Supporting Information

Transition-Metal-Free Amination Phosphoryl Azide for the Synthesis of Phosphoramidates

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Contents

1. General remarks

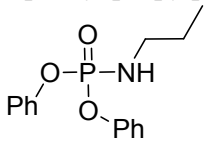
All non-aqueous reactions and manipulations were performed in air atmosphere. All solvents were purchased from Energy Chemical, Aladdin and used without further treatment. The reactions were monitored by GC (7820A, Hubei University of Science and Technology) and GC-MS (QP2010, Hunan University). The electron ionization (EI) method was used as the ionization method for the HRMS measurement, and the mass analyzer type is TOF for EI. The ^{1}H NMR and ^{13}C NMR spectra were recorded on a Brucker ADVANCE III spectrometer at 400 MHz and 100 MHz, respectively (Hubei University of Science and Technology). Flash column chromatography was performed using silica gel 40-70 μm (200-300 mu). Amines and azide compounds were purchased from Energy Chemical and used without further treatment.

2. General procedure

A 25 ml Schlenk-type tube equipped with a magnetic stir bar was charged with diphenyl phosphoryl azide **1** (0.2 mmol), and *n*-propylamine **2** (0.4 mmol) at room temperature, then the reaction mixture was stirred at 120 ºC for 12 h. The reaction was monitored by GC. After completion of the reaction, the resulting solution was cooled to room temperature, and neutralized with saturated NaCl solution. The product was extracted with EtOAc, dried over anhydrous Mg_2SO_4 and concentrated in vacuum. The crude product was purified by flash column chromatography on silica gel and eluted with EtOAc/Petroleum ether (1/5-1/10) give analytically pure product.

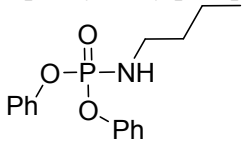
3. ^{1}H NMR, ^{13}C NMR and ^{31}P NMR data of products

diphenyl propylphosphoramidate (3a)[1]



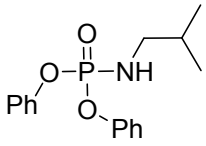
Following the general procedure (EtOAc/Petroleum ether 1:5), **3a** was obtained as a colorless liquid, isolated yield: 84%. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.24-7.36 (m, 8H), 7.11-7.15 (m, 2H), 3.84 (t, 1H, J = 6.4 Hz), 2.94-3.02 (m, 2H), 1.44 (q, 2H, J = 7.2 Hz), 0.83 (t, 3H, J = 7.4 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 150.9 (d, $J_{P\text{-}C}$ = 6.6 Hz), 129.6, 124.8 (d, $J_{P\text{-}C}$ = 0.9 Hz), 120.3 (d, $J_{P\text{-}C}$ = 5.0 Hz), 43.6 (d, $J_{P\text{-}C}$ = 1.4 Hz), 24.6 (d, $J_{P\text{-}C}$ = 6.3 Hz), 11.1; ^{31}P NMR (162 MHz, $CDCl_3$) δ 0.38; GC-MS: m/z = 291.

diphenyl butylphosphoramidate (3b)[1]



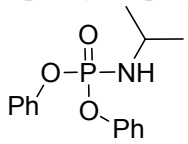
Following the general procedure (EtOAc/Petroleum ether 1:5), **3b** was obtained as a colorless liquid, isolated yield: 81%. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.33 (t, 4H, J = 7.8 Hz), 7.24-7.27 (m, 4H), 7.14-7.18 (m, 2H), 3.03-3.10 (m, 3H, NH and -CH_2-), 1.41-1.48 (m, 2H), 1.31 (q, 2H, J = 7.8 Hz), 0.87 (t, 3H, J = 7.2 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 150.9 (d, J_{P-C} = 6.6 Hz), 129.6, 124.8 (d, J_{P-C} = 0.9 Hz), 120.3 (d, J_{P-C} = 5.0 Hz), 43.6 (d, J_{P-C} = 1.4 Hz), 24.6 (d, J_{P-C} = 6.3 Hz), 11.1; ^{31}P NMR (162 MHz, $CDCl_3$) δ 0.38; GC-MS: m/z = 305

diphenyl isobutylphosphoramidate (3c)[1]



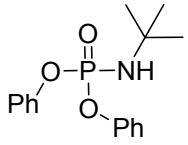
Following the general procedure (EtOAc/Petroleum ether 1:5), **3c** was obtained as a colorless liquid, isolated yield: 90%.δ 7.33 (t, 4H, J = 7.8 Hz), 7.24 (d, 4H, J =8.4 Hz), 7.14-7.18 (m, 2H), 3.12-3.18 (m, 1H), 2.86-2.92 (m, 2H), 1.67-1.72 (m, 1H), 0.86 (d, 6H, J = 6.8 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 150.9 (d, J_{P-C} = 6.7 Hz), 129.7, 124.9 (d, J_{P-C} = 0.9 Hz), 120.2 (d, J_{P-C} = 5.0 Hz), 49.3, 29.7 (d, J_{P-C} = 6.2 Hz), 19.8; ^{31}P NMR (162 MHz, $CDCl_3$) δ -0.46; GC-MS: m/z = 305.

diphenyl isopropylphosphoramidate (3d)[1]



Following the general procedure (EtOAc/Petroleum ether 1:5), **3d** was obtained as a colorless liquid, isolated yield: 81%. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.31 (t, 4H, J = 7.8 Hz), 7.25 (d, 4H, J = 8.4 Hz), 7.15 (t, 2H, J = 7.0 Hz), 3.54-3.65 (m, 1H), 3.05 (t, 1H, J = 10.8 Hz), 1.13 (d, 6H, J = 6.4 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 151.0 (d, J_{P-C} = 6.8 Hz), 129.6, 124.8, 120.2 (d, J_{P-C} = 5.0 Hz), 44.6, 25.1 (d, J_{P-C} = 5.7 Hz); ^{31}P NMR (162 MHz, $CDCl_3$) δ -1.8; GC-MS: m/z = 291.

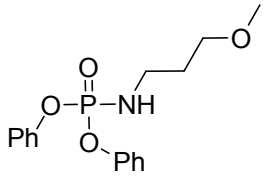
diphenyl tert-butylphosphoramidate (3e)



Following the general procedure (EtOAc/Petroleum ether 1:5), **3e** was obtained as a colorless liquid, isolated yield: 55%. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.32 (t, 4H, J = 7.8 Hz), 7.23-7.26 (m, 4H), 7.13-7.17 (m, 2H), 3.05 (d, 1H, J = 8.4 Hz), 1.35 (s, 9H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 151.1 (d, J_{P-C} = 7.1 Hz), 129.6, 124.7, 120.1 (d, J_{P-C} = 5.1 Hz), 51.8, 31.3 (d, J_{P-C} =

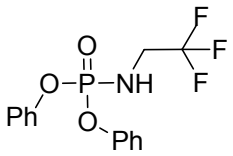
4.9 Hz); ^{31}P NMR (162 MHz, $CDCl_3$) δ -3.4; HRMS (EI): calcd for C16H20NO3P: 305.1181, found: 305.1170.

diphenyl (3-methoxypropyl)phosphoramidate (3f)



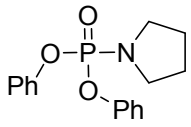
Following the general procedure (EtOAc/Petroleum ether 1:5), **3f** was obtained as a colorless liquid, isolated yield: 85%. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.25 (t, 4H, J = 7.8 Hz), 7.24-7.27 (d, 4H, J = 8.4 Hz), 7.08 (t, 2H, J = 7.4 Hz), 3.59 (d, 1H, J = 5.6 Hz), 3.32 (t, 2H, J = 5.6 Hz), 3.19 (s, 3H), 3.08-3.15 (m, 2H), 1.61-1.68 (m, 2H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 150.9 (d, J_{P-C} = 6.7 Hz), 129.67, 124.7, 120.3 (d, J_{P-C} = 4.9 Hz), 70.9, 58.7, 39.9, 30.8 (d, J_{P-C} = 6.3 Hz); ^{31}P NMR (162 MHz, $CDCl_3$) δ -0.63; HRMS (EI): calcd for C16H20NO4P: 321.1130, found: 321.1126

diphenyl (2,2,2-trifluoroethyl)phosphoramidate (3g)



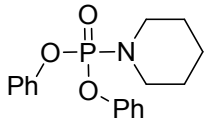
Following the general procedure (EtOAc/Petroleum ether 1:5), **3g** was obtained as a white solid, isolated yield: 52%. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.25 (t, 4H, J = 7.8 Hz), 7.10-7.19 (m, 6H), 3.55-3.68 (m, 3H, NH and–CH_2-); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 150.5 (d, J_{P-C} = 7.0 Hz), 129.8, 125.4, 120.1 (d, J_{P-C} = 5.0 Hz), 43.6 (q, J_{C-3F} = 35.0 Hz); ^{31}P NMR (162 MHz, $CDCl_3$) δ -2.6; HRMS (EI): calcd for C14H13F3NO3P: 331.0585, found: 331.0582.

diphenyl pyrrolidin-1-ylphosphonate (3h)[1]



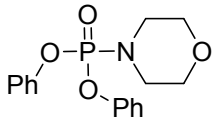
Following the general procedure (EtOAc/Petroleum ether 1:5), **3h** was obtained as a colorless liquid, isolated yield: 85%. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.32 (t, 4H, J = 7.8 Hz), 7.24 (d, 4H, J =8.8 Hz), 7.14 (t, 2H, J = 7.2 Hz), 3.29-3.33 (m, 4H), 1.79 (t, 4H, J = 6.6 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 150.5 (d, J_{P-C} = 6.6 Hz), 129.7, 124.7, 120.1 (d, J_{P-C} = 5.0 Hz), 47.2 (d, J_{P-C} = 4.9 Hz), 26.2 (d, J_{P-C} = 9.5 Hz); ^{31}P NMR (162 MHz, $CDCl_3$) δ -2.1; GC-MS: m/z = 303.

diphenyl piperidin-1-ylphosphonate (3i)[1]



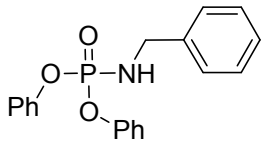
Following the general procedure (EtOAc/Petroleum ether 1:5), **3i** was obtained as a colorless liquid, isolated yield: 78%. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.42 (t, 4H, J = 8.0 Hz), 7.20-7.27 (m, 6H), 3.11-3.16 (m, 4H), 1.43-1.47 (m, 2H), 1.29-1.35 (m, 4H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 150.5 (d, J_{P-C} = 6.3 Hz), 129.3, 124.3, 119.4 (d, J_{P-C} = 5.0 Hz), 44.4 (d, J_{P-C} = 2.2 Hz), 24.7 (d, J_{P-C} = 4.4 Hz), 23.0; ^{31}P NMR (162 MHz, $CDCl_3$) δ -2.1; GC-MS: m/z = 317.

diphenyl morpholinophosphonate (3j)[1]



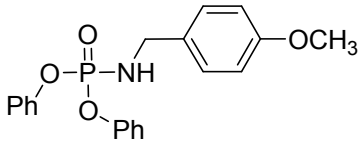
Following the general procedure (EtOAc/Petroleum ether 1:5), **3j** was obtained as a colorless liquid, isolated yield: 90%. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.34 (t, 4H, J = 7.8 Hz), 7.24 (d, 4H, J = 8.4 Hz), 7.17 (t, 2H, J = 7.4 Hz), 3.56 (t, 4H, J = 4.4 Hz), 3.28 (t, 4H, J = 4.6 Hz); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 150.7 (d, J_{P-C} = 6.8 Hz), 129.8, 125.1, 120.1 (d, J_{P-C} = 4.1 Hz), 66.7 (d, J_{P-C} = 5.3 Hz), 44.8; ^{31}P NMR (162 MHz, $CDCl_3$) δ -2.0; GC-MS: m/z = 319.

diphenyl benzylphosphoramidate (3k)[2]



Following the general procedure (EtOAc/Petroleum ether 1:10), **3k** was obtained as a white solid, isolated yield: 90%. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.31 (t, 4H, J = 7.8 Hz), 7.22-7.27 (m, 9H), 7.16 (t, 2H, J = 7.2 Hz), 4.25 (q, 2H, J = 5.0 Hz), 3.64-3.71 (m, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 150.8 (d, J_{P-C} = 6.7 Hz), 138.7 (d, J_{P-C} = 6.6 Hz), 129.7, 128.6, 127.6, 127.4, 124.9, 120.3 (d, J_{P-C} = 4.9 Hz), 45.7; ^{31}P NMR (162 MHz, $CDCl_3$) δ -1.8; GC-MS: m/z = 339.

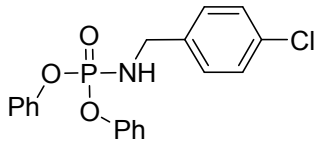
diphenyl 4-methoxybenzylphosphoramidate (3l)[2]



Following the general procedure (EtOAc/Petroleum ether 1:10), **3l** was obtained as a white solid, isolated yield: 92%. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.24 (d, 4H, J = 7.6 Hz), 7.15-7.18 (m, 4H), 7.04-7.11 (m, 4H), 6.71 (d, 2H, J = 8.4 Hz), 4.12 (q, 2H, J = 4.6 Hz), 3.70 (s, 3H), 3.32-3.38 (m, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 159.0, 150.9 (d, J_{P-C} = 6.7

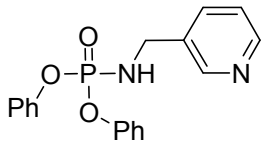
Hz), 130.9 (d, J_{P-C} = 6.6 Hz), 129.7, 128.8, 125.0, 120.3 (d, J_{P-C} = 4.9 Hz), 114.0, 55.3, 45.2; ^{31}P NMR (162 MHz, $CDCl_3$) δ -1.3; GC-MS: m/z = 369

diphenyl 4-chlorobenzylphosphoramidate (3m)[2]



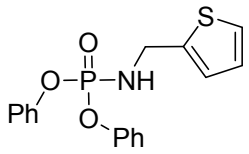
Following the general procedure (EtOAc/Petroleum ether 1:10), **3m** was obtained as a white solid, isolated yield: 85%. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.35 (t, 4H, *J* = 7.8 Hz), 7.26-7.31 (m, 9H), 7.18-7.26 (m, 2H), 4.29 (q, 2H, *J* = 5.0 Hz), 3.56-3.62 (m, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 150.8 (d, J_{P-C} = 6.8 Hz), 137.3 (d, J_{P-C} = 6.3 Hz), 133.3, 129.7, 128.8, 128.7, 125.1, 120.2 (d, J_{P-C} = 5.0 Hz), 45.1; ^{31}P NMR (162 MHz, $CDCl_3$) δ -1.2; GC-MS: m/z = 373

diphenyl (pyridin-3-ylmethyl)phosphoramidate (3n)[1]



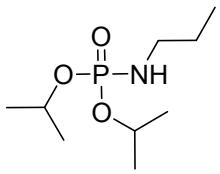
Following the general procedure (EtOAc/Petroleum ether 1:10), **3n** was obtained as a white solid, isolated yield: 81%. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 8.48 (t, 2H, *J* = 4.6 Hz), 7.53 (d, 1H, *J* = 8.0 Hz), 7.32 (t, 4H, *J* = 7.8 Hz), 7.16-7.23 (m, 7H), 4.27 (q, 2H, *J* = 5.4 Hz), 3.79-3.85 (m, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 150.7 (d, J_{P-C} = 6.8 Hz), 148.9 (d, J_{P-C} = 8.9 Hz), 135.2, 134.3, 129.8, 125.1, 123.5, 120.1 (d, J_{P-C} = 5.0 Hz), 43.3; ^{31}P NMR (162 MHz, $CDCl_3$) δ -1.4; GC-MS: m/z = 340

diphenyl (thiophen-2-ylmethyl)phosphoramidate (3o)[2]



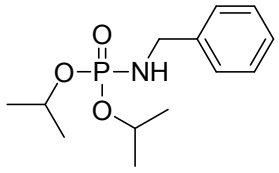
Following the general procedure (EtOAc/Petroleum ether 1:10), **3o** was obtained as a white solid, isolated yield: 78%. ^{1}H NMR ($CDCl_3$, 400 MHz): δ 7.33 (t, 4H, *J* = 7.8 Hz), 7.23 (d, 4H, *J* = 8.8 Hz), 7.15-7.20 (m, 3H), 6.90 (d, 2H, *J* = 3.6 Hz), 4.45 (q, 2H, *J* = 4.8 Hz), 3.50-3.57 (m, 1H); ^{13}C NMR ($CDCl_3$, 100 MHz): δ 150.8 (d, J_{P-C} = 6.8 Hz), 141.9 (d, J_{P-C} = 7.3 Hz), 129.8, 126.9, 125.7, 125.3, 125.1 (d, J_{P-C} = 1.0 Hz), 120.3 (d, J_{P-C} = 4.9 Hz), 40.8; ^{31}P NMR (162 MHz, $CDCl_3$) δ -2.1; GC-MS: m/z = 345

diisopropyl propylphosphoramidate (3p)[3]



Following the general procedure (EtOAc/Petroleum ether 1:10), **3p** was obtained as a colorless liquid, isolated yield: 83%. ^{1}H NMR (DMSO-*d*, 400 MHz): δ 4.49-4.60 (m, 2H), 2.75-2.85 (m, 3H, NH and -CH_2-), 1.21 (d, 6H, *J* = 6.0 Hz), 1.15 (d, 6H, *J* = 6.4 Hz); ^{13}C NMR (DMSO-*d*, 100 MHz): δ 70.6 (d, J_{P-C} = 6.0 Hz), 43.2 (d, J_{P-C} = 1.0 Hz), 24.8 (d, J_{P-C} = 6.0 Hz), 23.8, 23.7 (d, J_{P-C} = 2.0 Hz), 11.2; ^{31}P NMR (162 MHz, $CDCl_3$) δ 7.5; GC-MS: m/z = 223.

diisopropyl benzylphosphoramidate (3q)[3]

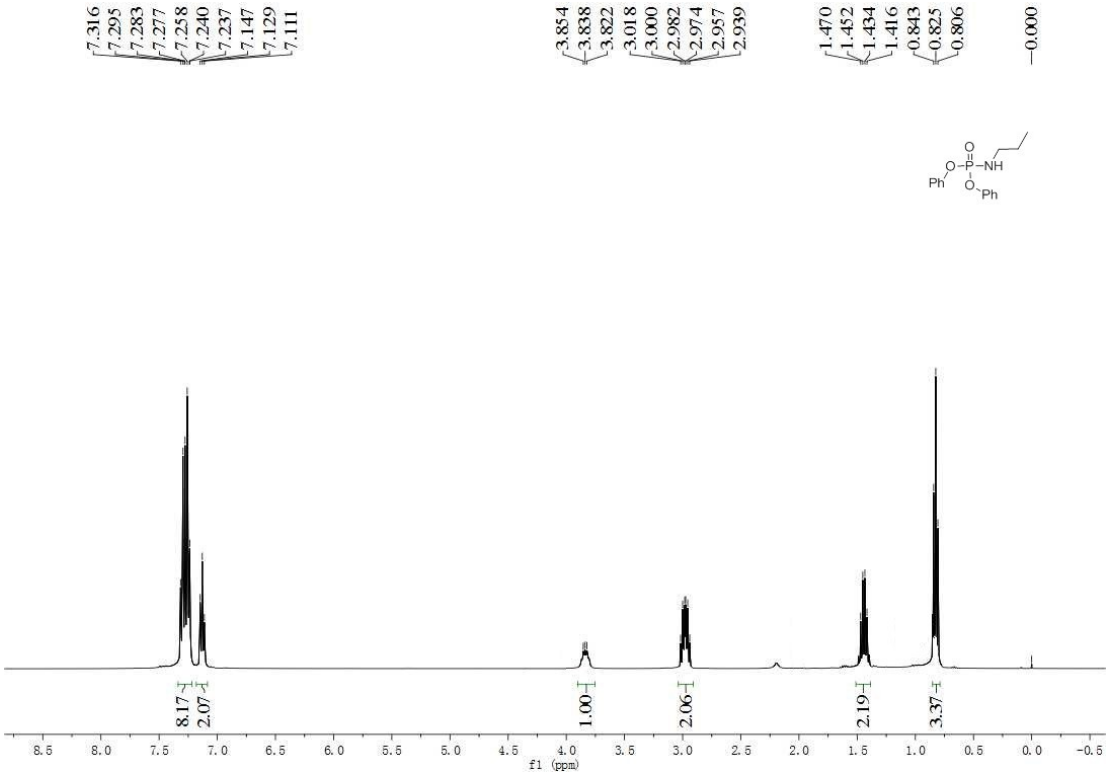


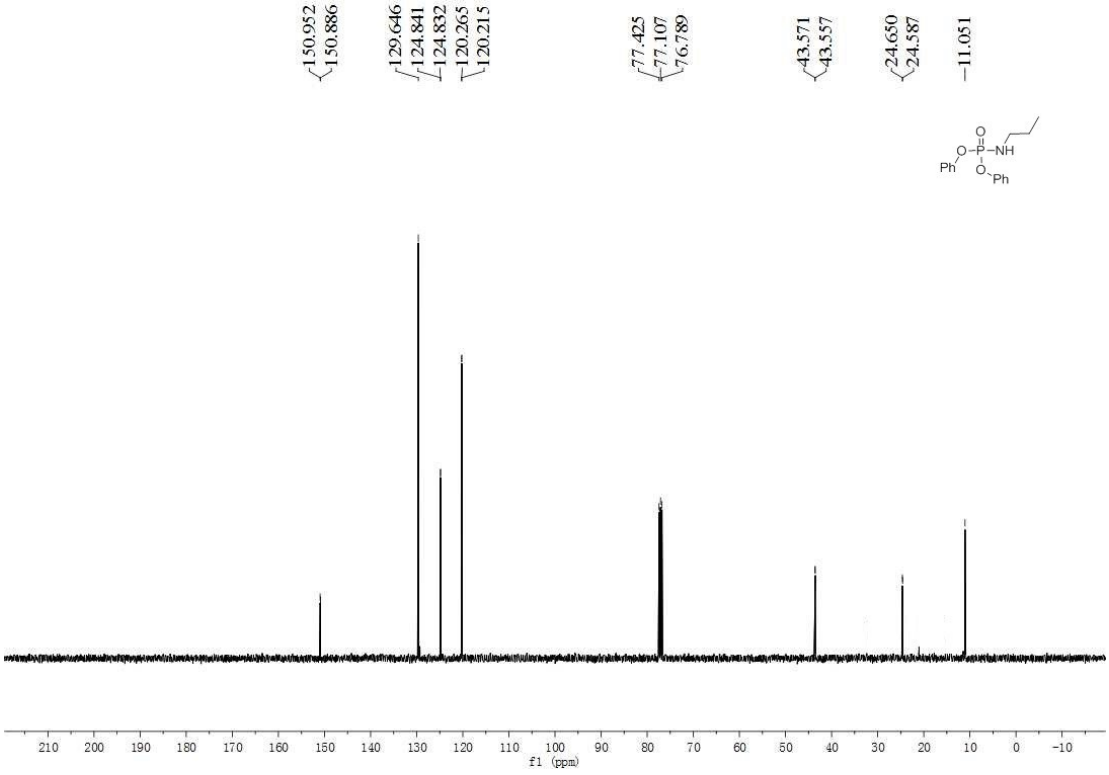
Following the general procedure (EtOAc/Petroleum ether 1:10), **3q** was obtained as a colorless liquid, isolated yield: 75%. ^{1}H NMR (DMSO-*d*, 400 MHz): δ 7.27 (d, 2H, *J* = 7.2 Hz), 7.21 (t, 2H, *J* = 7.4 Hz), 7.11 (t, 1H, *J* = 7.0 Hz), 4.45-4.53 (m, 2H), 3.97 (s, s, 3H, NH and -CH_2-), 1.43-1.51 (m, 2H), 1.27 (t, 12H, *J* = 5.8 Hz), 0.87 (t, 3H, *J* = 7.4 Hz); ^{13}C NMR (DMSO-*d*, 100 MHz): δ 140.1 (d, J_{P-C} = 6.4 Hz), 128.2, 127.2, 126.9, 70.4 (d, J_{P-C} = 4.9 Hz), 45.1, 23.7 (d, J_{P-C} = 4.3 Hz), 23.6 (d, J_{P-C} = 5.6 Hz), 11.2; ^{31}P NMR (162 MHz, $CDCl_3$) δ 7.1; GC-MS: m/z = 271.

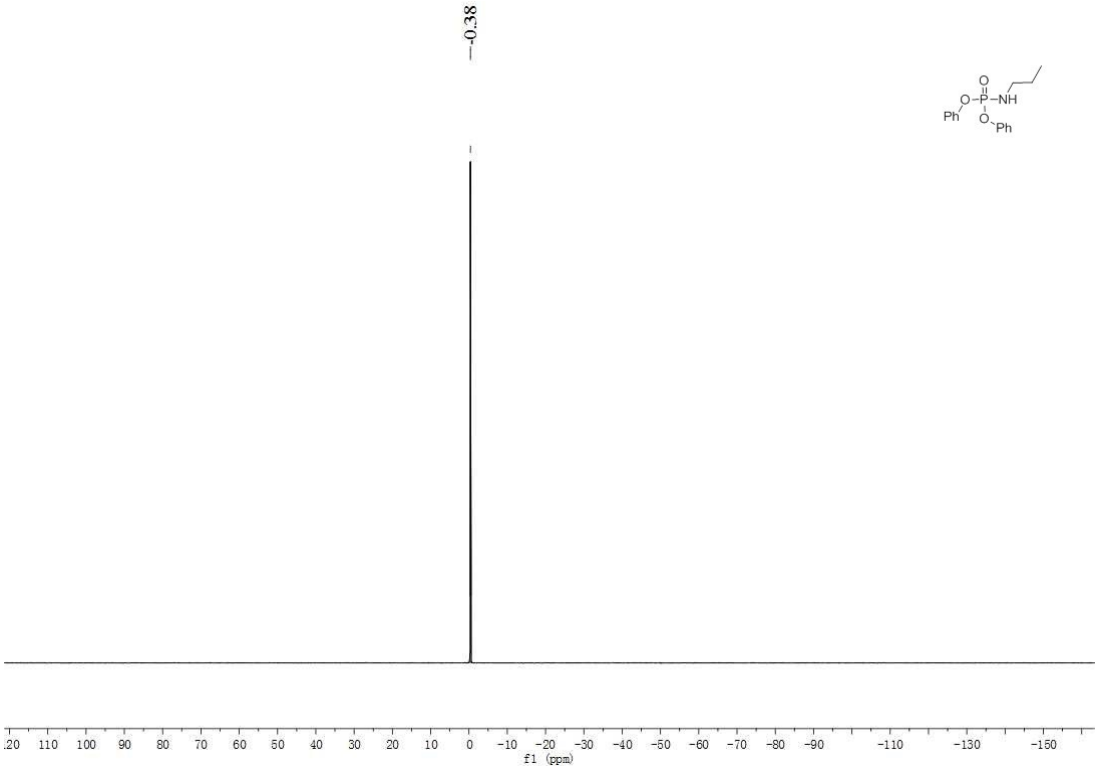
4. References

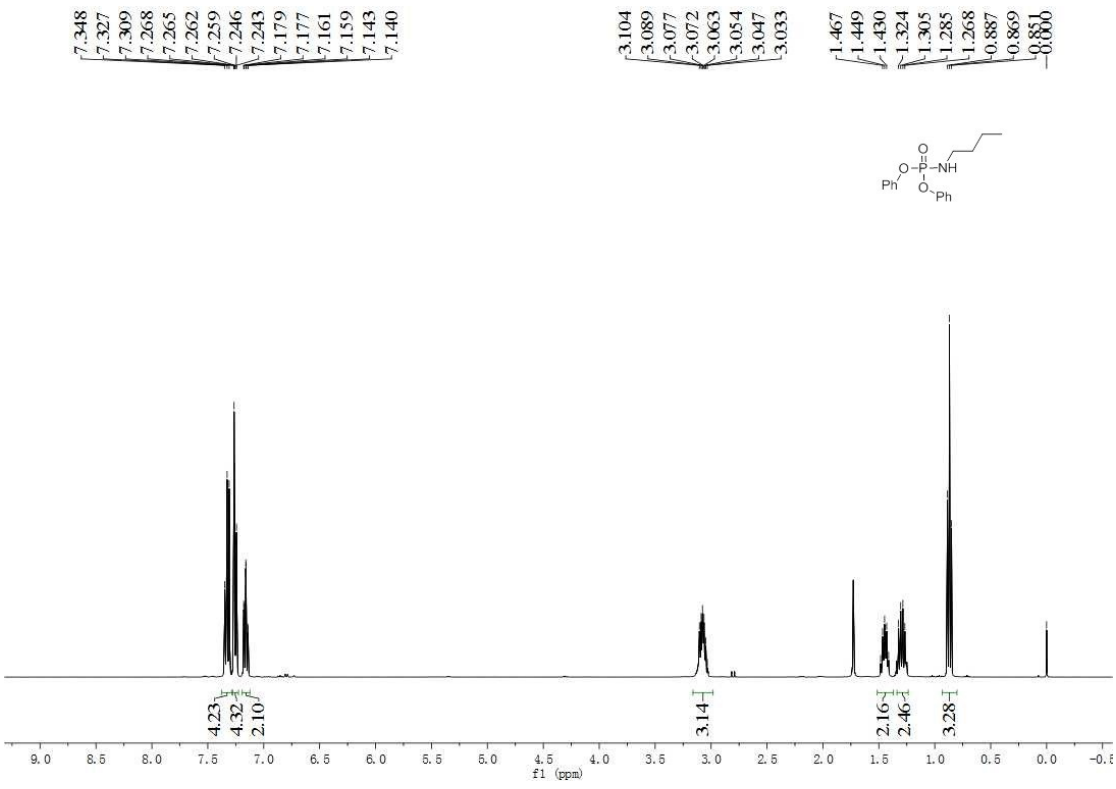
1. R. Zhu, C. Pan and Z. Gu, *Org. Lett*., 2015, **17**, 5862−5865.
2. G. Hong, X. Zhu, C. Hu, A. N. Aruma, S. Wu and L. Wang, *J. Org. Chem*., 2016, **81**, 6867-6874.
3. Y. Zhou, J. Yang, T. Chen, S. Yin, D. Han and L. Han, *Bull. Chem. Soc. Jpn*., 2014, **87**, 400-402.

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






-0.38
f1 (ppm)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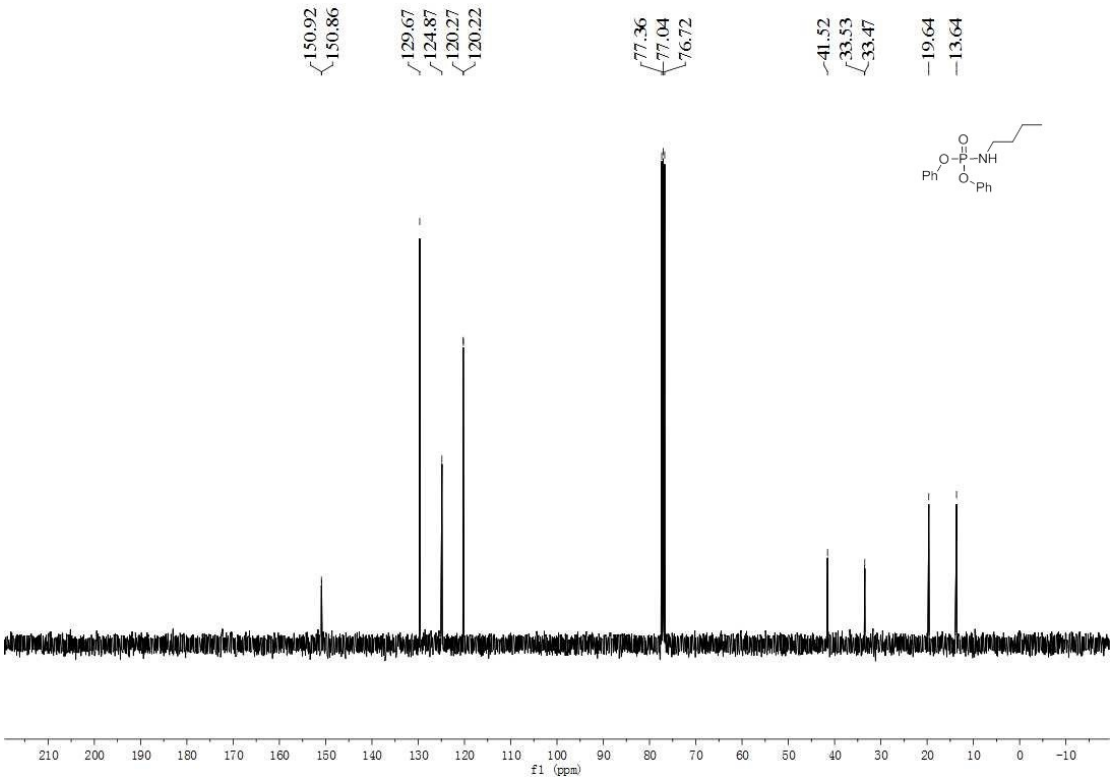
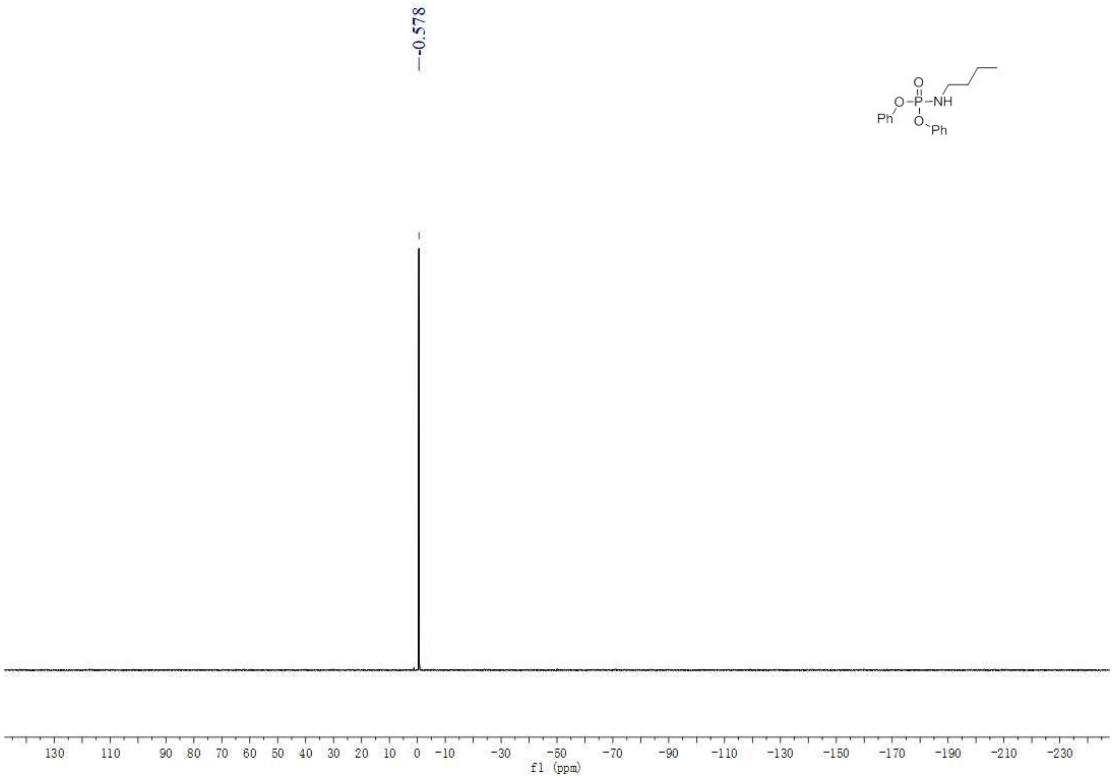
7.327
7.309
7.268
7.265
7.262
7.259
7.246
7.243
7.179
7.177
7.161
7.159
7.143
7.140
3.104
3.089
3.077
3.072
3.063
3.054
3.047
3.033
1.467
1.449
1.430
1.324
1.305
1.285
1.268
0.887
0.869
0.851
0.000
4.23
4.32
2.10
3.14
2.16
2.46
3.28
f1 (ppm)


150.92
150.86
129.67
124.87
120.27
120.22
77.36
77.04
76.72
41.52
33.53
33.47
19.64
13.64
O
O-P-NH
Ph
O
Ph
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)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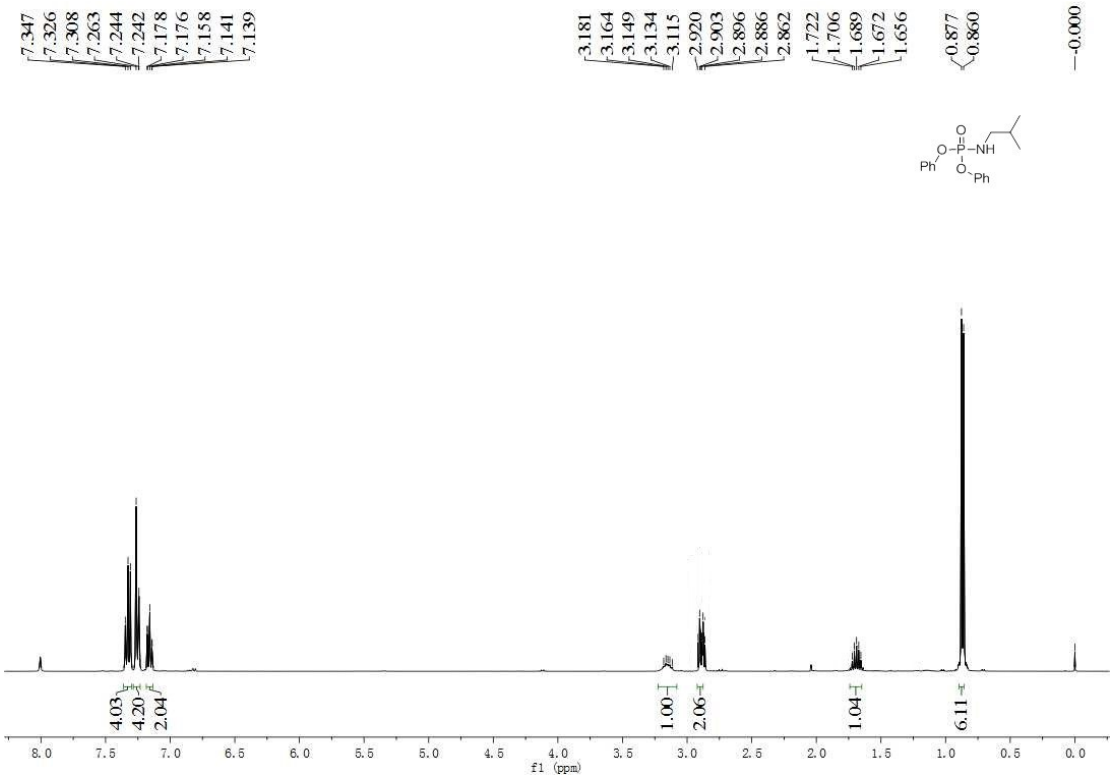
O
O-P-NH
Ph
O
Ph
130 110 90 80 70 60 50 40 30 20 10 0 -10 -30 -50 -70 -90 -110 -130 -150 -170 -190 -210 -230
f1 (ppm)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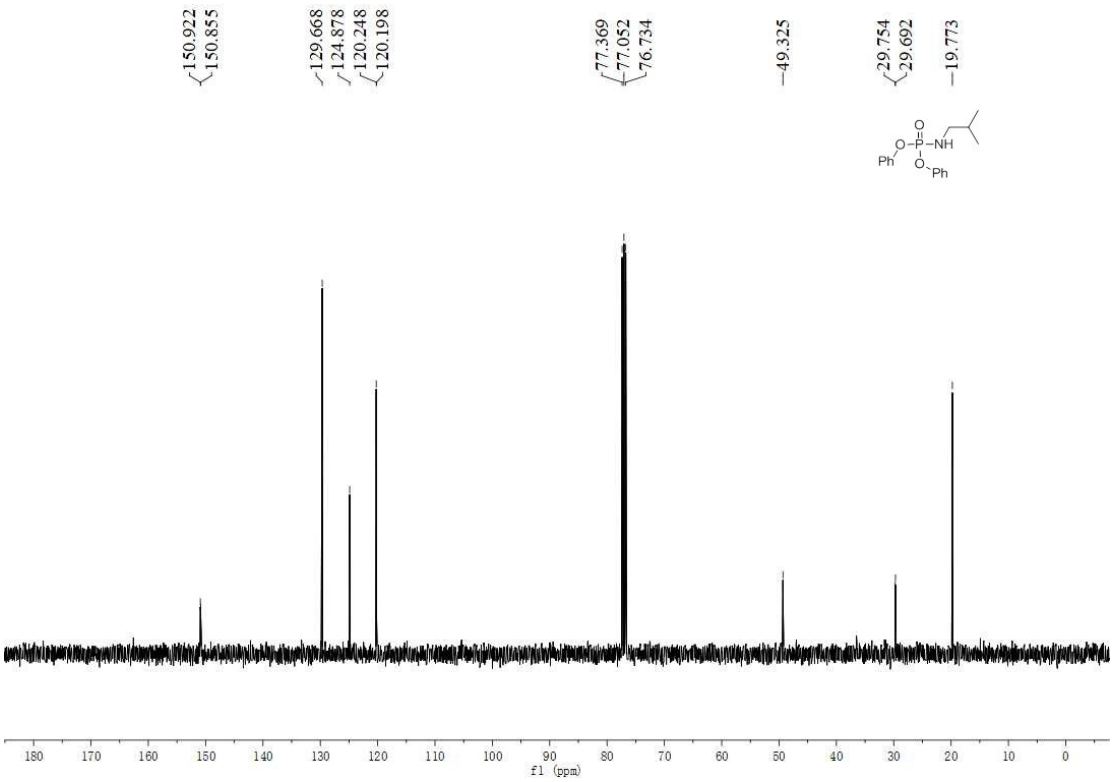
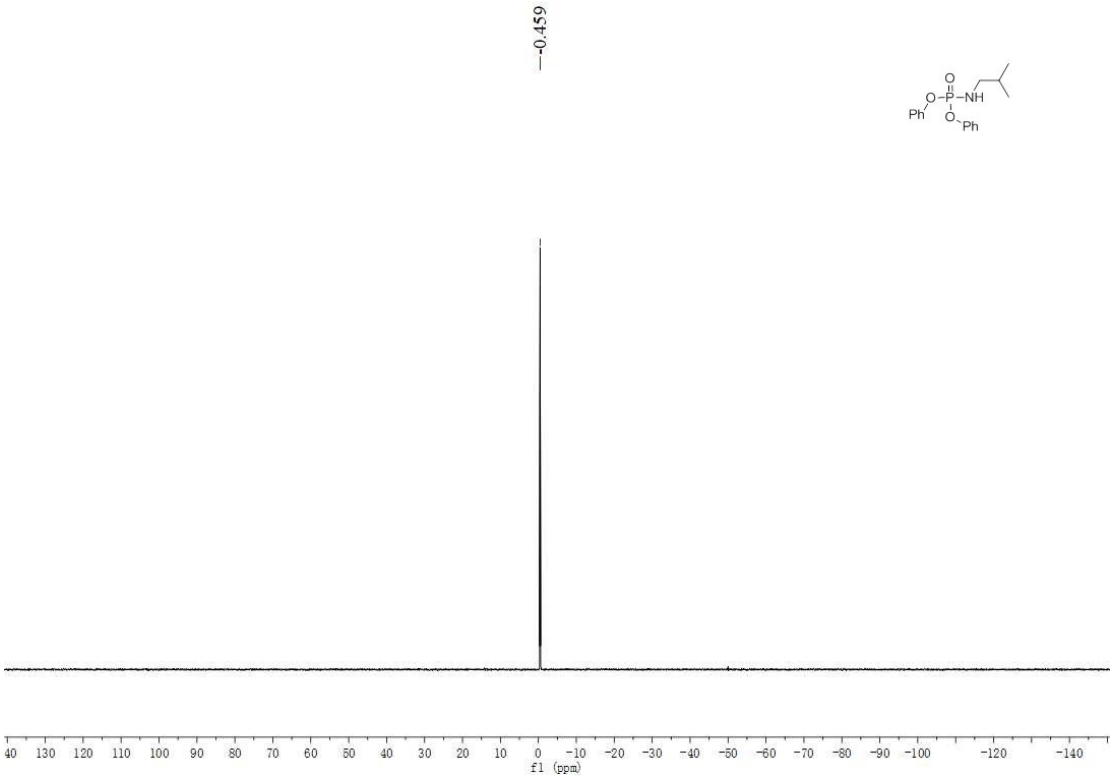
7.326
7.308
7.263
7.244
7.242
7.178
7.176
7.158
7.141
7.139
3.181
3.164
3.149
3.134
3.115
2.920
2.903
2.896
2.886
2.862
1.722
1.706
1.689
1.672
1.656
0.877
0.860
-0.000
4.03
4.20
2.04
1.00
2.06
1.04
6.11
f1 (ppm)


150.922
150.855
129.668
124.878
120.248
120.198
77.369
77.052
76.734
49.325
29.754
29.692
19.773
f1 (ppm)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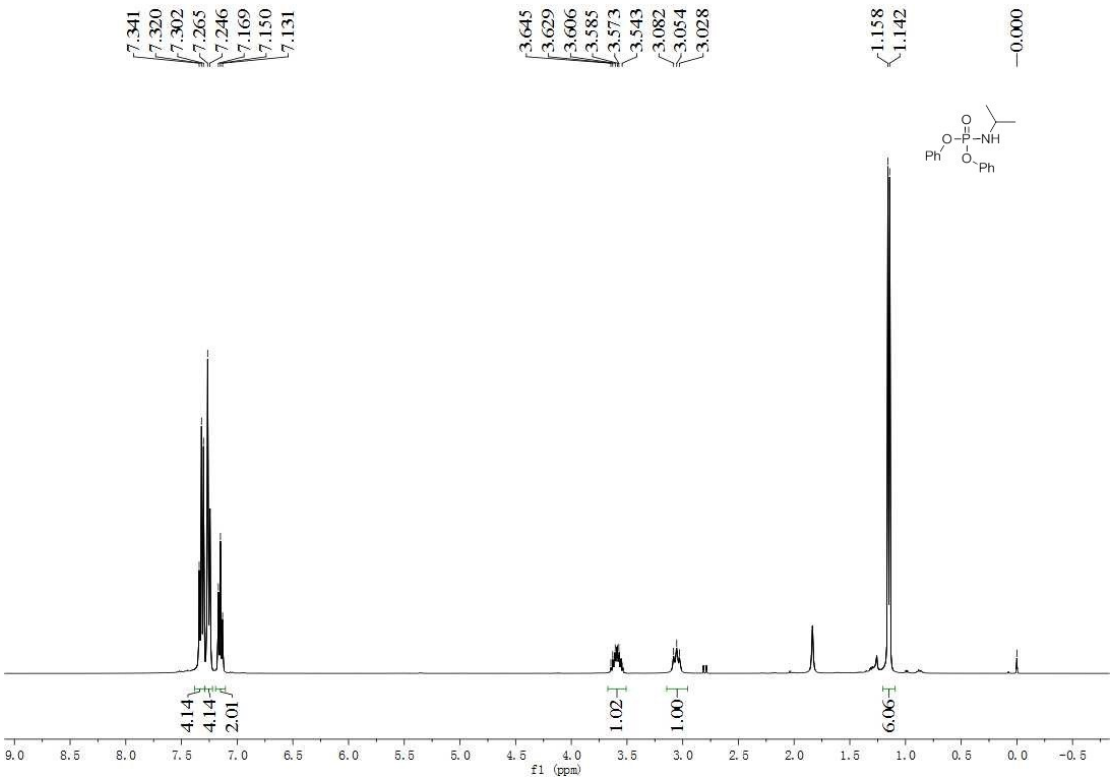
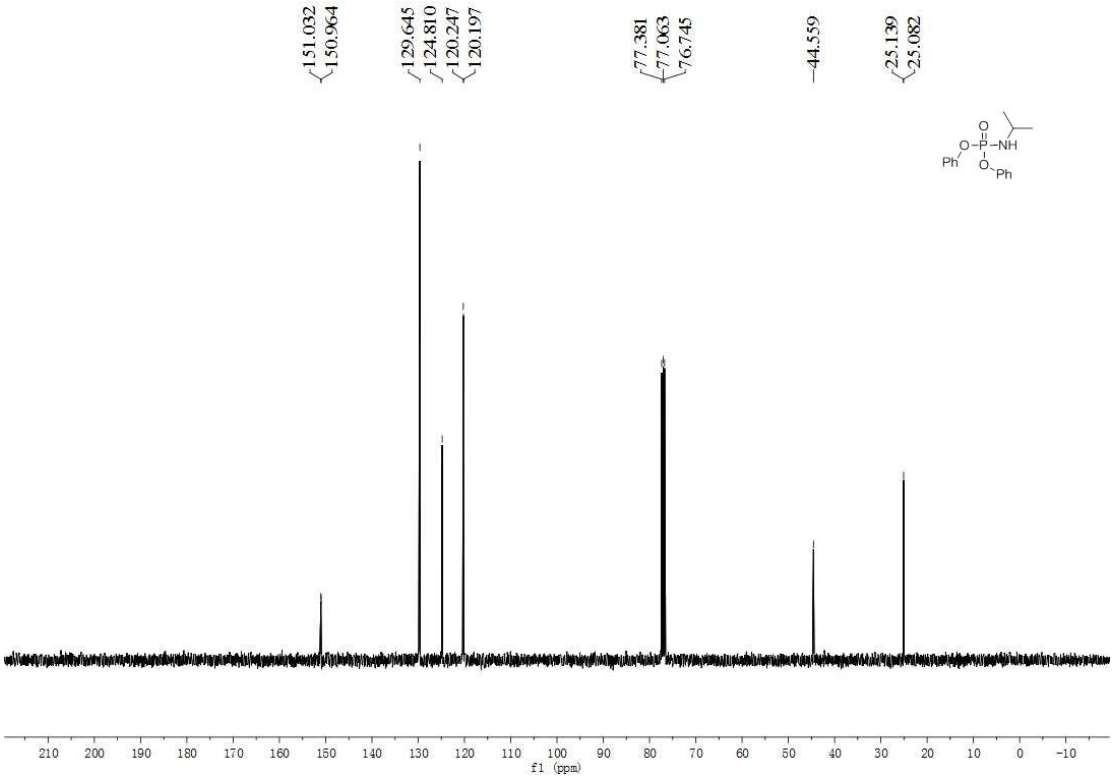
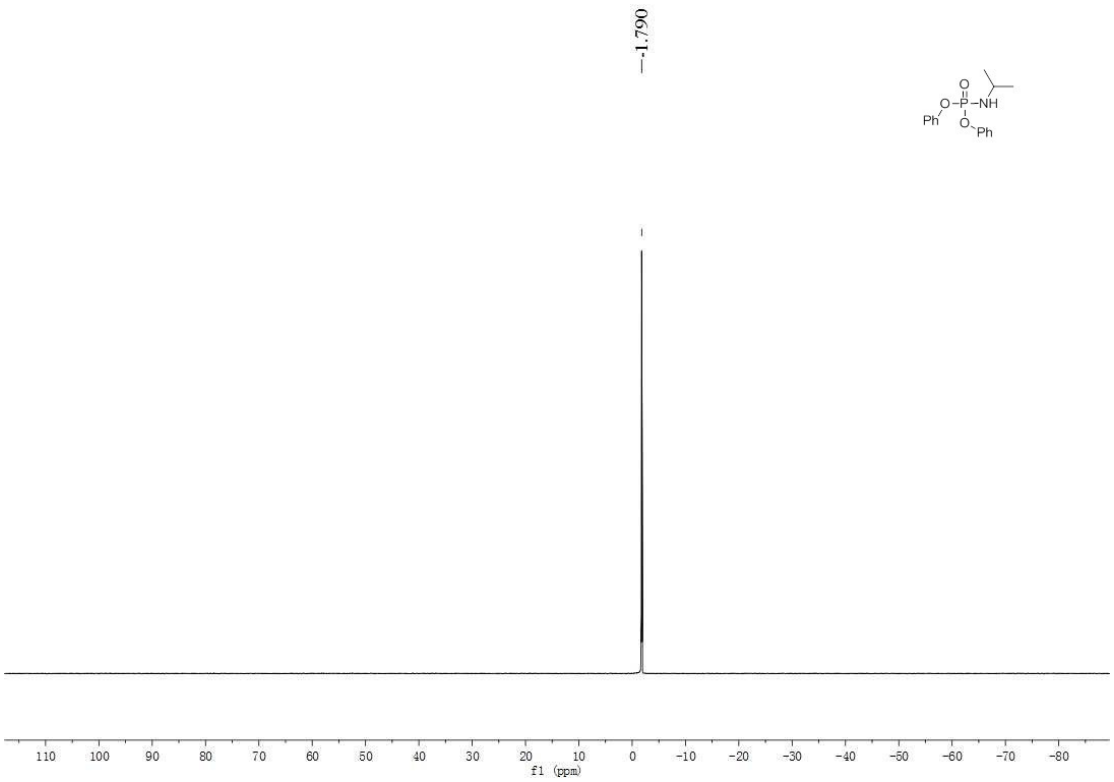
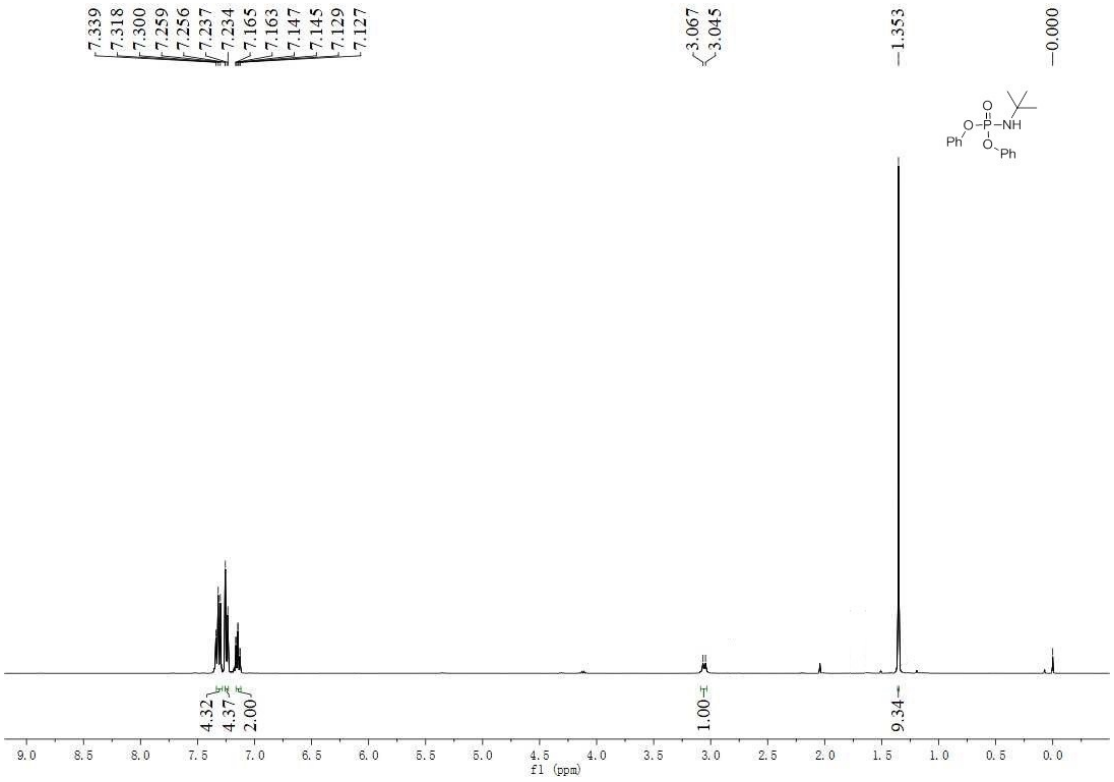
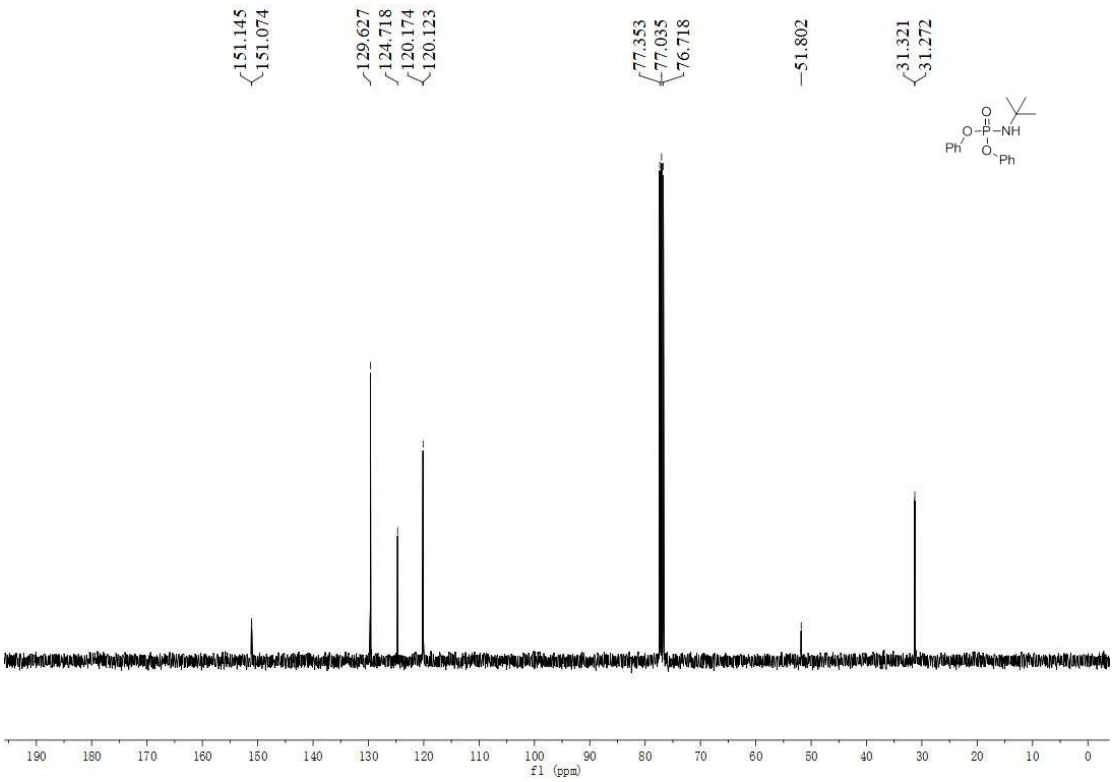
O
O-P-NH
Ph
O
Ph
40 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -120 -140
f1 (ppm)

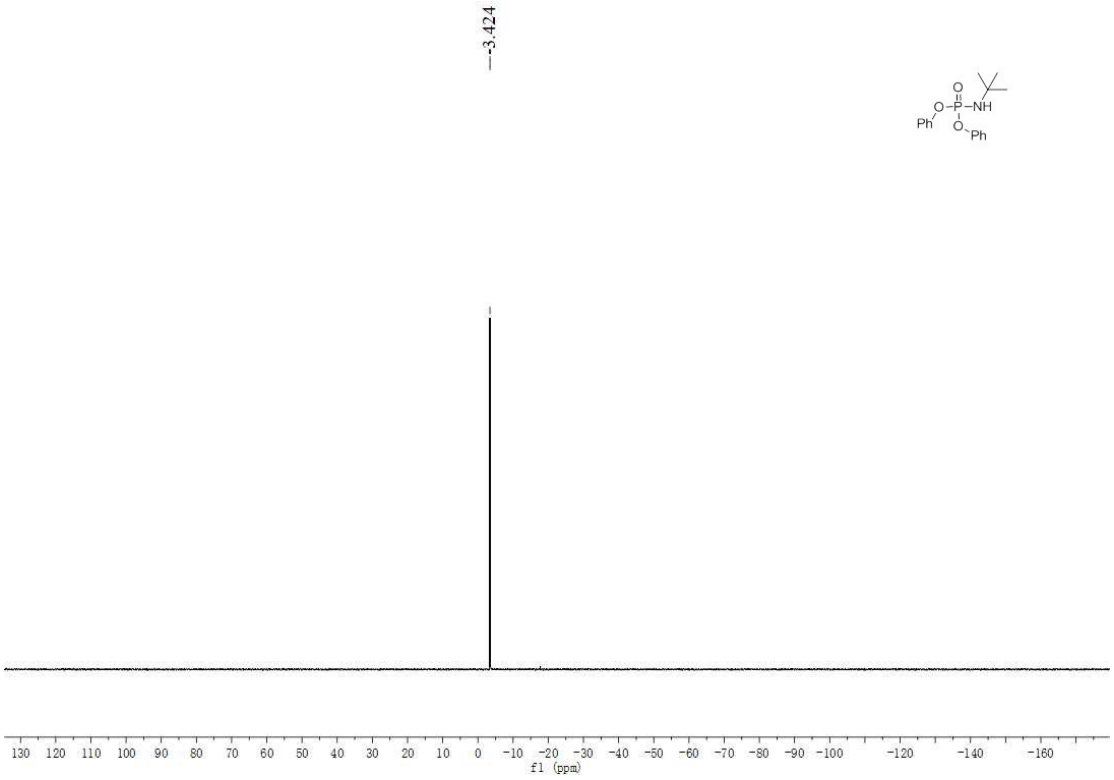

7.341
7.320
7.302
7.265
7.246
7.169
7.150
7.131
3.645
3.629
3.606
3.585
3.573
3.543
3.082
3.054
3.028
1.158
1.142
-0.000
O
O-P-NH
Ph
O
Ph
4.14
4.14
2.01
1.02
1.00
6.06
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0 -0.5
f1 (ppm)

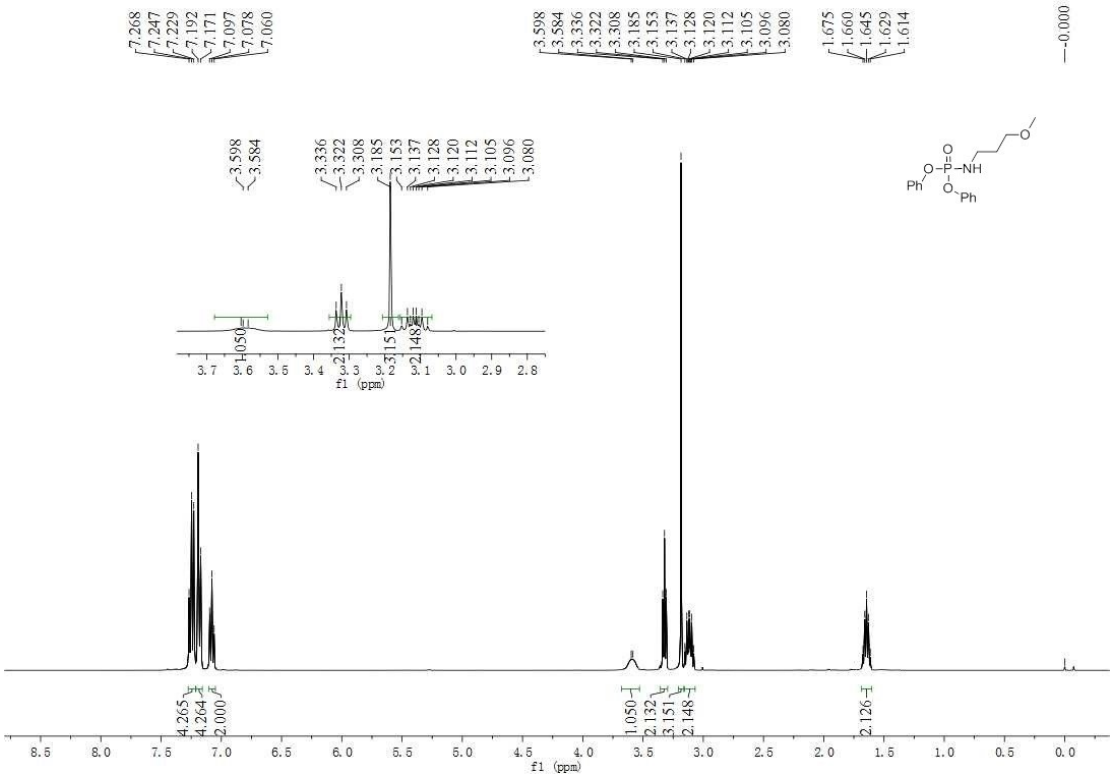

151.032
150.964
129.645
124.810
120.247
120.197
77.381
77.063
76.745
44.559
25.139
25.082
O
O-P-NH
Ph
O
Ph
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)

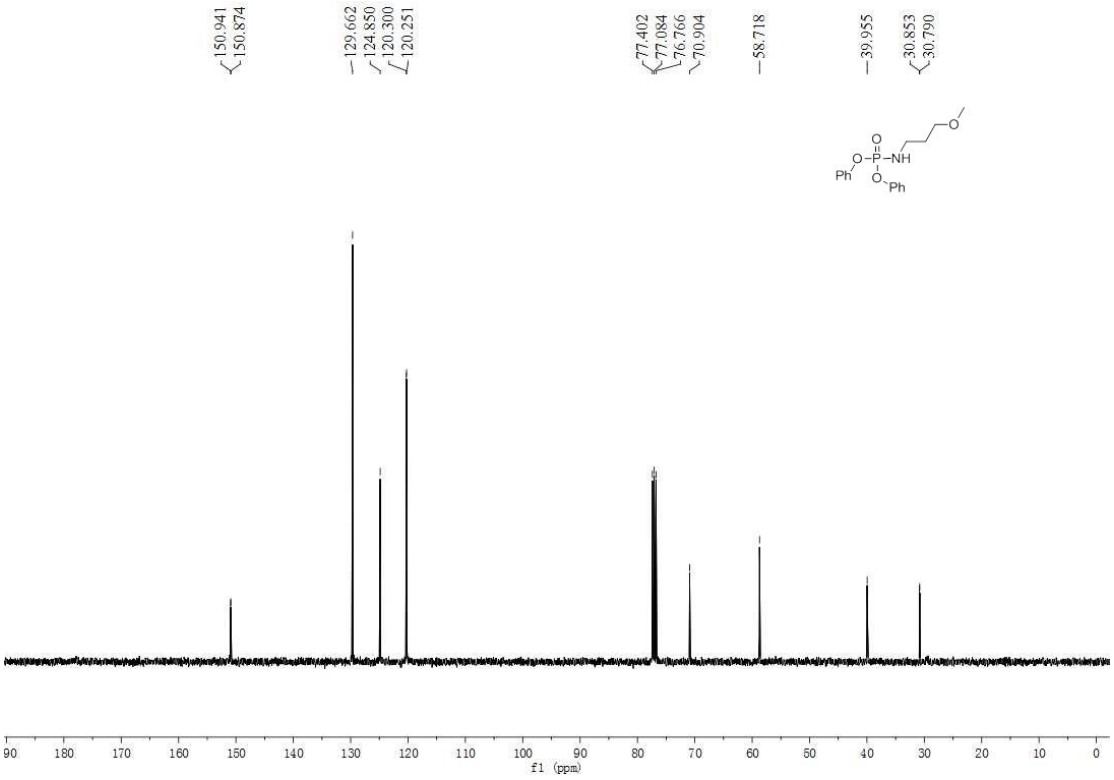

-1.790
O
O-P-NH
Ph
O
Ph
110 100 90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80
f1 (ppm)

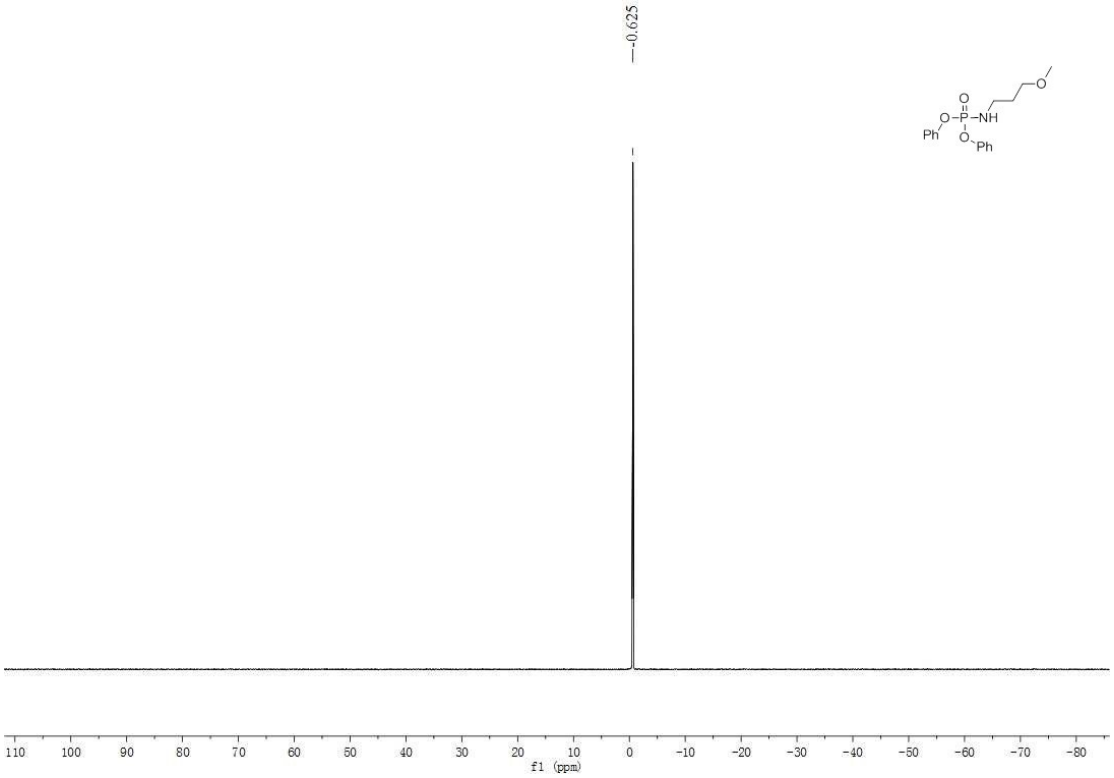

7.339
7.318
7.300
7.259
7.256
7.237
7.234
7.165
7.163
7.147
7.145
7.129
7.127
3.067
3.045
1.353
0.000
4.32
4.37
2.00
1.00
9.34
f1 (ppm)

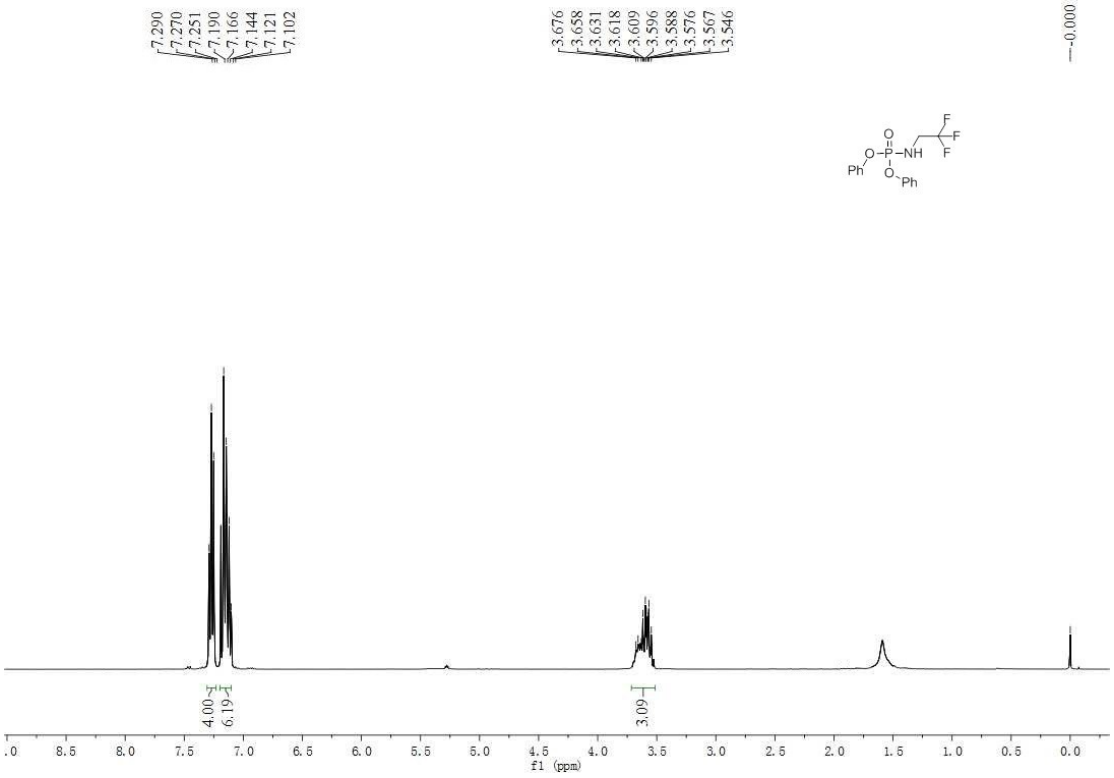

151.145
151.074
129.627
124.718
120.174
120.123
77.353
77.035
76.718
51.802
31.321
31.272
f1 (ppm)

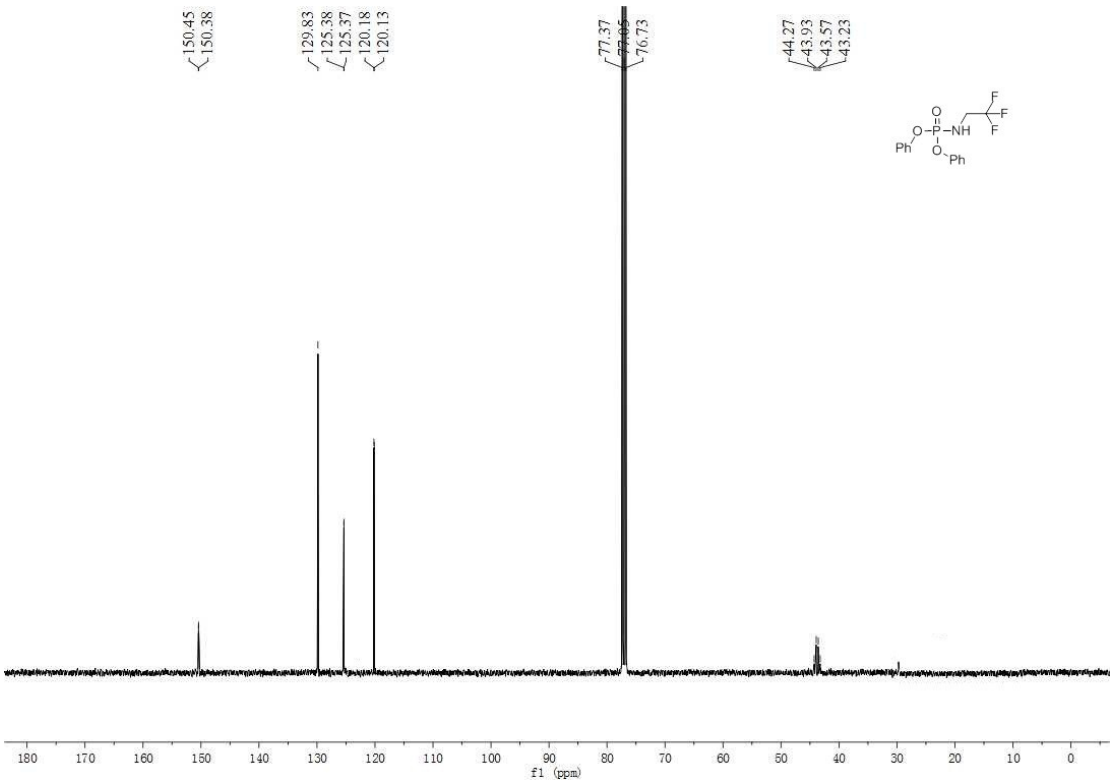

3.424
f1 (ppm)

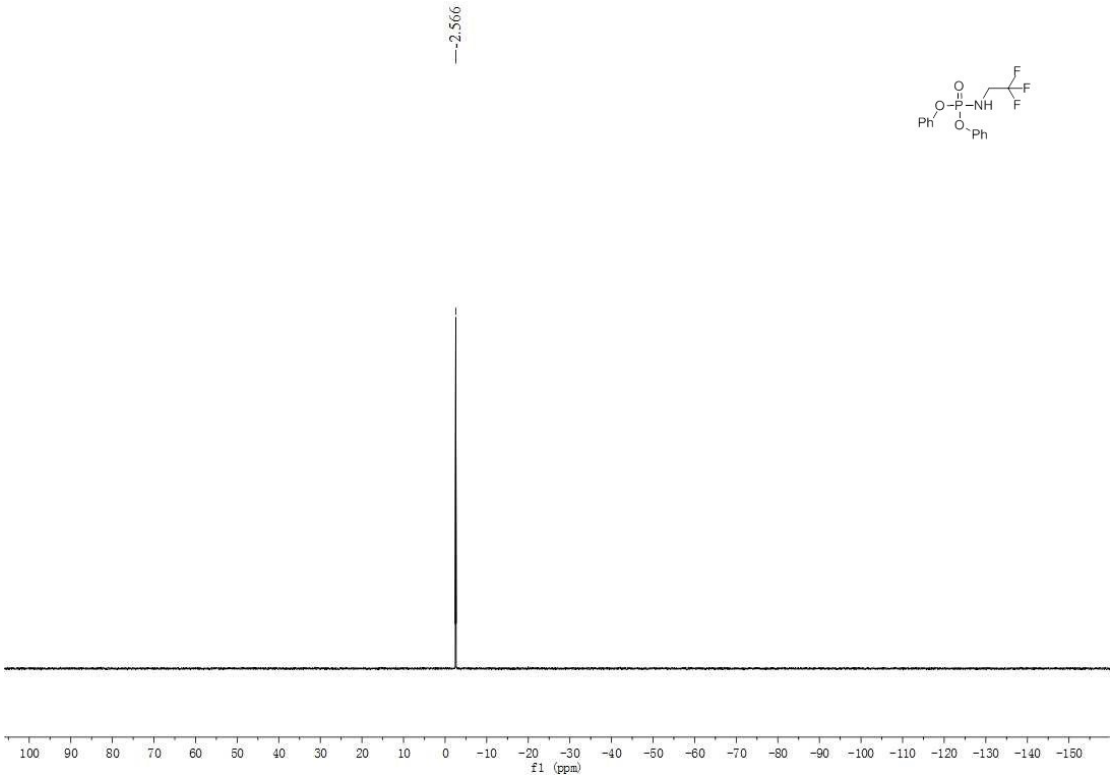

7.268
7.247
7.229
7.192
7.171
7.097
7.078
7.060
3.598
3.584
3.336
3.322
3.308
3.185
3.153
3.137
3.128
3.120
3.112
3.105
3.096
3.080
1.675
1.660
1.645
1.629
1.614
0.000
1.050
2.132
3.151
2.148
4.265
4.264
2.000
1.050
2.132
3.151
2.148
2.126
f1 (ppm)

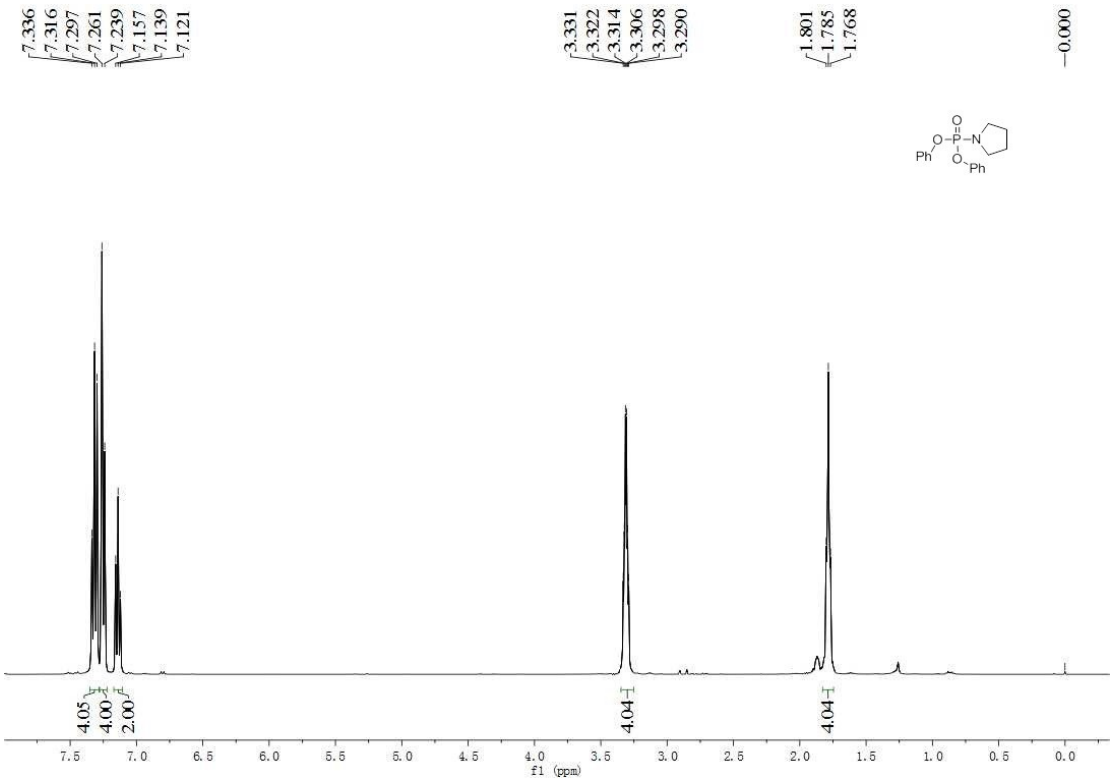

150.941
150.874
129.662
124.850
120.300
120.251
77.402
77.084
76.766
70.904
58.718
39.955
30.853
30.790
f1 (ppm)

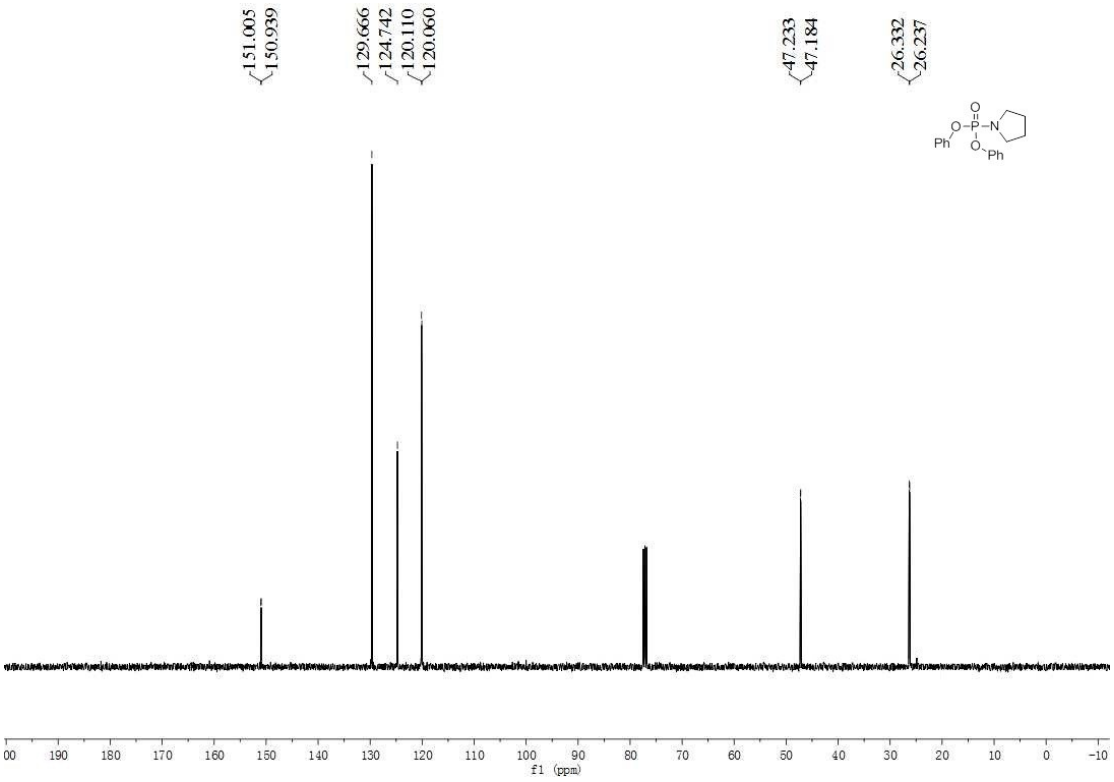

0.625
f1 (ppm)


7.290
7.270
7.251
7.190
7.166
7.144
7.121
7.102
3.676
3.658
3.631
3.618
3.609
3.596
3.588
3.576
3.567
3.546
-0.000
4.00
6.19
3.09
f1 (ppm)


150.45
150.38
129.83
125.38
125.37
120.18
120.13
77.37
77.05
76.73
44.27
43.93
43.57
43.23
f1 (ppm)


-2.566
F
F
F
O
P
NH
O
Ph
O
Ph
100 90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150
f1 (ppm)


7.336
7.316
7.297
7.261
7.239
7.157
7.139
7.121
3.331
3.322
3.314
3.306
3.298
3.290
1.801
1.785
1.768
0.000
O
P
N
Ph
O
Ph
4.05
4.00
2.00
4.04
4.04
7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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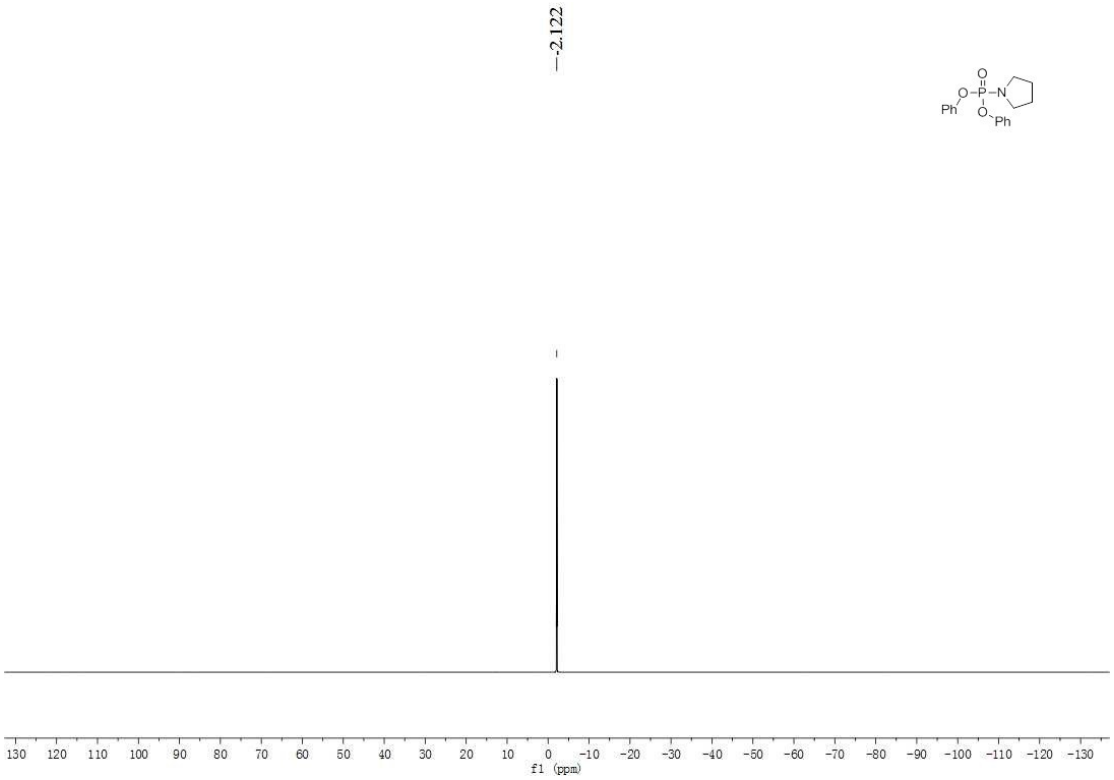
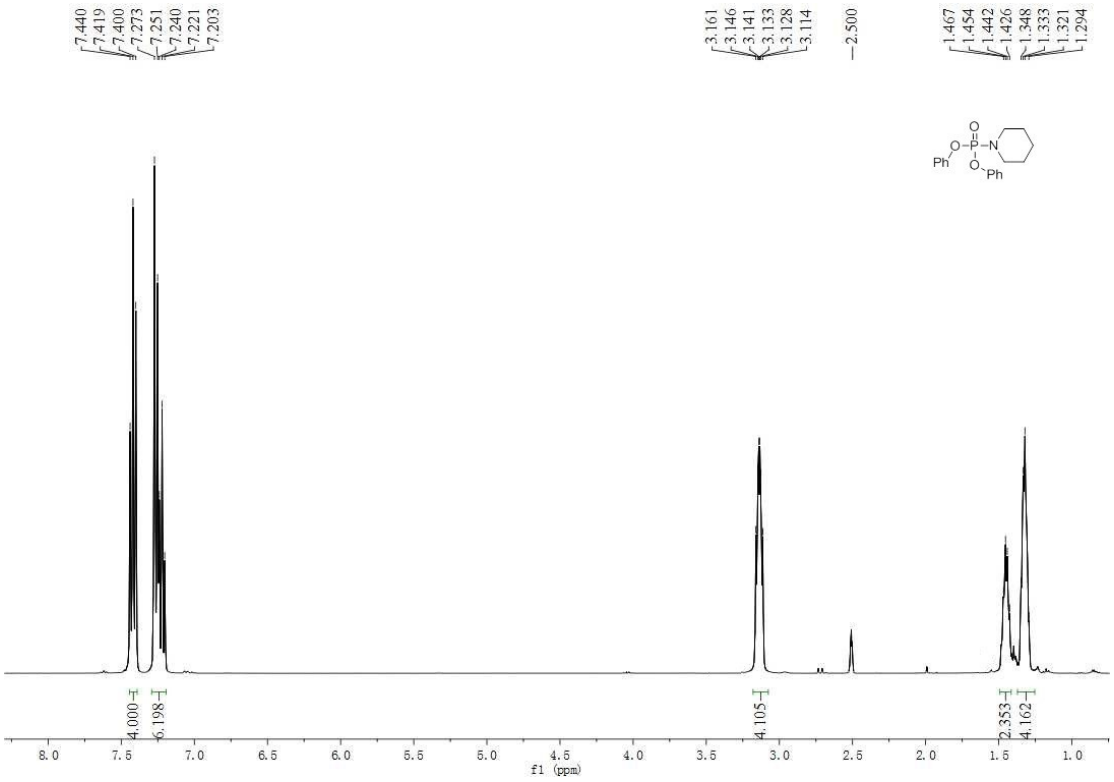
120.110
120.060
47.233
47.184
26.332
26.237
f1 (ppm)


-2.122
f1 (ppm)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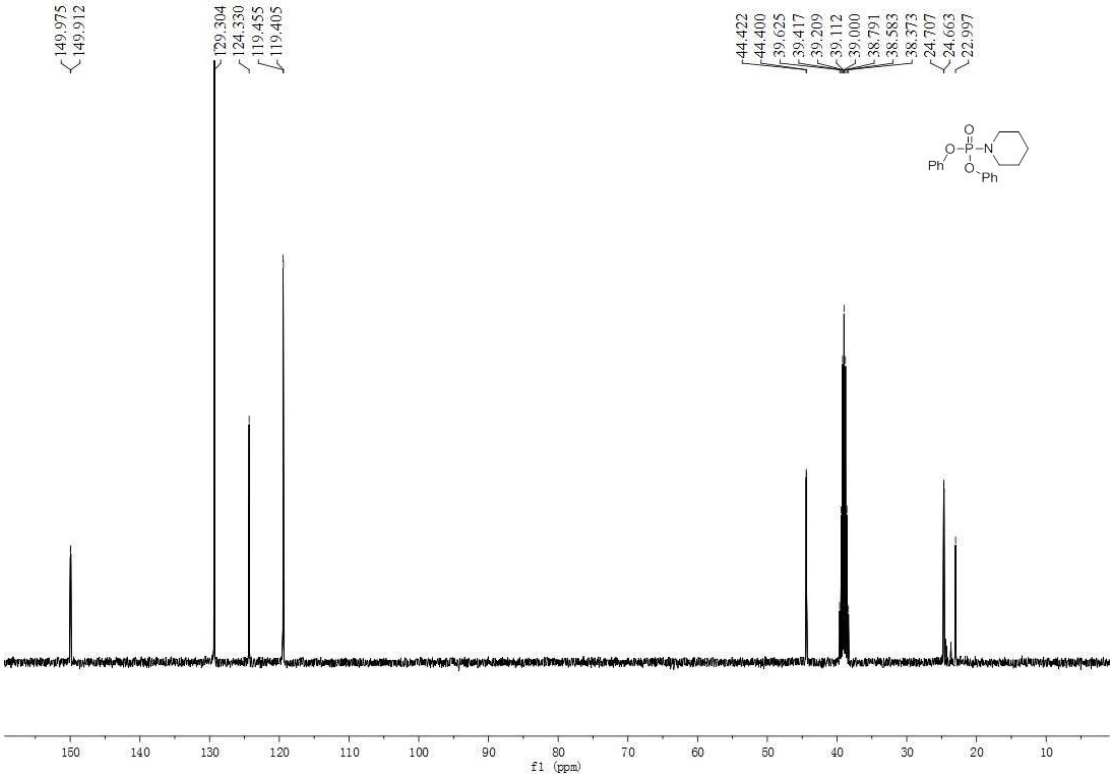
7.419
7.400
7.273
7.251
7.240
7.221
7.203
3.161
3.146
3.141
3.133
3.128
3.114
2.500
1.467
1.454
1.442
1.426
1.348
1.333
1.321
1.294
Ph
O
P
O
N
O
Ph
4.000
6.198
4.105
2.353
4.162
f1 (ppm)


149.975
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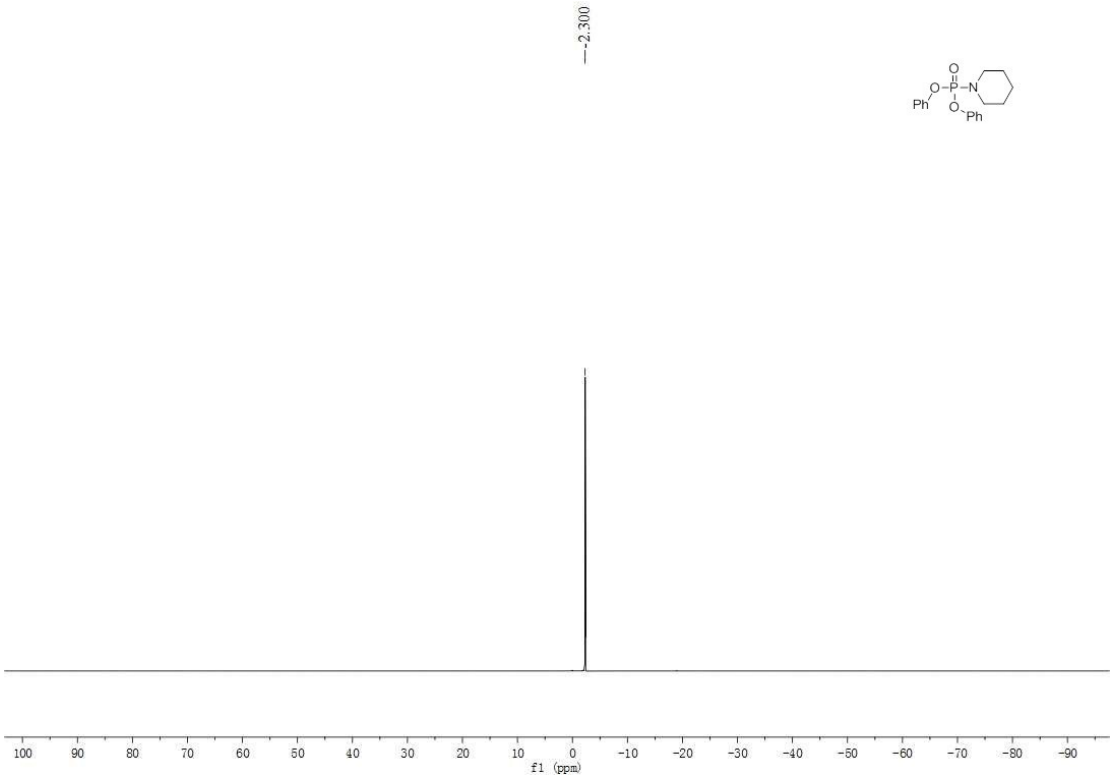
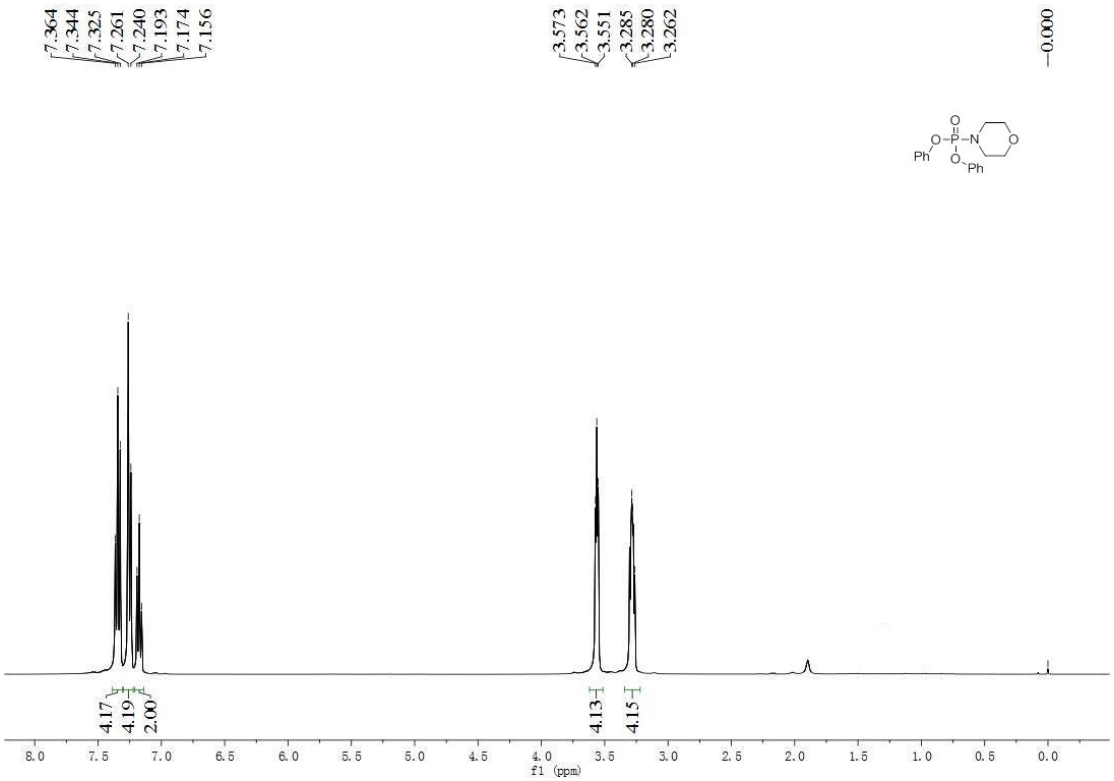
129.304
124.330
119.455
119.405
44.422
44.400
39.625
39.417
39.209
39.112
39.000
38.791
38.583
38.373
24.707
24.663
22.997
Ph
O
P
O
N
O
Ph
f1 (ppm)


-2.300
Ph
O
P
O
N
Ph
100 90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90
f1 (ppm)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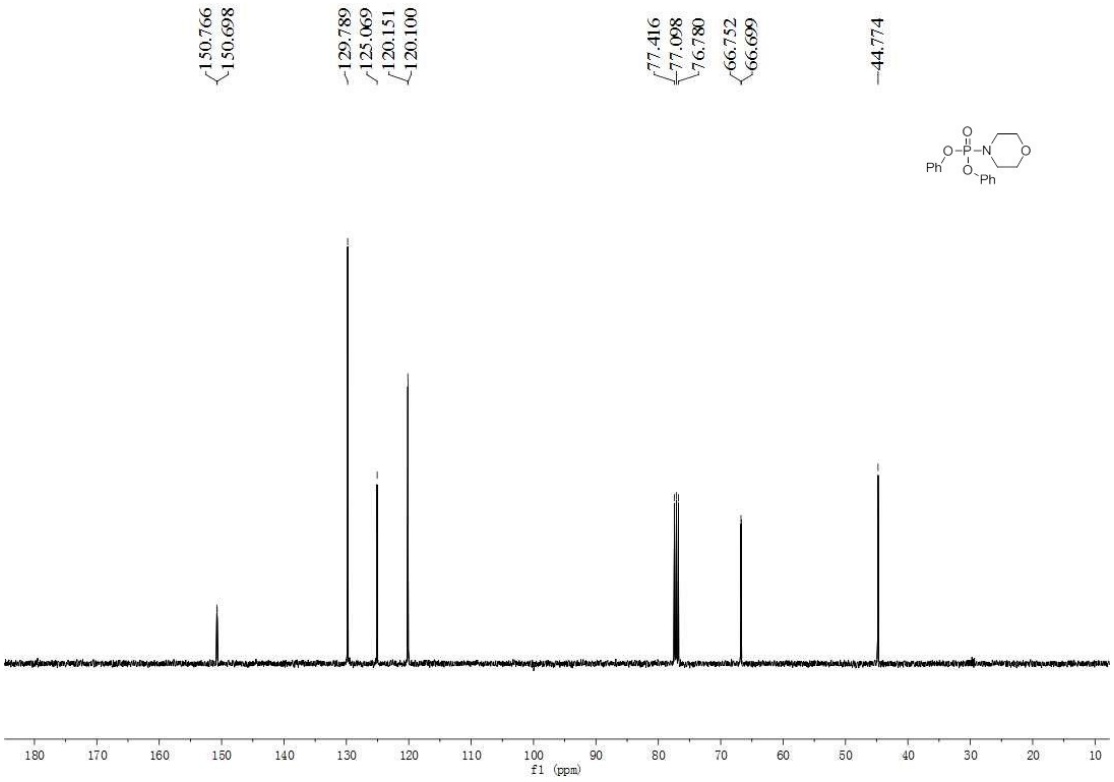
7.261
7.240
7.193
7.174
7.156
3.573
3.562
3.551
3.285
3.280
3.262
-0.000
Ph
O
P
O
N
O
Ph
4.17
4.19
2.00
4.13
4.15
8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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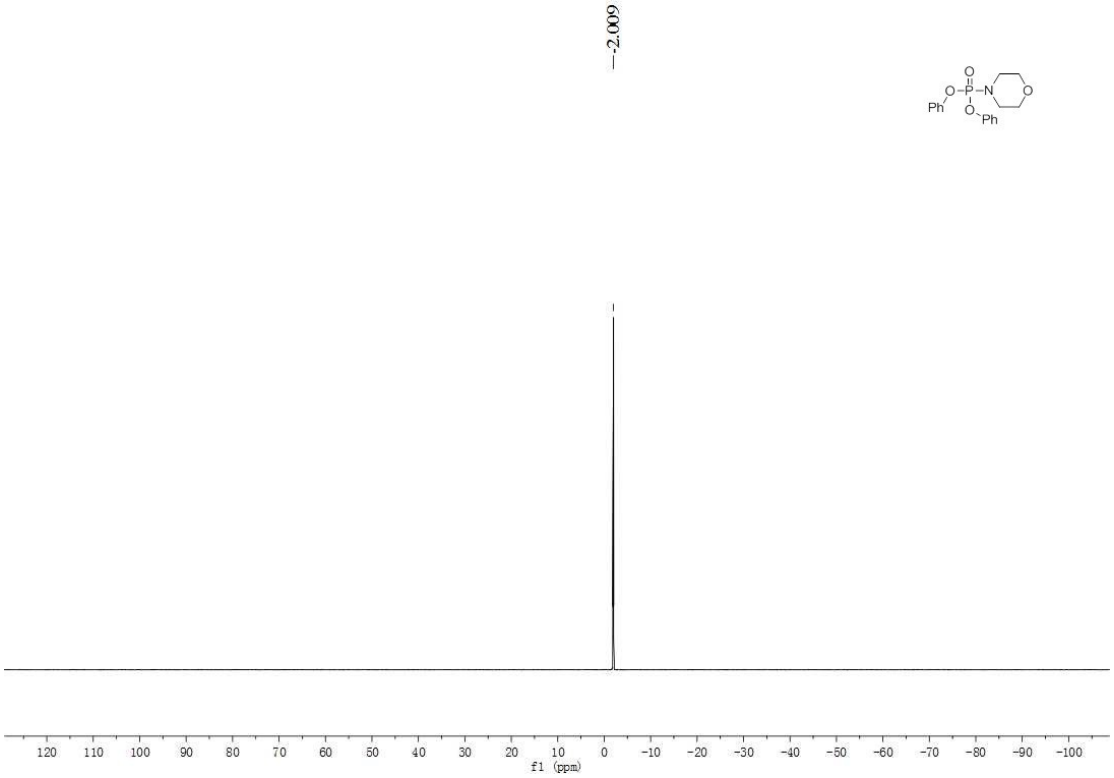
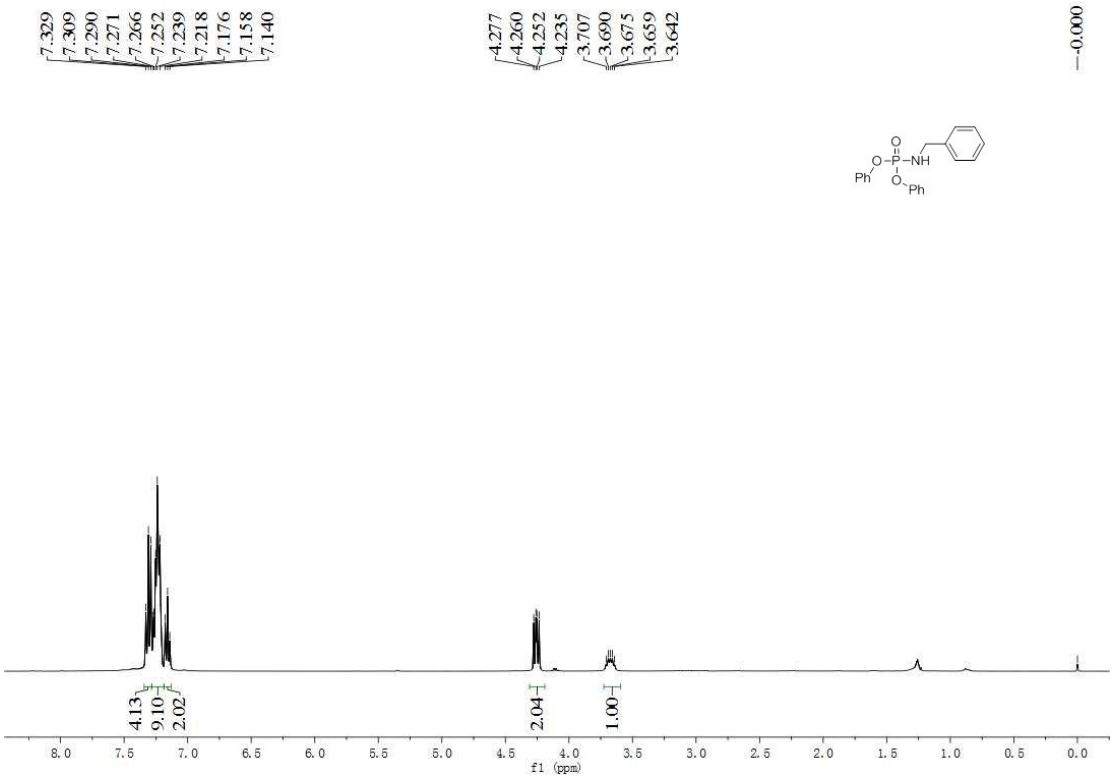
129.789
125.069
120.151
120.100
77.416
77.098
76.780
66.752
66.699
44.774
Ph
O
P
N
O
O
Ph
180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
f1 (ppm)


2.009
Ph
O
P
N
O
O
Ph
120 110 100 90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100
f1 (ppm)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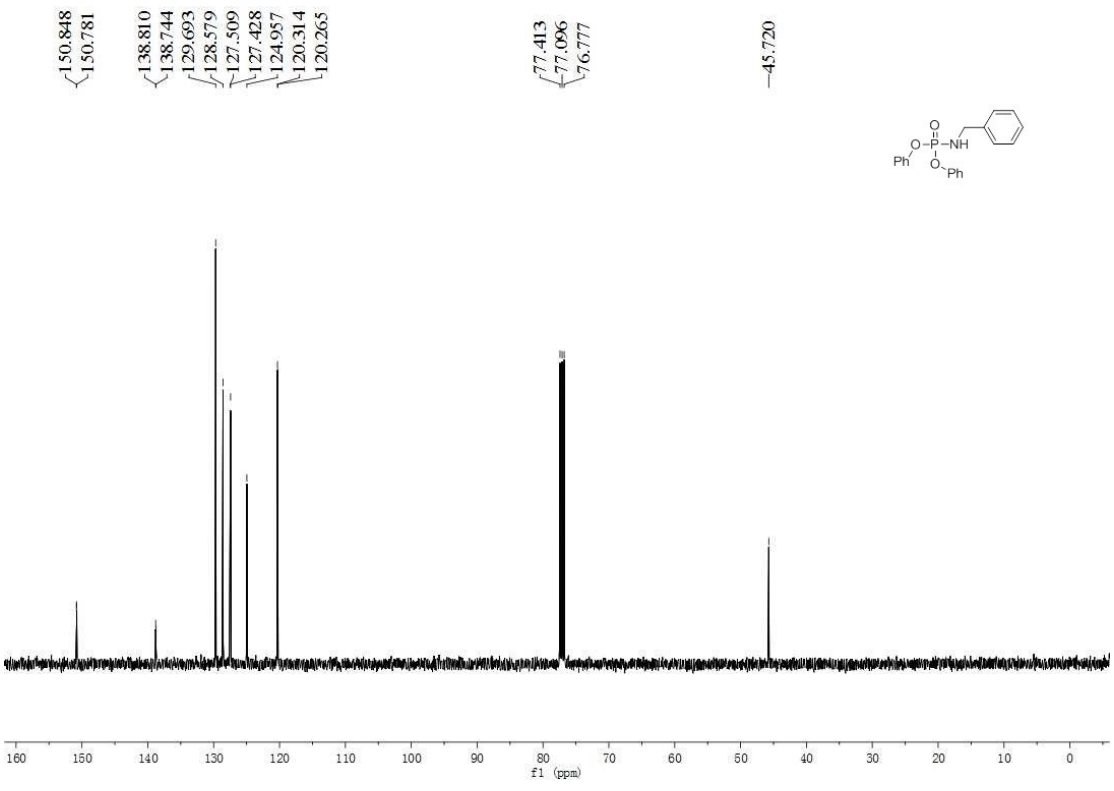
7.309
7.290
7.271
7.266
7.252
7.239
7.218
7.176
7.158
7.140
4.277
4.260
4.252
4.235
3.707
3.690
3.675
3.659
3.642
0.000
4.13
9.10
2.02
2.04
1.00
f1 (ppm)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138.744
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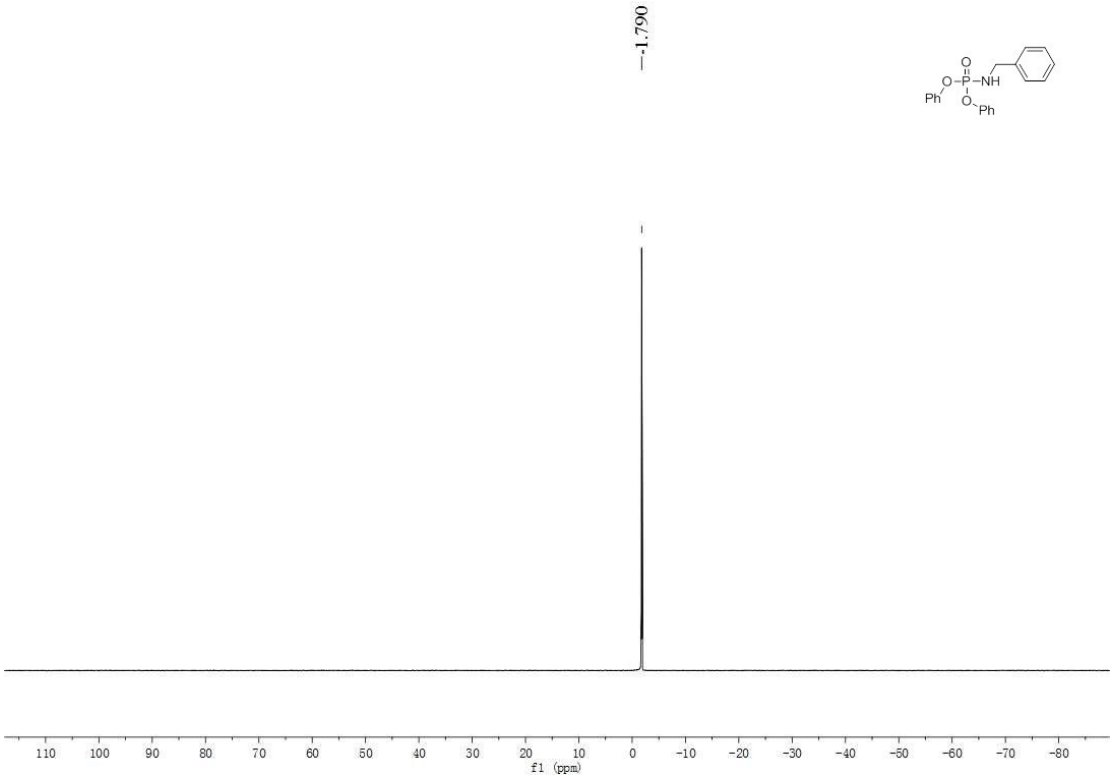
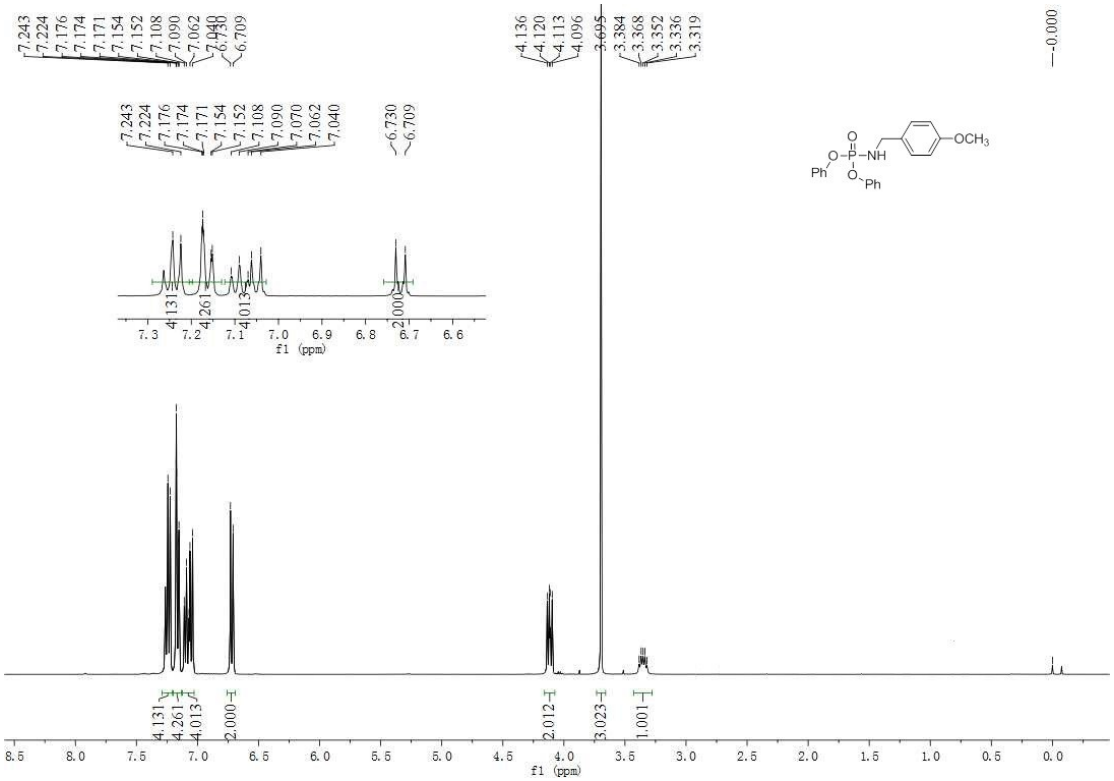
127.428
124.957
120.314
120.265
77.413
77.096
76.777
45.720
f1 (ppm)


-1.790
Ph
O
P
NH
Ph
110 100 90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80
f1 (ppm)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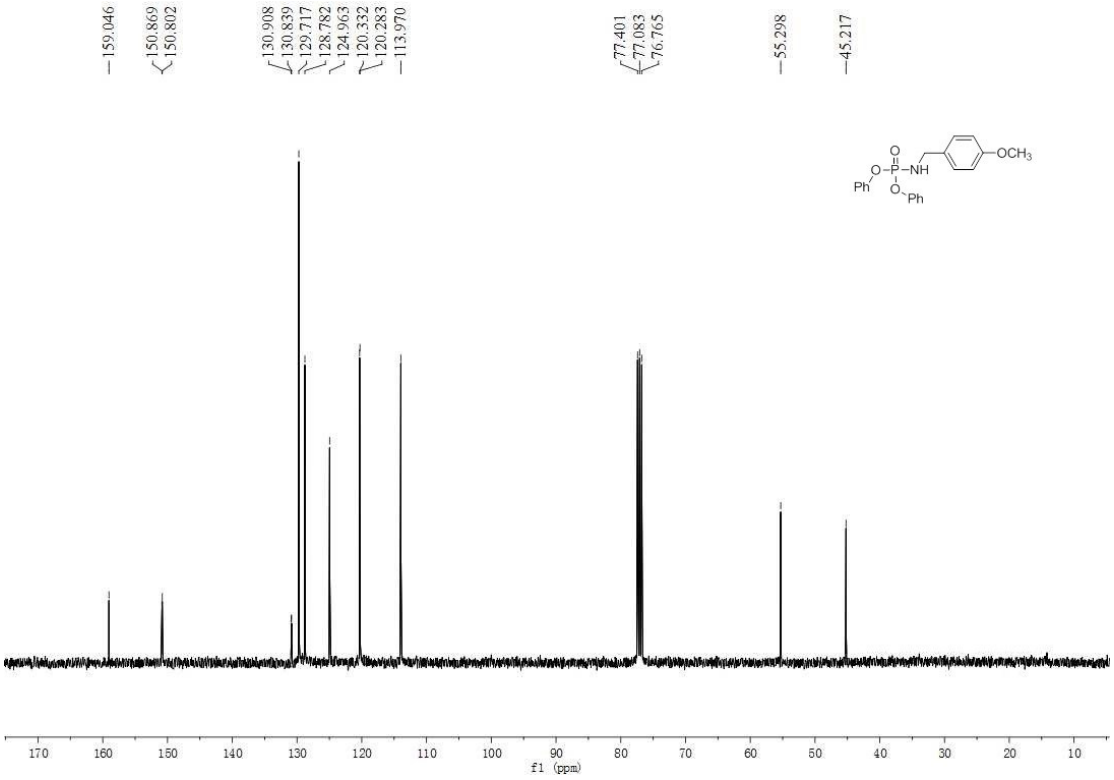
7.176
7.174
7.171
7.154
7.152
7.108
7.090
7.062
7.040
6.730
6.709
4.136
4.120
4.113
4.096
3.695
3.384
3.368
3.352
3.336
3.319
-0.000
OCH3
4.131
4.261
4.013
2.000
2.012
3.023
1.001
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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130.839
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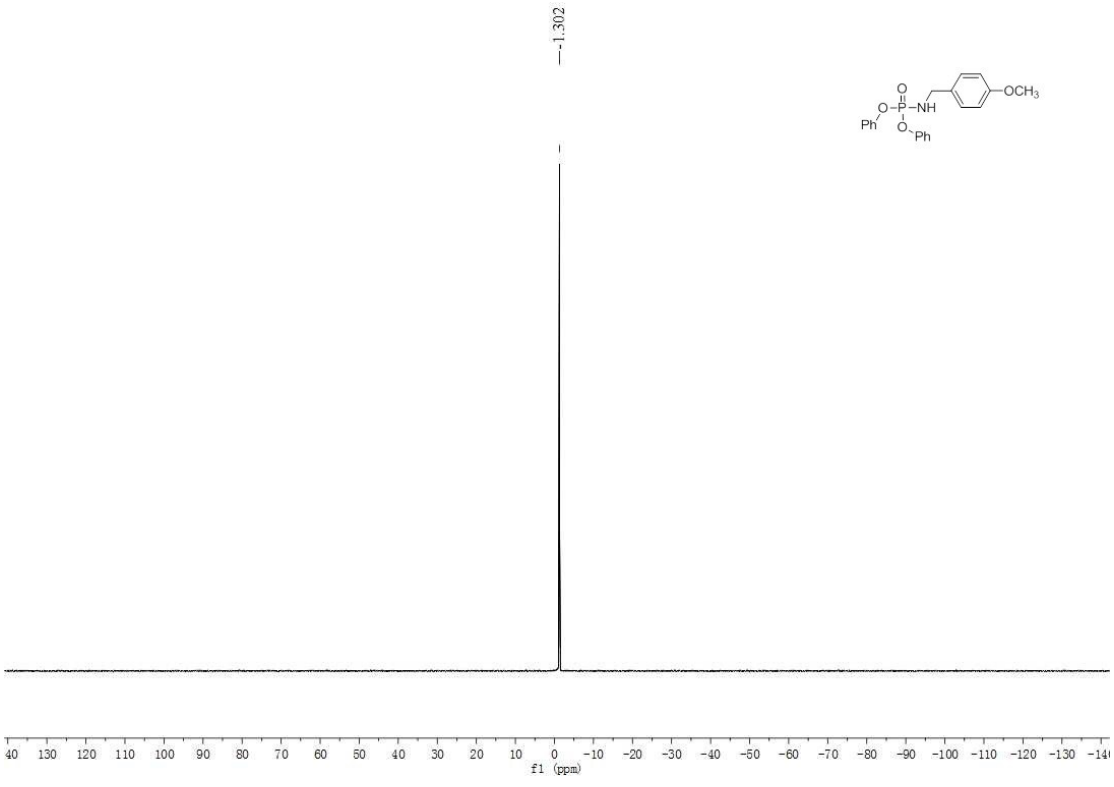
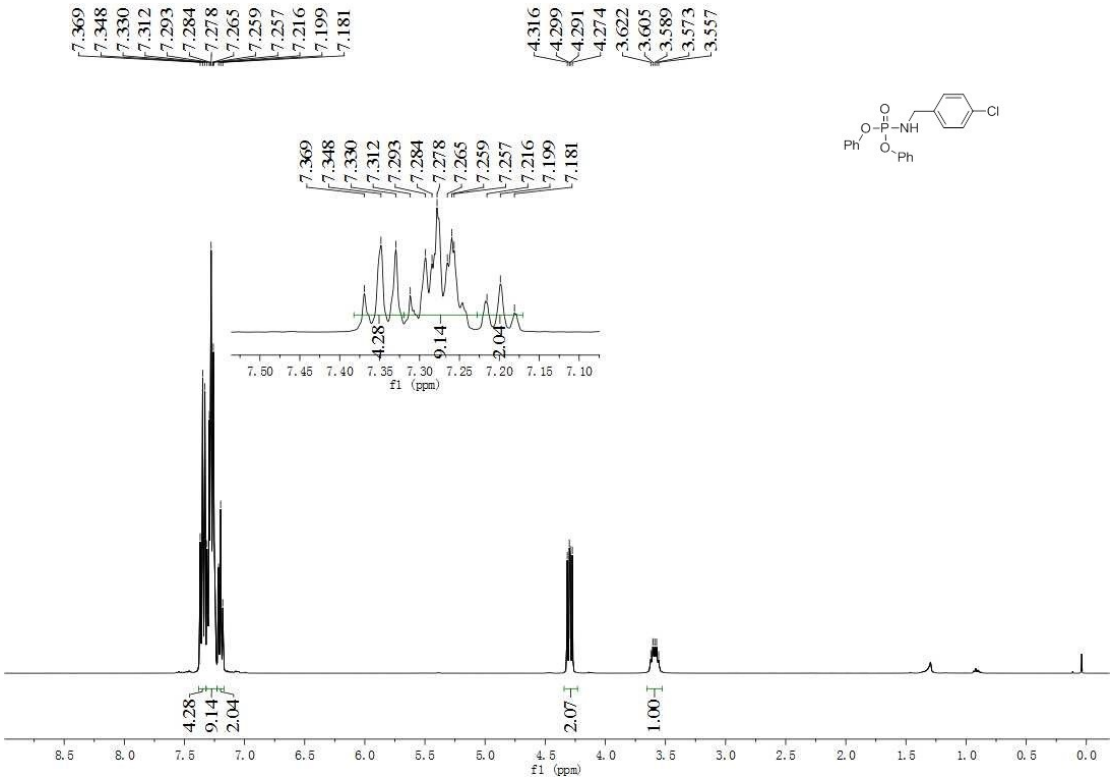
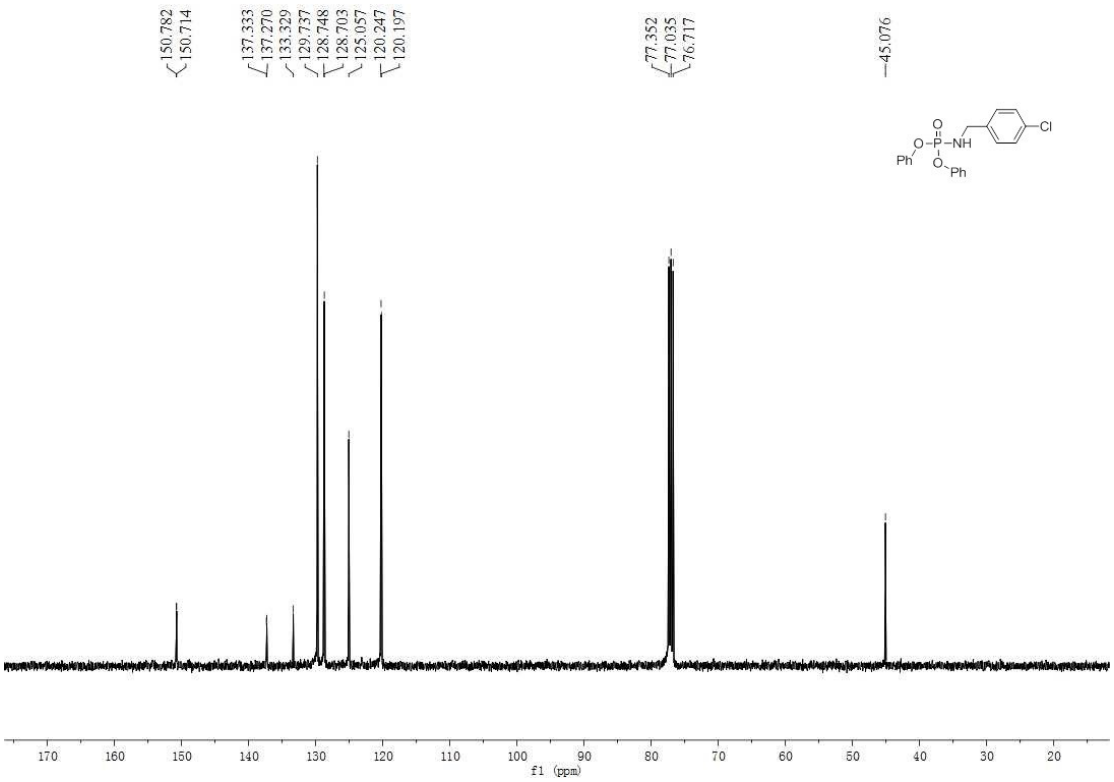
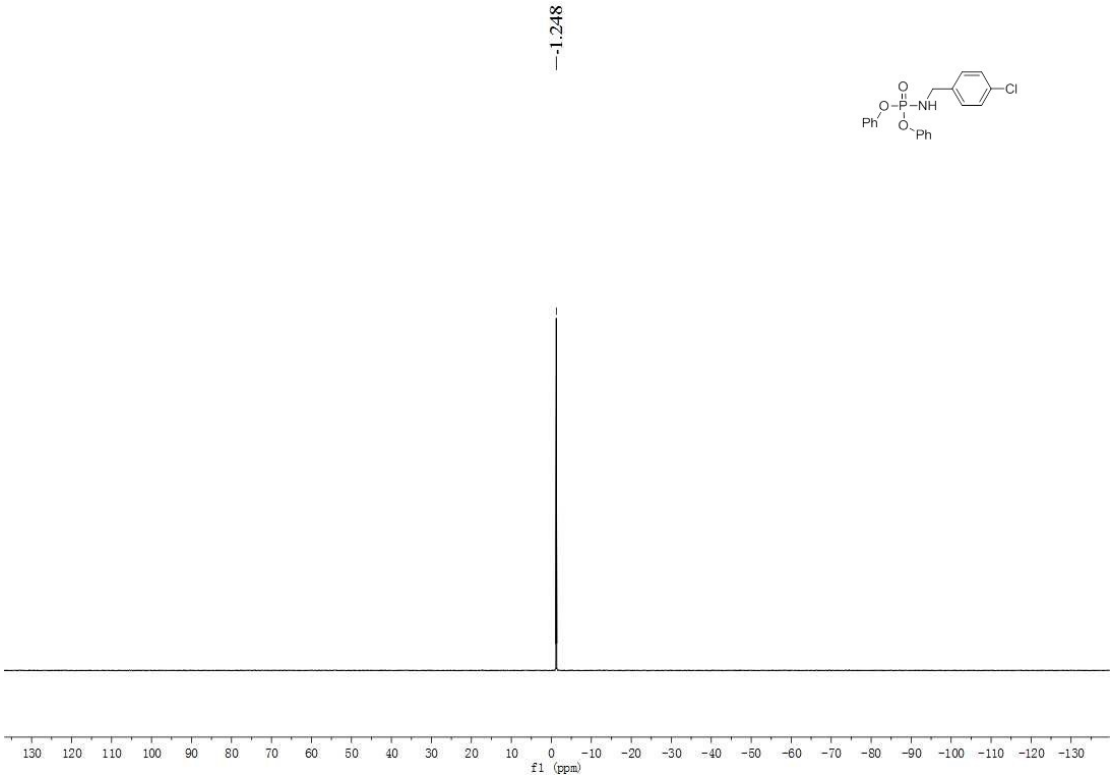
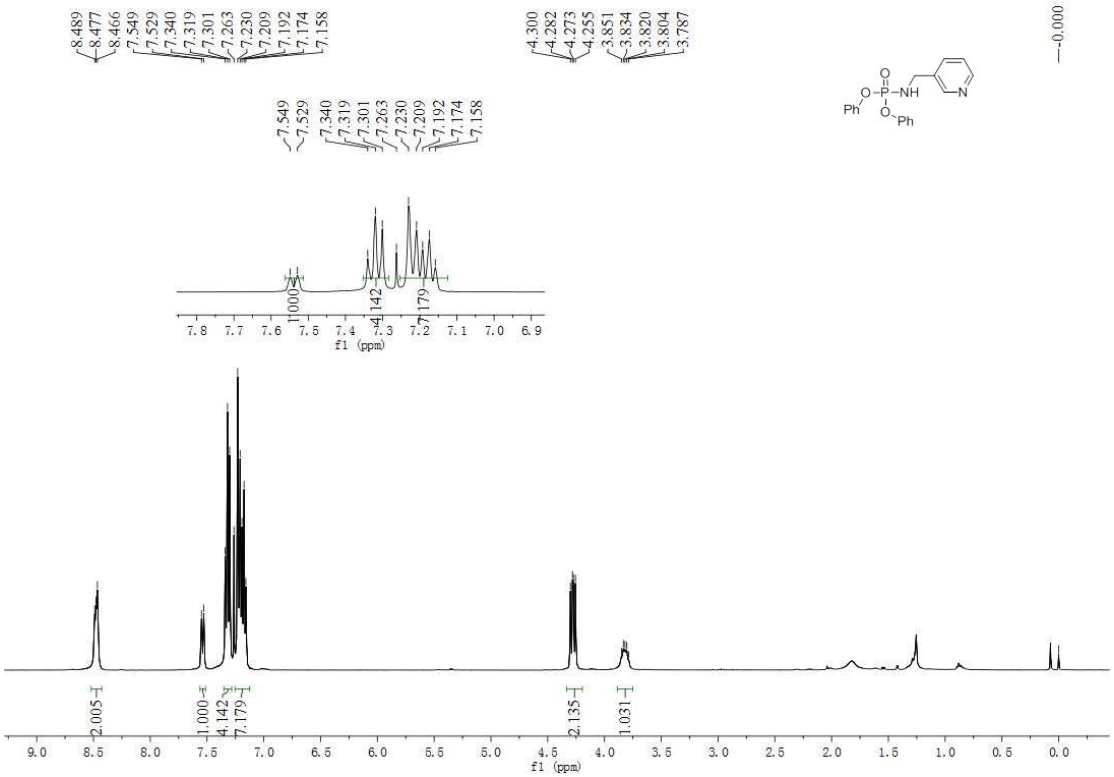
128.782
124.963
120.332
120.283
113.970
77.401
77.083
76.765
55.298
45.217
OCH3
O
P
NH
Ph
Ph
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
f1 (ppm)

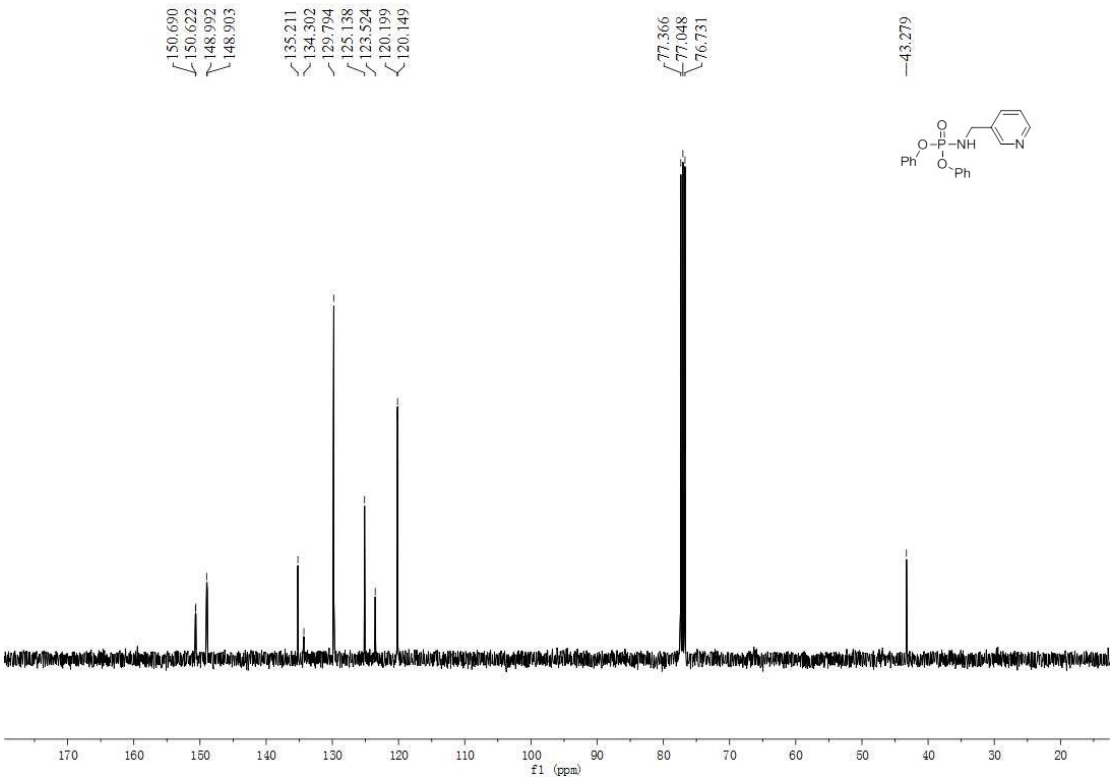

1.302
OCH3
O
P
NH
Ph
Ph
40 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -14
f1 (ppm)

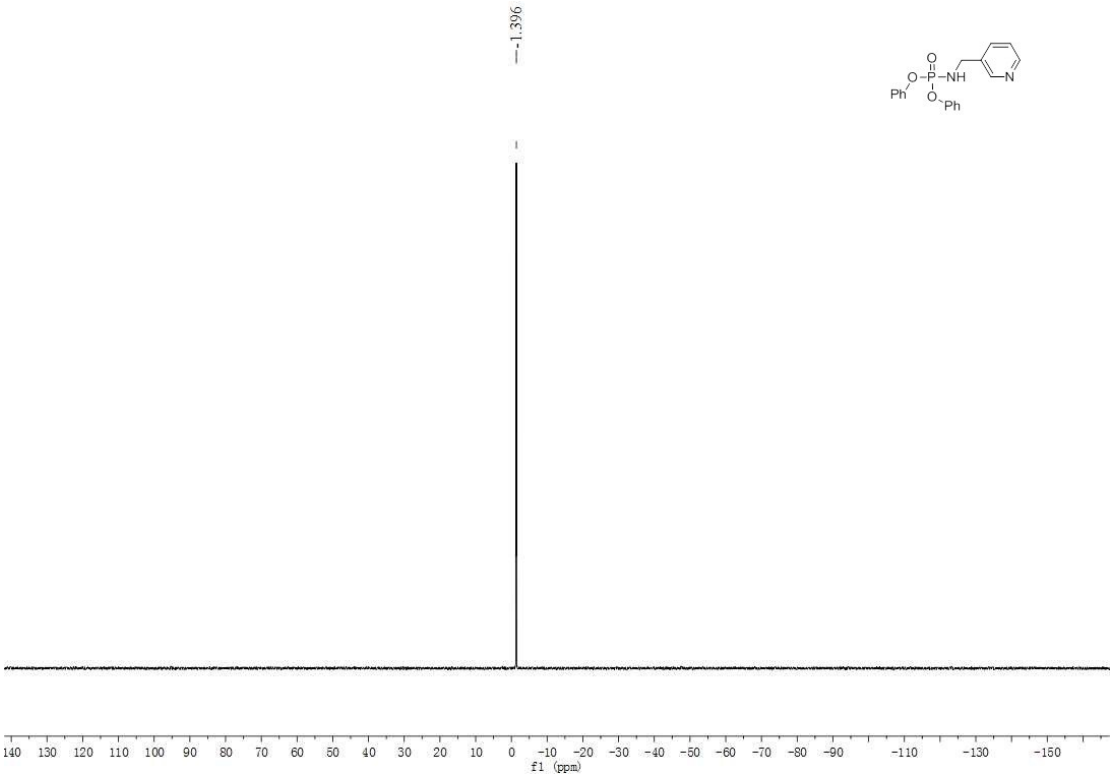

7.369
7.348
7.330
7.312
7.293
7.284
7.278
7.265
7.259
7.257
7.216
7.199
7.181
4.316
4.299
4.291
4.274
3.622
3.605
3.589
3.573
3.557
Cl
Ph
NH
4.28
9.14
2.04
2.07
1.00
f1 (ppm)

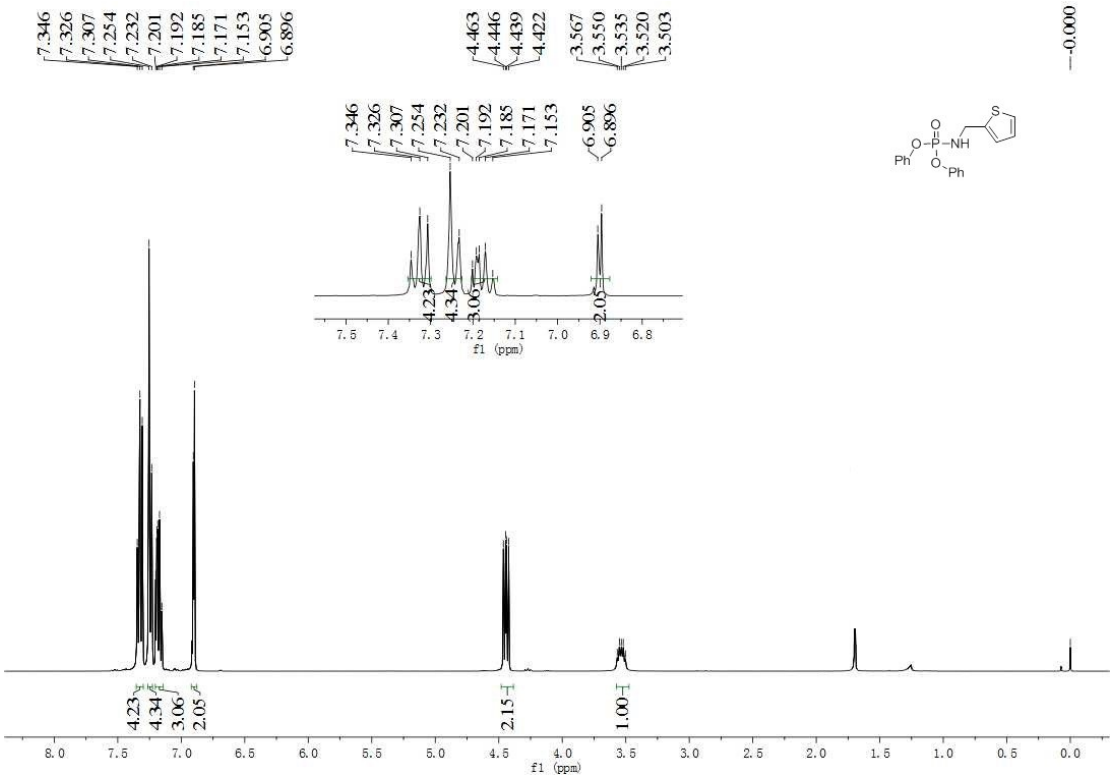

150.782
150.714
137.333
137.270
133.329
129.737
128.748
128.703
125.057
120.247
120.197
77.352
77.035
76.717
45.076
Cl
Ph
NH
f1 (ppm)

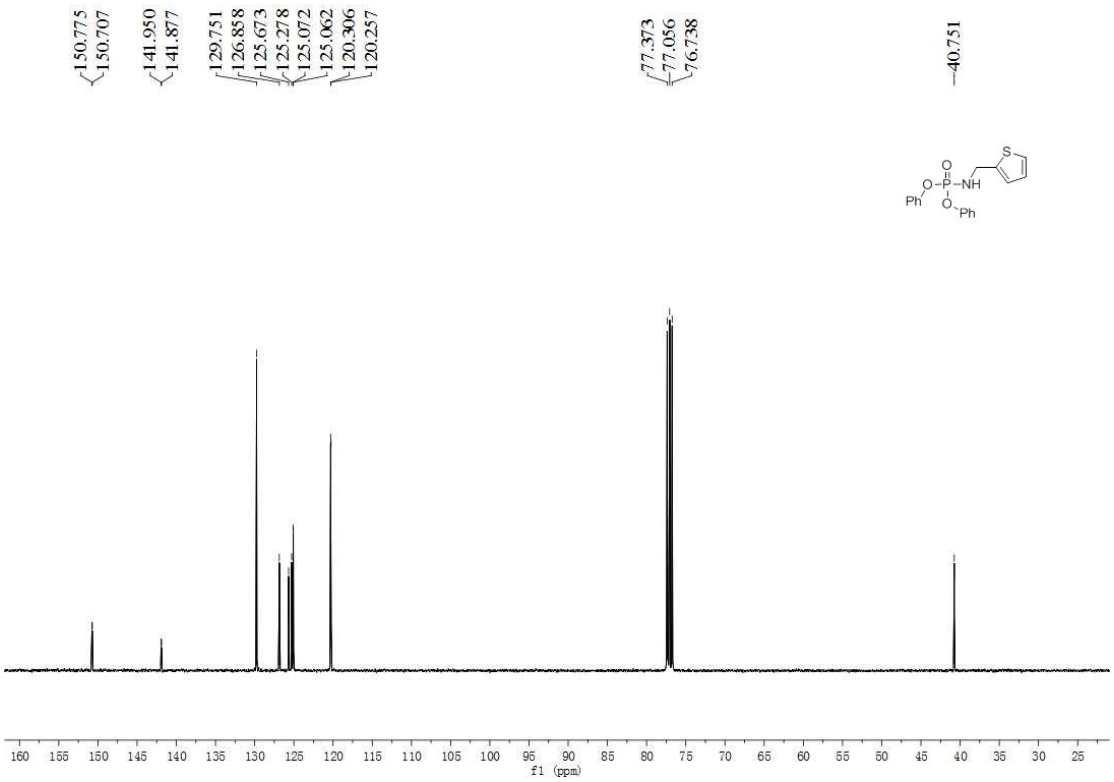

-1.248
Cl
Ph
Ph
130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130
f1 (ppm)

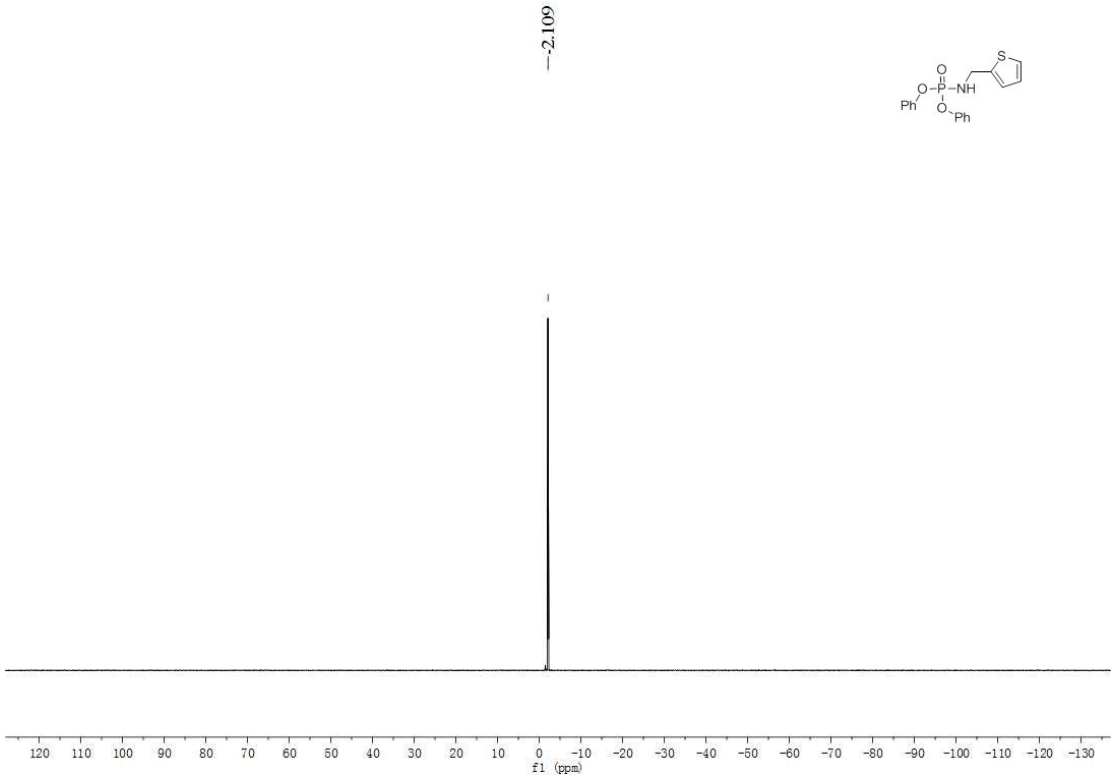

8.489
8.477
8.466
7.549
7.529
7.340
7.319
7.301
7.263
7.230
7.209
7.192
7.174
7.158
4.300
4.282
4.273
4.255
3.851
3.834
3.820
3.804
3.787
-0.000
Ph
Ph
1.000
4.142
7.179
2.005
1.000
4.142
7.179
2.135
1.031
f1 (ppm)

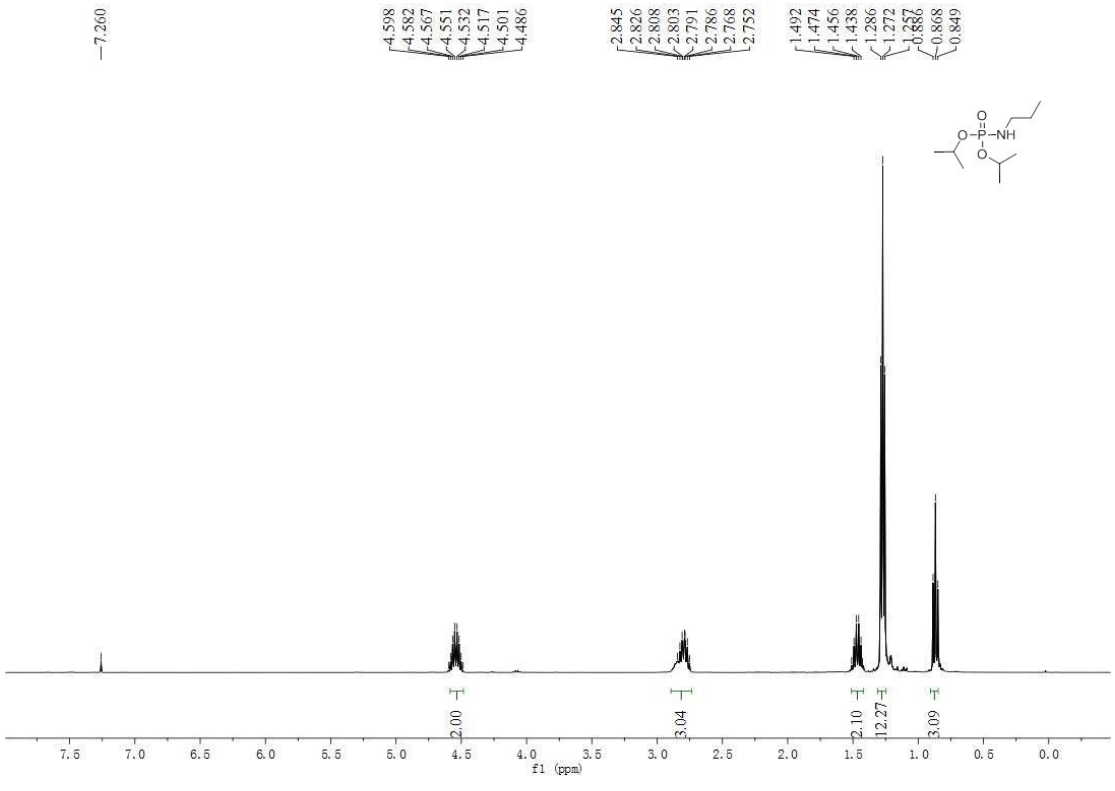

150.690
150.622
148.992
148.903
135.211
134.302
129.794
125.138
123.524
120.199
120.149
77.366
77.048
76.731
43.279
f1 (ppm)

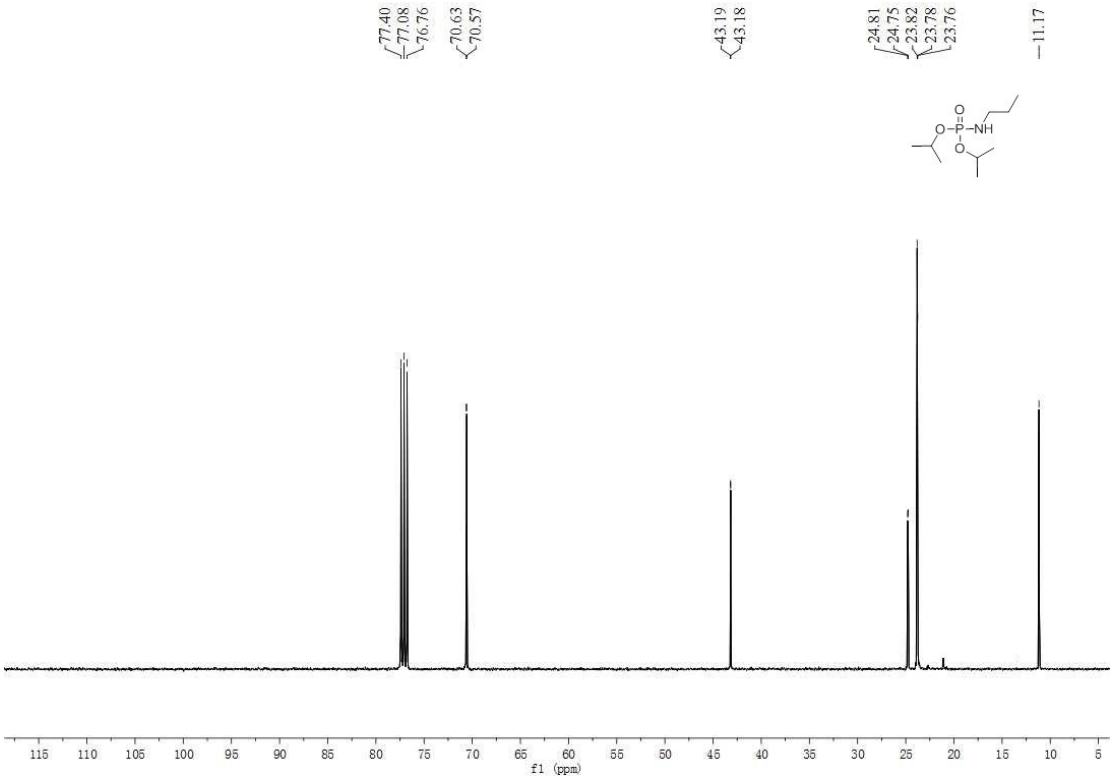

1.396
f1 (ppm)

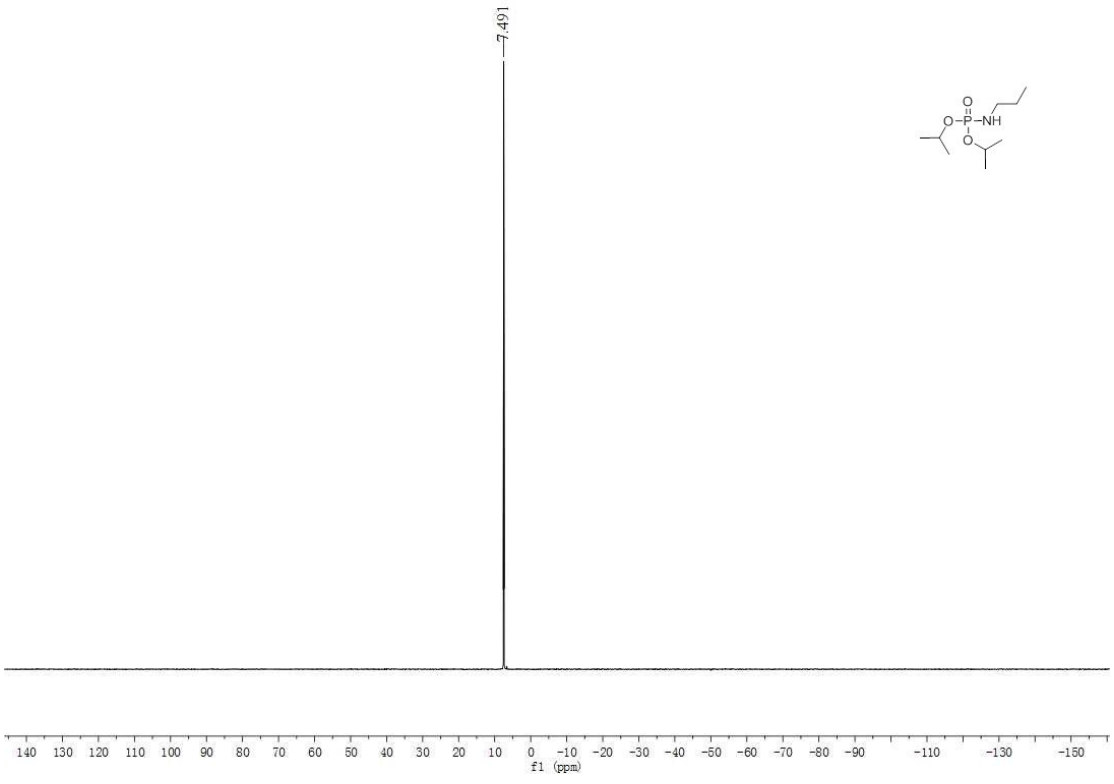

7.346
7.326
7.307
7.254
7.232
7.201
7.192
7.185
7.171
7.153
6.905
6.896
4.463
4.446
4.439
4.422
3.567
3.550
3.535
3.520
3.503
-0.000
4.23
4.34
3.06
2.05
2.15
1.00
f1 (ppm)

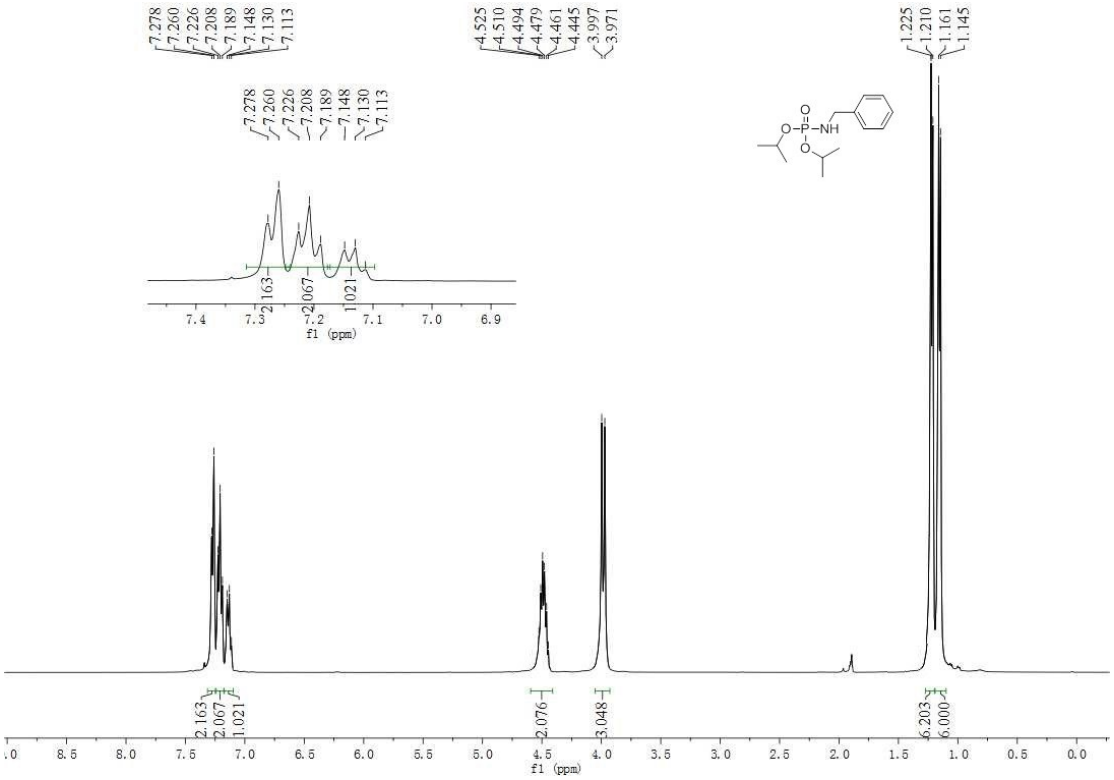

150.775
150.707
141.950
141.877
129.751
126.858
125.673
125.278
125.072
125.062
120.306
120.257
77.373
77.056
76.738
40.751
f1 (ppm)

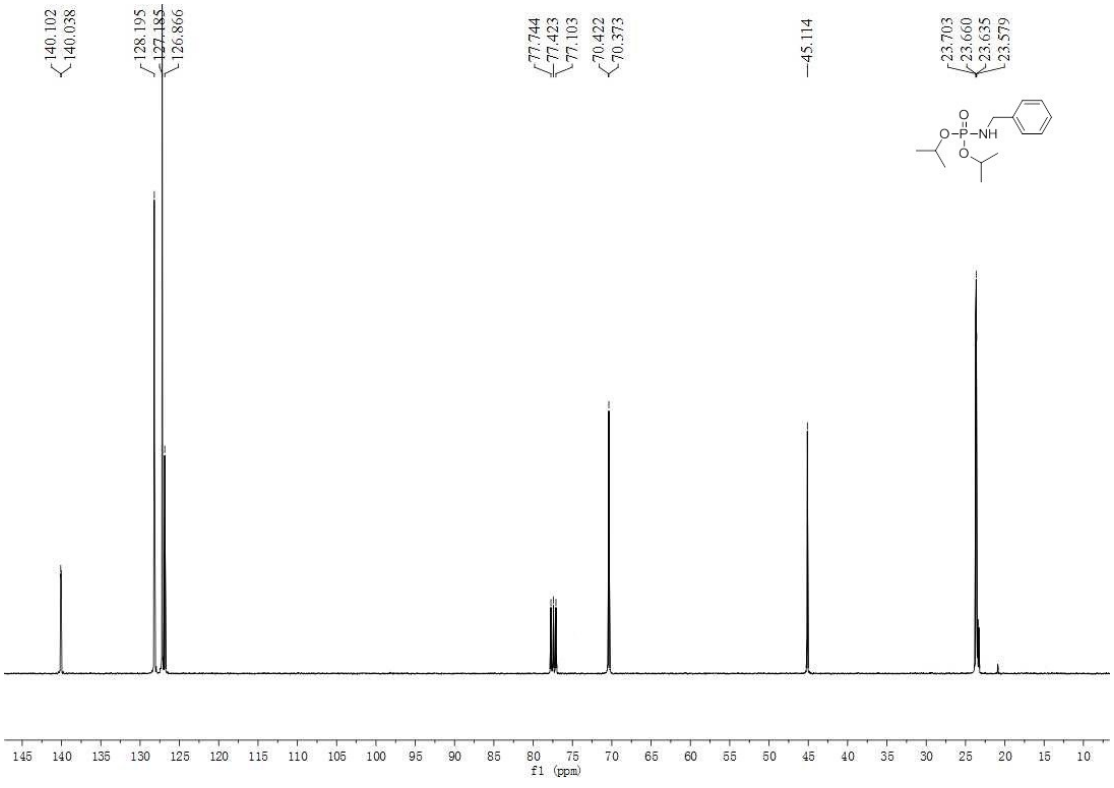

2.109
S
O
P
NH
Ph
O
Ph
120 110 100 90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130
f1 (ppm)

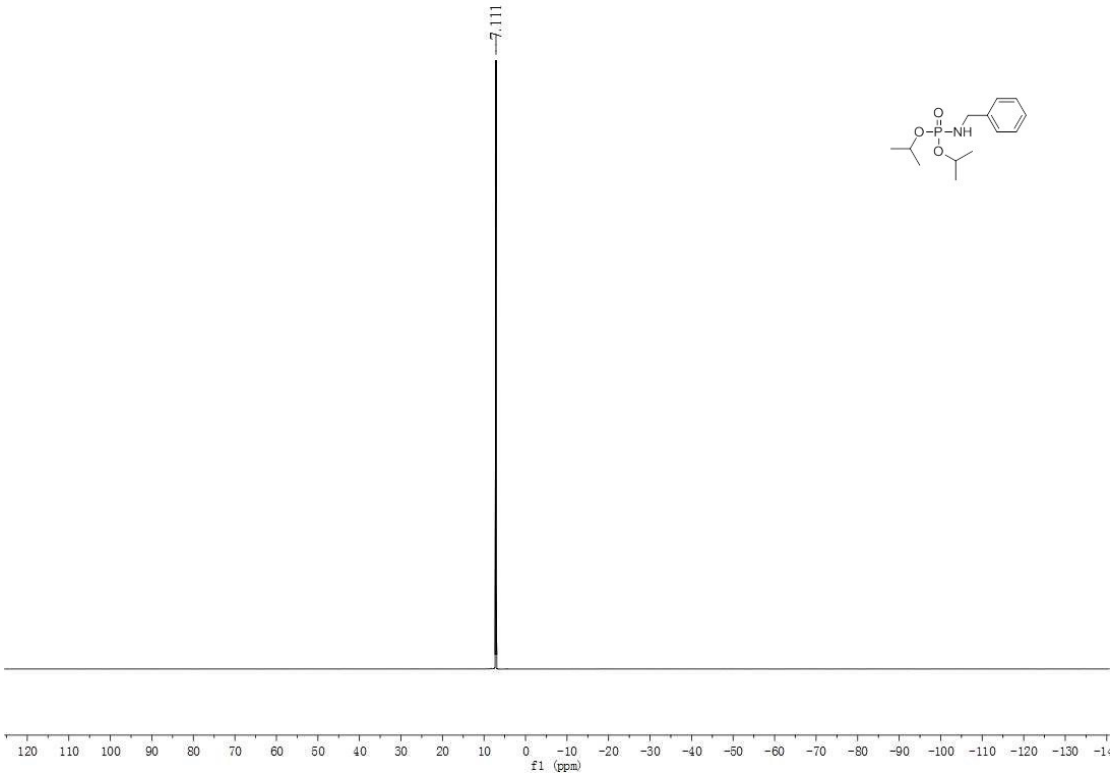

7.260
4.598
4.582
4.567
4.551
4.532
4.517
4.501
4.486
2.845
2.826
2.808
2.803
2.791
2.786
2.768
2.752
1.492
1.474
1.456
1.438
1.286
1.272
1.257
0.886
0.868
0.849
O
P
NH
O
O
2.00
3.04
2.10
12.27
3.09
7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)


77.40
77.08
76.76
70.63
70.57
43.19
43.18
24.81
24.75
23.82
23.78
23.76
11.17
O
O-P=O-NH
f1 (ppm)


7.491
O
O-P=O-NH
f1 (ppm)


7.278
7.260
7.226
7.208
7.189
7.148
7.130
7.113
4.525
4.510
4.494
4.479
4.461
4.445
3.997
3.971
1.225
1.210
1.161
1.145
2.163
2.067
1.021
2.076
3.048
6.203
6.000
f1 (ppm)


140.102
140.038
128.195
127.185
126.866
77.744
77.423
77.103
70.422
70.373
45.114
23.703
23.660
23.635
23.579
f1 (ppm)


7.111
O
O-P-NH
O
120 110 100 90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130
f1 (ppm)