

Supporting Information

Synthesis of Carbamoyl Fluorides *via* a Selective Fluorinative Beckmann Fragmentation

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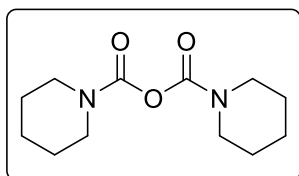
1. Materials and Methods

Dichloromethane (CH₂Cl₂), Tetrahydrofuran (THF), and Dimethylformamide (DMF) were directly used from SPS system (Hansen, Puresolve MD) without further purification. Thin layer chromatography (TLC) analysis was run on silica gel plates. Most of spots were visualized by exposure to ultraviolet (UV) light (254 nm). Some spots that were invisible to ultraviolet (UV) used KMnO₄ stain solution. High Resolution Mass Spectrometric analysis were performed on JEOL JMS-700 [Ionization mode: EI and FAB; Mass analyser type: Double-focusing type (magnetic sector-electrostatic sector)]. High-resolution mass spectra were reported for the molecular ion [M]⁺, [M+H]⁺. Nuclear magnetic resonance (NMR) spectra were recorded either on Bruker 500 UltraShield, Ascend 400, 300 UltraShield (either on 300, 400, 500 MHz for ¹H, 376 MHz for ¹⁹F NMR, and either on 100 or 125 MHz for ¹³C). The fluorine spectra are unreferenced. Chemical shifts for proton NMR spectra are reported in parts per million (ppm) relative to the singlet at 7.26 ppm for chloroform-*d*, to the quintet at 3.31 ppm for methanol-*d*₄, and to the quintet at 2.50 ppm for dimethylsulfoxide-*d*₆ and quintet at 2.05 ppm for acetone-*d*₆. Chemical shifts for carbon NMR spectra are reported in 77.2 ppm with the center line of triplet for chloroform-*d*, in 49.1 ppm with the center line of the septet for methanol-*d*₄ and in 39.5 ppm with the center line of the septet for dimethylsulfoxide-*d*₆. Data for ¹H NMR were presented as following: chemical shifts (δ, ppm), multiplicity (br = broad, s = singlet, d = doublet, t = triplet, q = quartet, p = pentet, dd = doublet of doublets, m = multiplet), coupling constant (Hz), and integration. The chemical shifts of peaks found were reported for ¹³C NMR spectra. Infrared spectra were recorded with a Smith Detection ATR-FTIR.

2. Experimental Procedures and Characterization Data

The known starting materials including **7a**¹, **7b**², **7d**², and **7e**¹ were not characterized.

The side-product identified during optimization (Table 1, entry 8):



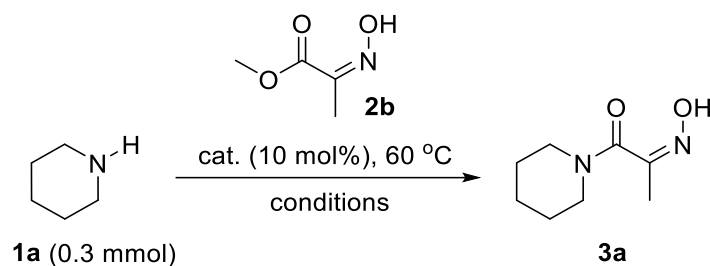
piperidine-1-carboxylic anhydride: light yellow solid; *R_f* = 0.4 (Hex:EtOAc = 3:1); ¹H NMR (400 MHz, CDCl₃) δ 3.50-3.48 (m, 4H), 3.42-3.40 (m, 4H), 1.60-1.56 (m, 12H). ¹³C NMR (125 MHz, CDCl₃) δ 150.1, 46.2, 45.3, 25.9, 25.3, 24.1. IR (neat) *v*_{max} 2936, 2862, 1748, 1684, 1402, 1201 cm⁻¹. HRMS[EI⁺] calcd for C₁₂H₂₀N₂O₃ [M]⁺ 240.1474, found

240.1463.

¹ Wei, W. T.; Zhu, W. M.; Ying, W. W.; Wu, Y.; Huang, Y. L.; Liang, H. Metal-Free Synthesis of Isatin Oximes via Radical Coupling Reactions of Oxindoles with *t*-BuONO in Water. *Org. Biomol. Chem.*, **2017**, *15*, 5254.

² Rad, M. N. S.; Khalafi-Nezhad, A.; Babamohammadi, S.; Behrouz, S. Microwave-Assisted Three-Component Synthesis of Some Novel 1-Alkyl-1*H*-indole-2,3-dione 3-(*O*-Alkyloxime) Derivatives as Potential Chemotherapeutic Agents. *Helv. Chim. Acta*, **2010**, *93*, 2454.

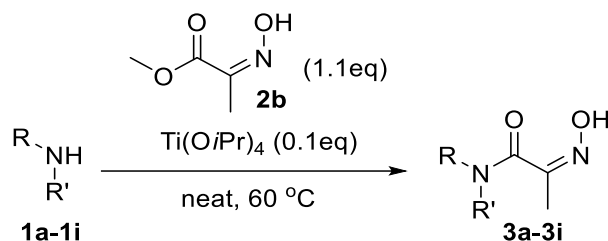
Optimization table for synthesis of α -oximinoamide **3a from piperidine^a**



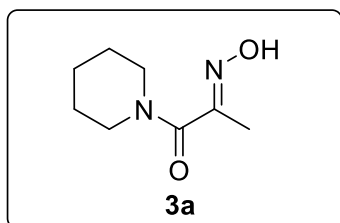
Entry	2b (equiv.)	Catalyst (10 mol%)	solvent	time	yield ^a
1	1.1	none	none	24h	53%
2	"	none	DCE	24h	trace
3	"	Sc(OTf) ₃	none	24h	45%
4	"	Nb(OEt)₅	none	14h	95%
5	"	MgCl ₂	none	4h	70%
6	"	ZrCl₄	none	4h	98%
7	"	Bi(OTf) ₃	none	24h	42%
8	"	Yb(OiPr) ₃	none	8h	18%
9	"	VO(OEt) ₃	none	24h	18%
10	"	Zr(OEt) ₄	none	24h	31%
11	"	Ti(OiPr)₄	none	1.5h	93%
12	"	Zr(OtBu)₄	none	8h	95%
13	"	NbCl ₅	none	5h	40%
14	"	Ca(OH) ₂	none	4h	57%
15	"	NaOMe	none	7h	45%
16	"	Cs ₂ CO ₃	none	7h	25%
17	"	CaCl ₂	none	24h	27%

^aNMR yield was determined with 1,3,5-trimethoxybenzene as the internal standard.

General Procedure for Lewis acid-assisted amidation

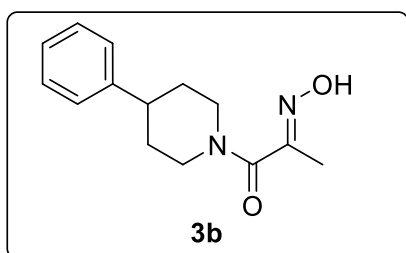


A mixture of amine **1** (2.0 mmol), methyl pyruvate oxime **2b** (258 mg, 2.2 mmol), and titanium isopropoxide (58 μL , 0.2 mmol) in 5 ml vial was heated at 60 $^\circ\text{C}$ in a pie-block for 2 hours. Then, the reaction mixture was cooled to room temperature. The crude product was recrystallized with ethyl acetate and hexane to afford **3a-3i**.



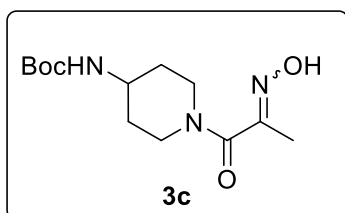
2-(hydroxyimino)-1-(piperidin-1-yl)propan-1-one (3a); piperidine (170 mg, 2.0 mmol) was used to provide **3a** (305 mg, 89%); white solid; R_f = 0.4 (Hex:EtOAc = 1:2); ^1H NMR (300 MHz, CDCl_3) δ 7.85 (br s, 1H), 3.59 (t, J = 5.7 Hz, 2H), 3.47 (t, J = 5.5 Hz, 2H), 2.07 (br s, 3H), 1.69-1.56 (m, 6H). ^{13}C NMR (100 MHz, CDCl_3) δ 165.3, 152.2, 48.0, 43.1, 26.5, 25.4, 24.5, 12.5. IR (neat) ν_{max} 3217, 2943, 1739, 1588, 1442, 1365 cm^{-1} . HRMS[EI^+] calcd for $\text{C}_8\text{H}_{14}\text{N}_2\text{O}_2$ $[\text{M}]^+$ 170.1055, found

170.1064.

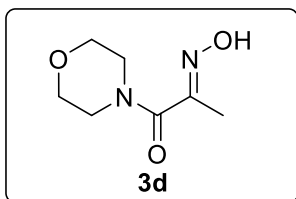


2-(hydroxyimino)-1-(4-phenylpiperidin-1-yl)propan-1-one (3b); 4-phenylpiperidine (322 mg, 2.0 mmol) was used to provide **3b** (327 mg, 79%); white solid; R_f = 0.5 (Hex:EtOAc = 1:2); ^1H NMR (500 MHz, CDCl_3) δ 7.62 (br s, 1H), 7.31 (t, J = 7.6 Hz, 2H), 7.24-7.19 (m, 3H), 4.76 (m, 1H), 4.16 (br s, 1H), 3.13 (br s, 1H), 2.81-2.74 (m, 2H), 2.11 (s, 3H), 1.92-1.90 (m, 2H), 1.73-1.65 (m, 2H). ^{13}C NMR (100 MHz, CDCl_3) δ 165.3, 152.4, 145.0, 128.6, 126.8, 126.6, 47.7, 42.8, 42.7, 33.9, 32.8, 12.5. IR (neat) ν_{max}

3168, 3061, 2856, 1616, 1493, 1370 cm^{-1} . HRMS[EI^+] calcd for $\text{C}_{14}\text{H}_{18}\text{N}_2\text{O}_2$ $[\text{M}]^+$ 246.1368, found 246.1356.

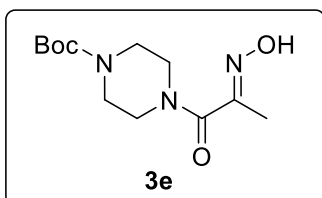


tert-butyl-(1-(2-(hydroxyimino)propanoyl)piperidin-4-yl)carbamate (3c); 4-(N-Boc-amino)piperidine (400 mg, 2.0 mmol) was used to provide **3c** (462 mg, 94%); white solid; R_f = 0.4 (Hex:EtOAc = 1:2); ^1H NMR (400 MHz, CDCl_3 , mixture of isomers, ratio 1:1) δ 10.66 (br s, 0.5H), 9.26 (br s, 1H), 6.12 (br s, 0.5H), 4.82 (m, 1H), 4.44 (m, 1H), 4.36 (m, 0.5H), 3.98 (m, 0.5H), 3.95 (m, 1H), 3.70 (s, 1H), 3.52 (m, 0.5H), 3.09 (t, J = 12.8 Hz, 1.5H), 2.83 (t, J = 8.8 Hz, 1.5H), 2.04 (s, 4.5H), 1.99-1.88 (m, 3.5H), 1.32-1.28 (m, 4.5H). ^{13}C NMR (100 MHz, CDCl_3) δ 165.4 (2C), 157.1, 155.3, 152.0, 151.5, 81.1, 80.0, 48.5, 47.8, 45.9, 45.4, 41.1, 40.7, 33.9, 33.2, 31.9, 31.4, 28.4 (2C), 12.4 (2C). IR (neat) ν_{max} 3342, 3205, 2956, 1696, 1595, 1508 cm^{-1} . HRMS[FAB $^+$] calcd for $\text{C}_{13}\text{H}_{24}\text{N}_3\text{O}_4$ $[\text{M}+\text{H}]^+$ 286.1767, found 286.1760.



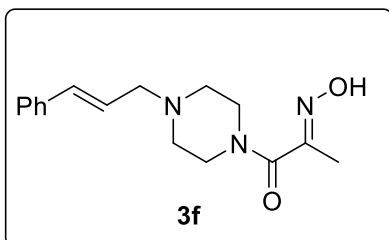
172.0838.

2-(hydroxyimino)-1-morpholinopropan-1-one (3d); morpholine (0.172 mL, 2.0 mmol) was used to provide **3d** (189 mg, 71%); white solid; $R_f = 0.4$ (Hex:EtOAc = 1:3); ^1H NMR (400 MHz, CDCl_3) δ 8.84 (br s, 1H), 3.71-3.62 (m, 8H), 2.06 (s, 3H). ^{13}C NMR (100 MHz, CDCl_3) δ 165.5, 151.7, 67.0, 66.7, 47.5, 42.6, 12.4. IR (neat) ν_{max} 3146, 2853, 1592, 1482, 1438, 1114 cm^{-1} . HRMS[EI^+] calcd for $\text{C}_7\text{H}_{12}\text{N}_2\text{O}_3$ $[\text{M}]^+$ 172.0848, found



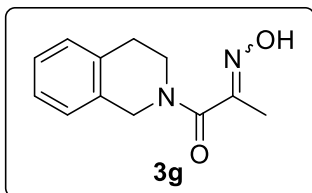
1608, 1417, 1165 cm^{-1} . HRMS[EI^+] calcd for $\text{C}_{12}\text{H}_{21}\text{N}_3\text{O}_4$ $[\text{M}]^+$ 271.1532, found 271.1531.

tert-butyl 4-(2-(hydroxyimino)propanoyl)piperazine-1-carboxylate (3e); 1-Boc-piperazine (372 mg, 2.0 mmol) was used to provide **3e** (401 mg, 86%); white solid; $R_f = 0.4$ (Hex:EtOAc = 1:2); ^1H NMR (400 MHz, CDCl_3) δ 9.12 (br s, 1H), 3.63-3.57 (m, 4H), 3.46-3.42 (m, 4H), 2.06 (s, 3H), 1.46 (s, 9H). ^{13}C NMR (100 MHz, CDCl_3) δ 165.5, 154.9, 151.8, 80.8, 46.8, 43.86, 43.81, 42.1, 28.4, 12.4. IR (neat) ν_{max} 3309, 2863, 1685, 1608, 1417, 1165 cm^{-1} . HRMS[EI^+] calcd for $\text{C}_{12}\text{H}_{21}\text{N}_3\text{O}_4$ $[\text{M}]^+$ 271.1532, found 271.1531.



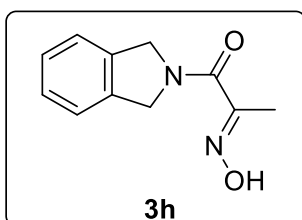
128.7, 127.9, 126.5, 124.9, 60.8, 53.2, 52.5, 46.5, 41.6, 12.4. IR (neat) ν_{max} 3021, 2940, 2632, 1740, 1616, 1465, 1357 cm^{-1} . HRMS[EI^+] calcd for $\text{C}_{16}\text{H}_{21}\text{N}_3\text{O}_2$ $[\text{M}]^+$ 287.1634, found 287.1635.

1-(4-cinnamylpiperazin-1-yl)-2-(hydroxyimino)propan-1-one (3f); *N*-cinnamylpiperazine (404 mg, 2.0 mmol) was used to provide **3f** (465 mg, 94%); off-white solid; $R_f = 0.4$ (10% MeOH in DCM); ^1H NMR (400 MHz, CDCl_3) δ 10.43 (br s, 1H), 7.36-7.20 (m, 5H), 6.49 (d, $J = 15.8$ Hz, 1H), 6.21 (dt, $J = 15.8, 6.8$ Hz, 1H), 3.73 (t, $J = 5.1$ Hz, 2H), 3.65 (t, $J = 5.1$ Hz, 2H), 3.15 (d, $J = 8.1$ Hz, 2H), 2.53 (t, $J = 5.0$ Hz, 2H), 2.45 (t, $J = 5.0$ Hz, 2H), 2.06 (s, 3H). ^{13}C NMR (100 MHz, CDCl_3) δ 165.5, 151.4, 136.5, 134.3, 128.7, 127.9, 126.5, 124.9, 60.8, 53.2, 52.5, 46.5, 41.6, 12.4. IR (neat) ν_{max} 3021, 2940, 2632, 1740, 1616, 1465, 1357 cm^{-1} . HRMS[EI^+] calcd for $\text{C}_{16}\text{H}_{21}\text{N}_3\text{O}_2$ $[\text{M}]^+$ 287.1634, found 287.1635.



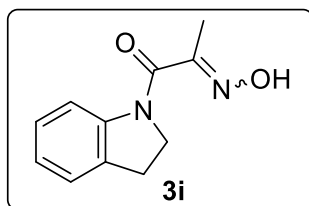
1.2H). ^{13}C NMR (100 MHz, $\text{DMSO}-d_6$) δ 165.4, 165.1, 150.6, 150.5, 134.4, 134.2, 133.3, 132.8, 128.66, 128.62, 126.59, 126.56, 126.4, 126.2, 126.18, 126.13, 48.0 (2C), 44.0, 43.8, 29.0, 27.6, 12.1, 12.0. IR (neat) ν_{max} 3215, 1739, 1641, 1487, 1444, 1366 cm^{-1} . HRMS[FAB $^+$] calcd for $\text{C}_{12}\text{H}_{15}\text{N}_2\text{O}_2$ $[\text{M}+\text{H}]^+$ 219.1134, found 219.1129.

1-(3,4-dihydroisoquinolin-2(1H)-yl)-2-(hydroxyimino)propan-1-one (3g); 1,2,3,4-tetrahydroisoquinoline (266 mg, 2.0 mmol) was used to provide **3g** (297 mg, 83%); off-white solid; $R_f = 0.4$ (Hex:EtOAc = 1:1); ^1H NMR (400 MHz, $\text{DMSO}-d_6$, mixture of isomers, ratio 1:1.5) δ 11.43 (br s, 0.4H), 11.41 (br s, 0.6H), 7.21-7.12 (m, 4H), 4.70 (s, 0.8H), 4.66 (s, 1.2H), 3.73 (t, $J = 5.8$ Hz, 2H), 2.85-2.80 (m, 2H), 1.94 (s, 1.8H), 1.91 (s, 1.2H). ^{13}C NMR (100 MHz, $\text{DMSO}-d_6$) δ 165.4, 165.1, 150.6, 150.5, 134.4, 134.2, 133.3, 132.8, 128.66, 128.62, 126.59, 126.56, 126.4, 126.2, 126.18, 126.13, 48.0 (2C), 44.0, 43.8, 29.0, 27.6, 12.1, 12.0. IR (neat) ν_{max} 3215, 1739, 1641, 1487, 1444, 1366 cm^{-1} . HRMS[FAB $^+$] calcd for $\text{C}_{12}\text{H}_{15}\text{N}_2\text{O}_2$ $[\text{M}+\text{H}]^+$ 219.1134, found 219.1129.



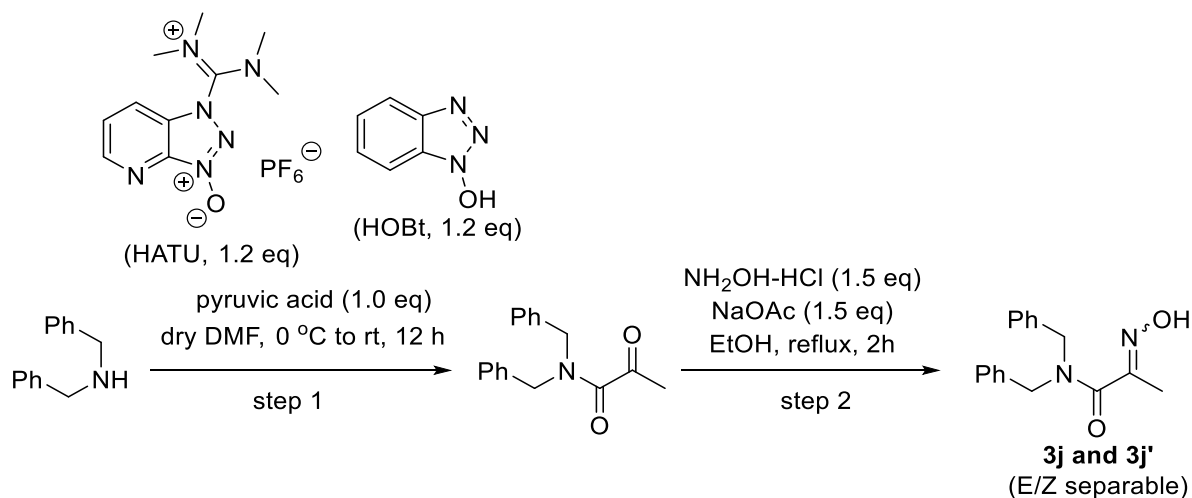
found 205.0993.

2-(hydroxyimino)-1-(isoindolin-2-yl)propan-1-one (3h); isoindoline (238 mg, 2.0 mmol) was used to provide **3h** (346 mg, 85%); brown solid; $R_f = 0.4$ (Hex:EtOAc = 2:1); ^1H NMR (400 MHz, CDCl_3) δ 8.29 (br s, 1H), 7.31-7.25 (m, 3H), 7.19 (m, 1H), 5.03 (s, 2H), 4.90 (s, 2H), 2.15 (s, 3H). ^{13}C NMR (100 MHz, CDCl_3) δ 164.4, 153.7, 137.0, 135.5, 127.7, 127.6, 122.9, 122.5, 54.8, 53.2, 11.5. IR (neat) ν_{max} 3204, 2863, 1740, 1641, 1580, 1443, 1352 cm^{-1} . HRMS[FAB $^+$] calcd for $\text{C}_{11}\text{H}_{13}\text{N}_2\text{O}_2$ $[\text{M}]^+$ 205.0977, found 205.0993.



2-(hydroxyimino)-1-(indolin-1-yl)propan-1-one (3i); indoline (238 mg, 2.0 mmol) was used to provide **3i** (251 mg, 76%); off-white solid; R_f = 0.6 (Hex:EtOAc = 2:1); ^1H NMR (400 MHz, acetone- d_6 , mixture of isomers, ratio 1:0.15, minor isomer was not characterized) δ 10.76 (br s, 1H), 8.14 (d, J = 7.64 Hz, 1H), 7.23-7.15 (m, 2H), 7.02 (t, J = 7.4 Hz, 1H), 4.24 (t, J = 8.4 Hz, 2H), 3.10 (t, J = 8.4 Hz, 2H), 2.07 (s, 3H). ^{13}C NMR (100 MHz, acetone- d_6) δ 164.8, 153.2, 143.9, 133.5, 127.7, 125.5, 124.7, 118.0, 52.3, 28.7, 11.4. IR (neat) ν_{max} 3299, 1732, 1621, 1591, 1482, 1426 cm^{-1} . HRMS[EI^+] calcd for $\text{C}_{11}\text{H}_{12}\text{N}_2\text{O}_2$ [M] $^+$ 204.0899, found 204.0892.

Procedures for noncyclic secondary amides (3j-3l)



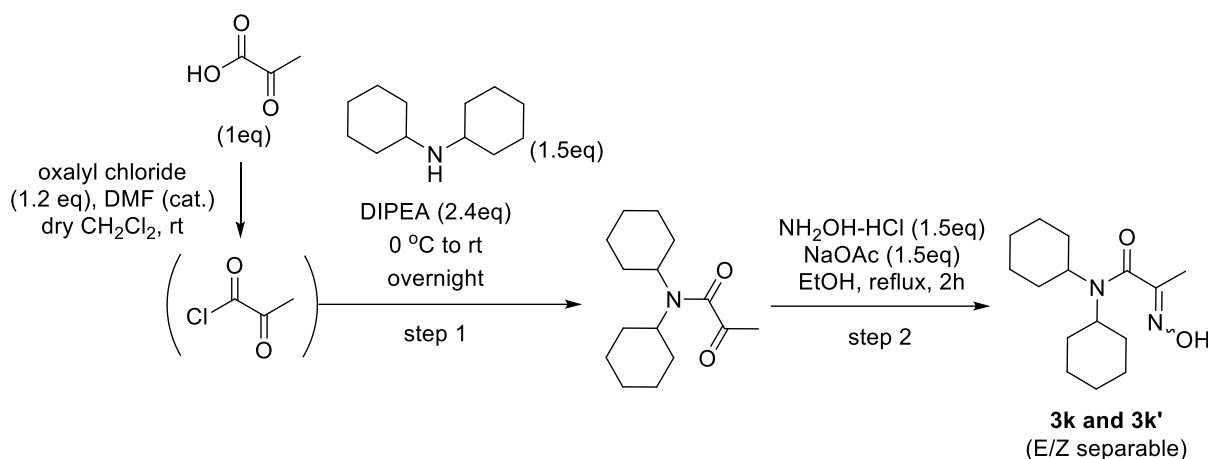
Step 1: To a stirred solution of pyruvic acid (0.35 mL, 5.0 mmol) in dry DMF (3.0 mL) was added dibenzylamine (0.95 mL, 5.0 mmol), a solution of 1-[Bis(dimethylamino)methylene]-1H-1,2,3-triazolo[4,5-b]pyridinium 3-oxide hexafluorophosphate (HATU, 2.28 g, 6.0 mmol), and hydroxybenzotriazole (HOBt, 810 mg, 6.0 mmol) in DMF (6.0 mL) under 0 °C. The reaction mixture was then stirred for 12 hours, concentrated, diluted with EtOAc (30 mL), and washed with 1N HCl (6.0 mL) and brine (6.0 mL). The organic solution was dried over MgSO_4 , filtered, and concentrated. The residue was subjected to silica gel column chromatography (EtOAc:Hex = 1:7 to 1:5) to afford *N,N*-dibenzyl-2-oxopropanamide (414 mg, 31%) as an oil; R_f = 0.6 (Hex:EtOAc = 3:1); ^1H NMR (400 MHz, CDCl_3) δ 7.38-7.31 (m, 6H), 7.26-7.19 (m, 4H), 4.55 (s, 2H), 4.40 (s, 2H), 2.40 (s, 3H). ^{13}C NMR (100 MHz, CDCl_3) δ 198.6, 167.5, 135.8, 135.6, 129.0, 128.9, 128.5, 128.2, 127.9, 127.8, 50.0, 47.2, 27.8. IR (neat) ν_{max} 3063, 3030, 2926, 1714, 1641, 1450, 1355 cm^{-1} . HRMS[EI^+] calcd for $\text{C}_{17}\text{H}_{17}\text{NO}_2$ [M] $^+$ 267.1259, found 267.1261.

Step 2: A mixture of the ketoamide obtained from step 1 (534 mg, 2.0 mmol), $\text{NH}_2\text{OH}\cdot\text{HCl}$ (206 mg, 3.0 mmol), and NaOAc (246 mg, 3.0 mmol) in EtOH (6.0 mL) was heated to reflux in heating mantle for 2 hours. Then, the reaction mixture was concentrated, diluted with EtOAc (15 mL), and washed with H_2O (3 mL). The organic solution was dried over MgSO_4 , filtered, and concentrated. The residue was subjected to silica gel column chromatography (EtOAc:Hex = 1:7 to 1:4) to afford **3j** (344 mg, 61%) and **3j'** (152 mg, 27 %).

(E)-N,N-dibenzyl-2-(hydroxyimino)propanamide (3j); yellow solid; R_f = 0.5 (Hex:EtOAc = 1:1); ^1H NMR (400 MHz, CDCl_3) δ 8.51 (br s, 1H), 7.39-7.26 (m, 8H), 7.18 (d, J = 6.9 Hz, 2H), 4.64 (s, 2H), 4.36 (s, 2H), 2.10 (s, 3H). ^{13}C NMR (100 MHz, CDCl_3) δ 167.0, 151.8, 135.8, 135.6, 128.9, 128.6,

128.2, 127.9, 127.7, 127.5, 50.2, 46.4, 17.4. IR (neat) ν_{\max} 3188, 3061, 2876, 1740, 1606, 1429 cm^{-1} . HRMS[EI^+] calcd for $\text{C}_{17}\text{H}_{18}\text{N}_2\text{O}_2$ [M] $^+$ 282.1368, found 282.1342.

(Z)-N,N-dibenzyl-2-(hydroxyimino)propanamide (3j'); white solid ; R_f = 0.6 (Hex:EtOAc = 2:1); ^1H NMR (400 MHz, CDCl_3) δ 7.80 (br s, 1H), 7.36-7.26 (m, 6H), 7.23 (d, J = 1.8 Hz, 1H), 7.21 (d, J = 1.6 Hz, 1H), 7.19 (d, J = 1.7 Hz, 1H), 7.17 (d, J = 2.5 Hz, 1H), 4.57 (s, 2H), 4.53 (s, 2H), 2.07 (s, 3H). ^{13}C NMR (100 MHz, CDCl_3) δ 167.3, 152.7, 136.48, 136.43, 128.87, 128.82, 128.5 (2C), 127.8, 127.7, 51.1, 47.5, 12.6. IR (neat) ν_{\max} 3331, 3029, 2970, 1617, 1359, 1175 cm^{-1} . HRMS[FAB $^+$] calcd for $\text{C}_{17}\text{H}_{19}\text{N}_2\text{O}_2$ [$\text{M}+\text{H}$] $^+$ 283.1447, found 283.1429.



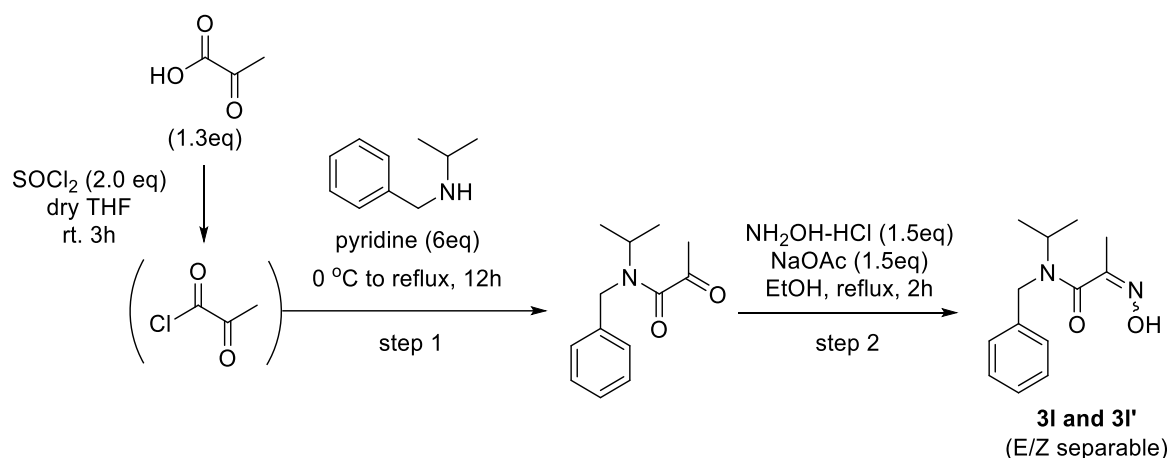
Step 1: To a stirred solution of pyruvic acid (0.35 mL, 5.0 mmol) in dry CH_2Cl_2 (6.0 mL) were added a catalytic amount of DMF (2 drops) and oxalyl chloride (0.51 mL, 6.0 mmol). The reaction mixture was stirred at room temperature for 2 hours. Then, a solution of dicyclohexylamine (1.48 mL, 7.5 mmol) and DIPEA (2.0 mL, 12.0 mmol) in CH_2Cl_2 (1.0 mL) was slowly added at 0 °C. The reaction mixture was stirred at room temperature for 12 h, diluted with water (10 mL), and extracted with CH_2Cl_2 (3 X 10 mL). The organic solution was dried over MgSO_4 , filtered, and concentrated. The residue was subjected to silica gel column chromatography (EtOAc:Hex = 1:7 to 1:5) to afford N,N-dicyclohexyl-2-oxopropanamide (239 mg, 19%) as a white solid; R_f = 0.5 (Hex:EtOAc = 10:1); ^1H NMR (300 MHz, CDCl_3) δ 3.18 (m, 1H), 3.05 (m, 1H), 2.41-2.29 (m, 4H), 1.82-1.73 (m, 6H), 1.66-1.46 (m, 6H), 1.43 (s, 1H), 1.30-1.15 (m, 5H), 1.08 (m, 1H). ^{13}C NMR (100 MHz, CDCl_3) δ 198.9, 167.8, 58.6, 55.7, 31.3, 29.6, 27.6, 26.4, 25.7, 25.2, 25.1. IR (neat) ν_{\max} 3007, 2856, 1740, 1629, 1444, 1352, 1177 cm^{-1} . HRMS[EI^+] calcd for $\text{C}_{15}\text{H}_{25}\text{NO}_2$ [M] $^+$ 251.1885, found 251.1897.

Step 2: A mixture of the ketoamide obtained from step 1 (503 mg, 2.0 mmol), $\text{NH}_2\text{OH}\cdot\text{HCl}$ (206 mg, 3.0 mmol), and NaOAc (246 mg, 3.0 mmol) in EtOH (6.0 mL) was heated to reflux in heating mantle for 2 hours. Then, the reaction mixture was concentrated, diluted with EtOAc (15 mL), and washed with H_2O (3 mL). The organic solution was dried over MgSO_4 , filtered, and concentrated. The residue was subjected to silica gel column chromatography (EtOAc:Hex = 1:5 to 1:3) to afford **3k** (287 mg, 54%) and **3k'** (170 mg, 32 %).

(E)-N,N-dicyclohexyl-2-(hydroxyimino)propanamide (3k); white solid ; R_f = 0.4 (Hex:EtOAc = 1:1); ^1H NMR (300 MHz, CDCl_3) δ 7.80 (br s, 1H), 3.22 (m, 1H), 2.96 (m, 1H), 2.57-2.46 (m, 2H), 1.98 (s, 3H), 1.81-1.77 (m, 6H), 1.61-1.41 (m, 6H), 1.33- 1.04 (m, 6H). ^{13}C NMR (100 MHz, CDCl_3) δ 165.4, 153.0, 59.5, 55.8, 31.6, 29.7, 26.6 (2C), 25.8, 25.3, 17.5. IR (neat) ν_{\max} 3222, 2928, 1740, 1602, 1451, 1374, 1184 cm^{-1} . HRMS[EI^+] calcd for $\text{C}_{15}\text{H}_{26}\text{N}_2\text{O}_2$ [M] $^+$ 266.1994, found 266.1996.

(Z)-N,N-dicyclohexyl-2-(hydroxyimino)propanamide (3k'); white solid; R_f = 0.6 (Hex:EtOAc = 2:1); ^1H NMR (300 MHz, CDCl_3) δ 8.40 (br s, 1H), 3.48 (m, 1H), 2.99 (m, 1H), 2.44-2.41 (m, 2H), 2.02 (s,

3H), 1.80-1.69 (m, 6H), 1.59-1.37 (m, 5H), 1.30-1.00 (m, 7H). ^{13}C NMR (100 MHz, CDCl_3) δ 166.4, 153.8, 59.4, 56.1, 31.3, 29.7, 26.6, 25.8, 25.3 (2C), 12.5. IR (neat) ν_{max} 3235, 2934, 1740, 1602, 1449, 1325, 1199 cm^{-1} . HRMS[EI^+] calcd for $\text{C}_{15}\text{H}_{26}\text{N}_2\text{O}_2$ [M] $^+$ 266.1994, found 266.1985.



Step 1: To a stirred solution of pyruvic acid (0.45 mL, 6.5 mmol) in dry THF (15 mL) was added thionyl chloride (0.70 mL, 10.0 mmol). After being stirred for 3 hours at room temperature, a solution of *N*-benzylpropan-2-amine (0.82 mL, 5.0 mmol) and pyridine (2.4 mL, 30 mmol) in THF (2.0 mL) was added to the reaction mixture at 0 °C, and the reaction mixture was heated to reflux for 12 hours. Then, it was quenched by adding 30 mL of 2N HCl solution and extracted with EtOAc (30 mL). The organic solution was dried over MgSO_4 , filtered, and concentrated. The residue was subjected to silica gel column chromatography (EtOAc:Hex = 1:5 to 1:3) to afford *N*-benzyl-*N*-isopropyl-2-oxopropanamide (267 mg, 23%) as brown oil; R_f = 0.4 (Hex:EtOAc = 5:1); ^1H NMR (400 MHz, CDCl_3 , mixture of isomers, ratio 1:1) δ 7.34-7.20 (m, 5H), 4.64 (sept, J = 6.8 Hz, 0.5H), 4.56 (s, 1H), 4.45 (s, 1H), 3.99 (sept, J = 6.6 Hz, 0.5H), 2.47 (s, 1.5H), 2.01 (s, 1.5H), 1.20 (d, J = 6.8 Hz, 3H), 1.15 (d, J = 6.6 Hz, 3H). ^{13}C NMR (100 MHz, CDCl_3) δ 199.1, 198.8, 168.2, 167.8, 138.2, 137.6, 128.8, 128.5, 127.8, 127.7, 127.2, 127.1, 50.0, 46.7, 46.4, 43.4, 28.0, 26.8, 21.7, 20.1. IR (neat) ν_{max} 2978, 1713, 1638, 1450, 1309 cm^{-1} . HRMS[EI^+] calcd for $\text{C}_{13}\text{H}_{17}\text{NO}_2$ [M] $^+$ 219.1259, found 219.1250.

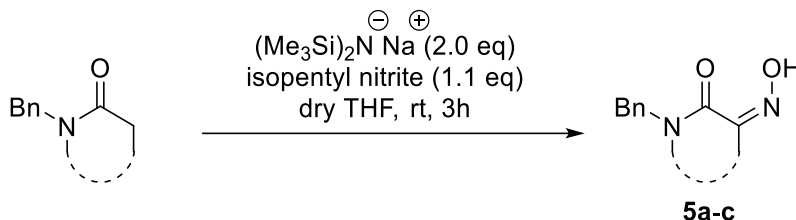
Step 2: A mixture of the ketoamide obtained from step 1 (438 mg, 2.0 mmol), $\text{NH}_2\text{OH}\cdot\text{HCl}$ (206 mg, 3.0 mmol), and NaOAc (246 mg, 3.0 mmol) in EtOH was heated to reflux in heating mantle for 2 hours. Then, the reaction mixture was concentrated, diluted with EtOAc (15 mL), and washed with H_2O (3 mL). The organic solution was dried over MgSO_4 , filtered, and concentrated. The residue was subjected to silica gel column chromatography (EtOAc:Hex = 1:4 to 1:2) to afford **3I** (241 mg, 52%) and **3I'** (148 mg, 32%).

(*E*)-*N*-benzyl-2-(hydroxyimino)-*N*-isopropylpropanamide (3I); white solid; R_f = 0.5 (Hex:EtOAc = 2:1); ^1H NMR (500 MHz, CDCl_3 , mixture of isomers, ratio 1: 0.42) δ 9.21 (br s, 1H), 7.33-7.18 (m, 5H), 4.64 (sept, J = 6.9 Hz, 0.3H), 4.61 (s, 1.45H), 4.41 (s, 0.55H), 3.94 (sept, J = 6.6 Hz, 0.7H), 2.11 (s, 2.2H), 1.71 (s, 0.8H), 1.19 (d, J = 6.8 Hz, 1.8H), 1.11 (d, J = 6.6 Hz, 4.2H). ^{13}C NMR (125 MHz, CDCl_3) δ 167.4, 166.4, 153.0, 152.5, 138.5, 138.0, 128.7, 128.4, 127.5, 127.3, 127.0, 126.8, 50.3, 47.5, 46.8, 43.2, 21.9, 20.3, 17.6, 17.1. IR (neat) ν_{max} 3241, 3028, 1607, 1467, 1420, 1225 cm^{-1} . HRMS[EI^+] calcd for $\text{C}_{13}\text{H}_{18}\text{N}_2\text{O}_2$ [M] $^+$ 234.1368, found 234.1375.

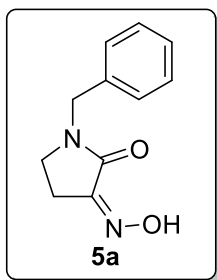
(*Z*)-*N*-benzyl-2-(hydroxyimino)-*N*-isopropylpropanamide (3I'); yellow solid; R_f = 0.7 (Hex:EtOAc = 2:1); ^1H NMR (500 MHz, CDCl_3 , mixture of isomers, ratio 1: 0.8) δ 8.65 (br s, 0.55H), 8.39 (br s, 0.45H), 7.32-7.19 (m, 5H), 4.69 (sept, J = 6.9 Hz, 0.45H), 4.59 (s, 1.1H), 4.55 (s, 0.9H), 4.32 (sept, J = 6.8 Hz, 0.55H), 2.14 (s, 1.65H), 1.69 (s, 1.35H), 1.20 (d, J = 6.7 Hz, 2.7H), 1.13 (d, J = 6.7 Hz, 3.3H). ^{13}C NMR (125 MHz, CDCl_3) δ 167.3 (2C), 153.5, 153.1, 138.7, 138.5, 128.6, 128.5, 127.48, 127.40,

127.0, 126.9, 50.5, 48.1, 46.9, 43.7, 21.7, 20.3, 12.7, 12.0. IR (neat) ν_{max} 3192, 3071, 1599, 1492, 1361, 1132 cm^{-1} . HRMS[EI^+] calcd for $\text{C}_{13}\text{H}_{18}\text{N}_2\text{O}_2$ [M] $^+$ 234.1368, found 234.1375.

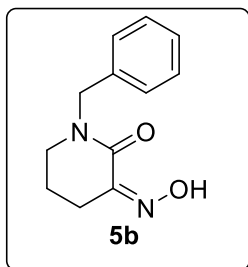
General procedure for preparation of 5a-5c



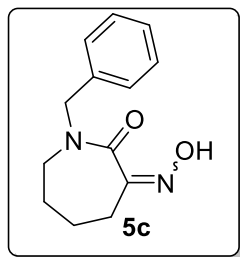
To a stirred solution of amide (3.0 mmol) in dry THF (15 mL) was added sodium hexamethyldisilazide (1.0M in THF, 6.0 mL, 6.0 mmol) at room temperature under Ar. After being stirred for 30 min, isopentyl nitrite (0.44 mL, 3.3 mmol) was added to the reaction mixture. After 3 hours, the reaction mixture was quenched with 1N HCl aq. sol'n (15 mL) and extracted with ethyl acetate (3 X 20 mL). The organic solution was dried over MgSO_4 , filtered, and concentrated. The residue was subjected to silica gel column chromatography (10% MeOH in DCM) to afford **5a-c**.



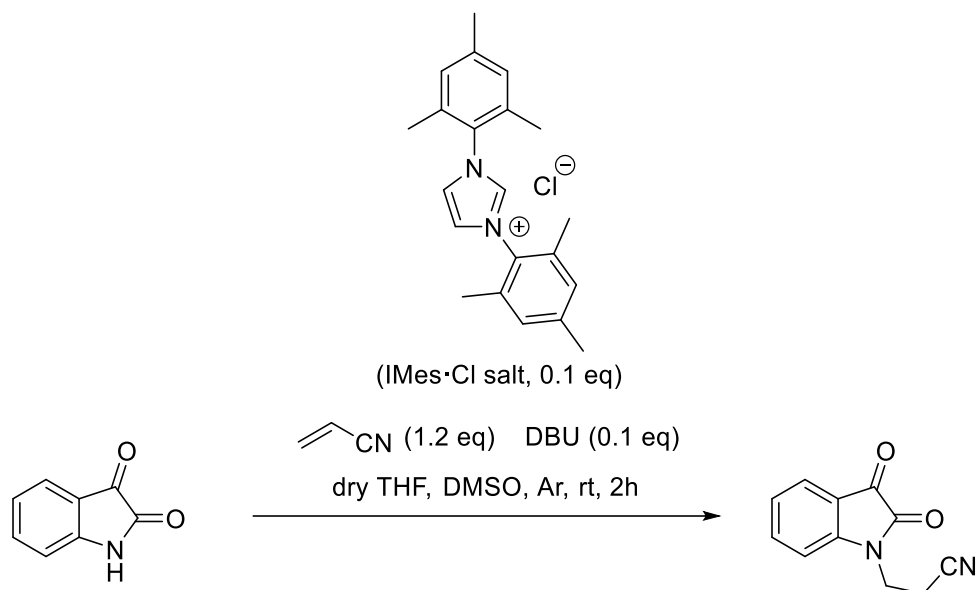
benzyl-3-(hydroxyimino)pyrrolidin-2-one (5a); 1-benzylpyrrolidin-2-one (525 mg, 3.0 mmol) was used to provide **5a** (151 mg, 25%) as brown solid; R_f = 0.5 (10% MeOH in DCM); ^1H NMR (500 MHz, methanol- d_4) δ 7.37-7.33 (m, 2H), 7.31-7.28 (m, 3H), 4.60 (s, 2H), 3.41 (t, J = 6.3 Hz, 2H), 2.81 (t, J = 6.5 Hz, 2H). ^{13}C NMR (100 MHz, methanol- d_4) δ 166.0, 152.9, 137.0, 129.9, 129.2, 128.9, 48.1, 44.0, 21.6. IR (neat) ν_{max} 3064, 2859, 1678, 1641, 1452, 1309 cm^{-1} . HRMS[EI^+] calcd for $\text{C}_{11}\text{H}_{12}\text{N}_2\text{O}_2$ [M] $^+$ 204.0899, found 204.0884.



benzyl-3-(hydroxyimino)piperidin-2-one (5b); 1-benzylpiperidin-2-one (567 mg, 3.0 mmol) was used to provide **5b** (98 mg, 15%) as brown solid; R_f = 0.5 (10% MeOH in DCM); ^1H NMR (500 MHz, methanol- d_4) δ 7.35-7.26 (m, 5H), 4.69 (s, 2H), 3.35 (t, J = 5.7 Hz, 2H), 2.73 (t, J = 6.6 Hz, 2H), 1.84 (quintet, J = 6.4 Hz, 2H). ^{13}C NMR (100 MHz, methanol- d_4) δ 163.2, 150.7, 138.0, 129.7, 129.0, 128.6, 51.6, 47.7, 24.0, 22.0. IR (neat) ν_{max} 3133, 2943, 2345, 1633, 1575, 1489, 1428 cm^{-1} . HRMS[EI^+] calcd for $\text{C}_{12}\text{H}_{14}\text{N}_2\text{O}_2$ [M] $^+$ 218.1055, found 218.1067.

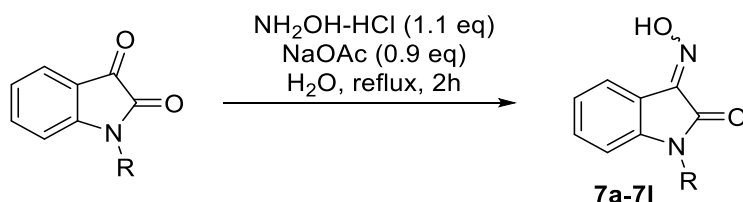


benzyl-3-(hydroxyimino)azepan-2-one (5c); 1-benzylazepan-2-one (609 mg, 3.0 mmol) was used to provide **5c** (88 mg, 13%) as brown solid; R_f = 0.5 (10% MeOH in DCM); ^1H NMR (500 MHz, methanol- d_4 , mixture of isomers, ratio 1:0.55) δ 7.35-7.26 (m, 5H), 4.64-4.63 (m, 2H), 3.35 (t, J = 5.8 Hz, 1.3H), 3.27 (m, 0.7H), 2.55-2.53 (m, 0.7H), 2.39-2.36 (m, 1.3H), 1.77 (m, J = 6.1 Hz, 0.7H), 1.67 (m, J = 6.3 Hz, 1.3H), 1.55-1.50 (m, 2H). ^{13}C NMR (100 MHz, methanol- d_4) δ 169.7, 168.6, 158.2, 155.6, 138.4, 137.9, 129.74, 129.72, 129.3, 129.2, 128.78, 128.70, 50.9, 50.3, 46.8 (2C), 30.2, 29.8, 27.9, 26.2, 24.6, 21.6. IR (neat) ν_{max} 3191, 2868, 1634, 1598, 1480, 1444 cm^{-1} . HRMS[EI^+] calcd for $\text{C}_{13}\text{H}_{16}\text{N}_2\text{O}_2$ [M] $^+$ 232.1212, found 232.1200.

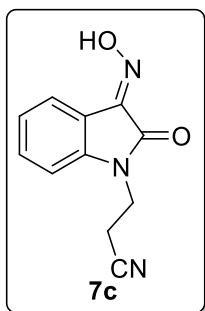


To a stirred solution of 1,3-bis(2,4,6-trimethylphenyl)imidazolium chloride (102 mg, 0.3 mmol) and 1,8-diazabicyclo[5.4.0]undec-7-ene (DBU, 44 μL , 0.3 mmol) in dry THF (4 mL) under Ar was added DMSO (0.3 mL) and acrylonitrile (0.23 mL, 3.6 mmol). Then, a solution of isatin (441 mg, 3.0 mmol) in dry THF (4 mL) was added dropwise at room temperature. After 2 hours, the reaction mixture was diluted with water (5 mL) and extracted with EtOAc (3 X 10 mL). The organic solution was dried over MgSO_4 , filtered, and concentrated. The residue was subjected to silica gel column chromatography (EtOAc:Hex = 1:7 to 1:2) to afford 3-(2,3-dioxindolin-1-yl)propanenitrile (207 mg, 35%) as brown solid; R_f = 0.4 (Hex:EtOAc = 1:2); ^1H NMR (400 MHz, CDCl_3) δ 7.67-7.63 (m, 2H), 7.18 (t, J = 7.5 Hz, 1H), 7.03 (d, J = 7.8 Hz, 1H), 4.05 (t, J = 6.8 Hz, 2H), 2.82 (t, J = 6.7 Hz, 2H). ^{13}C NMR (100 MHz, CDCl_3) δ 182.2, 158.3, 149.7, 138.8, 126.1, 124.6, 117.8, 117.0, 110.0, 36.4, 16.7. IR (neat) ν_{max} 3452, 3064, 2247, 2160, 1738, 1612, 1467 cm^{-1} . HRMS[EI^+] calcd for $\text{C}_{11}\text{H}_8\text{N}_2\text{O}_2$ [M] $^+$ 200.0586, found 200.0584.

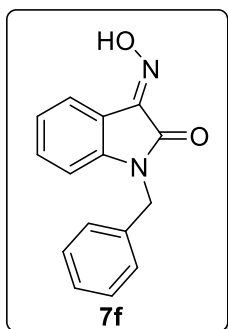
Conversion of ketoamides to 3-oximinoisatins 7a-7l



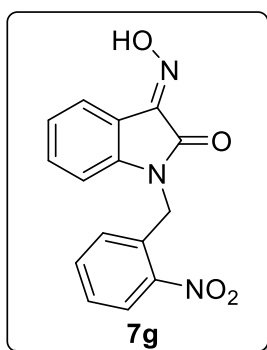
A mixture of *N*-substituted isatin (2.0 mmol) and hydroxylamine hydrochloride (152 mg, 2.2 mmol) in water (6 mL) was heated to reflux in heating mantle for 30 min. Then, sodium acetate (147 mg, 1.8 mmol) was added in and the solution was continued to reflux for another 2 hours. The mixture was cooled down to room temperature, diluted with water (5 mL), and extracted with EtOAc (3 X 10 mL). The organic solution was dried over MgSO_4 , filtered, and concentrated. The residue was subjected to silica gel column chromatography to afford **7a-7l**.



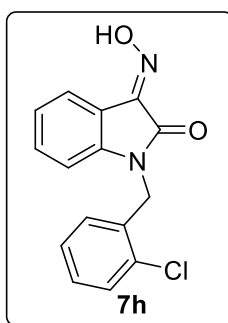
3-(3-(hydroxyimino)-2-oxoindolin-1-yl)propanenitrile (7c); 3-(2,3-dioxoindolin-1-yl)propanenitrile (400 mg, 2.0 mmol) was used to provide **7c** (274 mg, 63%) as yellow solid; $R_f = 0.4$ (Hex:EtOAc = 1:2); ^1H NMR (400 MHz, DMSO- d_6) δ 13.52 (br s, 1H), 8.01 (d, $J = 7.2$ Hz, 1H), 7.45 (t, $J = 7.7$ Hz, 1H), 7.25 (d, $J = 7.9$ Hz, 1H), 7.11 (t, $J = 7.5$ Hz, 1H), 4.02 (t, $J = 6.6$ Hz, 2H), 2.91 (t, $J = 6.5$ Hz, 2H). ^{13}C NMR (100 MHz, DMSO- d_6) δ 163.0, 143.2, 142.2, 132.0, 126.9, 122.9, 118.6, 115.2, 109.4, 35.1, 15.9. IR (neat) ν_{max} 3252, 2896, 2361, 1738, 1612, 1459 cm^{-1} . HRMS[EI^+] calcd for $\text{C}_{11}\text{H}_9\text{N}_3\text{O}_2$ [M] $^+$ 215.0695, found 215.0694.



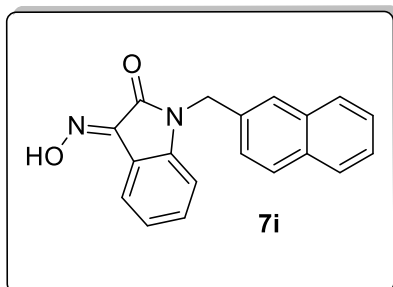
1-benzyl-3-(hydroxyimino)indolin-2-one (7f); 1-benzylindoline-2,3-dione (474 mg, 2.0 mmol) was used to provide **7f** (463 mg, 92%) as yellow solid; $R_f = 0.4$ (Hex:EtOAc = 1:1); ^1H NMR (400 MHz, DMSO- d_6) δ 13.52 (br s, 1H), 8.00 (dd, $J = 7.4, 1.2$ Hz, 1H), 7.37-7.31 (m, 5H), 7.25 (m, 1H), 7.06 (td, $J = 7.5, 0.9$ Hz, 1H), 6.98 (d, $J = 7.8$ Hz, 1H), 4.93 (s, 2H). ^{13}C NMR (100 MHz, DMSO- d_6) δ 163.2, 143.4, 142.7, 136.2, 131.9, 128.6, 127.4, 127.2, 126.9, 122.7, 115.3, 109.5, 42.5. IR (neat) ν_{max} 3184, 2362, 1706, 1610, 1466, 1358, 1195 cm^{-1} . HRMS[EI^+] calcd for $\text{C}_{15}\text{H}_{12}\text{N}_2\text{O}_2$ [M] $^+$ 252.0899, found 252.0901.



3-(hydroxyimino)-1-(2-nitrobenzyl)indolin-2-one (7g); 1-(2-nitrobenzyl)indoline-2,3-dione (564 mg, 2.0 mmol) was used to provide **7g** (364 mg, 61%) as yellow solid; $R_f = 0.4$ (Hex:EtOAc = 1:1); ^1H NMR (400 MHz, DMSO- d_6) δ 13.57 (br s, 1H), 8.17 (dd, $J = 8.0, 1.4$ Hz, 1H), 8.05 (d, $J = 7.2$ Hz, 1H), 7.65 (td, $J = 7.5, 1.4$ Hz, 1H), 7.56 (td, $J = 8.0, 1.4$ Hz, 1H), 7.34 (td, $J = 7.8, 1.3$ Hz, 1H), 7.21 (d, $J = 7.6$ Hz, 1H), 7.10 (t, $J = 7.6$ Hz, 1H), 6.96 (d, $J = 7.8$ Hz, 1H), 5.30 (s, 2H). ^{13}C NMR (100 MHz, DMSO- d_6) δ 163.5, 147.7, 143.3, 142.5, 134.3, 132.0, 131.2, 128.6, 127.3, 126.9, 125.3, 123.0, 115.5, 109.6, 40.6. IR (neat) ν_{max} 3092, 1729, 1607, 1522, 1463, 1331 cm^{-1} . HRMS[EI^+] calcd for $\text{C}_{15}\text{H}_{11}\text{N}_3\text{O}_4$ [M] $^+$ 297.0750, found 297.0749.

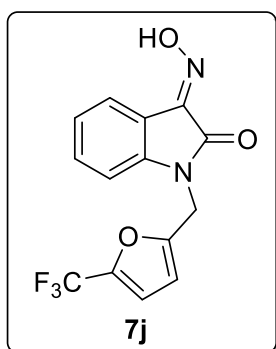


1-(2-chlorobenzyl)-3-(hydroxyimino)indolin-2-one (7h); 1-(2-chlorobenzyl)indoline-2,3-dione (542 mg, 2.0 mmol) was used to provide **7h** (439 mg, 77%) as yellow solid; $R_f = 0.5$ (Hex:EtOAc = 1:1); ^1H NMR (400 MHz, DMSO- d_6) δ 13.56 (br s, 1H), 8.04 (dd, $J = 7.5, 1.2$ Hz, 1H), 7.50 (dd, $J = 7.7, 1.4$ Hz, 1H), 7.35-7.26 (m, 3H), 7.14-7.07 (m, 2H), 6.86 (d, $J = 7.8$ Hz, 1H), 5.00 (s, 2H). ^{13}C NMR (100 MHz, DMSO- d_6) δ 163.2, 143.3, 142.6, 133.0, 132.0, 131.9, 129.6, 129.2, 127.8, 127.6, 127.0, 122.9, 115.4, 109.3, 40.7. IR (neat) ν_{max} 3087, 1730, 1604, 1463, 1442, 1342 cm^{-1} . HRMS[EI^+] calcd for $\text{C}_{15}\text{H}_{11}\text{ClN}_2\text{O}_2$ [M] $^+$ 286.0509, found 286.0511.

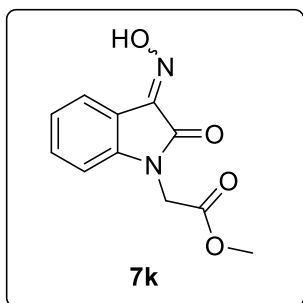


3-(hydroxyimino)-1-(naphthalen-2-ylmethyl)indolin-2-one (7i); 1-(naphthalen-1-ylmethyl)indoline-2,3-dione (574 mg, 2.0 mmol) was used to provide **7i** (401 mg, 67%) as yellow solid; $R_f = 0.4$ (Hex:EtOAc = 1:1); ^1H NMR (400 MHz, DMSO- d_6) δ 13.57 (br s, 1H), 8.23 (d, $J = 8.4$ Hz, 1H), 8.04 (dd, $J = 7.6, 1.2$ Hz, 1H), 7.97 (dd, $J = 7.8, 1.6$ Hz, 1H), 7.86 (d, $J = 8.1$ Hz, 1H), 7.64-7.55 (m, 2H), 7.42 (t, $J = 7.2$ Hz, 1H), 7.32-7.27 (m, 2H), 7.07 (td, $J = 7.6, 0.9$ Hz, 1H), 6.89 (d, $J = 7.8$ Hz, 1H), 5.43 (s, 2H). ^{13}C NMR (100 MHz, DMSO- d_6) δ 163.3, 143.4, 143.0, 133.4, 131.9, 130.9, 130.5,

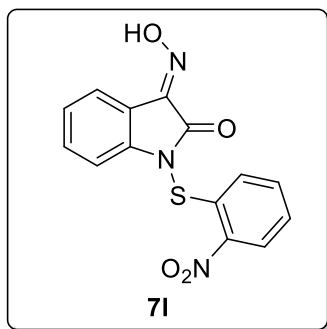
128.7, 127.9, 126.9, 126.5, 126.0, 125.4, 124.0, 123.1, 122.8, 115.4, 109.8, 41.0. IR (neat) ν_{\max} 3043, 2846, 1719, 1602, 1461, 1301 cm^{-1} . HRMS[FAB⁺] calcd for $\text{C}_{19}\text{H}_{13}\text{FN}_2\text{O}$ $[\text{M}]^+$ 302.1055, found 302.1062.



found 310.0579.



ν_{\max} 3227, 2418, 1708, 1605, 1463, 1345 cm^{-1} . HRMS[EI⁺] calcd for $\text{C}_{11}\text{H}_{10}\text{N}_2\text{O}_4$ $[\text{M}]^+$ 234.0641, found 234.0648.



found 315.0313.

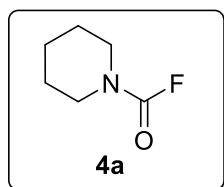
3-(hydroxyimino)-1-((5-(trifluoromethyl)furan-2-yl)methyl)indolin-2-one (7j); 1-((5-(trifluoromethyl)furan-2-yl)methyl)indoline-2,3-dione (590 mg, 2.0 mmol) was used to provide **7j** (364 mg, 59%) as a yellow solid; R_f = 0.5 (Hex:EtOAc = 1:1); ^1H NMR (400 MHz, DMSO- d_6) δ 13.56 (br s, 1H), 8.01 (dd, J = 7.6, 1.2 Hz, 1H), 7.42 (td, J = 7.8, 1.3 Hz, 1H), 7.18-7.14 (m, 2H), 7.10 (td, J = 7.5, 0.9 Hz, 1H), 6.70 (d, J = 3.4 Hz, 1H), 5.05 (s, 2H). ^{13}C NMR (100 MHz, DMSO- d_6) δ 162.7, 153.1 (q, $J_{\text{C,F}}$ = 1.5 Hz), 143.1, 142.2, 139.5 (q, $J_{\text{C,F}}$ = 41 Hz), 132.0, 126.9, 123.0, 118.9 (q, $J_{\text{C,F}}$ = 264 Hz), 115.3, 114.0 (q, $J_{\text{C,F}}$ = 2.8 Hz), 109.9, 109.3, 35.8. IR (neat) ν_{\max} 3251, 2361, 1718, 1614, 1453, 1318 cm^{-1} . HRMS[EI⁺] calcd for $\text{C}_{14}\text{H}_9\text{F}_3\text{N}_2\text{O}_3$ $[\text{M}]^+$ 310.0565,

Methyl 2-(3-(hydroxyimino)-2-oxoindolin-1-yl)acetate (7k); methyl 2-(2,3-dioxoindolin-1-yl)acetate (438 mg, 2.0 mmol) was used to provide **7k** (313 mg, 67%) as yellow solid; R_f = 0.4 (Hex:EtOAc = 1:1); ^1H NMR (400 MHz, acetone- d_6 , mixture of isomers, ratio 1:1) δ 12.49 (br s, 1H), 8.14 (d, J = 0.6 Hz, 0.5H), 8.12 (d, J = 0.6 Hz, 0.5H), 7.43 (td, J = 7.8, 1.3 Hz, 1H), 7.13 (td, J = 7.6, 0.9 Hz, 1H), 7.04 (t, J = 0.8 Hz, 0.5H), 7.02 (t, J = 0.7 Hz, 0.5H), 4.60 (s, 2H), 3.73 (s, 3H). ^{13}C NMR (100 MHz, acetone- d_6) δ 169.2, 168.9, 164.1, 164.0, 144.9, 144.8, 144.4, 144.2, 132.99, 132.98, 128.4, 128.3, 123.7, 123.6, 116.6 (2C), 109.8 (2C), 52.7 (2C), 41.4, 41.3. IR (neat)

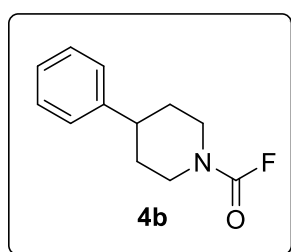
3-(hydroxyimino)-1-((2-nitrophenyl)thio)indolin-2-one (7l); 1-((2-nitrophenyl)thio)indoline-2,3-dione (600 mg, 2.0 mmol) was used to provide **7l** (318 mg, 51%) as yellow solid; R_f = 0.4 (Hex:EtOAc = 1:1); ^1H NMR (400 MHz, DMSO- d_6) δ 13.81 (br s, 1H), 8.41 (dd, J = 8.3, 1.4 Hz, 1H), 8.13 (dd, J = 7.6, 1.2 Hz, 1H), 7.71 (td, J = 7.1, 1.4 Hz, 1H), 7.51 (td, J = 7.1, 1.2 Hz, 1H), 7.44 (td, J = 7.9, 1.3 Hz, 1H), 7.28-7.21 (m, 2H), 7.16 (d, J = 7.8 Hz, 1H). ^{13}C NMR (100 MHz, DMSO- d_6) δ 164.9, 142.87, 142.80, 142.6, 137.9, 135.8, 132.4, 127.1, 126.9, 126.3, 124.3, 123.8, 117.3, 110.7. IR (neat) ν_{\max} 3100, 2369, 1736, 1604, 1511, 1329, 1305 cm^{-1} . HRMS[EI⁺] calcd for $\text{C}_{14}\text{H}_9\text{N}_3\text{O}_4\text{S}$ $[\text{M}]^+$ 315.0314,

General Procedure for preparation of carbamoyl fluorides

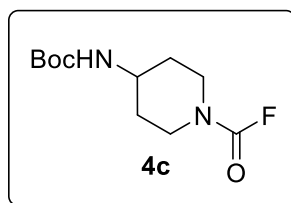
To a stirred solution of the oxime **3**, **5**, or **7** (0.3 mmol) in dry CH₂Cl₂ (DCM, 1.0 mL) was slowly added diethylaminosulfur trifluoride (DAST, 39 μ L, 0.3 mmol) at 0 °C under Ar. After 10 min, the reaction mixture was diluted with DCM (20 mL) and washed with sat. NaHCO₃ aq. sol'n (5.0 mL). The organic solution was dried over MgSO₄, filtered, and concentrated. The crude mixture was subjected to silica gel column chromatography to afford the carbamoyl fluoride **4**, **6**, or **8**.



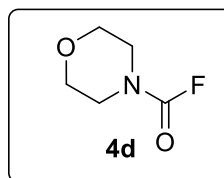
piperidine-1-carbonyl fluoride (4a); 3a (51 mg) was used to provide **4a** (33 mg, 85%) as a colorless oil; R_f = 0.4 (Hex:EtOAc = 7:1); ¹H NMR (400 MHz, CDCl₃) δ 3.44-3.39 (m, 4H), 1.64-1.57 (m, 6H). ¹⁹F NMR (376 MHz, CDCl₃) δ -25.05 (s, 1F). The spectral data is in agreement with the known literature values.³



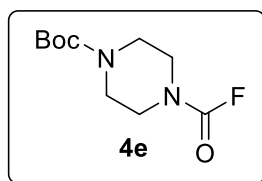
4-phenylpiperidine-1-carbonyl fluoride (4b); 3b (74 mg) was used to provide **4b** (49 mg, 79%) as white solid; R_f = 0.4 (Hex:EtOAc = 5:1); ¹H NMR (300 MHz, CDCl₃) δ 7.35-7.30 (m, 2H), 7.26-7.18 (m, 3H), 4.21 (m, 1H), 4.09 (m, 1H), 3.10-2.95 (m, 2H), 2.71 (tt, J = 12.0, 3.6 Hz, 1H), 1.95-1.88 (m, 2H), 1.82-1.68 (m, 2H). ¹⁹F NMR (376 MHz, CDCl₃) δ -24.58 (s, 1F). The spectral data is in agreement with the known literature values.⁴



tert-butyl (1-(fluorocarbonyl)piperidin-4-yl)carbamate (4c); 3c (85 mg) was used to provide **4c** (49 mg, 67%) as white solid; R_f = 0.4 (Hex:EtOAc = 3:1); ¹H NMR (400 MHz, CDCl₃) δ 4.48 (br s, 1H), 4.00 (d, J = 10.2, 1H), 3.89 (d, J = 10.7 Hz, 1H), 3.63 (s, 1H), 3.08-2.98 (m, 2H), 2.00 (m, 2H), 1.43-1.32 (m, 11H). ¹⁹F NMR (376 MHz, CDCl₃) δ -24.60 (s, 1F). The spectral data is in agreement with the known literature values.³



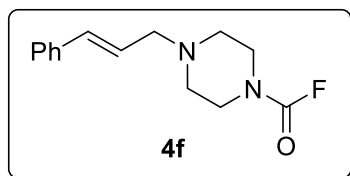
morpholine-4-carbonyl fluoride (4d); 3d (51 mg) was used to provide **4d** (31 mg, 78%) as a white solid; yellow oil; R_f = 0.3 (Hex:EtOAc = 3:1); ¹H NMR (500 MHz, CDCl₃) δ 3.72 (t, J = 4.6 Hz, 2H), 3.68 (t, J = 4.8 Hz, 2H), 3.50-3.46 (m, 4H). ¹⁹F NMR (376 MHz, CDCl₃) δ -24.38 (s, 1F). The spectral data is in agreement with the known literature values.⁵



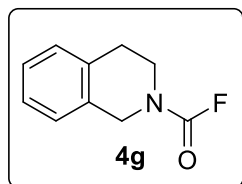
tert-butyl 4-(fluorocarbonyl)piperazine-1-carboxylate (4e); run in 0.1 M solution; **3e** (81 mg) was used to provide **4e** (41 mg, 60%) as white solid; R_f = 0.4 (Hex:EtOAc = 5:1); ¹H NMR (500 MHz, CDCl₃) δ 3.47-3.44 (m, 8H), 1.46 (s, 9H). ¹⁹F NMR (376 MHz, CDCl₃) δ -23.57 (s, 1F). The spectral data is in agreement with the known literature values.³

³ Onida, K.; Tlili, A. Direct Synthesis of Carbamoyl Fluorides by CO₂ Deoxyfluorination. *Angew. Chem. Int. Ed.* **2019**, *58*, 12545.

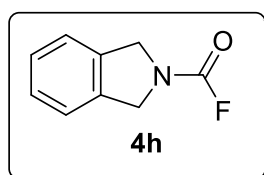
⁴ Turksoy, A.; Scattolin, T.; Bouayad-Gevais, S.; Schoenebeck, F. Facile Access to AgOCF₃ and Its New Applications as a Reservoir for OCF₂ for the Direct Synthesis of *N*-CF₃, Aryl or Alkyl Carbamoyl Fluorides. *Chem. Eur. J.* **2020**, *26*, 2183



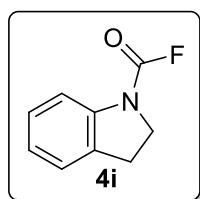
4-cinnamylpiperazine-1-carbonyl fluoride (4f); run in 0.1 M solution; **3f** (86 mg) was used to provide **4f** (45 mg, 61%) as white solid; $R_f = 0.5$ (3% MeOH in DCM); ^1H NMR (300 MHz, CDCl_3) δ 7.39-7.35 (m, 2H), 7.34-7.29 (m, 2H), 7.24 (m, 1H), 6.53 (d, $J = 15.8$ Hz, 1H), 6.21 (m, 1H), 3.52 (dt, $J = 8.9, 5.0$ Hz, 4H), 3.19 (dd, $J = 6.8, 1.3$ Hz, 2H), 2.56-2.49 (m, 4H). ^{19}F NMR (376 MHz, CDCl_3) δ -24.34 (s, 1F). The spectral data is in agreement with the known literature values.³



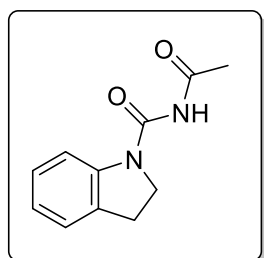
3,4-dihydroisoquinoline-2(1H)-carbonyl fluoride (4g); **3g** (86 mg) was used to provide **4g** (38 mg, 71%) as white solid; $R_f = 0.6$ (Hex:EtOAc = 5:1); ^1H NMR (400 MHz, CDCl_3 , mixture of isomers, ratio 1:1) δ 7.26-7.09 (m, 4H), 4.64 (s, 1H), 4.63 (s, 1H), 3.72 (t, $J = 5.9$ Hz, 1H), 3.69 (t, $J = 4.6$ Hz, 1H), 2.95-2.90 (m, 2H). ^{19}F NMR (376 MHz, CDCl_3) δ -20.23 (s, 0.5F), -23.19 (s, 0.5F). The spectral data is in agreement with the known literature values.³



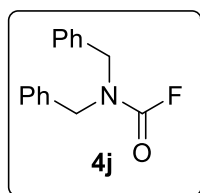
isoindoline-2-carbonyl fluoride (4h); **3h** (61 mg) was used to provide **4h** (33 mg, 68%) as yellow solid; $R_f = 0.5$ (Hex:EtOAc = 10:1); ^1H NMR (400 MHz, CDCl_3) δ 7.33-7.25 (m, 4H), 4.81 (s, 2H), 4.79 (s, 2H). ^{13}C NMR (100 MHz, CDCl_3) δ 146.0 (d, $J_{\text{C,F}} = 286$ Hz), 135.44, 135.40 (d, $J_{\text{C,F}} = 1.4$ Hz), 128.1 (d, $J_{\text{C,F}} = 4.2$ Hz), 122.9 (d, $J_{\text{C,F}} = 1.7$ Hz), 122.8, 52.8 (d, $J_{\text{C,F}} = 47$ Hz). ^{19}F NMR (376 MHz, CDCl_3) δ -14.28 (s, 1F). IR (neat) ν_{max} 2941, 2881, 1783, 1744, 1464, 1396 cm^{-1} . HRMS[EI⁺] calcd for $\text{C}_9\text{H}_8\text{FNO}$ $[\text{M}]^+$ 165.0590, found 165.0594.



indoline-1-carbonyl fluoride (4i); **3i** (61 mg) was used to provide **4i** (19 mg, 38%) as white solid; $R_f = 0.4$ (Hex:EtOAc = 3:1); ^1H NMR (500 MHz, CDCl_3 , mixture of isomers, ratio 1: 0.4) δ 7.77 (d, $J = 8.0$ Hz, 0.7H), 7.32 (dd, $J = 8.3, 4.5$ Hz, 0.3H), 7.27-7.20 (m, 2H), 7.07 (m, 1H), 4.12-4.07 (m, 2H), 3.22-3.18 (m, 2H). ^{19}F NMR (376 MHz, CDCl_3) δ -4.95 (s, 0.7F), -13.07 (s, 0.3F). The spectral data is in agreement with the known literature values.⁵

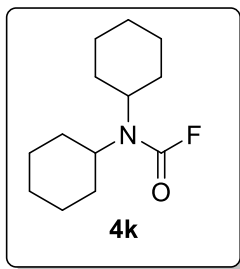


N-acetyl-2,3-dihydro-1H-indene-1-carboxamide; brown solid (16 mg, 26%); $R_f = 0.4$ (Hex:EtOAc = 1:1); ^1H NMR (500 MHz, CDCl_3) δ 8.26 (s, 1H), 7.89 (d, $J = 7.8$ Hz, 1H), 7.21-7.18 (m, 2H), 7.01 (t, $J = 7.4$ Hz, 1H), 4.07 (t, $J = 8.4$ Hz, 2H), 3.21 (t, $J = 8.5$ Hz, 2H), 2.52 (s, 3H). ^{13}C NMR (100 MHz, CDCl_3) δ 173.8, 150.1, 142.2, 131.3, 127.8, 125.0, 123.7, 115.9, 47.9, 27.9, 24.8. IR (neat) ν_{max} 3359, 1698, 1663, 1479, 1284, 1019 cm^{-1} . HRMS[EI⁺] calcd for $\text{C}_{11}\text{H}_{12}\text{N}_2\text{O}_2$ $[\text{M}]^+$ 204.0899, found 204.0903.

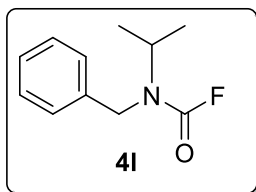


dibenzylcarbamic fluoride (4j); **3j** (84 mg) was used to provide **4j** (68 mg, 93%) as yellow oil; $R_f = 0.7$ (Hex:EtOAc = 7:1); ^1H NMR (400 MHz, CDCl_3) δ 7.40-7.32 (m, 6H), 7.29-7.25 (m, 2H), 7.22-7.20 (m, 2H), 4.42 (s, 2H), 4.34 (s, 2H). ^{19}F NMR (376 MHz, CDCl_3) δ -22.60 (s, 1F). The spectral data is in agreement with the known literature values.³

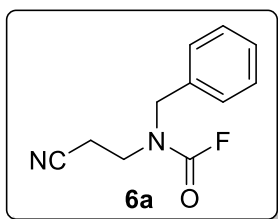
⁵ Song, H. X.; Han, Z. Z.; Zhang, C. P. Concise and Additive-Free Click Reactions between Amines and $\text{CF}_3\text{SO}_3\text{CF}_3$. *Chem. Eur. J.* **2019**, 25, 10907.



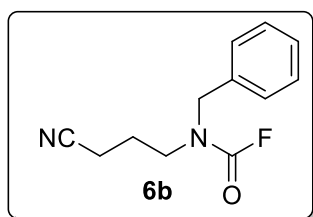
dicyclohexylcarbamic fluoride (4k); 3k (80 mg) was used to provide **4k** (59 mg, 87%) as white solid; R_f = 0.7 (Hex:EtOAc = 5:1); ^1H NMR (400 MHz, CDCl_3) δ 3.53 (m, 1H), 3.19 (m, 1H), 1.83-1.77 (m, 4H), 1.72-1.60 (m, 10H), 1.37-1.22 (m, 4H), 1.17-1.05 (m, 2H). ^{19}F NMR (376 MHz, CDCl_3) δ -13.08 (s, 1F). The spectral data is in agreement with the known literature values.⁵



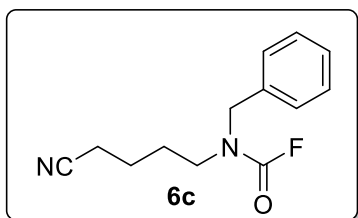
benzyl(isopropyl)carbamic fluoride (4l); 3l (70 mg) was used to provide **4l** (51 mg, 87%) as yellow solid; R_f = 0.5 (Hex:EtOAc = 5:1); ^1H NMR (400 MHz, CDCl_3 , mixture of isomers, ratio 1:0.8) δ 7.37-7.23 (m, 5H), 4.47 (s, 0.9H), 4.39 (s, 1.1H), 4.05 (sept, J = 9.1 Hz, 0.55H), 3.86 (sept, J = 9.0 Hz, 0.45H), 1.21-1.15 (m, 6H). ^{19}F NMR (376 MHz, CDCl_3) δ -15.75 (s, 0.55F), -19.21 (s, 0.45F). The spectral data is in agreement with the known literature values.³



benzyl(2-cyanoethyl)carbamic fluoride (6a); 5a (61 mg) was used to provide **6a** (50 mg, 81%) as yellow oil; R_f = 0.4 (Hex:EtOAc = 1:2); ^1H NMR (500 MHz, CDCl_3 , mixture of isomers, ratio 1: 0.66) δ 7.41-7.30 (m, 3.7H), 7.25 (m, 1.3H), 4.59 (s, 0.8H), 4.57 (s, 1.2H), 3.51 (m, 1.2H), 3.47 (m, 0.8H), 2.62 (t, J = 6.7 Hz, 1.2H), 2.50 (t, J = 6.8 Hz, 0.8H). ^{19}F NMR (376 MHz, CDCl_3) δ -20.27 (s, 0.4F), -21.16 (s, 0.6F). The spectral data is in agreement with the known literature values.⁶



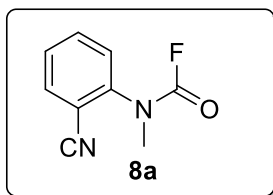
benzyl(3-cyanopropyl)carbamic fluoride (6b); 5b (65 mg) was used to provide **6b** (60 mg, 91%) as yellow oil; R_f = 0.4 (Hex:EtOAc = 1:2); ^1H NMR (400 MHz, CDCl_3 , mixture of isomers, ratio 1:0.8) δ 7.40-7.29 (m, 4H), 7.25 (m, 1H), 4.49 (s, 0.9H), 4.45 (s, 1.1H), 3.38 (t, J = 7.1 Hz, 1.1H), 3.31 (t, J = 7.2 Hz, 0.9H), 2.32 (m, 2H), 1.90 (q, J = 7.2 Hz, 1.1H), 1.84 (q, J = 7.2 Hz, 0.9H). ^{19}F NMR (376 MHz, CDCl_3) δ -21.048 (s, 0.55F), -21.049 (s, 0.45F). ^{13}C NMR (100 MHz, CDCl_3) δ 147.9 (d, $J_{\text{C,F}}$ = 286 Hz), 147.6 (d, $J_{\text{C,F}}$ = 288 Hz), 135.4, 135.3, 129.2, 129.1, 128.58, 128.55, 128.2, 127.6, 118.7, 118.4, 52.3, 51.8 (d, $J_{\text{C,F}}$ = 3.4 Hz), 46.9, 45.8 (d, $J_{\text{C,F}}$ = 2.5 Hz), 24.2, 23.2, 14.7, 14.6. IR (neat) ν_{max} 2946, 2247, 1786, 1422, 1219, 1057 cm^{-1} HRMS[EI^+] calcd for $\text{C}_{12}\text{H}_{13}\text{N}_2\text{O}$ [M]⁺ 220.1012, found 220.1019.



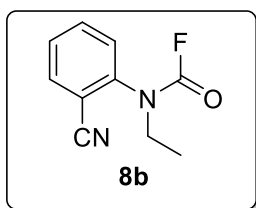
benzyl(4-cyanobutyl)carbamic fluoride (6c); 5c (69 mg) was used to provide **6c** (59 mg, 85%) as yellow oil; R_f = 0.4 (Hex:EtOAc = 1:3); ^1H NMR (400 MHz, CDCl_3 , mixture of isomers, ratio 1:0.9) δ 7.39-7.28 (m, 3.8H), 7.24 (m, 1.2H), 4.48 (s, 0.9H), 4.43 (s, 1.1H), 3.28 (t, J = 6.8 Hz, 1.1H), 3.21 (t, J = 6.7 Hz, 0.9H), 2.37-2.30 (m, 2H), 1.74-1.59 (m, 4H). ^{19}F NMR (376 MHz, CDCl_3) δ -21.50 (s, 0.52F), -21.99 (s, 0.48F). ^{13}C NMR (100 MHz, CDCl_3) δ 148.1 (d, $J_{\text{C,F}}$ = 286 Hz), 147.7 (d, $J_{\text{C,F}}$ = 287 Hz), 135.6, 135.5, 129.1, 129.0, 128.4, 128.3, 128.1, 127.5, 119.2, 119.0, 51.7, 51.1 (d, $J_{\text{C,F}}$ = 3.4 Hz), 46.8 (d, $J_{\text{C,F}}$ = 1.5 Hz), 46.0 (d, $J_{\text{C,F}}$ = 2.6 Hz), 27.2, 26.1, 22.5, 22.4, 16.9, 16.8. IR (neat) ν_{max} 2945, 2247, 1785, 1423, 1220, 1080 cm^{-1} . HRMS[EI^+] calcd for $\text{C}_{13}\text{H}_{15}\text{FN}_2\text{O}$ [M]⁺

⁶ Baars, H.; Engel, J.; Mertens, L.; Meister, D.; Bolm, C. The Reactivity of Difluorocarbene with Hydroxylamines: Synthesis of Carbamoyl Fluorides. *Adv. Synth. Catal.* **2016**, 358, 2293.

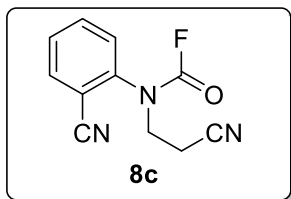
234.1168, found 234.1166.



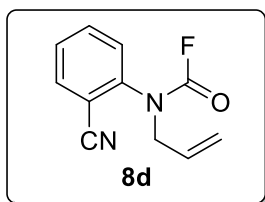
(2-cyanophenyl)(methyl)carbamic fluoride (8a); **7a** (53 mg) was used to provide **8a** (34 mg, 64%) as yellow oil; R_f = 0.5 (Hex:EtOAc = 1:1); ^1H NMR (400 MHz, CDCl_3 , mixture of isomers, ratio 1:2) δ 7.74 (dd, J = 7.8, 1.5 Hz, 1H), 7.69 (m, 1H), 7.75-7.46 (m, 1.3H), 7.40 (d, J = 8.0 Hz, 0.7H), 3.42 (d, J = 1.0 Hz, 1H), 3.40 (d, J = 0.7 Hz, 2H). ^{19}F NMR (376 MHz, CDCl_3) δ -13.30 (s, 0.67F), -17.84 (s, 0.33F). ^{13}C NMR (100 MHz, CDCl_3) δ 146.4 (d, $J_{\text{C,F}}$ = 291 Hz), 145.4 (d, $J_{\text{C,F}}$ = 280 Hz), 144.0 (d, $J_{\text{C,F}}$ = 6 Hz), 143.1 (d, $J_{\text{C,F}}$ = 2 Hz), 134.39, 134.37, 134.0, 133.9, 129.1, 128.9, 128.18, 128.14, 115.7, 115.5, 111.7, 111.6, 38.8 (d, $J_{\text{C,F}}$ = 2 Hz), 38.5 (d, $J_{\text{C,F}}$ = 3 Hz). IR (neat) ν_{max} 2952, 2232, 1799, 1598, 1494, 1372 cm^{-1} . HRMS[EI^+] calcd for $\text{C}_9\text{H}_7\text{FN}_2\text{O}$ [M] $^+$ 178.0542, found 178.0550.



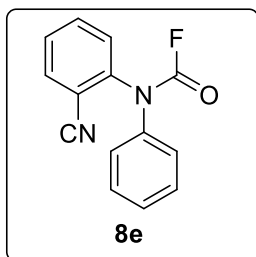
(2-cyanophenyl)(ethyl)carbamic fluoride (8b); **7b** (57 mg) was used to provide **8b** (42 mg, 73%) as yellow oil; R_f = 0.6 (Hex:EtOAc = 2:1); ^1H NMR (400 MHz, CDCl_3 , mixture of isomers, ratio 1:2.3) δ 7.76 (dd, J = 7.6, 1.6 Hz, 1H), 7.68 (m, 1H), 7.50 (m, 1H), 7.42 (d, J = 8.0 Hz, 0.3H), 7.36 (d, J = 8 Hz, 0.7H), 3.84- 3.77 (m, 2H), 1.28-1.22 (m, 3H). ^{19}F NMR (376 MHz, CDCl_3) δ -11.63 (s, 0.7F), -19.86 (s, 0.3F). ^{13}C NMR (100 MHz, CDCl_3) δ 146.3 (d, $J_{\text{C,F}}$ = 292 Hz), 145.0 (d, $J_{\text{C,F}}$ = 287 Hz), 142.5 (d, $J_{\text{C,F}}$ = 1.0 Hz), 141.5 (d, $J_{\text{C,F}}$ = 1.8 Hz), 134.2, 134.1, 134.0, 133.9, 129.1 (2C), 129.07, 129.03, 115.8, 115.7, 112.8 (2C), 47.1 (d, $J_{\text{C,F}}$ = 2.5 Hz), 47.0 (d, $J_{\text{C,F}}$ = 2.6 Hz), 14.0, 12.7. IR (neat) ν_{max} 2982, 2232, 1798, 1598, 1493, 1454, 1396 cm^{-1} . HRMS[EI^+] calcd for $\text{C}_{10}\text{H}_9\text{FN}_2\text{O}$ [M] $^+$ 192.0699, found 192.0697.



(2-cyanoethyl)(2-cyanophenyl)carbamic fluoride (8c); **7c** (64 mg) was used to provide **8c** (43 mg, 66%) as brown solid; R_f = 0.5 (Hex:EtOAc = 2:1); ^1H NMR (400 MHz, CDCl_3 , mixture of isomers, ratio 1: 4) δ 7.80-7.73 (m, 2H), 7.58-7.53 (m, 2H), 4.06-4.03 (m, 2H), 2.85 (s, 1.6H), 2.75 (t, J = 6.8 Hz, 0.4H). ^{19}F NMR (376 MHz, CDCl_3) δ -11.02 (s, 0.8F), -17.65 (s, 0.2F). ^{13}C NMR (100 MHz, CDCl_3) δ 145.4 (d, $J_{\text{C,F}}$ = 294 Hz), 145.0 (d, $J_{\text{C,F}}$ = 290 Hz), 141.6 (d, $J_{\text{C,F}}$ = 1.7 Hz), 141.1 (d, $J_{\text{C,F}}$ = 2.1 Hz), 134.76, 134.71, 134.2, 134.0, 129.99, 129.96, 129.5, 129.3, 116.8, 116.3, 115.5, 115.4, 112.3, 112.2, 47.8 (d, $J_{\text{C,F}}$ = 1.7 Hz), 47.2 (d, $J_{\text{C,F}}$ = 1.4 Hz), 17.9, 16.6. IR (neat) ν_{max} 2236, 1791, 1598, 1488, 1390, 1268, 1247 cm^{-1} . HRMS[EI^+] calcd for $\text{C}_{11}\text{H}_8\text{FN}_3\text{O}$ [M] $^+$ 217.0651, found 217.0654.

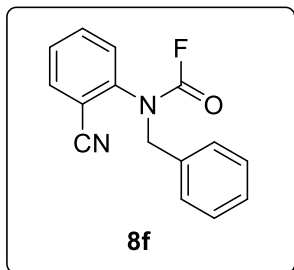


allyl(2-cyanophenyl)carbamic fluoride (8d); **7d** (61 mg) was used to provide **8d** (53 mg, 87%) as yellow oil; R_f = 0.6 (Hex:EtOAc = 2:1); ^1H NMR (400 MHz, CDCl_3 , mixture of isomers, ratio 1: 2.3) δ 7.73 (dd, J = 7.8, 1.7 Hz, 1H), 7.67 (m, 1H), 7.49 (m, 1H), 7.42 (d, J = 8.0 Hz, 0.3H), 7.34 (d, J = 8 Hz, 0.7H), 5.91 (m, 1H), 5.26-5.15 (m, 2H), 4.34-4.28 (m, 2H). ^{19}F NMR (376 MHz, CDCl_3) δ -12.05 (s, 0.7F), -18.63 (s, 0.3F). ^{13}C NMR (100 MHz, CDCl_3) δ 146.1 (d, $J_{\text{C,F}}$ = 293 Hz), 145.1 (d, $J_{\text{C,F}}$ = 288 Hz), 142.5 (d, $J_{\text{C,F}}$ = 1.4 Hz), 141.3 (d, $J_{\text{C,F}}$ = 1.8 Hz), 134.1, 134.0, 133.9, 133.8, 131.1, 130.5, 129.2 (2C), 129.1, 129.0, 120.9, 120.2, 115.8, 115.7, 112.7, 112.6, 54.5 (d, $J_{\text{C,F}}$ = 2.1 Hz), 54.4 (d, $J_{\text{C,F}}$ = 2.5 Hz). IR (neat) ν_{max} 3085, 2232, 1798, 1598, 1493, 1390, 1265 cm^{-1} . HRMS[EI^+] calcd for $\text{C}_{11}\text{H}_9\text{FN}_2\text{O}$ [M] $^+$ 204.0699, found 204.0699.

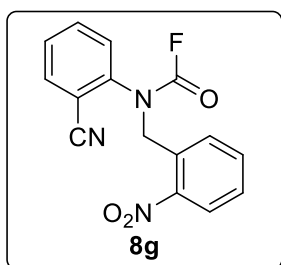


(2-cyanophenyl)(phenyl)carbamic fluoride (8e); **7e** (71 mg) was used to provide **8e** (50 mg, 70%) as brown solid; R_f = 0.5 (Hex:EtOAc = 2:1); ^1H NMR (400 MHz, CDCl_3 , mixture of isomers, ratio 1: 1) δ 7.75 (d, J = 7.6 Hz, 1H), 7.68 (t, J = 7.7 Hz, 1H), 7.49 (d, J = 8.2 Hz, 2H), 7.43-7.32 (m, 5H). ^{19}F NMR (376 MHz, CDCl_3) δ -7.32 (s, 0.5F), -12.83 (s, 0.5F). ^{13}C NMR (100 MHz,

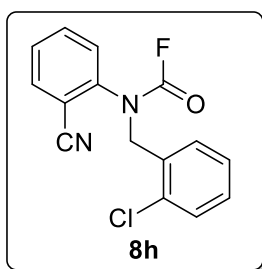
CDCl₃) δ 145.1 (d, $J_{C,F}$ = 295 Hz), 144.2 (d, $J_{C,F}$ = 290 Hz), 142.8 (d, $J_{C,F}$ = 8.0 Hz), 142.5 (d, $J_{C,F}$ = 80 Hz), 139.7 (d, $J_{C,F}$ = 2.1 Hz), 139.4 (d, $J_{C,F}$ = 51 Hz), 134.3 (2C), 134.1 (2C), 129.6, 129.5, 129.4, 129.2, 129.1, 128.9, 128.5, 127.8, 126.8, 125.5, 115.8, 115.6, 112.5, 112.3. IR (neat) ν_{\max} 2228, 1792, 1593, 1488, 1342, 1200 cm⁻¹. HRMS[EI^+] calcd for C₁₄H₉FN₂O [M]⁺ 240.0699, found 240.0700.



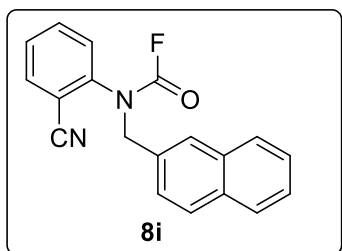
benzyl(2-cyanophenyl)carbamic fluoride (8f); 7f (76 mg) was used to provide **8f** (48 mg, 63%) as brown oil; R_f = 0.4 (Hex:EtOAc = 3:1); ¹H NMR (400 MHz, CDCl₃, mixture of isomers, ratio 1:3) δ 7.70 (m, 1H), 7.54 (m, 1H), 7.43 (td, J = 7.6, 1.2 Hz, 1H), 7.33-7.28 (m, 3H), 7.23-7.15 (m, 2.25), 7.04 (d, J = 7.9 Hz, 0.75H), 4.88 (s, 2H). ¹⁹F NMR (376 MHz, CDCl₃) δ -12.44 (s, 0.75F), -18.52 (s, 0.25F). ¹³C NMR (100 MHz, CDCl₃) δ 146.1 (d, $J_{C,F}$ = 292 Hz), 145.7 (d, $J_{C,F}$ = 288 Hz), 142.2 (d, $J_{C,F}$ = 1.2 Hz), 141.1 (d, $J_{C,F}$ = 1.8 Hz), 134.6, 134.4, 134.0, 133.8, 129.4, 129.3, 129.2 (2C), 129.1, 129.09, 129.06, 128.9 (2C), 128.7 (2C), 128.5, 115.7, 115.5, 112.6, 112.5, 55.4 (d, $J_{C,F}$ = 2.1 Hz), 55.3 (d, $J_{C,F}$ = 2.1 Hz). IR (neat) ν_{\max} 3089, 3037, 2229, 1789, 1577, 1189 cm⁻¹. HRMS[EI^+] calcd for C₁₅H₁₁FN₂O [M]⁺ 254.0855, found 254.0856.



(2-cyanophenyl)(2-nitrobenzyl)carbamic fluoride (8g); 7g (89 mg) was used to provide **8g** (55 mg, 61%) as yellow solid; R_f = 0.5 (Hex:EtOAc = 2:1); ¹H NMR (400 MHz, CDCl₃, mixture of isomers, ratio 1:3) δ 8.03 (d, J = 8.1 Hz, 0.25H), 7.95 (d, J = 8.1 Hz, 0.75H), 7.81 (d, J = 7.7 Hz, 1H), 7.72-7.66 (m, 2H), 7.60 (td, J = 7.8, 1.6 Hz, 1H), 7.54-7.44 (m, 2H), 7.29 (d, J = 8.1 Hz, 0.25H), 7.22 (d, J = 8.0 Hz, 0.75H), 5.35 (s, 2H). ¹⁹F NMR (376 MHz, CDCl₃) δ -12.07 (s, 0.75F), -16.95 (s, 0.25F). ¹³C NMR (100 MHz, CDCl₃) δ 148.6 (2C), 146.3 (d, $J_{C,F}$ = 375 Hz), 145.7 (d, $J_{C,F}$ = 289 Hz), 142.1 (d, $J_{C,F}$ = 1.3 Hz), 141.2 (d, $J_{C,F}$ = 1.7 Hz), 134.33, 134.30, 134.2, 134.1 (2C), 133.9, 131.8, 130.6, 130.0, 129.8, 129.5, 129.4 (2C), 129.2, 128.4, 128.3, 125.6, 125.2, 115.8, 115.5, 112.4 (2C), 52.0 (d, $J_{C,F}$ = 2.7 Hz), 51.8 (d, $J_{C,F}$ = 1.0 Hz). IR (neat) ν_{\max} 2229, 1783, 1596, 1518, 1274 cm⁻¹. HRMS[FAB^+] calcd for C₁₅H₁₁FN₃O₃ [M]⁺ 300.0784, found 300.0785.

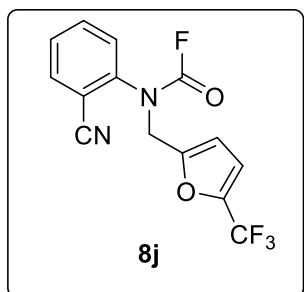


(2-chlorobenzyl)(2-cyanophenyl)carbamic fluoride (8h); 7h (86 mg) was used to provide **8h** (55 mg, 64%) as white solid; R_f = 0.4 (Hex:EtOAc = 5:1); ¹H NMR (400 MHz, CDCl₃, mixture of isomers, ratio 1: 3) δ 7.67 (m, 1H), 7.52 (td, J = 7.7, 1.6 Hz, 1H), 7.43 (m, 1.8H), 7.30 (m, 1.2H), 7.24-7.19 (m, 2H), 7.20 (m, 0.25H), 7.12 (d, J = 7.9 Hz, 0.75H), 5.11-5.08 (s, 2H). ¹⁹F NMR (376 MHz, CDCl₃) δ -12.32 (s, 0.75F), -18.33 (s, 0.25F). ¹³C NMR (100 MHz, CDCl₃) δ 146.1 (d, $J_{C,F}$ = 293 Hz), 145.5 (d, $J_{C,F}$ = 288 Hz), 141.8 (d, $J_{C,F}$ = 1.0 Hz), 140.8 (d, $J_{C,F}$ = 1.7 Hz), 134.4, 134.1, 133.99, 133.91, 133.8, 133.7, 132.0, 131.8 (2C), 130.8, 130.2 (2C), 130.1, 129.8, 129.3 (2C), 129.2, 129.1, 127.5, 127.4, 115.8, 115.6, 112.6, 112.5, 52.2 (d, $J_{C,F}$ = 2.6 Hz), 52.1 (d, $J_{C,F}$ = 2.1 Hz). IR (neat) ν_{\max} 2231, 1791, 1594, 1480, 1452, 1384, 1255 cm⁻¹. HRMS[EI^+] calcd for C₁₅H₁₀ClFN₂O [M]⁺ 288.0466, found 288.0446.



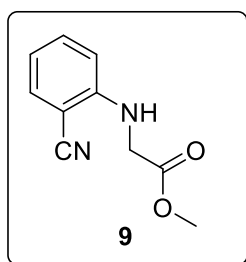
(2-cyanophenyl)(naphthalen-2-ylmethyl)carbamic fluoride (8i); 7i (91 mg) was used to provide **8i** (57 mg, 63%) as off-white solid; R_f = 0.6 (Hex:EtOAc = 2:1); ¹H NMR (400 MHz, CDCl₃, mixture of isomers, ratio 1:4) δ 8.08 (d, J = 8.3 Hz, 0.8H), 7.89 (s, 0.2H), 7.86 (d, J = 7.3 Hz, 1H), 7.81 (s, 0.2H), 7.78 (d, J = 8.0 Hz, 0.8H), 7.65 (m, 0.2H), 7.62 (dd, J = 6.7, 2.0 Hz, 0.8H), 7.59-7.50 (m, 2H), 7.37-7.29 (m, 2.4H), 7.25 (d, J = 15.1 Hz, 0.6H), 7.15 (d, J = 6.9 Hz, 0.8H), 6.92 (m, 0.2H), 6.73 (m, 0.2H), 6.66 (dd, J = 7.5, 1.1 Hz, 0.8H), 5.79-5.13 (m, 2H). ¹⁹F NMR (376 MHz, CDCl₃) δ -11.65 (s, 0.8F), -18.37 (s, 0.2F). ¹³C NMR (100 MHz, CDCl₃)

δ 147.2 (d, $J_{C,F}$ = 497 Hz), 145.5 (d, $J_{C,F}$ = 288 Hz), 141.8 (d, $J_{C,F}$ = 1.2 Hz), 140.4 (d, $J_{C,F}$ = 1.5 Hz), 134.1, 133.9, 133.8, 133.7, 133.6, 133.5, 132.4, 131.6, 131.2, 129.84, 129.82, 129.7, 129.6, 129.5, 129.17, 129.14, 129.0 (2C), 127.8, 127.3, 127.1, 126.3, 125.2, 125.0, 123.4, 122.6, 118.1, 115.8, 115.5, 115.2, 112.4 (2C), 52.6 (d, $J_{C,F}$ = 2.5 Hz), 52.4 (d, $J_{C,F}$ = 2.9 Hz). IR (neat) ν_{\max} 2228, 1775, 1488, 1455, 1378, 1251 cm^{-1} . HRMS[EI^+] calcd for $\text{C}_{19}\text{H}_{13}\text{FN}_2\text{O}$ [M] $^+$ 304.1012, found 304.1011.

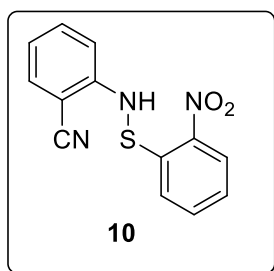


(2-cyanophenyl)((5-(trifluoromethyl)furan-2-yl)methyl)carbamic fluoride (8j); **7j** (93 mg) was used to provide **8j** (67 mg, 72%) as yellow oil; R_f = 0.5 (Hex:EtOAc = 2:1); ^1H NMR (400 MHz, CDCl_3 , mixture of isomers, ratio 1: 4) δ 7.74 (m, 1H), 7.65 (m, 1H), 7.51 (td, J = 7.7, 1.2 Hz, 1H), 7.32 (d, J = 8.0 Hz, 0.2H), 7.25 (d, J = 7.5 Hz, 0.8H), 6.73 (m, 1H), 6.46 (d, J = 3.2 Hz, 0.8H), 6.40 (d, J = 3.4 Hz, 0.2H), 5.02-4.69 (m, 2H) ^{19}F NMR (376 MHz, CDCl_3) δ -12.39 (s, 0.75F), -17.66 (s, 0.25F). ^{19}F NMR (376 MHz, CDCl_3) δ -12.39 (s, 0.8F), -17.66 (s, 0.2F), 64.37-64.38 (m, 3F). ^{13}C NMR (100 MHz, CDCl_3) δ 150.8 (2C), 150.7 (d, $J_{C,F}$ = 1.8 Hz),

145.6 (d, $J_{C,F}$ = 293 Hz), 145.1 (d, $J_{C,F}$ = 289 Hz), 142.4 (q, $J_{C,F}$ = 422 Hz), 141.8, 140.8 (d, $J_{C,F}$ = 1.8 Hz), 134.4, 134.3, 133.9, 133.8, 129.7, 129.6, 129.2, 129.1, 118.8 (q, $J_{C,F}$ = 265 Hz), 115.2, 114.8, 112.7 (q, $J_{C,F}$ = 2.8 Hz), 112.6 (2C), 112.5 (2C), 111.5, 111.0, 47.58, 47.56. IR (neat) ν_{\max} 3141, 2233, 1803, 1598, 1562, 1319 cm^{-1} . HRMS[EI^+] calcd for $\text{C}_{14}\text{H}_8\text{F}_4\text{N}_2\text{O}_2$ [M] $^+$ 312.0522, found 312.0535.

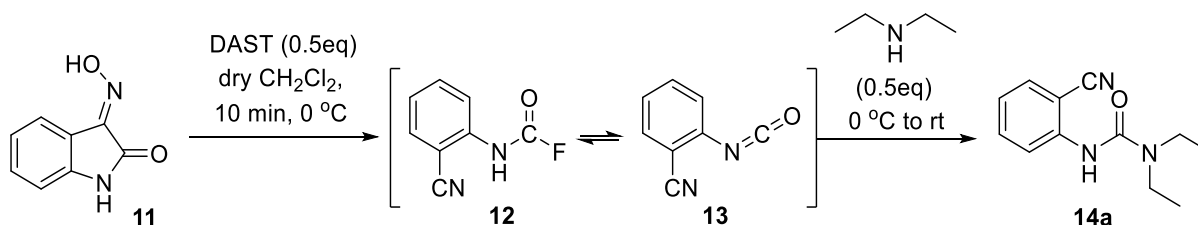


Methyl (2-cyanophenyl)glycinate (9); **7k** (70 mg) was used to provide **9** (25 mg, 44%) as white solid; R_f = 0.4 (Hex:EtOAc = 3:1); ^1H NMR (300 MHz, CDCl_3) 7.45-7.37 (m, 2H), 6.75 (td, J = 7.5, 0.9 Hz, 1H), 6.48 (d, J = 8.4 Hz, 1H), 5.13 (br s, 1H), 4.00 (d, J = 5.5 Hz, 2H), 3.80 (s, 3H). The data is in agreement with the literature.⁷



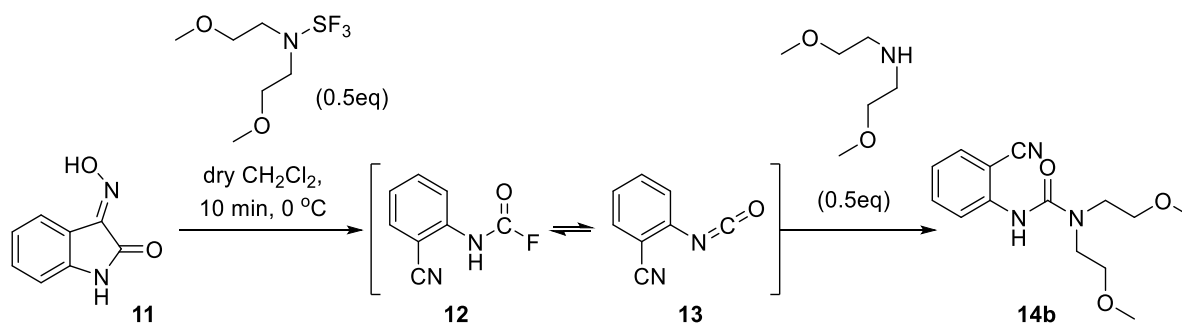
2-(((2-nitrophenyl)thio)amino)benzonitrile (10); **7l** (95 mg) was used to provide **10** (16 mg, 20%) as yellow solid; R_f = 0.7 (Hex:EtOAc = 2:1); ^1H NMR (300 MHz, CDCl_3) δ 8.35 (dd, J = 8.3, 1.4 Hz, 1H), 7.63-7.48 (m, 3H), 7.44 (td, J = 7.2, 1.6 Hz, 1H), 7.35 (td, J = 7.0, 1.4 Hz, 1H), 7.22 (d, J = 8.4 Hz, 1H), 6.96 (td, J = 7.5, 1.0 Hz, 1H), 5.98 (s, 1H). ^{13}C NMR (100 MHz, CDCl_3) δ 148.7, 143.2, 142.4, 134.79, 134.73, 132.8, 126.2, 126.0, 123.8, 121.0, 116.9, 114.1, 99.0. IR (neat) ν_{\max} 3273, 2225, 1591, 1569, 1485, 1451, 1332, 1285 cm^{-1} . HRMS[EI^+] calcd for $\text{C}_{14}\text{H}_8\text{F}_4\text{N}_2\text{O}_2$ [M] $^+$ 271.0415 found

271.0418.

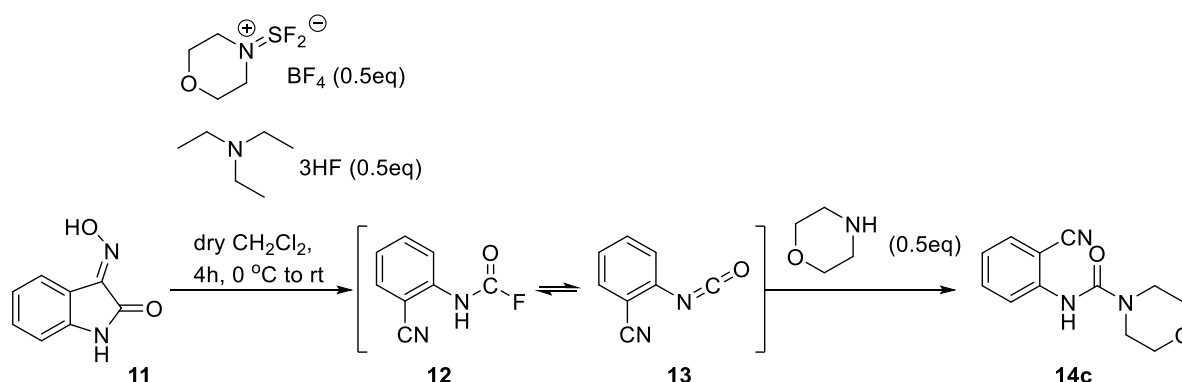


⁷ Romagnoli, R.; Prencipe, F.; Oliva, P.; Salvador, M.K.; Brancale, A.; Ferla, S.; Hamel, E.; Viola, G.; Bortolozzi, R.; Persoons, L.; Balzarini, J.; Liekens, S.; Schols, D. Design, Synthesis and Biological Evaluation of 2-Alkoxycarbonyl-3-Anilinoindoles as a New Class of Potent Inhibitors of Tubulin Polymerization. *Bioorg. Chem.* **2020**, *97*, 103665.

To a stirred solution of 3-(hydroxyimino)indolin-2-one **11** (162 mg, 1.0 mmol) in dry CH₂Cl₂ (3.0 mL) was slowly added diethylaminosulfur trifluoride (DAST, 66 μ L, 0.5 mmol) at 0 °C under Ar. After 10 minutes, diethylamine (52 μ L, 0.5 mmol) was slowly added to the reaction mixture at 0 °C. After being stirred for 30 minutes at rt, the reaction mixture was diluted with sat. NH₄Cl aq. sol'n (5.0 mL) and extracted with EtOAc (10 X 3 mL). The organic solution was dried over MgSO₄, filtered, and concentrated. The crude mixture was subjected to silica gel column chromatography (EtOAc:Hex = 1:7 to 1:3) to provide **14a** (210 mg, 97%) as a yellow oil. *R_f* = 0.4 (Hex:EtOAc = 1:3); ¹H NMR (400 MHz, DMSO-*d*₆) δ 8.48 (s, 1H), 7.71 (d, *J* = 7.7 Hz, 1H), 7.60 (t, *J* = 8.1 Hz, 1H), 7.45 (d, *J* = 8.1 Hz, 1H), 7.23 (t, *J* = 7.2 Hz, 1H), 3.36-3.33 (m, 4H), 1.13 (t, *J* = 7.0 Hz, 6H). The spectral data is in agreement with the known literature values.⁸



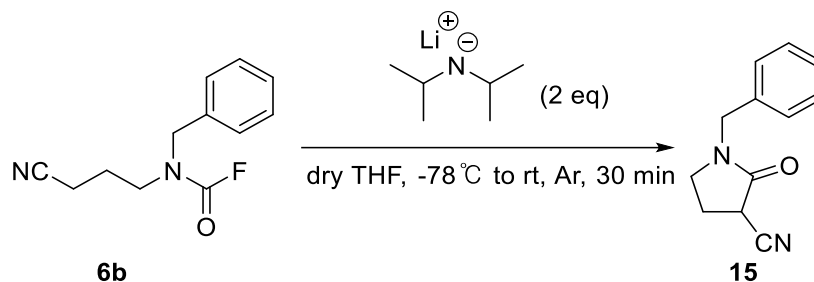
To a stirred solution of 3-(hydroxyimino)indolin-2-one **11** (162 mg, 1.0 mmol) in dry CH₂Cl₂ (3.0 mL) was slowly added bis(2-methoxyethyl)aminosulfur trifluoride (Deoxo-Fluor, 90 μ L, 0.5 mmol) at 0 °C under Ar. After 10 minutes, bis(2-methoxyethyl)amine (74 μ L, 0.5 mmol) was slowly added to the reaction mixture at 0 °C. After being stirred for 1 hour at rt, the mixture was diluted with sat. NH₄Cl aq. sol'n (5.0 mL) and extracted with EtOAc (3 X 10 mL). The organic solution was dried over MgSO₄, filtered, and concentrated. The crude mixture was subjected to silica gel column chromatography (EtOAc:Hex = 1:5 to 1:1) to provide **14b** (226 mg, 82%) as a yellow solid. *R_f* = 0.4 (Hex:EtOAc = 1:1); ¹H NMR (400 MHz, CDCl₃) δ 8.75 (s, 1H), 7.96 (d, *J* = 4.3 Hz, 1H), 7.49-7.43 (m, 2H), 6.97 (t, *J* = 7.6 Hz, 1H), 3.62-3.57 (m, 8H), 3.42 (s, 6H). ¹³C NMR (100 MHz, CDCl₃) 156.4, 143.3, 133.5, 132.7, 121.8, 120.9, 117.0, 101.3, 71.9, 59.0, 49.2. IR (neat) ν_{max} 3295, 2872, 2217, 1662, 1530, 1448, 1109 cm⁻¹. HRMS[*EI*⁺] calcd for C₁₄H₁₉N₃O₃ [*M*]⁺ 277.1420, found 277.1426.



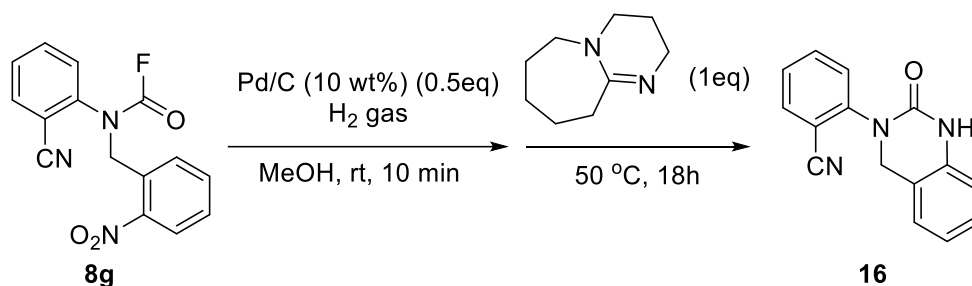
To a stirred solution of triethylamine trihydrofluoride (80 μ L, 0.5 mmol) in dry CH₂Cl₂ (3.0 mL) was added 3-(hydroxyimino)indolin-2-one **11** (162 mg, 1.0 mmol) and difluoro(morpholino)sulfonium tetrafluoroborate (XtalFluor-M, 114 mg, 0.5 mmol) at 0 °C under Ar. After stirring for 4 hours at rt, morpholine (43 μ L, 0.5 mmol) was slowly added to the reaction mixture at 0 °C. After 2 hours at rt, the

⁸ Holzschneider, K.; Mohr, F.; Kirsch, S. F. Synthesis and Reactivity of 3,3-Diazidooxindoles. *Org. Lett.* **2018**, *20*, 7066.

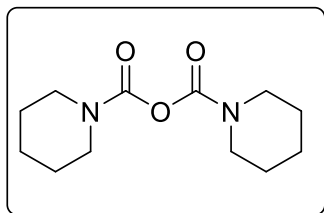
mixture was diluted with sat. NH_4Cl aq. sol'n (5.0 mL) and extracted with EtOAc (3 X 10 mL). The organic solution was dried over MgSO_4 , filtered, and concentrated. The crude mixture was subjected to silica gel column chromatography (1% to 2% MeOH in DCM) to provide **14c** [118 mg, 51% (71% brsm)] as a yellow solid. R_f = 0.4 (3% MeOH in DCM); ^1H NMR (400 MHz, $\text{DMSO}-d_6$) δ 8.88 (s, 1H), 7.74 (d, J = 6.9 Hz, 1H), 7.62 (t, J = 7.4 Hz, 1H), 7.42 (dd, J = 8.0, 1.5 Hz, 1H), 7.26 (td, J = 7.5, 1.9 Hz, 1H), 3.63-3.60 (m, 4H), 3.46-3.43 (m, 4H). The spectral data is in agreement with the known literature values.⁸



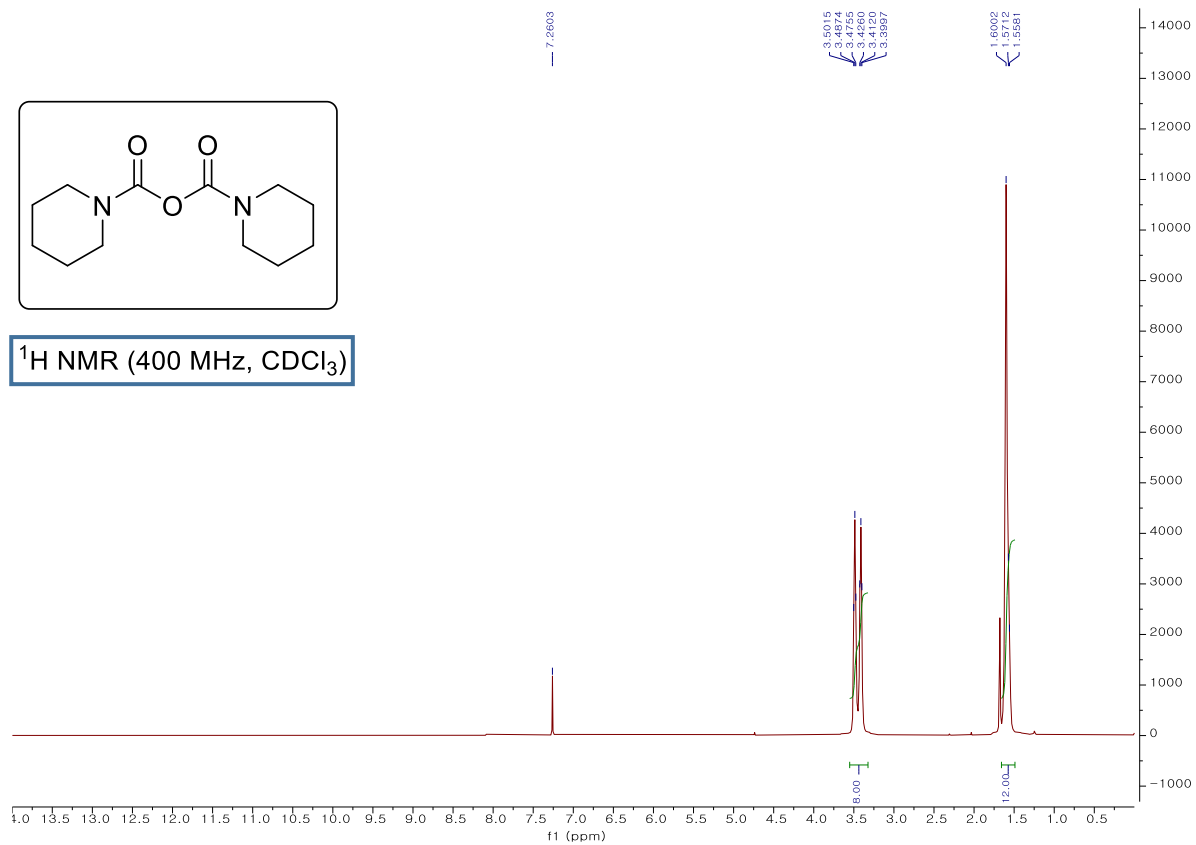
Lithium diisopropylamide (2.0 M in THF, 1.0 mL, 2.0 mmol) was added to a stirred solution of benzyl(3-cyanopropyl)carbamate **6b** (220 mg, 1.0 mmol) in dry THF (3.0 mL) at -78 °C under Ar. After 30 minutes, the reaction mixture warmed to rt and quenched with sat. NH_4Cl aq. sol'n (10 mL) and extracted with CH_2Cl_2 (3 X 10 mL). The organic solution was dried over MgSO_4 , filtered, and concentrated. The residue was subjected to silica gel column chromatography (1% to 2% MeOH in DCM) to afford 1-benzyl-2-oxopyrrolidine-3-carbonitrile **15** (136 mg, 68%) as pink oil. R_f = 0.4 (3% MeOH in DCM); ^1H NMR (300 MHz, CDCl_3) δ 7.37-7.21 (m, 5H), 4.52-4.41 (m, 2H), 3.56 (t, J = 8.9 Hz, 1H), 3.40-3.23 (m, 2H), 2.50-2.17 (m, 2H). ^{13}C NMR (100 MHz, CDCl_3) 166.0, 135.2, 129.0, 128.3, 128.2, 117.1, 47.5, 44.7, 33.7, 23.7. IR (neat) ν_{max} 2924, 2249, 1704, 1435, 1283 cm^{-1} . HRMS[EI^+] calcd for $\text{C}_{14}\text{H}_{19}\text{N}_3\text{O}_3$ [M]⁺ 200.0950, found 200.0957.



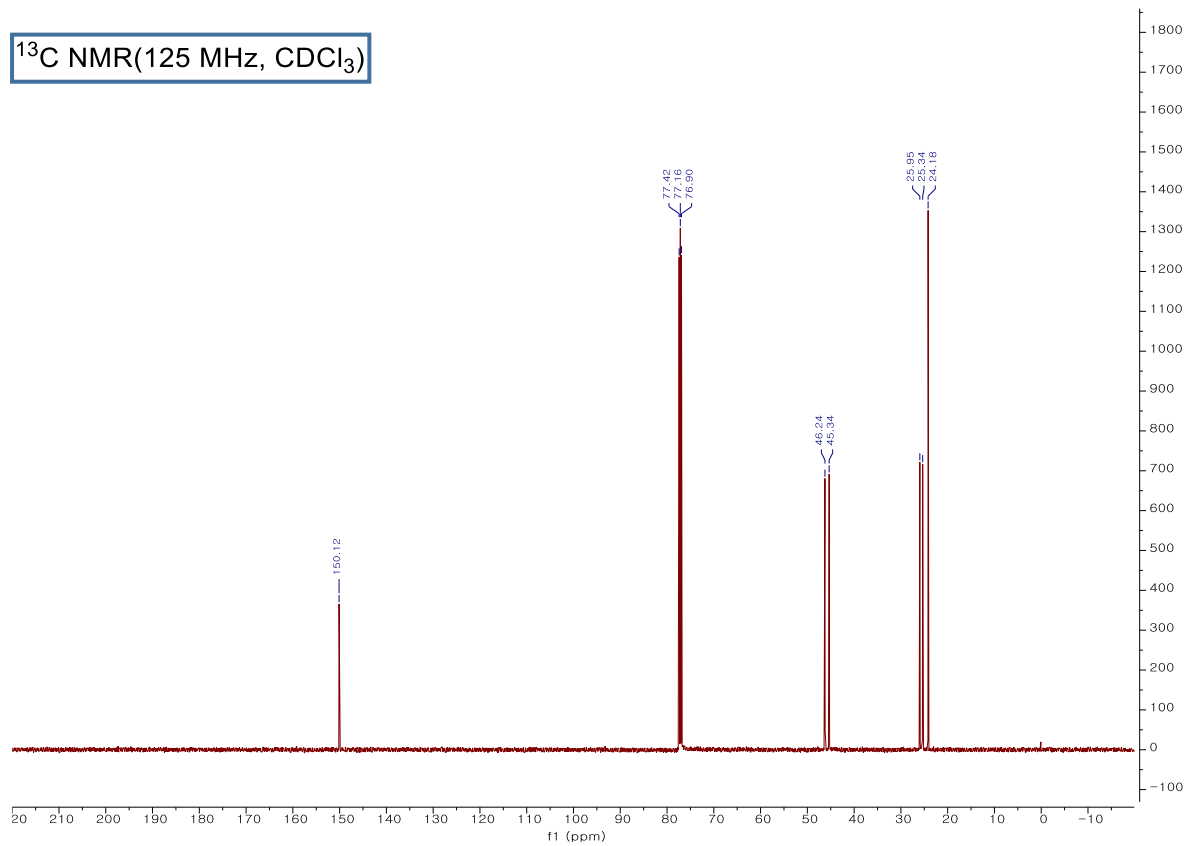
A two-neck 25 mL round bottom flask was charged with carbamoyl fluoride **8g** (300 mg, 1.0 mmol), 10% palladium on carbon (52 mg, 0.05 mmol), and MeOH (3.0 mL). The reaction flask was flushed with a balloon filled with hydrogen gas for 5 min and further stirred under atmospheric pressure for 10 min at rt. Then, 1,8-diazabicyclo[5.4.0]undec-7-ene (0.15 mL, 1.0 mmol) was added in and the reaction mixture was stirred for 18 hours at 50 °C in heating mantle. The reaction mixture was cooled to rt, filtered through a pad of Celite, and washed with ethyl acetate. The filtrate was then washed with water and brine. The organic solution was dried over MgSO_4 , filtered, and concentrated. The crude mixture was subjected to silica gel column chromatography (1% to 2% MeOH in DCM) to afford 2-(2-oxo-1,4-dihydroquinazolin-3(2H)-yl)benzonitrile **16** (170 mg, 68%) as a white solid. R_f = 0.5 (3% MeOH in DCM); ^1H NMR (300 MHz, CDCl_3) δ 8.33 (br s, 1H), 7.75-7.65 (m, 2H), 7.50 (d, J = 8.0 Hz, 1H), 7.42 (td, J = 7.6, 1.5 Hz, 1H), 7.19 (td, J = 7.5, 1.5 Hz, 1H), 7.06 (d, J = 7.5 Hz, 1H), 6.97 (td, J = 7.4, 1.1 Hz, 1H), 6.78 (d, J = 8.0 Hz, 1H), 4.86 (s, 2H). ^{13}C NMR (125 MHz, CDCl_3) 153.8, 144.8, 136.5, 134.0, 133.8, 128.7, 128.0, 127.6, 125.4, 122.6, 117.7, 116.6, 114.5, 112.4, 52.0. IR (neat) ν_{max} 2922, 2229, 1738, 1666, 1598, 1487, 1460 cm^{-1} . HRMS[EI^+] calcd for $\text{C}_{14}\text{H}_{19}\text{N}_3\text{O}_3$ [M]⁺ 249.0902, found 249.0901.

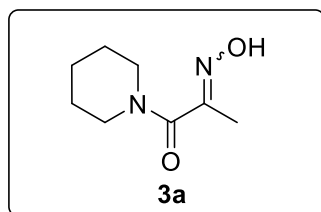


^1H NMR (400 MHz, CDCl_3)

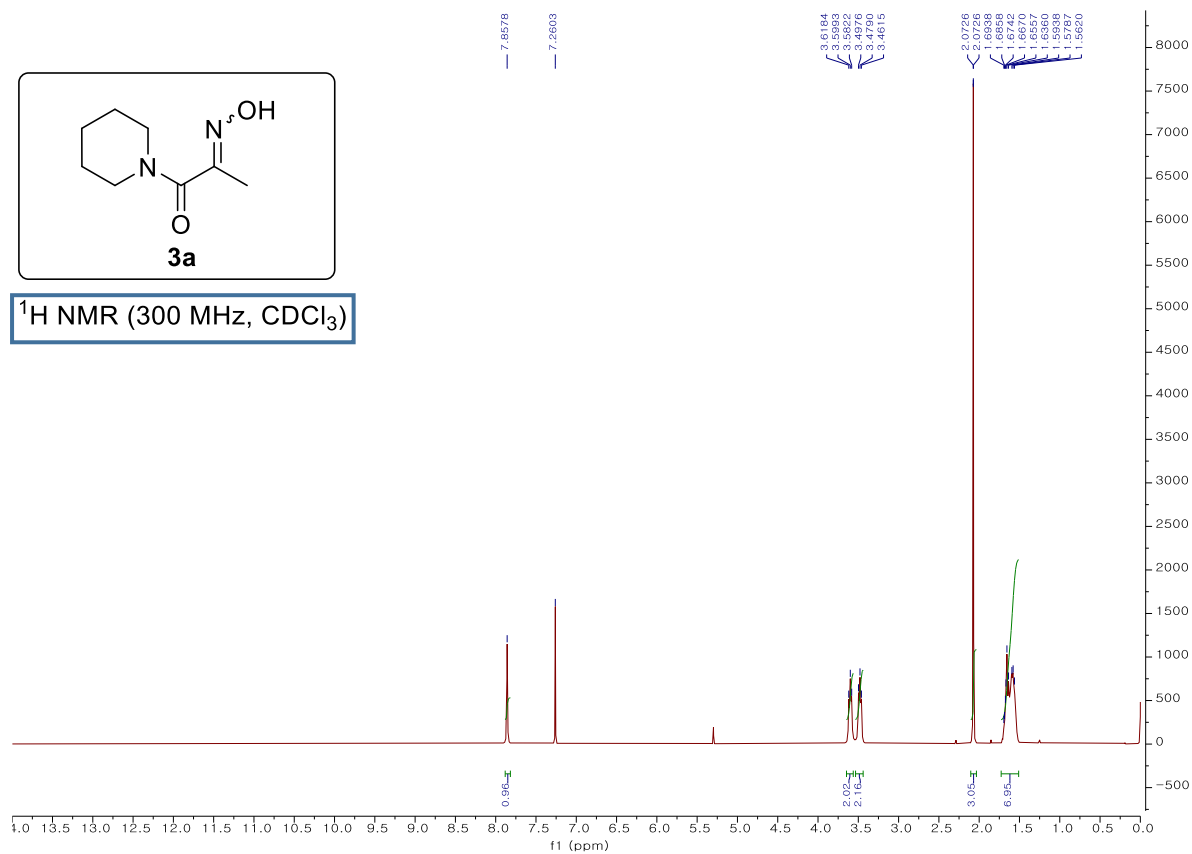


^{13}C NMR (125 MHz, CDCl_3)

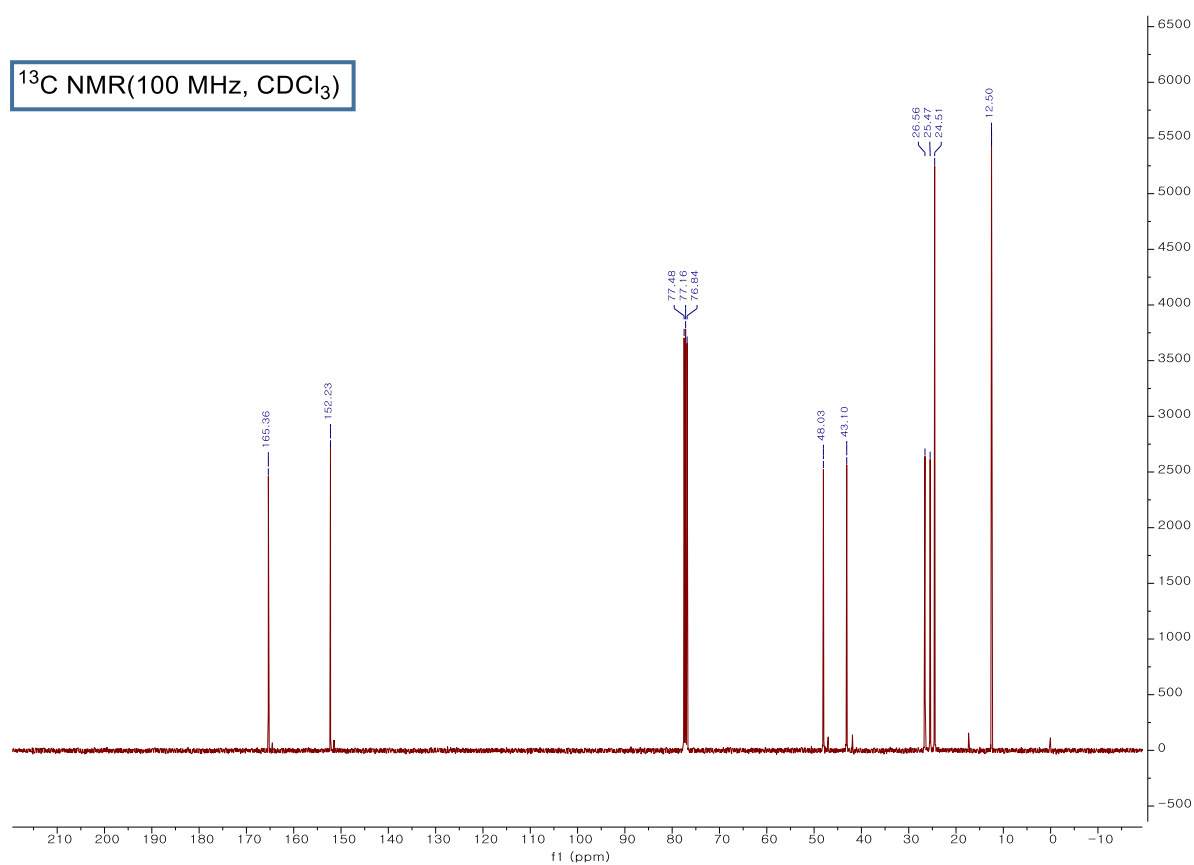


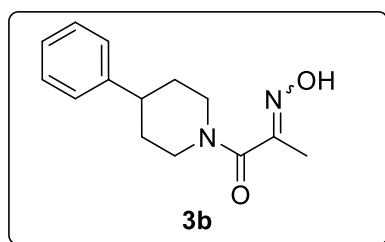


¹H NMR (300 MHz, CDCl₃)

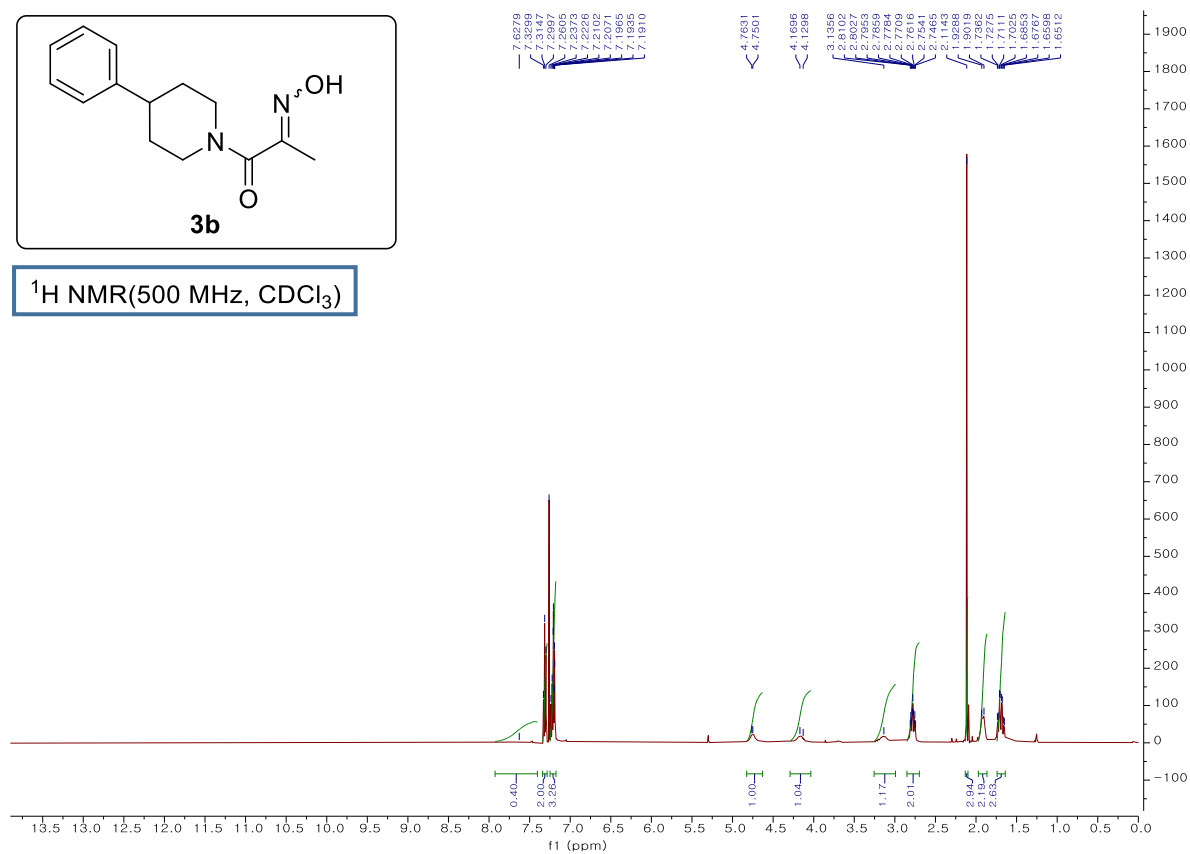


¹³C NMR (100 MHz, CDCl₃)

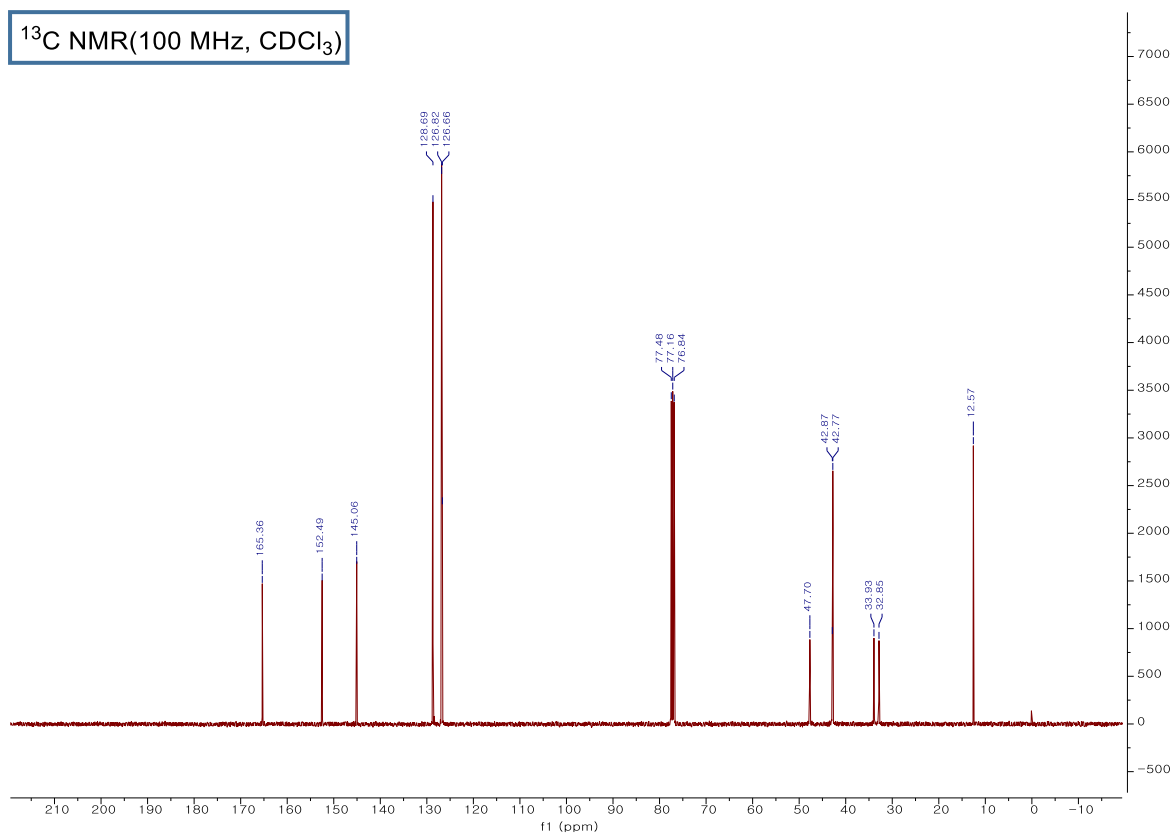


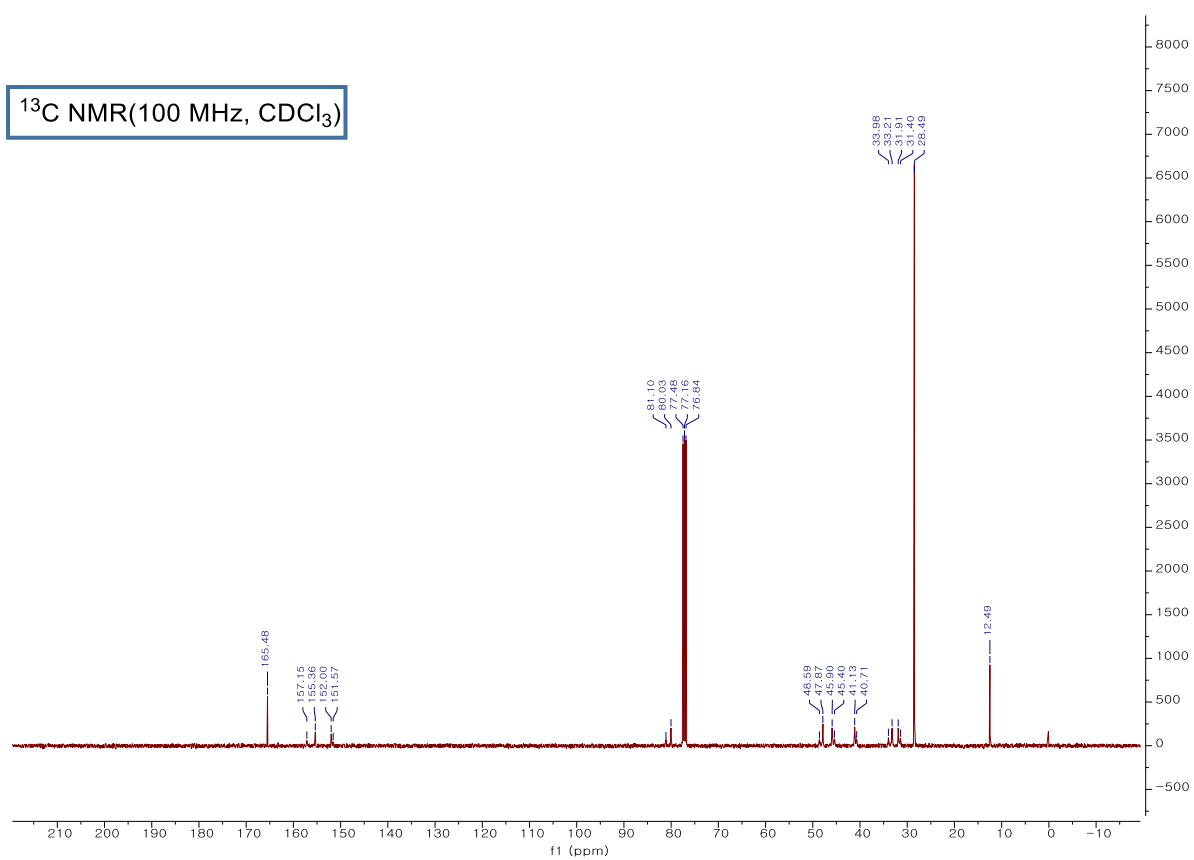
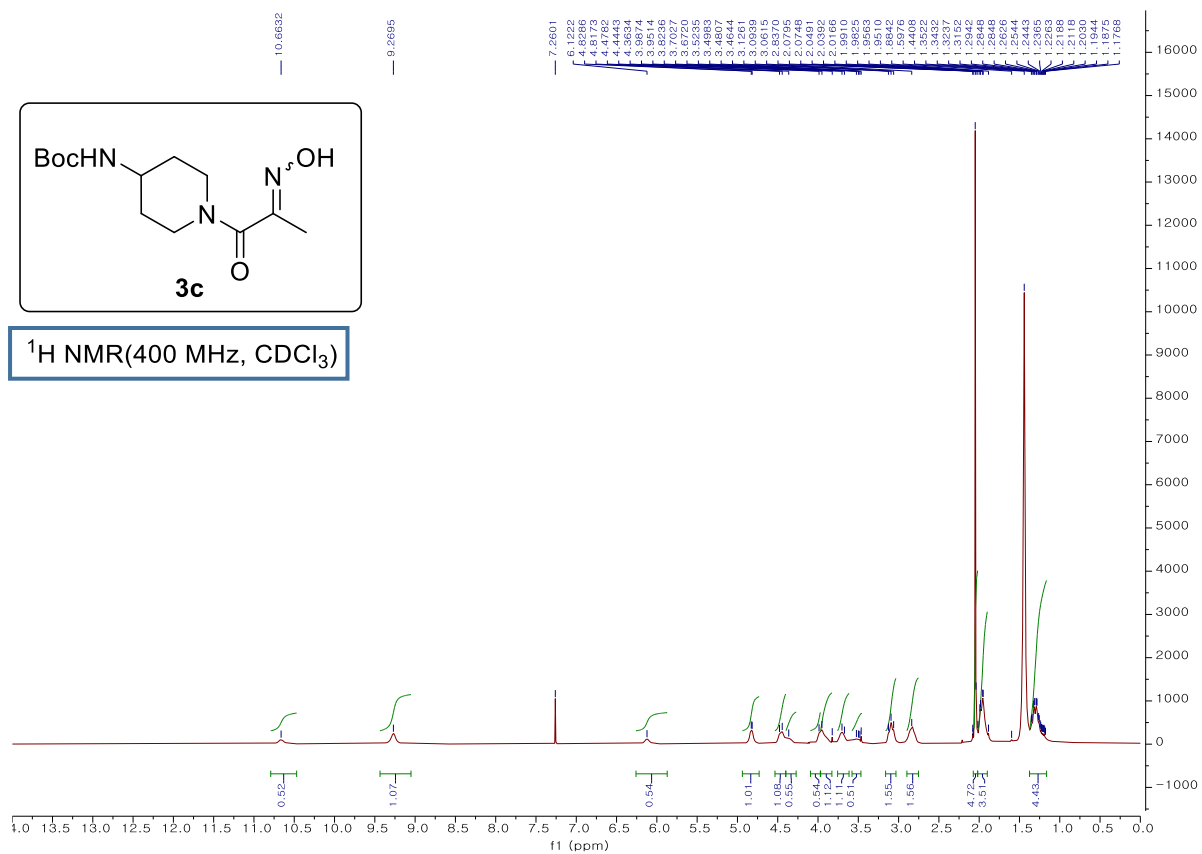


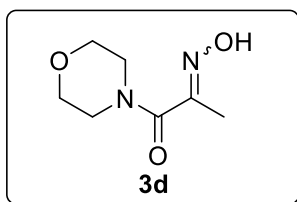
¹H NMR(500 MHz, CDCl₃)



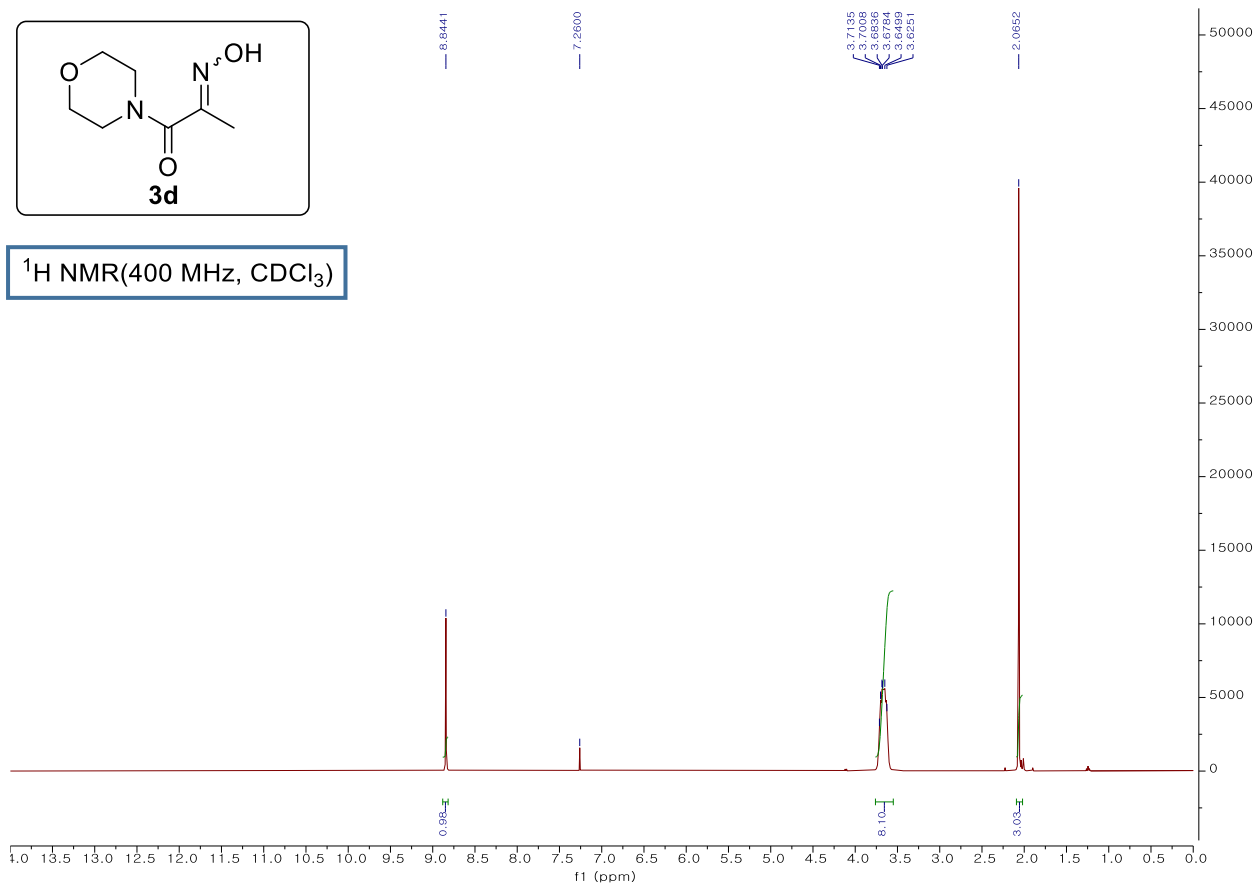
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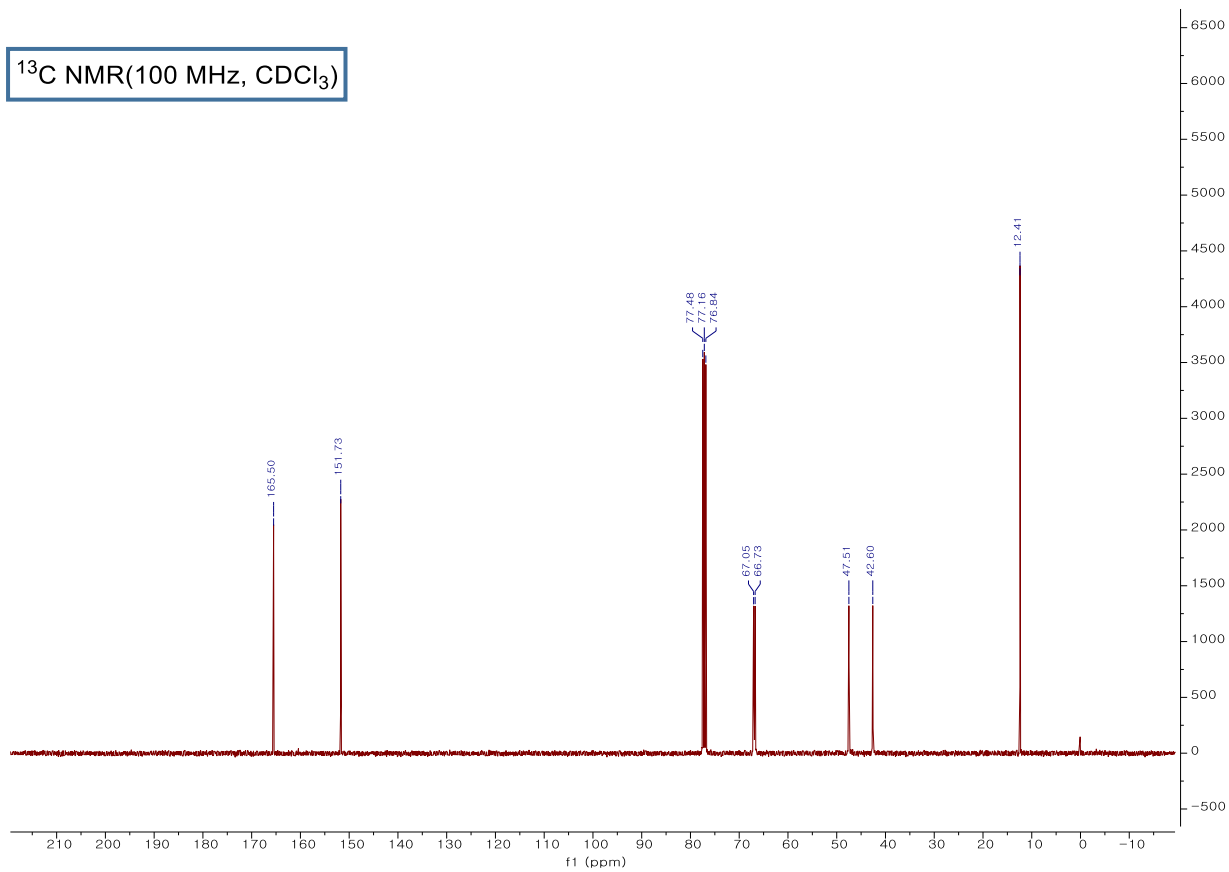


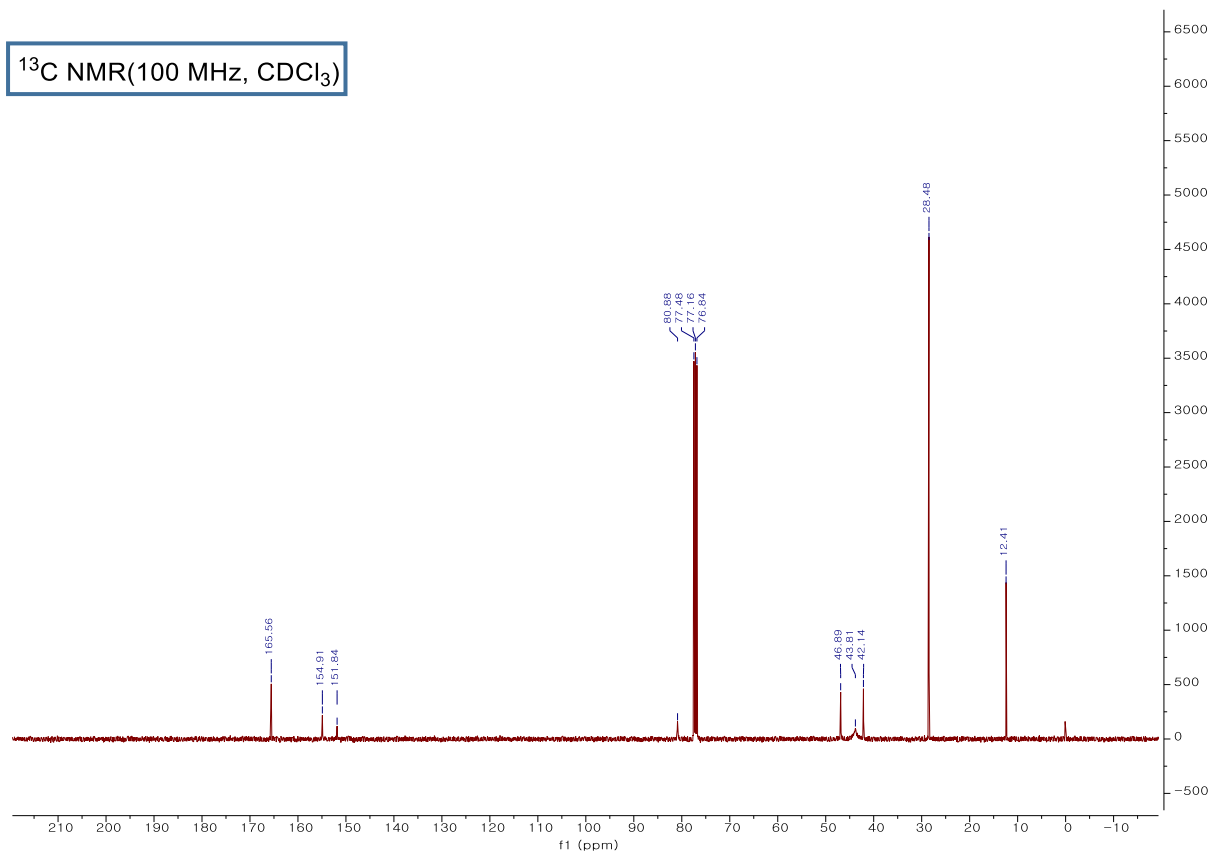
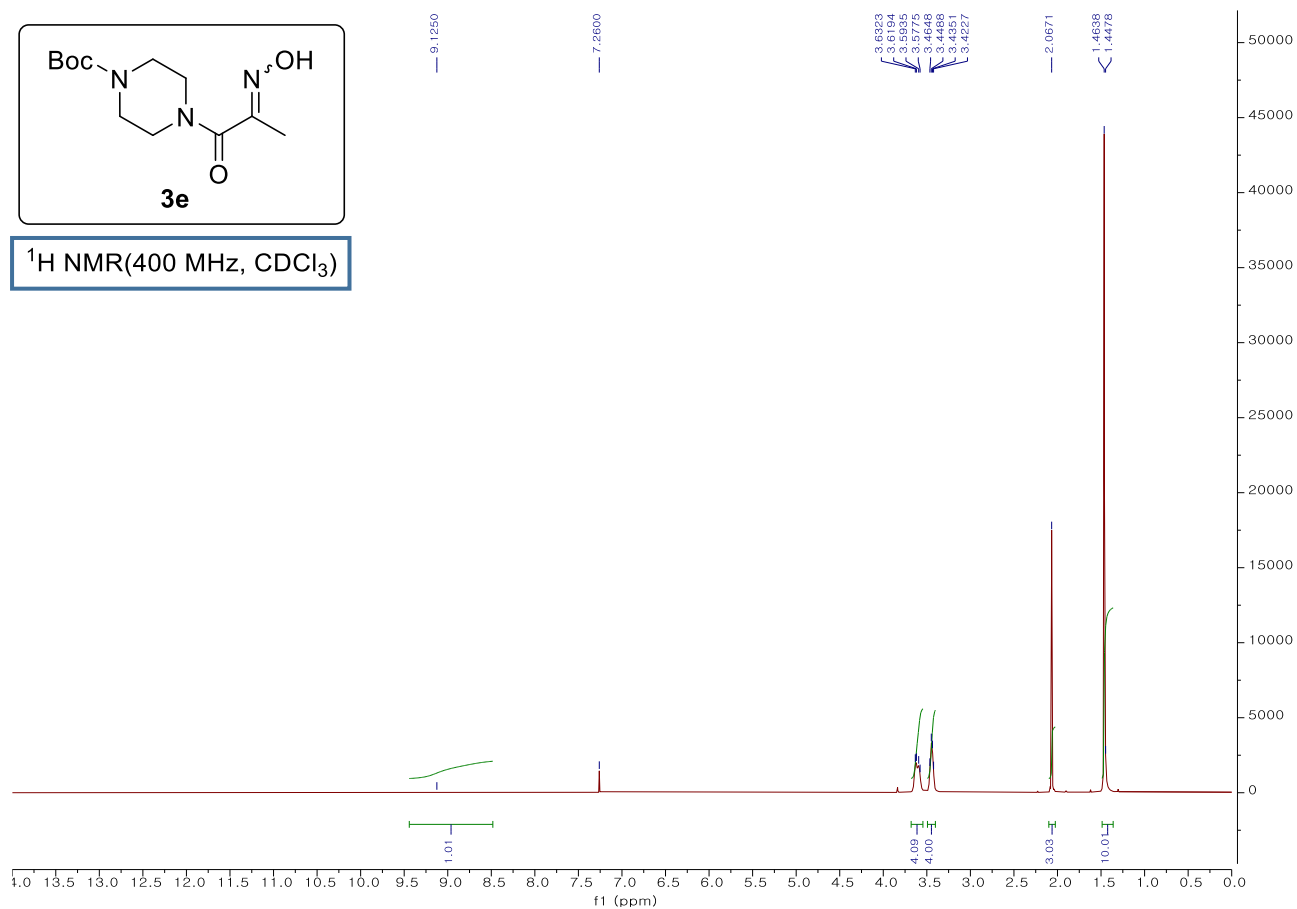


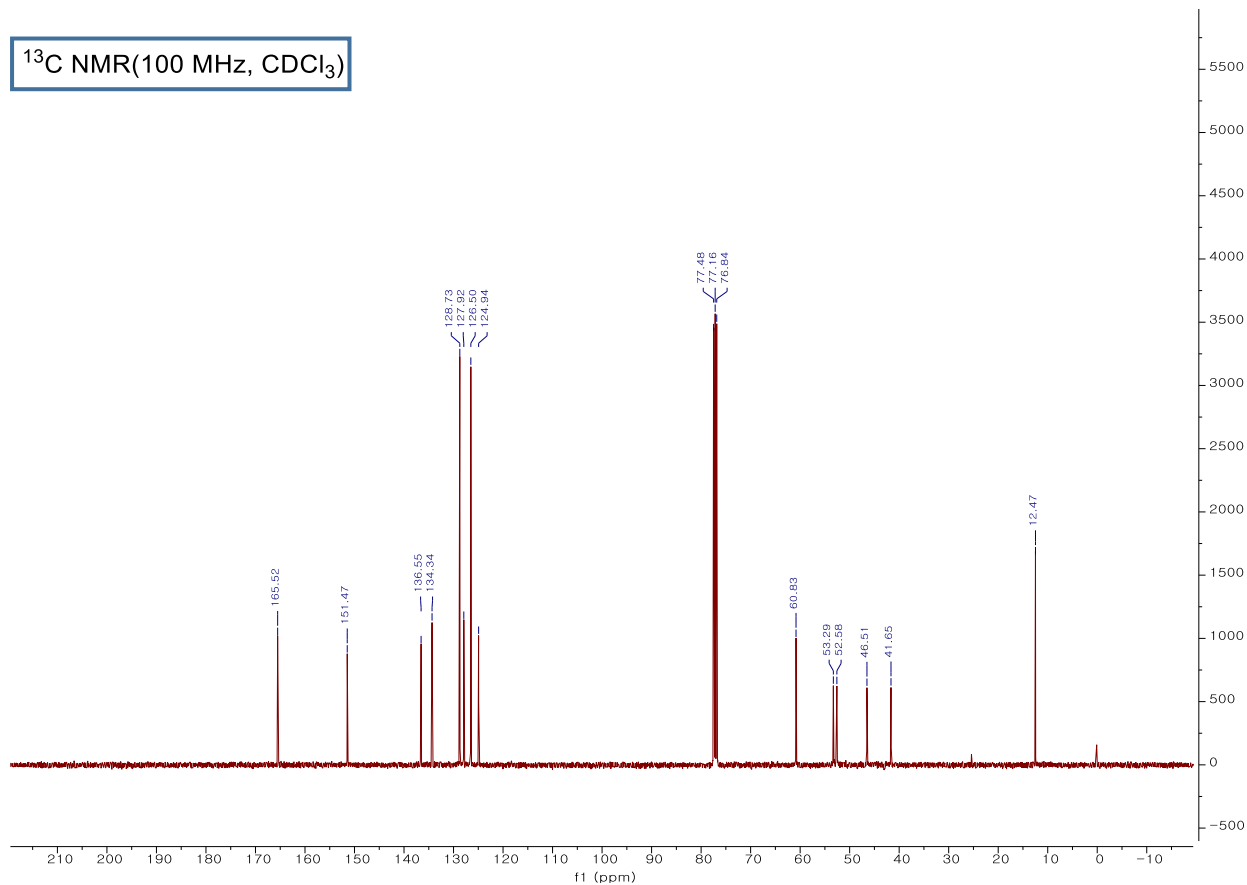
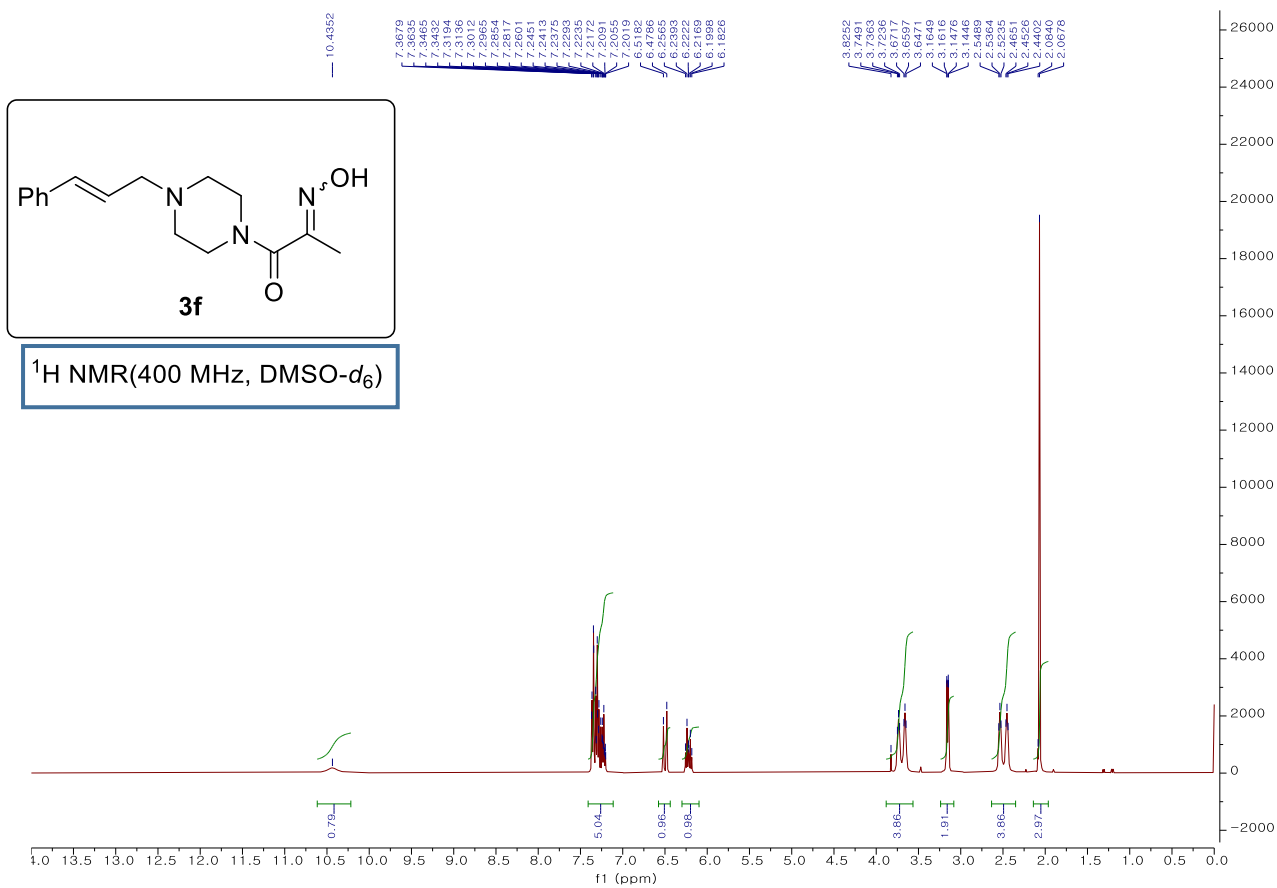
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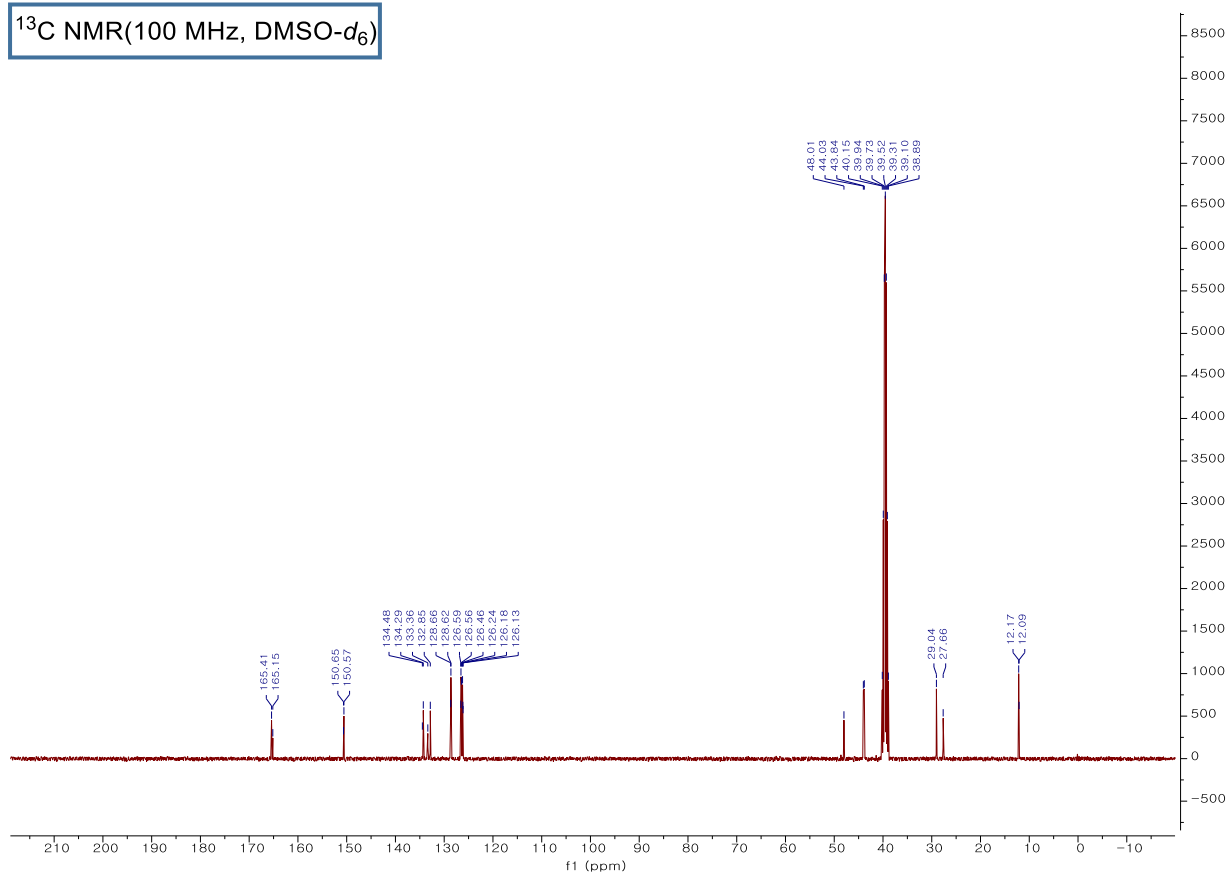
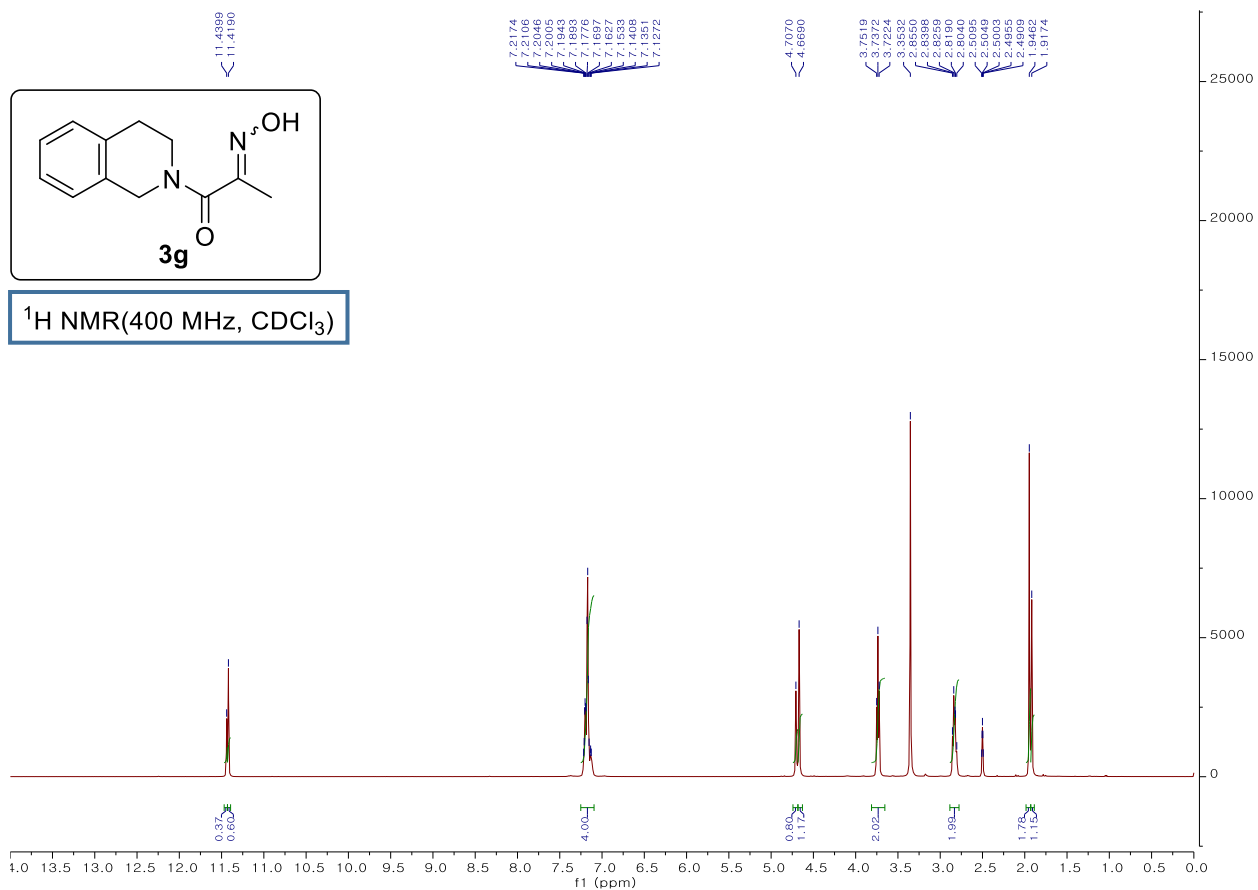


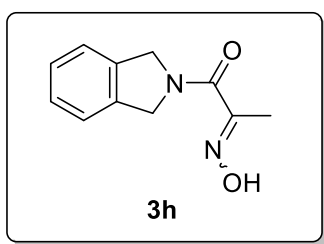
^{13}C NMR(100 MHz, CDCl_3)



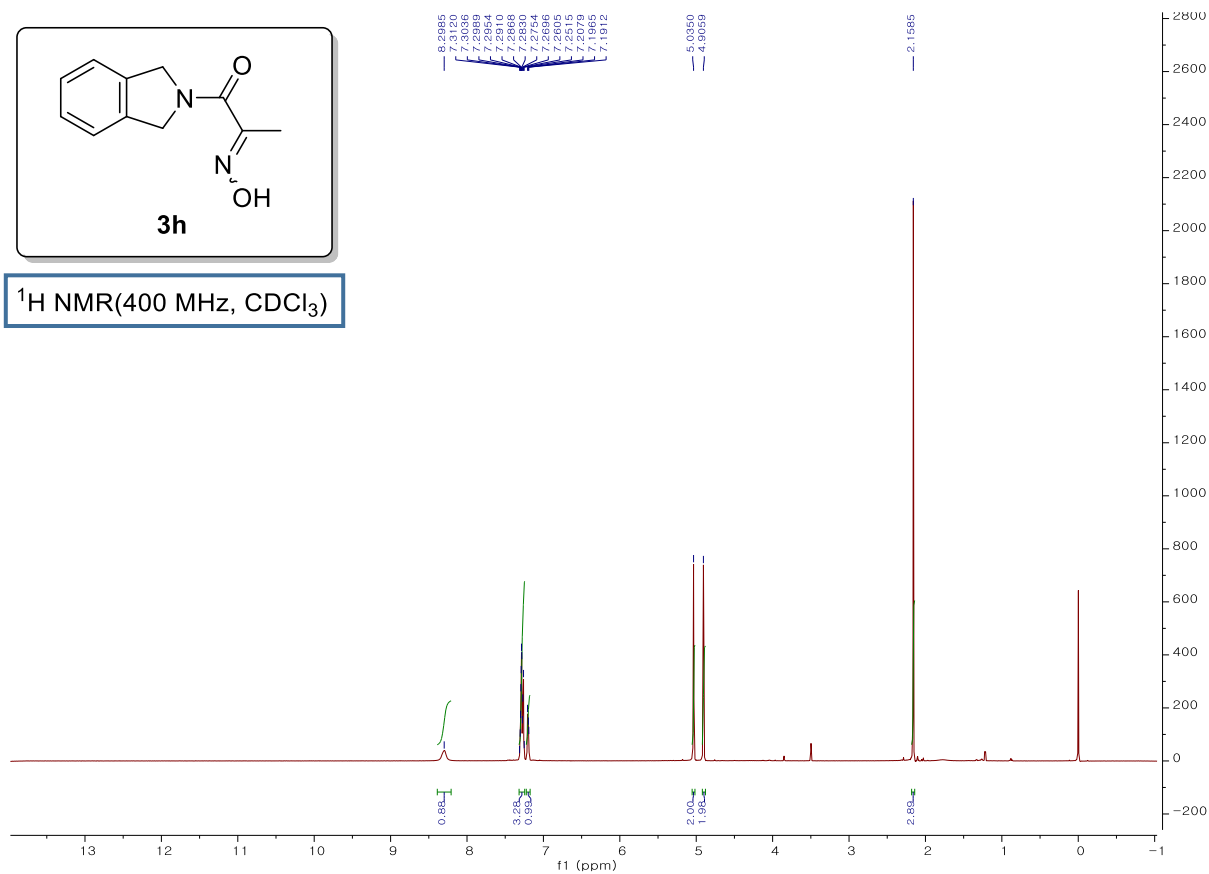




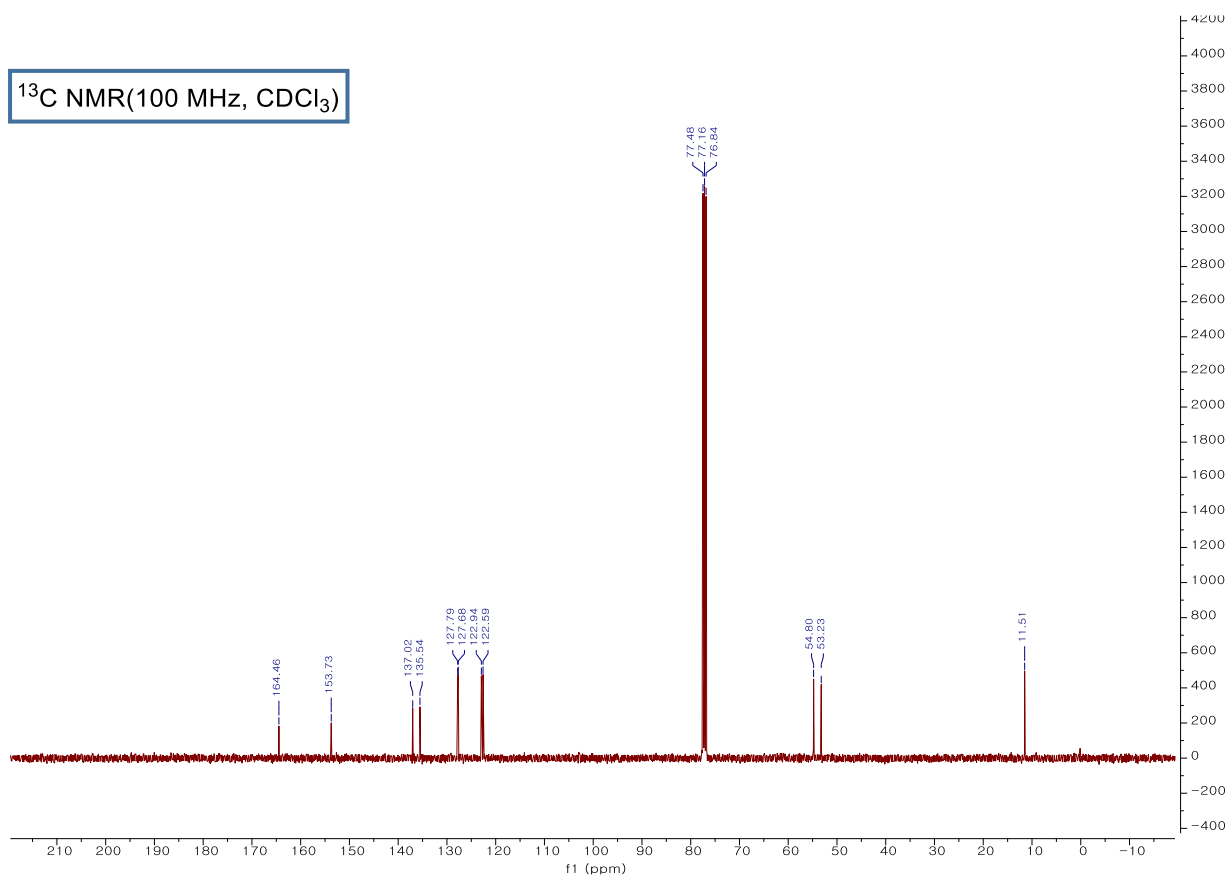


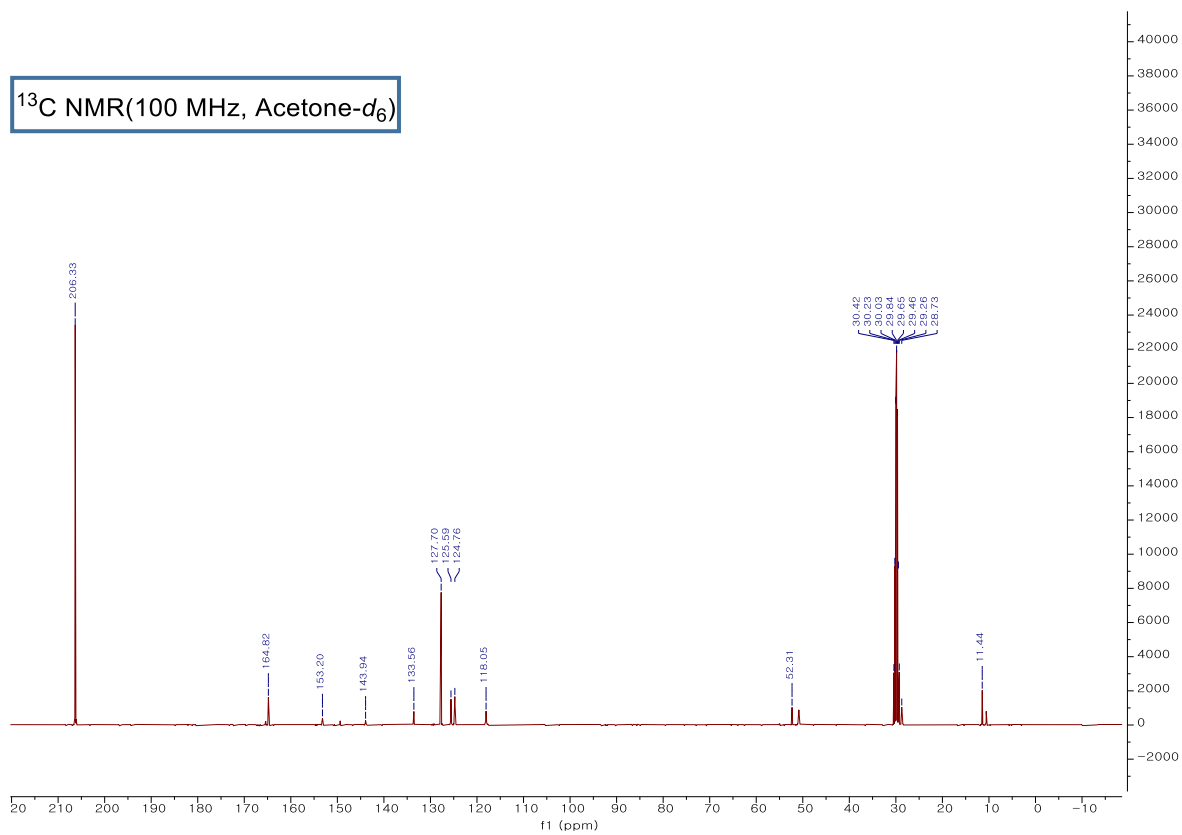
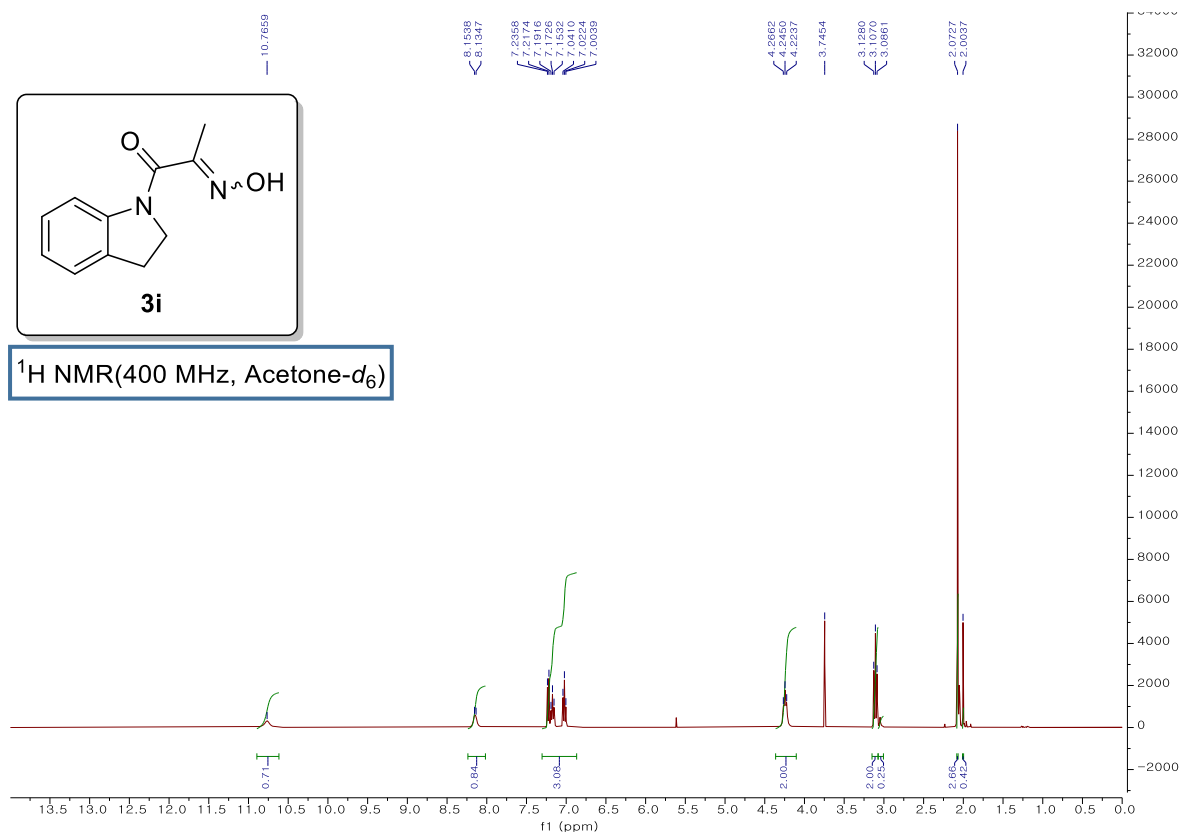


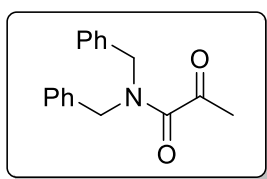
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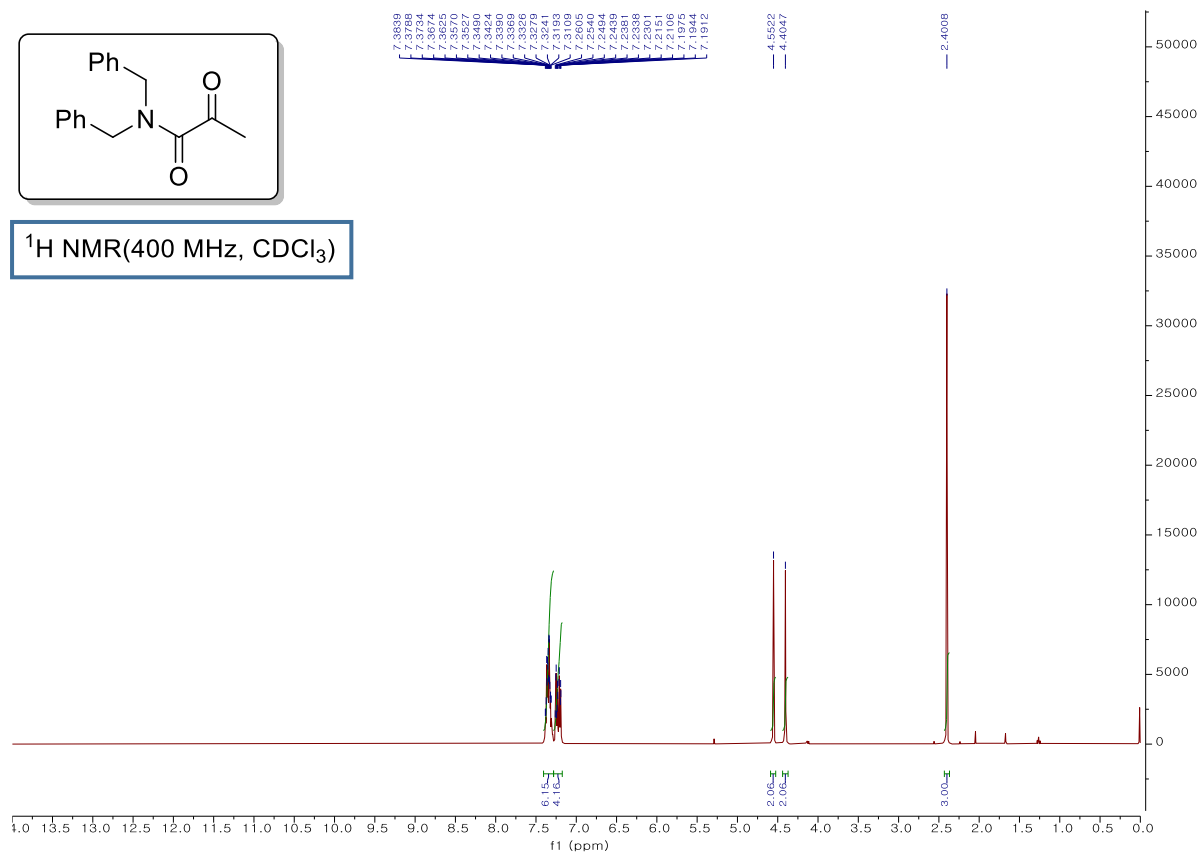
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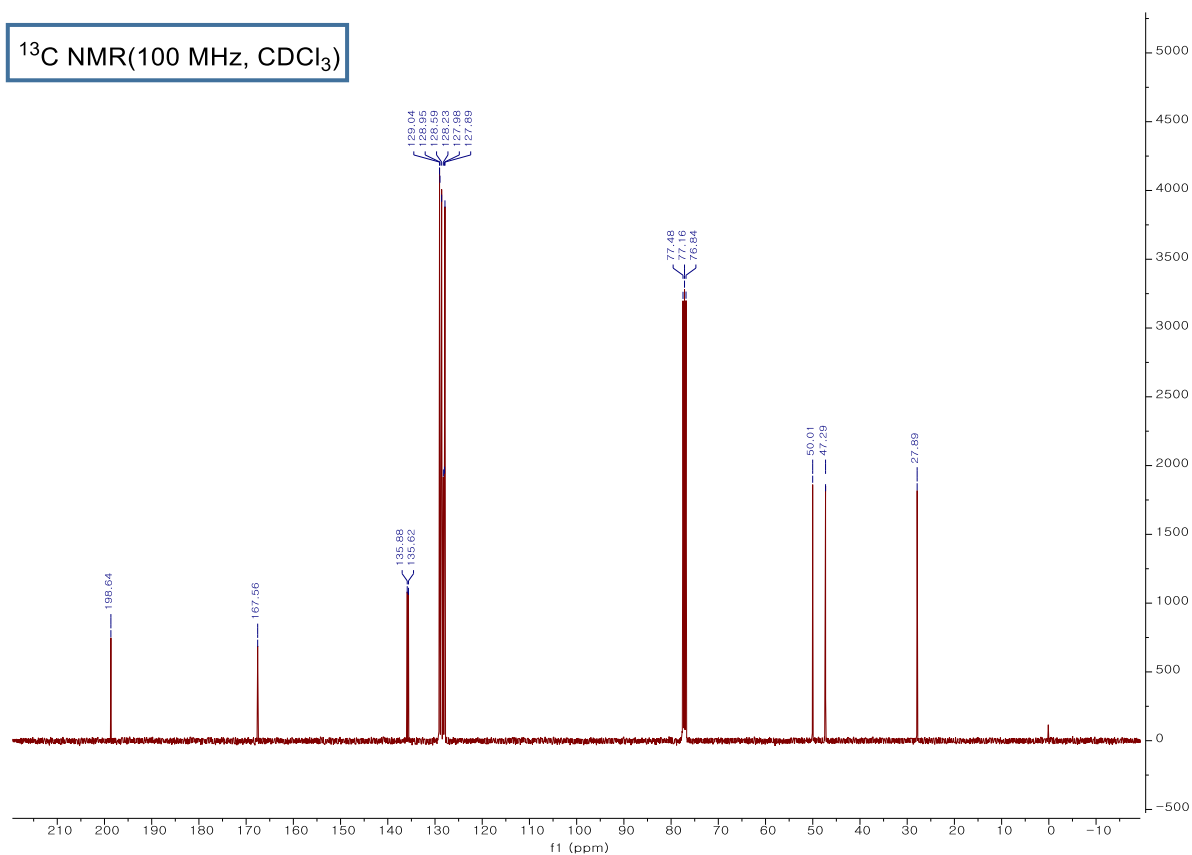


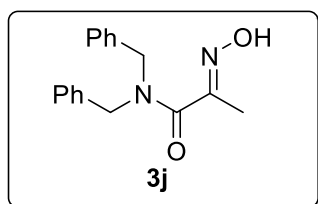


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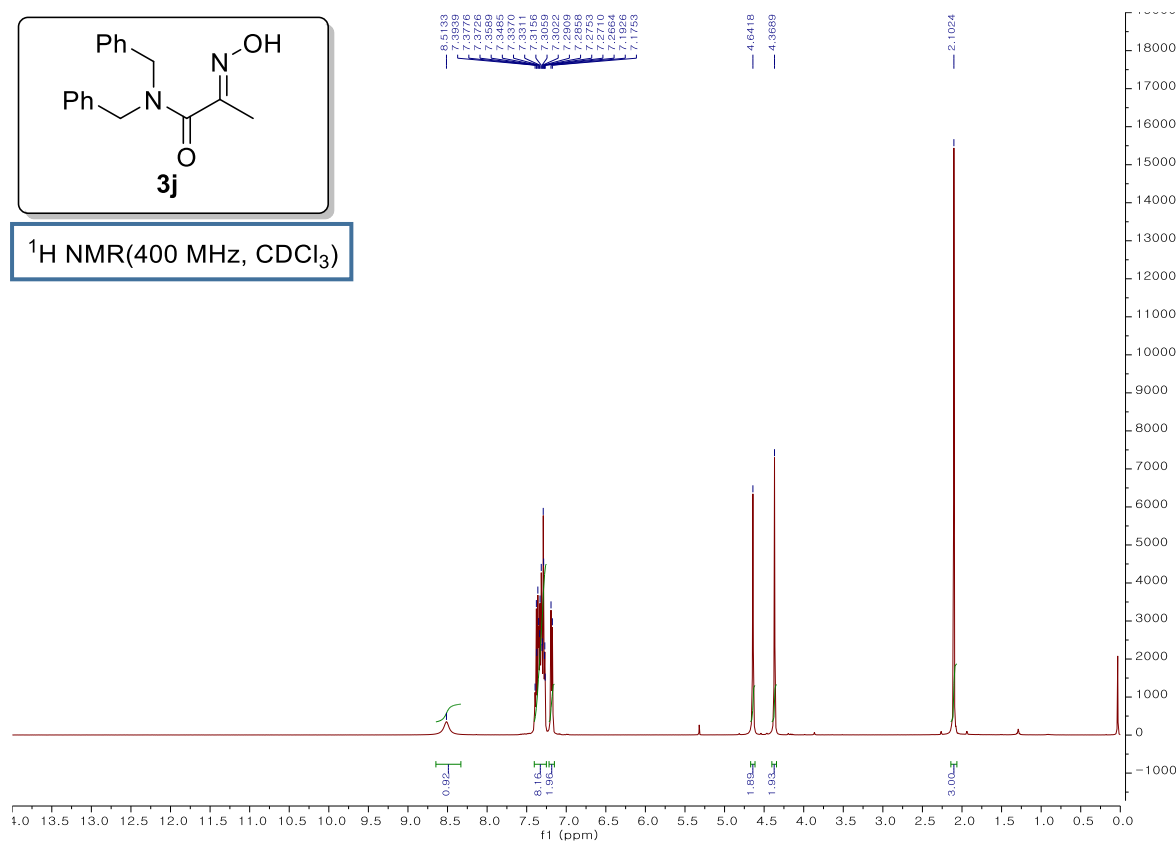


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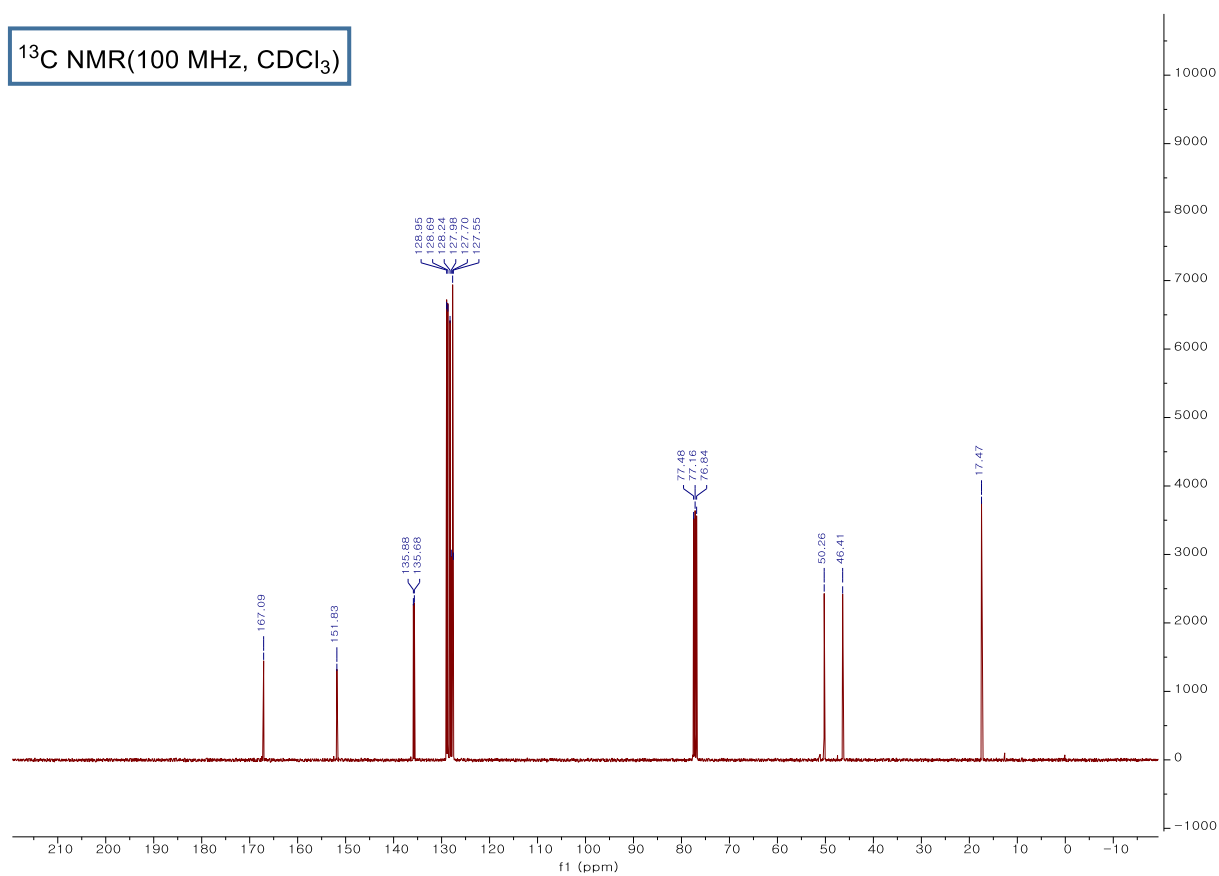


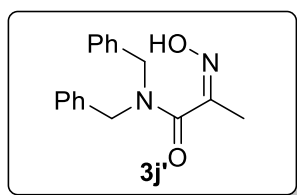


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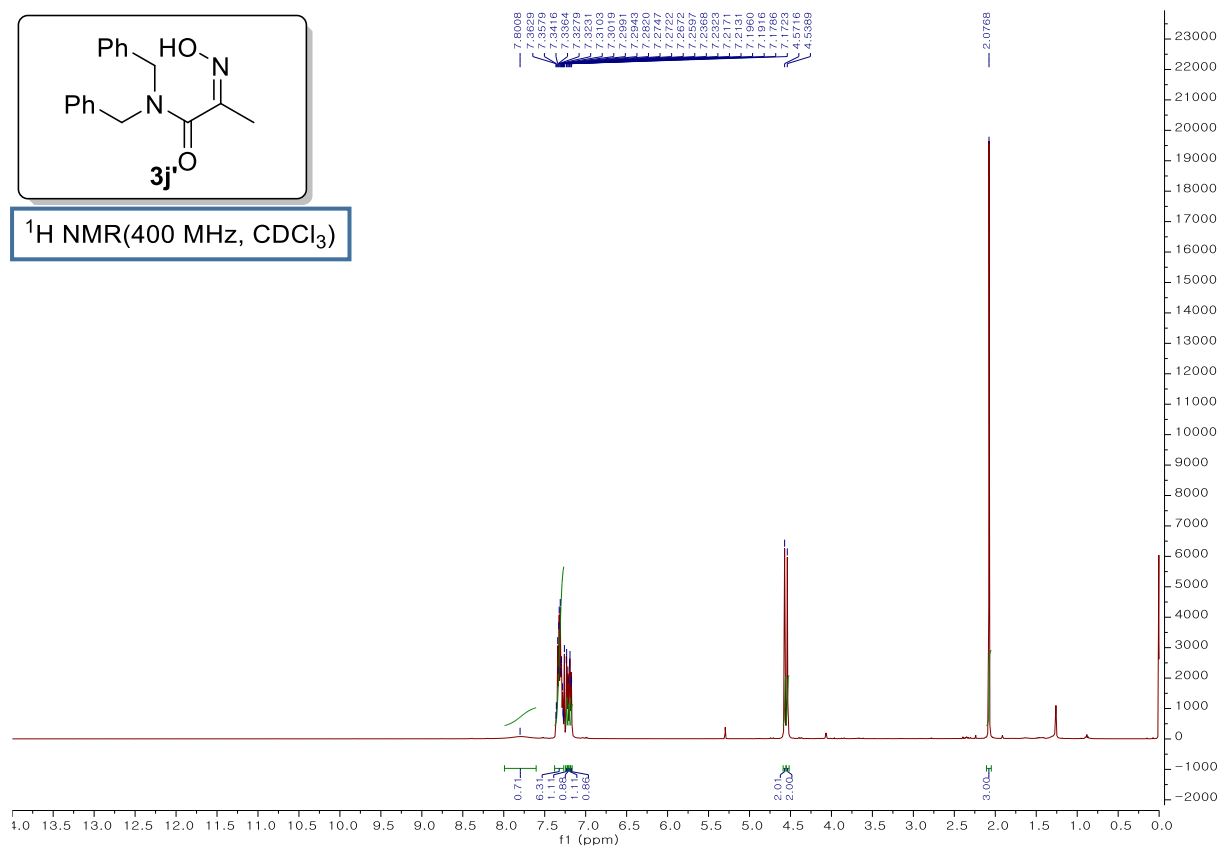


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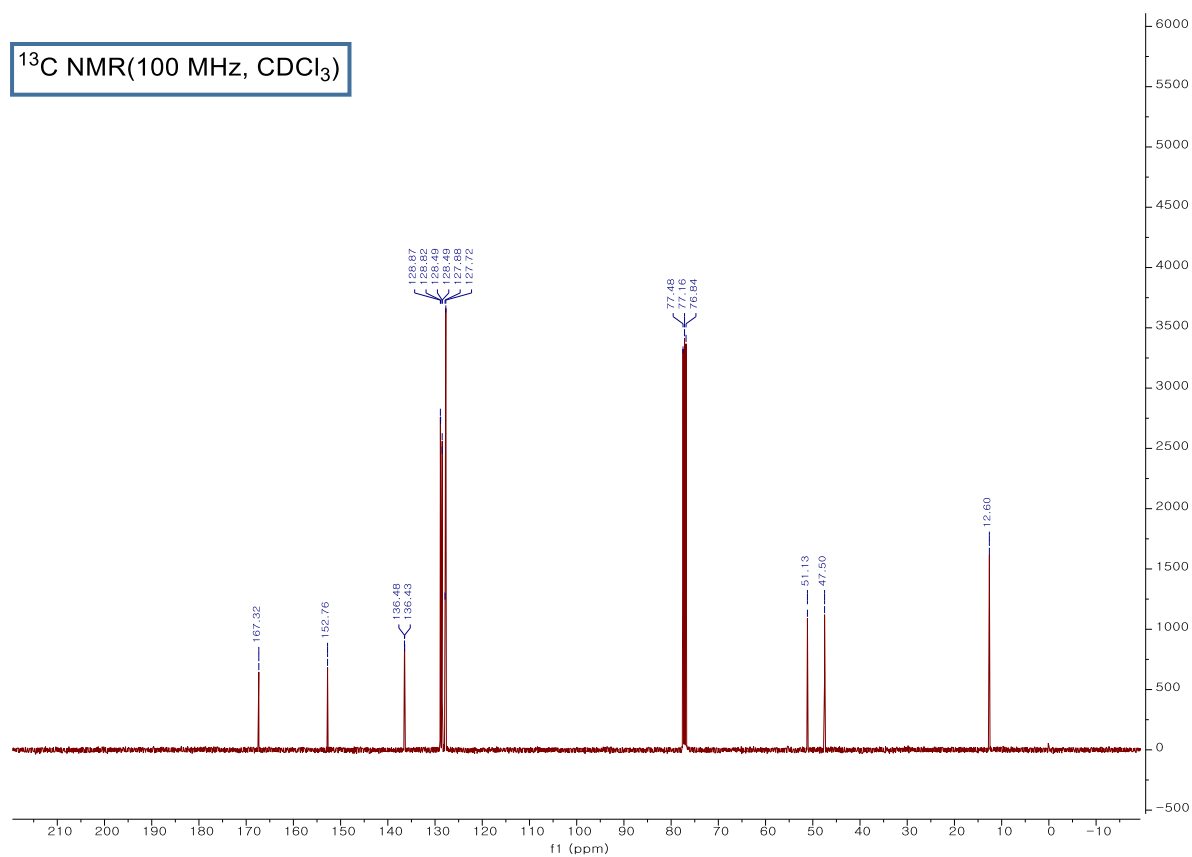


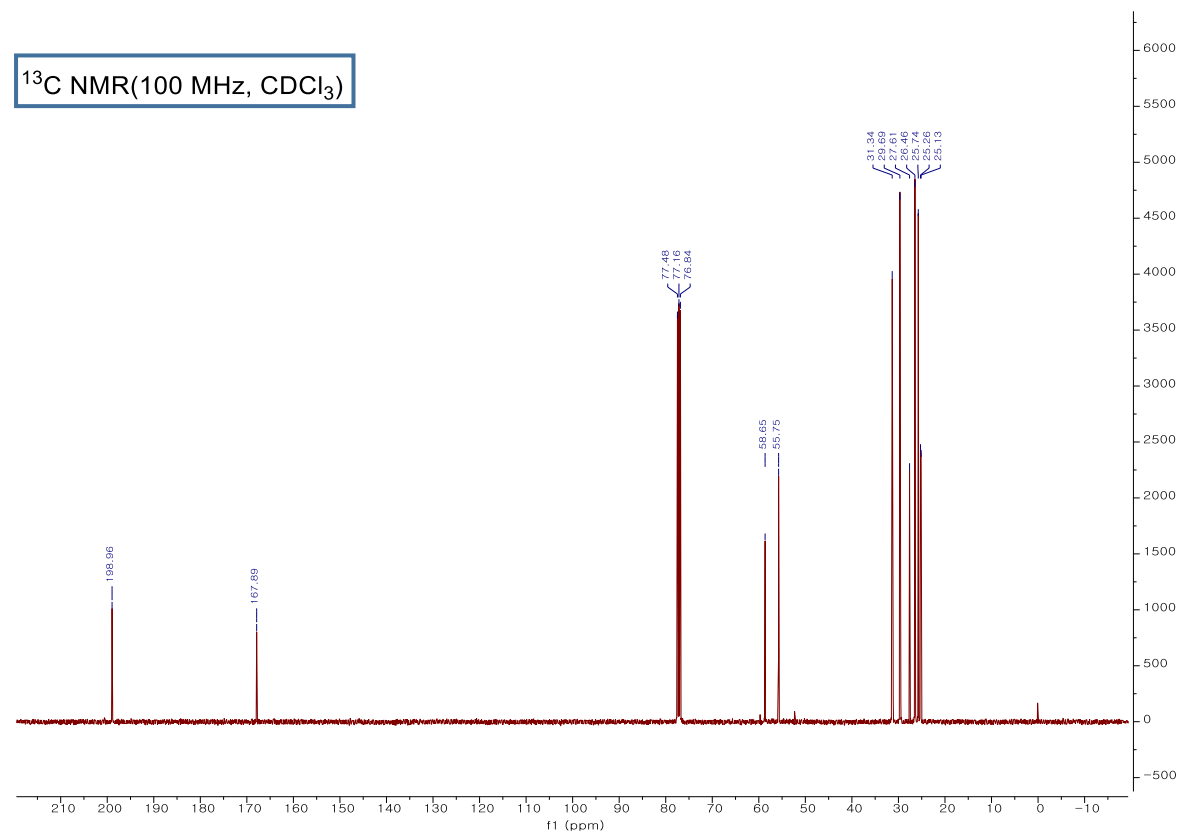
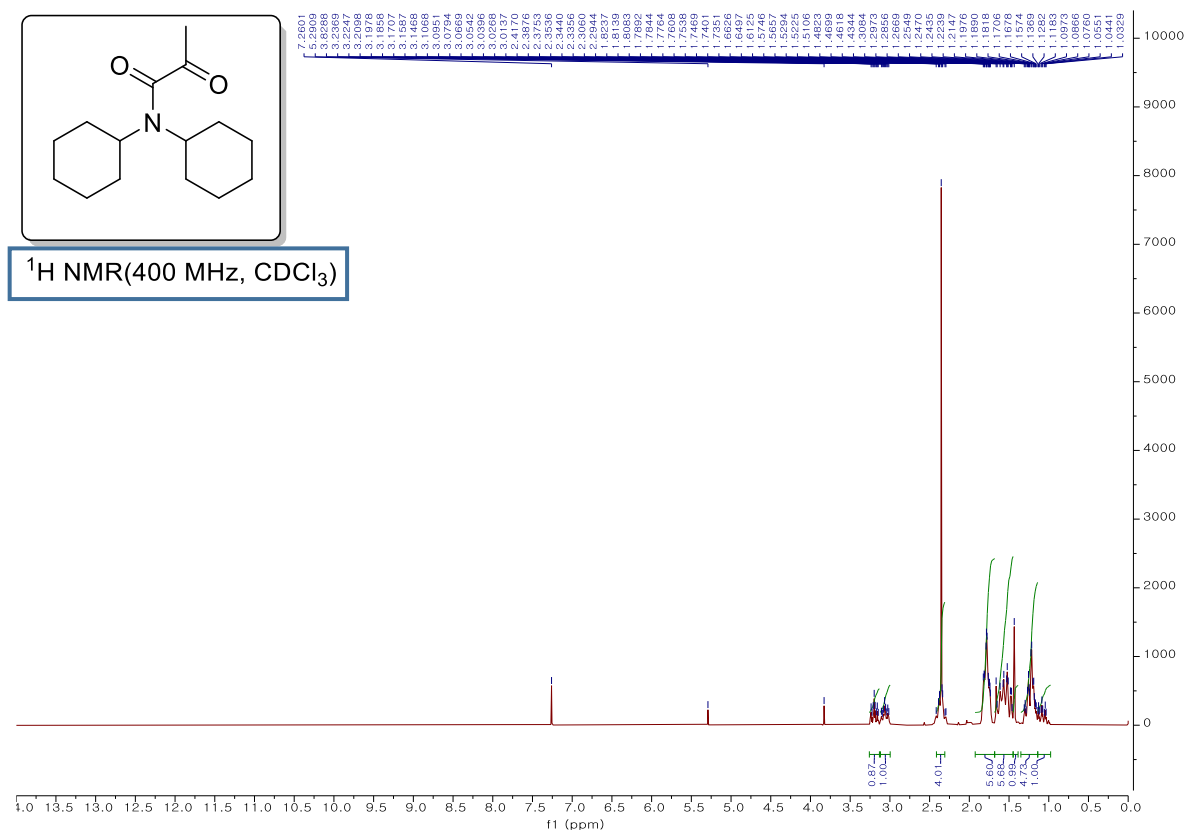


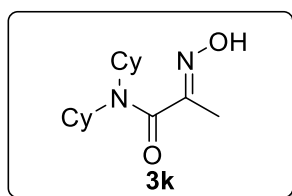
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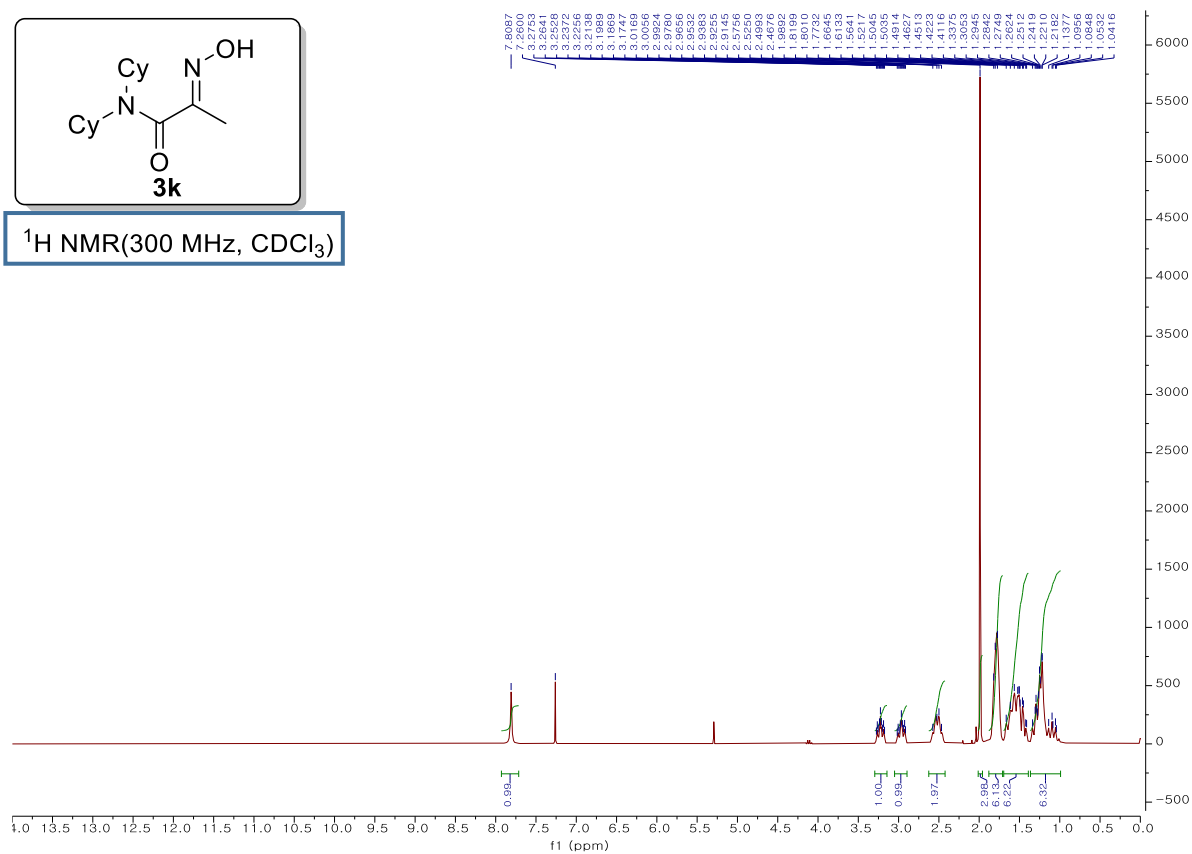
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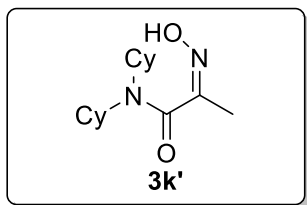




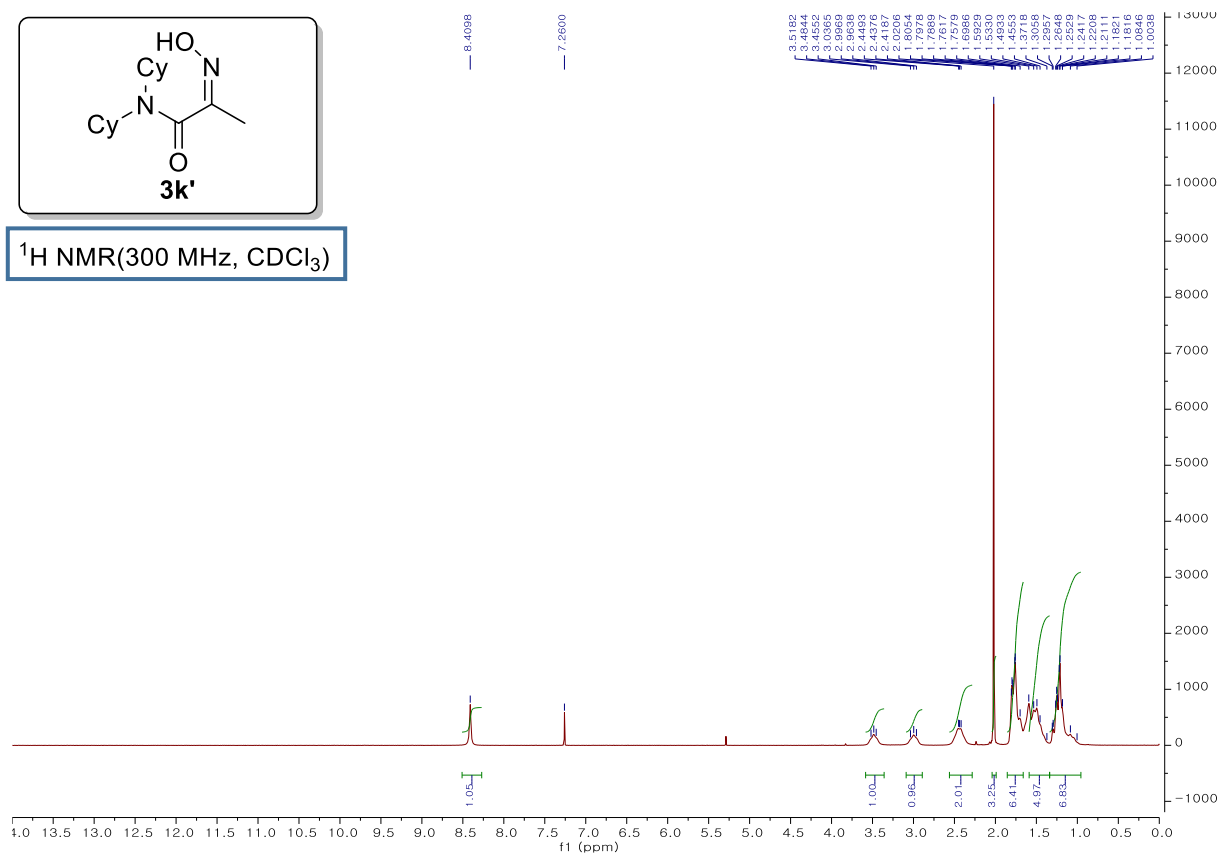


^1H NMR(300 MHz, CDCl_3)

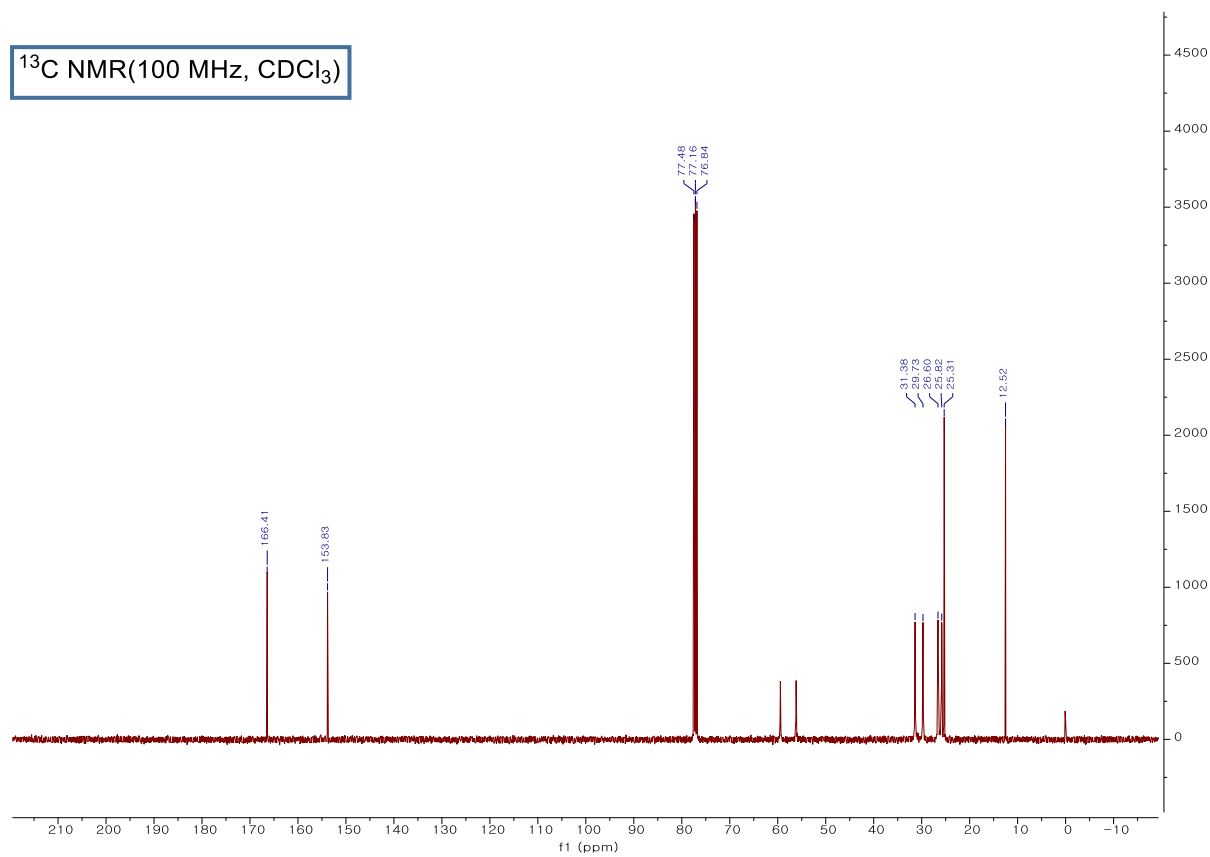


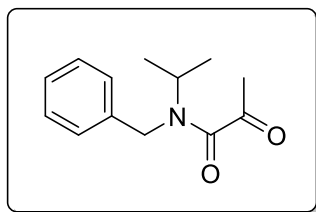


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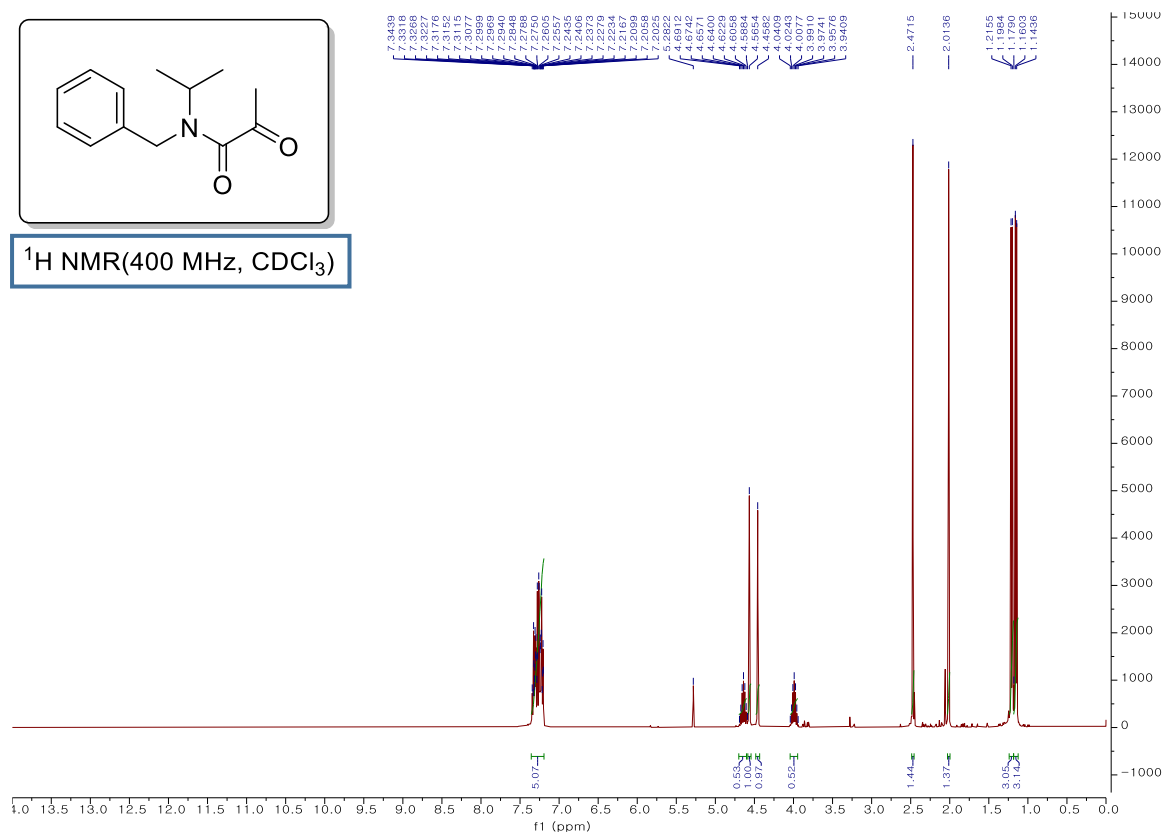


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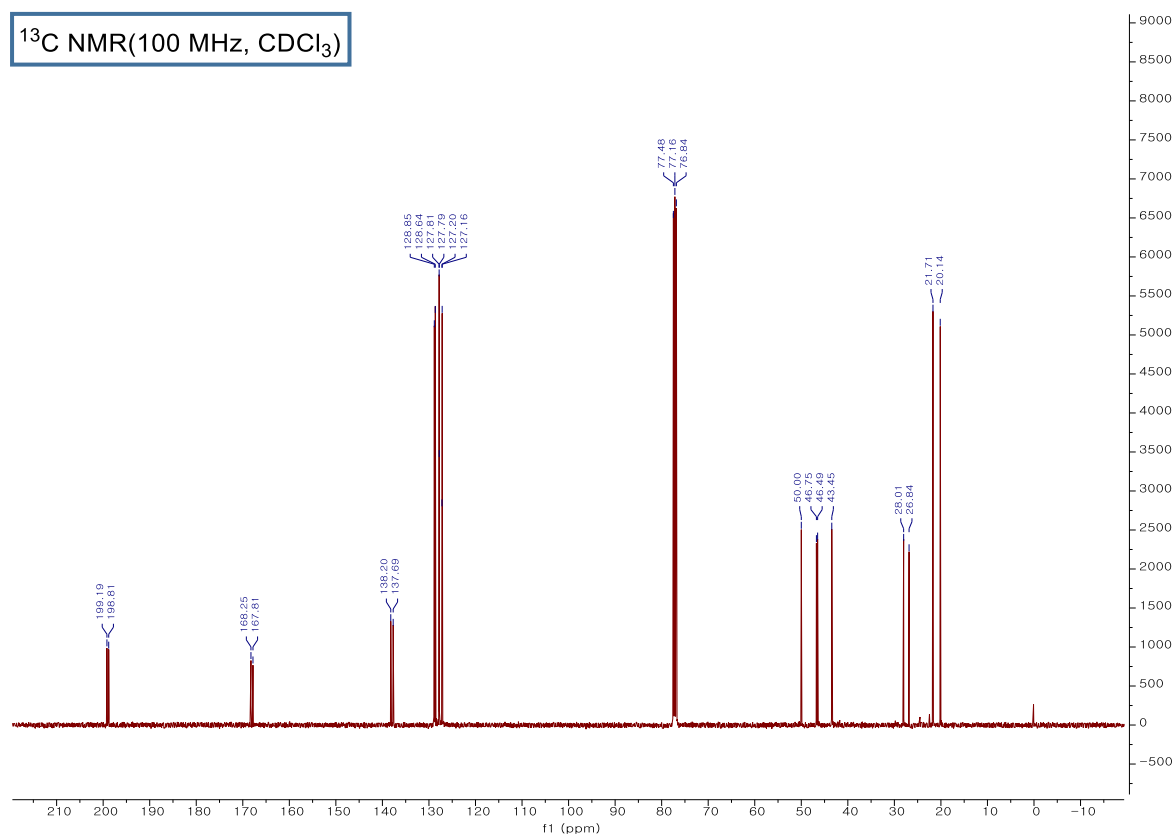


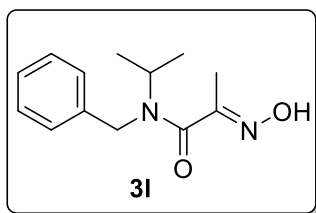


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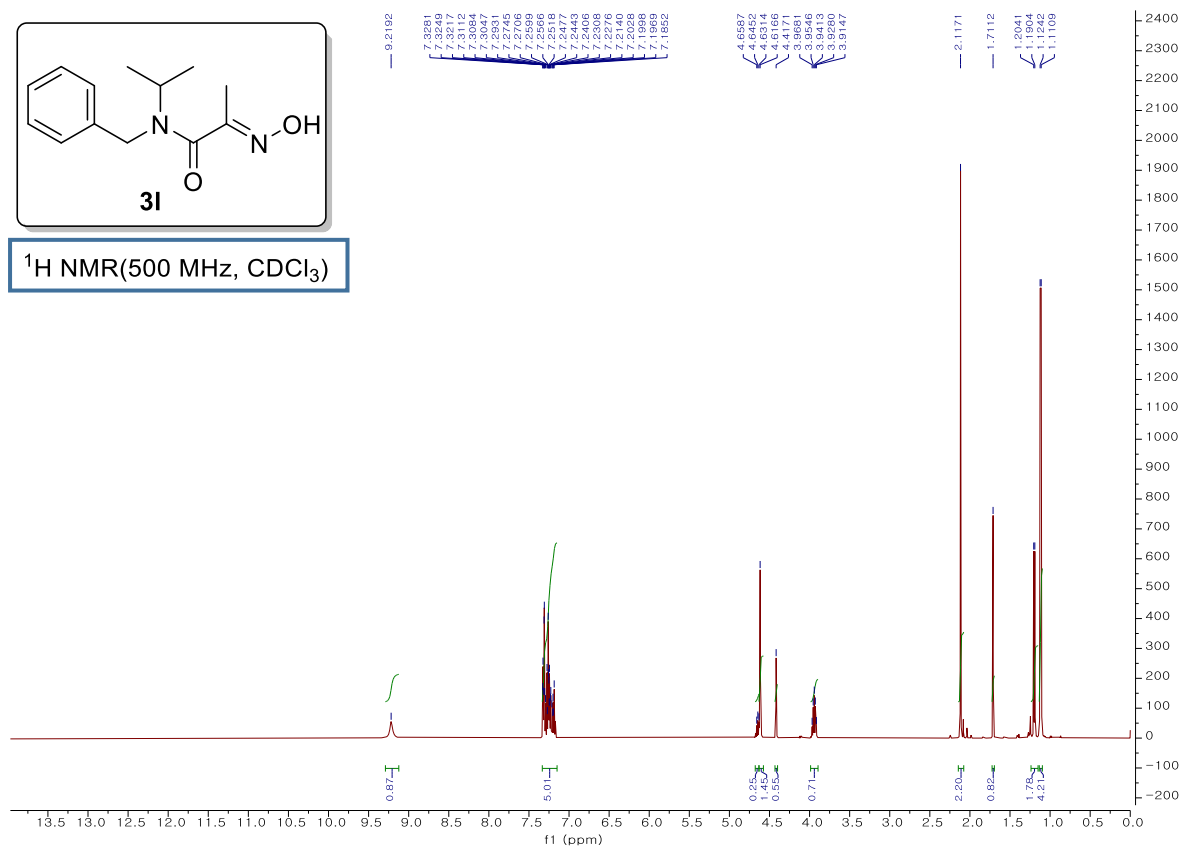


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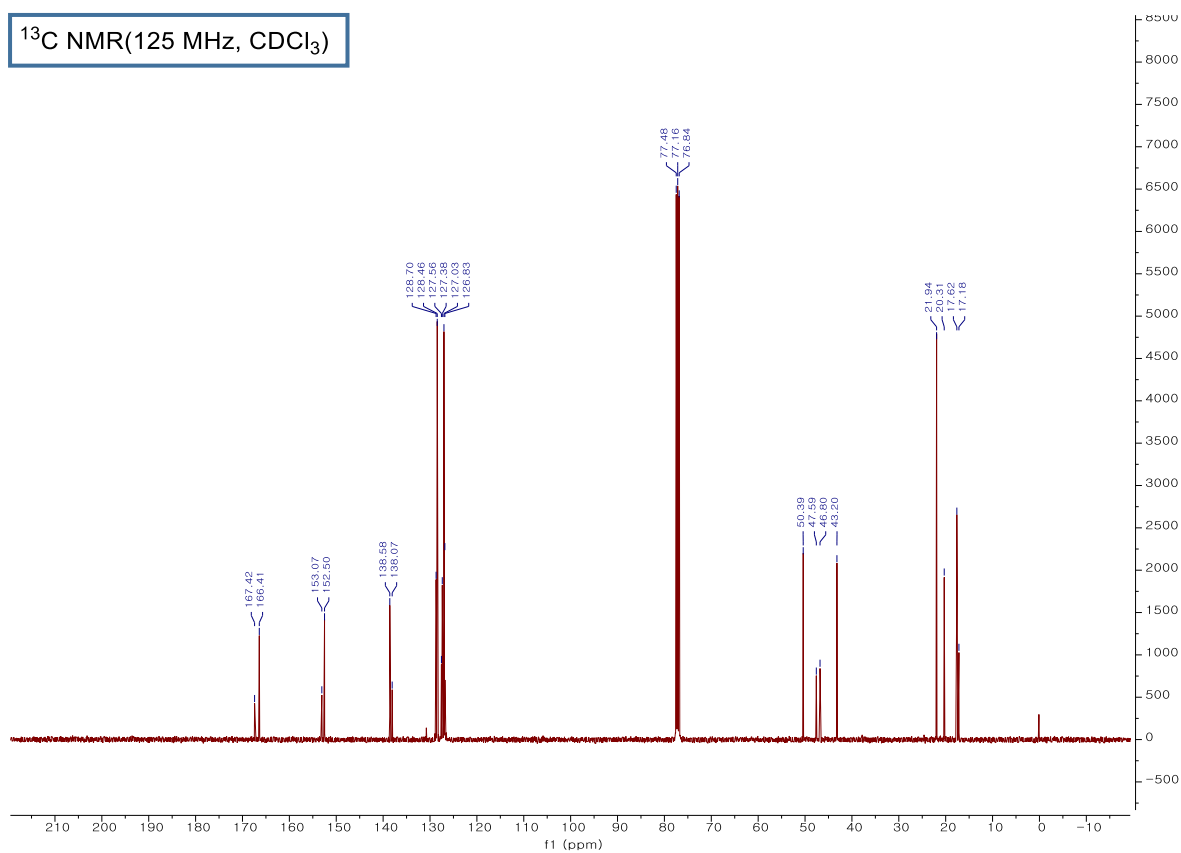


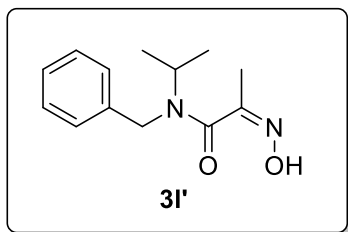


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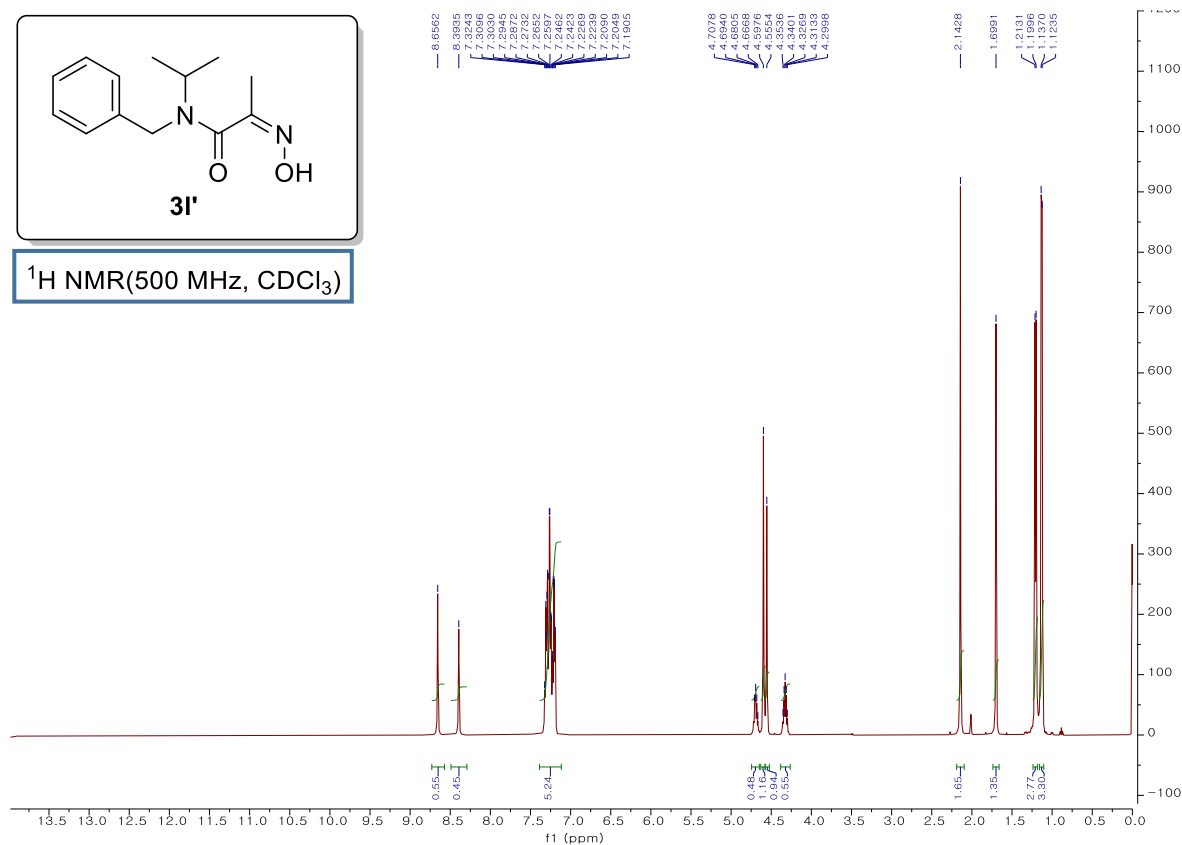


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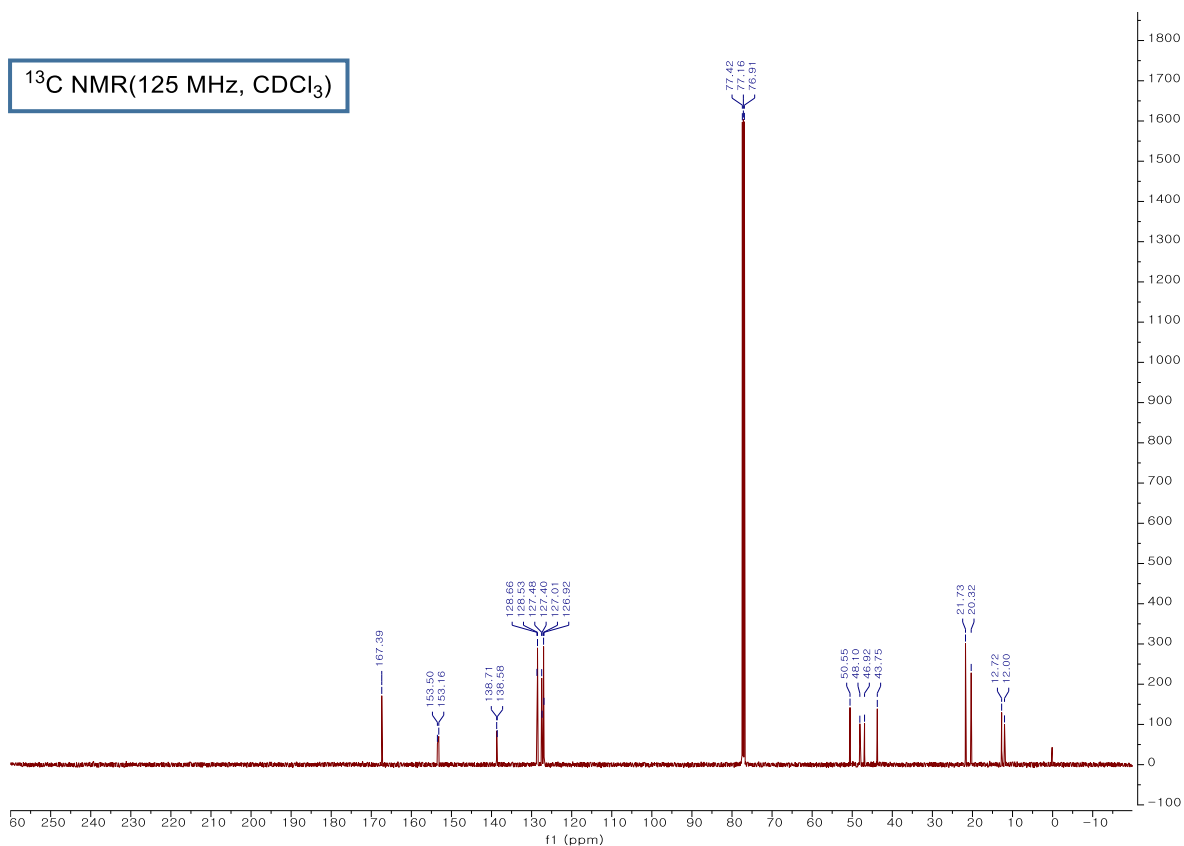


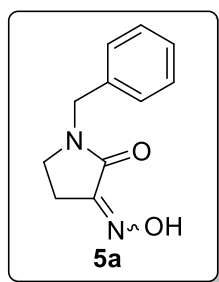


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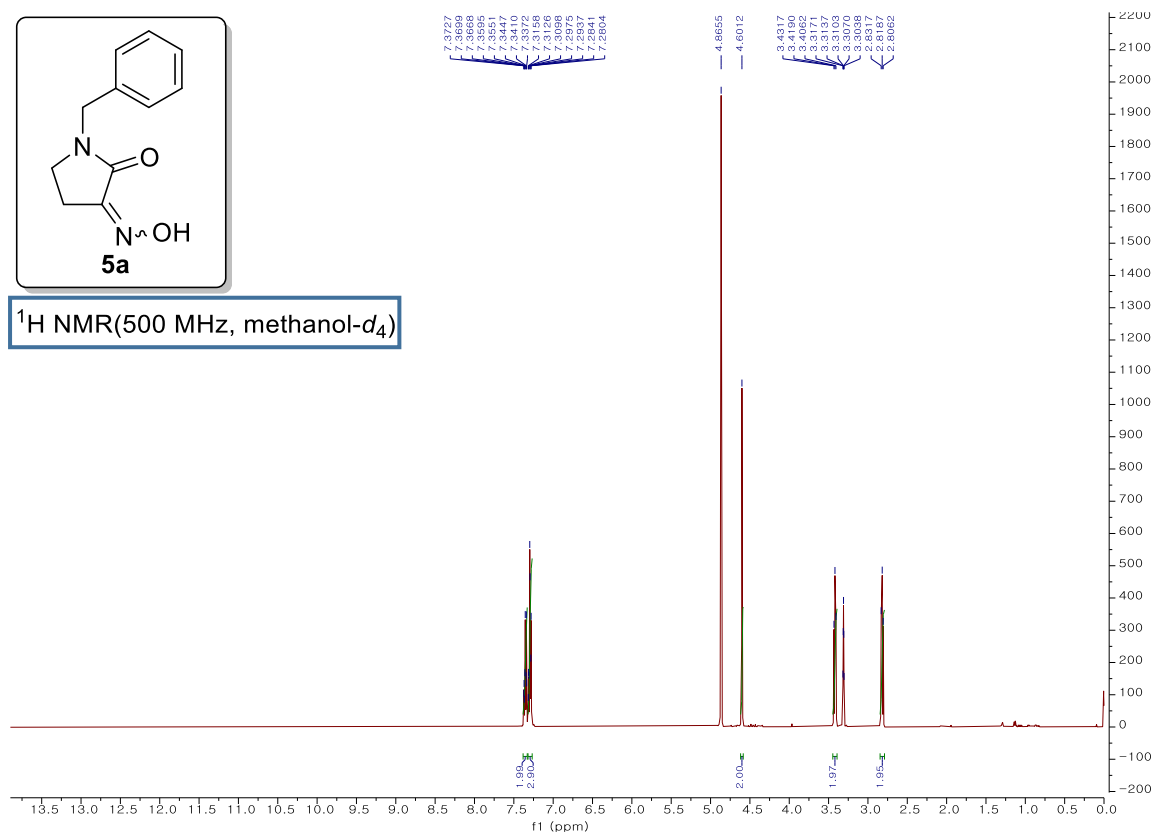


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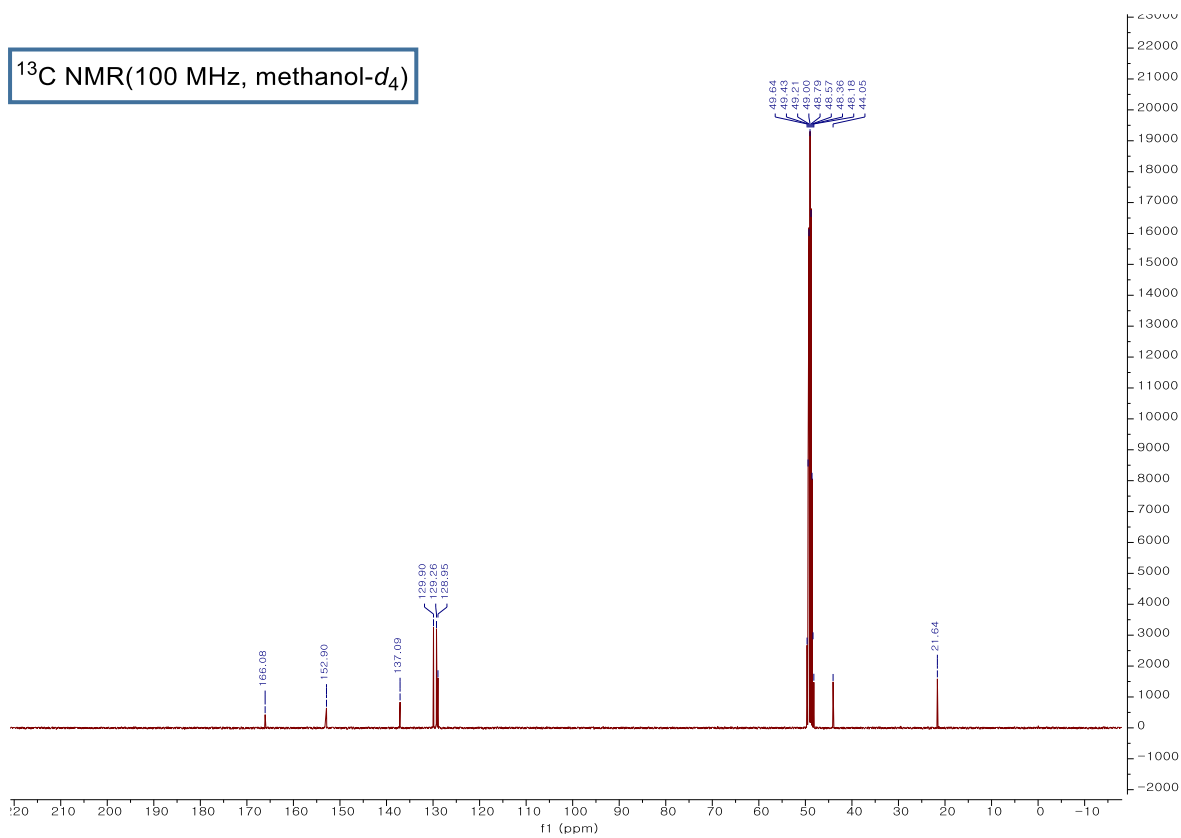


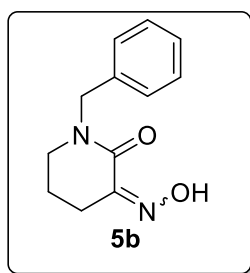


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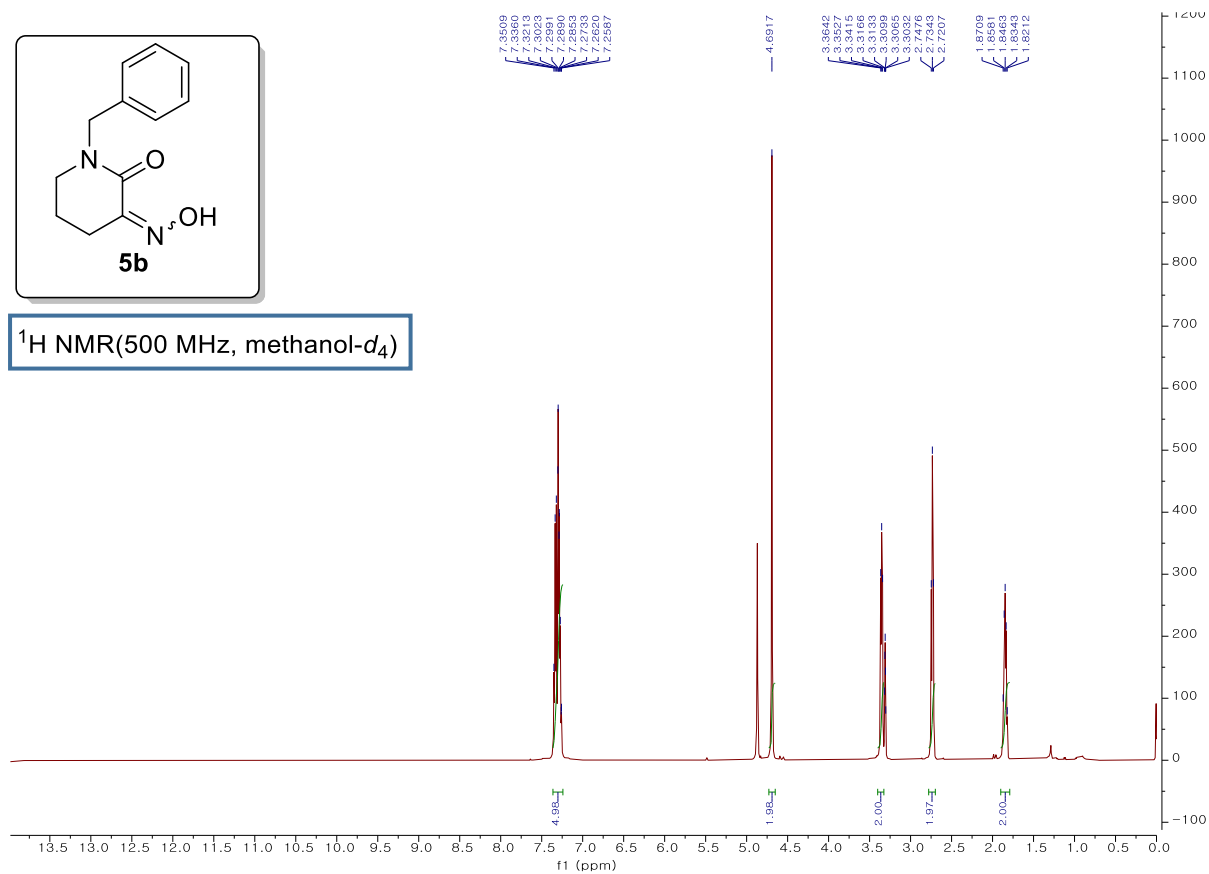


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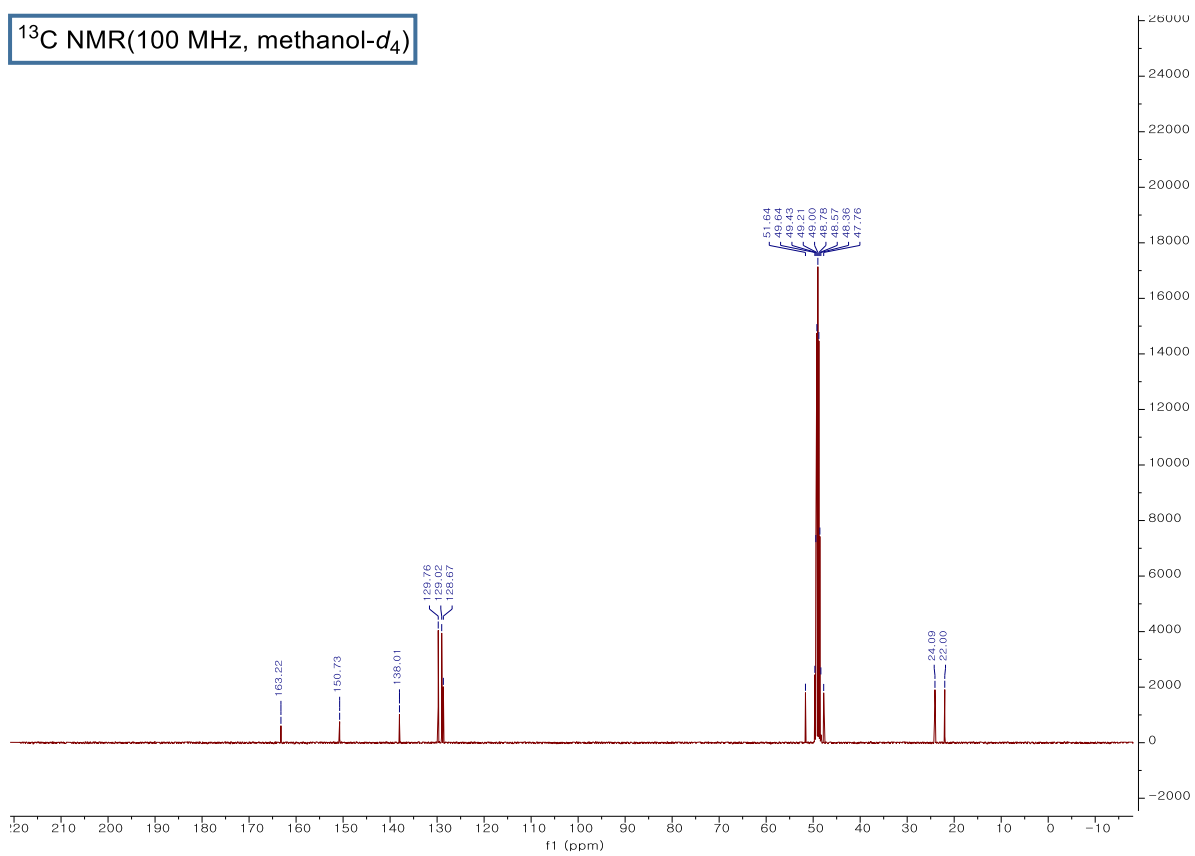


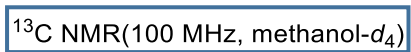


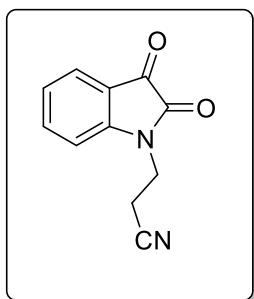
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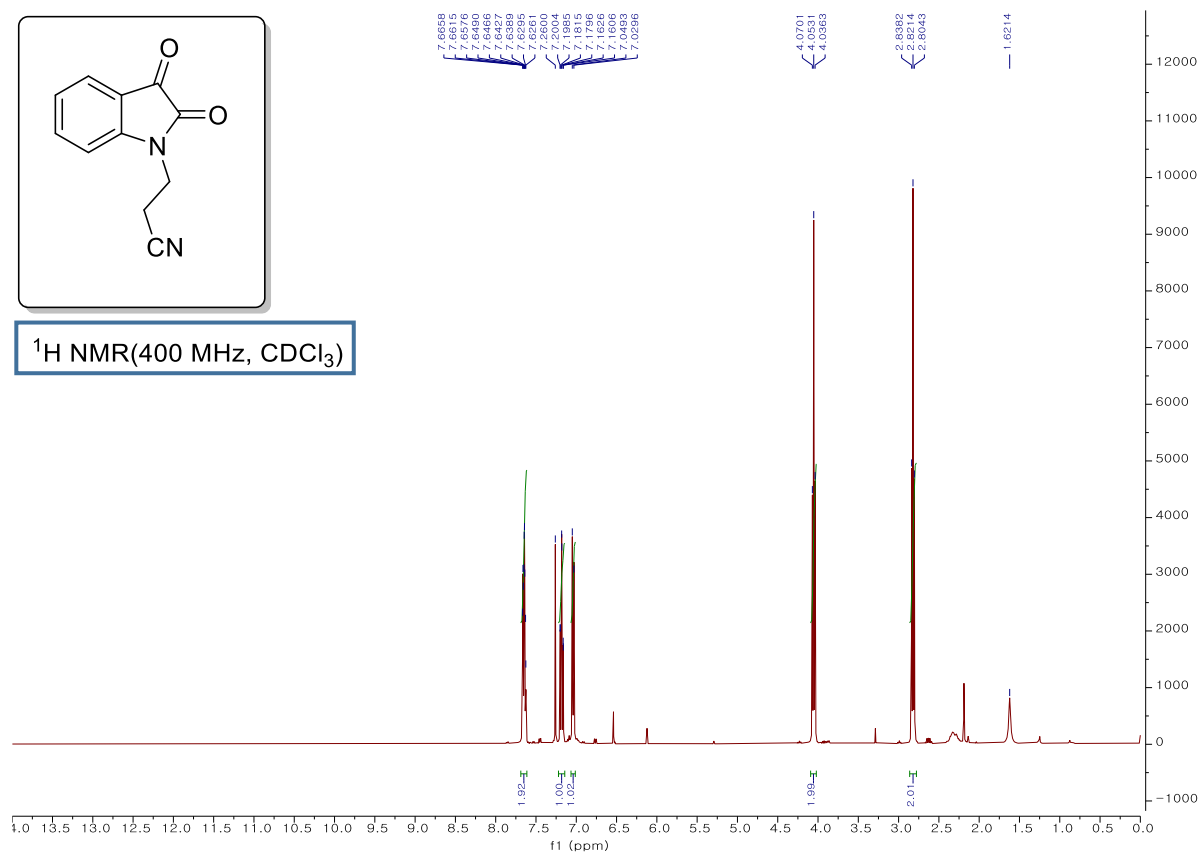
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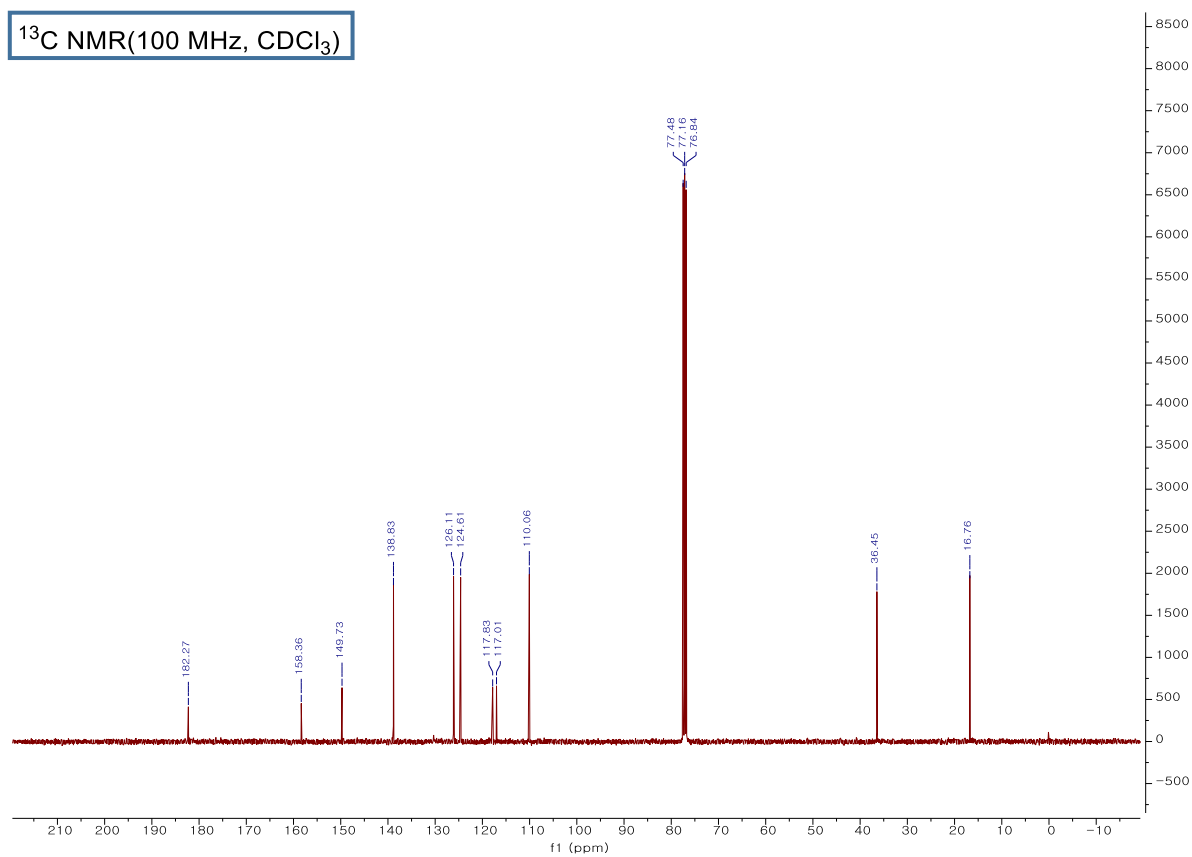


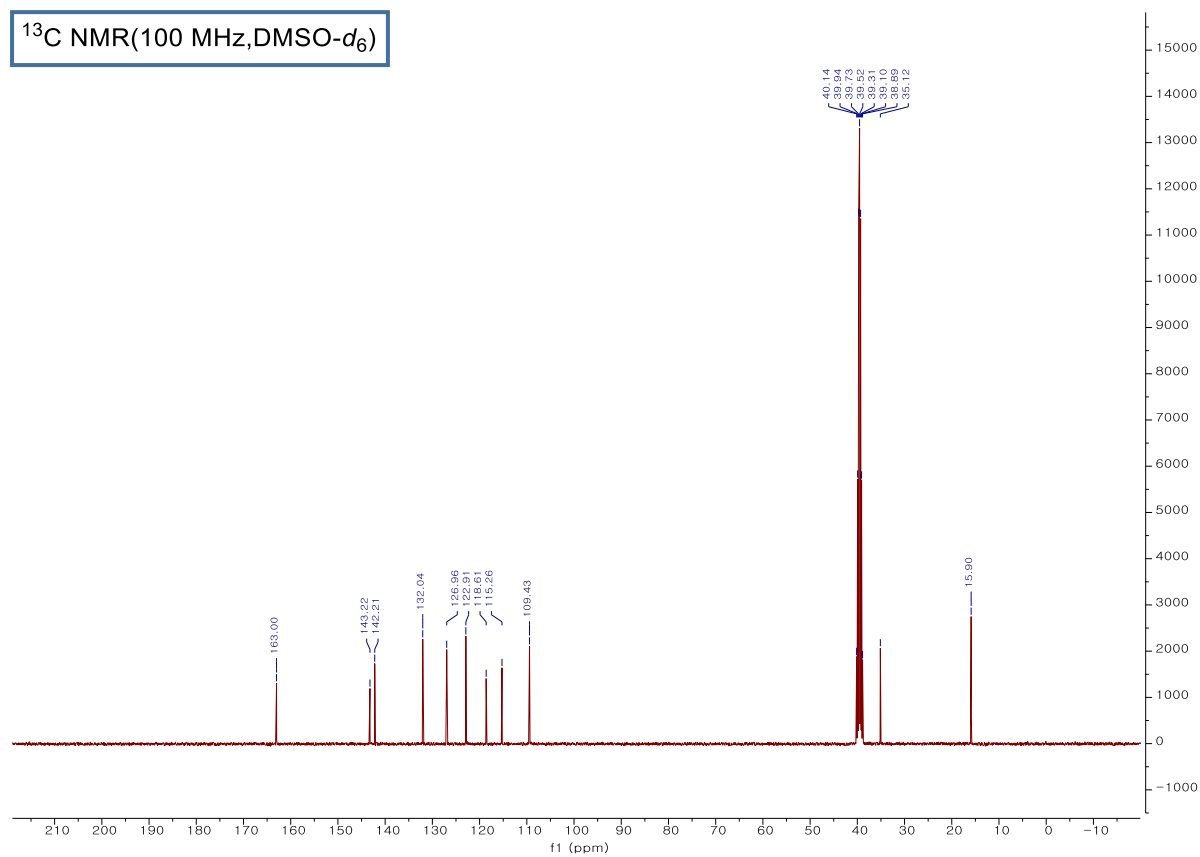
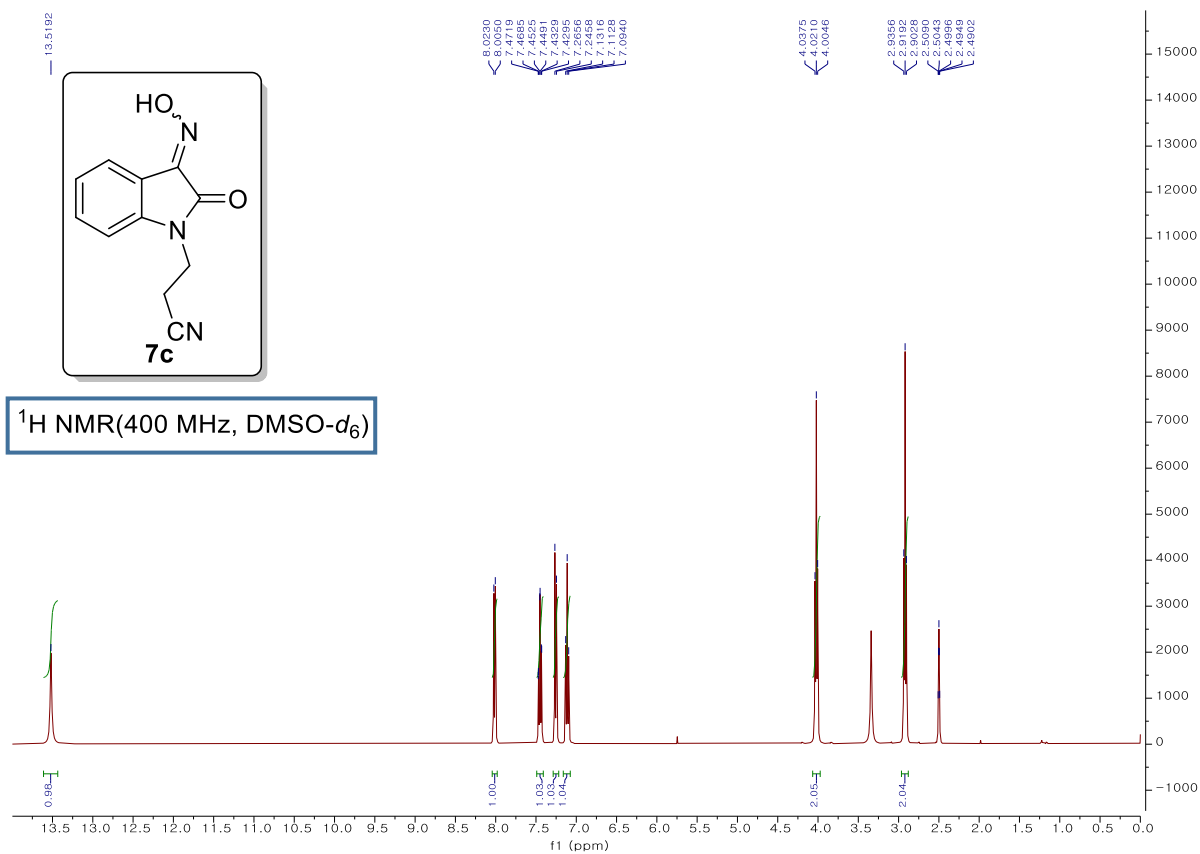


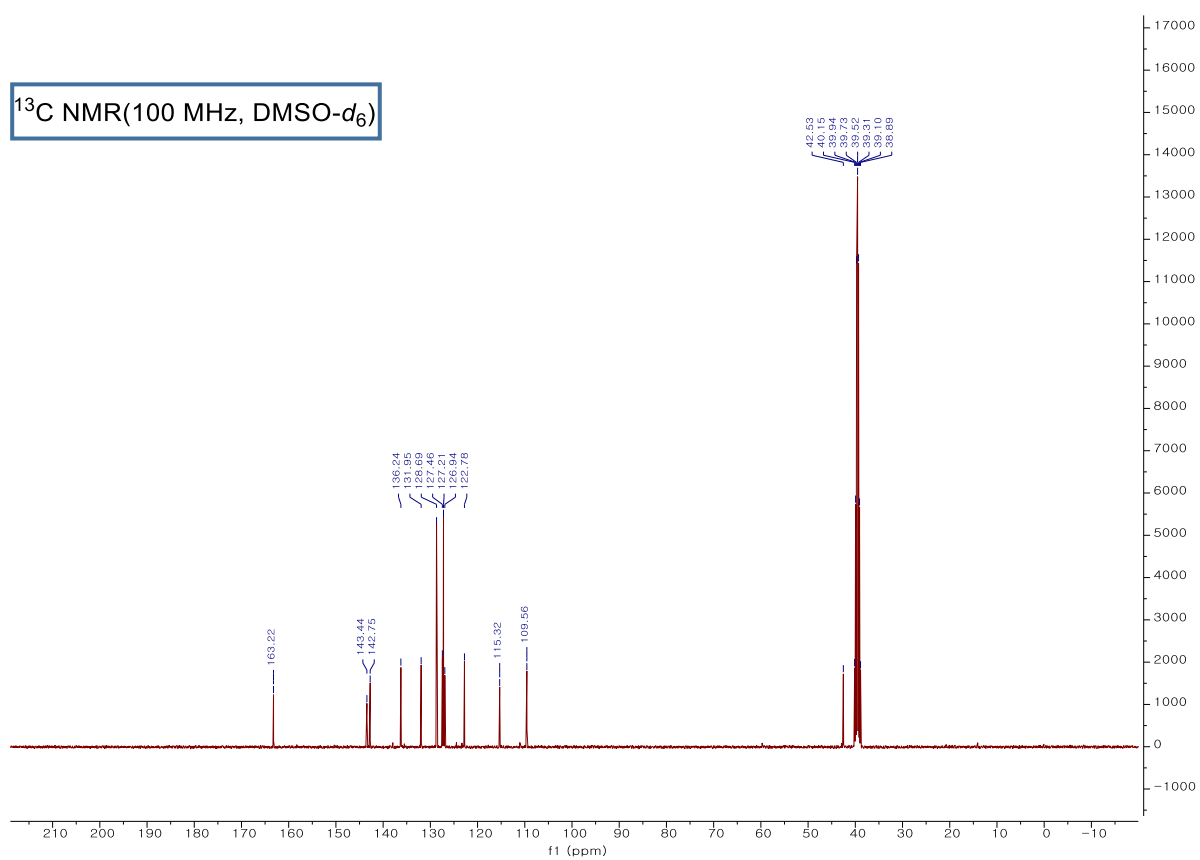
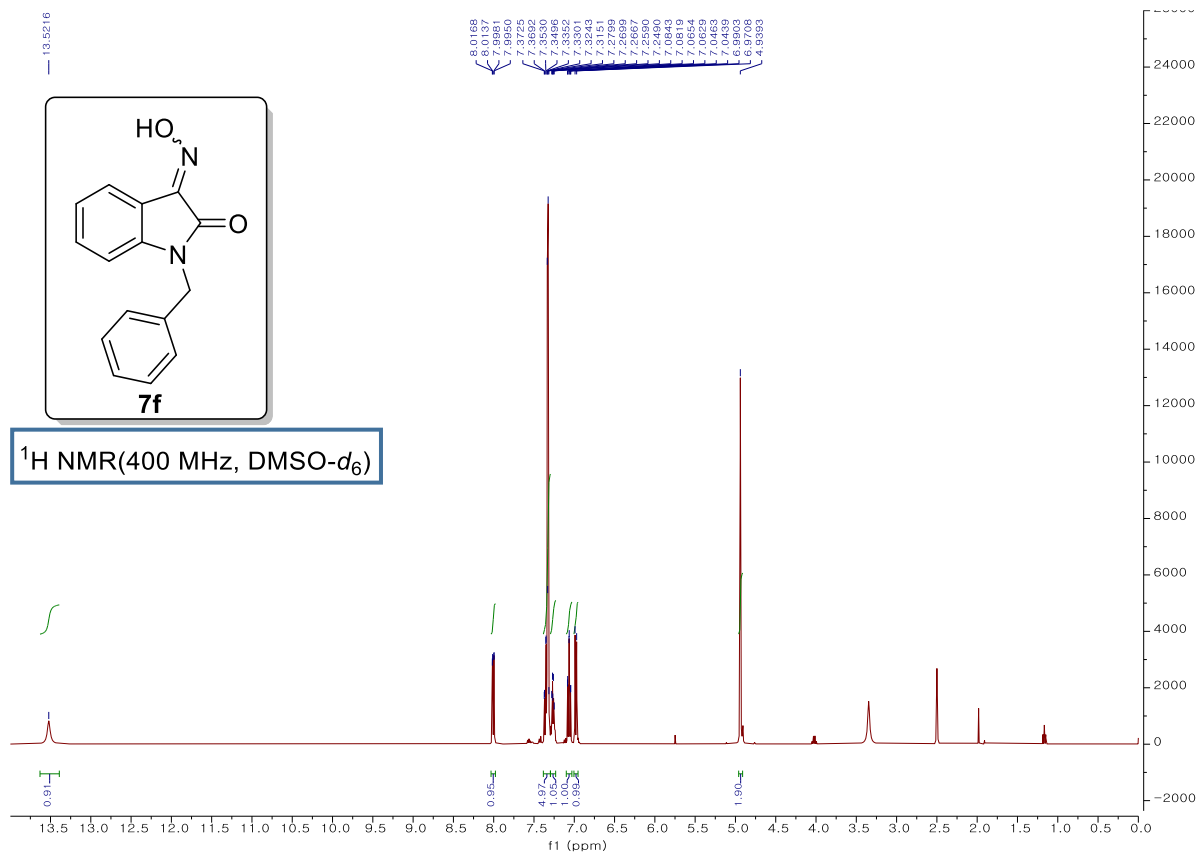
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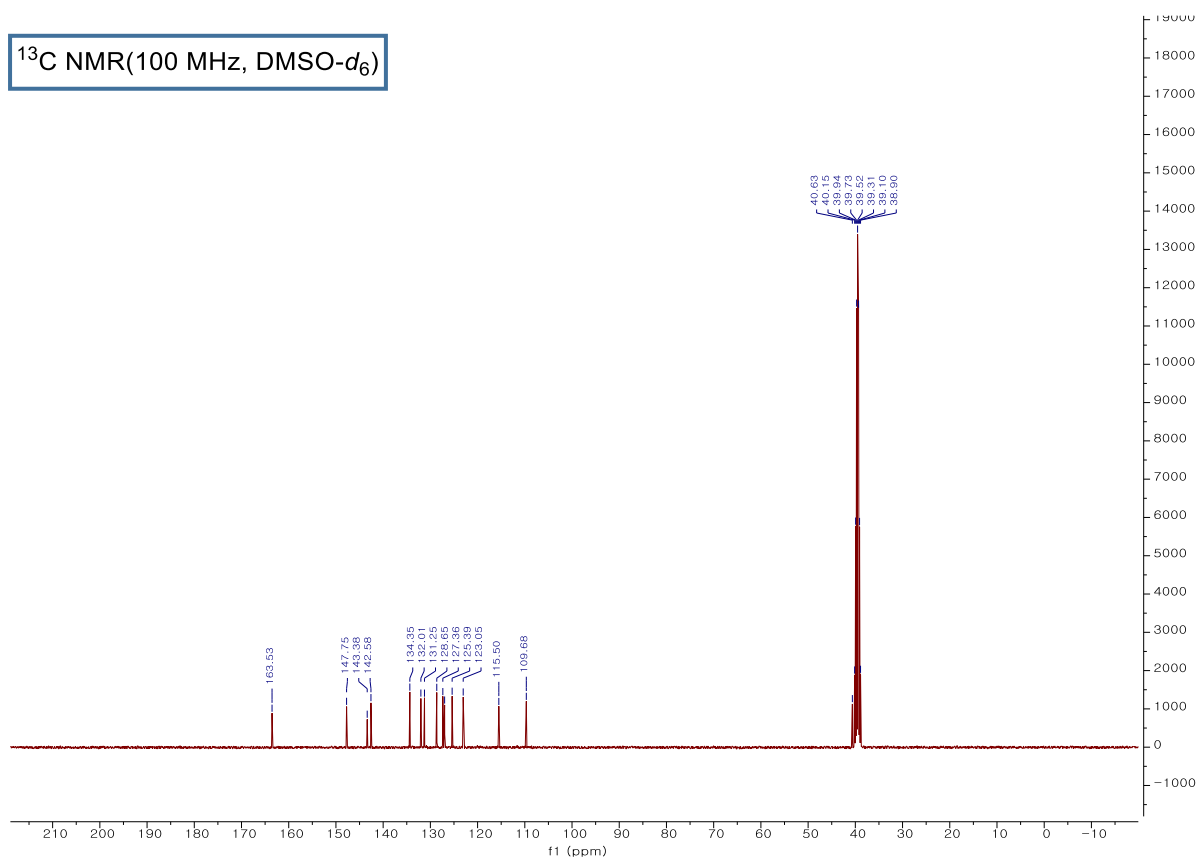
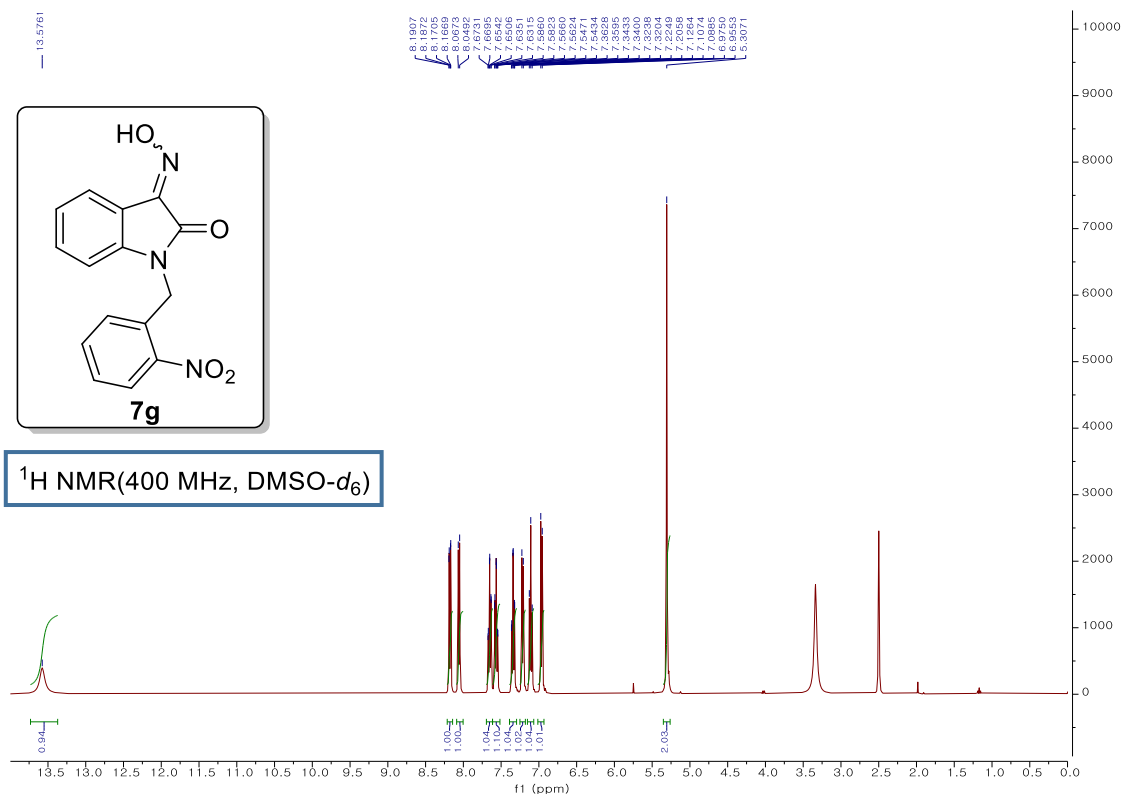


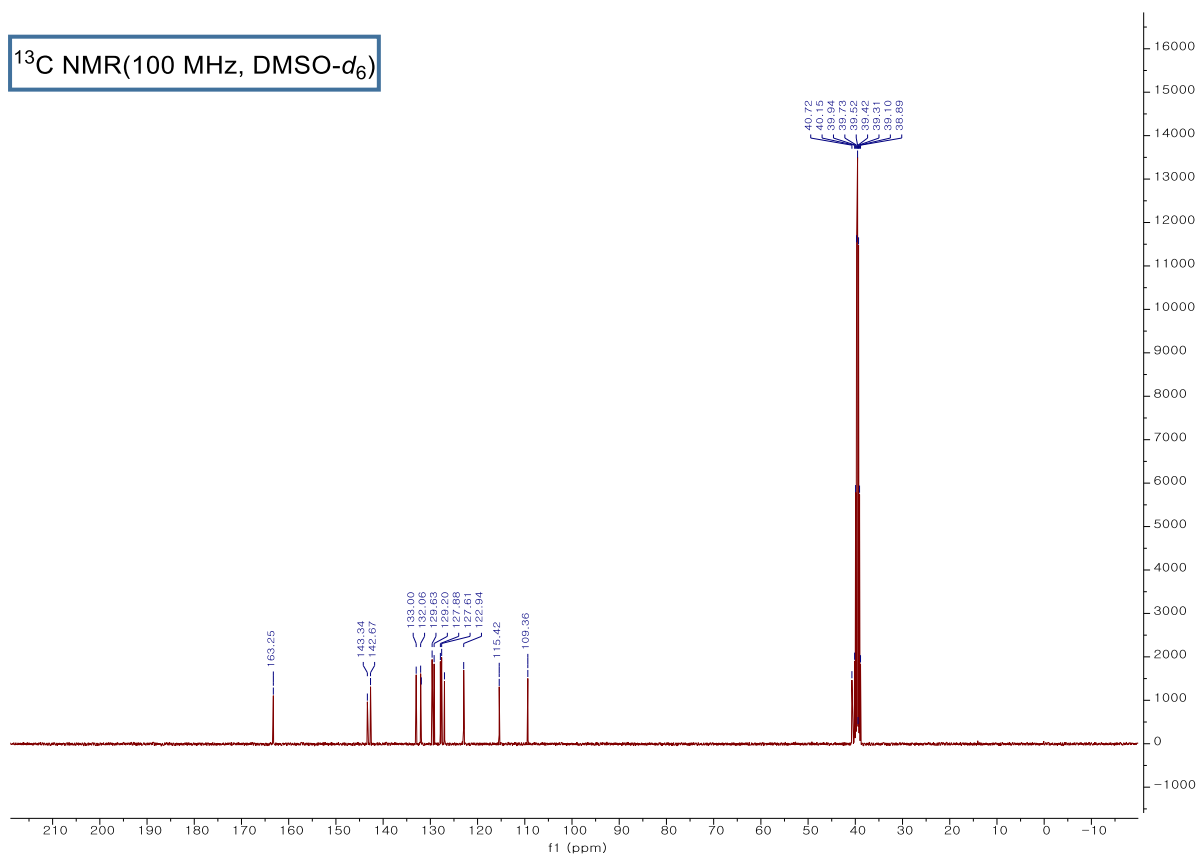
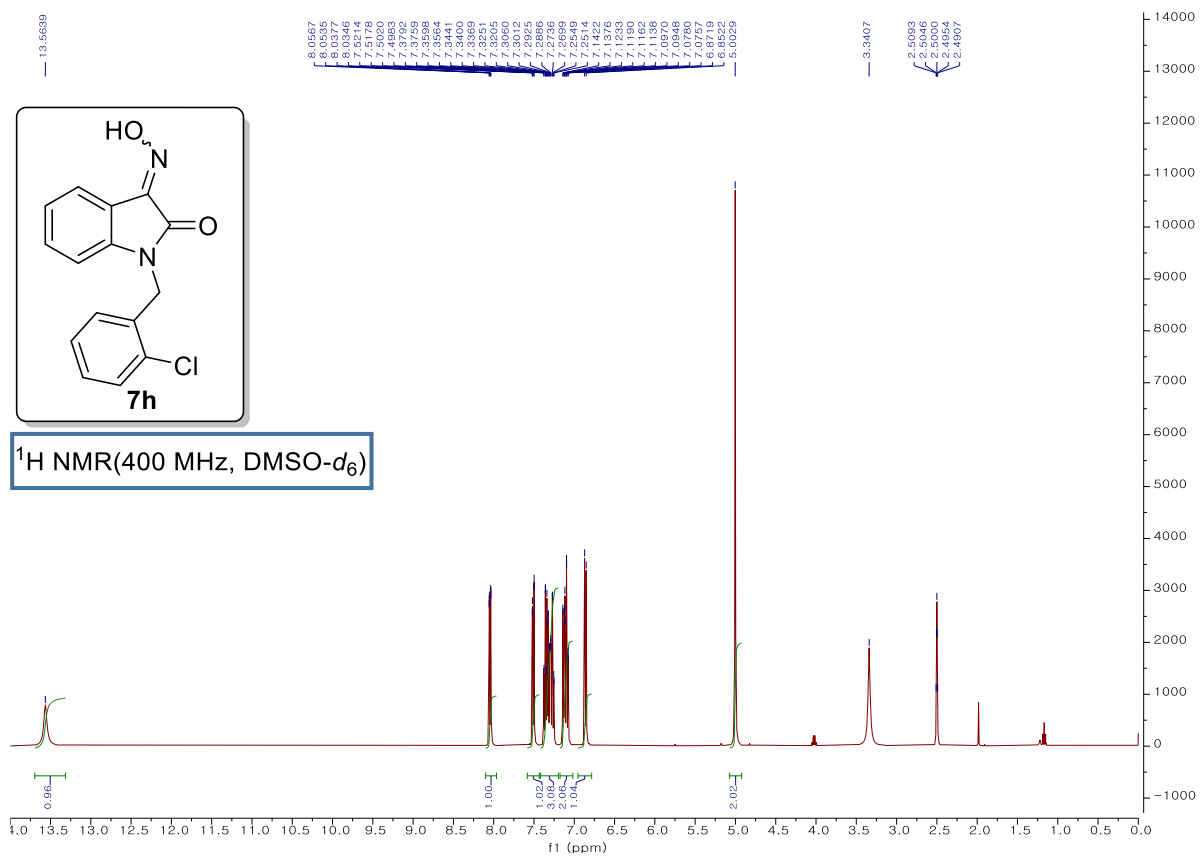
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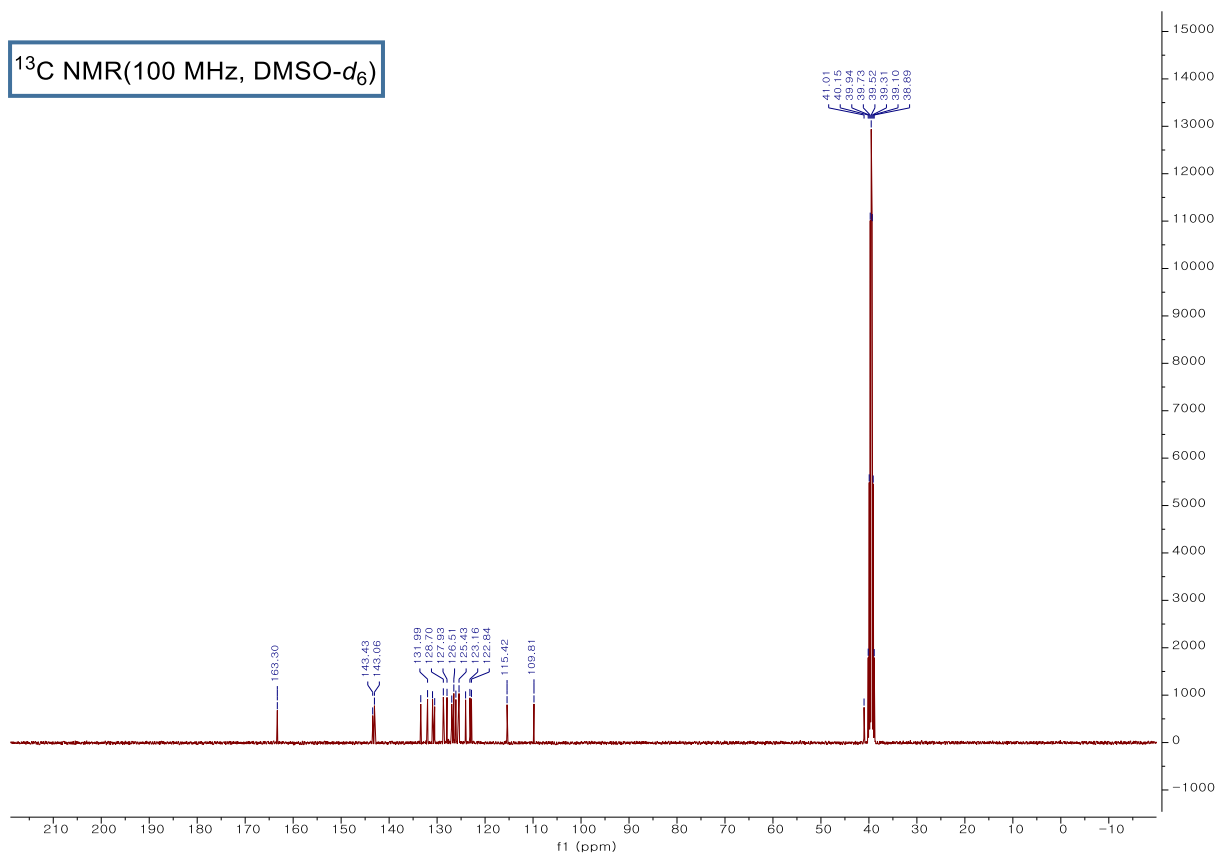
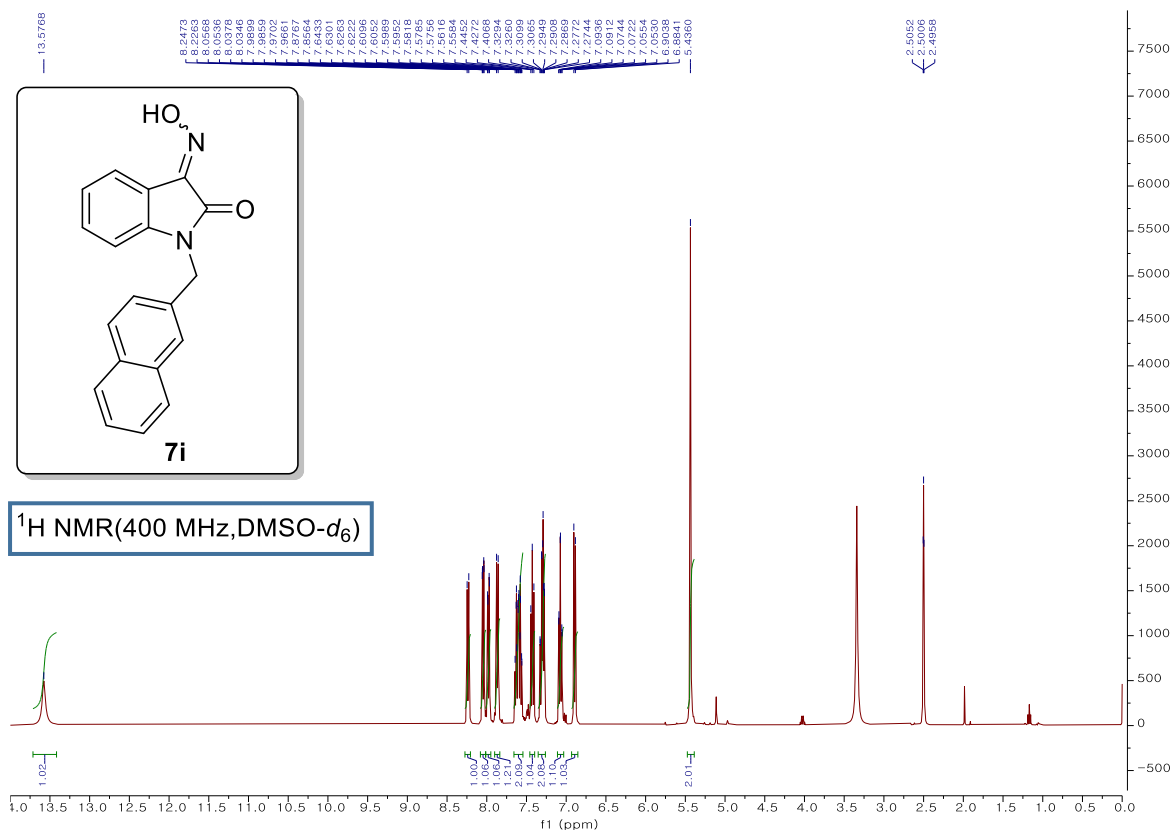


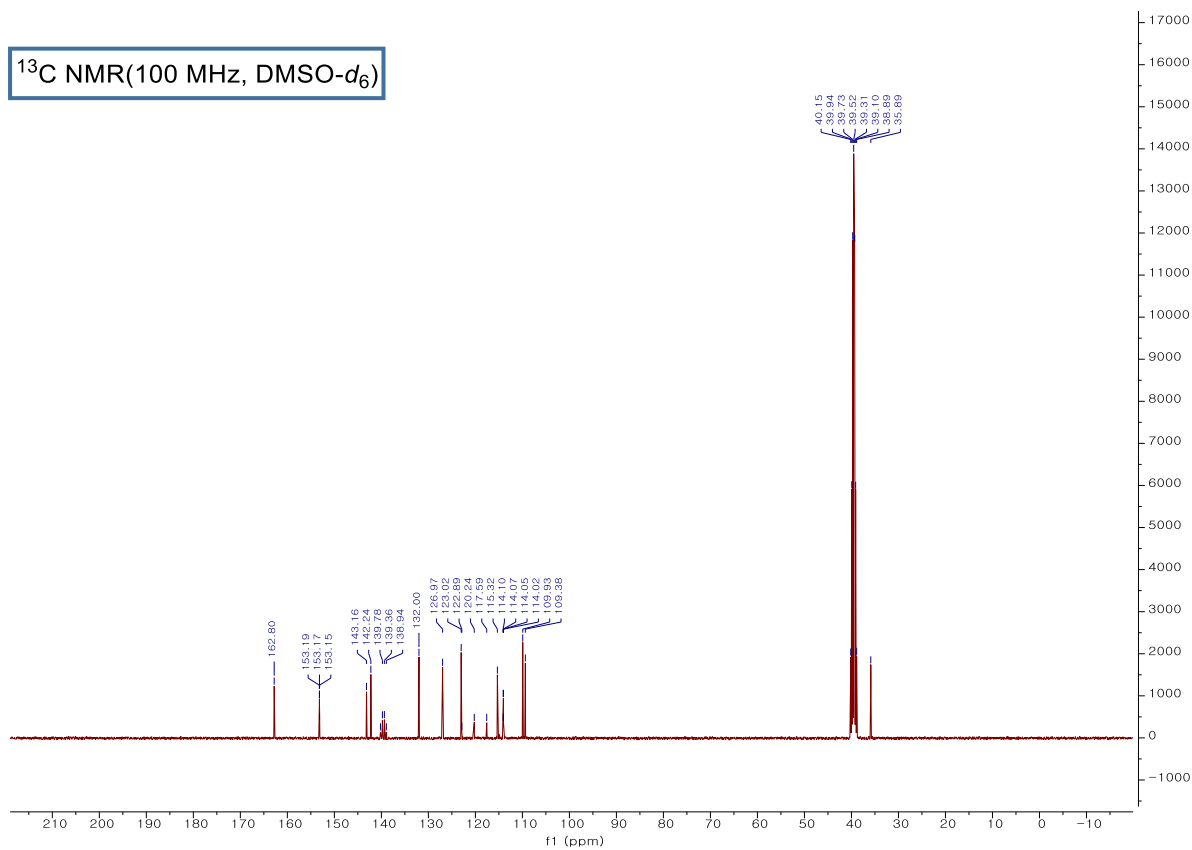
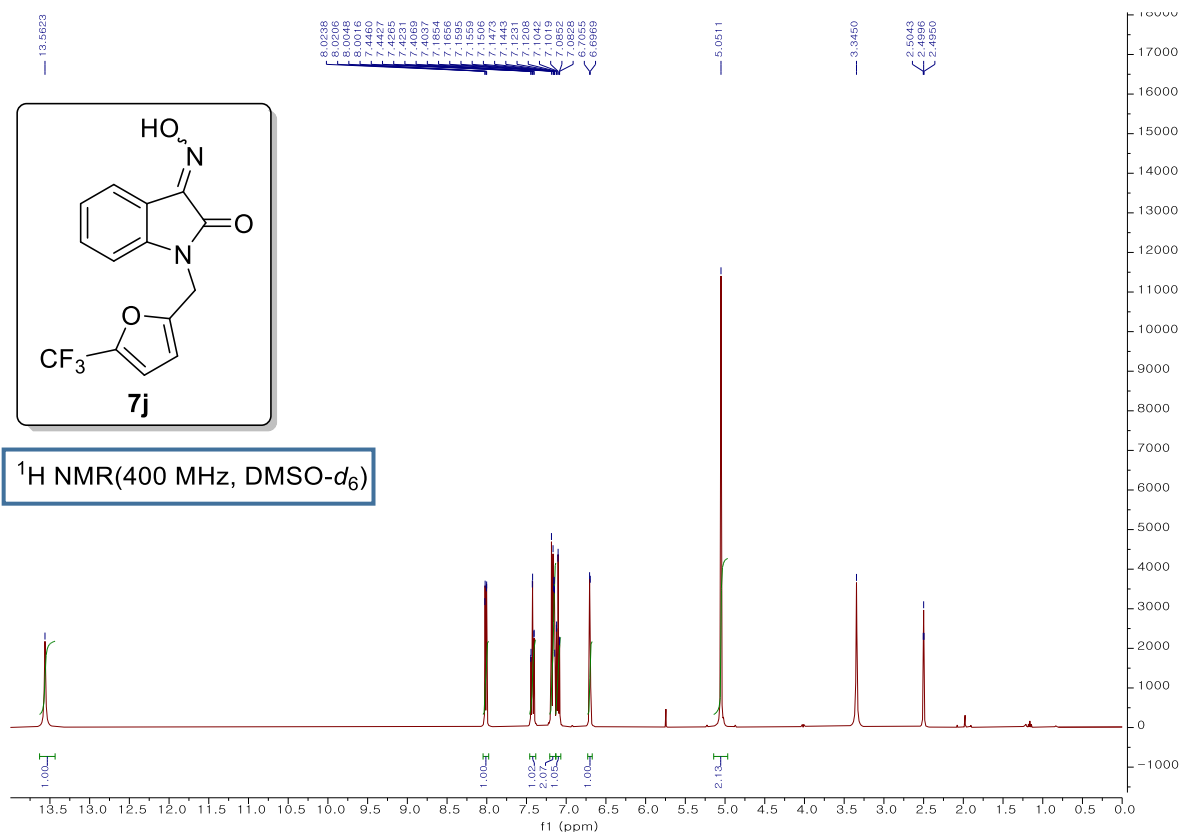


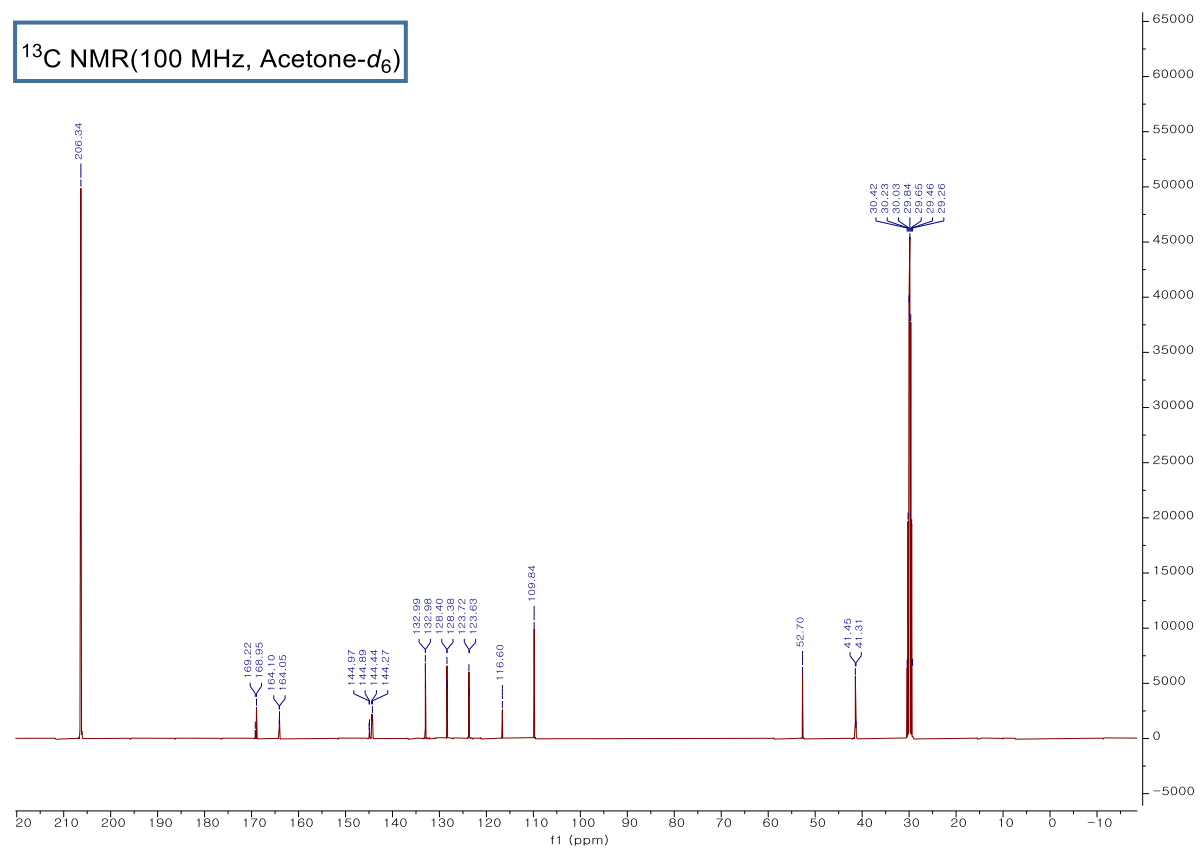
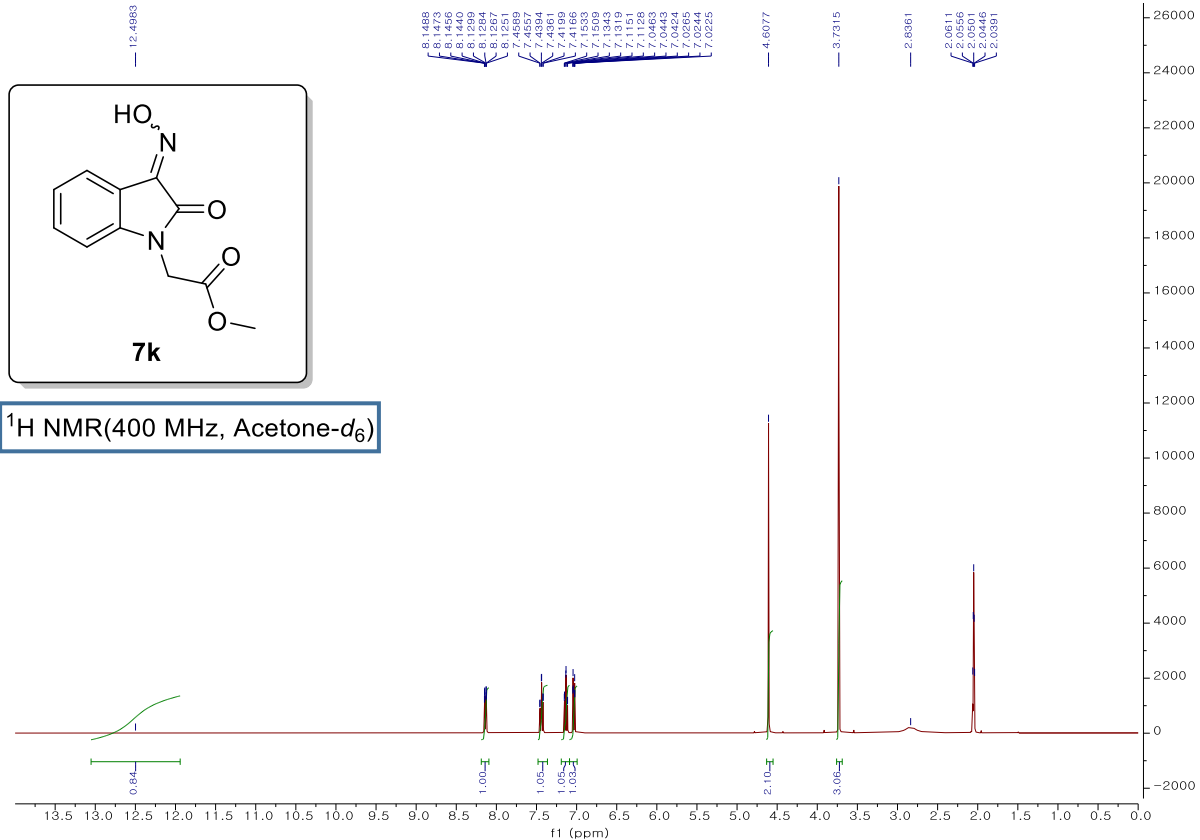


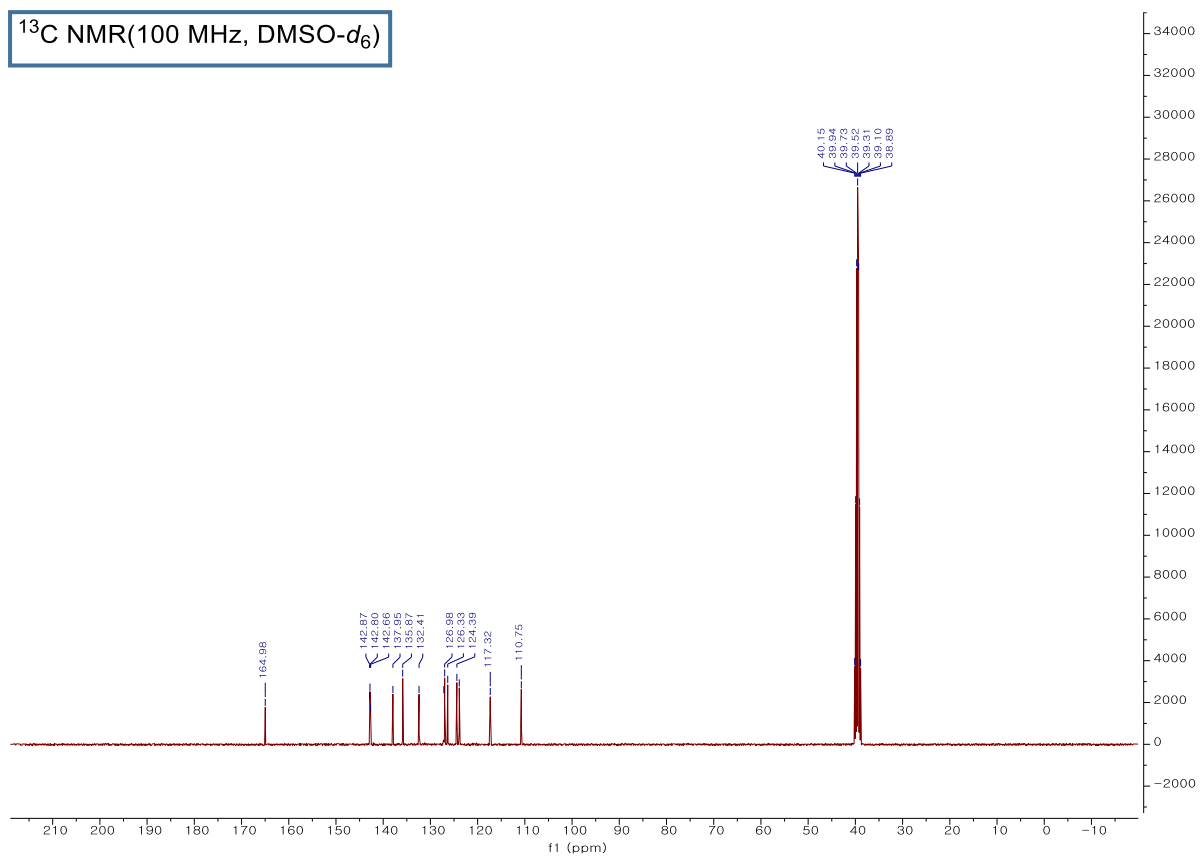
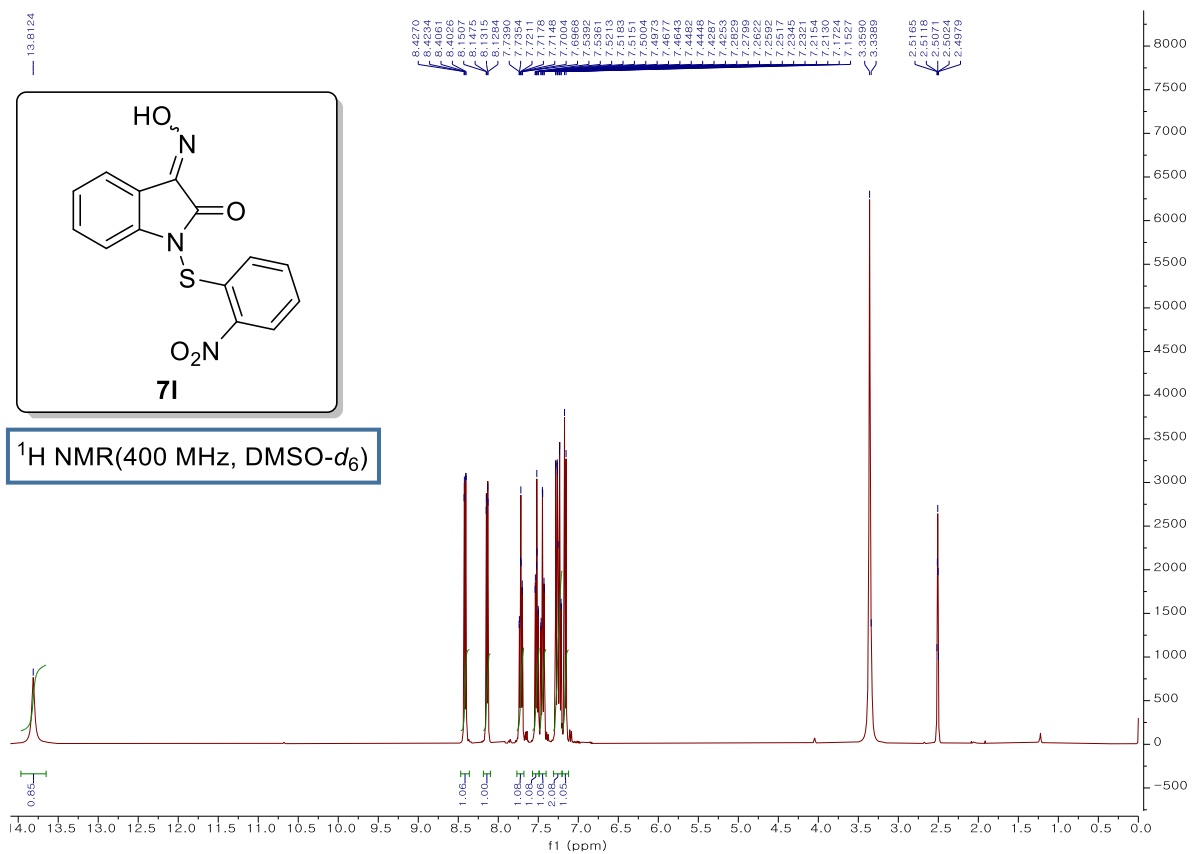


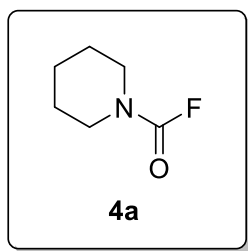




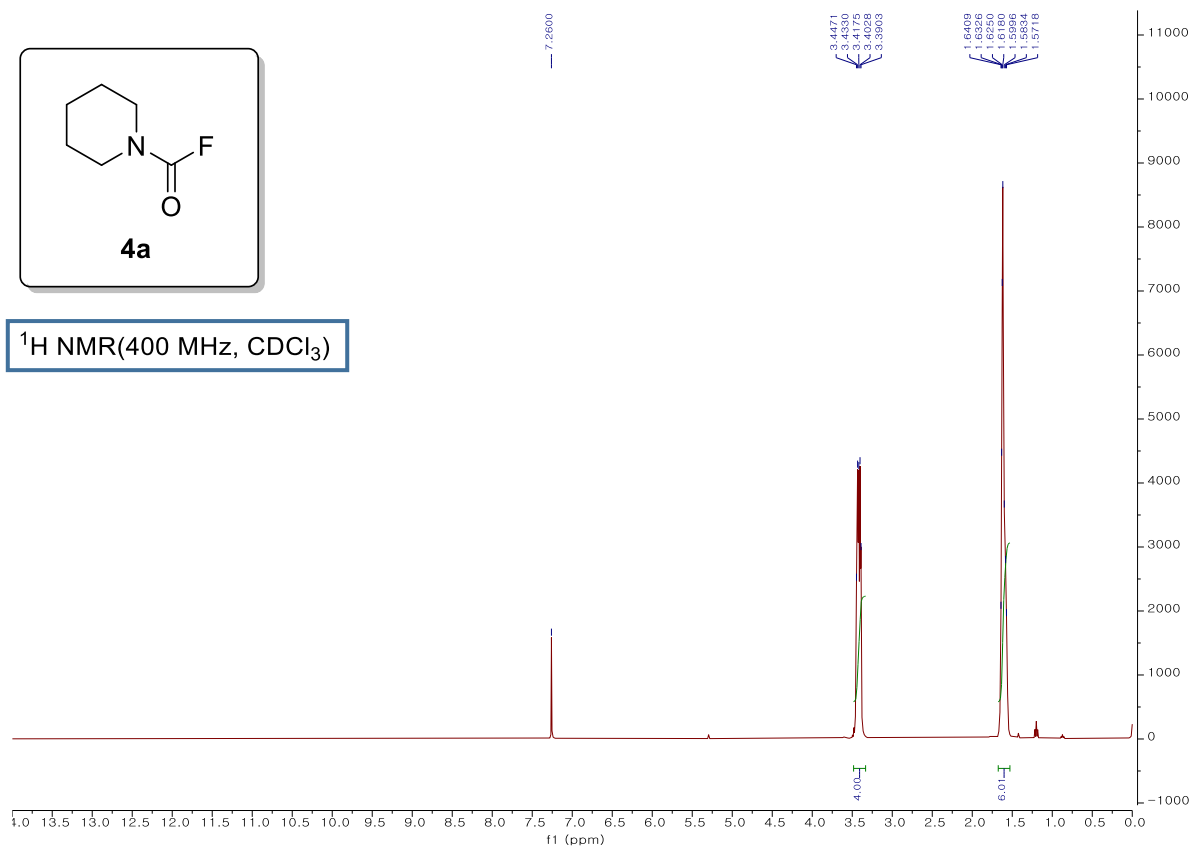




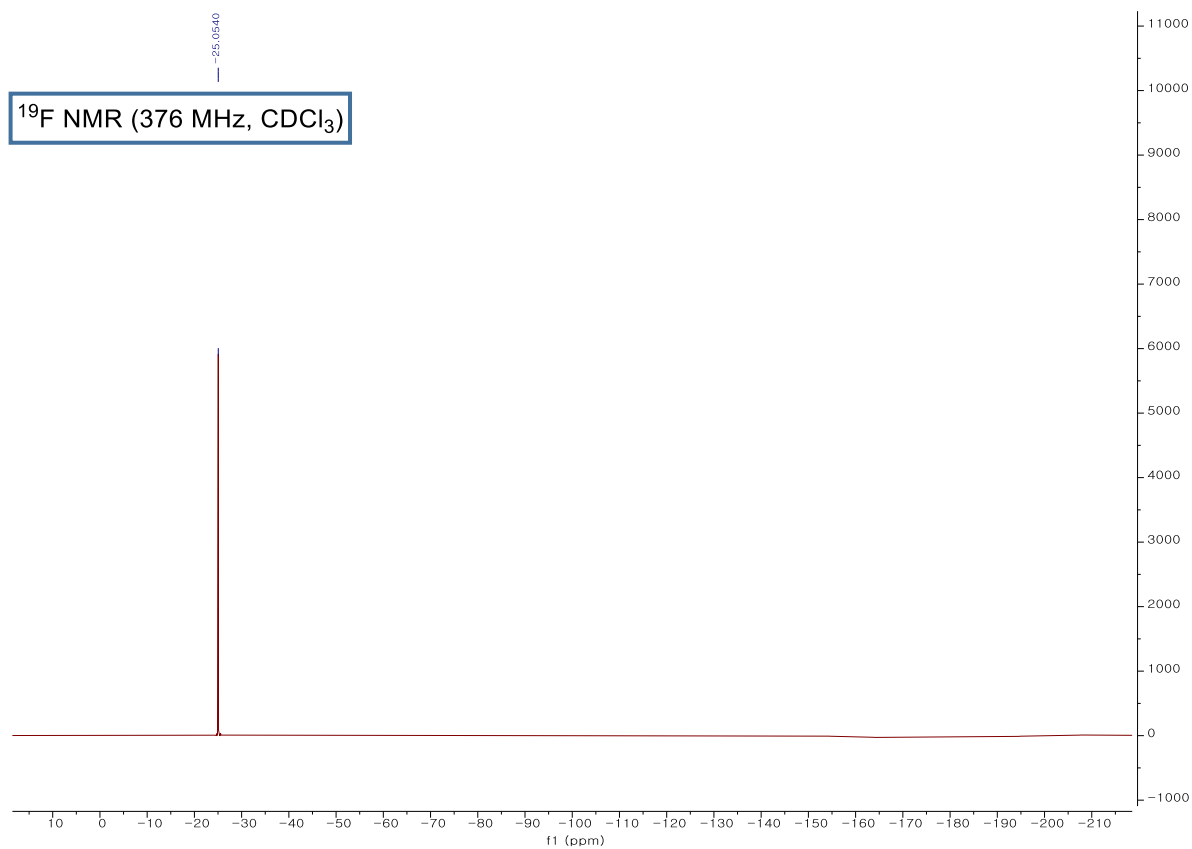


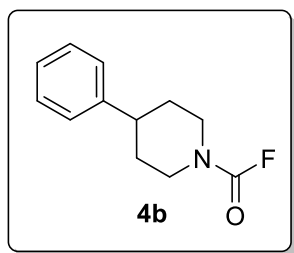


^1H NMR(400 MHz, CDCl_3)

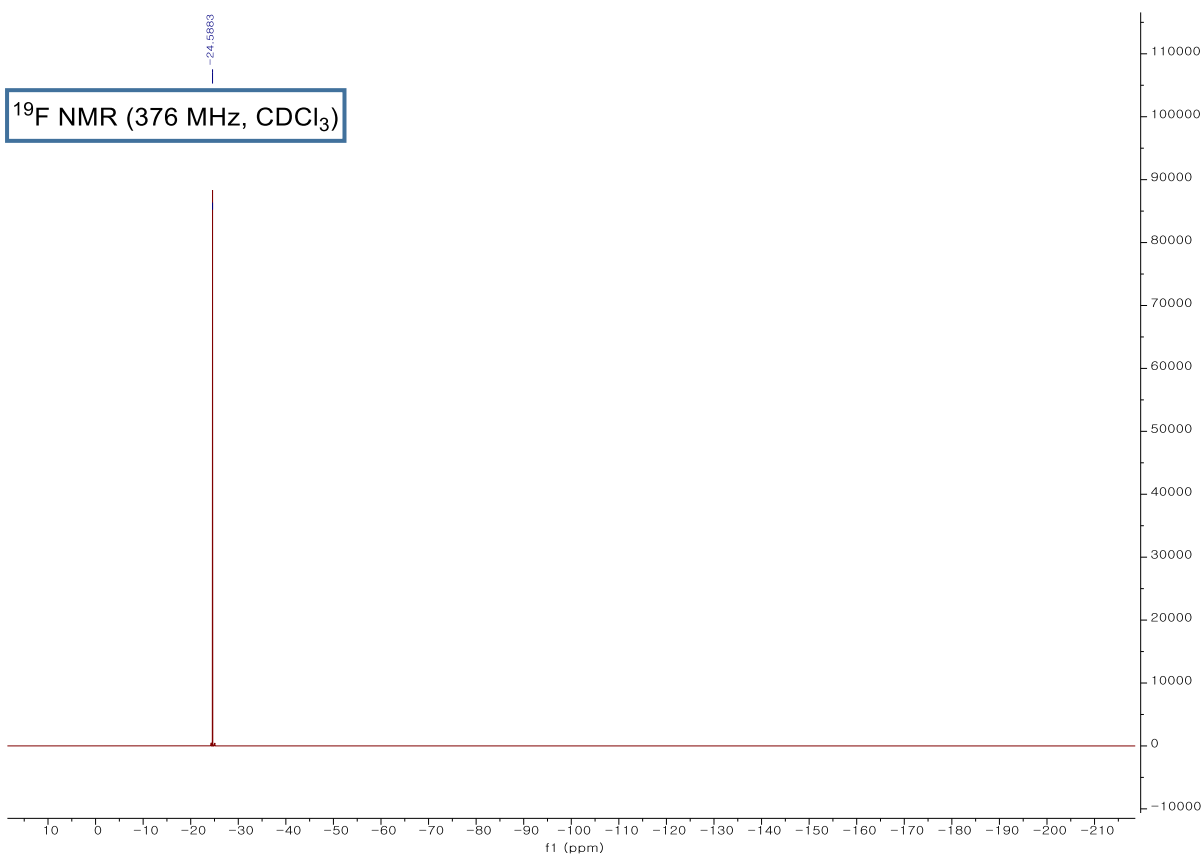
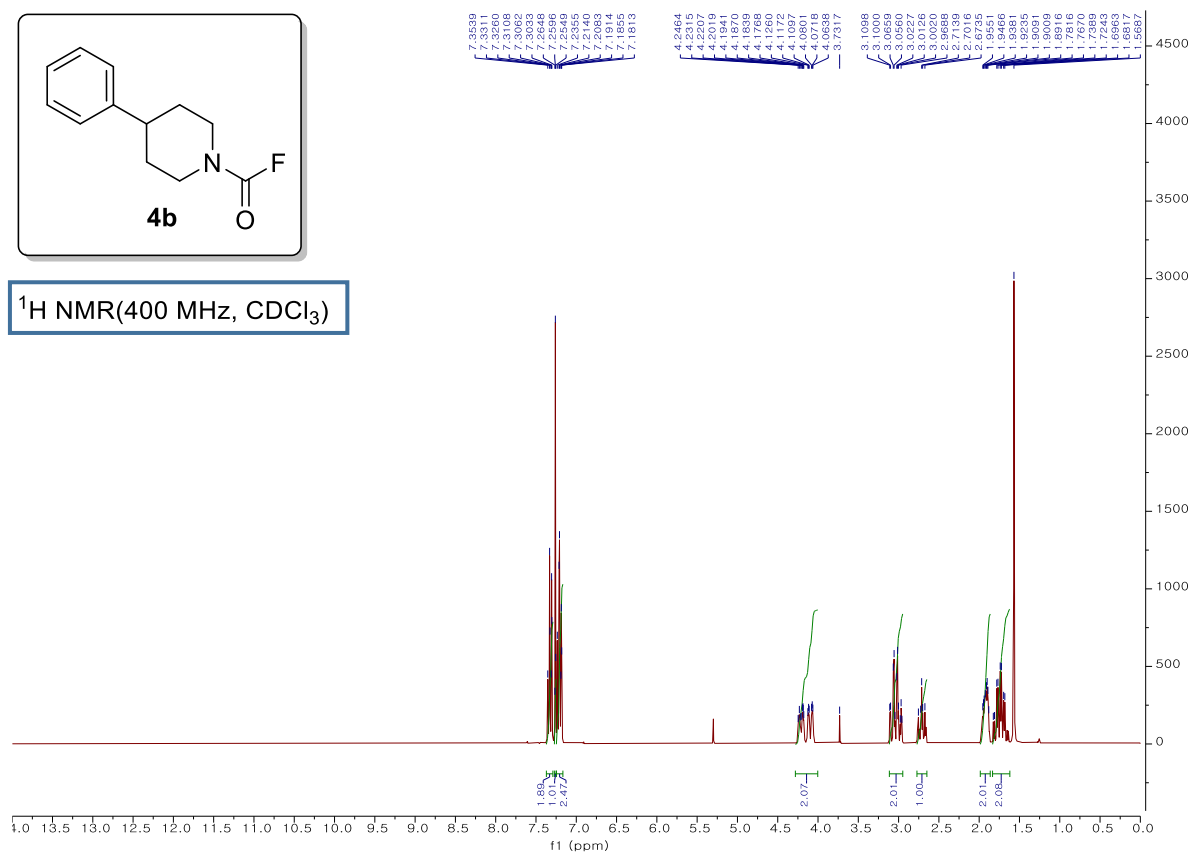


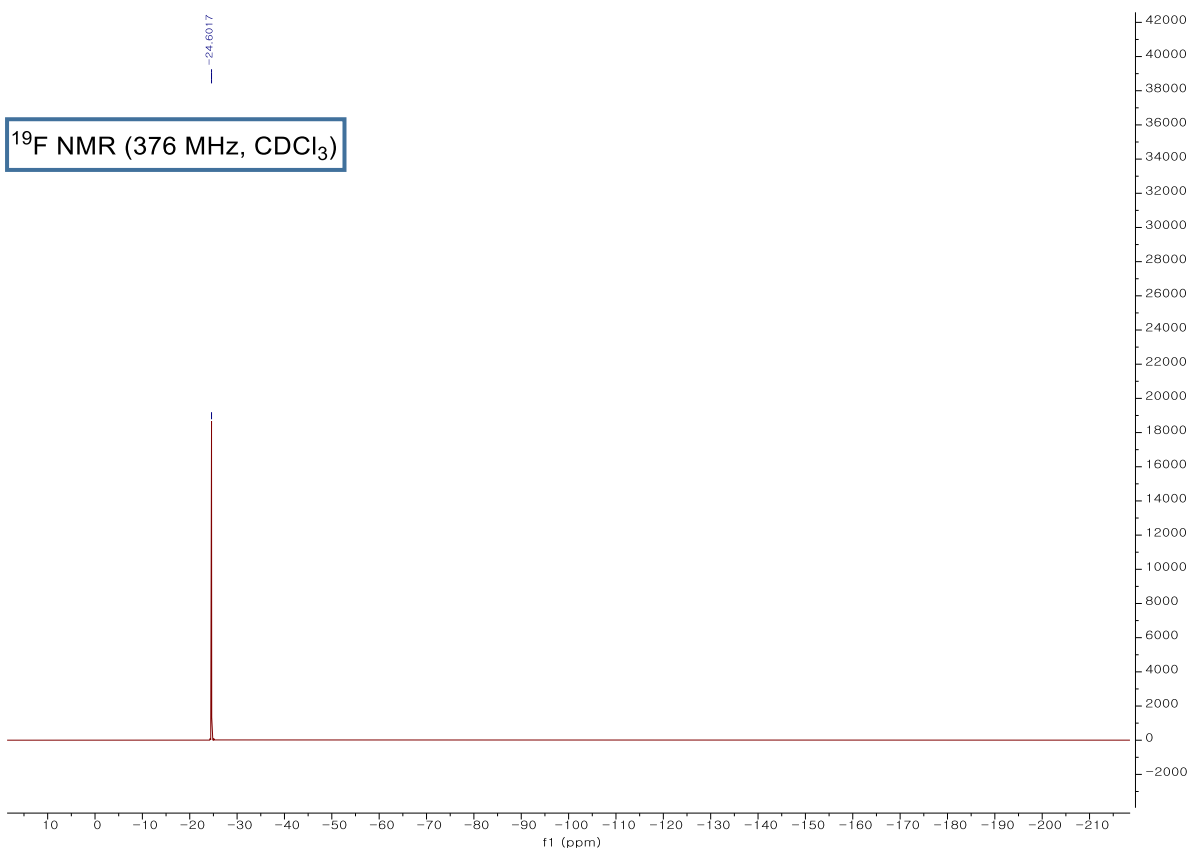
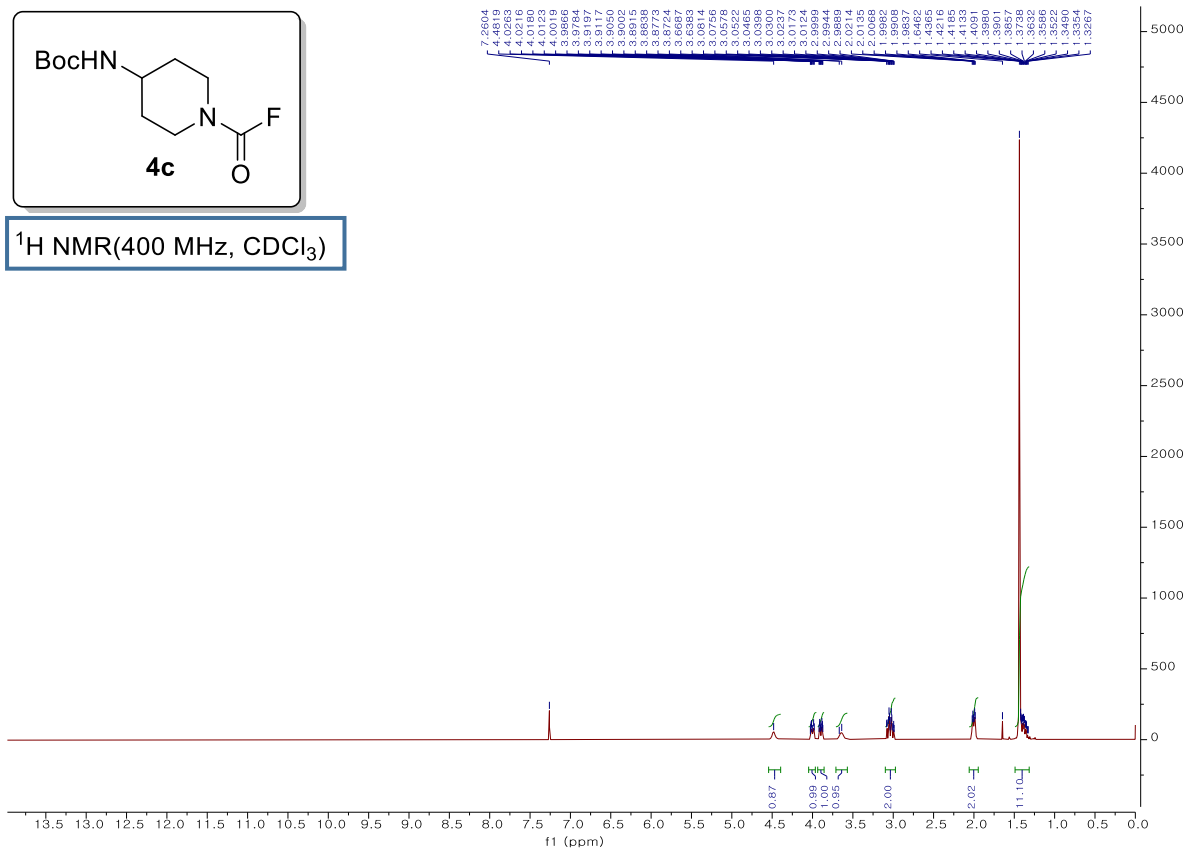
^{19}F NMR (376 MHz, CDCl_3)

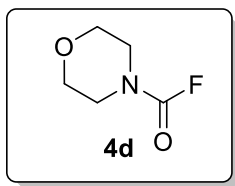




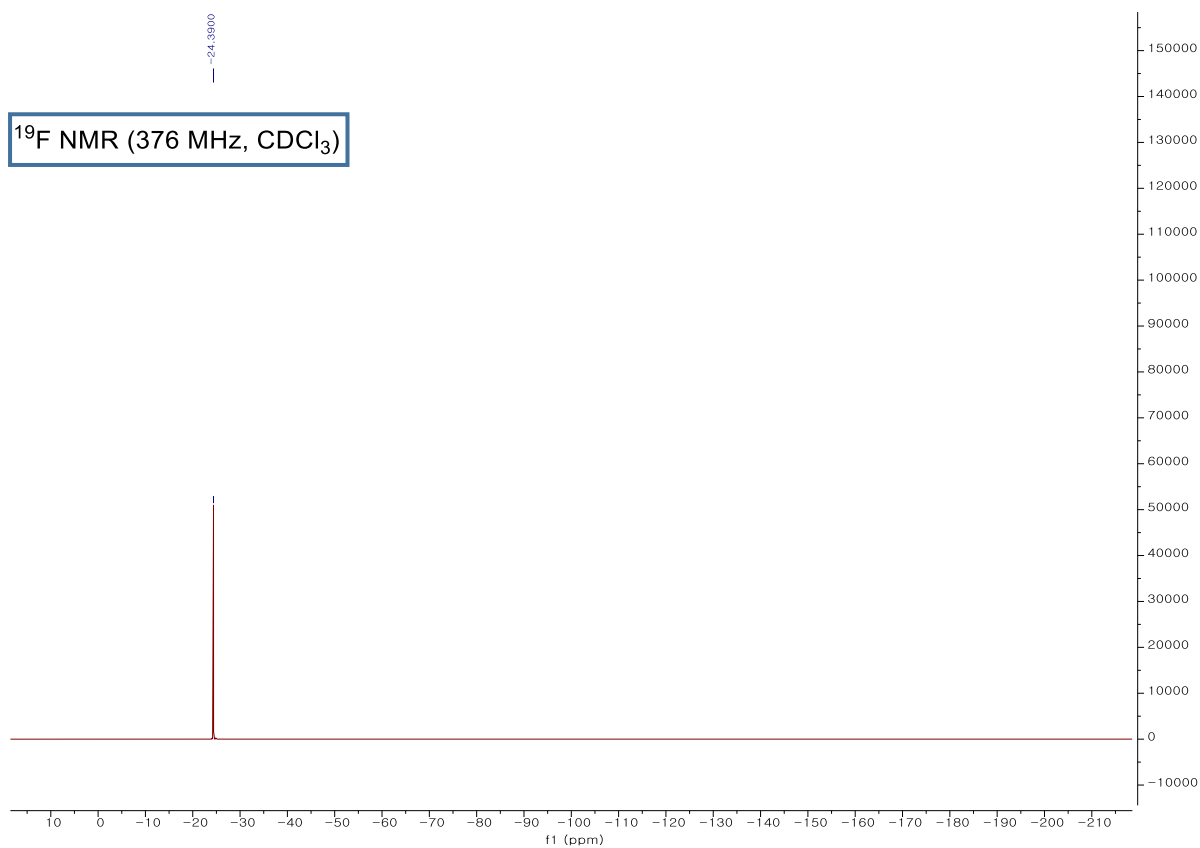
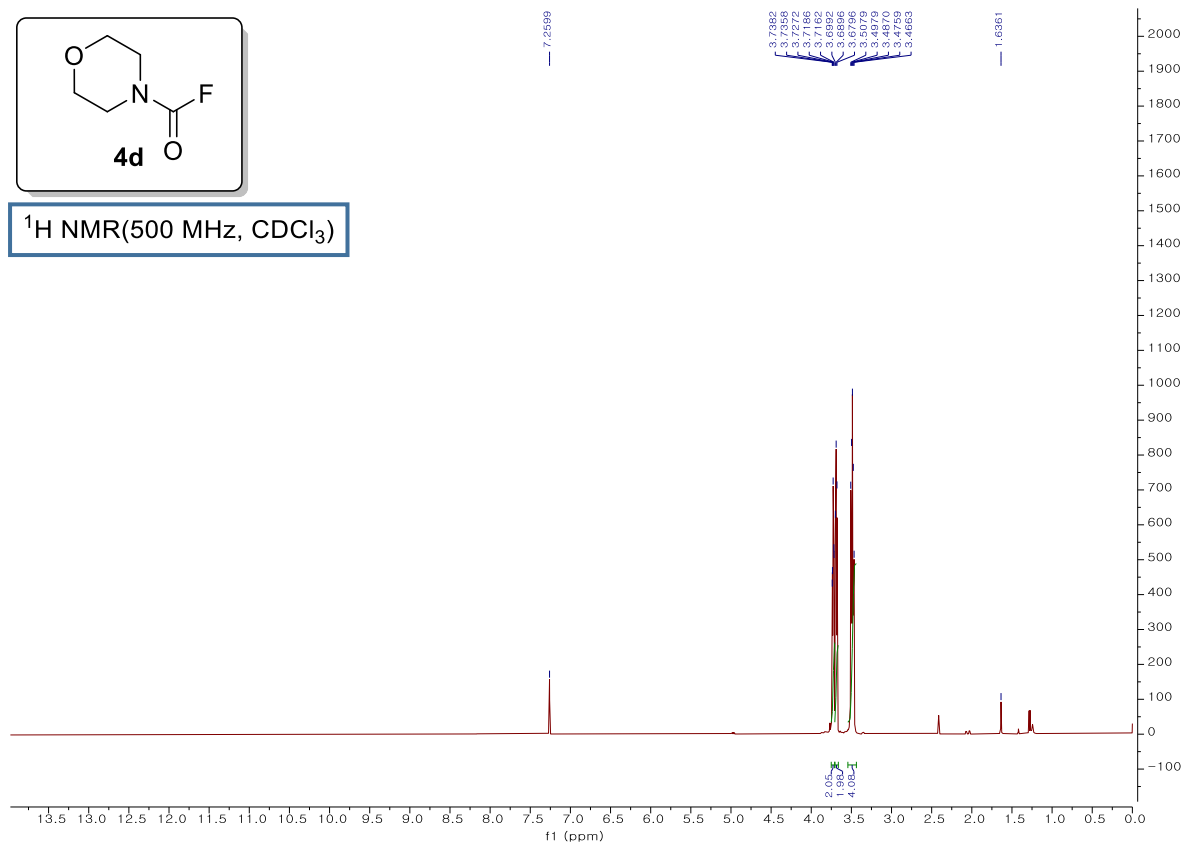
^1H NMR(400 MHz, CDCl_3)



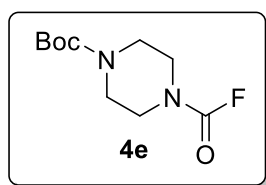




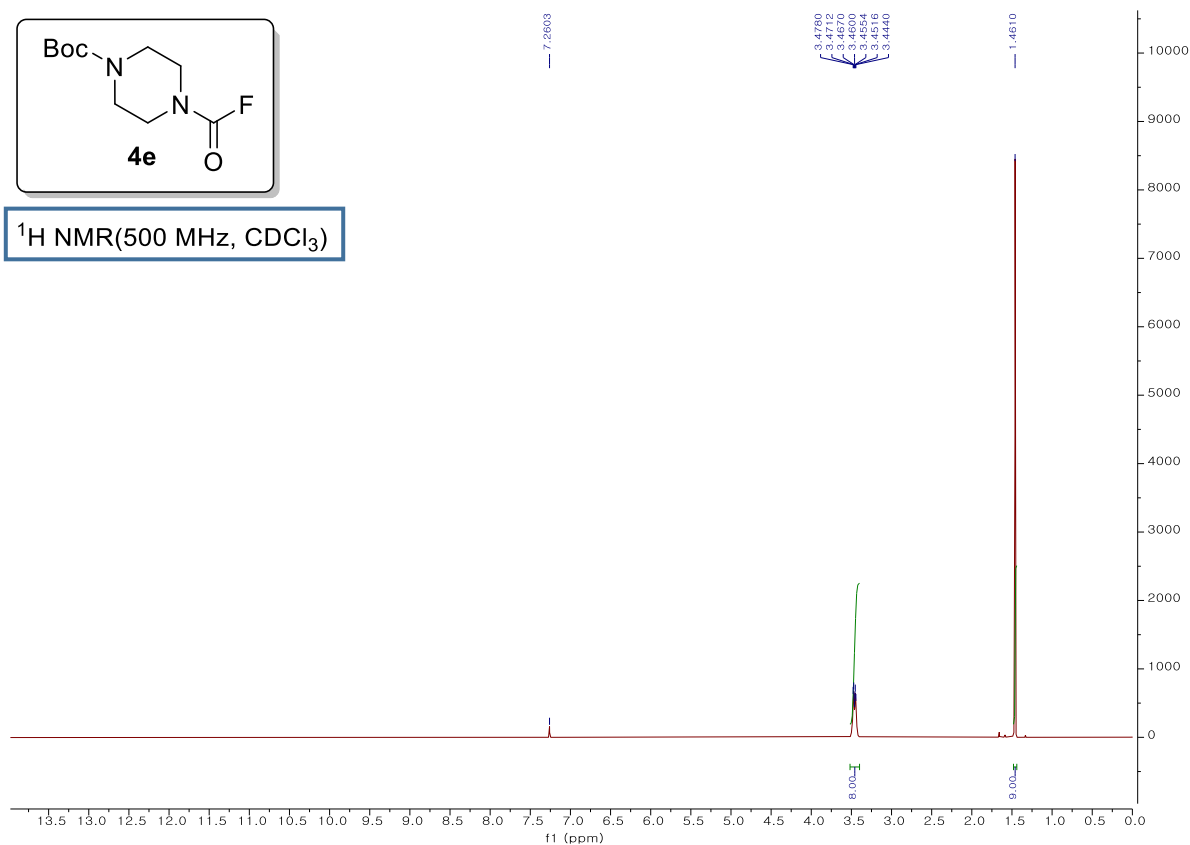
^1H NMR(500 MHz, CDCl_3)



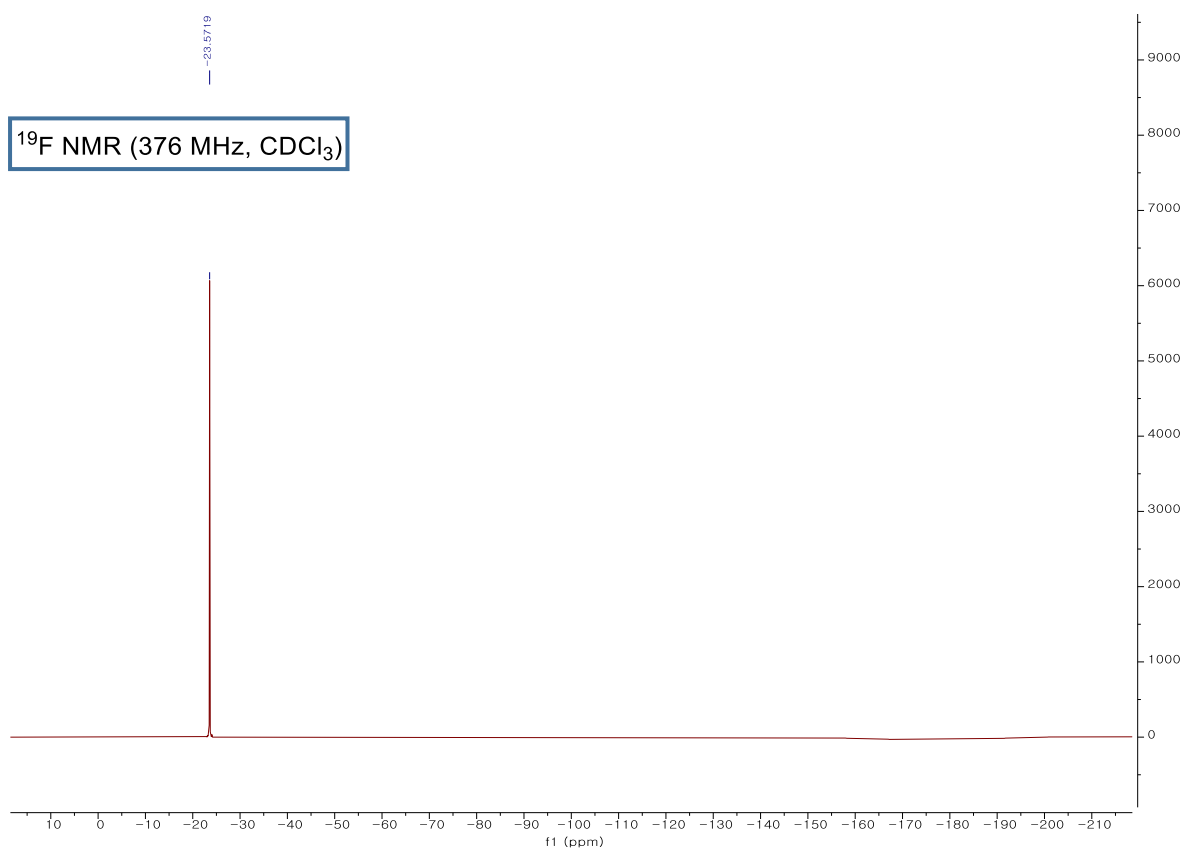
^{19}F NMR (376 MHz, CDCl_3)

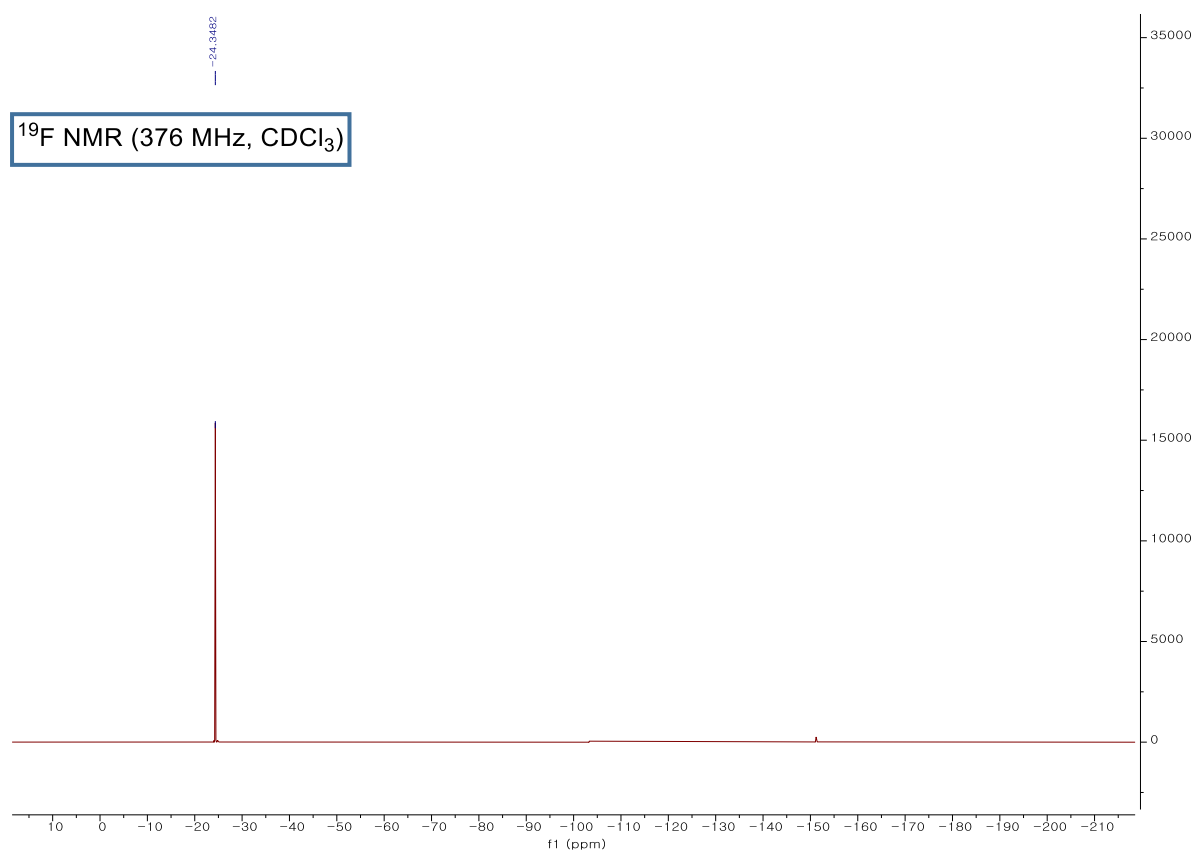
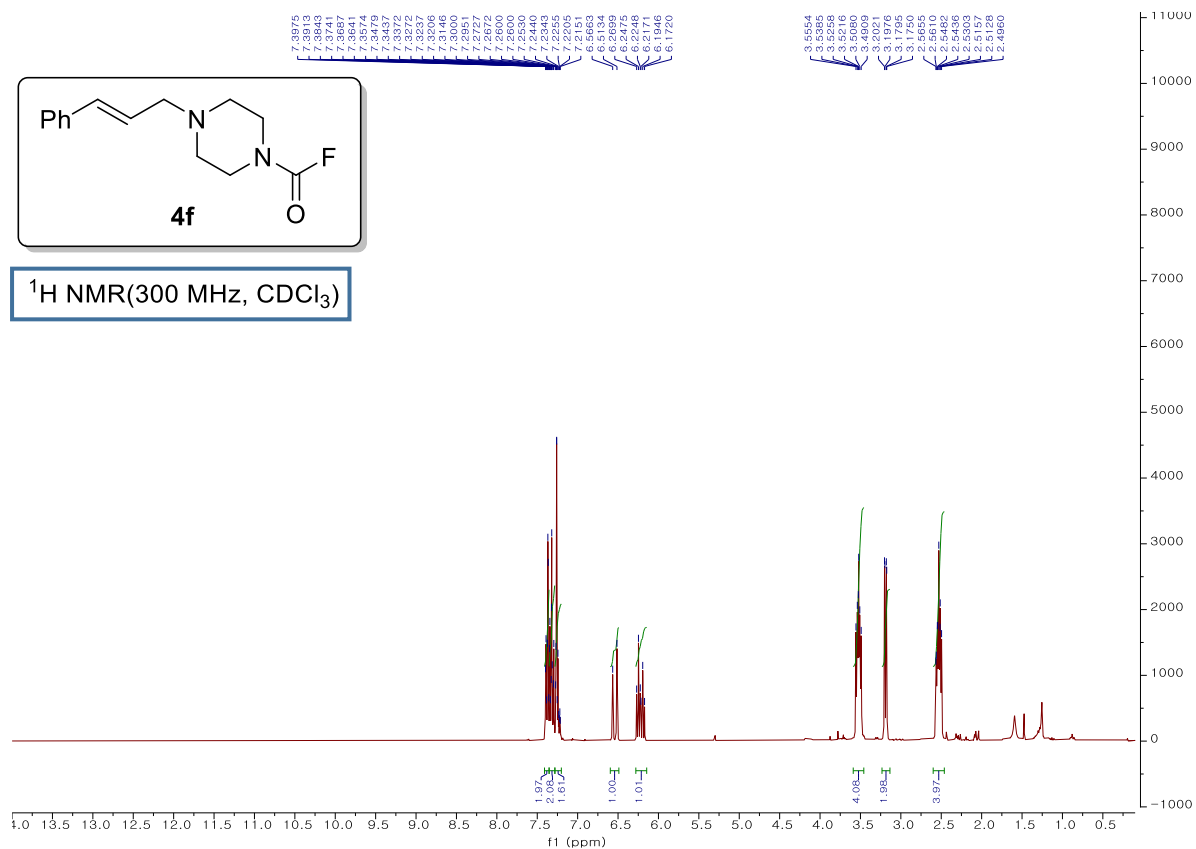


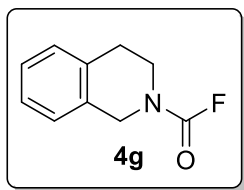
^1H NMR (500 MHz, CDCl_3)



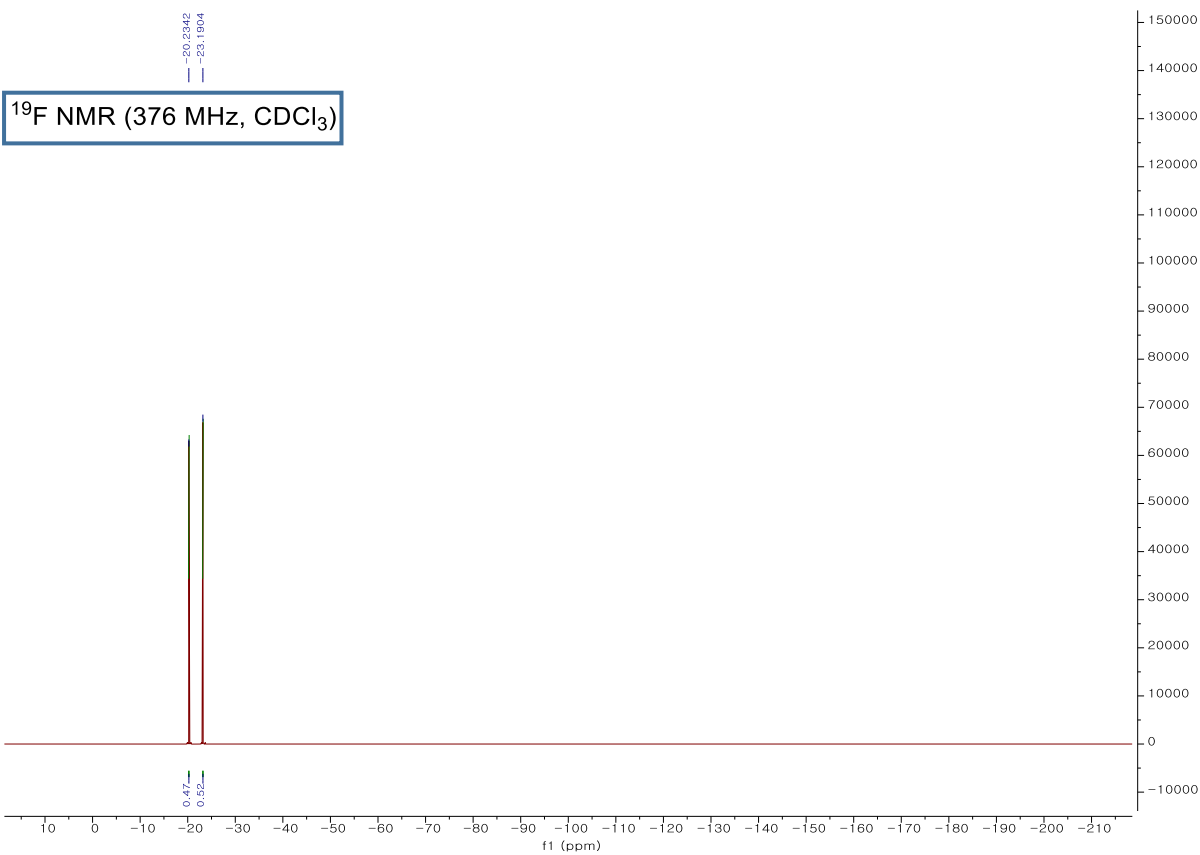
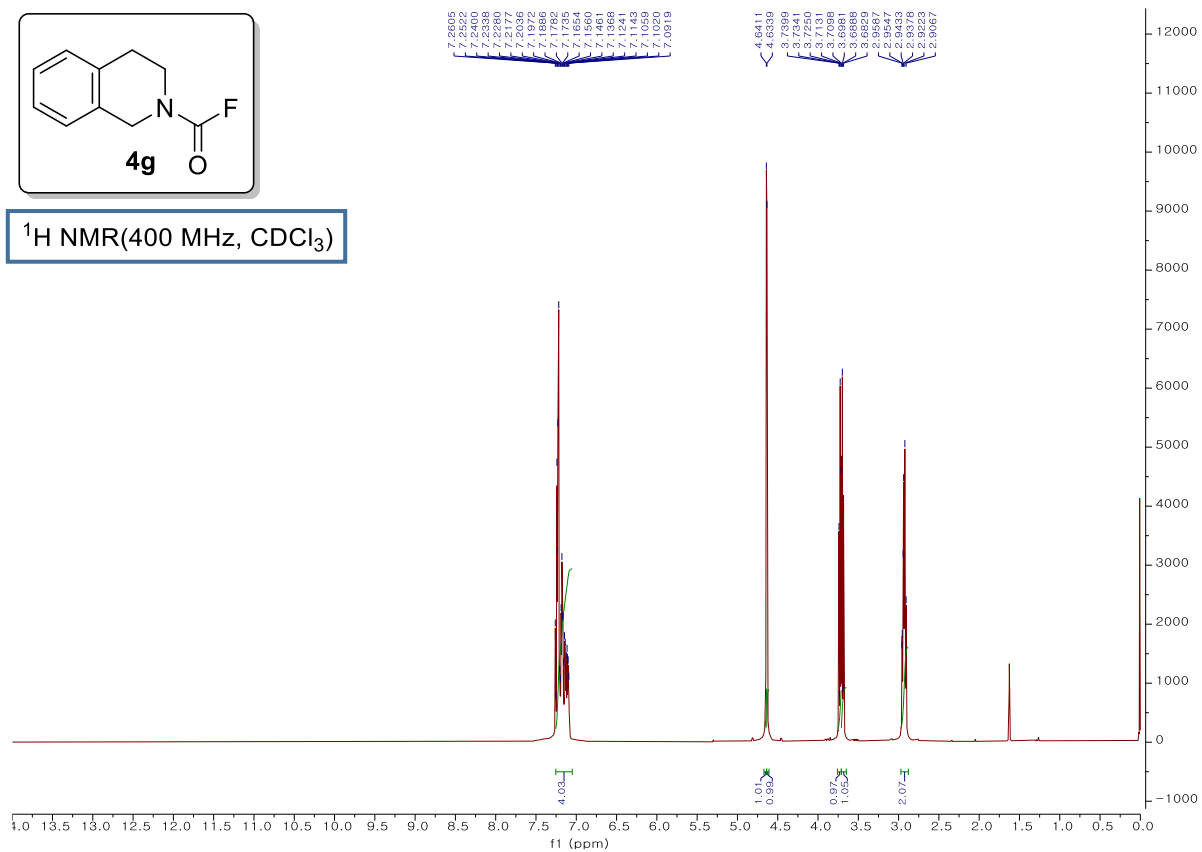
^{19}F NMR (376 MHz, CDCl_3)

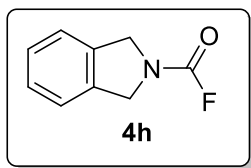




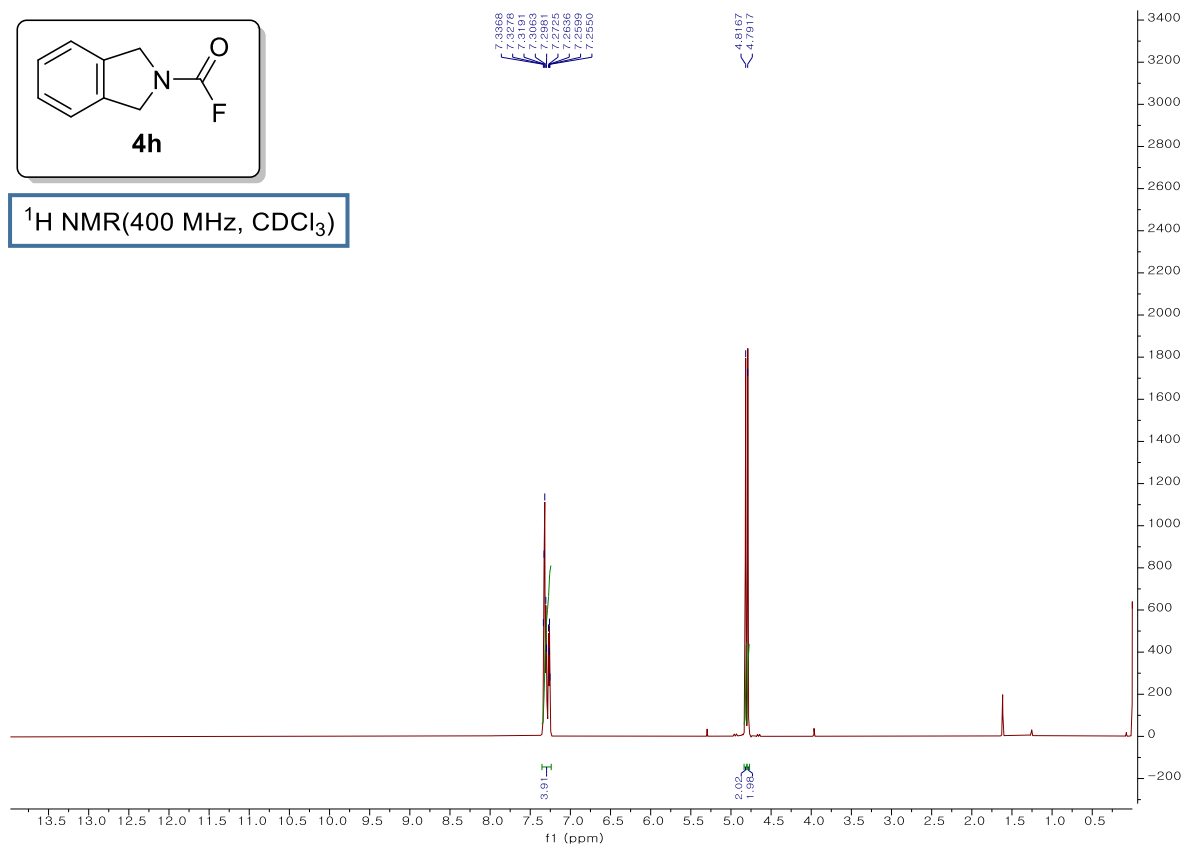


¹H NMR(400 MHz, CDCl₃)

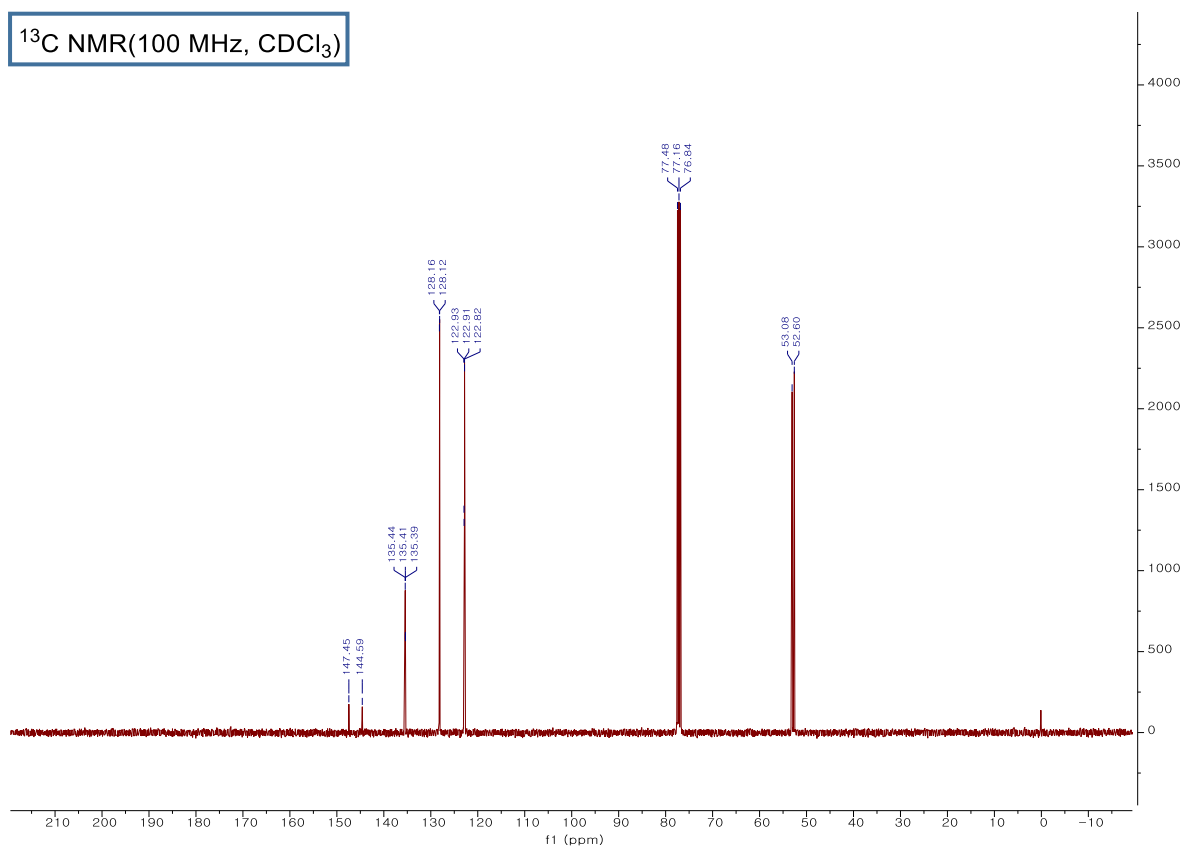


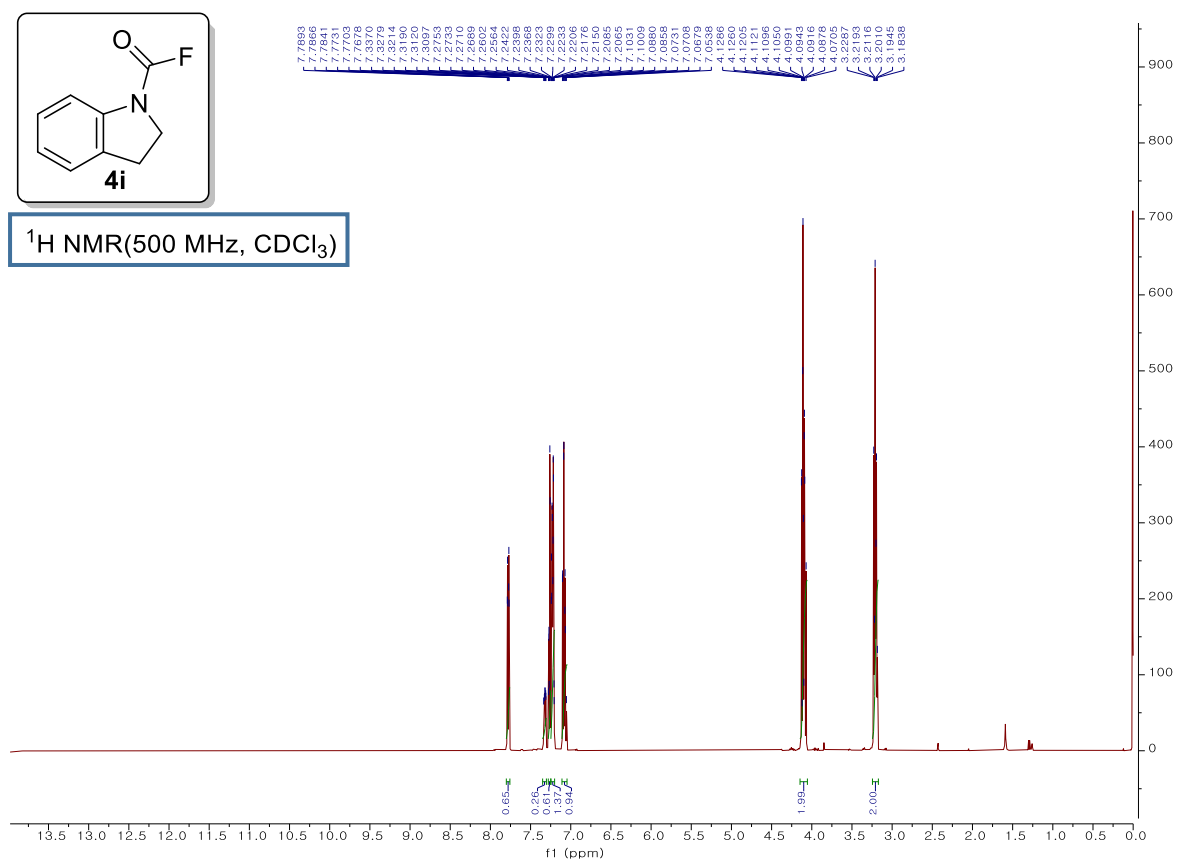
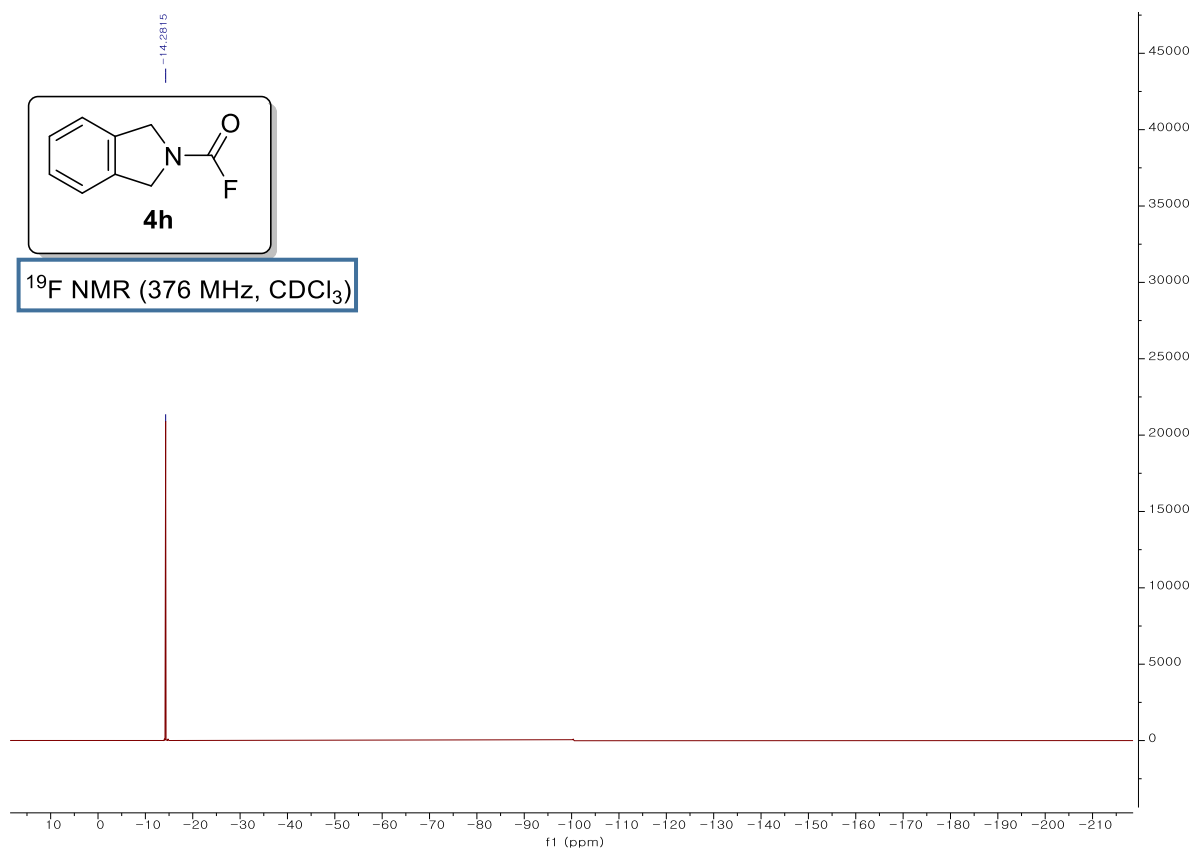


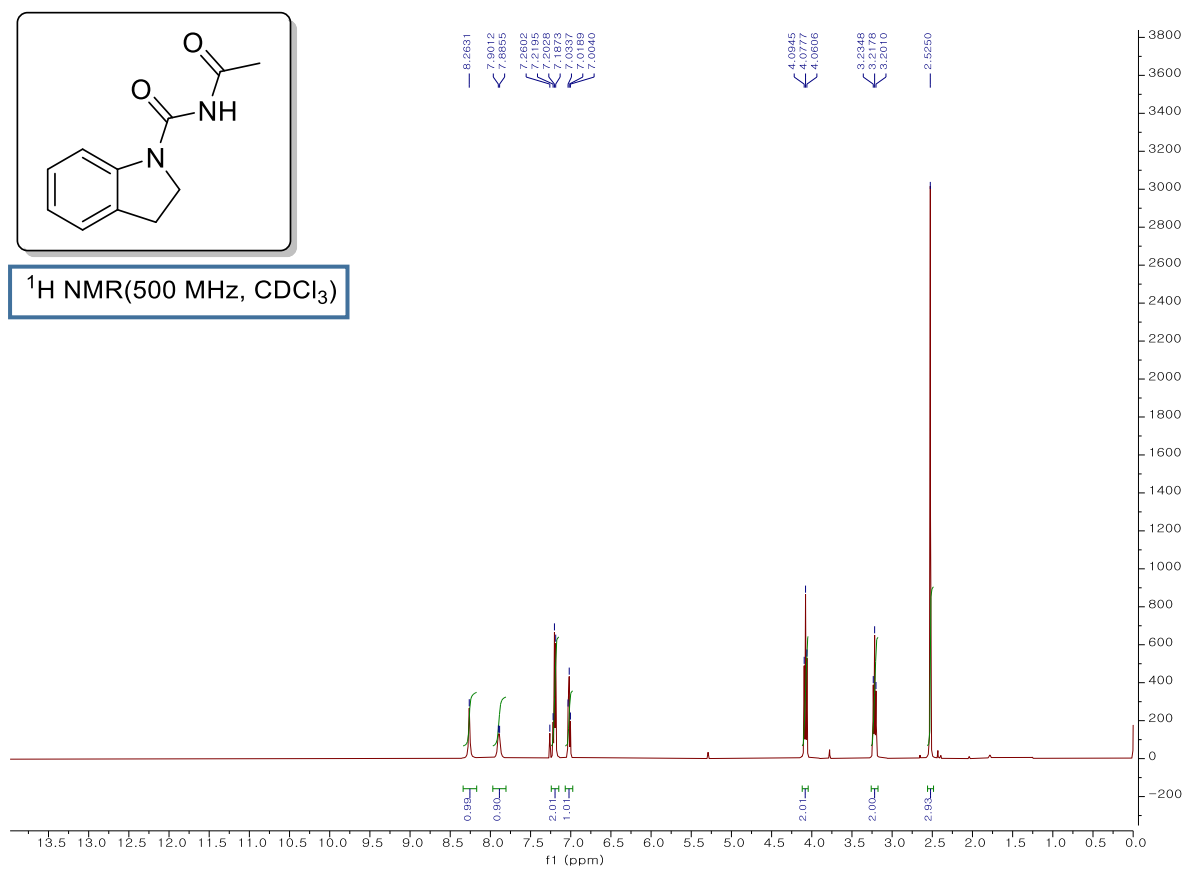
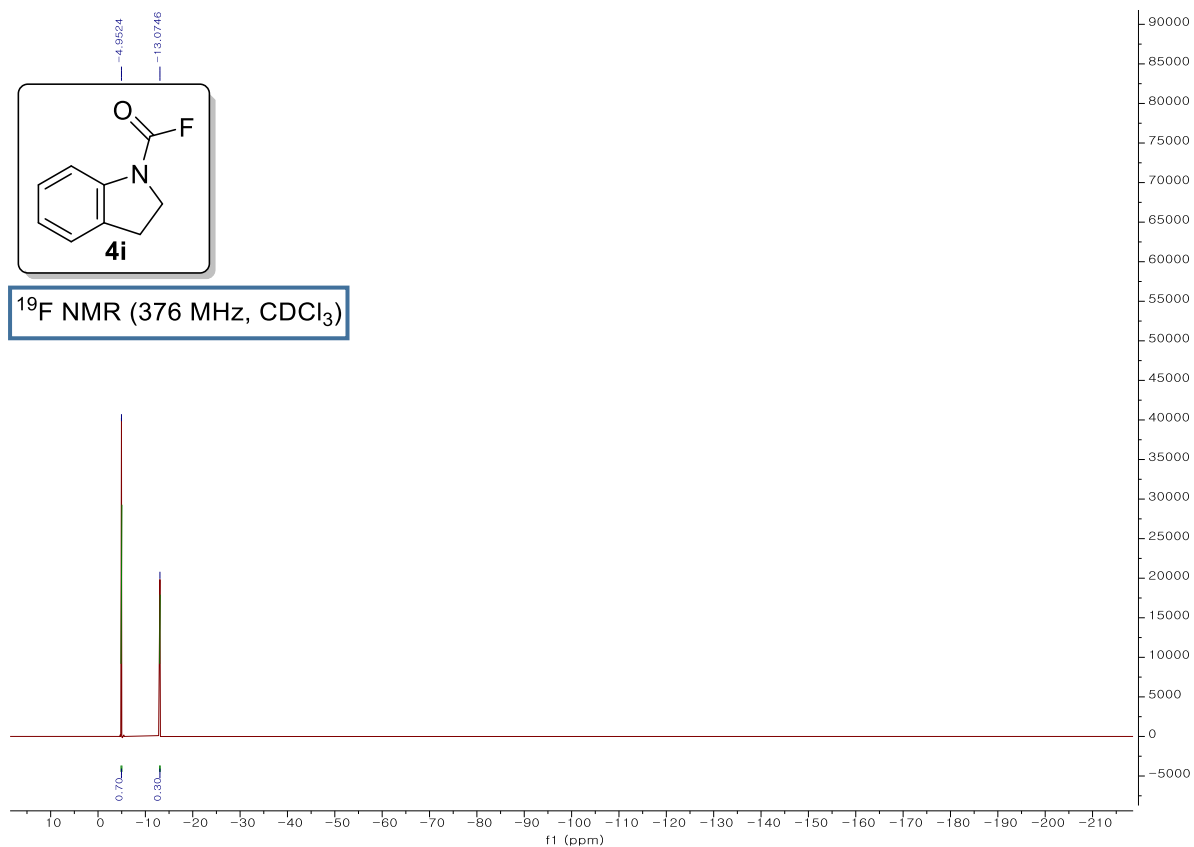
^1H NMR(400 MHz, CDCl_3)

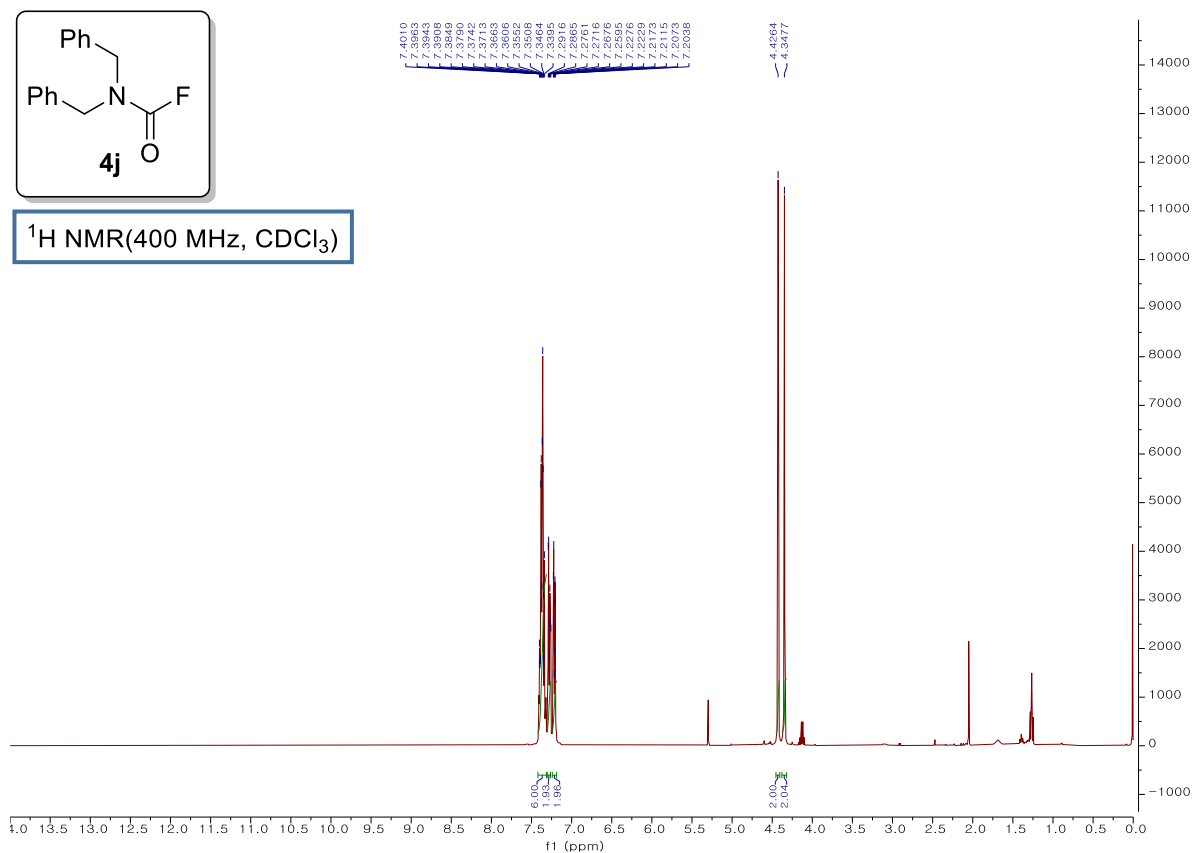
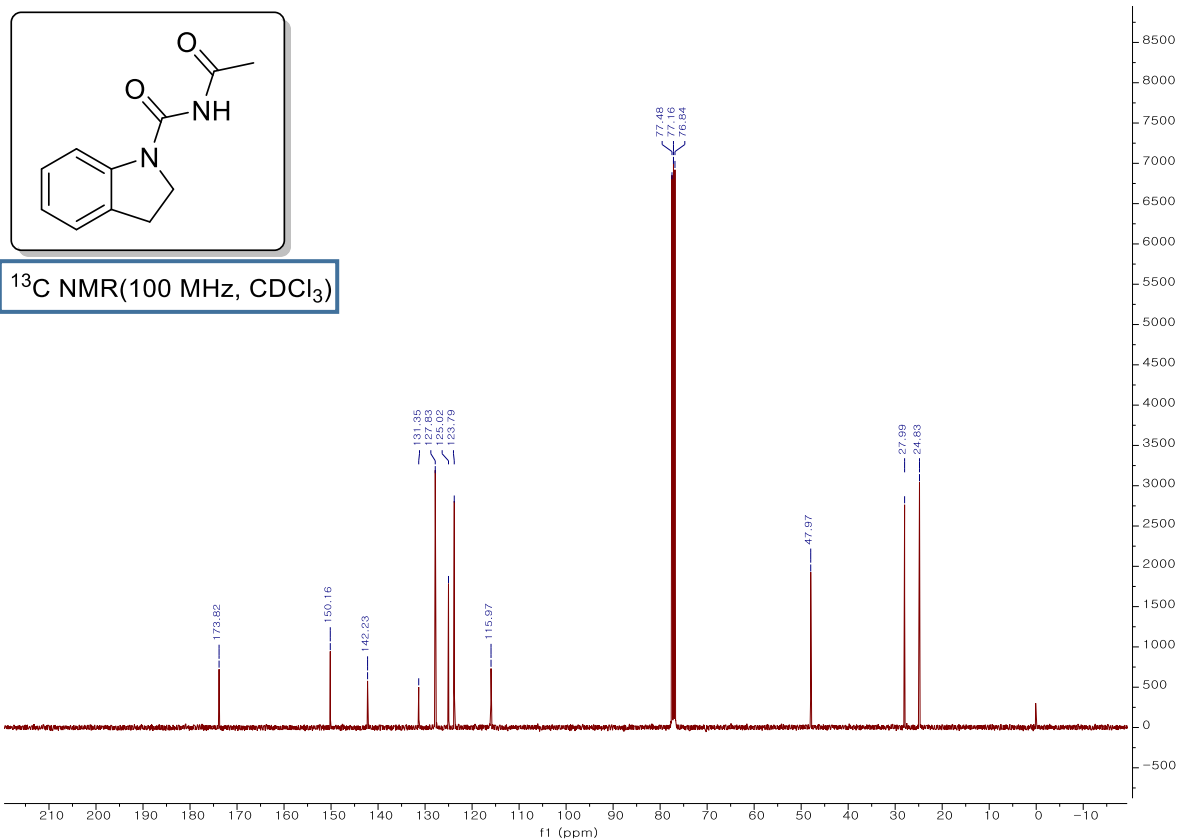


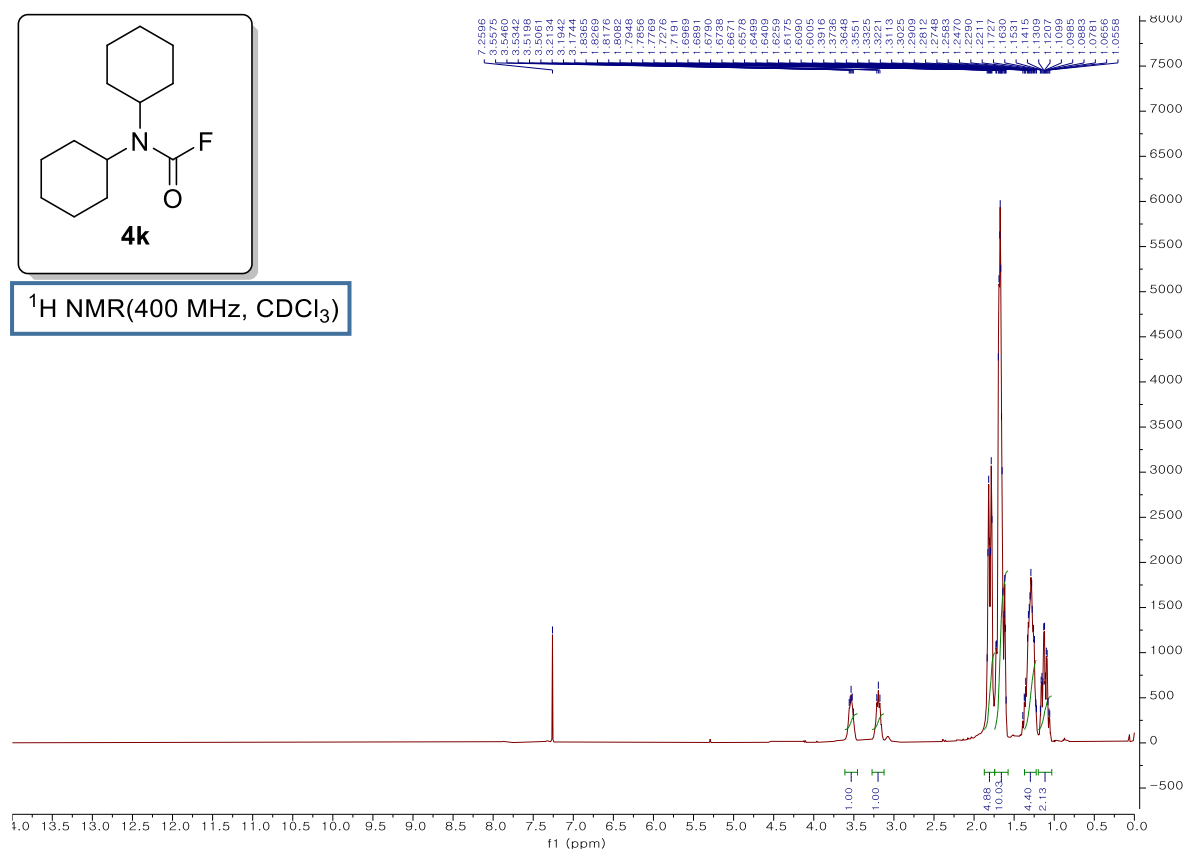
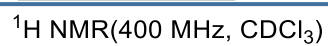
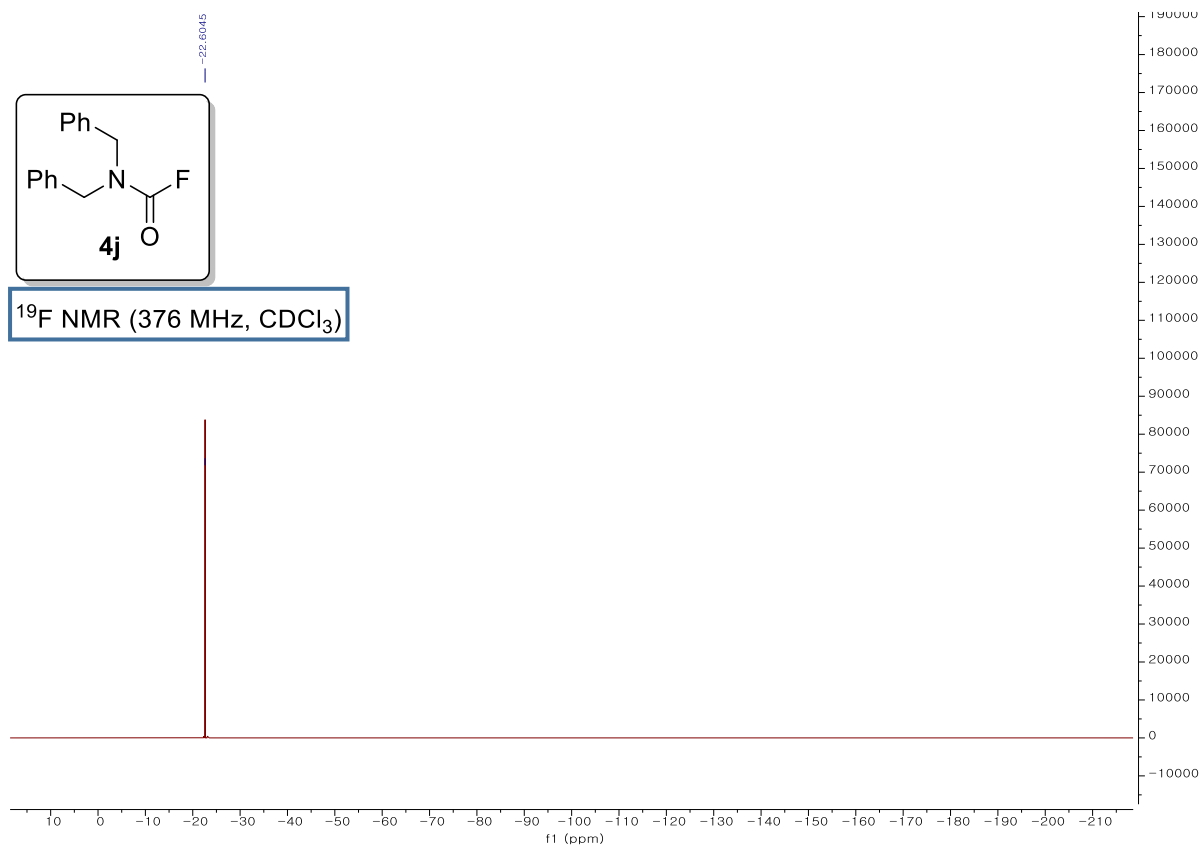
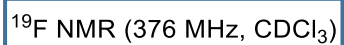
^{13}C NMR(100 MHz, CDCl_3)

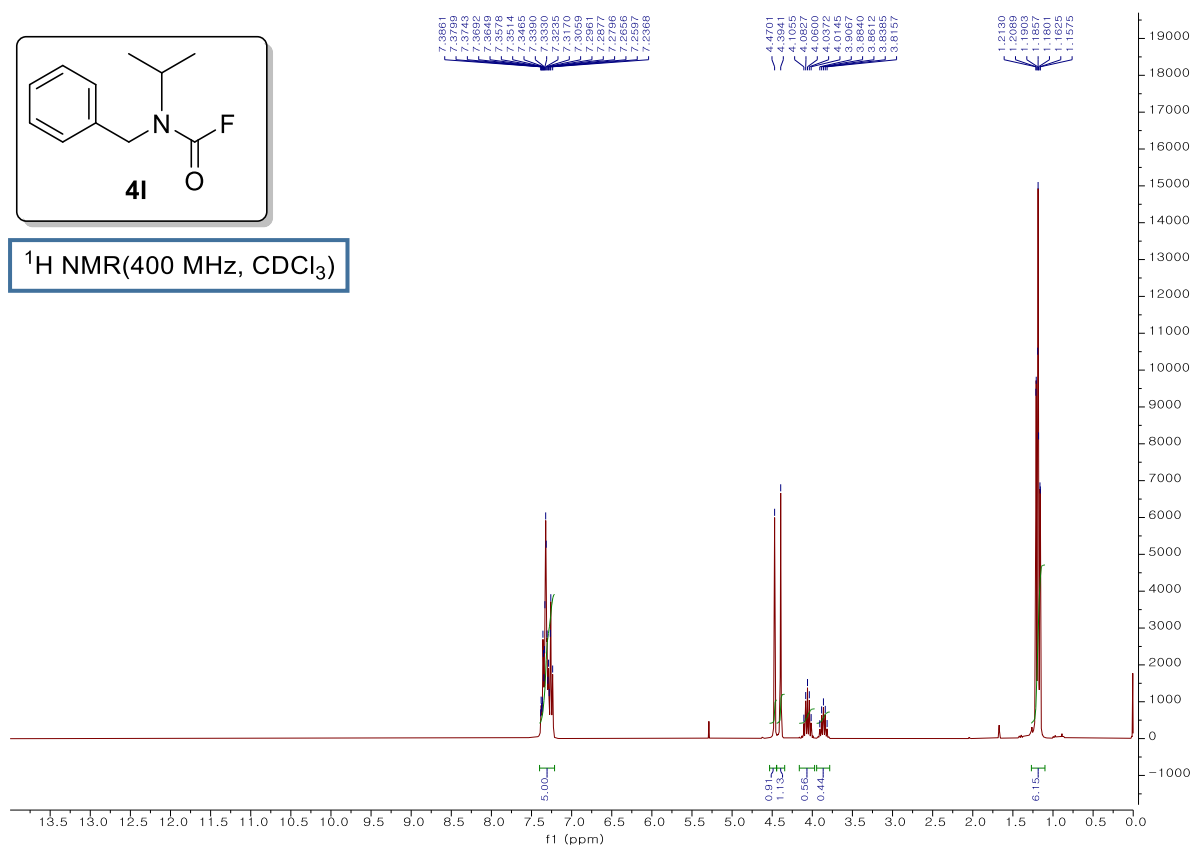
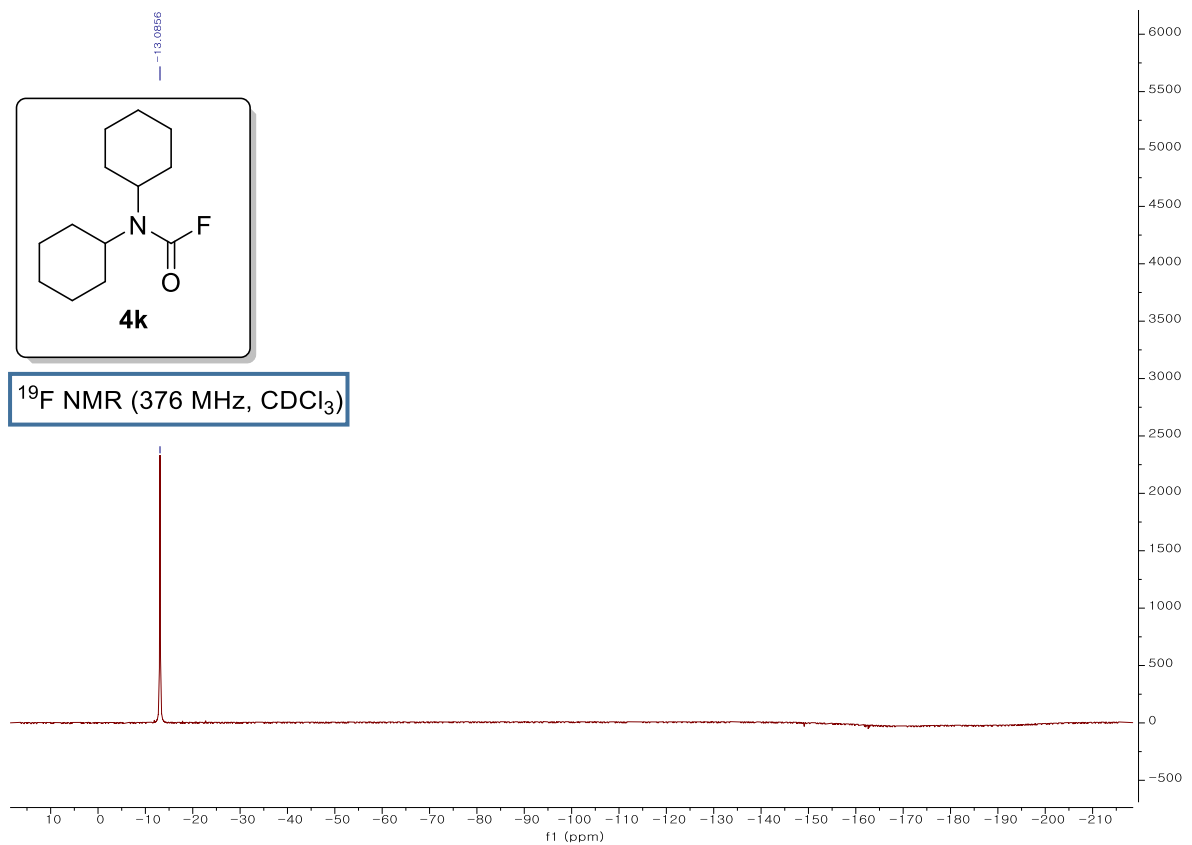


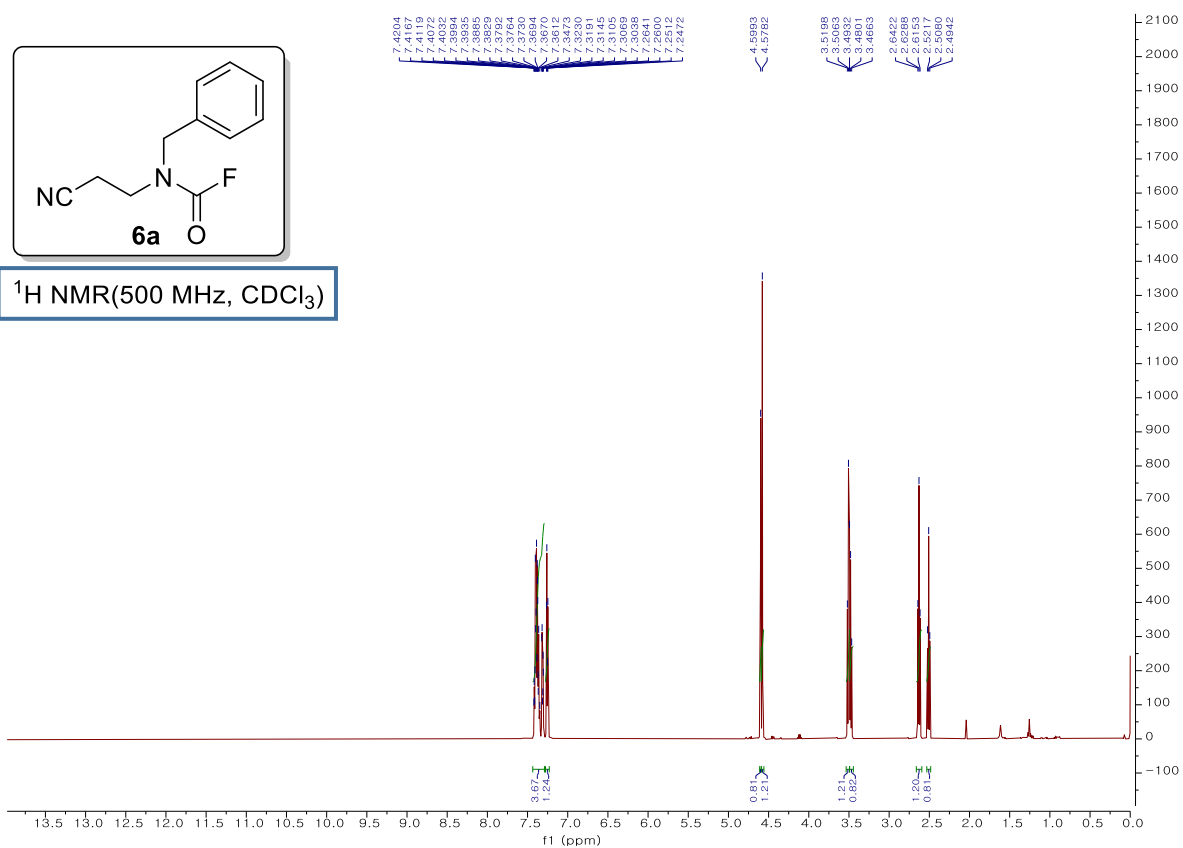
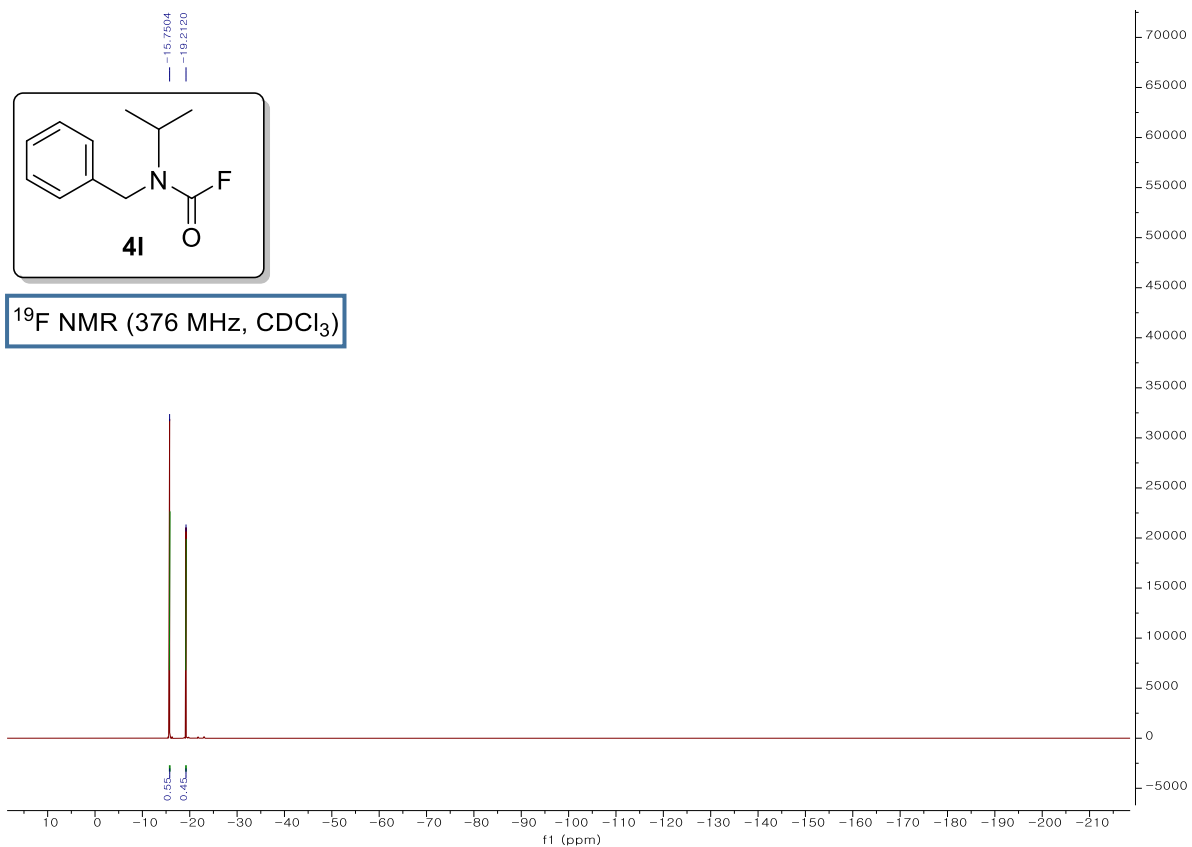


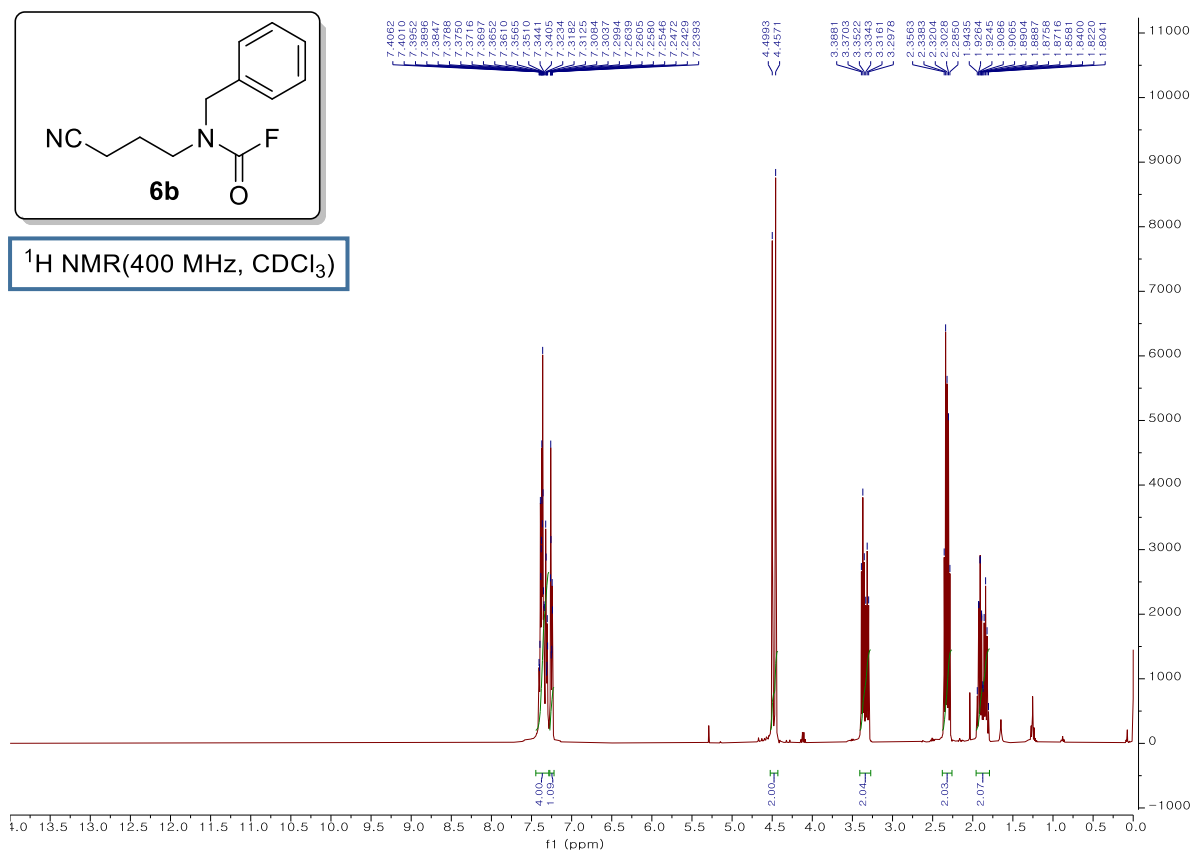
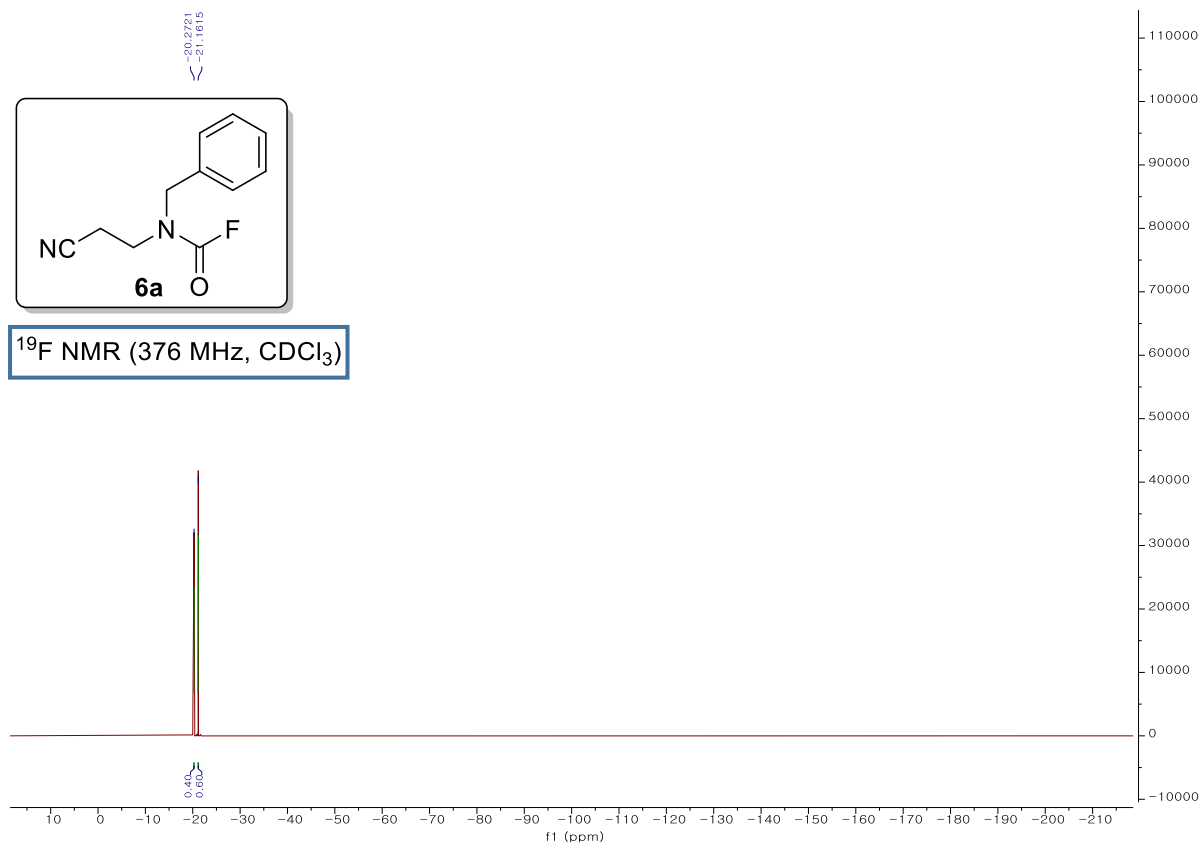


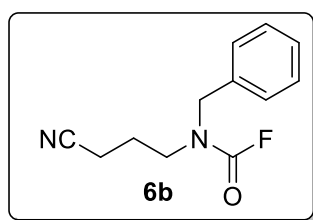




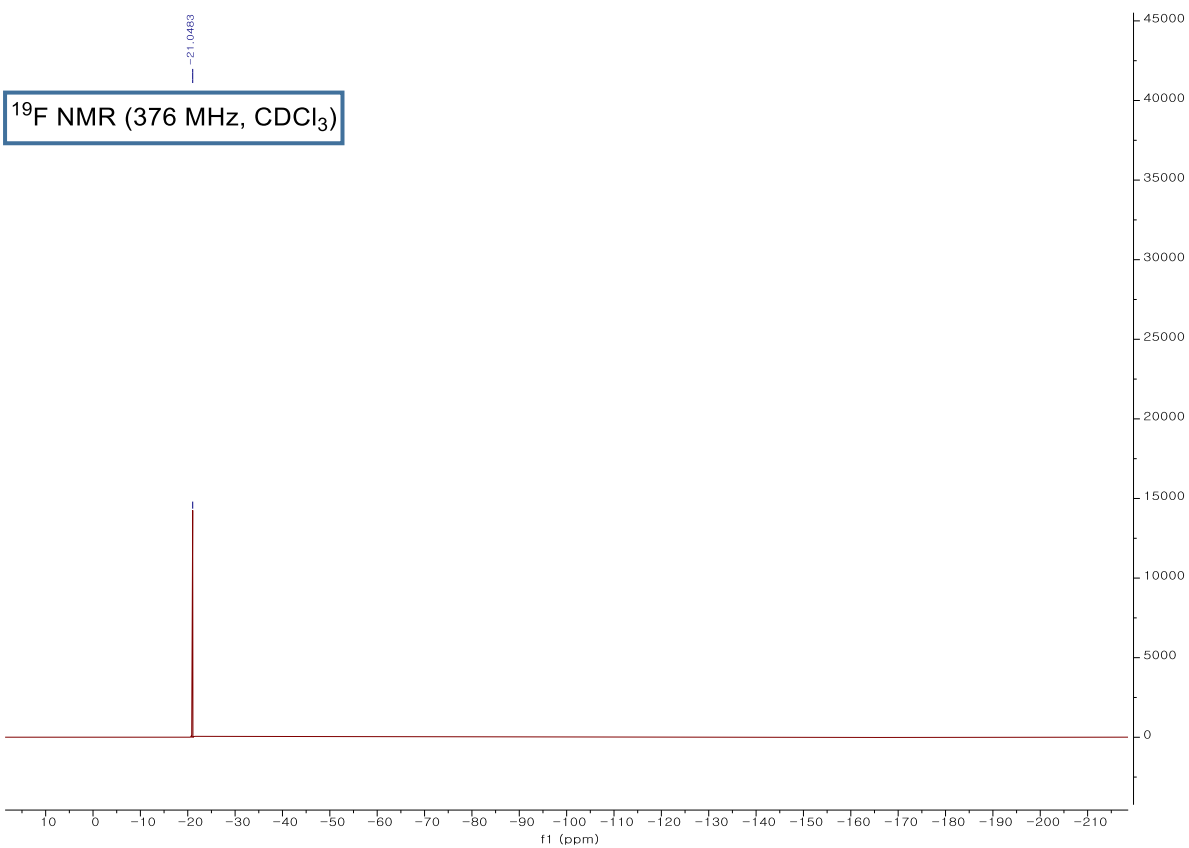
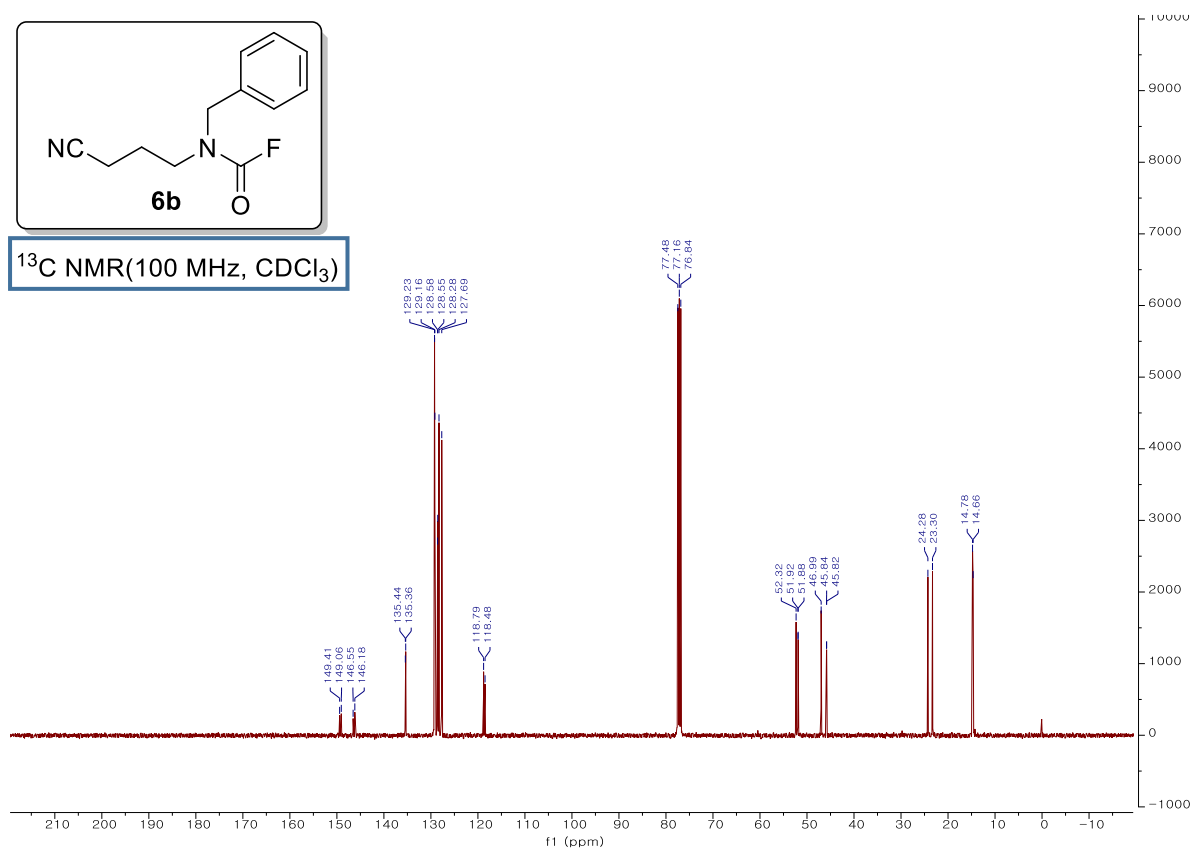


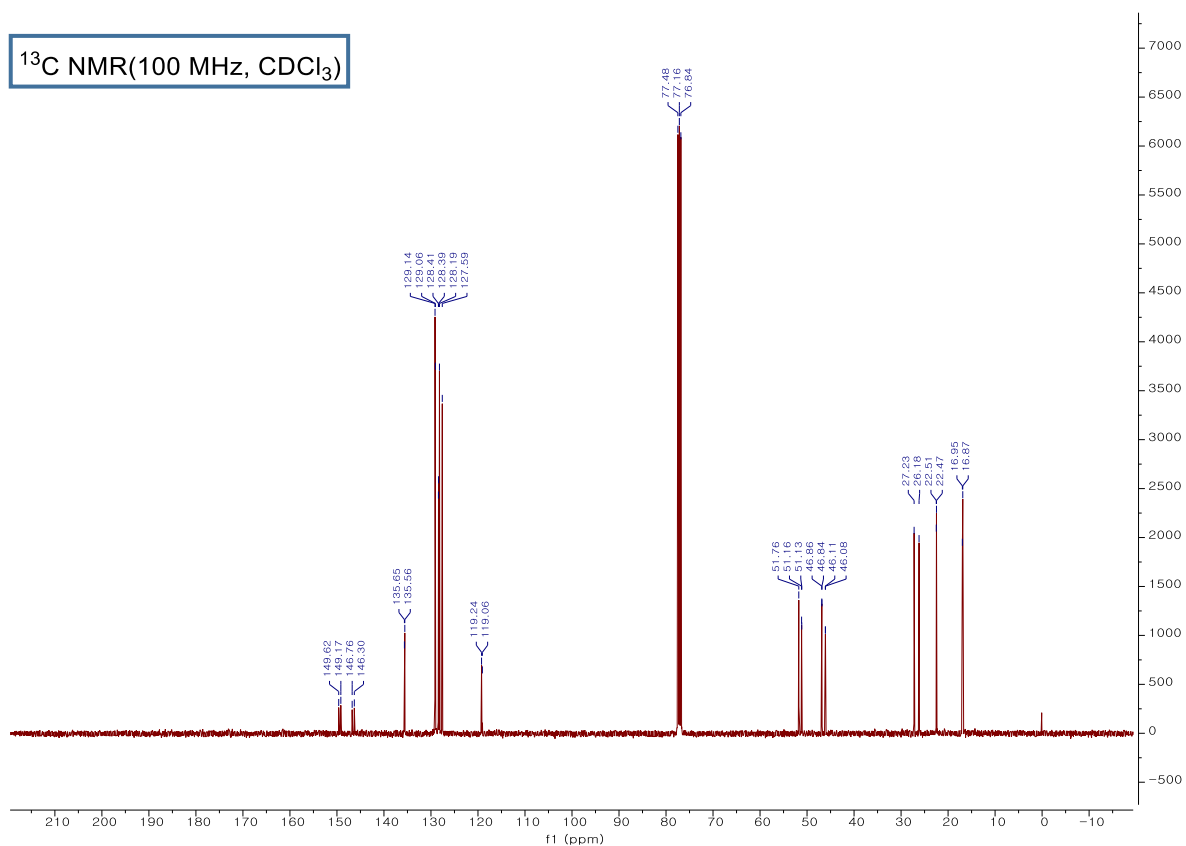
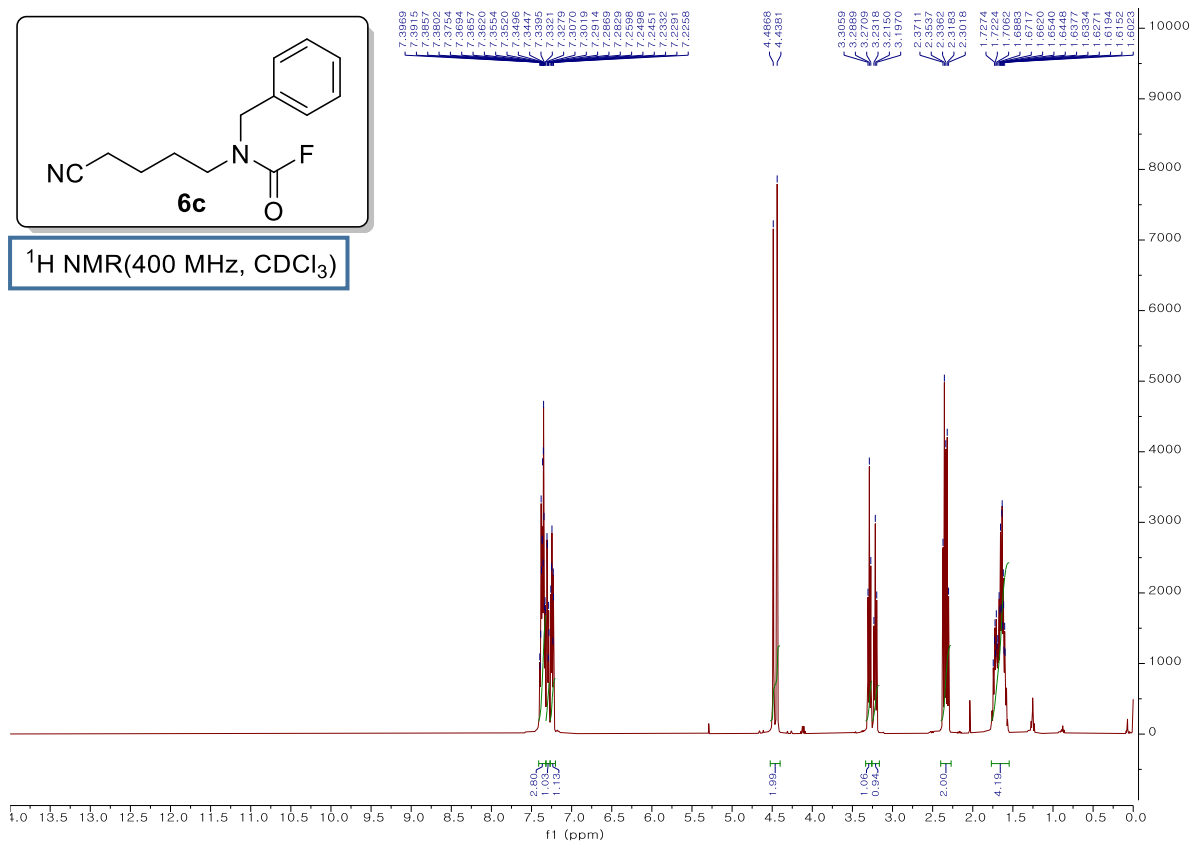


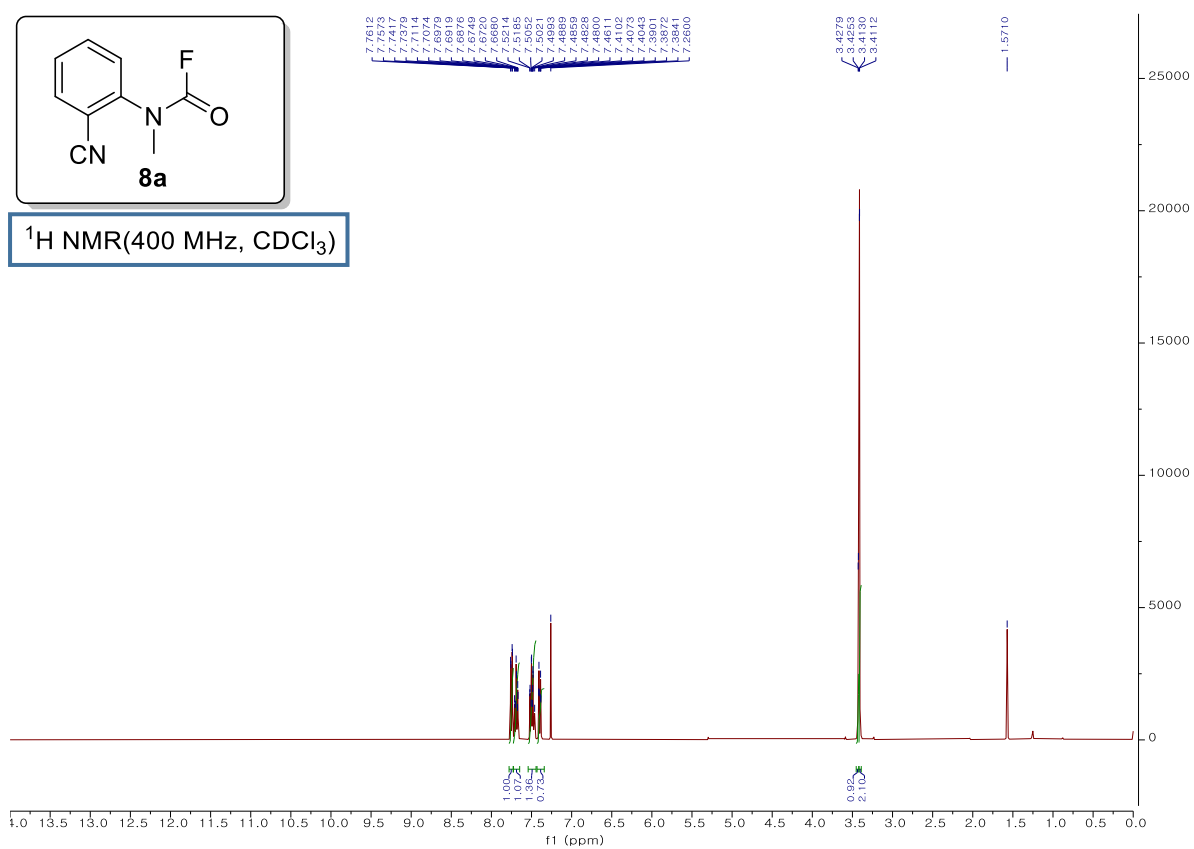
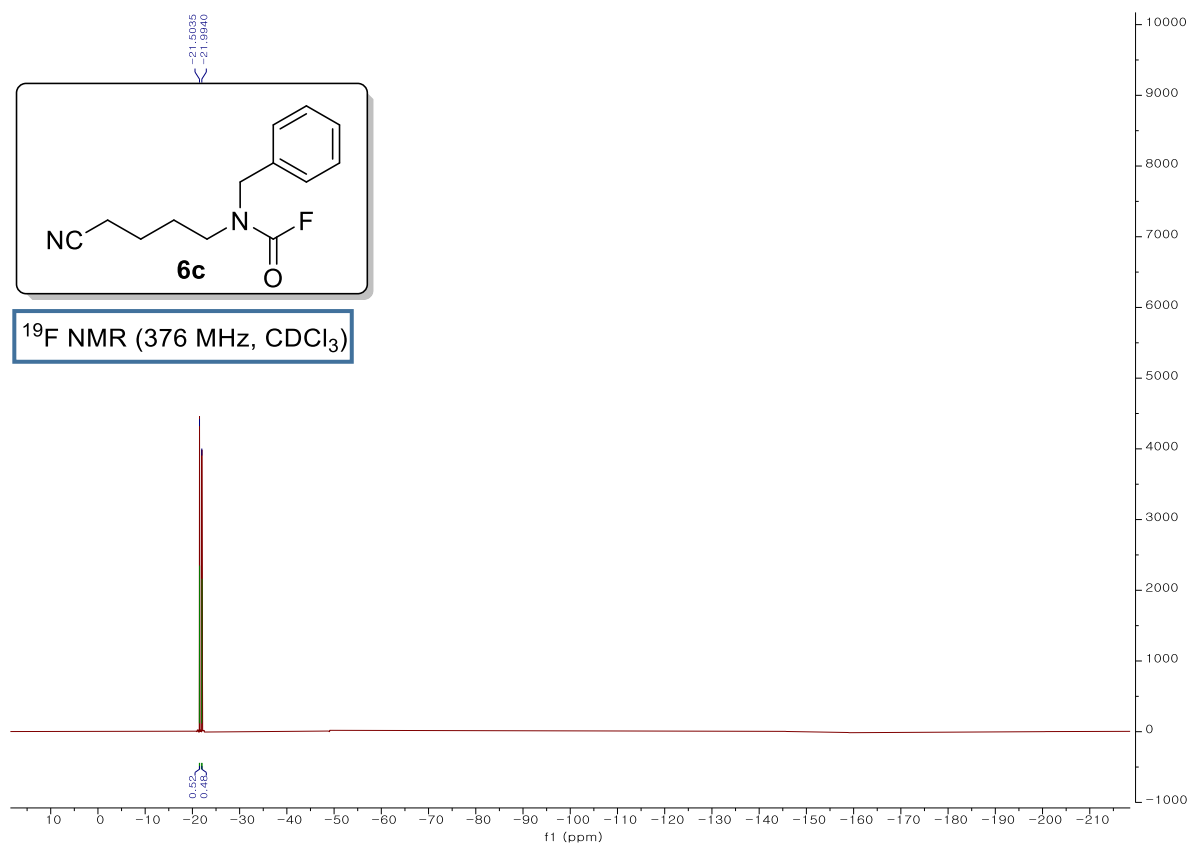


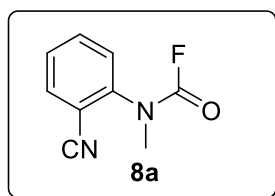


^{13}C NMR (100 MHz, CDCl_3)

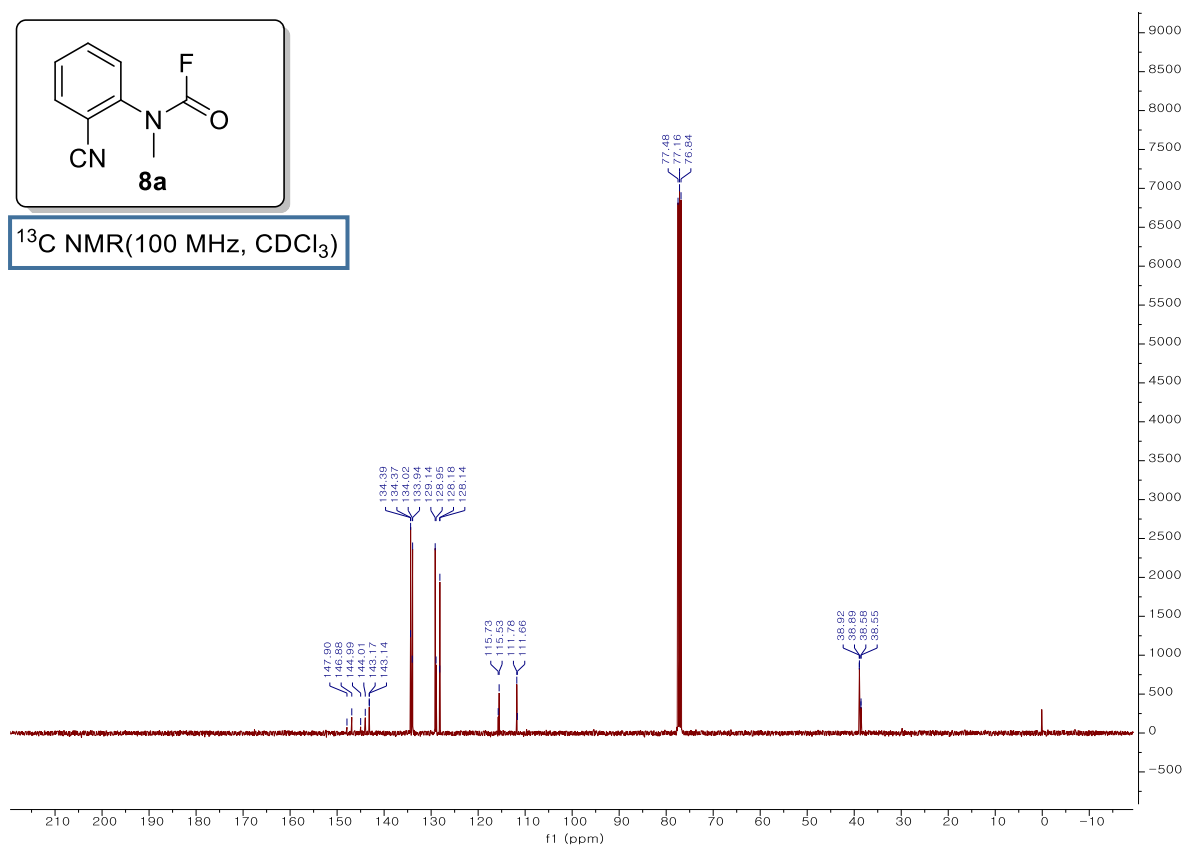




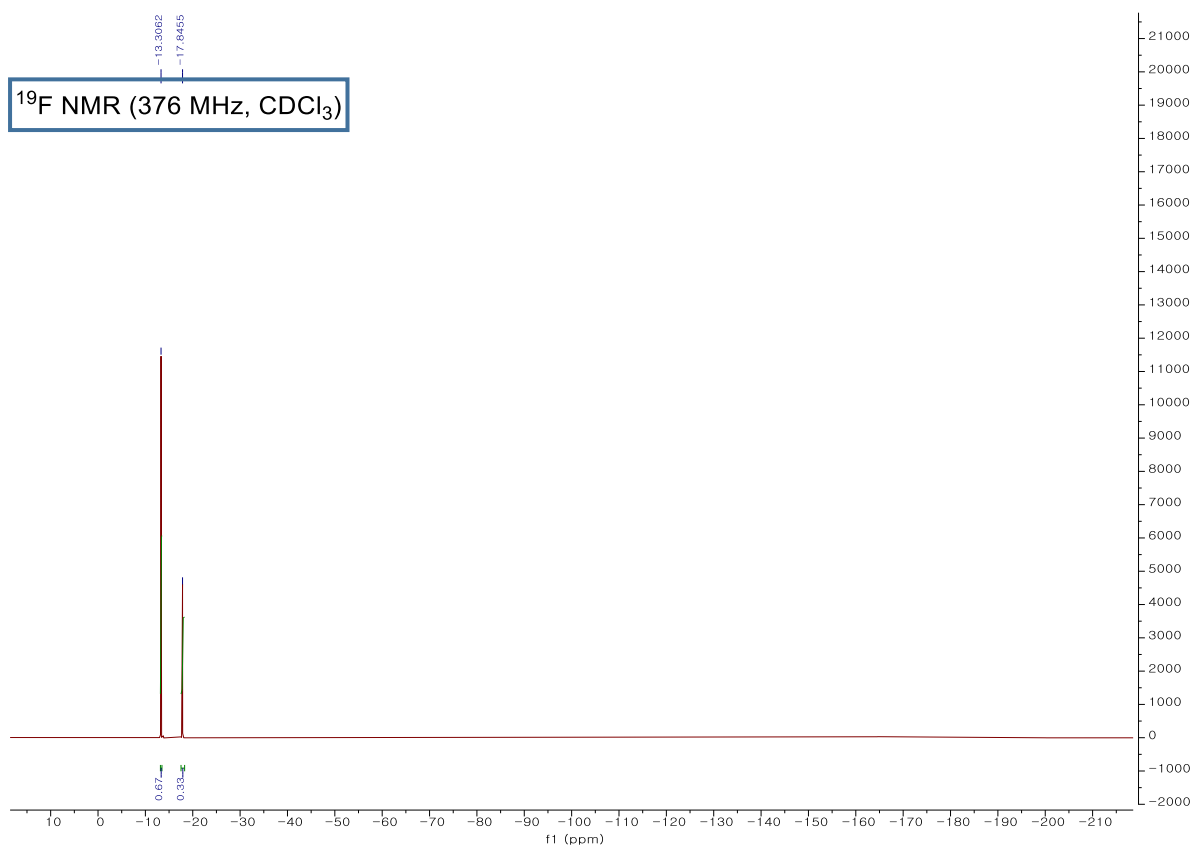


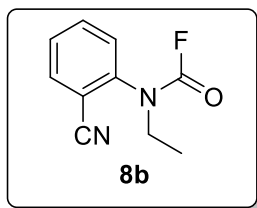


^{13}C NMR (100 MHz, CDCl_3)

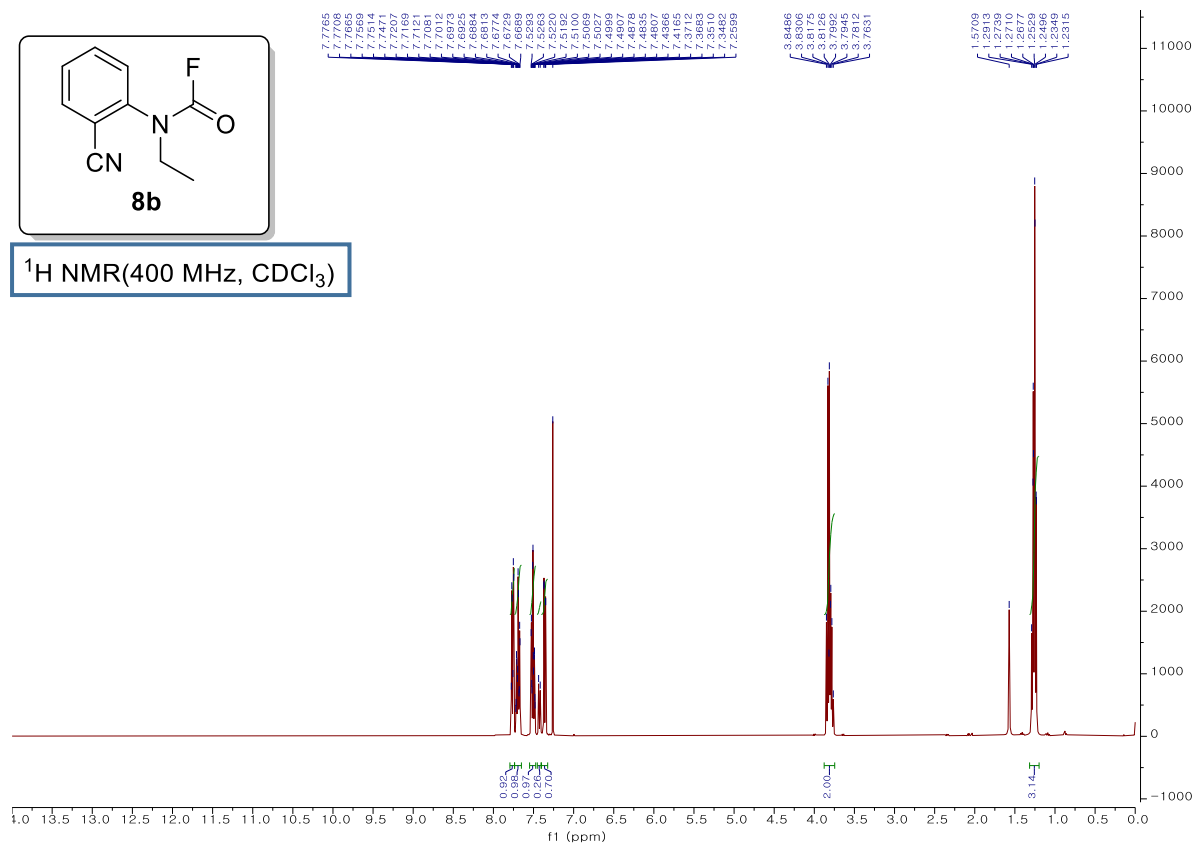


^{19}F NMR (376 MHz, CDCl_3)

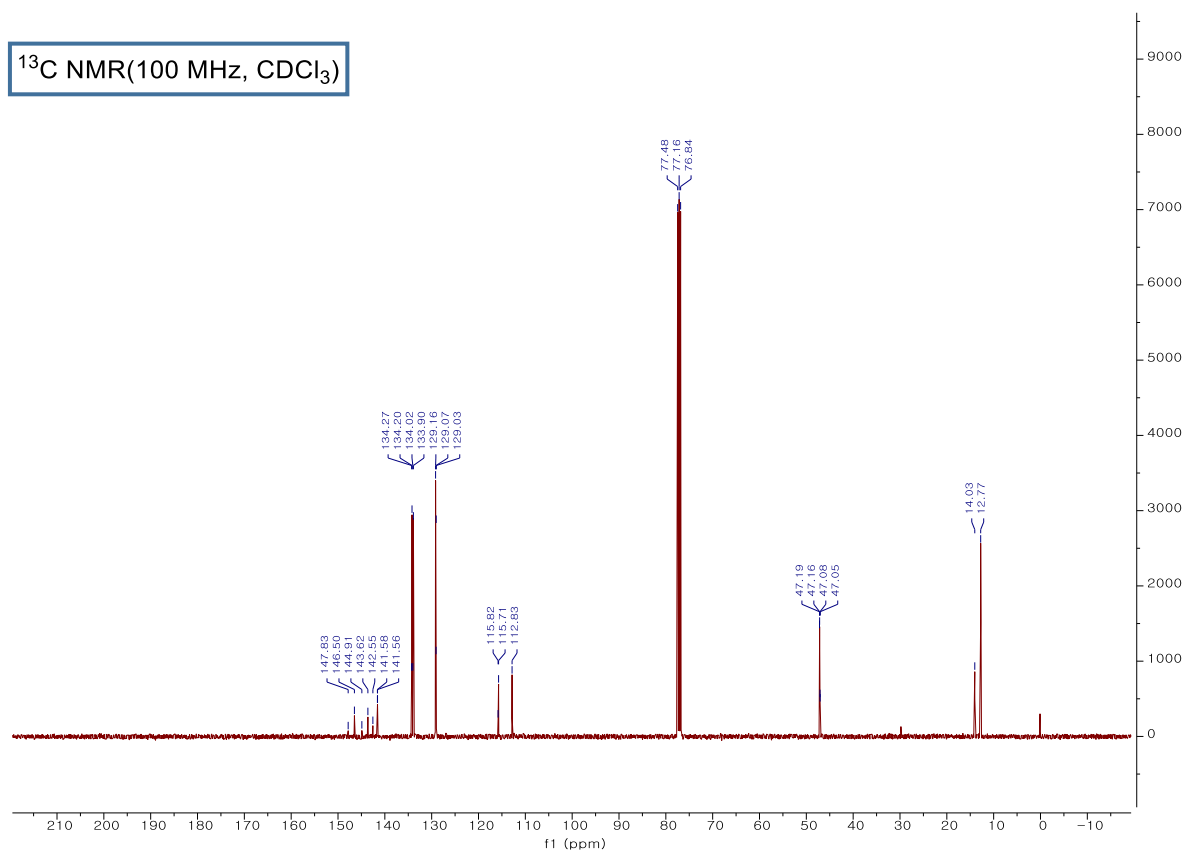


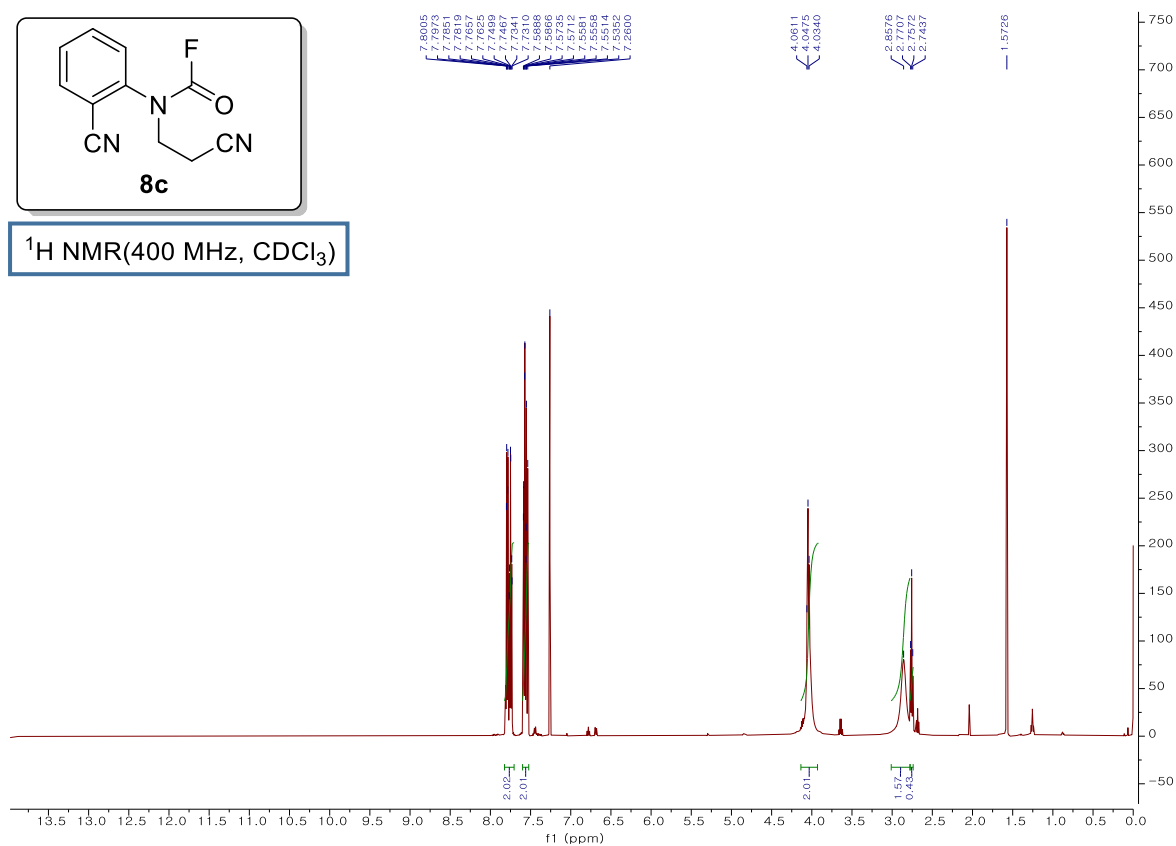
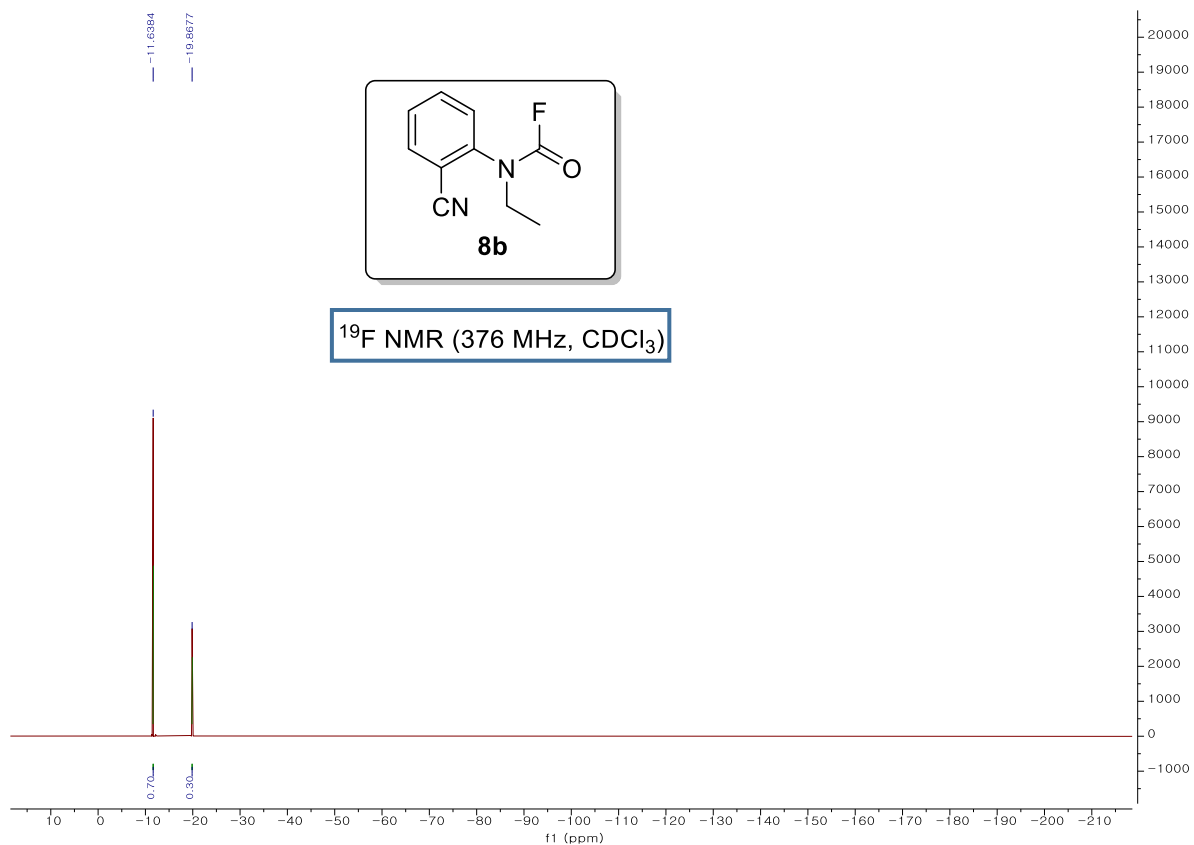


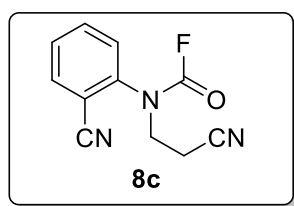
^1H NMR(400 MHz, CDCl_3)



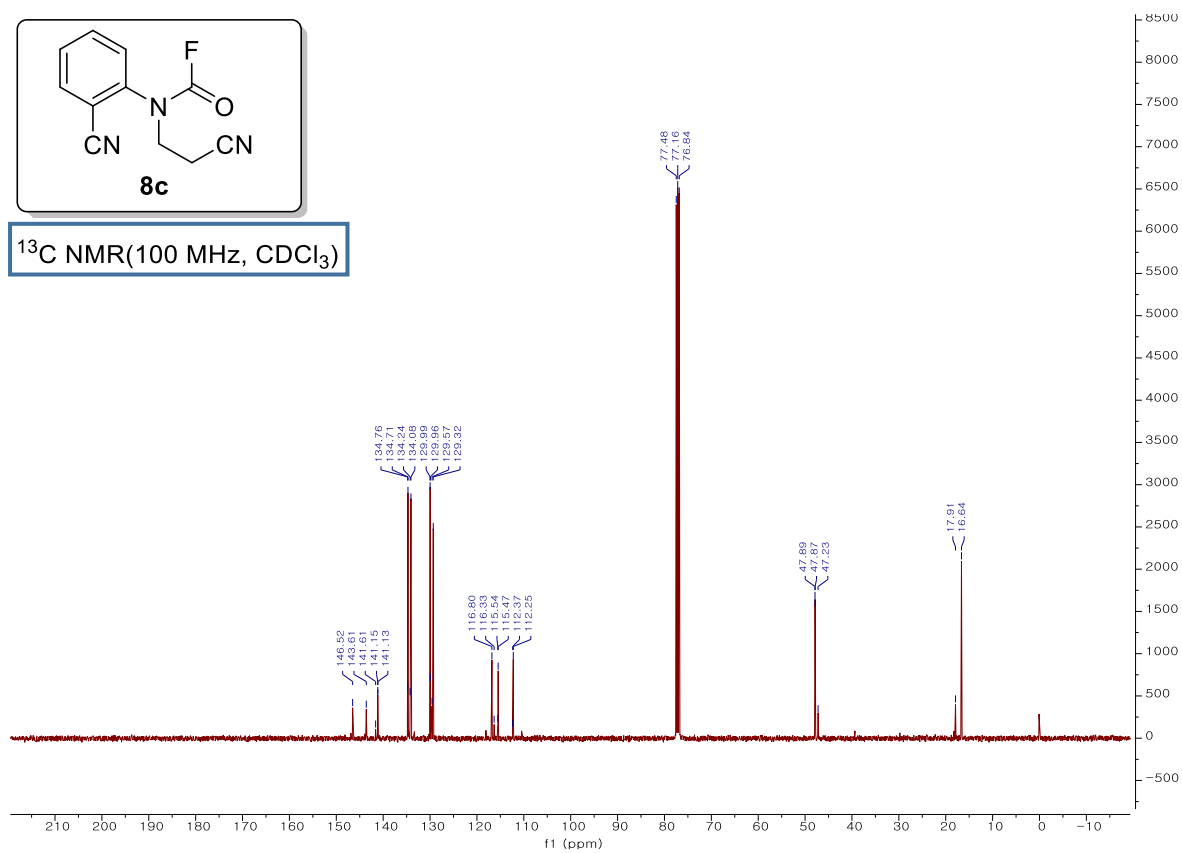
^{13}C NMR(100 MHz, CDCl_3)



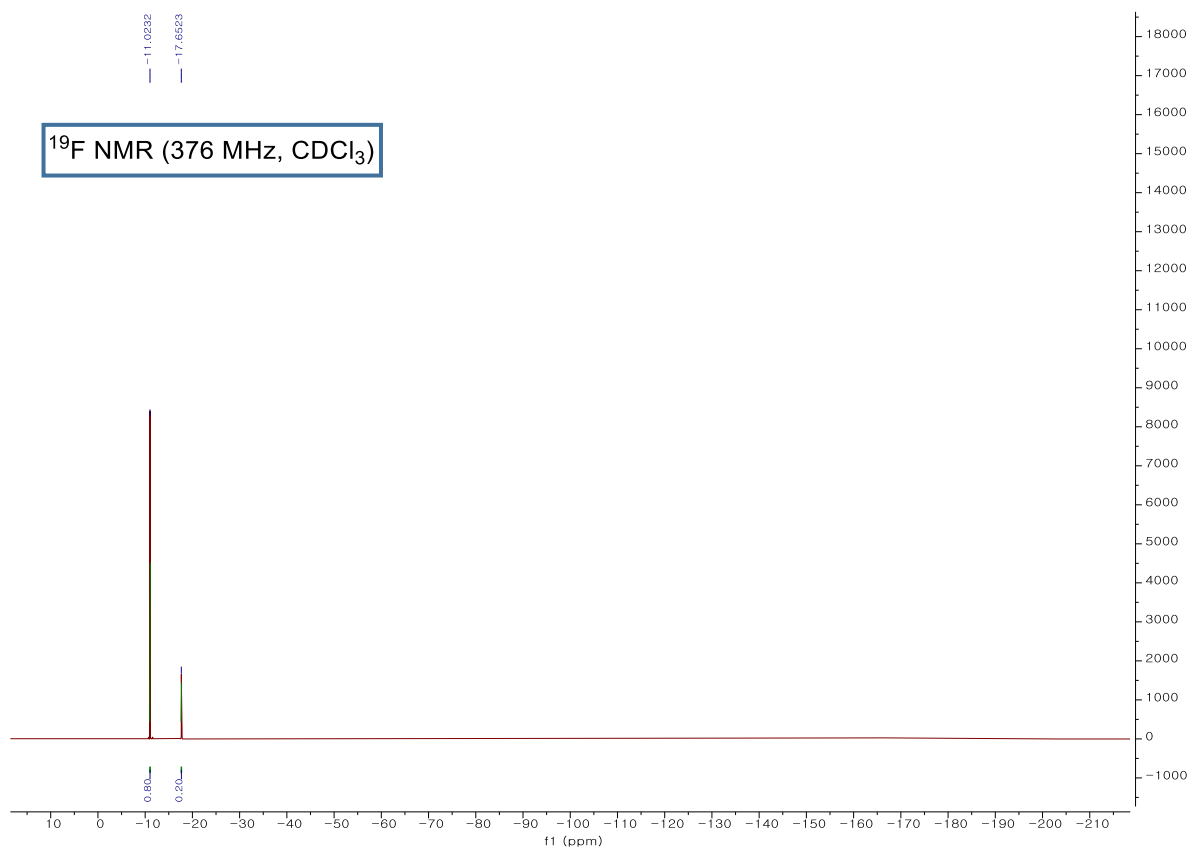


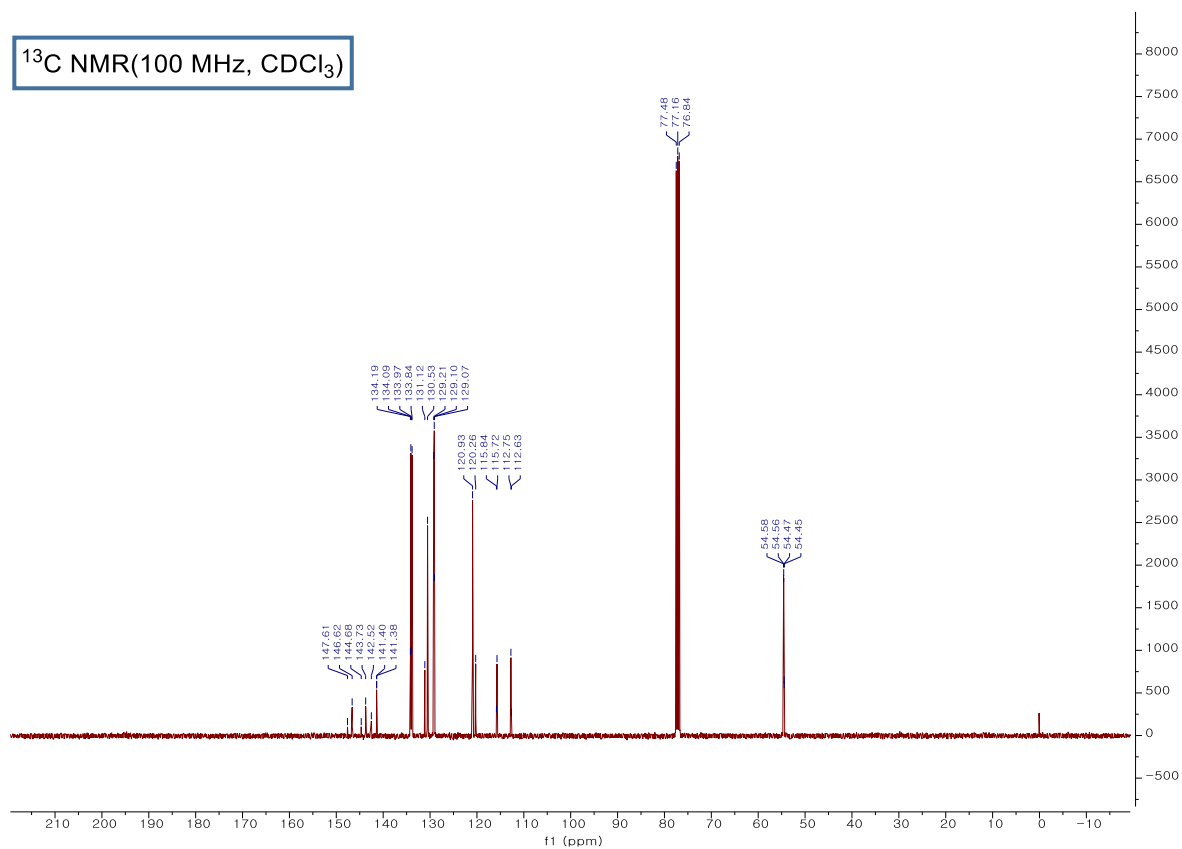
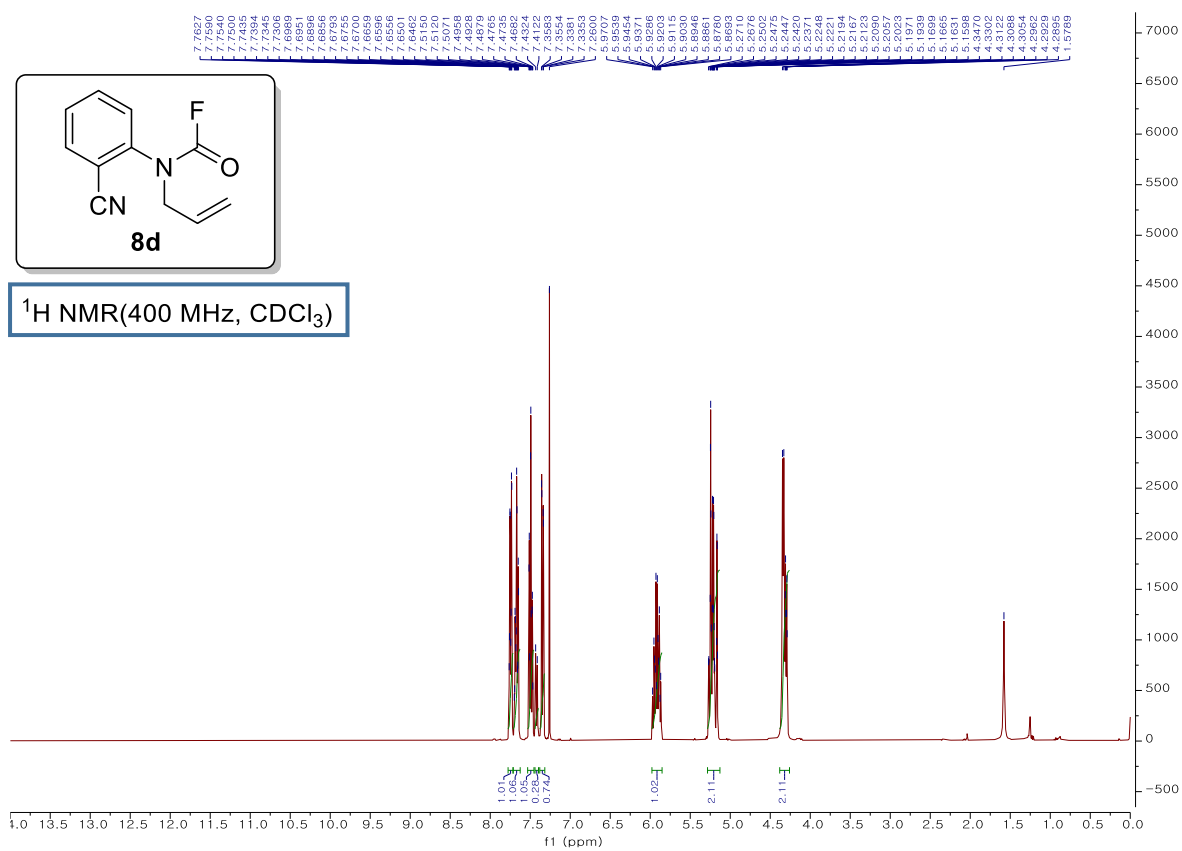


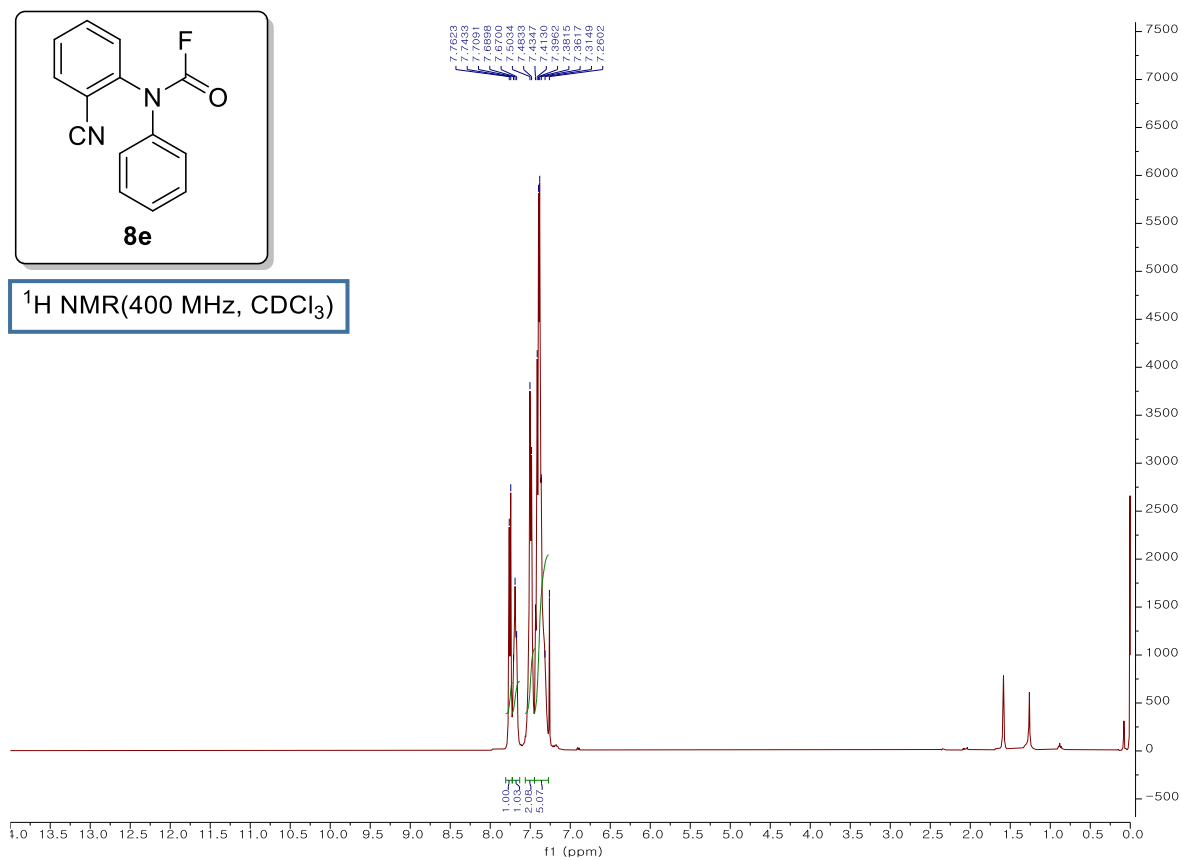
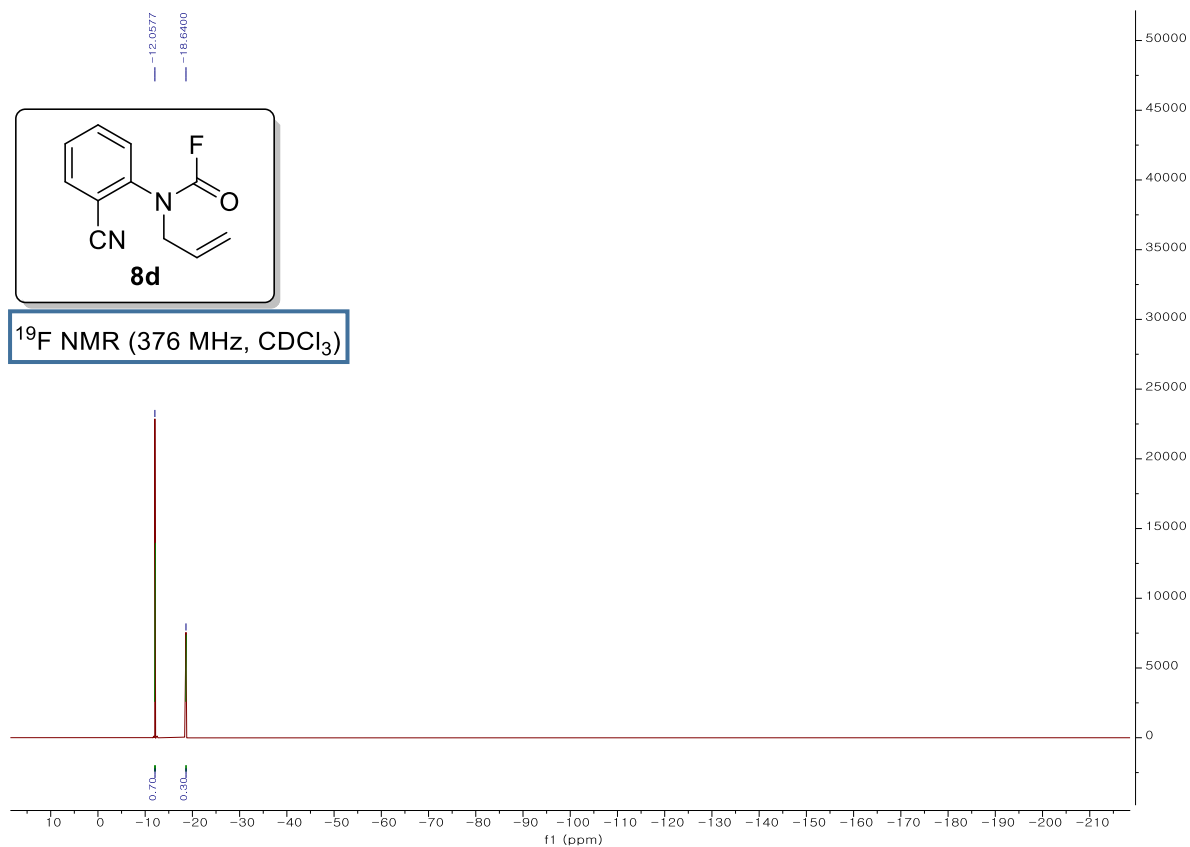
^{13}C NMR(100 MHz, CDCl_3)

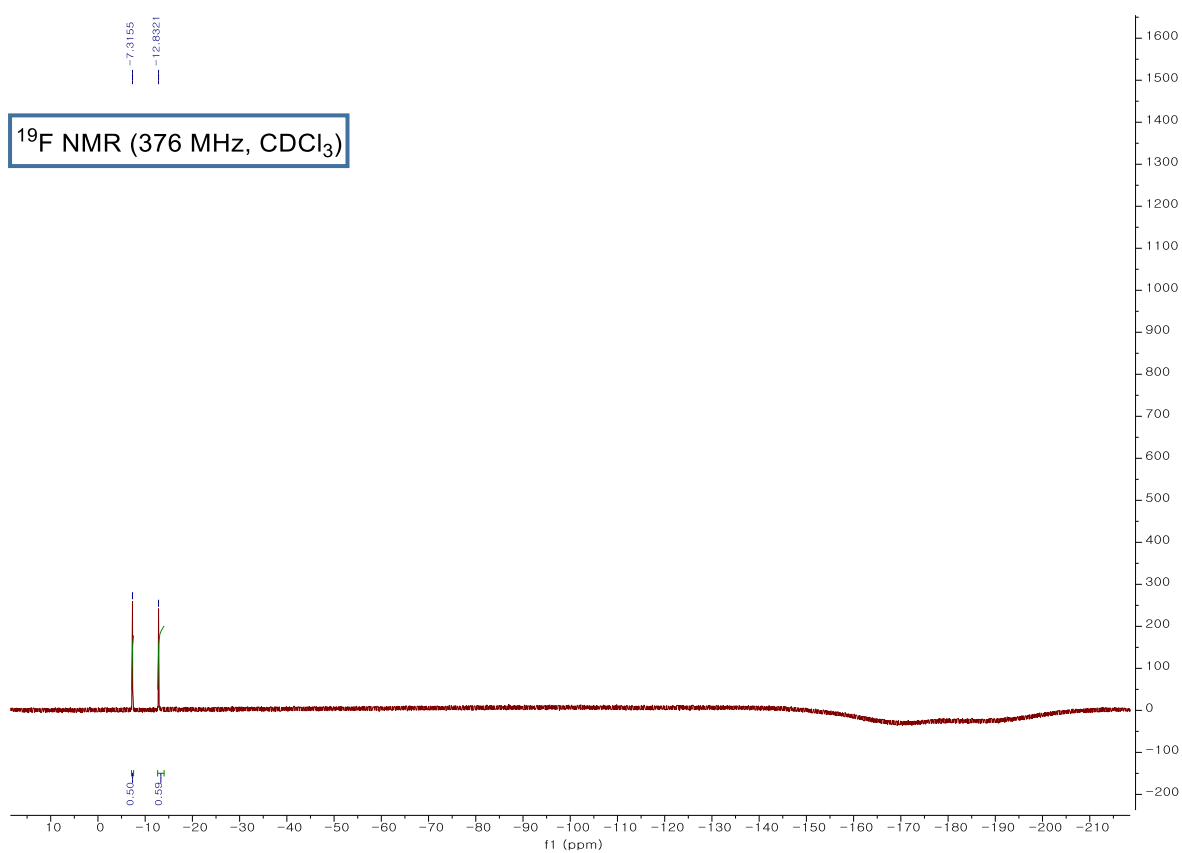
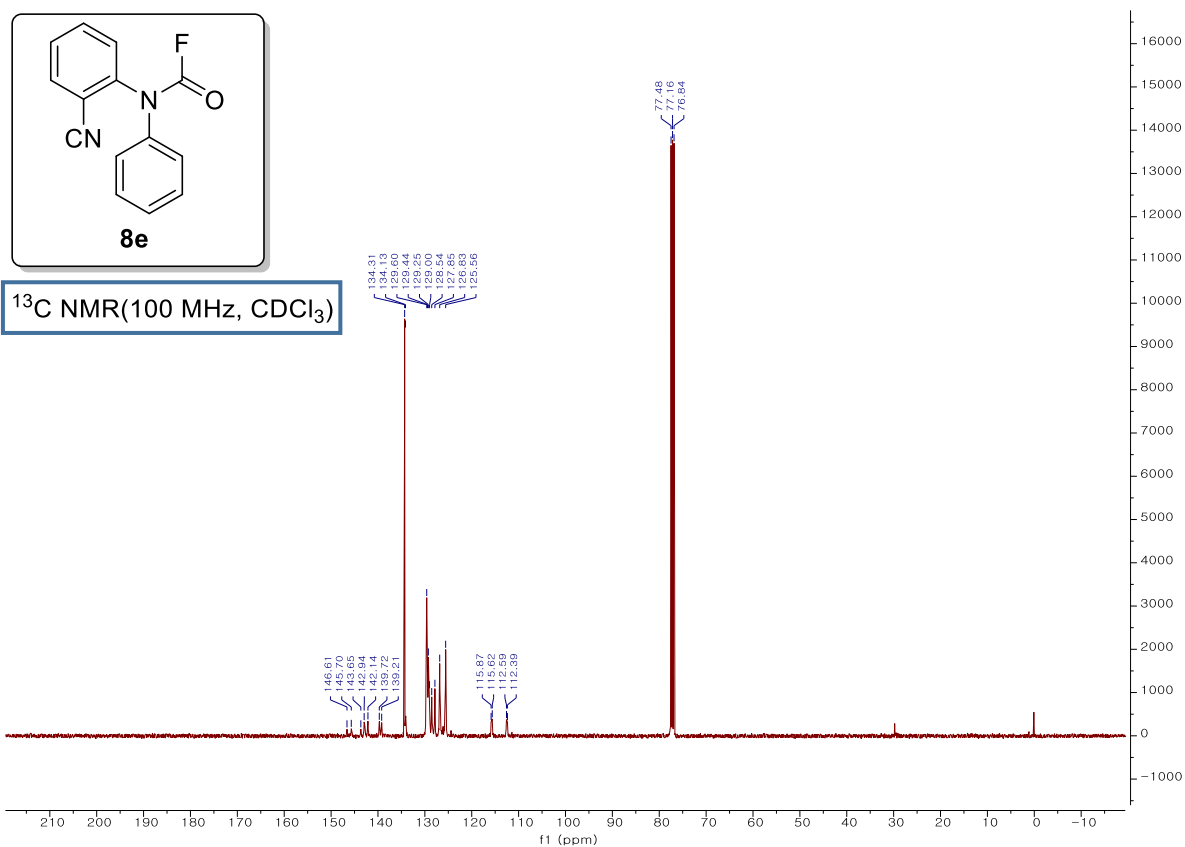


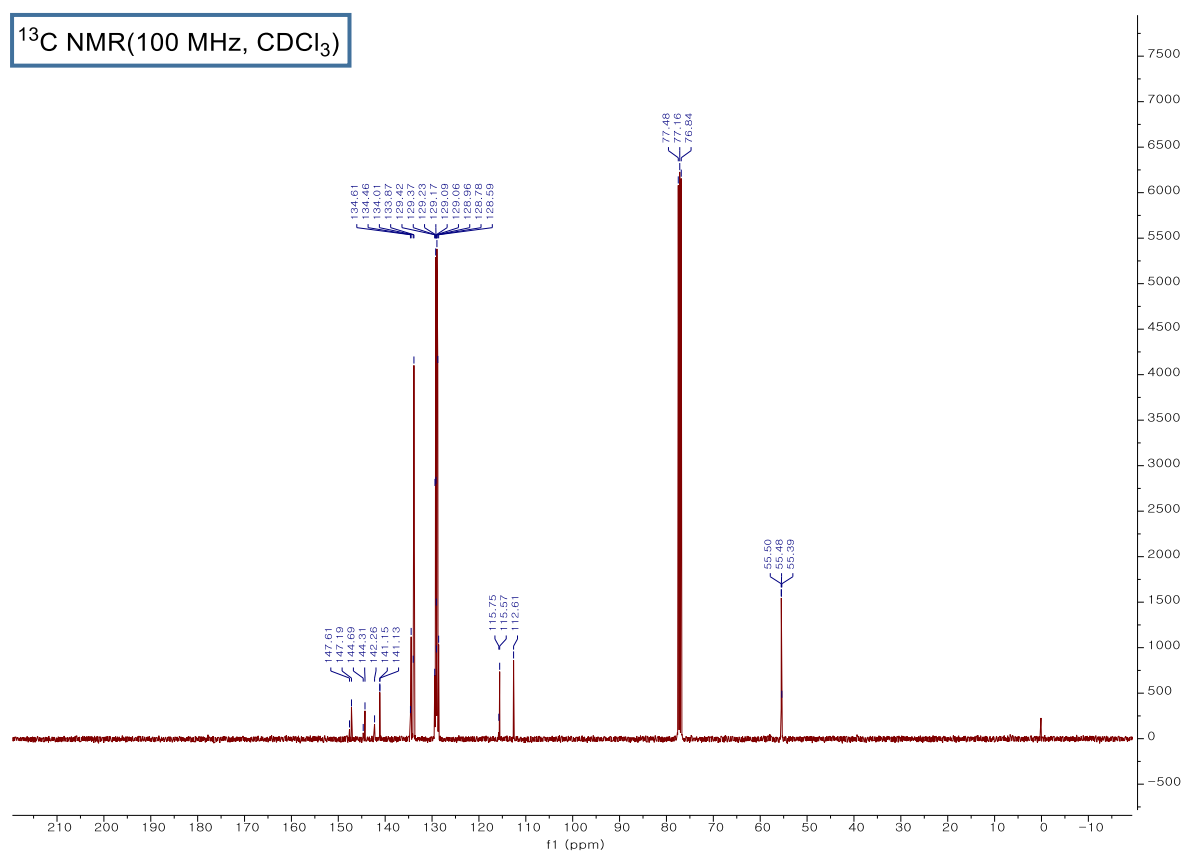
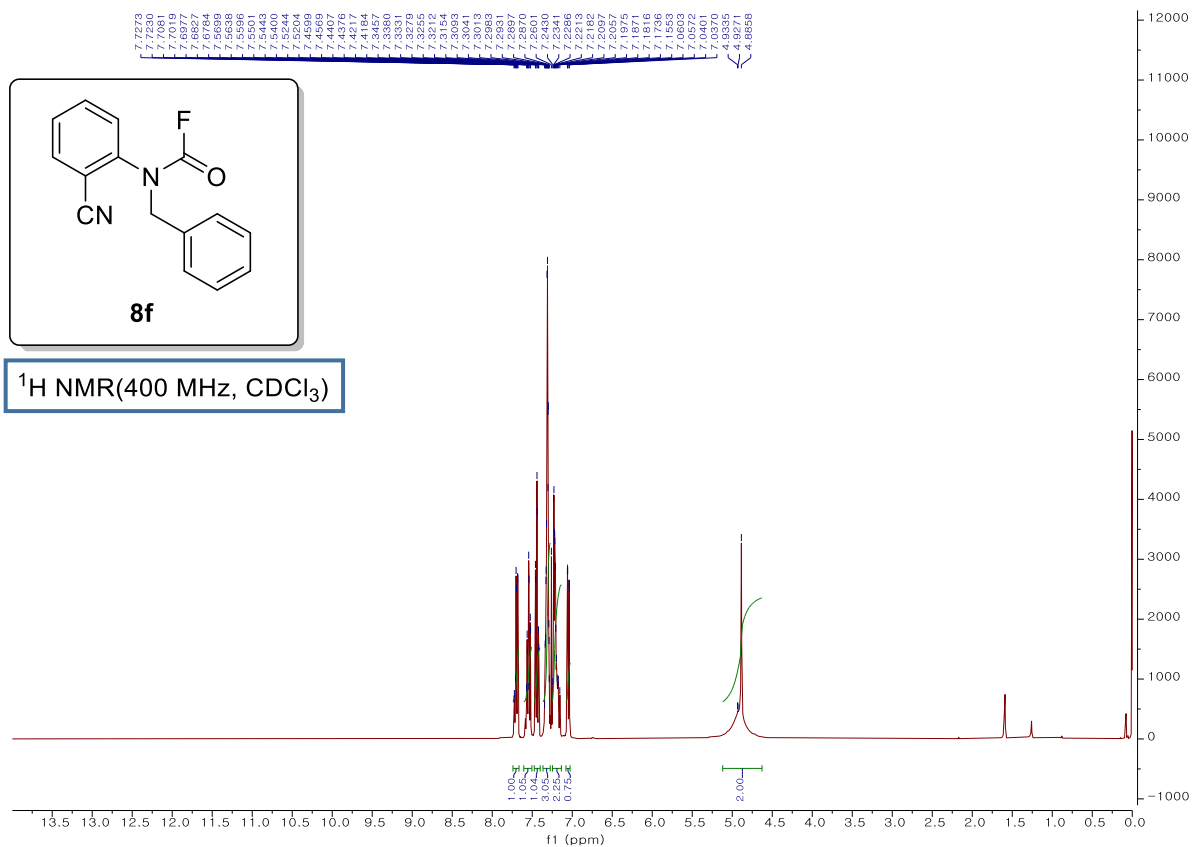
^{19}F NMR (376 MHz, CDCl_3)

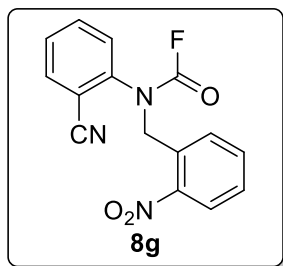




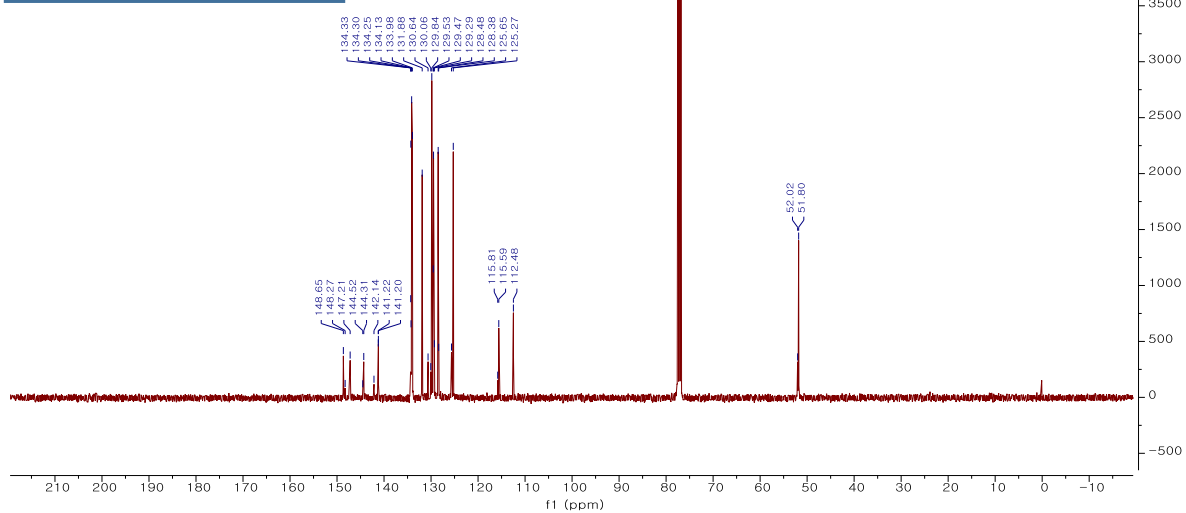




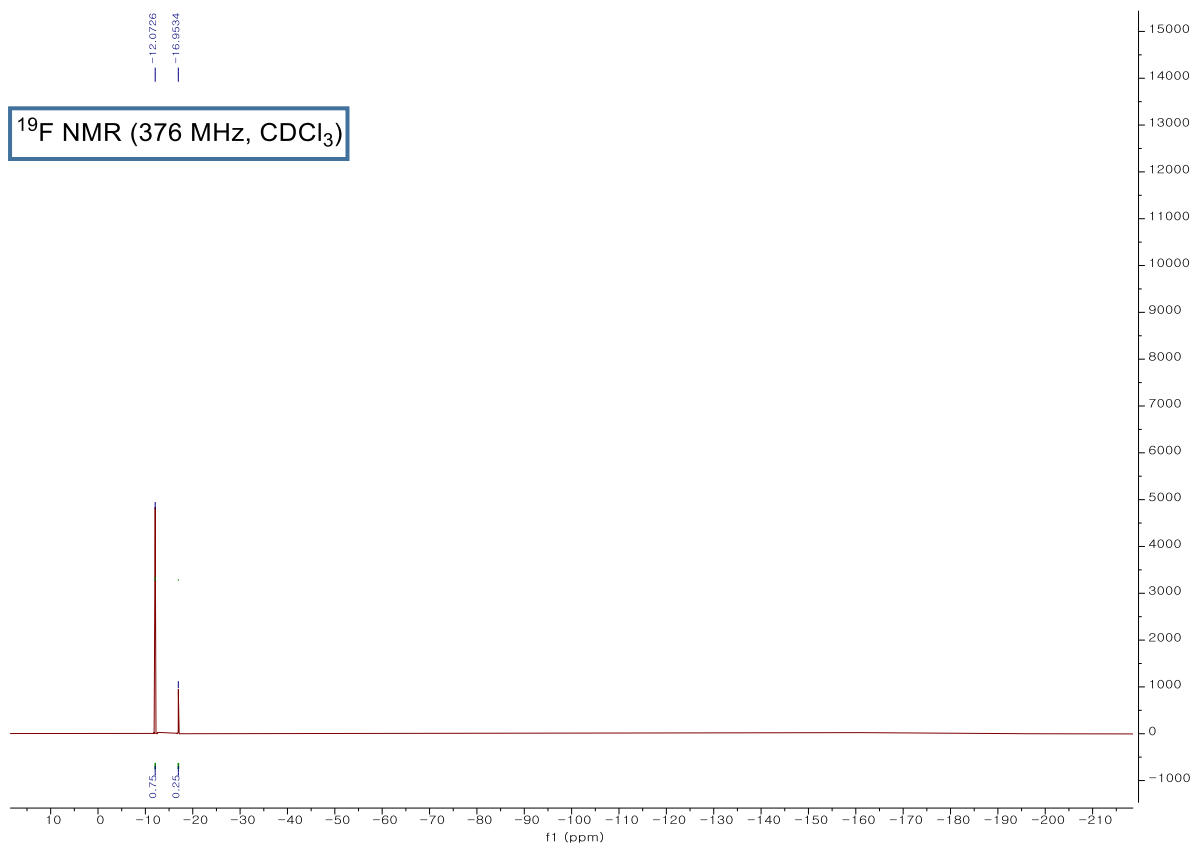


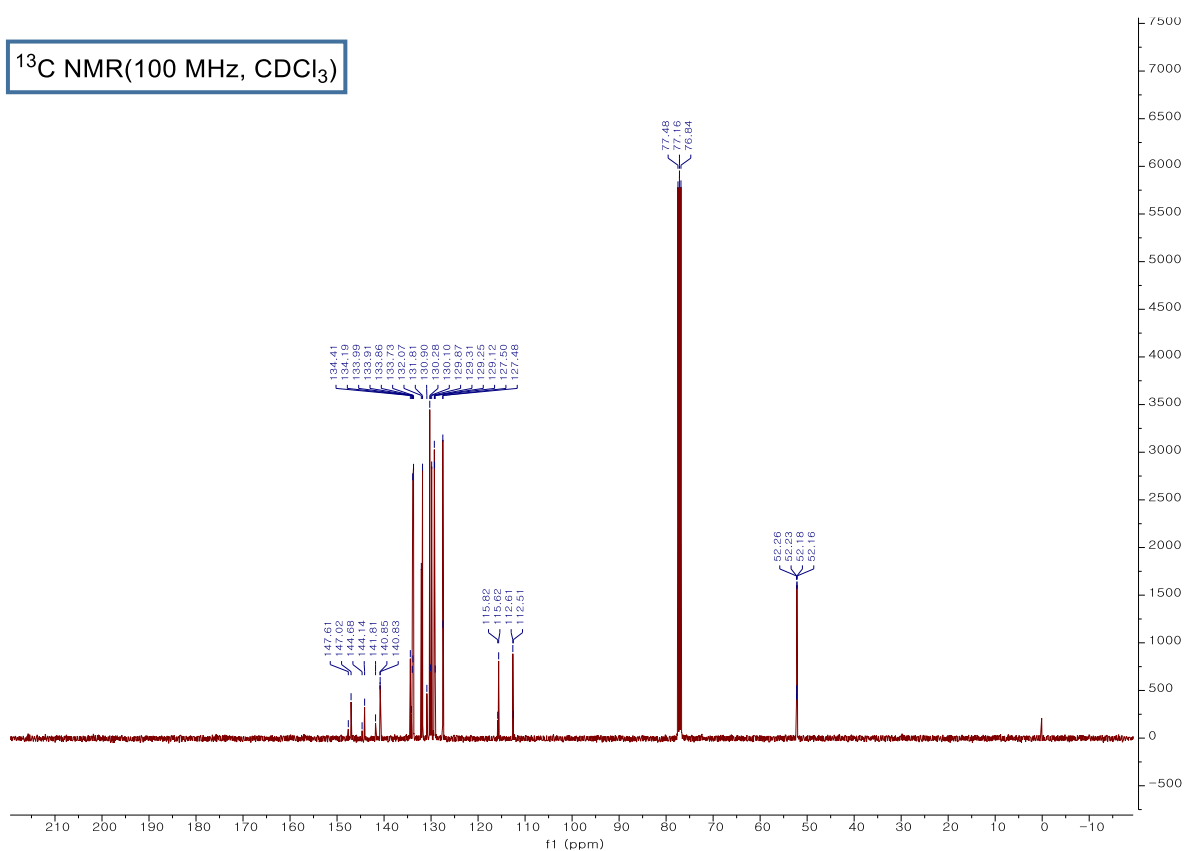
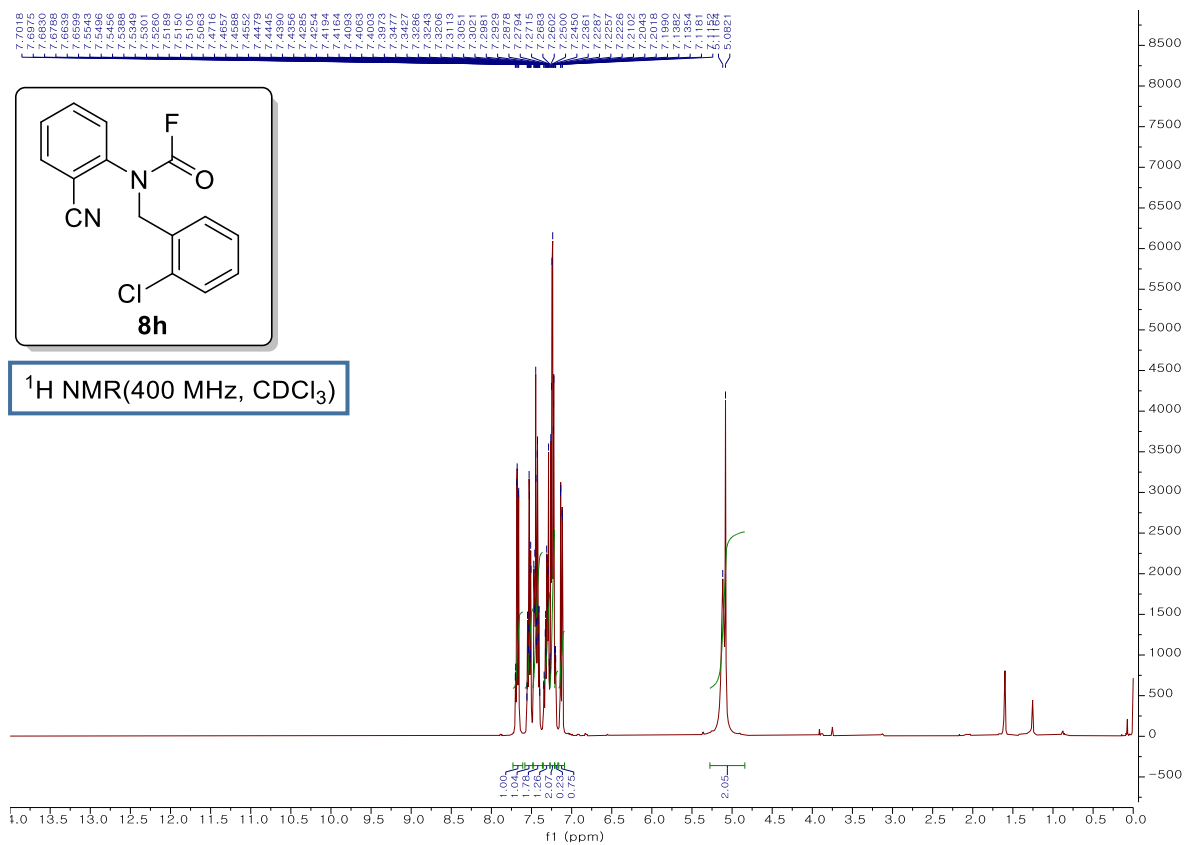


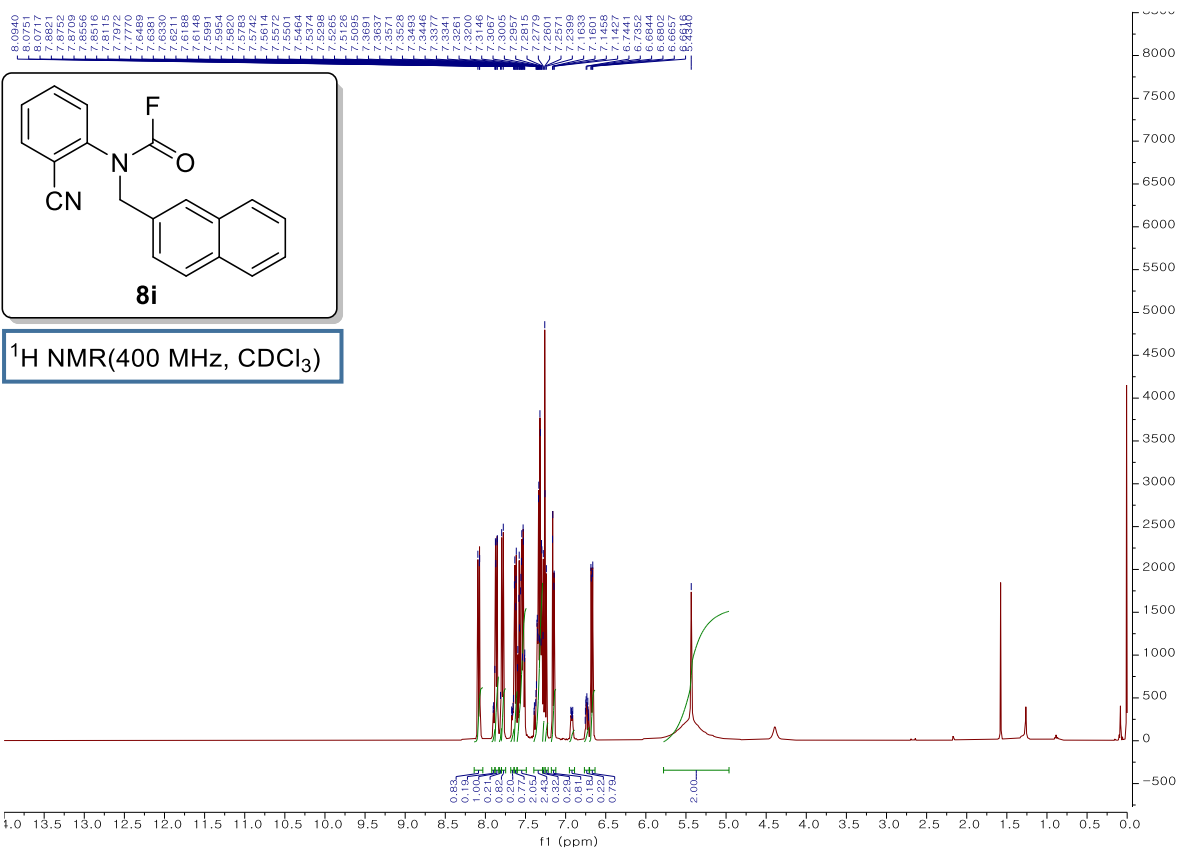
^{13}C NMR (100 MHz, CDCl_3)

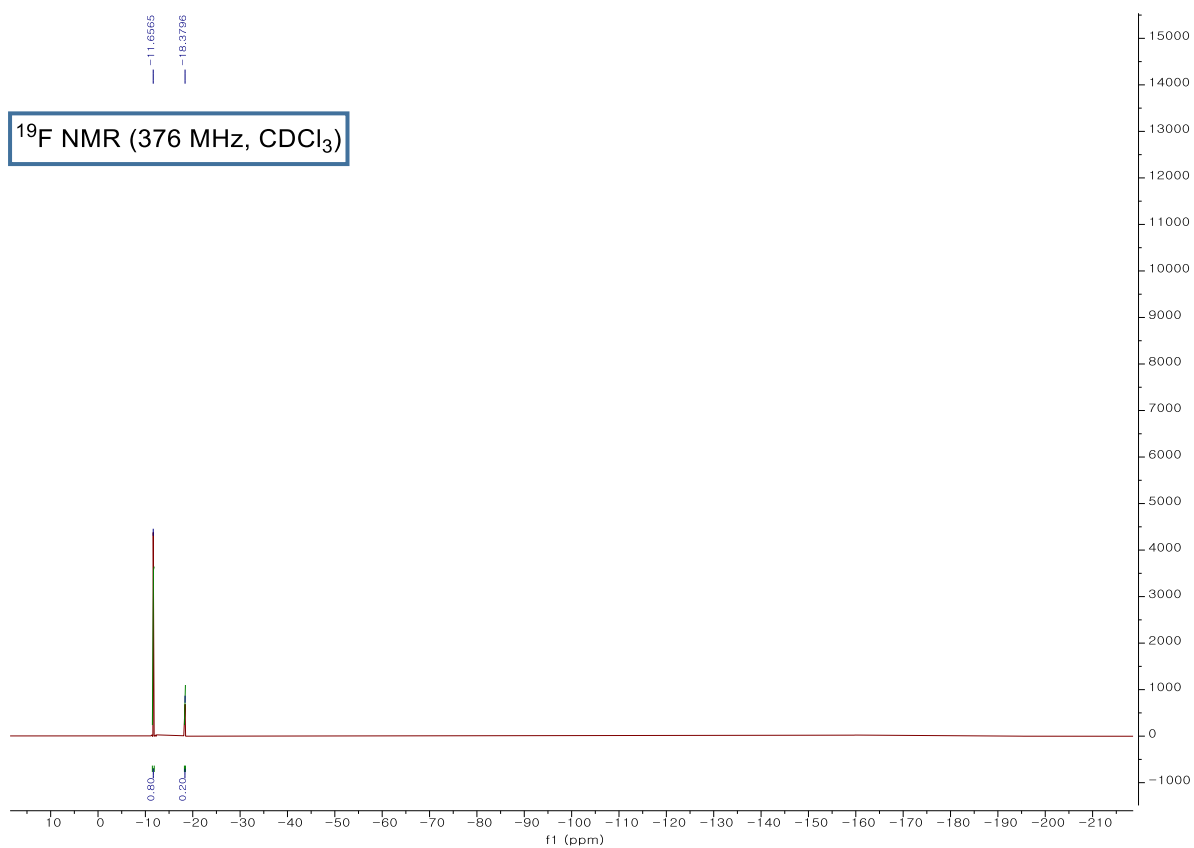
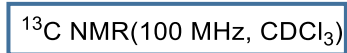


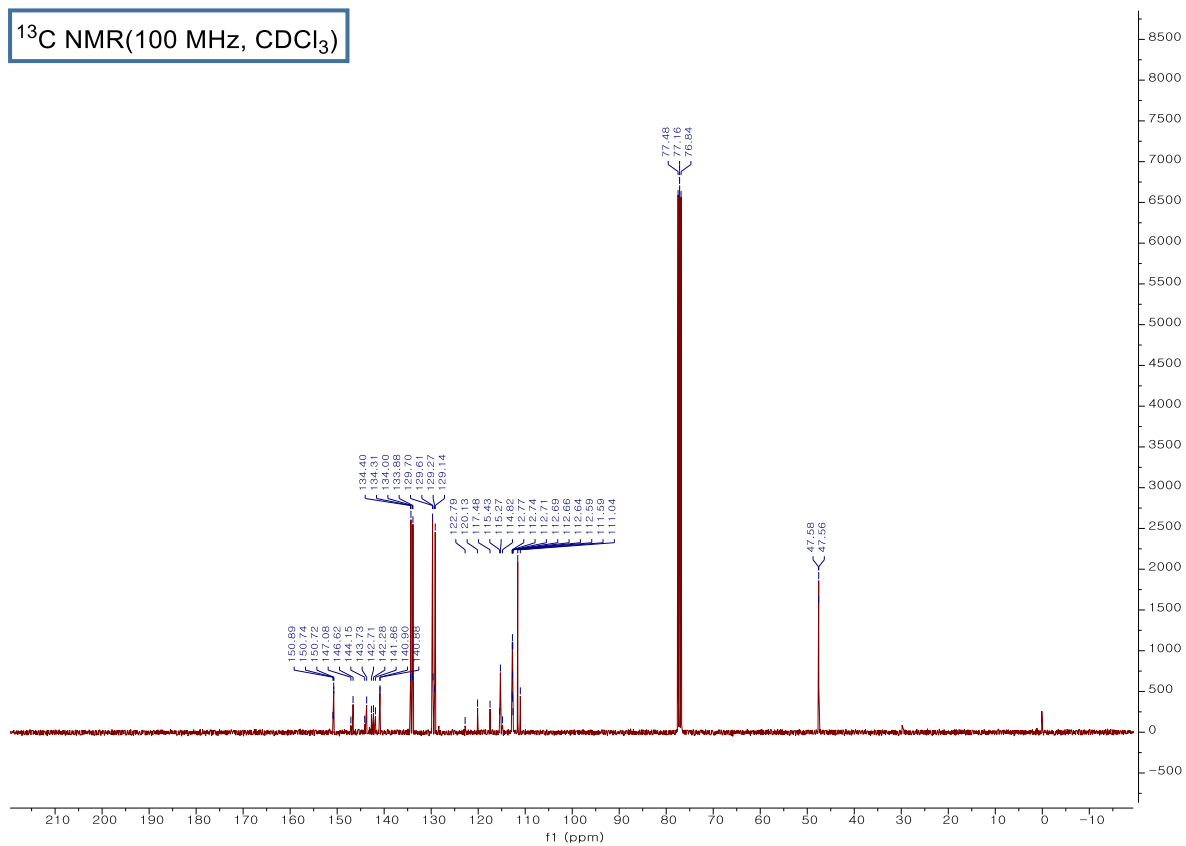
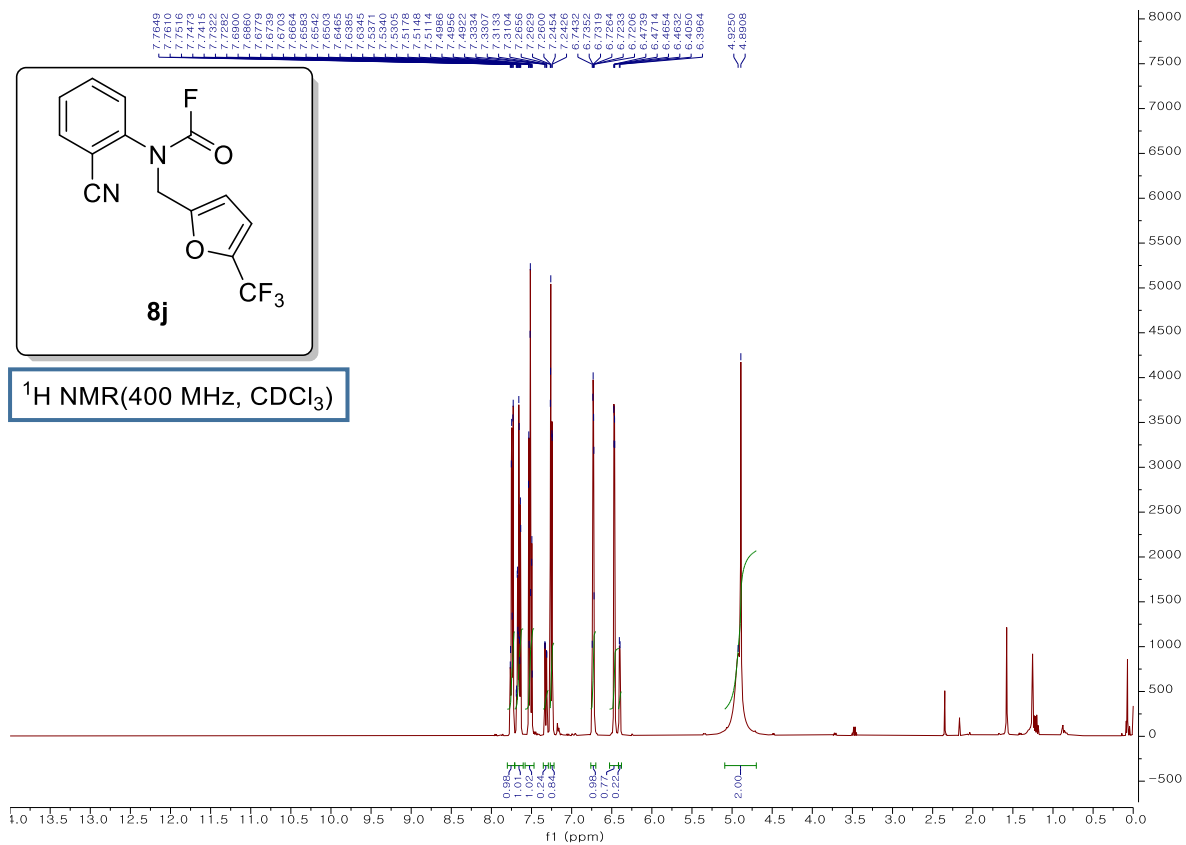
^{19}F NMR (376 MHz, CDCl_3)

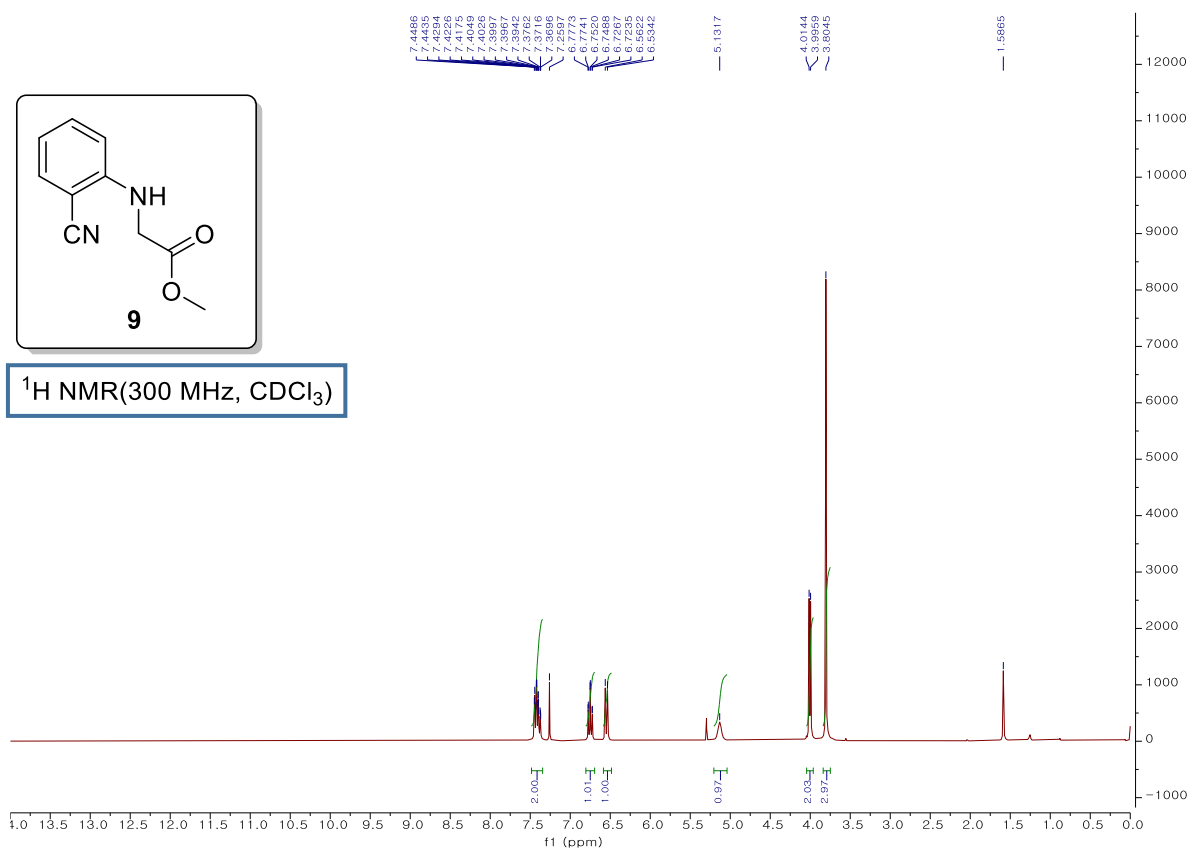
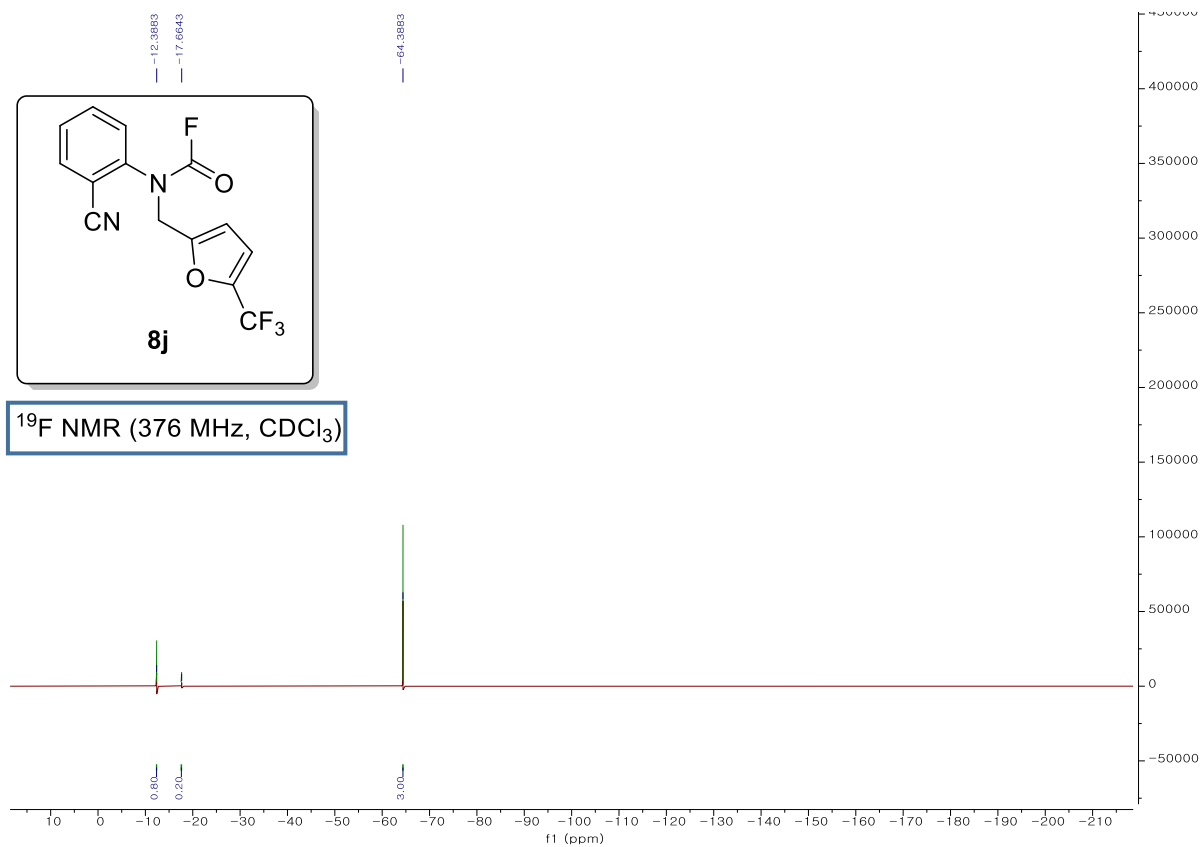


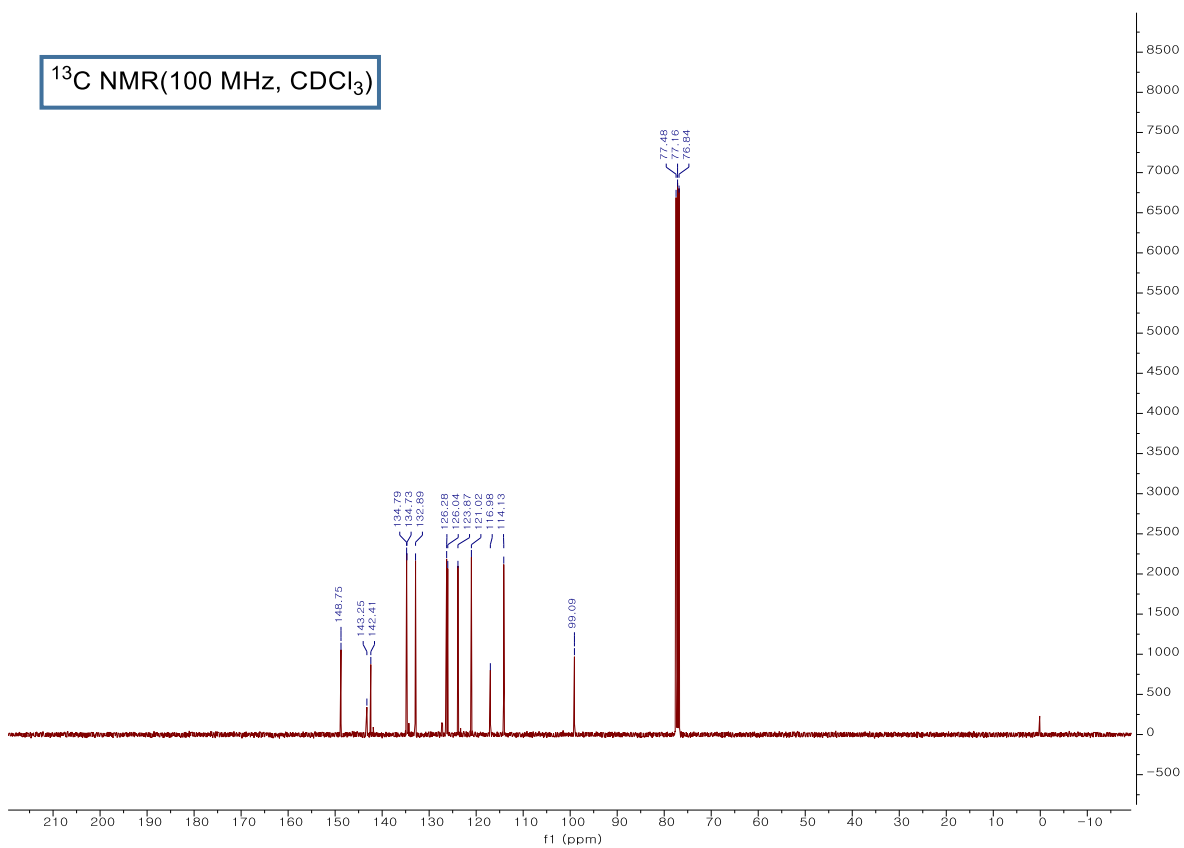
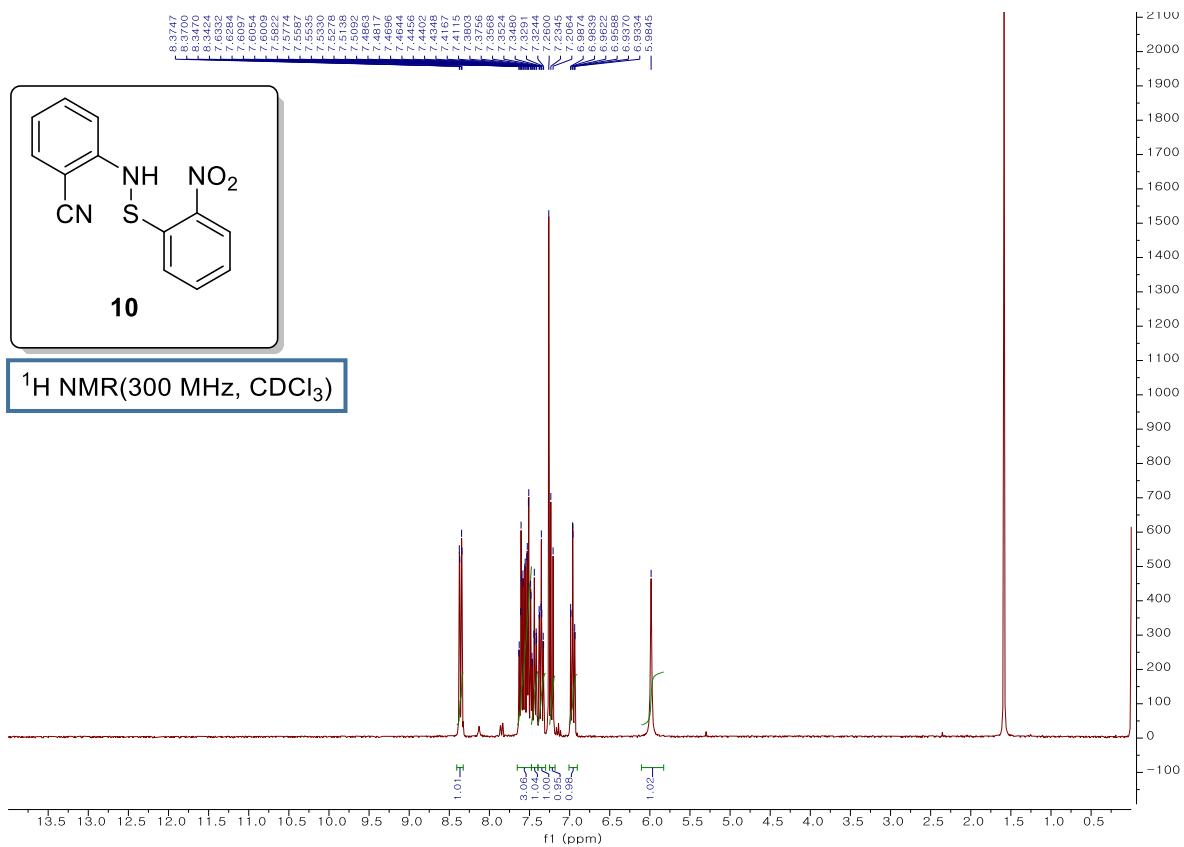


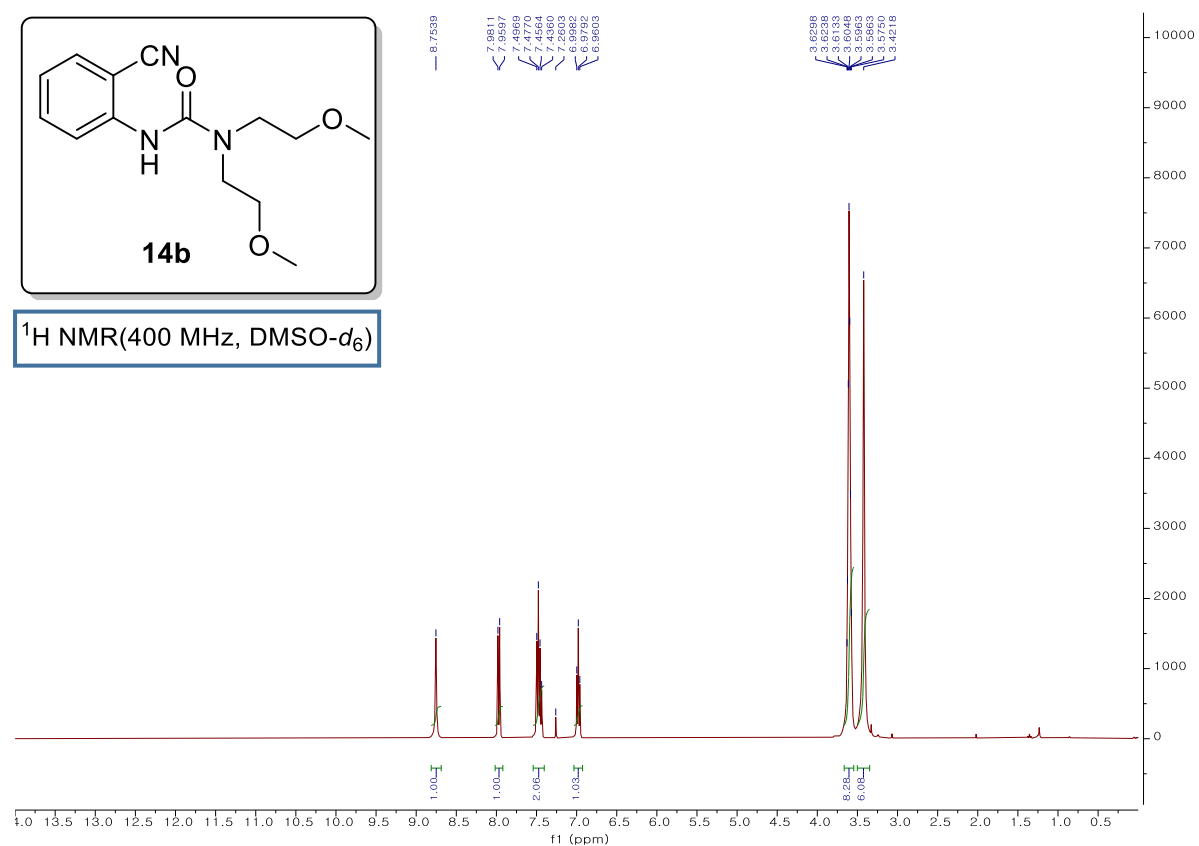
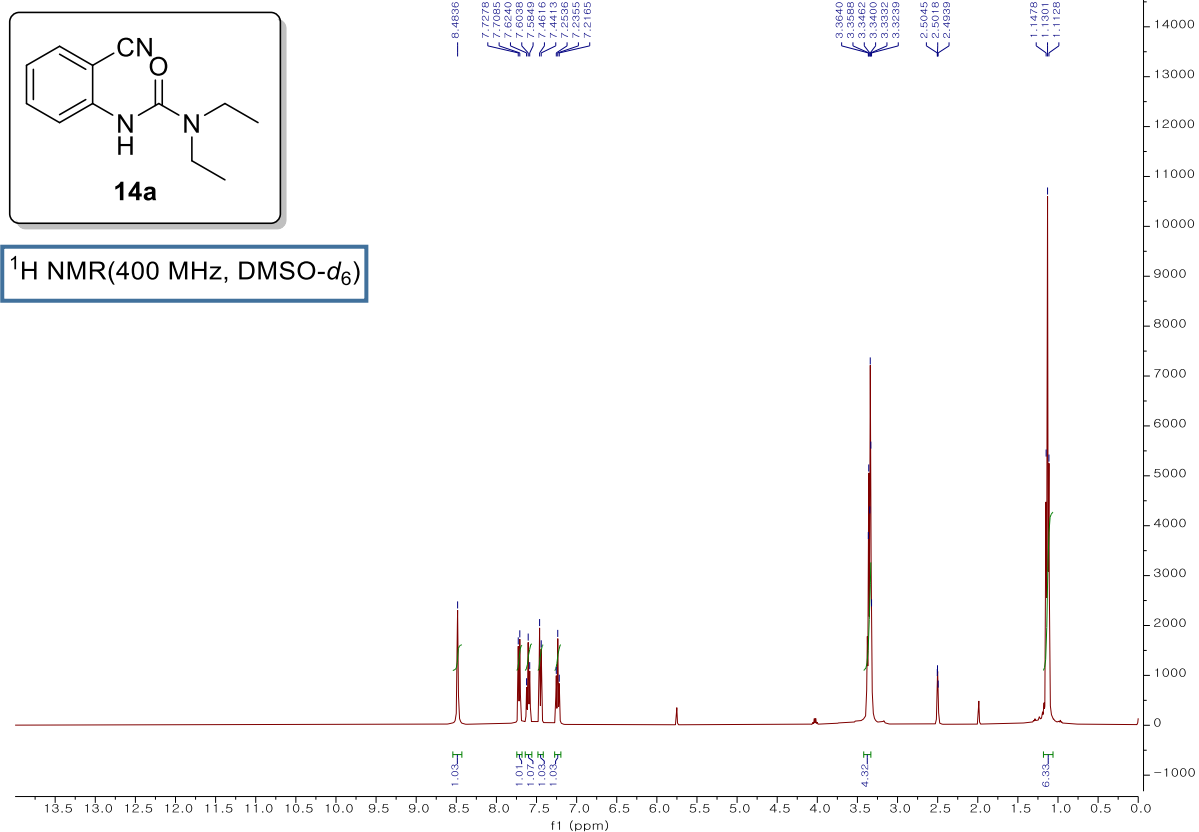


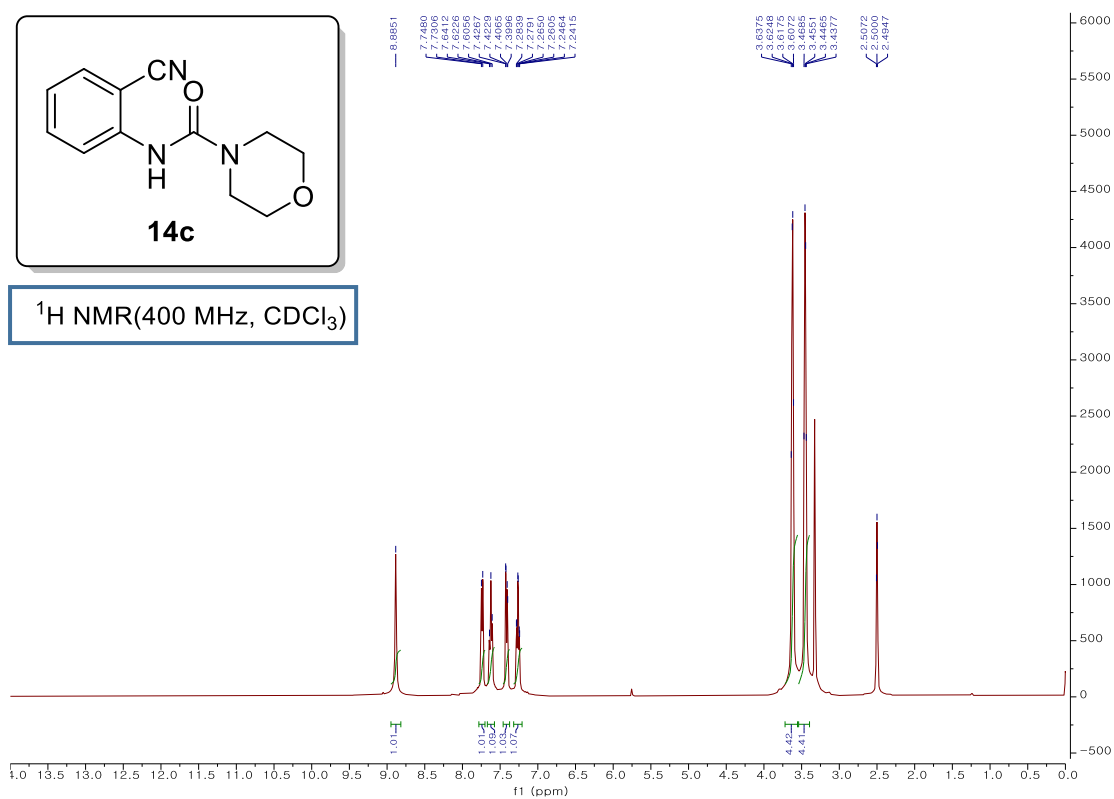
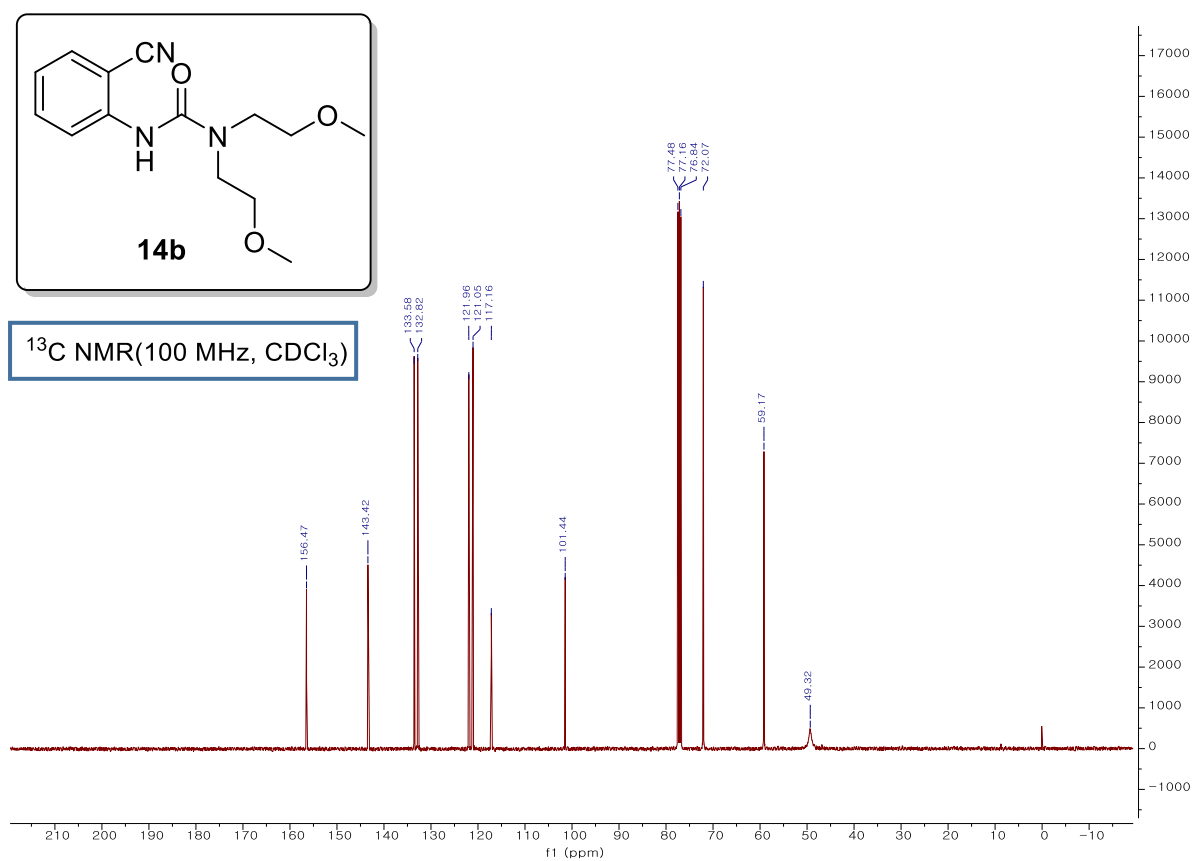


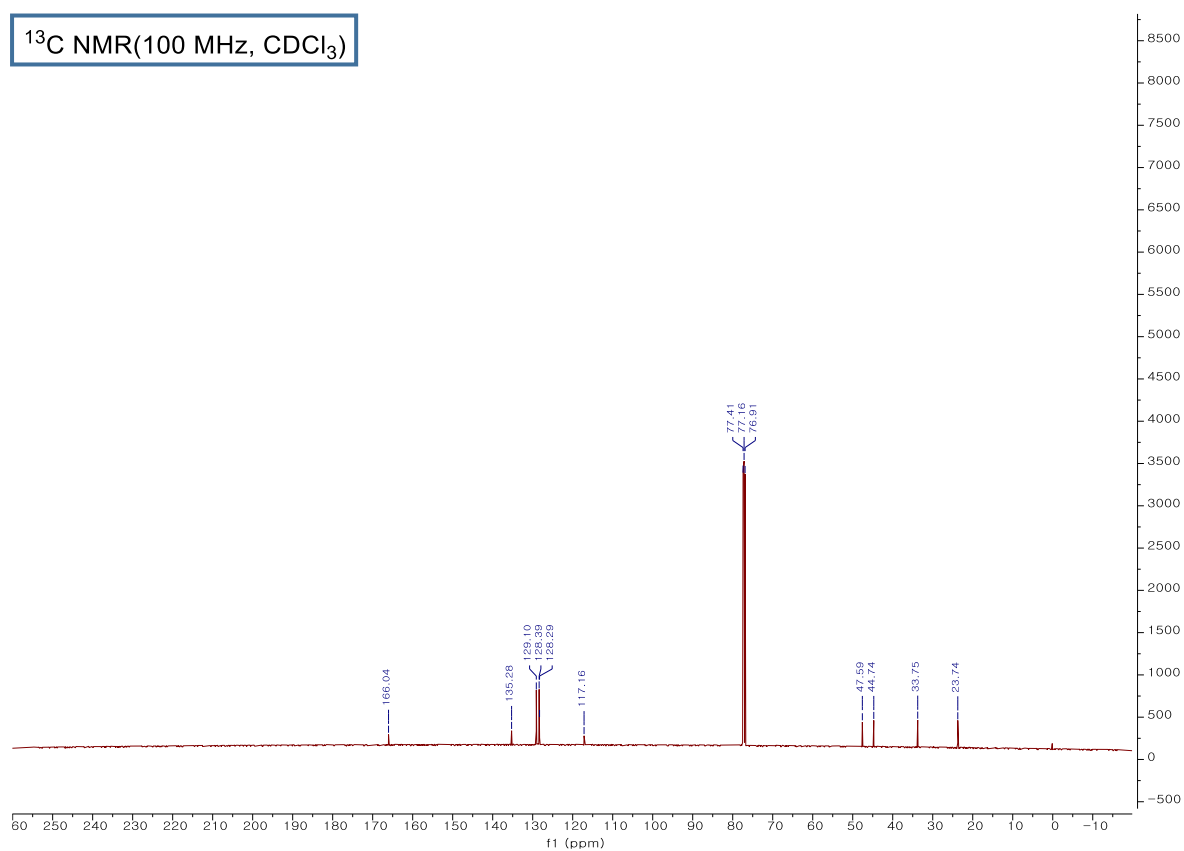
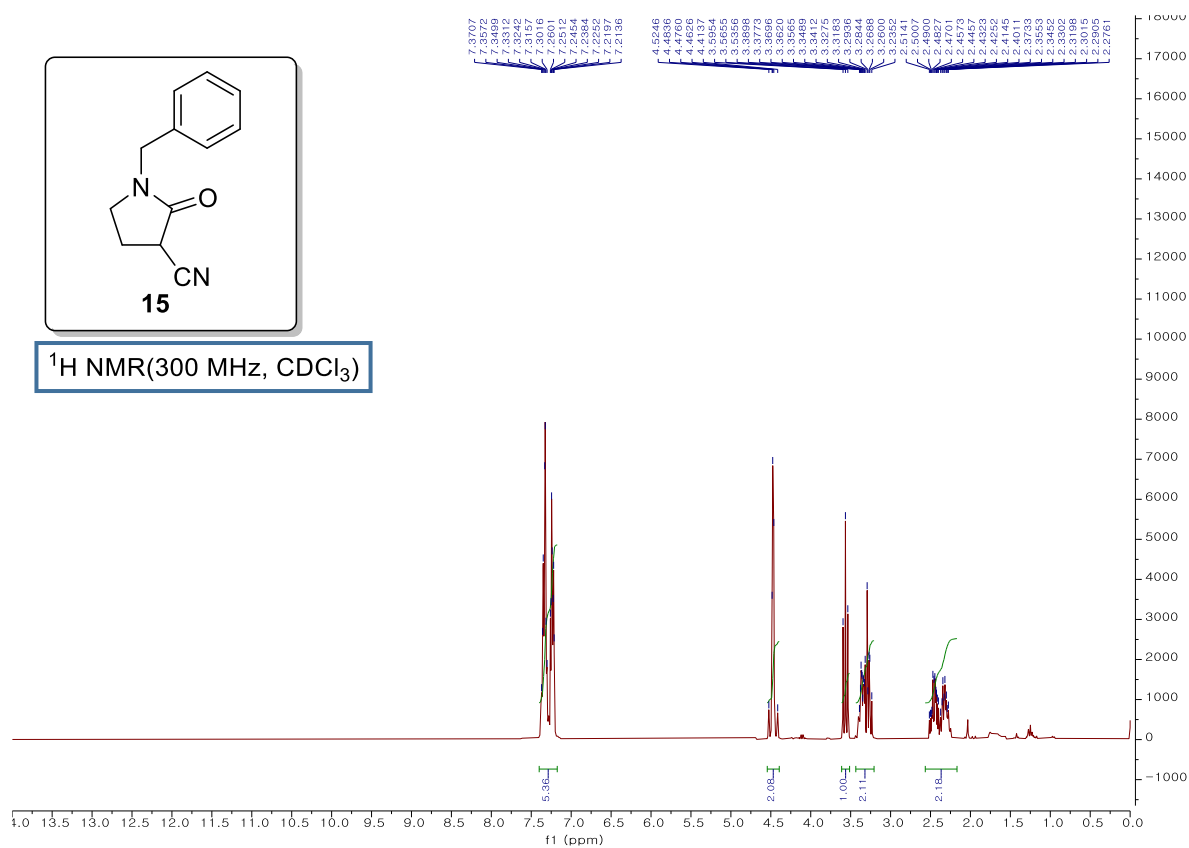


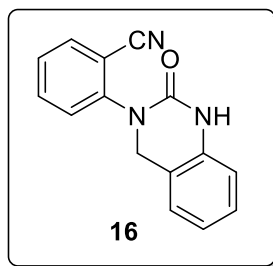




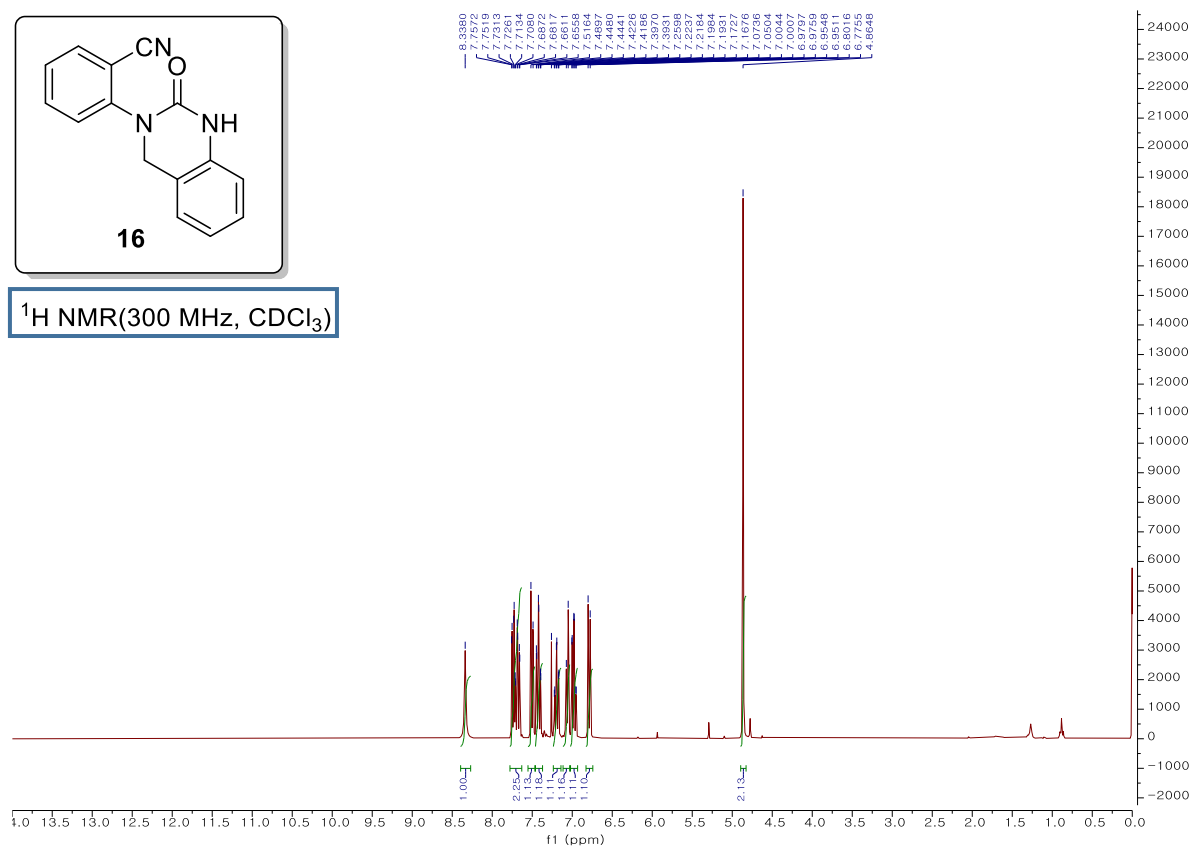








¹H NMR(300 MHz, CDCl₃)



¹³C NMR(125 MHz, CDCl₃)

