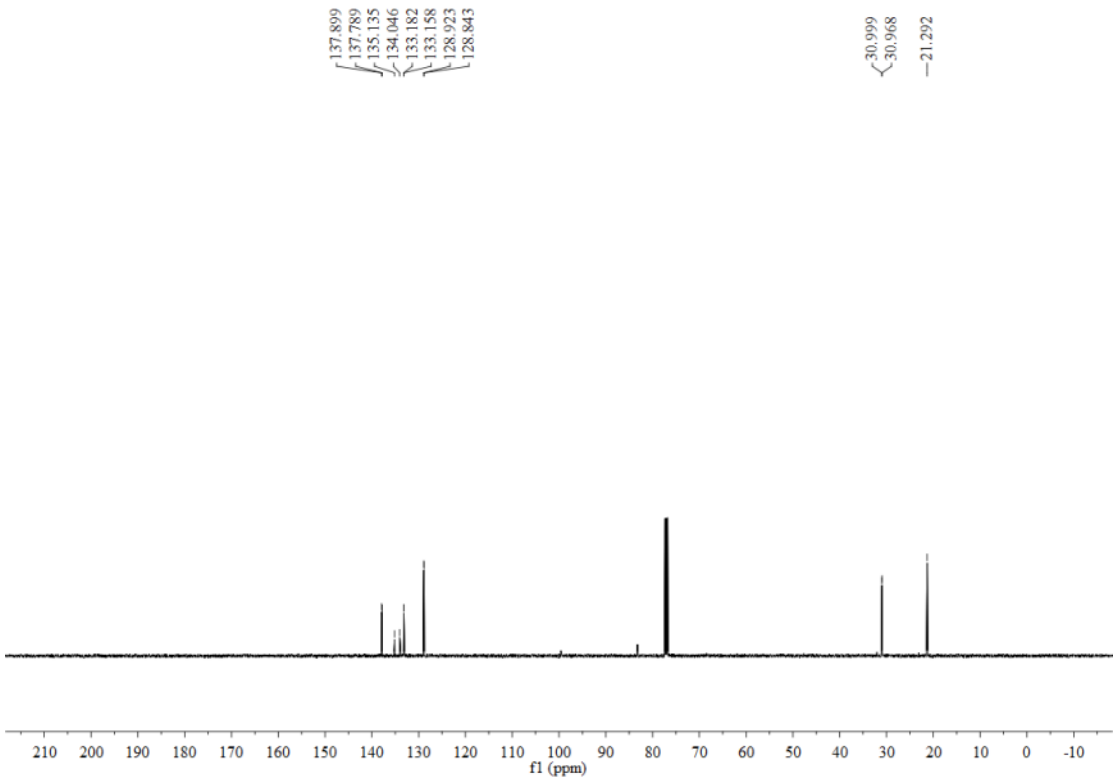
5. Copies of ^{1}H NMR, ^{13}C NMR and ^{31}P NMR Spectra

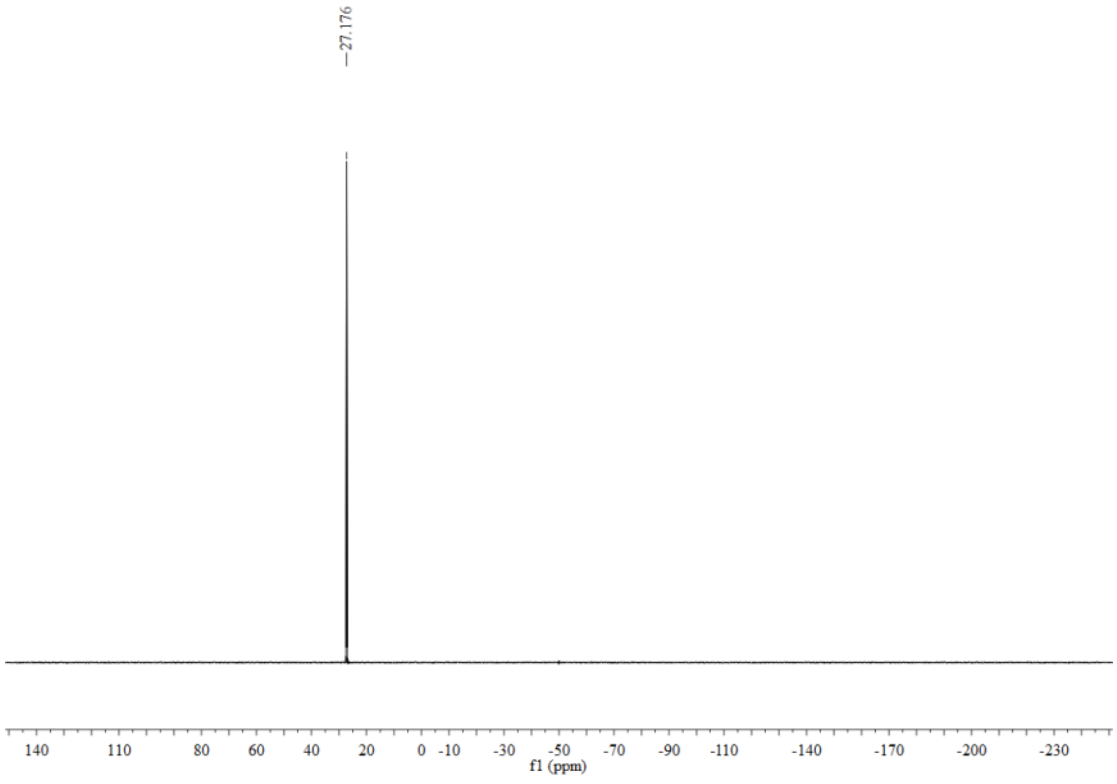





31.403
140
110
80
60
40
20
0
-10
-30
-50
-70
-90
-110
-140
-170
-200
-230
f1 (ppm)


7.744
7.728
7.721
7.705
7.272
7.258
7.253
7.242
7.237
2.654
2.632
2.369
O
P
N
3b
4.13
4.00
6.01
6.28
14.0
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.0
f1 (ppm)


137.899
137.789
135.135
134.046
133.182
133.158
128.923
128.843
30.999
30.968
21.292
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


27.176
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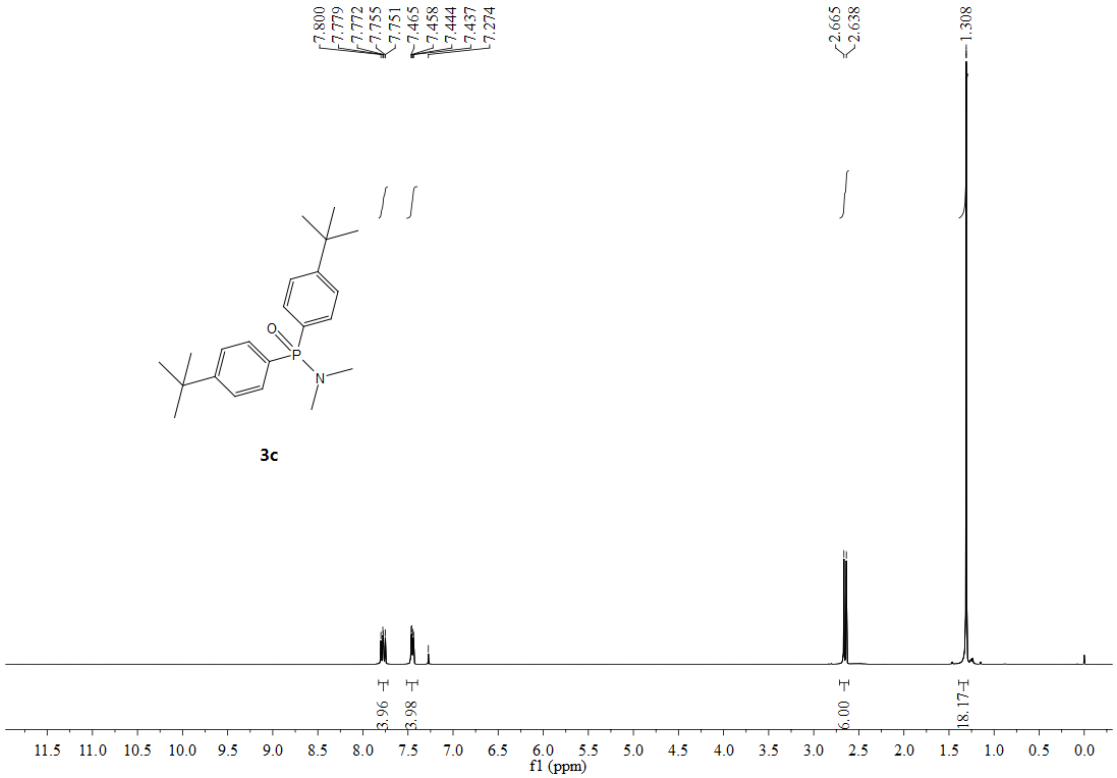
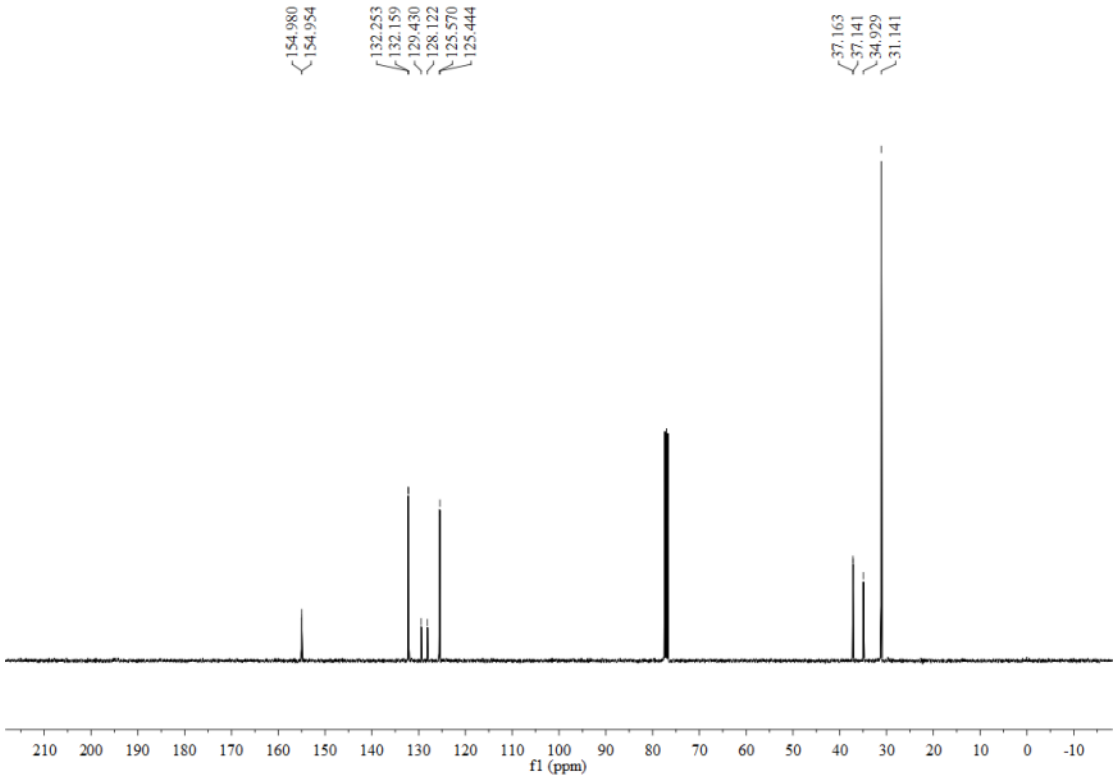
f1 (ppm)


7.800
7.779
7.772
7.755
7.751
7.465
7.458
7.444
7.437
7.274
2.665
2.638
1.308
O
P
N
3.96
3.98
6.00
18.17
11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

3c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154.954
132.253
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128.122
125.570
125.444
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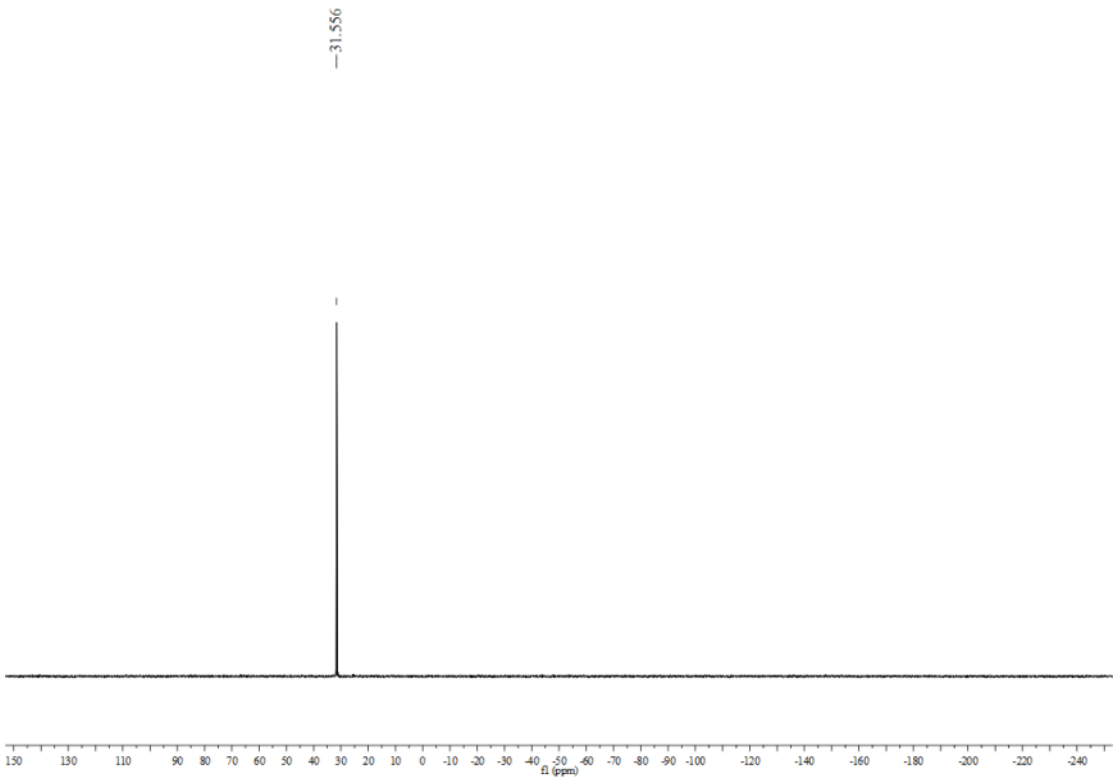
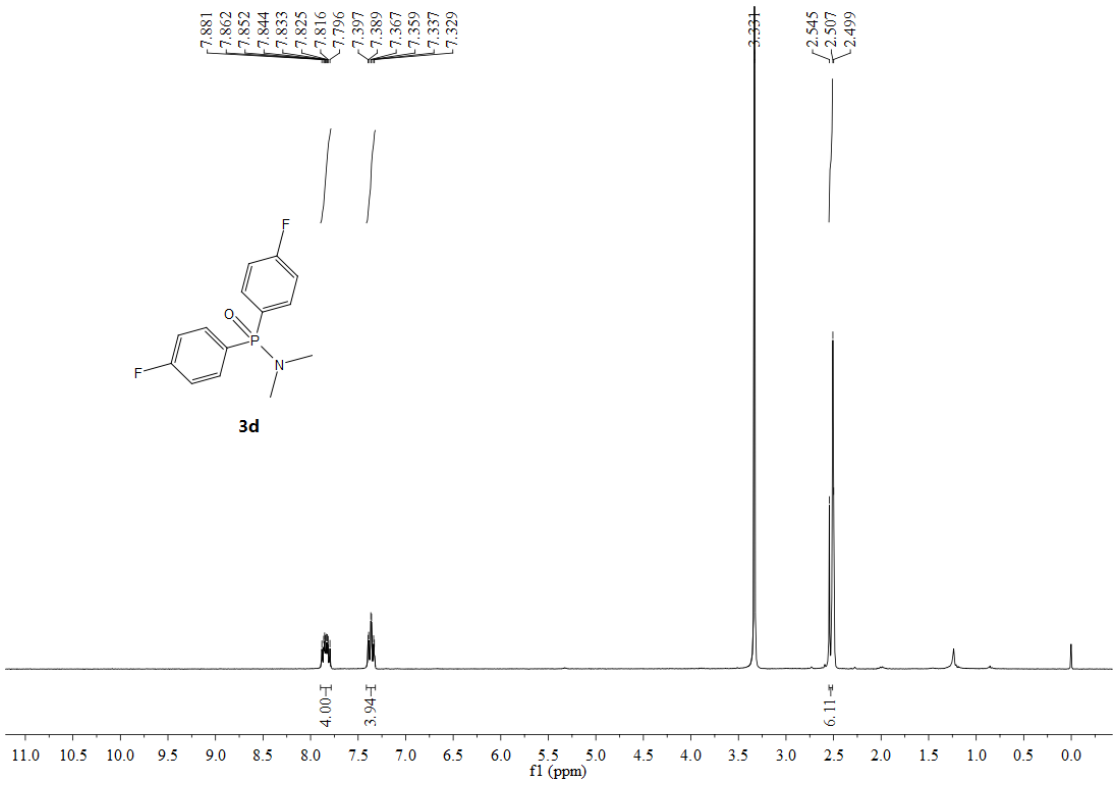
37.141
34.929
31.141
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


31.556
f1 (ppm)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7.852
7.844
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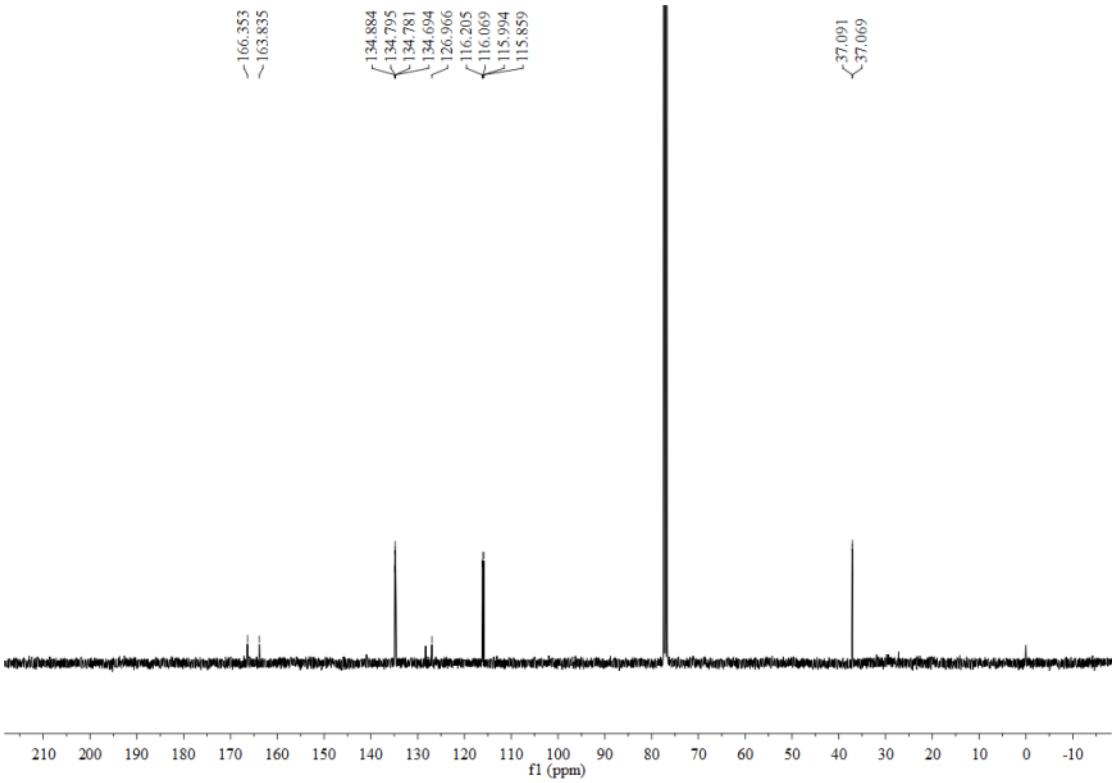
7.825
7.816
7.796
7.397
7.389
7.367
7.359
7.337
7.329
3.331
2.545
2.507
2.499
F
O
P
N
F
4.00
3.94
6.11
f1 (ppm)

3d


166.353
163.835
134.884
134.795
134.781
134.694
126.966
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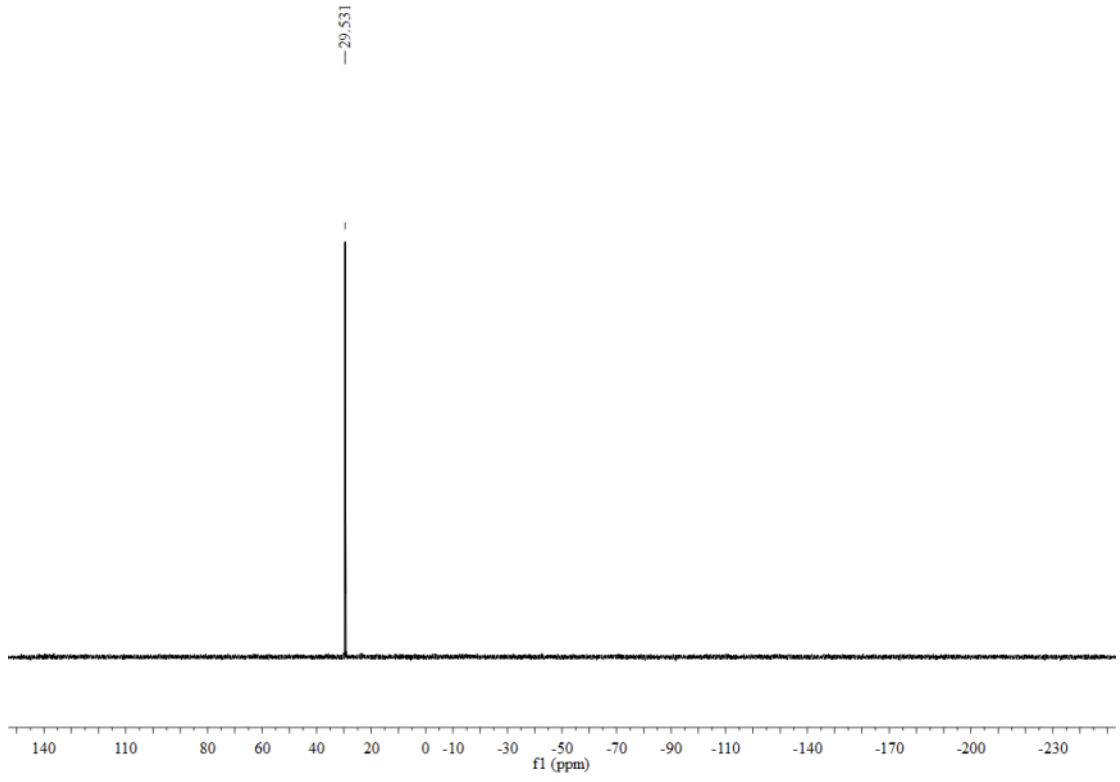
116.069
115.994
115.859
37.091
37.069
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


29.531
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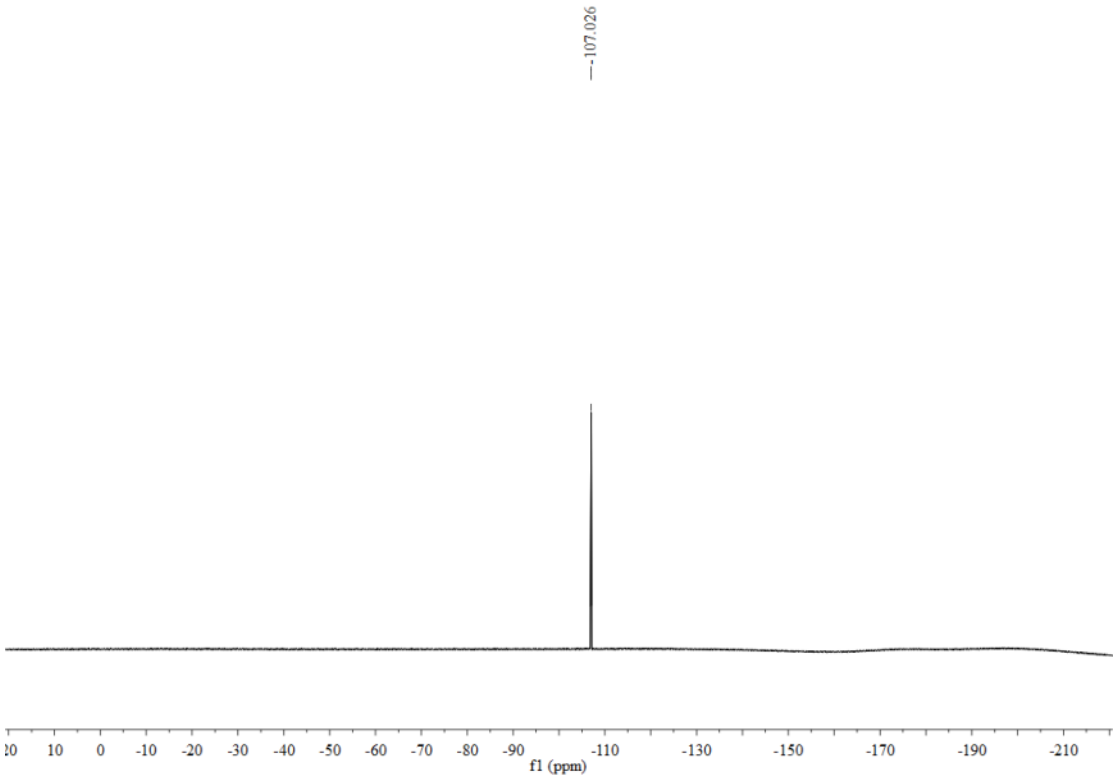
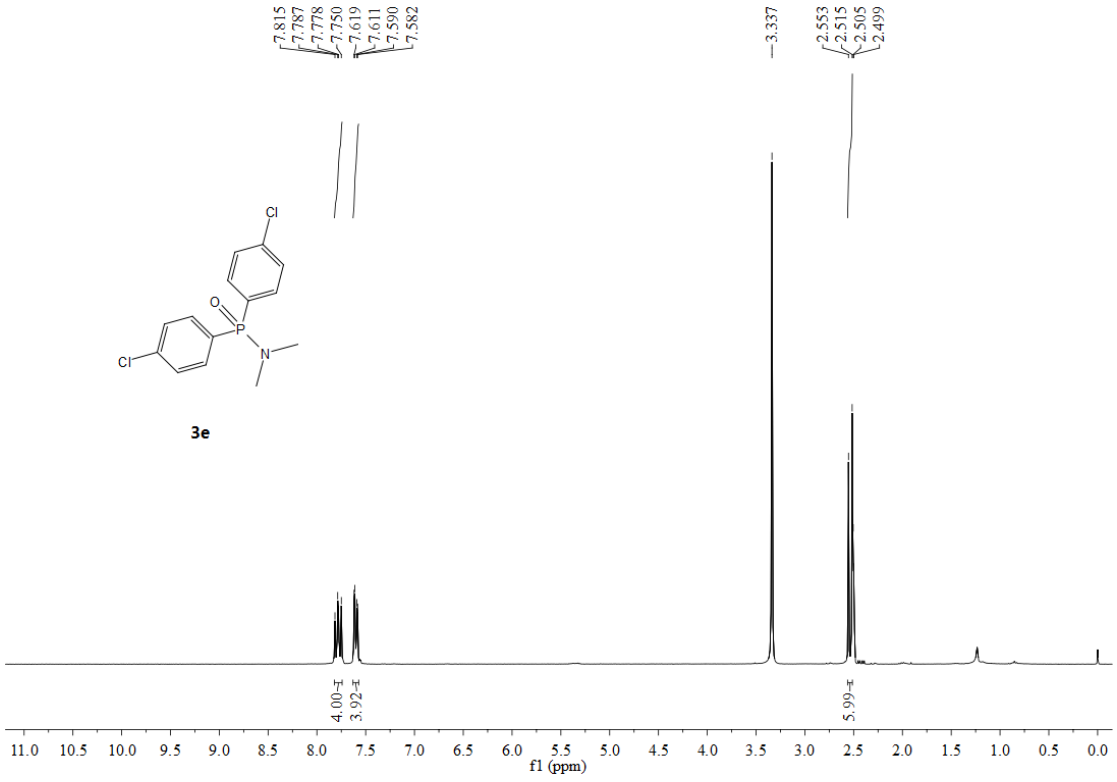
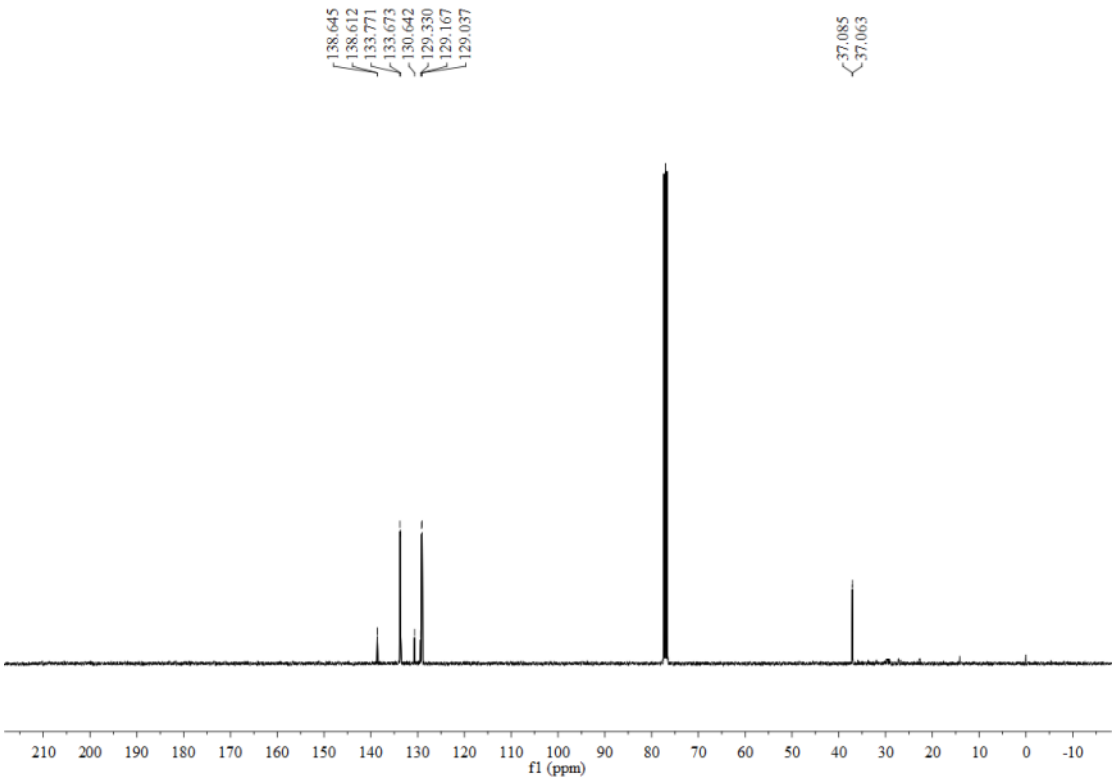
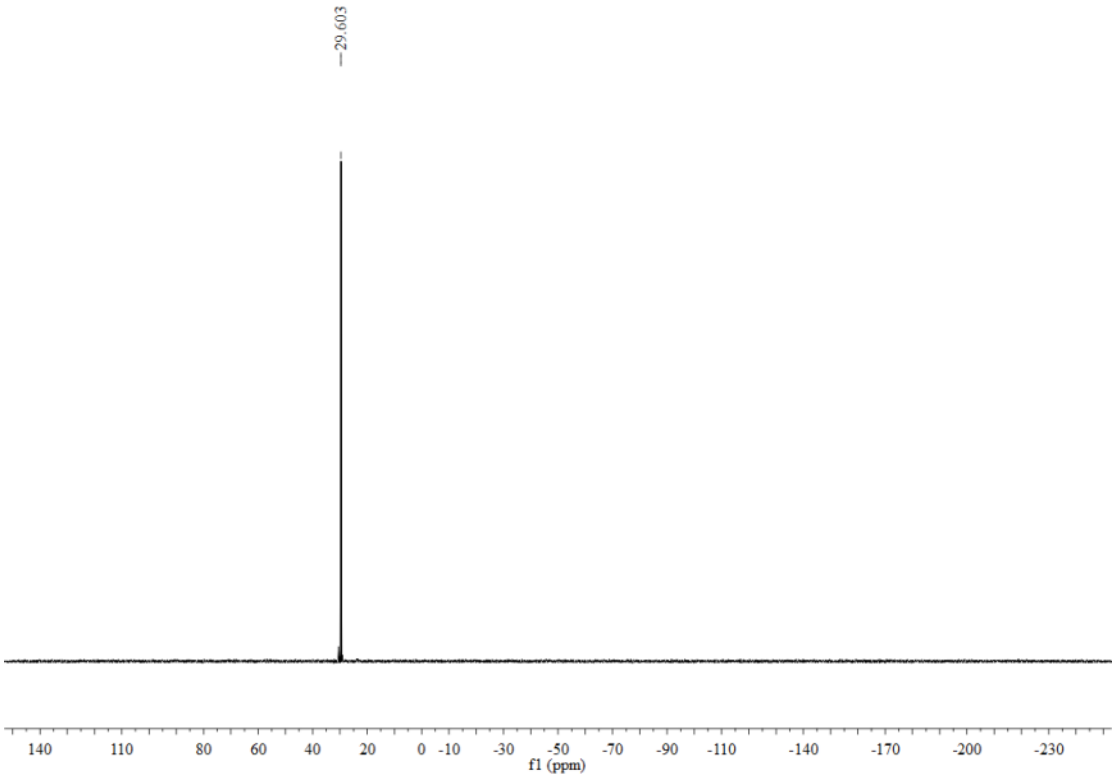
f1 (ppm)


107.026
f1 (ppm)


7.815
7.787
7.778
7.750
7.619
7.611
7.590
7.582
3.337
2.553
2.515
2.505
2.499
Cl
O
P
N
Cl
4.00
3.92
5.99
f1 (ppm)

3e


138.645
138.612
133.771
133.673
130.642
129.330
129.167
129.037
37.085
37.063
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


29.603
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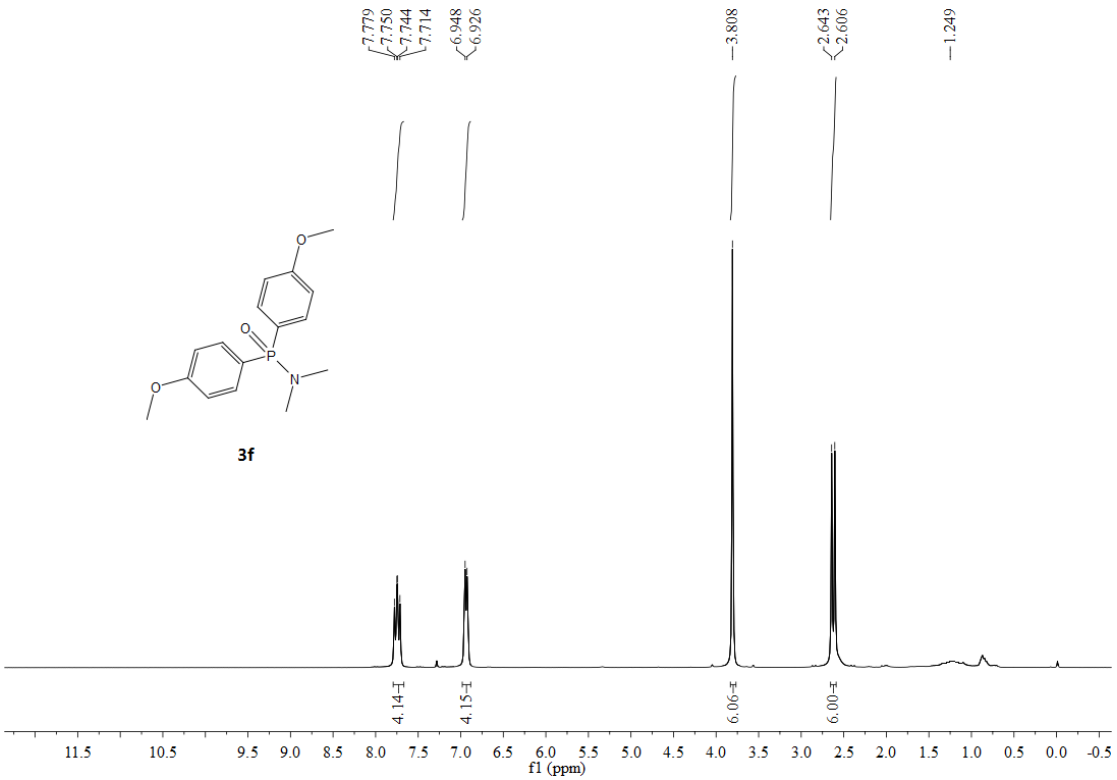
f1 (ppm)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7.714
6.948
6.926
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2.643
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1.249
4.14
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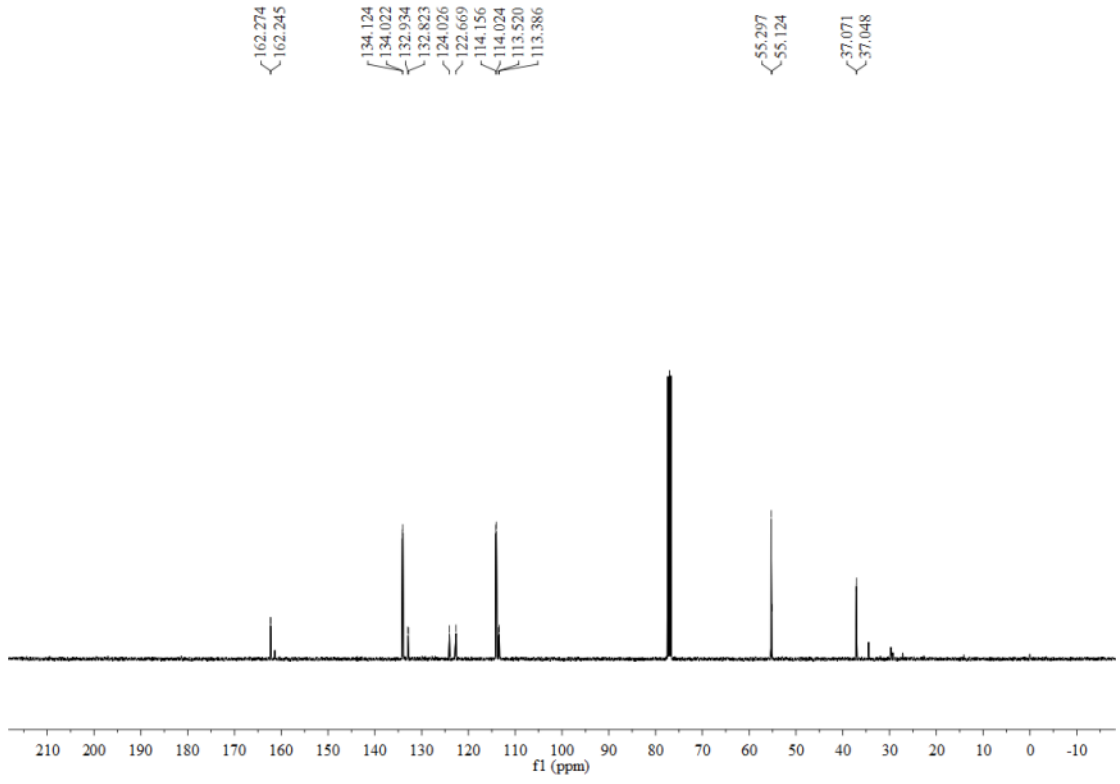
6.06
6.00
11.5 10.5 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

3f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134.124
134.022
132.934
132.823
124.026
122.669
114.156
114.024
113.520
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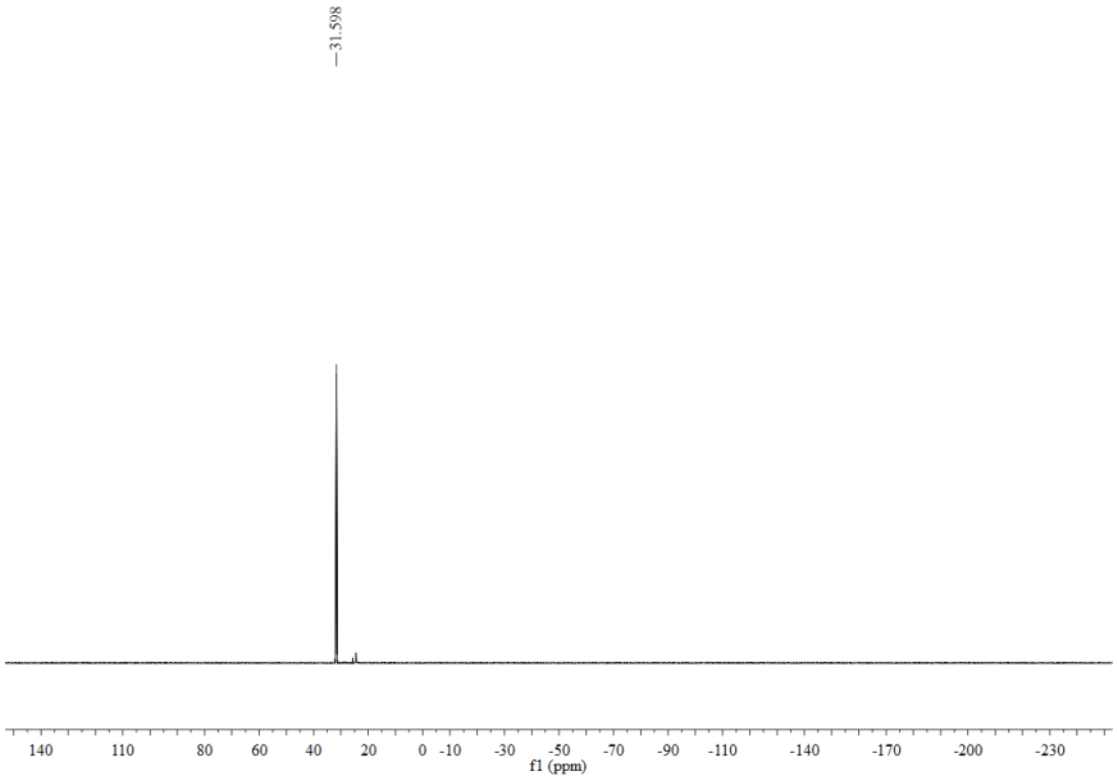
f1 (ppm)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20
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-30
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-110
-140
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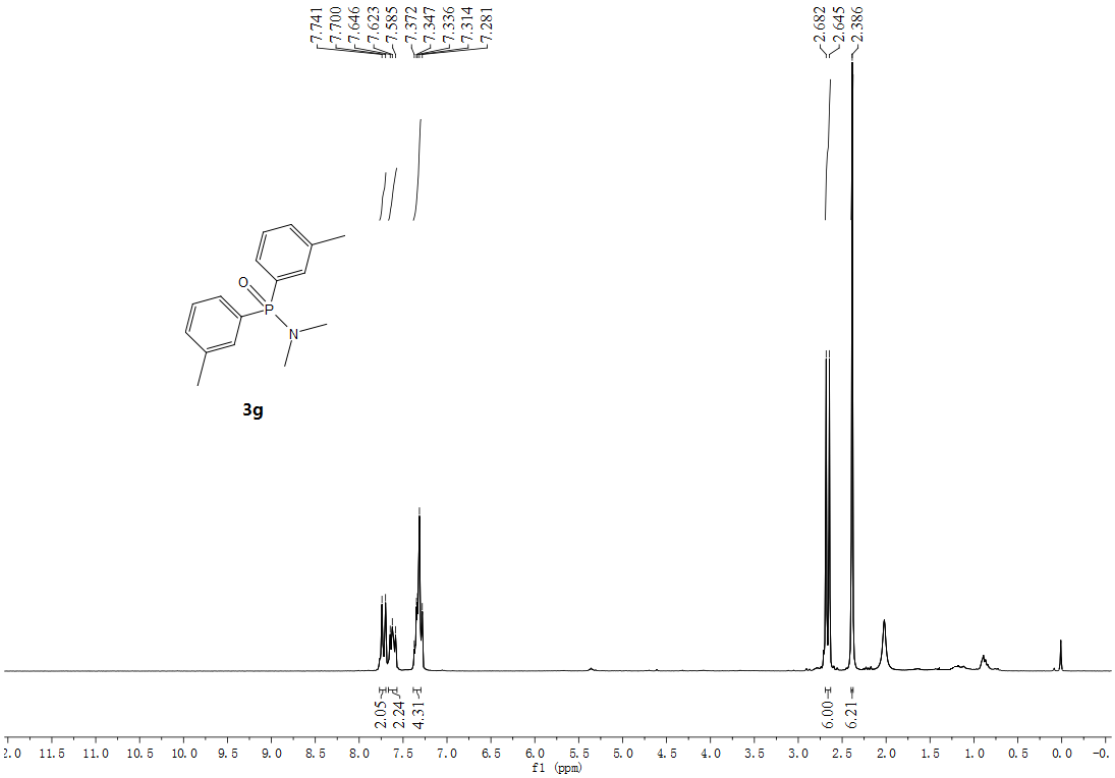
-200
-230
f1 (ppm)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O
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N
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6.00
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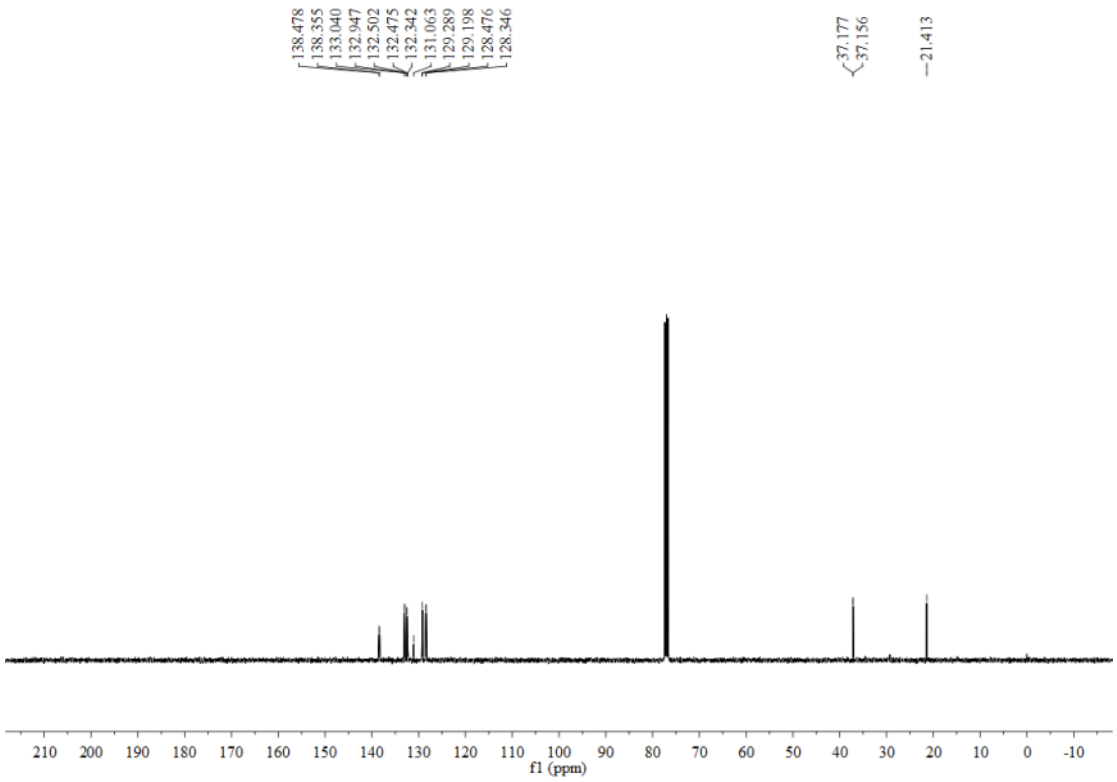
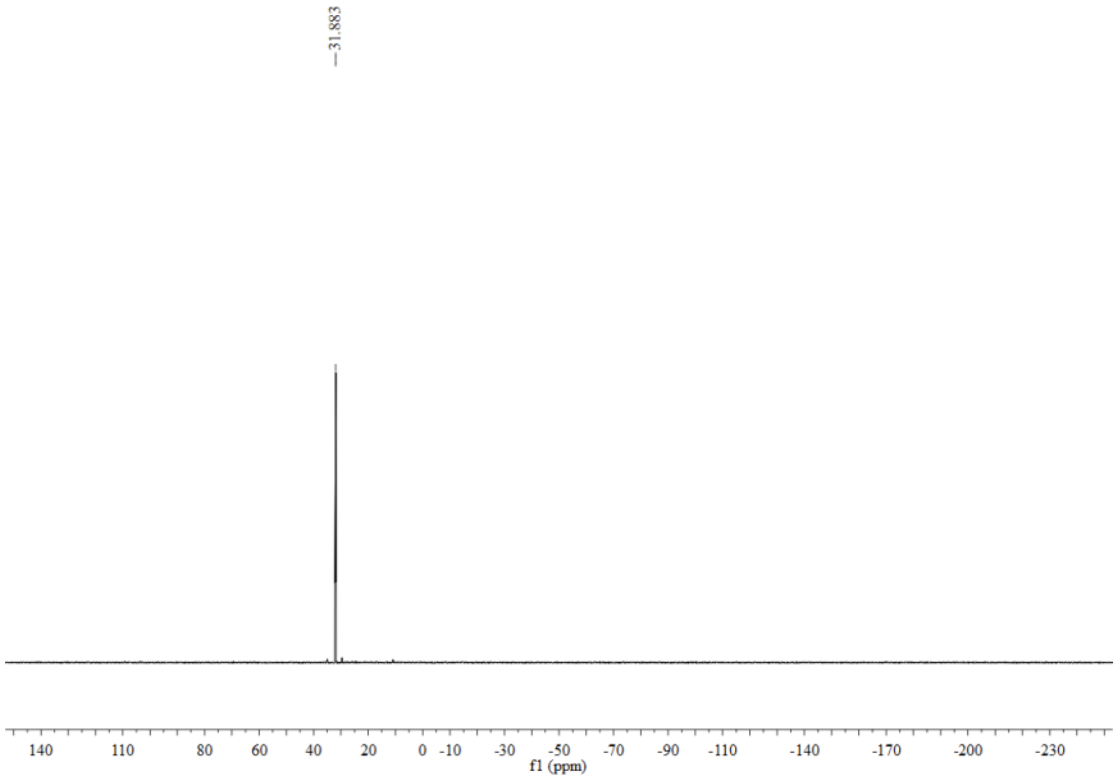
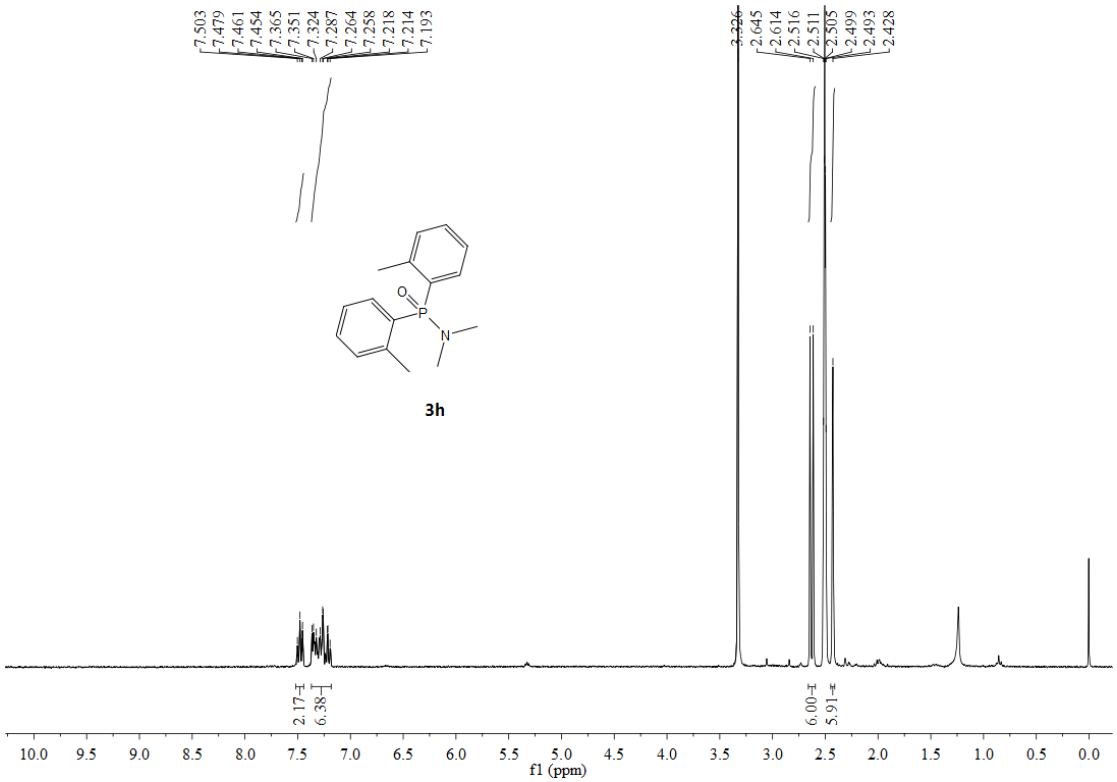
f1 (ppm)

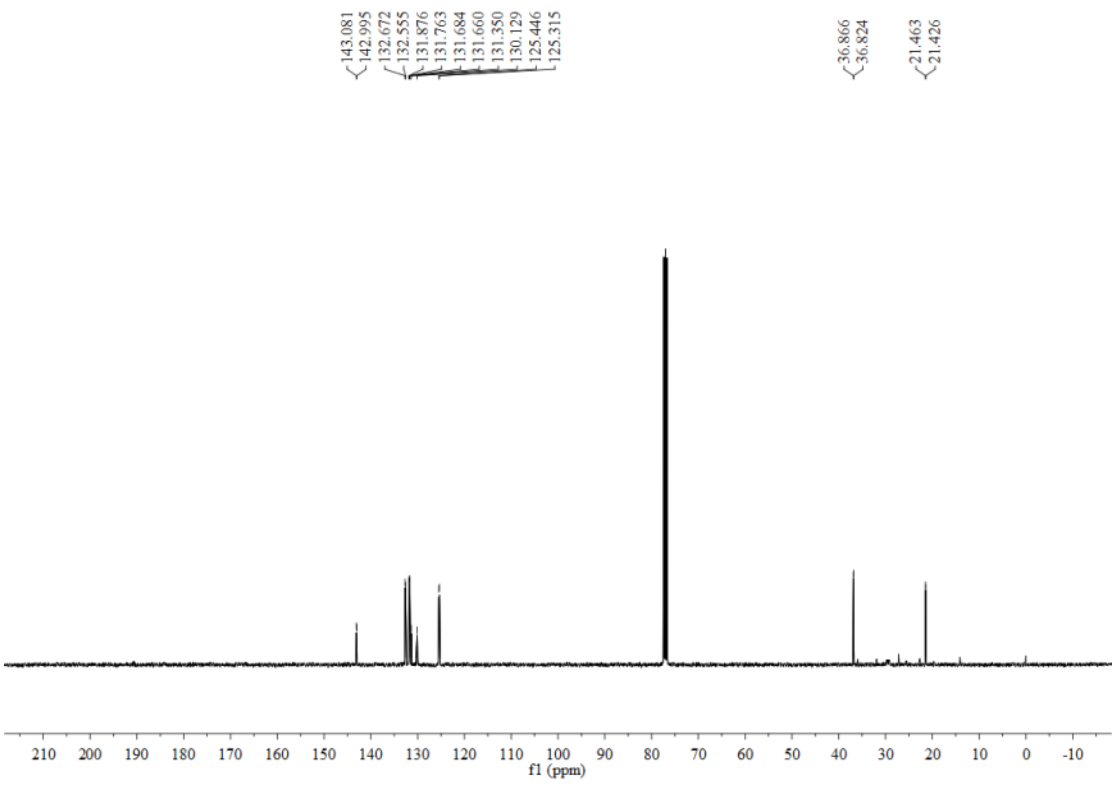
3g

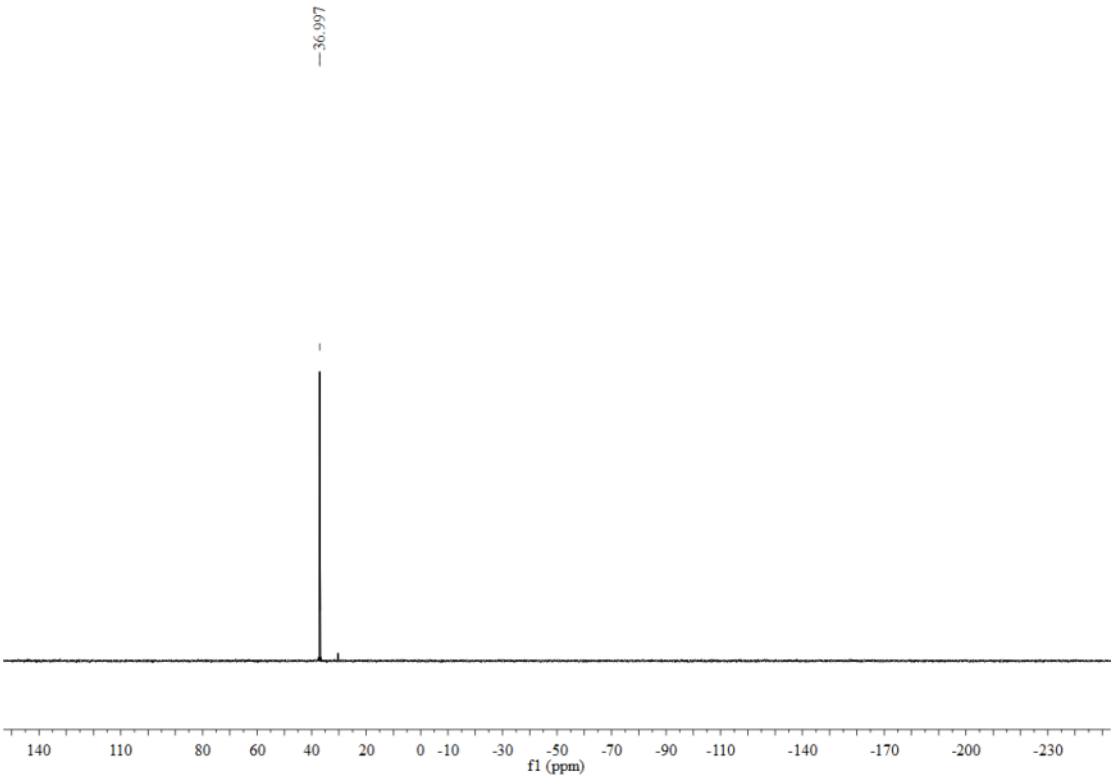

138.478
138.355
133.040
132.947
132.502
132.475
132.342
131.063
129.289
129.198
128.476
128.346
37.177
37.156
21.413
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

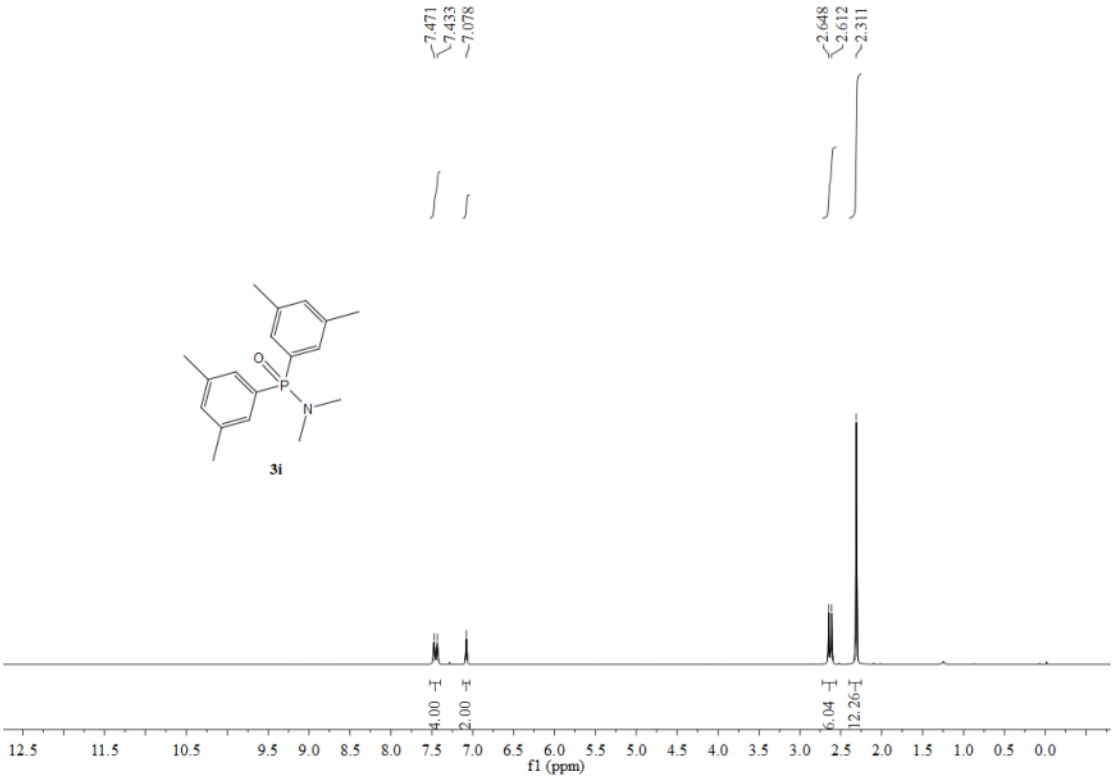

31.883
140 110 80 60 40 20 0 -10 -30 -50 -70 -90 -110 -140 -170 -200 -230
f1 (ppm)


7.503
7.479
7.461
7.454
7.365
7.351
7.324
7.287
7.264
7.258
7.218
7.214
7.193
3.326
2.645
2.614
2.516
2.511
2.505
2.499
2.493
2.428
O
P
N
2.17
6.38
6.00
5.91
f1 (ppm)

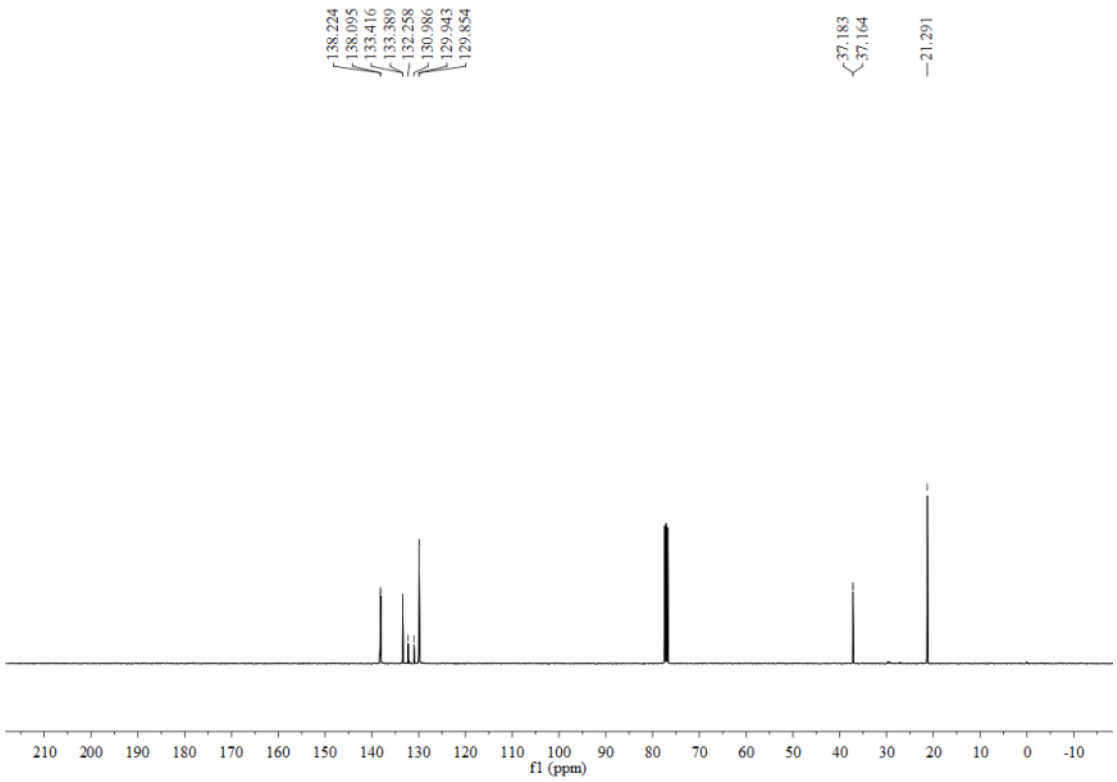
3h

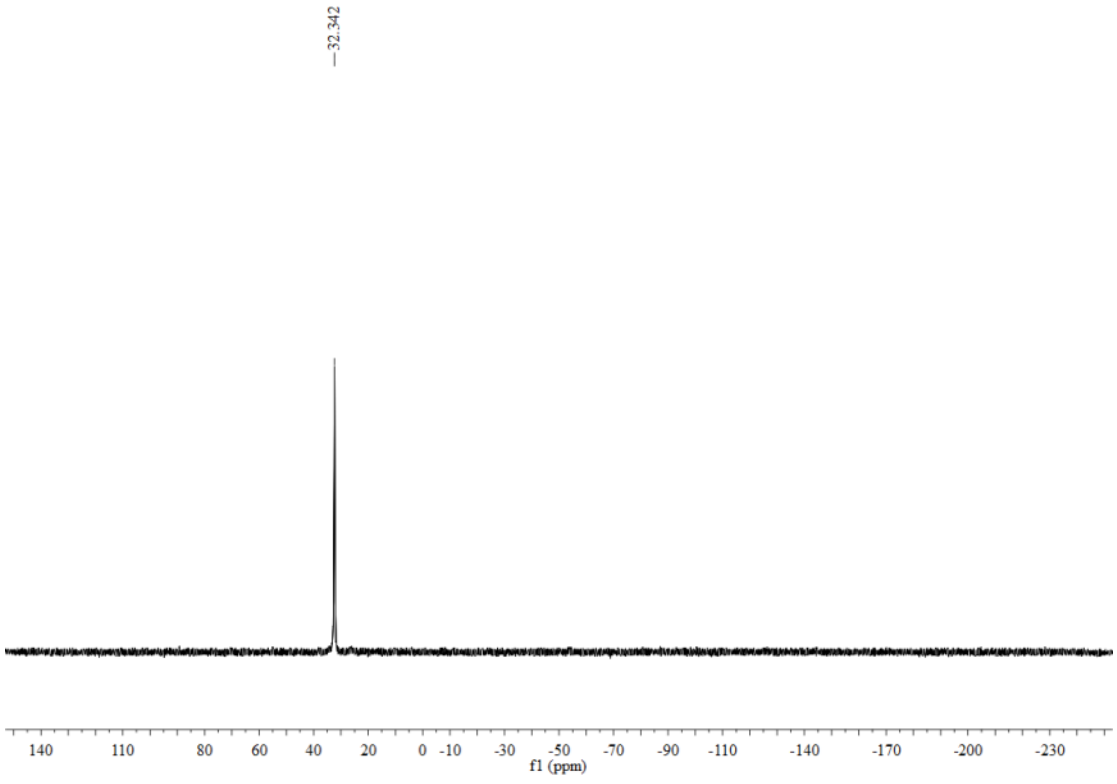

143.081
142.995
132.672
132.555
131.876
131.763
131.684
131.660
131.350
130.129
125.446
125.315
36.866
36.824
21.463
21.426
f1 (ppm)

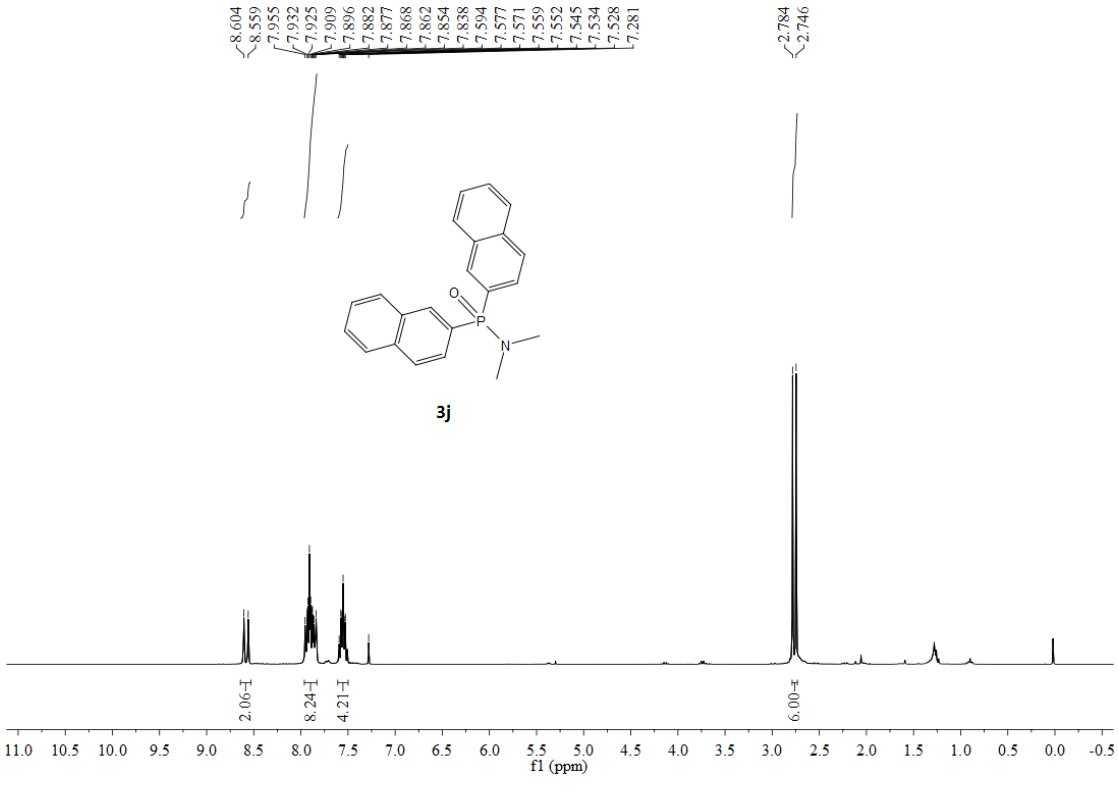

36.997
140
110
80
60
40
20
0
-10
-30
-50
-70
-90
-110
-140
-170
-200
-230
f1 (ppm)


7.471
7.433
7.078
2.648
2.612
2.311
O
P
N
4.00
2.00
6.04
12.26
12.5
11.5
10.5
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)

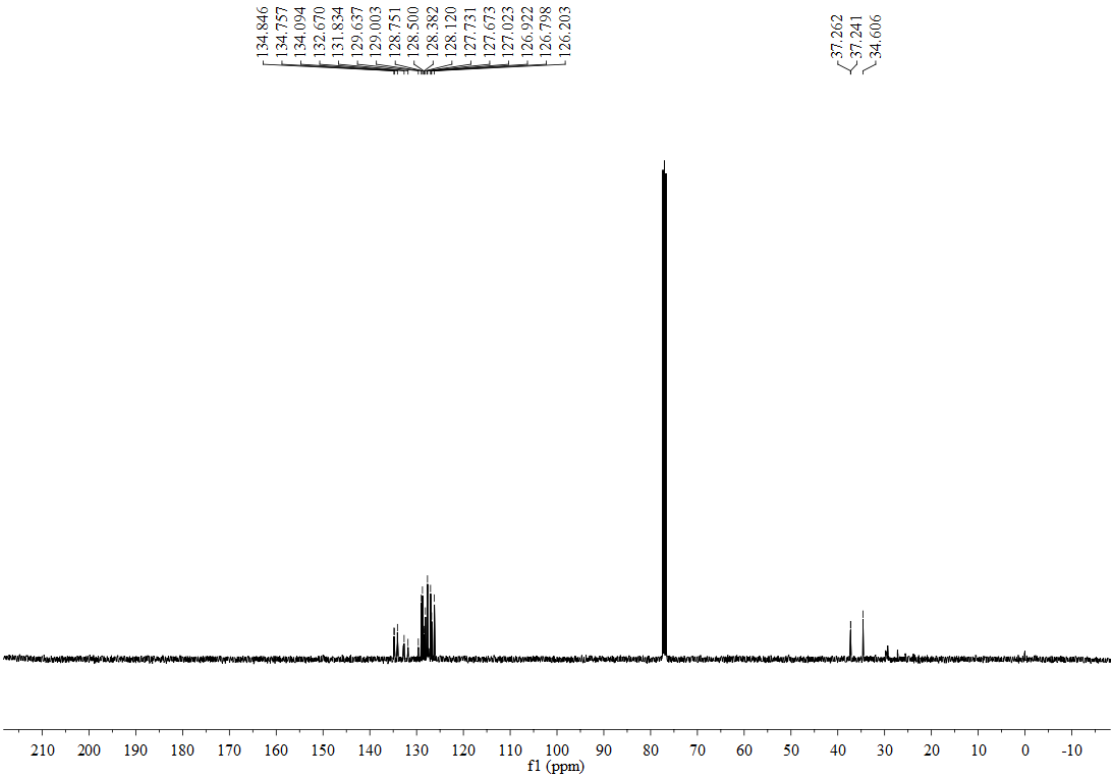
3i

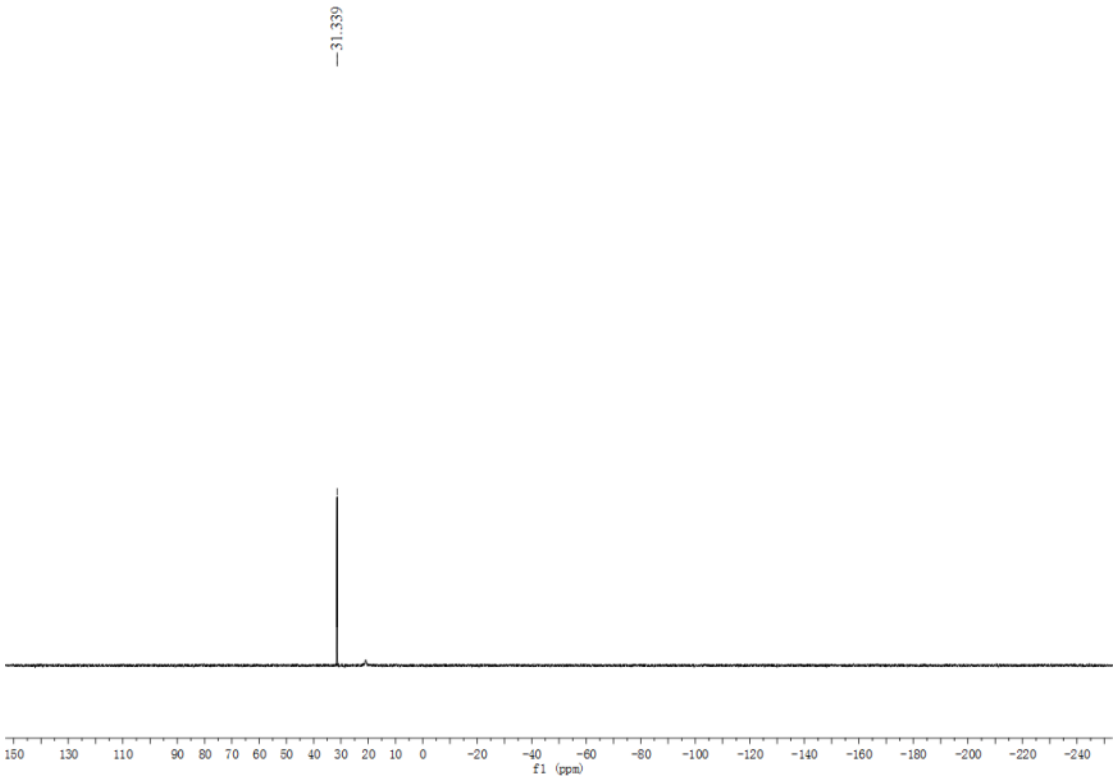

138.224
138.095
133.416
133.389
132.258
130.986
129.943
129.854
37.183
37.164
21.291
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

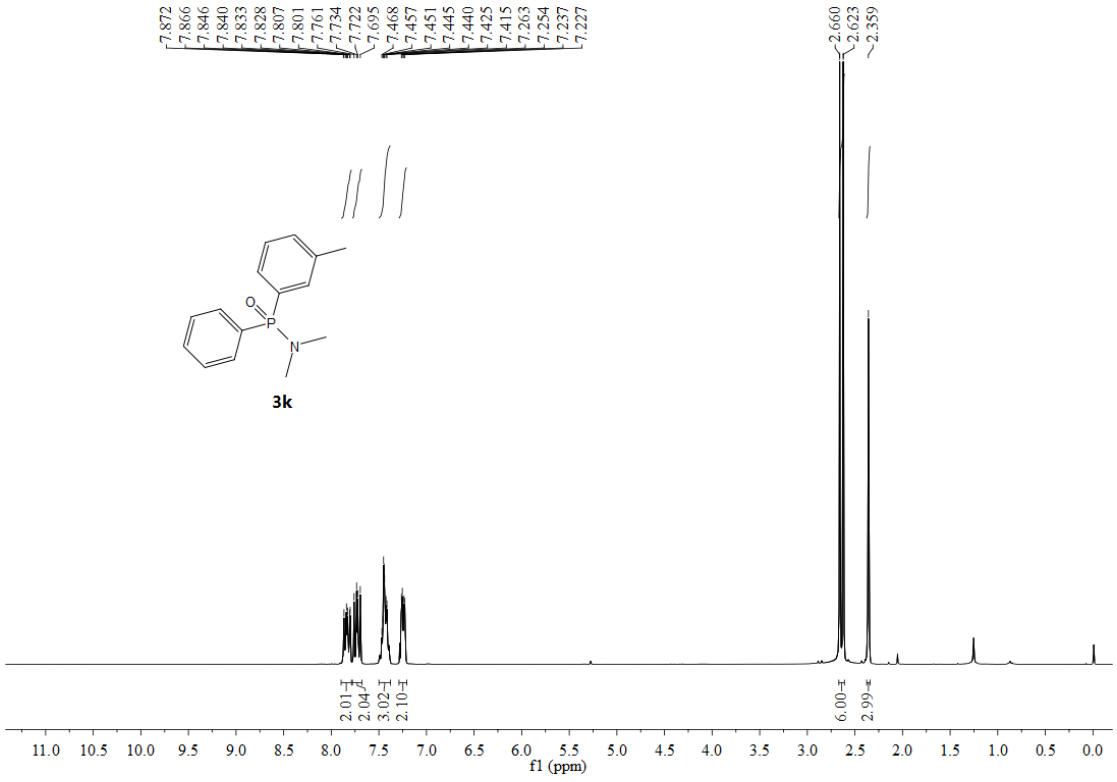

32.342
140 110 80 60 40 20 0 -10 -30 -50 -70 -90 -110 -140 -170 -200 -230
f1 (ppm)


8.604
8.559
7.955
7.932
7.925
7.909
7.896
7.882
7.877
7.868
7.862
7.854
7.838
7.594
7.577
7.571
7.559
7.552
7.545
7.534
7.528
7.281
2.784
2.746
O
P
N
2.06
8.24
4.21
6.00
11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

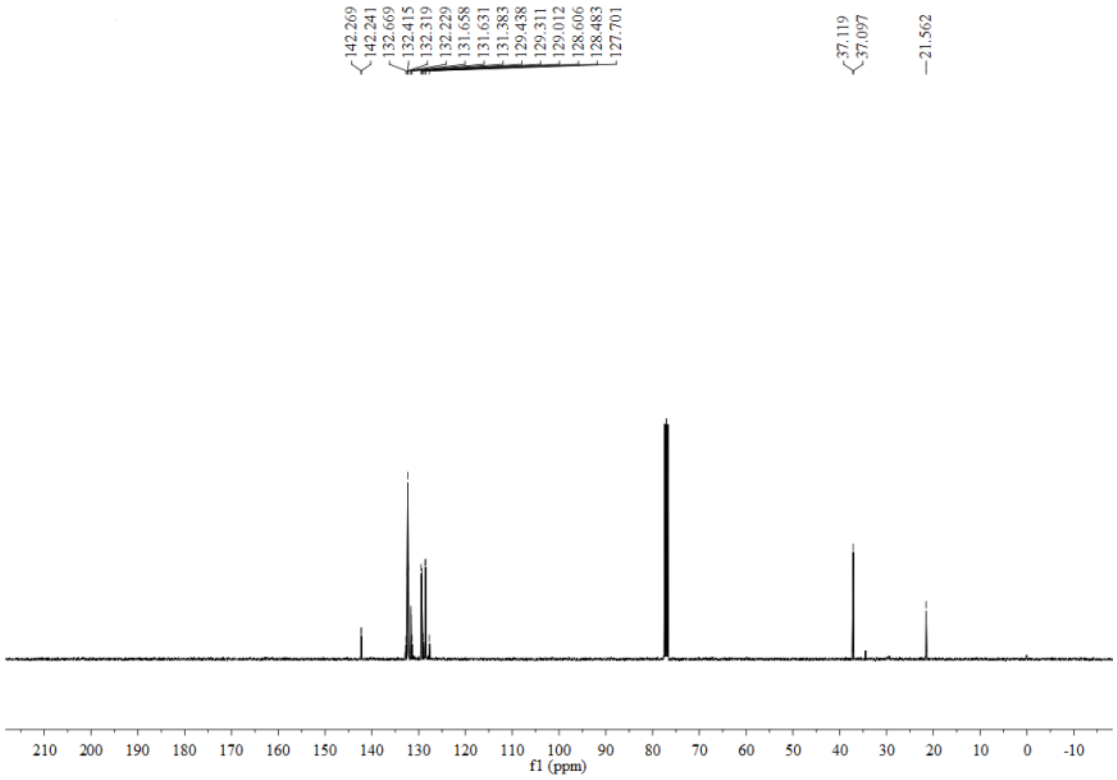
3j

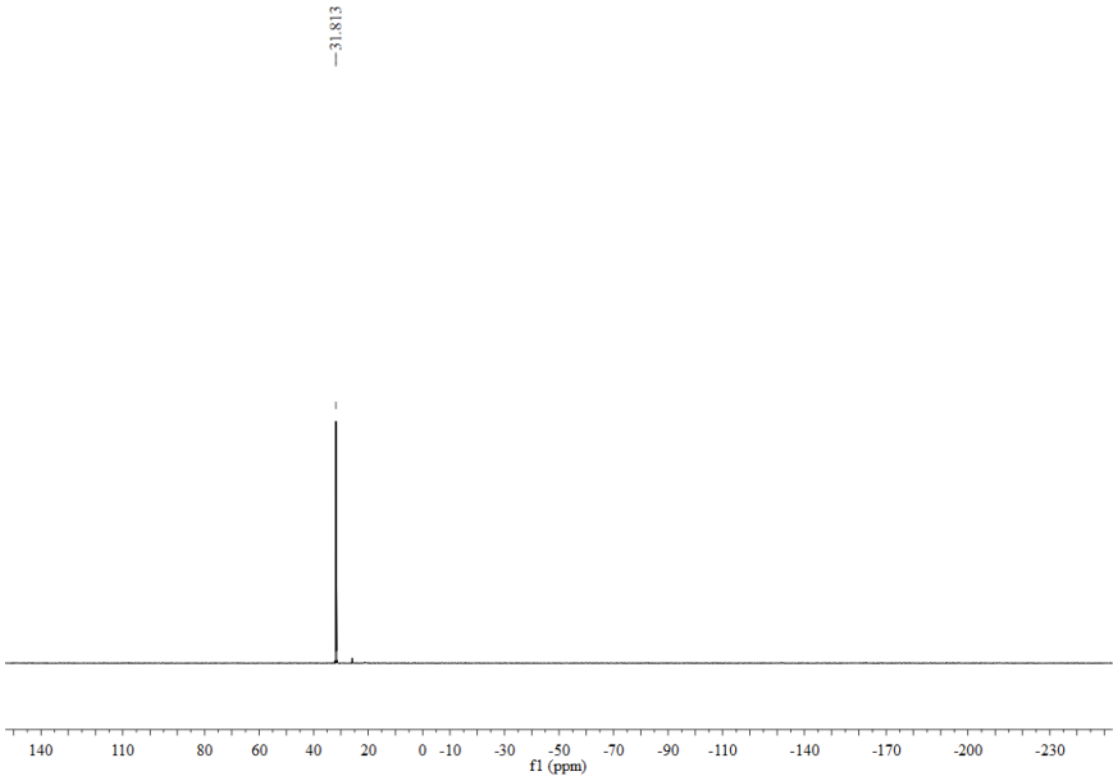

134.846
134.757
134.094
132.670
131.834
129.637
129.003
128.751
128.500
128.382
128.120
127.731
127.673
127.023
126.922
126.798
126.203
37.262
37.241
34.606
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

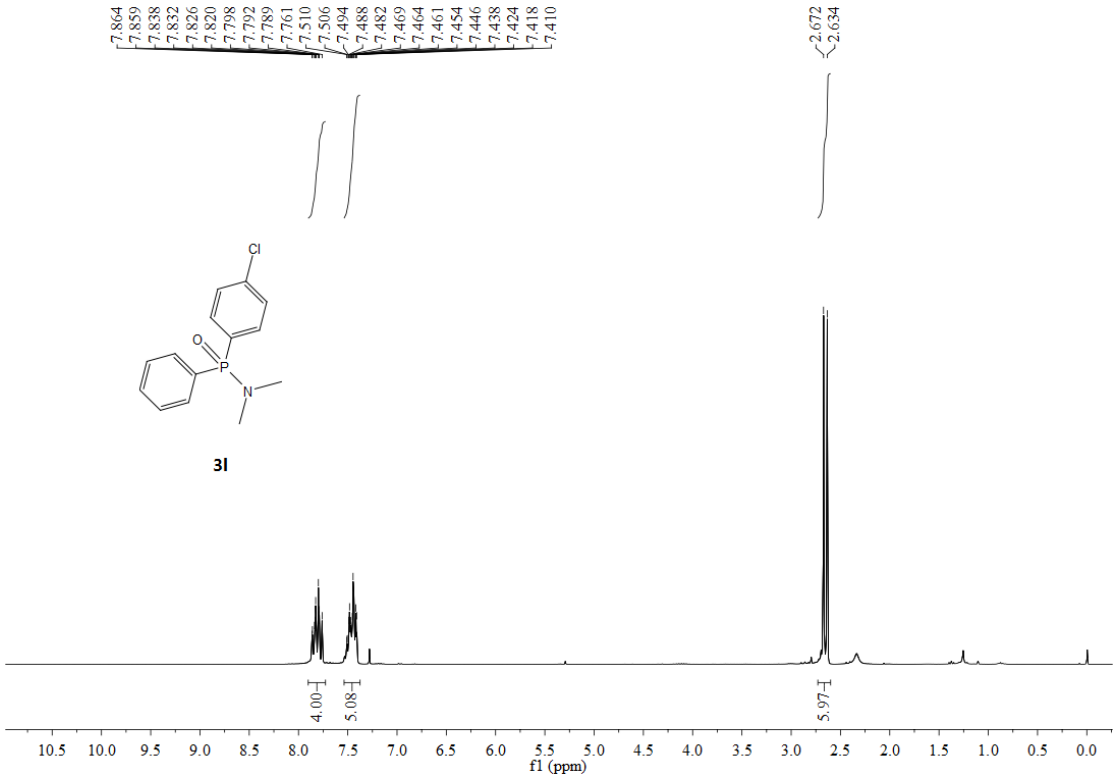

31.339
150 130 110 90 80 70 60 50 40 30 20 10 0 -20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220 -240
f1 (ppm)


7.872
7.866
7.846
7.840
7.833
7.828
7.807
7.801
7.761
7.734
7.722
7.695
7.468
7.457
7.451
7.445
7.440
7.425
7.415
7.263
7.254
7.237
7.227
2.660
2.623
2.359
O
P
N
2.01
2.04
3.02
2.10
6.00
2.99
11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

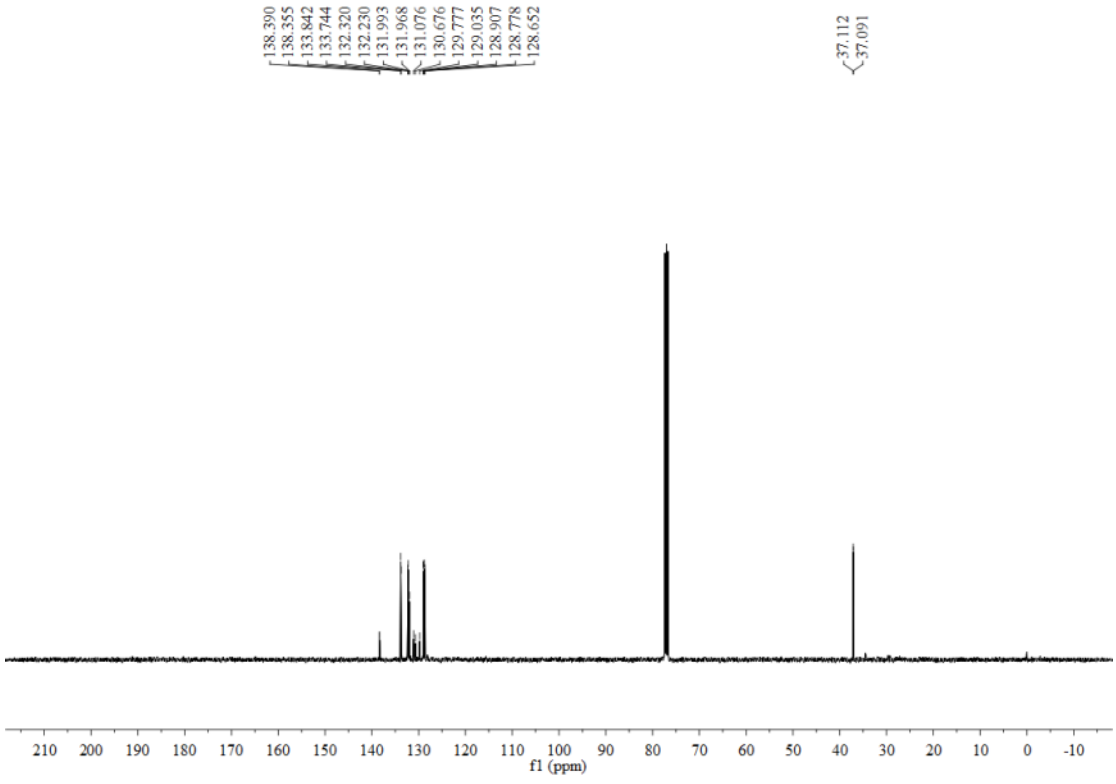
3k

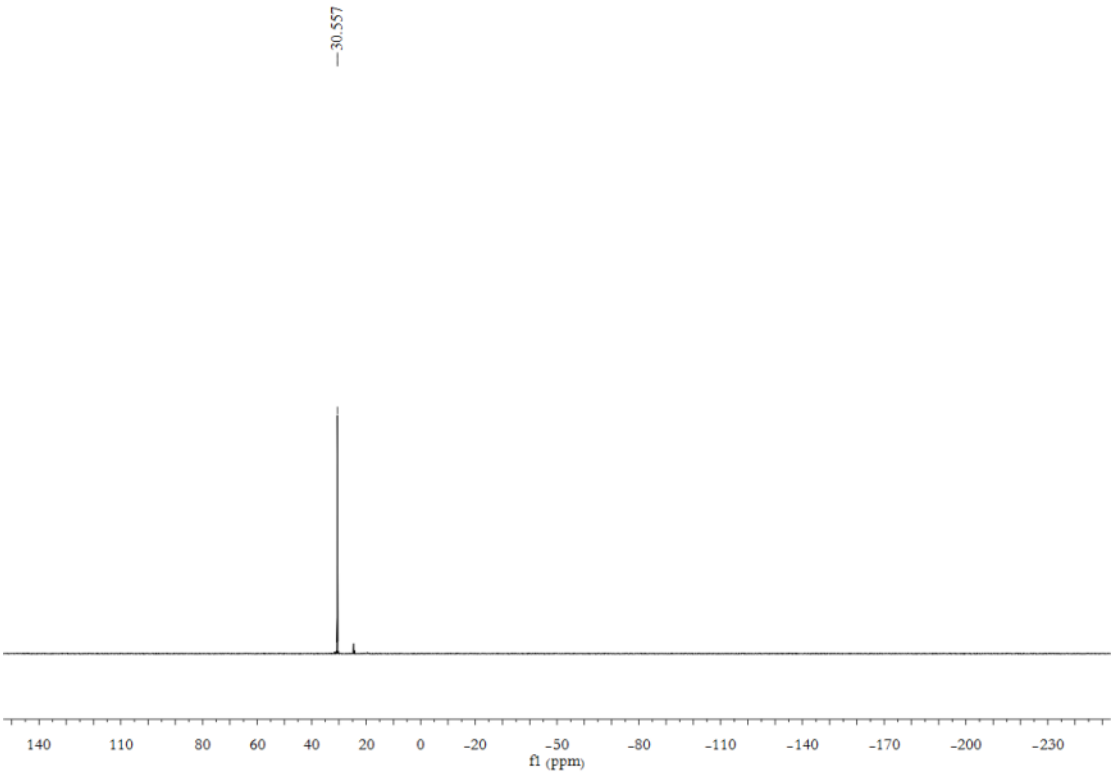

142.269
142.241
132.669
132.415
132.319
132.229
131.658
131.631
131.383
129.438
129.311
129.012
128.606
128.483
127.701
37.119
37.097
21.562
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

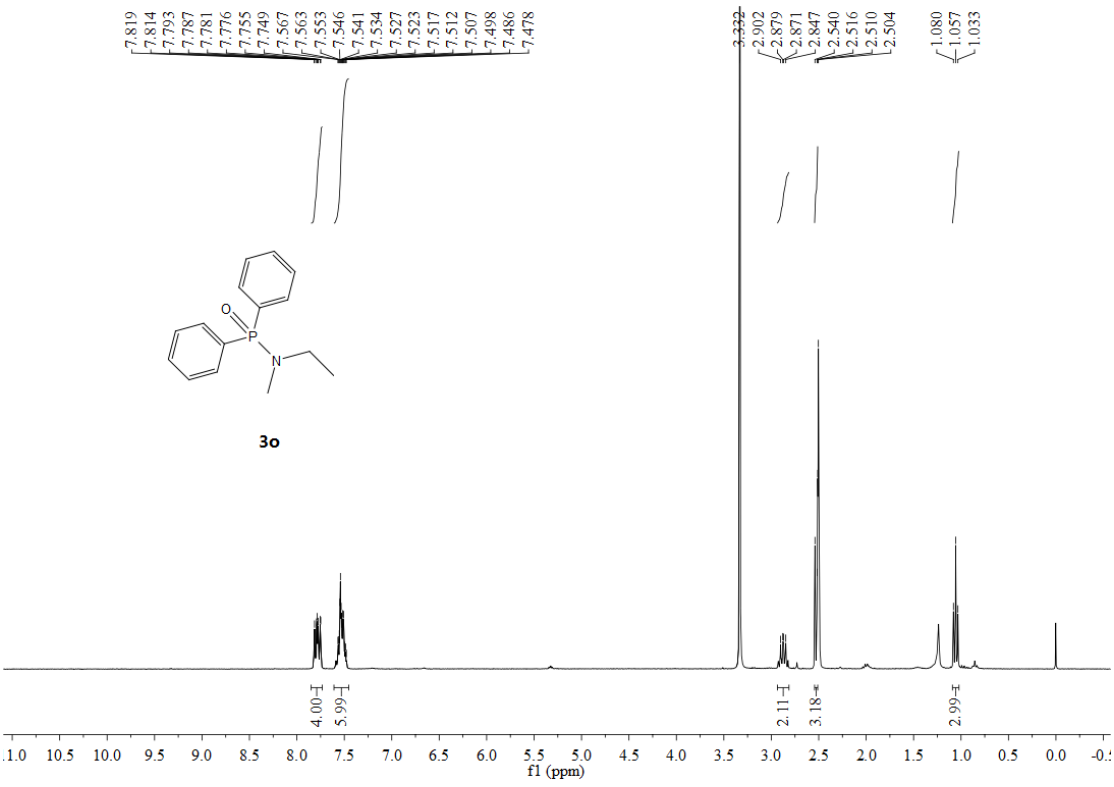

31.813
140 110 80 60 40 20 0 -10 -30 -50 -70 -90 -110 -140 -170 -200 -230
f1 (ppm)


7.864
7.859
7.838
7.832
7.826
7.820
7.798
7.792
7.789
7.761
7.510
7.506
7.494
7.488
7.482
7.469
7.464
7.461
7.454
7.446
7.438
7.424
7.418
7.410
2.672
2.634
Cl
O
P
N
4.00
5.08
5.97
f1 (ppm)

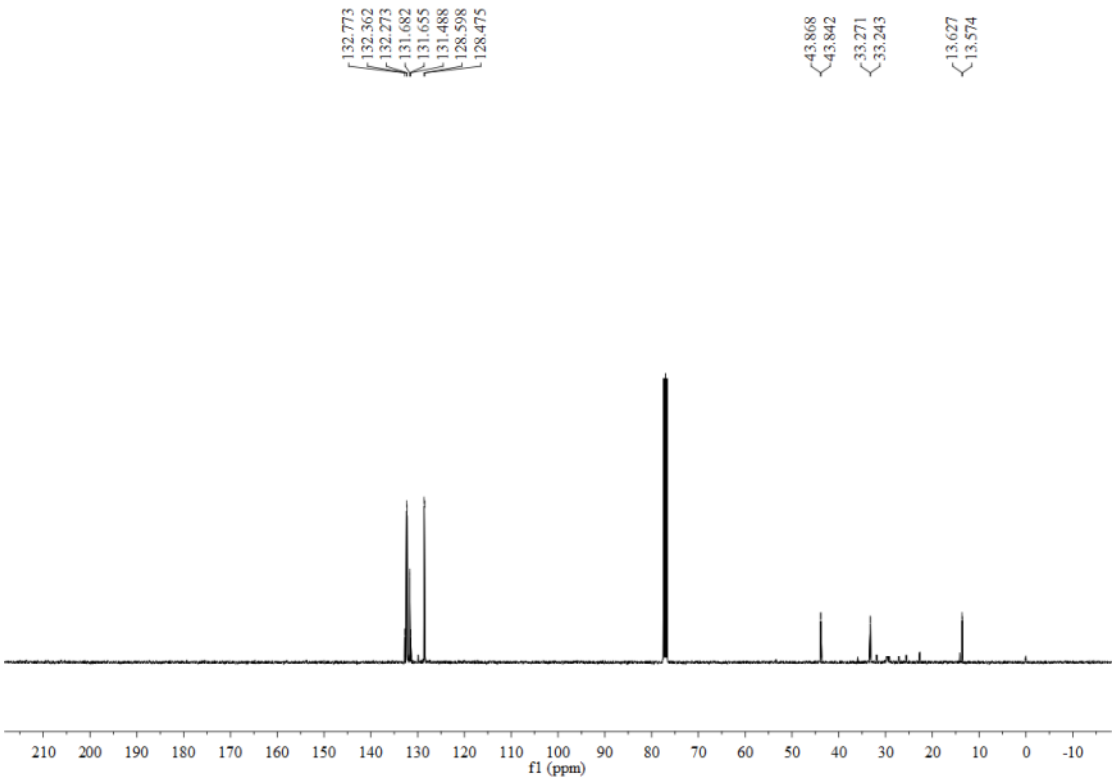
3l

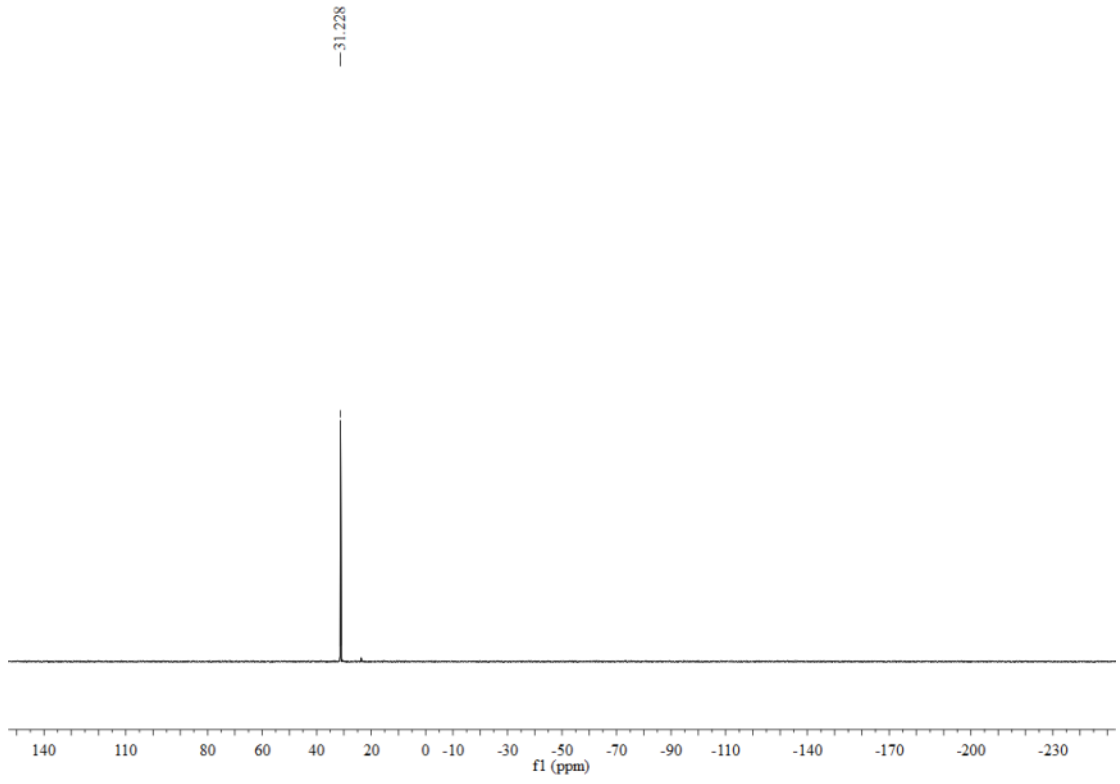

138.390
138.355
133.842
133.744
132.320
132.230
131.993
131.968
131.076
130.676
129.777
129.035
128.907
128.778
128.652
37.112
37.091
f1 (ppm)


30.557
140
110
80
60
40
20
0
-20
-50
-80
-110
-140
-170
-200
-230
f1 (ppm)

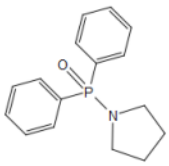

7.819
7.814
7.793
7.787
7.781
7.776
7.755
7.749
7.567
7.563
7.553
7.546
7.541
7.534
7.527
7.523
7.517
7.512
7.507
7.498
7.486
7.478
3.332
2.902
2.879
2.871
2.847
2.540
2.516
2.510
2.504
1.080
1.057
1.033
O
P
N
4.00
5.99
2.11
3.18
2.99
f1 (ppm)

3o

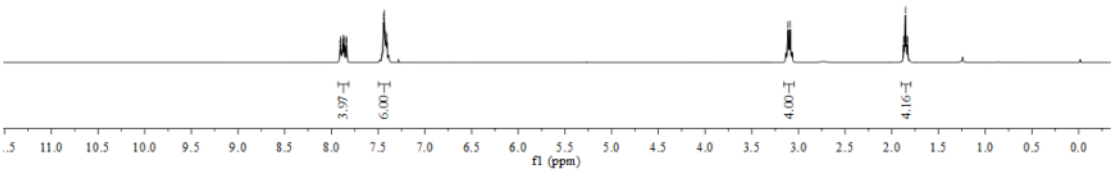

132.773
132.362
132.273
131.682
131.655
131.488
128.598
128.475
43.868
43.842
33.271
33.243
13.627
13.574
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

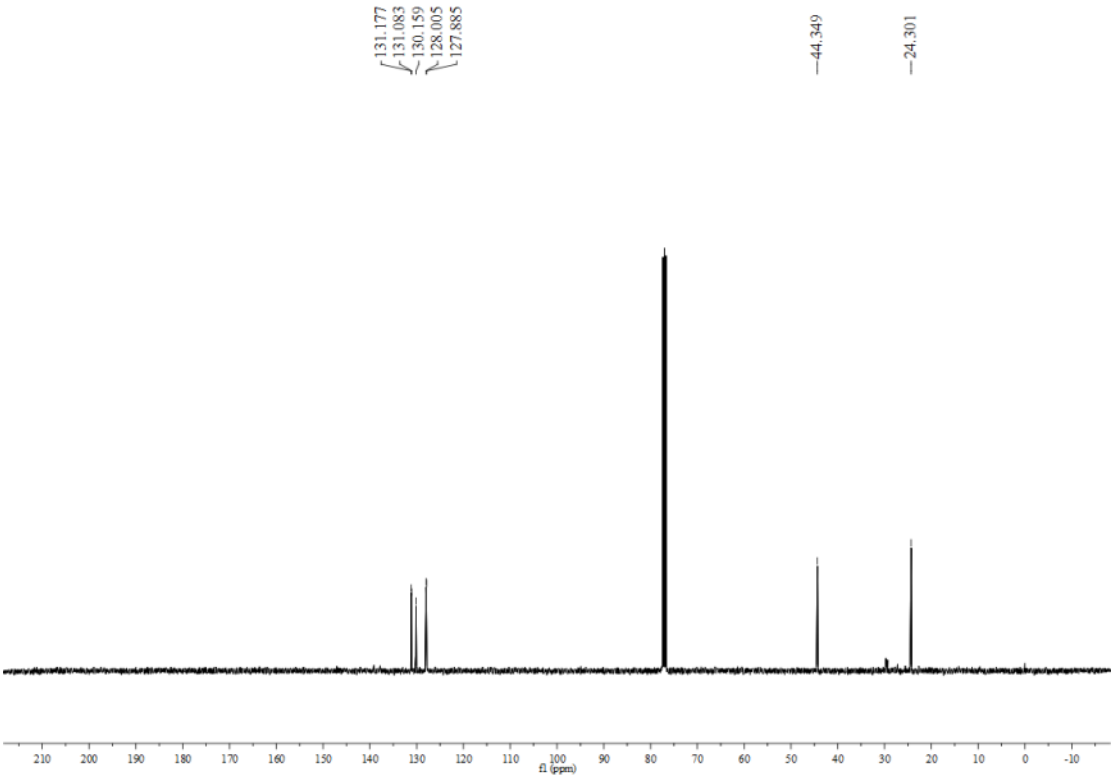

31.228
140 110 80 60 40 20 0 -10 -30 -50 -70 -90 -110 -140 -170 -200 -230
f1 (ppm)

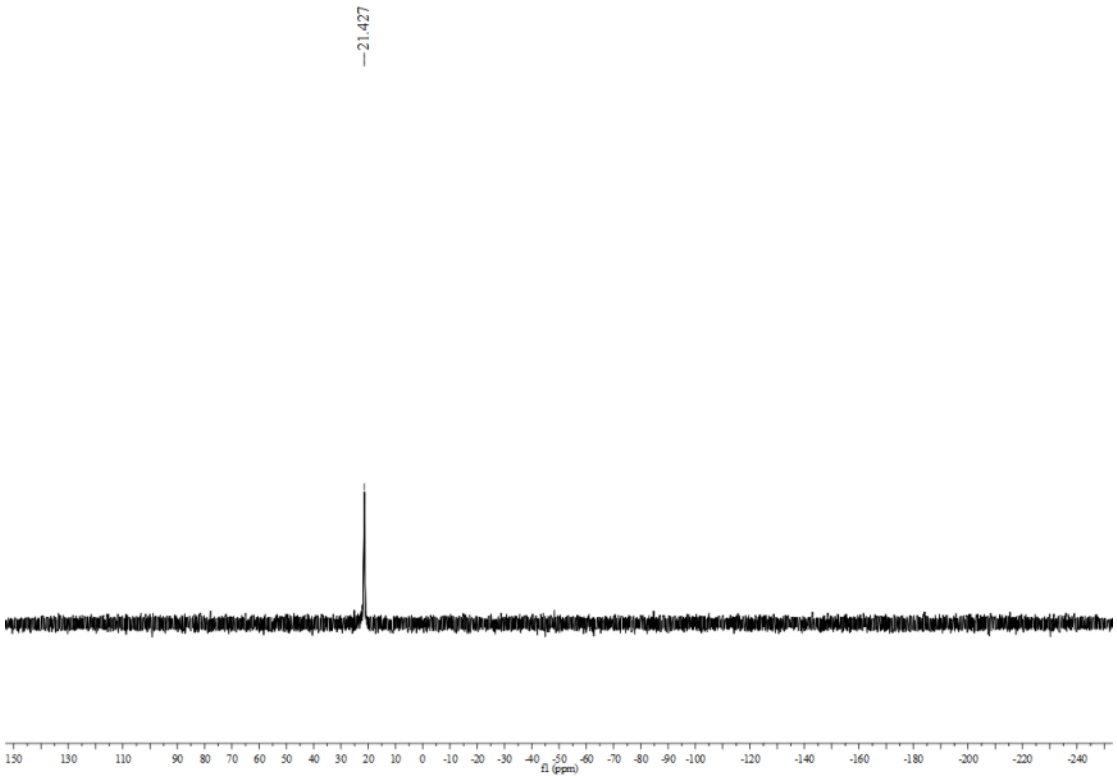

7.907
7.902
7.883
7.876
7.868
7.863
7.843
7.837
7.440
7.433
7.417
7.407
3.111
3.104
3.097
3.089
1.875
1.863
1.853
1.843
1.831


O
P
N

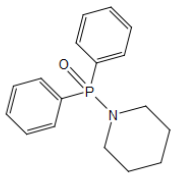
3p


3.97
6.00
4.00
4.16
f1 (ppm)

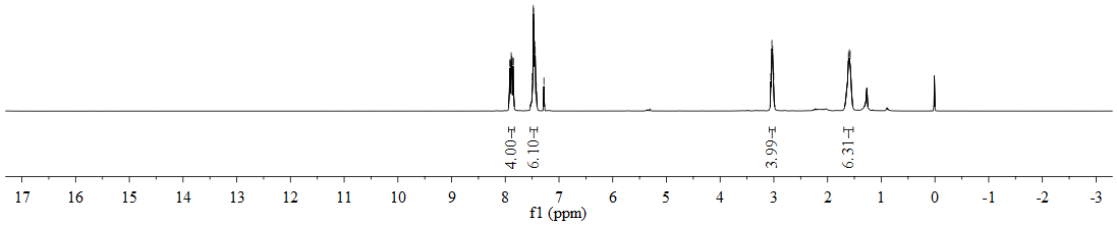

131.177
131.083
130.159
128.005
127.885
44.349
24.301
f1 (ppm)

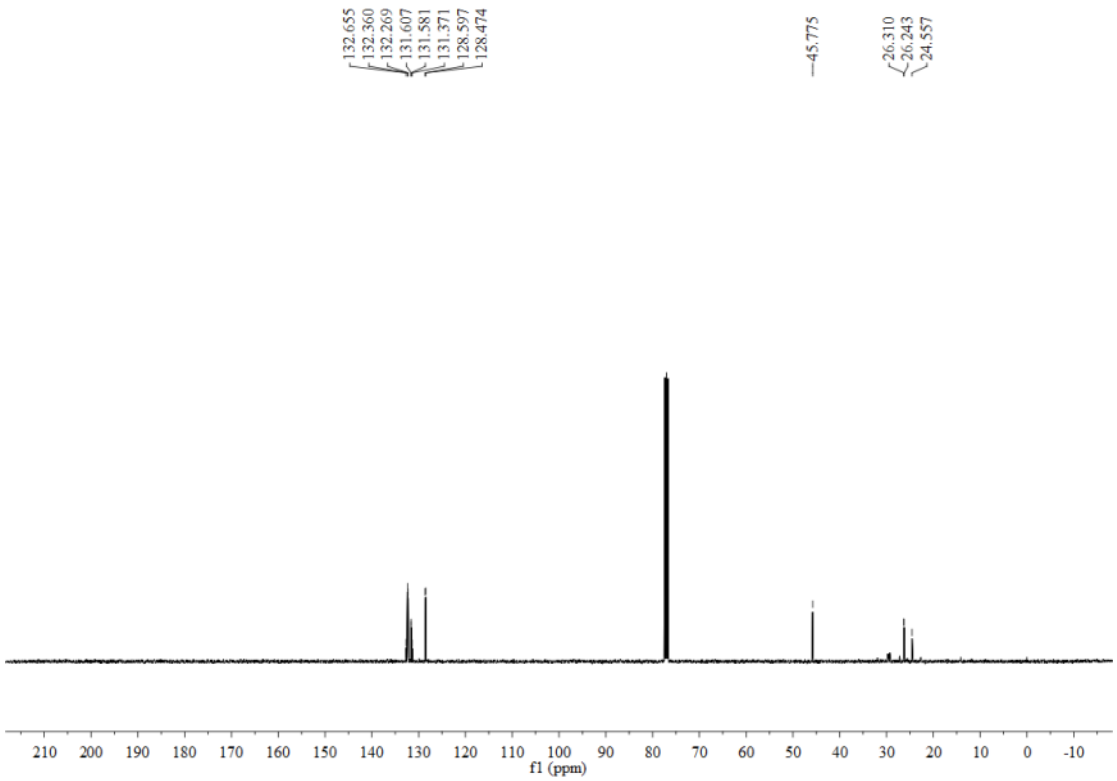

21.427
f1 (ppm)

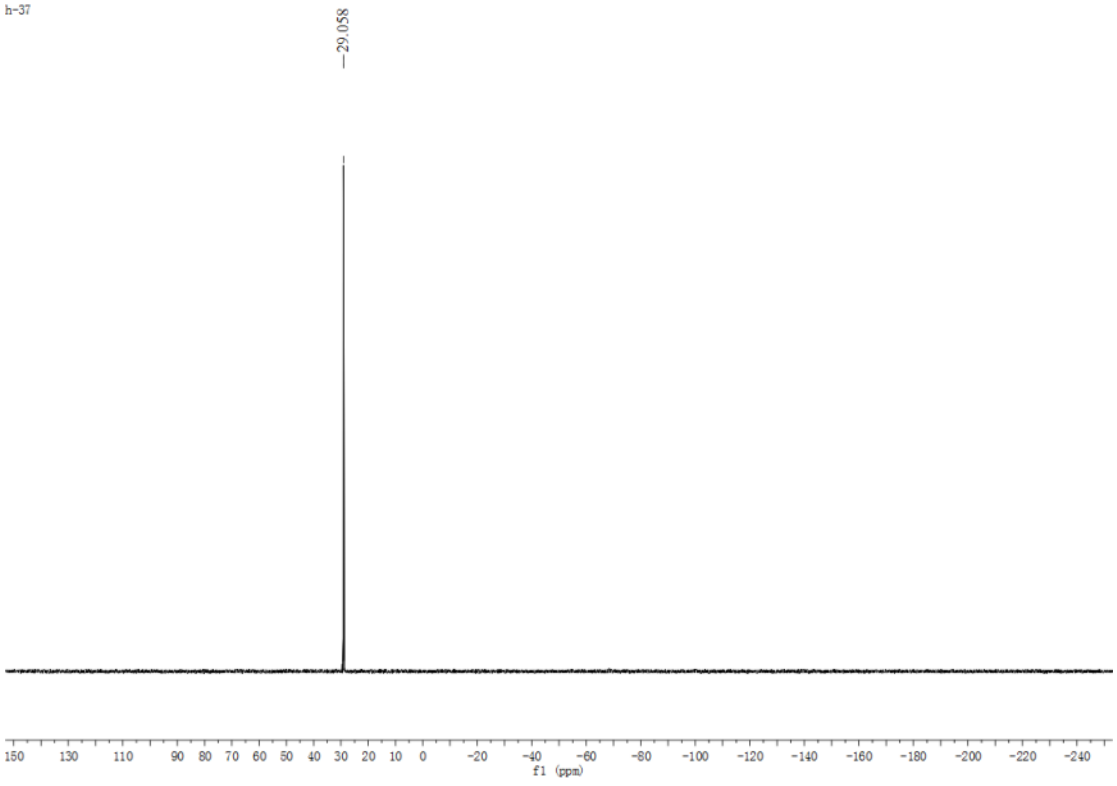

7.921
7.916
7.896
7.890
7.882
7.878
7.857
7.851
7.496
7.478
7.474
7.468
7.452
7.443
7.423
7.281
3.057
3.036
3.023
3.003
1.611
1.595
1.578

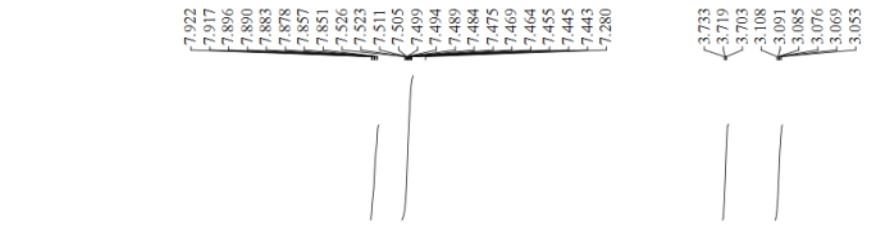

O
P
N

3q


4.00
6.10
3.99
6.31
f1 (ppm)


132.655
132.360
132.269
131.607
131.581
131.371
128.597
128.474
45.775
26.310
26.243
24.557
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


h-37
29.058
150 130 110 90 80 70 60 50 40 30 20 10 0 -20 -40 -60 -80 -100 -120 -140 -160 -180 -200 -220 -240
f1 (ppm)


7.922
7.917
7.896
7.890
7.883
7.878
7.857
7.851
7.526
7.523
7.511
7.505
7.499
7.494
7.489
7.484
7.475
7.469
7.464
7.455
7.445
7.443
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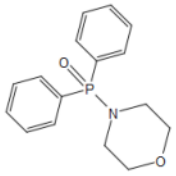
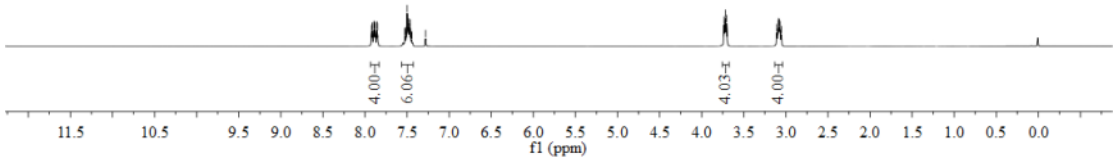
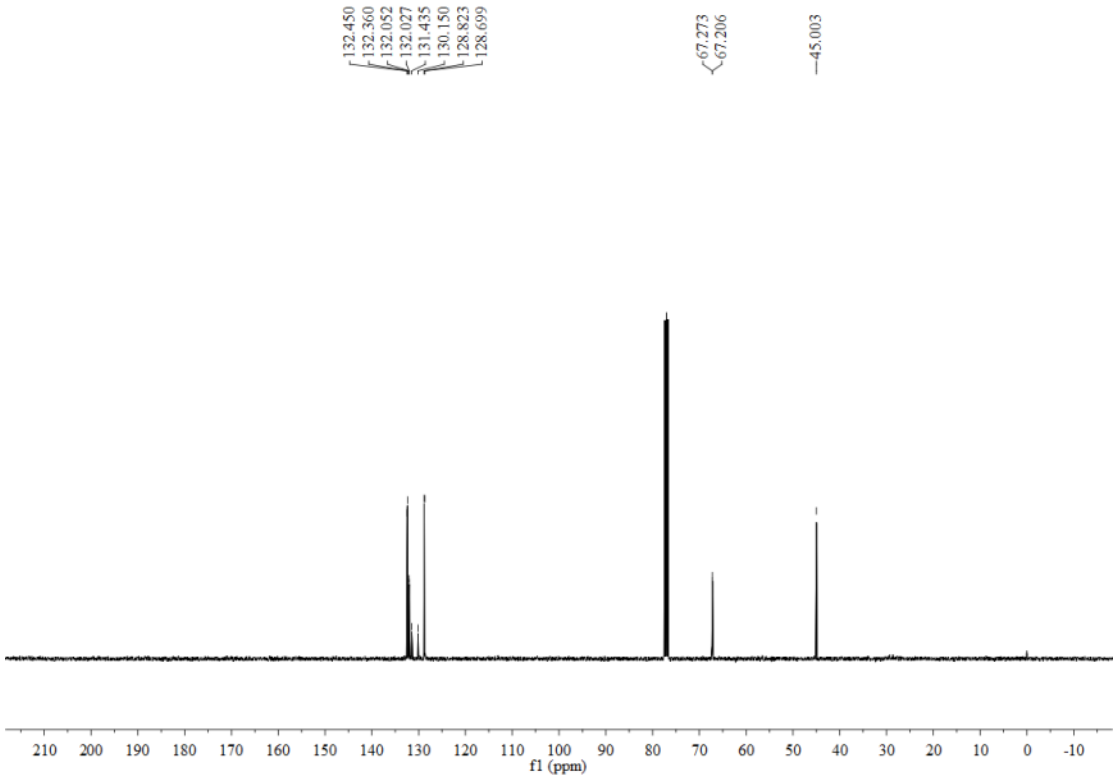
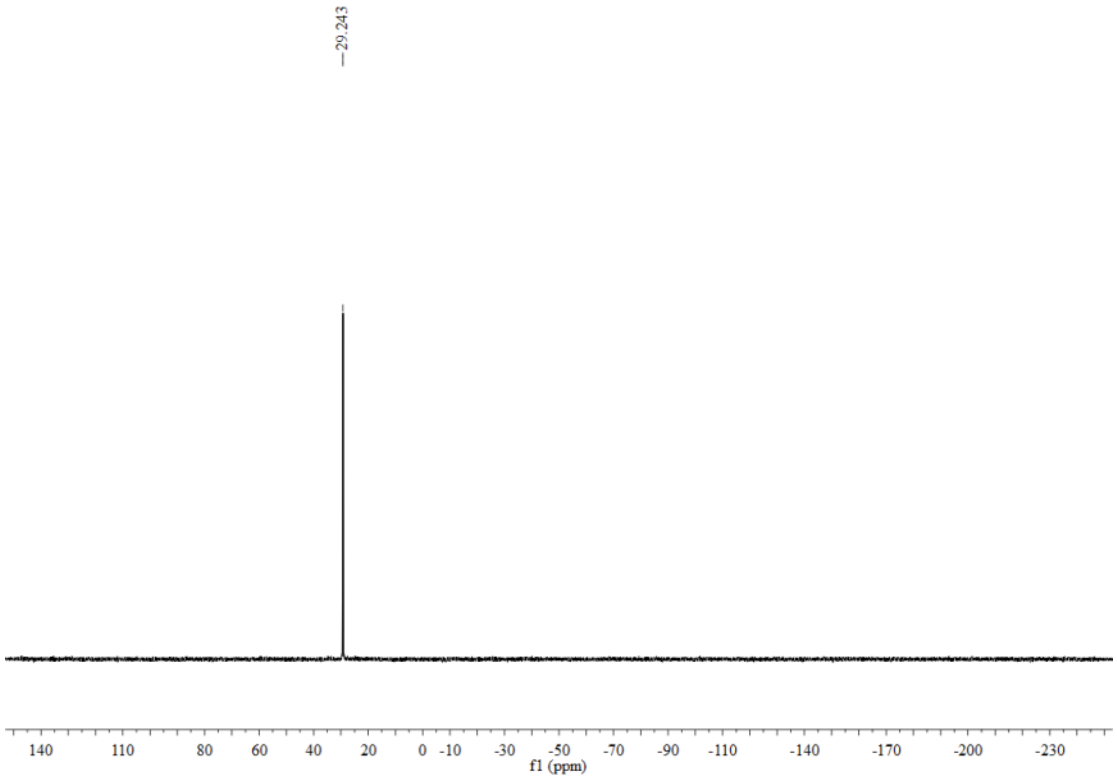
3.733
3.719
3.703
3.108
3.091
3.085
3.076
3.069
3.053

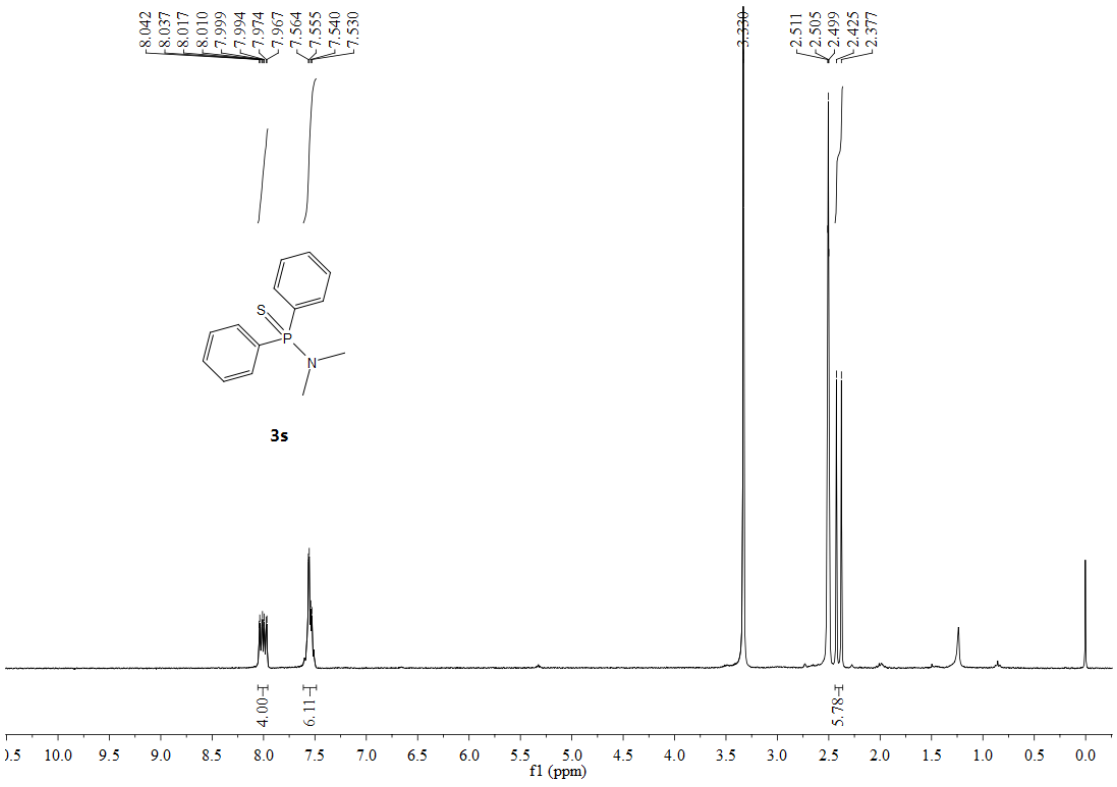

O
P
N
O

3r


4.00
6.06
4.03
4.00
11.5
10.5
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)


132.450
132.360
132.052
132.027
131.435
130.150
128.823
128.699
67.273
67.206
45.003
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10
f1 (ppm)


29.243
140
110
80
60
40
20
0
-10
-30
-50
-70
-90
-110
-140
-170
-200
-230
f1 (ppm)


8.042
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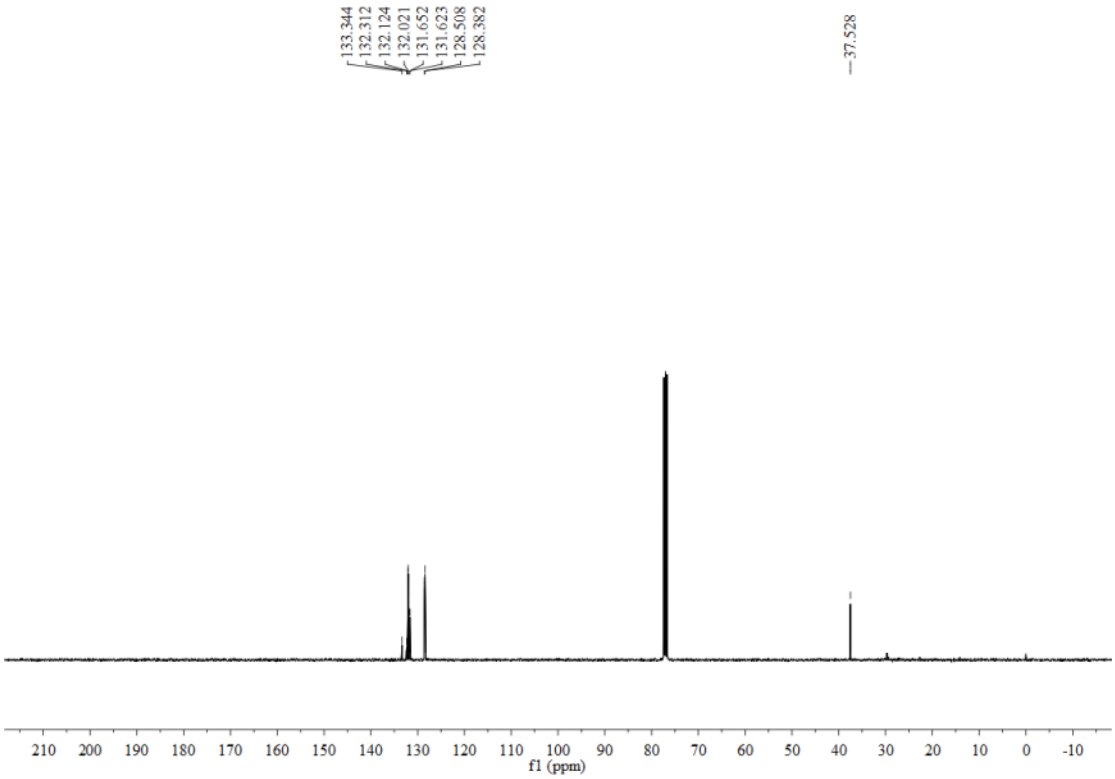
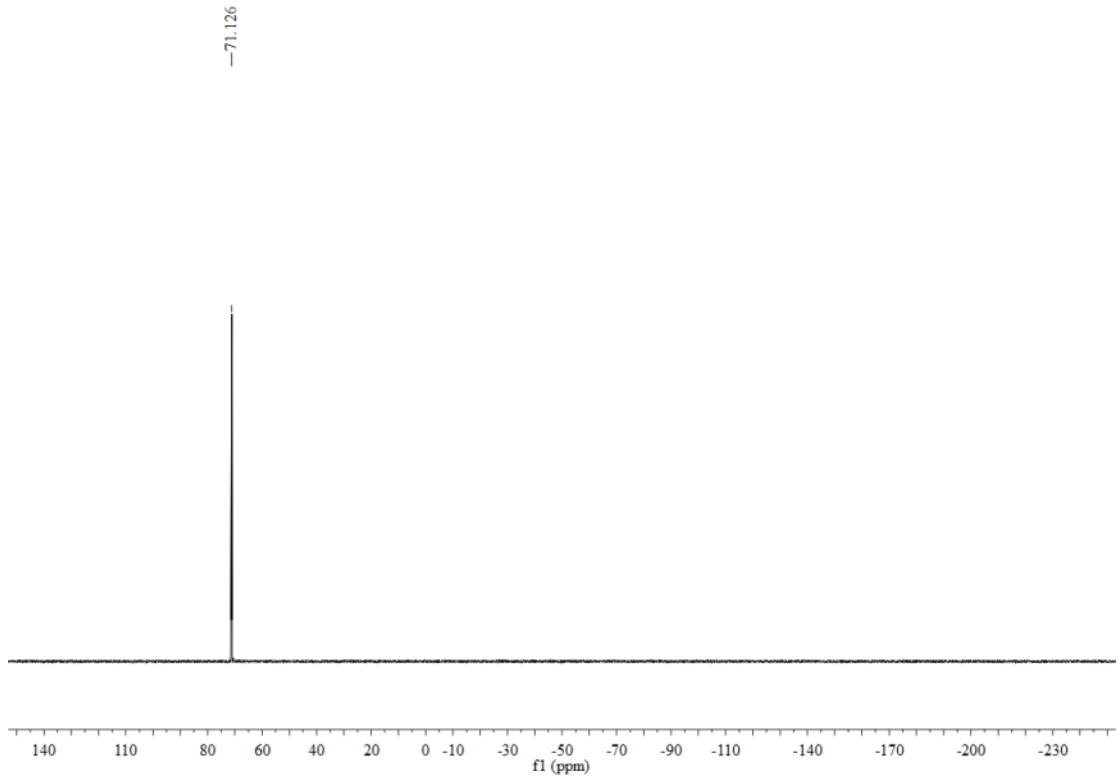
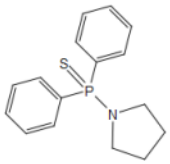
8.017
8.010
7.999
7.994
7.974
7.967
7.564
7.555
7.540
7.530
3.330
2.511
2.505
2.499
2.425
2.377
S
P
N
4.00
6.11
5.78
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

3s

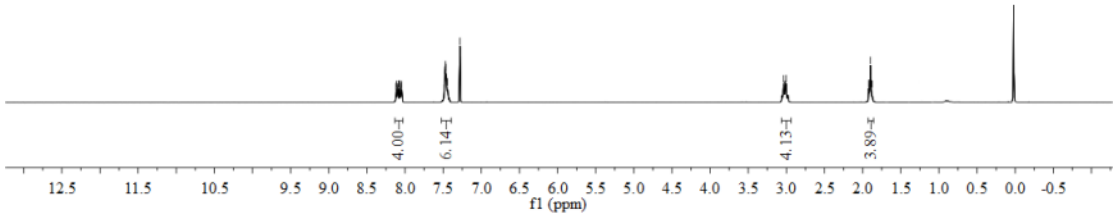

133.344
132.312
132.124
132.021
131.652
131.623
128.508
128.382
37.528
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

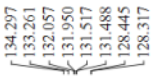

71.126
140 110 80 60 40 20 0 -10 -30 -50 -70 -90 -110 -140 -170 -200 -230
f1 (ppm)


8.118
8.113
8.102
8.096
8.086
8.075
8.069
8.064
8.051
8.043
7.487
7.478
7.473
7.468
7.465
7.457
7.443
7.280
3.036
3.027
3.013
3.004
1.921
1.909
1.899
1.888
1.876

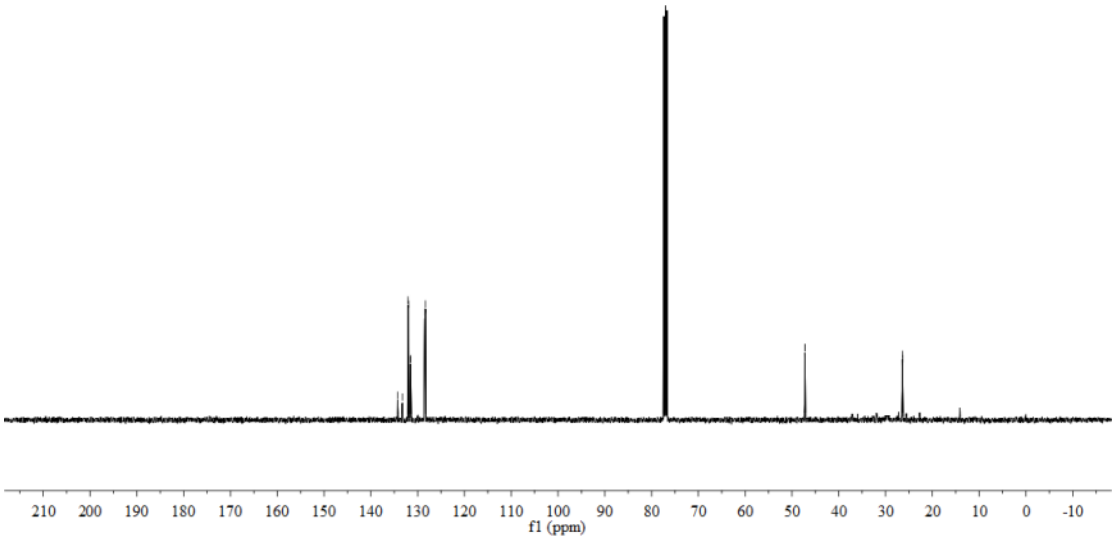

S
P
N

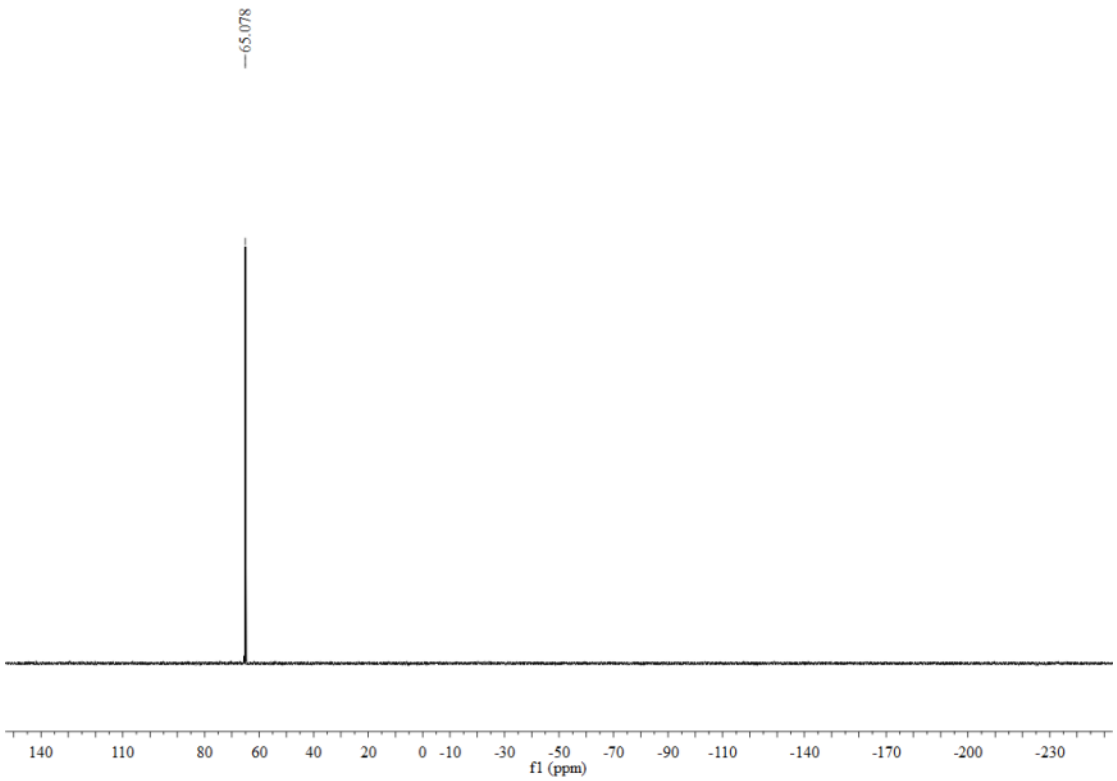
3t

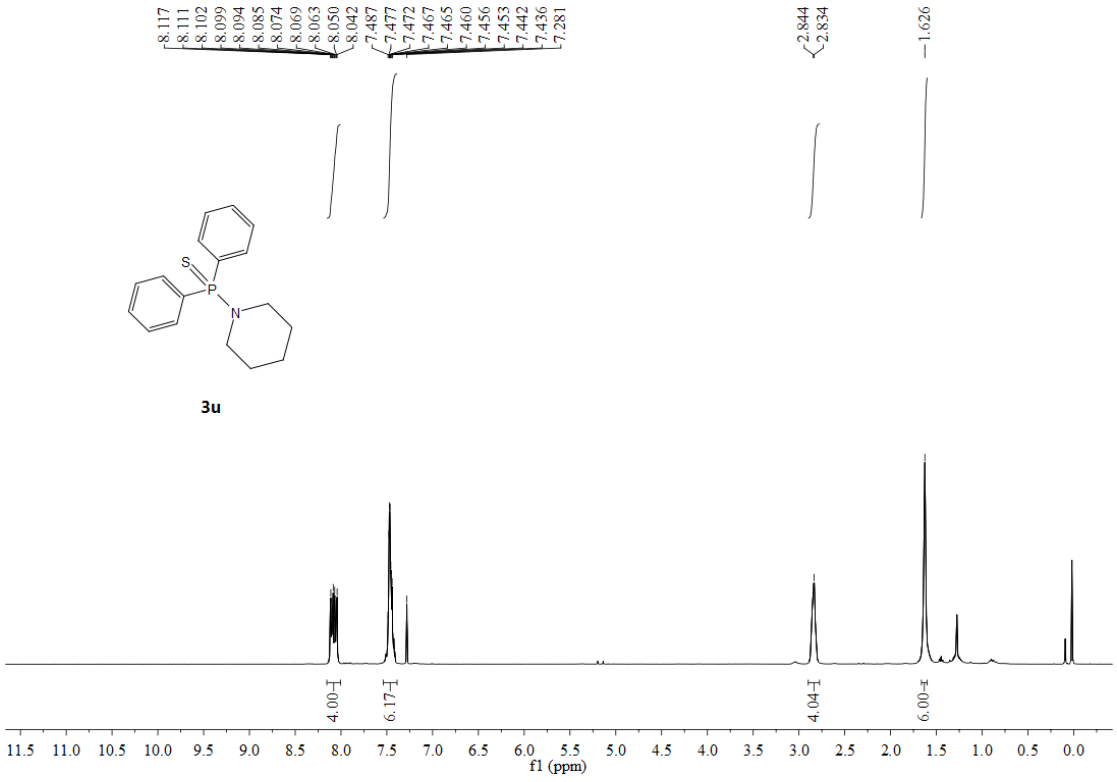

4.00
6.14
4.13
3.89
12.5 11.5 10.5 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)


134.297
133.261
132.057
131.950
131.517
131.488
128.445
128.317

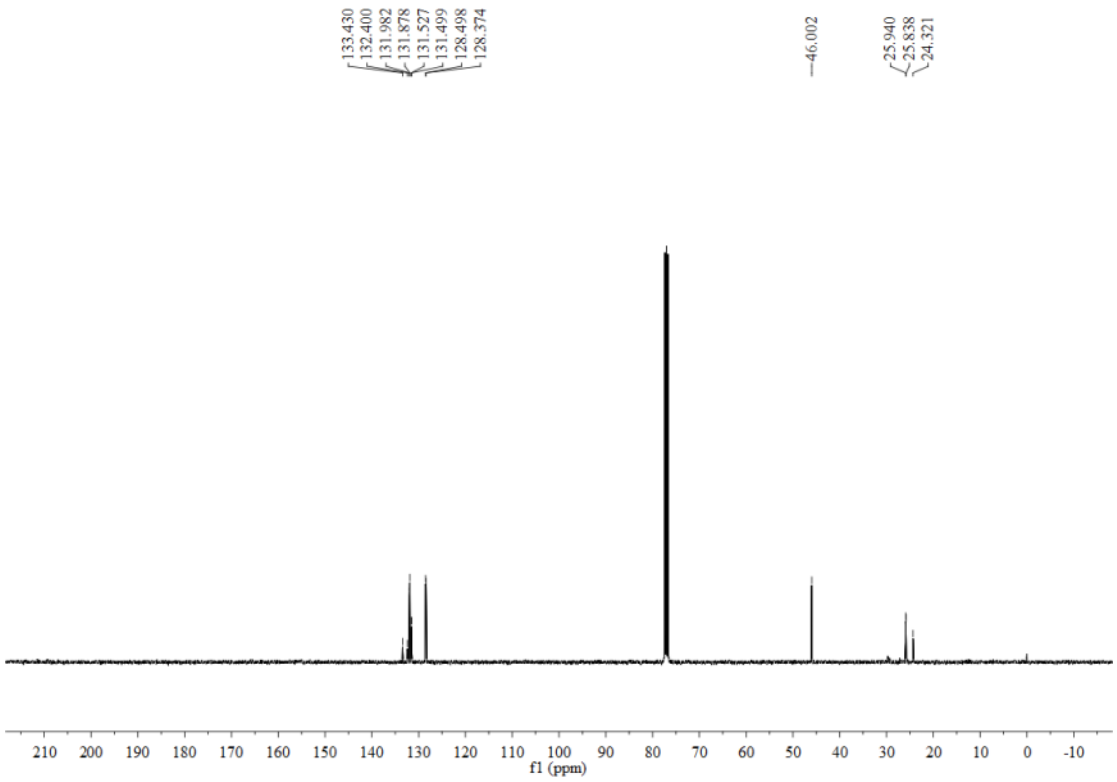

47.258
47.245
26.373
26.296

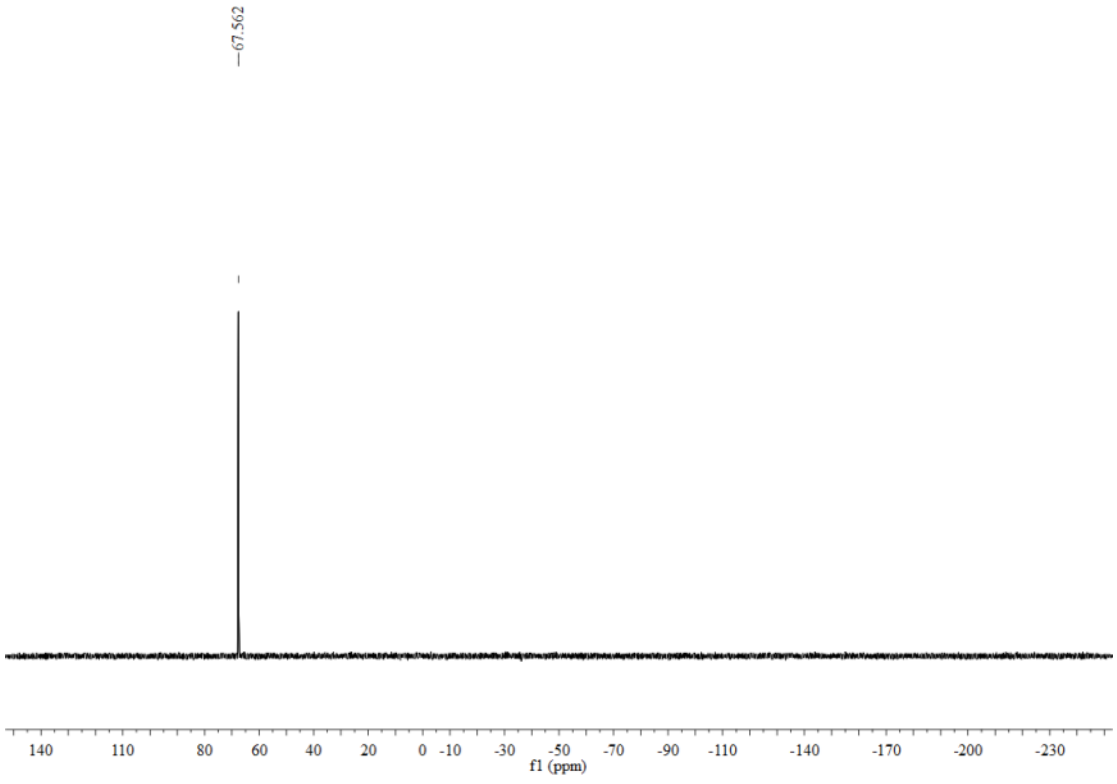

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

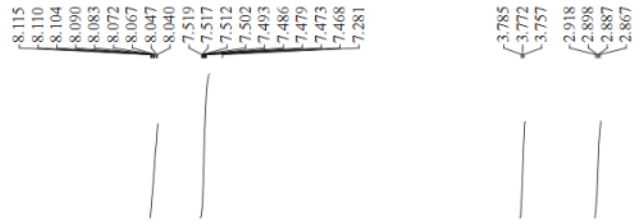

65.078
140 110 80 60 40 20 0 -10 -30 -50 -70 -90 -110 -140 -170 -200 -230
f1 (ppm)

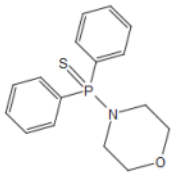

8.117
8.111
8.102
8.099
8.094
8.085
8.074
8.069
8.063
8.050
8.042
7.487
7.477
7.472
7.467
7.465
7.460
7.456
7.453
7.442
7.436
7.281
2.844
2.834
1.626
S
P
N
4.00
6.17
4.04
6.00
11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

3u

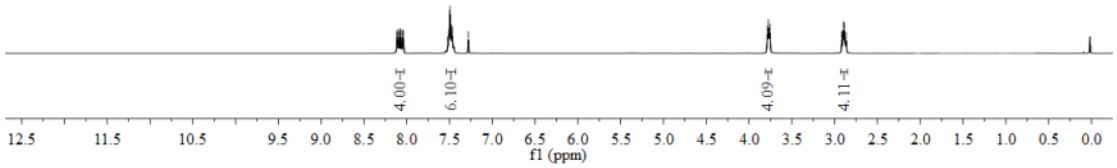

133.430
132.400
131.982
131.878
131.527
131.499
128.498
128.374
46.002
25.940
25.838
24.321
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


67.562
140 110 80 60 40 20 0 -10 -30 -50 -70 -90 -110 -140 -170 -200 -230
f1 (ppm)

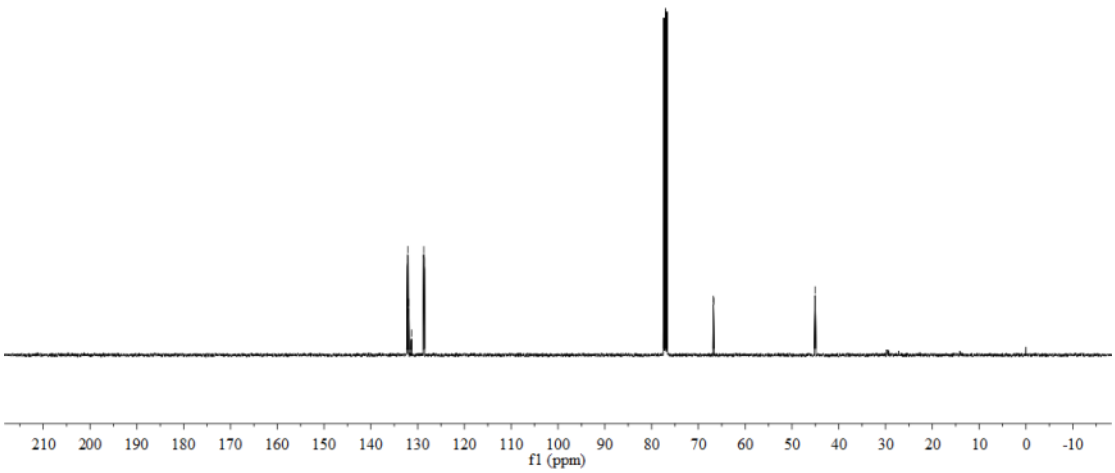

8.115
8.110
8.104
8.090
8.083
8.072
8.067
8.047
8.040
7.519
7.517
7.512
7.502
7.493
7.486
7.479
7.473
7.468
7.281
3.785
3.772
3.757
2.918
2.898
2.887
2.867

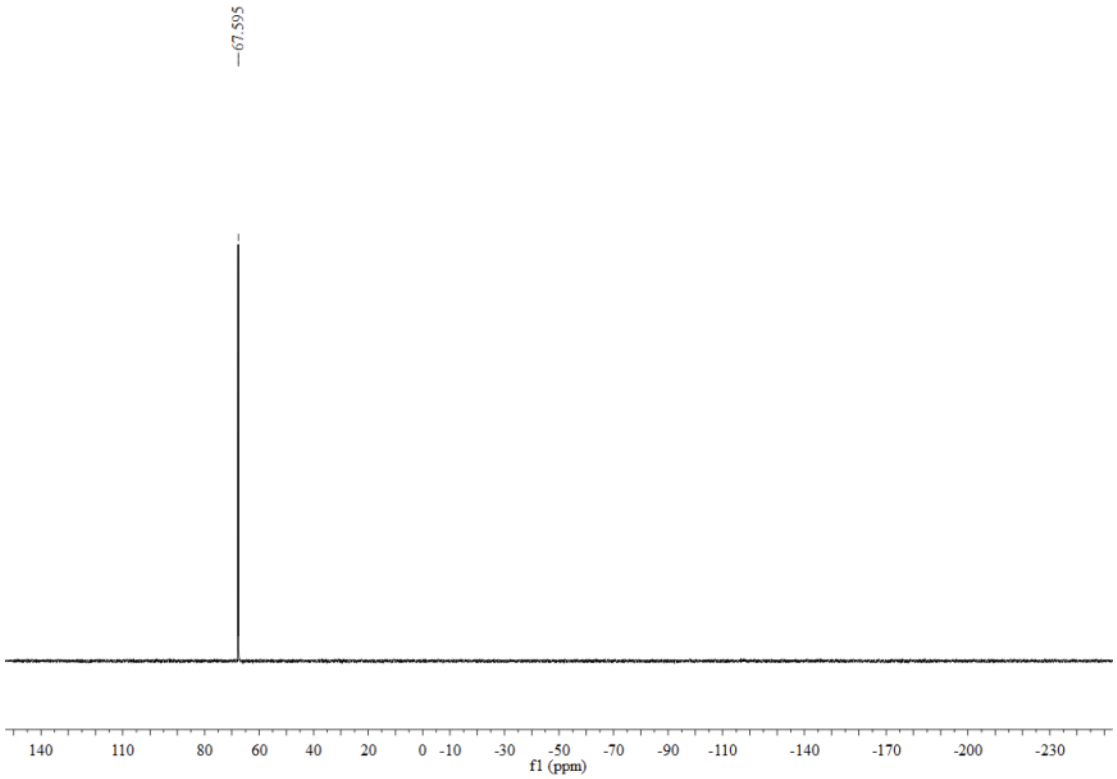

S
P
N
O

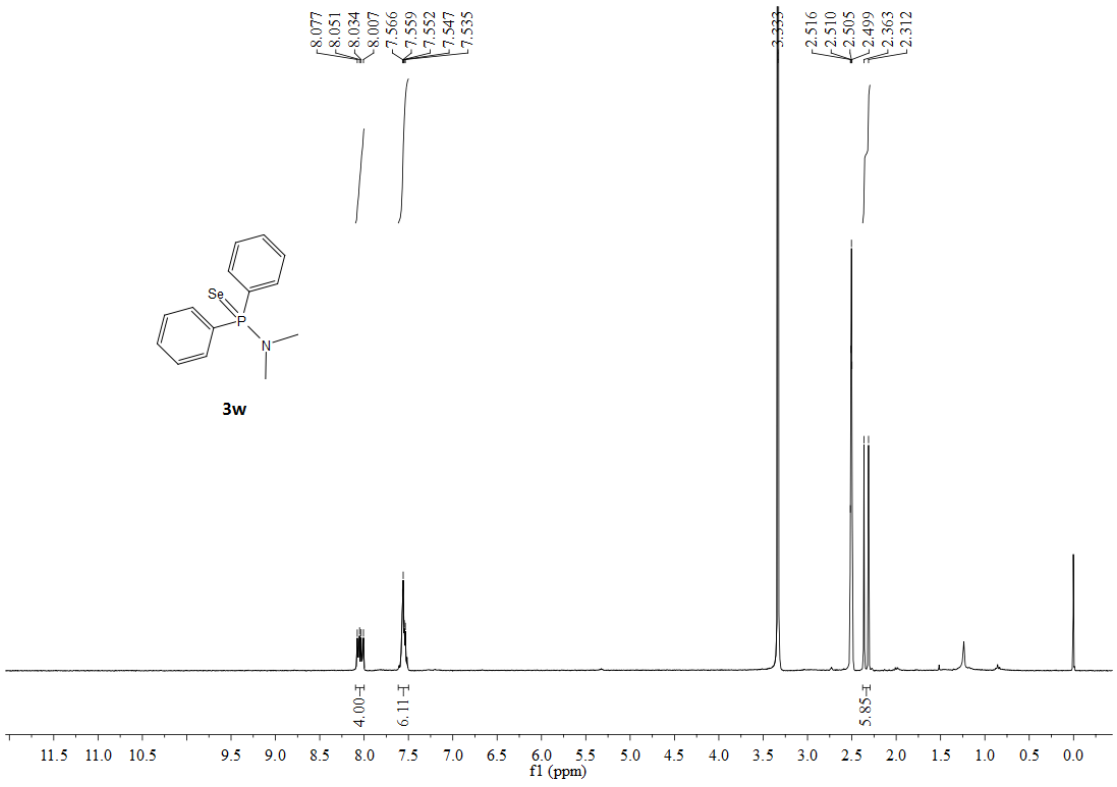
3v


4.00
6.10
4.09
4.11
12.5 11.5 10.5 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)

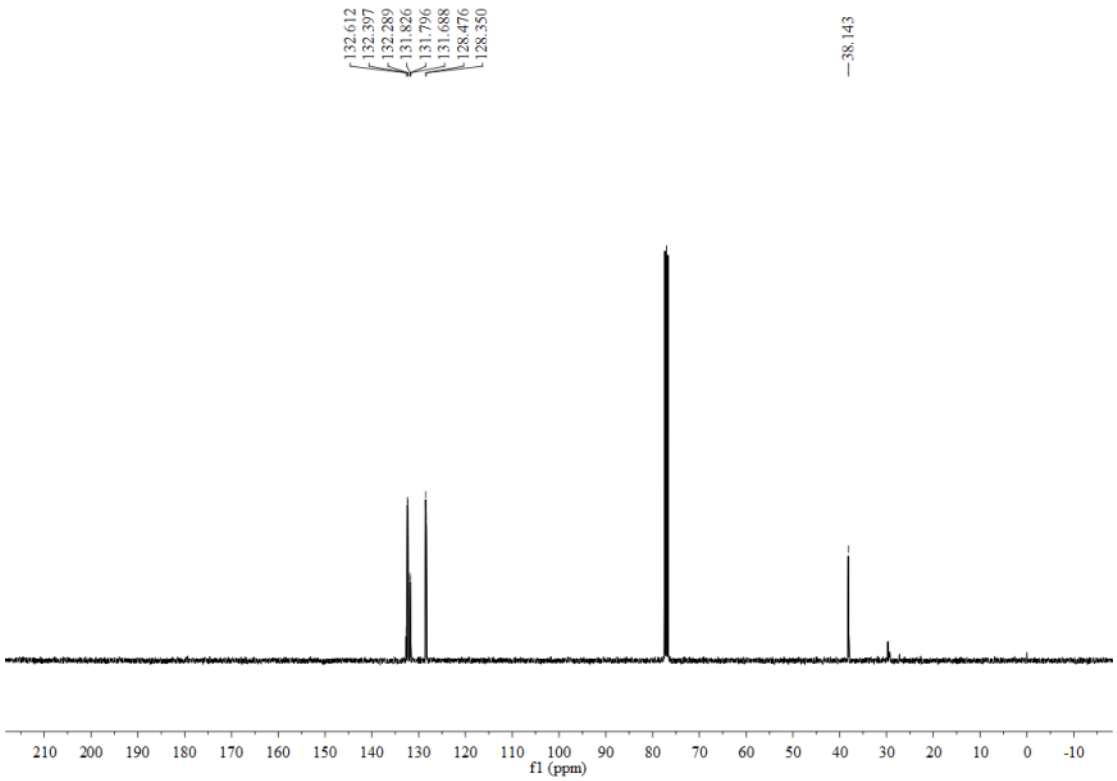

132.321
132.178
132.073
131.886
131.858
131.296
128.678
128.550
66.794
66.692
45.083

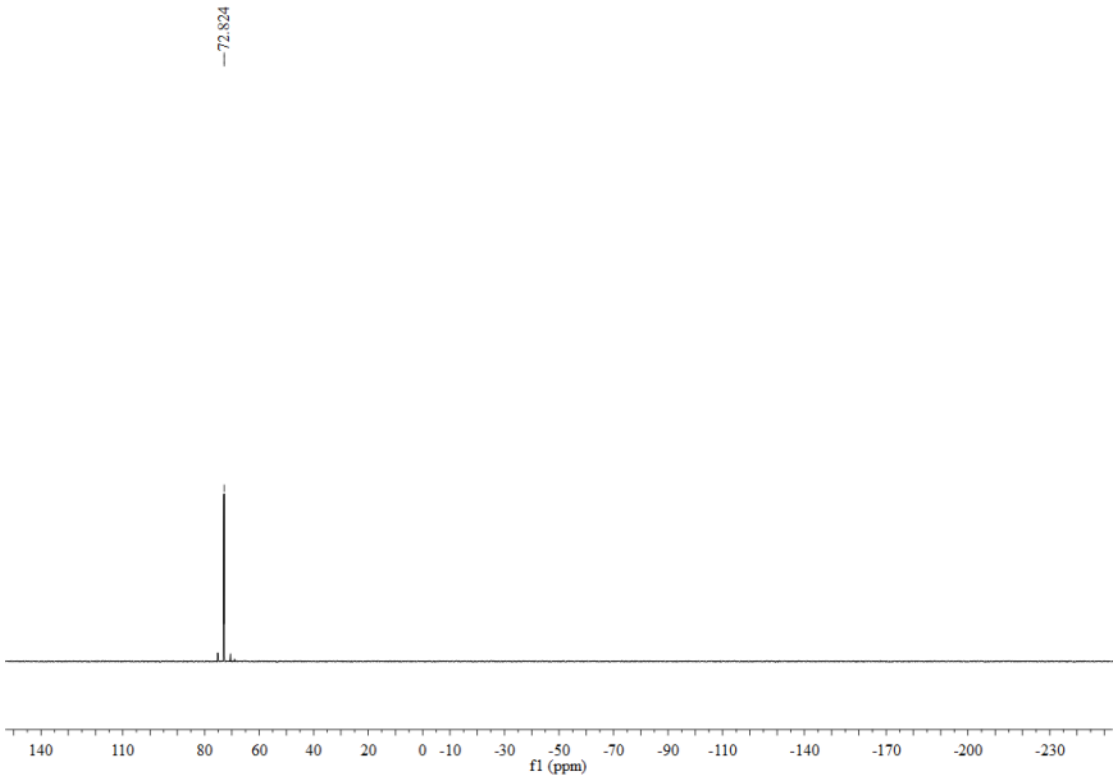

210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

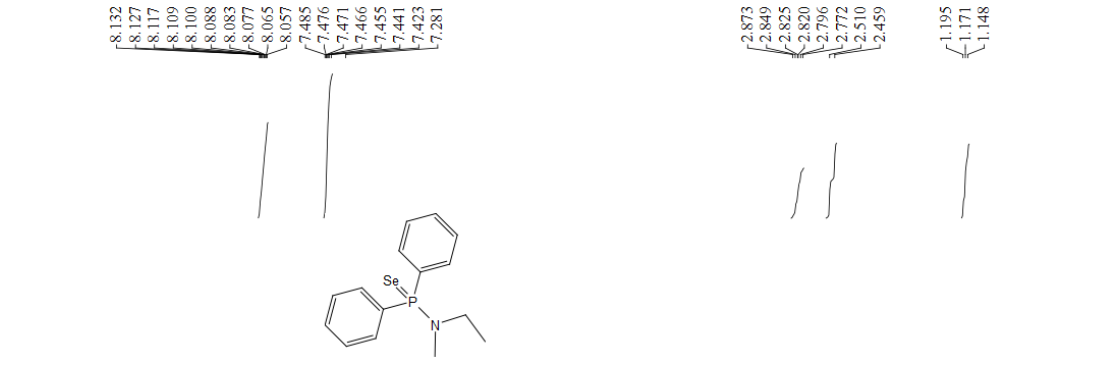

67.595
140
110
80
60
40
20
0
-10
-30
-50
-70
-90
-110
-140
-170
-200
-230
f1 (ppm)


8.077
8.051
8.034
8.007
7.566
7.559
7.552
7.547
7.535
3.333
2.516
2.510
2.505
2.499
2.363
2.312
Se
P
N
4.00
6.11
5.85
11.5
11.0
10.5
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)

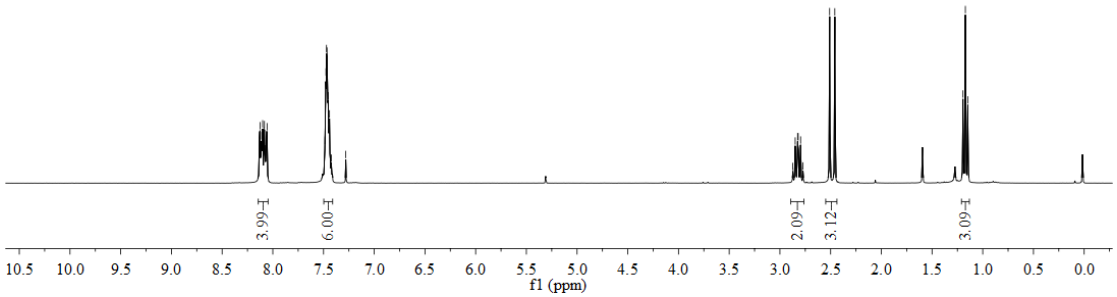
3w

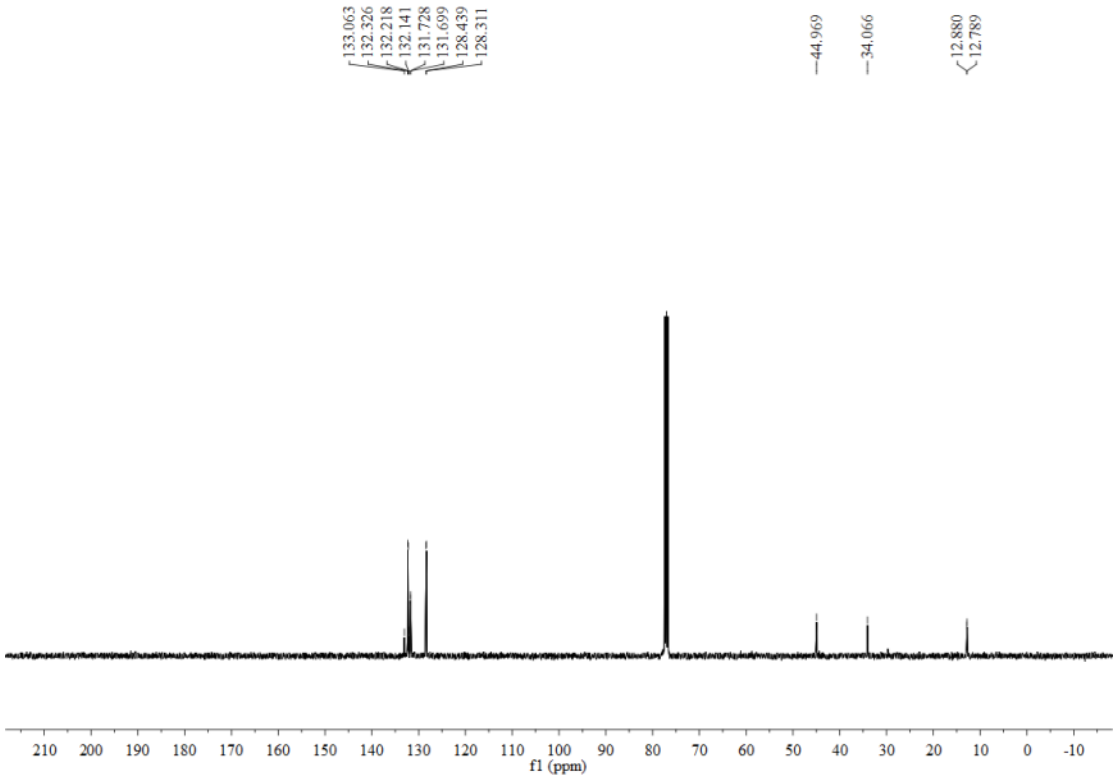

132.612
132.397
132.289
131.826
131.796
131.688
128.476
128.350
38.143
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

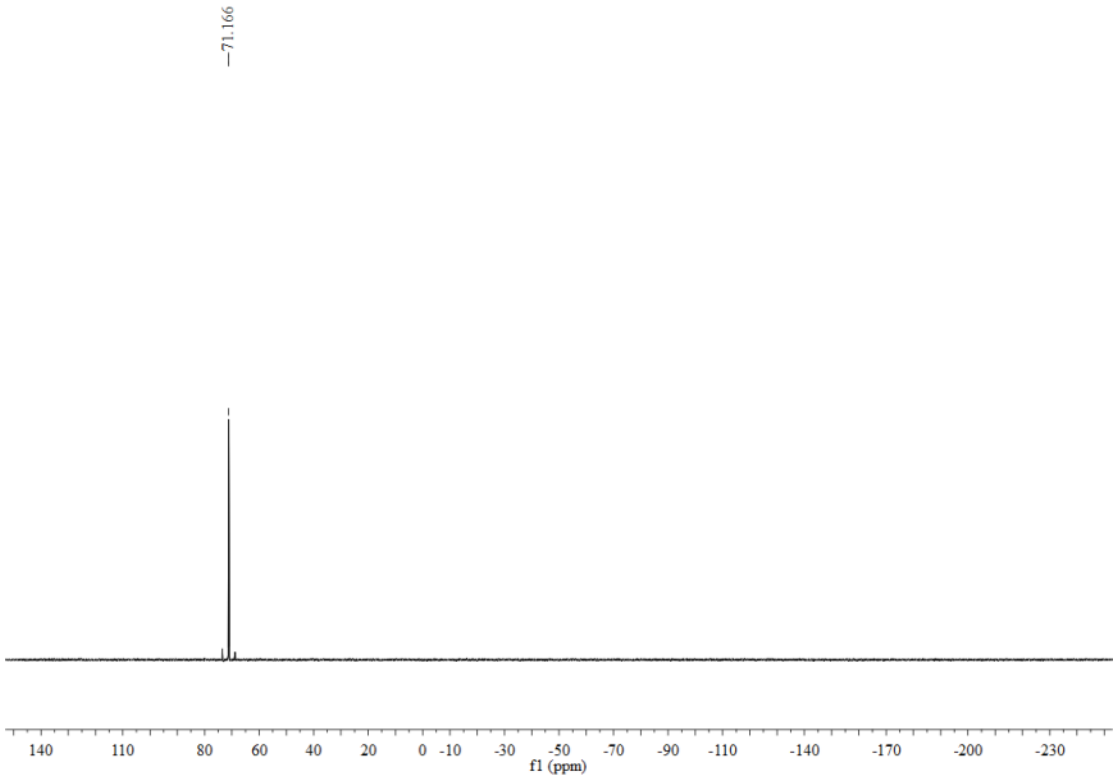

72.824
140 110 80 60 40 20 0 -10 -30 -50 -70 -90 -110 -140 -170 -200 -230
f1 (ppm)

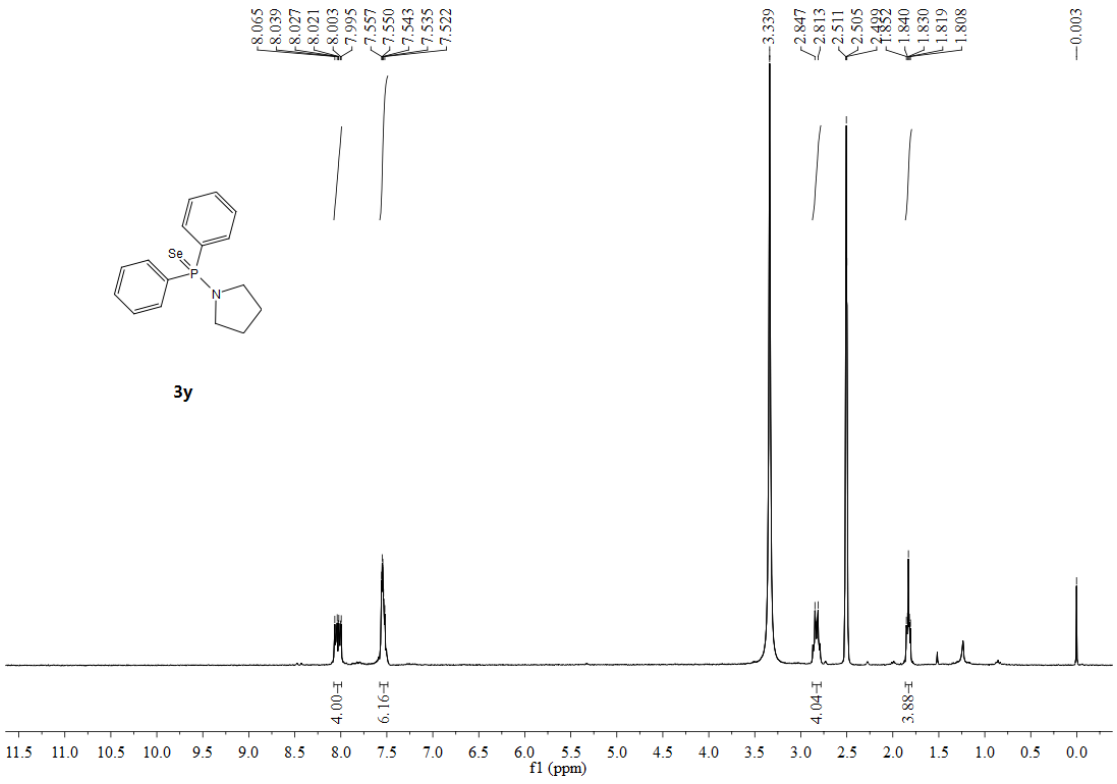

8.132
8.127
8.117
8.109
8.100
8.088
8.083
8.077
8.065
8.057
7.485
7.476
7.471
7.466
7.455
7.441
7.423
7.281
2.873
2.849
2.825
2.820
2.796
2.772
2.510
2.459
1.195
1.171
1.148
Se
P
N

3x

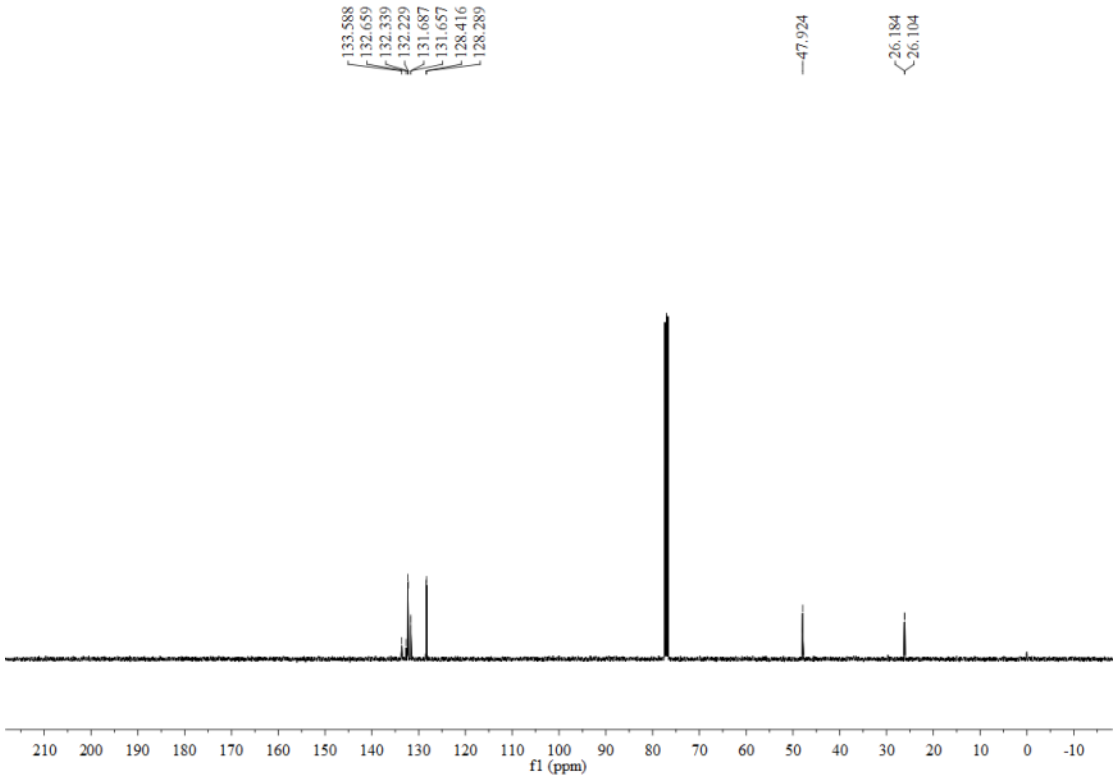

3.99
6.00
2.09
3.12
3.09
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

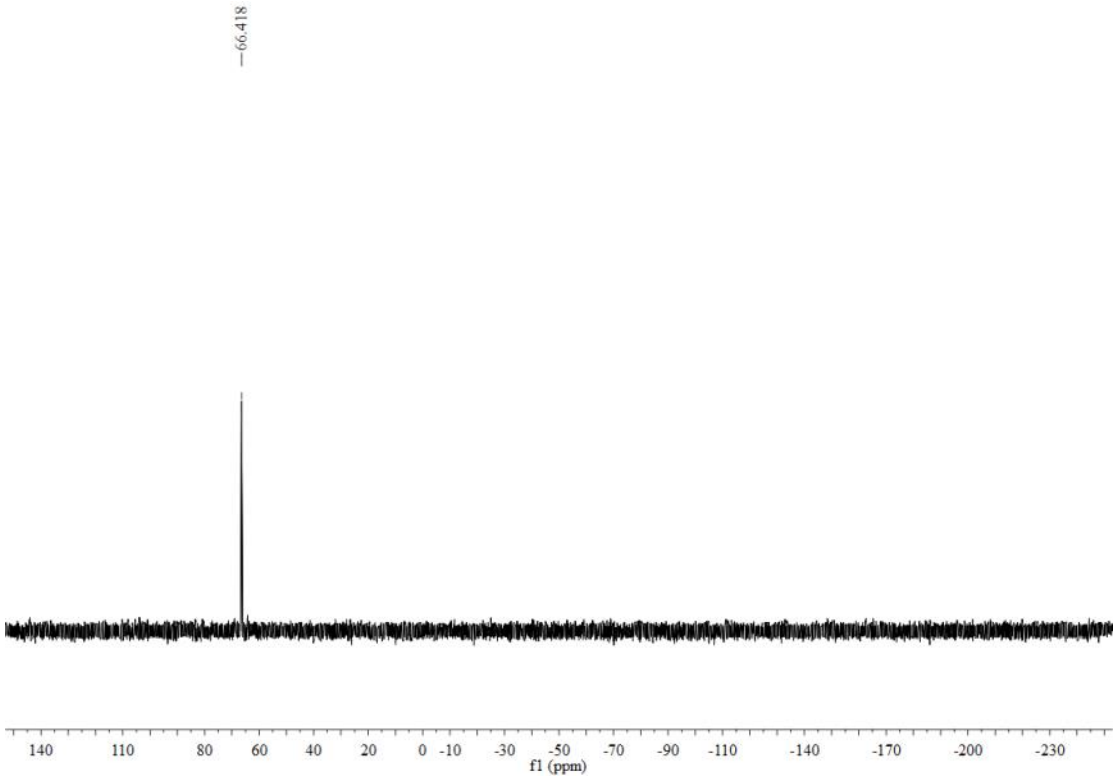

133.063
132.326
132.218
132.141
131.728
131.699
128.439
128.311
44.969
34.066
12.880
12.789
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

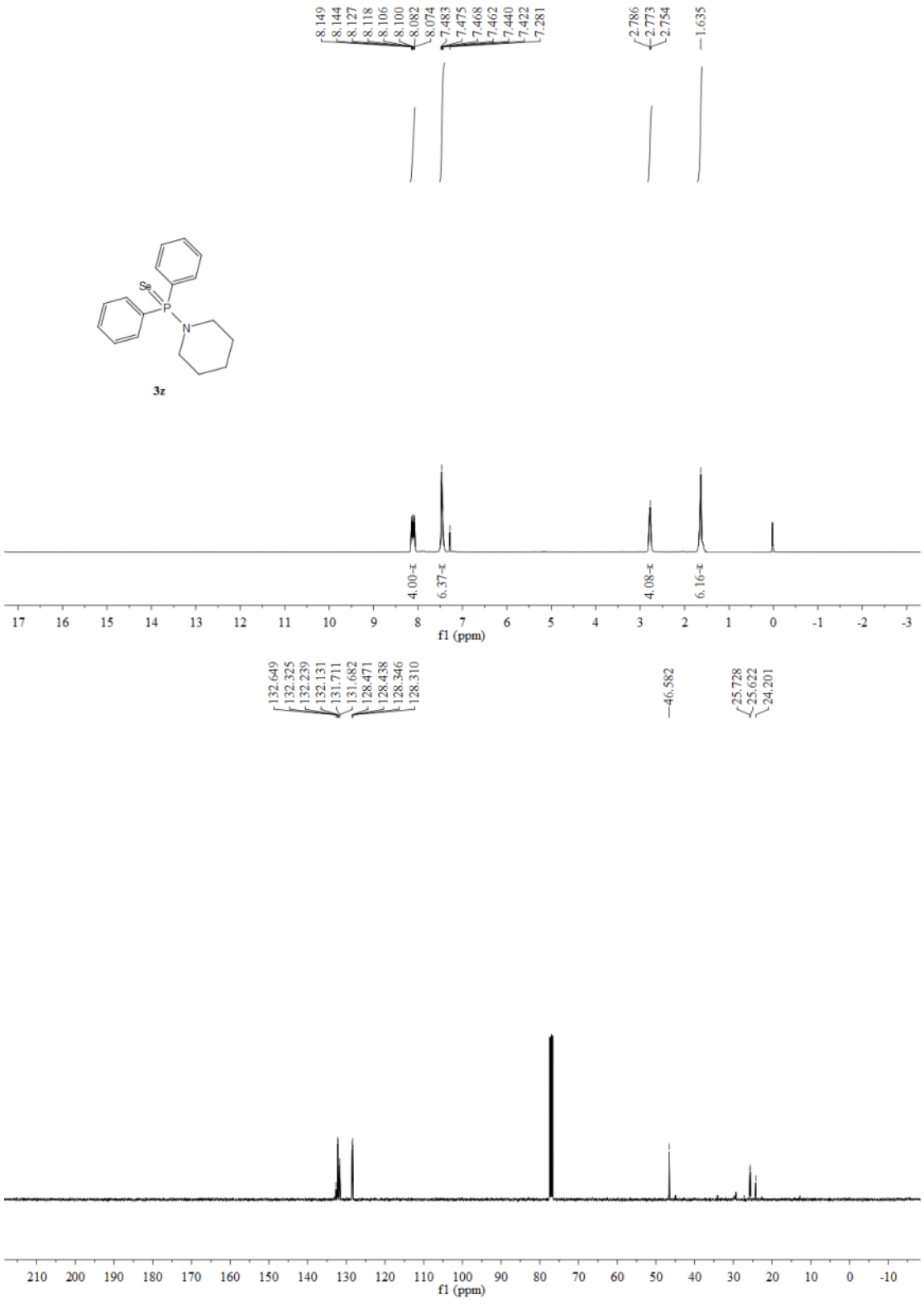

71.166
140 110 80 60 40 20 0 -10 -30 -50 -70 -90 -110 -140 -170 -200 -230
f1 (ppm)

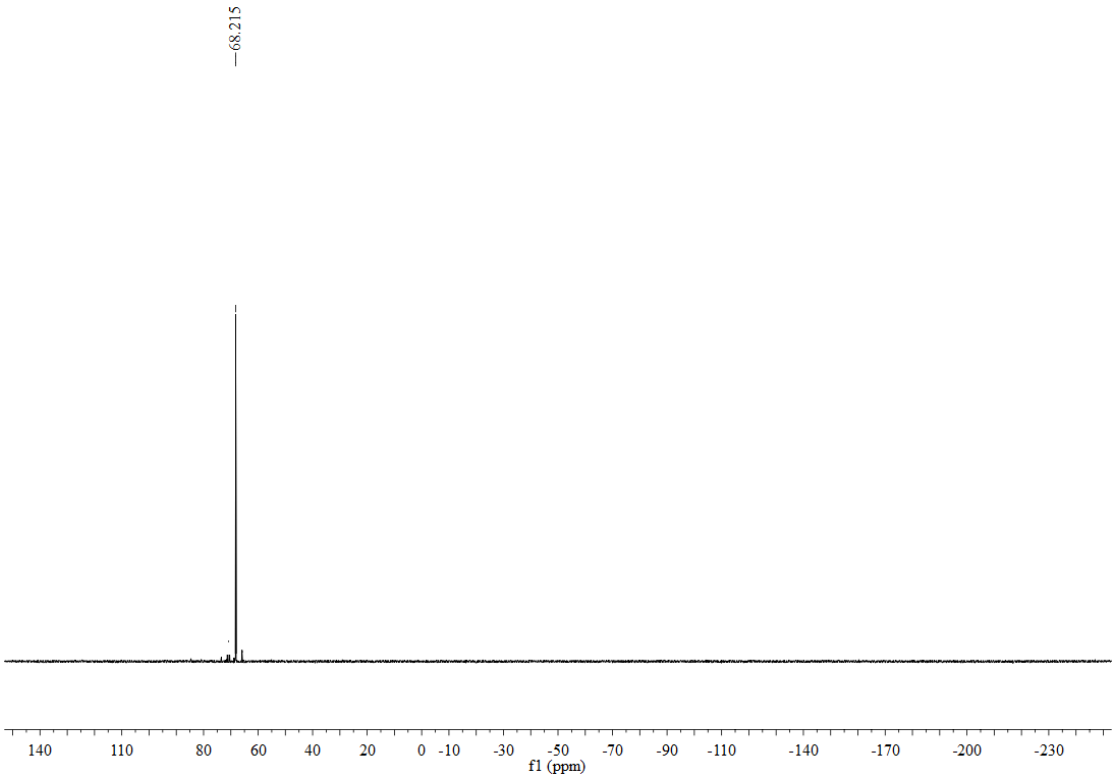

8.065
8.039
8.027
8.021
8.003
7.995
7.557
7.550
7.543
7.535
7.522
3.339
2.847
2.813
2.511
2.505
2.499
1.852
1.840
1.830
1.819
1.808
0.003
Se
P
N
4.00
6.16
4.04
3.88
11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

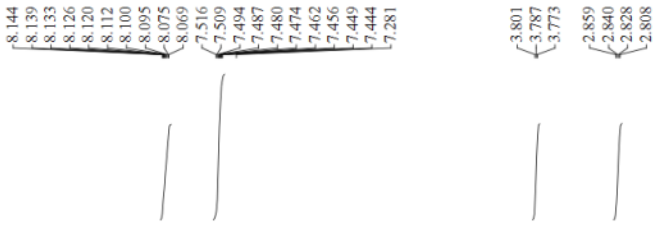
3y

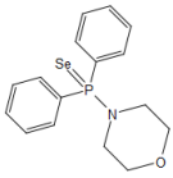

133.588
132.659
132.339
132.229
131.687
131.657
128.416
128.289
47.924
26.184
26.104
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


66.418
140 110 80 60 40 20 0 -10 -30 -50 -70 -90 -110 -140 -170 -200 -230
f1 (ppm)

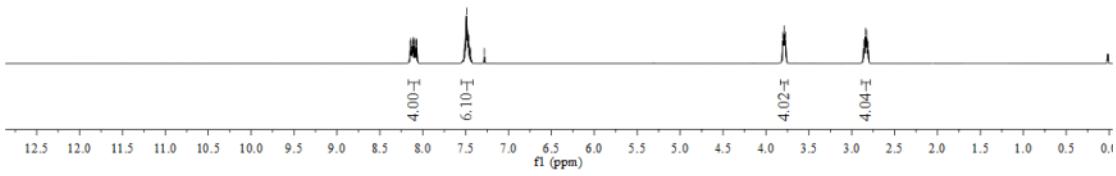

8.149
8.144
8.127
8.118
8.106
8.100
8.082
8.074
7.483
7.475
7.468
7.462
7.440
7.422
7.281
2.786
2.773
2.754
1.635
Se
P
N
3z
4.00
6.37
4.08
6.16
f1 (ppm)
132.649
132.325
132.239
132.131
131.711
131.682
128.471
128.438
128.346
128.310
46.582
25.728
25.622
24.201
f1 (ppm)

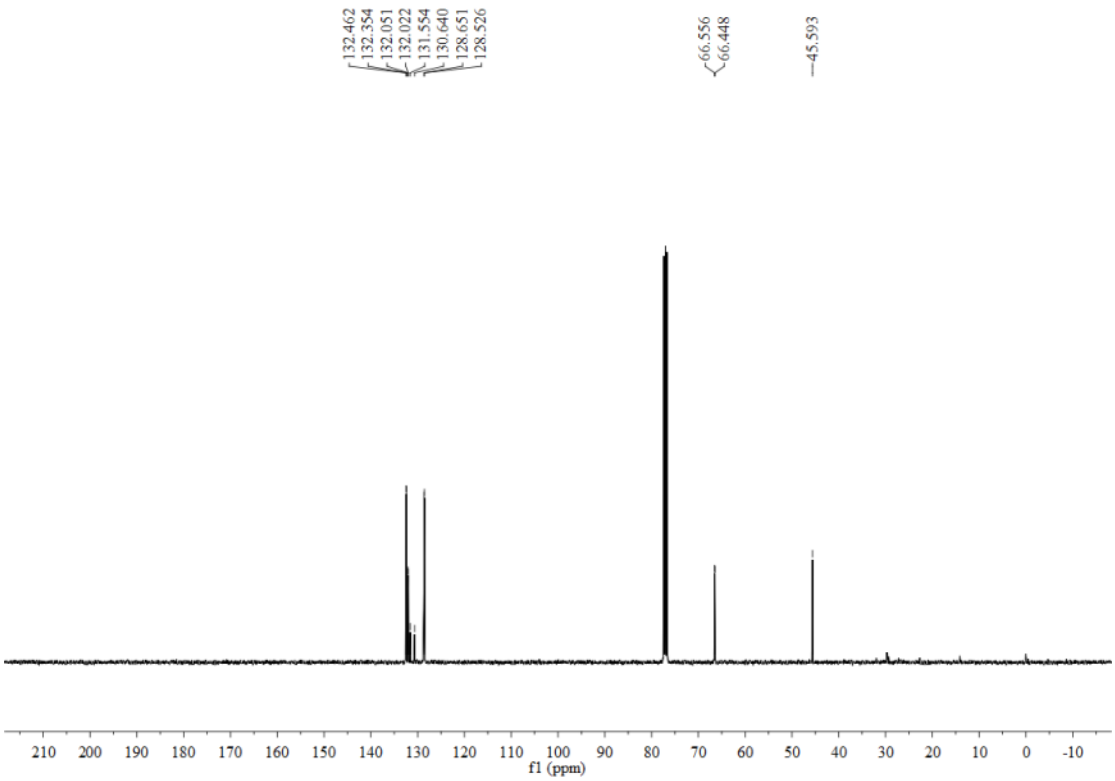

68.215
140 110 80 60 40 20 0 -10 -30 -50 -70 -90 -110 -140 -170 -200 -230
f1 (ppm)

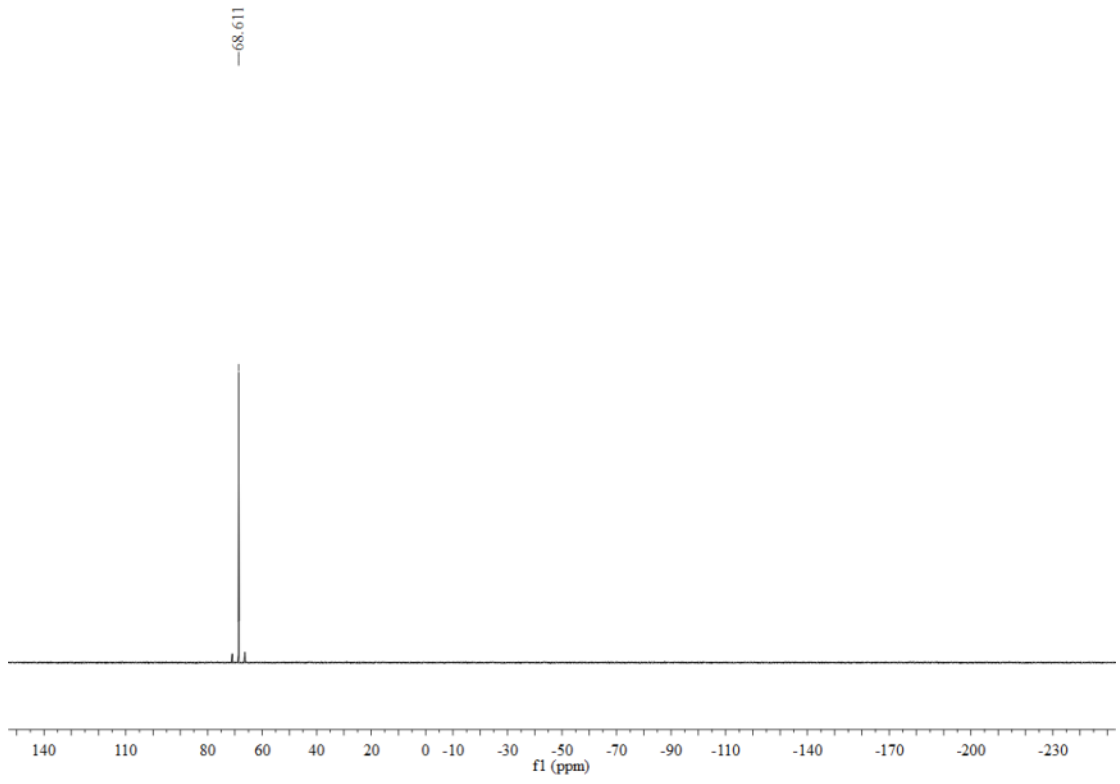

8.144
8.139
8.133
8.126
8.120
8.112
8.100
8.095
8.075
8.069
7.516
7.509
7.494
7.487
7.480
7.474
7.462
7.456
7.449
7.444
7.281
3.801
3.787
3.773
2.859
2.840
2.828
2.808

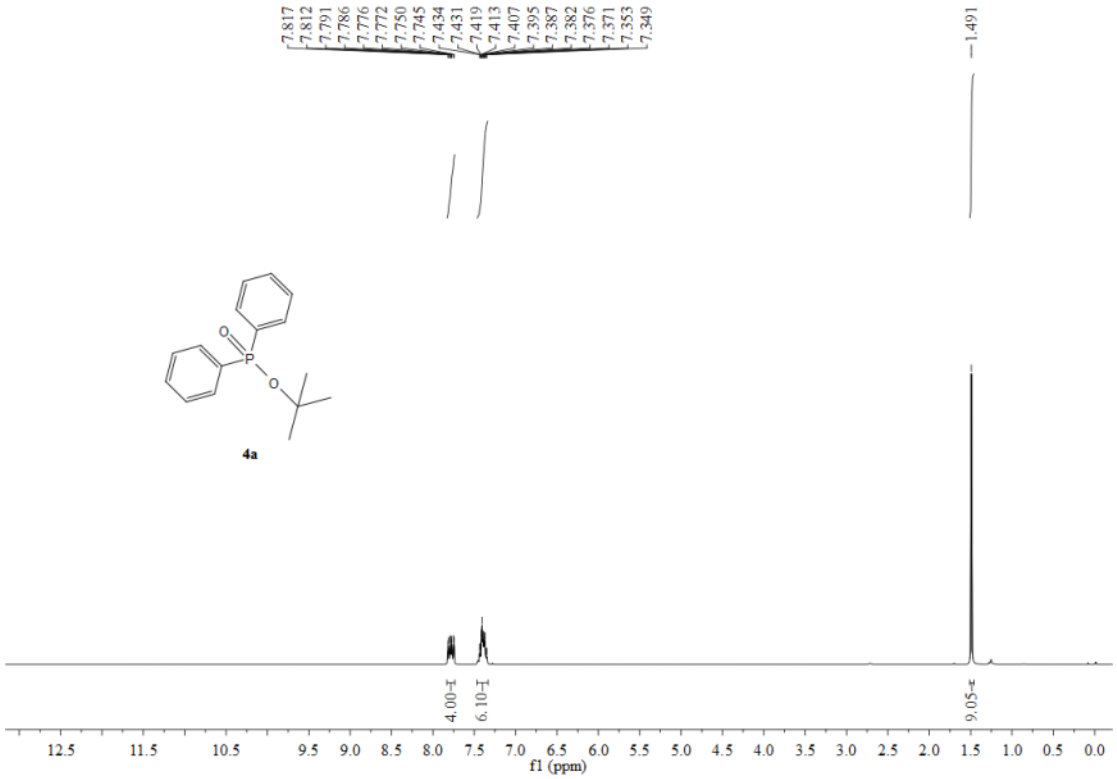

Se
P
N
O

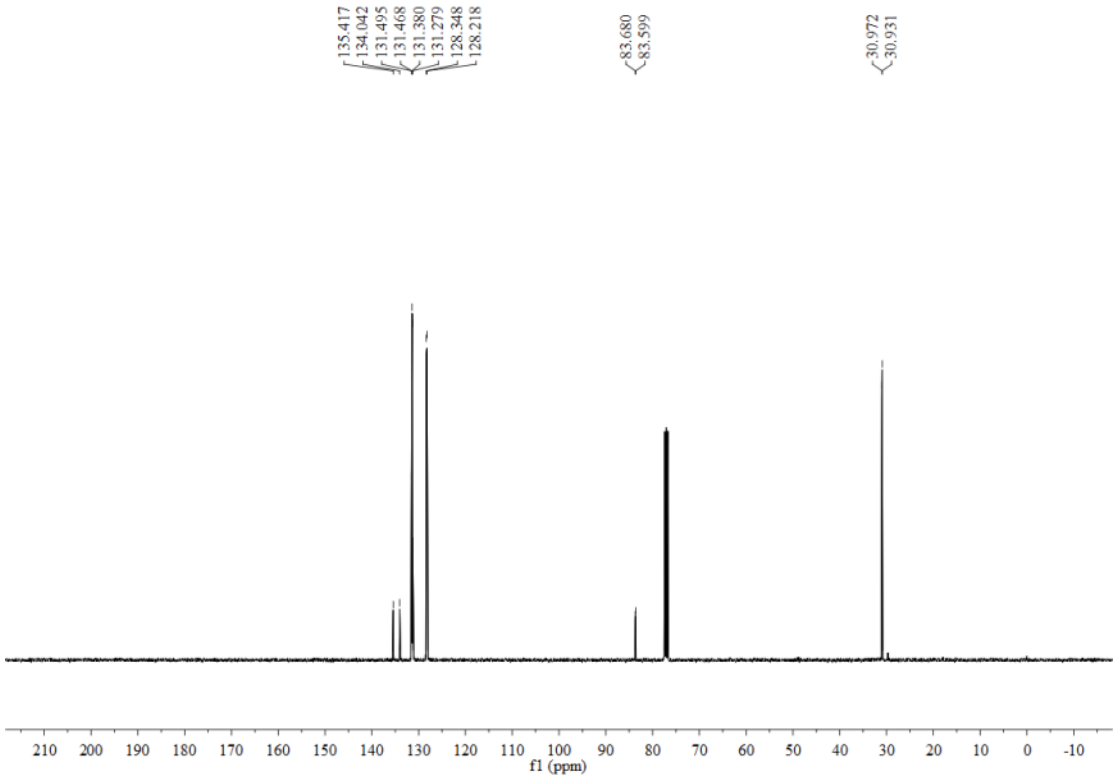
3aa

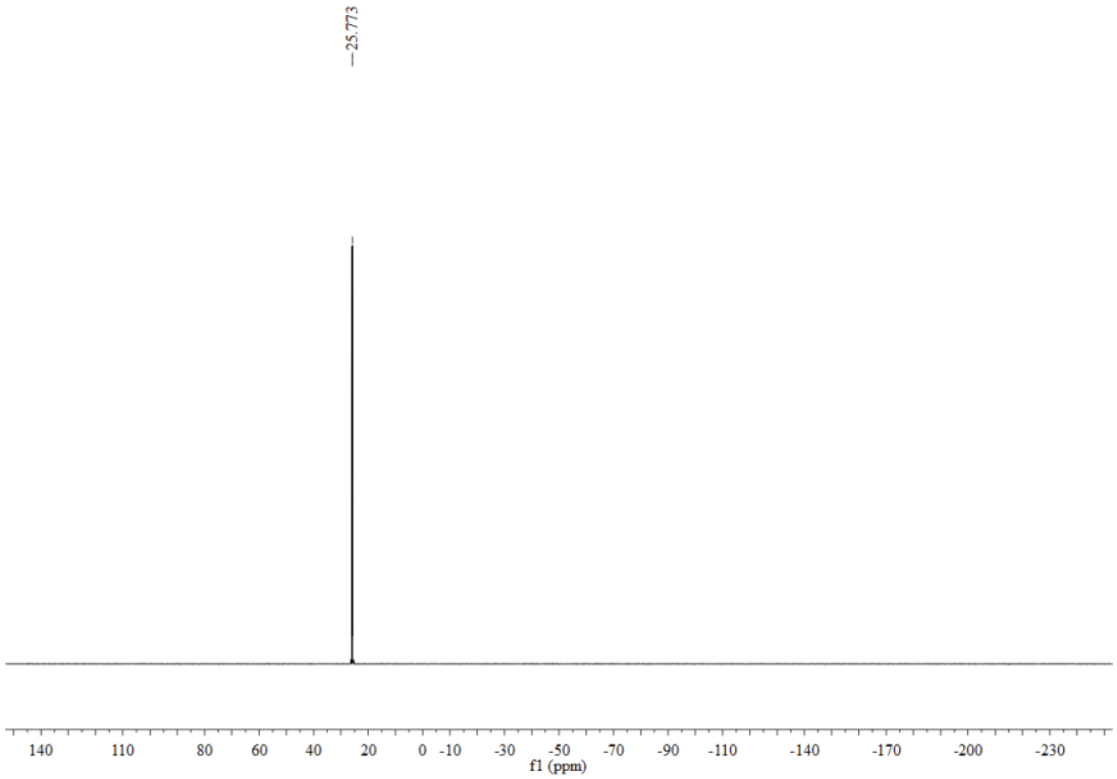

4.00
6.10
4.02
4.04
12.5 12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
f1 (ppm)

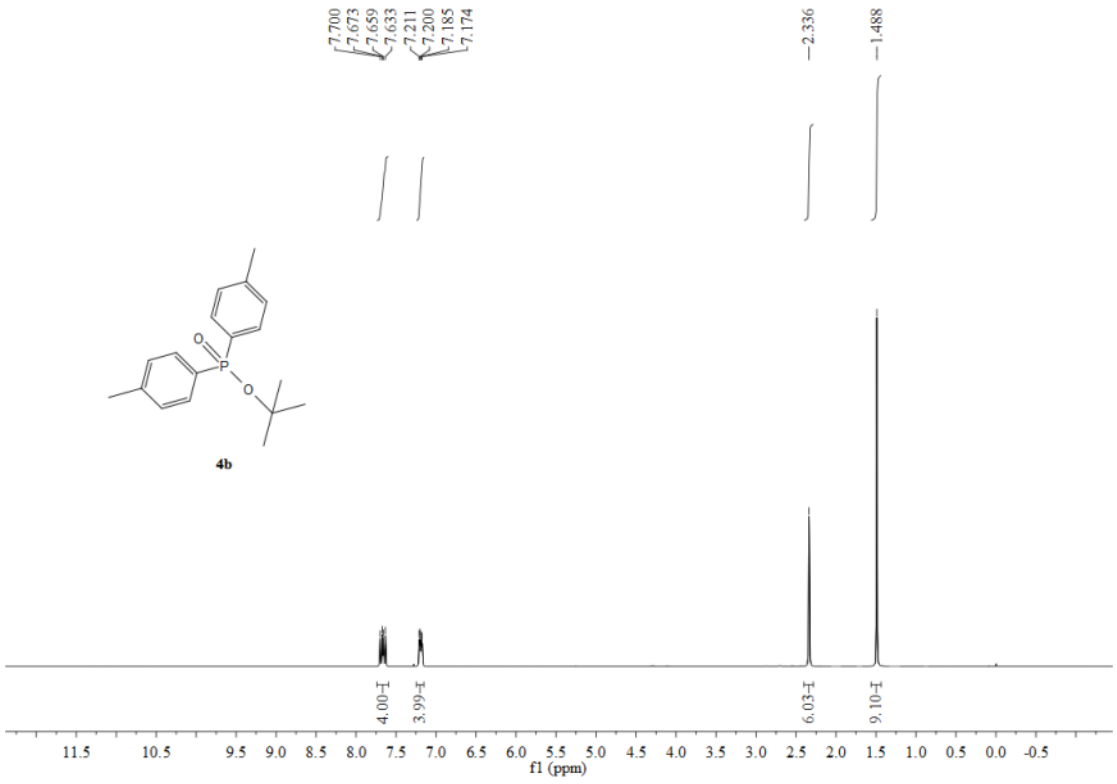

132.462
132.354
132.051
132.022
131.554
130.640
128.651
128.526
66.556
66.448
45.593
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


68.611
140 110 80 60 40 20 0 -10 -30 -50 -70 -90 -110 -140 -170 -200 -230
f1 (ppm)


7.817
7.812
7.791
7.786
7.776
7.772
7.750
7.745
7.434
7.431
7.419
7.413
7.407
7.395
7.387
7.382
7.376
7.371
7.353
7.349
1.491
O
P
O
4a
4.00
6.10
9.05
12.5 11.5 10.5 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)

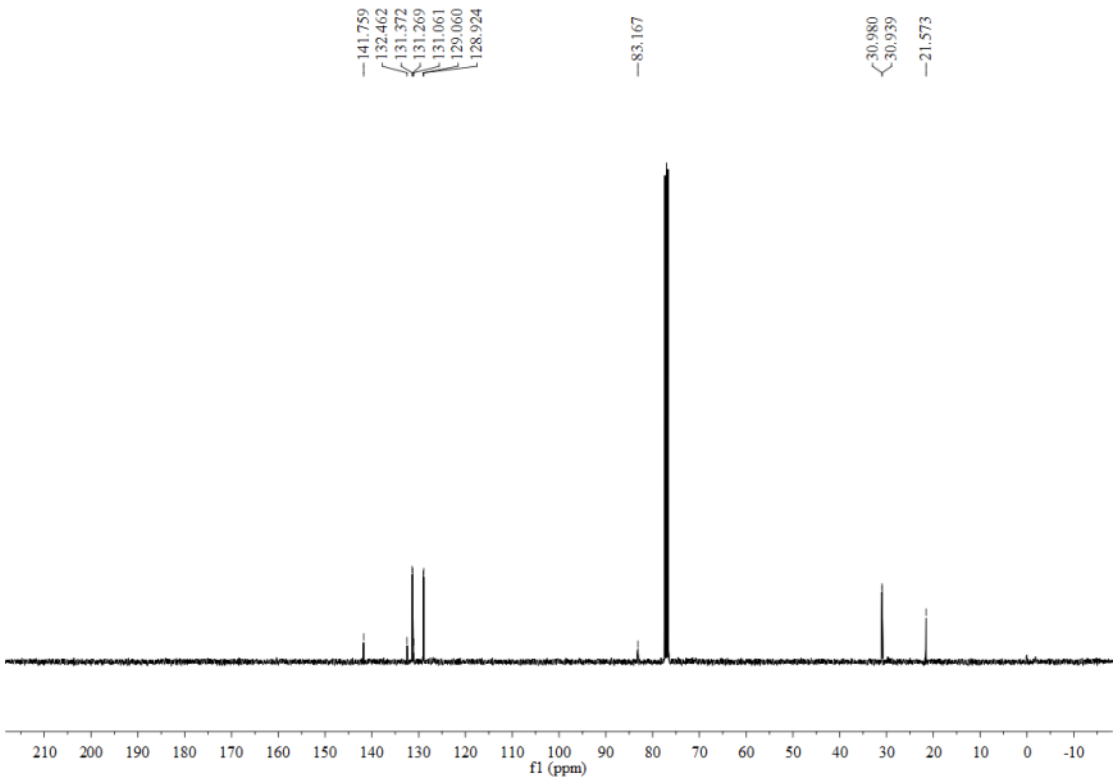

135.417
134.042
131.495
131.468
131.380
131.279
128.348
128.218
83.680
83.599
30.972
30.931
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

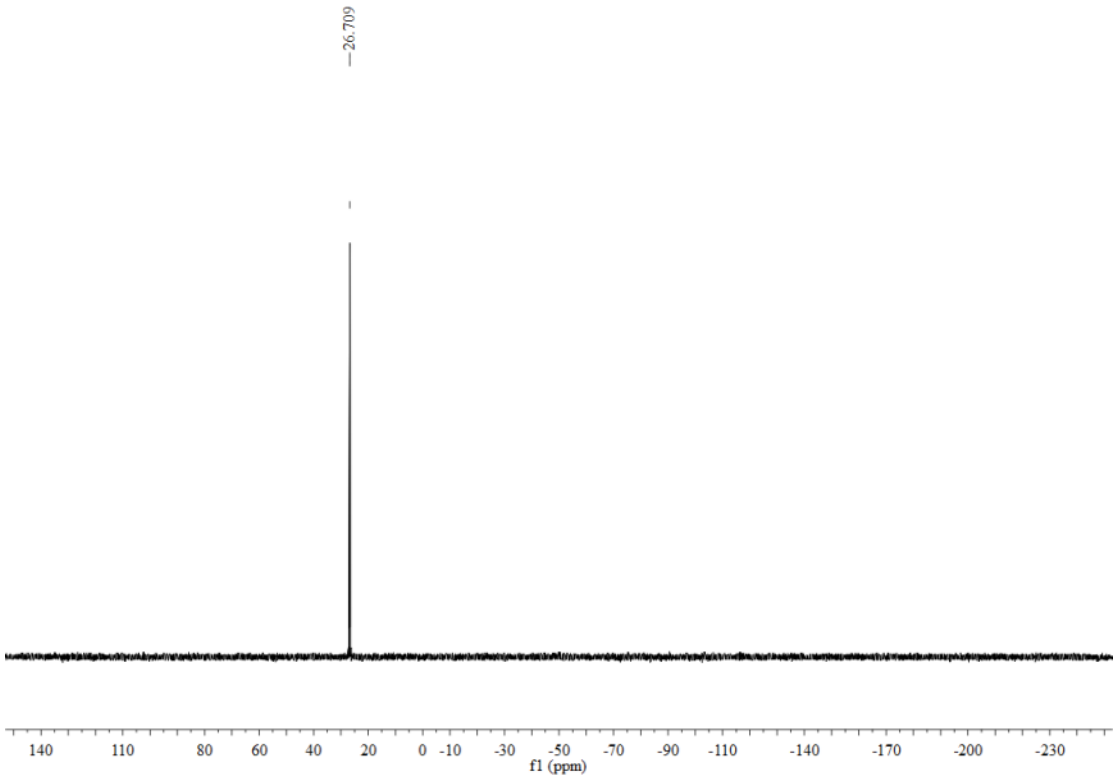

25.773
140 110 80 60 40 20 0 -10 -30 -50 -70 -90 -110 -140 -170 -200 -230
f1 (ppm)

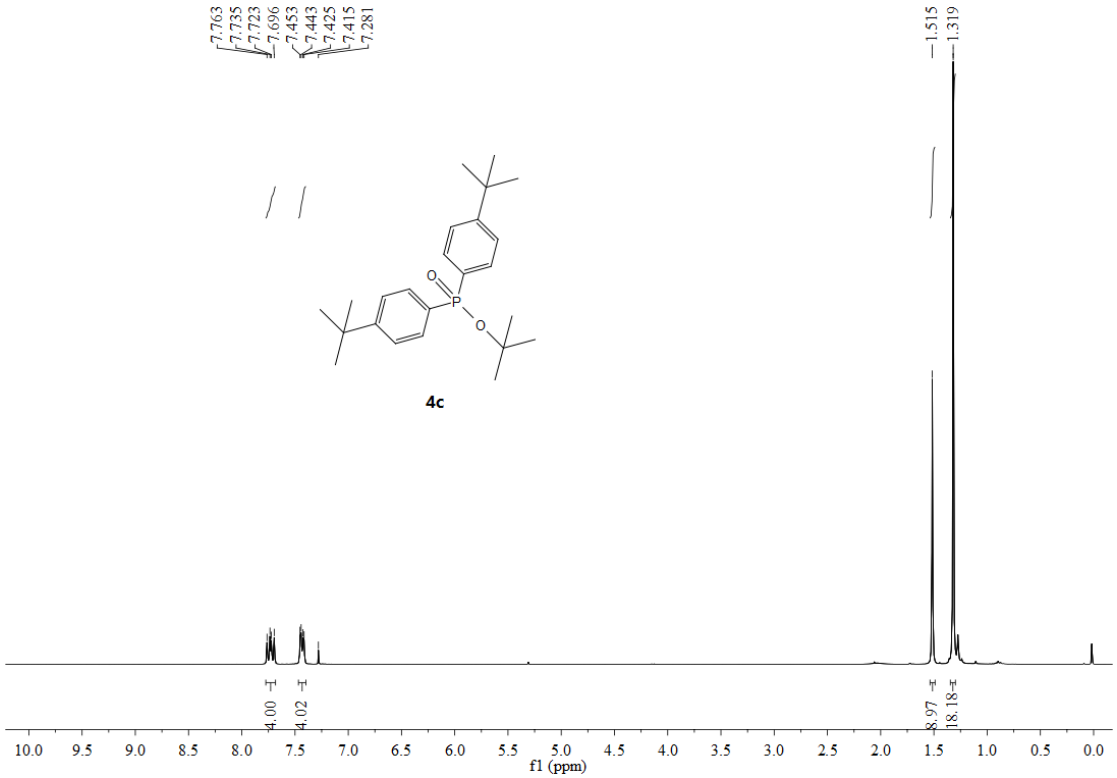

7.700
7.673
7.659
7.633
7.211
7.200
7.185
7.174
2.336
1.488
4.00
3.99
6.03
9.10
11.5 10.5 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

O
P
O

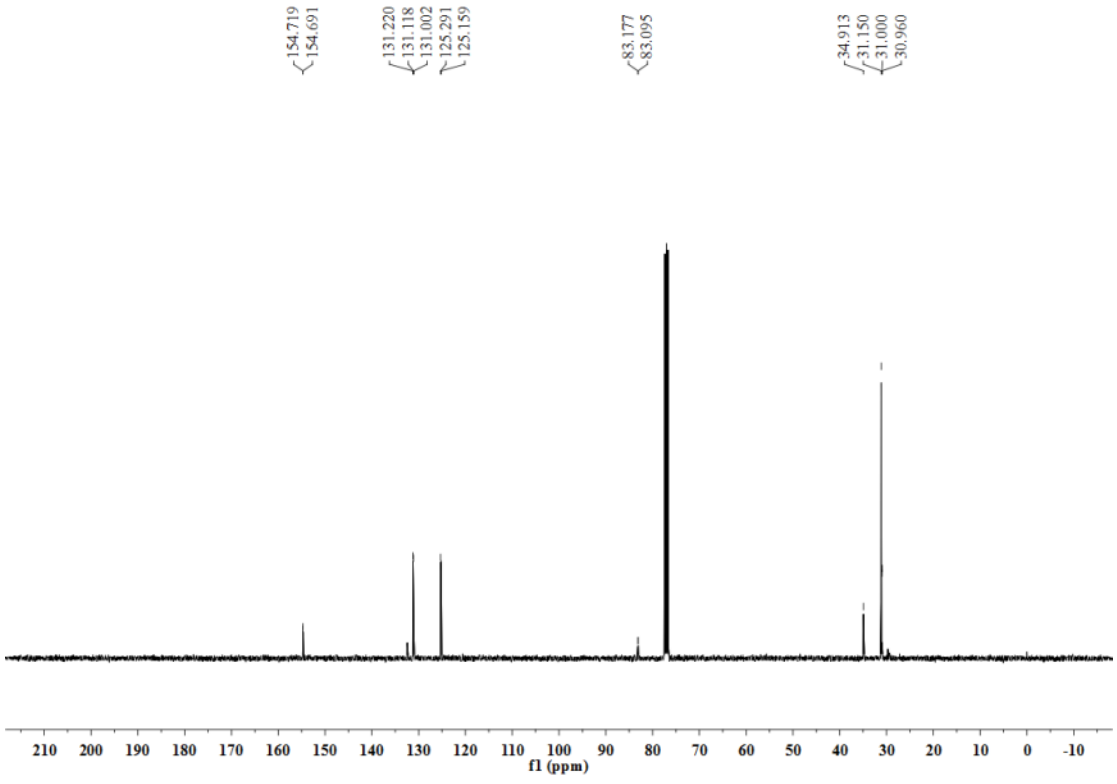
4b

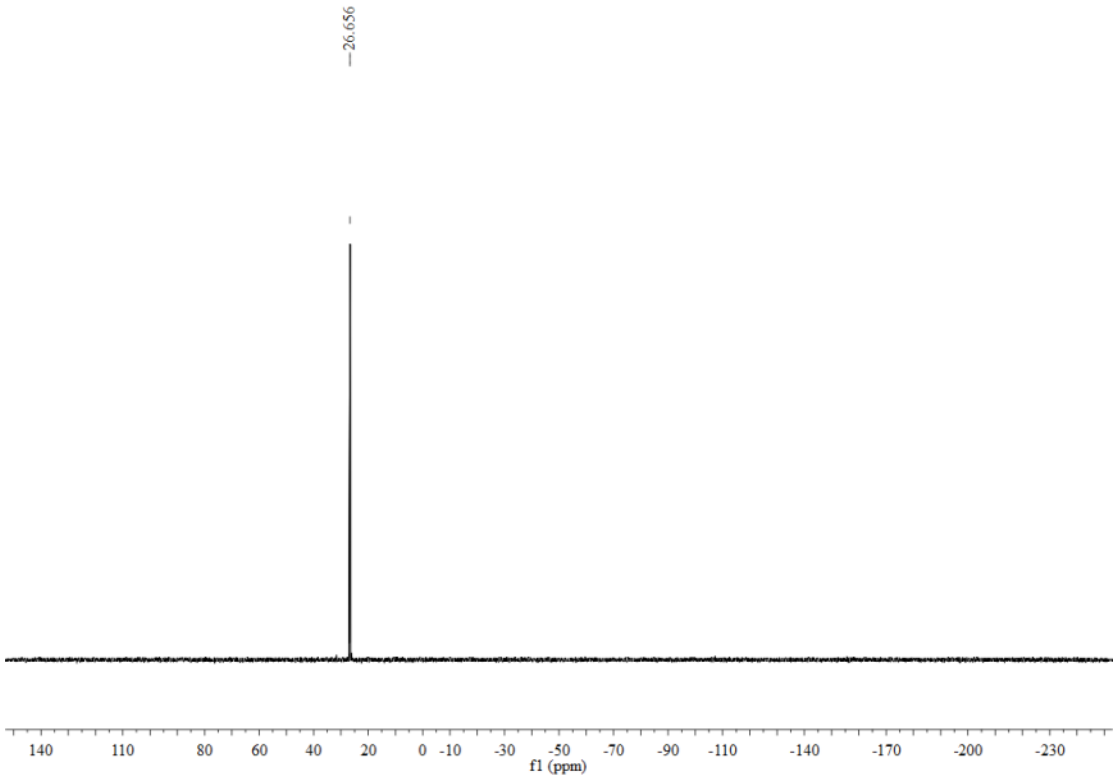

141.759
132.462
131.372
131.269
131.061
129.060
128.924
83.167
30.980
30.939
21.573
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

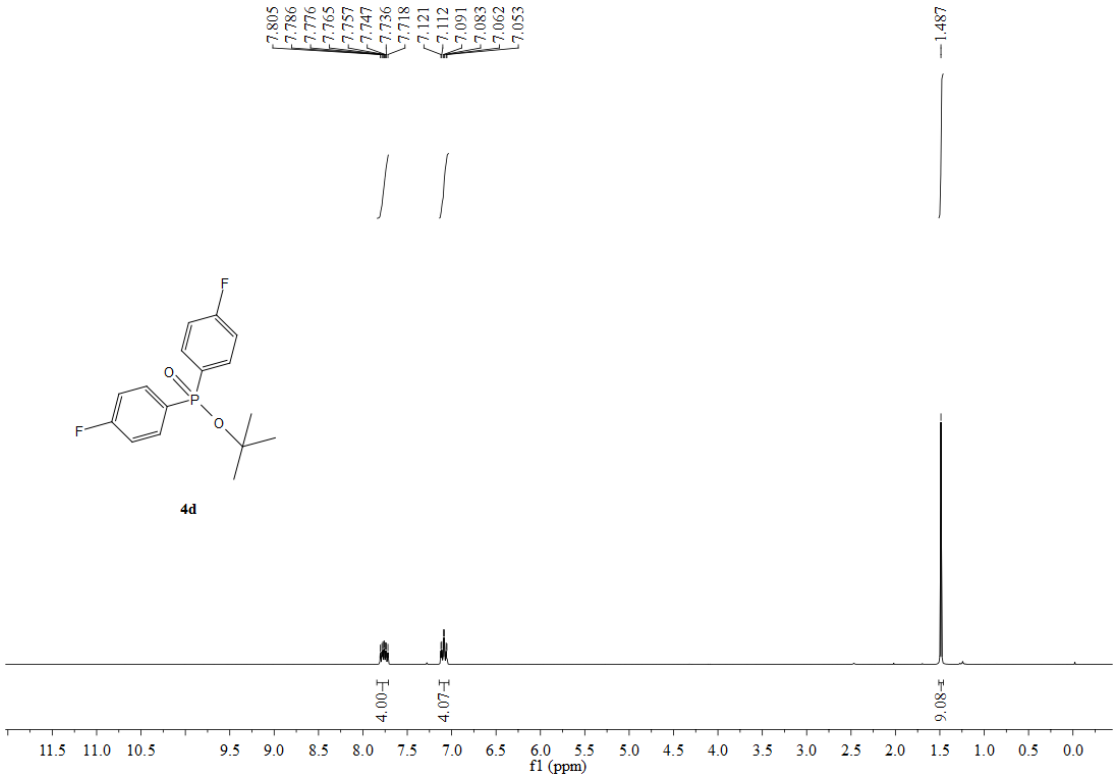

26.709
140 110 80 60 40 20 0 -10 -30 -50 -70 -90 -110 -140 -170 -200 -230
f1 (ppm)


7.763
7.735
7.723
7.696
7.453
7.443
7.425
7.415
7.281
1.515
1.319
O
P
O
4.00
4.02
8.97
18.18
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)

4c

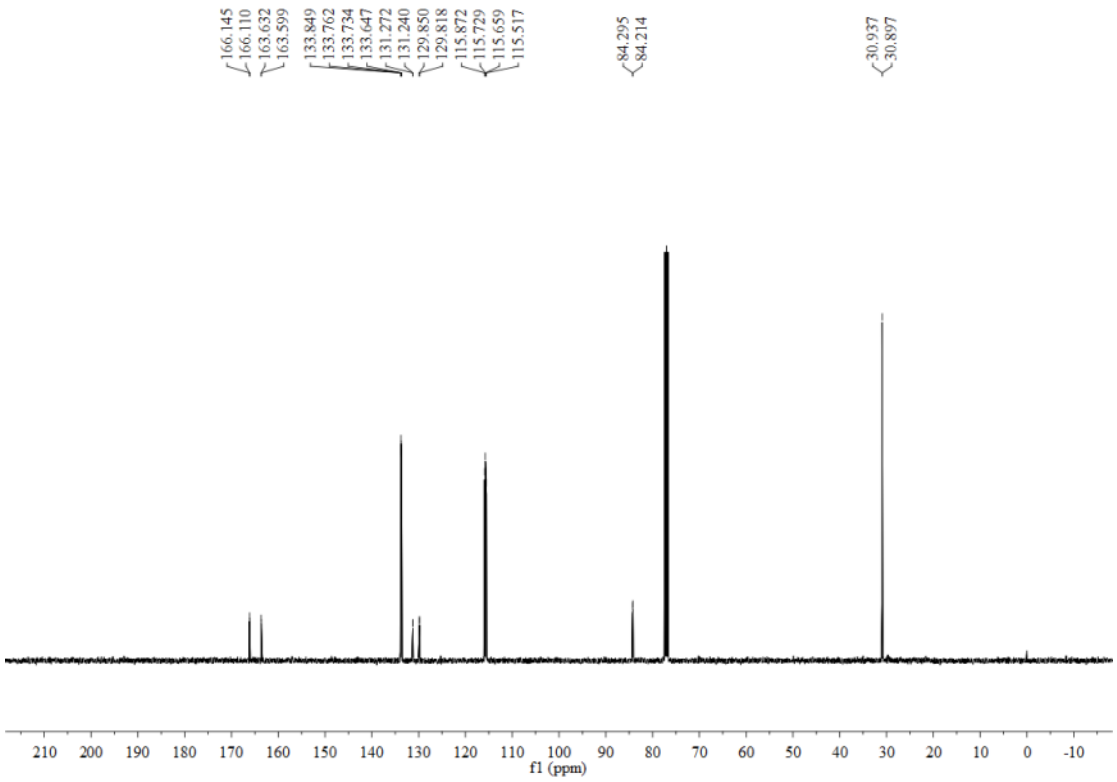

154.719
154.691
131.220
131.118
131.002
125.291
125.159
83.177
83.095
34.913
31.150
31.000
30.960
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

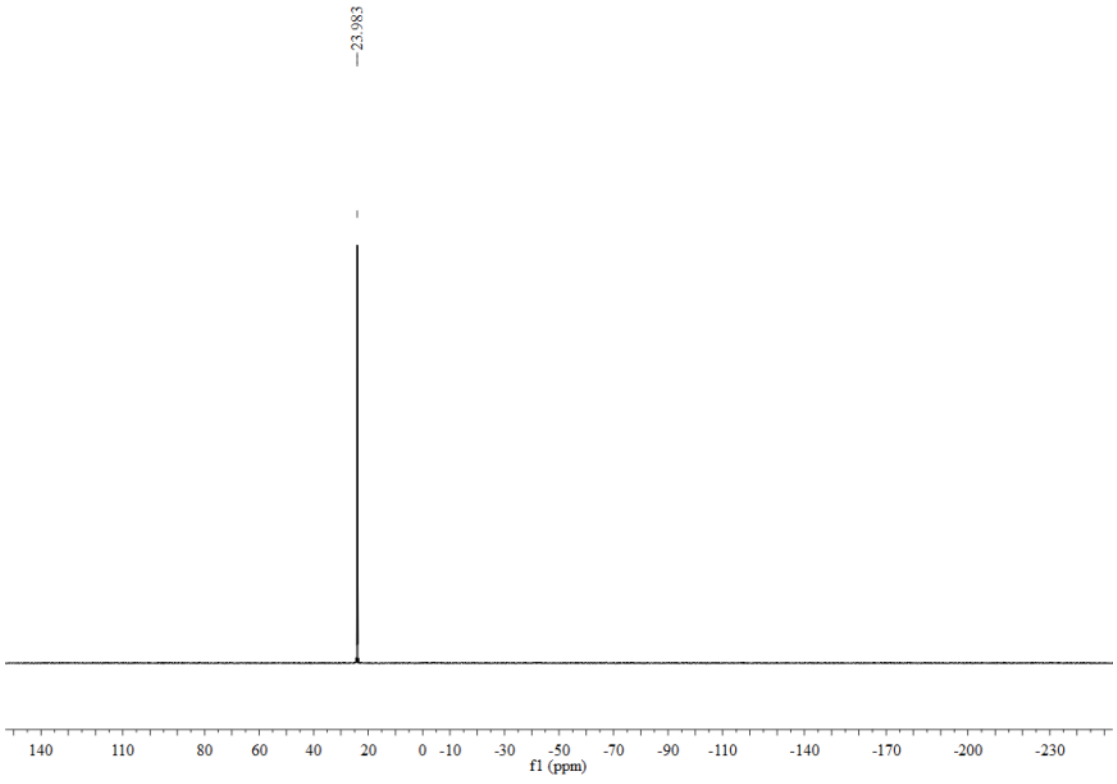

26.656
140
110
80
60
40
20
0
-10
-30
-50
-70
-90
-110
-140
-170
-200
-230
f1 (ppm)

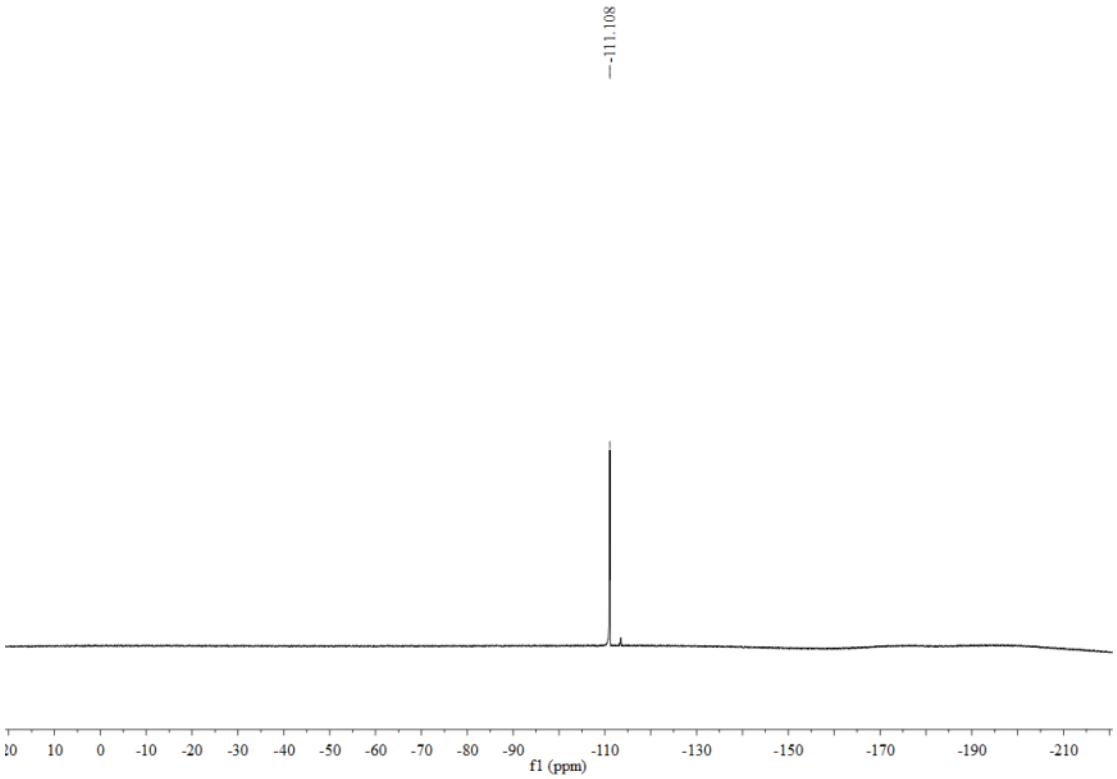

7.805
7.786
7.776
7.765
7.757
7.747
7.736
7.718
7.121
7.112
7.091
7.083
7.062
7.053
1.487
4.00
4.07
9.08
11.5
11.0
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

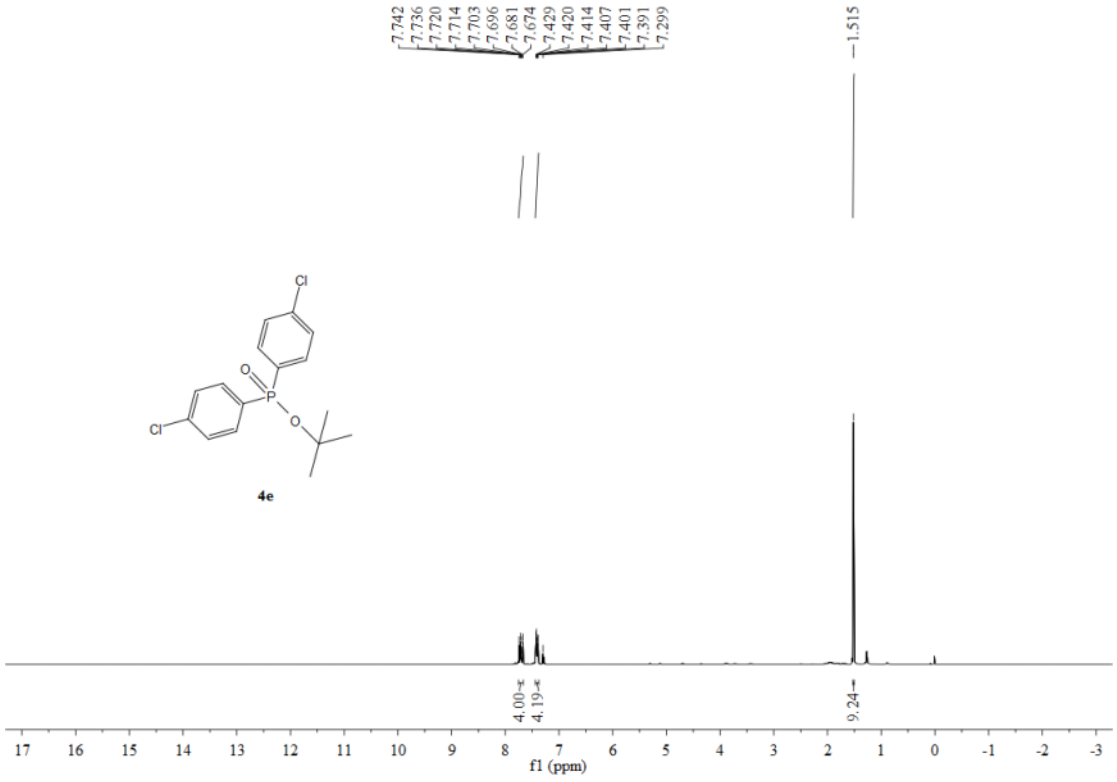
F
O
P
O
F

4d


166.145
166.110
163.632
163.599
133.849
133.762
133.734
133.647
131.272
131.240
129.850
129.818
115.872
115.729
115.659
115.517
84.295
84.214
30.937
30.897
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

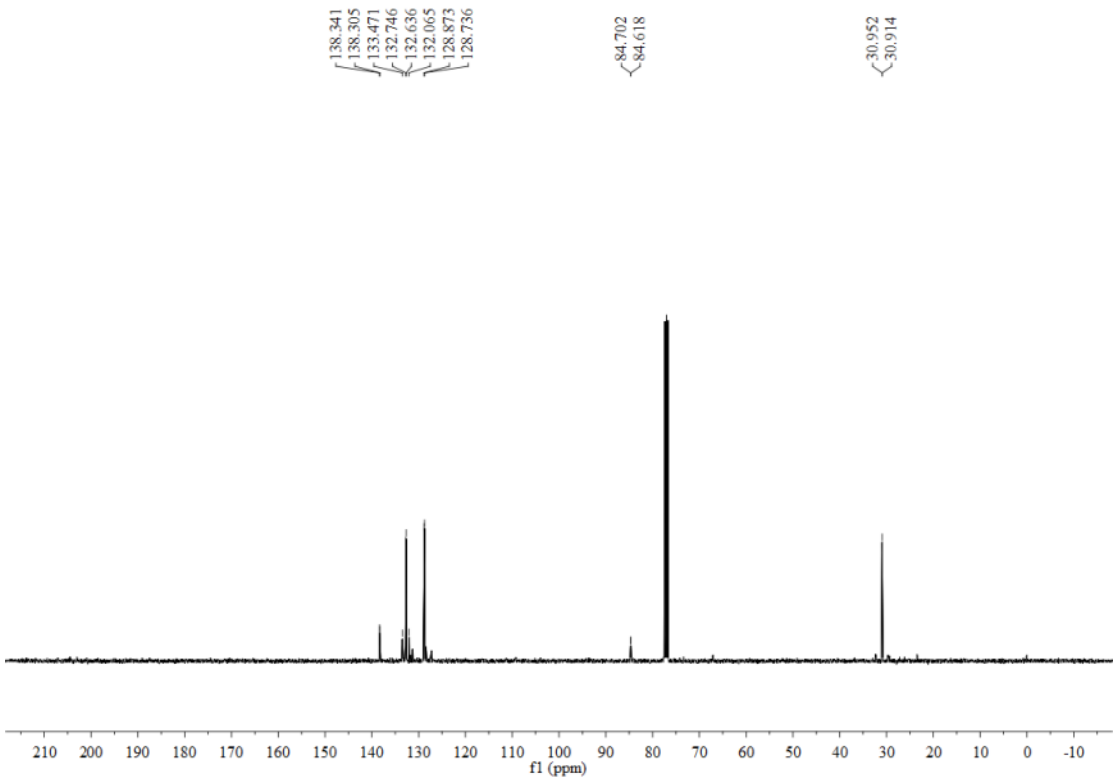

23.983
140 110 80 60 40 20 0 -10 -30 -50 -70 -90 -110 -140 -170 -200 -230
f1 (ppm)

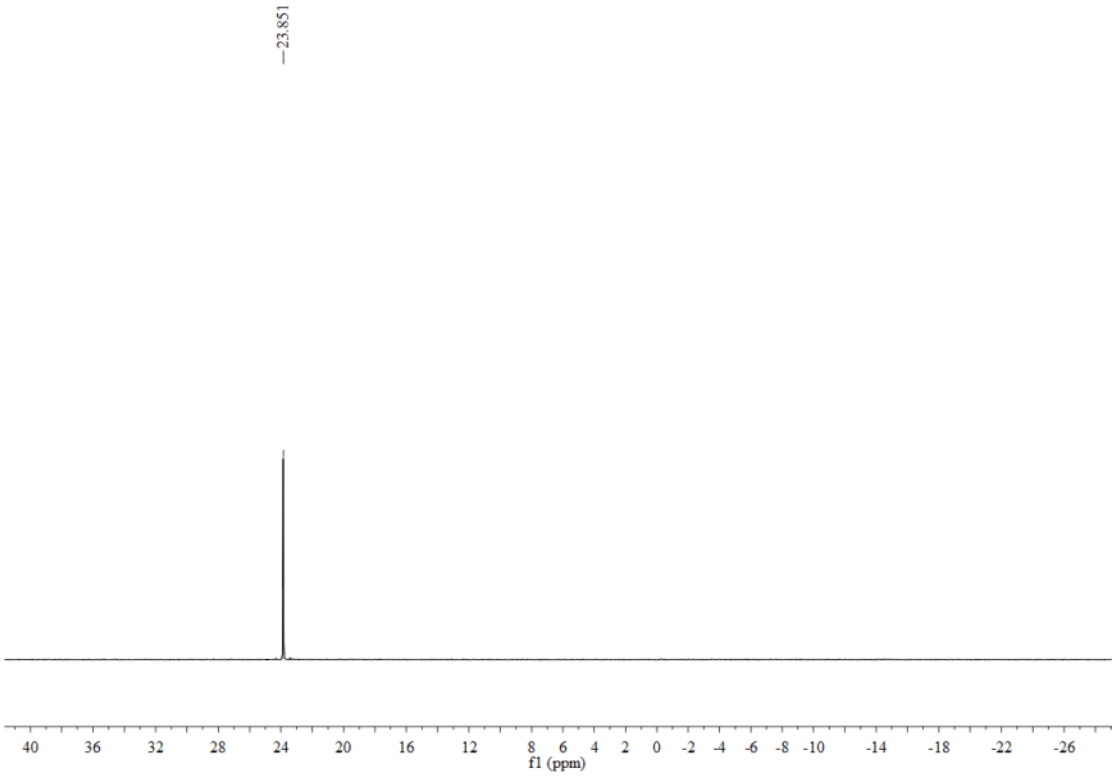

-111.108
f1 (ppm)

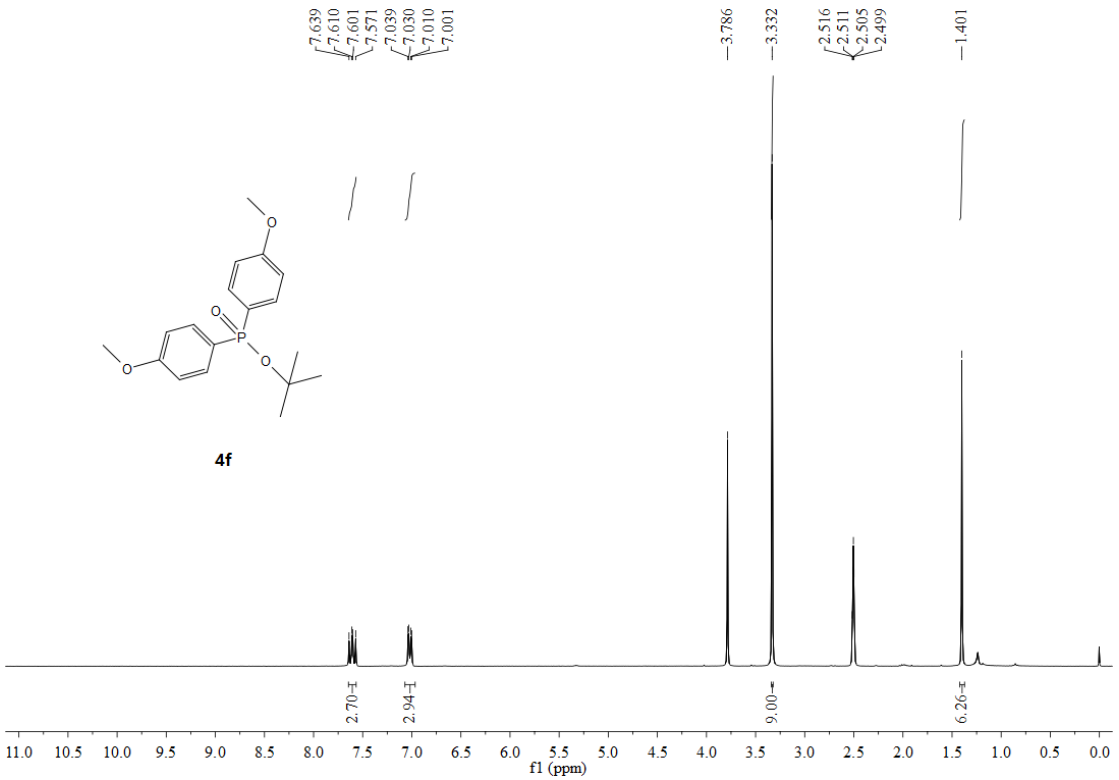

7.742
7.736
7.720
7.714
7.703
7.696
7.681
7.674
7.429
7.420
7.414
7.407
7.401
7.391
7.299
1.515
4.00
4.19
9.24
f1 (ppm)

Cl
O
P
O
Cl

4e


138.341
138.305
133.471
132.746
132.636
132.065
128.873
128.736
84.702
84.618
30.952
30.914
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


23.851
40 36 32 28 24 20 16 12 8 6 4 2 0 -2 -4 -6 -8 -10 -14 -18 -22 -26
f1 (ppm)


7.639
7.610
7.601
7.571
7.039
7.030
7.010
7.001
3.786
3.332
2.516
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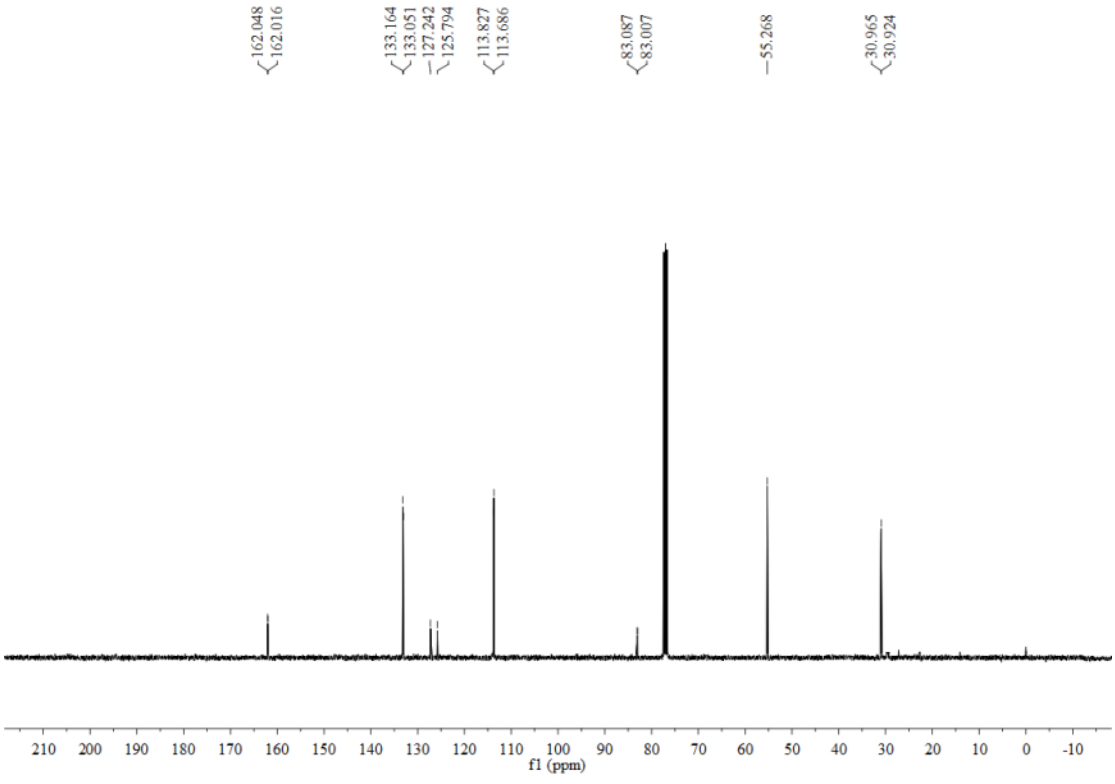
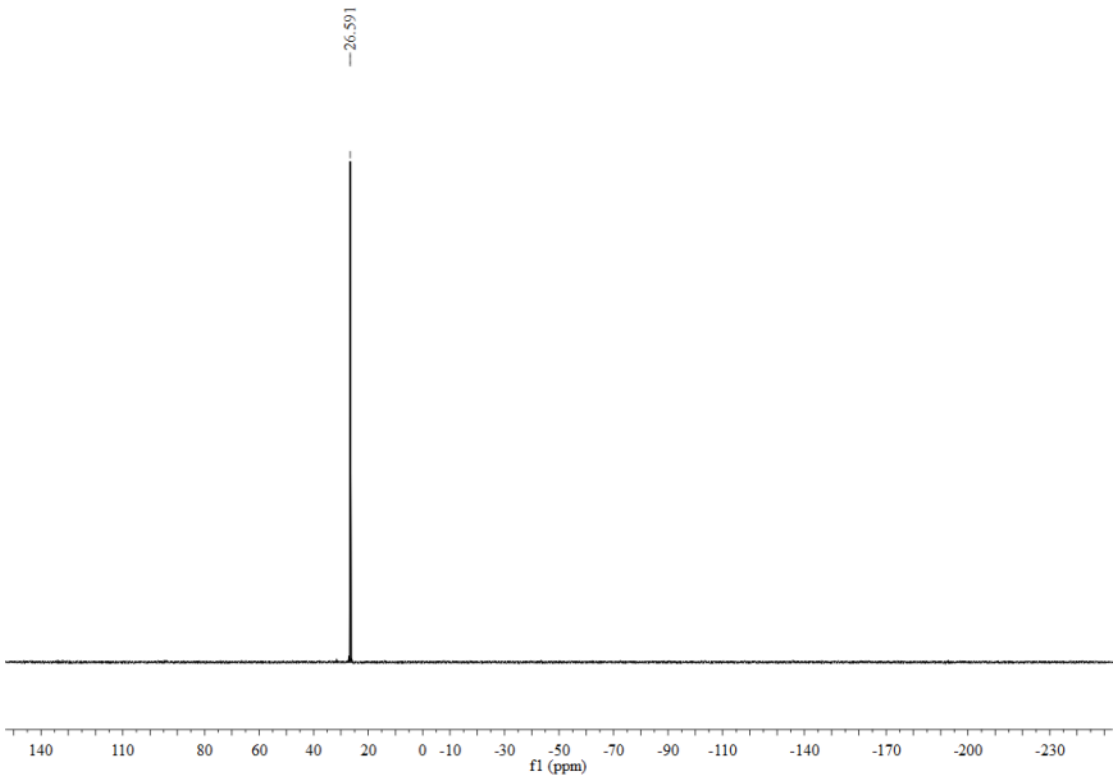
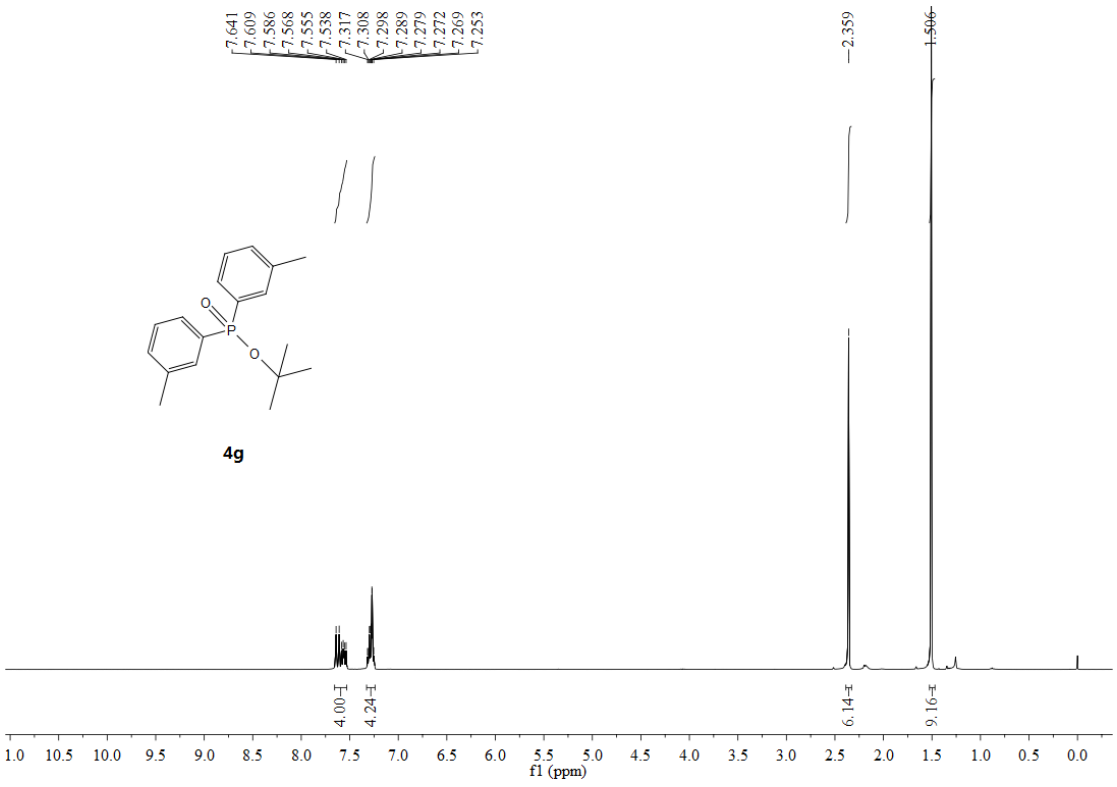
2.505
2.499
1.401
2.70
2.94
9.00
6.26
f1 (ppm)

4f

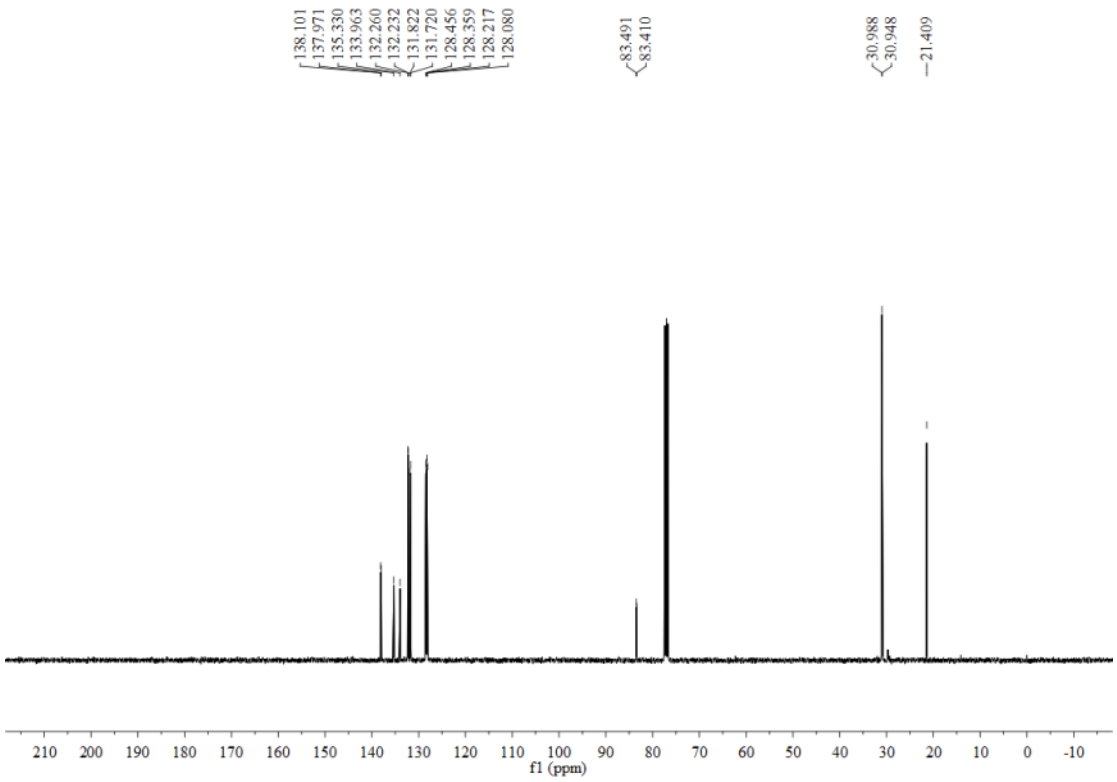

162.048
162.016
133.164
133.051
127.242
125.794
113.827
113.686
83.087
83.007
55.268
30.965
30.924
f1 (ppm)

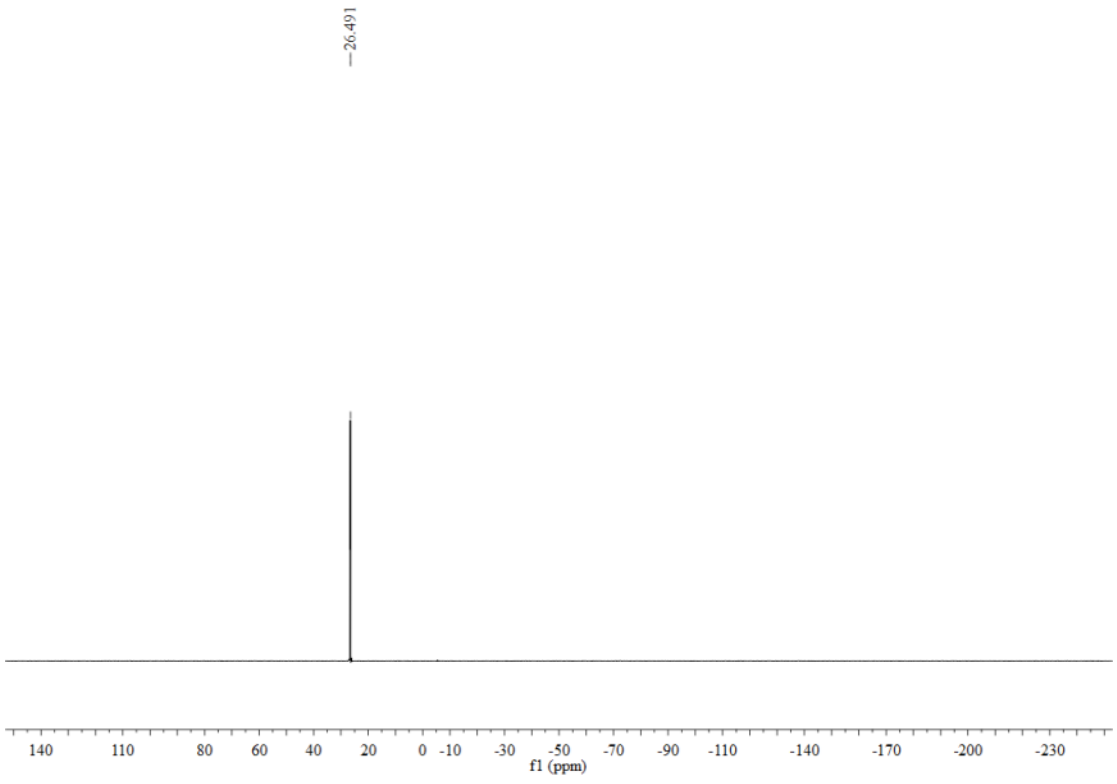

26.591
140 110 80 60 40 20 0 -10 -30 -50 -70 -90 -110 -140 -170 -200 -230
f1 (ppm)

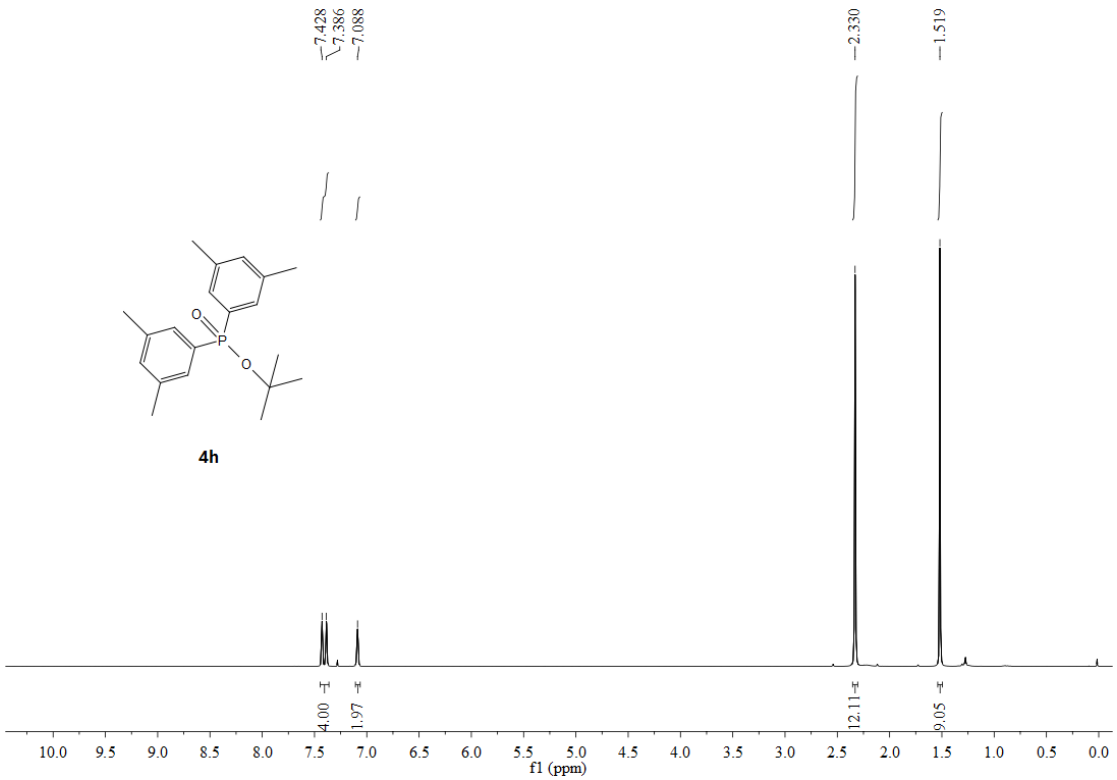

7.641
7.609
7.586
7.568
7.555
7.538
7.317
7.308
7.298
7.289
7.279
7.272
7.269
7.253
2.359
1.506
4.00
4.24
6.14
9.16
1.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

O
P
O

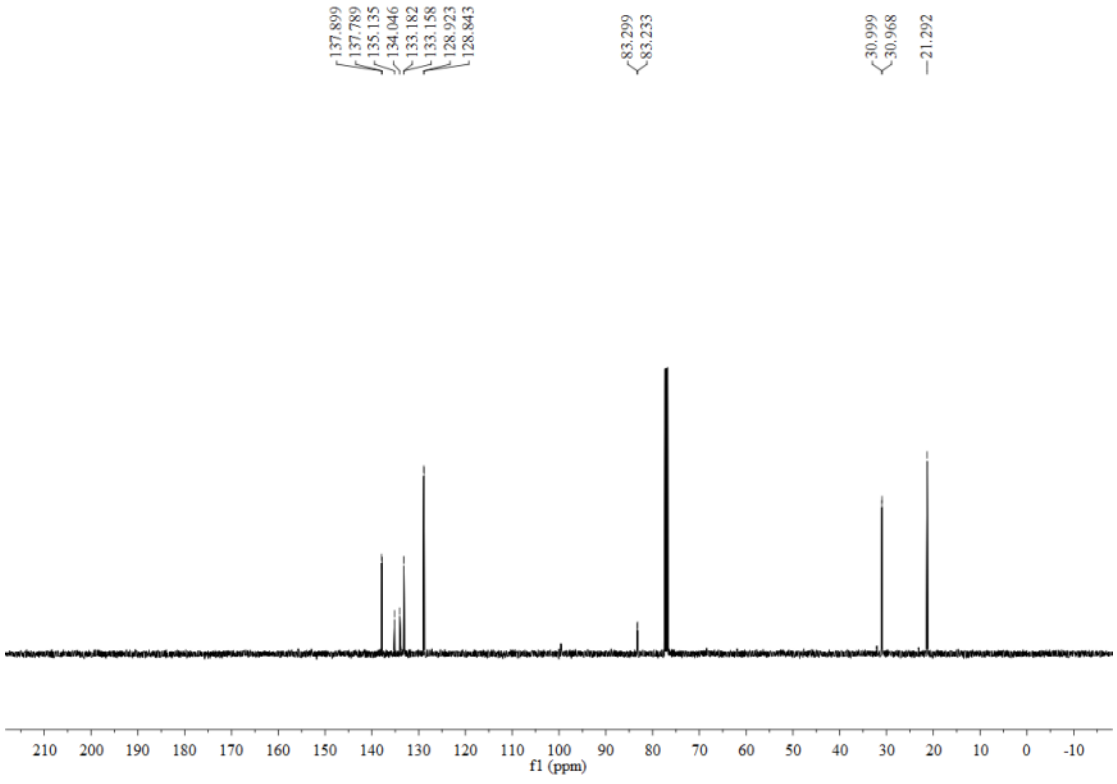
4g

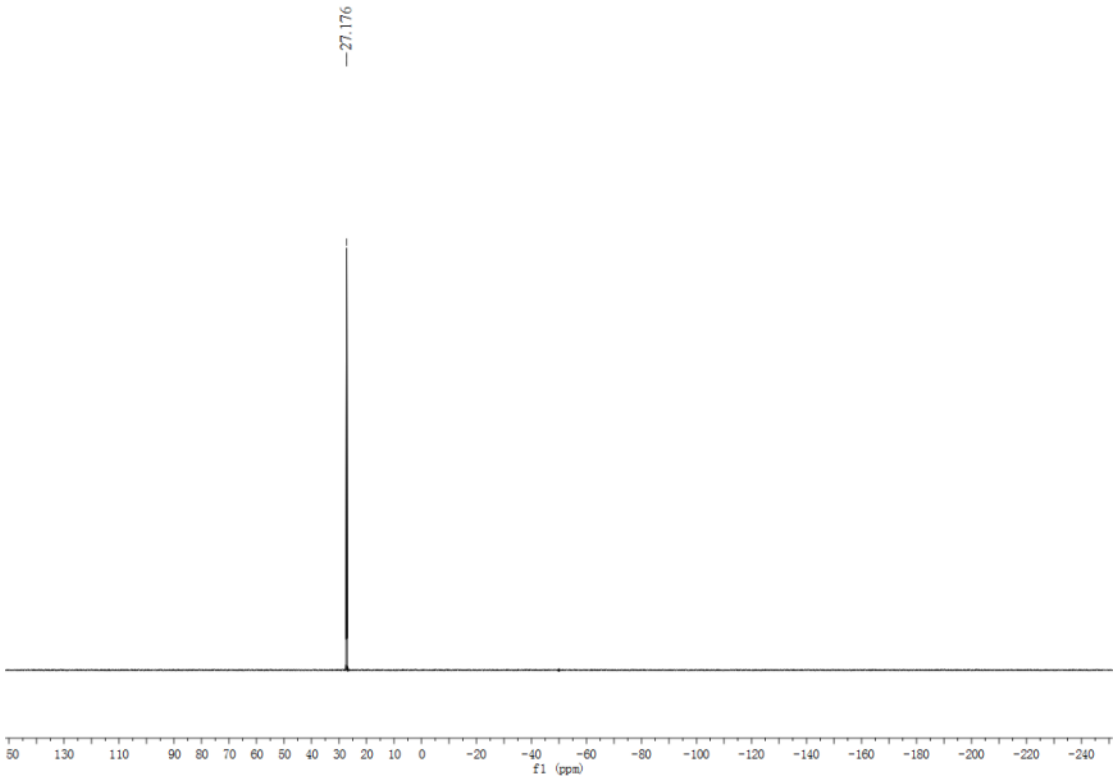

138.101
137.971
135.330
133.963
132.260
132.232
131.822
131.720
128.456
128.359
128.217
128.080
83.491
83.410
30.988
30.948
21.409
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

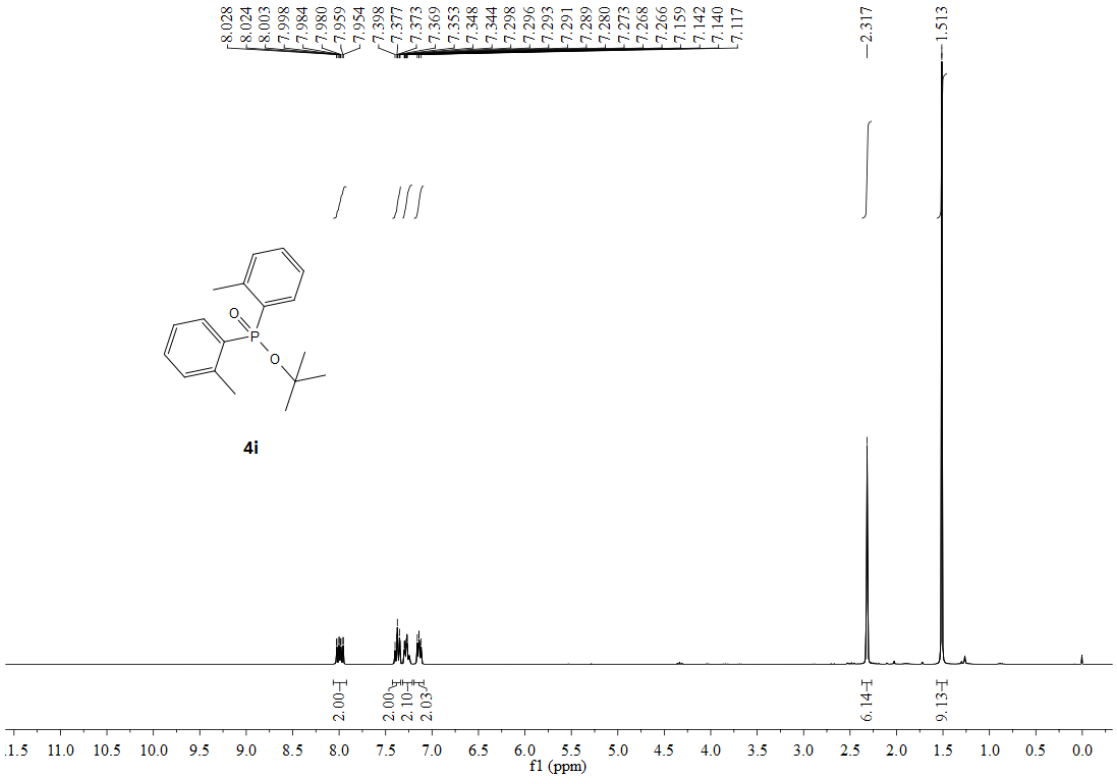

26.491
140 110 80 60 40 20 0 -10 -30 -50 -70 -90 -110 -140 -170 -200 -230
f1 (ppm)


7.428
7.386
7.088
2.330
1.519
O
P
O
4.00
1.97
12.11
9.05
f1 (ppm)

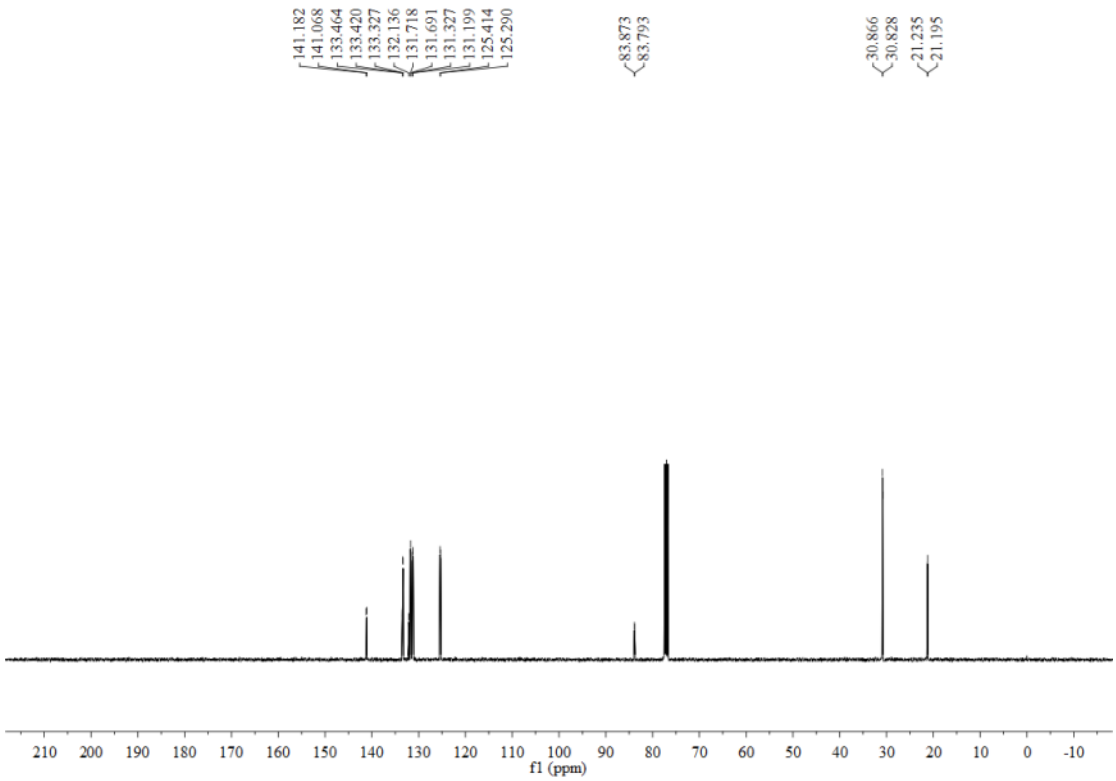
4h

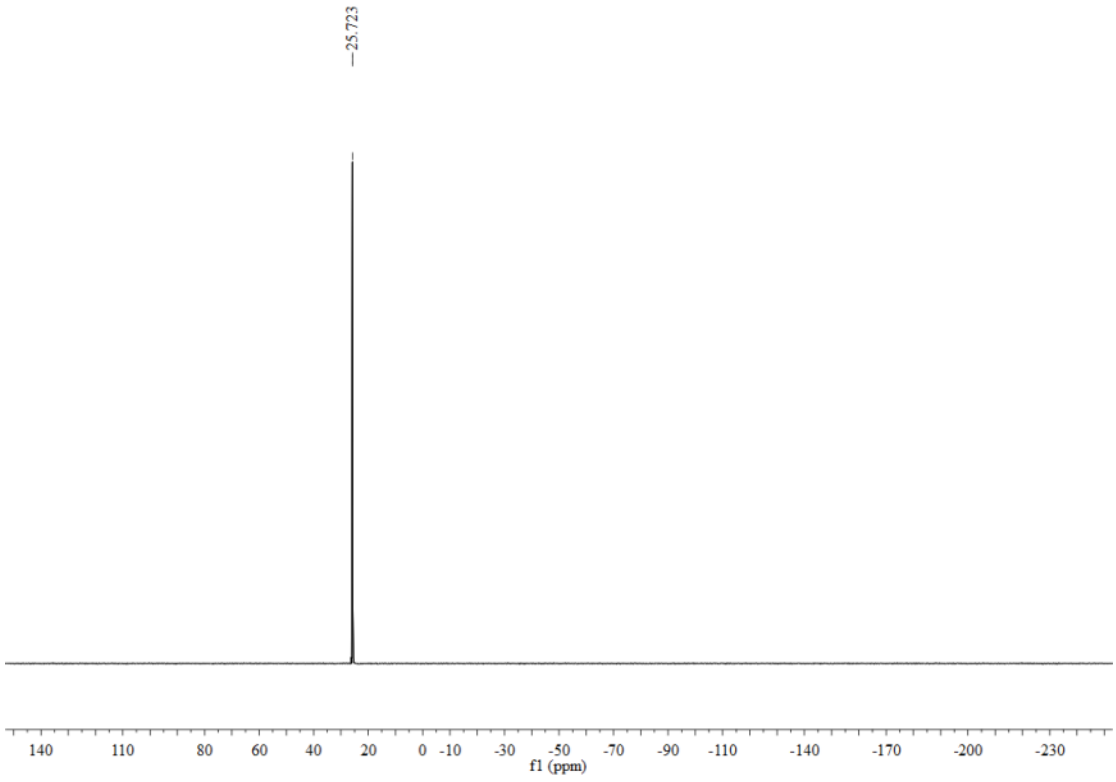

137.899
137.789
135.135
134.046
133.182
133.158
128.923
128.843
83.299
83.233
30.999
30.968
21.292
f1 (ppm)

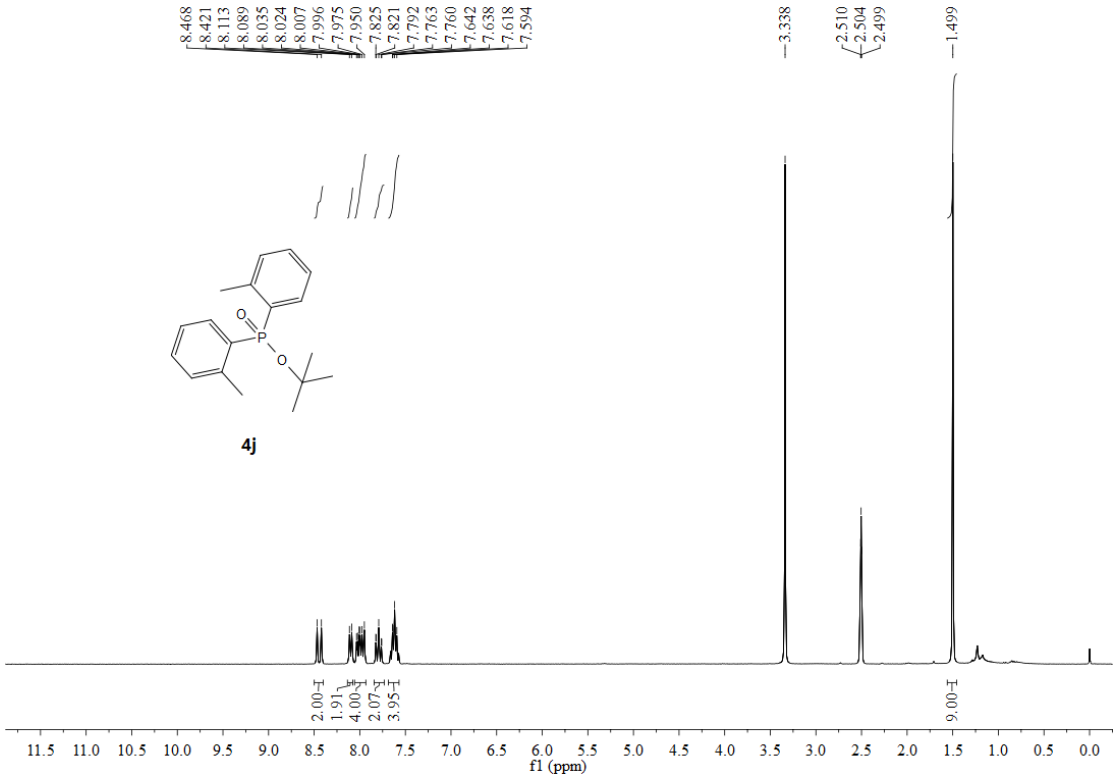

27.176
f1 (ppm)


8.028
8.024
8.003
7.998
7.984
7.980
7.959
7.954
7.398
7.377
7.373
7.369
7.353
7.348
7.344
7.298
7.296
7.293
7.291
7.289
7.280
7.273
7.268
7.266
7.159
7.142
7.140
7.117
2.317
1.513
O
P
O
2.00
2.00
2.10
2.03
6.14
9.13
f1 (ppm)

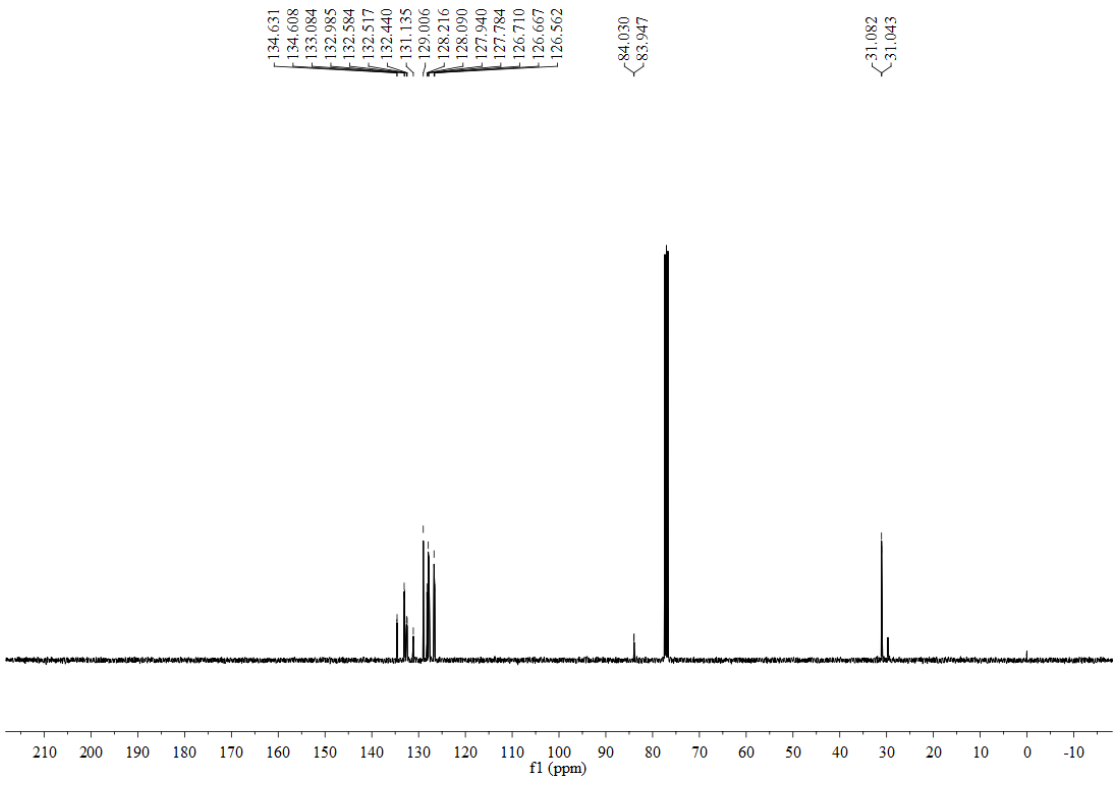
4i

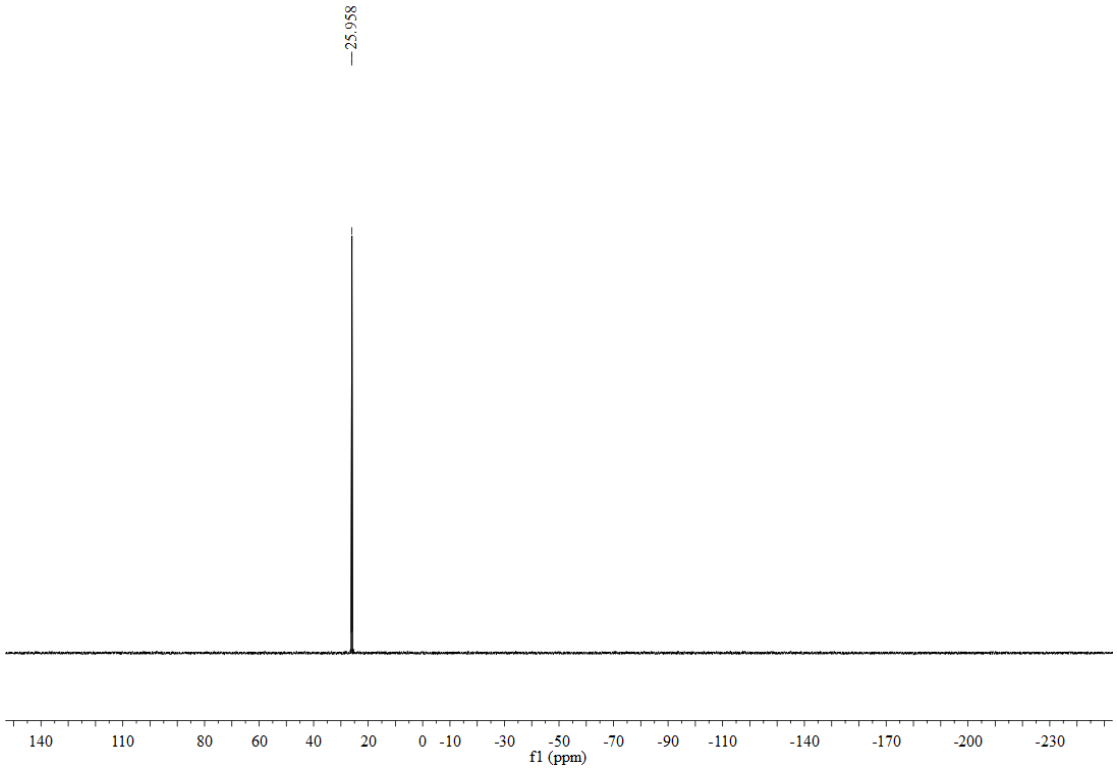

141.182
141.068
133.464
133.420
133.327
132.136
131.718
131.691
131.327
131.199
125.414
125.290
83.873
83.793
30.866
30.828
21.235
21.195
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

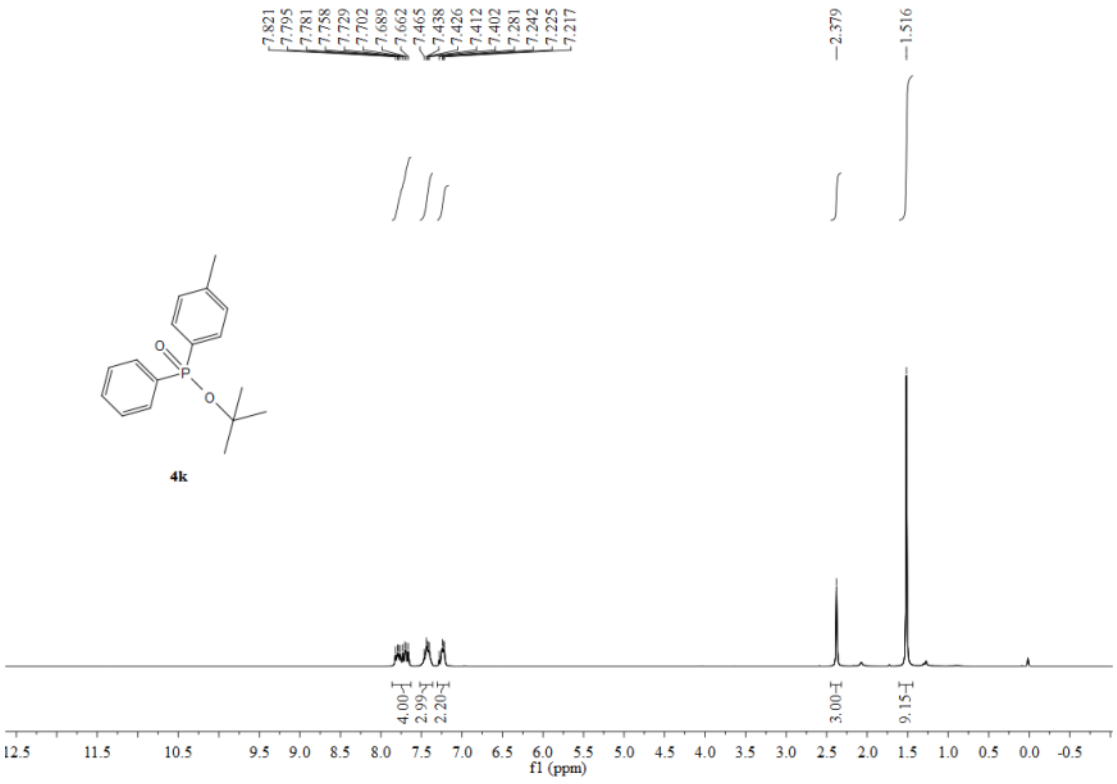

25.723
140 110 80 60 40 20 0 -10 -30 -50 -70 -90 -110 -140 -170 -200 -230
f1 (ppm)


8.468
8.421
8.113
8.089
8.035
8.024
8.007
7.996
7.975
7.950
7.825
7.821
7.792
7.763
7.760
7.642
7.638
7.618
7.594
3.338
2.510
2.504
2.499
1.499
O
P
O
2.00
1.91
4.00
2.07
3.95
9.00
11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

4j


134.631
134.608
133.084
132.985
132.584
132.517
132.440
131.135
129.006
128.216
128.090
127.940
127.784
126.710
126.667
126.562
84.030
83.947
31.082
31.043
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


25.958
140 110 80 60 40 20 0 -10 -30 -50 -70 -90 -110 -140 -170 -200 -230
f1 (ppm)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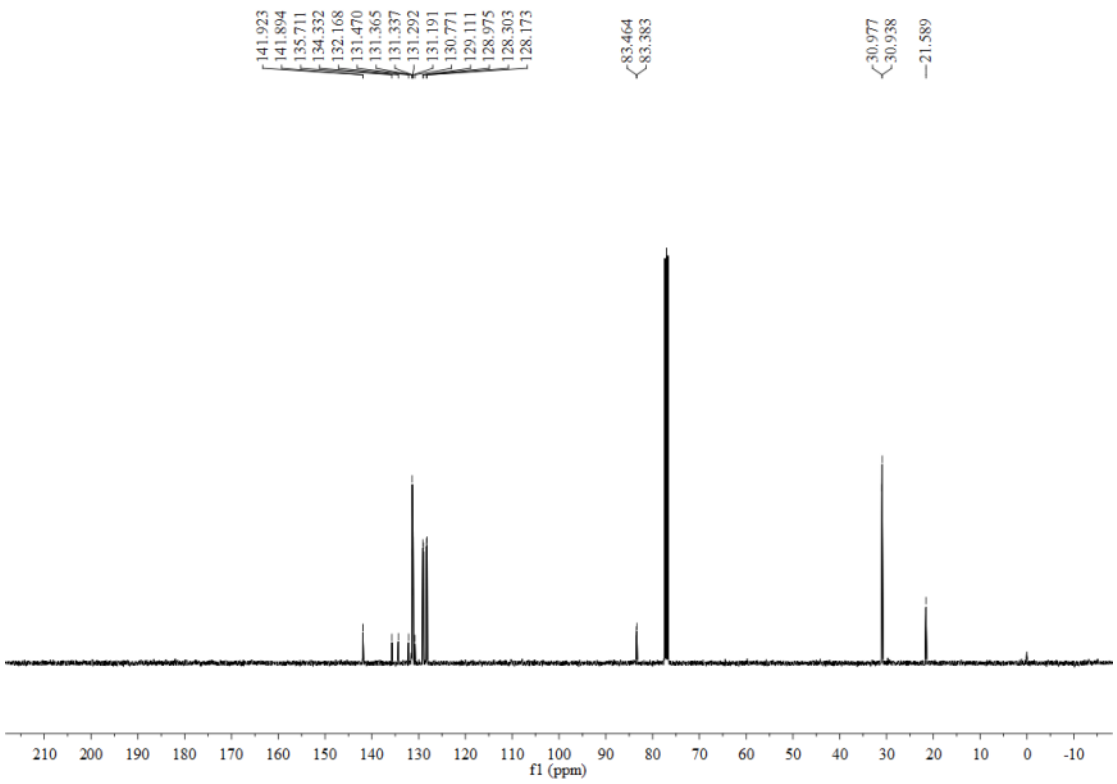
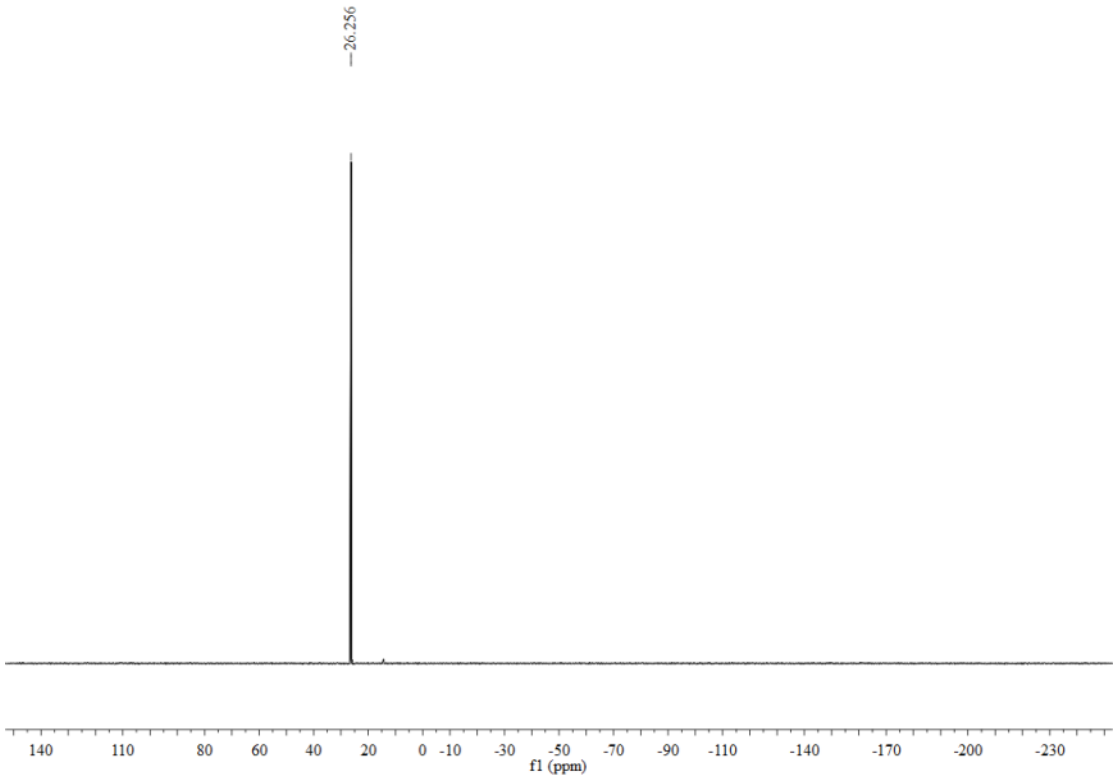
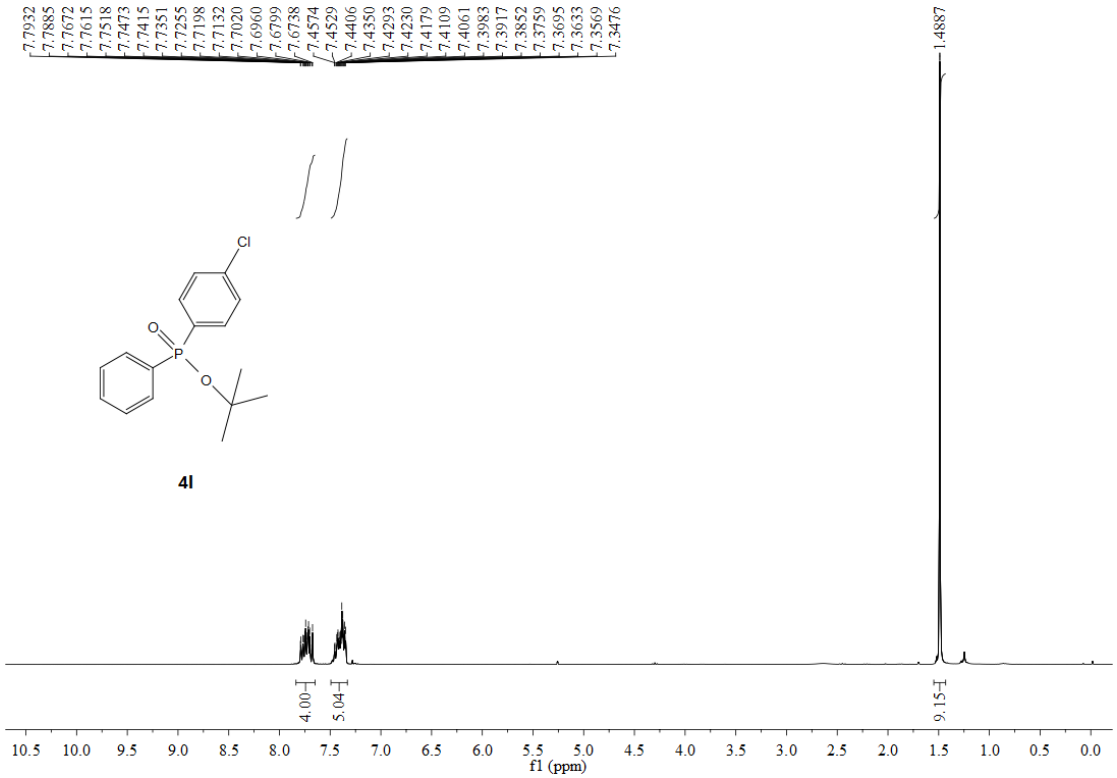
7.795
7.781
7.758
7.729
7.702
7.689
7.662
7.465
7.438
7.426
7.412
7.402
7.281
7.242
7.225
7.217
2.379
1.516
4.00
2.99
2.20
3.00
9.15
12.5 11.5 10.5 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

4k


141.923
141.894
135.711
134.332
132.168
131.470
131.365
131.337
131.292
131.191
130.771
129.111
128.975
128.303
128.173
83.464
83.383
30.977
30.938
21.589
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


26.256
140 110 80 60 40 20 0 -10 -30 -50 -70 -90 -110 -140 -170 -200 -230
f1 (ppm)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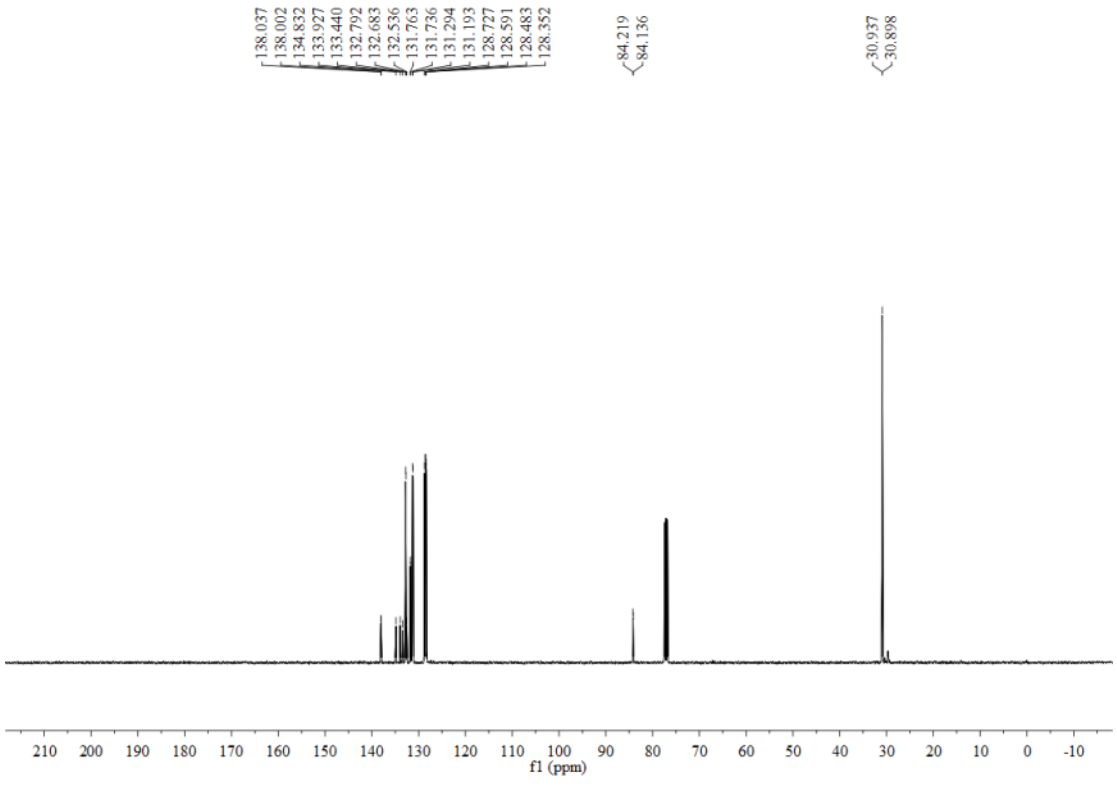
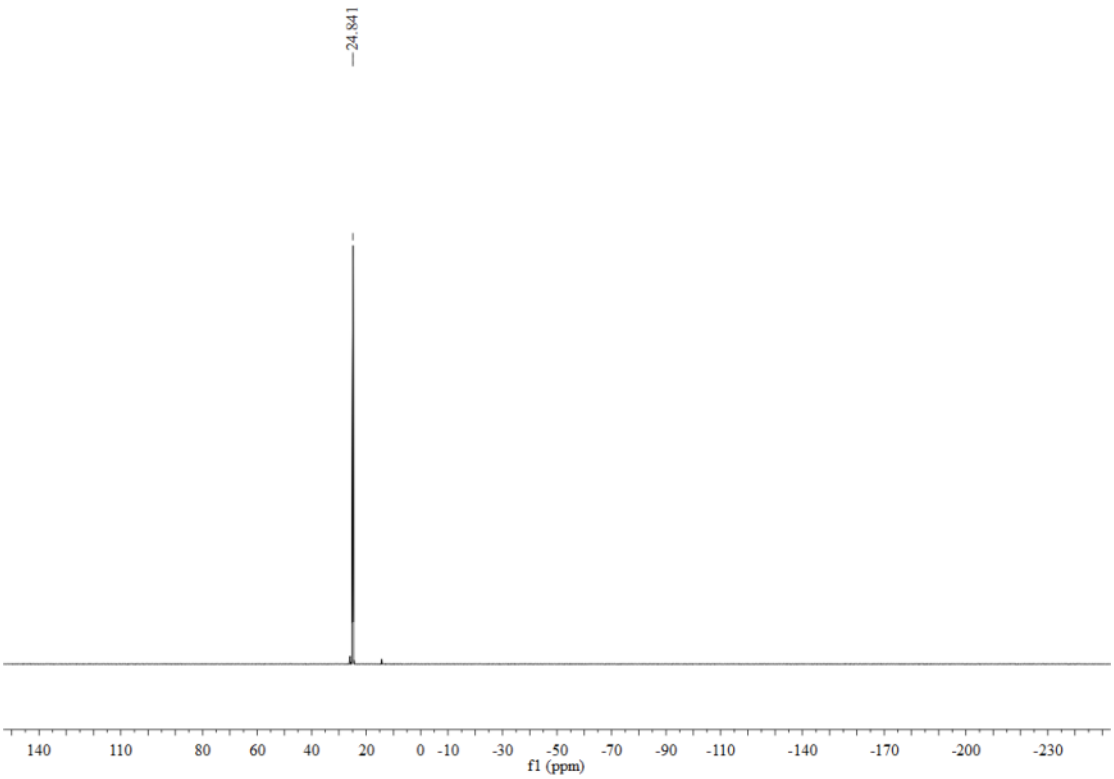
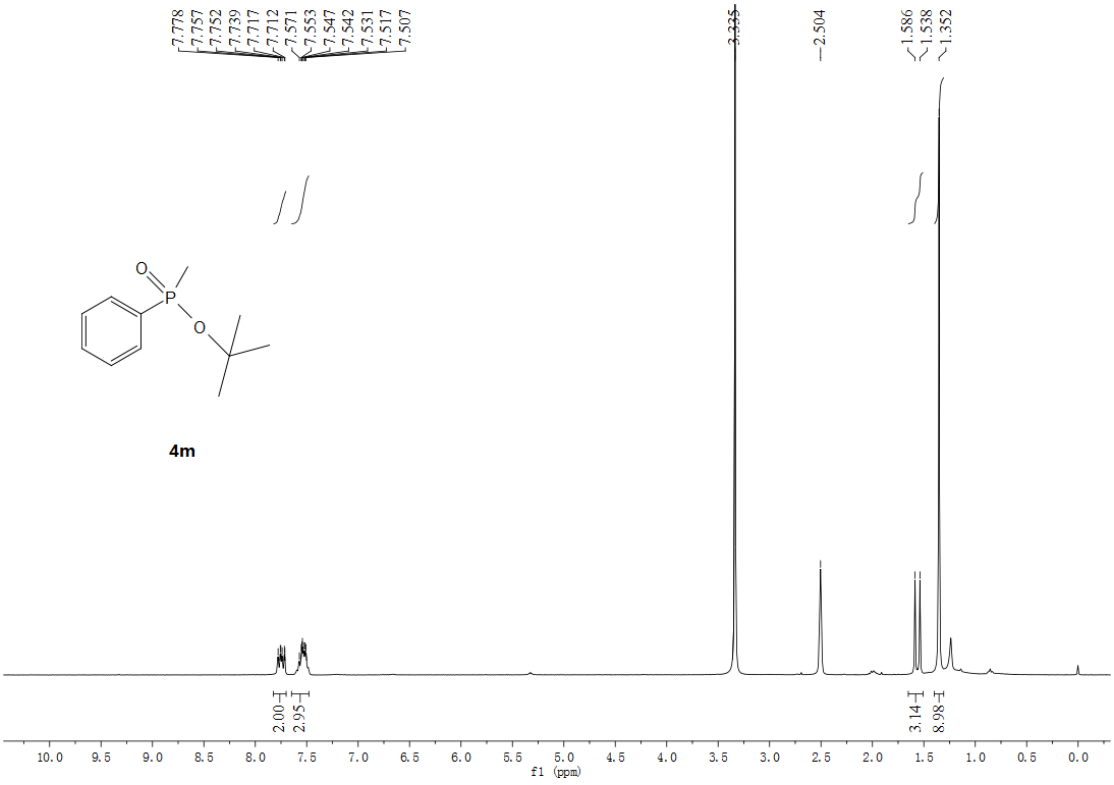
7.7672
7.7615
7.7518
7.7473
7.7415
7.7351
7.7255
7.7198
7.7132
7.7020
7.6960
7.6799
7.6738
7.4574
7.4529
7.4406
7.4350
7.4293
7.4230
7.4179
7.4109
7.4061
7.3983
7.3917
7.3852
7.3759
7.3695
7.3633
7.3569
7.3476
1.4887
Cl
O
P
O
4.00
5.04
9.15
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

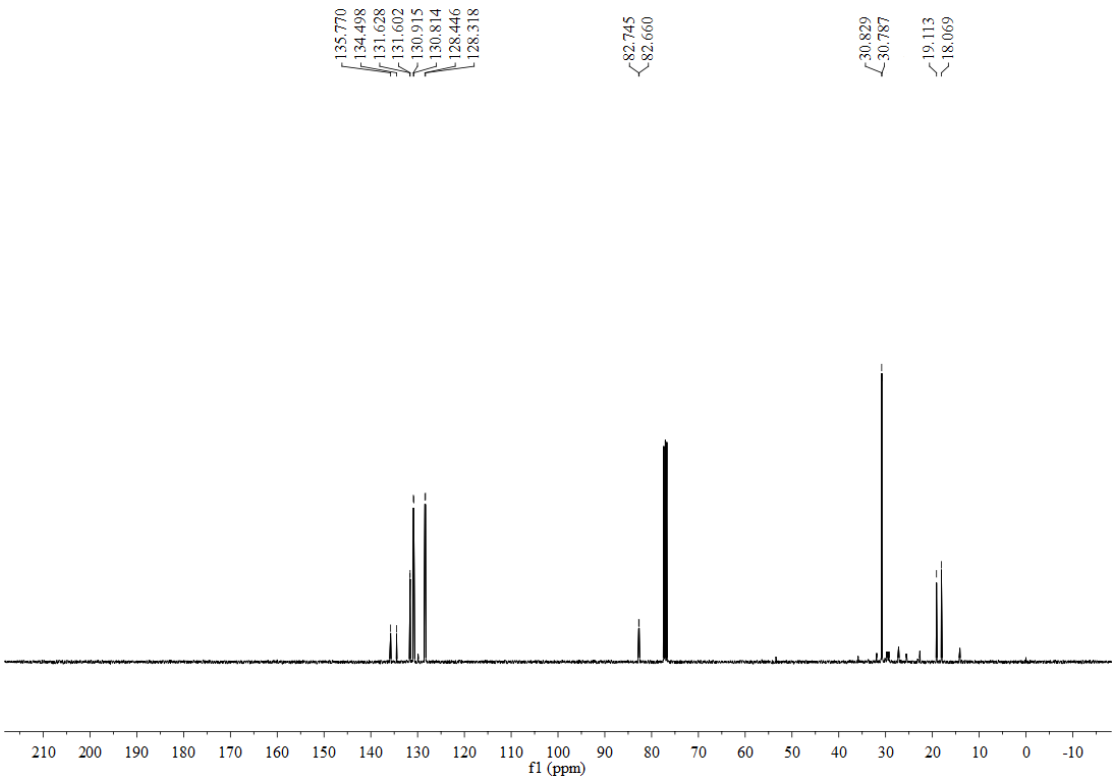
4l

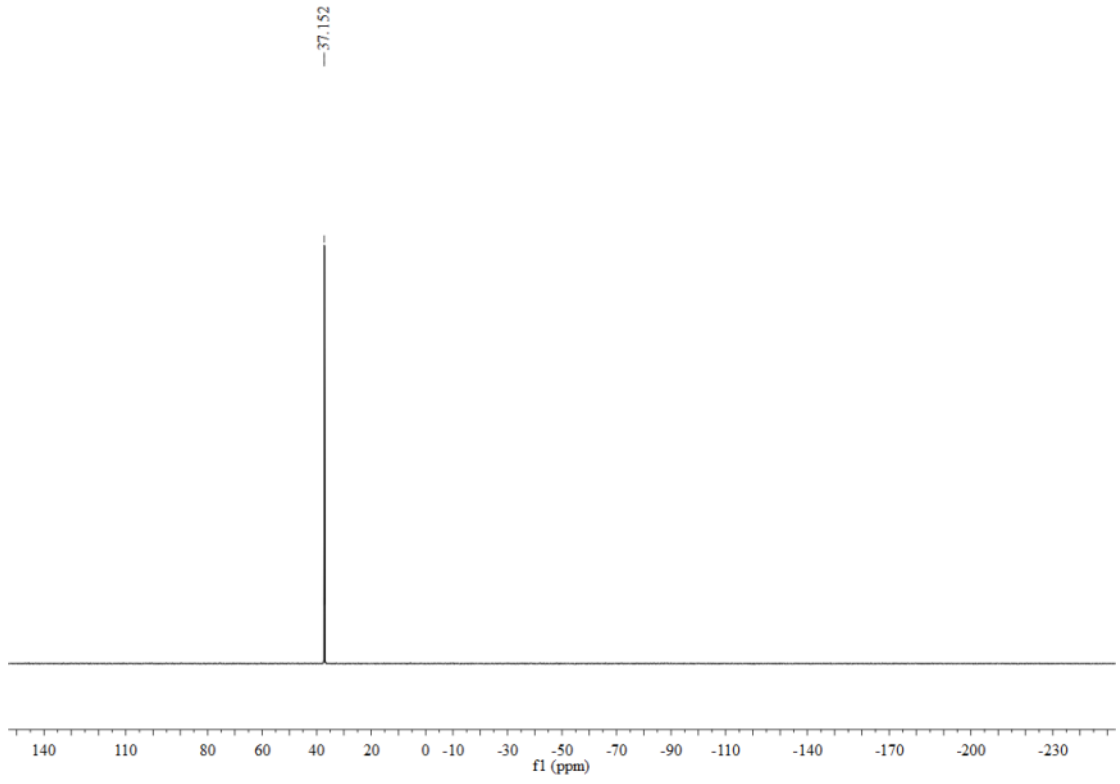

138.037
138.002
134.832
133.927
133.440
132.792
132.683
132.536
131.763
131.736
131.294
131.193
128.727
128.591
128.483
128.352
84.219
84.136
30.937
30.898
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

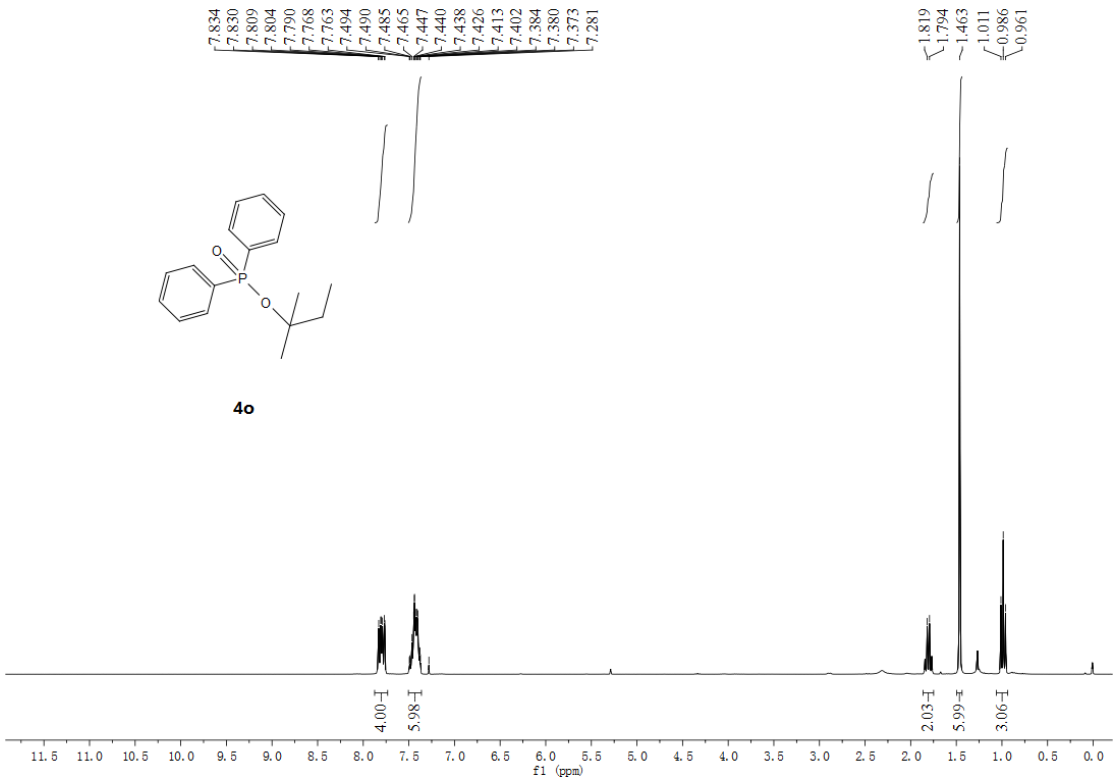

24.841
140
110
80
60
40
20
0
-10
-30
-50
-70
-90
-110
-140
-170
-200
-230
f1 (ppm)


7.778
7.757
7.752
7.739
7.717
7.712
7.571
7.553
7.547
7.542
7.531
7.517
7.507
3.335
2.504
1.586
1.538
1.352
O
P
O
2.00
2.95
3.14
8.98
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)

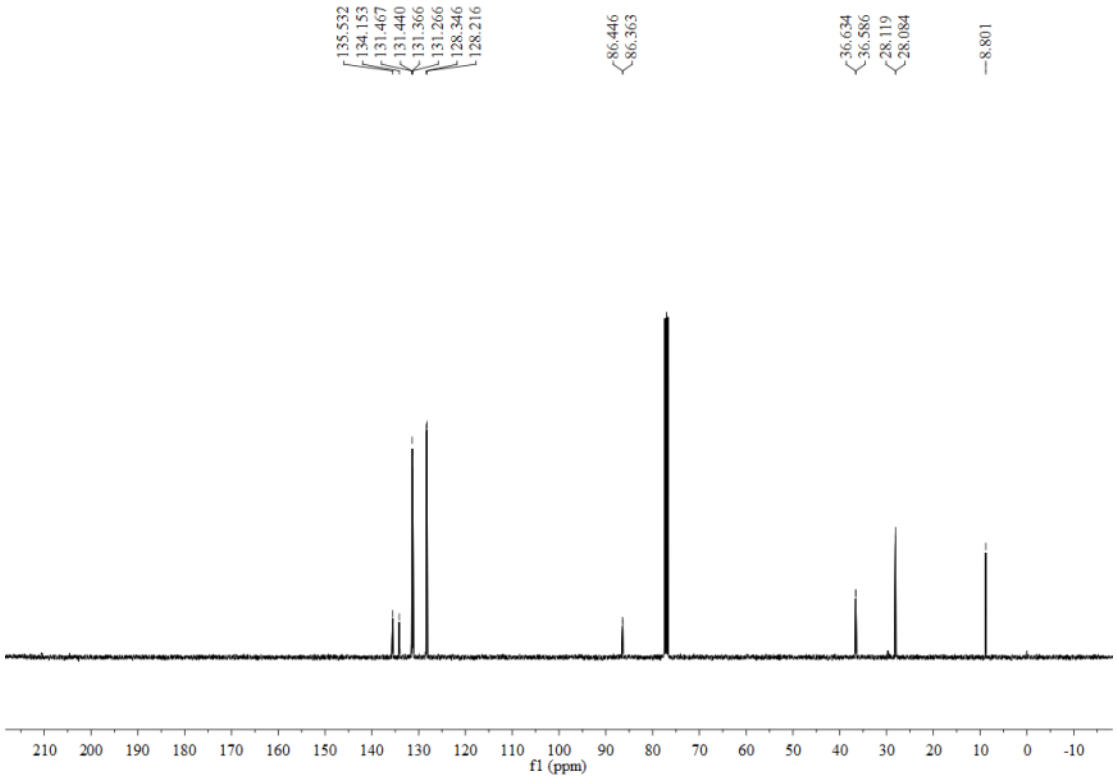
4m

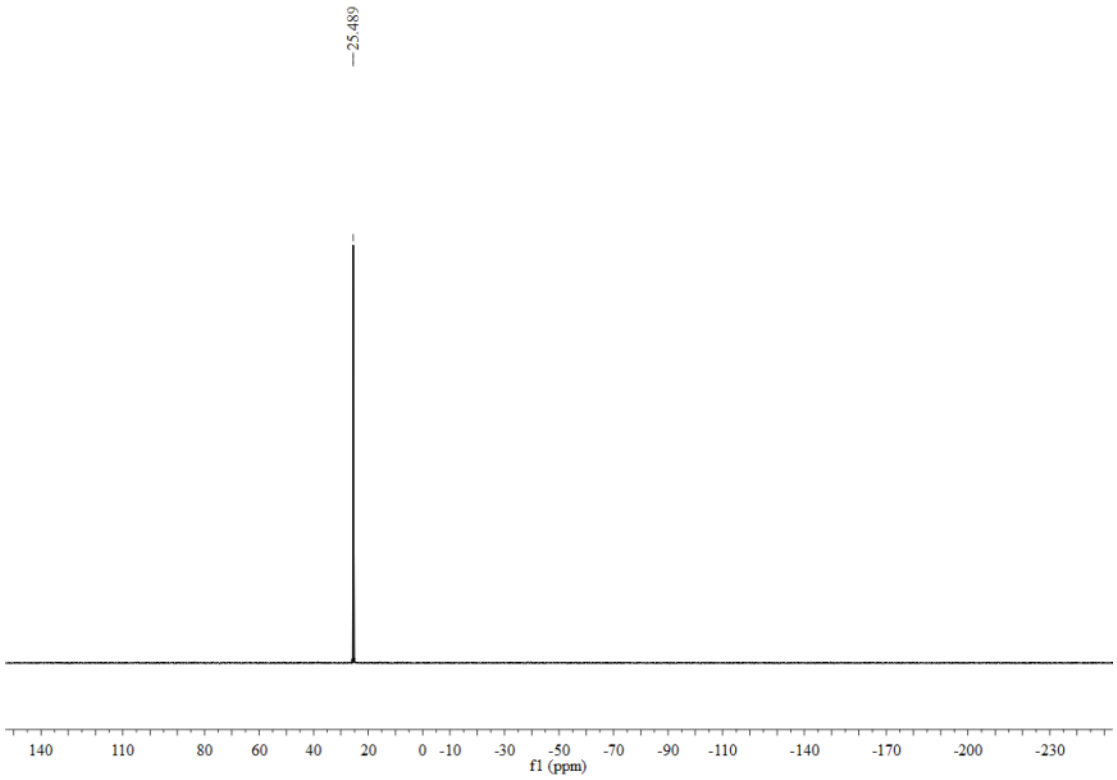

135.770
134.498
131.628
131.602
130.915
130.814
128.446
128.318
82.745
82.660
30.829
30.787
19.113
18.069
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)


37.152
140 110 80 60 40 20 0 -10 -30 -50 -70 -90 -110 -140 -170 -200 -230
f1 (ppm)


7.834
7.830
7.809
7.804
7.790
7.768
7.763
7.494
7.490
7.485
7.465
7.447
7.440
7.438
7.426
7.413
7.402
7.384
7.380
7.373
7.281
1.819
1.794
1.463
1.011
0.986
0.961
O
P
O
4.00
5.98
2.03
5.99
3.06
f1 (ppm)

4o


135.532
134.153
131.467
131.440
131.366
131.266
128.346
128.216
86.446
86.363
36.634
36.586
28.119
28.084
8.801
f1 (ppm)


25.489
140
110
80
60
40
20
0
-10
-30
-50
-70
-90
-110
-140
-170
-200
-230
f1 (ppm)