Electronic Supplementary Material (ESI) for Chemical Communications.

Supporting Information

Base-promoted, deborylative secondary alkylation of N-heteroaromatic *N*-oxides with internal *gem*-bis[(pinacolato)boryl] alkanes: a facile derivatization of 2,2′-bipyridyl analogues

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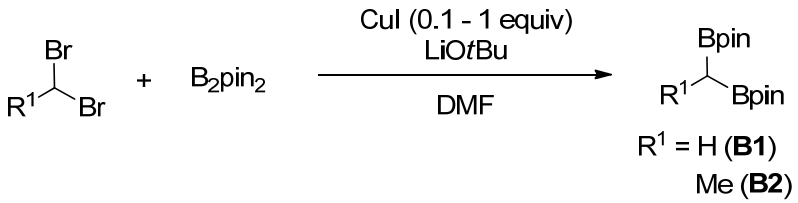
1. General experimental details

Unless otherwise stated, all air-sensitive manipulations were conducted under an inert atmosphere in a nitrogen-filled glovebox or by standard Schlenk techniques. Anhydrous toluene and 1,4-dioxane were purchased from Aldrich and used as received. Other solvents except toluene and 1,4-dioxane were freshly distilled before used. NaOMe was purchased from Alfa Aesar and used as received. Other reagents were directly used as purchased without further purification. N-Heteroaromatic *N*-oxides were synthesized according to literature procedures.[1,2] 9-*O*-Methylquinine *N*-oxide was synthesized according to a literature procedure.[2] Analytical thin layer chromatography (TLC) was performed on Merck pre-coated silica gel 60 F254 plates. Visualization on TLC was achieved by the use of UV light (254 nm), or treatment with $KMnO_4$ stain followed by heating. Column chromatography was undertaken on silica gel (400-630 mesh) using a proper eluent system. NMR spectrums were acquired on 300 MHz and 500 MHz Bruker instruments at the POSTECH NMR facility. Chemical shifts are reported in ppm relative to a residual solvent peak ($CDCl_3$ = 7.26 ppm for ^1H and 77.16 ppm for ^{13}C, CD_2Cl_2 = 5.32 ppm for ^1H and 54.00 ppm for ^{13}C). Mass spectral data were obtained from the Korea Basic Science Institute (Daegu) by using EI method.

2. General procedure for the preparation of starting materials

2.1 General procedure for the preparation of *gem*-bis[(pinacolato)boryl]alkanes



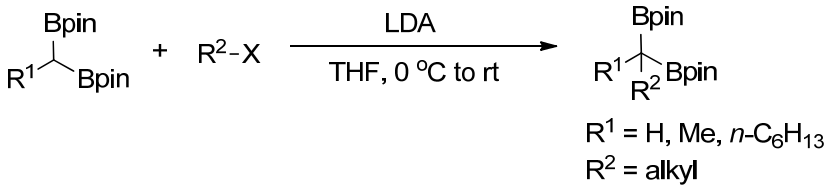
The reaction was performed according to the literature procedure with slight modifications.[3]

Bis[(pinacolato)boryl]methane (B1): To an oven-dried 250 mL round-bottomed flask equipped with a Teflon coated magnetic stirbar, copper iodide (1.0 g, 5.5 mmol), LiO*t*Bu (5.2 g, 137.5 mmol) and bis(pinacolato)diboron (25 g, 100 mmol) were added. The flask was evacuated and filled with argon (three cycles). DMF (150 mL) and dibromomethane (9.6 g, 55 mmol) were added via syringe under an argon atmosphere. The reaction mixture was stirred at 40 °C for 24 h, and then diluted with *n*-hexane (150 mL). The organic phase was washed with H_2O (200 mL) and the aqueous layer was extracted with *n*-hexane (200 mL x 3). The combined organic layers were dried over $MgSO_4$, filtered through silica gel and concentrated under reduced pressure. The crude mixture was purified by column chromatography on silica gel to give **B1** (9.4 g, 70 %) as a white solid.

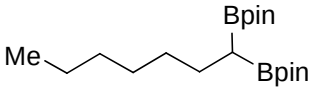
***gem*-Bis[(pinacolato)boryl]ethane (B2)**: To an oven-dried 250 mL round-bottomed flask equipped with a Teflon coated magnetic stirbar, copper iodide (4.2 g, 22 mmol), LiO*t*Bu (38 g, 66 mmol) and bis(pinacolato)diboron (10 g, 40 mmol) were added. The flask was evacuated and filled with argon (three cycles). DMF (120 mL) and 1,1-dibromoethane (4.1 g, 22 mmol) were added via syringe under an argon atmosphere. The reaction mixture was stirred at 40 °C for 24 h, and then then diluted with *n*-hexane (150 mL). The organic phase was washed with H_2O (200 mL) and the aqueous layer was extracted with *n*-hexane (200 mL x 3). The combined organic layers were dried over $MgSO_4$, filtered through silica gel and concentrated under

reduced pressure. The crude mixture was purified by column chromatography on silica gel to give **B2** (4.0 g, 71 %) as a colorless liquid.

2.2 General procedure for the preparation of internal *gem*-bis[(pinacolato)boryl]alkanes



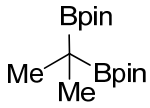
To a 100 mL round bottom flask containing a magnetic stirbar was added *gem*-bis[(pinacolato)boryl]alkane (1.0 equiv) in THF (0.5 M) under nitrogen. To this solution, lithium diisopropylamide (1.0 M in *n*-hexane, 1.1 equiv) was added via syringe at 0 °C. The reaction mixture was stirred for 30 min and then the corresponding alkyl halide (1.1 equiv) was added at 0 °C. The reaction mixture was stirred at 0 °C for 30 min, and allowed to room temperature and stirred for additional 2 h. The reaction mixture was diluted with Et_2O (20 mL) and quenched with a brine (20 mL). The aqueous layer was extracted with Et_2O (20 mL x 3) and the combined organic layers were dried over $MgSO_4$, filtered and concentrated under reduced pressure. The crude mixture was purified by column chromatography on silica gel.



***gem*-Bis[(pinacolato)boryl]heptane (B3)**

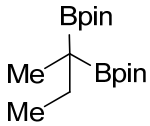
The reaction was performed according to the general procedure with bis[(pinacolato)boryl]methane **B1** (2.7 g, 10 mmol), lithium diisopropylamide (1.0 M in *n*-hexane, 10 mL, 10 mmol) and 1-bromohexane (1.7 g, 10 mmol) in THF (20 mL). The crude material was purified by column chromatography on silica gel (*n*-hexane:EtOAc, 30:1) to give the product **B3** as a colorless liquid (2.3 g, 67%); ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.56 – 1.48 (q, J = 7.2 Hz, 2H), 1.27 – 1.20 (m, 32H), 0.86 – 0.82 (t, J = 6.6 Hz, 3H), 0.72 – 0.67 (t, J =

7.9 Hz, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 83.0, 32.7, 31.9, 29.4, 25.8, 25.0, 24.6, 22.7, 14.2; ^{11}B NMR (193 MHz, $CDCl_3$) δ 33.8; The obtained ^{1}H and ^{13}C-NMR were in agreement with the literature.[4]



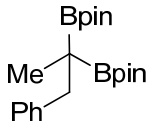
2,2-Bis[(pinacolato)boryl]propane (2a)

The reaction was performed according to the general procedure with *gem*-bis[(pinacolato)boryl]ethane (**B2**, 2.8 g, 10 mmol), lithium diisopropylamide (1.0 M in *n*-hexane, 11 mL, 11 mmol) and iodomethane (1.6 mg, 11 mmol) in THF (20 mL). The crude material was purified by column chromatography on silica gel (n-hexane:EtOAc, 20:1) to give the product **2a** as a white solid (2.5 g, 85%); ^{1}H NMR (300 MHz, $CDCl_3$) δ 1.21 (s, 24H), 1.06 (s, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 83.0, 24.8, 20.0; ^{11}B NMR (193 MHz, $CDCl_3$) δ 34.40; The obtained ^{1}H and ^{13}C-NMR were in agreement with the literature.[3]



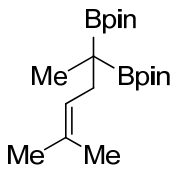
2,2-Bis[(pinacolato)boryl]butane (2b)

The reaction was performed according to the general procedure with *gem*-bis[(pinacolato)boryl]ethane (**B2**, 3.4 g, 12 mmol), lithium diisopropylamide (1.0 M in *n*-hexane, 14 mL, 14 mmol) and bromoethane (1.6 mg, 14 mmol) in THF (24 mL). The crude material was purified by column chromatography on silica gel (n-hexane:EtOAc, 20:1) to give the product **2b** as a white solid (3.1 g, 82%); ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.59 – 1.55 (m, 2H), 1.21 (s, 24H), 1.04 (s, 3H), 0.88 (t, J = 7.4 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 83.0, 26.8, 24.8, 15.5, 11.8; ^{11}B NMR (193 MHz, $CDCl_3$) δ 34.2; HRMS (EI) calc'd for $C_{16}H_{32}{}^{11}B_2O_4$ (M^+) 310.2487, found 310.2487.



2,2-Bis[(pinacolato)boryl]-1-phenylpropane (2c)

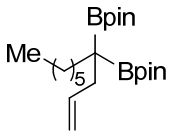
The reaction was performed according to the general procedure with *gem*-bis[(pinacolato)boryl]ethane (**B2**, 850 mg, 3.0 mmol), lithium diisopropylamide (1.0 M in *n*-hexane, 3.3 mL, 3.3 mmol) and benzyl bromide (560 mg, 3.3 mmol) in THF (6.0 mL). The crude material was purified by column chromatography on silica gel (n-hexane:EtOAc, 50:1) to give the product **2c** as a white solid (730 mg, 67%); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.27 – 7.25 (m, 2H), 7.22 – 7.19 (t, *J* = 7.5 Hz, 2H), 7.15 – 7.11 (m, 1H), 2.89 (s, 2H), 1.25 (s, 12H), 1.21 (s, 12H), 1.00 (s, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 141.9, 130.1, 127.7, 125.6, 83.3, 39.3, 24.8, 16.0; ^{11}B NMR (193 MHz, $CDCl_3$) δ 34.0; HRMS (EI) calc'd for $C_{21}H_{34}{}^{11}B_2O_4$ (M^+) 372.2643, found 372.2682.



2,2-Bis[(pinacolato)boryl]-5-methylhex-4-ene (2d)

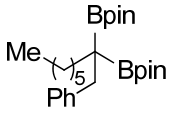
The reaction was performed according to the general procedure with *gem*-bis[(pinacolato)boryl]ethane (**B2** 1.4 g, 5.0 mmol), lithium diisopropylamide (1.0 M in *n*-hexane, 5.5 mL, 5.5 mmol) and 1-bromo-3-methylbut-2-ene (820 mg, 5.5 mmol) in THF (10 mL). The crude material was purified by column chromatography on silica gel (*n*-hexane:EtOAc, 20:1) to give the product **2e** as a colorless liquid (1.6 g, 92%); ^{1}H NMR (500 MHz, $CDCl_3$) δ 5.14 – 5.10 (m, 1H), 2.22 – 2.20 (d, *J* = 7.5 Hz, 2H), 1.65 (s, 3H), 1.59 (s, 3H), 1.21 (s, 24H), 1.02 – 1.01 (m, 3H); 13C NMR (126 MHz, $CDCl_3$) δ 131.8, 124.1, 83.0, 32.1, 26.1, 24.8, 18.2, 16.1; ^{11}B NMR (193 MHz, $CDCl_3$) δ 34.2; HRMS (EI) calc'd for $C_{19}H_{36}{}^{11}B_2O_4$

(M^+) 350.2800, found 350.2797.



4,4-Bis[(pinacolato)boryl]-dec-1-ene (2e)

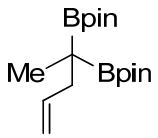
The reaction was performed according to the general procedure with *gem*-bis[(pinacolato)boryl]heptane (**B3**, 1.1 g, 3.0 mmol), lithium diisopropylamide (1.0 M in *n*-hexane, 3.3 mL, 3.3 mmol) and allyl bromide (400 mg, 3.3 mmol) in THF (6.0 mL). The crude material was purified by column chromatography on silica gel (*n*-hexane:EtOAc, 30:1) to give the product **2f** as a colorless liquid (1.1 g, 94%); ^{1}H NMR (500 MHz, $CDCl_3$) δ 5.78 – 5.70 (m, 1H), 5.03 – 4.99 (m, 1H), 4.93 – 4.91 (m, 1H), 2.38 – 2.36 (m, 2H), 1.58 – 1.56 (m, 2H), 1.26 – 1.20 (m, 32H), 0.87 – 0.85 (m, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 138.3, 115.4, 83.1, 33.9, 32.0, 30.1, 29.2, 27.1, 24.9, 24.9, 14.2; ^{11}B NMR (193 MHz, $CDCl_3$) δ 33.9; HRMS (EI) calc'd for $C_{22}H_{42}{}^{11}B_2O_4$ (M^+) 392.3269, found 392.3272.



2,2-Bis[(pinacolato)boryl]-1-phenyloctane (2f)

The reaction was performed according to the general procedure with *gem*-bis[(pinacolato)boryl]heptane (**B3**, 860 mg, 2.0 mmol), lithium diisopropylamide (1.0 M in *n*-hexane, 2.2 mL, 2.2 mmol) and benzyl bromide (380 mg, 2.2 mmol) in THF (4.0 mL). The crude material was purified by column chromatography on silica gel (*n*-hexane:EtOAc, 30:1) to give the product **2g** as a white solid (860 mg, 97%); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7z.24 – 7.21 (m, 2H), 7.19 – 7.16 (m, 2H), 7.11 – 7.08 (m, 1H), 2.97 (s, 2H), 1.53 – 1.49 (m, 2H), 1.37 – 1.31 (m, 2H), 1.27 – 1.24 (m, 6H), 1.23 (s, 12H), 1.19 (s, 12H), 0.88 – 0.84 (m, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 142.0, 129.8, 127.7, 125.5, 83.2, 34.6, 32.0, 30.0, 28.8, 27.2, 25.1,

24.8, 22.7, 14.1; ^{11}B NMR (193 MHz, $CDCl_3$) δ 34.0; HRMS (EI) calc'd for $C_{26}H_{44}{}^{11}B_2O_4$ (M^+) 442.3426, found 442.3428.



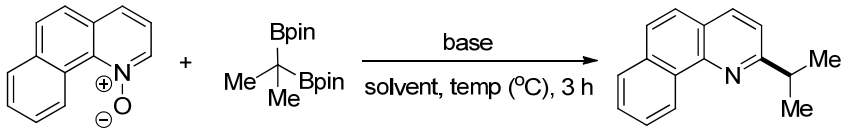
2,2-Bis[(pinacolato)boryl]-pent-4-ene (2e)

The reaction was performed according to the general procedure with *gem*-bis[(pinacolato)boryl]ethane (**B2**, 850 mg, 3.0 mmol), lithium diisopropylamide (1.0 M in *n*-hexane, 3.3 mL, 3.3 mmol) and allyl bromide (400 mg, 3.3 mmol) in THF (6.0 mL). The crude material was purified by column chromatography on silica gel (*n*-hexane:EtOAc, 20:1) to give the product **2d** as a colorless liquid (820 g, 85%); ^{1}H NMR (300 MHz, $CDCl_3$) δ 5.85 – 5.71 (ddt, J = 17.2, 10.0, 7.2 Hz, 1H), 5.04 – 4.97 (m, 1H), 4.95 – 4.91 (m, 1H), 2.30 – 2.27 (d, J = 7.2 Hz, 2H), 1.22 (s, 24H), 1.03 (s, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 138.2, 115.7, 83.1, 38.5, 24.9, 24.9, 16.0; ^{11}B NMR (193 MHz, $CDCl_3$) δ 34.2; The obtained ^{1}H and ^{13}C-NMR were in agreement with the literature.[3]

3. General procedure for the optimization study

To an oven-dried 4-dram vial equipped with a Teflon coated magnetic stirbar were added benzo[*h*]quinolone *N*-oxide (20 mg, 0.10 mmol), **2a** (59 mg, 0.20 mmol), base (0.30 mmol) and anhydrous solvent (1.0 mL). The vial was sealed with a PTFE/silicone-lined septum cap and the reaction mixture was stirred at the indicated temperature for 3 h. The reaction mixture was filtered through celite and washed with CH_2Cl_2 (60 mL). The filtrate was concentrated under reduced pressure. The ^{1}H-NMR yield was determined using 1,1,2,2-tetrachloroethane as an internal standard.

Table S1. Optimization study



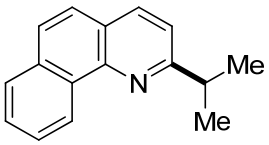
1a **2a** **3a**

entry	base	solvent	temp (°C)	^{1}H-NMR yield (%)
1	KO*t*Bu	toluene	120	62
2	NaO*t*Bu	toluene	120	62
3	LiO*t*Bu	toluene	120	9
4	KOMe	toluene	120	7
5	NaOMe	toluene	120	97
6	LiOMe	toluene	120	<1
7	CsF	toluene	120	<1
8	NaOMe	THF	120	93
9	NaOMe	1,4-dioxane	120	83
10	NaOMe	toluene	100	65
11	NaOMe	toluene	80	<5
12[a]	NaOMe	toluene	120	78
13	-	toluene	120	<1

[a] 2 equiv. of base were used.

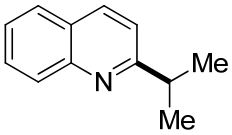
4. General procedure for the secondary alkylation of N-heteroaromatic *N*-oxides

To an oven-dried 4-dram vial equipped with a Teflon coated magnetic stirbar were added N-heteroaromatic *N*-oxide (0.20 mmol), NaOMe (3.0 equiv), internal *gem*-bis[(pinacolato)boryl]alkane (2.0 equiv) and anhydrous toluene (2.0 mL). The vial was sealed with a PTFE/silicone-lined septum cap and the reaction mixture was stirred at the indicated temperature for 3 h. The reaction mixture was filtered through celite and washed with CH_2Cl_2 (20 mL). The filtrate was concentrated under reduced pressure. To remove unreacted internal *gem*-bis[(pinacolato)boryl]alkane, $NaBO_3 \cdot 4H_2O$ (93 mg, 0.60 mmol) and THF/H_2O (3.0 mL, 1:1) were added to the above obtained crude mixture in a 20 mL vial and stirred for 3 h at room temperature. The reaction mixture was quenched with brine (5.0 mL) and extracted with EtOAc (10 mL x 3). The combined organic layers were dried over $MgSO_4$, filtered and concentrated under reduced pressure. The crude reaction mixture was purified by silica gel column chromatography to yield the desired product.

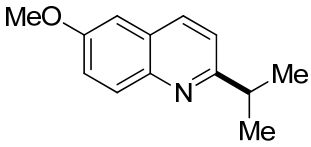


2-Isopropylbenzo[*h*]quinoline (3a): The reaction was performed according to the general procedure for the alkylation with benzo[*h*]quinoline-*N*-oxide (39 mg, 0.20 mmol), **2a** (120 mg, 0.40 mmol) and NaOMe (32 mg, 0.60 mmol) in anhydrous toluene (2.0 mL) at 120 ºC for 3 h. The crude mixture was purified by column chromatography on silica gel (*n*-hexane:EtOAc, 60:1) to give compound **3a** as an orange oil (42 mg, 95%); ^{1}H NMR (500 MHz, $CDCl_3$) δ 9.54 – 9.52 (dd, *J* = 8.1, 1.3 Hz, 1H), 8.09 – 8.07 (d, *J* = 8.2 Hz, 1H), 7.95 – 7.93 (d, *J* = 7.9 Hz, 1H), 7.82 – 7.76 (m, 2H), 7.75 – 7.71 (m, 1H), 7.68 – 7.66 (d, *J* = 8.8 Hz, 1H), 7.45 – 7.43 (d, *J* = 8.2 Hz, 1H), 3.46 – 3.38 (hept, *J* = 6.9 Hz, 1H), 1.57 – 1.56 (d, *J* = 6.9 Hz, 6H); ^{13}C NMR

(126 MHz, $CDCl_3$) δ 166.2, 145.8, 136.0, 133.8, 131.8, 127.9, 127.7, 126.7, 126.7, 125.3, 124.7, 124.5, 119.9, 37.1, 22.9; The obtained ^1H and ^{13}C-NMR were in agreement with the literature.[5]

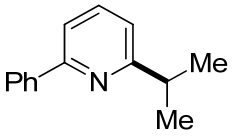


2-Isopropylquinoline (3b): The reaction was performed according to the general procedure for the alkylation with quinoline-*N*-oxide (29 mg, 0.20 mmol), **2a** (120 mg, 0.40 mmol) and NaOMe (32 mg, 0.60 mmol) in anhydrous toluene (2.0 mL) at 120 ºC for 3 h. The crude mixture was purified by column chromatography on silica gel (*n*-hexane:Et_2O, 50:1 to 20:1) to give compound **3b** as a light yellow oil (19 mg, 55%); ^1H NMR (500 MHz, $CDCl_3$) δ 8.10 – 8.04 (dd, *J* = 17.8, 8.5 Hz, 2H), 7.79 – 7.76 (m, 1H), 7.69 – 7.66 (ddd, *J* = 8.4, 6.9, 1.4 Hz, 1H), 7.50 – 7.46 (m, 1H), 7.36 – 7.34 (d, *J* = 8.5 Hz, 1H), 3.31 – 3.23 (hept, *J* = 6.9 Hz, 1H), 1.41 – 1.40 (d, *J* = 7.0 Hz, 6H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 167.8, 147.9, 136.5, 129.4, 129.2, 127.6, 127.1, 125.8, 119.3, 37.5, 22.7; The obtained ^1H and ^{13}C-NMR were in agreement with the literature.[6]

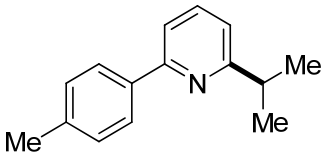


2-Isopropyl-6-methoxyquinoline (3c): The reaction was performed according to the general procedure for the alkylation with 6-methoxyquinoline-*N*-oxide (35 mg, 0.20 mmol), **2a** (120 mg, 0.40 mmol) and NaOMe (32 mg, 0.60 mmol) in anhydrous toluene (2.0 mL) at 120 ºC for 3 h. The crude mixture was purified by column chromatography on silica gel (*n*-hexane:EtOAc, 10:1) to give compound **3c** as a yellow oil (30 mg, 75%); ^1H NMR (300 MHz, $CDCl_3$) δ 7.96 – 7.93 (d, *J* = 8.8 Hz, 2H), 7.34 – 7.30 (dd, *J* = 9.2, 2.8 Hz, 1H), 7.28 – 7.25 (d, *J* = 8.5 Hz, 1H), 7.01 – 7.00 (d, *J* = 2.8 Hz, 1H), 3.87 (s, 3H), 3.28 – 3.14 (hept, *J* = 7.0 Hz, 1H), 1.38 –

1.36 (d, *J* = 7.0 Hz, 6H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 165.2, 157.2, 143.8, 135.3, 130.4, 127.8, 121.7, 119.4, 105.3, 55.5, 37.1, 22.7; The obtained ^{1}H and ^{13}C-NMR were in agreement with the literature.[7]

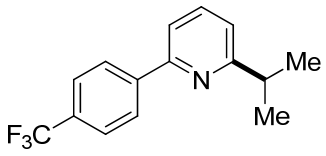


2-Isopropyl-6-phenylpyridine (3d): The reaction was performed according to the general procedure for the alkylation with 2-phenylpyridine-*N*-oxide (34 mg, 0.20 mmol), **2a** (120 mg, 0.40 mmol) and NaOMe (32 mg, 0.60 mmol) in anhydrous toluene (2.0 mL) at 120 ºC for 3 h. The crude mixture was purified by column chromatography on silica gel (*n*-hexane:EtOAc, 50:1) to give compound **3d** as a colorless oil (34 mg, 86%); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.08 – 8.05 (m, 2H), 7.68 – 7.65 (t, *J* = 7.7 Hz, 1H), 7.56 — 7.54 (dd, *J* = 7.8, 0.9 Hz, 1H), 7.50 – 7.47 (m, 2H), 7.42 – 7.39 (m, 1H), 7.13 – 7.11 (m, 1H), 3.20 – 3.12 (hept, *J* = 6.9 Hz, 1H), 1.39 – 1.38 (d, *J* = 6.9 Hz, 6H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 167.2, 156.4, 140.0, 137.0, 128.8, 128.7, 127.1, 119.0, 117.7, 36.6, 22.8; The obtained ^{1}H and ^{13}C-NMR were in agreement with the literature.[8]

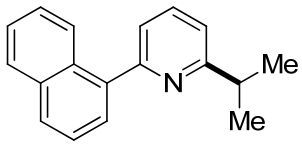


2-Isopropyl-6-(*p*-tolyl)pyridine (3e): The reaction was performed according to the general procedure for the alkylation with 2-(*p*-tolyl)pyridine-*N*-oxide (37 mg, 0.20 mmol), **2a** (120 mg, 0.40 mmol) and NaOMe (32 mg, 0.60 mmol) in anhydrous toluene (2.0 mL) at 120 ºC for 3 h. The crude mixture was purified by column chromatography on silica gel (*n*-hexane:EtOAc, 50:1) to give compound **3e** as an orange oil (34 mg, 80%); ^{1}H NMR (500 MHz, CD_2Cl_2) δ 7.97 – 7.96 (d, *J* = 8.0 Hz, 2H), 7.68 – 7.65 (t, *J* = 7.7 Hz, 1H), 7.55 – 7.54 (d, *J* = 7.8 Hz, 1H), 7.30

– 7.28 (d, J = 7.9 Hz, 2H), 7.11 – 7.10 (d, J = 7.7 Hz, 1H), 3.16 – 3.08 (hept, J = 6.9 Hz, 1H), 2.42 (s, 3H), 1.37 – 1.36 (d, J = 7.0 Hz, 6H); ^{13}C NMR (126 MHz, CD_2Cl_2) δ 167.5, 156.6, 139.3, 137.6, 137.5, 129.8, 127.2, 119.4, 117.7, 37.0, 23.0, 21.5.; The obtained ^{1}H and ^{13}C-NMR were in agreement with the literature.[9]

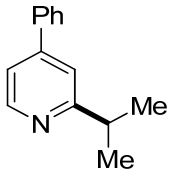


2-Isopropyl-6-(4-(trifluoromethyl)phenyl)pyridine (3f): The reaction was performed according to the general procedure for the alkylation with 2-(4-(trifluoromethyl)phenyl)pyridine-*N*-oxide (48 mg, 0.20 mmol), **2a** (120 mg, 0.40 mmol) and NaOMe (32 mg, 0.60 mmol) in anhydrous toluene (2.0 mL) at 120 °C for 3 h. The crude mixture was purified by column chromatography on silica gel (*n*-hexane:EtOAc, 50:1) to give compound **3f** as a light yellow oil (39 mg, 73%); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.17 – 8.15 (m, 2H), 7.72 – 7.68 (m, 3H), 7.58 – 7.56 (m, 1H), 7.18 – 7.17 (m, 1H), 3.19 – 3.11 (hept, J = 6.9 Hz, 1H), 1.38 – 1.36 (d, J = 6.9 Hz, 6H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 167.6, 154.9, 143.4, 137.3, 130.6 (q, $^{2}J_{C\text{-}F}$ = 32.8 Hz), 127.3, 125.7 (q, $^{3}J_{C\text{-}F}$ = 3.8 Hz), 124.4 (q, $^{1}J_{C\text{-}F}$ = 272.2 Hz), 120.1, 118.1, 36.6, 22.8; ^{19}F NMR (471 MHz, $CDCl_3$) δ -62.5; HRMS (EI) calc'd for $C_{15}H_{14}F_3N$ (M^+) 265.1078, found 265.1076.

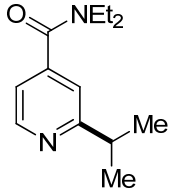


2-Isopropyl-6-(naphthalen-1-yl)pyridine (3g): The reaction was performed according to the general procedure for the alkylation with 2-(naphthalen-1-yl)pyridine-*N*-oxide (44 mg, 0.20 mmol), **2a** (120 mg, 0.40 mmol) and NaOMe (32 mg, 0.60 mmol) in anhydrous toluene (2.0 mL) at 120 °C for 3 h. The crude mixture was purified by column chromatography on silica

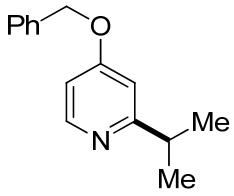
gel (*n*-hexane:EtOAc, 50:1) to give compound **3g** as a light yellow oil (39 mg, 79%); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.18 – 8.16 (m, 1H), 7.92 – 7.90 (m, 2H), 7.76 – 7.73 (t, *J* = 7.7 Hz, 1H), 7.64 – 7.62 (dd, *J* = 7.1, 1.3 Hz, 1H), 7.57 – 7.54 (m, 1H), 7.52 – 7.45 (m, 2H), 7.40 – 7.38 (dd, *J* = 7.6, 0.9 Hz, 1H), 7.24 – 7.22 (dd, *J* = 7.9, 0.9 Hz, 1H), 3.26 – 3.17 (hept, *J* = 7.0 Hz, 1H), 1.41 – 1.40 (d, *J* = 6.9 Hz, 6H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 167.3, 158.5, 139.1, 136.8, 134.2, 131.5, 128.8, 128.4, 127.6, 126.3, 126.1, 125.9, 125.5, 122.5, 118.6, 36.7, 22.9; HRMS (EI) calc'd for $C_{18}H_{17}N$ (M^+) 247.1361, found 247.1358.



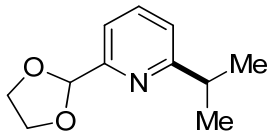
2-Isopropyl-4-phenylpyridine (3h): The reaction was performed according to the general procedure for the alkylation with 4-phenylpyridine-*N*-oxide (34 mg, 0.20 mmol), **2a** (120 mg, 0.40 mmol) and NaOMe (32 mg, 0.60 mmol) in anhydrous toluene (2.0 mL) at 120 ºC for 3 h. The crude mixture was purified by column chromatography on silica gel (*n*-hexane:EtOAc, 10:1) to give compound **3h** as a light yellow oil (19 mg, 48%); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.59 – 8.58 (d, *J* = 5.2 Hz, 1H), 7.64 – 7.62 (m, 2H), 7.49 – 7.47 (m, 6.6 Hz, 2H), 7.44 – 7.41 (m, 1H), 7.38 – 7.38 (m, 1H), 7.32 – 7.31 (dd, *J* = 5.2, 1.8 Hz, 1H), 3.18 – 3.09 (hept, *J* = 6.9 Hz, 1H), 1.37 – 1.36 (d, *J* = 6.9 Hz, 6H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 168.0, 149.6, 149.0, 138.9, 129.2, 129.0, 127.2, 119.4, 118.9, 36.6, 22.8; The obtained ^{1}H and ^{13}C-NMR were in agreement with the literature.[10]



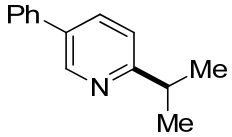
***N,N*-Diethyl-2-isopropylisonicotinamide (3i)**: The reaction was performed according to the general procedure for the alkylation with 4-(diethylcarbamoyl)pyridine-*N*-oxide (39 mg, 0.20 mmol), **2a** (120 mg, 0.40 mmol) and NaOMe (32 mg, 0.60 mmol) in anhydrous toluene (2.0 mL) at 120 °C for 3 h. The crude mixture was purified by column chromatography on silica gel (*n*-hexane:Et_2O, 3:1 to 1:2) to give compound **3i** as a light yellow oil (21 mg, 48%); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.57 – 8.56 (d, *J* = 4.9 Hz, 1H), 7.13 (s, 1H), 7.06 – 7.04 (dd, *J* = 5.0, 1.4 Hz, 1H), 3.56 – 3.51 (q, *J* = 7.1 Hz, 2H), 3.20 – 3.16 (q, *J* = 7.0 Hz, 2H), 3.12 – 3.03 (hept, *J* = 6.9 Hz, 1H), 1.31 – 1.29 (d, *J* = 6.9 Hz, 6H), 1.26 – 1.23 (t, *J* = 7.1 Hz, 3H), 1.11 – 1.09 (t, *J* = 7.1 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 169.3, 168.1, 149.5, 145.3, 118.1, 117.8, 43.3, 39.4, 36.5, 22.6, 14.4, 13.0; HRMS (EI) calc'd for $C_{13}H_{20}N_2O$ (M^+) 220.1576, found 220.1579.



4-(Benzyloxy)-2-isopropylpyridine (3j): The reaction was performed according to the general procedure for the alkylation with 4-(benzyloxy)pyridine-*N*-oxide (40 mg, 0.20 mmol), **2a** (120 mg, 0.40 mmol) and NaOMe (32 mg, 0.60 mmol) in anhydrous toluene (2.0 mL) at 120 °C for 3 h. The crude mixture was purified by column chromatography on silica gel (*n*-hexane:EtOAc, 10:1) to give compound **3j** as an orange oil (18 mg, 40%); ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.38 – 8.36 (d, *J* = 5.7 Hz, 1H), 7.44 – 7.33 (m, 5H), 6.77 – 6.77 (d, *J* = 2.4 Hz, 1H), 6.72 – 6.69 (dd, *J* = 5.7, 2.5 Hz, 1H), 5.09 (s, 2H), 3.07 – 2.94 (hept, *J* = 6.9 Hz, 1H), 1.30 – 1.27 (d, *J* = 6.9 Hz, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 169.3, 165.4, 150.5, 136.0, 128.9, 128.5, 127.7, 107.8, 107.5, 69.8, 36.5, 22.6; The obtained ^{1}H and ^{13}C-NMR were in agreement with the literature.[11]

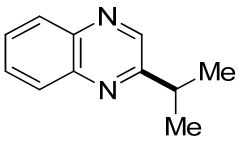


2-(1,3-Dioxolan-2-yl)-6-isopropylpyridine (3k): The reaction was performed according to the general procedure for the alkylation with 2-(1,3-dioxolan-2-yl)pyridine-*N*-oxide (33 mg, 0.20 mmol), **2a** (120 mg, 0.40 mmol) and NaOMe (32 mg, 0.60 mmol) in anhydrous toluene (2.0 mL) at 120 °C for 3 h. The crude mixture was purified by column chromatography on silica gel (*n*-hexane:EtOAc, 10:1) to give compound **3k** as a colorless oil (21 mg, 54%); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.66 – 7.63 (t, *J* = 7.7 Hz, 1H), 7.36 – 7.34 (d, *J* = 7.7 Hz, 1H), 7.17 – 7.16 (d, *J* = 7.8 Hz, 1H), 5.82 (s, 1H), 4.21 – 4.15 (m, 2H), 4.11 – 4.04 (m, 2H), 3.14 – 3.06 (hept, *J* = 7.0 Hz, 1H), 1.30 – 1.29 (d, J = 7.0 Hz, 6H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 167.3, 156.2, 137.2, 120.7, 117.7, 104.1, 65.7, 36.5, 22.8; HRMS (EI) calc'd for $C_{11}H_{15}NO_2$ (M^+) 193.1103, found 193.1100.

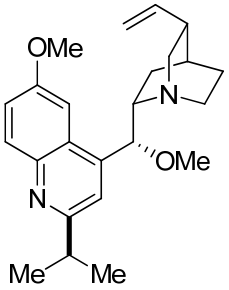


2-Isopropyl-5-phenylpyridine (3l): The reaction was performed according to the general procedure for the alkylation with 3-phenylpyridine-*N*-oxide (34 mg, 0.20 mmol), **2a** (120 mg, 0.40 mmol) and NaOMe (32 mg, 0.60 mmol) in anhydrous toluene (2.0 mL) at 120 °C for 3 h. The crude mixture was purified by column chromatography on silica gel (*n*-hexane:EtOAc, 20:1) to give compound **3l** as a light yellow oil (15 mg, 38%); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.78 – 8.77 (d, *J* = 2.6 Hz, 1H), 7.82 – 7.80 (dd, *J* = 8.1, 2.4 Hz, 1H), 7.58 – 7.56 (m, 2H), 7.48 – 7.45 (m, 2H), 7.40 – 7.36 (m, 1H), 7.26 – 7.24 (d, *J* = 8.3 Hz, 1H), 3.16 – 3.08 (hept, *J* = 6.9 Hz, 1H), 1.36 – 1.35 (d, *J* = 6.9 Hz, 6H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 166.3, 147.6, 138.2,

135.0, 134.1, 129.1, 127.9, 127.1, 120.6, 36.2, 22.8.; HRMS (EI) calc'd for $C_{14}H_{15}N$ (M^+) 197.1204, found 197.1202.

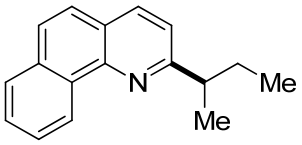


2-Isopropylquinoxaline (3m): The reaction was performed according to the general procedure for the alkylation with quinoxaline-*N*-oxide (29 mg, 0.20 mmol), **2a** (120 mg, 0.40 mmol) and NaOMe (32 mg, 0.60 mmol) in anhydrous toluene (2.0 mL) at 120 ºC for 3 h. The crude mixture was purified by column chromatography on silica gel (*n*-hexane:EtOAc, 20:1) to give compound **3m** as a light yellow oil (11 mg, 32%); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.78 (s, 1H), 8.08 – 8.04 (m, 2H), 7.75 – 7.68 (m, 2H), 3.36 – 3.28 (hept, *J* = 7.0 Hz, 1H), 1.45 – 1.44 (d, *J* = 6.9 Hz, 6H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 162.0, 144.9, 142.2, 141.5, 129.9, 129.2, 129.2, 129.0, 35.1, 22.2; The obtained ^{1}H and ^{13}C-NMR were in agreement with the literature.[12]

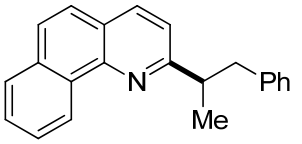


9-*O*-Methyl-2'-isopropylquinine (3n): The reaction was performed according to the general procedure for the alkylation with 9-*O*-methylquinine *N*-oxide (35 mg, 0.10 mmol), **2a** (89 mg, 0.30 mmol) and NaOMe (16 mg, 0.30 mmol) in anhydrous toluene (1.0 mL) at 120 ºC for 6 h. The crude mixture was purified by column chromatography on silica gel (EtOAc:MeOH, 100:0 to 20:1) to give compound **3n** as a light yellow oil (30 mg, 79%); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.99 – 7.97 (d, *J* = 9.2 Hz, 1H), 7.37 (s, 1H), 7.34 – 7.32 (dd, *J* = 9.2, 2.6 Hz, 1H), 7.25 – 7.24 (m, 1H), 5.74 – 5.67 (m, 1H), 5.04 (s, 1H), 4.95 – 4.91 (m, 1H), 4.89 – 4.87 (d, *J* = 10.3

Hz, 1H), 3.92 (s, 3H), 3.51 – 3.45 (m, 1H), 3.32 (s, 3H), 3.26 – 3.18 (hept, J = 6.8 Hz, 1H), 3.14 – 3.09 (m, 1H), 3.07 – 3.03 (m, 1H), 2.76 – 2.70 (m, 1H), 2.67 – 2.63 (m, 1H), 2.29 – 2.25 (m, 1H), 1.79 – 1.74 (m, 3H), 1.55 – 1.43 (m, 2H), 1.39 – 1.37 (dd, J = 7.0, 2.0 Hz, 6H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 164.9, 157.4, 144.6, 144.3, 142.0, 131.5, 126.1, 121.2, 116.5, 114.4, 101.4, 83.5, 60.1, 57.4, 57.2, 55.9, 43.5, 40.2, 37.2, 28.2, 27.8, 22.8, 22.8, 21.7; HRMS (EI) calc'd for $C_{24}H_{32}N_2O_2$ (M^+) 380.2464, found 380.2463.

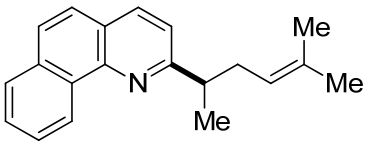


2-(*sec*-Butyl)benzo[*h*]quinoline (4a): The reaction was performed according to the general procedure for the alkylation with benzo[*h*]quinoline-*N*-oxide (39 mg, 0.20 mmol), **2b** (124 mg, 0.40 mmol) and NaOMe (32 mg, 0.60 mmol) in anhydrous toluene (2.0 mL) at 120 °C for 3 h. The crude mixture was purified by column chromatography on silica gel (*n*-hexane:EtOAc, 30:1) to give compound **4a** as a yellow oil (45 mg, 96%); ^{1}H NMR (500 MHz, $CDCl_3$) δ 9.43 – 9.41 (m, 1H), 8.08 – 8.07 (d, J = 8.1 Hz, 1H), 7.91 – 7.89 (m, 1H), 7.77 – 7.66 (m, 4H), 7.40 – 7.38 (d, J = 8.2 Hz, 1H), 3.13 – 3.06 (h, J = 6.9 Hz, 1H), 2.05 – 1.96 (m, 1H), 1.84 – 1.76 (m, 1H), 1.47 – 1.46 (d, J = 7.0 Hz, 3H), 0.96 – 0.93 (t, J = 7.4 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 165.6, 146.0, 135.9, 133.8, 131.9, 127.9, 127.7, 126.8, 126.7, 125.4, 124.8, 124.6, 120.8, 44.4, 30.3, 20.7, 12.4; HRMS (EI) calc'd for $C_{17}H_{17}N$ (M^+) 235.1361, found 235.1361.

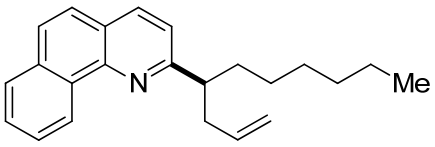


2-(1-Phenylpropan-2-yl)benzo[*h*]quinoline (4b): The reaction was performed according to the general procedure for the alkylation with benzo[*h*]quinoline-*N*-oxide (39 mg, 0.20 mmol), **2c** (150 mg, 0.40 mmol) and NaOMe (32 mg, 0.60 mmol) in anhydrous toluene (2.0 mL) at

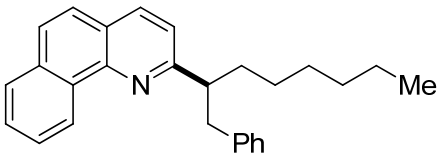
120 °C for 3 h. The crude mixture was purified by column chromatography on silica gel (*n*-hexane:benzene, 5:1) to give compound **4b** as a light yellow oil (56 mg, 94%); ^{1}H NMR (500 MHz, $CDCl_3$) δ 9.51 – 9.49 (d, *J* = 8.2 Hz, 1H), 8.02 – 8.00 (d, *J* = 8.1 Hz, 1H), 7.93 – 7.91 (m, 1H), 7.79 – 7.76 (m, 2H), 7.73 – 7.69 (m, 1H), 7.66 – 7.64 (d, *J* = 8.8 Hz, 1H), 7.28 – 7.16 (m, 6H), 3.51 – 3.46 (m, 1H), 3.45 – 3.40 (m, 1H), 3.08 – 3.04 (dd, *J* = 13.1, 7.4 Hz, 1H), 1.50 – 1.49 (d, *J* = 6.7 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 164.6, 146.0, 141.2, 135.9, 133.8, 131.8, 129.4, 128.2, 128.0, 127.8, 126.8, 126.8, 125.9, 125.4, 124.8, 124.7, 121.1, 44.6, 43.5, 20.7; HRMS (EI) calc'd for $C_{22}H_{19}N$ (M^+) 297.1517, found 297.1515.



2-(5-Methylhex-4-en-2-yl)benzo[*h*]quinoline (4c): The reaction was performed according to the general procedure for the alkylation with benzo[*h*]quinoline-*N*-oxide (39 mg, 0.20 mmol), **2d** (140 mg, 0.40 mmol) and NaOMe (32 mg, 0.60 mmol) in anhydrous toluene (2.0 mL) at 120 °C for 3 h. The crude mixture was purified by column chromatography on silica gel (*n*-hexane:benzene, 5:1) to give compound **4c** as a colorless oil (50 mg, 91%); ^{1}H NMR (500 MHz, $CDCl_3$) δ 9.46 – 9.44 (m, 1H), 8.08 – 8.06 (d, *J* = 8.1 Hz, 1H), 7.92 – 7.90 (m, 1H), 7.77 – 7.73 (m, 2H), 7.71 – 7.66 (m, 2H), 7.40 – 7.39 (d, *J* = 8.2 Hz, 1H), 5.25 – 5.21 (m, 1H), 3.25 – 3.18 (h, *J* = 7.0 Hz, 1H), 2.71 – 2.65 (m, 1H), 2.52 – 2.47 (m, 1H), 1.68 (s, 3H), 1.61 (s, 3H), 1.50 – 1.48 (d, *J* = 6.9 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 165.3, 146.0, 135.8, 133.8, 132.7, 131.9, 127.9, 127.7, 126.8, 126.7, 125.4, 124.8, 124.6, 123.1, 120.8, 43.2, 35.9, 25.9, 20.5, 18.0; HRMS (EI) calc'd for $C_{20}H_{21}N$ (M^+) 275.1674, found 275.1672.

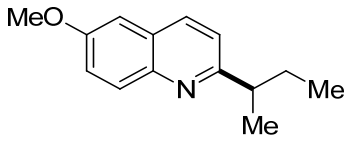


2-(Dec-1-en-4-yl)benzo[*h*]quinoline (4d): The reaction was performed according to the general procedure for the alkylation with benzo[*h*]quinoline-*N*-oxide (39 mg, 0.20 mmol), **2e** (157 mg, 0.40 mmol) and NaOMe (32 mg, 0.60 mmol) in anhydrous toluene (2.0 mL) at 120 °C for 3 h. The crude mixture was purified by column chromatography on silica gel (*n*-hexane:benzene, 20:1) to give compound **4d** as a colorless oil (45 mg, 71%); ^{1}H NMR (500 MHz, $CDCl_3$) δ 9.44 – 9.42 (d, *J* = 8.1 Hz, 1H), 8.08 – 8.06 (d, *J* = 8.2 Hz, 1H), 7.92 – 7.90 (d, *J* = 7.7 Hz, 1H), 7.77 – 7.66 (m, 4H), 7.36 – 7.34 (d, *J* = 8.1 Hz, 1H), 5.85 – 5.77 (ddt, *J* = 17.2, 10.2, 7.0 Hz, 1H), 5.05 – 5.01 (m, 1H), 4.94 – 4.92 (m, 1H), 3.15 – 3.09 (tt, 8.6, 5.7 Hz, 1H), 2.80 – 2.74 (m, 1H), 2.61 – 2.56 (m, 1H), 2.00 – 1.96 (m, 1H), 1.86 – 1.83 (m, 1H), 1.37 – 1.16 (m, 8H), 0.87 – 0.84 (t, *J* = 6.9 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 163.9, 146.1, 137.5, 135.6, 133.8, 131.9, 127.9, 127.7, 126.8, 126.7, 125.4, 124.9, 124.6, 121.8, 115.9, 48.4, 40.3, 35.5, 31.9, 29.6, 27.6, 22.8, 14.2; HRMS (EI) calc'd for $C_{23}H_{27}N$ (M^+) 317.2143, found 317.2141.

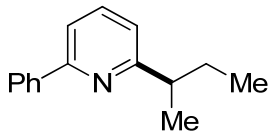


2-(1-Phenyloctan-2-yl)benzo[*h*]quinoline (4e): The reaction was performed according to the general procedure for the alkylation with benzo[*h*]quinoline-*N*-oxide (39 mg, 0.20 mmol), **2f** (180 mg, 0.40 mmol) and NaOMe (32 mg, 0.60 mmol) in anhydrous toluene (2.0 mL) at 120 °C for 3 h. The crude mixture was purified by column chromatography on silica gel (*n*-hexane:benzene, 10:1) to give compound **4e** as a colorless oil (63 mg, 86%); ^{1}H NMR (500 MHz, $CDCl_3$) δ 9.53 – 9.51 (d, *J* = 8.1 Hz, 1H), 8.00 – 7.98 (d, *J* = 8.1 Hz, 1H), 7.95 – 7.93 (d, *J* = 7.8 Hz, 1H), 7.81 – 7.77 (m, 2H), 7.75 – 7.71 (m, 1H), 7.67 – 7.66 (d, *J* = 8.8 Hz, 1H), 7.21 – 7.19 (m, 3H), 7.15 – 7.13 (m, 3H), 3.42 – 3.37 (m, 1H), 3.36 – 3.30 (m, 1H), 3.17 – 3.13 (dd,

J = 12.9, 5.9 Hz, 1H), 2.14 – 2.07 (m, 1H), 1.91 – 1.84 (m, 1H), 1.36 – 1.20 (m, 8H), 0.88 – 0.85 (t, *J* = 7.0 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 163.6, 146.2, 141.3, 135.5, 133.8, 131.9, 129.3, 128.1, 128.0, 127.7, 126.8, 126.7, 125.8, 125.5, 124.9, 124.6, 122.3, 50.6, 42.4, 35.5, 31.9, 29.6, 27.7, 22.8, 14.2; HRMS (EI) calc'd for $C_{27}H_{29}N$ (M^+) 367.2300, found 367.2300.

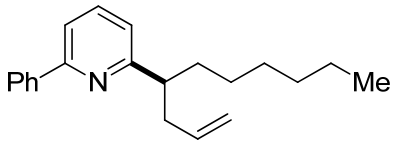


2-(*sec*-Butyl)-6-methoxyquinoline (4f): The reaction was performed according to the general procedure for the alkylation with 6-methoxyquinoline-*N*-oxide (35 mg, 0.20 mmol), **2b** (124 mg, 0.40 mmol) and NaOMe (32 mg, 0.60 mmol) in anhydrous toluene (2.0 mL) at 120 °C for 3 h. The crude mixture was purified by column chromatography on silica gel (*n*-hexane:EtOAc, 20:1) to give compound **4f** as a yellow oil (36 mg, 84%); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.97 – 7.94 (t, *J* = 8.5 Hz, 2H), 7.34 – 7.32 (dd, *J* = 9.2, 2.8 Hz, 1H), 7.25 – 7.24 (d, *J* = 8.5 Hz, 1H), 7.04 – 7.03 (d, *J* = 2.8 Hz, 1H), 3.90 (s, 3H), 3.00 – 2.93 (h, *J* = 7.1 Hz, 1H), 1.87 – 1.79 (m, 1H), 1.74 – 1.65 (m, 1H), 1.36 – 1.34 (d, *J* = 7.0 Hz, 3H), 0.90 – 0.87 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 164.6, 157.3, 144.0, 135.2, 130.6, 127.9, 121.7, 119.9, 105.3, 55.6, 44.5, 30.2, 20.6, 12.4; HRMS (EI) calc'd for $C_{14}H_{17}NO$ (M^+) 215.1310, found 215.1312.

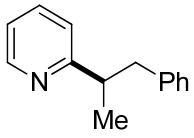


2-(*sec*-Butyl)-6-phenylpyridine (4g): The reaction was performed according to the general procedure for the alkylation with 2-phenylpyridine-*N*-oxide (34 mg, 0.20 mmol), **2b** (120 mg, 0.40 mmol) and NaOMe (32 mg, 0.60 mmol) in anhydrous toluene (2.0 mL) at 120 °C for 3 h. The crude mixture was purified by column chromatography on silica gel (*n*-hexane:benzene,

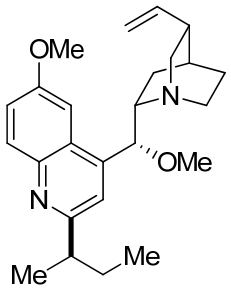
3:1) to give compound **4g** as a yellow oil (37 mg, 88%); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.08 – 8.06 (m, 2H), 7.68 – 7.64 (t, *J* = 7.7 Hz, 1H), 7.56 – 7.54 (d, *J* = 7.7 Hz, 1H), 7.50 – 7.47 (m, 2H), 7.43 – 7.39 (m, 1H), 7.09 – 7.07 (d, *J* = 7.6 Hz, 1H), 2.93 – 2.86 (h, *J* = 7.0 Hz, 1H), 1.92 – 1.84 (m, 1H), 1.74 – 1.65 (m, 1H), 1.37 – 1.35 (d, *J* = 7.0 Hz, 3H), 0.93 – 0.90 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 166.4, 156.5, 140.1, 136.8, 128.7, 127.1, 112.0, 117.7, 43.9, 30.1, 20.6, 12.3; HRMS (EI) calc'd for $C_{15}H_{17}N$ (M^+) 211.1361, found 211.1359.



2-(Dec-1-en-4-yl)-6-phenylpyridine (4h): The reaction was performed according to the general procedure for the alkylation with 2-phenylpyridine-*N*-oxide (34 mg, 0.20 mmol), **2e** (160 mg, 0.40 mmol) and NaOMe (32 mg, 0.60 mmol) in anhydrous toluene (2.0 mL) at 120 °C for 3 h. The crude mixture was purified by column chromatography on silica gel (*n*-hexane:EtOAc, 50:1) to give compound **4h** as a light yellow oil (50 mg, 85%); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.08 – 8.05 (m, 2H), 7.65 – 7.62 (t, *J* = 7.7 Hz, 1H), 7.55 – 7.54 (d, *J* = 7.8 Hz, 1H), 7.49 – 7.46 (t, *J* = 7.6 Hz, 2H), 7.42 – 7.39 (m, 1H), 7.03 – 7.01 (d, *J* = 7.6 Hz, 1H), 5.79 – 5.71 (ddt, *J* = 17.1, 10.1, 7.0 Hz, 1H), 5.01 – 4.97 (dd, *J* = 17.1, 2.0 Hz, 1H), 4.93 – 4.91 (dd, *J* = 10.2, 2.1 Hz, 1H), 2.91 – 2.85 (tt, *J* = 8.6, 5.8 Hz, 1H), 2.64 – 2.58 (m, 1H), 2.49 – 2.43 (m, 1H), 1.86 – 1.78 (m, 1H), 1.75 – 1.69 (m, 1H), 1.38 – 1.12 (m, 8H), 0.87 – 0.84 (t, *J* = 6.9 Hz, 3H). ^{13}C NMR (126 MHz, $CDCl_3$) δ 164.6, 156.6, 140.1, 137.5, 136.6, 128.8, 128.7, 127.0, 121.2, 117.8, 115.8, 47.9, 40.1, 35.1, 31.9, 29.6, 27.6, 22.8, 14.2; HRMS (EI) calc'd for $C_{21}H_{27}N$ (M^+) 293.2143, found 293.2141.

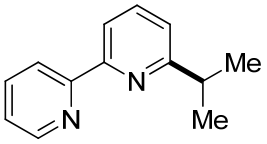


2-(1-Phenylpropan-2-yl)pyridine (4i): The reaction was performed according to the general procedure for the alkylation with pyridine-*N*-oxide (19 mg, 0.20 mmol), **2c** (150 mg, 0.40 mmol) and NaOMe (32 mg, 0.60 mmol) in anhydrous toluene (2.0 mL) at 120 °C for 3 h. The crude mixture was purified by column chromatography on silica gel (*n*-hexane:EtOAc, 20:1) to give compound **4i** as a light yellow oil (22 mg, 56%); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.59 – 8.57 (m, 1H), 7.55 – 7.52 (td, *J* = 7.7, 1.9 Hz, 1H), 7.24 – 7.20 (m, 2H), 7.17 – 7.13 (m, 1H), 7.10 – 7.08 (m, 3H), 7.03 – 7.01 (m, 1H), 3.22 – 3.15 (h, *J* = 6.9 Hz, 1H), 3.13 – 3.09 (m, 1H), 2.87 – 2.82 (dd, *J* = 13.2, 7.9 Hz, 1H), 1.30 – 1.29 (d, *J* = 6.8 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 165.7, 149.4, 140.8, 136.3, 129.3, 128.2, 126.0, 122.1, 121.3, 44.0, 43.5, 20.1; HRMS (EI) calc'd for $C_{14}H_{15}N$ (M^+) 197.1204, found 197.1202.

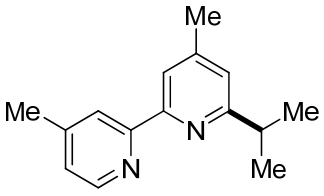


9-*O*-Methyl-2'-*sec*-butylquinine (4j): The reaction was performed according to the general procedure for the alkylation with 9-*O*-methylquinine *N*-oxide (35 mg, 0.10 mmol), **2b** (93 mg, 0.30 mmol) and NaOMe (16 mg, 0.30 mmol) in anhydrous toluene (1.0 mL) at 120 °C for 6 h. The crude mixture was purified by column chromatography on silica gel (EtOAc:MeOH, 100:0 to 20:1) to give compound **4j** as an orange oil (34 mg, 86%); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.99 – 7.97 (d, *J* = 9.2 Hz, 1H), 7.34 – 7.32 (m, 2H), 7.25 – 7.24 (m, 1H), 5.72 – 5.65 (m, 1H), 5.07 (s, 1H), 4.94 – 4.91 (d, *J* = 17.1 Hz, 1H), 4.89 – 4.87 (d, *J* = 10.3 Hz, 1H), 3.92 (s, 3H), 3.52 – 3.46 (m, 1H), 3.32 (s, 3H), 3.14 – 3.09 (m, 1H), 3.06 – 3.03 (m, 1H), 2.98 – 2.94 (m, 1H), 2.76 – 2.70 (m, 1H), 2.67 – 2.63 (m, 1H), 2.29 – 2.25 (m, 1H), 1.86 – 1.67 (m, 5H), 1.54 – 1.49 (m, 1H), 1.46 – 1.40 (m, 1H), 1.36 – 1.34 (d, *J* = 7.0 Hz, 3H), 0.88 – 0.85 (t, *J* = 7.4 Hz,

3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 164.2, 157.4, 144.3, 144.3, 141.9, 131.5, 126.0, 121.2, 116.9, 114.5, 101.3, 83.1, 60.0, 57.3, 57.1, 55.9, 44.5, 43.5, 40.2, 30.2, 28.1, 27.7, 21.6, 20.5, 12.3; HRMS (EI) calc'd for $C_{24}H_{32}N_2O_2$ (M^+) 394.2620, found 394.2617.

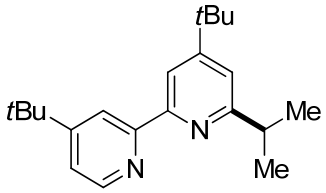


6-Isopropyl-2,2'-bipyridine (6a): The reaction was performed according to the general procedure for the alkylation with 2,2'-bipyridine-*N*-oxide (34 mg, 0.20 mmol), **2a** (120 mg, 0.40 mmol) and NaOMe (32 mg, 0.60 mmol) in anhydrous toluene (2.0 mL) at 120 °C for 3 h. The crude mixture was purified by column chromatography on silica gel (*n*-hexane:EtOAc, 60:1 to 30:1) to give compound **6a** as a light yellow oil (25 mg, 63%); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.66 – 8.65 (d, *J* = 4.5 Hz, 1H), 8.51 – 8.49 (d, *J* = 8.0 Hz, 1H), 8.21 – 8.19 (d, *J* = 7.8 Hz, 1H), 7.80 – 7.77 (td, *J* = 7.7, 1.6 Hz, 1H), 7.73 – 7.70 (t, *J* = 7.7 Hz, 1H), 7.27 – 7.25 (m, 1H), 7.18 – 7.16 (d, *J* = 7.7 Hz, 1H), 3.18 – 3.09 (hept, *J* = 6.8 Hz, 1H), 1.37 – 1.36 (d, *J* = 6.9 Hz, 6H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 166.7, 156.9, 155.2, 149.1, 137.2, 136.9, 123.5, 121.3, 120.8, 118.3, 36.5, 22.8; The obtained ^{1}H and ^{13}C-NMR were in agreement with the literature.[11]

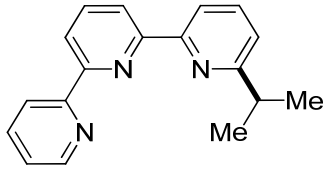


6-Isopropyl-4,4'-dimethyl-2,2'-bipyridine (6b): The reaction was performed according to the general procedure for the alkylation with 4,4'-dimethyl-2,2'-bipyridine-*N*-oxide (40 mg, 0.20 mmol), **2a** (120 mg, 0.40 mmol) and NaOMe (32 mg, 0.60 mmol) in anhydrous toluene (2.0 mL) at 120 °C for 3 h. The crude mixture was purified by column chromatography on silica

gel (*n*-hexane:EtOAc, 10:1) to give compound **6b** as a white solid (30 mg, 66%); ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.52 – 8.50 (d, *J* = 4.9 Hz, 1H), 8.29 – 8.28 (m, 1H), 8.01 – 8.00 (m, 1H), 7.10 – 7.08 (m, 1H), 7.01 – 7.00 (m, 1H), 3.17 – 3.03 (hept, *J* = 6.9 Hz, 1H), 2.43 (s, 3H), 2.39 (s, 3H), 1.36 – 1.34 (d, *J* = 6.9 Hz, 6H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 166.7, 156.8, 155.2, 148.9, 148.2, 148.0, 124.5, 122.2, 121.5, 119.4, 36.4, 22.9, 21.3; HRMS (EI) calc'd for $C_{15}H_{18}N_2$ (M^+) 226.1470, found 226.1472.

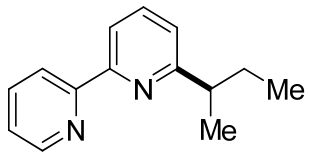


4,4'-Di-*tert*-butyl-6-isopropyl-2,2'-bipyridine (6c): The reaction was performed according to the general procedure for the alkylation with 4,4'-di-*tert*-butyl-2,2'-bipyridine-*N*-oxide (57 mg, 0.20 mmol), **2a** (120 mg, 0.40 mmol) and NaOMe (32 mg, 0.60 mmol) in anhydrous toluene (2.0 mL) at 120 °C for 3 h. The crude mixture was purified by column chromatography on silica gel (*n*-hexane:EtOAc, 30:1) to give compound **6c** as a white solid (45 mg, 72%); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.59 – 8.58 (d, *J* = 5.2 Hz, 1H), 8.52 – 8.52 (d, *J* = 1.9 Hz, 1H), 8.21 – 8.20 (d, *J* = 1.8 Hz, 1H), 7.28 – 7.26 (dd, *J* = 5.3, 2.0 Hz, 1H), 7.17 – 7.17 (d, *J* = 1.8 Hz, 1H), 3.18 – 3.10 (hept, *J* = 6.9 Hz, 1H), 1.39 – 1.38 (m, 24H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 166.5, 161.2, 160.7, 157.3, 155.6, 149.0, 120.6, 118.6, 117.7, 115.6, 36.6, 35.1, 35.0, 30.9, 30.7, 22.9; The obtained ^{1}H and ^{13}C-NMR were in agreement with the literature.[8]

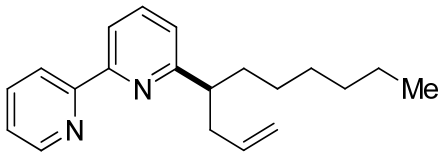


6-Isopropyl-2,2':6',2''-terpyridine (6d): The reaction was performed according to the general procedure for the alkylation with 2,2':6',2''-terpyridine-*N*-oxide (50 mg, 0.20 mmol), **2a** (120

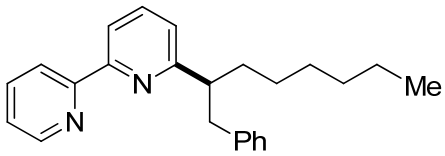
mg, 0.40 mmol) and NaOMe (32 mg, 0.60 mmol) in anhydrous toluene (2.0 mL) at 120 ºC for 3 h. The crude mixture was purified by column chromatography on silica gel (*n*-hexane:benzene:Et_2O, 10:3:1) to give compound **6d** as light yellow solid (39 mg, 71%); 1H NMR (500 MHz, $CDCl_3$) δ 8.71 – 8.69 (ddd, *J* = 4.8, 1.8, 0.9 Hz, 1H), 8.64 – 8.62 (dt, *J* = 7.9, 1.2 Hz, 1H), 8.56 – 8.55 (dd, *J* = 7.8, 1.0 Hz, 1H), 8.44 – 8.41 (ddd, *J* = 7.8, 5.1, 1.0 Hz, 2H), 7.96 – 7.93 (t, *J* = 7.8 Hz, 1H), 7.86 – 7.83 (td, *J* = 7.7, 1.8 Hz, 1H), 7.77 – 7.74 (t, *J* = 7.8 Hz, 1H), 7.33 – 7.30 (ddd, *J* = 7.5, 4.8, 1.2 Hz, 1H), 7.21 – 7.19 (d, *J* = 7.6 Hz, 1H), 3.20 – 3.20 – 3.11 (hept, *J* = 7.0 Hz, 1H), 1.39 – 1.38 (d, *J* = 6.9 Hz, 6H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 166.7, 156.6, 156.1, 155.3, 155.3, 149.2, 137.9, 137.2, 137.0, 123.8, 121.3, 121.3, 120.9, 120.8, 118.4, 36.5, 22.8.; HRMS (EI) calc'd for $C_{18}H_{17}N_3$ (M^+) 275.1422, found 275.1425.



6-(*sec*-Butyl)-2,2'-bipyridine (6e): The reaction was performed according to the general procedure for the alkylation with 2,2'-bipyridine-*N*-oxide (34 mg, 0.20 mmol), **2b** (124 mg, 0.40 mmol) and NaOMe (32 mg, 0.60 mmol) in anhydrous toluene (2.0 mL) at 120 ºC for 3 h. The crude mixture was purified by column chromatography on silica gel (*n*-hexane:Et_2O, 20:1) to give compound **6e** as a light red oil (31 mg, 73%); ^1H NMR (500 MHz, $CDCl_3$) δ 8.67 – 8.65 (m, 1H), 8.50 – 8.48 (dt, *J* = 7.8, 1.1 Hz, 1H), 8.20 – 8.18 (dd, *J* = 7.7, 1.0 Hz, 1H), 7.82 – 7.79 (td, *J* = 7.7, 1.8 Hz, 1H), 7.73 – 7.70 (t, *J* = 7.7 Hz, 1H), 7.29 – 7.27 (ddd, *J* = 7.5, 4.8, 1.2 Hz, 1H), 7.15 – 7.13 (dd, *J* = 7.7, 1.0 Hz, 1H), 2.90 – 2.83 (h, *J* = 6.9 Hz, 1H), 1.89 – 1.81 (m, 1H), 1.72 – 1.63 (m, 1H), 1.35 – 1.33 (d, *J* = 7.0 Hz, 3H), 0.90 – 0.87 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 166.0, 157.0, 155.4, 149.1, 137.1, 136.9, 123.6, 121.8, 121.4, 118.3, 43.8, 30.1, 20.6, 12.3; HRMS (EI) calc'd for $C_{14}H_{16}N_2$ (M^+) 212.1313, found 212.1310.

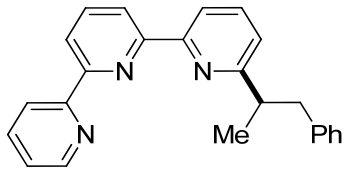


6-(Dec-1-en-4-yl)-2,2'-bipyridine (6f): The reaction was performed according to the general procedure for the alkylation with 2,2'-bipyridine-*N*-oxide (34 mg, 0.20 mmol), **2e** (157 mg, 0.40 mmol) and NaOMe (32 mg, 0.60 mmol) in anhydrous toluene (2.0 mL) at 120 °C for 3 h. The crude mixture was purified by column chromatography on silica gel (*n*-hexane:EtOAc, 30:1) to give compound **6f** as a light yellow oil (46 mg, 78%); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.67 – 8.65 (m, 1H), 8.50 – 8.49 (d, *J* = 7.9 Hz, 1H), 8.21 – 8.20 (d, *J* = 7.8 Hz, 1H), 7.82 – 7.78 (td, *J* = 7.7, 1.8 Hz, 1H), 7.71 – 7.68 (t, *J* = 7.7 Hz, 1H), 7.29 – 7.26 (ddd, *J* = 7.6, 4.9, 1.1 Hz, 1H), 7.09 – 7.08 (d, *J* = 7.6 Hz, 1H), 5.77 – 5.69 (ddt, *J* = 17.1, 10.1, 7.0 Hz, 1H), 4.99 – 4.95 (m, 1H), 4.92 – 4.89 (m, 1H), 2.90 – 2.84 (tt, 8.7, 5.7 Hz, 1H), 2.63 – 2.56 (m, 1H), 2.48 – 2.43 (m, 1H), 1.85 – 1.78 (m, 1H), 1.75 – 1.68 (m, 1H), 1.30 – 1.18 (m, 8H), 0.85 – 0.82 (t, *J* = 6.9 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 164.1, 157.0, 155.5, 149.1, 137.4, 136.9, 136.8, 123.5, 123.0, 121.4, 118.3, 115.8, 47.7, 40.1, 35.1, 31.9, 29.5, 27.5, 22.8, 14.2; HRMS (EI) calc'd for $C_{20}H_{26}N_2$ (M^+) 294.2096, found 294.2093.

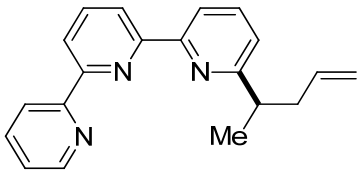


6-(1-Phenyloctan-2-yl)-2,2'-bipyridine (6g): The reaction was performed according to the general procedure for the alkylation with 2,2'-bipyridine-*N*-oxide (34 mg, 0.20 mmol), **2f** (180 mg, 0.40 mmol) and NaOMe (32 mg, 0.60 mmol) in anhydrous toluene (2.0 mL) at 120 °C for 3 h. The crude mixture was purified by column chromatography on silica gel (*n*-hexane:benzene:EtOAc, 60:20:3) to give compound **6g** as a light yellow oil (63 mg, 91%); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.69 – 8.68 (m, 1H), 8.55 – 8.53 (d, *J* = 8.0 Hz, 1H), 8.22 – 8.20

(d, *J* = 7.7 Hz, 1H), 7.85 – 7.81 (td, *J* = 7.7, 1.8 Hz, 1H), 7.63 – 7.60 (t, *J* = 7.7 Hz, 1H), 7.31 – 7.29 (m, 1H), 7.20 – 7.17 (m, 2H), 7.14 – 7.10 (m, 1H), 7.06 – 7.04 (m, 2H), 6.93 – 6.91 (d, *J* = 7.5 Hz, 1H), 3.20 – 3.16 (dd, *J* = 12.9, 8.0 Hz, 1H), 3.11 – 3.05 (m, 1H), 3.03 – 2.99 (dd, *J* = 12.9, 6.1 Hz, 1H), 1.97 – 1.90 (m, 1H), 1.78 – 1.71 (m, 1H), 1.31 – 1.16 (m, 8H), 0.86 – 0.83 (t, *J* = 7.0 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 163.6, 157.0, 155.5, 149.1, 141.1, 136.9, 136.7, 129.3, 128.1, 125.7, 123.6, 123.5, 121.4, 118.3, 50.0, 42.3, 35.1, 31.9, 29.5, 27.6, 22.7, 14.2; HRMS (EI) calc'd for $C_{24}H_{28}N_2$ (M^+) 344.2252, found 344.2253.



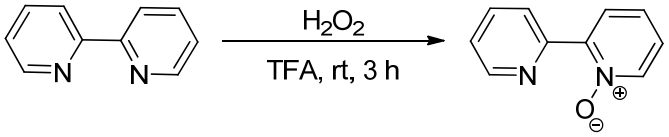
6-(1-Phenylpropan-2-yl)-2,2':6',2''-terpyridine (6h): The reaction was performed according to the general procedure for the alkylation with 2,2':6',2''-terpyridine-*N*-oxide (50 mg, 0.20 mmol), **2c** (150 mg, 0.40 mmol) and NaOMe (32 mg, 0.60 mmol) in anhydrous toluene (2.0 mL) at 120 °C for 3 h. The crude mixture was purified by column chromatography on silica gel (*n*-hexane:Et_2O, 10:1) to give compound **6h** as a light yellow oil (57 mg, 81%); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.72 (d, *J* = 4.6 Hz, 1H), 8.65 (d, *J* = 7.9 Hz, 1H), 8.59 (d, *J* = 7.7 Hz, 1H), 8.45 (dd, *J* = 13.0, 7.8 Hz, 2H), 7.98 (t, *J* = 7.8 Hz, 1H), 7.86 (td, *J* = 7.7, 1.8 Hz, 1H), 7.70 (t, *J* = 7.7 Hz, 1H), 7.36 – 7.31 (m, 1H), 7.24 (m, 2H), 7.19 – 7.12 (m, 3H), 7.05 (d, *J* = 7.6 Hz, 1H), 3.28 (m, 2H), 2.94 (m, 1H), 1.39 (d, J = 6.4 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 164.8, 156.5, 156.0, 155.5, 155.3, 149.2, 141.1, 137.9, 137.0(137.01), 137.0(136.95), 129.3, 128.4, 128.2, 125.9, 123.8, 122.2, 121.3, 120.9, 118.5, 44.0, 43.5, 20.4.; HRMS (EI) calc'd for $C_{24}H_{21}N_3$ (M^+) 351.1735, found 351.1733.



6-(Pent-4-en-2-yl)-2,2':6',2''-terpyridine (6i): The reaction was performed according to the general procedure for the alkylation with 2,2':6',2''-terpyridine-*N*-oxide (50 mg, 0.20 mmol), **2g** (130 mg, 0.40 mmol) and NaOMe (32 mg, 0.60 mmol) in anhydrous toluene (2.0 mL) at 120 ºC for 3 h. The crude mixture was purified by column chromatography on silica gel (*n*-hexane:Et_2O, 10:1) to give compound **6i** as a light yellow oil (46 mg, 76%); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.71 – 8.69 (m, 1H), 8.64 – 8.62 (m, 1H), 8.55 – 8.54 (dd, *J* = 7.8, 1.0 Hz, 1H), 8.44 – 8.43 (dd, *J* = 3.3, 1.0 Hz, 1H), 8.43 – 8.42 (dd, *J* = 3.3, 1.0 Hz, 1H), 7.96 – 7.93 (t, *J* = 7.8 Hz, 1H), 7.87 – 7.84 (td, *J* = 7.7, 1.8 Hz, 1H), 7.77 – 7.74 (t, *J* = 7.7 Hz, 1H), 7.34 – 7.30 (ddd, *J* = 7.5, 4.7, 1.2 Hz, 1H), 7.17 – 7.15 (d, *J* = 7.7, 1H), 5.84 – 5.76 (m, 1H), 5.06 – 5.01 (m, 1H), 4.98 – 4.96 (m, 1H), 3.10 – 3.03 (h, *J* = 7.0 Hz, 1H), 2.69 – 2.63 (m, 1H), 2.45 – 2.39 (m, 1H), 1.38 – 1.37 (d, *J* = 7.0 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 165.1, 156.5, 156.1, 155.5, 155.3, 149.2, 137.9, 137.3, 137.1, 137.0, 123.8, 121.9, 121.3, 120.8, 118.5, 116.1, 41.9, 41.4, 20.5; HRMS (EI) calc'd for $C_{15}H_{18}N_2$ (M^+) 301.1579, found 301.1576.

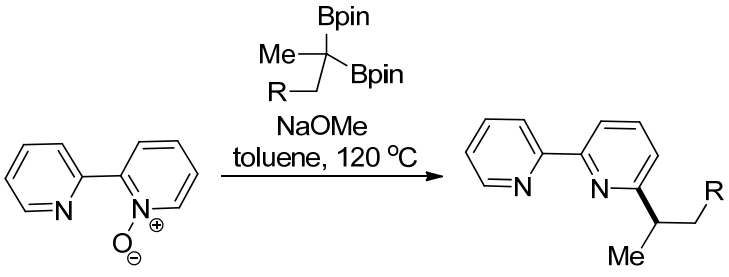
5. General procedure for synthetic applications

5.1 Scale-up reaction



5a

2,2'-bipyridine-*N*-oxide (5a): The reaction was performed according to the literature procedure.[13] To a 100 mL round bottom flask containing a stir bar were added 2,2'-bipyridine (1.6 g, 10 mmol) and trifluoroacetic acid (8 mL) under air. The solution was cooled to 10 °C, and then 1.6 mL of 30% hydrogen peroxide solution (12 mmol) was added. The reaction mixture was stirred for 3 h at room temperature. The organic phase was diluted with chloroform (30 mL) and washed with 3 M NaOH (15 mL x 2). The aqueous phase was extracted twice with chloroform (20 mL x 3), and the combined organic layers were dried over $MgSO_4$, filtered and concentrated under reduced pressure. The product **5a** was obtained as a white solid (1.6 g, 95%). ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.94 – 8.90 (dt, *J* = 8.1, 1.1 Hz, 1H), 8.75 – 8.72 (ddd, *J* = 4.9, 1.8, 0.9 Hz, 1H), 8.34 – 8.32 (dd, *J* = 6.4, 1.3 Hz, 1H), 8.20 – 8.16 (dd, *J* = 8.0, 2.3 Hz, 1H), 7.86 – 7.80 (td, *J* = 7.8, 1.9 Hz, 1H), 7.39 – 7.33 (m, 2H), 7.30 – 7.25 (m, 1H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 149.3, 149.1, 146.9, 140.3, 135.9, 127.5, 125.4, 125.1, 125.0, 124.0.

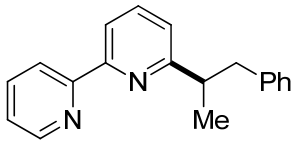


5a (5 mmol)

R = Me, **6e**, 71%
R = Ph, **6j**, 92%

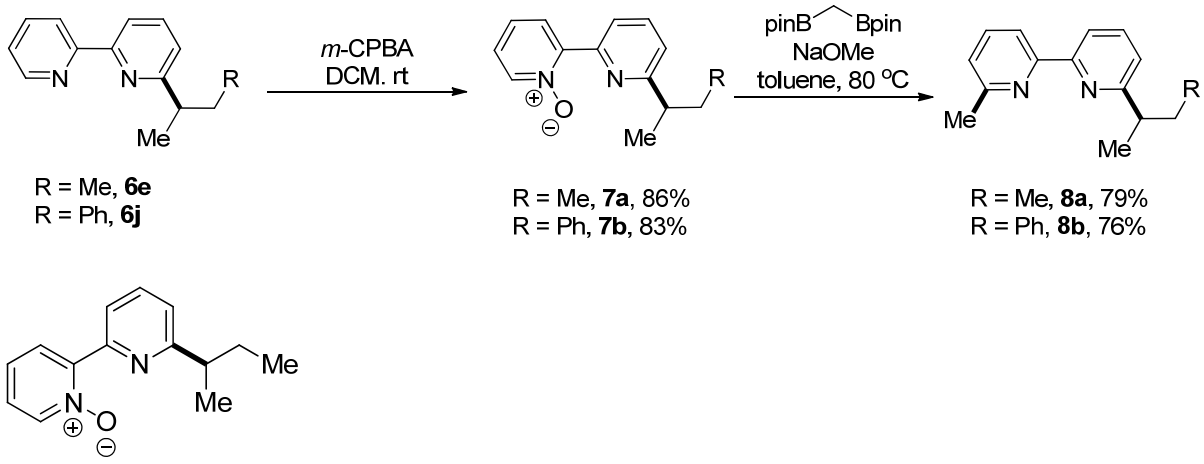
To a 100 mL round bottom flask equipped with a magnetic stirbar, 2,2'-bipyridine-*N*-oxide (**5a**, 860 mg, 5.0 mmol), **2b** (3.1 g, 10 mmol) or **2c** (3.7 g, 10 mmol), NaOMe (810 mg, 15 mmol)

and toluene (50 mL) were added under N_2. The reaction mixture was stirred for 3 h at 120 ºC. The reaction was quenched with a brine (20 mL) and the aqueous layer was extracted with EtOAc (30 mL x 3). The combined organic layers were dried over $MgSO_4$, filtered and concentrated under reduced pressure. To remove unreacted **2b** or **2c**, $NaBO_3 \cdot 4H_2O$ (1.2 g, 12 mmol) and THF/H_2O (20 mL, 1:1) were added to the above obtained crude mixture in a 100 mL round bottom flask. The solution was stirred for 3 h at room temperature. The reaction mixture was quenched with brine (15 mL) and extracted with EtOAc (20 mL x 3). The combined organic layers were dried over $MgSO_4$, filtered and concentrated under reduced pressure. The crude reaction mixture was purified by silica gel column chromatography (*n*-hexane:EtOAc, 20:1) to give compound **6e** (754 mg, 71%) or **6j** (1.26 g, 92%).

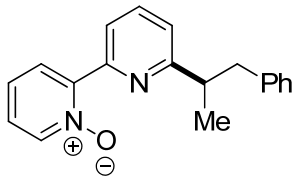


6-(1-Phenylpropan-2-yl)-2,2'-bipyridine (6j): a light yellow oil. ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.70 – 8.69 (d, *J* = 4.8 Hz, 1H), 8.55 – 8.54 (d, *J* = 8.0 Hz, 1H), 8.24 – 8.23 (d, *J* = 7.8 Hz, 1H), 7.85 – 7.81 (m, 1H), 7.69 – 7.65 (t, *J* = 7.8 Hz, 1H), 7.31 – 7.29 (m, 1H), 7.25 – 7.22 (m, 2H), 7.18 – 7.12 (m, 3H), 7.05 – 7.03 (d, *J* = 7.6 Hz, 1H), 3.31 – 3.22 (m, 2H), 2.96 – 2.90 (m, 1H), 1.39 – 1.37 (d, *J* = 6.5 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 164.8, 156.8, 155.4, 149.1, 141.0, 137.1, 136.9, 129.3, 128.2, 125.9, 123.6, 122.1, 121.3, 118.4, 43.9, 43.5, 20.4; HRMS (EI) calc'd for $C_{19}H_{18}N_2$ (M^+) 274.1470, found 274.1468.

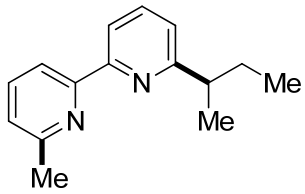
5.2. Sequential functionalization of 2,2'-bipyridine *N*-oxide



6'-(*sec*-Butyl)-2,2'-bipyridine-*N*-oxide (7a): To a 20 mL vial equipped with a magnetic stirbar, the above obtained product **6e** (754 mg, 3.55 mmol), *m*-chloroperbenzoic acid (70 wt%, 1.06 g, 4.3 mmol) and CH_2Cl_2 (15 mL) were added under N_2. The vial was sealed with a PTFE/silicone-lined septum cap and the mixture was stirred for 12 h at room temperature and then the organic phase was washed with a saturated aqueous $NaHCO_3$ solution (10 mL) and brine (10 mL). The aqueous layer was extracted with chloroform (20 mL x 5). The combined organic layers were dried over $MgSO_4$, filtered and concentrated under reduced pressure. The crude mixture was purified by column chromatography on silica gel (EtOAc:MeOH, 10:1) to give the product **7a** as a yellow liquid (697 mg, 86%); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.77 – 8.76 (m, 1H), 8.32 – 8.30 (m, 1H), 8.27 – 8.25 (dd, *J* = 8.1, 2.1 Hz, 1H), 7.75 – 7.72 (t, *J* = 7.8 Hz, 1H), 7.38 – 7.34 (m, 1H), 7.26 – 7.22 (ddd, *J* = 7.4, 6.5, 2.2 Hz, 1H), 7.19 – 7.17 (m, 1H), 2.89 – 2.82 (h, *J* = 6.9 Hz, 1H), 1.85 – 1.76 (m, 1H), 1.69 – 1.61 (m, 1H), 1.32 – 1.30 (d, *J* = 6.9 Hz, 3H), 0.88 – 0.85 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 166.2, 148.6, 148.0, 140.8, 136.6, 128.2, 125.8, 125.0, 122.9, 122.5, 43.8, 30.1, 20.6, 12.3; HRMS (EI) calc'd for $C_{14}H_{16}N_2O$ (M^+) 228.1263, found 228.1261.

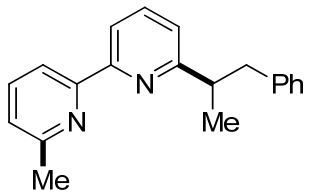


6'-(1-Phenylpropan-2-yl)-2,2'-bipyridine-*N*-oxide (7b)*:* To a 50 mL round bottomed flask equipped with a magnetic stirbar, the above obtained product **6j** (1.26 g, 4.6 mmol), *m*-chloroperbenzoic acid (70 wt%, 1.36 g, 5.5 mmol) and CH_2Cl_2 (15 mL) were added under N_2. The mixture was stirred for 12 h at room temperature and then the organic phase was washed with a saturated aqueous $NaHCO_3$ solution (10 mL) and brine (10 mL). The aqueous layer was extracted with chloroform (20 mL x 5). The combined organic layers were dried over $MgSO_4$, filtered and concentrated under reduced pressure. The crude mixture was purified by column chromatography on silica gel (EtOAc:MeOH, 10:1) to give the product **7b** as a colorless solid (1.11 g, 83%); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.79 – 8.77 (m, 1H), 8.30 – 8.29 (m, 1H), 8.22 – 8.20 (dd, *J* = 8.1, 2.2 Hz, 1H), 7.69 – 7.65 (t, *J* = 7.8 Hz, 1H), 7.36 – 7.32 (td, *J* = 7.8, 1.3 Hz, 1H), 7.24 – 7.20 (m, 3H), 7.16 – 7.13 (m, 1H), 7.09 – 7.07 (d, *J* = 7.8 Hz, 3H), 3.29 – 3.22 (h, *J* = 7.0 Hz, 1H), 3.15 – 3.11 (dd, *J* = 13.4, 7.2 Hz, 1H), 2.91 – 2.87 (dd, *J* = 13.4, 7.6 Hz, 1H), 1.34 – 1.32 (d, *J* = 6.9 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 165.0, 148.6, 147.7, 140.7, 140.7, 136.5, 129.2, 128.2, 128.1, 125.9, 125.7, 125.0, 123.0, 122.7, 43.9, 43.4, 20.3; HRMS (EI) calc'd for $C_{19}H_{18}N_2O$ (M^+) 290.1419, found 290.1421.



6-(*sec*-Butyl)-6'-methyl-2,2'-bipyridine (8a): To a 50 mL round bottomed flask equipped with a magnetic stirbar, the above obtained product **7a** (697 mg, 3.05 mmol), bis[(pinacolato)boryl]methane **B1** (1.60 g, 6.0 mmol), NaOMe (478 mg, 8.85 mmol) and

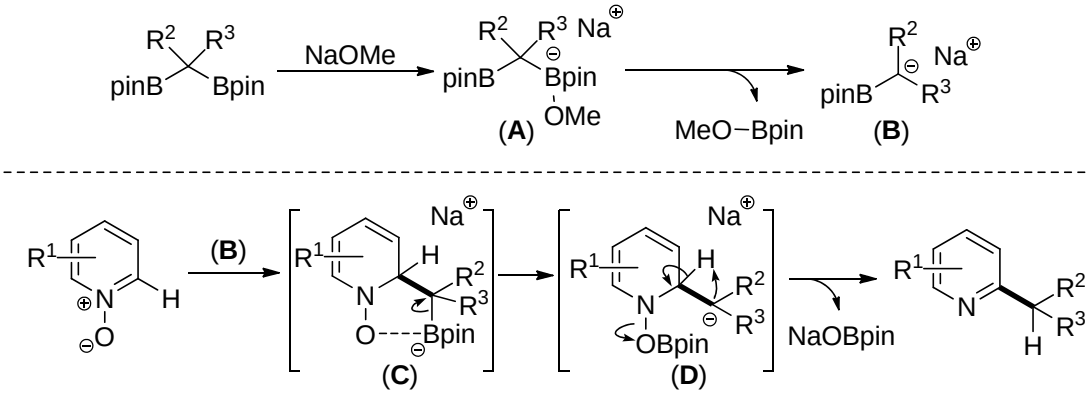
anhydrous toluene (30 mL) were added under N_2. The reaction mixture was stirred at 80 °C for 3 h. To remove unreacted bis[(pinacolato)boryl]methane, $NaBO_3 \cdot 4H_2O$ (1.38 g, 9.00 mmol) and THF/H_2O (25 mL, 1:1) were added and stirred for 3 h at room temperature. The reaction mixture was quenched with brine (15 mL) and extracted with EtOAc (25 mL x 3). The combined organic layers were dried over $MgSO_4$, filtered and concentrated under reduced pressure. The crude mixture was purified by column chromatography on silica gel (*n*-hexane:EtOAc, 20:1) to give the product **8a** as a light yellow oil (545 mg, 79%); ^{1}H NMR (300 MHz, $CDCl_3$) δ 8.27 – 8.25 (d, *J* = 7.8 Hz, 1H), 8.22 – 8.19 (dd, *J* = 7.8, 0.9 Hz, 1H), 7.72 – 7.65 (td, *J* = 7.7, 5.4 Hz, 2H), 7.15 – 7.10 (td, *J* = 7.3, 1.0 Hz, 2H), 2.92 – 2.80 (h, *J* = 6.9 Hz, 1H), 2.62 (s, 3H), 1.92 – 1.77 (m, 1H), 1.73 – 1.59 (m, 1H), 1.34 – 1.32 (d, *J* = 6.9 Hz, 3H), 0.90 – 0.85 (t, *J* = 7.4 Hz, 3H); ^{13}C NMR (75 MHz, $CDCl_3$) δ 165.9, 157.8, 156.4, 155.7, 137.1, 137.0, 123.0, 121.5, 118.4(118.37), 118.4(118.35), 43.8, 30.1, 24.8, 20.6, 12.3; HRMS (EI) calc'd for $C_{15}H_{18}N_2$ (M^+) 226.1470, found 226.1473.



6-Methyl-6'-(1-phenylpropan-2-yl)-2,2'-bipyridine (8b): To a 100 mL round bottomed flask equipped with a magnetic stirbar, the above obtained product **7b** (1.11 g, 3.8 mmol), bis[(pinacolato)boryl]methane **B1** (2.05 g, 7.65 mmol), NaOMe (620 mg, 11.5 mmol) and anhydrous toluene (38 mL) were added under N_2. The reaction mixture was stirred at 80 °C for 3 h. To remove unreacted bis[(pinacolato)boryl]methane, $NaBO_3 \cdot 4H_2O$ (1.77 g, 11.5 mmol) and THF/H_2O (25 mL, 1:1) were added and stirred for 3 h at room temperature. The reaction mixture was quenched with brine (15 mL) and extracted with EtOAc (25 mL x 3). The combined organic layers were dried over $MgSO_4$, filtered and concentrated under reduced

pressure. The crude mixture was purified by column chromatography on silica gel (*n*-hexane:EtOAc, 50:1 to 20:1) to give the product **8b** as a light yellow oil (833 mg, 76%); ^{1}H NMR (500 MHz, $CDCl_3$) δ 8.33 – 8.31 (d, *J* = 7.8 Hz, 1H), 8.25 – 8.23 (d, *J* = 7.8 Hz, 1H), 7.73 – 7.70 (t, *J* = 7.7 Hz, 1H), 7.67 – 7.64 (t, *J* = 7.7 Hz, 1H), 7.24 – 7.21 (m, 2H), 7.17 – 7.14 (m, 2H), 7.12 – 7.11 (d, *J* = 7.2 Hz, 2H), 7.02 – 7.00 (d, *J* = 7.6 Hz, 1H), 3.29 – 3.21 (m, 2H), 2.95 – 2.89 (m, 1H), 2.65 (s, 3H), 1.37 – 1.36 (d, *J* = 6.7 Hz, 3H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 164.8, 157.8, 156.3, 155.7, 141.1, 137.1, 137.0, 129.3, 128.2, 125.9, 123.1, 121.9, 118.5, 118.3, 44.0, 43.5, 24.8, 20.4.; HRMS (EI) calc'd for $C_{20}H_{20}N_2$ (M^+) 288.1626, found 288.1623.

6. Proposed Reaction Mechanism



Although more detailed mechanistic studies are still required, we proposed that α-borylcarbanion, generated *in-situ* by the reaction between *gem*-bis[(pinacolato)boryl]alkane and alkoxide base, could attack the electrophilic C2 position of N-heteroaromatic *N*-oxide and subsequent Bpin migration from benzylic position to oxygen atom was expected to generate benzylic anion. Finally, a proton migration of C2-H to the benzylic position, followed by releasing NaOBpin would generate the desired alkylated products.

7. References

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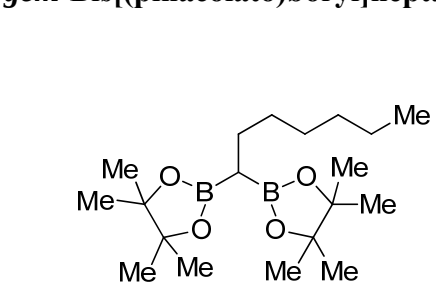
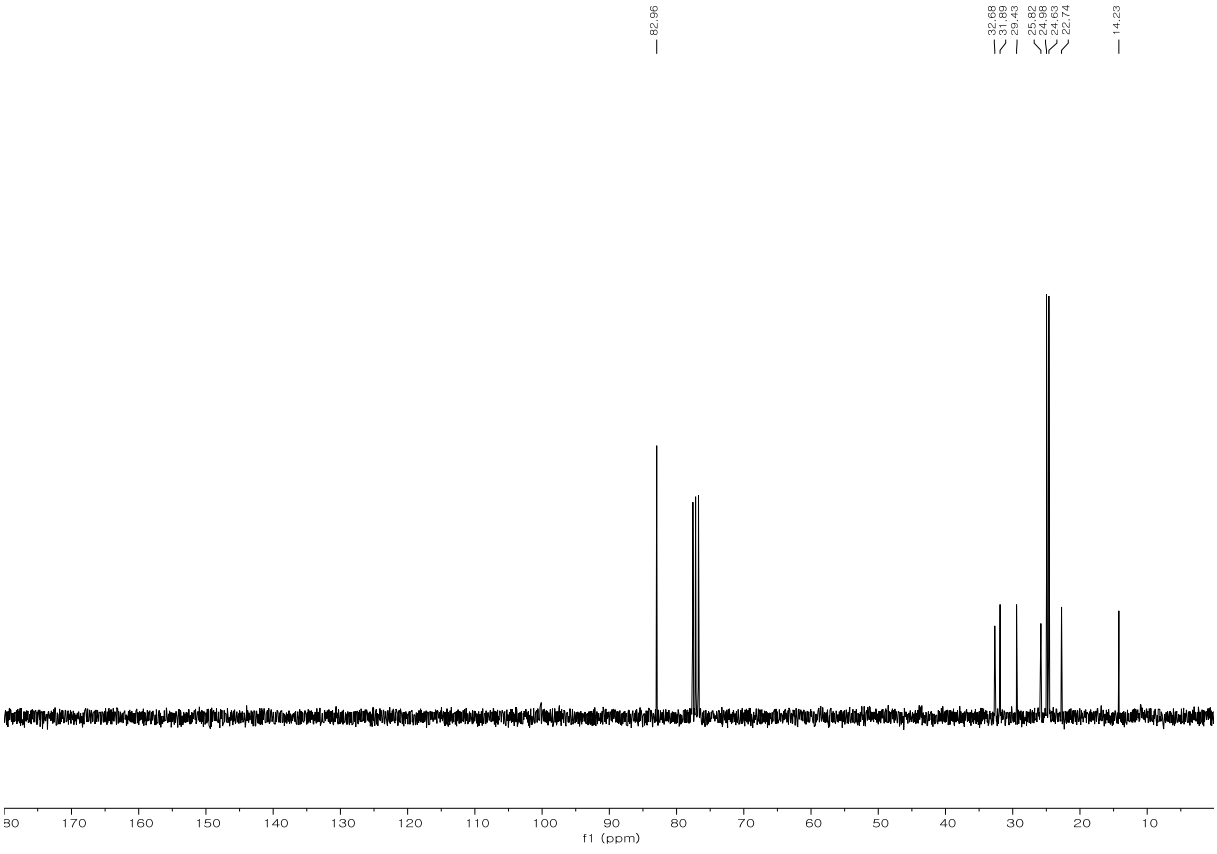
Appendix Ⅰ

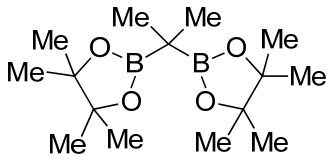
Spectral Copies of ^{1}H and ^{13}C NMR Data Obtained in this Study

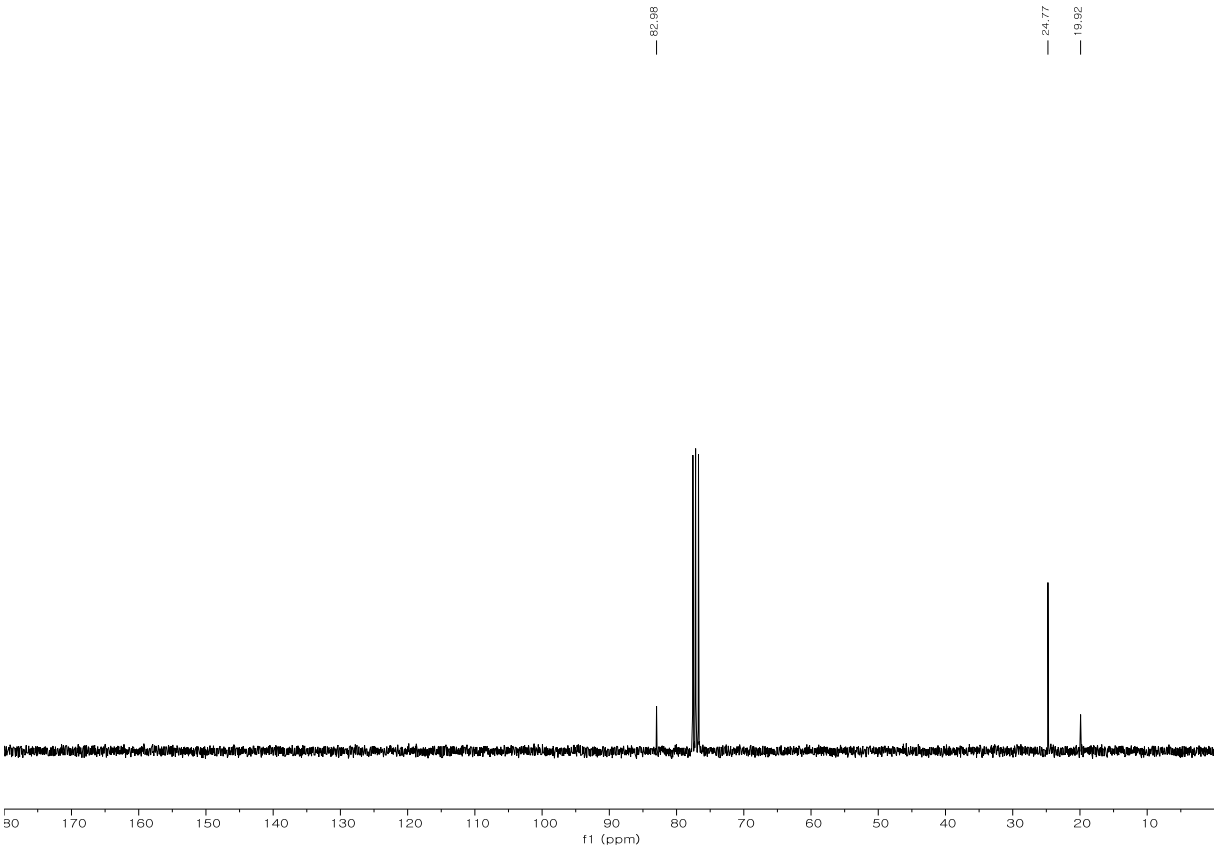
gem-Bis[(pinacolato)boryl]heptane (B3)



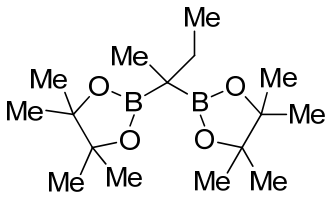


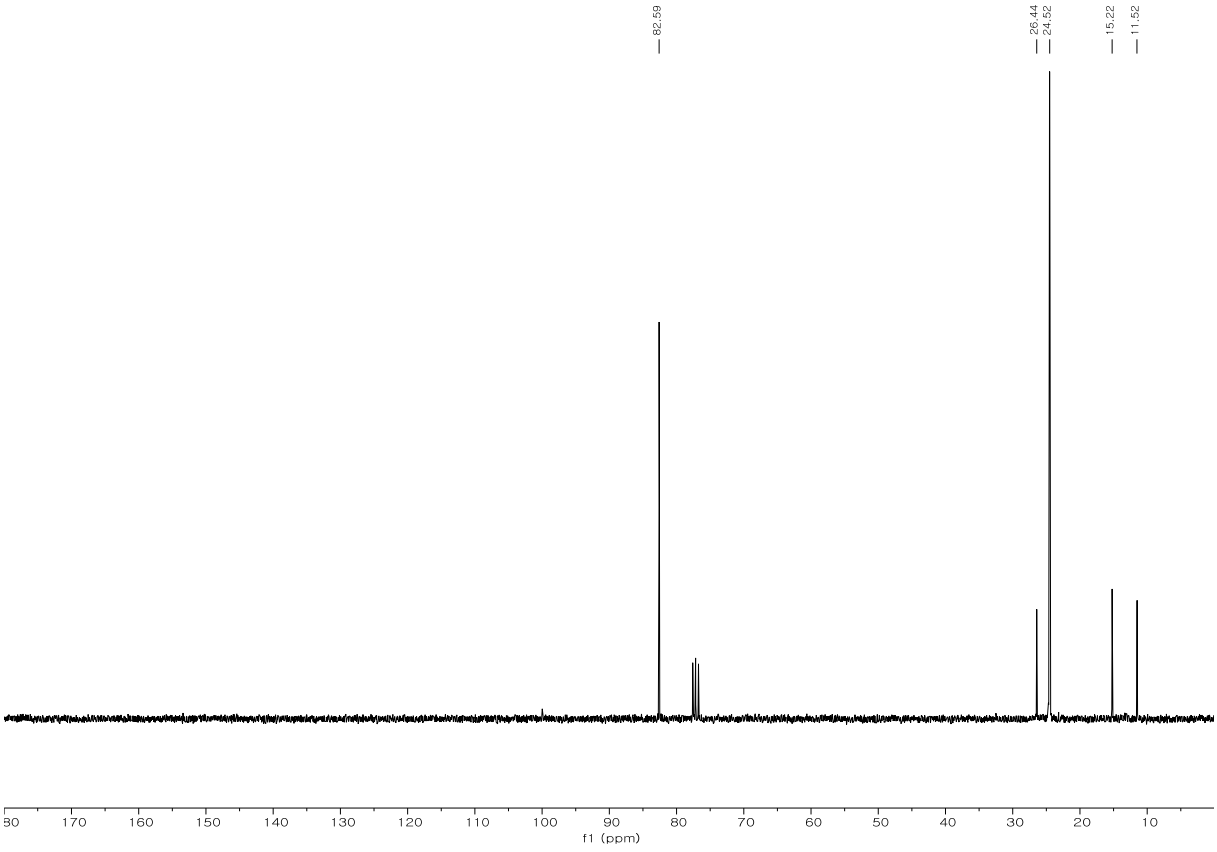
2,2-Bis[(pinacolato)boryl]propane (2a)



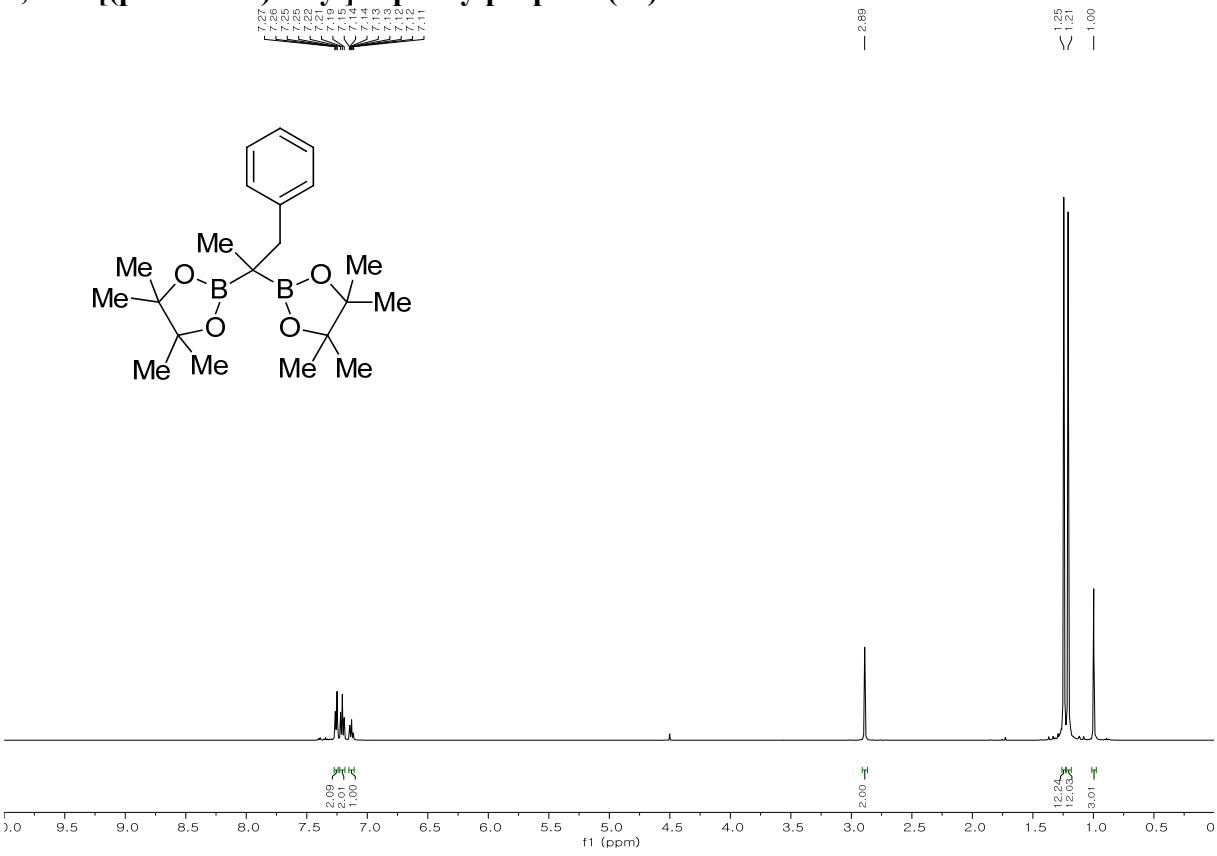


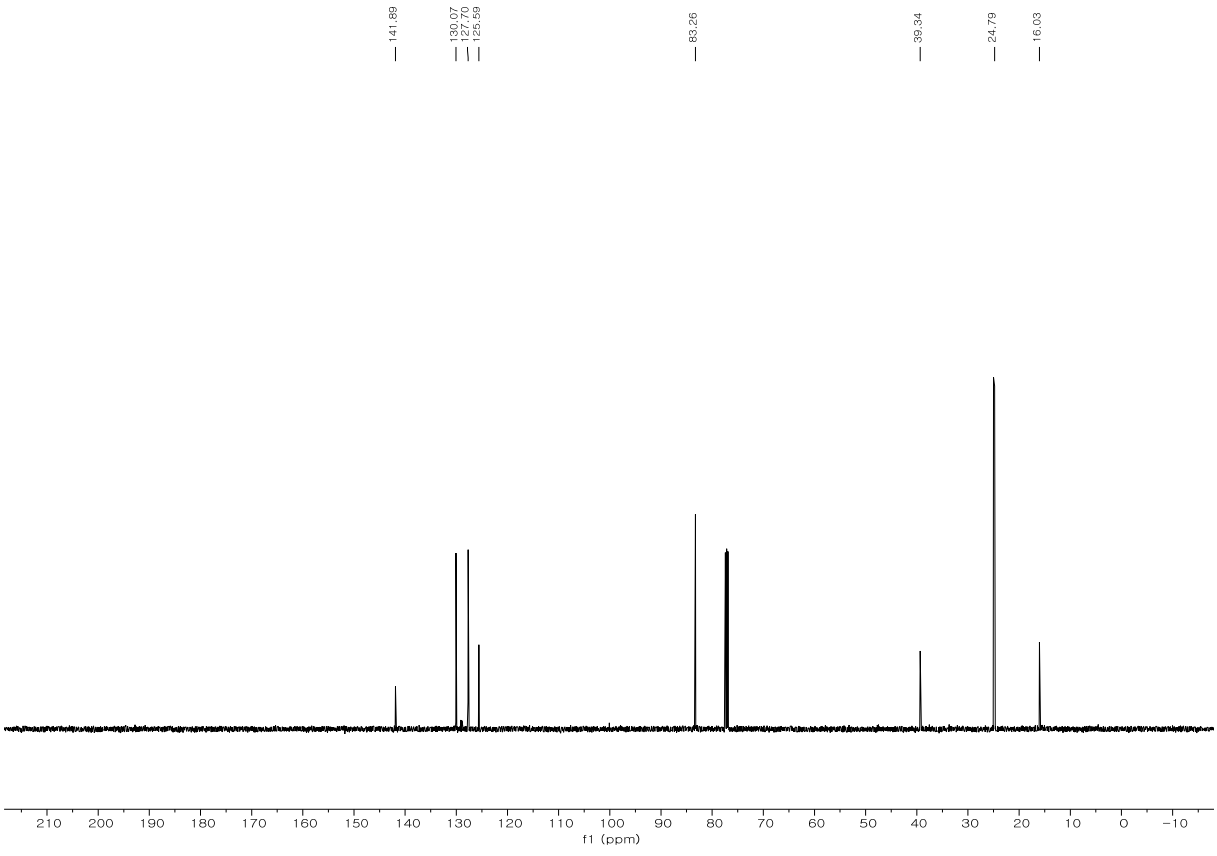
2,2-Bis[(pinacolato)boryl]butane (2b)



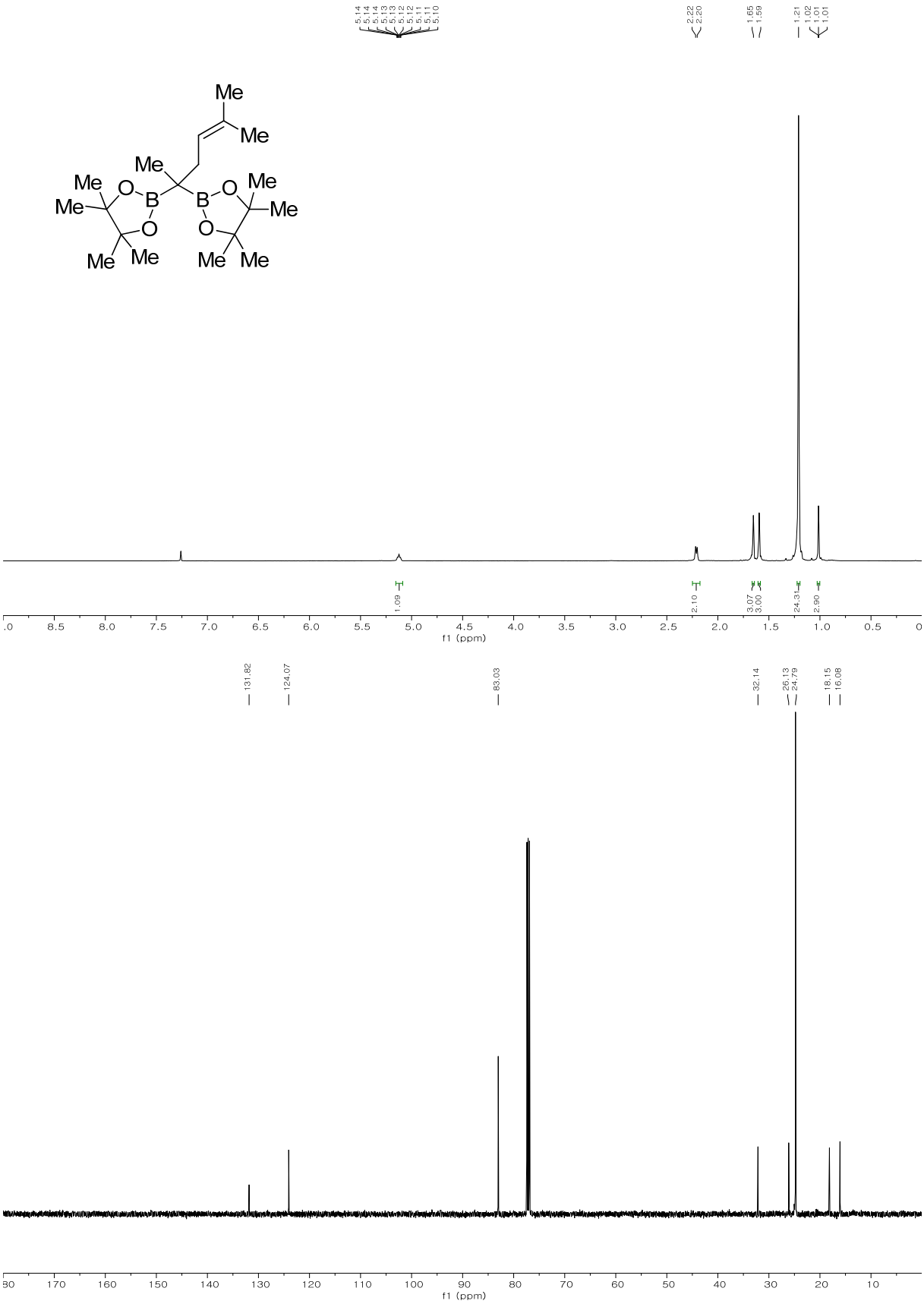


2,2-Bis[(pinacolato)boryl]-1-phenylpropane (2c)

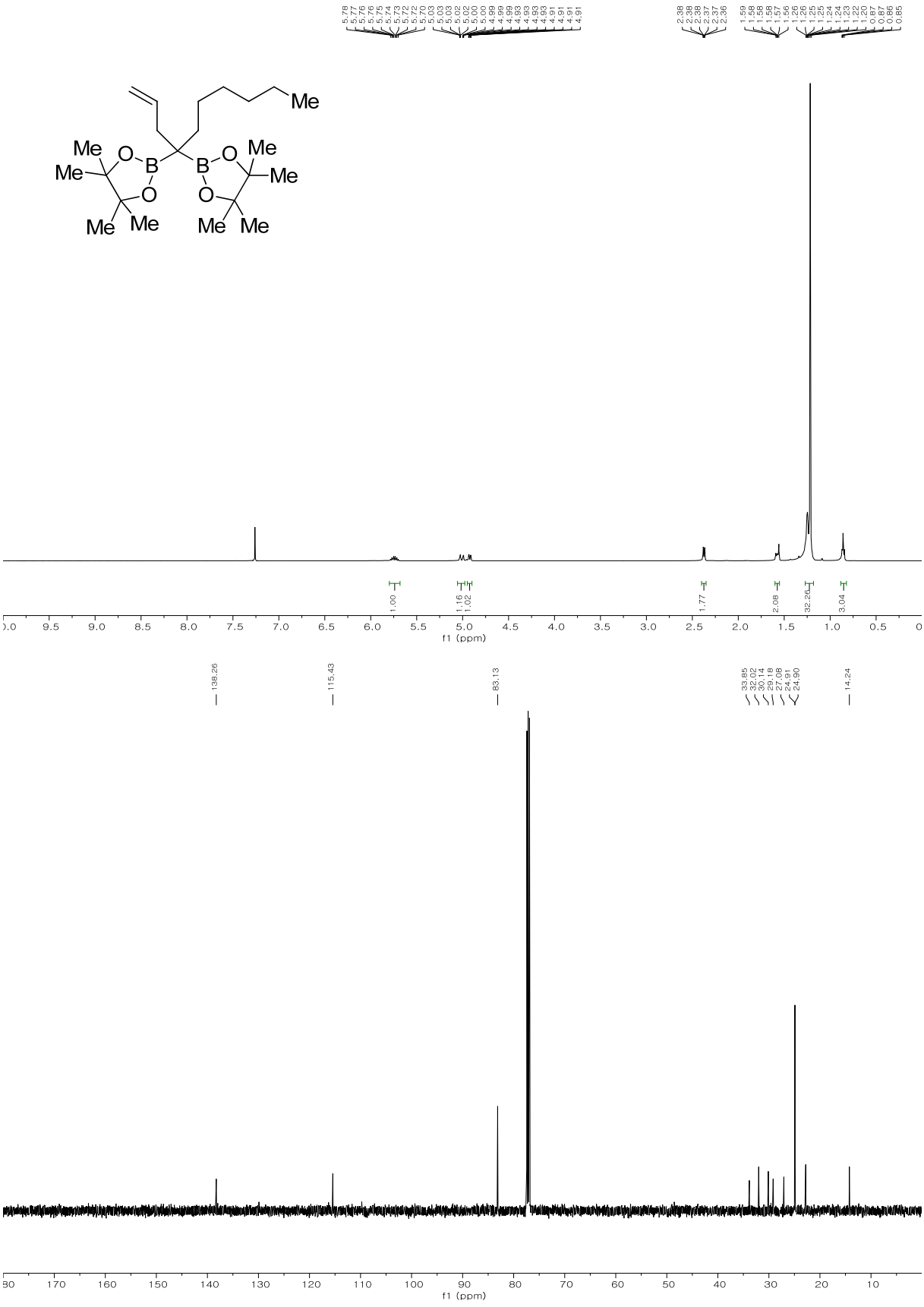




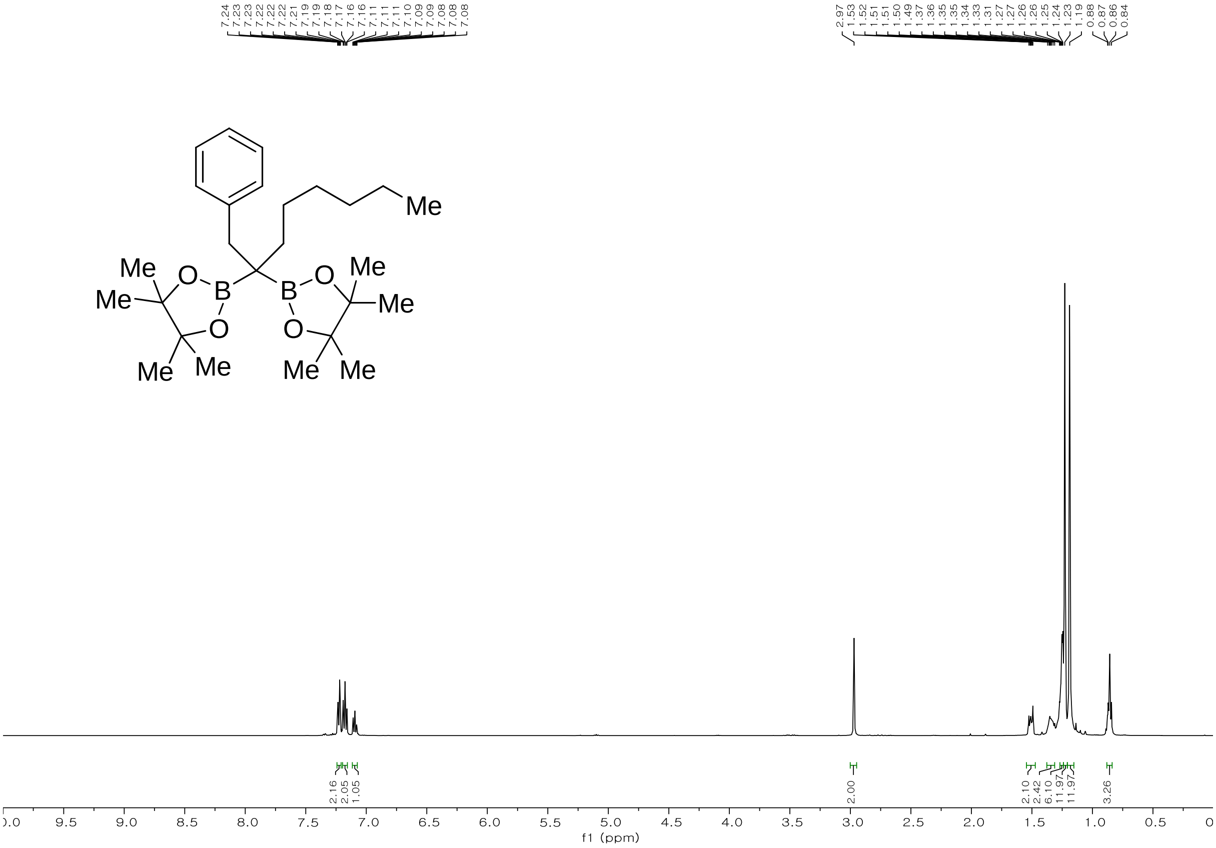
2,2-Bis[(pinacolato)boryl]-5-methylhex-4-ene (2d)

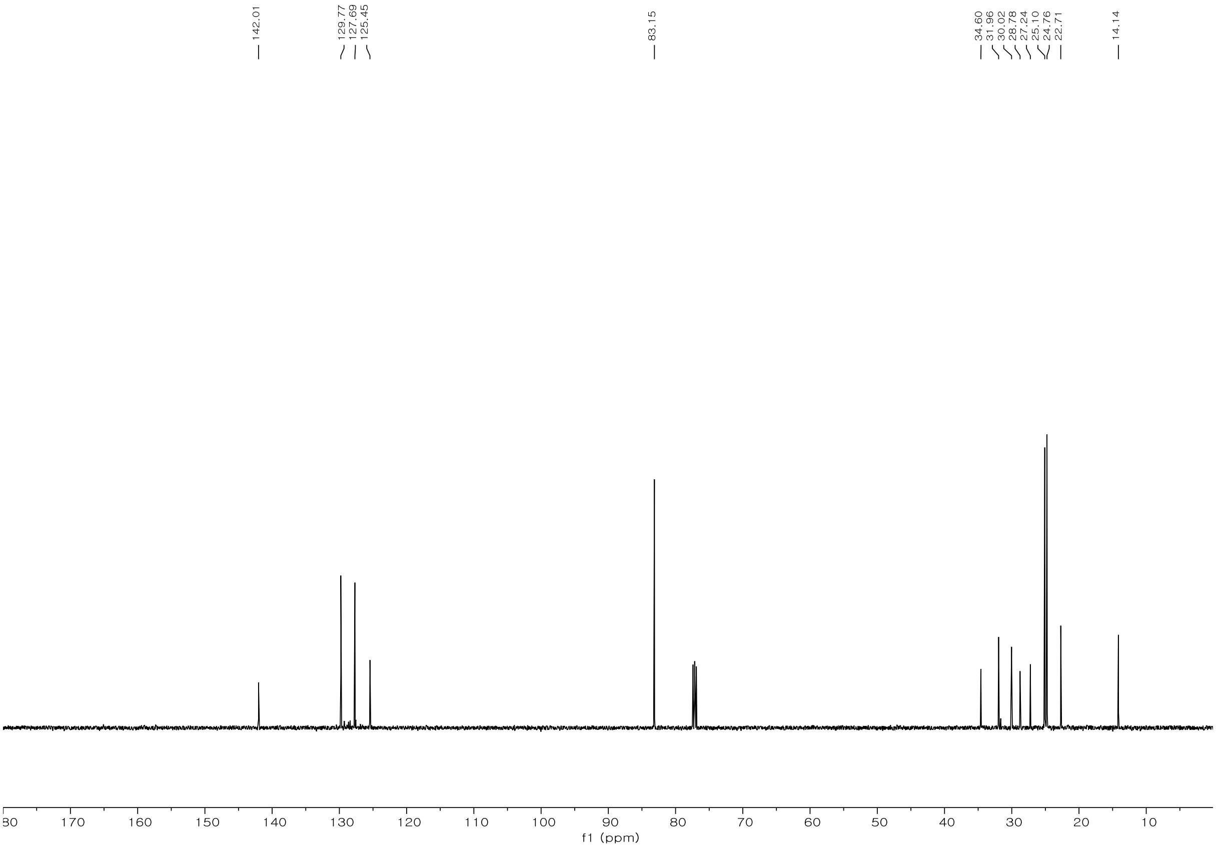


4,4-Bis[(pinacolato)boryl]-dec-1-ene (2e)

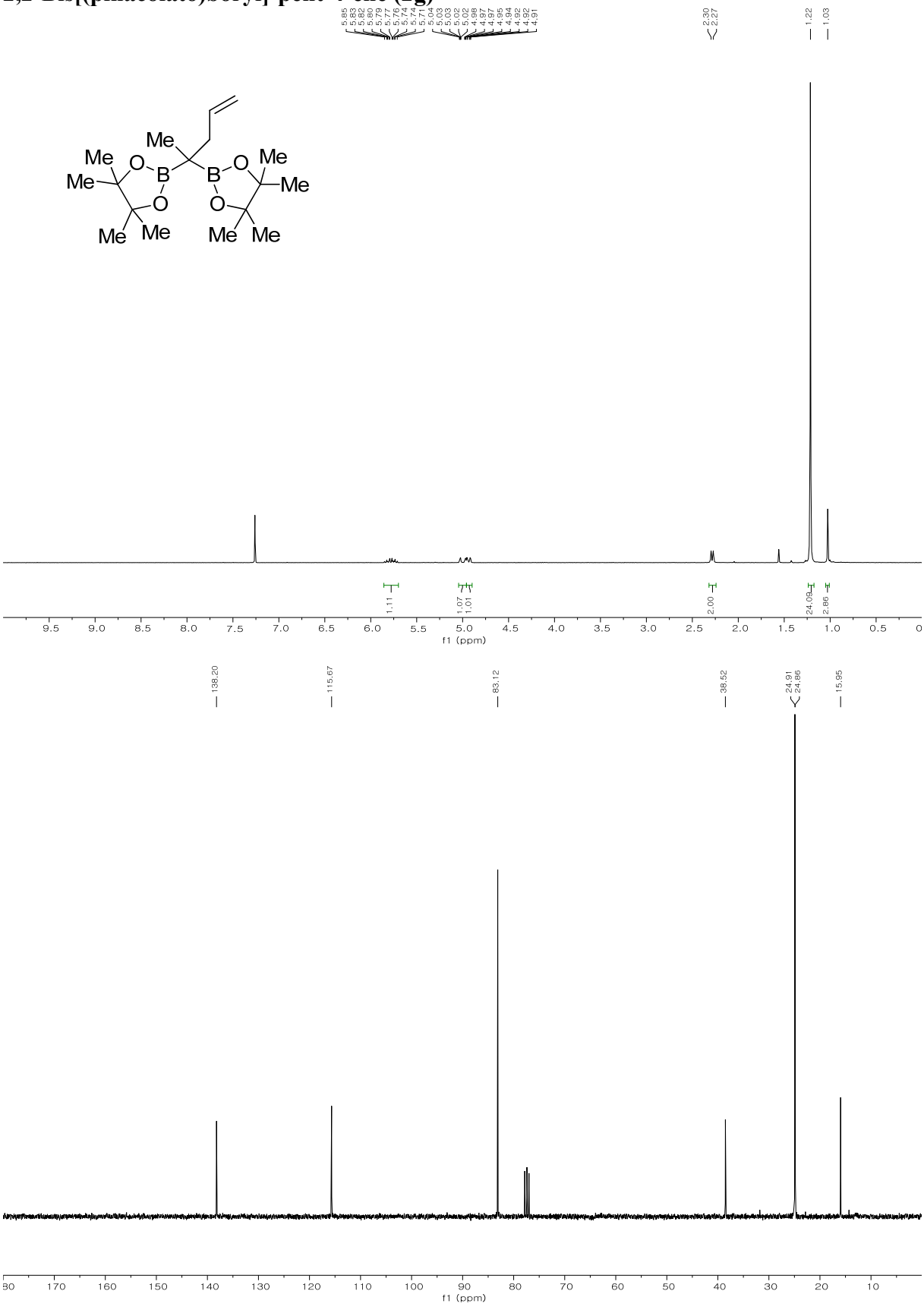


4,4-Bis[(pinacolato)boryl]-dec-1-ene (2f)

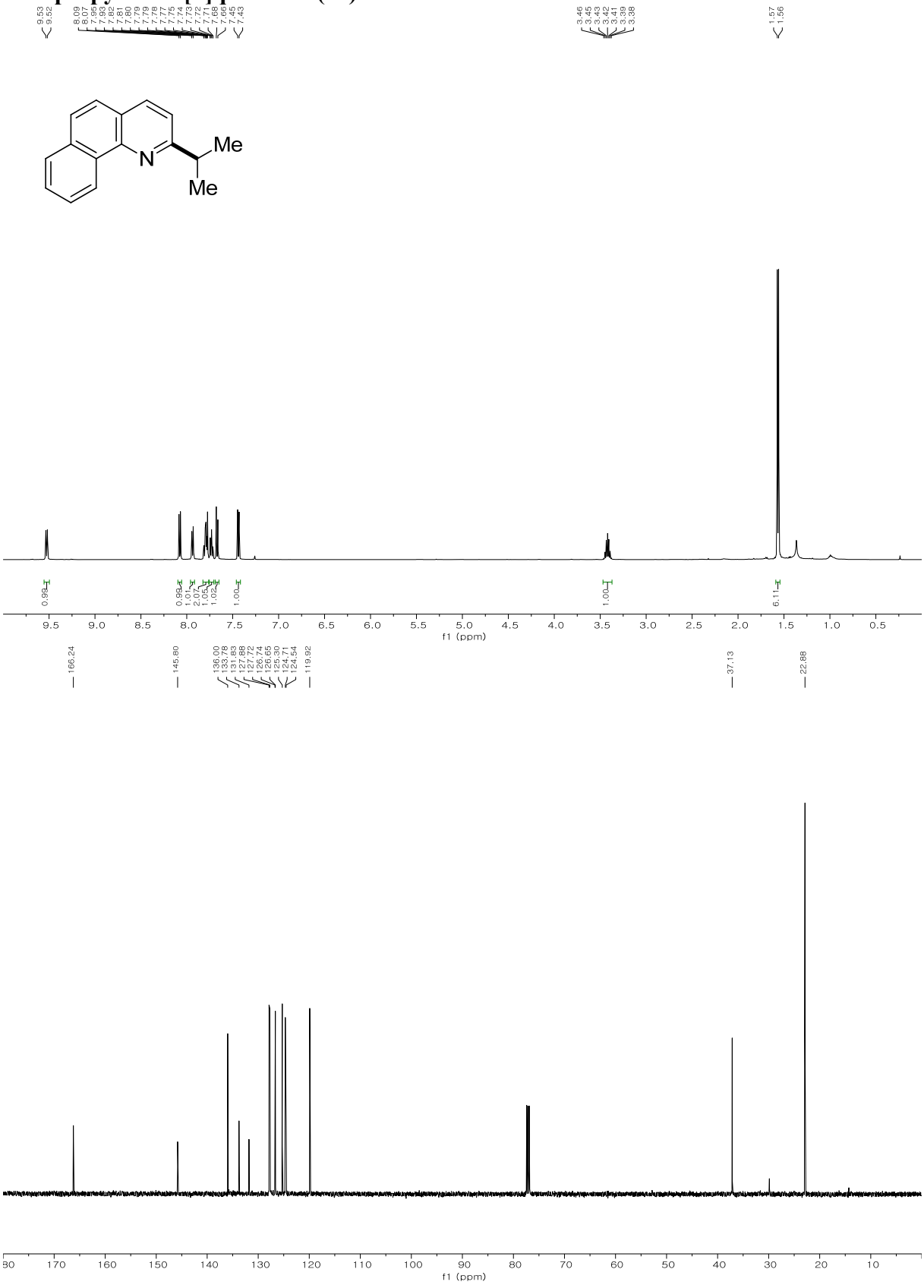




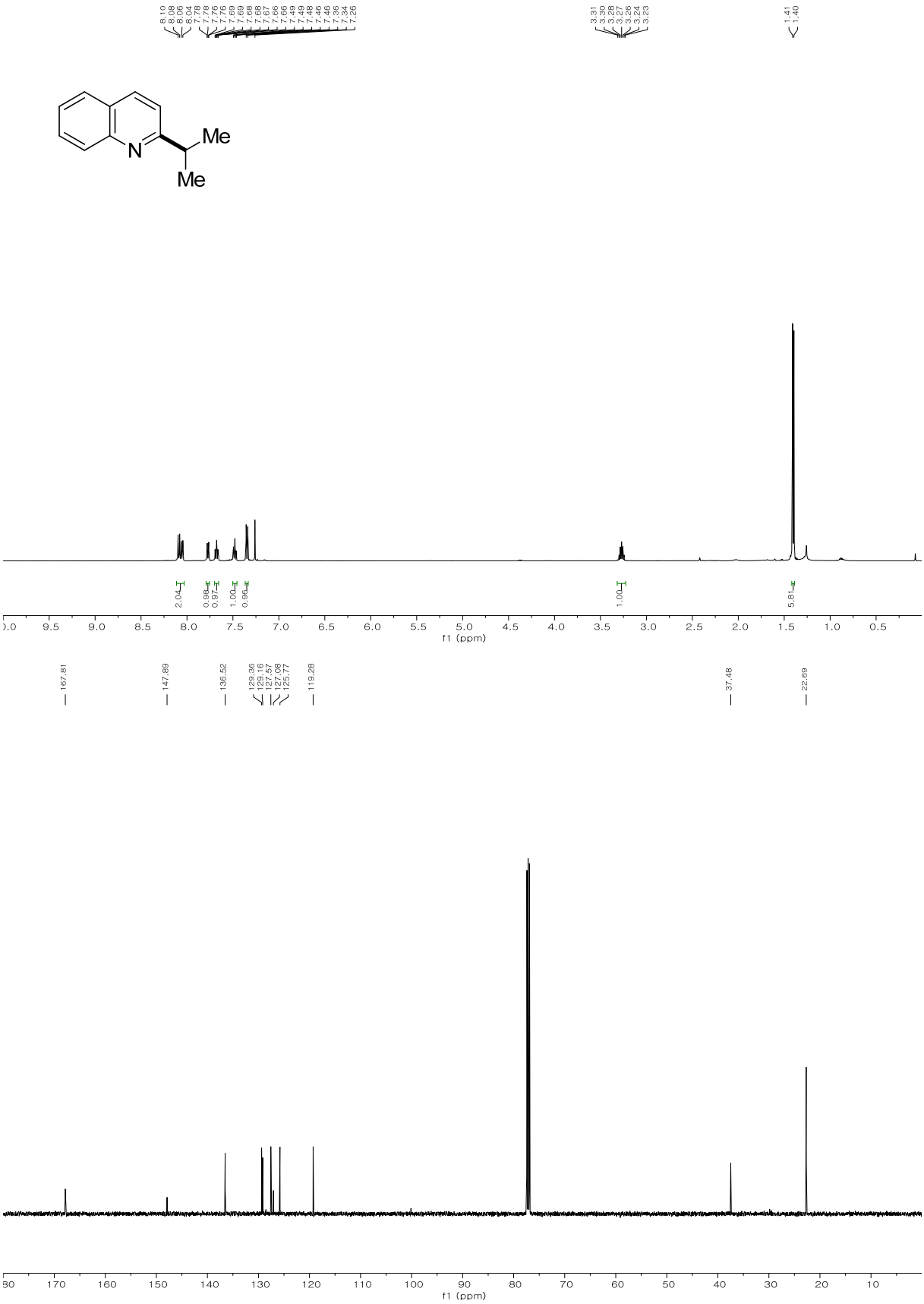
2,2-Bis[(pinacolato)boryl]-pent-4-ene (2g)



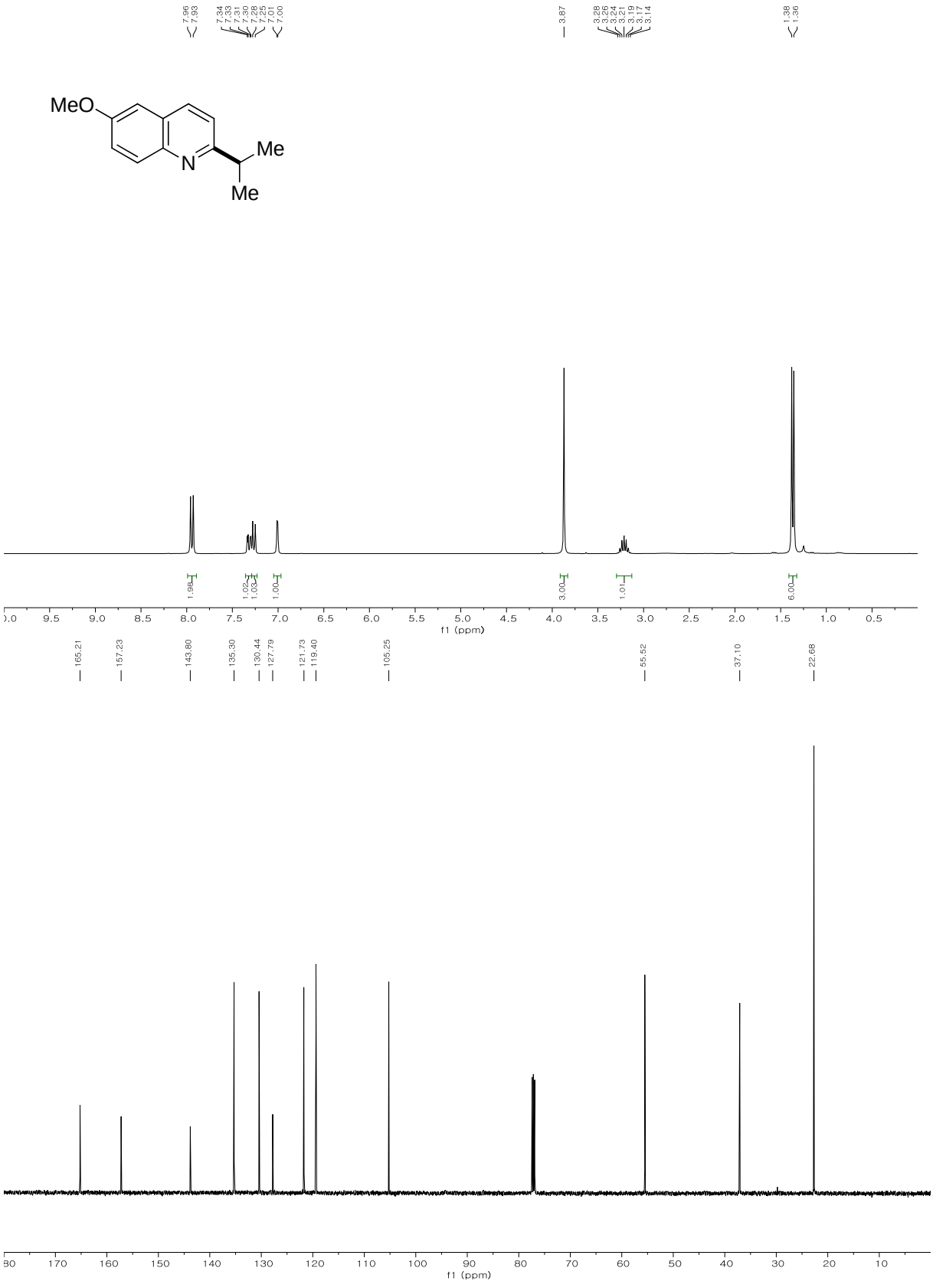
2-Isopropylbenzo[*h*]quinoline (3a)



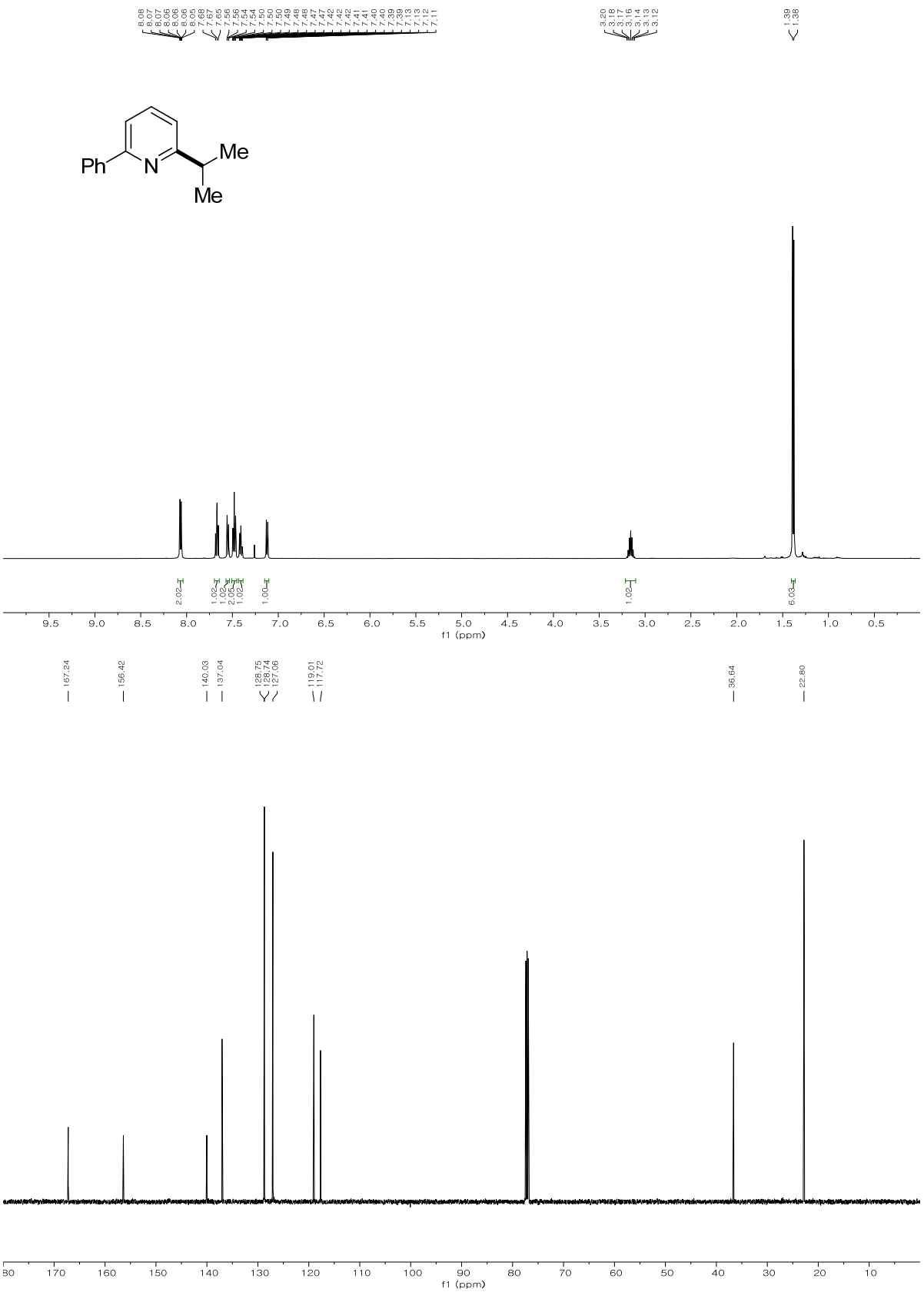
2-Isopropylquinoline (3b)



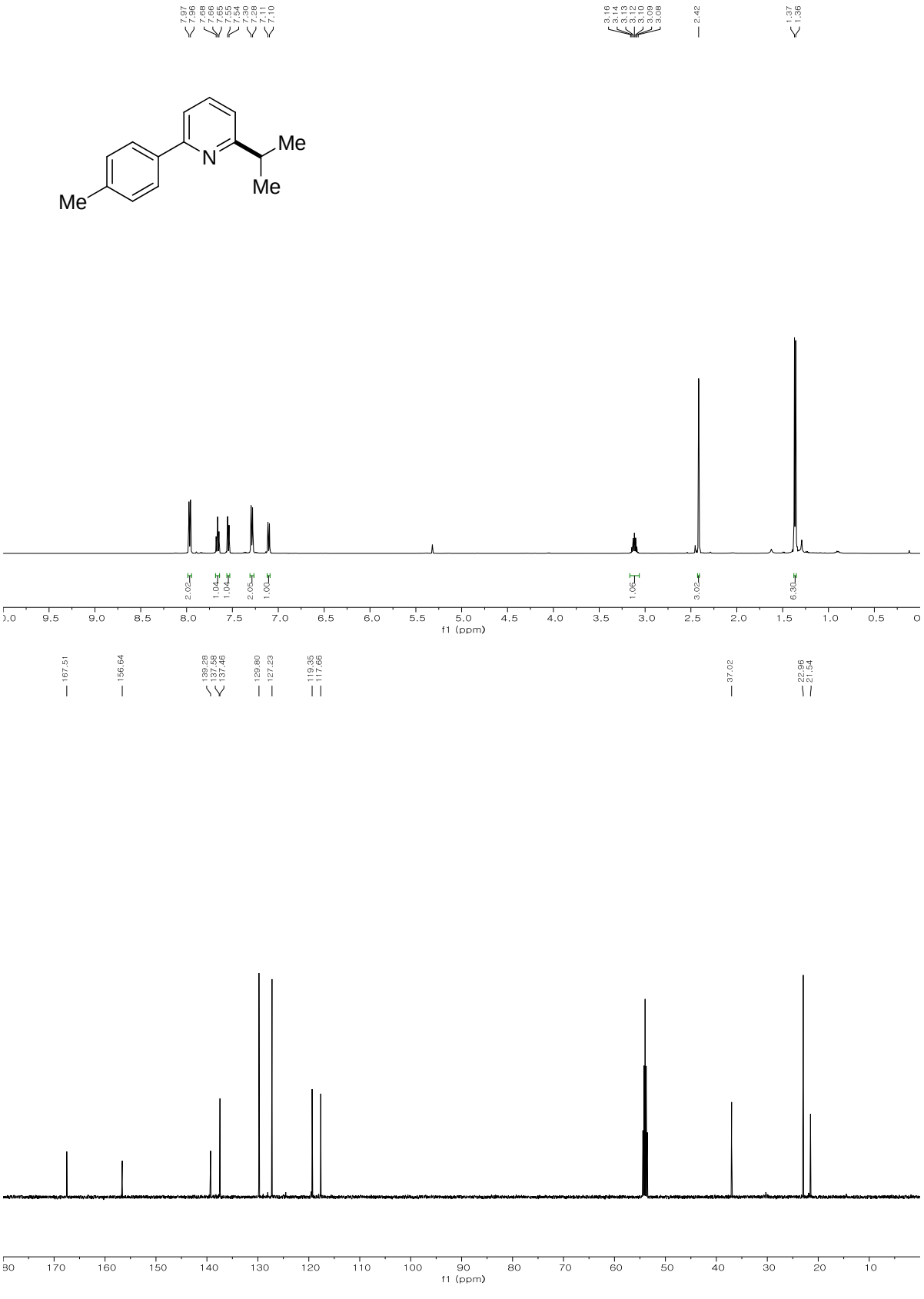
2-Isopropyl-6-methoxyquinoline (3c)



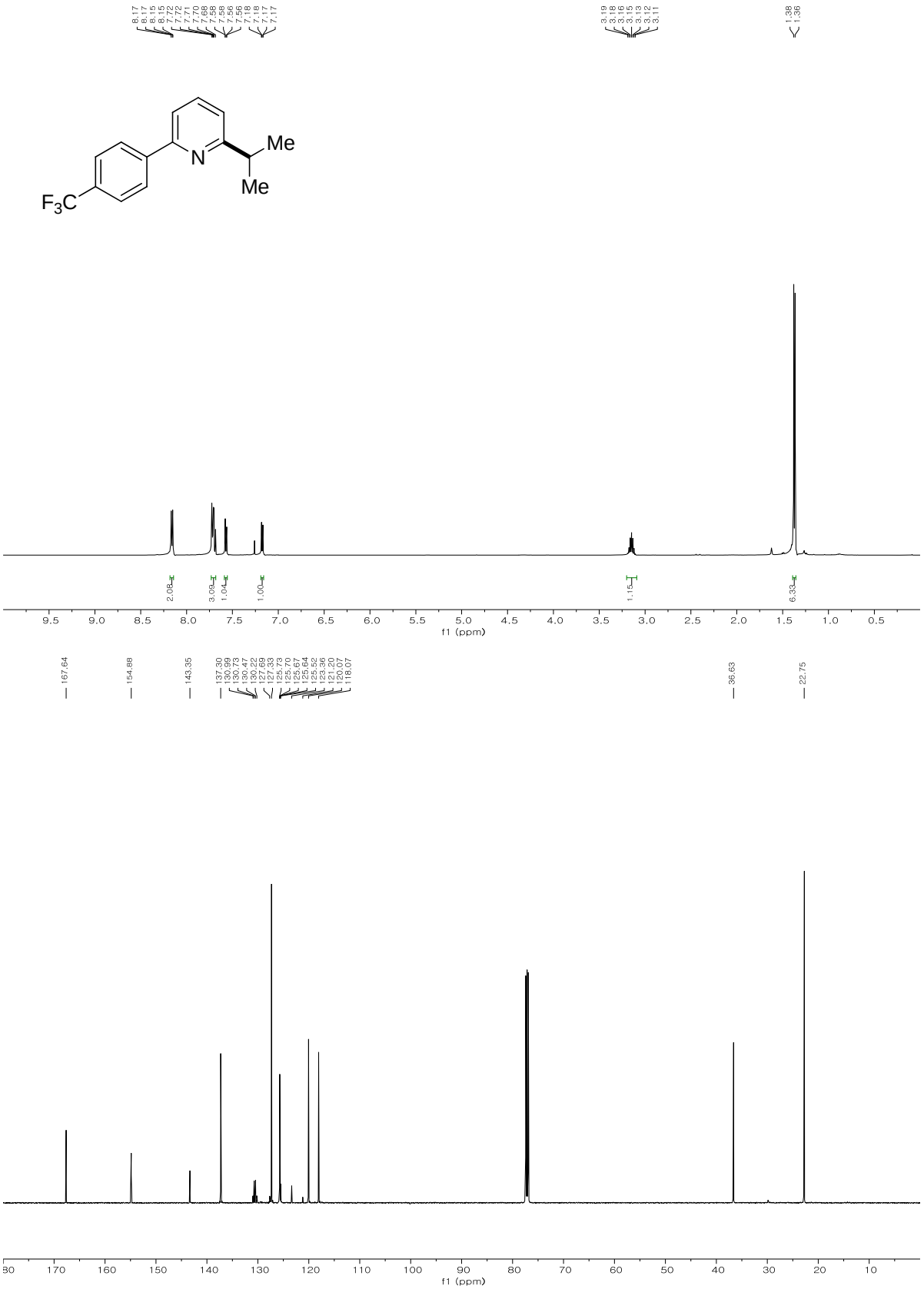
2-Isopropyl-6-phenylpyridine (3d)



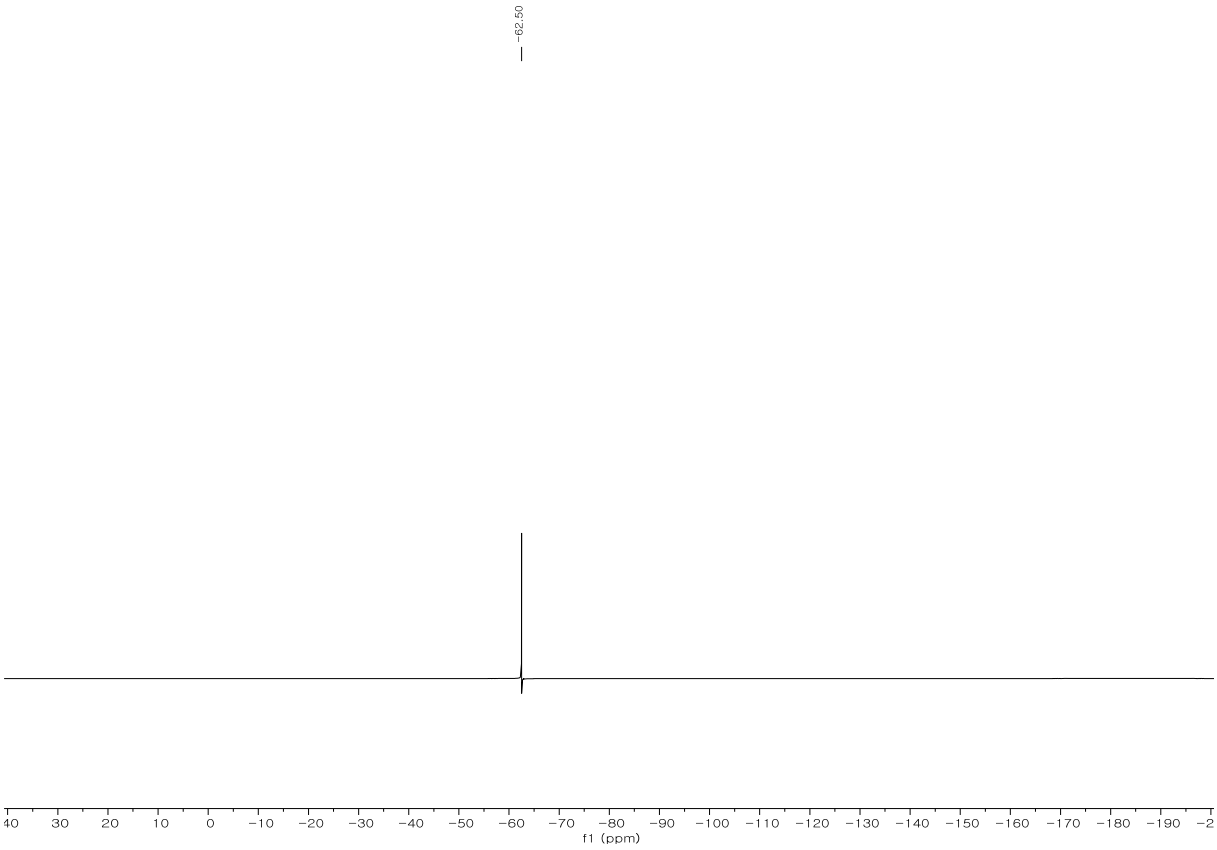
2-Isopropyl-6-(*p*-tolyl)pyridine (3e)



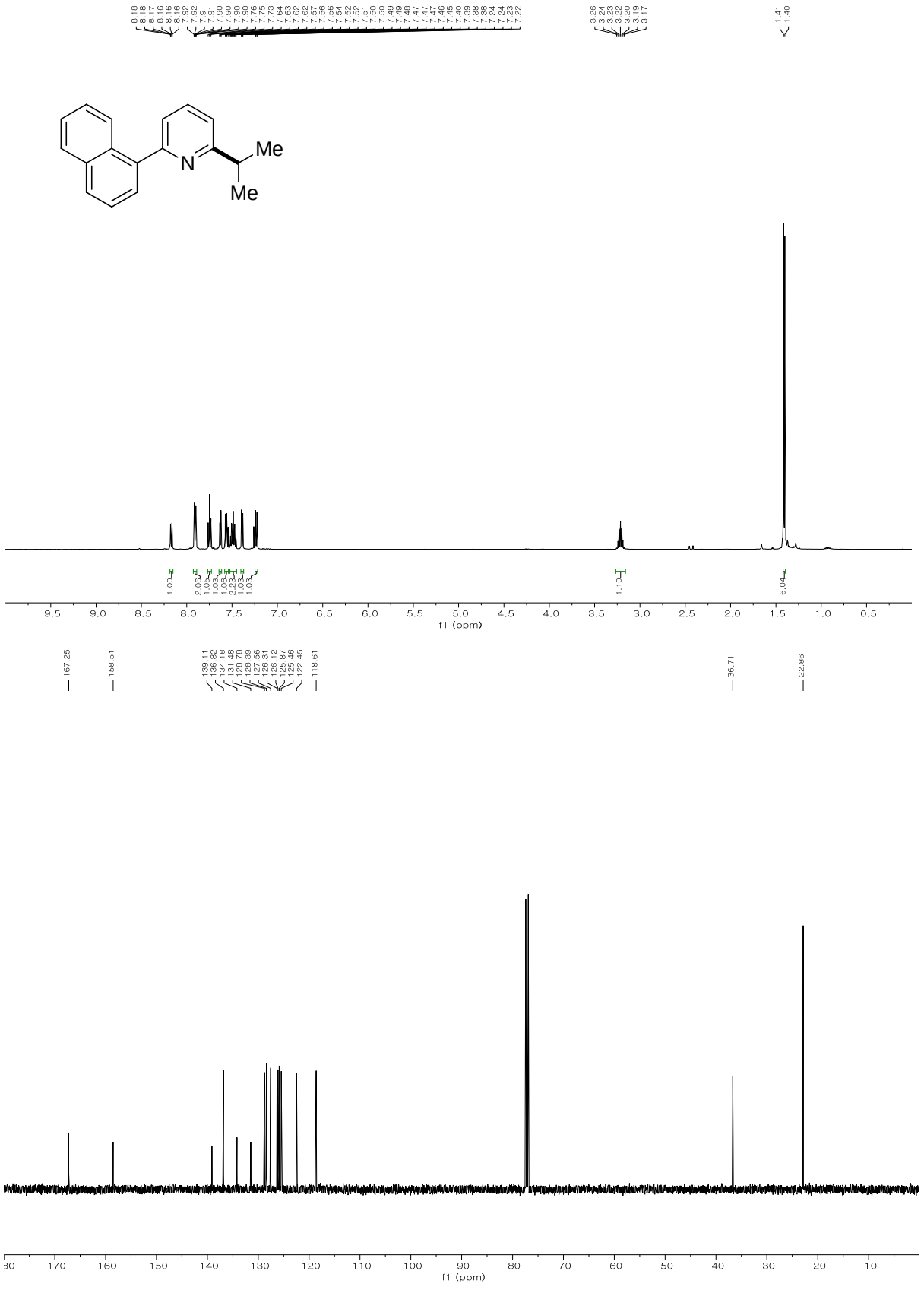
2-Isopropyl-6-(4-(trifluoromethyl)phenyl)pyridine (3f)



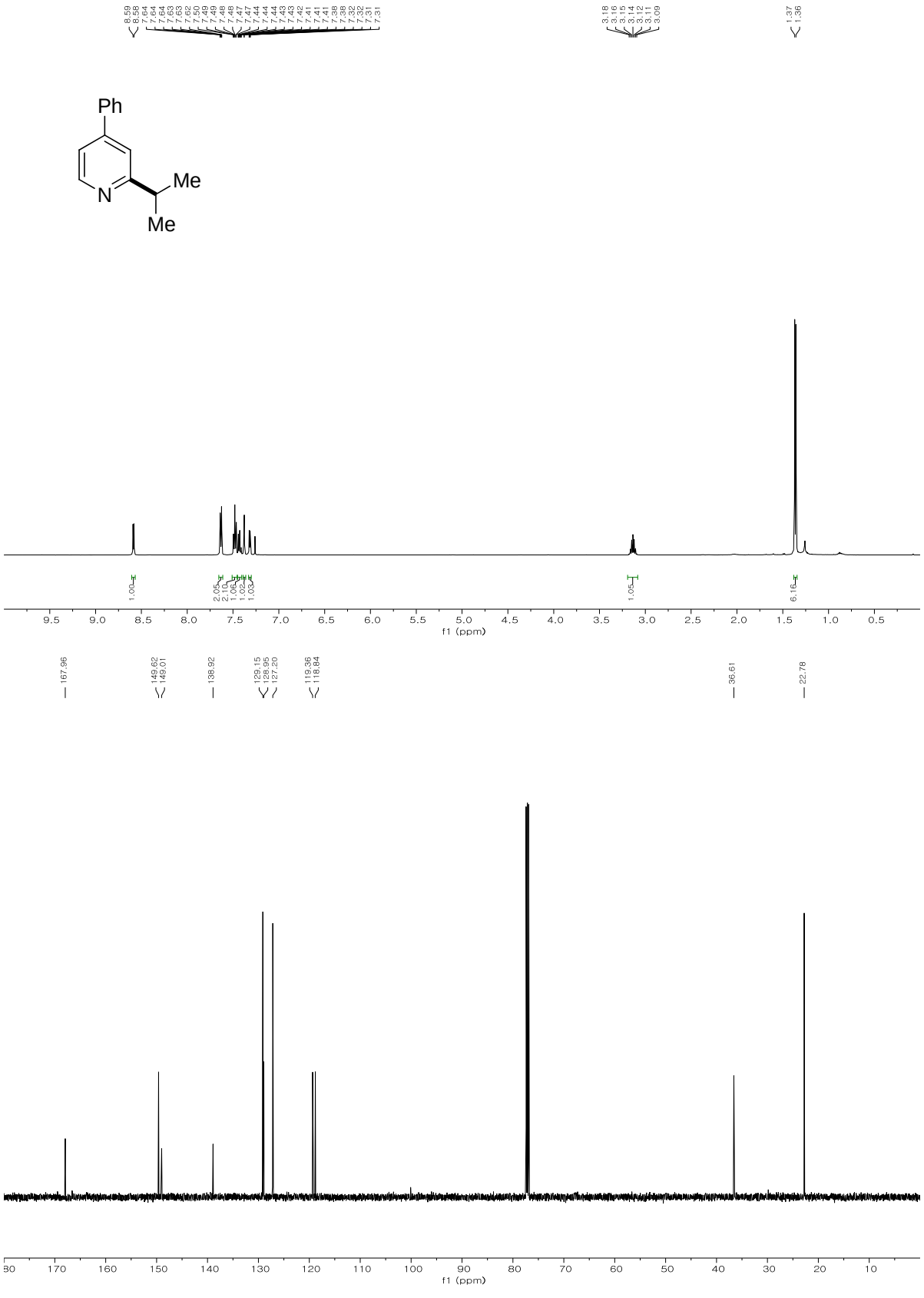
^{19}F NMR (471 MHz, $CDCl_3$)



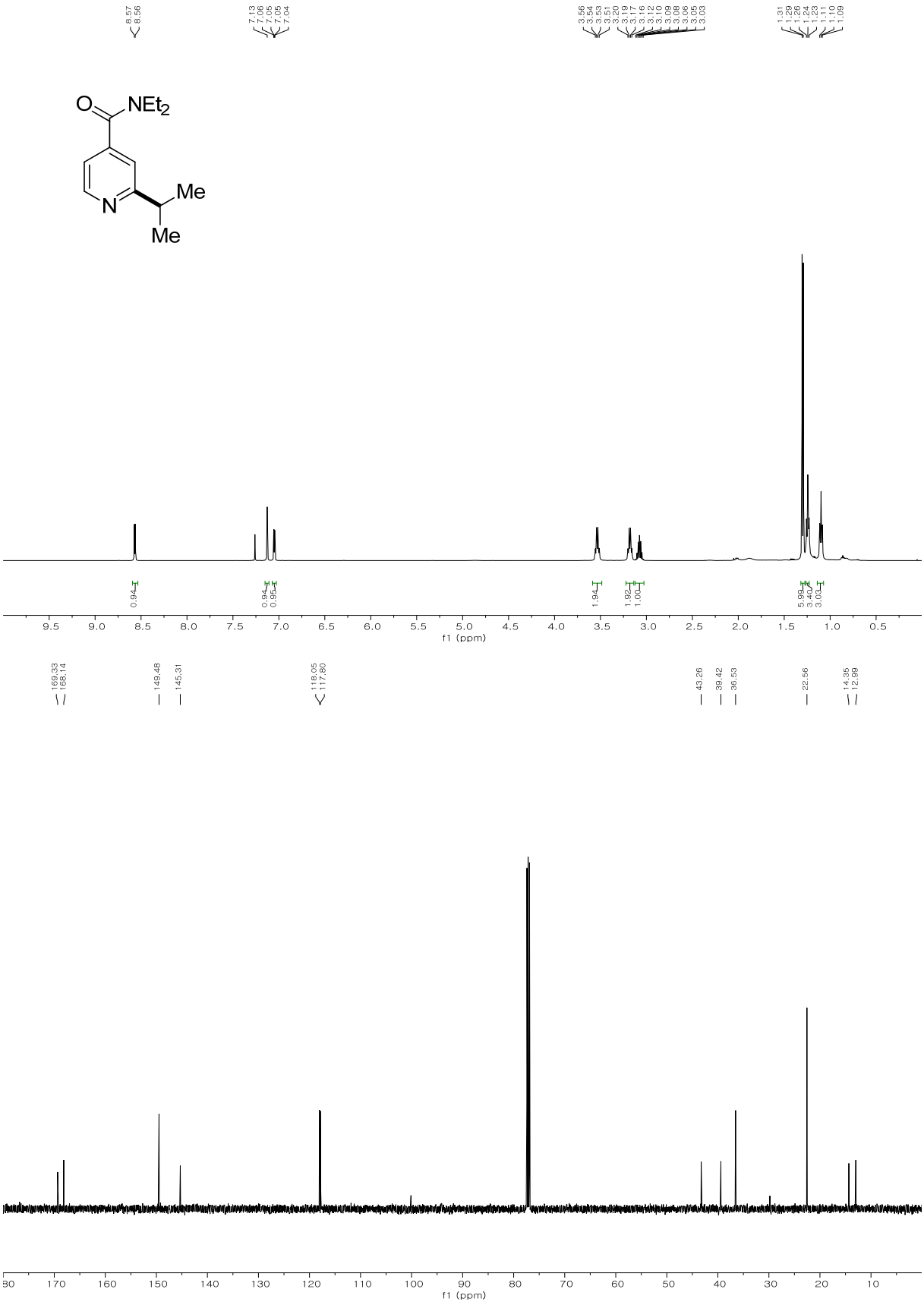
2-Isopropyl-6-(naphthalen-1-yl)pyridine (3g)



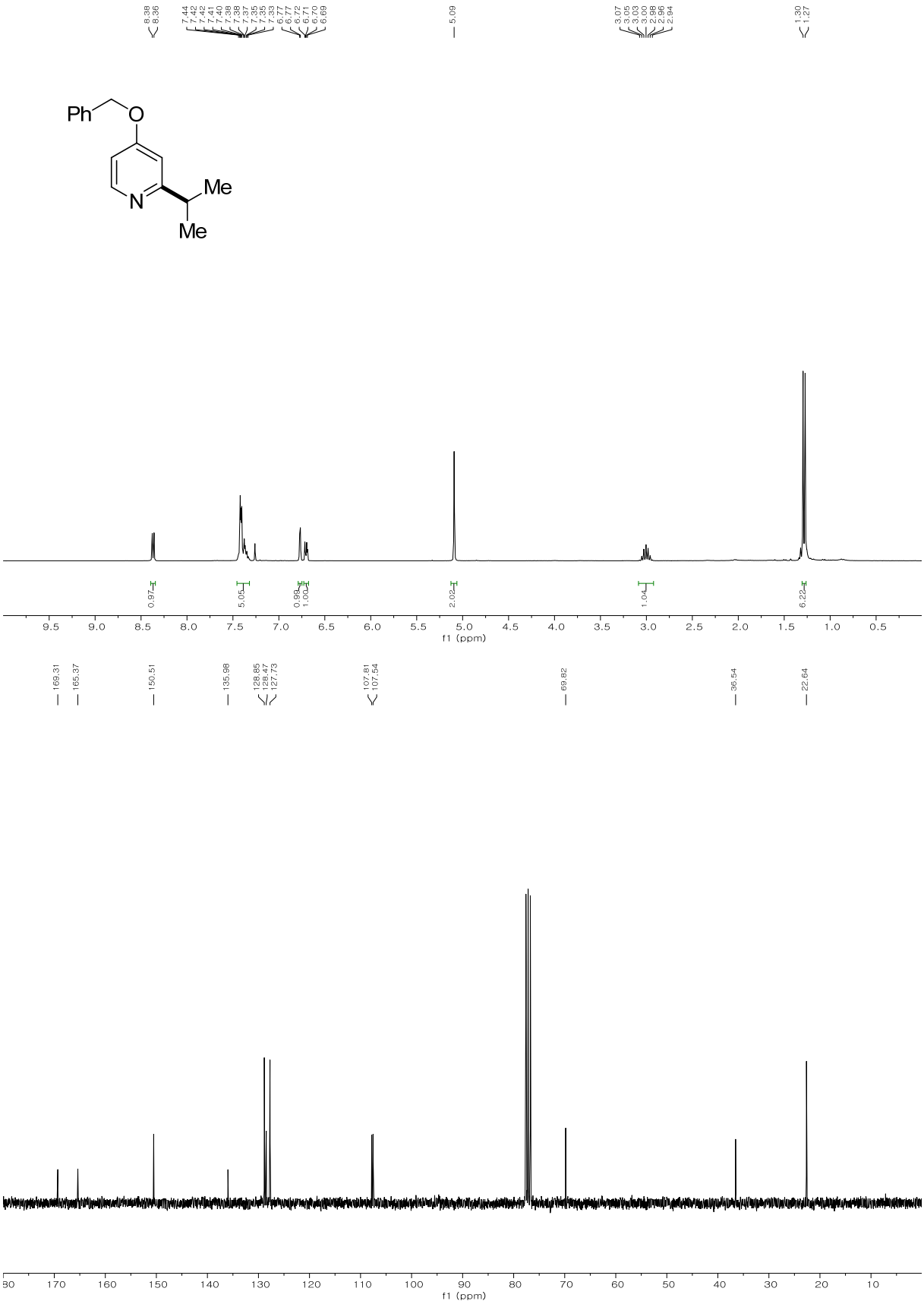
2-Isopropyl-4-phenylpyridine (3h)



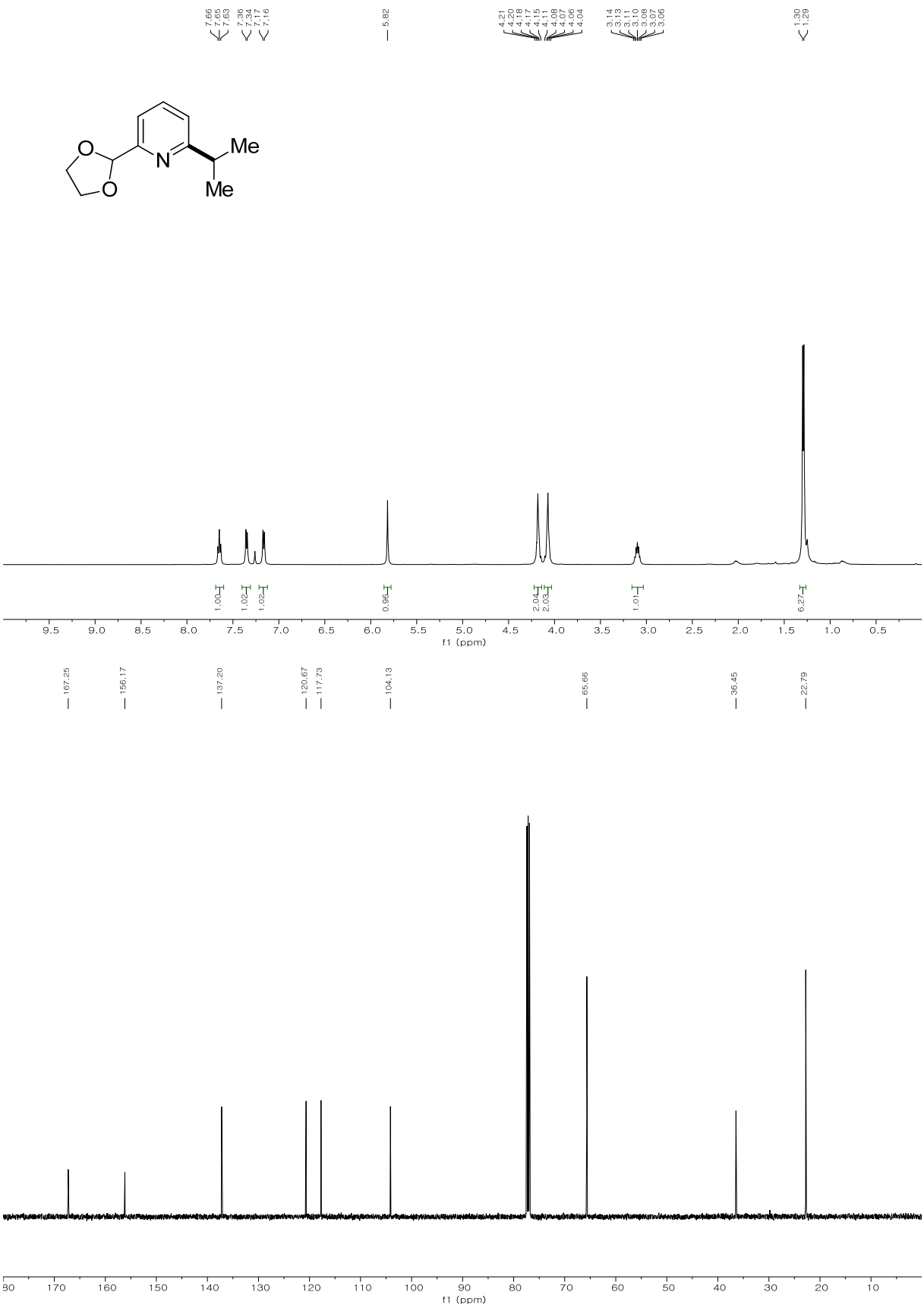
N,N-Diethyl-2-isopropylisonicotinamide (3i)



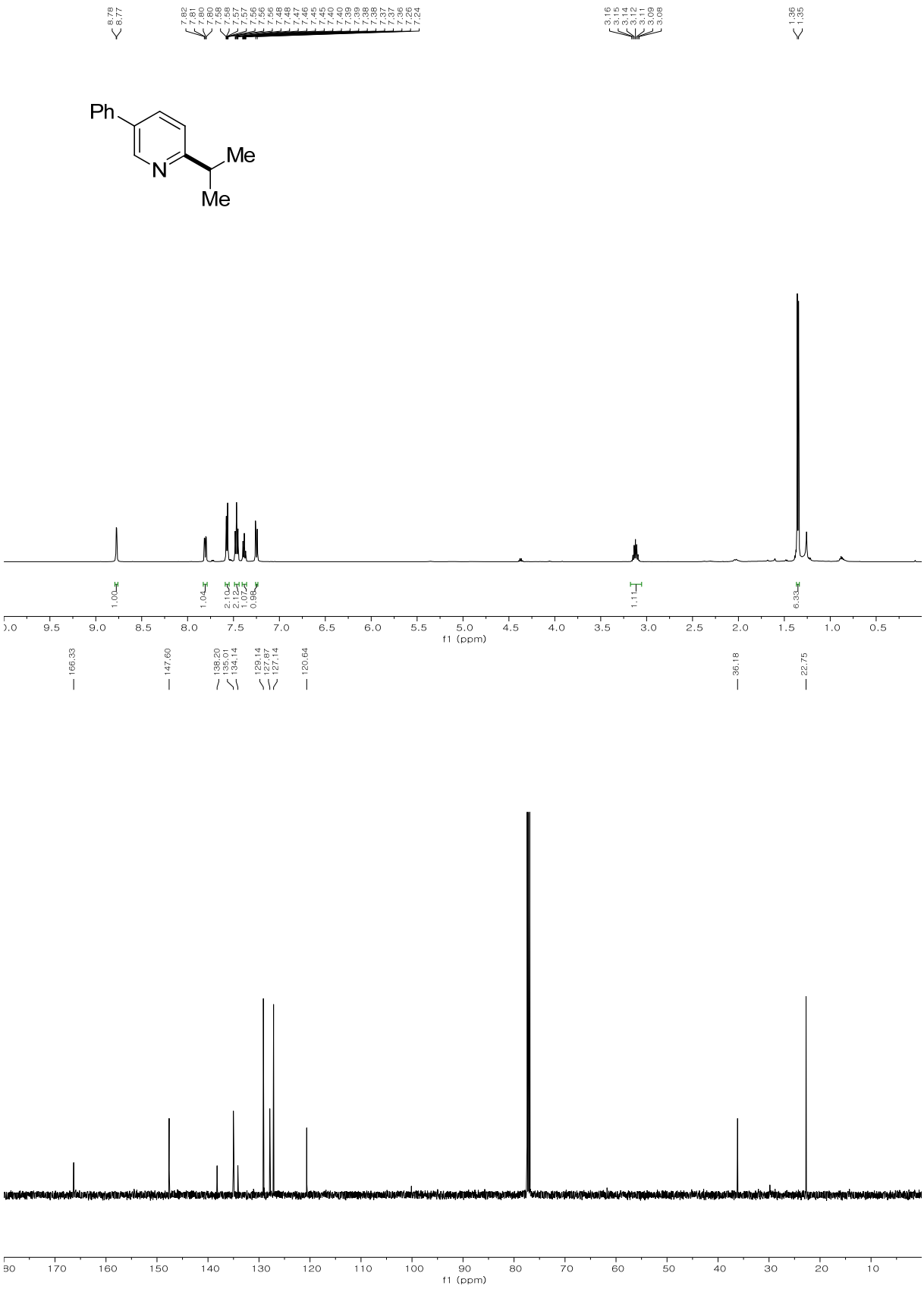
4-(Benzyloxy)-2-isopropylpyridine (3j)



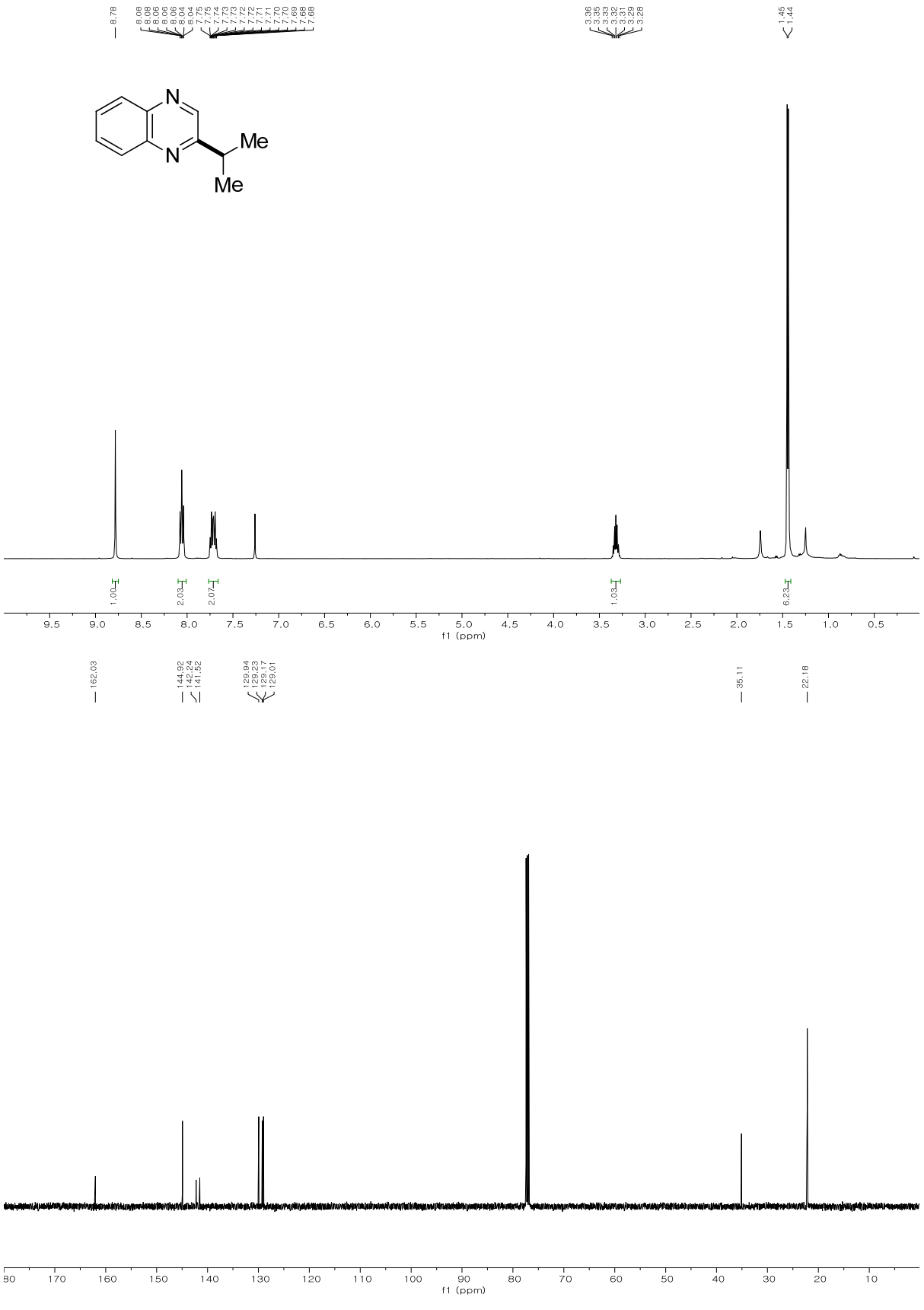
2-(1,3-Dioxolan-2-yl)-6-isopropylpyridine (3k)



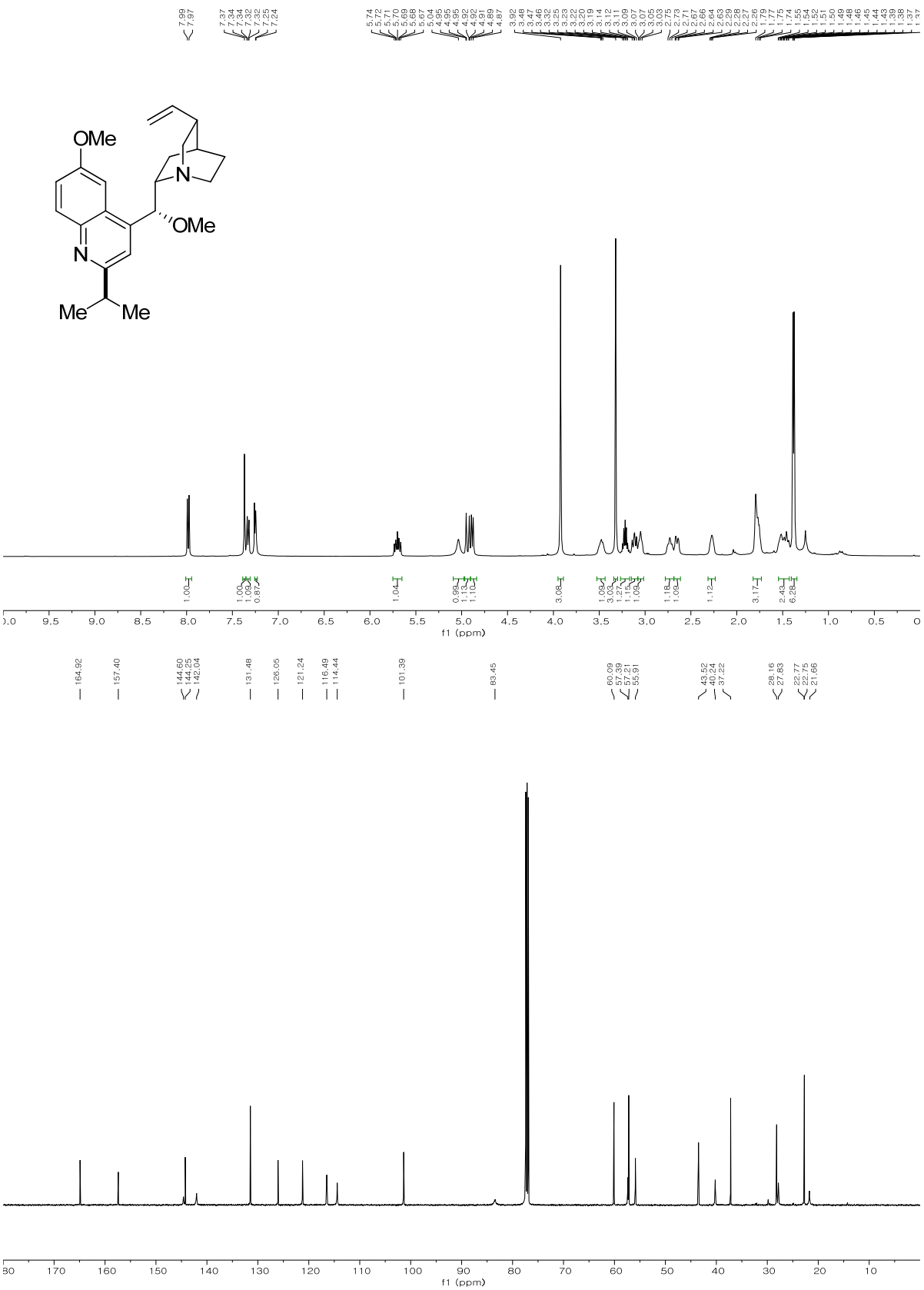
2-Isopropyl-5-phenylpyridine (3l)



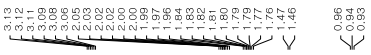
2-Isopropylquinoxaline (3m)

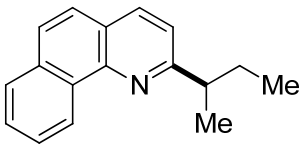


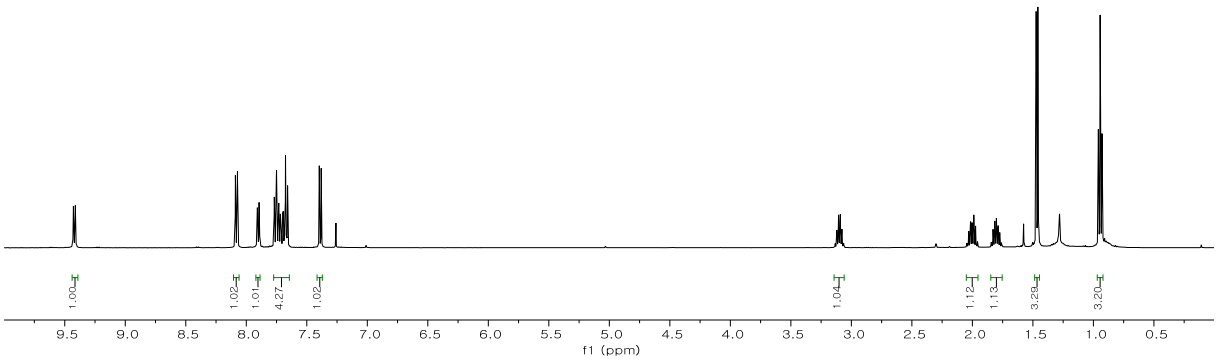
9-*O*-Methyl-2'-isopropylquinine (3n)

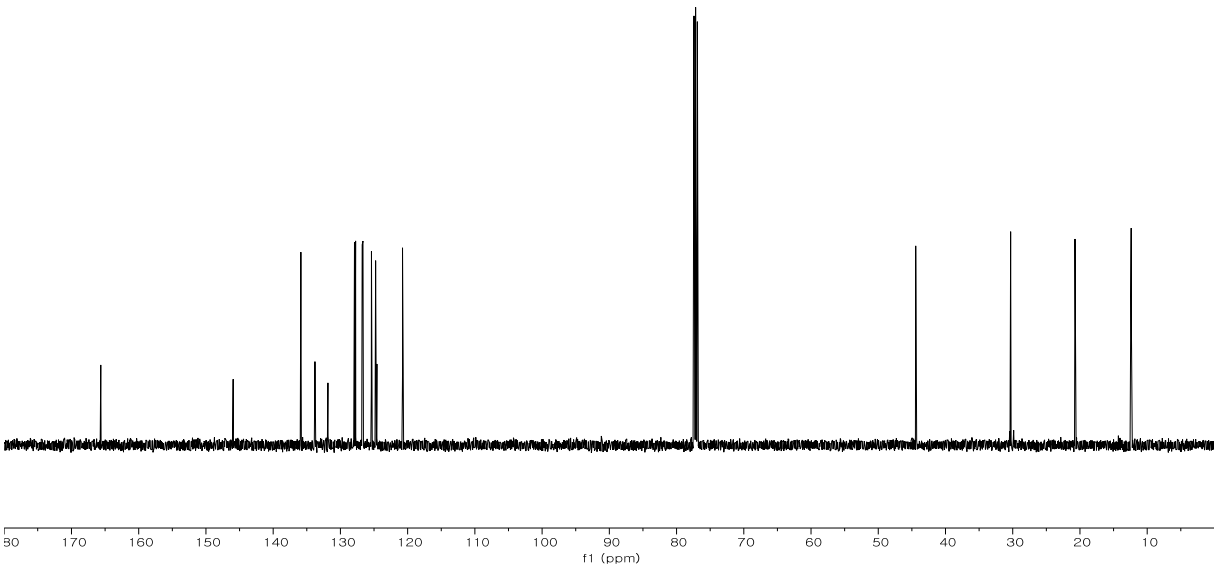


2-(*sec*-Butyl)benzo[*h*]quinoline (4a)

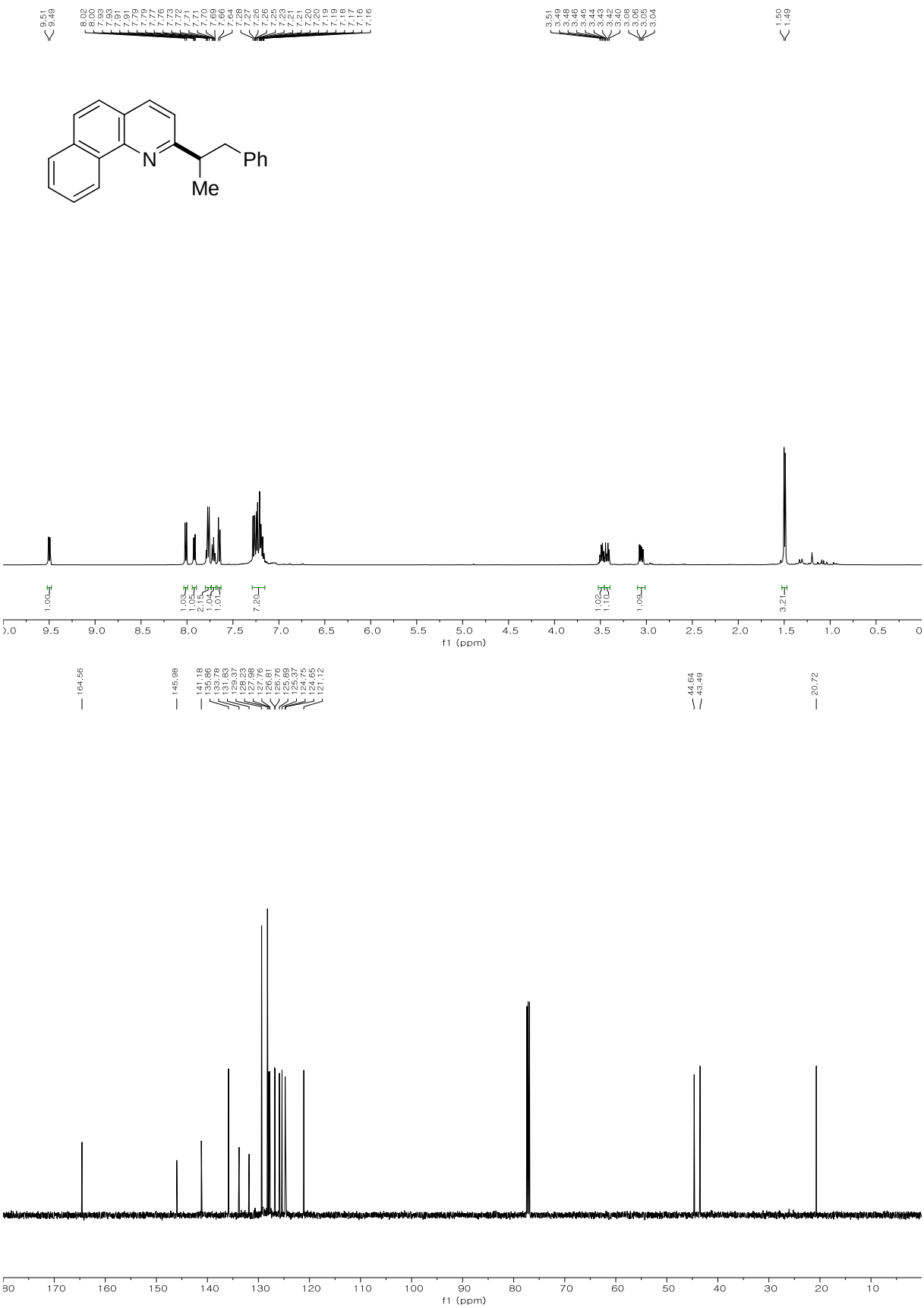




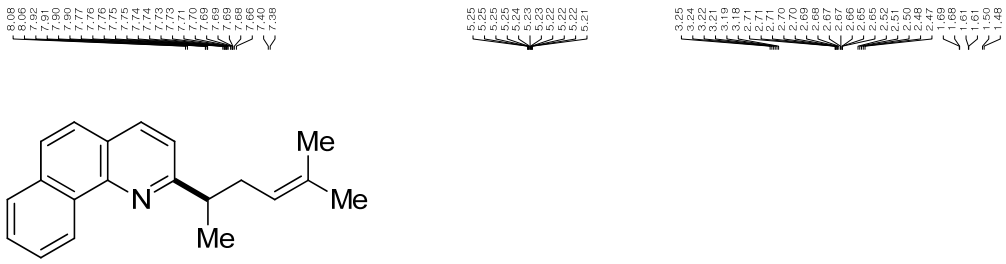


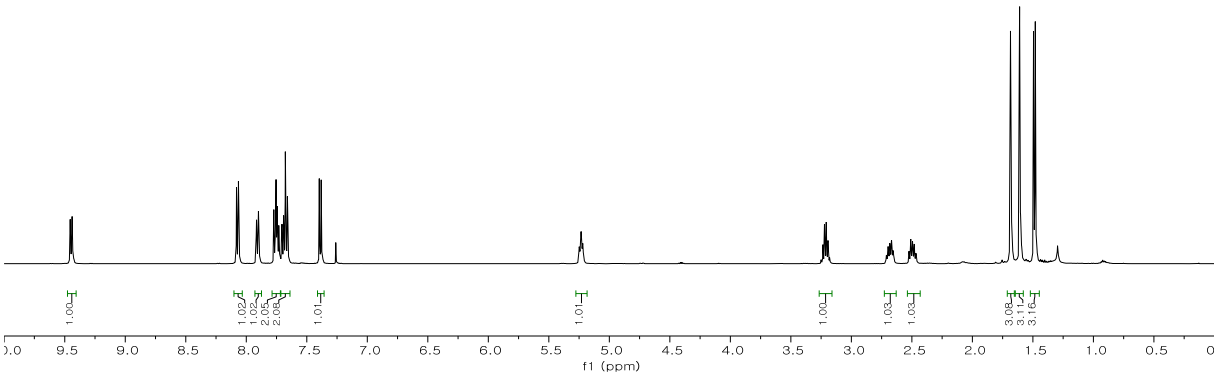


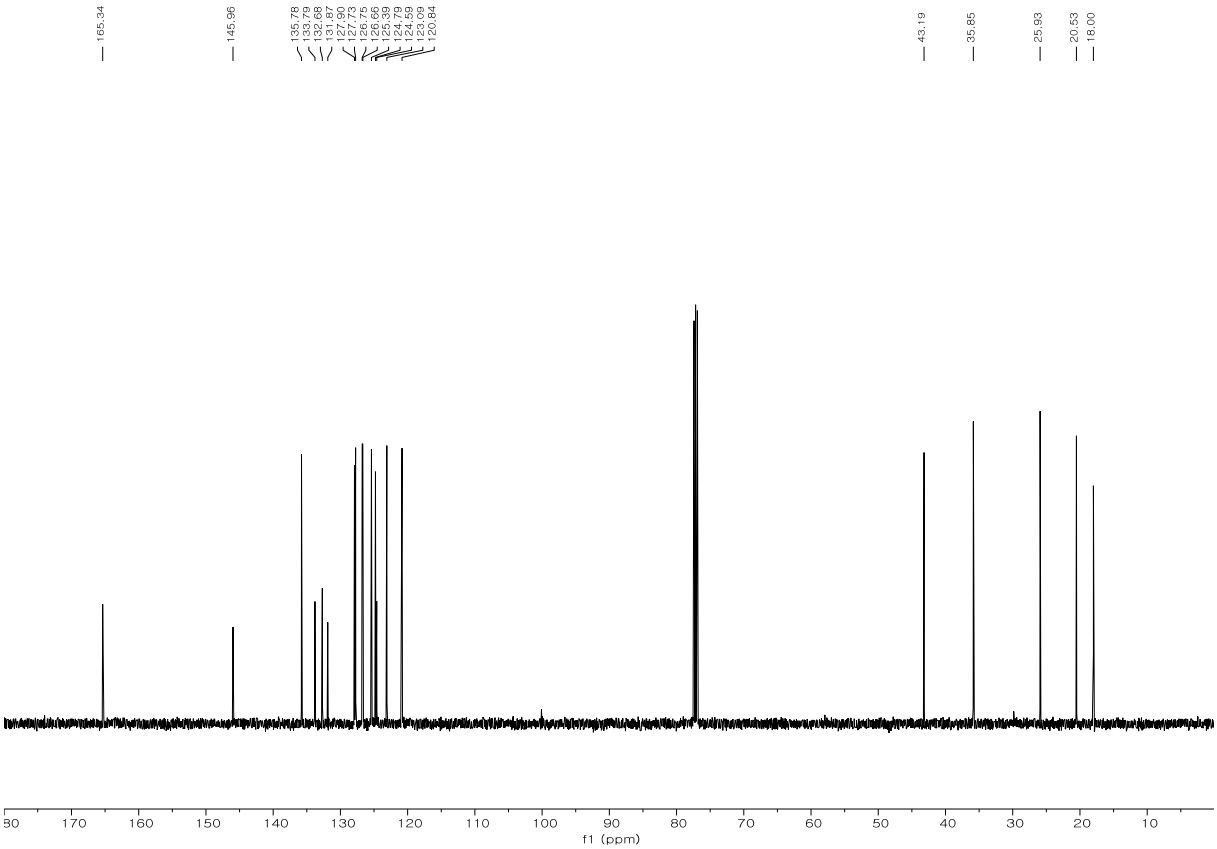
2-(1-Phenylpropan-2-yl)benzo[*h*]quinoline (4b)



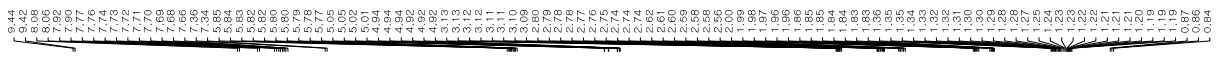
2-(5-Methylhex-4-en-2-yl)benzo[*h*]quinoline (4c)

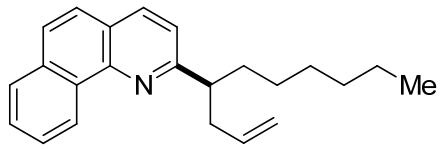


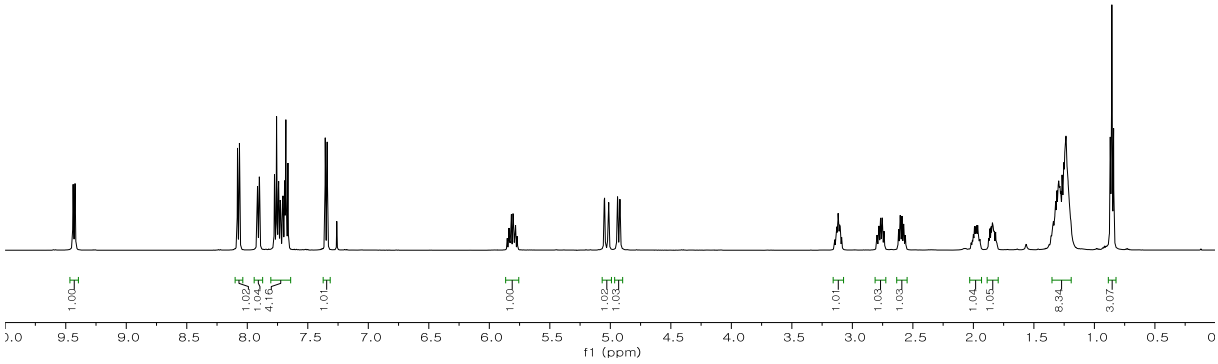


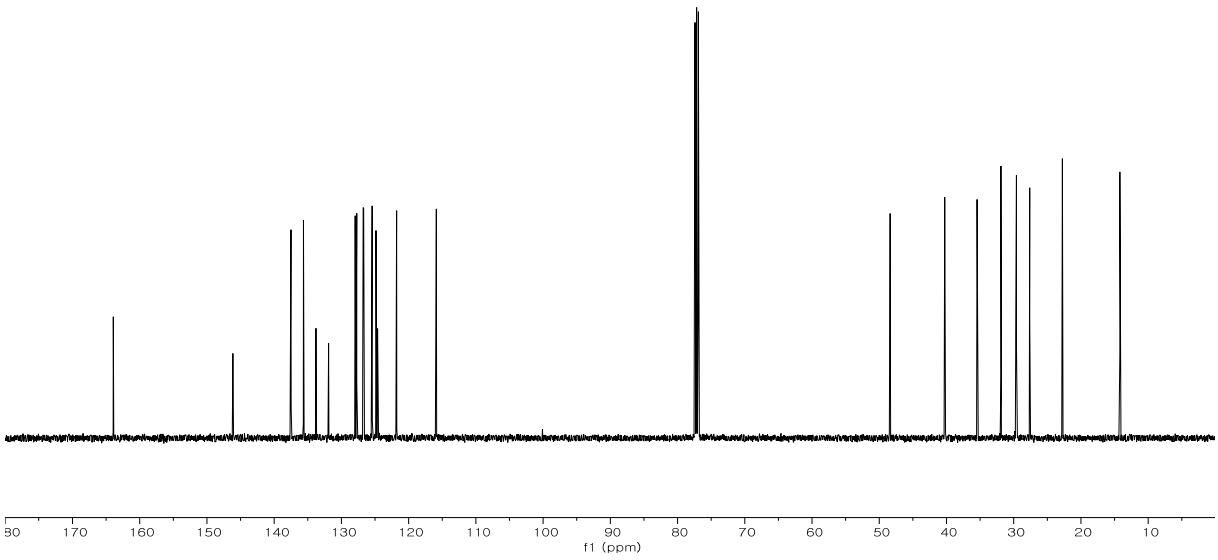


2-(Dec-1-en-4-yl)benzo[*h*]quinoline (4d)

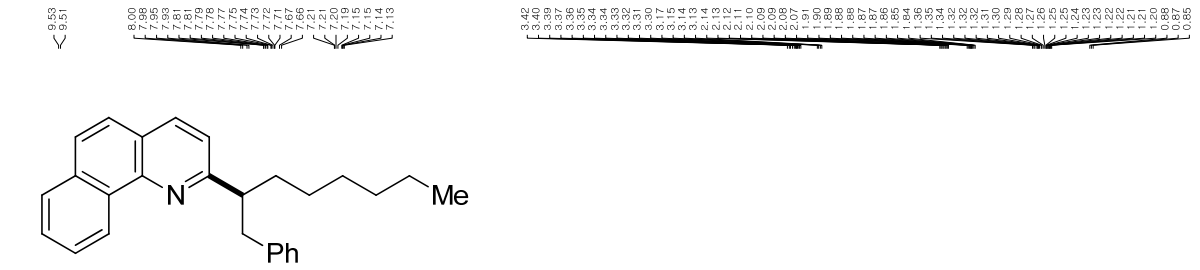


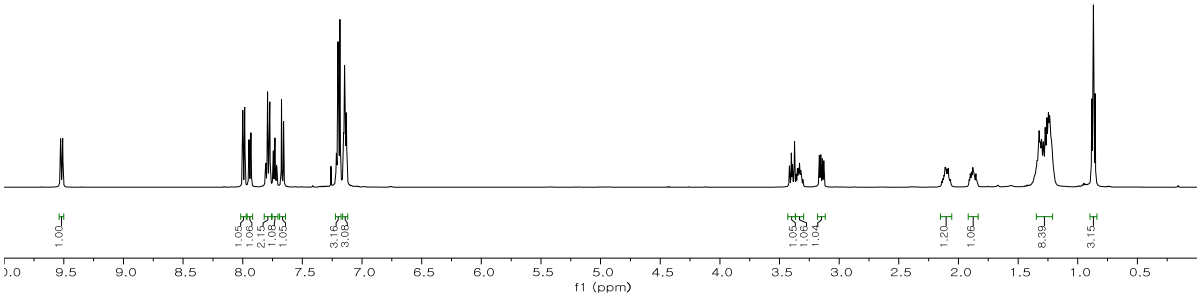


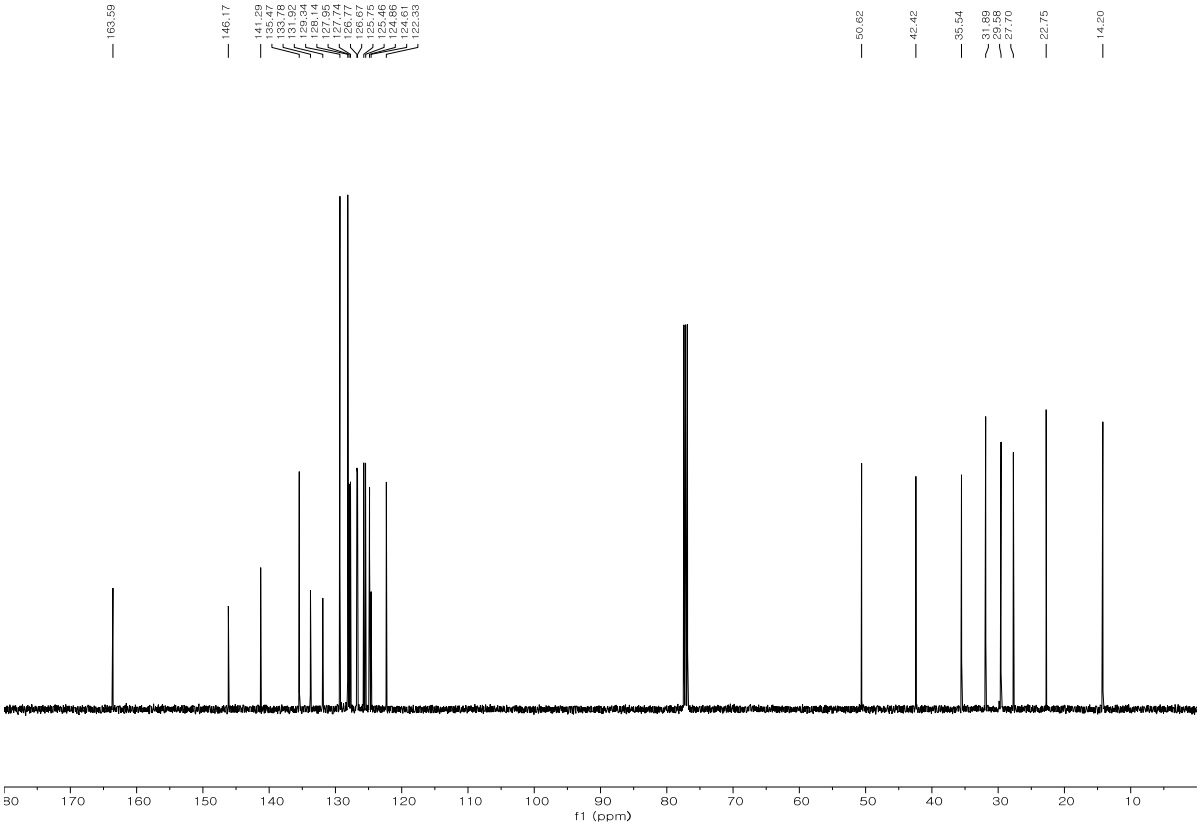




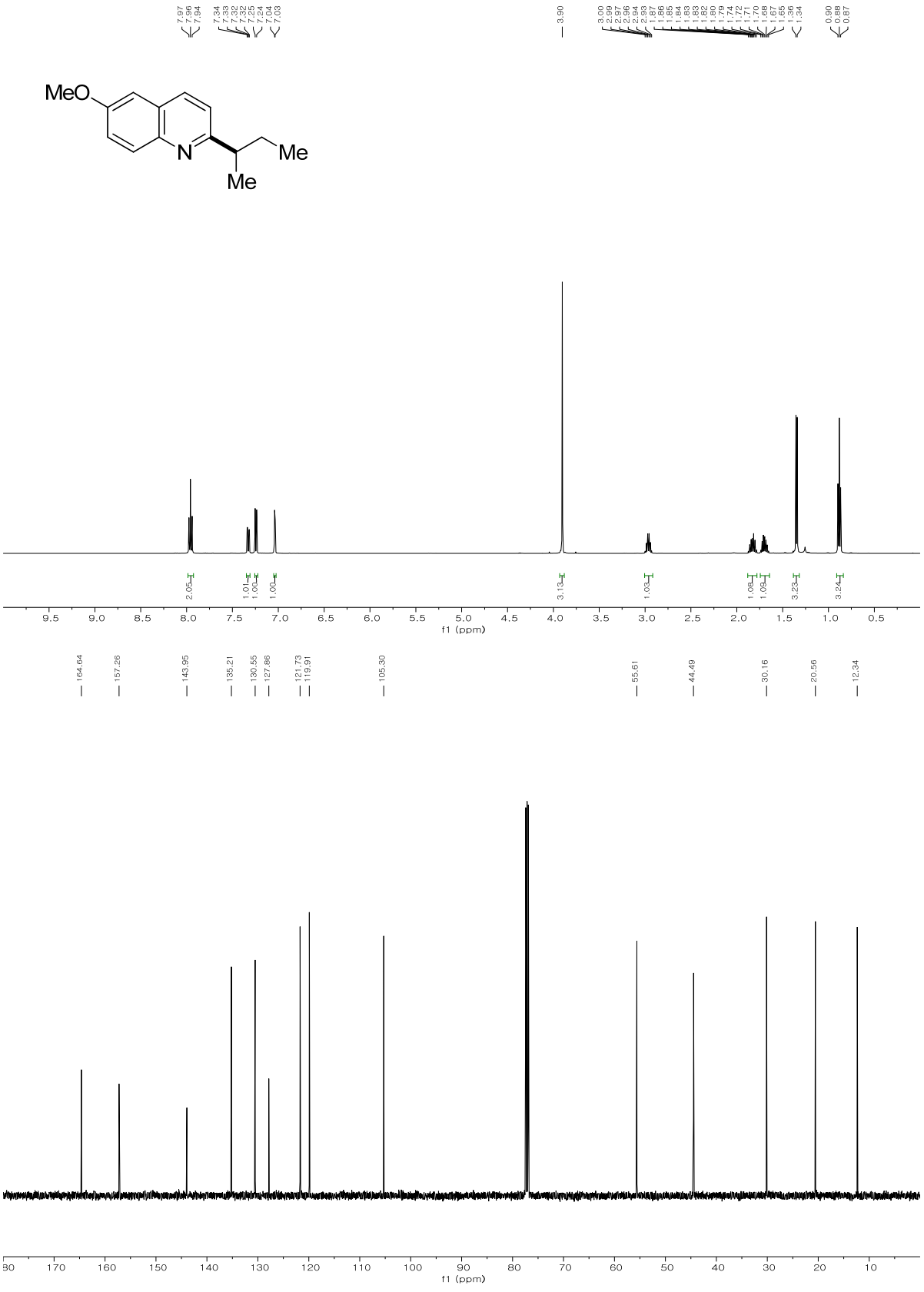
2-(1-Phenyloctan-2-yl)benzo[*h*]quinoline (4e)



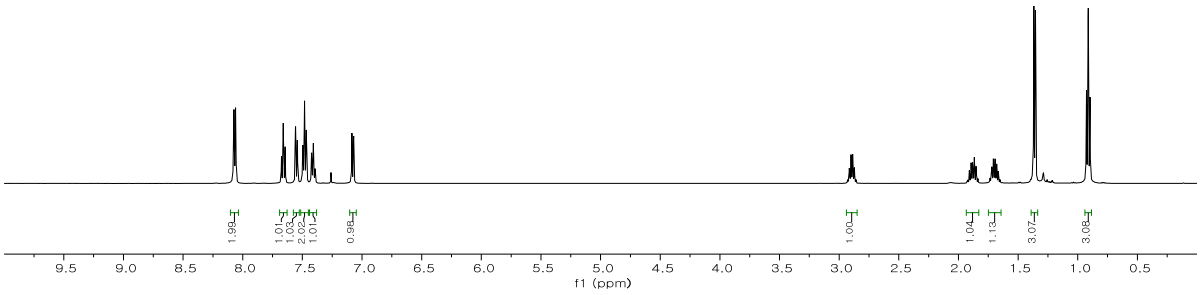


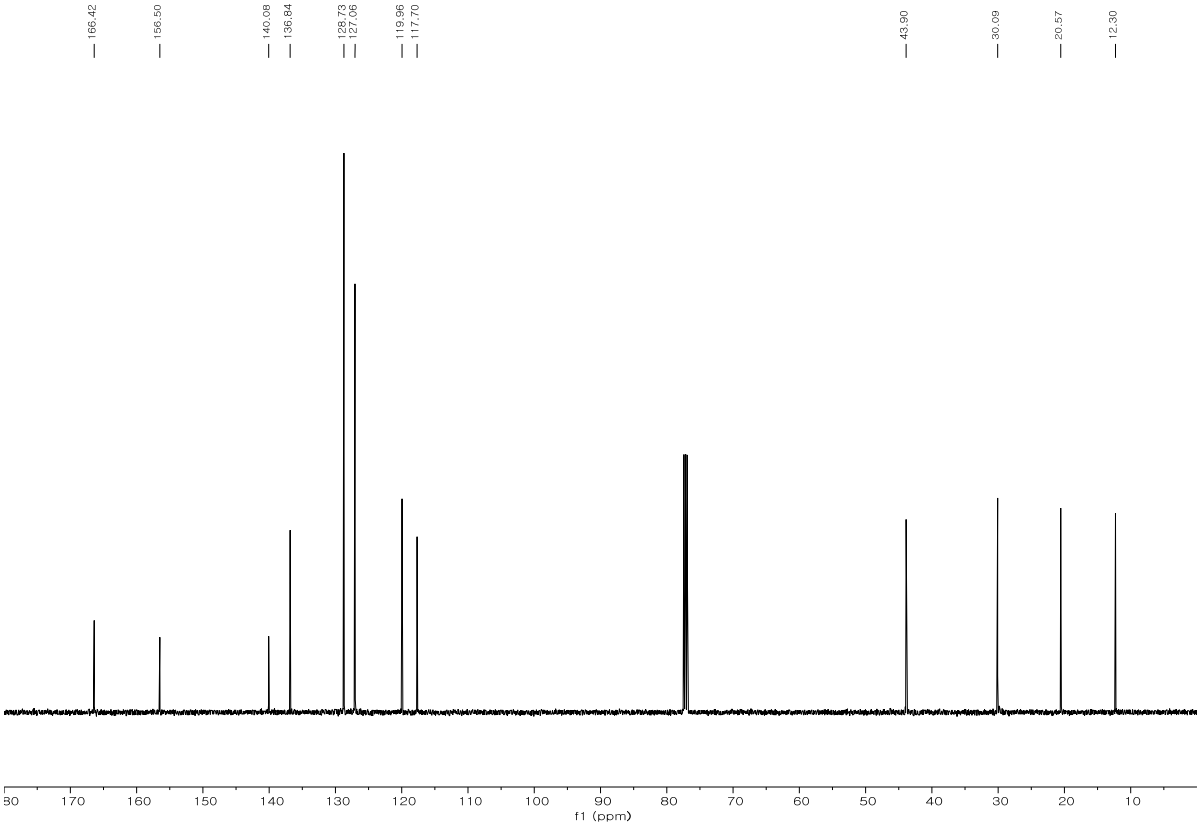


2-(*sec*-Butyl)-6-methoxyquinoline (4f)

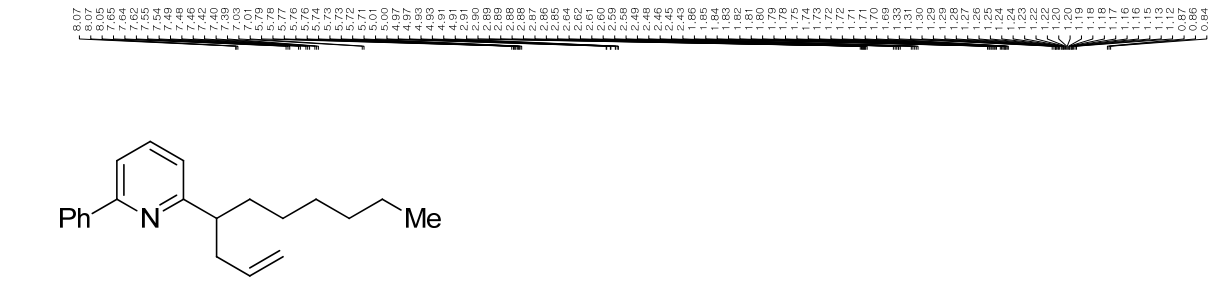


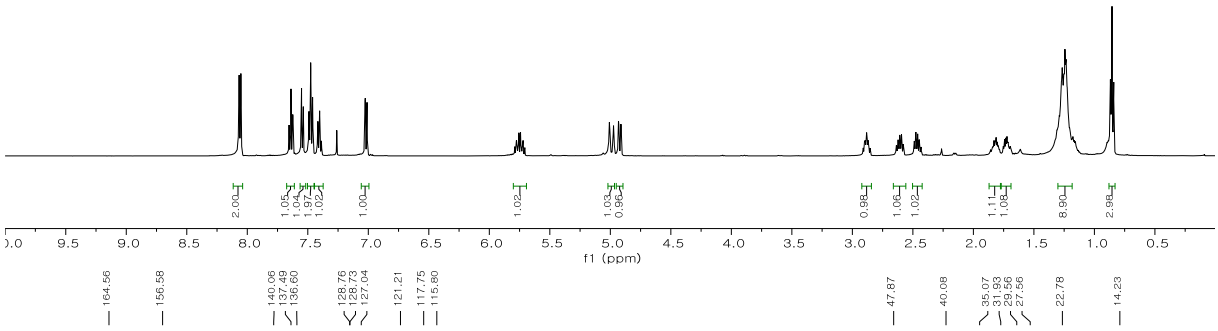
2-(sec-Butyl)-6-phenylpyridine (4g)

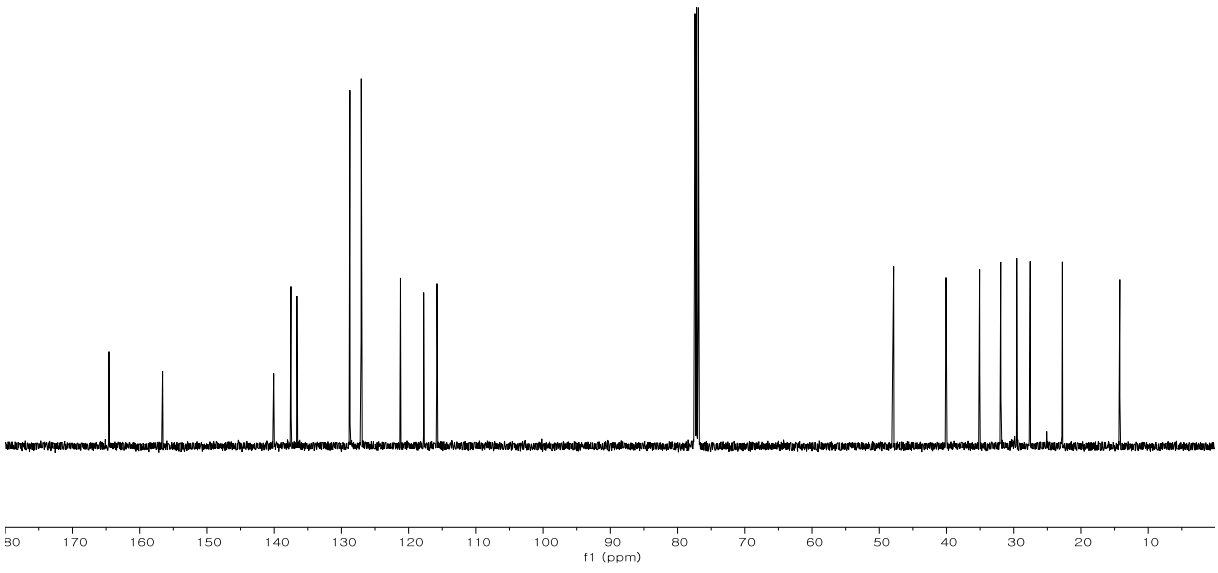




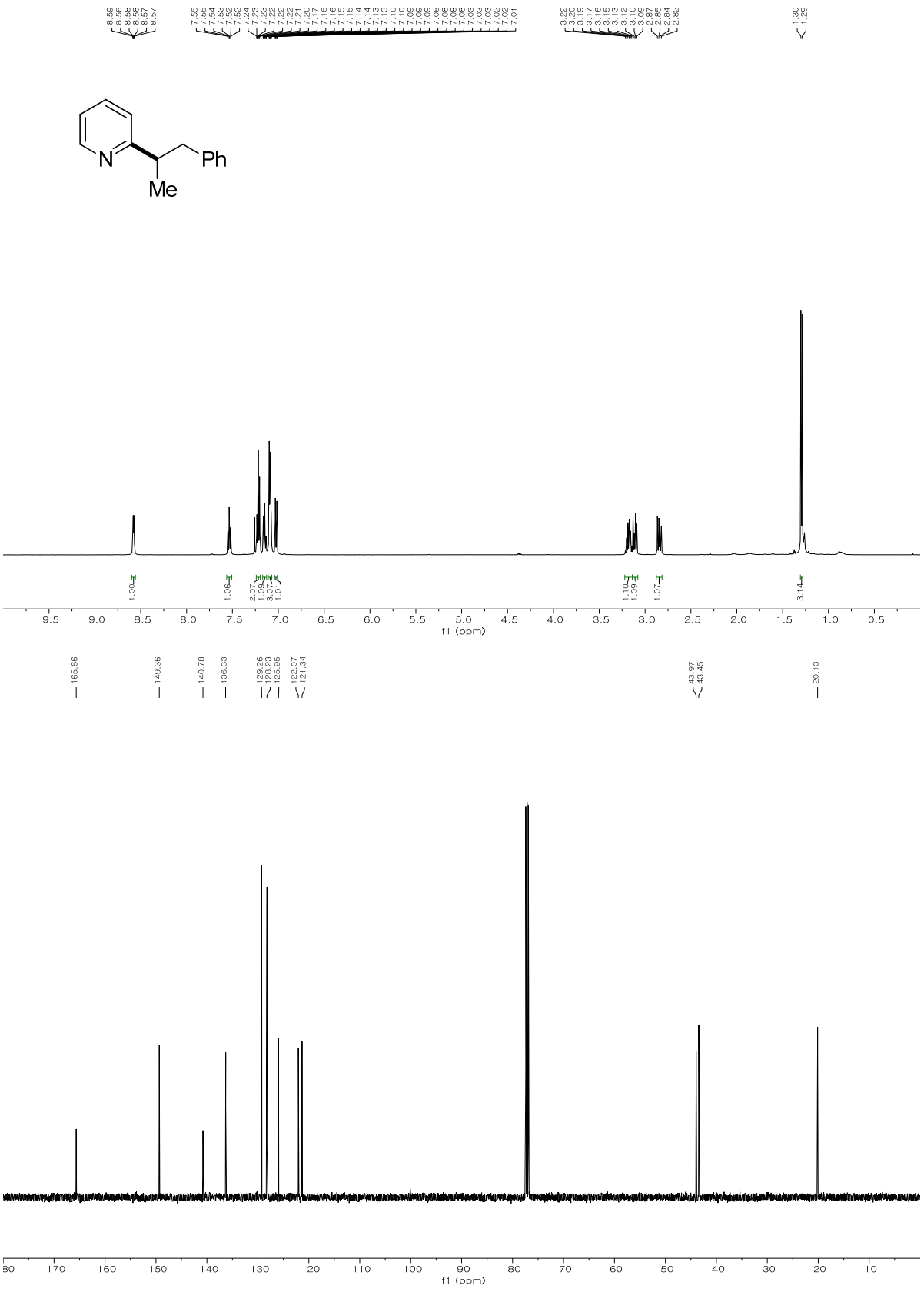
2-(Dec-1-en-4-yl)-6-phenylpyridine (4h)



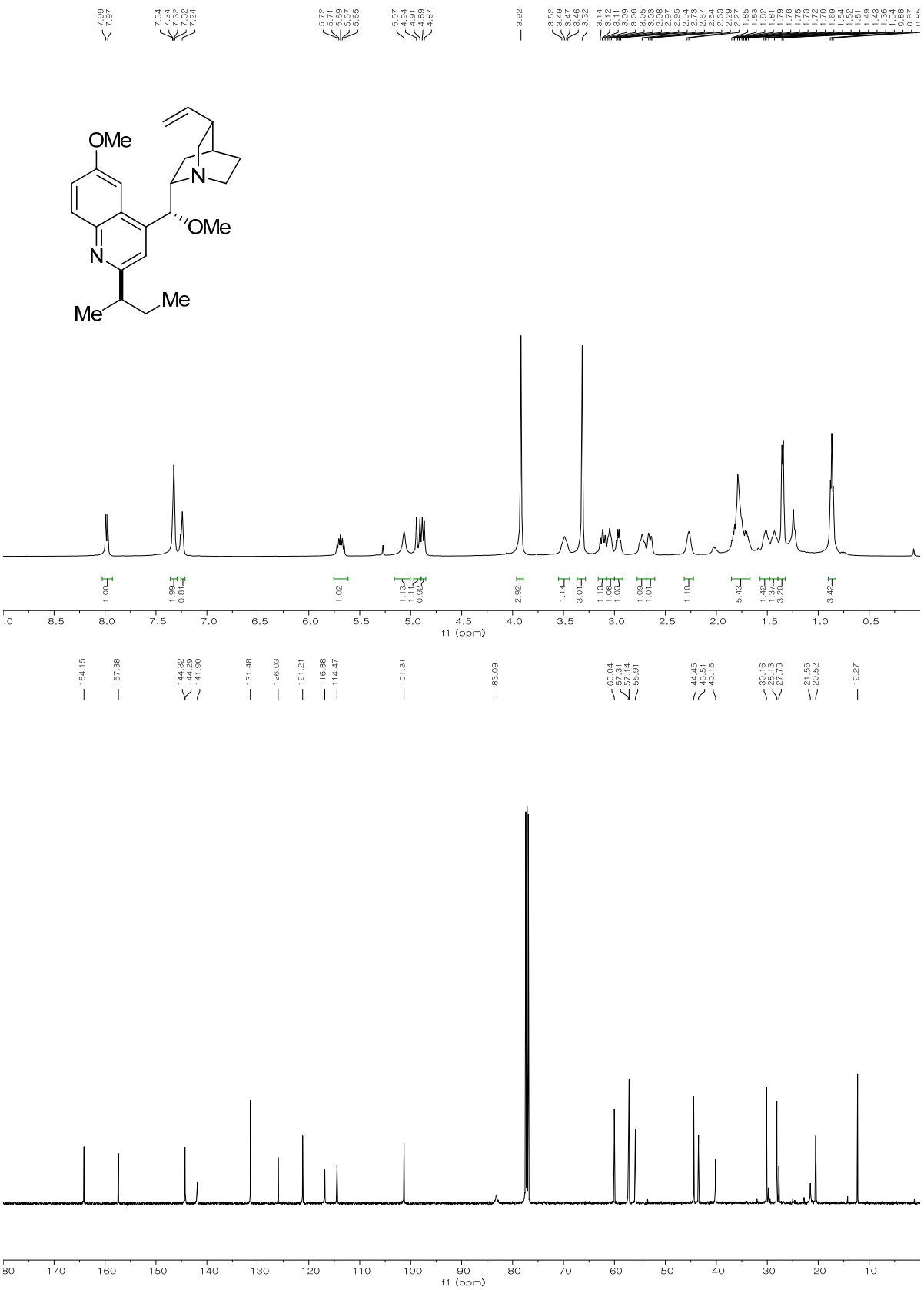




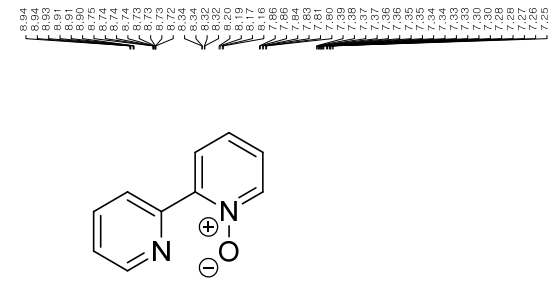
2-(1-Phenylpropan-2-yl)pyridine (4i)

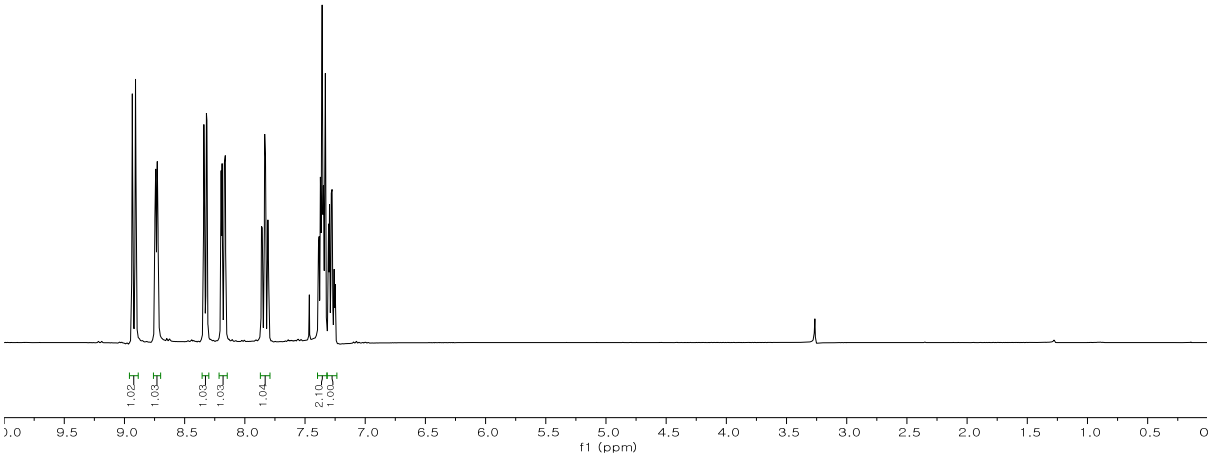


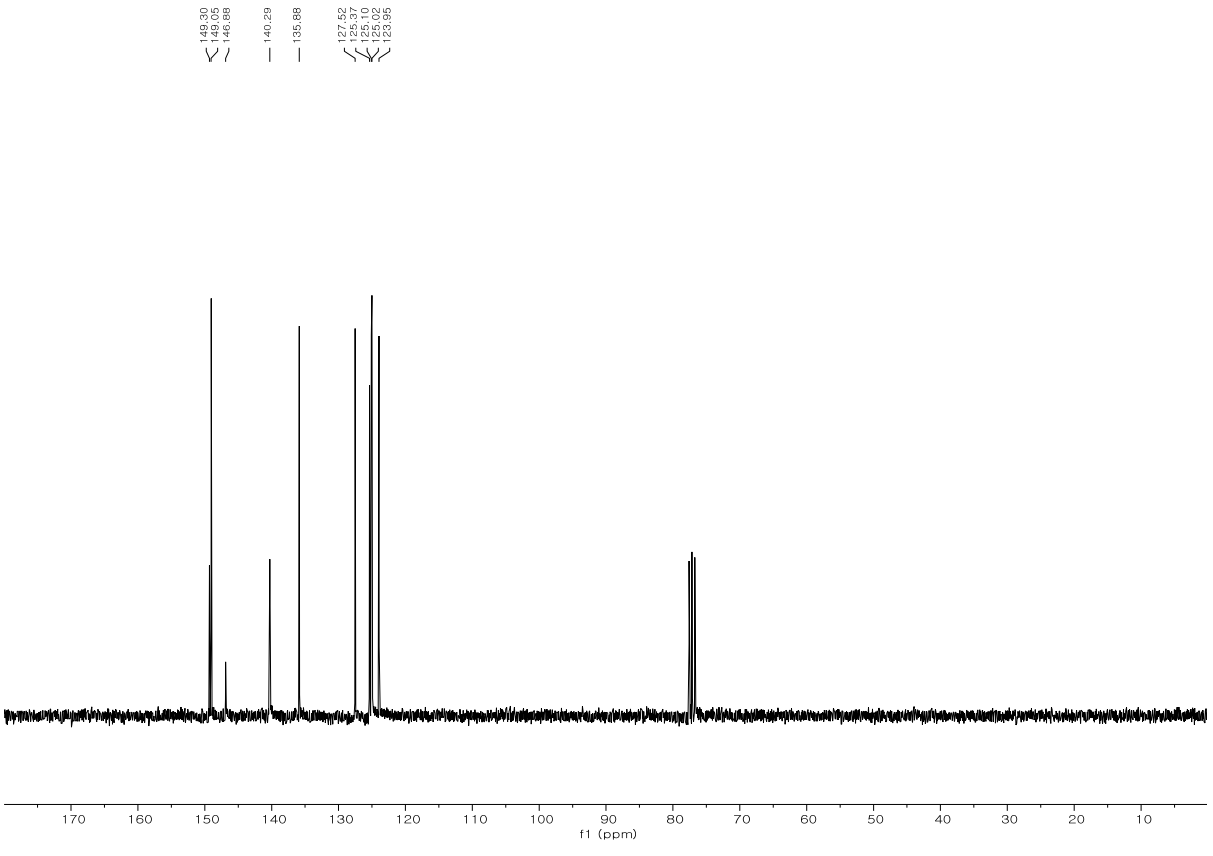
9-*O*-Methyl-2'-*sec*-butylquinine (4j)



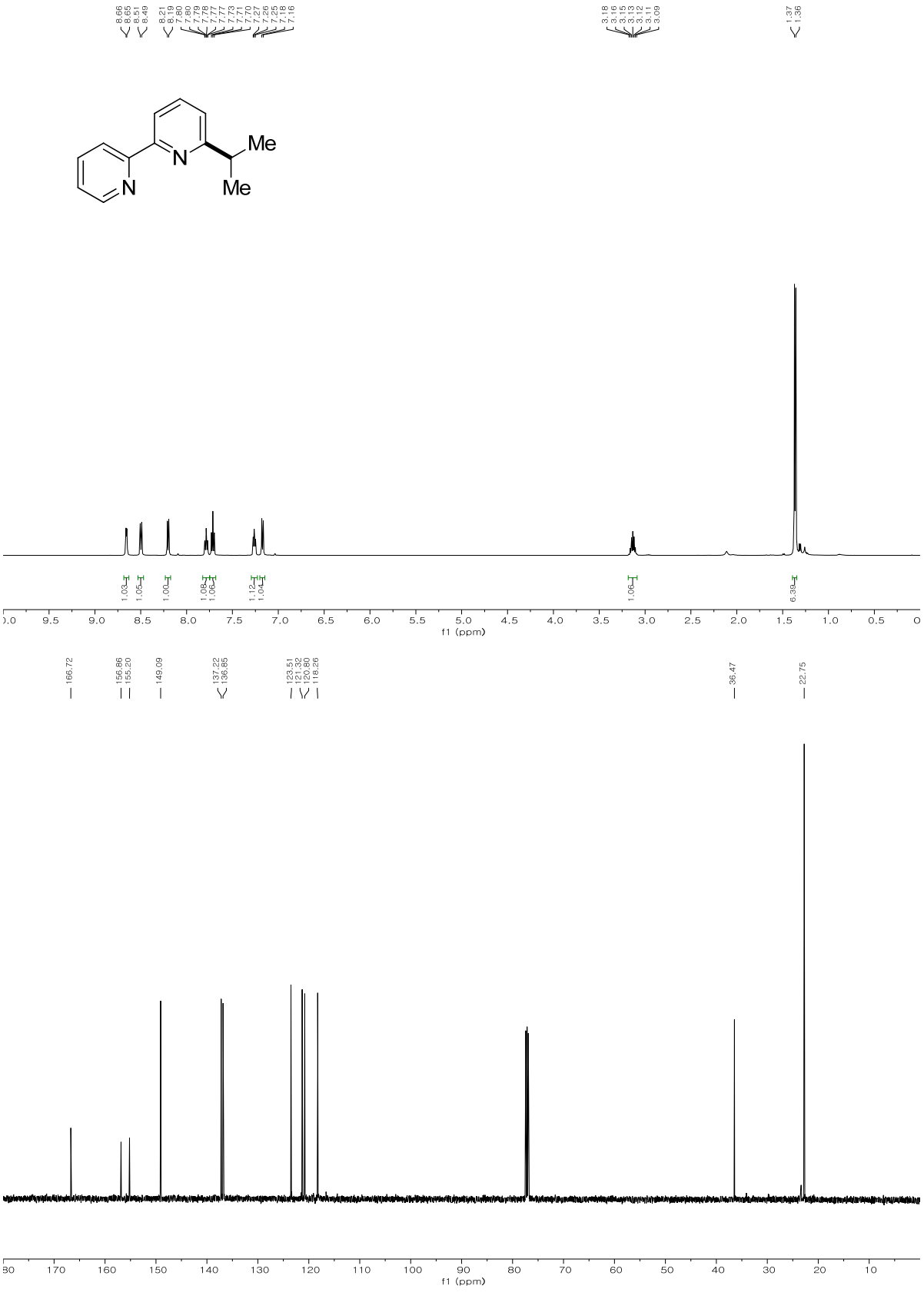
2,2'-Bipyridine-*N*-oxide (5a)



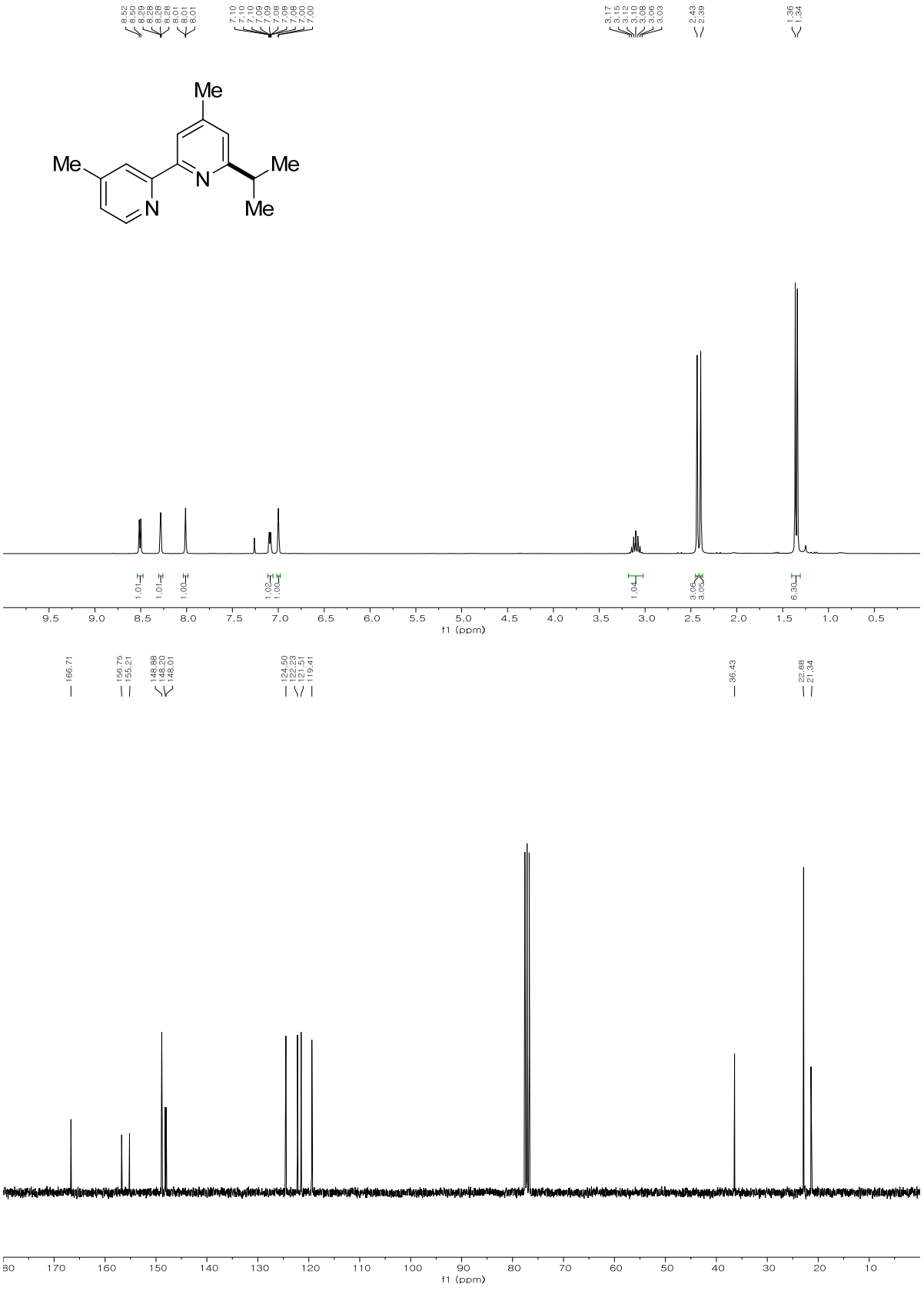




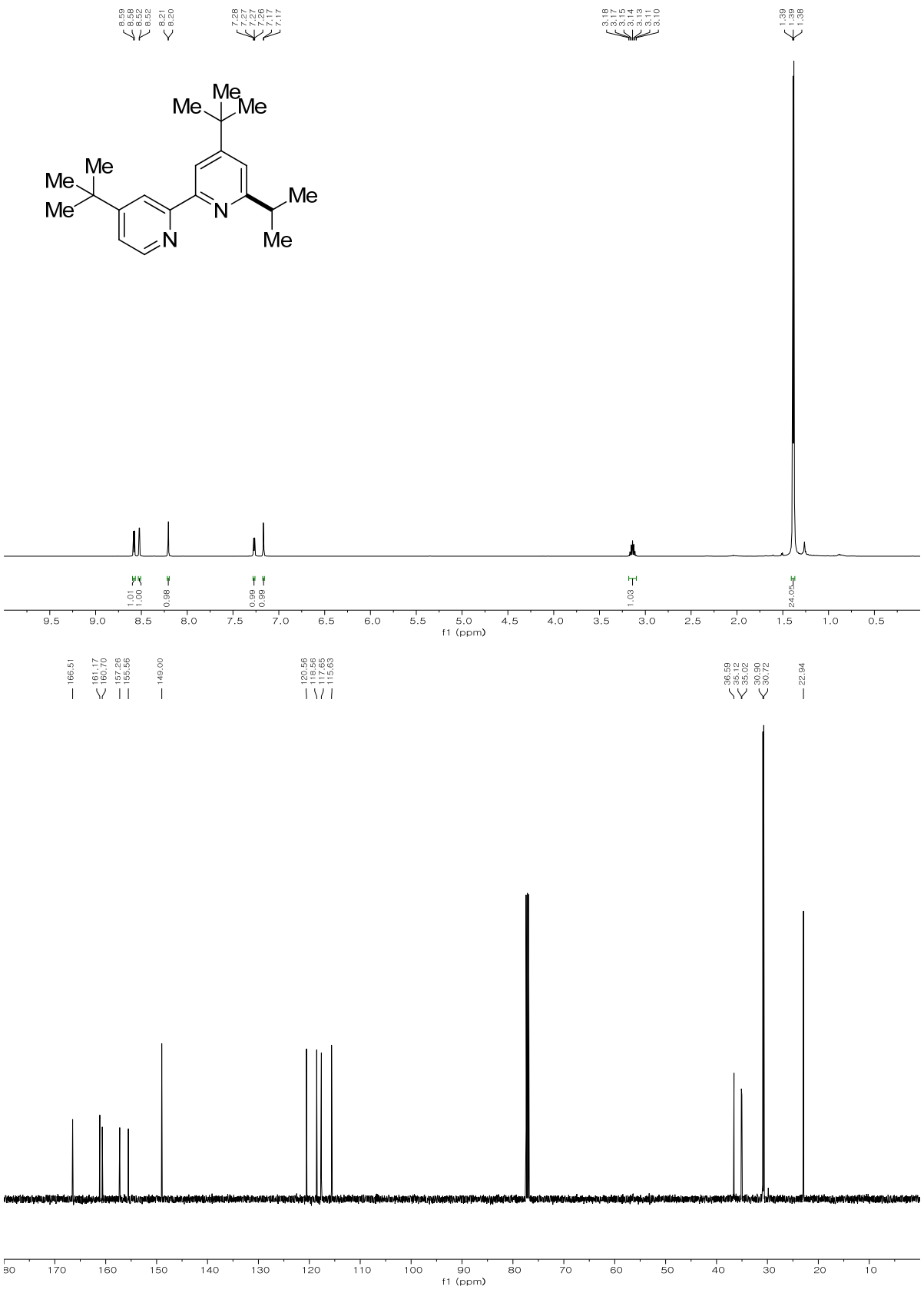
6-Isopropyl-2,2'-bipyridine (6a)



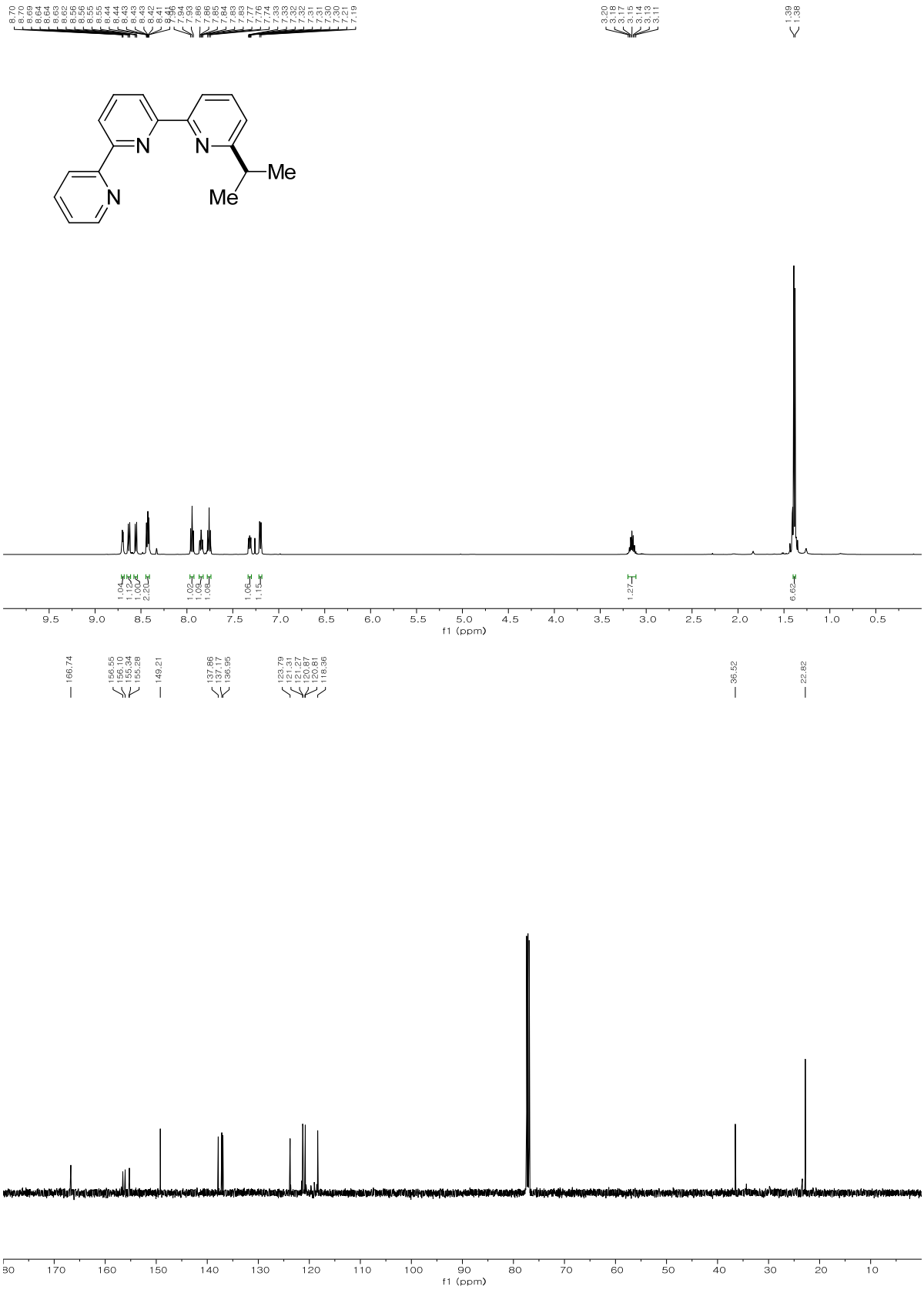
6-Isopropyl-4,4'-dimethyl-2,2'-bipyridine (6b)



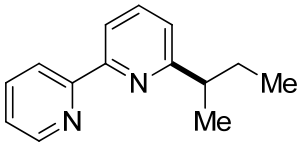
4,4'-Di-*tert*-butyl-6-isopropyl-2,2'-bipyridine (6c)

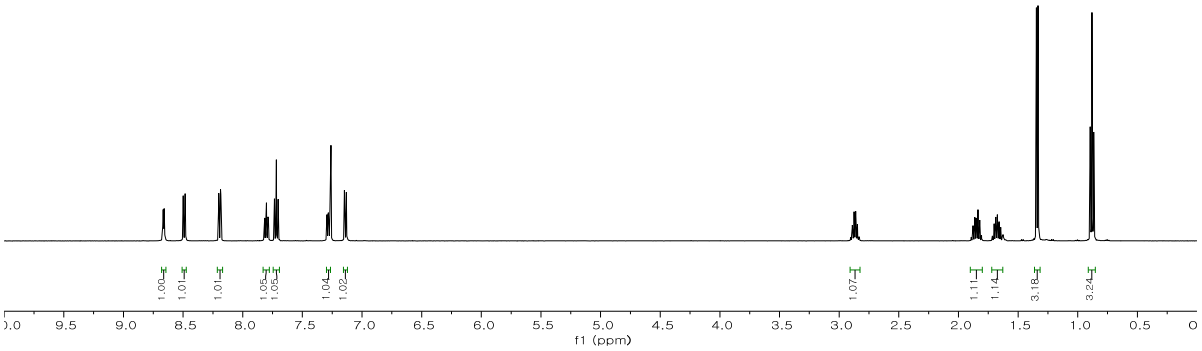


6-Isopropyl-2,2':6',2''-terpyridine (6d)

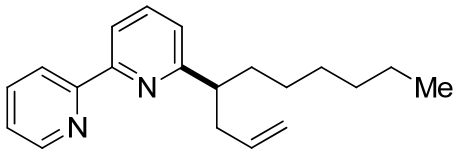


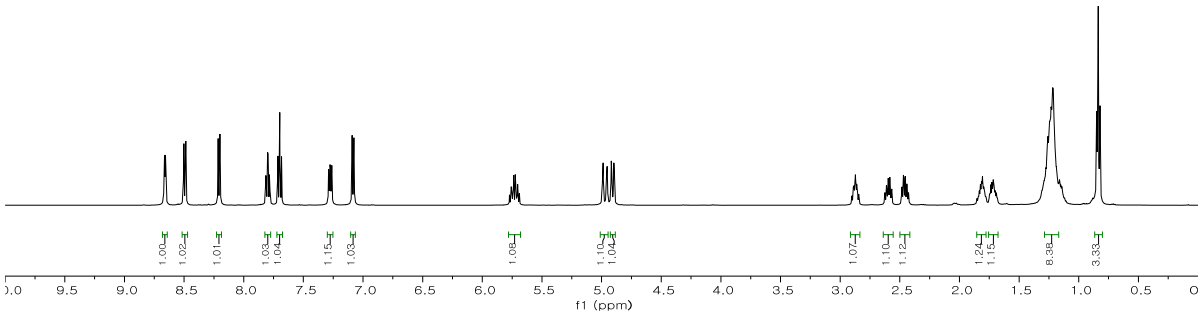
6-(*sec*-Butyl)-2,2'-bipyridine (6e)

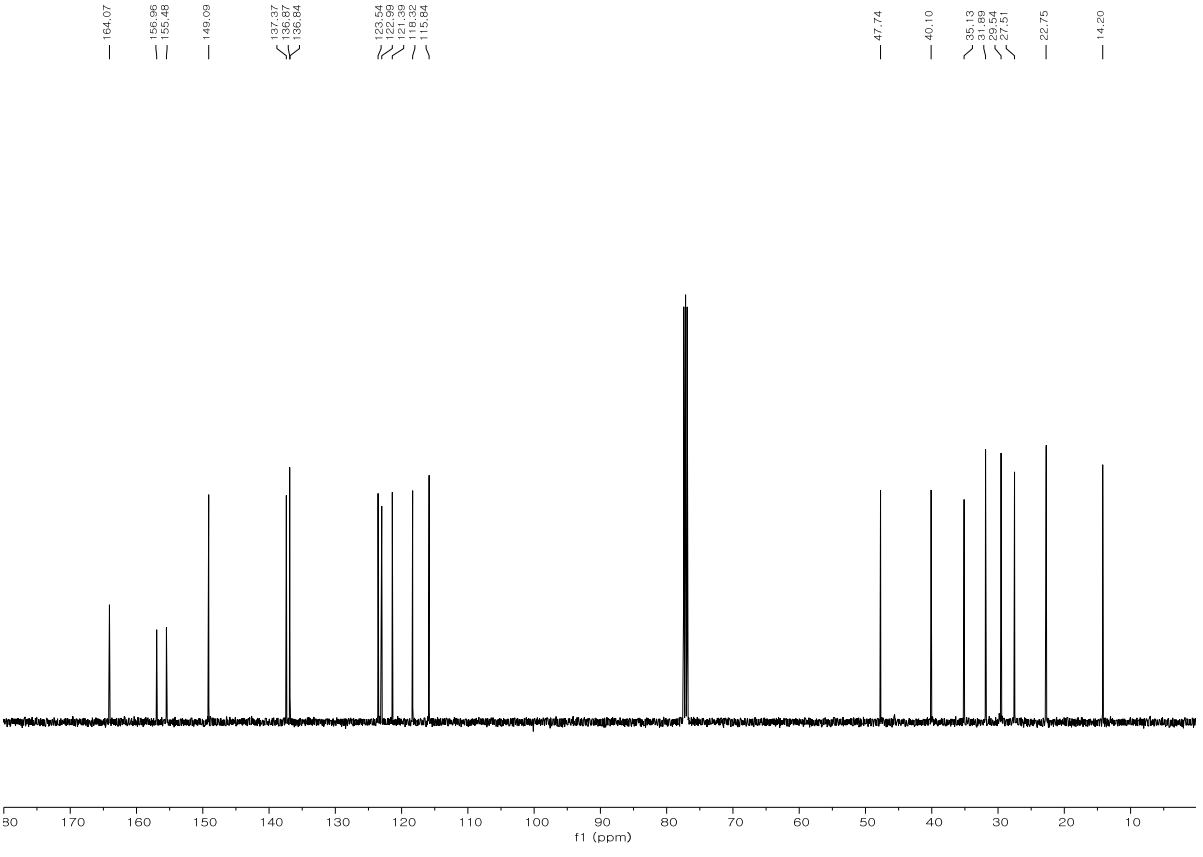




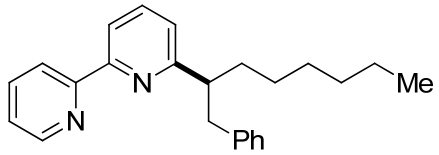
6-(Dec-1-en-4-yl)-2,2'-bipyridine (6f)

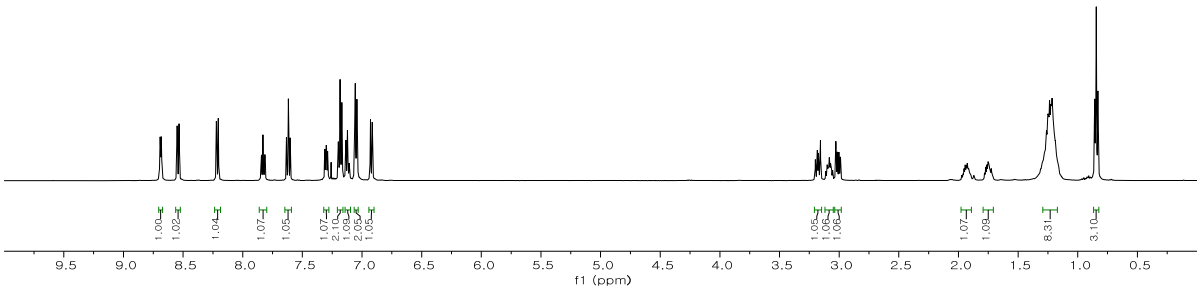


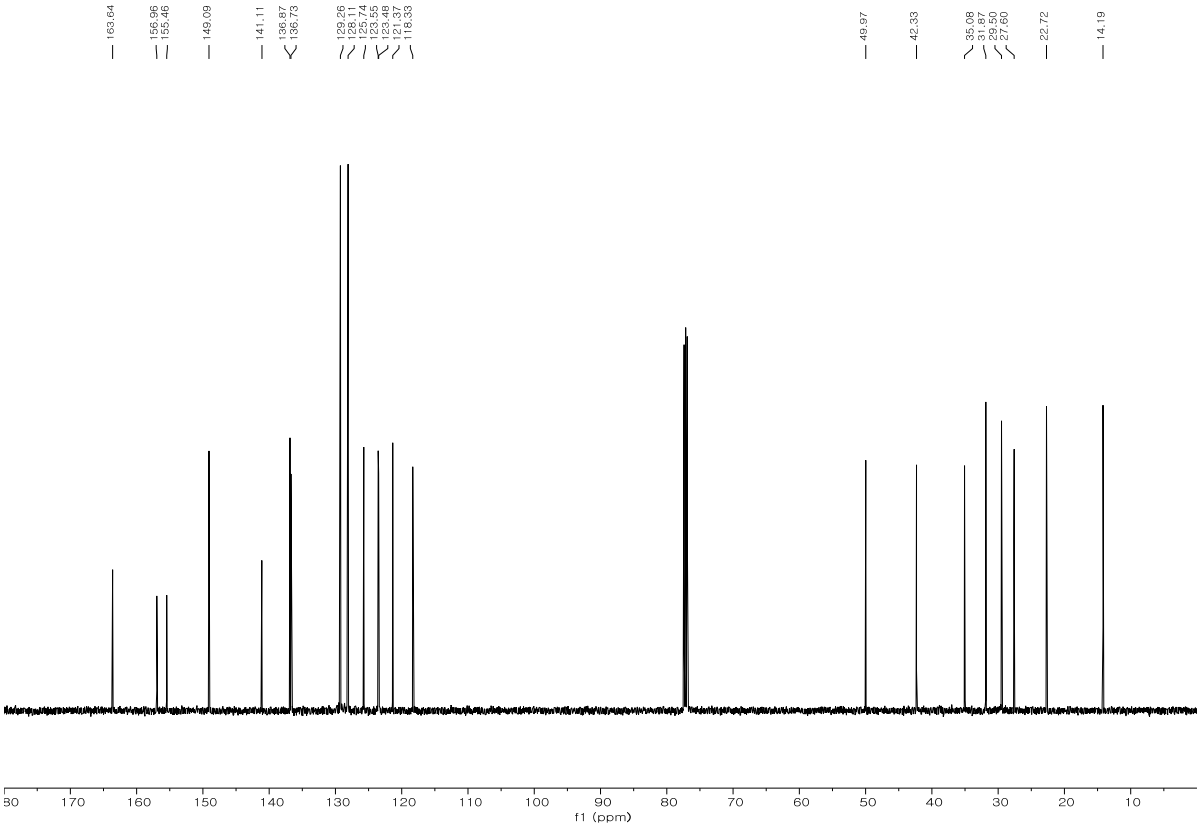




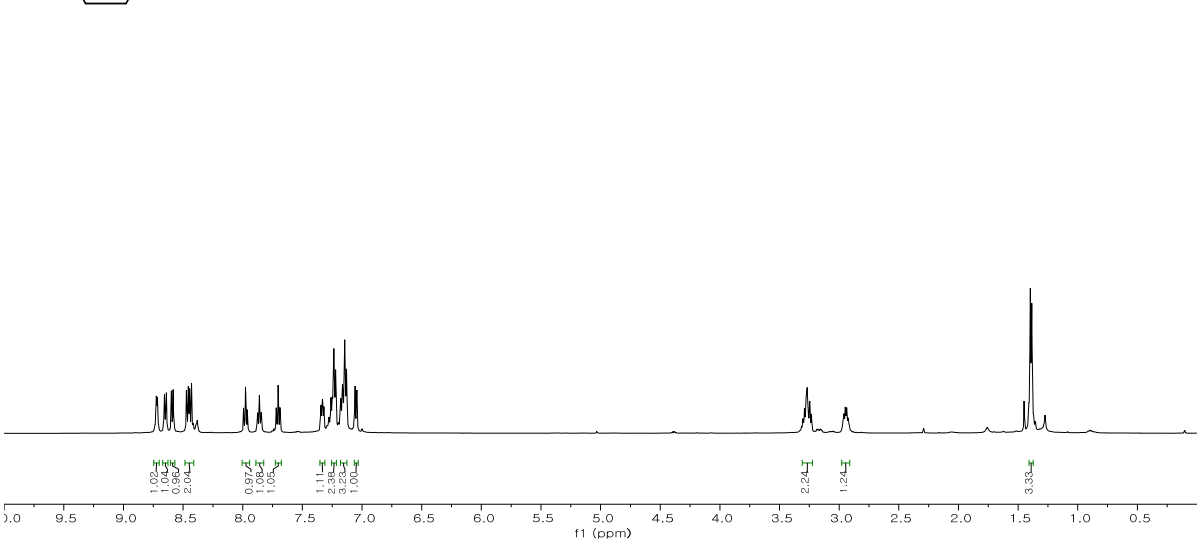
6-(1-Phenyloctan-2-yl)-2,2'-bipyridine (6g)

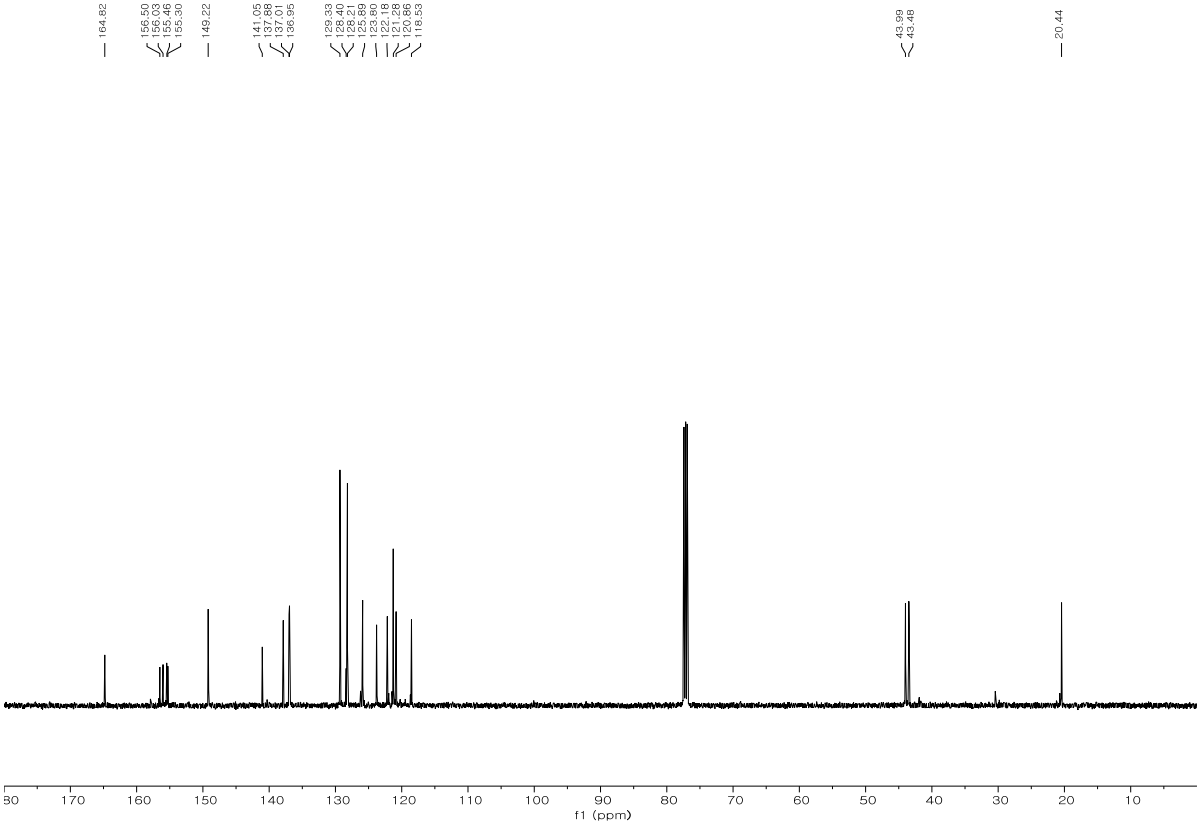




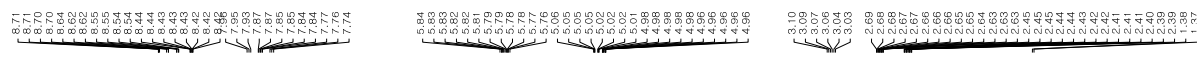


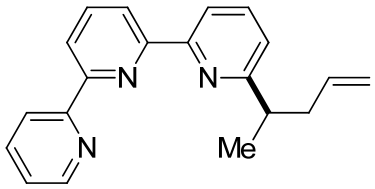
6-(1-Phenylpropan-2-yl)-2,2':6',2''-terpyridine (6h)

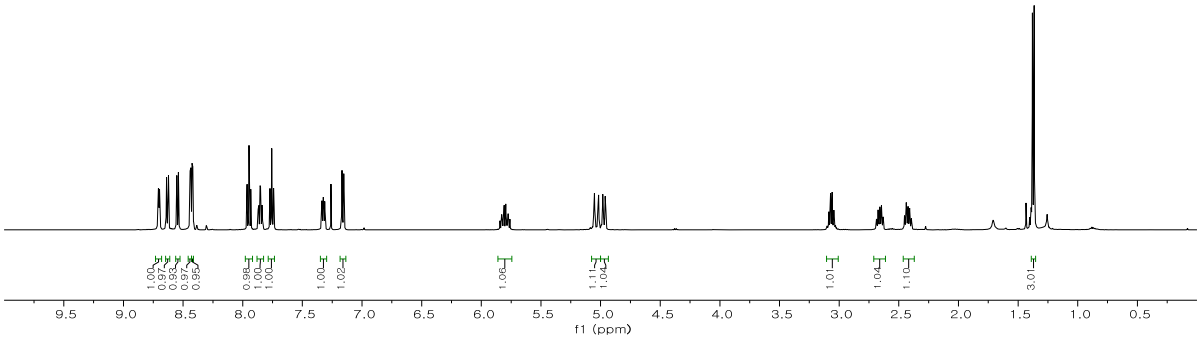


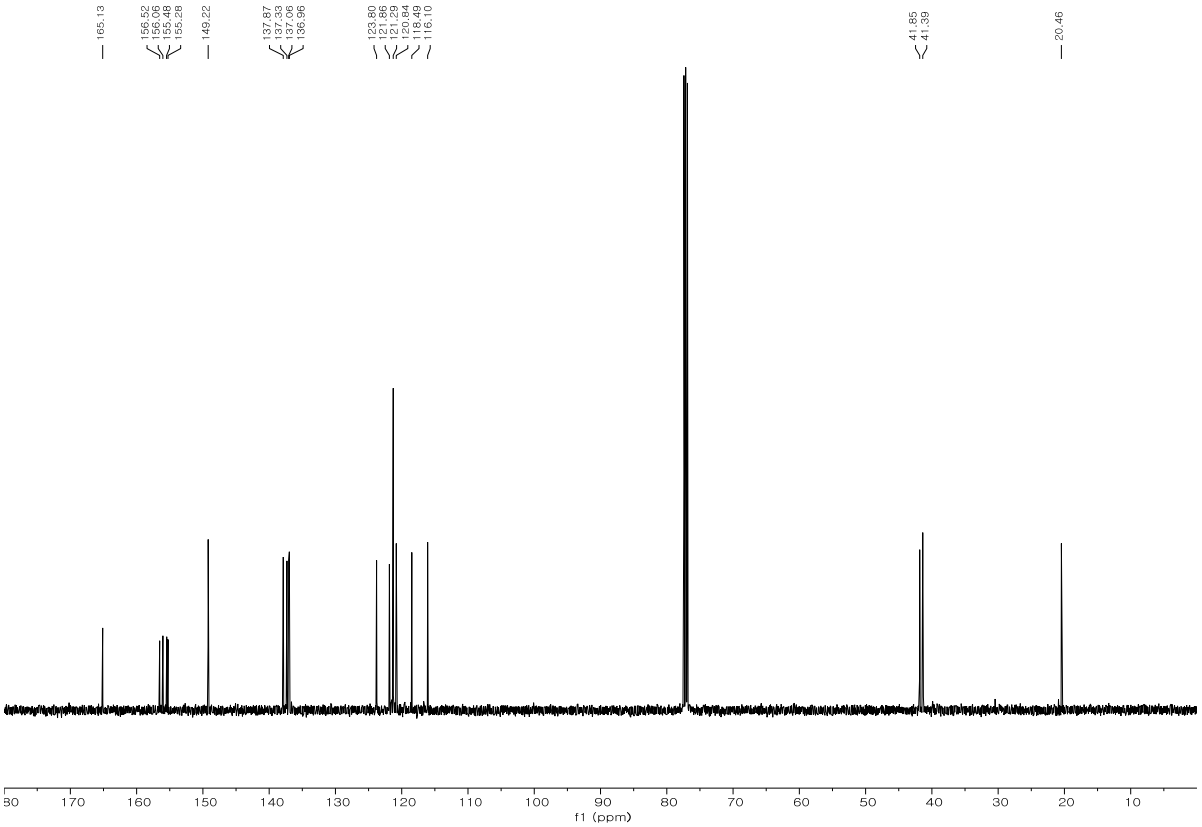


6-(Pent-4-en-2-yl)-2,2':6',2''-terpyridine (6i)

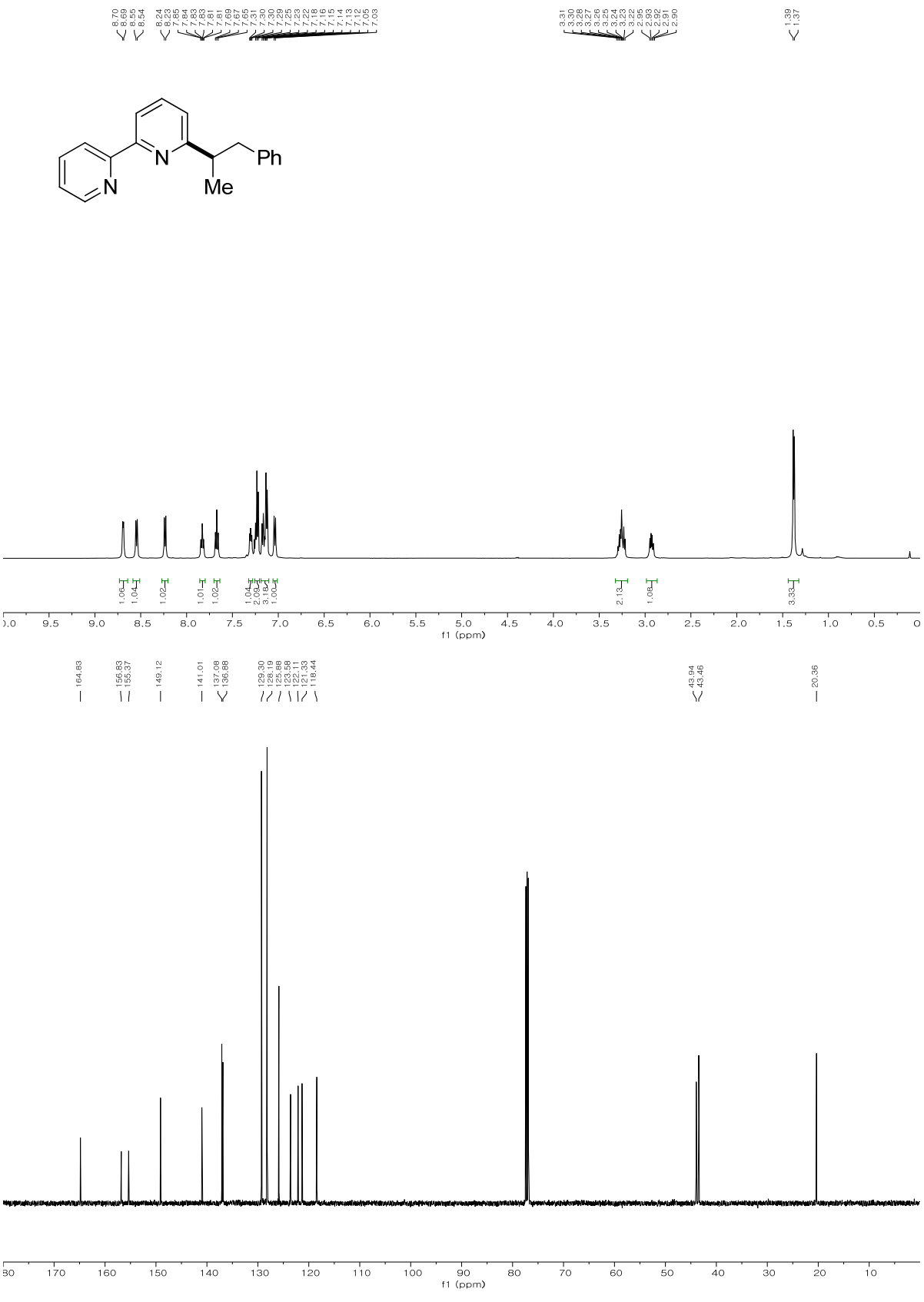




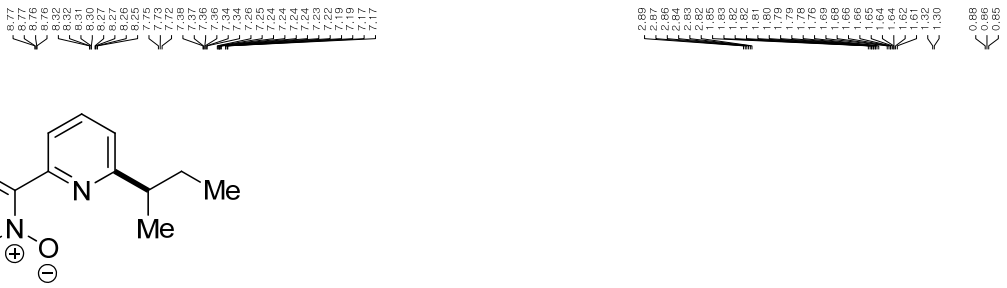


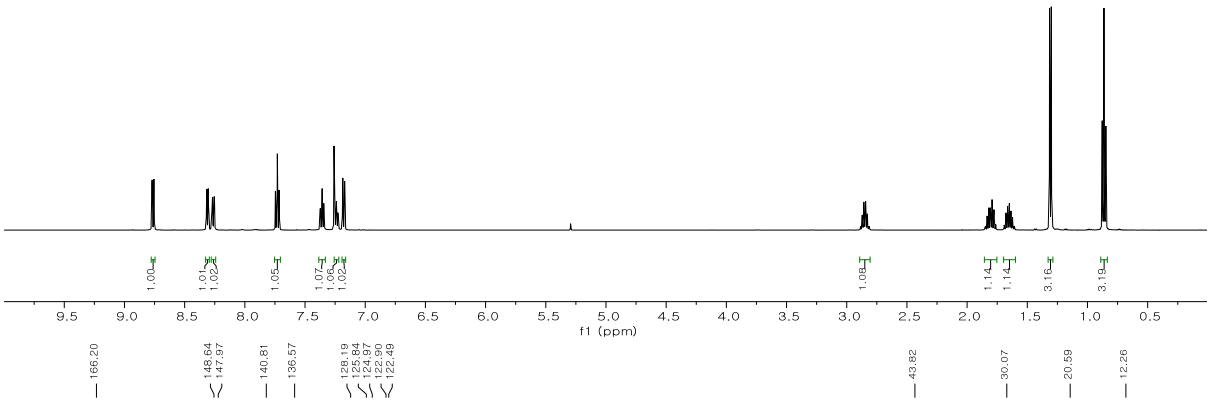


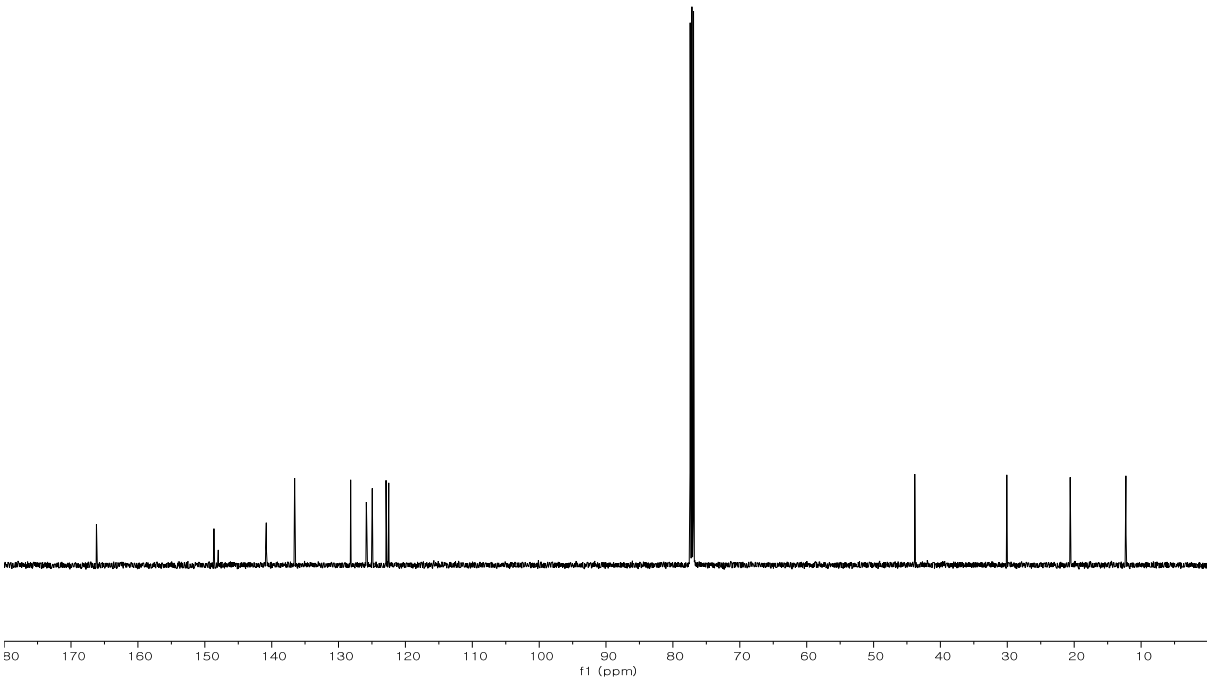
6-(1-Phenylpropan-2-yl)-2,2'-bipyridine (6j)



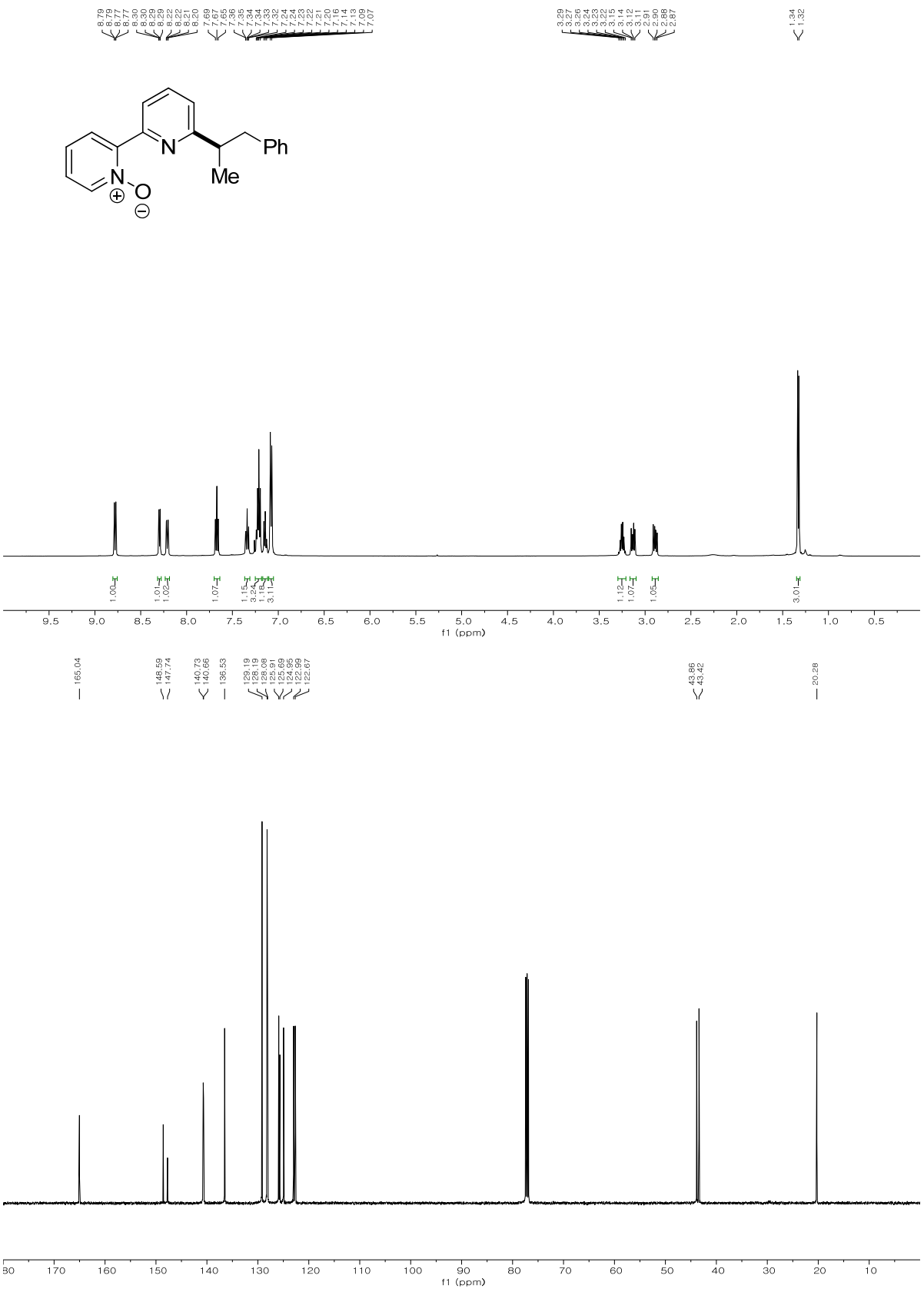
6'-(*sec*-Butyl)-2,2'-bipyridine-*N*-oxide (7a)



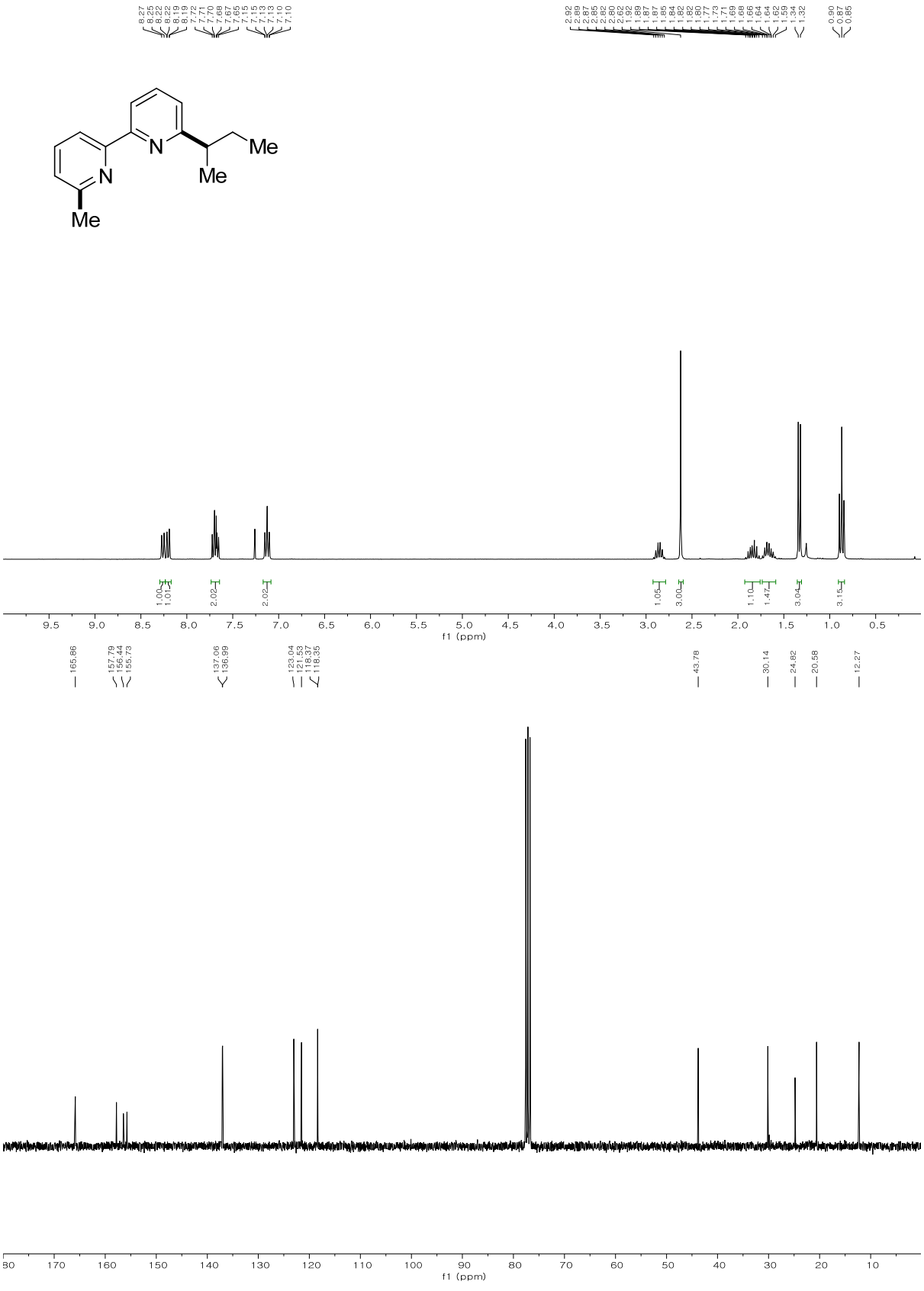




6'-(1-Phenylpropan-2-yl)-2,2'-bipyridine-*N*-oxide (7b)



6-(*sec*-Butyl)-6'-methyl-2,2'-bipyridine (8a)



6-Methyl-6'-(1-phenylpropan-2-yl)-2,2'-bipyridine (8b)