Supporting Information

Merging photoredox catalysis with transition metal catalysis: site-selective C4 or C5-H phosphonation of 8-aminoquinoline amides

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1. General Information

^{1}H, ^{13}C and ^{31}P NMR spectra were recorded on a Bruker DPX-400 spectrometer with $CDCl_3$ as the solvent and TMS as an internal standard. Melting points were measured using a WC-1 microscopic apparatus and are uncorrected. High resolution mass spectra were ensured on a MALDI-FTMS. All solvents were used directly without further purification. Dichloromethane (analytical grade), ethyl acetate (analytical grade), and hexane (analytical grade) were used for column chromatography. Alizarin red S (analytical grade), eosin Y (analytical grade), eosin B (analytical grade), acid red 94 (analytical grade), $Ru(bpy)_3Cl_2$ (analytical grade), $K_2S_2O_8$ (analytical grade), Ag_2O (analytical grade), phosphine oxides (analytical grade), and PivONa (analytical grade) were obtained from commercial sources and used as-received without further purification unless otherwise noted.

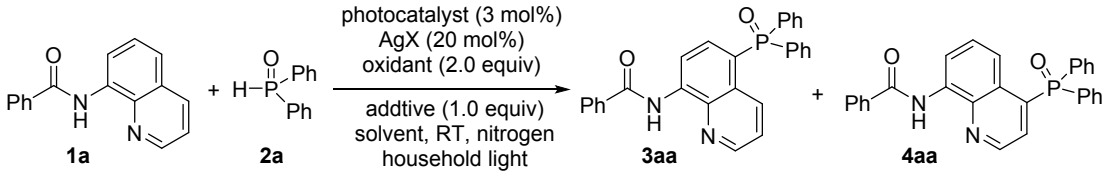
2. Preparation of Substrates

All amides were prepared from the corresponding acids and 8-aminoquinoline according to the reported procedure.[1]

3. Optimization of Reaction Conditions

A 10 mL reaction tube was equipped with a magnetic stir bar and charged with N-(quinolin-8-yl)benzamide **1a** (24.8 mg, 0.1 mmol), diarylphosphine oxide **2a** (41 mg, 0.2 mmol, 2 equiv), photocatalyst (0.003 mmol, 3 mol %), oxidant (0.2 mmol, 2 equiv), AgX (0.02 mmol, 20 mol %), additive (0.1 mmol, 1 equiv), and CH_3CN/H_2O (1.5 mL). The resulting mixture was stirred under the irradiation of 26 W household light under nitrogen at room temperature for 8 h. Upon completion, CH_2Cl_2 (20 mL) was added to the reaction system, which was extracted with H_2O (20 mL), and the aqueous layer was extracted with CH_2Cl_2 (2 × 10 mL). The combined organic layer was dried over anhydrous Na_2SO_4 and filtered. After evaporation of the solvent under vacuum, the residue was purified by column chromatography on silica gel (200–300 mesh) using hexane-EtOAc as an eluent to afford the pure product **3aa** and **4aa**.

Table S1 Screening of reaction conditions of the C5 position[a]



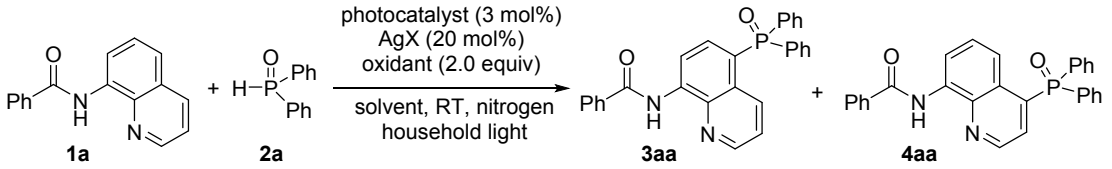
Entry	AgX	Oxidant	Solvent	Photocatalyst	Addtive	**3aa**[b] (%)	**4aa**[b] (%)
1	Ag_2O	$K_2S_2O_8$	CH_3CN/H_2O (1:1)	$[Ru(bpy)_3]Cl_2$	-	76	15
2	Ag_2SO_4	$K_2S_2O_8$	CH_3CN/H_2O (1:1)	$[Ru(bpy)_3]Cl_2$	-	63	12
3	Ag_3PO_4	$K_2S_2O_8$	CH_3CN/H_2O	$[Ru(bpy)_3]Cl_2$	-	61	11

			(1:1)				
4	$AgNO_3$	$K_2S_2O_8$	CH_3CN/H_2O (1:1)	$[Ru(bpy)_3]Cl_2$	-	47	21
5	AgOAc	$K_2S_2O_8$	CH_3CN/H_2O (1:1)	$[Ru(bpy)_3]Cl_2$	-	66	19
6	AgOTf	$K_2S_2O_8$	CH_3CN/H_2O (1:1)	$[Ru(bpy)_3]Cl_2$	-	60	15
7	Ag_2CO_3	$K_2S_2O_8$	CH_3CN/H_2O (1:1)	$[Ru(bpy)_3]Cl_2$	-	59	12
8	-	$K_2S_2O_8$	CH_3CN/H_2O (1:1)	$[Ru(bpy)_3]Cl_2$	-	Trace	Trace
9	Ag_2O	$Na_2S_2O_8$	CH_3CN/H_2O (1:1)	$[Ru(bpy)_3]Cl_2$	-	70	15
10	Ag_2O	$(NH_4)_2S_2O_8$	CH_3CN/H_2O (1:1)	$[Ru(bpy)_3]Cl_2$	-	48	19
11	Ag_2O	Oxone	CH_3CN/H_2O (1:1)	$[Ru(bpy)_3]Cl_2$	-	Trace	Trace
12	Ag_2O	$Mg(NO_3)_2$	CH_3CN/H_2O (1:1)	$[Ru(bpy)_3]Cl_2$	-	Trace	Trace
13	Ag_2O	BQ	CH_3CN/H_2O (1:1)	$[Ru(bpy)_3]Cl_2$	-	Trace	Trace
14	Ag_2O	TBHP	CH_3CN/H_2O (1:1)	$[Ru(bpy)_3]Cl_2$	-	Trace	Trace
15	Ag_2O	-	CH_3CN/H_2O (1:1)	$[Ru(bpy)_3]Cl_2$	-	Trace	Trace
16	Ag_2O	$K_2S_2O_8$	Acetone/H_2O (1:1)	$[Ru(bpy)_3]Cl_2$	-	67	21
17	Ag_2O	$K_2S_2O_8$	CH_2Cl_2/H_2O (1:1)	$[Ru(bpy)_3]Cl_2$	-	Trace	Trace
18	Ag_2O	$K_2S_2O_8$	Toluene/H_2O (1:1)	$[Ru(bpy)_3]Cl_2$	-	Trace	Trace
19	Ag_2O	$K_2S_2O_8$	Dioxane/H_2O (1:1)	$[Ru(bpy)_3]Cl_2$	-	Trace	Trace
20	Ag_2O	$K_2S_2O_8$	EtOH/H_2O (1:1)	$[Ru(bpy)_3]Cl_2$	-	47	42
21	Ag_2O	$K_2S_2O_8$	CH_3CN/H_2O (10:0)	$[Ru(bpy)_3]Cl_2$	-	34	18
22	Ag_2O	$K_2S_2O_8$	CH_3CN/H_2O (9:1)	$[Ru(bpy)_3]Cl_2$	-	52	27
23	Ag_2O	$K_2S_2O_8$	CH_3CN/H_2O (7:3)	$[Ru(bpy)_3]Cl_2$	-	70	17
24	Ag_2O	$K_2S_2O_8$	CH_3CN/H_2O (3:7)	$[Ru(bpy)_3]Cl_2$	-	68	18

25	Ag_2O	$K_2S_2O_8$	CH_3CN/H_2O (1:9)	$[Ru(bpy)_3]Cl_2$	-	43	25
26	Ag_2O	$K_2S_2O_8$	CH_3CN/H_2O (0:10)	$[Ru(bpy)_3]Cl_2$	-	Trace	Trace
27	Ag_2O	$K_2S_2O_8$	CH_3CN/H_2O (1:1)	$[Ru(bpy)_3](PF_6)_2$	-	61	24
28	Ag_2O	$K_2S_2O_8$	CH_3CN/H_2O (1:1)	Eosin Y	-	38	59
29	Ag_2O	$K_2S_2O_8$	CH_3CN/H_2O (1:1)	Eosin B	-	30	50
30	Ag_2O	$K_2S_2O_8$	CH_3CN/H_2O (1:1)	Acid red 94	-	32	63
31	Ag_2O	$K_2S_2O_8$	CH_3CN/H_2O (1:1)	Alizarin aed S	-	27	61
32	Ag_2O	$K_2S_2O_8$	CH_3CN/H_2O (1:1)	-	-	Trace	Trace
33	**Ag_2O**	**$K_2S_2O_8$**	**CH_3CN/H_2O (1:1)**	**$[Ru(bpy)_3]Cl_2$**	**PivONa**	**93**	**Trace**
34	Ag_2O	$K_2S_2O_8$	CH_3CN/H_2O (1:1)	$[Ru(bpy)_3]Cl_2$	PivOH	75	22
35	Ag_2O	$K_2S_2O_8$	CH_3CN/H_2O (1:1)	$[Ru(bpy)_3]Cl_2$	AcONa	88	Trace
36	Ag_2O	$K_2S_2O_8$	CH_3CN/H_2O (1:1)	$[Ru(bpy)_3]Cl_2$	Na_2CO_3	60	8
37	Ag_2O	$K_2S_2O_8$	CH_3CN/H_2O (1:1)	$[Ru(bpy)_3]Cl_2$	$NaHCO_3$	85	Trace
38[c]	Ag_2O	$K_2S_2O_8$	CH_3CN/H_2O (1:1)	$[Ru(bpy)_3]Cl_2$	PivONa	74	Trace
39[d]	Ag_2O	$K_2S_2O_8$	CH_3CN/H_2O (1:1)	$[Ru(bpy)_3]Cl_2$	PivONa	78	Trace
40[e]	Ag_2O	$K_2S_2O_8$	CH_3CN/H_2O (1:1)	$[Ru(bpy)_3]Cl_2$	PivONa	Trace	Trace
41[f]	Ag_2O	$K_2S_2O_8$	CH_3CN/H_2O (1:1)	$[Ru(bpy)_3]Cl_2$	PivONa	Trace	Trace
42[g]	Ag_2O	$K_2S_2O_8$	CH_3CN/H_2O (1:1)	$[Ru(bpy)_3]Cl_2$	PivONa	92	Trace
43[h]	Ag_2O	$K_2S_2O_8$	CH_3CN/H_2O (1:1)	$[Ru(bpy)_3]Cl_2$	PivONa	89	Trace

[a] Reaction conditions: **1a** (0.1 mmol), **2a** (0.2 mmol), photocatalyst (3 mol %), AgX (20 mol %), oxidant (0.2 mmol), additive (0.1 mmol), solvent (1.5 ml) at room temperature under nitrogen for 8 h. [b] Isolated yield. [c] blue LED. [d] green LED. [e] red LED. [f] dark. [g] For 9 h. [h] For 7 h.

Table S2 Screening of reaction conditions of the C4 position[a]



Entry	AgX	Oxidant	Solvent	Photocatalyst	**3aa**[b] (%)	**4aa**[b] (%)
1	Ag_2O	$K_2S_2O_8$	CH_3CN/H_2O (1:1)	Acid red 94	32	63
2	Ag_2SO_4	$K_2S_2O_8$	CH_3CN/H_2O (1:1)	Acid red 94	33	45
3	Ag_3PO_4	$K_2S_2O_8$	CH_3CN/H_2O (1:1)	Acid red 94	38	42
4	$AgNO_3$	$K_2S_2O_8$	CH_3CN/H_2O (1:1)	Acid red 94	27	55
5	AgOAc	$K_2S_2O_8$	CH_3CN/H_2O (1:1)	Acid red 94	32	44
6	AgOTf	$K_2S_2O_8$	CH_3CN/H_2O (1:1)	Acid red 94	29	51
7	Ag_2CO_3	$K_2S_2O_8$	CH_3CN/H_2O (1:1)	Acid red 94	37	47
8	-	$K_2S_2O_8$	CH_3CN/H_2O (1:1)	Acid red 94	Trace	Trace
9	Ag_2O	$Na_2S_2O_8$	CH_3CN/H_2O (1:1)	Acid red 94	30	56
10	Ag_2O	$(NH_4)_2S_2O_8$	CH_3CN/H_2O (1:1)	Acid red 94	19	42
11	Ag_2O	-	CH_3CN/H_2O (1:1)	Acid red 94	Trace	Trace
12	Ag_2O	$K_2S_2O_8$	Acetone/H_2O (1:1)	Acid red 94	30	45
13	Ag_2O	$K_2S_2O_8$	EtOH/H_2O (1:1)	Acid red 94	27	32
14	Ag_2O	$K_2S_2O_8$	CH_3CN/H_2O (10:0)	Acid red 94	20	39
15	Ag_2O	$K_2S_2O_8$	CH_3CN/H_2O (9:1)	Acid red 94	22	49
16	Ag_2O	$K_2S_2O_8$	CH_3CN/H_2O (4:1)	Acid red 94	25	63
17	Ag_2O	$K_2S_2O_8$	CH_3CN/H_2O (7:3)	Acid red 94	23	65
18	**Ag_2O**	**$K_2S_2O_8$**	**CH_3CN/H_2O (3:2)**	**Acid red 94**	**20**	**70**
19	Ag_2O	$K_2S_2O_8$	CH_3CN/H_2O (2:3)	Acid red 94	24	60
20	Ag_2O	$K_2S_2O_8$	CH_3CN/H_2O (3:7)	Acid red 94	21	55
21	Ag_2O	$K_2S_2O_8$	CH_3CN/H_2O (0:10)	Acid red 94	Trace	Trace
22	Ag_2O	$K_2S_2O_8$	CH_3CN/H_2O (3:2)	-	Trace	Trace
23[c]	Ag_2O	$K_2S_2O_8$	CH_3CN/H_2O (3:2)	Acid red 94	Trace	Trace
24[d]	Ag_2O	$K_2S_2O_8$	CH_3CN/H_2O (3:2)	Acid red 94	25	51
25[e]	Ag_2O	$K_2S_2O_8$	CH_3CN/H_2O (3:2)	Acid red 94	Trace	Trace
26[f]	Ag_2O	$K_2S_2O_8$	CH_3CN/H_2O (3:2)	Acid red 94	Trace	Trace

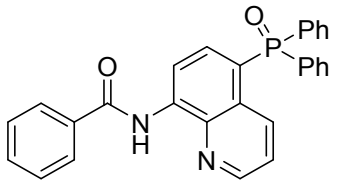
[a] Reaction conditions: **1a** (0.1 mmol), **2a** (0.2 mmol), photocatalyst (3 mol %), AgX (20 mol %), oxidant (0.2 mmol), solvent (1.5 ml) at room temperature under nitrogen for 8 h. [b] Isolated yield. [c] blue LED. [d] green LED. [e] red LED. [f] dark.

4. Typical Procedure for the Products

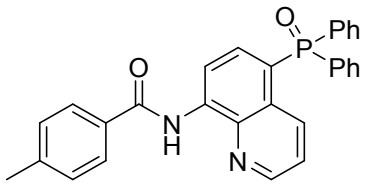
a) For the C5 position reaction: A 10 mL reaction tube was equipped with a magnetic stir bar and charged with **1** (0.1 mmol), **2** (0.2 mmol, 2 equiv), $[Ru(bpy)_3]Cl_2$ (1.9 mg, 0.003 mmol, 3 mol %), $K_2S_2O_8$ (54 mg, 0.2 mmol, 2 equiv), Ag_2O (2.3 mg, 0.01 mmol, 10 mol %), PivONa (14.2 mg, 0.1 mmol, 1 equiv), and CH_3CN/H_2O = 1:1 (1.5 mL). The resulting mixture was stirred under the

irradiation of 26 W household light under nitrogen at room temperature for 8 h. Upon completion, CH_2Cl_2 (20 mL) was added to the reaction system, which was extracted with H_2O (20 mL), and the aqueous layer was extracted with CH_2Cl_2 (2 × 10 mL). The combined organic layer was dried over anhydrous Na_2SO_4 and filtered. After evaporation of the solvent under vacuum, the residue was purified by column chromatography on silica gel (200–300 mesh) using CH_2Cl_2-EtOAc as an eluent to afford the pure product **3**.

b) For the C4 position reaction: A 10 mL reaction tube was equipped with a magnetic stir bar and charged with **1** (0.1 mmol), **2** (0.2 mmol, 2 equiv), Acid red 94 (3.1 mg, 0.003 mmol, 3 mol %), $K_2S_2O_8$ (54 mg, 0.2 mmol, 2 equiv), Ag_2O (2.3 mg, 0.01 mmol, 10 mol %), and CH_3CN/H_2O = 2:3 (1.5 mL). The resulting mixture was stirred under the irradiation of 26 W household light under nitrogen at room temperature for 8 h. Upon completion, CH_2Cl_2 (20 mL) was added to the reaction system, which was extracted with H_2O (20 mL), and the aqueous layer was extracted with CH_2Cl_2 (2 × 10 mL). The combined organic layer was dried over anhydrous Na_2SO_4 and filtered. After evaporation of the solvent under vacuum, the residue was purified by column chromatography on silica gel (200–300 mesh) using CH_2Cl_2-EtOAc as an eluent to afford the pure product **4**.

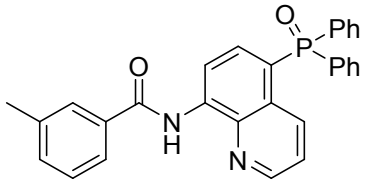


N-(5-(diphenylphosphoryl)quinolin-8-yl)benzamide (3aa): Light yellow solid (93%); mp 214-216 ^oC; ^1H NMR (400 MHz, $CDCl_3$) δ 10.98 (s, 1H), 9.10 (d, J = 8.1 Hz, 1H), 8.86 (d, J = 3.2 Hz, 1H), 8.82 (dd, J = 8.0 Hz, 1.9 Hz, 1H), 8.08 (d, J = 7.1 Hz, 2H), 7.71-7.66 (m, 4H), 7.60-7.54 (m, 5H), 7.50-7.43 (m, 5H), 7.36 (dd, $J_{H\text{-}P}$ = 15.0 Hz, 8.1 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.7, 148.6, 138.9 (d, $J_{C\text{-}P}$ = 9.3 Hz), 138.4 (d, $J_{C\text{-}P}$ = 2.7 Hz), 136.4 (d, $J_{C\text{-}P}$ = 4.9 Hz), 135.4 (d, $J_{C\text{-}P}$ = 11.7 Hz), 134.6, 132.3 (d, $J_{C\text{-}P}$ = 105.1 Hz), 132.2, 132.1 (d, $J_{C\text{-}P}$ = 2.7 Hz), 132.0 (d, $J_{C\text{-}P}$ = 10.1 Hz), 129.2 (d, $J_{C\text{-}P}$ = 8.5 Hz), 128.9, 128.7 (d, $J_{C\text{-}P}$ = 11.3 Hz), 127.3, 122.6 (d, $J_{C\text{-}P}$ = 105.7 Hz), 122.6, 114.2 (d, $J_{C\text{-}P}$ = 14.2 Hz); ^{31}P NMR (163 MHz, $CDCl_3$) δ 31.5; HRMS (ESI+): calcd for $C_{28}H_{21}N_2O_2P$ [M+H]+: 449.1413, Found: 449.1414.

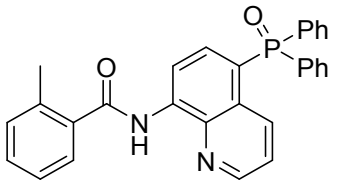


N-(5-(diphenylphosphoryl)quinolin-8-yl)-4-methylbenzamide (3ba): Light yellow solid (80%); mp 228-230 ^oC; ^1H NMR (400 MHz, $CDCl_3$) δ 10.94 (s, 1H), 9.09 (d, J = 8.5 Hz, 1H), 8.85 (d, J = 2.9 Hz, 1H), 8.80 (dd, J = 7.6 Hz, 2.1 Hz, 1H), 7.97 (d, J = 8.0 Hz, 2H), 7.70-7.66 (m, 4H), 7.58-7.55 (m, 2H), 7.49-7.42 (m, 5H), 7.37-7.32 (m, 3H), 2.44 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ

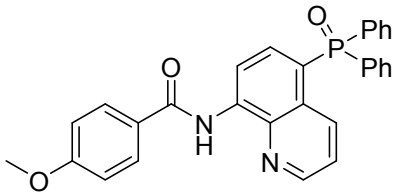
165.6, 148.5, 142.8, 138.9 (d, $J_{C\text{-}P}$ = 9.5 Hz), 138.6 (d, $J_{C\text{-}P}$ = 2.6 Hz), 136.3 (d, $J_{C\text{-}P}$ = 5.0 Hz), 135.5 (d, $J_{C\text{-}P}$ = 11.9 Hz), 132.3 (d, $J_{C\text{-}P}$ = 105.0 Hz), 132.1 (d, $J_{C\text{-}P}$ = 2.7 Hz), 132.0 (d, $J_{C\text{-}P}$ = 10.0 Hz), 131.8, 129.5, 129.2 (d, $J_{C\text{-}P}$ = 8.6 Hz), 128.7 (d, $J_{C\text{-}P}$ = 12.3 Hz), 127.4, 122.5, 122.3 (d, $J_{C\text{-}P}$ = 104.9 Hz), 114.1 (d, $J_{C\text{-}P}$ = 14.5 Hz), 21.5; ^{31}P NMR (163 MHz, $CDCl_3$) δ 31.6; HRMS (ESI+): calcd for $C_{29}H_{23}N_2O_2P$ [M+H]+: 463.1570, Found: 463.1573.



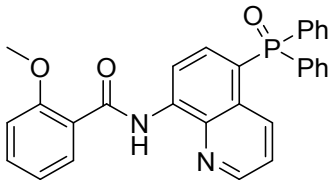
N-(5-(diphenylphosphoryl)quinolin-8-yl)-3-methylbenzamide (3ca): Light yellow solid (82%); mp 205-207 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.93 (s, 1H), 9.09 (d, J = 8.4 Hz, 1H), 8.85 (d, J = 2.9 Hz, 1H), 8.81 (dd, J = 8.0 Hz, 2.1 Hz, 1H), 7.87-7.84 (m, 2H), 7.71-7.66 (m, 4H), 7.59-7.55 (m, 2H), 7.50-7.39 (m, 7H), 7.35 (dd, $J_{H\text{-}P}$ = 15.1 Hz, 8.1 Hz, 1H), 2.47 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.9, 148.6, 138.9 (d, $J_{C\text{-}P}$ = 9.1 Hz), 138.8, 138.5 (d, $J_{C\text{-}P}$ = 2.5 Hz), 136.3 (d, $J_{C\text{-}P}$ = 5.1 Hz), 135.5 (d, $J_{C\text{-}P}$ = 12.0 Hz), 134.6, 133.0, 132.3 (d, $J_{C\text{-}P}$ = 105.2 Hz), 132.1 (d, $J_{C\text{-}P}$ = 2.5 Hz), 132.0 (d, $J_{C\text{-}P}$ = 10.0 Hz), 129.2 (d, $J_{C\text{-}P}$ = 8.5 Hz), 128.7, 128.7 (d, $J_{C\text{-}P}$ = 12.3 Hz), 128.1, 124.2, 122.6, 122.4 (d, $J_{C\text{-}P}$ = 106.5 Hz), 114.2 (d, $J_{C\text{-}P}$ = 14.4 Hz), 21.4; ^{31}P NMR (163 MHz, $CDCl_3$) δ 31.6; HRMS (ESI+): calcd for $C_{29}H_{23}N_2O_2P$ [M+H]+: 463.1570, Found: 463.1571.



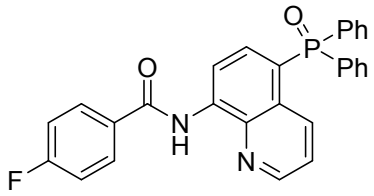
N-(5-(diphenylphosphoryl)quinolin-8-yl)-2-methylbenzamide (3da): Light yellow solid (84%); mp 181-182 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.44 (s, 1H), 9.08 (d, J = 8.4 Hz, 1H), 8.81 (dd, J = 7.8 Hz, 1.8 Hz, 1H), 8.77 (d, J = 2.8 Hz, 1H), 7.71-7.66 (m, 5H), 7.59-7.55 (m, 2H), 7.50-7.47 (m, 4H), 7.43-7.30 (m, 5H), 2.59 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 168.4, 148.5, 138.7 (d, $J_{C\text{-}P}$ = 9.3 Hz), 138.5 (d, $J_{C\text{-}P}$ = 2.6 Hz), 136.8, 136.3 (d, $J_{C\text{-}P}$ = 4.9 Hz), 136.0, 135.4 (d, $J_{C\text{-}P}$ = 11.7 Hz), 132.3 (d, $J_{C\text{-}P}$ = 105.4 Hz), 132.1 (d, $J_{C\text{-}P}$ = 2.7 Hz), 132.0 (d, $J_{C\text{-}P}$ = 9.9 Hz), 131.5, 130.6, 129.2 (d, $J_{C\text{-}P}$ = 8.5 Hz), 128.7 (d, $J_{C\text{-}P}$ = 12.3 Hz), 127.2, 126.1, 122.7 (d, $J_{C\text{-}P}$ = 105.2 Hz), 122.6, 114.2 (d, $J_{C\text{-}P}$ = 14.5 Hz), 20.2; ^{31}P NMR (163 MHz, $CDCl_3$) δ 31.6; HRMS (ESI+): calcd for $C_{29}H_{23}N_2O_2P$ [M+H]+: 463.1570, Found: 463.1572.



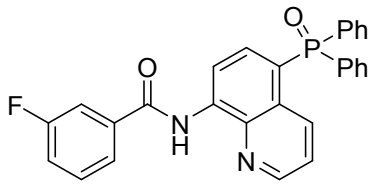
N-(5-(diphenylphosphoryl)quinolin-8-yl)-4-methoxybenzamide (3ea): Light yellow solid (81%); mp 198-200 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.90 (s, 1H), 9.07 (d, J = 8.4 Hz, 1H), 8.84 (d, J = 2.8 Hz, 1H), 8.78 (dd, J = 8.0 Hz, 2.1 Hz, 1H), 8.04 (d, J = 8.7 Hz, 2H), 7.70-7.65 (m, 4H), 7.58-7.54 (m, 2H), 7.49-7.41 (m, 5H), 7.35 (dd, $J_{H\text{-}P}$ = 15.0 Hz, 8.0 Hz, 1H), 7.03 (d, J = 8.7 Hz, 2H), 3.88 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.2, 162.8, 148.5, 138.8 (d, $J_{C\text{-}P}$ = 9.4 Hz), 138.6 (d, $J_{C\text{-}P}$ = 2.6 Hz), 136.3 (d, $J_{C\text{-}P}$ = 5.0 Hz), 135.5 (d, $J_{C\text{-}P}$ = 11.9 Hz), 132.3 (d, $J_{C\text{-}P}$ = 105.5 Hz), 132.1 (d, $J_{C\text{-}P}$ = 2.8 Hz), 132.0 (d, $J_{C\text{-}P}$ = 10.0 Hz), 129.3, 129.2 (d, $J_{C\text{-}P}$ = 8.7 Hz), 128.7 (d, $J_{C\text{-}P}$ = 12.3 Hz), 126.8, 122.5, 122.0 (d, $J_{C\text{-}P}$ = 105.6 Hz), 114.0, 114.0 (d, $J_{C\text{-}P}$ = 14.1 Hz), 55.4; ^{31}P NMR (163 MHz, $CDCl_3$) δ 31.7; HRMS (ESI+): calcd for $C_{29}H_{23}N_2O_3P$ [M+H]+: 479.1519, Found: 479.1519.



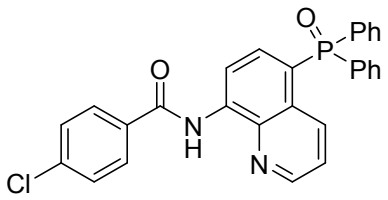
N-(5-(diphenylphosphoryl)quinolin-8-yl)-2-methoxybenzamide (3fa): Light yellow solid (92%); mp 237-238 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 12.56 (s, 1H), 9.06 (d, J = 8.4 Hz, 1H), 8.90 (dd, J = 8.0 Hz, 2.0 Hz, 1H), 8.85 (d, J = 2.9 Hz, 1H), 8.30 (d, J = 7.5 Hz, 1H), 7.70-7.65 (m, 4H), 7.56-7.44 (m, 7H), 8.40 (dd, J = 8.4 Hz, 4.2 Hz, 1H), 7.33 (dd, $J_{H\text{-}P}$ = 15.4 Hz, 8.1 Hz, 1H), 7.10 (t, J = 7.6 Hz, 1H), 7.05 (d, J = 8.4 Hz, 1H), 4.17 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 163.9, 157.7, 148.4, 139.7 (d, $J_{C\text{-}P}$ = 2.8 Hz), 139.3 (d, $J_{C\text{-}P}$ = 9.3 Hz), 136.1 (d, $J_{C\text{-}P}$ = 5.3 Hz), 135.6 (d, $J_{C\text{-}P}$ = 11.6 Hz), 133.5, 132.4 (d, $J_{C\text{-}P}$ = 104.8 Hz), 132.4, 132.0, 131.9, 129.2 (d, $J_{C\text{-}P}$ = 8.5 Hz), 128.6 (d, $J_{C\text{-}P}$ = 12.1 Hz), 122.3, 121.9 (d, $J_{C\text{-}P}$ = 105.6 Hz), 121.8, 121.3, 114.9 (d, $J_{C\text{-}P}$ = 14.4 Hz), 111.6, 56.1; ^{31}P NMR (163 MHz, $CDCl_3$) δ 31.6; HRMS (ESI+): calcd for $C_{29}H_{23}N_2O_3P$ [M+H]+: 479.1519, Found: 479.1521.



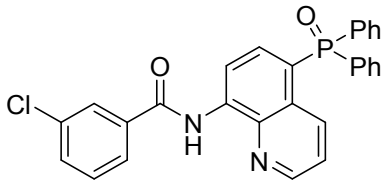
N-(5-(diphenylphosphoryl)quinolin-8-yl)-4-fluorobenzamide (3ga): Light yellow solid (73%); mp 211-212 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.95 (s, 1H), 9.12 (d, J = 8.4 Hz, 1H), 8.88 (d, J = 2.8 Hz, 1H), 8.81 (dd, J = 8.0 Hz, 2.0 Hz, 1H), 8.14-8.10 (m, 2H), 7.74-7.69 (m, 4H), 7.63-7.59 (m, 2H), 7.53-7.47 (m, 5H), 7.38 (dd, $J_{H\text{-}P}$ = 15.0 Hz, 7.9 Hz, 1H), 7.30-7.24 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.2 (d, $J_{C\text{-}F}$ = 253.0 Hz), 164.5, 148.6, 138.8 (d, $J_{C\text{-}P}$ = 9.3 Hz), 138.3 (d, $J_{C\text{-}P}$ = 2.8 Hz), 136.4 (d, $J_{C\text{-}P}$ = 4.8 Hz), 135.4 (d, $J_{C\text{-}P}$ = 11.8 Hz), 132.2 (d, $J_{C\text{-}P}$ = 105.2 Hz), 132.2 (d, $J_{C\text{-}P}$ = 2.5 Hz), 132.0 (d, $J_{C\text{-}P}$ = 10.1 Hz), 130.8 (d, $J_{C\text{-}P}$ = 3.0 Hz), 129.8 (d, $J_{C\text{-}F}$ = 9.2 Hz), 129.2 (d, $J_{C\text{-}P}$ = 8.5 Hz), 128.7 (d, $J_{C\text{-}P}$ = 12.2 Hz), 122.7, 122.6 (d, $J_{C\text{-}P}$ = 105.8 Hz), 116.0 (d, $J_{C\text{-}F}$ = 22.3 Hz), 114.2 (d, $J_{C\text{-}P}$ = 14.2 Hz); ^{31}P NMR (163 MHz, $CDCl_3$) δ 31.7; HRMS (ESI+): calcd for $C_{28}H_{20}FN_2O_2P$ [M+H]+: 467.1319, Found: 467.1323.



N-(5-(diphenylphosphoryl)quinolin-8-yl)-3-fluorobenzamide (3ha): Light yellow solid (77%); mp 202-203 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.95 (s, 1H), 9.09 (d, J = 8.5 Hz, 1H), 8.85 (d, J = 2.9 Hz, 1H), 8.78 (dd, J = 8.0 Hz, 2.0 Hz, 1H), 7.84 (d, J = 7.7 Hz, 1H), 7.77 (d, J = 9.0 Hz, 1H), 7.70-7.65 (m, 4H), 7.59-7.44 (m, 8H), 7.38-7.27 (m, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 164.3 (d, $J_{C\text{-}F}$ = 2.3 Hz), 163.0 (d, $J_{C\text{-}F}$ = 247.9 Hz), 148.7, 138.8 (d, $J_{C\text{-}P}$ = 9.4 Hz), 138.1 (d, $J_{C\text{-}P}$ = 2.9 Hz), 136.8 (d, $J_{C\text{-}F}$ = 6.6 Hz), 136.4 (d, $J_{C\text{-}P}$ = 5.2 Hz), 135.4 (d, $J_{C\text{-}P}$ = 11.8 Hz), 132.2 (d, $J_{C\text{-}P}$ = 105.1 Hz), 132.2 (d, $J_{C\text{-}P}$ = 2.5 Hz), 132.0 (d, $J_{C\text{-}P}$ = 9.9 Hz), 130.5 (d, $J_{C\text{-}F}$ = 7.9 Hz), 129.2 (d, $J_{C\text{-}P}$ = 8.4 Hz), 128.7 (d, $J_{C\text{-}P}$ = 12.2 Hz), 123.0 (d, $J_{C\text{-}P}$ = 105.3 Hz), 122.7 (d, $J_{C\text{-}F}$ = 2.9 Hz), 122.7, 119.2 (d, $J_{C\text{-}F}$ = 21.3 Hz), 114.8 (d, $J_{C\text{-}F}$ = 22.9 Hz), 114.4 (d, $J_{C\text{-}P}$ = 14.4 Hz); ^{31}P NMR (163 MHz, $CDCl_3$) δ 31.6; HRMS (ESI+): calcd for $C_{28}H_{20}FN_2O_2P$ [M+H]+: 467.1319, Found: 467.1323.

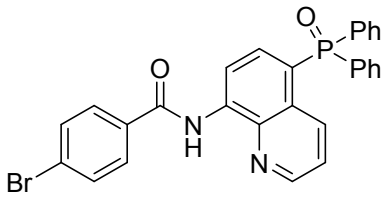


4-chloro-N-(5-(diphenylphosphoryl)quinolin-8-yl)benzamide (3ia): Light yellow solid (72%); mp 248-249 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.92 (s, 1H), 9.08 (d, J = 8.5 Hz, 1H), 8.83 (d, J = 2.9 Hz, 1H), 8.77 (dd, J = 8.0 Hz, 1.9 Hz, 1H), 7.99 (d, J = 8.4 Hz, 2H), 7.70-7.65 (m, 4H), 7.58-7.54 (m, 2H), 7.51-7.42 (m, 7H), 7.34 (dd, $J_{H\text{-}P}$ = 15.4 Hz, 8.0 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 164.5, 148.6, 138.8 (d, $J_{C\text{-}P}$ = 9.5 Hz), 138.5, 138.2 (d, $J_{C\text{-}P}$ = 2.5 Hz), 136.4 (d, $J_{C\text{-}P}$ = 4.9 Hz), 135.4 (d, $J_{C\text{-}P}$ = 11.8 Hz), 132.9, 132.2 (d, $J_{C\text{-}P}$ = 2.5 Hz), 132.1 (d, $J_{C\text{-}P}$ = 105.3 Hz), 132.1, 132.0 (d, $J_{C\text{-}P}$ = 10.0 Hz), 129.1 (d, $J_{C\text{-}P}$ = 7.2 Hz), 129.1, 128.7 (d, $J_{C\text{-}P}$ = 11.0 Hz), 122.7 (d, $J_{C\text{-}P}$ = 105.4 Hz), 122.6, 114.3 (d, $J_{C\text{-}P}$ = 14.5 Hz); ^{31}P NMR (163 MHz, $CDCl_3$) δ 31.8; HRMS (ESI+): calcd for $C_{28}H_{20}ClN_2O_2P$ [M+H]+: 483.1024, Found: 483.1026.

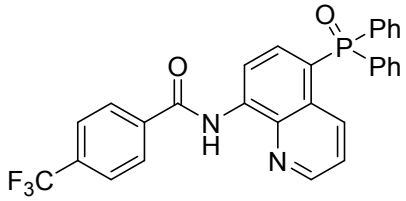


3-chloro-N-(5-(diphenylphosphoryl)quinolin-8-yl)benzamide (3ja): Light yellow solid (79%); mp 195-197 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.92 (s, 1H), 9.08 (d, J = 8.5 Hz, 1H), 8.85 (d, J = 3.1 Hz, 1H), 8.81 (dd, J = 7.9 Hz, 1.8 Hz, 1H), 8.04 (s, 1H), 7.92 (d, J = 7.6 Hz, 1H), 7.70-7.65 (m, 4H), 7.59-7.55 (m, 3H), 7.50-7.43 (m, 6H), 7.35 (dd, $J_{H\text{-}P}$ = 15.0 Hz, 8.0 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 164.2, 148.7, 138.8 (d, $J_{C\text{-}P}$ = 9.6 Hz), 138.1 (d, $J_{C\text{-}P}$ = 2.7 Hz), 136.4 (d, $J_{C\text{-}P}$ = 5.1

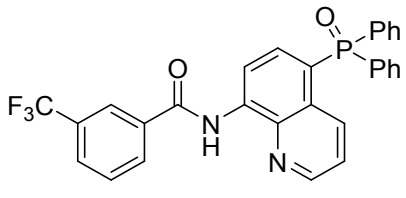
Hz), 136.3, 135.3 (d, $J_{C\text{-}P}$ = 11.9 Hz), 135.1, 132.2, 132.2 (d, $J_{C\text{-}P}$ = 2.6 Hz), 132.1 (d, $J_{C\text{-}P}$ = 105.5 Hz), 132.0 (d, $J_{C\text{-}P}$ = 10.0 Hz), 130.1, 129.2 (d, $J_{C\text{-}P}$ = 8.4 Hz), 128.7 (d, $J_{C\text{-}P}$ = 12.4 Hz), 127.8, 125.2, 122.9 (d, $J_{C\text{-}P}$ = 105.2 Hz), 122.7, 114.4 (d, $J_{C\text{-}P}$ = 14.5 Hz); ^{31}P NMR (163 MHz, $CDCl_3$) δ 31.7; HRMS (ESI+): calcd for $C_{28}H_{20}ClN_2O_2P$ [M+H]+: 483.1024, Found: 483.1024.



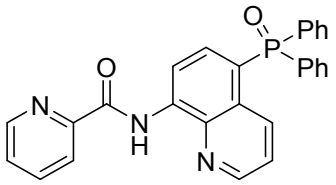
4-bromo-N-(5-(diphenylphosphoryl)quinolin-8-yl)benzamide (3ka): Light yellow solid (62%); mp 247-249 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.93 (s, 1H), 9.09 (d, J = 8.5 Hz, 1H), 8.85 (d, J = 3.9 Hz, 1H), 8.77 (dd, J = 8.1 Hz, 1.9 Hz, 1H), 7.93 (d, J = 8.4 Hz, 2H), 7.70-7.65 (m, 6H), 7.59-7.56 (m, 2H), 7.50-7.43 (m, 5H), 7.35 (dd, $J_{H\text{-}P}$ = 15.2 Hz, 8.0 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 164.7, 148.7, 138.8 (d, $J_{C\text{-}P}$ = 9.4 Hz), 138.2 (d, $J_{C\text{-}P}$ = 2.5 Hz), 136.4 (d, $J_{C\text{-}P}$ = 4.9 Hz), 135.4 (d, $J_{C\text{-}P}$ = 11.8 Hz), 133.4, 132.2 (d, $J_{C\text{-}P}$ = 2.7 Hz), 132.1 (d, $J_{C\text{-}P}$ = 104.4 Hz), 132.1, 132.0 (d, $J_{C\text{-}P}$ = 10.0 Hz), 129.2 (d, $J_{C\text{-}P}$ = 8.2 Hz), 128.9, 128.7 (d, $J_{C\text{-}P}$ = 12.5 Hz), 127.1, 122.8 (d, $J_{C\text{-}P}$ = 105.2 Hz), 122.7, 114.3 (d, $J_{C\text{-}P}$ = 14.6 Hz); ^{31}P NMR (163 MHz, $CDCl_3$) δ 31.7; HRMS (ESI+): calcd for $C_{28}H_{20}BrN_2O_2P$ [M+H]+: 527.0519, Found: 527.0519.



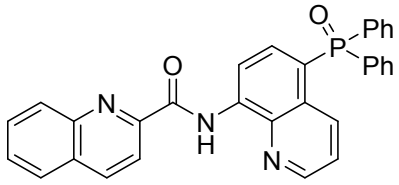
N-(5-(diphenylphosphoryl)quinolin-8-yl)-4-(trifluoromethyl)benzamide (3la): Light yellow solid (68%); mp 226-227 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 11.00 (s, 1H), 9.09 (d, J = 8.5 Hz, 1H), 8.85 (d, J = 3.0 Hz, 1H), 8.79 (dd, J = 8.0 Hz, 1.9 Hz, 1H), 8.18 (d, J = 8.0 Hz, 2H), 7.82 (d, J = 8.0 Hz, 2H), 7.70-7.66 (m, 4H), 7.60-7.56 (m, 2H), 7.50-7.44 (m, 5H), 7.36 (dd, $J_{H\text{-}P}$ = 15.1 Hz, 8.0 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 164.3, 148.8, 138.8 (d, $J_{C\text{-}P}$ = 9.3 Hz), 138.0 (d, $J_{C\text{-}P}$ = 2.8 Hz), 137.8, 136.5 (d, $J_{C\text{-}P}$ = 5.0 Hz), 135.3 (d, $J_{C\text{-}P}$ = 11.9 Hz), 133.8 (q, $J_{C\text{-}F}$ = 33.2 Hz), 132.2 (d, $J_{C\text{-}P}$ = 2.4 Hz), 132.2 (d, $J_{C\text{-}P}$ = 105.5 Hz), 132.0 (d, $J_{C\text{-}P}$ = 10.0 Hz), 129.2 (d, $J_{C\text{-}P}$ = 8.5 Hz), 128.7 (d, $J_{C\text{-}P}$ = 12.3 Hz), 127.8, 126.0 (q, $J_{C\text{-}F}$ = 3.6 Hz), 123.7 (q, $J_{C\text{-}F}$ = 272.9 Hz), 123.2 (d, $J_{C\text{-}P}$ = 105.2 Hz), 122.8, 114.5 (d, $J_{C\text{-}P}$ = 14.5 Hz); ^{31}P NMR (163 MHz, $CDCl_3$) δ 31.7; HRMS (ESI+): calcd for $C_{29}H_{20}F_3N_2O_2P$ [M+H]+: 517.1287, Found: 517.1288.



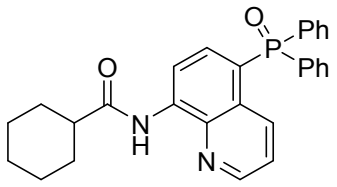
N-(5-(diphenylphosphoryl)quinolin-8-yl)-3-(trifluoromethyl)benzamide (3ma): Light yellow solid (73%); mp 210-211 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 11.00 (s, 1H), 9.09 (d, J = 8.4 Hz, 1H), 8.87 (d, J = 3.1 Hz, 1H), 8.79 (dd, J = 7.9 Hz, 2.0 Hz, 1H), 8.33 (s, 1H), 8.23 (d, J = 7.7 Hz, 1H), 7.85 (d, J = 7.6 Hz, 1H), 7.77-7.66 (m, 5H), 7.60-7.56 (m, 2H), 7.50-7.45 (m, 5H), 7.35 (dd, $J_{H\text{-}P}$ = 15.3 Hz, 8.0 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 164.1, 148.8, 138.8 (d, $J_{C\text{-}P}$ = 9.5 Hz), 138.0 (d, $J_{C\text{-}P}$ = 2.8 Hz), 136.4 (d, $J_{C\text{-}P}$ = 5.2 Hz), 135.4, 135.3 (d, $J_{C\text{-}P}$ = 11.8 Hz), 132.2 (d, $J_{C\text{-}P}$ = 2.6 Hz), 132.1 (d, $J_{C\text{-}P}$ = 105.4 Hz), 132.0 (d, $J_{C\text{-}P}$ = 10.0 Hz), 131.5 (q, $J_{C\text{-}F}$ = 32.7 Hz), 130.2, 129.5, 129.2 (d, $J_{C\text{-}P}$ = 8.5 Hz), 128.7 (d, $J_{C\text{-}P}$ = 12.3 Hz), 128.7, 124.8 (q, $J_{C\text{-}F}$ = 3.8 Hz), 123.8 (q, $J_{C\text{-}F}$ = 272.4 Hz), 123.1 (d, $J_{C\text{-}P}$ = 105.0 Hz), 122.7, 114.4 (d, $J_{C\text{-}P}$ = 14.4 Hz); ^{31}P NMR (163 MHz, $CDCl_3$) δ 31.7; HRMS (ESI+): calcd for $C_{29}H_{20}F_3N_2O_2P$ [M+H]+: 517.1287, Found: 517.1294.



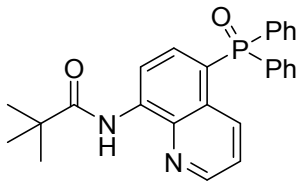
N-(5-(diphenylphosphoryl)quinolin-8-yl)picolinamide (3na): Light yellow solid (55%); mp 213-214 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 12.47 (s, 1H), 9.05 (d, J = 8.4 Hz, 1H), 8.96 (d, J = 2.9 Hz, 1H), 8.87 (dd, J = 7.9 Hz, 2.0 Hz, 1H), 8.78 (d, J = 4.2 Hz, 1H), 8.32 (d, J = 7.8 Hz, 1H), 7.92 (t, J = 7.5 Hz, 1H), 7.71-7.66 (m, 4H), 7.59-7.55 (m, 2H), 7.53-7.43 (m, 6H), 7.35 (dd, $J_{H\text{-}P}$ = 15.5 Hz, 8.0 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 163.1, 150.0, 149.0, 148.6, 139.4 (d, $J_{C\text{-}P}$ = 9.3 Hz), 138.4 (d, $J_{C\text{-}P}$ = 2.5 Hz), 137.5, 136.1 (d, $J_{C\text{-}P}$ = 5.2 Hz), 135.3 (d, $J_{C\text{-}P}$ = 11.7 Hz), 132.3 (d, $J_{C\text{-}P}$ = 105.1 Hz), 132.1 (d, $J_{C\text{-}P}$ = 2.8 Hz), 132.0 (d, $J_{C\text{-}P}$ = 10.0 Hz), 129.3 (d, $J_{C\text{-}P}$ = 8.5 Hz), 128.7 (d, $J_{C\text{-}P}$ = 12.4 Hz), 126.6, 122.7 (d, $J_{C\text{-}P}$ = 105.6 Hz), 122.6, 122.5, 114.4 (d, $J_{C\text{-}P}$ = 14.6 Hz); ^{31}P NMR (163 MHz, $CDCl_3$) δ 31.7; HRMS (ESI+): calcd for $C_{27}H_{20}N_3O_2P$ [M+H]+: 450.1366, Found: 450.1370.



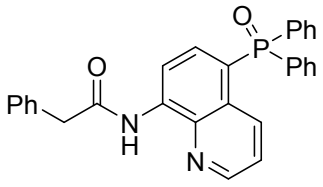
N-(5-(diphenylphosphoryl)quinolin-8-yl)quinoline-2-carboxamide (3oa): Light yellow solid (36%); mp 287-288 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 12.70 (s, 1H), 9.08 (d, J = 8.4 Hz, 1H), 9.01 (d, J = 2.9 Hz, 1H), 8.91 (dd, J = 7.7 Hz, 1.4 Hz, 1H), 8.42-8.36 (m, 3H), 7.91 (d, J = 8.1 Hz, 1H), 7.83 (t, J = 7.3 Hz, 1H), 7.72-7.64 (m, 5H), 7.59-7.56 (m, 2H), 7.50-7.47 (m, 5H), 7.38 (dd, $J_{H\text{-}P}$ = 15.1 Hz, 8.1 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 163.3, 149.8, 149.0, 146.6, 139.5 (d, $J_{C\text{-}P}$ = 9.2 Hz), 138.5 (d, $J_{C\text{-}P}$ = 2.8 Hz), 137.7, 136.1 (d, $J_{C\text{-}P}$ = 5.2 Hz), 135.3 (d, $J_{C\text{-}P}$ = 11.8 Hz), 132.4 (d, $J_{C\text{-}P}$ = 105.4 Hz), 132.1 (d, $J_{C\text{-}P}$ = 3.7 Hz), 132.0 (d, $J_{C\text{-}P}$ = 10.2 Hz), 130.3, 130.2, 129.5, 129.4 (d, $J_{C\text{-}P}$ = 8.6 Hz), 128.7 (d, $J_{C\text{-}P}$ = 12.3 Hz), 128.3, 127.7, 122.7 (d, $J_{C\text{-}P}$ = 105.3 Hz), 122.6, 118.8, 114.4 (d, $J_{C\text{-}P}$ = 14.7 Hz); ^{31}P NMR (163 MHz, $CDCl_3$) δ 31.7; HRMS (ESI+): calcd for $C_{31}H_{22}N_3O_2P$ [M+H]+: 500.1522, Found: 500.1527.



N-(5-(diphenylphosphoryl)quinolin-8-yl)cyclohexanecarboxamide (3pa): Light yellow solid (73%); mp 198-201 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.11 (s, 1H), 9.04 (d, J = 8.4 Hz, 1H), 8.80 (d, J = 3.1 Hz, 1H), 8.65 (dd, J = 8.0 Hz, 2.1 Hz, 1H), 7.67-7.62 (m, 4H), 7.56-7.53 (m, 2H), 7.47-7.39 (m, 5H), 7.27 (dd, $J_{H\text{-}P}$ = 15.8 Hz, 8.1 Hz, 1H) 2.51-2.45 (m, 1H), 2.06 (d, J = 12.0 Hz, 2H), 1.86 (d, J = 12.7 Hz, 2H), 1.72 (d, J = 11.5 Hz, 1H), 1.65-1.56 (m, 2H), 1.42-1.26 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 175.2, 148.4, 138.6 (d, $J_{C\text{-}P}$ = 10.0 Hz), 138.5 (d, $J_{C\text{-}P}$ = 2.9 Hz), 136.3 (d, $J_{C\text{-}P}$ = 5.0 Hz), 135.5 (d, $J_{C\text{-}P}$ = 11.7 Hz), 132.3 (d, $J_{C\text{-}P}$ = 105.1 Hz), 132.1 (d, $J_{C\text{-}P}$ = 2.7 Hz), 132.0 (d, $J_{C\text{-}P}$ = 10.0 Hz), 129.1 (d, $J_{C\text{-}P}$ = 8.4 Hz), 128.3 (d, $J_{C\text{-}P}$ = 12.3 Hz), 122.4, 121.9 (d, $J_{C\text{-}P}$ = 107.3 Hz), 114.1 (d, $J_{C\text{-}P}$ = 14.5 Hz), 46.9, 29.6, 25.6, 25.6; ^{31}P NMR (163 MHz, $CDCl_3$) δ 31.7; HRMS (ESI+): calcd for $C_{28}H_{27}N_2O_2P$ [M+H]+: 455.1883, Found: 455.1886.

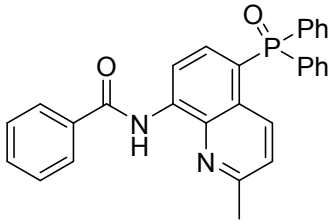


N-(5-(diphenylphosphoryl)quinolin-8-yl)pivalamide (3qa): Light yellow solid (76%); mp 184-186 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.49 (s, 1H), 9.04 (d, J = 8.4 Hz, 1H), 8.80 (d, J = 2.9 Hz, 1H), 8.65 (dd, J = 8.0 Hz, 2.0 Hz, 1H), 7.67-7.62 (m, 4H), 7.57-7.53 (m, 2H), 7.47-7.39 (m, 5H), 7.28 (dd, $J_{H\text{-}P}$ = 15.0 Hz, 8.1 Hz, 1H), 1.41 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 177.6, 148.5, 138.9 (d, $J_{C\text{-}P}$ = 9.5 Hz), 138.5 (d, $J_{C\text{-}P}$ = 2.6 Hz), 136.3 (d, $J_{C\text{-}P}$ = 5.1 Hz), 135.5 (d, $J_{C\text{-}P}$ = 11.8 Hz), 132.3 (d, $J_{C\text{-}P}$ = 105.4 Hz), 132.1 (d, $J_{C\text{-}P}$ = 2.7 Hz), 132.0 (d, $J_{C\text{-}P}$ = 9.9 Hz), 129.1 (d, $J_{C\text{-}P}$ = 8.5 Hz), 128.6 (d, $J_{C\text{-}P}$ = 12.3 Hz), 122.4, 121.8 (d, $J_{C\text{-}P}$ = 105.9 Hz), 113.9 (d, $J_{C\text{-}P}$ = 14.5 Hz), 40.5, 27.6; ^{31}P NMR (163 MHz, $CDCl_3$) δ 31.8; HRMS (ESI+): calcd for $C_{26}H_{25}N_2O_2P$ [M+H]+: 429.1726, Found: 429.1729.

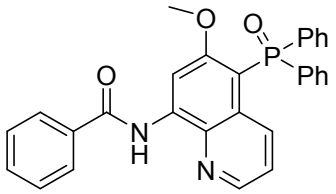


N-(5-(diphenylphosphoryl)quinolin-8-yl)-2-phenylacetamide (3ra): Light yellow solid (78%); mp 203-204 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.12 (s, 1H), 9.00 (d, J = 8.4 Hz, 1H), 8.66 (d, J = 3.0 Hz, 1H), 8.65 (dd, J = 8.0 Hz, 1.8 Hz, 1H), 7.65-7.60 (m, 4H), 7.56-7.53 (m, 2H), 7.47-7.40 (m, 8H), 7.37-7.32 (m, 2H), 7.26 (dd, $J_{H\text{-}P}$ = 15.0 Hz, 8.4 Hz, 1H), 3.89 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 169.9, 148.4, 138.5 (d, $J_{C\text{-}P}$ = 9.6 Hz), 138.2 (d, $J_{C\text{-}P}$ = 2.7 Hz), 136.1 (d, $J_{C\text{-}P}$ = 5.0

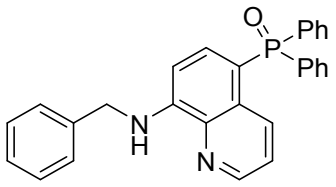
Hz), 135.3 (d, $J_{C\text{-}P}$ = 11.7 Hz), 134.2, 132.2 (d, $J_{C\text{-}P}$ = 105.3 Hz), 132.1 (d, $J_{C\text{-}P}$ = 2.6 Hz), 132.0 (d, $J_{C\text{-}P}$ = 9.8 Hz), 129.5, 129.0, 129.0 (d, $J_{C\text{-}P}$ = 7.8 Hz), 128.6 (d, $J_{C\text{-}P}$ = 12.2 Hz), 127.5, 122.4 (d, $J_{C\text{-}P}$ = 105.5 Hz), 122.4, 114.0 (d, $J_{C\text{-}P}$ = 14.5 Hz), 45.4; ^{31}P NMR (163 MHz, $CDCl_3$) δ 31.6; HRMS (ESI+): calcd for $C_{29}H_{23}N_2O_2P$ [M+H]+: 463.1570, Found: 463.1572.



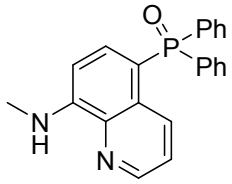
N-(5-(diphenylphosphoryl)-2-methylquinolin-8-yl)benzamide (3sa): Light yellow solid (82%); mp 213-214 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 11.05 (s, 1H), 8.95 (d, J = 8.7 Hz, 1H), 8.78 (dd, J = 8.0 Hz, 2.0 Hz, 1H), 8.08 (d, J = 6.9 Hz, 2H), 7.71-7.66 (m, 4H), 7.62-7.55 (m, 5H), 7.50-7.47 (m, 4H), 7.33-7.27 (m, 2H), 2.75 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.6, 157.7, 138.3 (d, $J_{C\text{-}P}$ = 9.6 Hz), 137.8 (d, $J_{C\text{-}P}$ = 2.7 Hz), 136.2 (d, $J_{C\text{-}P}$ = 4.8 Hz), 134.7, 134.4 (d, $J_{C\text{-}P}$ = 11.8 Hz), 132.4 (d, $J_{C\text{-}P}$ = 104.7 Hz), 132.1 (d, $J_{C\text{-}P}$ = 5.1 Hz), 132.1, 132.0 (d, $J_{C\text{-}P}$ = 9.8 Hz), 128.9, 128.6 (d, $J_{C\text{-}P}$ = 12.3 Hz), 127.3 (d, $J_{C\text{-}P}$ = 10.7 Hz), 127.3, 123.4, 122.2 (d, $J_{C\text{-}P}$ = 105.6 Hz), 114.2 (d, $J_{C\text{-}P}$ = 14.4 Hz), 25.3; ^{31}P NMR (163 MHz, $CDCl_3$) δ 31.6; HRMS (ESI+): calcd for $C_{29}H_{23}N_2O_2P$ [M+H]+: 463.1570, Found: 463.1573.



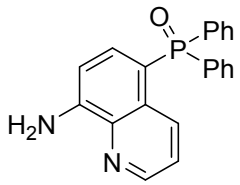
N-(5-(diphenylphosphoryl)-6-methoxyquinolin-8-yl)benzamide (3ta): Light yellow solid (95%); mp 226-228 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 11.13 (s, 1H), 10.07 (d, J = 8.6 Hz, 1H), 8.77 (d, J = 5.0 Hz, 1H), 8.73 (d, J = 2.8 Hz, 1H), 8.08 (d, J = 6.9 Hz, 2H), 7.78-7.73 (m, 4H), 7.61-7.55 (m, 3H), 7.52-7.43 (m, 7H), 3.42 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.9, 160.8 (d, $J_{C\text{-}P}$ = 3.1 Hz), 146.2, 140.4 (d, $J_{C\text{-}P}$ = 2.7 Hz), 134.0 (d, $J_{C\text{-}P}$ = 108.7 Hz), 135.4 (d, $J_{C\text{-}P}$ = 3.1 Hz), 134.9 (d, $J_{C\text{-}P}$ = 9.3 Hz), 134.4, 132.3, 132.1 (d, $J_{C\text{-}P}$ = 6.3 Hz), 131.3 (d, $J_{C\text{-}P}$ = 8.1 Hz), 131.2, 128.9, 128.1 (d, $J_{C\text{-}P}$ = 12.7 Hz), 127.3, 123.0, 104.6 (d, $J_{C\text{-}P}$ = 105.9 Hz), 103.3 (d, $J_{C\text{-}P}$ = 7.1 Hz), 55.6; ^{31}P NMR (163 MHz, $CDCl_3$) δ 32.2; HRMS (ESI+): calcd for $C_{29}H_{23}N_2O_3P$ [M+H]+: 479.1519, Found: 479.1524.



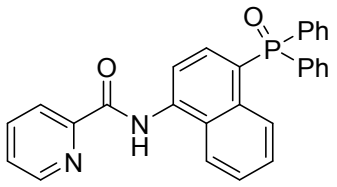
(8-(benzylamino)quinolin-5-yl)diphenylphosphine oxide (3va): Light yellow solid (81%); mp 42-43 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.82 (d, J = 8.3 Hz, 1H), 8.68 (d, J = 2.9 Hz, 1H), 7.67-7.63 (m, 4H), 7.53-7.50 (m, 2H), 7.44-7.28 (m, 10H), 8.19 (d, J = 5.1 Hz, 1H), 7.05 (dd, $J_{H\text{-}P}$ = 15.2 Hz, 8.1 Hz, 1H), 6.43 (dd, J = 8.1 Hz, 1.7 Hz, 1H), 4.55 (d, J = 5.7 Hz, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 147.9 (d, $J_{C\text{-}P}$ = 1.7 Hz), 147.1, 138.2 (d, $J_{C\text{-}P}$ = 9.8 Hz), 138.1, 136.5 (d, $J_{C\text{-}P}$ = 12.5 Hz), 135.8 (d, $J_{C\text{-}P}$ = 5.4 Hz), 133.1 (d, $J_{C\text{-}P}$ = 104.8 Hz), 132.0 (d, $J_{C\text{-}P}$ = 9.8 Hz), 131.7 (d, $J_{C\text{-}P}$ = 2.4 Hz), 129.7 (d, $J_{C\text{-}P}$ = 9.0 Hz), 128.7, 128.4 (d, $J_{C\text{-}P}$ = 12.2 Hz), 127.4, 127.2, 122.4, 112.5 (d, $J_{C\text{-}P}$ = 113.1 Hz), 102.7 (d, $J_{C\text{-}P}$ = 15.5 Hz), 47.1; ^{31}P NMR (163 MHz, $CDCl_3$) δ 32.4; HRMS (ESI+): calcd for $C_{28}H_{23}N_2OP$ [M+H]+: 435.1621, Found: 435.1627.



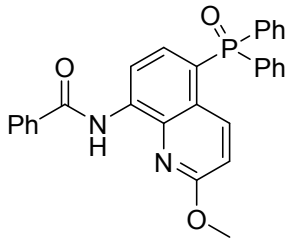
(8-(methylamino)quinolin-5-yl)diphenylphosphine oxide (3wa): Light yellow solid (52%); mp 215-216 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.83 (d, J = 8.5 Hz, 1H), 8.66 (d, J = 4.0 Hz, 1H), 7.69-7.64 (m, 4H), 7.54-7.50 (m, 2H), 7.46-7.42 (m, 4H), 7.30 (dd, J = 8.6 Hz, 4.2 Hz, 1H), 7.14 (dd, $J_{H\text{-}P}$ = 15.1 Hz, 8.1 Hz, 1H), 6.73 (s, 1H), 6.44 (dd, J = 8.1 Hz, 2.4 Hz, 1H), 3.03 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 149.1 (d, $J_{C\text{-}P}$ = 2.0 Hz), 147.0, 138.2 (d, $J_{C\text{-}P}$ = 9.8 Hz), 136.6 (d, $J_{C\text{-}P}$ = 12.5 Hz), 135.8 (d, $J_{C\text{-}P}$ = 5.3 Hz), 133.4 (d, $J_{C\text{-}P}$ = 105.0 Hz), 132.1 (d, $J_{C\text{-}P}$ = 10.0 Hz), 131.6 (d, $J_{C\text{-}P}$ = 2.7 Hz), 129.7 (d, $J_{C\text{-}P}$ = 8.9 Hz), 128.4 (d, $J_{C\text{-}P}$ = 12.2 Hz), 122.4, 111.9 (d, $J_{C\text{-}P}$ = 113.5 Hz), 101.6 (d, $J_{C\text{-}P}$ = 15.5 Hz), 29.5; ^{31}P NMR (163 MHz, $CDCl_3$) δ 32.0; HRMS (ESI+): calcd for $C_{22}H_{19}N_2OP$ [M+H]+: 359.1308, Found: 359.1310.



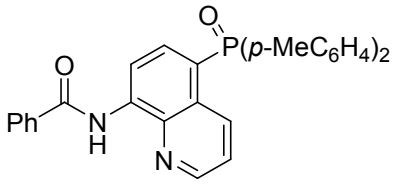
(8-aminoquinolin-5-yl)diphenylphosphine oxide (3xa): Light yellow solid (34%); mp 240-242 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.82 (d, J = 8.4 Hz, 1H), 8.69 (d, J = 2.9 Hz, 1H), 7.67-7.62 (m, 4H), 7.53-7.49 (m, 2H), 7.44-7.41 (m, 4H), 7.28 (dd, J = 8.5 Hz, 4.0 Hz, 1H), 7.04 (dd, $J_{H\text{-}P}$ = 15.0 Hz, 7.9 Hz, 1H), 6.68 (dd, J = 7.9 Hz, 2.1 Hz, 1H), 5.54 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 148.3 (d, $J_{C\text{-}P}$ = 2.2 Hz), 147.5, 138.2 (d, $J_{C\text{-}P}$ = 9.9 Hz), 135.9 (d, $J_{C\text{-}P}$ = 12.5 Hz), 135.6 (d, $J_{C\text{-}P}$ = 5.4 Hz), 133.1 (d, $J_{C\text{-}P}$ = 104.9 Hz), 132.0 (d, $J_{C\text{-}P}$ = 9.8 Hz), 131.7 (d, $J_{C\text{-}P}$ = 2.5 Hz), 130.1 (d, $J_{C\text{-}P}$ = 8.8 Hz), 128.5 (d, $J_{C\text{-}P}$ = 12.2 Hz), 122.3, 114.2 (d, $J_{C\text{-}P}$ = 111.7 Hz), 107.0 (d, $J_{C\text{-}P}$ = 15.4 Hz); ^{31}P NMR (163 MHz, $CDCl_3$) δ 31.8; HRMS (ESI+): calcd for $C_{21}H_{17}N_2OP$ [M+H]+: 344.1151, Found: 344.1158.



N-(4-(diphenylphosphoryl)naphthalen-1-yl)picolinamide (3ya): Light yellow solid (86%); mp 252-253 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 11.06 (s, 1H), 8.74-8.70 (m, 2H), 8.44 (dd, J = 8.0 Hz, 1.9 Hz, 1H), 8.33 (d, J = 7.8 Hz, 1H), 8.16 (d, J = 8.5 Hz, 1H), 7.96-7.92 (m, 1H), 7.72-7.67 (m, 4H), 7.61 (t, J = 7.5 Hz, 1H), 7.56-7.51 (m, 3H), 7.48-7.44 (m, 5H), 7.34 (dd, $J_{H\text{-}P}$ = 15.6 Hz, 8.0 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 162.2, 149.5, 148.2, 137.8, 136.7 (d, $J_{C\text{-}P}$ = 3.0 Hz), 134.6, 134.6 (d, $J_{C\text{-}P}$ = 12.6 Hz), 132.7 (d, $J_{C\text{-}P}$ = 105.4 Hz), 132.1 (d, $J_{C\text{-}P}$ = 9.8 Hz), 131.9 (d, $J_{C\text{-}P}$ = 2.7 Hz), 128.6, 128.5 (d, $J_{C\text{-}P}$ = 12.0 Hz), 127.4, 126.8 (d, $J_{C\text{-}P}$ = 6.7 Hz), 126.0 (d, $J_{C\text{-}P}$ = 9.4 Hz), 124.6 (d, $J_{C\text{-}P}$ = 105.5 Hz), 122.6, 120.5, 115.3 (d, $J_{C\text{-}P}$ = 14.3 Hz); ^{31}P NMR (163 MHz, $CDCl_3$) δ 32.5; HRMS (ESI+): calcd for $C_{28}H_{21}N_2O_2P$ [M+H]+: 449.1413, Found: 449.1415.

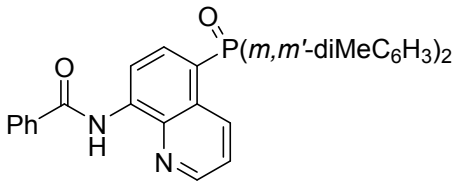


N-(5-(diphenylphosphoryl)-2-methoxyquinolin-8-yl)benzamide (3za): Light yellow solid; mp 288-290 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.58 (s, 1H), 8.96 (d, J = 9.2 Hz, 1H), 8.76 (dd, J = 8.2 Hz, 2.6 Hz, 1H), 8.05-8.03 (m, 2H), 7.69-7.64 (m, 4H), 7.61-7.52 (m, 5H), 7.49-7.45 (m, 4H), 7.18 (dd, J = 15.2 Hz, 8.1 Hz, 1H), 6.94 (d, J = 9.2 Hz, 1H), 4.12 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.3, 161.4, 139.1 (d, $J_{C\text{-}P}$ = 5.0 Hz), 136.9 (d, $J_{C\text{-}P}$ = 10.3 Hz), 136.8 (d, $J_{C\text{-}P}$ = 2.9 Hz), 134.8, 132.5 (d, $J_{C\text{-}P}$ = 98.7 Hz), 132.3 (d, $J_{C\text{-}P}$ = 11.8 Hz), 132.1 (d, $J_{C\text{-}P}$ = 10.3 Hz), 132.0 (d, $J_{C\text{-}P}$ = 9.7 Hz), 129.0, 128.6 (d, $J_{C\text{-}P}$ = 12.1 Hz), 127.0, 125.9, 125.8, 122.6 (d, $J_{C\text{-}P}$ = 105.1 Hz), 115.0 (d, $J_{C\text{-}P}$ = 14.6 Hz), 114.3, 53.3; ^{31}P NMR (163 MHz, $CDCl_3$) δ 31.7; HRMS (ESI+): calcd for $C_{29}H_{23}N_2O_3P$ [M+H]+: 479.1519, Found: 479.1523.

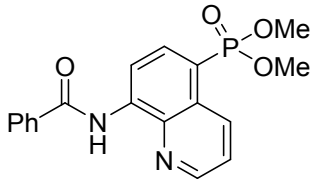


N-(5-(di-p-tolylphosphoryl)quinolin-8-yl)benzamide (3ab): Light yellow solid (79%); mp 242-243 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.97 (s, 1H), 9.10 (d, J = 8.5 Hz, 1H), 8.85-8.80 (m, 2H), 8.08 (d, J = 7.3 Hz, 2H), 7.60-7.53 (m, 7H), 7.44 (dd, J = 8.5 Hz, 4.1 Hz, 1H), 7.36 (dd, $J_{H\text{-}P}$ = 15.3 Hz, 8.0 Hz, 1H), 7.28 (d, J = 7.5 Hz, 4H), 2.42 (s, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.7, 148.5, 142.6 (d, $J_{C\text{-}P}$ = 2.7 Hz), 138.8 (d, $J_{C\text{-}P}$ = 9.3 Hz), 138.2 (d, $J_{C\text{-}P}$ = 2.7 Hz), 136.5 (d, $J_{C\text{-}P}$ =

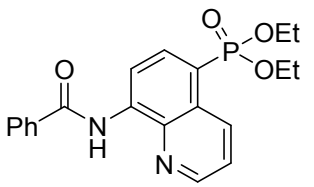
5.0 Hz), 135.3 (d, $J_{C\text{-}P}$ = 11.7 Hz), 134.6, 132.2, 132.0 (d, $J_{C\text{-}P}$ = 10.2 Hz), 129.4 (d, $J_{C\text{-}P}$ = 12.8 Hz), 129.2 (d, $J_{C\text{-}P}$ = 8.5 Hz), 129.2 (d, $J_{C\text{-}P}$ = 107.9 Hz), 128.8, 127.3, 123.1 (d, $J_{C\text{-}P}$ = 105.2 Hz), 122.5, 114.2 (d, $J_{C\text{-}P}$ = 14.6 Hz), 21.6; ^{31}P NMR (163 MHz, $CDCl_3$) δ 32.0; HRMS (ESI+): calcd for $C_{30}H_{25}N_2O_2P$ [M+H]+: 477.1726, Found: 477.1732.



N-(5-(bis(3,5-dimethylphenyl)phosphoryl)quinolin-8-yl)benzamide (3ac): Light yellow solid (60%); mp 167-168 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.97 (s, 1H), 9.08 (d, J = 8.5 Hz, 1H), 8.85-8.80 (m, 2H), 8.08 (d, J = 6.9 Hz, 2H), 7.62-7.54 (m, 3H), 7.45 (dd, J = 8.5 Hz, 4.2 Hz, 1H), 7.37 (dd, $J_{H\text{-}P}$ = 15.5 Hz, 8.0 Hz, 1H), 7.28 (d, J = 12.1 Hz, 4H), 7.18 (s, 2H), 2.31 (s, 12H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.7, 148.5, 138.8 (d, $J_{C\text{-}P}$ = 9.4 Hz), 138.3 (d, $J_{C\text{-}P}$ = 12.9 Hz), 138.2 (d, $J_{C\text{-}P}$ = 2.8 Hz), 136.5 (d, $J_{C\text{-}P}$ = 5.0 Hz), 135.4 (d, $J_{C\text{-}P}$ = 11.9 Hz), 134.6, 133.9 (d, $J_{C\text{-}P}$ = 2.6 Hz), 132.2, 132.0 (d, $J_{C\text{-}P}$ = 104.5 Hz), 129.5 (d, $J_{C\text{-}P}$ = 9.9 Hz), 129.2 (d, $J_{C\text{-}P}$ = 8.4 Hz), 128.9, 127.3, 123.0 (d, $J_{C\text{-}P}$ = 103.2 Hz), 122.5, 114.3 (d, $J_{C\text{-}P}$ = 14.5 Hz), 21.3; ^{31}P NMR (163 MHz, $CDCl_3$) δ 32.3; HRMS (ESI+): calcd for $C_{32}H_{29}N_2O_2P$ [M+H]+: 505.2039, Found: 505.2047.

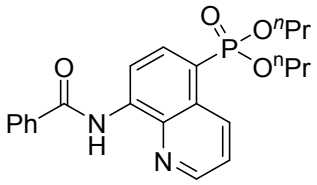


dimethyl (8-benzamidoquinolin-5-yl)phosphonate (3ae): Light yellow solid (45%); mp 150-151 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.99 (s, 1H), 8.97-8.87 (m, 3H), 8.26 (dd, $J_{H\text{-}P}$ = 15.9 Hz, 8.1 Hz, 1H), 8.08 (d, J = 7.0 Hz, 2H), 7.62-7.54 (m, 4H), 3.81 (s, 3H), 3.78 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.7, 148.5, 139.0 (d, $J_{C\text{-}P}$ = 3.5 Hz), 138.5 (d, $J_{C\text{-}P}$ = 13.7 Hz), 136.5 (d, $J_{C\text{-}P}$ = 8.8 Hz), 135.5 (d, $J_{C\text{-}P}$ = 3.6 Hz), 134.5, 132.2, 128.9, 128.1 (d, $J_{C\text{-}P}$ = 11.7 Hz), 127.3, 122.9, 116.5 (d, $J_{C\text{-}P}$ = 190.4 Hz), 114.6 (d, $J_{C\text{-}P}$ = 16.6 Hz), 52.8 (d, $J_{C\text{-}P}$ = 5.4 Hz); ^{31}P NMR (163 MHz, $CDCl_3$) δ 20.7; HRMS (ESI+): calcd for $C_{18}H_{17}N_2O_4P$ [M+H]+: 357.0999, Found: 385.1009.

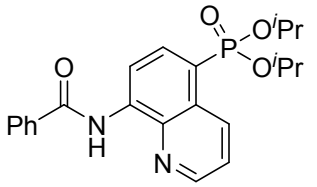


dimethyl (8-benzamidoquinolin-5-yl)phosphonate (3af): Light yellow solid (47%); mp 82-84 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.99 (s, 1H), 8.99-8.90 (m, 3H), 8.28 (dd, $J_{H\text{-}P}$ = 15.9 Hz, 8.0 Hz, 1H), 8.09 (d, J = 7.0 Hz, 2H), 7.62-7.55(m, 4H), 4.26-4.06 (m, 4H), 1.31 (d, J = 7.0 Hz, 6H);

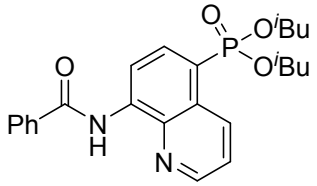
^{13}C NMR (100 MHz, $CDCl_3$) δ 165.7, 148.4, 138.8 (d, $J_{C\text{-}P}$ = 3.4 Hz), 138.5 (d, $J_{C\text{-}P}$ = 13.4 Hz), 136.2 (d, $J_{C\text{-}P}$ = 9.1 Hz), 135.7 (d, $J_{C\text{-}P}$ = 3.6 Hz), 134.6, 132.2, 128.9, 128.1 (d, $J_{C\text{-}P}$ = 11.6 Hz), 127.4, 122.7, 118.1 (d, $J_{C\text{-}P}$ = 188.6 Hz), 114.7 (d, $J_{C\text{-}P}$ = 16.5 Hz), 62.3 (d, $J_{C\text{-}P}$ = 5.3 Hz), 16.3 (d, $J_{C\text{-}P}$ = 6.5 Hz); ^{31}P NMR (163 MHz, $CDCl_3$) δ 17.6; HRMS (ESI+): calcd for $C_{20}H_{21}N_2O_4P$ [M+H]+: 385.1312, Found: 385.1318.



dipropyl (8-benzamidoquinolin-5-yl)phosphonate (3ag): Light yellow solid (40%); mp 141-142 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.98 (s, 1H), 8.98-8.89 (m, 3H), 8.28 (dd, $J_{H\text{-}P}$ = 15.9 Hz, 8.0 Hz, 1H), 8.08 (d, J = 6.9 Hz, 2H), 7.61-7.54 (m, 4H), 4.13-4.05 (m, 2H), 4.02-3.94 (m, 2H), 1.72-1.64 (m, 4H), 0.91 (t, J = 7.4 Hz, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.7, 148.4, 138.7 (d, $J_{C\text{-}P}$ = 3.6 Hz), 138.5 (d, $J_{C\text{-}P}$ = 13.4 Hz), 136.2 (d, $J_{C\text{-}P}$ = 8.8 Hz), 135.7 (d, $J_{C\text{-}P}$ = 3.6 Hz), 134.6, 132.2, 128.9, 128.1 (d, $J_{C\text{-}P}$ = 11.7 Hz), 127.3, 122.7, 118.1 (d, $J_{C\text{-}P}$ = 189.5 Hz), 114.7 (d, $J_{C\text{-}P}$ = 16.5 Hz), 67.8 (d, $J_{C\text{-}P}$ = 5.6 Hz), 23.7 (d, $J_{C\text{-}P}$ = 6.7 Hz), 10.1; ^{31}P NMR (163 MHz, $CDCl_3$) δ 17.8; HRMS (ESI+): calcd for $C_{22}H_{25}N_2O_4P$ [M+H]+: 413.1625, Found: 413.1621.

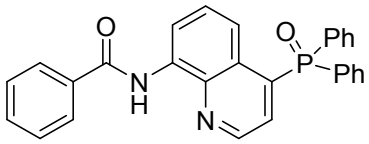


diisopropyl (8-benzamidoquinolin-5-yl)phosphonate (3ah): Light yellow solid (44%); mp 76-77 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.98 (s, 1H), 8.98-8.89 (m, 3H), 8.31 (dd, $J_{H\text{-}P}$ = 15.7 Hz, 8.0 Hz, 1H), 8.09 (d, J = 6.9 Hz, 2H), 7.61-7.55 (m, 4H), 4.78-4.69 (m, 2H), 1.40 (d, J = 6.1 Hz, 6H), 1.17 (d, J = 6.2 Hz, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.7, 148.4, 138.6 (d, $J_{C\text{-}P}$ = 13.2 Hz), 138.5 (d, $J_{C\text{-}P}$ = 3.6 Hz), 136.1 (d, $J_{C\text{-}P}$ = 9.2 Hz), 135.9 (d, $J_{C\text{-}P}$ = 3.6 Hz), 134.7, 132.2, 128.9, 128.0 (d, $J_{C\text{-}P}$ = 11.5 Hz), 127.4, 122.5, 119.7 (d, $J_{C\text{-}P}$ = 189.1 Hz), 114.7 (d, $J_{C\text{-}P}$ = 16.6 Hz), 71.6 (d, $J_{C\text{-}P}$ = 5.5 Hz), 24.1 (d, $J_{C\text{-}P}$ = 3.9 Hz), 23.8 (d, $J_{C\text{-}P}$ = 4.9 Hz); ^{31}P NMR (163 MHz, $CDCl_3$) δ 15.2; HRMS (ESI+): calcd for $C_{22}H_{25}N_2O_4P$ [M+H]+: 413.1625, Found: 413.1629.

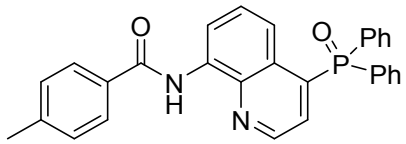


diisobutyl (8-benzamidoquinolin-5-yl)phosphonate (3ai): Light yellow solid (42%); mp 39-40 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.98 (s, 1H), 8.98-8.89 (m, 3H), 8.28 (dd, $J_{H\text{-}P}$ = 15.8 Hz, 8.1

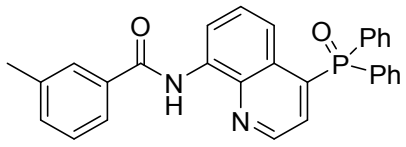
Hz, 1H), 8.08 (d, J = 7.0 Hz, 2H), 7.60-7.54 (m, 4H), 3.93-3.88 (m, 2H), 3.81-3.75 (m, 2H), 1.98-1.89 (m, 2H), 0.91 (s, 6H), 0.89 (s, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.7, 148.4, 138.7 (d, J_{C-P} = 3.7 Hz), 138.5 (d, J_{C-P} = 13.4 Hz), 136.1 (d, J_{C-P} = 9.7 Hz), 135.7 (d, J_{C-P} = 3.6 Hz), 134.6, 132.2, 128.9, 128.1 (d, J_{C-P} = 11.5 Hz), 127.3, 122.6, 118.1 (d, J_{C-P} = 189.8 Hz), 114.7 (d, J_{C-P} = 16.8 Hz), 72.2 (d, J_{C-P} = 5.9 Hz), 29.1 (d, J_{C-P} = 6.9 Hz), 18.7; ^{31}P NMR (163 MHz, $CDCl_3$) δ 17.7; HRMS (ESI+): calcd for $C_{24}H_{29}N_2O_4P$ [M+H]+: 441.1938, Found: 441.1944.



N-(4-(diphenylphosphoryl)quinolin-8-yl)benzamide (4aa): Light yellow solid (70%); mp 196-198 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.75 (s, 1H), 8.95 (d, J = 7.7 Hz, 1H), 8.83 (t, J = 3.8 Hz, 1H), 8.18 (d, J = 8.5 Hz, 1H), 8.06 (d, J = 6.9 Hz, 2H), 7.71-7.66 (m, 4H), 7.62-7.49 (m, 10H), 7.25 (dd, J_{H-P} = 14.1 Hz, 4.4 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.4, 146.8 (d, J_{C-P} = 11.8 Hz), 144.6 (d, J_{C-P} = 2.2 Hz), 139.2 (d, J_{C-P} = 94.3 Hz), 139.0 (d, J_{C-P} = 7.7 Hz), 135.2 (d, J_{C-P} = 2.3 Hz), 135.0, 132.5 (d, J_{C-P} = 2.6 Hz), 131.9 (d, J_{C-P} = 10.0 Hz), 131.9, 131.1 (d, J_{C-P} = 105.4 Hz), 128.9, 128.9 (d, J_{C-P} = 13.7 Hz), 127.6 (d, J_{C-P} = 7.0 Hz), 127.2, 126.6 (d, J_{C-P} = 9.4 Hz), 121.4 (d, J_{C-P} = 5.5 Hz), 117.2; ^{31}P NMR (163 MHz, $CDCl_3$) δ 30.2; HRMS (ESI+): calcd for $C_{29}H_{23}N_2O_2P$ [M+H]+: 449.1413, Found: 449.1416.

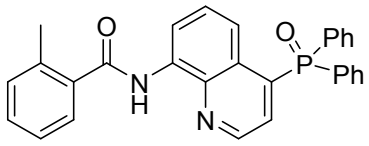


N-(4-(diphenylphosphoryl)quinolin-8-yl)-4-methylbenzamide (4ba): Light yellow solid (62%); mp 187-189 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.71 (s, 1H), 8.93 (d, J = 7.7 Hz, 1H), 8.83 (t, J = 3.9 Hz, 1H), 8.16 (d, J = 8.4 Hz, 1H), 7.95 (d, J = 7.9 Hz, 2H), 7.71-7.66 (m, 4H), 7.61-7.58 (m, 2H), 7.54-7.48 (m, 5H), 7.33 (d, J = 7.9 Hz, 2H), 7.25 (dd, J_{H-P} = 14.0 Hz, 4.7 Hz, 1H), 2.43 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.4, 146.7 (d, J_{C-P} = 11.7 Hz), 142.4, 139.1 (d, J_{C-P} = 94.5 Hz), 139.0 (d, J_{C-P} = 7.8 Hz), 135.3 (d, J_{C-P} = 2.2 Hz), 132.5 (d, J_{C-P} = 2.7 Hz), 132.1, 131.9 (d, J_{C-P} = 10.0 Hz), 131.1 (d, J_{C-P} = 105.5 Hz), 129.4, 128.9, 128.8 (d, J_{C-P} = 12.3 Hz), 127.6 (d, J_{C-P} = 7.2 Hz), 127.2, 126.6 (d, J_{C-P} = 9.5 Hz), 121.2 (d, J_{C-P} = 5.5 Hz), 117.1, 21.5; ^{31}P NMR (163 MHz, $CDCl_3$) δ 30.3; HRMS (ESI+): calcd for $C_{28}H_{21}N_2O_2P$ [M+H]+: 463.1570, Found: 463.1576.

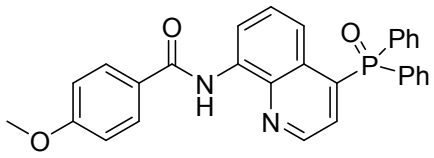


N-(4-(diphenylphosphoryl)quinolin-8-yl)-3-methylbenzamide (4ca): Light yellow solid (60%); mp 153-155 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.70 (s, 1H), 8.94 (d, J = 7.7 Hz, 1H), 8.84 (t, J =

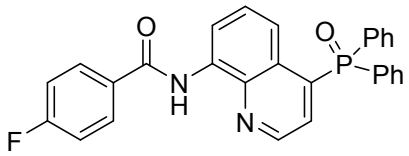
3.8 Hz, 1H), 8.17 (d, J = 8.3 Hz, 1H), 7.87-7.83 (m, 2H), 7.71-7.66 (m, 4H), 7.62-7.58 (m, 2H), 7.55-7.49 (m, 5H), 7.44-7.37 (m, 2H), 7.25 (dd, $J_{H\text{-}P}$ = 14.6 Hz, 4.2 Hz, 1H), 2.47 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.6, 146.7 (d, $J_{C\text{-}P}$ = 11.8 Hz), 139.1 (d, $J_{C\text{-}P}$ = 94.7 Hz), 139.0 (d, $J_{C\text{-}P}$ = 7.8 Hz), 138.7, 135.2 (d, $J_{C\text{-}P}$ = 2.0 Hz), 135.0, 132.7, 132.6 (d, $J_{C\text{-}P}$ = 2.5 Hz), 131.9 (d, $J_{C\text{-}P}$ = 10.1 Hz), 131.1 (d, $J_{C\text{-}P}$ = 105.8 Hz), 128.9 (d, $J_{C\text{-}P}$ = 12.6 Hz), 128.6, 128.0, 127.6 (d, $J_{C\text{-}P}$ = 7.1 Hz), 127.2, 126.6 (d, $J_{C\text{-}P}$ = 9.5 Hz), 124.1, 121.3 (d, $J_{C\text{-}P}$ = 5.6 Hz), 117.2, 21.4; ^{31}P NMR (163 MHz, $CDCl_3$) δ 30.3; HRMS (ESI+): calcd for $C_{28}H_{21}N_2O_2P$ [M+H]+: 463.1570, Found: 463.1571.



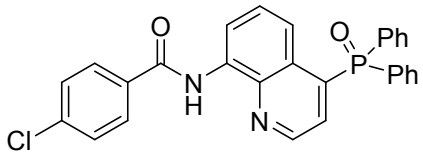
N-(4-(diphenylphosphoryl)quinolin-8-yl)-2-methylbenzamide (4da): Light yellow solid (67%); mp 193-196 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.21 (s, 1H), 8.94 (d, J = 7.6 Hz, 1H), 8.76 (t, J = 3.8 Hz, 1H), 8.19 (d, J = 8.6 Hz, 1H), 7.70-7.66 (m, 5H), 7.62-7.58 (m, 2H), 7.56-7.48 (m, 5H), 7.40 (t, J = 6.4 Hz, 1H), 7.31 (t, J = 6.8 Hz, 2H), 7.23 (dd, $J_{H\text{-}P}$ = 14.7 Hz, 4.4 Hz, 1H), 2.59 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 168.1, 146.7 (d, $J_{C\text{-}P}$ = 11.7 Hz), 139.1 (d, $J_{C\text{-}P}$ = 94.6 Hz), 138.8 (d, $J_{C\text{-}P}$ = 7.6 Hz), 136.7, 136.4, 135.3 (d, $J_{C\text{-}P}$ = 2.3 Hz), 132.5 (d, $J_{C\text{-}P}$ = 2.6 Hz), 131.9 (d, $J_{C\text{-}P}$ = 10.1 Hz), 131.4, 131.1 (d, $J_{C\text{-}P}$ = 105.6 Hz), 130.4, 128.9 (d, $J_{C\text{-}P}$ = 12.5 Hz), 128.8, 127.6 (d, $J_{C\text{-}P}$ = 7.2 Hz), 127.2, 126.6 (d, $J_{C\text{-}P}$ = 9.8 Hz), 126.0, 121.4 (d, $J_{C\text{-}P}$ = 5.6 Hz), 117.1, 20.2; ^{31}P NMR (163 MHz, $CDCl_3$) δ 30.3; HRMS (ESI+): calcd for $C_{28}H_{21}N_2O_2P$ [M+H]+: 463.1570, Found: 463.1572.



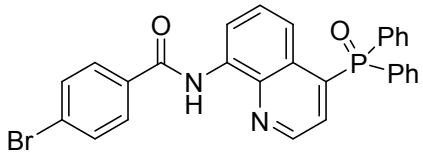
N-(4-(diphenylphosphoryl)quinolin-8-yl)-4-methoxybenzamide (4ea): Light yellow solid (65%); mp 167-168 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.67 (s, 1H), 8.92 (d, J = 7.6 Hz, 1H), 8.83 (t, J = 3.8 Hz, 1H), 8.15 (d, J = 8.4 Hz, 1H), 8.03 (d, J = 8.6 Hz, 2H), 7.71-7.66 (m, 4H), 7.62-7.58 (m, 2H), 7.54-7.48 (m, 5H), 7.25 (dd, $J_{H\text{-}P}$ = 14.6 Hz, 4.4 Hz, 1H), 7.02 (d, J = 8.7 Hz, 2H), 3.88 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 164.9, 162.6, 146.6 (d, $J_{C\text{-}P}$ = 11.9 Hz), 142.4, 139.1 (d, $J_{C\text{-}P}$ = 94.6 Hz), 139.0 (d, $J_{C\text{-}P}$ = 7.8 Hz), 135.4 (d, $J_{C\text{-}P}$ = 2.2 Hz), 132.5 (d, $J_{C\text{-}P}$ = 2.5 Hz), 131.9 (d, $J_{C\text{-}P}$ = 10.0 Hz), 131.1 (d, $J_{C\text{-}P}$ = 105.7 Hz), 129.1, 128.9 (d, $J_{C\text{-}P}$ = 12.6 Hz), 127.6 (d, $J_{C\text{-}P}$ = 7.1 Hz), 127.3, 126.6 (d, $J_{C\text{-}P}$ = 9.5 Hz), 121.1 (d, $J_{C\text{-}P}$ = 5.6 Hz), 117.0, 114.0, 55.4; ^{31}P NMR (163 MHz, $CDCl_3$) δ 30.4; HRMS (ESI+): calcd for $C_{29}H_{23}N_2O_3P$ [M+H]+: 479.1519, Found: 479.1524.



N-(4-(diphenylphosphoryl)quinolin-8-yl)-4-fluorobenzamide (4fa): Light yellow solid (60%); mp 228-230 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.69 (s, 1H), 8.91 (d, J = 7.6 Hz, 1H), 8.83 (t, J = 3.9 Hz, 1H), 8.19 (d, J = 8.5 Hz, 1H), 8.09-8.06 (m, 2H), 7.71-7.66 (m, 4H), 7.62-7.59 (m, 2H), 7.54-7.49 (m, 5H), 7.28-7.19 (m, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.1 (d, $J_{C\text{-}F}$ = 253.0 Hz), 164.3, 146.8 (d, $J_{C\text{-}P}$ = 11.8 Hz), 139.3 (d, $J_{C\text{-}P}$ = 94.0 Hz), 138.9 (d, $J_{C\text{-}P}$ = 7.7 Hz), 135.0 (d, $J_{C\text{-}P}$ = 2.1 Hz), 132.6 (d, $J_{C\text{-}P}$ = 2.7 Hz), 131.9 (d, $J_{C\text{-}P}$ = 10.0 Hz), 131.2 (d, $J_{C\text{-}P}$ = 3.0 Hz), 131.1 (d, $J_{C\text{-}P}$ = 105.8 Hz), 129.6 (d, $J_{C\text{-}F}$ = 9.0 Hz), 128.9, 128.9 (d, $J_{C\text{-}P}$ = 12.3 Hz), 127.6 (d, $J_{C\text{-}P}$ = 7.0 Hz), 126.7 (d, $J_{C\text{-}P}$ = 9.6 Hz), 121.5 (d, $J_{C\text{-}P}$ = 5.4 Hz), 117.2, 115.9 (d, $J_{C\text{-}F}$ = 21.9 Hz); ^{31}P NMR (163 MHz, $CDCl_3$) δ 30.2; HRMS (ESI+): calcd for $C_{28}H_{20}FN_2O_2P$ [M+H]+: 467.1319, Found: 467.1324.

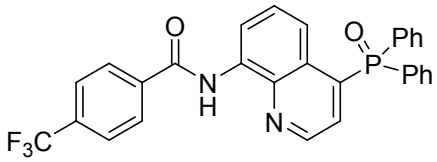


4-chloro-N-(4-(diphenylphosphoryl)quinolin-8-yl)benzamide (4ga): Light yellow solid (63%); mp 238-240 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.70 (s, 1H), 8.91 (d, J = 7.7 Hz, 1H), 8.83 (t, J = 3.8 Hz, 1H), 8.19 (d, J = 8.6 Hz, 1H), 8.00 (d, J = 8.4 Hz, 2H), 7.71-7.66 (m, 4H), 7.62-7.59 (m, 2H), 7.55-7.50 (m, 7H), 7.25 (dd, $J_{H\text{-}P}$ = 14.7 Hz, 4.3 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 164.3, 146.8 (d, $J_{C\text{-}P}$ = 11.9 Hz), 139.3 (d, $J_{C\text{-}P}$ = 94.0 Hz), 138.9 (d, $J_{C\text{-}P}$ = 7.7 Hz), 138.2, 134.9 (d, $J_{C\text{-}P}$ = 2.1 Hz), 133.4, 132.6 (d, $J_{C\text{-}P}$ = 2.7 Hz), 131.9 (d, $J_{C\text{-}P}$ = 10.1 Hz), 131.0 (d, $J_{C\text{-}P}$ = 105.7 Hz), 129.0 (d, $J_{C\text{-}P}$ = 11.2 Hz), 128.9 (d, $J_{C\text{-}P}$ = 4.8 Hz), 128.8, 128.7, 127.6 (d, $J_{C\text{-}P}$ = 7.1 Hz), 126.7 (d, $J_{C\text{-}P}$ = 9.7 Hz), 121.6 (d, $J_{C\text{-}P}$ = 5.7 Hz), 117.2; ^{31}P NMR (163 MHz, $CDCl_3$) δ 30.3; HRMS (ESI+): calcd for $C_{28}H_{20}ClN_2O_2P$ [M+H]+: 483.1024, Found: 483.1024.

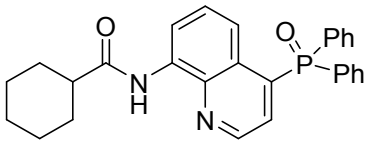


4-bromo-N-(4-(diphenylphosphoryl)quinolin-8-yl)benzamide (4ha): Light yellow solid (57%); mp 244-245 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.71 (s, 1H), 8.91 (d, J = 7.7 Hz, 1H), 8.83 (t, J = 3.8 Hz, 1H), 8.20 (d, J = 8.5 Hz, 1H), 7.93 (d, J = 8.4 Hz, 2H), 7.71-7.66 (m, 6H), 7.62-7.59 (m, 2H), 7.56-7.49 (m, 5H), 7.26 (dd, $J_{H\text{-}P}$ = 14.8 Hz, 4.3 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 164.4, 146.9 (d, $J_{C\text{-}P}$ = 11.8 Hz), 139.4 (d, $J_{C\text{-}P}$ = 93.5Hz), 138.9 (d, $J_{C\text{-}P}$ = 8.5 Hz), 135.0 (d, $J_{C\text{-}P}$ = 2.1 Hz), 133.9, 132.6 (d, $J_{C\text{-}P}$ = 2.6 Hz), 132.1, 132.0 (d, $J_{C\text{-}P}$ = 10.1 Hz), 131.1 (d, $J_{C\text{-}P}$ = 105.8 Hz), 128.9 (d, $J_{C\text{-}P}$ = 11.2 Hz), 128.9 (d, $J_{C\text{-}P}$ = 4.1 Hz), 128.9, 127.6 (d, $J_{C\text{-}P}$ = 7.1 Hz), 126.8, 126.7 (d, $J_{C\text{-}P}$ = 9.8 Hz), 121.7 (d, $J_{C\text{-}P}$ = 5.7 Hz), 117.3; ^{31}P NMR (163 MHz, $CDCl_3$) δ 30.2;

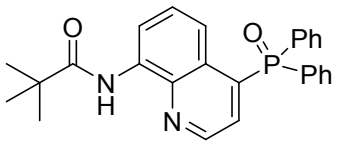
HRMS (ESI+): calcd for $C_{28}H_{20}BrN_2O_2P$ [M+H]+: 527.0519, Found: 527.0518.



N-(4-(diphenylphosphoryl)quinolin-8-yl)-4-(trifluoromethyl)benzamide (4ia): Light yellow solid (61%); mp 220-221 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.78 (s, 1H), 8.92 (d, J = 7.6 Hz, 1H), 8.84 (t, J = 3.8 Hz, 1H), 8.23 (d, J = 8.5 Hz, 1H), 8.16 (d, J = 8.0 Hz, 2H), 7.81 (d, J = 8.0 Hz, 2H), 7.71-7.66 (m, 4H), 7.62-7.59 (m, 2H), 7.57-7.49 (m, 5H), 7.26 (dd, $J_{H\text{-}P}$ = 14.8 Hz, 4.2 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 164.0, 146.9 (d, $J_{C\text{-}P}$ = 11.8 Hz), 139.4(d, $J_{C\text{-}P}$ = 94.4 Hz), 138.9 (d, $J_{C\text{-}P}$ = 7.8 Hz), 138.3, 134.7 (d, $J_{C\text{-}P}$ = 2.1 Hz), 133.5 (q, $J_{C\text{-}F}$ = 32.6 Hz), 132.6 (d, $J_{C\text{-}P}$ = 2.7 Hz), 131.9 (d, $J_{C\text{-}P}$ = 10.0 Hz), 131.1 (d, $J_{C\text{-}P}$ = 105.9 Hz), 128.9 (d, $J_{C\text{-}P}$ = 12.3 Hz), 128.8, 127.7, 127.6 (d, $J_{C\text{-}P}$ = 7.6 Hz), 126.7 (d, $J_{C\text{-}P}$ = 9.7 Hz), 125.8 (q, $J_{C\text{-}F}$ = 3.8 Hz), 123.6 (q, $J_{C\text{-}F}$ = 273.3 Hz), 121.9 (d, $J_{C\text{-}P}$ = 5.5 Hz), 117.4; ^{31}P NMR (163 MHz, $CDCl_3$) δ 30.2; HRMS (ESI+): calcd for $C_{29}H_{20}F_3N_2O_2P$ [M+H]+: 517.1287, Found: 517.1290.

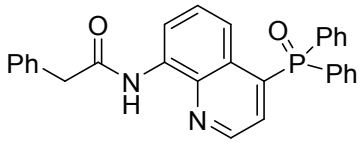


N-(4-(diphenylphosphoryl)quinolin-8-yl)cyclohexanecarboxamide (4ja): Light yellow solid (72%); mp 244-246 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.91 (s, 1H), 8.82-8.80 (m, 2H), 8.13 (d, J = 8.5 Hz, 1H), 7.71-7.66 (m, 4H), 7.63-7.59 (m, 2H), 7.52-7.46 (m, 5H), 7.25 (dd, $J_{H\text{-}P}$ = 19.5 Hz, 5.3 Hz, 1H), 2.51-2.45 (m, 1H), 2.09 (d, J = 12.0 Hz, 2H), 1.88 (d, J = 12.3 Hz, 2H), 1.75 (d, J = 11.1 Hz, 1H), 1.68-1.60 (s, 2H), 1.44-1.35 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 174.7, 146.5 (d, $J_{C\text{-}P}$ = 11.8 Hz), 139.0 (d, $J_{C\text{-}P}$ = 94.5 Hz), 138.7 (d, $J_{C\text{-}P}$ = 7.8 Hz), 135.2 (d, $J_{C\text{-}P}$ = 2.2 Hz), 132.5 (d, $J_{C\text{-}P}$ = 2.6 Hz), 131.9 (d, $J_{C\text{-}P}$ = 10.0 Hz), 131.2 (d, $J_{C\text{-}P}$ = 105.7 Hz), 128.9, 128.8 (d, $J_{C\text{-}P}$ = 12.3 Hz), 127.5 (d, $J_{C\text{-}P}$ = 7.1 Hz), 126.5 (d, $J_{C\text{-}P}$ = 9.6 Hz), 120.9 (d, $J_{C\text{-}P}$ = 5.6 Hz), 117.0, 46.9, 29.7, 29.6, 25.7; ^{31}P NMR (163 MHz, $CDCl_3$) δ 30.2; HRMS (ESI+): calcd for $C_{28}H_{27}N_2O_2P$ [M+H]+: 455.1883, Found: 455.1885.

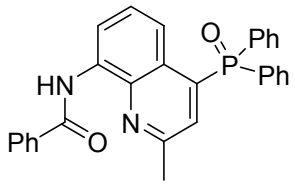


N-(4-(diphenylphosphoryl)quinolin-8-yl)pivalamide (4ka): Light yellow solid (61%); mp 190-191 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.26 (s, 1H), 8.81-8.79 (m, 2H), 8.11 (d, J = 8.5 Hz, 1H), 7.69-7.64 (m, 4H), 7.61-7.57 (m, 2H), 7.50-7.45 (m, 5H), 7.23 (dd, $J_{H\text{-}P}$ = 15.5 Hz, 5.5 Hz, 1H), 1.41 (s, 9H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 177.2, 146.6 (d, $J_{C\text{-}P}$ = 11.6 Hz), 139.0 (d, $J_{C\text{-}P}$ = 7.7 Hz), 138.9 (d, $J_{C\text{-}P}$ = 94.6 Hz), 135.3 (d, $J_{C\text{-}P}$ = 2.3 Hz), 132.5 (d, $J_{C\text{-}P}$ = 2.6 Hz), 131.9 (d, $J_{C\text{-}P}$ =

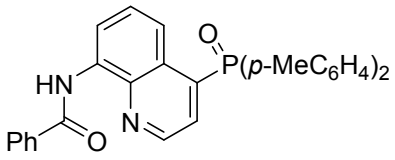
10.0 Hz), 131.2 (d, $J_{C\text{-}P}$ = 106.4 Hz), 128.9, 128.8 (d, $J_{C\text{-}P}$ = 11.1 Hz), 127.5 (d, $J_{C\text{-}P}$ = 7.4 Hz), 126.5 (d, $J_{C\text{-}P}$ = 9.6 Hz), 120.9 (d, $J_{C\text{-}P}$ = 5.5 Hz), 116.9, 40.4, 27.7; ^{31}P NMR (163 MHz, $CDCl_3$) δ 30.3; HRMS (ESI+): calcd for $C_{26}H_{25}N_2O_2P$ [M+H]+: 429.1726, Found: 429.1727.



N-(4-(diphenylphosphoryl)quinolin-8-yl)-2-phenylacetamide (4la): Light yellow solid (73%); mp 195-196 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 9.91 (s, 1H), 8.75 (d, J = 7.6 Hz, 1H), 8.66 (t, J = 3.9 Hz, 1H), 8.10 (d, J = 8.5 Hz, 1H), 7.67-7.56 (m, 6H), 7.49-7.37 (m, 9H), 7.34-7.30 (m, 1H), 7.25 (dd, $J_{H\text{-}P}$ = 15.0 Hz, 4.2 Hz, 1H), 3.87 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 169.4, 146.6 (d, $J_{C\text{-}P}$ = 12.0 Hz), 138.9 (d, $J_{C\text{-}P}$ = 94.3 Hz), 138.6 (d, $J_{C\text{-}P}$ = 7.7 Hz), 134.9 (d, $J_{C\text{-}P}$ = 2.5 Hz), 134.5, 132.5 (d, $J_{C\text{-}P}$ = 2.5 Hz), 131.9 (d, $J_{C\text{-}P}$ = 10.1 Hz), 131.1 (d, $J_{C\text{-}P}$ = 105.9 Hz), 129.5, 129.0, 128.8 (d, $J_{C\text{-}P}$ = 12.5 Hz), 128.7, 127.4 (d, $J_{C\text{-}P}$ = 7.2 Hz), 127.3, 126.5 (d, $J_{C\text{-}P}$ = 9.5 Hz), 121.2 (d, $J_{C\text{-}P}$ = 5.5 Hz), 116.9, 45.3; ^{31}P NMR (163 MHz, $CDCl_3$) δ 30.3; HRMS (ESI+): calcd for $C_{29}H_{23}N_2O_2P$ [M+H]+: 463.1570, Found: 463.1569.



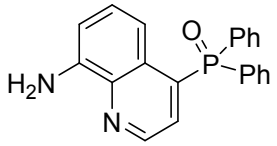
N-(4-(diphenylphosphoryl)-2-methylquinolin-8-yl)benzamide (4ma): Light yellow solid (60%); mp 259-260 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.81 (s, 1H), 8.90 (d, J = 7.7 Hz, 1H), 8.07-8.02 (m, 3H), 7.71-7.66 (m, 4H), 7.61-7.42 (m, 10H), 7.23 (d, $J_{H\text{-}P}$ = 15.2 Hz, 1H), 2.72 (s, 3H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 166.3, 155.8 (d, $J_{C\text{-}P}$ = 11.7 Hz), 139.3 (d, $J_{C\text{-}P}$ = 94.1 Hz), 138.5 (d, $J_{C\text{-}P}$ = 8.1 Hz), 135.2, 134.5 (d, $J_{C\text{-}P}$ = 2.4 Hz), 132.5 (d, $J_{C\text{-}P}$ = 2.5 Hz), 131.9 (d, $J_{C\text{-}P}$ = 10.1 Hz), 131.8, 131.3 (d, $J_{C\text{-}P}$ = 105.7 Hz), 128.8 (d, $J_{C\text{-}P}$ = 12.4 Hz), 128.8, 127.7, 127.6 (d, $J_{C\text{-}P}$ = 7.6 Hz), 127.2, 125.6 (d, $J_{C\text{-}P}$ = 7.4 Hz), 121.1 (d, $J_{C\text{-}P}$ = 5.4 Hz), 117.1, 25.5; ^{31}P NMR (163 MHz, $CDCl_3$) δ 29.8; HRMS (ESI+): calcd for $C_{29}H_{23}N_2O_2P$ [M+H]+: 463.1570, Found: 463.1572.



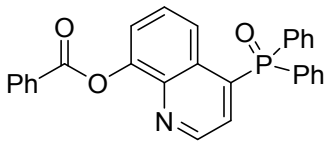
N-(4-(di-p-tolylphosphoryl)quinolin-8-yl)benzamide (4ab): Light yellow solid (45%); mp 186-187 ^{o}C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.76 (s, 1H), 8.94 (d, J = 7.5 Hz, 1H), 8.83 (t, J = 3.8 Hz, 1H), 8.19 (d, J = 8.5 Hz, 1H), 8.07 (d, J = 6.8 Hz, 2H), 7.58-7.52 (m, 8H), 7.31-7.24 (m, 5H), 2.42 (s, 6H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.4, 146.8 (d, $J_{C\text{-}P}$ = 11.7 Hz), 143.1 (d, $J_{C\text{-}P}$ = 2.6 Hz), 139.6 (d, $J_{C\text{-}P}$ = 94.1 Hz), 138.9 (d, $J_{C\text{-}P}$ = 7.6 Hz), 135.1 (d, $J_{C\text{-}P}$ = 2.5 Hz), 135.0, 131.9 (d, $J_{C\text{-}P}$ =

10.2 Hz), 131.9, 129.6 (d, $J_{C\text{-}P}$ = 12.6 Hz), 128.8, 128.0 (d, $J_{C\text{-}P}$ = 108.4 Hz), 127.6 (d, $J_{C\text{-}P}$ = 7.0 Hz), 127.2, 126.6 (d, $J_{C\text{-}P}$ = 9.6 Hz), 121.5 (d, $J_{C\text{-}P}$ = 5.5 Hz), 117.1, 21.6; ^{31}P NMR (163 MHz, $CDCl_3$) δ 30.6; HRMS (ESI+): calcd for $C_{30}H_{25}N_2O_2P$ [M+H]+: 477.1726, Found: 477.1733.

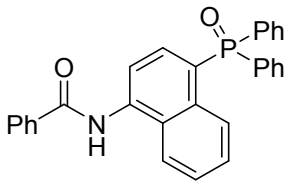
c) A 10 mL reaction tube was equipped with a magnetic stir bar and charged with **3aa** or **4aa** (44.8 mg, 0.1 mmol), NOH (20 mg, 0.5 mmol, 5 equiv), and CH_3CH_2OH (2.0 mL). The resulting mixture was heated at 80 °C for 12 h, and cooled to room temperature. Upon completion, CH_2Cl_2 (20 mL) was added to the reaction system, and the resulting mixture was filtered through a pad of Celite. The filtrate was extracted with H_2O (20 mL), and the aqueous layer was extracted with CH_2Cl_2 (2 × 10 mL). The combined organic layer was dried over anhydrous Na_2SO_4 and filtered. After evaporation of the solvent under vacuum, the residue was purified by column chromatography on silica gel (200–300 mesh) using CH_2Cl_2-EtOAc as an eluent to afford the pure product **3xa** or **4pa**.



(8-aminoquinolin-4-yl)diphenylphosphine oxide (4pa): Light yellow solid (92%); mp 257-258 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.82 (t, J = 4.0 Hz, 1H), 7.73-7.63 (m, 5H), 7.56-7.53 (m, 2H), 7.47-7.44 (m, 4H), 7.22 (t, J = 8.0 Hz, 1H), 7.04 (dd, $J_{H\text{-}P}$ = 15.2 Hz, 7.2 Hz, 1H), 6.88 (dd, J = 7.4, 1H), 5.08 (s, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 145.5 (d, $J_{C\text{-}P}$ = 12.1 Hz), 144.6 (d, $J_{C\text{-}P}$ = 2.2 Hz), 138.4 (d, $J_{C\text{-}P}$ = 7.7 Hz), 137.8 (d, $J_{C\text{-}P}$ = 95.7 Hz), 132.2 (d, $J_{C\text{-}P}$ = 2.8 Hz), 131.9 (d, $J_{C\text{-}P}$ = 9.9 Hz), 131.4 (d, $J_{C\text{-}P}$ = 105.2 Hz), 128.8, 128.7 (d, $J_{C\text{-}P}$ = 12.4 Hz), 128.1 (d, $J_{C\text{-}P}$ = 7.0 Hz), 126.5 (d, $J_{C\text{-}P}$ = 9.9 Hz), 115.5 (d, $J_{C\text{-}P}$ = 5.9 Hz), 110.4; ^{31}P NMR (163 MHz, $CDCl_3$) δ 30.6; HRMS (ESI+): calcd for $C_{21}H_{17}N_2OP$ [M+H]+: 344.1151, Found: 344.1153.



4-(diphenylphosphoryl)quinolin-8-yl benzoate (7): Light yellow solid; mp 88-89 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 8.85 (t, J = 3.9 Hz, 1H), 8.51 (d, J = 8.0 Hz, 1H), 8.32 (d, J = 7.5 Hz, 2H), 7.72-7.49 (m, 15H), 7.15 (dd, $J_{H\text{-}P}$ = 14.9 Hz, 4.2 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 165.4, 149.0 (d, $J_{C\text{-}P}$ = 11.6 Hz), 148.1 (d, $J_{C\text{-}P}$ = 2.8 Hz), 141.8 (d, $J_{C\text{-}P}$ = 7.1 Hz), 138.6 (d, $J_{C\text{-}P}$ = 94.5 Hz), 133.6, 132.5 (d, $J_{C\text{-}P}$ = 2.7 Hz), 131.9 (d, $J_{C\text{-}P}$ = 10.0 Hz), 131.0 (d, $J_{C\text{-}P}$ = 105.7 Hz), 130.5, 129.3, 128.9 (d, $J_{C\text{-}P}$ = 12.5 Hz), 128.8, 128.6, 127.6, 126.6 (d, $J_{C\text{-}P}$ = 9.5 Hz), 121.5 (d, $J_{C\text{-}P}$ = 5.5 Hz), 122.2; ^{31}P NMR (163 MHz, $CDCl_3$) δ 30.8; HRMS (ESI+): calcd for $C_{29}H_{22}NO_2P$ [M+H]+: 450.1254, Found: 450.1260.

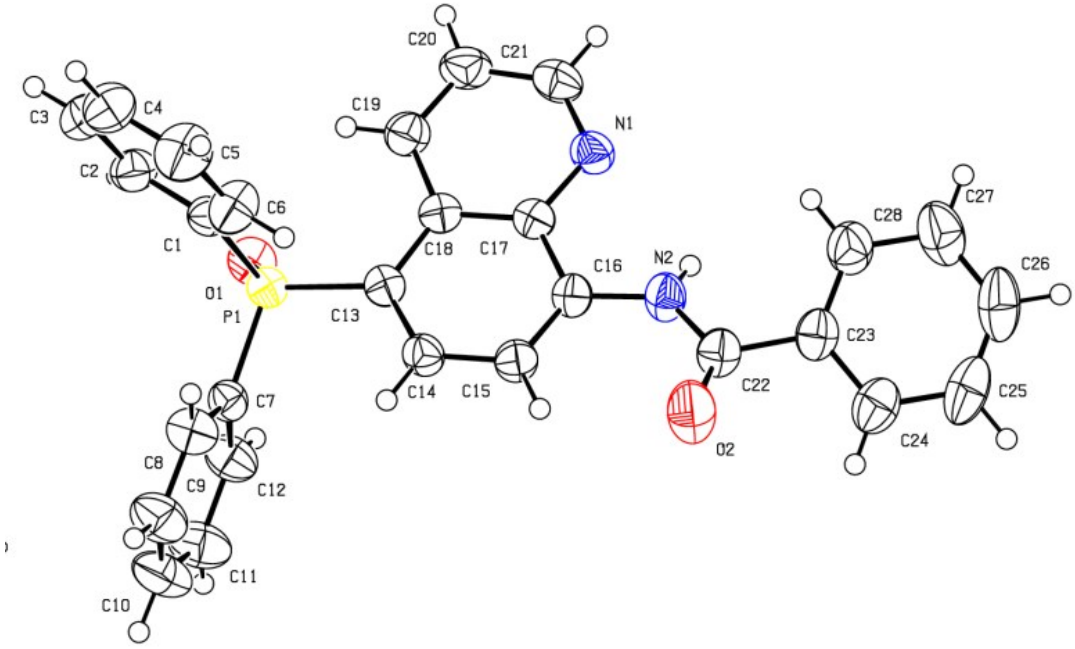


N-(4-(diphenylphosphoryl)naphthalen-1-yl)benzamide (9): Light yellow solid; mp 287-288 °C; ^{1}H NMR (400 MHz, $CDCl_3$) δ 10.38 (s, 1H), 8.36 (d, J = 7.0 Hz, 2H), 8.23 (d, J = 8.4 Hz, 1H), 8.00 (d, J = 8.2 Hz, 1H), 7.65-7.51 (m, 9H), 7.44-7.36 (m, 5H), 7.26-7.23 (m, 1H), 7.15 (t, J = 7.7 Hz, 1H), 6.82 (dd, $J_{H\text{-}P}$ = 15.8 Hz, 7.7 Hz, 1H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 166.7, 137.8 (d, $J_{C\text{-}P}$ = 3.2 Hz), 134.4, 133.7 (d, $J_{C\text{-}P}$ = 14.8 Hz), 133.7, 132.4 (d, $J_{C\text{-}P}$ = 104.2 Hz), 131.9 (d, $J_{C\text{-}P}$ = 3.3 Hz), 131.9, 128.6 (d, $J_{C\text{-}P}$ = 11.9 Hz), 128.6, 128.3 (d, $J_{C\text{-}P}$ = 9.2 Hz), 128.0, 127.5 (d, $J_{C\text{-}P}$ = 5.9 Hz), 126.8, 126.2, 124.8 (d, $J_{C\text{-}P}$ = 105.1 Hz), 122.9, 120.5 (d, $J_{C\text{-}P}$ = 14.5 Hz); ^{31}P NMR (163 MHz, $CDCl_3$) δ 32.3; HRMS (ESI+): calcd for $C_{28}H_{20}NO_3P$ [M+H]+: 448.1461, Found: 448.1467.

5. References

1 T. Truong, K. Klimovica and O. Daugulis, *J. Am. Chem. Soc.*, 2013, **135**, 9342.

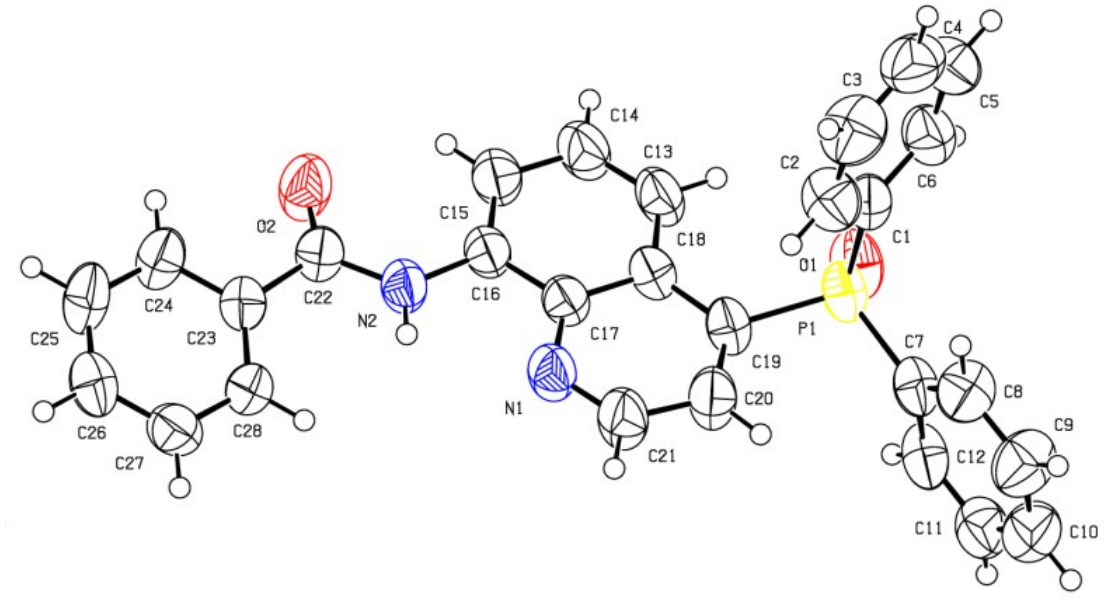
6. The Single Crystal X-ray Diffraction Study of 3aa, 4aa and 3ya.



CCDC 1527635 (**3aa**) contains the supplementary crystallographic data for this paper. These data can be obtained free of charge from The Cambridge Crystallographic Data Centre *via* www.ccdc.cam.ac.uk/data_request/cif.

Table S3 Crystal data and structure refinement for **3aa**.

Identification code	201608113
Empirical formula	$C_{28}H_{21}N_2O_2P$
Formula weight	448.44
Temperature/K	293(2)
Crystal system	monoclinic
Space group	$P2_1/c$
a/Å	12.9056(3)
b/Å	8.9810(2)
c/Å	20.4045(5)
α/°	90
β/°	106.848(3)
γ/°	90
Volume/Å^3	2263.47(10)
Z	4
ρ_{calc}g/cm^3	1.316
μ/mm^{-1}	1.302
F(000)	936.0
Crystal size/mm^3	0.22 × 0.2 × 0.15
Radiation	CuKα (λ = 1.54184)
2Θ range for data collection/°	7.156 to 134.15
Index ranges	$-15 \leq h \leq 13$, $-10 \leq k \leq 9$, $-24 \leq l \leq 24$
Reflections collected	8616
Independent reflections	4050 [R_{int} = 0.0364, R_{sigma} = 0.0361]
Data/restraints/parameters	4050/0/303
Goodness-of-fit on F^2	1.041
Final R indexes [I>=2σ (I)]	R_1 = 0.0412, wR_2 = 0.1062
Final R indexes [all data]	R_1 = 0.0506, wR_2 = 0.1138
Largest diff. peak/hole / e Å^{-3}	0.34/-0.31

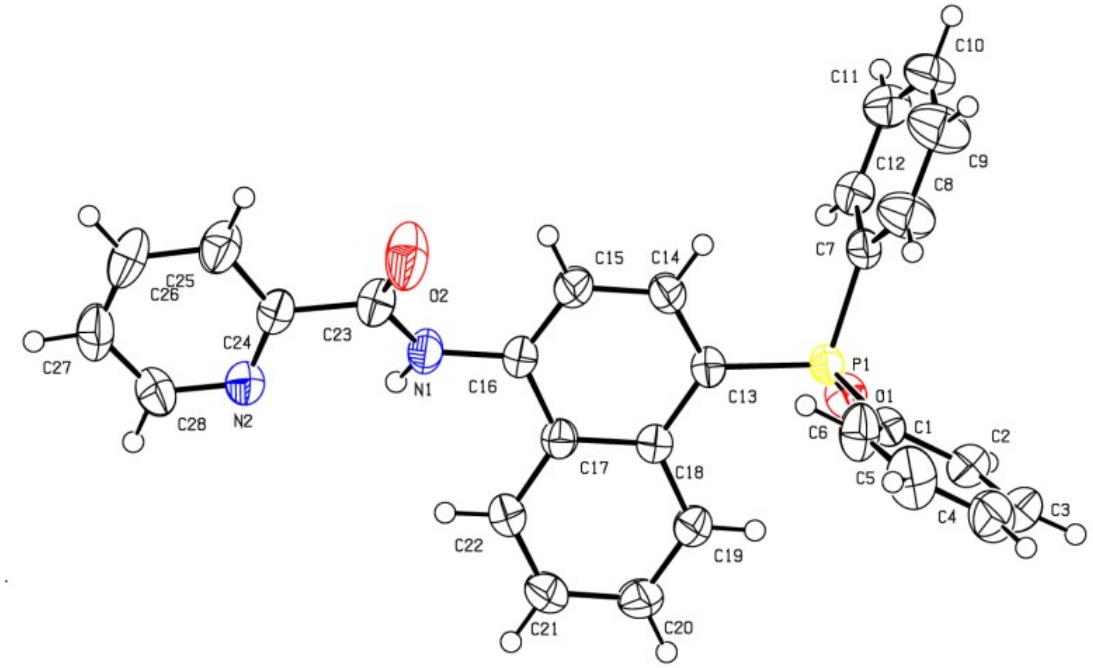


CCDC 1527636 (**4aa**) contains the supplementary crystallographic data for this paper. These data can be obtained free of charge from The Cambridge Crystallographic Data Centre *via* www.ccdc.cam.ac.uk/data_request/cif.

Table S4 Crystal data and structure refinement for **4aa**.

Identification code	201608114
Empirical formula	$C_{28}H_{21}N_2O_2P$
Formula weight	448.44
Temperature/K	293(2)
Crystal system	monoclinic
Space group	$P2_1/n$
a/Å	14.3374(5)
b/Å	9.7100(4)
c/Å	18.7718(7)
α/°	90
β/°	105.341(4)
γ/°	90
Volume/Å^3	2520.23(16)
Z	4
ρ_{calc}g/cm^3	1.182
μ/mm^{-1}	1.169
F(000)	936.0
Crystal size/mm^3	0.21 × 0.18 × 0.16
Radiation	CuKα (λ = 1.54184)
2Θ range for data collection/°	6.942 to 134.16
Index ranges	$-16 \le h \le 17$, $-7 \le k \le 11$, $-22 \le l \le 13$
Reflections collected	9535

Independent reflections	4509 [R_{int} = 0.0261, R_{sigma} = 0.0291]
Data/restraints/parameters	4509/0/299
Goodness-of-fit on F^2	1.049
Final R indexes [I>=2σ (I)]	R_1 = 0.0467, wR_2 = 0.1343
Final R indexes [all data]	R_1 = 0.0561, wR_2 = 0.1436
Largest diff. peak/hole / e $Å^{-3}$	0.28/-0.20

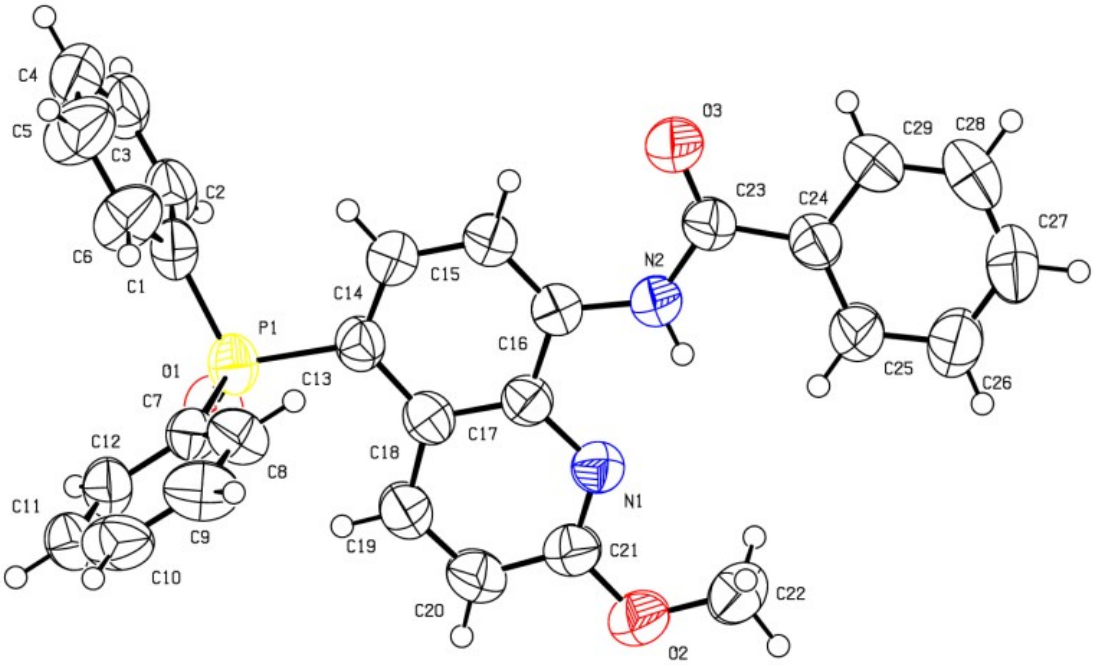


CCDC 1543497 (**3ya**) contains the supplementary crystallographic data for this paper. These data can be obtained free of charge from The Cambridge Crystallographic Data Centre *via* www.ccdc.cam.ac.uk/data_request/cif.

Table S5 Crystal data and structure refinement for **3ya**.

Identification code	20170442
Empirical formula	$C_{28}H_{21}N_2O_2P$
Formula weight	448.44
Temperature/K	293(2)
Crystal system	monoclinic
Space group	$P2_1/c$
a/Å	11.9961(5)
b/Å	8.6310(3)
c/Å	21.6563(7)
α/°	90
β/°	95.014(4)
γ/°	90
Volume/$Å^3$	2233.68(15)
Z	4

ρ_{calc}g/cm^3	1.333
μ/mm^{-1}	1.319
F(000)	936.0
Crystal size/mm^3	0.18 × 0.15 × 0.1
Radiation	CuKα (λ = 1.54184)
2Θ range for data collection/°	7.398 to 134.174
Index ranges	-14 ≤ h ≤ 11, -10 ≤ k ≤ 6, -25 ≤ l ≤ 22
Reflections collected	8345
Independent reflections	3994 [R_{int} = 0.0279, R_{sigma} = 0.0348]
Data/restraints/parameters	3994/0/299
Goodness-of-fit on F^2	1.058
Final R indexes [I>=2σ (I)]	R_1 = 0.0406, wR_2 = 0.1051
Final R indexes [all data]	R_1 = 0.0494, wR_2 = 0.1133
Largest diff. peak/hole / e Å^{-3}	0.29/-0.29



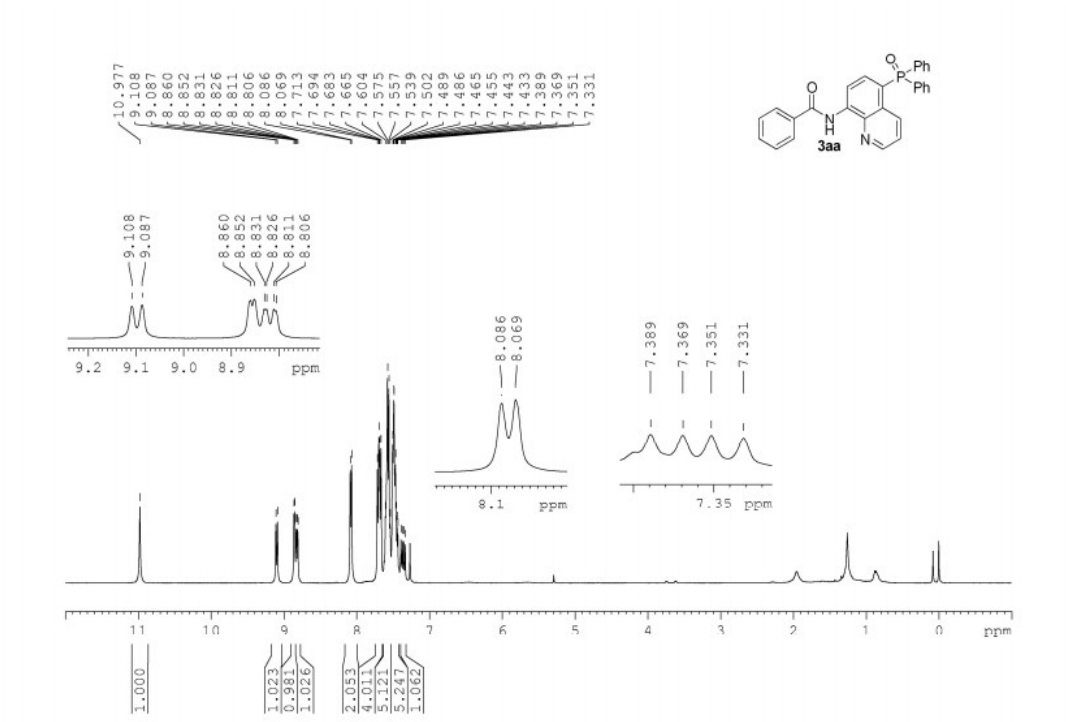
CCDC 1554232 (**3za**) contains the supplementary crystallographic data for this paper. These data can be obtained free of charge from The Cambridge Crystallographic Data Centre *via* www.ccdc.cam.ac.uk/data_request/cif.

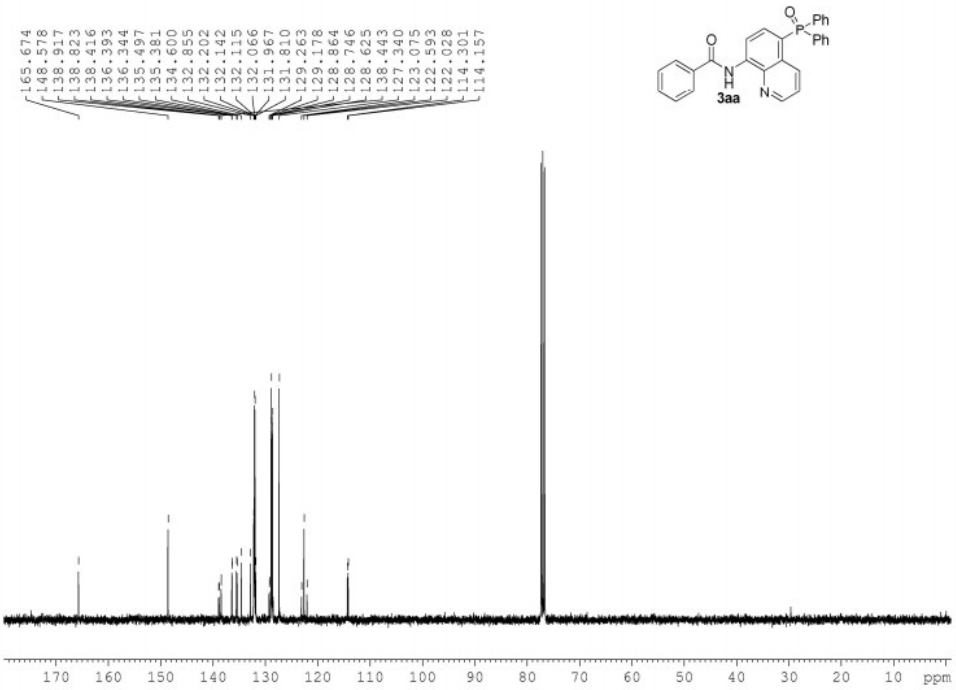
Table S6 Crystal data and structure refinement for **3za**.

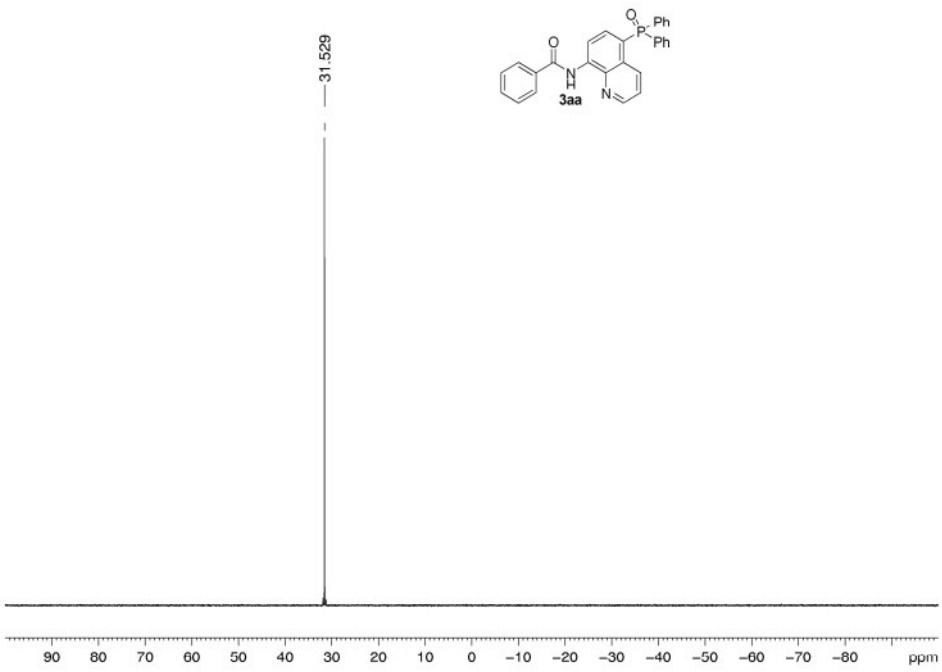
Identification code	20170698
Empirical formula	$C_{29}H_{23}N_2O_3P$
Formula weight	478.46
Temperature/K	293(2)
Crystal system	triclinic
Space group	P-1

a/Å	9.5853(9)
b/Å	9.8739(8)
c/Å	14.7007(14)
α/°	103.110(8)
β/°	94.035(8)
γ/°	114.371(8)
Volume/Å^3	1213.1(2)
Z	2
ρ_{calc}g/cm^3	1.310
μ/mm^{-1}	1.279
F(000)	500.0
Crystal size/mm^3	0.15 × 0.11 × 0.1
Radiation	CuKα (λ = 1.54184)
2Θ range for data collection/°	10.25 to 134.006
Index ranges	-11 ≤ h ≤ 8, -11 ≤ k ≤ 11, -16 ≤ l ≤ 17
Reflections collected	8680
Independent reflections	4325 [R_{int} = 0.0222, R_{sigma} = 0.0318]
Data/restraints/parameters	4325/0/322
Goodness-of-fit on F^2	1.021
Final R indexes [I>=2σ (I)]	R_1 = 0.0467, wR_2 = 0.1246
Final R indexes [all data]	R_1 = 0.0583, wR_2 = 0.1360
Largest diff. peak/hole / e Å^{-3}	0.25/-0.25

7. Copies of ^{1}H, ^{13}C and ^{31}P NMR Spectra for the Products



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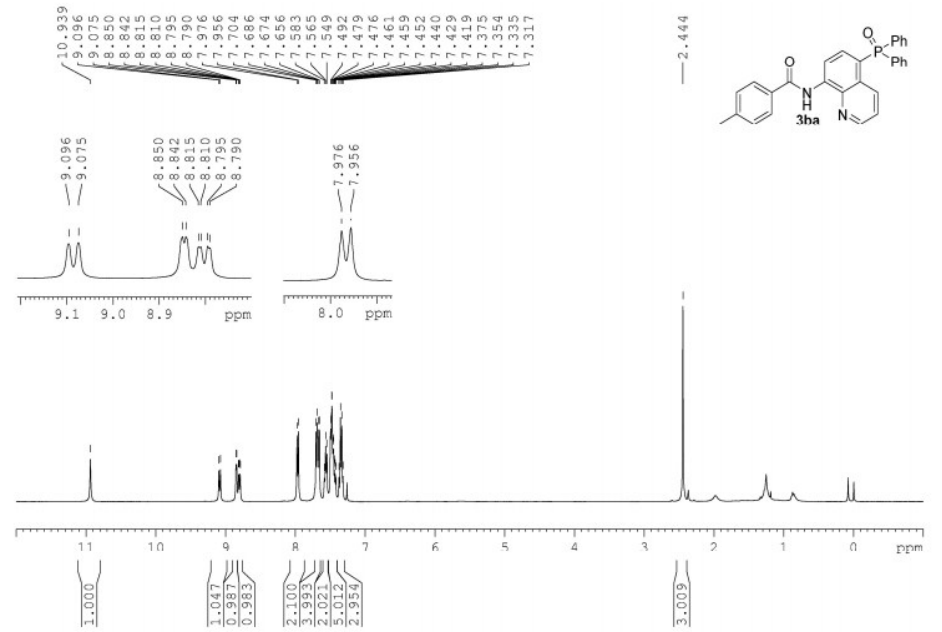
3aa
90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 ppm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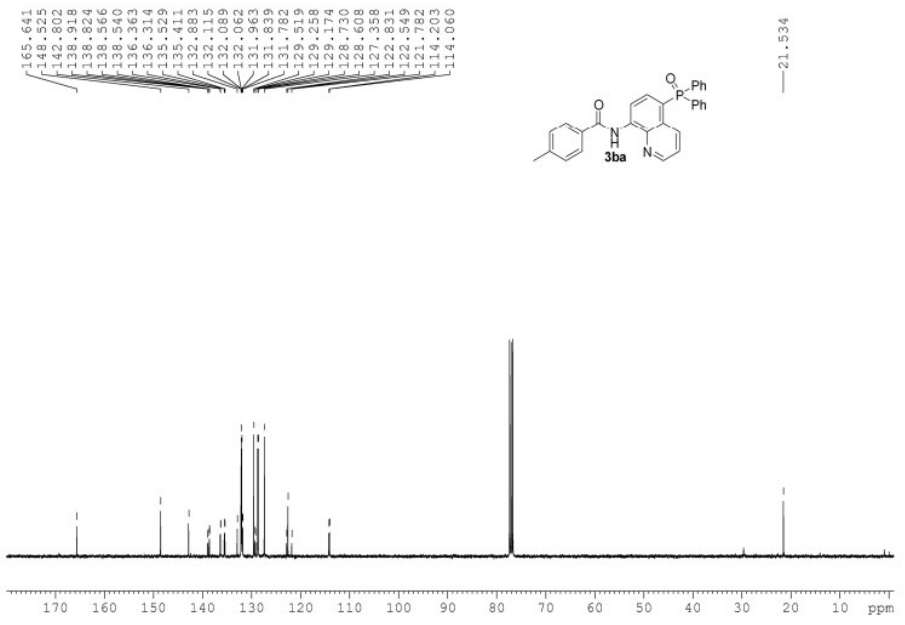
9.096
9.075
8.850
8.842
8.815
8.810
8.795
8.790
7.976
7.956
7.704
7.686
7.674
7.656
7.583
7.565
7.549
7.492
7.479
7.476
7.461
7.459
7.452
7.440
7.429
7.419
7.375
7.354
7.335
7.317
2.444
3ba
9.1 9.0 8.9 ppm
8.0 ppm
11 10 9 8 7 6 5 4 3 2 1 0 ppm
1.000
1.047
0.987
0.983
2.100
3.993
2.021
5.012
2.954
3.009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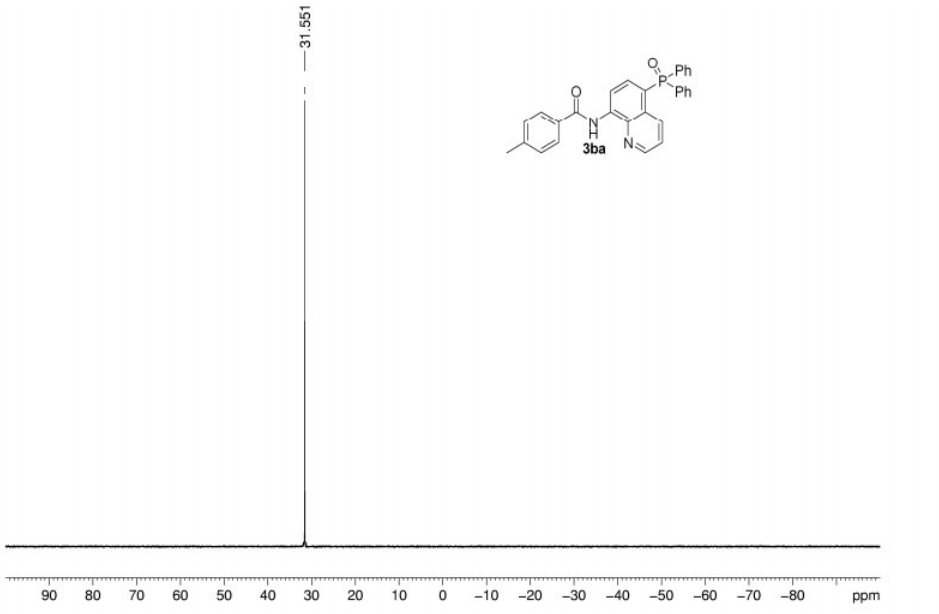
148.525
142.802
138.918
138.824
138.566
138.540
136.363
136.314
135.529
135.411
132.883
132.115
132.089
132.062
131.963
131.839
131.782
129.519
129.258
129.174
128.730
128.608
127.358
122.831
122.549
121.782
114.203
114.060
21.534
Ph
Ph
O
P
O
N
H
N
3ba
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm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Ph
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P
O
N
H
N
3ba
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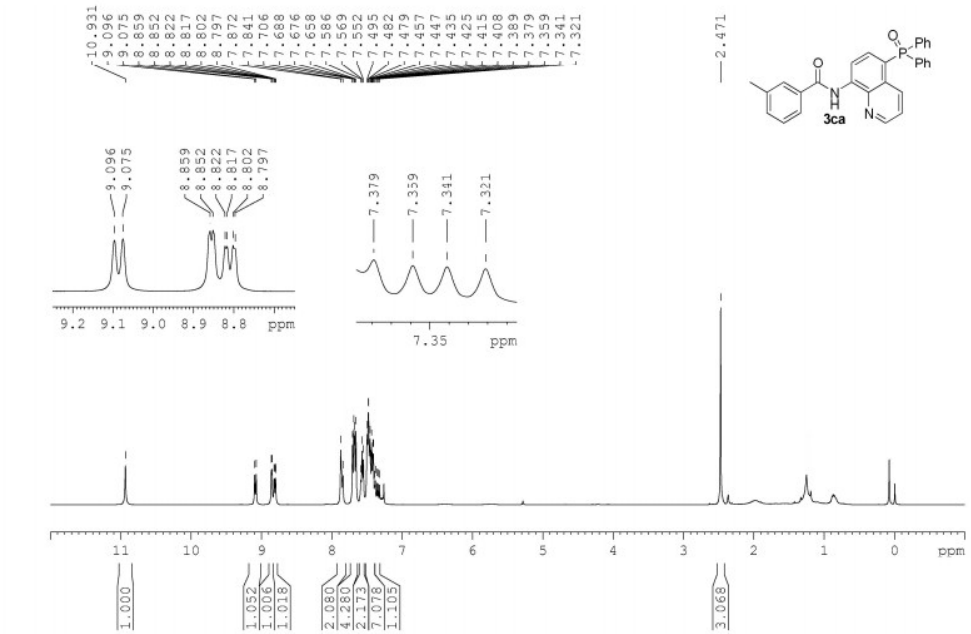
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9.075
8.859
8.852
8.822
8.817
8.802
8.797
7.872
7.841
7.706
7.688
7.676
7.658
7.586
7.569
7.552
7.495
7.482
7.479
7.457
7.447
7.435
7.425
7.415
7.408
7.389
7.379
7.359
7.341
7.321
2.471
3ca
9.2 9.1 9.0 8.9 8.8 ppm
7.35 ppm
11 10 9 8 7 6 5 4 3 2 1 0 ppm
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1.006
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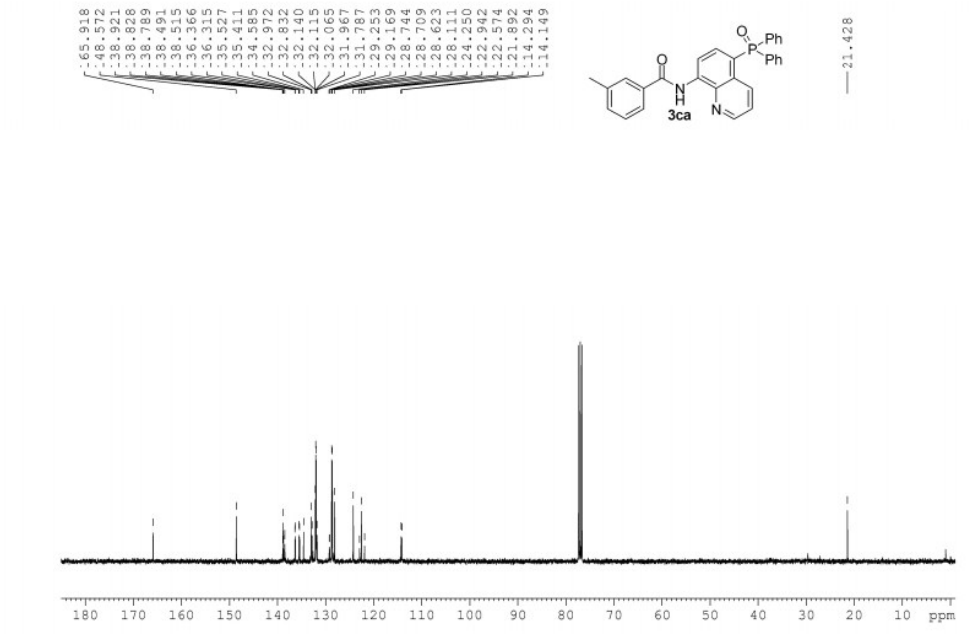
2.080
4.280
2.173
7.078
1.105
3.068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48.572
38.921
38.828
38.789
38.491
38.515
36.366
36.315
35.527
35.411
34.885
32.972
32.832
32.140
32.115
32.065
31.967
31.787
29.253
29.169
28.744
28.709
28.623
28.111
24.250
22.942
22.574
21.892
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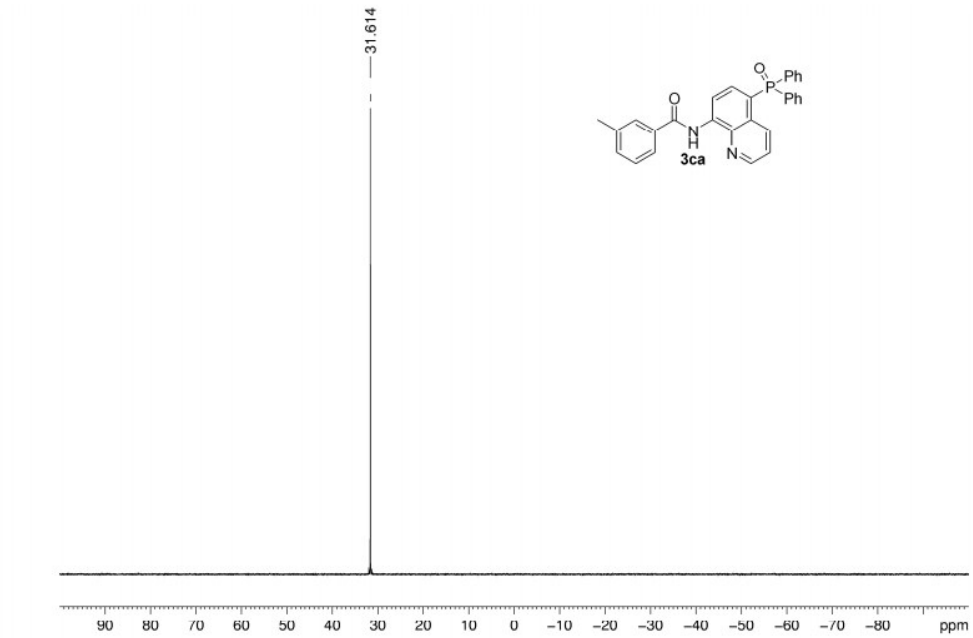
14.149
3ca
21.428
180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm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Ph
Ph
O
P
O
N
H
N
3ca
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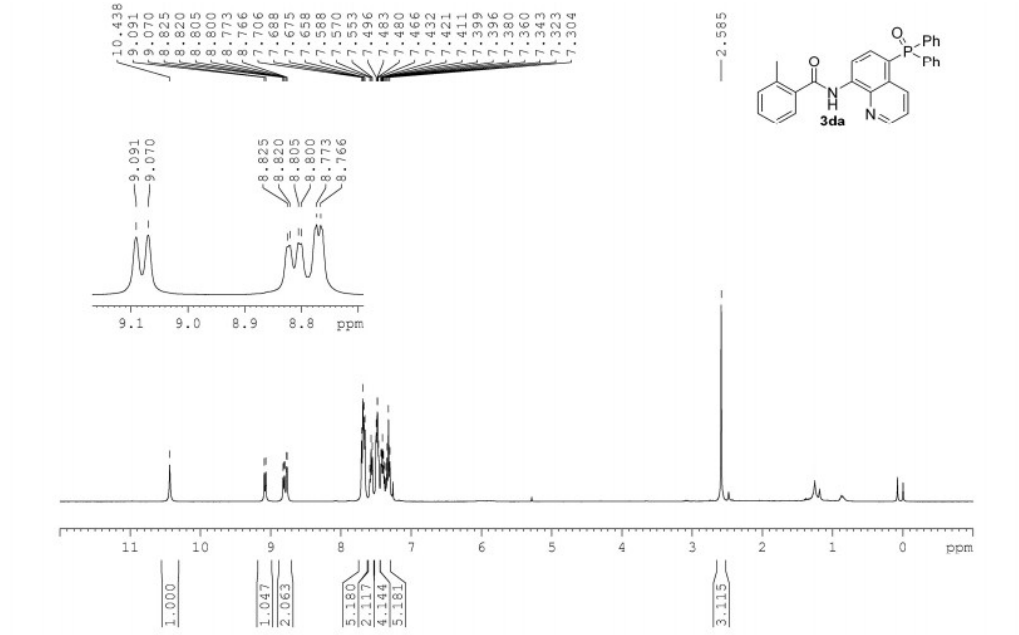
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9.070
8.825
8.820
8.805
8.800
8.773
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7.588
7.570
7.553
7.496
7.483
7.480
7.466
7.432
7.421
7.411
7.399
7.396
7.380
7.360
7.343
7.323
7.304
2.585
Ph
Ph
O
P
O
N
H
N
3da
9.1 9.0 8.9 8.8 ppm
11 10 9 8 7 6 5 4 3 2 1 0 ppm
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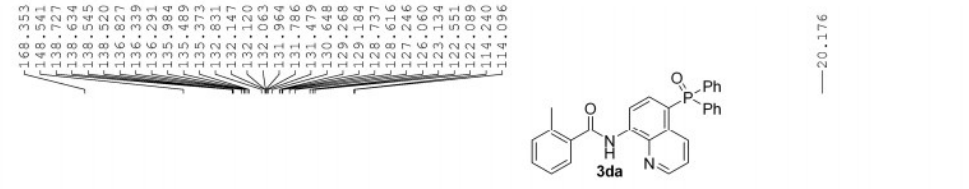
1.047
2.063
5.180
2.117
4.144
5.181
3.115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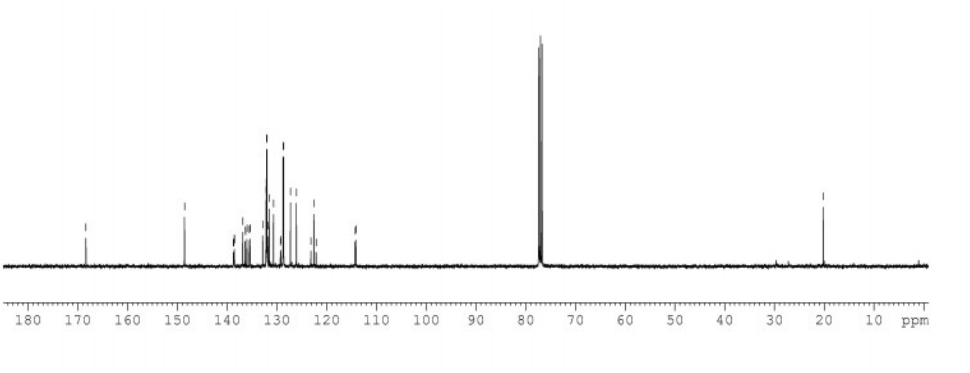
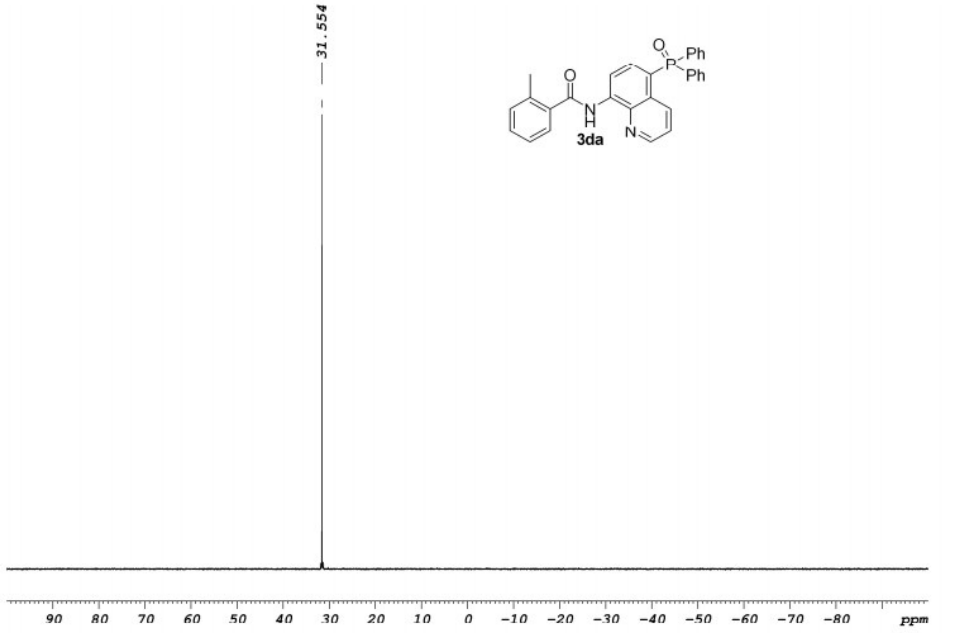
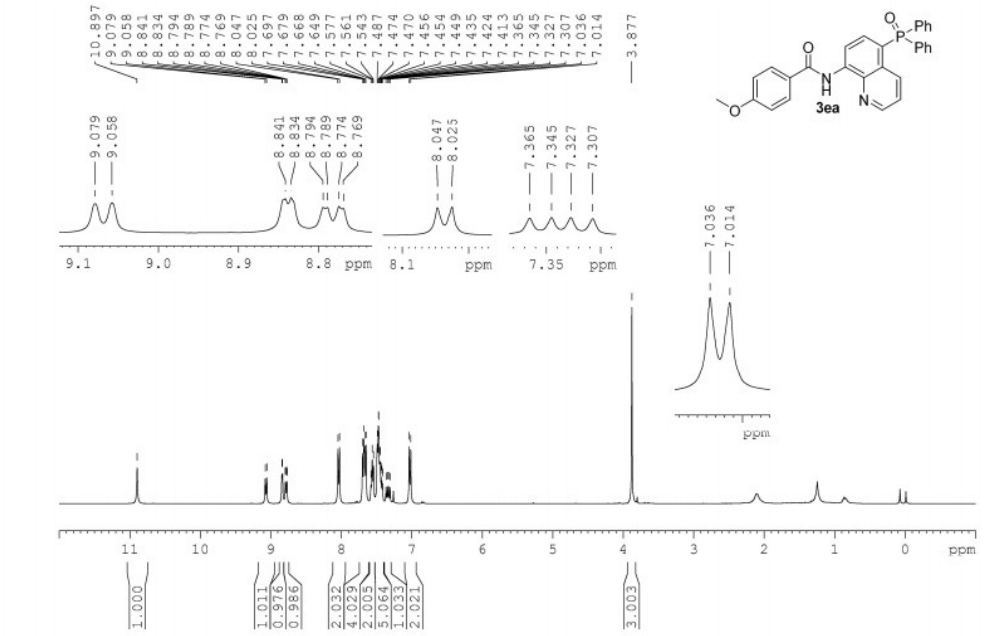
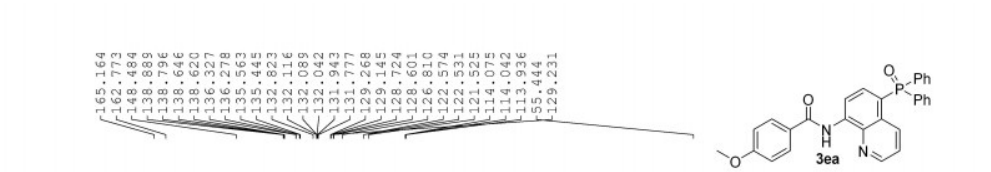
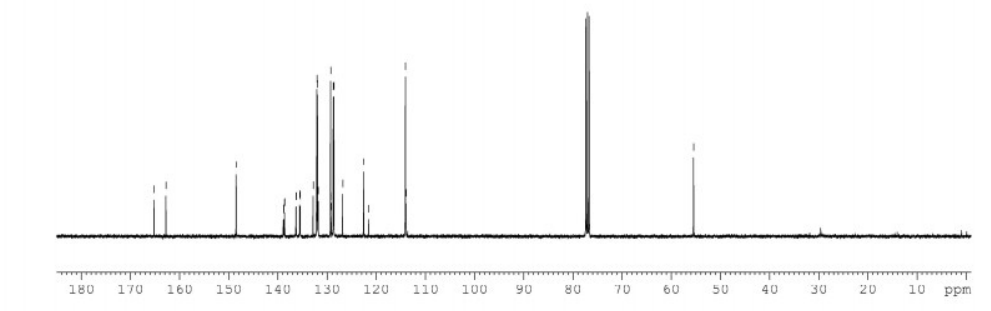
138.520
136.827
136.339
136.291
135.984
135.489
135.373
132.831
132.147
132.120
132.063
131.964
131.786
131.479
130.648
129.268
129.184
128.737
128.616
127.246
126.060
123.134
122.551
122.089
114.240
114.096
20.176
O
Ph
P
Ph
O
N
H
N
3da

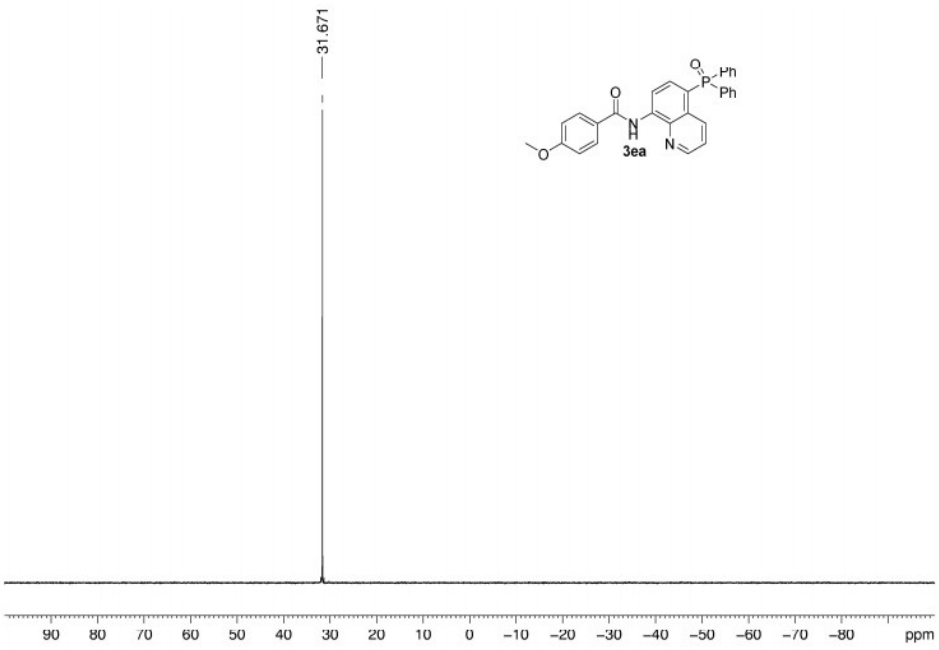

180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

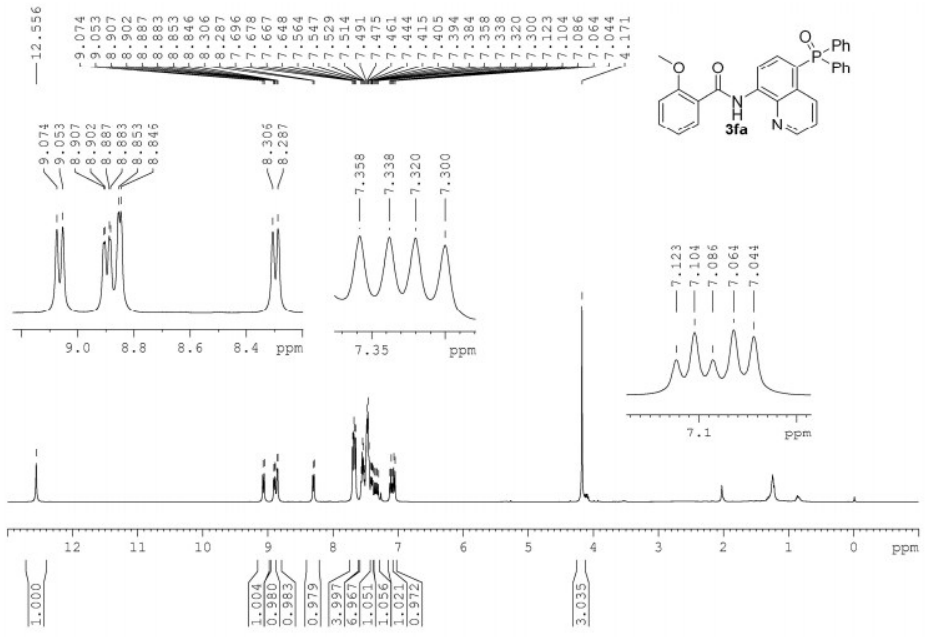

31.554
O
Ph
P
Ph
O
N
H
N
3da
90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 ppm

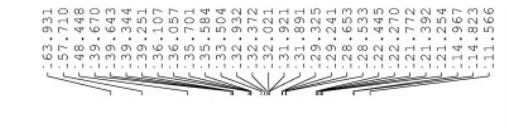

10.897
9.079
9.058
8.841
8.834
8.794
8.789
8.774
8.769
8.047
8.025
7.697
7.679
7.668
7.649
7.577
7.561
7.543
7.487
7.474
7.470
7.456
7.454
7.449
7.435
7.424
7.413
7.365
7.345
7.327
7.307
7.036
7.014
3.877
3ea
ppm
1.000
1.011
0.976
0.986
2.032
4.029
2.005
5.064
1.033
2.021
3.003

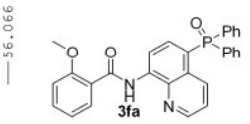

165.164
162.773
148.484
138.889
138.796
138.646
138.620
136.327
136.278
135.563
135.445
132.823
132.116
132.089
132.042
131.943
131.777
129.268
129.145
128.724
128.601
126.810
122.574
122.531
121.525
114.075
114.042
113.936
55.444
129.231
3ea

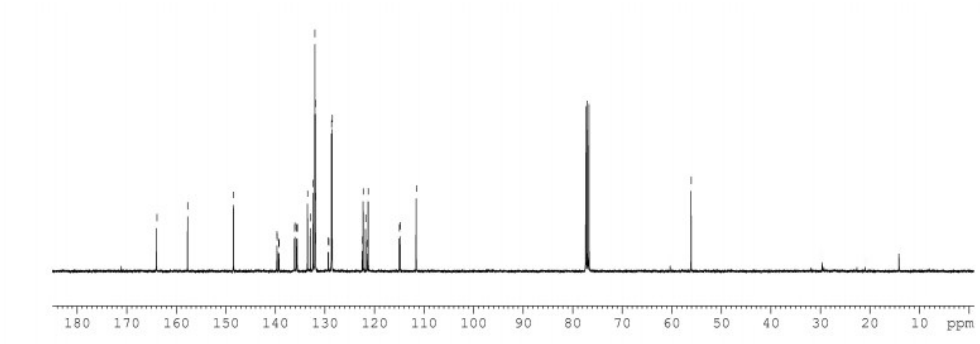

ppm

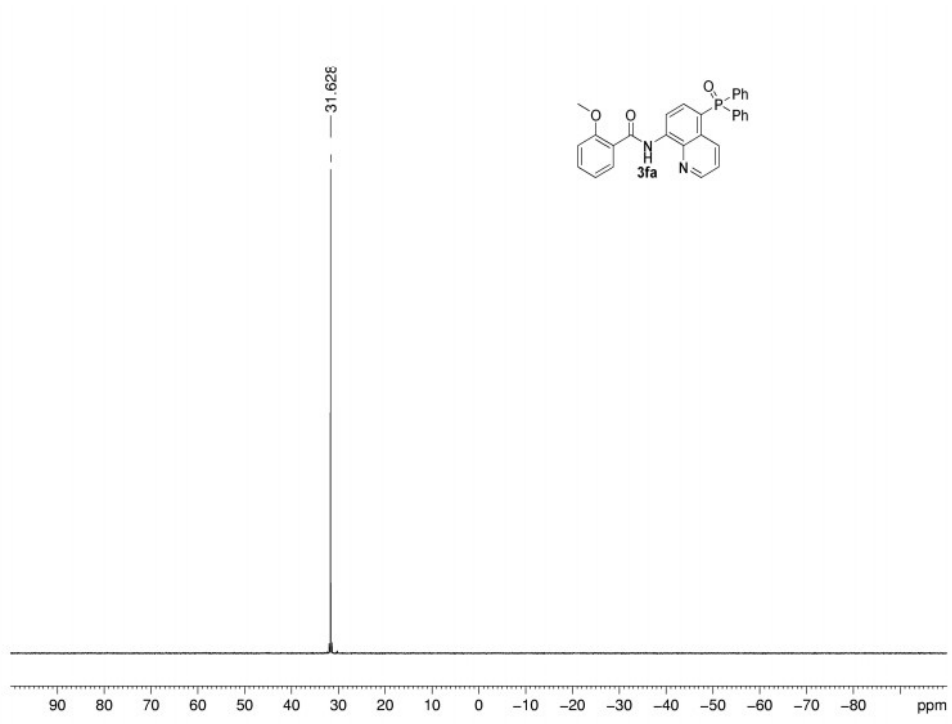

31.671
3ea
90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 ppm

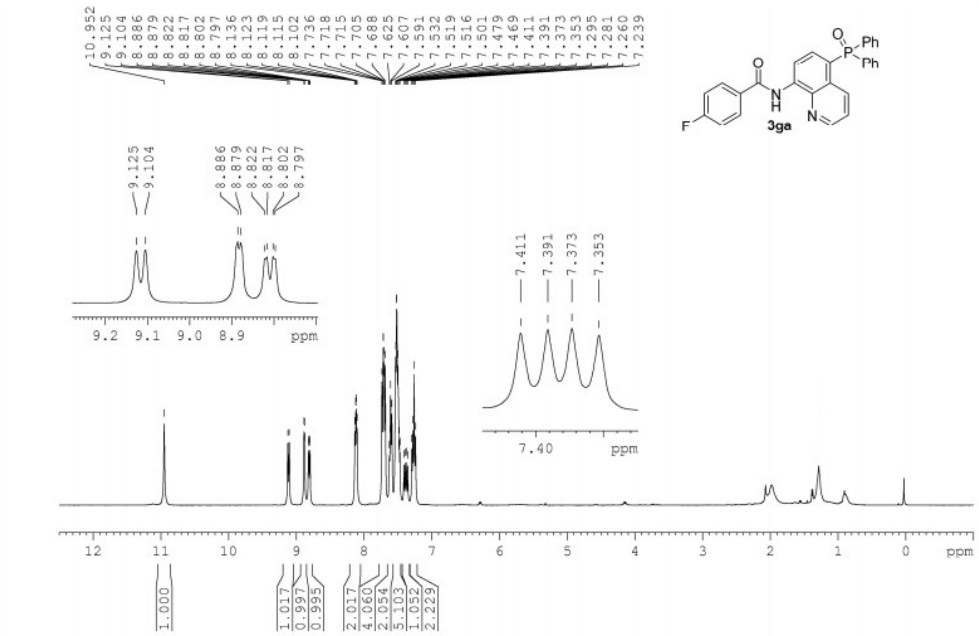

12.556
9.074
9.053
8.907
8.902
8.887
8.883
8.853
8.846
8.306
8.287
7.696
7.678
7.667
7.648
7.564
7.547
7.529
7.514
7.491
7.475
7.461
7.444
7.415
7.405
7.394
7.384
7.358
7.338
7.320
7.300
7.123
7.104
7.086
7.064
7.044
4.171
3fa
9.0 8.8 8.6 8.4 ppm
7.35 ppm
7.1 ppm
12 11 10 9 8 7 6 5 4 3 2 1 0 ppm
1.000
1.004
0.980
0.983
0.979
3.997
6.967
1.051
1.056
1.021
0.972
3.035

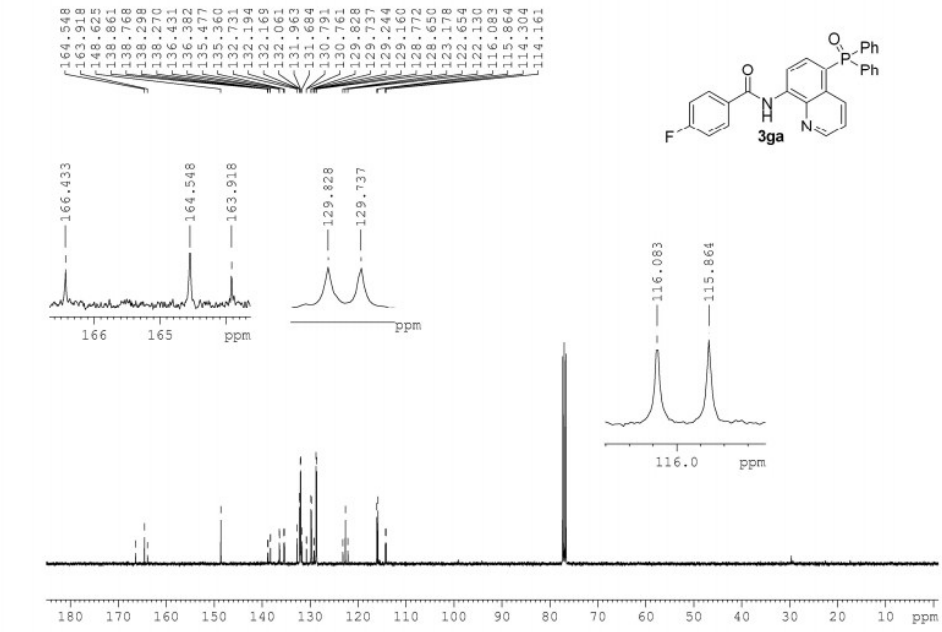

163.931
157.710
148.448
139.670
139.643
139.344
139.251
136.107
136.057
135.701
135.584
133.504
132.932
132.372
132.021
131.921
131.891
129.325
129.241
128.653
128.533
122.445
122.270
121.772
121.392
121.254
114.967
114.823
111.566

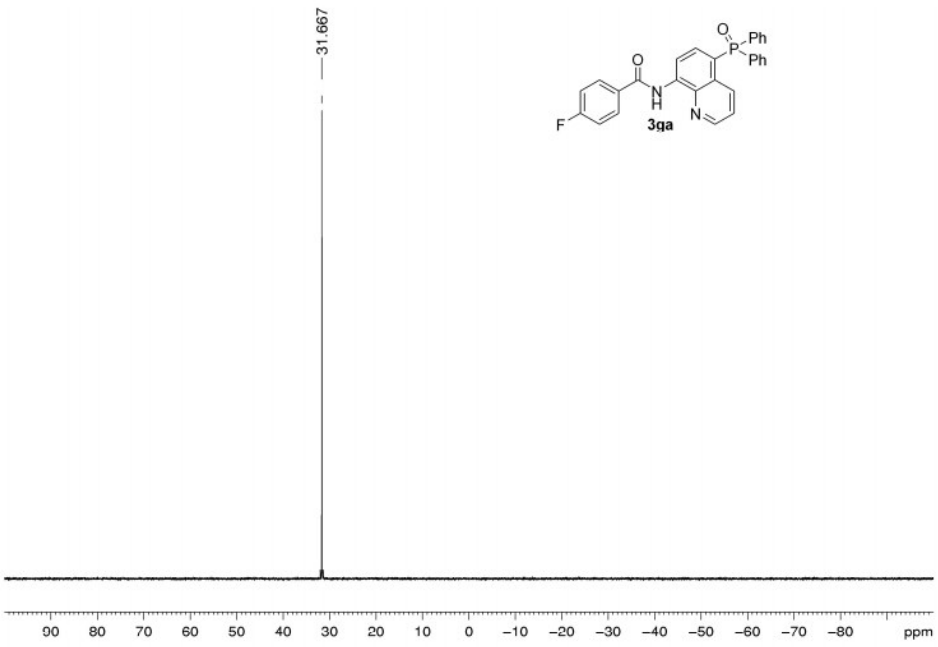

56.066
O
Ph
P
Ph
O
O
N
H
3fa
N

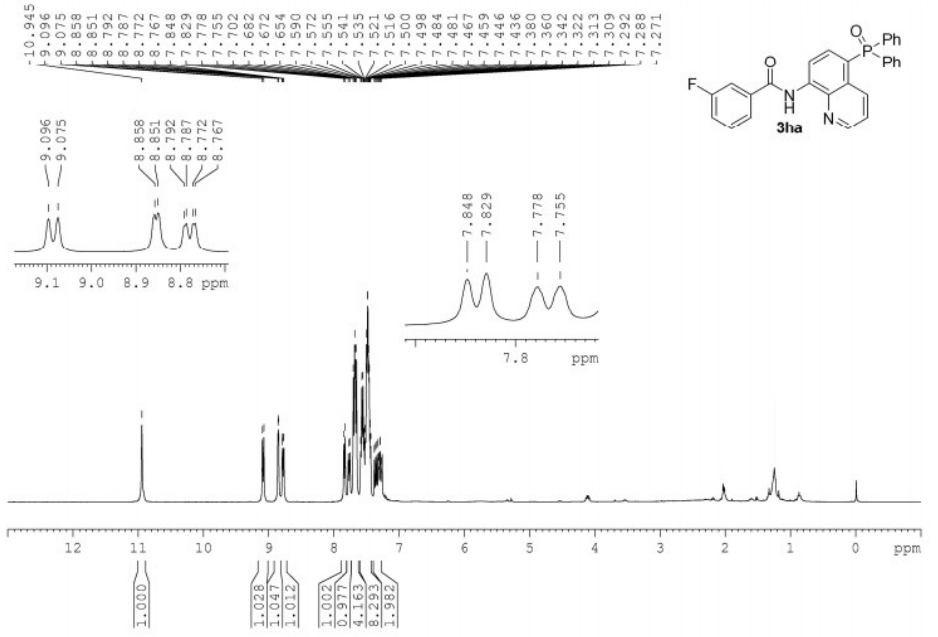

180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

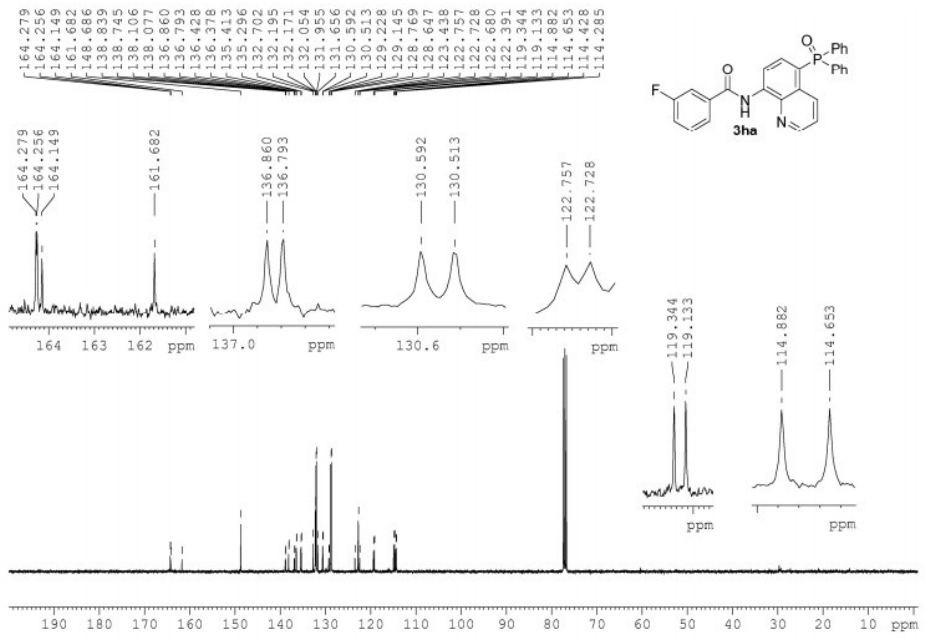

31.628
O
Ph
P
Ph
O
O
N
H
3fa
N
90
80
70
60
50
40
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
−80
ppm

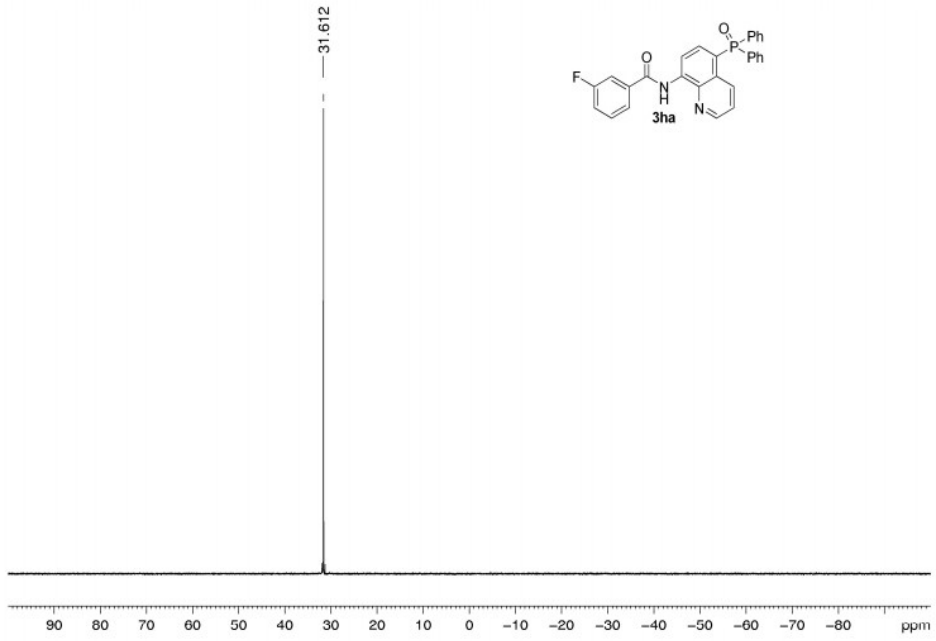

10.952
9.125
9.104
8.886
8.879
8.822
8.817
8.802
8.797
8.136
8.123
8.119
8.115
8.102
7.736
7.718
7.715
7.705
7.688
7.625
7.607
7.591
7.532
7.519
7.516
7.501
7.479
7.469
7.411
7.391
7.373
7.353
7.295
7.281
7.260
7.239
3ga
ppm
1.000
1.017
0.997
0.995
2.017
4.060
2.054
5.103
1.052
2.229

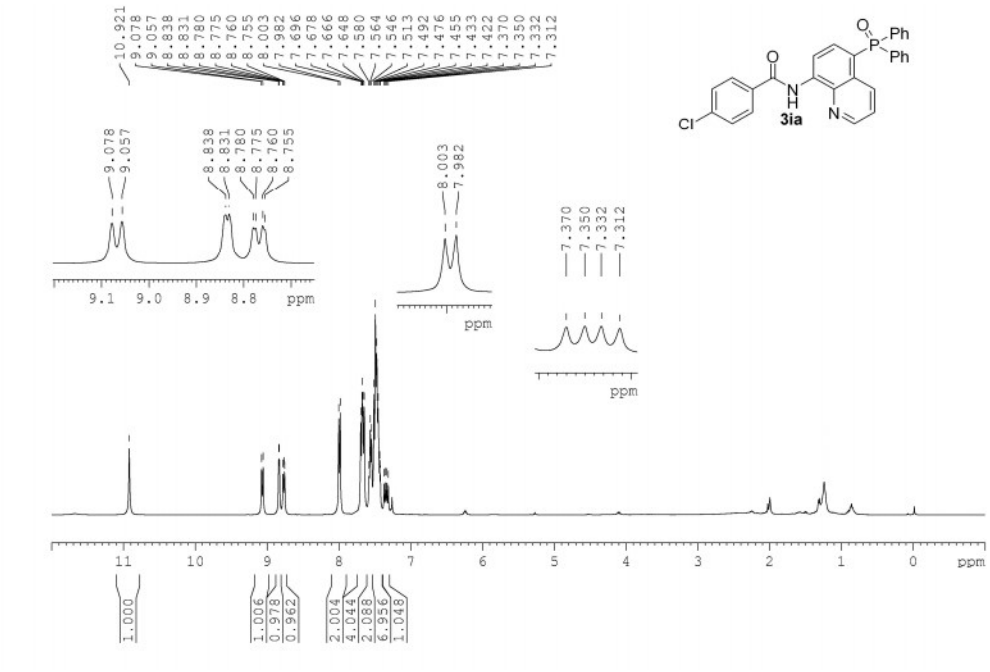

164.548
163.918
148.625
138.861
138.768
138.298
138.270
136.431
136.382
135.477
135.360
132.731
132.194
132.169
132.061
131.963
131.684
130.791
130.761
129.828
129.737
129.244
129.160
128.772
128.650
123.178
122.654
122.130
116.083
115.864
114.304
114.161
3ga
ppm

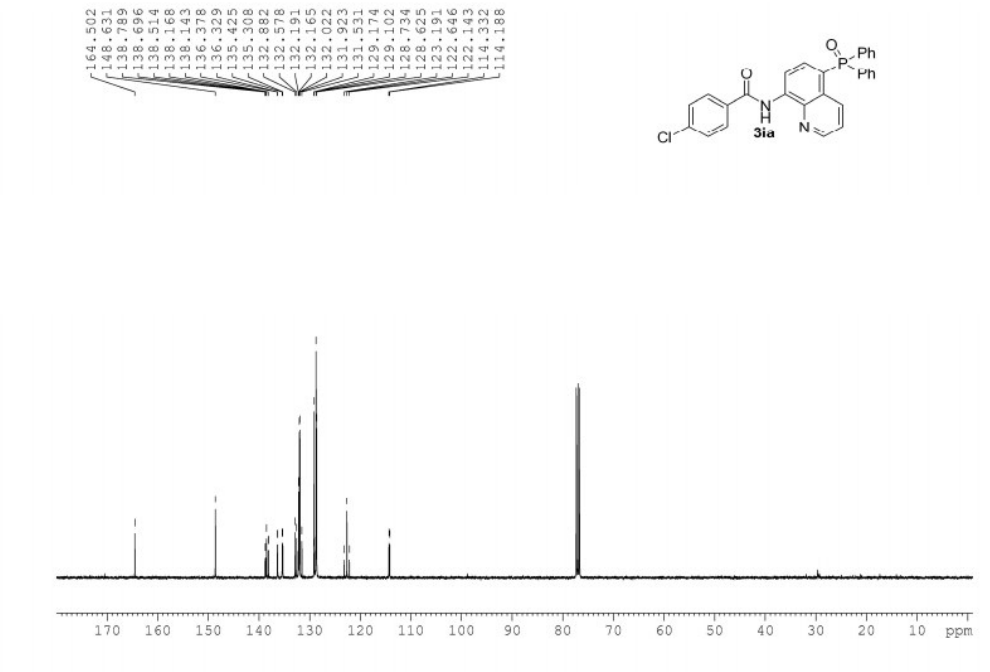

31.667
3ga
90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 ppm

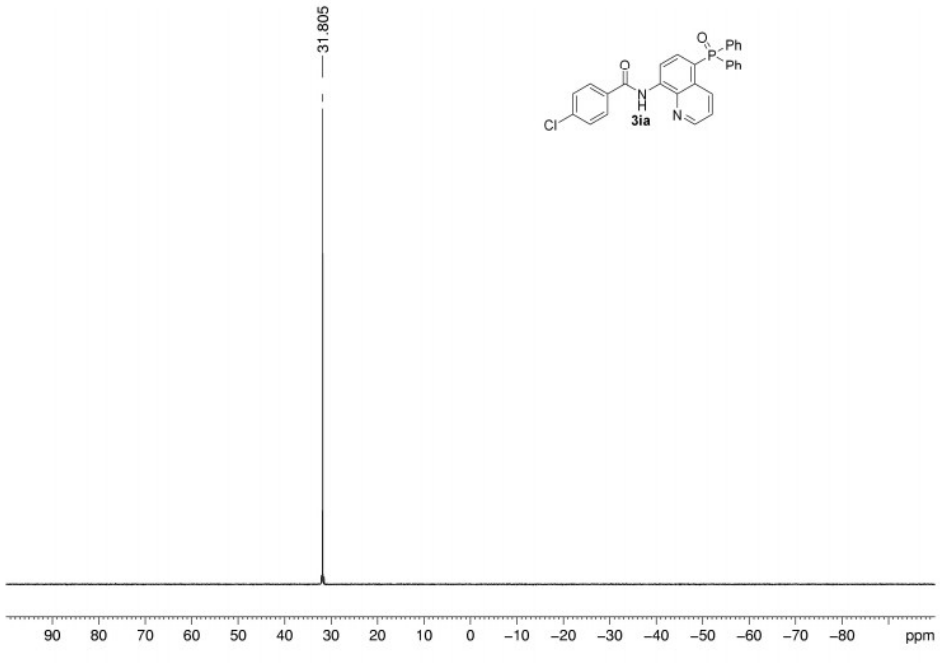

3ha
9.1 9.0 8.9 8.8 ppm
7.8 ppm
12 11 10 9 8 7 6 5 4 3 2 1 0 ppm
1.000
1.028
1.047
1.012
1.002
0.977
4.163
8.293
1.982

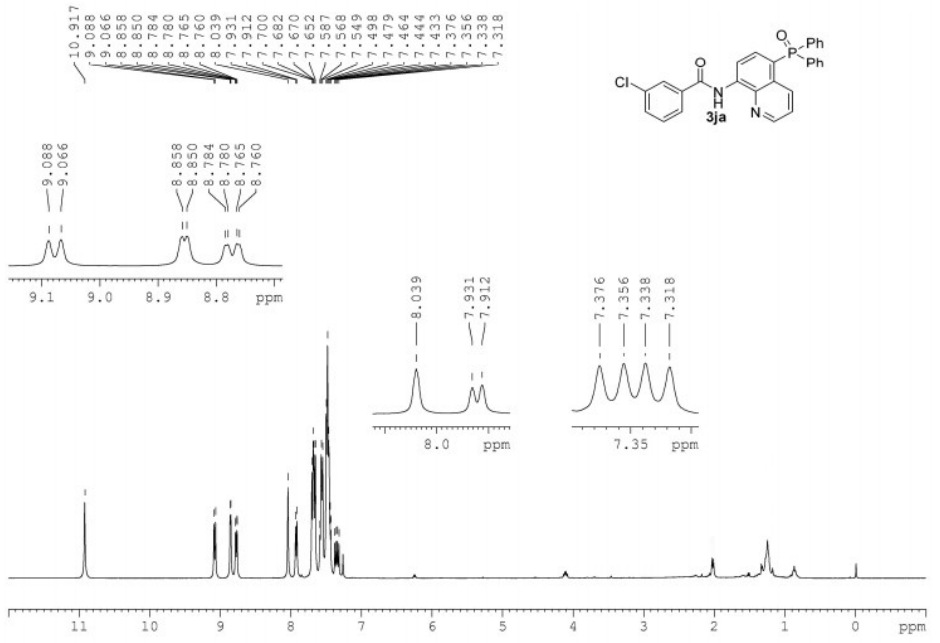

164.279
164.256
164.149
161.682
148.686
138.839
138.745
138.106
138.077
136.860
136.793
136.428
136.378
135.413
135.296
132.702
132.195
132.171
132.054
131.955
131.656
130.592
130.513
129.228
129.145
128.769
128.647
123.438
122.757
122.728
122.680
122.391
119.344
119.133
114.882
114.653
114.428
114.285
3ha
ppm

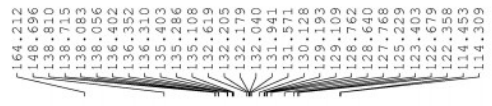

31.612
3ha
ppm

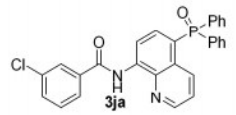

10.921
9.078
9.057
8.838
8.831
8.780
8.775
8.760
8.755
8.003
7.982
7.696
7.678
7.666
7.648
7.580
7.564
7.546
7.513
7.492
7.476
7.455
7.433
7.422
7.370
7.350
7.332
7.312
3ia
ppm
1.000
1.006
0.978
0.962
2.004
4.044
2.088
6.956
1.048

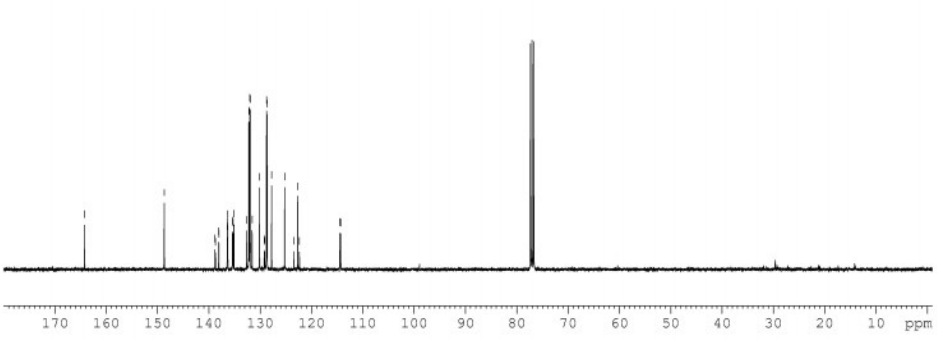

164.502
148.631
138.789
138.696
138.514
138.168
138.143
136.378
136.329
135.425
135.308
132.882
132.578
132.191
132.165
132.022
131.923
131.531
129.174
129.102
128.734
128.625
123.191
122.646
122.143
114.332
114.188
3ia
ppm

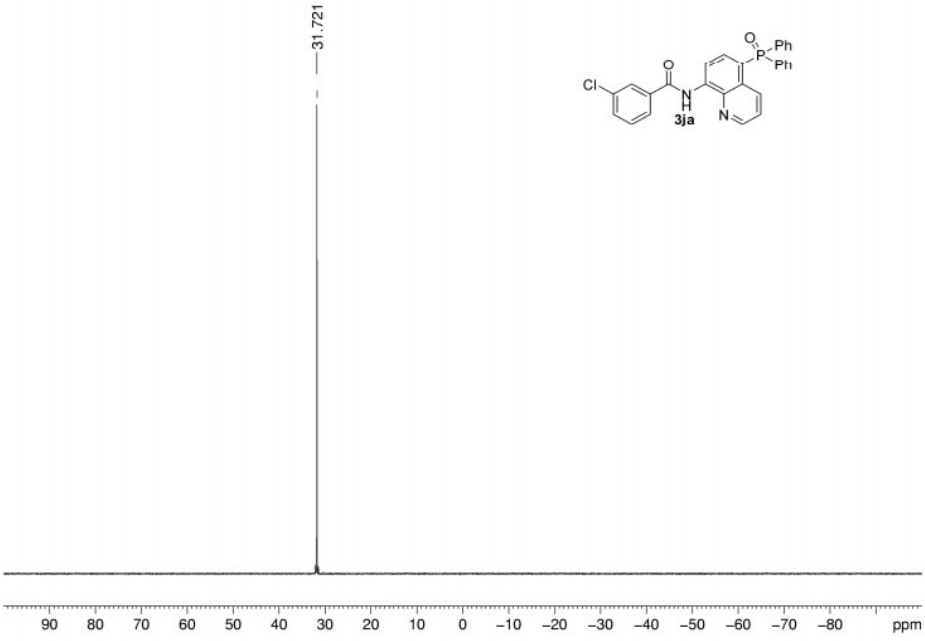

31.805
3ia
90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 ppm


10.917
9.088
9.066
8.858
8.850
8.784
8.780
8.765
8.760
8.039
7.931
7.912
7.700
7.682
7.670
7.652
7.587
7.568
7.549
7.498
7.479
7.464
7.444
7.433
7.376
7.356
7.338
7.318
3ja
9.1 9.0 8.9 8.8 ppm
8.0 ppm
7.35 ppm
11 10 9 8 7 6 5 4 3 2 1 0 ppm

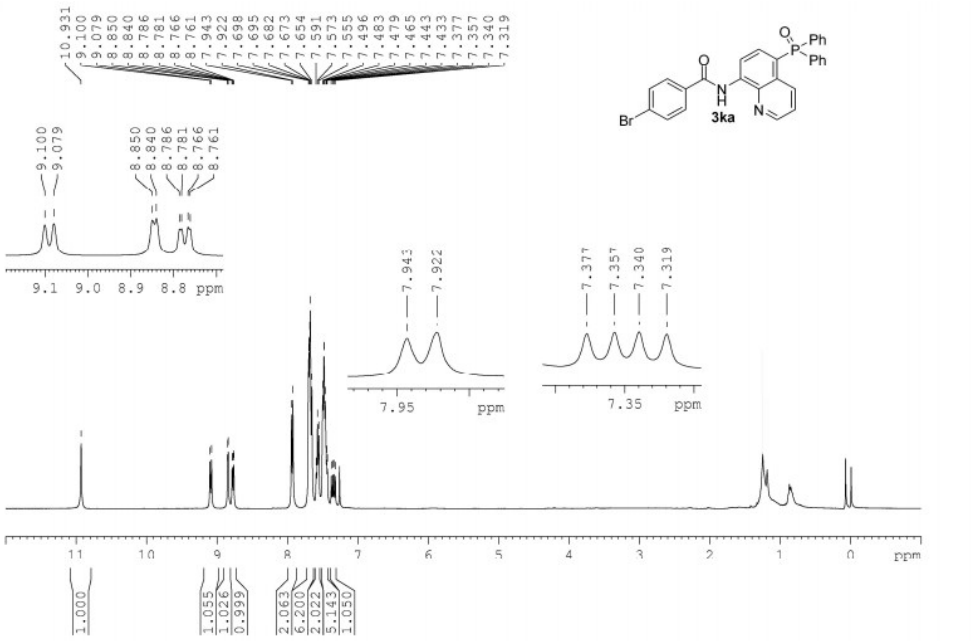

164.212
148.696
138.810
138.715
138.083
138.056
136.402
136.352
136.310
135.403
135.286
135.108
132.619
132.205
132.179
132.040
131.941
131.571
130.128
129.193
129.109
128.762
128.640
127.768
125.229
123.403
122.679
122.358
114.453
114.309

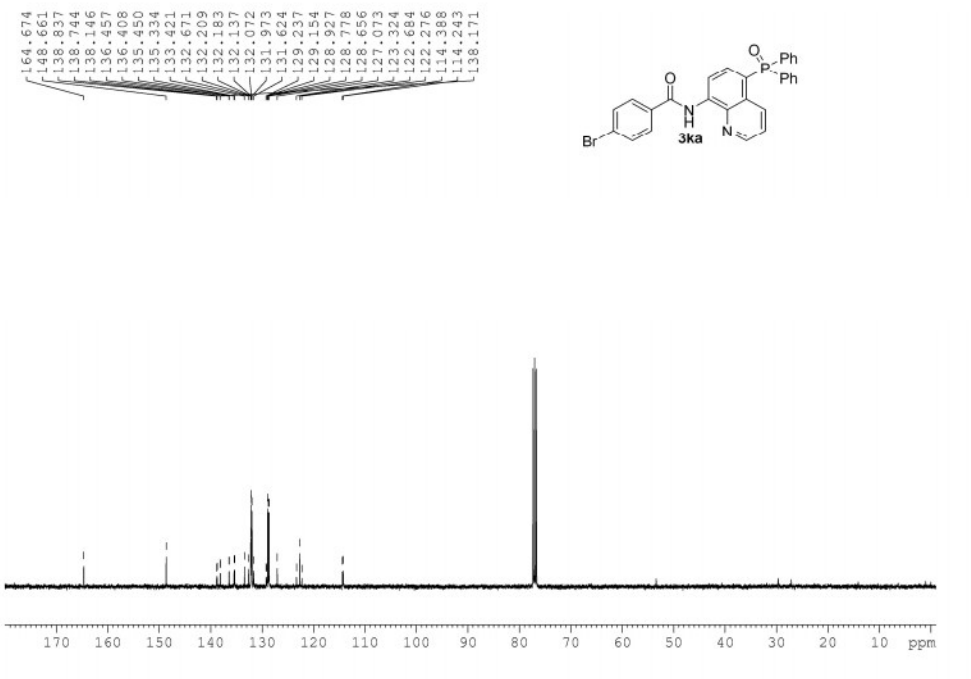

O
P
Ph
Ph
Cl
O
N
H
3ja
N

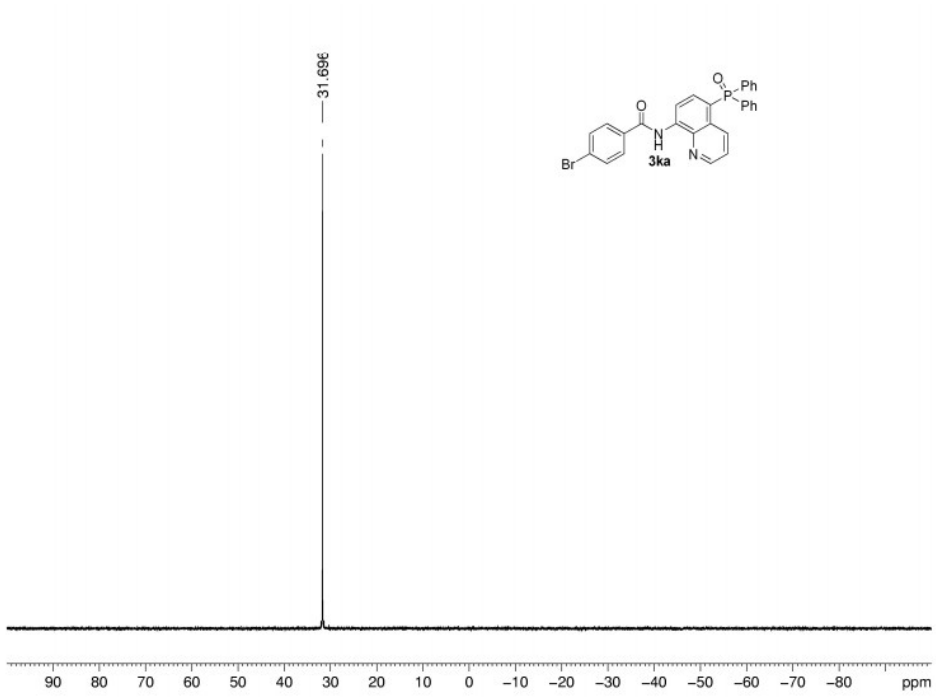

170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

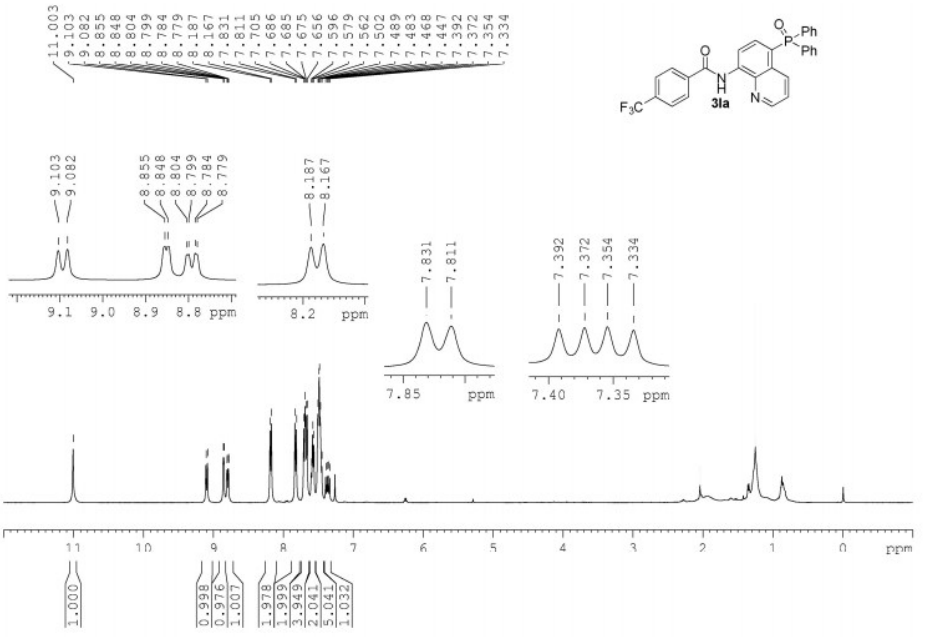

31.721
90
80
70
60
50
40
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
−80
ppm

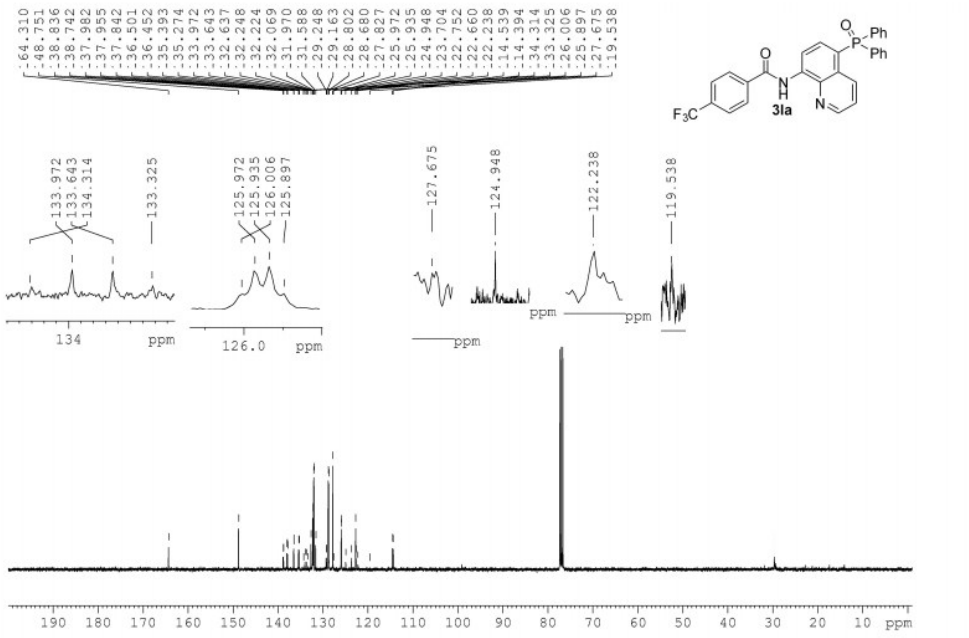
O
P
Ph
Ph
Cl
O
N
H
3ja
N

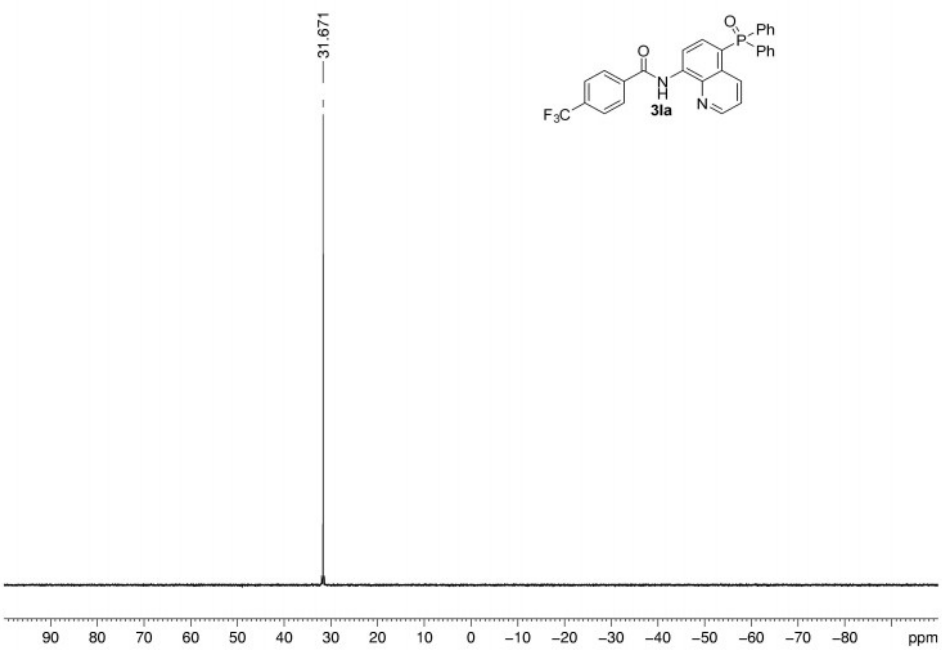

10.931
9.100
9.079
8.850
8.840
8.786
8.781
8.766
8.761
7.943
7.922
7.698
7.695
7.682
7.673
7.654
7.591
7.573
7.555
7.496
7.483
7.479
7.465
7.443
7.433
7.377
7.357
7.340
7.319
Br
3ka
Ph
Ph
9.1 9.0 8.9 8.8 ppm
7.95 ppm
7.35 ppm
ppm
1.000
1.055
1.026
0.999
2.063
6.200
2.022
5.143
1.050

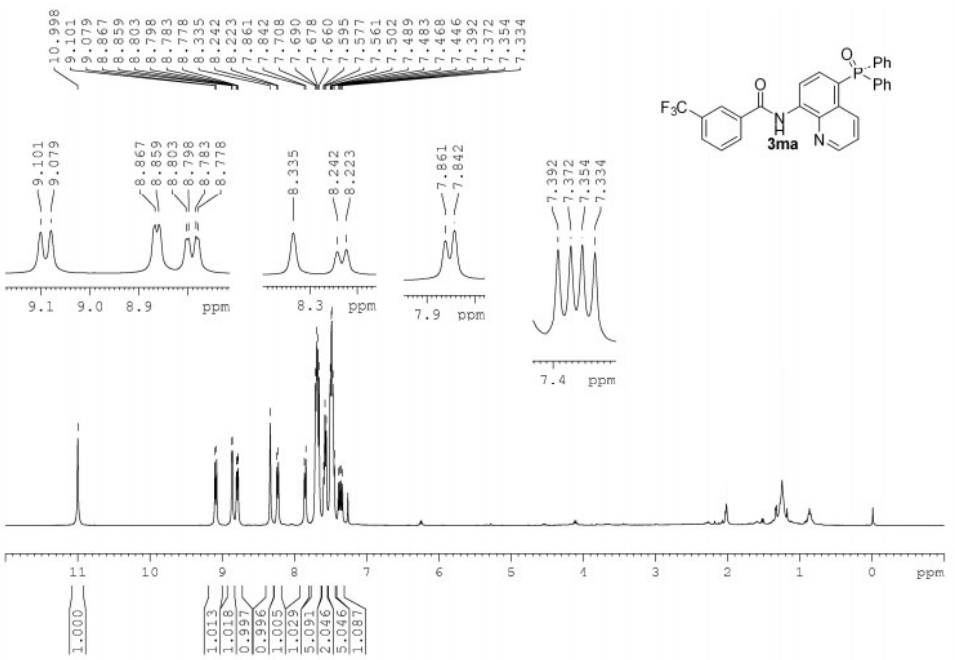

164.674
148.661
138.837
138.744
138.146
136.457
136.408
135.450
135.334
133.421
132.671
132.209
132.183
132.137
132.072
131.973
131.624
129.237
129.154
128.927
128.778
128.656
127.073
123.324
122.684
122.276
114.388
114.243
108.171
Br
3ka
Ph
Ph
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

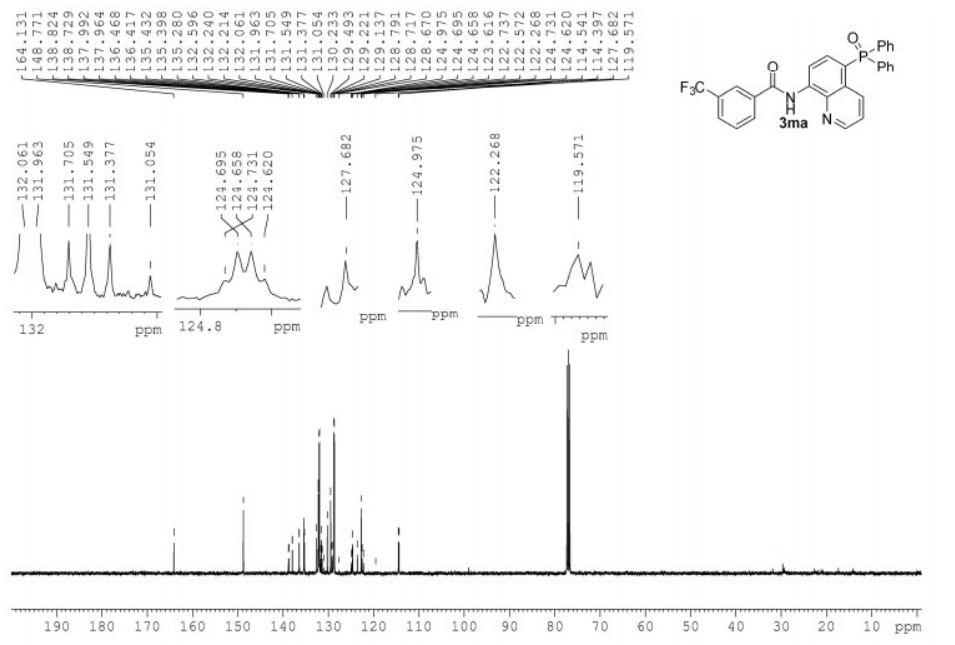

31.696
Br
3ka
90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 ppm

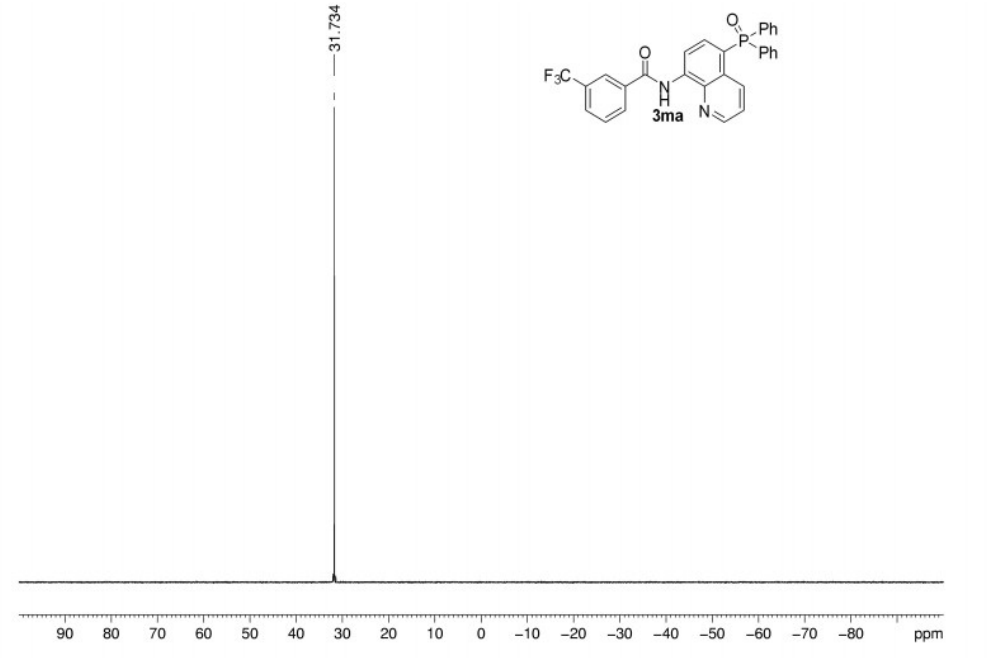

11.003
9.103
9.082
8.855
8.848
8.804
8.799
8.784
8.779
8.187
8.167
7.831
7.811
7.705
7.686
7.685
7.675
7.656
7.596
7.579
7.562
7.502
7.489
7.483
7.468
7.447
7.392
7.372
7.354
7.334
F3C
3la
9.1 9.0 8.9 8.8 ppm
8.2 ppm
7.85 ppm
7.40 7.35 ppm
11 10 9 8 7 6 5 4 3 2 1 0 ppm
1.000
0.998
0.976
1.007
1.978
1.999
3.949
2.041
5.041
1.032

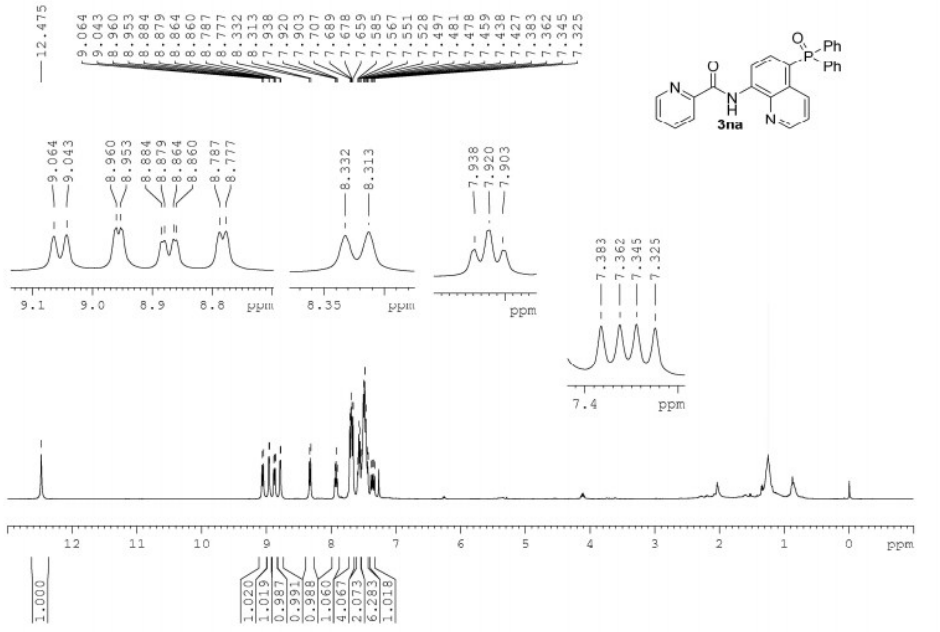

64.310
48.751
38.836
38.742
37.982
37.955
37.842
36.501
36.452
35.393
35.274
33.972
33.643
32.637
32.248
32.224
32.069
31.970
31.588
29.248
29.163
28.802
28.680
27.827
25.972
25.935
24.948
23.704
22.752
22.660
22.238
14.539
14.394
34.314
33.325
26.006
25.897
27.675
19.538
133.972
133.643
134.314
133.325
125.972
125.935
126.006
125.897
127.675
124.948
122.238
119.538
134
ppm
126.0
ppm
ppm
ppm
ppm
3Ia
190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

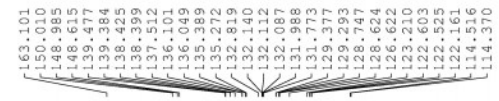

31.671
3Ia
90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 ppm

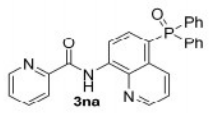

10.998
9.101
9.079
8.867
8.859
8.803
8.798
8.783
8.778
8.335
8.242
8.223
7.861
7.842
7.708
7.690
7.678
7.660
7.595
7.577
7.561
7.502
7.489
7.483
7.468
7.446
7.392
7.372
7.354
7.334
3ma
ppm
1.000
1.013
1.018
0.997
0.996
1.005
1.029
5.091
2.046
5.046
1.087

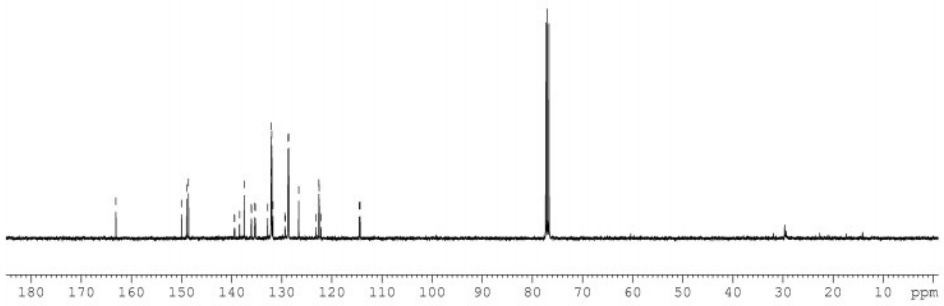

164.131
148.771
138.824
138.729
137.992
137.964
136.468
136.417
135.432
135.398
135.280
132.596
132.240
132.214
132.061
131.963
131.705
131.549
131.377
131.054
130.233
129.493
129.221
129.137
128.791
128.717
128.670
124.975
124.695
124.658
123.616
122.737
122.572
122.268
124.731
124.620
114.541
114.397
127.682
119.571
3ma
ppm

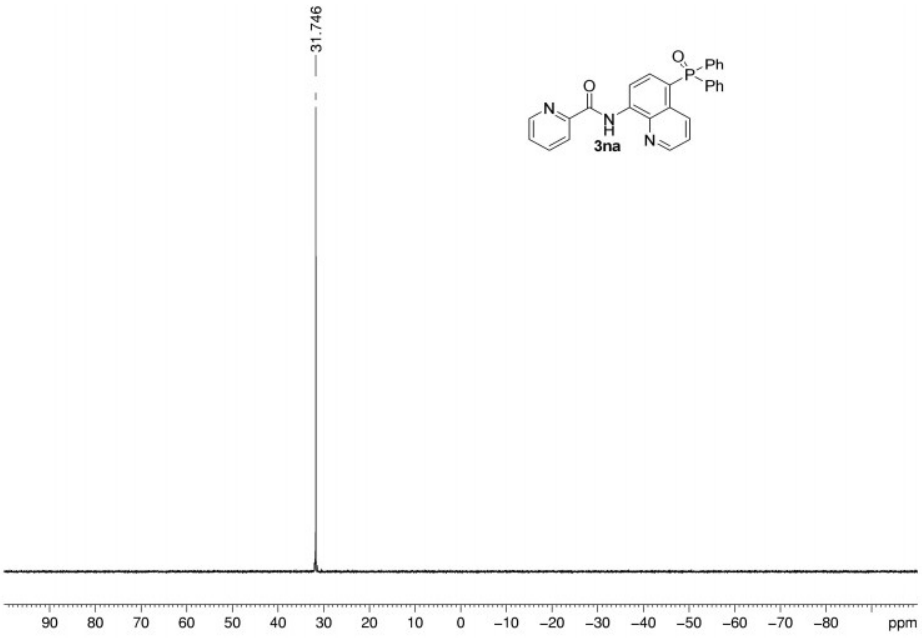

31.734
3ma
90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 ppm


12.475
9.064
9.043
8.960
8.953
8.884
8.879
8.864
8.860
8.787
8.777
8.332
8.313
7.938
7.920
7.903
7.707
7.689
7.678
7.659
7.585
7.567
7.551
7.528
7.497
7.481
7.478
7.459
7.438
7.427
7.383
7.362
7.345
7.325
3na
ppm
1.000
1.020
1.019
0.987
0.991
0.988
1.060
4.067
2.073
6.283
1.018

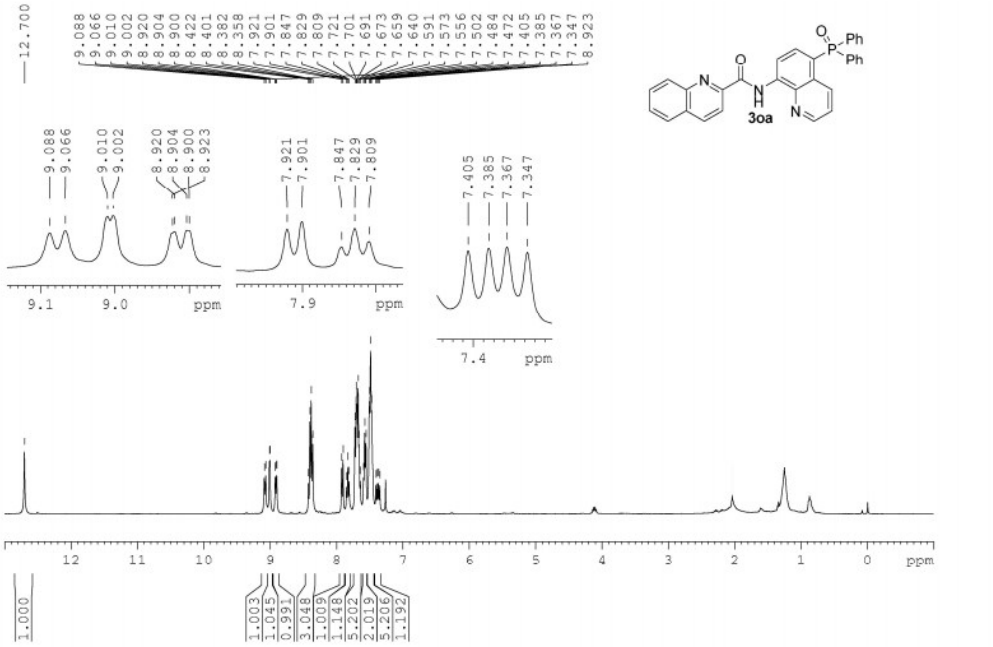

163.101
150.010
148.985
148.615
139.477
139.384
138.425
138.399
137.512
136.101
136.049
135.389
135.272
132.819
132.140
132.112
132.087
131.988
131.773
129.377
129.293
128.747
128.624
126.622
123.210
122.603
122.525
122.161
114.516
114.370

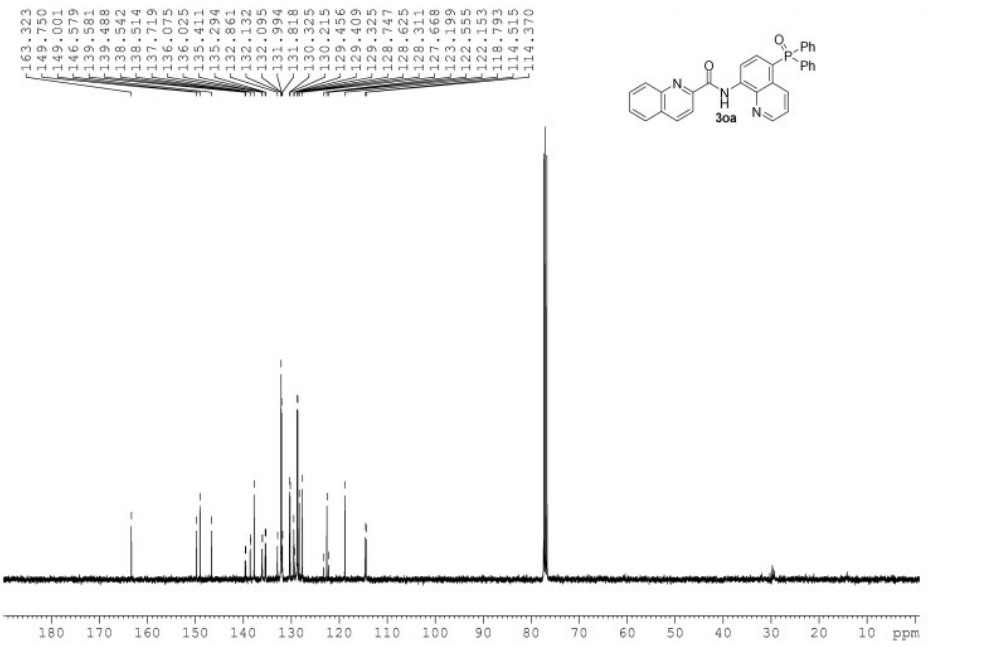

O
Ph
P
Ph
N
O
N
H
N
3na

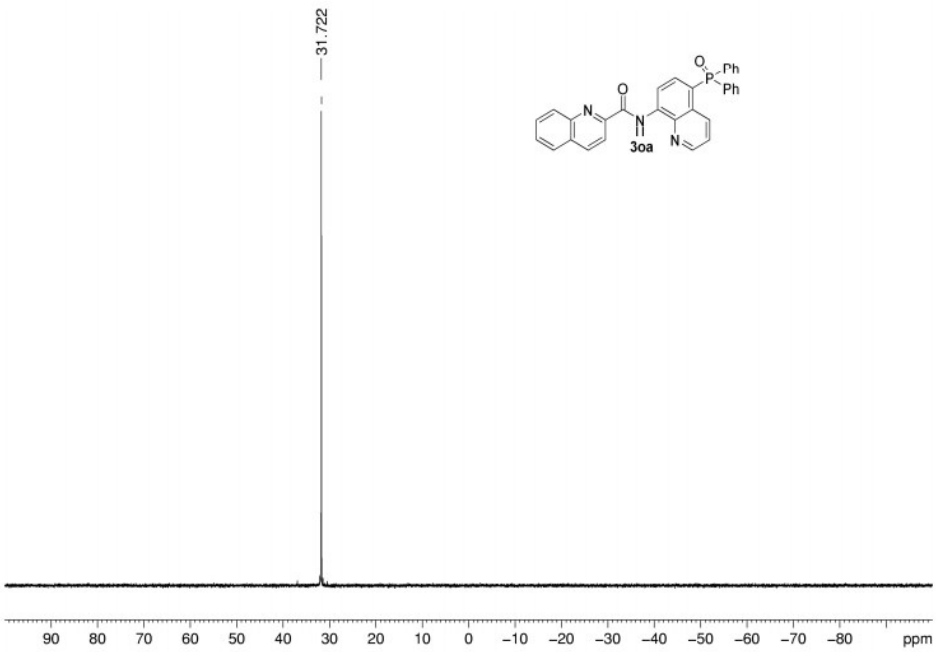

180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

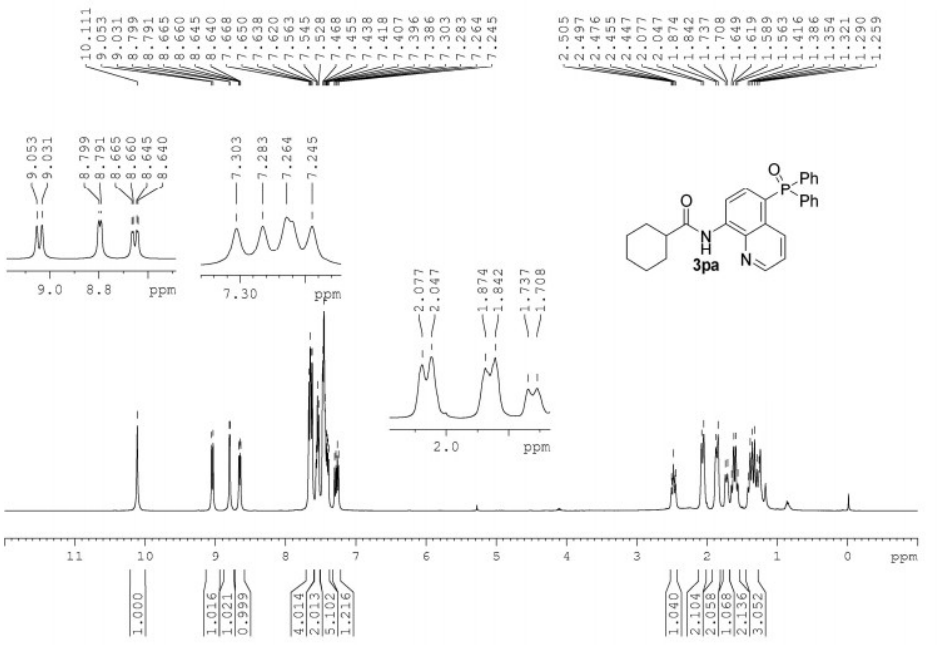

31.746
90
80
70
60
50
40
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
−80
ppm

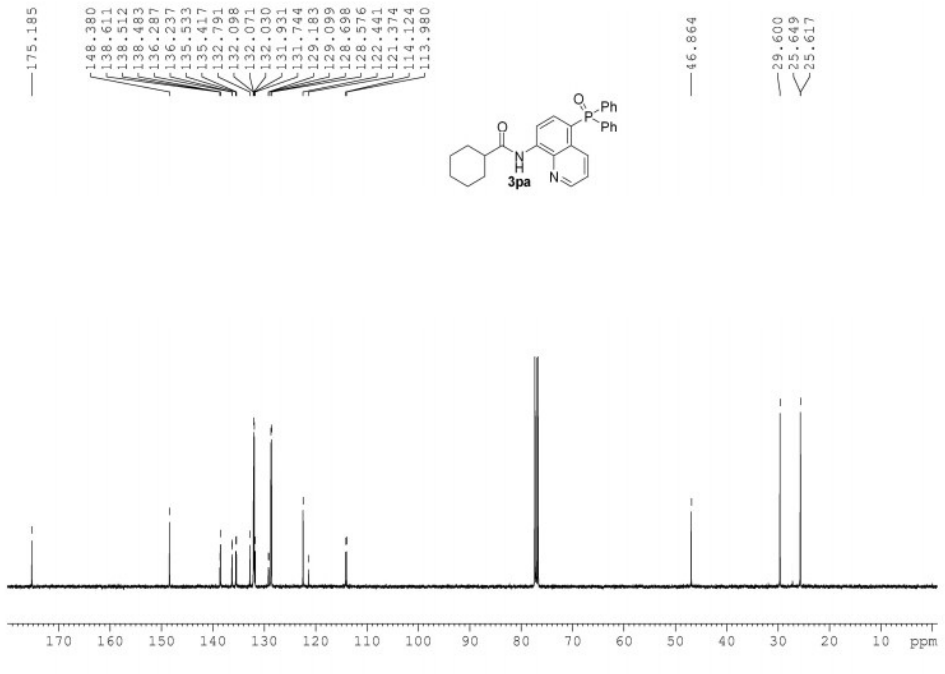
O
Ph
P
Ph
N
O
N
H
N
3na

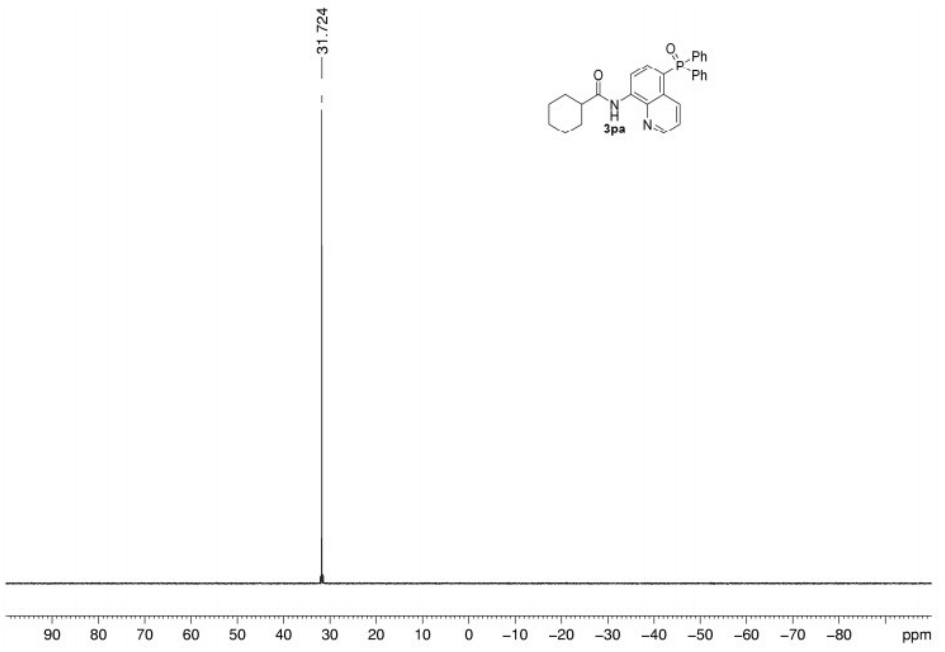

12.700
9.088
9.066
9.010
9.002
8.920
8.904
8.900
8.422
8.401
8.382
8.358
7.921
7.901
7.847
7.829
7.809
7.721
7.701
7.691
7.673
7.659
7.640
7.591
7.573
7.556
7.502
7.484
7.472
7.405
7.385
7.367
7.347
8.923
9.1
9.0
ppm
7.9
ppm
7.4
ppm
12
11
10
9
8
7
6
5
4
3
2
1
0
ppm
1.000
1.003
1.045
0.991
3.048
1.009
1.148
5.202
2.019
5.206
1.192
Ph
Ph
O
P
N
H
N
O
3oa

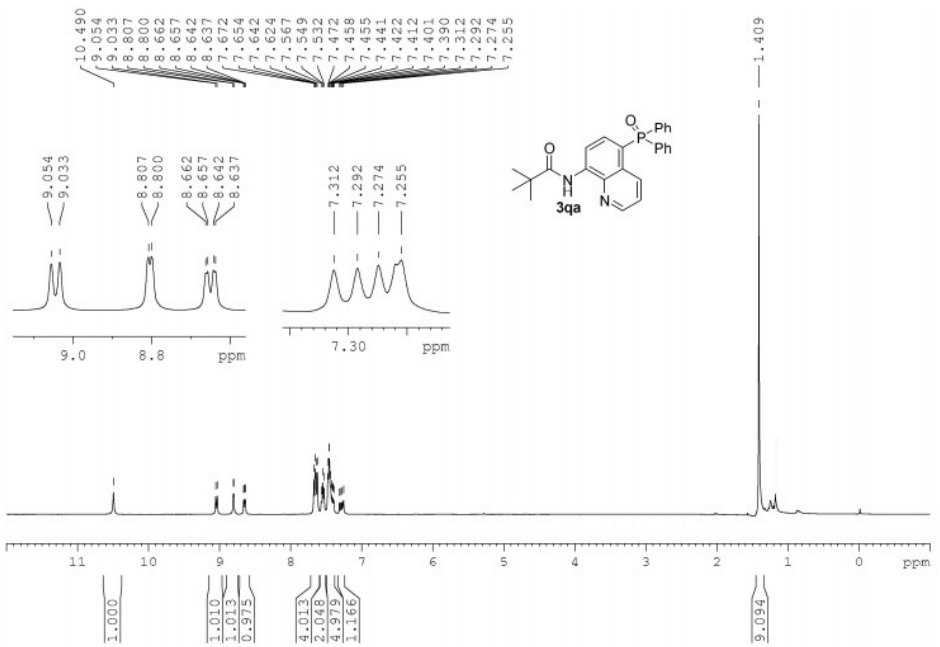

163.323
149.750
149.001
146.579
139.581
139.488
138.542
138.514
137.719
136.075
136.025
135.411
135.294
132.861
132.132
132.095
131.994
131.818
130.325
130.215
129.456
129.409
129.325
128.747
128.625
128.311
127.668
123.199
122.555
122.153
118.793
114.515
114.370
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm
Ph
Ph
O
P
N
H
N
O
3oa

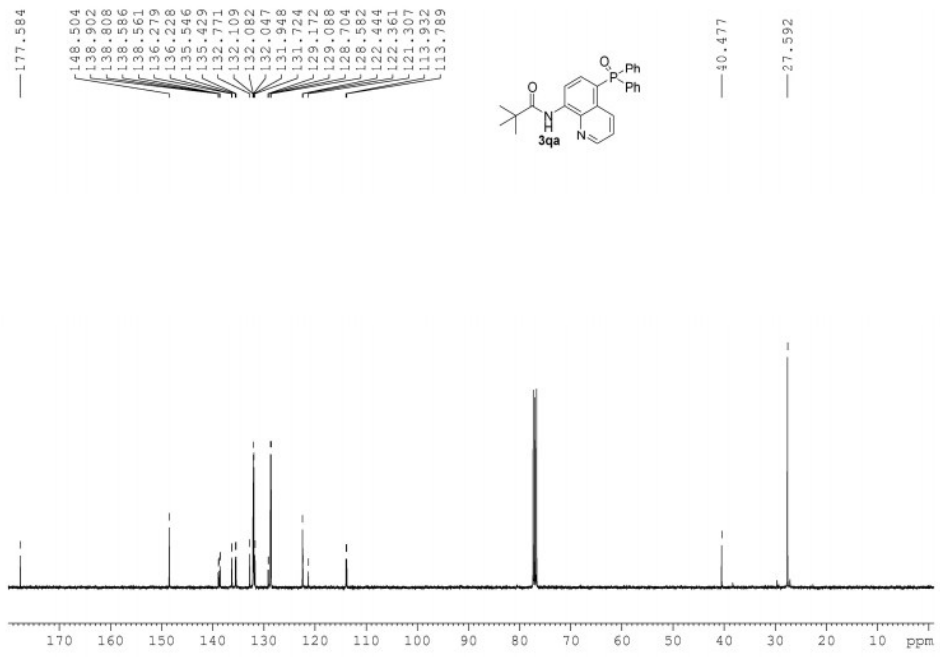

31.722
3oa
90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 ppm

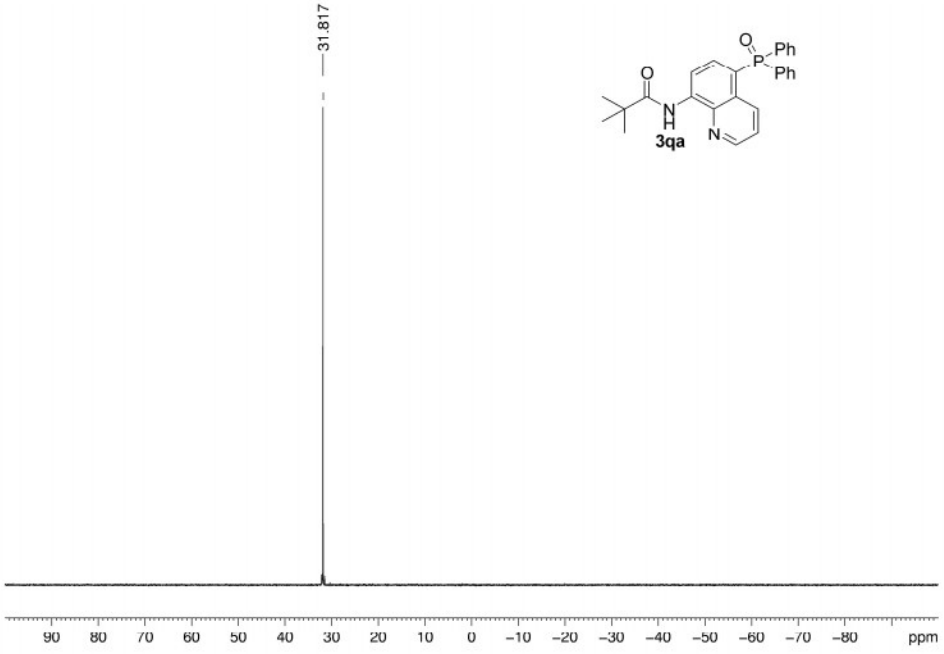

3pa
9.0 8.8 ppm
7.30 ppm
2.0 ppm
11 10 9 8 7 6 5 4 3 2 1 0 ppm

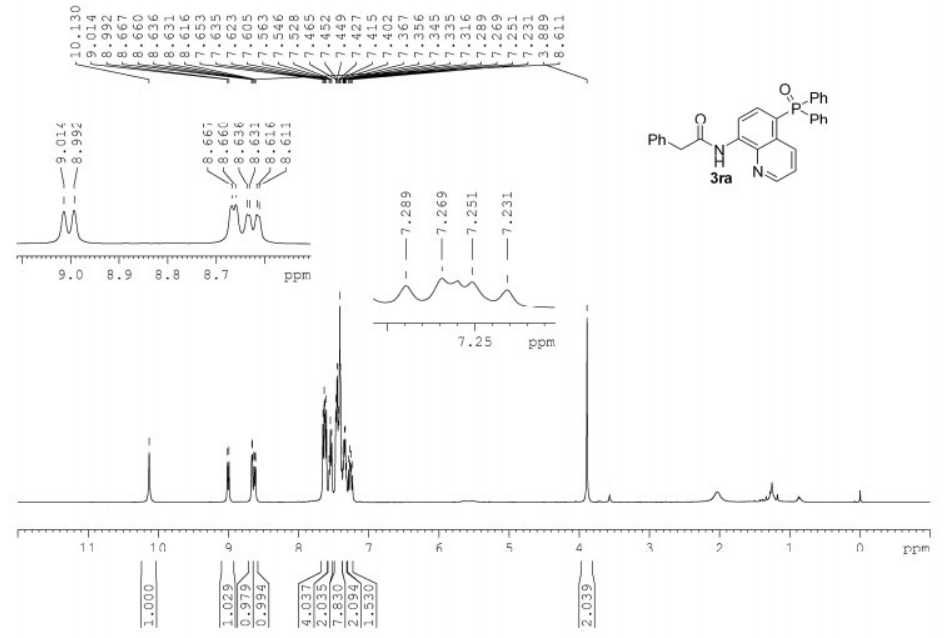

175.185
148.380
138.611
138.512
138.483
136.287
136.237
135.533
135.417
132.791
132.098
132.071
132.030
131.931
131.744
129.183
129.099
128.698
128.576
122.441
121.374
114.124
113.980
46.864
29.600
25.649
25.617
3pa
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

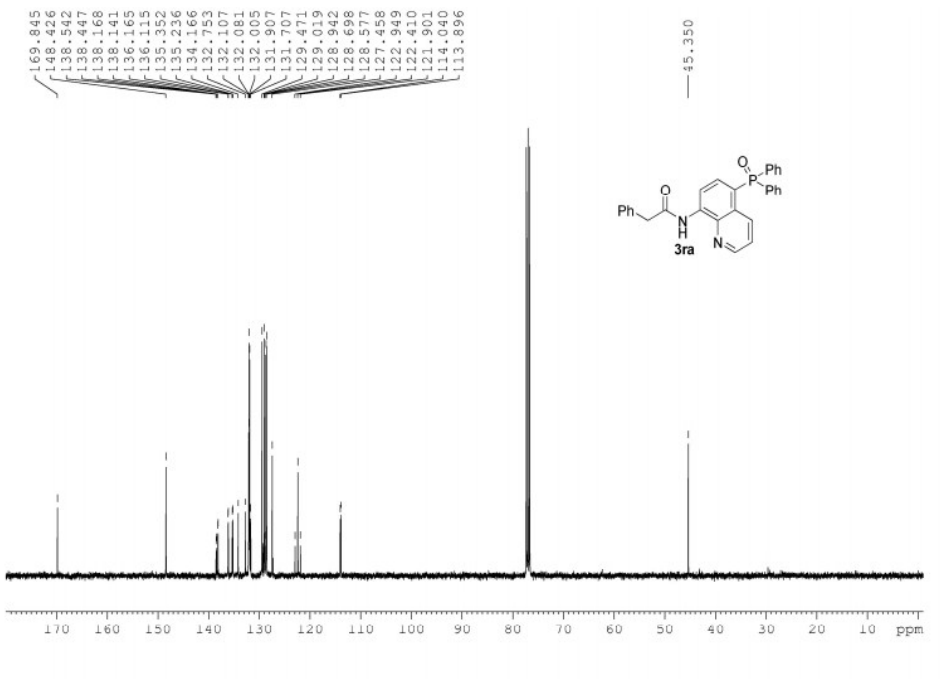

31.724
3pa
90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 ppm

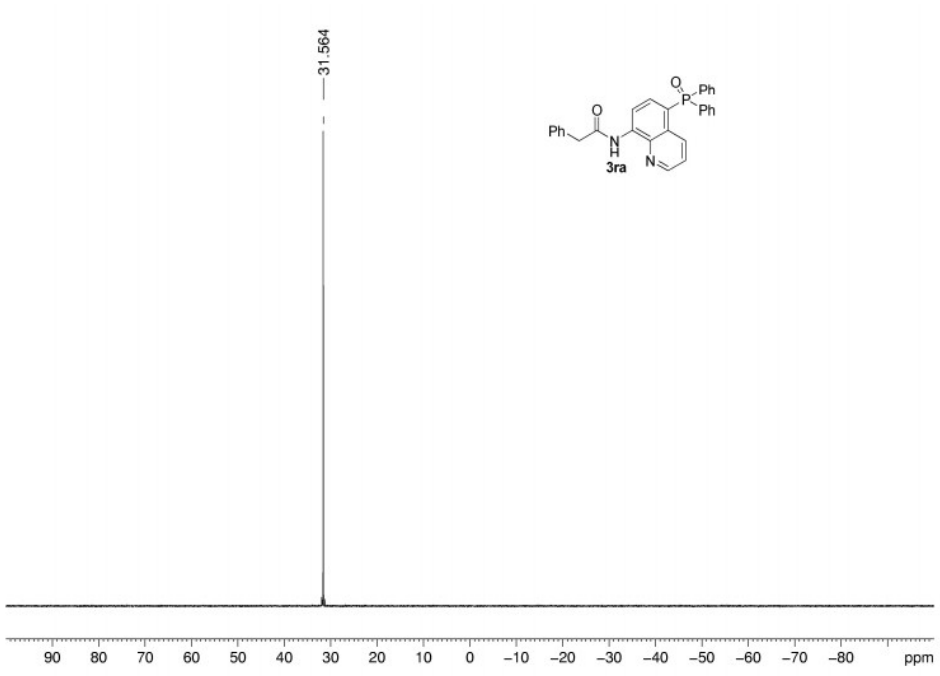

10.490
9.054
9.033
8.807
8.800
8.662
8.657
8.642
8.637
7.672
7.654
7.642
7.624
7.567
7.549
7.532
7.472
7.458
7.455
7.441
7.422
7.412
7.401
7.390
7.312
7.292
7.274
7.255
1.409
3qa
ppm
1.000
1.010
1.013
0.975
4.013
2.048
4.979
1.166
9.094

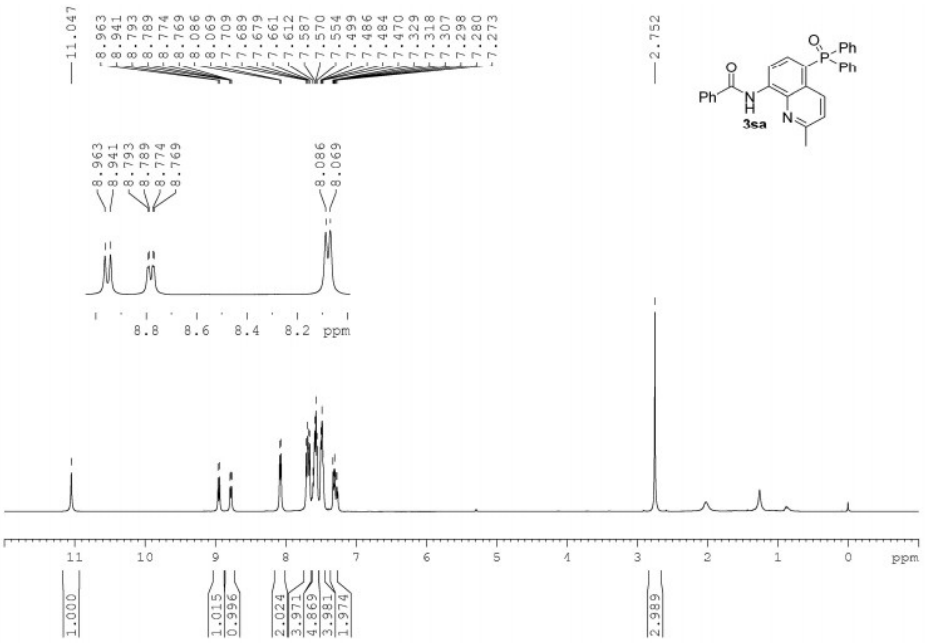

177.584
148.504
138.902
138.808
138.586
138.561
136.279
136.228
135.546
135.429
132.771
132.109
132.082
132.047
131.948
131.724
129.172
129.088
128.704
128.582
122.444
122.361
121.307
113.932
113.789
40.477
27.592
3qa
ppm

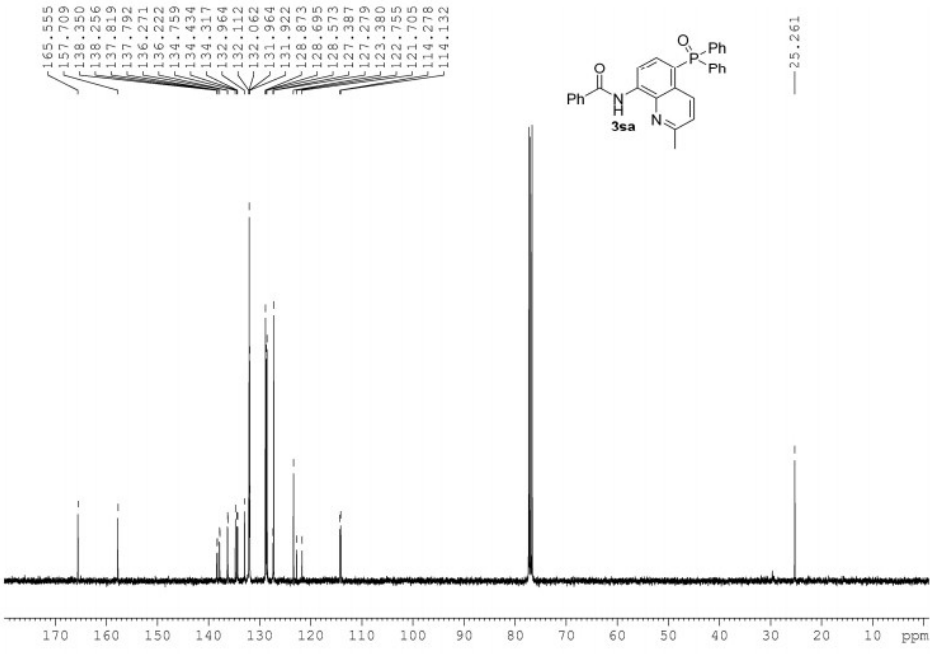

31.817
O
P
Ph
Ph
O
N
H
N
3qa
90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 ppm

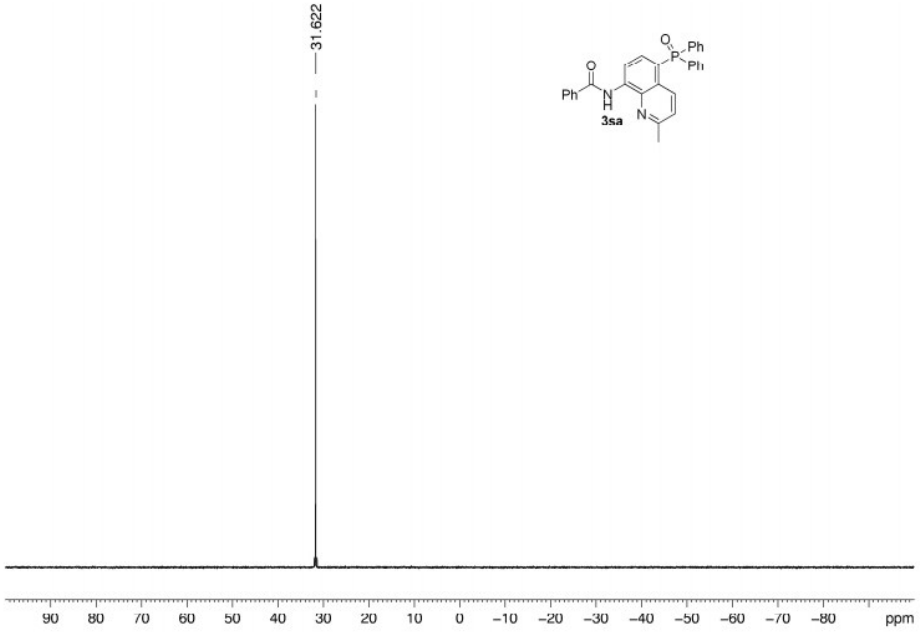

10.130
9.014
8.992
8.667
8.660
8.636
8.631
8.616
7.653
7.635
7.623
7.605
7.563
7.546
7.528
7.465
7.452
7.449
7.427
7.415
7.402
7.367
7.356
7.345
7.335
7.316
7.289
7.269
7.251
7.231
3.889
8.611
9.014
8.992
8.667
8.660
8.636
8.631
8.616
8.611
9.0 8.9 8.8 8.7 ppm
7.289
7.269
7.251
7.231
7.25 ppm
O
P
Ph
Ph
Ph
O
N
H
N
3ra
11 10 9 8 7 6 5 4 3 2 1 0 ppm
1.000
1.029
0.979
0.994
4.037
2.035
7.830
2.094
1.530
2.039

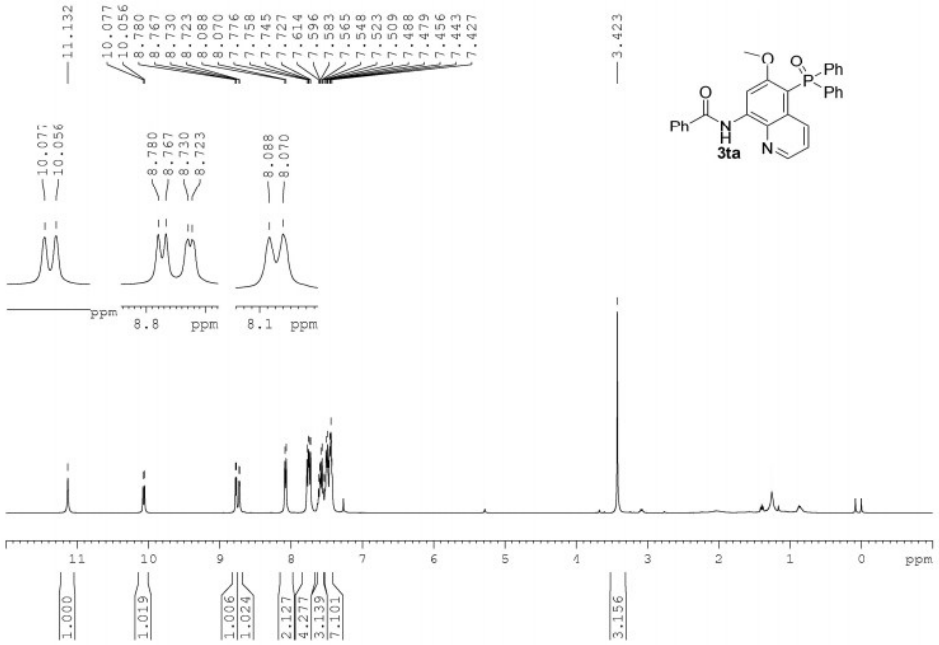

169.845
148.426
138.542
138.447
138.168
138.141
136.165
136.115
135.352
135.236
134.166
132.753
132.107
132.081
132.005
131.907
131.707
129.471
129.019
128.942
128.698
128.577
127.458
122.949
122.410
121.901
114.040
113.896
45.350
Ph
O
N
H
P
Ph
Ph
3ra
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

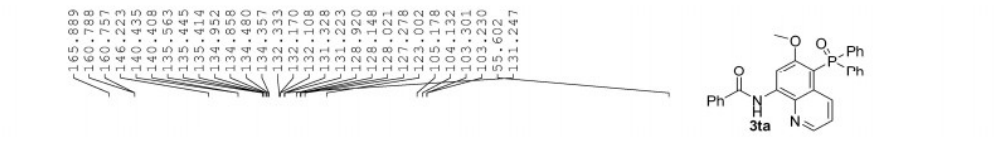

31.564
Ph
O
N
H
P
Ph
Ph
3ra
90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 ppm

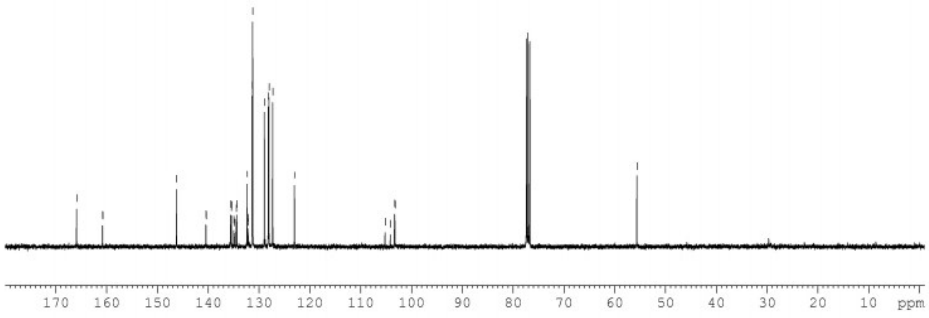

11.047
8.963
8.941
8.793
8.789
8.774
8.769
8.086
8.069
7.709
7.689
7.679
7.661
7.612
7.587
7.570
7.554
7.499
7.486
7.484
7.470
7.329
7.318
7.307
7.298
7.280
7.273
2.752
Ph
O
P
Ph
Ph
O
N
H
N
3sa
8.8
8.6
8.4
8.2 ppm
11
10
9
8
7
6
5
4
3
2
1
0
ppm
1.000
1.015
0.996
2.024
3.971
4.869
3.981
1.974
2.989

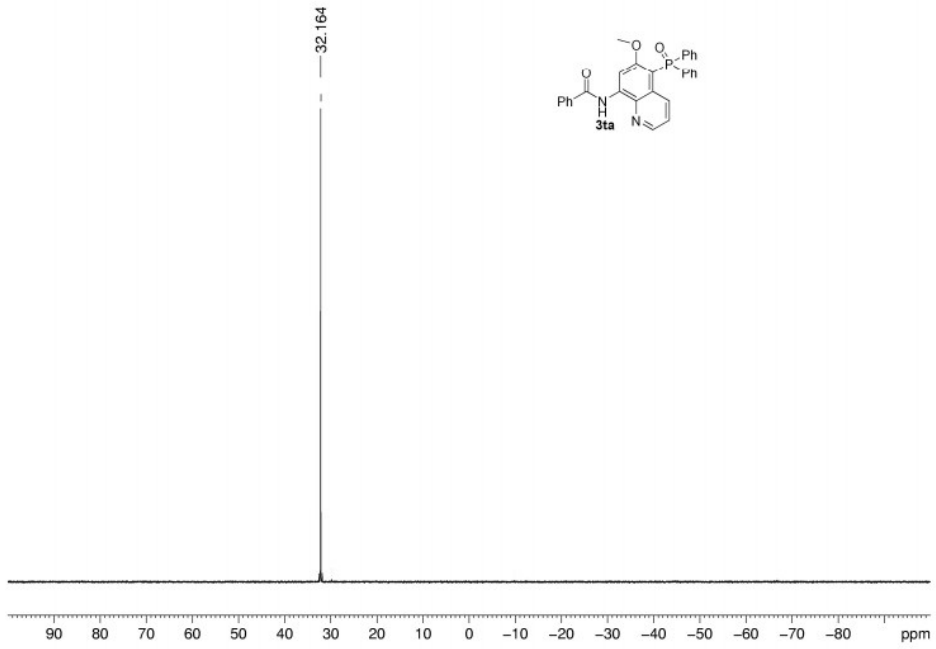

165.555
157.709
138.350
138.256
137.819
137.792
136.271
136.222
134.759
134.434
134.317
132.964
132.112
132.062
131.964
131.922
128.873
128.695
128.573
127.387
127.279
123.380
122.755
121.705
114.278
114.132
25.261
Ph
O
P
Ph
Ph
O
N
H
N
3sa
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

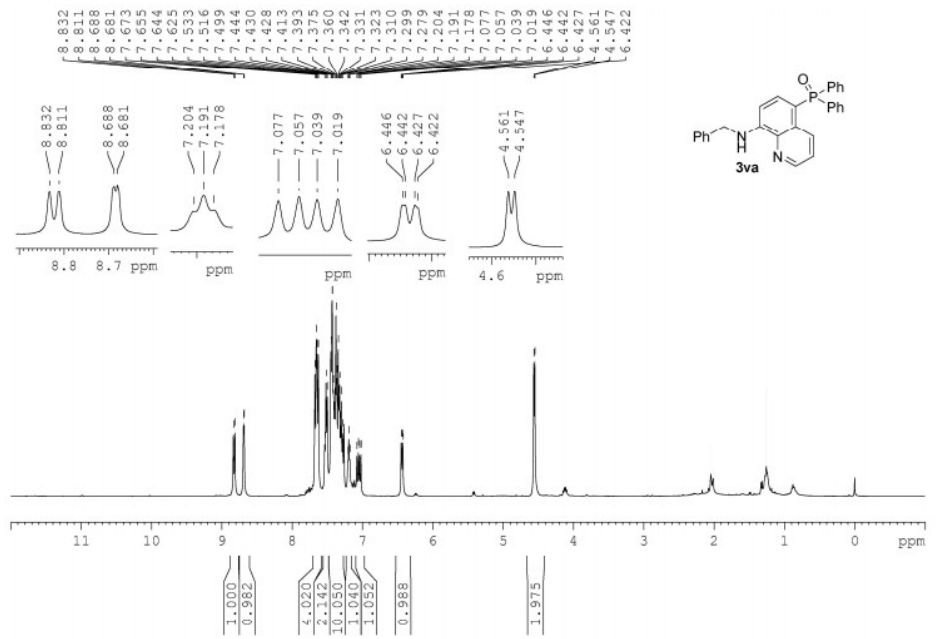

31.622
3sa
90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 ppm

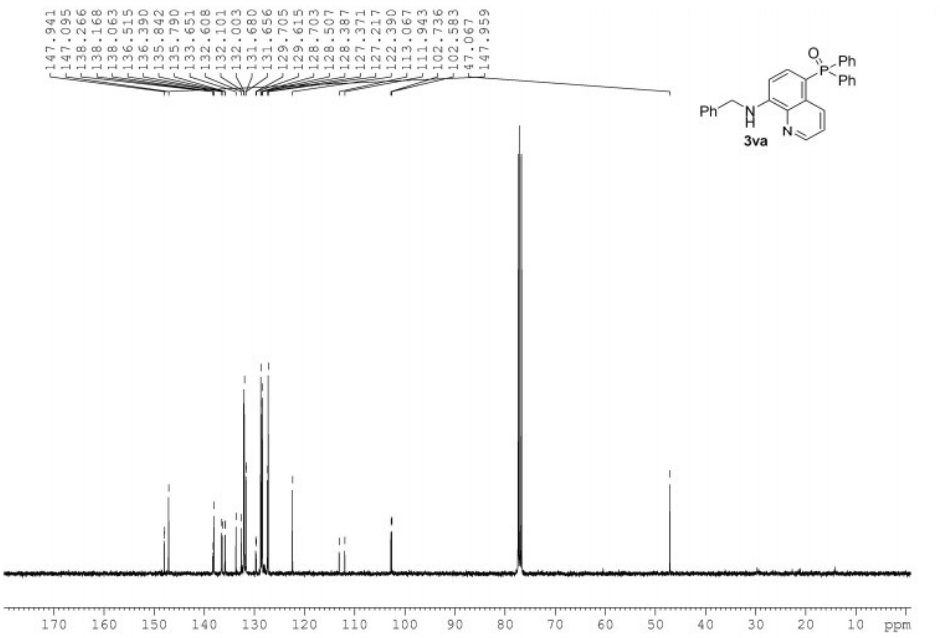

11.132
10.077
10.056
8.780
8.767
8.730
8.723
8.088
8.070
7.776
7.758
7.745
7.727
7.614
7.596
7.583
7.565
7.548
7.523
7.509
7.488
7.479
7.456
7.443
7.427
3.423
3ta
8.8 ppm
8.1 ppm
11 10 9 8 7 6 5 4 3 2 1 0 ppm
1.000
1.019
1.006
1.024
2.127
4.277
3.139
7.101
3.156

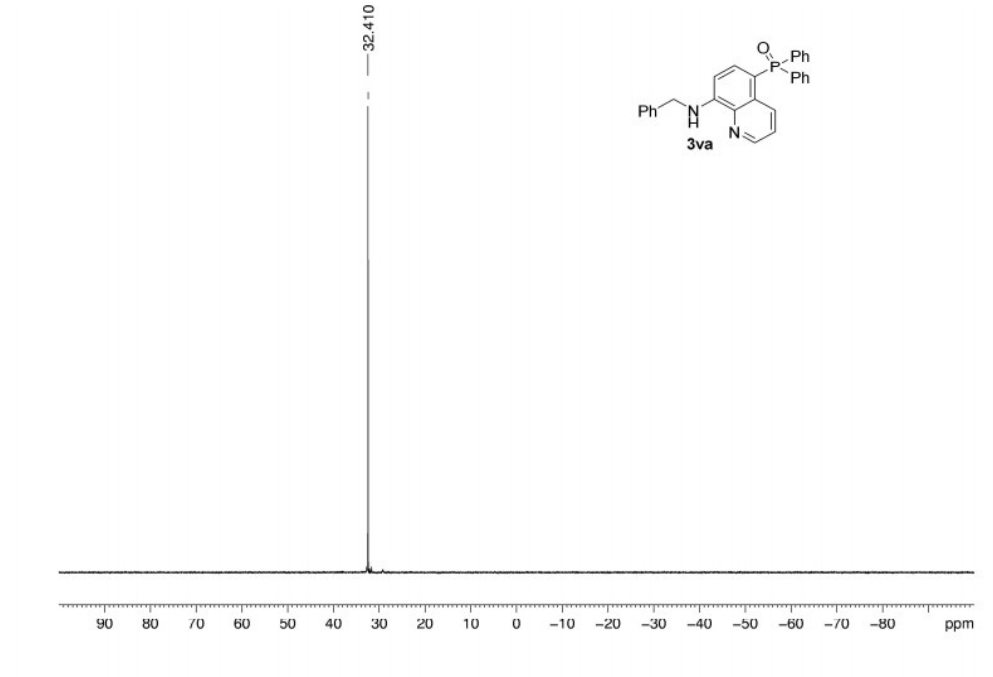

165.889
160.788
160.757
146.223
140.435
140.408
135.563
135.445
135.414
134.952
134.858
134.480
134.357
132.333
132.170
132.108
131.328
131.223
128.920
128.148
128.021
127.278
123.002
105.178
104.132
103.301
103.230
55.602
31.247
Ph
O
N
H
3ta
O
P
Ph
Ph
N

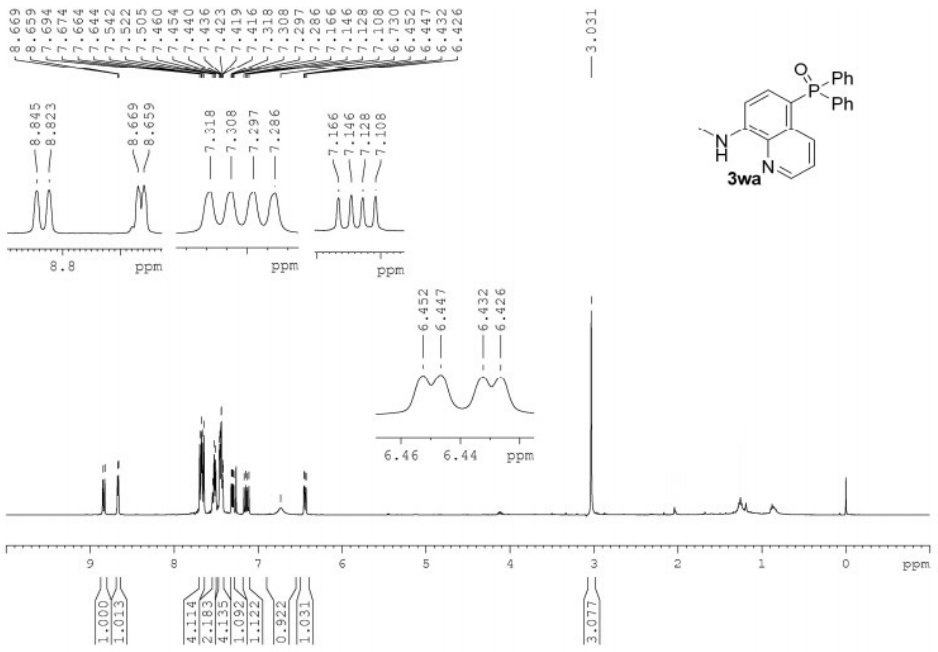

170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

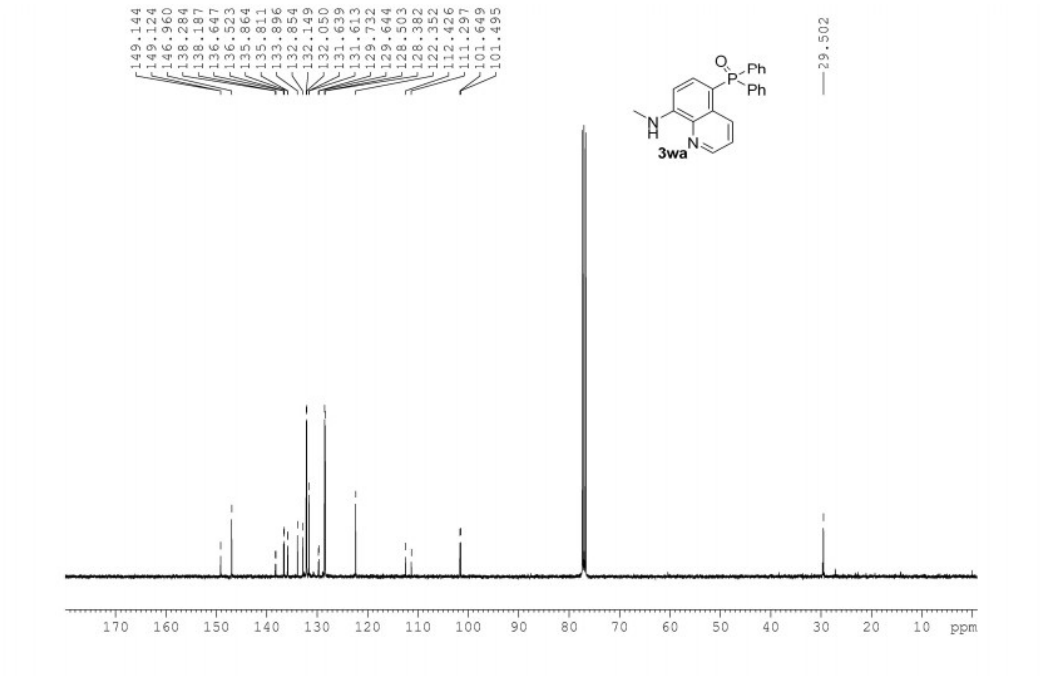

32.164
Ph
O
N
H
3ta
O
P
Ph
Ph
N
90
80
70
60
50
40
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
−80
ppm

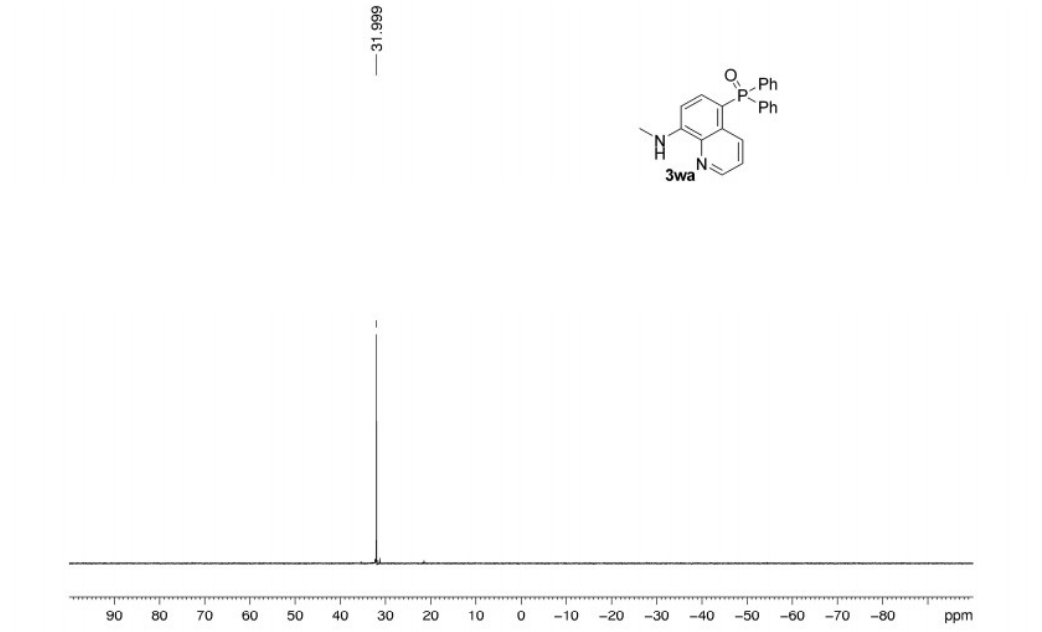

3va

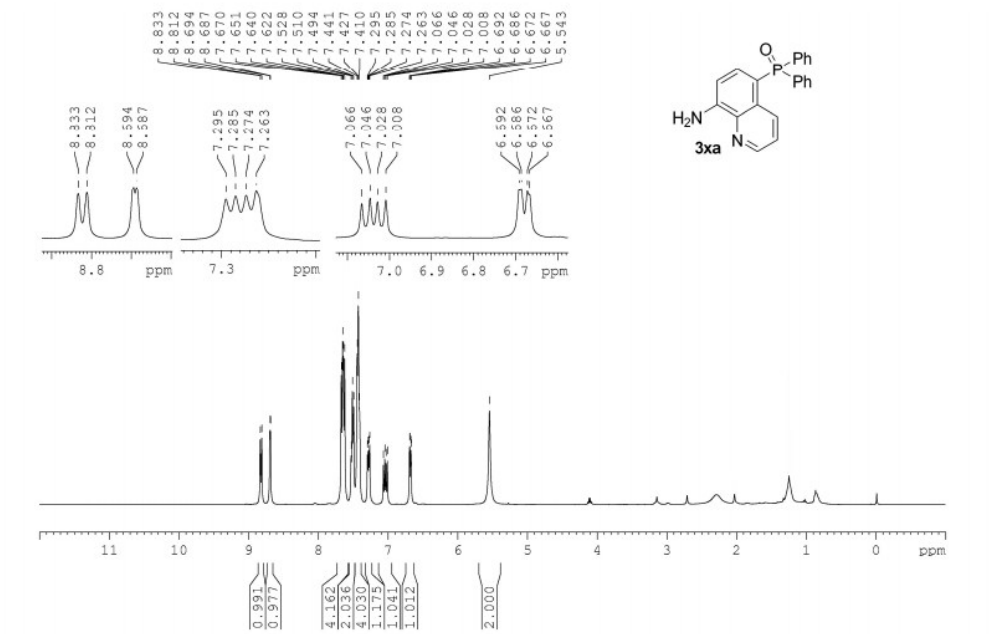

3va

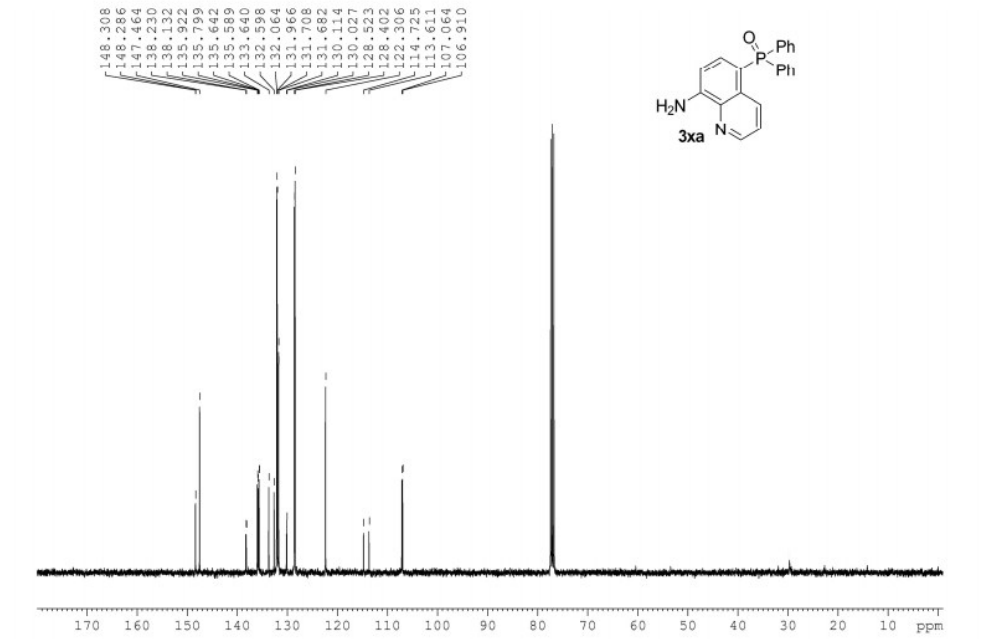

32.410
Ph
Ph
O
P
Ph
N
H
N
3va
90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 ppm

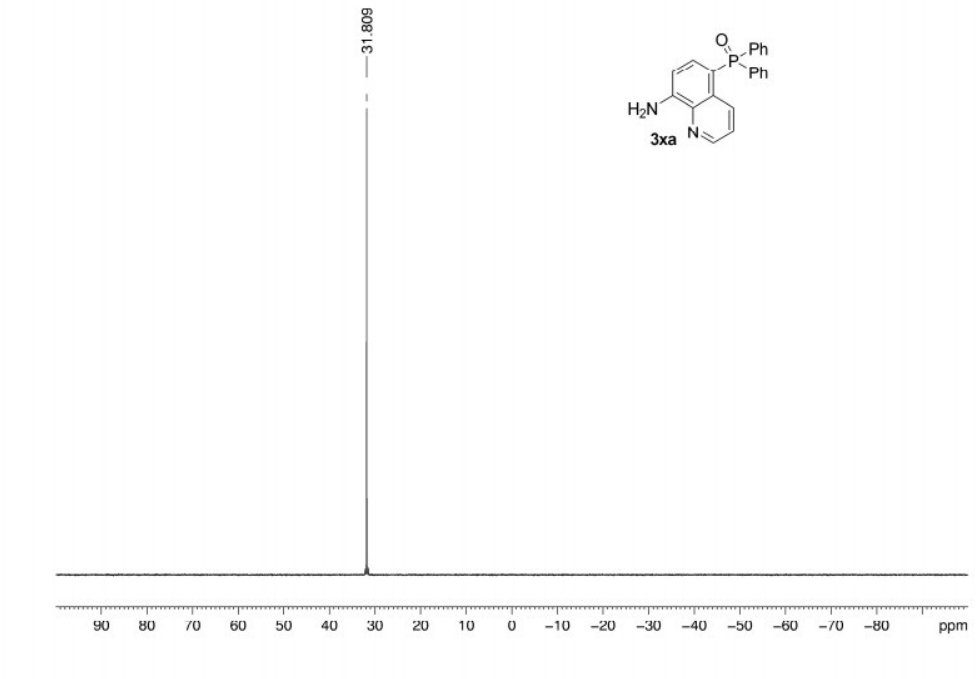

8.669
8.659
7.694
7.674
7.664
7.644
7.542
7.522
7.505
7.460
7.454
7.440
7.436
7.423
7.419
7.416
7.318
7.308
7.297
7.286
7.166
7.146
7.128
7.108
6.730
6.452
6.447
6.432
6.426
3.031
8.845
8.823
8.669
8.659
7.318
7.308
7.297
7.286
7.166
7.146
7.128
7.108
8.8 ppm
ppm
ppm
6.452
6.447
6.432
6.426
6.46 6.44 ppm
O
P
Ph
Ph
N
H
N
3wa
9 8 7 6 5 4 3 2 1 0 ppm
1.000
1.013
4.114
2.183
4.135
1.092
1.122
0.922
1.031
3.077

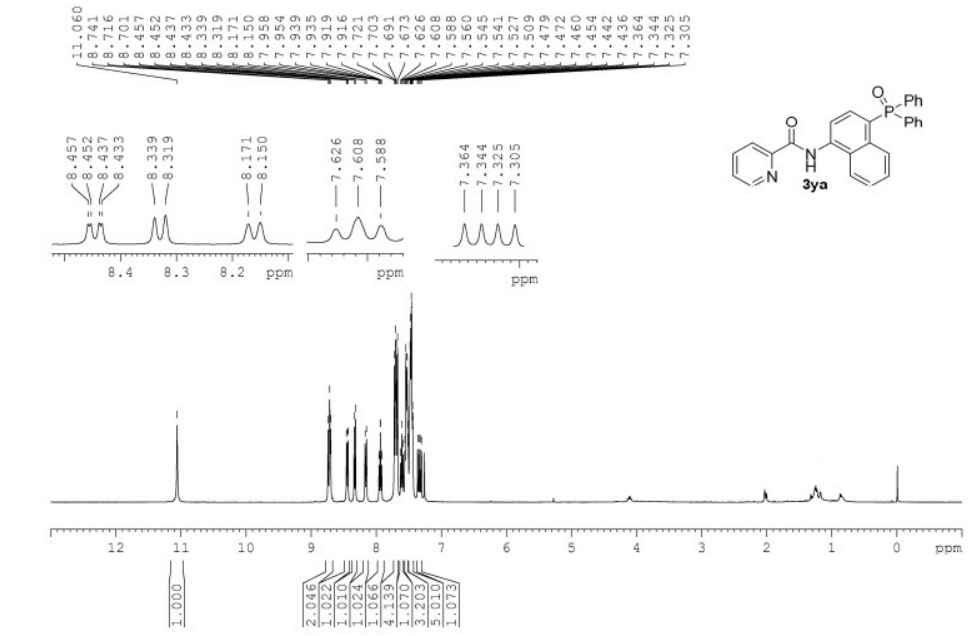

149.144
149.124
146.960
138.284
138.187
136.647
136.523
135.864
135.811
133.896
132.854
132.149
132.050
131.639
131.613
129.732
129.644
128.503
128.382
122.352
112.426
111.297
101.649
101.495
29.502
Ph
Ph
O
P
N
H
N
3wa
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

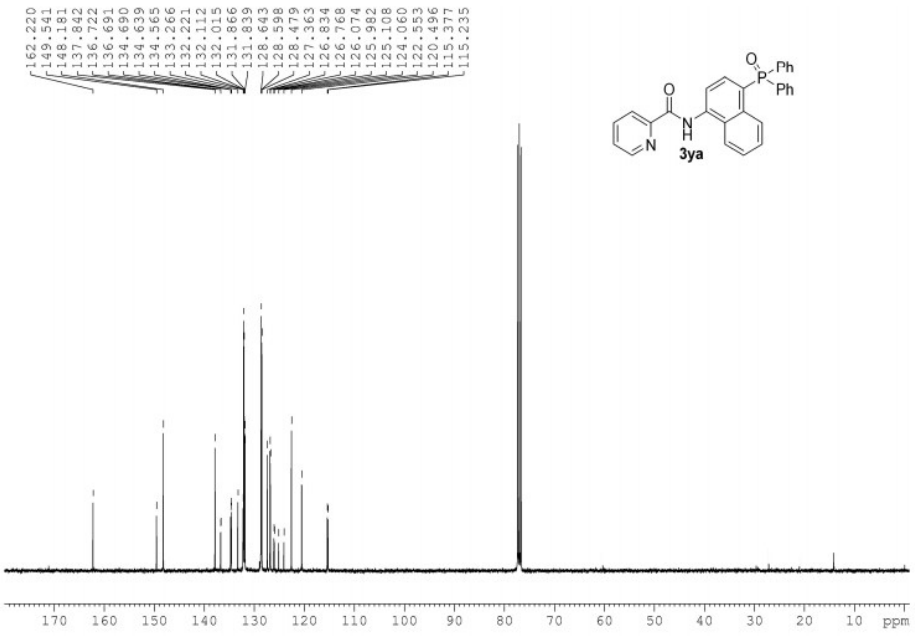

31.999
Ph
Ph
O
P
N
H
N
3wa
90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 ppm

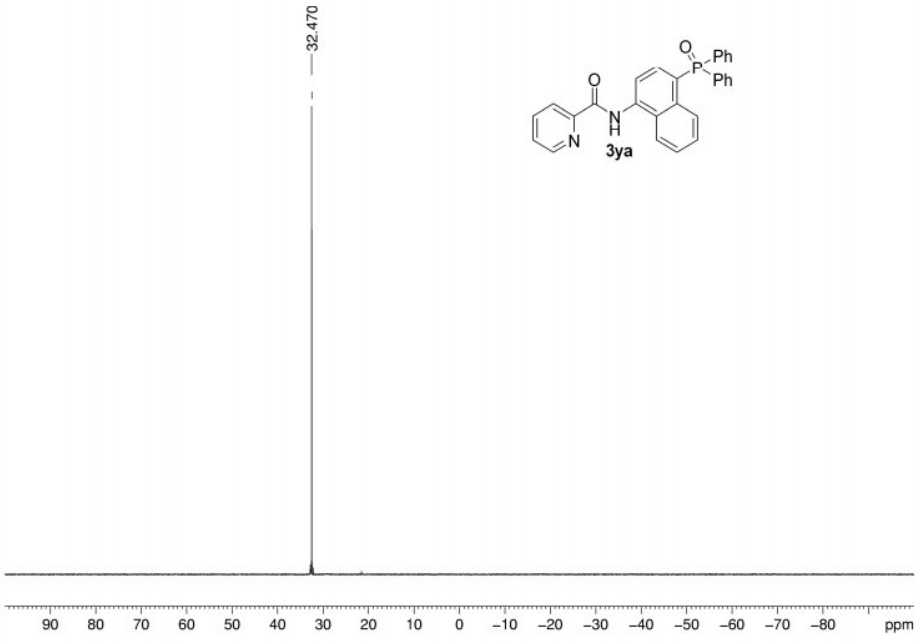

8.833
8.812
8.694
8.687
7.670
7.651
7.640
7.622
7.528
7.510
7.494
7.441
7.427
7.410
7.295
7.285
7.274
7.263
7.066
7.046
7.028
7.008
6.692
6.686
6.672
6.667
5.543
8.333
8.312
8.594
8.587
7.295
7.285
7.274
7.263
7.066
7.046
7.028
7.008
6.592
6.586
6.572
6.567
8.8 ppm
7.3 ppm
7.0 6.9 6.8 6.7 ppm
O
P
Ph
Ph
H2N
N
3xa
11 10 9 8 7 6 5 4 3 2 1 0 ppm
0.991
0.977
4.162
2.036
4.030
1.175
1.041
1.012
2.000

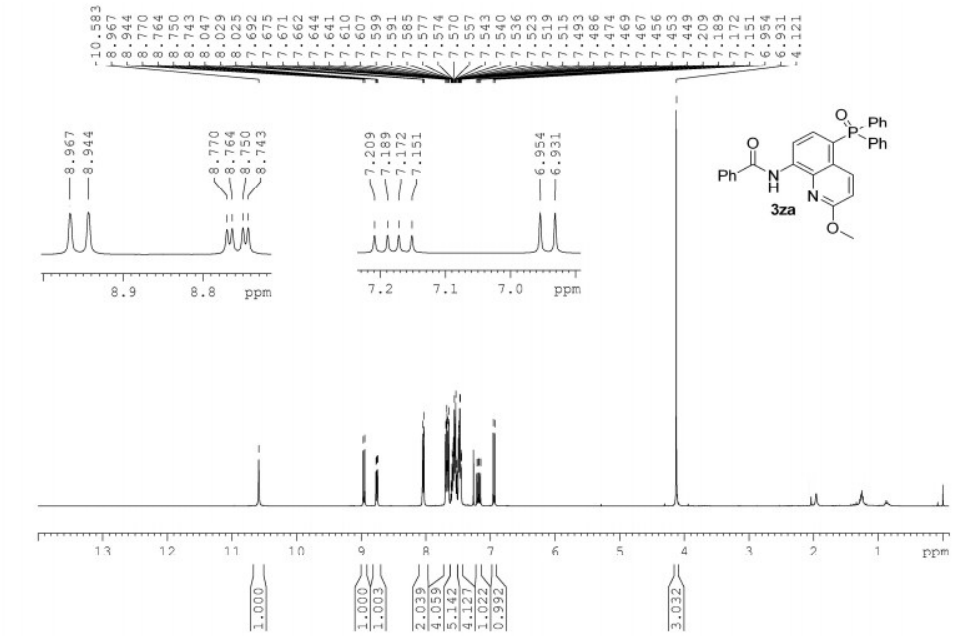

148.308
148.286
147.464
138.230
138.132
135.922
135.799
135.642
135.589
133.640
132.598
132.064
131.966
131.708
131.682
130.114
130.027
128.523
128.402
122.306
114.725
113.611
107.064
106.910
O
P
Ph
Ph
H2N
N
3xa
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

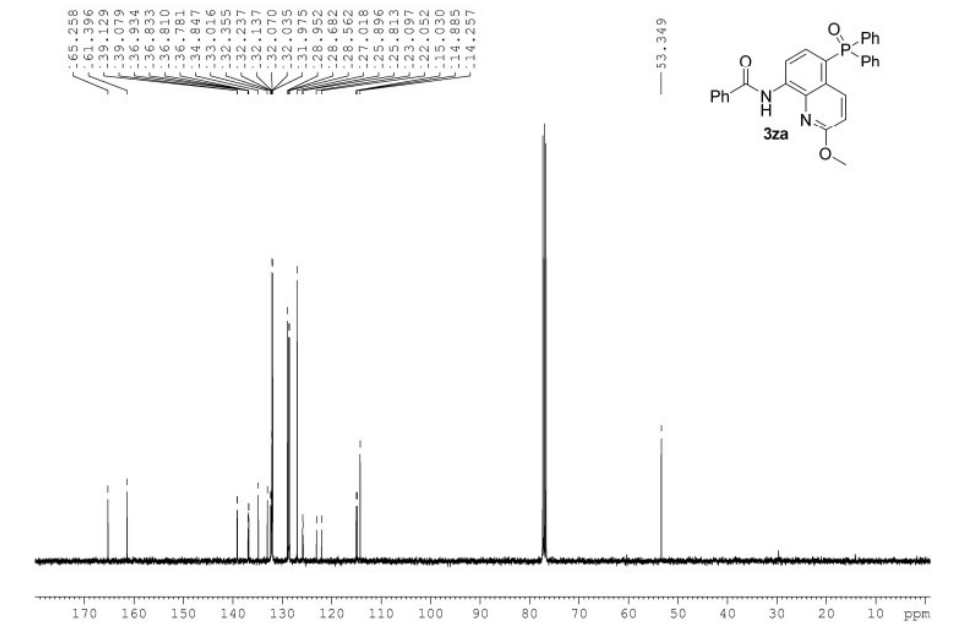

31.809
O
P
Ph
Ph
H2N
N
3xa
90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 ppm

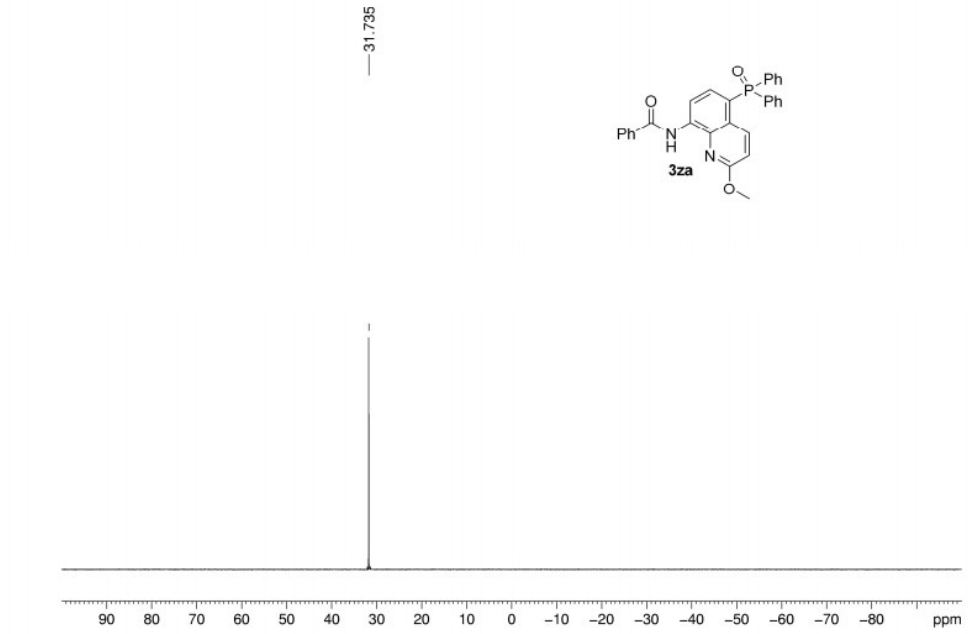

11.060
8.741
8.716
8.701
8.457
8.452
8.437
8.433
8.339
8.319
8.171
8.150
7.958
7.954
7.939
7.935
7.919
7.916
7.721
7.703
7.691
7.673
7.626
7.608
7.588
7.560
7.545
7.541
7.527
7.509
7.479
7.472
7.460
7.454
7.442
7.436
7.364
7.344
7.325
7.305
O
P
Ph
Ph
O
N
H
N
3ya
8.4 8.3 8.2 ppm
ppm
ppm
12 11 10 9 8 7 6 5 4 3 2 1 0 ppm
1.000
2.046
1.022
1.010
1.024
1.066
4.139
1.070
3.203
5.010
1.073

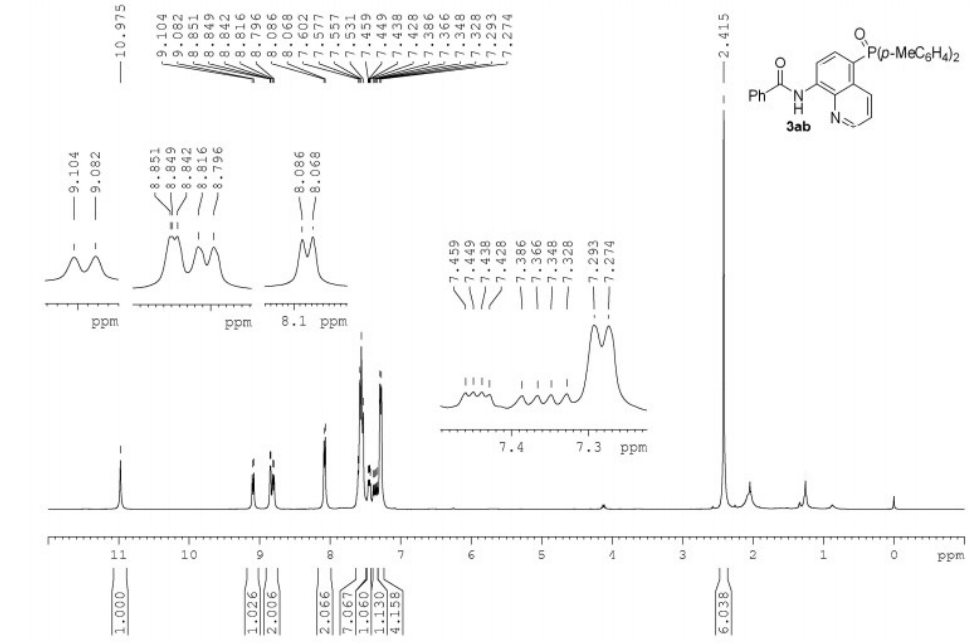

162.220
149.541
148.181
137.842
136.722
136.691
134.690
134.639
134.565
133.266
132.221
132.112
132.015
131.866
131.839
128.643
128.598
128.479
127.363
126.834
126.768
126.074
125.982
125.108
124.060
122.553
120.496
115.377
115.235
O
Ph
P
Ph
O
N
H
N
3ya
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

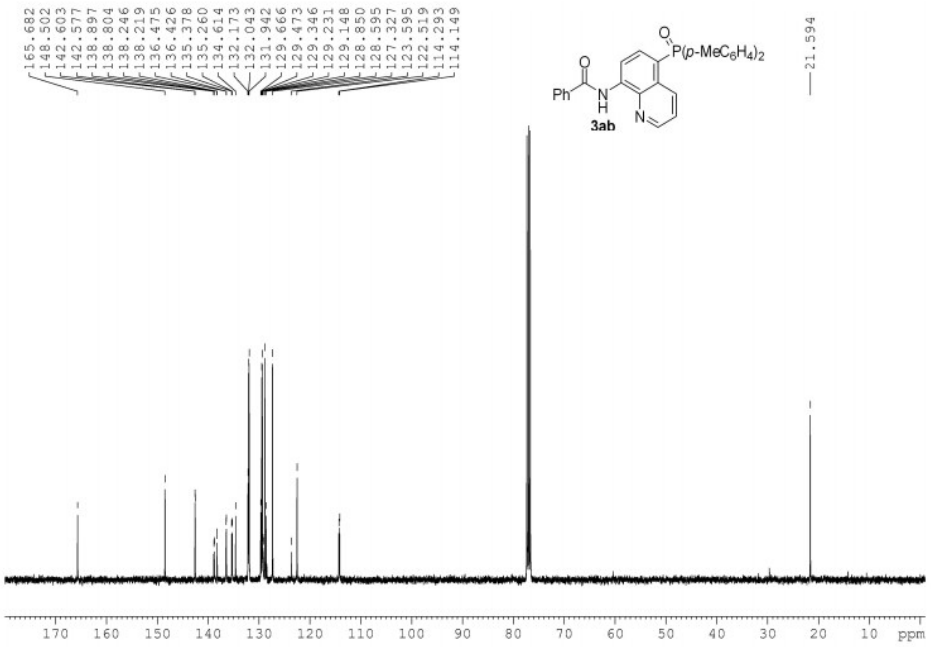

32.470
O
Ph
P
Ph
O
N
H
N
3ya
90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 ppm

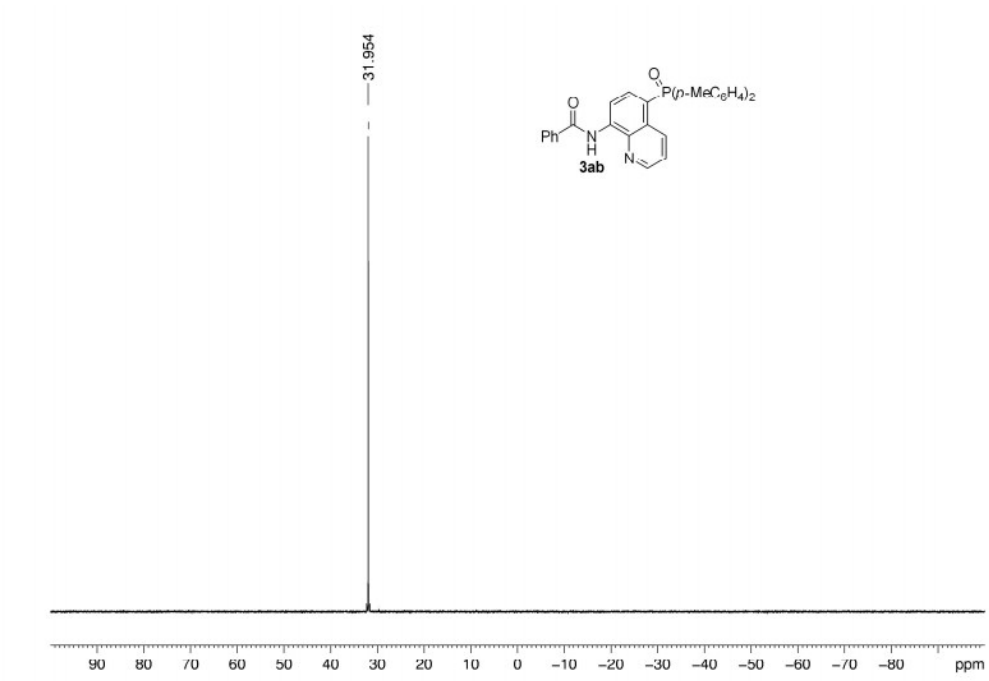

10.583
8.967
8.944
8.770
8.764
8.750
8.743
8.047
8.029
8.025
7.692
7.675
7.671
7.662
7.644
7.641
7.610
7.607
7.599
7.591
7.585
7.577
7.574
7.570
7.557
7.543
7.540
7.536
7.523
7.519
7.515
7.493
7.486
7.474
7.469
7.467
7.456
7.453
7.449
7.209
7.189
7.172
7.151
6.954
6.931
4.121
8.9
8.8
ppm
7.2
7.1
7.0
ppm
Ph
O
P
Ph
Ph
O
N
H
N
3za
O
13
12
11
10
9
8
7
6
5
4
3
2
1
ppm
1.000
1.000
1.003
2.039
4.059
5.142
4.127
1.022
0.992
3.032

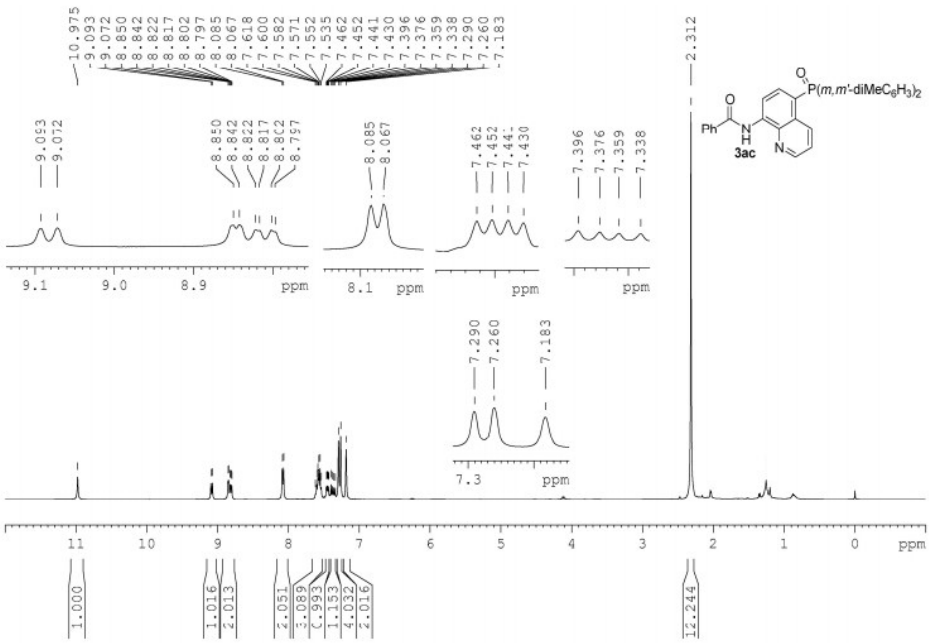

65.258
61.396
39.129
39.079
36.934
36.833
36.810
36.781
34.847
33.016
32.355
32.237
32.137
32.070
32.035
31.975
28.952
28.682
28.562
27.018
25.896
25.813
23.097
22.052
15.030
14.885
14.257
53.349
Ph
O
P
Ph
Ph
O
N
H
N
3za
O
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

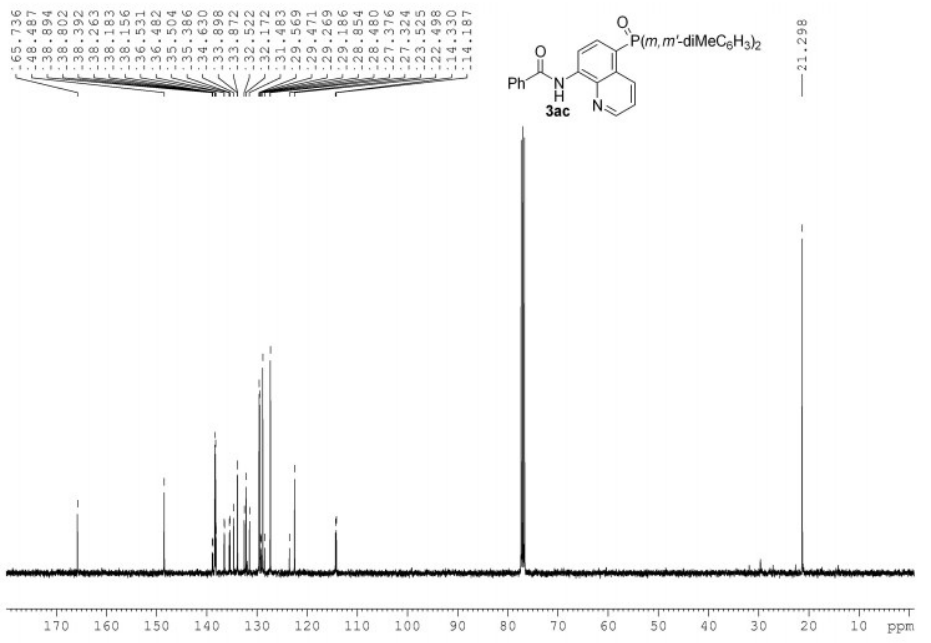

31.735
Ph
O
N
H
P
Ph
Ph
O
N
3za
O
90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 ppm

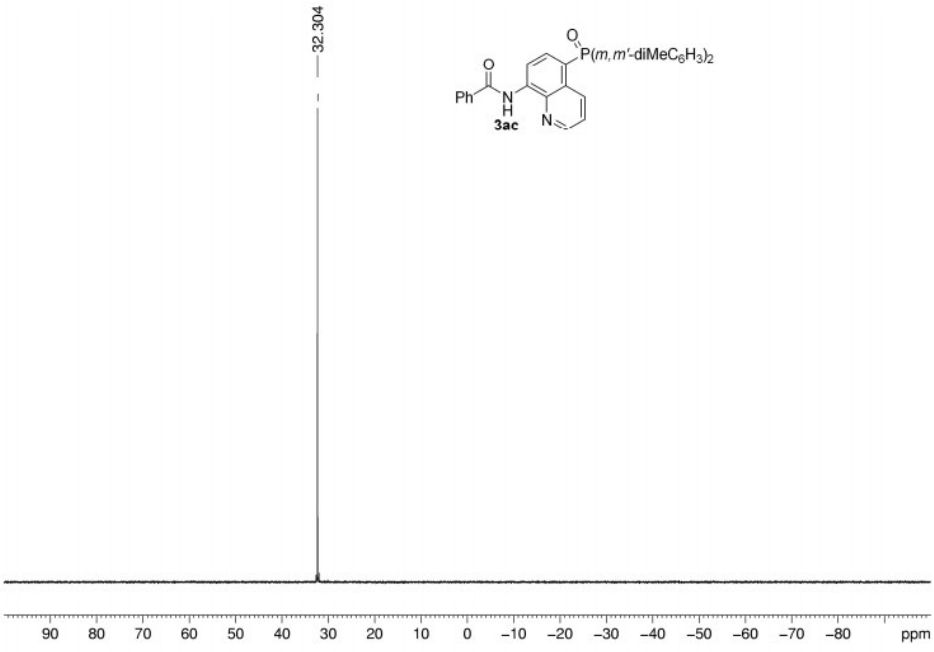

10.975
9.104
9.082
8.851
8.849
8.842
8.816
8.796
8.086
8.068
7.602
7.577
7.557
7.531
7.459
7.449
7.438
7.428
7.386
7.366
7.348
7.328
7.293
7.274
2.415
Ph
O
N
H
N
O
P(p-MeC6H4)2
3ab
ppm
8.1 ppm
7.4
7.3 ppm
11 10 9 8 7 6 5 4 3 2 1 0 ppm
1.000
1.026
2.006
2.066
7.067
1.060
1.130
4.158
6.038

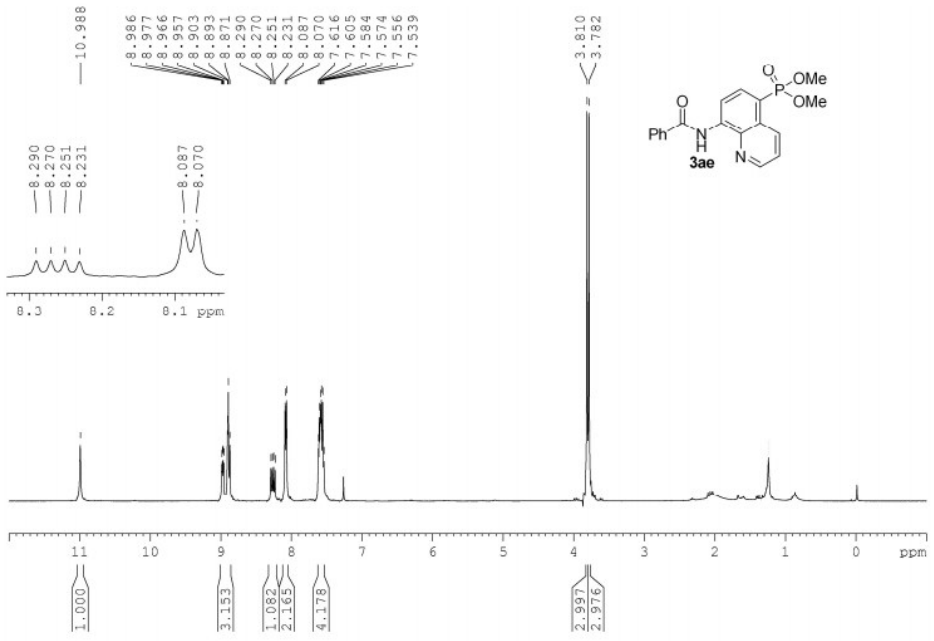

165.682
148.502
142.603
142.577
138.897
138.804
138.246
138.219
136.475
136.426
135.378
135.260
134.614
132.173
132.043
131.942
129.666
129.473
129.346
129.231
129.148
128.850
128.595
127.327
123.595
122.519
114.293
114.149
21.594
P(p-MeC6H4)2
Ph
N
H
3ab
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

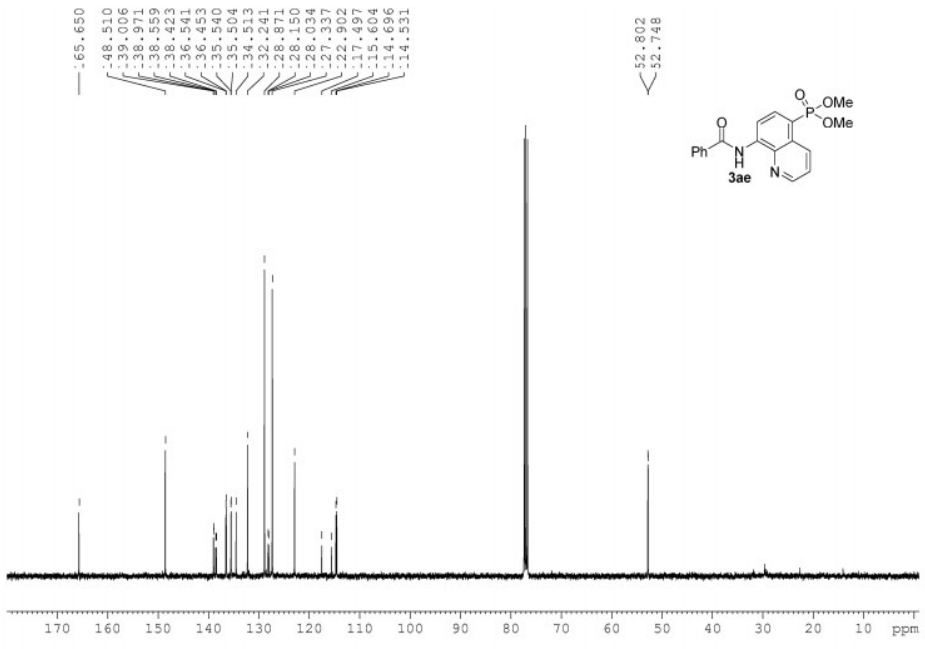

31.954
P(p-MeC6H4)2
Ph
N
H
3ab
90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 ppm

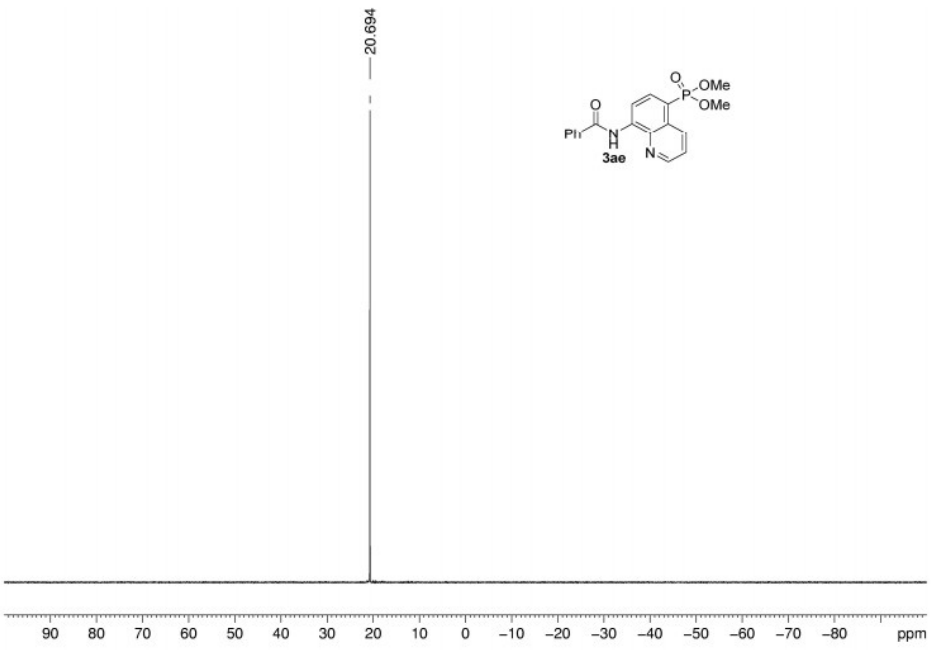

10.975
9.093
9.072
8.850
8.842
8.822
8.817
8.802
8.797
8.085
8.067
7.618
7.600
7.582
7.571
7.552
7.535
7.462
7.452
7.441
7.430
7.396
7.376
7.359
7.338
7.290
7.260
7.183
2.312
P(m,m'-diMeC6H3)2
Ph
N
H
3ac
9.053
9.072
8.850
8.842
8.822
8.817
8.802
8.797
8.085
8.067
7.462
7.452
7.441
7.430
7.396
7.376
7.359
7.338
9.1
9.0
8.9
ppm
8.1
ppm
ppm
ppm
7.290
7.260
7.183
7.3
ppm
11
10
9
8
7
6
5
4
3
2
1
0
ppm
1.000
1.016
2.013
2.051
3.089
0.993
1.153
4.032
2.016
12.244

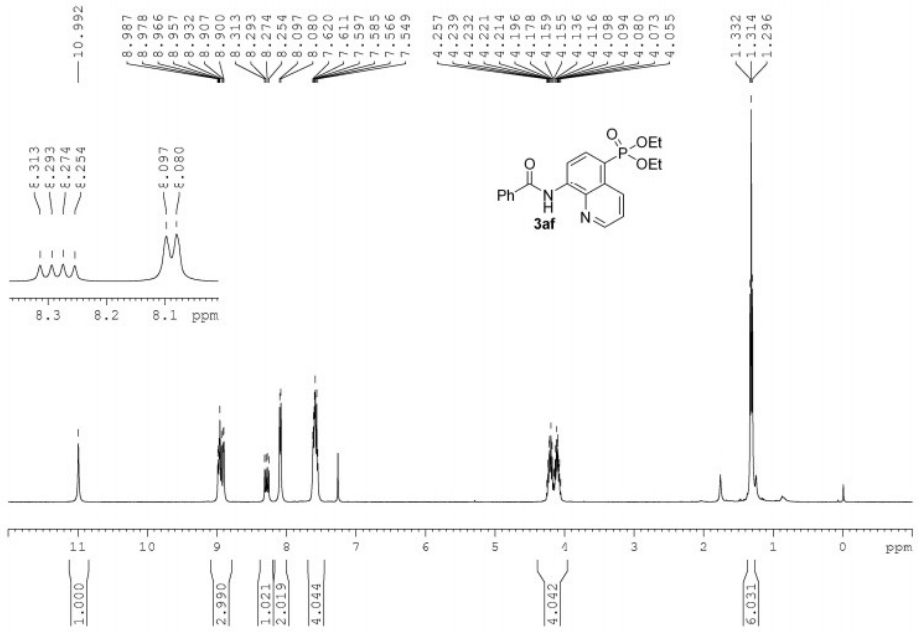

65.736
48.487
38.894
38.802
38.392
38.263
38.183
38.156
36.531
36.482
35.504
35.386
34.630
33.898
33.872
32.522
32.172
31.483
29.569
29.471
29.269
29.186
28.854
28.480
27.376
27.324
23.525
22.498
14.330
14.187
P(m,m'-diMeC6H3)2
Ph
N
H
3ac
21.298
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

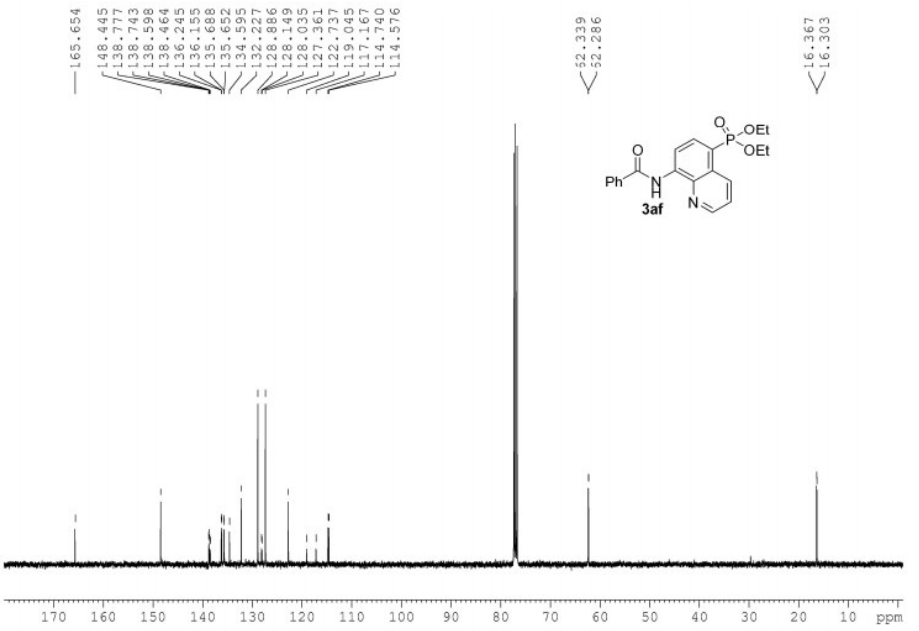

32.304
P(m,m'-diMeC6H3)2
Ph
N
H
3ac
90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 ppm

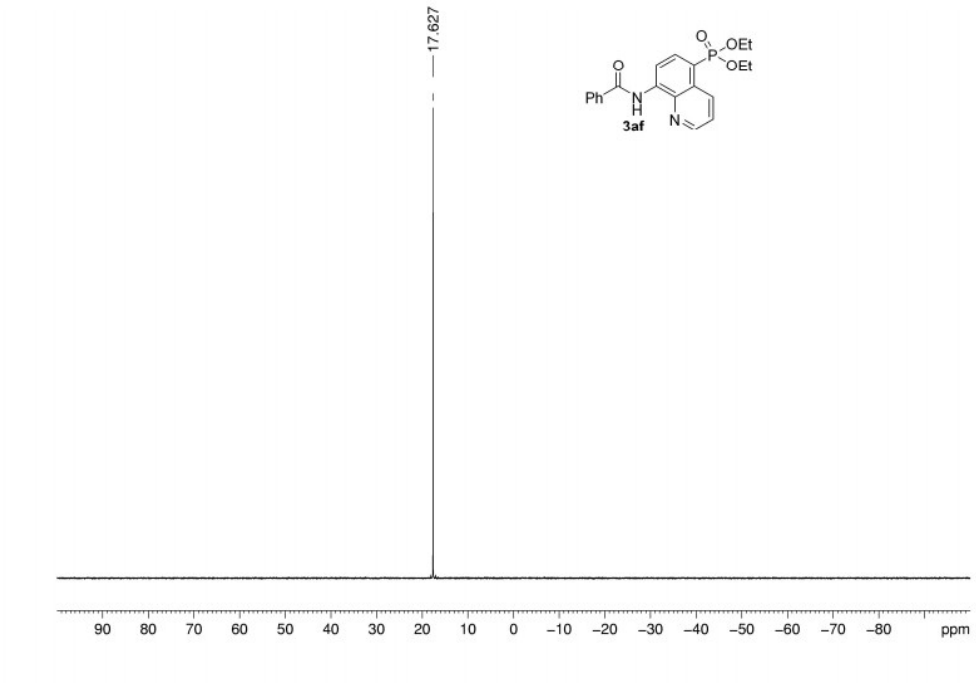

10.988
8.986
8.977
8.966
8.957
8.903
8.893
8.871
8.290
8.270
8.251
8.231
8.087
8.070
7.616
7.605
7.584
7.574
7.556
7.539
3.810
3.782
OMe
OMe
Ph
N
H
3ac
8.3 8.2 8.1 ppm
11 10 9 8 7 6 5 4 3 2 1 0 ppm
1.000
3.153
1.082
2.165
4.178
2.997
2.976

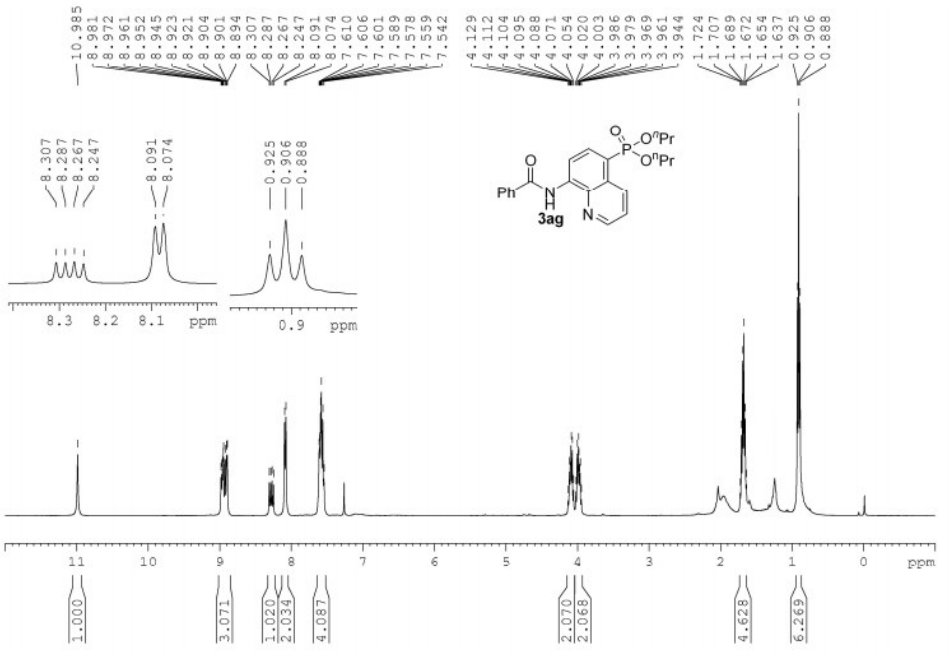

165.650
148.510
139.006
138.971
138.559
138.423
136.541
136.453
135.540
135.504
134.513
132.241
128.871
128.150
128.034
127.337
122.902
117.497
115.604
114.696
114.531
52.802
52.748
OMe
OMe
Ph
3ae
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

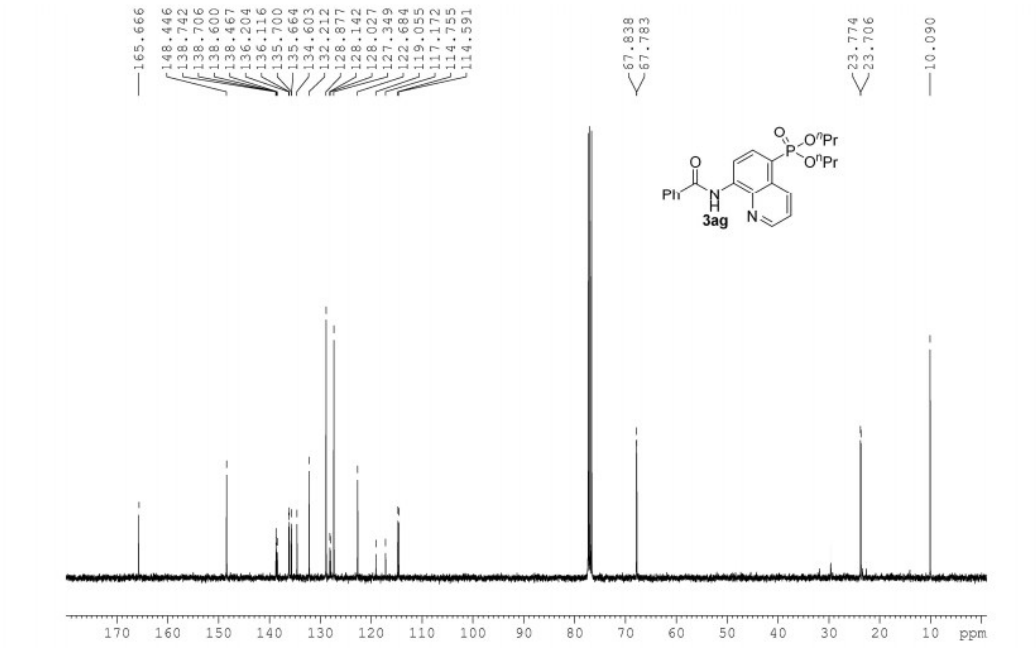

20.694
OMe
OMe
Ph
3ae
90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 ppm

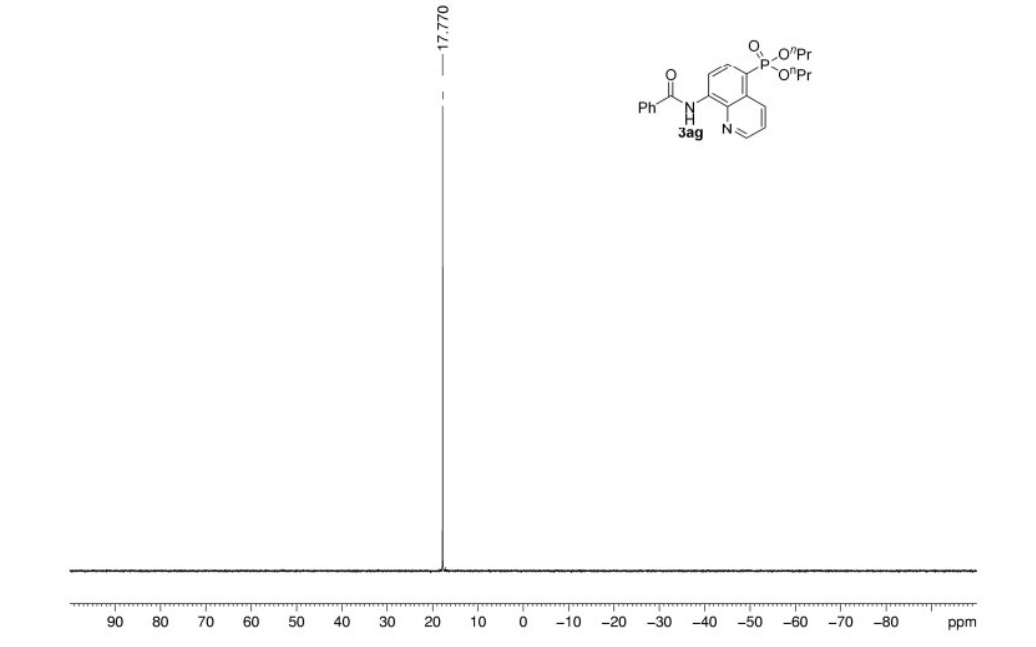

10.992
8.987
8.978
8.966
8.957
8.932
8.907
8.900
8.313
8.293
8.274
8.254
8.097
8.080
7.620
7.611
7.597
7.585
7.566
7.549
4.257
4.239
4.232
4.221
4.214
4.196
4.178
4.159
4.155
4.136
4.116
4.098
4.094
4.080
4.073
4.055
1.332
1.314
1.296
8.313
8.293
8.274
8.254
8.097
8.080
8.3
8.2
8.1 ppm
OEt
OEt
Ph
3af
11
10
9
8
7
6
5
4
3
2
1
0 ppm
1.000
2.990
1.021
2.019
4.044
4.042
6.031

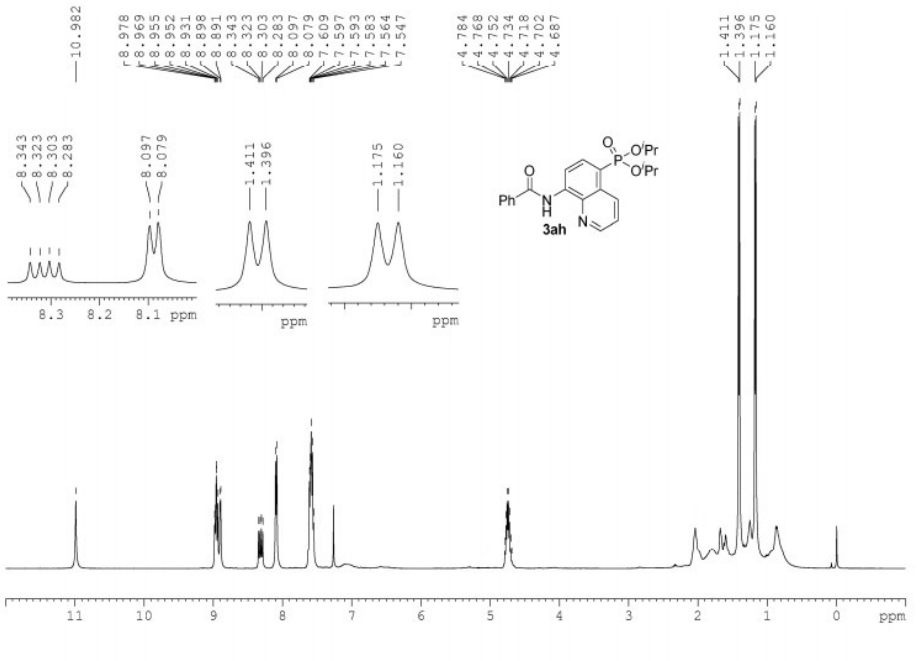

165.654
148.445
138.777
138.743
138.598
138.464
136.245
136.155
135.688
135.652
134.595
132.227
128.886
128.149
128.035
127.361
122.737
119.045
117.167
114.740
114.576
52.339
52.286
16.367
16.303
OEt
OEt
Ph
3af
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10 ppm

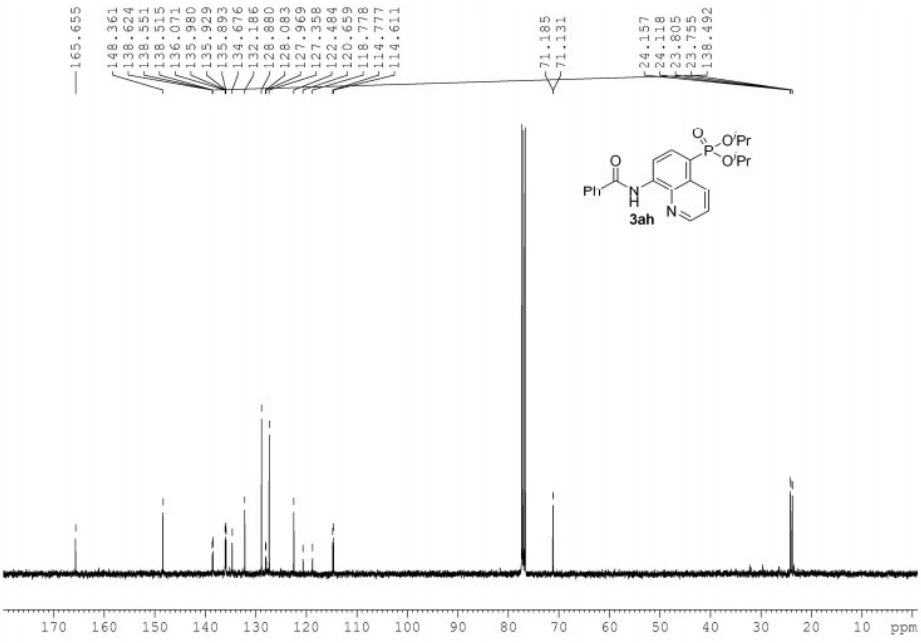

17.627
3af
90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 ppm

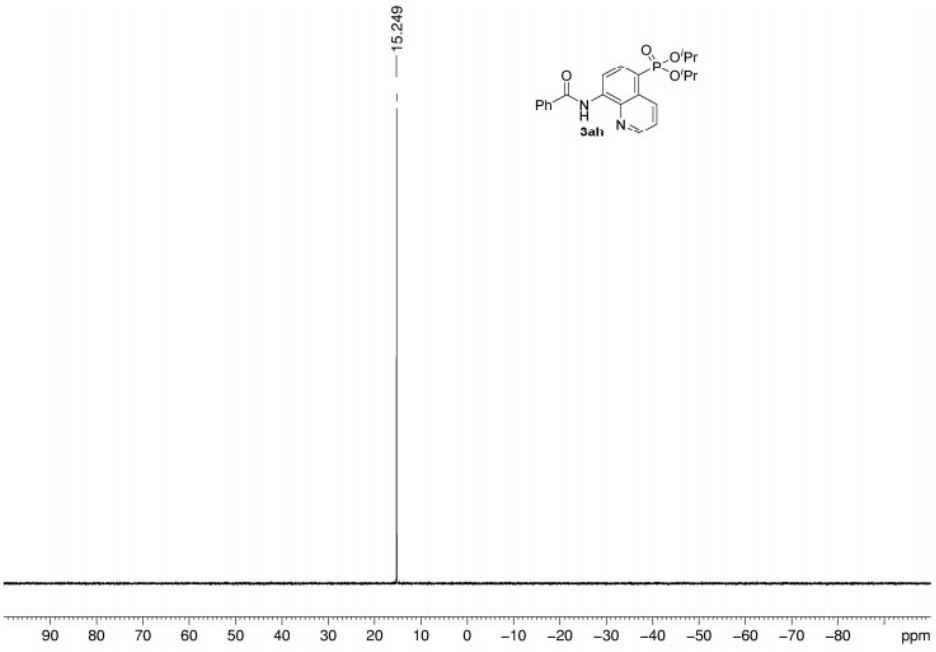

10.985
8.981
8.972
8.961
8.952
8.945
8.923
8.921
8.904
8.901
8.894
8.307
8.287
8.267
8.247
8.091
8.074
7.610
7.606
7.601
7.589
7.578
7.559
7.542
4.129
4.112
4.104
4.095
4.088
4.071
4.054
4.020
4.003
3.986
3.979
3.969
3.961
3.944
1.724
1.707
1.689
1.672
1.654
1.637
0.925
0.906
0.888
3ag
8.3 8.2 8.1 ppm
0.9 ppm
11 10 9 8 7 6 5 4 3 2 1 0 ppm
1.000
3.071
1.020
2.034
4.087
2.070
2.068
4.628
6.269

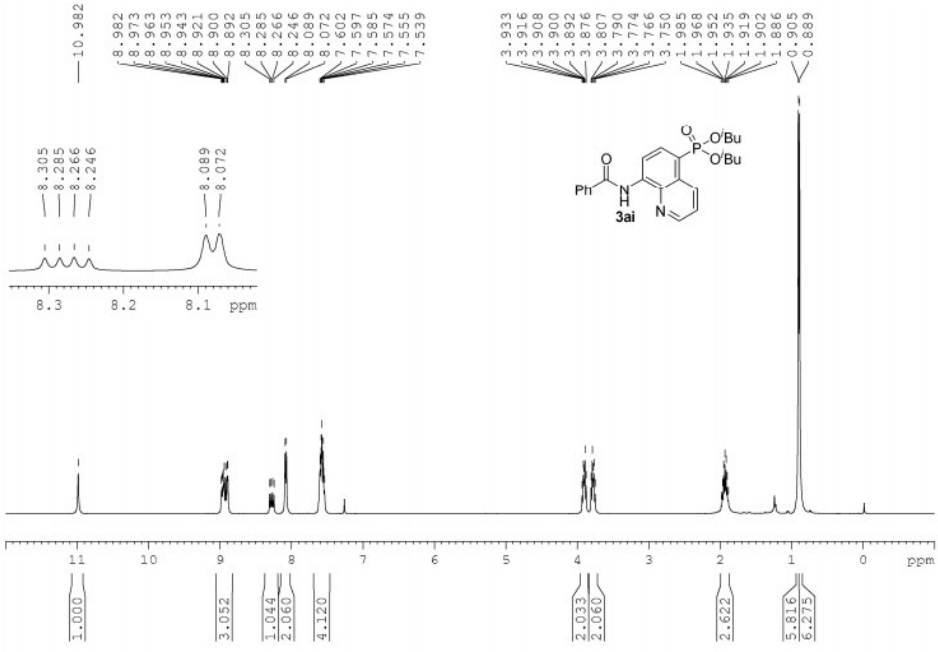

165.666
148.446
138.742
138.706
138.600
138.467
136.204
136.116
135.700
135.664
134.603
132.212
128.877
128.142
128.027
127.349
122.684
119.055
117.172
114.755
114.591
67.838
67.783
23.774
23.706
10.090
3ag
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

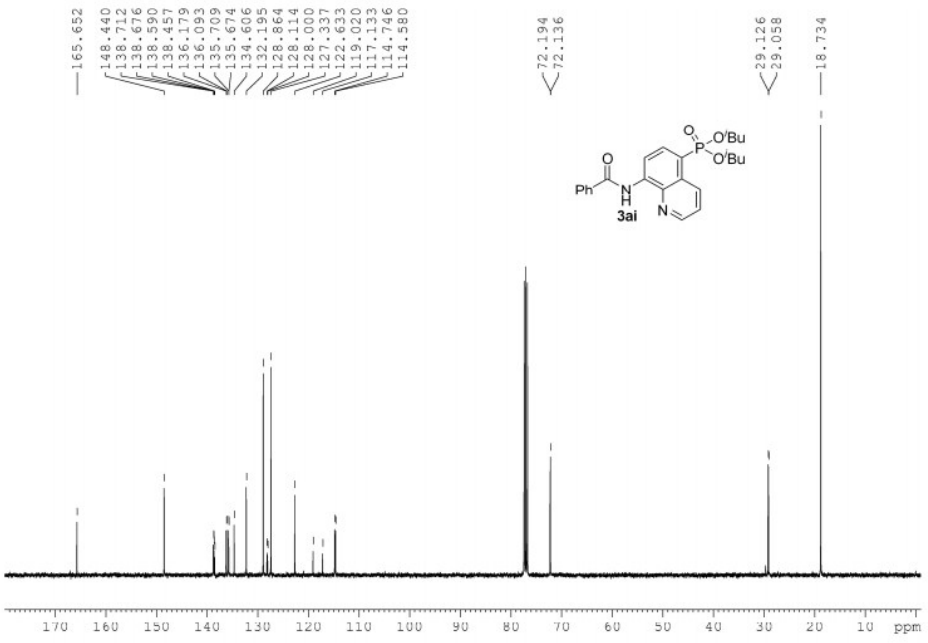

17.770
3ag
90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 ppm

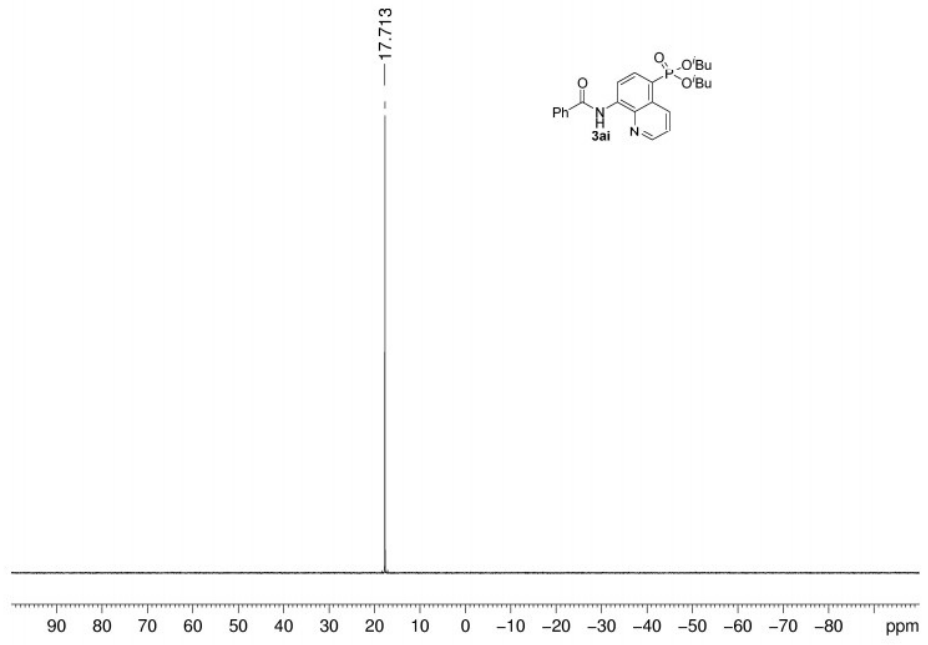

10.982
8.978
8.969
8.955
8.952
8.931
8.898
8.891
8.343
8.323
8.303
8.283
8.097
8.079
7.609
7.597
7.593
7.583
7.564
7.547
4.784
4.768
4.752
4.734
4.718
4.702
4.687
1.411
1.396
1.175
1.160
3ah
ppm

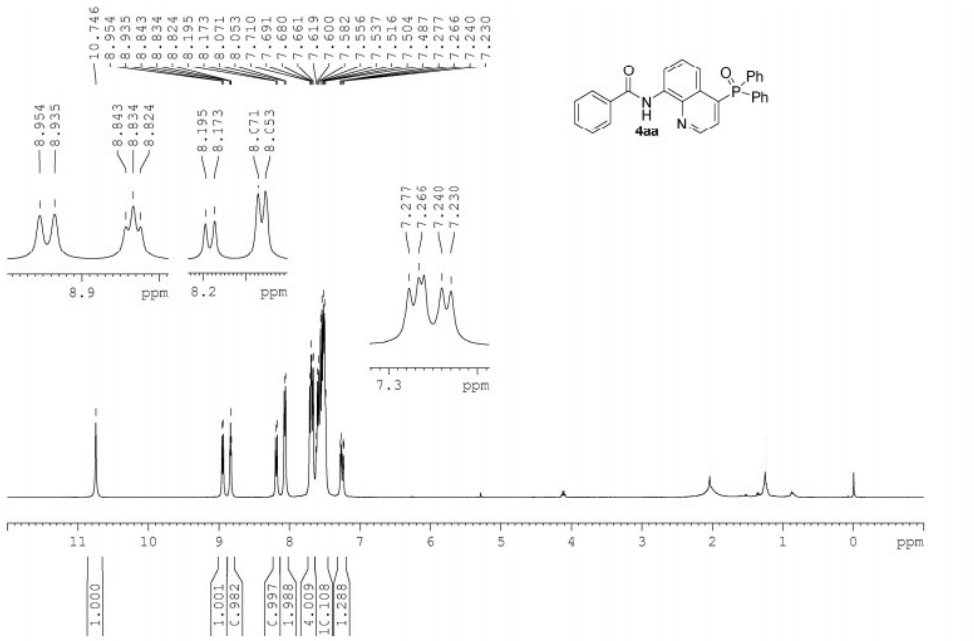

165.655
148.361
138.624
138.531
138.515
136.071
135.980
135.929
135.893
134.676
132.186
128.880
128.083
127.969
127.358
122.484
120.659
118.778
114.777
114.611
71.185
71.131
24.157
24.118
23.805
23.755
138.492
3ah
ppm

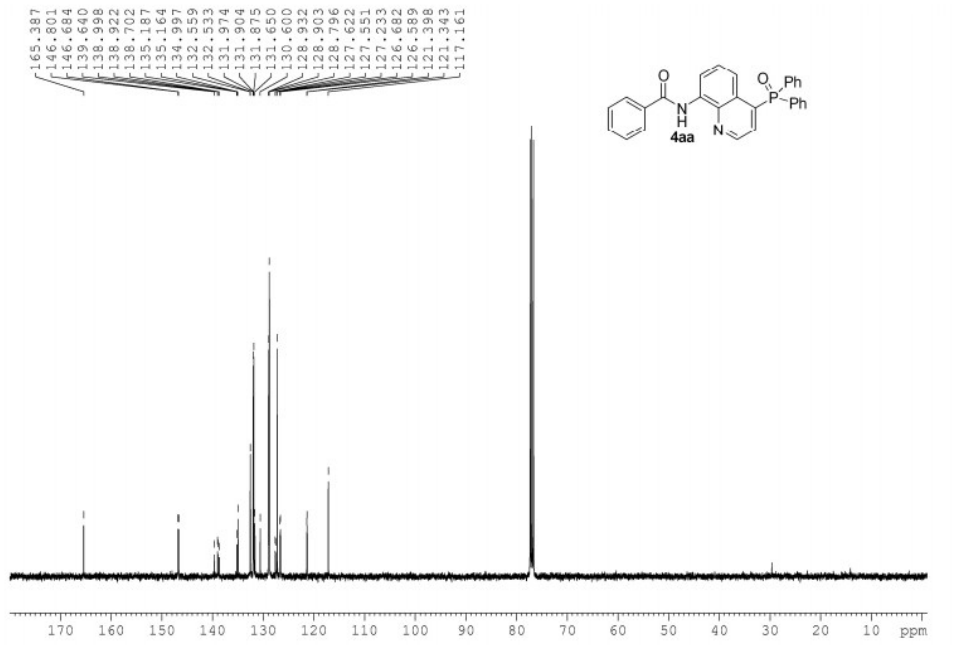

15.249
O
O'Pr
O'Pr
Ph
N
H
3ah
N
90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 ppm

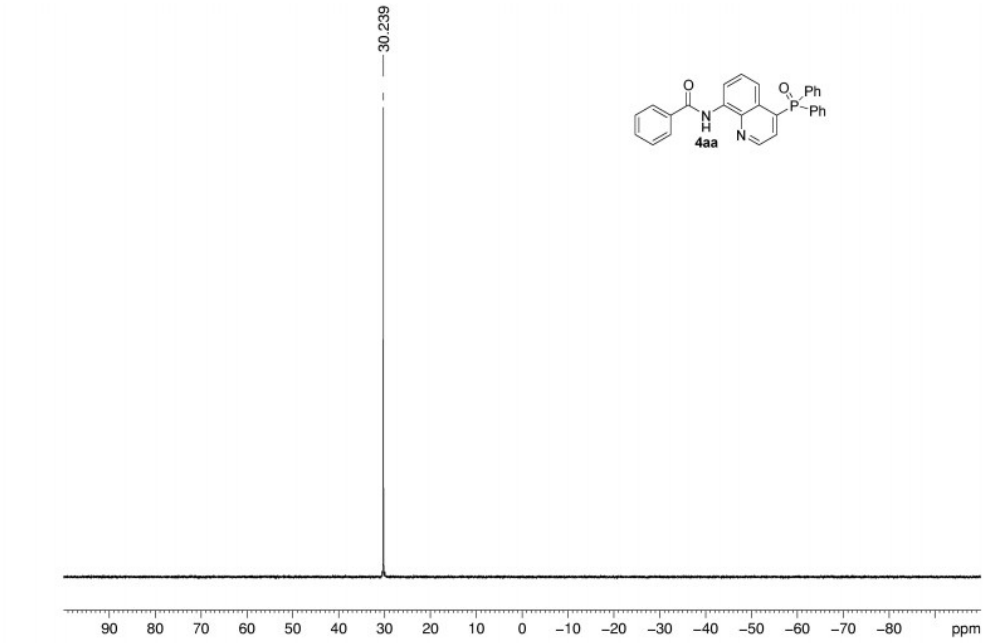

10.982
8.982 8.973 8.963 8.953 8.943 8.921 8.900 8.892 8.305 8.285 8.266 8.246 8.089 8.072 7.602 7.597 7.585 7.574 7.555 7.539
3.933 3.916 3.908 3.900 3.892 3.876 3.807 3.790 3.774 3.766 3.750 1.985 1.968 1.952 1.935 1.919 1.902 1.886 0.905 0.889
8.305 8.285 8.266 8.246 8.089 8.072
8.3 8.2 8.1 ppm
O
O'Bu
O'Bu
Ph
N
H
3ai
N
11 10 9 8 7 6 5 4 3 2 1 0 ppm
1.000 3.052 1.044 2.060 4.120 2.033 2.060 2.622 5.816 6.275

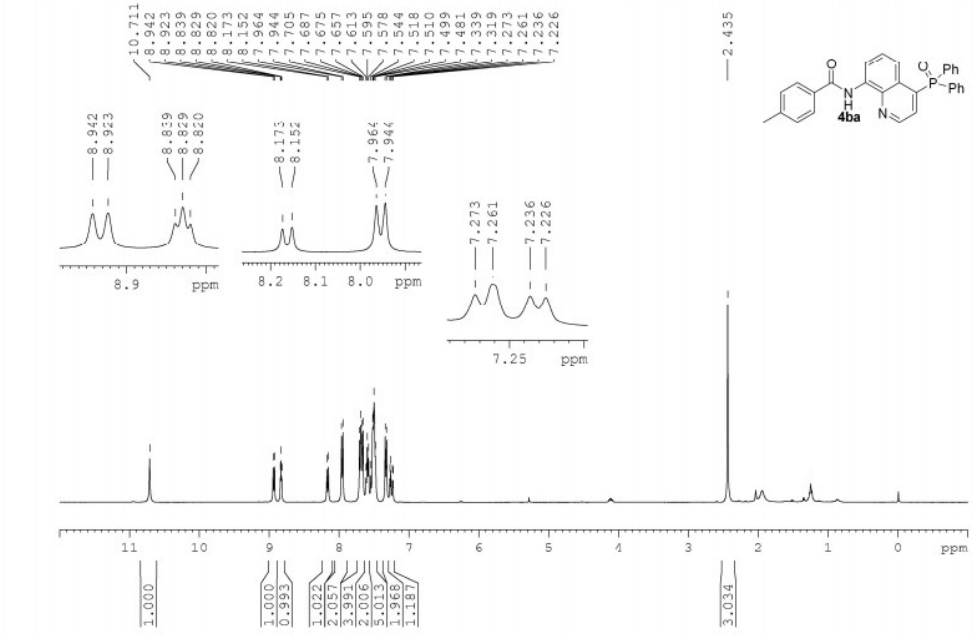

165.652
148.440
138.712
138.676
138.590
138.457
136.179
136.093
135.709
135.674
134.606
132.195
128.864
128.114
128.000
127.337
122.633
119.020
117.133
114.746
114.580
72.194
72.136
29.126
29.058
18.734
O'Bu
O'Bu
Ph
3ai
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

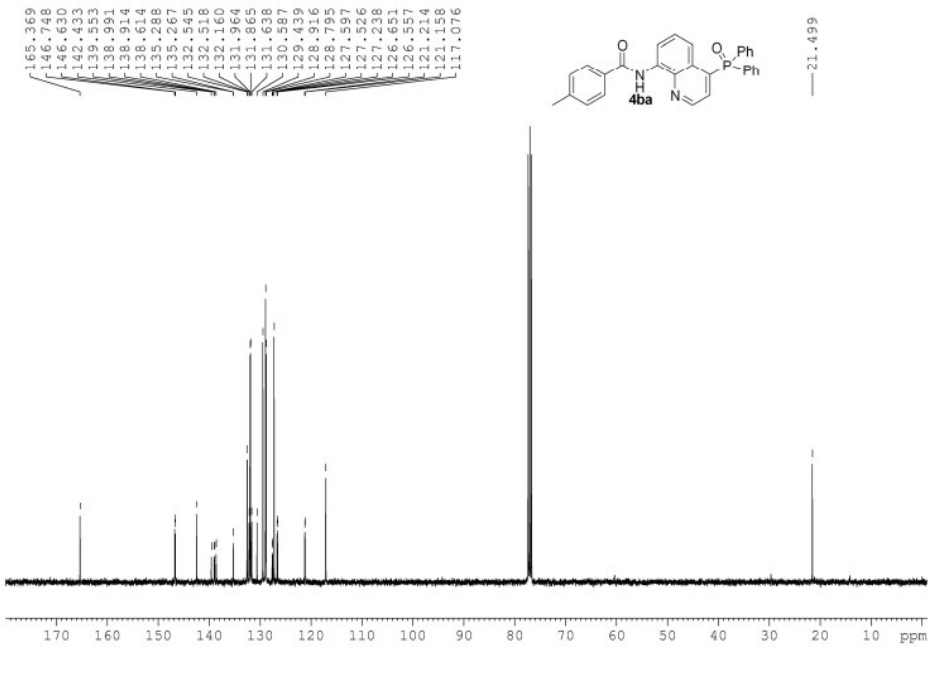

17.713
O'Bu
O'Bu
Ph
3ai
90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 ppm

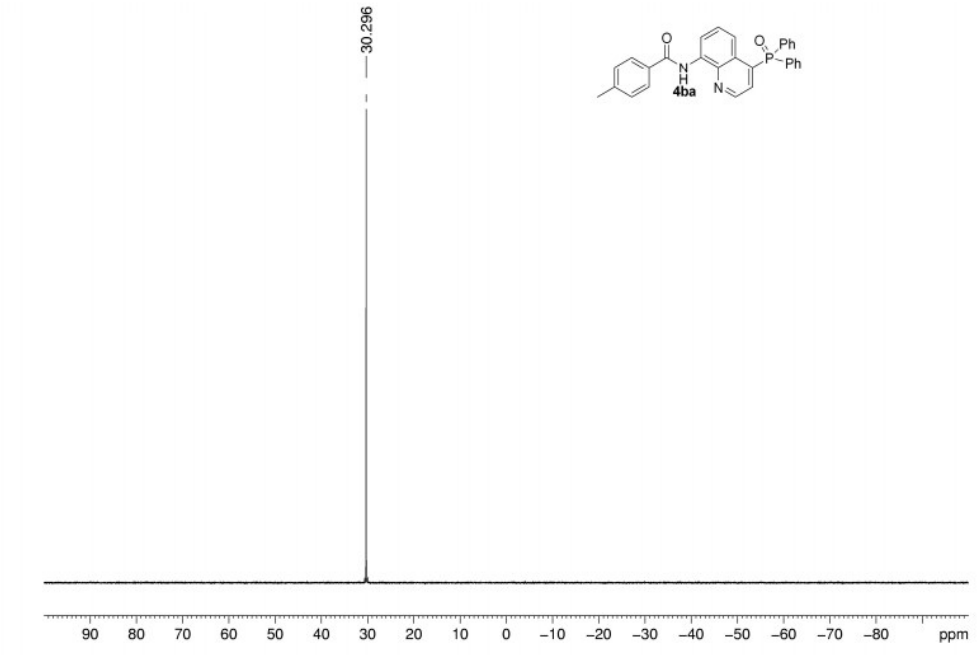

10.746
8.954
8.935
8.843
8.834
8.824
8.195
8.173
8.071
8.053
7.710
7.691
7.680
7.661
7.619
7.600
7.582
7.556
7.537
7.516
7.504
7.487
7.277
7.266
7.240
7.230
4aa
ppm
1.000
1.001
0.982
0.997
1.988
4.009
1.108
1.288

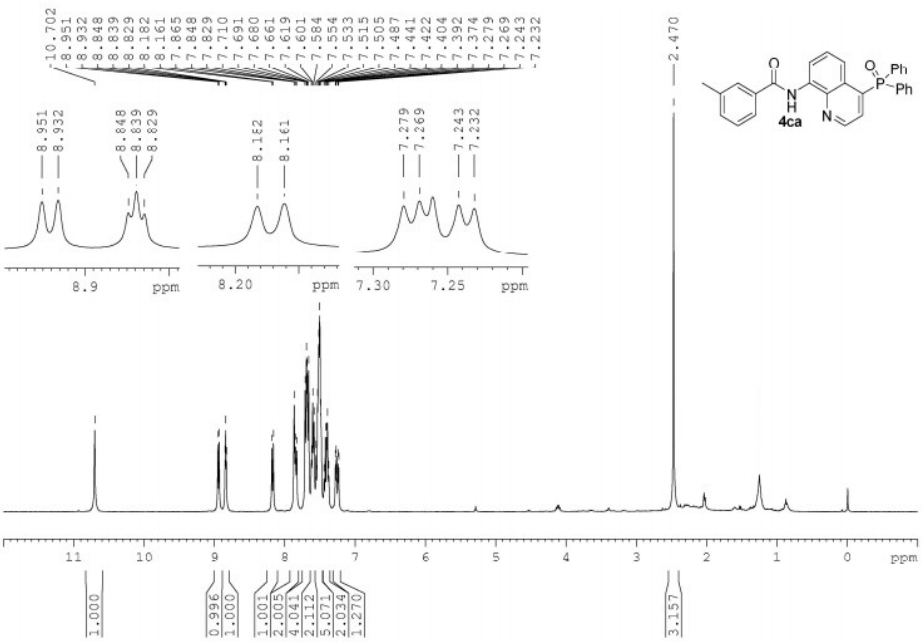

165.387
146.801
146.684
139.640
138.998
138.922
138.702
135.187
135.164
134.997
132.559
132.533
131.974
131.904
131.875
131.650
130.600
128.932
128.903
128.796
127.622
127.551
127.233
126.682
126.589
121.398
121.343
117.161
4aa
ppm

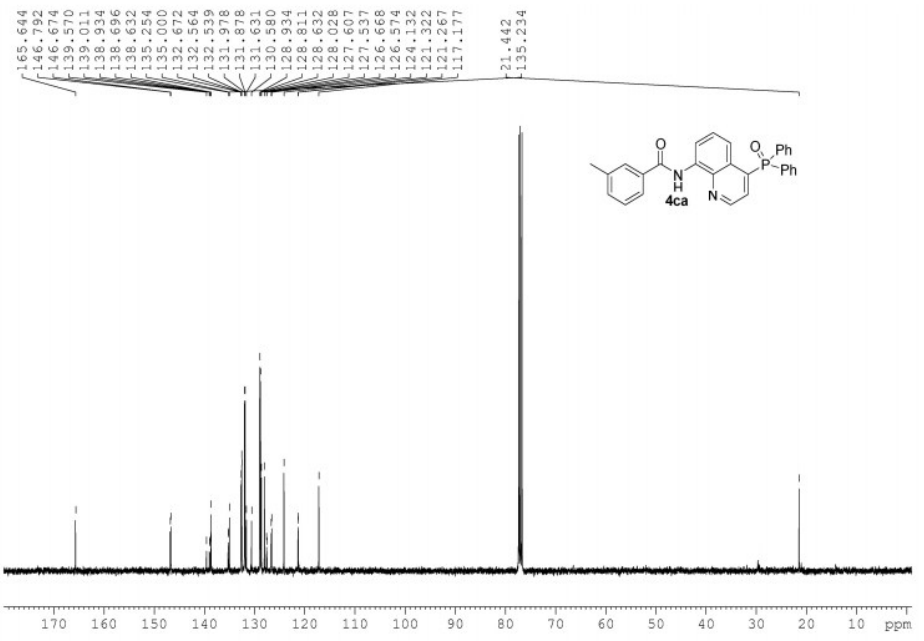

30.239
4aa
90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 ppm

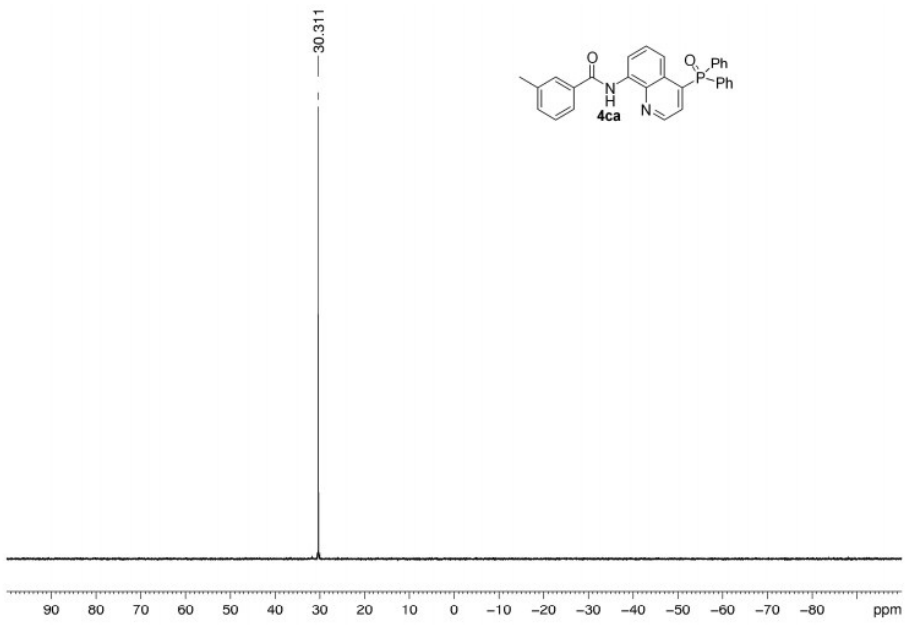

10.711
8.942
8.923
8.839
8.829
8.820
8.173
8.152
7.964
7.944
7.705
7.687
7.675
7.657
7.613
7.595
7.578
7.544
7.518
7.510
7.499
7.481
7.339
7.319
7.273
7.261
7.236
7.226
2.435
4ba
8.9 ppm
8.2 8.1 8.0 ppm
7.25 ppm
11 10 9 8 7 6 5 4 3 2 1 0 ppm
1.000
1.000
0.993
1.022
2.057
3.991
2.006
5.013
1.968
1.187
3.034

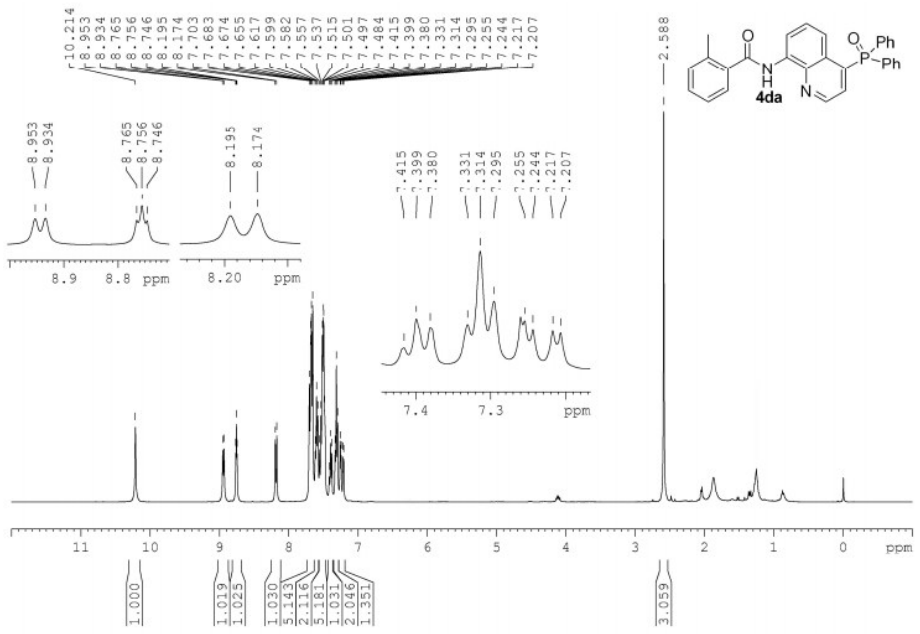

165.369
146.748
146.630
142.433
139.553
138.991
138.914
138.614
135.288
135.267
132.545
132.518
132.160
131.964
131.865
131.638
130.587
129.439
128.916
128.795
127.597
127.526
127.238
126.651
126.557
121.214
121.158
117.076
21.499
4ba
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

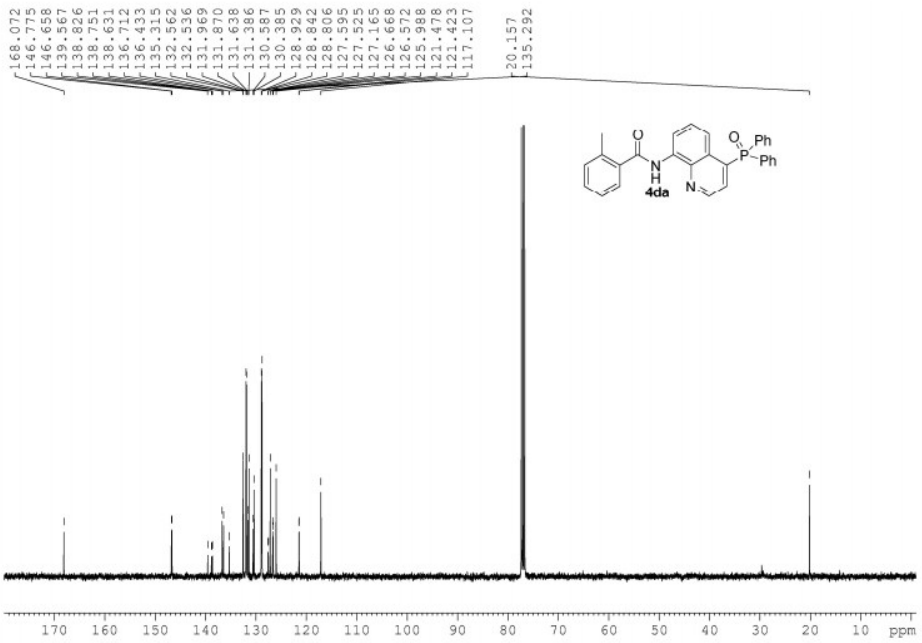

30.296
4ba
90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 ppm

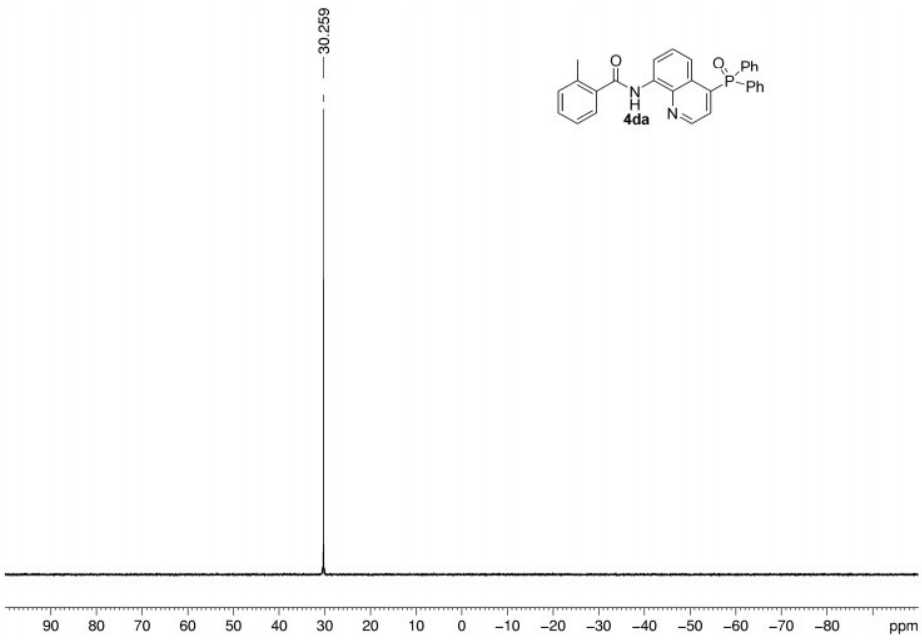

10.702
8.951
8.932
8.848
8.839
8.829
8.182
8.161
7.865
7.848
7.829
7.710
7.691
7.680
7.661
7.619
7.601
7.584
7.554
7.533
7.515
7.505
7.487
7.441
7.422
7.404
7.392
7.374
7.279
7.269
7.243
7.232
2.470
4ca
ppm
1.000
0.996
1.000
1.001
2.005
4.041
2.112
5.071
2.034
1.270
3.157

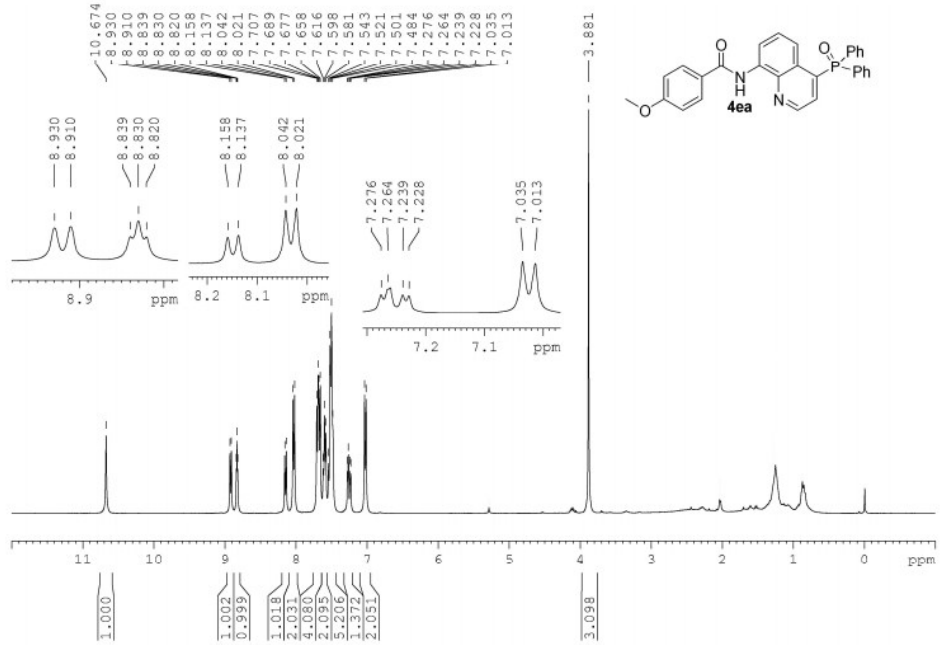

165.644
146.792
146.674
139.570
139.011
138.934
138.696
138.632
135.254
135.000
132.672
132.564
132.539
131.978
131.878
131.631
130.580
128.934
128.811
128.632
128.028
127.607
127.537
126.668
126.574
124.132
121.322
121.267
117.177
21.442
135.234
4ca
ppm

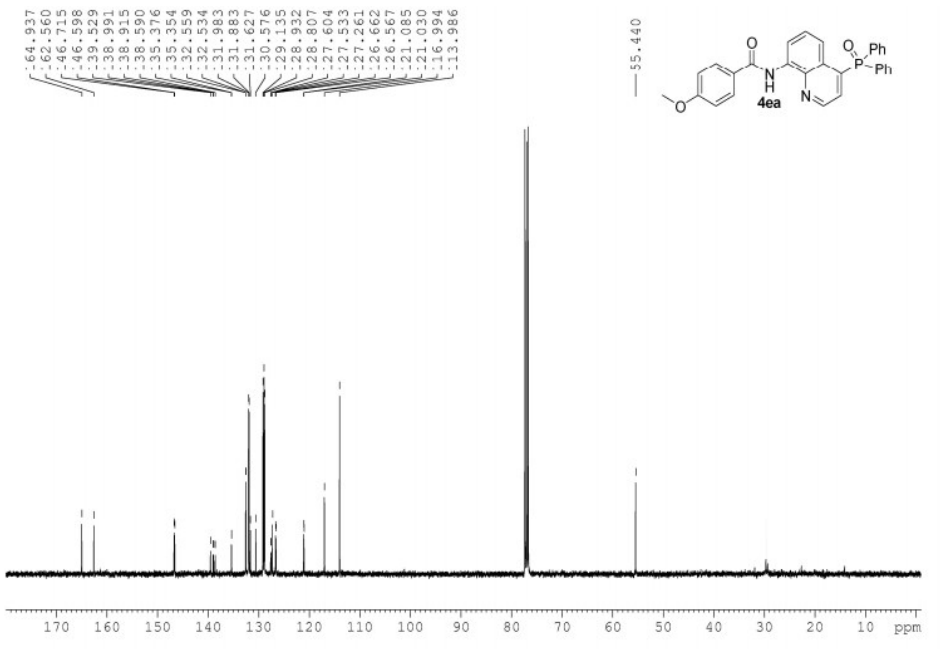

30.311
4ca
90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 ppm

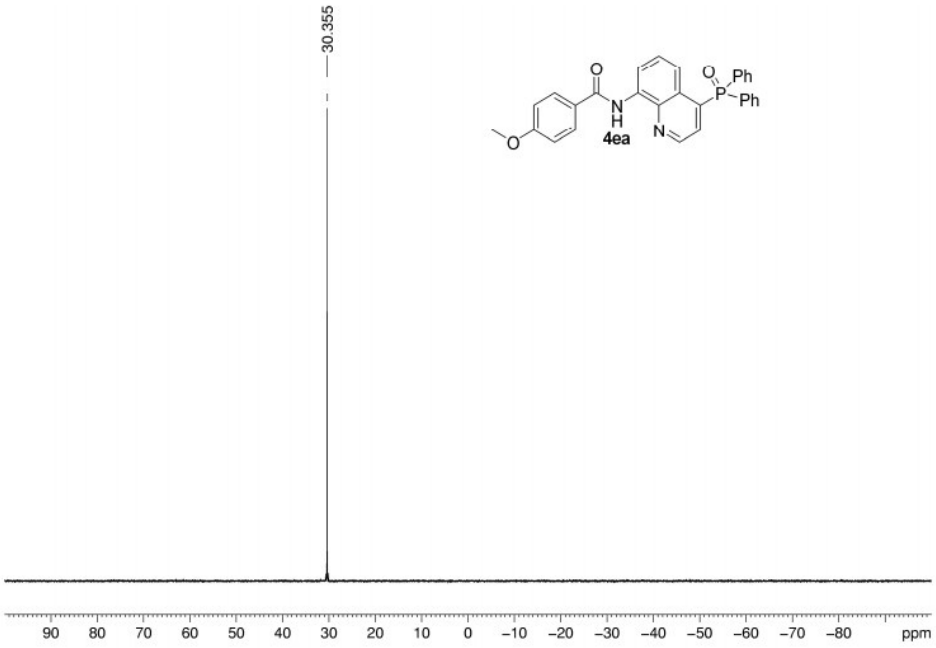

10.214
8.953
8.934
8.765
8.756
8.746
8.195
8.174
7.703
7.683
7.674
7.655
7.617
7.599
7.582
7.557
7.537
7.515
7.501
7.497
7.484
7.415
7.399
7.380
7.331
7.314
7.295
7.255
7.244
7.217
7.207
2.588
4da
8.9 8.8 ppm
8.20 ppm
7.4 7.3 ppm
11 10 9 8 7 6 5 4 3 2 1 0 ppm
1.000
1.019
1.025
1.030
5.143
2.116
5.181
1.031
2.046
1.351
3.059

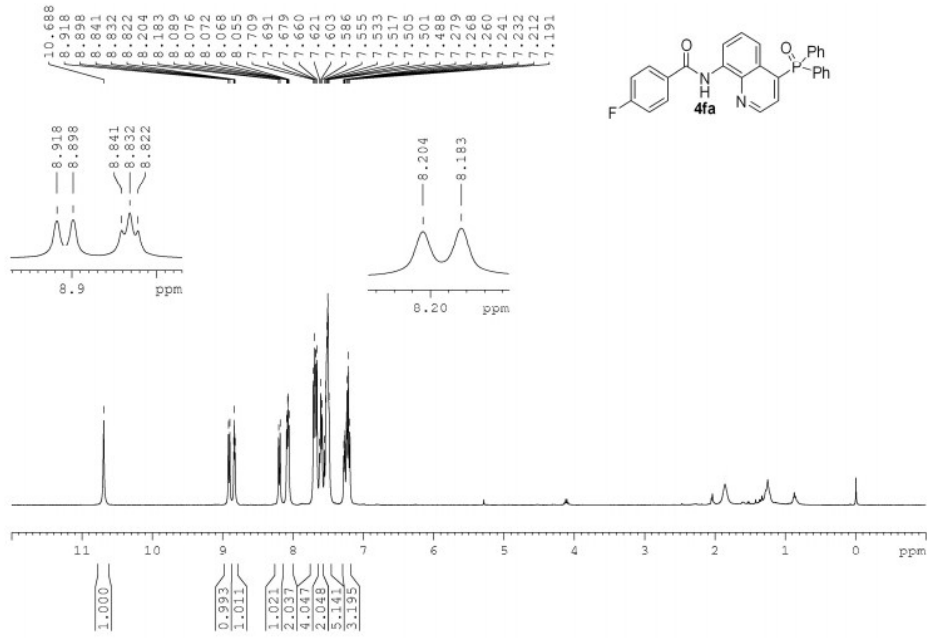

168.072
146.775
146.658
139.567
138.826
138.751
138.631
136.712
136.433
135.315
132.562
132.536
131.969
131.870
131.638
131.386
130.587
130.385
128.929
128.842
128.806
127.595
127.525
127.165
126.668
126.572
125.988
121.478
121.423
117.107
20.157
135.292
O
N
H
4da
O
P
Ph
Ph
N
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

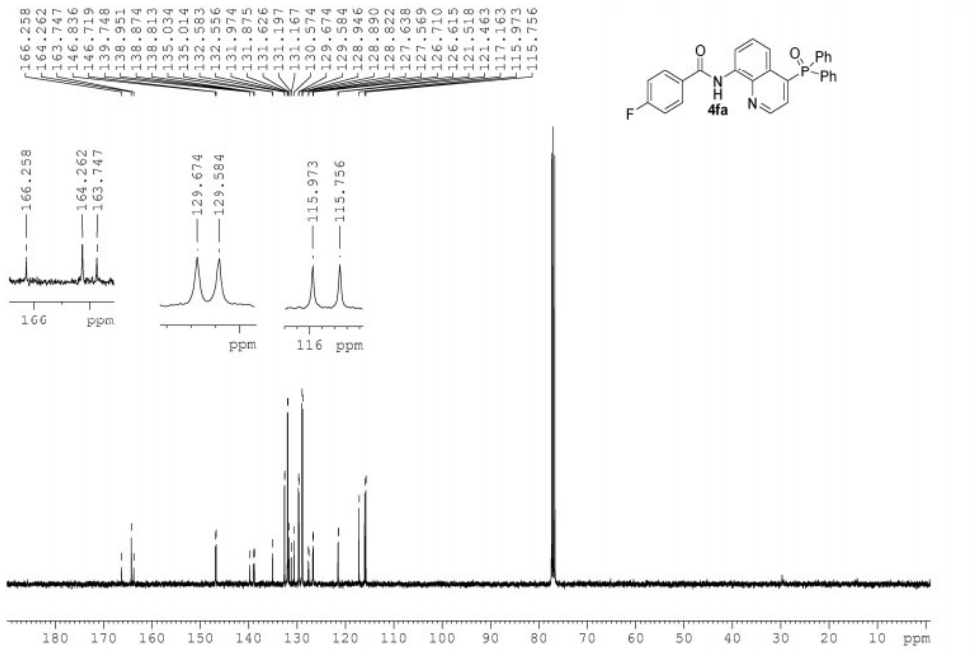

30.259
O
N
H
4da
O
P
Ph
Ph
N
90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 ppm

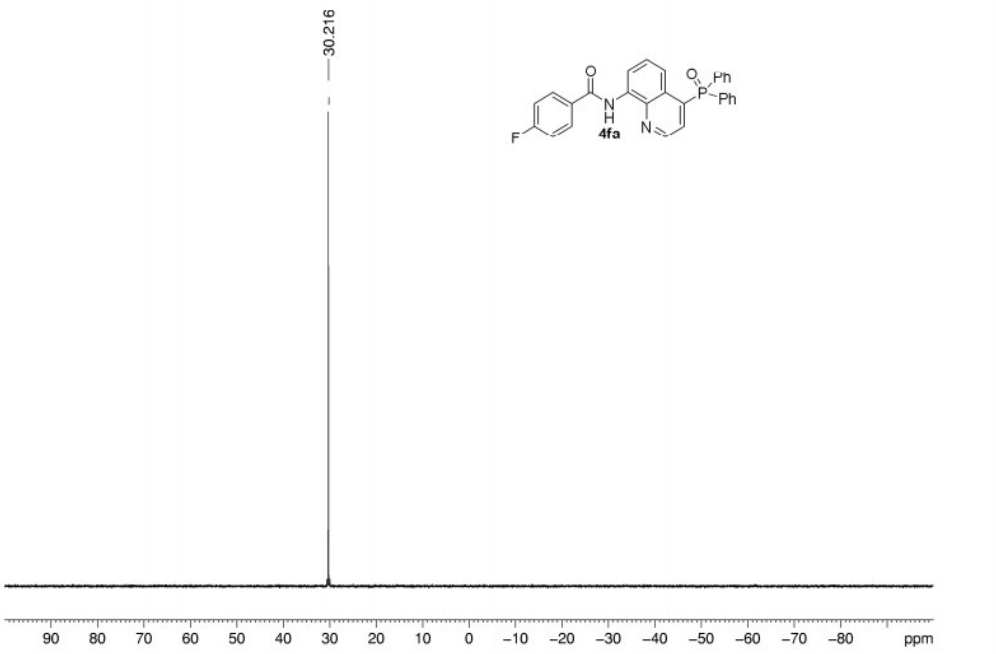

10.674
8.930
8.910
8.839
8.830
8.820
8.158
8.137
8.042
8.021
7.707
7.689
7.677
7.658
7.616
7.598
7.581
7.543
7.521
7.501
7.484
7.276
7.264
7.239
7.228
7.035
7.013
3.881
4ea
ppm
1.000
1.002
0.999
1.018
2.031
4.080
2.095
5.206
1.372
2.051
3.098

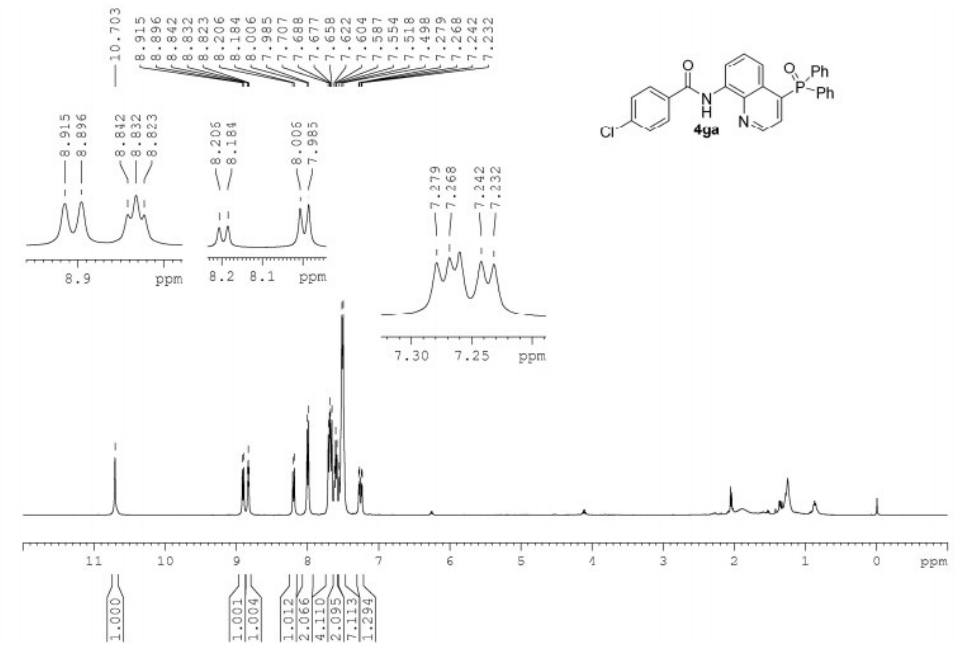

64.937
62.560
46.715
46.598
39.529
38.991
38.915
38.590
35.376
35.354
32.559
32.534
31.983
31.883
31.627
30.576
29.135
28.932
28.807
27.604
27.533
27.261
26.662
26.567
21.085
21.030
16.994
13.986
55.440
4ea
ppm

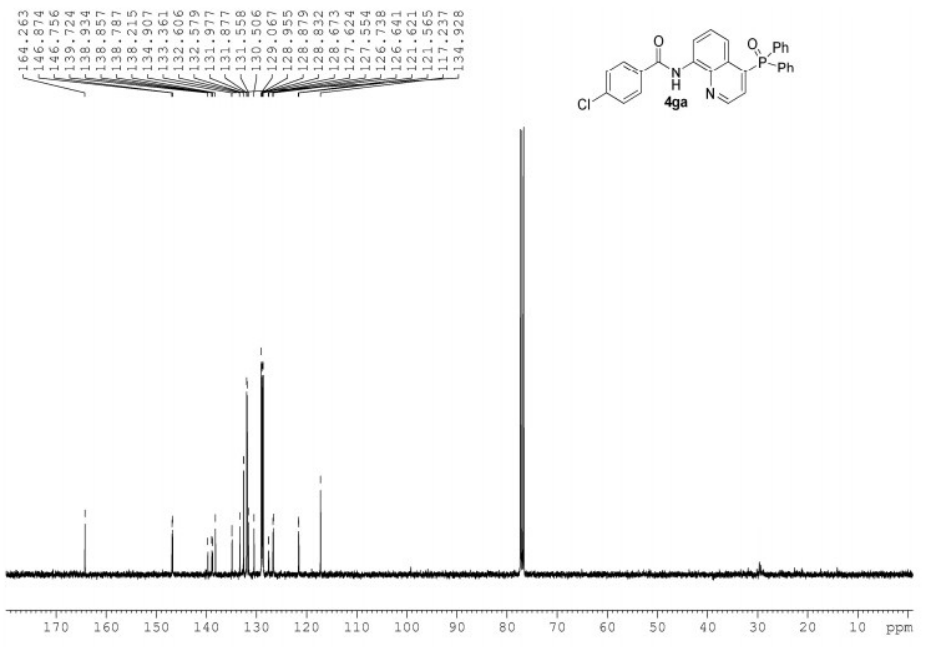

30.355
4ea
90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 ppm

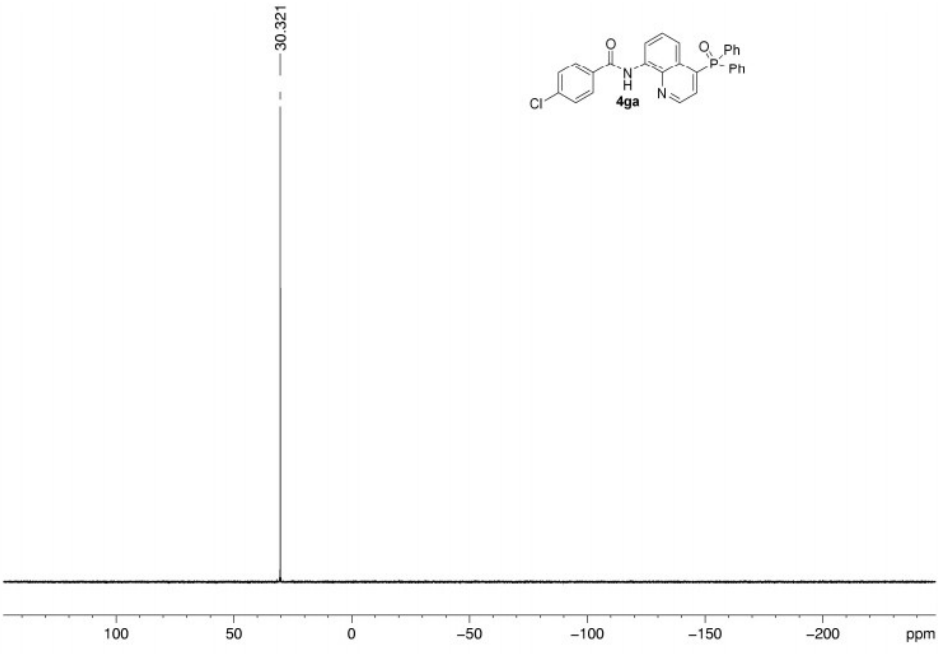

10.688
8.918
8.898
8.841
8.832
8.822
8.204
8.183
8.089
8.076
8.072
8.068
8.055
7.709
7.691
7.679
7.660
7.621
7.603
7.586
7.555
7.533
7.517
7.505
7.501
7.488
7.279
7.268
7.260
7.241
7.232
7.212
7.191
4fa
8.9 ppm
8.20 ppm
11 10 9 8 7 6 5 4 3 2 1 0 ppm
1.000
0.993
1.011
1.021
2.037
4.047
2.048
5.141
3.195

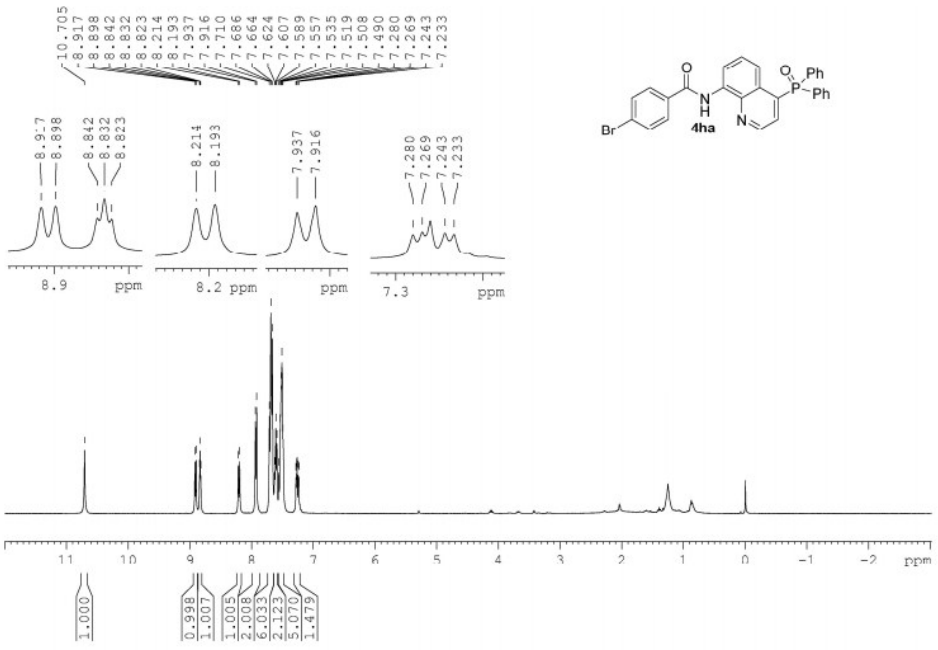

166.258
164.262
163.747
146.836
146.719
139.748
138.951
138.874
138.813
135.034
135.014
132.583
132.556
131.974
131.875
131.626
131.197
131.167
130.574
129.674
129.584
128.946
128.890
128.822
127.638
127.569
126.710
126.615
121.518
121.463
117.163
115.973
115.756
O
N
H
F
O
P
Ph
Ph
4fa
166.258
164.262
163.747
129.674
129.584
115.973
115.756
166
ppm
ppm
116
ppm
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm

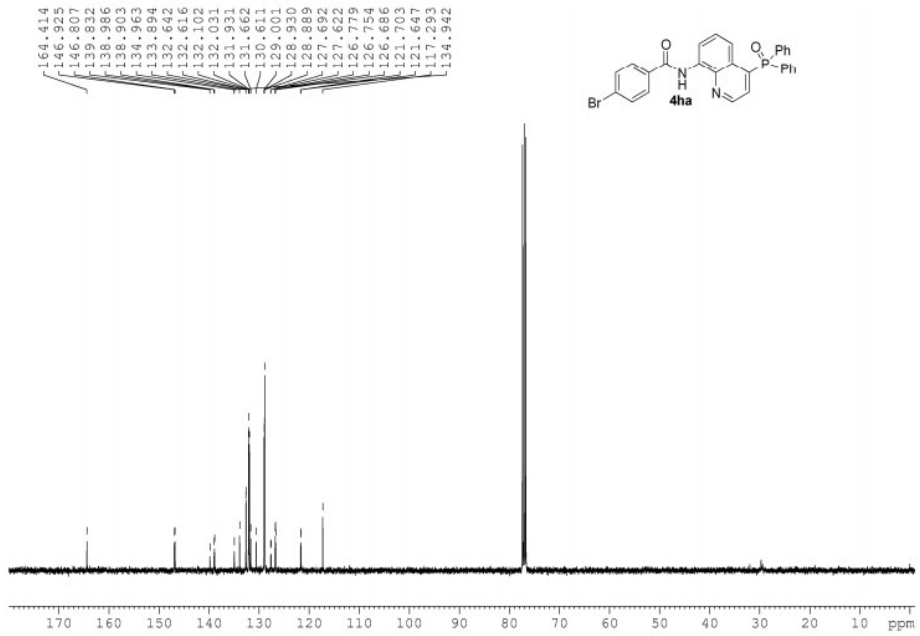

30.216
O
N
H
F
O
P
Ph
Ph
4fa
90
80
70
60
50
40
30
20
10
0
−10
−20
−30
−40
−50
−60
−70
−80
ppm

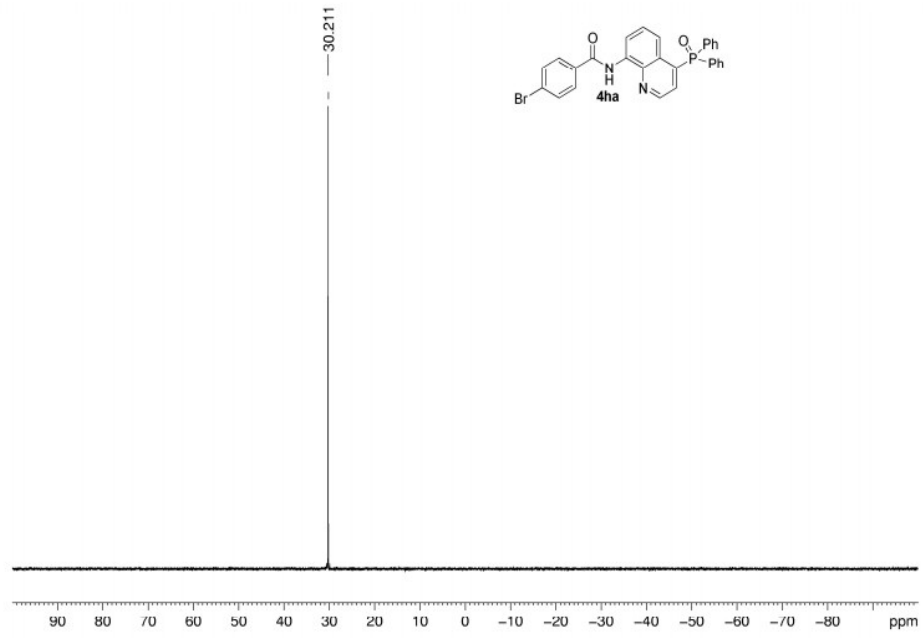

10.703
8.915
8.896
8.842
8.832
8.823
8.206
8.184
8.006
7.985
7.707
7.688
7.677
7.658
7.622
7.604
7.587
7.554
7.518
7.498
7.279
7.268
7.242
7.232
4ga
ppm
1.000
1.001
1.004
1.012
2.066
4.110
2.095
7.113
1.294

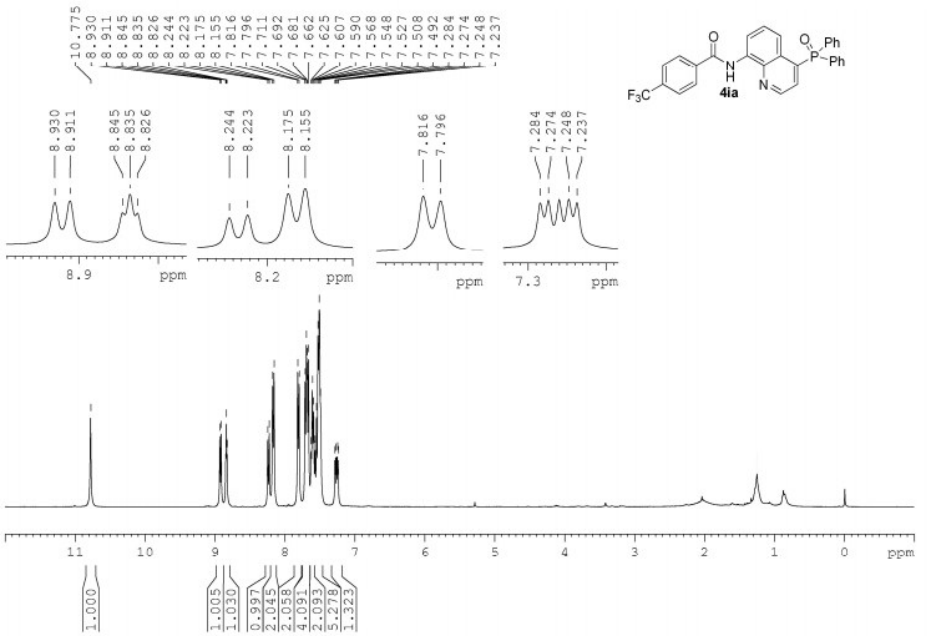

164.263
146.874
146.756
139.724
138.934
138.857
138.787
138.215
134.907
133.361
132.606
132.579
131.977
131.877
131.558
130.506
129.067
128.955
128.879
128.832
128.673
127.624
127.554
126.738
126.641
121.621
121.565
117.237
134.928
4ga
ppm

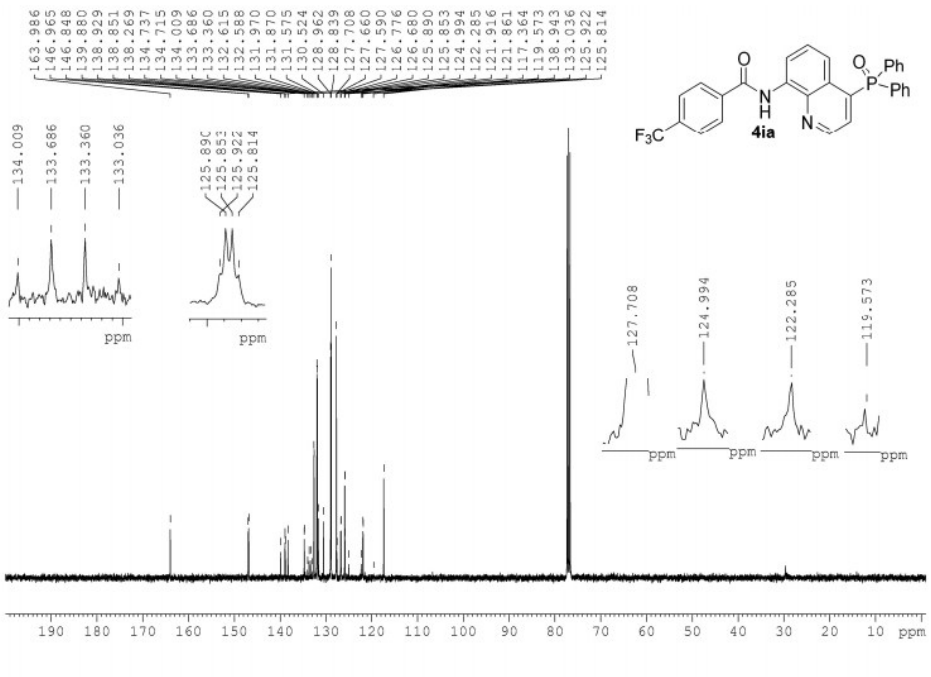

30.321
Cl
4ga
100
50
0
−50
−100
−150
−200
ppm

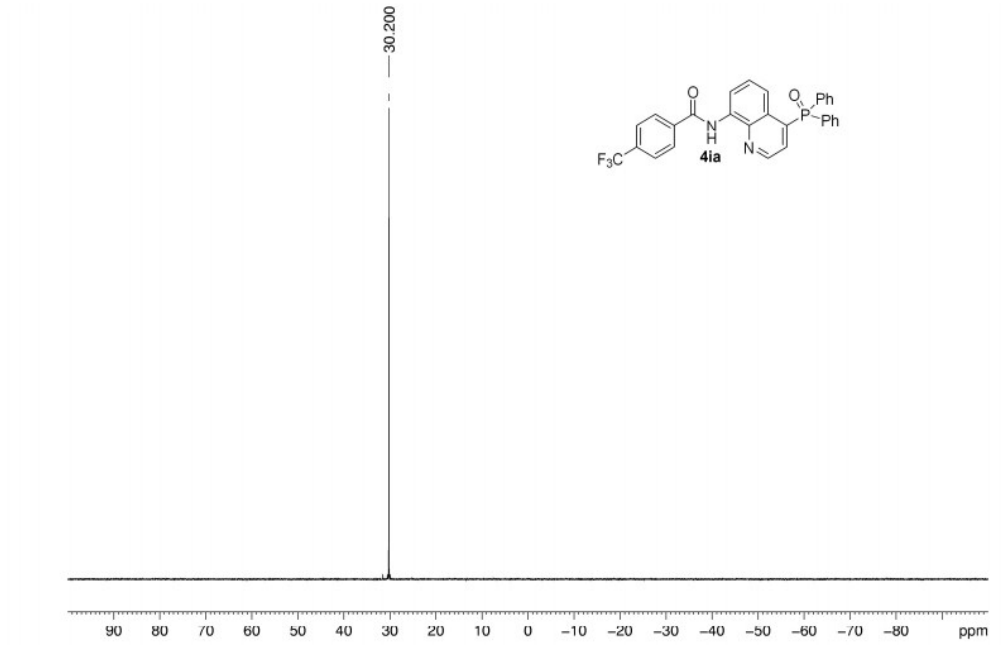

10.705
8.917
8.898
8.842
8.832
8.823
8.214
8.193
7.937
7.916
7.710
7.686
7.664
7.624
7.607
7.589
7.557
7.535
7.519
7.508
7.490
7.280
7.269
7.243
7.233
8.9 ppm
8.2 ppm
7.3 ppm
Br
4ha
1.000
0.998
1.007
1.005
2.008
6.033
2.123
5.070
1.479
ppm

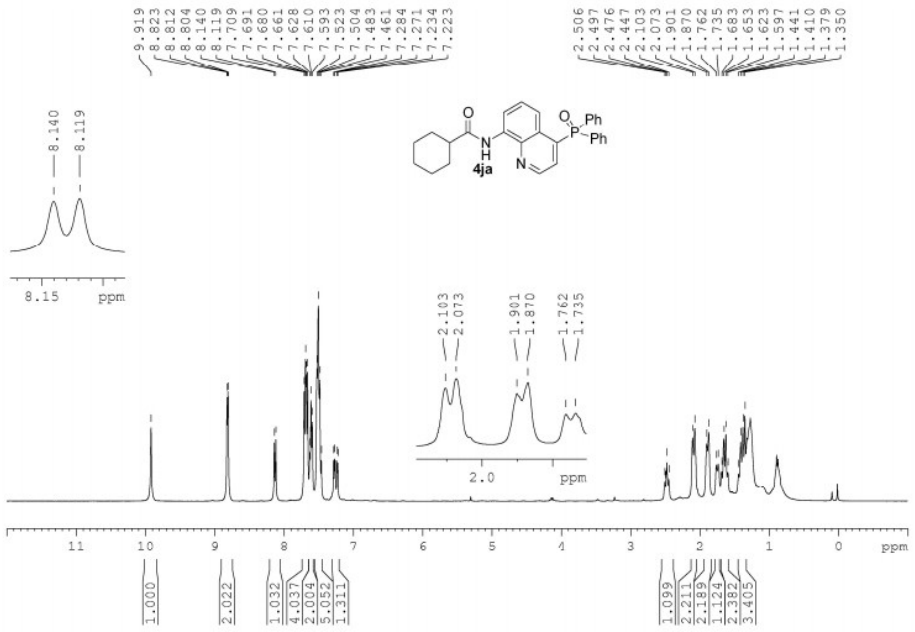

164.414
146.925
146.807
139.832
138.986
138.903
134.963
133.894
132.642
132.616
132.102
132.031
131.931
131.662
130.611
129.001
128.930
128.889
127.692
127.622
126.754
126.686
121.703
121.647
117.293
134.942
4ha
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

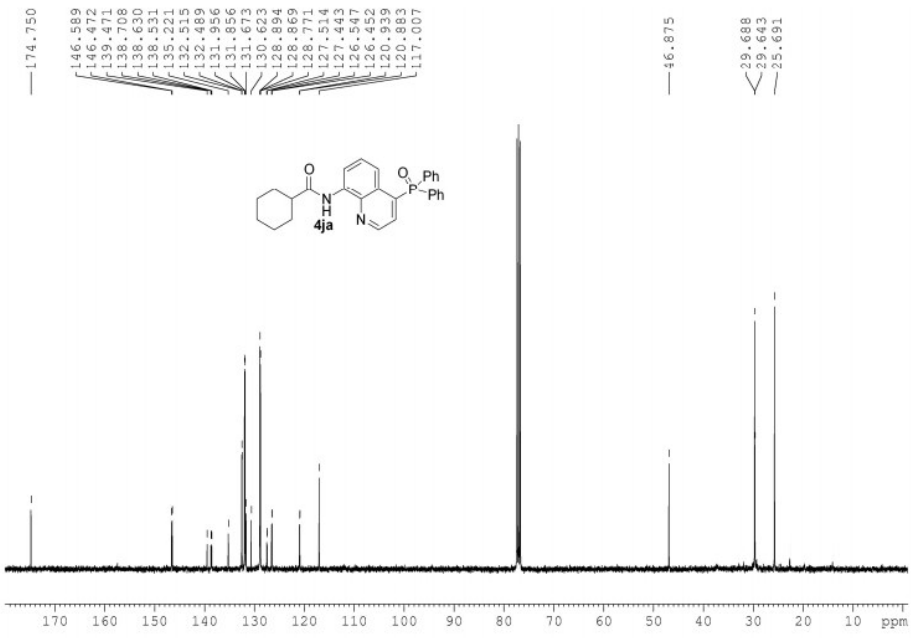

30.211
4ha
90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 ppm

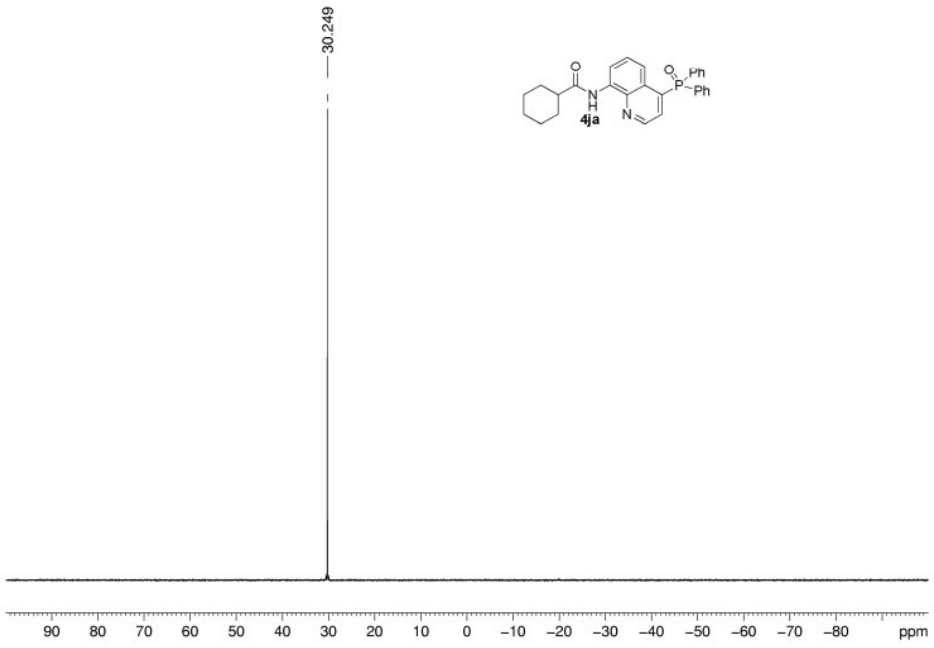

4ia

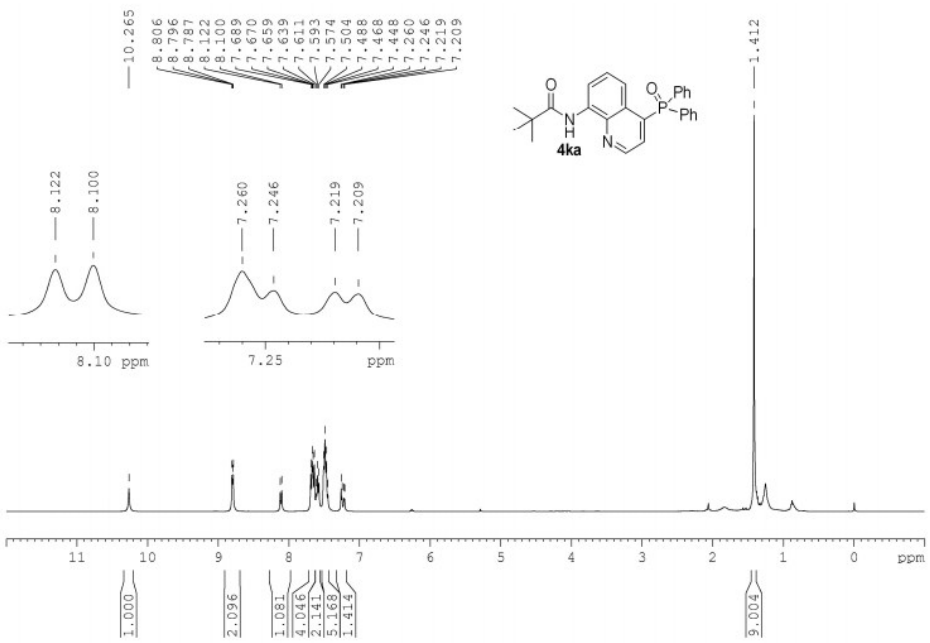

4ia

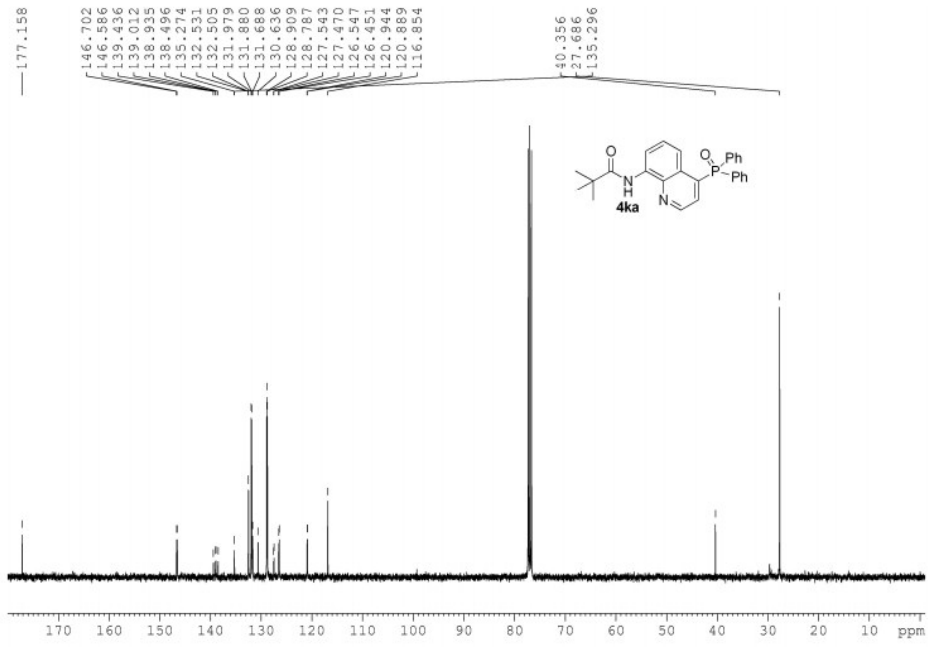

30.200
4ia
90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 ppm

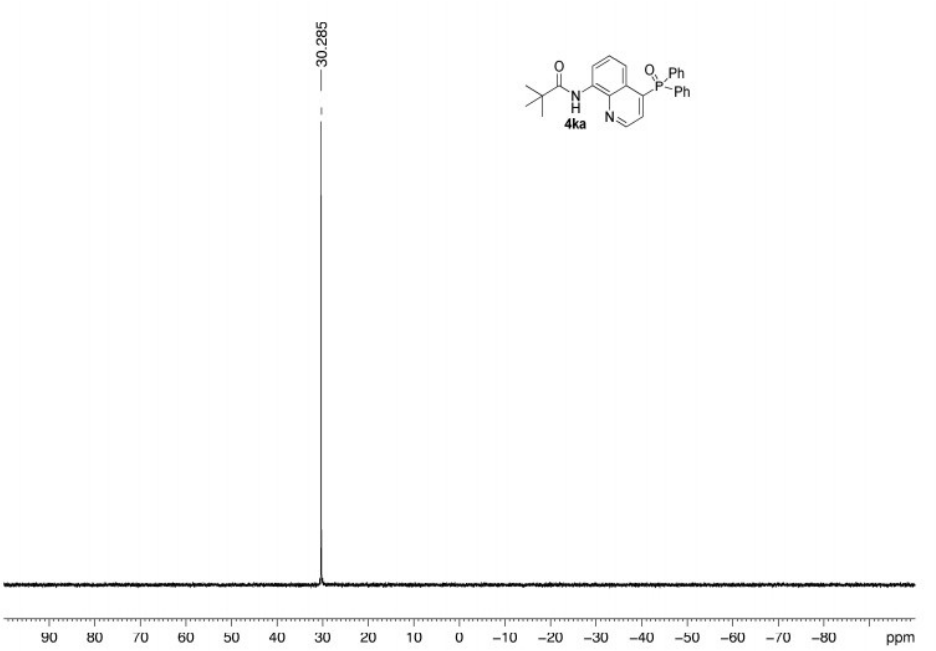

9.919
8.823
8.812
8.804
8.140
8.119
7.709
7.691
7.680
7.661
7.628
7.610
7.593
7.523
7.504
7.483
7.461
7.284
7.271
7.234
7.223
2.506
2.497
2.476
2.447
2.103
2.073
1.901
1.870
1.762
1.735
1.683
1.653
1.623
1.597
1.441
1.410
1.379
1.350
4ja
8.140
8.119
8.15 ppm
2.103
2.073
1.901
1.870
1.762
1.735
2.0 ppm
11 10 9 8 7 6 5 4 3 2 1 0 ppm
1.000
2.022
1.032
4.037
2.004
5.052
1.311
1.099
2.211
2.189
1.124
2.382
3.405

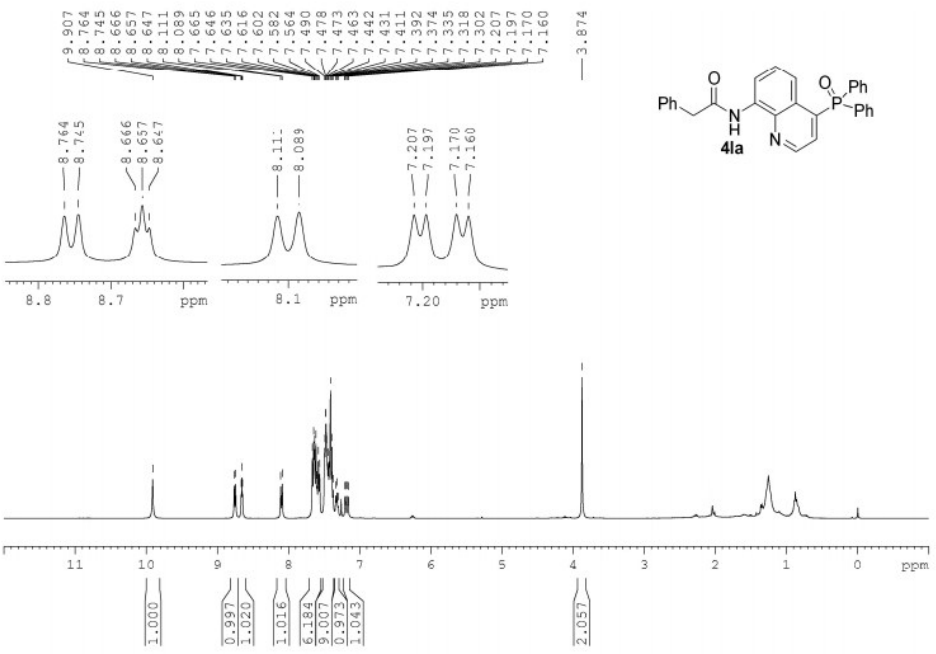

174.750
146.589
146.472
139.471
138.708
138.630
138.531
135.221
132.515
132.489
131.956
131.856
131.673
130.623
128.894
128.869
128.771
127.514
127.443
126.547
126.452
120.939
120.883
117.007
46.875
29.688
29.643
25.691
4ja
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

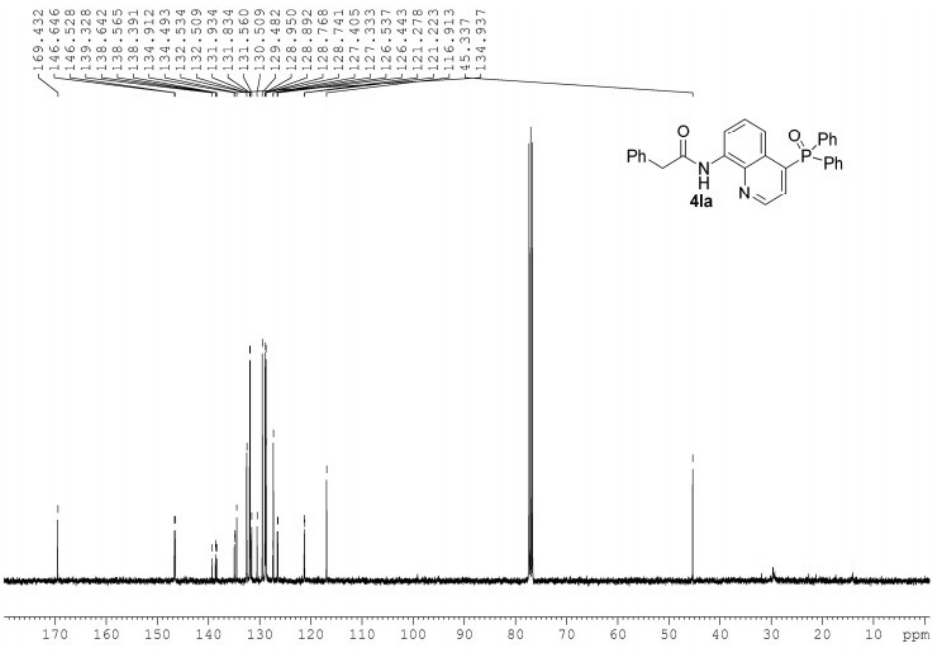

30.249
4ja
90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 ppm

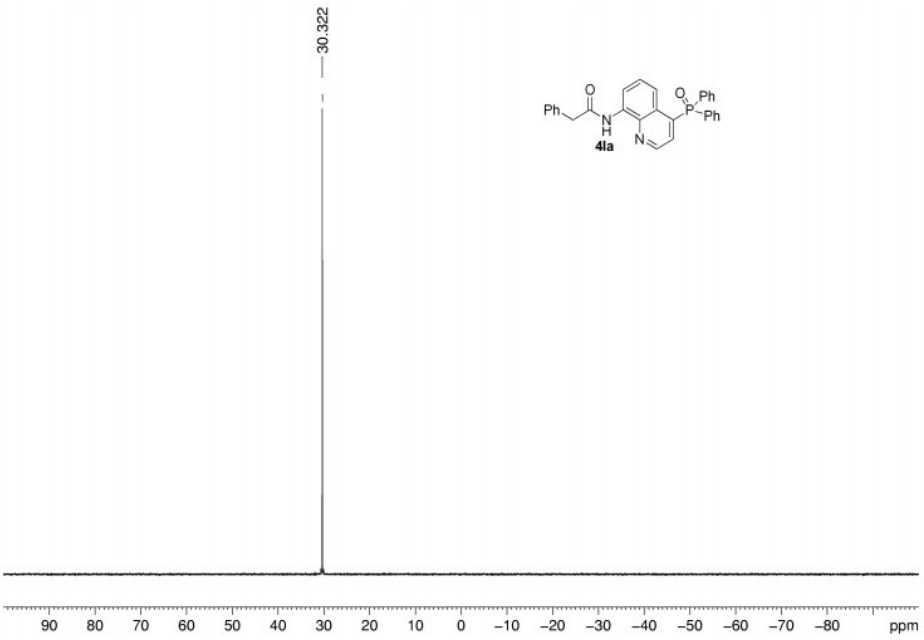

10.265
8.806
8.796
8.787
8.122
8.100
7.689
7.670
7.659
7.639
7.611
7.593
7.574
7.504
7.488
7.468
7.448
7.260
7.246
7.219
7.209
1.412
8.122
8.100
7.260
7.246
7.219
7.209
8.10 ppm
7.25 ppm
4ka
11 10 9 8 7 6 5 4 3 2 1 0 ppm
1.000
2.096
1.081
4.046
2.141
5.168
1.414
9.004

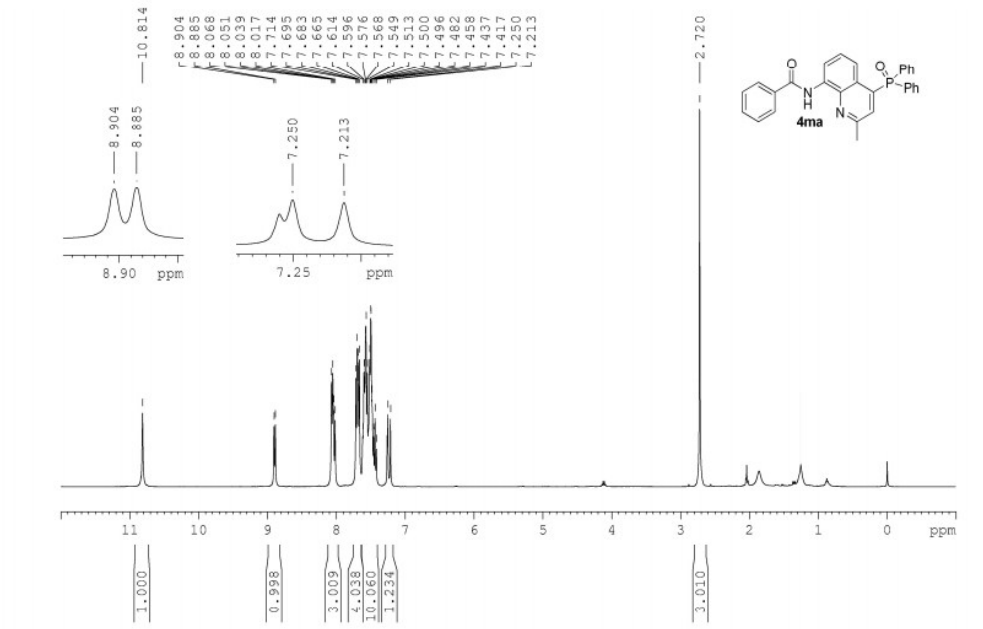

177.158
146.702
146.586
139.436
139.012
138.935
138.496
135.274
132.531
132.505
131.979
131.880
131.688
130.636
128.909
128.787
127.543
127.470
126.547
126.451
120.944
120.889
116.854
40.356
27.686
135.296
4ka
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

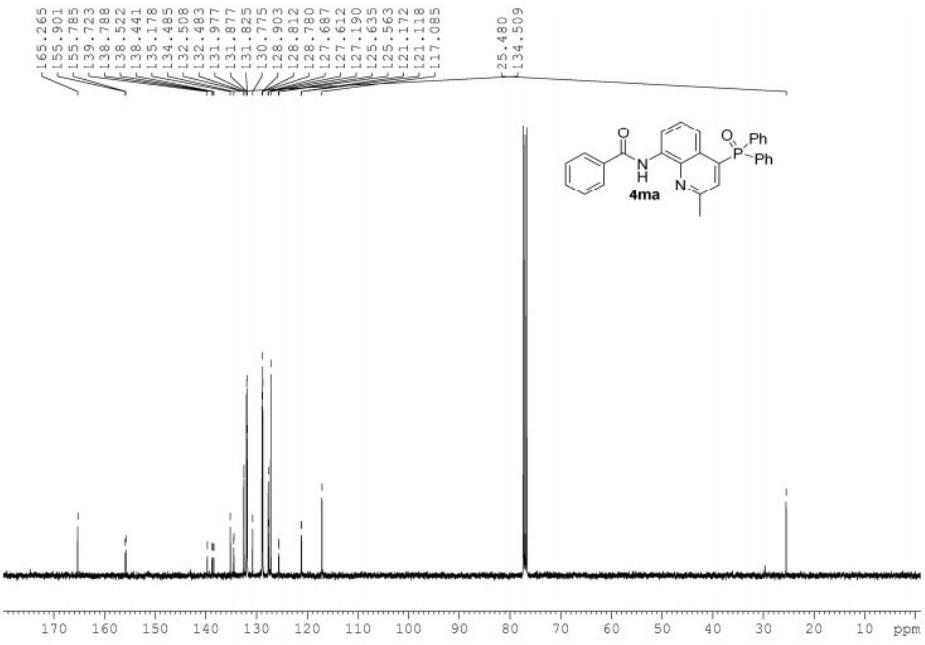

30.285
4ka
90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 ppm

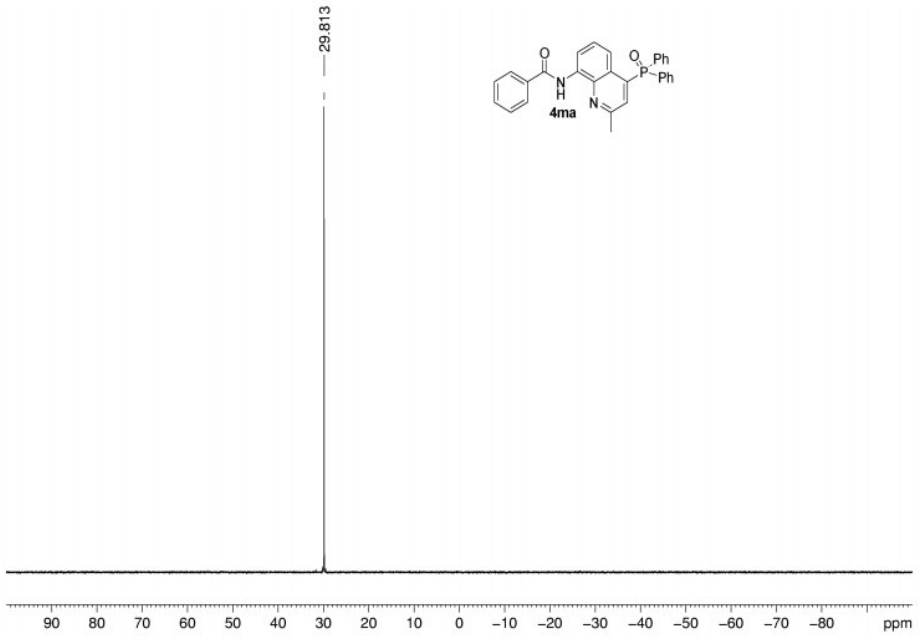

4la
8.8 8.7 ppm
8.1 ppm
7.20 ppm
11 10 9 8 7 6 5 4 3 2 1 0 ppm

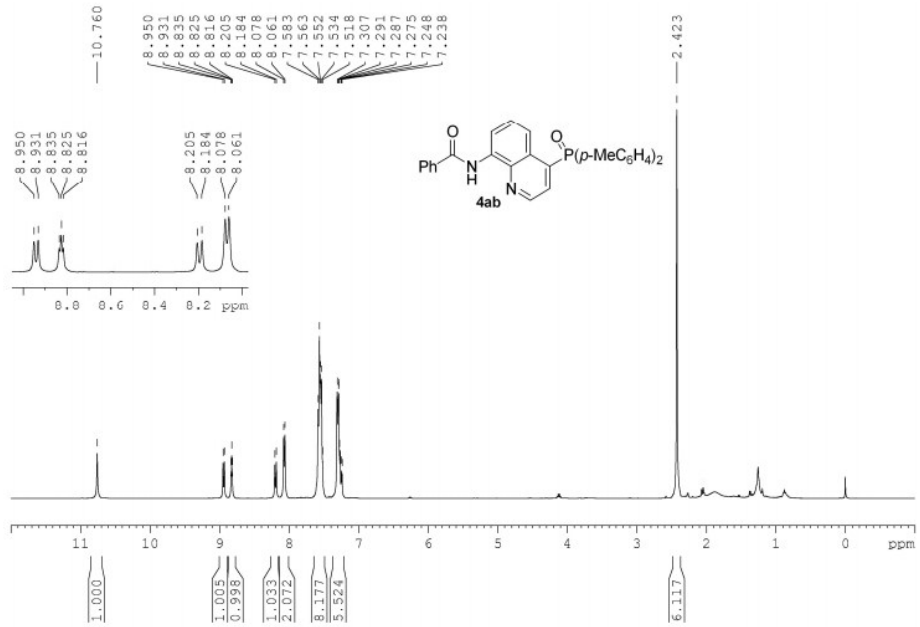

169.432
146.646
146.528
139.328
138.642
138.565
138.391
134.912
134.493
132.534
132.509
131.934
131.834
131.560
130.509
129.482
128.950
128.892
128.768
128.741
127.405
127.333
126.537
126.443
121.278
121.223
116.913
45.337
34.937
Ph
O
N
H
4la
O
Ph
P
Ph
N
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

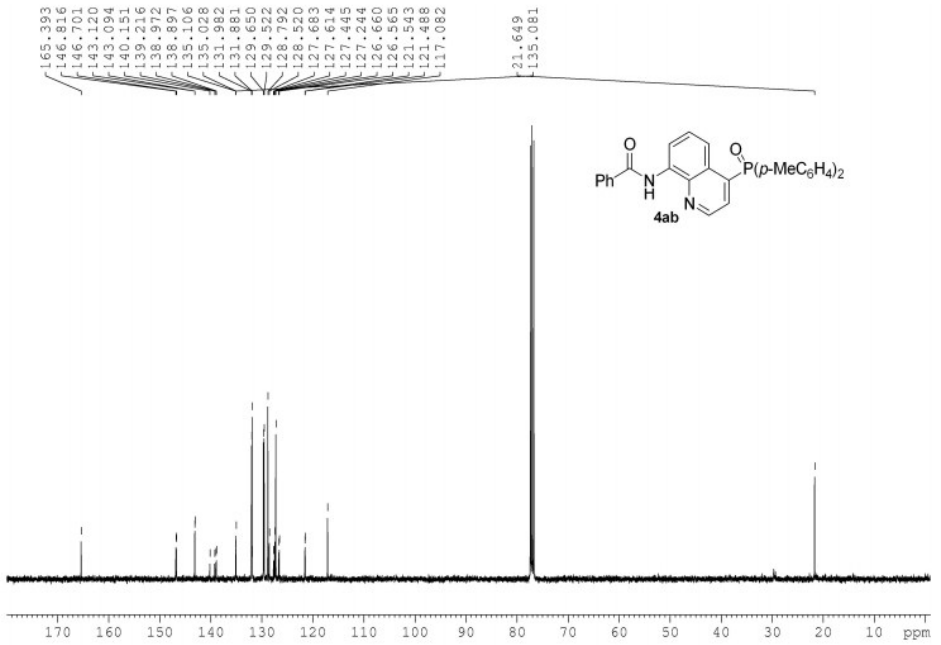

30.322
Ph
O
N
H
4la
O
Ph
P
Ph
N
90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 ppm

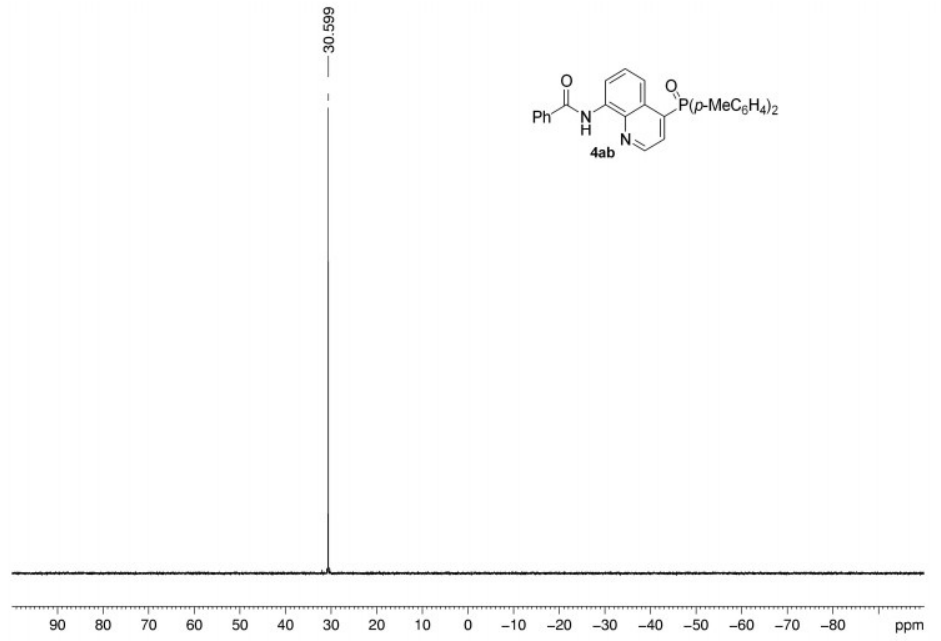

10.814
8.904
8.885
8.068
8.051
8.039
8.017
7.714
7.695
7.683
7.665
7.614
7.596
7.576
7.568
7.549
7.513
7.500
7.496
7.482
7.458
7.437
7.417
7.250
7.213
2.720
8.904
8.885
8.90 ppm
7.250
7.213
7.25 ppm
4ma
11 10 9 8 7 6 5 4 3 2 1 0 ppm
1.000
0.998
3.009
4.038
10.060
1.234
3.010

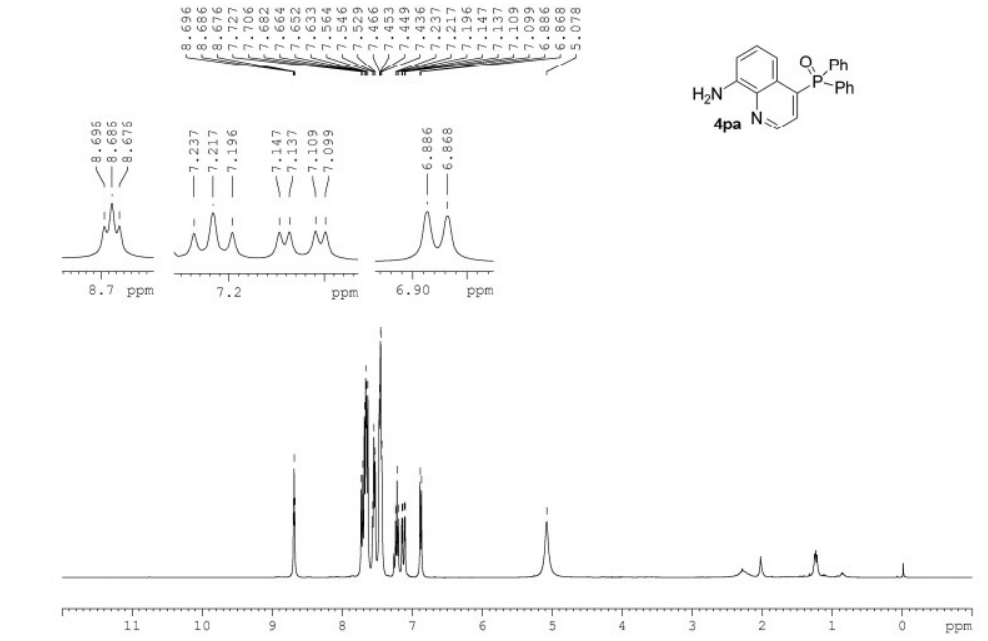

165.265
155.901
155.785
139.723
138.788
138.522
138.441
135.178
134.485
132.508
132.483
131.977
131.877
131.825
130.775
128.903
128.812
128.780
127.687
127.612
127.190
125.635
125.563
121.172
121.118
117.085
25.480
134.509
4ma
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

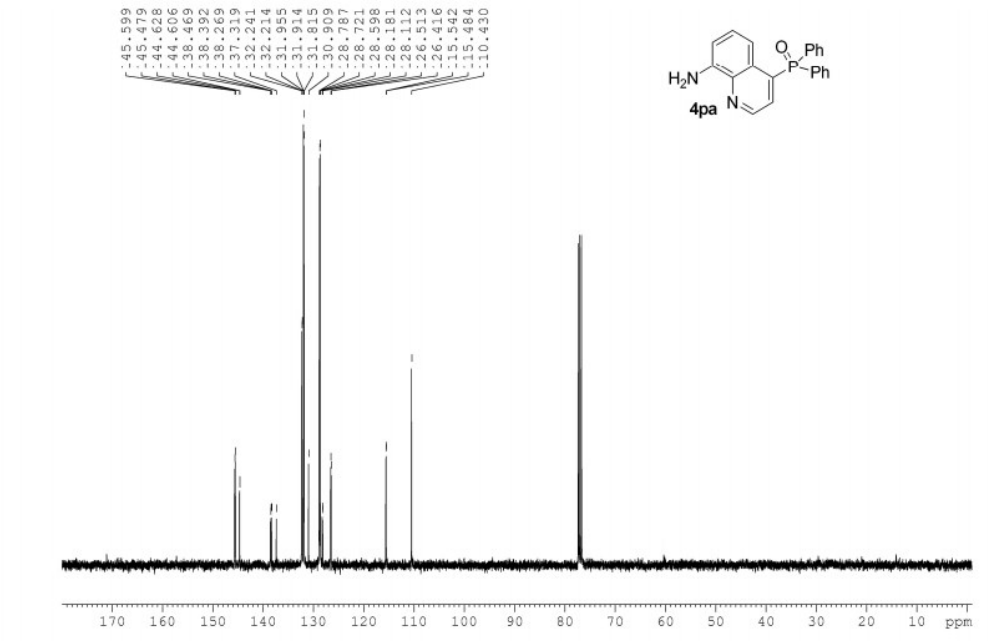

29.813
4ma
90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 ppm

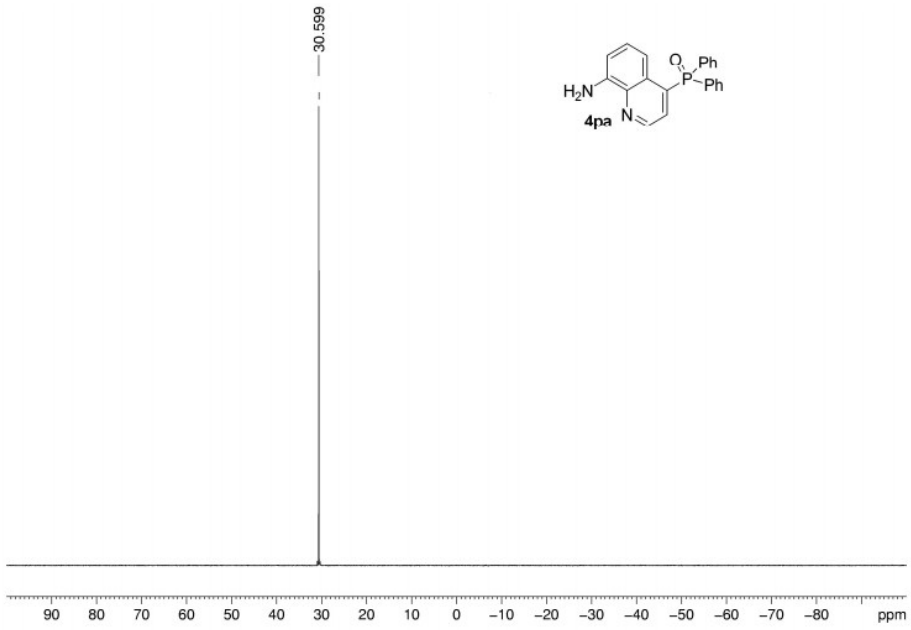

10.760
8.950
8.931
8.835
8.825
8.816
8.205
8.184
8.078
8.061
7.583
7.563
7.552
7.534
7.518
7.307
7.291
7.287
7.275
7.248
7.238
2.423
4ab
11 10 9 8 7 6 5 4 3 2 1 0 ppm
1.000
1.005
0.998
1.033
2.072
8.177
5.524
6.117

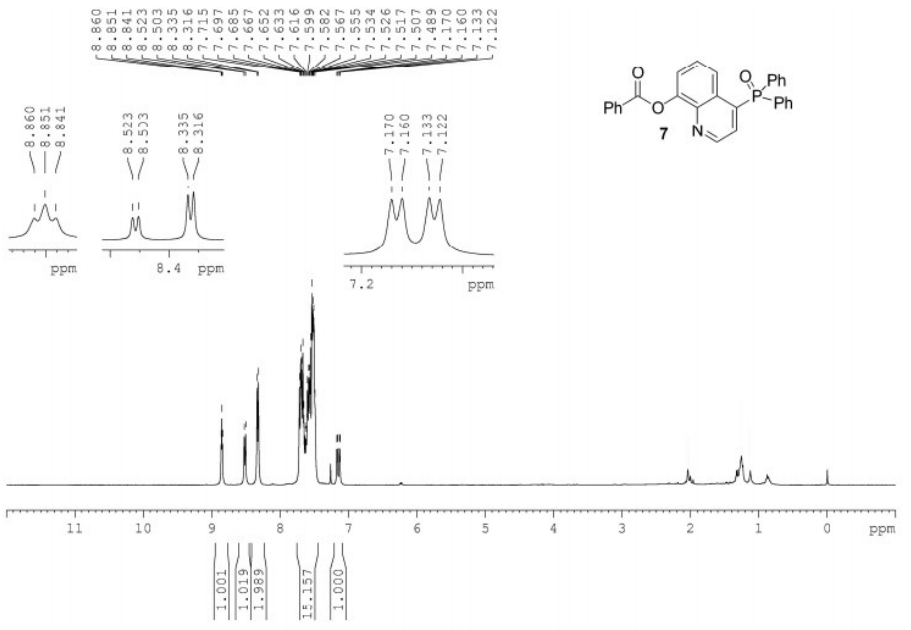

165.393
146.816
146.701
143.120
143.094
140.151
139.216
138.972
138.897
135.106
135.028
131.982
131.881
129.650
129.522
128.792
128.520
127.683
127.614
127.445
127.244
126.660
126.565
121.543
121.488
117.082
21.649
135.081
Ph
N
H
O
O
P(p-MeC6H4)2
N
4ab
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

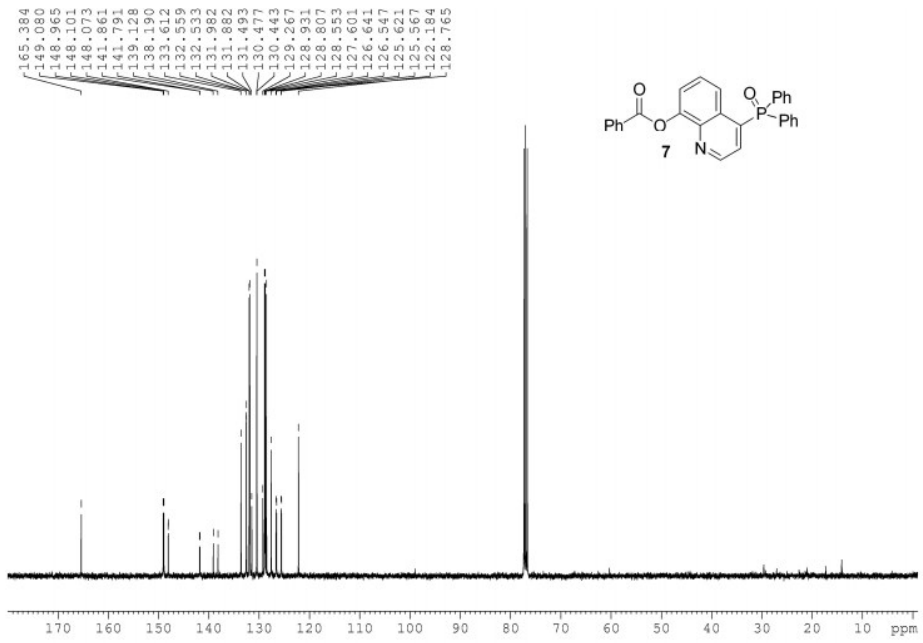

30.599
Ph
N
H
O
O
P(p-MeC6H4)2
N
4ab
90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 ppm

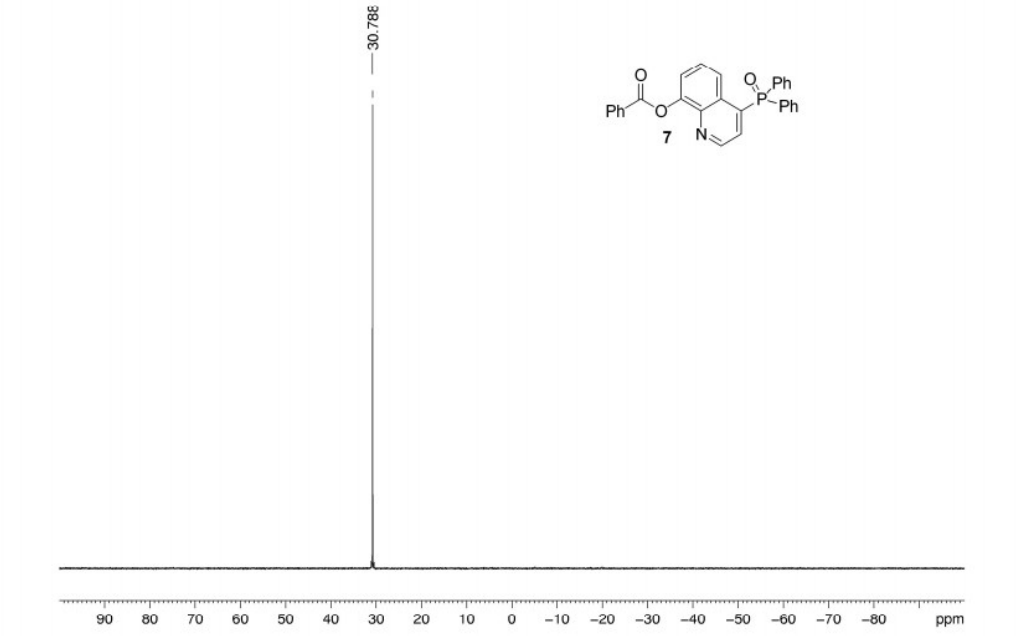

8.696
8.686
8.676
7.727
7.706
7.682
7.664
7.652
7.633
7.564
7.546
7.529
7.466
7.453
7.449
7.436
7.237
7.217
7.196
7.147
7.137
7.109
7.099
6.886
6.868
5.078
8.7 ppm
7.2 ppm
6.90 ppm
H_2N
Ph
Ph
O
P
N
4pa
11 10 9 8 7 6 5 4 3 2 1 0 ppm

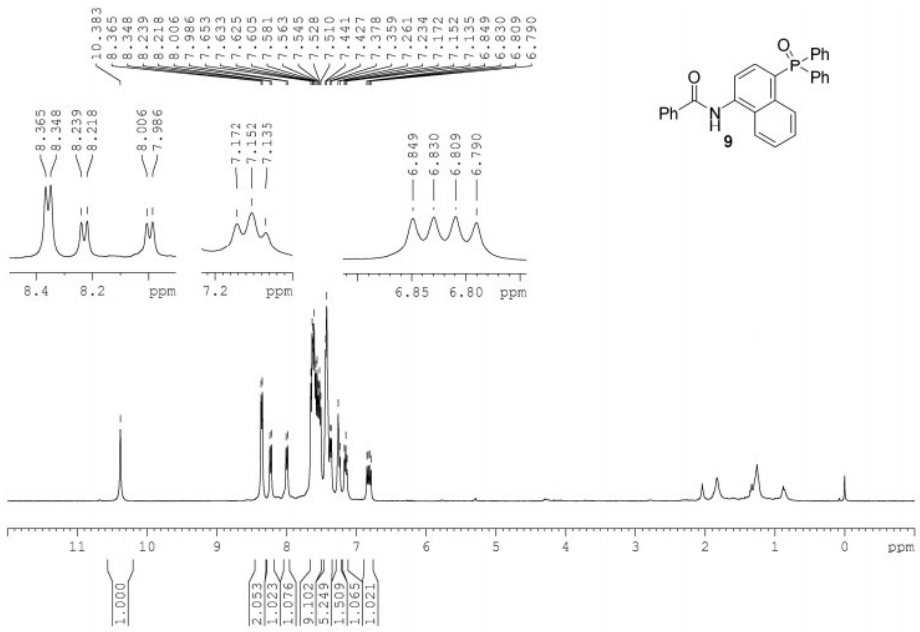

145.599
145.479
144.628
144.606
138.469
138.392
138.269
137.319
132.241
132.214
131.955
131.914
131.815
130.909
128.787
128.721
128.598
128.181
128.112
126.513
126.416
115.542
115.484
110.430
H_2N
Ph
Ph
O
P
N
4pa
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm

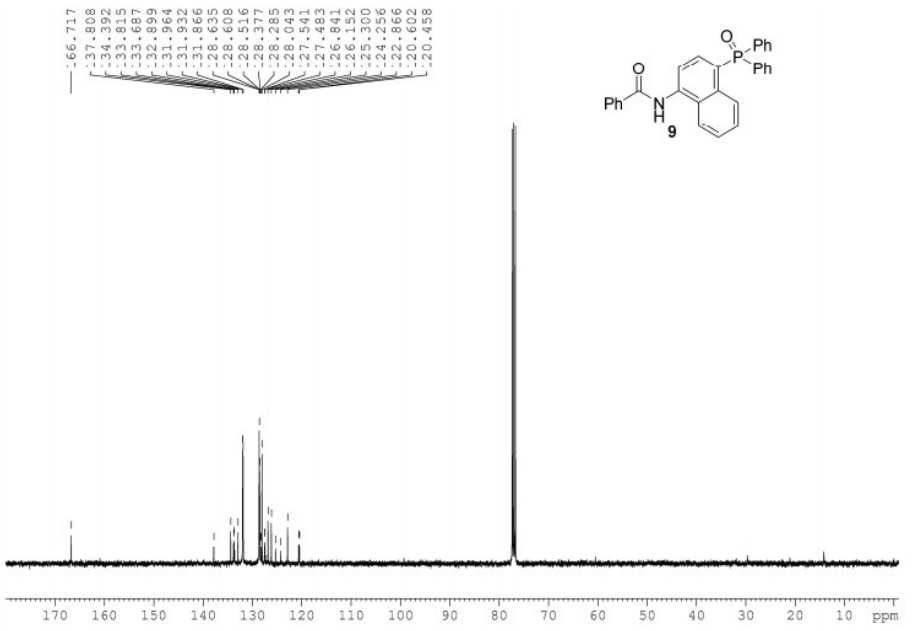

30.599
4pa
90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 ppm

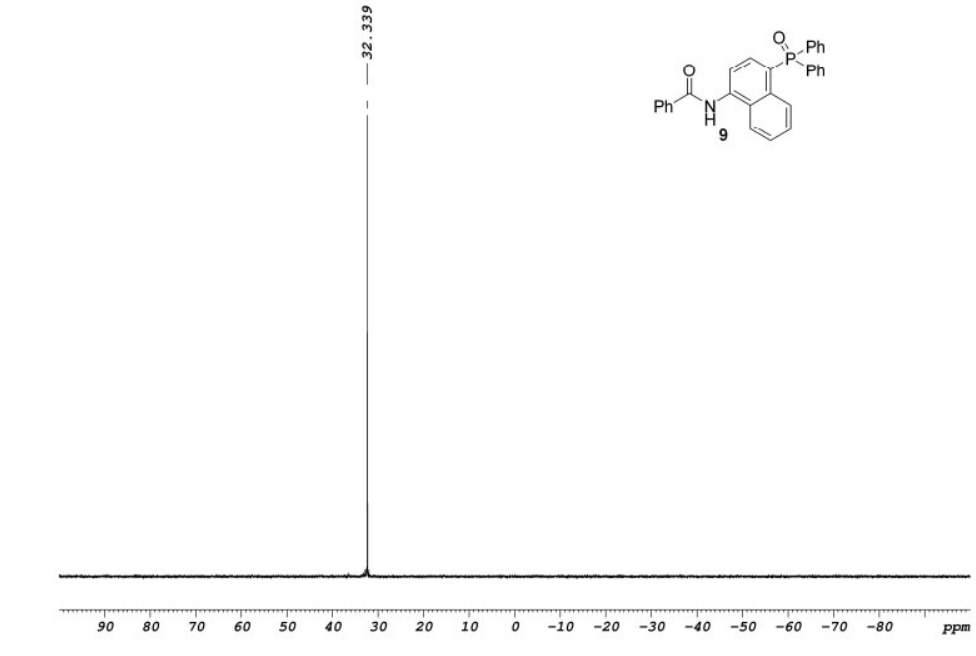

8.860
8.851
8.841
8.523
8.503
8.335
8.316
7.715
7.697
7.685
7.667
7.652
7.633
7.616
7.599
7.582
7.567
7.555
7.534
7.526
7.517
7.507
7.489
7.170
7.160
7.133
7.122
7
ppm
8.4 ppm
7.2 ppm
11 10 9 8 7 6 5 4 3 2 1 0 ppm
1.001
1.019
1.989
15.157
1.000


165.384
149.080
148.965
148.101
148.073
141.861
141.791
139.128
138.190
133.612
132.559
132.533
131.982
131.882
131.493
130.477
130.443
129.267
128.931
128.807
128.553
127.601
126.641
126.547
125.621
125.567
122.184
120.765
O
Ph
O
O
P
Ph
Ph
N
7
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 ppm


30.786
O
Ph
O
O
P
Ph
Ph
N
7
90 80 70 60 50 40 30 20 10 0 −10 −20 −30 −40 −50 −60 −70 −80 ppm


10.383
8.365
8.348
8.239
8.218
8.006
7.986
7.653
7.633
7.625
7.605
7.581
7.563
7.545
7.528
7.510
7.441
7.427
7.378
7.359
7.261
7.234
7.172
7.152
7.135
6.849
6.830
6.809
6.790
8.4
8.2
ppm
7.2
ppm
6.85
6.80
ppm
Ph
O
P
Ph
Ph
O
N
H
9
11
10
9
8
7
6
5
4
3
2
1
0
ppm
1.000
2.053
1.023
1.076
9.102
5.249
1.509
1.065
1.021


66.717
37.808
34.392
33.815
33.687
32.899
31.964
31.932
31.866
28.635
28.608
28.516
28.377
28.285
28.043
27.941
27.483
26.841
26.152
25.300
24.256
22.866
20.602
20.458
Ph
O
P
Ph
Ph
O
N
H
9
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
ppm


32.339
O
Ph
P
Ph
Ph
O
N
H
9
90 80 70 60 50 40 30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 ppm