Supporting Information

Enantioselective Reaction of *N*-Cyano Imines: Decarboxylative Mannich-type Reaction with Malonic Acid Half Thioesters

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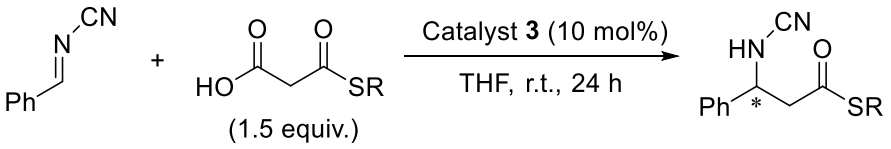
Experimental Section

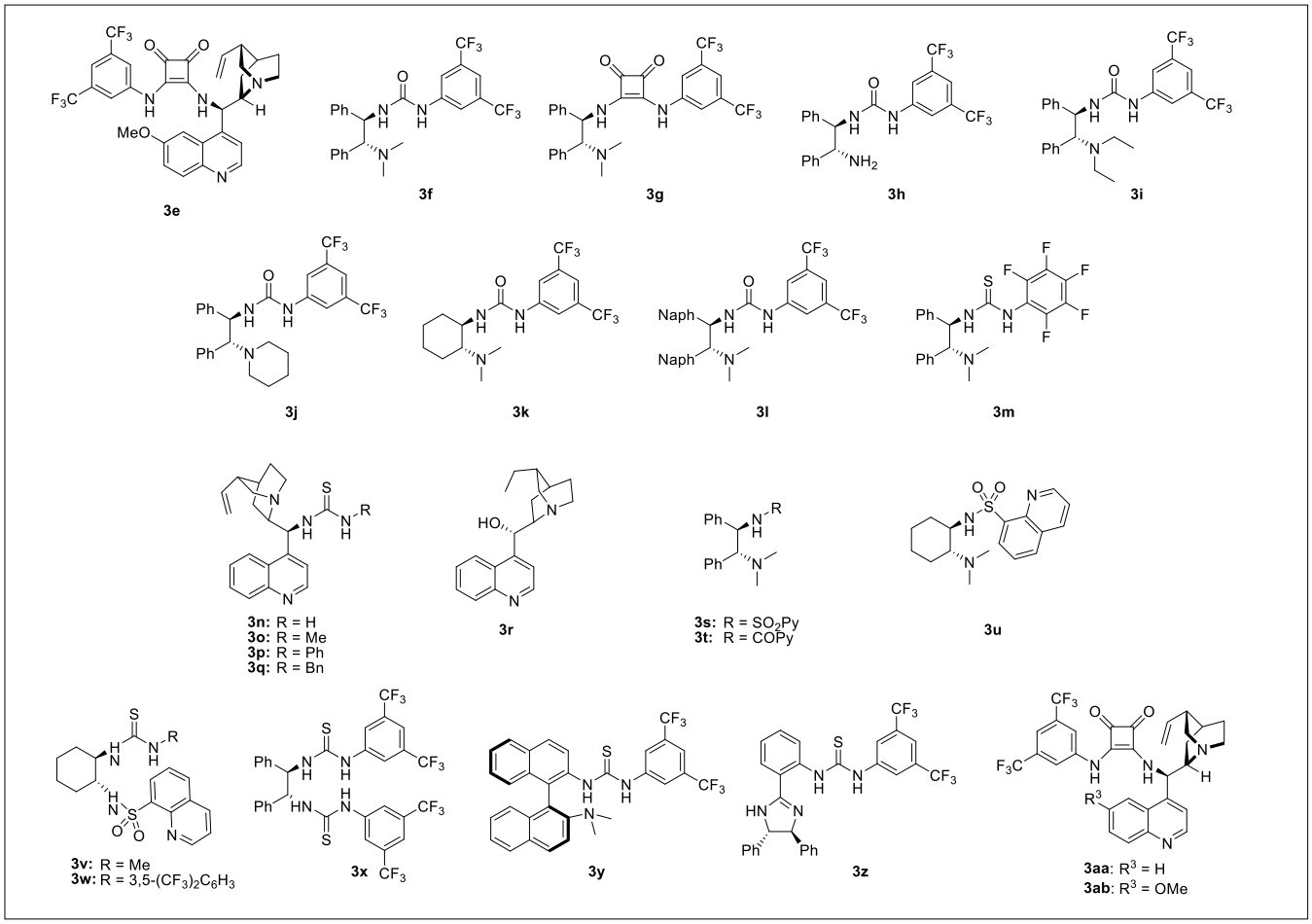
General method: All reactions were performed in oven-dried glassware under a positive pressure of nitrogen. Solvents were transferred via syringe and were introduced into the reaction vessels through a rubber septum. All reactions were monitored by thin-layer chromatography (TLC) carried out on 0.25 mm Merck silica-gel (60-F254). The TLC plates were visualized with UV light. Column chromatography was carried out on a column packed with silica-gel 60N spherical neutral size 63-210 µm. The ^{1}H NMR (300 MHz) and ^{19}F NMR (282 MHz) spectra for solution in $CDCl_3$ or $(CD_3)_2SO$ were recorded on Varian Mercury 300, and ^{13}C NMR (125 MHz) spectra for solution in $CDCl_3$ or $(CD_3)_2SO$ were recorded on Bruker Avance 500. Chemical shifts (δ) are expressed in ppm downfield from internal TMS. HPLC analyses were performed on a SHIMADZU LC-2010A HT using 4.6 x 250 mm CHIRALPAK® IE-3, ID, AD-3 and CHIRALCEL® OD-H column. HRMS were recorded on a Waters SYNAPT G2 (ESI). ESI Mass spectra were recorded on a SHIMADZU LCMS-2020 using positive mode. Optical rotations were measured on a JASCO P-2200.Infrared spectra were recorded on a JASCO FT/IR-4600 spectrometer with ZnSe ATR unit. The imines were prepared by published procedures.[1)] Malonic acid half thioesters were synthesized by published procedures.[2)]

Optimization of Catalysts

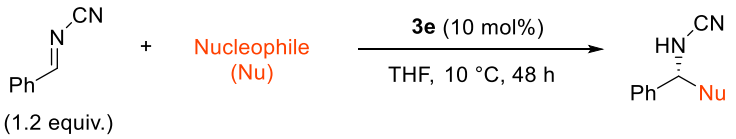


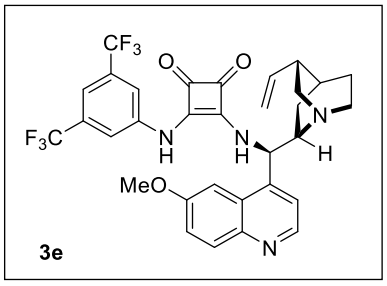
Entry	Catalyst	R	Yield (%)	Ee (%)
1	**3e**	Duryl	91	91 (*R*)
2	**3f**	Ph	81	80 (*S*)
3	**3g**	Ph	75	85 (*S*)
4	**3h**	Ph	6	16 (*S*)
5	**3i**	Ph	99	71 (*S*)
6	**3j**	Ph	81	71 (*S*)
7	**3k**	Ph	92	80 (*S*)
8	**3l**	Ph	90	86 (*S*)
9	**3m**	Ph	85	57 (*S*)
10	**3n**	Ph	82	40 (*S*)
11	**3o**	Ph	83	48 (*S*)
12	**3p**	Ph	80	60 (*S*)

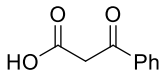
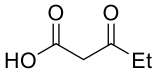
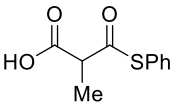
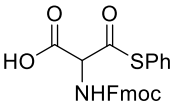
Entry	Catalyst	R	Yield (%)	Ee (%)
13	**3q**	Ph	80	45 (*R*)
14	**3r**	Ph	77	7 (*S*)
15	**3s**	Ph	99	5 (*S*)
16	**3t**	Ph	91	8 (*S*)
17	**3u**	Ph	91	2 (*S*)
18	**3v**	Ph	63	2 (*S*)
19	**3w**	Ph	57	2 (*S*)
20	**3x**	Ph	47	5 (*S*)
21	**3y**	Ph	19	1 (*S*)
22	**3z**	Ph	50	44 (*S*)
23	**3aa**	Ph	96	77 (*S*)
24	**3ab**	Ph	91	81 (*S*)



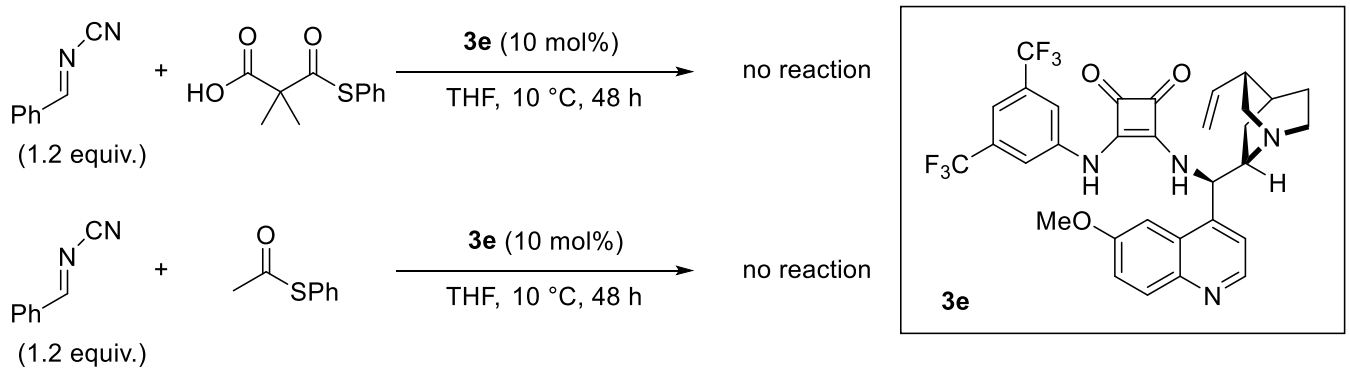
Reaction with Various Nucleophiles



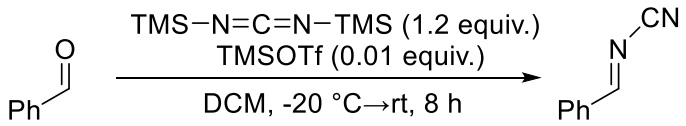


Entry	Nucleophile	Yield (%)	Ee (%)
1		96	50
2		86	18
3		n.r.	-
4		n.r.	-

Control Experiments

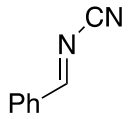


General Procedure for Synthesis of *N*-Cyano imines[1)]



To a stirred solution of bis(trimethylsilyl)carbodiimide (2.9 mL, 12.8 mmol, 1.2 equiv.) in CH_2Cl_2 (5.8 mL) was added benzaldehyde (1.1 mL, 11.6 mmol, 1.0 equiv.) at room temperature. After cooling to – 20 ˚C, trimethylsilyl trifluoromethanesulfonate (21.0 μL, 0.12 mmol, 0.01 equiv.) was added dropwise. The reaction mixture was stirred for 30 min, and warmed to room temperature, then the reaction mixture was stirred for 8 h. The reaction mixture was recrystallized by CH_2Cl_2/hexane to give **1a** (1.45 g, 96%). The other *N*-Cyano imines **1b-1q** were synthesized by similar procedure using the corresponding aldehydes.

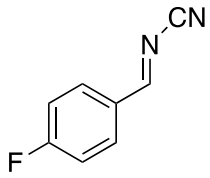
***N*-Benzylidenecyanamide (1a)**



According to the general procedure, the reaction using benzaldehyde (1.1 mL, 11.6 mmol), bis(trimethylsilyl)carbodiimide (2.9 mL, 12.8 mmol), and trimethylsilyl trifluoromethanesulfonate (21.0 μL, 0.12 mmol) gave **1a** (1.45 g, 96%) as a white solid.

mp = 66.0-66.5 ˚C; ^{1}H NMR ($CDCl_3$, 300 MHz) δ 9.02 (s, 1H), 7.93-7.90 (m, 2H), 7.73-7.68 (m, 1H), δ7.57-7.52 (m, 2H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 182.5, 135.9, 133.4, 130.6, 129.4, 115.8; IR (ATR) 2188, 1607, 1594, 1568, 1450, 1231, 1023, 994, 754, 680 cm^{-1}; HRMS (ESI) m/z: $[M+Na]^+$ Calcd. for $C_8H_6N_2Na$ 153.0423; Found: 153.0414.

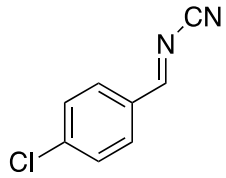
***N*-(4-Fluorobenzylidene)cyanamide (1g)**



According to the general procedure, the reaction using 4-fluorobenzaldehyde (105.2 μL, 1.0 mmol), bis(trimethylsilyl)carbodiimide (0.27 mL, 1.2 mmol), and trimethylsilyl trifluoromethanesulfonate (1.8 μL, 0.01 mmol) gave **1g** (118.4 mg, 80%) as a white solid.

mp = 84.1-84.9 ˚C; ^{1}H NMR ($CDCl_3$, 300 MHz) δ 8.98 (s, 1H), 7.97-7.93 (m, 2H), δ 7.24-7.20 (m, 2H); ^{19}F NMR ($CDCl_3$, 282 MHz): δ −99.1; ^{13}C NMR ($CDCl_3$, 125 MHz) δ 180.6, 167.5 (d, $J_{C\text{-}F}$ = 259.0 Hz), 133.1 (d, $J_{C\text{-}F}$ = 9.8 Hz), 129.8 (d, $J_{C\text{-}F}$ = 2.8 Hz), 117.0 (d, $J_{C\text{-}F}$ = 22.5 Hz), δ 115.7; IR (ATR) 2194, 1598, 1576, 1419, 1299, 1234, 1154, 1009, 997, 871, 834 cm^{-1}; HRMS (ESI) m/z: $[M+Na]^+$ Calcd. for $C_8H_5N_2FNa$ 171.0329; Found: 171.0335.

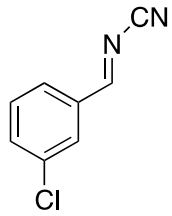
***N*-(4-Chlorobenzylidene)cyanamide (1h)**



According to the general procedure, the reaction using 4-chlorobenzaldehyde (140.6 mg, 1.0 mmol), bis(trimethylsilyl)carbodiimide (0.27 mL, 1.2 mmol), and trimethylsilyl trifluoromethanesulfonate (1.8 μL, 0.01 mmol) gave **1h** (113.6 mg, 69%) as a white solid.

mp = 147.0-147.4 ˚C; ^{1}H NMR ($CDCl_3$, 300 MHz) δ 8.98 (s, 1H), 7.86 (d, *J* = 8.6 Hz, 2H), 7.52 (d, *J* = 8.6 Hz, 2H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 180.9, 142.6, 131.8, 131.6, 129.9, 115.5; IR (ATR) 2195, 1592, 1561, 1488, 1382, 1230, 1174, 1278, 1089, 1005, 824 cm^{-1}; HRMS (ESI) m/z: $[M+Na]^+$ Calcd. for $C_8H_5N_2NaCl$ 187.0033; Found: 187.0038.

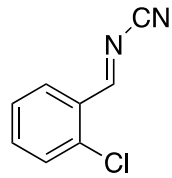
***N*-(3-Chlorobenzylidene)cyanamide (1i)**



According to the general procedure, the reaction using 3-chlorobenzaldehyde (113.0 μL, 1.0 mmol), bis(trimethylsilyl)carbodiimide (0.27 mL, 1.2 mmol), and trimethylsilyl trifluoromethanesulfonate (1.8 μL, 0.01 mmol) gave **1i** (116.2 mg, 71%) as a white solid.

mp = 117.5-118.2 ˚C; ^{1}H NMR ($CDCl_3$, 300 MHz) δ 8.98 (s, 1H), 7.92 (s, 1H), 7.79-7.77 (m, 1H), 7.68-7.65 (m, 1H), 7.52-7.47 (m, 1H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 181.0, 135.8, 135.6, 134.9, 130.6, 129.6, 128.9, 115.2; IR (ATR) 2193, 1604, 1560, 1380, 1232, 1093, 1077, 995, 893, 705, 633 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ Calcd. for $C_8H_6N_2Cl$ 165.0214; Found: 165.0216.

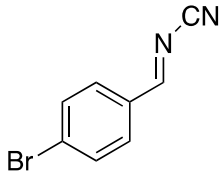
***N*-(2-Chlorobenzylidene)cyanamide (1j)**



According to the general procedure, the reaction using 2-chlorobenzaldehyde (113.0 mg, 1.0 mmol), bis(trimethylsilyl)carbodiimide (0.27 mL, 1.2 mmol), and trimethylsilyl trifluoromethanesulfonate (1.8 μL, 0.01 mmol) gave **1j** (78.8 mg, 48%) as a white solid.

mp = 81.0-81.6 ˚C; ^{1}H NMR ($CDCl_3$, 300 MHz) δ 9.49 (s,1H), 8.16 (d, *J* = 9.0 Hz, 1H), 7.64-7.59 (m, 1H), 7.52-7.50 (m, 1H), 7.44-7.39 (m, 1H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 179.7, 139.0, 136.7, 130.7, 130.7, 128.7, 127.7, 115.8; IR (ATR) 2193, 1597, 1441, 1373, 1275, 1160, 1056, 1013, 981, 857, 766 cm^{-1}; HRMS (ESI) m/z: $[M+H]^+$ Calcd. for $C_8H_6N_2Cl$ 165.0214; Found: 165.0217.

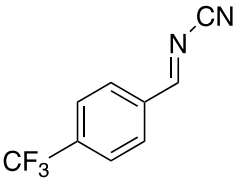
***N*-(4-Bromobenzylidene)cyanamide (1k)**



According to the general procedure, the reaction using 4-bromobenzaldehyde (185.0 mg, 1.0 mmol), bis(trimethylsilyl)carbodiimide (0.27 mL, 1.2 mmol), and trimethylsilyl trifluoromethanesulfonate (1.8 μL, 0.01 mmol) gave **1k** (190.2 mg, 91%) as a white solid.

mp = 157.9-158.4 ˚C; ^{1}H NMR ($CDCl_3$, 300 MHz) δ 8.97 (s, 1H), δ 7.78 (d, 2H, *J* = 8.6 Hz), 7.70 (d, 2H, *J* = 8.6 Hz); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 181.1, 132.9, 132.1, 131.6, 131.5, 115.5; IR (ATR) 2195, 1598, 1484, 1407, 1379, 1282, 1066, 1008, 995, 858, 820 cm^{-1}; HRMS (ESI) m/z: $[M+Na]^+$ Calcd. for $C_8H_5N_2NaBr$ 230.9528; Found: 230.9539.

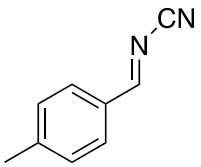
***N*-(4-Trifluoromethylbenzylidene)cyanamide (1l)**



According to the general procedure, the reaction using 4-(trifluoromethyl)benzaldehyde (134.0 μL, 1.0 mmol), bis(trimethylsilyl)carbodiimide (0.27 mL, 1.2 mmol), and trimethylsilyl trifluoromethanesulfonate (1.8 μL, 0.01 mmol) gave **1l** (118.9 mg, 60%) as a white solid.

mp = 112.5-113.0 ˚C; ^{1}H NMR ($CDCl_3$, 300 MHz) δ 9.09 (s, 1H), 8.05 (d, 2H, *J* = 8.3 Hz), 7.81 (d, 2H, *J* = 8.3 Hz); ^{19}F NMR ($CDCl_3$, 282MHz) δ −63.4; ^{13}C NMR ($CDCl_3$, 125 MHz): δ 181.2, 136.7 (q, $J_{C\text{-}F}$ = 32.8 Hz), 136.1, 130.7, 126.3 (q, $J_{C\text{-}F}$ = 3.7 Hz), 123.2 (q, $J_{C\text{-}F}$ = 257.7 Hz), 115.0; IR (ATR) 2197, 1606, 1571, 1321, 1231, 1164, 1109, 1016, 862, 839, 764 cm^{-1}; HRMS (ESI) m/z: $[M+Na]^+$ Calcd. for $C_9H_5N_2F_3Na$ 221.0297; Found: 221.0302.

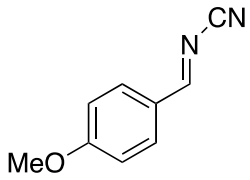
***N*-(4-Methylbenzylidene)cyanamide (1m)**



According to the general procedure, the reaction using 4-methylbenzaldehyde (117.8 μL, 1.0 mmol), bis(trimethylsilyl)carbodiimide (0.27 mL, 1.2 mmol), and trimethylsilyl trifluoromethanesulfonate (1.8 μL, 0.01 mmol) gave **1m** (93.7 mg, 65%) as a white solid.

mp = 93.5-94.2 ˚C; ^{1}H NMR ($CDCl_3$, 300 MHz) δ 8.96 (s, 1H), 7.80 (d, 2H, *J* = 8.0 Hz), 7.34 (d, 2H, *J* = 8.0 Hz), 2.47 (s, 3H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 181.6, 147.3, 130.6, 130.3, 129.8, 115.8, 21.8; IR (ATR) 2189, 1590, 1557, 1509, 1379, 1235, 1166, 1044, 866, 775, 637 cm^{-1}; HRMS (ESI) m/z: $[M+Na]^+$ Calcd. for $C_9H_8N_2Na$ 167.0580; Found: 167.0598.

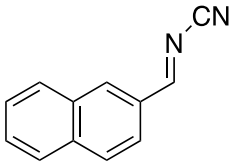
***N*-(4-Methoxybenzylidene)cyanamide (1n)**



According to the general procedure, the reaction using 4-methoxybenzaldehyde (121.6 μL, 1.0 mmol), bis(trimethylsilyl)carbodiimide (0.27 mL, 1.2 mmol), and trimethylsilyl trifluoromethanesulfonate (1.8 μL, 0.01 mmol) gave **1n** (124.9 mg, 78%) as a white solid.

mp = 123.5-124.0 ˚C; ^{1}H NMR ($CDCl_3$, 300 MHz) δ 8.89 (s, 1H), 7.86 (d, 2H, *J* = 8.9 Hz), 7.01 (d, 2H, *J* = 8.9 Hz), 3.92 (s, 3H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 180.6, 166.0, 133.0, 126.4, 116.6, 114.9, 55.8; IR (ATR) 2180, 1592, 1509, 1427, 1301, 1112, 1002, 995, 836, 632, 604 cm^{-1}; HRMS (ESI) m/z: $[M+Na]^+$ Calcd. for $C_9H_8N_2ONa$ 183.0529; Found: 183.0542.

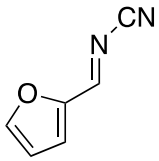
***N*-(2-Naphthylidene)cyanamide (1o)**



According to the general procedure, the reaction using 2-naphthaldehyde (156.2 mg, 1.0 mmol), bis(trimethylsilyl)carbodiimide (0.27 mL, 1.2 mmol), and trimethylsilyl trifluoromethanesulfonate (1.8 μL, 0.01 mmol) gave **1o** (99.1 mg, 55%) as a white solid.

mp = 105.0-105.8 ˚C; ^{1}H NMR ($CDCl_3$, 300 MHz) δ 9.15 (s, 1H), 8.30 (s, 1H), 8.03-7.91 (m, 4H), 7.72-7.59 (m, 2H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 182.1, 137.0, 136.3, 132.6, 131.2, 130.1, 129.7, 129.6, 128.2, 127.6, 122.6, 116.1; IR (ATR) 2189, 1625, 1590, 1371, 1269, 1178, 1016, 891, 817, 777, 754 cm^{-1}; HRMS (ESI) m/z: Calcd. for $C_{12}H_8N_2Na$ 203.0580; Found: 203.0586.

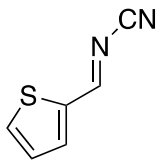
***N*-(2-Furylidene)cyanamide (1p)**



According to the general procedure, the reaction using furfural (82.8 μL, 1.0 mmol), bis(trimethylsilyl)carbodiimide (0.27 mL, 1.2 mmol), and trimethylsilyl trifluoromethanesulfonate (1.8 μL, 0.01 mmol) gave **1p** (52.8 mg, 44%) as a white solid.

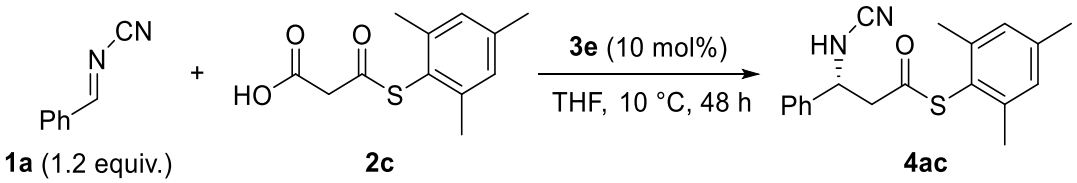
mp = 92.0-92.8 ˚C; ^{1}H NMR ($CDCl_3$, 300 MHz) δ 8.68 (s, 1H), 7.82-7.79 (m, 1H), 7.40-7.38 (m, 1H), 6.74-6.70 (m, 1H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 166.2, 150.6, 149.2, 115.9, 114.3, 114.1; IR (ATR) 3112, 2191, 1536, 1465, 1397, 1304, 1021, 1007, 976, 881, 772 cm^{-1}; HRMS (ESI) m/z: $[M+Na]^+$ Calcd. for $C_6H_4N_2ONa$ 143.0216; Found: 143.0216.

***N*-(2-Thienylidene)cyanamide (1q)**



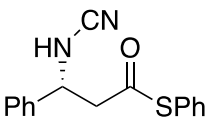
According to the general procedure, the reaction using 2-thiophenecarboxaldehyde (91.2 μL, 1.0 mmol), bis(trimethylsilyl)carbodiimide (0.27 mL, 1.2 mmol), and trimethylsilyl trifluoromethanesulfonate (1.8 μL, 0.01 mmol) gave **1q** (104.9 mg, 77%) as a white solid. mp = 73.1-73.9 ˚C; ^{1}H NMR ($CDCl_3$, 300 MHz) δ 9.03 (s, 1H), 7.85-7.78 (m, 2H), 7.28-7.26 (m, 1H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 173.0, 139.4, 139.4, 137.4, 129.3, 115.7; IR (ATR) 2184, 1573, 1513, 1414, 1375, 1256, 1050, 1023, 1003, 982, 846 cm^{-1}; HRMS (ESI) m/z: $[M+Na]^+$ Calcd. for $C_6H_4N_2NaS$ 158.9987; Found: 159.0002.

General procedure for the enantioselective decarboxylative Mannich reaction of malonic acid half thioesters with *N*-cyano imines catalyzed by chiral organocatalysts



N-Cyano imine **1a** (6.3 mg, 0.048 mmol, 1.2 equiv.), **2c** (9.6 mg, 0.040 mmol, 1.0 equiv.), and **3e** (2.5 mg, 0.004 mmol, 10 mol%) in THF was stirred for 48 h at 10 ˚C. After removal solvent, the residue was purified by silica gel column chromatography (eluent: Hexane/AcOEt, 70:30) to afford (*R*)-**4aa** (11.2mg, 99%) as a yellow oil.

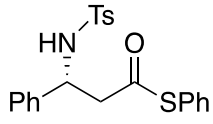
(*R*)-*S*-Phenyl 3-phenyl-3-(cyanoamino)propanethioate (4aa)



Reaction of **1a** (6.3 mg, 0.048 mmol), **2a** (7.9 mg, 0.04 mmol) and **3e** (2.5 mg, 0.004 mmol) in THF (1.0 mL) at r.t. for 24 h. After removal of solvent, the residue was purified by silica gel column chromatography (eluent: Hexane/AcOEt, 70:30) gave **4aa** (11.2 mg, 99%, 85% ee) as a pale yellow oil.

$[\alpha]_D^{25}$ +54.3 (80% ee, *c* 0.58, $CHCl_3$); ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.45-7.33 (m, 10H), 4.81 (br, 1H), 4.74-4.69 (m, 1H), 3.28-3.09 (m, 2H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 196.1, 137.6, 134.4, 130.0, 129.4, 129.1, 129.1, 126.8, 126.4, 114.3, 56.8, 48.3; IR (ATR) 2219, 1709, 1478, 1454, 1358, 1220, 1059, 1024, 975, 747, 689 cm^{-1}; HRMS (ESI) m/z: $[M+Na]^+$ Calcd. for $C_{16}H_{14}N_2ONaS$ 305.0719; Found: 305.0719; HPLC (CHIRALPAK IE-3, Hexane/^{i}PrOH = 90:10, 1.0 mL/min, 254 nm) 80% ee, t_R 20.4 (major), t_R 23.3 (minor) min.

(*S*)-*S*-Phenyl 3-phenyl-3-(tosylamino)propanethioate (4ba)

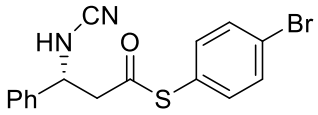


Reaction of **1b** (12.5 mg, 0.048 mmol), **2a** (7.9 mg, 0.04 mmol) and **3a** (2.a mg, 0.004 mmol) in THF (1.0 mL) at r.t. for 24 h. After removal of solvent, the residue was purified by silica gel column chromatography (eluent: Hexane/AcOEt, 80:20)gave **4ba** (16.0 mg, 97%, 45% ee) as a white solid.

$[\alpha]_D^{25}$ +113.8 (45% ee, *c* 0.58, $CHCl_3$); ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.60-7.57 (m, 2H), 7.39-7.34 (m, 3H), 7.24-7.08 (m, 9H), 5.61 (d, *J* = 6.0 Hz, 1H), 4.77 (ddd, 1H, *J* = 6.0, 6.0, 6.2 Hz), 3.18 (dd, 1H, *J* = 6.0, 15.6 Hz), 3.06 (dd, 1H, *J* = 6.2, 15.6 Hz), 2.37 (s, 3H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 195.6, 143.3, 138.8, 137.2, 134.3, 129.7, 129.5, 129.3, 128.6, 127.9, 127.1, 126.8, 126.5, 55.0, 49.4, 21.5; IR (ATR) 3260, 1712, 1683, 1441, 1358, 1159, 1058, 942, 754, 665 cm^{-1}; HRMS (ESI) m/z: $[M+Na]^+$ Calcd. for

$C_{22}H_{21}NO_3NaS$ 434.0855; Found: 434.0860; HPLC (CHIRALCEL OD-H, Hexane/^{i}PrOH = 90:10, 1.0 mL/min, 254 nm) 45% ee, t_R 21.8 (minor), t_R 24.3 (major) min.

(*R*)-*S*-(4-Bromophenyl) 3-phenyl-3-(cyanoamino)propanethioate (4ab)



Reaction of **1a** (6.3 mg, 0.048 mmol), **2b** (11.0 mg, 0.04 mmol) and **3e** (2.5 mg, 0.004 mmol) in THF (1.0 mL) at r.t. for 24 h. After removal of solvent, the residue was purified by silica gel column chromatography (eluent: Hexane/AcOEt, 70:30) gave **4ab** (13.2 mg, 91%, 76% ee) as a pale yellow solid.

mp = 85.5-86.0 ˚C; $[\alpha]_D^{25}$ −56.0 (75% ee, *c* 0.58, $CHCl_3$); ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.59-7.20 (m, 9H), 4.76-4.70 (m, 1H), 4.65 (br, 1H), 3.27 (dd, 1H, *J* = 4.7, 16.2 Hz), 3.14 (dd, 1H, *J* = 4.7, 16.2 Hz); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 195.4, 137.5, 135.9, 132.7, 129.2, 129.2, 126.8, 126.8, 125.4, 124.8, 114.0, 56.8, 48.4; IR (KBr) 2920, 2218, 1711, 1471, 1359, 1219, 1066, 1007, 813, 697 cm^{-1}; HRMS (ESI) m/z: $[M+Na]^+$ Calcd. for $C_{16}H_{13}N_2ONaSBr$ 382.9824; Found: 382.9827; HPLC (CHIRALPAK IE-3, Hexane/^{i}PrOH = 90:10, 1.0 mL/min, 254nm) 76% ee, t_R 34.3 (major), t_R 39.3 (minor) min.

Absolute configuration was determined by X-ray crystal analysis: Hexane was slowly added to the sample tube containing the sample dissolved in chloroform. Once the crystals precipitated, they were allowed to stand for a day in the refrigerator. After recrystallization, the enantioselectivity of the crystals was 92% ee.

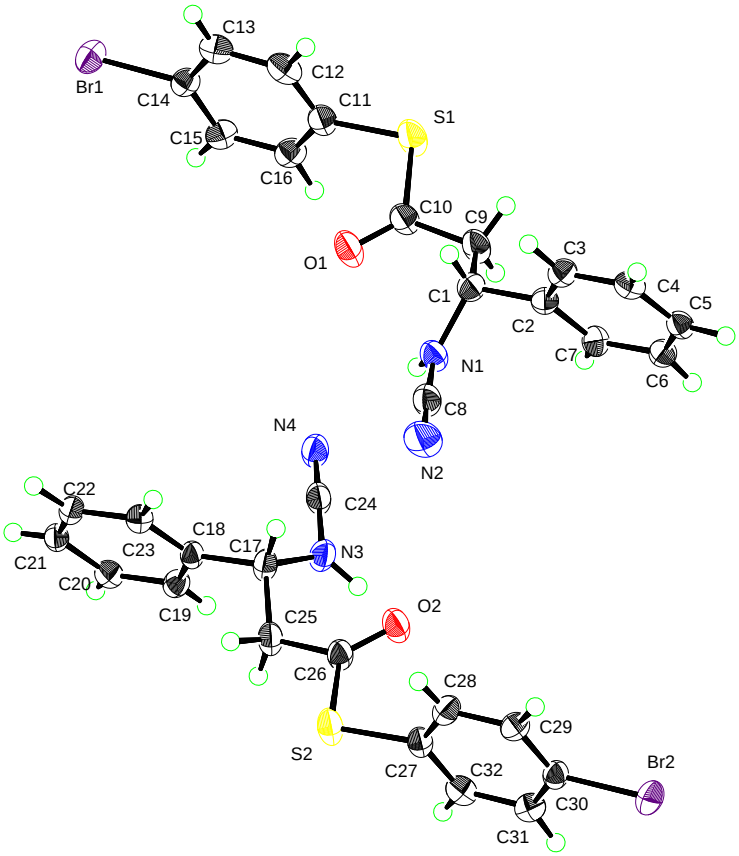
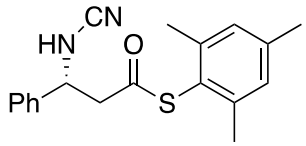


Figure S1. X-ray crystallography analysis for (*R*)-**4ab** (CCDC No. 2054566).

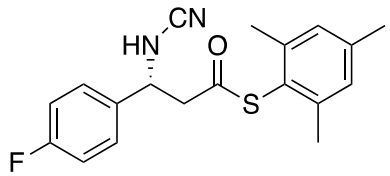
(*R*)-*S*-(2,4,6-Trimethylphenyl) 3-phenyl-3-(cyanoamino)propanethioate (4ac)



Reaction of **1a** (6.3 mg, 0.048 mmol), **2c** (9.6 mg, 0.04 mmol) and **3e** (2.5 mg, 0.004 mmol) in THF (1.0 mL) at 10 ˚C for 48 h. After removal of solvent, the residue was purified by silica gel column chromatography (eluent: Hexane/AcOEt, 70:30) gave **4ac** (12.9 mg, 99%, 95% ee) as a yellow oil.

$[\alpha]_D^{25}$ +49.9 (95% ee, *c* 0.58, $CHCl_3$); ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.40-7.34 (m, 5H), 6.97 (s, 2H), 4.79 (br, 1H), 4.74-4.68 (m, 1H), 3.30-3.13 (m, 2H), 2.29 (s, 3H), 2.19 (s, 6H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 195.7, 142.4, 140.6, 137.7, 129.4, 129.1, 129.0, 126.8, 122.5, 114.3, 57.1, 48.0, 21.4, 21.2; IR (ATR) 2214, 1713, 1666, 1417, 1220, 1092, 1008, 851, 698, 681 cm^{-1}; HRMS (ESI) m/z: $[M+Na]^+$ Calcd. for $C_{19}H_{20}N_2ONaS$ 347.1189; Found: 347.1204; HPLC (CHIRALPAK IE-3, Hexane/^{i}PrOH = 90:10, 1.0 mL/min, 254 nm) 95% ee, t_R 18.2 (major), t_R 21.0 (minor) min.

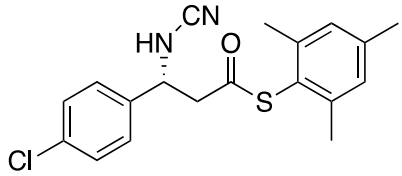
(*R*)-*S*-(2,4,6-Trimethylphenyl) 3-(4-fluorophenyl)-3-(cyanoamino)propanethioate (5)



Reaction of **1g** (7.1 mg, 0.048 mmol), **2c** (9.6 mg, 0.04 mmol) and **3e** (2.5 mg, 0.004 mmol) in THF (1.0 mL) at 10 ˚C for 72 h. After removal of solvent, the residue was purified by silica gel column chromatography (eluent: Hexane/AcOEt, 70:30) gave **5** (12.2 mg, 89%, 95% ee) as a pale yellow oil.

$[\alpha]_D^{25}$ −2.8 (95% ee, *c* 0.58, $CHCl_3$); ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.38-7.33 (m, 2H), 7.12-7.07 (m, 2H), 6.97 (s, 2H), 4.78 (br, 1H), 4.73-4.67 (m, 1H), 3.27-3.11 (m, 2H), 2.29 (s, 3H), 2.20 (s, 6H); ^{19}F NMR ($CDCl_3$, 282 MHz) δ −112.4; ^{13}C NMR ($CDCl_3$, 125 MHz) δ 195.7, 162.9 (d, $J_{C\text{-}F}$ = 247.0 Hz), 142.3, 140.6, 133.4 (d, $J_{C\text{-}F}$ = 3.2 Hz), 129.4, 128.7 (d, $J_{C\text{-}F}$ = 8.4 Hz), 122.3, 116.1 (d, $J_{C\text{-}F}$ = 21.7 Hz), 114.0, 56.4, 48.0, 21.4, 21.1; IR (ATR) 2212, 1713, 1667, 1511, 1445, 1414, 1284, 1161, 1006, 846 cm^{-1}; HRMS (ESI) m/z: $[M+Na]^+$ Calcd. for $C_{19}H_{19}N_2ONaSF$ 365.1100; Found: 365.1094; HPLC (CHIRALPAK IE-3, Hexane/^{i}PrOH = 90:10, 1.0 mL/min, 254 nm) 95% ee, t_R 14.7 (major), t_R 17.6 (minor) min.

(*R*)-*S*-(2,4,6-Trimethylphenyl) 3-(4-chlorophenyl)-3-(cyanoamino)propanethioate (6)

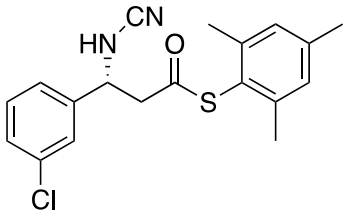


Reaction of **1h** (7.9 mg, 0.048 mmol), **2c** (9.6 mg, 0.04 mmol) and **3e** (2.5 mg, 0.004 mmol) in THF (1.0 mL) at 10 ˚C for 48 h. After removal of solvent, the residue was purified by silica gel column chromatography (eluent: Hexane/AcOEt, 70:30) gave **6** (12.6 mg, 88%, 94% ee) as a pale yellow oil.

$[\alpha]_D^{25}$ −11.4 (94% ee, *c* 0.58, $CHCl_3$); ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.40-7.29 (m, 4H), 6.98 (s, 2H), 4.80 (br, 1H), 4.72-4.66 (m, 1H), 3.23 (dd, 1H, *J* = 5.1, 16.0 Hz), 3.14 (dd, 1H, *J* = 5.1, 16.0 Hz), 2.29 (s,

3H), 2.20 (s, 6H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 195.7, 142.3, 140.7, 136.1, 135.0, 129.4, 129.4, 128.2, 122.2, 114.0, 56.5, 47.8, 21.4, 21.2; IR (ATR) 2220, 1711, 1435, 1359, 1219, 1091, 1013, 979, 851, 754 cm^{-1}; HRMS (ESI) m/z: $[M+Na]^+$ Calcd. for $C_{19}H_{19}N_2ONaSCl$ 381.0799; Found: 381.0800(100.0%), $[M+Na+2]^+$ 383.0775, Found: 383.0770(35.7 %); HPLC (CHIRALPAK IE-3, Hexane/^{i}PrOH = 90:10, 1.0 mL/min, 254 nm) 94% ee, t_R 14.4 (major), t_R 17.4 (minor) min.

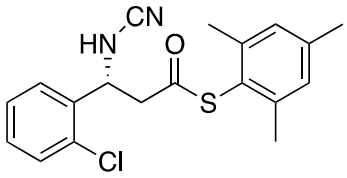
(*R*)-*S*-(2,4,6-Trimethylphenyl) 3-(3-chlorophenyl)-3-(cyanoamino)propanethioate (7)



Reaction of **1i** (7.9 mg, 0.048 mmol), **2c** (9.6 mg, 0.04 mmol) and **3e** (2.5 mg, 0.004 mmol) in THF (1.0 mL) at 10 ˚C for 48 h. After removal of solvent, the residue was purified by silica gel column chromatography (eluent: Hexane/AcOEt, 70:30) gave **7** (13.2 mg, 92%, 88% ee) as a pale yellow oil.

$[\alpha]_D^{25}$ +17.7 (88% ee, *c* 0.58, $CHCl_3$); ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.35 (s, 3H), 7.28 (s, 1H), 6.98 (s, 2H), 4.86 (br, 1H), 4.71-4.65 (m, 1H), 3.23 (dd, 1H, *J* = 5.2, 16.0 Hz), 3.15 (dd, 1H, *J* = 5.2, 16.0 Hz), 2.29 (s, 3H), 2.20 (s, 6H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 195.6, 142.3, 140.7, 139.7, 135.1, 130.4, 129.4, 129.2, 127.0, 125.0, 122.2, 113.9, 56.7, 47.7, 21.4, 21.2; IR (ATR) 3005, 2221, 1711, 1433, 1359, 1219, 1092, 852, 790, 756 cm^{-1}; HRMS (ESI) m/z: $[M+Na]^+$ Calcd. for $C_{19}H_{19}N_2ONaSCl$ 381.0799; Found: 381.0810, $[M+Na+2]^+$ 383.0770, Found: 383.0778 (36.4 %); HPLC (CHIRALPAK IE-3, Hexane/^{i}PrOH = 90:10, 1.0 mL/min, 254 nm) 88% ee, t_R 18.2 (major), t_R 20.6 (minor) min.

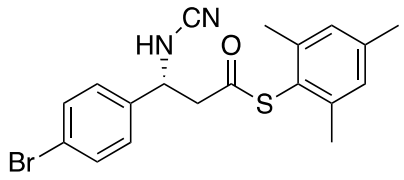
(*R*)-*S*-(2,4,6-Trimethylphenyl) 3-(2-chlorophenyl)-3-(cyanoamino)propanethioate (8)



Reaction of **1j** (7.9 mg, 0.048 mmol), **2c** (9.6 mg, 0.04 mmol) and **3e** (2.5 mg, 0.004 mmol) in THF (1.0 mL) at 10 ˚C for 48 h. After removal of solvent, the residue was purified by silica gel column chromatography (eluent: Hexane/AcOEt, 70:30) gave **8** (13.8 mg, 96%, 95% ee) as a pale yellow oil.

$[\alpha]_D^{25}$ +52.3 (95% ee, *c* 0.58, $CHCl_3$); ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.48-7.31 (m, 4H), 6.97 (s, 2H), 5.18-5.12 (m, 1H), 5.08 (br, 1H), 3.27 (dd, 1H, *J* = 7.3, 16.0 Hz), 3.20 (dd, 1H, *J* = 5.2, 16.0 Hz), 2.29 (s, 3H), 2.17 (s, 6H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 196.0, 142.3, 140.6, 135.0, 132.7, 130.3, 130.0, 129.4, 127.8, 127.6, 122.4, 114.0, 54.2, 45.8, 21.4, 21.2; IR (ATR) 2921, 2225, 1711, 1679, 1457, 1358, 1220, 1029, 981, 843, 695 cm^{-1}; HRMS (ESI) m/z: $[M+Na]^+$ Calcd. for $C_{19}H_{19}N_2ONaSCl$ 381.0799; Found: 381.0813 $[M+Na+2]^+$ 383.0770, Found: 383.0784 (36.2 %); HPLC (CHIRALPAK IE-3, Hexane/^{i}PrOH = 90:10, 1.0 mL/min, 254 nm) 95% ee, t_R 18.6 (major), t_R 20.5 (minor) min.

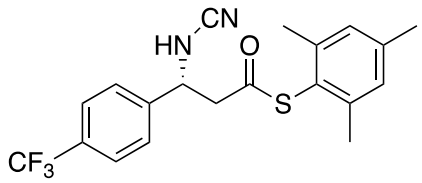
(*R*)-*S*-(2,4,6-Trimethylphenyl) 3-(4-bromophenyl)-3-(cyanoamino)propanethioate (9)



Reaction of **1k** (10.0 mg, 0.048 mmol), **2c** (9.6 mg, 0.04 mmol) and **3e** (2.5 mg, 0.004 mmol) in THF (1.0 mL) at 10 ˚C for 48 h. After removal of solvent, the residue was purified by silica gel column chromatography (eluent: Hexane/AcOEt, 70:30) gave **9** (13.9 mg, 86%, 93% ee) as a pale yellow amorphous solid.

$[\alpha]_D^{25}$ −38.2 (93% ee, *c* 0.58, $CHCl_3$); ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.54 (d, *J* = 8.6 Hz, 2H), 7.25 (d, 2H, *J* = 8.6 Hz), 6.98 (s, 2H), 4.81 (br, 1H), 4.70-4.65 (m, 1H), 3.26-3.10 (m, 2H), 2.29 (s, 3H), 2.20 (s, 6H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 195.7, 142.3, 140.7, 136.6, 132.3, 129.4, 128.5, 123.1, 122.2, 114.0, 56.6, 47.8, 21.4, 21.2; IR (ATR) 2921, 2220, 1711, 1488, 1435, 1219, 1073, 1009, 851, 751 cm^{-1}; HRMS (ESI) m/z: $[M+Na]^+$ Calcd. for $C_{19}H_{19}N_2ONaSBr$ 425.0294; Found: 425.0306 (95.1%), $[M+Na+2]^+$ 427.0274, Found: 427.0282 (100.0%); HPLC (CHIRALPAK IE-3, Hexane/^{i}PrOH = 90:10, 1.0 mL/min, 254 nm) 93% ee, t_R 15.2 (major), t_R 18.5 (minor) min.

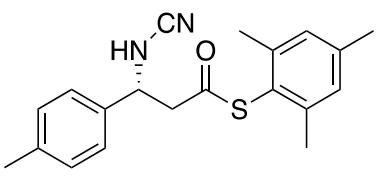
(*R*)-*S*-(2,4,6-Trimethylphenyl) 3-(4-trifluoromethylphenyl)-3-(cyanoamino)propanethioate (10)



Reaction of **1l** (9.5 mg, 0.048 mmol), **2c** (9.6 mg, 0.04 mmol) and **3e** (2.5 mg, 0.004 mmol) in THF (1.0 mL) at 10 ˚C for 48 h. After removal of solvent, the residue was purified by silica gel column chromatography (eluent: Hexane/AcOEt, 70:30) gave **10** (15.6 mg, 99%, 93% ee) as a pale yellow oil.

$[\alpha]_D^{25}$ +15.4 (93% ee, *c* 0.58, $CHCl_3$); ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.69-7.66 (m, 2H), 7.51-7.49 (m, 2H), 6.97 (s, 2H), 4.93 (br, 1H), 4.80-4.75 (m, 1H), 3.30-3.14 (m, 2H), 2.29 (s, 3H), 2.17 (s, 6H); ^{19}F NMR ($CDCl_3$, 282MHz): δ −62.8; ^{13}C NMR ($CDCl_3$, 125 MHz) δ 195.6, 142.6, 141.6, 140.8, 131.3 (q, $J_{C\text{-}F}$ = 32.6 Hz), 129.5, 127.3, 127.0, 126.2 (q, $J_{C\text{-}F}$ = 3.8 Hz), 123.8 (q, $J_{C\text{-}F}$ = 270.6 Hz), 122.1, 113.9, 56.7, 47.7, 21.3, 21.2; IR (ATR) 2924, 2222, 1712, 1620, 1421, 1359, 1219, 1165, 1068, 978, 847 cm^{-1}; HRMS (ESI) m/z: $[M+Na]^+$ Calcd. for $C_{20}H_{19}N_2ONaSF_3$ 415.1062; Found: 415.1062; HPLC (CHIRALPAK IE-3, Hexane/^{i}PrOH = 90:10, 0.5 mL/min, 254 nm) 93% ee, t_R 28.9 (major), t_R 36.3 (minor) min.

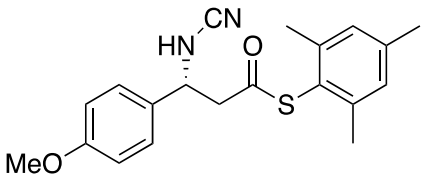
(*R*)-*S*-(2,4,6-Trimethylphenyl) 3-(4-methylphenyl)-3-(cyanoamino)propanethioate (11)



Reaction of **1m** (6.9 mg, 0.048 mmol), **2c** (9.6 mg, 0.04 mmol) and **3e** (2.5 mg, 0.004 mmol) in THF (1.0 mL) at 10 ˚C for 48 h. After removal of solvent, the residue was purified by silica gel column chromatography (eluent: Hexane/AcOEt, 70:30) gave **11** (13.0 mg, 96%, 92% ee) as a pale yellow oil.

$[\alpha]_D^{25}$ +55.4 (92% ee, *c* 0.58, $CHCl_3$); ^1H NMR ($CDCl_3$, 300 MHz) δ 7.23-7.19 (m, 4H), 6.97 (s, 2H), 4.70-4.64 (m, 2H), 3.28-3.11 (m, 2H), 2.35 (s, 3H), 2.29 (s, 3H), 2.21 (s, 6H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 195.8, 142.4, 140.5, 138.9, 134.6, 129.8, 129.4, 126.8, 122.5, 114.3, 56.9, 48.1, 21.4, 21.2; IR (ATR) 2918, 2218, 1711, 1601, 1515, 1436, 1220, 1151, 978, 851 cm^{-1}; HRMS (ESI) m/z: $[M+Na]^+$ Calcd. for $C_{20}H_{22}N_2ONaS$ 361.1345; Found: 361.1347; HPLC (CHIRALPAK IE-3, Hexane/^{i}PrOH = 90:10, 1.0 mL/min, 254 nm) 92% ee, t_R 22.3 (major), t_R 25.6 (minor) min.

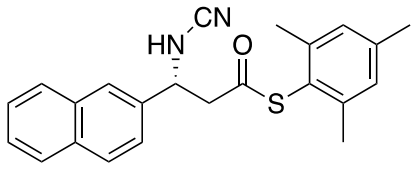
(*R*)-*S*-(2,4,6-Trimethylphenyl) 3-(4-methoxyphenyl)-3-(cyanoamino)propanethioate (12)



Reaction of **1n** (7.7 mg, 0.048 mmol), **2c** (9.6 mg, 0.04 mmol) and **3e** (2.5 mg, 0.004 mmol) in THF (1.0 mL) at 10 ˚C for 48 h. After removal of solvent, the residue was purified by silica gel column chromatography (eluent: Hexane/AcOEt, 70:30) gave **12** (14.1 mg, 99%, 88% ee) as a pale yellow oil.

$[\alpha]_D^{25}$ +44.6 (88% ee, *c* 0.58, $CHCl_3$); ^1H NMR ($CDCl_3$, 300 MHz) δ 7.31-7.27 (m, 2H), 6.97-6.90 (m, 4H), 4.69-4.64 (m, 2H), 3.81 (s, 3H), 3.28-3.11 (m, 2H), 2.29 (s, 3H), 2.21 (s, 6H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 196.0, 160.1, 142.4, 140.6, 129.4, 128.2, 122.5, 114.5, 114.3, 56.6, 55.4, 48.2, 21.5, 21.2; IR (ATR) 2219, 1711, 1611, 1561, 1358, 1219, 1030, 828, 731, 620 cm^{-1}; HRMS (ESI) m/z: $[M+Na]^+$ Calcd. for $C_{20}H_{22}N_2O_2NaS$ 377.1294; Found: 377.1305; HPLC (CHIRALPAK IE-3, Hexane/^{i}PrOH = 90:10, 1.0 mL/min, 254 nm) 88% ee, t_R 31.1 (major), t_R 35.2 (minor) min.

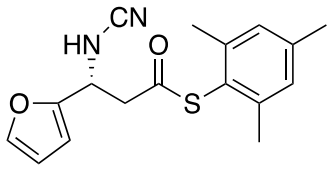
(*R*)-*S*-(2,4,6-Trimethylphenyl) 3-(2-naphthyl)-3-(cyanoamino)propanethioate (13)



Reaction of **1o** (8.7 mg, 0.048 mmol), **2c** (9.6 mg, 0.04 mmol) and **3e** (2.5 mg, 0.004 mmol) in THF (1.0 mL) at 10 ˚C for 72 h. After removal of solvent, the residue was purified by silica gel column chromatography (eluent: Hexane/AcOEt, 70:30) gave **13** (12.0 mg, 80%, 90% ee) as a pale yellow amorphous solid.

$[\alpha]_D^{25}$ −23.6 (90% ee, *c* 0.58, $CHCl_3$); ^1H NMR ($CDCl_3$, 300 MHz) δ 7.91-7.81 (m, 4H), 7.54-7.45 (m, 3H), 6.95 (s, 2H), 4.90-4.85 (m, 2H), 3.35 (dd, 1H, *J* = 4.6, 15.9 Hz), 3.24 (dd, 1H, *J* = 4.6, 15.9 Hz), 2.28 (s, 3H), 2.15 (s, 6H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 195.8, 142.3, 140.5, 134.9, 133.4, 133.1, 129.3, 129.2, 128.1, 127.7, 126.7, 126.7, 126.3, 123.8, 122.4, 114.2, 57.3, 47.9, 21.3, 21.1; IR (ATR) 2922, 2219, 1710, 1601, 1435, 1360, 1219, 1089, 907 cm^{-1}; HRMS (ESI) m/z: $[M+Na]^+$ Calcd. for $C_{23}H_{22}N_2ONaS$ 397.1345; Found: 397.1348; HPLC (CHIRALPAK IE-3, Hexane/^{i}PrOH = 90:10, 1.0 mL/min, 254 nm) 90% ee, t_R 26.7 (major), t_R 30.9 (minor) min.

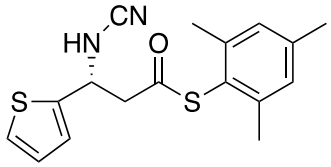
(*R*)-*S*-(2,4,6-Trimethylphenyl) 3-(2-furyl)-3-(cyanoamino)propanethioate (14)



Reaction of **1p** (5.8 mg, 0.048 mmol), **2c** (9.6 mg, 0.04 mmol) and **3e** (2.5 mg, 0.004 mmol) in THF (1.0 mL) at 10 ˚C for 48 h. After removal of solvent, the residue was purified by silica gel column chromatography (eluent: Hexane/AcOEt, 70:30) gave **14** (11.6 mg, 92%, 87% ee) as a pale yellow oil.

$[\alpha]_D^{25}$ +18.6 (87% ee, *c* 0.58, $CHCl_3$); ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.43-7.42 (m, 1H), 6.98 (s, 2H), 6.40-6.36 (m, 2H), 4.79-4.73 (m, 1H), 4.67 (br, 1H), 3.41-3.20 (m, 2H), 2.29 (s, 3H), 2.26 (s, 6H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 195.2, 150.2, 143.2, 142.4, 140.6, 129.4, 122.4, 113.7, 110.7, 108.6, 50.9, 45.1, 21.5, 21.1; IR (ATR) 2219, 1710, 1438, 1419, 1283, 1220, 1143, 1017, 855, 740 cm^{-1}; HRMS (ESI) m/z: $[M+Na]^+$ Calcd. for $C_{17}H_{18}N_2O_2NaS$ 337.0981; Found: 337.0985; HPLC (CHIRALPAK ID, Hexane/^{i}PrOH = 90:10, 0.75 mL/min, 254 nm) 87% ee, t_R 32.3 (major), t_R 38.4 (minor) min.

(*R*)-*S*-(2,4,6-Trimethylphenyl) 3-(2-thienyl)-3-(cyanoamino)propanethioate (15)

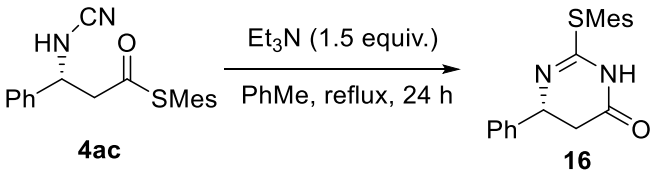


Reaction of **1q** (6.5 mg, 0.048 mmol), **2c** (9.6 mg, 0.04 mmol) and **3e** (2.5 mg, 0.004 mmol) in THF (1.0 mL) at 10 ˚C for 48 h. After removal of solvent, the residue was purified by silica gel column chromatography (eluent: Hexane/AcOEt, 70:30) gave **15** (12.6 mg, 95%, 86% ee) as a pale yellow oil.

$[\alpha]_D^{25}$ −79.1 (86% ee, *c* 0.58, $CHCl_3$); ^{1}H NMR ($CDCl_3$, 300 MHz) δ 7.35-7.32 (m, 1H), 7.22-7.10 (m, 1H), 7.02-6.98 (m, 3H), 5.00-4.94 (m, 1H), 4.79 (br, 1H), 3.37 (dd, *J* = 5.0, 16.1 Hz, 1H), 3.25 (dd, *J* = 5.0, 16.1 Hz, 1H), 2.29 (s, 3H), 2.24 (s, 6H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 195.4, 142.4, 140.6, 140.5, 129.4, 127.1, 126.4, 126.3, 122.3, 113.6, 52.9, 48.1, 21.4, 21.1; IR (ATR) 3196, 2222, 1711, 1673, 1219, 1083, 1040, 1015, 853, 670 cm^{-1}; HRMS (ESI) m/z: $[M+Na]^+$ Calcd. for $C_{17}H_{18}N_2ONaS$ 353.0753; Found: 353.1754; HPLC (CHIRALPAK ID, Hexane/^{i}PrOH = 90:10, 0.75 mL/min, 254 nm) 86% ee, t_R 35.6 (minor), t_R 38.2 (major) min.

General procedure for synthetic application of products:

(*R*)-2-(2,4,6-Trimethylphenyl)thio-4-oxo-6-phenyl-5,6-dihydropyrimidone (16)

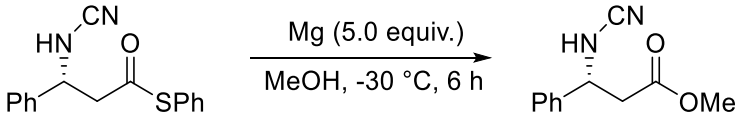


4ac **16**

A solution of **4ac** (16.2 mg, 0.05 mmol, 1.0 equiv.) and Et_3N (10.4 μL, 0.075 mmol, 1.5 equiv.) in toluene was stirred for 24 h under reflux in an oil bath and removal of solvent under reduced pressure gave a residue, which was purified by column chromatography (Hexane/AcOEt= 70/30) to afford **16** (12.7 mg, 78%, 94% ee) as a off white solid.

$[\alpha]_D^{25}$ +40.1 (94% ee, *c* 0.58, $CHCl_3$); ^1H NMR ($CDCl_3$, 300 MHz) δ 7.35-7.24 (m, 5H), 7.12 (s, 1H), 7.01 (s, 2H), 4.86-4.80 (m, 1H), 2.76 (dd, 1H, *J* = 5.4, 16.7 Hz), 2.55-2.45 (m, 7H), 2.30 (s, 3H); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 168.7, 144.1, 130.1, 129.4, 129.1, 128.7, 127.5, 126.8, 126.4, 59.3, 57.1, 37.6, 22.1, 21.2; IR (ATR) 2922, 2360, 2342, 1702, 1619, 1453, 1321, 1024, 945, 758 cm^{-1}; HRMS (ESI) m/z: $[M+Na]^+$ Calcd. for $C_{12}H_{14}N_2ONa$ 347.1189; Found: 347.1187; HPLC (CHIRALPAK IE-3, Hexane/^{i}PrOH = 90:10, 0.75 mL/min, 254 nm) 94% ee, t_R 36.8 (major), t_R 45.8 (minor) min.

(*R*)-Methyl 3-phenyl-3-(cyanoamino)propanoate (17)

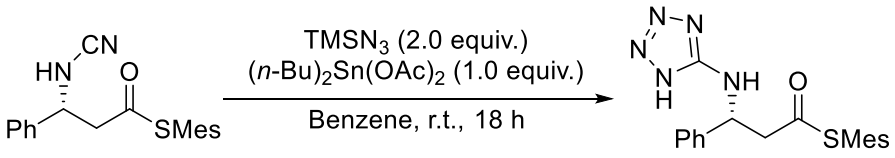


4aa **17**

A solution of **4aa** (28.2 mg, 0.1 mmol, 1.0 equiv.) in MeOH was added to solution of Mg (12.0 mg, 0.5 mmol, 5.0 equiv.) in MeOH at −30 °C. The suspension was stirred for 6 h in argon atmosphere which was directly purified by column chromatography (Hexane/AcOEt= 60/40) to afford **17** (17.6 mg, 86%, 93% ee) as a colorless oil.

$[\alpha]_D^{25}$ −9.5 (93% ee, *c* 0.58, $CHCl_3$); ^1H NMR ($CDCl_3$, 300 MHz) δ 7.43-7.31 (m, 5H), 4.83 (br, 1H), 4.70-4.65 (m, 1H), 3.72 (s, 3H), 2.94 (dd, 1H, *J* = 7.8, 16.6 Hz,), 2.83 (dd, 1H, *J* = 7.8, 16.6 Hz); ^{13}C NMR ($CDCl_3$, 125 MHz) δ 171.5, 137.9, 129.2, 129.0, 126.8, 114.5, 58.5, 52.3, 39.9; IR (ATR) 2352, 2218, 1731, 1554, 1495, 1265, 1201, 988, 762 cm^{-1}; HRMS (ESI) m/z: $[M+Na]^+$ Calcd. for $C_{11}H_{12}N_2O_2Na$ 227.0791; Found: 227.0798; HPLC (CHIRALPAK AD-3, Hexane/^{i}PrOH = 90:10, 1.0 mL/min, 254 nm) 93% ee, t_s 8.6 (minor), t_R 11.1 (major) min.

(*R*)-2-(2,4,6-Trimethylphenyl)thio-3-phenyl-3-(2*H*-tetrazole-5-amino)propanoate (18)

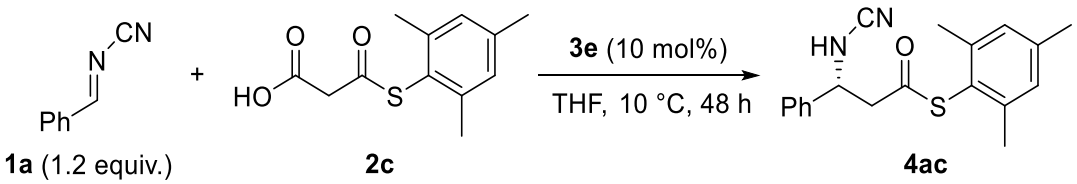


4ac **18**

To solution of **4ac** (32.4 mg, 0.1 mmol, 1.0 equiv.) in benzene, $TMSN_3$ (26 μL, 0.2 mmol, 2.0 equiv.) and $(n\text{-}Bu)_2Sn(OAc)_2$ (27 μL, 0.1 mmol, 1.0 equiv.) were added at room temperature. The solution was stirred for 18 h in argon atmosphere. After white solid precipitated, which was filtered. Filter cake was dried under vacuum to afford **18** (32.2 mg, 96%, 95% ee) as a white solid.

mp = 192.2-193.0 ˚C; $[\alpha]_D^{25}$ +108.4 (95% ee, *c* 0.58, $CHCl_3$); ^{1}H NMR ($(CD_3)_2SO$, 300 MHz) δ 7.35 (s, 5H), 6.97 (s, 2H), 6.86 (br, 2H), 5.96-5.91 (m, 1H), 3.37 (dd, 1H, *J* = 7.7, 16.2 Hz), 3.25 (dd, 1H, *J* = 7.7, 16.2 Hz), 2.21 (s, 3H), 2.04 (s, 6H); ^{13}C NMR ($(CD_3)_2SO$, 125 MHz) δ 193.6, 155.5, 142,5, 140.1, 138.0, 129.4, 129.2, 128.8, 127.4, 123.4, 55.2, 48.0, 21.4, 21.1; IR (ATR) 3319, 3158, 1738, 1688, 1580, 1495, 1428, 1354, 1215, 1051, 618 cm^{-1}; HRMS (ESI) m/z: $[M+Na]^+$ Calced. for $C_{19}H_{21}N_5OSNa$ 390.1359; Found: 390.1356; HPLC (CHIRALPAK IE-3, Hexane/^{i}PrOH = 80:20, 1.0 mL/min, 254 nm) 95% ee, t_S 16.2 (minor), t_R 18.8 (major) min.

Large scale experiment procedure:

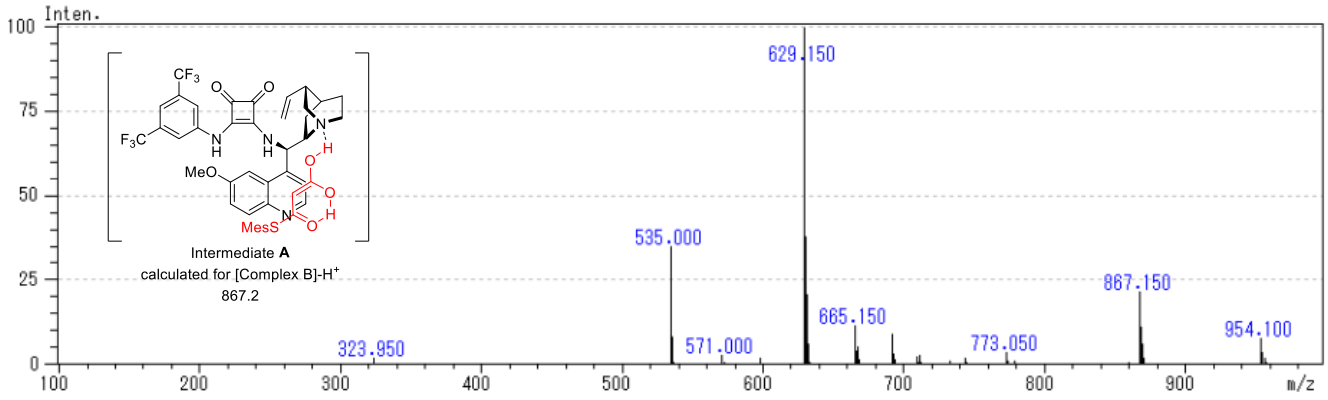


1a (1.2 equiv.) **2c** **4ac**

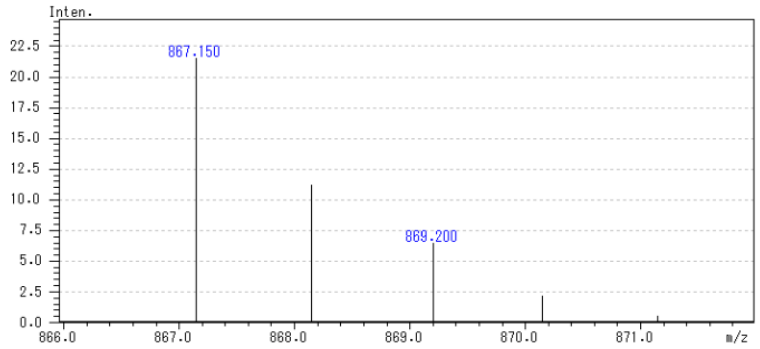
N-Cyano imine **1a** (312.4 mg, 2.4 mmol), **2c** (476.6 mg, 2.0 mmol), and **3e** (126. mg, 0.2 mmol) in THF was stirred for 48 h at 10 ˚C. After removal solvent, the residue was purified by silica gel column chromatography (eluent: Hexane/AcOEt, 70:30) to afford (*R*)-**4ac** (590.4mg, 91%, 92% ee) as a yellow oil.

ESI-Mass spectroscopic analysis:

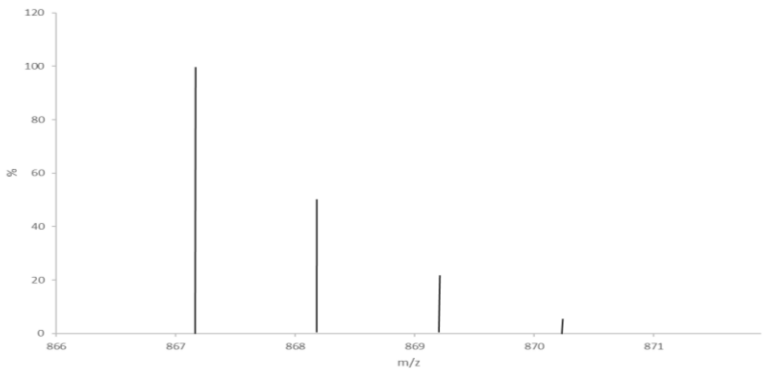
To clarify the assumed reaction mechanism, we also investigated some other spectroscopic analysis. The ESI-Mass spectroscopic analysis of intermediate **A** (**3e** and malonic acid half thioester **2c** in a 1:1 ratio in MeOH, anion mode).



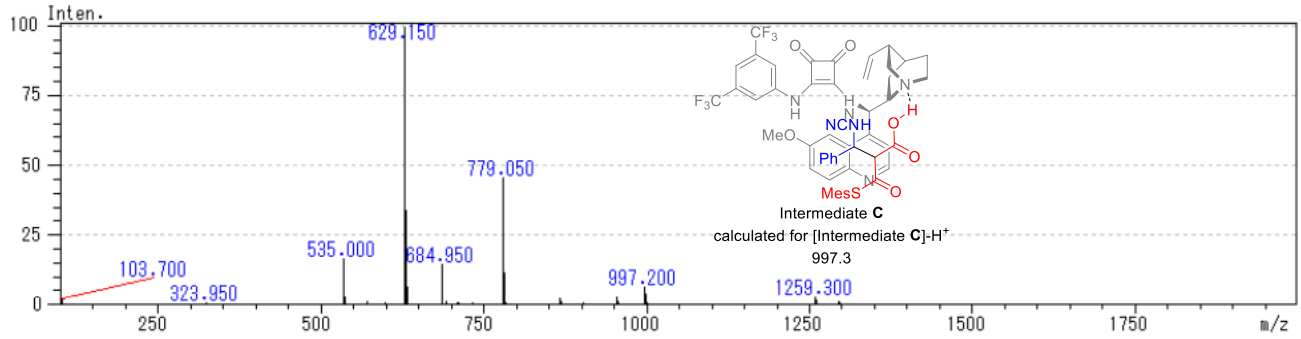
(a) Peaks for intermediate **A**



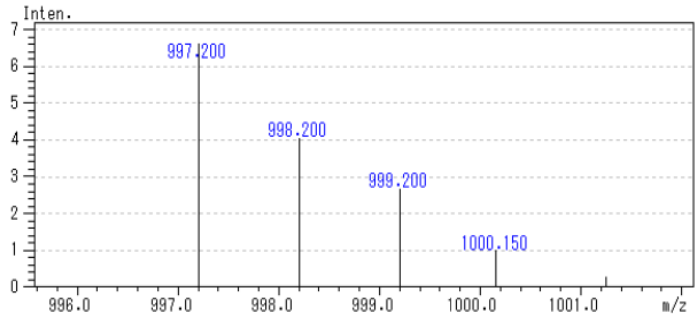
(b) Theoretical peaks for intermediate **A**



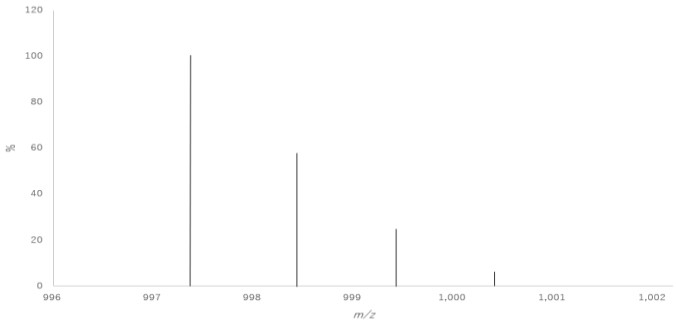
The ESI-Mass spectroscopic analysis of intermediate **C** (**3e**, *N*-cyano imine **1a** and malonic acid half thioester **2c** in 1:1:1 ratio in MeOH, anion mode);



(a) Peaks for intermediate **C**



(b) Theoretical peaks for intermediate **C**



MO Calculations:

The calculation was performed using Gaussian 16 revision C.01. Geometry optimizations were performed using B3LYP functional with 6-31G(d,p) basis set. After optimization of structures, frequency calculations were performed at the same level of the theory to confirm that the obtained structures were a transition state (one imaginary frequency). Single point energy calculations for the optimized geometry were performed using M06-2X functional with 6-311G+(d,p) basis set for all the atoms in SMD solvation model (THF).

The calculation results for TS-*R* and TS-*S* were shown in Figure S2. The relative energies of the optimized structures were depicted. As a result, the TS-*R* was most stable complex. Figure S3 showed the energy diagram for the complexes.

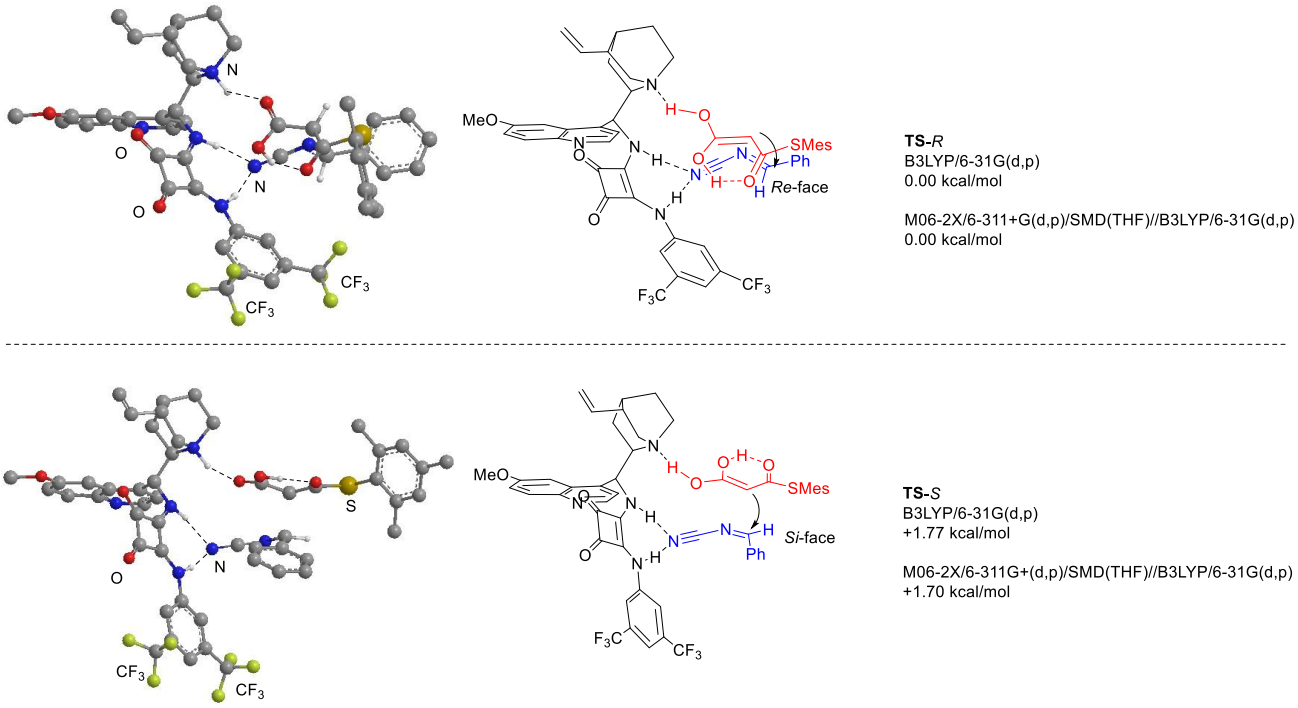


Figure S2. MO calculation for transition state of **1a** and **2c** using **3e** by Gaussian 16 B3LYP/6-31G(d,p) and M06-2X/6-311+G(d,p)/CPCM(THF)//B3LYP/6-31G(d,p). H atoms have been omitted for clarity.

Calculated Transition states

TS-*R*

B3LYP/6-31G(d,p) free energy: -3787.56295047 (a.u.)

Number of imaginary frequencies: 1 (-256.9878)

M06-2X/6-311+G(d,p)/SMD(THF) single point energy: -3787.21792477 (a.u.)

C	6.35706400	0.37610300	-1.14356100
C	7.23799600	0.51484700	-2.27251900
N	6.93051600	0.07824000	-3.52703200
C	5.75575300	-0.48815900	-3.70347700
C	4.82002800	-0.69959300	-2.66320800
C	5.11051200	-0.29230900	-1.37716700
C	4.11120700	-0.56210300	-0.25072900
C	4.00179100	-2.09025700	-0.03154500
C	6.76404500	0.90526500	0.10571600
C	8.49337200	1.14528200	-2.08650200
H	5.51489800	-0.81351000	-4.71409100
H	3.86859100	-1.16647300	-2.90461100
H	4.47880800	-0.11484300	0.67107500
C	5.31146900	-2.70065000	0.53802200
N	2.87052200	-2.46498900	0.90932900
H	3.72813700	-2.56238300	-0.97913800
C	3.15610500	-2.04926100	2.33029400
C	4.34236200	-2.88632000	2.88962100
C	4.97965600	-3.65930100	1.69678100
C	2.64386300	-3.95912800	0.84743400
C	3.95675500	-4.69395200	1.19318800
H	5.98034100	-1.90587800	0.88006700
H	5.84329000	-3.23444500	-0.25417900
H	3.37045000	-0.97832800	2.33453000
H	2.23314900	-2.20464700	2.89226800
H	3.95000700	-3.63943700	3.58349100
H	5.89004800	-4.15842800	2.03908500
H	2.26666000	-4.17623300	-0.15221600
H	1.83460300	-4.16753500	1.54783300
H	3.76915500	-5.45486800	1.95659800
C	7.99690900	1.52195800	0.24819500
C	8.87641900	1.63585500	-0.86003400
H	6.11380000	0.89921200	0.97367500
H	9.13937200	1.23184200	-2.95361700
H	9.84128200	2.11603600	-0.75113200
H	4.35048100	-5.21188200	0.31288800
N	2.80899600	0.04649800	-0.50083500
C	-2.05560900	-1.82961300	-2.11982700
C	0.07293500	-1.07492100	-2.59145100
N	0.93774800	-0.26304100	-2.63802800
C	-3.09574400	-2.76408800	-2.62925200
C	-4.38358900	-2.28689000	-2.90168100
C	-2.78978700	-4.10578000	-2.90247700
C	-5.35446100	-3.13887300	-3.43129500
H	-4.61534200	-1.24053700	-2.72756300
C	-3.76279100	-4.95647500	-3.41812800
H	-1.78069300	-4.46105800	-2.71986000
C	-5.04931300	-4.47579300	-3.68295600
H	-6.34630700	-2.75472500	-3.65050600
H	-3.51863700	-5.99487800	-3.62336600
H	-5.80555900	-5.14025000	-4.09065400
N	-0.81063600	-2.01575900	-2.62878300
H	-2.41304100	-0.80674400	-1.96932600

H	1.95154600	-2.05153900	0.59484200
S	-4.62627100	-2.70989800	0.75173000
C	-5.71926400	-1.70810700	1.77153200
C	-6.48493800	-0.67017100	1.20283900
C	-5.83914500	-2.03481100	3.13894000
C	-7.36231400	0.03546100	2.03275600
C	-6.73633500	-1.30063200	3.92071800
C	-7.50175500	-0.25915200	3.39065400
H	-7.95445300	0.83823400	1.59990800
H	-6.83429200	-1.54902200	4.97485200
C	-3.19849600	-1.63292200	0.52944700
C	-2.03377600	-2.25915600	-0.08865300
H	-2.03869700	-3.34128000	-0.14868600
O	-3.22532700	-0.44183500	0.87279600
C	-0.72878200	-1.72226200	0.31625000
O	0.31052300	-2.38842800	0.21072200
O	-0.66509000	-0.46071600	0.74293000
H	-1.60556400	-0.13102100	0.83500700
H	2.29374800	-0.15640300	-1.37230100
C	5.31410900	-2.02334900	3.65412000
H	5.67994400	-1.13007400	3.14924400
C	5.72682000	-2.28344500	4.89408100
H	5.37058600	-3.14934100	5.44762200
H	6.43223600	-1.63590100	5.40467500
C	2.41447400	1.11723600	0.21158300
C	1.35878900	2.03233100	0.09064700
C	2.87693600	1.70041700	1.47806100
C	1.75393500	2.73752600	1.35072500
O	3.75764900	1.40468700	2.27929300
O	1.35388200	3.68678200	1.99347000
N	0.41656700	2.10872600	-0.87364100
H	0.50460600	1.39171000	-1.60230700
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C	-1.72715100	2.46578100	-1.86123100
C	-1.11699800	3.79932200	0.07009900
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H	-0.40237200	4.08471400	0.83695500
C	-3.31226600	4.05932800	-0.95718700
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F	-3.24982100	4.86073400	2.15597800
F	-1.65836900	6.15799900	1.44585300
F	-3.65662900	6.31235300	0.59104400

O	8.28551100	1.99444000	1.49212500
C	9.49507500	2.71301000	1.69291600
H	9.54766400	3.60410600	1.05568400
H	9.48612300	3.02163300	2.73880400
H	10.37661500	2.08535700	1.51142200
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H	-5.41430300	0.17746400	-0.46337800
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H	-7.16495400	0.41872800	-0.52434700
C	-8.43456200	0.54242600	4.26622400
H	-7.92510000	1.42079800	4.68158000
H	-9.29912900	0.90588000	3.70287000
H	-8.80153600	-0.04997800	5.10950000

TS-*S*

B3LYP/6-31G(d,p) free energy: -3787.56012352 (a.u.)

Number of imaginary frequencies: 1 (-267.9050)

M06-2X/6-311+G(d,p)/SMD(THF) single point energy: -3787.21522261 (a.u.)

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N	-5.21764900	-2.26782900	4.11232400
C	-3.90642400	-2.15570400	4.11332400
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C	-5.91120400	-2.30361300	0.44838200
C	-7.25851600	-2.42271400	2.90236400
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H	-2.04207200	-2.01973300	3.03504700
H	-3.49773600	-2.21295200	-0.44103400
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C	-1.33980800	-3.36740100	-2.00888300
C	-2.03674000	-4.71424400	-2.36210700
C	-2.17182300	-5.54260200	-1.04857400
C	0.05180500	-4.61037500	-0.38982600
C	-0.75620800	-5.91264200	-0.57286000
H	-3.85779900	-4.41712100	-0.25684900
H	-2.99382800	-5.34560900	0.95340000
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H	-2.75242000	-6.44515700	-1.25674400
H	0.49157300	-4.50273800	0.60126000
H	0.85412700	-4.49615200	-1.12132900
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C	-7.29345500	-2.39558600	0.48662600
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H	-0.24707000	-2.59303600	-0.33191200
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C	9.84353300	-1.79744300	-0.97286500
H	10.24254600	0.08307200	-0.01207700
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O	4.84921800	-1.41585000	-0.81673300
C	2.17747100	-1.79278100	0.18163900
O	1.06751500	-2.05882000	0.66499400
O	2.31433100	-1.73855700	-1.14628300
H	3.27341900	-1.53201100	-1.33936300
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C	-3.34061300	-4.49010900	-3.08844900
H	-4.00316600	-3.72553400	-2.68657700
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H	-1.27602300	1.82747700	0.93644100
C	-3.34007600	-0.11214500	-1.76845500
C	-3.20078200	1.39872200	-1.94122000
O	-3.87119500	-1.04486300	-2.36593100
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C	-1.58059000	3.64822900	-0.01390400
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C	-0.84970600	4.29570600	0.99626600
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H	-2.70002100	3.91447800	-1.85080400
C	-0.66250300	5.67267600	0.94592800
H	-0.44145500	3.71929200	1.81935100
C	-1.19240100	6.42918000	-0.10075000
H	-1.05847700	7.50289000	-0.12915900
C	0.16754900	6.35309900	2.00298700
C	-2.44929000	6.56576200	-2.26638600
F	-0.28388400	7.60044700	2.26395000
F	1.45838400	6.47780900	1.61621700
F	0.16801400	5.66827000	3.16634300
F	-2.61903500	7.87109100	-1.95590200
F	-1.60065100	6.51967400	-3.32033400
F	-3.63634300	6.09213400	-2.69523300
C	8.10825300	0.45633900	1.56643200
H	7.18443600	0.97556100	1.29265900
H	7.99942600	0.14667400	2.61069100
H	8.92964700	1.17497400	1.51100000
C	6.81801900	-4.06175500	-0.46852500

H	7.28694700	-4.85275700	-1.05920200
H	6.54082300	-4.47746600	0.50525100
H	5.89364500	-3.76306200	-0.97285900
C	11.10298800	-1.78207800	-1.80508400
H	10.93108100	-1.28624500	-2.76855700
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O	-7.92202700	-2.41372200	-0.72098000
C	-9.34256400	-2.42798700	-0.75832400
H	-9.77010500	-1.55137300	-0.25664300
H	-9.61135300	-2.40147200	-1.81485500
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C	3.04797600	1.26593800	0.43567900
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C	1.95496900	1.43223900	-0.43029700
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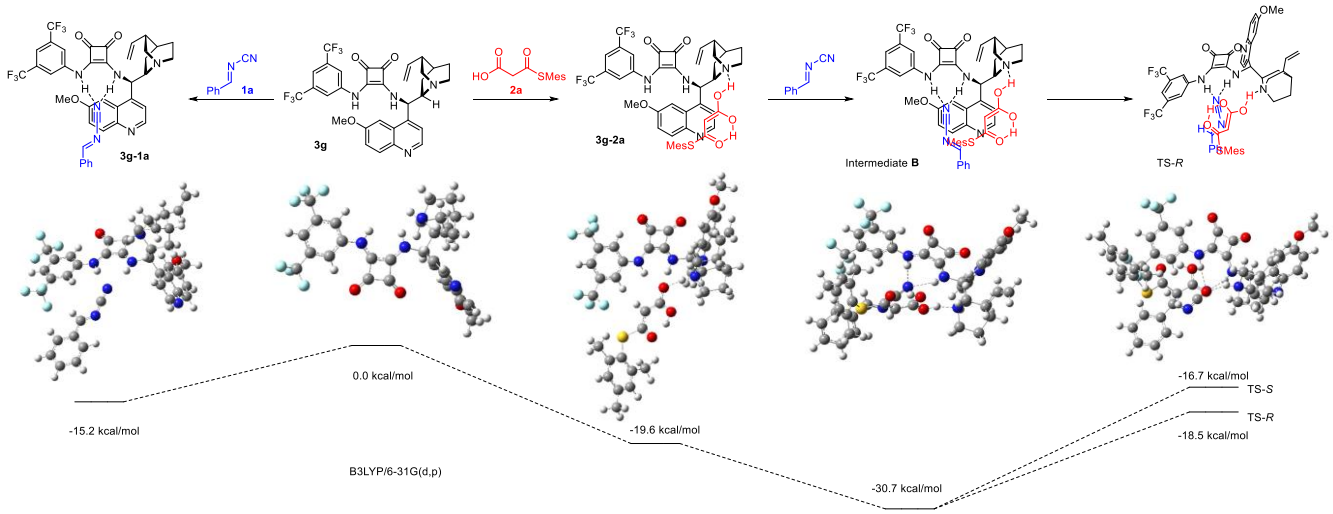
H	1.02976500	0.90064500	-0.24497400
C	3.23397600	2.97288300	-1.79143900
H	5.25239800	3.34861100	-1.13175100
H	1.19436800	2.40153800	-2.19007000
H	3.30105200	3.63539000	-2.64912800
H	3.95348400	0.42144800	2.19699600

Figure S3. Energy diagram for intermediates and transition states by Gaussian 16 B3LYP/6-31G(d,p)

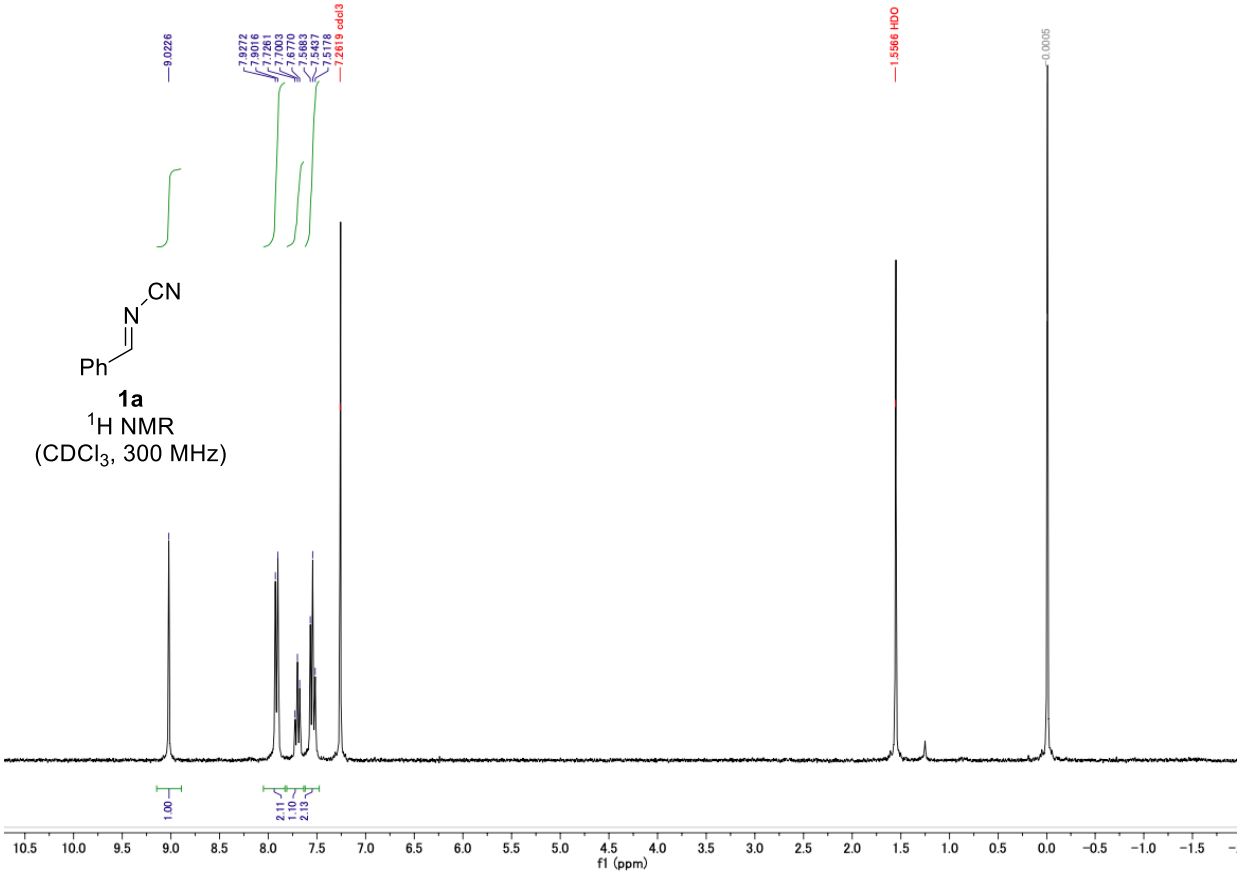


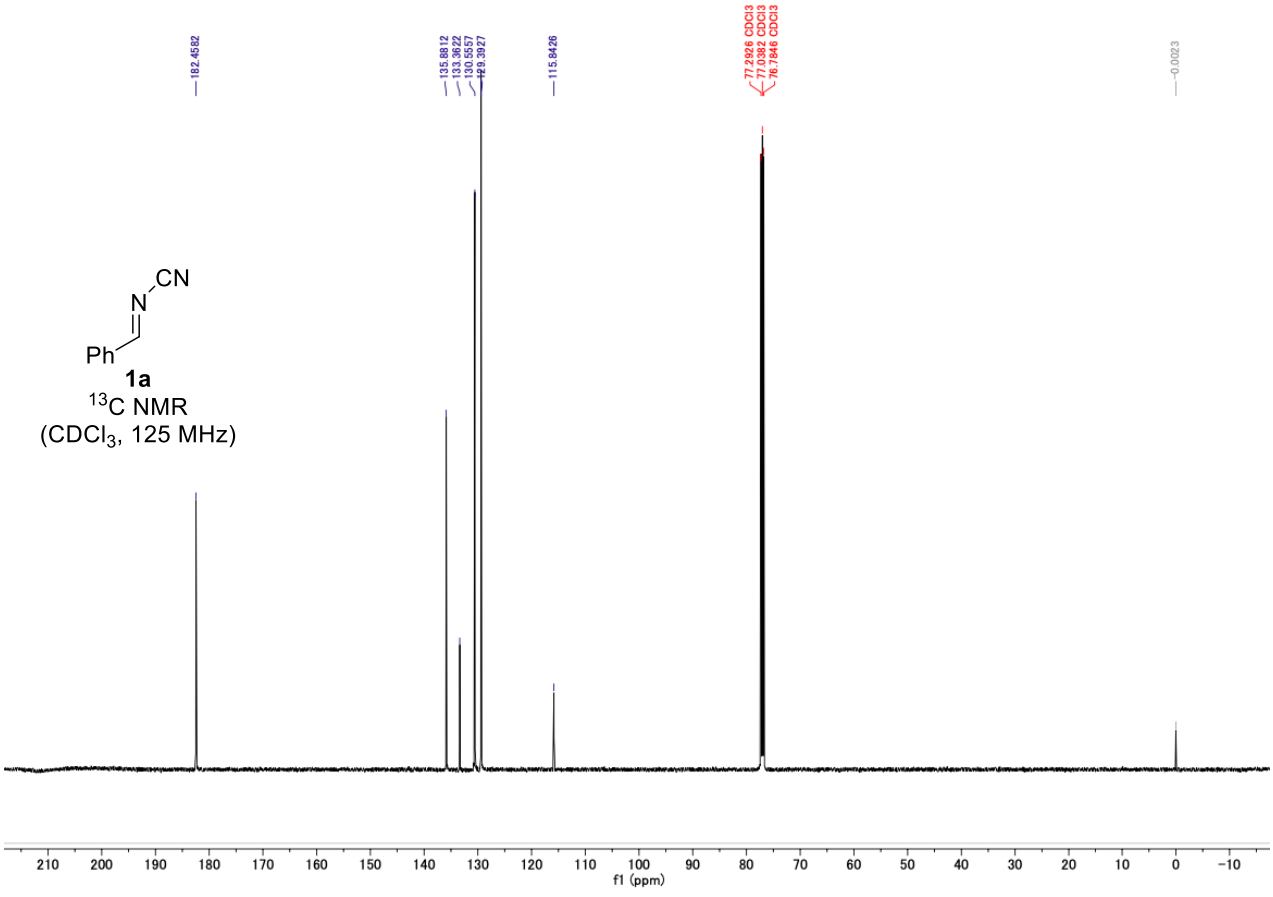
References

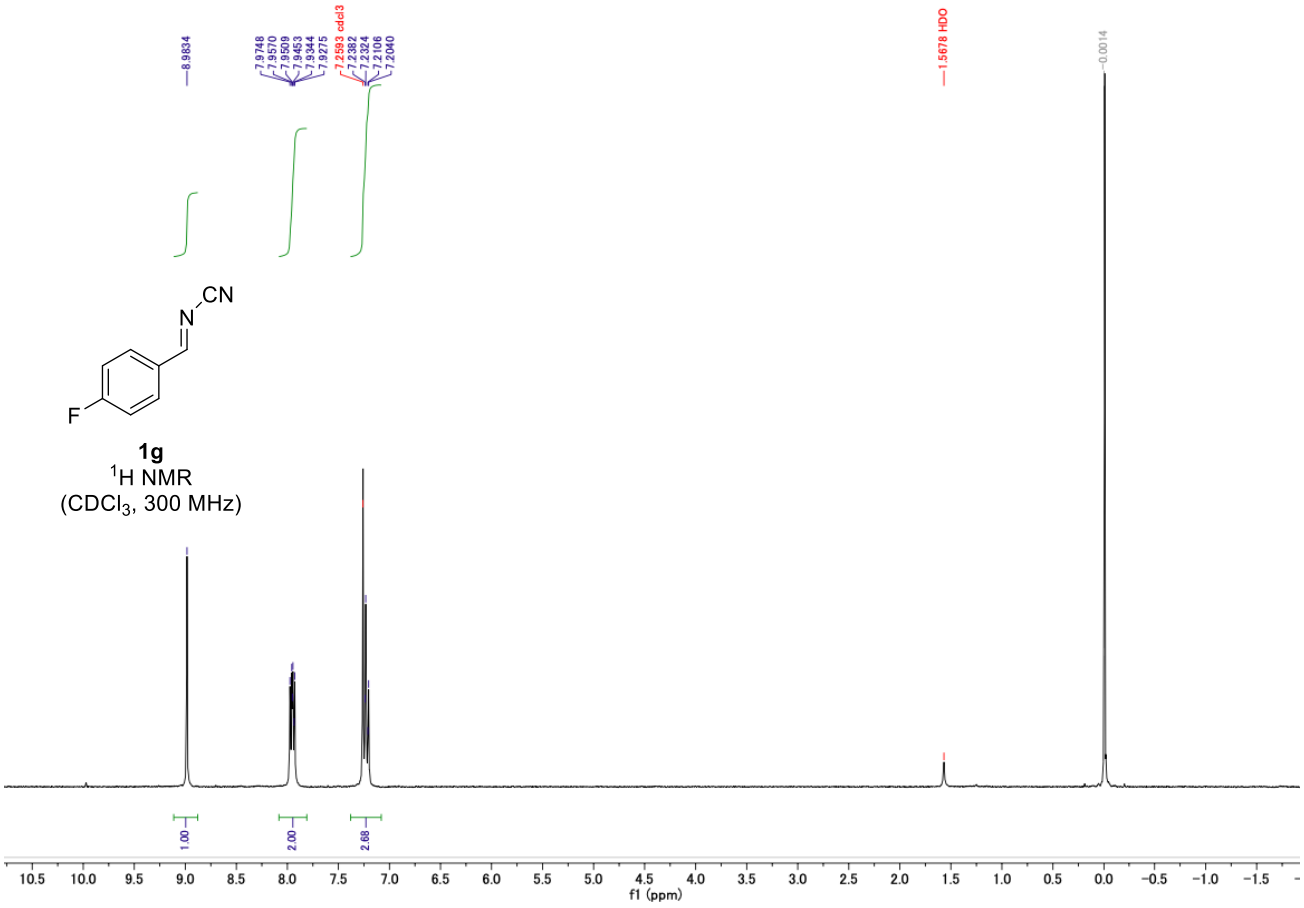
1. A. Aumuller, S. Hunig, *Angew. Chem. Int. Ed. Engl.* **1984**, *23*, 447-448.

2. T. Imamoto, M. Kodera, M. Yokoyama, *Bull. Chem. Soc. Jpn.* **1982**, *55*, 2303-2304.

^{1}H, ^{13}C and ^{19}F NMR



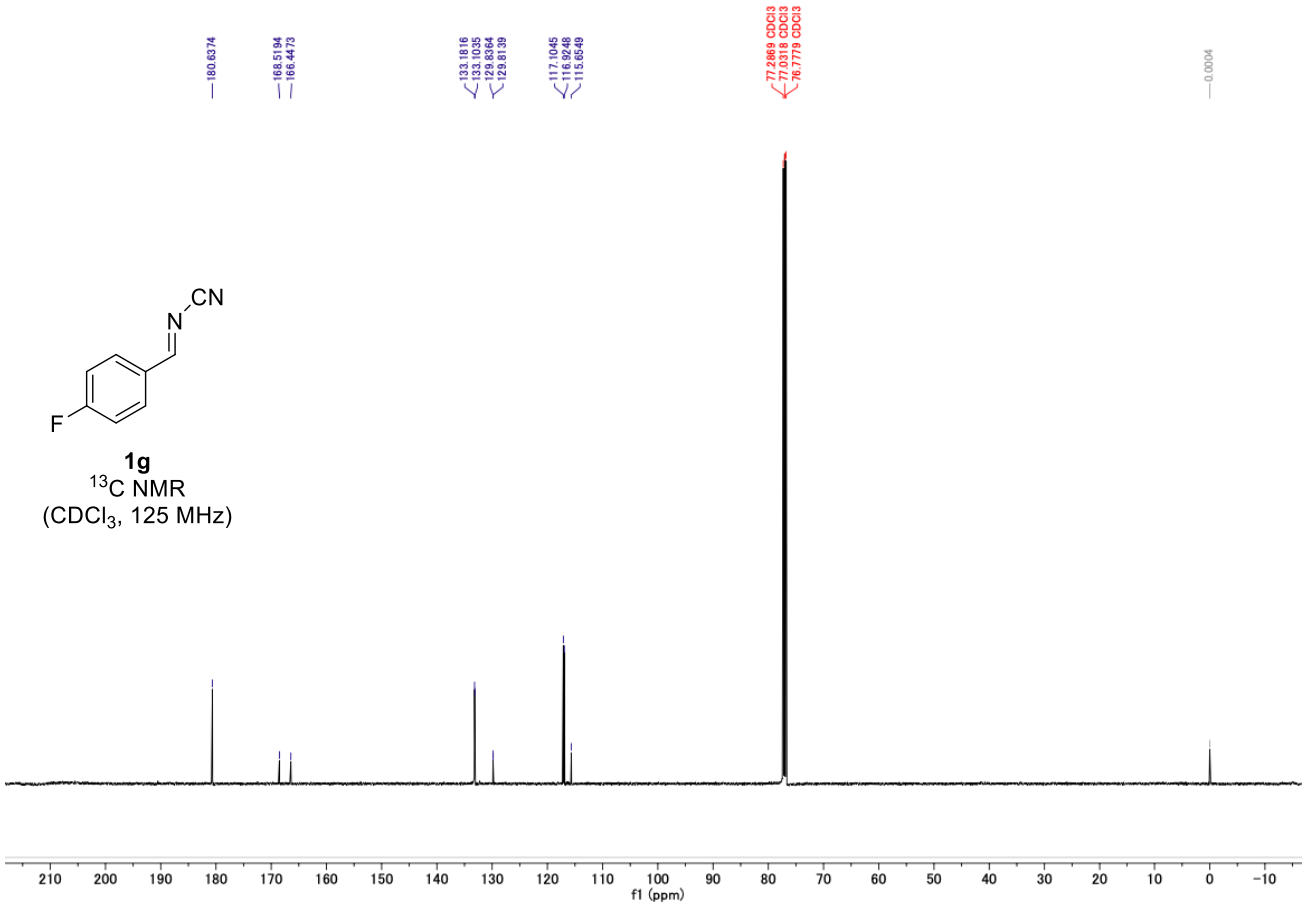




1g

^{1}H NMR

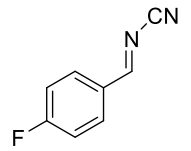
($CDCl_3$, 300 MHz)



1g

^{13}C NMR

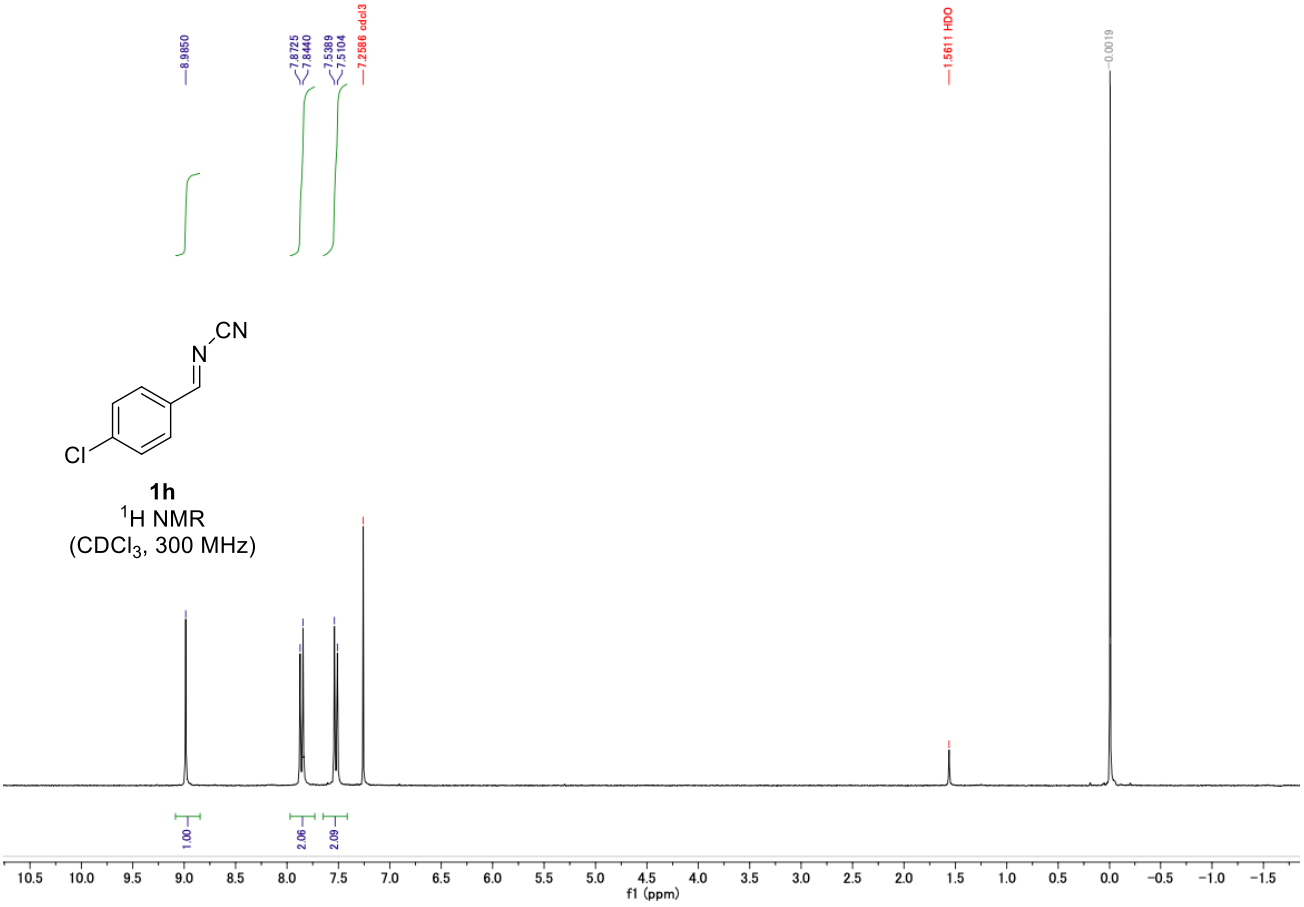
($CDCl_3$, 125 MHz)



1g

^{19}F NMR

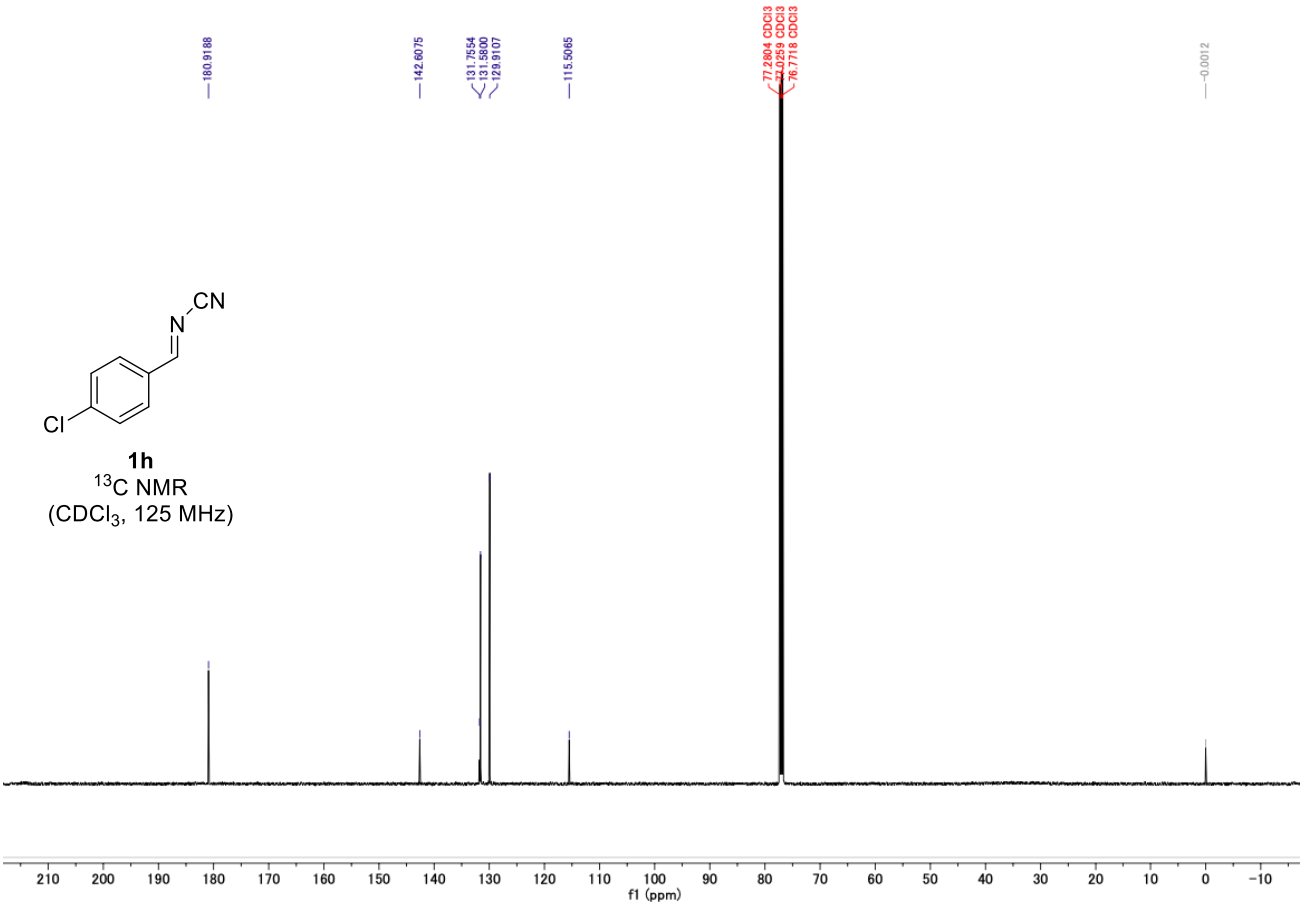
($CDCl_3$, 282 MHz)



1h

^{1}H NMR

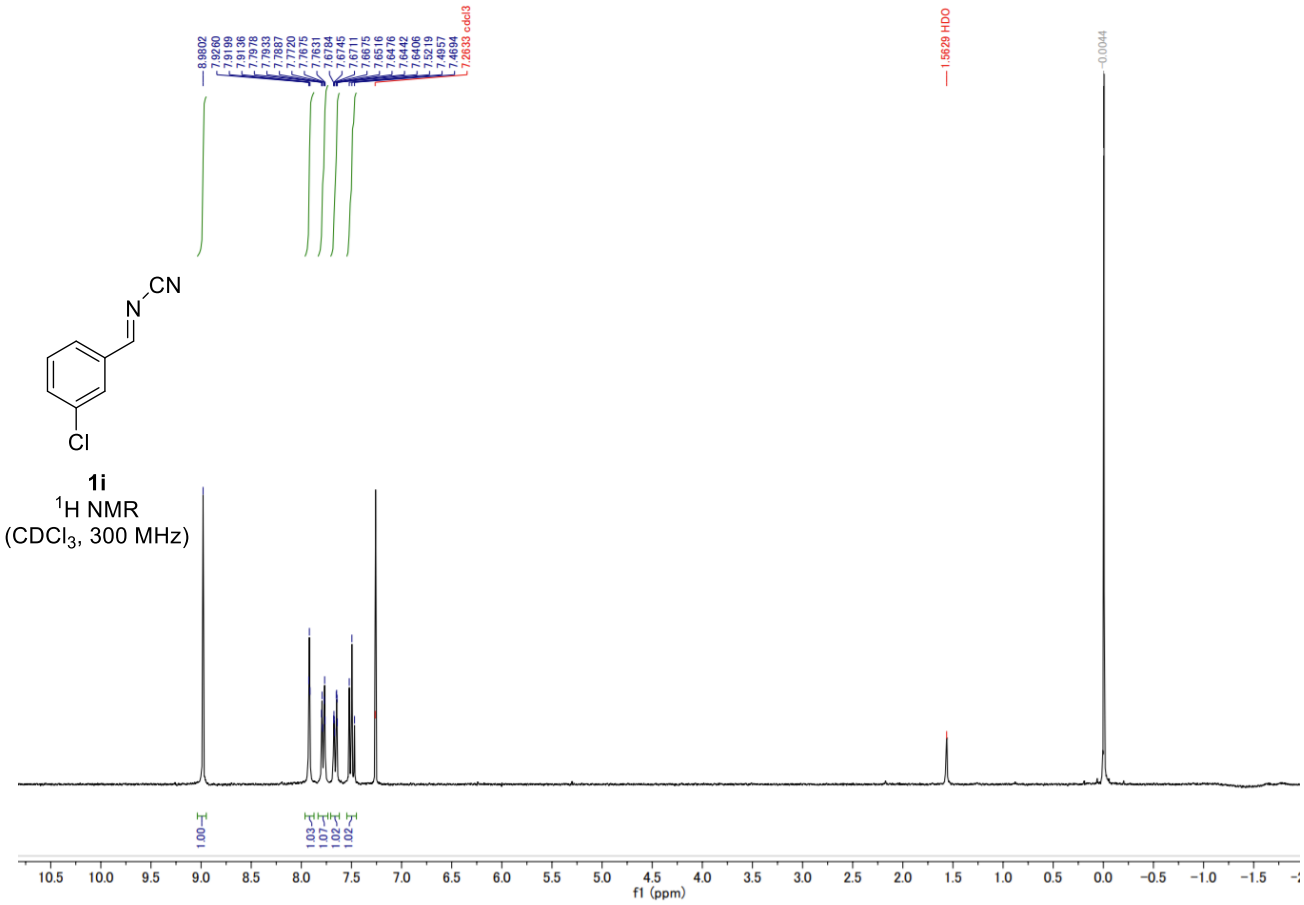
($CDCl_3$, 300 MHz)



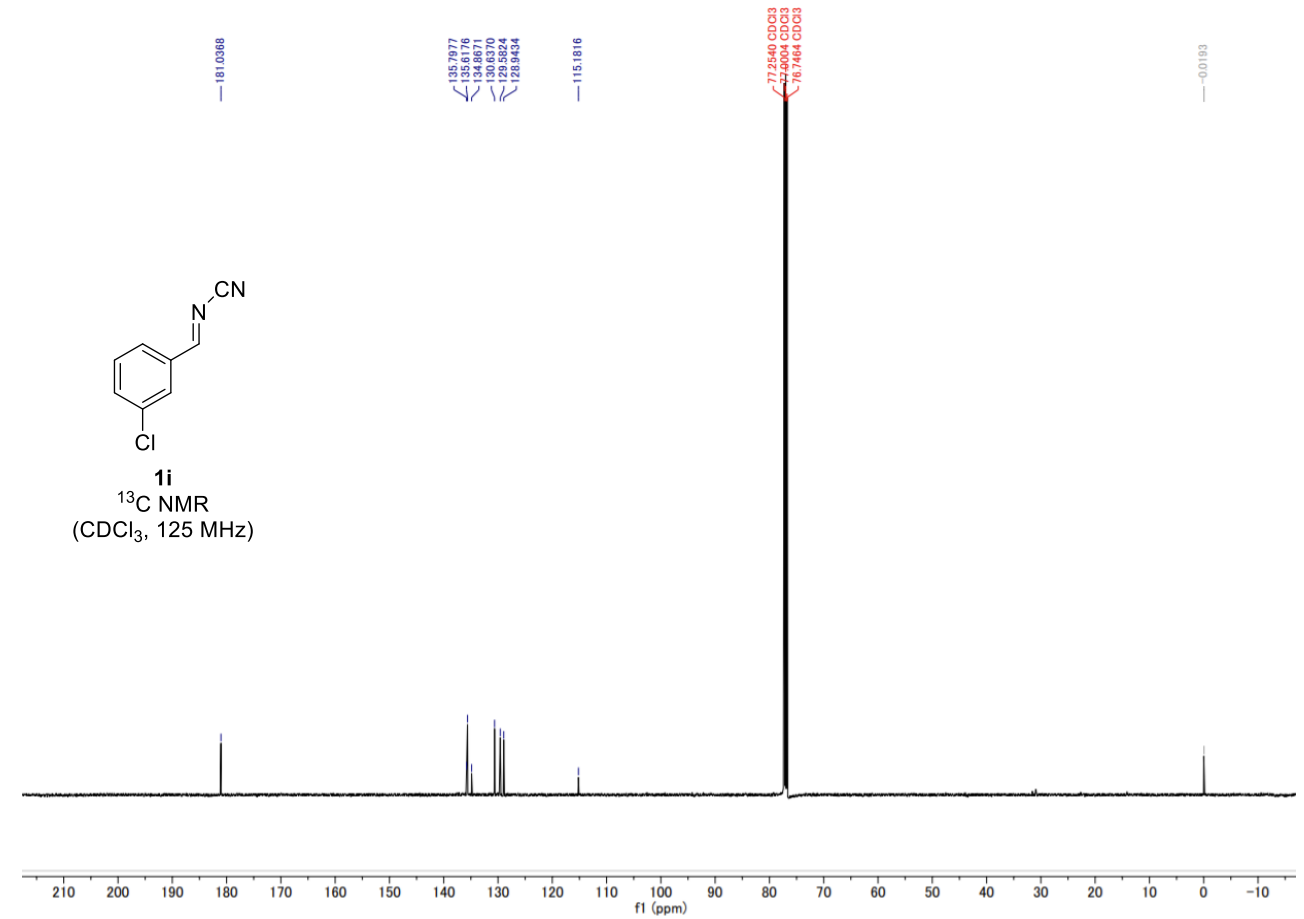
1h

^{13}C NMR

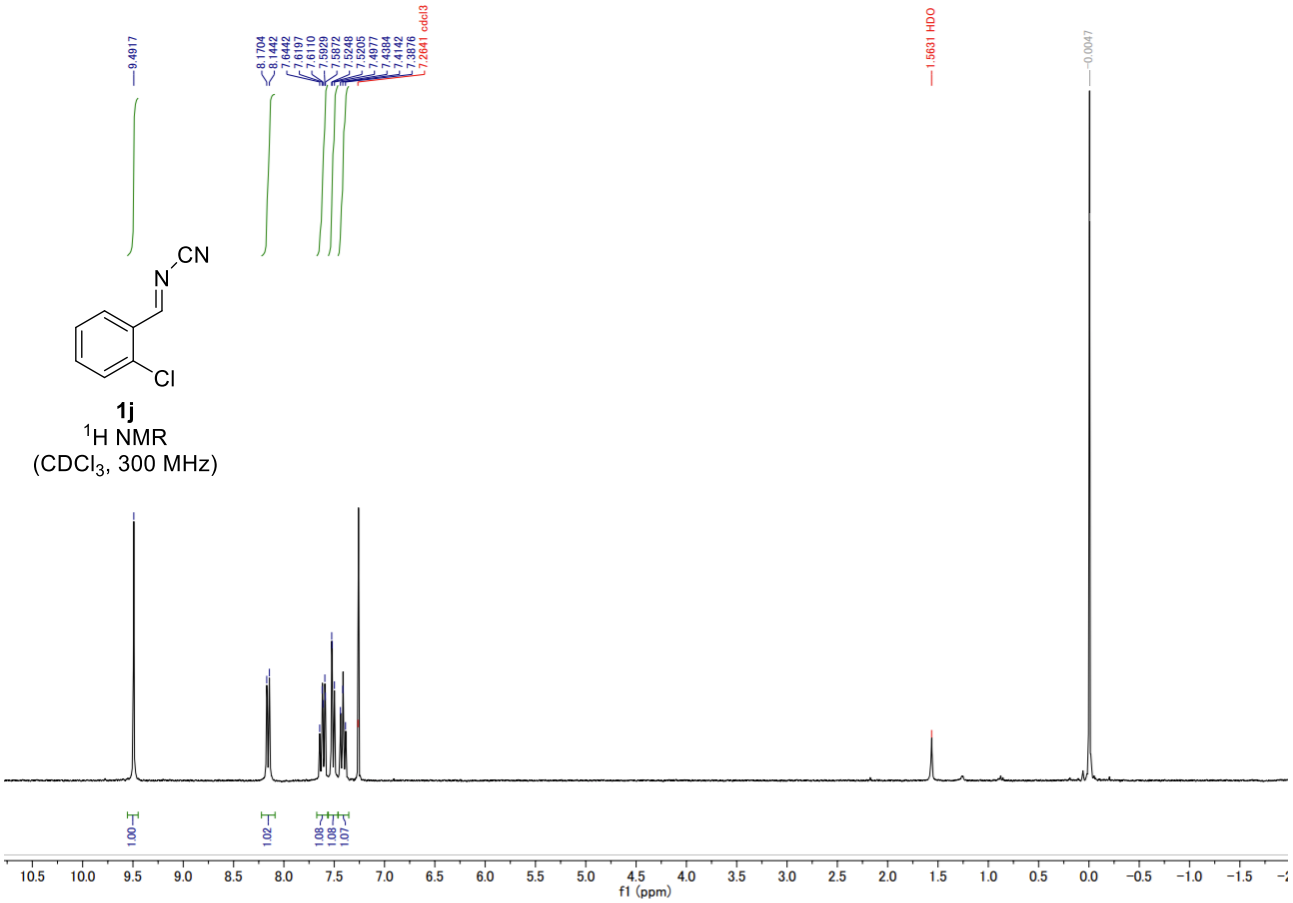
($CDCl_3$, 125 MHz)



1i
^{1}H NMR
($CDCl_3$, 300 MHz)



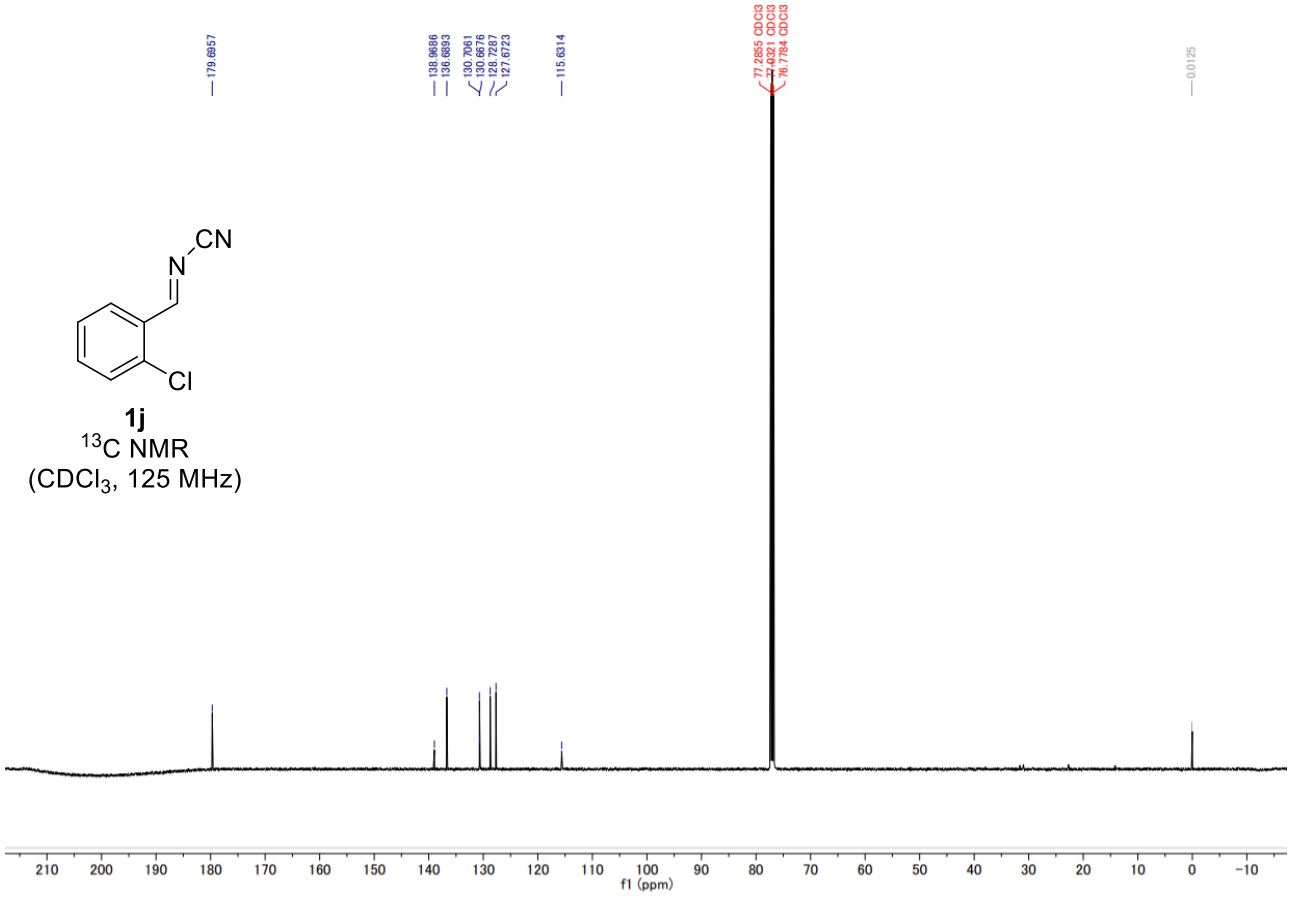
1i
^{13}C NMR
($CDCl_3$, 125 MHz)



1j

^{1}H NMR

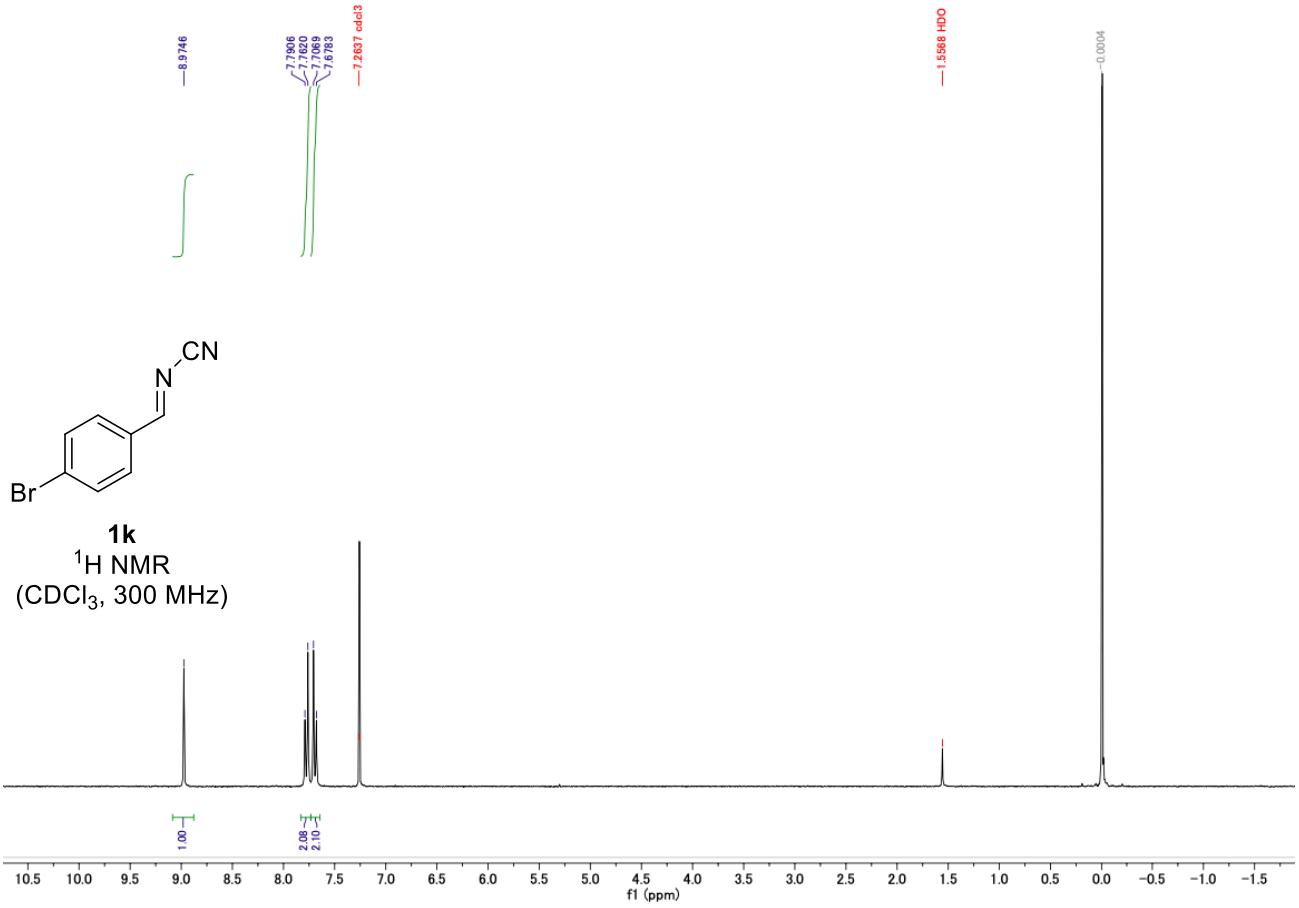
($CDCl_3$, 300 MHz)



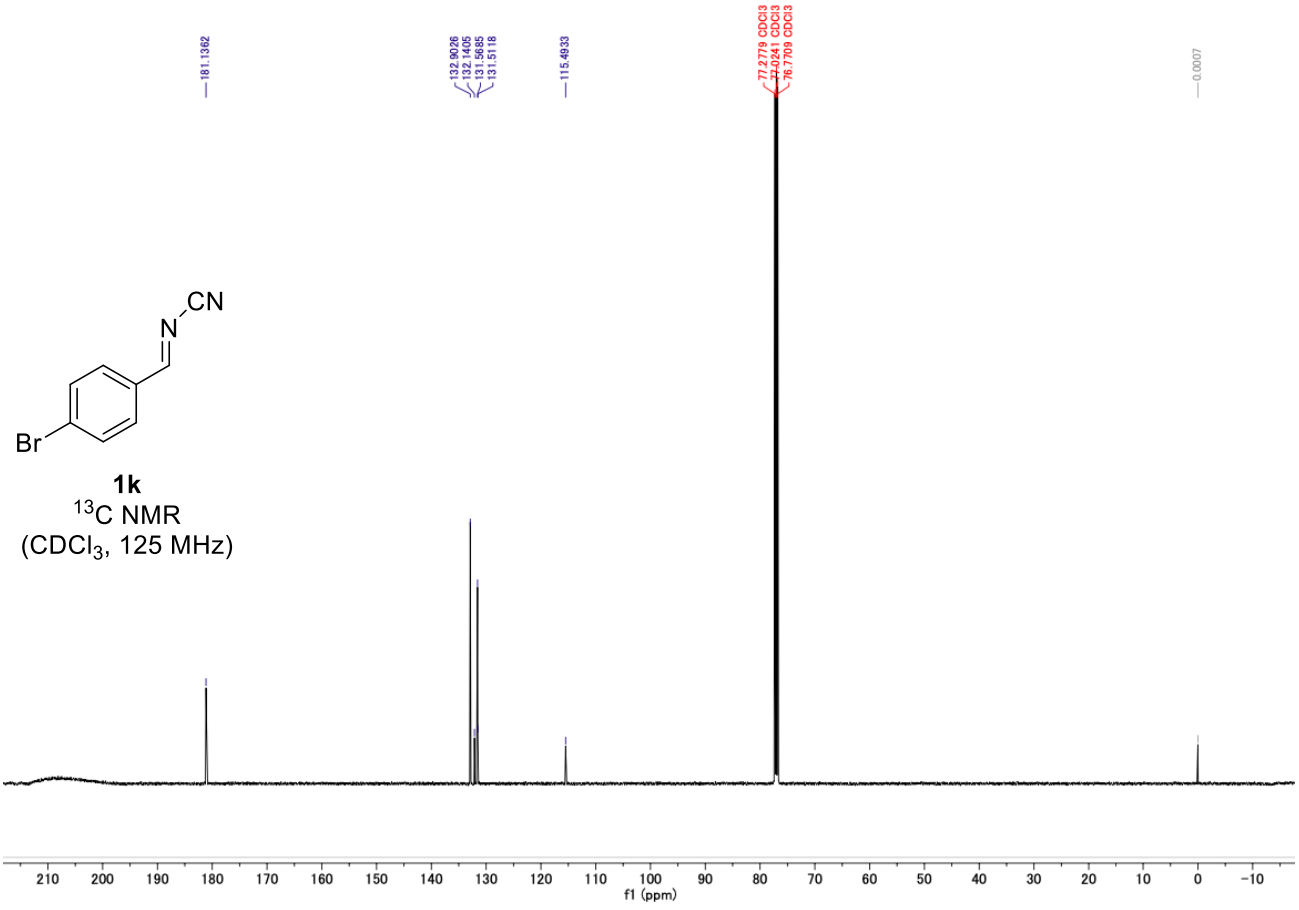
1j

^{13}C NMR

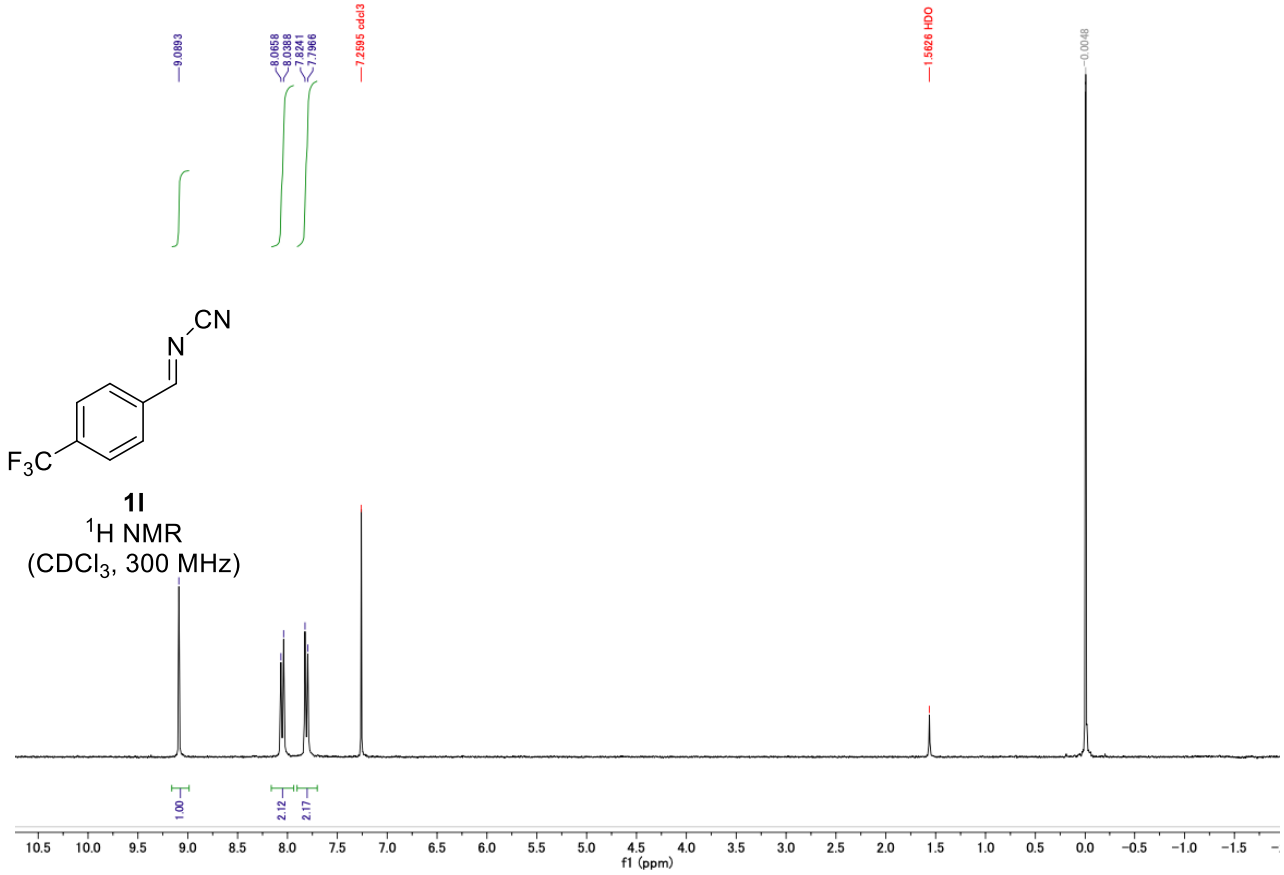
($CDCl_3$, 125 MHz)



1k
^{1}H NMR
($CDCl_3$, 300 MHz)



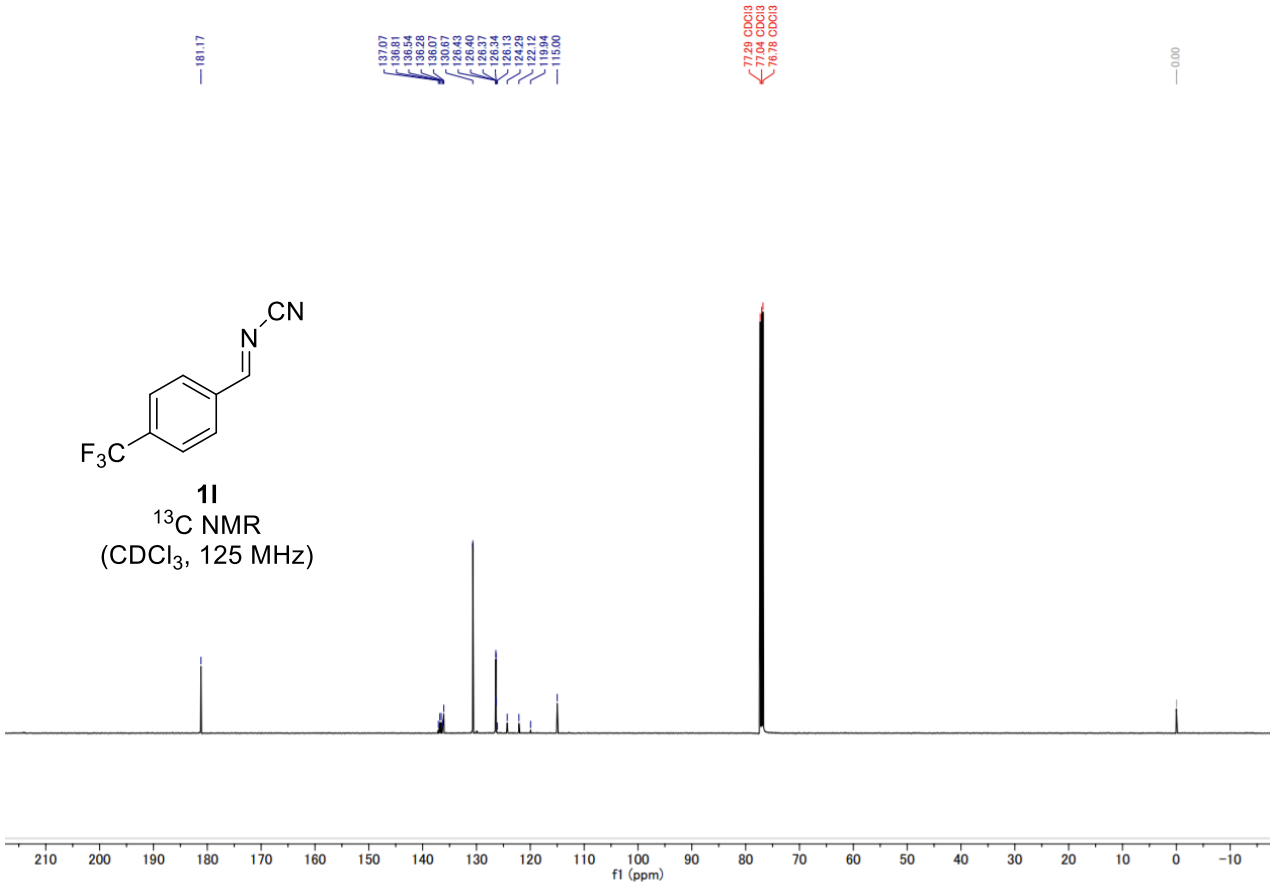
1k
^{13}C NMR
($CDCl_3$, 125 MHz)



1l

^{1}H NMR

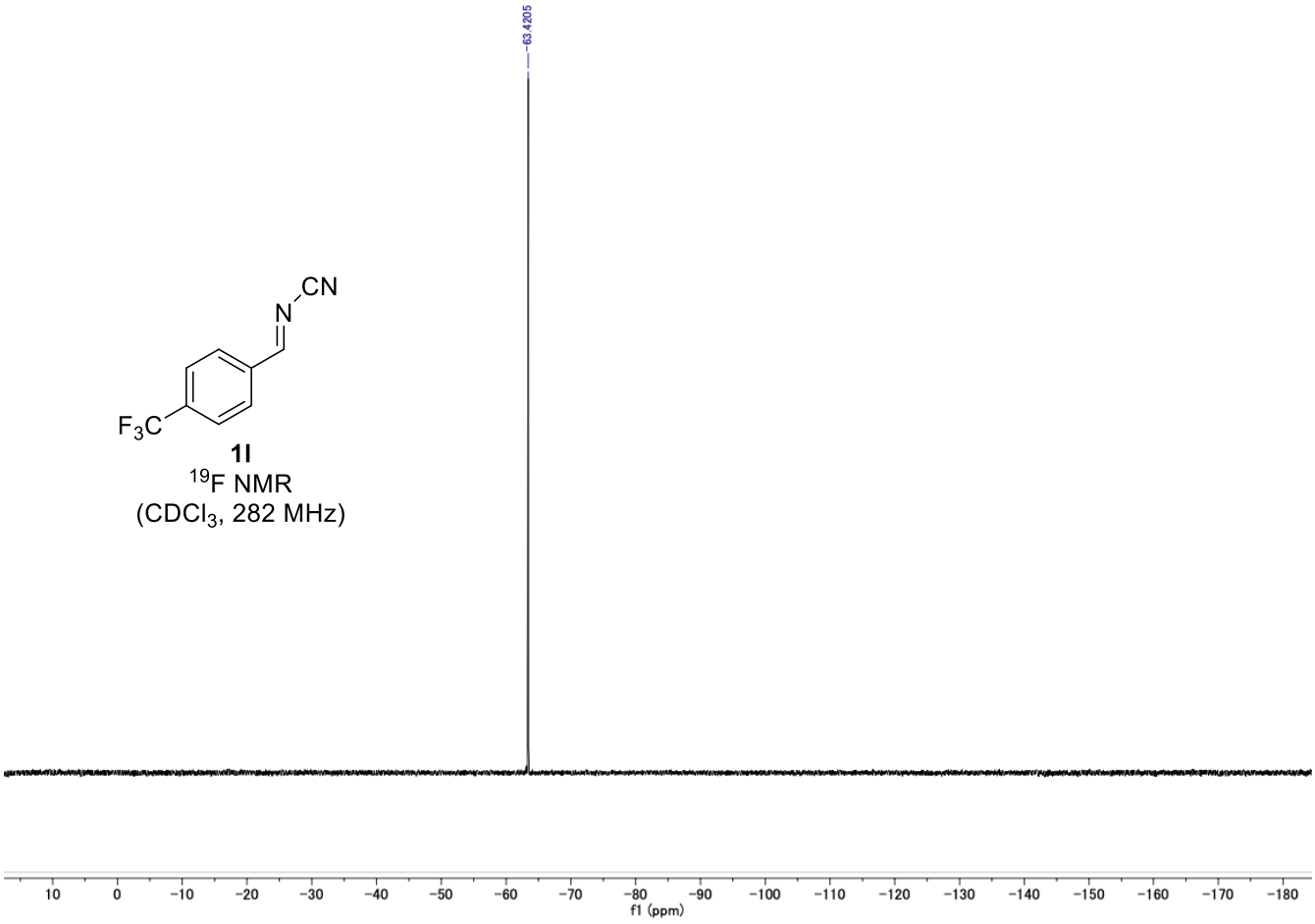
($CDCl_3$, 300 MHz)



1l

^{13}C NMR

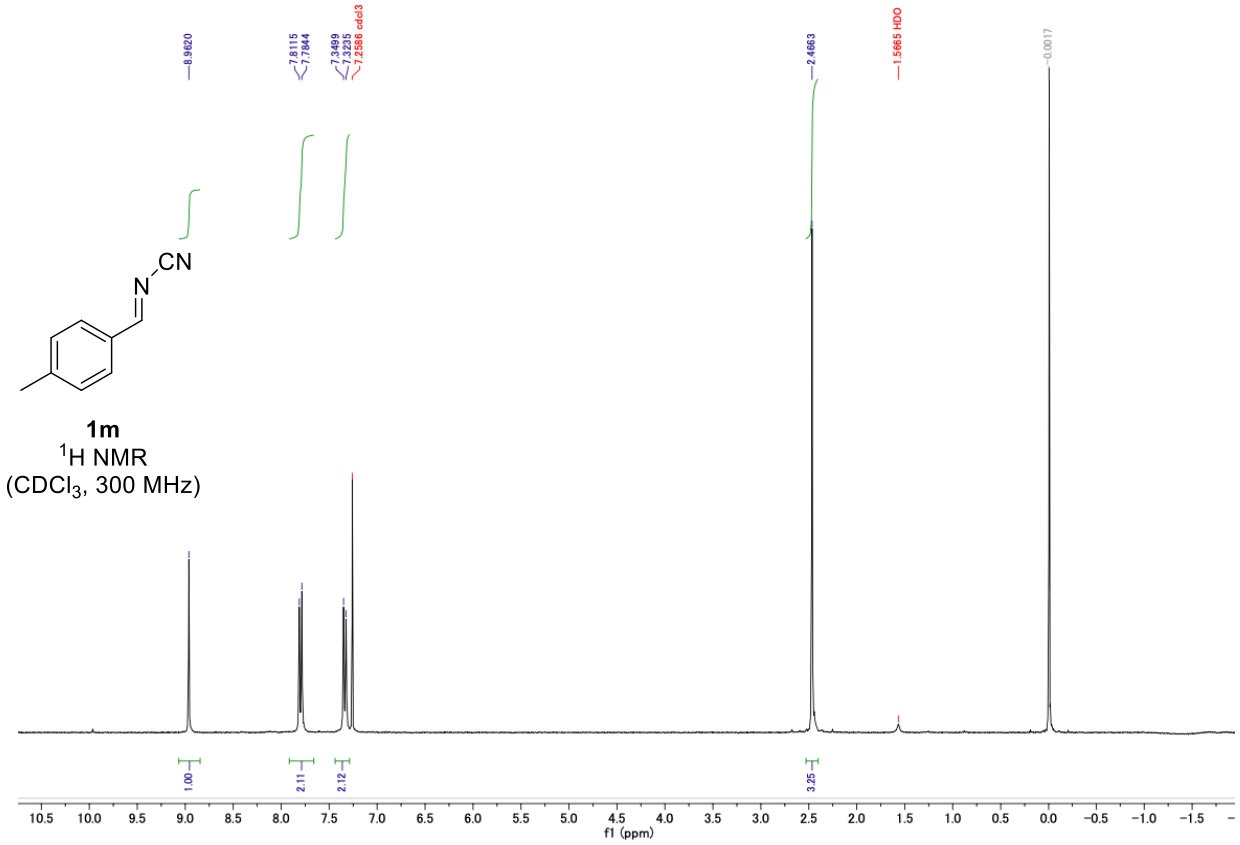
($CDCl_3$, 125 MHz)



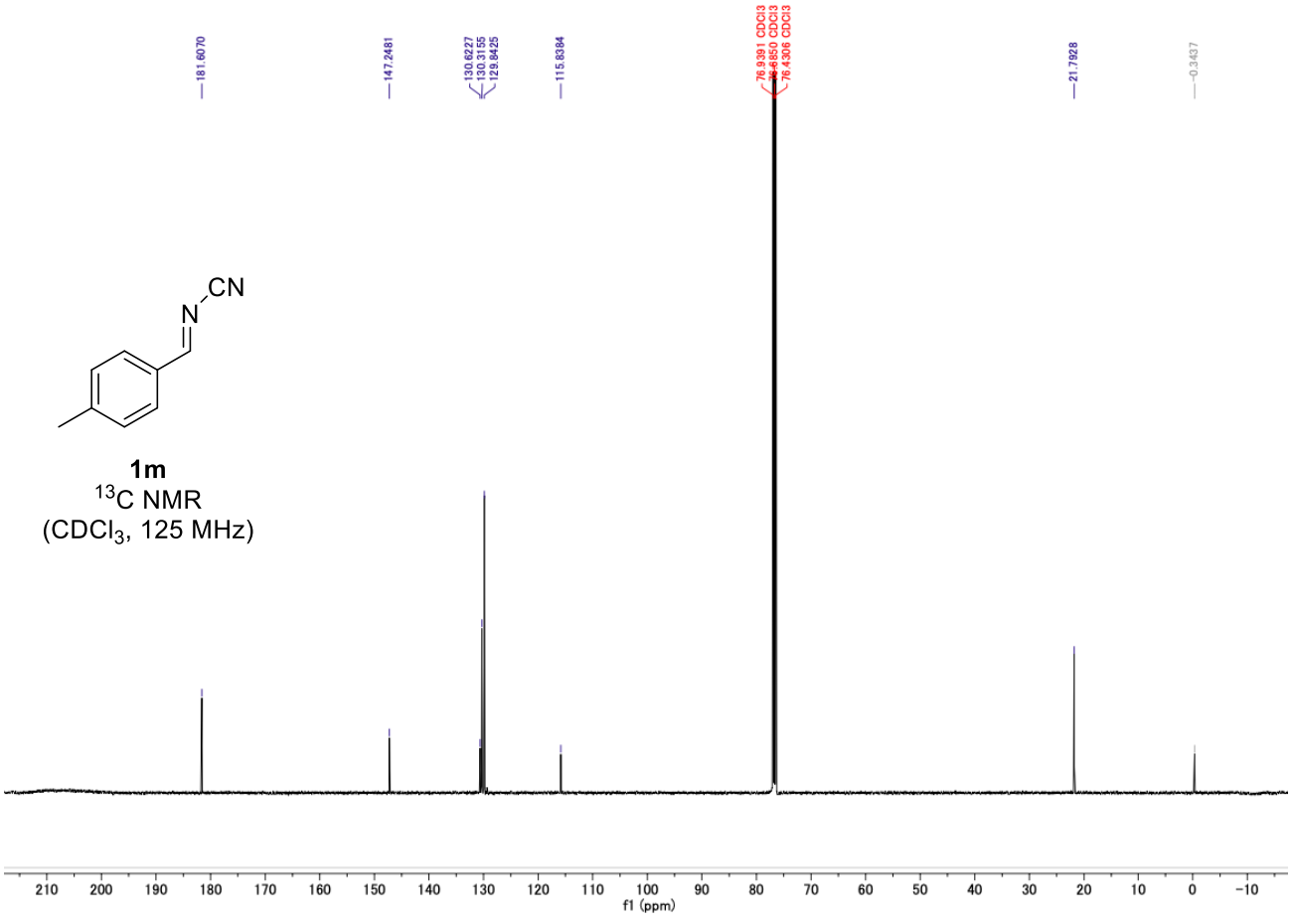
1l

^{19}F NMR

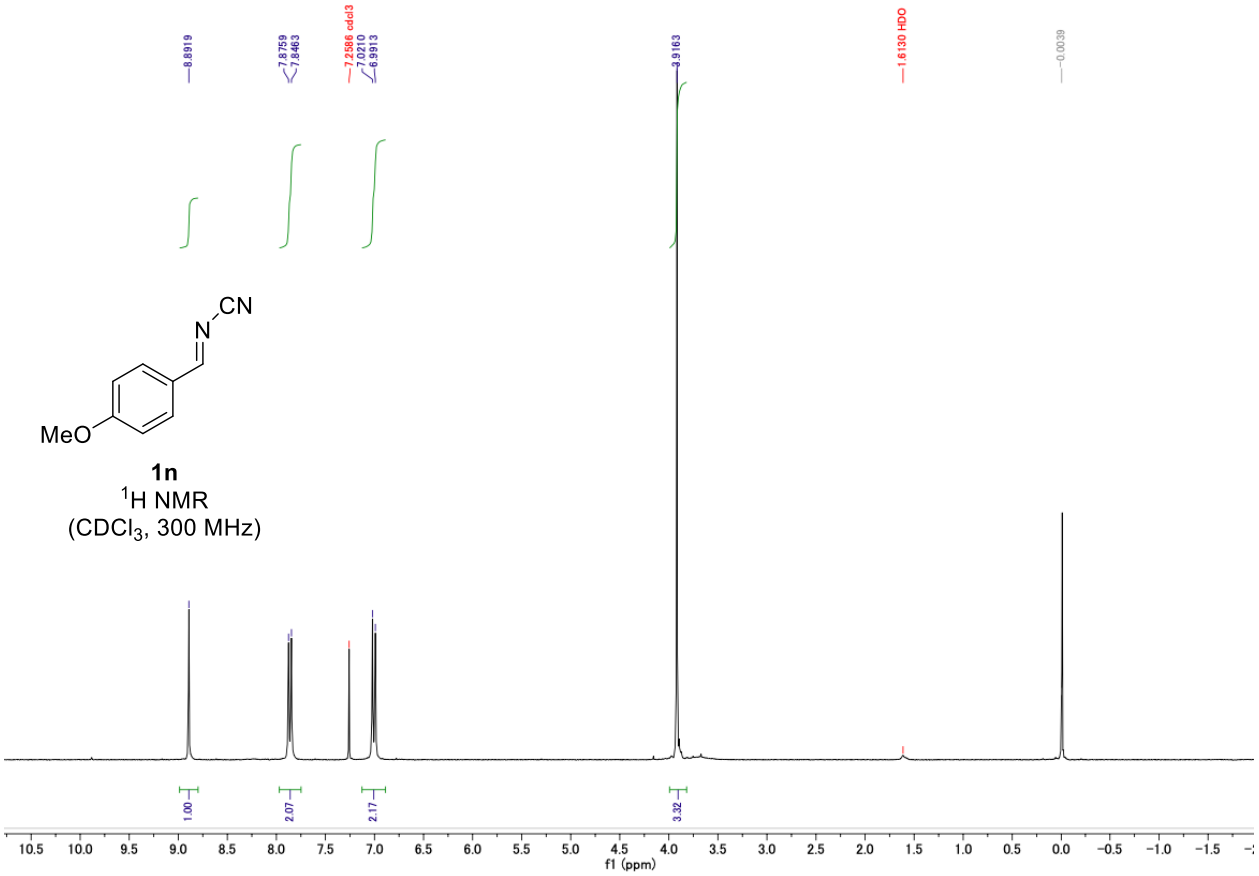
($CDCl_3$, 282 MHz)



1m
^{1}H NMR
($CDCl_3$, 300 MHz)



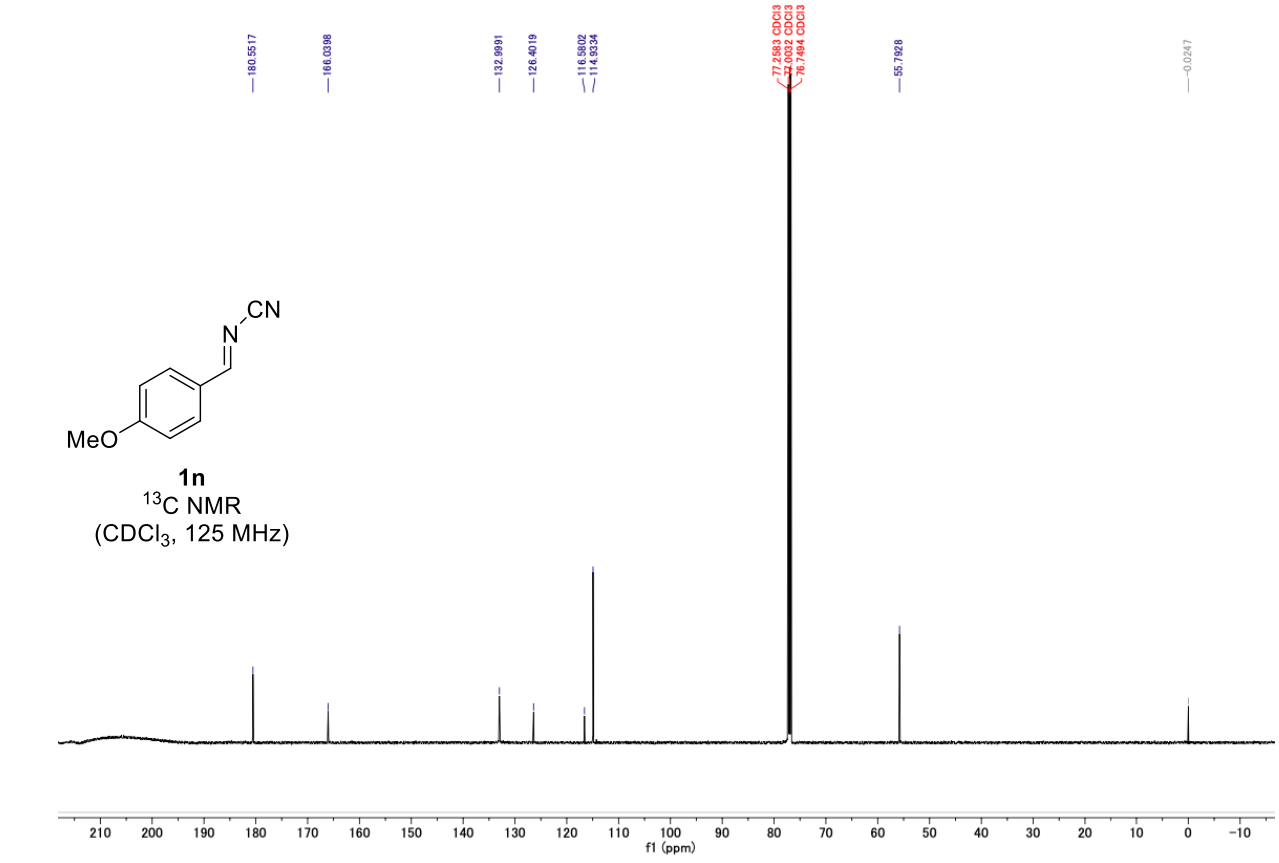
1m
^{13}C NMR
($CDCl_3$, 125 MHz)



1n

^{1}H NMR

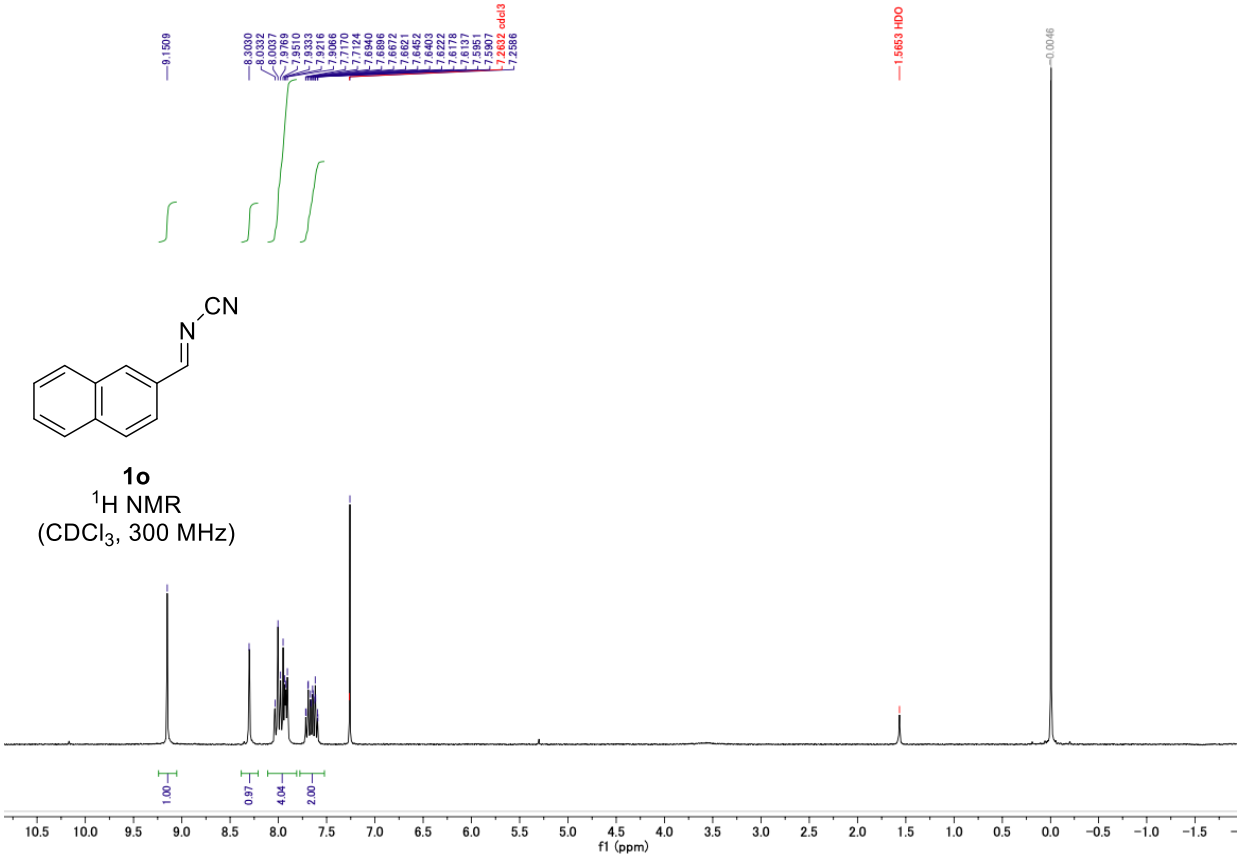
($CDCl_3$, 300 MHz)



1n

^{13}C NMR

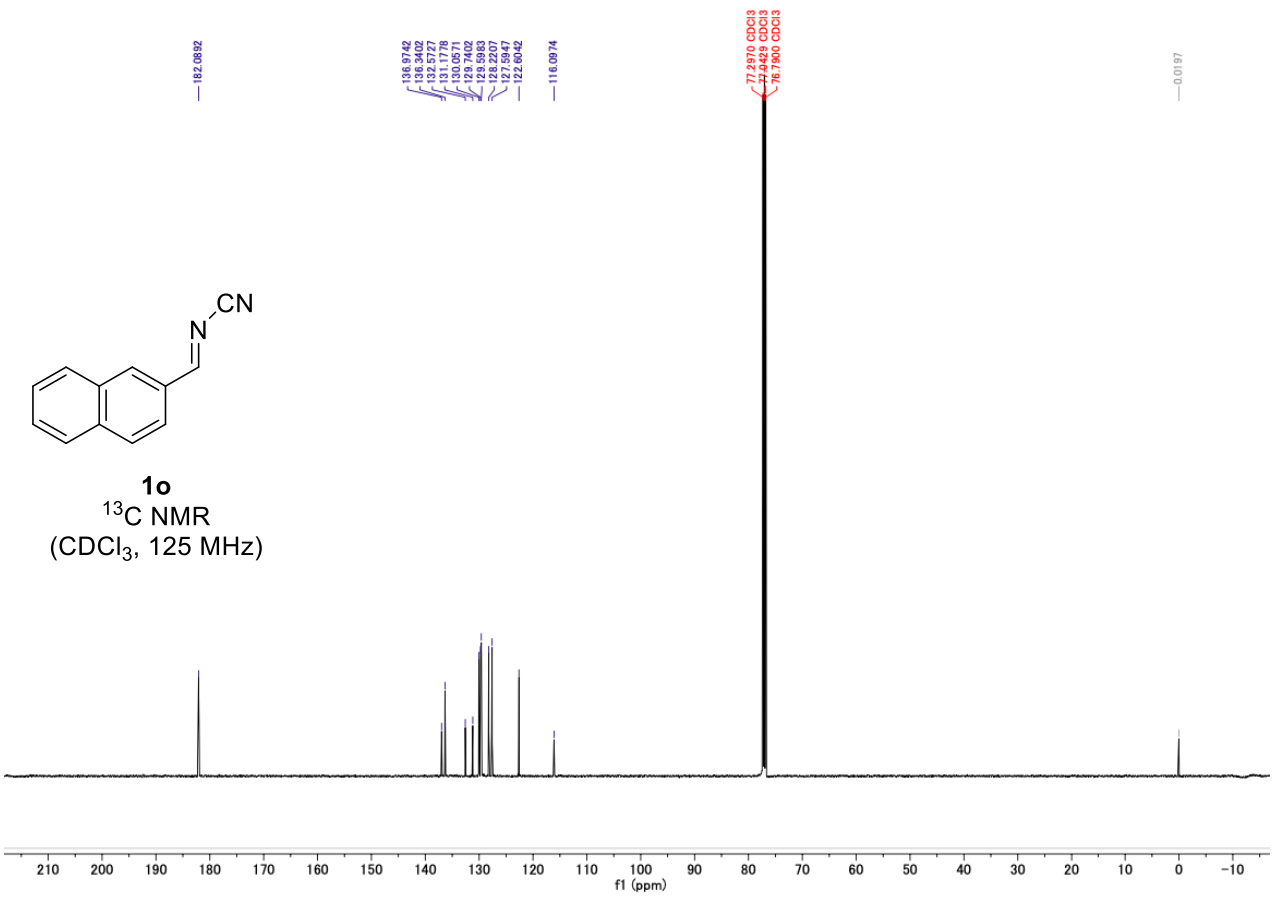
($CDCl_3$, 125 MHz)



1o

^{1}H NMR

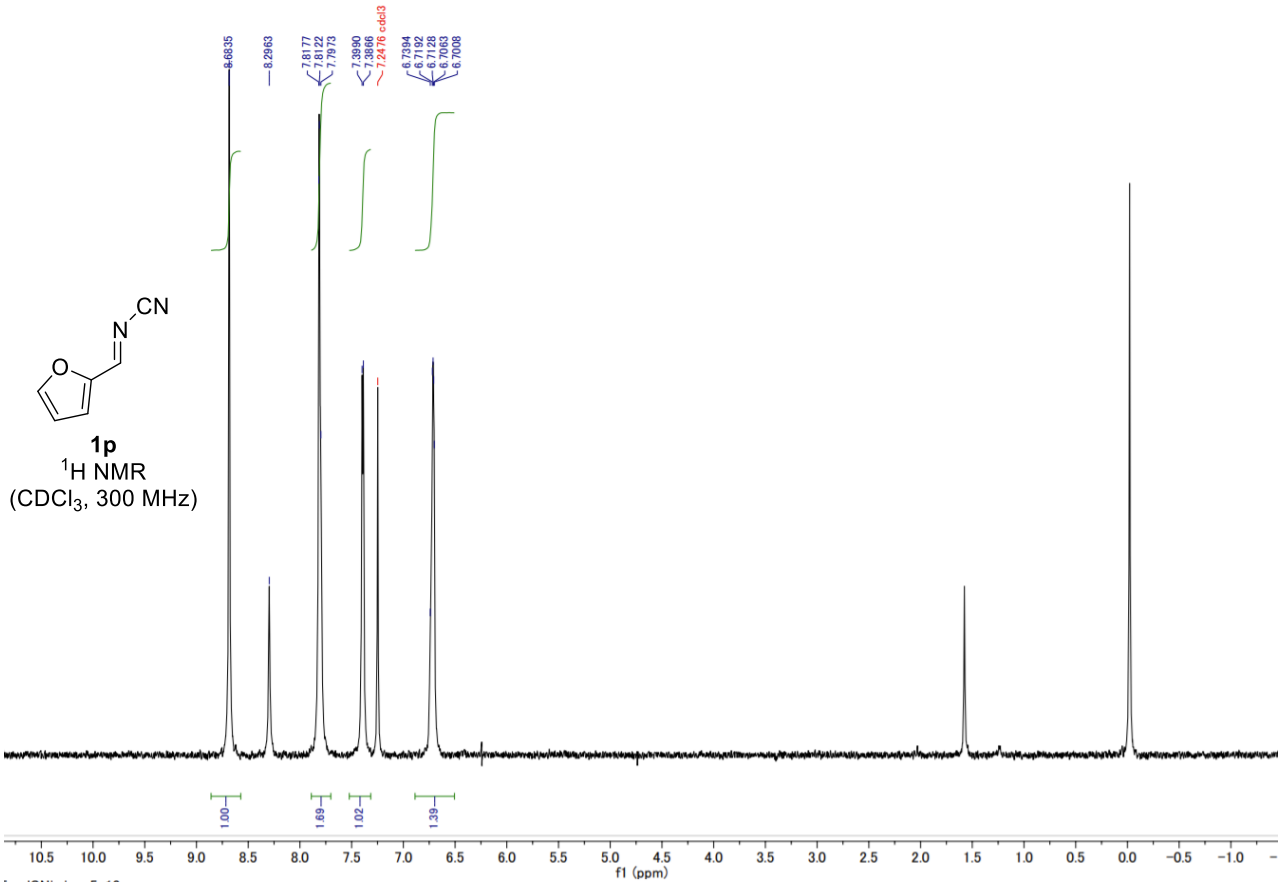
($CDCl_3$, 300 MHz)



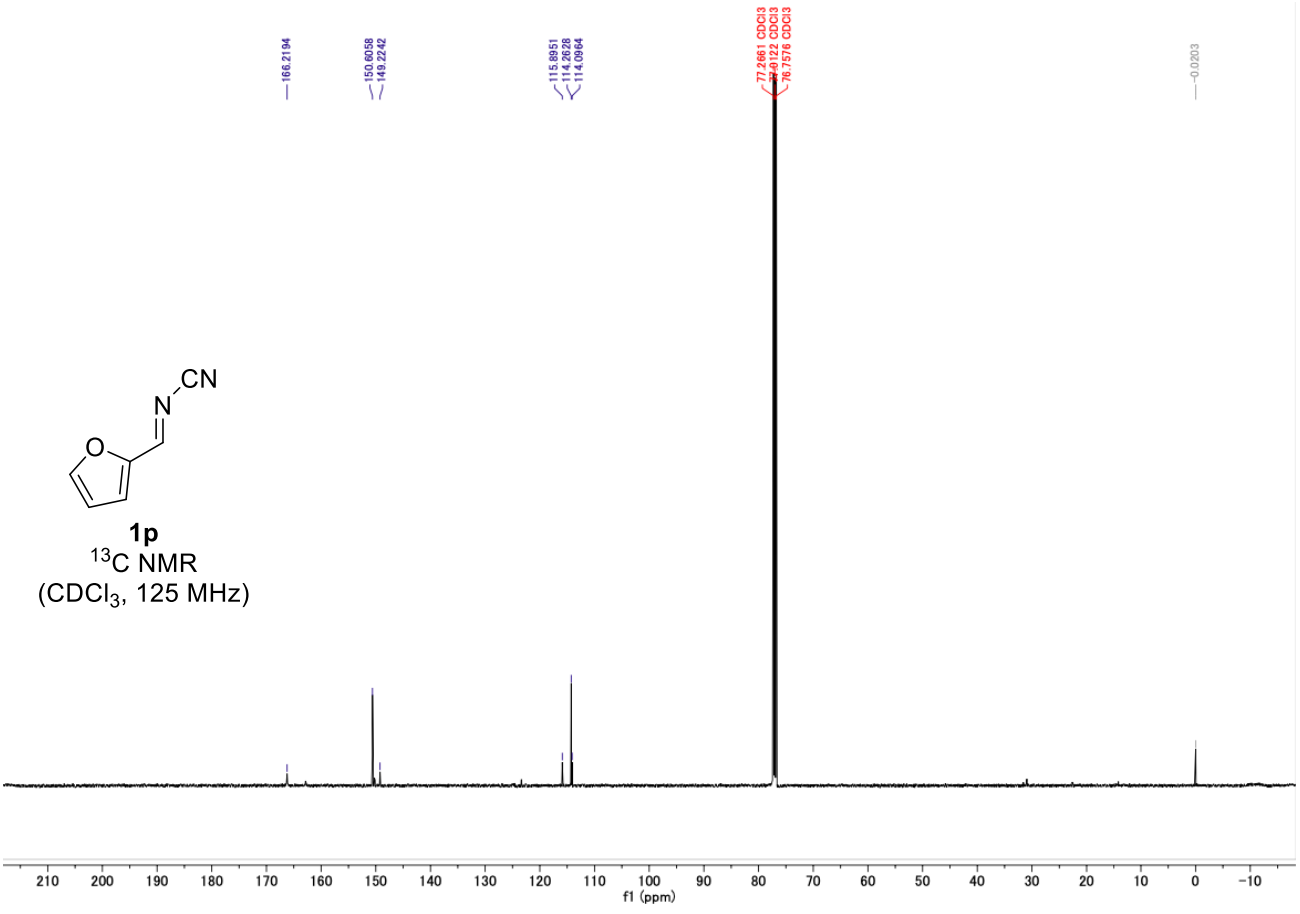
1o

^{13}C NMR

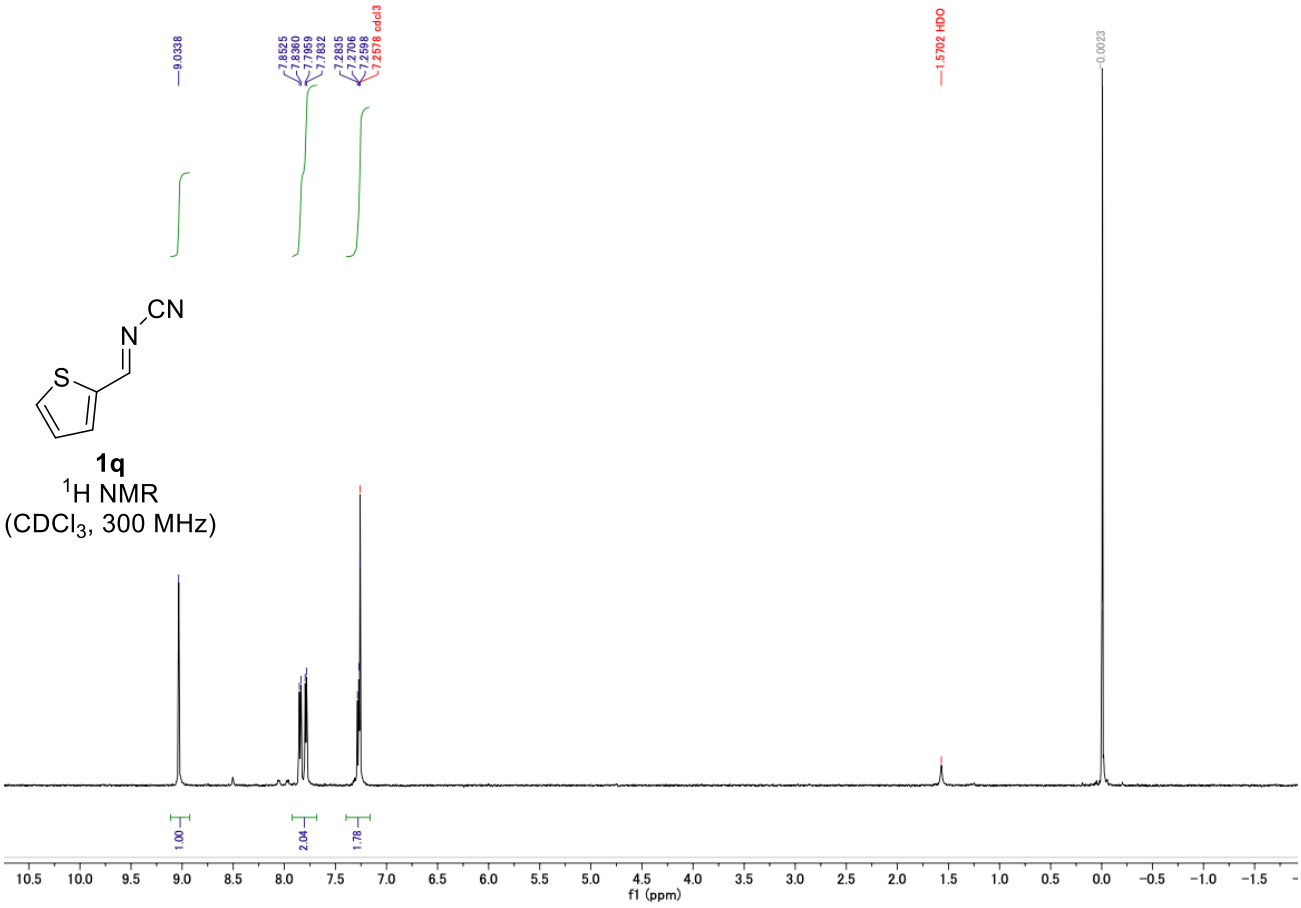
($CDCl_3$, 125 MHz)

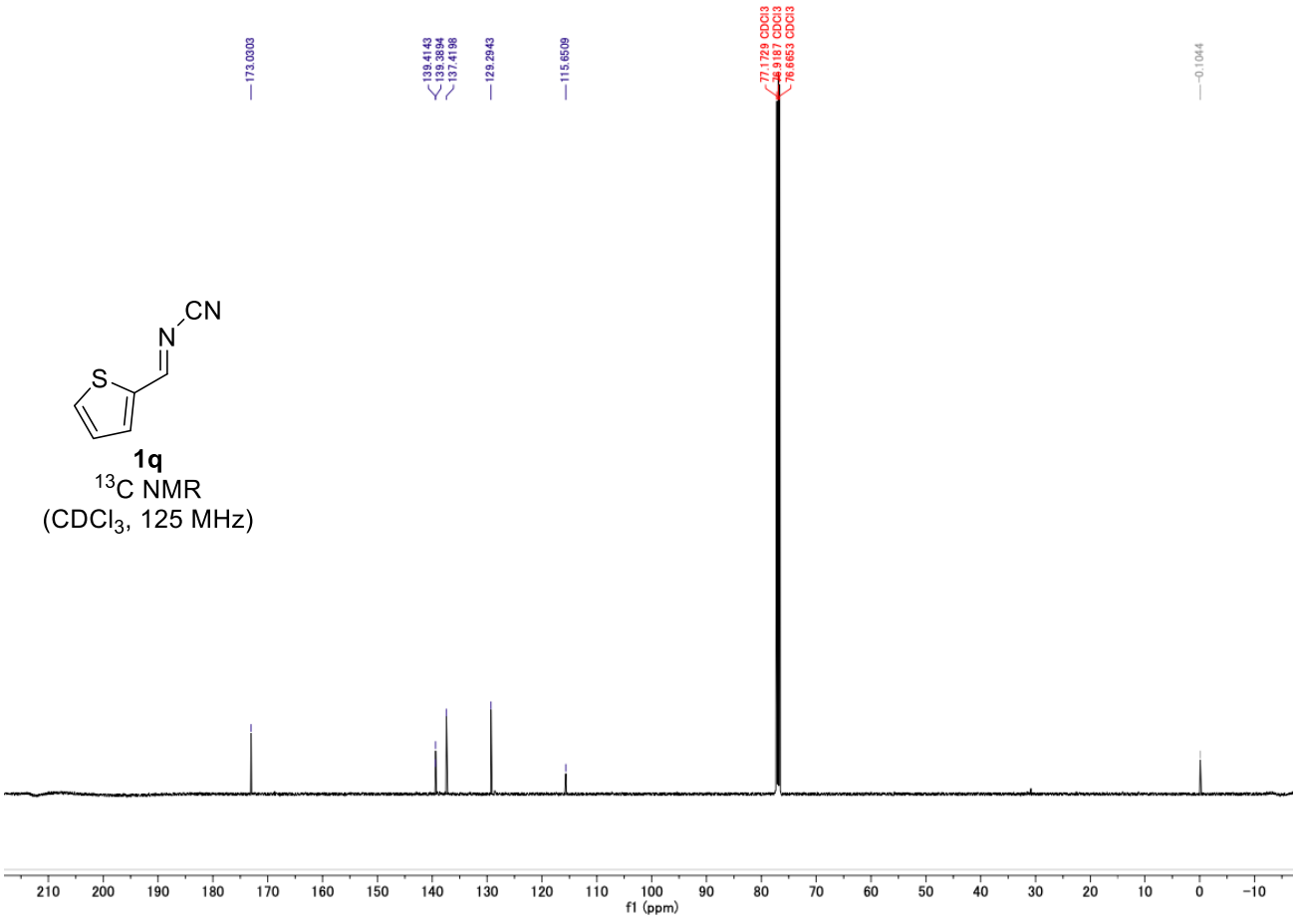


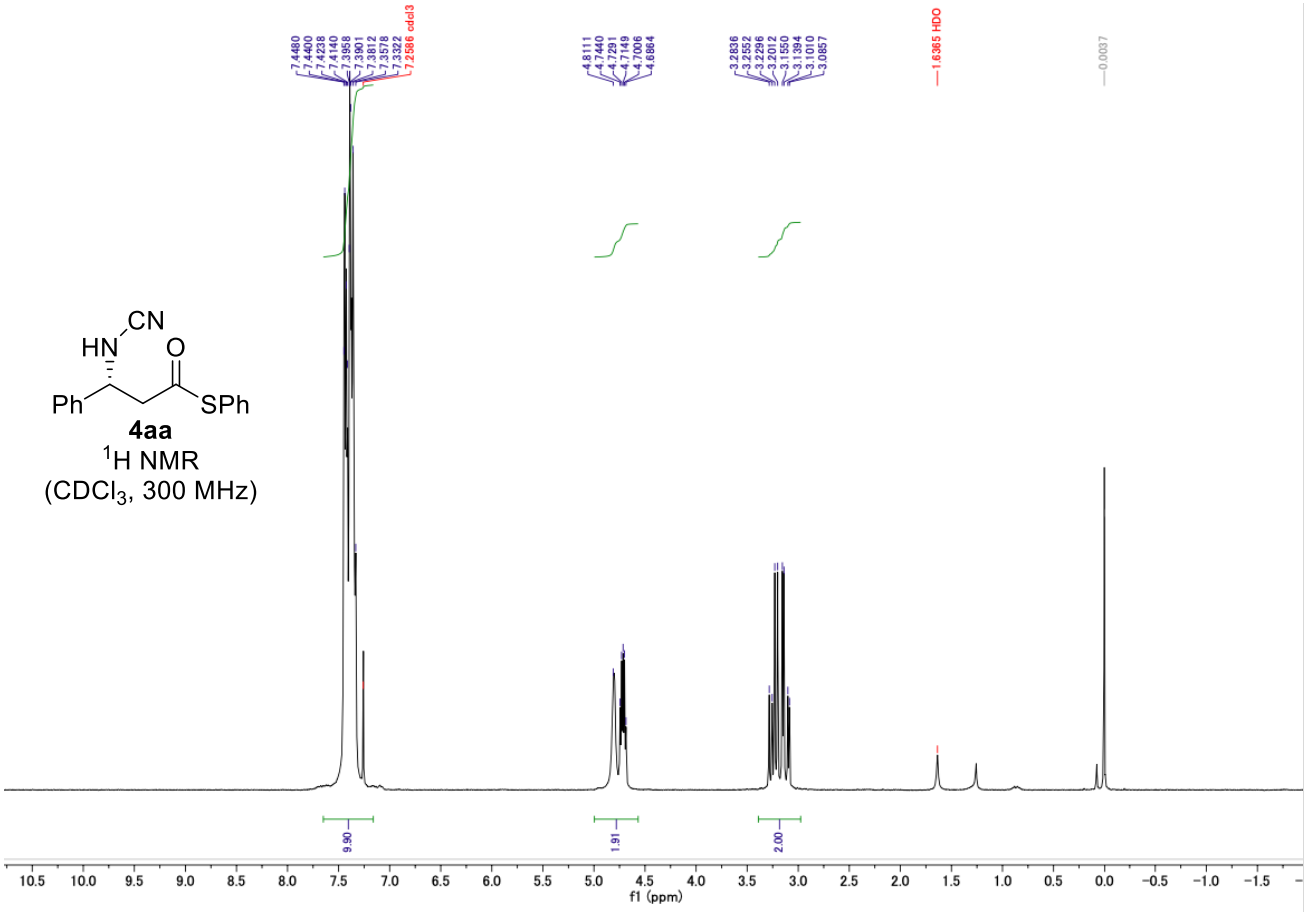
1p
^{1}H NMR
($CDCl_3$, 300 MHz)

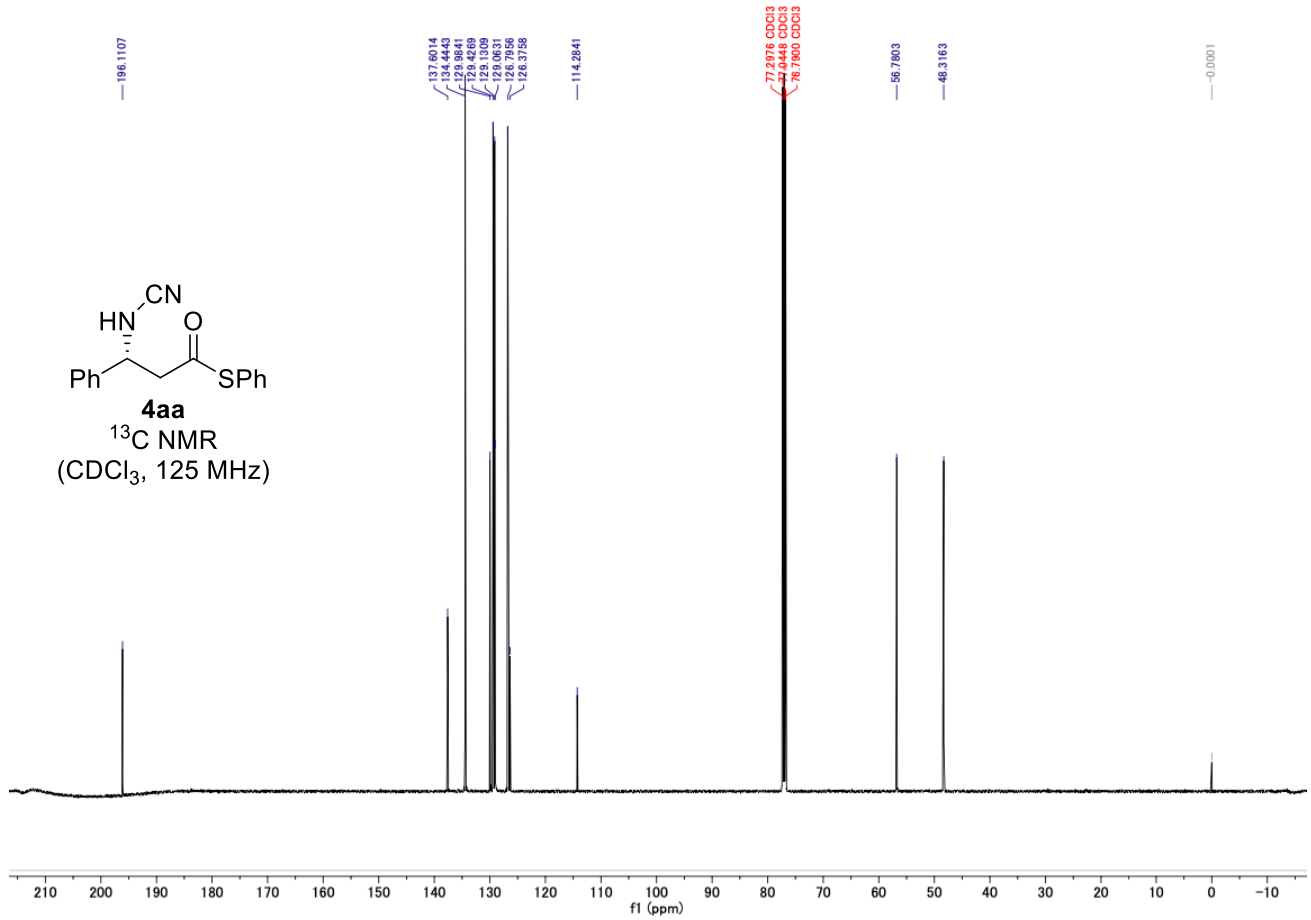


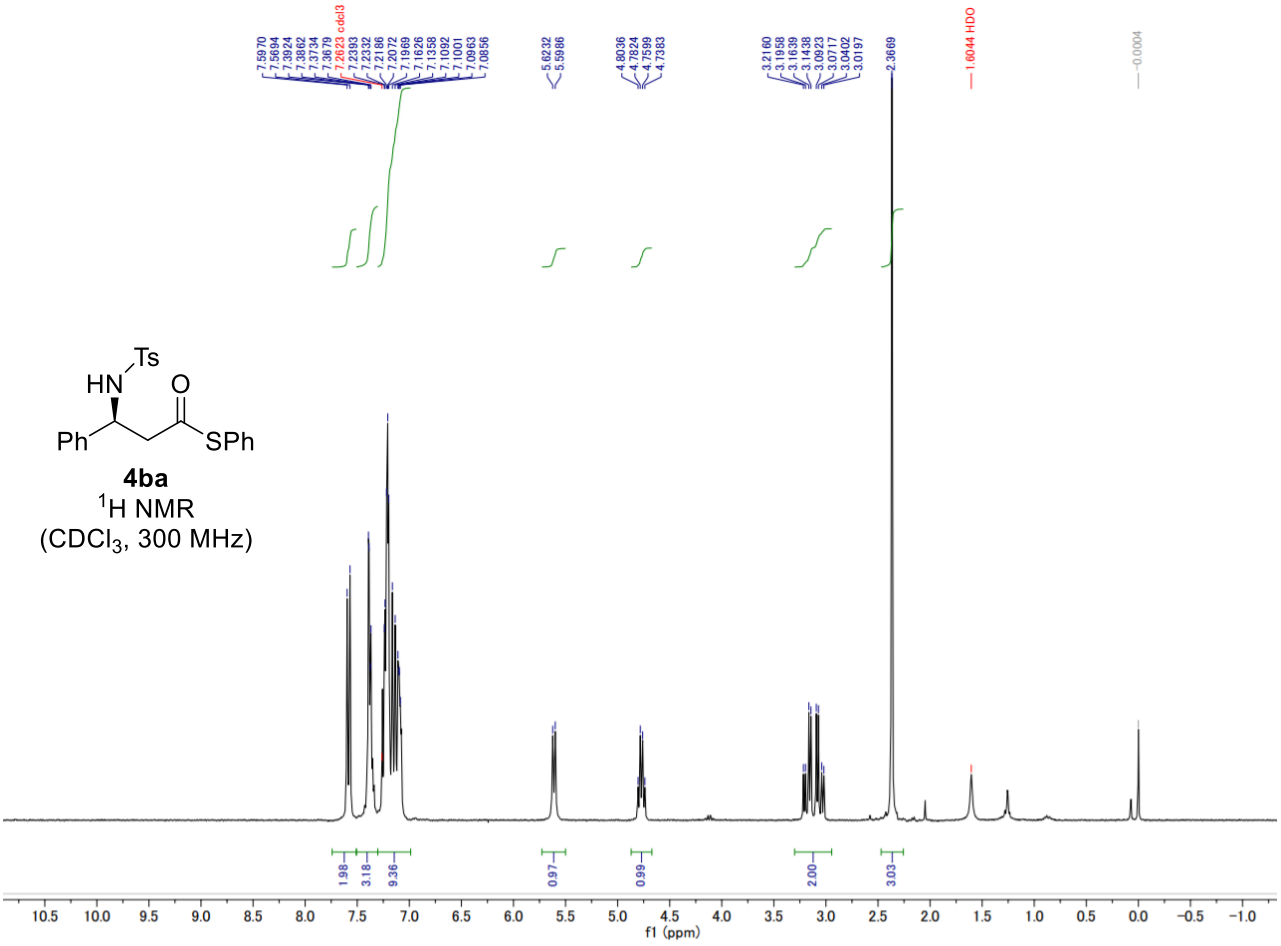
1p
^{13}C NMR
($CDCl_3$, 125 MHz)


9.0338
7.8525
7.8360
7.7959
7.7832
7.2835
7.2706
7.2598
7.2578 cdcl3
1.5702 HDO
0.0023
CN
N
S
1q
1H NMR
(CDCl3, 300 MHz)
1.00
2.04
1.78
f1 (ppm)

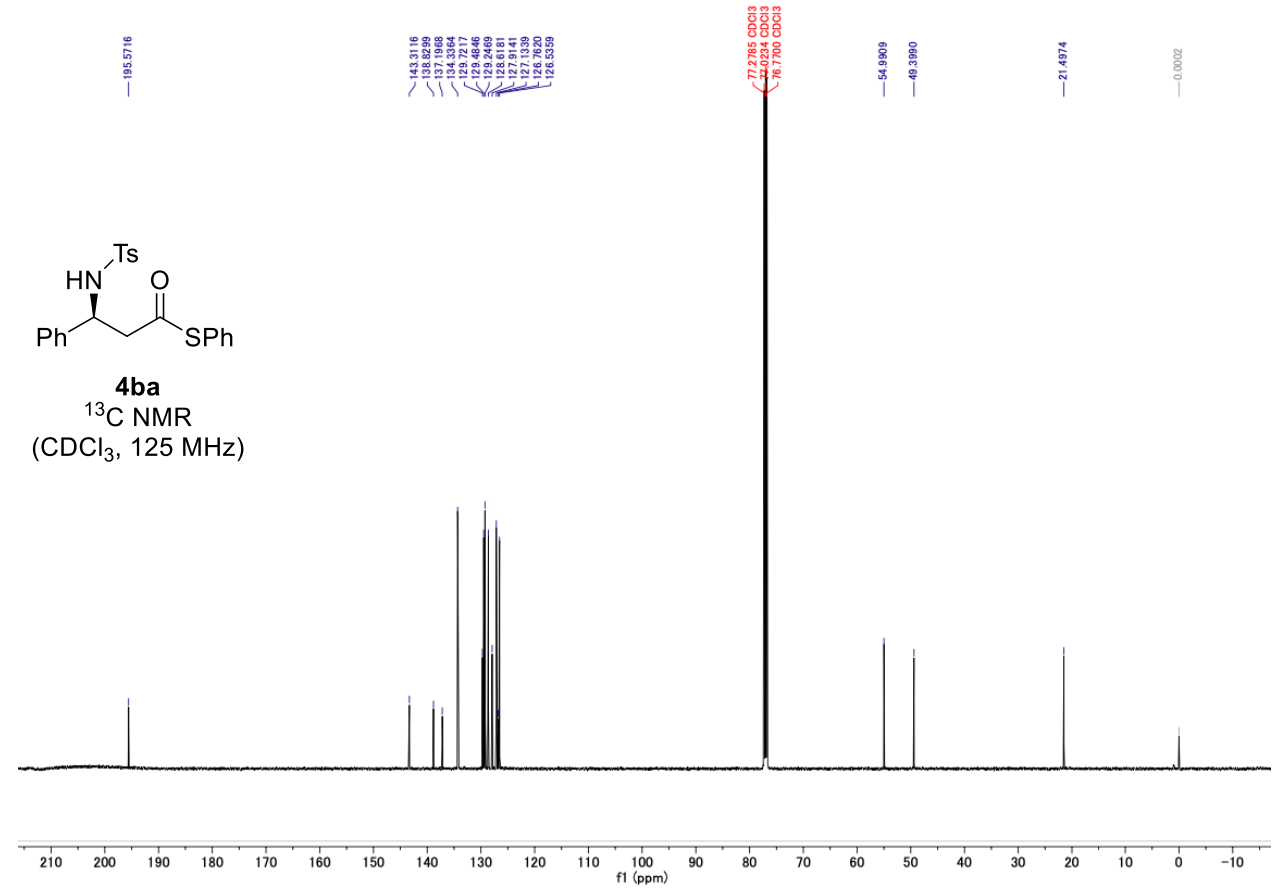

173.0303
139.4143
135.3894
127.4196
129.2943
115.6509
77.1729 CDCl3
76.6653 CDCl3
-0.1044
CN
N
S
1q
13C NMR
(CDCl3, 125 MHz)
f1 (ppm)


CN
HN
O
Ph
SPh
4aa
1H NMR
(CDCl3, 300 MHz)
f1 (ppm)

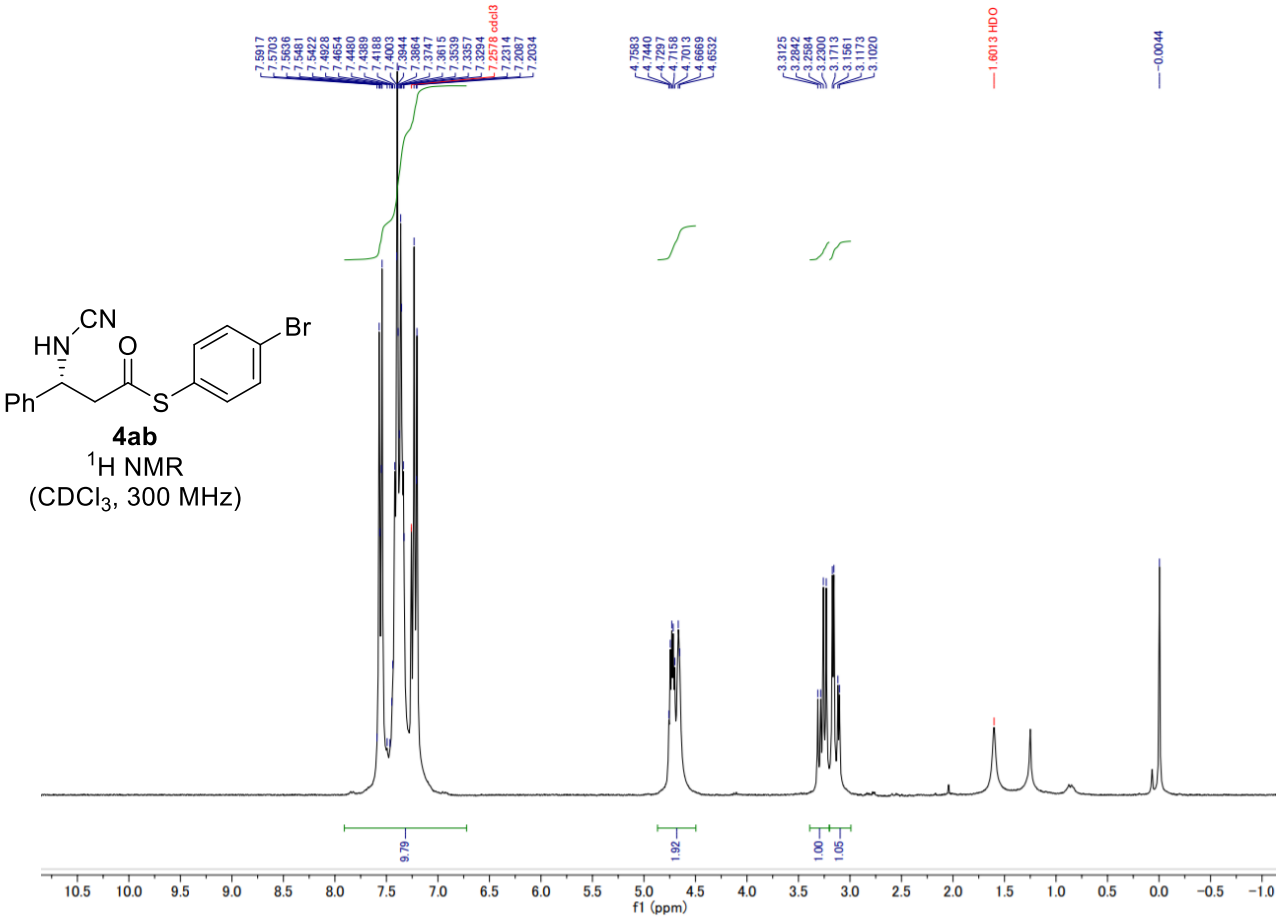

CN
HN
O
Ph
SPh
4aa
13C NMR
(CDCl3, 125 MHz)
f1 (ppm)

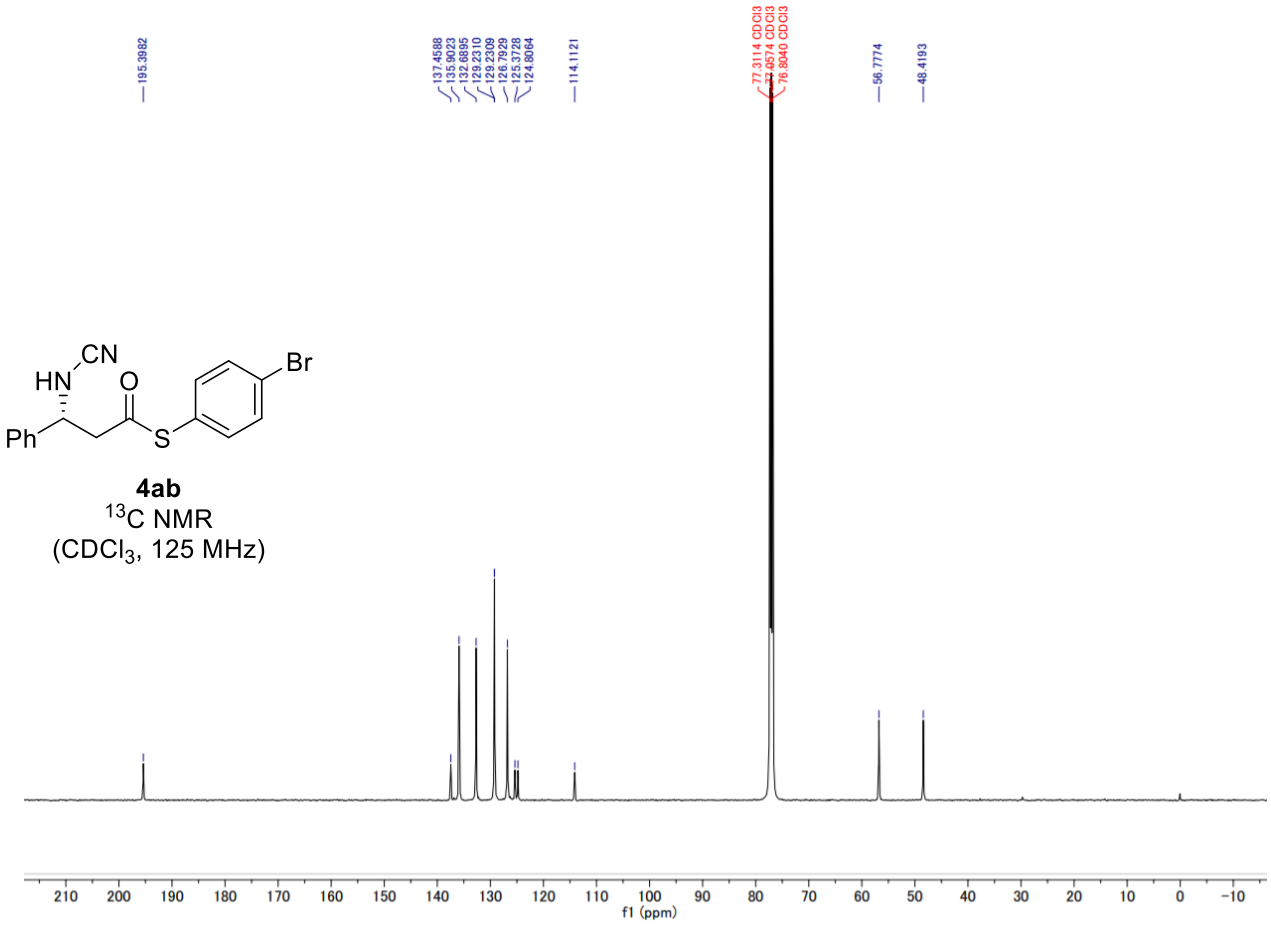


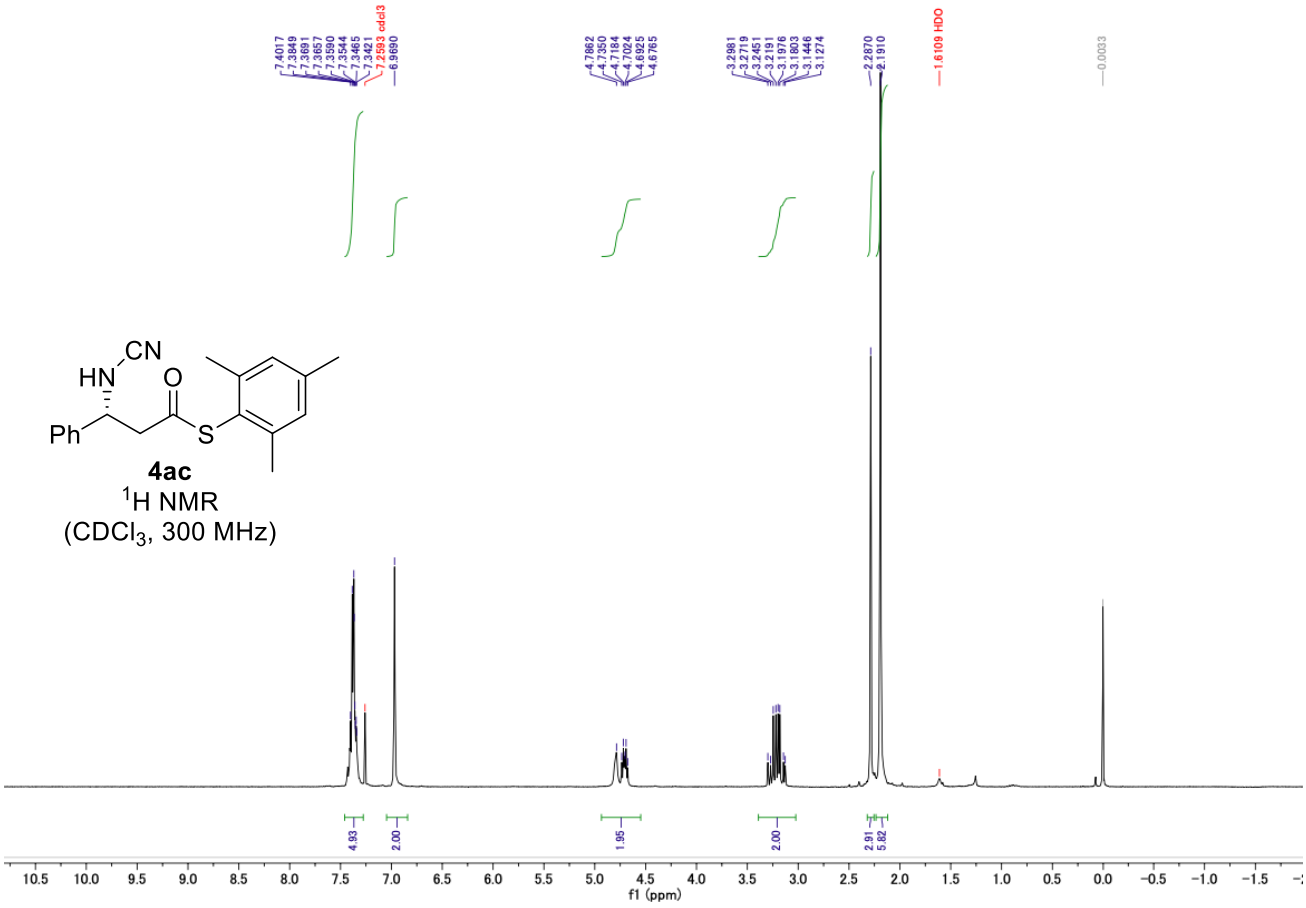
4ba
^{1}H NMR
($CDCl_3$, 300 MHz)

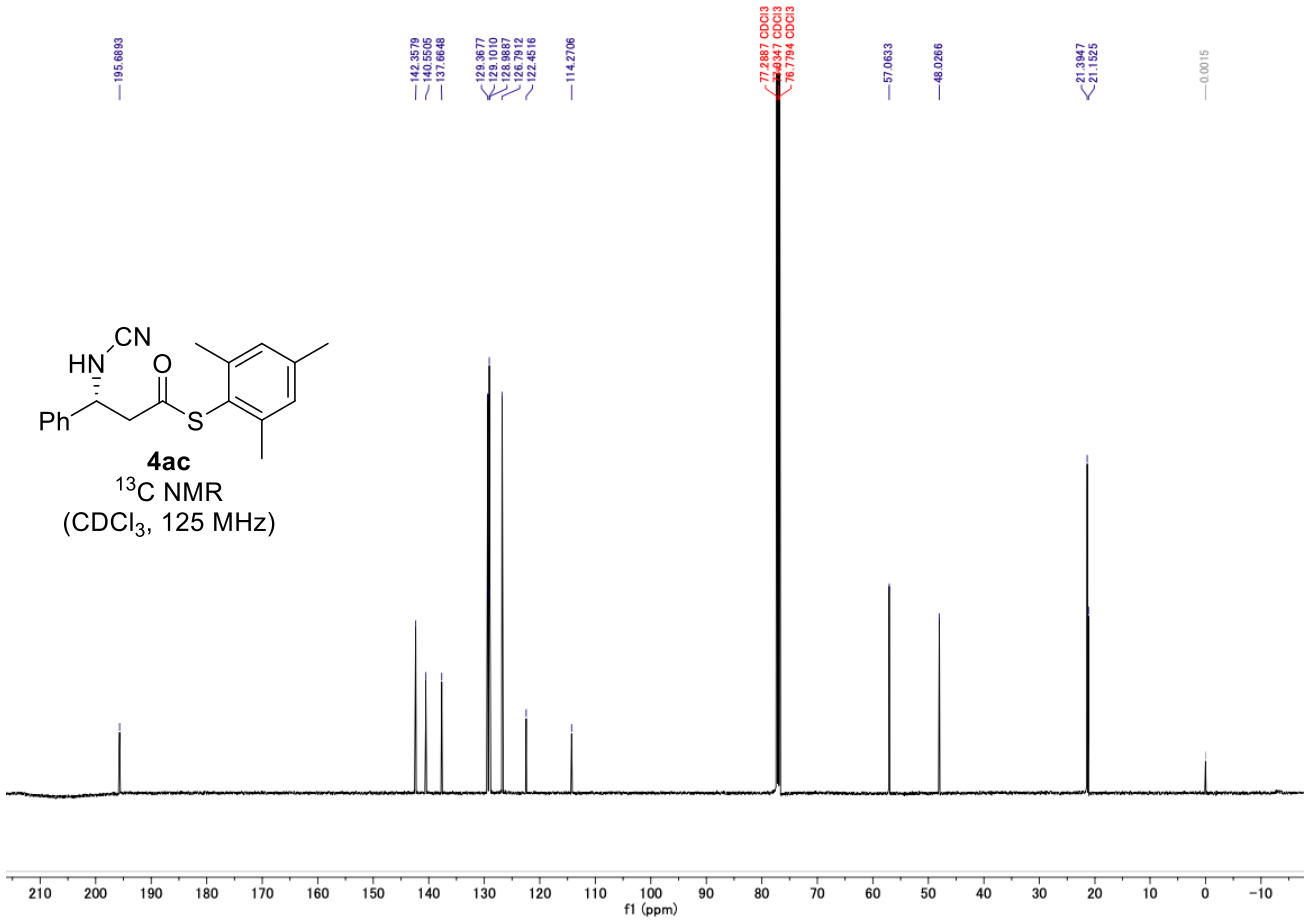


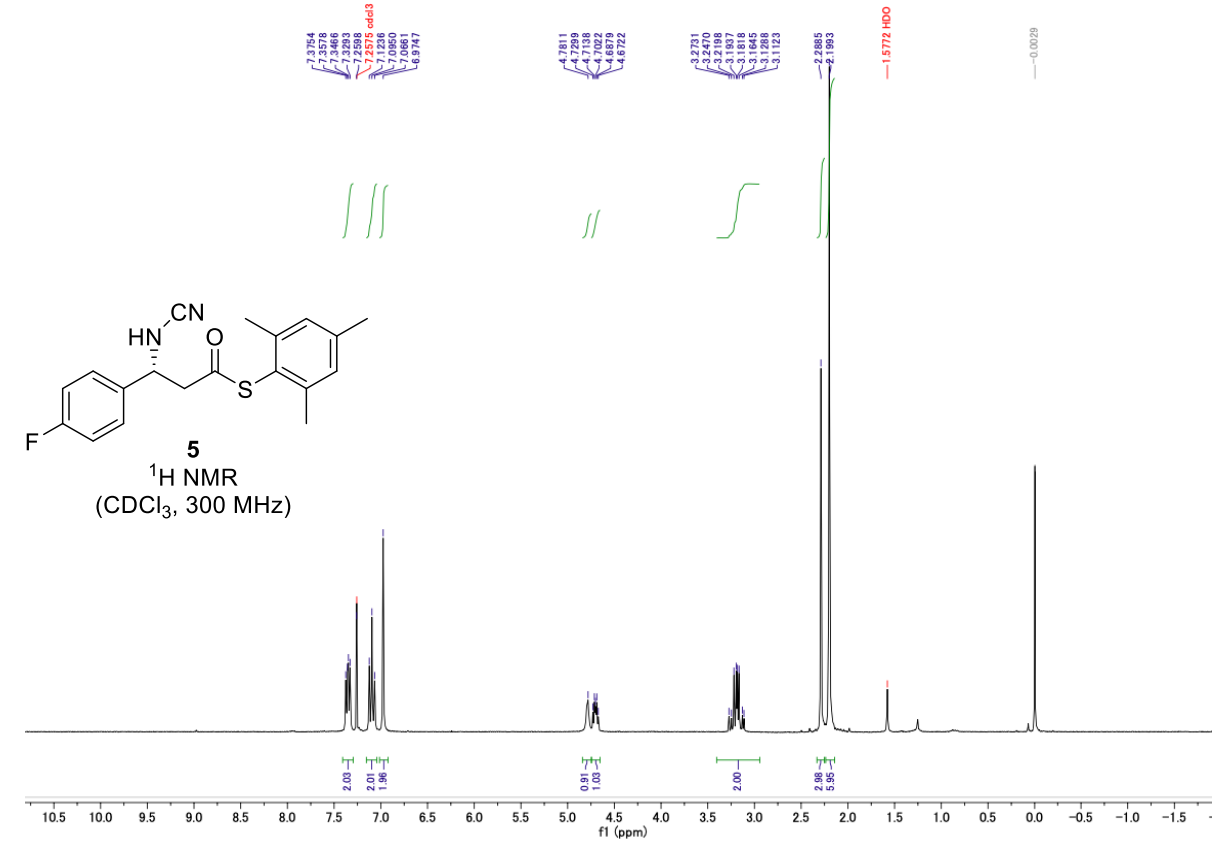
4ba
^{13}C NMR
($CDCl_3$, 125 MHz)

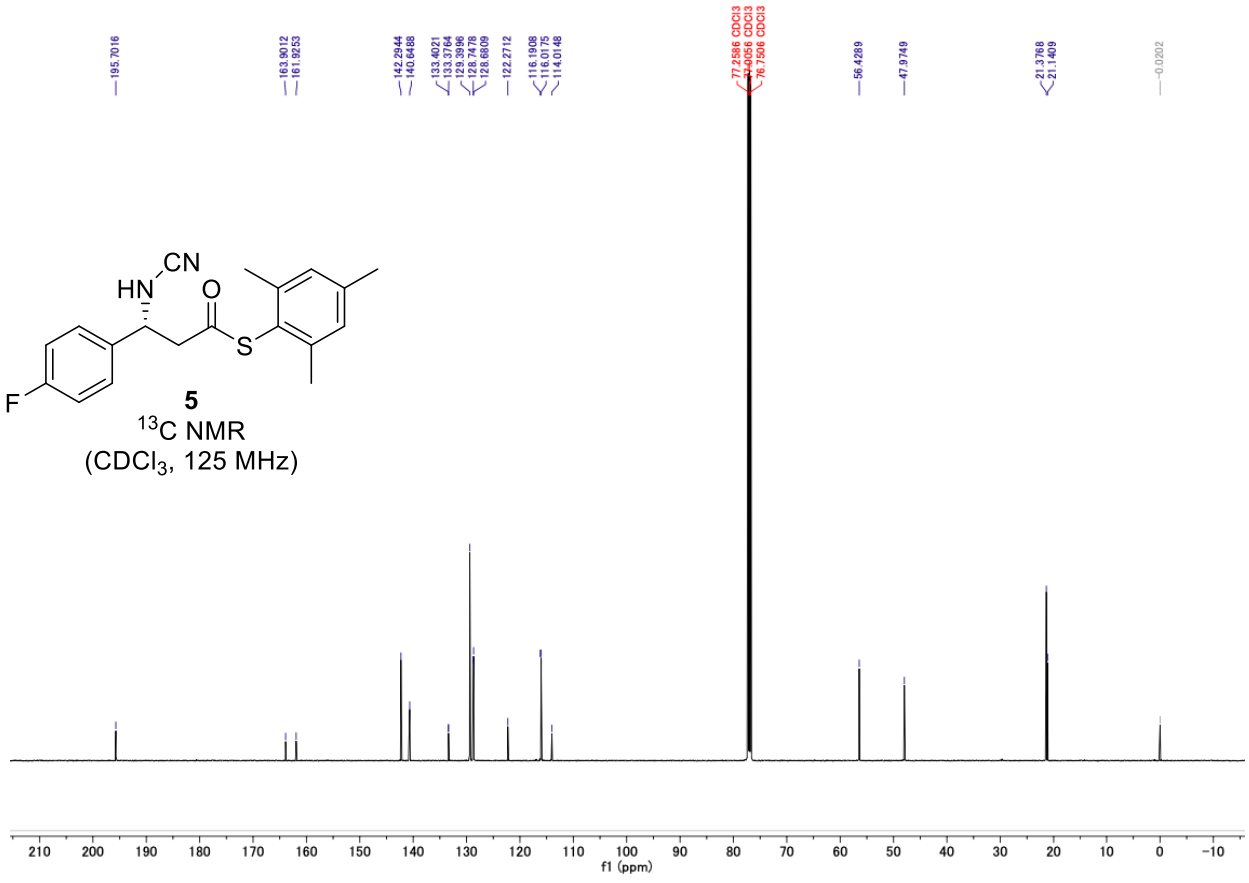

CN
HN
O
Ph
S
Br
4ab
1H NMR
(CDCl3, 300 MHz)
f1 (ppm)

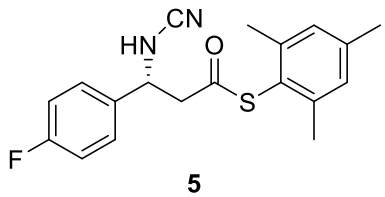

CN
HN
O
Ph
S
Br
4ab
13C NMR
(CDCl3, 125 MHz)
f1 (ppm)


CN
HN
O
Ph
S
4ac
1H NMR
(CDCl3, 300 MHz)
f1 (ppm)


CN
HN
O
Ph
S
4ac
13C NMR
(CDCl3, 125 MHz)
f1 (ppm)


CN
HN
O
S
F
5
1H NMR
(CDCl3, 300 MHz)
f1 (ppm)

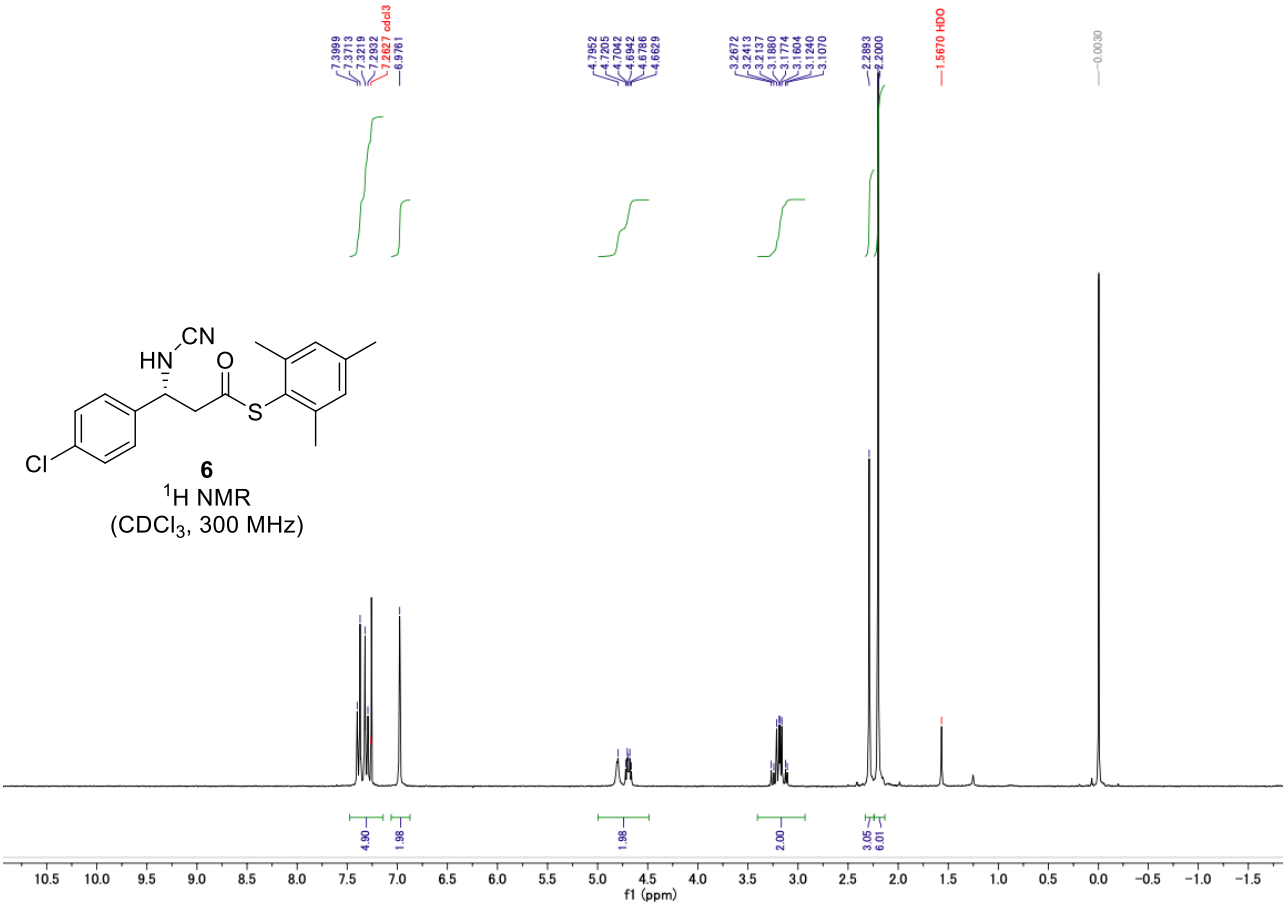

CN
HN
O
S
F
5
13C NMR
(CDCl3, 125 MHz)
f1 (ppm)



5

^{19}F NMR

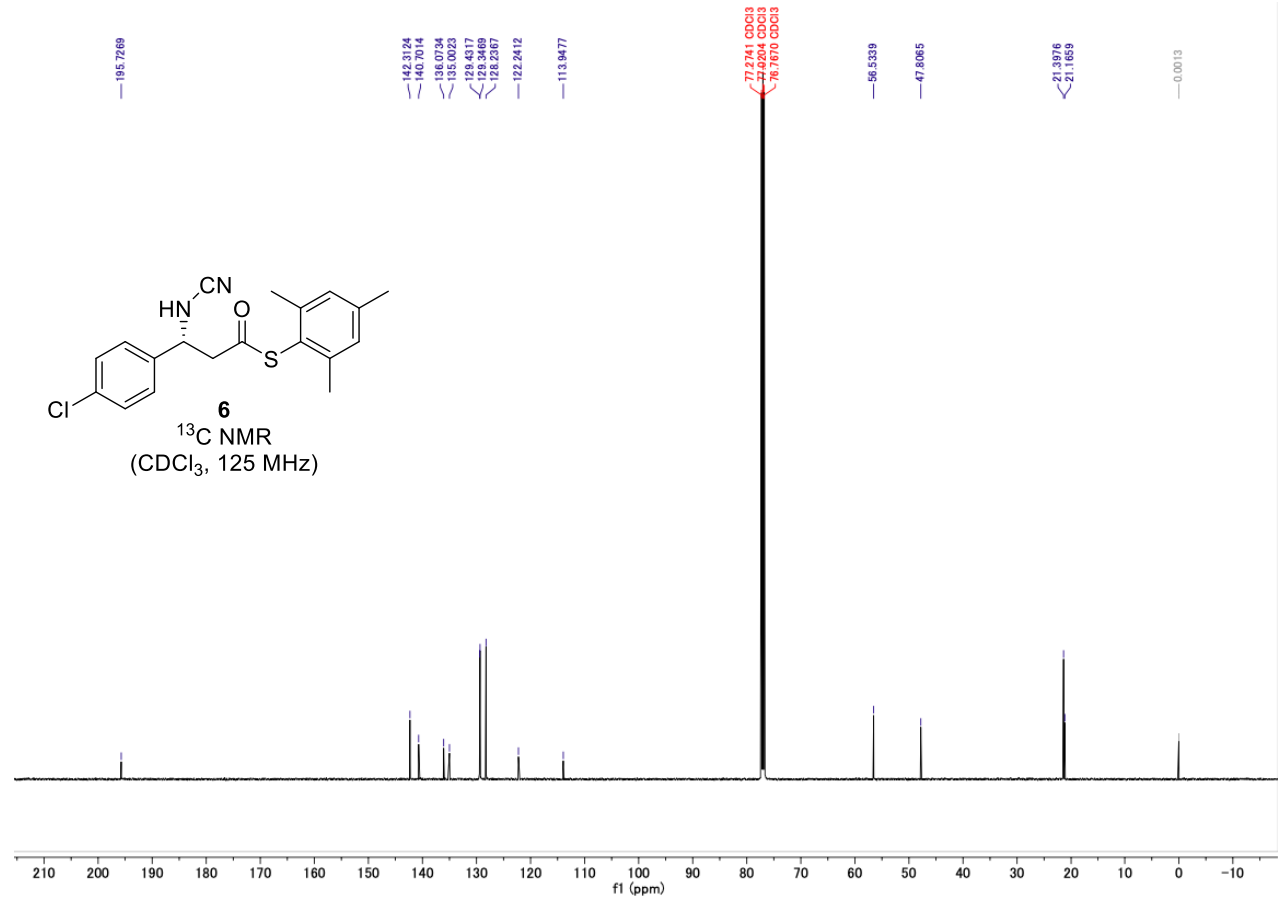
($CDCl_3$, 282 MHz)



6

^{1}H NMR

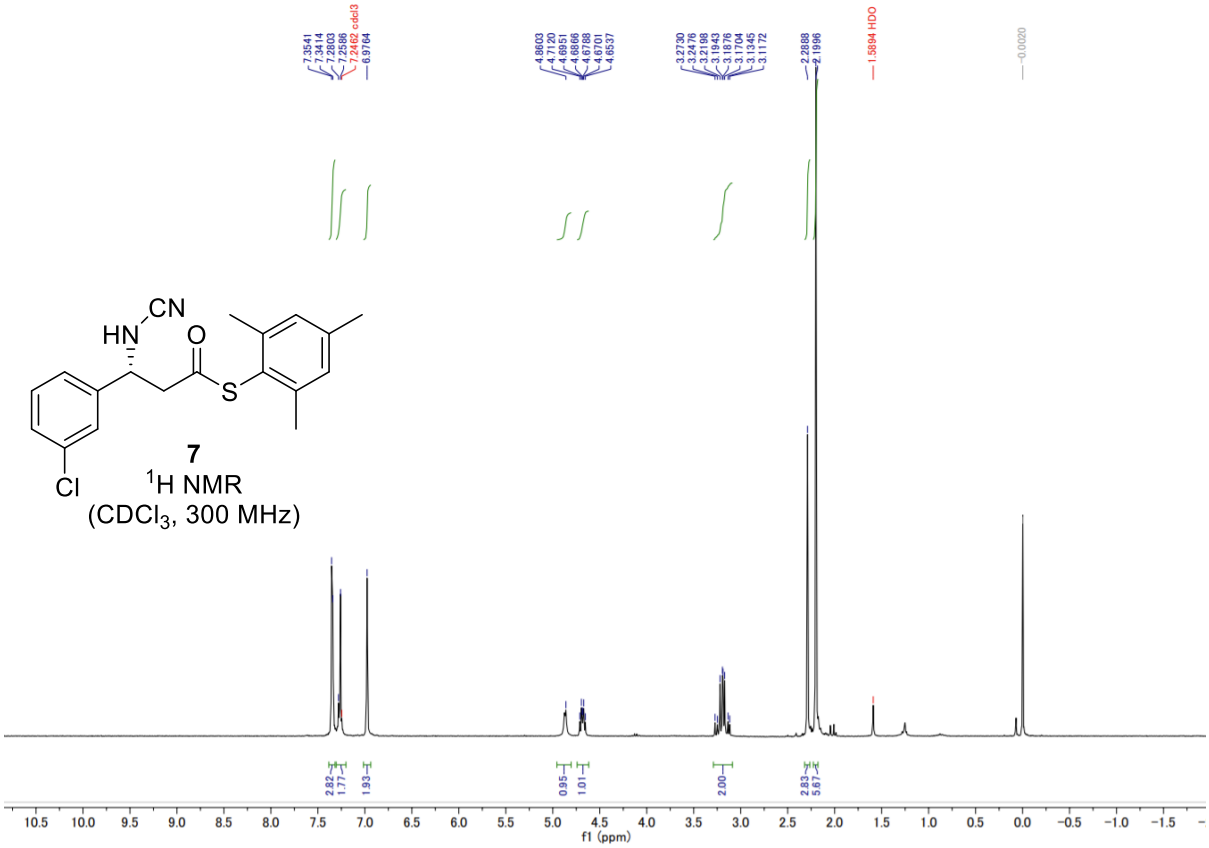
($CDCl_3$, 300 MHz)

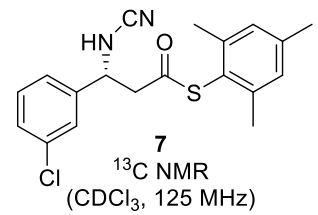


6

^{13}C NMR

($CDCl_3$, 125 MHz)





7

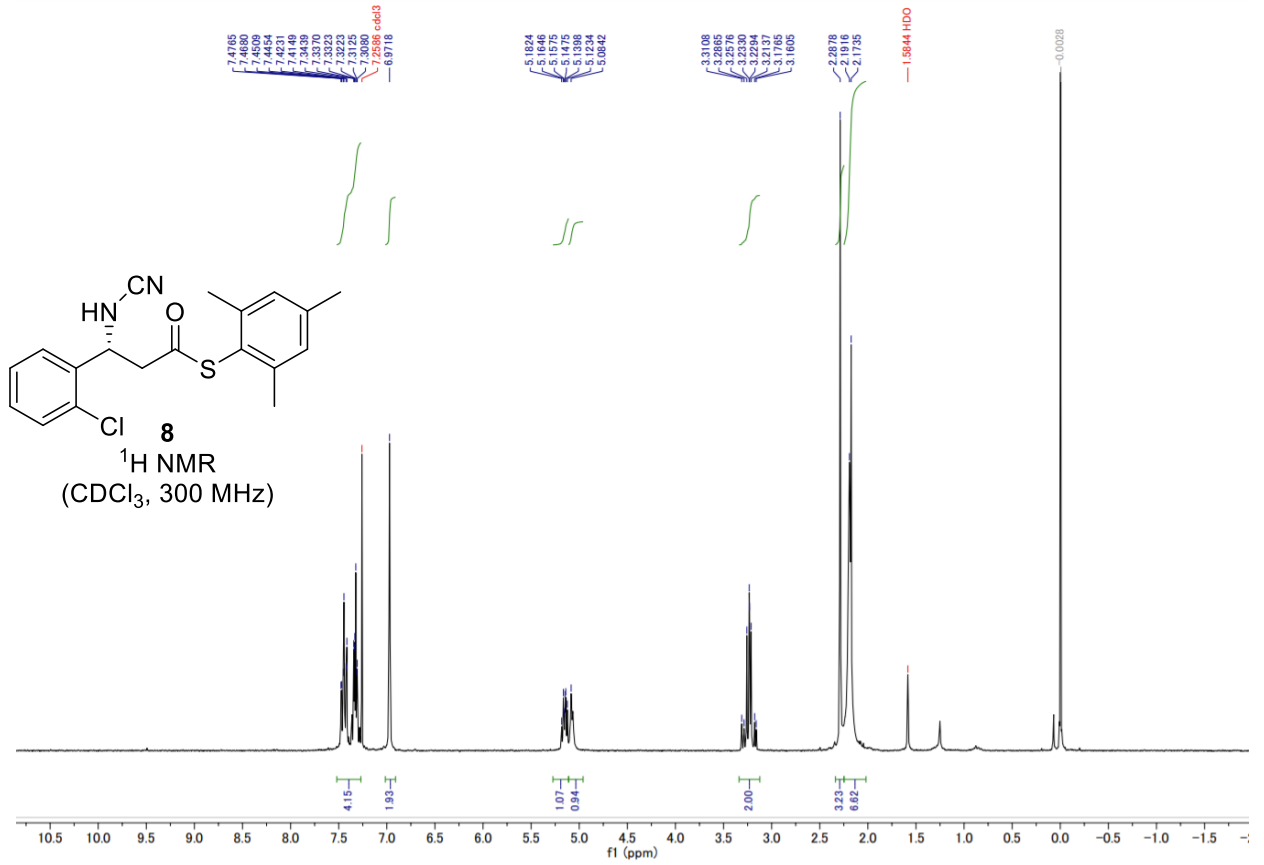
^{1}H NMR

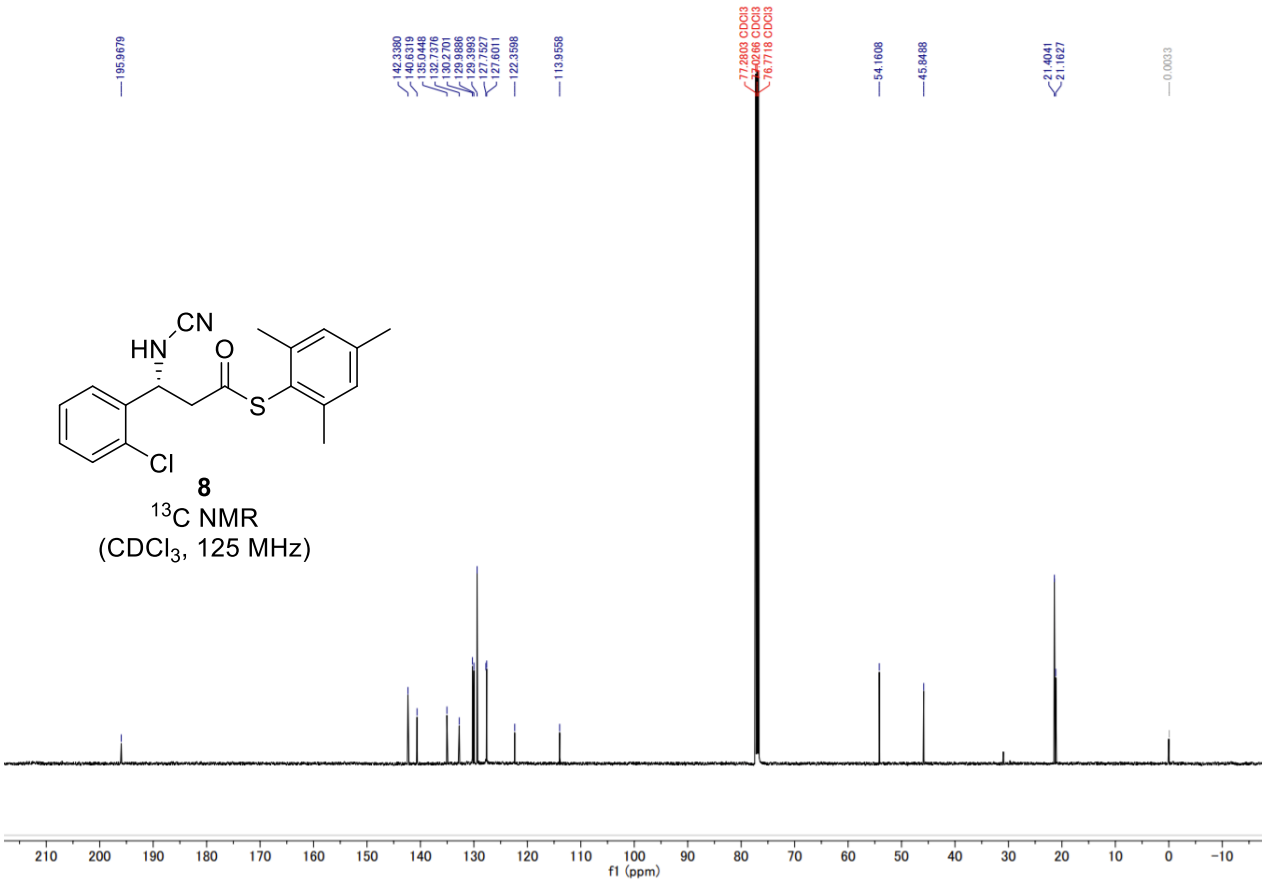
($CDCl_3$, 300 MHz)

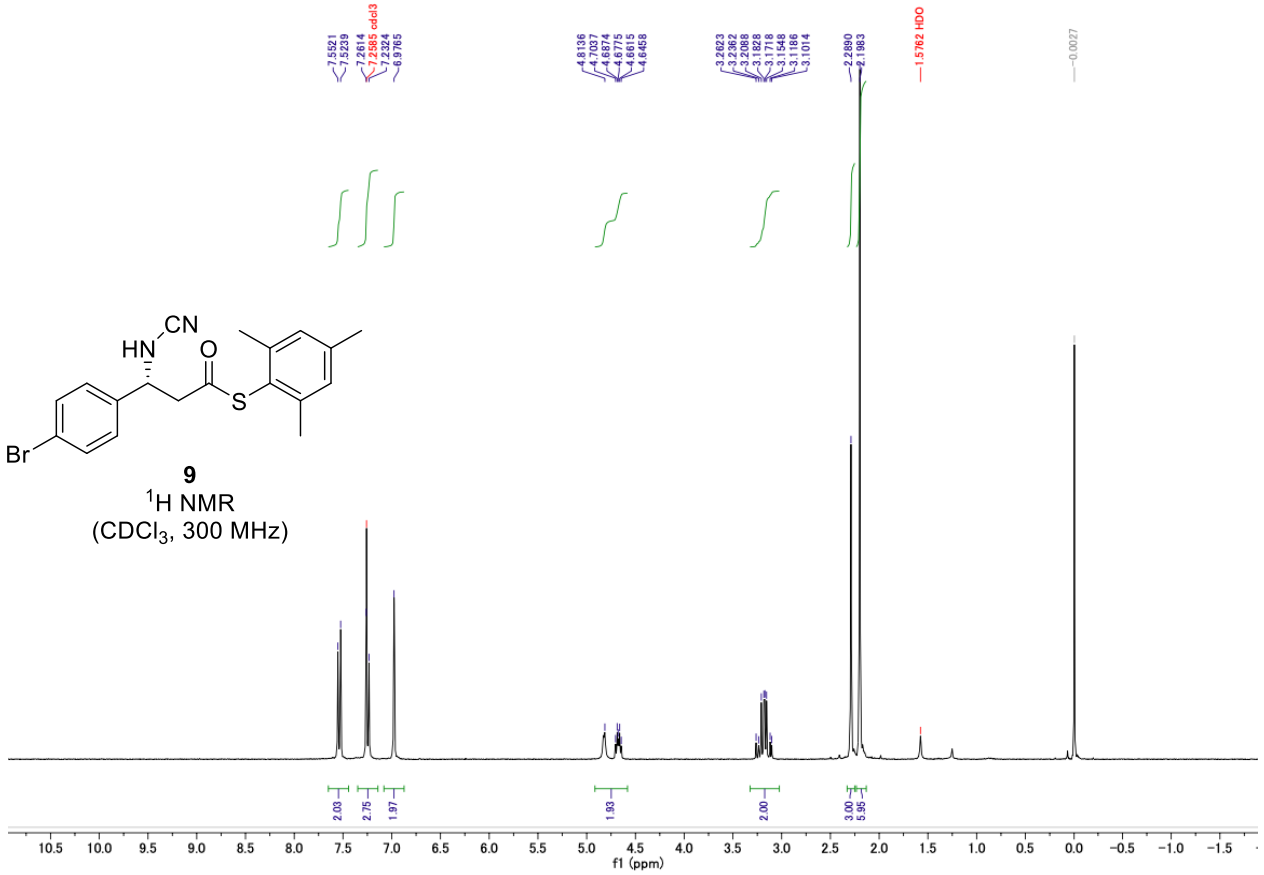
7

^{13}C NMR

($CDCl_3$, 125 MHz)


CN
HN
O
S
Cl
8
1H NMR
(CDCl3, 300 MHz)
f1 (ppm)

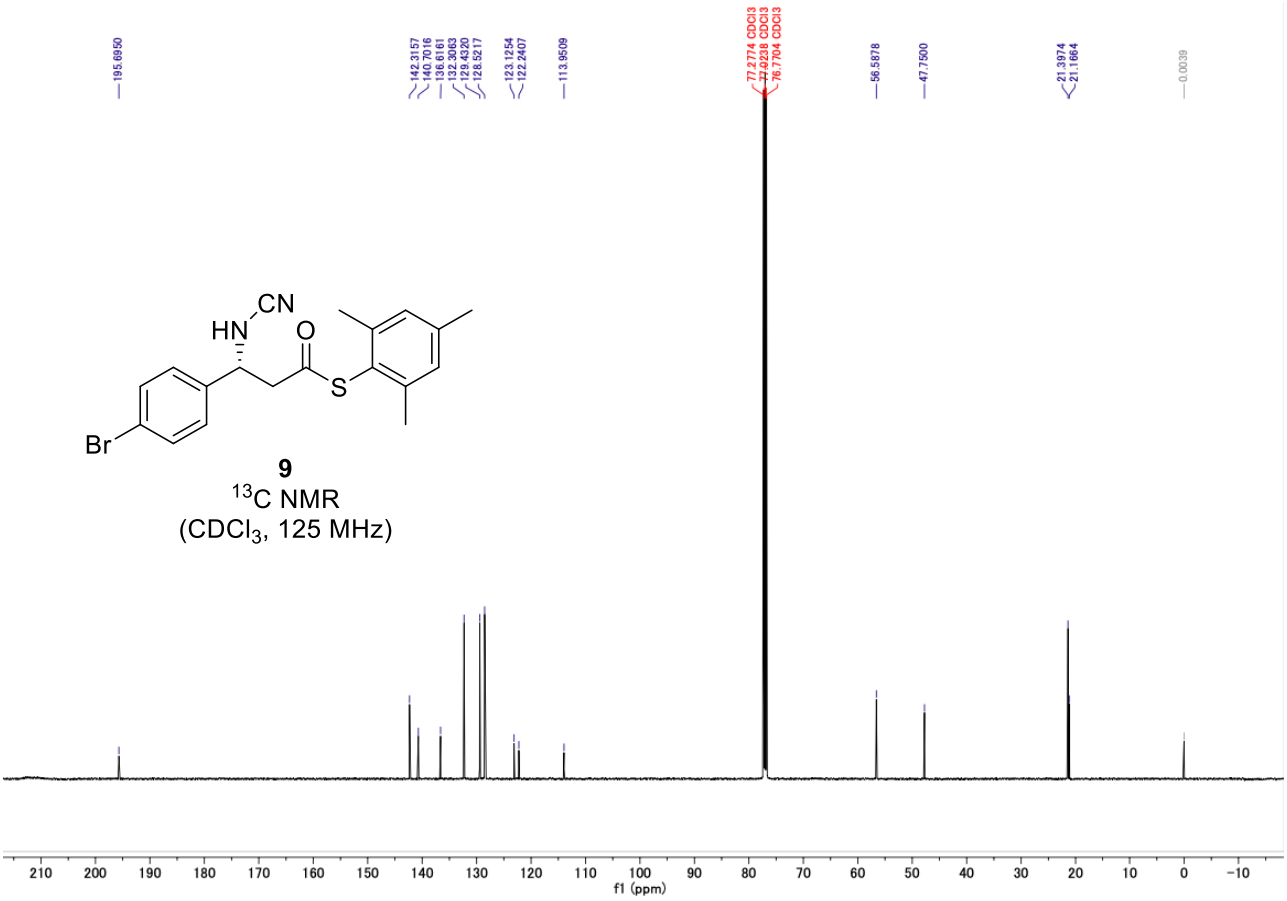

CN
HN
O
S
Cl
8
13C NMR
(CDCl3, 125 MHz)
f1 (ppm)



9

^{1}H NMR

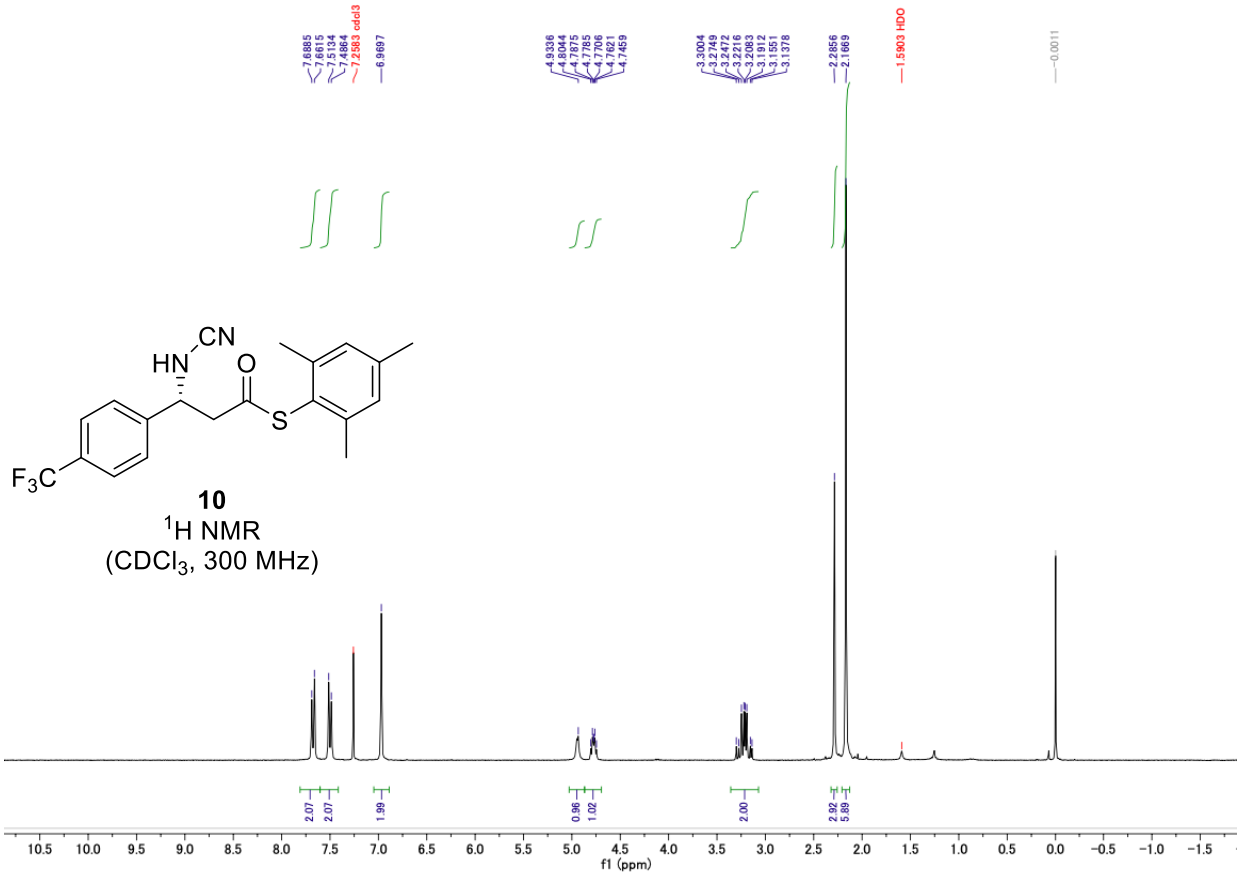
($CDCl_3$, 300 MHz)



9

^{13}C NMR

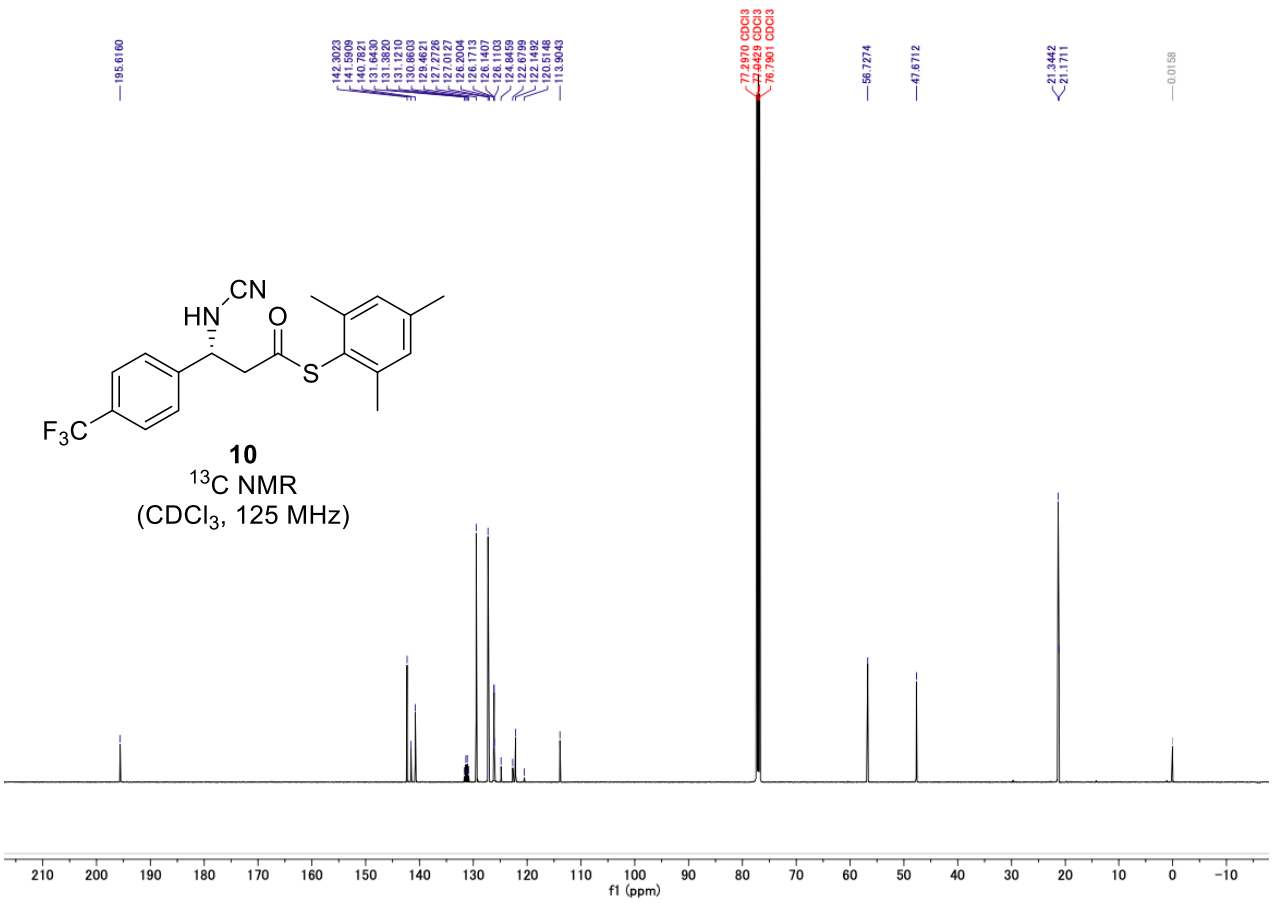
($CDCl_3$, 125 MHz)



10

^{1}H NMR

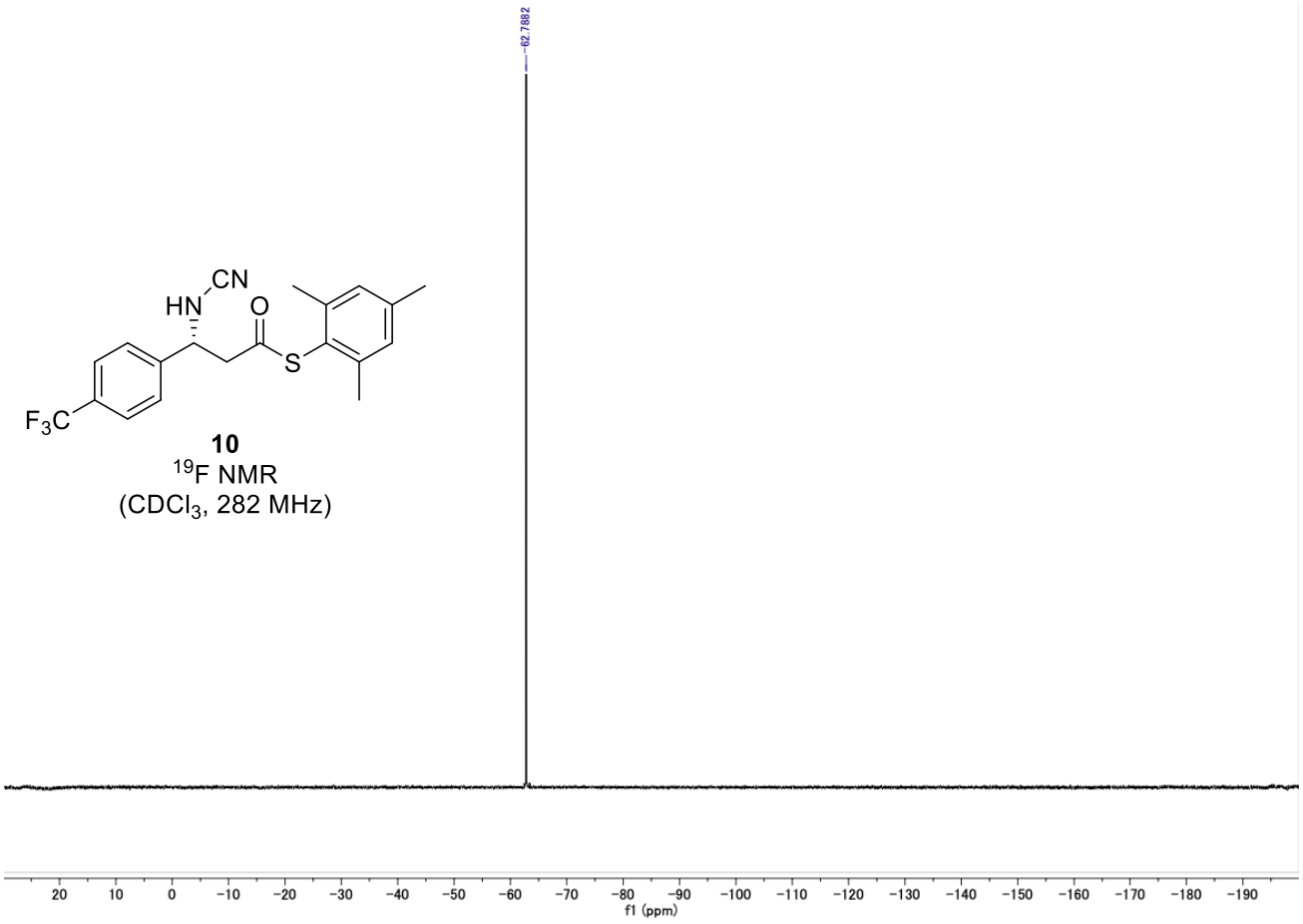
($CDCl_3$, 300 MHz)



10

^{13}C NMR

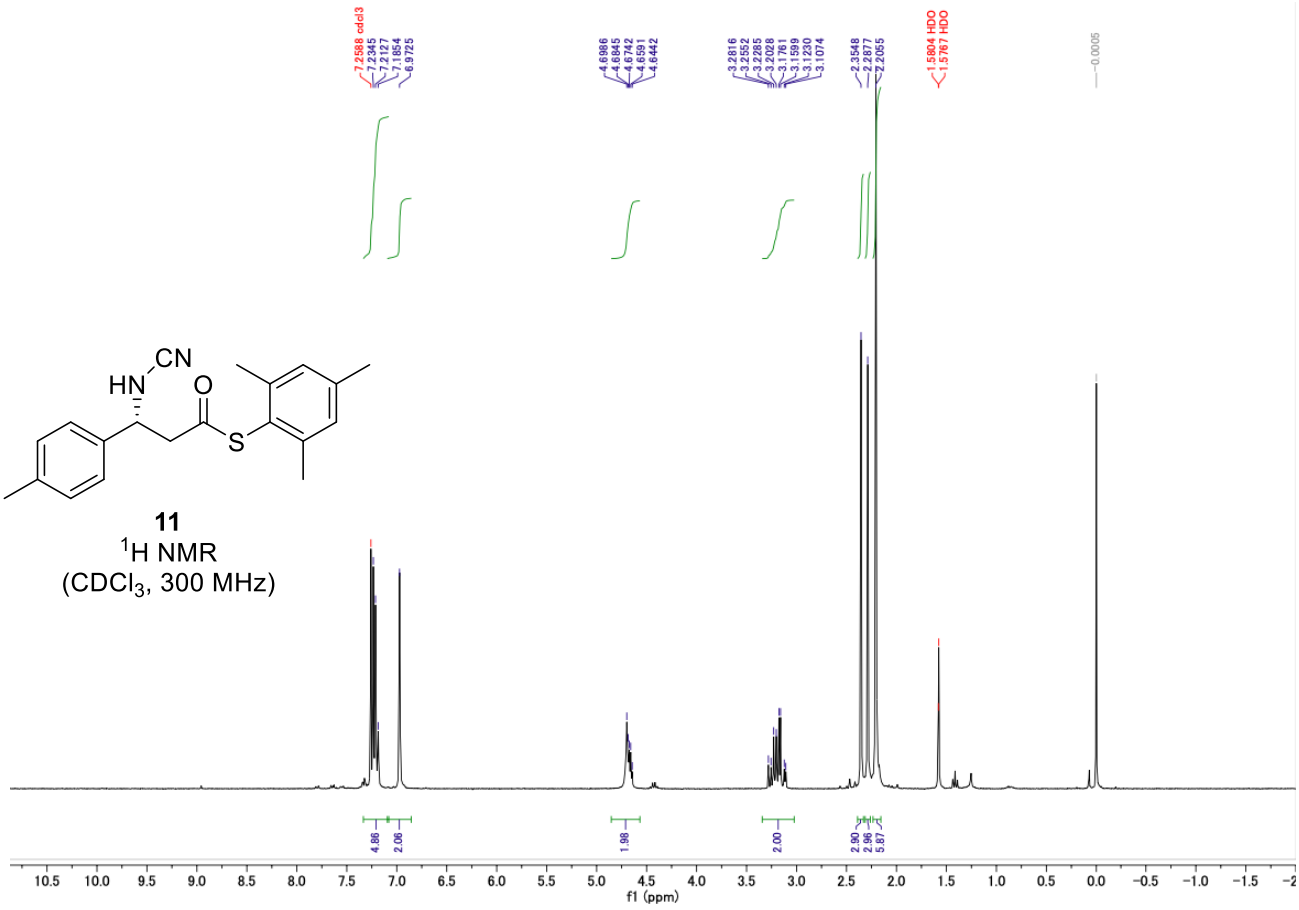
($CDCl_3$, 125 MHz)

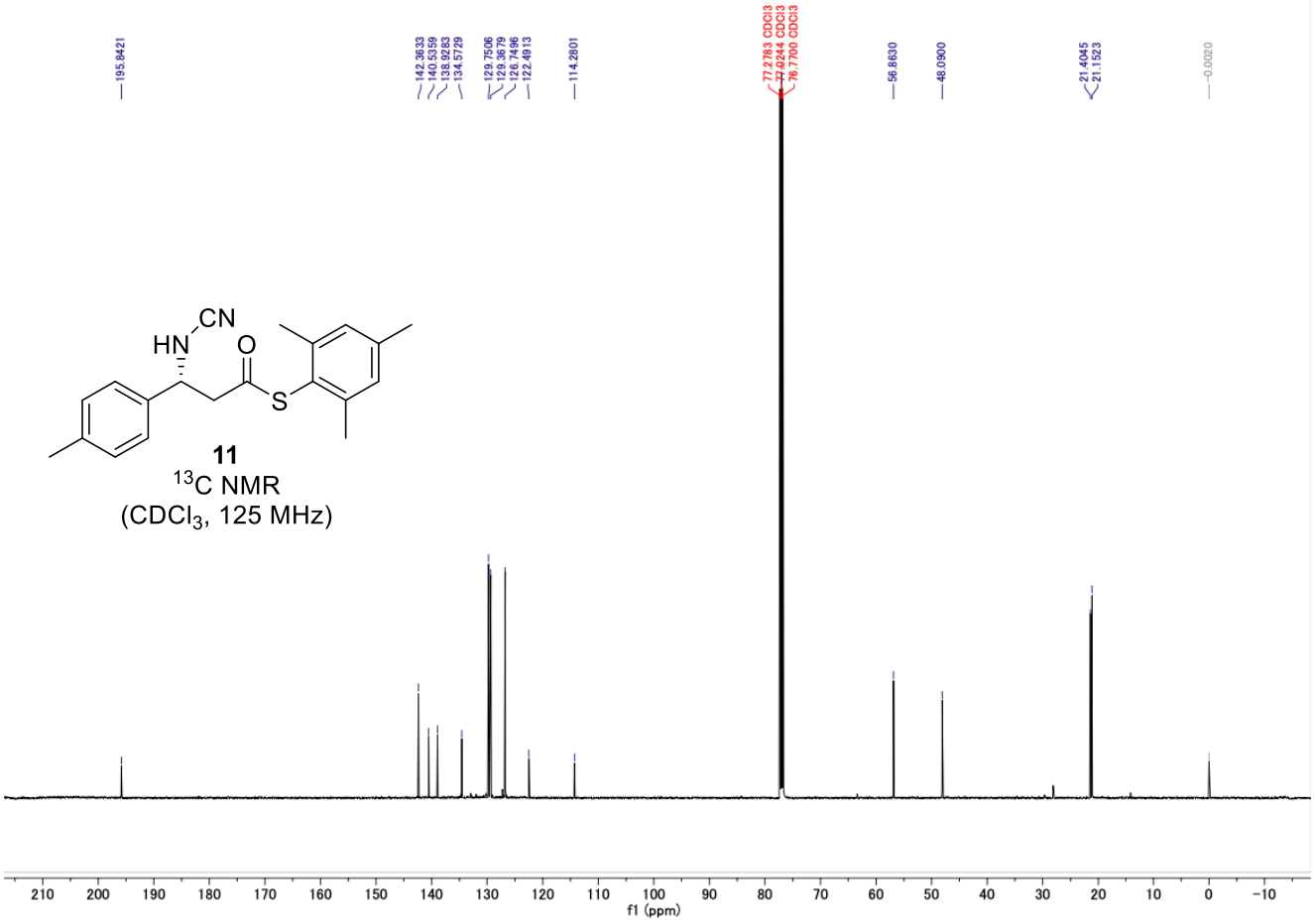


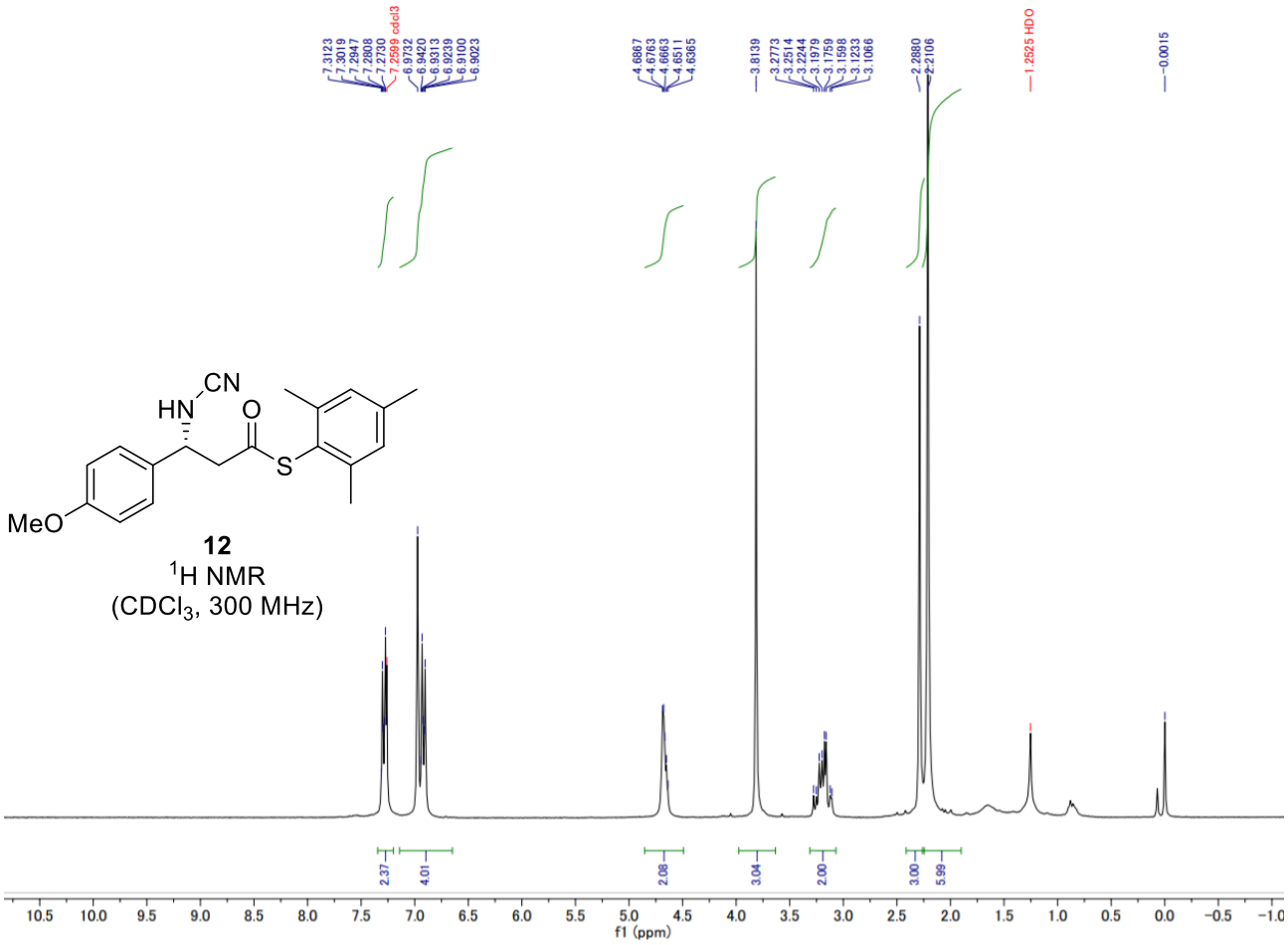
10

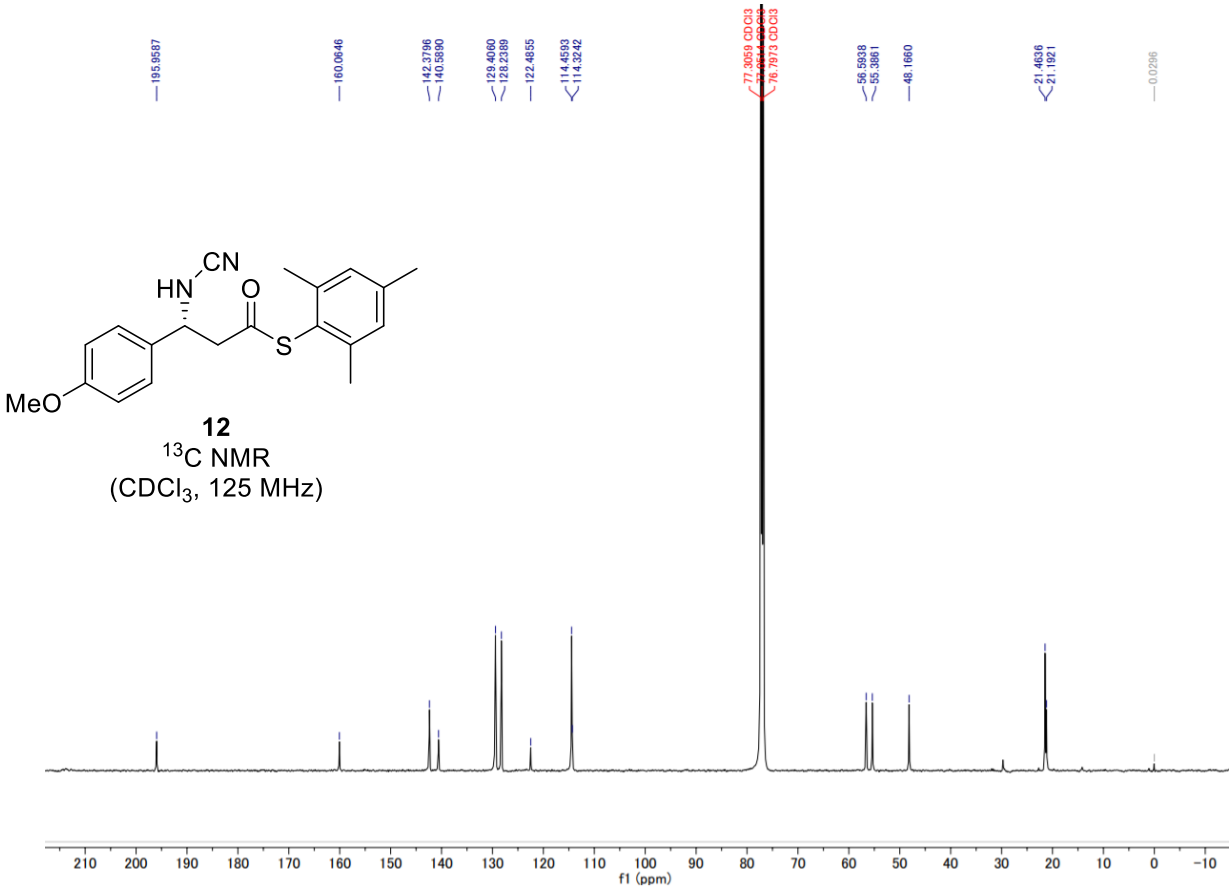
^{19}F NMR

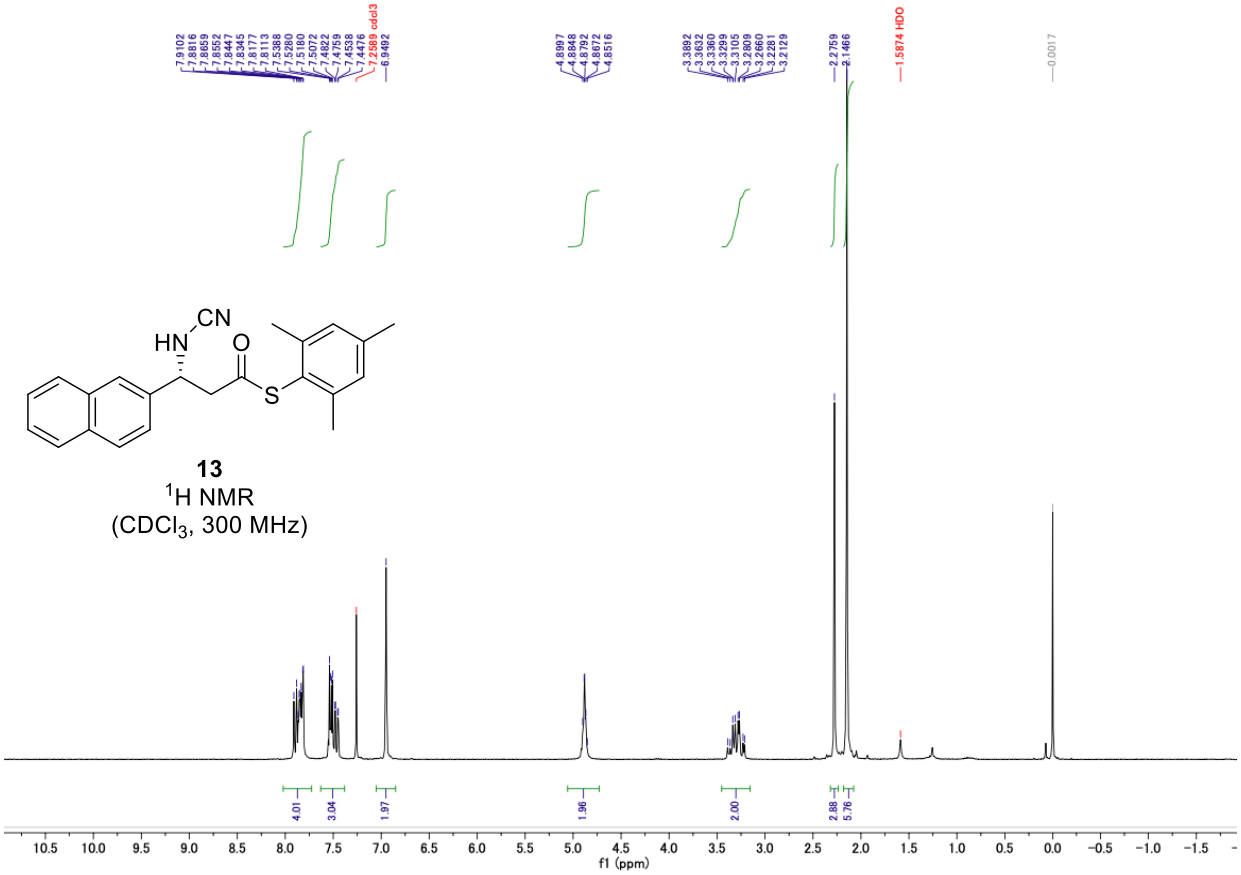
($CDCl_3$, 282 MHz)

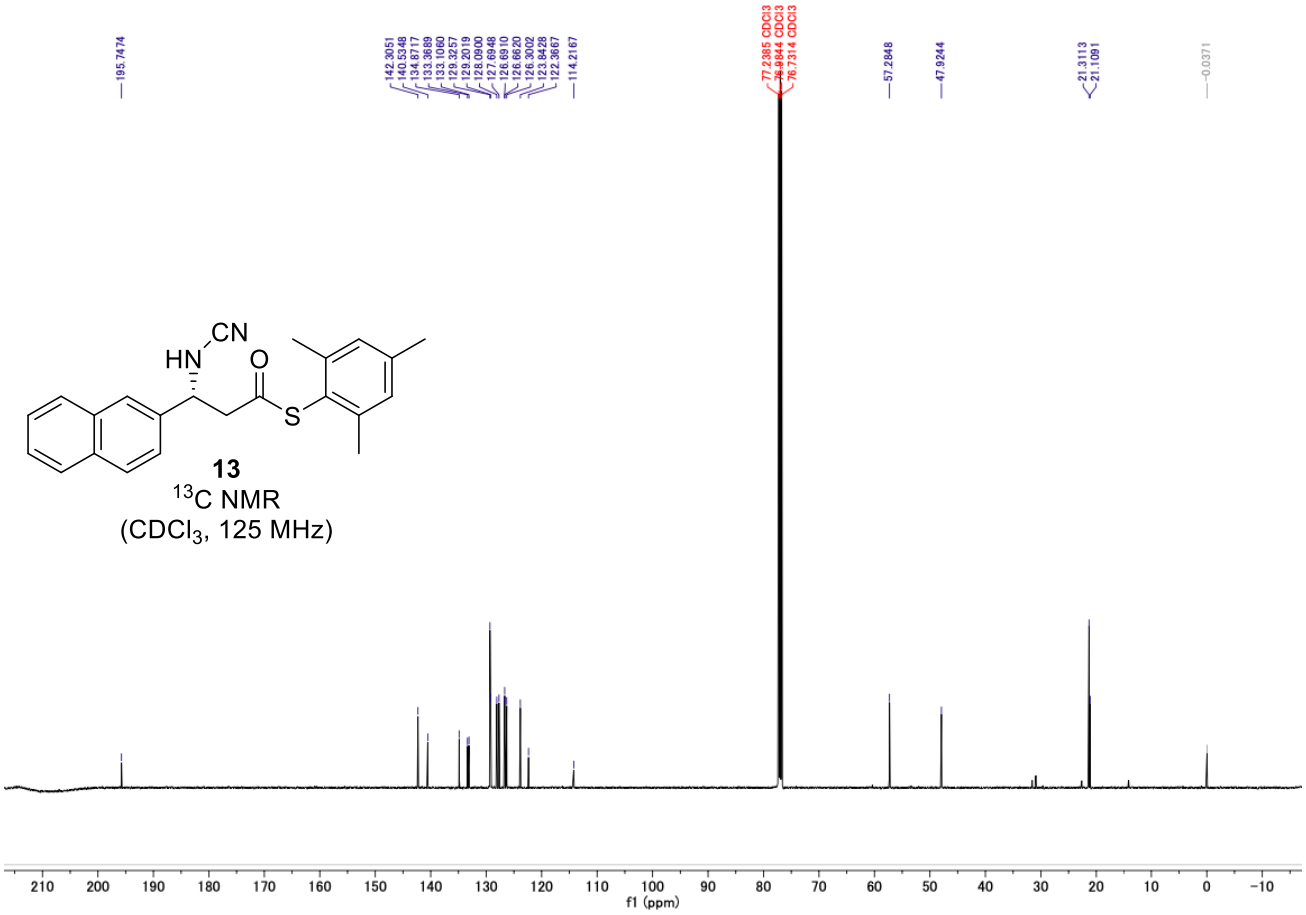

CN
HN
O
S
11
1H NMR
(CDCl3, 300 MHz)
f1 (ppm)

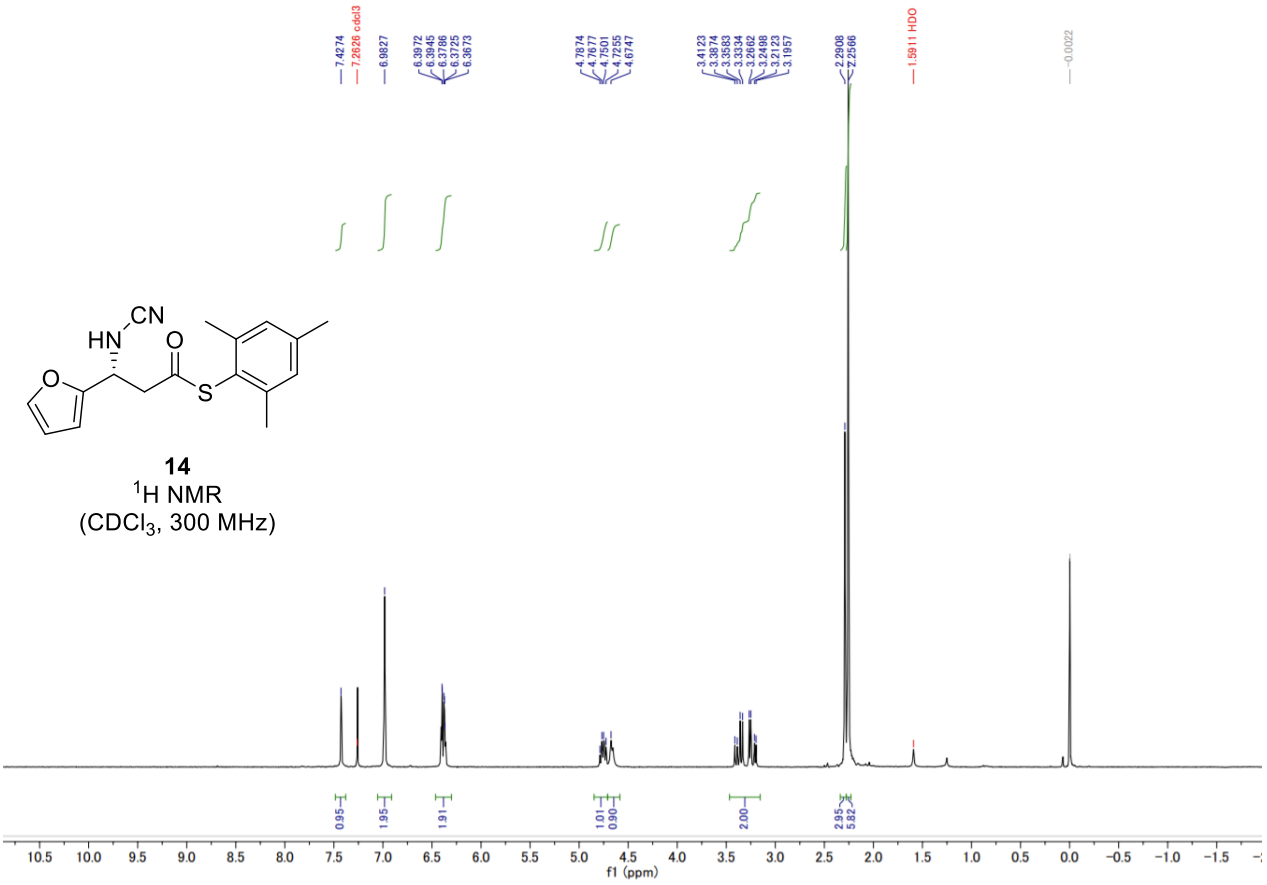

CN
HN
O
S
11
13C NMR
(CDCl3, 125 MHz)
f1 (ppm)


CN
HN
O
S
MeO
12
1H NMR
(CDCl3, 300 MHz)
f1 (ppm)


CN
HN
O
S
MeO
12
13C NMR
(CDCl3, 125 MHz)
f1 (ppm)


CN
HN
O
S
13
1H NMR
(CDCl3, 300 MHz)
f1 (ppm)

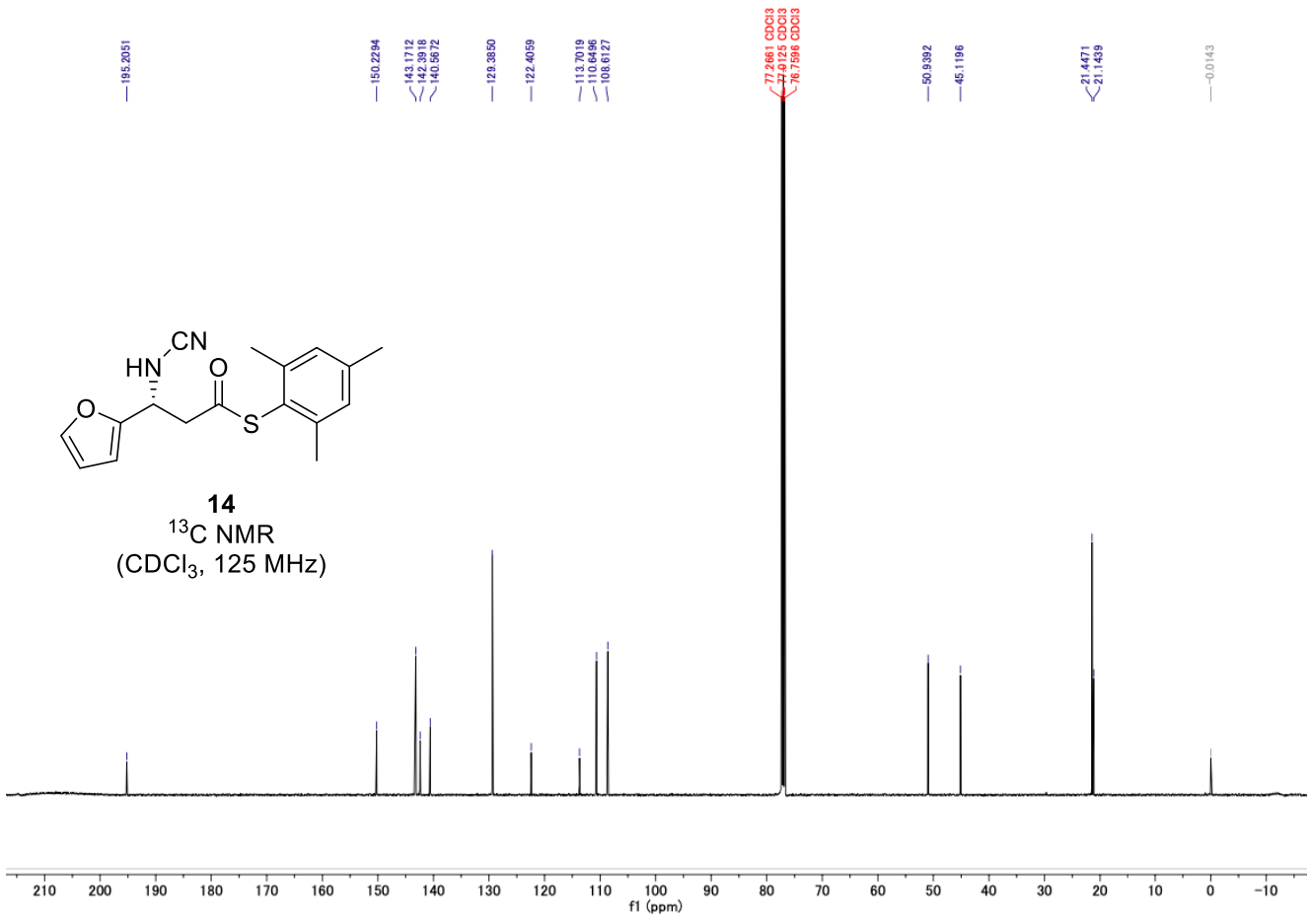

CN
HN
O
S
13
13C NMR
(CDCl3, 125 MHz)
f1 (ppm)



14

^{1}H NMR

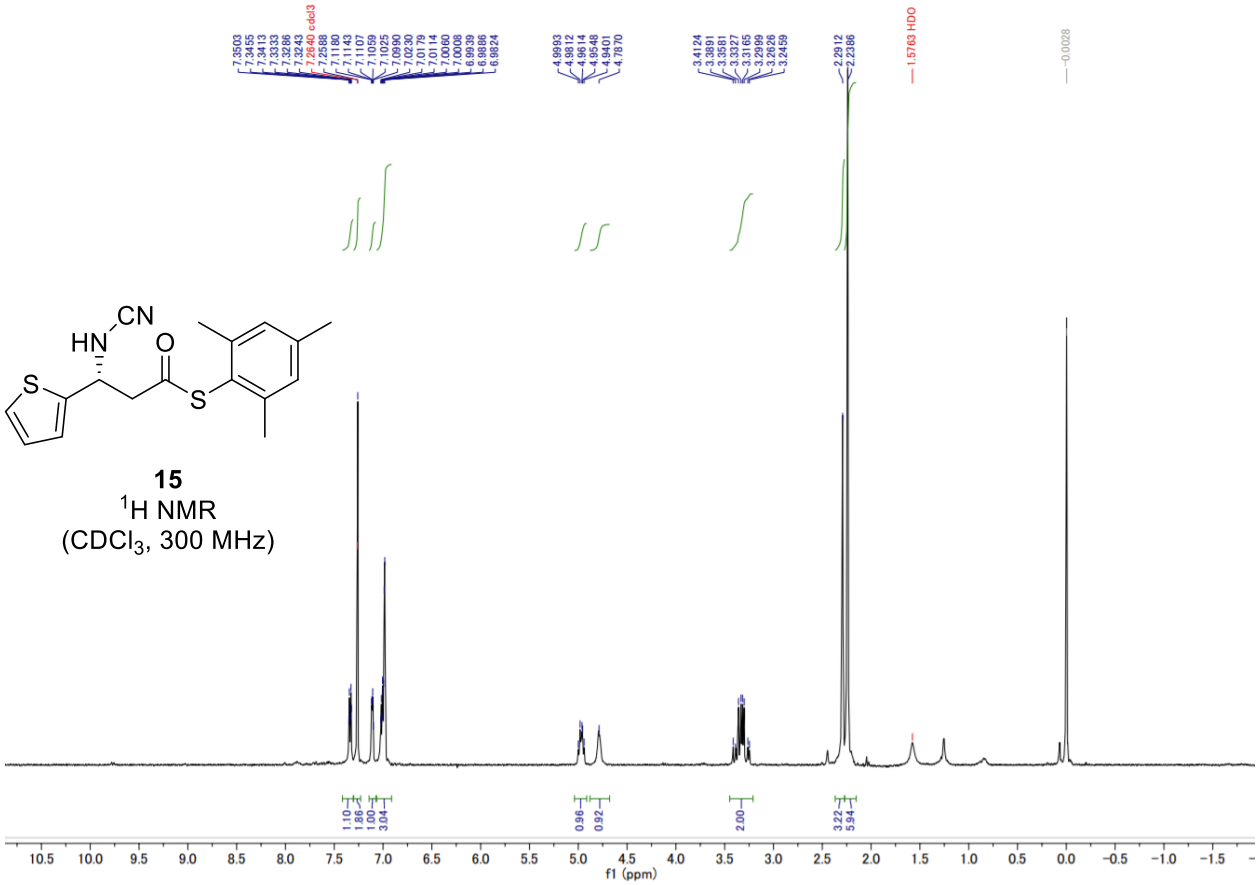
($CDCl_3$, 300 MHz)

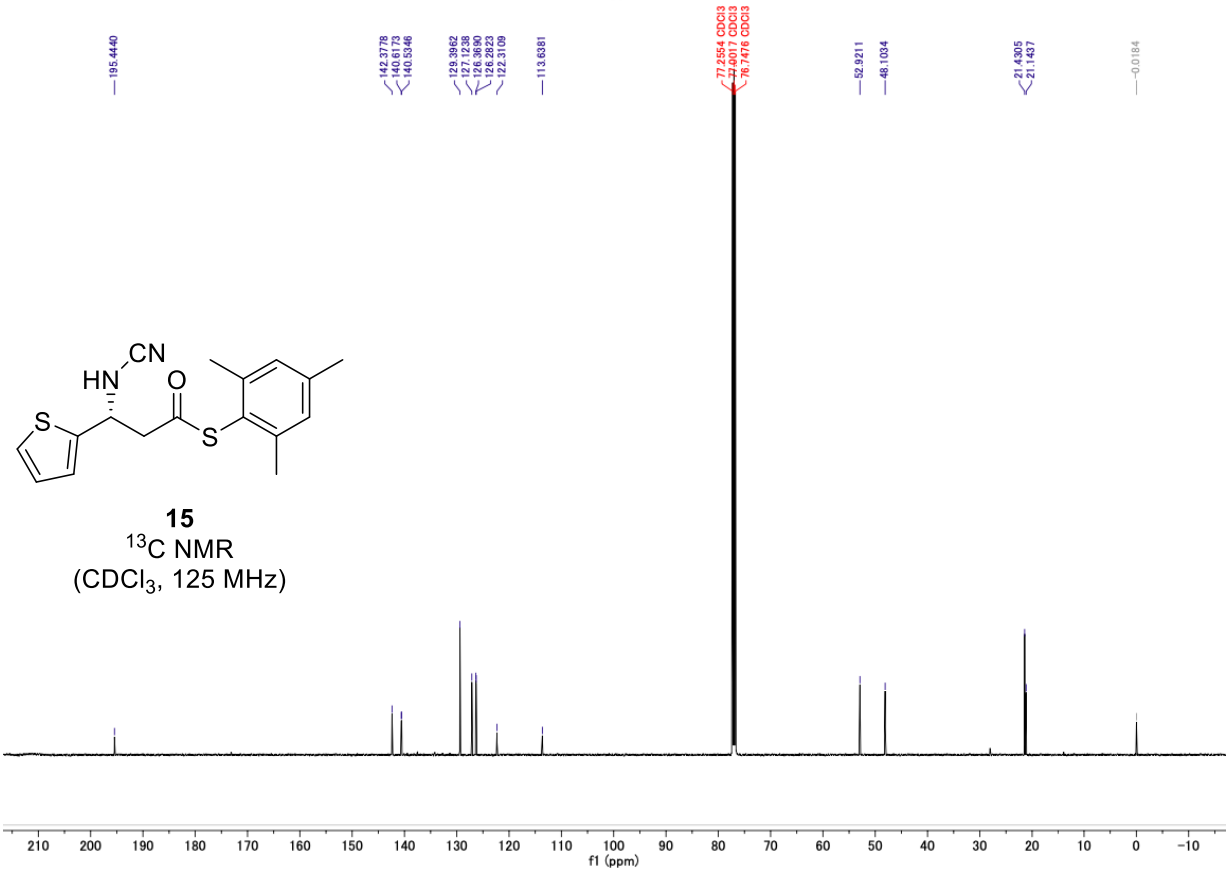


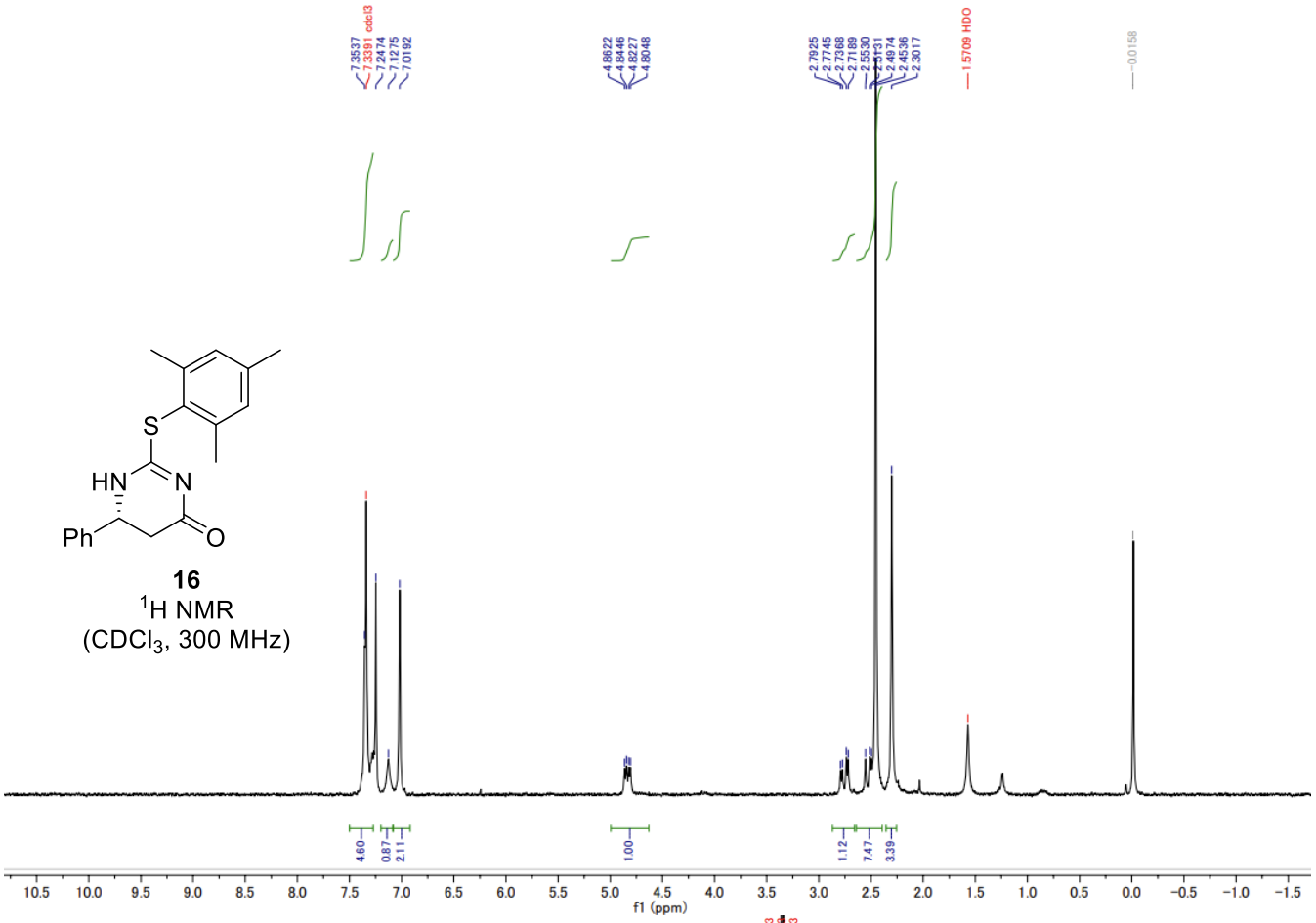
14

^{13}C NMR

($CDCl_3$, 125 MHz)


CN
HN
O
S
S
15
1H NMR
(CDCl3, 300 MHz)
f1 (ppm)

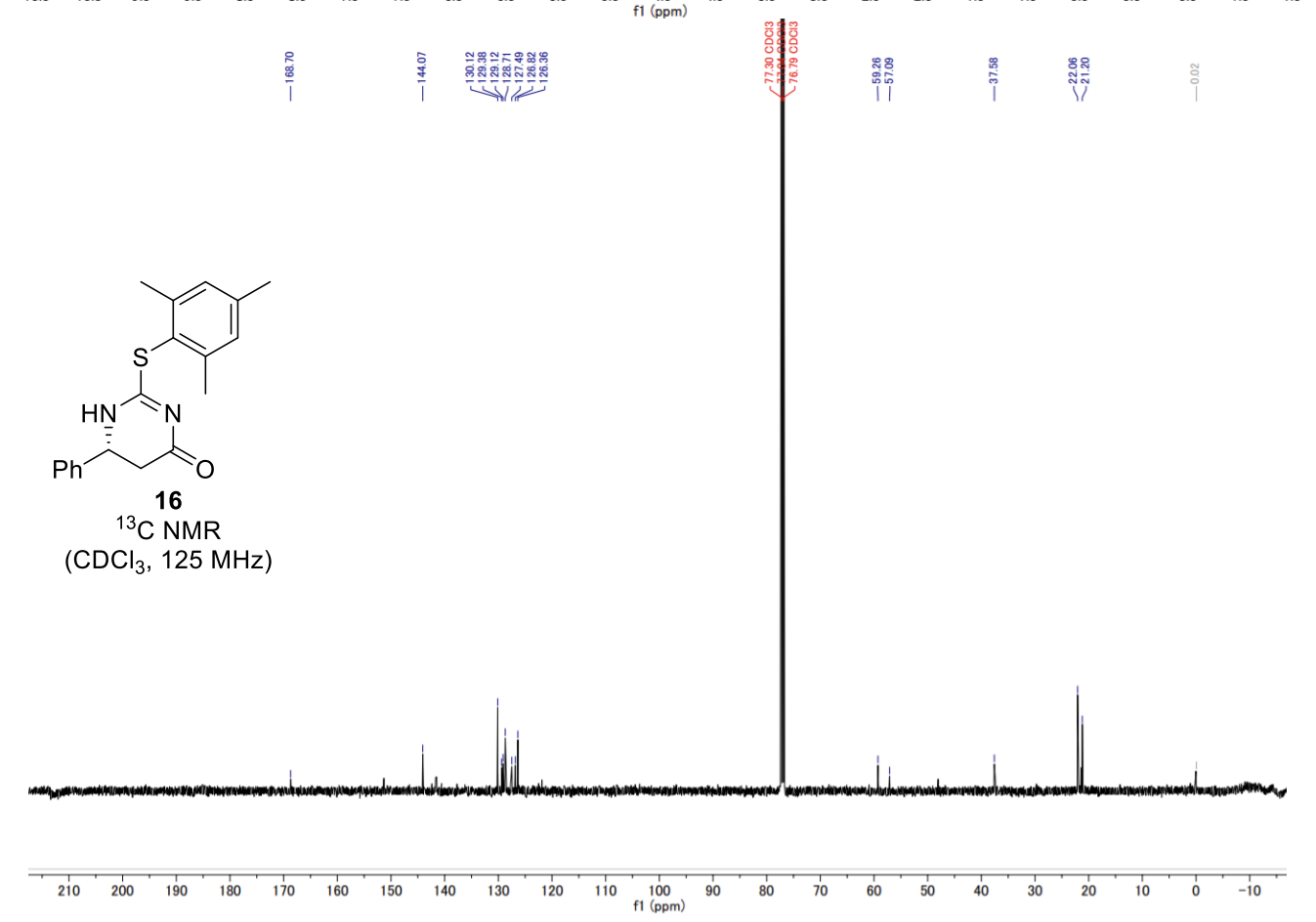

CN
HN
O
S
S
15
13C NMR
(CDCl3, 125 MHz)
f1 (ppm)



16

^{1}H NMR

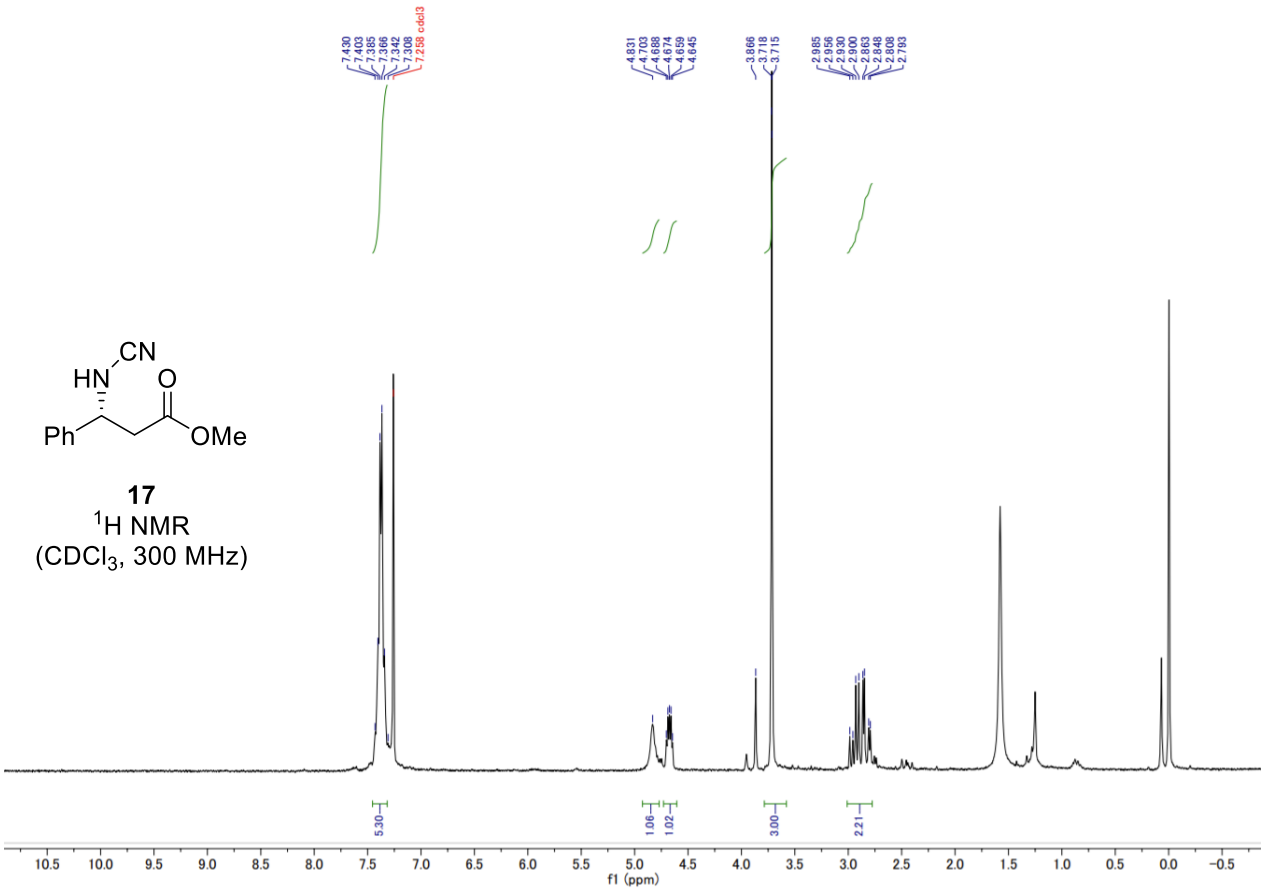
($CDCl_3$, 300 MHz)



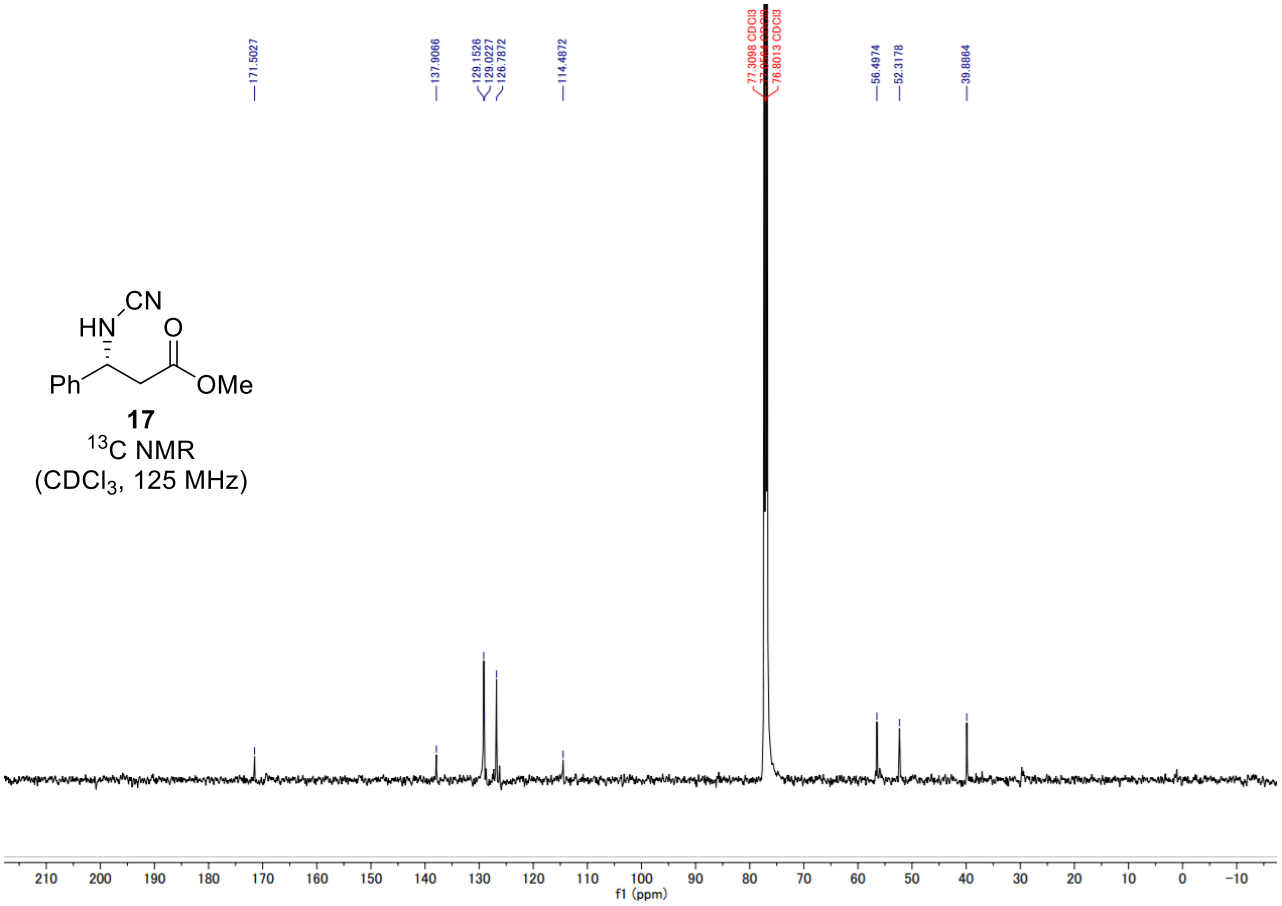
16

^{13}C NMR

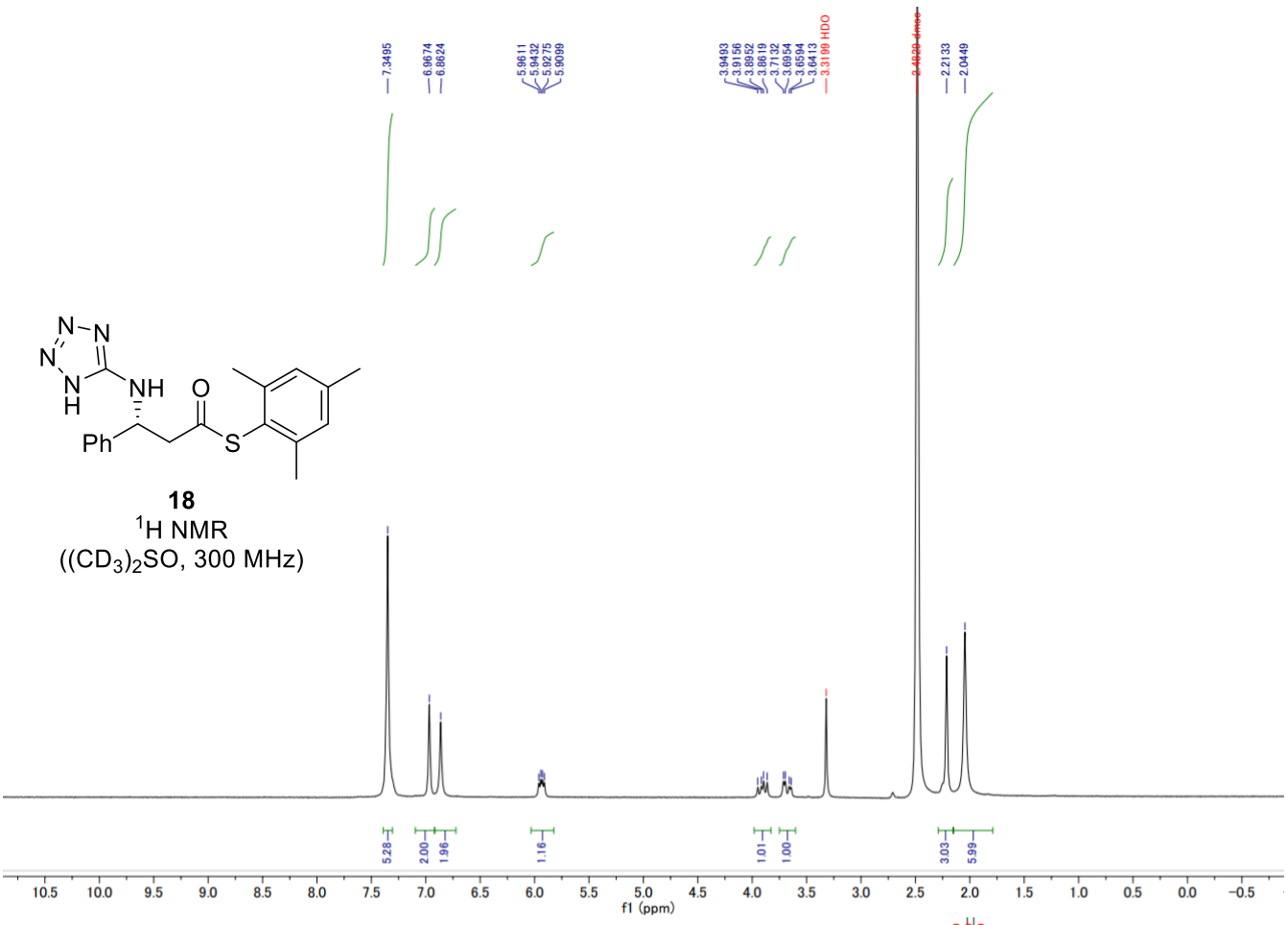
($CDCl_3$, 125 MHz)



17
^{1}H NMR
($CDCl_3$, 300 MHz)



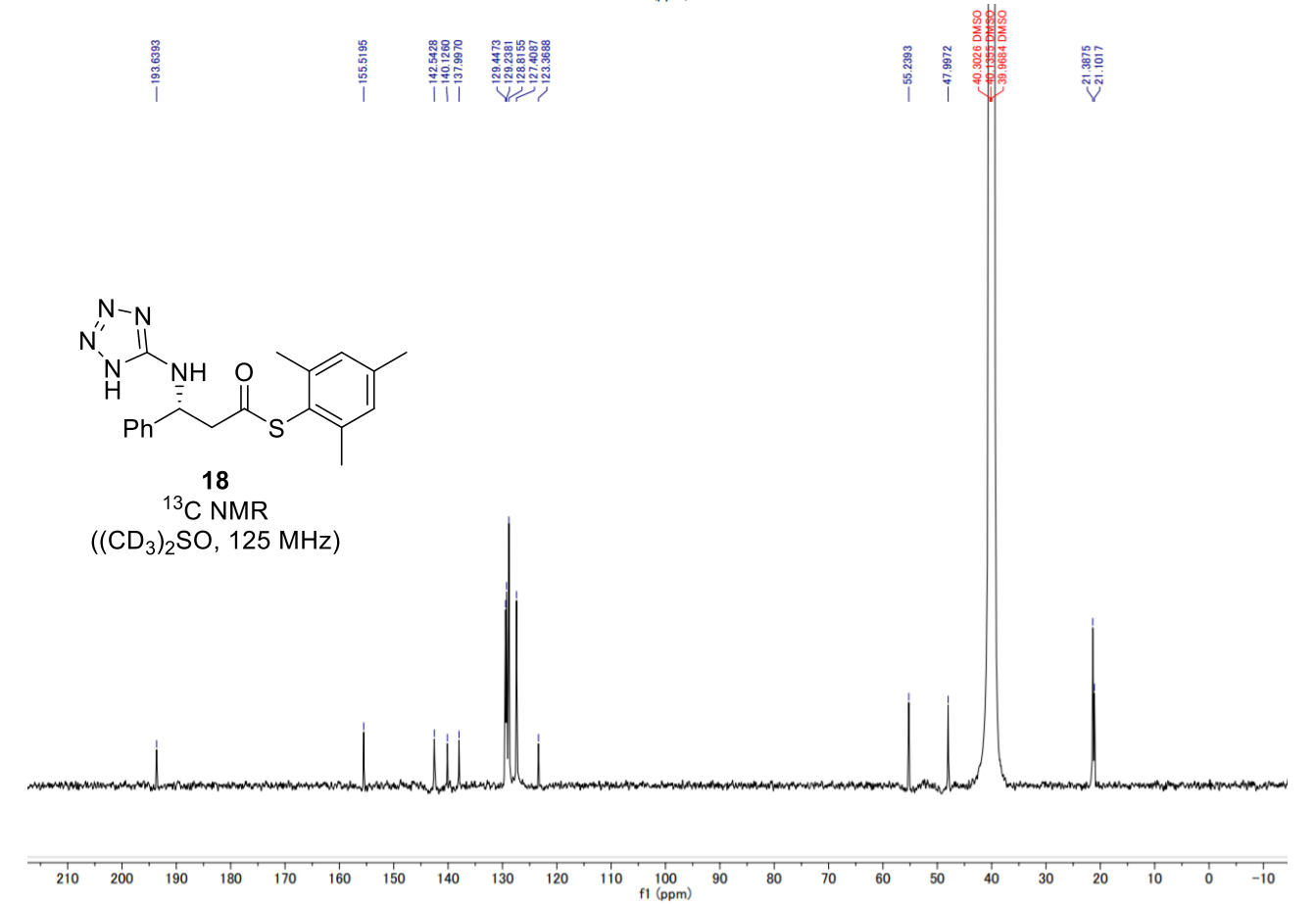
17
^{13}C NMR
($CDCl_3$, 125 MHz)



18

^{1}H NMR

($(CD_3)_2SO$, 300 MHz)



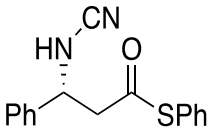
18

^{13}C NMR

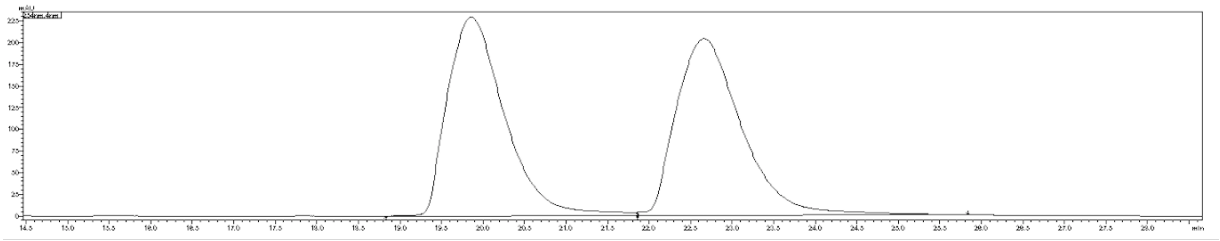
($(CD_3)_2SO$, 125 MHz)

HPLC analysis

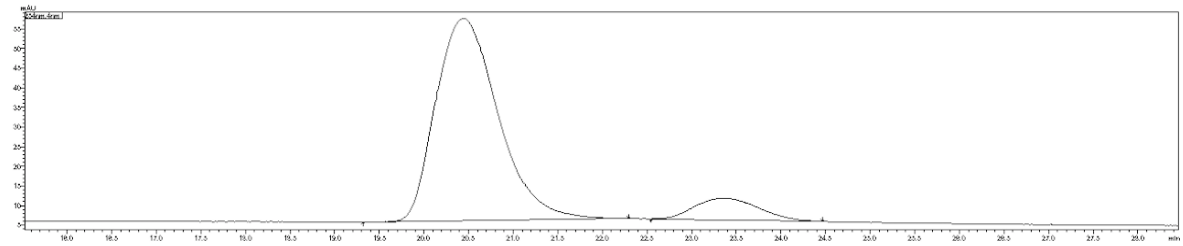
(*R*)-*S*-Phenyl 3-phenyl-3-(cyanoamino)propanethioate (4aa)



racemic-**4aa**



(*R*)-**4aa**



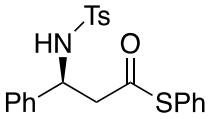
racemic-**4aa**

Peak	tR (min)	Area (%)
1	19.9	49.8
2	22.6	50.2

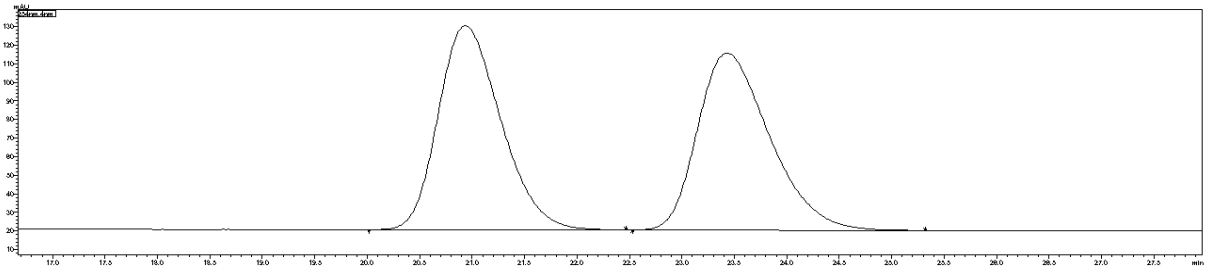
(*R*)-**4aa**

Peak	tR (min)	Area (%)
1	20.4	90.1
2	23.3	9.9

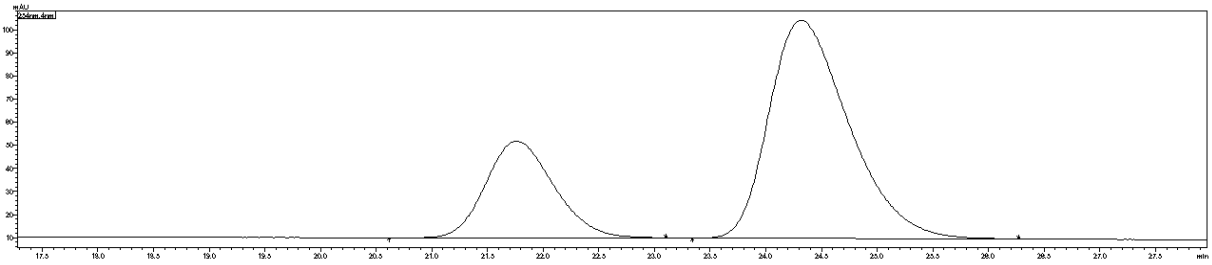
(*S*)-*S*-Phenyl 3-phenyl-3-(tosylamino)propanethioate (4ba)



racemic-**4ba**



(*S*)-**4ba**



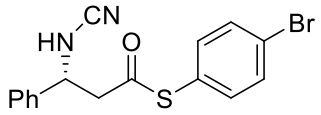
racemic-**4ba**

Peak	tR (min)	Area (%)
1	21.0	50.0
2	23.5	50.0

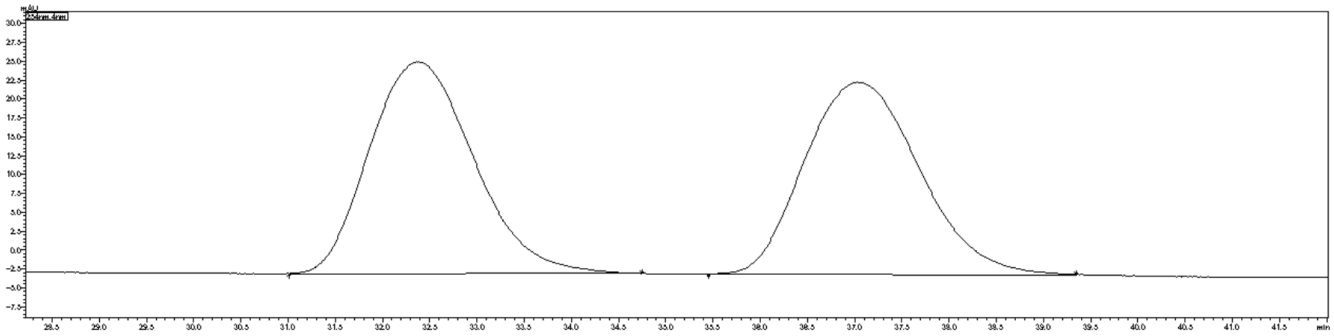
(*R*)-**4ba**

Peak	tR (min)	Area (%)
1	21.7	27.5
2	24.3	72.5

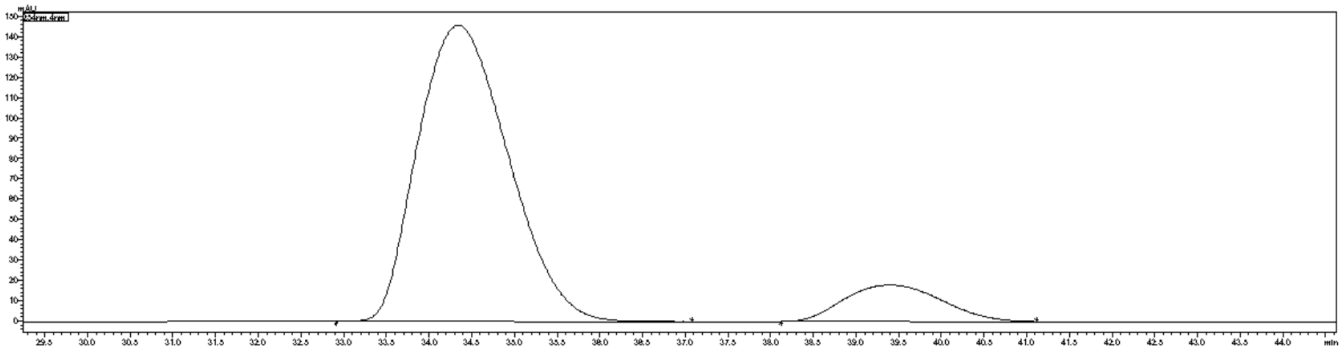
(*R*)-*S*-(4-Bromophenyl) 3-phenyl-3-(cyanoamino)propanethioate (4ab)



racemic-**4ab**



(*S*)-**4ab**



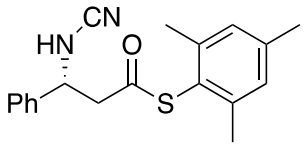
racemic-**4ab**

Peak	tR (min)	Area (%)
1	32.4	50.1
2	37.0	49.9

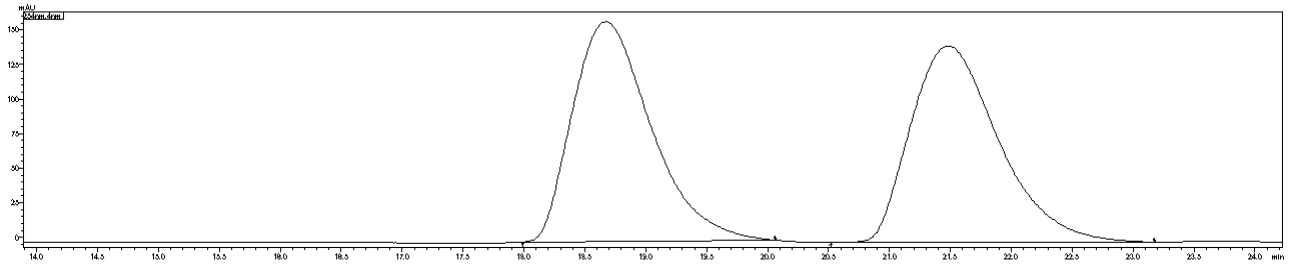
(*R*)-**4ab**

Peak	tR (min)	Area (%)
1	34.3	88.2
2	39.3	11.8

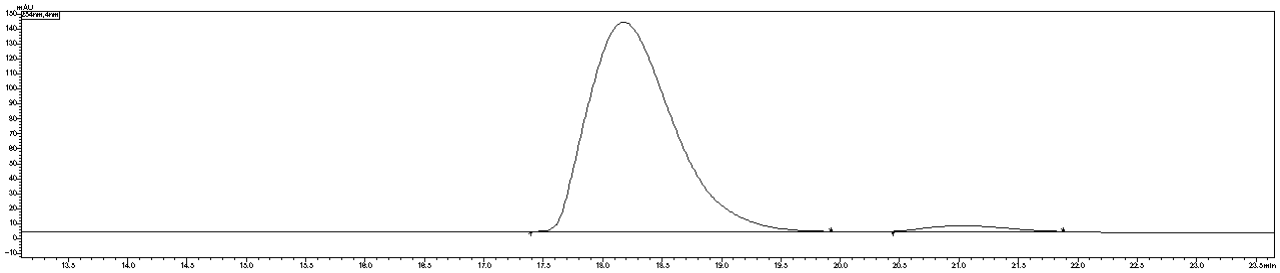
(*R*)-*S*-(2,4,6-Trimethylphenyl) 3-phenyl-3-(cyanoamino)propanethioate (4ac)



racemic-**4ac**



(*R*)-**4ac**



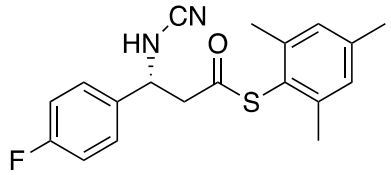
racemic-**4ac**

Peak	tR (min)	Area (%)
1	18.6	50.0
2	21.3	50.0

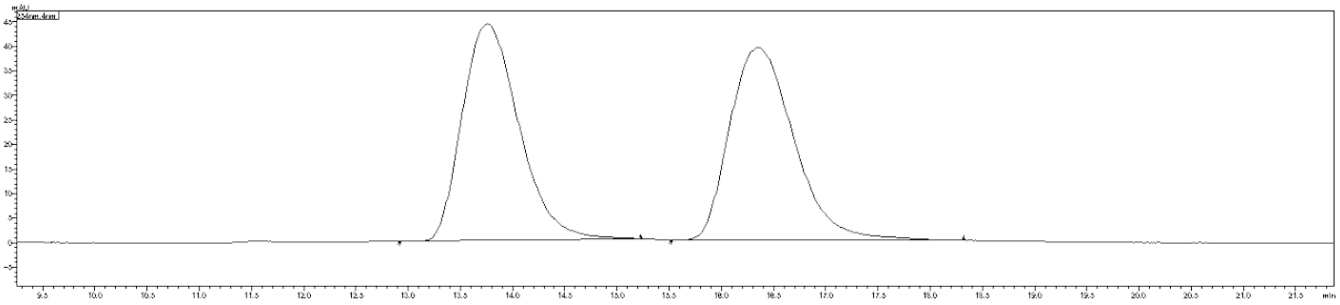
(*R*)-**4ac**

Peak	tR (min)	Area (%)
1	18.2	97.5
2	20.0	2.5

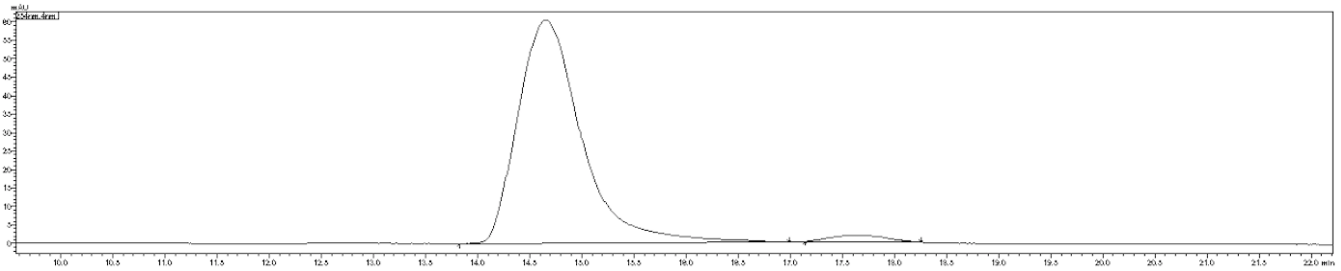
(*R*)-*S*-(2,4,6-Trimethylphenyl) 3-(4-fluorophenyl)-3-(cyanoamino)propanethioate (5)



racemic-**5**



(*R*)-**5**



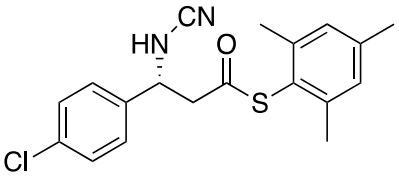
racemic-**5**

Peak	tR (min)	Area (%)
1	13.8	49.9
2	16.4	50.1

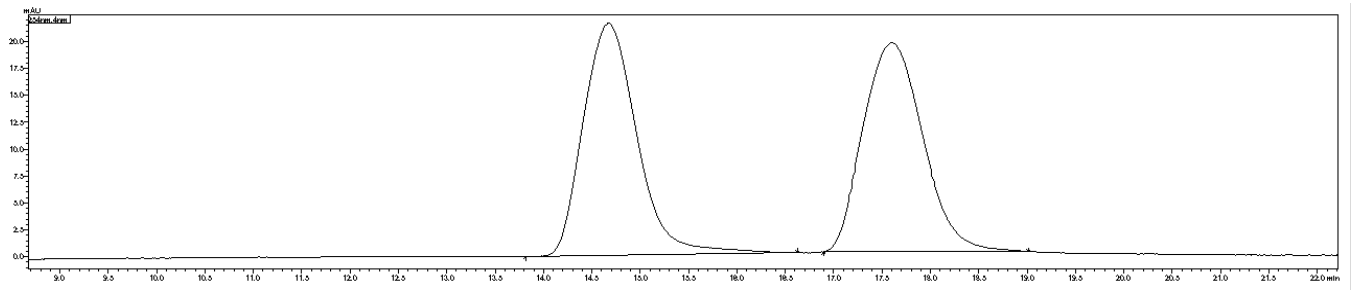
(*R*)-**5**

Peak	tR (min)	Area (%)
1	14.7	97.4
2	17.6	2.6

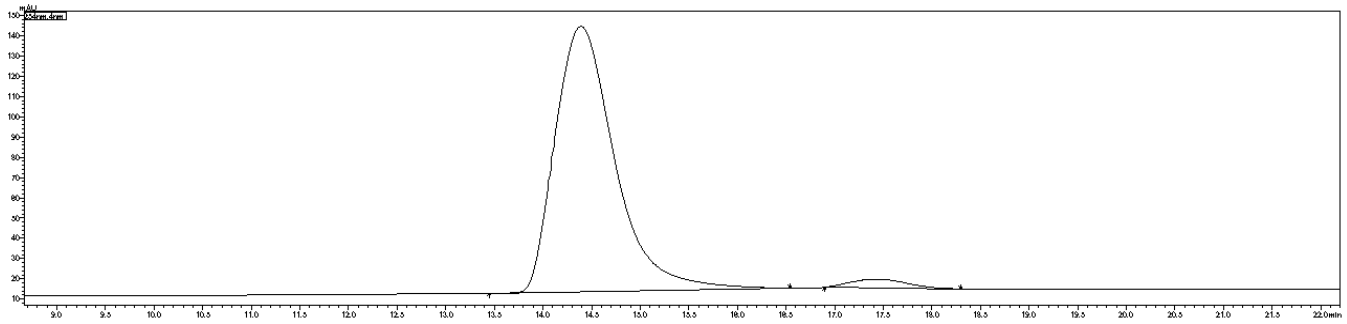
(*R*)-*S*-(2,4,6-Trimethylphenyl) 3-(4-chlorophenyl)-3-(cyanoamino)propanethioate (6)



racemic-**6**



(*R*)-**6**



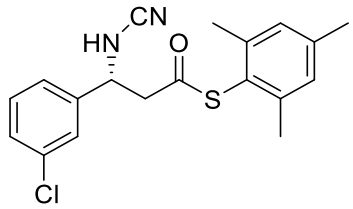
racemic-**6**

Peak	tR (min)	Area (%)
1	14.7	50.0
2	17.6	50.0

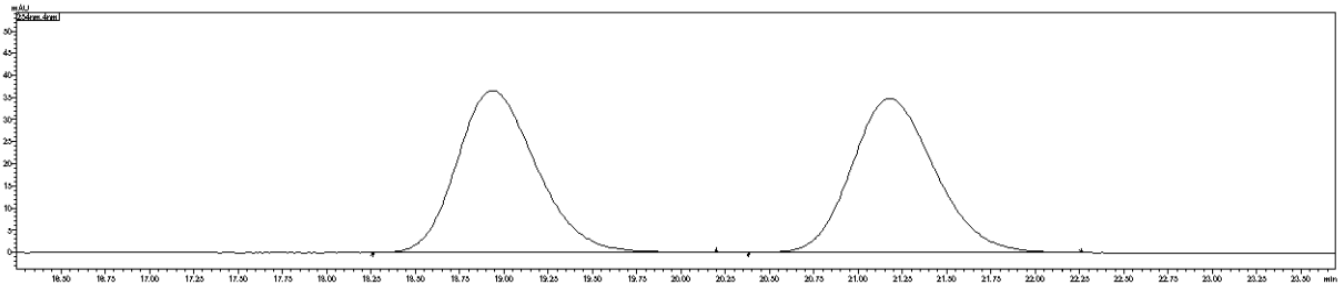
(*R*)-**6**

Peak	tR (min)	Area (%)
1	14.4	97.0
2	17.4	3.0

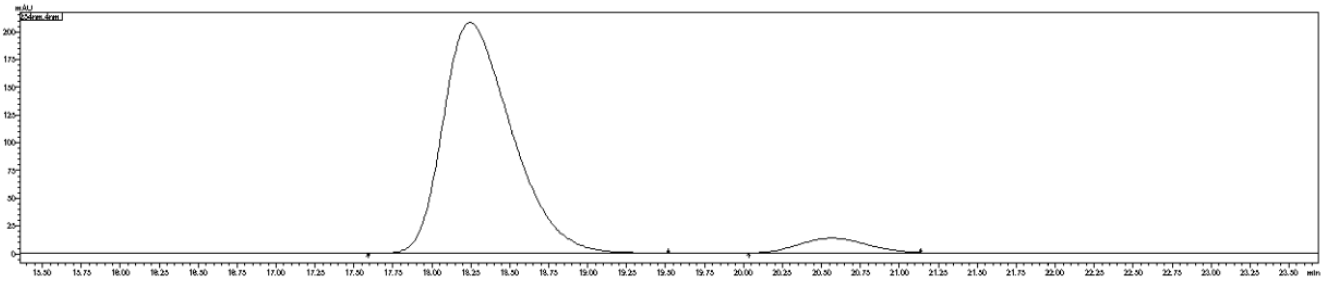
(*R*)-*S*-(2,4,6-Trimethylphenyl) 3-(3-chlorophenyl)-3-(cyanoamino)propanethioate (7)



racemic-**7**



(*R*)-**7**



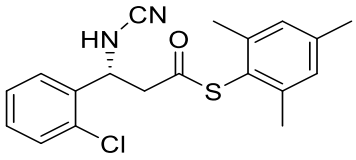
racemic-**7**

Peak	tR (min)	Area (%)
1	18.9	50.1
2	21.2	49.9

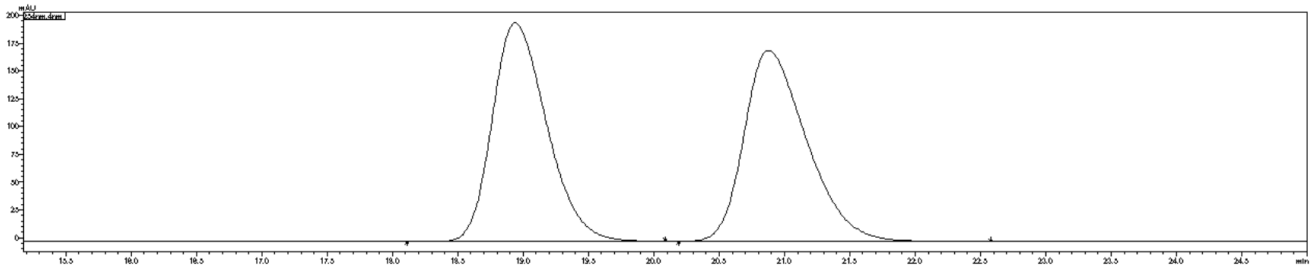
(*R*)-**7**

Peak	tR (min)	Area (%)
1	18.2	94.2
2	20.6	5.8

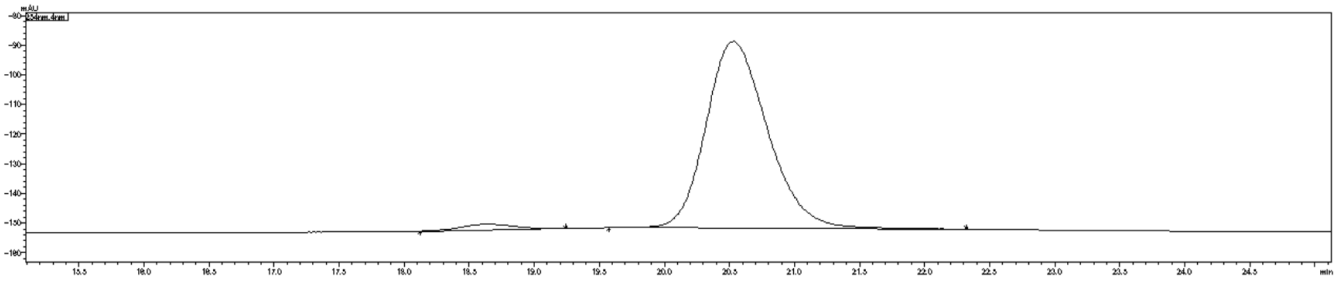
(*R*)-*S*-(2,4,6-Trimethylphenyl) 3-(2-chlorophenyl)-3-(cyanoamino)propanethioate (8)



racemic-**8**



(*R*)-**8**



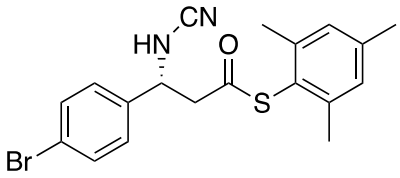
racemic-**8**

Peak	tR (min)	Area (%)
1	18.9	49.9
2	20.9	50.1

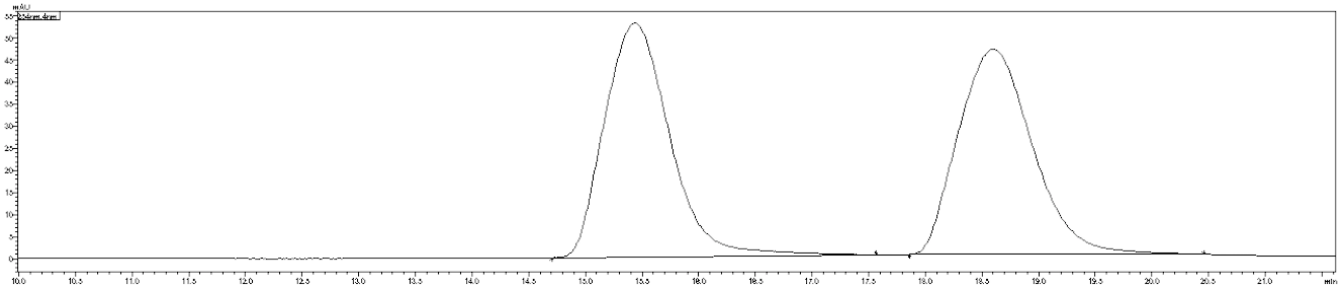
(*R*)-**8**

Peak	tR (min)	Area (%)
1	18.6	2.4
2	20.5	97.6

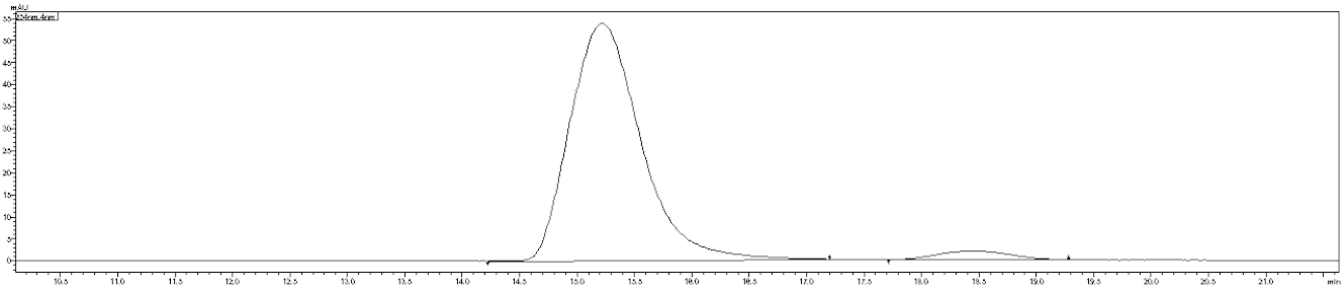
(*R*)-*S*-(2,4,6-Trimethylphenyl) 3-(4-bromophenyl)-3-(cyanoamino)propanethioate (9)



racemic-**9**



(*R*)-**9**



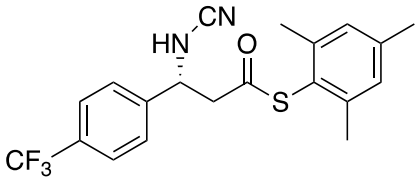
racemic-**9**

Peak	tR (min)	Area (%)
1	15.4	50.0
2	18.6	50.0

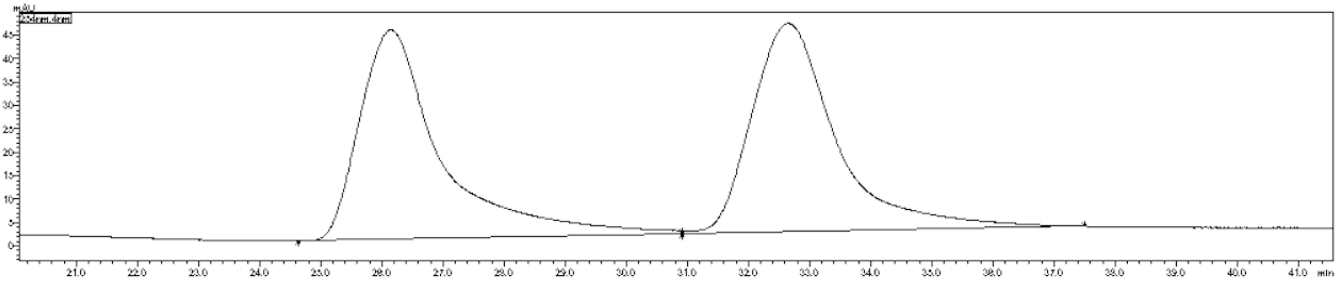
(*R*)-**9**

Peak	tR (min)	Area (%)
1	15.2	96.6
2	18.5	3.4

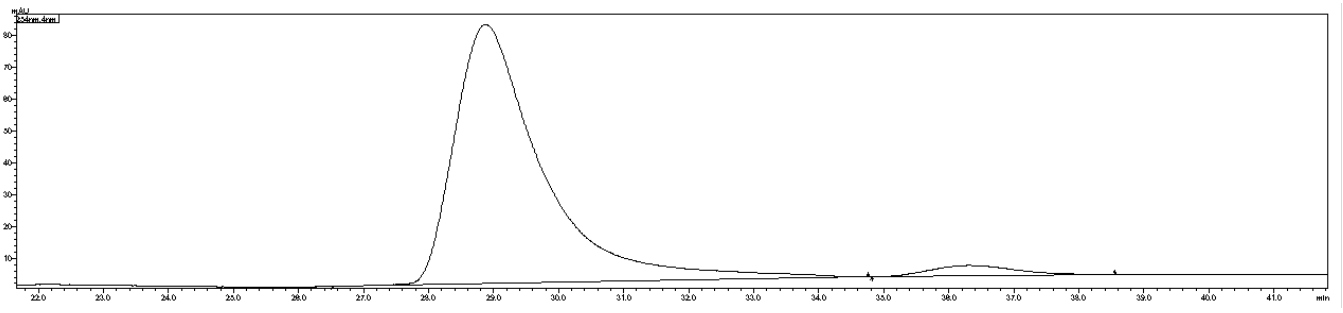
(*R*)-*S*-(2,4,6-Trimethylphenyl) 3-(4-trifluoromethylphenyl)-3-(cyanoamino)propanethioate (10)



racemic-**10**



(*R*)-**10**



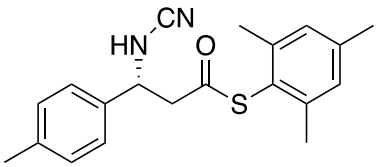
racemic-**10**

Peak	tR (min)	Area (%)
1	26.1	49.9
2	36.7	50.1

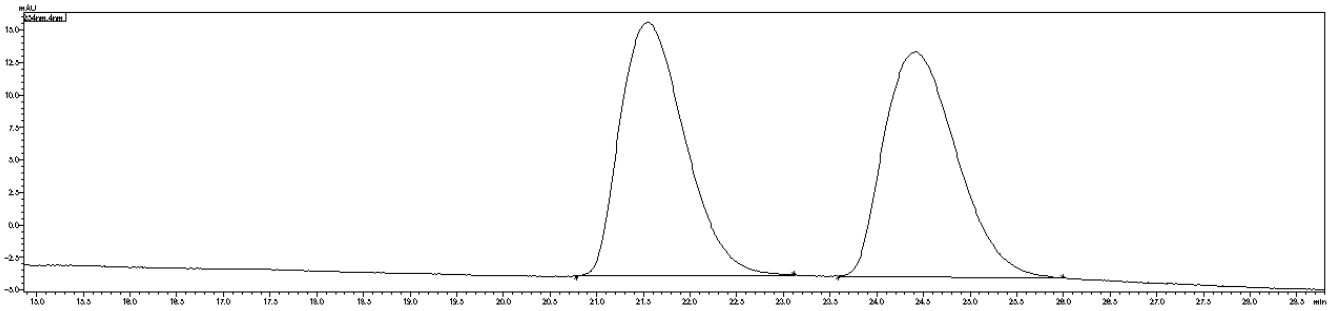
(*R*)-**10**

Peak	tR (min)	Area (%)
1	28.8	96.3
2	36.2	3.7

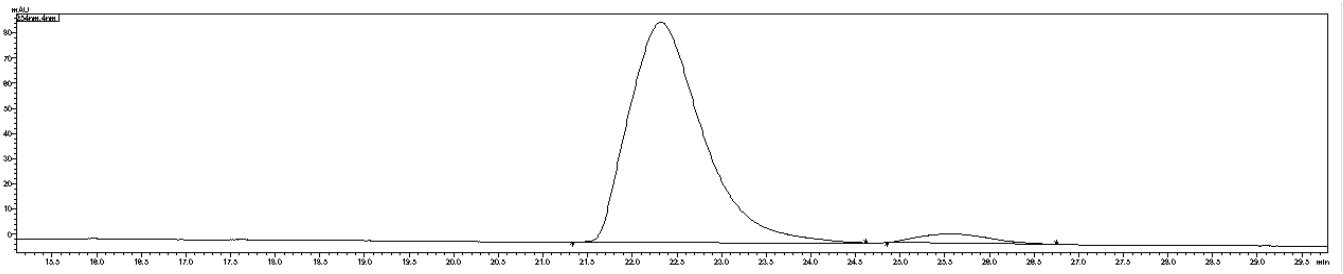
(*R*)-*S*-(2,4,6-Trimethylphenyl) 3-(4-methylphenyl)-3-(cyanoamino)propanethioate (11)



racemic-**11**



(*R*)-**11**



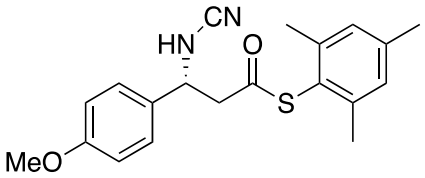
racemic-**11**

Peak	tR (min)	Area (%)
1	21.5	49.9
2	24.4	50.1

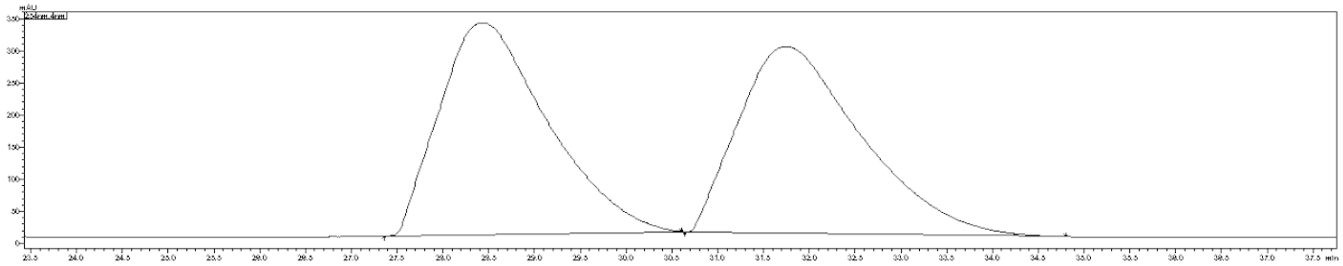
(*R*)-**11**

Peak	tR (min)	Area (%)
1	22.3	96.1
2	25.6	3.9

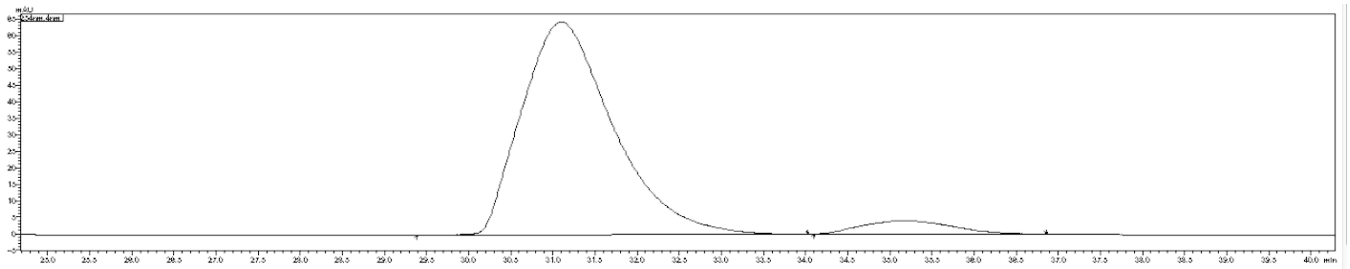
(*R*)-*S*-(2,4,6-Trimethylphenyl) 3-(4-methoxyphenyl)-3-(cyanoamino)propanethioate (12)



racemic-**12**



(*R*)-**12**



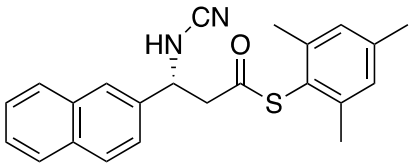
racemic-**12**

Peak	tR (min)	Area (%)
1	28.4	49.9
2	31.7	50.1

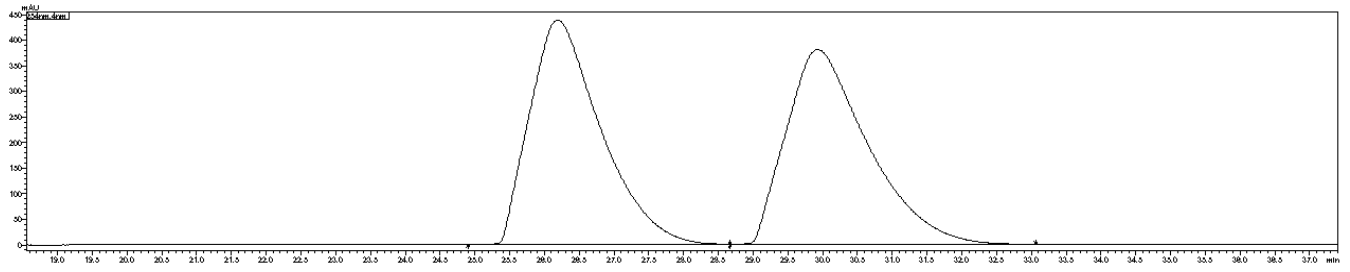
(*R*)-**12**

Peak	tR (min)	Area (%)
1	31.1	94.0
2	35.1	6.0

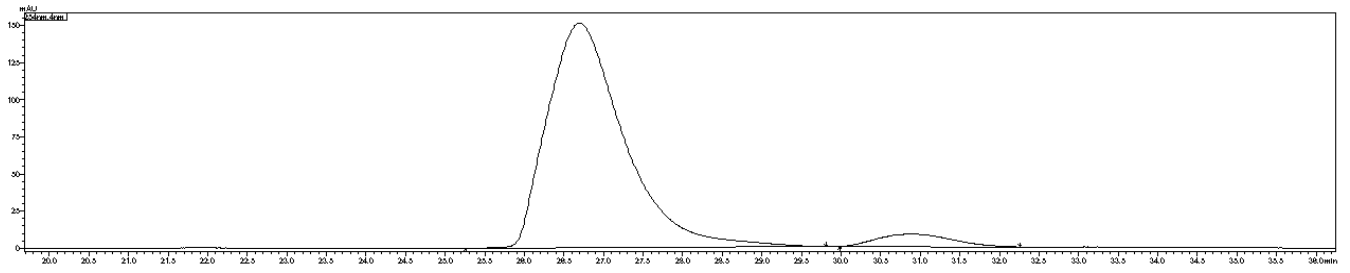
(*R*)-*S*-(2,4,6-Trimethylphenyl) 3-(2-naphthyl)-3-(cyanoamino)propanethioate (13)



racemic-**13**



(*R*)-**13**



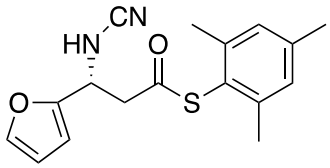
racemic-**13**

Peak	tR (min)	Area (%)
1	26.2	50.0
2	29.9	50.0

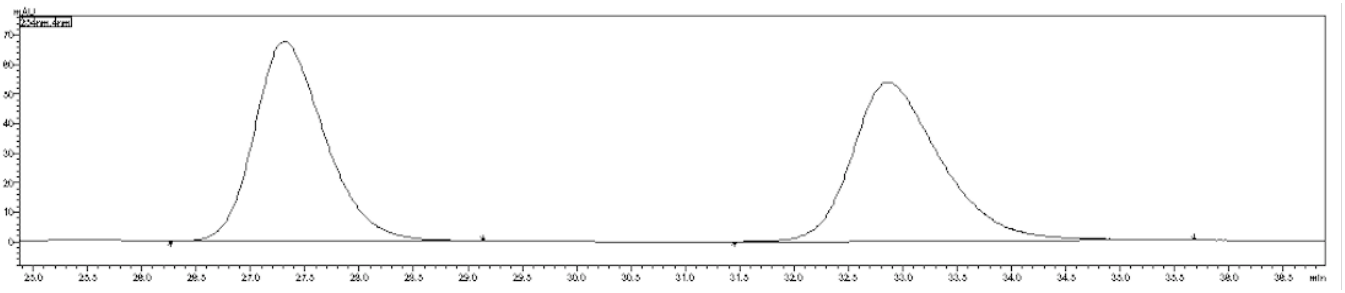
(*R*)-**13**

Peak	tR (min)	Area (%)
1	26.7	94.9
2	30.9	5.1

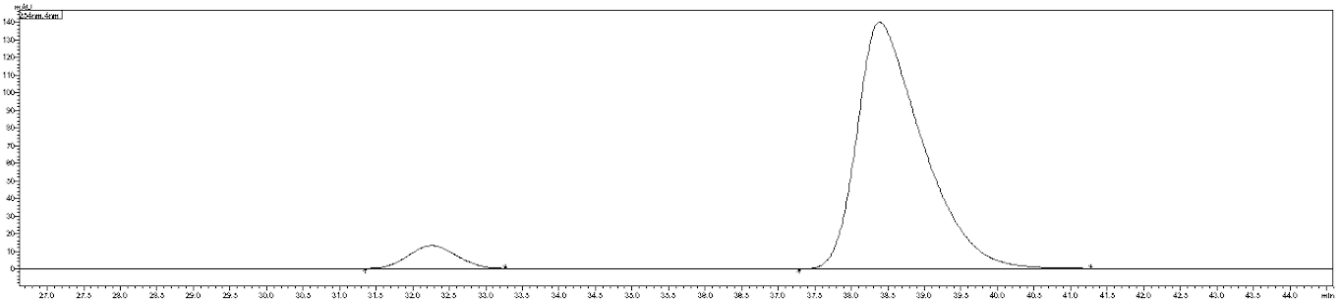
(*R*)-*S*-(2,4,6-Trimethylphenyl) 3-(2-furyl)-3-(cyanoamino)propanethioate (14)



racemic-**14**



(*R*)-**14**



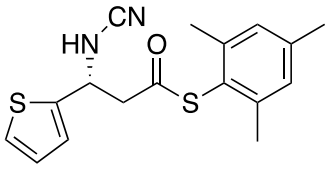
racemic-**14**

Peak	tR (min)	Area (%)
1	27.3	49.9
2	32.9	50.1

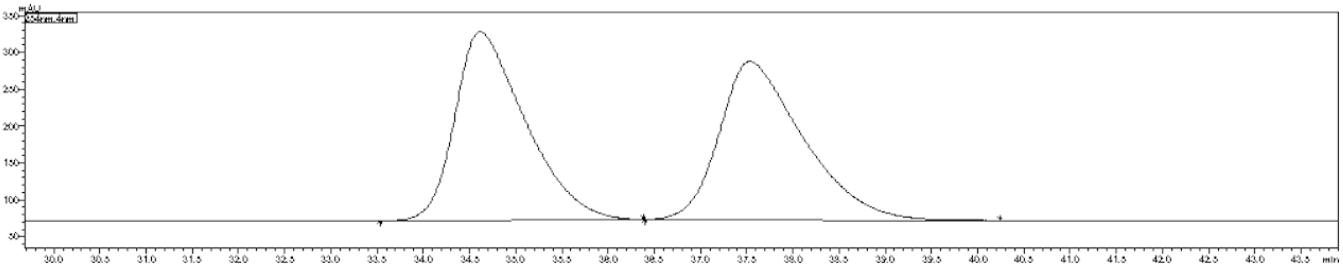
(*R*)-**14**

Peak	tR (min)	Area (%)
1	32.2	6.5
2	38.4	93.5

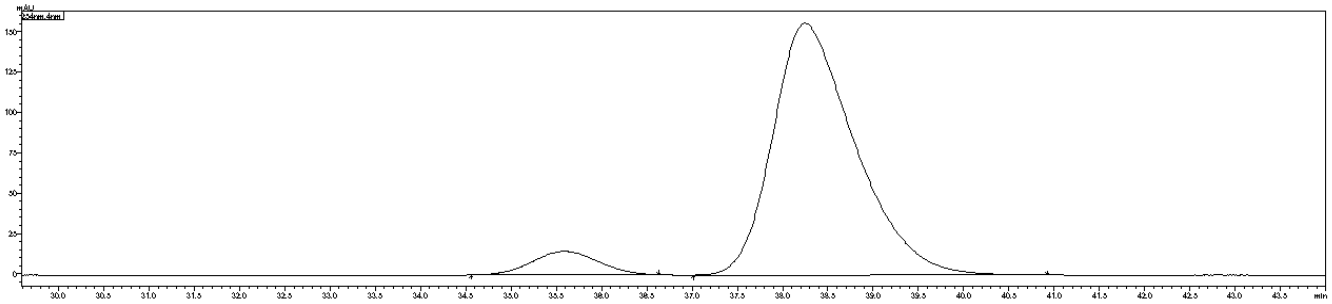
(*R*)-*S*-(2,4,6-Trimethylphenyl) 3-(2-thienyl)-3-(cyanoamino)propanethioate (15)



racemic-**15**



(*R*)-**15**



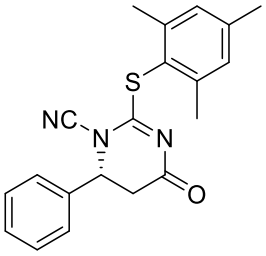
racemic-**15**

Peak	tR (min)	Area (%)
1	34.6	50.1
2	37.5	49.9

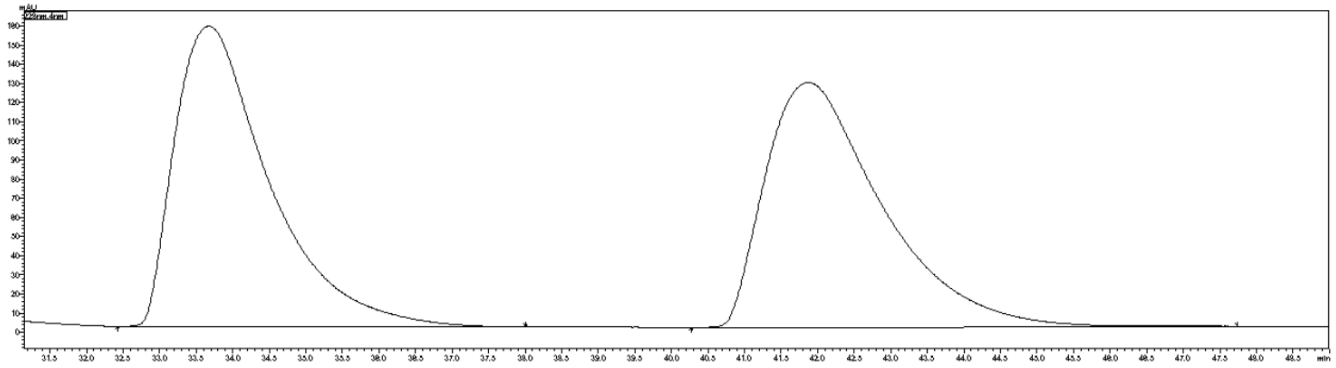
(*R*)-**15**

Peak	tR (min)	Area (%)
1	35.6	7.0
2	38.2	93.0

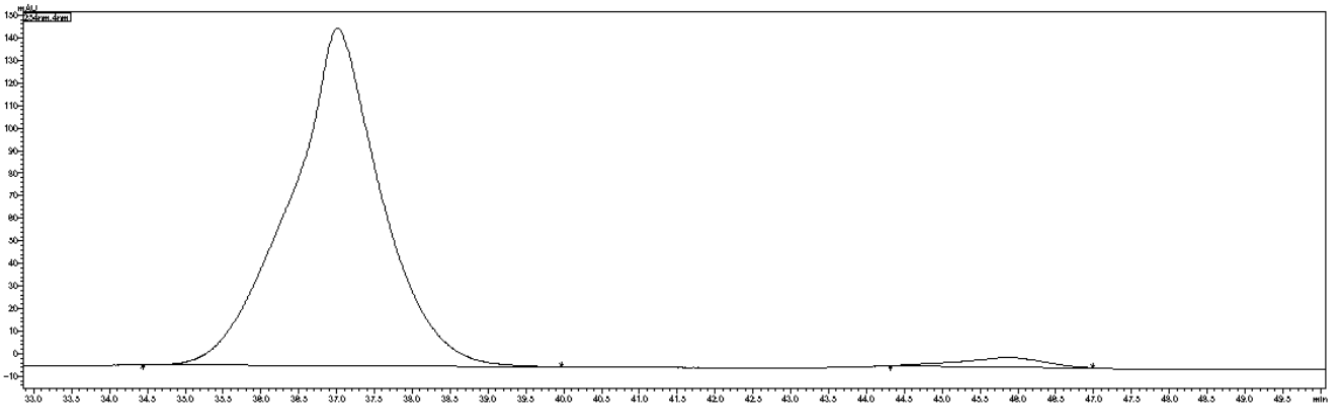
(*R*)-2-(2,4,6-Trimethylphenyl)thio-4-oxo-6-phenyl-5,6-dihydropyrimidone (16)



racemic-**16**



(*R*)-**16**



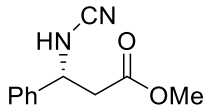
racemic-**16**

Peak	tR (min)	Area (%)
1	33.8	49.9
2	41.9	50.1

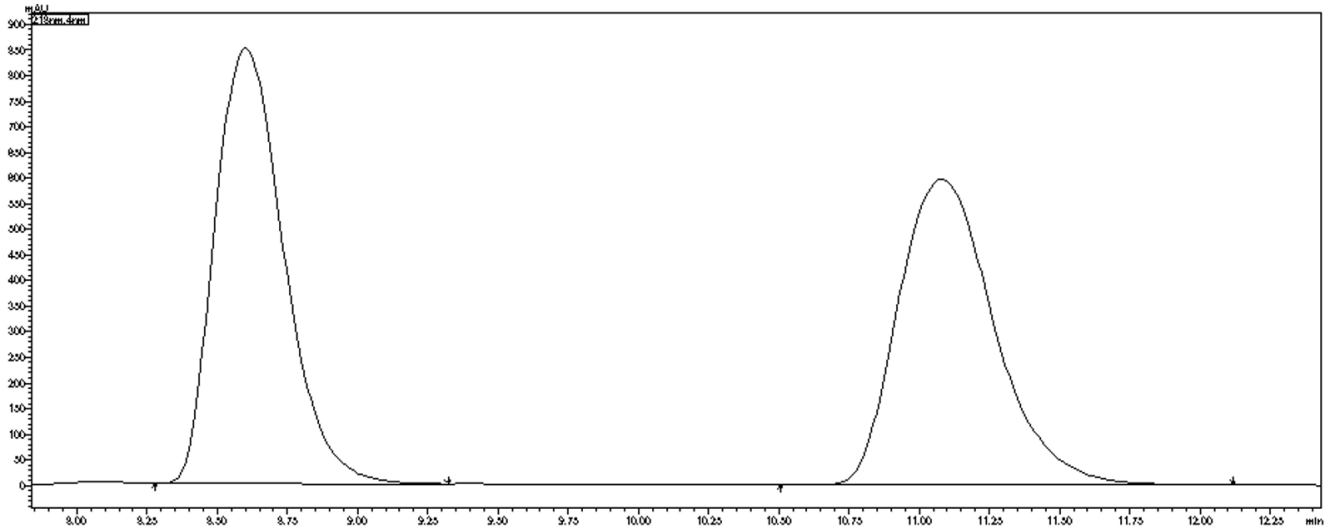
(*R*)-**16**

Peak	tR (min)	Area (%)
1	36.8	97.6
2	45.8	92.4

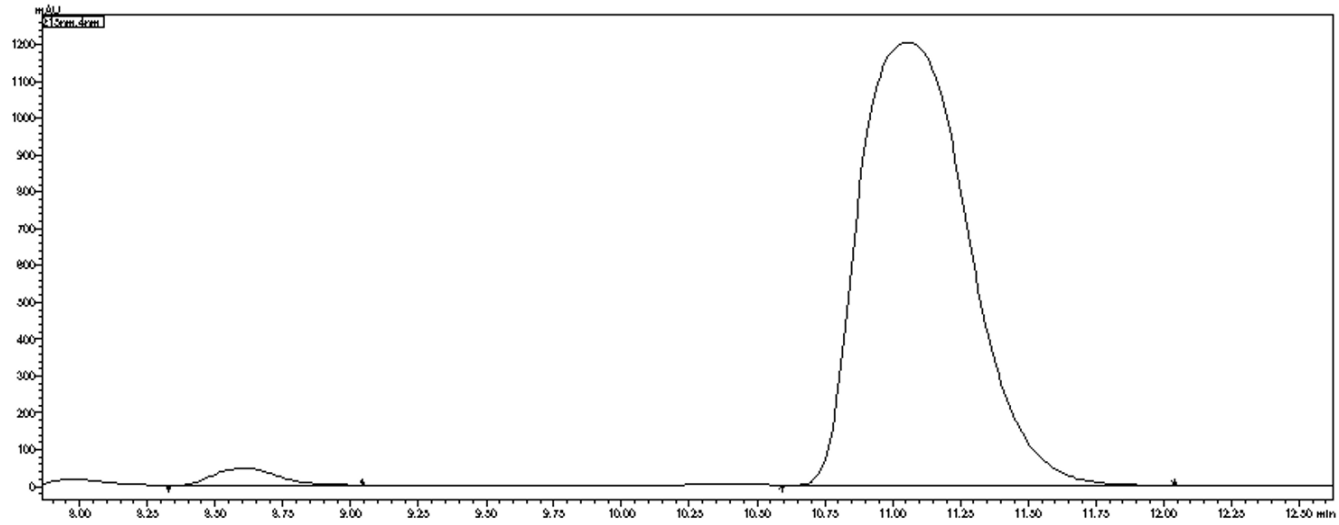
(*R*)-Methyl 3-phenyl-3-(cyanoamino)propanoate (17)



racemic-**17**



(*R*)-**17**



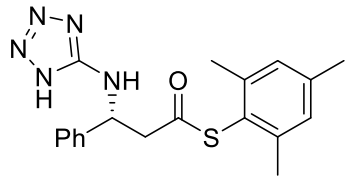
racemic-**17**

Peak	tR (min)	Area (%)
1	8.6	50.1
2	11.1	49.9

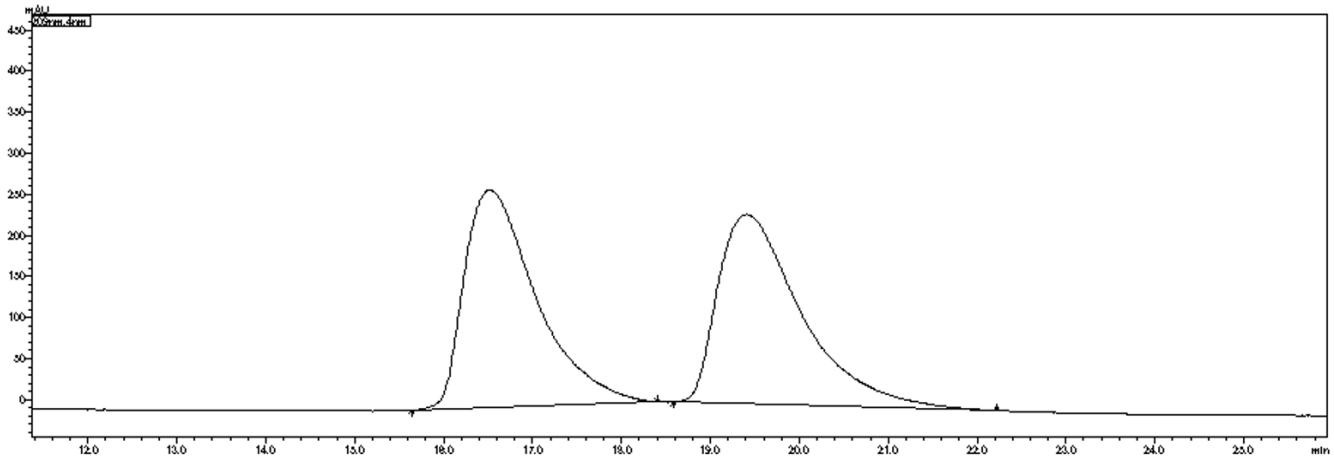
(*R*)-**17**

Peak	tR (min)	Area (%)
1	8.6	3.4
2	11.1	96.6

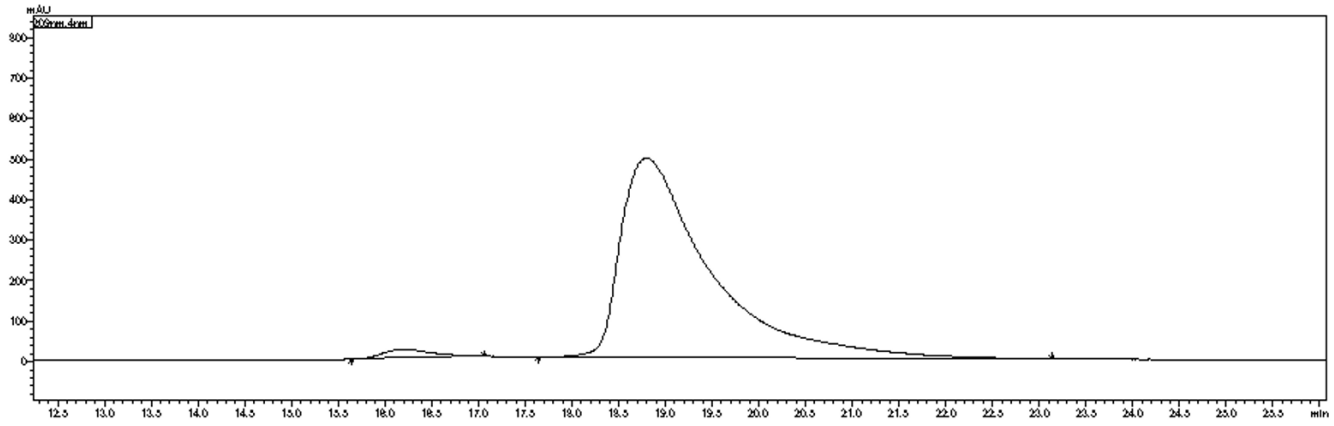
(*R*)-2-(2,4,6-Trimethylphenyl)thio-3-phenyl-3-(2*H*-tetrazole-5-amino)propanoate (18)



racemic-**18**



(*R*)-**18**



racemic-**18**

Peak	tR (min)	Area (%)
1	16.5	49.9
2	19.4	50.1

(*R*)-**18**

Peak	tR (min)	Area (%)
1	16.2	2.3
2	18.8	97.7