Supporting Information

Synthesis of 2-Phosphonotetrahydroquinolines with Site-Selective C-H bond Phosphonylation through Intramolecular Hydroarylation-Redox CDC Reaction

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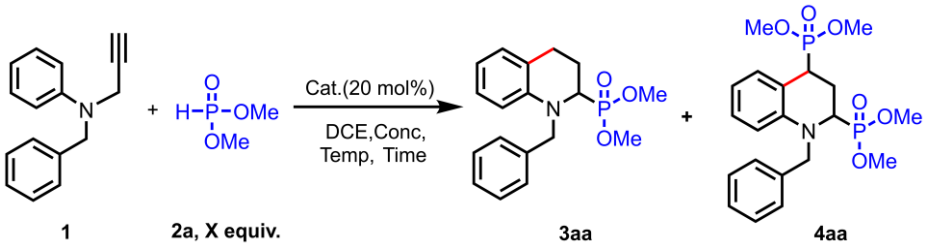
1. General information

NMR spectra were recorded on a Bruker biospin AVANCE II (400 MHz for ^{1}H, 101 MHz for ^{13}C, 162 MHz for ^{31}P) instrument in the indicated solvent. Chemical shifts are reported in unit parts per million (ppm) relative to the signal (0.00 ppm) for internal tetramethylsilane for solutions in $CDCl_3$ (7.26 ppm for ^{1}H, 77.16 ppm for ^{13}C). Multiplicities are reported using the following abbreviations: s; singlet, d; doublet, dd; doublet of doublets, t; triplet, q; quartet, m; multiplet, br; broad, *J*; coupling constants in Hertz. IR spectra were recorded on a JASCO FT/IR-4200 spectrometer. Only the strongest and/or structurally important peaks are reported as IR data given in cm^{-1}. Mass spectra were measured using a JMS-700 Mstation and Bruker micro TOF II. HRMS (EI, 70 eV) was calibrated as perfluorokerosene and HRMS (ESITOF) was calibrated as sodium formate. All reactions were monitored by thin-layer chromatography carried out on 0.2 mm E. Merck silica gel plates (60F-254) with UV light (254 nm) and visualized using an aqueous alkaline $KMnO_4$ solution. Gel permeation chromatography (GPC) for purification was performed on Japan Analytical Industry Model LC- 9225 NEXT (recycling preparative HPLC) and a Japan Analytical Industry Model UV-600 NEXT ultra violet detector with a polystyrene gel column (JAIGEL-1H, 20 mm x 600 mm), using chloroform as solvent (3.5 mL/min). Column chromatography was performed on Silica Gel 60 N, purchased from Fuji Silysia Chemical Ltd. Preparative thin-layer chromatography (PTLC) was performed using Wakogel B5-F silica coated plates (1.0 mm) prepared in our laboratory.

2. Optimization of the Reaction Conditions(Table S1)



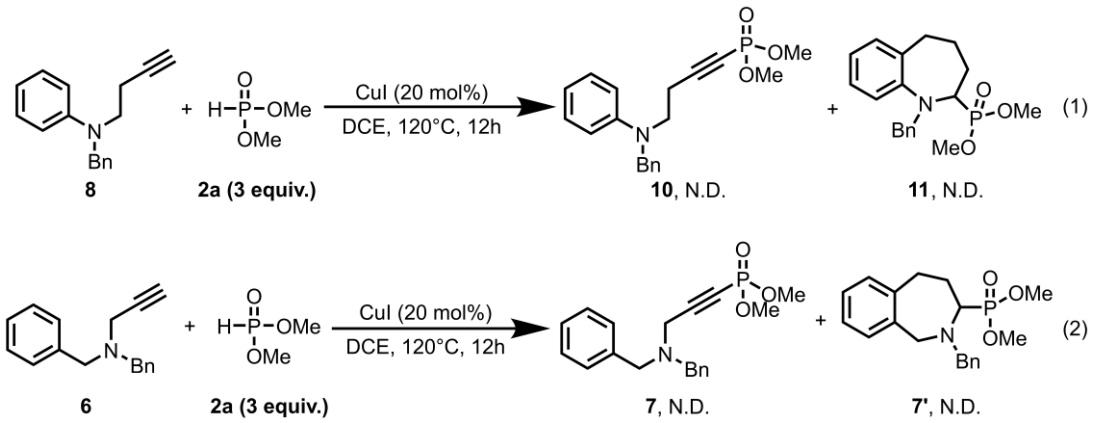
1 2a, X equiv. 3aa 4aa

Entry	Cat.	X	Conc. (M)	Temp. (°C)	T (h)	**3aa**[a] (%)	**4aa**[a] (%)	Rec.**1a**[a] (%)
1	CuI	1	1	120	12	42	8	N.D.
2	CuI	2	1	120	12	55	12	N.D.
3	CuI	4	1	120	12	75	9	N.D.
4	CuI	5	1	120	12	76	9	N.D.
5	CuI	6	1	120	12	78	9	N.D.
6	CuI	3	1	120	4	37	3	54
7	CuI	3	1	120	8	64	7	4
8	CuI	3	1	120	24	70	11	N.D.
9	CuI	3	1	120	36	51	17	N.D.
10	CuI	3	1	140	12	N.D.	N.D.	N.D.
11	CuI	3	1	100	12	60	8	15
12	CuI	3	1	80	12	44	4	51
13	CuI	20	1.250	120	12	60	12	N.D.
14	CuI	20	0.625	120	12	64	11	N.D.
15	CuI	20	0.500	120	12	67	15	N.D.
16	CuI	20	0.400	120	12	63	15	N.D.

[a] ^{1}H-NMR yield; [b] Isolated yield

3. Control Experiment

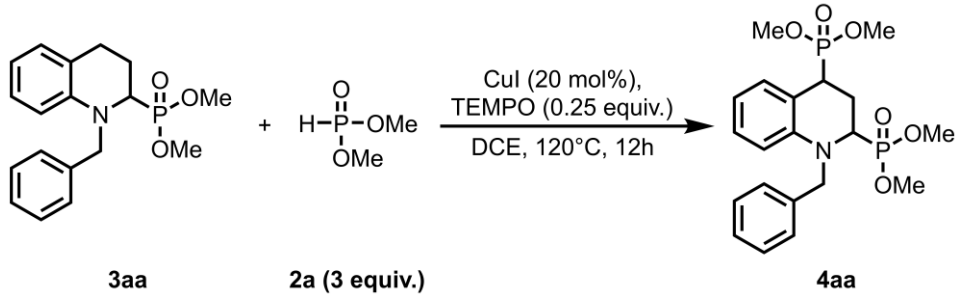
3.1 Research on the reaction pathway



Scheme S1. Experiments of Reaction Pathway

Compound **8** (**6**), CuI (9.5 mg, 0.05 mmol) and dimethyl phosphite (79.2 mg, 0.75 mmol) in 1,2-dichloroethane (0.25 mL) were stirred at 120°C for 12 hours in a closed vial tube protected with Ar (Table 1, entry 1). The resulting mixture was concentrated under reduced pressure. The residue was determined by crude ^{1}H NMR with 1,1,2-trichloroethane as internal standard and purified by silica gel column chromatography (petroleum ether : ethyl acetate = 1:1 (v/v)) to give the final products.

3.2 Research on the radical mechanism



Scheme S2. Research on radical mechanism

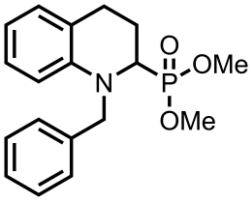
Dimethyl (1-benzyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate (**3aa**, 0.25 mmol) , CuI (9.5 mg, 0.05 mmol) and dimethyl phosphite (79.2 mg, 0.75 mmol), TEMPO (9.77 mg, 0.0625 mmol) in 1,2-dichloroethane (0.25 mL) were stirred at 120°C for 12 hours in a closed vial tube protected with Ar. The resulting mixture was concentrated under reduced pressure. The residue was determined by crude ^{1}H NMR with 1,1,2-trichloroethane as internal standard and purified by silica gel column chromatography (hexane : ethyl acetate = 1:1 (v/v)) to give tetramethyl (1-benzyl-1,2,3,4-tetrahydroquinoline-2,4-diyl)bis(phosphonate) **4aa** as the product.

4. Representative procedure

4.1 Reaction of *N*-propargylaniline 1 with dimethyl phosphite 2

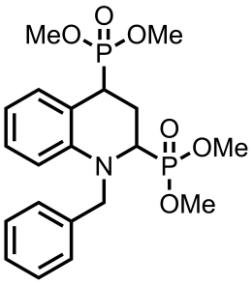
Represent procedure for the reaction of *N*-propargylaniline 1 with phosphite ester 2

N-benzyl-*N*-(2-propynyl)aniline (**1a**), CuI (9.5 mg, 0.05 mmol) and dimethyl phosphite (79.2 mg, 0.75 mmol) in 1,2-dichloroethane (0.25 mL) were stirred at 120°C for 12 hours in a closed vial tube protected with Ar. The resulting mixture was concentrated under reduced pressure. The residue was purified by silica gel column chromatography (petroleum ether : ethyl acetate = 1:1 (v/v)) to give dimethyl (1-benzyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate (**3aa**, 58 mg, 75% yield) as yellow oil.



Dimethyl (1-benzyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3aa

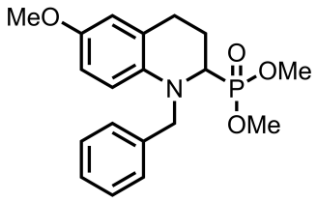
Following the representative procedure using *N*-Benzyl-*N*-(2-propynyl)aniline **1a** (55.3 mg, 0.25 mmol), dimethyl (1-benzyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate was obtained (58.0 mg, 0.18 mmol, 70% yield) as yellow oil. ^{1}H-NMR (400 MHz, $CDCl_3$): δ 7.21-7.34 (m, 5H), 7.01 (dd, J = 16.0, 8.0 Hz, 2H), 6.65 (t, J = 7.3 Hz, 1H), 6.61 (d, J = 8.3 Hz, 1H), 4.77 (ABq, J = 16.9 Hz, 2H), 3.88 (t, J = 6.0 Hz, 1H), 3.65 (q, J = 10.4 Hz, 6H), 3.08-3.21 (m, 1H), 2.76 (d, J = 14.2 Hz, 1H), 2.34-2.44 (m, 1H), 2.04-2.25 (m, 1H); ^{13}C-NMR (101 MHz, $CDCl_3$): δ 143.5, 138.0, 129.3. 128.7, 127.2, 127.0, 126.8, 121.9, 116.9, 112.3, 55.3 (d, J = 154.9 Hz), 54.3, 53.1 (d, J = 6.8 Hz), 52.4 (d, J = 7.5 Hz), 24.9 (d, J = 3.2 Hz), 22.3; ^{31}P-NMR (162 MHz, $CDCl_3$): δ 27.1877; FT-IR (neat) 3073, 2952, 2851, 2462, 1540, 1451, 1353, 970, 870, 733 cm^{-1}; HRMS (ESI) m/z Calcd for $C_{18}H_{22}NO_3P$ $[M+Na]^+$: 354.1229. Found: 354.1224.



[4-(Dimethoxy-phosphoryl)-1,2,3,4-tetrahydro-quinolin-2-yl]-phosphonic acid dimethyl ester 4aa

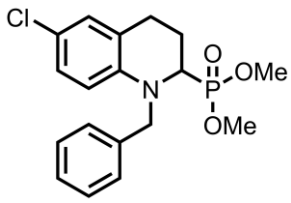
Following the representative procedure using *N*-Benzyl-*N*-(2-propynyl)aniline **1a** (55.3 mg, 0.25 mmol), [4-(Dimethoxy-phosphoryl)-1,2,3,4-tetrahydro-quinolin-2-yl]-phosphonic acid dimethyl ester was obtained (9.9 mg, 0.10 mmol, 12% yield) as yellow oil. The configurations of Major (M) to minor is 13:1 observerd in the ^{31}P-NMR spectra according to the report.[4] ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.67 (d, J = 7.5 Hz, 1H), 7.33 (dq, J = 14.6, 7.1 Hz, 4H), 7.24 (q, J = 7.3 Hz, 1H), 6.98 (t, J = 7.8 Hz, 1H), 6.69 – 6.58 (m, 2H), 4.81 (d, J = 16.8 Hz, 1H), 4.59 (d, J = 16.8 Hz, 1H), 4.09 – 4.02 (m, 1H), 3.82 – 3.75 (m, 1H), 3.73 (d, J = 10.6 Hz, 3H), 3.62 (d, J = 10.5 Hz, 3H), 3.59 (d, J = 10.5 Hz, 3H), 3.54 (d, J = 10.4 Hz, 3H), 2.60 – 2.38 (m, 2H). ^{13}C NMR (101 MHz, $CDCl_3$) δ 144.5 (d, J = 8.1 Hz), 138.0 (d, J = 1.0 Hz), 129.6 (d, J = 5.1 Hz), 128.7, 128.2, 127.2, 127.1, 117.9, 117.1 (d, J = 5.9 Hz), 113.7, 55.4, 54.0 (dd, J = 152.4,

10.8 Hz), 53.6 (d, *J* = 7.1 Hz), 52.7 (d, *J* = 7.1 Hz), 52.8 (d, *J* = 7.1 Hz), 52.3 (d, *J* = 7.5 Hz), 32.7 (dd, *J* = 142.1, 3.8 Hz), 25.4 (d, *J* = 2.9 Hz). ^{31}P NMR (162 MHz, Chloroform-*d*) δ 30.86, 26.88. HRMS (ESI-TOF) m/z Calcd for $C_{20}H_{27}NO_6P_2$ $[M+H]^+$: 440.1392. Found: 440.1377.



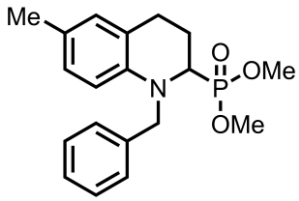
Dimethyl (1-benzyl-6-methoxy-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ba

Following the representative procedure using *N*-benzyl-4-methoxy-*N*-(prop-2-yn-1-yl)aniline **1b** (62.9 mg, 0.25 mmol), dimethyl (1-benzyl-6-methoxy-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate was obtained (66.9 mg, 0.19 mmol, 74% yield) as yellow oil. ^{1}H-NMR (400 MHz, $CDCl_3$): *δ* 7.18-7.34 (m, 5H), 6.50-6.66 (m, 3H), 4.66 (ABq, *J* = 16.9 Hz, 2H), 3.76-3.85 (m, 1H), 3.71 (s, 3H), 3.61 (q, *J* = 10.4 Hz, 6H), 3.03-3.14 (m, 1H), 2.70 (d, *J* = 14.2 Hz, 1H), 2.27-2.38 (m, 1H), 2.01-2.23 (m, 1H); ^{13}C-NMR (101 MHz, $CDCl_3$): *δ* 151.5, 138.4, 137.9, 128.7, 127.1, 127.0, 123.8, 115.0, 113.9, 112.6, 55.7, 55.3 (d, *J* = 154.4 Hz), 55.4, 53.0 (d, *J* = 6.8 Hz), 52.4 (d, *J* = 7.5 Hz), 25.3 (d, *J* = 3.2 Hz), 22.5; ^{31}P-NMR (162 MHz, $CDCl_3$): *δ* 27.8887; FT-IR (neat) 3027, 2948, 2831, 2462, 1505, 1452, 1352, 1207, 1026, 801, 733, 695 cm^{-1}; HRMS (ESI) m/z Calcd for $C_{19}H_{24}NO_4P$ $[M+Na]^+$: 384.1335. Found: 384.1333.



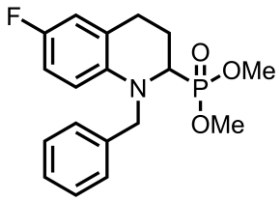
Dimethyl (1-benzyl-6-chloro-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ca

Following the representative procedure using *N*-benzyl-4-chloro-*N*-(prop-2-yn-1-yl)aniline **1c** (63.9 mg, 0.25 mmol), dimethyl (1-benzyl-6-chloro-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate was obtained (58.5 mg, 0.16 mmol, 64% yield) as yellow solid. m.p**.** 93-97 ℃; ^{1}H-NMR (400 MHz, $CDCl_3$): *δ* 7.16-7.32 (m, 5H), 6.98 (d, *J* = 2.4 Hz, 1H), 6.90 (dd, *J* = 8.8, 2.4 Hz, 1H), 6.48 (d, *J* = 8.8 Hz, 1H), 4.71 (ABq, *J* = 16.7 Hz, 1H), 3.81-3.88 (m, 1H), 3.65 (q, *J* = 10.4 Hz, 6H), 3.05-3.16 (m, 1H), 2.70 (dd, *J* = 14.2, 4.6 Hz, 1H), 2.31-2.41 (m, 1H), 1.99-2.20 (m, 1H); ^{13}C-NMR (101 MHz, $CDCl_3$): *δ* 142.0, 137.5, 128.9, 128.8, 127.2, 127.0, 126.6, 123.6, 121.6, 113.4, 55.3 (d, *J* = 153.9 Hz), 54.5, 53.2 (d, *J* = 6.8 Hz), 52.5 (d, *J* = 7.5 Hz), 24.8 (d, *J* = 3.2 Hz), 22.0; ^{31}P-NMR (162 MHz, $CDCl_3$): *δ* 27.1212; FT-IR (neat) 3028, 2951, 2849, 1596, 1494, 1353, 1236, 1189, 1027, 800, 733, 697, 634 cm^{-1}; HRMS (ESI) m/z Calcd for $C_{18}H_{21}NO_3ClP$ $[M+Na]^+$: 388.0838. Found: 388.0837.



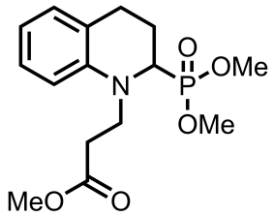
Dimethyl (1-benzyl-6-methyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3da

Following the representative procedure using *N*-Benzyl-*N*-(2-propynyl)-4-methylaniline **1d** (58.8 mg, 0.25 mmol), dimethyl (1-benzyl-6-methyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate was obtained (50.1 mg, 0.15 mmol, 58% yield) as yellow oil. ^{1}H-NMR (400 MHz, $CDCl_3$): δ 7.18-7.32 (m, 5H), 6.83 (s, 1H), 6.78 (d, J = 8.3 Hz, 1H), 6.50 (d, J = 8.3 Hz, 1H), 4.71 (ABq, J = 16.7 Hz, 1H), 3.80-3.88 (m, 1H), 3.62 (q, J = 10.4 Hz, 6H), 3.03-3.15 (m, 1H), 2.69 (d, J = 16.2 Hz, 1H), 2.30-2.40 (m, 1H), 2.19 (s, 3H), 2.00-2.17 (m, 1H); ^{13}C-NMR (101 MHz, $CDCl_3$): δ 141.2, 138.3, 130.0, 128.7, 127.7, 127.0, 126.9, 126.0, 122.0, 112.4, 55.3 (d, J = 156.6 Hz), 54.6, 53.0 (d, J = 6.8 Hz), 52.5 (d, J = 7.5 Hz), 25.0 (d, J = 3.2 Hz), 22.4, 20.4; ^{31}P-NMR (162 MHz, $CDCl_3$): δ 27.7089; FT-IR (neat) 3026, 2951, 2854, 1671, 1508, 1453, 1374, 1268, 1200, 1050, 802, 733, 697 cm^{-1}; HRMS (ESI) m/z Calcd for $C_{19}H_{24}NO_3P$ $[M+Na]^+$: 368.1386. Found: 368.1386.



Dimethyl (1-benzyl-6-fluoro-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ea

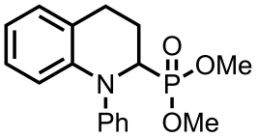
Following the representative procedure using *N*-Benzyl-*N*-(2-propynyl)-4-fluoroaniline **1e** (59.8 mg, 0.25 mmol), dimethyl (1-benzyl-6-fluoro-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate was obtained (55.1 mg, 0.16 mmol, 63% yield) as yellow oil. ^{1}H-NMR (400 MHz, $CDCl_3$): δ 7.19-7.32 (m, 2H), 6.74 (dd, J = 8.9, 3.0 Hz, 1H), 6.67 (td, J = 8.6, 3.0 Hz, 1H), 6.49 (dd, J = 9.0, 4.6 Hz, 1H), 4.69 (ABq, J = 16.7 Hz, 1H), 3.80-3.86 (m, 1H), 3.63 (q, J = 10.4 Hz, 6H), 3.05-3.16 (m, 1H), 2.70 (dd, J = 16.2, 2.7 Hz, 1H), 2.30-2.40 (m, 1H), 2.01-2.23 (m, 1H); ^{13}C-NMR (101 MHz, $CDCl_3$): δ 155.3 (d, J = 236.1 Hz), 139.8, 137.9, 128.7, 127.0, 126.8, 123.7, 115.6 (d, J = 22.2 Hz), 113.4 (d, J = 22.1 Hz), 113.3 (d, J = 6.9 Hz), 55.3 (d, J = 154.8 Hz), 54.5, 52.9 (d, J = 7.5 Hz), 52.4 (d, J = 7.7 Hz), 25.1 (d, J = 3.3 Hz), 22.2; ^{31}P-NMR (162 MHz, $CDCl_3$): δ 27.4498; FT-IR (neat) 3467, 3028, 2952, 2851, 1504, 1353, 1205, 1028, 800, 734, 693 cm^{-1}; HRMS (ESI) m/z Calcd for $C_{18}H_{21}NO_3FP$ $[M+Na]^+$: 372.1135. Found: 372.1129.



Methyl 3-(2-(dimethoxyphosphoryl)-3,4-dihydroquinolin-1(2H)-yl) propanoate 3fa

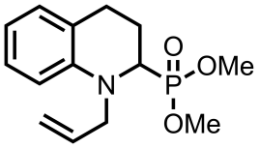
Following the representative procedure using methyl 3-(phenyl(prop-2-yn-1-yl)amino)propanoate **1f** (54.3 mg, 0.25 mmol), methyl 3-(2-(dimethoxyphosphoryl)-3,4-dihydroquinolin-1(2H)-yl) propanoate was obtained (49.1 mg, 0.15 mmol, 60% yield) as yellow oil. ^{1}H-NMR (400 MHz, $CDCl_3$): δ 7.08 (t, J = 7.3 Hz, 1H), 6.98 (d, J = 7.3 Hz, 1H), 6.65 (t, J = 7.6 Hz, 2H), 3.91-3.97 (m, 1H), 3.81-3.90 (m,1H), 3.70-3.81 (m, 1H), 3.66 (t, J = 5.8 Hz), 3.61 (d, J = 10.3 Hz, 3H), 2.98-3.09 (m, 1H), 2.58-2.73 (m, 1H), 2.27-2.36 (m, 1H), 1.86-2.08 (m, 1H); ^{13}C-NMR (101 MHz, $CDCl_3$): δ 172.7, 142.2, 129.5, 127.2, 122.5, 117.0, 111.6, 56.0 (d, J = 156.2 Hz), 53.0 (d, J = 7.3 Hz), 52.5 (d, J = 8.1 Hz), 51.7, 47.3, 31.5 (d, J = 1.4 Hz), 24.8 (d, J = 3.4 Hz), 22.0; ^{31}P-NMR (162 MHz, $CDCl_3$): δ 27.3967; FT-IR (neat) 3734, 3648, 3073, 2950,

2850, 1732, 1630, 1508, 1363, 1167, 981, 853, 760. 639 cm^{-1}; HRMS (ESI) m/z Calcd for $C_{15}H_{22}NO_5P$ $[M+Na]^+$: 350.1128. Found: 350.1127.



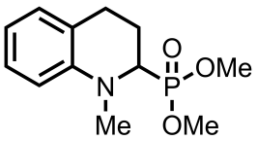
Dimethyl (1-phenyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ga

Following the representative procedure using *N*-phenyl-*N*-(prop-2-yn-1-yl)aniline **1g** (51.8 mg, 0.25 mmol), dimethyl (1-phenyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate was obtained (46.0 mg, 0.15 mmol, 58% yield) as yellow oil. ^{1}H-NMR (400 MHz, $CDCl_3$): δ 7.36-7.41 (m, 2H), 7.23-7.34 (m, 2H), 7.08 (t, *J* = 7.3 Hz, 2H), 6.95 (t, *J* = 7.0 Hz, 1H), 6.76-6.83 (m, 2H), 4.15-4.24 (m, 1H), 3.67 (d, *J* = 10.4 Hz, 3H), 3.54 (d, *J* = 10.4 Hz, 3H), 3.06-3.16 (m, 1H), 2.80 (dd, *J* = 16.7, 4.4 Hz, 1H), 2.27-2.36 (m, 1H), 2.07-2.27 (m, 1H); ^{13}C-NMR (101 MHz, $CDCl_3$): δ 149.7, 142.5, 129.6, 129.5, 126.4, 125.3, 124.7, 124.1, 120.0, 119.5, 58.3 (d, *J* = 162.0 Hz), 53.2 (d, *J* = 6.5 Hz,), 52.7 (d, *J* = 8.0 Hz), 24.6 (d, *J* = 2.6 Hz), 21.9; ^{31}P-NMR (162 MHz, $CDCl_3$): δ 27.0869; FT-IR (neat) 3031, 2951, 2849, 1684, 1592, 1491, 1360, 1269, 1027, 829, 755, 696 cm^{-1}; HRMS (ESI) m/z Calcd for $C_{17}H_{20}NO_3P$ $[M+Na]^+$: 340.1073. Found: 340.1071.



Dimethyl (1-allyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ha

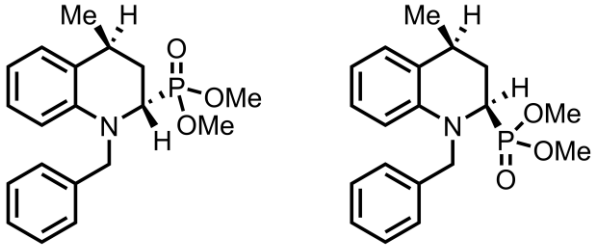
Following the representative procedure using *N*-allyl-*N*-(prop-2-yn-1-yl)aniline **1h** (42.8 mg, 0.25 mmol), dimethyl (1-allyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate was obtained (38.0 mg, 0.13 mmol, 54% yield) as yellow oil. ^{1}H-NMR (400 MHz, $CDCl_3$): δ 7.04 (t, *J* = 7.6 Hz, 1H), 6.97 (d, *J* = 7.3 Hz, 1H), 6.66 (d, *J* = 8.3 Hz, 1H), 6.63 (t, *J* = 7.3 Hz, 1H), 5.75-5.87 (m, 1H), 5.12-5.22 (m, 2H), 4.24 (dt, *J* = 17.3, 2.0 Hz, 1H), 4.01 (ddd, *J* = 16.0, 6.0, 1.0 Hz, 1H), 3.77-3.84 (m, 1H), 3.65 (q, *J* = 10.4 Hz, 6H), 3.00-3.12 (m, 1H), 2.68 (d, *J* = 16.2 Hz, 1H), 2.30-2.40 (m, 1H), 1.88-2.10 (m, 1H); ^{13}C-NMR (101 MHz, $CDCl_3$): δ 143.2, 133.2, 129.2, 127.1, 122.1, 116.8, 116.7, 112.3, 55.1 (d, *J* = 158.2 Hz), 53.5, 53.2 (d, *J* = 7.0 Hz), 52.5 (d, *J* = 7.8 Hz), 25.0 (d, *J* = 3.2 Hz), 22.0; ^{31}P-NMR (162 MHz, $CDCl_3$): δ 27.3162; FT-IR (neat) 3015, 2951, 2850, 1601, 1497, 1234, 1025, 826, 745, 665 cm^{-1}; HRMS (ESI) m/z Calcd for $C_{14}H_{20}NO_3P$ $[M+Na]^+$: 304.1073. Found: 304.1074.



Dimethyl (1-methyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ia

Following the representative procedure using *N*-methyl-*N*-(prop-2-yn-1-yl)aniline **1i** (42.8 mg, 0.25 mmol), dimethyl (1-methyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate was obtained (43.4 mg, 0.17 mmol, 68% yield) as yellow oil. ^{1}H-NMR (400 MHz, $CDCl_3$): δ 7.09 (t, *J* = 7.7 Hz, 1H), 6.97 (d, *J* = 7.28 Hz, 1H), 6.63 (q, *J* = 8.4 Hz, 2H), 3.71-3.76 (m, 1H), 3.64 (t, *J* = 10.8 Hz, 6H), 3.07 (d, *J* = 0.8 Hz, 3H), 2.99-3.06 (m, 1H), 2.69 (d, *J* = 16.2 Hz, 1H), 2.28-2.38 (m, 1H), 2.00-2.21 (m, 1H); ^{13}C-NMR (101 MHz, $CDCl_3$): δ 144.4, 128.9, 127.3, 121.9, 116.8, 111.1, 57.4 (d, *J* = 153.6 Hz), 52.9 (d, *J* = 6.4 Hz), 52.5 (d,

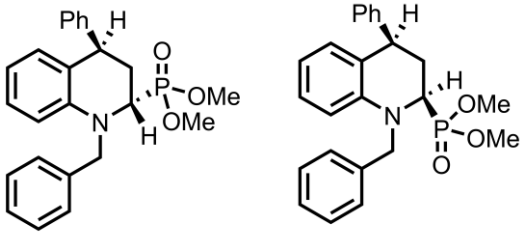
J = 7.6 Hz), 39.9, 24.9 (d, J = 3.3 Hz), 22.1; ^{31}P-NMR (162 MHz, $CDCl_3$): δ 27.6214; FT-IR (neat) 2959, 2903, 2827, 1671, 1477, 1366, 1271, 1208, 1132, 1042, 840, 757, 636 cm^{-1}; HRMS (ESI) m/z Calcd for $C_{12}H_{18}NO_3P$ $[M+Na]^+$: 278.0916. Found: 278.0913.



***trans*-3ja** ***cis*-3ja**

Dimethyl (1-benzyl-4-methyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ja

Following the representative procedure using *N*-benzyl-*N*-(but-2-yn-1-yl)aniline **1j** (58.8 mg, 0.25 mmol), dimethyl (1-benzyl-4-methyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate was obtained (58.7 mg, 0.17 mmol, 68% yield) as yellow oil. The configurations were assigned by the coupling constant of 2-H and 4-H according to our previous reports.[2] *Trans/cis* isomer total yield: 68% (total weight: 58.7 mg), a mixture of *trans*-isomer and *cis*-isomer (*trans*/*cis* = 8:1) observed in the ^{31}P-NMR spectra. Trans isomer: yellow oil; ^{1}H-NMR (400 MHz, $CDCl_3$): δ 7.15-7.32 (m, 7H), 6.95-7.01 (m, 1H), 6.68 (t, J = 7.4 Hz, 2H), 6.58 (d, J = 8.4 Hz, 1H), 4.72 (ABq, J = 17.0 Hz, 2H), 3.82-3.87 (m, 1H), 3.64 (d, J = 10.5 Hz, 3H), 3.60 (d, J = 10.5 Hz, 3H), 3.15-3.26 (m, 1H), 2.31-2.39 (m, 1H), 1.80-1.99 (m, 2H), 1.36 (d, J = 6.7 Hz); ^{13}C-NMR (101 MHz, $CDCl_3$): δ 143.3, 138.0, 128.7, 127.3, 127.2, 127.1, 127.0, 126.9, 117.2, 112.4, 55.3 (d, J = 154 Hz), 54.6, 53.0 (d, J = 6.4 Hz), 52.5 (d, J = 7.5 Hz), 31.6, 28.0 (d, J = 3.1 Hz), 20.7; ^{31}P-NMR (162 MHz, $CDCl_3$): δ 28.8702, 28.4707; FT-IR (neat) 3030, 2960, 2871, 2360, 1671, 1493, 1450, 1375, 1293, 1201, 1048, 835, 731, 696 cm^{-1}; HRMS (ESI) m/z Calcd for $C_{19}H_{24}NO_3P$ $[M+Na]^+$: 368.1386. Found: 368.1386.

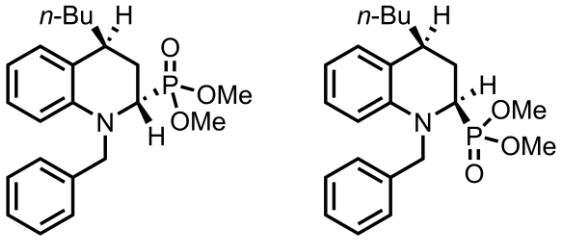


***trans*-3ka** ***cis*-3ka**

Dimethyl (1-benzyl-4-phenyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ka

Following the representative procedure using *N*-benzyl-*N*-(3-phenylprop-2-yn-1-yl)aniline **1k** (74.4 mg, 0.25 mmol), dimethyl (1-benzyl-4-phenyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate was obtained (51.9 mg, 0.13 mmol, 51% yield) as yellow solid. The configurations were assigned by the coupling constant of 2-H and 4-H according to our previous reports.[1] *Trans/cis* isomer total yield: 51% (total weight: 51.9 mg), a mixture of *trans*-isomer and *cis*-isomer (*trans*/*cis* = 9:1) observed in the ^{31}P-NMR spectra. m.p. 103-107 ℃; Trans isomer: ^{1}H-NMR (400 MHz, $CDCl_3$): δ 7.27-7.33 (m, 6H), 7.20-7.28 (m, 5H), 6.95-7.02 (m, 1H), 6.63-6.68 (m, 2H), 6.54 (t, J = 7.4 Hz, 1H), 4.77 (ABq, J = 17.0 Hz, 2H), 4.39 (dd, J = 12.0, 5.6 Hz, 1H), 3.85-3.91 (m, 1H), 3.65 (q, J = 10.5 Hz, 6H), 2.47-2.57 (m, 1H), 2.22-2.42 (m, 1H); ^{13}C-NMR (101 MHz, $CDCl_3$): δ 145.6, 143.9, 138.1, 130.0, 128.9, 128.8, 128.7, 127.5. 127.2, 127.0,

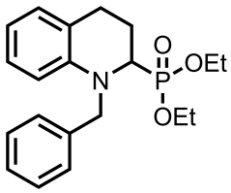
126.7, 125.8, 117.2, 112.6, 55.4 (d, J = 154.0 Hz), 54.9, 53.2 (d, J = 6.8 Hz), 52.5 (d, J = 7.8 Hz), 41.1 (d, J = 2.6 Hz), 32.2; ^{31}P-NMR (162 MHz, $CDCl_3$): δ 27.5889, 27.4191; FT-IR (neat) 3027, 2951, 2849, 1674, 1598, 1491, 1352, 1240, 1047, 827, 731, 677 cm^{-1}; HRMS (ESI) m/z Calcd for $C_{24}H_{26}NO_3P$ $[M+Na]^+$: 430.1542. Found: 430.1541.



***trans*-3la** ***cis*-3la**

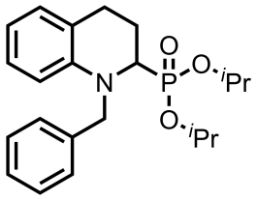
Dimethyl (1-benzyl-4-butyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3la

Following the representative procedure using *N*-benzyl-*N*-(hept-2-yn-1-yl)aniline **1l** (69.4 mg, 0.25 mmol), dimethyl (1-benzyl-4-butyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate was obtained (41.7 mg, 0.10 mmol, 43% yield) as yellow oil. The configurations were assigned by the coupling constant of 2-H and 4-H according to our previous reports.[2] *Trans/cis* isomer total yield: 43% (total weight: 41.7 mg), a mixture of *trans*-isomer and *cis*-isomer (*trans*/*cis* = 6:1) observed in the ^{31}P-NMR spectra. Trans isomer: yellow oil; ^{1}H-NMR (400 MHz, $CDCl_3$): δ 7.18-7.31 (m, 5H), 7.13 (d, J = 7.5 Hz, 1H), 6.96-7.03 (m, 1H), 6.64-6.72 (t, J = 8.4 Hz, 2H), 4.73 (ABq, J = 69.3 Hz, 2H), 3.80 (ABq, J = 6.0 Hz, 1H), 3.61 (q, J = 10.5 Hz, 6H), 2.94-3.04 (m, 1H), 2.31-2.51 (m, 1H), 1.85-2.02 (m, 1H), 1.71-1.83 (m, 1H), 1.22-1.47 (m, 6H), 0.90 (t, J = 6.6 Hz, 3H); ^{13}C-NMR (151 MHz, $CDCl_3$): δ 144.1, 138.0, 128.6, 128.5, 128.0, 127.3, 127.1, 127.0, 117.5, 113.8, 55.1, 54.3 (d, J = 152.4 Hz), 53.1 (d, J = 6.6 Hz), 52.4 (d, J = 7.1 Hz), 34.5, 33.4 (d, J = 5.0 Hz), 29.0, 28.8, 23.0, 14.2; ^{31}P-NMR (162 MHz, $CDCl_3$): δ 29.1352, 28.8756; FT-IR (neat) 3029, 2952, 2857, 1598, 1493, 1351, 1237, 1027, 821, 744, 641 cm^{-1}; HRMS (ESI) m/z Calcd for $C_{22}H_{30}NO_3P$ $[M+Na]^+$: 410.1855. Found: 410.1850.



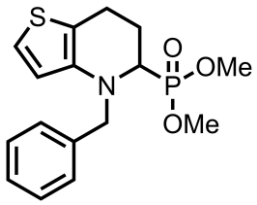
Diethyl (1-benzyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ab

Following the representative procedure using diethyl phosphite **2b** (103.6 mg, 0.75 mmol, 96.6 μL), diethyl (1-benzyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate (69.2 mg, 0.19 mmol, 77% yield) as yellow oil. ^{1}H-NMR (400 MHz, $CDCl_3$): δ 7.18-7.32 (m, 5H), 6.96 (q, J = 7.6 Hz, 2H), 6.60 (t, J = 7.3 Hz, 1H), 6.61 (d, J = 8.3 Hz, 1H), 4.77 (ABq, J = 16.9 Hz, 2H), 3.98-4.09 (m, 3H), 3.80-3.93 (m, 2H), 3.10-3.22 (m, 1H), 2.68-2.77 (m, 1H), 2.34-2.43 (m, 1H), 2.04-2.22 (m, 1H), 1.21 (t, J = 7.0 Hz, 3H), 1.12 (t, J = 7.0 Hz, 3H); ^{13}C-NMR (101 MHz, $CDCl_3$): δ 143.7, 138.2, 129.2, 128.7, 127.1, 127.0, 126.8, 122.1, 116.8, 112.1, 62.6 (d, J = 7.1 Hz), 61.8 (d, J = 7.6 Hz), 56.7 (d, J = 155.5 Hz), 54.3, 25.0 (d, J = 3.1 Hz), 22.4, 16.5 (d, J = 2.4 Hz), 16.4 (d, J = 2.5 Hz); ^{31}P-NMR (162 MHz, $CDCl_3$): δ 24.9946; FT-IR (neat) 3029, 2981, 2906, 1681, 1601, 1496, 1452, 1388, 1230, 1045, 961, 735, 696 cm^{-1}; HRMS (ESI) m/z Calcd for $C_{20}H_{26}NO_3P$ $[M+Na]^+$: 382.1542. Found: 382.1540.



Diisopropyl (1-benzyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ac

Following the representative procedure using diisopropyl phosphite **2c** (124.6 mg, 0.75 mmol, 124.6 μL), diisopropyl (1-benzyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate (59.1 mg, 0.15 mmol, 61% yield) as yellow oil. ^{1}H-NMR (400 MHz, $CDCl_3$): δ 7.16-7.31 (m, 5H), 6.95 (q, J = 7.0 Hz, 2H), 6.59 (t, J = 7.3 Hz, 1H), 6.54 (d, J = 8.2 Hz, 1H), 4.82 (ABq, J = 17.5 Hz, 2H), 4.59-4.73 (m, 2H), 3.74- 3.81 (m, 1H), 3.10-3.22 (m, 1H), 2.70 (d, J = 16 Hz, 1H), 2.34-2.44 (m, 1H), 1.99-2.20 (m, 1H), 1.27 (d, J = 6.2 Hz, 6H), 1.22 (d, J = 6.2 Hz, 3H), 0.95 (d, J = 6.2 Hz, 3H); ^{13}C-NMR (101 MHz, $CDCl_3$): δ 143.7, 138.3, 129.1, 128.6, 127.1, 126.8, 126.7, 122.1, 116.4, 111.9, 71.6 (d, J = 7.9 Hz), 70.3 (d, J = 8.2 Hz), 56.3 (d, J = 158.1 Hz), 54.1, 25.0 (d, J = 3.0 Hz), 24.6 (d, J = 2.8 Hz,), 24.2 (d, J = 4.0 Hz), 24.1 (d, J = 5.6 Hz), 23.5 (d, J = 5.1 Hz), 22.4; ^{31}P-NMR (162 MHz, $CDCl_3$): δ 22.8750, 22.6391; FT-IR (neat) 3029, 2976, 2930, 1601, 1499, 1451, 1384, 1229, 1105, 979, 784, 665 cm^{-1}; HRMS (ESI) m/z Calcd for $C_{22}H_{30}NO_3P$ $[M+Na]^+$: 410.1855. Found: 410.1850.

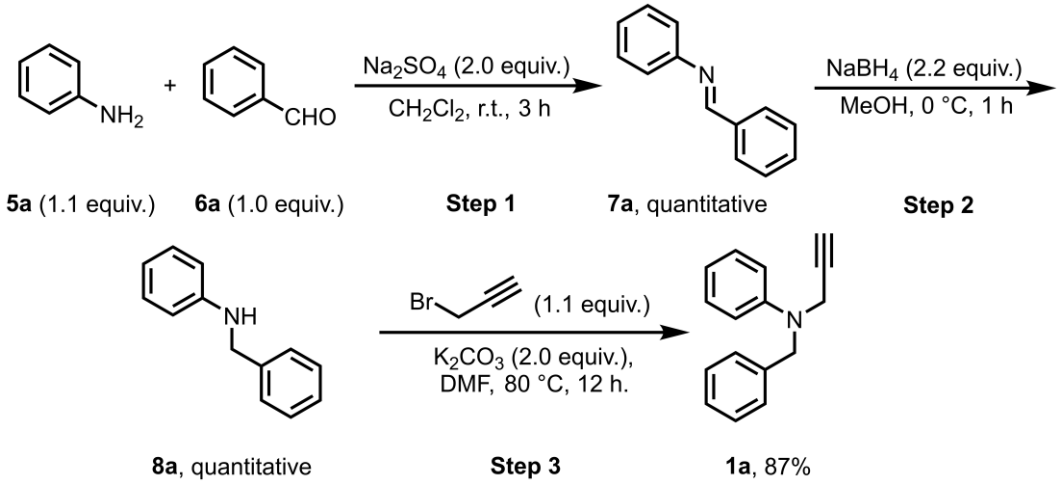


Dimethyl (4-benzyl-4,5,6,7-tetrahydrothieno[3,2-b]pyridin-5-yl)phosphonate 3ma

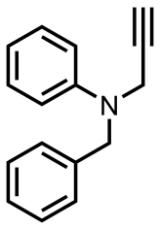
Following the representative procedure using *N*-benzyl-*N*-(prop-2-yn-1-yl)thiophen-3-amine **1m** (56.8 mg, 0.25 mmol), dimethyl (4-benzyl-4,5,6,7-tetrahydrothieno[3,2-b]pyridin-5-yl)phosphonate (17.7 mg, 0.05 mmol, 21% yield). ^{1}H-NMR (400 MHz, $CDCl_3$): δ 7.21-7.33 (m, 5H), 6.99 (d, J = 5.3 Hz, 1H), 6.68 (d, J = 5.3 Hz, 1H), 4.64 (d, J = 15.8 Hz, 1H), 4.42 (d, J = 15.8 Hz, 1H), 3.65- 3.74 (m, 1H), 3.63 (d, J = 10.4 Hz, 3H), 3.56 (d, J = 10.4 Hz, 3H), 2.84-2.95 (m, 1H), 2.70 (dd, J = 16.3, 5.2 Hz, 1H), 2.21-2.31 (m, 1H), 1.75-1.97 (m, 1H); ^{13}C-NMR (101 MHz, $CDCl_3$): δ 142.2, 138.4, 128.6, 127.8, 127.5, 121.4, 118.6, 111.7, 57.6 (d, J = 5.1 Hz), 53.7 (d, J = 158.3 Hz), 53.0 (d, J = 6.8 Hz), 52.6 (d, J = 7.6 Hz), 21.8, 20.5 (d, J = 3.1 Hz); ^{31}P-NMR (162 MHz, $CDCl_3$): δ 27.1969; FT-IR (neat) 3103, 2844, 1667, 1561, 1419, 1343, 1267, 1205, 1137, 1041, 976, 850, 732, 699 cm^{-1}; HRMS (ESI) m/z Calcd for $C_{16}H_{20}NO_3PS$ $[M+Na]^+$: 360.0793. Found: 360.0790.

4.2 Synthesis of starting materials

Represent procedure A of *N*-benzyl-*N*-(2-propynyl)anilines 1a-e, 1h-1j

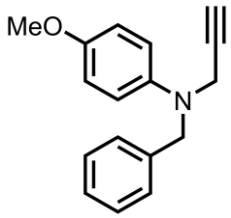


To a solution of aniline (**5a**, 2.2 mmol) in dry CH_2Cl_2 (5 mL) was added sodium sulfate (2.0 equiv.), followed by benzaldehyde (**6a**, 2.0 mmol) at room temperature. The resultant mixture was stirred for 3 hours at room temperature. The reaction mixture was filtered and concentrated to afford the crude residue **7a** (2.0 mmol). The crude residue was continuously used in the next step without further purifications. To a solution of **7a** in MeOH (5 mL) was slowly added sodium tetrahydridoborate (2.2 equiv.) at 0℃. The reaction was monitored by TLC and after the full conversion, the solvent was removed under reduced pressure and the crude product was purified by column chromatography in silica gel to afford **8a** in quantitative. To a solution of **8a** (2.0 mmol) in DMF (5 mL) was added potassium carbonate (4.0 mmol, 2.0 equiv.) followed by propargyl bromide (2.4 mmol, 1.2 equiv.) and the resultant mixture was stirred overnight at 80℃. The reaction was quenched by saturated NH_4Cl aqueous solution and the mixture was extracted three times with ethyl acetate. The combined organic layer was washed with saturated aqueous NaCl solution, dried over anhydrous $MgSO_4$, and concentrated in vacuo. The resulting residue was purified by silica gel column chromatography (hexane : ethyl acetate = 49 : 1 (v:v)) to give *N*-Benzyl-*N*-(2-propynyl)aniline.



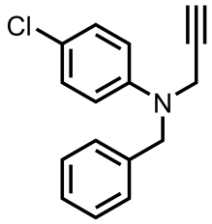
***N*-Benzyl-*N*-(2-propynyl)aniline 1a**

Following the representative procedure A using *N*-benzylaniline **8a** (366.5 mg, 2.0 mmol), *N*-Benzyl-*N*-(2-propynyl)aniline was obtained (198.5 mg, 1.8 mmol, 87% yield) as light yellowish oil. ^{1}H NMR (400 MHz; $CDCl_3$): δ 7.33 (d, J = 4.7 Hz, 4H), 7.30-7.22 (m, 3H), 6.91 (d, J = 8.1 Hz, 2H), 6.82 (t, J = 7.3 Hz, 1H), 4.56 (s, 2H), 4.03 (d, J = 2.2 Hz, 2H), 2.22 (t, J = 2.3 Hz, 1H). Spectral data are in accordance with the reported data.[2]



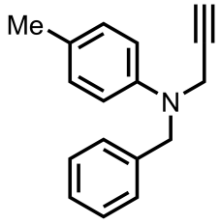
***N*-benzyl-4-methoxy-*N*-(prop-2-yn-1-yl)aniline 1b**

Following the representative procedure A using *N*-benzyl-4-methoxyaniline **8b** (213.3 mg, 1.0 mmol), *N*-benzyl-4-methoxy-*N*-(prop-2-yn-1-yl)aniline was obtained (246.3 mg, 1.0 mmol, 99% yield) as white solid. ^{1}H NMR (400 MHz; CDCl3): 7.30-7.37 (m, 4H), 7.22-7.28 (m, 1H), 6.89-6.94 (m, 2H), 6.80-6.88 (m, 2H), 4.42 (s, 2H), 3.90 (d, *J* = 3.2 Hz, 2H), 3.75 (s, 3H), 2.22 (t, *J* = 2.4 Hz, 1H). Spectral data are in accordance with the reported data.[2]



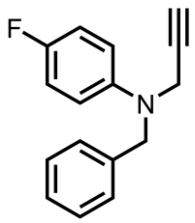
***N*-benzyl-4-chloro-*N*-(prop-2-yn-1-yl)aniline 1c**

Following the representative procedure A using *N*-benzyl-4-chloroaniline **8c** (217.7 mg, 1.0 mmol), *N*-benzyl-4-chloro-*N*-(prop-2-yn-1-yl)aniline was obtained (202.1 mg, 0.8 mmol, 84% yield) as light yellow oil. ^{1}H NMR (400 MHz; $CDCl_3$): 7.23-7.37 (m, 5H), 7.18 (d, *J*= 7.8 Hz, 2H), 6.80 (d, *J*= 7.8 Hz, 2H), 4.52 (s, 2H), 4.00 (d. *J*= 2.4 Hz, 2H), 2.23 (t, *J*= 1.5 Hz, 1H). Spectral data are in accordance with the reported data.[2]



***N*-Benzyl-*N*-(2-propynyl)-4-methylaniline 1d**

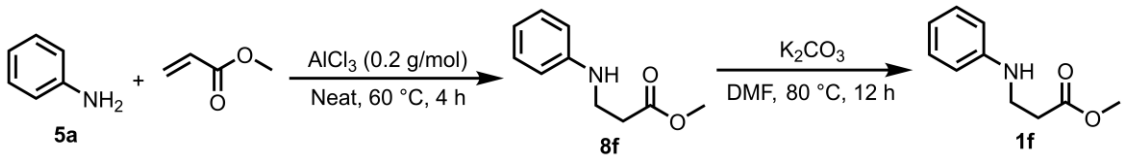
Following the representative procedure A using *N*-benzyl-4-methylaniline **8c** (197.3 mg, 1.0 mmol), *N*-Benzyl-*N*-(2-propynyl)-4-methylaniline was obtained (188.3 mg, 0.8 mmol, 80% yield) as yellow oil. ^{1}H-NMR (400 MHz, $CDCl_3$): δ 7.16-7.42 (m, 5H), 7.07 (d, *J* = 8.2 Hz, 2H), 6.84 (d, *J* = 8.4 Hz, 1H), 4.50 (s, 2H), 3.98 (d, *J* = 1.9 Hz, 1H), 2.26 (s, 3H), 2.20 (t, *J* = 2.0 Hz, 1H). Spectral data are in accordance with the reported data.[2]



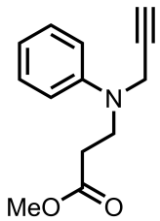
***N*-Benzyl-*N*-(2-propynyl)-4-fluoroaniline 1e**

Following the representative procedure A using *N*-benzyl-4-fluoroaniline **8c** (201.24 mg, 1.0 mmol), *N*-Benzyl-*N*-(2-propynyl)-4-fluoroaniline was obtained (208.4 mg, 0.9 mmol, 91% yield) as brown oil. ^{1}H NMR (400MHz; $CDCl_3$): 7.22-7.37 (m, 5H), 6.90-6.98 (m, 2H), 6.81-6.89 (m, 2H), 4.45 (s, 2H), 3.94 (d, *J*=2.4 Hz, 2H), 2.21 (t, *J*=2.4 Hz, 1H). Spectral data are in accordance with the reported data.[2]

Synthesis of Methyl 3-(phenyl(prop-2-yn-1-yl)amino)propanoate 1f



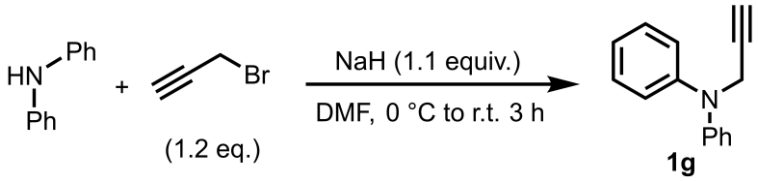
To a sealing tube add **5a** (3.0 mmol), followed by methyl acrylate (1.1 equiv.). Then add $AlCl_3$ (0.6 g) to the liquid mixture. The mixture was stirred at 60℃ for 4 h under Ar. The reaction was quenched by saturated NH_4Cl aqueous solution and the mixture was extracted three times with ethyl acetate. The combined organic layer was washed with saturated aqueous NaCl solution, dried over anhydrous $MgSO_4$, and concentrated in vacuo. The resulting residue was purified by silica gel column chromatography and gave the desired product **8f**. To a solution of **8f** (2.0 mmol) in DMF (5 mL) was added potassium carbonate (4.0 mmol, 2.0 equiv.) followed by propargyl bromide (2.4 mmol, 1.2 equiv.) and the resultant mixture was stirred overnight at 80℃. The reaction was quenched by saturated NH_4Cl aqueous solution and the mixture was extracted three times with ethyl acetate. The combined organic layer was washed with saturated aqueous NaCl solution, dried over anhydrous $MgSO_4$, and concentrated in vacuo. The resulting residue was purified by silica gel column chromatography (hexane : ethyl acetate = 9 : 1 (v:v)) to give methyl 3-(phenyl(prop-2-yn-1-yl)amino)propanoate as yellow oil (308.4 mg, 1.7 mmol, 57% yield).



Methyl 3-(phenyl(prop-2-yn-1-yl)amino)propanoate 1f

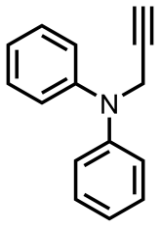
^{1}H NMR (400 MHz; $CDCl_3$): 7.23-7.29 (m, 2H), 6.83-6.87 (m, 2H), 6.78-6.82 (m, 1H), 4.05 (d, *J* = 2.4 Hz, 2H), 3.72 (t, *J* = 7.0 Hz, 2H), 3.68 (s, 3H), 2.67 (t, *J*= 6.4 Hz, 2H), 2.19 (t, *J* = 2.4 Hz, 1H). ^{13}C NMR (101 MHz; $CDCl_3$): 172.6, 147.3, 129.4, 118.4, 114.0, 80.0, 72.2, 51.8, 47.3, 40.4, 32.4. HRMS (ESI) m/z Calcd for $C_{13}H_{15}NO_2$ $[M+Na]^+$: 240.0994. Found: 240.0993.

Synthesis of *N*-phenyl-*N*-(prop-2-yn-1-yl)aniline 1g



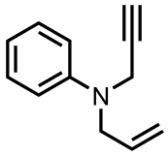
To a dry dimethylformamide solution (5 mL) of diphenylamine (3 mmol) was added 60% NaH (1.1equiv.) at 0 °C under Ar, and the mixture was stirred for 30 min at 0°C. Then propargyl bromide (1.2 equiv.) was added to the reaction media and let stirring continue for 3 h at room temperature. The reaction

was quenched by saturated NH_4Cl aqueous solution and the mixture was extracted three times with ethyl acetate. The combined organic layer was washed with saturated aqueous NaCl solution, dried over anhydrous $MgSO_4$, and concentrated in vacuo. The resulting residue was purified by silica gel column chromatography (petroleum ether : ethyl acetate = 30 : 1 (v:v)) to give *N*-phenyl-*N*-(prop-2-yn-1-yl)aniline **1g** as light yellow oil (391.7 mg, 1.9 mmol, 63% yield).



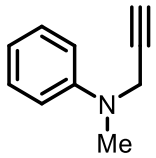
***N*-phenyl-*N*-(prop-2-yn-1-yl)aniline 1g**

^{1}H- NMR (400 MHz; $CDCl_3$): 7.32 (t, *J* = 8.0 Hz, 4H), 7.11 (d, *J* = 8.0 Hz, 4H), 7.04 (t, *J* = 8.0 Hz, 2H), 4.38 (d, *J* = 2.0 Hz, 2H), 2.20 (t, *J* = 2.0 Hz, 1H). Spectral data are in accordance with the reported data.[2]



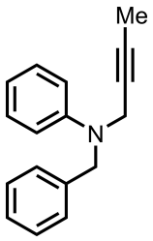
***N*-allyl-*N*-(prop-2-yn-1-yl)aniline 1h**

Following the representative procedure A using *N*-allylaniline **8h** (399.5 mg, 3.0 mmol), *N*-allyl-*N*-(prop-2-yn-1-yl)aniline was obtained (442.8 mg, 2.7 mmol, 89% yield) as yellow oil. ^{1}H- NMR (400 MHz; $CDCl_3$):7.25 (t, *J*= 8.0 Hz, 2H), 6.85 (d, *J* = 8.0 Hz, 2H), 6.79 (t, *J* = 7.5 Hz, 1H), 5.86-5.91 (m, 1H), 5.27 (dd, *J* = 17.0 Hz, 1.5 Hz, 1H), 5.19 (dd, *J* = 10.5 Hz, 1.5 Hz, 1H), 4.05 (d, *J* = 2.5 Hz, 2H), 3.96 (dt, *J* =5.5 Hz, 1.5 Hz, 2H), 2.18 (t, *J* = 2.5 Hz, 1H). Spectral data are in accordance with the reported data.[2]



***N*-methyl-*N*-(prop-2-yn-1-yl)aniline 1i**

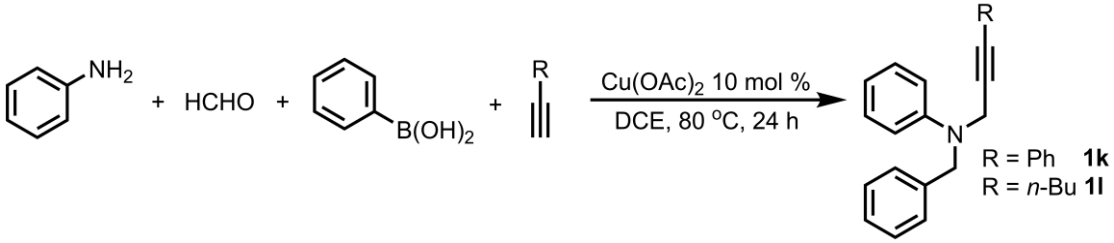
Following the representative procedure A using *N*-methylaniline **8i** (107.2 mg, 1.0 mmol), *N*-methyl-*N*-(prop-2-yn-1-yl)aniline was obtained (103.8 mg, 0.9 mmol, 85% yield) as colorless oil. ^{1}H-NMR (400 MHz, $CDCl_3$): δ 7.29-7.38 (m, 3H), 6.85-6.95 (m, 3H), 4.10 (d, *J* = 2.3 Hz, 2H), 3.02 (s, 3H), 2.22 (t, *J* = 2.3 Hz, 1H). Spectral data are in accordance with the reported data.[2]



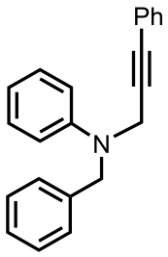
***N*-benzyl-*N*-(but-2-yn-1-yl)aniline 1j**

Following the representative procedure A using *N*-benzylaniline **8a** (549.7 mg, 3.0 mmol), *N*-benzyl-*N*-(but-2-yn-1-yl)aniline was obtained (308.4 mg, 1.5 mmol, 53% yield) as yellow oil. ^{1}H NMR (400 MHz; $CDCl_3$): 7.20-7.33 (m, 7H), 6.87-6.89 (m, 2H), 6.76-6.81 (m, 1H), 4.56 (s, 2H), 3.99 (q, *J* =2.2 Hz, 2H), 1.81 (t, *J* =2.3 Hz, 3H). Spectral data are in accordance with the reported data.[2]

Represent procedure B for *N*-benzyl-*N*-(2-propynyl)anilines 1k, 1l

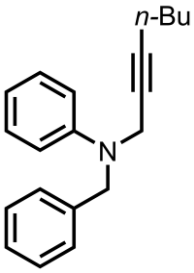


A mixture of aniline (2.0 mmol, 1.0 equiv), formaldehyde (40% aqueous solution) (2.2 mmol, 1.1 equiv.), phenylboronic acid (1.0 mmol, 0.5 equiv.), alkyne (1.2 mmol, 0.6 equiv.), Copper(II) acetate (0.2 mmol, 10 mmol%) and 1, 2-dichloroethane (5 mL) was stirred in a sealed glass tube at 80°C for 24 hours. After completion of the reaction, the reaction solution was filtered. After evaporating the solvents in vacuum, the residue was purified by silica gel column chromatography (hexane : ethyl acetate = 30 : 1 (v:v)) to give the pure products.



***N*-benzyl-*N*-(3-phenylprop-2-yn-1-yl)aniline 1k**

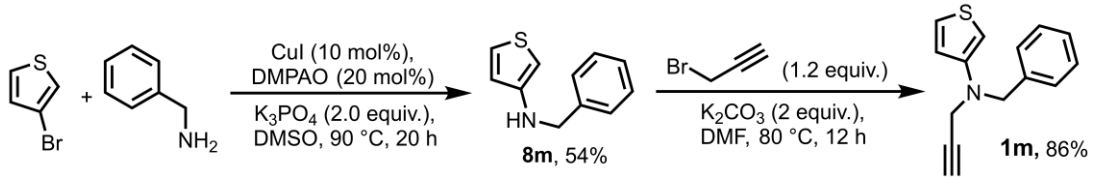
Following the representative procedure b using aniline (186.2 mg, 2.0 mmol), *N*-benzyl-*N*-(3-phenylprop-2-yn-1-yl)aniline was obtained (571.1 mg, 1.9 mmol, 96% yield) as green oil. ^{1}H NMR (400 MHz; $CDCl_3$): 7.43 (d, *J* = 2.0 Hz, 1H), 7.21-7.38 (m, 8H), 7.14-7.18 (m, 1H), 6.90-6.94 (m, 2H), 6.82 (tt, *J* =7.2 Hz, 0.96 Hz, 1H), 4.60 (s, 2H), 4.22 (s, 2H). Spectral data are in accordance with the reported data.[2]



***N*-benzyl-*N*-(hept-2-yn-1-yl)aniline 1l**

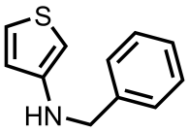
Following the representative procedure b using aniline (93.1 mg, 1.0 mmol), *N*-benzyl-*N*-(hept-2-yn-1-yl)aniline was obtained (255.2 mg, 0.9 mmol, 92% yield) as yellow oil. ^{1}H NMR (400 MHz; $CDCl_3$): 7.25-7.32 (m, 4H), 7.15-7.24 (m, 3H), 6.85 (d, *J* = 8.0 Hz, 2H), 6.70 (t, *J* = 7.5 Hz, 1H), 4.52 (s, 2H), 3.97 (t, *J* =6.0 Hz, 2H), 2.32-2.38 (m, 2H), 2.09-2.17 (m, 2H), 1.29-1.49 (m, 2H), 0.87 (t, *J* =6.4 Hz, 3H). Spectral data are in accordance with the reported data.[2]

Synthesis of *N*-benzyl-*N*-(prop-2-yn-1-yl)thiophen-3-amine 1m



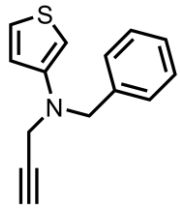
A mixture of 3-bromothiphene (2.0 mmol), benzylamine (1.1 equiv.), DMAPO (20 mmol%), K_3PO_4 (2.0 equiv.), Copper(I) iodide (10 mmol%) and DMSO (5 mL) was stirred in a sealed glass tube at 90°C for 20 hours. After completion of the reaction, the reaction solution was filtered. After evaporating the solvents in vacuum, the residue was purified by silica gel column chromatography (hexane : ethyl acetate = 10 : 1 (v:v)) to give *N*-benzylthiophen-3-amine **8m** as deep red oil (204.4 mg, 1.1 mmol, 54% yield).

To a solution of **8m** (1.1 mmol) in DMF (5 mL) was added potassium carbonate (2.0 equiv.) followed by propargyl bromide (1.2 equiv.) and the resultant mixture was stirred at 80°C for 12 h. The reaction mixture was filtered and concentrated to afford the crude residue, which was purified by silica gel column chromatography (hexane : ethyl acetate = 10 : 1 (v:v)) to afford *N*-benzyl-*N*-(prop-2-yn-1-yl)thiophen-3-amine **1o** as yellow solid (211.1 mg, 0.9 mmol, 86% yield).



***N*-benzylthiophen-3-amine 8m**

^{1}H-NMR (400 MHz; $CDCl_3$): 7.23-7.29 (m, 5H), 7.13 (q, *J*=3.2 Hz, 1H), 6.62 (dd, *J*=1.2 Hz, 5.2 Hz, 1H), 5.95 (q, *J*=1.2 Hz, 1H), 4.24 (s, 1H), 3.92 (br, 1H). Spectral data are in accordance with the reported data.[3]



***N*-benzyl-*N*-(prop-2-yn-1-yl)thiophen-3-amine 1m**

^{1}H-NMR (400 MHz; $CDCl_3$): 7.31-7.38 (m, 4H), 7.26-7.30 (m, 1H), 7.23 (q, *J* =3.2 Hz, 1H), 6.87 (dd, *J* =1.2 Hz, 5.2 Hz, 1H), 6.26 (q, *J* =1.2 Hz, 1H), 4.39 (s, 2H), 3.86 (d, *J* =1.2 Hz, 2H), 2.21 (t, *J* = 2.4 Hz, 1H). ^{13}C NMR (101 MHz; $CDCl_3$): 150.2, 138.1, 128.7, 128.2, 127.5, 125.4, 120.2, 100.7, 79.3, 72.7, 56.2, 41.0. HRMS (ESI) m/z Calcd for $C_{14}H_{13}NS$ $[M+H]^+$: 228.0841. Found: 228.0839.

5. Reference

1 G. Li, H. Nakamura, *Angew. Chem. Int. Ed*. **2016**, 55, 6758.

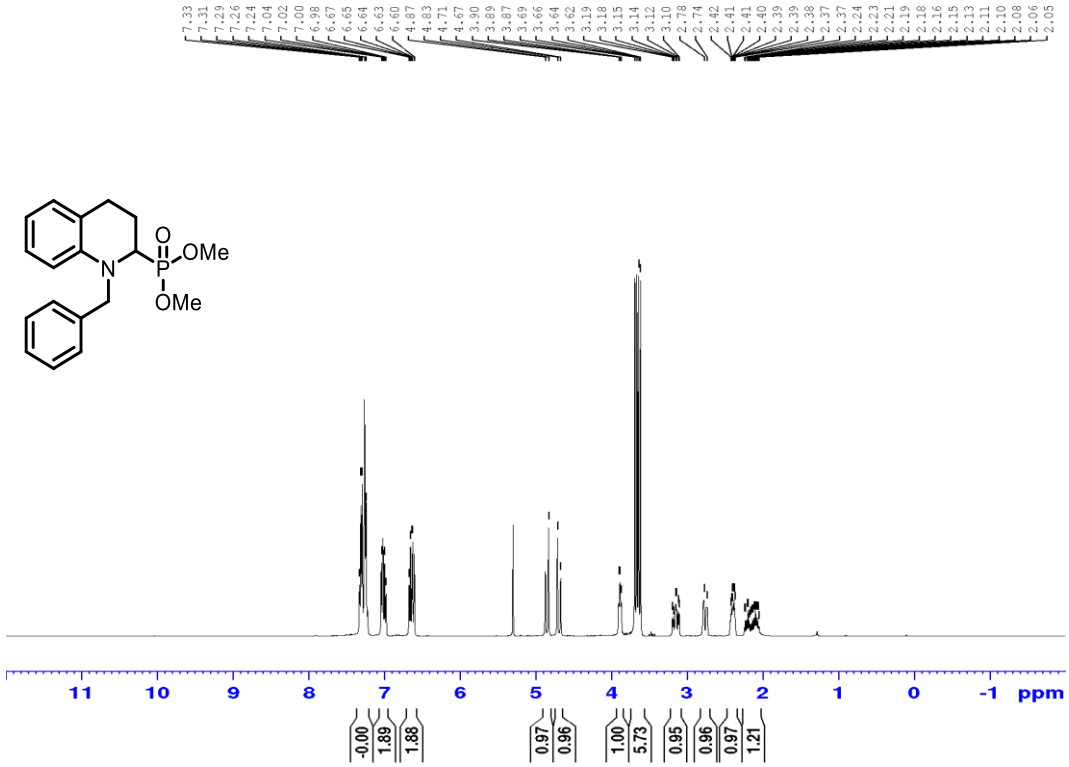
2 G. Li, C. Wang, Y. Li, K. Shao, G. Yu, S. Wang, X. Guo, W. Zhao and H. Nakamura, *Chem. Commun*. **2020**, 56, 7333.

3 Y. Zhang, X. Yang, Q. Yao, D. Ma. *Org. Lett.* **2012**, 12, 3056.

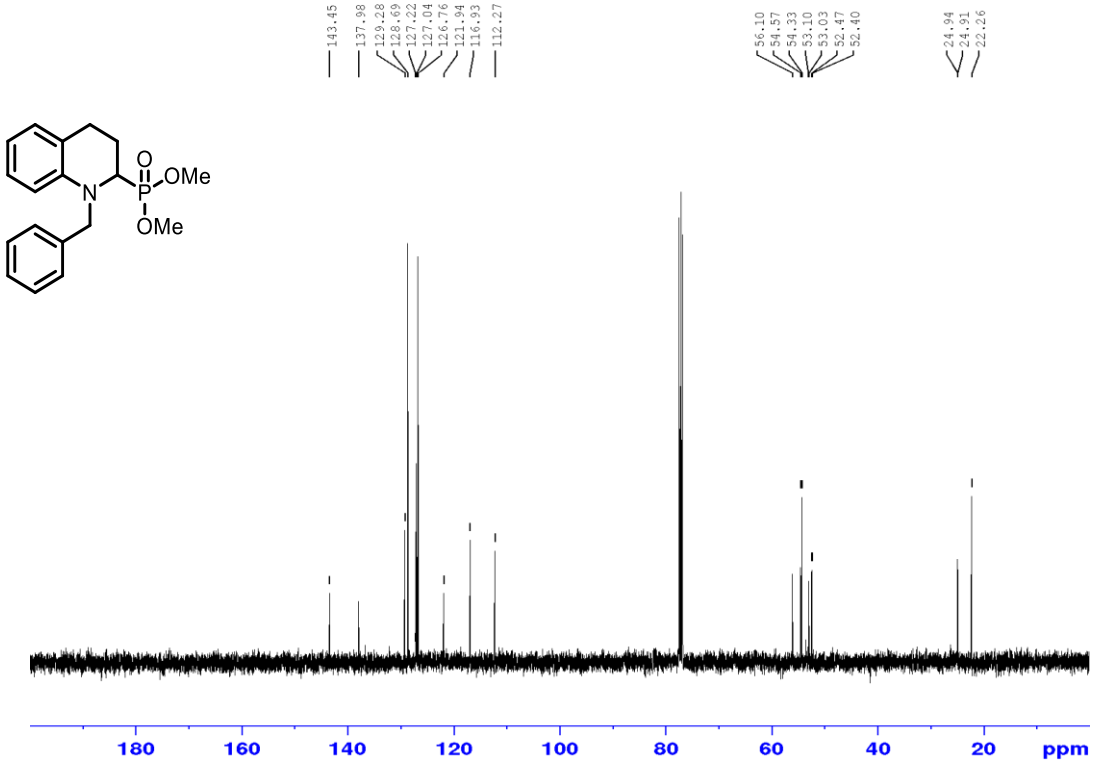
4 A. D. Blieck, K. G. R. Masschelein, F. Dhaene, E. R. Sokolowska, B. Marciniak, J. Drabowiczc and C. V. Stevens, *Chem. Commun*, 2010, **46**, 258.

6. Copies of ^{1}H-NMR, ^{13}C-NMR spectra, ^{31}P-NMR spectra

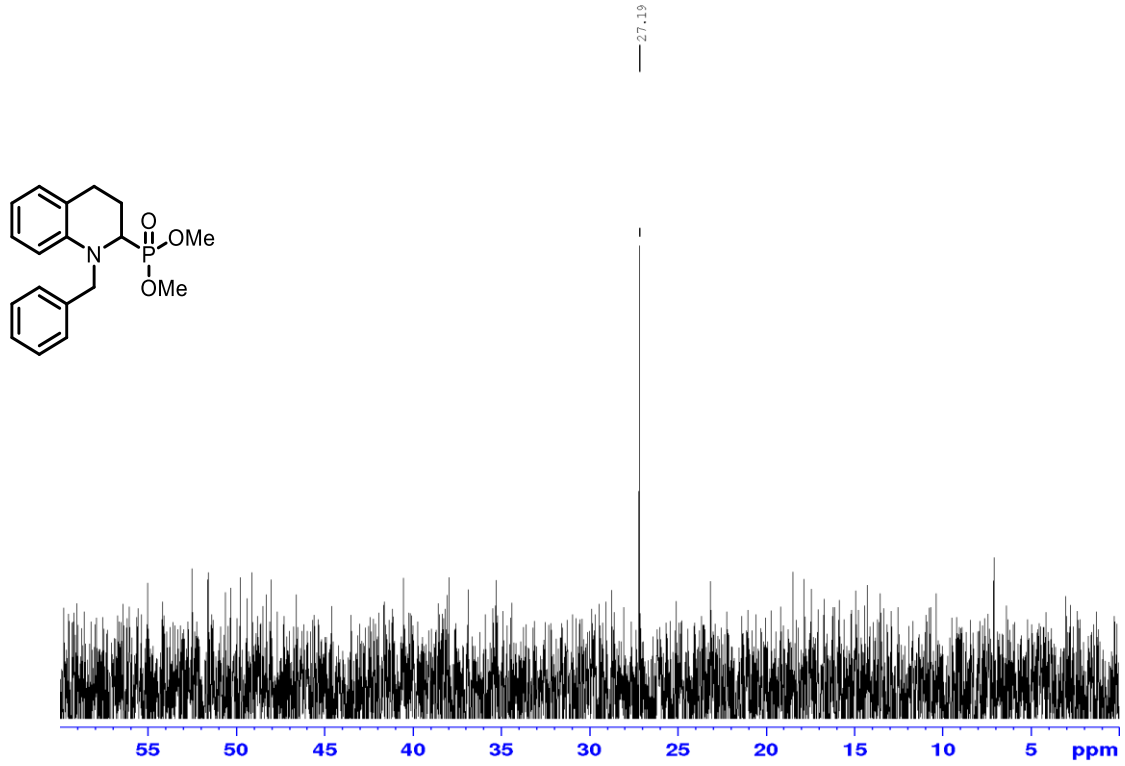
Dimethyl (1-benzyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3aa
(^{1}H NMR, 400 MHz, $CDCl_3$)



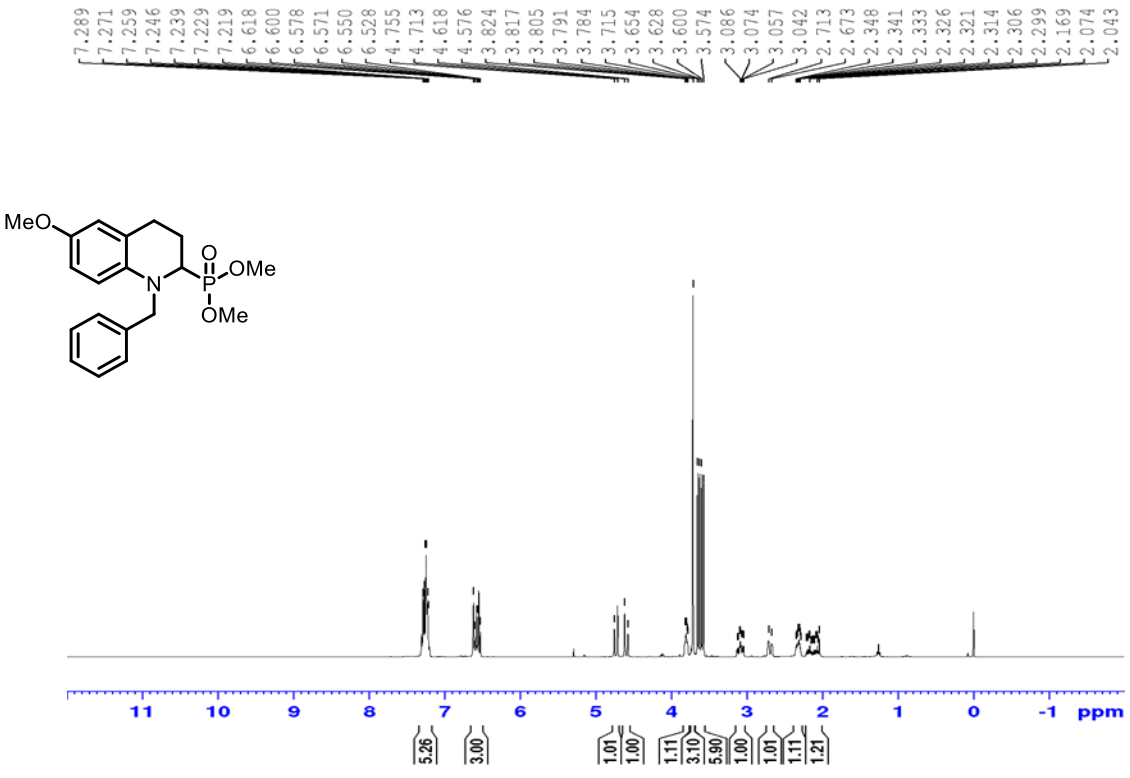
Dimethyl (1-benzyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3aa
(^{13}C NMR, 101 MHz, $CDCl_3$)



Dimethyl (1-benzyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3aa
(^{31}P NMR, 162 MHz, $CDCl_3$)

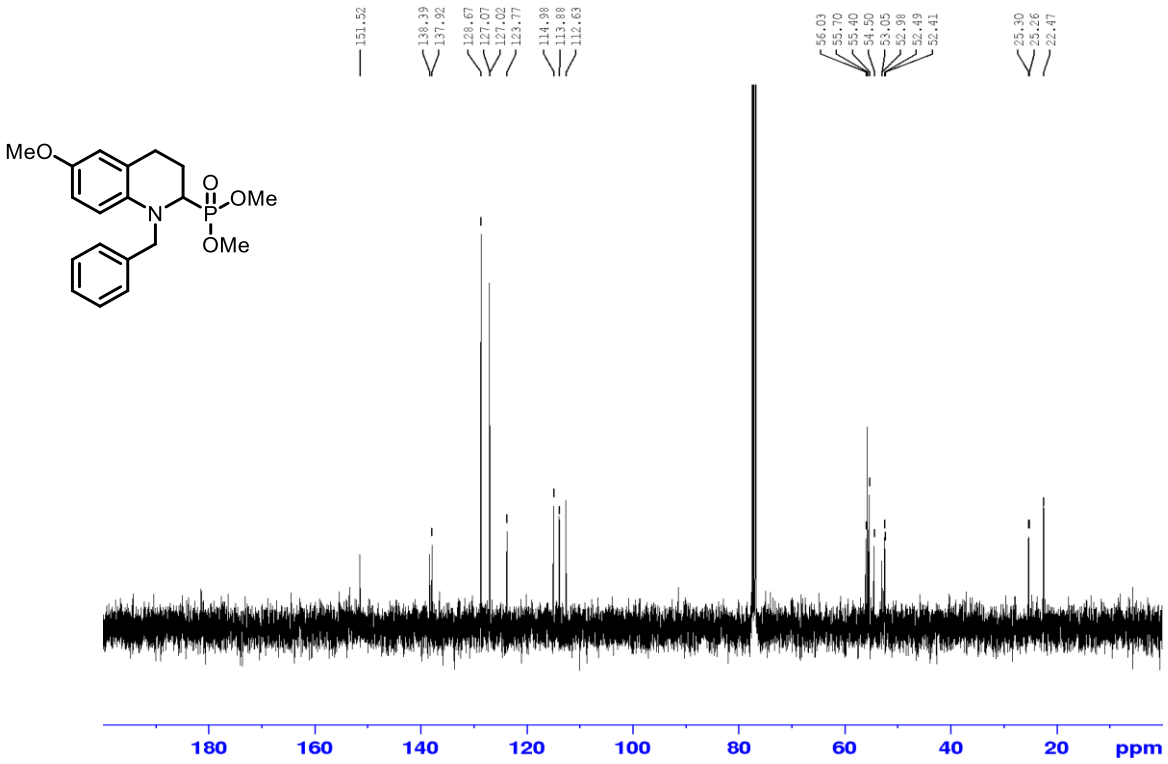


Dimethyl (1-benzyl-6-methoxy-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ba
(^{1}H NMR, 400 MHz, $CDCl_3$)



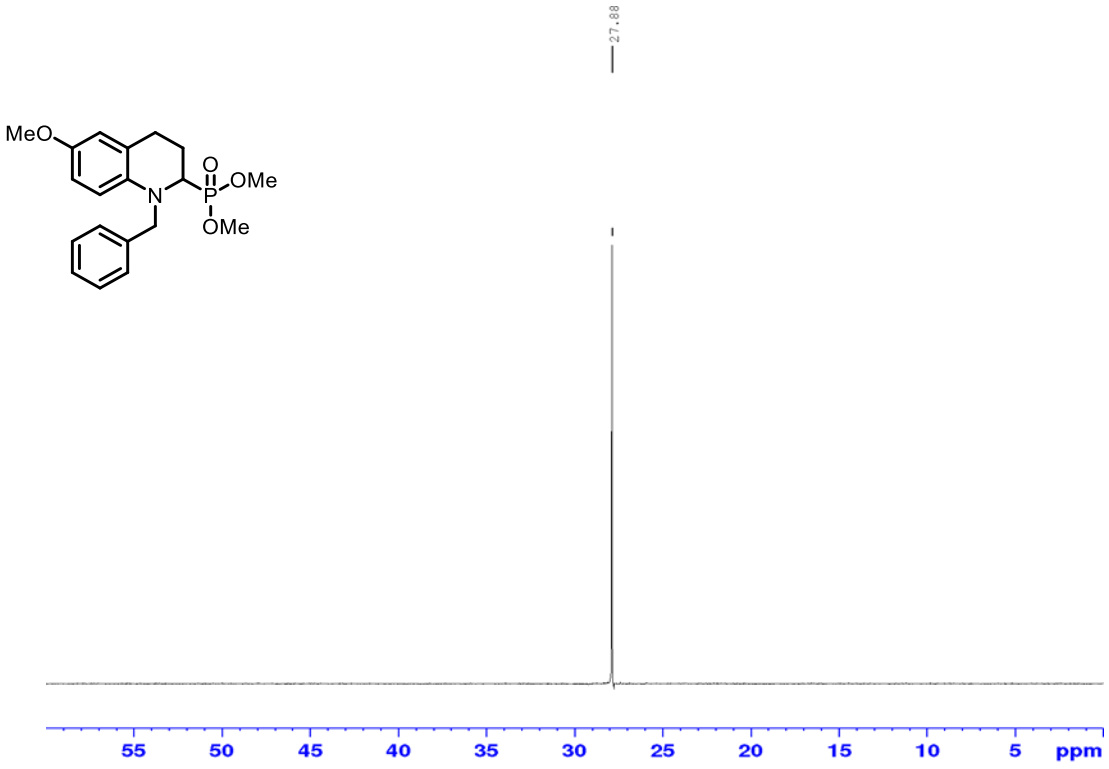
Dimethyl (1-benzyl-6-methoxy-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ba

(^{13}C NMR, 101 MHz, $CDCl_3$)

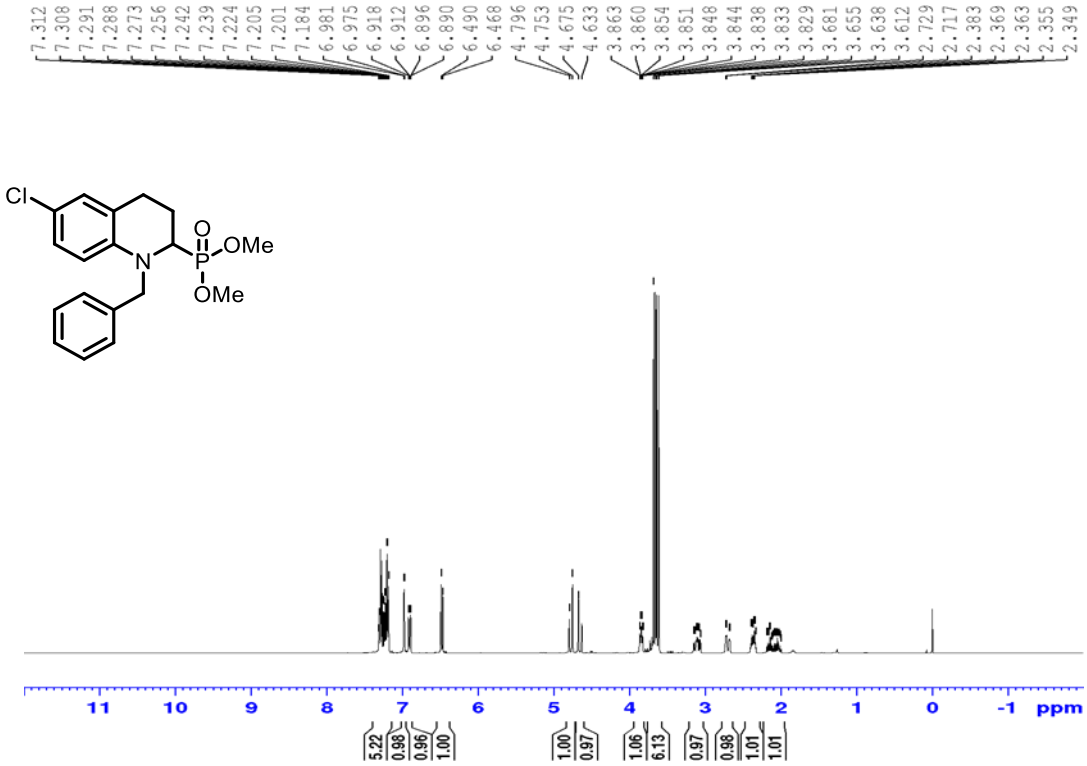


Dimethyl (1-benzyl-6-methoxy-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ba

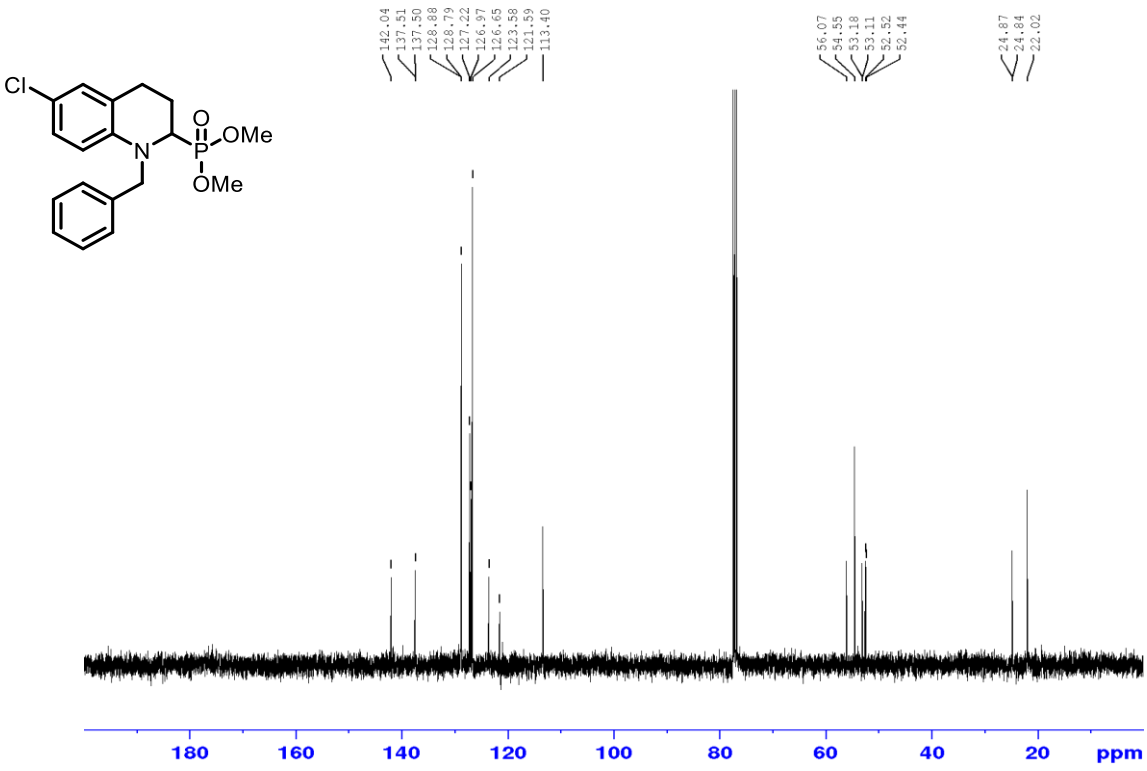
(^{31}P NMR, 162 MHz, $CDCl_3$)



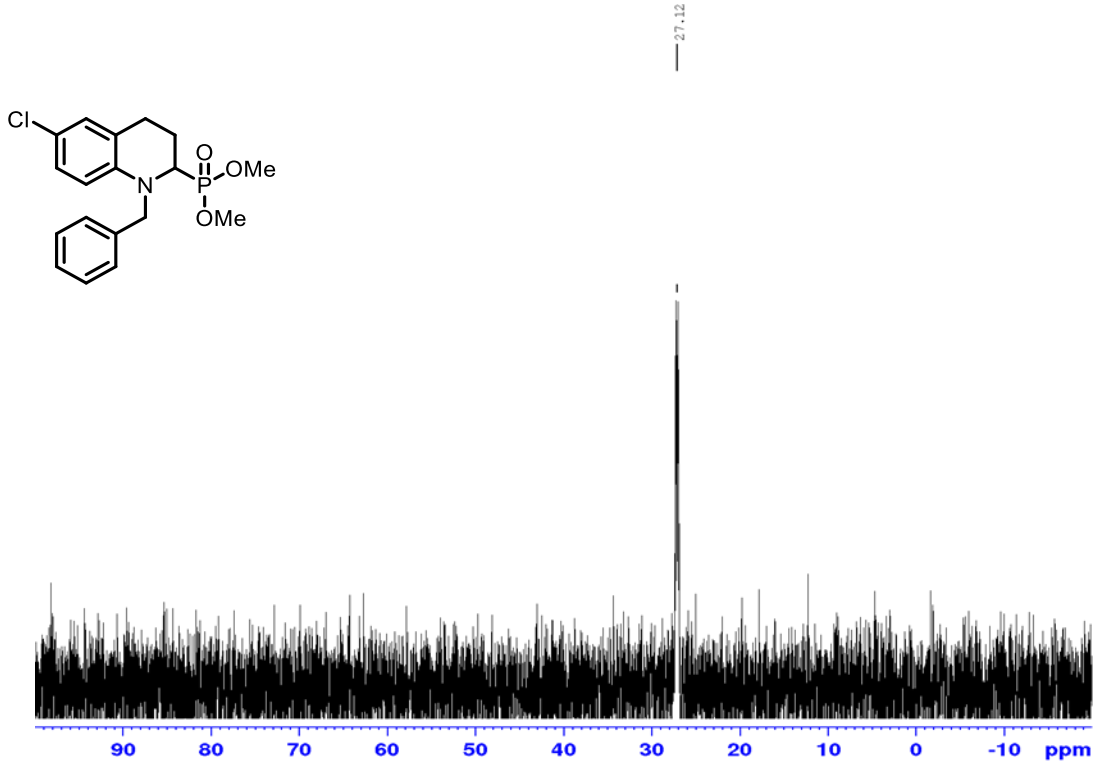
Dimethyl (1-benzyl-6-chloro-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ca (^{1}H NMR, 400 MHz, $CDCl_3$)



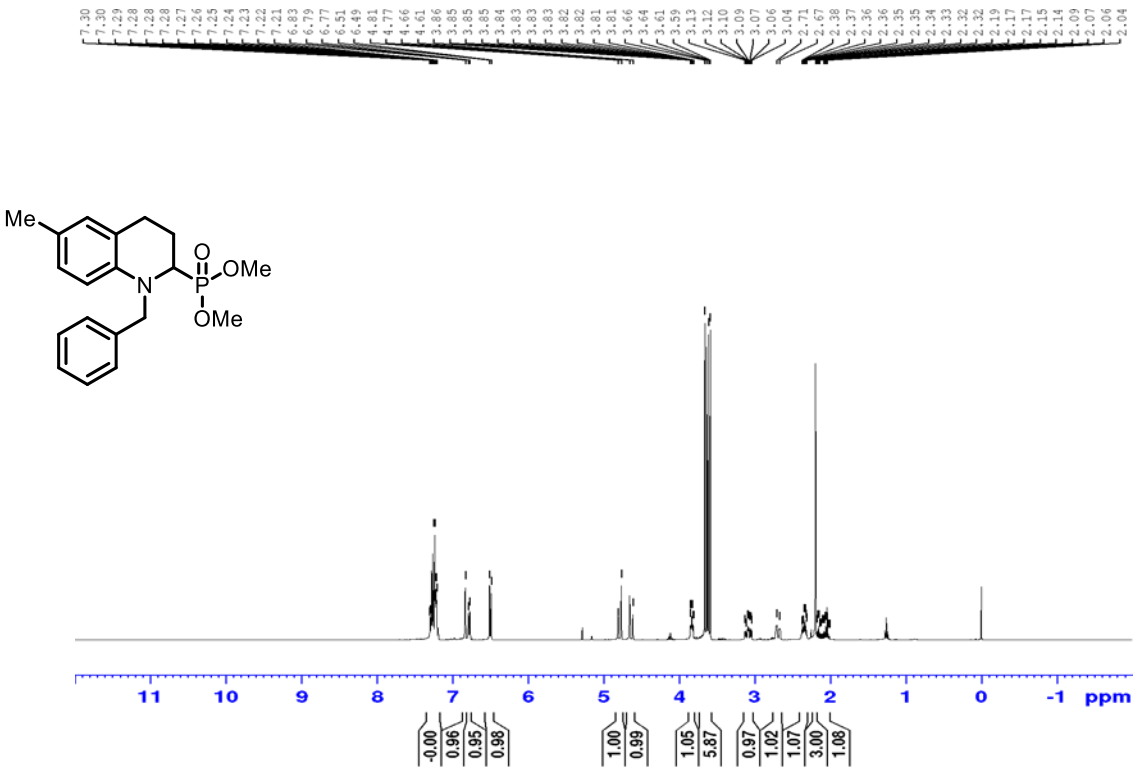
Dimethyl (1-benzyl-6-chloro-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ca (^{13}C NMR, 101 MHz, $CDCl_3$)



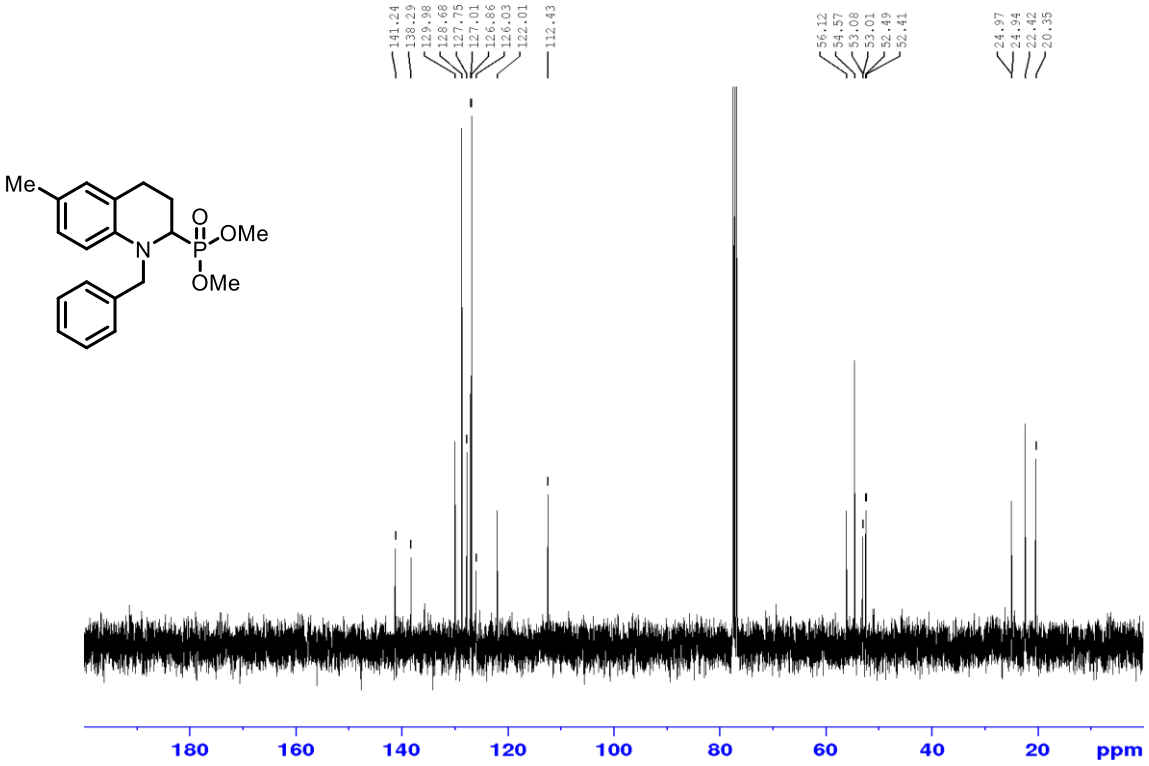
Dimethyl (1-benzyl-6-chloro-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ca (^{31}P NMR, 162 MHz, $CDCl_3$)



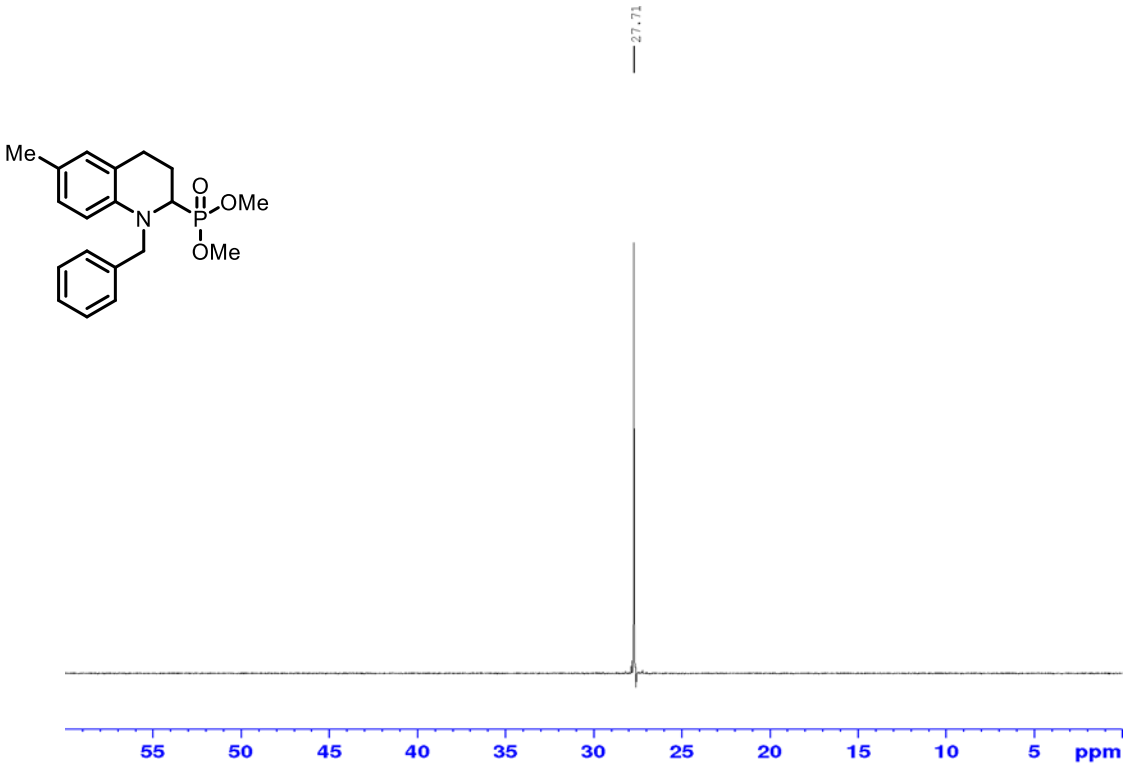
Dimethyl (1-benzyl-6-methyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3da (^{1}H NMR, 400 MHz, $CDCl_3$)



Dimethyl (1-benzyl-6-methyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3da (^{13}C NMR, 101 MHz, $CDCl_3$)

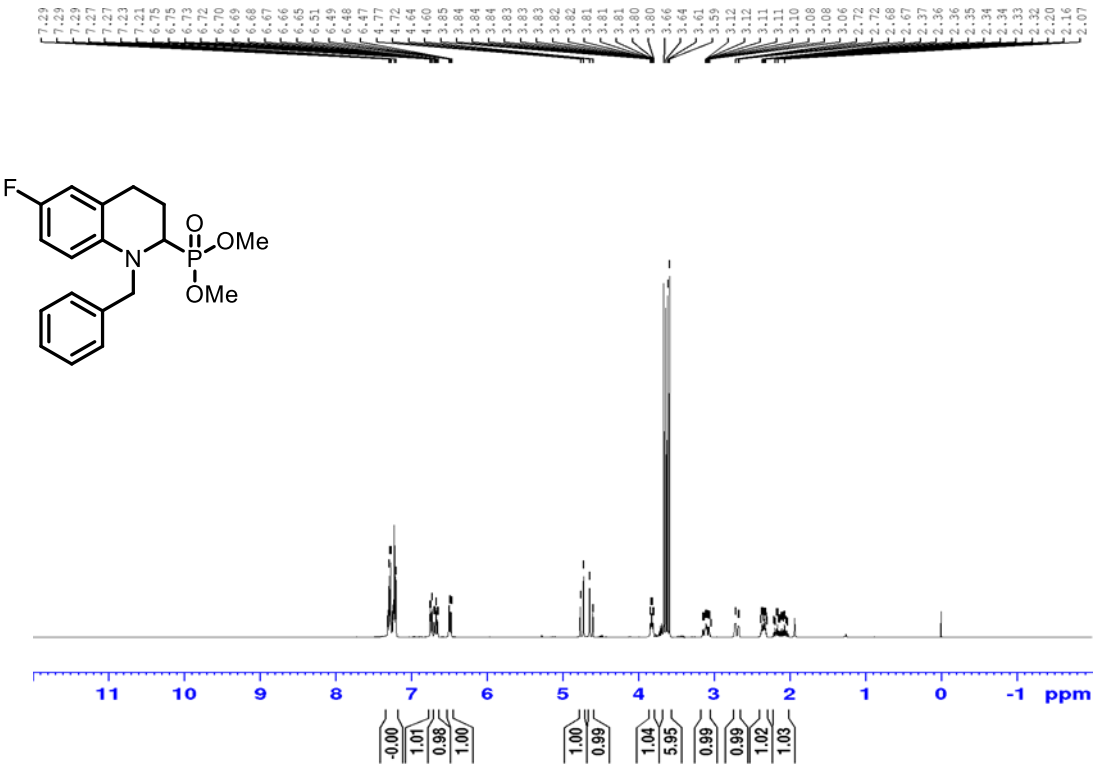


Dimethyl (1-benzyl-6-methyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3da (^{31}P NMR, 162 MHz, $CDCl_3$)



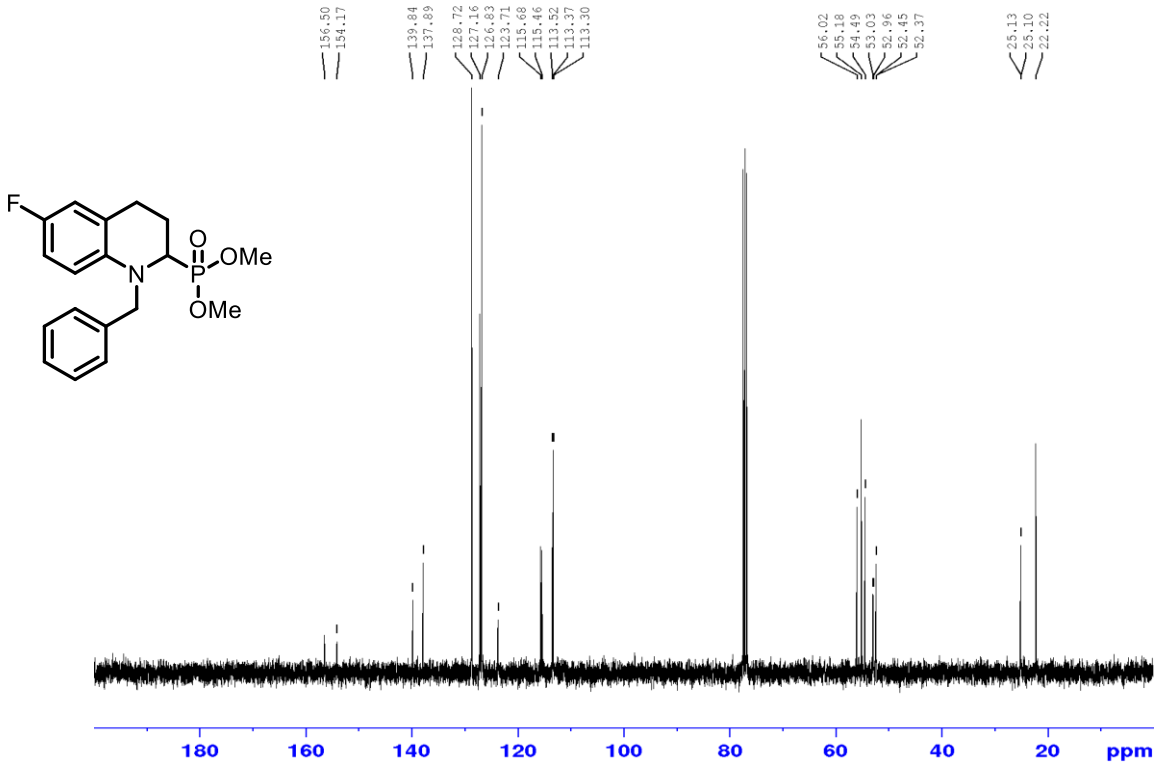
Dimethyl (1-benzyl-6-fluoro-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ea

(^{1}H NMR, 400 MHz, $CDCl_3$)

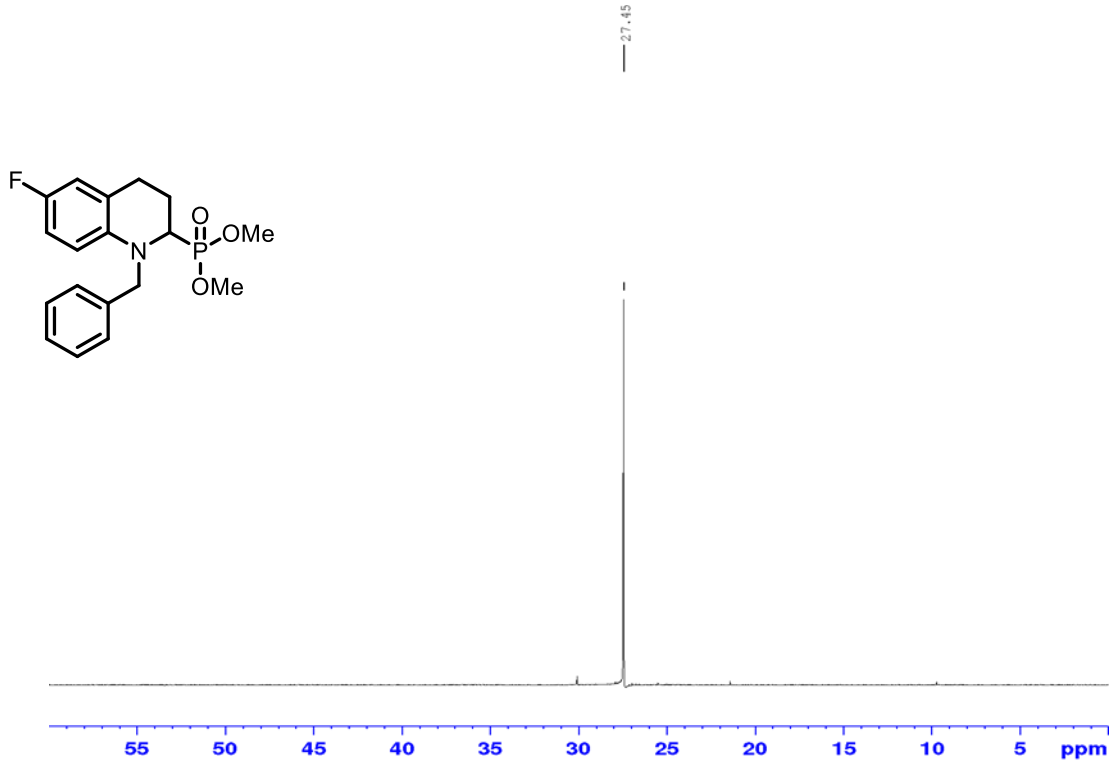


Dimethyl (1-benzyl-6-fluoro-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ea

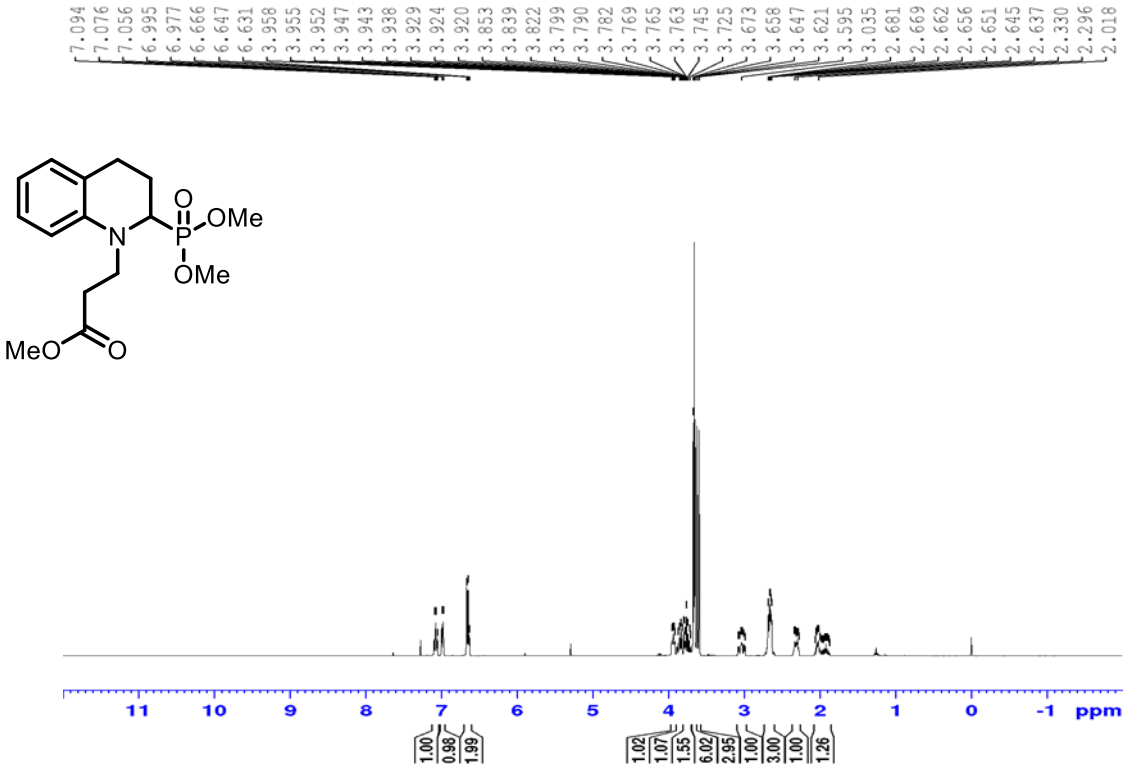
(^{13}C NMR, 101 MHz, $CDCl_3$)



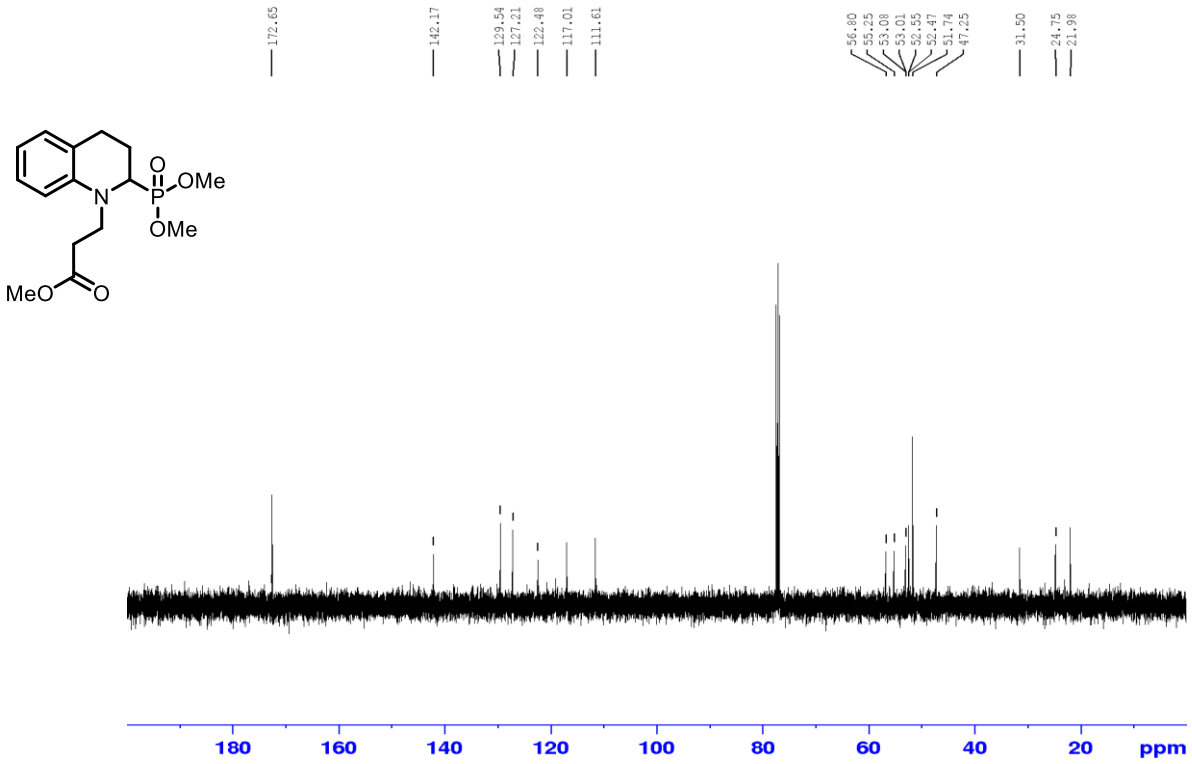
Dimethyl (1-benzyl-6-fluoro-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ea (^{31}P NMR, 162 MHz, $CDCl_3$)



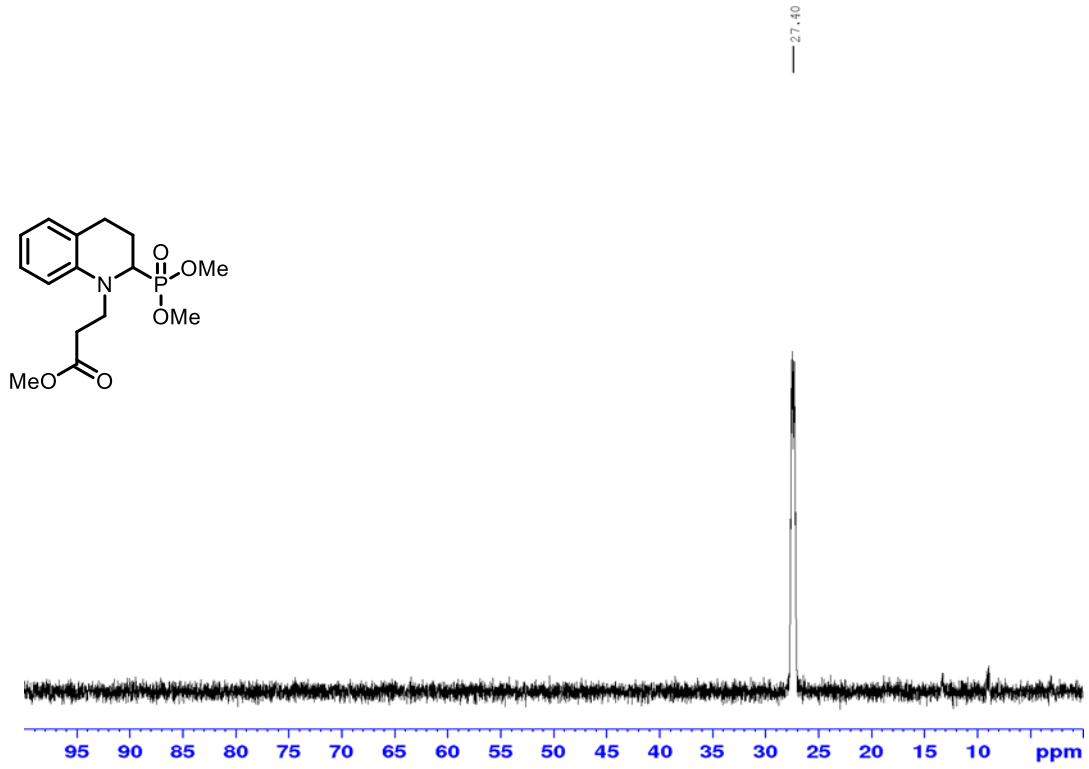
Methyl 3-(2-(dimethoxyphosphoryl)-3,4-dihydroquinolin-1(2H)-yl) propanoate 3fa (^{1}H NMR, 400 MHz, $CDCl_3$)



Methyl 3-(2-(dimethoxyphosphoryl)-3,4-dihydroquinolin-1(2H)-yl) propanoate 3fa (^{13}C NMR, 101 MHz, $CDCl_3$)

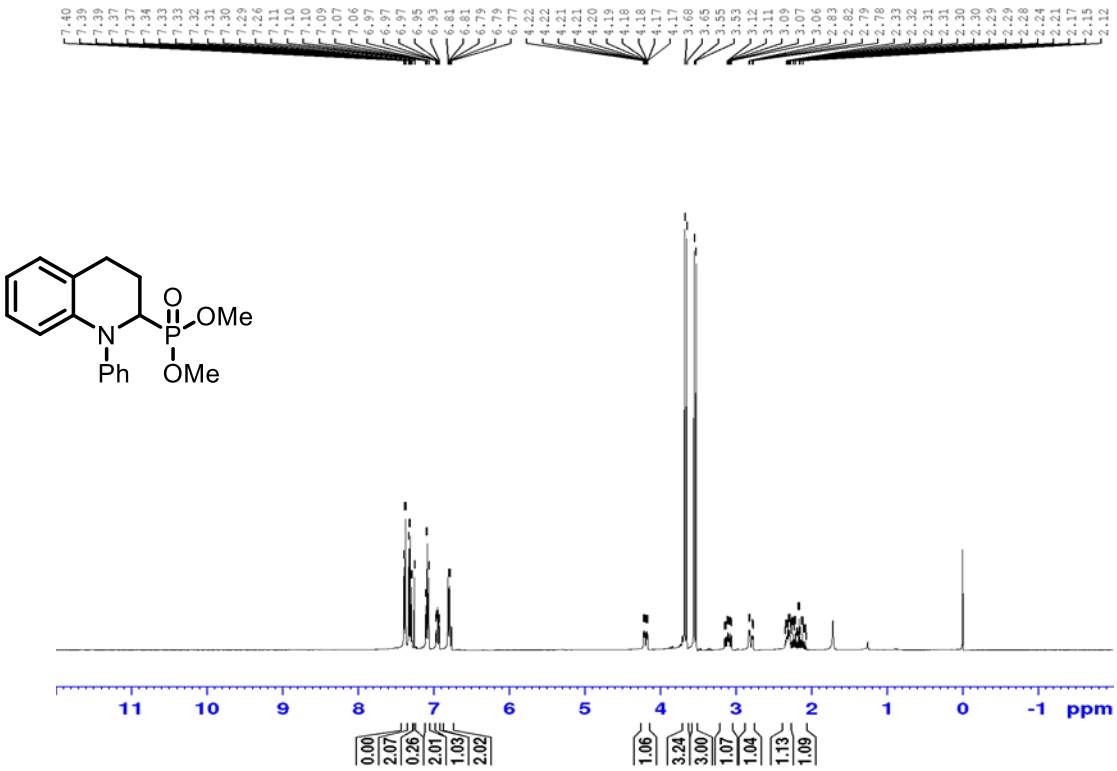


Methyl 3-(2-(dimethoxyphosphoryl)-3,4-dihydroquinolin-1(2H)-yl) propanoate 3fa (^{31}P NMR, 162 MHz, $CDCl_3$)



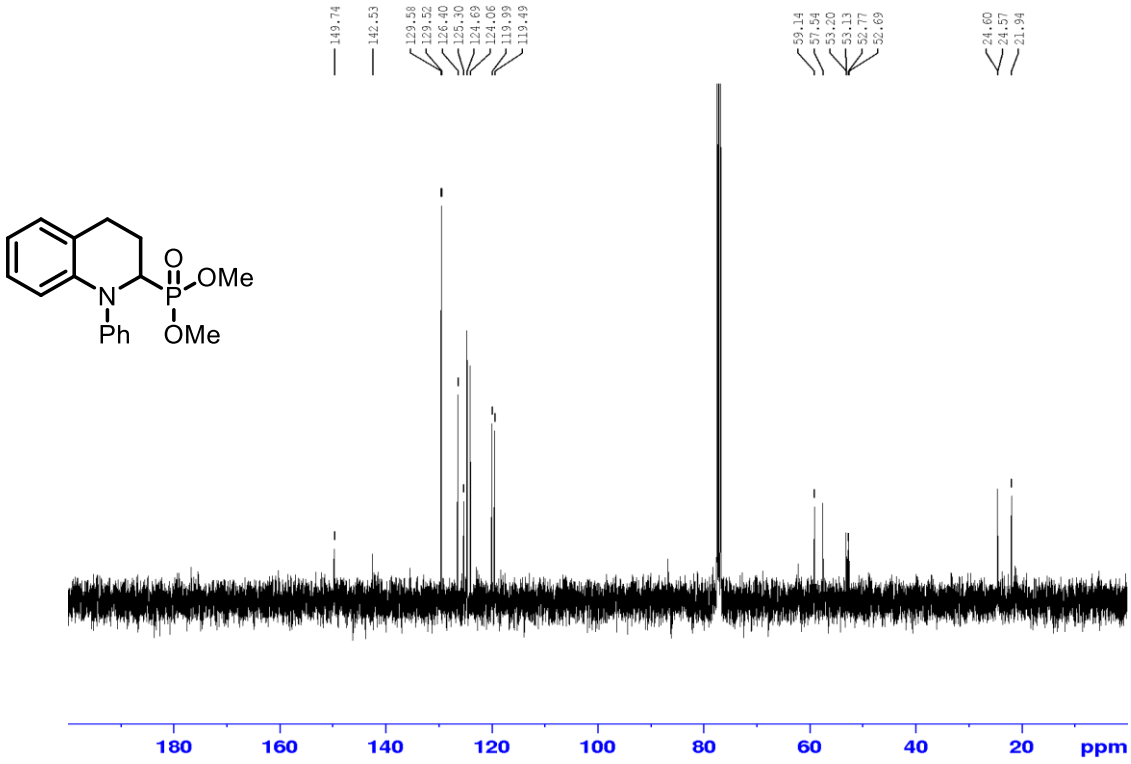
Dimethyl (1-phenyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ga

(^{1}H NMR, 400 MHz, $CDCl_3$)

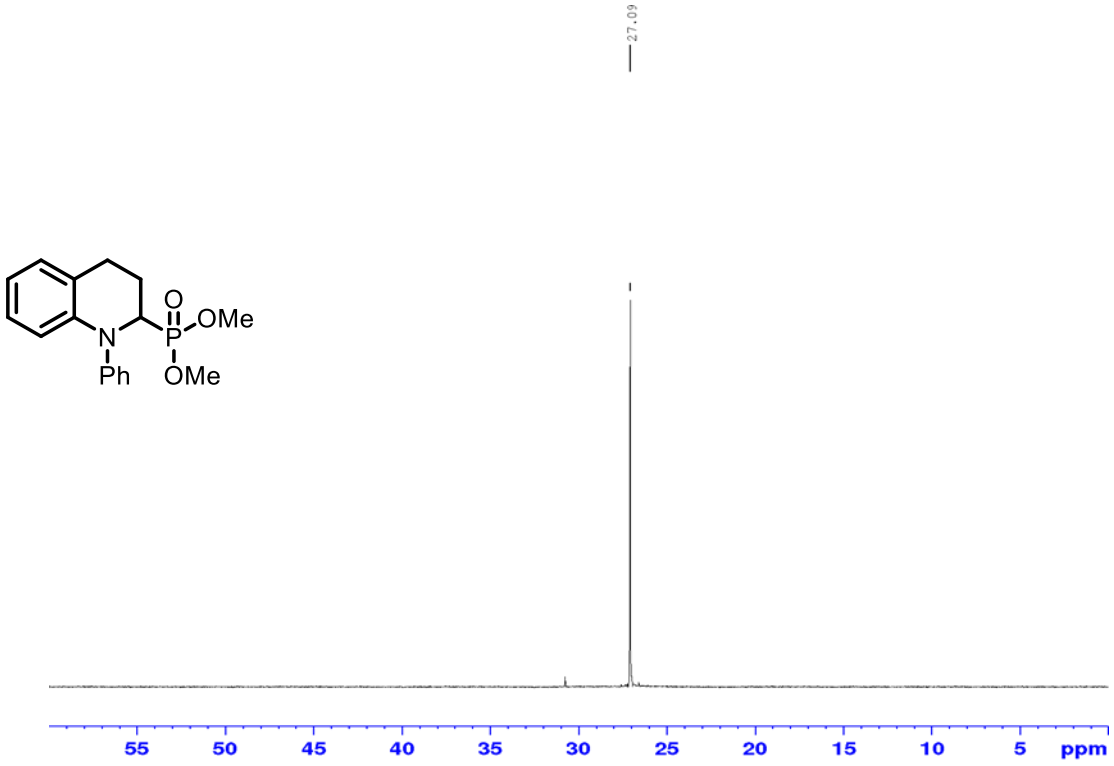


Dimethyl (1-phenyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ga

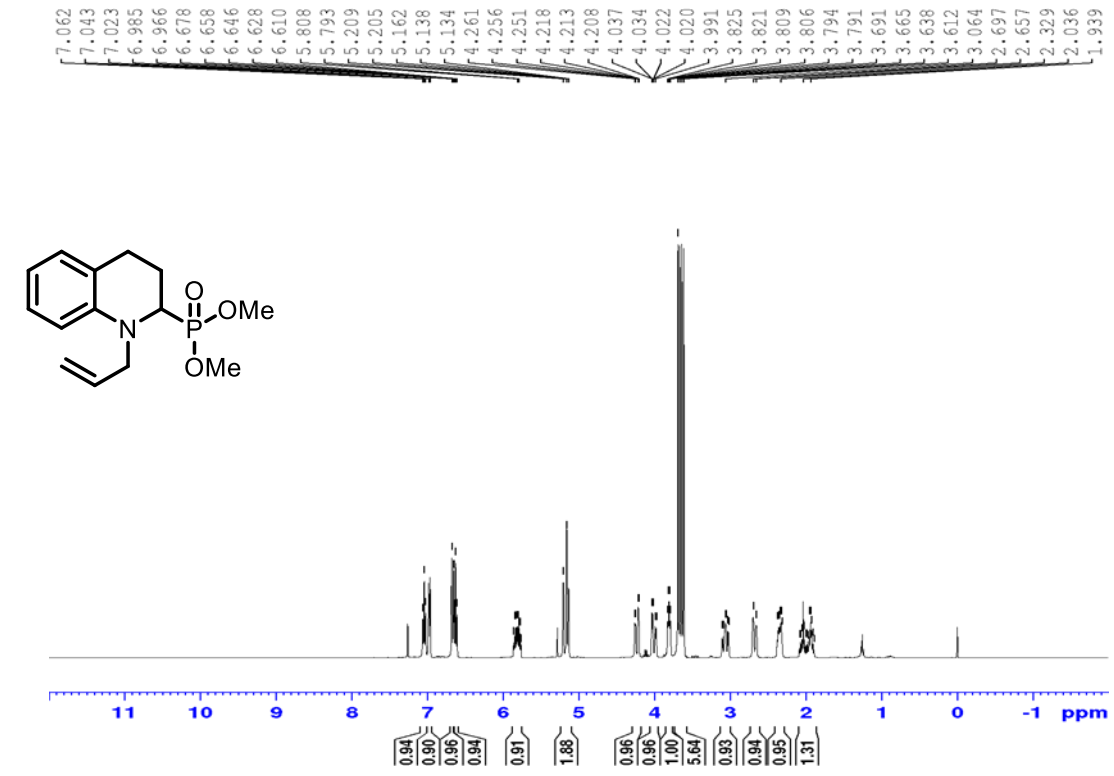
(^{13}C NMR, 101 MHz, $CDCl_3$)



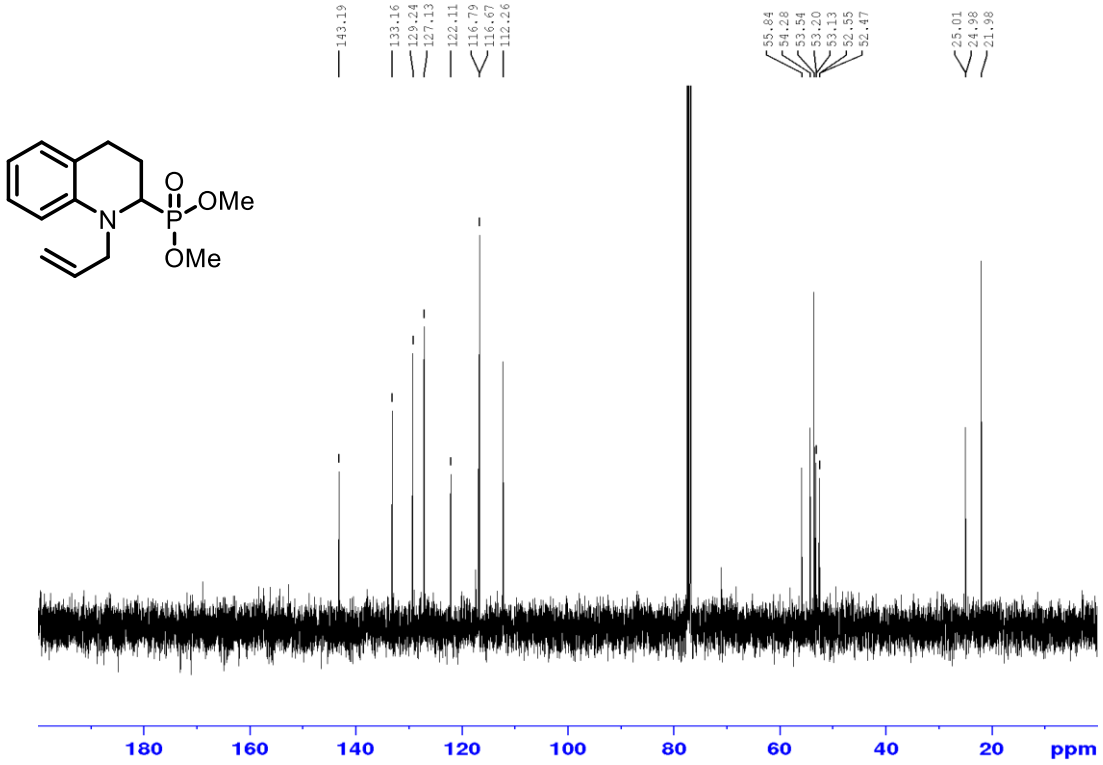
Dimethyl (1-phenyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ga
(^{31}P NMR, 162 MHz, $CDCl_3$)



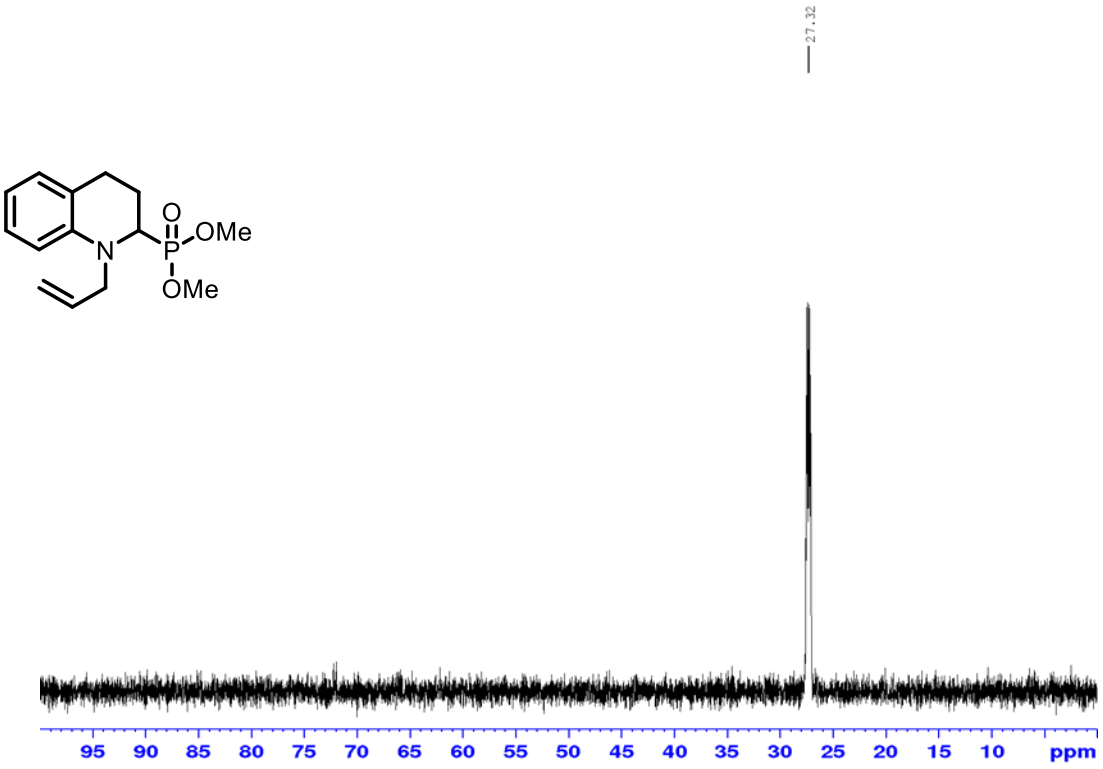
Dimethyl (1-allyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ha
(^{1}H NMR, 400 MHz, $CDCl_3$)



Dimethyl (1-allyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ha
(^{13}C NMR, 101 MHz, $CDCl_3$)

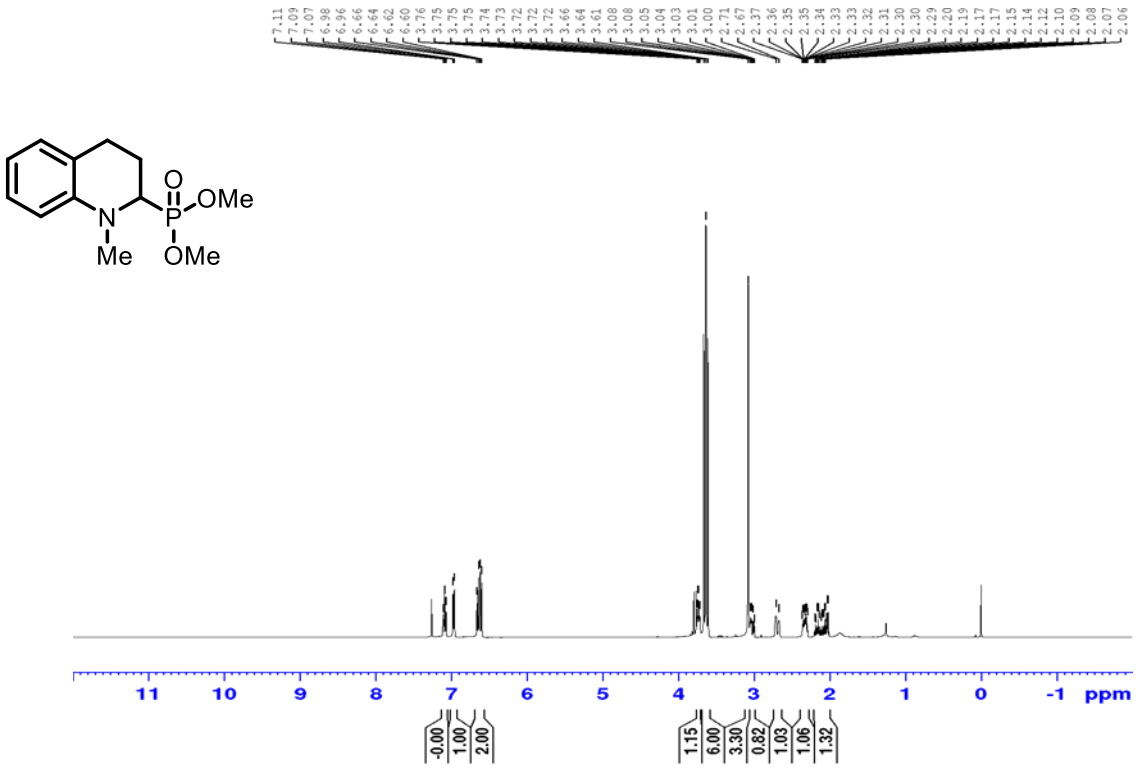


Dimethyl (1-allyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ha
(^{31}P NMR, 162 MHz, $CDCl_3$)



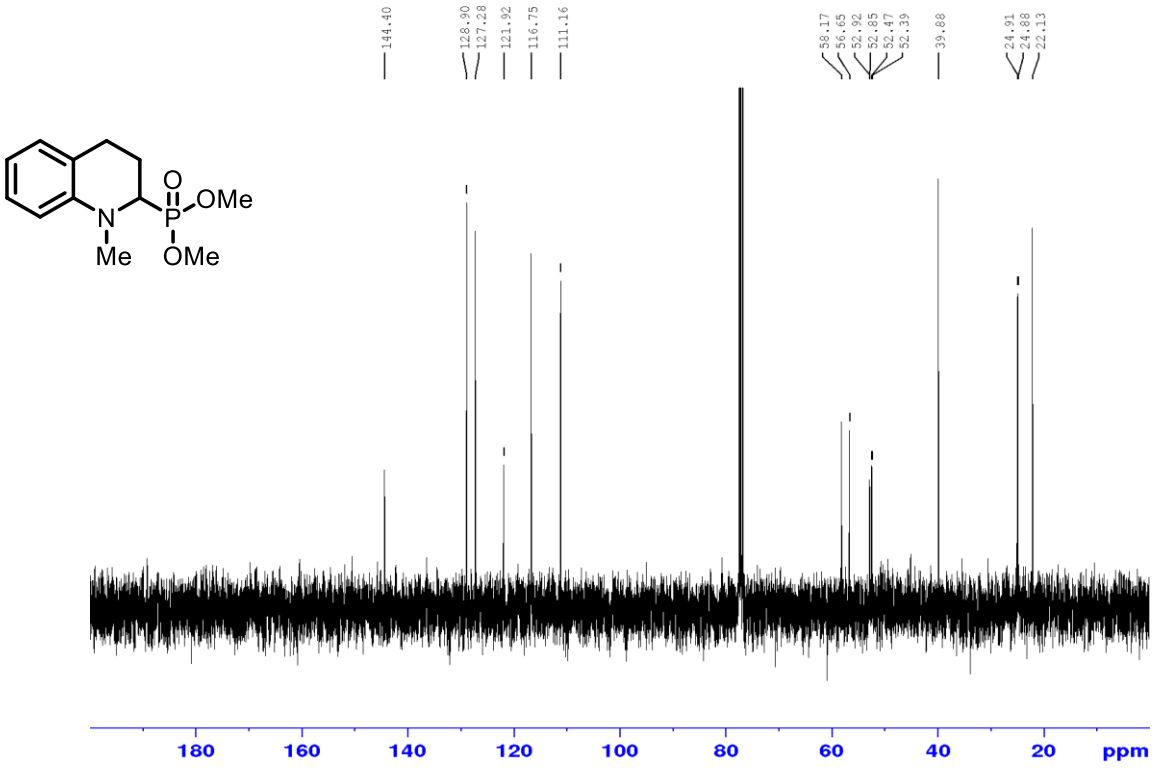
Dimethyl (1-methyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ia

(^{1}H NMR, 400 MHz, $CDCl_3$)

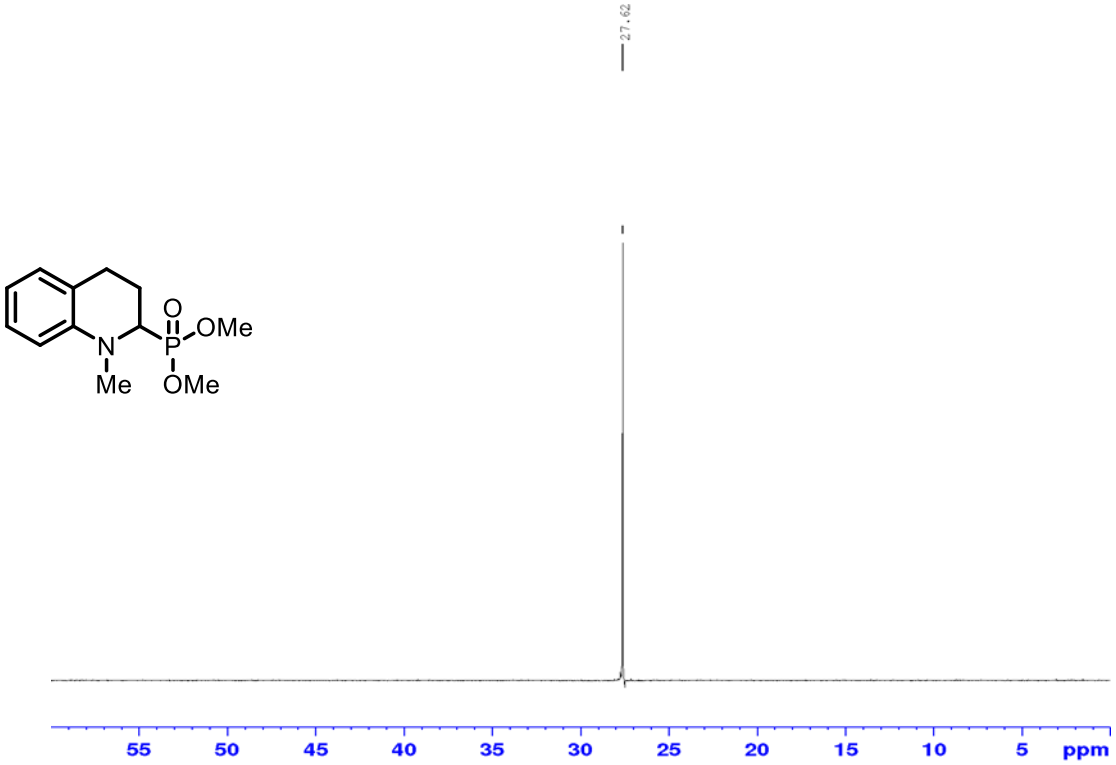


Dimethyl (1-methyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ia

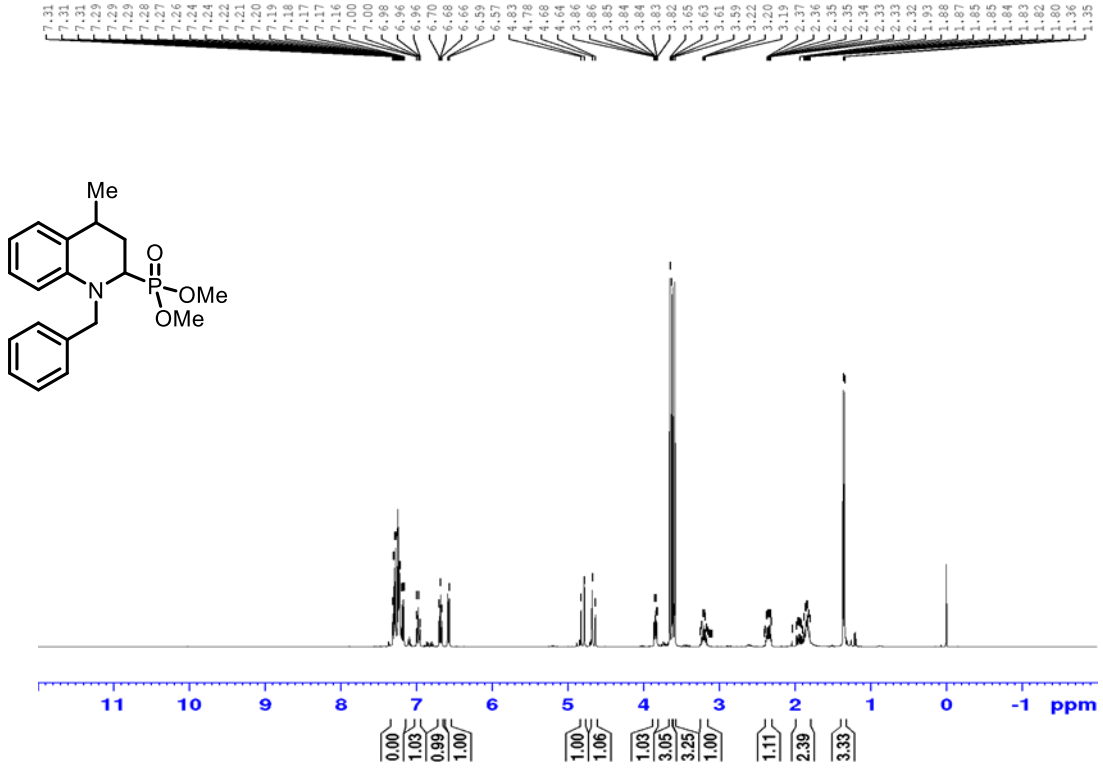
(^{13}C NMR, 101 MHz, $CDCl_3$)



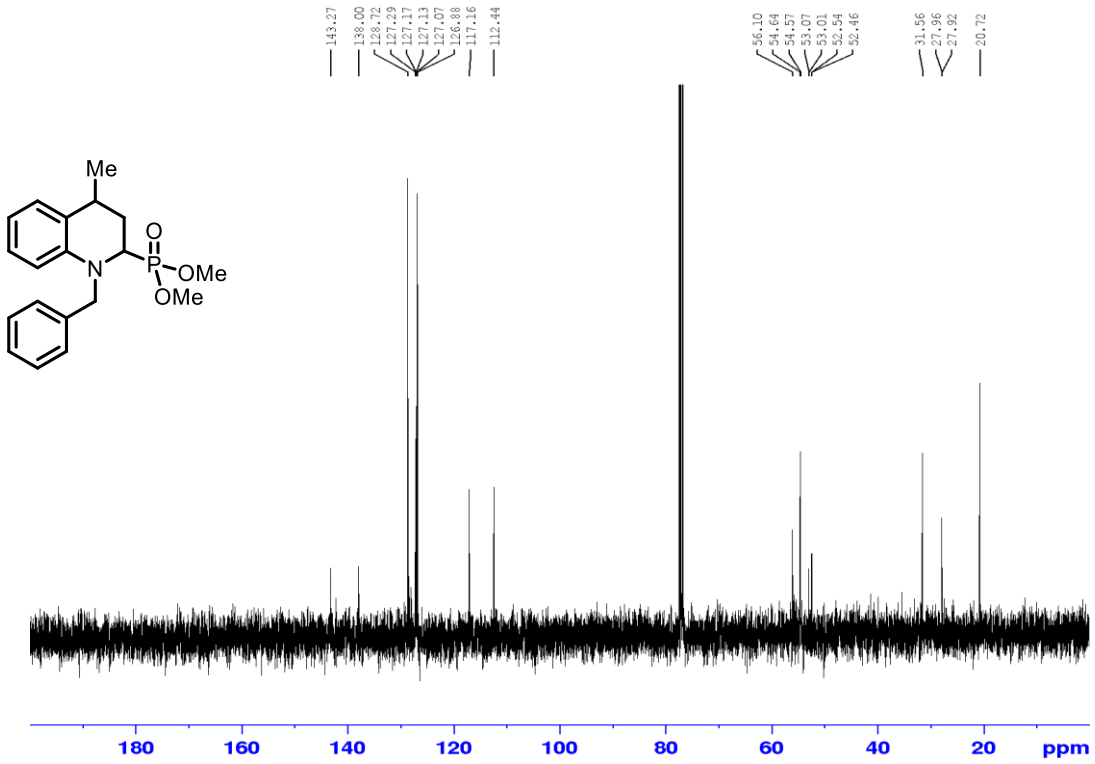
Dimethyl (1-methyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ia
(^{31}P NMR, 162 MHz, $CDCl_3$)



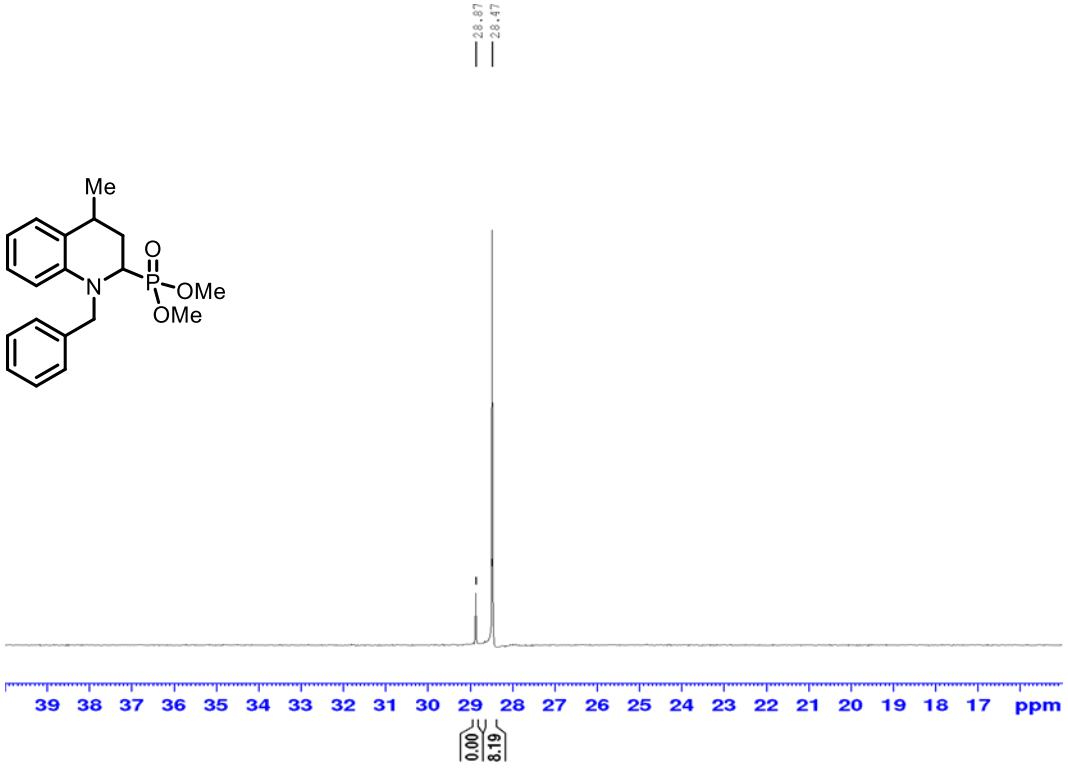
Dimethyl (1-benzyl-4-methyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ja
(^{1}H NMR, 400 MHz, $CDCl_3$)



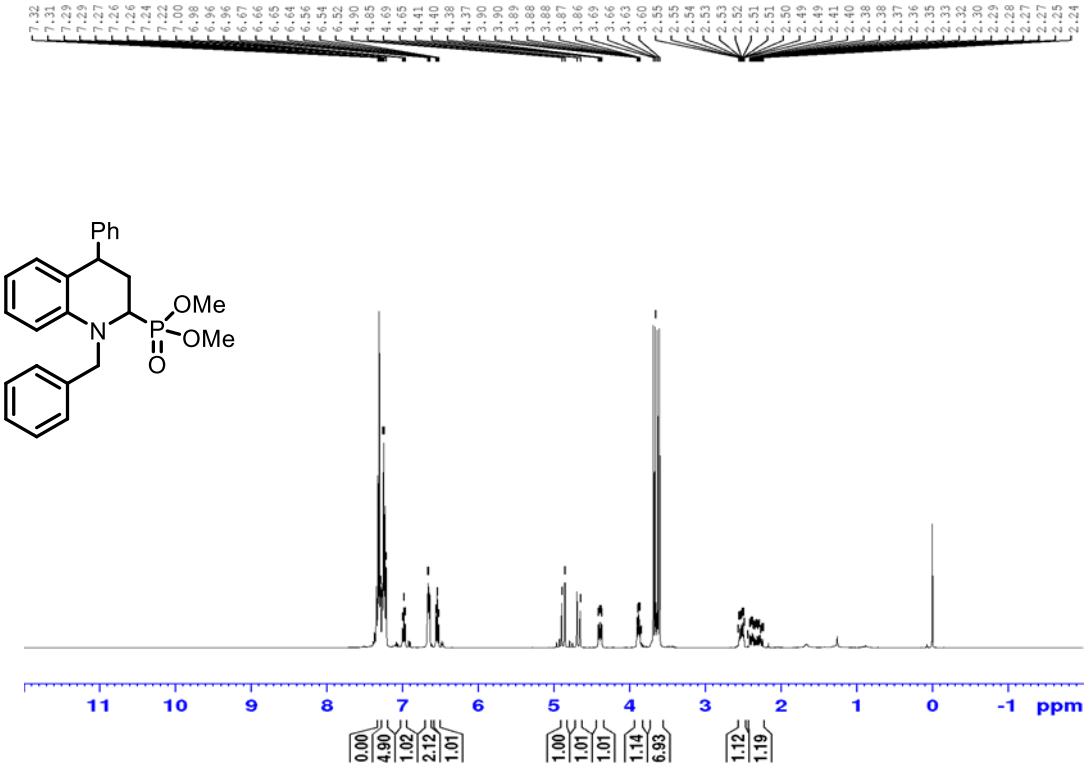
Dimethyl (1-benzyl-4-methyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ja (^{13}C NMR, 101 MHz, $CDCl_3$)



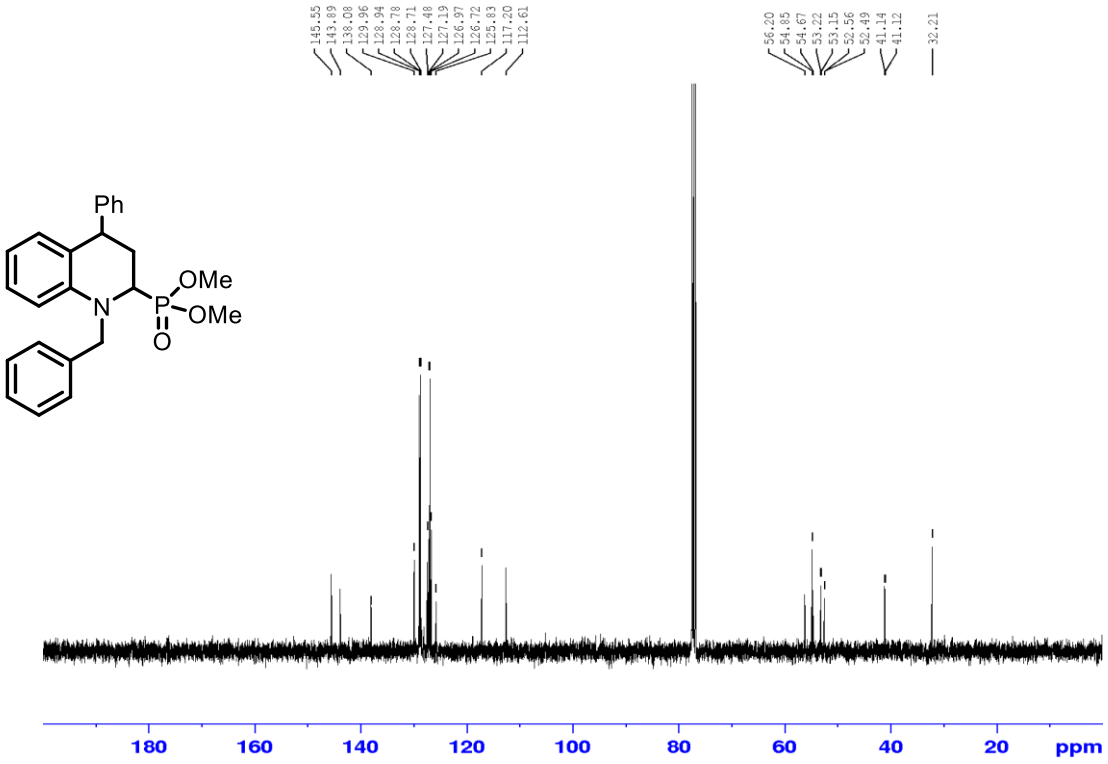
Dimethyl (1-benzyl-4-methyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ja (^{31}P NMR, 162 MHz, $CDCl_3$)



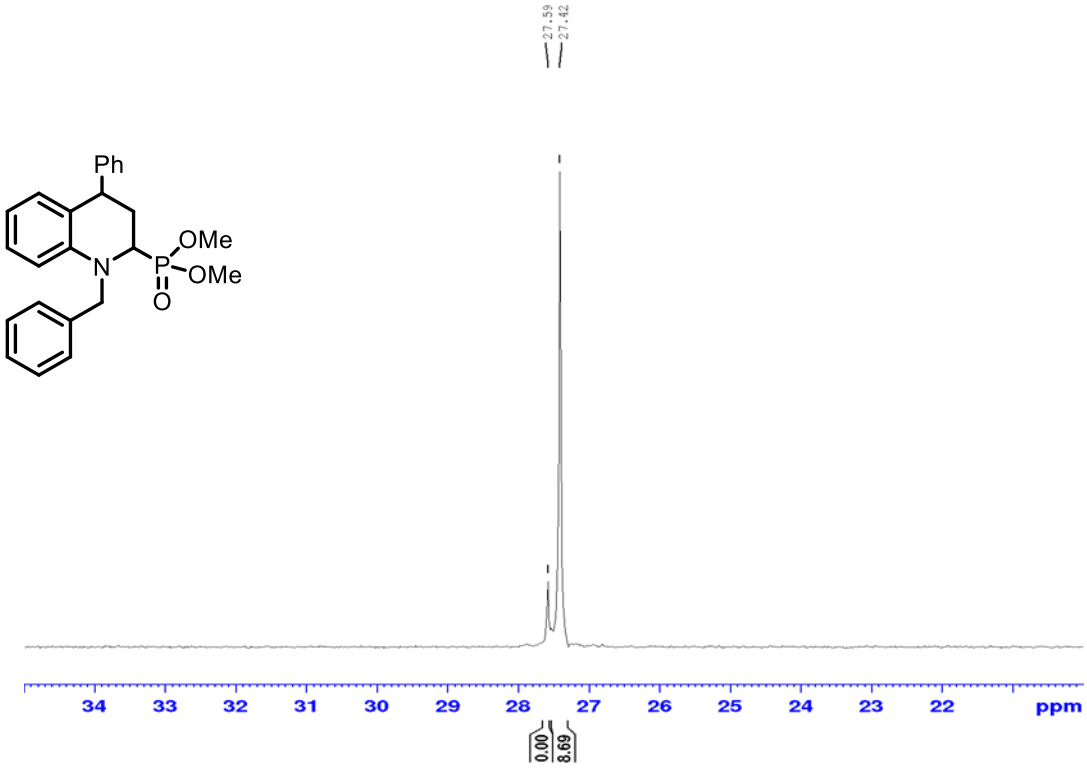
Dimethyl (1-benzyl-4-phenyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ka
(^{1}H NMR, 400 MHz, $CDCl_3$)



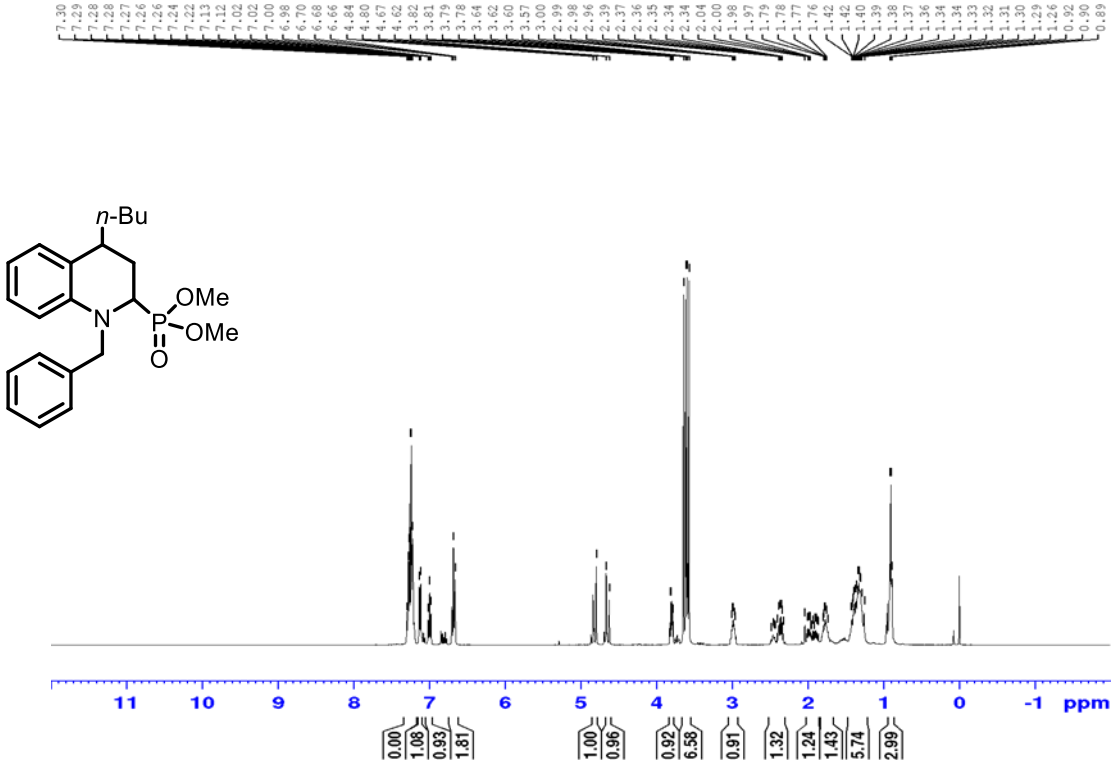
Dimethyl (1-benzyl-4-phenyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ka
(^{13}C NMR, 101 MHz, $CDCl_3$)



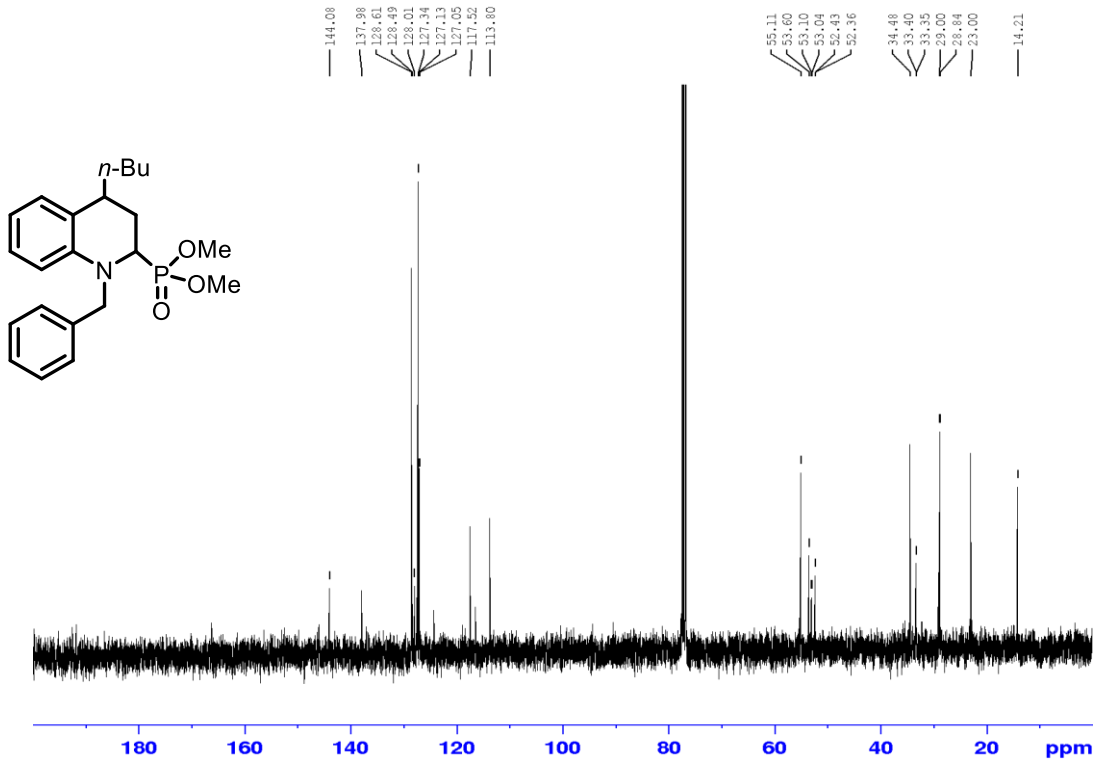
Dimethyl (1-benzyl-4-phenyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ka
(^{31}P NMR, 162 MHz, $CDCl_3$)



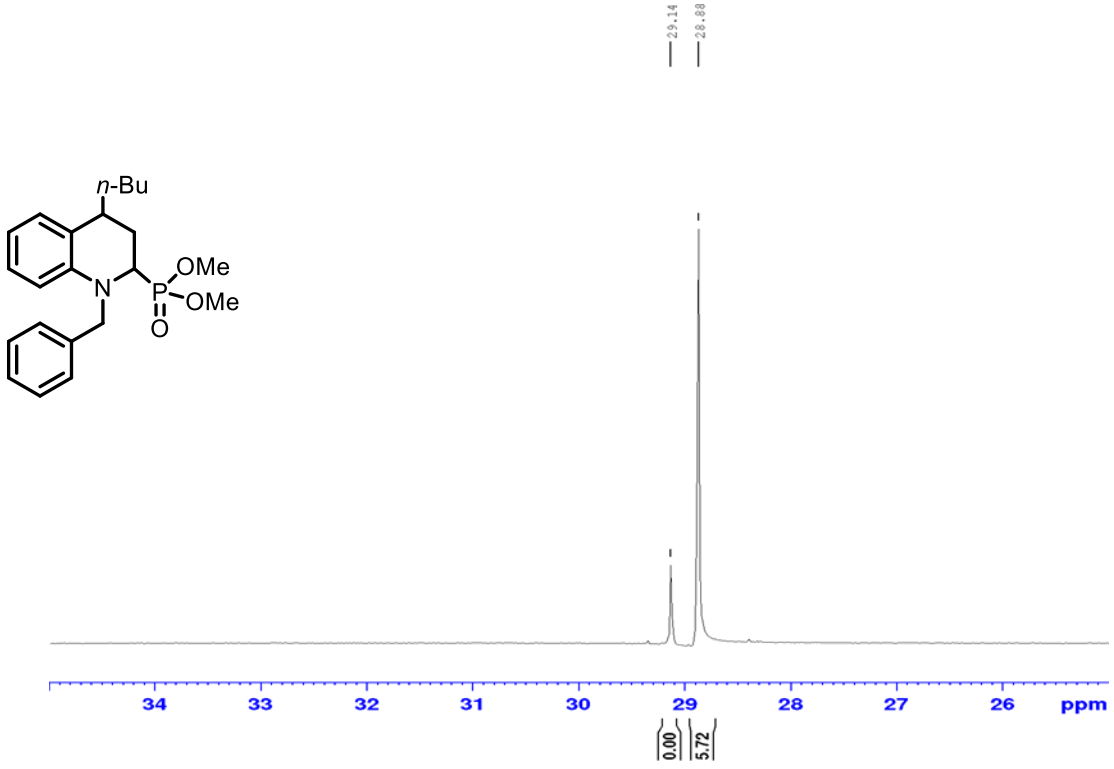
Dimethyl (1-benzyl-4-butyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3la
(^{1}H NMR, 400 MHz, $CDCl_3$)



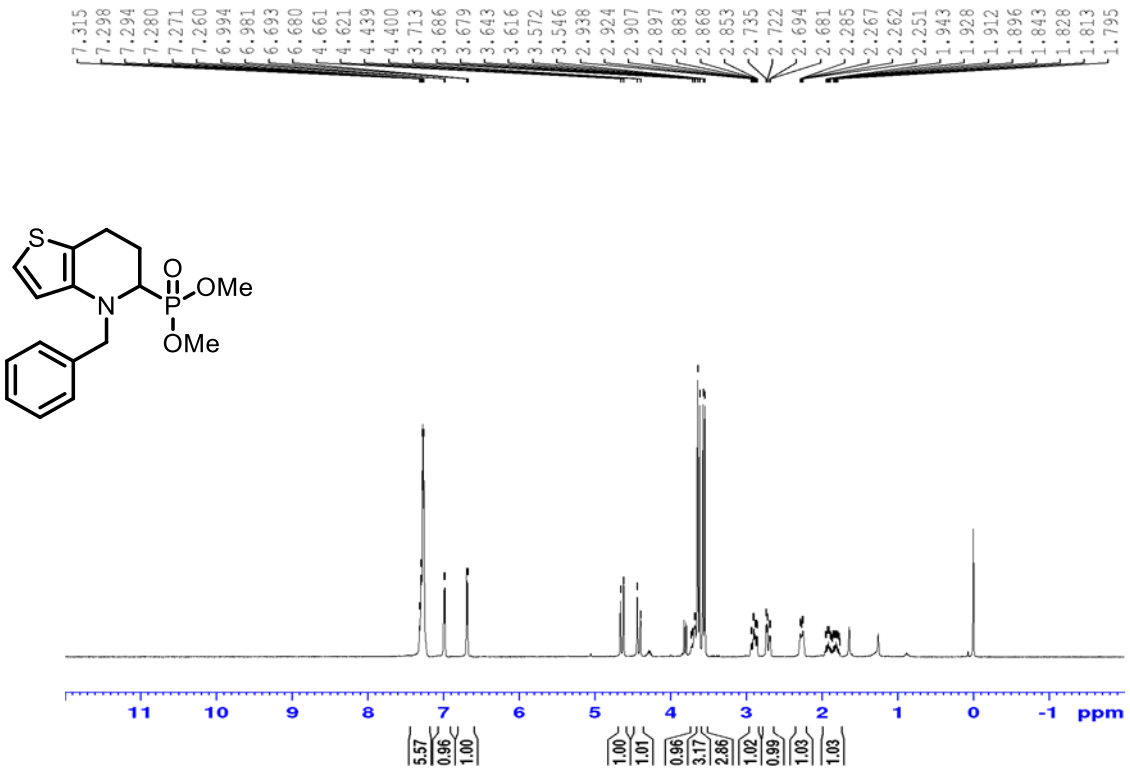
Dimethyl (1-benzyl-4-butyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3la (^{13}C NMR, 101 MHz, $CDCl_3$)



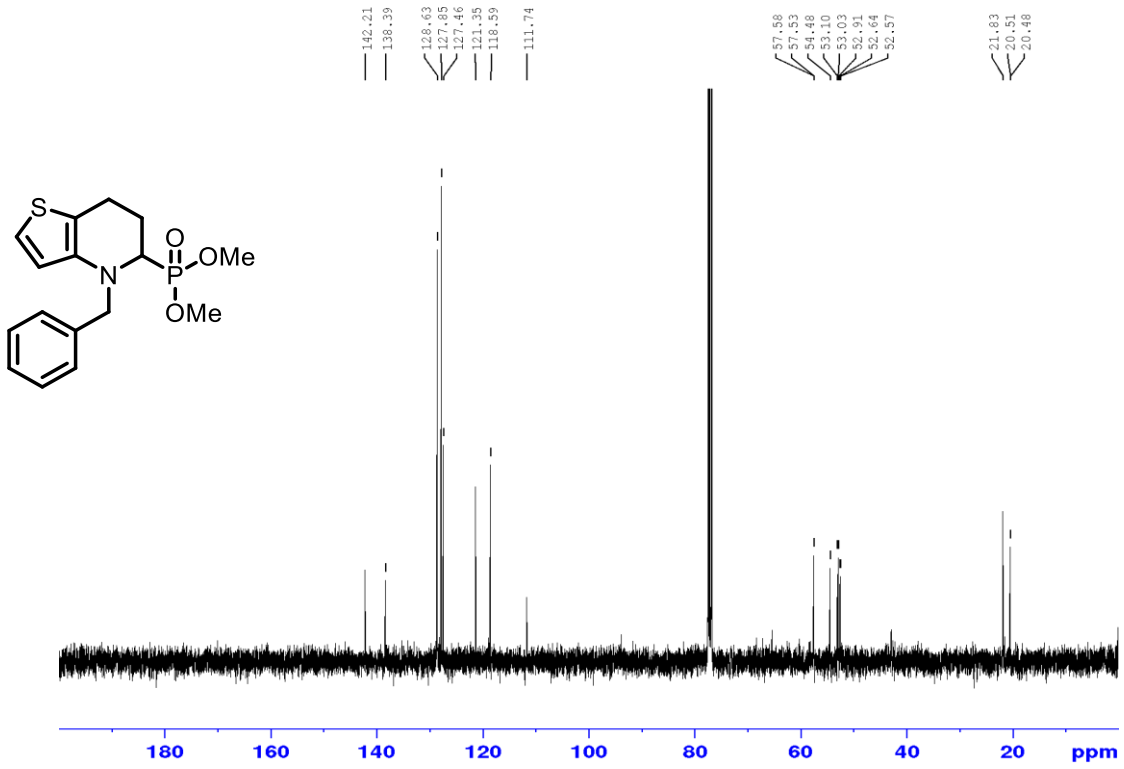
Dimethyl (1-benzyl-4-butyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3la (^{31}P NMR, 162 MHz, $CDCl_3$)



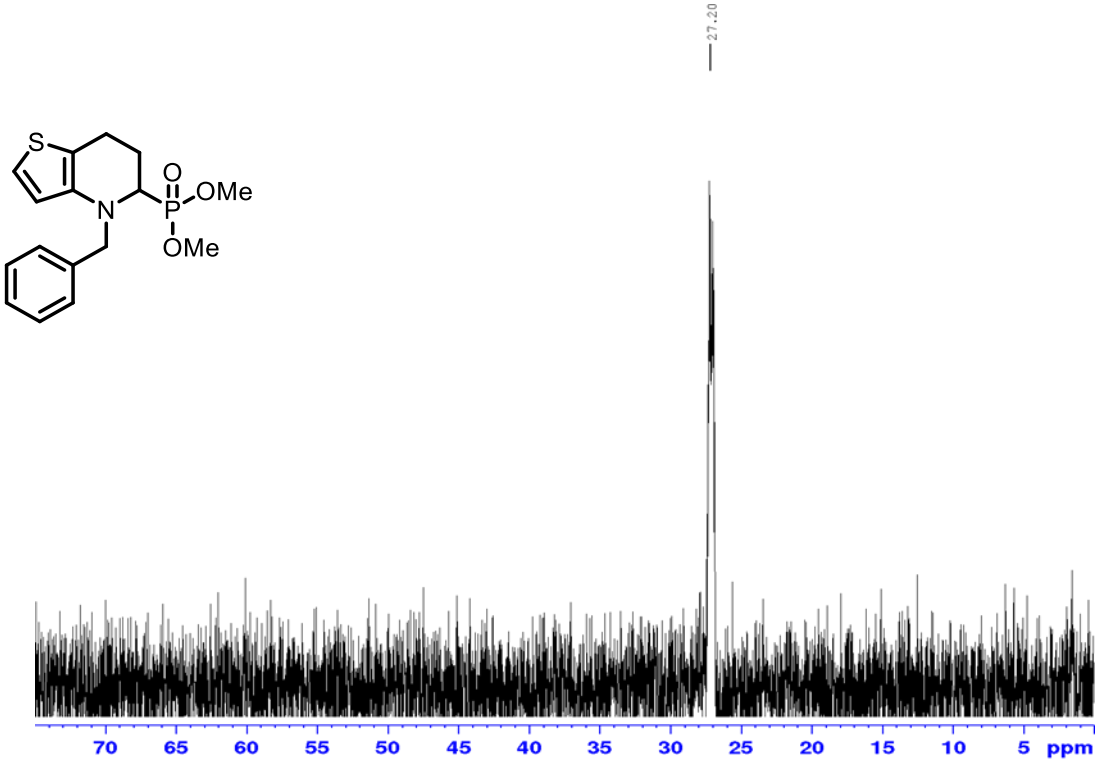
Dimethyl (4-benzyl-4,5,6,7-tetrahydrothieno[3,2-b]pyridin-5-yl)phosphonate 3ma
(^{1}H NMR, 400 MHz, $CDCl_3$)



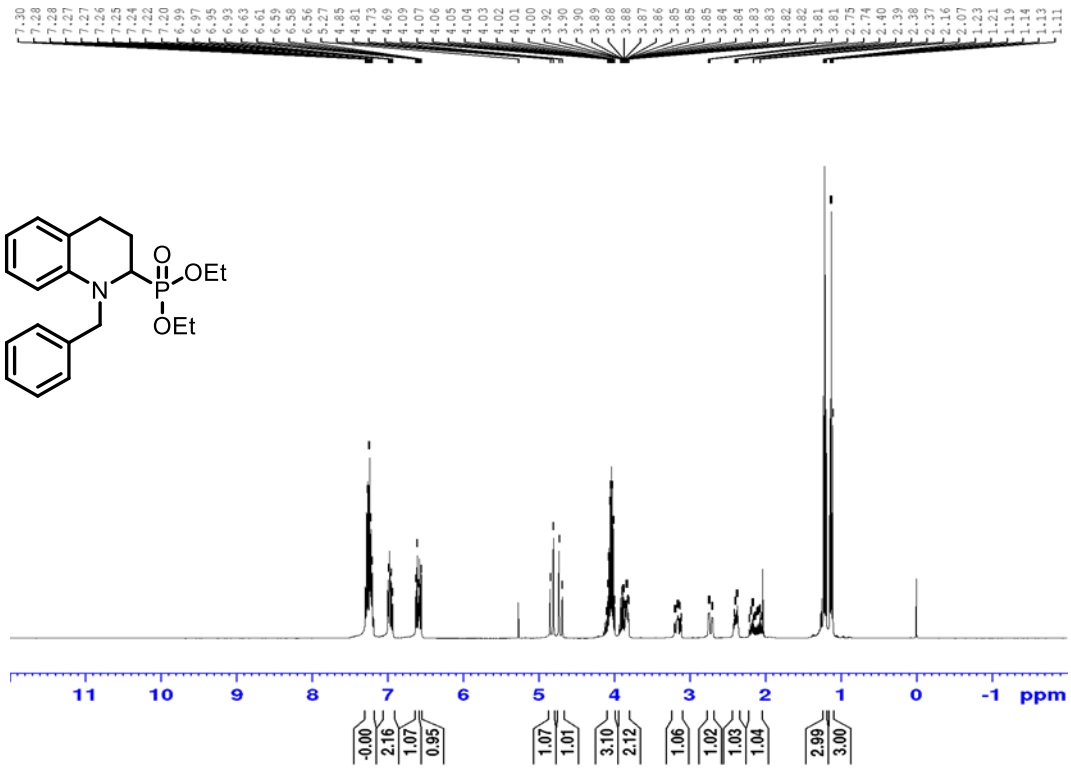
Dimethyl (4-benzyl-4,5,6,7-tetrahydrothieno[3,2-b]pyridin-5-yl)phosphonate 3ma
(^{13}C NMR, 101 MHz, $CDCl_3$)



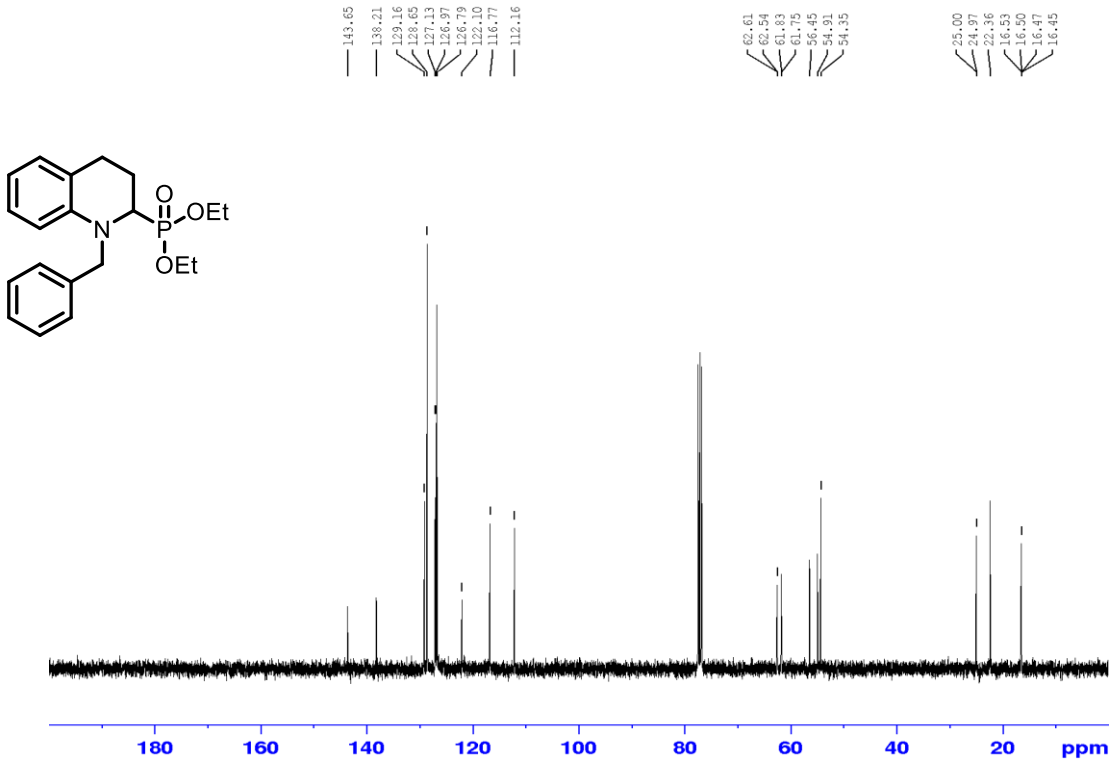
Dimethyl (4-benzyl-4,5,6,7-tetrahydrothieno[3,2-b]pyridin-5-yl)phosphonate 3ma
(^{31}P NMR, 162 MHz, $CDCl_3$)



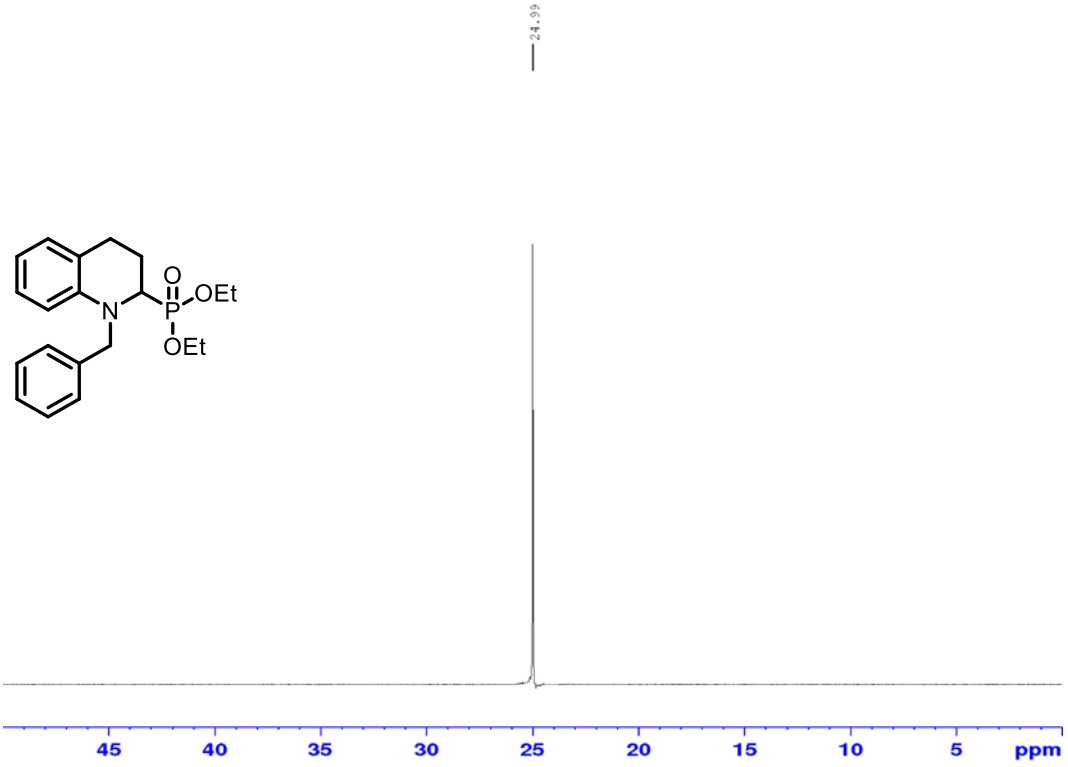
Diethyl (1-benzyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ab
(^{1}H NMR, 400 MHz, $CDCl_3$)



Diethyl (1-benzyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ab
(^{13}C NMR, 101 MHz, $CDCl_3$)

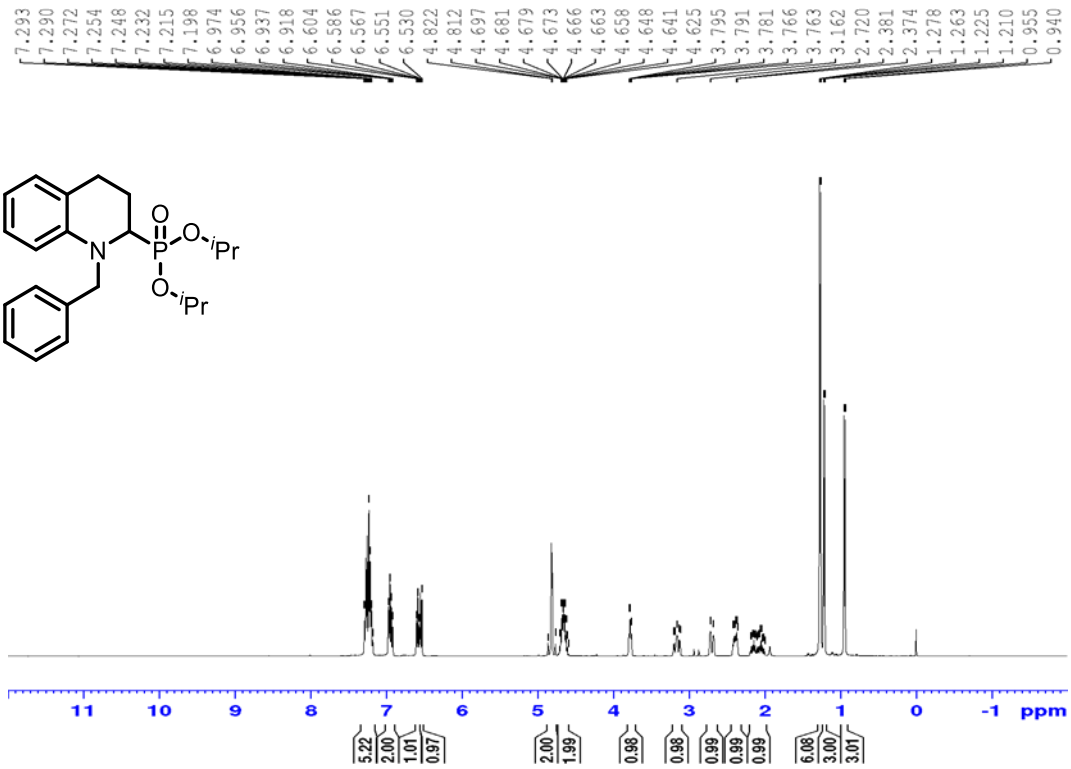


Diethyl (1-benzyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ab
(^{31}P NMR, 162 MHz, $CDCl_3$)



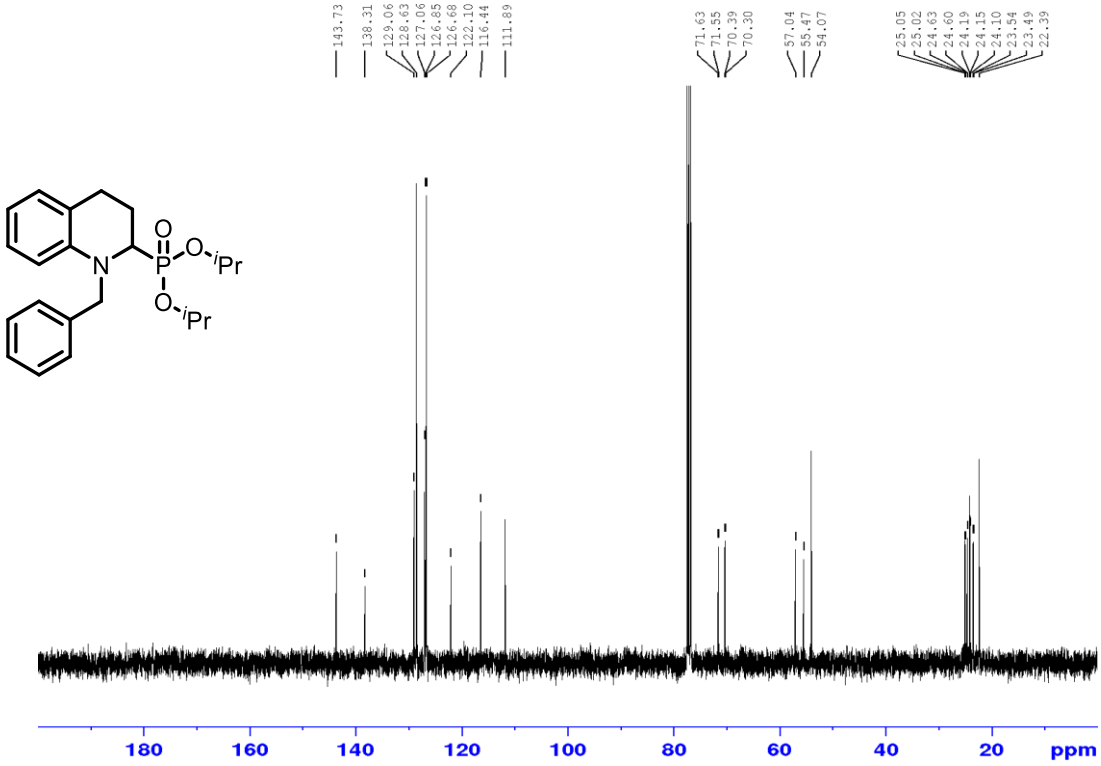
Diisopropyl (1-benzyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ac

(^{1}H NMR, 400 MHz, $CDCl_3$)



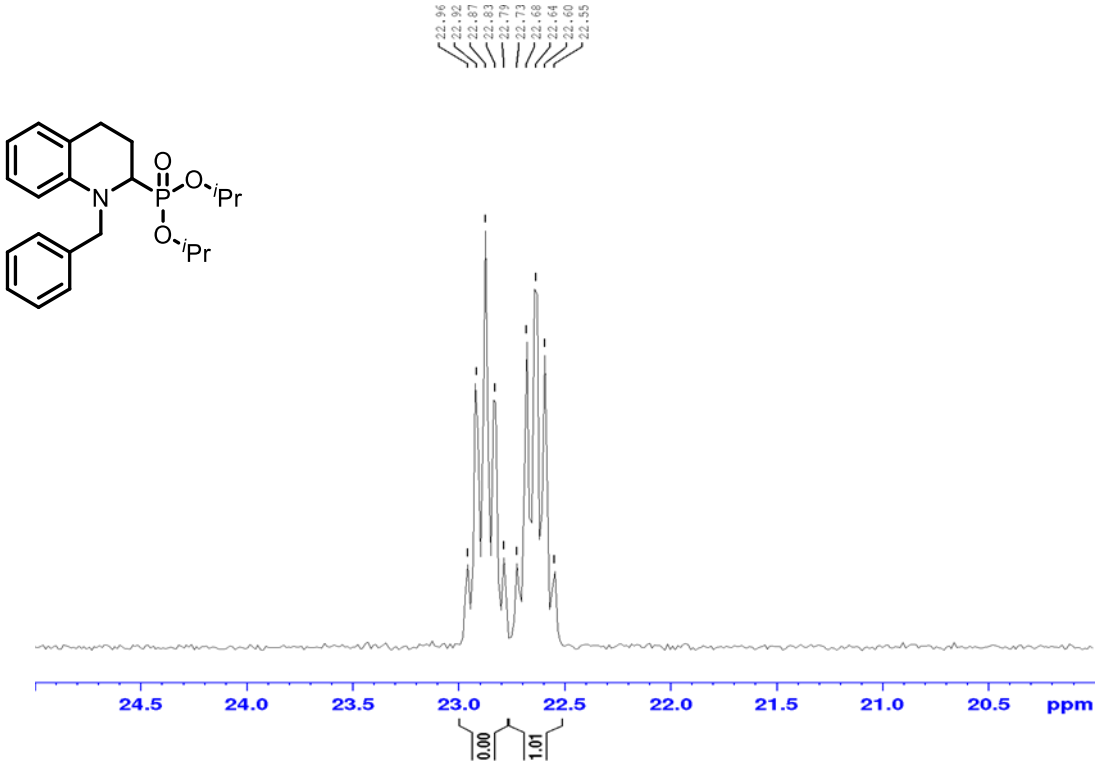
Diisopropyl (1-benzyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ac

(^{13}C NMR, 101 MHz, $CDCl_3$)



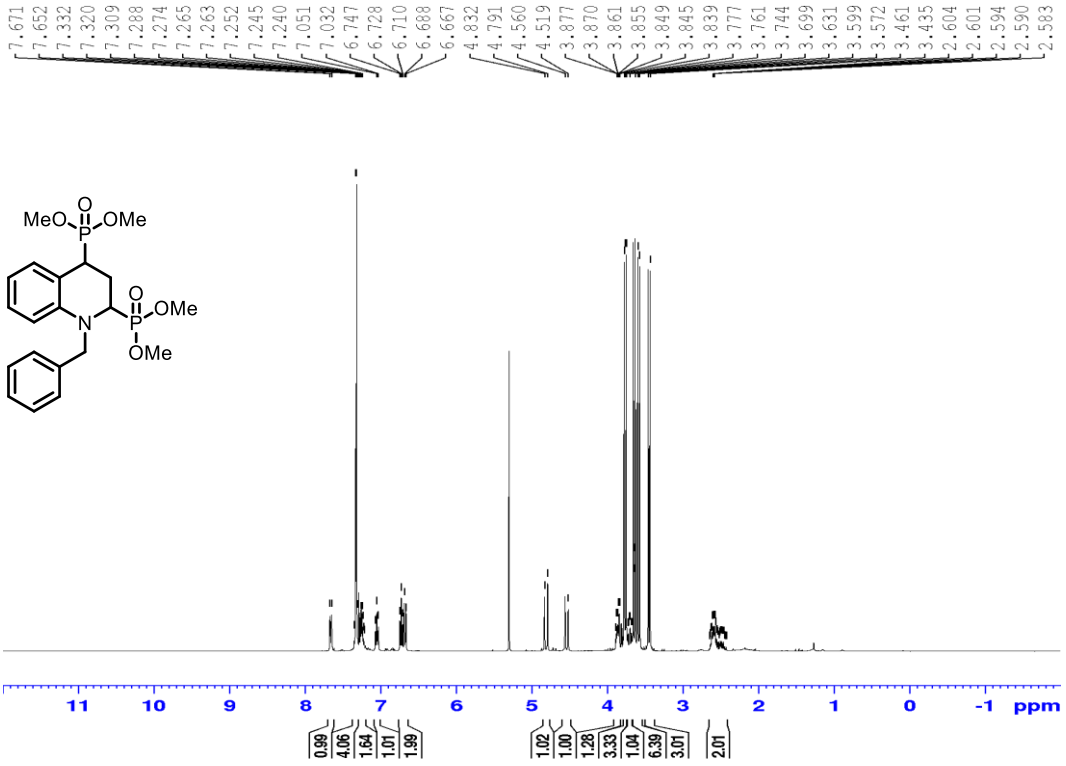
Diisopropyl (1-benzyl-1,2,3,4-tetrahydroquinolin-2-yl)phosphonate 3ac

(^{31}P NMR, 162 MHz, $CDCl_3$)

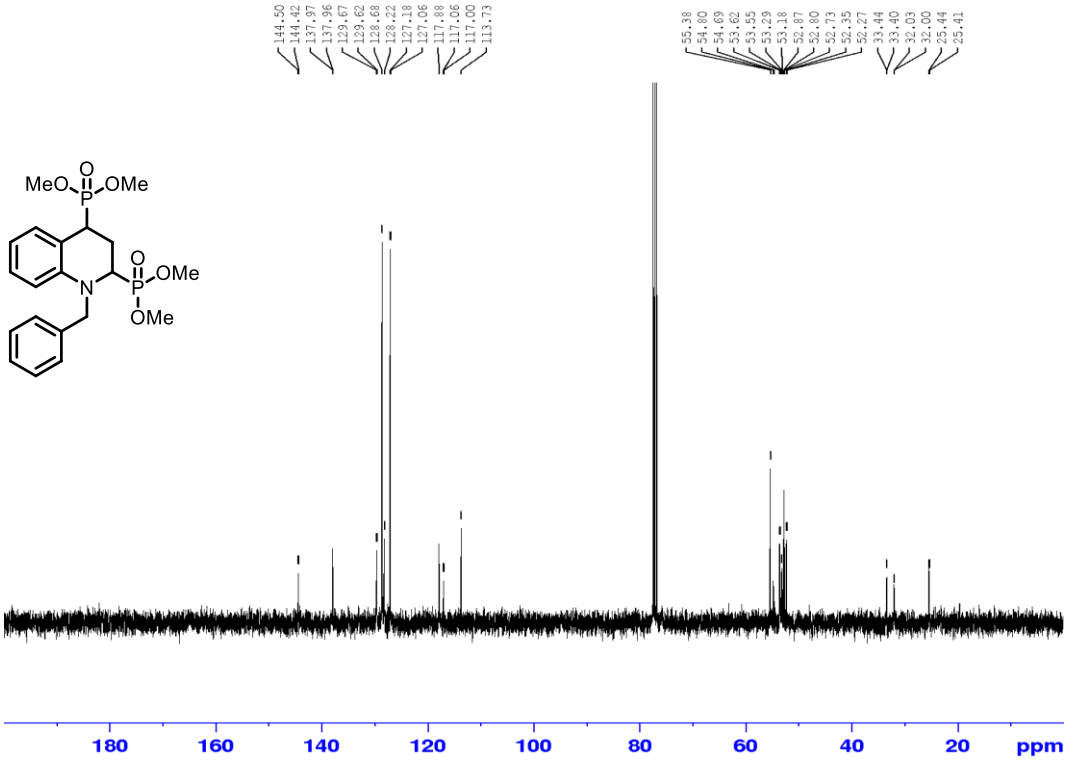


[4-(Dimethoxy-phosphoryl)-1,2,3,4-tetrahydro-quinolin-2-yl]-phosphonic acid dimethyl ester 4aa

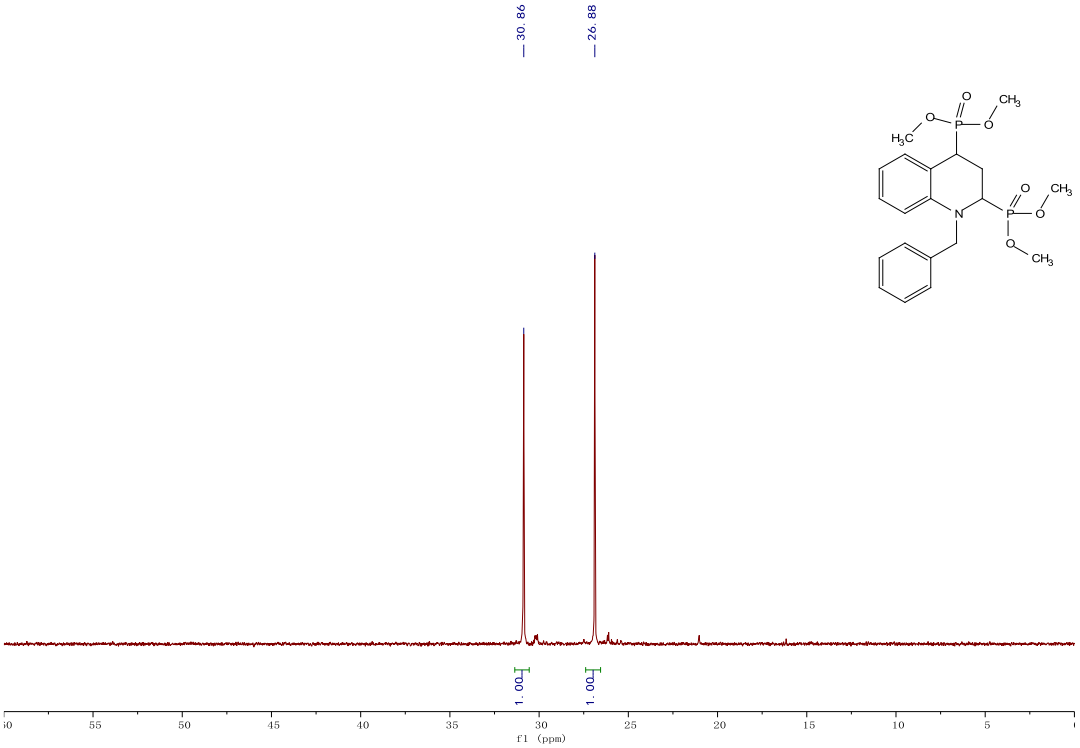
(^{1}H NMR, 400 MHz, $CDCl_3$)



[4-(Dimethoxy-phosphoryl)-1,2,3,4-tetrahydro-quinolin-2-yl]-phosphonic acid dimethyl ester 4aa (^{13}C NMR, 101 MHz, $CDCl_3$)

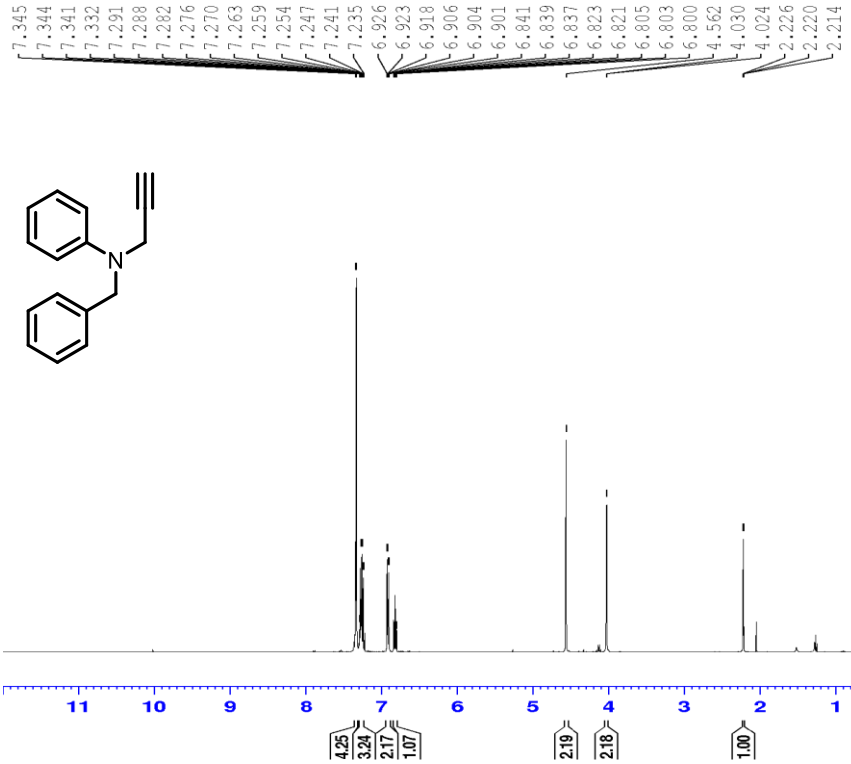


[4-(Dimethoxy-phosphoryl)-1,2,3,4-tetrahydro-quinolin-2-yl]-phosphonic acid dimethyl ester 4aa (^{31}P NMR, 162 MHz, $CDCl_3$)



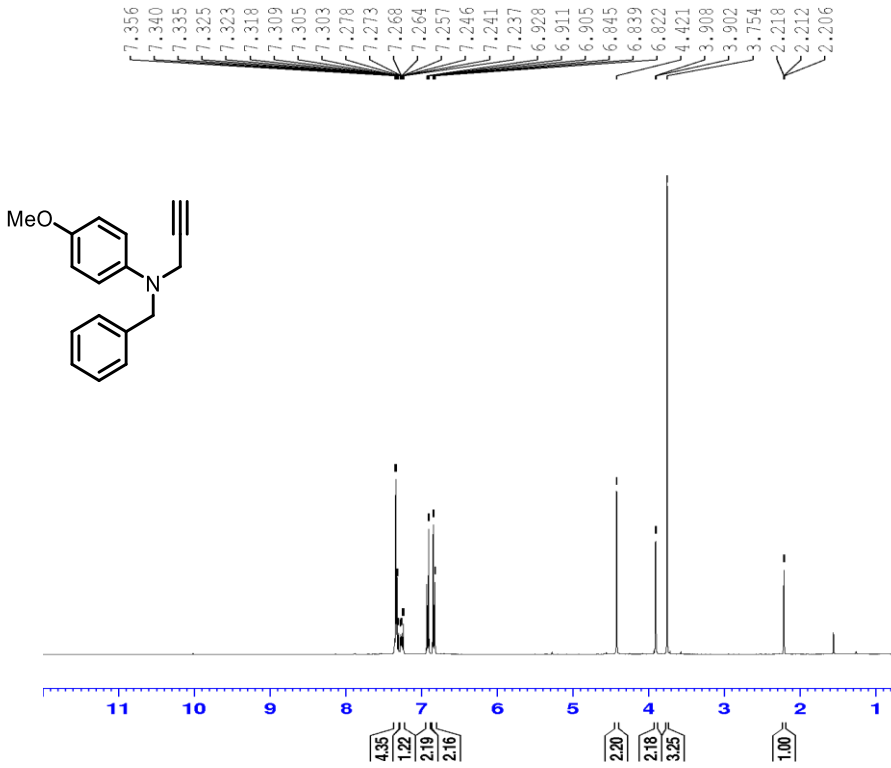
_N_-Benzyl-_N_-(2-propynyl)aniline 1a

(^{1}H NMR, 400 MHz, $CDCl_3$)



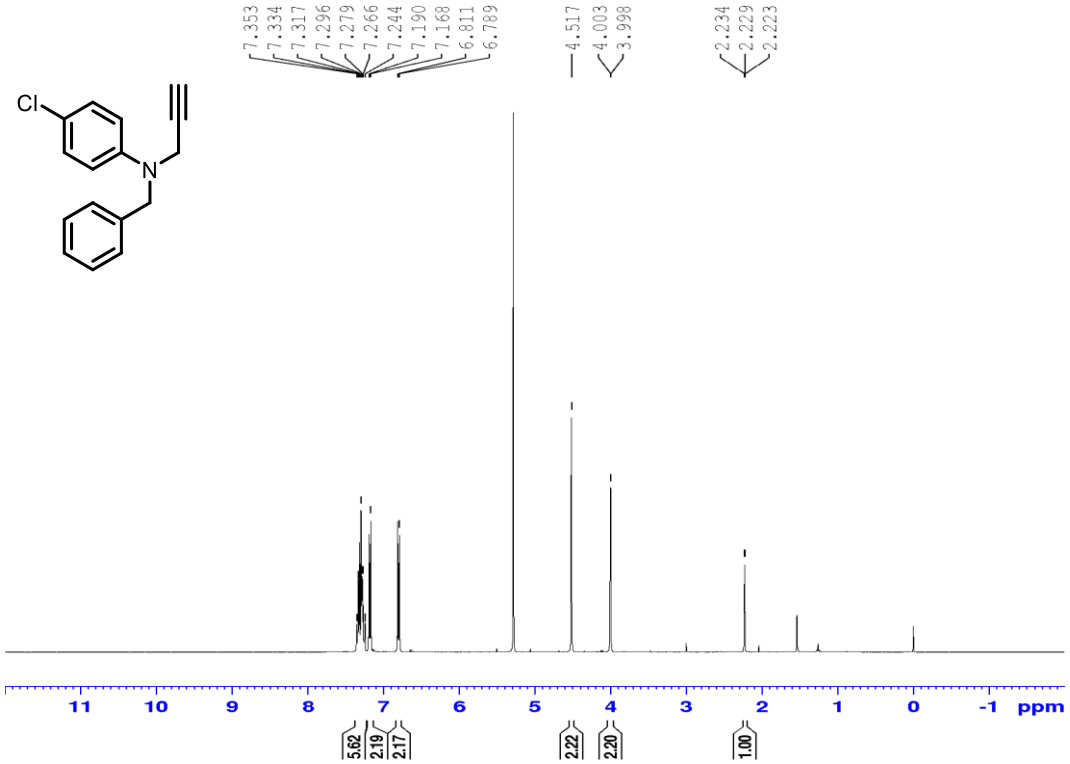
_N_-benzyl-4-methoxy-_N_-(prop-2-yn-1-yl)aniline 1b

(^{1}H NMR, 400 MHz, $CDCl_3$)



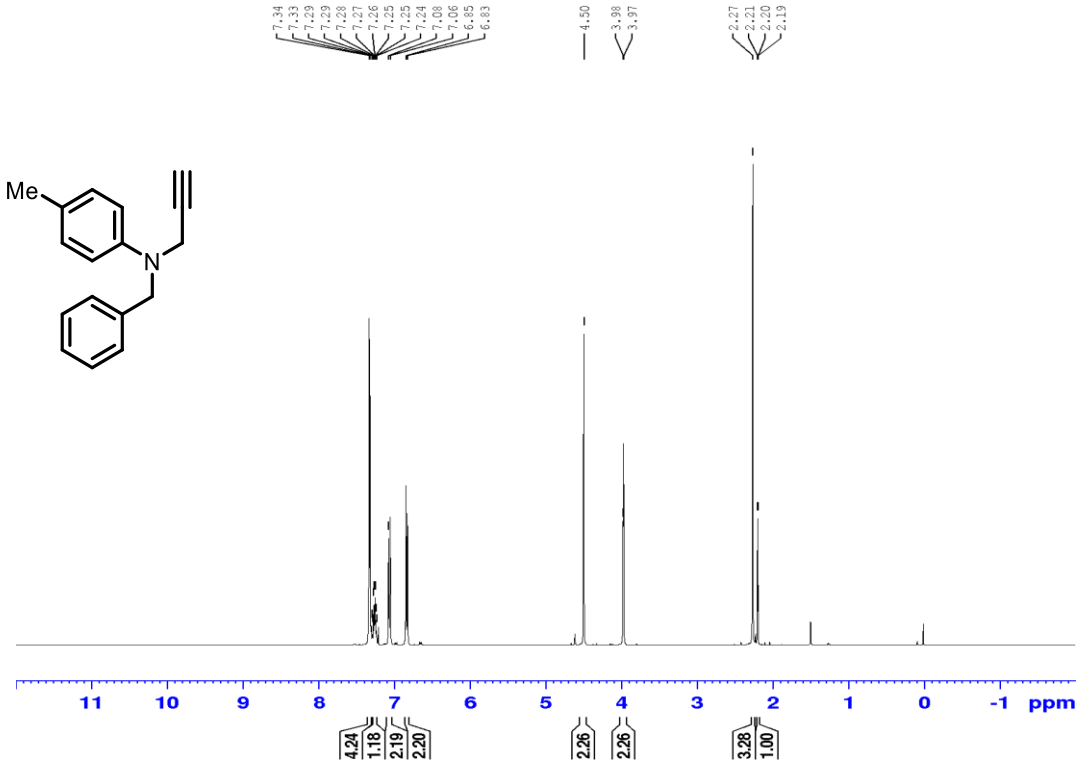
_N_-benzyl-4-chloro-_N_-(prop-2-yn-1-yl)aniline 1c

(^{1}H NMR, 400 MHz, $CDCl_3$)



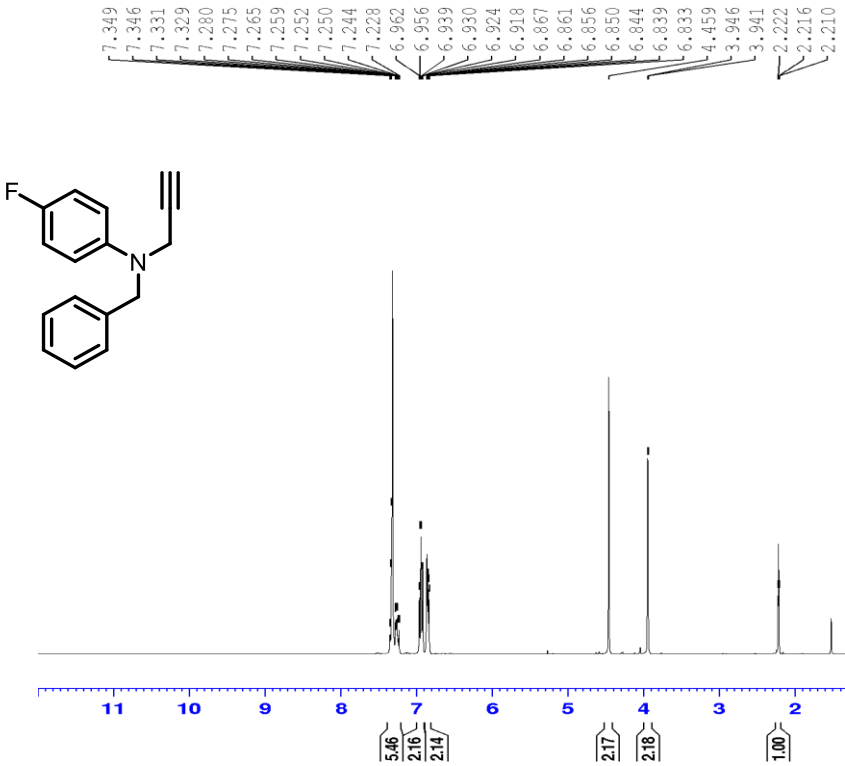
_N_-Benzyl-_N_-(2-propynyl)-4-methylaniline 1d

(^{1}H NMR, 400 MHz, $CDCl_3$)



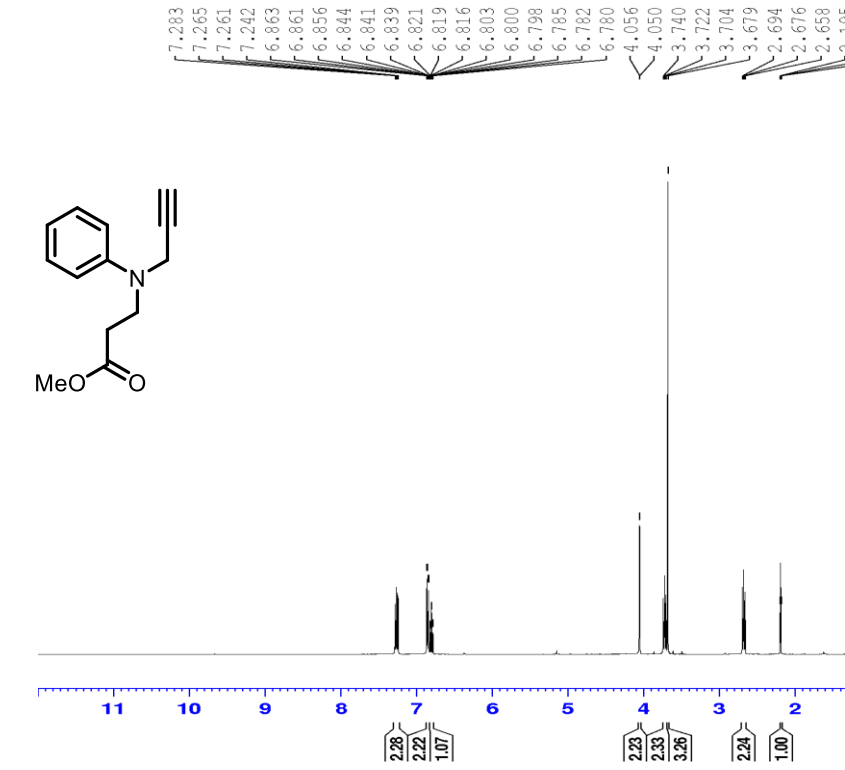
_N_-Benzyl-_N_-(2-propynyl)-4-fluoroaniline 1e

(^{1}H NMR, 400 MHz, $CDCl_3$)



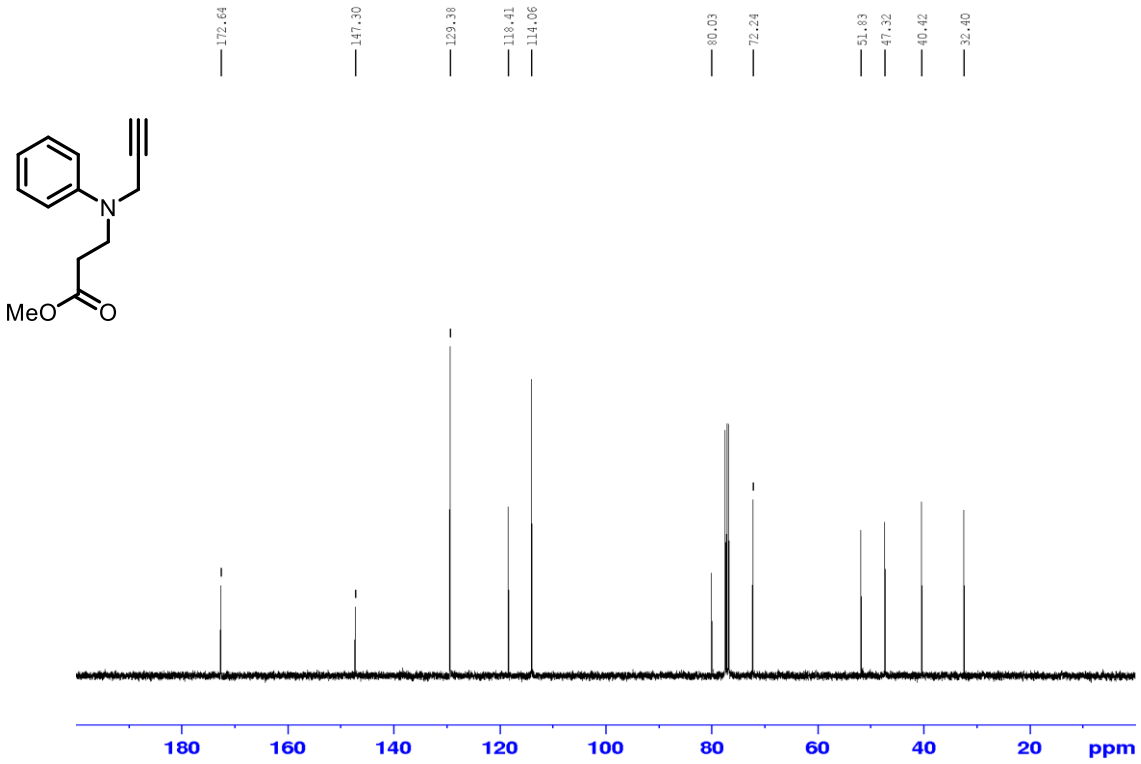
Methyl 3-(phenyl(prop-2-yn-1-yl)amino)propanoate 1f

(^{1}H NMR, 400 MHz, $CDCl_3$)



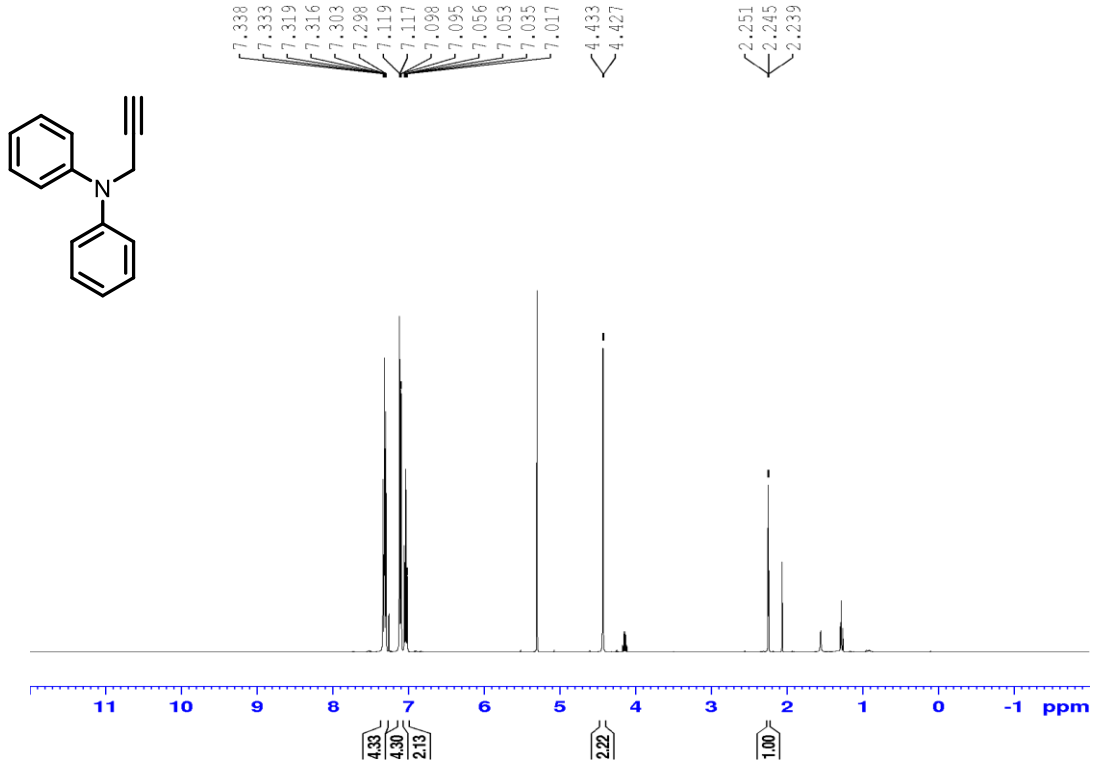
Methyl 3-(phenyl(prop-2-yn-1-yl)amino)propanoate 1f

(^{13}C NMR, 101 MHz, $CDCl_3$)



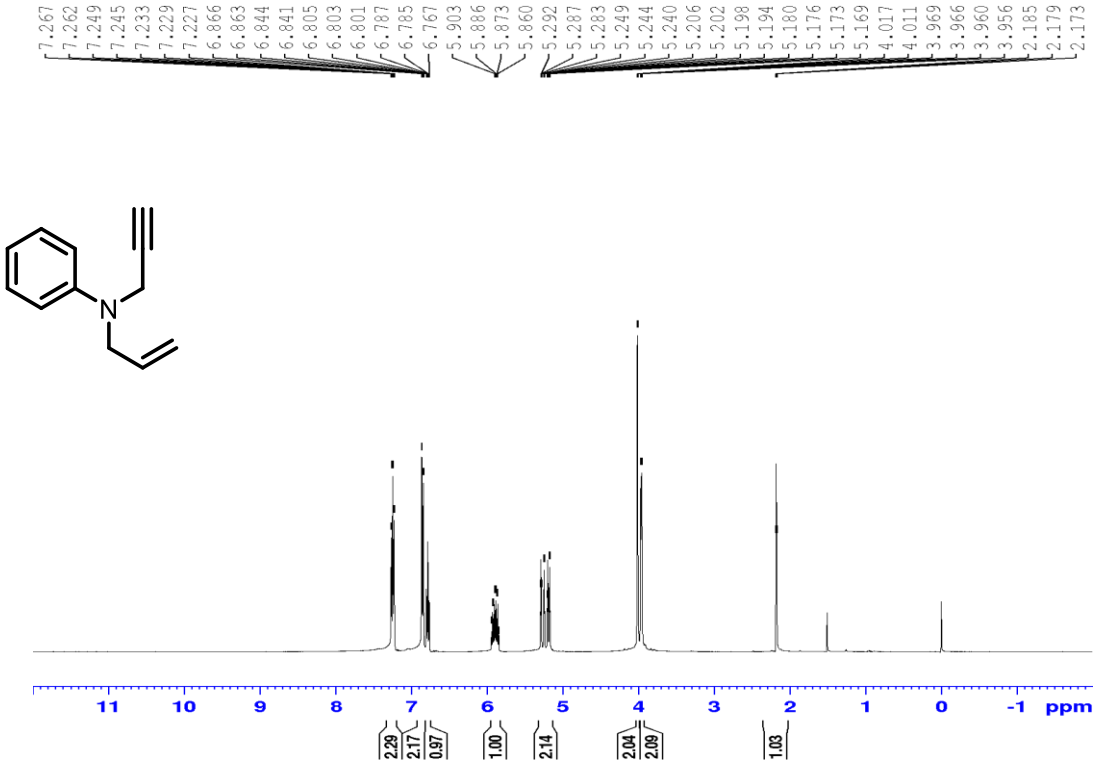
***N*-phenyl-*N*-(prop-2-yn-1-yl)aniline 1g**

(^{1}H NMR, 400 MHz, $CDCl_3$)



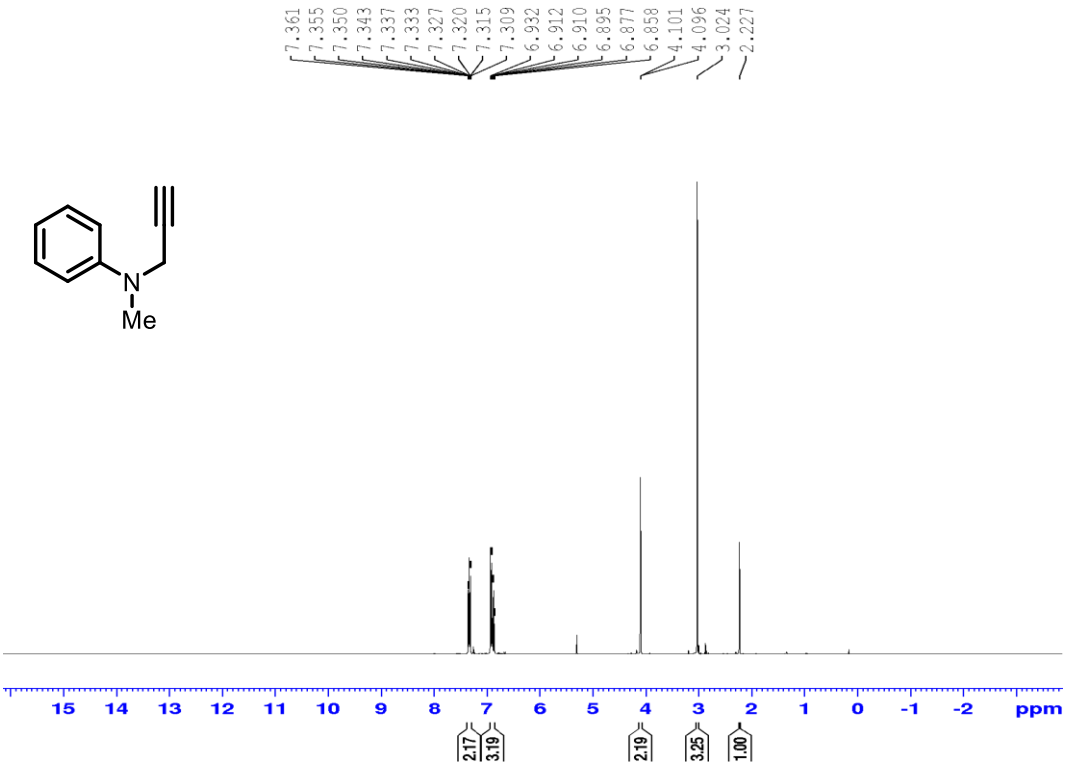
_N_-allyl-_N_-(prop-2-yn-1-yl)aniline 1h

(^{1}H NMR, 400 MHz, $CDCl_3$)



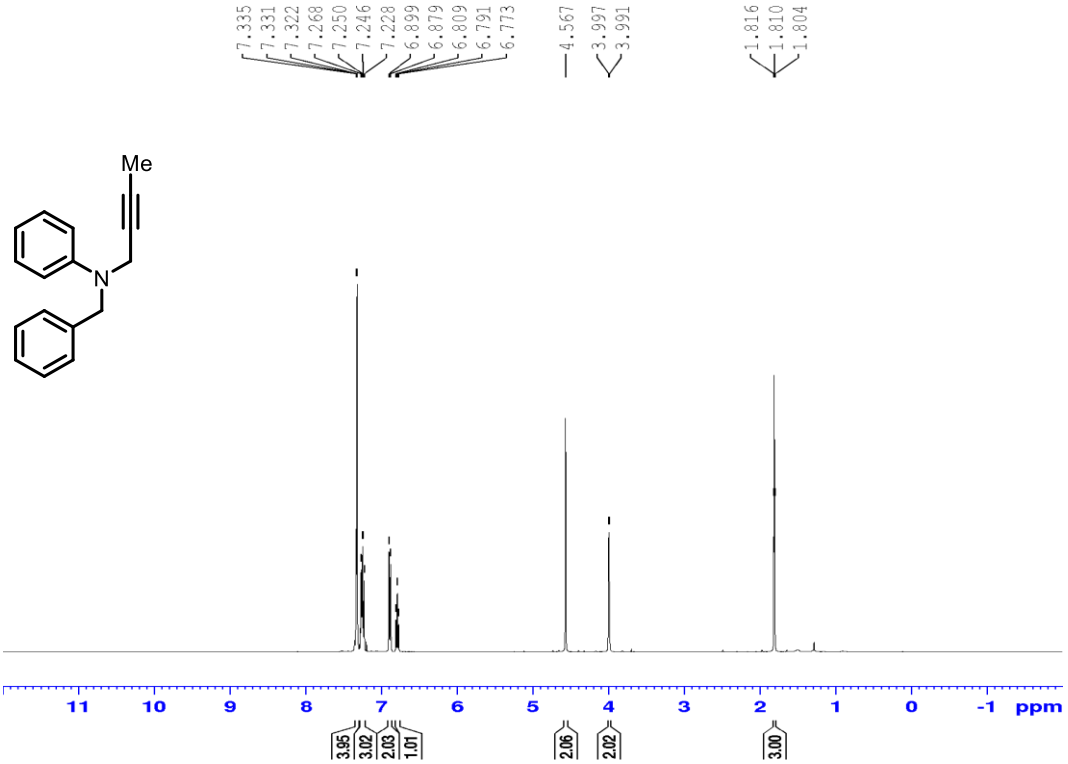
_N_-methyl-_N_-(prop-2-yn-1-yl)aniline 1i

(^{1}H NMR, 400 MHz, $CDCl_3$)



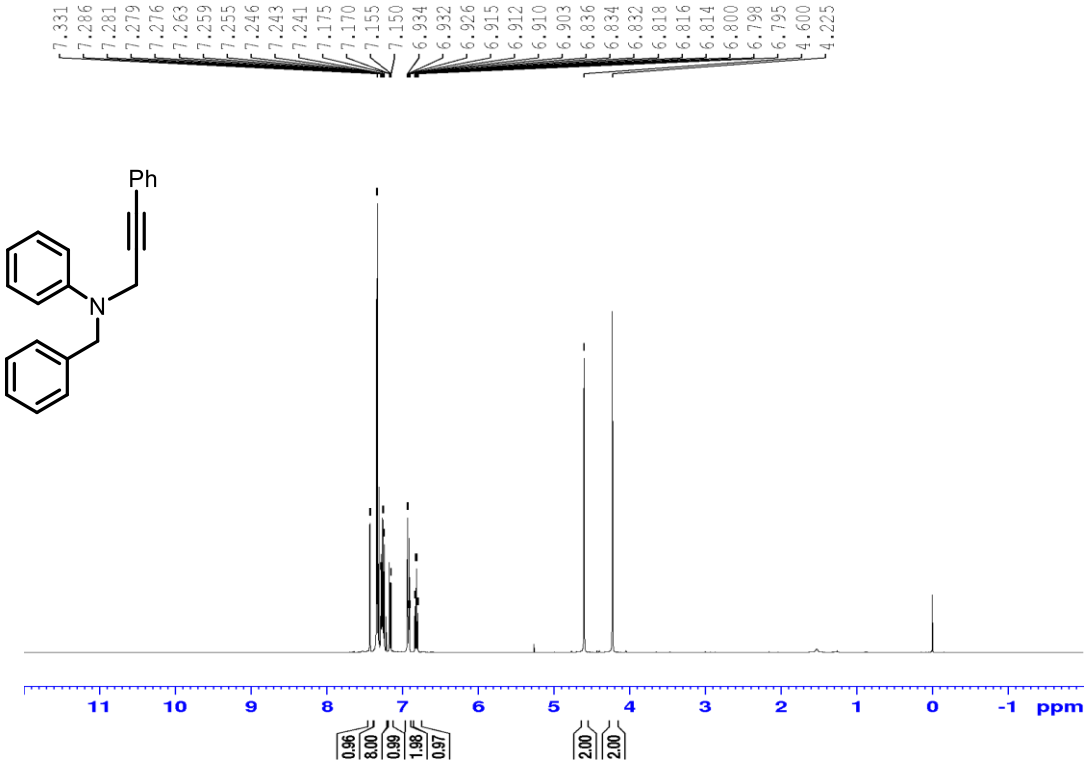
_N_-benzyl-_N_-(but-2-yn-1-yl)aniline 1j

(^{1}H NMR, 400 MHz, $CDCl_3$)



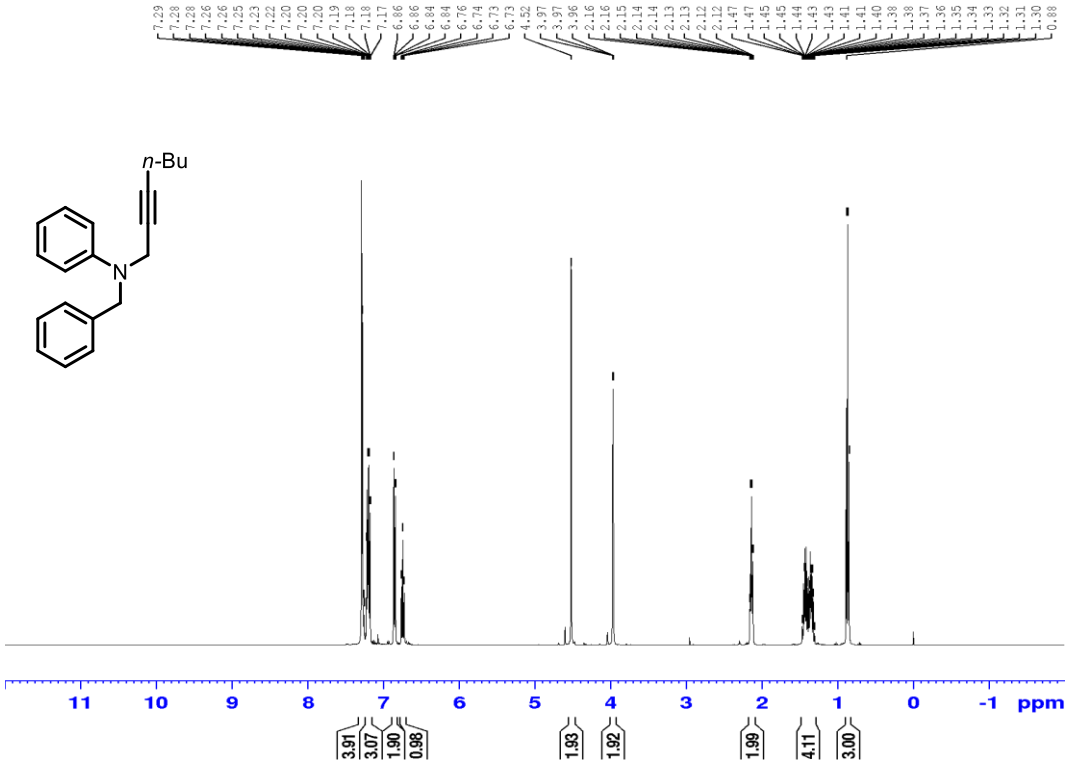
_N_-benzyl-_N_-(3-phenylprop-2-yn-1-yl)aniline 1k

(^{1}H NMR, 400 MHz, $CDCl_3$)



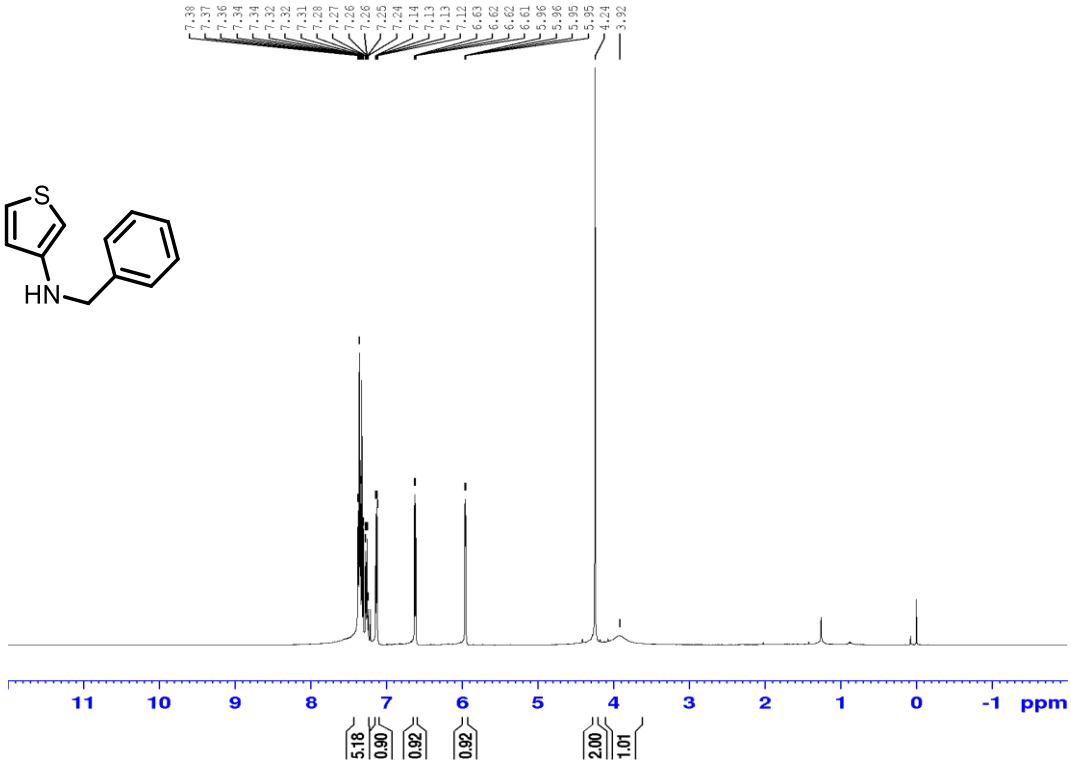
_N_-benzyl-_N_-(hept-2-yn-1-yl)aniline 1l

(^{1}H NMR, 400 MHz, $CDCl_3$)



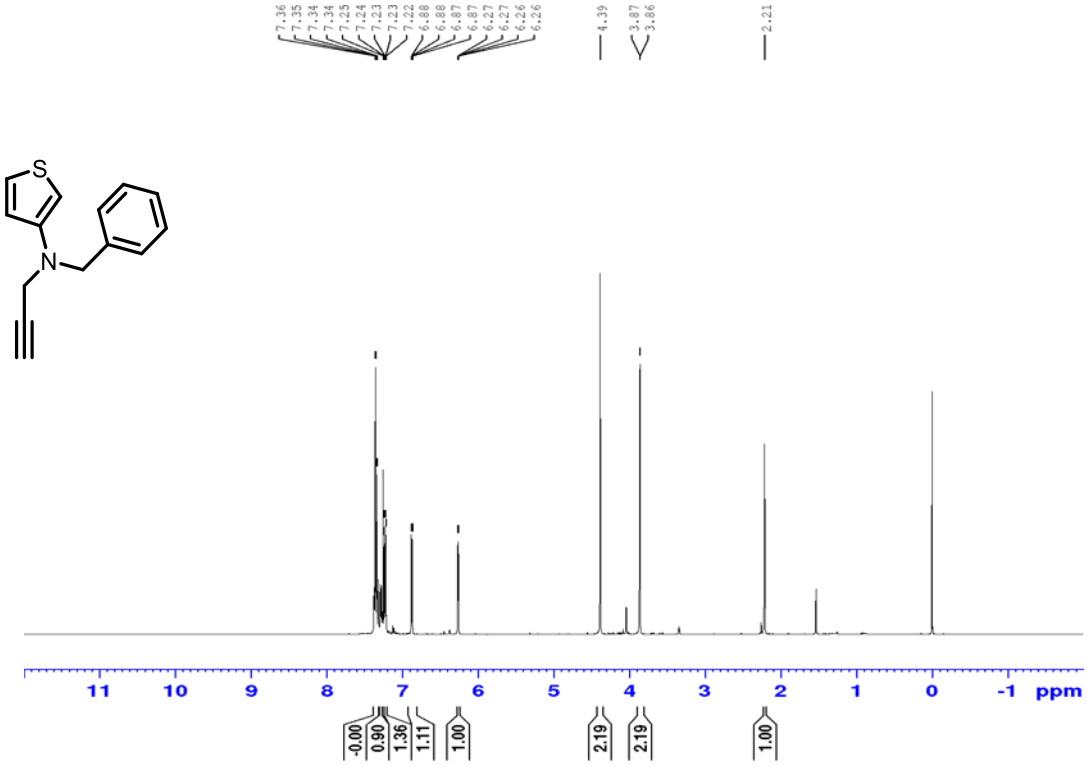
_N_-benzylthiophen-3-amine 8m

(^{1}H NMR, 400 MHz, $CDCl_3$)



_N_-benzyl-_N_-(prop-2-yn-1-yl)thiophen-3-amine 1m

(^{1}H NMR, 400 MHz, $CDCl_3$)



_N_-benzyl-_N_-(prop-2-yn-1-yl)thiophen-3-amine 1m

(^{13}C NMR, 101 MHz, CDC