Supporting Information

Thiazolobenzyne: A versatile intermediate for multisubstituted benzothiazoles

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Contents

General Remarks

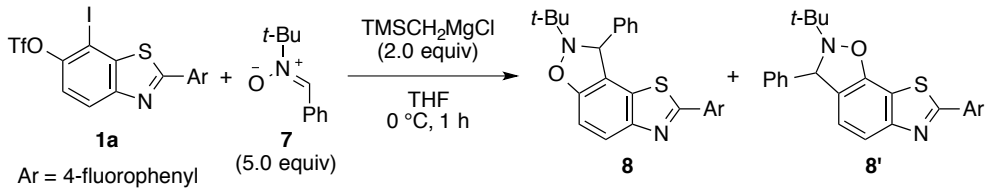
All reactions were performed in a dry glassware under atmosphere of argon otherwise noted. Analytical thin-layer chromatography (TLC) was performed on precoated (0.25 mm) silica-gel plates (Merck Chemicals, Silica Gel 60 F_{254}, Cat. No. 1.05715). Column chromatography was conducted using Biotage® ZIP Sphere cartridge [silica-gel] 30 g (Cat. No. 445-3000-FZ-20), 45 g (Cat. No. 445-4500-SZ-20), 80 g (Cat. No. 445-8000-JZ-20), or 120 g (Cat. No. 445-120G-UZ-20) or Biotage® SNAP Ultra 10 g (Cat. No. FSUL-0442-0010) with medium pressure liquid chromatography (Yamazen, W-Prep 2XY A-type). Preparative thin-layer chromatography (PTLC) was performed on silica-gel (Wako Pure Chemical Industries Ltd., Wakogel B5-F, Cat. No. 230-00043). Melting points (Mp) were measured on an OptiMelt MPA100 (Stanford Research Systems), and are uncorrected. ^{1}H NMR spectra were obtained with a Bruker AVANCE 400 spectrometer or a Bruker AVANCE 500 spectrometer at 400 or 500 MHz, respectively. ^{13}C NMR spectra were obtained with a Bruker AVANCE 500 spectrometer at 126 MHz. ^{19}F NMR spectra (^{1}H decoupled) were obtained with a Bruker AVANCE 400 spectrometer at 376 MHz. All NMR measurements were carried out at 23 ºC unless otherwise noted. $CDCl_3$ (Acros Organics, Cat. No. 368651000) was used as a solvent for obtaining NMR spectra. Chemical shifts (δ) are given in parts per million (ppm) downfield from $(CH_3)_4Si$ (δ 0.00 for ^{1}H NMR and ^{13}C NMR in $CDCl_3$) as an internal reference, or α,α,α-trifluorotoluene (δ –63.0 ppm for ^{19}F NMR in $CDCl_3$) as an external standard with coupling constants (*J*) in hertz (Hz). The abbreviations s, d, t, q, sept, m, and br signify singlet, doublet, triplet, quartet, septet, multiplet, and broad, respectively. IR spectra were measured by diffuse reflectance method on a Shimadzu IRPrestige-21 spectrometer attached with DRS-8000A with the absorption band given in cm^{-1}. High-resolution mass spectra (HRMS) were measured on a Bruker micrOTOF mass spectrometer under positive electrospray ionization (ESI^+) conditions or a JEOL Mass Spectrometer Model JMS-AX505H under fast atom bombardment (FAB^+) conditions. Elemental analyses were carried out at A Rabbit Science Japan Co. Ltd. X-ray crystallographic data was collected using a Rigaku R-AXIS RAPID diffractometer with Cu-K radiation (λ = 1.5418 Å) at 123 K.

(Trimethylsilylmethyl)magnesium chloride, *n*-butyllithium, isopropylmagnesium chloride, isopropyl-magnesium chloride–lithium chloride complex, *tert*-butylmagnesium chloride, and phenylmagnesium bromide

were used after titrimetric determination of the concentration by the 1,10-phenanthroline method.[S1] All other chemical reagents used were commercial grade and used as received.

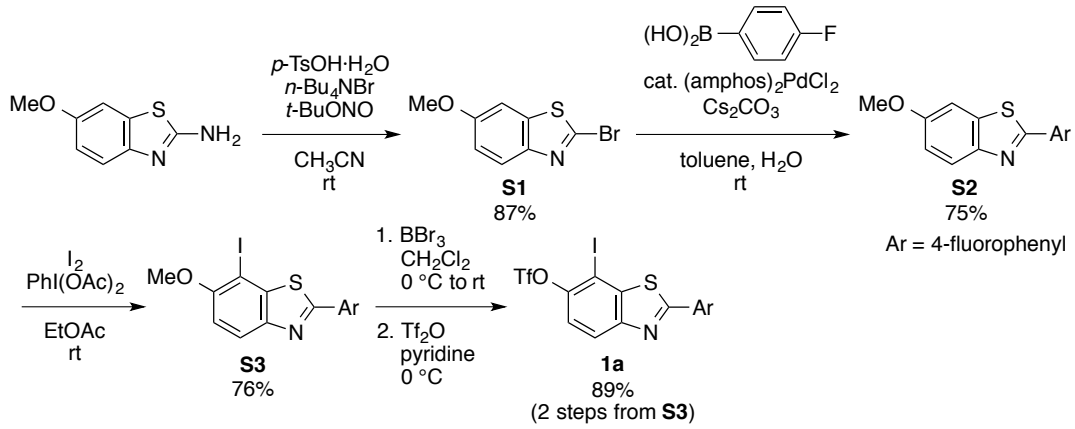
Experimental Procedures

A typical procedure for the cycloadditions between thiazolobenzynes and arynophiles



To a solution of 2-(4-fluorophenyl)-7-iodo-6-triflyloxybenzo[*d*]thiazole (**1a**) (255 mg, 0.507 mmol) and *N*-*tert*-butyl-α-phenylnitrone (451 mg, 2.54 mmol) dissolved in THF (17.0 mL) was added (trimethylsilylmethyl)magnesium chloride (1.0 M in Et_2O, 1.0 mL, 1.0 mmol) over 5 min at 0 °C. After stirring for 1 h at the same temperature, to the mixture was added saturated aqueous ammonium chloride (20 mL). The mixture was extracted with EtOAc (20 mL × 3), and the combined organic extract was washed with brine (30 mL), dried (Na_2SO_4), and after filtration, the filtrate was concentrated under reduced pressure. The residue was purified by flash column chromatography (silica-gel, Biotage Zip® Sphere cartridge 30 g, *n*-hexane/EtOAc = 10/1 to 4/1) to afford a regioisomeric mixture of 7-(*tert*-butyl)-2-(4-fluorophenyl)-8-phenyl-7,8-dihydrothiazolo[4',5':5,6]benzo[1,2-*d*]isoxazole (**8**) and 2-(*tert*-butyl)-7-(4-fluorophenyl)-3-phenyl-2,3-dihydrothiazolo[5',4':3,4]benzo[1,2-*d*]isoxazole (**8'**) (196 mg, 0.485 mmol, 95.6%, **8**:**8'** = 80:20) as a pale brown solid. For characterization purpose, the mixture of isomers were separated by flash column chromatography (silica-gel, Biotage® SNAP Ultra cartridge 10 g, CH_2Cl_2) to afford **8** and **8'**.

*Synthesis of 2-(4-fluorophenyl)-7-iodo-6-triflyloxybenzo[d]thiazole (**1a**)*



To a solution of 2-amino-6-methoxybenzo[*d*]thiazole (2.00 g, 11.1 mmol; commercial) dissolved in CH_3CN (20.0 mL) were added $CuBr_2$ (30.7 mg, 0.137 mmol), *p*-TsOH·H_2O (2.73 g, 14.4 mmol), tetrabutylammonium bromide (7.17 g, 22.2 mmol), and *t*-BuONO (1.70 mL, 14.3 mmol) at room temperature.[S2] After stirring for 1 h at the same temperature, to the mixture was added water (100 mL). The mixture was extracted with EtOAc (50 mL × 3), and the combined organic extract was washed with saturated aqueous $NaHCO_3$ (50 mL), brine (50 mL), dried (Na_2SO_4), and after filtration, the filtrate was concentrated under reduced pressure. The residue was purified by flash column chromatography (silica-gel, Biotage Zip® Sphere cartridge 80 g, *n*-hexane/EtOAc = 9/1 to 2/1) to afford 2-bromo-6-methoxybenzo[*d*]thiazole (**S1**) (2.36 g, 9.67 mmol, 87.1%) as a colorless solid.

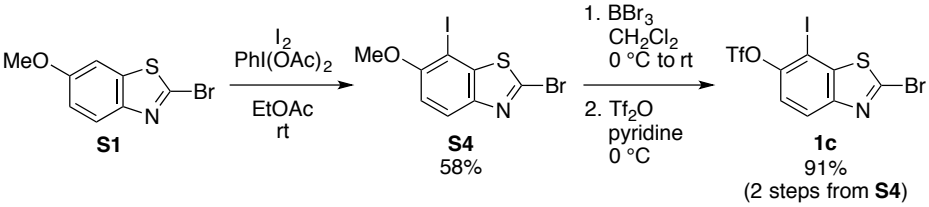
To a solution of 2-bromo-6-methoxybenzo[*d*]thiazole (**S1**) (2.35 g, 9.62 mmol) dissolved in toluene (24.0 mL) and H_2O (6.0 mL) were added cesium carbonate (9.40 g, 28.8 mmol), bis(di-*tert*-butyl(4-dimethylaminophenyl)phosphine)dichloropalladium(II) ($(amphos)_2PdCl_2$) (356 mg, 0.502 mmol), and 4-fluorophenylboronic acid (1.74 g, 12.4 mmol) at room temperature.[S3] After stirring for 12 h at the same temperature, to the mixture was added water (50 mL). The mixture was extracted with EtOAc (50 mL × 3), and the combined organic extract was washed with saturated aqueous ammonium chloride (50 mL), brine (50 mL), dried (Na_2SO_4), and after filtration, the filtrate was concentrated under reduced pressure. The residue was

purified by flash column chromatography (silica-gel, Biotage Zip® Sphere cartridge 45 g, *n*-hexane/EtOAc = 9/1 to 4/1) to afford 2-(4-fluorophenyl)-6-methoxybenzo[*d*]thiazole (**S2**) (1.87 g, 7.21 mmol, 74.9%) as a colorless solid.

To a solution of 2-(4-fluorophenyl)-6-methoxybenzo[*d*]thiazole (**S2**) (1.11 g, 4.29 mmol) dissolved in EtOAc (12.0 mL) was added iodine (1.18 g, 4.66 mmol) and iodobenzene diacetate (2.77 g, 8.58 mmol) at room temperature.[S4] After stirring for 5 h at the same temperature, to the mixture was added saturated aqueous sodium thiosulfate (30 mL) at 0 °C. The mixture was extracted with EtOAc (30 mL × 3), and the combined organic extract was washed with saturated aqueous $NaHCO_3$ (50 mL), brine (50 mL), dried (Na_2SO_4), and after filtration, the filtrate was concentrated under reduced pressure. The residue was purified by flash column chromatography (silica-gel, Biotage Zip® Sphere 45 g, *n*-hexane/EtOAc = 19/1 to 4/1) to afford 2-(4-fluorophenyl)-7-iodo-6-methoxybenzo[*d*]thiazole (**S3**) (1.26 g, 3.27 mmol, 76.2%) as a colorless solid.

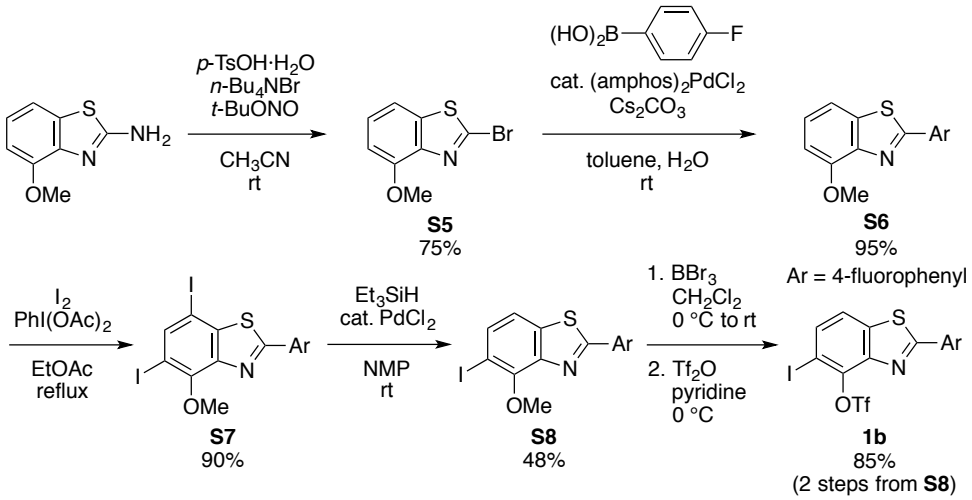
To a solution of 2-(4-fluorophenyl)-7-iodo-6-methoxybenzo[*d*]thiazole (**S3**) (1.15 g, 2.99 mmol) dissolved in CH_2Cl_2 (25.0 mL) was slowly added boron tribromide (1.0 M in CH_2Cl_2, 10.0 mL, 10 mmol) at 0 °C. After stirring for 3.5 h at room temperature, to the mixture was slowly added saturated aqueous $NaHCO_3$ (40 mL) at 0 °C. The mixture was extracted with CH_2Cl_2 (30 mL × 3), and the combined organic extract was dried with $MgSO_4$, and after filtration, the filtrate was concentrated under reduced pressure. The residue was dissolved in pyridine (8.0 mL) and to the solution was added trifluoromethanesulfonic anhydride (Tf_2O) (754 µL, 4.48 mmol) at 0 °C. After stirring for 5 h at the same temperature, to the mixture was slowly added water (20 mL) and saturated aqueous $NaHCO_3$ (20 mL) at 0 °C. The mixture was extracted with EtOAc (20 mL × 3), and the combined organic extract was washed with brine (50 mL), dried (Na_2SO_4), and after filtration, the filtrate was concentrated under reduced pressure. Recrystallization from EtOAc provided 2-(4-fluorophenyl)-7-iodo-6-triflyloxybenzo[*d*]thiazole (**1a**) (1.16 g, 2.31 mmol, 77.1%) as a colorless solid. The mother liquor was concentrated under reduced pressure and the residue was purified by flash column chromatography (silica-gel, Biotage Zip® Sphere cartridge 45 g, *n*-hexane only to *n*-hexane/EtOAc = 6/1) to afford **1a** (185 mg, 0.368 mmol, 12.3%; total yield 89.4%) as a colorless solid.

*Synthesis of 2-bromo-7-iodo-6-triflyloxybenzo[d]thiazole (**1c**)*



According to the procedure for the synthesis of **1a** from **S2**, 2-bromo-7-iodo-6-triflyloxybenzo[*d*]thiazole (**1c**) was prepared from 2-bromo-6-methoxybenzo[*d*]thiazole (**S1**) via 2-bromo-7-iodo-6-methoxybenzo[*d*]thiazole (**S4**).

*Synthesis of 2-(4-fluorophenyl)-5-iodo-4-triflyloxybenzo[d]thiazole (**1b**)*



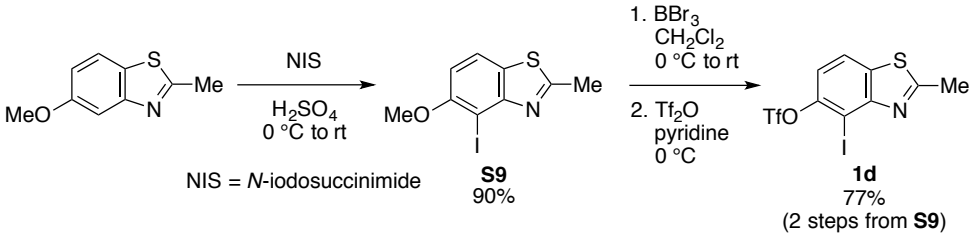
According to the procedure for the synthesis of **S2**, 2-(4-fluorophenyl)-4-methoxybenzo[*d*]thiazole (**S6**) was prepared from 2-amino-4-methoxybenzo[*d*]thiazole (commercial).

To a solution of 2-(4-fluorophenyl)-4-methoxybenzo[*d*]thiazole (**S6**) (9.43 g, 24.5 mmol) in EtOAc (200 mL) was added iodine (13.5 g, 53.0 mmol) and iodobenzene diacetate (19.4 g, 60.1 mmol) at room temperature. After stirring for 3 h at 85 °C, the mixture was cooled to room temperature and to this was added saturated aqueous sodium thiosulfate (100 mL) at the same temperature. The mixture was extracted with EtOAc (100 mL × 3), and the combined organic extract was washed with brine (200 mL), dried (Na_2SO_4), and after filtration, the filtrate was concentrated under reduced pressure. The residue was purified by recrystallization from EtOAc to afford 2-(4-fluorophenyl)-5,7-diiodobenzo[*d*]thiazole (**S7**) (1st crop: 8.26 g, 2nd crop: 3.02 g; total 11.3 g, 22.1 mmol, 90.1%) as a colorless solid.

To a solution of 2-(4-fluorophenyl)-5,7-diiodobenzo[*d*]thiazole (**S7**) (2.15 g, 4.20 mmol) in *N*-methylpyrrolidone (NMP) (15 mL) was added triethylsilane (1.0 mL, 6.3 mmol) and palladium(II) dichloride (112 mg, 0.635 mmol) at room temperature.[S5] After stirring the mixture for 2.5 h at the same temperature, the resulting suspension was filtered through a Celite® pad (washed with EtOAc), and the filtrate was concentrated under reduced pressure. To the mixture was added water (50 mL), and the mixture was extracted with EtOAc (50 mL × 3). The combined organic extract was washed with brine (30 mL), dried (Na_2SO_4), and after filtration, the filtrate was concentrated under reduced pressure. The residue was purified by flash column chromatography (silica-gel, Biotage Zip® Sphere cartridge 120 g, *n*-hexane/CH_2Cl_2 = 5/1 to 4/1) to afford 2-(4-fluorophenyl)-5-iodo-4-methoxybenzo[*d*]thiazole (**S8**) (778 mg, 2.02 mmol, 48.0%) as a colorless solid. The starting material 2-(4-fluorophenyl)-5,7-diiodo-4-methoxybenzo[*d*]thiazole (**S7**) was also recovered (987 mg, 1.91 mmol, 45.4%).

According to the procedure for the synthesis of **1a** from **S3**, 2-(4-fluorophenyl)-5-iodo-4-triflyloxybenzo[*d*]thiazole (**1b**) was prepared from 2-(4-fluorophenyl)-5-iodo-4-methoxybenzo[*d*]thiazole (**S8**).

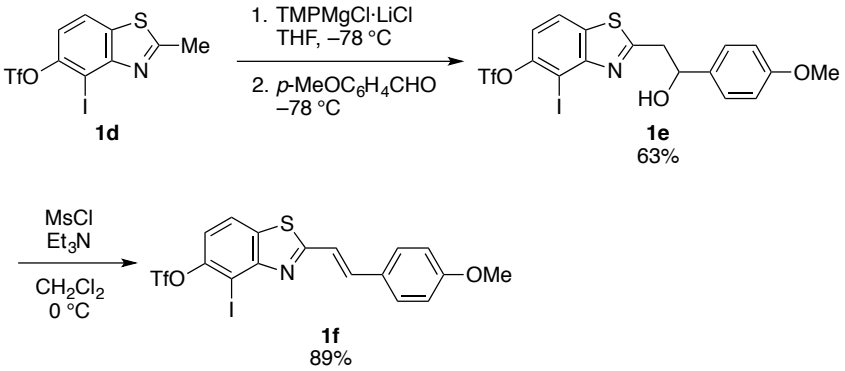
*Synthesis of 4-iodo-2-methyl-5-triflyloxybenzo[d]thiazole (**1d**)*



To a solution of 5-methoxy-2-methylbenzo[*d*]thiazole (1.03 g, 5.75 mmol; commercial in concentrated sulfuric acid (5.0 mL) was added *N*-iodosuccinimide (1.36 g, 6.06 mmol) at 0 °C.[S6] After stirring for 2 h at room temperature, the resulting mixture was slowly added to water (100 mL) at 0 °C. The mixture was extracted with EtOAc (30 mL × 3), and the combined organic extract was washed with saturated aqueous $NaHCO_3$ (50 mL), brine (50 mL), dried (Na_2SO_4), and after filtration, the filtrate was concentrated under reduced pressure. The residue was purified by flash column chromatography (silica-gel, Biotage Zip® Sphere cartridge 45 g, *n*-hexane/EtOAc = 9/1 to 4/1) to afford 4-iodo-5-methoxy-2-methylbenzo[*d*]thiazole (**S9**) (1.58 g, 5.18 mmol, 90.1%) as a colorless solid.

According to the procedure for the synthesis of **1a** from **S3**, 4-iodo-2-methyl-5-triflyloxybenzo[*d*]thiazole (**1d**) was prepared from 4-iodo-5-methoxy-2-methylbenzo[*d*]thiazole (**S9**).

*Synthesis of C2-alkyl and C2-alkenyl group-substituted thiazolobenzyne precursors **1e** and **1f***

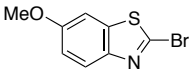


To a solution of 4-iodo-2-methyl-5-triflyloxybenzo[*d*]thiazole (**1d**) (2.12 g, 5.01 mmol) in THF (50 mL) was added 2,2,6,6-tetramethylpiperidinylmagnesium chloride–lithium chloride complex (1.0 M in THF/toluene, 6.0 mL, 6.0 mmol) at –78 °C. After stirring for 5 min at the same temperature, *p*-methoxybenzaldehyde (0.91 mL, 7.5 mmol) was added to the reaction mixture. After stirring for 10 min at the same temperature, to the mixture was added saturated aqueous ammonium chloride (100 mL). The mixture was extracted with EtOAc (50 mL × 3), and the combined organic extract was dried (Na_2SO_4) and after filtration, the filtrate was concentrated under reduced pressure. The residue was purified by flash column chromatography (silica-gel, Biotage SNAP® Sphere cartridge 100 g, *n*-hexane/EtOAc = 4/1 to 2/1) to afford 2-(4-iodo-5-triflyloxybenzo[*d*]thiazol-2-yl)-1-(4-methoxyphenyl)ethan-1-ol (**1e**) (1.77 g, 3.16 mmol, 63.2%) as a colorless oil.

To a solution of 2-(4-iodo-5-triflyloxybenzo[*d*]thiazol-2-yl)-1-(4-methoxyphenyl)ethan-1-ol (**1e**) (449 mg, 0.803 mmol) in CH_2Cl_2 (4.0 mL) were added triethylamine (0.22 mL, 1.6 mmol) and methanesulfonyl chloride (93 μL, 1.2 mmol) at 0 °C. After stirring for 5 min at the same temperature, to the mixture was added saturated aqueous ammonium chloride (10 mL). The mixture was extracted with CH_2Cl_2 (5 mL × 3), and the combined organic extract was dried (Na_2SO_4) and after filtration, the filtrate was concentrated under reduced pressure. The residue was purified by flash column chromatography (silica-gel, Biotage ZIP® Sphere cartridge 45 g, *n*-hexane/EtOAc = 1/0 to 4/1) to afford (*E*)-4-iodo-5-trifryloxy-2-(4-methoxystyryl)benzo[*d*]thiazole (**1f**) (385 mg, 0.711 mmol, 88.6%) as a pale yellow solid.

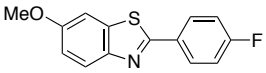
Characterization Data of New Compounds

2-Bromo-6-methoxybenzo[*d*]thiazole (**S1**)



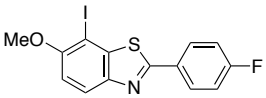
Colorless solid; Mp 51–53 °C; TLC R_f 0.75 (*n*-hexane/EtOAc = 1/1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.86 (s, 3H), 7.05 (dd, 1H, J = 9.0, 2.6 Hz), 7.24 (d, 1H, J = 2.6 Hz), 7.85 (d, 1H, J = 9.0 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ 55.8 (1C), 103.6 (1C), 115.7 (1C), 123.3 (1C), 135.4 (1C), 138.6 (1C), 146.8 (1C), 158.1 (1C); IR (KBr, cm^{-1}) 978, 1026, 1220, 1256, 1432, 1455, 1484, 1601, 2832, 3003; Anal. calcd for C_8H_6BrNOS: C, 39.36; H, 2.48; N, 5.74%; Found: C, 39.28; H, 2.40; N, 5.63%.

2-(4-Fluorophenyl)-6-methoxybenzo[*d*]thiazole (**S2**)



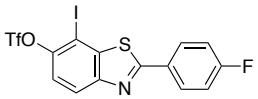
Colorless solid; Mp 107–108 °C; TLC R_f 0.74 (*n*-hexane/EtOAc = 2/1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 3.89 (s, 3H), 7.09 (dd, 1H, J = 9.0, 2.6 Hz), 7.13–7.19 (AA'BB'X, 2H), 7.35 (d, 1H, J = 2.6 Hz), 7.93 (d, 1H, J = 9.0 Hz), 8.00–8.05 (AA'BB'X, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 55.8 (1C), 104.2 (1C), 115.7 (1C), 116.1 (d, 2C, $^2J_{C–F}$ = 22.1 Hz), 123.7 (1C), 129.1 (d, 2C, $^3J_{C–F}$ = 8.6 Hz), 130.1 (d, 1C, $^4J_{C–F}$ = 2.9 Hz), 136.4 (1C), 148.7 (1C), 157.8 (1C), 164.3 (1C), 164.3 (d, 1C, $^1J_{C–F}$ = 251.3 Hz); ^{19}F NMR (376 MHz, $CDCl_3$) δ –110.1 (s); IR (KBr, cm^{-1}) 832, 913, 1224, 1265, 1436, 1464, 1518, 1608, 2836, 2959; Anal. calcd. for $C_{14}H_{10}FNOS$: C, 64.85; H, 3.89; N, 5.40%; Found: C, 64.71; H, 3.95; N, 5.39%.

2-(4-Fluorophenyl)-7-iodo-6-methoxybenzo[*d*]thiazole (**S3**)



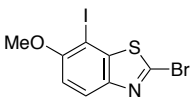
Colorless solid; Mp 167–169 °C; TLC R_f 0.30 (*n*-hexane/EtOAc = 5/1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.98 (s, 3H), 7.02 (d, 1H, J = 8.8 Hz), 7.15–7.22 (AA'BB'X, 2H), 7.95 (d, 1H, J = 8.8 Hz), 8.01–8.07 (AA'BB'X, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 57.2 (1C), 74.3 (1C), 110.4 (1C), 116.2 (d, 2C, $^2J_{C–F}$ = 22.1 Hz), 123.4 (1C), 129.2 (d, 2C, $^3J_{C–F}$ = 8.6 Hz), 129.9 (d, 1C, $^4J_{C–F}$ = 3.1 Hz), 145.0 (1C), 146.3 (1C), 156.6 (1C), 163.5 (1C), 164.4 (d, 1C, $^1J_{C–F}$ = 251.9 Hz); ^{19}F NMR (376 MHz, $CDCl_3$) δ –109.4 (s); IR (KBr, cm^{-1}) 990, 1047, 1260, 1376, 1456, 1472, 1589, 2841, 2938, 3028; HRMS (ESI^+) *m/z* 385.9490 ($[M+H]^+$, $C_{14}H_{10}FINOS^+$ requires 385.9506).

2-(4-Fluorophenyl)-7-iodo-6-triflyloxybenzo[*d*]thiazole (**1a**)



Colorless solid; Mp 157–159 °C; TLC R_f 0.72 (*n*-hexane/EtOAc = 4/1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 7.18–7.24 (AA'BB'X, 2H), 7.42 (d, 1H, J = 8.9 Hz), 8.03 (d, 1H, J = 8.9 Hz), 8.05–8.11 (AA'BB'X, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 79.7 (1C), 116.5 (d, 2C, $^2J_{C–F}$ = 22.1 Hz), 118.8 (q, 1C, $^1J_{C–F}$ = 321.6 Hz), 120.1 (1C), 123.8 (1C), 129.3 (d, 1C, $^4J_{C–F}$ = 3.5 Hz), 129.7 (d, 2C, $^3J_{C–F}$ = 8.6 Hz), 145.4 (1C), 147.8 (1C), 150.3 (1C), 165.0 (d, 1C, $^1J_{C–F}$ = 253.7 Hz), 167.9 (1C); ^{19}F NMR (376 MHz, $CDCl_3$) δ –73.4 (s, 3F), –107.5 (s, 1F); IR (KBr, cm^{-1}) 837, 913, 1146, 1222, 1420, 1434, 1593, 1603, 3034, 3077, 3082; Anal. calcd for $C_{14}H_6F_4INO_3S_2$: C, 33.42; H, 1.20; N, 2.78%; Found: C, 33.56; H, 1.22; N, 2.80%.

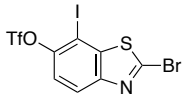
2-Bromo-7-iodo-6-methoxybenzo[*d*]thiazole (**S4**)



Colorless solid; Mp 160–162 °C; TLC R_f 0.37 (*n*-hexane/EtOAc = 9/1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 3.96 (s, 3H), 6.98 (d, 1H, J = 8.8 Hz), 7.88 (d, 1H, J = 8.8 Hz); ^{13}C NMR (126 MHz, $CDCl_3$) δ 57.2 (1C), 73.2 (1C),

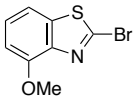
110.3 (1C), 123.0 (1C), 134.7 (1C), 144.8 (1C), 147.0 (1C), 156.8 (1C); IR (KBr, cm^{-1}) 797, 827, 991, 1047, 1249, 1261, 1376, 1429, 1457, 1473, 1545, 1589, 2939; HRMS (FAB^+) *m/z* 369.8394 ($[M+H]^+$, $C_8H_6BrINOS^+$ requires 369.8393).

2-Bromo-7-iodo-6-trifryloxybenzo[*d*]thiazole (**1c**)



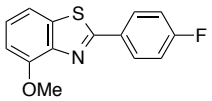
Colorless solid; Mp 169–171 °C; TLC R_f 0.43 (*n*-hexane/EtOAc = 9/1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.43 (d, 1H, *J* = 8.9 Hz), 8.00 (d, 1H, *J* = 8.9 Hz); ^{13}C NMR (126 MHz, $CDCl_3$) δ 78.6 (1C), 118.7 (q, 1C, $^1J_{C–F}$ = 321.0 Hz), 120.4 (1C), 123.6 (1C), 139.6 (1C), 147.5 (1C), 148.3 (1C), 148.9 (1C); ^{19}F NMR (376 MHz, $CDCl_3$) δ –73.1 (s); IR (KBr, cm^{-1}) 602, 830, 887, 917, 926, 993, 1134, 1142, 1186, 1211, 1233, 1254, 1431, 1463; HRMS (FAB^+) *m/z* 487.7739 ($[M+H]^+$, $C_8H_3BrF_3INO_3S_2^+$ requires 487.7729).

2-Bromo-4-methoxybenzo[*d*]thiazole (**S5**)



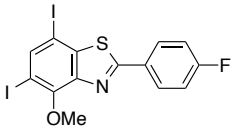
Pale brown solid; Mp 71–72 °C; TLC R_f 0.50 (*n*-hexane/EtOAc = 2/1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 4.03 (s, 3H), 6.89 (dd, 1H, *J* = 6.3, 2.7 Hz), 7.32–7.37 (m, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 56.0 (1C), 107.2 (1C), 112.8 (1C), 126.8 (1C), 137.1 (1C), 138.9 (1C), 142.5 (1C), 152.8 (1C); IR (KBr, cm^{-1}) 988, 1048, 1272, 1326, 1407, 1467, 1572, 2835, 2935, 3076; Anal. calcd for C_8H_6BrNOS: C, 39.36; H, 2.48; N, 5.74%; Found: C, 39.41; H, 2.43; N, 5.65%.

2-(4-Fluorophenyl)-4-methoxybenzo[*d*]thiazole (**S6**)



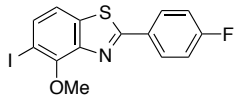
Colorless solid: Mp 89–90 °C; TLC R_f 0.35 (*n*-hexane/EtOAc = 4/1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 4.07 (s, 3H), 6.91 (d, 1H, *J* = 8.0 Hz), 7.12–7.18 (AA'BB'X, 2H), 7.32 (dd, 1H, *J* = 8.0, 8.0 Hz), 7.46 (d, 1H, *J* = 8.0 Hz), 8.08–8.14 (AA'BB'X, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 56.1 (1C), 106.9 (1C), 113.6 (1C), 116.0 (d, 2C, $^2J_{C–F}$ = 22.1 Hz), 126.2 (1C), 129.6 (d, 2C, $^3J_{C–F}$ = 8.8 Hz), 129.9 (d, 1C, $^4J_{C–F}$ = 2.9 Hz), 136.7 (1C), 144.2 (1C), 153.5 (1C), 164.4 (d, 1C, $^1J_{C–F}$ = 251.7 Hz), 165.5 (1C); ^{19}F NMR (376 MHz, $CDCl_3$) δ –109.8 (s); IR (KBr, cm^{-1}) 839, 1047, 1156, 1226, 1262, 1475, 1600, 2836, 2958, 3074; Anal. calcd for $C_{14}H_{10}FNOS$: C, 64.85; H, 3.89; N, 5.40%; Found: C, 64.85; H, 3.86; N, 5.36%.

2-(4-Fluorophenyl)-5,7-diiodo-4-methoxybenzo[*d*]thiazole (**S7**)



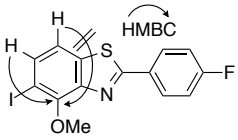
Colorless solid; Mp 163–165 °C: TLC R_f 0.65 (*n*-hexane/EtOAc = 3/1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 4.36 (s, 3H), 7.15–7.22 (AA'BB'X, 2H), 7.99 (s, 1H), 8.04–8.09 (AA'BB'X, 2H); ^{13}C NMR (100 MHz, $CDCl_3$) δ 62.2 (1C), 75.7 (1C), 86.7 (1C), 116.3 (d, 2C, $^2J_{C–F}$ = 22.1 Hz), 129.46 (d, 1C, $^4J_{C–F}$ = 2.7 Hz), 129.52 (d, 2C, $^3J_{C–F}$ = 8.7 Hz), 142.7 (1C), 143.0 (1C), 145.4 (1C), 153.6 (1C), 164.0 (1C), 164.7 (d, 1C, $^1J_{C–F}$ = 252.7 Hz); ^{19}F NMR (376 MHz, $CDCl_3$) δ –108.3 (s); IR (KBr, cm^{-1}) 835, 1015, 1154, 1231, 1417, 1479, 1604, 2945, 2978, 3033; Anal. calcd for $C_{14}H_8FI_2NOS$: C, 32.90; H, 1.58; N, 2.74%; Found: C, 32.93; H, 1.59; N, 2.65%.

2-(4-Fluorophenyl)-5-iodo-4-methoxybenzo[*d*]thiazole (**S8**)

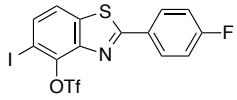


Colorless solid, Mp 119–121 °C; TLC R_f 0.55 (*n*-hexane/CH_2Cl_2 = 5/1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 4.36 (s, 3H), 7.15–7.21 (AA'BB'X, 2H), 7.32 (d, 1H, *J* = 8.5 Hz), 7.70 (d, 1H, *J* = 8.5 Hz), 8.04–8.10 (AA'BB'X, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 62.1 (1C), 86.2 (1C), 116.2 (d, 2C, $^2J_{C–F}$ = 22.2 Hz), 117.5 (1C), 129.58 (d, 1C, $^4J_{C–F}$ = 3.6 Hz), 129.60 (d, 2C, $^3J_{C–F}$ = 8.5 Hz), 135.3 (1C), 137.6 (1C), 146.2 (1C), 153.4 (1C), 164.6 (d, 1C, $^1J_{C–F}$ = 252.6 Hz), 165.5 (1C); ^{19}F NMR (376 MHz, $CDCl_3$) δ –108.9 (s); IR (KBr, cm^{-1}) 834, 1156, 1223, 1233, 1296, 1421, 1483, 1601, 2829, 2943; Anal. calcd for $C_{14}H_9FINOS$: C, 43.65; H, 2.36; N, 3.64%; Found: C, 43.66; H, 2.26; N, 3.52%.

The structure was confirmed by the HMBC experiment.

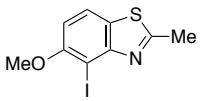


2-(4-Fluorophenyl)-5-iodo-4-triflyloxybenzo[*d*]thiazole (**1b**)



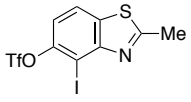
Colorless solid; Mp 114–116 °C; TLC R_f 0.50 (*n*-hexane/CH_2Cl_2 = 4/1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 7.14–7.21 (AA'BB'X, 2H), 7.56 (d, 1H, *J* = 8.4 Hz), 7.77 (d, 1H, *J* = 8.4 Hz), 8.03–8.10 (AA'BB'X, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 85.9 (1C), 116.4 (d, 2C, $^2J_{C–F}$ = 22.3 Hz), 118.7 (q, 1C, $^1J_{C–F}$ = 321.1 Hz), 122.4 (1C), 128.8 (d, 1C, $^4J_{C–F}$ = 3.2 Hz), 129.9 (d, 2C, $^3J_{C–F}$ = 9.0 Hz), 135.5 (1C), 137.3 (1C), 143.8 (1C), 147.2 (1C), 164.9 (d, 1C, $^1J_{C–F}$ = 253.7 Hz), 168.9 (1C); ^{19}F NMR (376 MHz, $CDCl_3$) δ –72.3 (s, 3F), –107.3 (s, 1F); IR (KBr, cm^{-1}) 828, 961, 1074, 1173, 1297, 1438, 1464, 1599, 3037, 3077; Anal. calcd for $C_{14}H_6F_4INO_3S_2$: C, 33.42; H, 1.20; N, 2.78%; Found: C, 33.61; H, 1.13; N, 2.92%.

4-Iodo-5-methoxy-2-methylbenzo[*d*]thiazole (**S9**)



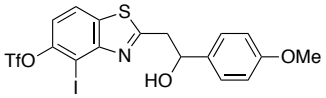
Colorless solid; Mp 86–87 °C; TLC R_f 0.44 (*n*-hexane/EtOAc = 3/1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 2.85 (s, 3H), 3.95 (s, 3H), 6.91 (d, 1H, *J* = 8.7 Hz), 7.66 (d, 1H, *J* = 8.7 Hz); ^{13}C NMR (126 MHz, $CDCl_3$) δ 20.4 (1C), 57.2 (1C), 80.4 (1C), 109.6 (1C), 121.4 (1C), 126.8 (1C), 155.8 (1C), 157.5 (1C), 168.7 (1C); IR (KBr, cm^{-1}) 999, 1175, 1274, 1394, 1455, 1518, 1588, 2835, 2935, 2961; Anal. calcd for C_9H_8INOS: C, 35.43; H, 2.64; N, 4.59%; Found: C, 35.33; H, 2.64; N, 4.56%.

4-Iodo-2-methyl-5-triflyloxybenzo[*d*]thiazole (**1c**)



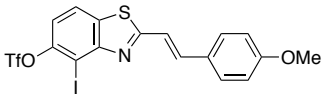
Colorless solid; Mp 157–159 °C; TLC R_f 0.23 (*n*-hexane/EtOAc = 5/1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 2.90 (s, 3H), 7.30 (d, 1H, *J* = 8.7 Hz), 7.81 (d, 1H, *J* = 8.7 Hz); ^{13}C NMR (100 MHz, $CDCl_3$) δ 20.5 (1C), 85.9 (1C), 118.3 (1C), 118.8 (q, 1C, $^1J_{C–F}$ = 320.7 Hz), 122.1 (1C), 133.6 (1C), 149.2 (1C), 156.1 (1C), 170.4 (1C); ^{19}F NMR (376 MHz, $CDCl_3$) δ –73.5 (s); IR (KBr, cm^{-1}) 852, 958, 1136, 1234, 1240, 1392, 1427, 1520, 2985, 3065, 3096; HRMS (ESI^+) *m/z* 445.8616 ($[M+Na]^+$, $C_9H_5F_3INNaO_3S_2^+$ requires 445.8600).

2-(4-Iodo-5-triflyloxybenzo[*d*]thiazol-2-yl)-1-(4-methoxyphenyl)ethan-1-ol (**1e**)



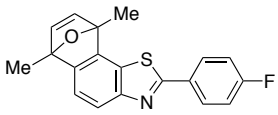
Colorless oil; TLC R_f 0.38 (*n*-hexane/EtOAc = 3/2); ^{1}H NMR (500 MHz, $CDCl_3$) δ 3.46–3.55 (m, 2H), 3.82 (s, 3H), 3.89 (d, 1H, J = 3.2 Hz), 5.28 (ddd, 1H, J = 7.4, 4.9, 3.2 Hz), 6.90–6.94 (AA'BB', 2H), 7.34 (d, 1H, J = 8.7 Hz), 7.38–7.41 (AA'BB', 2H), 7.85 (d, 1H, J = 8.7 Hz); ^{13}C NMR (126 MHz, $CDCl_3$) δ 43.2 (1C), 55.3 (1C), 72.2 (1C), 86.3 (1C), 114.0 (2C), 118.7 (1C), 118.8 (q, 1C, $^1J_{C–F}$ = 320.8 Hz), 122.3 (1C), 127.1 (2C), 132.8 (1C), 134.5 (1C), 149.4 (1C), 155.4 (1C), 159.4 (1C), 172.3 (1C); ^{19}F NMR (376 MHz, $CDCl_3$) δ –73.2 (s); IR (KBr, cm^{-1}) 630, 737, 742, 809, 836, 976, 1036, 1136, 1183, 1215, 1251, 1303, 1391, 1427, 1514, 1610, 3422; HRMS (FAB^+) *m*/*z* 559.9311 ($[M+H]^+$, $C_{17}H_{14}F_3INO_5S_2^+$ requires 559.9305).

(*E*)-4-Iodo-2-(4-methoxystyryl)-5-trifryloxybenzo[*d*]thiazole (**1f**)



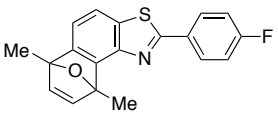
Pale yellow solid; Mp 155–157 °C; TLC R_f 0.49 (*n*-hexane/EtOAc = 4/1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 3.86 (s, 3H), 6.93–6.96 (AA'BB', 2H), 7.28 (d, 1H, J = 8.6 Hz), 7.34 (d, 1H, J = 16.2 Hz), 7.49 (d, 1H, J = 16.2 Hz), 7.53–7.56 (AA'BB', 2H), 7.81 (d, 1H, J = 8.6 Hz); ^{13}C NMR (126 MHz, $CDCl_3$) δ 55.4 (1C), 86.2 (1C), 114.5 (2C), 118.4 (1C), 118.8 (q, 1C, $^1J_{C–F}$ = 320.8 Hz), 119.4 (1C), 122.0 (1C), 127.6 (1C), 129.3 (2C), 132.1 (1C), 139.6 (1C), 149.4 (1C), 156.6 (1C), 161.2 (1C), 170.4 (1C); ^{19}F NMR (376 MHz, $CDCl_3$) δ –73.3 (s); IR (KBr, cm^{-1}) 586, 610, 855, 980, 1140, 1209, 1259, 1424, 1516, 1605, 3448; HRMS (FAB^+) *m*/*z* 541.9209 ($[M+H]^+$, $C_{17}H_{12}F_3INO_4S_2^+$ requires 541.9199).

2-(4-Fluorophenyl)-6,9-dihydro-6,9-dimethyl-6,9-epoxynaphtho[2,1-*d*]thiazole (**3a**)



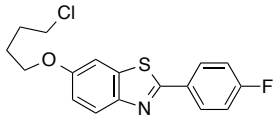
Colorless solid; Mp 161–163 °C; TLC R_f 0.33 (*n*-hexane/EtOAc = 4/1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.96 (s, 3H), 2.07 (s, 3H), 6.87 (d, 1H, J = 5.3 Hz), 6.92 (d, 1H, J = 5.3 Hz), 7.10–7.17 (AA'BB'X, 2H), 7.28 (d, 1H, J = 7.8 Hz), 7.69 (d, 1H, J = 7.8 Hz), 8.00–8.07 (AA'BB'X, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 15.5 (1C), 15.9 (1C), 89.2 (1C), 89.5 (1C), 116.2 (d, 2C, $^2J_{C–F}$ = 22.1 Hz), 117.2 (1C), 119.4 (1C), 126.7 (1C), 129.6 (d, 2C, $^3J_{C–F}$ = 8.9 Hz), 129.8 (d, 1C, $^4J_{C–F}$ = 2.9 Hz), 146.7 (1C), 146.9 (1C), 148.0 (1C), 150.7 (1C), 153.6 (1C), 164.5 (d, 1C, $^1J_{C–F}$ = 252.1 Hz), 166.1 (1C); ^{19}F NMR (376 MHz, $CDCl_3$) δ –109.1 (s); IR (KBr, cm^{-1}) 871, 1304, 1381, 1489, 1524, 1604, 2866, 2930, 2975, 3072; HRMS (ESI^+) *m*/*z* 324.0860 ($[M+H]^+$, $C_{19}H_{15}FNOS^+$ requires 324.0853).

2-(4-Fluorophenyl)-6,9-dihydro-6,9-dimethyl-6,9-epoxynaphtho[1,2-*d*]thiazole (**3b**)



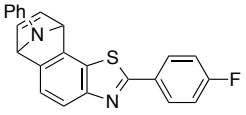
Yellow solid; Mp 139–141 °C; TLC R_f 0.45 (*n*-hexane/EtOAc = 4/1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.99 (s, 3H), 2.34 (s, 3H), 6.89 (d, 1H, J = 5.3 Hz), 7.00 (d, 1H, J = 5.3 Hz), 7.14–7.20 (AA'BB'X, 2H), 7.21 (d, 1H, J = 7.6 Hz), 7.52 (d, 1H, J = 7.6 Hz), 8.07–8.12 (AA'BB'X, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 15.5 (1C), 17.1 (1C), 89.1 (1C), 90.1 (1C), 116.0 (1C), 116.1 (d, 2C, $^2J_{C–F}$ = 22.1 Hz), 117.8 (1C), 129.6 (d, 2C, $^3J_{C–F}$ = 8.9 Hz), 130.0 (d, 1C, $^4J_{C–F}$ = 2.9 Hz), 133.6 (1C), 146.2 (1C), 147.4 (1C), 147.87 (1C), 147.92 (1C), 153.1 (1C), 164.5 (d, 1C, $^1J_{C–F}$ = 251.9 Hz), 167.5 (1C); ^{19}F NMR (376 MHz, $CDCl_3$) δ 109.0 (s); IR (KBr, cm^{-1}) 977, 1100, 1156, 1233, 1332, 1488, 1602, 2932, 2979, 3072; HRMS (ESI^+) *m*/*z* 324.0854 ($[M+H]^+$, $C_{19}H_{15}FNOS^+$ requires 324.0853).

6-(4-Chlorobutyloxy)-2-(4-fluorophenyl)benzo[*d*]thiazole (**4**)



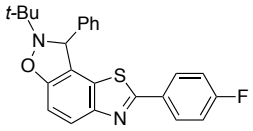
Colorless solid; Mp 94–95 °C; TLC R_f 0.37 (*n*-hexane/EtOAc = 6/1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.97–2.06 (m, 4H), 3.65 (t, 2H, *J* = 6.1 Hz), 4.08 (t, 2H, *J* = 5.7 Hz), 7.08 (dd, 1H, *J* = 8.9, 2.5 Hz), 7.13–7.19 (AA'BB'X, 2H), 7.34 (d, 1H, *J* = 2.5 Hz), 7.92 (d, 1H, *J* = 8.9 Hz), 8.00–8.06 (AA'BB'X, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 26.7 (1C), 29.3 (1C), 44.7 (1C), 67.7 (1C), 104.9 (1C), 116.0 (1C), 116.1 (d, 2C, $^2J_{C–F}$ = 21.6 Hz), 123.7 (1C), 129.2 (d, 2C, $^3J_{C–F}$ = 8.6 Hz), 130.1 (d, 1C, $^4J_{C–F}$ = 3.4 Hz), 136.4 (1C), 148.7 (1C), 157.1 (1C), 164.2 (d, 1C, $^1J_{C–F}$ = 251.7 Hz), 164.3 (1C); ^{19}F NMR (376 MHz, $CDCl_3$) δ –110.1 (s); IR (KBr, cm^{-1}) 834, 1068, 1229, 1270, 1490, 1521, 1707, 2872, 2924, 2960; HRMS (ESI^+) *m*/*z* 336.0611 ($[M+H]^+$, $C_{17}H_{16}ClFNOS^+$ requires 336.0620).

2-(4-Fluorophenyl)-10-phenyl-6,9-dihydro-6,9-iminonaphtho[2,1-*d*]thiazole (**6**)



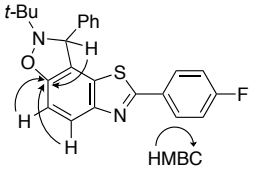
Pale brown solid; Mp 160–162 °C; TLC R_f 0.15 (*n*-hexane/EtOAc = 6/1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 5.57–5.63 (m, 2H), 6.80–6.87 (m, 3H), 7.07 (ddd, 1H, *J* = 5.5, 2.9, 0.4 Hz), 7.10 (ddd, 1H, *J* = 5.5, 2.9, 0.4 Hz), 7.14–7.21 (m, 4H), 7.44 (d, 1H, *J* = 7.8 Hz), 7.66 (d, 1H, *J* = 7.8 Hz), 8.02–8.05 (AA'BB'X, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 69.5 (1C), 70.1 (1C), 116.2 (d, 2C, $^2J_{C–F}$ = 22.2 Hz), 118.0 (2C), 119.6 (1C), 120.2 (1C), 121.2 (1C), 129.0 (2C), 129.4 (1C), 129.6 (d, 2C, $^3J_{C–F}$ = 8.9 Hz), 129.9 (d, 1C, $^4J_{C–F}$ = 3.3 Hz), 141.1 (1C), 142.9 (1C), 143.5 (1C), 146.4 (1C), 146.6 (1C), 153.1 (1C), 164.5 (d, 1C, $^1J_{C–F}$ = 252.0 Hz), 165.6 (1C); ^{19}F NMR (376 MHz, $CDCl_3$) δ –109.2 (s); IR (KBr, cm^{-1}) 838, 909, 1156, 1233, 1297, 1491, 1599, 3036, 3061; HRMS (ESI^+) *m*/*z* 371.1025 ($[M+H]^+$, $C_{23}H_{16}FN_2S^+$ requires 371.1013).

7-(*tert*-Butyl)-2-(4-fluorophenyl)-8-phenyl-7,8-dihydroisoxazolo[4',5':6,5]benzo[2,1-*d*]thiazole (**8**)

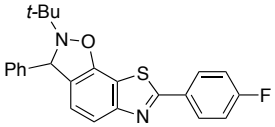


Pale brown solid; Mp 140–142 °C; TLC R_f 0.49 (*n*-hexane/EtOAc = 10/1), 0.58 (CH_2Cl_2); ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.22 (s, 9H,), 5.75 (s, 1H), 7.00 (d, 1H, *J* = 8.8 Hz), 7.06–7.12 (AA'BB'X, 2H), 7.28–7.32 (AA'BB'C, 1H), 7.33–7.39 (AA'BB'C, 2H), 7.46–7.52 (AA'BB'C, 2H), 7.85 (d, 1H, *J* = 8.8 Hz), 7.88–7.93 (AA'BB'X, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 25.5 (3C), 61.3 (1C), 67.9 (1C), 106.9 (1C), 116.0 (d, 2C, $^2J_{C–F}$ = 22.1 Hz), 123.4 (1C), 128.09 (1C), 128.12 (2C), 128.8 (2C), 129.17 (d, 2C, $^3J_{C–F}$ = 8.6 Hz), 129.20 (1C), 129.9 (d, 1C, $^4J_{C–F}$ = 3.4 Hz), 130.3 (1C), 141.1 (1C), 150.2 (1C), 154.1 (1C), 163.8 (1C), 164.1 (d, 1C, $^1J_{C–F}$ = 250.8 Hz); ^{19}F NMR (376 MHz, $CDCl_3$) δ –110.1 (s); IR (KBr, cm^{-1}) 839, 942, 1156, 1233, 1365, 1464, 1491, 1609, 2934, 2975, 3030; HRMS (ESI^+) *m*/*z* 427.1268 ($[M+Na]^+$, $C_{24}H_{21}FN_2NaOS^+$ requires 427.1251).

The regiochemistry was determined by the HMBC experiment.



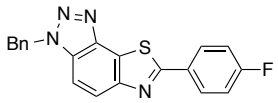
2-(*tert*-Butyl)-7-(4-fluorophenyl)-3-phenyl-2,3-dihydroisoxazolo[4',5':5,6]benzo[2,1-*d*]thiazole (**8'**)



Brown oil; TLC R_f 0.49 (*n*-hexane/EtOAc = 10/1), 0.62 (CH_2Cl_2); ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.24 (s, 9H), 5.76 (s, 1H), 7.01 (d, 1H, *J* = 8.2 Hz), 7.15–7.21 (AA'BB'X, 2H), 7.24–7.30 (AA'BB'C, 1H), 7.31–7.38

(AA'BB'C, 2H), 7.41–7.45 (AA'BB'C, 2H), 7.56 (d, 1H, J = 8.2 Hz), 8.04–8.10 (AA'BB'X, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 25.5 (3C), 61.6 (1C), 67.8 (1C), 113.8 (1C), 115.9 (1C), 116.2 (d, 2C, $^2J_{C–F}$ = 22.1 Hz), 121.7 (1C), 125.3 (1C), 127.4 (2C), 127.7 (1C), 128.7 (2C), 129.6 (d, 2C, $^3J_{C–F}$ = 8.5 Hz), 129.8 (d, 1C, $^4J_{C–F}$ = 2.9 Hz), 143.5 (1C), 150.0 (1C), 156.5 (1C), 164.5 (d, 1C, $^1J_{C–F}$ = 252.0 Hz), 167.0 (1C); ^{19}F NMR (376 MHz, $CDCl_3$) δ –109.3 (s); IR (KBr, cm^{-1}) 838, 1048, 1157, 1175, 1232, 1461, 1490, 1572, 1600, 2934, 2976; HRMS (ESI^+) m/z 427.1252 ($[M+Na]^+$, $C_{24}H_{21}FN_2NaOS^+$ requires 427.1251).

3-Benzyl-7-(4-fluorophenyl)-3*H*-1,2,3-triazolo[3,4]benzo[1,2-*d*]thiazole (**10**)



Colorless solid; Mp 177–178 °C; TLC R_f 0.32 (*n*-hexane/EtOAc = 4/1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 5.93 (s, 2H), 7.17–7.23 (AA'BB'X, 2H), 7.28–7.39 (m, 5H), 7.43 (d, 1H, J = 8.9 Hz), 8.06 (d, 1H, J = 8.9 Hz), 8.08–8.13 (AA'BB'X, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 52.8 (1C), 108.5 (1C), 116.3 (d, 2C, $^2J_{C–F}$ = 22.2 Hz), 123.3 (1C), 124.7 (1C), 127.6 (2C), 128.7 (1C), 129.2 (2C), 129.4 (d, 2C, $^3J_{C–F}$ = 8.5 Hz), 129.7 (d, 1C, $^4J_{C–F}$ = 2.9 Hz), 131.2 (1C), 134.4 (1C), 141.0 (1C), 152.1 (1C), 164.4 (d, 1C, $^1J_{C–F}$ = 252.0 Hz), 166.3 (1C); ^{19}F NMR (376 MHz, $CDCl_3$) δ –109.3 (s); IR (KBr, cm^{-1}) 946, 1048, 1222, 1298, 1431, 1455, 1492, 1596, 3037, 3068; HRMS (ESI^+) m/z 361.0913 ($[M+H]^+$, $C_{20}H_{14}FN_4S^+$ requires 361.0918); Selected crystal data: triclinic, *P*–1 (No. 2), a = 12.2528(5) Å, b = 13.059(3) Å, c = 13.682(3) Å, α = 69.528(14)°, β = 89.026(17)°, γ = 78.107(17)°, V = 1623.1(6) Å^3, Z = 4, R_1 = 0.0741, wR_2 = 0.1402. CCDC 1481578 contains the supplementary crystallographic data for this paper. These data can be obtained free of charge from The Cambridge Crystallographic Data Centre via www.ccdc.cam.ac.uk/data_request/cif.

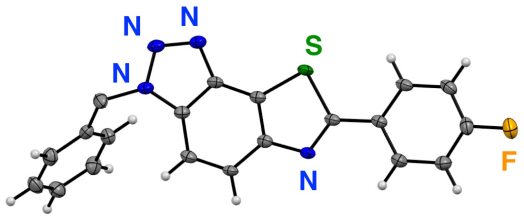
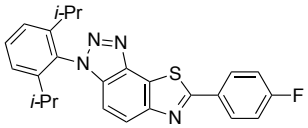


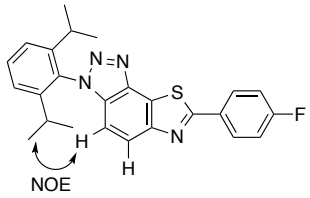
Fig. S1 X-ray structure of **10**.

3-(2,6-Diisopropylphenyl)-7-(4-fluorophenyl)-3*H*-1,2,3-triazolo[3,4]benzo[1,2-*d*]thiazole (**12**)

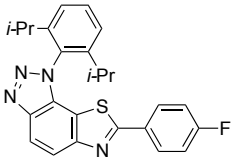


Colorless solid; Mp 163–164 °C; TLC R_f 0.27 (*n*-hexane/EtOAc = 10/1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.04 (d, 6H, J = 6.9 Hz), 1.14 (d, 6H, J = 6.9 Hz), 2.10 (tt, 2H, J = 7.0, 7.0 Hz), 7.20–7.24 (AA'BB'X, 2H), 7.27 (d, 1H, J = 8.9 Hz), 7.40 (d, 2H, J = 8.0 Hz), 7.60 (t, 1H, J = 8.0 Hz), 8.14 (d, 1H, J = 8.9 Hz), 8.15–8.19 (AA'BB'X, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 23.8 (2C), 24.4 (2C), 28.6 (2C), 108.7 (1C), 116.4 (d, 2C, $^2J_{C–F}$ = 22.1 Hz), 123.9 (1C), 124.3 (2C), 124.8 (1C), 129.5 (d, 2C, $^3J_{C–F}$ = 8.5 Hz), 129.7 (d, 1C, $^4J_{C–F}$ = 3.2 Hz), 131.2 (1C), 131.4 (2C), 133.7 (1C), 139.9 (1C), 147.2 (1C), 152.3 (1C), 164.5 (d, 1C, $^1J_{C-F}$ = 252.0 Hz), 166.4 (1C); ^{19}F NMR (376 MHz, $CDCl_3$) δ –109.0 (s); IR (KBr, cm^{-1}) 840, 913, 1074, 1157, 1236, 1470, 1596, 1602, 2928, 2967; HRMS (ESI^+) m/z 453.1506 ($[M+Na]^+$, $C_{25}H_{23}FN_4NaS^+$ requires 453.1520).

The regiochemistry was determined by the NOESY experiment.

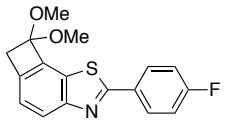


1-(2,6-Diisopropylphenyl)-7-(4-fluorophenyl)-1*H*-1,2,3-triazolo[3,4]benzo[1,2-*d*]thiazole (**12'**)



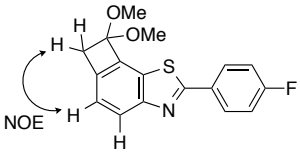
Colorless solid; Mp 181–184 °C; TLC R_f 0.27 (*n*-hexane/EtOAc = 10/1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 0.98 (d, 6H, *J* = 6.9 Hz), 1.12 (d, 6H, *J* = 6.9 Hz), 2.10 (tt, 2H, *J* = 6.9, 6.9 Hz), 7.12–7.18 (AA'BB'X, 2H), 7.44 (d, 2H, *J* = 7.9 Hz), 7.69 (t, 1H, *J* = 7.9 Hz), 7.97–8.03 (AA'BB'X, 2H), 8.11 (d, 1H, *J* = 9.0 Hz), 8.23 (d, 1H, *J* = 9.0 Hz); ^{13}C NMR (126 MHz, $CDCl_3$) δ 23.1 (2C), 24.7 (2C), 28.6 (2C), 115.7 (1C), 116.3 (d, 2C, $^2J_{C–F}$ = 22.4 Hz), 118.5 (1C), 120.4 (1C), 124.4 (2C), 129.4 (d, 1C, $^4J_{C–F}$ = 3.5 Hz), 129.5 (d, 2C, $^3J_{C–F}$ = 8.6 Hz), 130.5 (1C), 131.1 (1C), 131.8 (2C), 143.0 (1C), 147.5 (1C), 154.9 (1C), 164.6 (d, 1C, $^1J_{C–F}$ = 252.7 Hz), 167.9 (1C); ^{19}F NMR (376 MHz, $CDCl_3$) δ –108.7 (s); IR (KBr, cm^{-1}) 809, 966, 1035, 1233, 1409, 1495, 1602, 2871, 2929, 3071; HRMS (ESI^+) *m*/*z* 453.1518 ($[M+Na]^+$, $C_{25}H_{23}FN_4NaS^+$ requires 453.1520).

2-(4-Fluorophenyl)-7,7-dimethoxy-6,7-dihydrocyclobuta[3,4]benzo[1,2-*d*]thiazole (**14**)

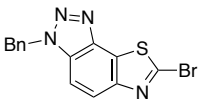


Colorless solid; Mp 155–157 °C; TLC R_f 0.72 (*n*-hexane/EtOAc = 4/1); ^{1}H NMR (400 MHz, $CDCl_3$) δ 3.48 (s, 2H), 3.55 (s, 6H), 7.14–7.21 (AA'BB'X, 2H), 7.35 (d, 1H, *J* = 8.1 Hz), 8.04 (d, 1H, *J* = 8.1 Hz), 8.04–8.10 (AA'BB'X, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 43.3 (1C), 52.0 (2C), 104.9 (1C), 116.2 (d, 2C, $^2J_{C–F}$ = 22.2 Hz), 121.9 (1C), 125.5 (1C), 127.6 (1C), 129.5 (d, 2C, $^3J_{C–F}$ = 8.2 Hz), 129.8 (d, 1C, $^4J_{C–F}$ = 3.4 Hz), 137.9 (1C), 139.1 (1C), 154.8 (1C), 164.5 (d, 1C, $^1J_{C–F}$ = 251.9 Hz), 165.6 (1C); ^{19}F NMR (376 MHz, $CDCl_3$) δ –109.3 (s); IR (KBr, cm^{-1}) 821, 1066, 1149, 1246, 1489, 1606, 2827, 2957; Anal. calcd for $C_{17}H_{14}FNO_2S$: C, 64.75; H, 4.47; N, 4.44%; Found: C, 64.86; H, 4.60; N, 4.31%.

The regiochemistry was determined by the NOESY experiment.

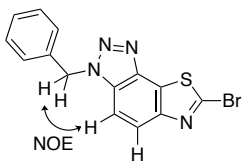


3-Benzyl-7-bromo-3*H*-1,2,3-triazolo[3,4]benzo[1,2-*d*]thiazole (**15**)

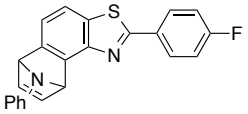


Pale yellow solid; Mp 179–181 °C; TLC R_f 0.35 (*n*-hexane/EtOAc = 4/1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 5.92 (s, 2H), 7.27–7.37 (m, 5H), 7.41 (d, 1H, *J* = 8.9 Hz), 7.98 (d, 1H, *J* = 8.9 Hz); ^{13}C NMR (126 MHz, $CDCl_3$) δ 52.9 (1C), 108.8 (1C), 122.7 (1C), 127.2 (1C), 127.6 (2C), 128.8 (1C), 129.2 (2C), 131.2 (1C), 134.1 (1C), 137.3 (1C), 140.1 (1C), 150.2 (1C); IR (KBr, cm^{-1}) 719, 800, 910, 942, 958, 1043, 1070, 1095, 1168, 1208, 1243, 1428, 1443, 1456, 1482, 2927; HRMS (FAB^+) *m*/*z* 344.9817 ($[M+H]^+$, $C_{14}H_{10}BrN_4S^+$ requires 344.9804).

The regiochemsitry was determined by the NOESY experiment.

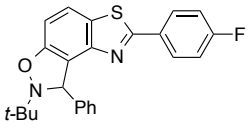


2-(4-Fluorophenyl)-10-phenyl-6,9-dihydro-6,9-iminonaphtho[1,2-*d*]thiazole (**16**)



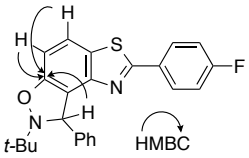
Brown solid; Mp 189–190 °C; TLC R_f 0.25 (*n*-hexane/EtOAc = 4/1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 5.57–5.60 (m, 1H), 6.12–6.14 (m, 1H), 6.79–6.83 (AA'BB'C, 1H), 6.87–6.92 (AA'BB'C, 2H), 7.09 (dd, 1H, *J* = 5.4, 2.5 Hz), 7.13 (dd, 1H, *J* = 5.4, 2.5 Hz), 7.14–7.20 (m, 4H), 7.34 (d, 1H, *J* = 7.6 Hz), 7.45 (d, 1H, *J* = 7.6 Hz), 8.05–8.11 (AA'BB'X, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 67.9 (1C), 69.9 (1C), 116.1 (d, 2C, $^2J_{C–F}$ = 22.1 Hz), 117.8 (1C), 118.0 (2C), 119.0 (1C), 120.9 (1C), 128.8 (2C), 129.6 (d, 2C, $^3J_{C–F}$ = 8.6 Hz), 130.0 (d, 1C, $^4J_{C–F}$ = 3.0 Hz), 132.9 (1C), 142.1 (1C), 143.0 (1C), 143.3 (1C), 146.8 (1C), 148.5 (1C), 149.2 (1C), 164.5 (d, 1C, $^1J_{C–F}$ = 252.0 Hz), 167.7 (1C); ^{19}F NMR (376 MHz, $CDCl_3$) δ –109.2 (s); IR (KBr, cm^{-1}) 839, 988, 1157, 1233, 1397, 1409, 1599, 3011, 3036, 3061; Anal. calcd for $C_{23}H_{15}FN_2S$: C, 74.57; H, 4.08; N, 7.56%; Found: C, 74.54; H, 4.07; N, 7.40%.

7-(*tert*-Butyl)-2-(4-fluorophenyl)-8-phenyl-7,8-dihydroisoxazolo[4',5':6,5]benzo[1,2-*d*]thiazole (**17**)

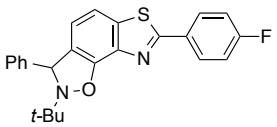


Pale yellow solid; Mp 167–168 °C; TLC R_f 0.45 (*n*-hexane/EtOAc = 10/1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.22 (s, 9H), 6.15 (s, 1H), 6.95 (d, 1H, *J* = 8.5 Hz), 7.11–7.17 (AA'BB'X, 2H), 7.20–7.24 (AA'BB'C, 1H), 7.30–7.35 (AA'BB'C, 2H), 7.65 (d, 1H, *J* = 8.5 Hz), 7.68–7.71 (AA'BB'C, 2H), 7.94–8.00 (AA'BB'X, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 25.4 (3C), 61.4 (1C), 66.0 (1C), 106.1 (1C), 116.1 (d, 2C, $^2J_{C–F}$ = 22.1 Hz), 121.1 (1C), 121.6 (1C), 127.2 (1C), 127.6 (2C), 128.0 (1C), 128.3 (2C), 129.4 (d, 2C, $^3J_{C–F}$ = 8.6 Hz), 130.1 (d, 1C, $^4J_{C–F}$ = 3.0 Hz), 143.1 (1C), 149.6 (1C), 156.8 (1C), 164.4 (d, 1C, $^1J_{C–F}$ = 251.6 Hz), 168.5 (1C); ^{19}F NMR (376 MHz, $CDCl_3$) δ –109.4 (s); IR (KBr, cm^{-1}) 839, 1037, 1235, 1364, 1408, 1479, 1600, 2872, 2974, 3030; HRMS (ESI^+) *m*/*z* 427.1253 ($[M+Na]^+$, $C_{24}H_{21}FN_2NaOS^+$ requires 427.1251).

The regiochemistry was determined by the HMBC experiment.

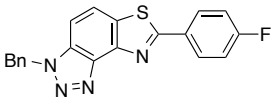


2-(*tert*-Butyl)-7-(4-fluorophenyl)-3-phenyl-2,3-dihydroisoxazolo[4',5':5,6]benzo[1,2-*d*]thiazole (**17'**)



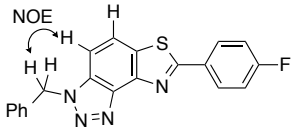
Pale yellow solid; Mp 177–178 °C; TLC R_f 0.34 (*n*-hexane/EtOAc = 10/1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.27 (s, 9H), 5.77 (s, 1H), 6.90 (d, 1H, *J* = 8.0 Hz), 7.14–7.19 (AA'BB'X, 2H), 7.24–7.28 (AA'BB'C, 1H), 7.31 (d, 1H, *J* = 8.0 Hz), 7.32–7.36 (m, 2H), 7.44–7.48 (d, 2H, *J* = 7.3 Hz), 8.09–8.13 (AA'BB'X, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 25.5 (3C), 61.5 (1C), 67.7 (1C), 113.6 (1C), 116.0 (d, 2C, $^2J_{C–F}$ = 20.3 Hz), 120.6 (1C), 127.3 (2C), 127.5 (1C), 127.6 (1C), 128.7 (2C), 129.7 (d, 2C, $^3J_{C–F}$ = 8.6 Hz), 129.9 (d, 1C, $^4J_{C–F}$ = 3.4 Hz), 136.5 (1C), 137.2 (1C), 144.1 (1C), 149.0 (1C), 164.4 (d, 1C, $^1J_{C–F}$ = 251.3 Hz), 166.5 (1C); ^{19}F NMR (376 MHz, $CDCl_3$) δ –109.5 (s); IR (KBr, cm^{-1}) 836, 1157, 1228, 1274, 1365, 1482, 1522, 1575, 1600, 2973; HRMS (ESI^+) *m*/*z* 427.1264 ($[M+Na]^+$, $C_{24}H_{21}FN_2NaOS^+$ requires 427.1251).

3-Benzyl-7-(4-fluorophenyl)-3*H*-1,2,3-triazolo[3,4]benzo[2,1-*d*]thiazole (**18**)

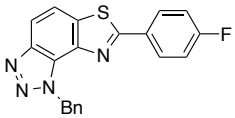


Colorless solid; Mp 206–207 °C; R_f 0.15 (*n*-hexane/EtOAc = 4/1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 5.94 (s, 2H), 7.15–7.23 (AA'BB'X, 2H), 7.27–7.31 (m, 2H), 7.32–7.37 (m, 3H), 7.35 (d, 1H, *J* = 8.3 Hz), 7.84 (d, 1H, *J* = 8.3 Hz), 8.20–8.25 (AA'BB'X, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 52.7 (1C), 107.6 (1C), 116.2 (d, 2C, $^2J_{C–F}$ = 22.2 Hz), 120.7 (1C), 127.5 (2C), 128.6 (1C), 129.1 (2C), 129.7 (d, 2C, $^3J_{C–F}$ = 8.9 Hz), 129.8 (d, 1C, $^4J_{C–F}$ = 2.6 Hz), 130.9 (1C), 132.9 (1C), 134.6 (1C), 140.6 (1C), 144.8 (1C), 164.6 (d, 1C, $^1J_{C–F}$ = 252.1 Hz), 169.3 (1C); ^{19}F NMR (376 MHz, $CDCl_3$) δ –108.9 (s); IR (KBr, cm^{-1}) 835, 1098, 1236, 1408, 1596, 2926, 3033, 3065; Anal. calcd for $C_{20}H_{13}FN_4S$: C, 66.65; H, 3.64; N, 15.55%; Found: C, 66.84; H, 3.51; N, 15.63%.

The structure was confirmed by the NOESY experiment.

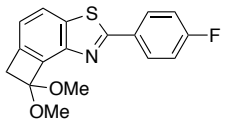


1-Benzyl-7-(4-fluorophenyl)-1*H*-1,2,3-triazolo[3,4]benzo[2,1-*d*]thiazole (**18'**)



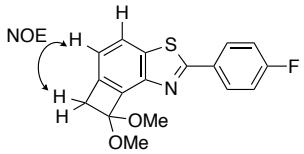
Colorless solid; Mp 196–197 °C; TLC R_f 0.25 (*n*-hexane/EtOAc = 4/1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 6.35 (s, 2H), 7.20–7.33 (m, 5H), 7.57–7.61 (AA'BB'C, 2H), 7.78 (d, 1H, *J* = 8.8 Hz), 8.01 (d, 1H, *J* = 8.8 Hz), 8.10–8.15 (AA'BB'X, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 53.3 (1C), 116.4 (d, 2C, $^2J_{C–F}$ = 22.4 Hz), 117.1 (1C), 117.4 (1C), 127.3 (1C), 128.3 (1C), 128.4 (2C), 128.8 (2C), 129.2 (d, 2C, $^3J_{C–F}$ = 8.5 Hz), 129.7 (d, 1C, $^4J_{C–F}$ = 3.0 Hz), 134.4 (1C), 136.0 (1C), 138.7 (1C), 146.0 (1C), 164.6 (d, 1C, $^1J_{C–F}$ = 252.7 Hz), 167.8 (1C); ^{19}F NMR (376 MHz, $CDCl_3$) δ –108.8 (s); IR (KBr, cm^{-1}) 839, 1100, 1157, 1233, 1409, 1603, 2955, 3033, 3069; Anal. calcd for $C_{20}H_{13}FN_4S$: C, 66.65; H, 3.64; N, 15.55%; Found: C, 66.47; H, 3.53; N, 15.49%.

2-(4-Fluorophenyl)-7,7-dimethoxy-6,7-dihydrocyclobuta[5,6]benzo[1,2-*d*]thiazole (**19**)

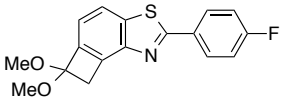


Colorless solid; Mp 111–112 °C; TLC R_f 0.63 (*n*-hexane/EtOAc = 4/1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 3.50 (s, 2H), 3.67 (s, 6H), 7.12–7.19 (AA'BB'X, 2H), 7.25 (d, 1H, *J* = 7.5 Hz), 7.88 (d, 1H, *J* = 7.5 Hz), 8.08–8.14 (AA'BB'X, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 43.4 (1C), 52.3 (2C), 105.9 (1C), 115.9 (d, 2C, $^2J_{C–F}$ = 22.3 Hz), 120.4 (1C), 123.6 (1C), 129.7 (d, 2C, $^3J_{C–F}$ = 8.5 Hz), 129.9 (d, 1C, $^4J_{C–F}$ = 3.0 Hz), 134.8 (1C), 137.8 (1C), 140.5 (1C), 146.9 (1C), 164.5 (d, 1C, $^1J_{C–F}$ = 252.0 Hz), 168.3 (1C); ^{19}F NMR (376 MHz, $CDCl_3$) δ –109.2 (s); IR (KBr, cm^{-1}) 858, 964, 1063, 1109, 1207, 1404, 1599, 2832, 2933, 2988; Anal. calcd for $C_{17}H_{14}FNO_2S$: C, 64.75; H, 4.47; N, 4.44. Found: C, 64.61; H, 4.39; N, 4.41%.

The regiochemistry was determined by the NOESY experiment.

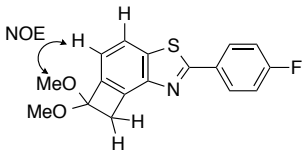


2-(4-Fluorophenyl)-6,6-dimethoxy-6,7-dihydrocyclobuta[5,6]benzo[1,2-*d*]thiazole (**19'**)

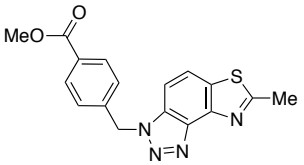


Colorless solid; Mp 90–93 °C; TLC R_f 0.55 (*n*-hexane/EtOAc = 4/1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 3.51 (s, 6H), 3.74 (s, 2H), 7.17–7.21 (AA'BB'X, 2H), 7.33 (d, 1H, *J* = 7.9 Hz), 7.84 (d, 1H, *J* = 7.9 Hz), 8.06–8.11 (AA'BB'X, 2H, aromatic); ^{13}C NMR (126 MHz, $CDCl_3$) δ 42.9 (1C), 51.6 (2C), 105.3 (1C), 116.2 (d, 2C, $^2J_{C\text{-}F}$ = 22.3 Hz), 117.8 (1C), 121.2 (1C), 129.7 (d, 2C, $^3J_{C\text{-}F}$ = 8.9 Hz), 129.9 (d, 1C, $^4J_{C\text{-}F}$ = 3.6 Hz), 135.0 (1C), 137.3 (1C), 143.9 (1C), 149.4 (1C), 164.6 (d, 1C, $^1J_{C\text{-}F}$ = 252.3 Hz), 168.2 (1C); ^{19}F NMR (376 MHz, $CDCl_3$) δ –109.1 (s); IR (KBr, cm^{-1}) 838, 975, 1041, 1165, 1275, 1599, 2830, 2904, 2936, 2952; HRMS (ESI^+) *m*/*z* 338.0608 ($[M+Na]^+$, $C_{17}H_{14}FNNaO_2S^+$ requires 338.0621).

The regiochemistry was determined by the NOESY experiment.

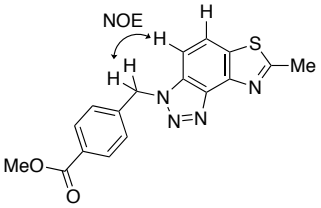


3*H*-3-(4-Methoxycarbonylbenzyl)-7-methyl-1,2,3-triazolo[3,4]benzo[2,1-*d*]thiazole (**21**)

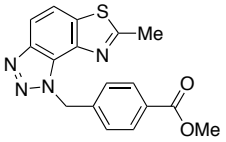


Colorless solid; Mp 233–234 °C; TLC R_f 0.32 (*n*-hexane/EtOAc = 1/2); ^{1}H NMR (500 MHz, $CDCl_3$) δ 2.98 (s, 3H), 3.89 (s, 3H), 5.98 (s, 2H), 7.29 (d, 1H, *J* = 8.8 Hz), 7.31–7.34 (AA'BB', 2H), 7.81 (d, 1H, *J* = 8.8 Hz), 7.97–8.02 (AA'BB', 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 20.3 (1C), 52.2 (1C), 52.3 (1C), 106.6 (1C), 120.9 (1C), 127.4 (2C), 130.35 (2C), 130.44 (1C), 131.4 (1C), 132.6 (1C), 139.5 (1C), 140.3 (1C), 144.0 (1C), 166.4 (1C), 170.0 (1C); IR (KBr, cm^{-1}) 835, 1089, 1109, 1176, 1240, 1432, 1613, 1722, 2956, 3010; HRMS (ESI^+) *m*/*z* 361.0719 ($[M+Na]^+$, $C_{17}H_{14}N_4NaO_2S^+$ requires 361.0730).

The regiochemsitry was determined by the NOESY experiment.

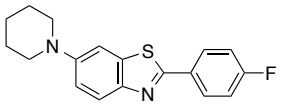


1*H*-1-(4-Methoxycarbonylbenzyl)-7-methyl-1,2,3-triazolo[3,4]benzo[2,1-*d*]thiazole (**21'**)



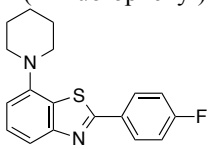
Colorless solid; Mp 175–176 °C; TLC R_f 0.64 (*n*-hexane/EtOAc = 1/2); ^{1}H NMR (500 MHz, $CDCl_3$) δ 2.94 (s, 3H), 3.89 (s, 3H), 6.35 (s, 2H), 7.58 (d, 2H, *J* = 8.3 Hz), 7.76 (d, 1H, *J* = 8.9 Hz), 7.99 (d, 2H, *J* = 8.3 Hz), 8.00 (d, 1H, *J* = 8.9 Hz); ^{13}C NMR (126 MHz, $CDCl_3$) δ 20.2 (1C), 52.2 (1C), 52.6 (1C), 116.4 (1C), 117.4 (1C), 127.0 (1C), 128.3 (2C), 130.0 (2C+1C, two signals overlapped), 135.1 (1C), 137.6 (1C), 140.8 (1C), 145.7 (1C), 166.7 (1C), 168.0 (1C); IR (KBr, cm^{-1}) 918, 1021, 1179, 1238, 1418, 1615, 1716, 2951, 2996; HRMS (ESI^+) *m*/*z* 339.0898 ($[M+H]^+$, $C_{17}H_{15}N_4O_2S^+$ requires 339.0910).

2-(4-Fluorophenyl)-6-piperidinobenzo[*d*]thiazole (**23**)



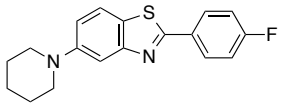
Pale yellow solid; Mp 162–164 °C; TLC R_f 0.48 (*n*-hexane/EtOAc = 4/1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.58–1.64 (m, 2H), 1.71–1.78 (m, 4H), 3.21–3.25 (m, 4H), 7.12–7.18 (m, 3H), 7.32 (d, 1H, J = 2.4 Hz), 7.88 (d, 1H, J = 9.0 Hz), 7.98–8.03 (AA'BB'X, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 24.2 (1C), 25.9 (2C), 51.2 (2C), 107.0 (1C), 116.0 (d, 2C, $^2J_{C–F}$ = 22.1 Hz), 117.8 (1C), 123.1 (1C), 129.0 (d, 2C, $^3J_{C–F}$ = 8.5 Hz), 130.4 (d, 1C, $^4J_{C–F}$ = 3.4 Hz), 136.7 (1C), 147.6 (1C), 150.5 (1C), 163.2 (1C), 164.0 (d, 1C, $^1J_{C–F}$ = 250.5 Hz); ^{19}F NMR (376 MHz, $CDCl_3$) δ –110.6 (s); IR (KBr, cm^{-1}) 838, 937, 1096, 1159, 1466, 1486, 1589, 1605, 2814, 2932; HRMS (ESI$^+$) m/z 313.1162 ([M+H]$^+$, $C_{18}H_{18}FN_2S^+$ requires 313.1169).

2-(4-Fluorophenyl)-7-piperidinobenzo[*d*]thiazole (**23'**)



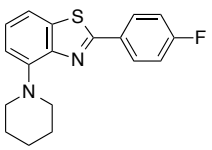
Pale yellow solid; Mp 105–108 °C; TLC R_f 0.63 (*n*-hexane/EtOAc = 4/1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.62–1.68 (m, 2H), 1.76–1.83 (m, 4H), 3.14–3.19 (m, 4H), 6.94 (dd, 1H, J = 9.8, 1.0 Hz), 7.15–7.19 (AA'BB'X, 2H), 7.41 (dd, 1H, J = 9.8, 9.8 Hz), 7.71 (dd, 1H, J = 9.8, 1.0 Hz), 8.07–8.13 (AA'BB'X, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 24.5 (1C), 26.4 (2C), 52.3 (2C), 113.6 (1C), 116.1 (d, 2C, $^2J_{C–F}$ = 22.1 Hz), 117.1 (1C), 127.2 (1C), 128.8 (1C), 129.4 (d, 2C, $^3J_{C–F}$ = 8.5 Hz), 130.1 (d, 1C, $^4J_{C–F}$ = 2.9 Hz), 148.5 (1C), 155.3 (1C), 164.4 (d, 1C, $^1J_{C–F}$ = 251.3 Hz), 166.4 (1C); ^{19}F NMR (376 MHz, $CDCl_3$) δ –109.8 (s); IR (KBr, cm^{-1}) 838, 1155, 1220, 1380, 1465, 1519, 1602, 2807, 2853, 2935; HRMS (ESI$^+$) m/z 335.0998 ([M+Na]$^+$, $C_{18}H_{17}FN_2NaS^+$ requires 335.0989).

2-(4-Fluorophenyl)-5-piperidinobenzo[*d*]thiazole (**24**)



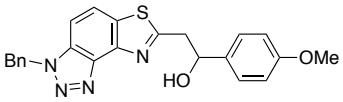
Pale yellow solid; Mp 110–111 °C; TLC R_f 0.65 (*n*-hexane/EtOAc = 3/1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.57–1.64 (m, 2H), 1.72–1.79 (m, 4H), 3.20–3.25 (m, 4H), 7.09 (dd, 1H, J = 8.8, 2.4 Hz), 7.10–7.26 (AA'BB'X, 2H), 7.54 (d, 1H, J = 2.4 Hz), 7.67 (d, 1H, J = 8.8 Hz), 8.00–8.05 (AA'BB'X, 2H, aromatic); ^{13}C NMR (126 MHz, $CDCl_3$) δ 24.3 (1C), 25.8 (2C), 51.3 (2C), 109.3 (1C), 116.1 (d, 2C, $^2J_{C–F}$ = 22.1 Hz), 117.5 (1C), 121.4 (1C), 125.6 (1C), 129.3 (d, 2C, $^3J_{C–F}$ = 8.7 Hz), 130.3 (d, 1C, $^4J_{C–F}$ = 3.4 Hz), 151.9 (1C), 155.6 (1C), 164.3 (1C, $^1J_{C–F}$ = 251.2 Hz), 167.2 (1C); ^{19}F NMR (376 MHz, $CDCl_3$) δ –109.9 (s); IR (KBr, cm^{-1}) 810, 838, 910, 958, 970, 1026, 1097, 1127, 1155, 1188, 1231, 1339, 1385, 1464, 1519, 1544, 1599, 2807, 2852, 2933, 3071; Anal. calcd for $C_{18}H_{17}FN_2S$: C, 69.20; H, 5.49; N, 8.97%; Found: C, 69.20; H, 5.44; N, 8.89%.

2-(4-Fluorophenyl)-4-piperidinobenzo[*d*]thiazole (**24'**)



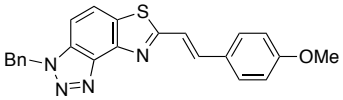
Yellow oil; TLC R_f 0.75 (*n*-hexane/EtOAc = 3/1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 1.63–1.70 (m, 2H), 1.85–1.91 (m, 4H), 3.42–3.47 (m, 4H), 6.90 (dd, 1H, J = 8.0, 0.7 Hz), 7.13–7.18 (AA'BB'X, 2H), 7.27 (dd, 1H, J = 8.0, 8.0 Hz), 7.44 (dd, 1H, J = 8.0, 0.7 Hz), 8.05–8.10 (AA'BB'X, 2H); ^{13}C NMR (126 MHz, $CDCl_3$) δ 24.6 (1C), 26.2 (2C), 52.4 (2C), 113.0 (1C), 113.7 (1C), 116.0 (d, 2C, $^2J_{C–F}$ = 22.1 Hz), 126.1 (1C), 129.3 (d, 2C, $^3J_{C–F}$ = 8.7 Hz), 130.3 (d, 1C, $^4J_{C–F}$ = 2.9 Hz), 136.7 (1C), 146.4 (1C), 147.7 (1C), 163.1 (1C), 164.2 (d, 1C, $^1J_{C–F}$ = 251.0 Hz); ^{19}F NMR (376 MHz, $CDCl_3$) δ –110.3 (s); IR (KBr, cm^{-1}) 837, 947, 981, 1155, 1231, 1247, 1311, 1385, 1449, 1486, 1519, 1568, 1603, 2804, 2852, 2933, 3064; HRMS (ESI$^+$) m/z 313.1165 ([M+H]$^+$, $C_{18}H_{18}FN_2S^+$ requires 313.1169).

3-Benzyl-7-(2-hydroxy-2-(4-methoxyphenyl)ethyl)-3*H*-1,2,3-triazolo[3,4]benzo[2,1-*d*]thiazole (**25**)



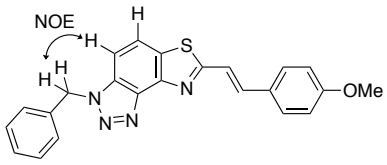
Pale yellow oil; TLC R_f 0.37 (*n*-hexane/EtOAc = 7/3); ^{1}H NMR (500 MHz, $CDCl_3$) δ 3.54–3.62 (m, 2H), 3.76 (br s, 1H), 3.80 (s, 3H), 5.34–5.39 (m, 1H), 5.93 (s, 2H), 6.88–6.91 (AA'BB', 2H), 7.27–7.37 (m, 6H), 7.37–7.40 (AA'BB', 2H), 7.77 (d, 1H, J = 8.8 Hz); ^{13}C NMR (126 MHz, $CDCl_3$) δ 43.4 (1C), 52.7 (1C), 55.3 (1C), 72.4 (1C), 107.3 (1C), 113.9 (2C), 120.6 (1C), 127.1 (2C), 127.5 (2C), 128.6 (1C), 129.1 (2C), 130.8 (1C), 132.7 (1C), 134.6 (1C), 135.0 (1C), 140.2 (1C), 143.5 (1C), 159.2 (1C), 171.3 (1C); IR (KBr, cm^{-1}) 703, 734, 833, 909, 1033, 1103, 1176, 1200, 1246, 1301, 1357, 1456, 1513, 1611, 3356; HRMS (FAB^+) *m*/*z* 417.1390 ($[M+H]^+$, $C_{23}H_{21}N_4O_2S^+$ requires 417.1380).

(*E*)-3-Benzyl-7-(4-methoxystyryl)-3*H*-1,2,3-triazolo[3,4]benzo[2,1-*d*]thiazole (**26**)



Pale yellow solid; Mp 135–137 °C; TLC R_f 0.63 (CH_2Cl_2/EtOAc = 9/1); ^{1}H NMR (500 MHz, $CDCl_3$) δ 3.86 (s, 3H), 5.93 (s, 2H), 6.93–6.97 (AA'BB', 2H), 7.27–7.36 (m, 6H), 7.38 (d, 1H, J = 16.1 Hz), 7.54–7.58 (AA'BB', 2H), 7.69 (d, 1H, J = 16.1 Hz), 7.80 (d, 1H, J = 8.8 Hz); ^{13}C NMR (126 MHz, $CDCl_3$) δ 52.7 (1C), 55.4 (1C), 107.1 (1C), 114.4 (2C), 119.4 (1C), 120.6 (1C), 127.5 (2C), 128,1 (1C), 128.5 (1C), 129.1 (2C+2C, two signals overlapped), 130.0 (1C), 132.8 (1C), 134.6 (1C), 137.4 (1C), 140.4 (1C), 144.7 (1C), 160.8 (1C), 169.9 (1C); IR (KBr, cm^{-1}) 704, 730, 910, 1034, 1099, 1179, 1249, 1288, 1306, 1447, 1456, 1513, 1610; HRMS (FAB^+) *m*/*z* 399.1277 ($[M+H]^+$, $C_{23}H_{19}N_4OS^+$ requires 399.1274).

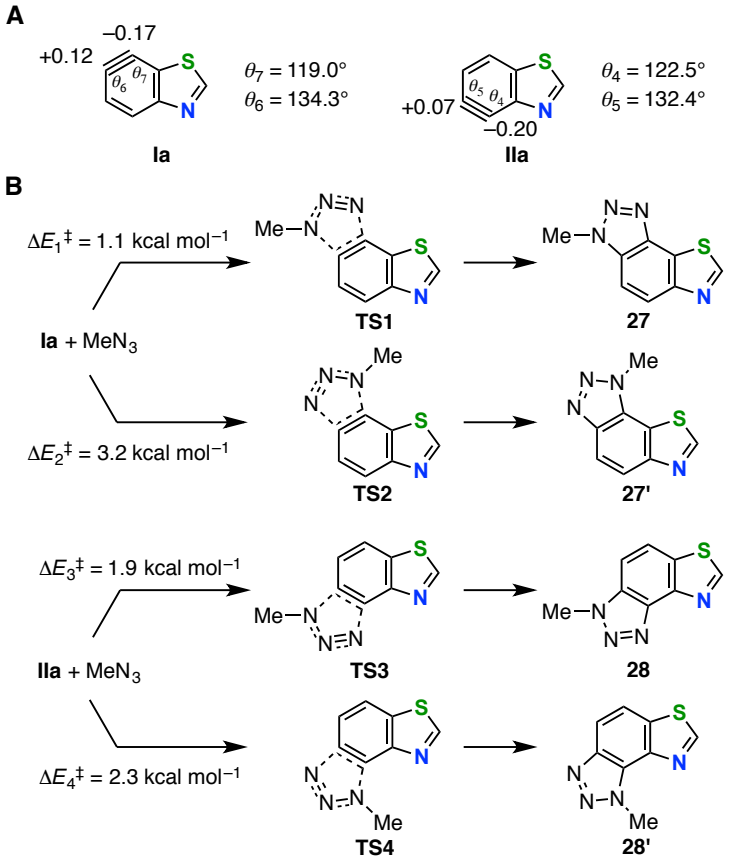
The regiochemsitry was determined by the NOESY experiment.



Computational Methods

Cartesian Coordinates

In the following pages (S17–S25) are shown the optimized Cartesian coordinates of methyl azide, thiazolobenzynes (**Ia** and **IIa**), reactant complexes, transition states (**TS1–4**), and products (**27**, **27'**, **28**, and **28'**) obtained at the M11-L/6-31G(d) level of theory.[S7,S8] The values are shown in units of Angstrom. Total energies and zero-point energies (ZPEs, with no scaling) are shown in units of Hartree. Imaginary vibrational frequencies (in cm^{-1}) at the transition states are also included. Atomic charges of thiazolobenzynes (**Ia** and **IIa**) were calculated using the CHELPG scheme.[S9]



Methyl azide
Total Energy: -204.0219829942 [hartree]
ZPE: 0.050419 [hartree]

N	-3.5121383987	-2.0822188190	1.1151151143
N	-3.2373219760	-1.0880286709	0.6532866173
N	-2.7893046745	-0.0909458108	0.1181349115
C	-3.6884780119	1.0398283968	0.0985033278
H	-4.6170756999	0.8279510490	-0.4622061509
H	-3.9592936493	1.3782421811	1.1152112516
H	-3.1564395897	1.8546796738	-0.4076290715

6,7-Thiazolobenzyne (Ia)
Total Energy: -721.2480608773 [hartree]
ZPE: 0.076727 [hartree]

C	-0.0548463212	-1.3956235819	0.0000000000
C	-0.2738627715	1.3231500523	0.0000000000
C	1.0069890880	0.8308374556	0.0000000000
C	1.0976850694	-0.5935783717	0.0000000000
C	-1.2294793239	0.5224489577	0.0000000000
C	-1.3344712705	-0.8465275419	0.0000000000
H	-2.2466118836	-1.4471653881	0.0000000000
H	0.0718195266	-2.4838067192	0.0000000000
S	2.5870721506	1.5171482817	0.0000000000
N	2.3720819923	-1.0716709280	0.0000000000
C	3.2099433882	-0.1013962164	0.0000000000
H	4.2936803555	-0.2538160003	0.0000000000

4,5-Thiazolobenzyne (IIa)
Total Energy: -721.2485683007 [hartree]
ZPE: 0.076847 [hartree]

C	-0.0898356269	-1.2560099262	0.0000000000
C	-0.1745334046	1.4508882502	0.0000000000
C	1.0402687677	0.7628452218	0.0000000000
C	1.1578094348	-0.6637732207	0.0000000000
C	-1.3872701730	0.7584781533	0.0000000000
C	-1.1438405569	-0.5936314956	0.0000000000
H	-2.3556141080	1.2649669649	0.0000000000
H	-0.1866029278	2.5469505051	0.0000000000
S	2.6301106371	1.4240700462	0.0000000000
N	2.4151414832	-1.1606813246	0.0000000000
C	3.2553693207	-0.1915646197	0.0000000000
H	4.3389971536	-0.3425385546	0.0000000000

Reactant Complex (Ia + methyl azide)
Total Energy: -925.2761816401 [hartree]
ZPE: 0.128158 [hartree]

C	-0.0978591362	-2.0129898015	0.2316618459
H	-0.5759990593	-2.9853637804	0.3721558123
C	-0.6642114384	-0.7737365620	0.3572753640
C	1.2455447124	-1.8543497724	-0.0996328762
C	1.8140738660	-0.5788836934	-0.2503701186
C	-0.2975741152	0.4207519747	0.2535175051
C	1.0300510442	0.5973211931	-0.0695438788
H	1.8851621010	-2.7321811771	-0.2415451102
S	2.0230415041	1.9899885450	-0.3161382486
C	3.3420429044	0.9098824068	-0.6270466643
N	3.1188559557	-0.3517437196	-0.5659148725
H	4.3262517037	1.3251985305	-0.8656245668
N	-3.2616234506	-0.9399678611	0.7313816716
N	-3.3381177028	0.2775396801	0.6817162224
N	-3.2954975211	1.4001550191	0.7764155958
C	-3.7245679478	-1.6189254763	-0.4598504603
H	-3.1777775315	-1.2961606523	-1.3641556846
H	-3.5400781767	-2.6889104921	-0.3005064878
H	-4.8074614835	-1.4752553461	-0.6227574742

TS1
Total Energy: -925.2746162017 [hartree]
ZPE: 0.128352 [hartree]
Imaginary frequency: *i* 190.2 [cm^{-1}]

C	-0.2005821079	-1.9907228254	0.1632285534
H	-0.6877696868	-2.9628497856	0.2837079504
C	-0.7852323729	-0.7553107539	0.2731569926
C	1.1531120143	-1.8555124355	-0.1178400839
C	1.7316515566	-0.5833163502	-0.2412777085
C	-0.4067341930	0.4554758784	0.2036496264
C	0.9386280837	0.5851197184	-0.0752908488
H	1.7882457463	-2.7389680603	-0.2409550816
S	1.9492745439	1.9792767659	-0.2762138245
C	3.2747843741	0.9020460654	-0.5537362743
N	3.0477717252	-0.3603027414	-0.5113007682
H	4.2674896480	1.3163094756	-0.7570453326
N	-2.9318221714	-0.9034361997	0.6584214557
N	-3.1722962462	0.3022121091	0.6346391788
N	-3.0479888343	1.4205960937	0.7147353088
C	-3.6323780355	-1.6983145235	-0.3241768616
H	-3.4595179956	-1.3404408673	-1.3542399382
H	-3.2413078990	-2.7195614865	-0.2336302908
H	-4.7156791492	-1.7279520772	-0.1207090530

27

Total Energy: -925.4508899522 [hartree]
ZPE: 0.135573 [hartree]

C	-1.2560749993	-1.6400418442	-0.2726585707
H	-2.0982218963	-2.3245445630	-0.4142862965
C	-1.4182069517	-0.2509608239	-0.3202908439
C	0.0114205773	-2.1075664669	-0.0389123438
C	1.0898788341	-1.2177632021	0.1462933165
C	-0.3795198277	0.6664867186	-0.1420897900
C	0.9027408889	0.1721237545	0.0983368796
H	0.2178082667	-3.1810655462	0.0103599239
S	2.3877170660	0.9727039809	0.3626285467
C	3.1279835404	-0.5912298995	0.5125597277
N	2.3709376980	-1.6170025265	0.3836824538
H	4.2018135528	-0.6584485754	0.7099989097
N	-0.8717450903	1.9211179392	-0.2514803052
N	-2.1285964292	1.8361504203	-0.4829699680
N	-2.4804444317	0.5452683864	-0.5285124212
C	-3.8303003154	0.1849945698	-0.7787588311
H	-4.4008592616	1.1121232971	-0.9167647391
H	-3.9100210393	-0.4293149670	-1.6905177750
H	-4.2522611814	-0.3784106522	0.0695031266

Reactant Complex (Ia + methyl azide)
Total Energy: -925.2756970761 [hartree]
ZPE: 0.128016 [hartree]

C	0.6334546673	-1.9083227418	1.2382588100
H	0.4862539993	-2.7678125975	1.8950087356
C	-0.3240323294	-1.1672932768	0.5992999284
C	1.8827281138	-1.3920696830	0.9024465644
C	2.0167199857	-0.2869502977	0.0459274121
C	-0.3507493619	-0.1775707126	-0.1656524340
C	0.8716700743	0.3506306515	-0.5154364668
H	2.7913810541	-1.8534811421	1.3042100512
S	1.3761540602	1.6654508628	-1.5143314182
C	3.0112393207	1.2568432752	-1.1057617990
N	3.2071891294	0.2633842399	-0.3193487218
H	3.8295320800	1.8495443457	-1.5262954418
N	-3.0420960509	-2.0166581749	0.9587925708
N	-3.2993939862	-1.0974148644	0.3511798545
N	-3.5362765515	-0.2048800819	-0.4350505542
C	-3.6947924114	1.1027250102	0.1645151148
H	-4.6254144939	1.1710460542	0.7564478511
H	-2.8373260008	1.3712792062	0.8059955617
H	-3.7559022988	1.8212999269	-0.6618136190

TS2
Total Energy: -925.2708735637 [hartree]
ZPE: 0.128254 [hartree]
Imaginary frequency: *i* 244.2 [cm^{-1}]

C	0.6830325255	-2.0716532794	1.3569348601
H	0.7343276874	-2.9598971740	1.9961297153
C	-0.4933631348	-1.4993182679	0.8932780979
C	1.8339212575	-1.4212335637	0.9336299934
C	1.7695071088	-0.2877820458	0.1095803265
C	-0.5512900766	-0.4737169383	0.1573491921
C	0.5132163322	0.2281536261	-0.3202911899
H	2.8232969285	-1.7840167372	1.2334114740
S	0.7567203353	1.6124042260	-1.3187082325
C	2.4655080691	1.3925049485	-1.0785782890
N	2.8453338237	0.4111124334	-0.3499959743
H	3.1623184078	2.0874882968	-1.5564697529
N	-3.1085429418	-1.7153873242	1.1544723940
N	-3.1197299057	-0.7634062210	0.5386770860
N	-2.6997533595	0.0862489575	-0.2437571856
C	-2.9806847663	1.4594055447	0.0979102672
H	-4.0416322295	1.7080548569	-0.0738676495
H	-2.7092860445	1.7019044739	1.1403512386
H	-2.3739340169	2.0757761875	-0.5793833714

27'

Total Energy: -925.4492135145 [hartree]
ZPE: 0.135514 [hartree]

C	0.3287186372	-2.1505306519	1.1727251798
H	0.2416625309	-3.0935120155	1.7197840940
C	-0.7974195190	-1.3324512208	1.0022829917
C	1.5179038640	-1.7325279720	0.6408973856
C	1.6018482623	-0.5087991533	-0.0581856217
C	-0.7257937013	-0.1187988596	0.3113188727
C	0.4780123410	0.3160424066	-0.2318712744
H	2.4308434394	-2.3266526600	0.7402591398
S	0.9118234435	1.7213040451	-1.1168066698
C	2.5321084280	1.0987720551	-1.1791642500
N	2.7490546276	-0.0277933873	-0.6114851195
H	3.3059291899	1.6768367907	-1.6922493054
N	-2.0765645497	-1.5041470876	1.4197055666
N	-2.7701379694	-0.5022220036	1.0386619293
N	-1.9796576018	0.3515783343	0.3663147438
C	-2.5176840806	1.5524541990	-0.1666394360
H	-2.4140371797	1.5811290632	-1.2641236176
H	-3.5834928433	1.5794457631	0.0945990894
H	-2.0176753189	2.4358793545	0.2641123017

Reactant Complex (IIa + methyl azide)
Total Energy: -925.2756412279 [hartree]
ZPE: 0.128106 [hartree]

C	-0.2042787952	-1.8911567613	0.2911426420
H	-0.6779603140	-2.8729304440	0.3729057872
C	-0.8098204355	-0.6619900367	0.2731416671
C	1.1791922673	-1.7227947451	0.1990959838
C	1.7311619008	-0.4431259857	0.1097525788
C	-0.3981866645	0.5146142113	0.1941821505
C	0.9610562416	0.7623682558	0.1020843273
H	1.8280419898	-2.6060797589	0.2036407947
N	1.6662859919	1.9156449137	0.0132516718
C	2.9184745499	1.6487902051	-0.0440463815
S	3.3964198793	-0.0179294237	0.0012323951
H	3.6905610563	2.4203491340	-0.1187749302
N	-3.5755601238	-0.7261409554	0.1775149673
N	-3.5301971329	0.4908832311	0.1048801622
N	-3.4310108161	1.6107616120	0.1949963095
C	-3.7534495451	-1.3917785199	-1.0946526991
H	-2.9641485134	-1.1249969638	-1.8207915990
H	-3.6969266365	-2.4692282886	-0.8939961175
H	-4.7403194976	-1.1744034602	-1.5418055197

TS3
Total Energy: -925.2728102346 [hartree]
ZPE: 0.128260 [hartree]
Imaginary frequency: *i* 218.0 [cm^{-1}]

C	-0.3287365757	-1.8561608536	0.1599392314
H	-0.8158116564	-2.8356817499	0.1989566232
C	-0.9344335945	-0.6263999965	0.1516298337
C	1.0570974977	-1.7162488673	0.1207631968
C	1.6196796916	-0.4396196543	0.0881538493
C	-0.5268900665	0.5735245041	0.1350411439
C	0.8482542471	0.7609119644	0.0951016621
H	1.6932393320	-2.6080653303	0.1205650835
N	1.5680360434	1.9152831310	0.0669018654
C	2.8190923083	1.6463406242	0.0390717474
S	3.2906059870	-0.0247822662	0.0445389930
H	3.5967640571	2.4156931441	0.0126721967
N	-3.1278016508	-0.7070368704	0.1777017331
N	-3.2999408967	0.5070668389	0.0672578338
N	-3.0878533869	1.6151689227	0.1308846226
C	-3.6875814849	-1.5167681250	-0.8780172280
H	-3.3393316794	-1.2054769070	-1.8786524189
H	-3.3531480961	-2.5451618193	-0.6903285311
H	-4.7901010762	-1.5079096896	-0.8533104379

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Total Energy: -925.4470553708 [hartree]
ZPE: 0.135465 [hartree]

C	-0.4522964833	-1.9216310666	-0.1047487915
H	-0.8711835779	-2.9301298903	-0.1791656481
C	-1.2614399460	-0.7820467278	-0.0693891934
C	0.9053850906	-1.7219417270	-0.0426486337
C	1.4117736401	-0.4168214596	0.0508246987
C	-0.7804412582	0.5262139214	0.0271665664
C	0.6074314809	0.7353647153	0.0900447292
H	1.5876436834	-2.5773936965	-0.0675316583
N	1.2610841161	1.9183740538	0.1795732098
C	2.5274087967	1.7066137863	0.2085170842
S	3.0622684757	0.0641212935	0.1316836587
H	3.2660466269	2.5104179355	0.2786153766
N	-2.5927726734	-0.6089090863	-0.1135073436
N	-2.9046605202	0.6921411150	-0.0498821592
N	-1.8297838353	1.3813017370	0.0352589144
C	-3.6195049379	-1.5818985892	-0.2225998358
H	-3.5226066596	-2.1556798401	-1.1590787594
H	-3.5930192134	-2.2812237743	0.6291088248
H	-4.5795966331	-1.0502628801	-0.2231627258

Reactant Complex (IIa + methyl azide)
Total Energy: -925.2765848614 [hartree]
ZPE: 0.128152 [hartree]

C	-1.7353914502	1.8241802416	-0.4108592936
H	-2.6180788522	2.4481606683	-0.5754442929
C	-1.7087487063	0.5184053180	0.0264455728
C	-0.4390405864	2.2958401801	-0.6245331809
C	0.6650760411	1.4692048578	-0.4065841035
C	-0.7421980968	-0.2420648999	0.2273879880
C	0.5749035826	0.1146190679	0.0428404910
H	-0.2936275094	3.3276350888	-0.9647007134
N	1.7448374137	-0.5499160449	0.1888679371
C	2.7168639197	0.2301276385	-0.1182723271
S	2.3334043738	1.8433150851	-0.6183553335
H	3.7653197990	-0.0792405831	-0.0766014504
N	-3.5042457132	-2.2726222172	0.6101182551
N	-2.4427297217	-2.6099799361	0.8022860408
N	-1.3131487254	-2.8771674681	1.1630554962
C	-0.4526145520	-3.4407751320	0.1439609741
H	-0.5525409433	-4.5406772711	0.1083303455
H	-0.6542199193	-3.0281008103	-0.8600210932
H	0.5795998158	-3.1879958821	0.4218591169

TS4
Total Energy: -925.2735289432 [hartree]
ZPE: 0.128674 [hartree]
Imaginary frequency: *i* 217.3 [cm^{-1}]

C	-1.7268274944	1.7778784525	0.1863162834
H	-2.6293342700	2.3992439896	0.2350892271
C	-1.7192427319	0.3899137256	0.2382315018
C	-0.4713542756	2.3689835766	0.0722582387
C	0.6720555490	1.5709237600	0.0100187913
C	-0.6559765944	-0.2879769023	0.1733731654
C	0.6394669881	0.1470629648	0.0600724535
H	-0.3810746425	3.4608084824	0.0331972625
N	1.8340288034	-0.4898347258	-0.0221448619
C	2.7711891281	0.3822567431	-0.1255223311
S	2.3208148446	2.0531108712	-0.1384306763
H	3.8286991582	0.1134395216	-0.2044013255
N	-3.2490706957	-1.9444844201	0.2854755818
N	-2.2091765099	-2.3845669362	0.2044357245
N	-0.9872086849	-2.4651222808	0.2945645391
C	-0.3014708485	-3.1761804758	-0.7587503017
H	-0.4450241394	-4.2653881395	-0.6613752864
H	-0.6223498105	-2.8511269896	-1.7639034512
H	0.7642552261	-2.9458932173	-0.6316985351

28'

Total Energy: -925.4514722995 [hartree]
ZPE: 0.135597 [hartree]

C	-1.8851033234	1.3058450474	-0.1251509130
H	-2.8384153408	1.8412603984	-0.1545603147
C	-1.8572378593	-0.0719546342	0.1315652783
C	-0.6948253059	1.9543781919	-0.3365691239
C	0.5058795268	1.2247717897	-0.2869616814
C	-0.6585427052	-0.7850783629	0.1740354060
C	0.5725743639	-0.1542202012	-0.0329212750
H	-0.6761077629	3.0288014700	-0.5418172705
N	1.8083902462	-0.7138247286	-0.0143792198
C	2.6875684051	0.1948328485	-0.2462540994
S	2.1107322916	1.8031884246	-0.5088619574
H	3.7617794516	-0.0068651650	-0.2823185966
N	-2.8743231500	-0.9386285696	0.3699117133
N	-2.3798505218	-2.1031564225	0.5480058588
N	-1.0430373382	-2.0388195287	0.4363293001
C	-0.2524250659	-3.2124187608	0.5752593393
H	-0.9333109462	-4.0398896984	0.8122645204
H	0.2882387021	-3.4306810384	-0.3587932634
H	0.4854314658	-3.0909091230	1.3828262406

References for Supporting Information

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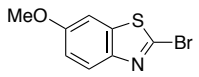
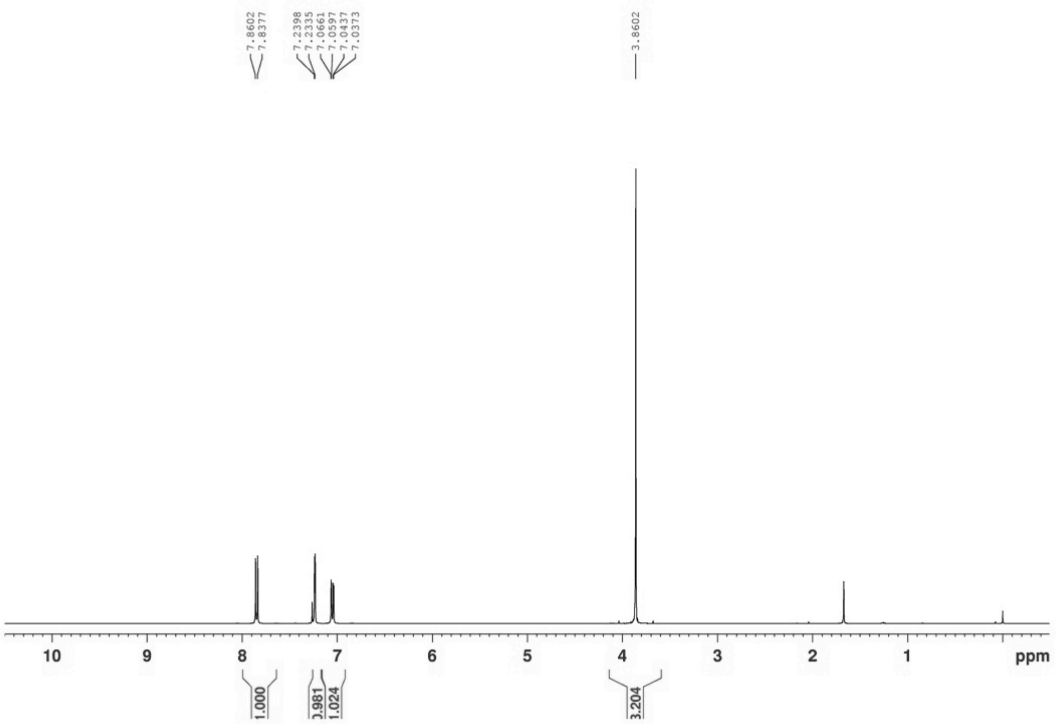
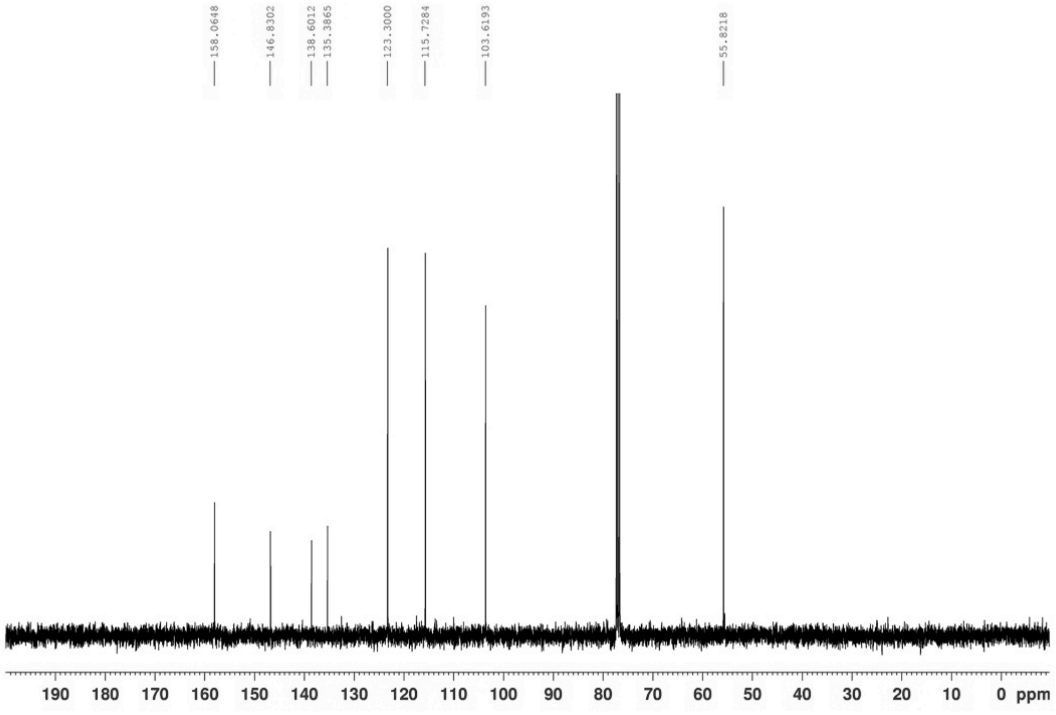
^{1}H and ^{13}C NMR Spectra of Compounds

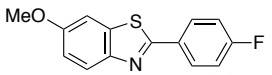
^{1}H NMR (400 MHz) and ^{13}C NMR (100 MHz) spectra of **S1** ($CDCl_3$)

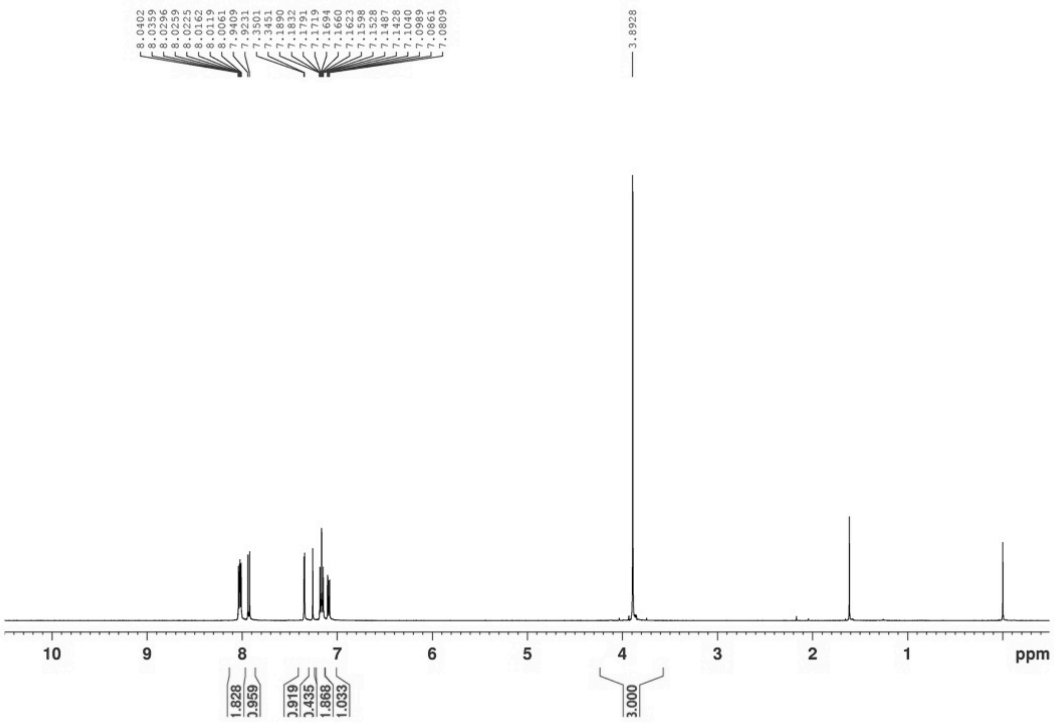


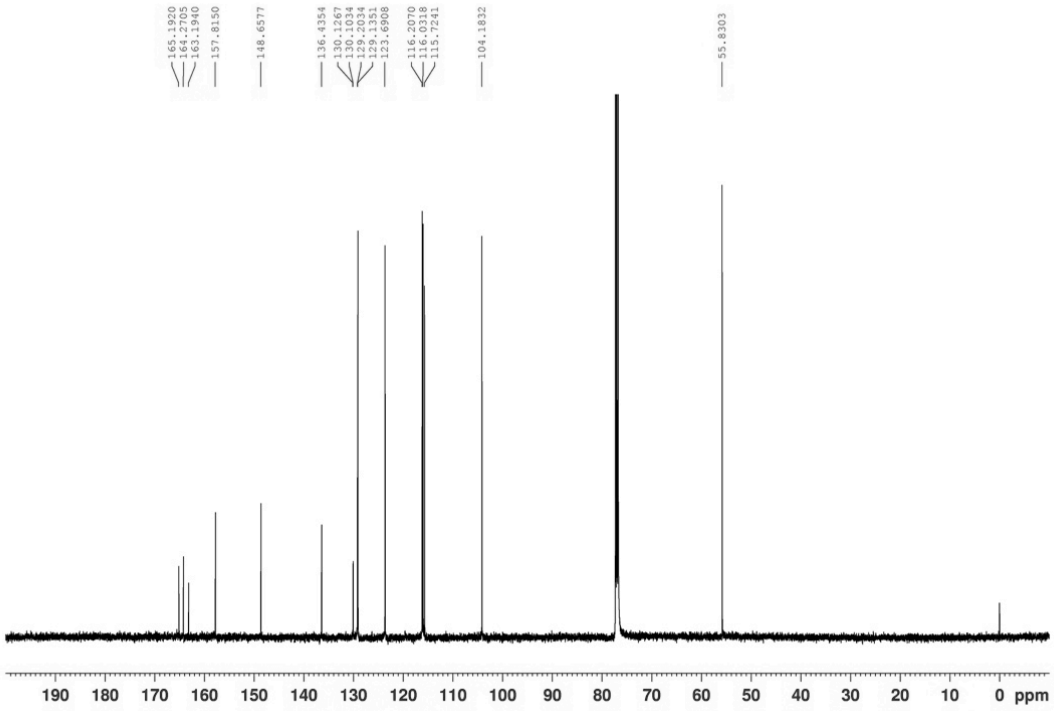




^{1}H NMR (500 MHz) and ^{13}C NMR (126 MHz) spectra of **S2** ($CDCl_3$)







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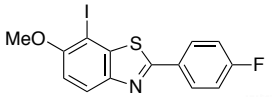
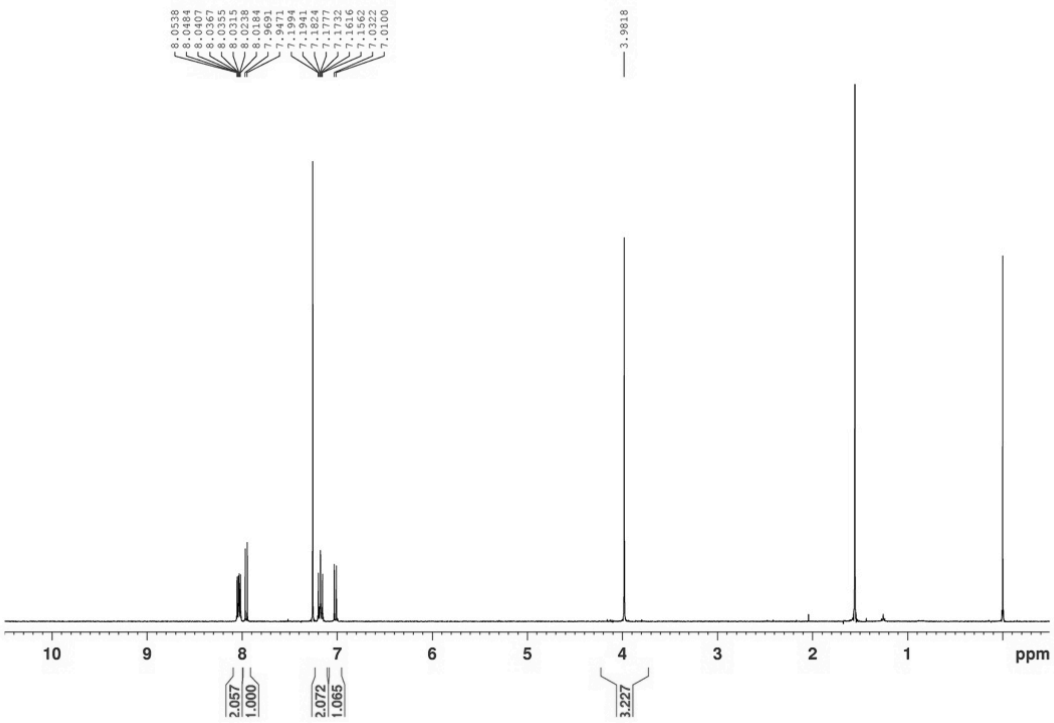
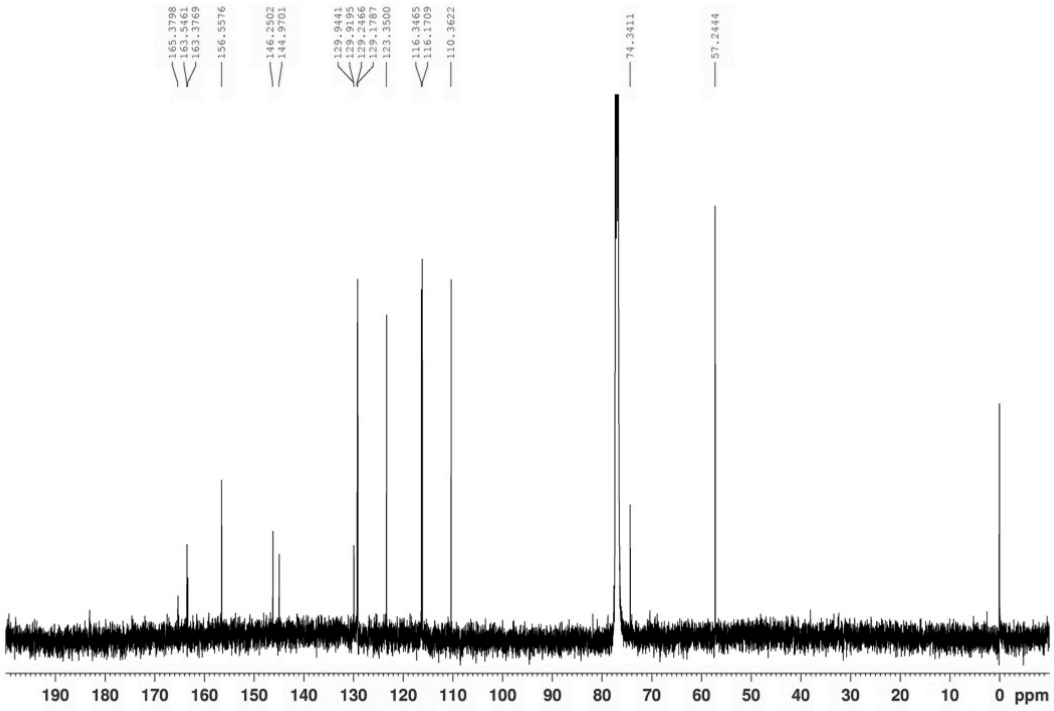
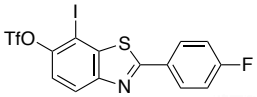
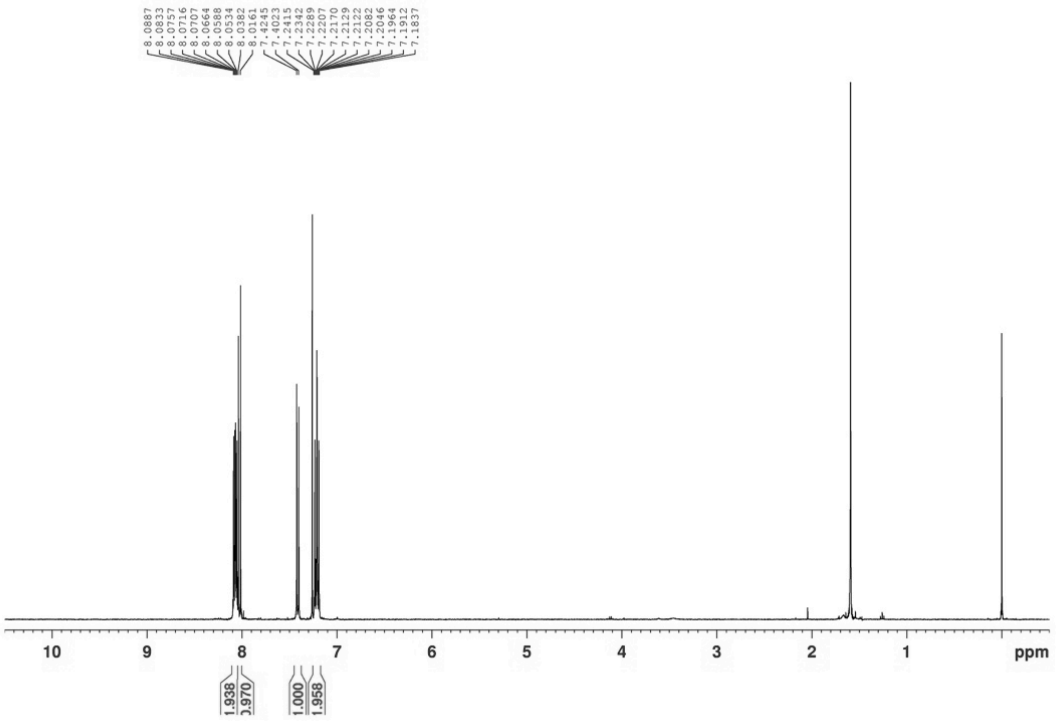


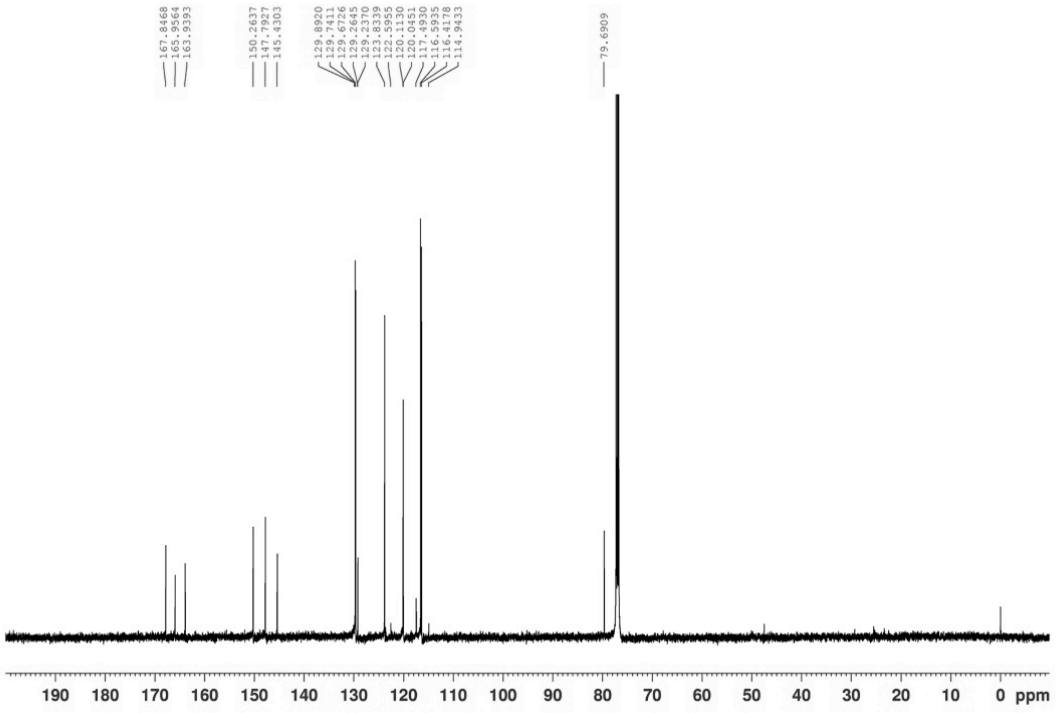




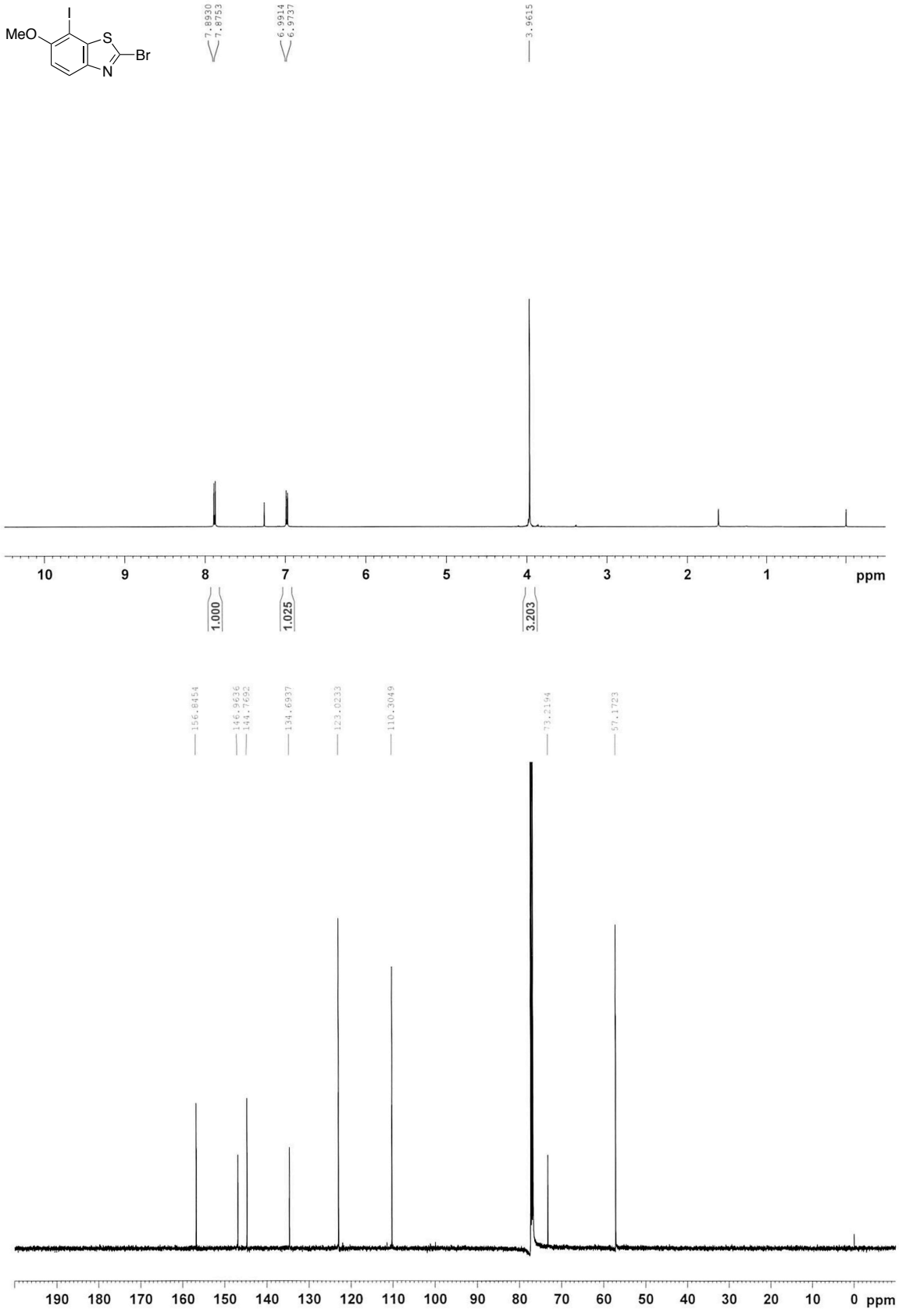
^{1}H NMR (400 MHz) and ^{13}C NMR (126 MHz) spectra of **1a** ($CDCl_3$)



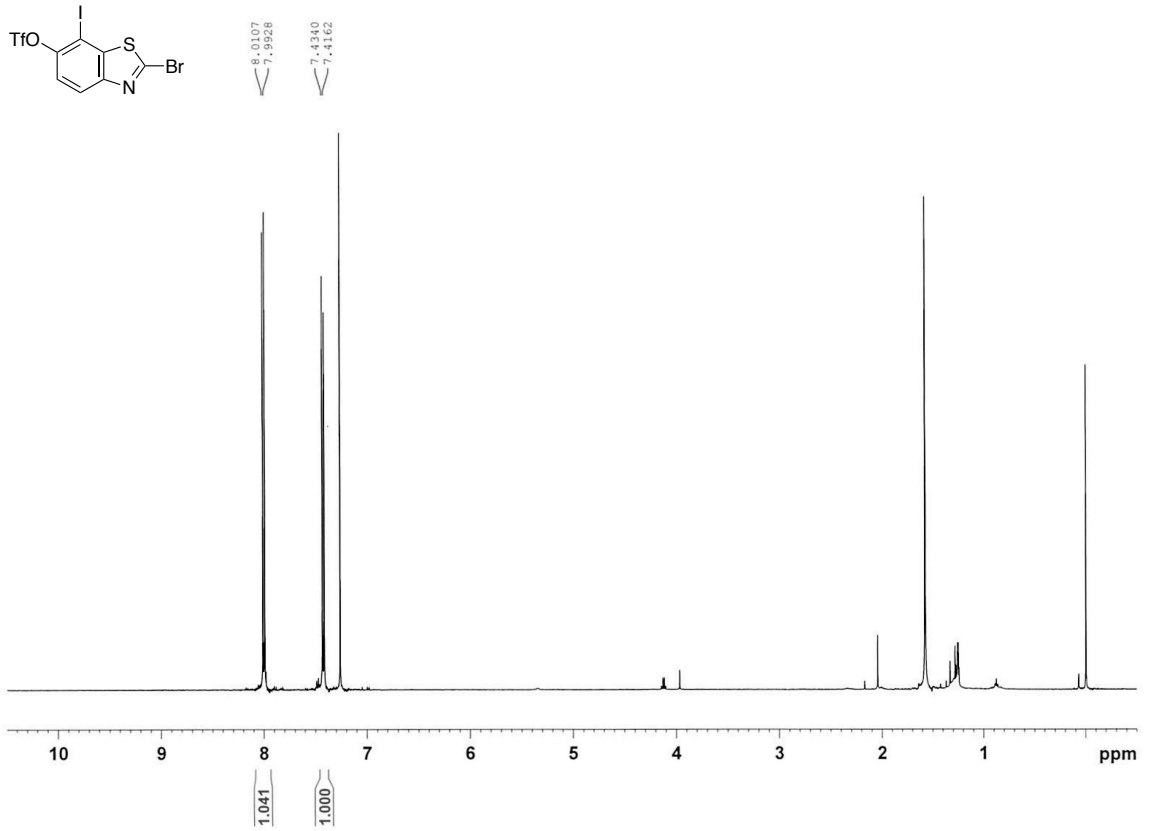


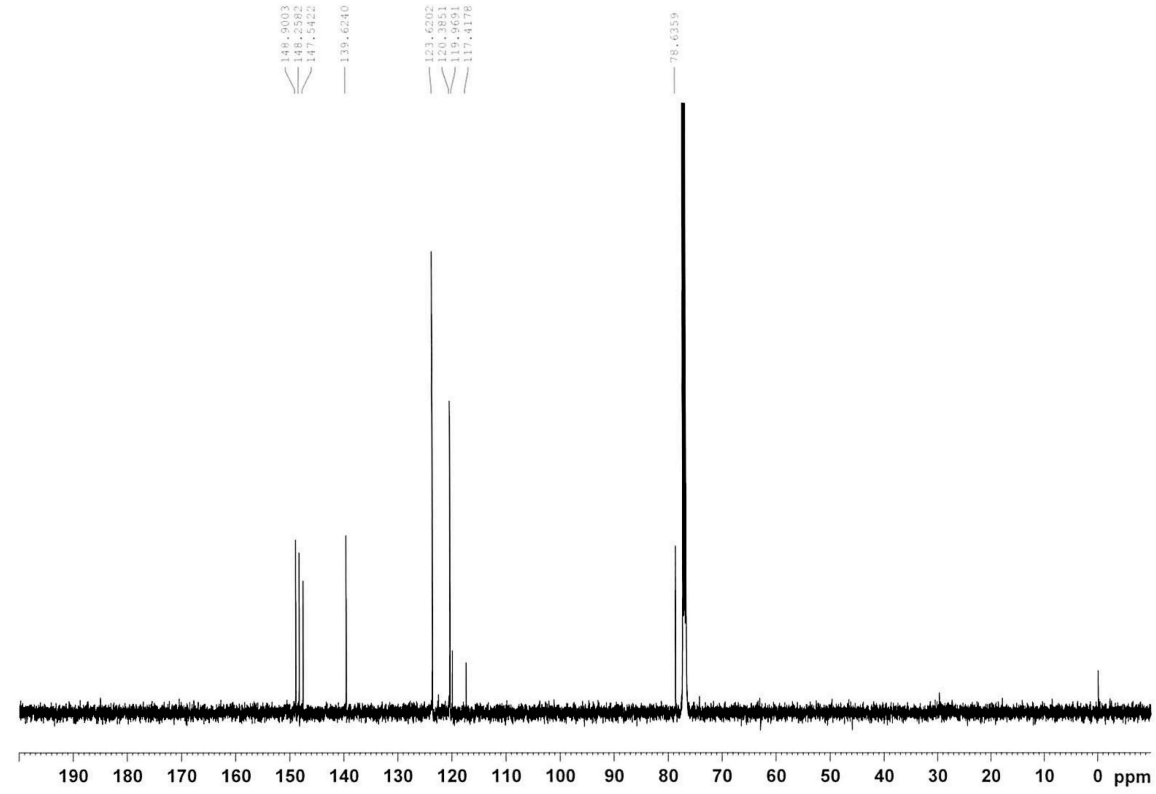


^{1}H NMR (500 MHz) and ^{13}C NMR (126 MHz) spectra of **S4** ($CDCl_3$)

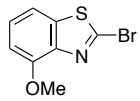


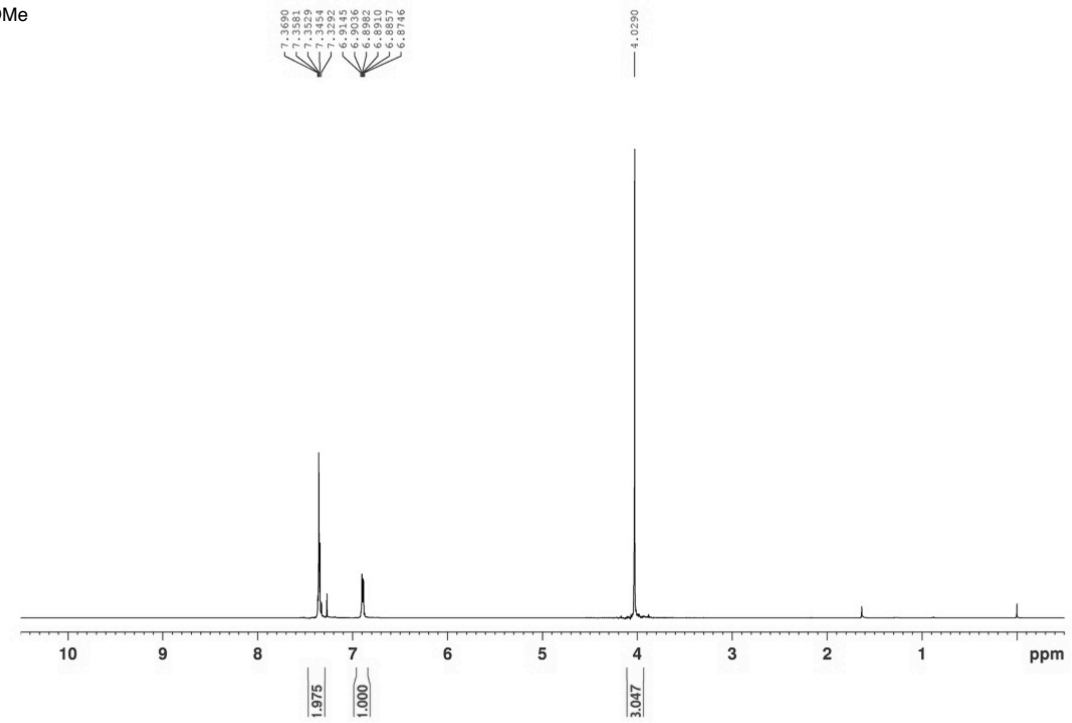
^{1}H NMR (500 MHz) and ^{13}C NMR (126 MHz) spectra of **1c** ($CDCl_3$)

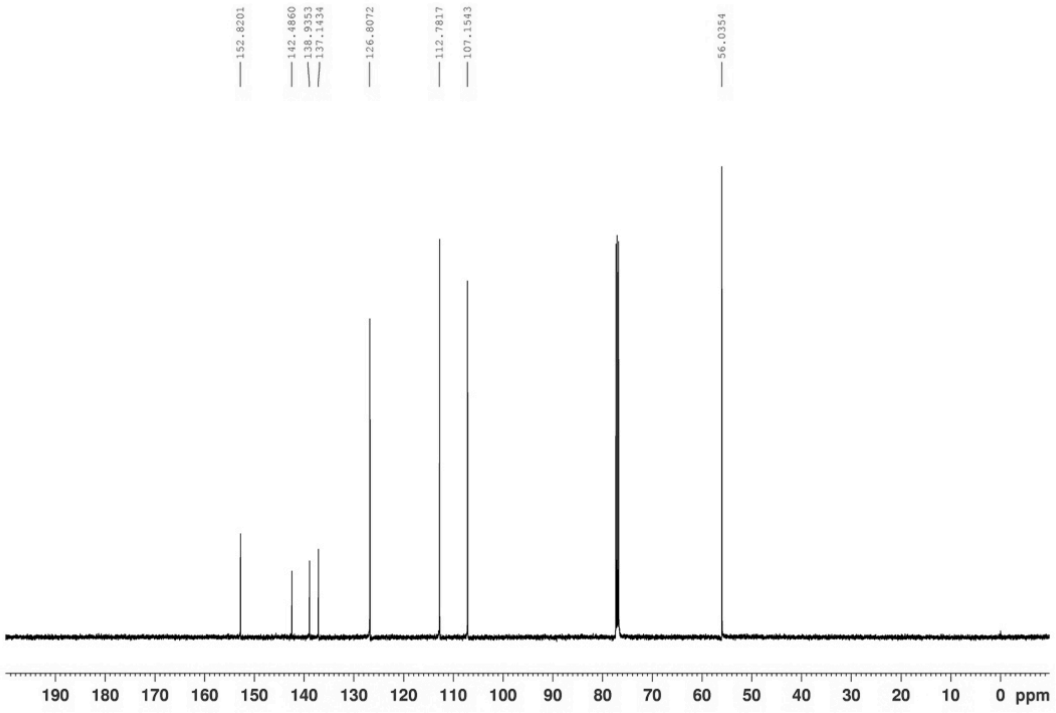




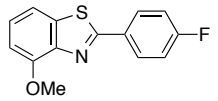
^{1}H NMR (500 MHz) and ^{13}C NMR (126 MHz) spectra of **S5** ($CDCl_3$)

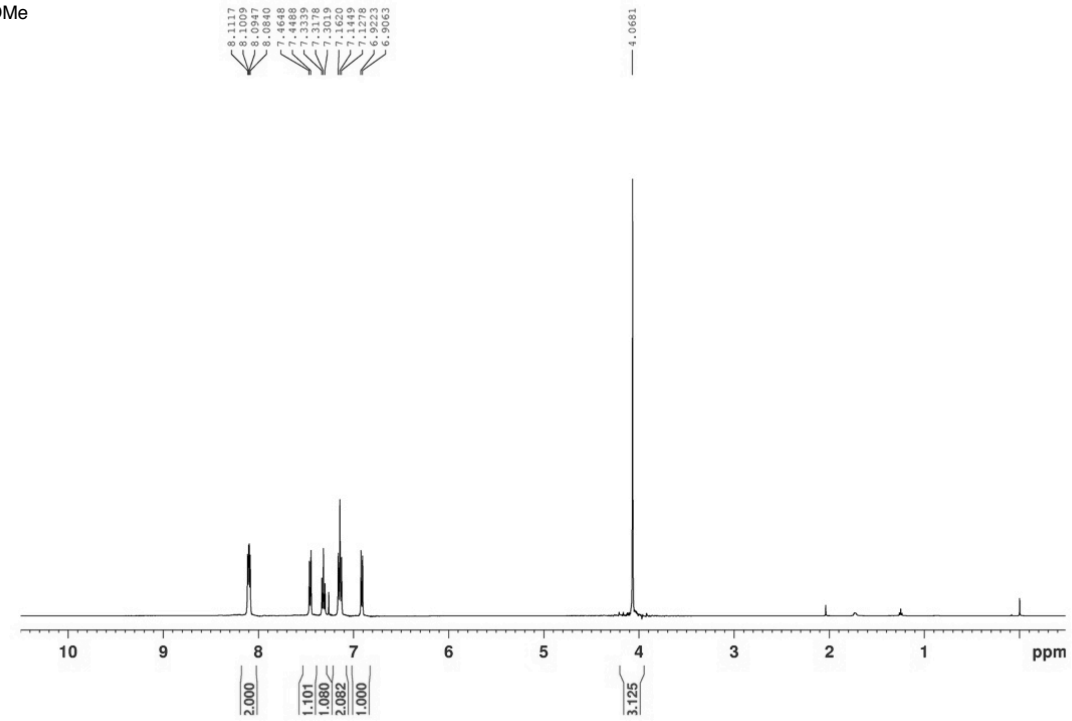


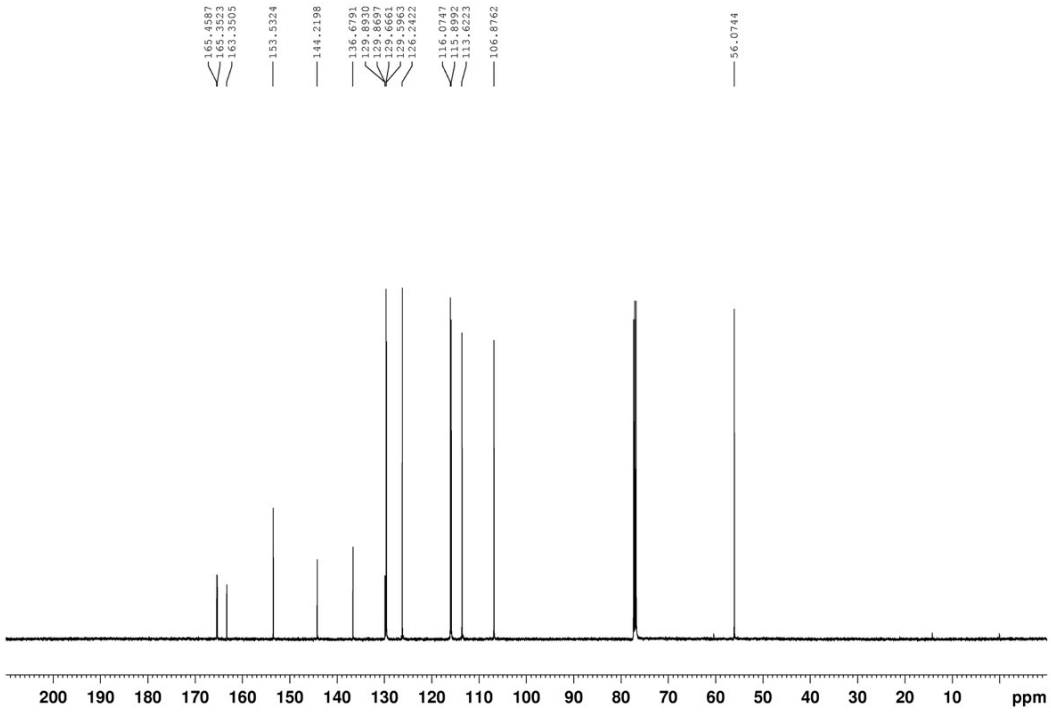




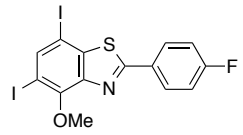
^{1}H NMR (500 MHz) and ^{13}C NMR (126 MHz) spectra of **S6** ($CDCl_3$)

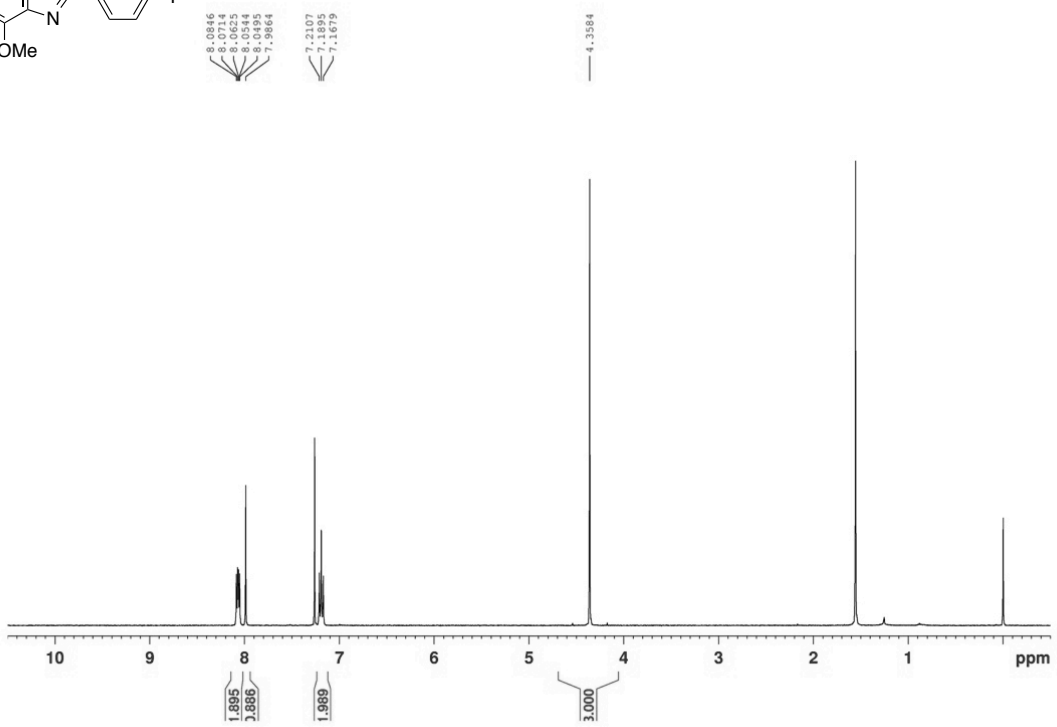


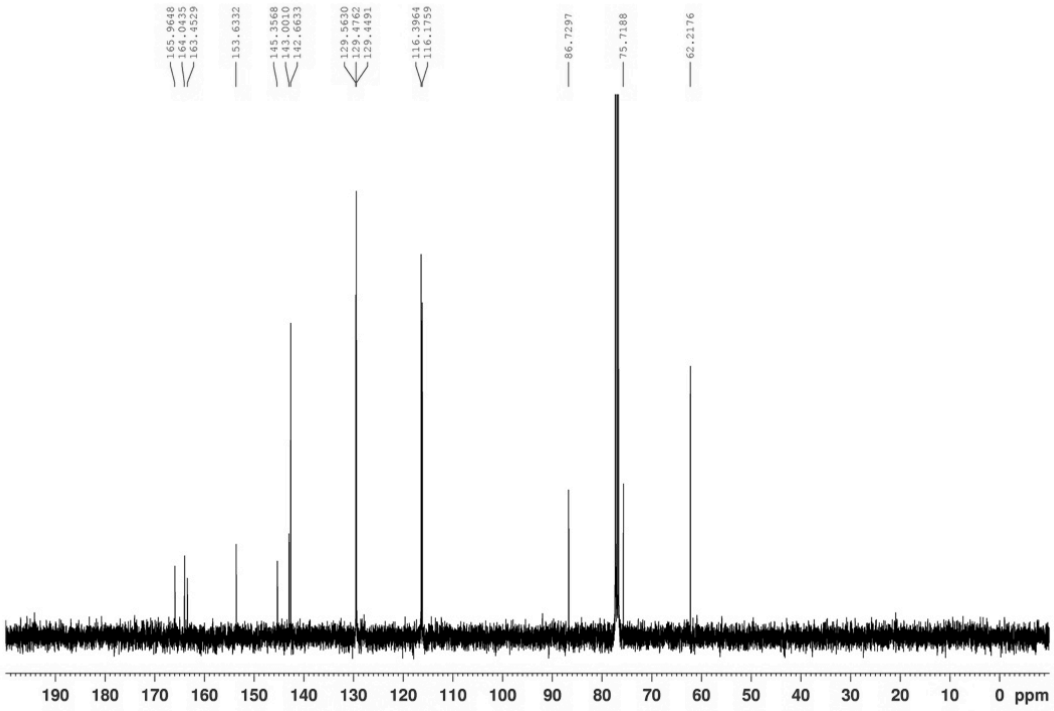




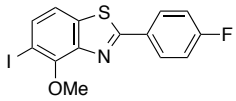
^{1}H NMR (400 MHz) and ^{13}C NMR (100 MHz) spectra of **S7** ($CDCl_3$)

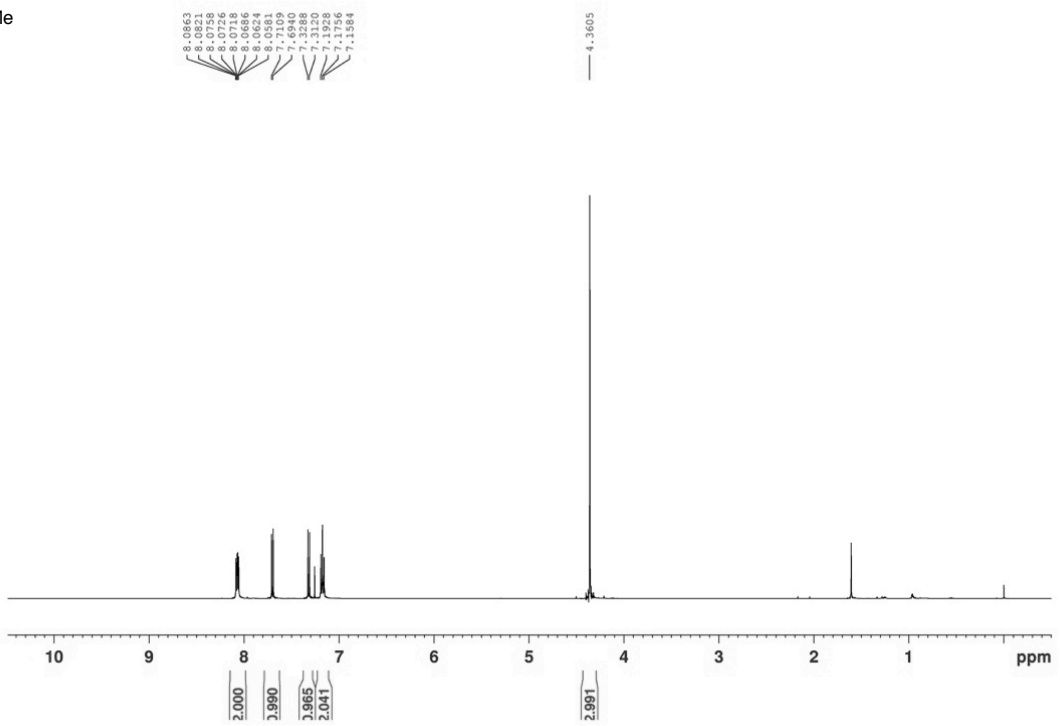


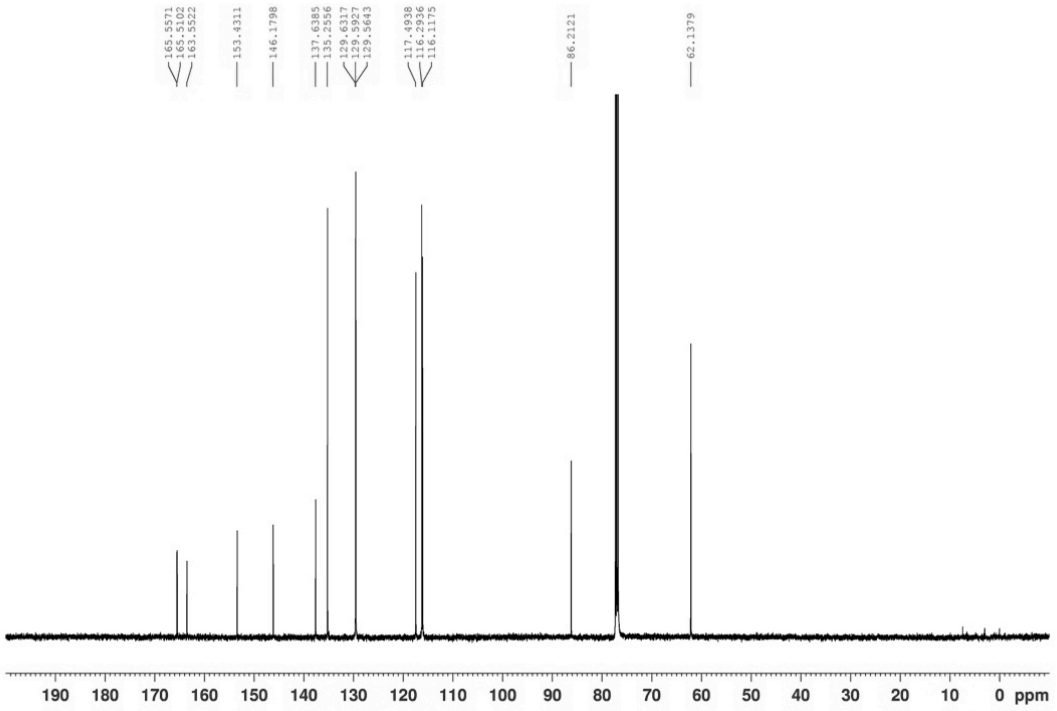




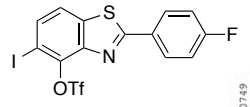
^{1}H NMR (500 MHz) and ^{13}C NMR (126 MHz) spectra of **S8** ($CDCl_3$)

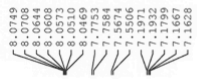


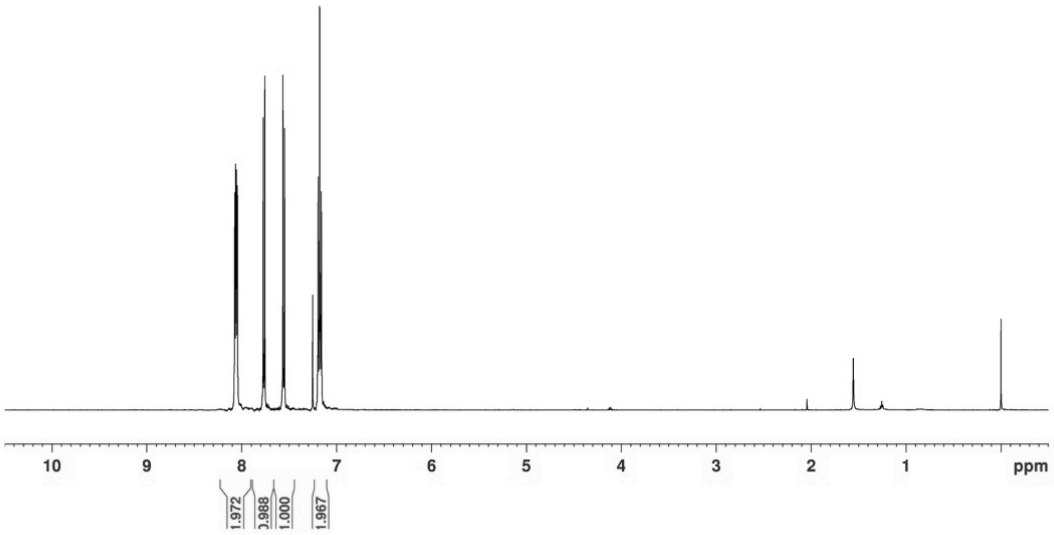


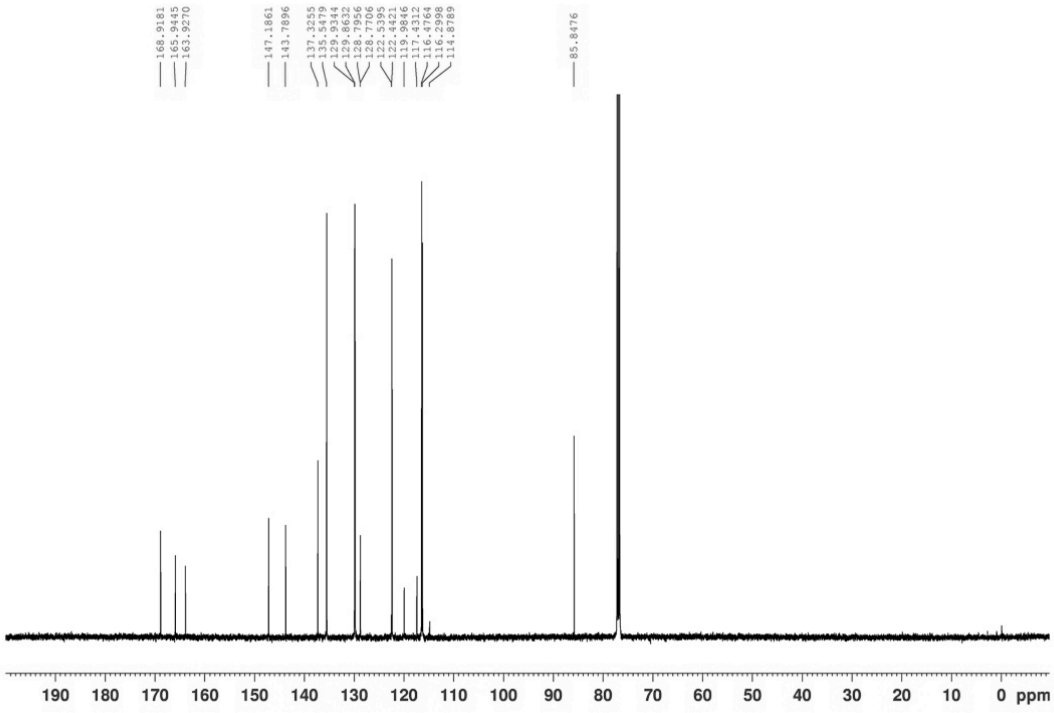


^{1}H NMR (500 MHz) and ^{13}C NMR (126 MHz) spectra of **1b** ($CDCl_3$)

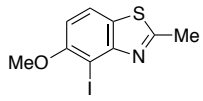


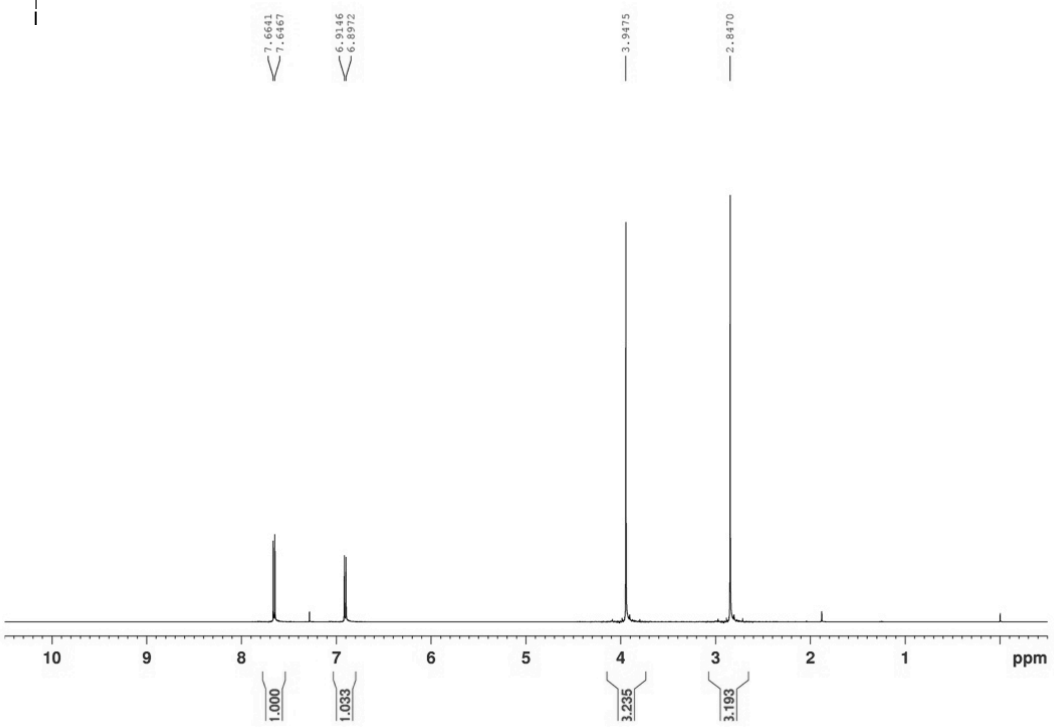


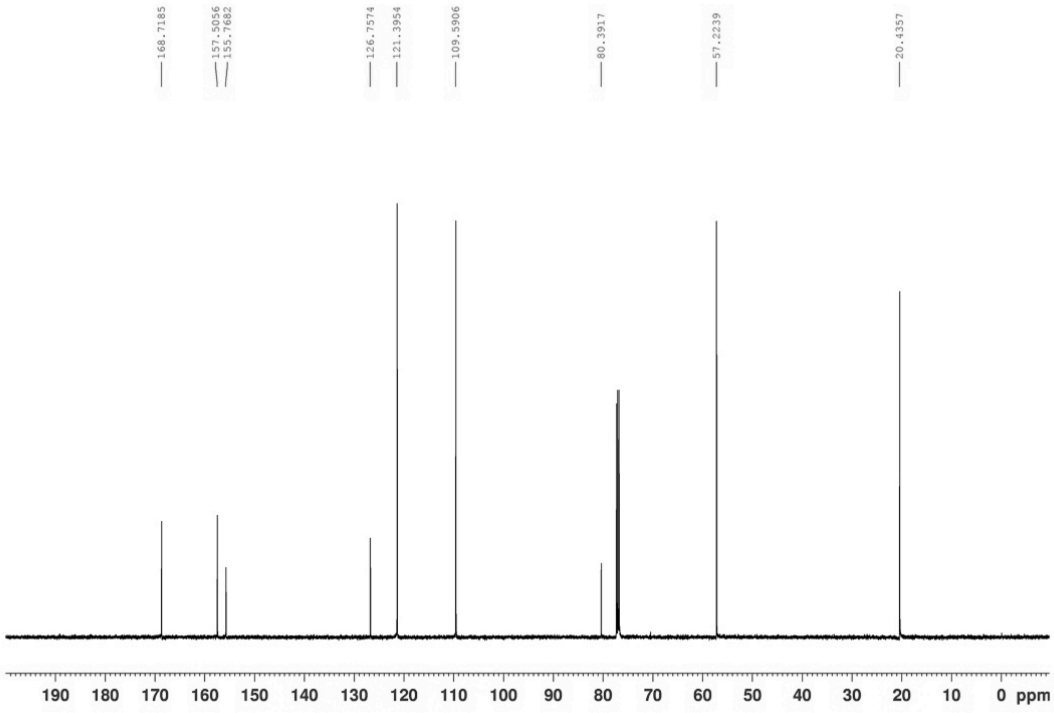




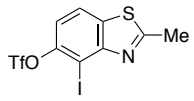
^{1}H NMR (500 MHz) and ^{13}C NMR (126 MHz) spectra of **S9** ($CDCl_3$)

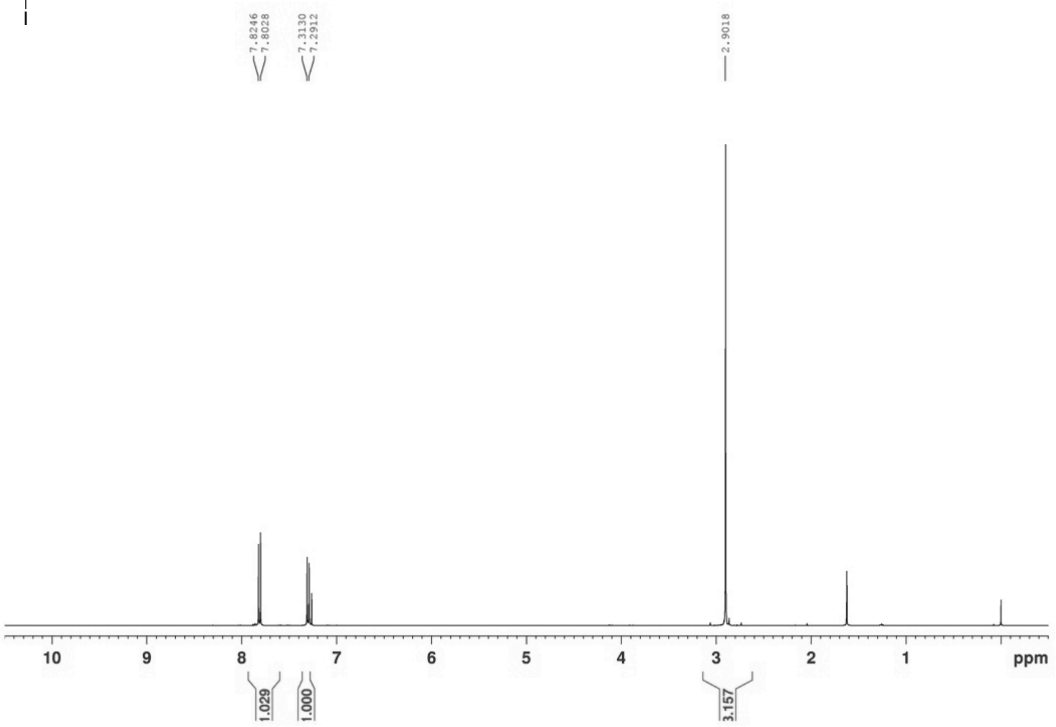


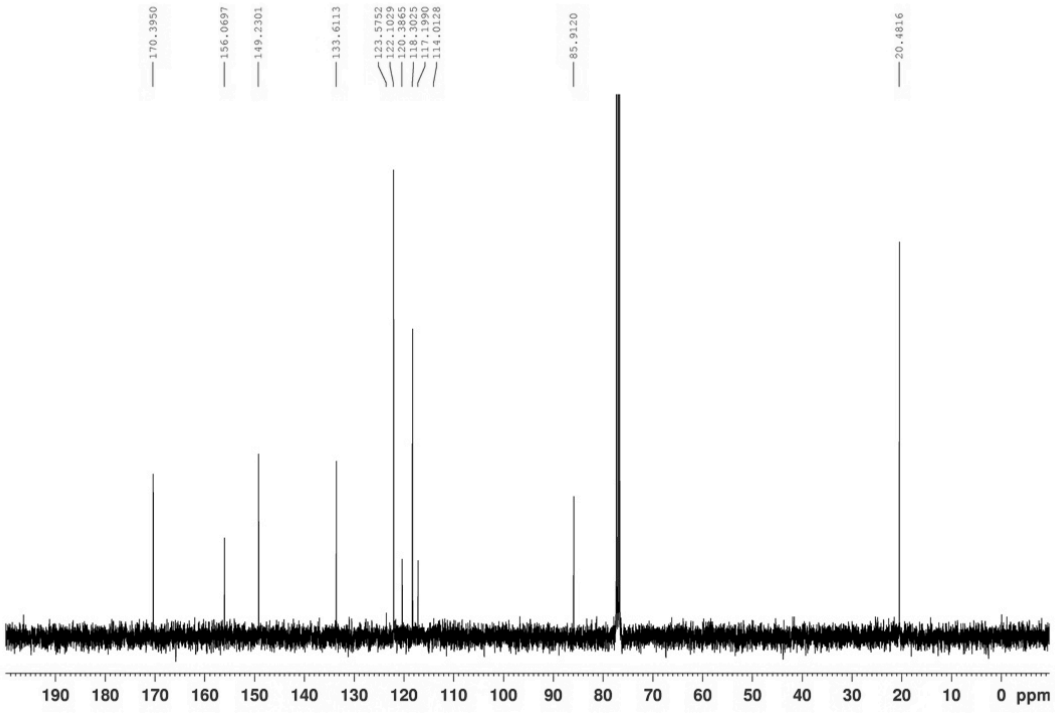




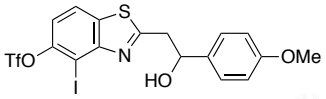
^{1}H NMR (400 MHz) and ^{13}C NMR (100 MHz) spectra of **1d** ($CDCl_3$)

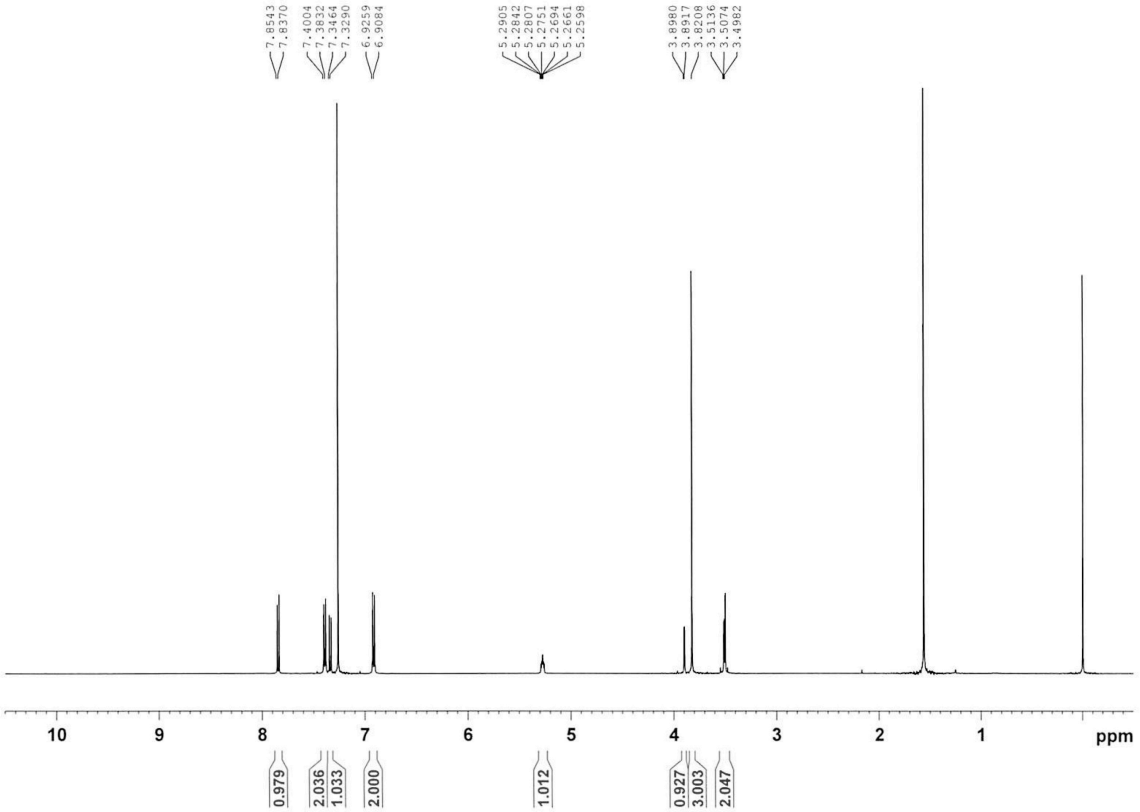


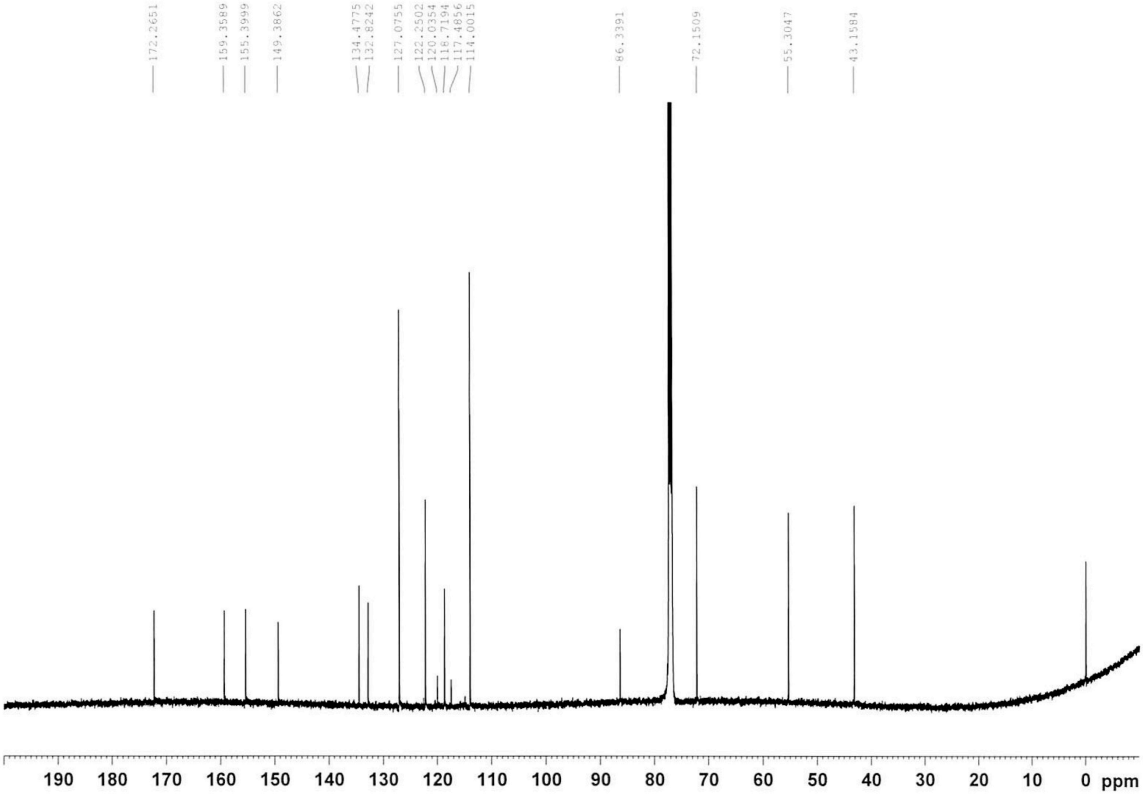




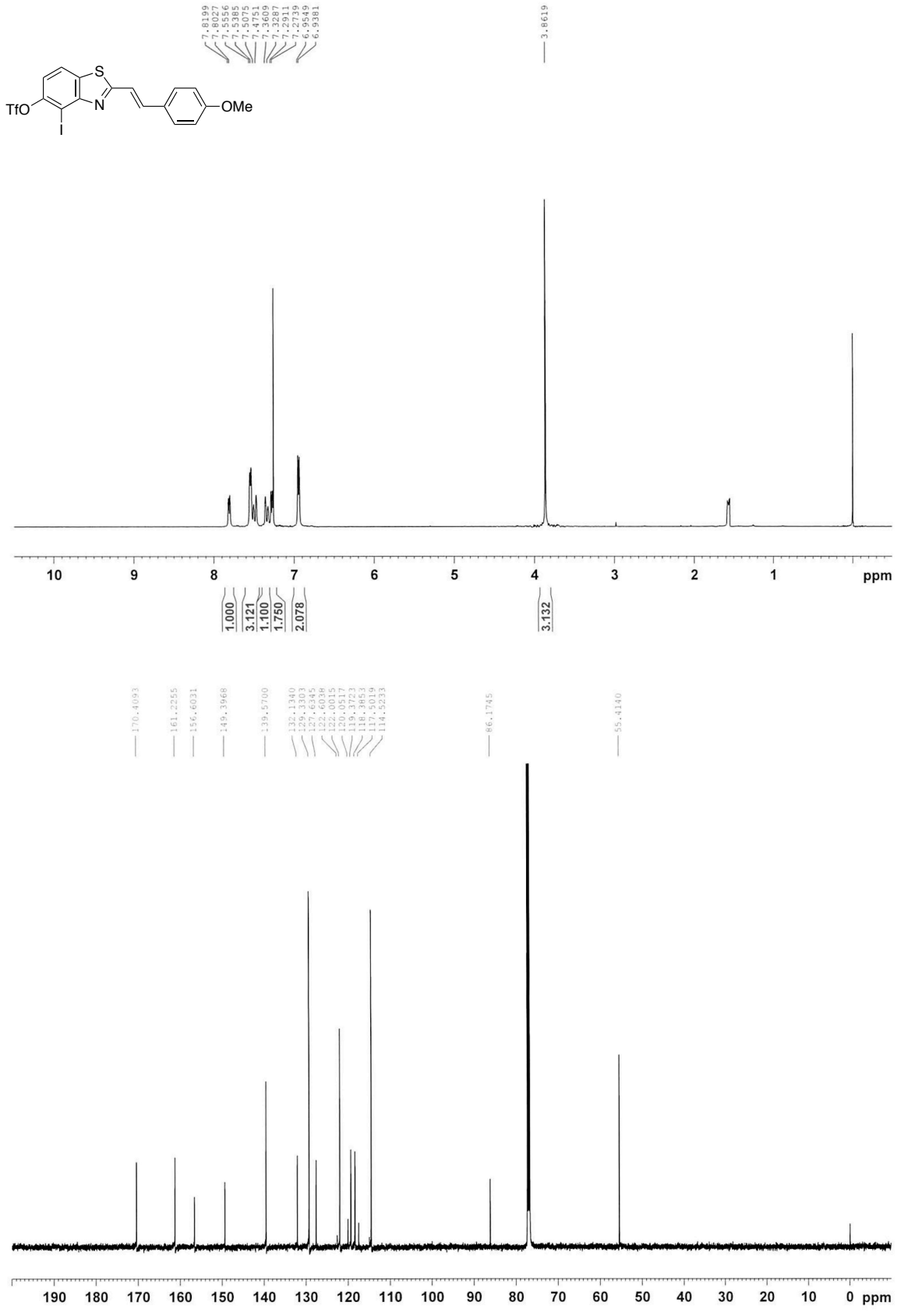
^{1}H NMR (500 MHz) and ^{13}C NMR (126 MHz) spectra of **1e** ($CDCl_3$)



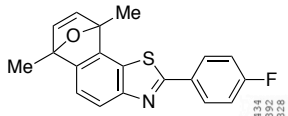


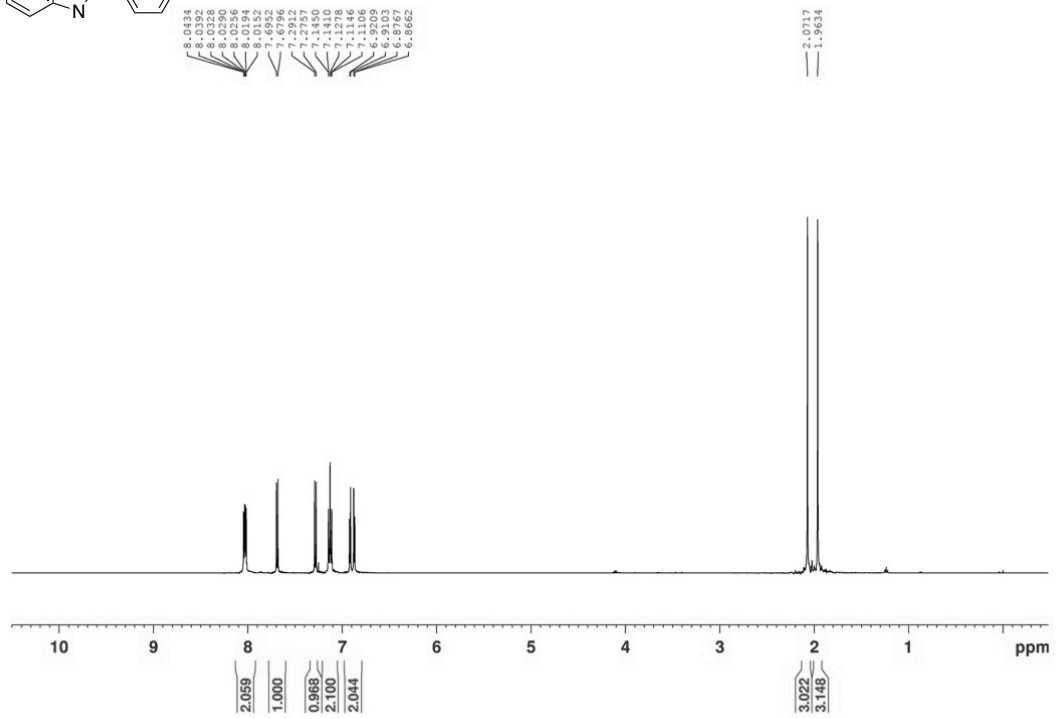


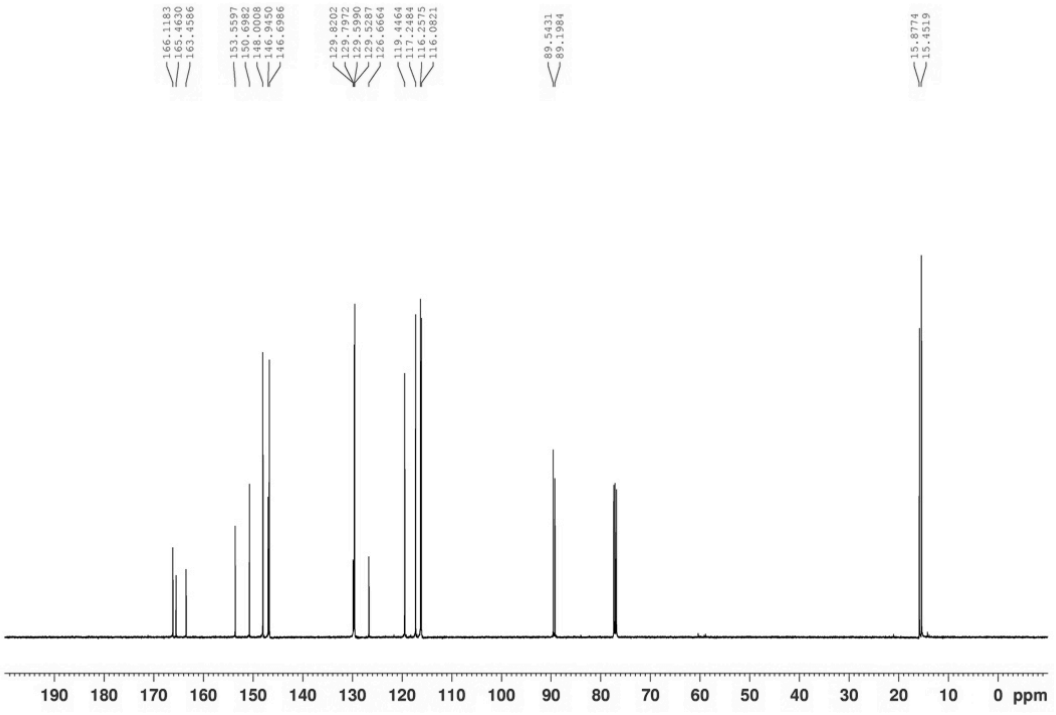
^{1}H NMR (500 MHz) and ^{13}C NMR (126 MHz) spectra of **1f** ($CDCl_3$)



^{1}H NMR (500 MHz) and ^{13}C NMR (126 MHz) spectra of **3a** ($CDCl_3$)







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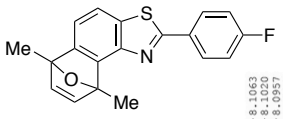
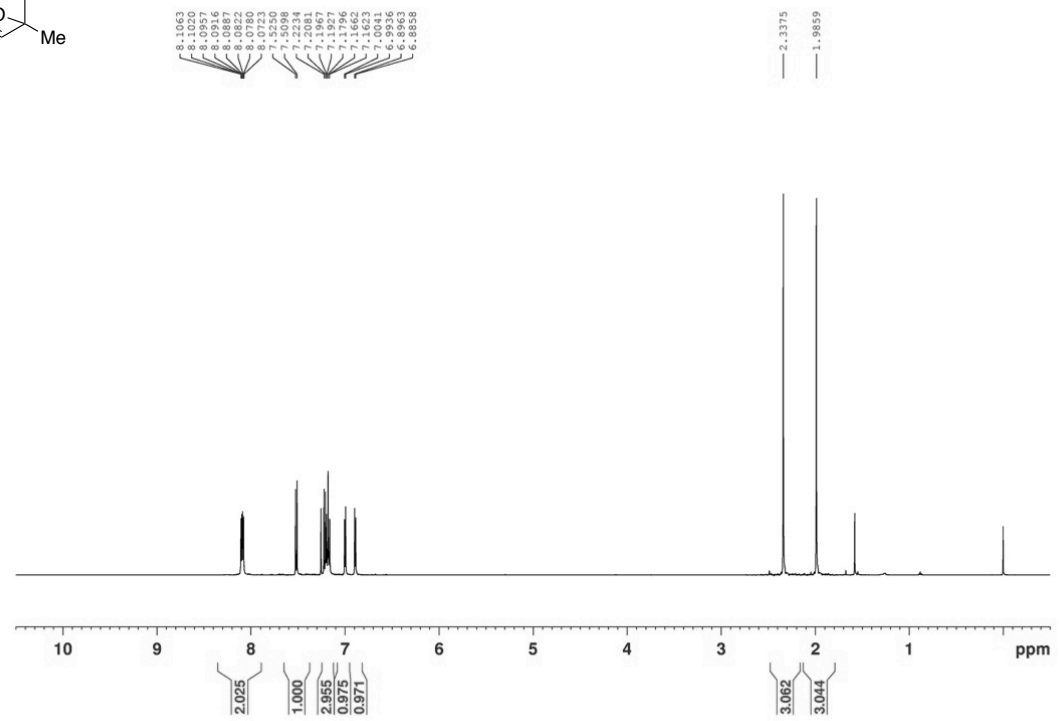
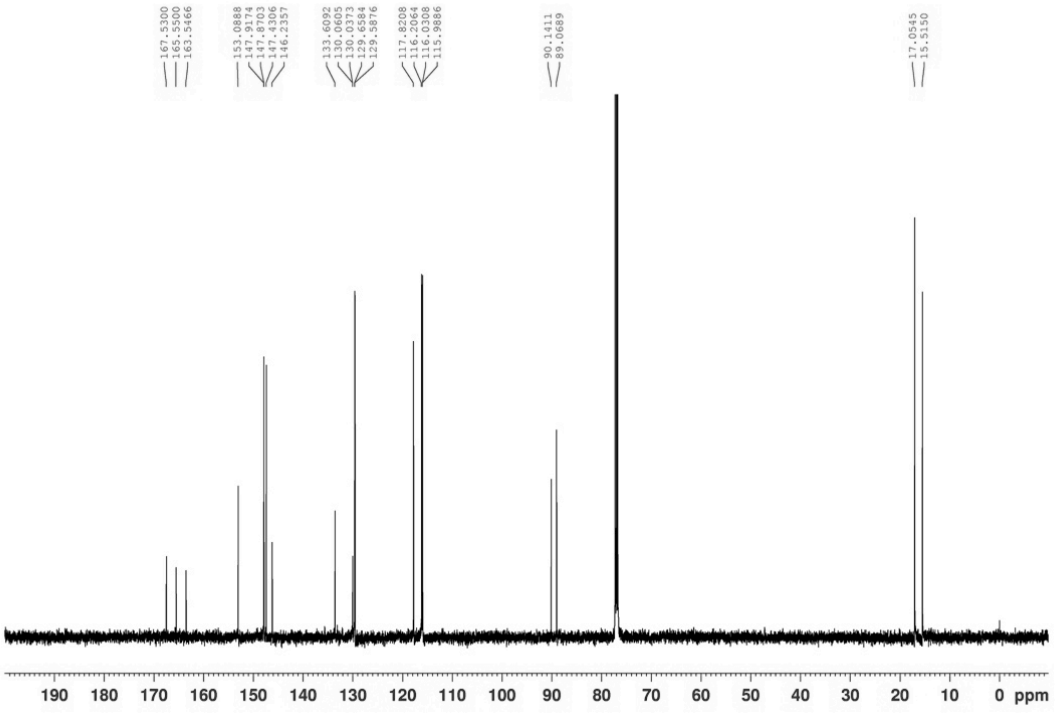
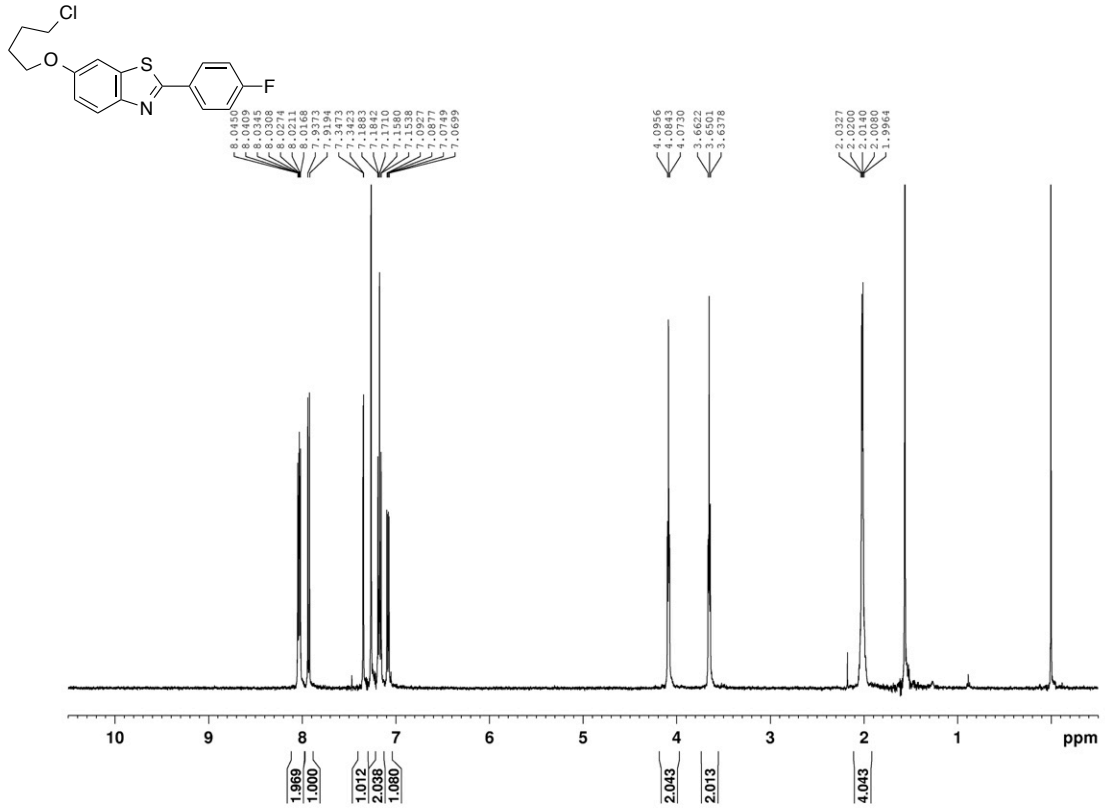
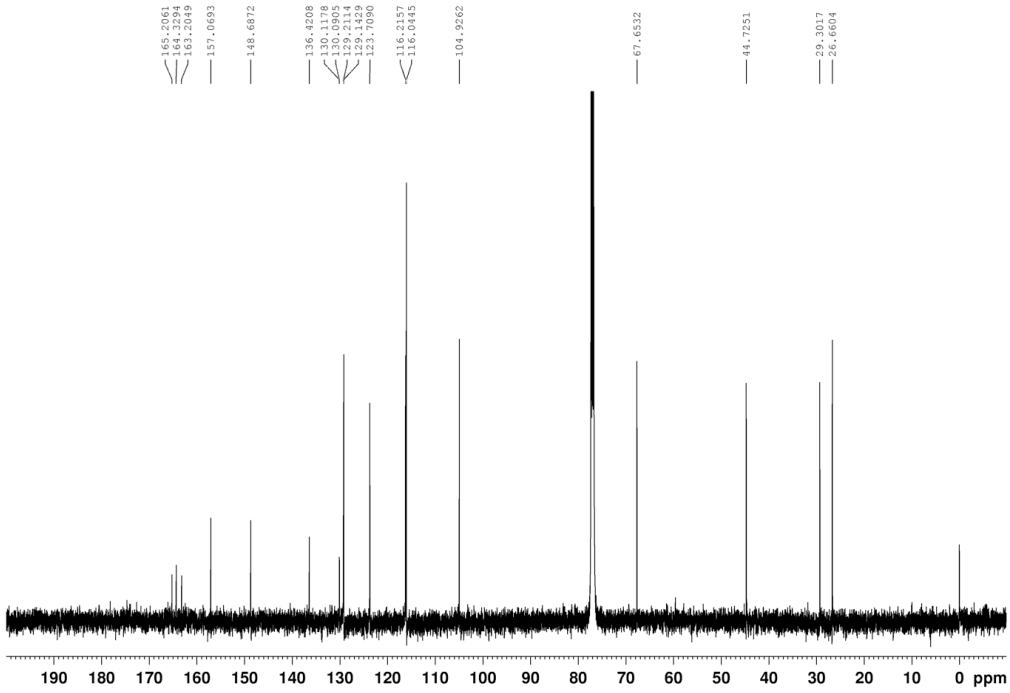




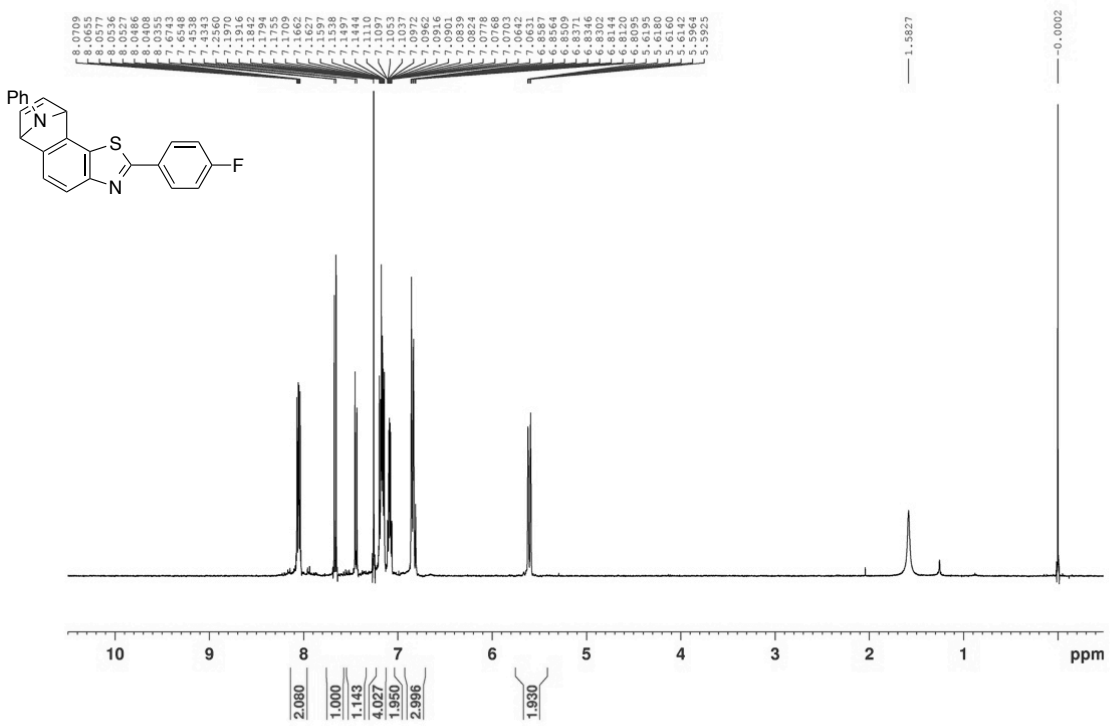


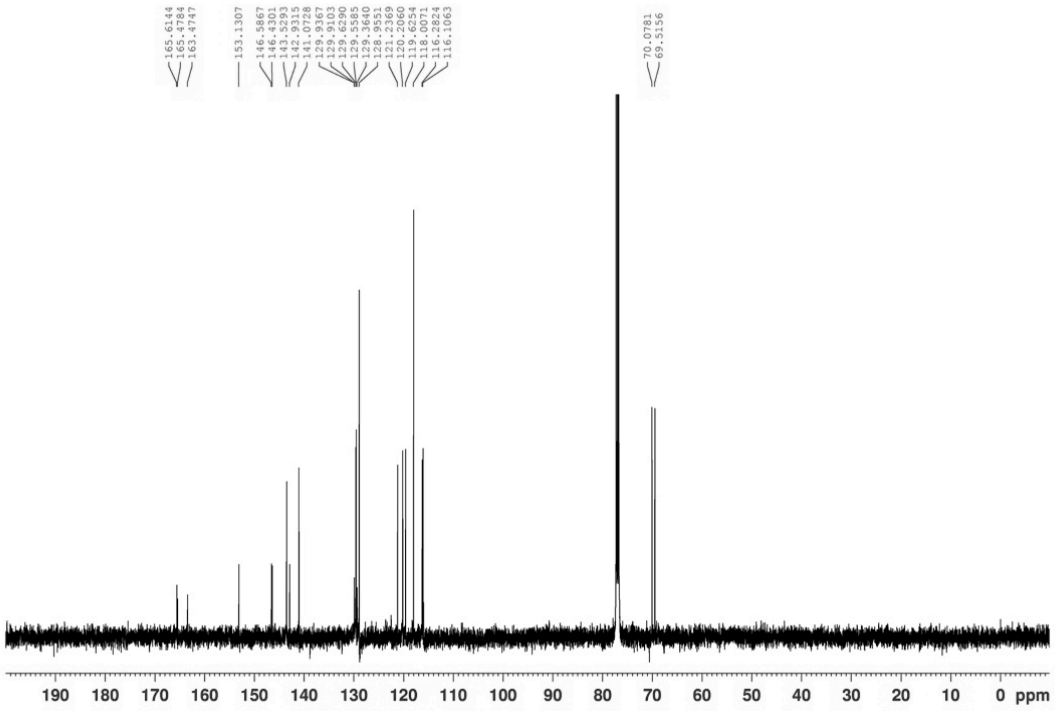
^{1}H NMR (500 MHz) and ^{13}C NMR (126 MHz) spectra of **4** ($CDCl_3$)



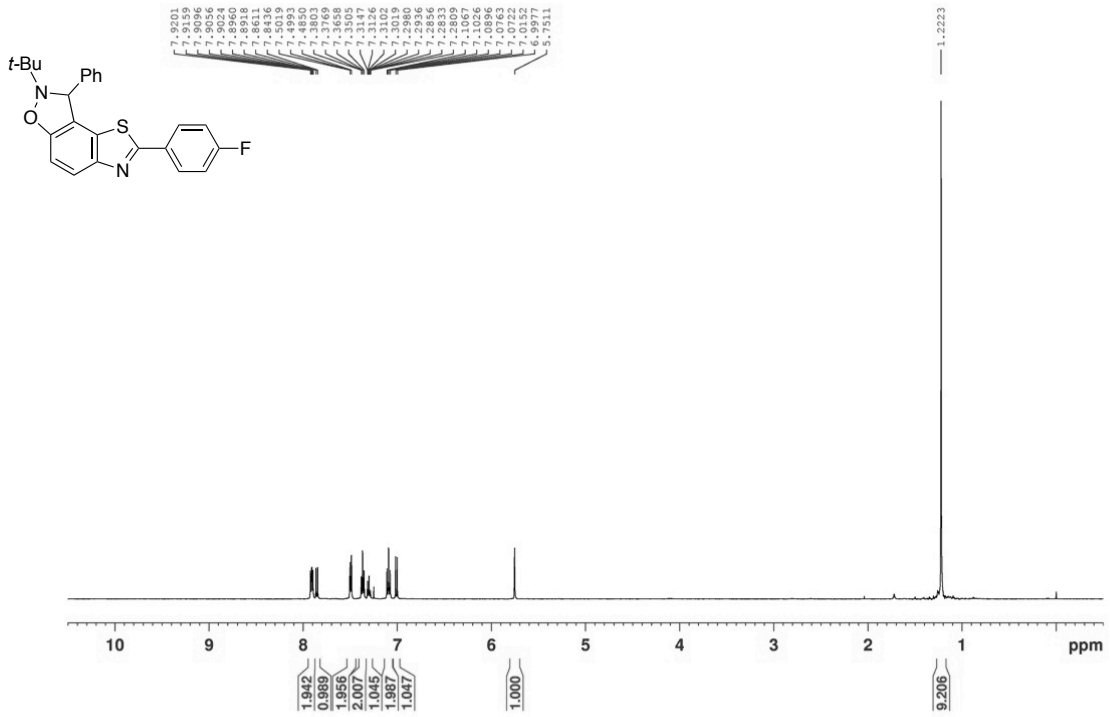


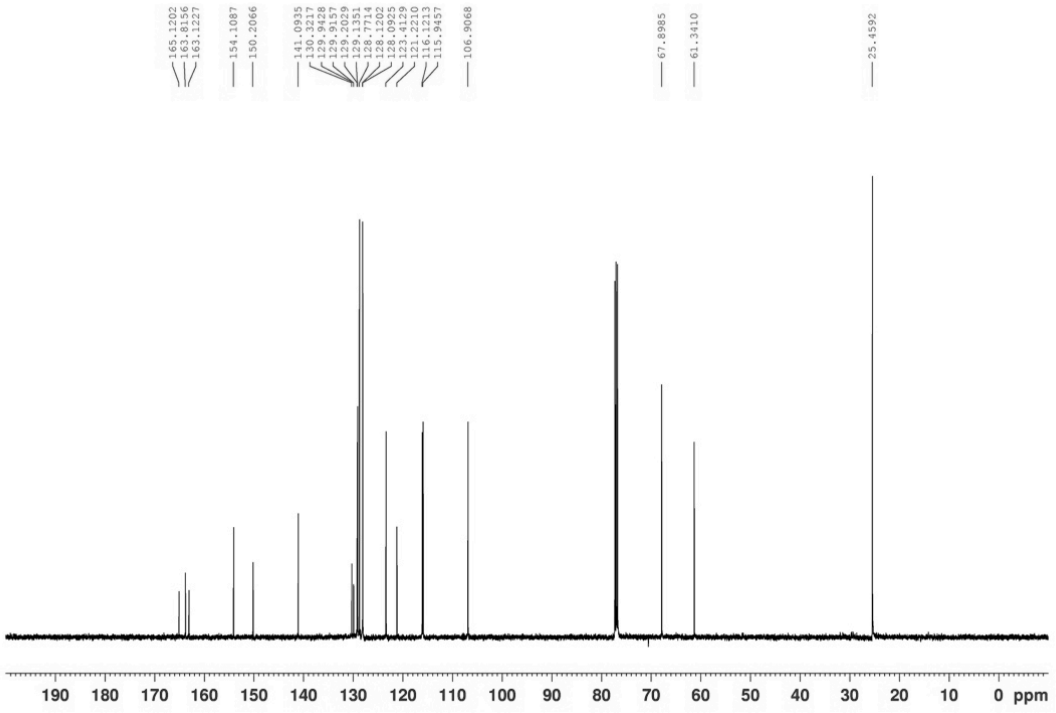
^{1}H NMR (400 MHz) and ^{13}C NMR (126 MHz) spectra of **6** ($CDCl_3$)



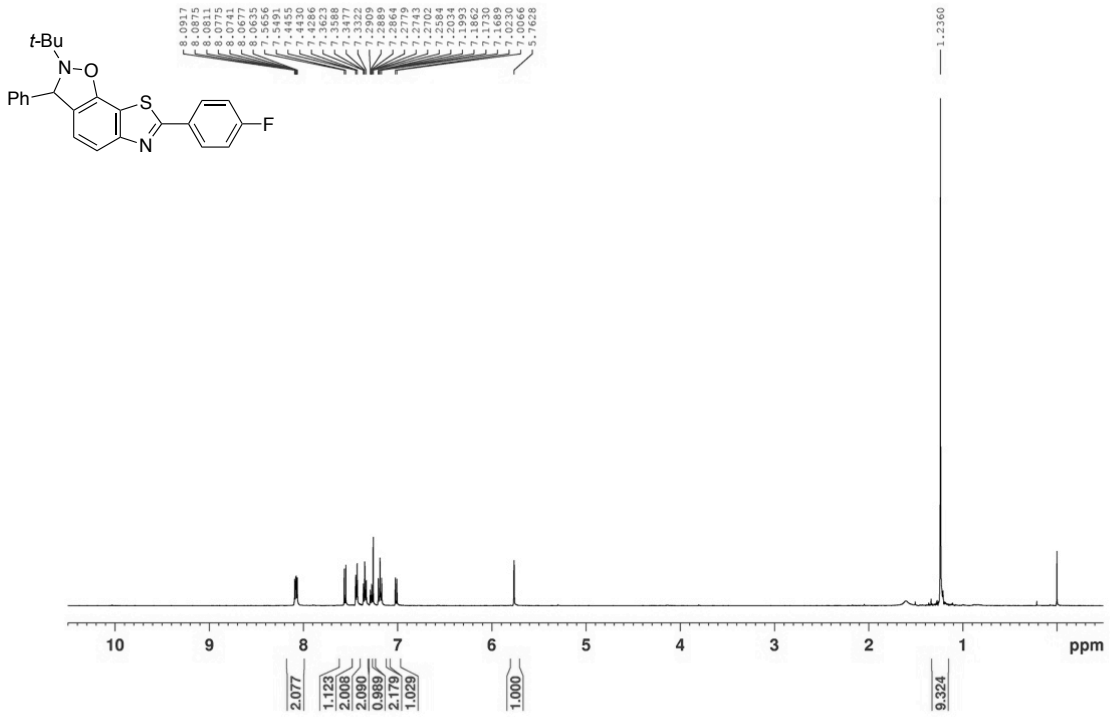


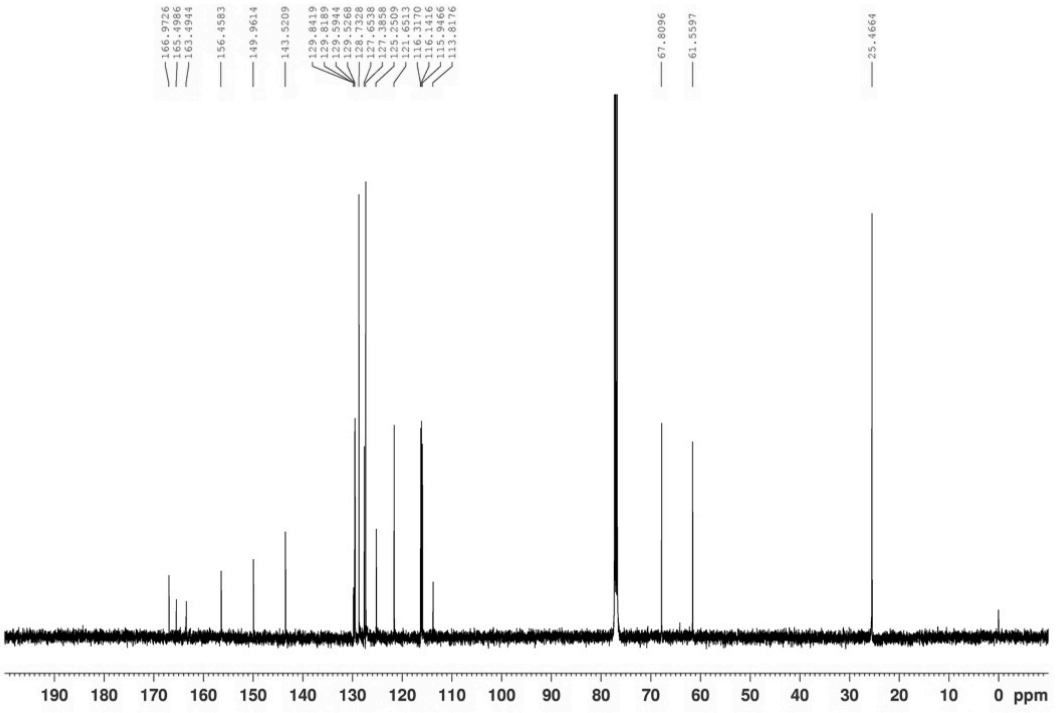
^{1}H NMR (500 MHz) and ^{13}C NMR (126 MHz) spectra of **8** ($CDCl_3$)



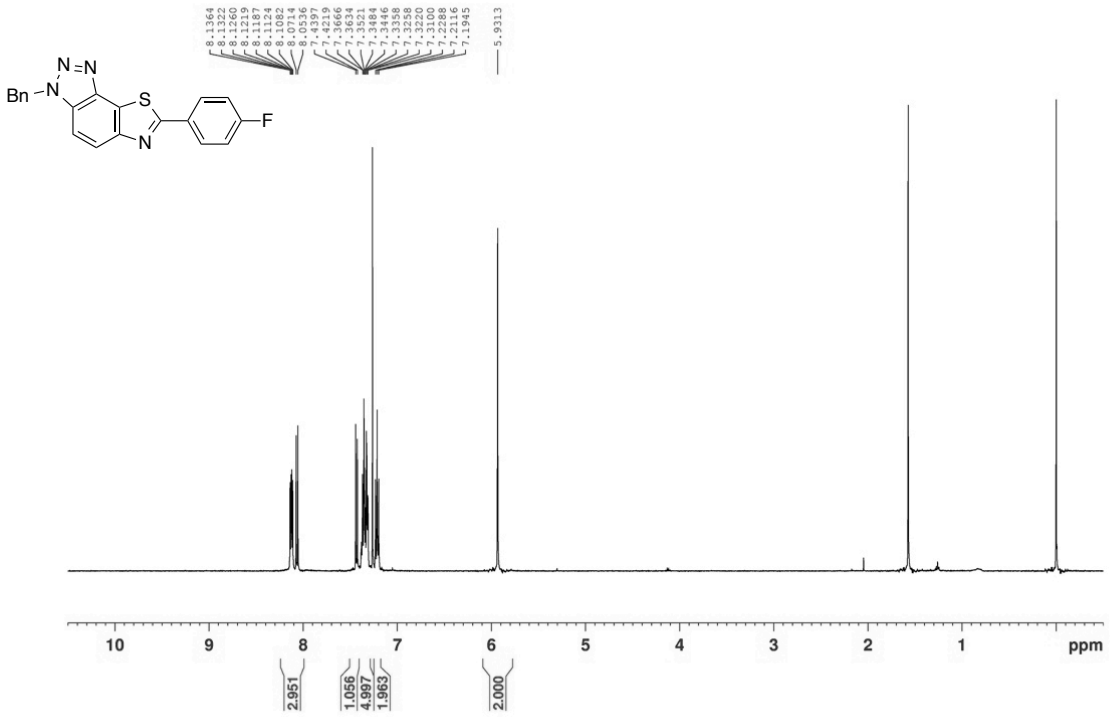


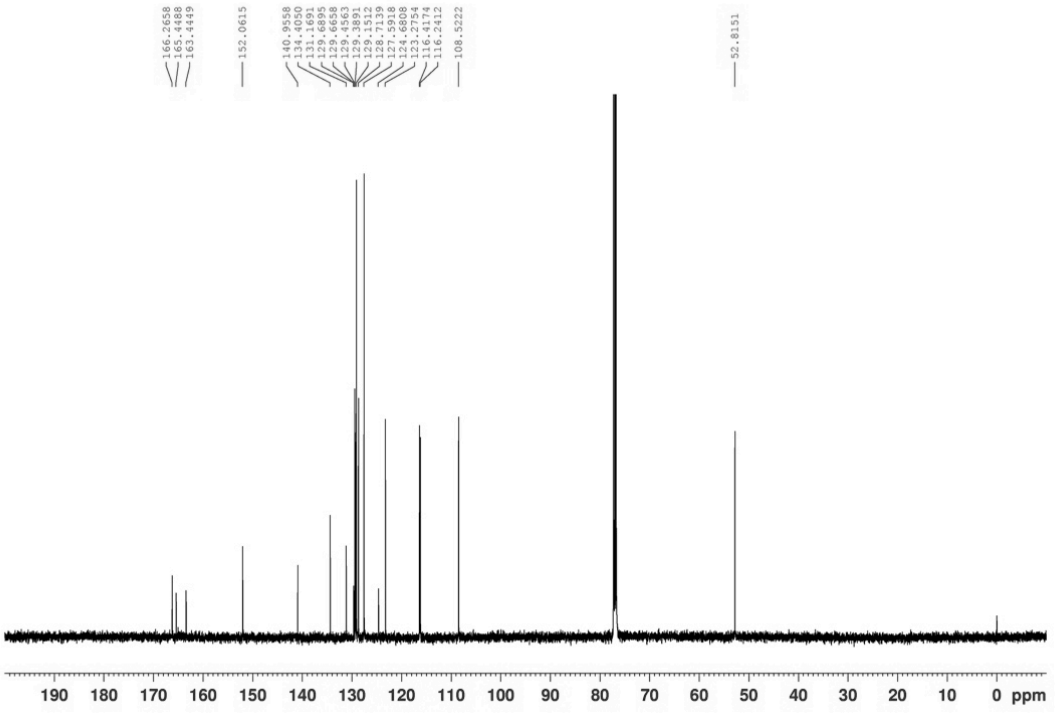
^{1}H NMR (500 MHz) and ^{13}C NMR (126 MHz) spectra of **8'** ($CDCl_3$)



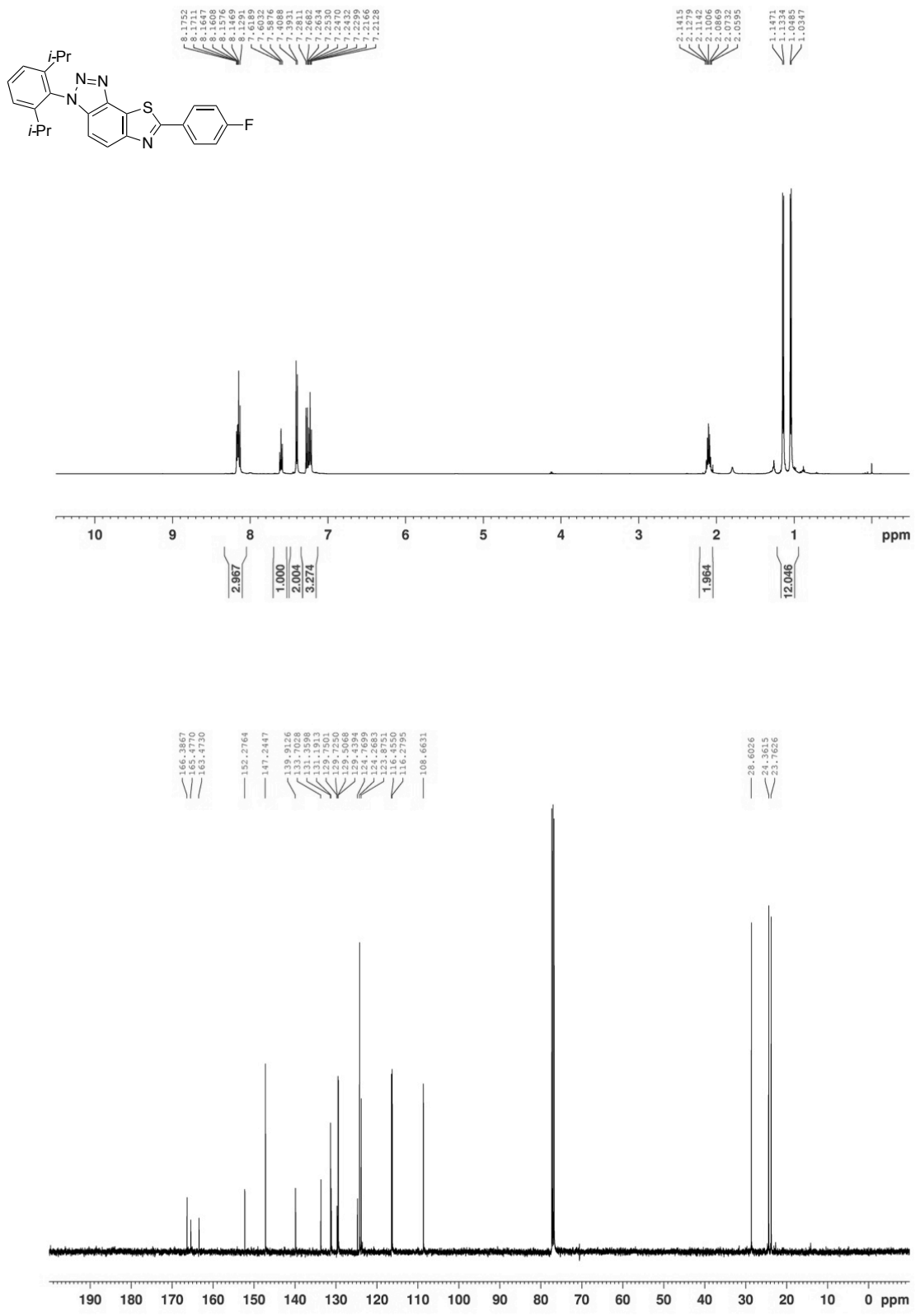


^{1}H NMR (500 MHz) and ^{13}C NMR (126 MHz) spectra of **10** ($CDCl_3$)

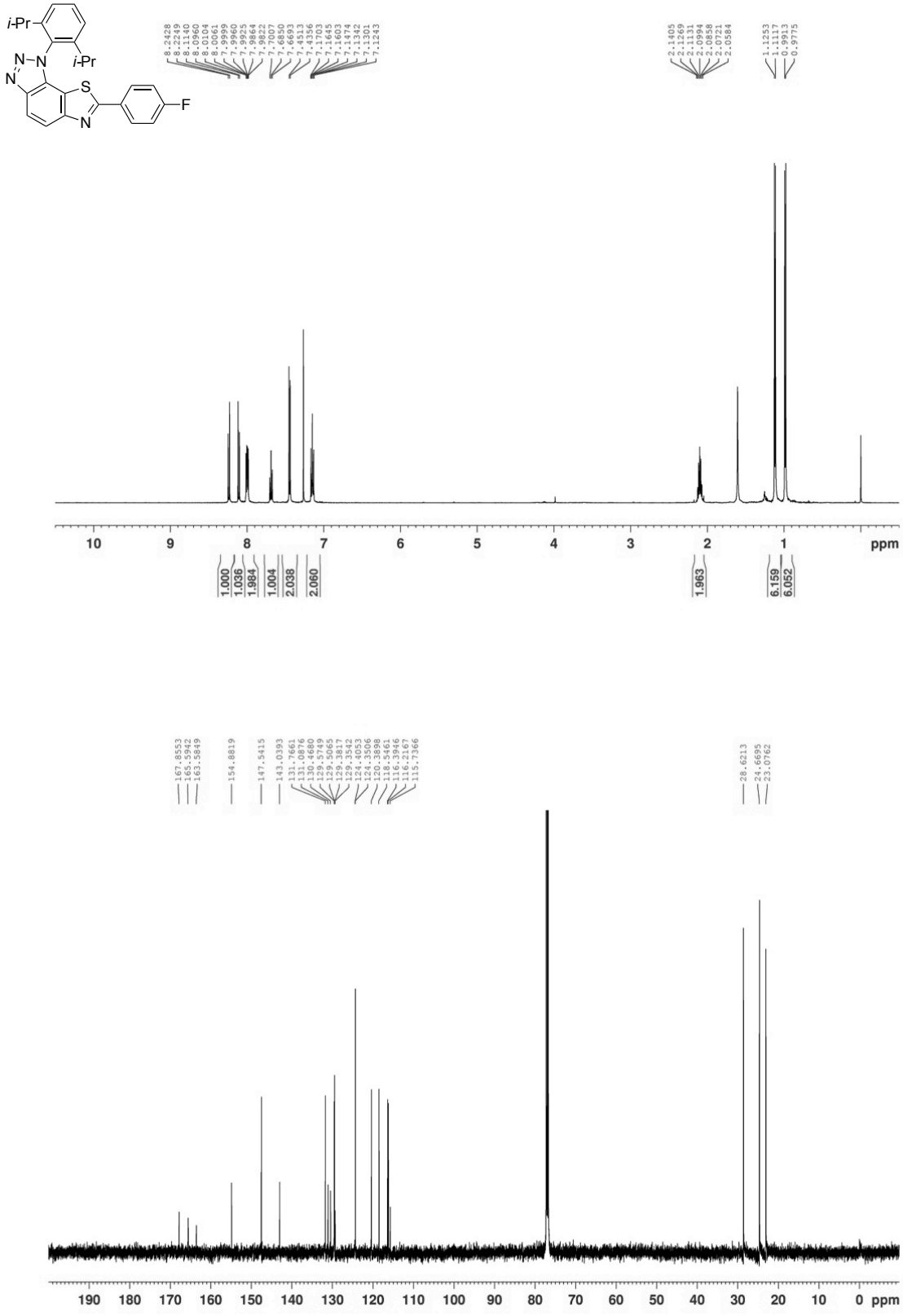




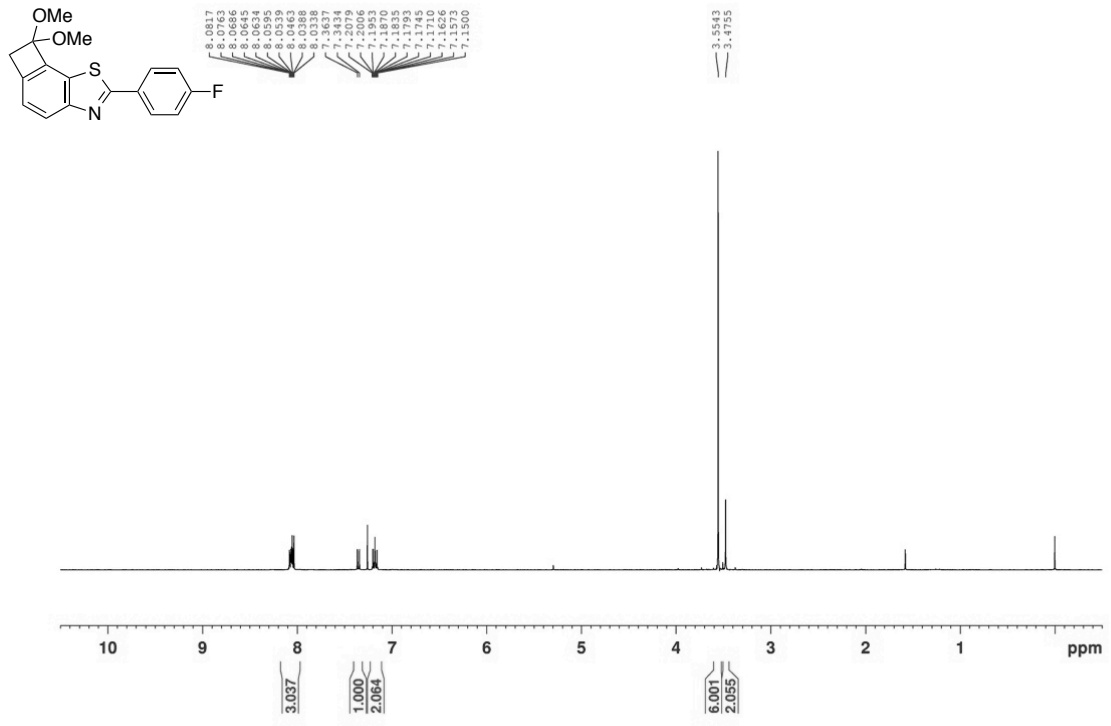
^{1}H NMR (500 MHz) and ^{13}C NMR (126 MHz) spectra of **12** ($CDCl_3$)

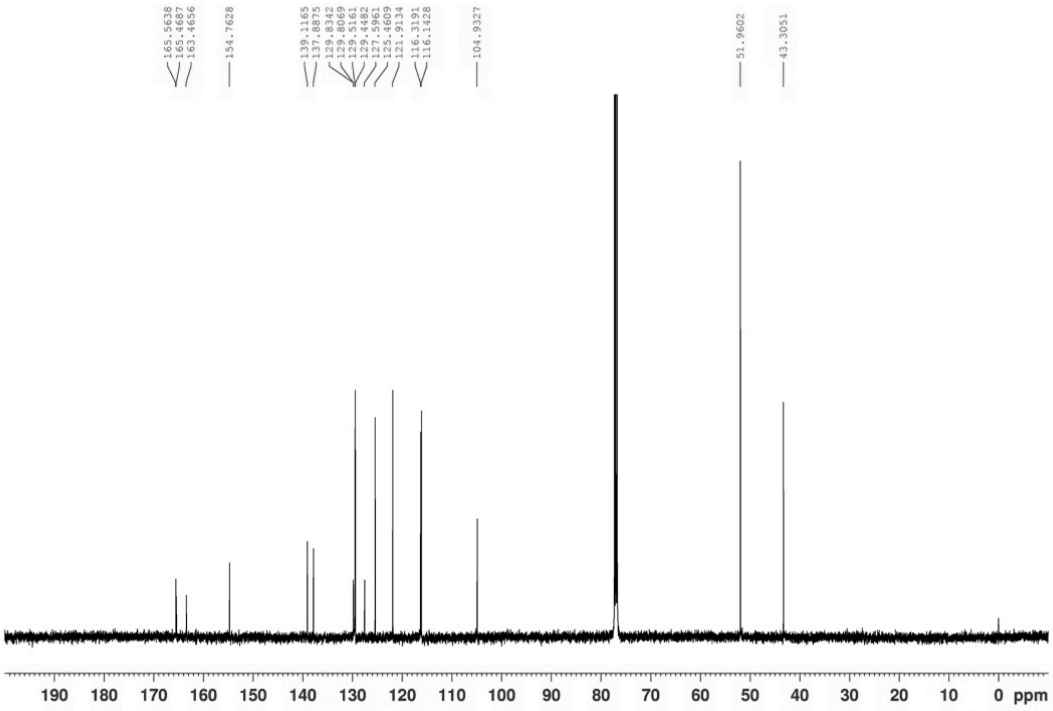


^{1}H NMR (500 MHz) and ^{13}C NMR (126 MHz) spectra of **12'** ($CDCl_3$)

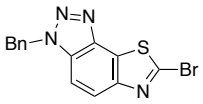


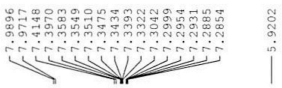
^{1}H NMR (400 MHz) and ^{13}C NMR (126 MHz) spectra of **14** ($CDCl_3$)

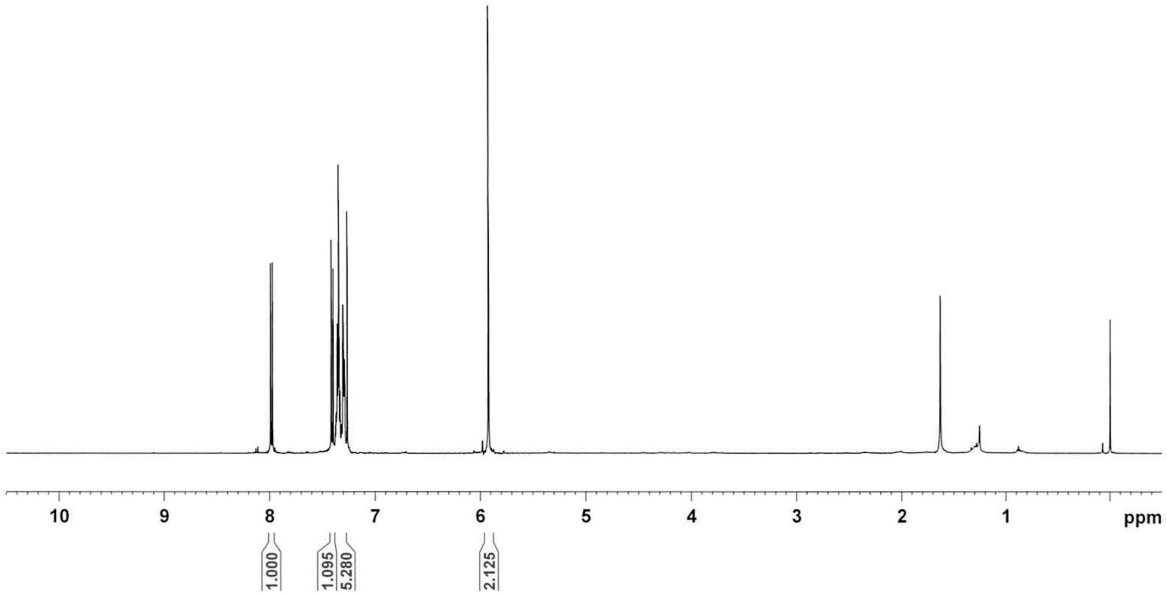


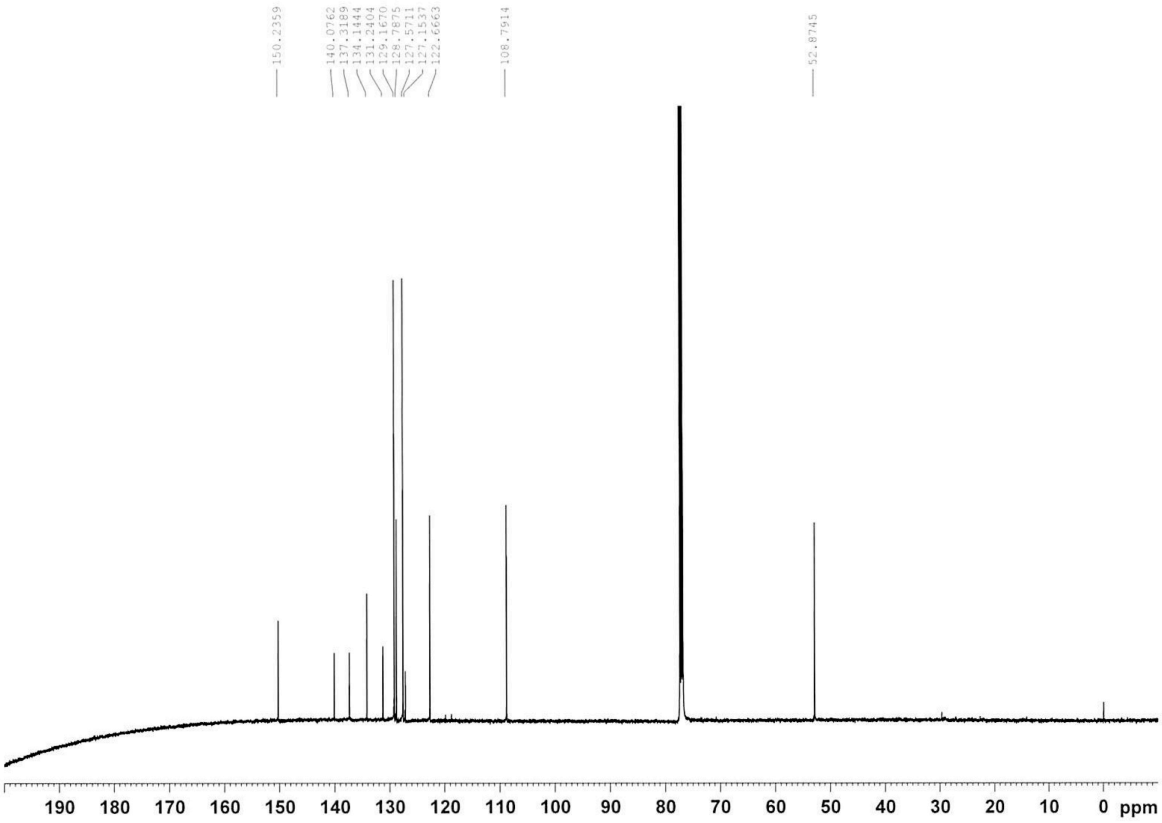


^{1}H NMR (500 MHz) and ^{13}C NMR (126 MHz) spectra of **15** ($CDCl_3$)

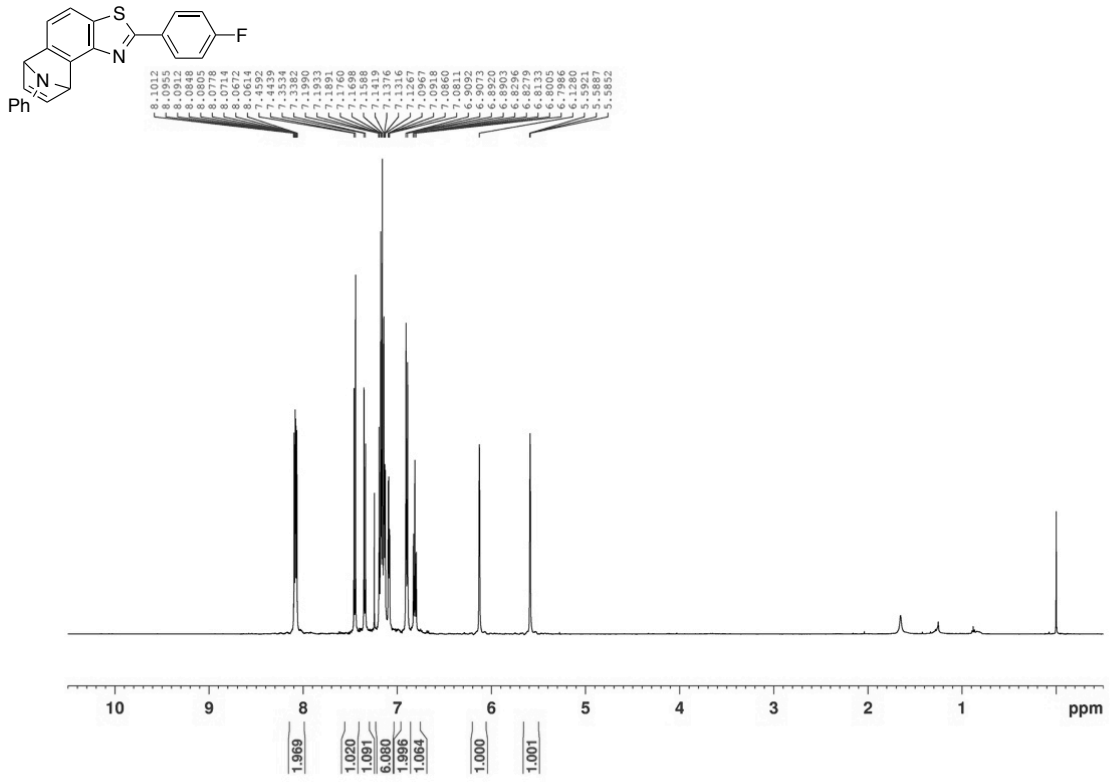


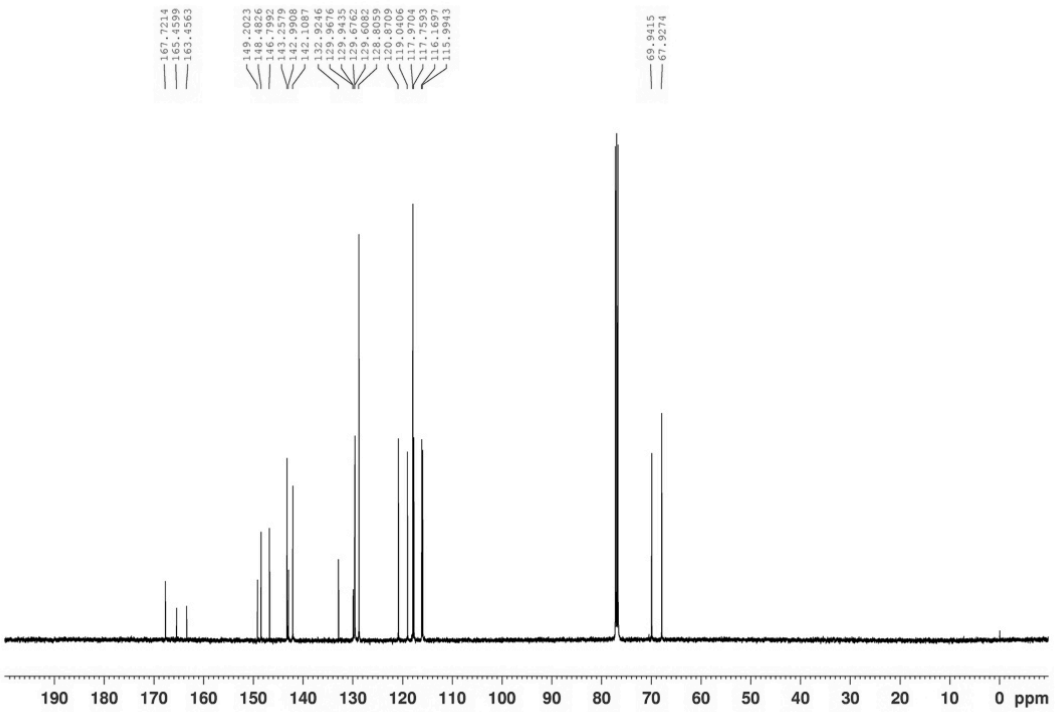




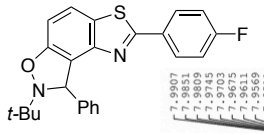


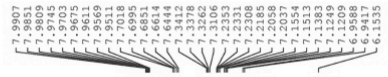
^{1}H NMR (500 MHz) and ^{13}C NMR (126 MHz) spectra of **16** ($CDCl_3$)

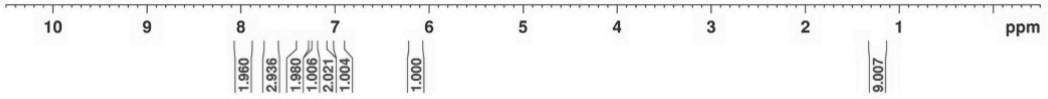


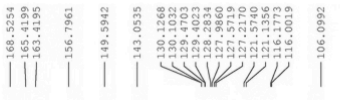


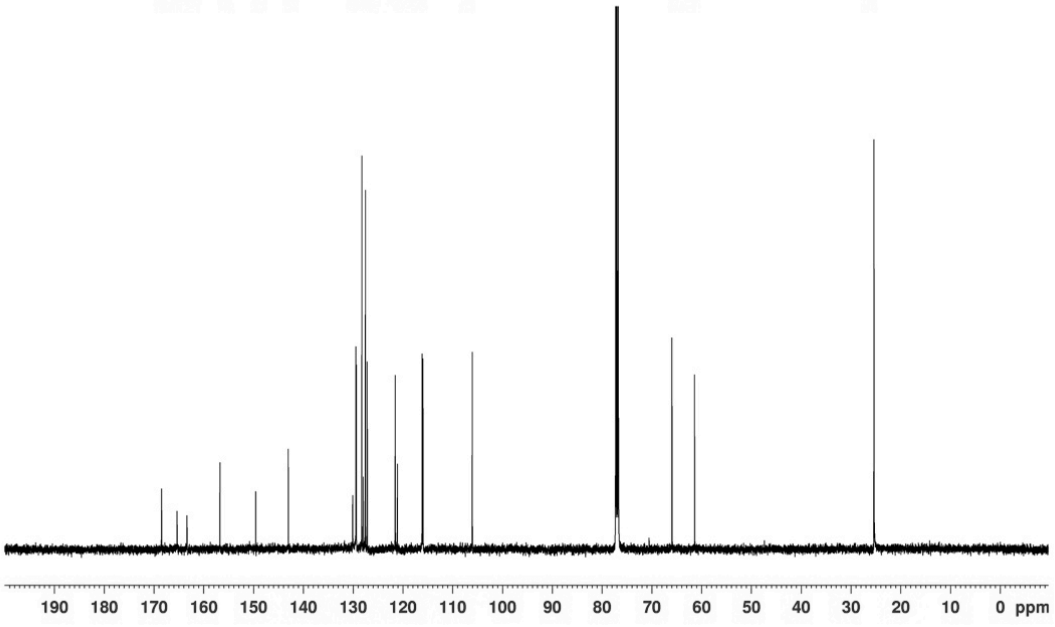
^{1}H NMR (500 MHz) and ^{13}C NMR (126 MHz) spectra of **17** ($CDCl_3$)



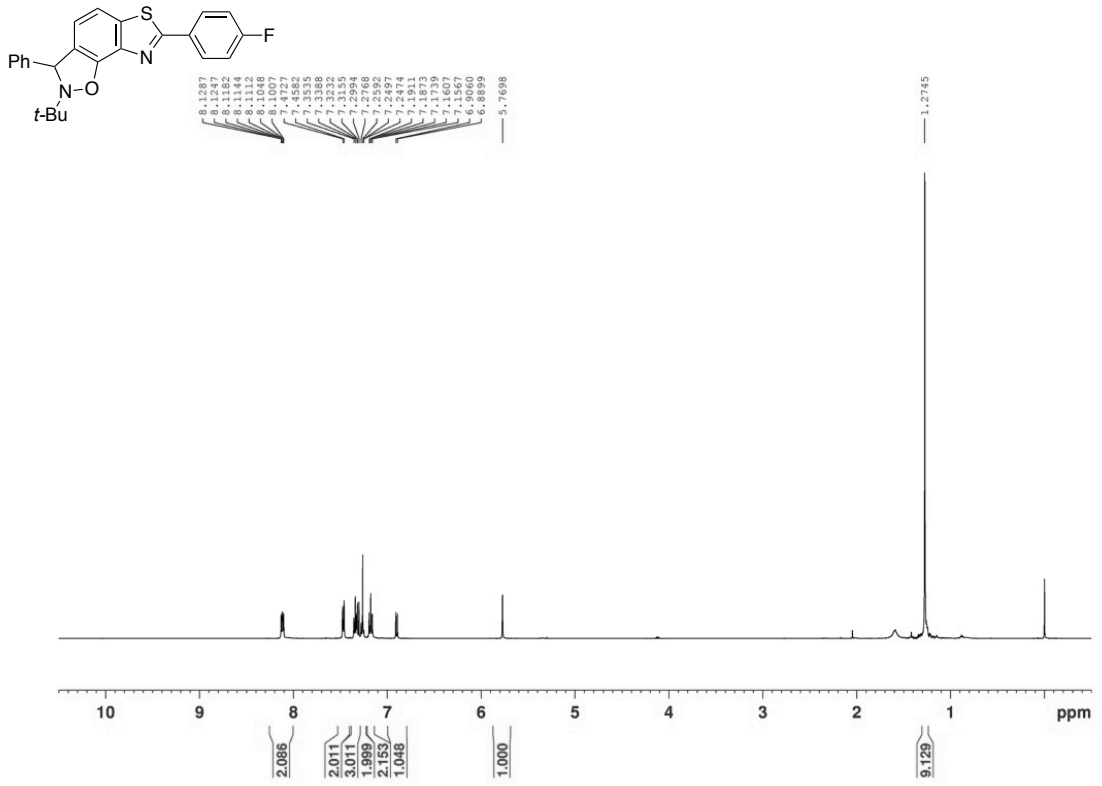


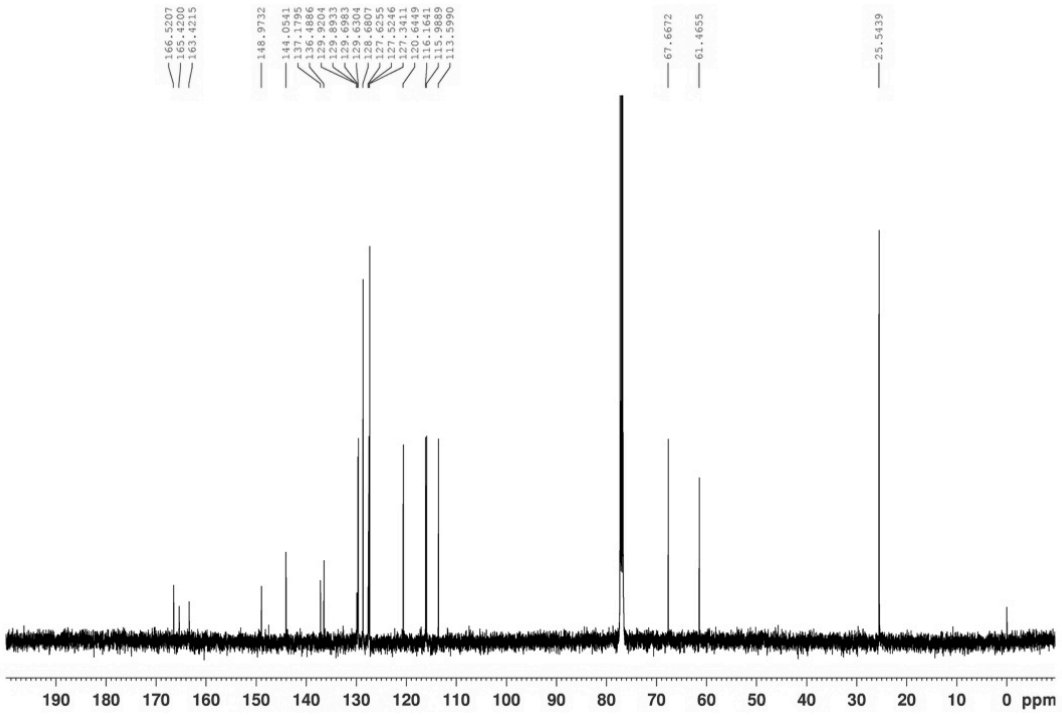




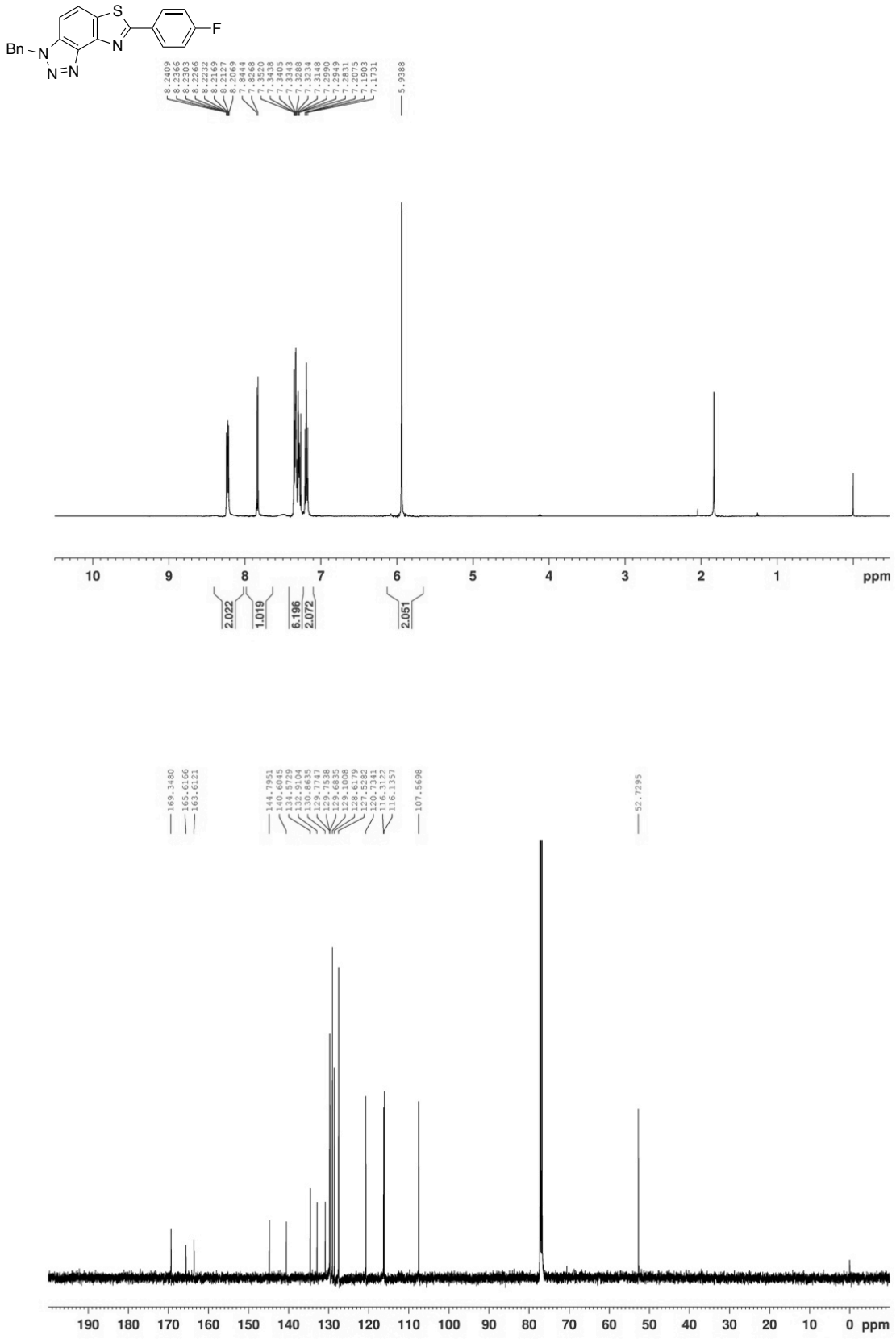


^{1}H NMR (500 MHz) and ^{13}C NMR (126 MHz) spectra of **17'** ($CDCl_3$)

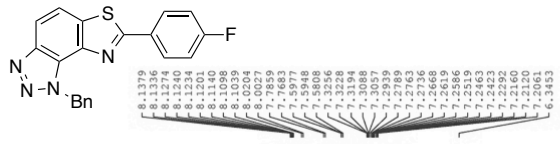


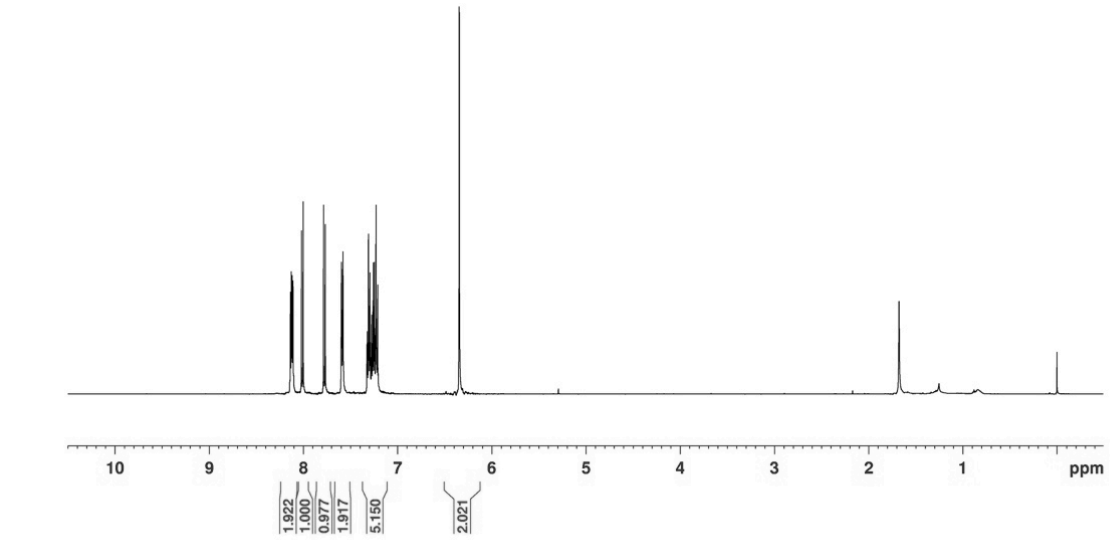


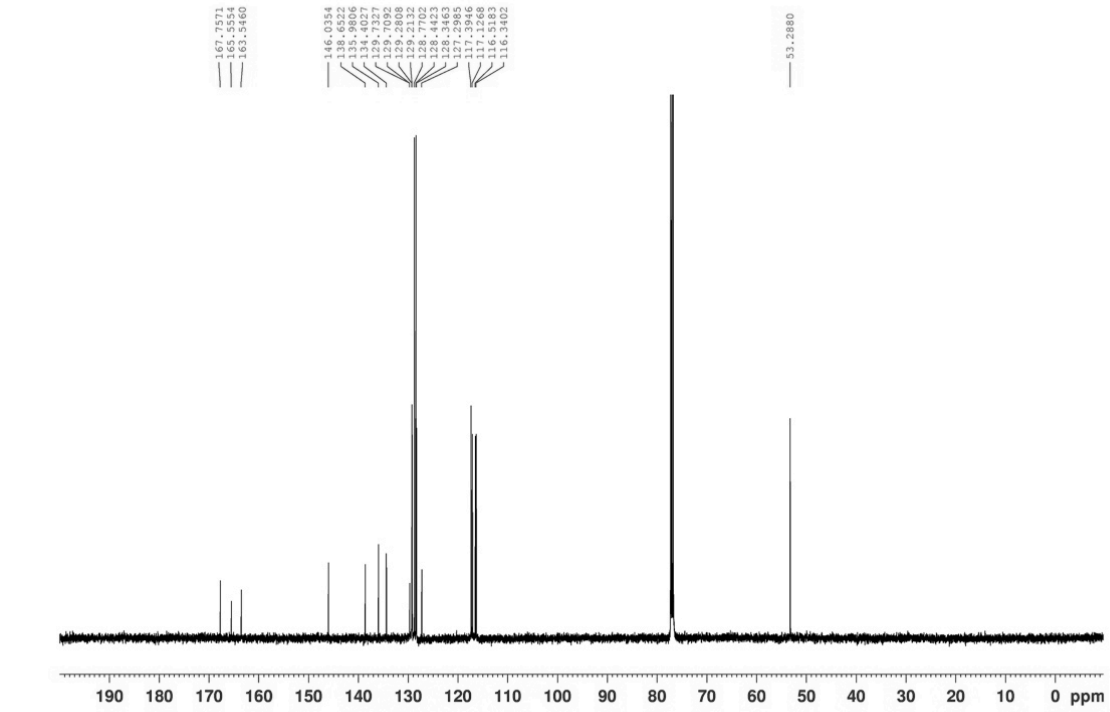
^{1}H NMR (500 MHz) and ^{13}C NMR (126 MHz) spectra of **18** ($CDCl_3$)



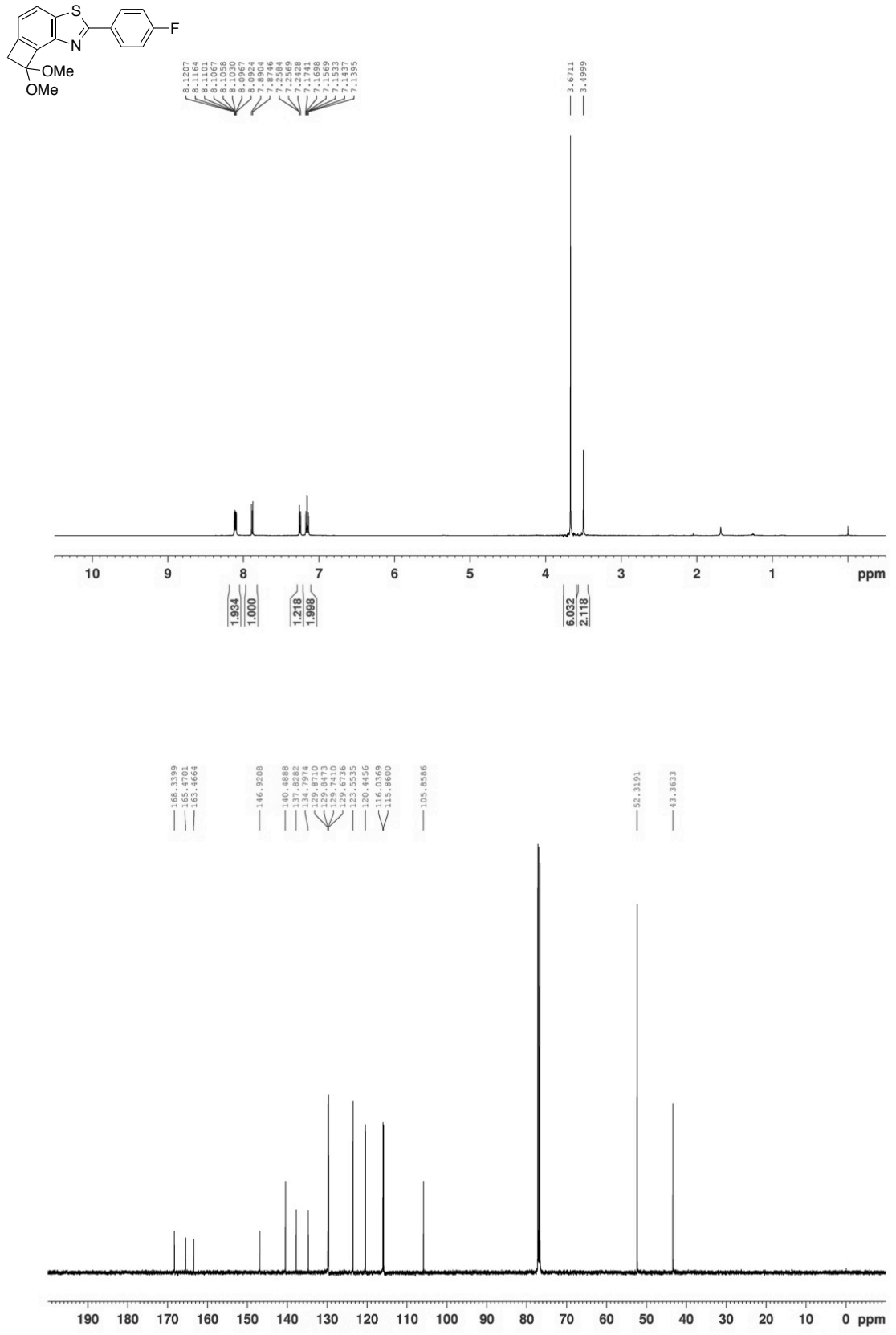
^{1}H NMR (500 MHz) and ^{13}C NMR (126 MHz) spectra of **18'** ($CDCl_3$)



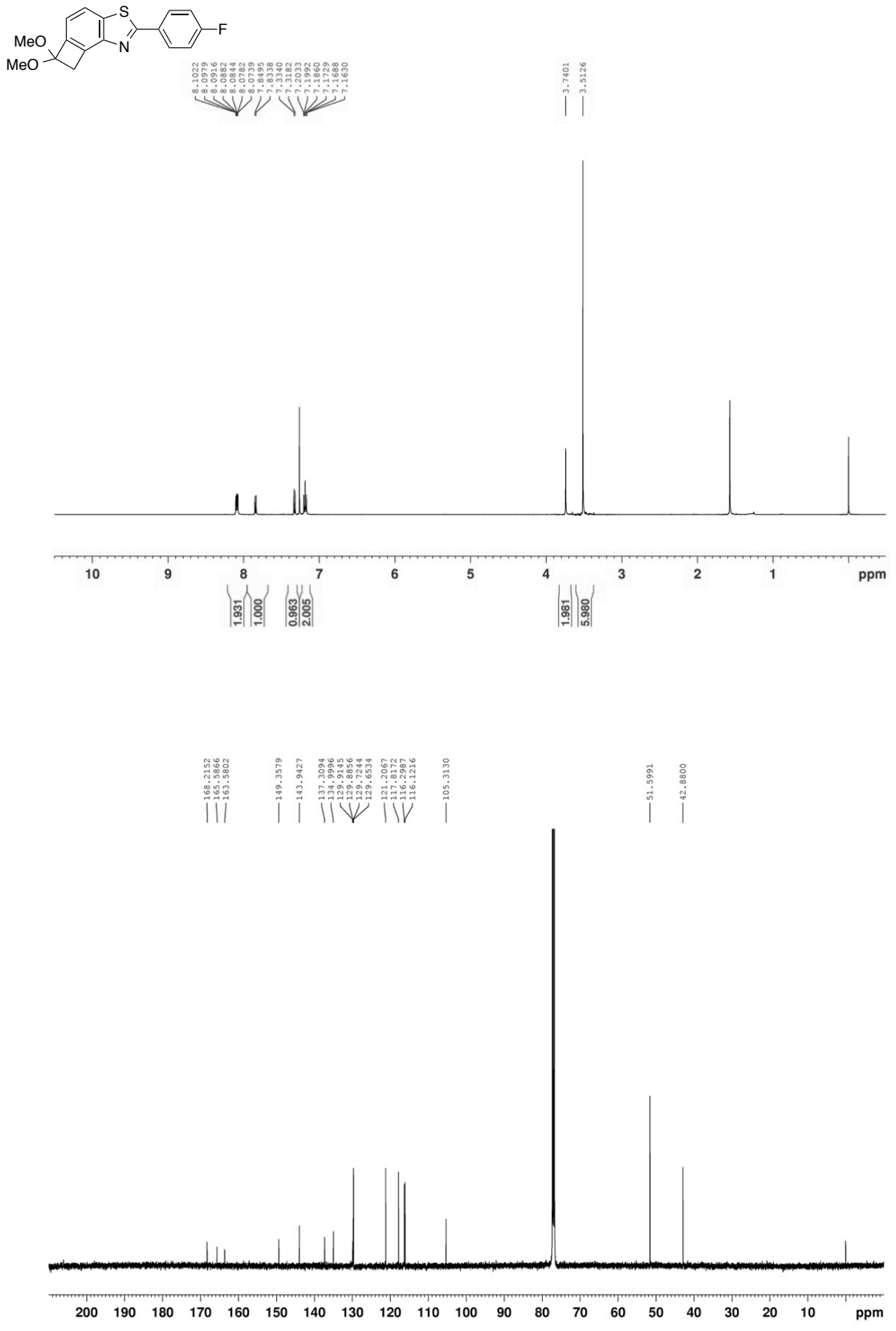




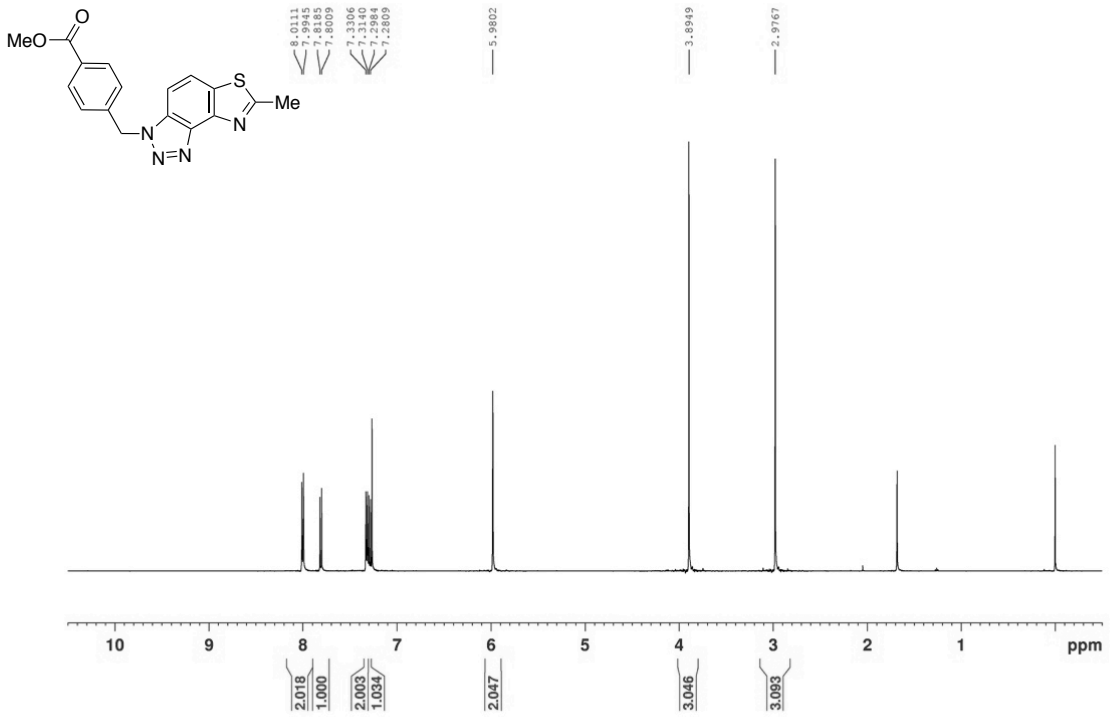
^{1}H NMR (500 MHz) and ^{13}C NMR (126 MHz) spectra of **19** ($CDCl_3$)

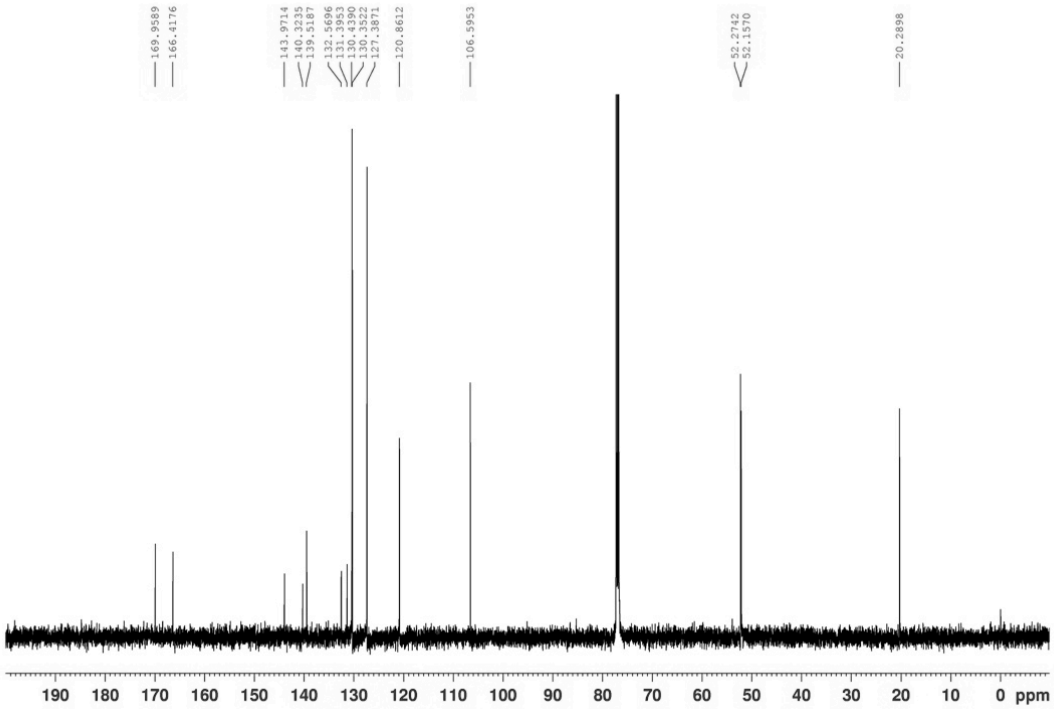


^{1}H NMR (500 MHz) and ^{13}C NMR (126 MHz) spectra of **19'** ($CDCl_3$)

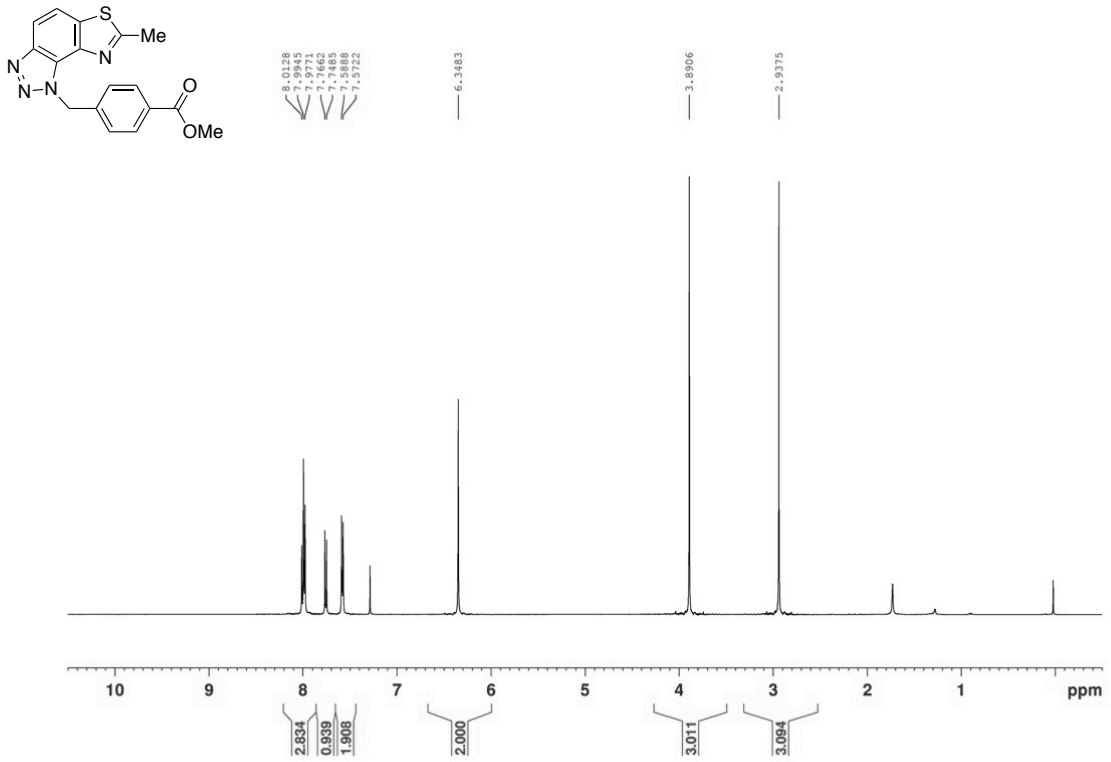


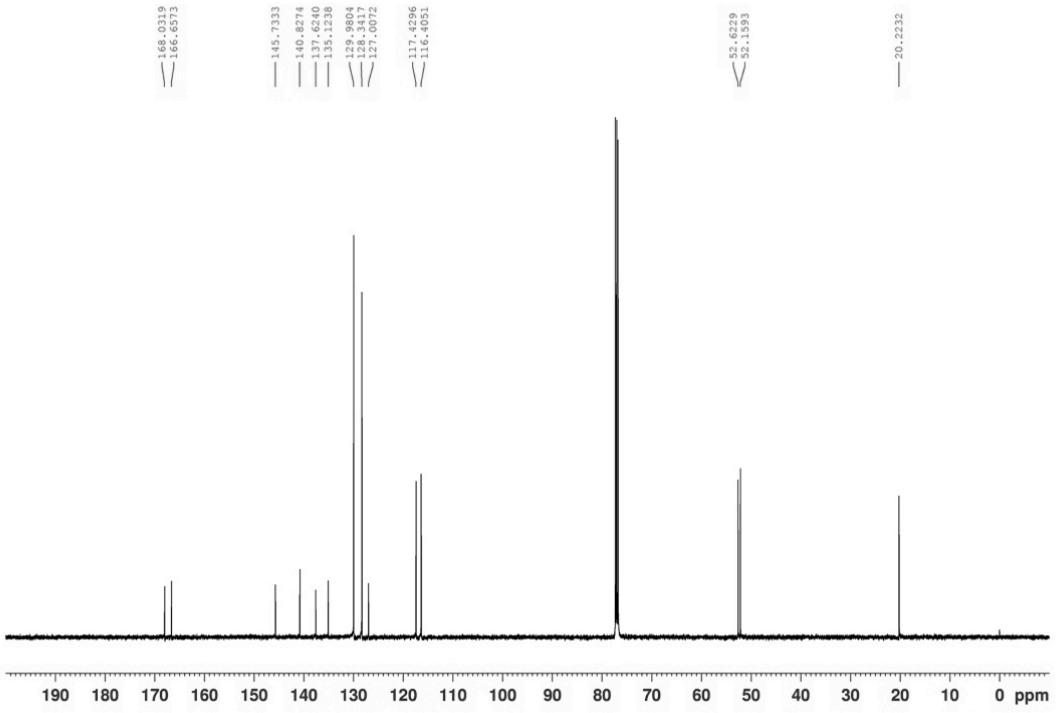
^{1}H NMR (500 MHz) and ^{13}C NMR (126 MHz) spectra of **21** ($CDCl_3$)



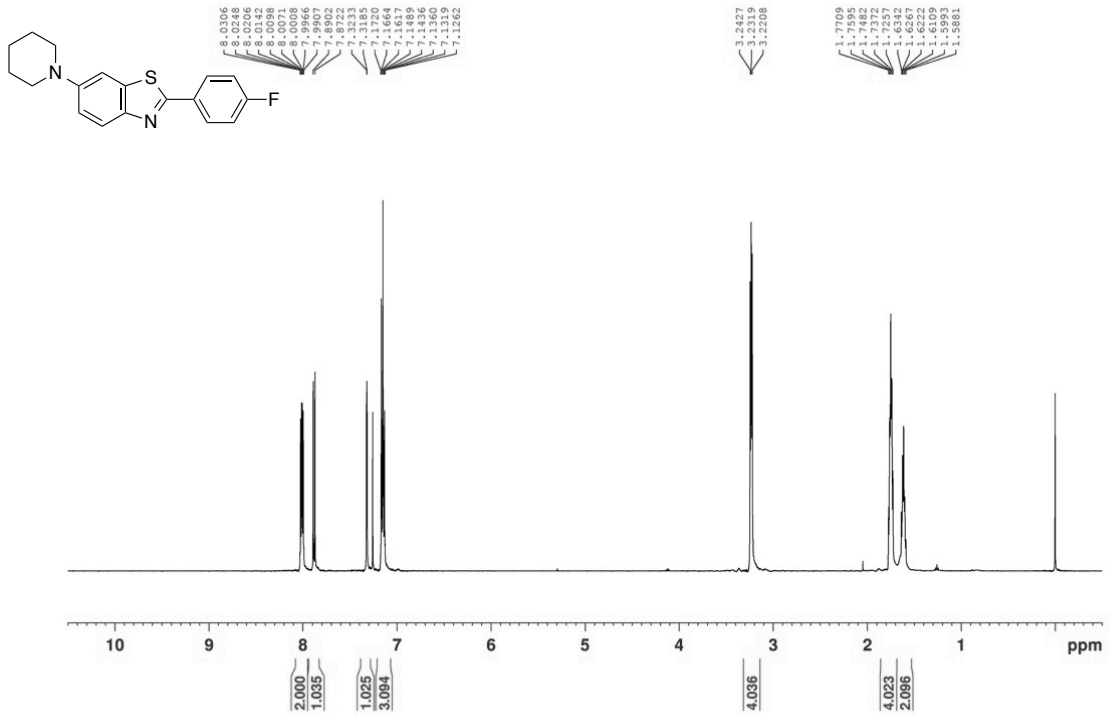


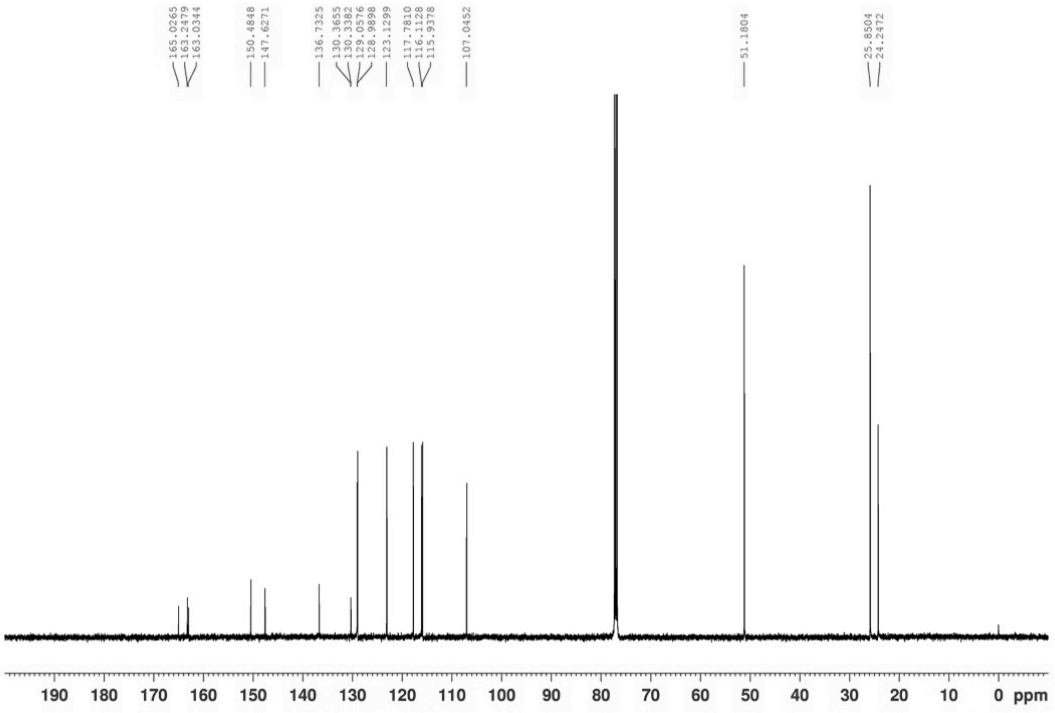
^{1}H NMR (500 MHz) and ^{13}C NMR (126 MHz) spectra of **21'** ($CDCl_3$)



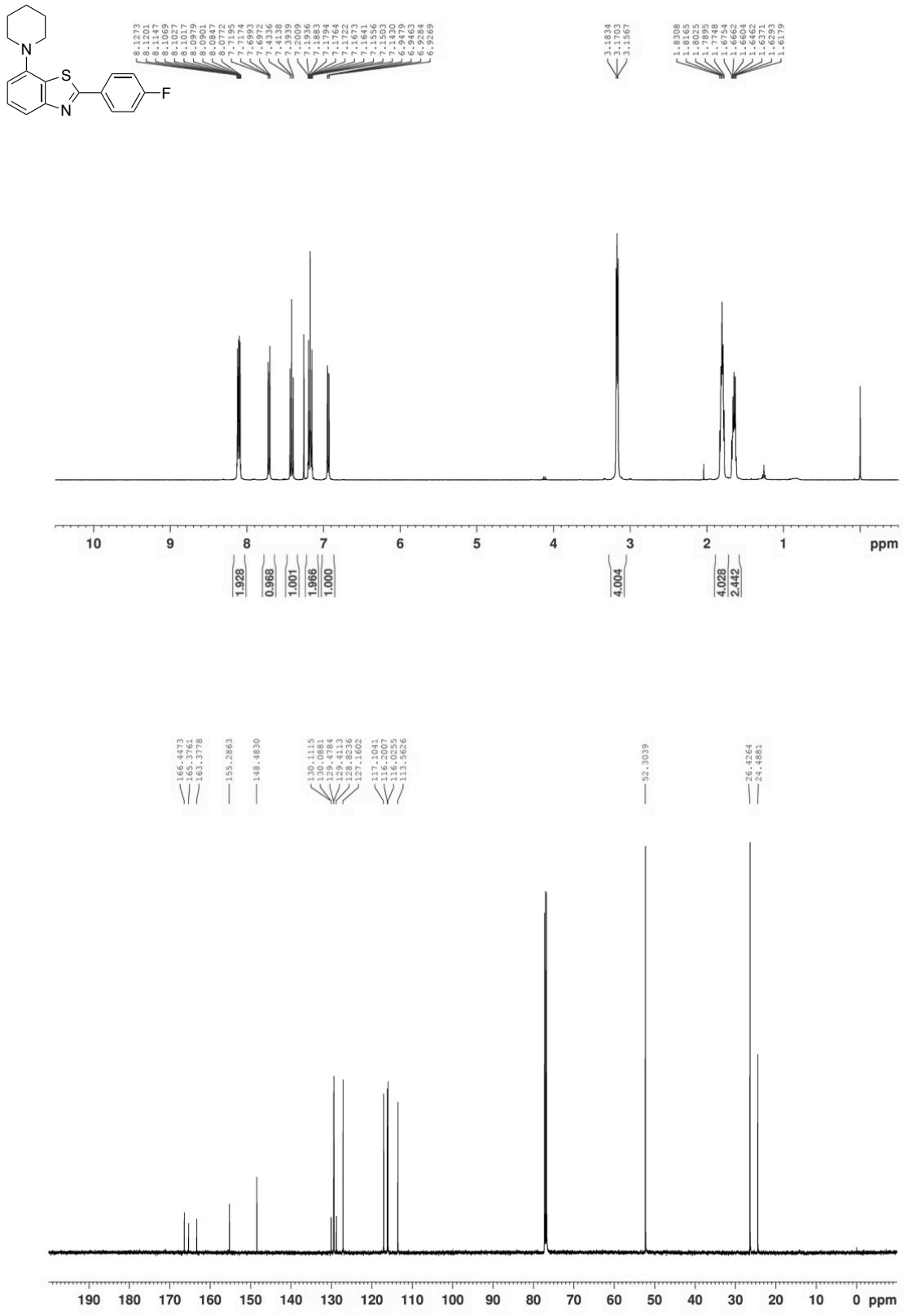


^{1}H NMR (500 MHz) and ^{13}C NMR (126 MHz) spectra of **23** ($CDCl_3$)

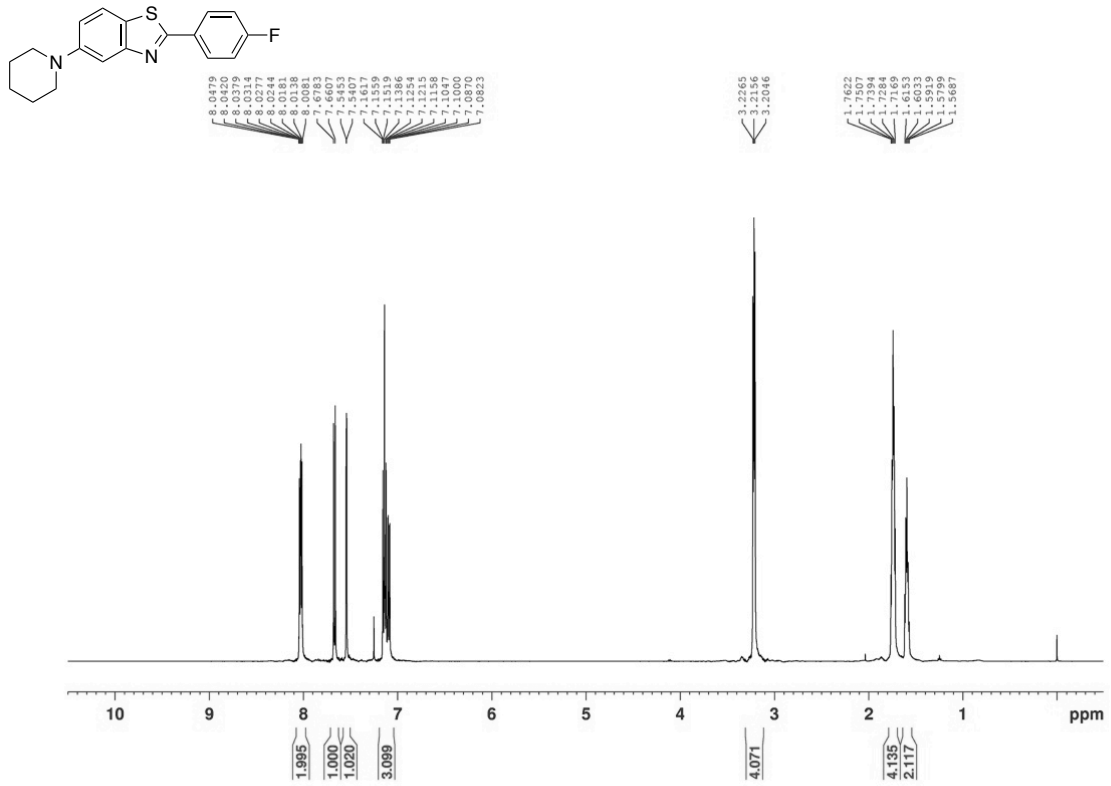


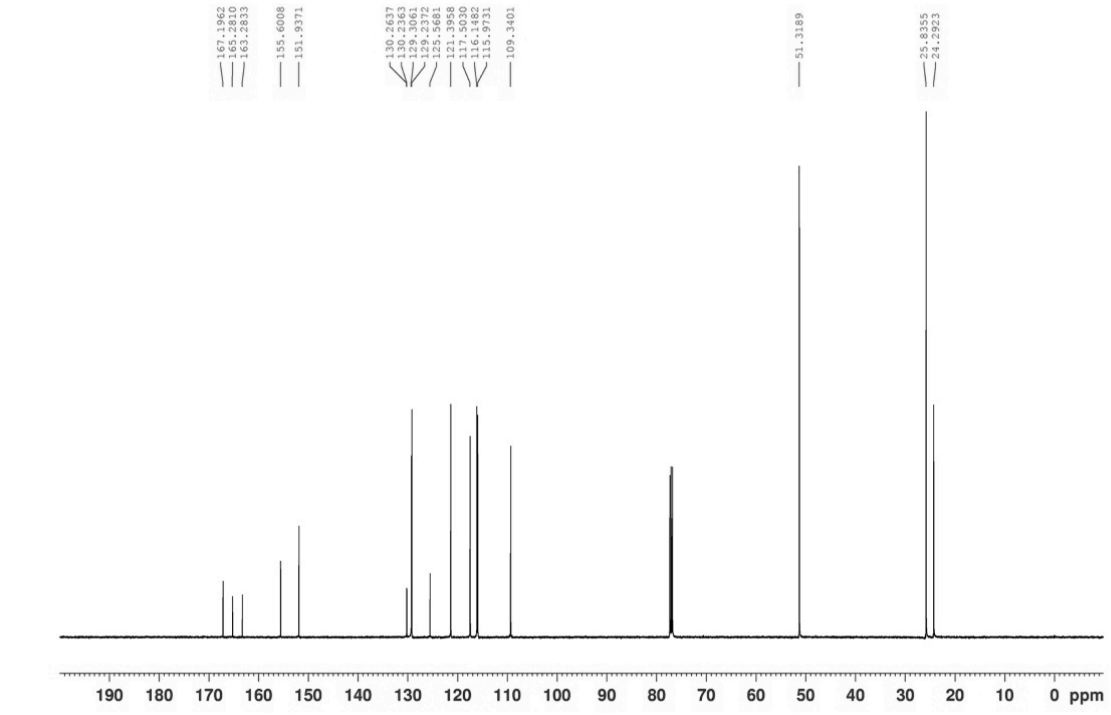


^{1}H NMR (500 MHz) and ^{13}C NMR (126 MHz) spectra of **23'** ($CDCl_3$)

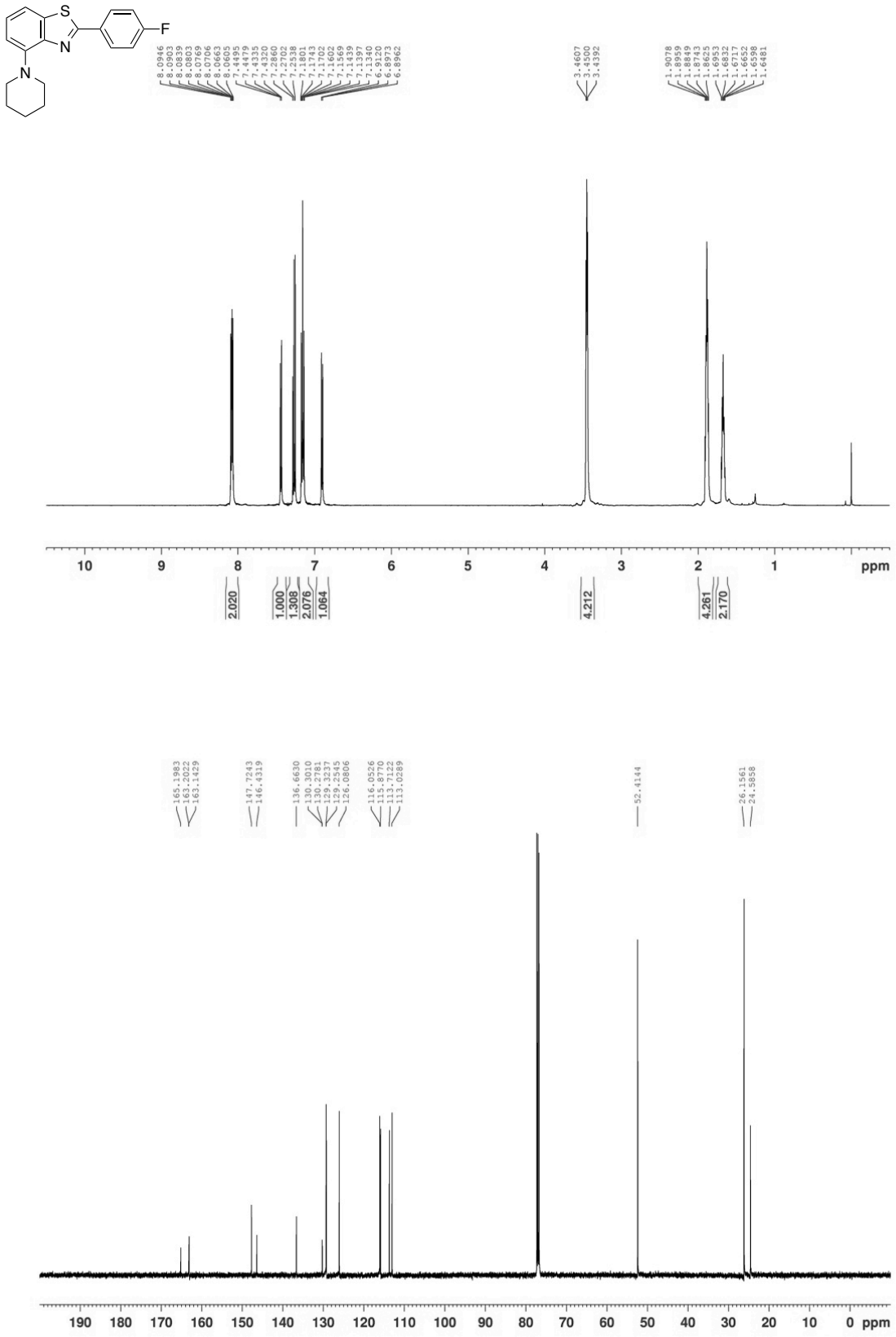


^{1}H NMR (500 MHz) and ^{13}C NMR (126 MHz) spectra of **24** ($CDCl_3$)

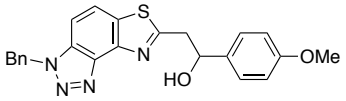


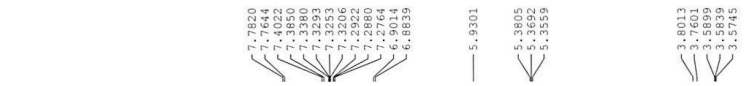


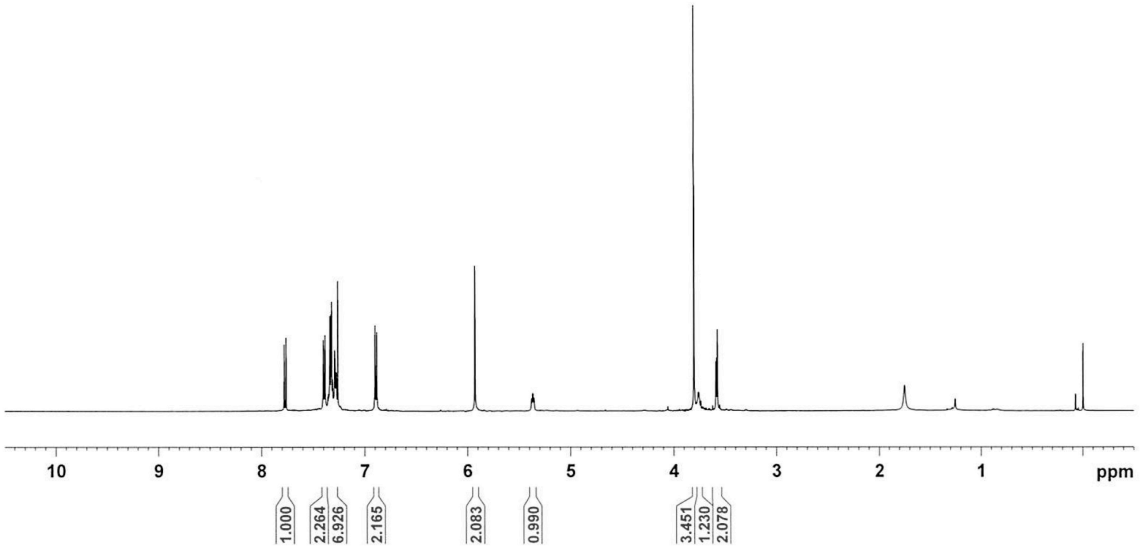
^{1}H NMR (500 MHz) and ^{13}C NMR (126 MHz) spectra of **24'** ($CDCl_3$)

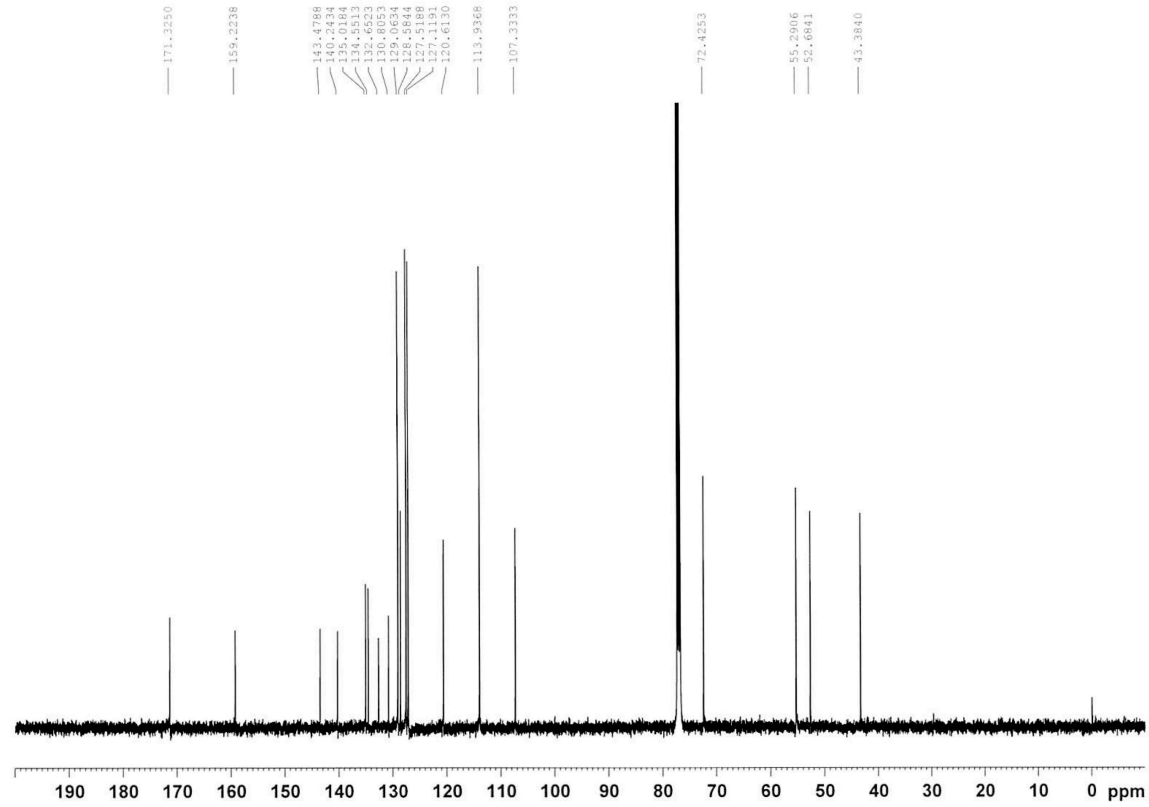


^{1}H NMR (500 MHz) and ^{13}C NMR (126 MHz) spectra of **25** ($CDCl_3$)









^{1}H NMR (500 MHz) and ^{13}C NMR (126 MHz) spectra of **26** ($CDCl_3$)