Supporting Information

General and Chemoselective Bisphosphonylation of Secondary and Tertiary Amides

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Contents

General Information: Melting points were uncorrected. Infrared spectra were measured using film KBr pellet techniques. ^{1}H NMR, ^{13}C NMR and ^{31}P NMR spectra were recorded on 400 (or 500) MHz spectrometer with $CDCl_3$ as solvent and tetramethylsilane (TMS) as internal standard or 85% H_3PO_4 as external standard for ^{31}P NMR. Chemical shifts were reported in units (ppm) by assigning TMS resonance in the ^{1}H spectrum as 0.00 ppm and $CDCl_3$ resonance in the ^{13}C spectrum as 77.23 ppm. High-resolution mass spectra (HRMS) were recorded on ESI-TOF mass spectrometer. Flash chromatography was performed with silica gel (300-400 mesh) supplied by yantai Silica Gel Factory (China), eluting with DCM / MeOH. Dichloromethane and 2,6-Lutidine were distilled over calcium hydride under N_2. Trifluoromethanesulfonic anhydride (Tf_2O) was distilled over phosphorous pentoxide and was stored for no more than a week before redistilling. All other commercially available compounds were used as received.

General Procedure A for Bisphosphonylation of Secondary Amides

Tf_2O (201 μL, 1.2 mmol, 1.2 equiv) was added dropwise to a cooled (0 °C) solution of secondary amide (1.0 mmol, 1.0 equiv) and 2,6-lutidine (138 μL, 1.2 mmol, 1.2 equiv) in dichloromethane (5 mL). The reaction was stirred for 30 min in an ice bath. Then, the $HP(O)(OEt)_2$ (386 μL, 3.0 mmol, 3.0 equiv) (unless otherwise stated) was added to the mixture and stirred for 3 h at room temperature. The reaction was quenched with saturated sodium hydrogen carbonate solution (5 mL) and extracted with CH_2Cl_2 (3 × 5 mL). The combined organic layers were washed with brine, dried over anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure. The residue was purified by flash column chromatography on silica gel (eluent: DCM / MeOH = 50 / 1) to afford the desired product.

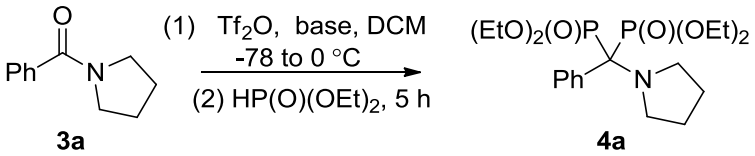
General Procedure B for Bisphosphonylation of Tertiary Amides

Tf_2O (201 μL, 1.2 mmol, 1.2 equiv) was added dropwise to a cooled (−78 °C) solution of tertiary amide (1.0 mmol, 1.0 equiv) and DTBMP (820 mg, 4.0 mmol, 4.0

equiv) in dichloromethane (5 mL) and stirred for 30 min, then 0 °C (in an ice bath) for 10 min. Then $HP(O)(OEt)_2$ (386 μL, 3.0 mmol, 3.0 equiv) (unless otherwise stated) was added to the mixture and stirred for 5 h. The reaction was quenched with saturated sodium hydrogen carbonate solution (10 mL) and extracted with CH_2Cl_2 (3 × 10 mL). The combined organic layers were washed with brine, dried over anhydrous Na_2SO_4, filtered, and concentrated under reduced pressure. The residue was purified by flash column chromatography on silica gel (eluent: DCM / MeOH = 50 / 1) to afford the desired product.

Reaction Optimization for Bisphosphonylation of Tertiary Amides

Table 1. Reaction Optimization for Bisphosphonylation of Tertiary Amides[a]



3a **4a**

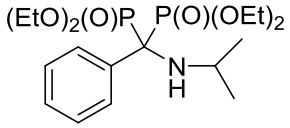
Entry	Base	Equiv of Base	Equiv of $HP(O)(OEt)_2$	Yield (%)[b]
1	none	-	3.0	-[d]
2	Et_3N	1.2	3.0	-[d]
3	*i*-Pr_2NEt	1.2	3.0	-[d]
4	Pyridine	1.2	3.0	33
5	2-fluoropyridine	1.2	3.0	28
6	2-chloropyridine	1.2	3.0	46
7	2-chloropyridine	2.0	3.0	44
8	2,6-lutidine	1.2	3.0	47
9	2,6-lutidine	2.0	3.0	47
10	DTBMP	1.2	3.0	45
11	DTBMP	2.0	3.0	63
12	DTBMP	3.0	3.0	84
13	DTBMP	4.0	3.0	96 (92[c])
14	DTBMP	5.0	3.0	97
15	DTBMP	4.0	2.0	62
16	DTBMP	4.0	2.5	92

17	DTBMP	4.0	4.0	98

[a] Reaction conditions: Tf_2O (1.2 equiv), base, DCM (0.2 M), -78 °C, 30 min. then $HP(O)(OEt)_2$, rt, 5 h. [b] Determined by ^{31}P NMR. [c] Isolated yield. [d] No desired product detected.

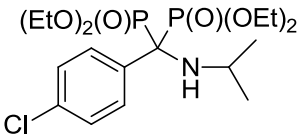
Characterization of the Compounds

Tetraethyl ((isopropylamino)(phenyl)methylene)bis(phosphonate) (2a)



The reaction was performed according to the general procedure A to yield bisphosphonate **2a** (392 mg, yield: 93%) as a colorless oil. IR (film): 3343, 3058, 2980, 2930, 2868, 1478, 1444, 1389, 1366, 1243, 1163, 1096, 1024, 966, 898, 827, 790, 733, 702, 583, 549 cm^{-1}; ^1H NMR (500 MHz, $CDCl_3$) δ 1.12 (d, J = 6.3 Hz, 6H), 1.22 (t, J = 7.1 Hz, 6H), 1.29 (t, J = 7.1 Hz, 6H), 2.05 (br s, 1H), 3.18 (septet, J = 6.3 Hz, 1H), 4.06-4.23 (m, 8H), 7.24-7.35 (m, 3H), 7.92-7.98 (m, 2H) ppm; ^{13}C NMR (125 MHz, $CDCl_3$) δ 16.1 (t, J_{CP} = 2.6 Hz), 16.2 (t, J_{CP} = 2.6 Hz), 25.5, 45.9 (t, J_{CP} = 8.2 Hz), 63.1 (t, J_{CP} = 3.4 Hz), 63.6 (t, J_{CP} = 3.2 Hz), 68.3 (t, J_{CP} = 136.9 Hz), 127.0, 127.3, 129.5 (t, J_{CP} = 5.6 Hz), 134.5 ppm; ^{31}P NMR (202 MHz, $CDCl_3$) δ 19.5 ppm. HRMS (ESI) calcd for $C_{18}H_{33}NNaO_6P_2$ [M+Na^+]: 444.1675; found: 444.1671.

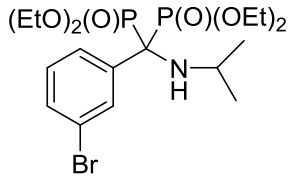
Tetraethyl ((4-chlorophenyl)(isopropylamino)methylene)bis(phosphonate) (2b)



The reaction was performed according to the general procedure A to yield bisphosphonate **2b** (400 mg, yield: 88%) as a colorless oil. IR (film): 3343, 2980, 2930, 2868, 1490, 1443, 1390, 1366, 1244, 1163, 1094, 1024, 969, 912, 837, 789, 738, 623, 610, 581, 549, 460 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 1.10 (d, J = 6.3 Hz, 6H),

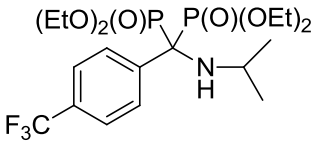
1.24 (t, J = 7.1 Hz, 6H), 1.30 (t, J = 7.1 Hz, 6H), 2.05 (br s, 1H), 3.16 (septet, J = 6.3 Hz, 1H), 4.06-4.26 (m, 8H), 7.25-7.32 (m, 2H), 7.86-7.94 (m, 2H) ppm; ^{13}C NMR (125 MHz, $CDCl_3$) δ 16.2 (t, J_{CP} = 3.4 Hz), 16.4 (t, J_{CP} = 3.0 Hz), 25.5, 46.1 (t, J_{CP} = 8.1 Hz), 63.3 (t, J_{CP} = 3.5 Hz), 63.9 (t, J_{CP} = 3.5 Hz), 67.9 (t, J_{CP} = 137.0 Hz), 127.2, 131.0 (t, J_{CP} = 5.5 Hz), 133.2, 133.5 ppm; ^{31}P NMR (162 MHz, $CDCl_3$) δ 19.1 ppm. HRMS (ESI) calcd for $C_{18}H_{32}ClNNaO_6P_2$ [M+Na^+]: 478.1286; found: 478.1284.

Tetraethyl ((3-bromophenyl)(isopropylamino)methylene)bis(phosphonate) (2c)



The reaction was performed according to the general procedure A to yield bisphosphonate **2c** (414 mg, yield: 83%) as a colorless oil. IR (film): 3342, 3065, 2979, 2930, 2868, 1592, 1562, 1472, 1443, 1389, 1366, 1245, 1163, 1097, 1024, 967, 908, 825, 790, 737, 693, 644, 584, 560, 526 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.10 (d, J = 6.3 Hz, 6H), 1.22 (t, J = 7.1 Hz, 6H), 1.29 (t, J = 7.1 Hz, 6H), 1.95 (br s, 1H), 3.15 (septet, J = 6.3 Hz, 1H), 4.07-4.20 (m, 8H), 7.16 (t, J = 8.0 Hz, 1H), 7.38 (d, J = 8.0 Hz, 1H), 7.88-7.94 (m, 1H), 8.05-8.10 (m, 1H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.1, 16.2, 25.5, 46.2 (t, J_{CP} = 7.9 Hz), 63.3, 63.9, 68.0 (t, J_{CP} = 135.8 Hz), 121.2, 128.2 (t, J_{CP} = 5.2 Hz), 128.6, 130.3, 132.6 (t, J_{CP} = 5.6 Hz), 137.4 ppm; ^{31}P NMR (162 MHz, $CDCl_3$) δ 18.8 ppm. HRMS (ESI) calcd for $C_{18}H_{32}BrNNaO_6P_2$ [M+Na^+]: 522.0780; found: 522.0779.

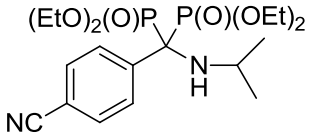
Tetraethyl ((isopropylamino)(4-(trifluoromethyl)phenyl)methylene)bis-(phosphonate) (2d)



The reaction was performed according to the general procedure A to yield bisphosphonate **2d** (401 mg, yield: 82%) as a colorless oil. IR (film): 3344, 2981,

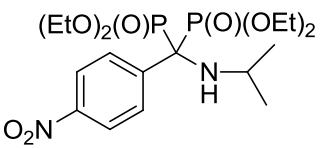
2932, 2870, 1617, 1478, 1444, 1411, 1390, 1367, 1329, 1247, 1165, 1124, 1097, 1020, 971, 916, 844, 790, 744, 660, 608, 546, 493 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.05 (d, J = 6.3 Hz, 6H), 1.17 (t, J = 7.1 Hz, 6H), 1.24 (t, J = 7.1 Hz, 6H), 2.04 (br s, 1H), 3.11 (septet, J = 6.3 Hz, 1H), 4.01-4.22 (m, 8H), 7.51 (d, J = 8.3 Hz, 2H), 8.03 (d, J = 8.3 Hz, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.1 (t, J_{CP} = 2.8 Hz), 16.3 (t, J_{CP} = 2.9 Hz), 25.5, 46.3 (t, J = 8.1 Hz), 63.3 (t, J_{CP} = 3.4 Hz), 64.0 (t, J_{CP} = 3.3 Hz), 68.4 (t, J_{CP} = 136.2 Hz), 123.9, 124.1 (q, J_{CF} = 272.6 Hz), 129.4 (q, J_{CF} = 32.3 Hz), 129.9 (t, J_{CP} = 5.4 Hz), 139.5 ppm; ^{31}P NMR (162 MHz, $CDCl_3$) δ 18.8 ppm. HRMS (ESI) calcd for $C_{19}H_{32}F_3NNaO_6P_2$ [M+Na^+]: 512.1549; found: 512.1547.

Tetraethyl ((4-cyanophenyl)(isopropylamino)methylene)bis(phosphonate) (2e)



The reaction was performed according to the general procedure A to yield bisphosphonate **2e** (339 mg, yield: 76%) as a colorless oil. IR (film): 3343, 3043, 2980, 2931, 2869, 2227, 1605, 1502, 1477, 1443, 1390, 1367, 1246, 1163, 1023, 971, 916, 842, 790, 739, 618, 583, 565, 539, 483 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.06 (d, J = 6.3 Hz, 6H), 1.20 (t, J = 7.1 Hz, 6H), 1.27 (t, J = 7.1 Hz, 6H), 2.01 (br s, 1H), 3.14 (septet, J = 6.3 Hz, 1H), 4.06-4.24 (m, 8H), 7.55-7.60 (m, 2H), 8.02-8.11 (m, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.1, 16.3, 25.2, 46.3 (t, J_{CP} = 7.5 Hz), 63.5, 64.2, 68.2 (t, J_{CP} = 137.1 Hz), 110.9, 118.5, 130.1 (t, J_{CP} = 5.1 Hz), 130.6, 140.9 ppm; ^{31}P NMR (162 MHz, $CDCl_3$) δ 18.4 ppm. HRMS (ESI) calcd for $C_{19}H_{32}N_2NaO_6P_2$ [M+Na^+]: 469.1628; found: 469.1629.

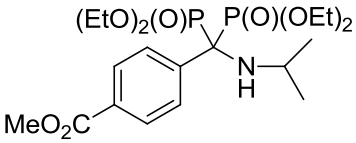
Tetraethyl ((isopropylamino)(4-nitrophenyl)methylene)bis(phosphonate) (2f)



The reaction was performed according to the general procedure A to yield

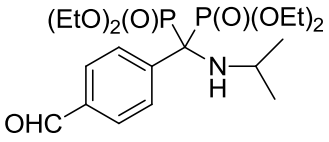
bisphosphonate **2f** (354 mg, yield: 76%) as a colorless oil. IR (film): 3343, 2980, 2931, 2869, 1594, 1521, 1491, 1443, 1390, 1347, 1292, 1247, 1163, 1096, 1023, 972, 917, 852, 790, 733, 696, 607, 582, 549 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.06 (d, J = 6.3 Hz, 6H), 1.19 (t, J = 7.1 Hz, 6H), 1.27 (t, J = 7.1 Hz, 6H), 2.07 (br s, 1H), 3.15 (septet, J = 6.3 Hz, 1H), 4.06-4.25 (m, 8H), 8.06-8.17 (m, 4H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.2 (t, J_{CP} = 2.8 Hz), 16.3 (t, J_{CP} = 2.9 Hz), 25.4, 46.6 (t, J_{CP} = 8.1 Hz), 63.5 (t, J_{CP} = 3.5 Hz), 64.2, 68.5 (t, J_{CP} = 135.9 Hz), 122.0, 130.4 (t, J_{CP} = 5.2 Hz), 143.3, 147.0 ppm; ^{31}P NMR (162 MHz, $CDCl_3$) δ 18.3 ppm. HRMS (ESI) calcd for $C_{18}H_{32}KN_2O_8P_2$ [M+K^+]: 505.1265; found: 505.1264.

Methyl 4-(bis(diethoxyphosphoryl)(isopropylamino)methyl)benzoate (2g)



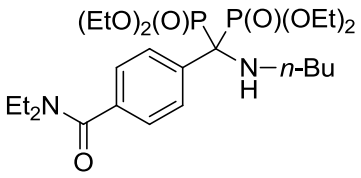
The reaction was performed according to the general procedure A to yield bisphosphonate **2g** (393 mg, yield: 82%) as a colorless oil. IR (film): 3343, 2980, 2930, 2869, 1724, 1609, 1437, 1389, 1366, 1279, 1245, 1190, 1163, 1111, 1022, 971, 918, 820, 791, 735, 704, 605, 582, 550, 485 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.05 (d, J = 6.3 Hz, 6H), 1.17 (t, J = 7.1 Hz, 6H), 1.24 (t, J = 7.1 Hz, 6H), 2.09 (br s, 1H), 3.11 (septet, J = 6.3 Hz, 1H), 3.85 (s, 3H), 4.03-4.18 (m, 8H), 7.90-7.96 (m, 2H), 7.97-8.03 (m, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.1 (t, J_{CP} = 2.9 Hz), 16.3 (t, J_{CP} = 2.6 Hz), 25.4, 46.3 (t, J_{CP} = 8.2 Hz), 51.9, 63.4 (t, J_{CP} = 3.4 Hz), 64.0, 68.5 (t, J_{CP} = 136.6 Hz), 128.2, 129.0, 129.5 (t, J_{CP} = 5.5 Hz), 140.5, 166.8 ppm; ^{31}P NMR (162 MHz, $CDCl_3$) δ 18.8 ppm. HRMS (ESI) calcd for $C_{20}H_{35}NNaO_8P_2$ [M+Na^+]: 502.1730; found: 502.1732.

Tetraethyl ((4-formylphenyl)(isopropylamino)methylene)bis(phosphonate) (2h)



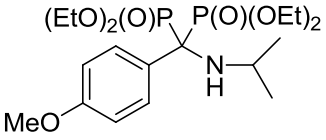
The reaction was performed according to the general procedure A to yield bisphosphonate **2h** (287 mg, yield: 64%) as a colorless oil. IR (film): 3340, 2980, 2929, 2868, 1702, 1604, 1572, 1443, 1389, 1367, 1245, 1213, 1163, 1096, 1024, 971, 915, 839, 789, 737, 581, 550 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.07 (d, J = 6.3 Hz, 6H), 1.18 (t, J = 7.1 Hz, 6H), 1.26 (t, J = 7.1 Hz, 6H), 2.28 (br s, 1H), 3.14 (septet, J = 6.3 Hz, 1H), 4.05-4.25 (m, 8H), 7.75-7.85 (m, 2H), 8.05-8.15 (m, 2H), 9.97 (s, 1H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.2 (t, J_{CP} = 2.8 Hz), 16.3 (t, J_{CP} = 2.9 Hz), 25.5, 46.5 (t, J = 8.14 Hz), 63.4 (t, J_{CP} = 3.4 Hz), 64.1 (t, J_{CP} = 2.9 Hz), 68.8 (t, J_{CP} = 137.0 Hz), 128.3, 130.2 (t, J_{CP} = 5.5 Hz), 135.3, 142.5 (t, J_{CP} = 3.6 Hz), 191.9 ppm; ^{31}P NMR (162 MHz, $CDCl_3$) δ 18.6 ppm. HRMS (ESI) calcd for $C_{19}H_{33}NNaO_7P_2$ [M+Na^+]: 472.1624; found: 472.1624.

Tetraethyl ((butylamino)(4-(diethylcarbamoyl)phenyl)methylene)bis-(phosphonate) (2i)



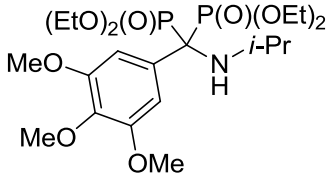
The reaction was performed according to the general procedure A to yield bisphosphonate **2i** (331 mg, yield: 62%) as a colorless oil. IR (film): 3336, 3050, 2979, 2931, 2872, 1631, 1473, 1458, 1427, 1382, 1366, 1288, 1244, 1162, 1097, 1023, 968, 912, 790, 735, 701, 651, 587, 543 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.88 (t, J = 7.2 Hz, 3H), 1.04-1.28 (m, 18H), 1.32-1.41 (m, 2H), 1.43-1.55 (m, 2H), 2.23 (br s, 1H), 2.61 (t, J = 6.9 Hz, 2H), 3.10-3.35 (m, 2H), 3.40-3.65 (m, 2H), 3.97-4.19 (m, 8H), 7.30-7.36 (m, 2H), 7.75-7.85 (m, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 12.7, 13.8, 13.9, 16.2, 16.3, 20.1, 33.0, 39.1, 43.2, 43.3 (t, J_{CP} = 8.2 Hz), 63.4, 63.6, 67.8 (t, J_{CP} = 135.7 Hz), 125.5, 128.9 (t, J_{CP} = 5.2 Hz), 134.5, 135.9, 170.9 ppm; ^{31}P NMR (162 MHz, $CDCl_3$) δ 19.0 ppm. HRMS (ESI) calcd for $C_{24}H_{44}N_2NaO_7P_2$ [M+Na^+]: 557.2516; found: 557.2511.

Tetraethyl ((isopropylamino)(4-methoxyphenyl)methylene)bis(phosphonate) (2j)



Following the general procedure A, reaction of the secondary amide **1j** (193 mg, 1mmol) with 2,6-lutidine (138 μL, 1.2 mmol), Tf_2O (201μL, 1.2 mmol) and $HP(O)(OEt)_2$ (1.16 mL, 9.0 mmol) afforded bisphosphonate **2j** (324 mg, yield: 72%) as a colorless oil. IR (film): 3343, 3049, 2980, 2931, 2868, 1609, 1580, 1511, 1465, 1443, 1389, 1366, 1294, 1243, 1182, 1163, 1027, 966, 909, 837, 795, 737, 701, 626, 582, 552 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 1.08 (d, J = 6.3 Hz, 6H), 1.20 (t, J = 7.1 Hz, 6H), 1.26 (t, J = 7.1 Hz, 6H), 2.01 (br s, 1H), 3.14 (septet, J = 6.3 Hz, 1H), 3.78 (s, 3H), 4.03-4.22 (m, 8H), 6.78-6.90 (m, 2H), 7.75-7.90 (m, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.3 (t, J_{CP} = 2.7 Hz), 16.4 (t, J_{CP} = 2.8 Hz), 25.6, 45.8 (t, J_{CP} = 8.1 Hz), 55.1, 63.2 (t, J_{CP} = 3.5 Hz), 63.6 (t, J_{CP} = 3.3 Hz), 67.7 (t, J_{CP} = 137.7 Hz), 112.5, 126.2, 130.8 (t, J_{CP} = 5.6 Hz), 158.8 ppm; ^{31}P NMR (162 MHz, $CDCl_3$) δ 18.8 ppm. HRMS (ESI) calcd for $C_{19}H_{35}NNaO_7P_2$ [M+Na^+]: 474.1781; found: 474.1773.

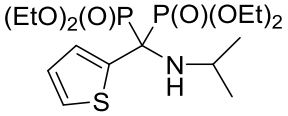
Tetraethyl ((isopropylamino)(3,4,5-trimethoxyphenyl)methylene)bis-(phosphonate) (2k)



Following the general procedure A, reaction of the secondary amide **1k** (253 mg, 1 mmol) with 2,6-lutidine (138 μL, 1.2 mmol), Tf_2O (201μL, 1.2 mmol) and $HP(O)(OEt)_2$ (1.16 mL, 9.0 mmol) afforded bisphosphonate **2k** (401 mg, yield: 79%) as a colorless oil. IR (film): 3342, 2980, 2933, 2836, 1587, 1510, 1464, 1415, 1389, 1366, 1320, 1243, 1162, 1128, 1027, 965, 790, 738, 639, 542 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 1.15 (d, J = 6.3 Hz, 6H), 1.23 (t, J = 7.0 Hz, 6H), 1.30 (t, J = 7.1 Hz, 6H), 2.05 (br s, 1H), 3.18 (septet, J = 6.3 Hz, 1H), 3.85 (s, 9H), 4.06-4.23 (m, 8H), 7.27-7.29 (m, 2H) ppm; ^{13}CNMR (100 MHz, $CDCl_3$) δ 16.3 (t, J_{CP} = 2.8 Hz), 16.4 (t,

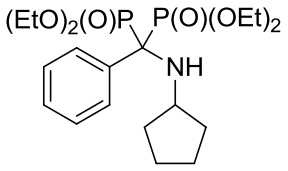
J_{CP} = 3.0 Hz), 25.8, 45.8 (t, J_{CP} = 8.0 Hz), 56.0, 60.8, 63.3 (t, J_{CP} = 3.2 Hz), 63.8 (t, J_{CP} = 3.0 Hz), 68.3 (t, J_{CP} = 136.1 Hz), 107.1, 129.7, 137.2, 151.9 ppm; ^{31}P NMR (162 MHz, $CDCl_3$) δ 20.3 ppm. HRMS (ESI) calcd for $C_{21}H_{40}NO_9P_2$ [M+H$^+$]: 512.2173; found: 512.2161.

Tetraethyl ((isopropylamino)(thiophen-2-yl)methylene)bis(phosphonate) (2n)



Following the general procedure A, reaction of the secondary amide **1n** (169 mg, 1 mmol) with 2,6-lutidine (138 μL, 1.2 mmol), Tf_2O (201μL, 1.2 mmol) and $HP(O)(OEt)_2$ (1.16 mL, 9.0 mmol) afforded bisphosphonate **2n** (342 mg, yield: 80%) as a colorless oil. IR (film): 3336, 3050, 2980, 2929, 2867, 1702, 1477, 1442, 1390, 1366, 1250, 1163, 1096, 1025, 967, 790, 732, 698, 590, 540 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.17 (d, J = 6.3 Hz, 6H), 1.25 (t, J = 7.1 Hz, 6H), 1.31 (t, J = 7.1 Hz, 6H), 2.76 (br s, 1H), 3.40 (septet, J = 6.3 Hz, 1H), 4.03-4.25 (m, 8H), 6.93-7.05 (m, 1H), 7.24-7.32 (m, 1H), 7.55-7.63 (m, 1H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.2 (t, J_{CP} = 2.9 Hz), 16.3 (t, J_{CP} = 3.0 Hz), 25.6, 45.7 (t, J_{CP} = 6.3 Hz), 63.7 (t, J_{CP} = 3.9 Hz), 63.8 (t, J_{CP} = 3.5 Hz), 65.2 (t, J_{CP} = 139.7 Hz), 125.3, 126.2, 128.3 (t, J_{CP} = 5.9 Hz), 139.1 ppm; ^{31}P NMR (162 MHz, $CDCl_3$) δ 17.5 ppm. HRMS (ESI) calcd for $C_{16}H_{31}NNaO_6P_2S$ [M+Na$^+$]: 450.1240; found: 450.1239.

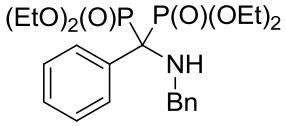
Tetraethyl ((cyclopentylamino)(phenyl)methylene)bis(phosphonate) (2o)



The reaction was performed according to the general procedure A to yield bisphosphonate **2o** (371 mg, yield: 83%) as a colorless oil. IR (film): 3343, 3058, 2979, 2931, 2867, 1495, 1476, 1444, 1390, 1366, 1244, 1163, 1097, 1027, 962, 902, 790, 734, 701, 656, 557 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.22 (t, J = 7.1 Hz, 6H), 1.31 (t, J = 7.1 Hz, 6H), 1.35-1.55 (m, 4H), 1.58-1.74 (m, 2H), 1.96-2.08 (m, 2H),

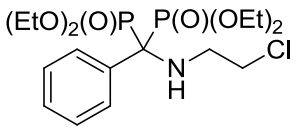
2.20 (br s, 1H), 3.19 (q, J = 7.5 Hz, 1H), 4.00-4.28 (m, 8H), 7.25-7.39 (m, 3H), 7.85-8.00 (m, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.2, 16.4, 23.7, 35.5, 56.2 (t, J_{CP} = 8.0 Hz), 63.2 (t, J_{CP} = 3.2 Hz), 63.8, 68.5 (t, J_{CP} = 137.3 Hz), 127.3, 129.5 (t, J_{CP} = 5.4 Hz), 134.3 (t, J_{CP} = 3.7 Hz) ppm; ^{31}P NMR (162 MHz, $CDCl_3$) δ 19.4 ppm. HRMS (ESI) calcd for $C_{20}H_{35}NNaO_6P_2$ [M+Na$^+$]: 470.1832; found: 470.1830.

Tetraethyl ((benzylamino)(phenyl)methylene)bis(phosphonate) (2p)



The reaction was performed according to the general procedure A to yield bisphosphonate **2p** (356 mg, yield: 76%) as a colorless oil. IR (film): 3331, 3061, 3026, 2981, 2929, 2907, 2868, 1601, 1495, 1475, 1444, 1390, 1367, 1244, 1162, 1096, 1024, 962, 898, 791, 733, 702, 674, 613, 583, 553, 498 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.23 (t, J = 7.1 Hz, 6H), 1.30 (t, J = 7.1 Hz, 6H), 2.62 (br s, 1H), 3.89 (d, J = 7.2 Hz, 2H), 4.07-4.27 (m, 8H), 7.24-7.32 (m, 2H), 7.32-7.40 (m, 4H), 7.42-7.48 (m, 2H), 7.84-7.93 (m, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.3 (t, J_{CP} = 3.0 Hz), 16.5 (t, J_{CP} = 2.7 Hz), 47.7 (t, J_{CP} = 8.1 Hz), 63.6 (t, J_{CP} = 3.4 Hz), 63.8, 68.0 (t, J_{CP} = 136.4 Hz), 126.8, 127.4, 127.6, 127.7, 128.3, 128.8 (t, J_{CP} = 5.3 Hz), 132.9, 140.5 ppm; ^{31}P NMR (162 MHz, $CDCl_3$) δ 19.1 ppm. HRMS (ESI) calcd for $C_{22}H_{33}NNaO_6P_2$ [M+Na$^+$]: 492.1675; found: 492.1680.

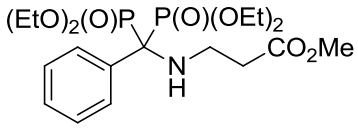
Tetraethyl (((2-chloroethyl)amino)(phenyl)methylene)bis(phosphonate) (2q)



The reaction was performed according to the general procedure A to yield bisphosphonate **2q** (353 mg, yield: 80%) as a colorless oil. IR (film): 3327, 3059, 2981, 2930, 2909, 2869, 1478, 1444, 1390, 1367, 1292, 1244, 1162, 1031, 965, 896, 792, 734, 703, 666, 584, 549, 486 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.17 (t, J = 7.1

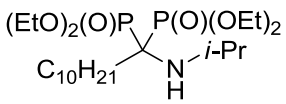
Hz, 6H), 1.27 (t, J = 7.1 Hz, 6H), 2.63 (br s, 1H), 3.02 (t, J = 5.8 Hz, 2H), 3.64 (t, J = 5.8 Hz, 2H), 3.98-4.24 (m, 8H), 7.20-7.38 (m, 3H), 7.72-7.88 (m, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.3 (t, J_{CP} = 2.8 Hz), 16.4 (t, J_{CP} = 2.8 Hz), 45.2 (t, J_{CP} = 8.3 Hz), 45.3, 63.5 (t, J_{CP} = 3.4 Hz), 63.9 (t, J_{CP} = 3.2 Hz), 67.3 (t, J_{CP} = 137.3 Hz), 127.5, 127.7, 128.7 (t, J_{CP} = 5.2 Hz), 132.8 (t, J_{CP} = 4.2 Hz) ppm; ^{31}P NMR (162 MHz, $CDCl_3$) δ 18.8 ppm. HRMS (ESI) calcd for $C_{17}H_{30}ClNNaO_6P_2$ [M+Na$^+$]: 464.1129; found: 464.1122.

Methyl 3-((bis(diethoxyphosphoryl)(phenyl)methyl)amino)propanoate (2r)



The reaction was performed according to the general procedure A to yield bisphosphonate **2r** (395 mg, yield: 85%) as a colorless oil. IR (film): 3329, 3059, 2982, 2931, 1738, 1600, 1478, 1442, 1390, 1367, 1244, 1169, 1030, 962, 901, 870, 792, 734, 703, 671, 582, 549, 486 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.20 (t, J = 7.1 Hz, 6H), 1.30 (t, J = 7.1 Hz, 6H), 2.56 (t, J = 6.5 Hz, 2H), 2.98 (t, J = 6.5 Hz, 2H), 3.71 (s, 3H), 4.00-4.24 (m, 8H), 7.24-7.40 (m, 3H), 7.75-7.85 (m, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.2, 16.4, 35.5, 39.4 (t, J_{CP} = 8.8 Hz), 51.4, 63.5, 63.8, 67.7 (t, J_{CP} = 136.6 Hz), 127.4, 127.6, 128.7 (t, J_{CP} = 5.1 Hz), 132.7, 172.7 ppm; ^{31}P NMR (162 MHz, $CDCl_3$) δ 19.0 ppm. HRMS (ESI) calcd for $C_{19}H_{33}NNaO_8P_2$ [M+Na$^+$]: 488.1574; found: 488.1572.

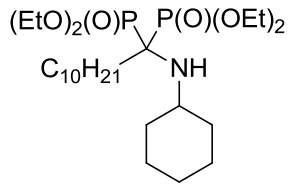
Tetraethyl (1-(isopropylamino)undecane-1,1-diyl)bis(phosphonate) (2s)



The reaction was performed according to the general procedure A to yield bisphosphonate **2s** (277 mg, yield: 57%) as a colorless oil. IR (film): 3340, 2961, 2925, 2854, 1686, 1466, 1390, 1364, 1244, 1163, 1097, 1027, 962, 791, 731, 638, 585, 537 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.83 (t, J = 7.0 Hz, 3H), 1.05 (d, J = 6.3 Hz,

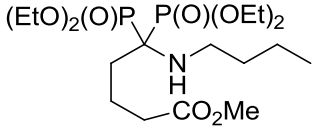
6H), 1.20-1.33 (m, 26H), 1.47-1.78 (m, 3H), 1.82-2.02 (m, 2H), 3.28 (septet, J = 6.3 Hz, 1H), 4.11-4.23 (m, 8H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 14.0, 16.4 (m, 4C), 22.6, 24.0 (t, J_{PC} = 4.9 Hz), 25.9 (2C), 29.2 (2C), 29.5 (2C), 30.4, 31.7, 31.8, 44.0 (t, J_{PC} = 6.8 Hz), 62.6 (t, J_{PC} = 3.5 Hz, 2C), 63.0 (t, J_{PC}= 140.6 Hz), 63.1 (t, J_{PC} = 3.3 Hz, 2C) ppm; ^{31}P NMR (162 MHz, $CDCl_3$) δ 22.7 ppm. HRMS (ESI) calcd for $C_{22}H_{49}NNaO_6P_2$ [M+Na^+]: 508.2927; found: 508.2924.

Tetraethyl (1-(cyclohexylamino)undecane-1,1-diyl)bis(phosphonate) (2t)



The reaction was performed according to the general procedure A to yield bisphosphonate **2t** (373 mg, yield: 71%) as a colorless oil. IR (film): 3337, 2980, 2926, 2853, 1669, 1448, 1391, 1368, 1241, 1160, 1097, 1031, 965, 793, 638, 550 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.85 (t, J = 7.1 Hz, 3H), 1.00-1.13 (m, 3H), 1.15-1.46 (m, 28H), 1.49-1.71 (m, 6H), 1.81-1.97 (m, 4H), 2.82-2.95 (m, 1H), 4.11-4.24 (m, 8H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 14.0, 16.2 (m, 4C), 22.5, 24.0 (t, J_{CP} = 5.1 Hz), 25.5 (2C), 25.7, 29.2 (2C), 29.4 (2C), 30.4, 31.8 (2C), 36.4 (2C), 51.4 (t, J_{CP} = 6.5 Hz), 62.6 (t, J_{CP} = 3.5 Hz, 2C), 62.7 (t, J_{CP} = 140.6 Hz), 63.0 (t, J_{CP} = 3.3 Hz, 2C) ppm; ^{31}P NMR (162 MHz, $CDCl_3$) δ 22.7 ppm. HRMS (ESI) calcd for $C_{25}H_{53}NNaO_6P_2$ [M+Na^+]: 548.3240; found: 548.3243.

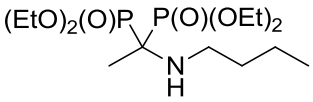
Methyl 5-(butylamino)-5,5-bis(diethoxyphosphoryl)pentanoate (2u)



The reaction was performed according to the general procedure A to yield bisphosphonate **2u** (289 mg, yield: 63%) as a colorless oil. IR (film): 3340, 2980, 2931, 2871, 1739, 1441, 1390, 1367, 1244, 1165, 1025, 965, 791, 748, 551 cm^{-1}; ^{1}H

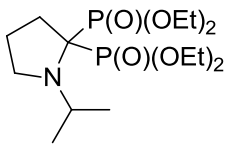
NMR (400 MHz, $CDCl_3$) δ 0.88 (t, J = 7.1 Hz, 3H), 1.26-1.42 (m, 16H), 1.85-2.01 (m, 5H), 2.30 (t, J = 7.1 Hz, 2H), 2.73 (t, J = 6.8 Hz, 2H), 3.63 (s, 3H), 4.12-4.24 (m, 8H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 13.9, 16.4 (m), 19.2 (t, J_{CP} = 6.5 Hz), 20.2, 29.7, 32.9, 34.4, 42.9 (t, J_{CP} = 6.4 Hz), 51.3, 62.2 (t, J_{CP} = 141.6 Hz), 62.7 (t, J_{CP} = 3.5 Hz), 63.1 (t, J_{CP} = 3.0 Hz), 173.5 ppm; ^{31}P NMR (162 MHz, $CDCl_3$) δ 22.4 ppm. HRMS (ESI) calcd for $C_{18}H_{39}NNaO_8P_2$ [M+Na^+]: 482.2043; found: 482.2043.

Tetraethyl (1-(butylamino)ethane-1,1-diyl)bis(phosphonate) (2v)



The reaction was performed according to the general procedure A to yield bisphosphonate **2v** (205 mg, yield: 55%) as a colorless oil. IR (film): 3319, 2980, 2931, 2871, 1470, 1455, 1391, 1367, 1247, 1163, 1096, 1027, 965, 835, 791, 643, 539 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.86 (t, J = 7.2 Hz, 3H), 1.26-1.42 (m, 16H), 1.51 (t, J_{PH} = 17.0 Hz, 3H), 2.02 (br s, 1H), 2.71-2.82 (m, 2H), 4.10-4.28 (m, 8H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 13.8, 16.2 (t, J_{CP} = 3.7 Hz), 16.4 (m), 20.2, 33.0, 42.8 (t, J_{CP} = 6.0 Hz), 57.7 (t, J_{CP} = 144.2 Hz), 62.7 (t, J_{CP} = 3.6 Hz), 63.3 (t, J_{CP} = 3.0 Hz) ppm; ^{31}P NMR (162 MHz, $CDCl_3$) δ 22.8 ppm. HRMS (ESI) calcd for $C_{14}H_{33}NNaO_6P_2$ [M+Na^+]: 396.1675; found: 396.1670.

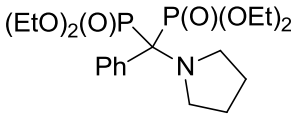
Tetraethyl (1-isopropylpyrrolidine-2,2-diyl)bis(phosphonate) (2y)



The reaction was performed according to the general procedure A to yield bisphosphonate **2y** (211 mg, yield: 55%) as a colorless oil. IR (film): 2980, 2930, 2870, 1686, 1443, 1391, 1243, 1164, 1097, 1047, 961, 791, 642, 580, 541 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.10 (d, J = 6.6 Hz, 6H), 1.29 (t, J = 7.1 Hz, 12H), 1.74 (tt,

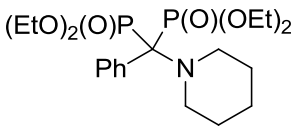
apparent quint, J_1 = 6.7 Hz, J_2 = 6.7 Hz, 2H), 2.32 (tt, J_{PH} = 17.6 Hz, J_{HH} = 7.1 Hz, 2H), 2.88 (tt, J_{HH} = 6.2 Hz, J_{PH} = 2.2 Hz, 2H), 3.90 (septet, J = 6.6 Hz, 1H), 4.09-4.24 (m, 8H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.4 (t, J_{CP} = 2.8 Hz), 20.8 (t, J_{CP} = 2.4 Hz), 23.4 (t, J_{CP} = 3.3 Hz), 32.1 (t, J_{CP} = 4.1 Hz), 43.3, 46.7, 62.3 (t, J_{CP} = 3.7 Hz), 62.7 (t, J_{CP} = 3.3 Hz), 64.5 (t, J_{CP} = 151.7 Hz) ppm; ^{31}P NMR (162 MHz, $CDCl_3$) δ 23.3 ppm. HRMS (ESI) calcd for $C_{15}H_{33}NNaO_6P_2$ [M+Na$^+$]: 408.1675; found: 408.1677.

Tetraethyl (phenyl(pyrrolidin-1-yl)methylene)bis(phosphonate) (4a)



The reaction was performed according to the general procedure B to yield bisphosphonate **4a** (399 mg, yield: 92%) as a pale yellow solid. Mp: 73.7-76.2 ^{o}C. IR (film): 2977, 2929, 2869, 1479, 1445, 1390, 1366, 1241, 1162, 1096, 1025, 964, 886, 787, 729, 701, 585, 554 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.24 (dt, J_{PH} = 14.7 Hz, J_{HH} = 7.1 Hz, 12H), 1.70-1.84 (m, 4H), 2.98-3.12 (m, 4H), 3.93-4.18 (m, 8H), 7.23-7.35 (m, 3H), 7.82-7.95 (m, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.3 (t, J_{CP} = 2.6 Hz), 16.4 (t, J_{CP} = 2.7 Hz), 24.1, 47.8 (t, J_{CP} = 2.9 Hz), 62.6 (t, J_{CP} = 3.6 Hz), 62.8 (t, J_{CP} = 3.5 Hz), 70.7 (t, J_{CP} = 135.1 Hz), 127.1, 127.3, 129.8 (t, J_{CP} = 5.0 Hz), 135.5 (t, J_{CP} = 3.5 Hz) ppm; ^{31}P NMR (162 MHz, $CDCl_3$) δ 20.4 ppm. HRMS (ESI) calcd for $C_{19}H_{33}NNaO_6P_2$ [M+Na$^+$]: 456.1675; found: 456.1676.

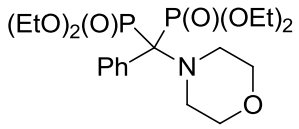
Tetraethyl (phenyl(piperidin-1-yl)methylene)bis(phosphonate) (4b)



The reaction was performed according to the general procedure B to yield bisphosphonate **4b** (424 mg, yield: 95%) as a pale yellow solid. Mp: 91.5-92.7 ^{o}C. IR (film): 2981, 2929, 2848, 1444, 1388, 1237, 1160, 1093, 1024, 955, 869, 813, 732, 699, 581, 551 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.25 (dt, J_{PH} = 14.4 Hz, J_{HH} = 7.1

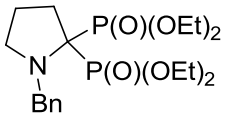
Hz, 12H), 1.45-1.68 (m, 6H), 2.80-3.05 (m, 4H), 3.82-4.25 (m, 8H), 7.20-7.37 (m, 3H), 7.90-8.10 (m, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.2 (t, J_{CP} = 2.8 Hz),16.4 (t, J_{CP} = 2.8 Hz), 24.8, 27.3, 50.8 (t, J_{CP} = 3.8 Hz), 62.4 (t, J_{CP} = 3.4 Hz), 62.8 (t, J_{CP} = 3.0 Hz), 75.0 (t, J_{CP} = 135.4 Hz), 127.1, 127.3, 129.9 (t, J_{CP} = 5.0 Hz), 136.6 (t, J_{CP} = 3.6 Hz) ppm; ^{31}P NMR (162 MHz, $CDCl_3$) δ 20.9 ppm. HRMS (ESI) calcd for $C_{20}H_{35}NNaO_6P_2$ [M+Na$^+$]: 470.1832; found: 470.1828.

Tetraethyl (morpholino(phenyl)methylene)bis(phosphonate) (4c)



The reaction was performed according to the general procedure B to yield bisphosphonate **4c** (418 mg, yield: 93%) as a white solid. Mp: 110.1-112.3 ^{o}C. IR (film): 2979, 2928, 2850, 1491, 1446, 1390, 1366, 1293, 1242, 1162, 1116, 1097, 1024, 961, 875, 825, 786, 730, 701, 699, 587, 554 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.26 (dt, J_{PH} = 8.0 Hz, J_{HH} = 7.2 Hz, 12H), 2.93-3.17 (m, 4H), 3.66-3.80 (m, 4H), 3.84-4.26 (m, 8H), 7.20-7.42 (m, 3H), 7.95-8.10 (m, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.2 (t, J_{CP} = 2.8 Hz), 16.4 (t, J_{CP} = 2.9 Hz), 50.1 (t, J_{CP} = 3.8 Hz), 62.5 (t, J_{CP} = 3.2 Hz), 63.0 (t, J_{CP} = 3.3 Hz), 67.9, 73.6 (t, J_{CP} = 135.4 Hz), 127.1, 127.4, 129.8 (t, J_{CP} = 4.8 Hz), 135.2 (t, J_{CP} = 3.7 Hz) ppm; ^{31}P NMR (162 MHz, $CDCl_3$) δ 20.0 ppm. HRMS (ESI) calcd for $C_{19}H_{33}NNaO_7P_2$ [M+Na$^+$]: 472.1624; found: 472.1619.

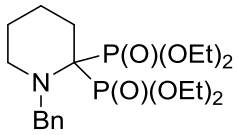
Tetraethyl (1-benzylpyrrolidine-2,2-diyl)bis(phosphonate) (4d)



The reaction was performed according to the general procedure B to yield bisphosphonate **4d** (403 mg, yield: 93%) as a colorless oil. IR (film): 2980, 2930, 2818, 1723, 1494, 1477, 1443, 1390, 1370, 1244, 1161, 1096, 1024, 962, 862, 791, 740, 702, 608, 591, 581, 540, 466 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.34 (dt, J_{PH} =

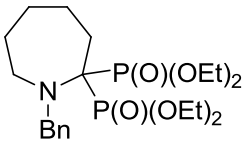
1.0 Hz, J_{HH} = 7.1 Hz, 12H), 1.78 (tt, apparent quint, J_1 = 6.6 Hz, J_2 = 6.6 Hz, 2H), 2.48 (tt, J_{PH} = 18.0 Hz, J_{HH} = 7.2 Hz, 2H), 2.69-2.76 (m, 2H), 4.18-4.32 (m, 10H), 7.18-7.32 (m, 3H), 7.37-7.45 (m, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.5 (m), 23.8, 32.2, 51.4 (t, J_{CP} = 3.9 Hz), 54.9, 62.7 (t, J_{CP} = 3.7 Hz), 63.0 (t, J_{CP} = 3.4 Hz), 64.9 (t, J_{CP} = 150.3 Hz), 126.5, 127.9, 128.5, 140.6 ppm; ^{31}P NMR (162 MHz, $CDCl_3$) δ 22.8 ppm. HRMS (ESI) calcd for $C_{19}H_{33}NNaO_6P_2$ [M+Na^+]: 456.1675; found: 456.1670.

Tetraethyl (1-benzylpiperidine-2,2-diyl)bis(phosphonate) (4e)



Following the general procedure B, reaction of thetertiary amide **3e** (189 mg, 1 mmol) with 2,6-lutidine (138 μL, 1.2 mmol), Tf_2O (201μL, 1.2 mmol) and $HP(O)(OEt)_2$ (643 μL, 5.0 mmol) afforded bisphosphonate **4e** (362 mg, yield: 81%) as a pale yellow oil. IR (film): 2980, 2930, 2853, 1494, 1451, 1389, 1368, 1284, 1243, 1162, 1097, 1024, 961, 866, 794, 732, 699, 647, 599, 579, 544 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.35 (dt, J_{PH} = 3.8 Hz, J_{HH} = 7.1 Hz, 12H), 1.45-1.52 (m, 2H), 1.65-1.75 (m, 2H), 2.24-2.38 (m, 2H), 2.70-2.79 (m, 2H), 4.17-4.28 (m, 8H), 4.33 (s, 2H), 7.17-7.31 (m, 3H), 7.38-7.46 (m, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.5 (m), 19.9 (t, J_{CP} = 7.1 Hz), 25.1, 29.6, 47.2 (t, J_{CP} = 6.1 Hz), 58.3, 62.2 (t, J_{CP} = 3.6 Hz), 62.7 (t, J_{CP} = 3.3 Hz),64.9 (t, J_{CP} = 137.6 Hz), 126.3, 127.8, 128.0, 140.7 ppm; ^{31}P NMR (162 MHz, $CDCl_3$) δ 24.2 ppm. HRMS (ESI) calcd for $C_{20}H_{35}NNaO_6P_2$ [M+Na^+]: 470.1832; found: 470.1831.

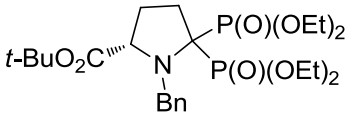
Tetraethyl (1-benzylazepane-2,2-diyl)bis(phosphonate) (4f)



Following the general procedure B, reaction of the tertiary amide **3f** (203 mg, 1 mmol)

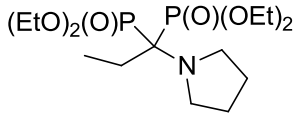
with DTBMP (820 mg, 4.0 mmol), Tf_2O (201 μL, 1.2 mmol) and $HP(O)(OEt)_2$ (643 μL, 5.0 mmol) afforded bisphosphonate **4f** (424 mg, yield 92%) as a colorless oil. IR (film): 2979, 2927, 2853, 1452, 1389, 1242, 1162, 1096, 1025, 959, 787, 749, 700, 569, 545 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 1.30-1.46 (m, 16H), 1.95-2.05 (m, 2H), 2.34-2.48 (m, 2H), 2.83-2.97 (m, 2H), 4.16-4.30 (m, 8H), 4.34 (s, 2H), 7.17-7.32 (m, 3H), 7.47-7.58 (m, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.5, 16.6, 24.1 (t, J_{CP} = 8.4 Hz), 30.1, 31.1, 32.9 (t, J_{CP} = 4.1 Hz), 49.8 (t, J_{CP} = 5.2 Hz), 59.2, 62.1 (t, J_{CP}= 3.5 Hz), 62.6 (t, J_{CP} = 3.4 Hz), 68.8 (t, J_{CP} = 140.1 Hz), 126.4, 127.7, 128.7, 141.4 ppm; ^{31}P NMR (162 MHz, $CDCl_3$) δ 25.0 ppm. HRMS (ESI) calcd for $C_{21}H_{37}NNaO_6P_2$ [M+Na^+]: 484.1988; found: 484.1986.

(*S*)-*tert*-Butyl 1-benzyl-5,5-bis(diethoxyphosphoryl)pyrrolidine-2-carboxylate (4g)



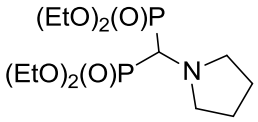
Following the general procedure B, reaction of the tertiary amide **3g** (275 mg, 1 mmol) with DTBMP (820 mg, 4.0 mmol), Tf_2O (201 μL, 1.2 mmol) and $HP(O)(OEt)_2$ (643 μL, 5.0 mmol) afforded bisphosphonate **4g** (384 mg, yield 72%) as a colorless oil. IR (film): 2979, 2930, 1740, 1495, 1478, 1455, 1391, 1366, 1293, 1247, 1152, 1097, 1028, 964, 792, 754, 700, 663, 584, 540, 472 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 1.09 (s, 9H), 1.26-1.36 (m, 12H), 1.65-1.83 (m, 1H), 2.23-2.38 (m, 1H), 2.42-2.64 (m, 2H), 3.38-3.52 (m, 1H), 3.85 (dd, J_1 = 13.3 Hz, J_2 = 4.6 Hz, 1H), 4.15-4.28 (m, 6H), 4.32-4.45 (m, 2H), 4.82 (d, J = 13.3 Hz, 1H), 7.10-7.22 (m, 3H), 7.34-7.42 (m, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.4 (m, 4C), 27.5 (3C), 29.3 (d, J_{CP} = 8.8 Hz), 31.0 (t, J_{CP} = 3.8 Hz), 56.1 (d, J_{CP} = 4.0 Hz), 62.3 (t, J_{CP} = 8.1 Hz, 2C), 62.6 (d, J_{CP} = 8.0 Hz), 64.1 (d, J_{CP} = 6.8 Hz), 67.2 (d, J_{CP} = 10.8 Hz), 69.0 (dd, J_{CP1} = 163.8 Hz, J_{CP2} = 128.2 Hz), 79.7, 126.7, 127.7, 129.5, 139.4, 172.8 (d, J_{CP} = 3.2 Hz) ppm; ^{31}P NMR (162 MHz, $CDCl_3$) δ 20.2 (d, J = 82.5 Hz), 24.2 (d, J = 82.5 Hz) ppm. HRMS (ESI) calcd for $C_{24}H_{41}NNaO_8P_2$ [M+Na^+]: 556.2200; found: 556.2198.

Tetraethyl (1-(pyrrolidin-1-yl)propane-1,1-diyl)bis(phosphonate) (4h)



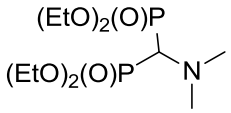
Following the general procedure B, reaction of the tertiary amide **3h** (128 mg, 1 mmol) with DTBMP (820 mg, 4.0 mmol), Tf_2O (201 μL, 1.2 mmol) and $HP(O)(OEt)_2$ (643 μL, 5.0 mmol) afforded bisphosphonate **4h** (347 mg, yield 90%) as a pale red oil. IR (film): 2978, 2933, 2872, 1444, 1390, 1366, 1296, 1242, 1162, 1097, 1024, 963, 876, 790, 764, 587, 557, 528 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 1.05 (t, J = 7.3 Hz, 3H), 1.30 (t, J = 7.1 Hz, 12H), 1.62-1.75 (m, 4H), 2.04-2.18 (m, 2H), 2.94-3.14 (m, 4H), 4.04-4.30 (m, 8H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 8.8 (t, J_{CP} = 8.3 Hz), 16.5 (m), 24.3, 25.8, 47.7, 61.9, 62.2, 66.8 (t, J_{CP} = 136.4 Hz) ppm; ^{31}P NMR (162 MHz, $CDCl_3$) δ 24.2 ppm. HRMS (ESI) calcd for $C_{15}H_{33}NNaO_6P_2$ [M+Na^+]: 408.1675; found: 408.1677.

Tetraethyl (pyrrolidin-1-ylmethylene)bis(phosphonate) (4i)



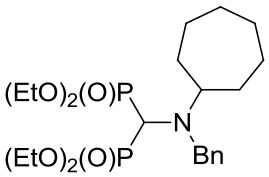
The reaction was performed according to the general procedure B to yield bisphosphonate **4i** (336 mg, yield: 94%) as a pale yellow oil. IR (film): 2979, 2932, 2908, 2872, 1644, 1478, 1443, 1391, 1367, 1249, 1163, 1097, 1024, 967, 858, 795, 575, 533 cm^{-1}; ^1H NMR (400 MHz, $CDCl_3$) δ 1.26 (dt, J_{PH} = 1.7 Hz, J_{HH} = 7.1 Hz, 12H), 1.63-1.75 (m, 4H), 2.94-3.05 (m, 4H), 3.62 (t, J_{PH} = 24.5 Hz, 1H), 4.05-4.20 (m, 8H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.3 (m), 24.5, 51.2 (t, J_{CP} = 4.0 Hz), 57.3 (t, J_{CP} = 141.0 Hz), 62.3 (t, J_{CP} = 3.3 Hz),62.6 (t, J_{CP} = 3.2 Hz) ppm; ^{31}P NMR (162 MHz, $CDCl_3$) δ 19.2 ppm. HRMS (ESI) calcd for $C_{13}H_{29}NNaO_6P_2$ [M+Na^+]: 380.1362; found: 380.1357.

Tetraethyl ((dimethylamino)methylene)bis(phosphonate) (4j)



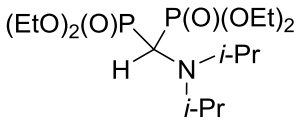
The reaction was performed according to the general procedure B to yield bisphosphonate **4j** (308 mg, yield: 93%) as a colorless oil. IR (film): 2982, 2933, 2874, 2841, 2798, 1477, 1443, 1391, 1367, 1249, 1163, 1097, 1044, 968, 862, 796, 757, 600, 539 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.28 (t, J = 7.1 Hz, 12H), 2.57 (t, J_{PH} = 1.6 Hz, 6H), 3.28 (t, J_{PH} = 24.9 Hz, 1H), 4.08-4.22 (m, 8H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.3 (m), 44.0 (t, J_{CP} = 4.6 Hz), 61.3 (t, J_{CP} = 141.2 Hz), 62.3 (t, J_{CP} = 3.3 Hz), 62.7 (t, J_{CP} = 3.2 Hz) ppm; ^{31}P NMR (162 MHz, $CDCl_3$) δ 19.2 ppm. HRMS (ESI) calcd for $C_{11}H_{27}NNaO_6P_2$[M+Na^+]: 354.1206; found: 354.1201.

Tetraethyl ((benzyl(cycloheptyl)amino)methylene)bis(phosphonate) (4k)



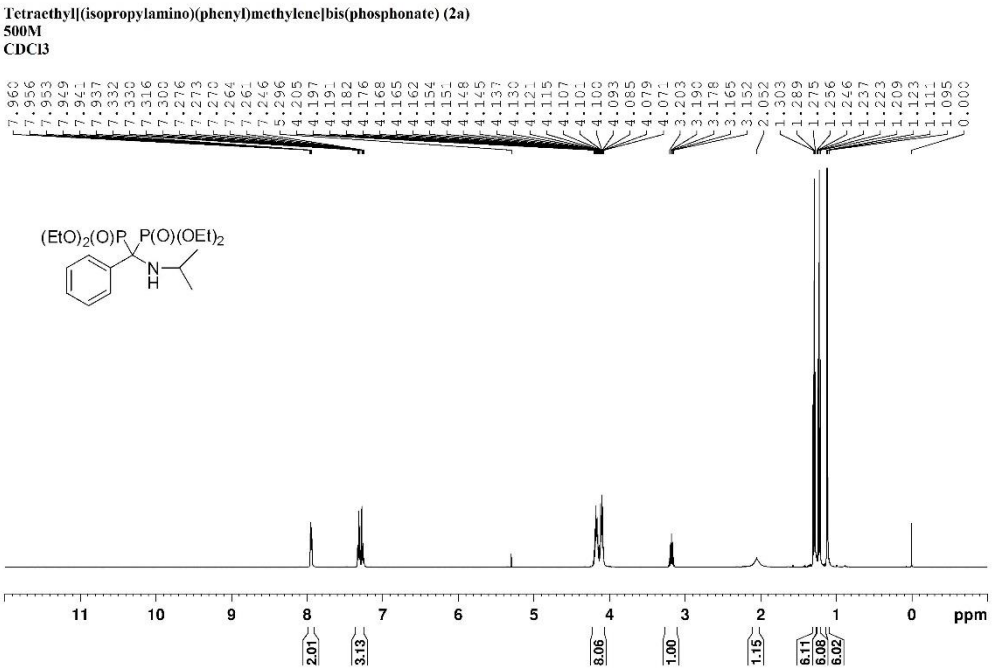
The reaction was performed according to the general procedure B to yield bisphosphonate **4k** (450 mg, yield: 92%) as a colorless oil. IR (film): 2980, 2926, 2856, 1602, 1494, 1453, 1390, 1367, 1251, 1162, 1096, 1031, 965, 850, 832, 794, 743, 700, 609, 534, 490 cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 1.28-1.58 (m, 20H), 1.60-1.72 (m, 2H), 2.08-2.25 (m, 2H), 3.05-3.32 (m, 1H), 3.58 (t, J_{PH} = 25.7 Hz, 1H), 4.01-4.28 (m, 10H), 7.19-7.34 (m, 3H), 7.36-7.46 (m, 2H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.3, 25.4, 27.8, 32.6, 52.3, 55.0 (t, J_{CP} = 144.0 Hz), 60.5, 62.2 (t, J_{CP} = 3.5 Hz), 62.3 (t, J_{CP} = 3.5 Hz), 126.8, 127.9, 129.1, 140.0 ppm; ^{31}P NMR (162 MHz, $CDCl_3$) δ 21.0 ppm. HRMS (ESI) calcd for $C_{23}H_{41}NNaO_6P_2$ [M+Na^+]: 512.2301; found: 512.2294.

Tetraethyl ((diisopropylamino)methylene)bis(phosphonate) (4l)

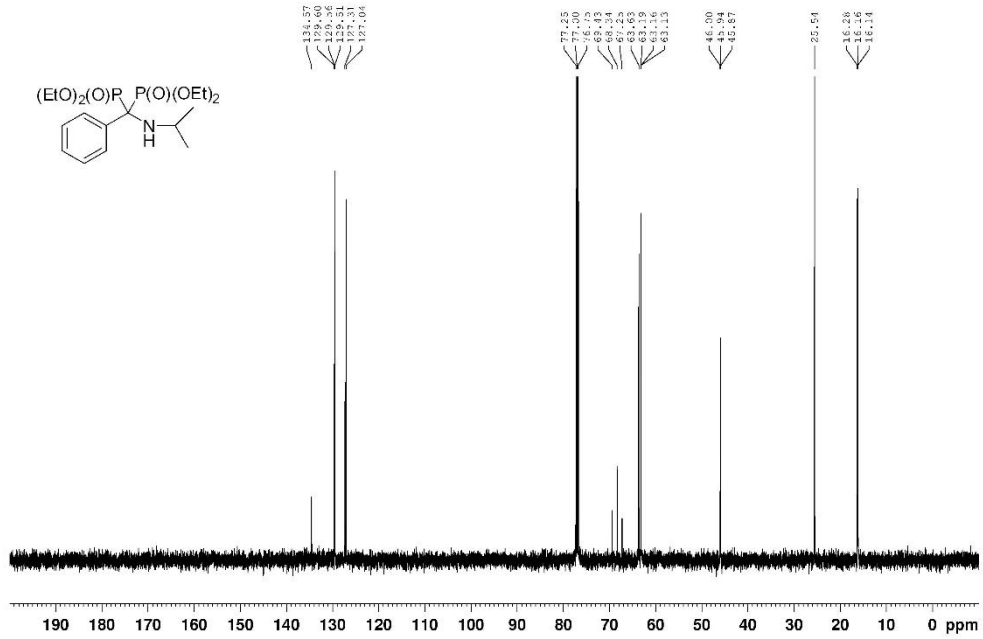


The reaction was performed according to the general procedure B to yield bisphosphonate **4l** (313 mg, yield: 81%) as colorless oil. IR (film): 2980, 2929,

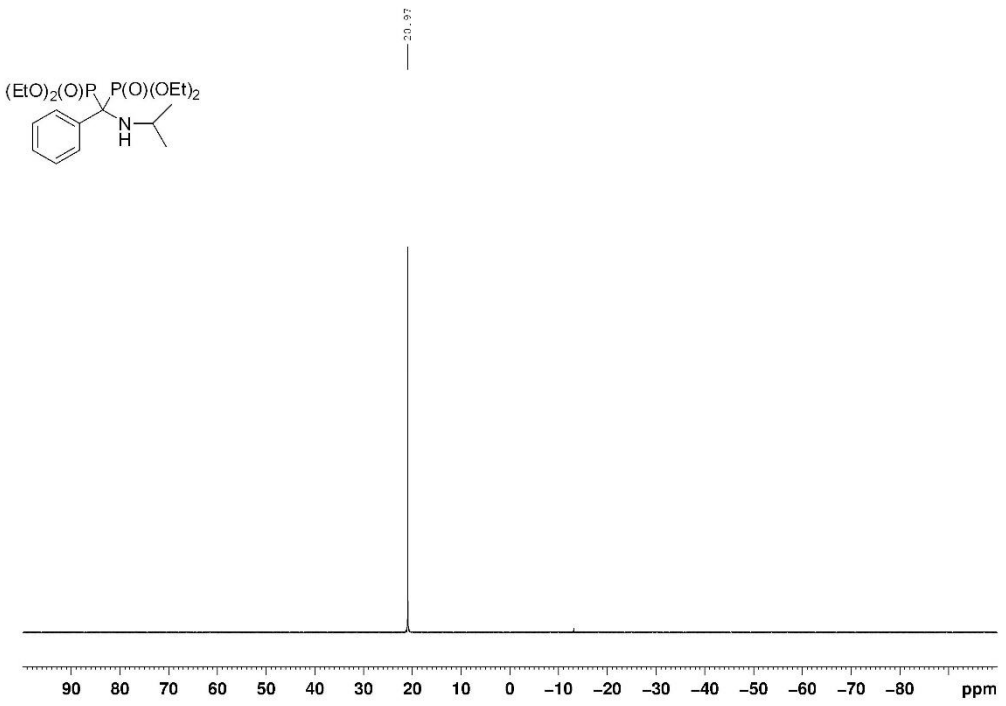
2863, 1389, 1365, 1249, 1179, 1097, 1026, 963, 798, 606, 530cm^{-1}; ^{1}H NMR (400 MHz, $CDCl_3$) δ 0.95-1.20 (m, 12H), 1.30 (t, J = 7.1 Hz, 12H), 3.15-3.75(m, 2H), 3.61 (t, J_{PH} = 26.6 Hz, 1H), 4.10-4.20 (m, 8H) ppm; ^{13}C NMR (100 MHz, $CDCl_3$) δ 16.3 (m), 21.7, 22.8, 44.7, 50.5, 52.8 (t, J_{CP} = 147.5 Hz), 62.1 (m) ppm; ^{31}P NMR (162 MHz, $CDCl_3$) δ 21.4 ppm. HRMS (ESI) calcd for $C_{15}H_{36}NO_6P_2$ [M+H$^+$]: 388.2012; found: 388.2010.



Tetraethyl[(isopropylamino)(phenyl)methylene]bis(phosphonate) (2a)
125M
CDCl3



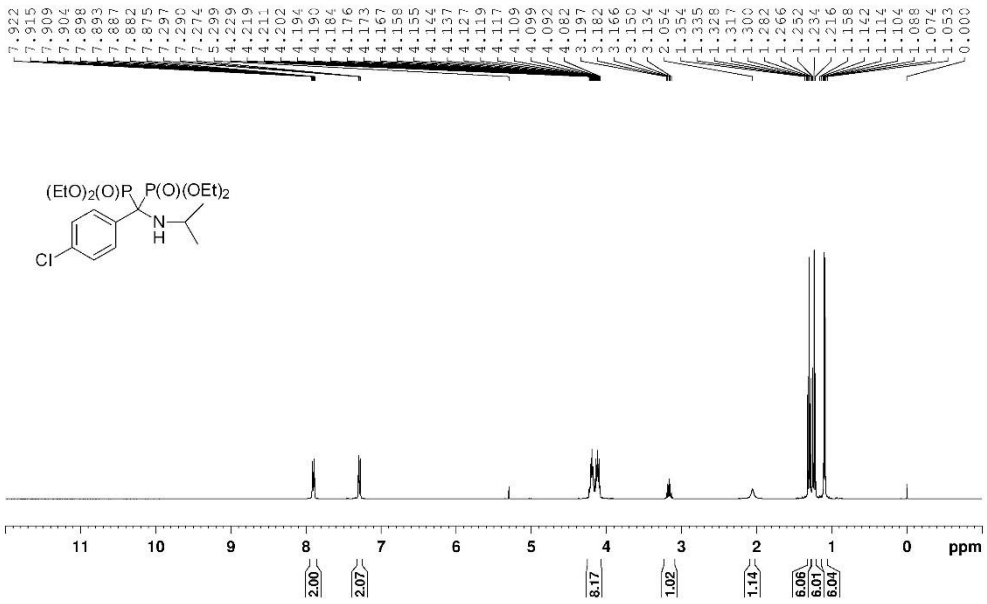
Tetraethyl[(isopropylamino)(phenyl)methylene]bis(phosphonate) (2a)
202M
CDCl3



Tetraethyl[(4-chlorophenyl)(isopropylamino)methylene]bis(phosphonate) (2b)

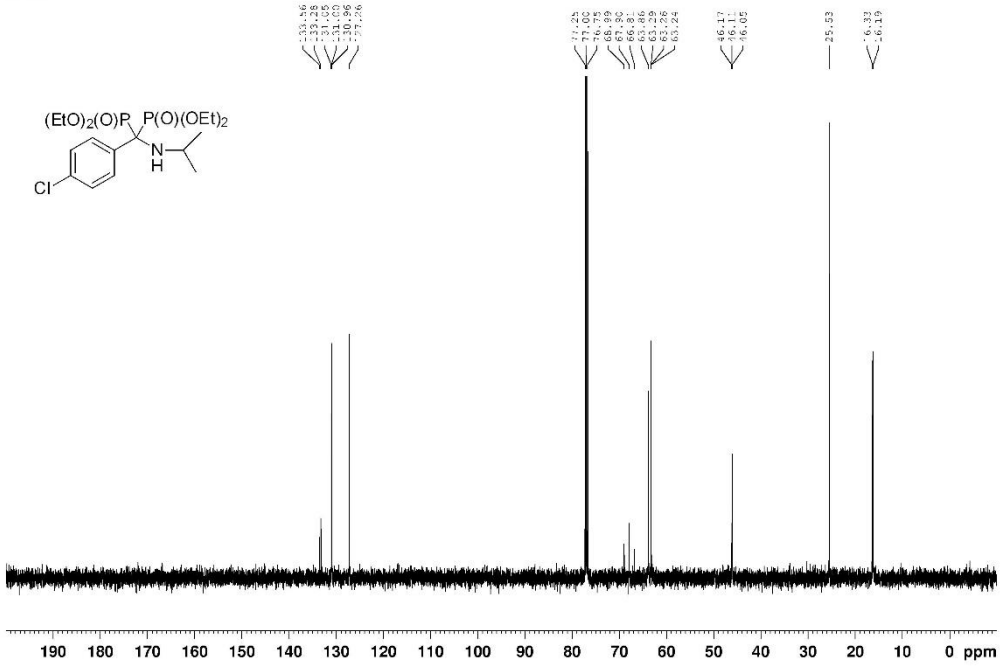
400 M

CDCl3



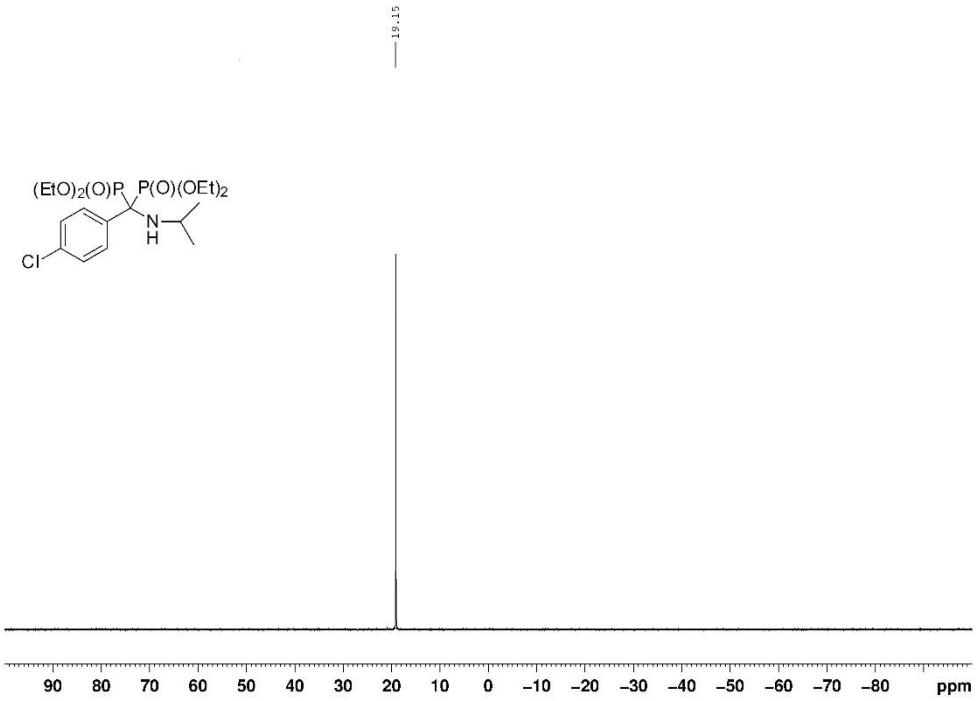
Tetraethyl[(4-chlorophenyl)(isopropylamino)methylene]bis(phosphonate) (2b)

125M CDCl3



Tetraethyl[(4-chlorophenyl)(isopropylamino)methylene]bis(phosphonate) (2b)

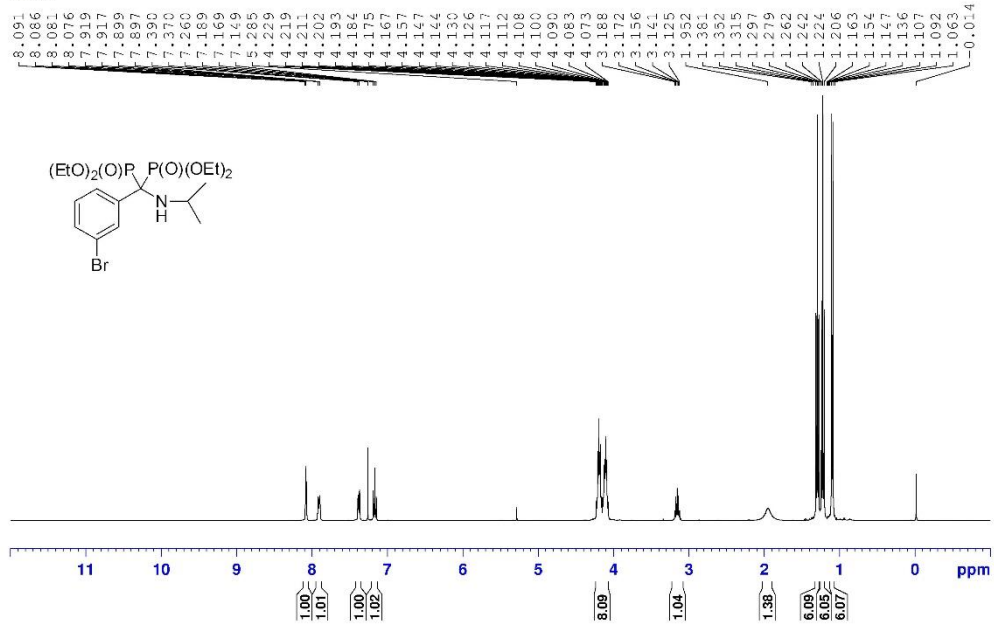
162 M CDCl3



Tetraethyl[(3-bromophenyl)(isopropylamino)methylene]bis(phosphonate) (2c)

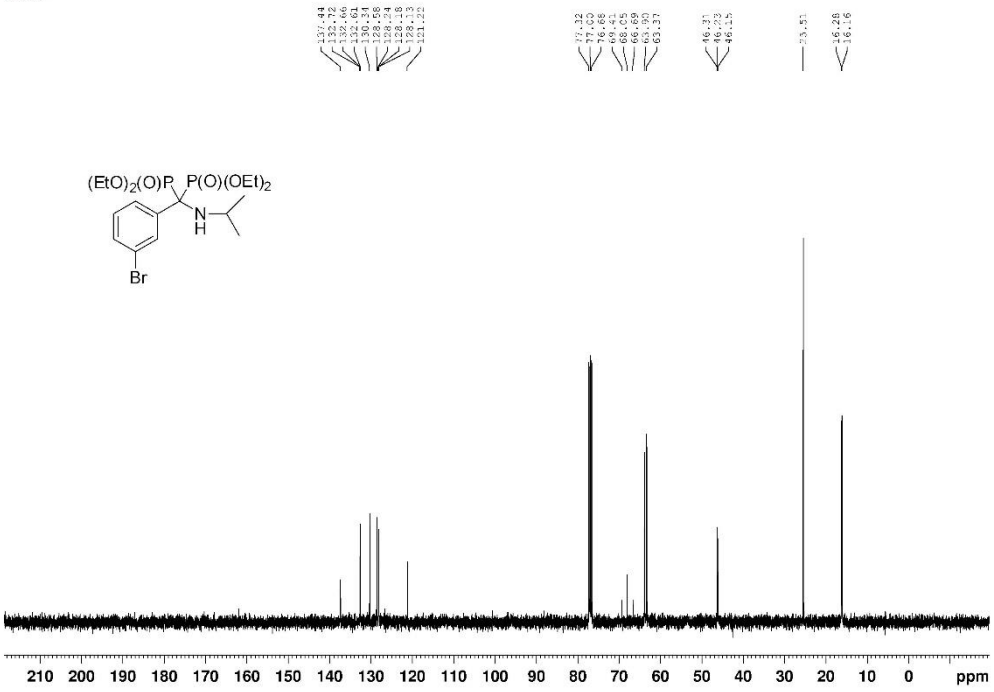
400 M

CDCl3



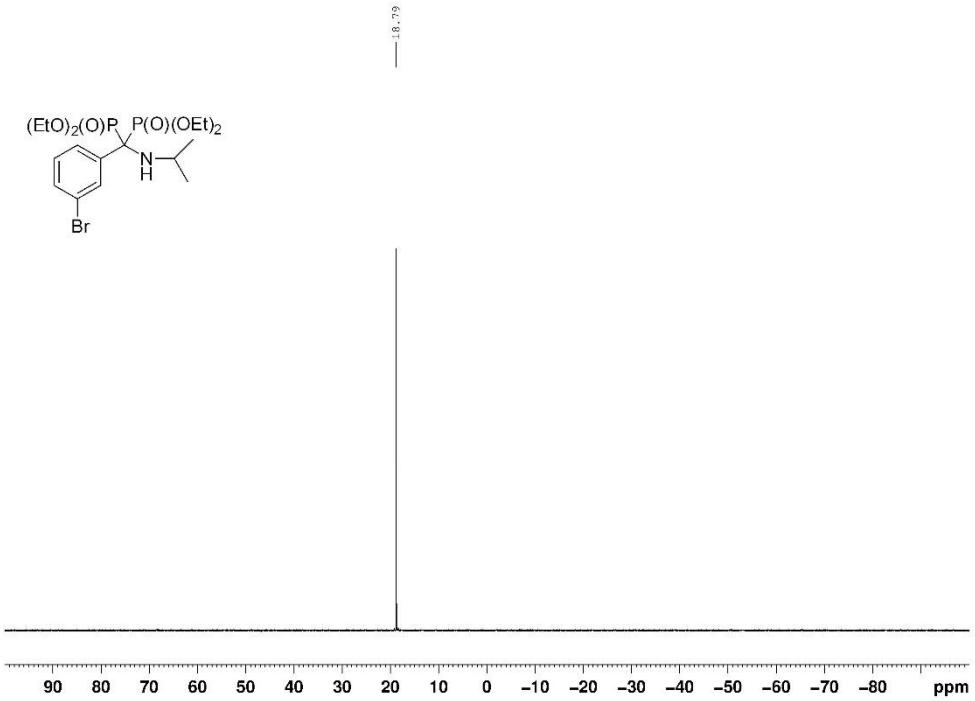
Tetracthyl[(3-bromophenyl)(isopropylamino)methylene]bis(phosphonate) (2c)

100 M CDCl3



Tetraethyl[(3-bromophenyl)(isopropylamino)methylene]bis(phosphonate) (2c)

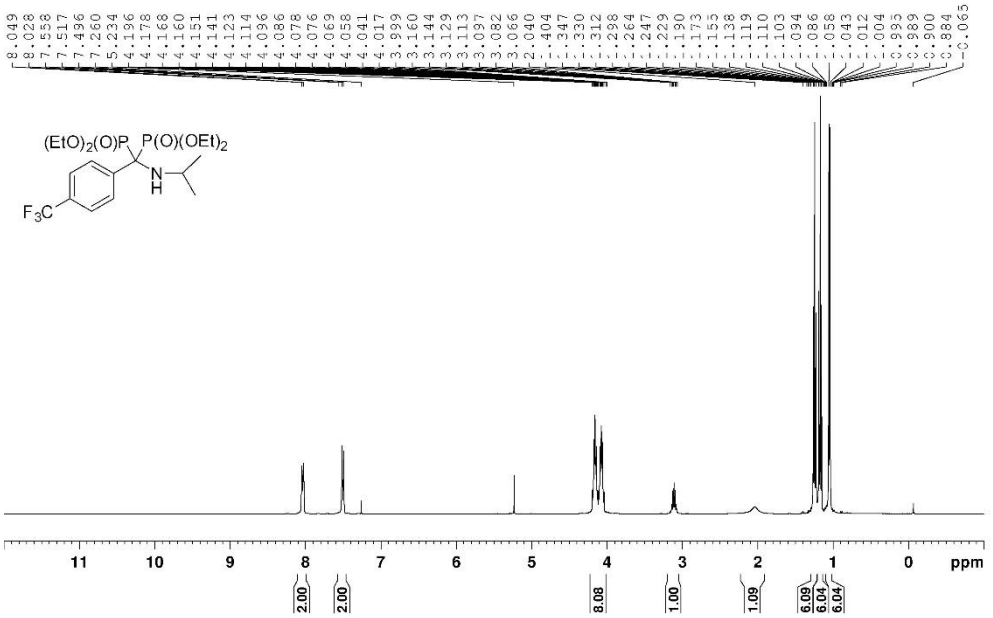
162 M CDCl3



Tetraethyl{(isopropylamino)[4-(trifluoromethyl)phenyl]methylene}bis(phosphonate) (2d)

400 M

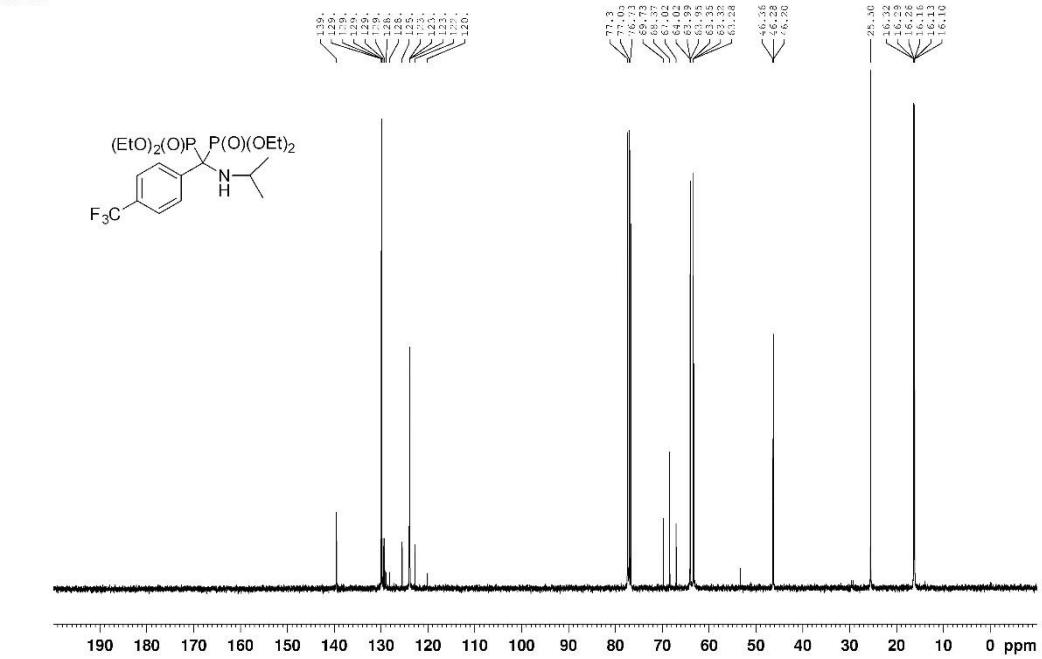
CDCl3



Tetraethyl{(isopropylamino)[4-(trifluoromethyl)phenyl]methylene}bis(phosphonate) (2d)

100 M

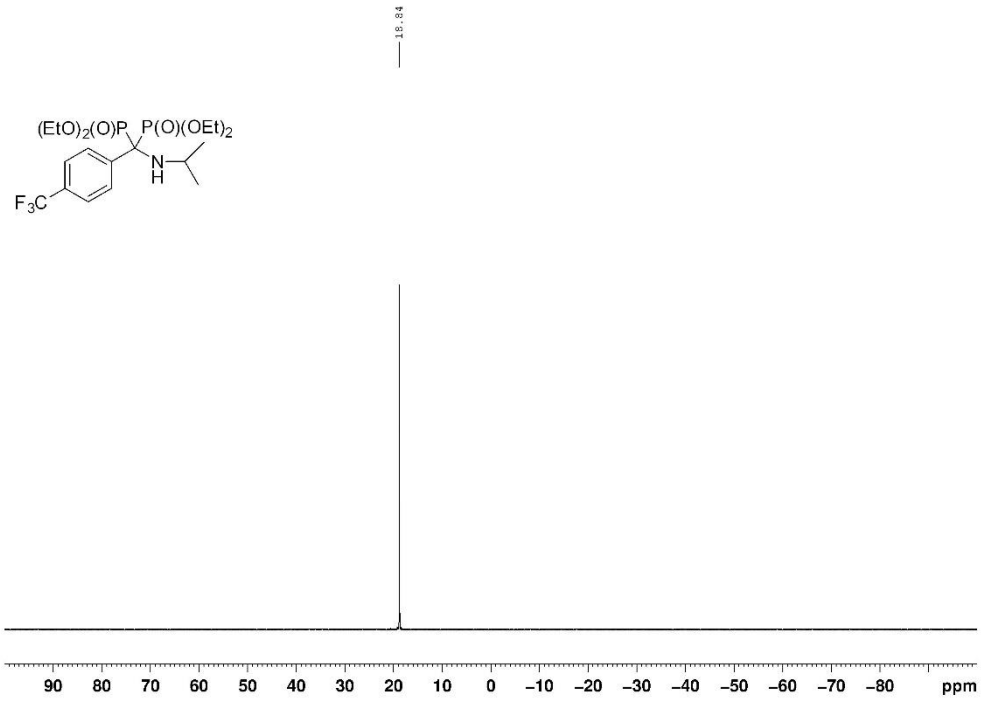
CDCl3



Tetraethyl{(isopropylamino)[4-(trifluoromethyl)phenyl]methylene}bis(phosphonate) (2d)

162 M

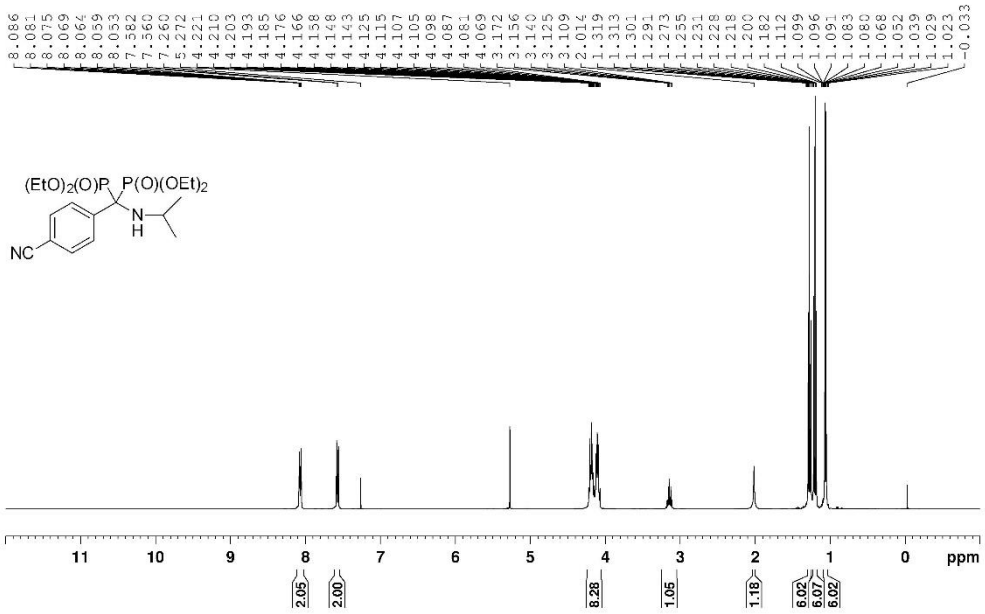
CDCl3



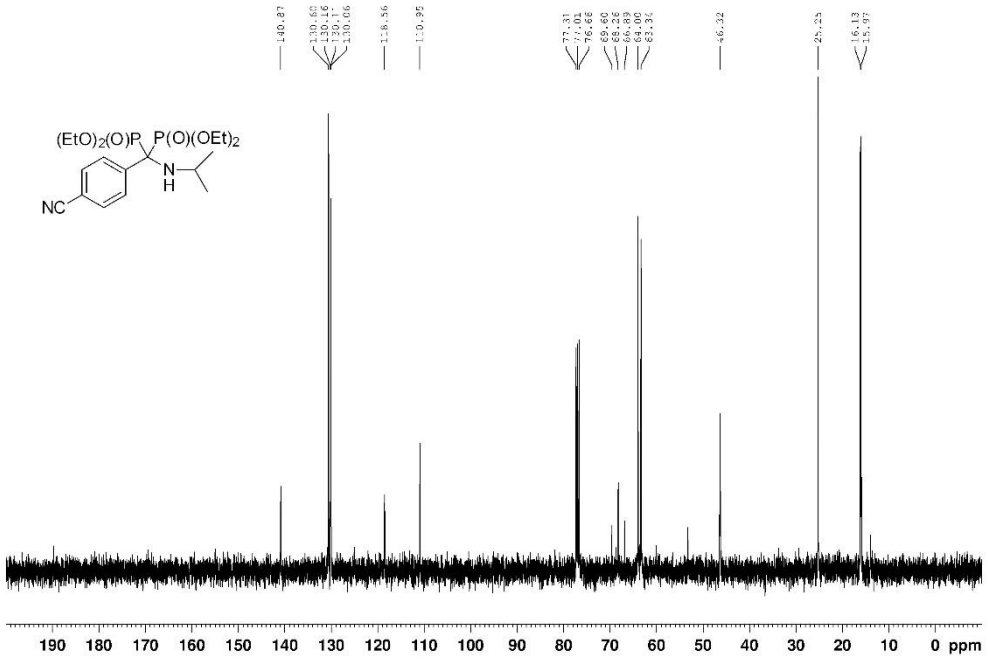
Tetraethyl[(4-cyanophenyl)(isopropylamino)methylene]bis(phosphonate) (2e)

400M

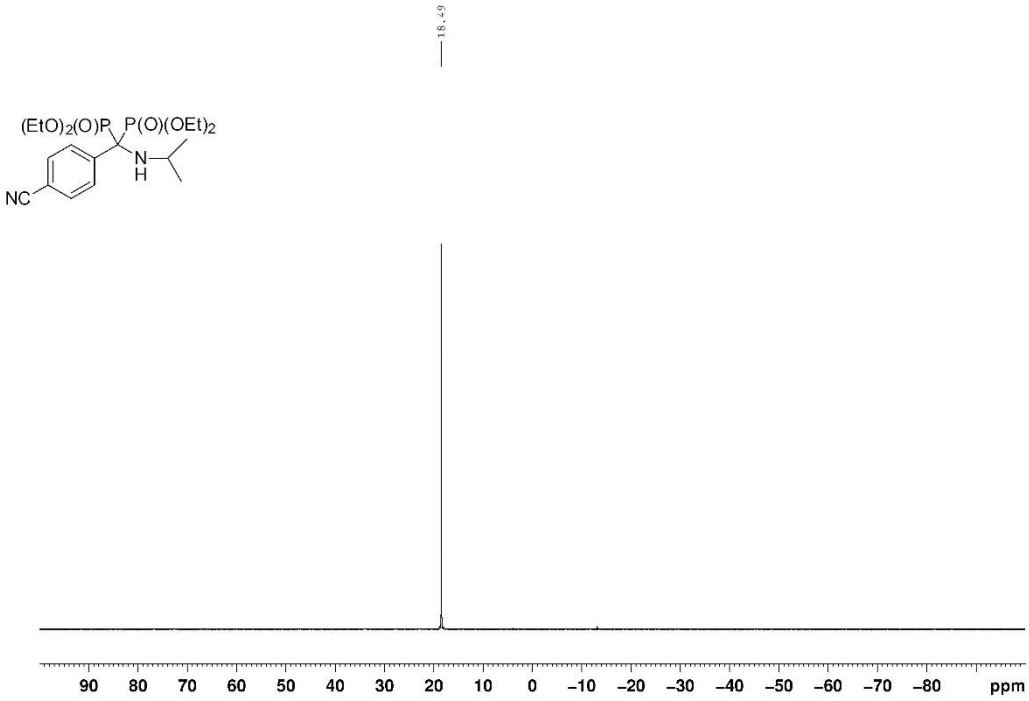
CDCl3



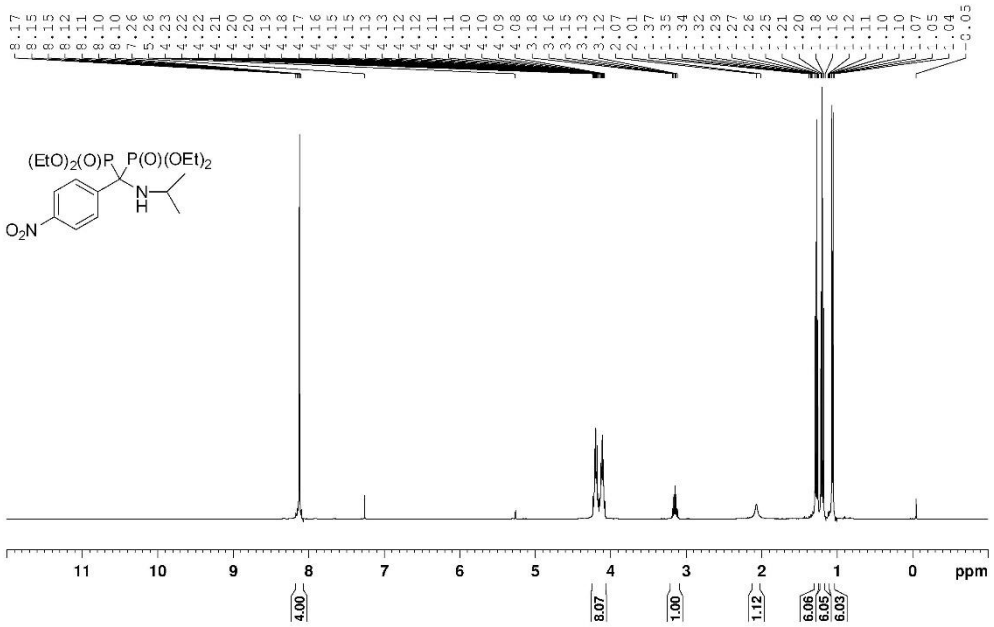
Tetraethyl[(4-cyanophenyl)(isopropylamino)methylene]bis(phosphonate) (2e)
100 M
CDCl3



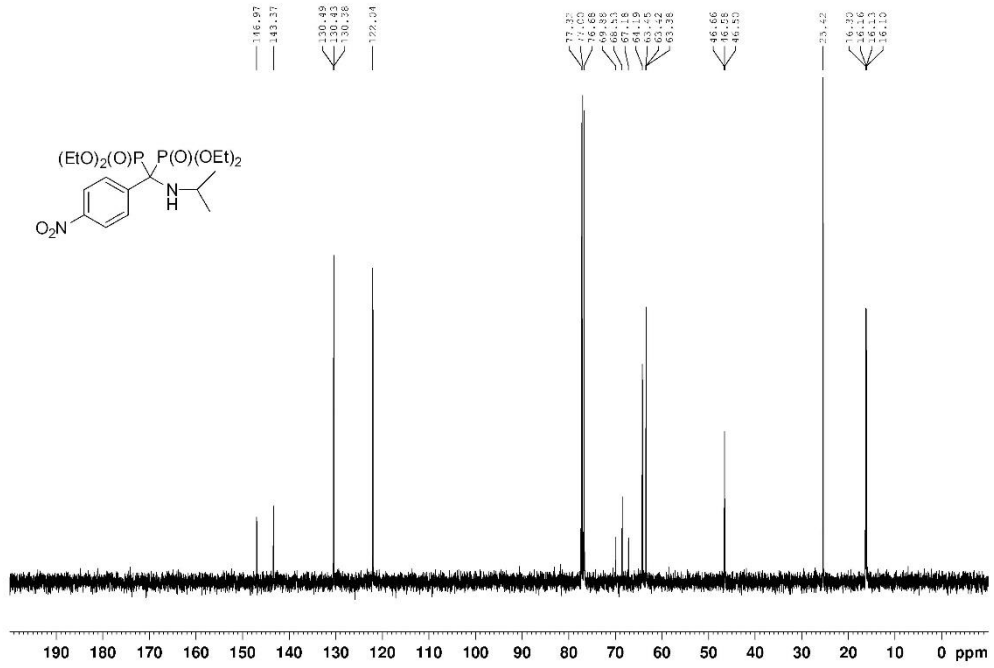
Tetraethyl[(4-cyanophenyl)(isopropylamino)methylene]bis(phosphonate) (2e)
162 M
CDCl3



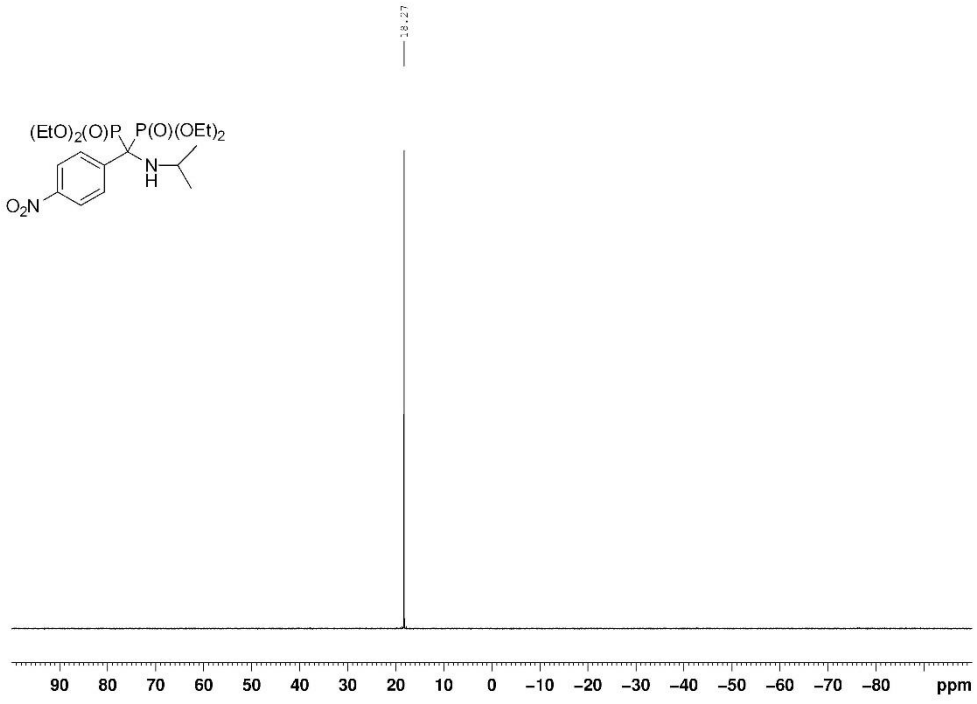
Tetraethyl[(isopropylamino)(4-nitrophenyl)methylene]bis(phosphonate) (2f)
400 M
CDCl3



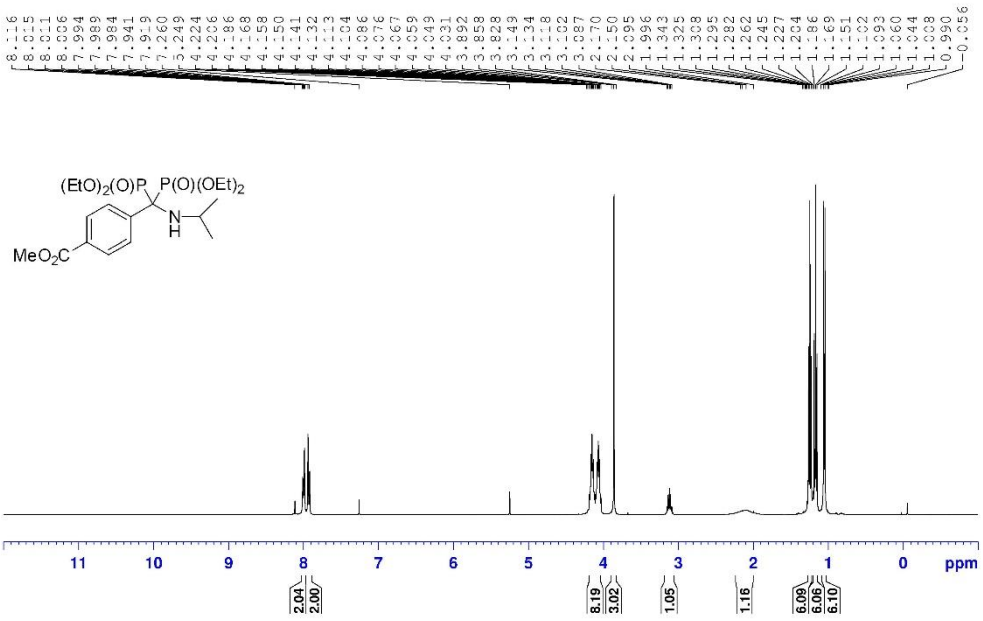
Tetraethyl[(isopropylamino)(4-nitrophenyl)methylene]bis(phosphonate) (2f)
100 M
CDCl3



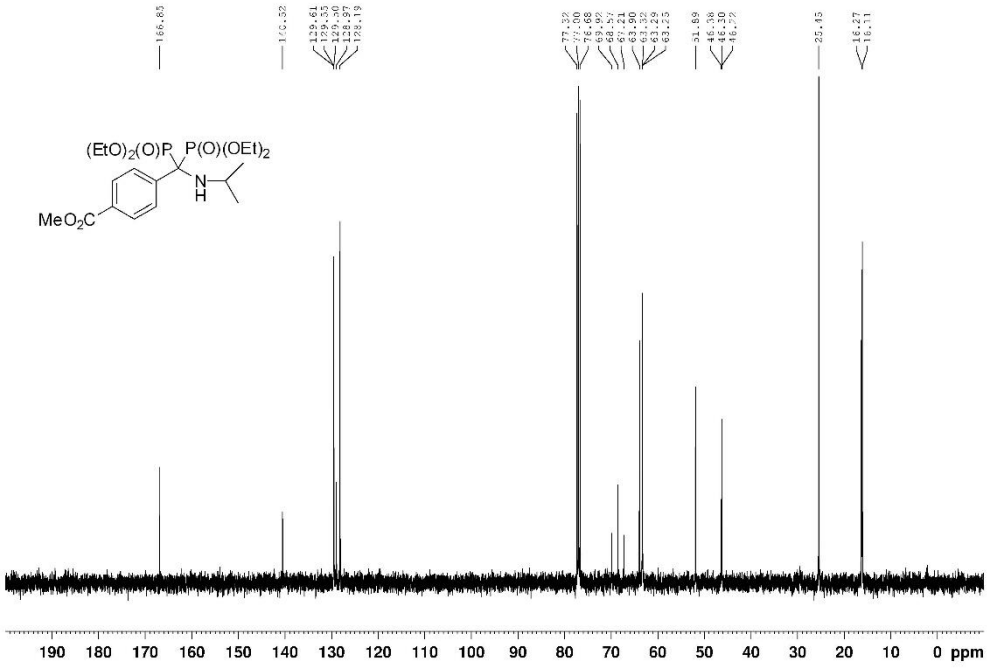
Tetraethyl[(isopropylamino)(4-nitrophenyl)methylene]bis(phosphonate) (2f)
162 M
CDCl3



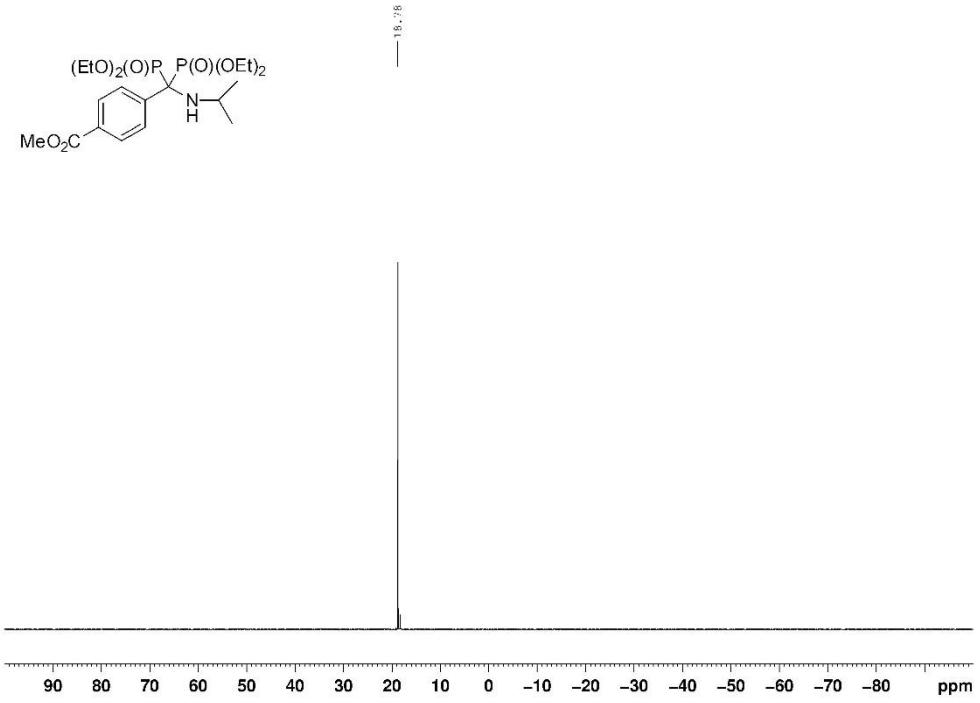
Methyl 4-[bis(diethoxyphosphoryl)(isopropylamino)methyl]benzoate (2g)
400M
CDCl3



Methyl 4-[bis(diethoxyphosphoryl)(isopropylamino)methyl]benzoate (2g)
100M
CDCl3



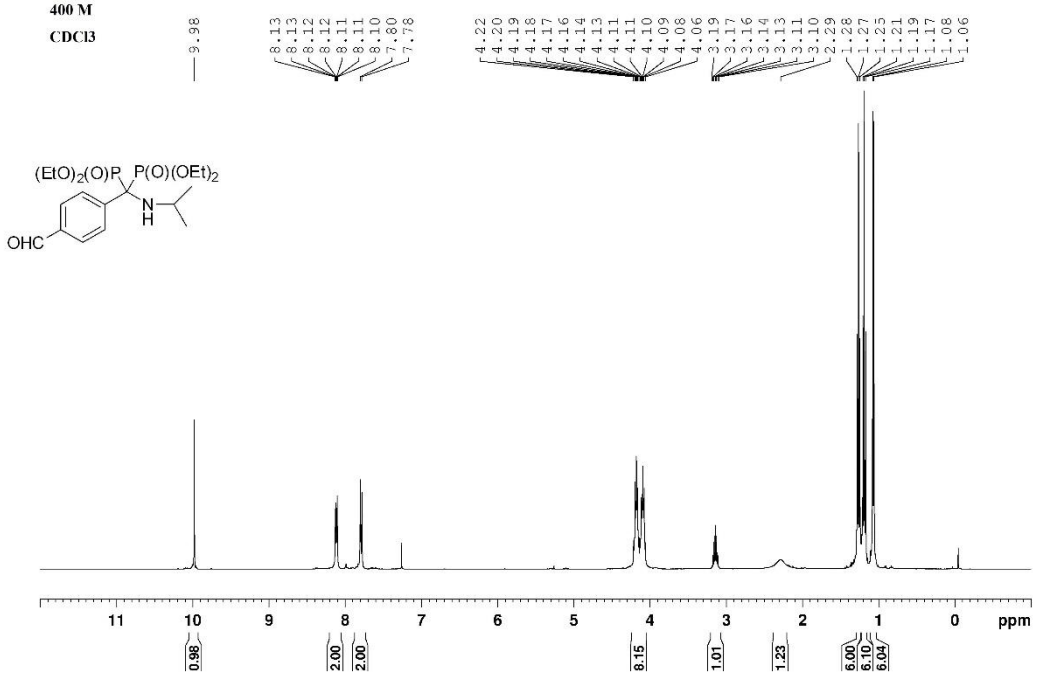
Methyl 4-[bis(diethoxyphosphoryl)(isopropylamino)methyl]benzoate (2g)
100M
CDCl3



Tetraethyl[(4-formylphenyl)(isopropylamino)methylene]bis(phosphonate) (2h)

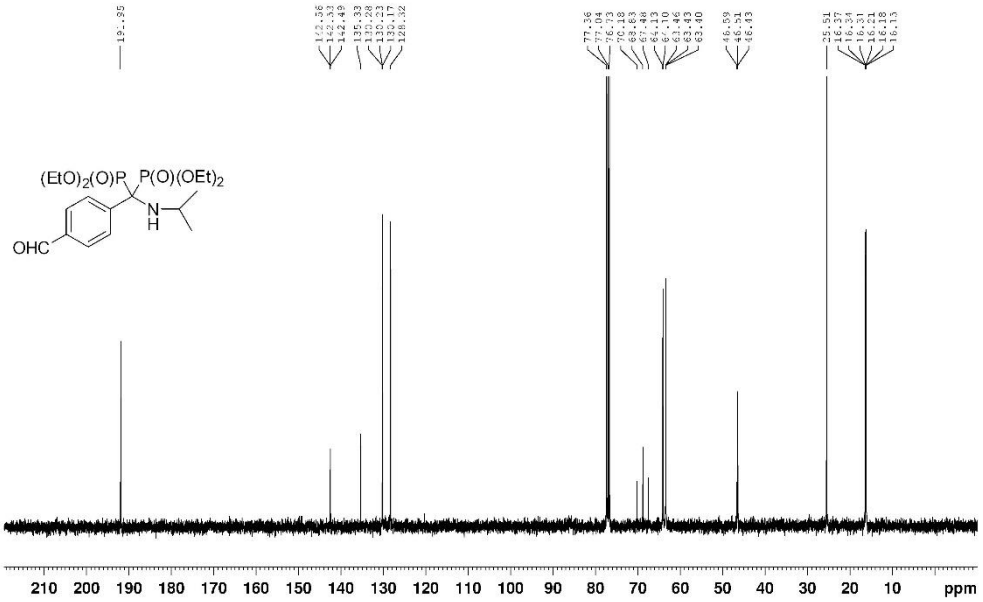
400 M

CDCl3

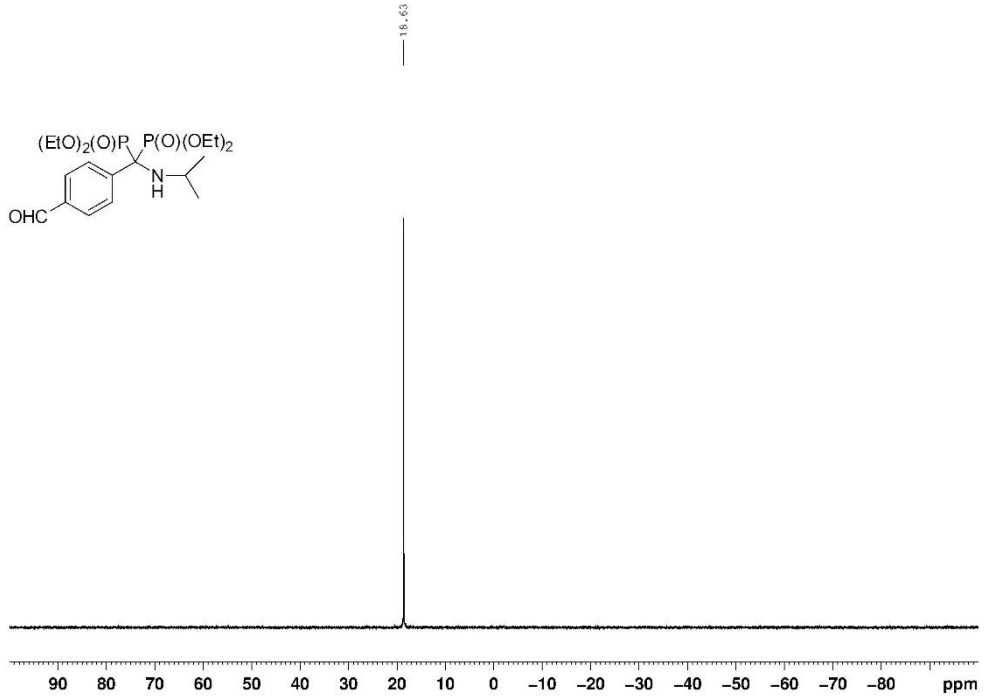


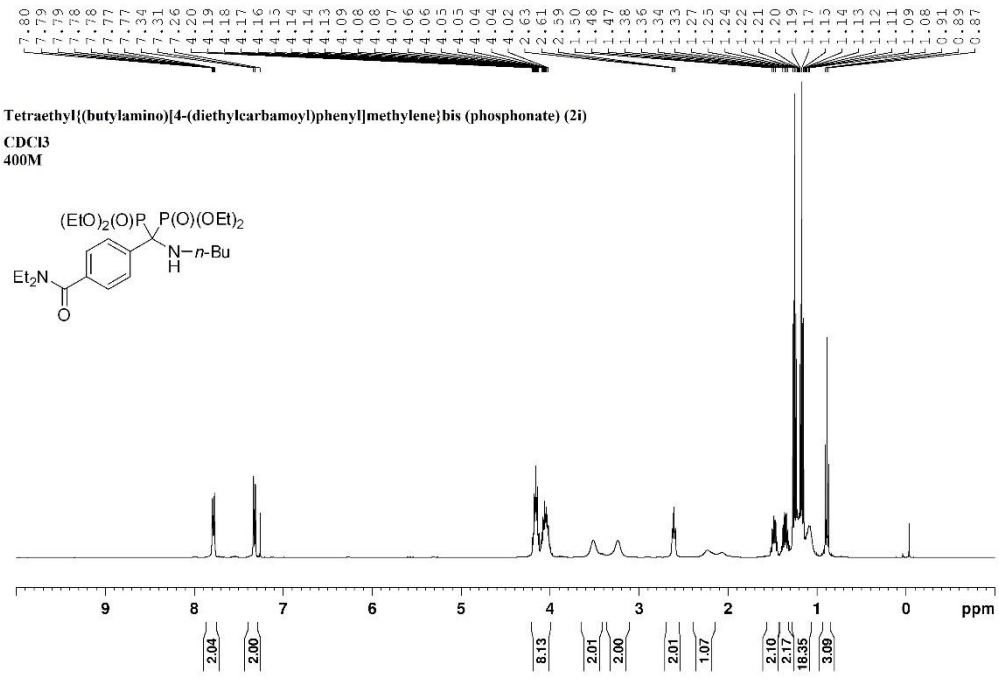
Tetraethyl[(4-formylphenyl)(isopropylamino)methylene]bis(phosphonate) (2h)

100M CDCl3



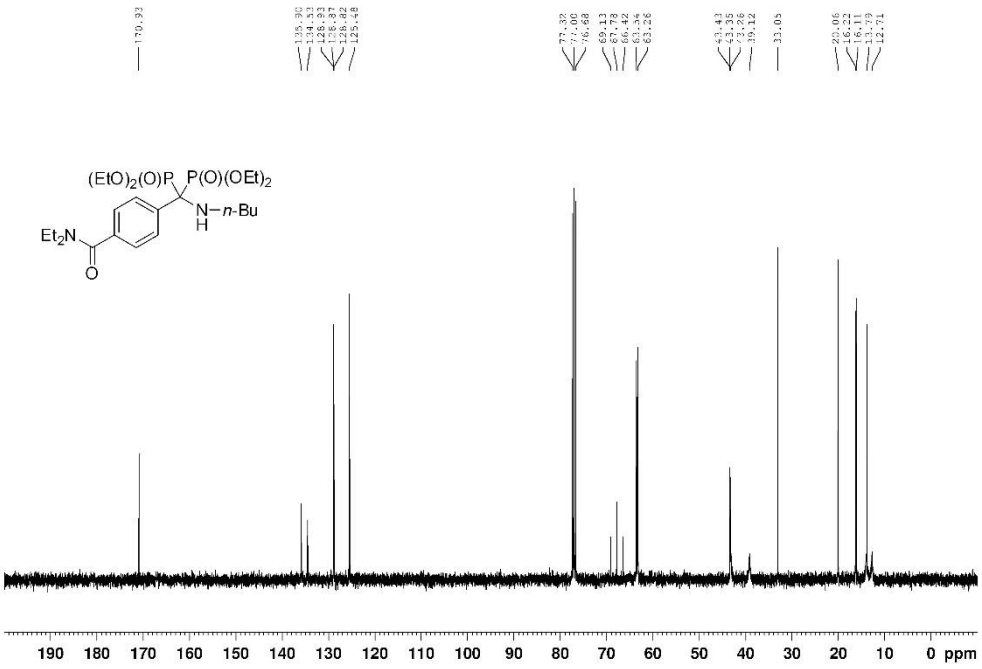
Tetraethyl[(4-formylphenyl)(isopropylamino)methylene]bis(phosphonate) (2h)
162M CDCl3



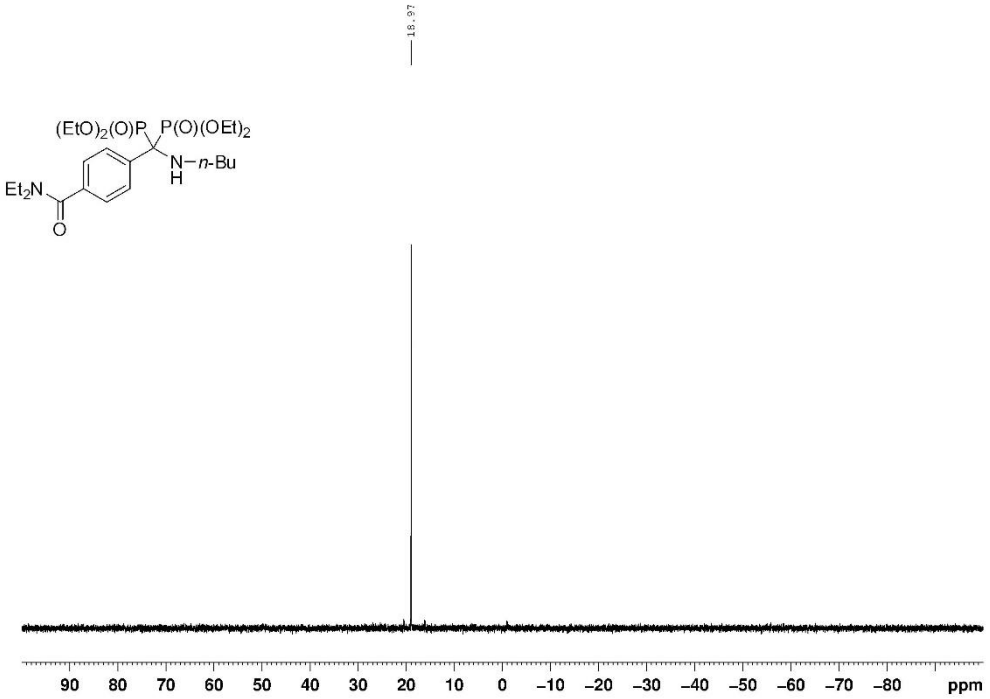


Tetraethyl{(butylamino)[4-(diethylcarbamoyl)phenyl]methylene}bis (phosphonate) (2i)
CDCl3
400M

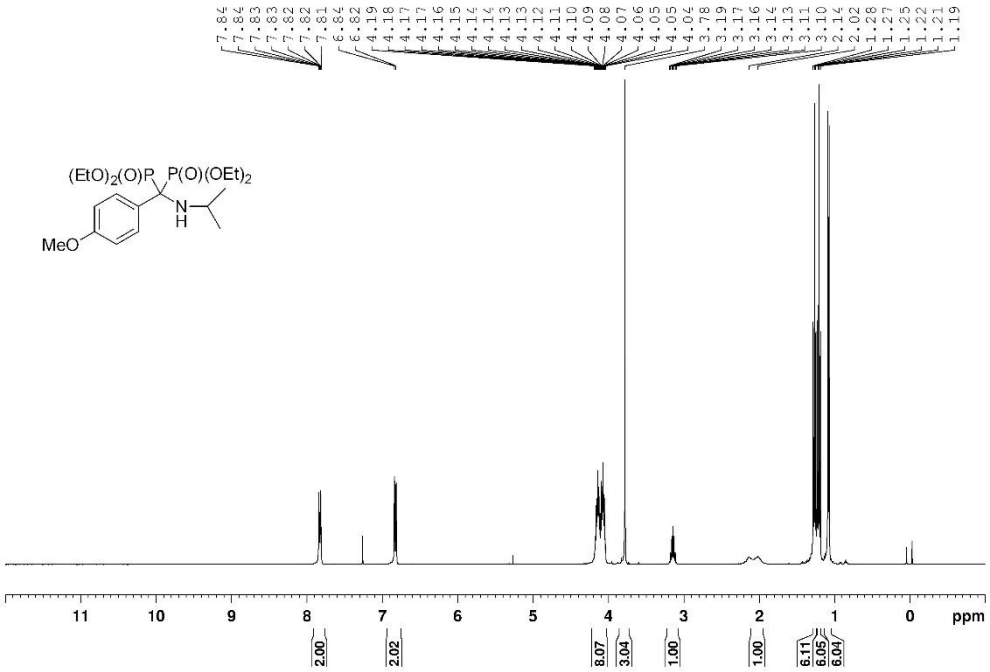
Tetraethyl{(butylamino)[4-(diethylcarbamoyl)phenyl]methylene}bis (phosphonate) (2i)
100M CDCl3



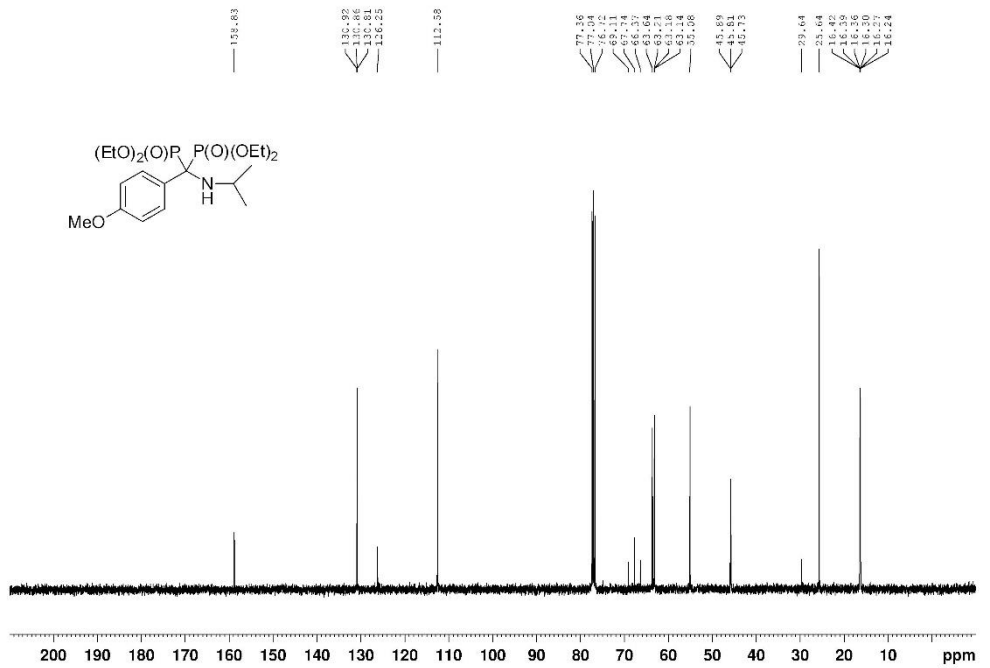
Tetraethyl{(butylamino)[4-(diethylcarbamoyl)phenyl]methylene}bis (phosphonate) (2i)
162M CDCl3



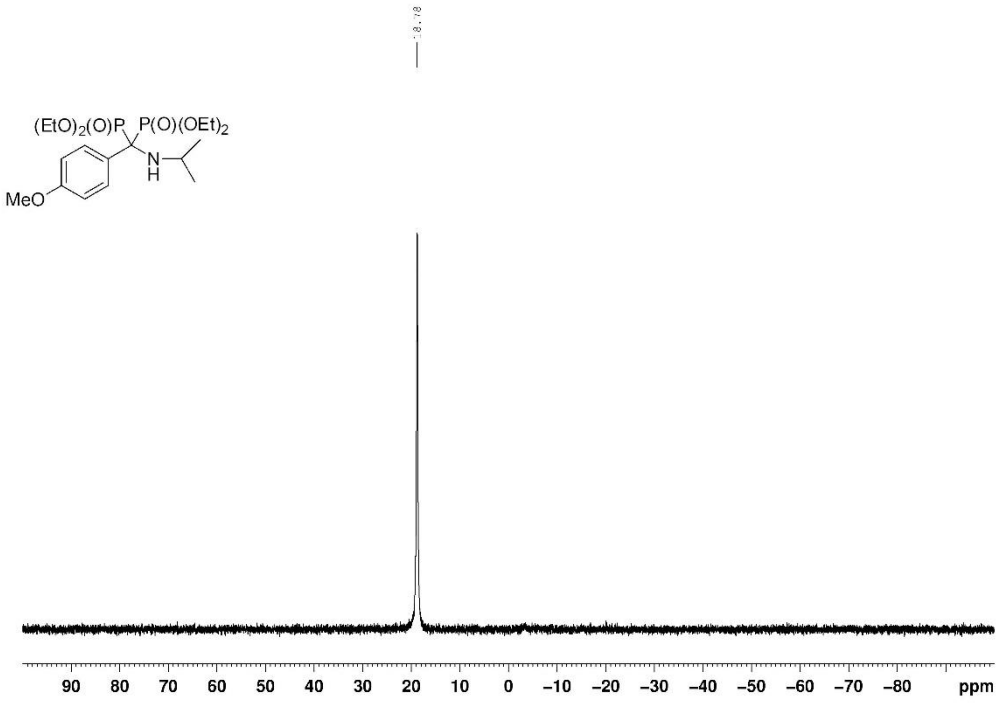
Tetraethyl[(isopropylamino)(4-methoxyphenyl)methylene]bis(phosphonate) (2j)
400M CDCl3



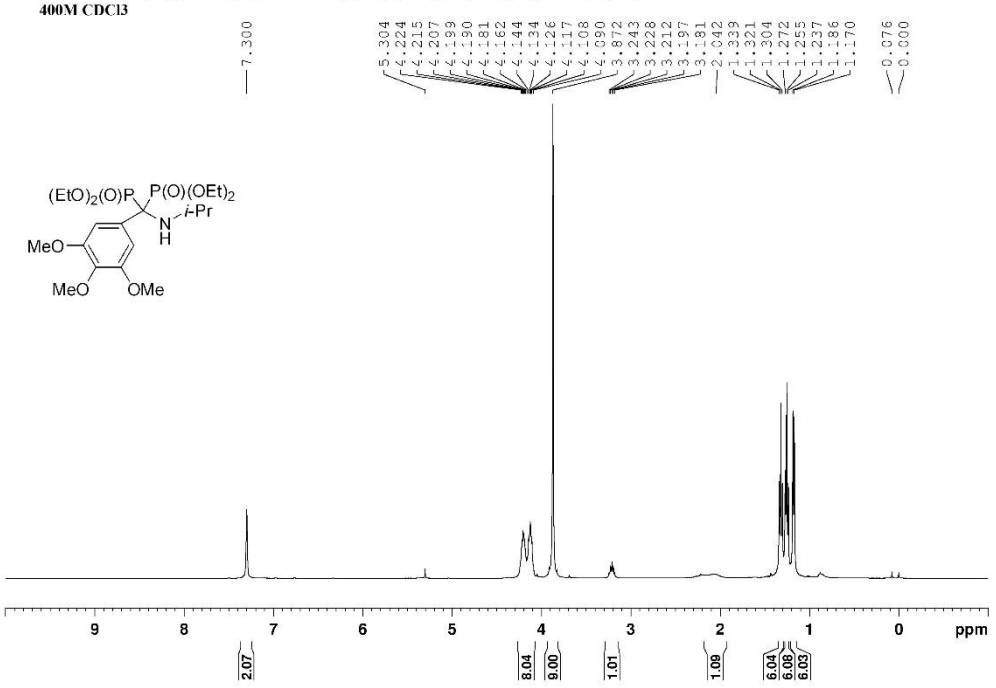
Tetraethyl[(isopropylamino)(4-methoxyphenyl)methylene]bis(phosphonate) (2j)
100M CDCl3



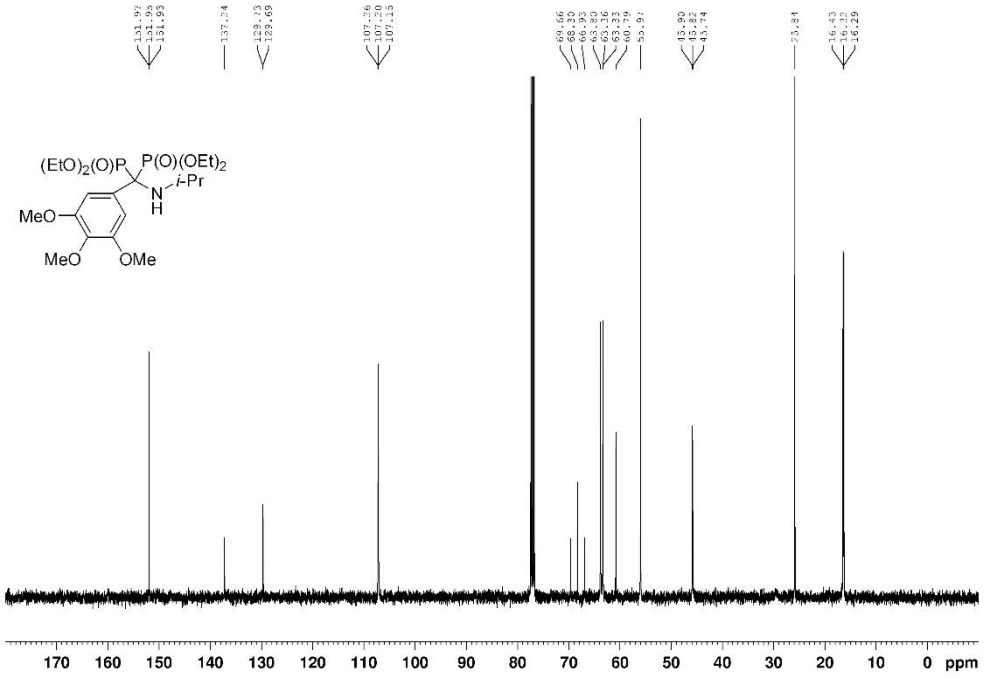
Tetraethyl[(isopropylamino)(4-methoxyphenyl)methylene]bis(phosphonate) (2j)
162M CDCl3



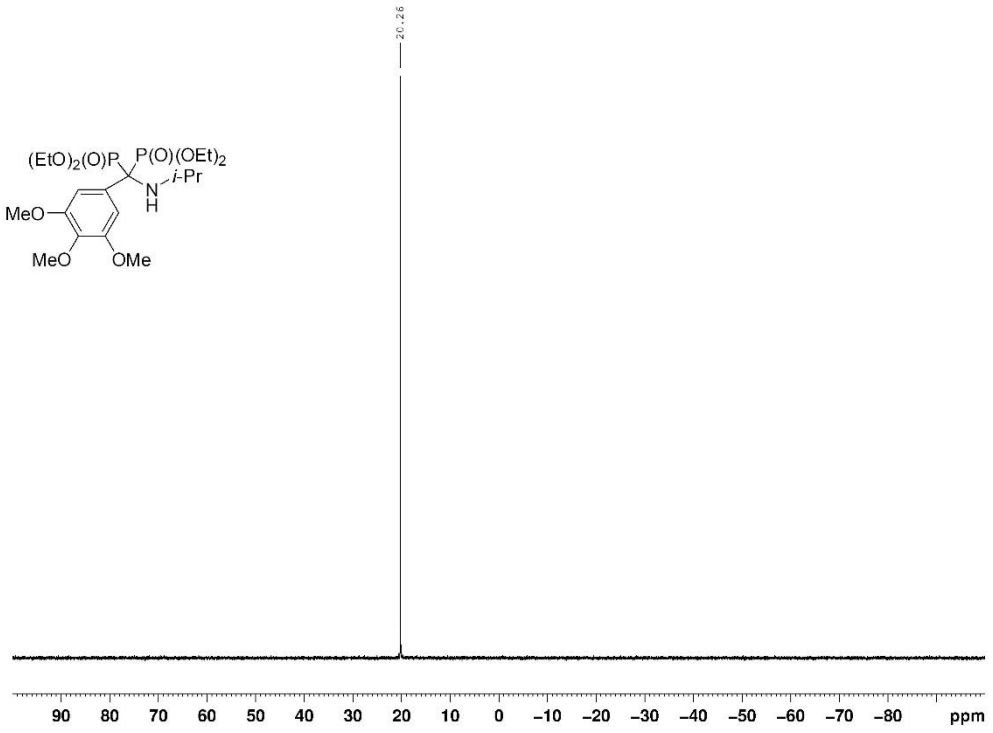
Tetraethyl ((isopropylamino)(3,4,5 trimethoxyphenyl)methylene)bis (phosphonate) (2k)
400M CDCl3



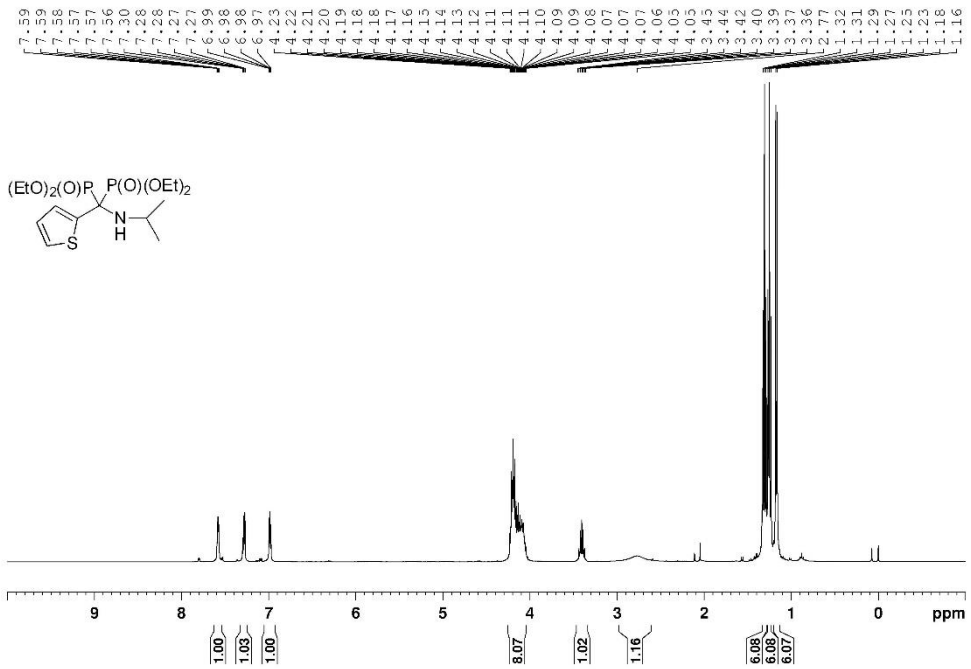
Tetraethyl ((isopropylamino)(3,4,5 trimethoxyphenyl)methylene)bis (phosphonate) (2k)
100M CDCl3



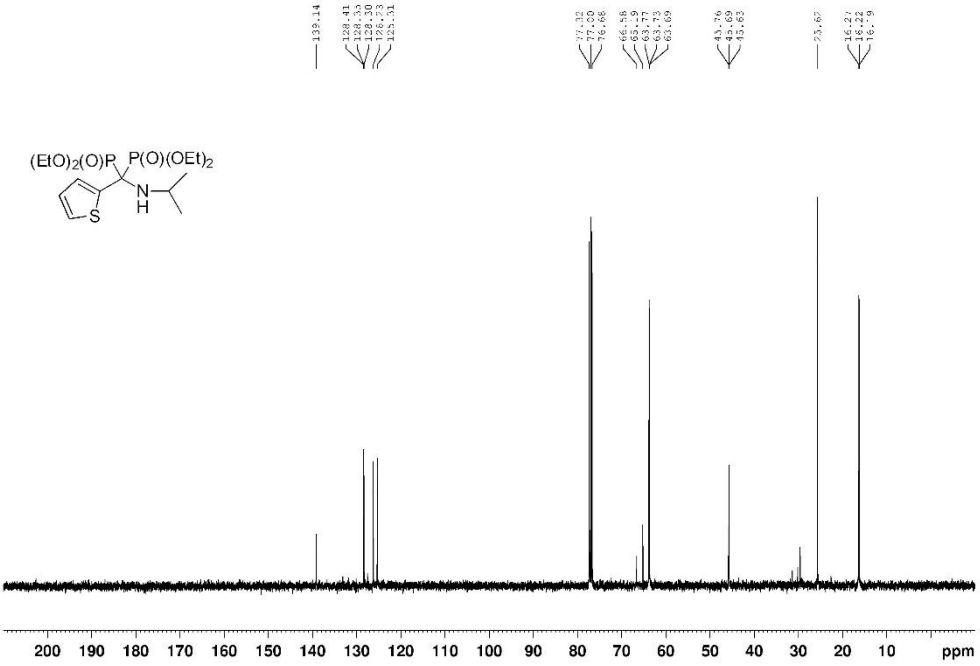
Tetraethyl ((isopropylamino)(3,4,5 trimethoxyphenyl)methylene)bis (phosphonate) (2k)
162M CDCl3



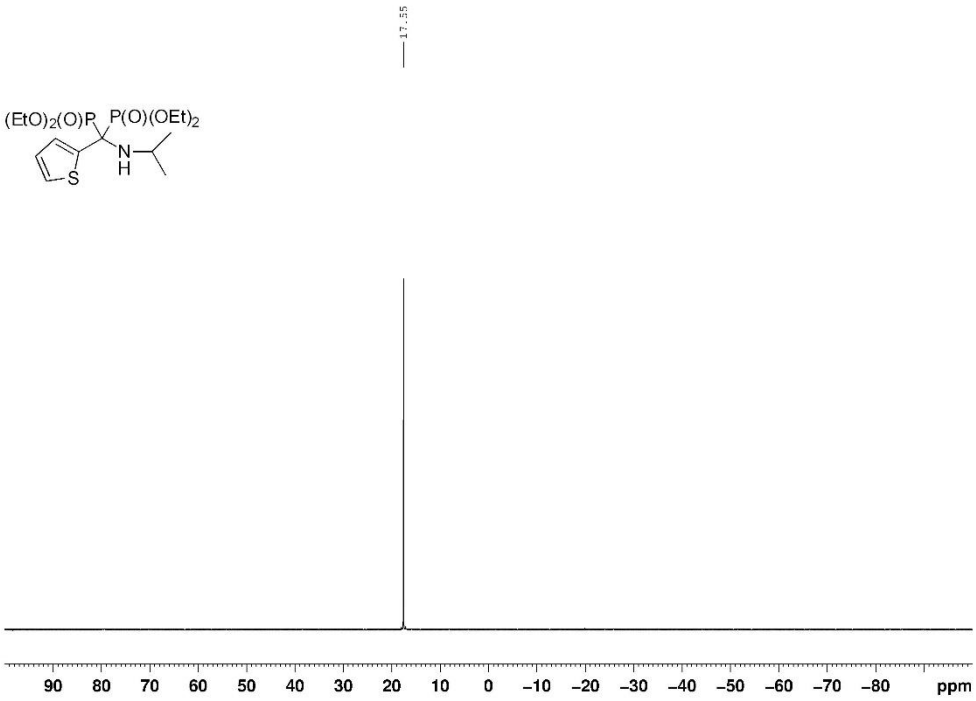
Tetraethyl[(isopropylamino)(thiophen-2-yl)methylene]bis(phosphonate) (2n)
400M CDCl3



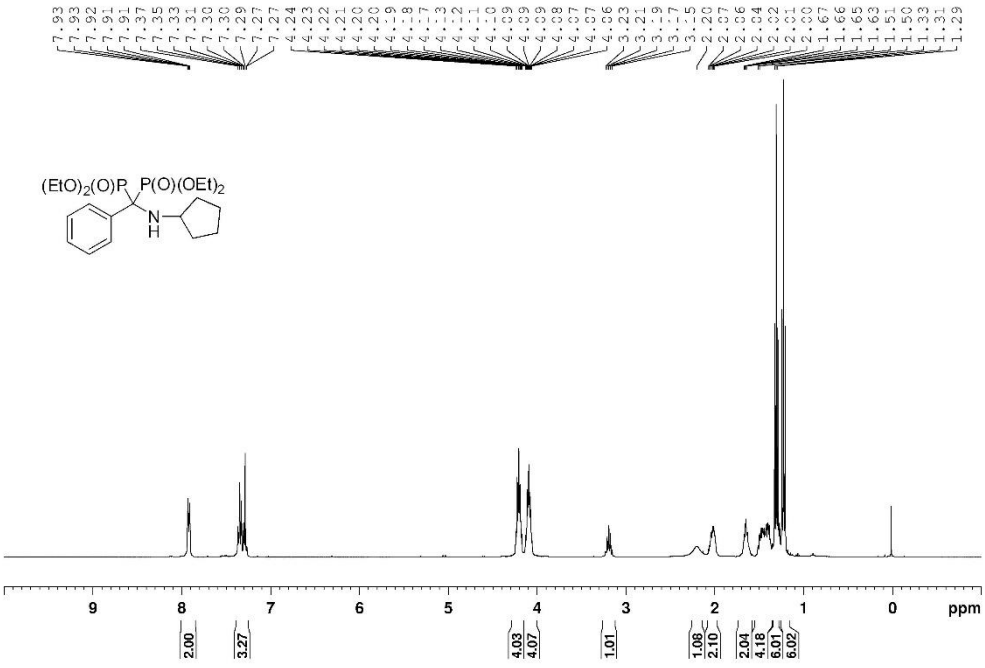
Tetraethyl[(isopropylamino)(thiophen-2-yl)methylene]bis(phosphonate) (2n)
100M CDCl3



Tetraethyl[(isopropylamino)(thiophen-2-yl)methylene]bis(phosphonate) (2n)
162M CDCl3

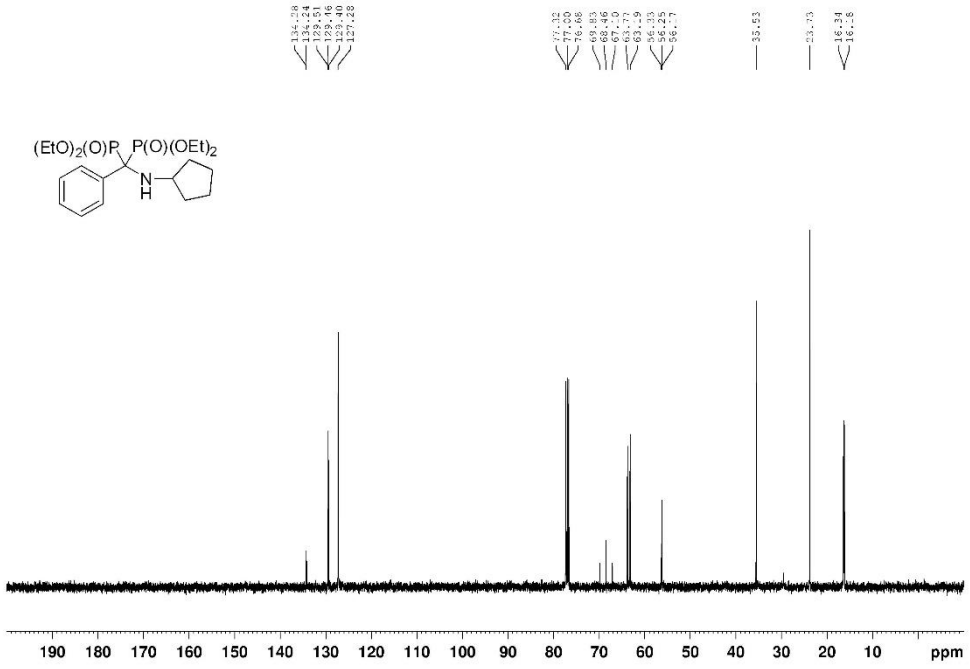


Tetraethyl[(cyclopentylamino)(phenyl)methylene]bis(phosphonate) (2o)
CDCl3 400M



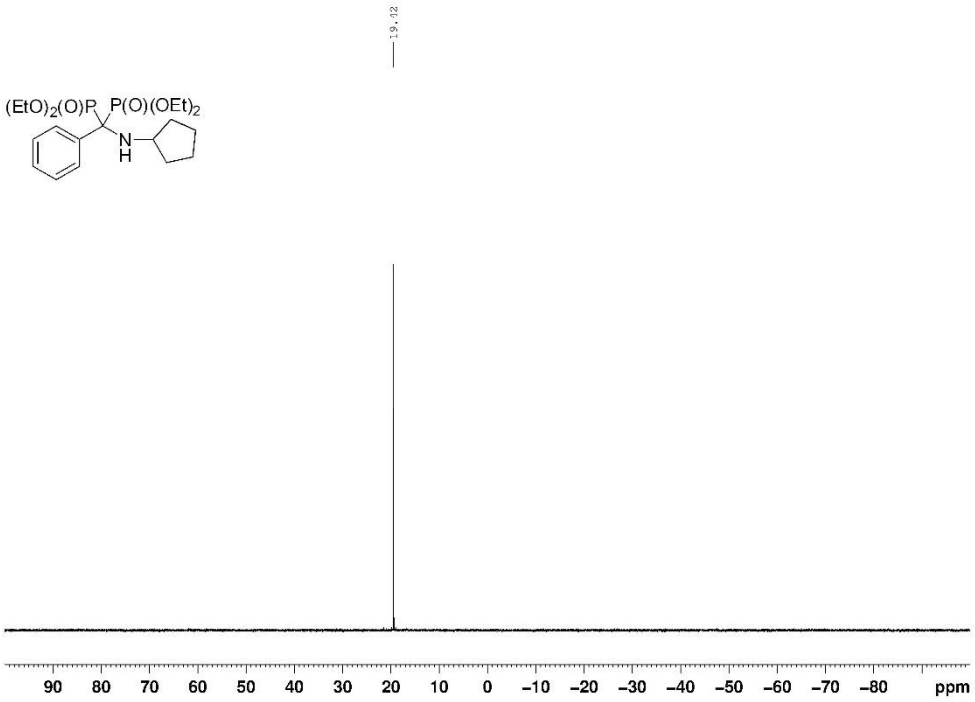
Tetraethyl[(cyclopentylamino)(phenyl)methylene]bis(phosphonate) (2o)

CDCl3 100M

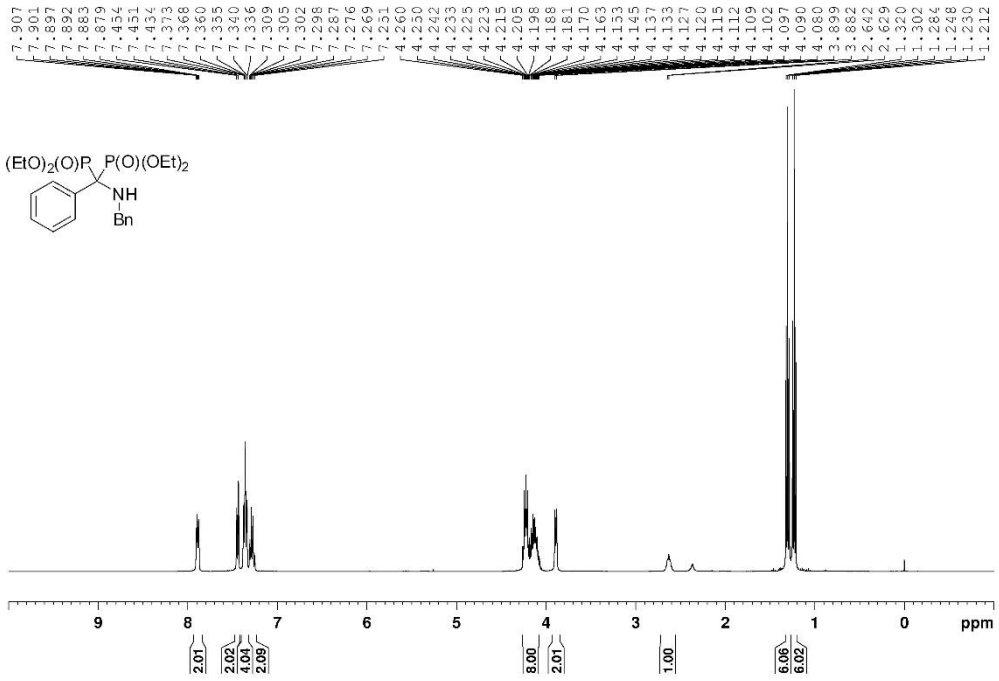


Tetraethyl[(cyclopentylamino)(phenyl)methylene]bis(phosphonate) (2o)

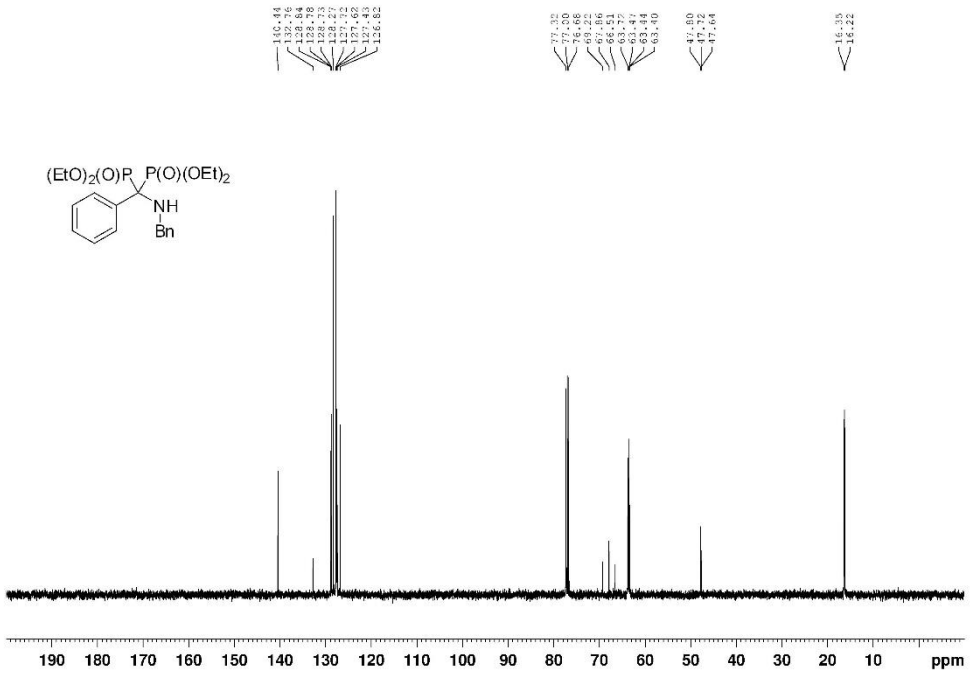
CDCl3 162M



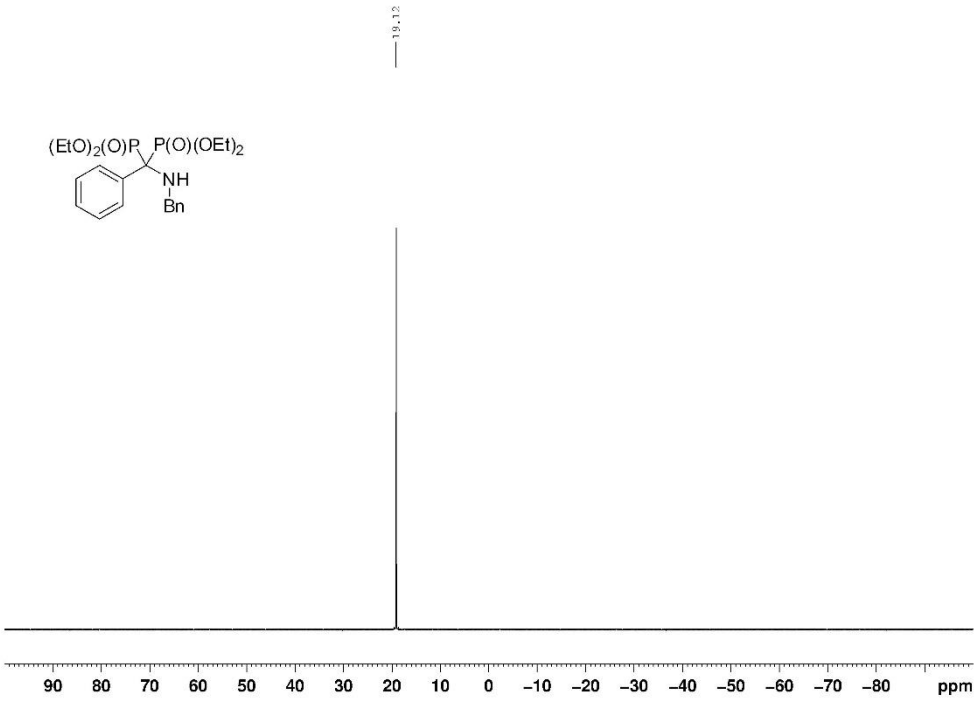
Tetraethyl[(benzylamino)(phenyl)methylene]bis(phosphonate) (2p)
400M CDCl3



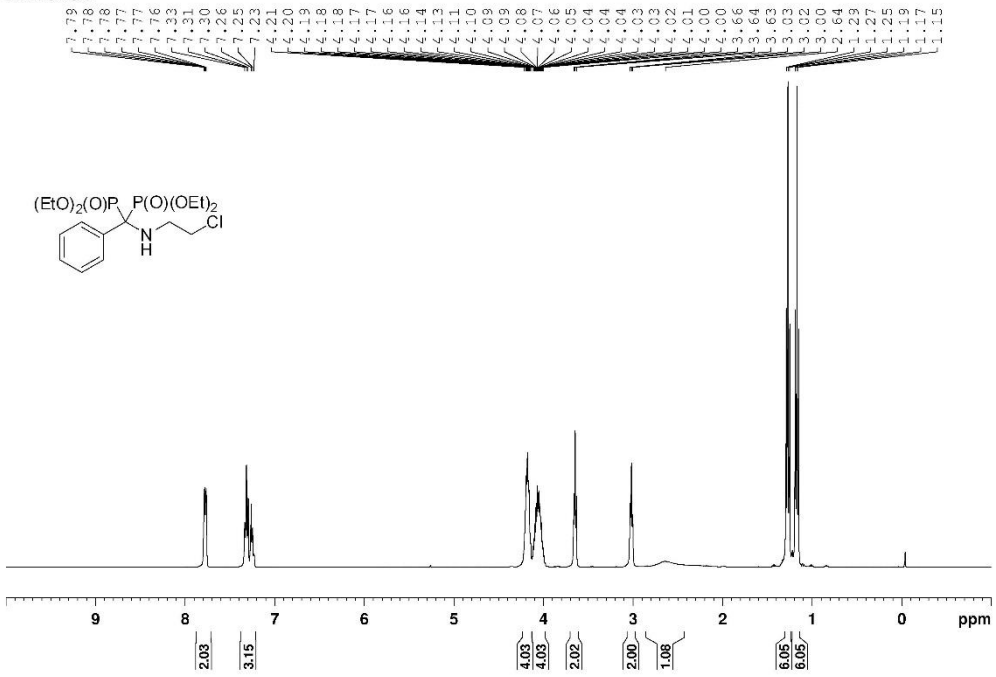
Tetraethyl[(benzylamino)(phenyl)methylene]bis(phosphonate) (2p)
100M CDCl3



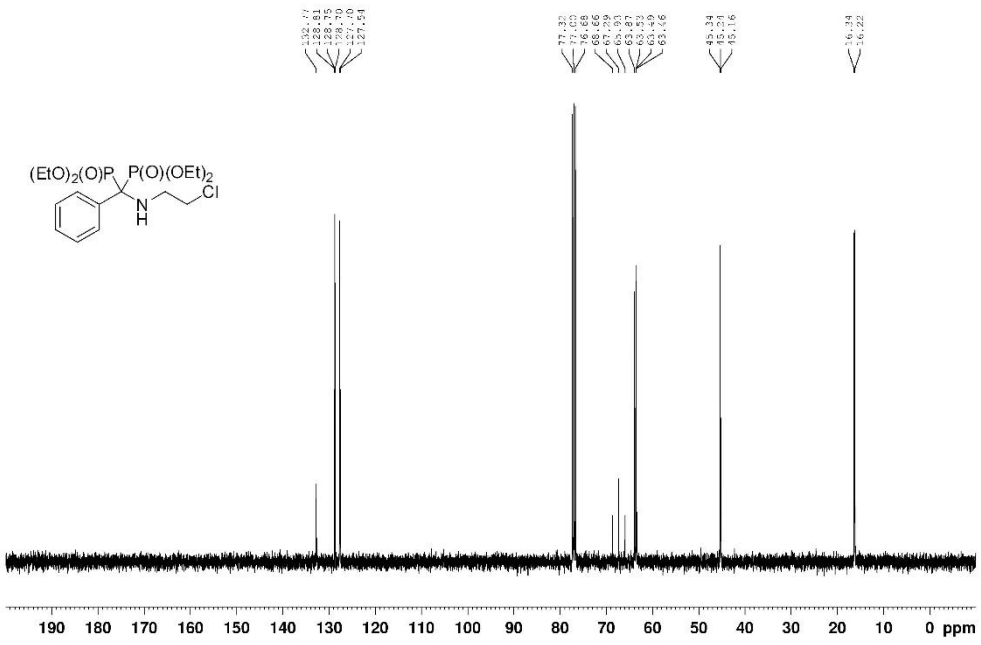
Tetraethyl[(benzylamino)(phenyl)methylene]bis(phosphonate) (2p)
162M CDCl3



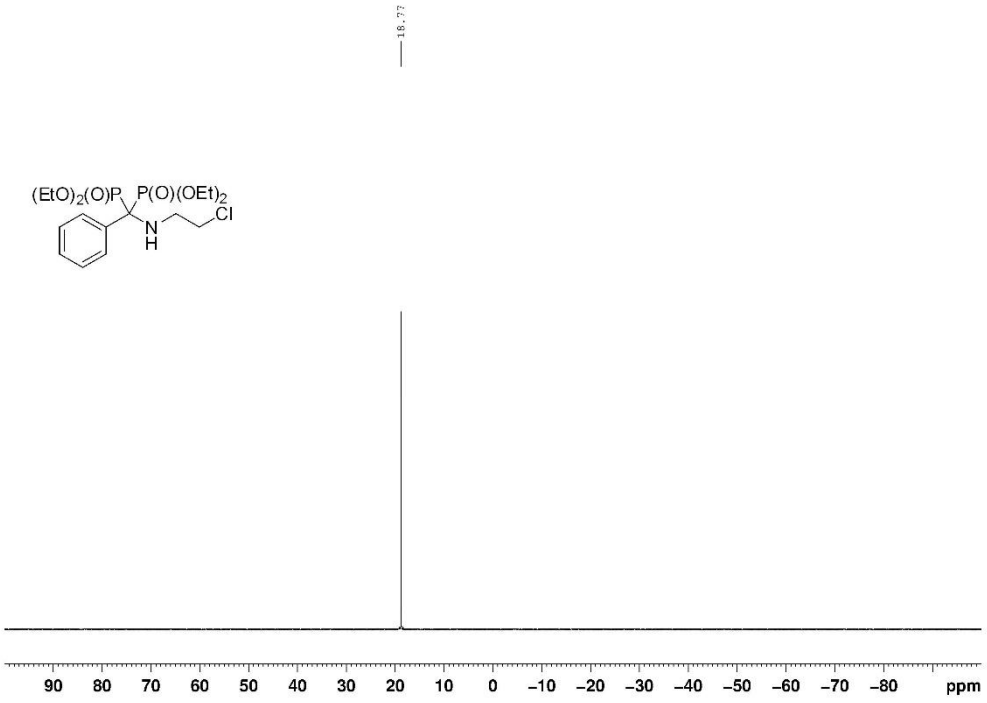
Tetraethyl{[(2-chloroethyl)amino](phenyl)methylene}bis(phosphonate) (2q)
400M CDCl3



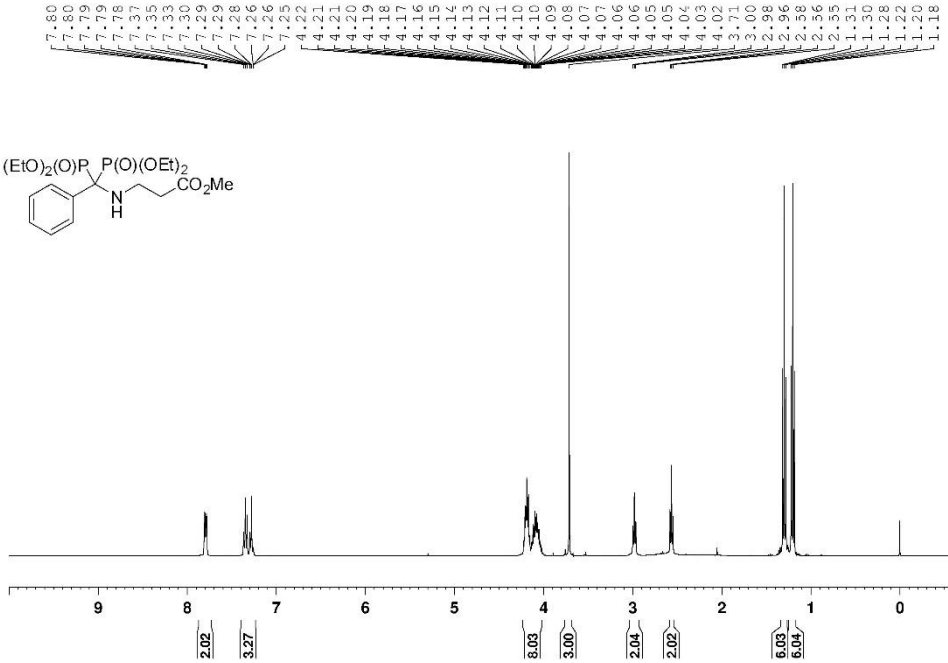
Tetraethyl{[(2-chloroethyl)amino](phenyl)methylene}bis(phosphonate) (2q)
100M CDCl3



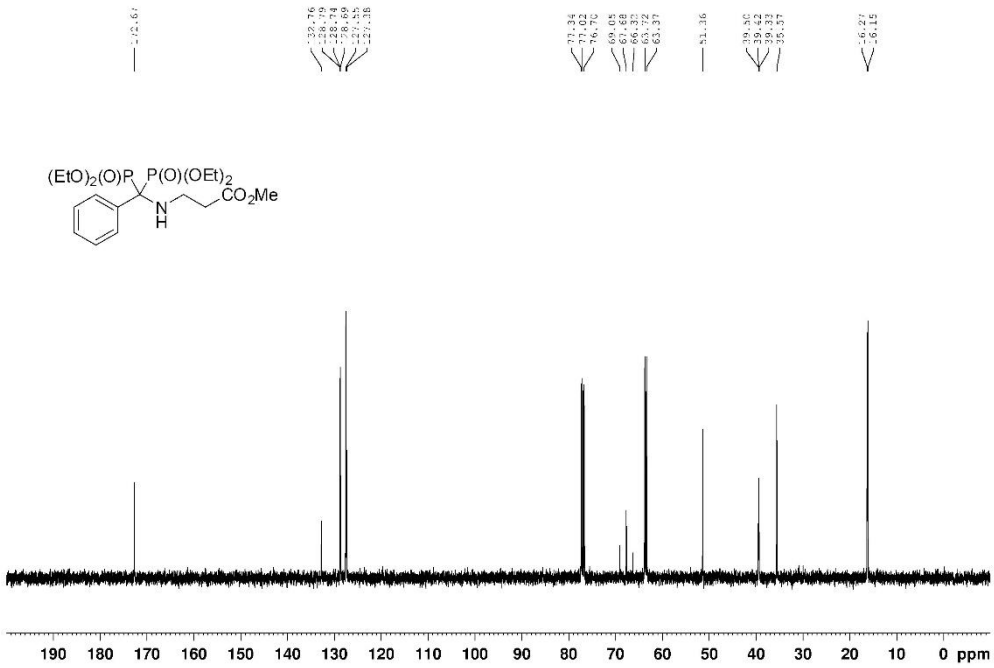
Tetraethyl{[(2-chloroethyl)amino](phenyl)methylene}bis(phosphonate) (2q)
162M CDCl3



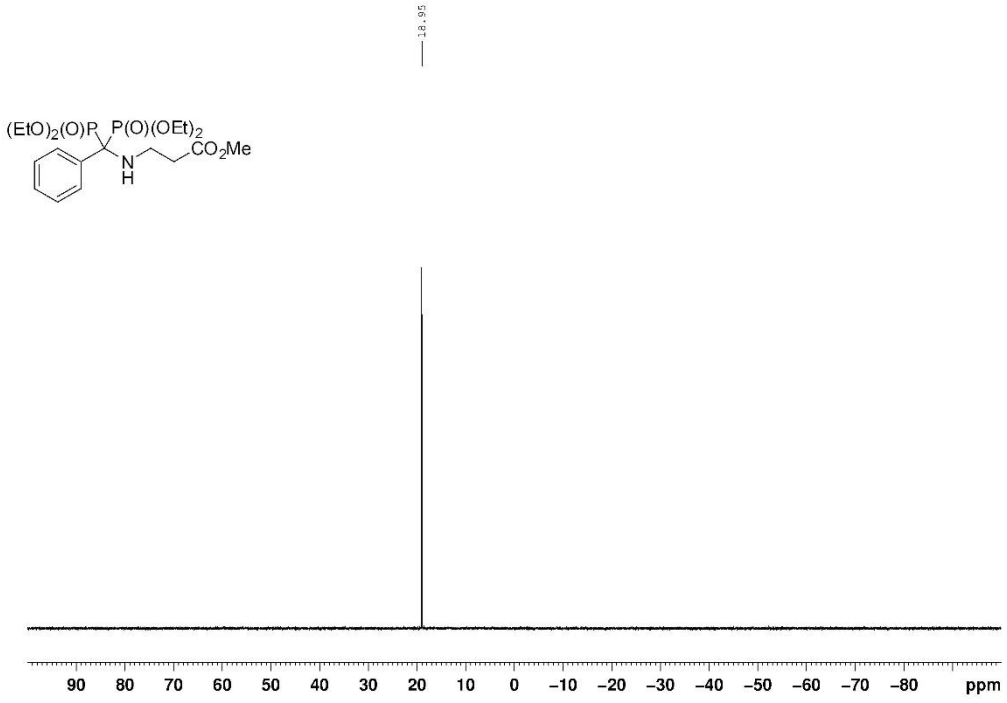
Methyl 3-{[bis(diethoxyphosphoryl)(phenyl)methyl]amino}propanoate (2r)
400M CDCl3



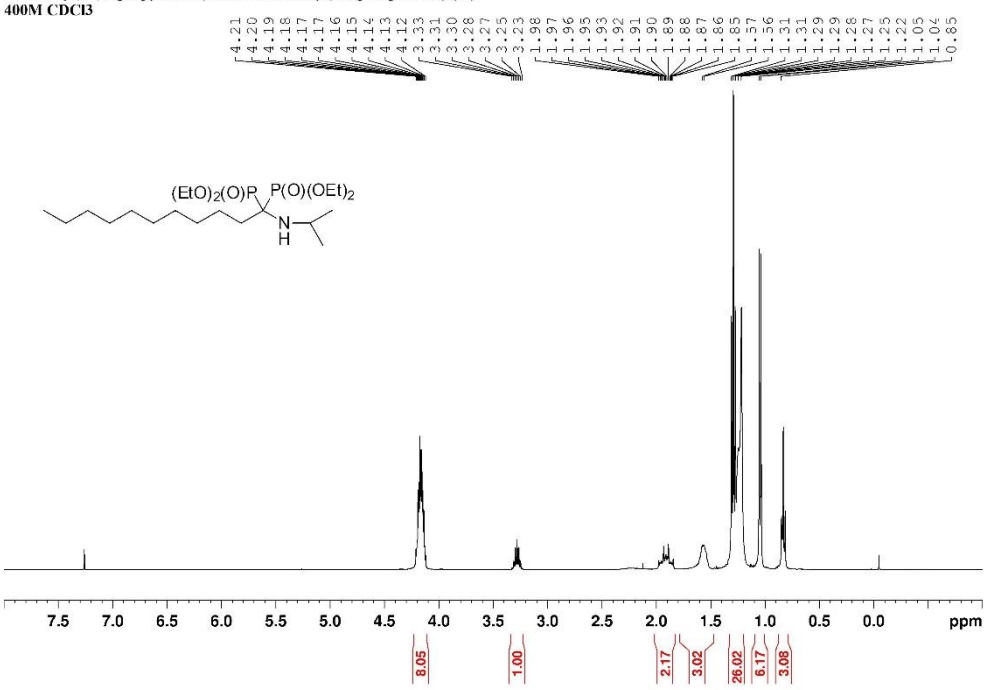
Methyl 3-{[bis(diethoxyphosphoryl)(phenyl)methyl]amino}propanoate (2r)
100M CDCl3



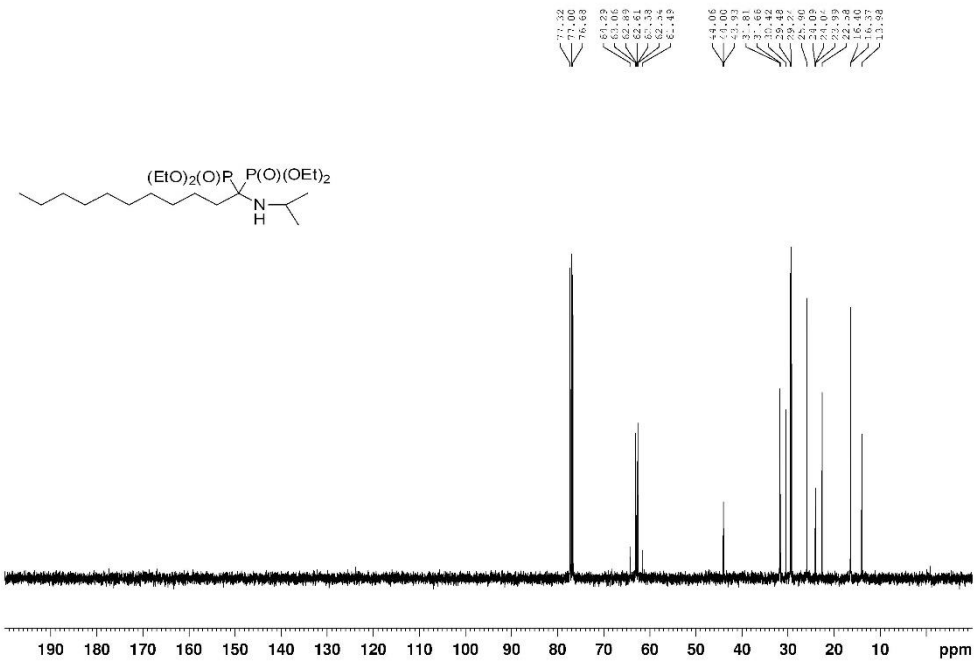
Methyl 3-{[bis(diethoxyphosphoryl)(phenyl)methyl]amino}propanoate (2r)
162M CDCl3



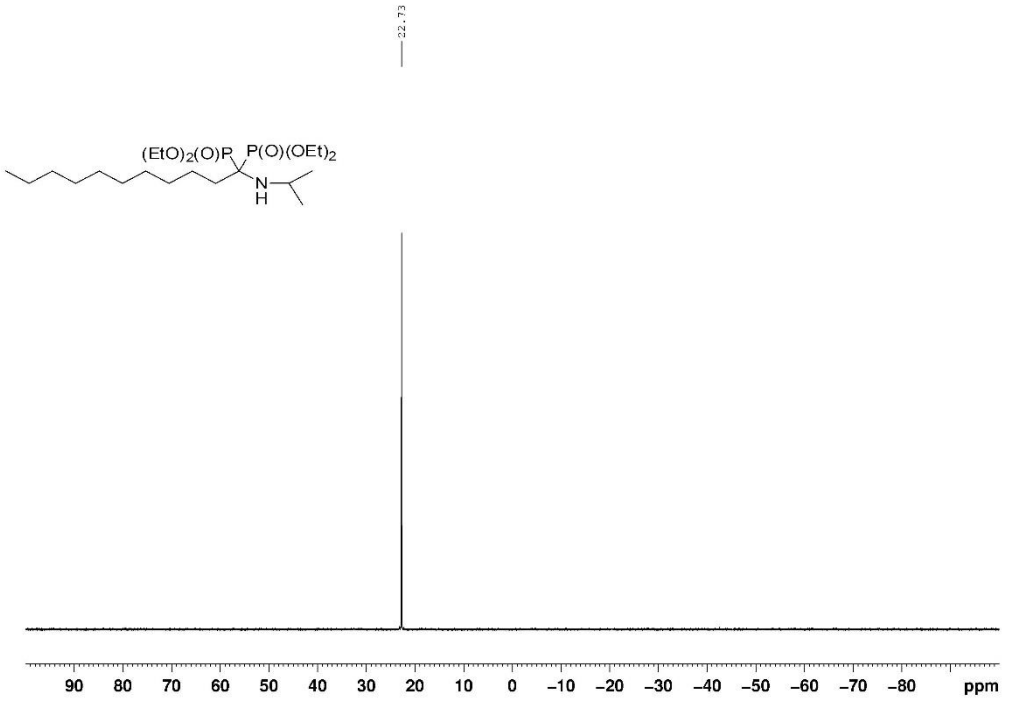
Tetraethyl[1-(isopropylamino)undecane-1,1-diyl]bis(phosphonate) (2s)
400M CDCl3



Tetraethyl[1-(isopropylamino)undecane-1,1-diyl]bis(phosphonate) (2s)
100M CDCl3

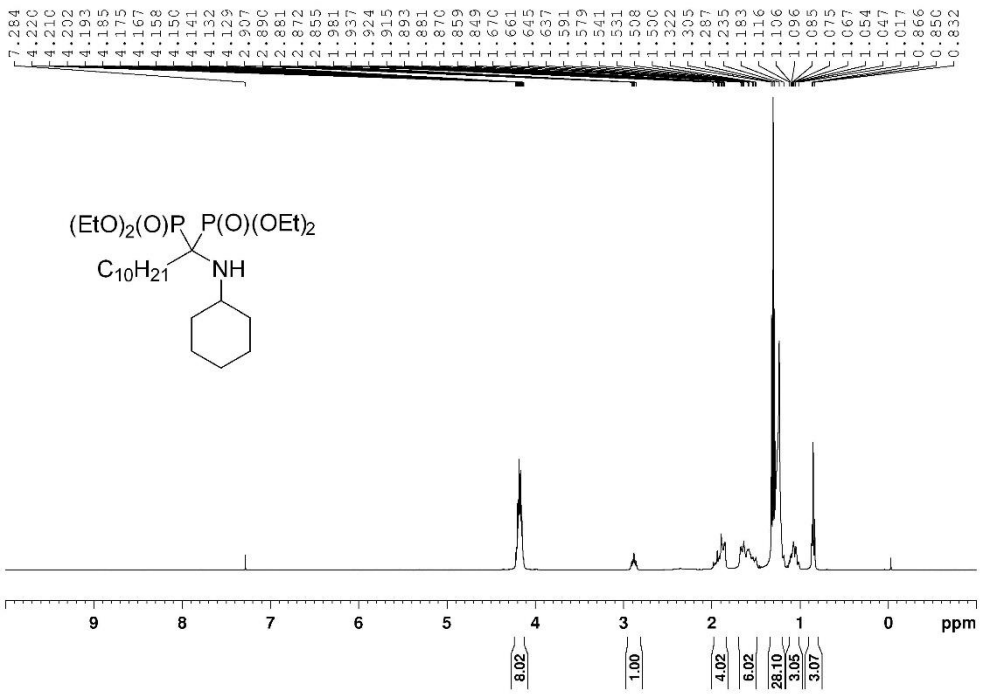


Tetraethyl[1-(isopropylamino)undecane-1,1-diyl]bis(phosphonate) (2s)
162M CDCl3



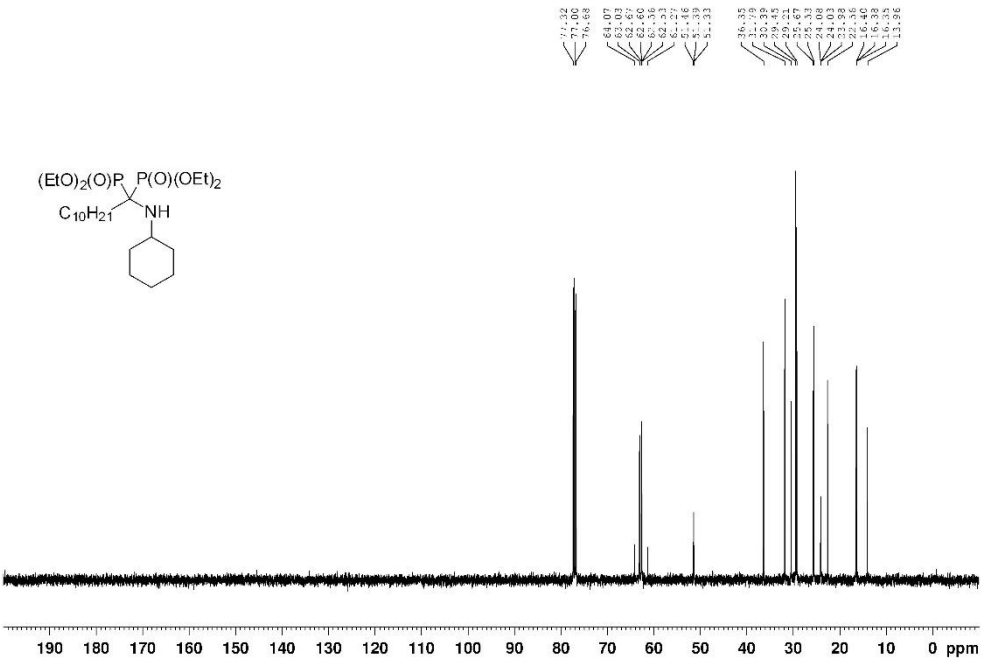
Tetracthyl[1-(cyclohexylamino)undecanc-1,1-diyl]bis(phosphonatc) (2t)

CDCl3 400M

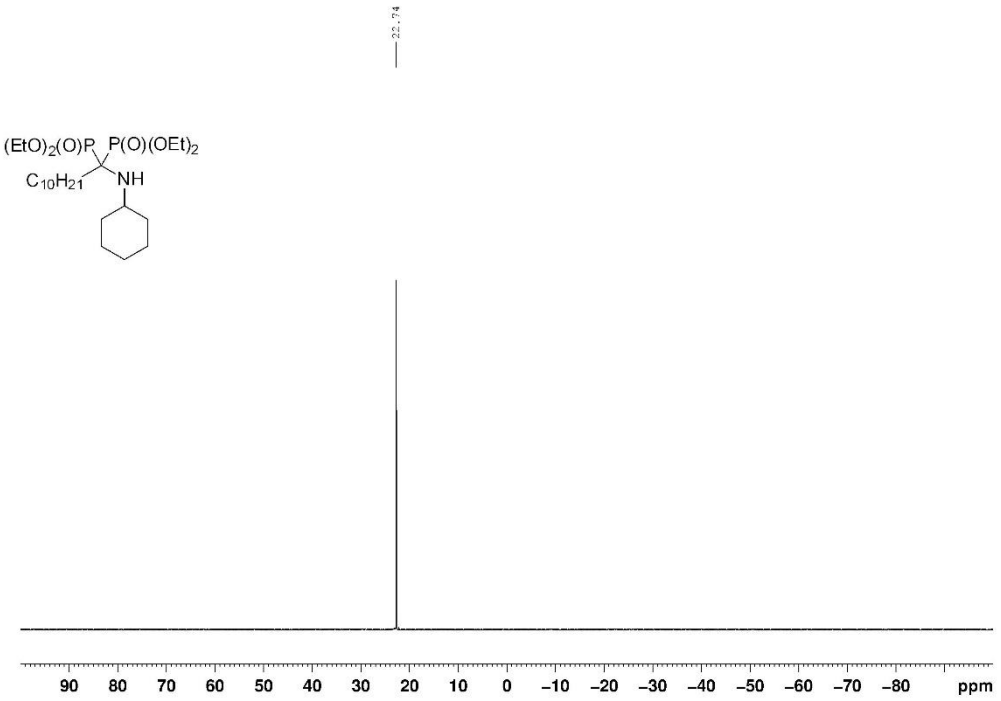


Tetraethyl[1-(cyclohexylamino)undecane-1,1-diyl]bis(phosphonate) (2t)

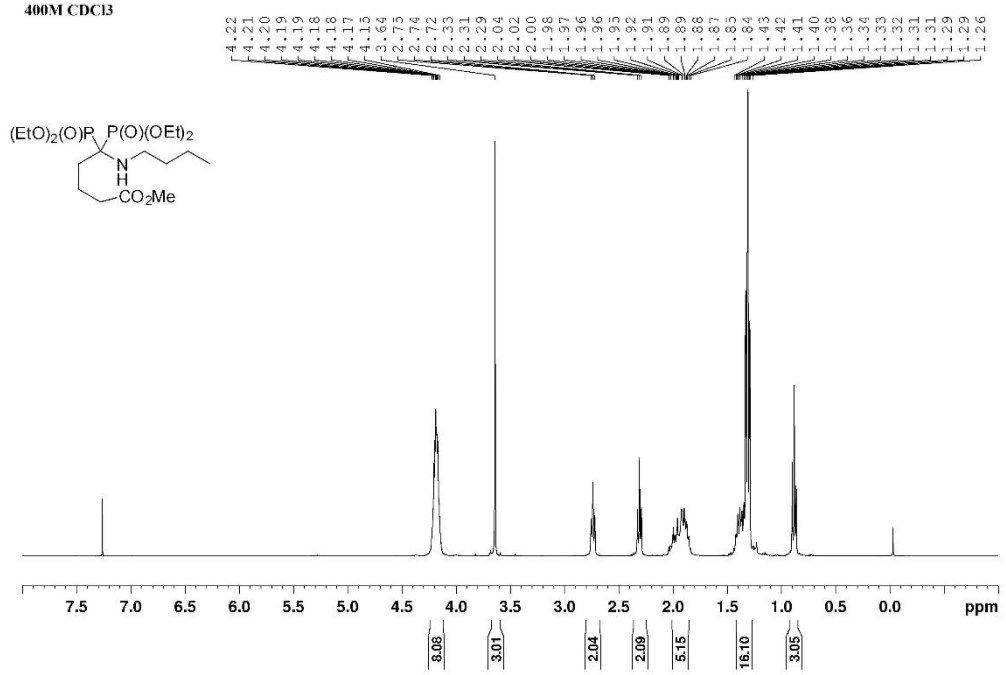
CDCl3 100M



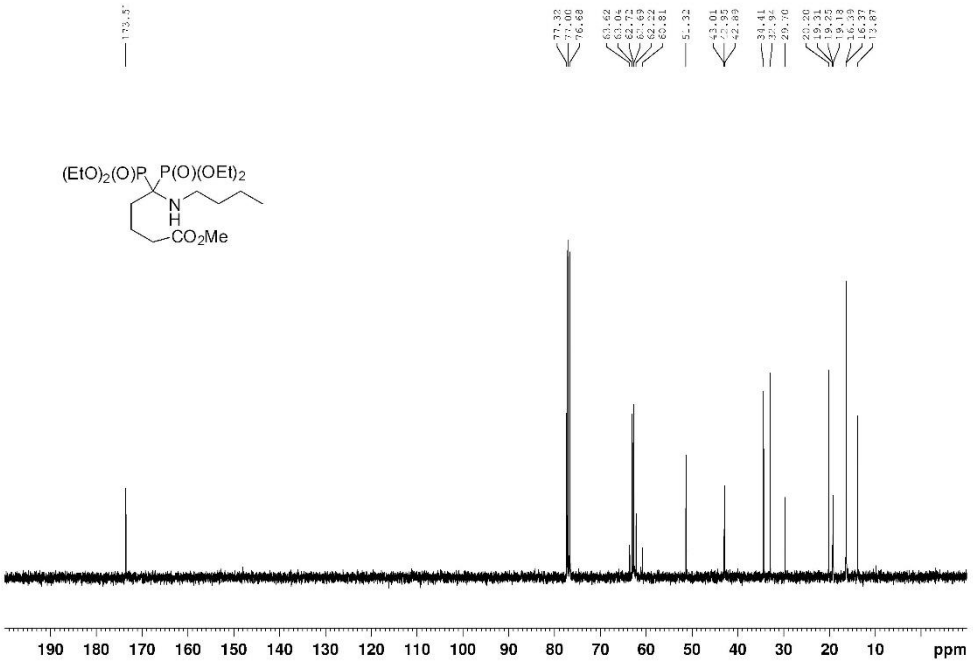
Tetraethyl[1-(cyclohexylamino)undecane-1,1-diyl]bis(phosphonate) (2t)
CDCl3 162M



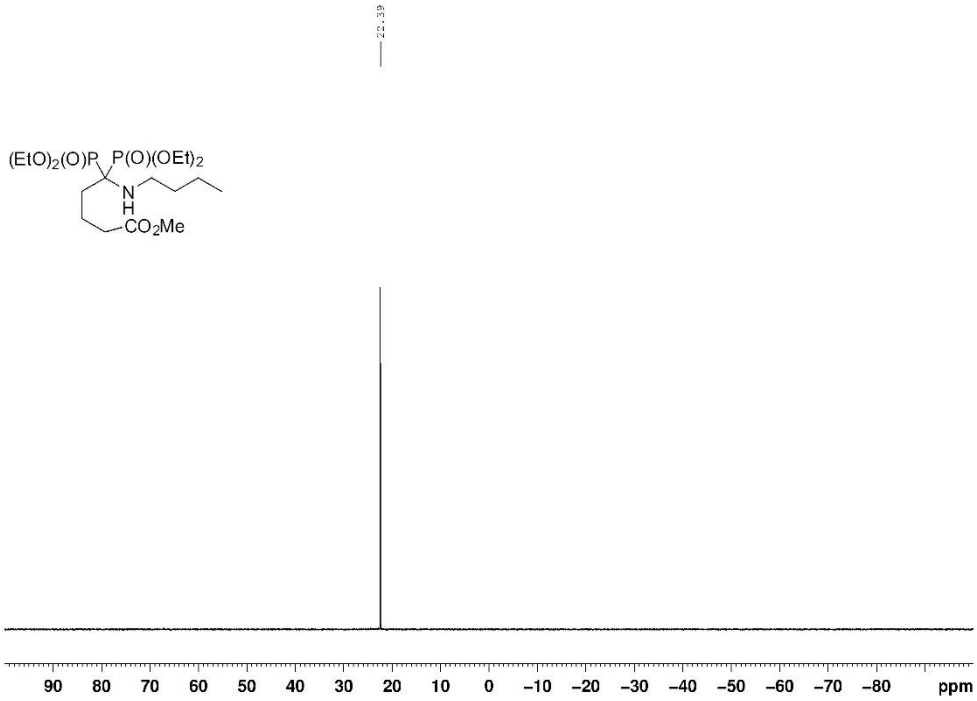
Methyl 5-(butylamino)-5,5-bis(diethoxyphosphoryl)pentanoate (2u)
400M CDCl3



Methyl 5-(butylamino)-5,5-bis(diethoxyphosphoryl)pentanoate (2u)
100M CDCl3

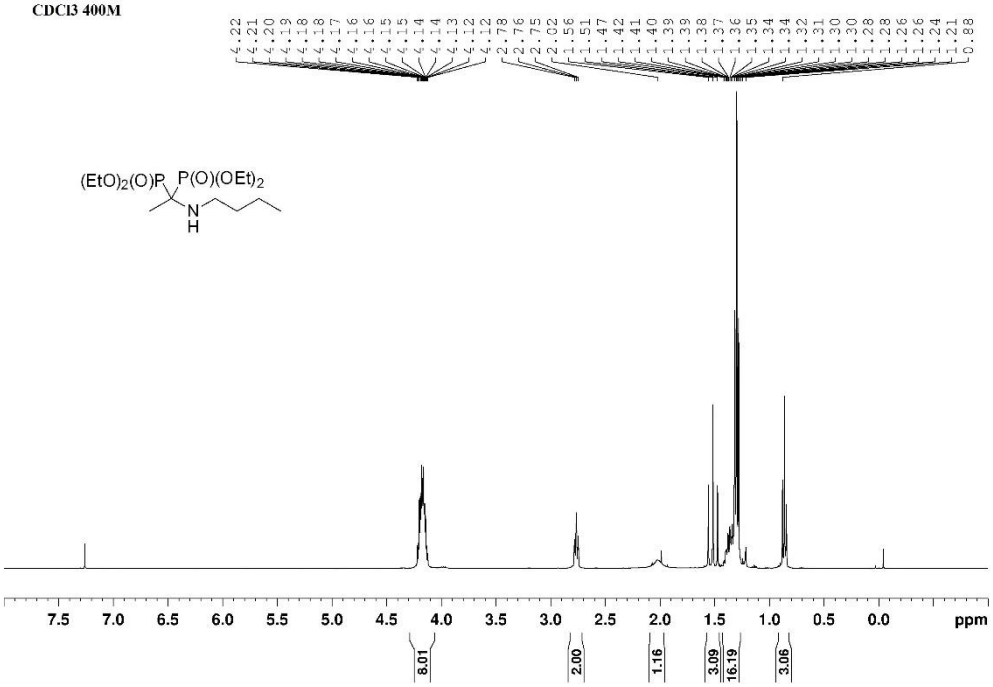


Methyl 5-(butylamino)-5,5-bis(diethoxyphosphoryl)pentanoate (2u)
162M CDCl3



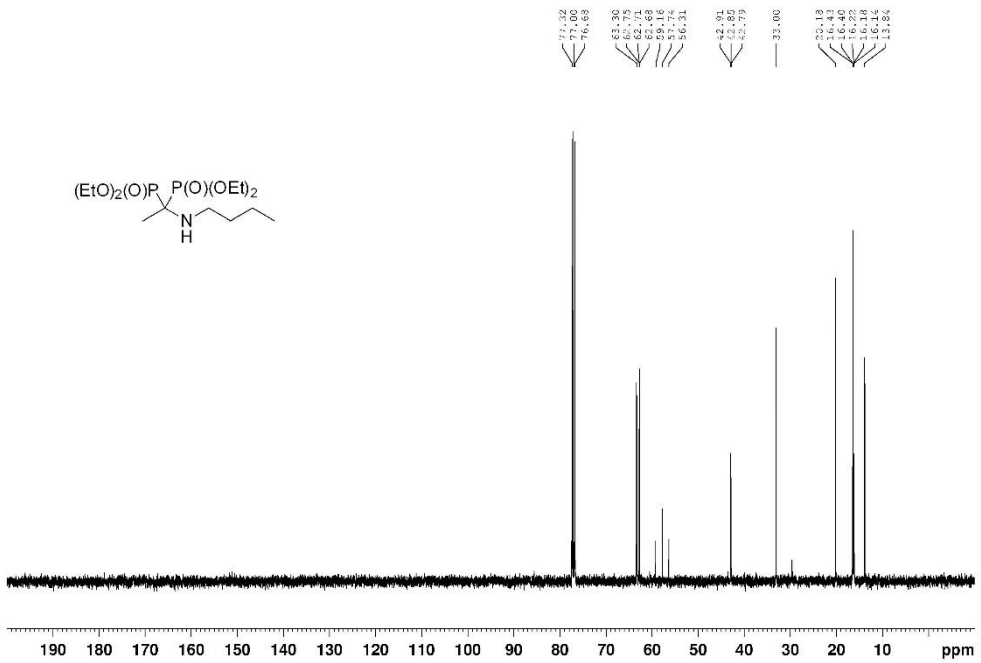
Tetraethyl(1-(butylamino)ethane-1,1-diyl)bis(phosphonate) (2v)

CDCl3 400M

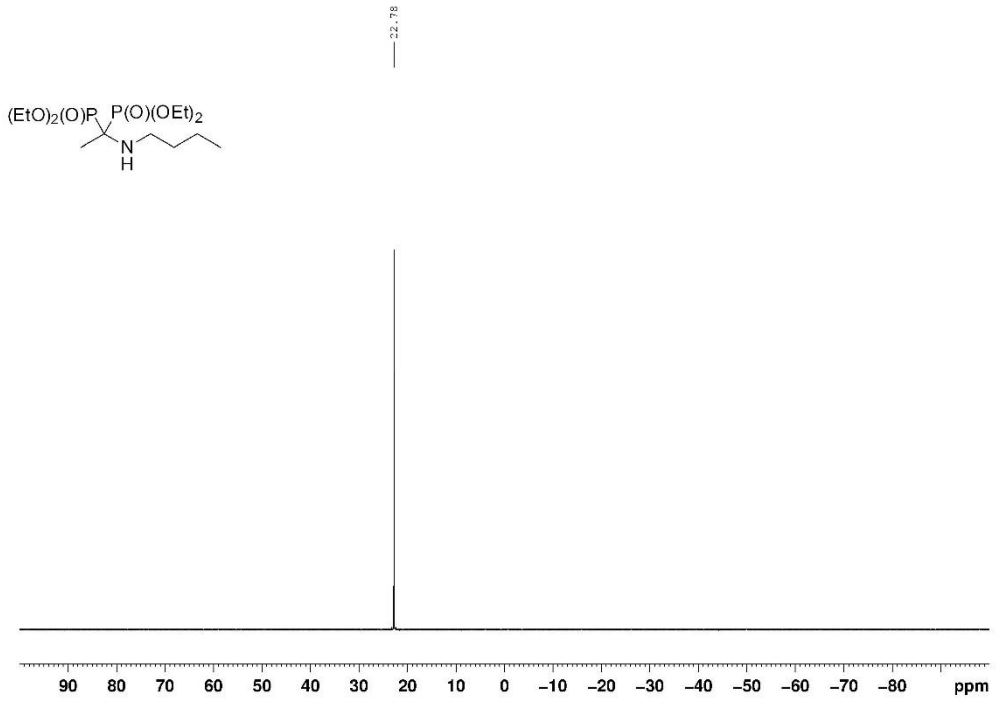


Tetraethyl(1-(butylamino)ethane-1,1-diyl)bis(phosphonate) (2v)

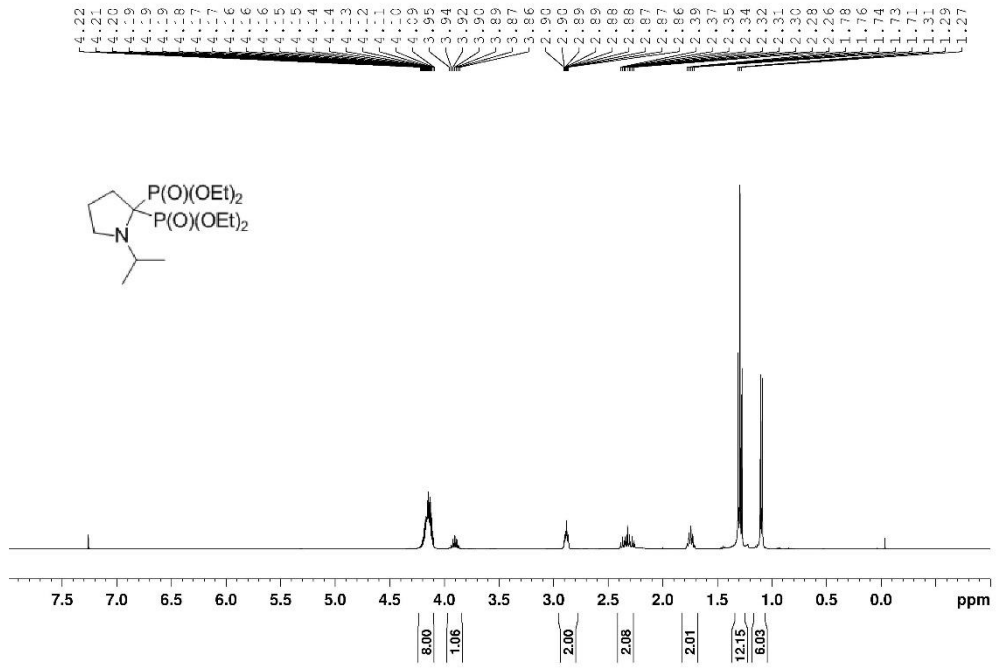
CDCl3 100M



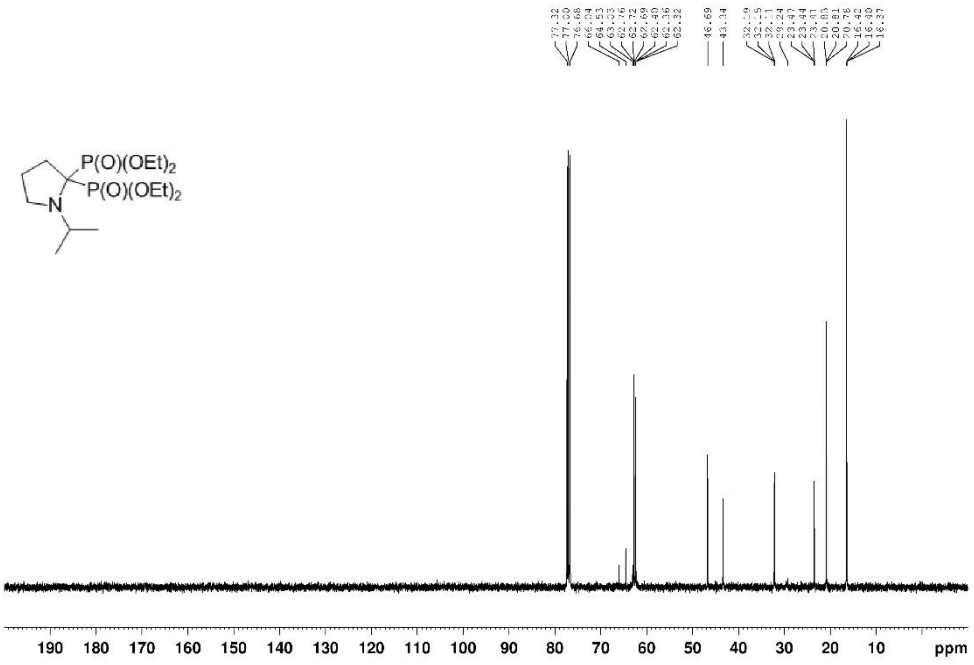
Tetraethyl(1-(butylamino)ethane-1,1-diyl)bis(phosphonate) (2v)
CDCl3 162M



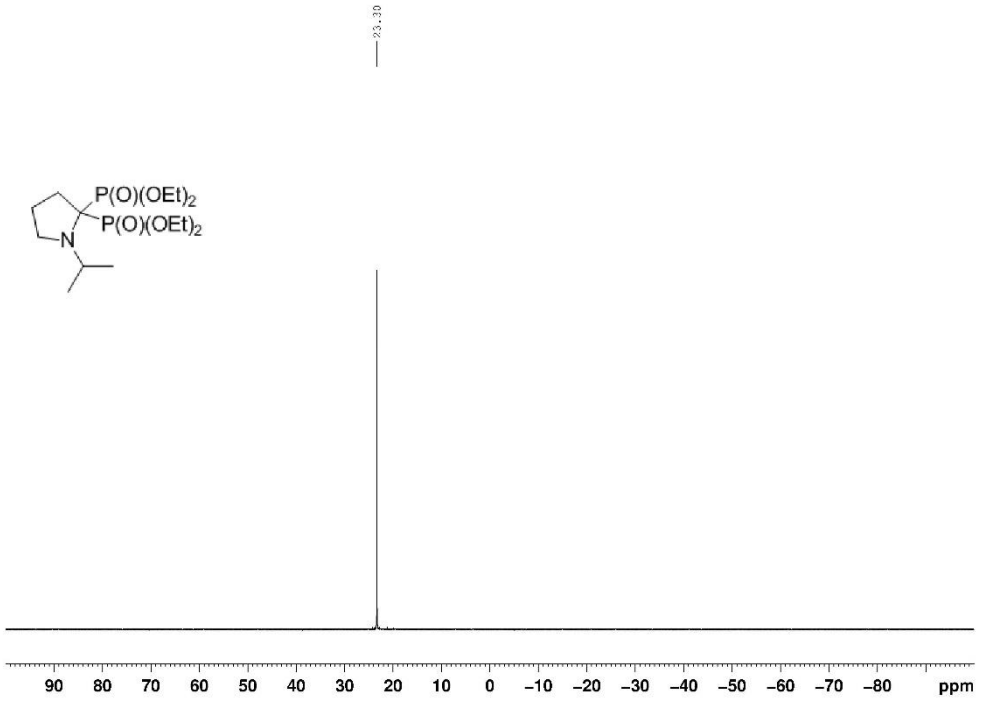
Tetraethyl(1-isopropylpyrrolidine-2,2-diyl)bis(phosphonate) (2y)
CDCl3 400M



Tetraethyl(1-isopropylpyrrolidine-2,2-diyl)bis(phosphonate) (2y)
CDCl3 100M

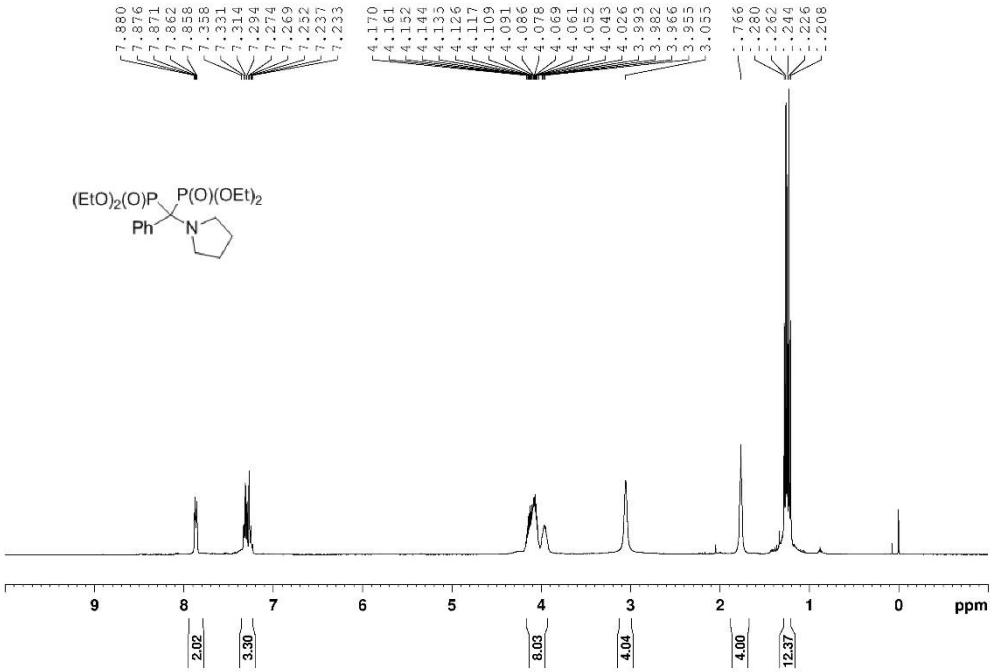


Tetraethyl(1-isopropylpyrrolidine-2,2-diyl)bis(phosphonate) (2y)
CDCl3 162M



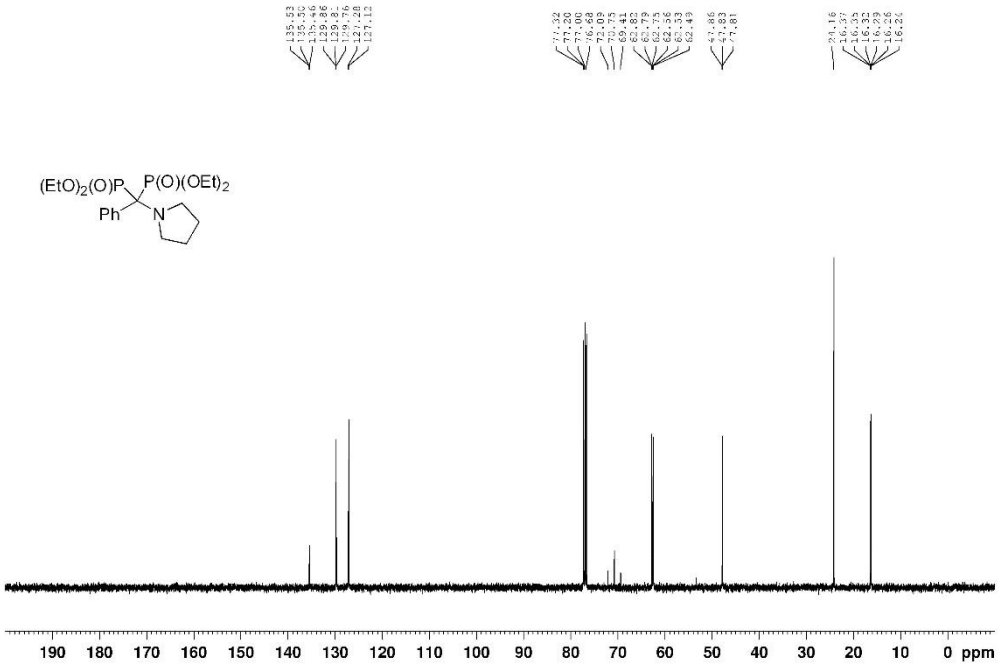
Tetraethyl[phenyl(pyrrolidin-1-yl)methylene]bis(phosphonate) (4a)

CDCl3 400M



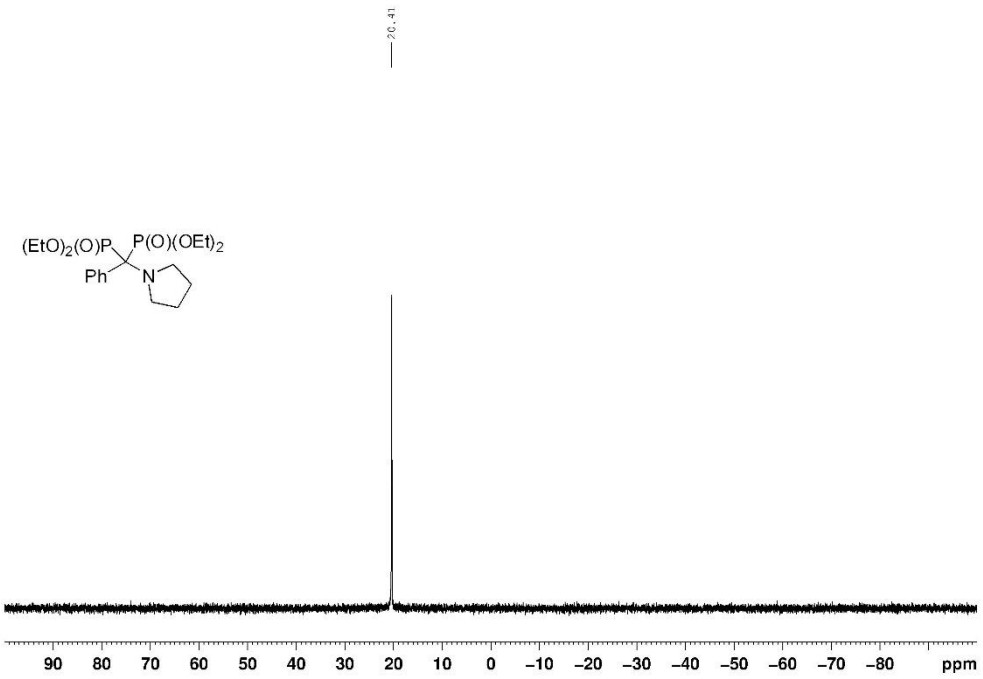
Tetraethyl[phenyl(pyrrolidin-1-yl)methylene]bis(phosphonate) (4a)

CDCl3 100M



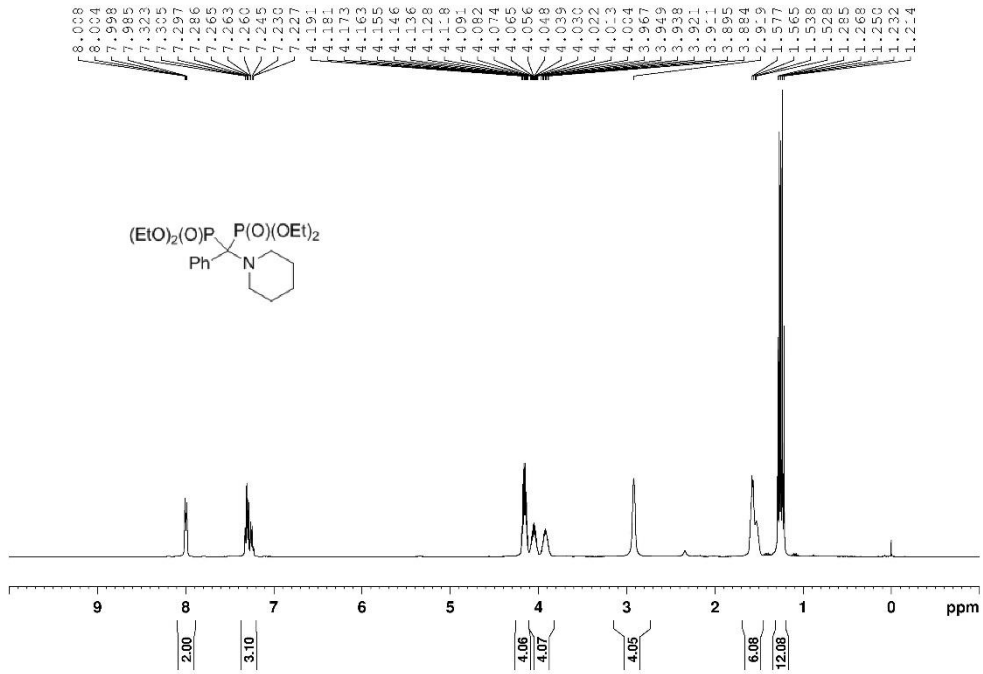
Tetraethyl[phenyl(pyrrolidin-1-yl)methylene]bis(phosphonate) (4a)

CDCl3 162M

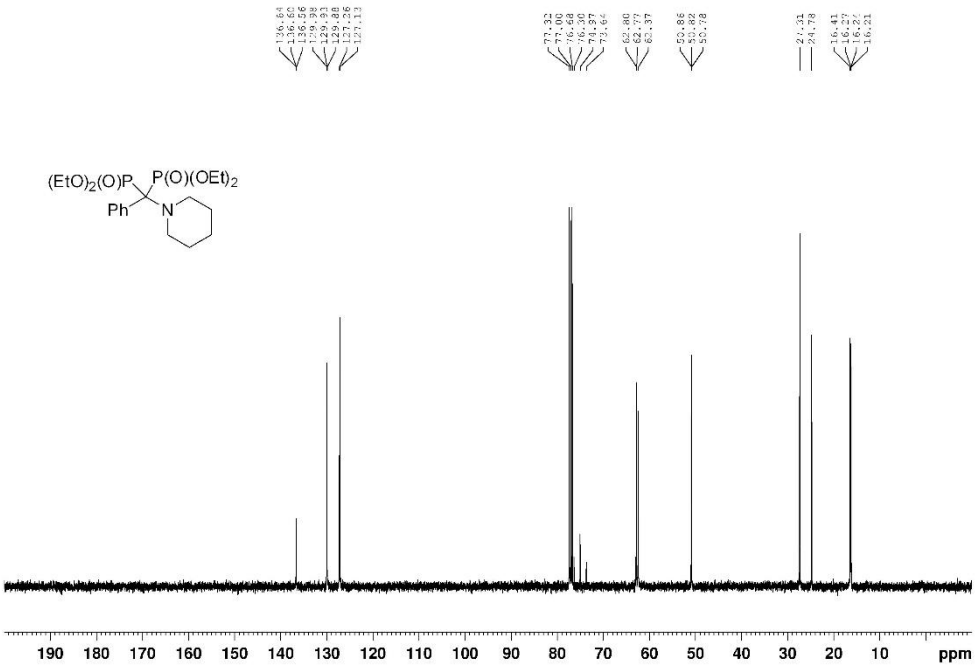


Tetraethyl[phenyl(piperidin-1-yl)methylene]bis(phosphonate) (4b)

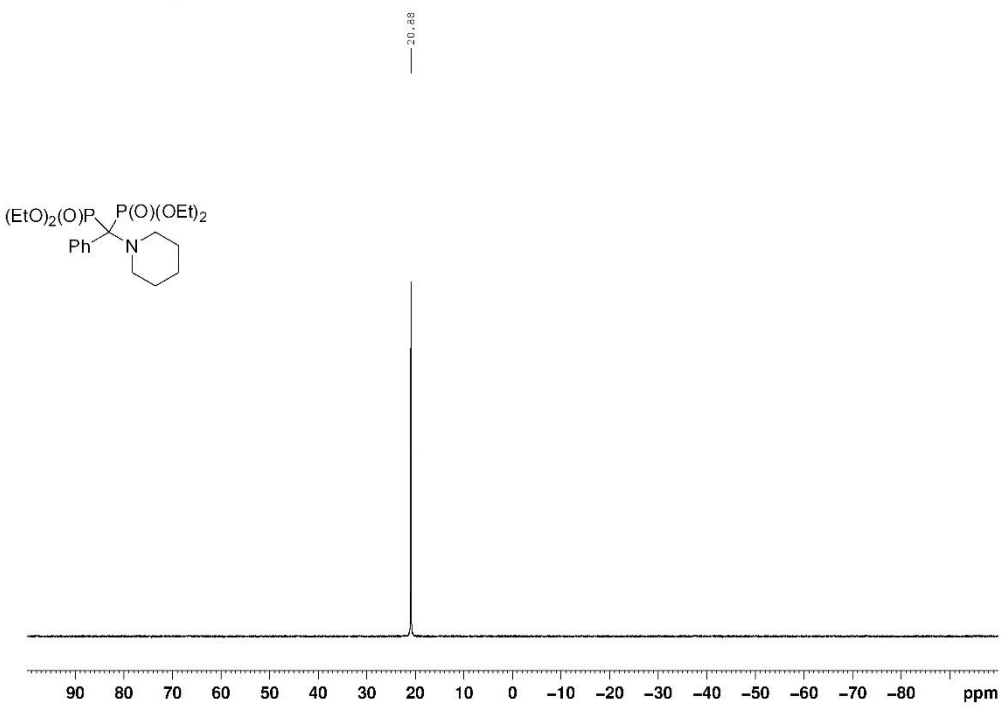
CDCl3 400M



Tetraethyl[phenyl(piperidin-1-yl)methylene]bis(phosphonate) (4b)
CDCl3 100M

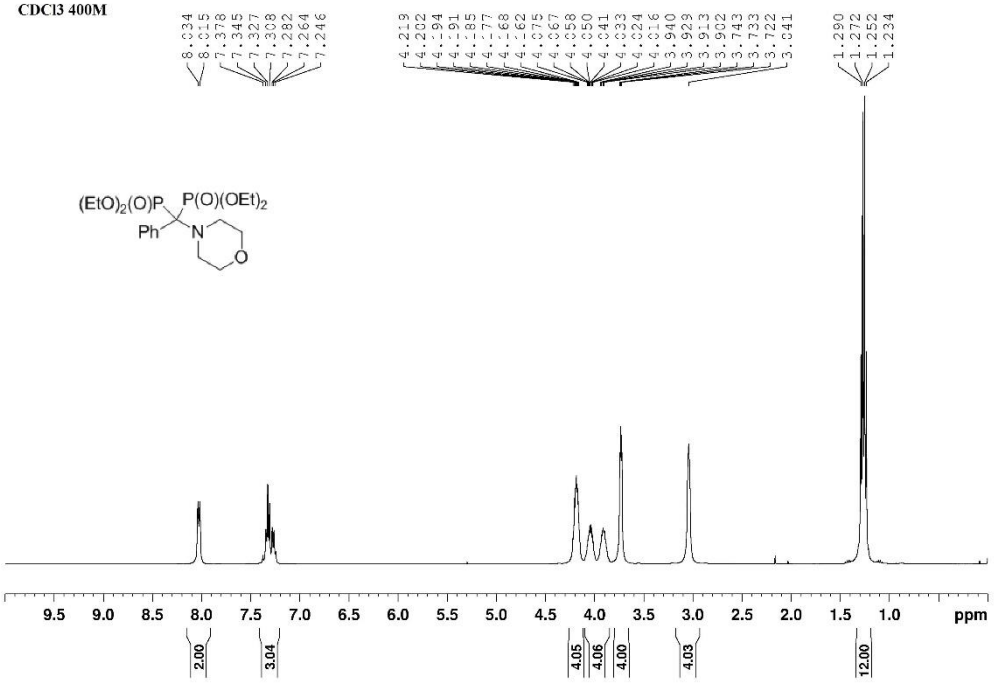


Tetraethyl[phenyl(piperidin-1-yl)methylene]bis(phosphonate) (4b)
CDCl3 162M



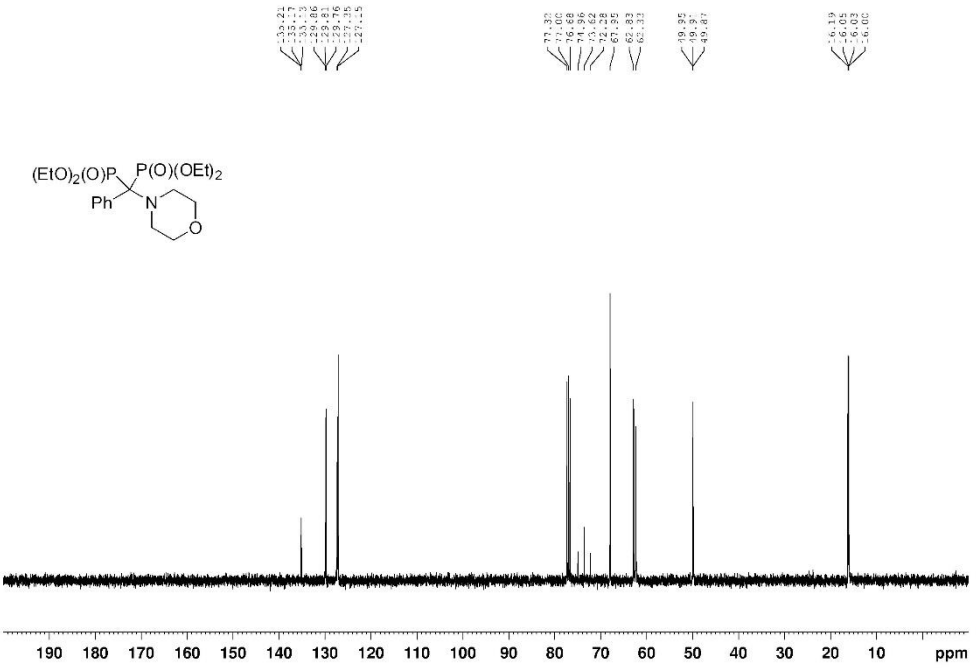
Tetraethyl[morpholino(phenyl)methylene]bis(phosphonate) (4c)

CDCl3 400M

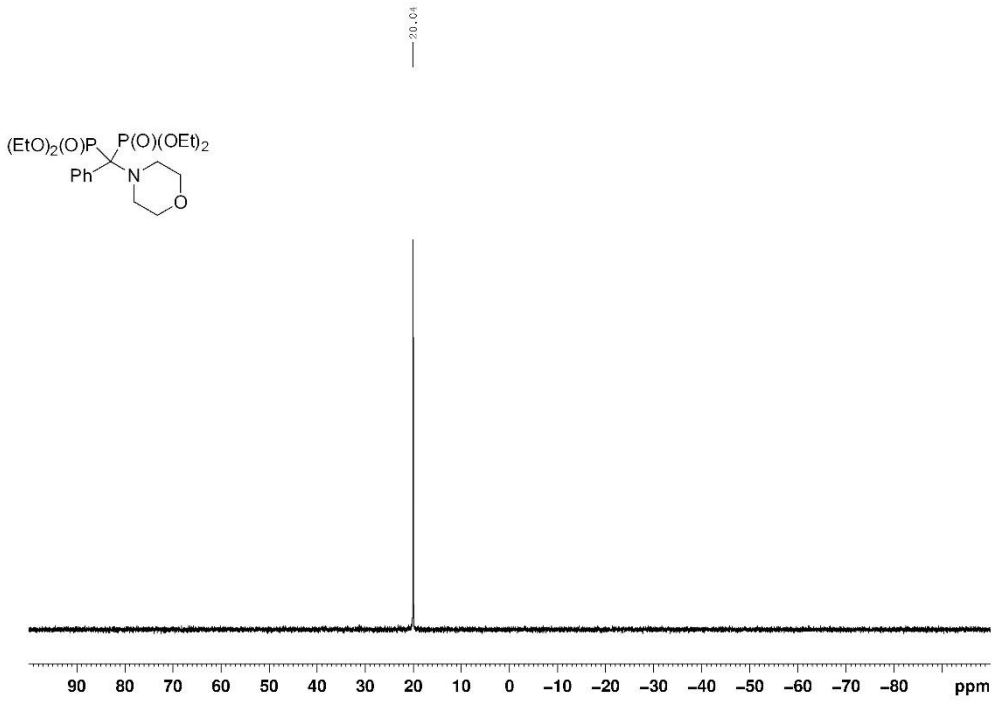


Tetraethyl[morpholino(phenyl)methylene]bis(phosphonate) (4c)

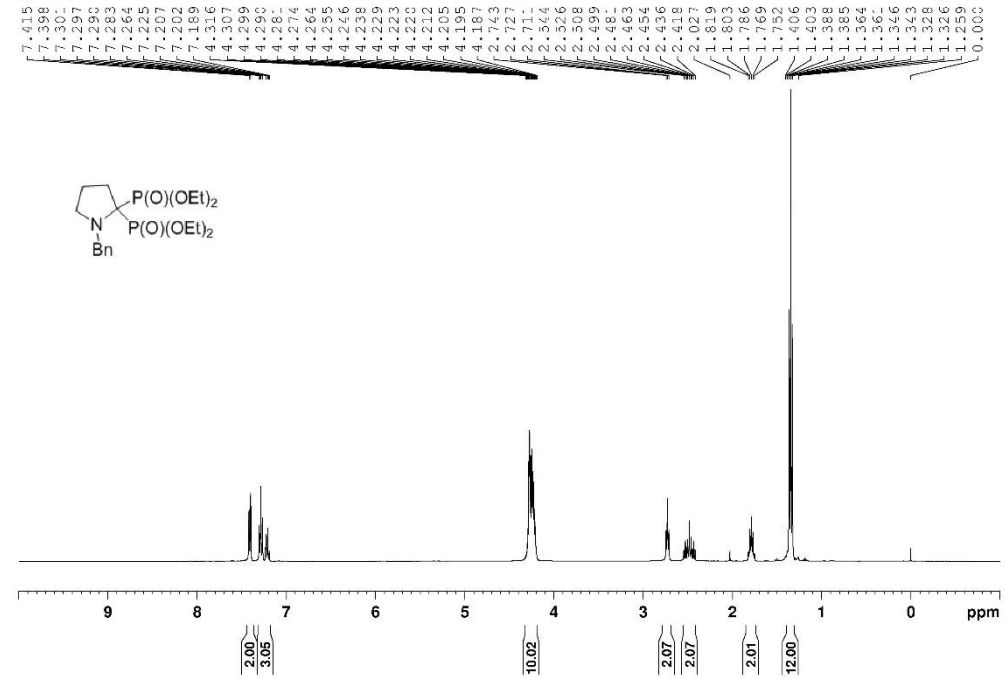
100M CDCl3



Tetraethyl[morpholino(phenyl)methylene]bis(phosphonate) (4c)
162M CDCl3

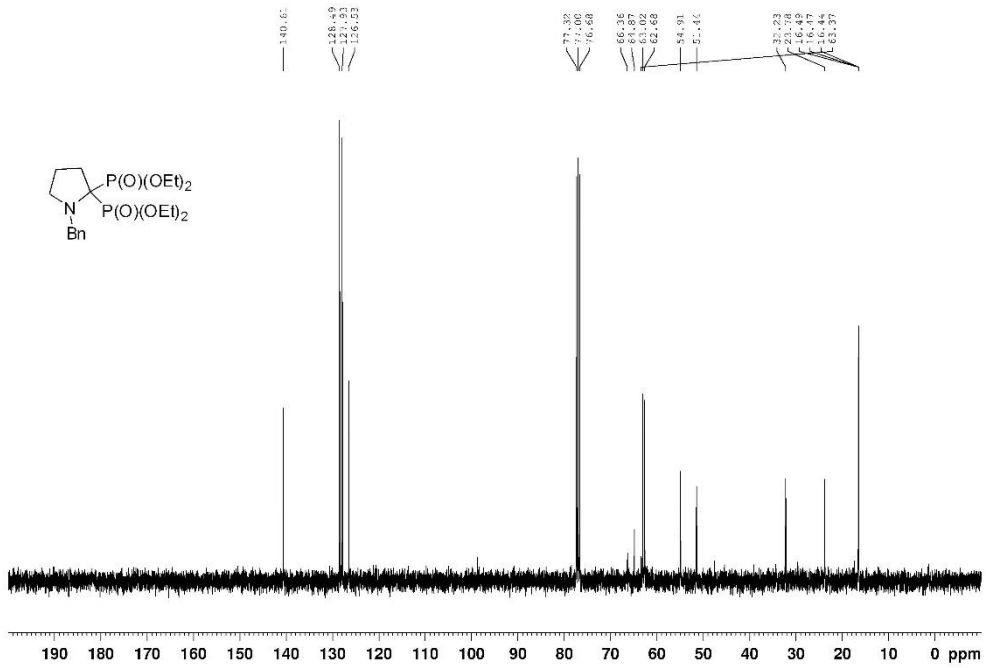


Tetraethyl(1-benzylpyrrolidine-2,2-diyl)bis(phosphonate) (4d)
CDCl3 400M



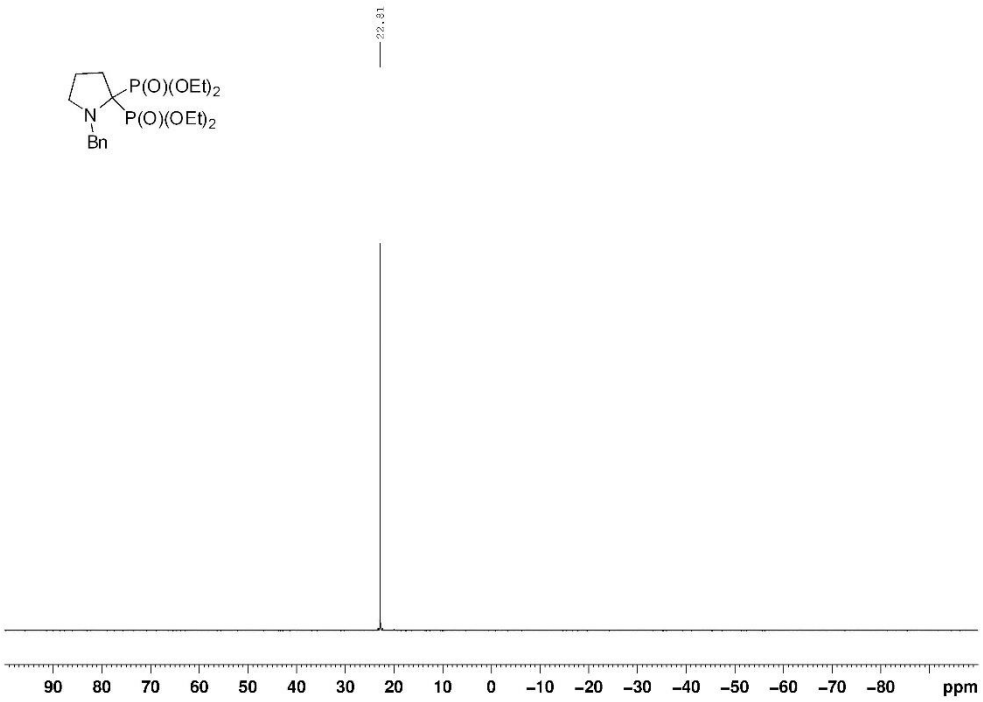
Tetraethyl(1-benzylpyrrolidine-2,2-diyl)bis(phosphonate) (4d)

CDCl3 100M



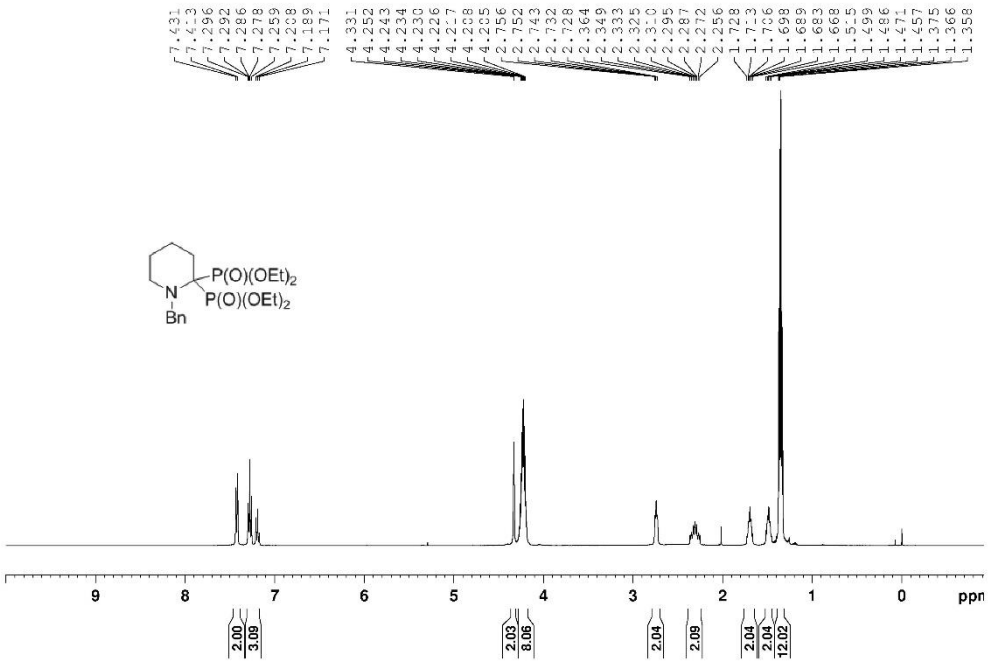
Tetraethyl(1-benzylpyrrolidine-2,2-diyl)bis(phosphonate) (4d)

CDCl3 162M



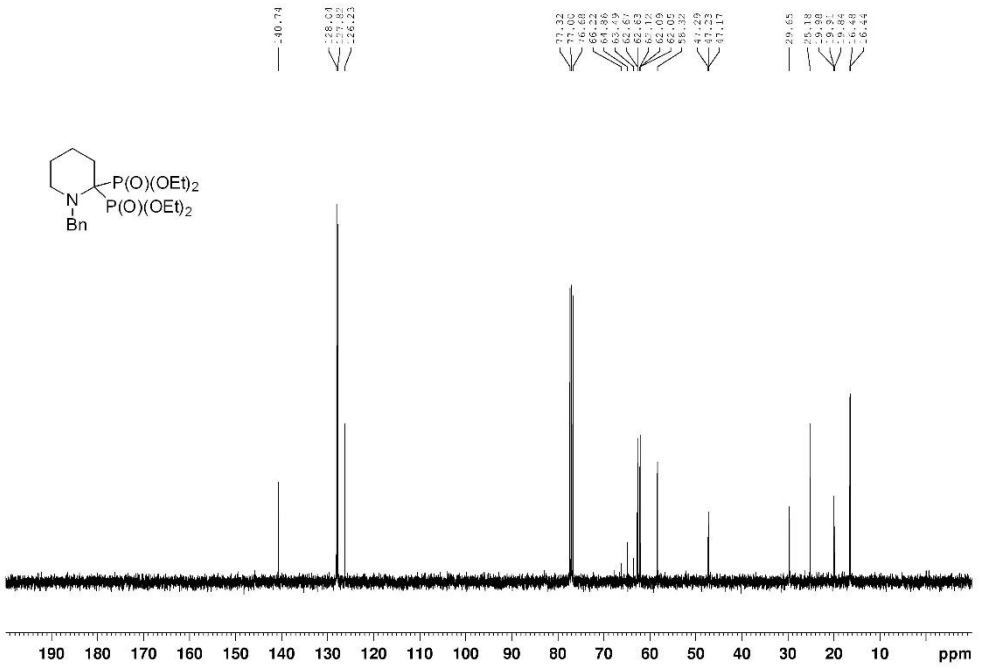
Tetraethyl(1-benzylpiperidine-2,2-diyl)bis(phosphonate) (4e)

CDCl3 400M



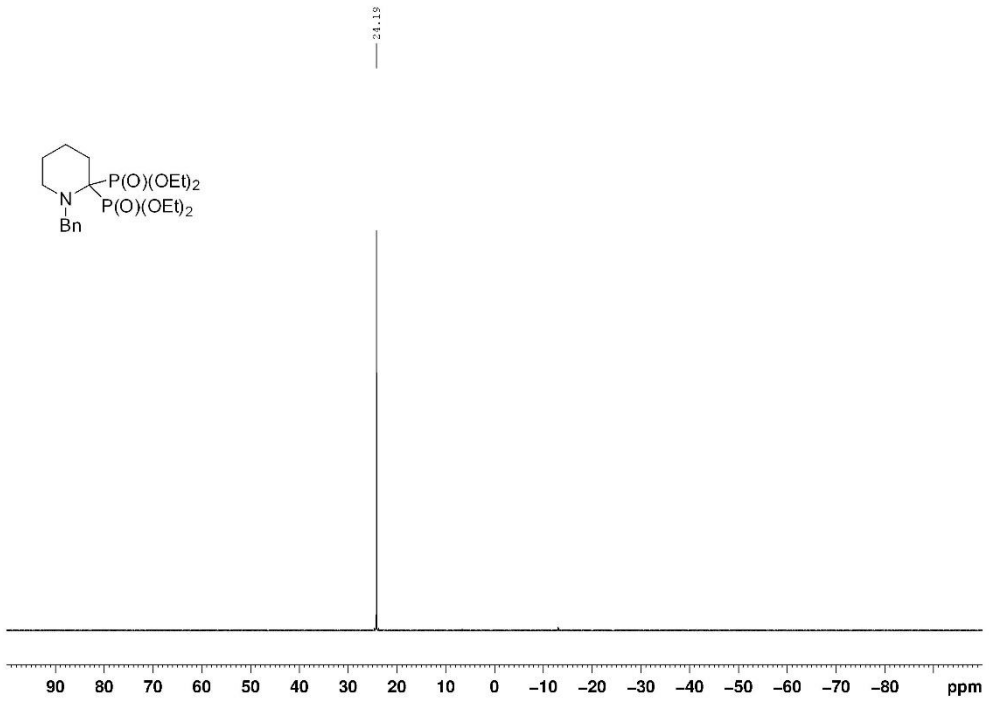
Tetraethyl(1-benzylpiperidine-2,2-diyl)bis(phosphonate) (4e)

CDCl3 100M



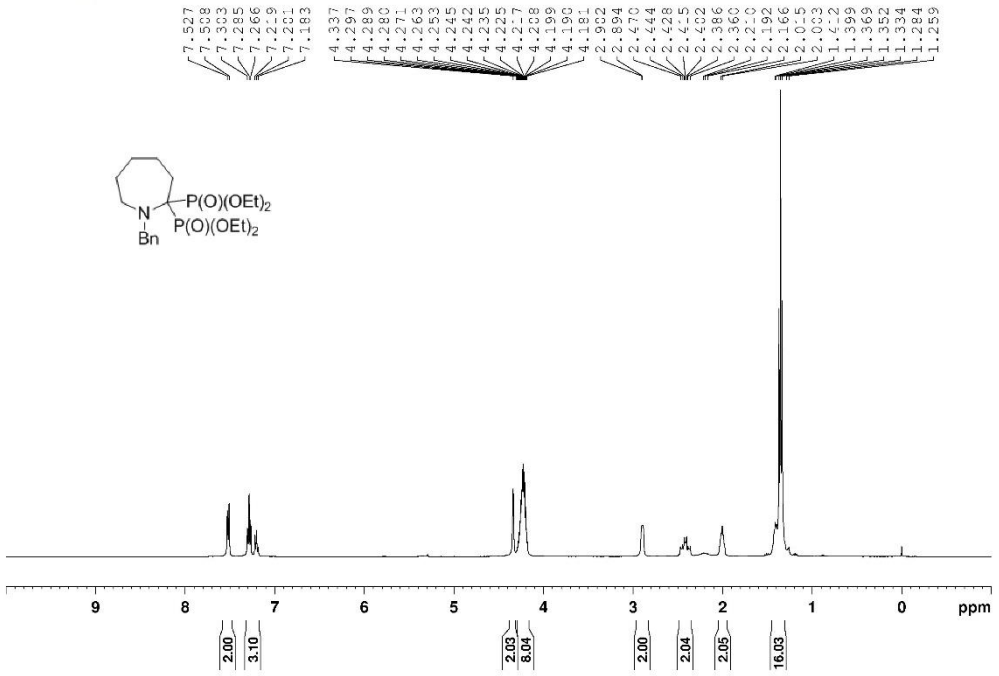
Tetraethyl(1-benzylpiperidine-2,2-diyl)bis(phosphonate) (4e)

CDCl3 162M



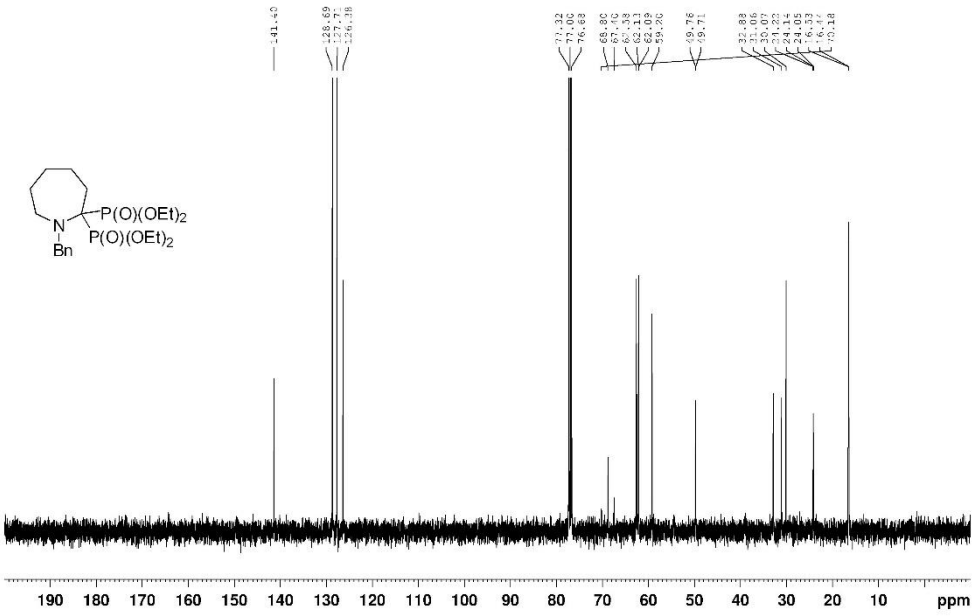
Tetraethyl(1-benzylazepane-2,2-diyl)bis(phosphonate) (4f)

CDCl3 400M



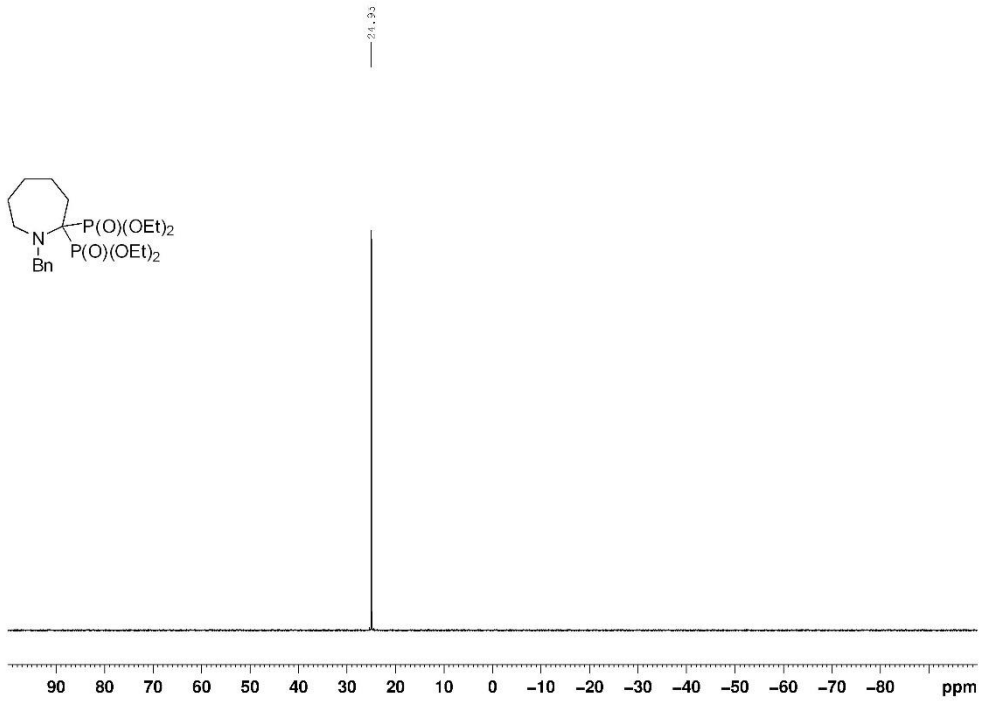
Tetraethyl(1-benzylazepane-2,2-diyl)bis(phosphonate) (4f)

CDCl3 100M



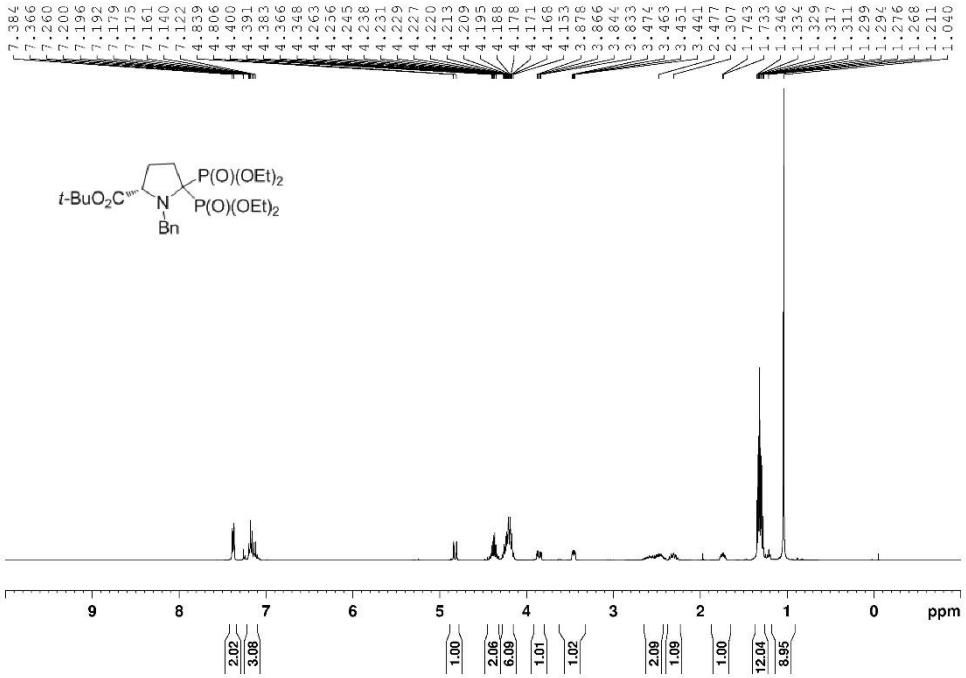
Tetraethyl(1-benzylazepane-2,2-diyl)bis(phosphonate) (4f)

CDCl3 162M



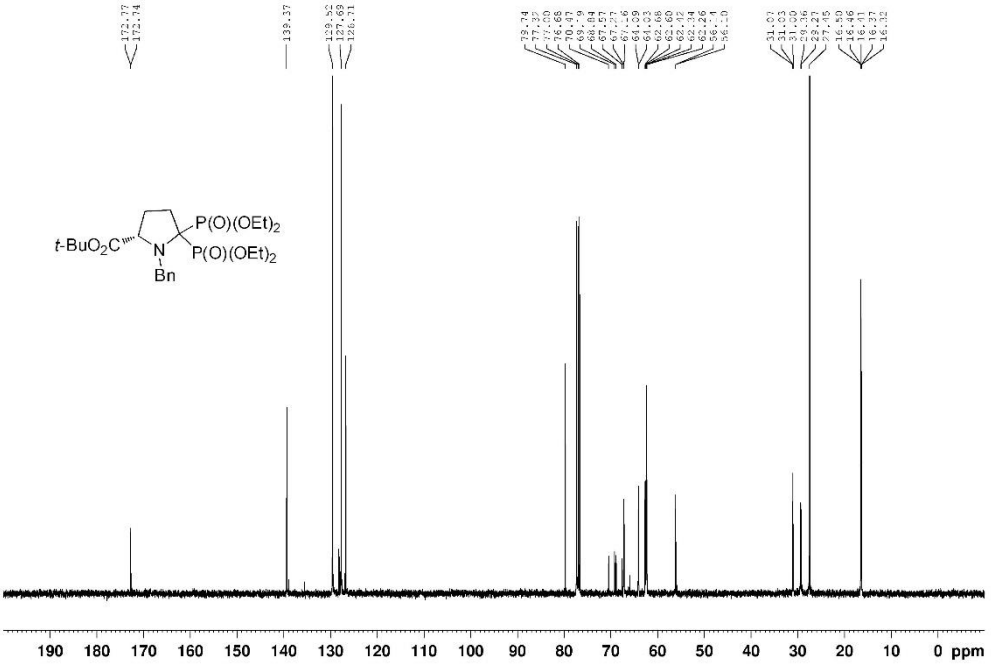
(*S*)-*tert*-Butyl-1-benzyl-5,5-bis(diethoxyphosphoryl)pyrrolidine-2-carboxylate (4g)

CDCl3 400M

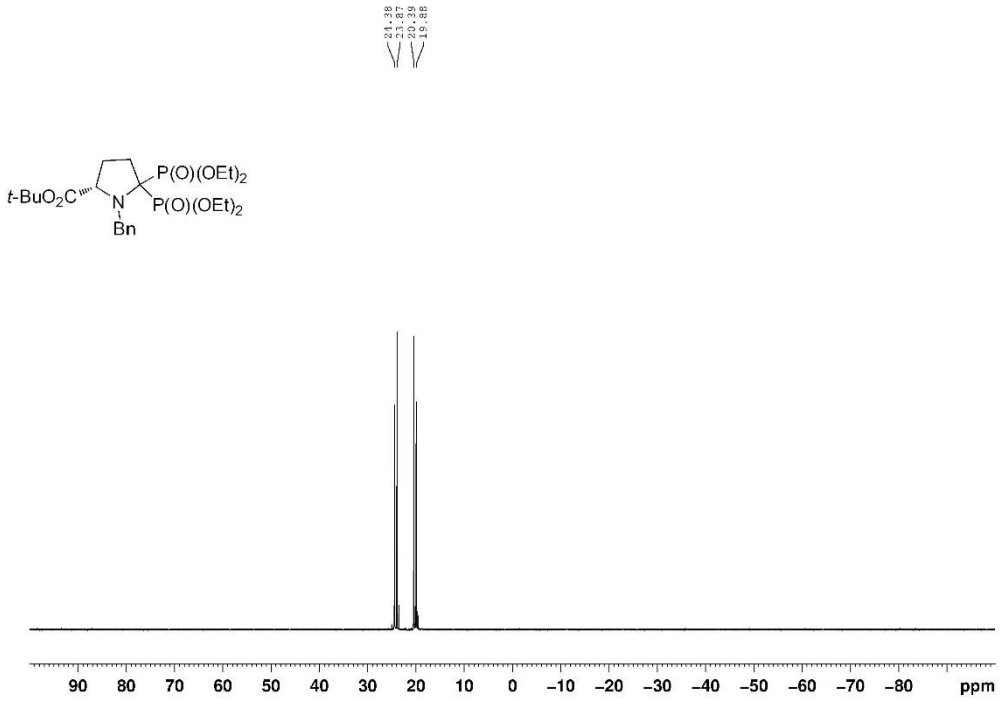


(*S*)-*tert*-Butyl-1-benzyl-5,5-bis(diethoxyphosphoryl)pyrrolidine-2-carboxylate (4g)

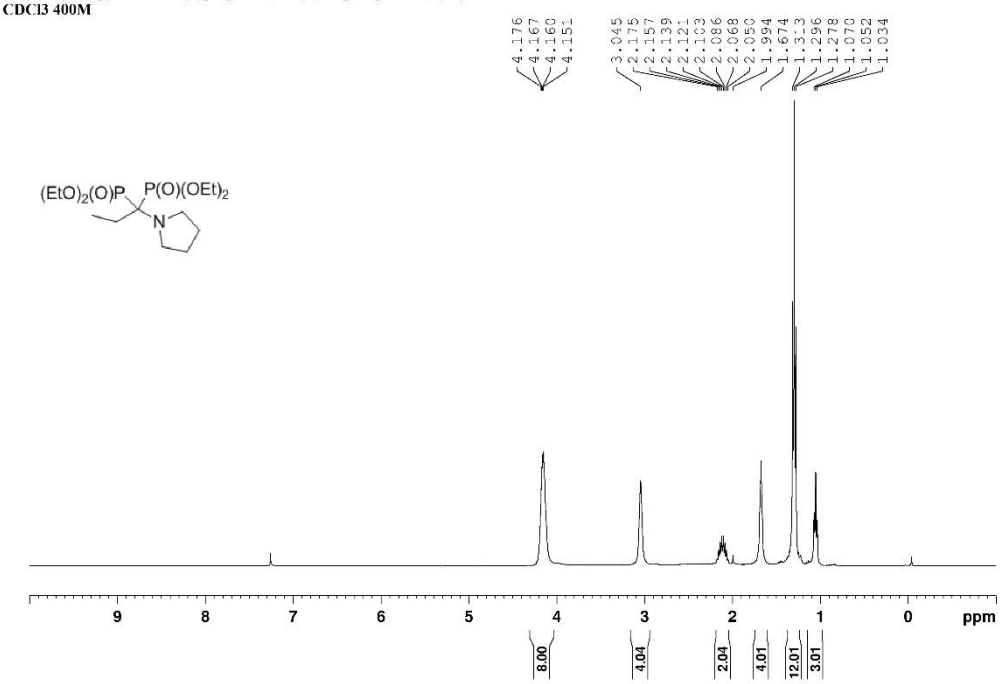
CDCl3 100M



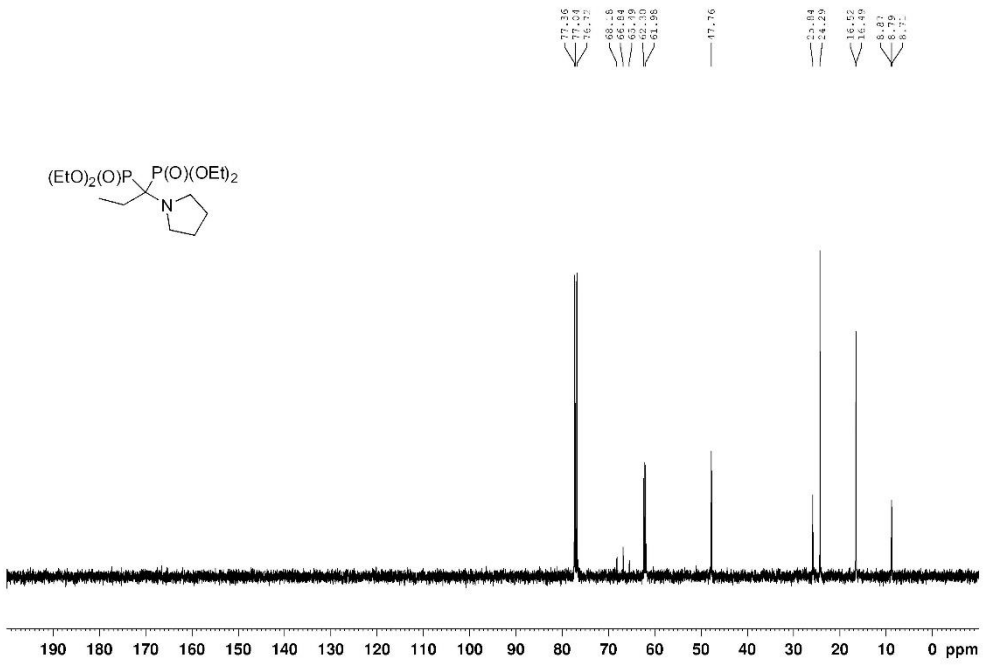
(*S*)-*tert*-Butyl-1-benzyl-5,5-bis(diethoxyphosphoryl)pyrrolidine-2-carboxylate (4g)
CDCl3 162M



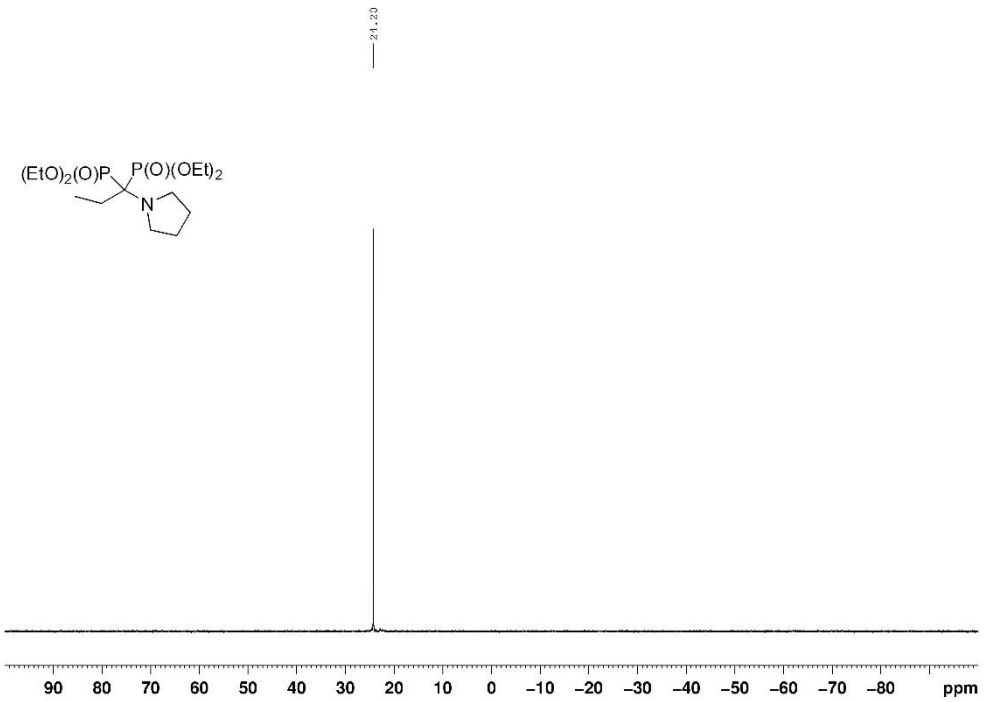
Tetraethyl[1-(pyrrolidin-1-yl)propane-1,1-diyl]bis(phosphonate) (4h)
CDCl3 400M



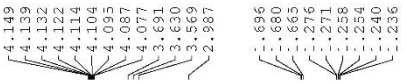
Tetraethyl[1-(pyrrolidin-1-yl)propane-1,1-diyl]bis(phosphonate) (4h)
CDCl3 100M

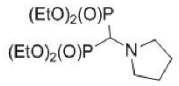


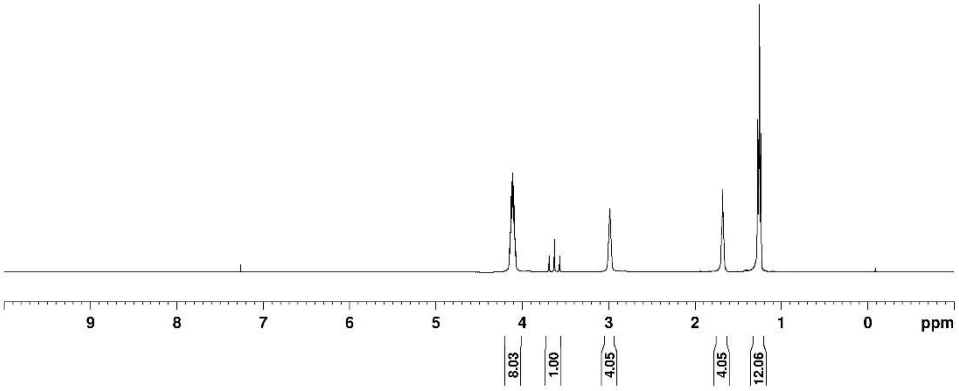
Tetraethyl[1-(pyrrolidin-1-yl)propane-1,1-diyl]bis(phosphonate) (4h)
CDCl3 162M



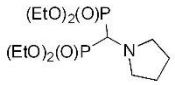
Tetraethyl(pyrrolidin-1-ylmethylene)bis(phosphonate) (4i)
CDCl3 400M

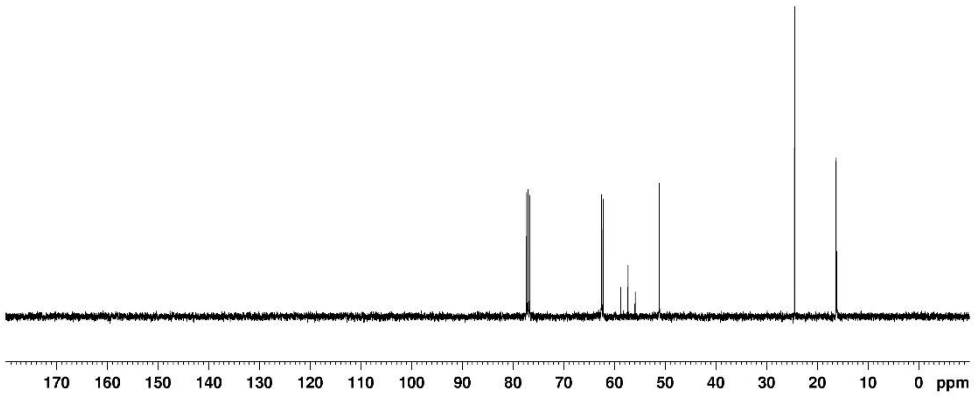




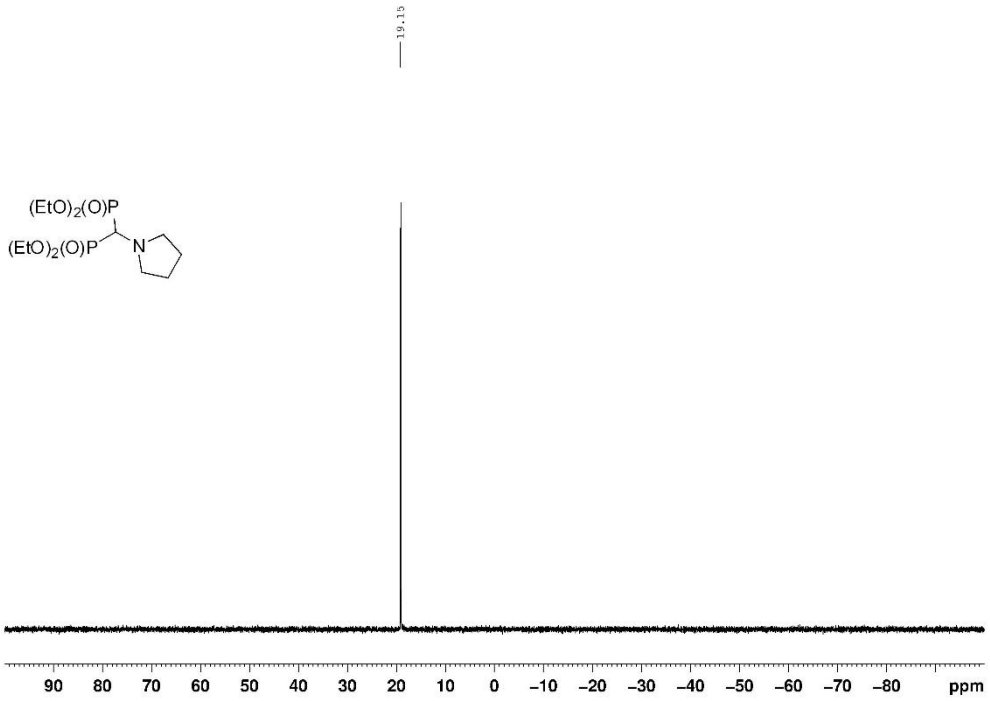


Tetraethyl(pyrrolidin-1-ylmethylene)bis(phosphonate) (4i)
CDCl3 100M

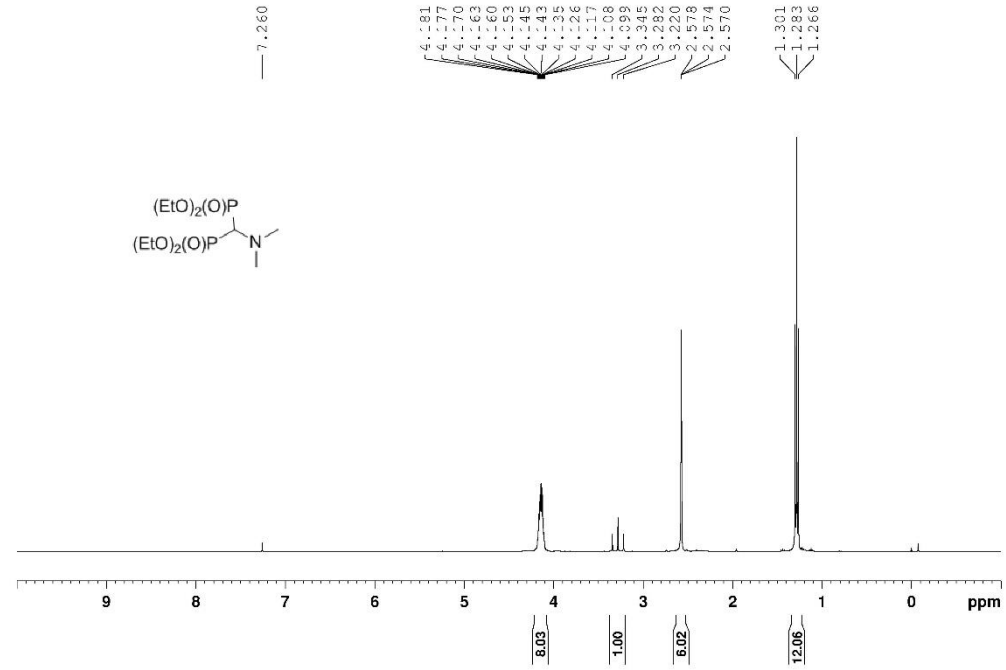




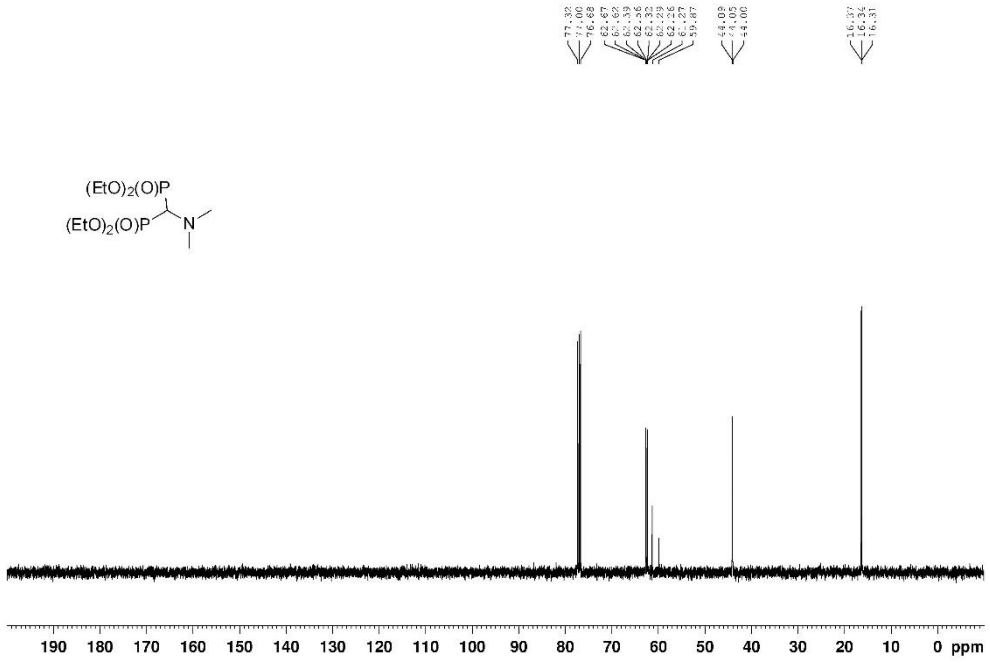
Tetraethyl(pyrrolidin-1-ylmethylene)bis(phosphonate) (4i)
CDCl3 162M



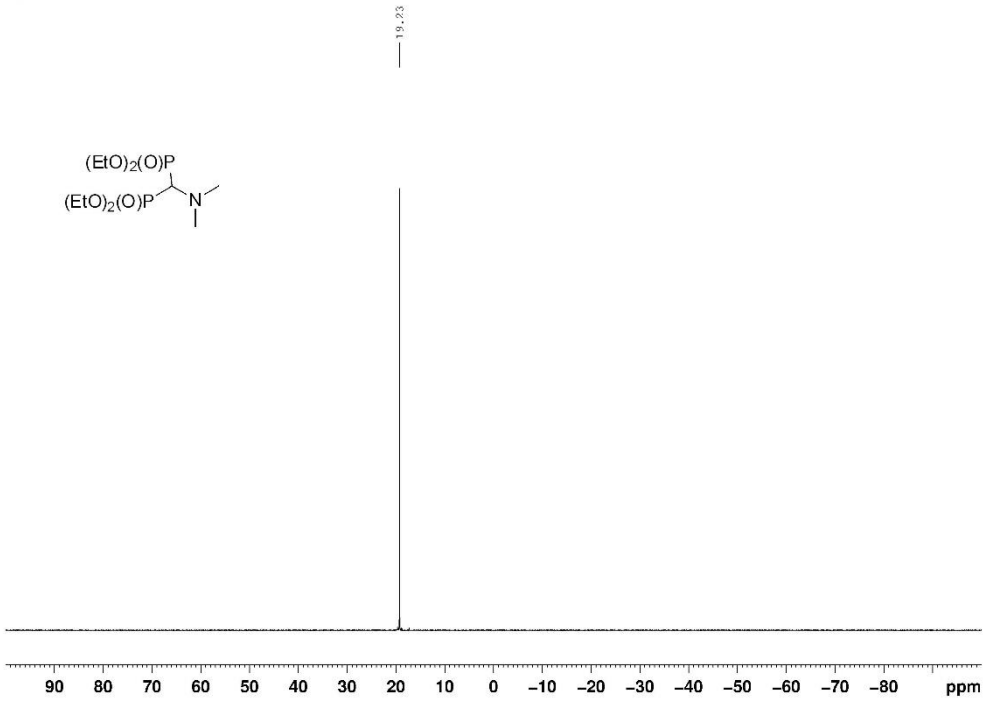
Tetraethyl[(dimethylamino)methylene]bis(phosphonate) (4j)
CDCl3 400M



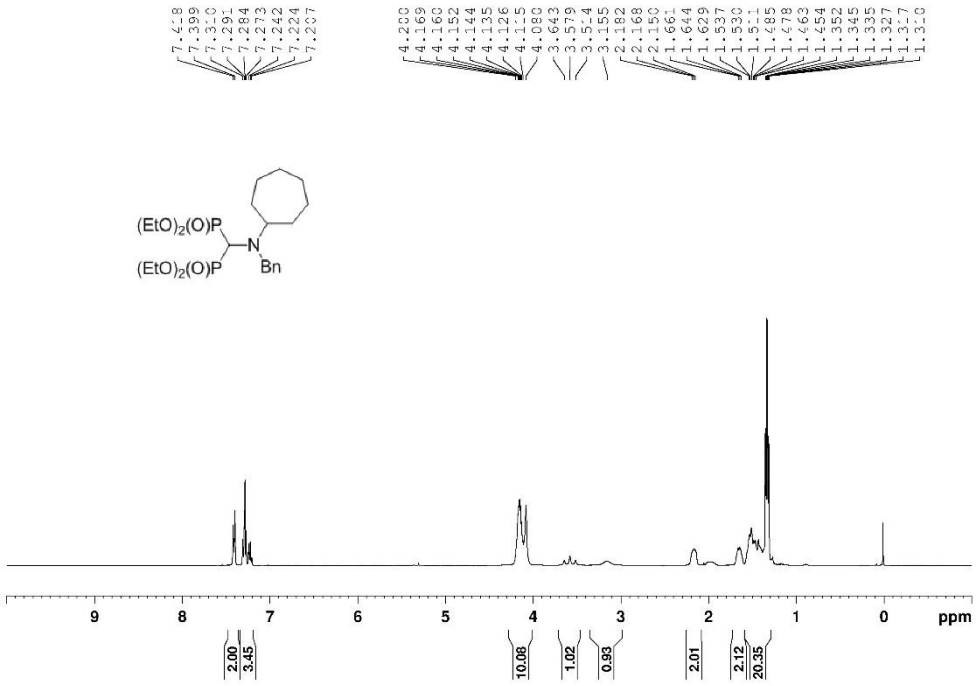
Tetraethyl[(dimethylamino)methylene]bis(phosphonate) (4j)
CDCl3 100M



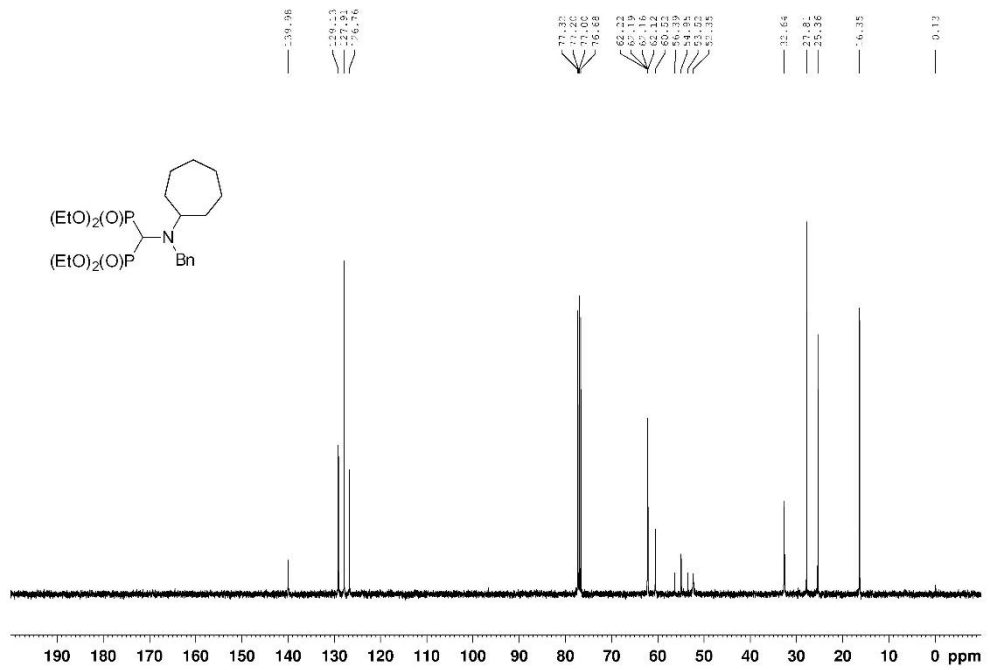
Tetraethyl[(dimethylamino)methylene]bis(phosphonate) (4j)
CDCl3 162M



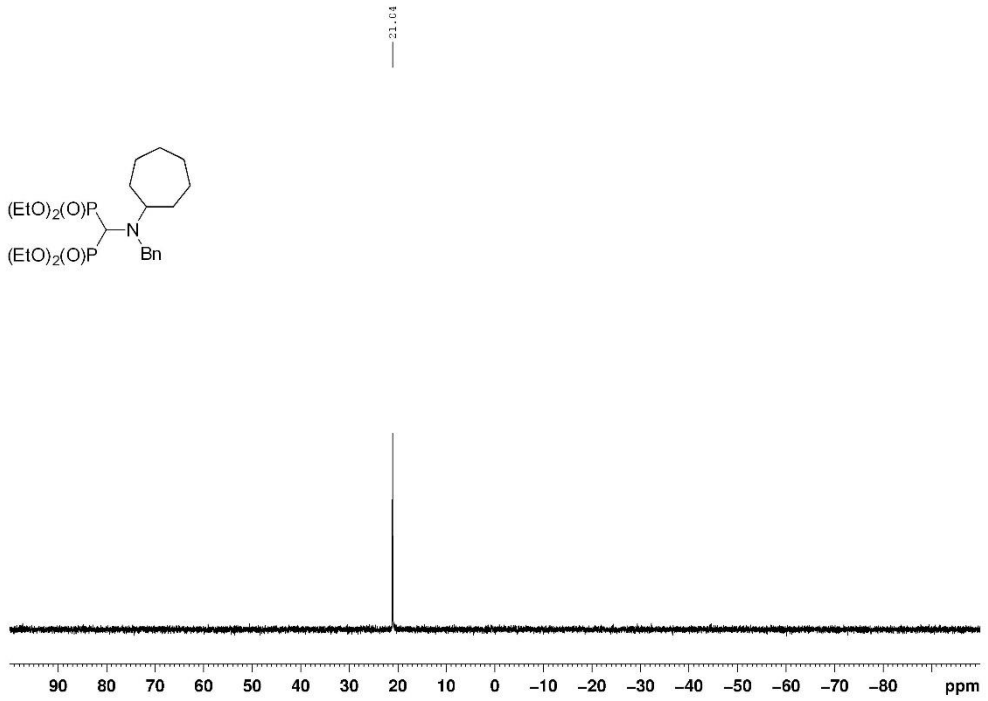
Tetraethyl{[benzyl(cycloheptyl)amino]methylene}bis(phosphonate) (4k)
CDCl3 400M



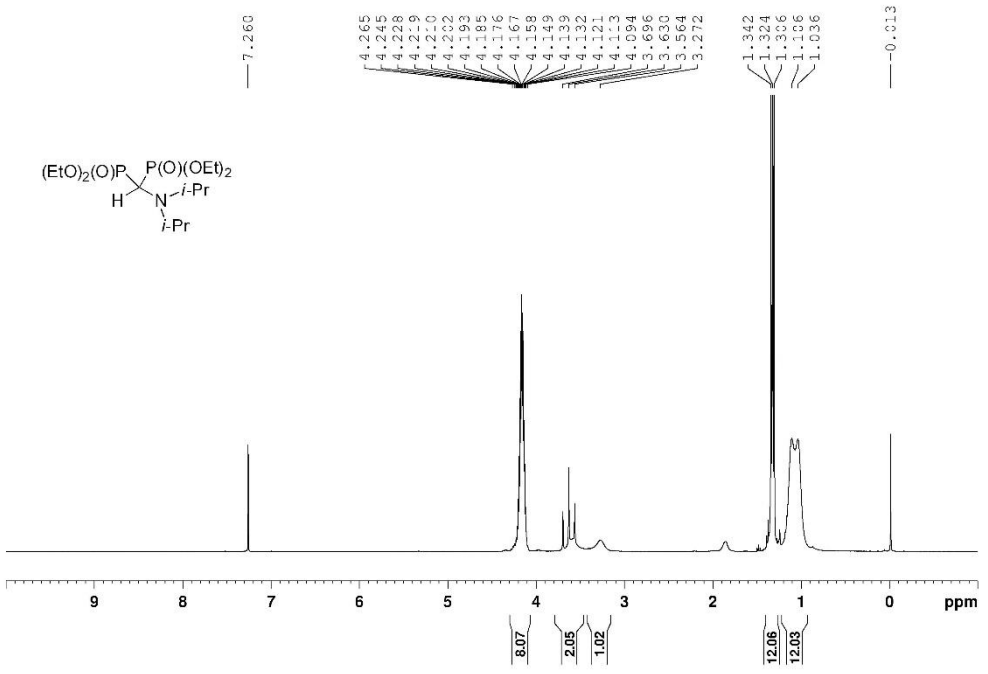
Tetraethyl{[benzyl(cycloheptyl)amino]methylene}bis(phosphonate) (4k)
CDCl3 100M



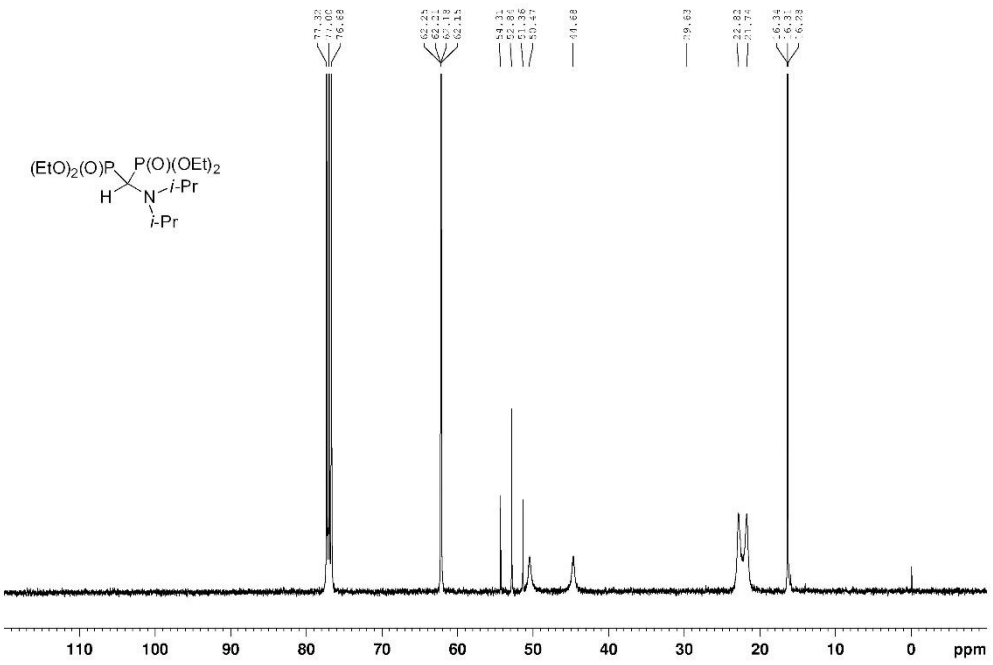
Tetraethyl{[benzyl(cycloheptyl)amino]methylene}bis(phosphonate) (4k)
CDCl3 162M



Tetraethyl ((diisopropylamino)methylene)bis(phosphonate) (4l)
CDCl3 400M



Tetraethyl ((diisopropylamino)methylene)bis(phosphonate) (4l)
CDCl3 100M



Tetraethyl ((diisopropylamino)methylene)bis(phosphonate) (4l)
CDCl3 162M