

o-Naphthoquinone-Catalyzed Aerobic Oxidation of Amines to (Ket)imines:

A Modular Catalyst Approach

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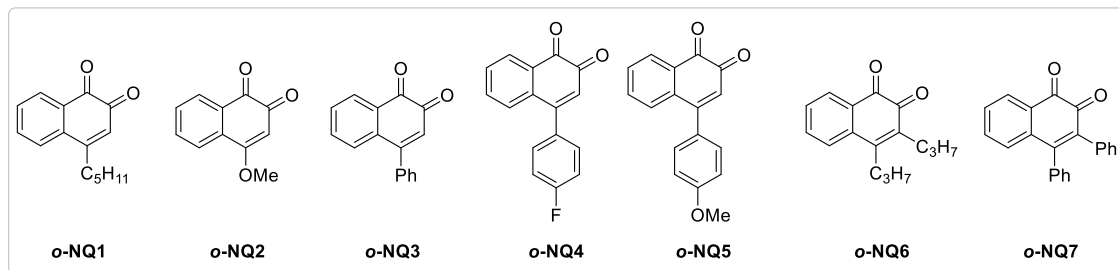
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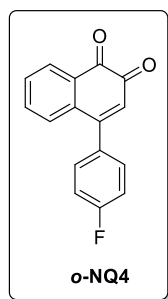
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General Methods. All reactions were carried out under argon atmosphere with oven-dried glassware. The progress of all reactions was monitored by thin-layer chromatography on Dynamic Adsorbent, Inc. precoated silica gel plates (250 μm) and visualized by ultra-violet light or by staining with KMnO_4 stain. HPLC grade CH_3CN was used without further dry. Unless otherwise specified, all chemicals were purchased from Sigma Aldrich or Alfa Aesar and all solvents were purchased from Fischer Scientific. The ^1H NMR and ^{13}C NMR spectra were obtained on Varian 600 MHz Fourier transform spectrometers. Chemical Shifts are reported in units of parts per million downfield from tetramethylsilane and all coupling constants are reported in Hertz. The infrared spectra were obtained using a Thermo Nicolet IR 300 Spectrometer. Silica gel (32-64u, Dynamic Adsorbent, Inc.) was used for column chromatography. Melting points were recorded on a Buchi-B-450 melting point apparatus and the melting point values were uncorrected.

Preparation and Characterization of Catalysts:

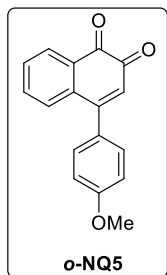


(a) Syntheses of Catalysts *o*-NQ1, *o*-NQ3, *o*-NQ6, and *o*-NQ7 were previously reported.¹ Additional *ortho*-naphthoquinone derivatives (*o*-NQ4, *o*-NQ5) were prepared and characterized.



4-(4-Fluorophenyl)naphthalene-1,2-dione (*o*-NQ4): Orange solid; 91 mg (72%); mp 156-158 $^{\circ}\text{C}$; ^1H NMR (CDCl_3 , 600 MHz): δ 8.21 (d, $J = 7.5$ Hz, 1H), 7.60 (t, $J = 7.6$ Hz, 1H), 7.55 (t, $J = 7.0$ Hz, 1H), 7.46 – 7.40 (m, 2H), 7.27 – 7.20 (m, 3H), 6.41 (s, 1H); ^{13}C NMR (CDCl_3 , 150 MHz): δ 180.5, 179.5, 163.6 (d, $J = 250.6$ Hz), 156.1, 135.3, 135.1, 132.6 (d, $J = 3.4$ Hz), 131.8, 131.1, 130.8, 130.3 (d, $J = 8.5$ Hz), 129.5, 127.8, 116.2 (d, J

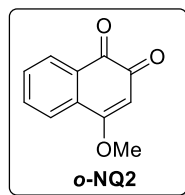
= 21.8 Hz); IR (neat): 2360, 2341, 1693, 1602, 1508, 1316, 1231, 1161, 845, 776, 731 cm^{-1} ; HRMS (ESI): m/z calcd for $\text{C}_{16}\text{H}_{10}\text{FO}_2$ $[\text{M}+\text{H}]^+$ 253.0659 Found 253.0657.



4-(4-Methoxyphenyl)naphthalene-1,2-dione (**o-NQ5**): orange amorphous solid; 82 mg (62%); ^1H NMR (CDCl_3 , 600 MHz): δ 8.19 (d, $J = 7.4$ Hz, 1H), 7.61 – 7.56 (m, 1H), 7.53 (t, $J = 7.5$ Hz, 1H), 7.39 (dd, $J = 14.3, 8.2$ Hz, 3H), 7.03 (d, $J = 8.6$ Hz, 2H), 6.41 (s, 1H), 3.89 (s, 3H); ^{13}C NMR (CDCl_3 , 150 MHz): δ 180.6, 179.9, 161.1, 157.0, 135.4, 135.1, 131.9, 130.8, 130.6, 129.9, 129.7, 128.8, 127.2, 114.4, 55.6; IR (neat): 2359, 2341, 1698,

1652, 1604, 1509, 1290, 1250, 1211, 1178, 1027, 774, 668 cm^{-1} ; HRMS (ESI): m/z calcd for $\text{C}_{17}\text{H}_{13}\text{O}_3$ $[\text{M}+\text{H}]^+$ 265.0859 Found 265.0857.

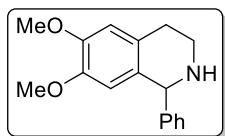
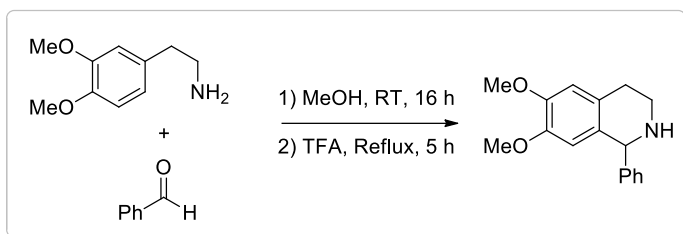
(b) **Catalyst o-NQ2** was prepared by literature procedure and spectral data was consistent with literature data.^{2a}



4-Methoxynaphthalene-1,2-dione (**o-NQ2**): yellow solid; 56 mg (59%); ^1H NMR (CDCl_3 , 600 MHz): δ 8.11 (d, $J = 7.6$ Hz, 1H), 7.86 (d, $J = 7.8$ Hz, 1H), 7.69 (t, $J = 7.6$ Hz, 1H), 7.58 (t, $J = 7.1$ Hz, 1H), 5.97 (s, 1H), 4.01 (s, 3H); ^{13}C NMR (CDCl_3 , 150 MHz): δ 179.6, 179.5, 168.8, 135.1, 132.1, 131.6, 130.5, 129.2, 124.8, 103.2, 56.9.

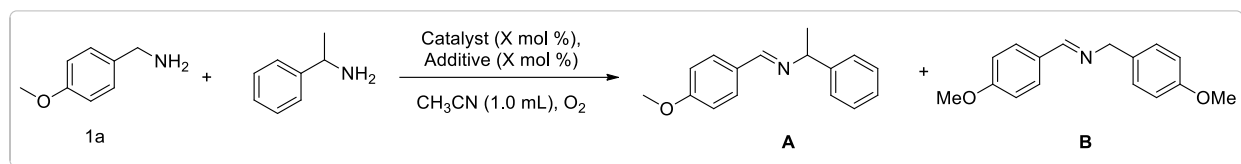
Synthesis and Characterization of 1-Phenyl-6,7-dimethoxy-1,2,3,4-tetrahydroisoquinoline:

Tetrahydroisoquinoline was prepared by literature procedure.³



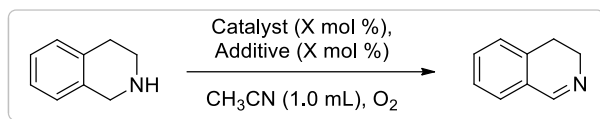
6,7-Dimethoxy-1-phenyl-1,2,3,4-tetrahydroisoquinoline: ¹H NMR and ¹³C NMR spectra for this compound are consistent with previously reported literature data.³

¹H NMR (CDCl₃, 600 MHz): δ 7.32 (t, *J* = 7.4 Hz, 2H), 7.29 – 7.23 (m, 3H), 6.63 (s, 1H), 6.25 (s, 1H), 5.04 (s, 1H), 3.87 (s, 3H), 3.63 (s, 3H), 3.25 – 3.18 (m, 1H), 3.07 – 3.01 (m, 1H), 2.96 – 2.89 (m, 1H), 2.79 – 2.71 (m, 1H), 1.85 (s, 1H); ¹³C NMR (CDCl₃, 150 MHz): δ 147.7, 147.1, 145.0, 130.0, 128.9, 128.5, 127.8, 127.4, 111.5, 111.1, 61.5, 55.9, 55.9, 41.9, 29.4.

Table S1: Detailed Optimization Conditions for the Cross Coupling of Amines^a

No	Catalyst (X mol %)	Additive (X mol %)	Solvent	Temperature	Time	Imine Selectivity ^b A:B
1	<i>o</i> -NQ3 (5)	$\text{Cu}(\text{OAc})_2$ (2)	CH_3CN	RT	48 h	58:42
2	<i>o</i> -NQ3 (5)	CuCl_2 (2)	CH_3CN	RT	48 h	52:48
3	<i>o</i> -NQ3 (5)	$\text{Cu}(\text{OAc})_2$ (2)	CH_3CN	60 °C	24 h	81:19 ^c
4	<i>o</i> -NQ3 (5)	----	CH_3CN	60 °C	48 h	72:28 ^c
5	<i>o</i> -NQ3 (5)	$\text{Cu}(\text{OAc})_2$ (2)	THF	60 °C	48 h	75:25 ^c
6	<i>o</i> -NQ2 (5)	$\text{Cu}(\text{OAc})_2$ (2)	CH_3CN	RT	24 h	45:55
7	<i>o</i> -NQ3 (5)	TFA (10)	CH_3CN	RT	24 h	78:22
8	<i>o</i> -NQ3 (5)	TFA (20)	CH_3CN	RT	24 h	79:21
9	<i>o</i> -NQ3 (5)	TFA (20)	CH_3CN	RT	24 h	88:12 ^d
10	<i>o</i> -NQ3(10)	TFA (20)	CH_3CN	RT	24 h	100:0 ^d

^a**Conditions:** Amine **1a** (0.2 mmol), α -Methylbenzylamine (0.2 mmol), Catalyst (X mol %), Additive (X mol %), O_2 balloon, MeCN (1.0 mL), rt or 60 °C, 24-48 h. ^bMolar ratio based on the ^1H NMR spectrum of the crude reaction mixture. ^cHomo coupling product of α -Methylbenzylamine was observed. ^d0.4 mmol of α -Methylbenzylamine was used.

Table S2: Detailed Optimization Conditions for the Oxidation of Secondary Amine^a

No	Catalyst (X mol %)	Additive (X mol %)	Solvent	Temperature	Time	Conversion ^b
1	<i>o</i> -NQ3(10)	Cu(OAc) ₂ (2)	CH ₃ CN	60 °C	24 h	----
2	<i>o</i> -NQ3(10)	TFA (20)	CH ₃ CN	60 °C	24 h	<5%
3	<i>o</i> -NQ3(10)	----	CH ₃ CN	60 °C	24 h	53%
4	<i>o</i> -NQ3(10)	----	MeOH	60 °C	24 h	21%
5	<i>o</i> -NQ3(10)	----	THF	60 °C	24 h	25%
6	<i>o</i> -NQ3(10)	Et ₃ N(100)	CH ₃ CN	RT	48 h	62%
7	<i>o</i> -NQ3(10)	DBU(100)	CH ₃ CN	RT	24 h	<5%
8	<i>o</i> -NQ3(10)	Ag ₂ CO ₃ (10)	CH ₃ CN	RT	24 h	84%
9	<i>o</i> -NQ3(10)	Ag ₂ CO ₃ (20)	CH ₃ CN	RT	24 h	94%
10	<i>o</i> -NQ3(10)	Ag ₂ CO ₃ (20)	CH ₃ CN	RT	36 h	100%
11	<i>o</i> -NQ3(5)	Ag ₂ CO ₃ (20)	CH ₃ CN	RT	36 h	68%
12	<i>o</i> -NQ3(10)	K ₂ CO ₃ (20)	CH ₃ CN	RT	24 h	54%
13	<i>o</i> -NQ3(10)	Na ₂ CO ₃ (20)	CH ₃ CN	RT	24 h	39%
14	<i>o</i> -NQ3(10)	CS ₂ CO ₃ (20)	CH ₃ CN	RT	24 h	21%

^a**Conditions:** Isoquinoline (0.2 mmol), Catalyst (X mol %), Additive (X mol %), O₂ balloon, MeCN (1.0 mL), rt or 60 °C, 24-48 h. ^bConversion based on the ¹H NMR spectrum of the crude reaction mixture.

Experimental Procedures:

(A) General Procedure for the Oxidation of Homo-coupled Amines:

A flame-dried 10mL flask was charged with catalyst ***o*-NQ3** (2-5 mol %), Cu(OAc)₂ (2-5 mol %), benzylamine (0.4 mmol) and 1.0 mL of CH₃CN with an O₂ balloon. The initial color of reaction solution was dark blue and changed to faint yellow in 2 h. The reaction was stirred at ambient temperature until reaction complete by TLC (18–48 h). The reaction mixture was then concentrated under reduced pressure and chromatographed on deactivated silica gel (hexanes or 10% EtOAc in hexanes) to afford the title compound.

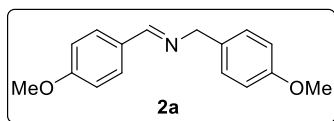
(B) General Procedure for the Oxidation of Cross-coupled Amines:

To a dry flask charged with catalyst ***o*-NQ3** (10 mol %), benzylamine (0.2 mmol), and RNH₂ (0.4 mmol) were added 1.0 mL of CH₃CN and 20 mol % TFA. The reaction was continued to stir under O₂ balloon at ambient temperature until the reaction was complete by TLC (24 h). The color of reaction solution was changed from dark blue to pale yellow in 2 h. The solution was concentrated under reduced pressure and purified to give the desired product (deactivated silica, hexanes or 10% EtOAc in hexanes).

(C) General Procedure for the Oxidation of Secondary Amines:

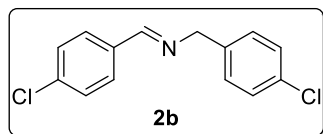
Catalyst ***o*-NQ3** (10 mol %), isoquinoline (0.2 mmol), and Ag₂CO₃ (20 mol %) were added to a flame-dried flask with 1.0 mL of CH₃CN. The reaction was stirred under O₂ at ambient temperature until the reaction was complete by TLC (36 h). The mixture was concentrated under reduced pressure and loaded on deactivated silica for a column chromatography (10-20% EtOAc in hexanes) to afford the desired product.

Characterization of the Homo-coupled Imine Products:



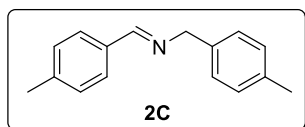
(*E*)-N-(4-Methoxybenzyl)-1-(4-methoxyphenyl)methanimine (**2a**): The product was prepared by general procedure A. yellow liquid; 95 mg (93%);

¹H NMR and ¹³C NMR spectra for this compound are consistent with previously reported literature data.⁴ ¹H NMR (CDCl₃, 600 MHz): δ 8.30 (s, 1H), 7.72 (d, *J* = 8.8 Hz, 2H), 7.28 – 7.22 (m, 2H), 6.92 (d, *J* = 8.7 Hz, 2H), 6.88 (d, *J* = 8.6 Hz, 2H), 4.73 (s, 2H), 3.84 (s, 3H), 3.80 (s, 3H); ¹³C NMR (CDCl₃, 150 MHz): δ 161.7, 161.0, 158.7, 131.8, 129.9, 129.3, 129.2, 114.1, 114.0, 64.5, 55.4, 55.4.



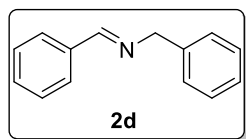
(*E*)-N-(4-Chlorobenzyl)-1-(4-chlorophenyl)methanimine (**2b**): The product was prepared by general procedure A. off white solid; 101 mg (96%); ¹H

NMR and ¹³C NMR spectra for this compound are consistent with previously reported literature data.⁴ ¹H NMR (CDCl₃, 600 MHz): δ 8.34 (s, 1H), 7.71 (d, *J* = 8.5 Hz, 2H), 7.39 (d, *J* = 8.4 Hz, 2H), 7.31 (d, *J* = 8.4 Hz, 2H), 7.26 (d, *J* = 7.3 Hz, 2H), 4.77 (s, 2H); ¹³C NMR (CDCl₃, 150 MHz): δ 160.98, 137.73, 137.04, 134.59, 132.98, 129.60, 129.40, 129.08, 128.78, 64.32.



(*E*)-N-(4-Methylbenzyl)-1-(p-tolyl)methanimine (**2c**): The product was prepared by general procedure A. white solid; 85 mg (95%); ¹H NMR and ¹³C

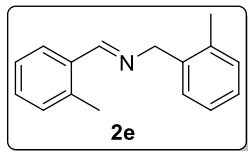
NMR spectra for this compound are consistent with previously reported literature data.⁵ ¹H NMR (CDCl₃, 600 MHz): δ 8.34 (s, 1H), 7.67 (d, *J* = 8.1 Hz, 2H), 7.24 – 7.20 (m, 4H), 7.17 – 7.13 (m, 2H), 4.77 (s, 2H), 2.38 (s, 3H), 2.34 (s, 3H); ¹³C NMR (CDCl₃, 150 MHz): δ 161.8, 141.1, 136.6, 136.4, 133.7, 129.4, 129.2, 128.3, 128.0, 64.9, 21.6, 21.2.



(*E*)-N-Benzyl-1-phenylmethanimine (**2d**): The product was prepared by general procedure A. yellow liquid; 66 mg (84%); ¹H NMR and ¹³C NMR spectra for this

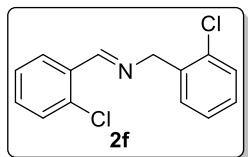
compound are consistent with previously reported literature data.⁴ ¹H NMR (CDCl₃, 600 MHz): δ 8.40 (s, 1H), 7.81 – 7.76 (m, 2H), 7.44 – 7.39 (m, 3H), 7.37 – 7.32 (m, 4H), 7.29 –

7.24 (m, 1H), 4.83 (s, 2H); ^{13}C NMR (CDCl_3 , 150 MHz): δ 162.1, 139.4, 136.3, 130.8, 128.7, 128.6, 128.4, 128.1, 127.1, 65.2.



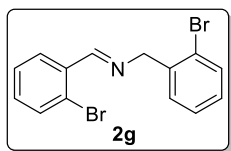
(*E*)-N-(2-Methylbenzyl)-1-(*o*-tolyl)methanimine (**2e**): The product was prepared by general procedure A. yellow liquid; 79 mg (88%); ^1H NMR and ^{13}C NMR spectra for this compound are consistent with previously reported literature data.⁴

^1H NMR (CDCl_3 , 600 MHz): δ 8.67 (s, 1H), 7.92 (d, $J = 7.6$ Hz, 1H), 7.32 – 7.27 (m, 2H), 7.25 – 7.22 (m, 1H), 7.20 – 7.15 (m, 4H), 4.83 (s, 2H), 2.51 (s, 3H), 2.39 (s, 3H); ^{13}C NMR (CDCl_3 , 150 MHz): δ 160.6, 137.8, 137.7, 136.2, 134.3, 130.9, 130.3, 130.2, 128.4, 127.8, 127.1, 126.3, 126.2, 63.4, 19.5, 19.4.



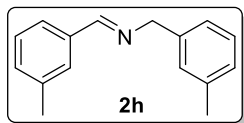
(*E*)-N-(2-Chlorobenzyl)-1-(2-chlorophenyl)methanimine (**2f**): The product was prepared by general procedure A. yellow liquid; 81 mg (77%); ^1H NMR and ^{13}C NMR spectra for this compound are consistent with previously reported literature

data.⁵ ^1H NMR (CDCl_3 , 600 MHz): δ 8.87 (s, 1H), 8.12 (dd, $J = 7.8, 1.8$ Hz, 1H), 7.43 (dd, $J = 7.7, 1.8$ Hz, 1H), 7.40 – 7.33 (m, 3H), 7.30 (t, $J = 6.9$ Hz, 1H), 7.28 – 7.24 (m, 1H), 7.22 (td, $J = 7.6, 1.8$ Hz, 1H), 4.95 (s, 2H); ^{13}C NMR (CDCl_3 , 150 MHz): δ 159.8, 136.9, 135.4, 133.5, 133.2, 131.8, 129.9, 129.8, 129.4, 128.6, 128.4, 127.1, 127.0, 62.3.



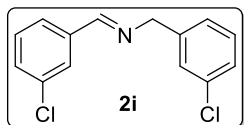
(*E*)-N-(2-Bromobenzyl)-1-(2-bromophenyl)methanimine (**2g**): The product was prepared by general procedure A. brown solid; 127 mg (90%); ^1H NMR and ^{13}C NMR spectra for this compound are consistent with previously reported literature

data.⁶ ^1H NMR (CDCl_3 , 600 MHz): δ 8.81 (s, 1H), 8.11 (dd, $J = 7.8, 1.8$ Hz, 1H), 7.59 (d, $J = 7.6$ Hz, 2H), 7.43 (dd, $J = 7.7, 1.8$ Hz, 1H), 7.38 – 7.33 (m, 1H), 7.33 – 7.27 (m, 2H), 7.15 (m, 1H), 4.94 (s, 2H); ^{13}C NMR (CDCl_3 , 150 MHz): δ 162.1, 138.5, 134.6, 133.2, 132.7, 132.1, 129.9, 129.0, 128.7, 127.7, 127.6, 125.3, 123.7, 64.5.



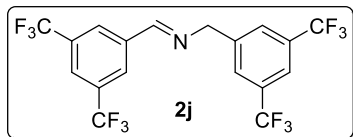
(*E*)-*N*-(3-Methylbenzyl)-1-(*m*-tolyl)methanimine (**2h**): The product was prepared by general procedure A. yellow liquid; 80 mg (90%); ^1H NMR and ^{13}C NMR spectra for this compound are consistent with previously reported literature data.⁵

^1H NMR (CDCl_3 , 600 MHz): δ 8.36 (s, 1H), 7.65 (s, 1H), 7.54 (d, $J = 7.7$ Hz, 1H), 7.31 (t, $J = 7.6$ Hz, 1H), 7.26 – 7.21 (m, 2H), 7.16 – 7.11 (m, 2H), 7.08 (d, $J = 7.5$ Hz, 1H), 4.78 (s, 2H), 2.39 (s, 3H), 2.35 (s, 3H); ^{13}C NMR (CDCl_3 , 150 MHz): δ 162.2, 139.3, 138.4, 138.2, 136.2, 131.7, 128.9, 128.6, 128.6, 128.5, 127.8, 126.0, 125.2, 65.2, 21.5, 21.4.



(*E*)-*N*-(3-Chlorobenzyl)-1-(3-chlorophenyl)methanimine (**2i**): The product was prepared by general procedure A. yellow liquid; 97 mg (92%); ^1H NMR and ^{13}C NMR spectra for this compound are consistent with previously reported literature data.⁴

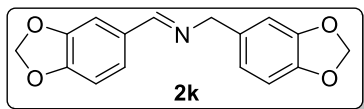
^1H NMR (CDCl_3 , 600 MHz): δ 8.34 (s, 1H), 7.81 (t, $J = 1.9$ Hz, 1H), 7.63 (dt, $J = 7.6, 1.4$ Hz, 1H), 7.41 (m, 1H), 7.38 – 7.31 (m, 2H), 7.30 – 7.20 (m, 3H), 4.79 (s, 2H); ^{13}C NMR (CDCl_3 , 150 MHz): δ 161.0, 141.1, 137.8, 135.0, 134.5, 131.0, 130.0, 129.9, 128.1, 128.1, 127.4, 126.7, 126.1, 64.4.



(*E*)-*N*-(3,5-Bis(trifluoromethyl)benzyl)-1-(3,5-bis(trifluoromethyl)phenyl)

methanimine (**2j**): The product was prepared by general procedure A. white solid; 76 mg (57%); ^1H NMR and ^{13}C NMR spectra

for this compound are consistent with previously reported literature data.⁷ ^1H NMR (CDCl_3 , 600 MHz): δ 8.55 (s, 1H), 8.26 (s, 2H), 7.97 (s, 1H), 7.83 (d, $J = 5.9$ Hz, 3H), 4.97 (s, 2H); ^{13}C NMR (CDCl_3 , 150 MHz): δ 160.2, 141.1, 137.6, 132.5 (q, $J = 33.8$ Hz), 132.0 (q, $J = 33.3$ Hz), 128.4, 128.3, 128.2, 128.2, 124.7 – 124.6 (m), 123.4 (q, $J = 272.7$ Hz), 123.2 (q, $J = 272.7$ Hz), 121.5 – 121.4 (m), 64.0.

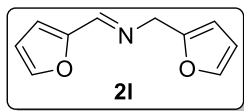


(*E*)-1-(Benzo[d][1,3]dioxol-5-yl)-*N*-(benzo[d][1,3]dioxol-5-ylmethyl)

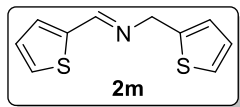
methanimine (**2k**): The product was prepared by general procedure A. off white solid; 107 mg (94%); ^1H NMR and ^{13}C NMR spectra for this

compound are consistent with previously reported literature data.⁴ ^1H NMR (CDCl_3 , 600 MHz): δ 8.23 (s,

1H), 7.39 (d, $J = 1.6$ Hz, 1H), 7.14 (dd, $J = 7.9, 1.6$ Hz, 1H), 6.83 (d, $J = 8.1$ Hz, 2H), 6.78 (d, $J = 1.1$ Hz, 2H), 6.00 (s, 2H), 5.93 (s, 2H), 4.68 (s, 2H); ^{13}C NMR (CDCl_3 , 150 MHz): δ 161.0, 150.0, 148.4, 147.8, 146.6, 133.4, 131.1, 124.6, 121.1, 108.7, 108.3, 108.1, 106.8, 101.5, 101.0, 64.6.

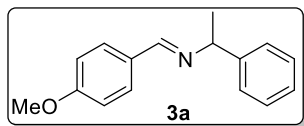


(*E*)-1-(Furan-2-yl)-N-(furan-2-ylmethyl)methanimine (**2l**): The product was prepared by general procedure A. yellow oil; 36 mg (51%); ^1H NMR and ^{13}C NMR spectra for this compound are consistent with previously reported literature data.⁴ ^1H NMR (CDCl_3 , 600 MHz): δ 8.11 (s, 1H), 7.51 (s, 1H), 7.38 (dd, $J = 2.0, 0.9$ Hz, 1H), 6.79 (d, $J = 3.4$ Hz, 1H), 6.47 (dd, $J = 3.4, 1.8$ Hz, 1H), 6.34 (dd, $J = 3.2, 1.8$ Hz, 1H), 6.27 (d, $J = 3.1$ Hz, 1H), 4.75 (s, 2H); ^{13}C NMR (CDCl_3 , 150 MHz): δ 151.9, 151.6, 151.3, 145.0, 142.4, 114.6, 111.8, 110.51, 108.0, 56.9.



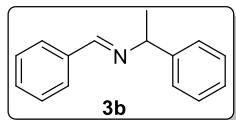
(*E*)-1-(Thiophen-2-yl)-N-(thiophen-2-ylmethyl)methanimine (**2m**): The product was prepared by general procedure A. oil; 46 mg (56%); ^1H NMR and ^{13}C NMR spectra for this compound are consistent with previously reported literature data.⁸ ^1H NMR (CDCl_3 , 600 MHz): δ 8.42 (m, 1H), 7.42 (dt, $J = 5.0, 1.1$ Hz, 1H), 7.33 (m, 1H), 7.24 (m, 1H), 7.08 (m, 1H), 7.01 – 6.96 (m, 2H), 4.95 (s, 2H); ^{13}C NMR (CDCl_3 , 150 MHz): δ 155.5, 142.3, 141.7, 131.0, 129.4, 127.5, 127.0, 125.4, 124.9, 58.6.

Characterization of the Cross-coupled Imine Products:

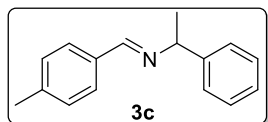


(*E*)-1-(4-Methoxyphenyl)-N-(1-phenylethyl)methanimine (**3a**): The product was prepared by general procedure B. yellow solid; 44 mg (92%); ^1H NMR and ^{13}C NMR spectra for this compound are consistent with previously reported literature data.⁹ ^1H NMR (CDCl_3 , 600 MHz): δ 8.31 (s, 1H), 7.73 (d, $J = 8.7$ Hz, 2H), 7.43 (d, $J = 7.6$ Hz, 2H), 7.34 (t, $J = 7.7$ Hz, 2H), 7.23 (t, $J = 7.3$ Hz, 1H), 6.92 (d, $J = 8.7$ Hz, 2H), 4.51 (q, $J = 6.7$ Hz,

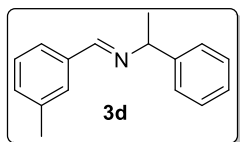
1H), 3.84 (s, 3H), 1.59 (d, $J = 6.7$ Hz, 3H); ^{13}C NMR (CDCl_3 , 150 MHz): δ 161.7, 158.9, 145.5, 129.9, 129.5, 128.5, 126.8, 126.7, 114.0, 69.7, 55.5, 25.0.



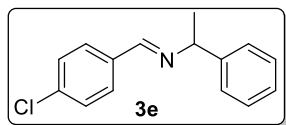
(*E*)-1-Phenyl-N-(1-phenylethyl)methanimine (**3b**): The product was prepared by general procedure B. yellow liquid; 38 mg (90%); ^1H NMR and ^{13}C NMR spectra for this compound are consistent with previously reported literature data.⁴ ^1H NMR (CDCl_3 , 600 MHz): δ 8.37 (s, 1H), 7.81 – 7.75 (m, 2H), 7.46 – 7.36 (m, 5H), 7.37 – 7.30 (m, 2H), 7.27 – 7.20 (m, 1H), 4.54 (q, $J = 6.6$ Hz, 1H), 1.59 (d, $J = 6.7$ Hz, 3H); ^{13}C NMR (CDCl_3 , 150 MHz): δ 159.6, 145.3, 136.5, 130.7, 128.6, 128.5, 128.4, 126.9, 126.7, 69.8, 24.9.



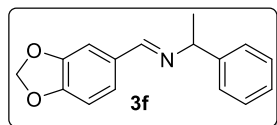
(*E*)-N-(1-Phenylethyl)-1-(p-tolyl)methanimine (**3c**): The product was prepared by general procedure B. off white solid; 41 mg (93%); ^1H NMR and ^{13}C NMR spectra for this compound are consistent with previously reported literature data.¹⁰ ^1H NMR (CDCl_3 , 600 MHz): δ 8.33 (s, 1H), 7.67 (d, $J = 7.9$ Hz, 2H), 7.44 – 7.40 (m, 2H), 7.35 – 7.31 (m, 2H), 7.25 – 7.18 (m, 3H), 4.52 (q, $J = 6.7$ Hz, 1H), 2.37 (s, 3H), 1.58 (d, $J = 6.7$ Hz, 3H); ^{13}C NMR (CDCl_3 , 150 MHz): δ 159.5, 145.4, 140.9, 133.9, 129.3, 128.5, 128.3, 126.8, 126.7, 69.7, 24.9, 21.6.



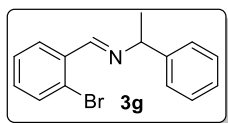
(*E*)-N-(1-Phenylethyl)-1-(m-tolyl)methanimine (**3d**): The product was prepared by general procedure B. yellow liquid; 42 mg (95%); ^1H NMR (CDCl_3 , 600 MHz): δ 8.34 (s, 1H), 7.64 (s, 1H), 7.52 (d, $J = 8.0$ Hz, 1H), 7.42 (d, $J = 7.7$ Hz, 2H), 7.36 – 7.31 (m, 2H), 7.29 (t, $J = 7.6$ Hz, 1H), 7.23 (dd, $J = 12.4, 6.5$ Hz, 2H), 4.53 (t, $J = 6.7$ Hz, 1H), 2.38 (s, 3H), 1.59 (d, $J = 6.7$ Hz, 3H); ^{13}C NMR (CDCl_3 , 150 MHz): δ 159.8, 145.2, 138.4, 136.4, 131.5, 128.5, 126.9, 126.7, 125.9, 69.8, 24.8, 21.4; IR(neat): 3060, 3026, 2970, 2924, 2845, 2360, 2341, 1644, 1602, 1491, 140, 1276, 1030, 999, 784, 762, 668 cm^{-1} ; HRMS (ESI): m/z calcd for $\text{C}_{16}\text{H}_{18}\text{N}$ $[\text{M}+\text{H}]^+$ 224.1433 Found 224.1431.



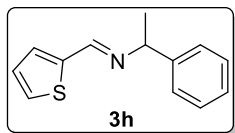
(*E*)-1-(4-Chlorophenyl)-*N*-(1-phenylethyl)methanimine (**3e**): The product was prepared by general procedure B. yellow amorphous solid; 44 mg (90%); ^1H NMR (CDCl_3 , 600 MHz): 8.31 (s, 1H), 7.71 (d, $J = 8.4$ Hz, 2H), 7.41 (d, $J = 7.8$ Hz, 2H), 7.38 – 7.31 (m, 4H), 7.26 – 7.22 (m, 1H), 4.53 (q, $J = 6.6$ Hz, 1H), 1.58 (d, $J = 6.7$ Hz, 3H); ^{13}C NMR (CDCl_3 , 150 MHz): δ 158.1, 145.0, 136.6, 135.0, 129.5, 128.9, 128.5, 127.0, 126.7, 69.8, 24.9; IR (neat): 3084, 3027, 2971, 2845, 2360, 2341, 1644, 1490, 1376, 1085, 1030, 824, 761, 668 cm^{-1} ; HRMS (ESI): m/z calcd for $\text{C}_{15}\text{H}_{15}\text{ClN}$ $[\text{M}+\text{H}]^+$ 244.0887 Found 244.0887.



(*E*)-1-(Benzo[d][1,3]dioxol-5-yl)-*N*-(1-phenylethyl)methanimine (**3f**): The product was prepared by general procedure B. yellow liquid; 49 mg (97%); ^1H NMR (CDCl_3 , 600 MHz): δ 8.25 (s, 1H), 7.47 – 7.40 (m, 3H), 7.34 (t, $J = 7.7$ Hz, 2H), 7.27 – 7.22 (m, 1H), 7.16 – 7.10 (m, 1H), 6.82 (d, $J = 7.9$ Hz, 1H), 5.99 (q, $J = 1.4$ Hz, 2H), 4.51 (q, $J = 6.6$ Hz, 1H), 1.58 (d, $J = 6.7$ Hz, 3H); ^{13}C NMR (CDCl_3 , 150 MHz): δ 158.6, 149.8, 148.3, 145.4, 131.4, 128.5, 126.9, 126.7, 124.4, 108.1, 106.9, 101.5, 69.5, 25.0; IR (neat): 3061, 3026, 2970, 2894, 2360, 2341, 1642, 1604, 1488, 1447, 1254, 1078, 1038, 933, 808, 700, 540 cm^{-1} ; HRMS (ESI): m/z calcd for $\text{C}_{16}\text{H}_{16}\text{NO}_2$ $[\text{M}+\text{H}]^+$ 254.1175 Found 254.1173.

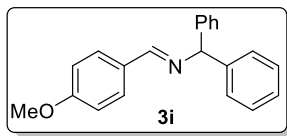


(*E*)-1-(2-Bromophenyl)-*N*-(1-phenylethyl)methanimine (**3g**): The product was prepared by general procedure B. yellow oil; 52 mg (91%); ^1H NMR and ^{13}C NMR spectra for this compound are consistent with previously reported literature data.⁹ ^1H NMR (CDCl_3 , 600 MHz): δ 8.74 (s, 1H), 8.10 (d, $J = 7.8$ Hz, 1H), 7.54 (dd, $J = 7.7, 1.2$ Hz, 1H), 7.44 (d, $J = 8.3$ Hz, 2H), 7.37 – 7.30 (m, 3H), 7.27 – 7.21 (m, 2H), 4.62 (q, $J = 6.6$ Hz, 1H), 1.60 (d, $J = 6.7$ Hz, 3H); ^{13}C NMR (CDCl_3 , 150 MHz): δ 158.6, 145.0, 134.8, 133.0, 131.8, 129.2, 128.6, 127.6, 127.0, 126.7, 125.1, 69.9, 25.0.



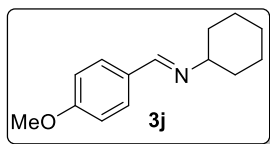
(*E*)-*N*-(1-phenylethyl)-1-(thiophen-2-yl)methanimine (**3h**): The product was prepared by general procedure B. yellow oil; 30 mg (69%); ^1H NMR and ^{13}C NMR spectra for this compound are consistent with previously reported literature data.⁹

^1H NMR (CDCl_3 , 600 MHz): 8.44 (s, 1H), 7.44 – 7.38 (m, 3H), 7.35 (t, $J = 7.7$ Hz, 2H), 7.31 (d, $J = 3.6$ Hz, 1H), 7.28 – 7.23 (m, 1H), 7.07 (d, $J = 8.6$ Hz, 1H), 4.54 (q, $J = 6.7$ Hz, 1H), 1.60 (d, $J = 6.7$ Hz, 3H); ^{13}C NMR (CDCl_3 , 150 MHz): δ 152.8, 145.0, 142.8, 130.4, 128.9, 128.5, 127.3, 126.9, 126.7, 69.2, 24.8.



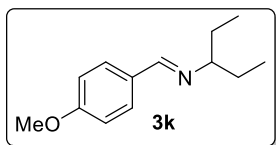
(*E*)-*N*-Benzhydryl-1-(4-methoxyphenyl)methanimine (**3i**): The product was prepared by general procedure B. white solid; 58 mg (97%); ^1H NMR and ^{13}C NMR spectra for this compound are consistent with previously reported

literature data.¹¹ ^1H NMR (CDCl_3 , 600 MHz): δ 8.36 (s, 1H), 7.79 (d, $J = 8.8$ Hz, 2H), 7.40 (d, $J = 7.8$ Hz, 4H), 7.32 (t, $J = 7.7$ Hz, 4H), 7.23 (t, $J = 7.9$ Hz, 2H), 6.93 (d, $J = 8.8$ Hz, 2H), 5.57 (s, 1H), 3.84 (s, 3H); ^{13}C NMR (CDCl_3 , 150 MHz): δ 161.8, 160.1, 144.2, 130.1, 129.5, 128.5, 127.8, 127.0, 114.0, 77.9, 55.5.



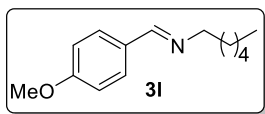
(*E*)-*N*-Cyclohexyl-1-(4-methoxyphenyl)methanimine (**3j**): The product was prepared by general procedure B. yellow oil; 38 mg (87%); ^1H NMR and ^{13}C NMR spectra for this compound are consistent with previously reported

literature data.¹² ^1H NMR (CDCl_3 , 600 MHz): δ 8.24 (s, 1H), 7.66 (d, $J = 8.7$ Hz, 2H), 6.91 (d, $J = 8.7$ Hz, 2H), 3.83 (s, 3H), 3.19 – 3.09 (m, 1H), 1.83 (dd, $J = 13.3, 3.5$ Hz, 2H), 1.78 – 1.63 (m, 3H), 1.62 – 1.52 (m, 2H), 1.40 – 1.31 (m, 2H), 1.26 (ddd, $J = 15.9, 12.5, 3.4$ Hz, 1H); ^{13}C NMR (CDCl_3 , 150 MHz): δ 161.4, 158.0, 129.6, 114.0, 70.0, 55.4, 34.6, 25.8, 25.0.



(*E*)-1-(4-Methoxyphenyl)-*N*-(pentan-3-yl)methanimine (**3k**): The product was prepared by general procedure B. yellow oil; 39 mg (96%); ^1H NMR and ^{13}C NMR spectra for this compound are consistent with previously reported

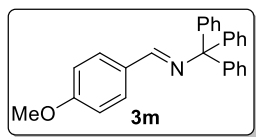
literature data.¹⁰ ¹H NMR (CDCl₃, 600 MHz): δ 8.15 (s, 1H), 7.69 (d, J = 8.8 Hz, 2H), 6.92 (d, J = 8.7 Hz, 2H), 3.84 (s, 3H), 2.87 – 2.81 (m, 1H), 1.69 – 1.56 (m, 4H), 0.83 (t, J = 7.4 Hz, 6H); ¹³C NMR (CDCl₃, 150 MHz): δ 161.4, 158.7, 129.7, 129.5, 114.0, 75.1, 55.4, 29.0, 11.2.



(*E*)-N-Hexyl-1-(4-methoxyphenyl)methanimine (**3l**): The product was

prepared by general procedure B. yellow oil; 40 mg (92%); ¹H NMR and ¹³C NMR spectra for this compound are consistent with previously reported

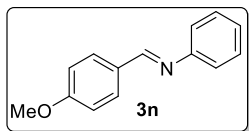
literature data.¹² ¹H NMR (CDCl₃, 600 MHz): δ 8.19 (s, 1H), 7.66 (d, J = 8.7 Hz, 2H), 6.91 (d, J = 8.7 Hz, 2H), 3.83 (s, 3H), 3.56 (t, J = 7.1 Hz, 2H), 1.67 (p, J = 7.1 Hz, 2H), 1.38 – 1.29 (m, 6H), 0.88 (t, J = 6.8 Hz, 3H); ¹³C NMR (CDCl₃, 150 MHz): δ 161.5, 160.1, 129.6, 129.5, 114.0, 61.8, 55.4, 31.8, 31.1, 27.1, 22.7, 14.2.



(*E*)-1-(4-Methoxyphenyl)-N-tritylmethanimine (**3m**): The product was prepared

by general procedure B. white solid; 69 mg (92%); mp 143-145 °C; ¹H NMR (CDCl₃, 600 MHz): δ 7.81 (d, J = 8.7 Hz, 2H), 7.78 (s, 1H), 7.34 – 7.24 (m, 15H),

6.96 (d, J = 8.7 Hz, 2H), 3.86 (s, 3H); ¹³C NMR (CDCl₃, 150 MHz): δ 161.8, 158.9, 146.2, 130.2, 129.9(8), 129.9(5), 127.8, 126.8, 114.0, 78.1, 55.5; IR (neat): 3057, 3020, 2957, 2360, 2341, 1605, 1151, 1489, 1445, 1250, 1180, 1164, 1031, 906, 760, 668, 640 cm⁻¹; HRMS (ESI): m/z calcd for C₂₇H₂₄NO [M+H]⁺ 378.1852 Found 378.1847.



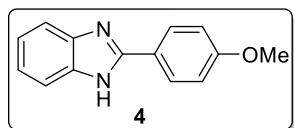
(*E*)-1-(4-Methoxyphenyl)-N-phenylmethanimine (**3n**): The product was prepared

by general procedure B. white solid; 30 mg (70%); ¹H NMR and ¹³C NMR spectra for this compound are consistent with previously reported literature data.¹² ¹H

NMR (CDCl₃, 600 MHz): δ 8.39 (s, 1H), 7.86 (d, J = 8.7 Hz, 2H), 7.39 (d, J = 7.8 Hz, 2H), 7.21 (m, 3H), 6.99 (d, J = 8.8 Hz, 2H), 3.88 (s, 3H); ¹³C NMR (CDCl₃, 150 MHz): δ 162.3, 159.8, 152.5, 130.6, 129.4, 129.2, 125.6, 121.0, 114.3, 55.5.

Synthesis and Characterization of 2-Substituted Benzimidazole:

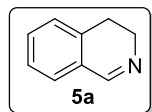
To a flame-dried 10 mL flask charged with catalyst ***o*-NQ3** (10 mol %), 4-methoxybenzylamine (0.2 mmol), and *o*-Phenylene diamine (0.4 mmol), were added 1.0 mL of CH₃CN and 20 mol % TFA under an O₂ balloon. The dark-black reaction solution was stirred at ambient temperature for 24 h. After reaction was complete, the mixture was concentrated under reduced pressure and loaded on silica gel for column chromatography (50% EtOAc in hexanes) to give the desired product.



2-(4-Methoxyphenyl)-1*H*-benzo[*d*]imidazole (**4**): white solid; 39 mg (86%);

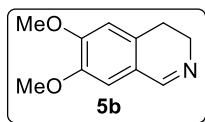
¹H NMR and ¹³C NMR spectra for this compound are consistent with previously reported literature data.¹³ ¹H NMR (DMSO-*d*₆, 600 MHz): δ 12.74 (s, 1H), 8.12 (d, *J* = 8.8 Hz, 2H), 7.62 (d, *J* = 6.1 Hz, 1H), 7.49 (d, *J* = 7.0 Hz, 1H), 7.18 (s, 2H), 7.11 (d, *J* = 8.8 Hz, 2H), 3.84 (s, 3H); ¹³C NMR (DMSO-*d*₆, 150 MHz): δ 160.5, 151.3, 143.8, 134.9, 127.9, 122.7, 122.0, 121.4, 118.4, 114.3, 111.0, 55.3.

Synthesis and Characterization of the Oxidation of Secondary Amine Products:-



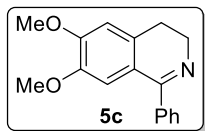
3,4-Dihydroisoquinoline (**5a**): The product was prepared by general procedure C. yellow oil; 23 mg (86%); ¹H NMR and ¹³C NMR spectra for this compound are consistent with previously reported literature data.¹⁴ ¹H NMR (CDCl₃, 600 MHz): δ 8.34 (s, 1H), 7.39 –

7.33 (m, 1H), 7.29 (dt, *J* = 13.9, 7.7 Hz, 2H), 7.16 (d, *J* = 7.3 Hz, 1H), 3.77 (t, *J* = 7.0 Hz, 2H), 2.75 (t, *J* = 7.7 Hz, 2H); ¹³C NMR (CDCl₃, 150 MHz): δ 160.5, 136.4, 131.1, 128.6, 127.5, 127.3, 127.2, 47.4, 25.1.



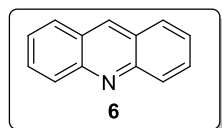
6,7-Dimethoxy-3,4-dihydroisoquinoline (**5b**): The product was prepared by general procedure C. white solid; 35 mg (91%); ¹H NMR and ¹³C NMR spectra for this compound are consistent with previously reported literature data.¹⁴ ¹H NMR (CDCl₃,

600 MHz): δ 8.23 (s, 1H), 6.81 (s, 1H), 6.67 (s, 1H), 3.91 (s, 3H), 3.89 (s, 3H), 3.72 (t, *J* = 8.8 Hz, 2H), 2.71 – 2.66 (m, 2H); ¹³C NMR (CDCl₃, 150 MHz): δ 159.9, 151.5, 148.0, 130.0, 121.5, 110.6, 110.5, 56.2, 56.2, 47.2, 24.9.



3,4-Dihydroisoquinoline (**5c**): The product was prepared by general procedure C. white solid; 52 mg (97%); ^1H NMR and ^{13}C NMR spectra for this compound are consistent with previously reported literature data.¹⁴ ^1H NMR (CDCl_3 , 600 MHz): δ

7.61 (d, $J = 5.2$ Hz, 2H), 7.43 (t, $J = 5.1$ Hz, 3H), 6.80 (s, 1H), 6.78 (s, 1H), 3.95 (s, 3H), 3.84 – 3.79 (m, 2H), 3.72 (s, 3H), 2.78 – 2.70 (m, 2H); ^{13}C NMR (CDCl_3 , 150 MHz): δ 166.9, 151.1, 147.2, 139.2, 132.7, 129.4, 128.9, 128.3, 121.6, 111.7, 110.4, 56.3, 56.1, 47.7, 26.1.



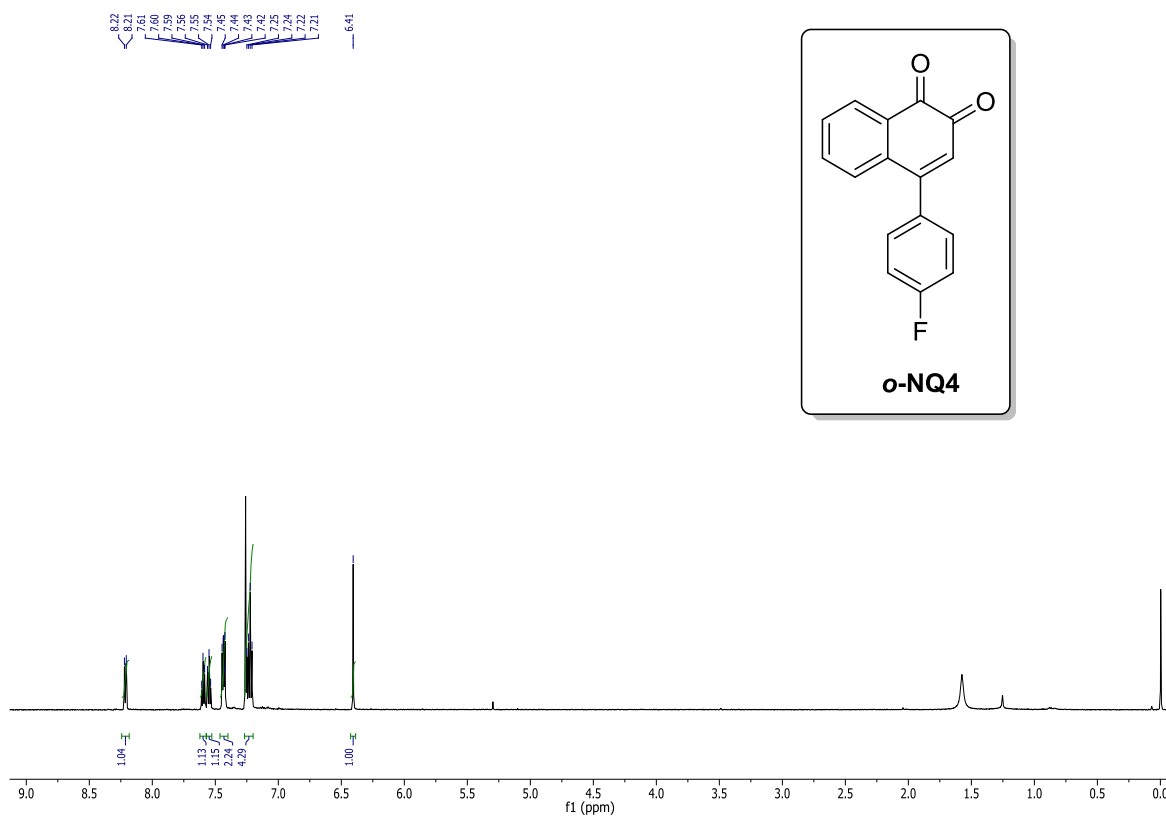
Acridine (**6**): The product was prepared by general procedure C. white solid; 35 mg (98%); ^1H NMR and ^{13}C NMR spectra for this compound are consistent with previously reported literature data.¹⁵ ^1H NMR (CDCl_3 , 600 MHz): δ 8.77 (s, 1H),

8.24 (d, $J = 8.3$ Hz, 2H), 8.00 (d, $J = 8.4$ Hz, 2H), 7.81 – 7.76 (m, 2H), 7.57 – 7.50 (m, 2H); ^{13}C NMR (CDCl_3 , 150 MHz): δ 149.1, 136.2, 130.4, 129.5, 128.3, 126.7, 125.8.

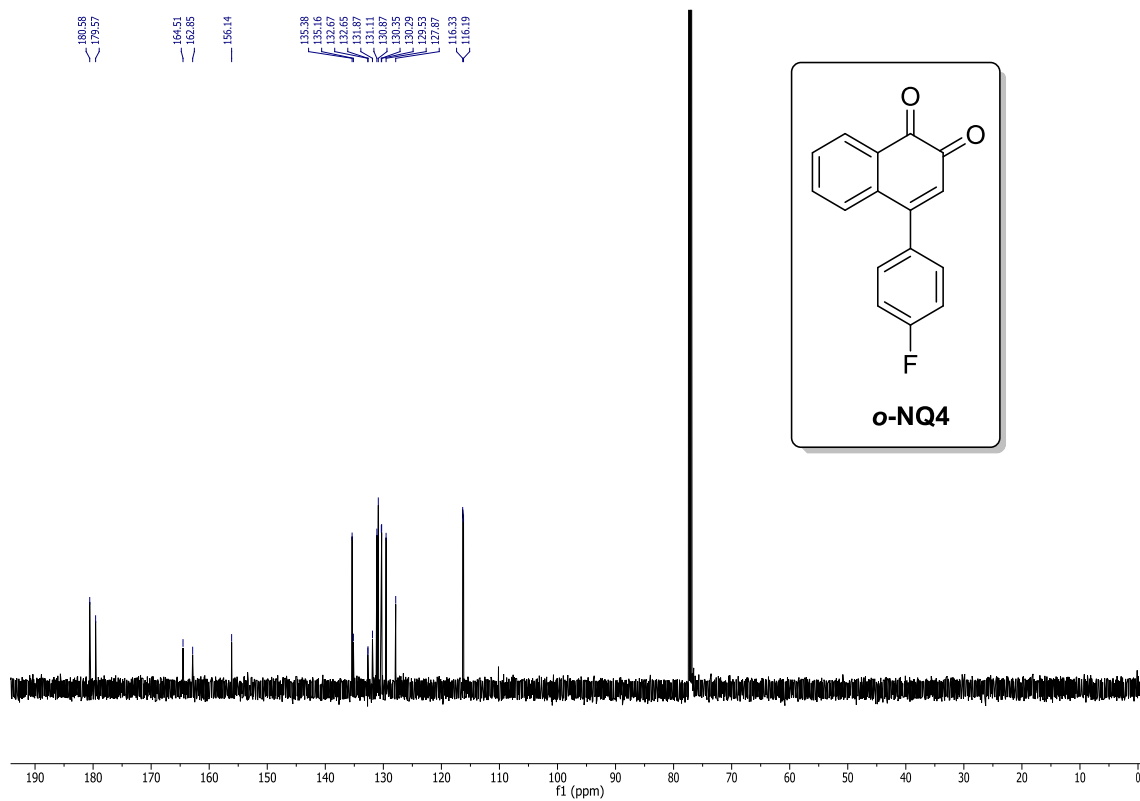
References

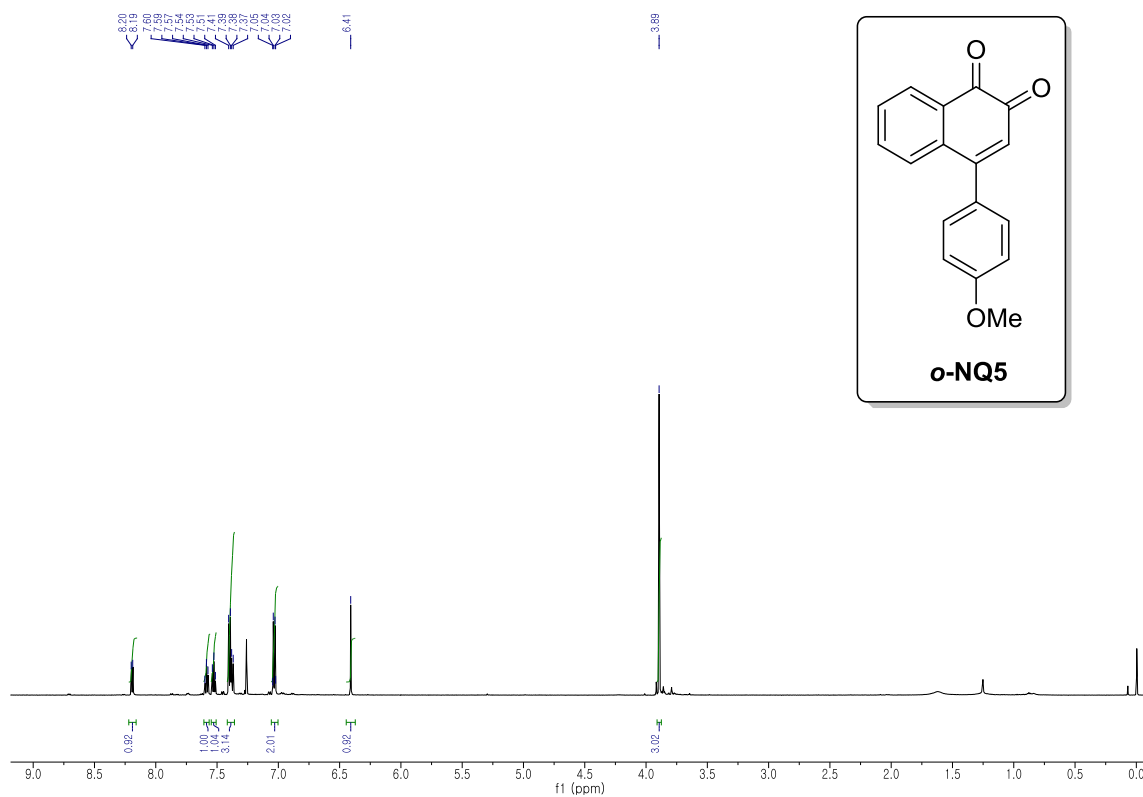
1. (a) Kim, H. Y.; Oh, K. *Org. Lett.* **2014**, *16*, 5934-5936; (b) Kim, H. Y.; Takizawa, S.; Oh, K. *Org. Biomol. Chem.* **2016**, *14*, 7191-7196.
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3. Wendlandt, A. E.; Stahl, S. S. *J. Am. Chem. Soc.* **2014**, *136*, 506-512.
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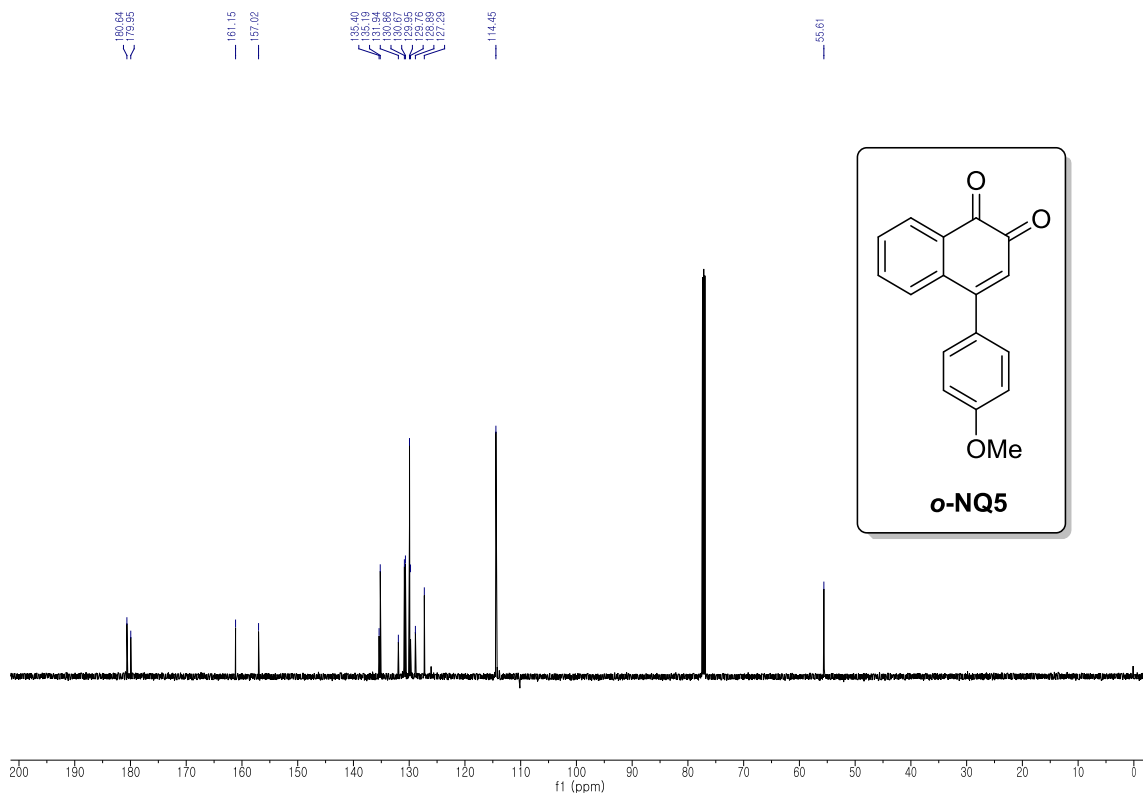


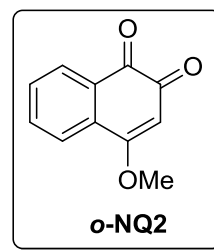
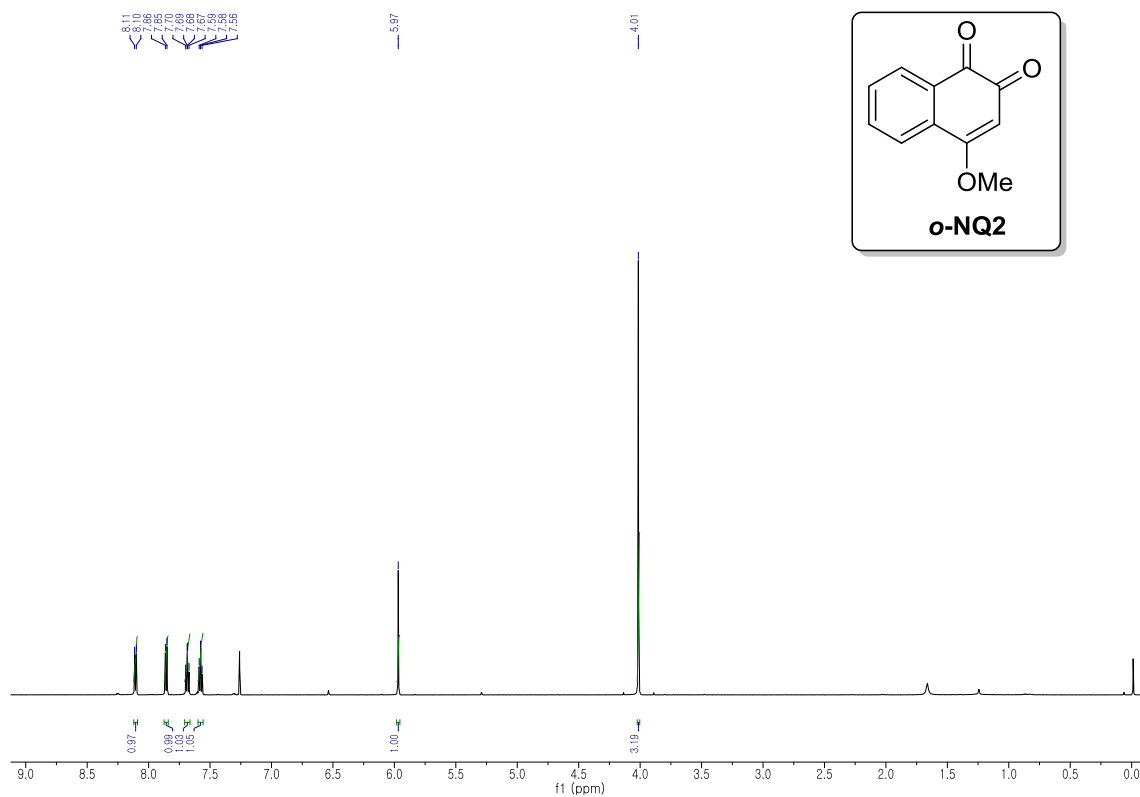
¹H NMR (CDCl₃, 600 MHz) and ¹³C NMR (CDCl₃, 150 MHz) spectra of compound **o-NQ4**



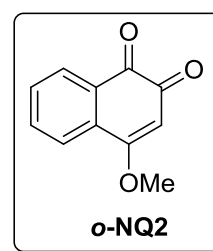
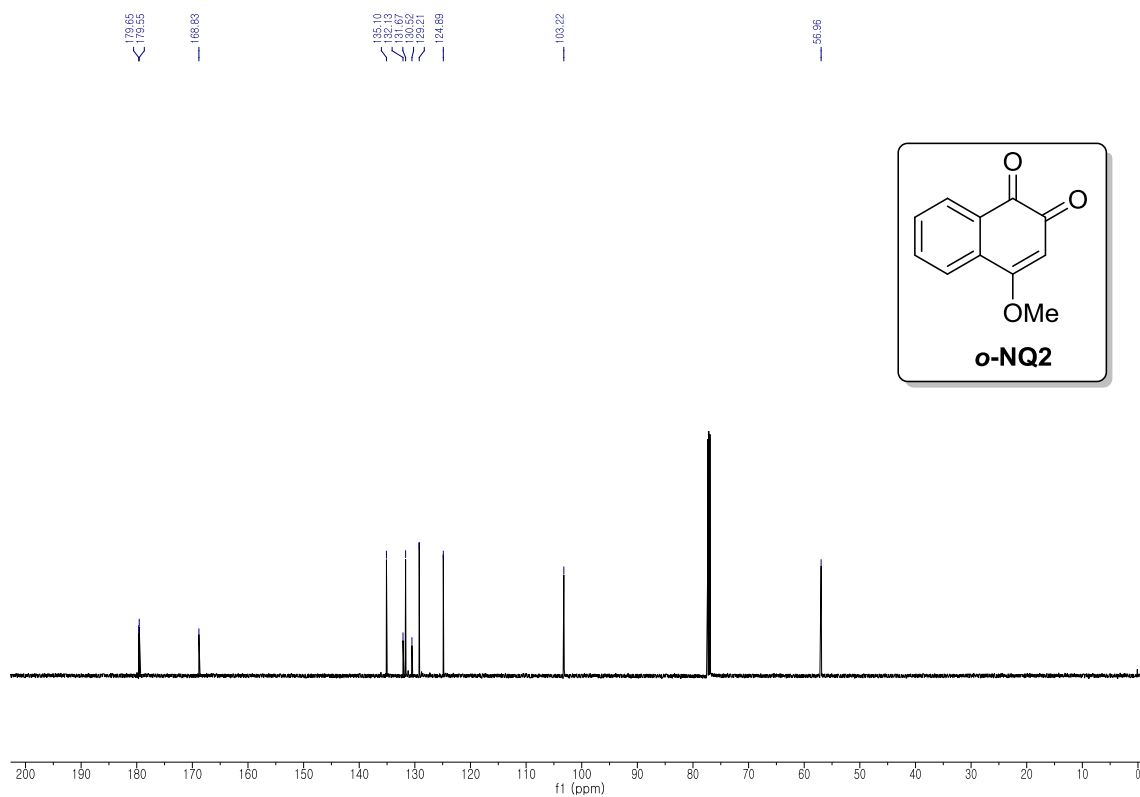


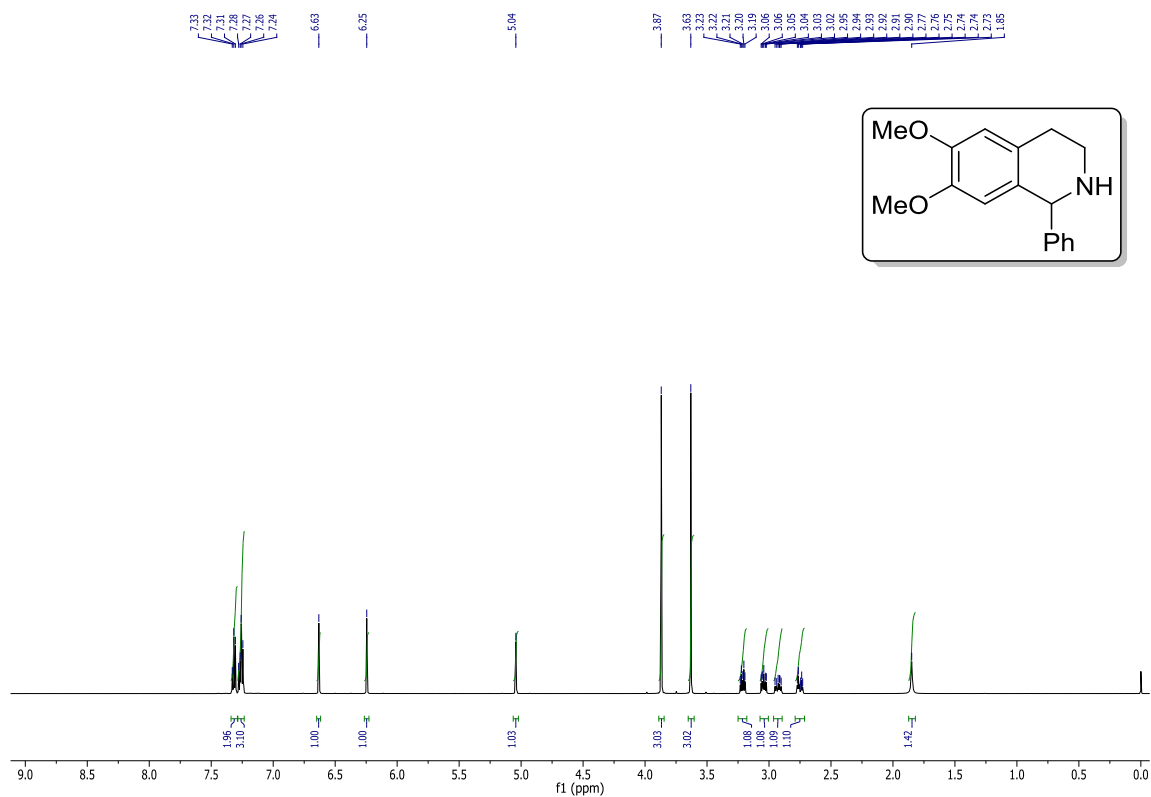
¹H NMR (CDCl₃, 600 MHz) and ¹³C NMR (CDCl₃, 150 MHz) spectra of compound **o-NQ5**



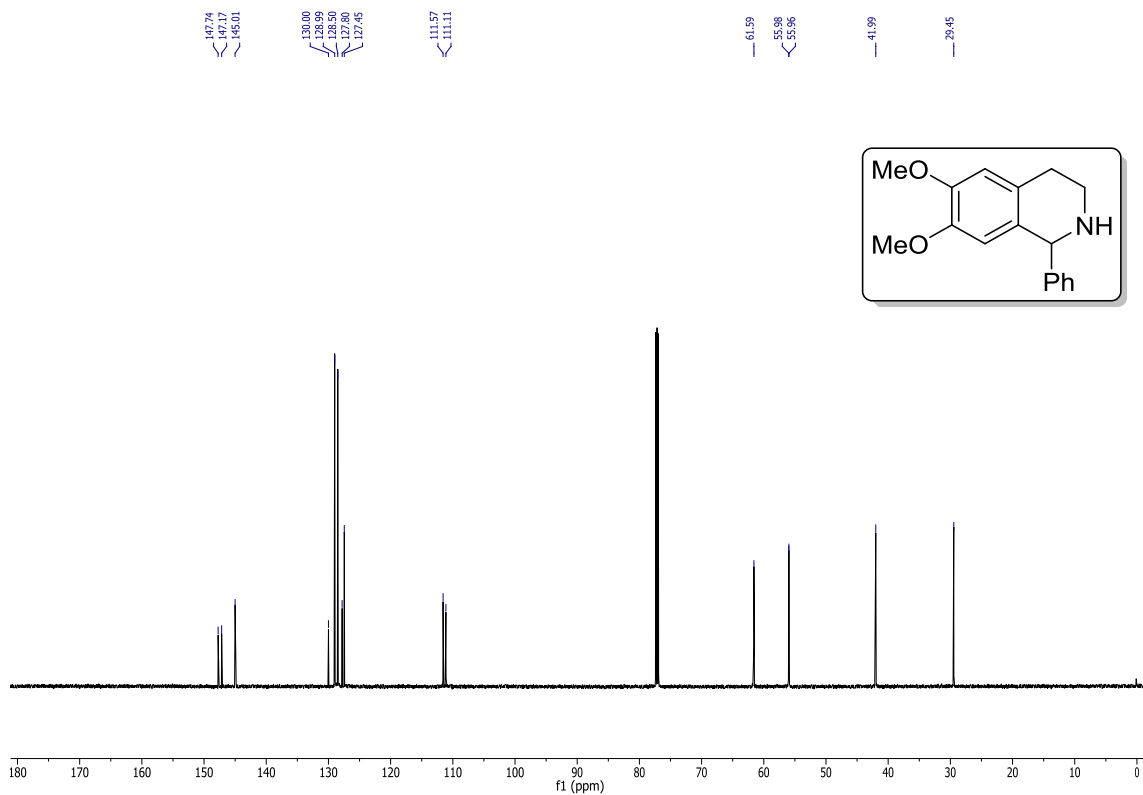


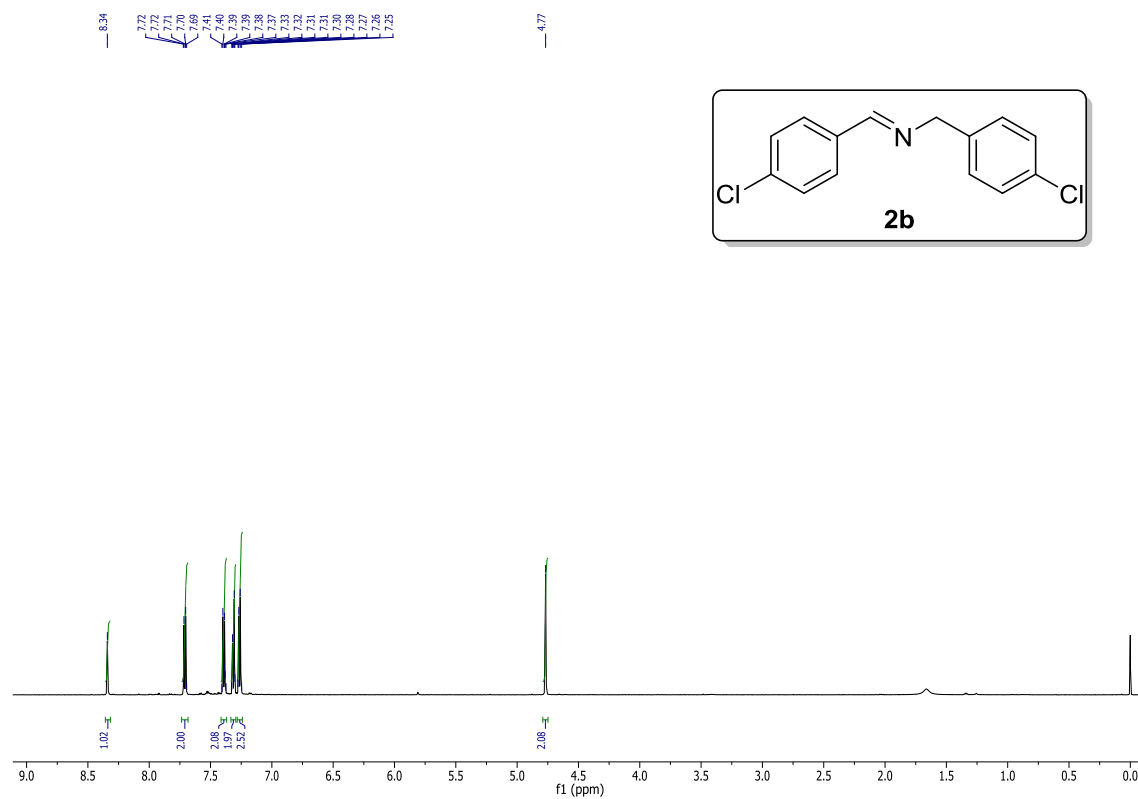
¹H NMR (CDCl₃, 600 MHz) and ¹³C NMR (CDCl₃, 150 MHz) spectra of compound **o-NQ2**



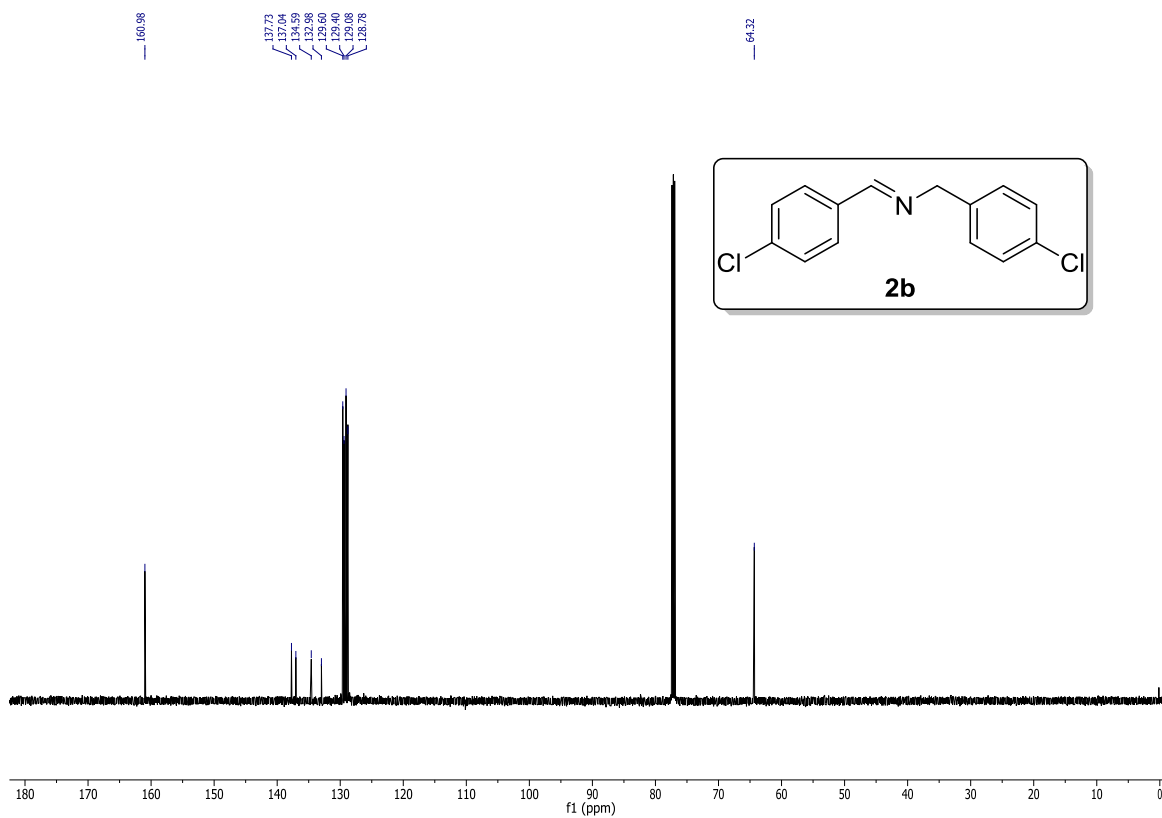


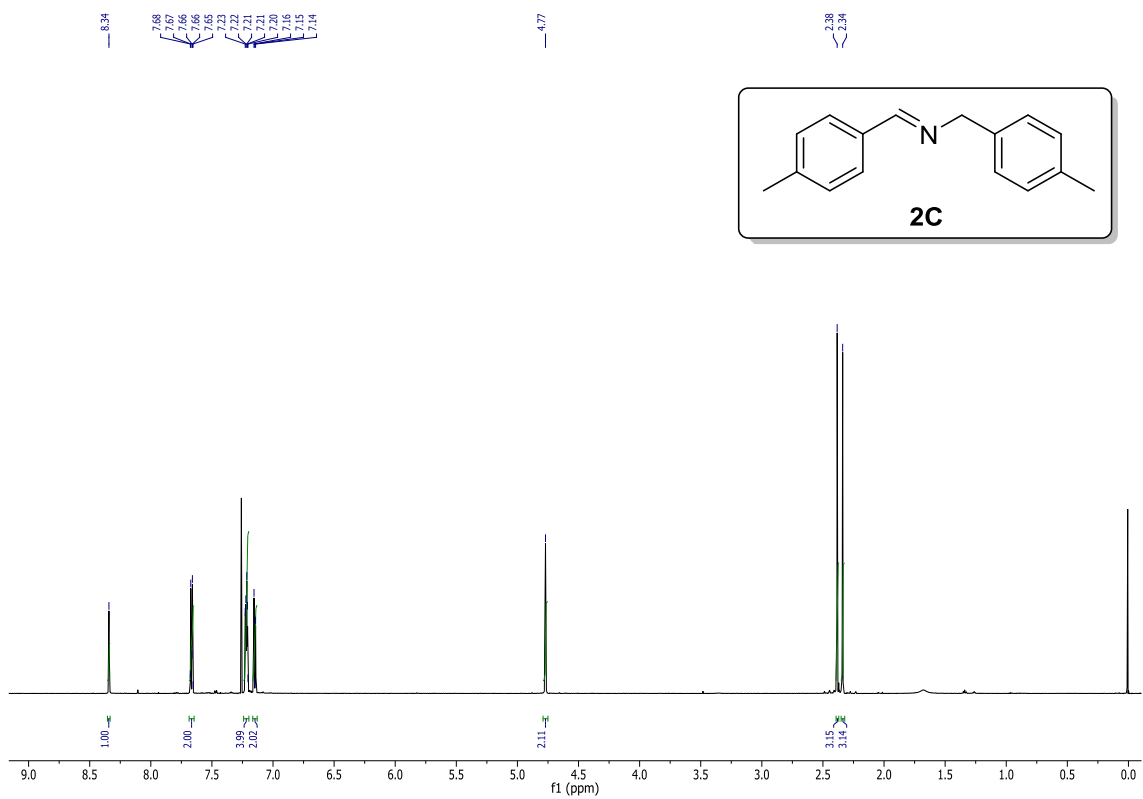
¹H NMR (CDCl₃, 600 MHz) and ¹³C NMR (CDCl₃, 150 MHz) spectra



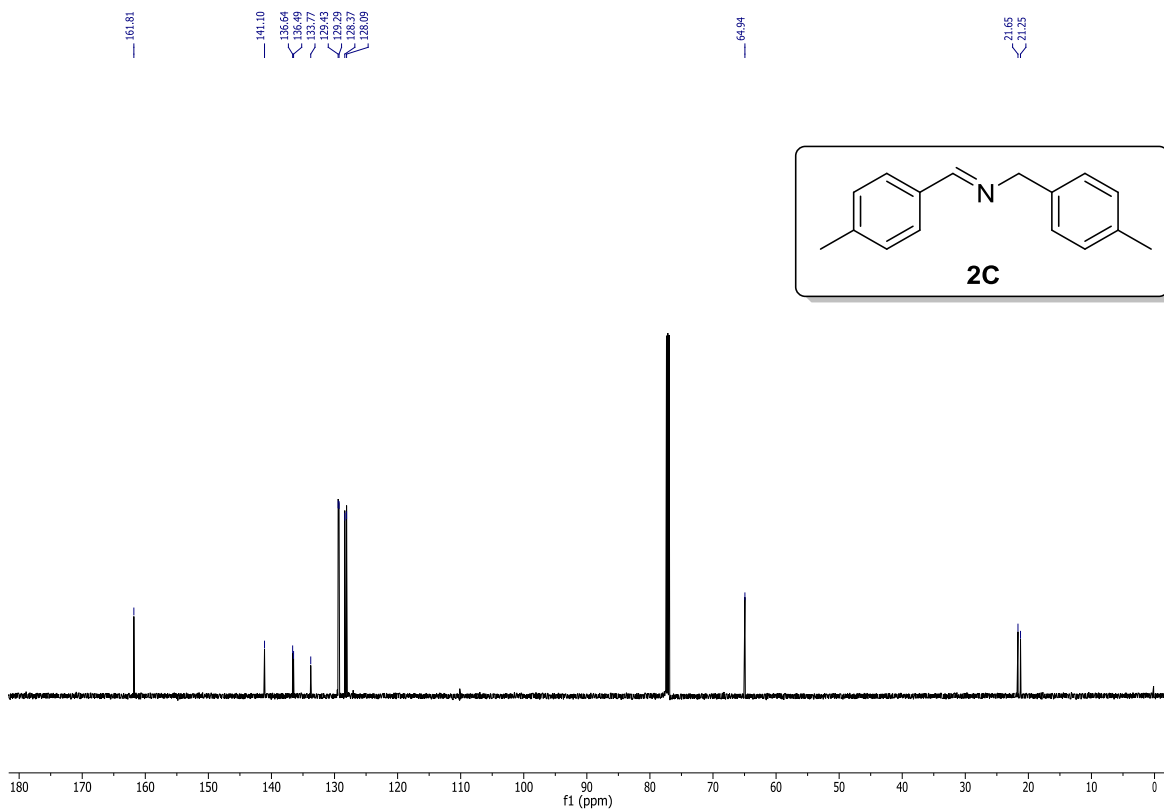


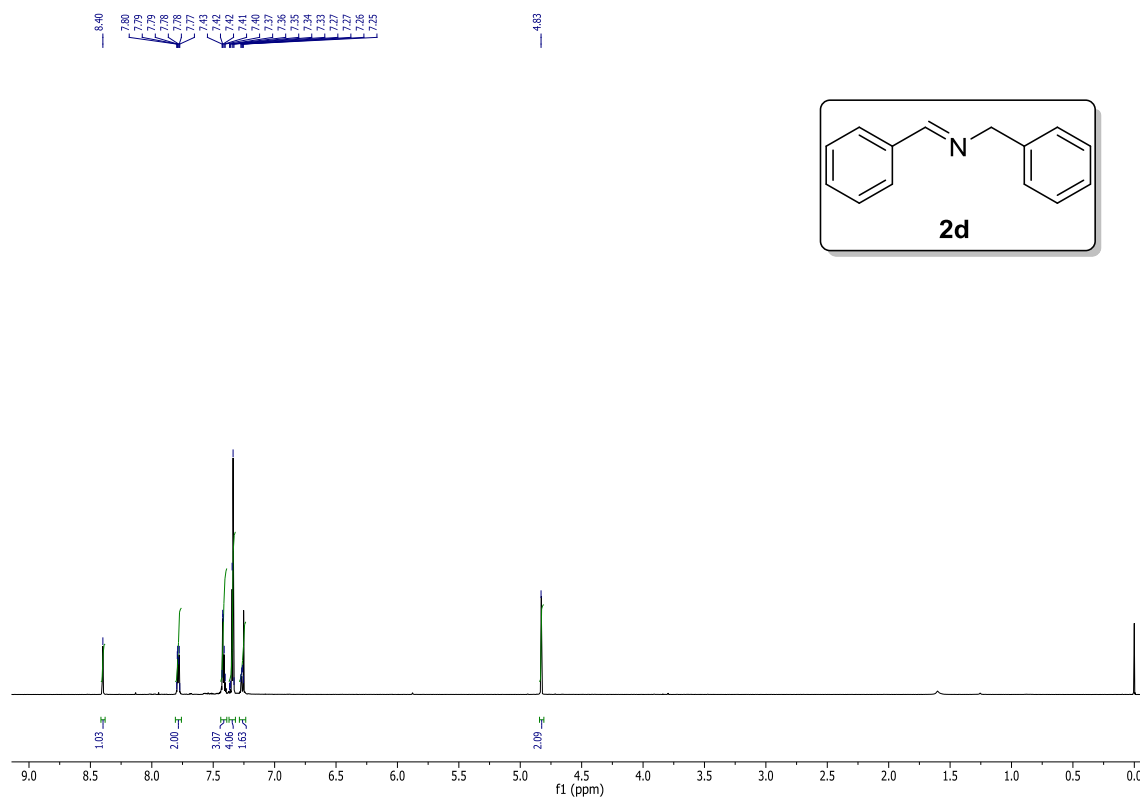
¹H NMR (CDCl₃, 600 MHz) and ¹³C NMR (CDCl₃, 150 MHz) spectra of compound **2b**



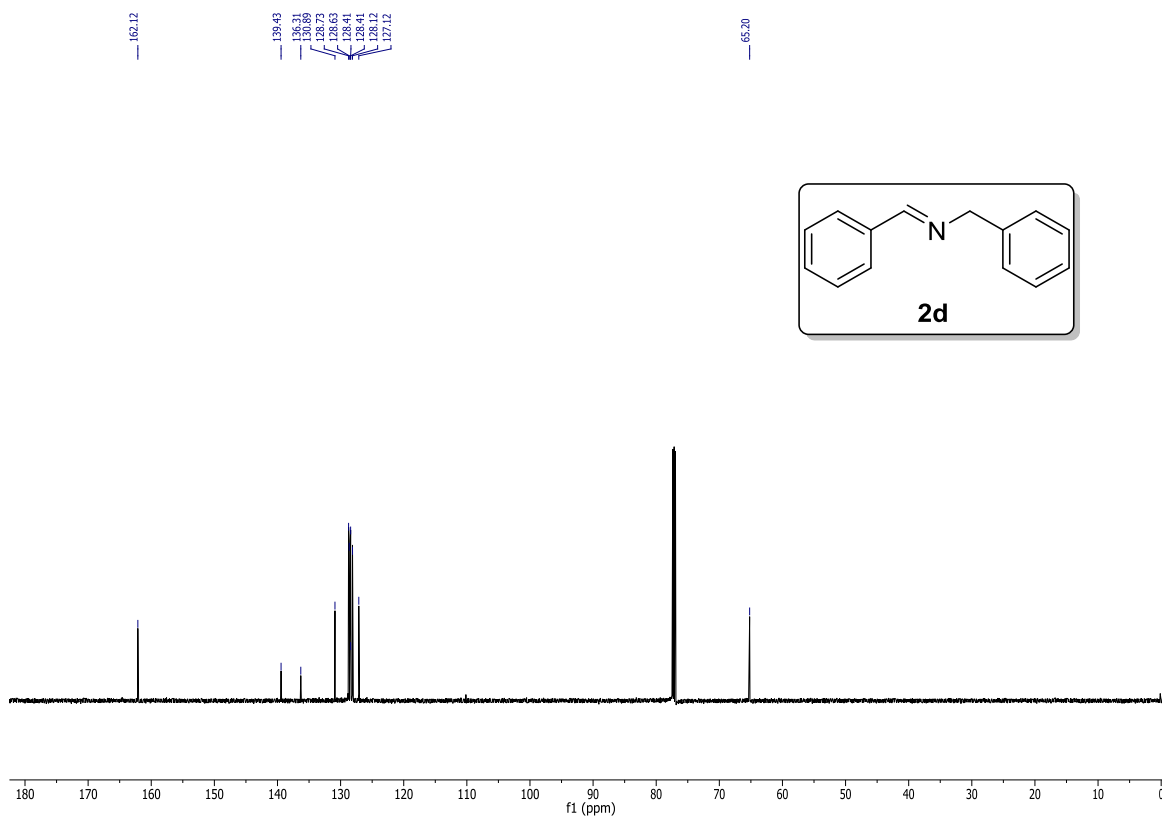


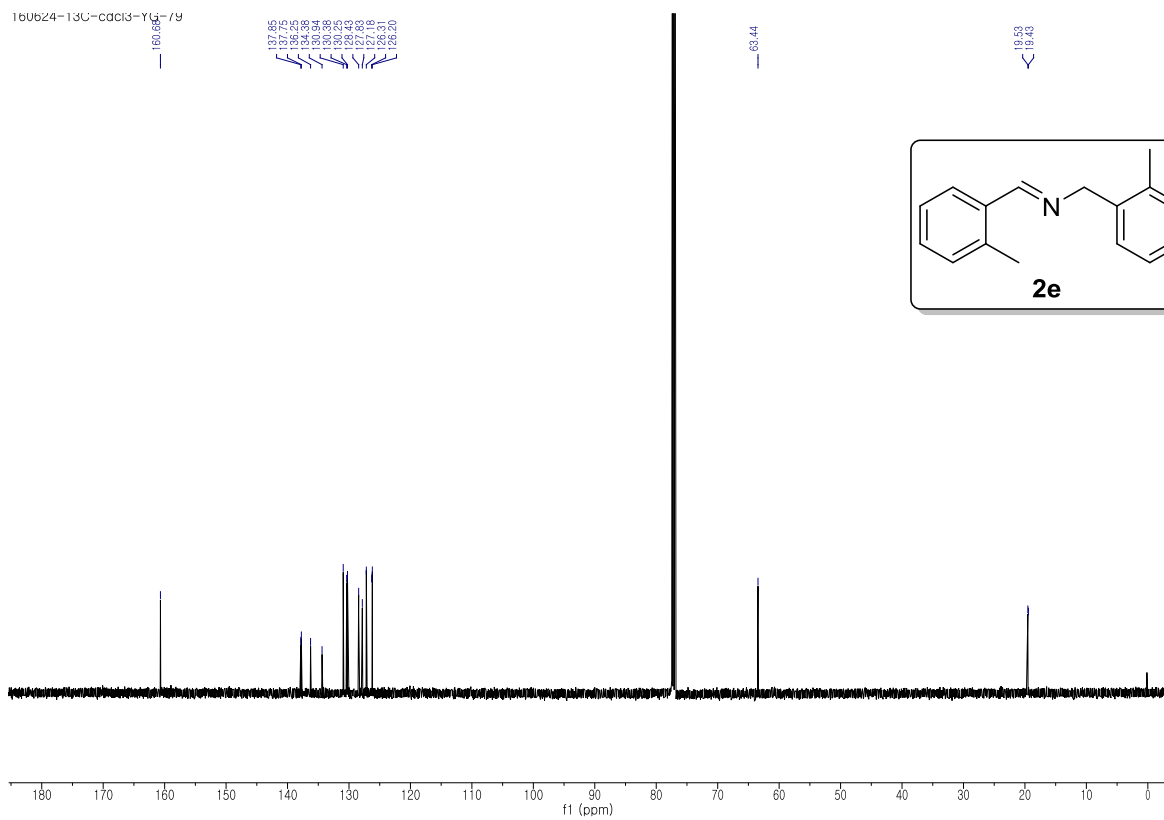
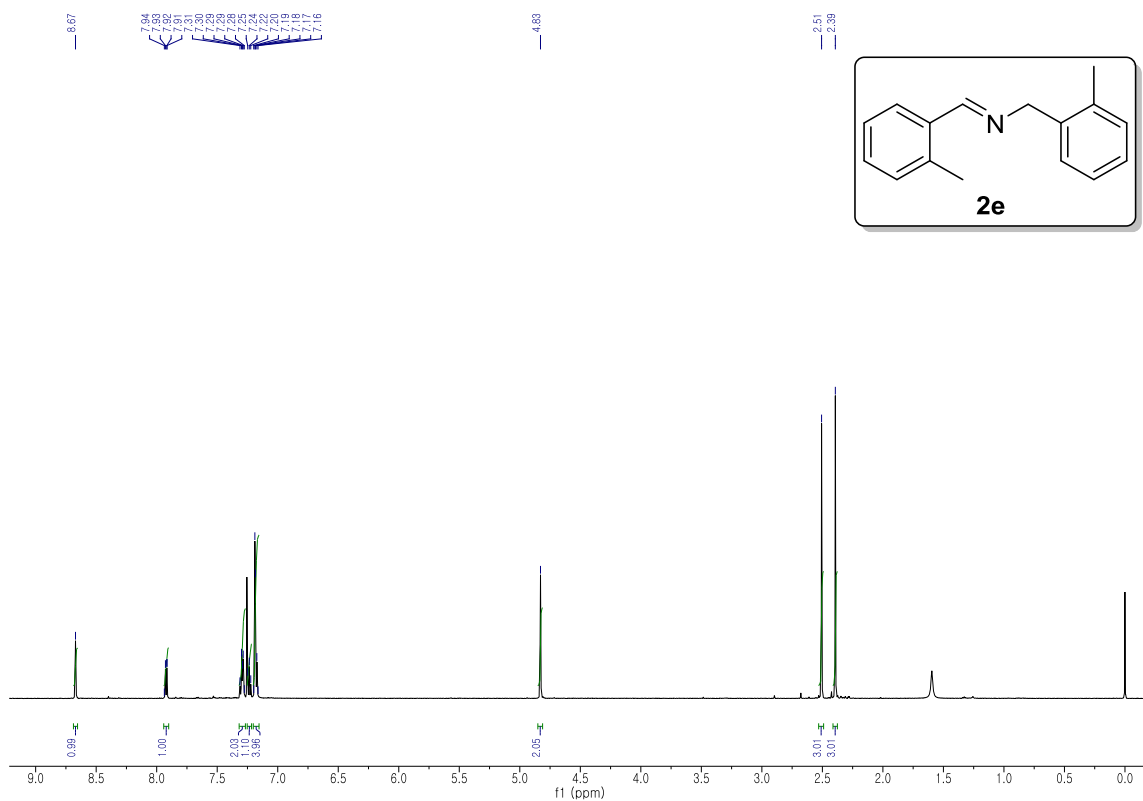
¹H NMR (CDCl₃, 600 MHz) and ¹³C NMR (CDCl₃, 150 MHz) spectra of compound **2c**

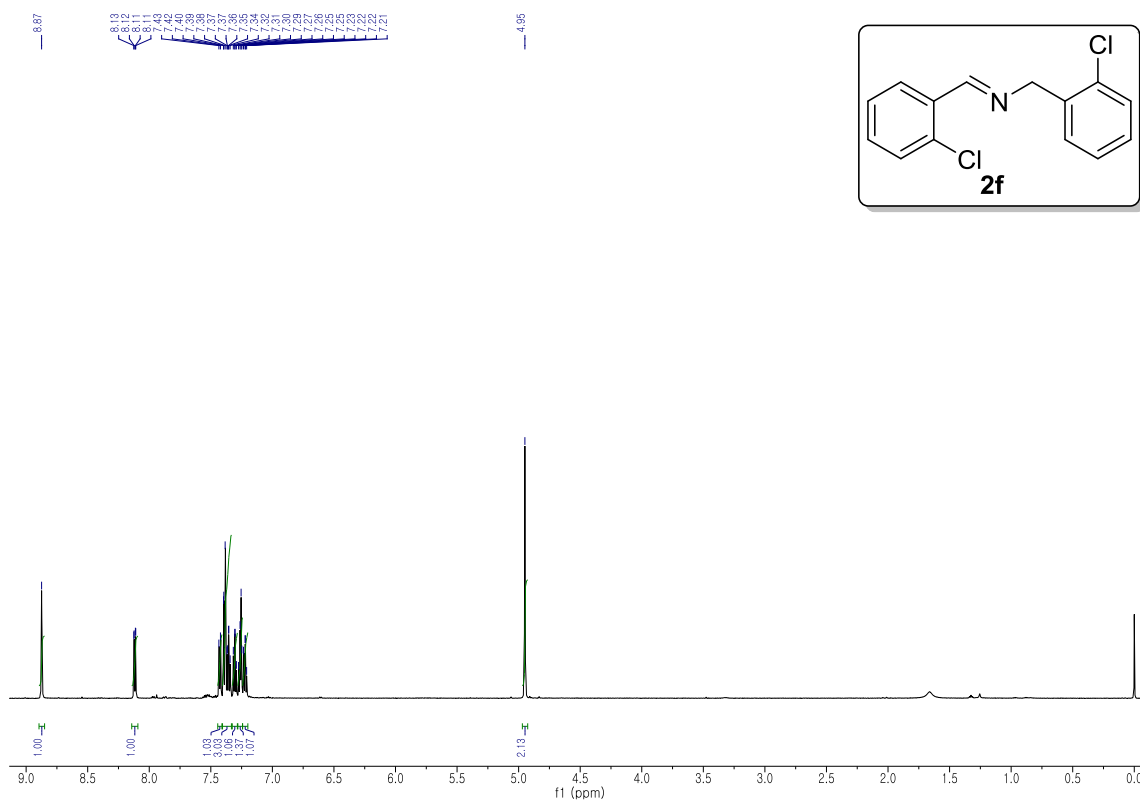




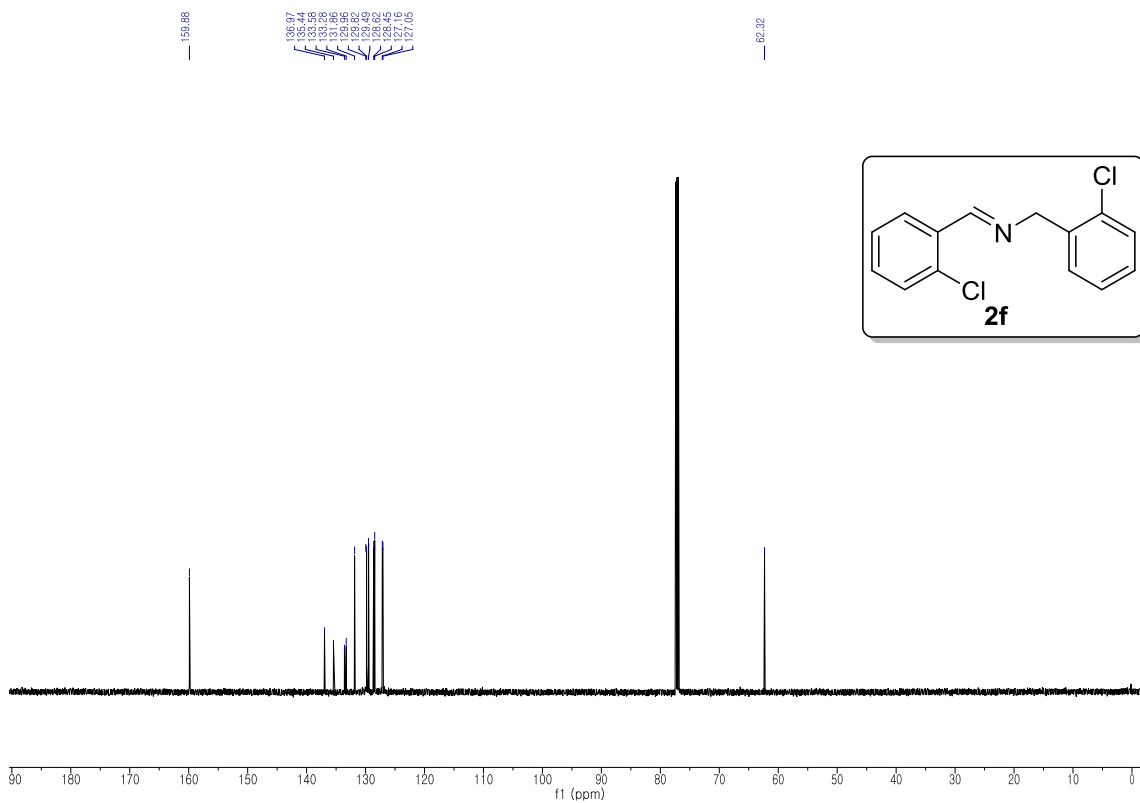
¹H NMR (CDCl₃, 600 MHz) and ¹³C NMR (CDCl₃, 150 MHz) spectra of compound **2d**

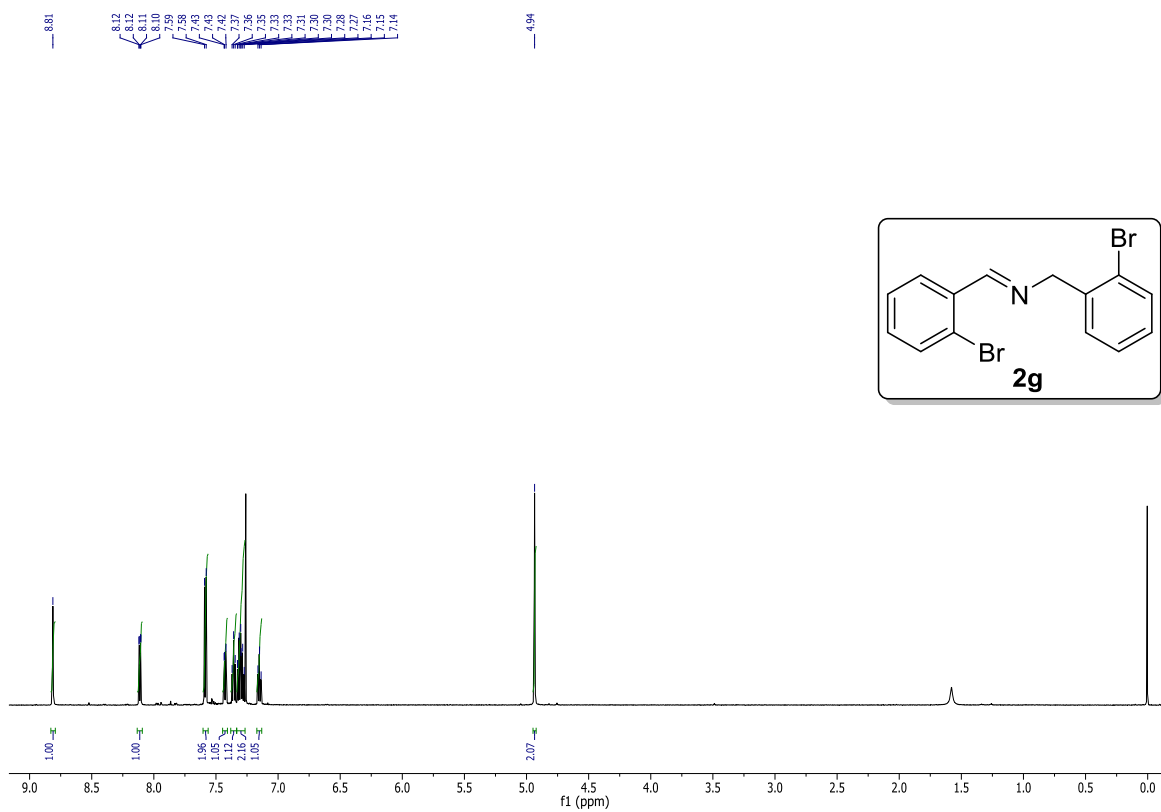




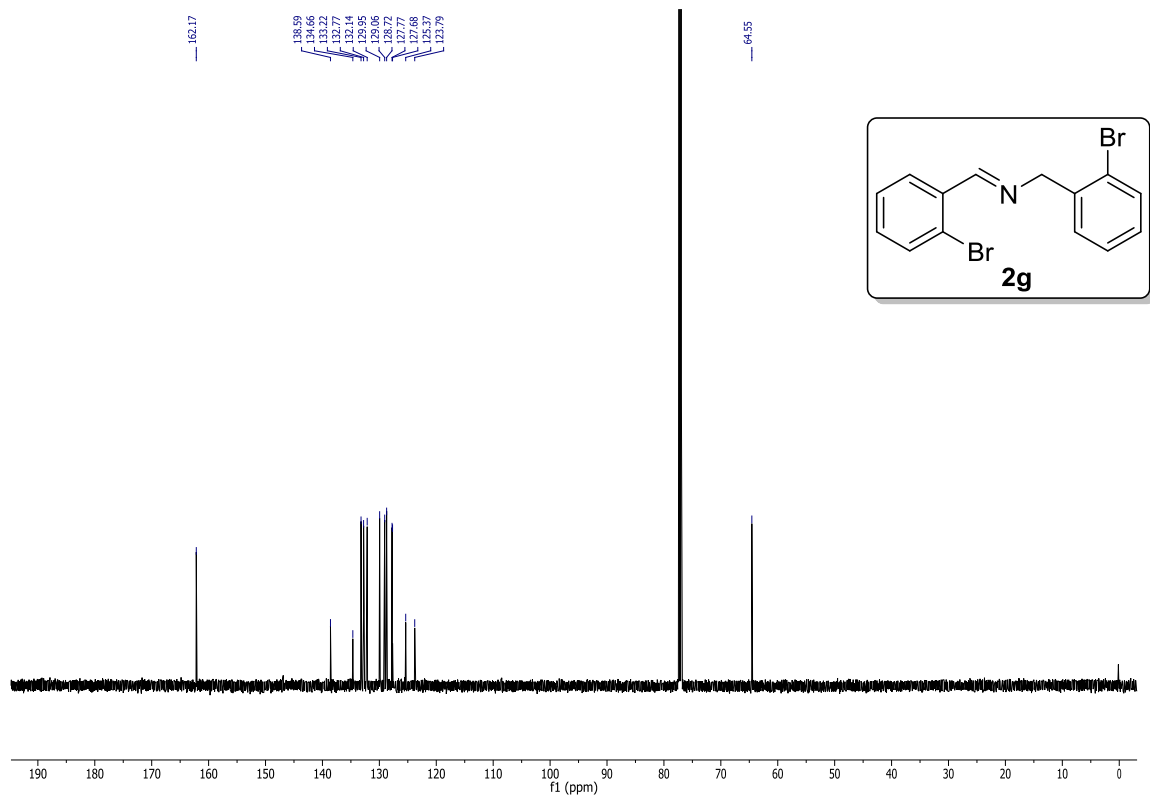


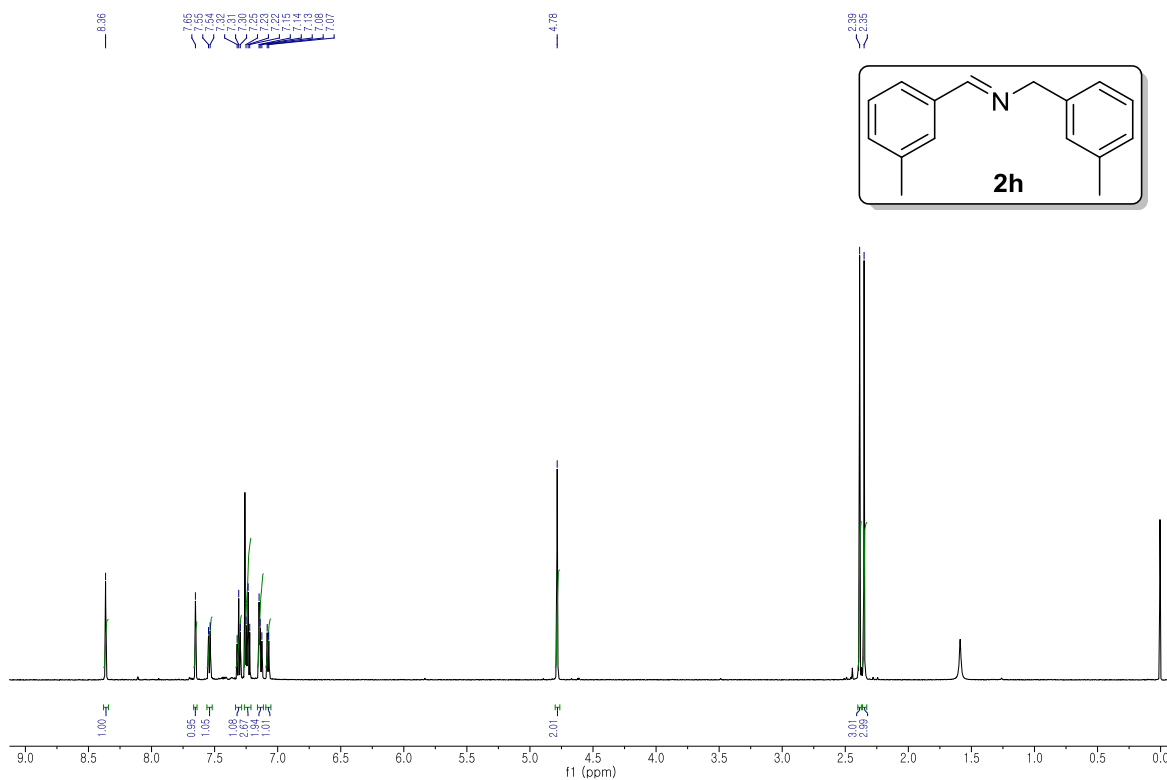
¹H NMR (CDCl₃, 600 MHz) and ¹³C NMR (CDCl₃, 150 MHz) spectra of compound **2f**



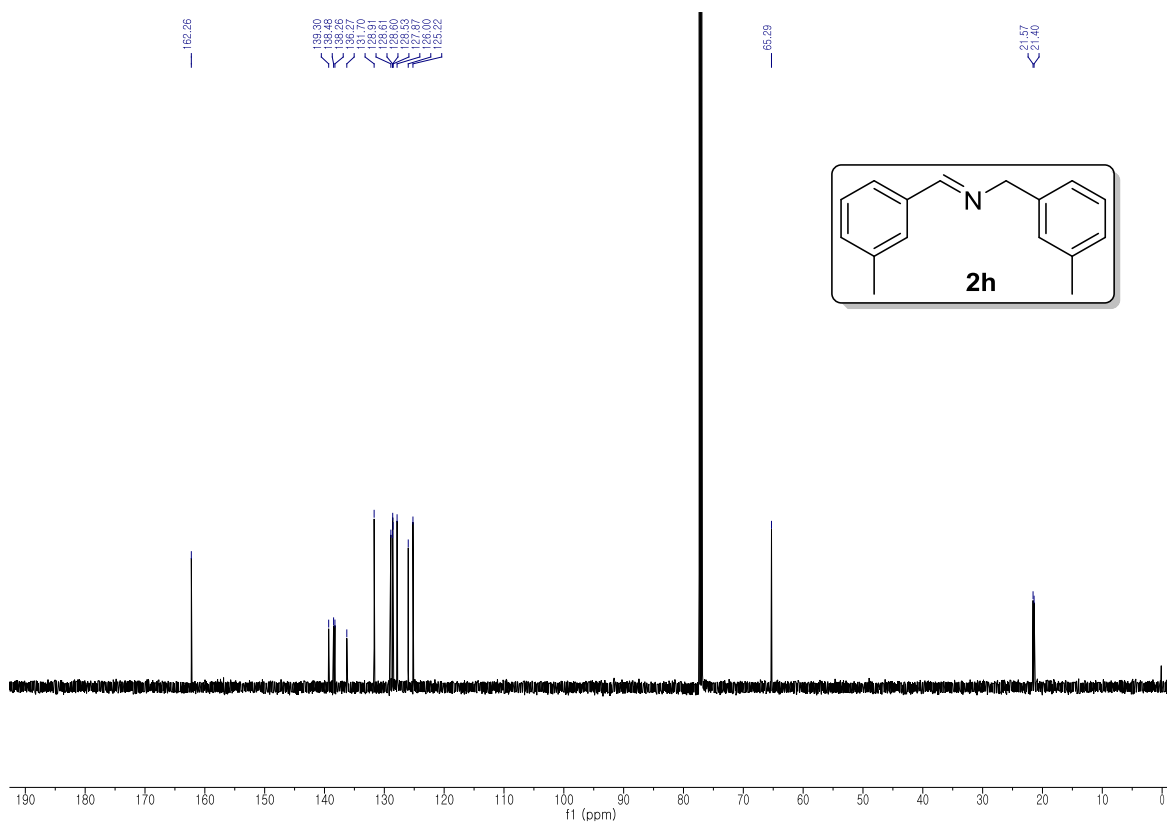


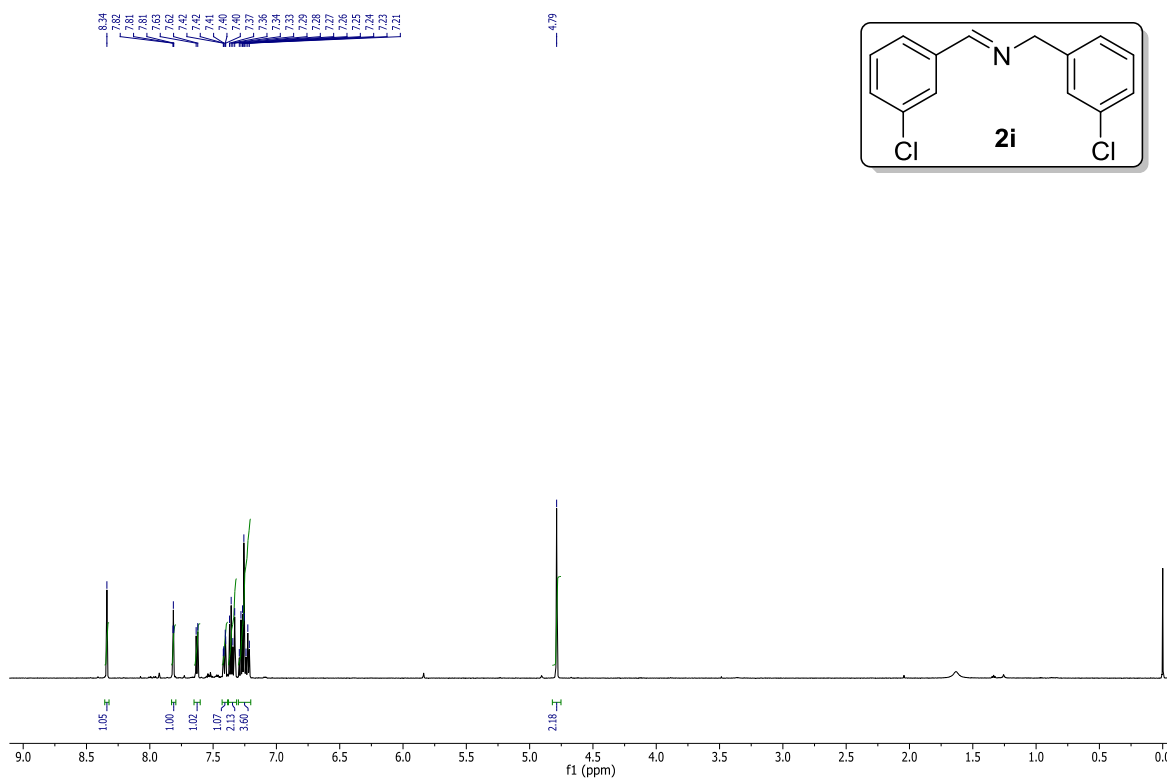
¹H NMR (CDCl₃, 600 MHz) and ¹³C NMR (CDCl₃, 150 MHz) spectra of compound **2g**



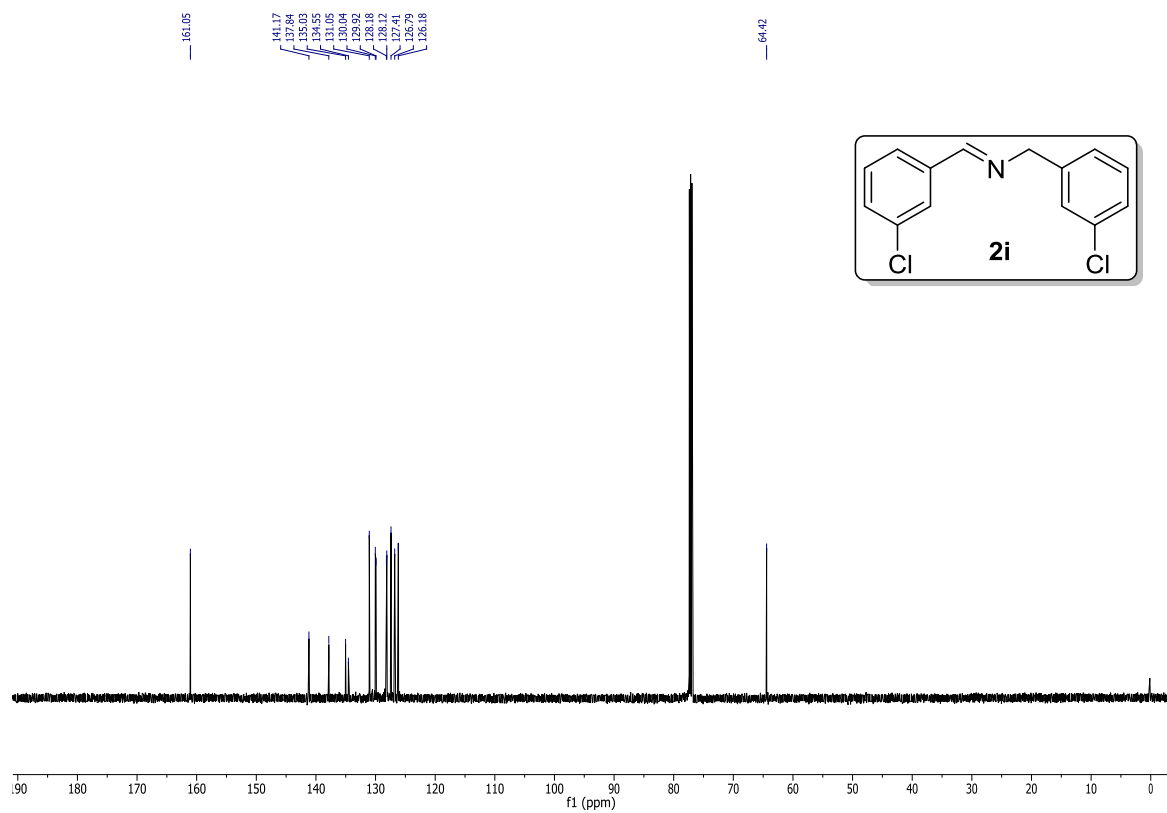


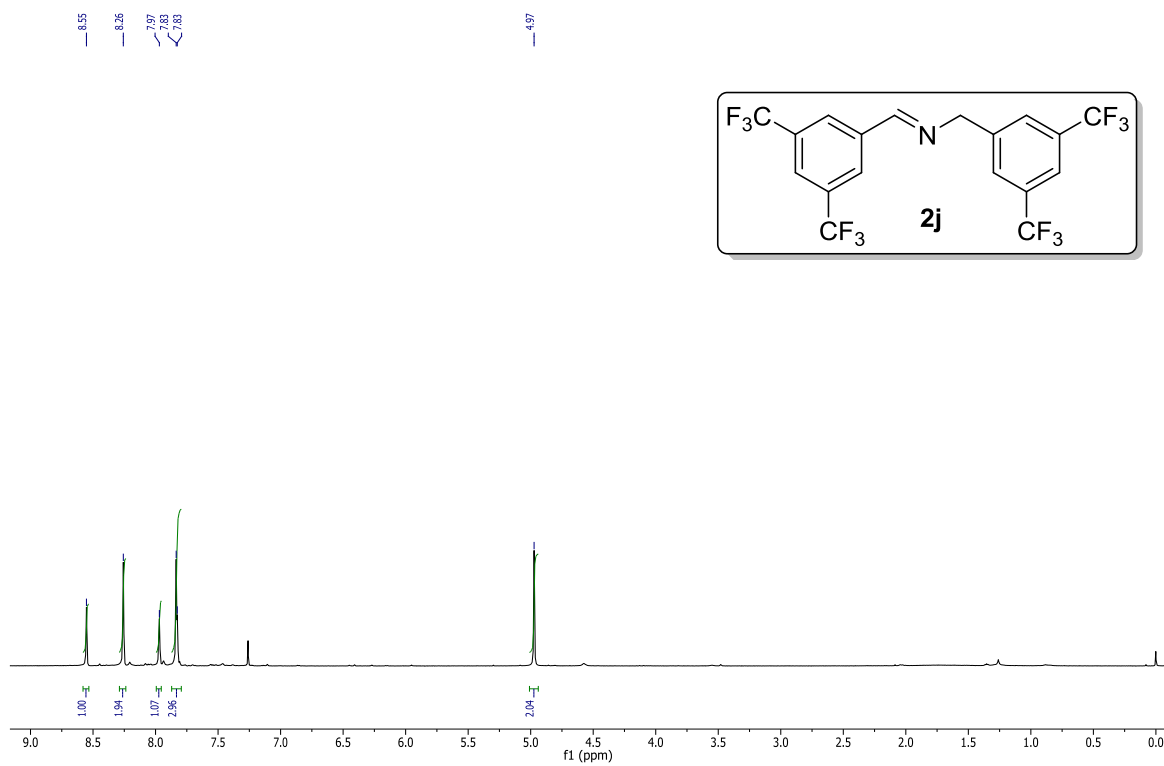
¹H NMR (CDCl₃, 600 MHz) and ¹³C NMR (CDCl₃, 150 MHz) spectra of compound **2h**



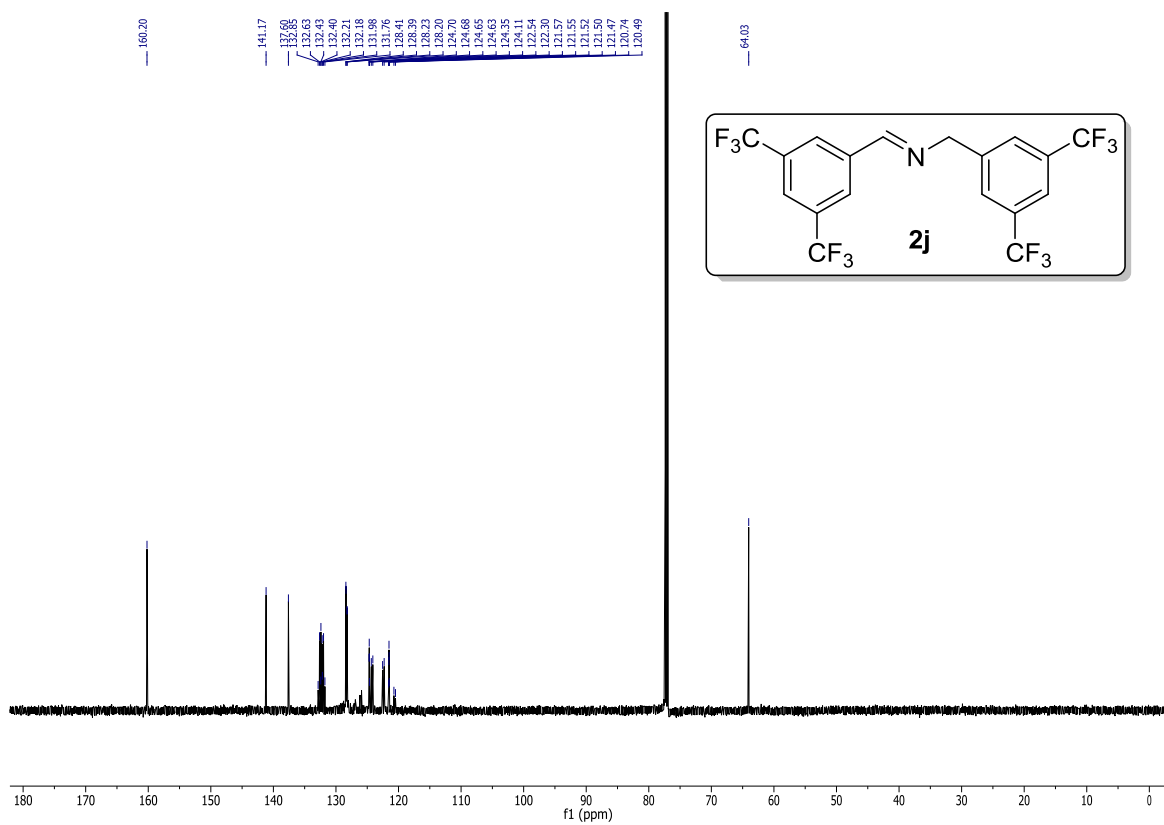


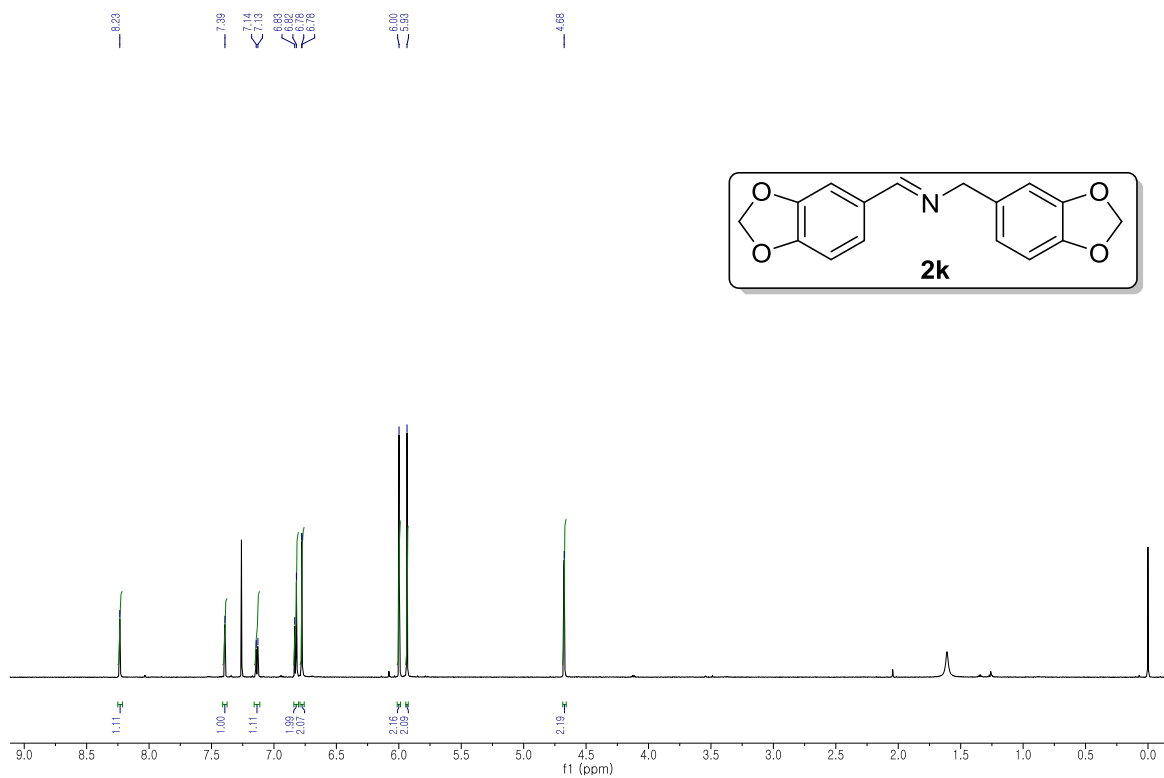
¹H NMR (CDCl₃, 600 MHz) and ¹³C NMR (CDCl₃, 150 MHz) spectra of compound **2i**



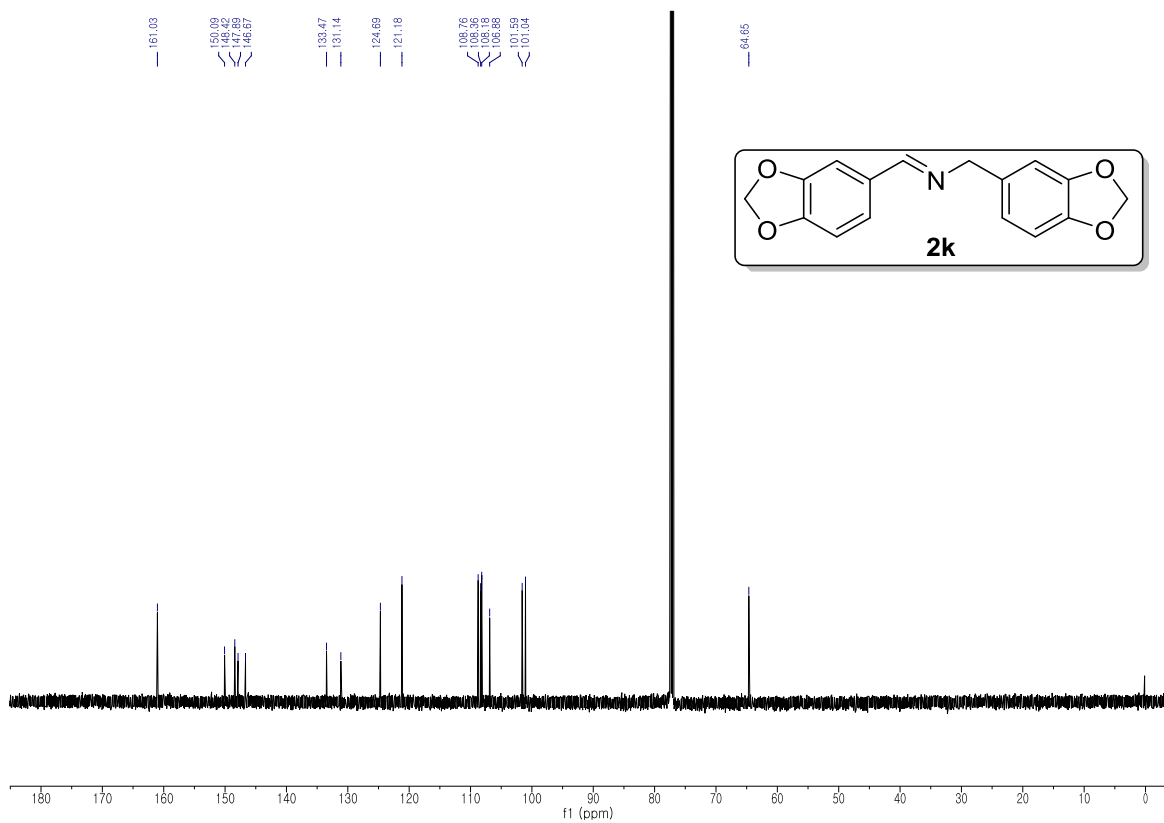


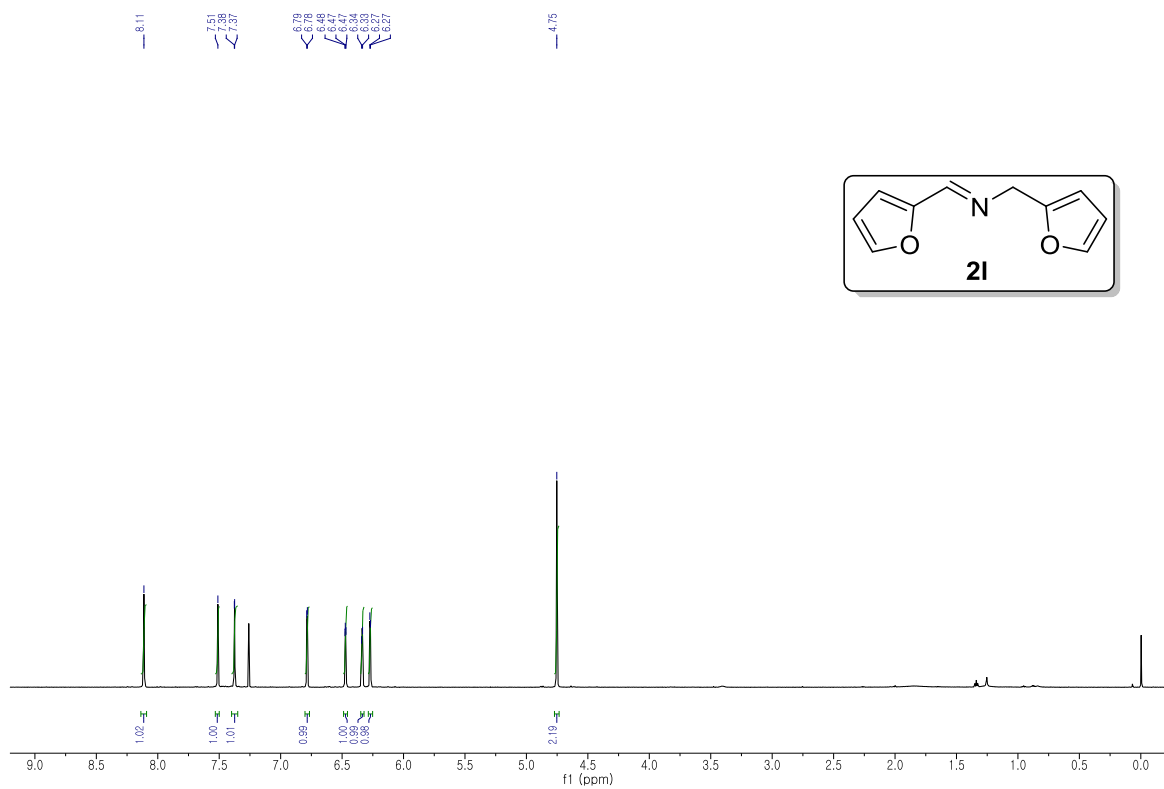
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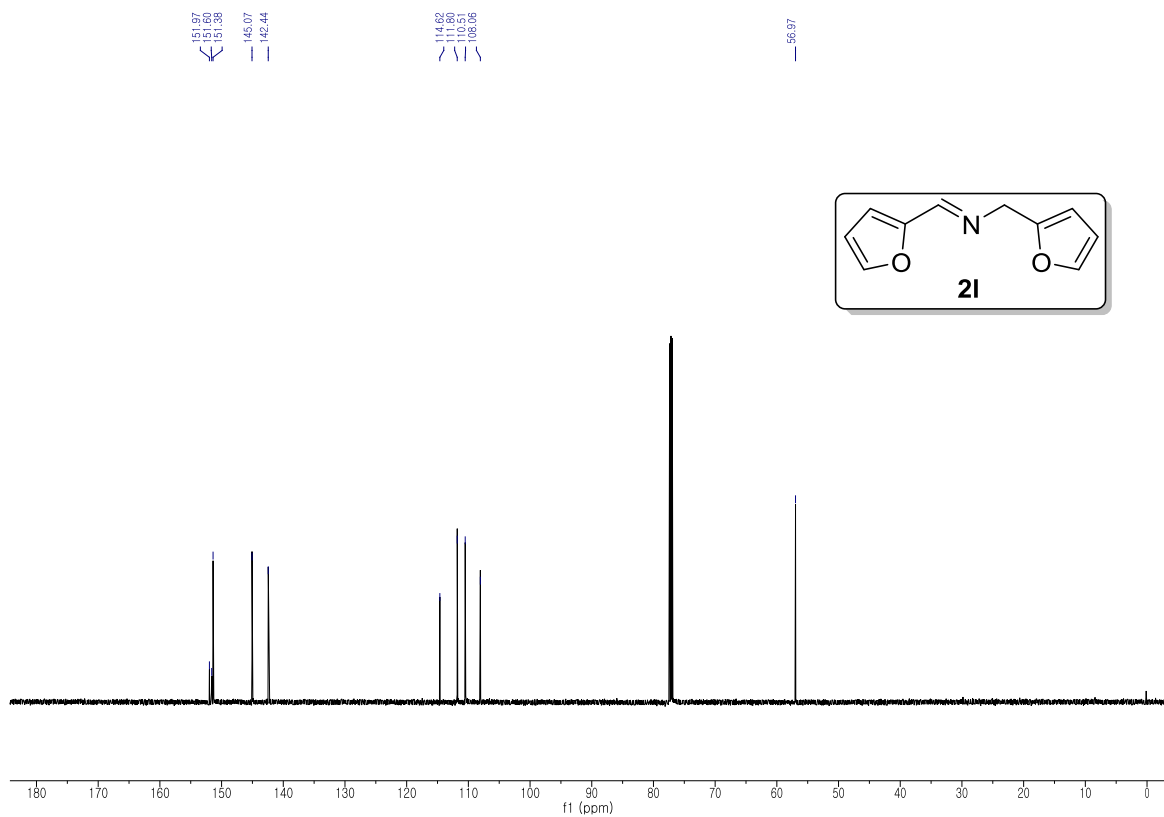


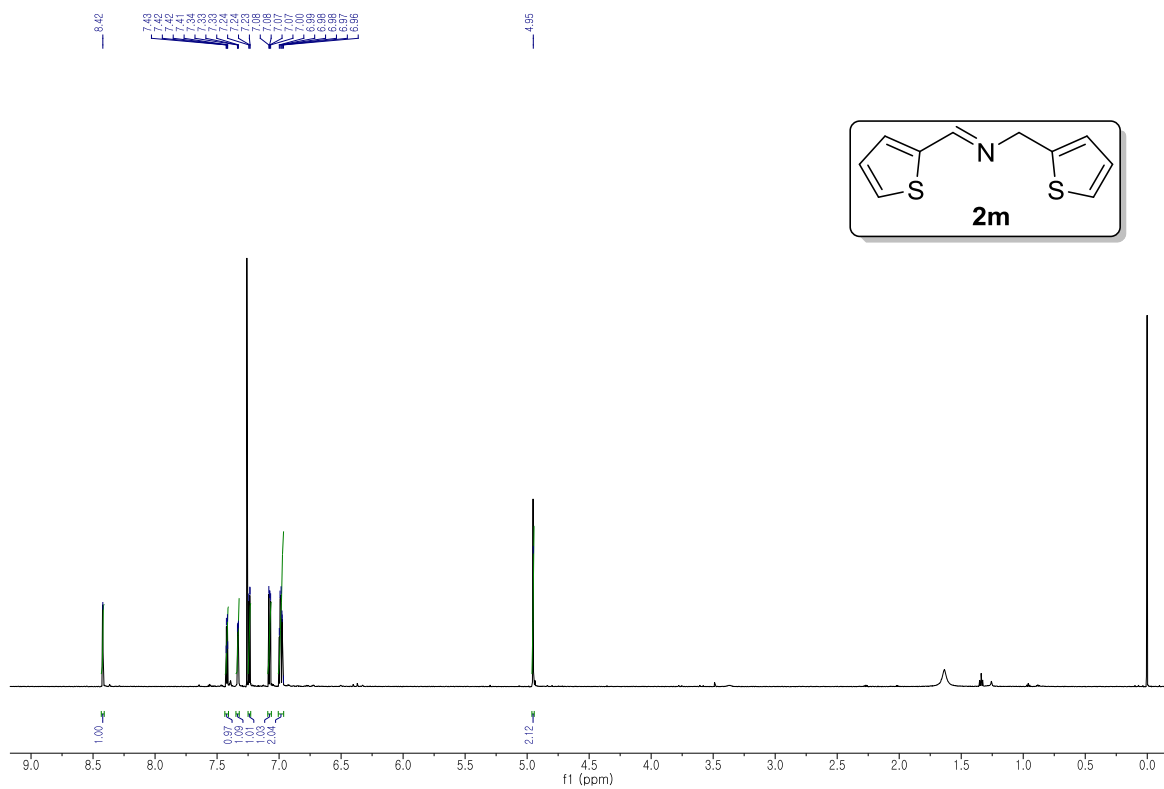
¹H NMR (CDCl₃, 600 MHz) and ¹³C NMR (CDCl₃, 150 MHz) spectra of compound **2k**



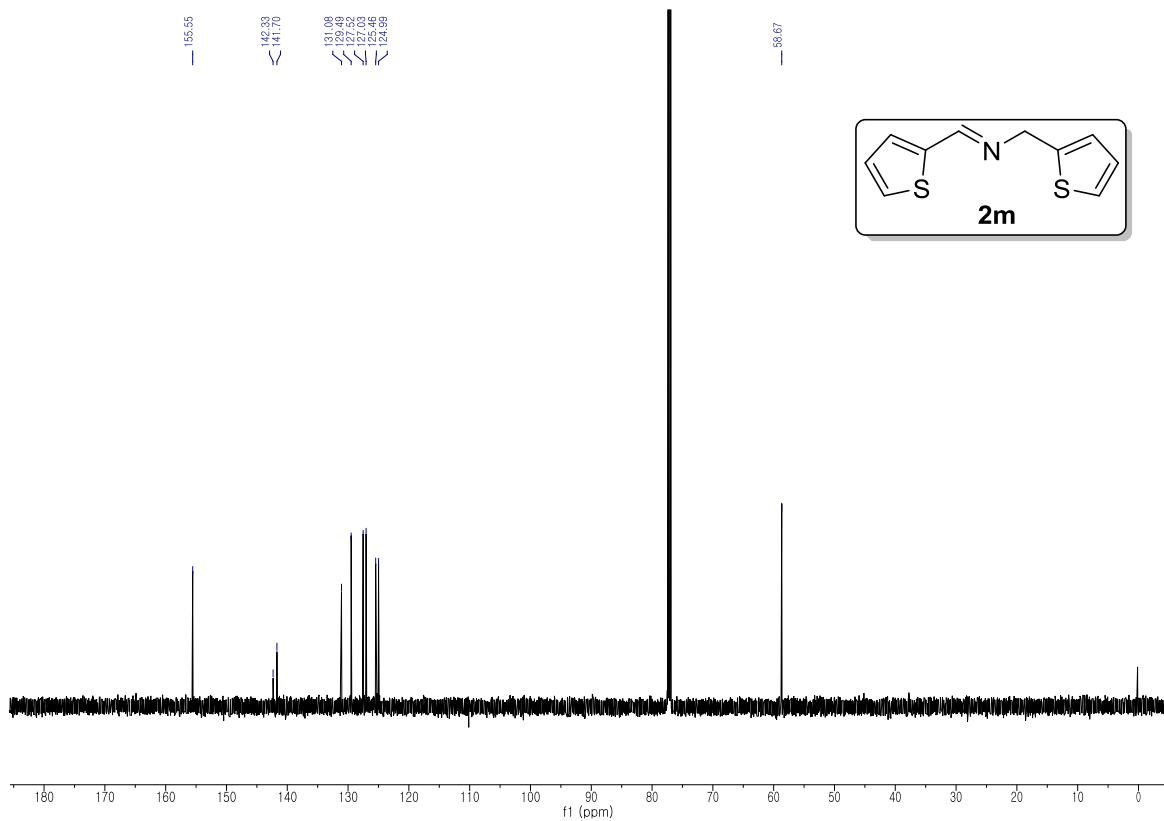


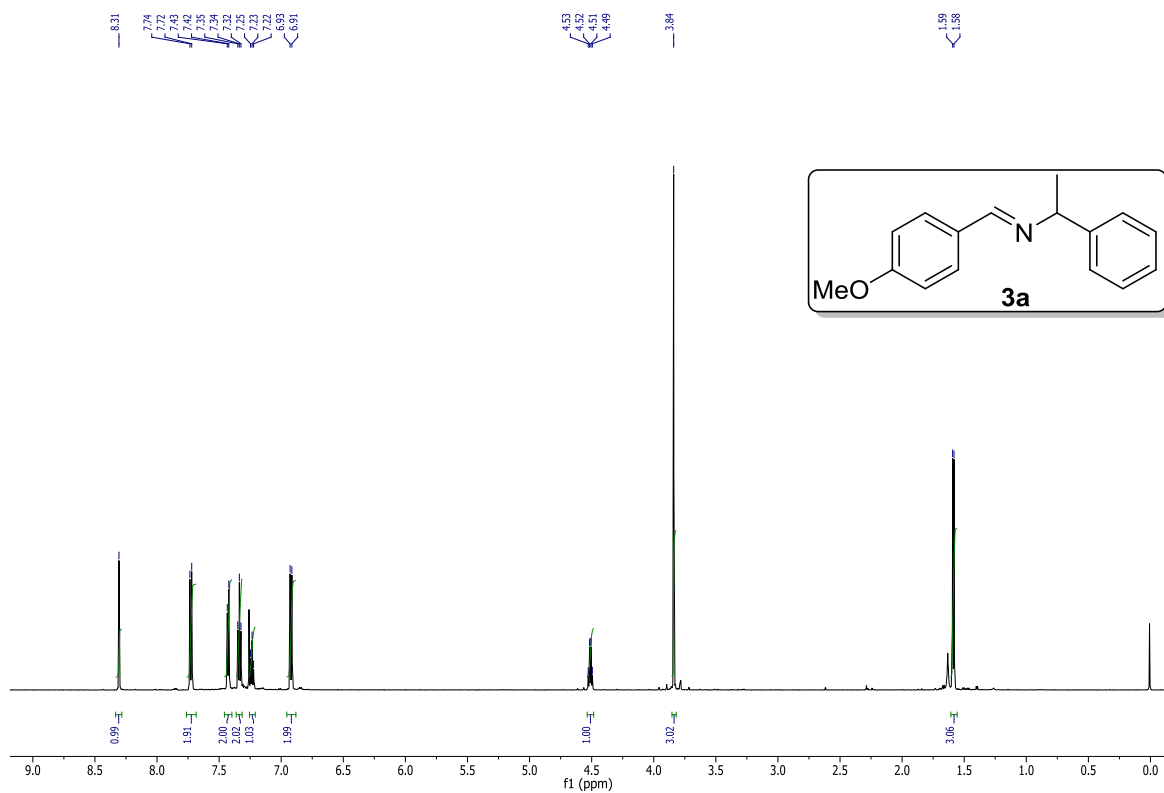
¹H NMR (CDCl₃, 600 MHz) and ¹³C NMR (CDCl₃, 150 MHz) spectra of compound **2I**



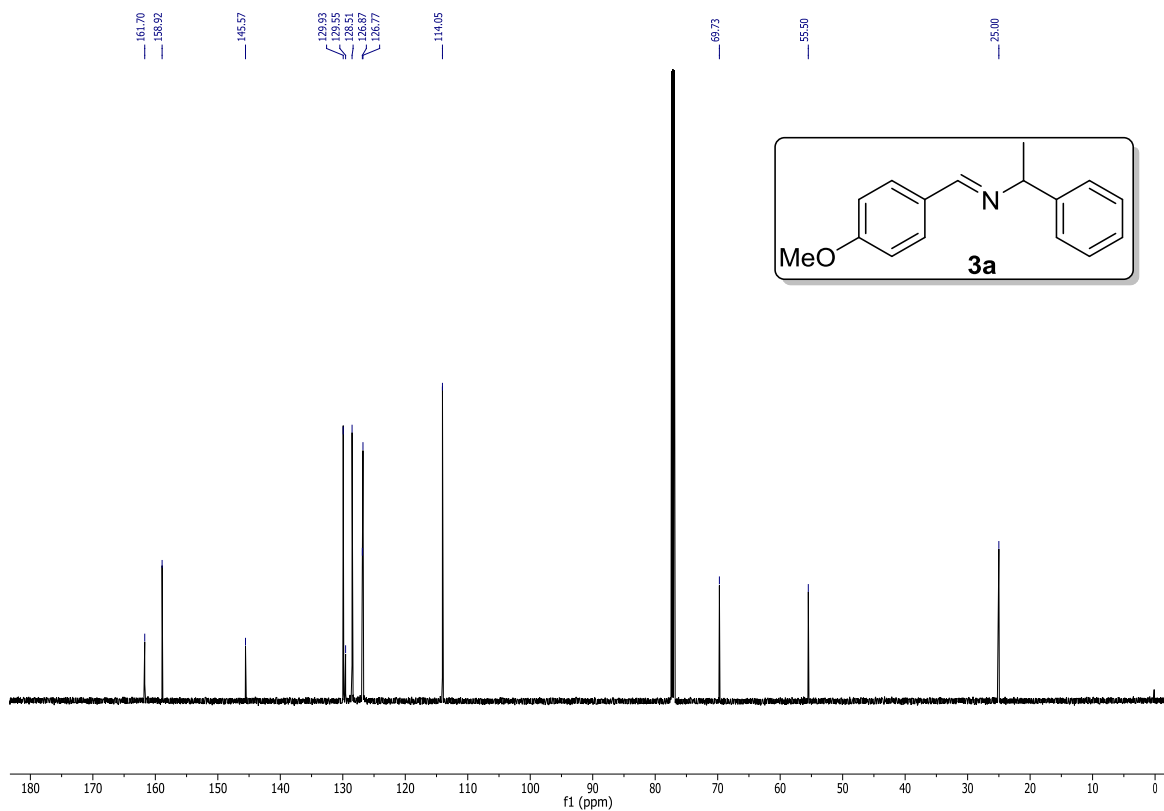


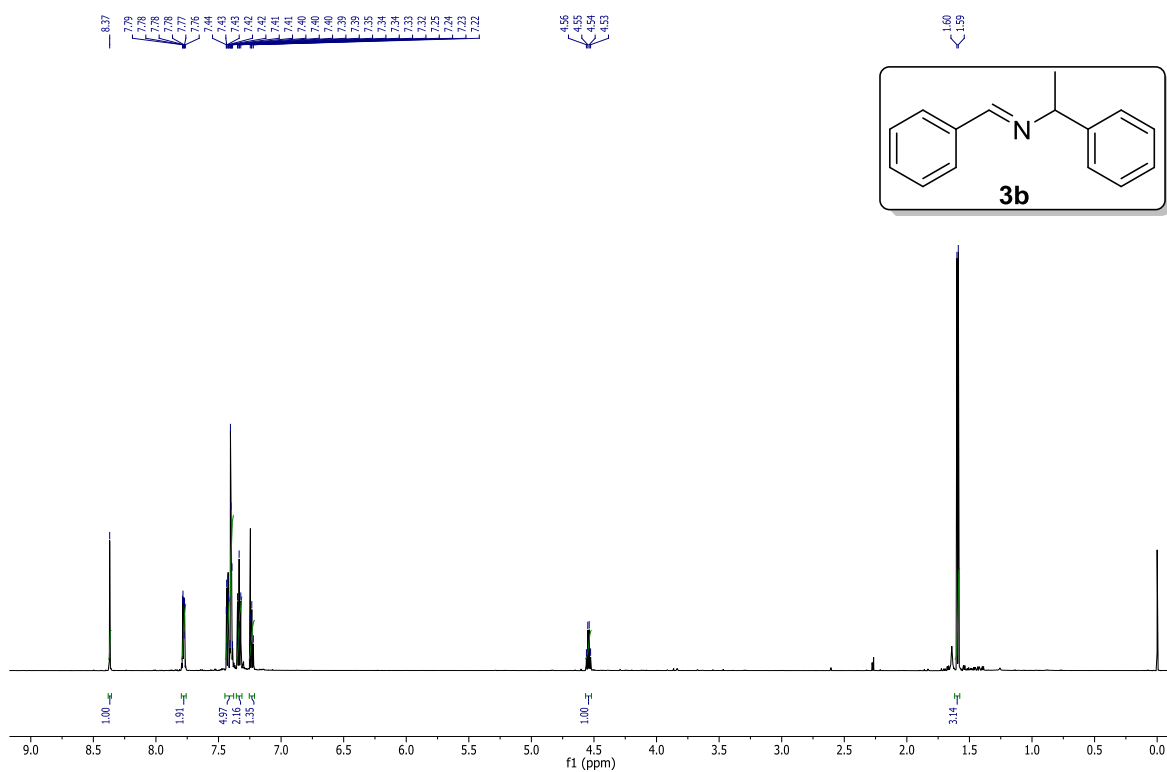
¹H NMR (CDCl₃, 600 MHz) and ¹³C NMR (CDCl₃, 150 MHz) spectra of compound **2m**



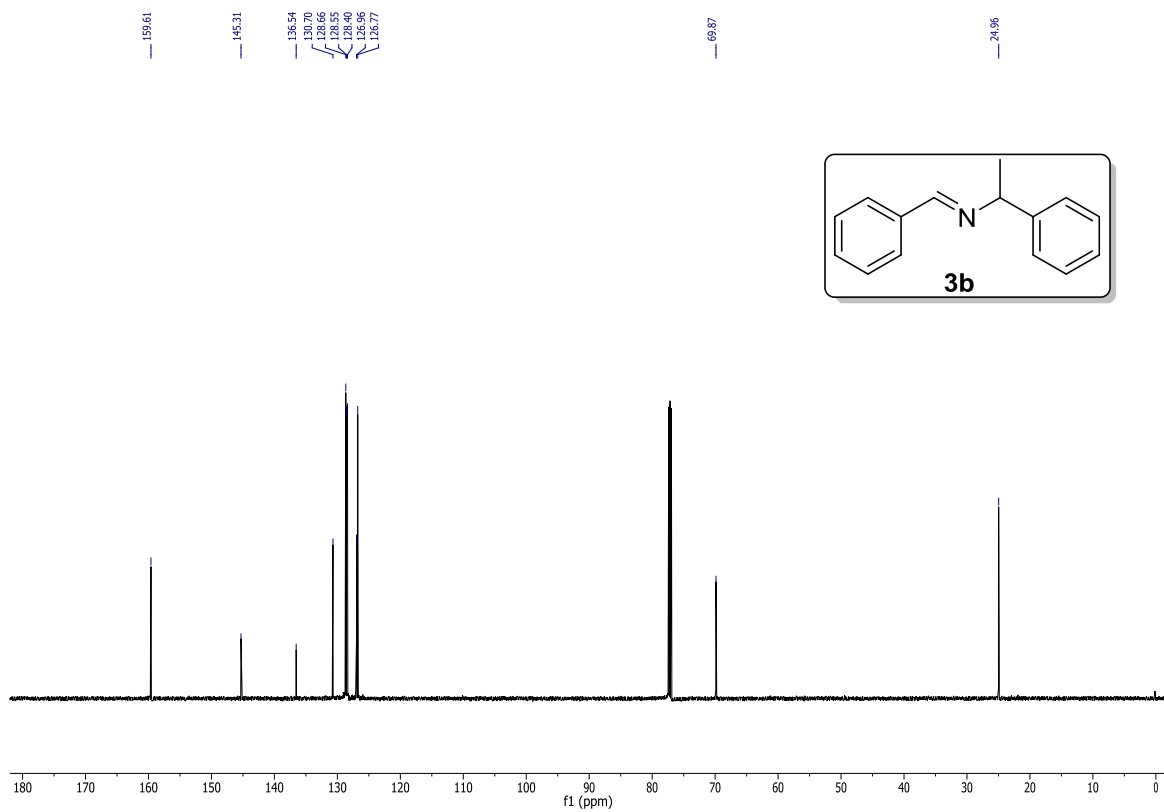


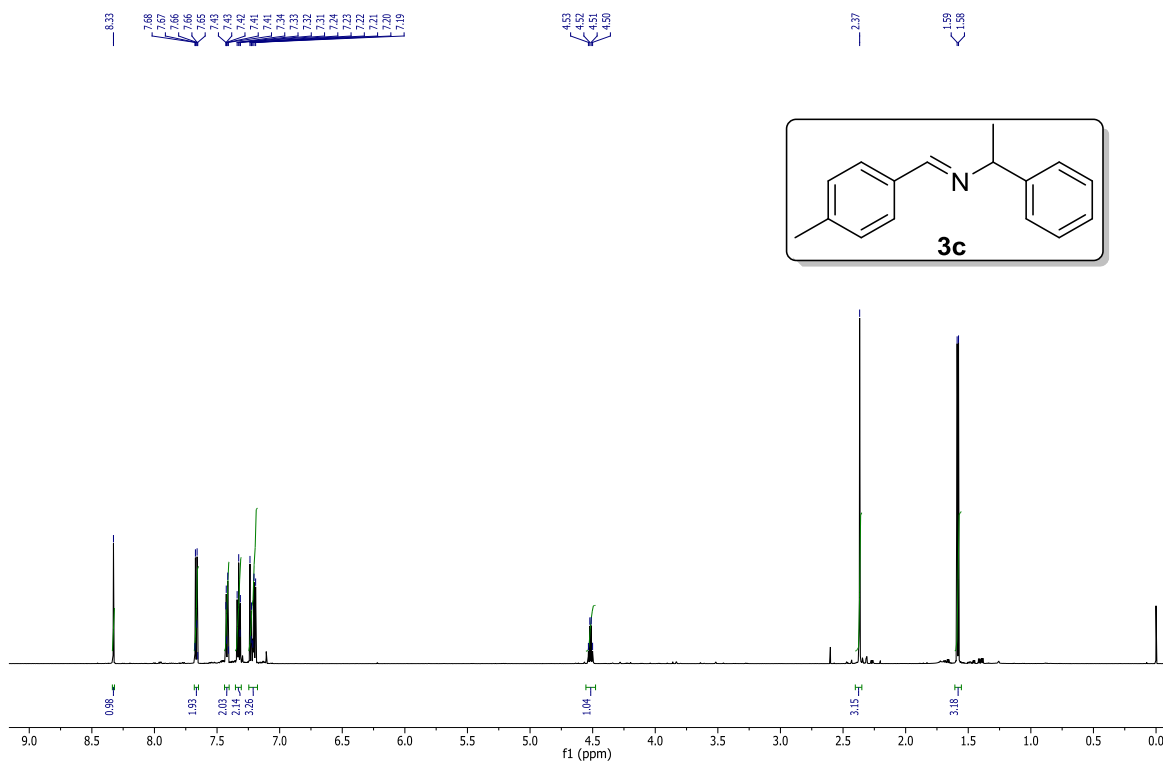
¹H NMR (CDCl₃, 600 MHz) and ¹³C NMR (CDCl₃, 150 MHz) spectra of compound **3a**



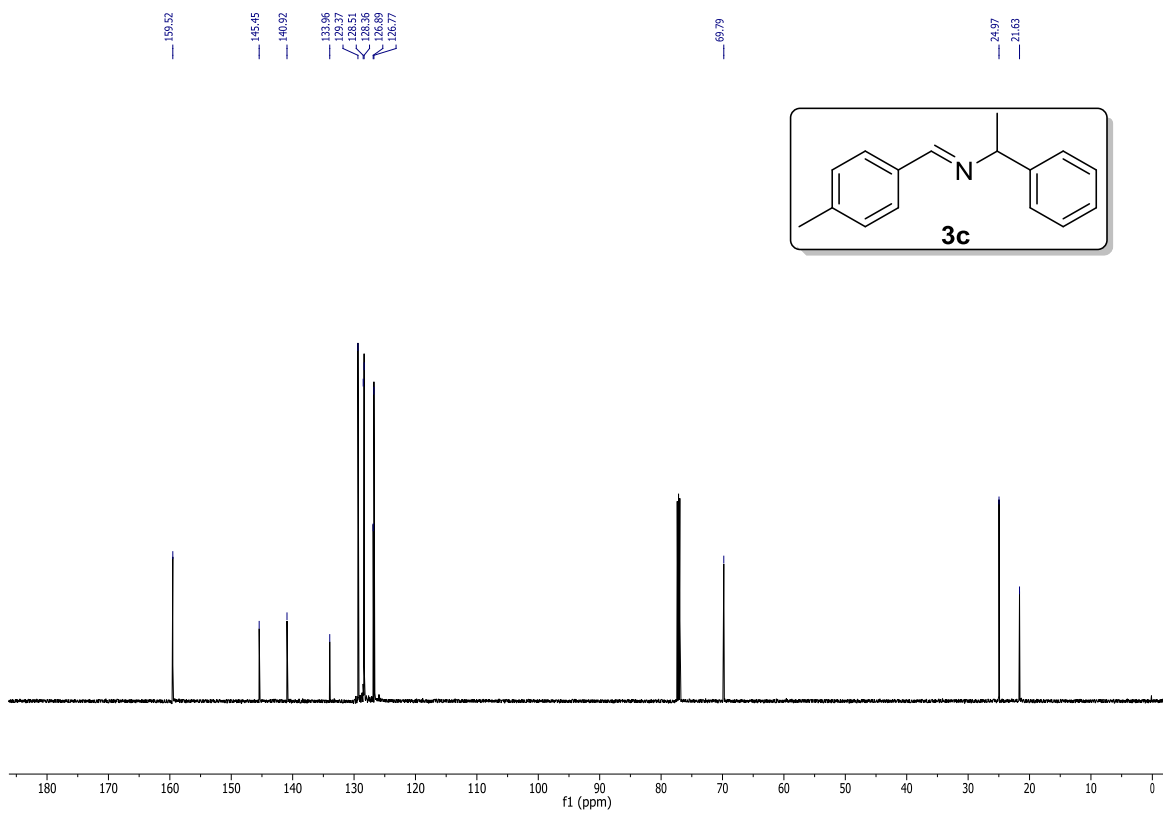


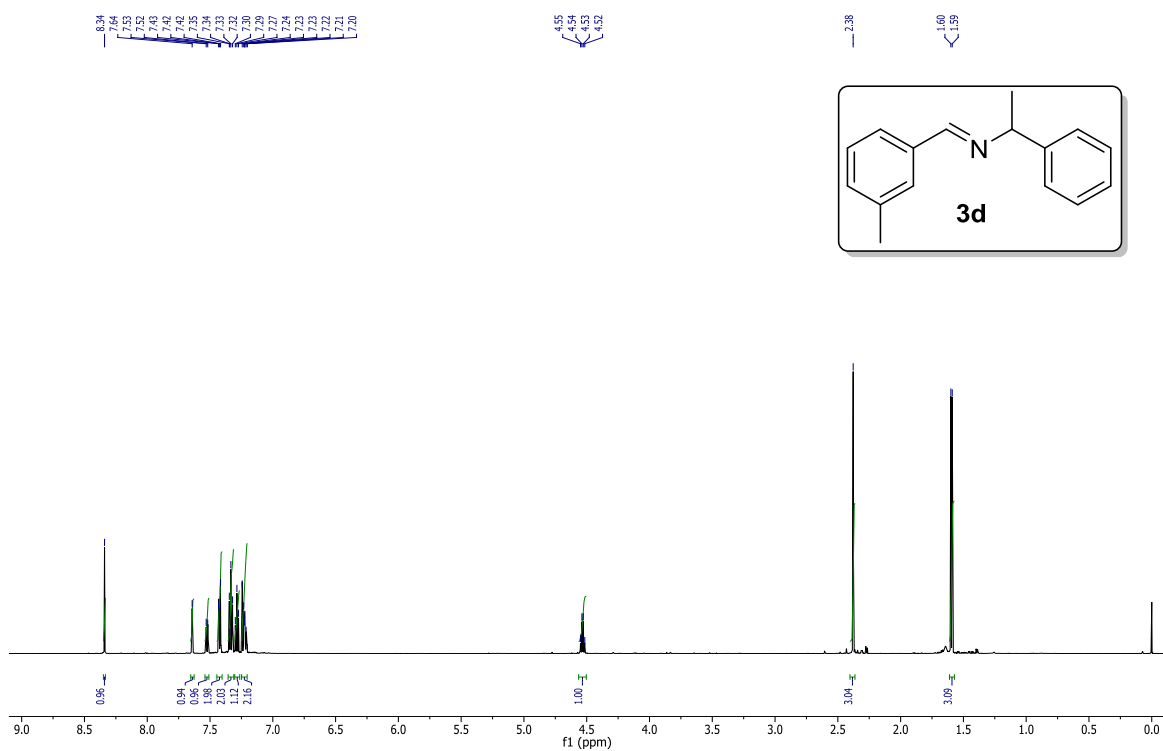
¹H NMR (CDCl₃, 600 MHz) and ¹³C NMR (CDCl₃, 150 MHz) spectra of compound **3b**



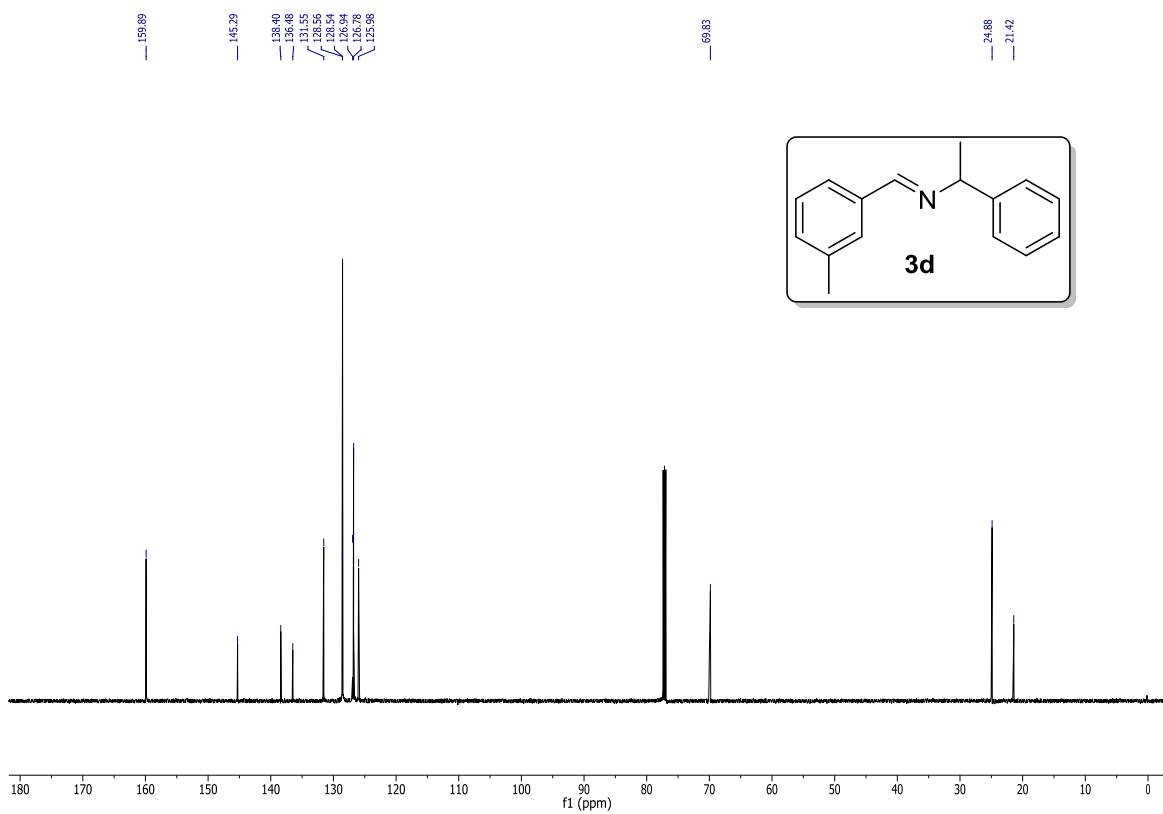


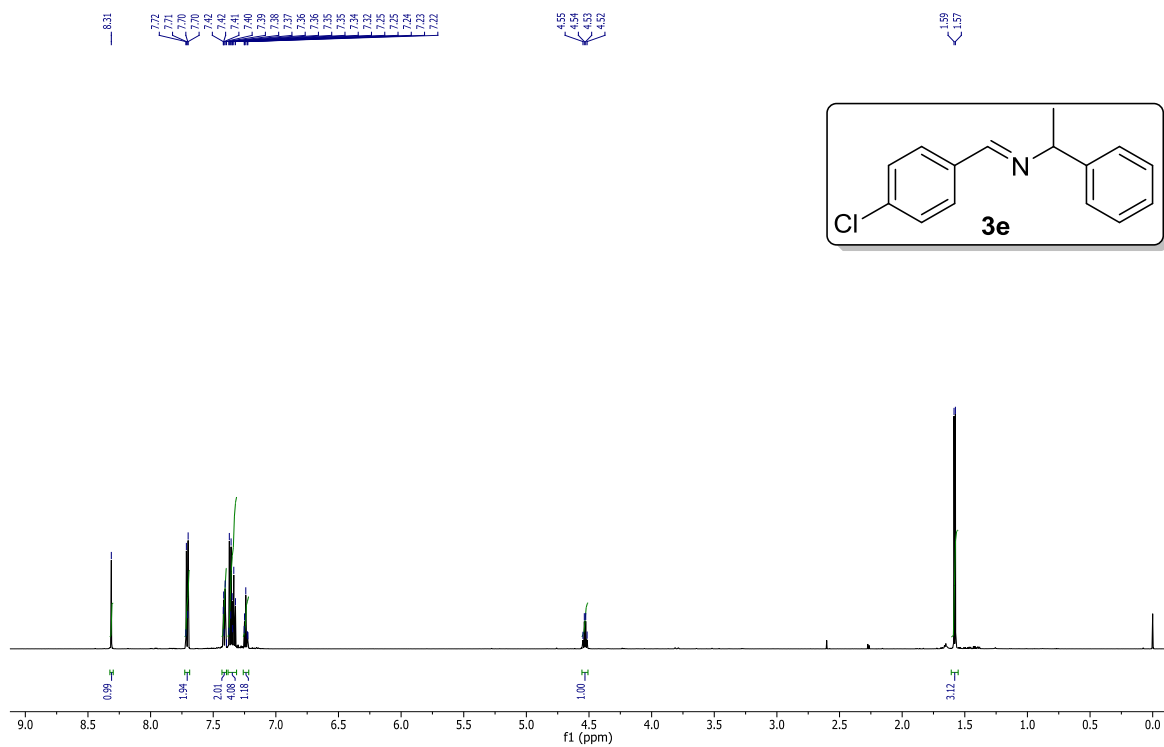
¹H NMR (CDCl₃, 600 MHz) and ¹³C NMR (CDCl₃, 150 MHz) spectra of compound **3c**



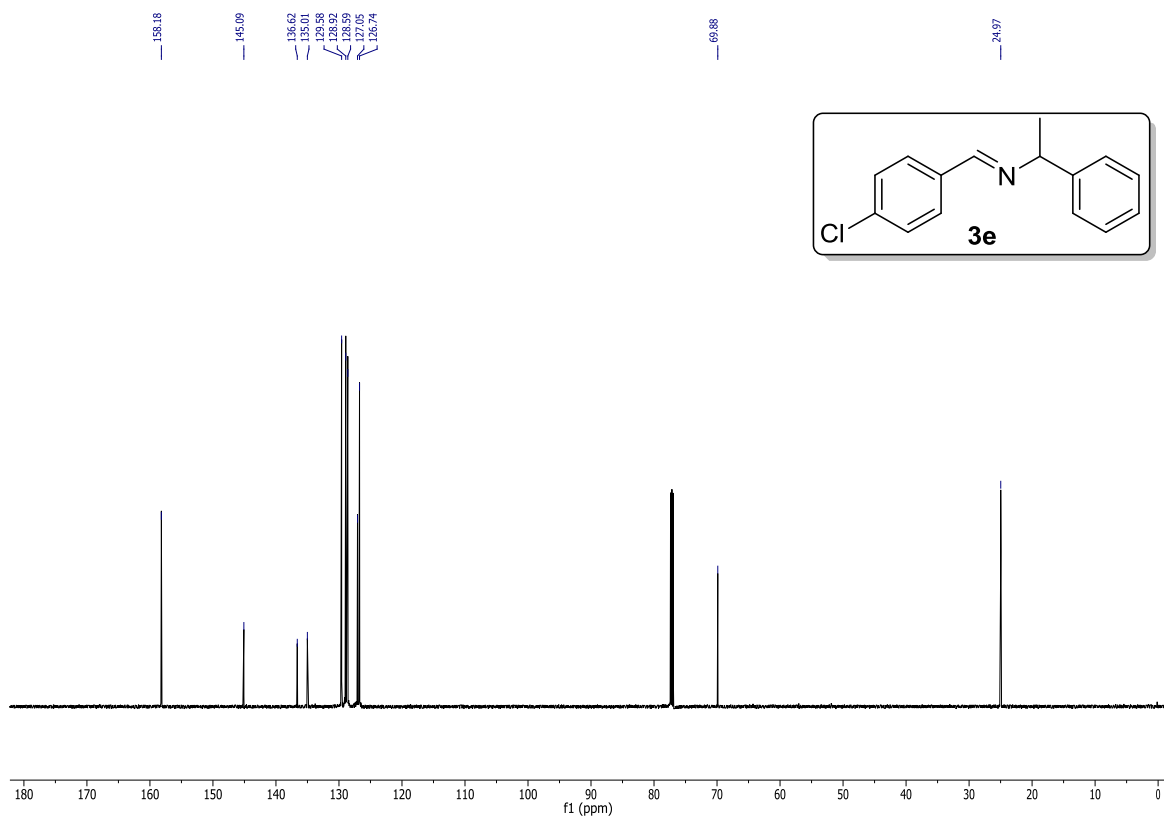


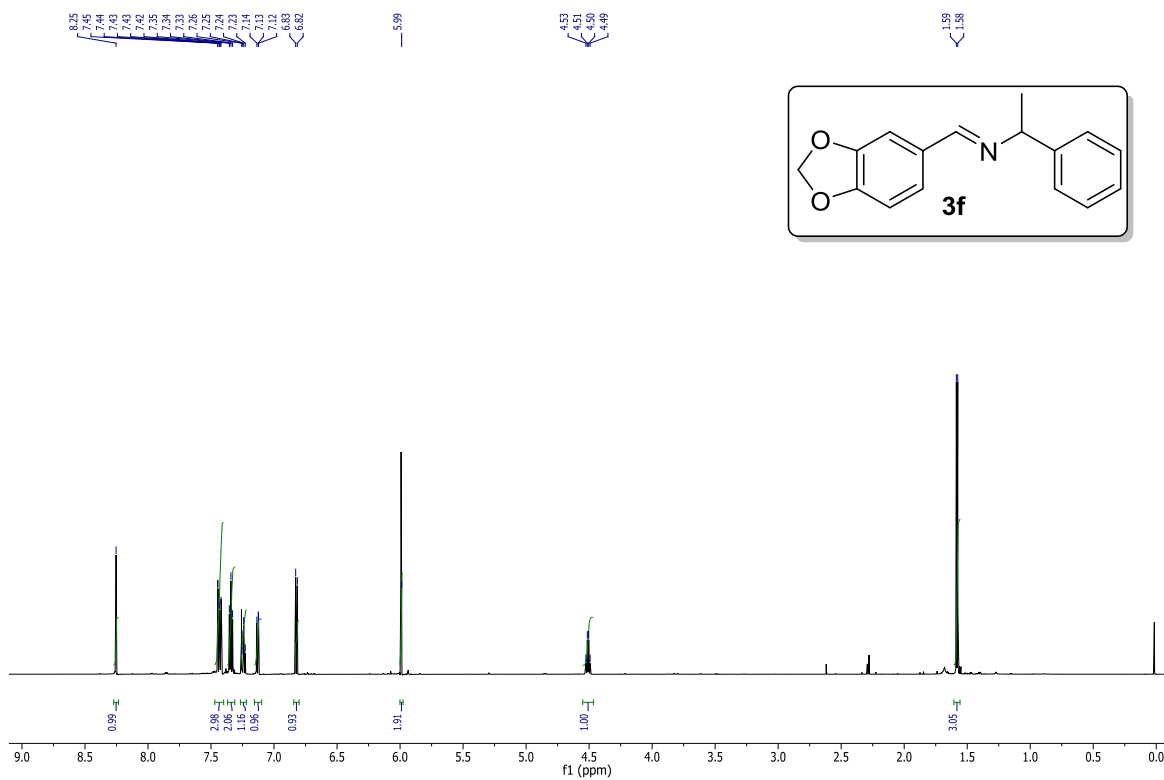
¹H NMR (CDCl₃, 600 MHz) and ¹³C NMR (CDCl₃, 150 MHz) spectra of compound **3d**



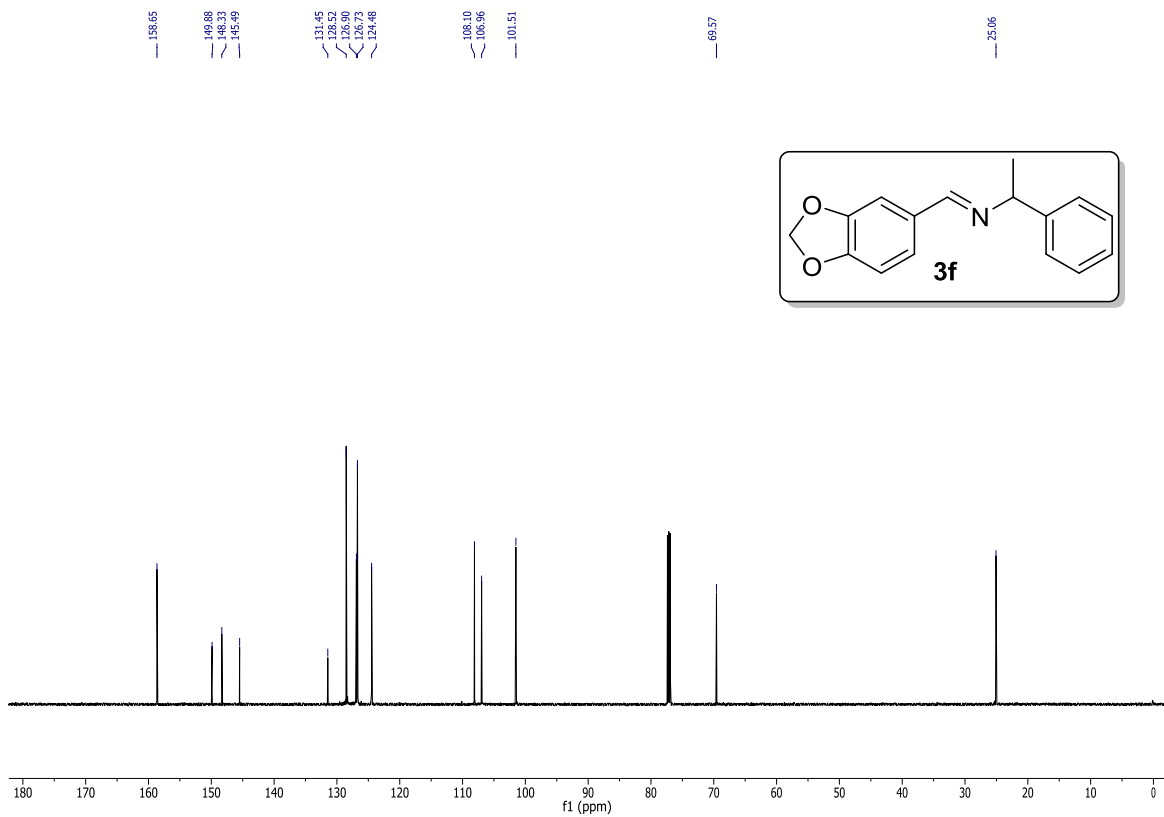


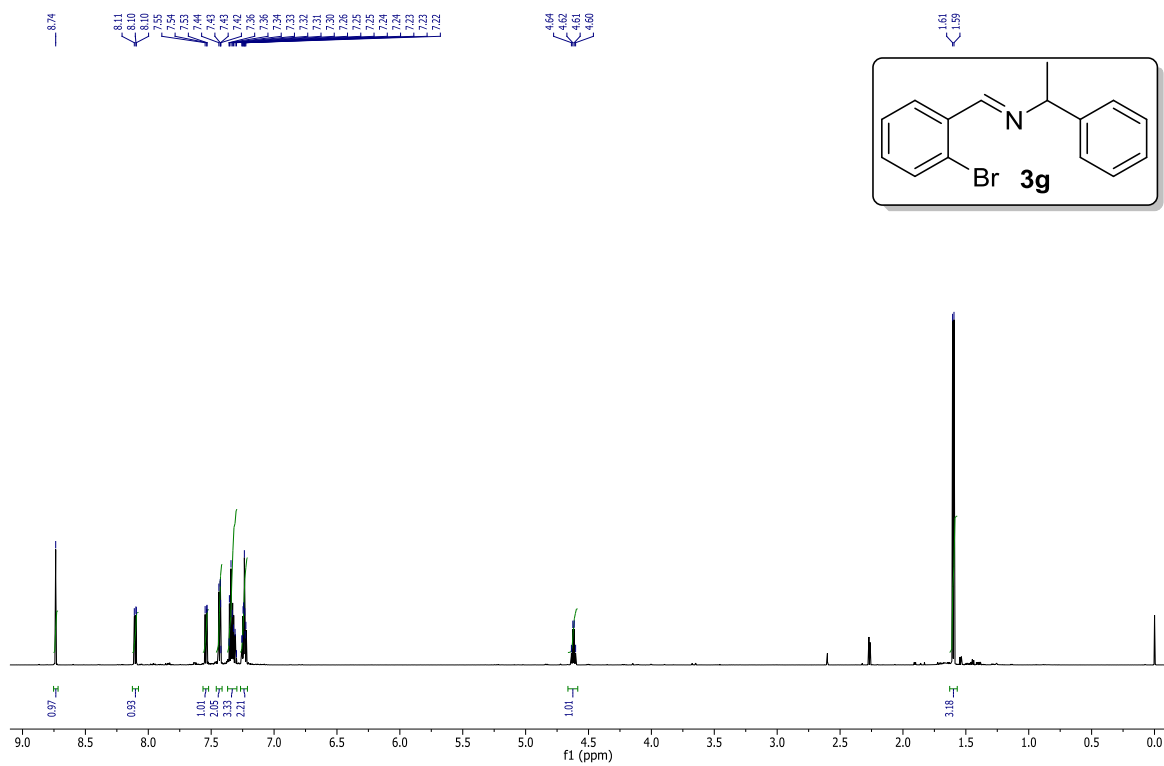
¹H NMR (CDCl₃, 600 MHz) and ¹³C NMR (CDCl₃, 150 MHz) spectra of compound **3e**



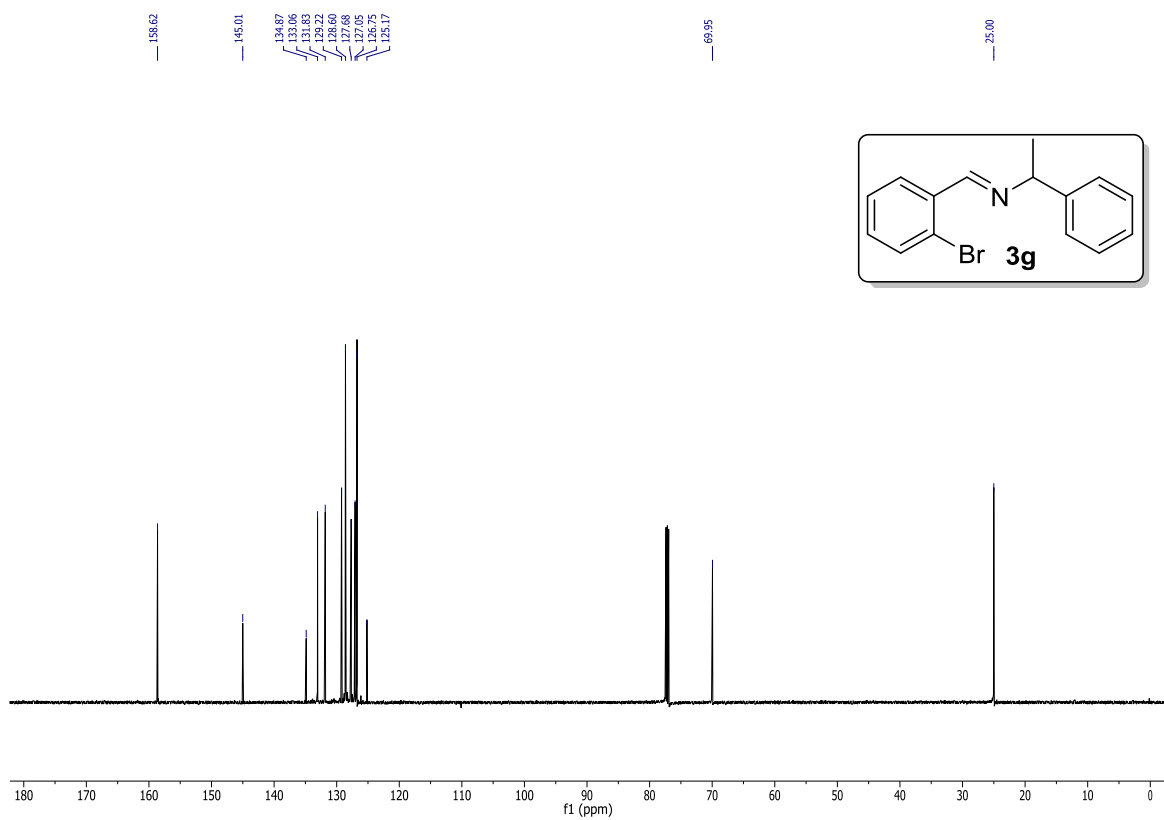


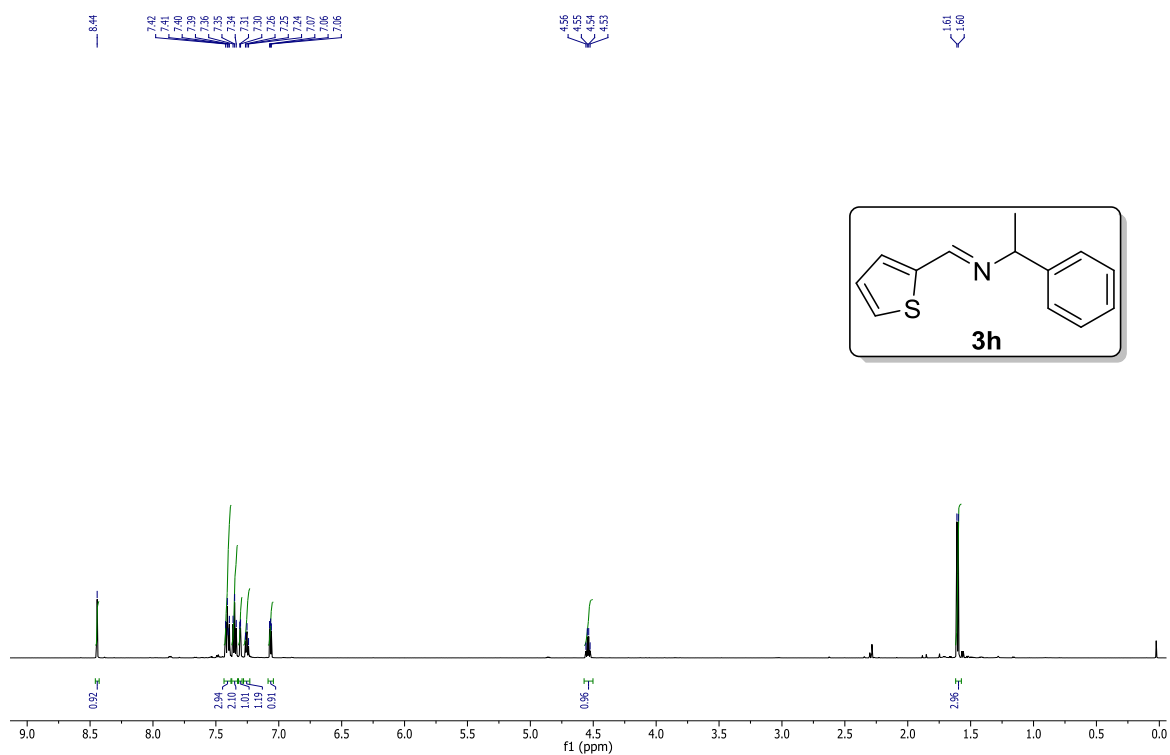
¹H NMR (CDCl₃, 600 MHz) and ¹³C NMR (CDCl₃, 150 MHz) spectra of compound **3f**



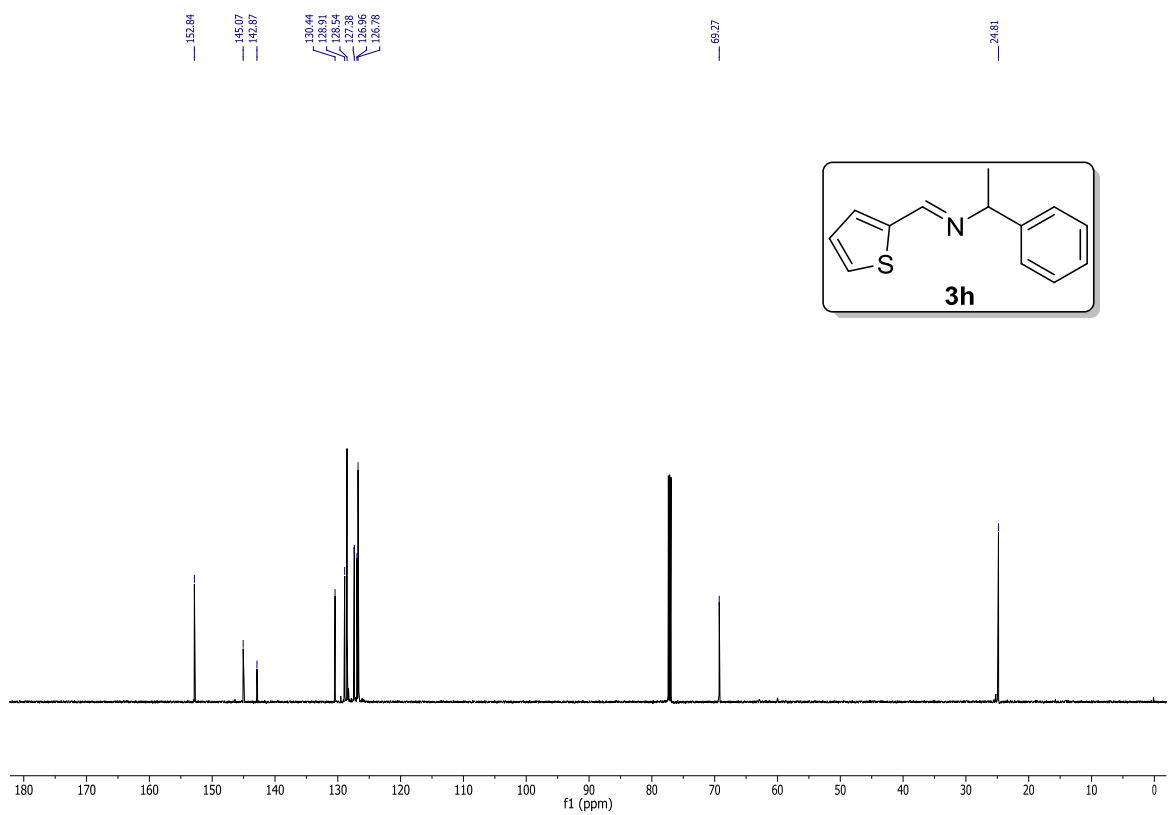


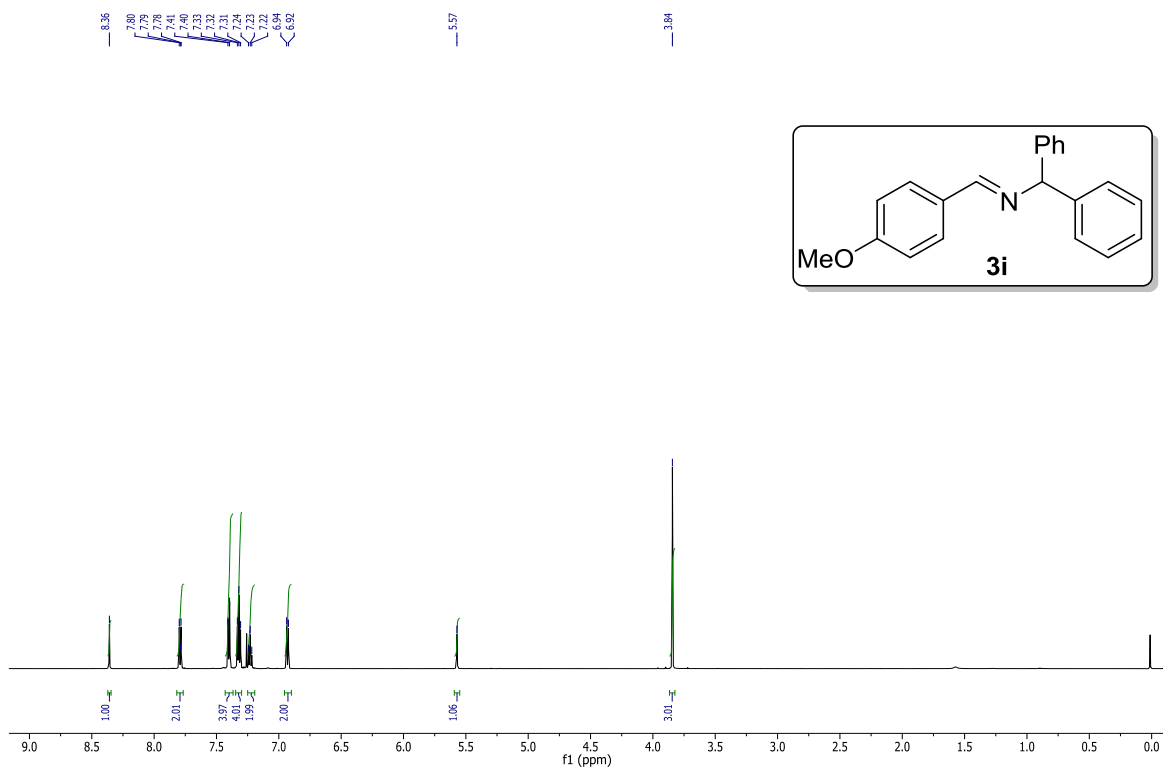
¹H NMR (CDCl₃, 600 MHz) and ¹³C NMR (CDCl₃, 150 MHz) spectra of compound **3g**



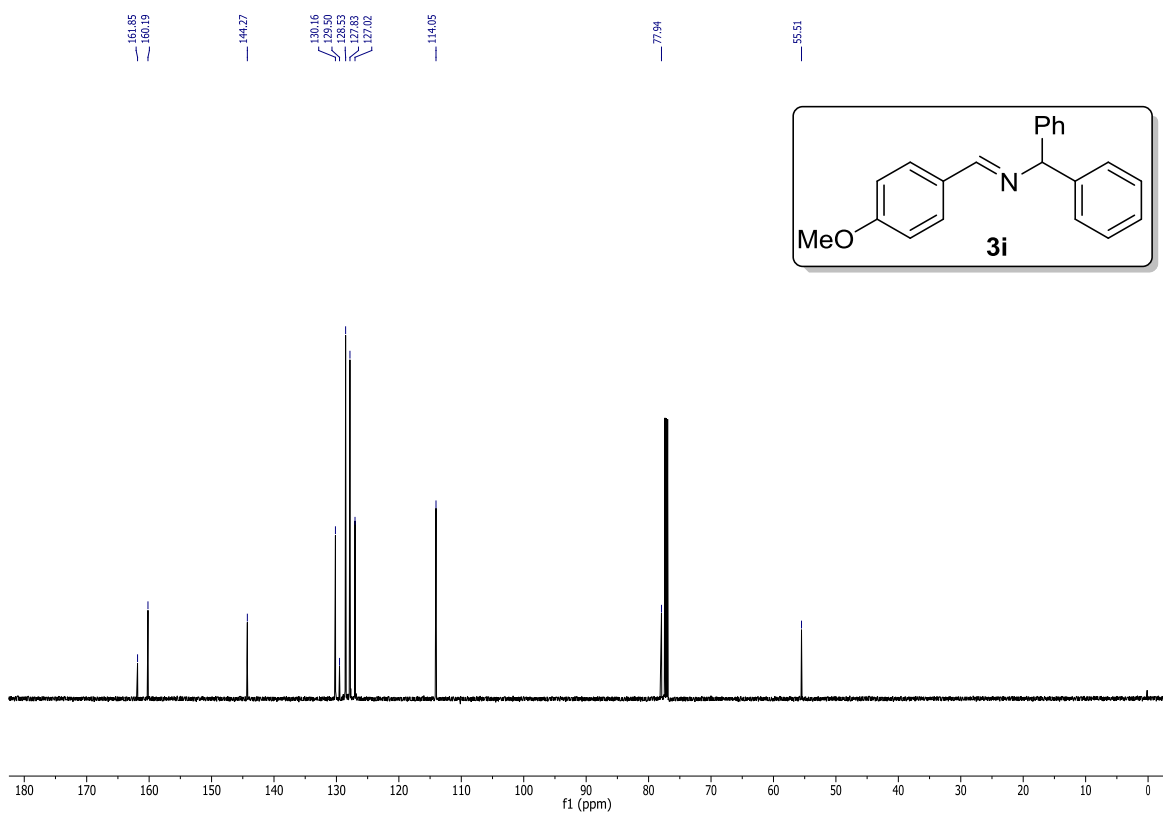


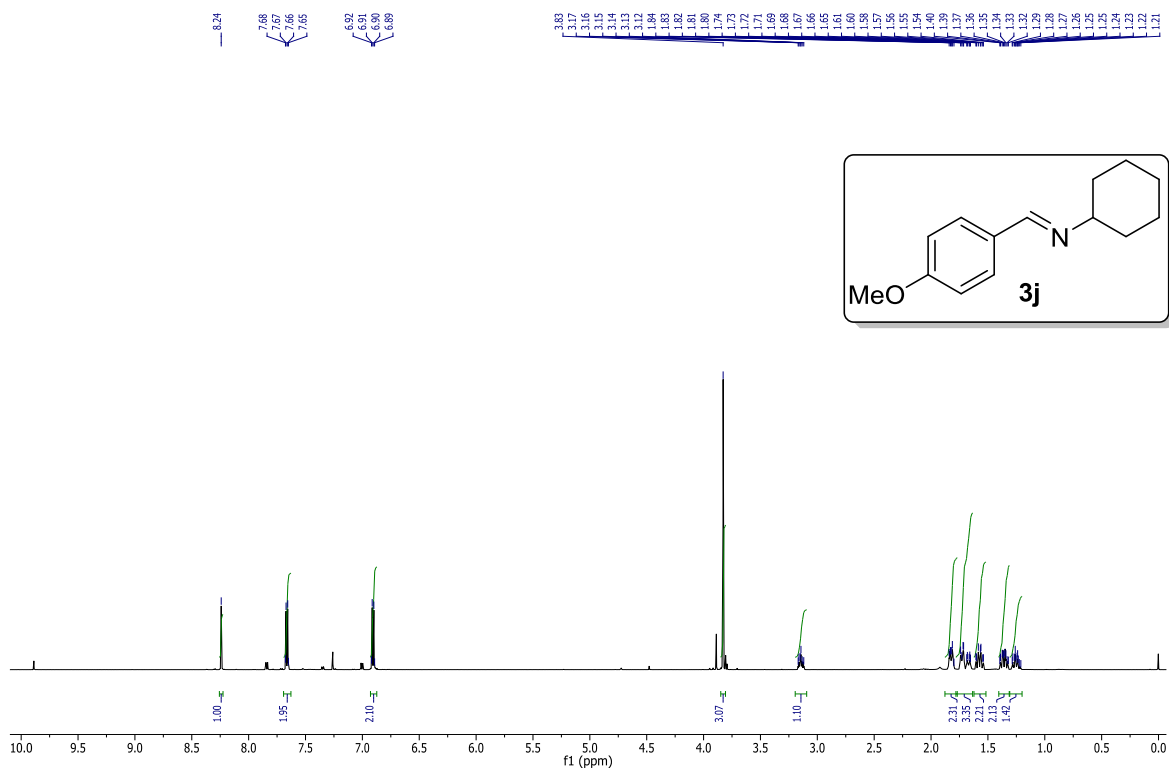
¹H NMR (CDCl₃, 600 MHz) and ¹³C NMR (CDCl₃, 150 MHz) spectra of compound **3h**



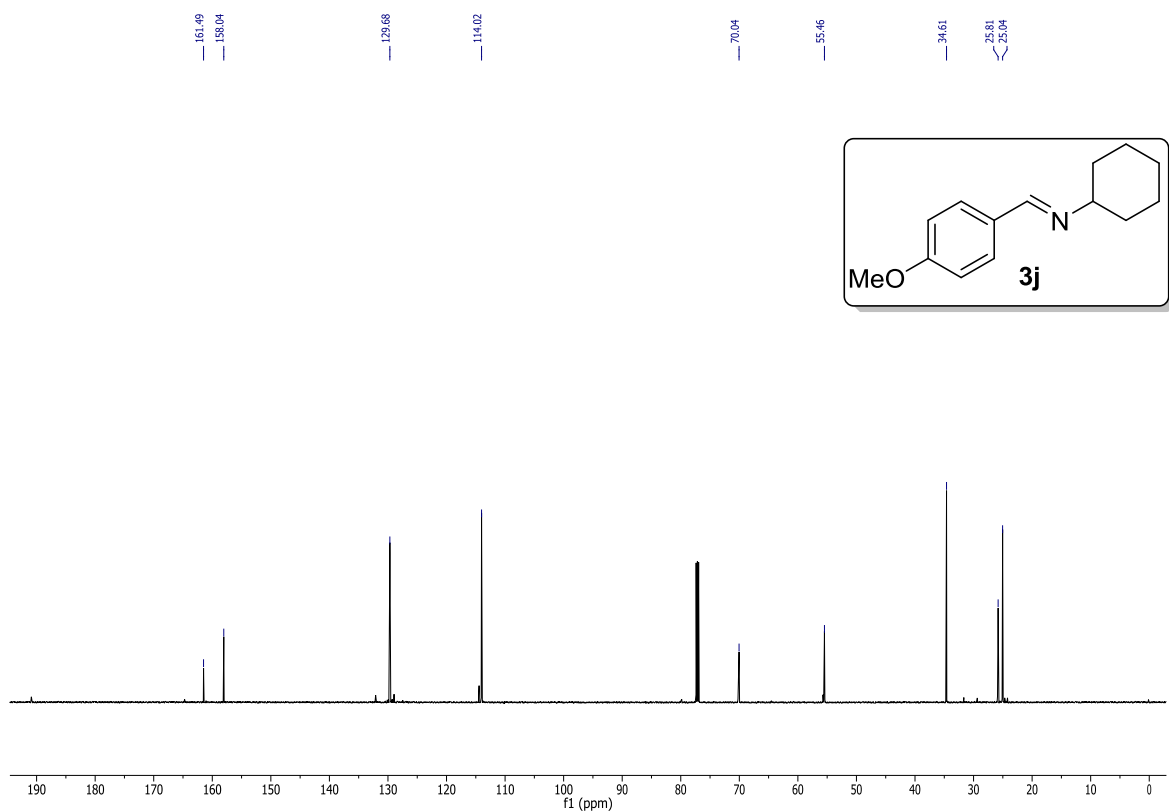


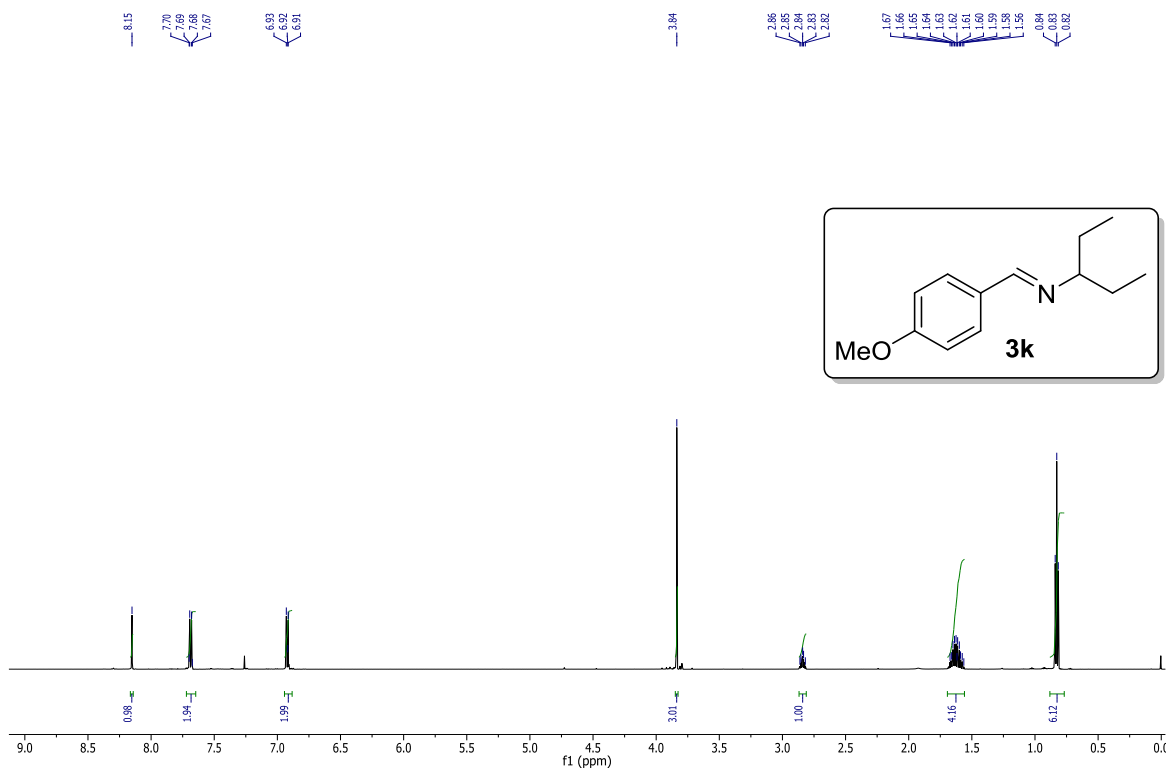
¹H NMR (CDCl₃, 600 MHz) and ¹³C NMR (CDCl₃, 150 MHz) spectra of compound **3i**



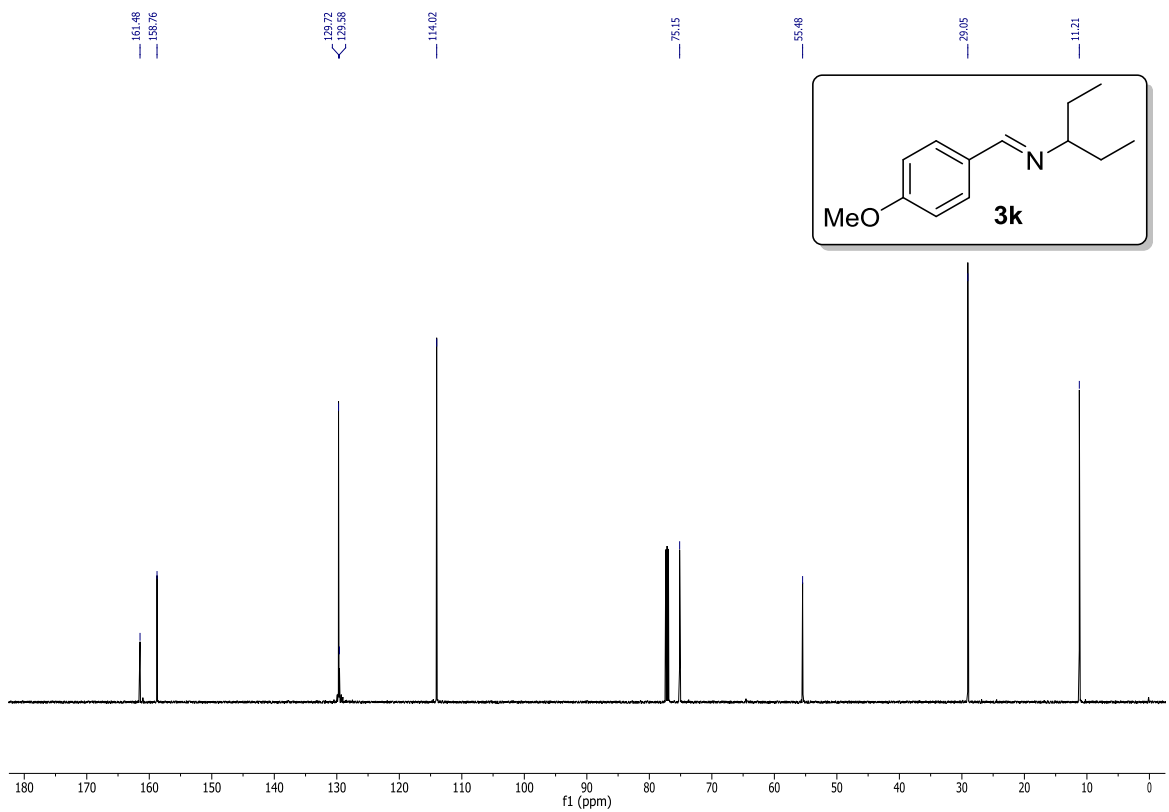


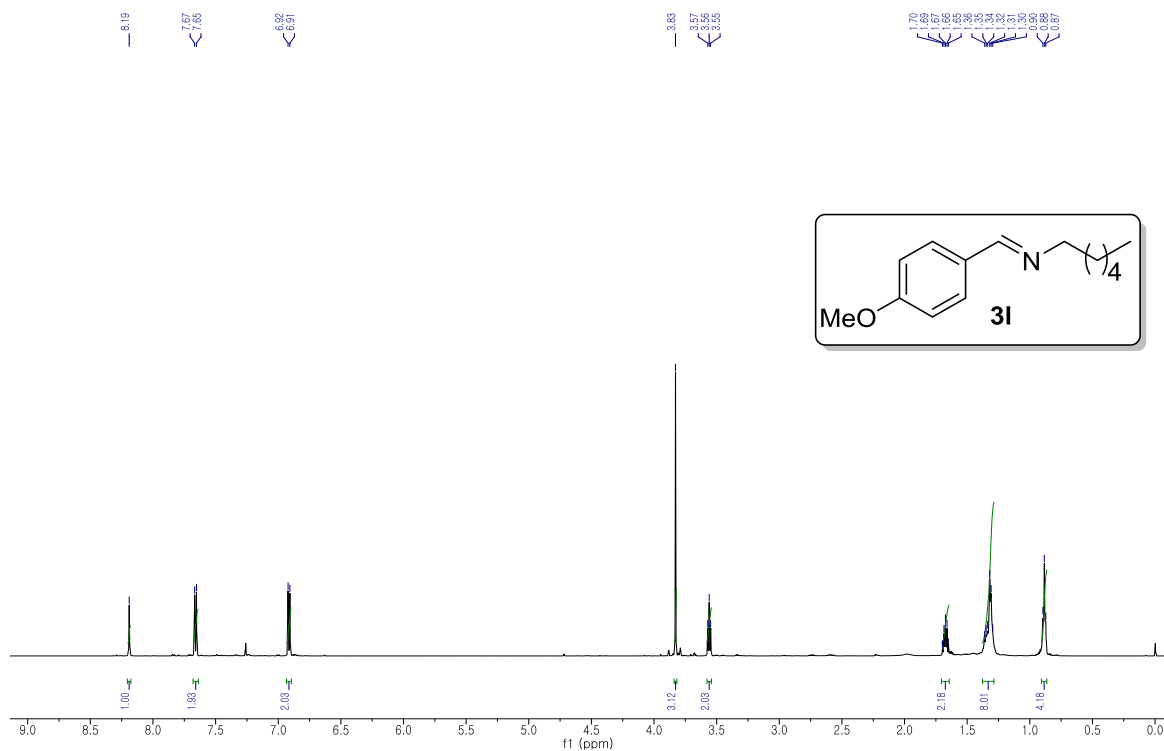
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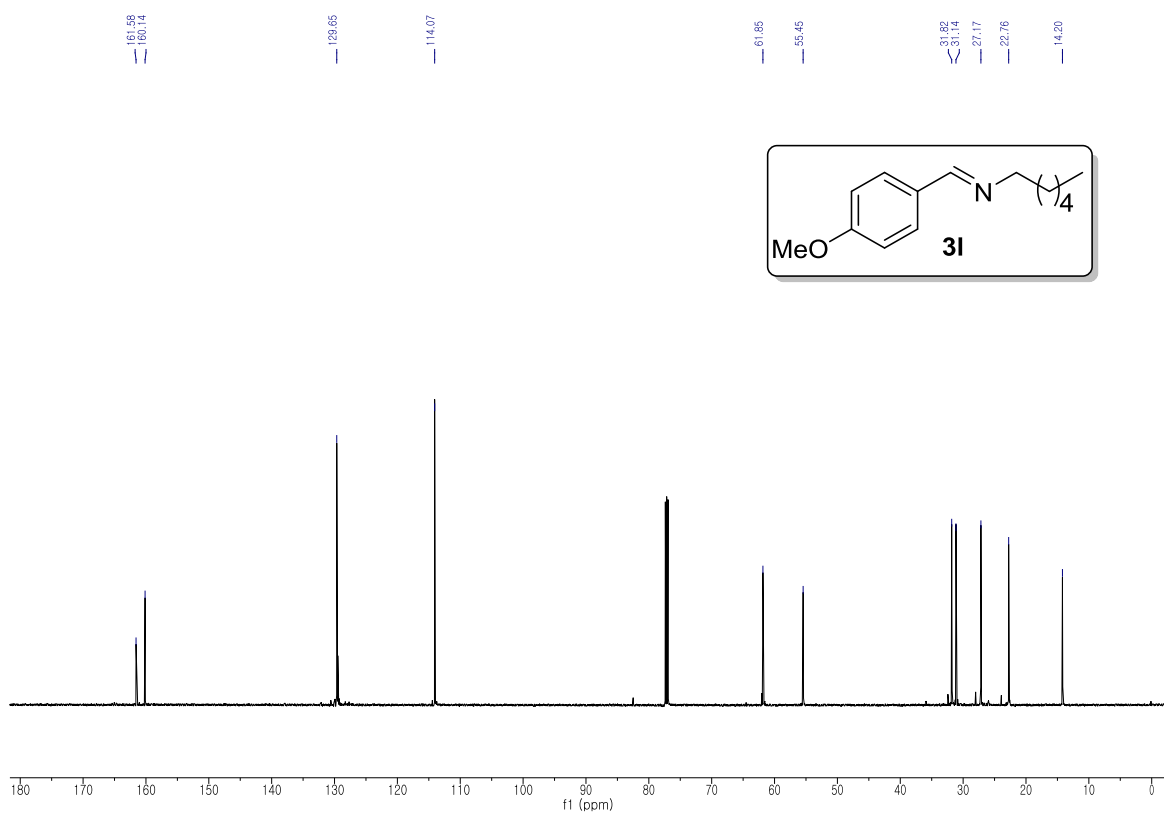


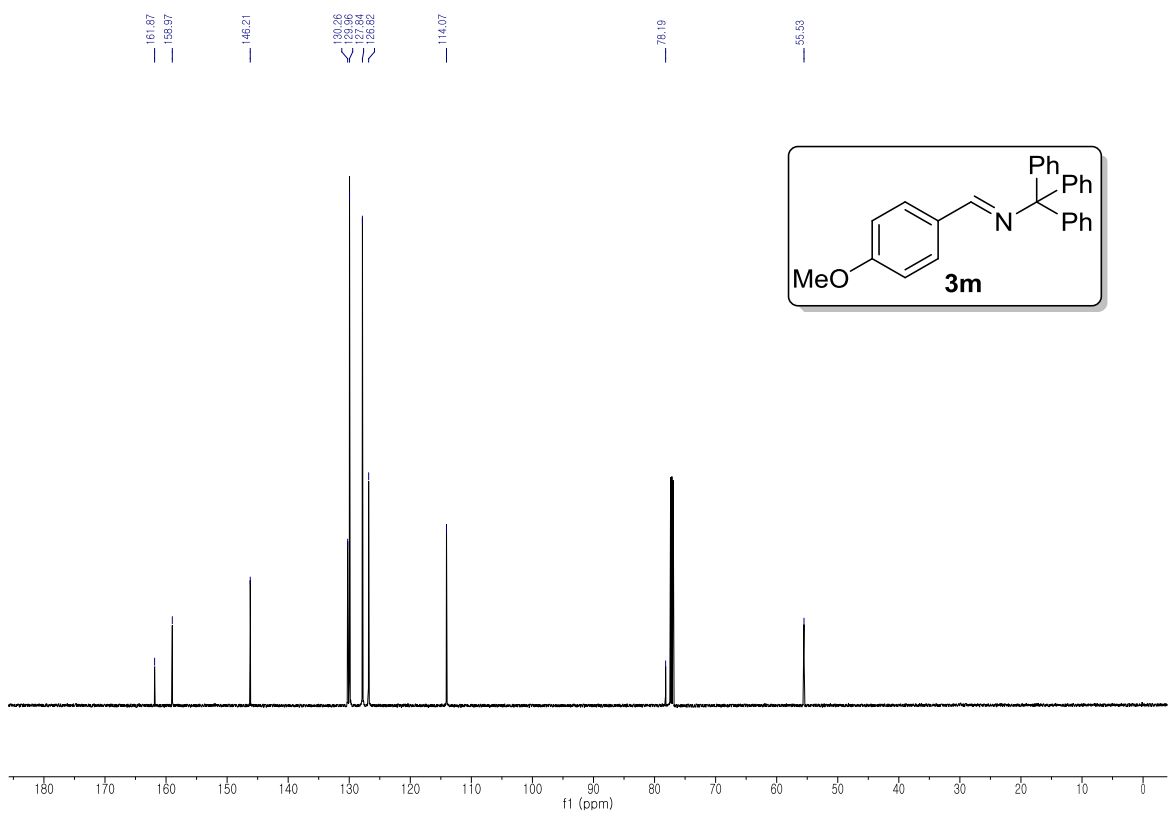
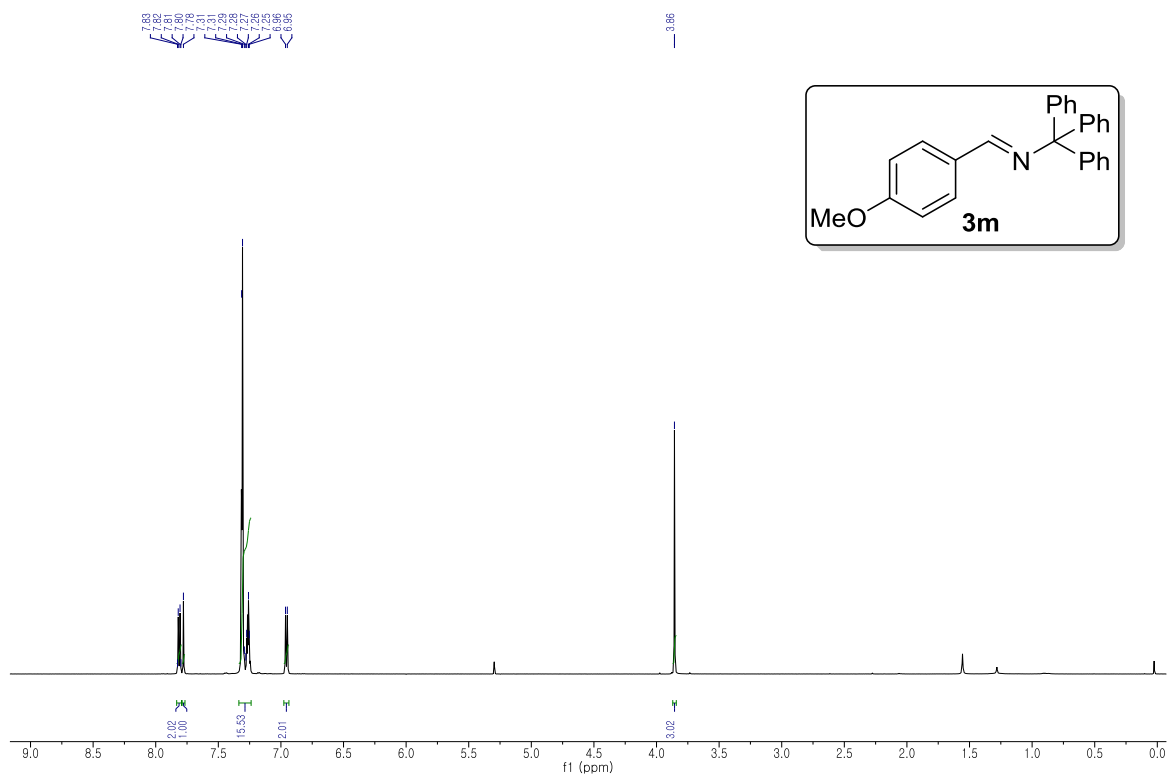
¹H NMR (CDCl₃, 600 MHz) and ¹³C NMR (CDCl₃, 150 MHz) spectra of compound **3k**

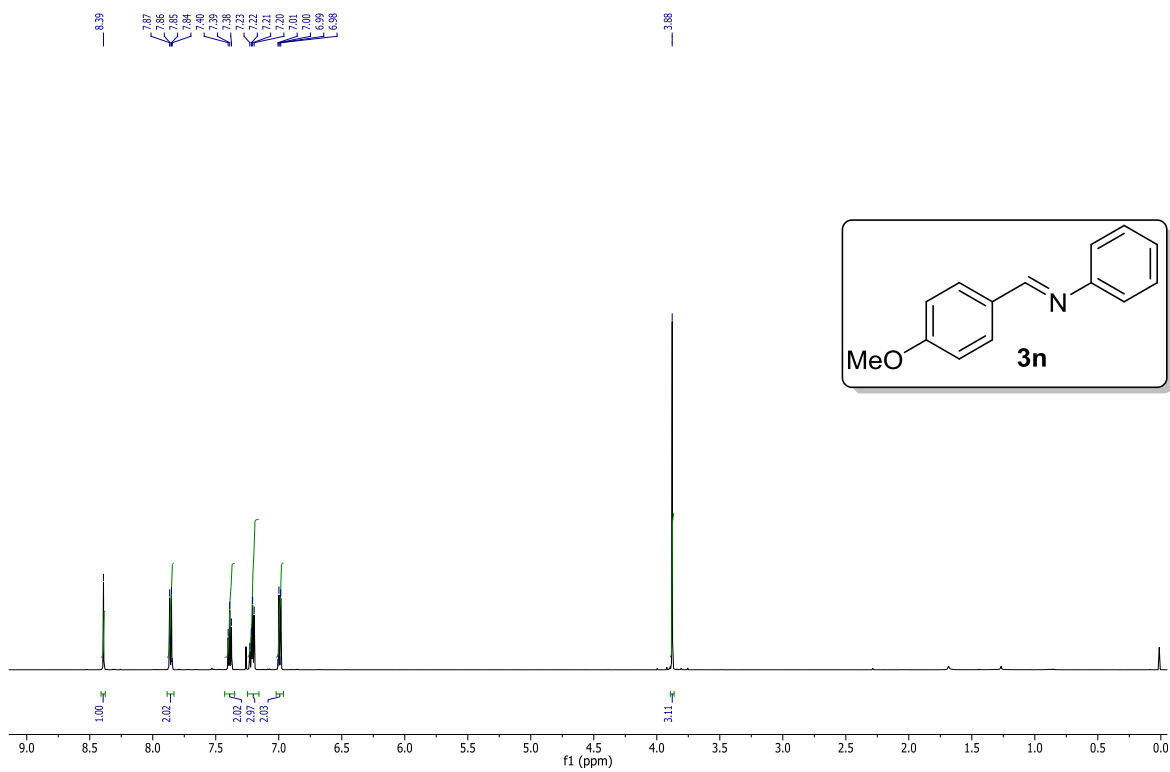




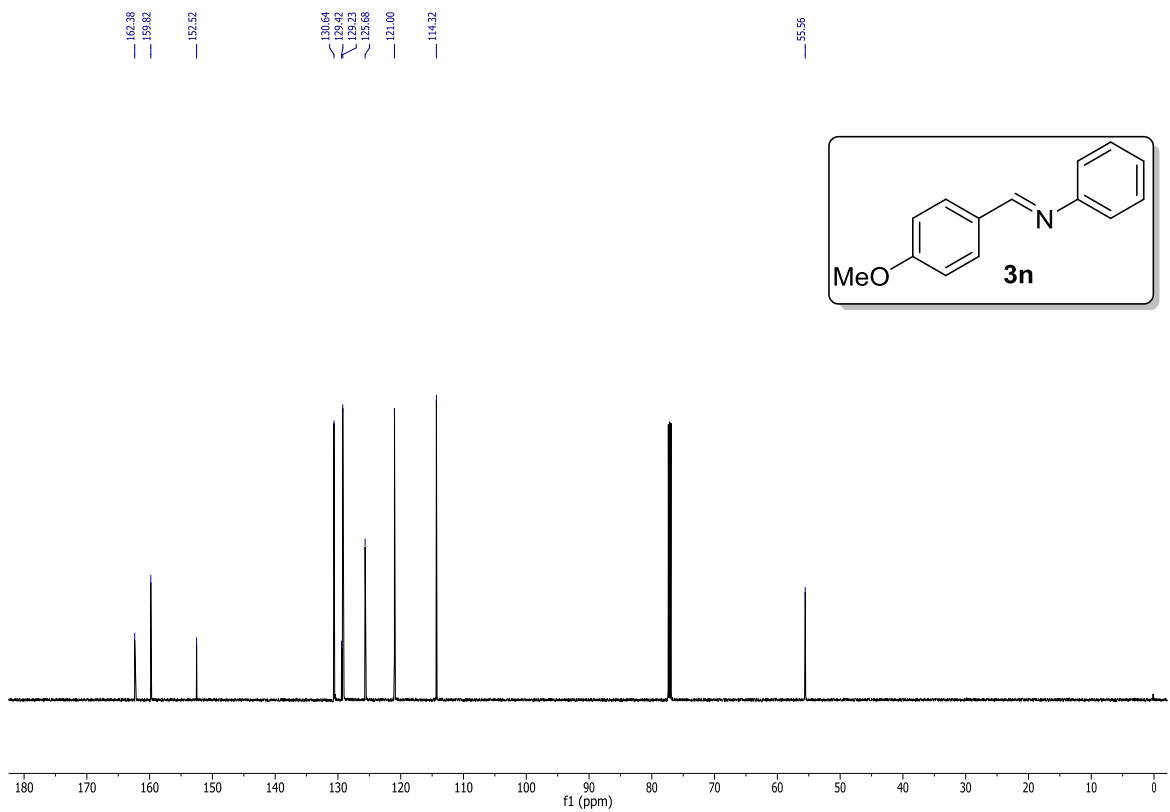
¹H NMR (CDCl₃, 600 MHz) and ¹³C NMR (CDCl₃, 150 MHz) spectra of compound **3I**

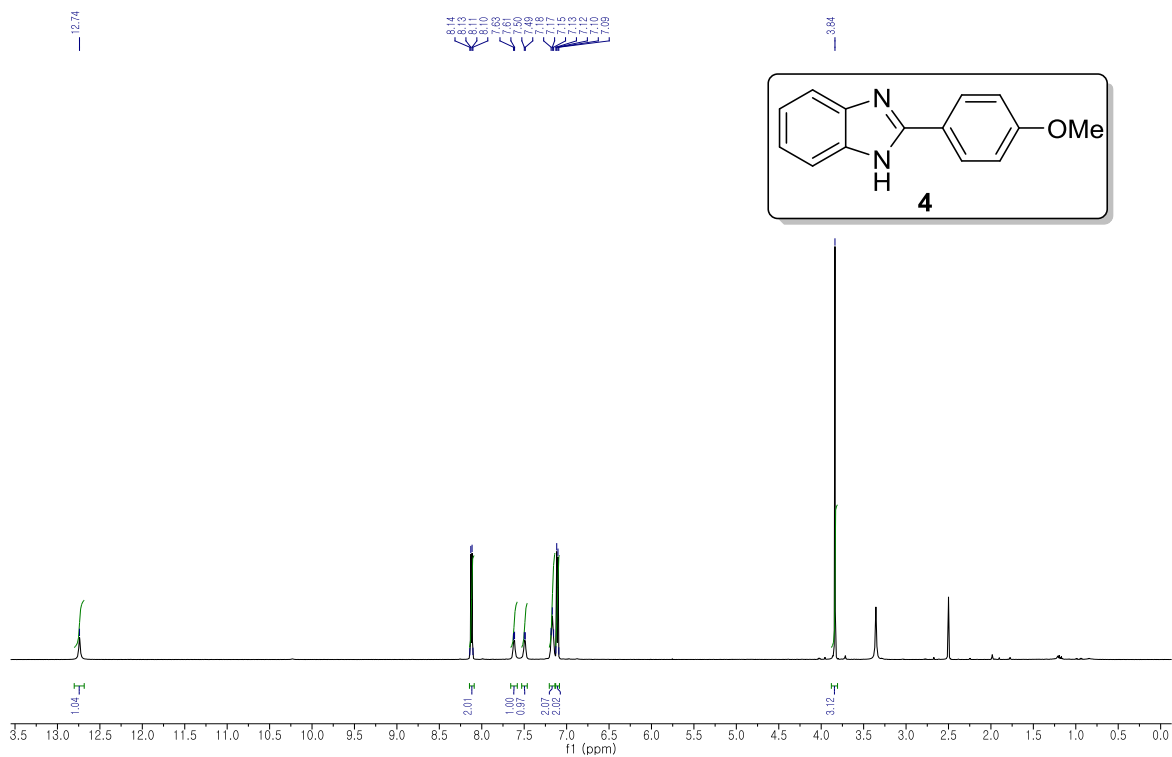




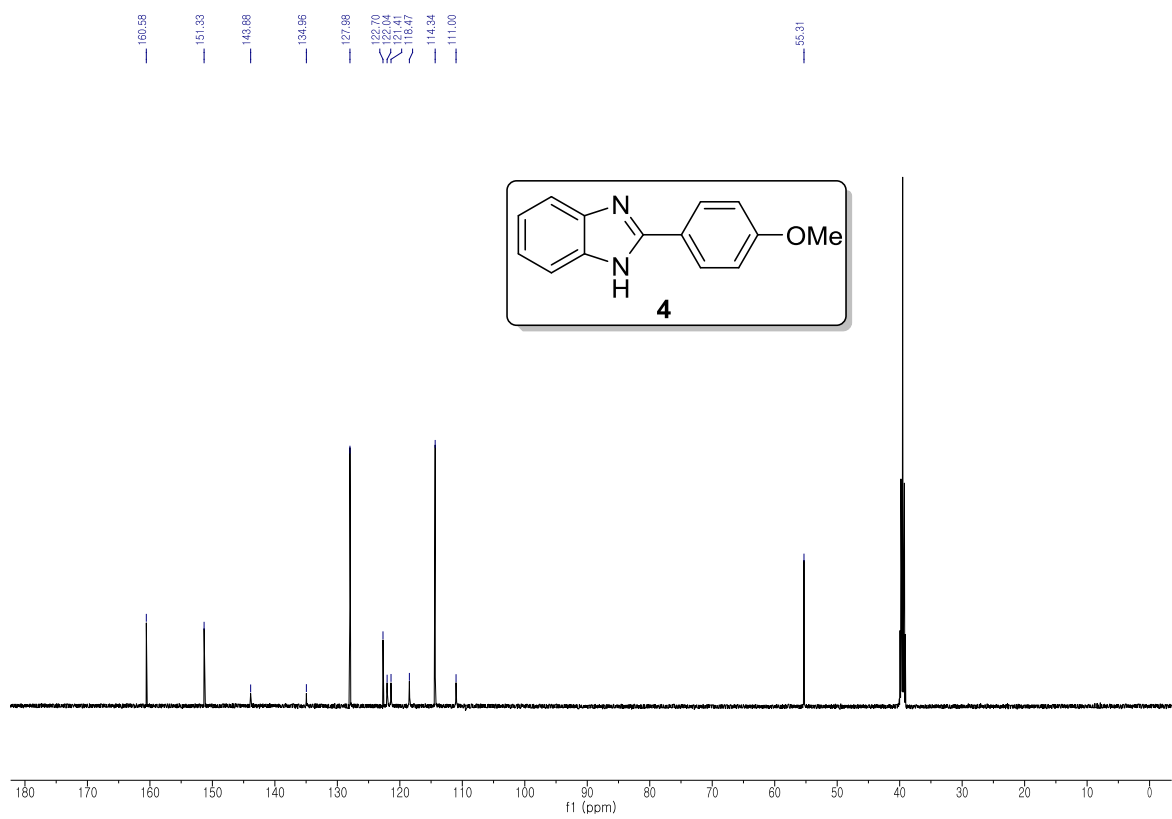


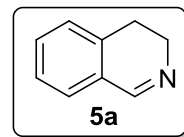
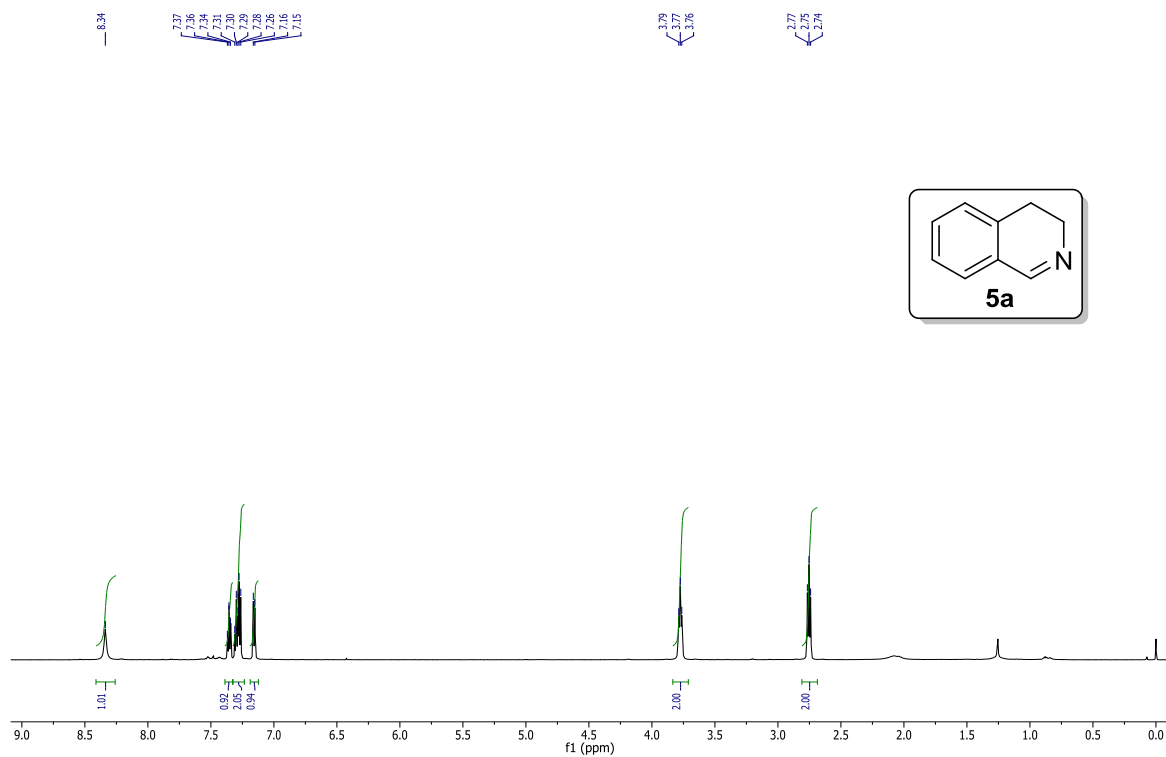
¹H NMR (CDCl₃, 600 MHz) and ¹³C NMR (CDCl₃, 150 MHz) spectra of compound **3n**



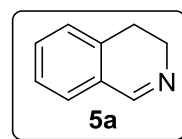
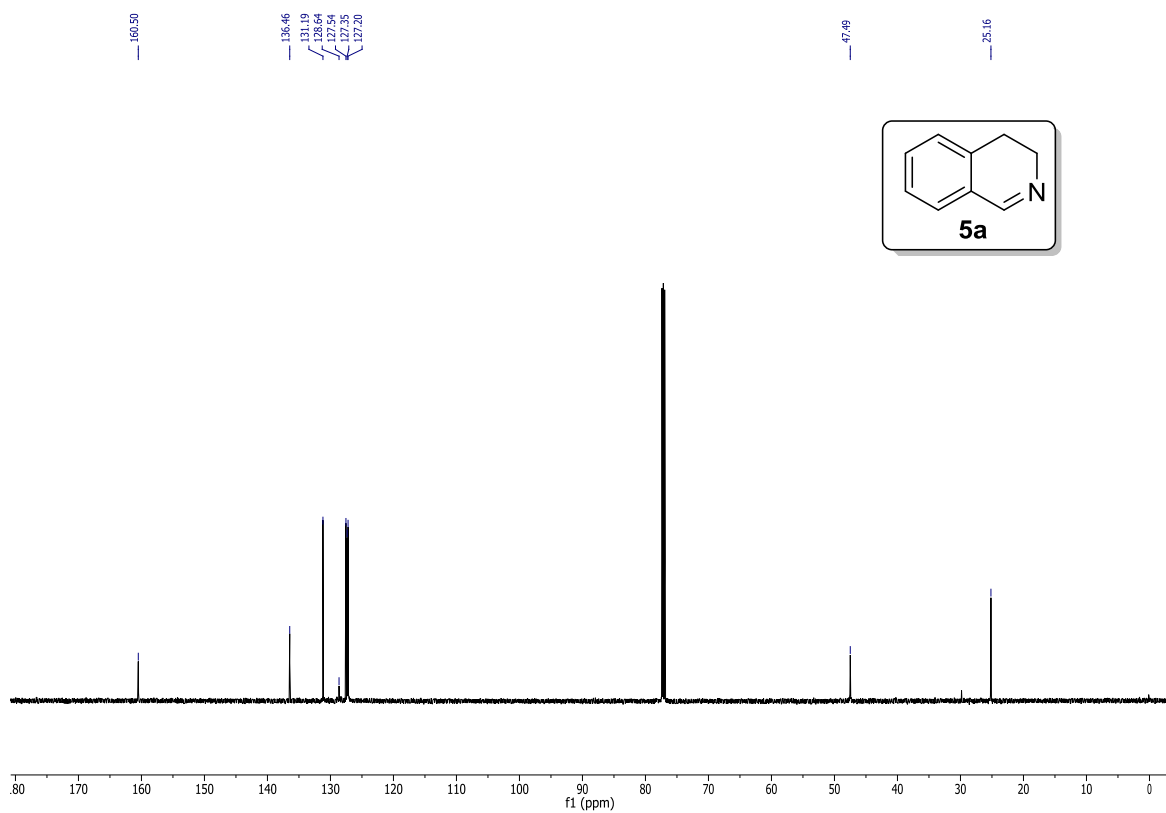


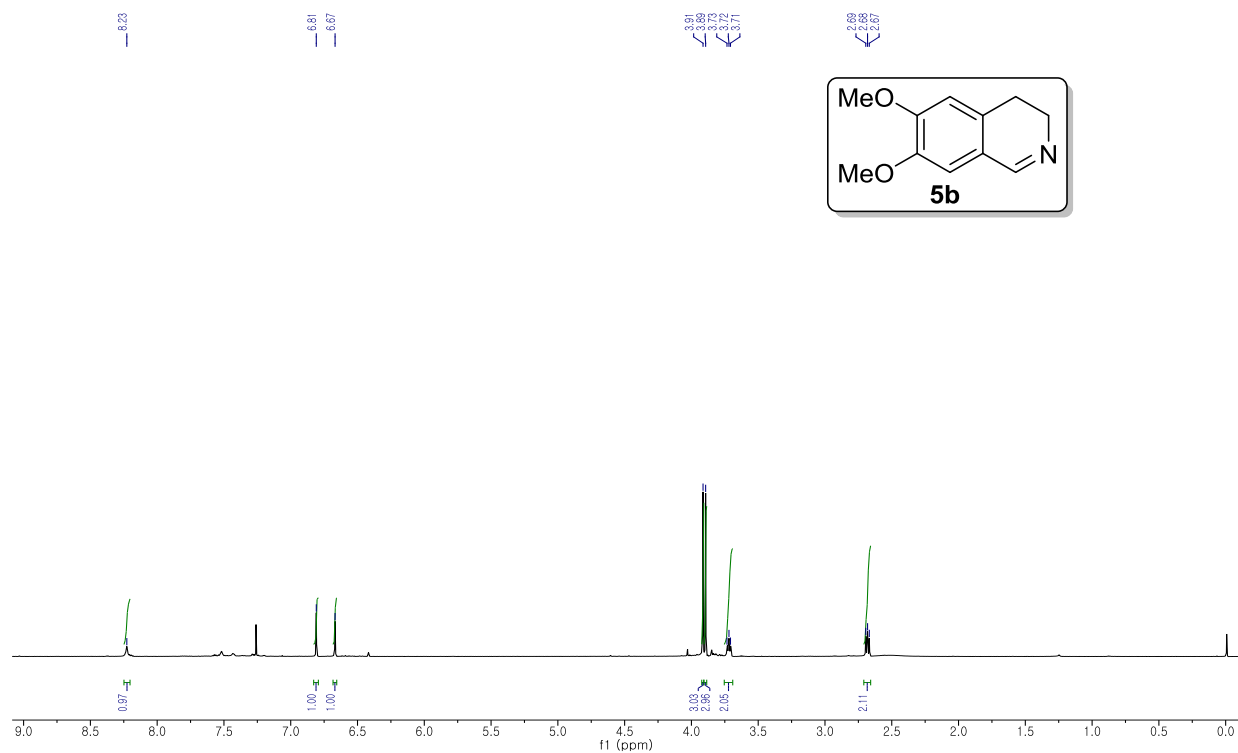
¹H NMR (DMSO-d₆, 600 MHz) and ¹³C NMR (DMSO-d₆, 150 MHz) spectra of compound **4**



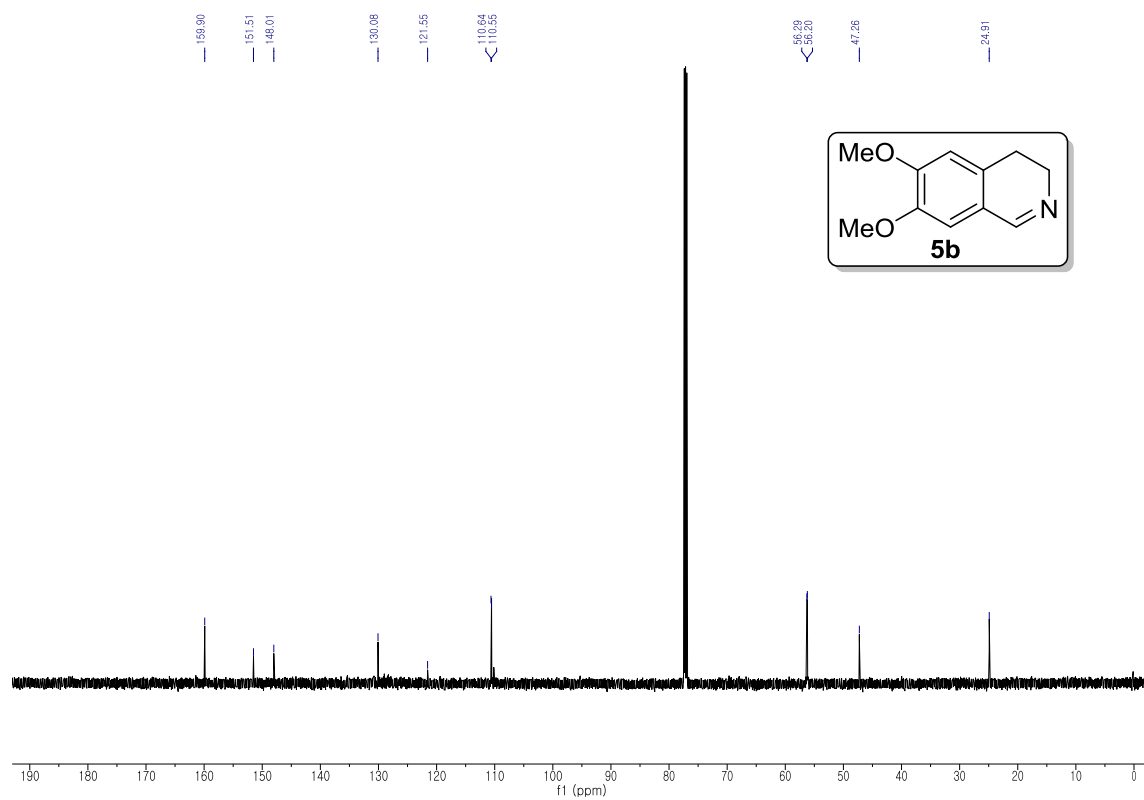


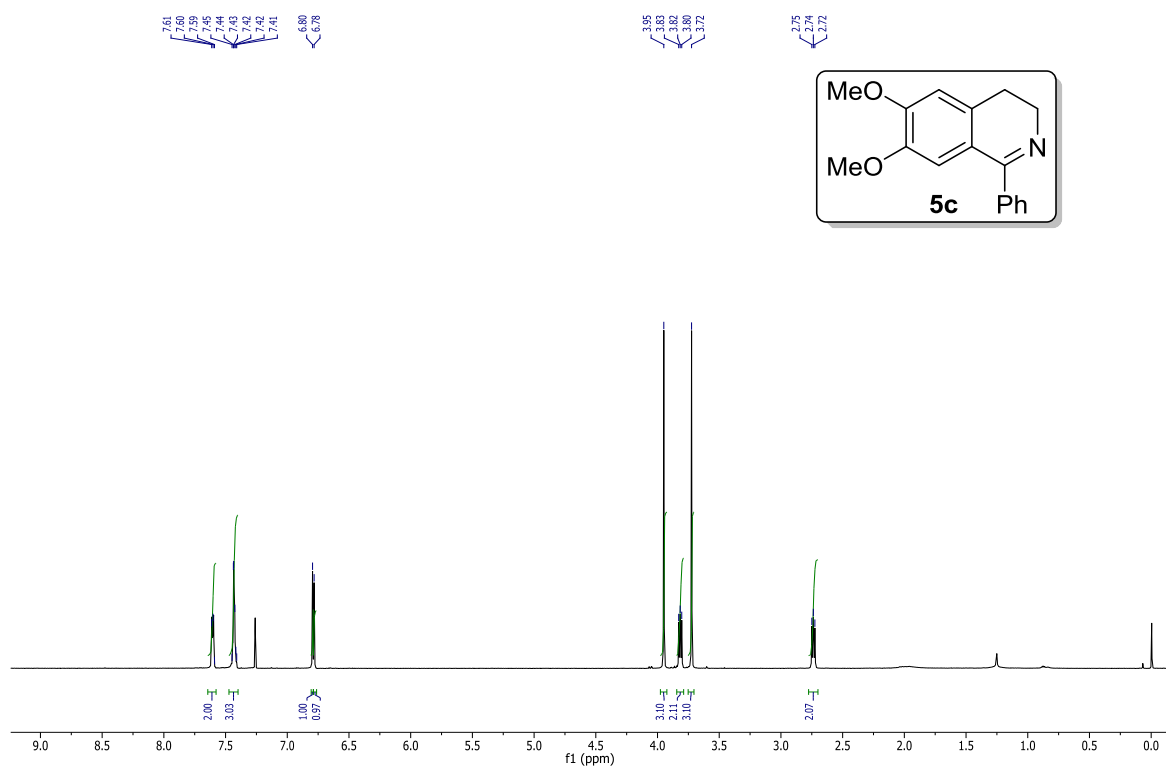
¹H NMR (CDCl₃, 600 MHz) and ¹³C NMR (CDCl₃, 150 MHz) spectra of compound **5a**



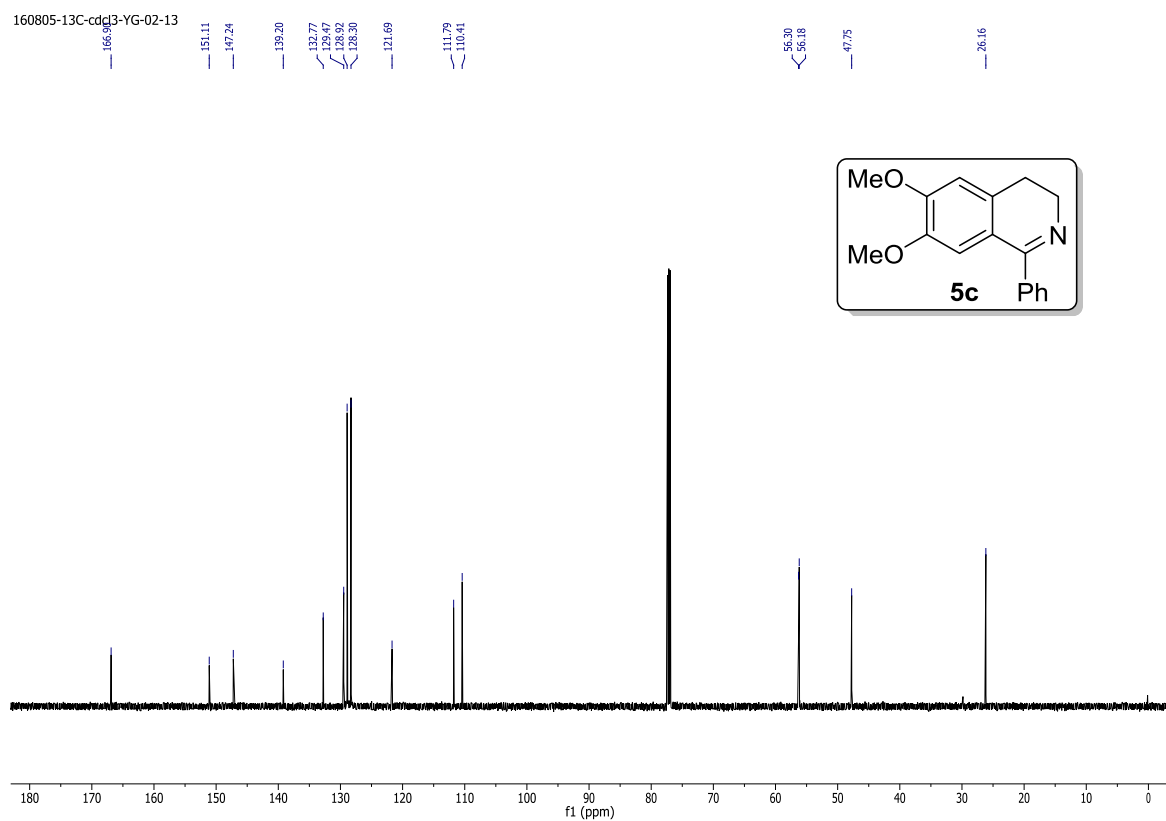


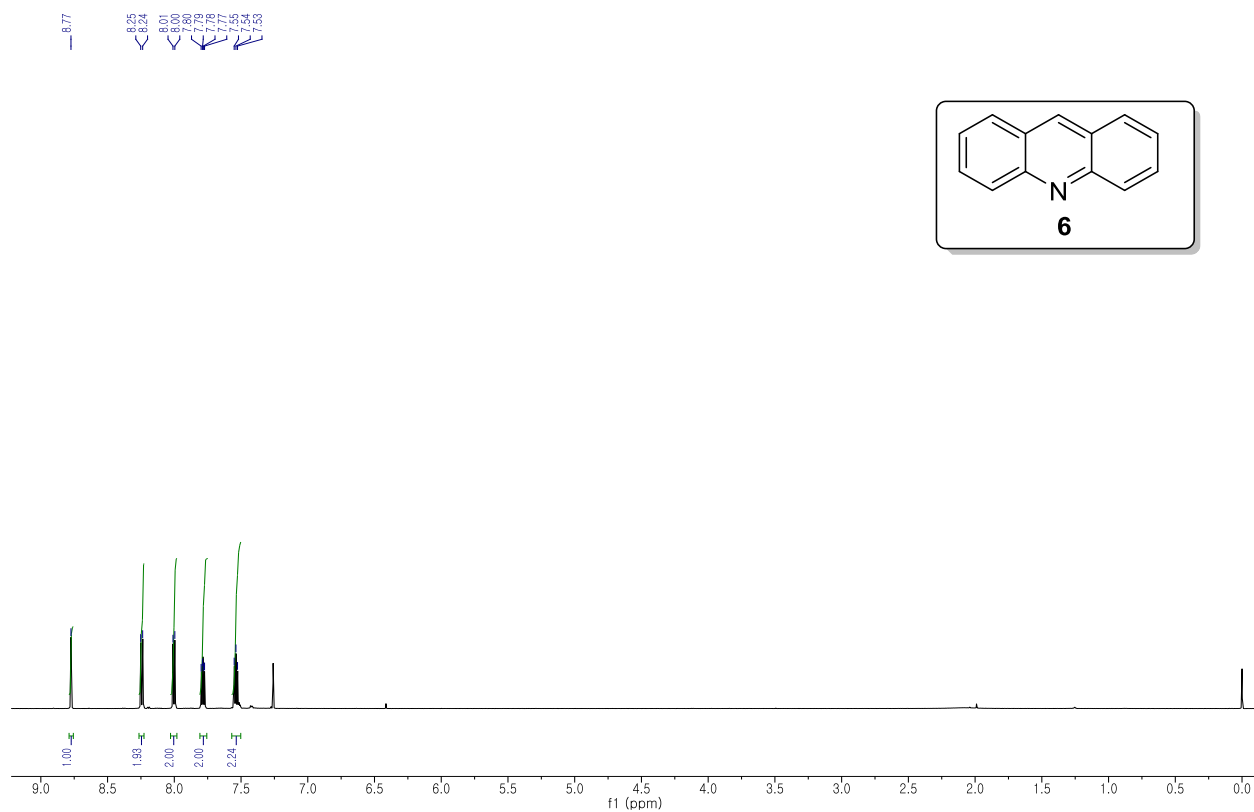
¹H NMR (CDCl₃, 600 MHz) and ¹³C NMR (CDCl₃, 150 MHz) spectra of compound **5b**





¹H NMR (CDCl₃, 600 MHz) and ¹³C NMR (CDCl₃, 150 MHz) spectra of compound **5c**





¹H NMR (CDCl₃, 600 MHz) and ¹³C NMR (CDCl₃, 150 MHz) spectra of compound **6**

