Supporting Information

Access to Thiazoles *via* [3+2] Cycloaddition of 1,2,3-Thiadiazoles with Isonitriles

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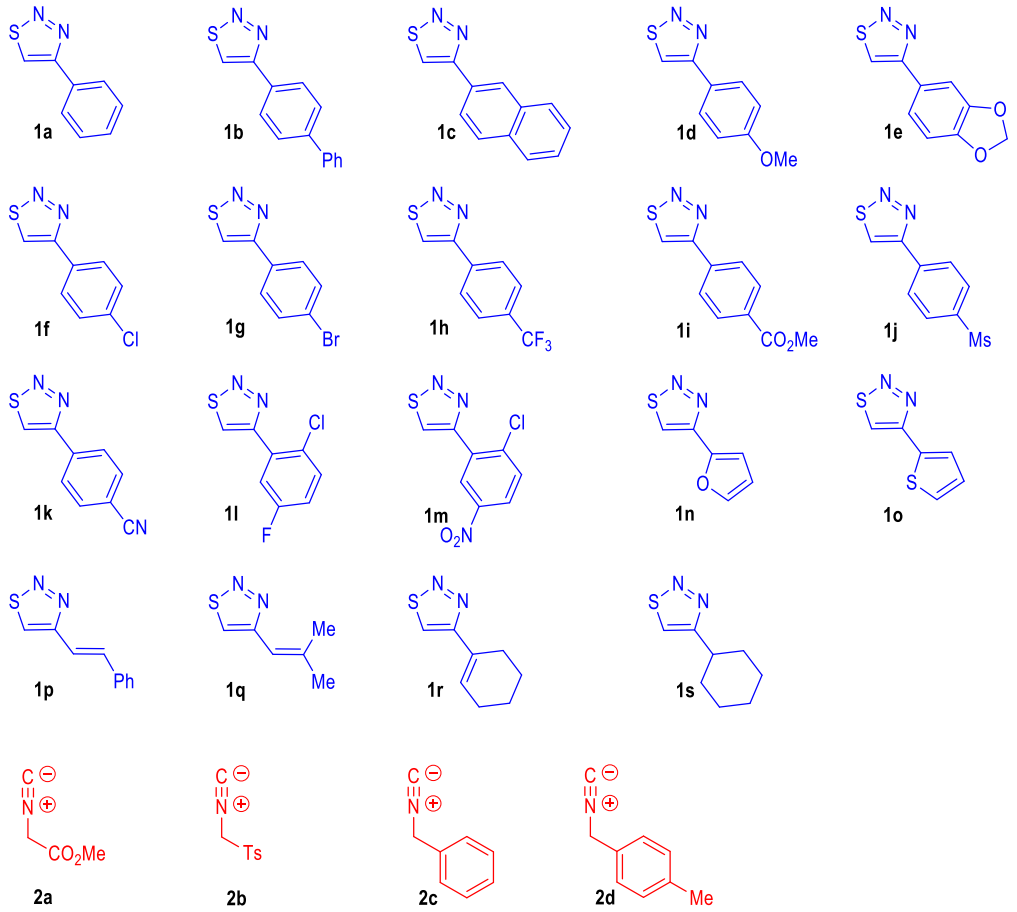
1 General Information

All reactions were conducted under argon atmosphere using flame-dried seal the tube with magnetic stirring unless otherwise noted. All solvents were dried or distilled by standard methods. Reactions were monitored by qualitative thin-layer chromatography (TLC) on silica gel F254 plates. Visualization on TLC was achieved by the use of UV light (254 nm). ^{1}H and ^{13}C NMR spectra were recorded on a Bruker 500 spectrometer (^{1}H at 500 MHz and ^{13}C at 125 MHz), ^{19}F NMR spectra were recorded on a Bruker 600 spectrometer (^{19}F at 564 MHz). ^{1}H NMR spectra data were reported as values in ppm relative to TMS (0.00), ^{13}C NMR spectra data were reported as values in ppm relative to chloroform (77.00). ^{1}H NMR coupling constants were reported in Hz, and multiplicity were indicated as follows: s (singlet); d (doublet); t (triplet); m (multiplet); q (quartet). IR spectra were measured on a Nicolet iS50 FT-IR spectrometer using KBr plates. The HRMS analysis was obtained on a Bruker Apex II FT-ICR mass spectrometer with ESI ionization method. Single crystal X-ray diffraction measurement was performed on an Agilent SuperNova-CCD X-ray diffractometer. Melting points were measured on a microscopic melting point apparatus and are uncorrected.

2 Preparation of substrates 1

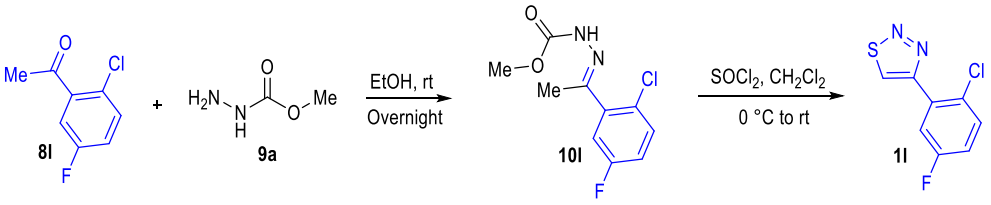
The substrates **1a**,[1] **1b**–**1c**,[2] **1d**–**1j**,[1] **1k**,[2] **1l**–**1m**,[1] **1n**–**1o**,[3] **1p**,[1] **1q**–**1s**[2], **2d**[4] are synthesized base on the reported literatures. Isonitriles **2a**–**2c** are commercially available. The preparation of new compounds, and their characterization data are provided as follows.



3 General procedure

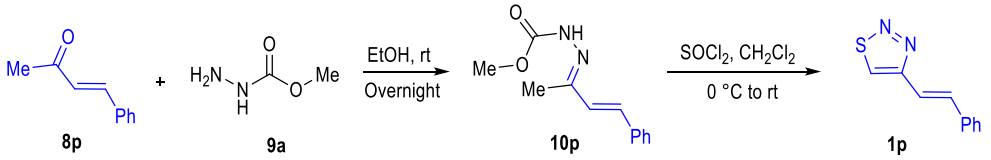
3.1 Syntheses of substrates 1

3.1.1 Synthesis of 1,2,3-thiadazole 1l



To a 100 ml round bottom flask equipped with a stir bar, 1-(2-chloro-5-fluorophenyl)ethan-1-one **8l** (0.69 mL, 5.0 mmol) was added to a solution of methyl hydrazinecarboxylate **9a** (450.4 mg, 5.0 mmol) in EtOH (20.0 mL) under argon atmosphere. The reaction mixture was stirred at room temperature overnight and then concentrated in *vacuo*. The crude hydrazone **10l** was washed with EtOH, dried in the vacuum and directly used for the next step without further purification. Then, $SOCl_2$ (0.36 mL, 25.0 mmol) was added dropwise to the solution of hydrazone **10l** (5.0 mmol) in CH_2Cl_2 (20.0 mL) at 0 °C. The reaction mixture was stirred at room temperature overnight. After the reaction was completely transformed by TLC analysis, the mixture was washed with 5% $NaHCO_3$ solution (10.0 mL×3) and extracted with EtOAc (30.0 mL×3). The combined organic layer was dried over anhydrous Na_2SO_4 and concentrated in *vacuo*. The crude product was purified by column chromatography (PE:EA = 30:1) to afford 1,2,3-thiadiazole **1l**[1] (837.1 mg, 78% for two steps).

3.1.2 Synthesis of 1,2,3-thiadazole 1p



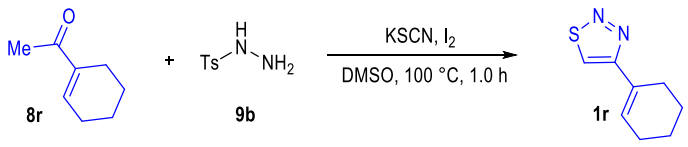
To a 100 ml round bottom flask equipped with a stir bar, (*E*)-4-phenylbut-3-en-2-one **8p** (731.0 mg, 5.0 mmol) was added to a solution of methyl hydrazinecarboxylate **9a** (450.4 mg, 5.0 mmol) in EtOH (20.0 mL) under argon atmosphere. The reaction mixture was stirred at room temperature overnight

and then concentrated in *vacuo*. The crude hydrazone **10p** was washed with EtOH, dried in the vacuum and used for the next step without further purification. Then, $SOCl_2$ (0.36 mL, 25.0 mmol) was added dropwise to the solution of hydrazone **10p** (5.0 mmol) in CH_2Cl_2 (20.0 mL) at 0 °C. The reaction mixture was stirred at room temperature overnight. After the reaction was completely transformed by TLC analysis, the mixture was washed with 5% $NaHCO_3$ solution (10.0 mL×3) and extracted with EtOAc (30.0 mL×3). The combined organic layer was dried over anhydrous Na_2SO_4 and concentrated in *vacuo*. The crude product was purified by column chromatography (PE:EA = 30:1) to afford 1,2,3-thiadiazole **1p**[1] (677.7 mg, 72% for two steps).

3.1.3 Synthesis of 1,2,3-thiadazole 1q

To a 100 ml round bottom flask equipped with a stir bar, 4-methylpent-3-en-2-one **8q** (0.57 mL, 5.0 mmol) was added to a solution of *p*-toluenesulfonyl hydrazide **9b** (931.2 mg, 5.0 mmol) in DMSO (20.0 mL) under argon atmosphere. Then, KSCN (485.9 mg, 5.0 mmol) and I_2 (2.54 g, 10.0 mmol) were added at room temperature. The resulting mixture was stirred at 100 °C for 1.0 h. After the reaction was completely transformed by TLC analysis, the mixture was quenched with saturated $Na_2S_2O_3$ solution (50.0 mL) and extracted with EtOAc (50.0 mL×3). The combined organic layer was washed with brine, dried over anhydrous Na_2SO_4 and concentrated in *vacuo*. The crude product was purified by column chromatography (PE:EA = 100:1) to offer 1,2,3-thiadiazole **1q**[2] (441.8 mg, 63%).

3.1.4 Synthesis of 1,2,3-thiadazole 1r

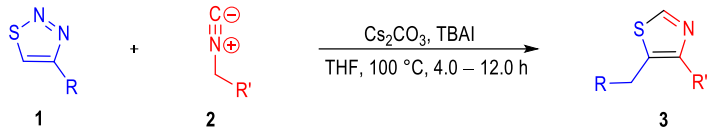


To a 100 ml round bottom flask equipped with a stir bar, 1-(cyclohex-1-en-1-yl)ethan-1-one **8r** (0.6 mL, 5.0 mmol) was added to a solution of

p-toluenesulfonyl hydrazide **9b** (931.2 mg, 5.0 mmol) in DMSO (20.0 mL) under argon atmosphere. Then, KSCN (485.9 mg, 5.0 mmol) and I_2 (2.54 g, 10.0 mmol) were added at room temperature. The resulting mixture was stirred at 100 °C for 1.0 h. After the reaction was completely transformed by TLC analysis, the mixture was quenched with saturated $Na_2S_2O_3$ solution (50.0 mL) and extracted with EtOAc (50.0 mL×3). The combined organic layer was washed with brine, dried over anhydrous Na_2SO_4 and concentrated in *vacuo*. The crude product was purified by column chromatography (PE:EA = 75:1) to offer 1,2,3-thiadiazole **1r**[2] (465.5 mg, 56%).

3.2 Syntheses of thiazole products 3

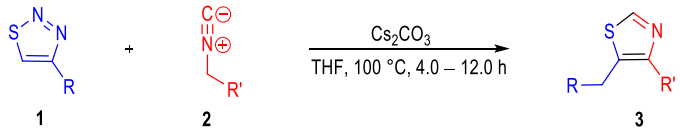
3.2.1 General Procedure A



1 2 3

To a 10 mL flame dried sealed tube equipped with a stir bar, 1,2,3-thiadiazoles **1** (0.20 mmol), Cs_2CO_3 (0.15 mmol) and TBAI (10 mmol%) were added in anhydrous THF (1.0 mL) under argon atmosphere, and isonitriles **2** (0.10 mmol, 1.0 eq.) was added dropwise into the mixture. Then, the resulting mixture was stirred at 100 ℃. After isonitrile was completely consumed by TLC analysis, the residue was directly concentrated in *vacuo* and purified by column chromatography (PE:EA = 5:1) to afford the desired product **3** (**3a**–**3g**, **3n**–**3o**, **3s**–**3t**).

3.2.2 General Procedure B



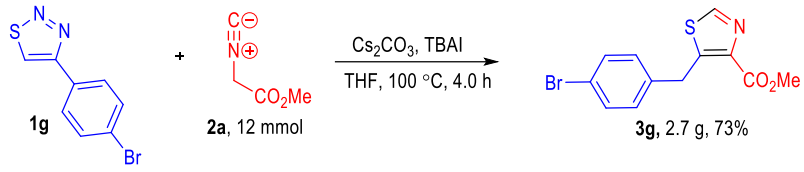
1 2 3

To a 10 mL flame dried sealed tube equipped with a stir bar, 1,2,3-thiadiazoles **1** (0.20 mmol) and Cs_2CO_3 (0.15 mmol) were added in anhydrous THF (1.0 mL) under argon atmosphere, and isonitriles **2** (0.10 mmol, 1.0 eq.) was added dropwise into the mixture. Then, the resulting mixture was stirred at 100 ℃. After isonitrile was

completely consumed by TLC analysis, the residue was directly concentrated in *vacuo* and purified by column chromatography (PE:EA = 5:1) to afford the desired product **3** (**3h**–**3m**, **3p**–**3r**).

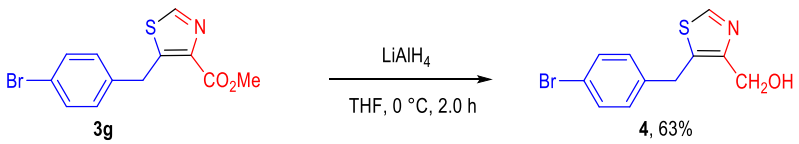
3.3 Synthetic transformations and applications

3.3.1 Gram-scale synthesis of 3g



To a 100 ml round bottom flask equipped with a stir bar, 1,2,3-thiadiazole **1g** (5.76 g, 24.0 mmol) and TBAI (443.0 mg, 1.2 mmol) were added in anhydrous THF under argon atmosphere, Cs_2CO_3 (5.86 g, 18.0 mmol) was added batches, and methyl isocyanoacetate **2a** (1.1 mL, 12.0 mmol) was added dropwise into the mixture. Then, the resulting mixture was stirred at 100 ℃ for 4.0 h. After isonitrile was completely consumed by TLC analysis, the residue was directly concentrated in *vacuo* and purified by column chromatography (PE:EA = 5:1) to afford the desired product **3g** (2.7 g, 73%).

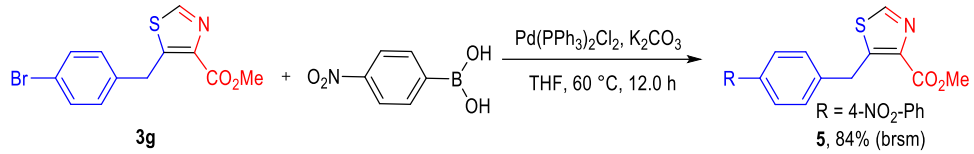
3.3.2 The reduction of 3g



To a 10 mL flame dried test tube equipped with a stir bar, the solution of 1,2,3-thiadiazole **3g** (31.2 mg, 0.1 mmol) in anhydrous THF (0.5 mL) was added to a suspension of $LiAlH_4$ (7.6 mg, 0.2 mmol) in anhydrous THF (0.5 mL) under argon atmosphere at 0 ℃. After the substrate was completely consumed by TLC analysis, the reaction system was slowly quenched with EtOAc at 0 ℃. Then, water was added to the mixture and the aqueous phase was extracted with EtOAc. The combined organic layer was dried over anhydrous Na_2SO_4 and concentrated in *vacuo*. Finally, the residue purified by column chromatography (PE:EA = 1:1) to afford the desired

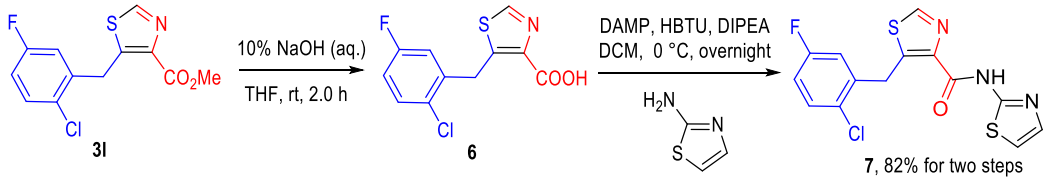
product **4**[5] (16.7 mg, 63%).

3.3.3 The Suzuki coupling reaction of 3g



To a 10 mL flame dried test tube equipped with a stir bar, 1,2,3-thiadiazole **3g** (31.2 mg, 0.1 mmol), 4-nitrophenylboronic acid (25.0 mg, 0.15 mmol), $Pd(PPh_3)_2Cl_2$ (1.5 mg, 2 mmol%) and K_2CO_3 (27.6 mg, 0.2 mmol) were added in anhydrous THF (1.0 mL) at 60 ℃ under argon atmosphere. After stirring for about 12.0 h, the residue was directly concentrated in *vacuo* and purified by column chromatography (PE:EA = 3:1) to afford the desired product **5** (21.7 mg, 84%, brsm).

3.3.4 Synthesis of bioactive compound 7

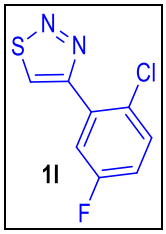


To a stirred solution of thiazole **3l** (285.7 mg, 1.0 mmol) in THF (10.0 mL), 10% NaOH aqueous solution (1.0 mL) was added at rt. After the reaction was completely transformed by TLC analysis, HCl (5.0 M) was added until pH = 3.0. The aqueous phase was extracted with DCM (20.0 mL×3). The combined organic layer was washed with brine (20.0 mL×3), dried over anhydrous Na_2SO_4, and concentrated in *vacuo*. The crude product **6** was directly used without further purification.

HBTU (455.1 mg, 1.2 mmol), DIPEA (0.36 mL, 2.2 mmol) and 4-DMAP (24.4 mg, 0.2 mmol) were added to a stirred solution of the amine (100.1 mg, 1.0 mmol) and acid **6** (1.0 mmol) under argon atmosphere in dry DCM at 0 °C. The resulting mixture was stirred at rt overnight. Then the mixture was filtered through celite, washed with $CHCl_3$ and evaporated in *vacuo*. The crude was redissolved in DCM, washed with 5% HCl and then with saturated solution of $NaHCO_3$, dried over anhydrous Na_2SO_4 and evaporated in *vacuo*. The crude product was purified by flash chromatography to obtain amide **7**[6,7] (289.3 mg, 82% for two steps).

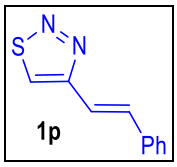
4 Characterization data for compounds

4-(2-chloro-5-fluorophenyl)-1,2,3-thiadiazole (**1l**)



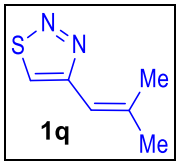
White amorphous solid. **^{1}H NMR (500 MHz, $CDCl_3$)** δ 8.89 (s, 1H), 7.98 – 7.95 (m, 1H), 7.13 – 7.11 (m, 1H), 7.02 – 6.99 (m, 1H); **^{13}C NMR (125 MHz, $CDCl_3$)** δ 163.3, 161.3, 157.9, 134.4, 132.9 (d, *J* = 35.5 Hz), 125.8 (d, *J* = 15.0 Hz), 117.6 (d, *J* = 99.5 Hz), 114.6 (d, *J* = 84.0 Hz); **^{19}F NMR (564 MHz, $CDCl_3$)** δ – 109.5 (q, *J* = 7.3 Hz, 1F); **IR (cm^{-1}):** ν 3456, 3120, 1605, 1463, 1260, 1207, 889, 856, 786; **HRMS:** m/z: $[M + H]^+$ calculated for $C_8H_5ClFN_2S^+$, 214.9841, found 214.9836.

(*E*)-4-styryl-1,2,3-thiadiazole (**1p**)



Yellow amorphous solid. **^{1}H NMR (500 MHz, $CDCl_3$)** δ 8.24 (s, 1H), 7.59 – 7.55 (m, 1H), 7.43 (d, *J* = 7.0 Hz, 2H), 7.30 – 7.25 (m, 3H), 7.21 (d, *J* = 7.0 Hz, 1H); **^{13}C NMR (125 MHz, $CDCl_3$)** δ 161.0, 135.9, 134.4, 130.3, 128.7, 128.5, 126.8, 116.9; **IR (cm^{-1}):** ν 3464, 3070, 2923, 1638, 1497, 1242, 961, 754, 694; **HRMS:** m/z: $[M + H]^+$ calculated for $C_{10}H_9N_2S^+$, 189.0481, found 189.0477.

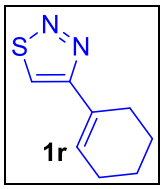
4-(2-methylprop-1-en-1-yl)-1,2,3-thiadiazole (**1q**)



Yellow oil. **^{1}H NMR (500 MHz, $CDCl_3$)** δ 8.15 (s, 1H), 6.57 (s, 1H), 2.00 (s, 3H), 1.94 (s, 3H); **^{13}C NMR (125 MHz, $CDCl_3$)** δ 160.7, 141.6, 130.9, 114.5, 27.0, 20.4;

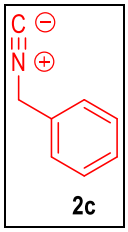
IR (cm^{-1}): ν 3449, 2962, 1701, 1384, 1261, 1095, 1023, 803; **HRMS:** m/z: $[M + H]^+$ calculated for $C_6H_9N_2S^+$, 141.0481, found 141.0477.

4-(cyclohex-1-en-1-yl)-1,2,3-thiadiazole (**1r**)



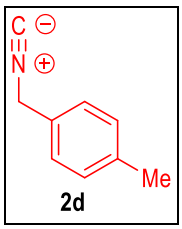
Yellow oil. **^{1}H NMR (500 MHz, CDCl$_3$)** δ 8.11 (s, 1H), 6.90 – 6.89 (m, 1H), 2.46 – 2.44 (m, 2H), 2.24 – 2,21 (m, 2H), 1.79 – 1.74 (m, 2H), 1.67 – 1.62 (m, 2H); **^{13}C NMR (125 MHz, CDCl$_3$)** δ 164.1, 129.4, 127.7, 127.4, 26.6, 25.1, 22.0, 21.5; **IR (cm^{-1}):** ν 3425, 2930, 1650, 1449, 1225, 1077, 891, 571; **HRMS:** m/z: $[M + H]^+$ calculated for $C_8H_{11}N_2S^+$, 167.0637, found 167.0634.

(isocyanomethyl)benzene (**2c**)



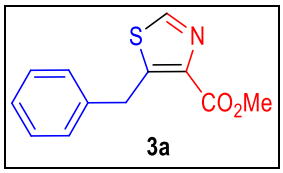
Yellow oil. **^{1}H NMR (500 MHz, CDCl$_3$)** δ 7.31 – 7.28 (m, 2H), 7.26 – 7.22 (m, 3H), 4.51 (s, 2H).[8]

1-(isocyanomethyl)-4-methylbenzene (**2d**)



Yellow oil. **^{1}H NMR (500 MHz, CDCl$_3$)** δ 7.08 (d, *J* = 8.0 Hz, 2H), 7.05 (d, *J* = 8.0 Hz, 2H), 4.40 (s, 2H), 2.22 (s, 3H).[4]

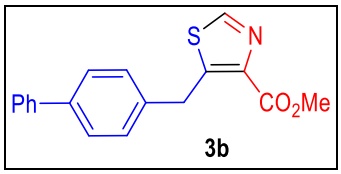
methyl 5-benzylthiazole-4-carboxylate (**3a**)



3a

Compound **3a** as a white amorphous solid (21.4 mg) was obtained *via the General Procedure A* in 92% yield. **^{1}H NMR (500 MHz, $CDCl_3$)** δ 8.53 (s, 1H), 7.27 – 7.24 (m, 2H), 7.21 – 7.18 (m, 3H), 4.55 (s, 2H), 3.91 (s, 3H); **^{13}C NMR (125 MHz, $CDCl_3$)** δ 162.8, 150.3, 150.2, 141.1, 139.1, 128.8, 128.7, 127.1, 52.3, 33.3; **IR (cm^{-1}):** ν 3423, 2925, 1717, 1440, 1327, 1269, 1156, 1009, 703; **HRMS:** m/z: $[M + H]^+$ calculated for $C_{12}H_{12}NO_2S^+$, 234.0583, found 234.0578.

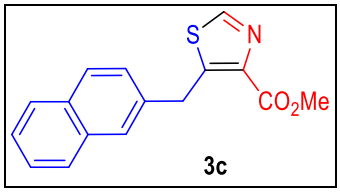
methyl 5-([1,1'-biphenyl]-4-ylmethyl) thiazole-4-carboxylate (**3b**)



3b

Compound **3b** as a yellow amorphous solid (22.1 mg) was obtained *via the General Procedure A* in 71% yield. **^{1}H NMR (500 MHz, $CDCl_3$)** δ 8.55 (s, 1H), 7.50 (d, *J* = 8.5 Hz, 2H), 7.48 (d, *J* = 8.5 Hz, 2H), 7.37 – 7.34 (m, 3H), 7.28 – 7.26 (m, 3H), 4.58 (s, 2H), 3.91 (s, 3H); **^{13}C NMR (125 MHz, $CDCl_3$)** δ 162.8, 150.3, 150.0, 141.1, 140.6, 140.0, 138.1, 129.1, 128.7, 127.5, 127.3, 127.0, 52.3, 32.9; **IR (cm^{-1}):** ν 2925, 2360, 1704, 1653, 1507, 1457, 1319, 737, 668; **HRMS:** m/z: $[M + Na]^+$ calculated for $C_{18}H_{15}NNaO_2S^+$, 332.0716, found 332.0711.

methyl 5-(naphthalen-1-ylmethyl) thiazole-4-carboxylate (**3c**)

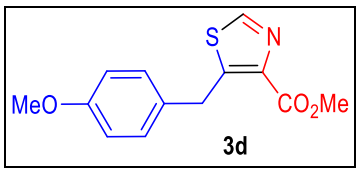


3c

Compound **3c** as a white amorphous solid (24.2 mg) was obtained *via the General Procedure A* in 86% yield. **^{1}H NMR (500 MHz, $CDCl_3$)** δ 8.53 (s, 1H), 7.73 (q, *J* = 7.0 Hz, 3H), 7.64 (s, 1H), 7.42 – 7.37 (m, 2H), 7.32 – 7.30 (m, 1H), 4.70 (s, 2H), 3.92

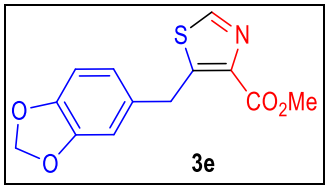
(s, 3H); **^{13}C NMR (125 MHz, CDCl$_3$)** δ 162.8, 150.4, 150.1, 141.2, 136.6, 133.5, 132.4, 128.6, 127.7, 127.7, 127.2, 126.9, 126.3, 125.9, 52.3, 33.5; **IR (cm^{-1}):** ν 2924, 2360, 1717, 1653, 1507, 1457, 752, 668; **HRMS:** m/z: $[M + H]^+$ calculated for $C_{16}H_{14}NO_2S^+$, 284.0740, found 284.0732.

methyl 5-(4-methoxybenzyl) thiazole-4-carboxylate (**3d**)



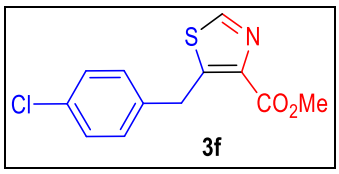
Compound **3d** as a white amorphous solid (24.8 mg) was obtained *via the General Procedure A* in 94% yield. **^{1}H NMR (500 MHz, CDCl$_3$)** δ 8.51 (s, 1H), 7.12 (d, *J* = 8.0 Hz, 2H), 6.78 (d, *J* = 8.0 Hz, 2H), 4.46 (s, 2H), 3.89 (s, 3H), 3.71 (s, 3H); **^{13}C NMR (125 MHz, CDCl$_3$)** δ 162.7, 158.6, 151.1, 150.1, 140.7, 131.2, 129.7, 114.1, 55.1, 52.1, 32.5; **IR (cm^{-1}):** ν 3069, 2360, 1715, 1515, 1438, 1270, 1152, 837; **HRMS:** m/z: $[M + Na]^+$ calculated for $C_{13}H_{13}NNaO_3S^+$, 286.0508, found 286.0506.

methyl 5-(benzo[*d*] [1,3] dioxol-4-ylmethyl) thiazole-4-carboxylate (**3e**)



Compound **3e** as a yellow amorphous solid (24.6 mg) was obtained *via the General Procedure A* in 89% yield. **^{1}H NMR (500 MHz, CDCl$_3$)** δ 8.53 (s, 1H), 6.70 – 6.66 (m, 3H), 5.88 (s, 2H), 4.44 (s, 2H), 3.91 (s, 3H); **^{13}C NMR (125 MHz, CDCl$_3$)** δ 162.8, 150.6, 150.3, 147.9, 146.6, 140.9, 132.9, 121.8, 109.2, 108.4, 101.1, 52.3, 33.0; **IR (cm^{-1}):** ν 3087, 2917, 2360, 1709, 1440, 1250, 1038, 810; **HRMS:** m/z: $[M + H]^+$ calculated for $C_{13}H_{12}NO_4S^+$, 278.0482, found 278.0477.

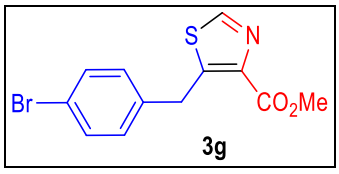
methyl 5-(4-chlorobenzyl) thiazole-4-carboxylate (**3f**)



3f

Compound **3f** as a yellow amorphous solid (23.8 mg) was obtained *via the General Procedure A* in 89% yield. **^{1}H NMR (500 MHz, CDCl$_3$)** δ 8.55 (s, 1H), 7.22 (d, *J* = 8.5 Hz, 2H), 7.14 (d, *J* = 8.5 Hz, 2H), 4.51 (s, 2H), 3.90 (s, 3H); **^{13}C NMR (125 MHz, CDCl$_3$) δ** 162.7, 150.4, 149.2, 141.2, 137.5, 133.0, 130.0, 128.9, 52.3, 32.5; **IR (cm^{-1}):** ν 3061, 2951, 1713, 1508, 1494, 1355, 1172, 854, 782; **HRMS:** m/z: $[M + H]^+$ calculated for $C_{12}H_{11}ClNO_2S^+$, 268.0194, found 268.0187.

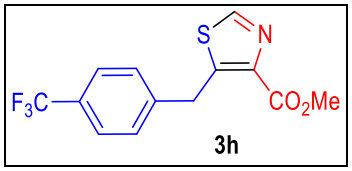
methyl 5-(4-bromobenzyl) thiazole-4-carboxylate (**3g**)



3g

Compound **3g** as a yellow amorphous solid (28.8 mg) was obtained *via the General Procedure A* in 92% yield. **^{1}H NMR (500 MHz, CDCl$_3$)** δ 8.55 (s, 1H), 7.38 – 7.35 (m, 2H), 7.09 – 7.06 (m, 2H), 4.49 (s, 2H), 3.89 (s, 3H); **^{13}C NMR (125 MHz, CDCl$_3$)** δ 162.6, 150.4, 149.0, 141.2, 138.0, 131.9, 130.3, 121.0, 52.3, 32.5; **IR (cm^{-1}):** ν 3105, 2942, 1712, 1509, 1488, 1334, 1170, 855, 777; **HRMS:** m/z: $[M + Na]^+$ calculated for $C_{12}H_{10}BrNNaO_2S^+$, 333.9508, found 333.9501.

methyl 5-(4-(trifluoromethyl) benzyl) thiazole-4-carboxylate (**3h**)

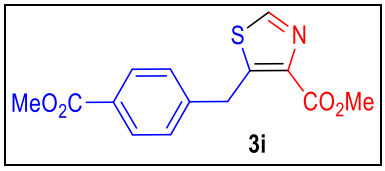


3h

Compound **3h** as a white solid (22.4 mg) was obtained *via the General Procedure B* in 74% yield. **m.p.**: 73.0 – 75.2 °C. **^{1}H NMR (500 MHz, CDCl$_3$)** δ 8.57 (s, 1H), 7.50 (d, *J* = 8.0 Hz, 2H), 7.31 (d, *J* = 8.0 Hz, 2H), 4.61 (s, 2H), 3.90 (s, 3H); **^{13}C NMR (125 MHz, CDCl$_3$)** δ 162.6, 150.5, 148.0, 142.8, 141.5, 129.3 (q, *J* = 7.5 Hz), 128.9, 125.7 (q, *J* = 14.5 Hz), 124.0 (q, *J* = 1082.0 Hz), 52.3, 32.8; **^{19}F NMR (564 MHz, CDCl$_3$)** δ – 62.6 (s, 3F); **IR (cm^{-1}):** ν 3102, 1715, 1327, 1443, 1169, 1121, 1066, 860,

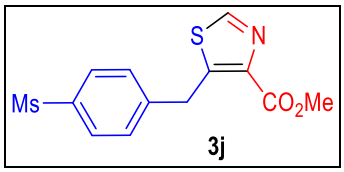
777; **HRMS:** m/z: $[M + Na]^+$ calculated for $C_{13}H_{10}F_3NNaO_2S^+$, 324.0277, found 324.0266.

methyl 5-(4-(methoxycarbonyl) benzyl) thiazole-4-carboxylate (**3i**)



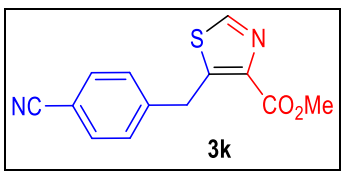
Compound **3i** as a yellow amorphous solid (19.4 mg) was obtained *via the General Procedure B* in 67% yield. **^{1}H NMR (500 MHz, $CDCl_3$)** δ 8.57 (s, 1H), 7.92 (d, *J* = 8.0 Hz, 2H), 7.27 (d, *J* = 8.0 Hz, 2H), 4.61 (s, 2H), 3.90 (s, 3H), 3.83 (s, 3H); **^{13}C NMR (125 MHz, $CDCl_3$)** δ 166.7, 162.6, 150.5, 148.4, 144.1, 141.5, 130.1, 129.0, 128.7, 52.3, 52.1, 33.1; **IR (cm^{-1}):** ν 3070, 2951, 1724, 1436, 1268, 1153, 1110, 857, 728; **HRMS**: m/z: $[M + Na]^+$ calculated for $C_{14}H_{13}NNaO_4S^+$, 314.0457, found 314.0451.

methyl 5-(4-(methylsulfonyl) benzyl) thiazole-4-carboxylate (**3j**)



Compound **3j** as a yellow amorphous solid (21.8 mg) was obtained *via the General Procedure B* in 70% yield. **^{1}H NMR (500 MHz, $CDCl_3$)** δ 8.61 (s, 1H), 7.82 (d, *J* = 7.5 Hz, 2H), 7.41 (d, *J* = 7.5 Hz, 2H), 4.66 (s, 2H), 3.91 (s, 3H), 2.98 (s, 3H); **^{13}C NMR (125 MHz, $CDCl_3$)** δ 162.6, 150.7, 147.1, 145.1, 141.8, 139.3, 129.5, 127.9, 52.4, 44.5, 32.7; **IR (cm^{-1}):** ν 3078, 2360, 1717, 1519, 1439, 1297, 1147, 1013, 752; **HRMS:** m/z: $[M + H]^+$ calculated for $C_{13}H_{14}NO_4S_2^+$, 312.0359, found 312.0358.

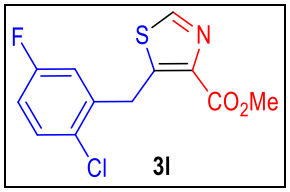
methyl 5-(4-cyanobenzyl) thiazole-4-carboxylate (**3k**)



Compound **3k** as a yellow oil (13.2 mg) was obtained *via the General Procedure B* in

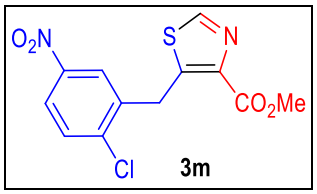
51% yield. **^{1}H NMR (500 MHz, $CDCl_3$)** δ 8.61 (s, 1H), 7.55 (d, *J* = 8.0 Hz, 2H), 7.32 (d, *J* = 8.0 Hz, 2H), 4.62 (s, 2H), 3.90 (s, 3H); **^{13}C NMR (125 MHz, $CDCl_3$)** δ 162.6, 150.7, 147.1, 144.2, 141.8, 132.6, 129.4, 118.6, 111.1, 52.4, 32.9; **IR (cm^{-1}):** ν 3079, 2360, 2227, 1717, 1506, 1446, 1264, 1144, 997, 787; **HRMS:** m/z: $[M + Na]^+$ calculated for $C_{13}H_{10}N_2NaO_2S^+$, 281.0355, found 281.0347.

methyl 5-(2-chloro-5-fluorobenzyl) thiazole-4-carboxylate (**3l**)



Compound **3l** as a yellow amorphous solid (20.6 mg) was obtained *via the General Procedure B* in 72% yield. **^{1}H NMR (500 MHz, $CDCl_3$)** δ 8.55 (s, 1H), 7.23 – 7.20 (m, 1H), 7.10 – 7.08 (m, 1H), 6.90 – 6.86 (m, 1H), 4.63 (s, 2H), 3.91 (s, 3H); **^{13}C NMR (125 MHz, $CDCl_3$)** δ 162.7, 162.6, 160.7, 150.4, 148.2, 141.5, 134.4 (d, *J* = 40.5 Hz), 133.0 (d, *J* = 14.5 Hz), 131.6 (d, *J* = 34.5 Hz), 117.1 (d, *J* = 98.5 Hz), 114.5 (d, *J* = 84.0 Hz), 52.3, 30.3; **IR (cm^{-1}):** ν 3083, 2360, 1714, 1489, 1297, 1199, 1016, 849; **^{13}F NMR (564 MHz, $CDCl_3$)** δ – 112.6 (q, *J* = 7.3 Hz, 1F); **HRMS:** m/z: $[M + H]^+$ calculated for $C_{12}H_{10}ClFNO_2S^+$, 286.0099, found 286.0095.

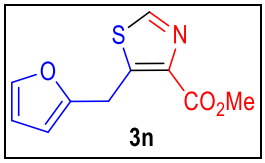
methyl 5-(2-chloro-5-nitrobenzyl) thiazole-4-carboxylate (**3m**)



Compound **3m** as a white amorphous solid (19.0 mg) was obtained *via the General Procedure B* in 61% yield. **^{1}H NMR (500 MHz, $CDCl_3$)** δ 8.63 (s, 1H), 8.09 (s, 1H), 8.04 (d, *J* = 9.0 Hz, 1H), 7.53 (d, *J* = 9.0 Hz, 1H), 4.78 (s, 2H), 3.93 (s, 3H); **^{13}C NMR (125 MHz, $CDCl_3$)** δ 162.6, 150.9, 146.8, 145.4, 142.3, 140.7, 138.7, 130.7, 125.4, 123.5, 52.5, 30.8; **IR (cm^{-1}):** ν 3083, 2360, 2341, 1713, 1513, 1348, 1271, 1046, 668; **HRMS:** m/z: $[M + H]^+$ calculated for $C_{12}H_{10}ClN_2O_4S^+$, 313.0044, found

313.0036.

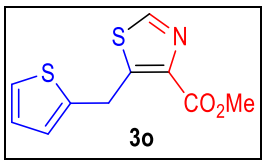
methyl 5-(furan-2-ylmethyl) thiazole-4-carboxylate (**3n**)



3n

Compound **3n** as a yellow oil (12.2 mg) was obtained *via the General Procedure A* in 55% yield. **^{1}H NMR (500 MHz, CDCl$_3$)** δ 8.58 (s, 1H), 7.29 (s, 1H), 6.26 – 6.25 (m, 1H), 6.12 – 6.11 (m, 1H), 4.59 (s, 2H), 3.90 (s, 3H); **^{13}C NMR (125 MHz, CDCl$_3$)** δ 162.7, 151.7, 150.5, 146.6, 142.0, 141.4, 110.5, 107.2, 52.3, 26.2; **IR (cm^{-1}):** ν 2923, 2360, 1716, 1683, 1653, 1559, 1540, 1507, 1457, 668; **HRMS:** m/z: $[M+H]^+$ calculated for $C_{10}H_{10}NO_3S^+$, 224.0376, found 224.0371.

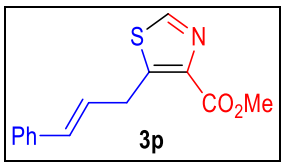
methyl 5-(thiophen-2-ylmethyl) thiazole-4-carboxylate (**3o**)



3o

Compound **3o** as a yellow oil (14.8 mg) was obtained *via the General Procedure A* in 62% yield. **^{1}H NMR (500 MHz, CDCl$_3$)** δ 8.55 (s, 1H), 7.14 – 7,12 (m, 1H), 6.89 – 6.88 (m, 2H), 4.74 (s, 2H), 3.91 (s, 3H); **^{13}C NMR (125 MHz, CDCl$_3$)** δ 162.6, 150.4, 149.4, 141.0, 127.0, 126.2, 124.8, 52.3, 27.5; **IR (cm^{-1}):** ν 2924, 2360, 1717, 1683, 1653, 1559, 1507, 1457, 668; **HRMS:** m/z: $[M+Na]^+$ calculated for $C_{10}H_9NNaO_2S_2^+$, 261.9967, found 261.9962.

methyl 5-cinnamylthiazole-4-carboxylate (**3p**)

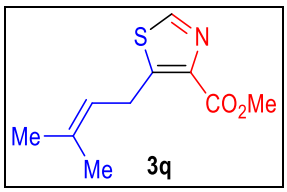


3p

Compound **3p** as a yellow oil (16.6 mg) was obtained *via the General Procedure B* in 64% yield. **^{1}H NMR (500 MHz, CDCl$_3$)** δ 8.57 (s, 1H), 7.30 (d, *J* = 7.0 Hz, 2H), 7.26 – 7.23 (m, 2H), 7.19 – 7.5 (m, 1H), 6.49 (d, *J* = 15.5 Hz, 1H), 6.31 – 6.27 (m, 1H),

4.11 (d, *J* = 7.0 Hz, 2H), 3.90 (s, 3H); **^{13}C NMR (125 MHz, CDCl$_3$)** δ 162.7, 150.1, 149.1, 141.0, 136.6, 132.9, 128.6, 127.7, 126.3, 126.2, 52.2, 30.8; **IR (cm^{-1}):** ν 2924, 2360, 1716, 1653, 1559, 1541, 1507, 1457, 668; **HRMS:** m/z: $[M + H]^+$ calculated for $C_{14}H_{14}NO_2S^+$, 260.0740, found 260.0735.

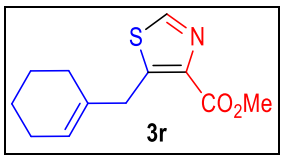
methyl 5-(3-methylbut-2-en-1-yl) thiazole-4-carboxylate (**3q**)



3q

Compound **3q** as a yellow oil (13.2 mg) was obtained *via the General Procedure B* in 62% yield. **^{1}H NMR (500 MHz, CDCl$_3$)** δ 8.52 (s, 1H), 5.35 – 5.31 (m, 1H), 3.89 (s, 3H), 3.89 (s, 2H), 1.70 (s, 3H), 1.64 (s, 3H); **^{13}C NMR (125 MHz, CDCl$_3$)** δ 162.8, 151.5, 149.6, 140.4, 135.6, 121.1, 52.1, 26.4, 25.5, 17.9; **IR (cm^{-1}):** ν 2926, 1717, 1440, 1328, 1267, 1201, 1156, 785; **HRMS:** m/z: $[M + H]^+$ calculated for $C_{10}H_{14}NO_2S^+$, 212.0740, found 212.0735.

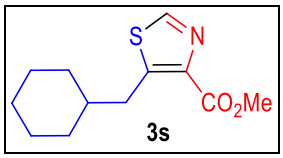
methyl 5-(cyclohex-1-en-1-ylmethyl) thiazole-4-carboxylate (**3r**)



3r

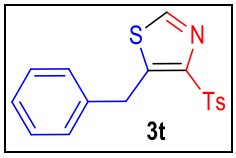
Compound **3r** as a yellow oil (12.6 mg) was obtained *via the General Procedure B* in 53% yield. **^{1}H NMR (500 MHz, CDCl$_3$)** δ 8.55 (s, 1H), 5.50 (s, 1H), 4.64 (s, 2H), 3.88 (s, 3H), 3.84 (s, 2H), 1.96 (s, 2H), 1.88 (s, 2H), 1.55 – 1.53 (m, 2H), 1.49 – 1.47 (m, 2H); **^{13}C NMR (125 MHz, CDCl$_3$)** δ 162.8, 150.1, 150.1, 141.4, 136.0, 124.7, 52.1, 35.4, 28.0, 25.1, 22.7, 22.0; **IR (cm^{-1}):** ν 2925, 2360, 1717, 1653, 1559, 1507, 1457, 1437, 668; **HRMS:** m/z: $[M + H]^+$ calculated for $C_{12}H_{16}NO_2S^+$, 238.0896, found 238.0893.

methyl 5-(cyclohexylmethyl) thiazole-4-carboxylate (**3s**)



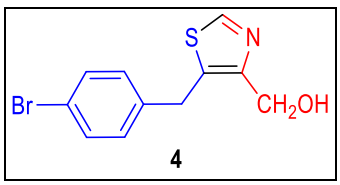
Compound **3s** as a yellow oil (22.2 mg) was obtained *via the General Procedure A* in 93% yield. **^{1}H NMR (500 MHz, CDCl$_3$)** δ 8.55 (s, 1H), 3.88 (s, 3H), 3.12 – 3.01 (m, 2H), 1.67 – 1.62 (m, 5H), 1.57 – 1.53 (m, 3H), 1.16 – 1.12 (m, 3H); **^{13}C NMR (125 MHz, CDCl$_3$)** δ 162.7, 149.5, 149.4, 141.5, 52.1, 40.3, 34.4, 32.9, 26.2, 26.0; **IR (cm^{-1}):** ν 2924, 2360, 1717, 1653, 1559, 1507, 1457, 1269, 668; **HRMS:** m/z: [M + H]$^+$ calculated for $C_{12}H_{18}NO_2S^+$, 240.1053, found 240.1050.

5-benzyl-4-tosylthiazole (**3t**)



Compound **3t** as a yellow oil (25.4 mg) was obtained *via the General Procedure A* in 77% yield. **^{1}H NMR (500 MHz, CDCl$_3$)** δ 8.49 (s, 1H), 7.81 (d, *J* = 8.0 Hz, 2H), 7.27 – 7.22 (m, 5H), 7.19 (d, *J* = 8.0 Hz, 2H), 4.60 (s, 2H), 2.34 (s, 3H), 1.70 (s, 3H), 1.64 (s, 3H); **^{13}C NMR (125 MHz, CDCl$_3$)** δ 151.6, 148.3, 146.6, 144.7, 138.6, 137.6, 129.7, 128.9, 128.8, 128.2, 127.3, 32.4, 21.6; **IR (cm^{-1}):** ν 3449, 2924, 1719, 1460, 1378, 1145, 812; **HRMS:** m/z: [M + H]$^+$ calculated for $C_{17}H_{15}NNaO_2S_2^+$, 352.0436, found 352.0441.

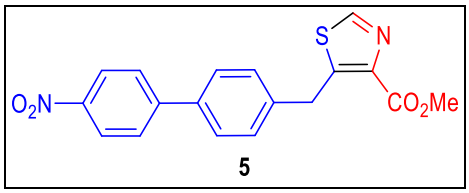
(5-(4-bromobenzyl) thiazol-4-yl) methanol (**4**)



Yellow oil. **^{1}H NMR (500 MHz, CDCl$_3$)** δ 8.57 (s, 1H), 7.36 (d, *J* = 7.5 Hz, 2H), 7.01 (d, *J* = 7.5 Hz, 2H), 4.69 (s, 2H), 4.07 (s, 2H), 2.83 (s, 1H); **^{13}C NMR (125 MHz, CDCl$_3$)** δ 152.0, 151.2, 138.2, 133.2, 131.9, 130.0, 120.8, 58.5, 31.3; **IR (cm^{-1}):** ν

3290, 2922, 1485, 1408, 1010, 816, 719, 486; **HRMS:** m/z: $[M + H]^+$ calculated for $C_{11}H_{11}BrNOS^+$, 283.9739, found 283.9737.

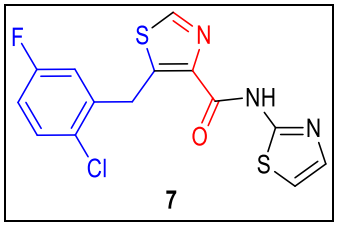
methyl 5-((4'-nitro-[1,1'-biphenyl]-4-yl) methyl) thiazole-4-carboxylate (**5**)



5

Yellow amorphous solid. **^{1}H NMR (500 MHz, $CDCl_3$)** δ 8.56 (s, 1H), 8.18 (d, *J* = 8.0 Hz, 2H), 7.63 (d, *J* = 8.0 Hz, 2H), 7.50 (d, *J* = 7.5 Hz, 2H), 7.32 (d, *J* = 7.5 Hz, 2H), 4.60 (s, 2H), 3.90 (s, 3H); **^{13}C NMR (125 MHz, $CDCl_3$)** δ 162.6, 150.4, 148.9, 146.9, 146.9, 141.3, 139.9, 137.4, 129.4, 127.7, 127.5, 124.0, 52.2, 32.7; **IR (cm^{-1}):** ν 3433, 3082, 1705, 1513, 1343, 1204, 1166, 850; **HRMS:** m/z: $[M + H]^+$ calculated for $C_{18}H_{15}N_2O_4S^+$, 355.0747, found 355.0746.

5-(2-chloro-5-fluorobenzyl)-*N*-(thiazol-2-yl) thiazole-4-carboxamide (**7**)



7

White solid. **m.p.**: 152.3 – 154.5 °C. **^{1}H NMR (500 MHz, $CDCl_3$)** δ 10.92 (s, 1H), 8.51 (s, 1H), 7.46 (d, *J* = 3.5 Hz, 1H), 7.33 – 7.32 (m, 1H), 7.08 – 7.07 (m, 1H), 6.94 (d, *J* = 3.5 Hz, 1H), 6.88 – 6.85 (m, 1H), 4.78 (s, 2H); **^{13}C NMR (125 MHz, $CDCl_3$)** δ 162.6, 160.7, 159.4, 157.5, 150.3, 147.1, 141.6, 138.1, 134.4 (d, *J* = 40.5 Hz), 133.1 (d, *J* = 14.5 Hz), 131.9 (d, *J* = 34.5 Hz), 117.0 (d, *J* = 98.5 Hz), 114.6 (d, *J* = 84.0 Hz), 113.5, 30.0; **^{19}F NMR (564 MHz, $CDCl_3$)** δ – 112.5 (q, *J* = 7.3 Hz, 1F); **IR (cm^{-1}):** ν 3455, 2924, 1667, 1532, 1492, 1312, 1271, 1166, 878, 709; **HRMS:** m/z: $[M + H]^+$ calculated for $C_{14}H_9ClFN_3NaOS_2^+$, 375.9752, found 375.9749.

5 X-ray structure

The single crystal was obtained by slow evaporation of a saturated solution in ethyl acetate in a lossely capped vial. Structure information was deposited at the Cambridge Crystallographic Data Center (CCDC).

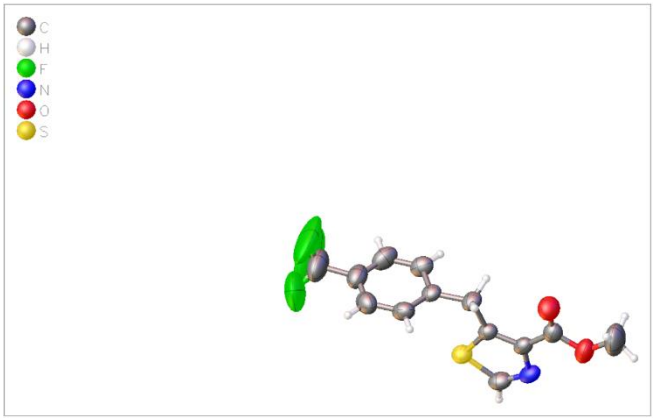


Fig. X-ray crystallographic sturcture of **3h** (CCDC 2042211).

6 References

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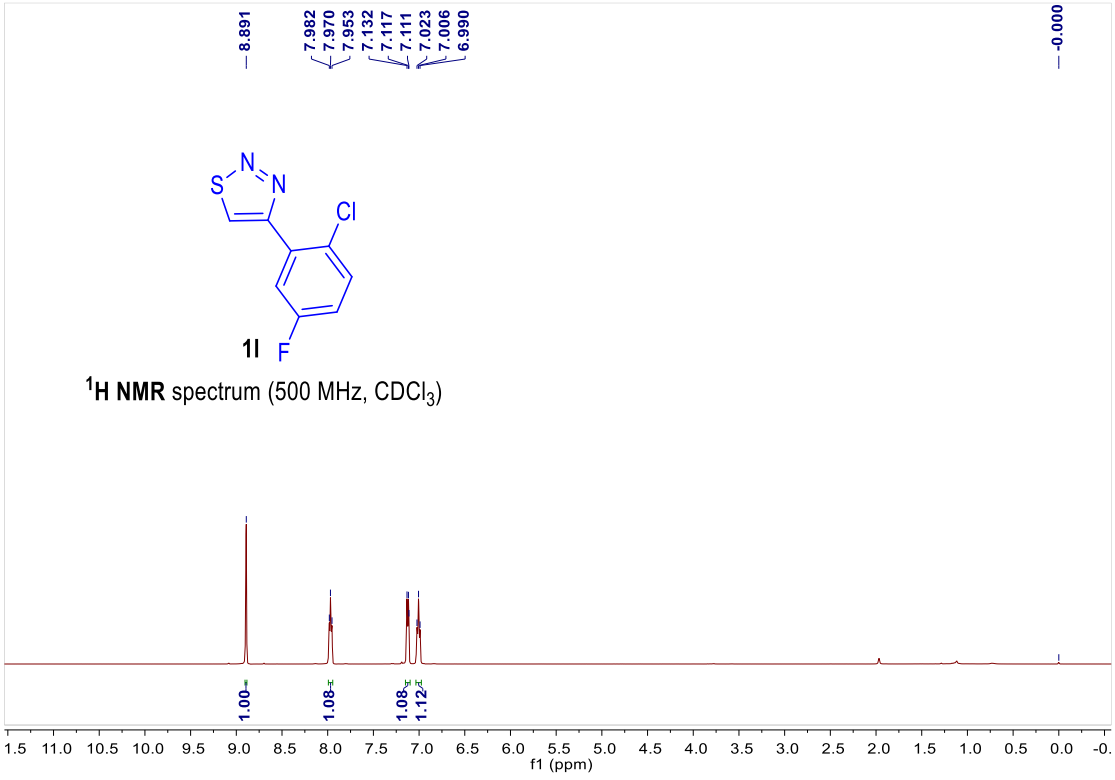
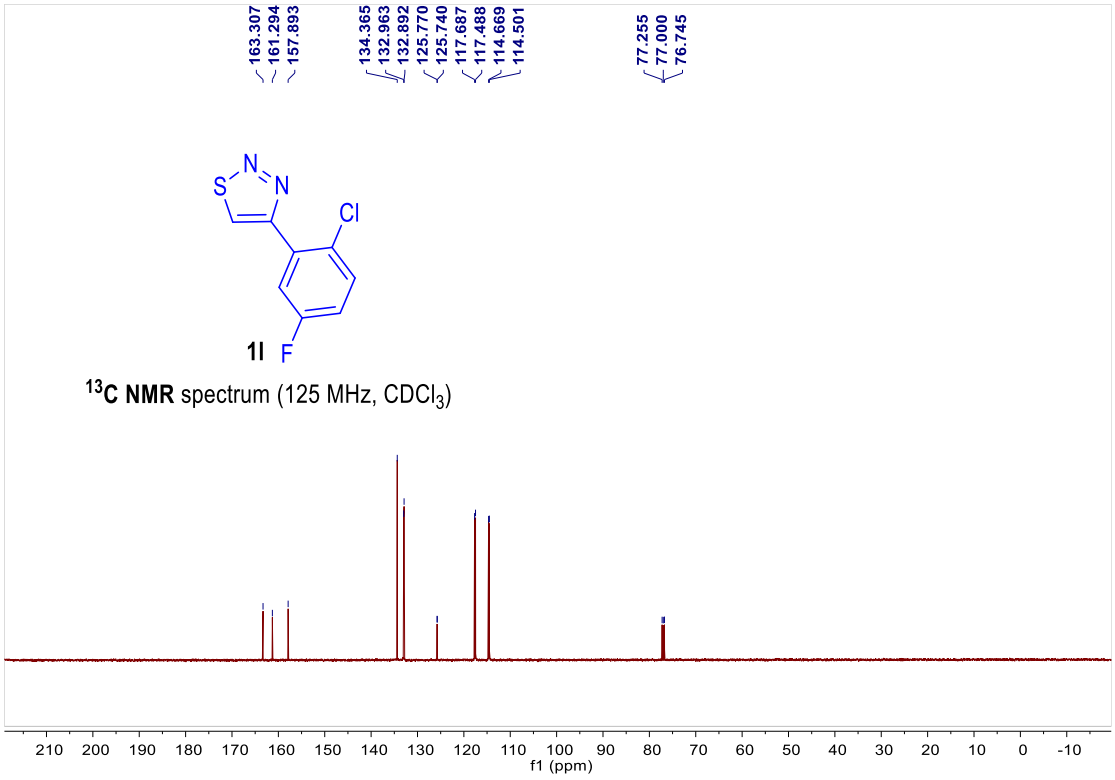
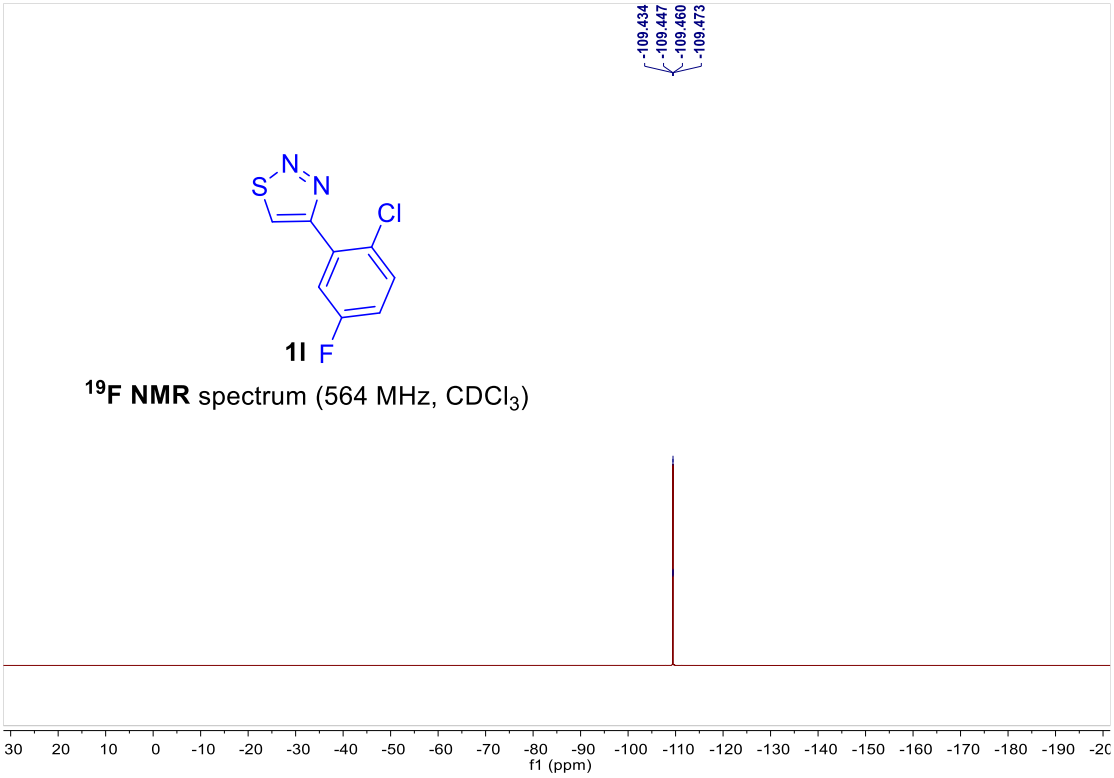
7 Copies of NMR spectra

1l



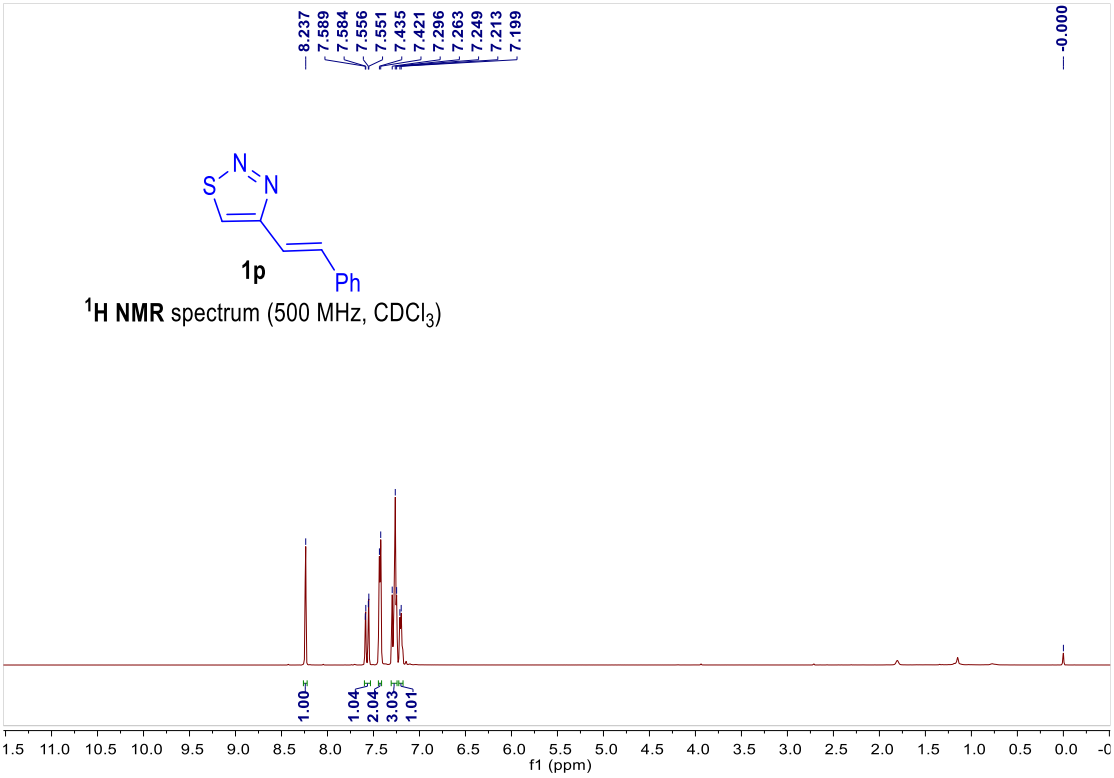




1l

^{19}F NMR spectrum (564 MHz, $CDCl_3$)

1p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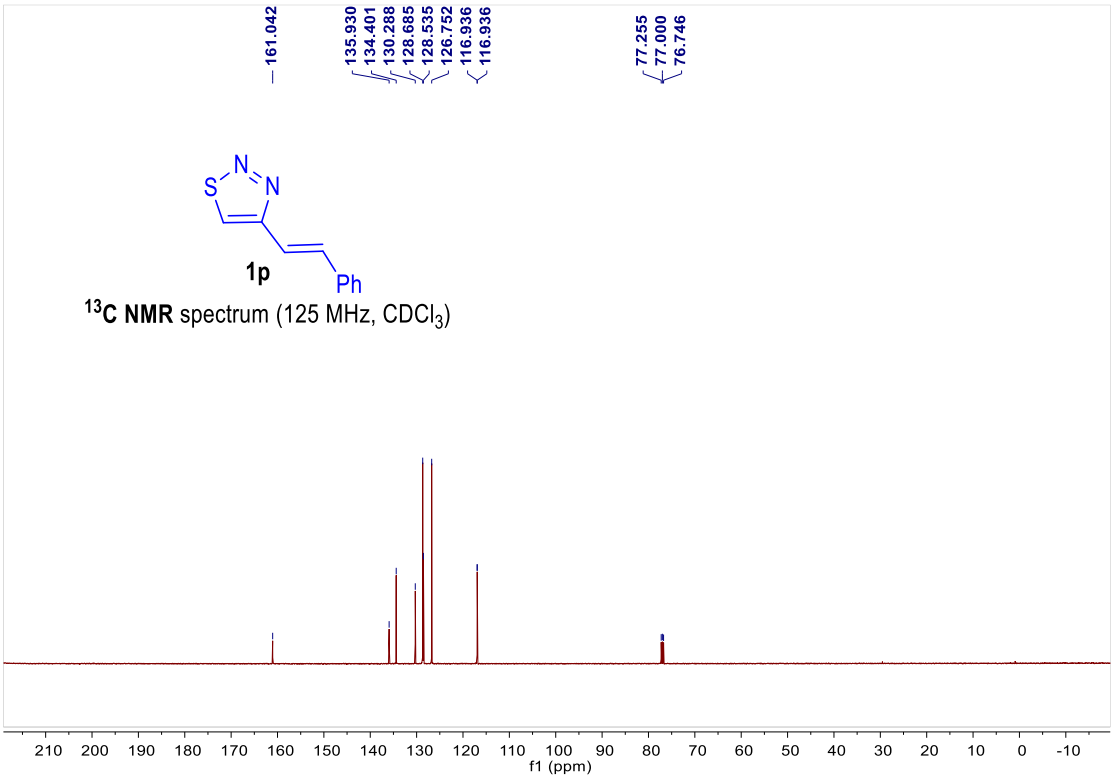
7.589
7.584
7.556
7.551
7.435
7.421
7.296
7.263
7.249
7.213
7.199
-0.000
1p
Ph
1H NMR spectrum (500 MHz, CDCl3)
1.00
1.04
2.04
3.03
1.01
f1 (ppm)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135.930
134.401
130.288
128.685
128.535
126.752
116.936
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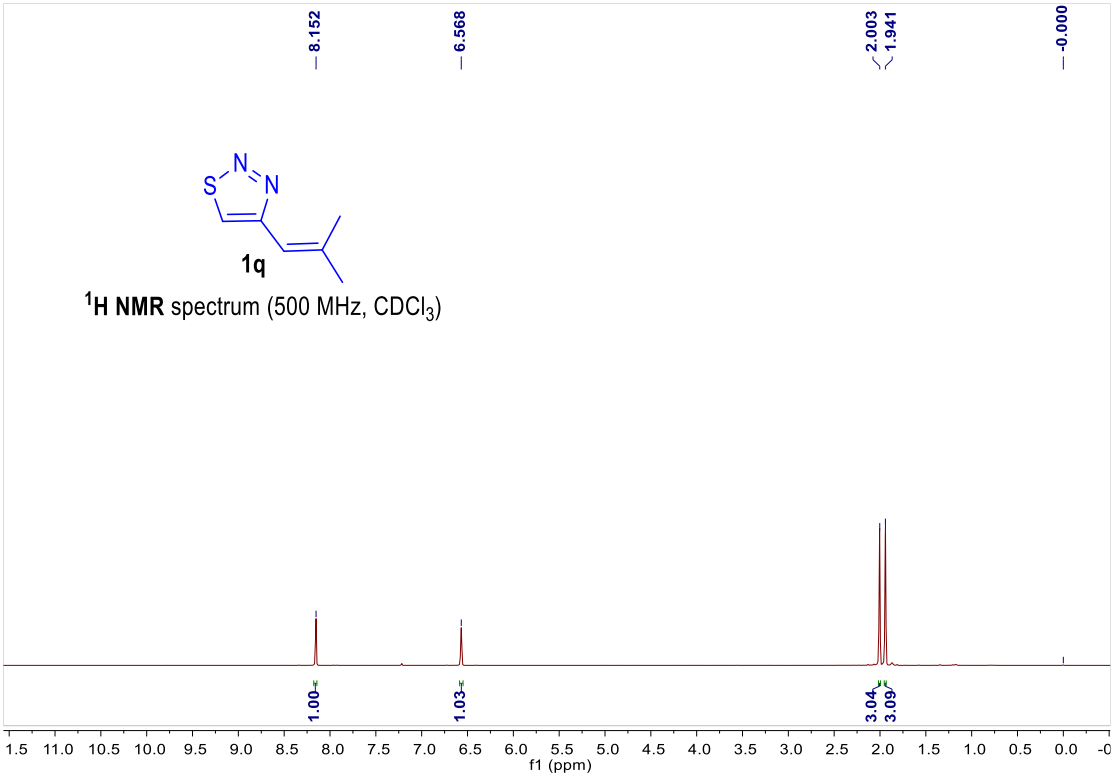
77.255
77.000
76.746
1p
Ph
13C NMR spectrum (125 MHz, CDCl3)
f1 (ppm)

1q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6.568
2.003
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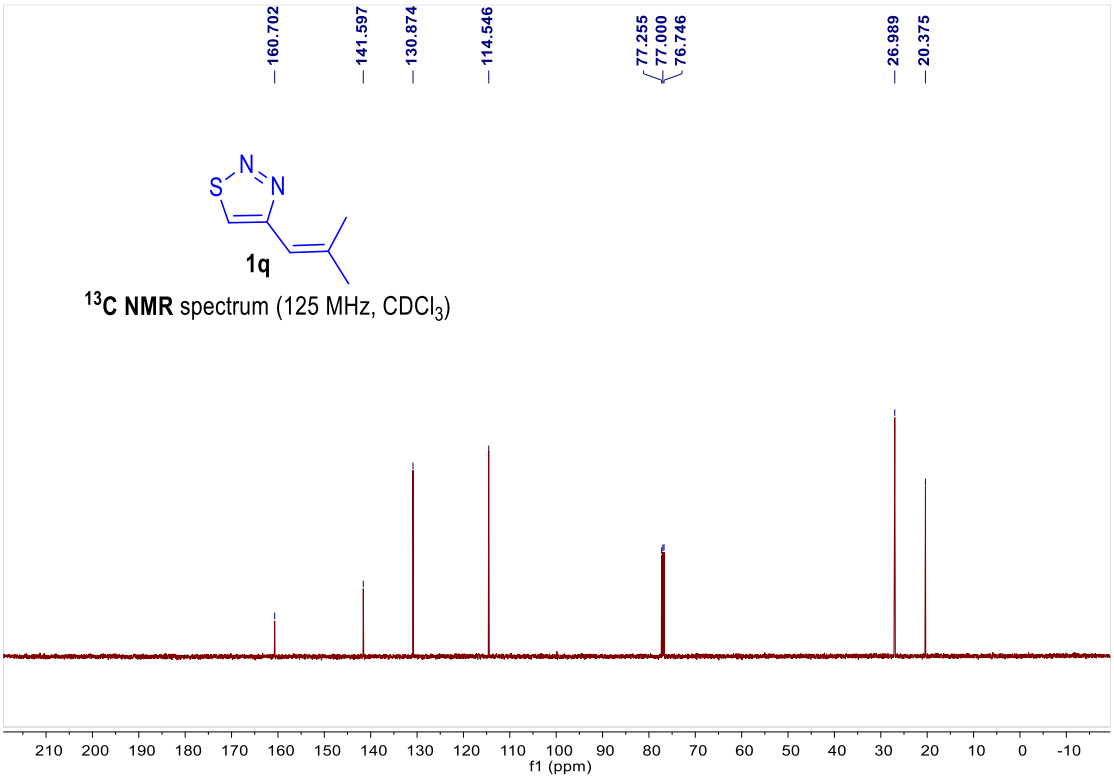
1.03
3.04
3.09
f1 (ppm)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141.597
130.874
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26.989
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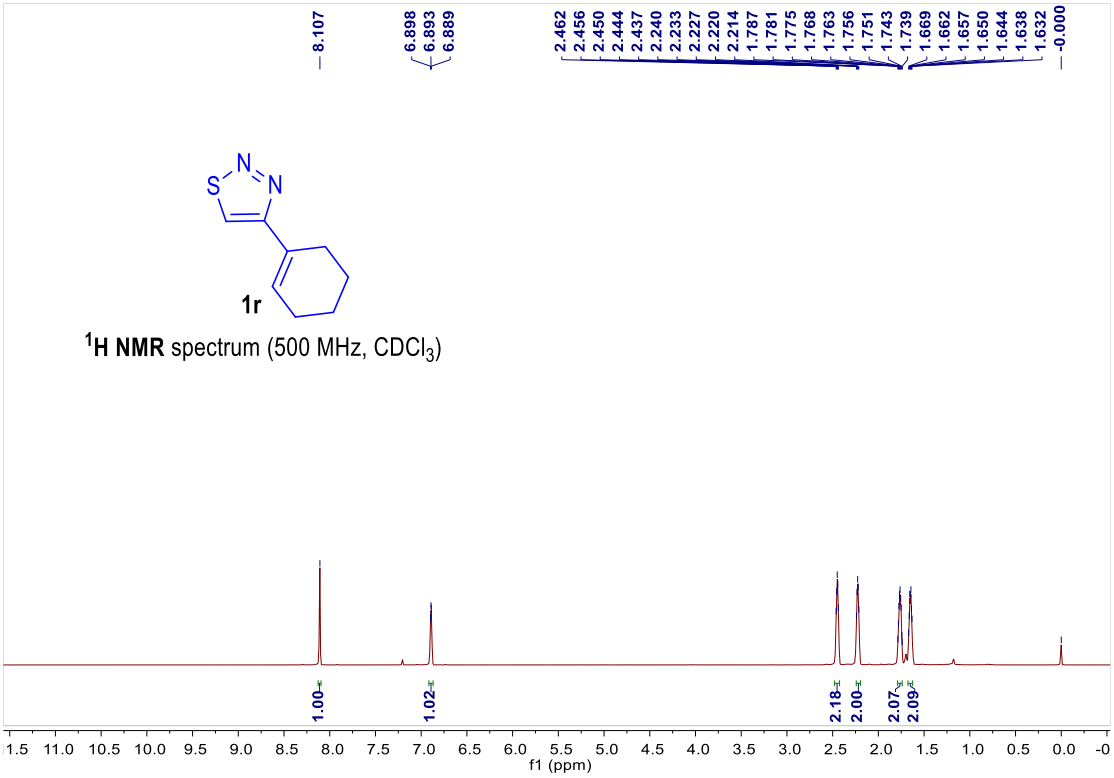
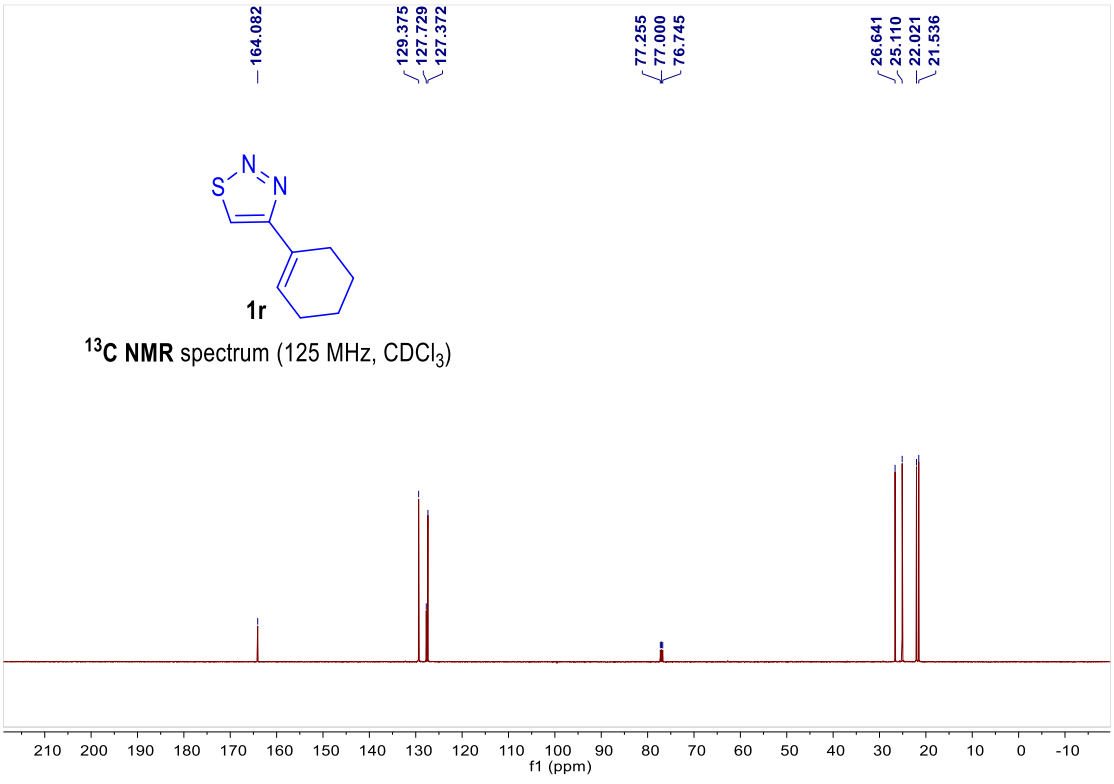
13C NMR spectrum (125 MHz, CDCl3)
f1 (ppm)

1r



1r

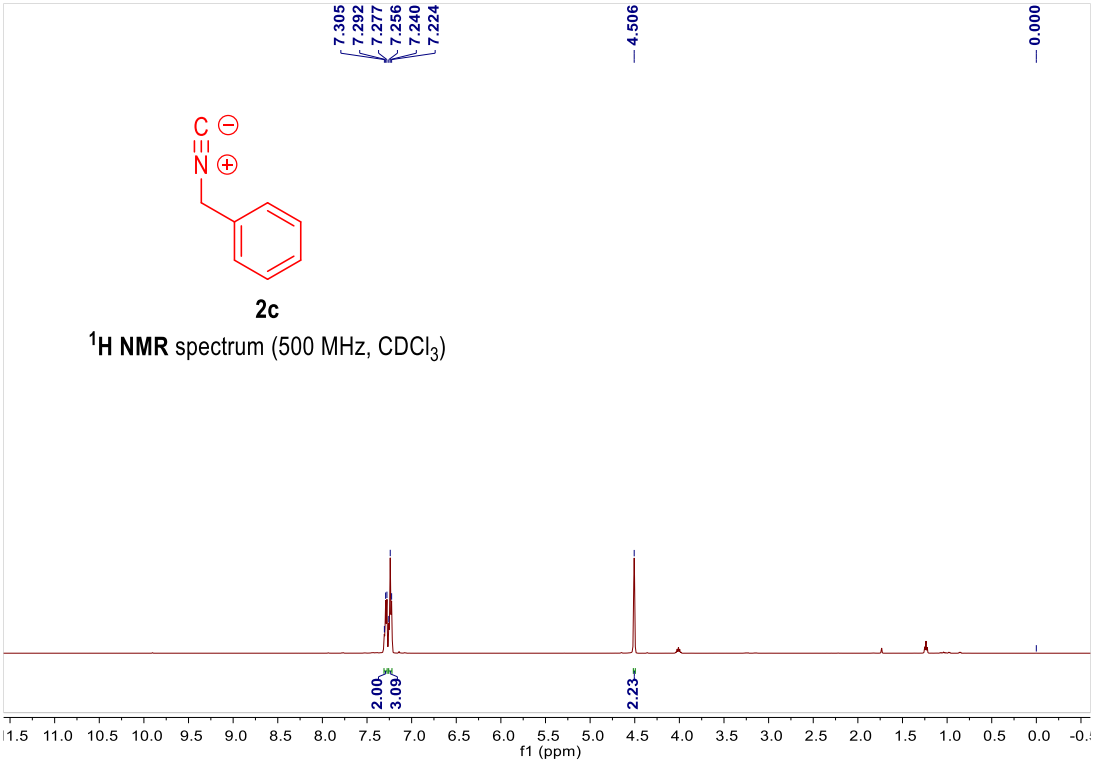
^{1}**H NMR** spectrum (500 MHz, $CDCl_3$)



1r

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

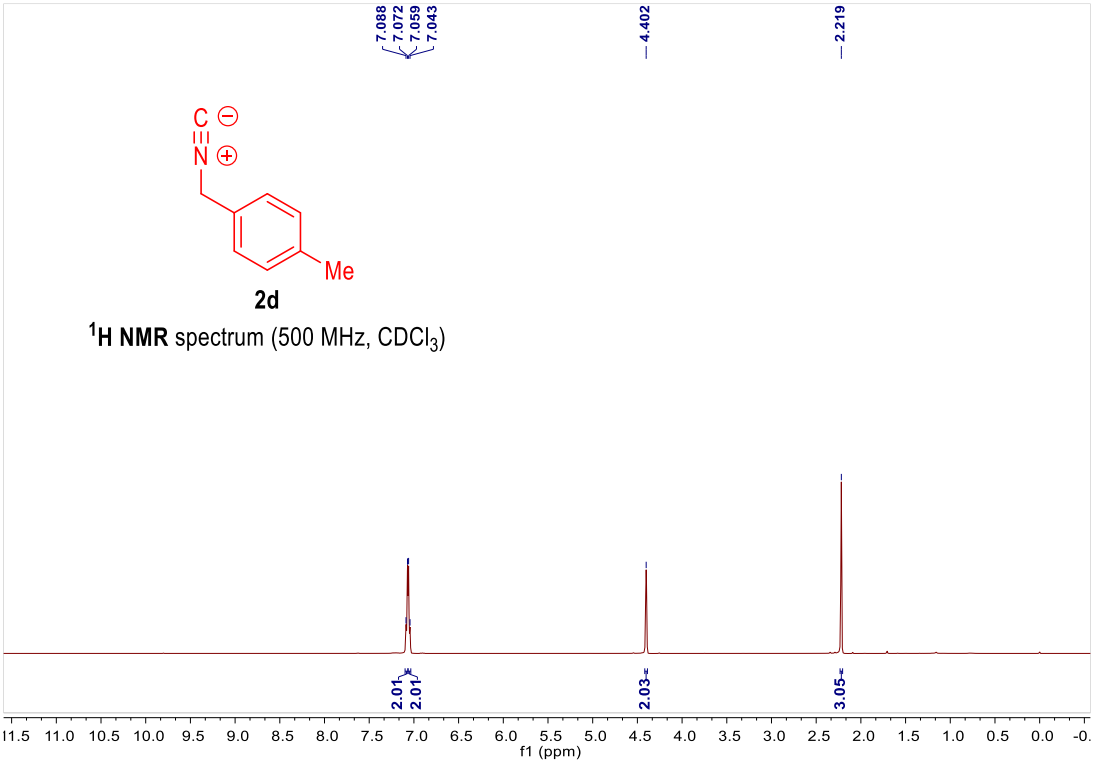
2c



2c

^{1}H NMR spectrum (500 MHz, $CDCl_3$)

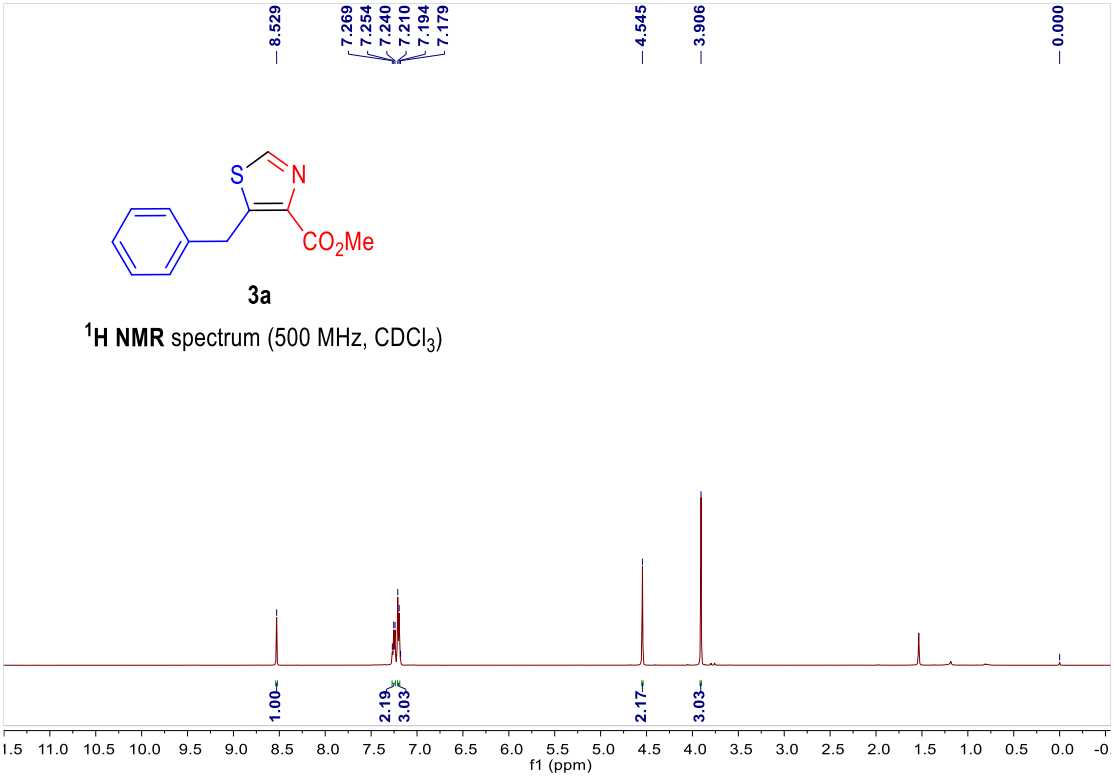
2d



2d

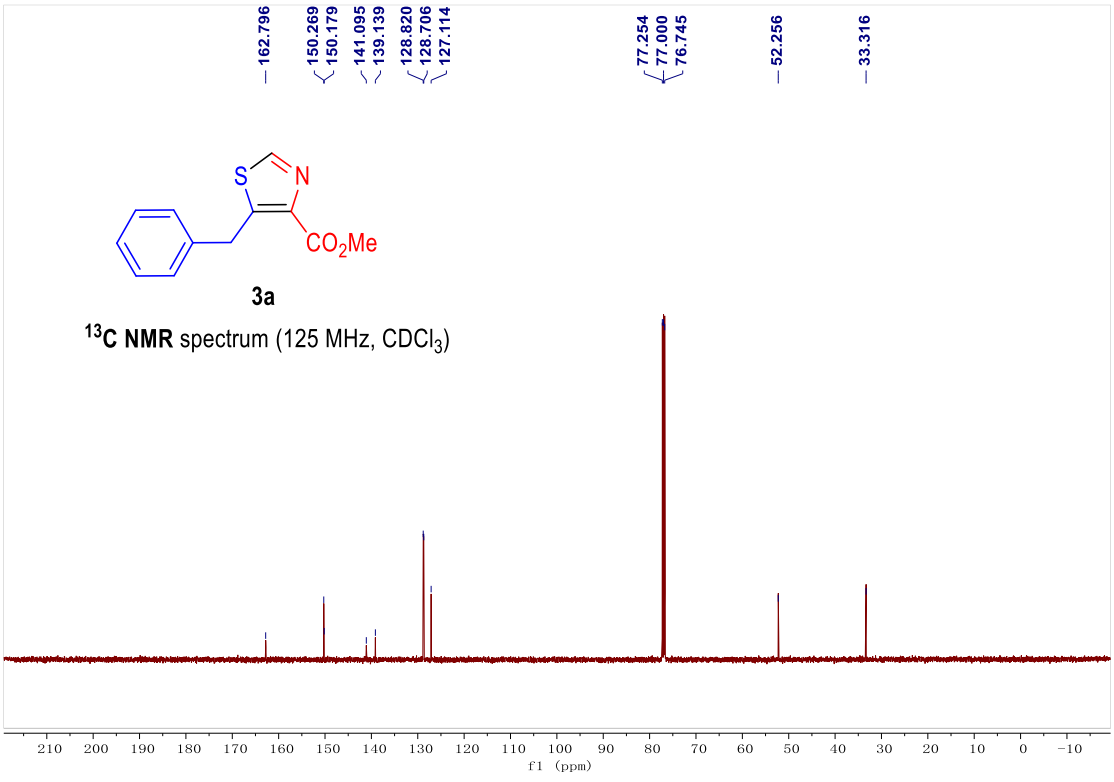
^{1}H NMR spectrum (500 MHz, $CDCl_3$)

3a



3a

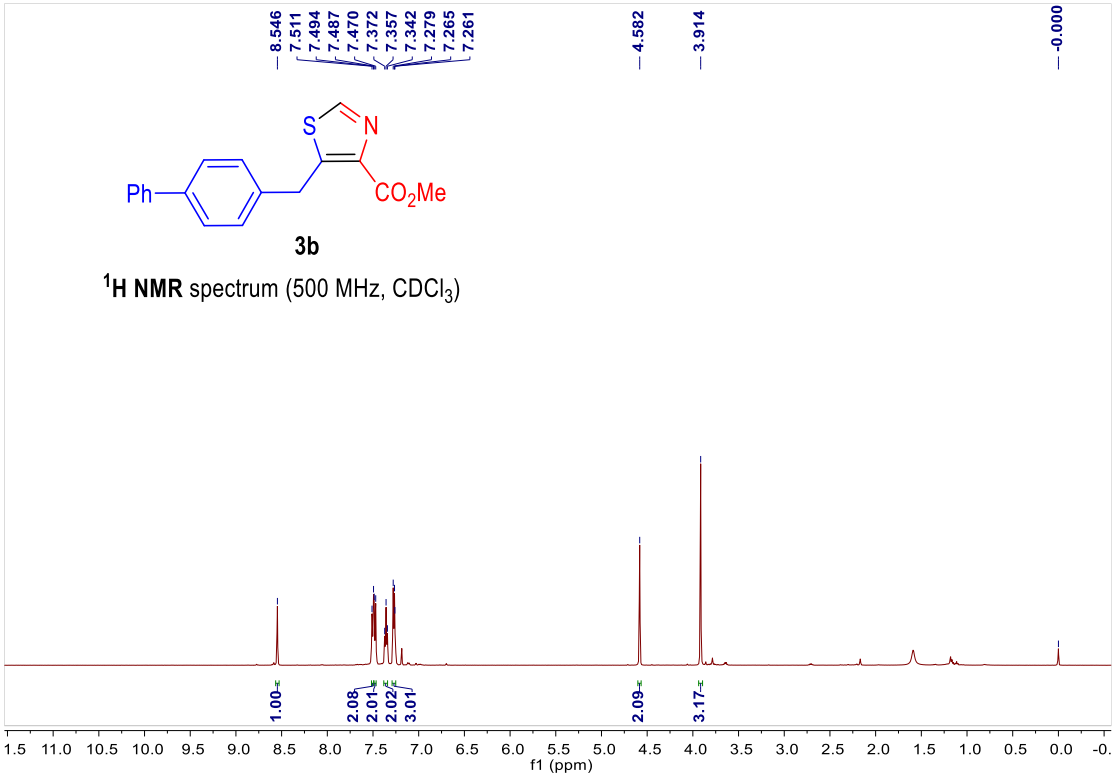
^{1}**H NMR** spectrum (500 MHz, $CDCl_3$)



3a

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

3b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7.342
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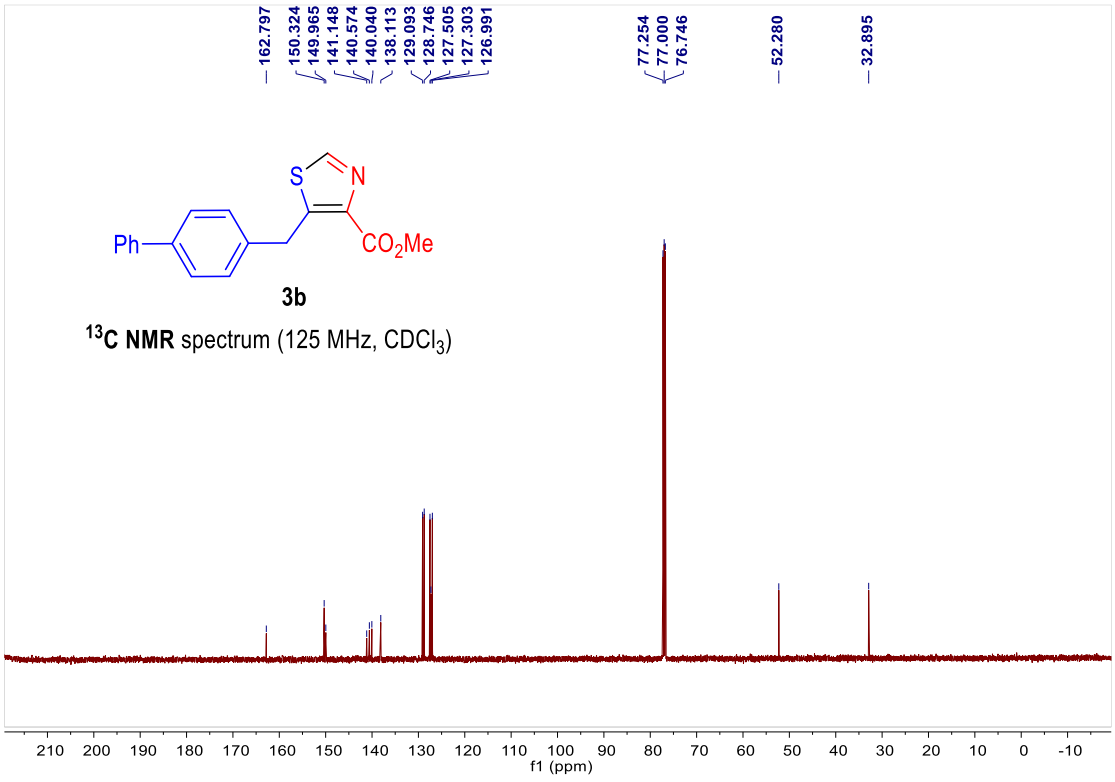
7.265
7.261
4.582
3.914
-0.000
S
N
Ph
CO2Me
3b
1H NMR spectrum (500 MHz, CDCl3)
1.00
2.08
2.01
2.02
3.01
2.09
3.17
f1 (ppm)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77.254
77.000
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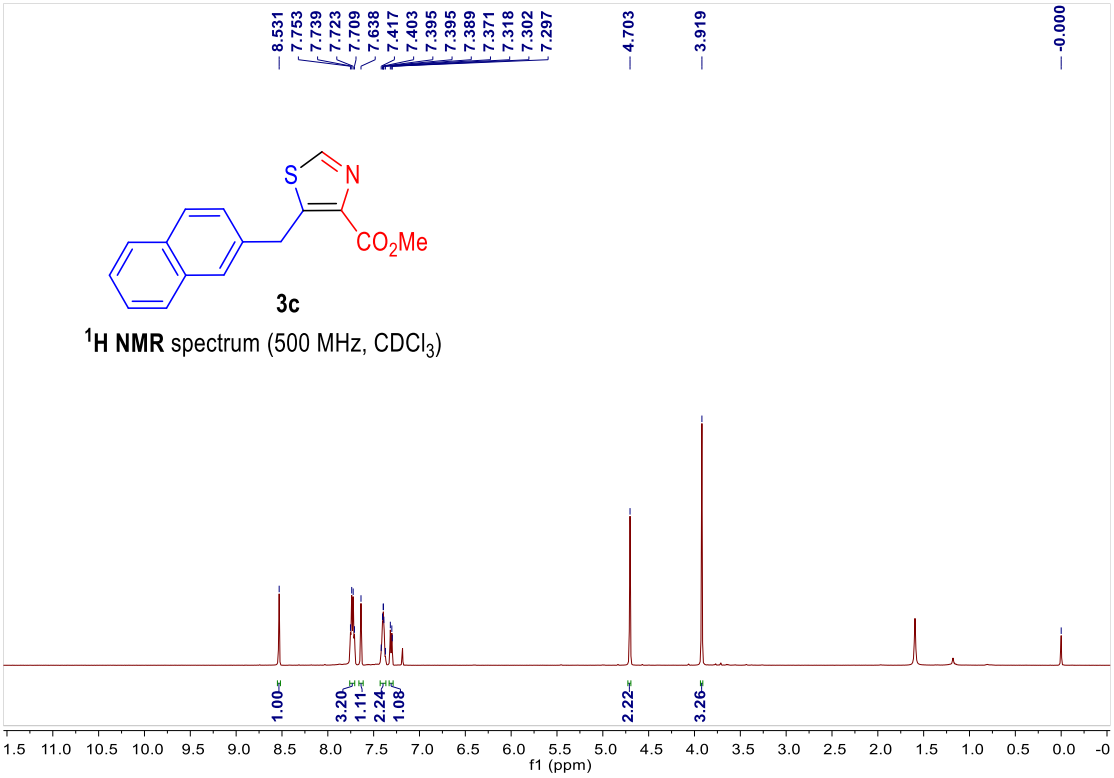
52.280
32.895
S
N
Ph
CO2Me
3b
13C NMR spectrum (125 MHz, CDCl3)
f1 (ppm)

3c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7.395
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7.371
7.318
7.302
7.297
4.703
3.919
-0.000
S
N
CO2Me
3c
1H NMR spectrum (500 MHz, CDCl3)
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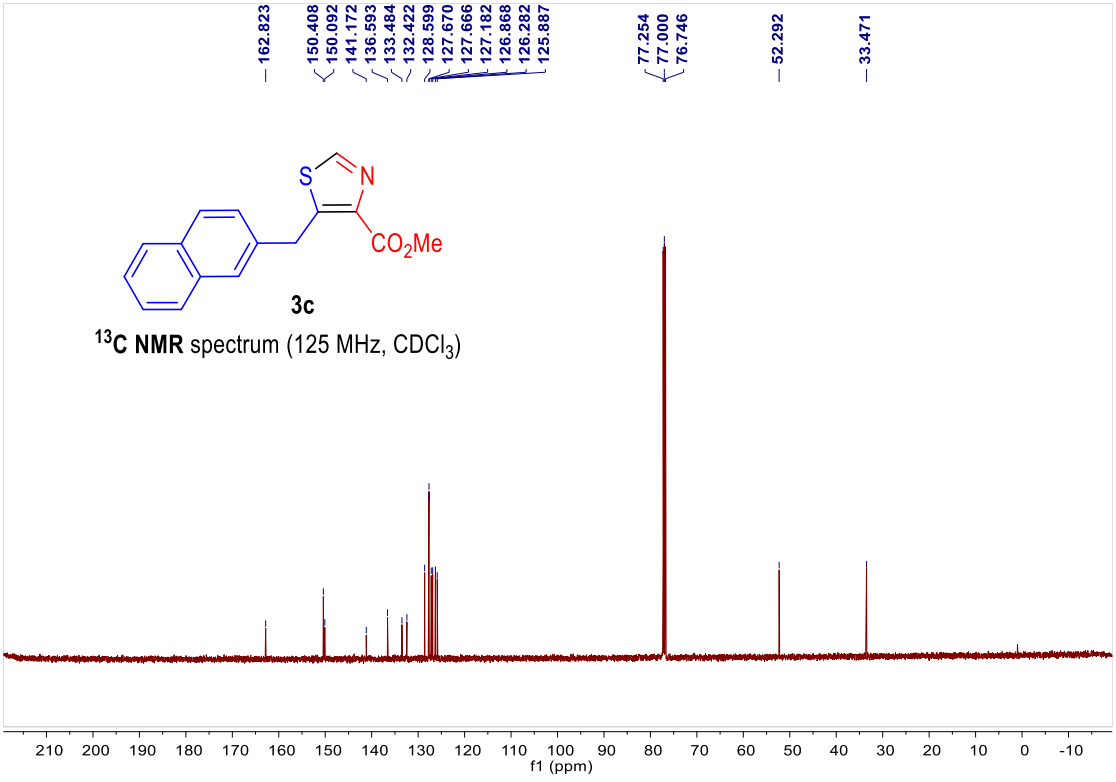
3.20
1.11
2.24
1.08
2.22
3.26
f1 (ppm)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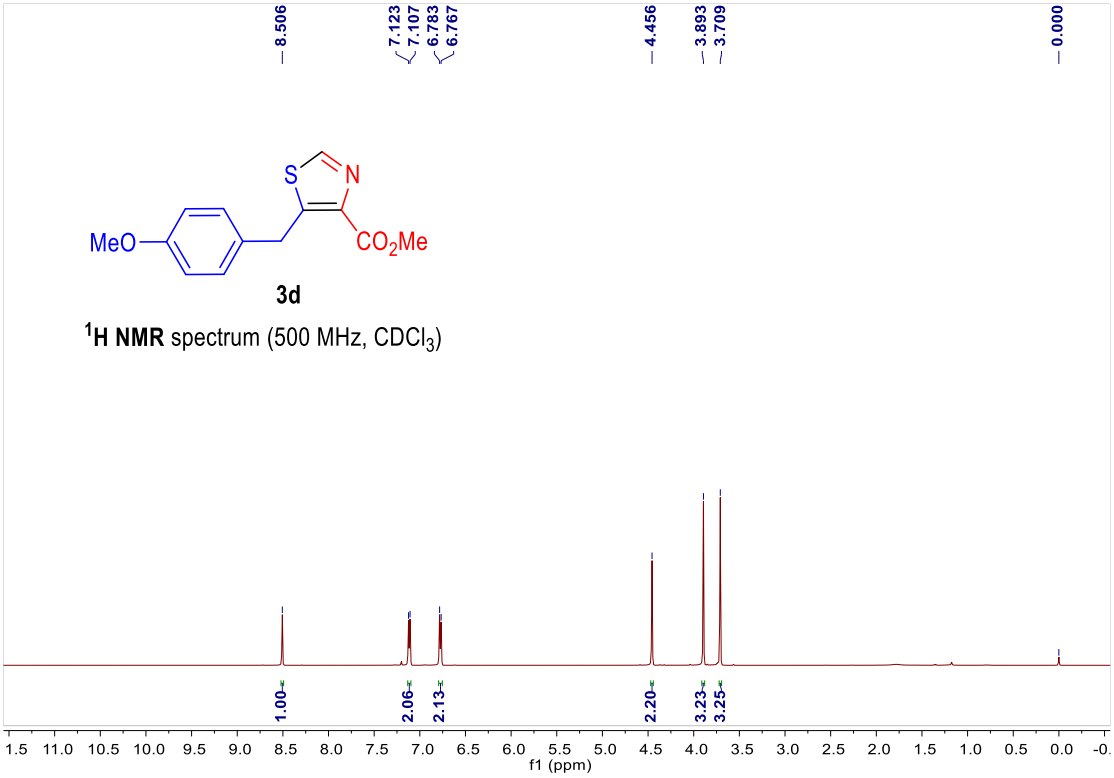
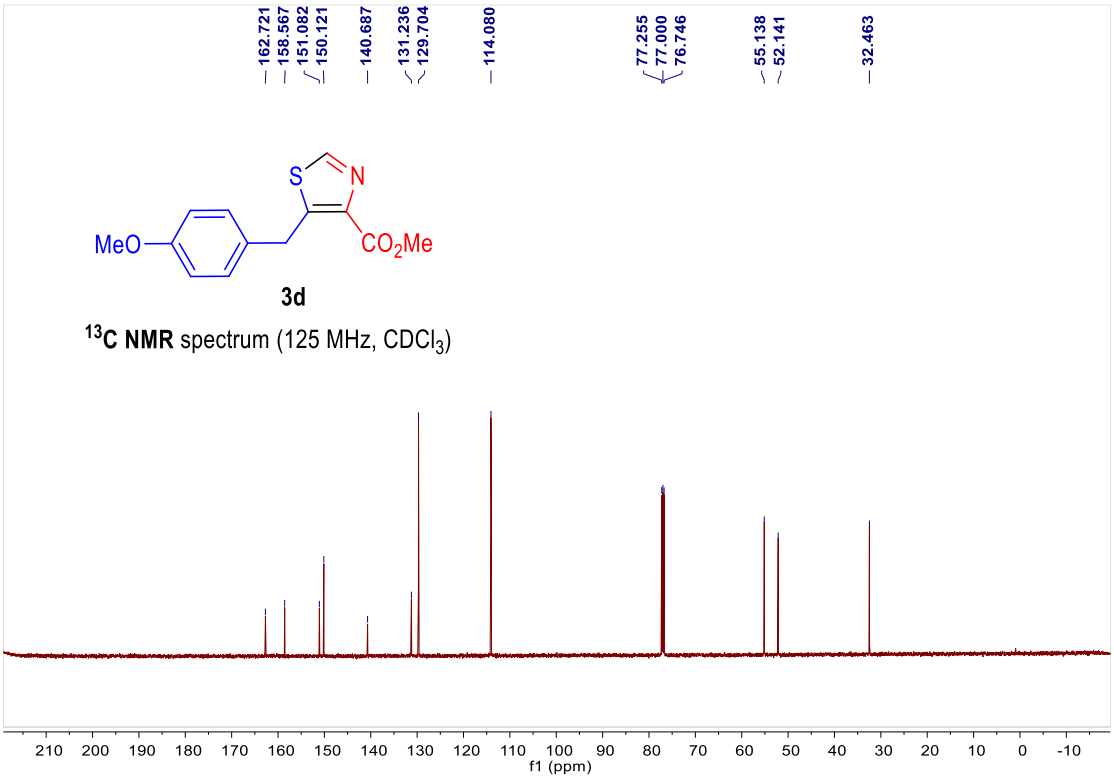
127.666
127.182
126.868
126.282
125.887
77.254
77.000
76.746
52.292
33.471
S
N
CO2Me
3c
13C NMR spectrum (125 MHz, CDCl3)
f1 (ppm)

3d



3d

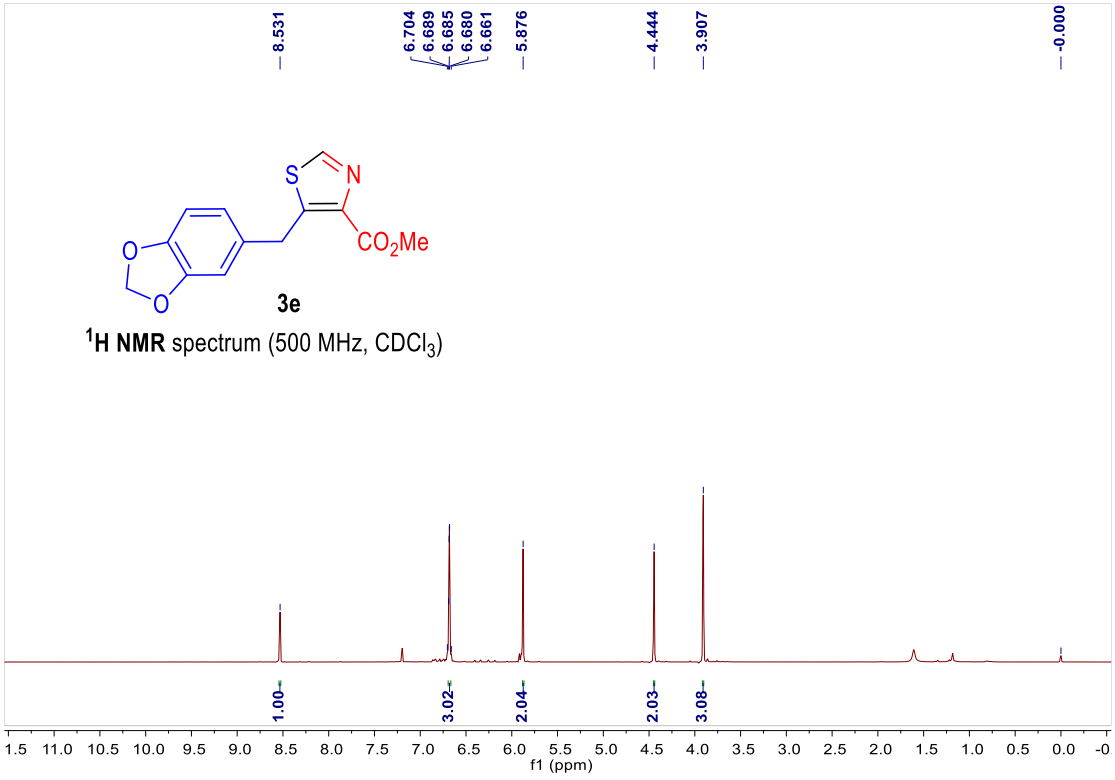
^{1}**H NMR** spectrum (500 MHz, $CDCl_3$)



3d

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

3e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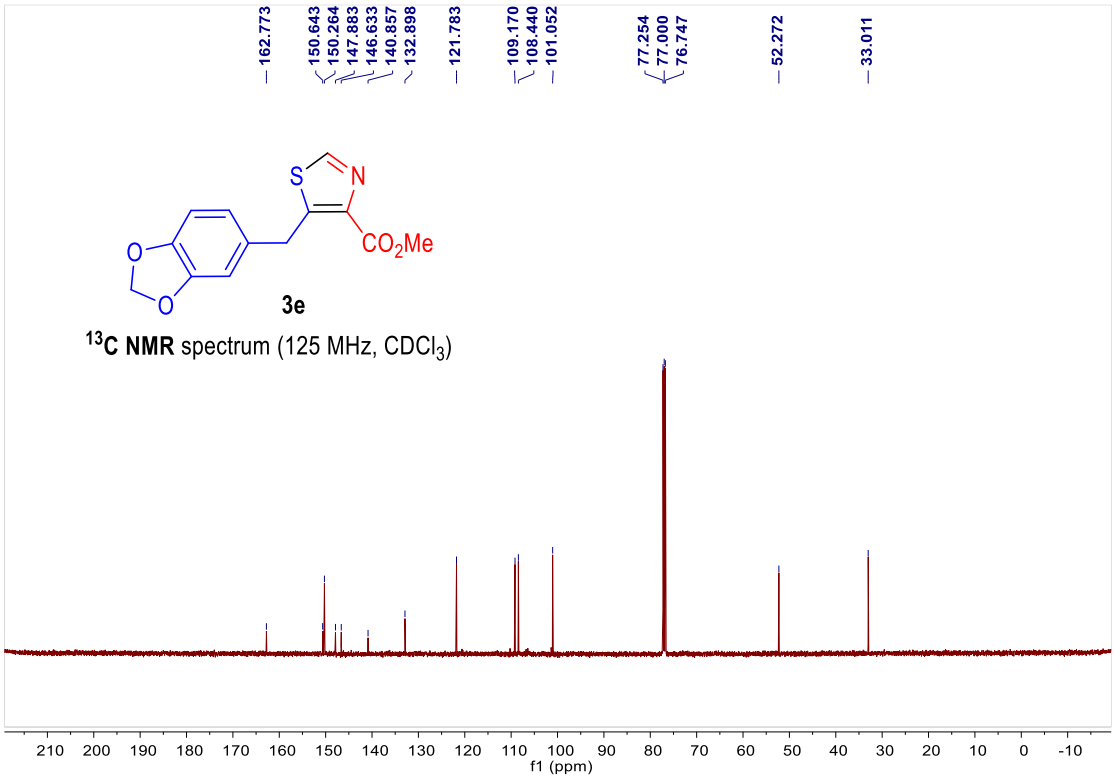
-0.000
S
N
O
O
CO2Me
3e
1H NMR spectrum (500 MHz, CDCl3)
1.00
3.02
2.04
2.03
3.08
f1 (ppm)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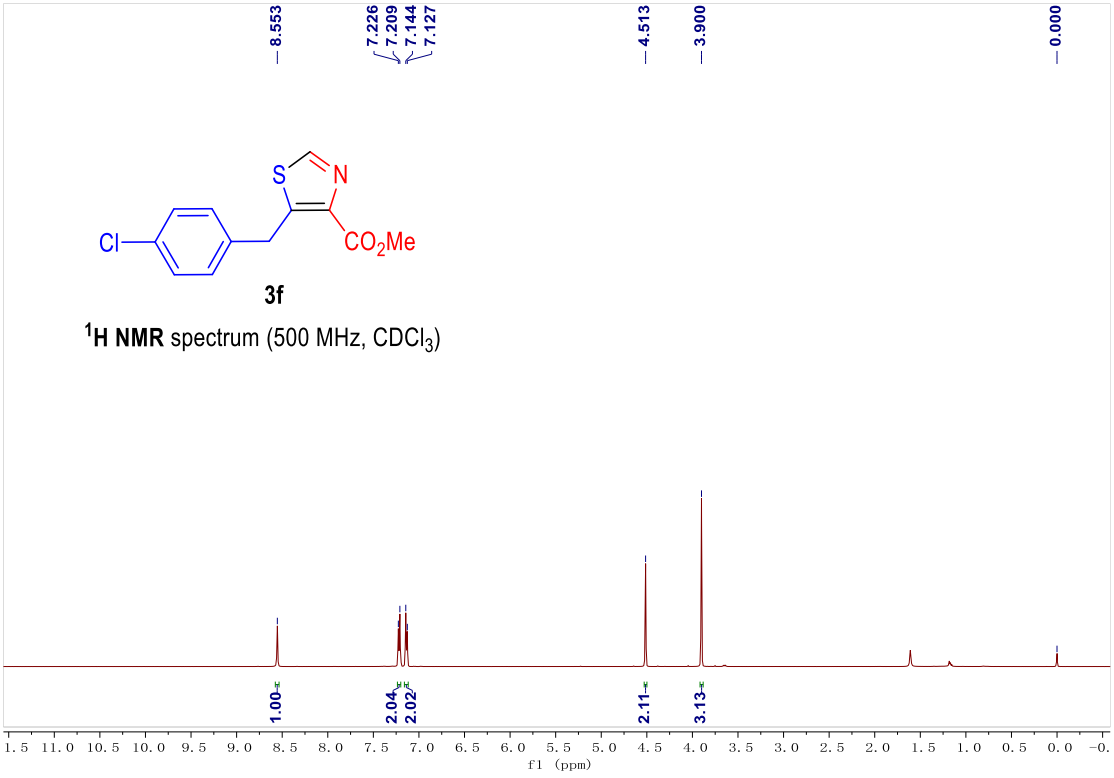
108.440
101.052
77.254
77.000
76.747
52.272
33.011
S
N
O
O
CO2Me
3e
13C NMR spectrum (125 MHz, CDCl3)
f1 (ppm)

3f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S
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Cl
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3f
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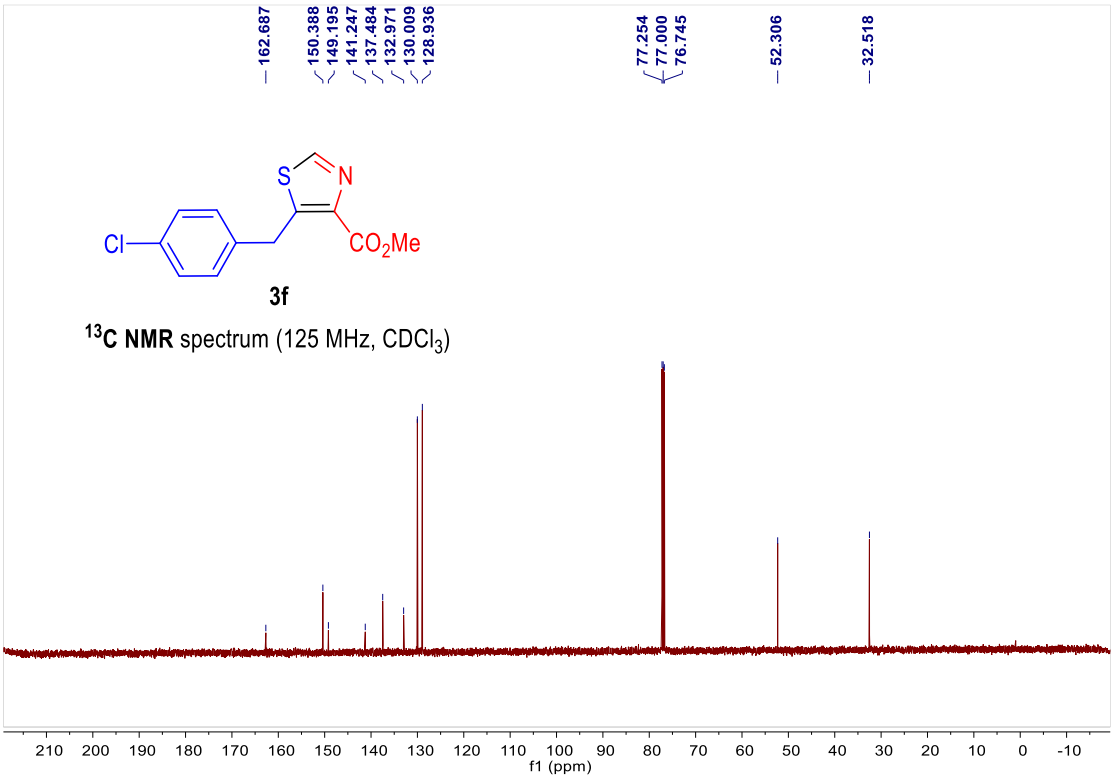
3.13
f1 (ppm)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130.009
128.936
77.254
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76.745
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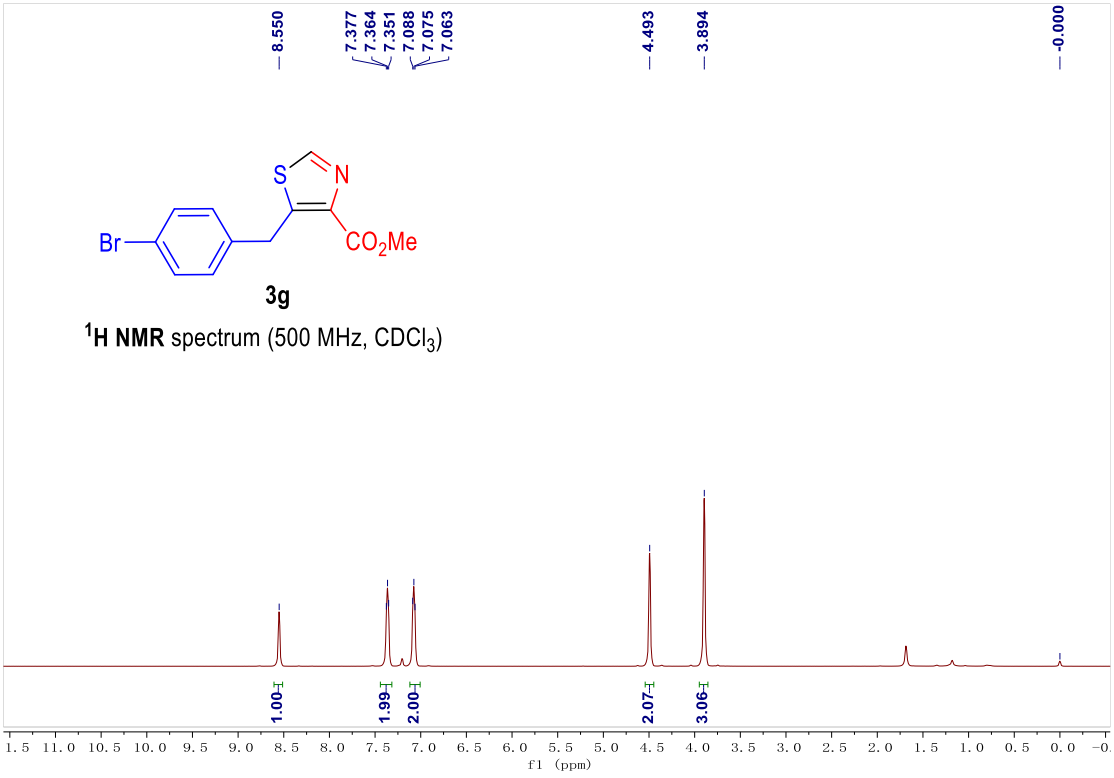
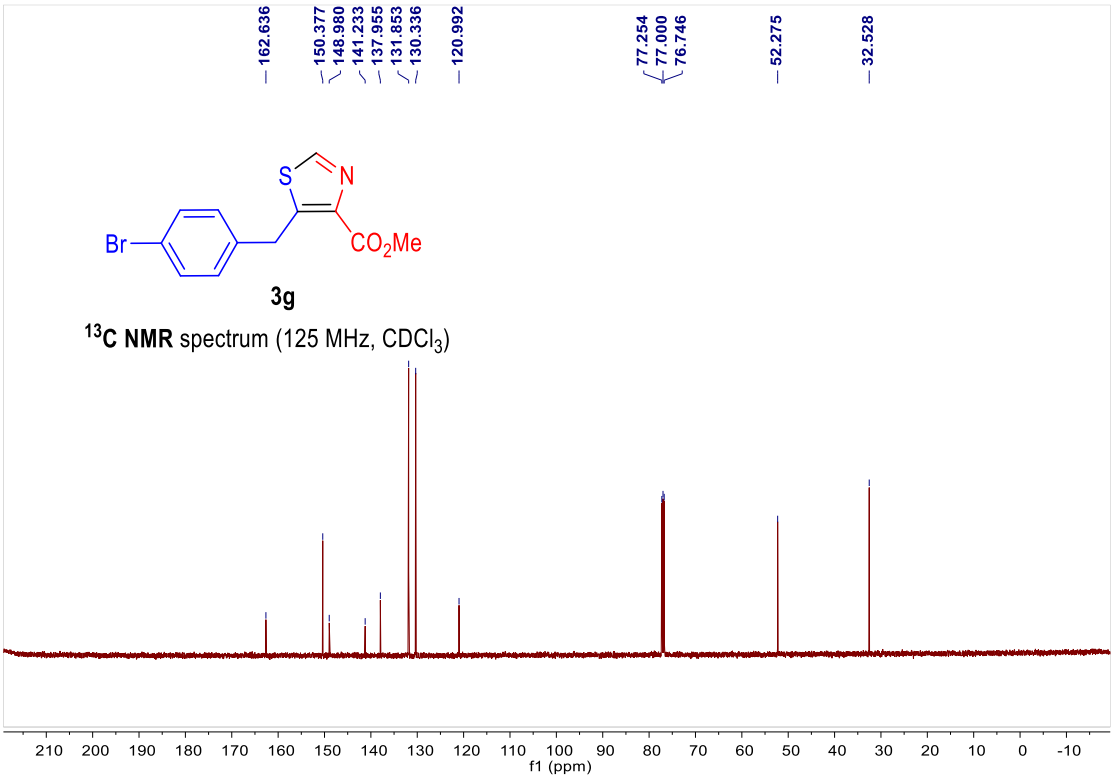
32.518
S
N
Cl
CO2Me
3f
13C NMR spectrum (125 MHz, CDCl3)
f1 (ppm)

3g



3g

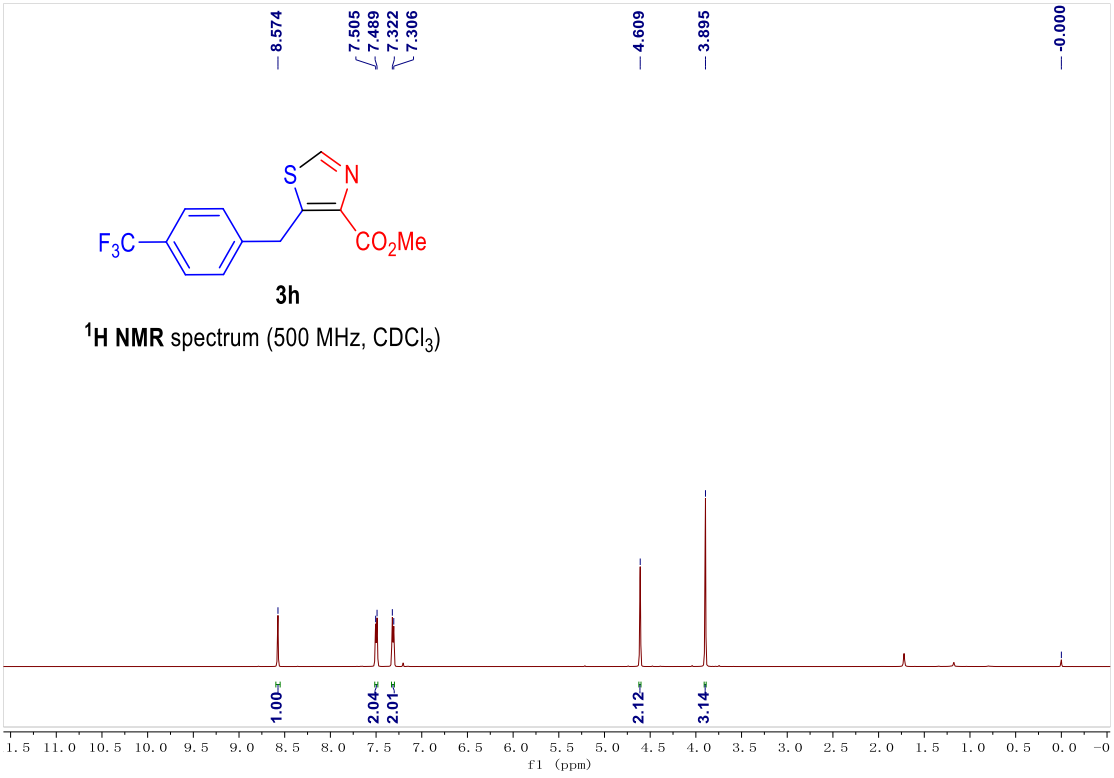
^{1}**H NMR** spectrum (500 MHz, $CDCl_3$)



3g

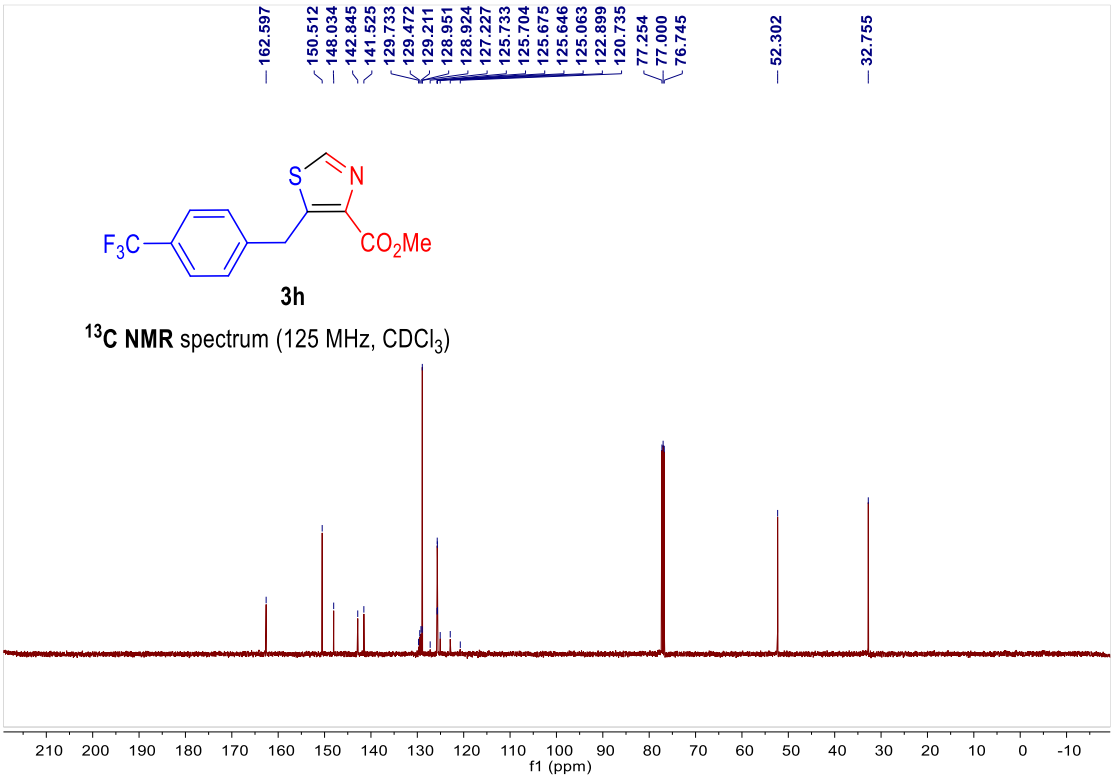
^{13}**C NMR** spectrum (125 MHz, $CDCl_3$)

3h



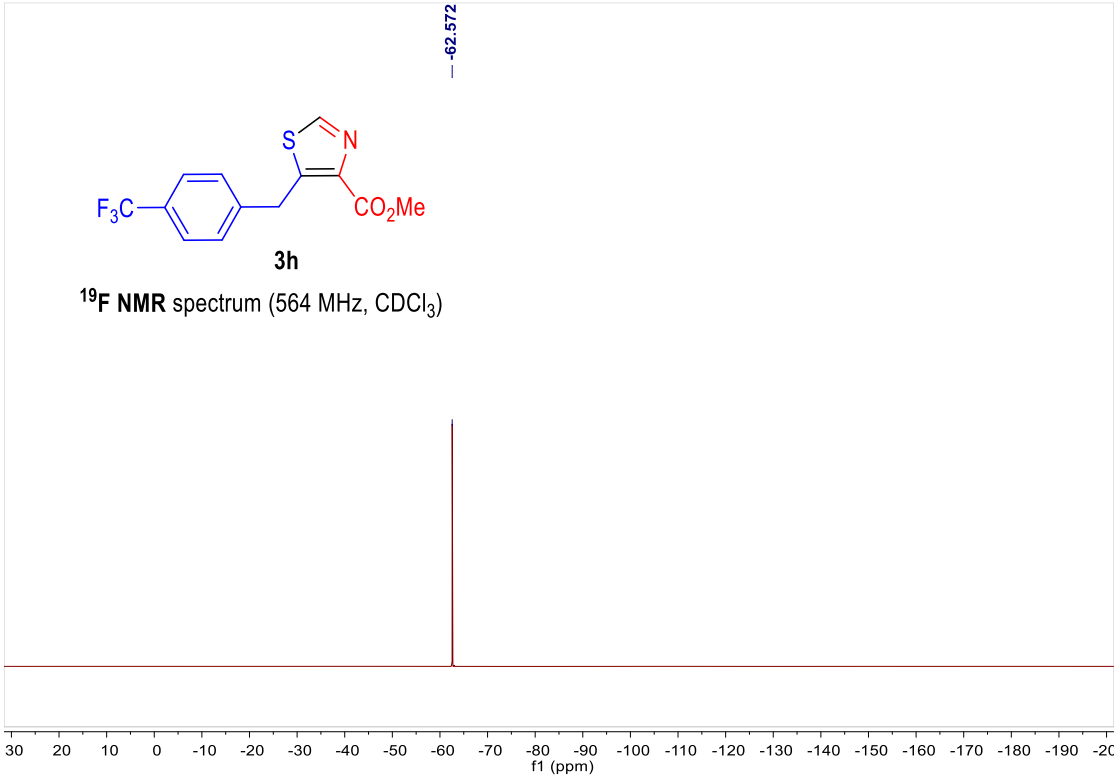
3h

^{1}**H NMR** spectrum (500 MHz, $CDCl_3$)



3h

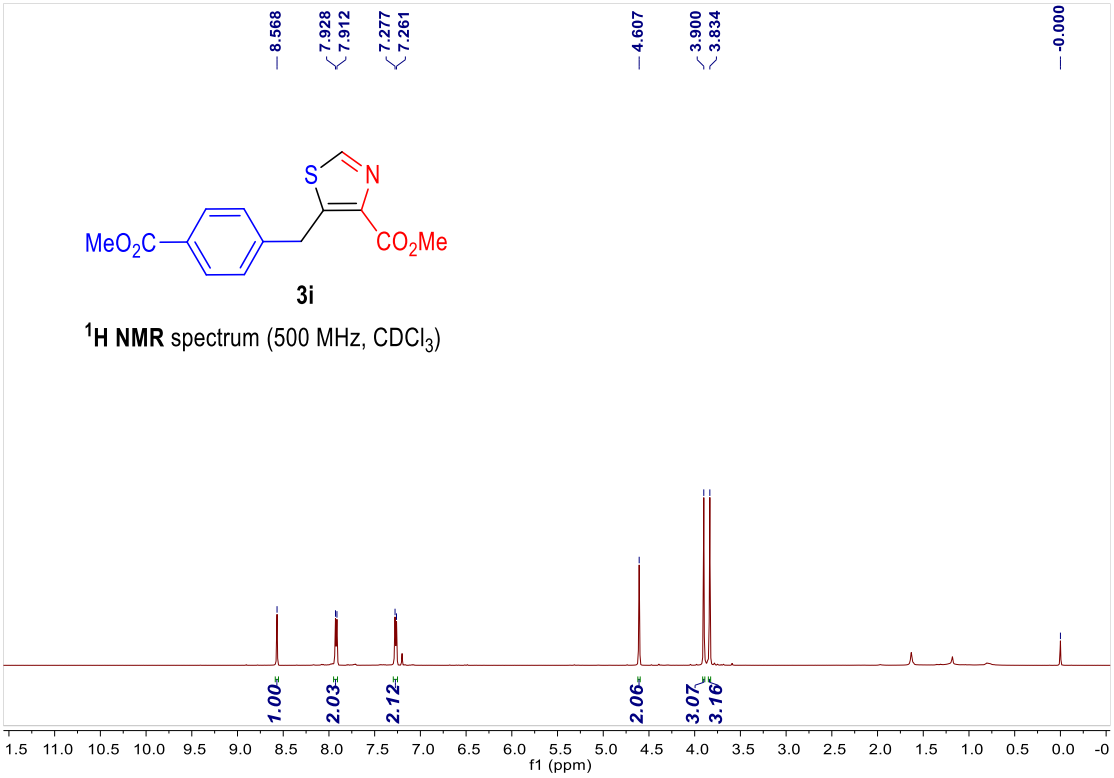
^{13}**C NMR** spectrum (125 MHz, $CDCl_3$)



3h

^{19}F NMR spectrum (564 MHz, $CDCl_3$)

3i



3i

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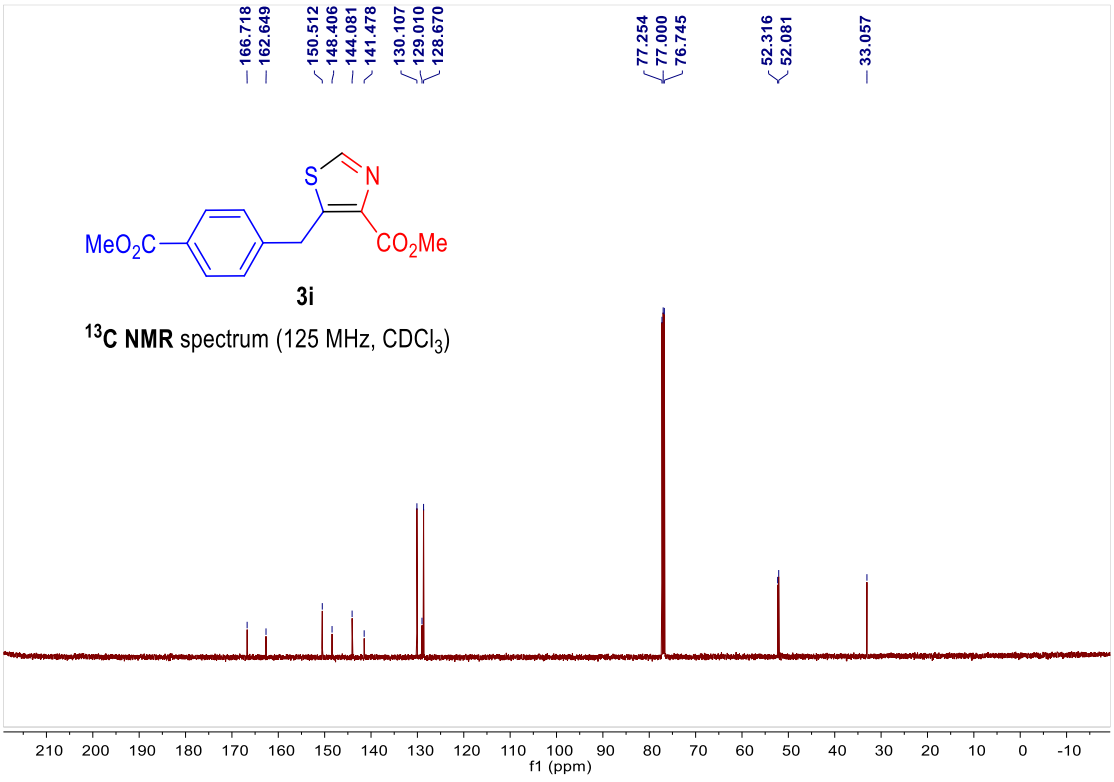
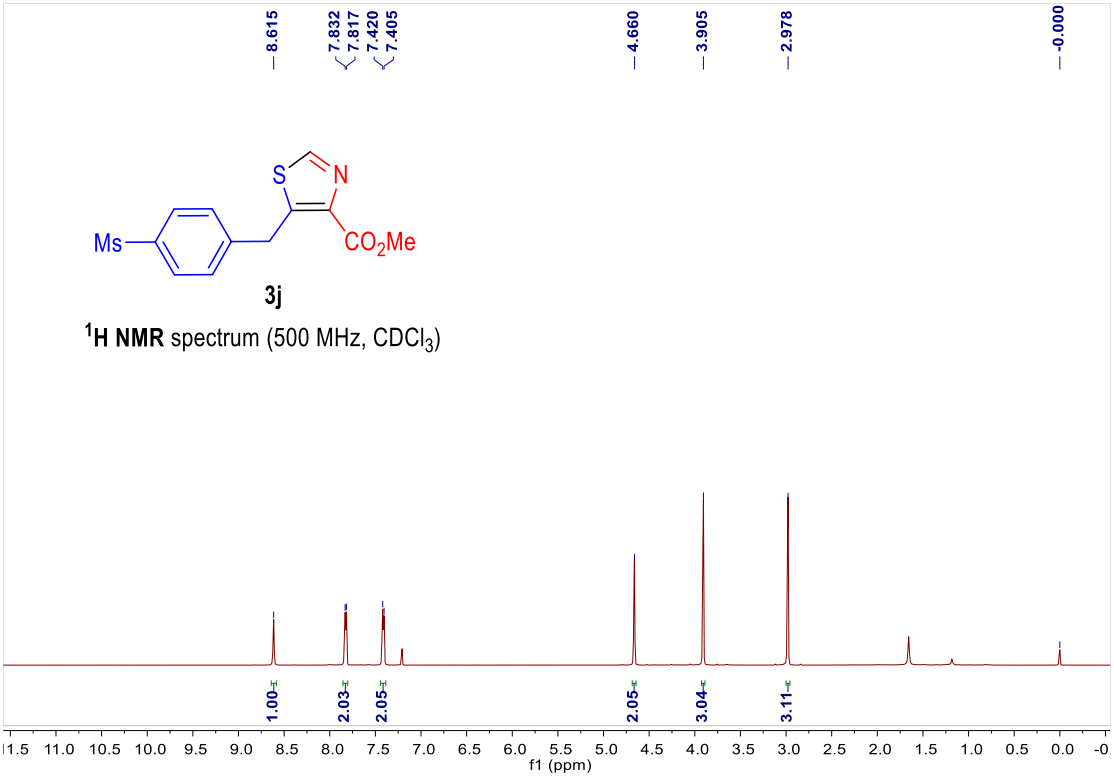


3i

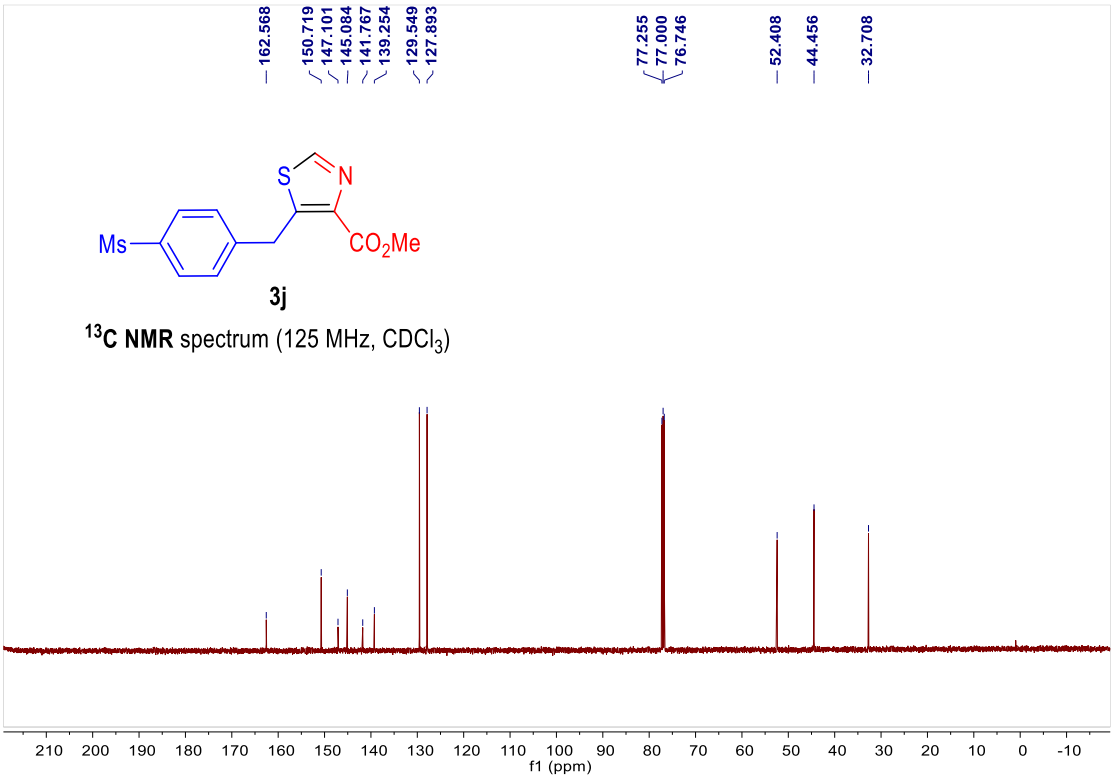
^{13}**C NMR** spectrum (125 MHz, $CDCl_3$)

3j



3j

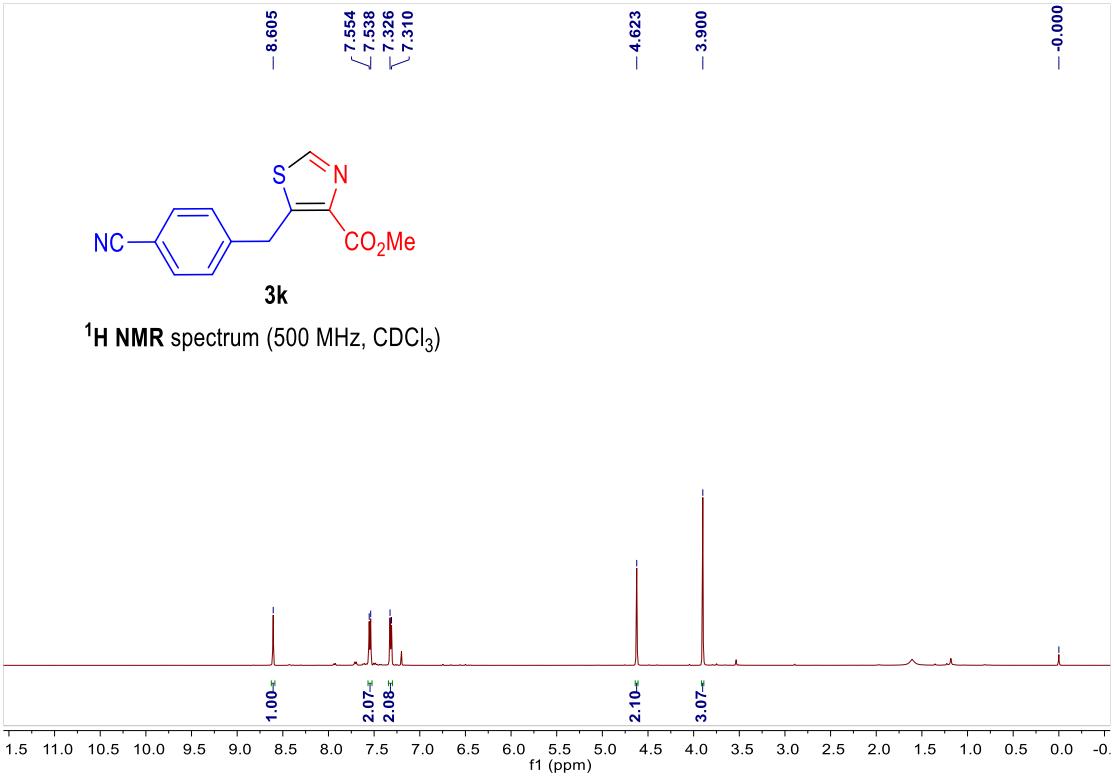
^{1}**H NMR** spectrum (500 MHz, $CDCl_3$)



3j

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

3k



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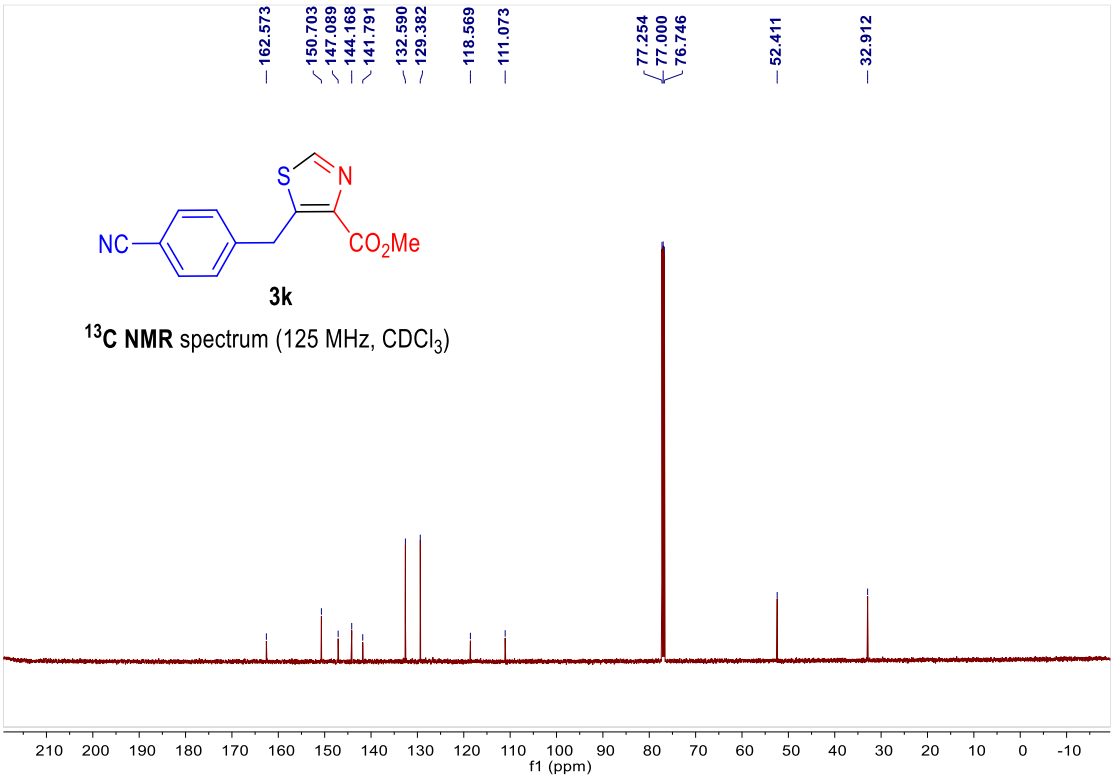
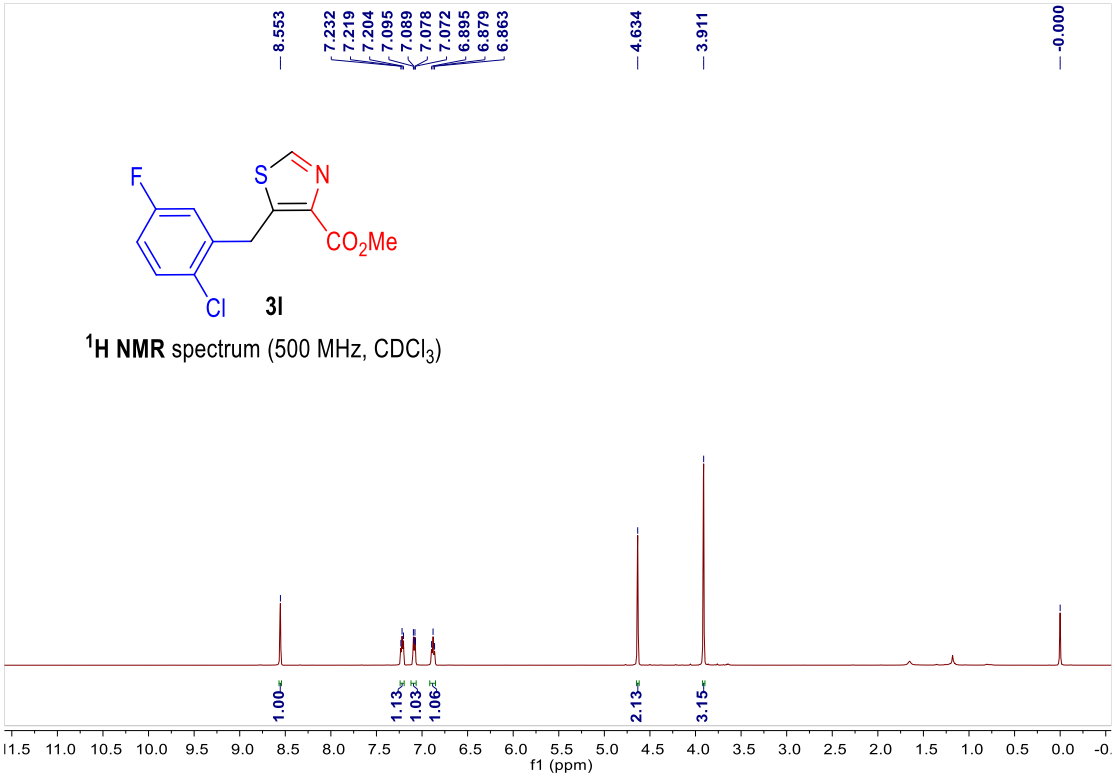
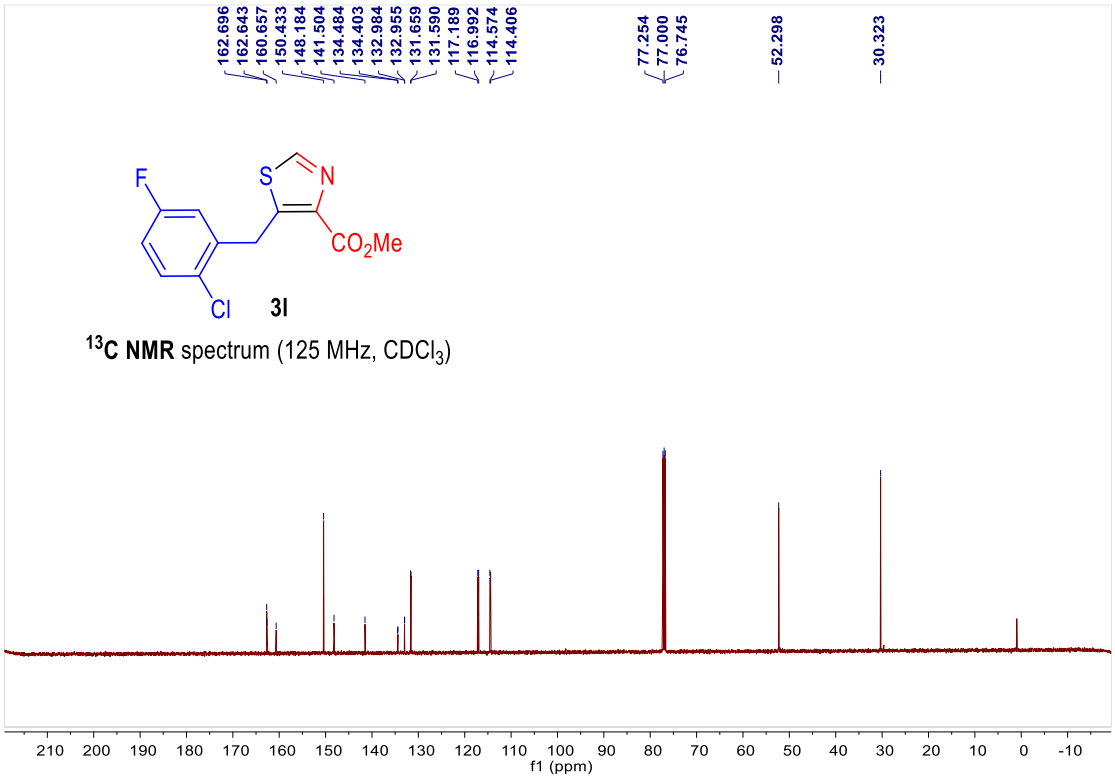


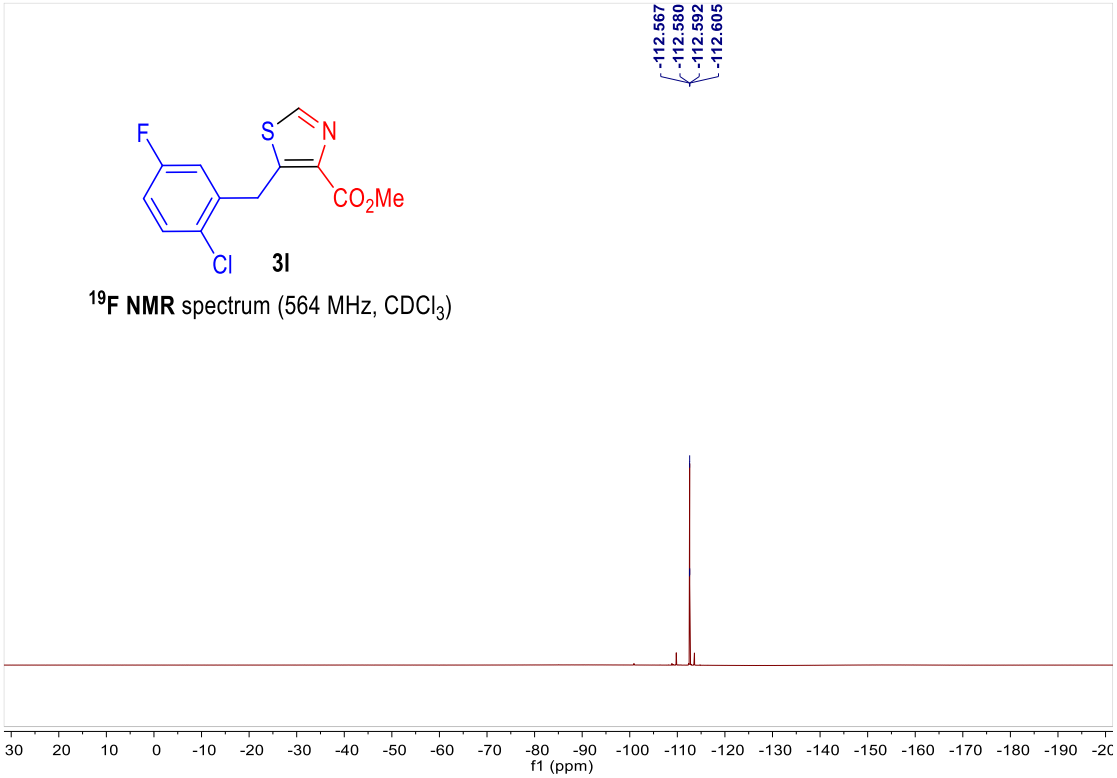
3k

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

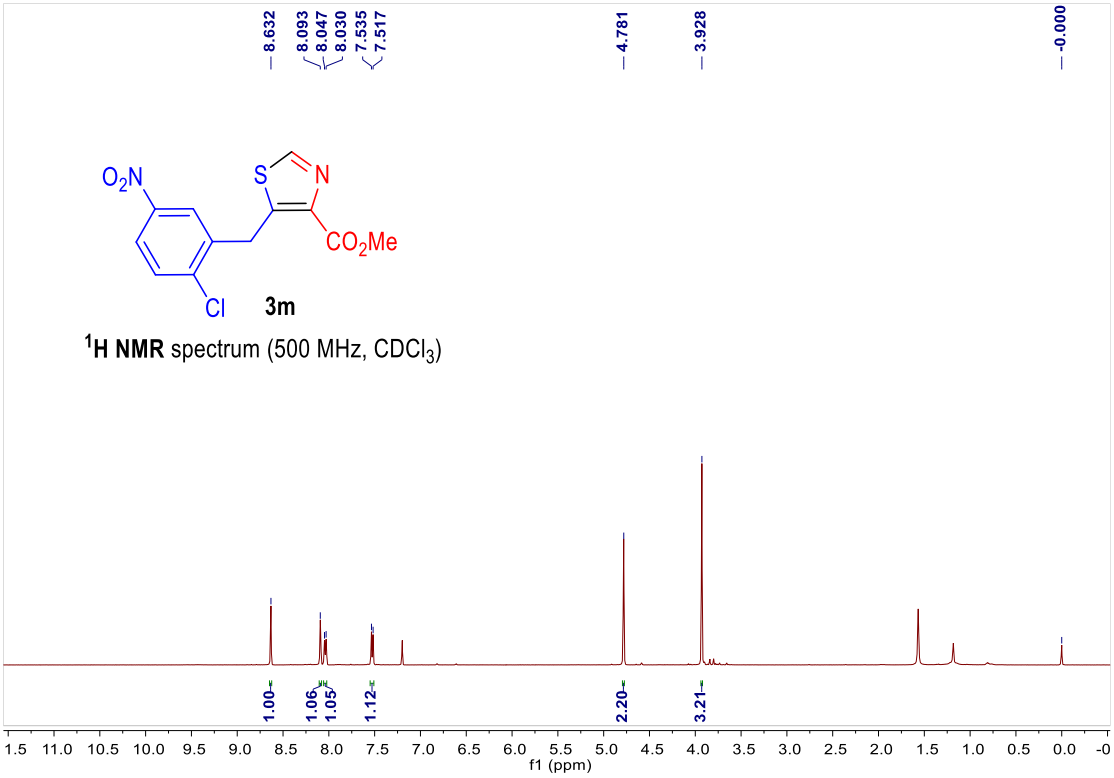
3l

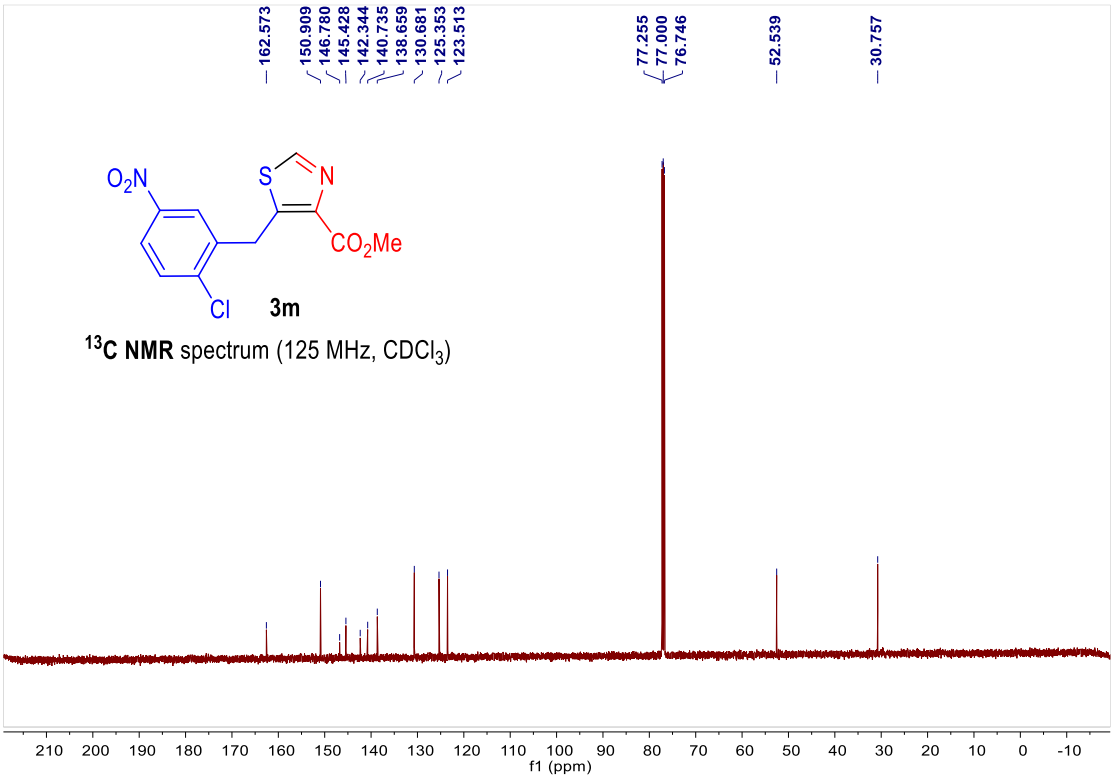

8.553
7.232
7.219
7.204
7.095
7.089
7.078
7.072
6.895
6.879
6.863
4.634
3.911
-0.000
F
S
N
CO2Me
Cl
3l
1H NMR spectrum (500 MHz, CDCl3)
1.00
1.13
1.03
1.06
2.13
3.15
f1 (ppm)


162.696
162.643
160.657
150.433
148.184
141.504
134.484
134.403
132.984
132.955
131.659
131.590
117.189
116.992
114.574
114.406
77.254
77.000
76.745
52.298
30.323
F
S
N
CO2Me
Cl
3l
13C NMR spectrum (125 MHz, CDCl3)
f1 (ppm)

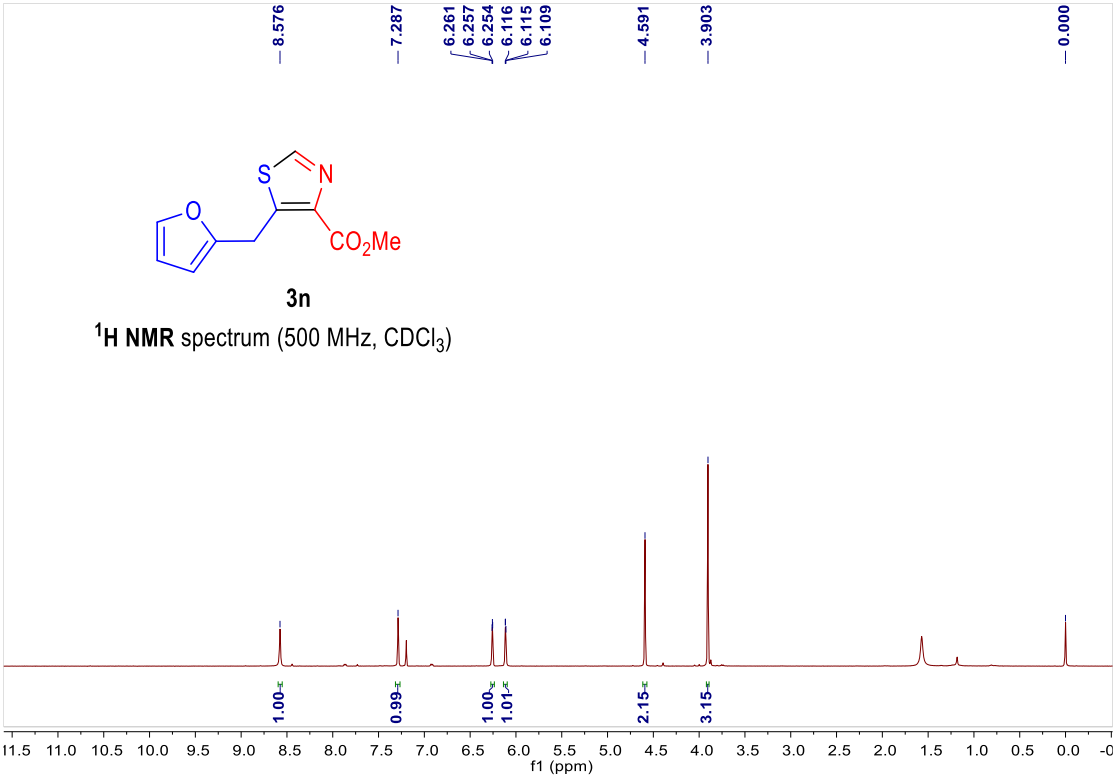

-112.567
-112.580
-112.592
-112.605
F
S
N
CO2Me
Cl
3l
19F NMR spectrum (564 MHz, CDCl3)
30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -20
f1 (ppm)

3m


8.632
8.093
8.047
8.030
7.535
7.517
4.781
3.928
-0.000
O2N
S
N
CO2Me
Cl
3m
1H NMR spectrum (500 MHz, CDCl3)
1.00
1.06
1.05
1.12
2.20
3.21
f1 (ppm)

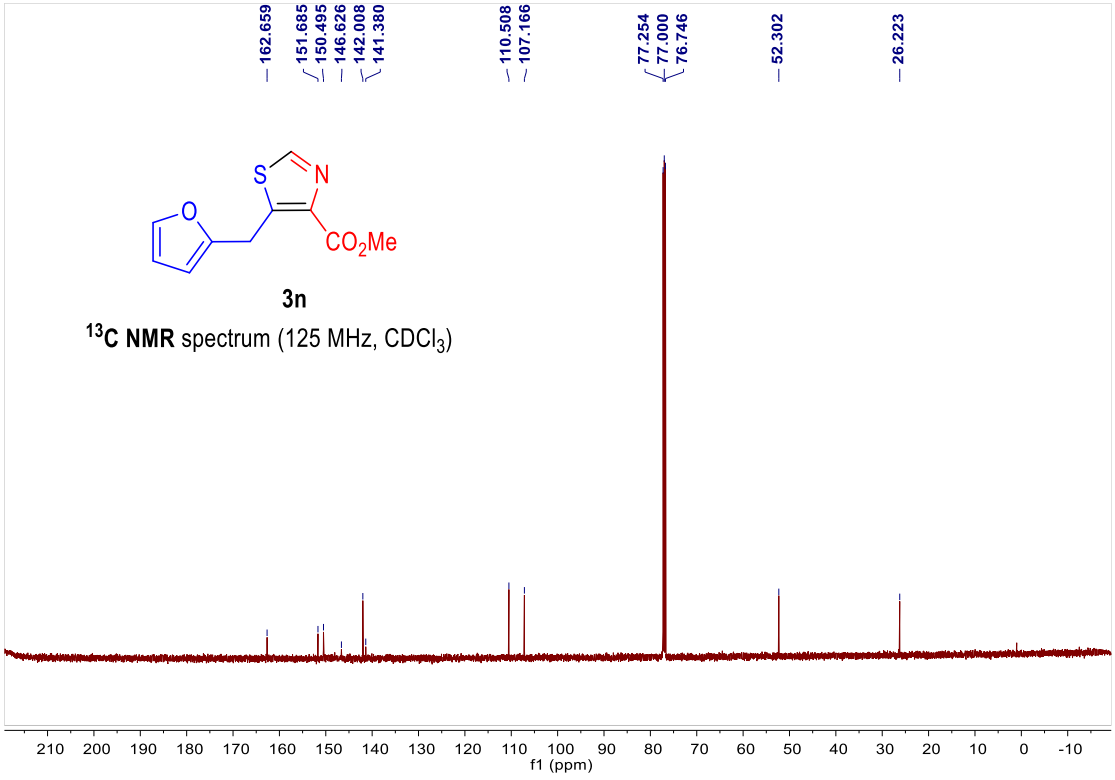

162.573
150.909
146.780
145.428
142.344
140.735
138.659
130.681
125.353
123.513
77.255
77.000
76.746
52.539
30.757
O2N
S
N
CO2Me
Cl
3m
13C NMR spectrum (125 MHz, CDCl3)
f1 (ppm)

3n



3n

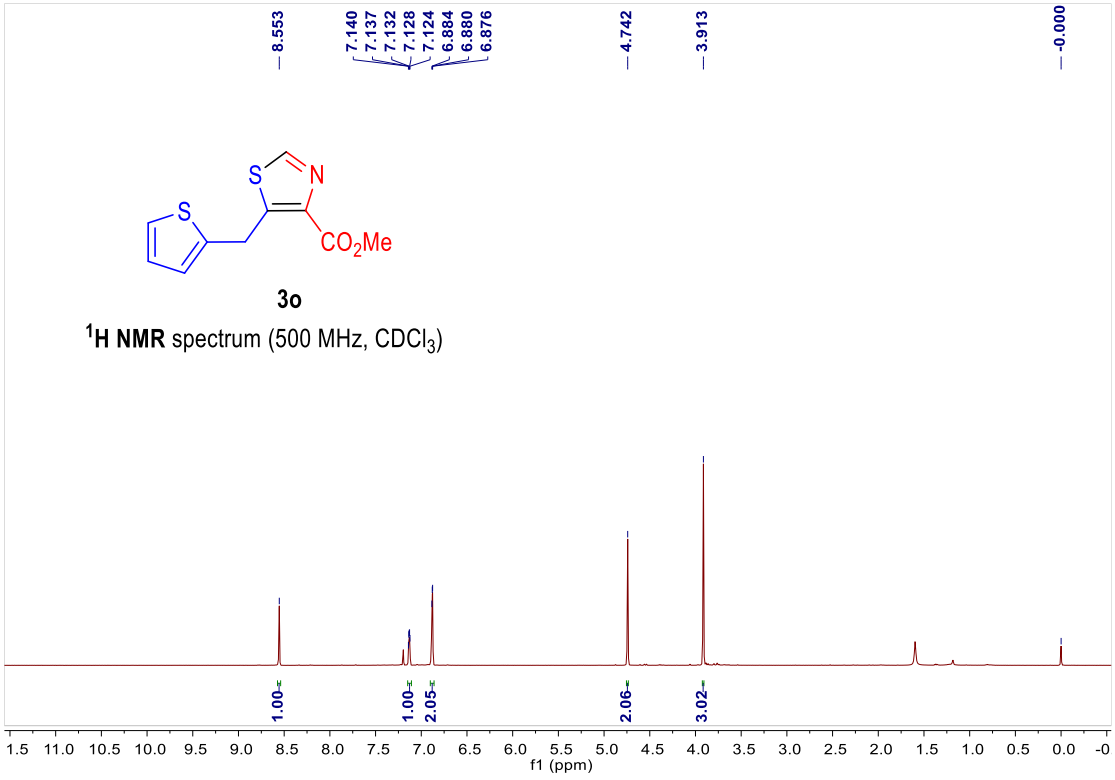
^{1}**H NMR** spectrum (500 MHz, $CDCl_3$)



3n

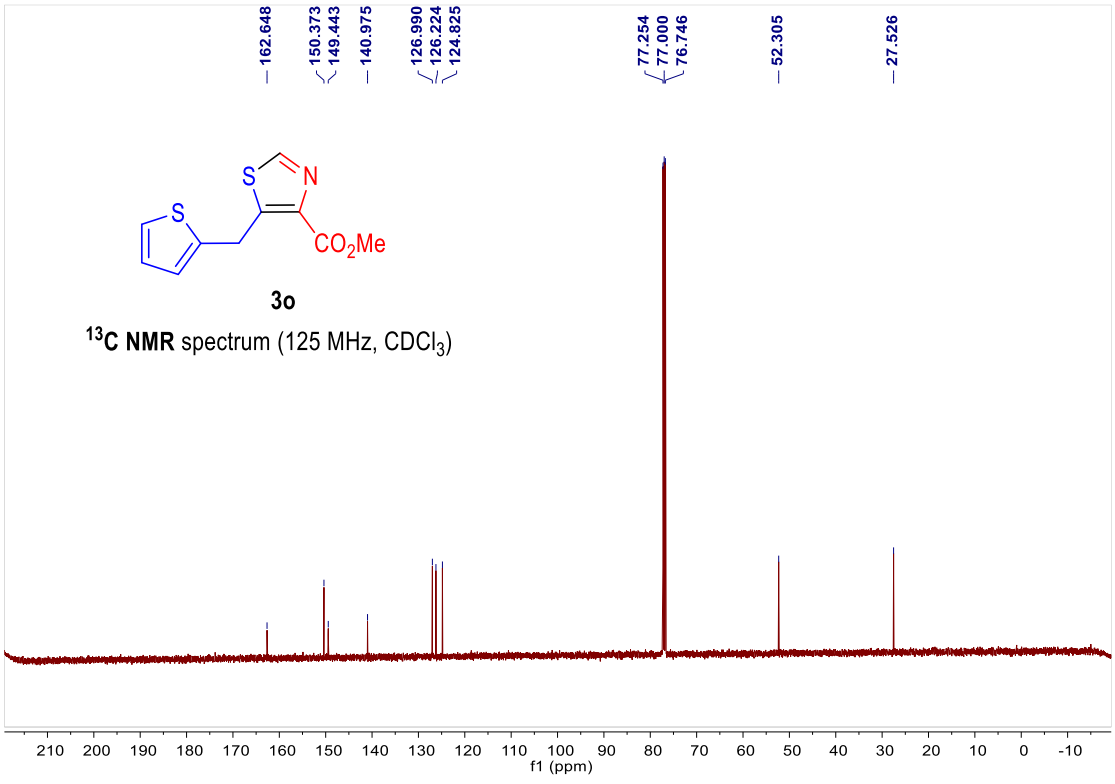
^{13}**C NMR** spectrum (125 MHz, $CDCl_3$)

3o



3o

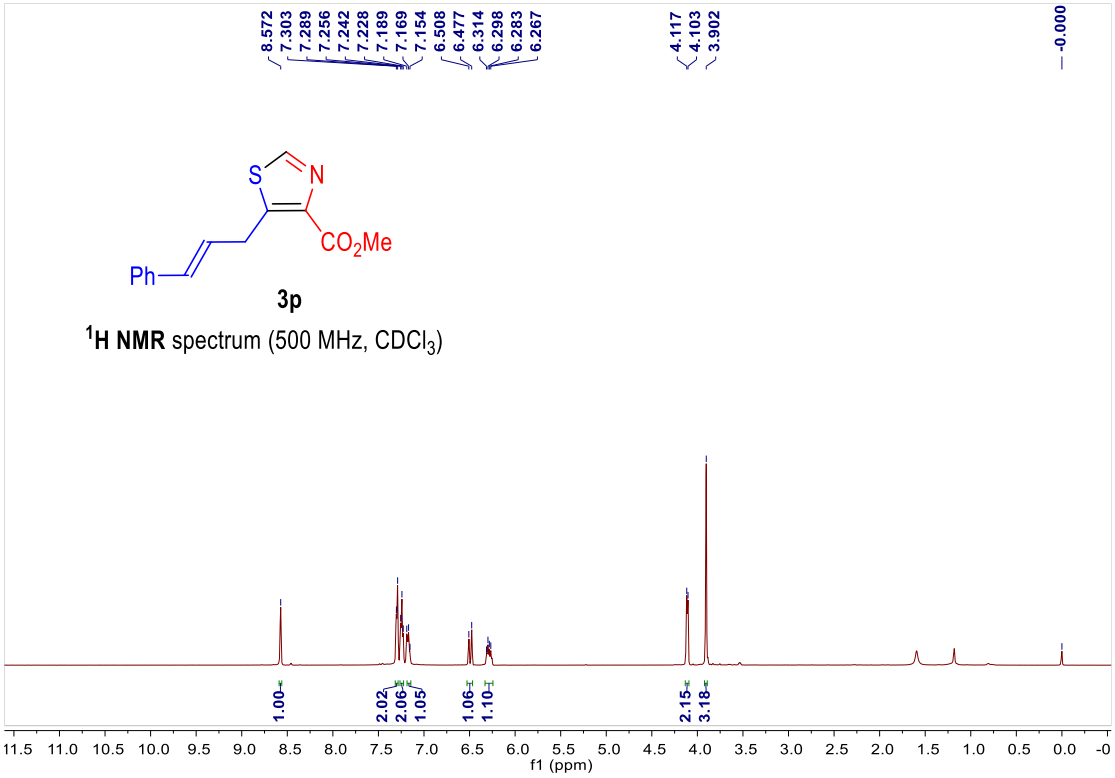
^{1}**H NMR** spectrum (500 MHz, $CDCl_3$)

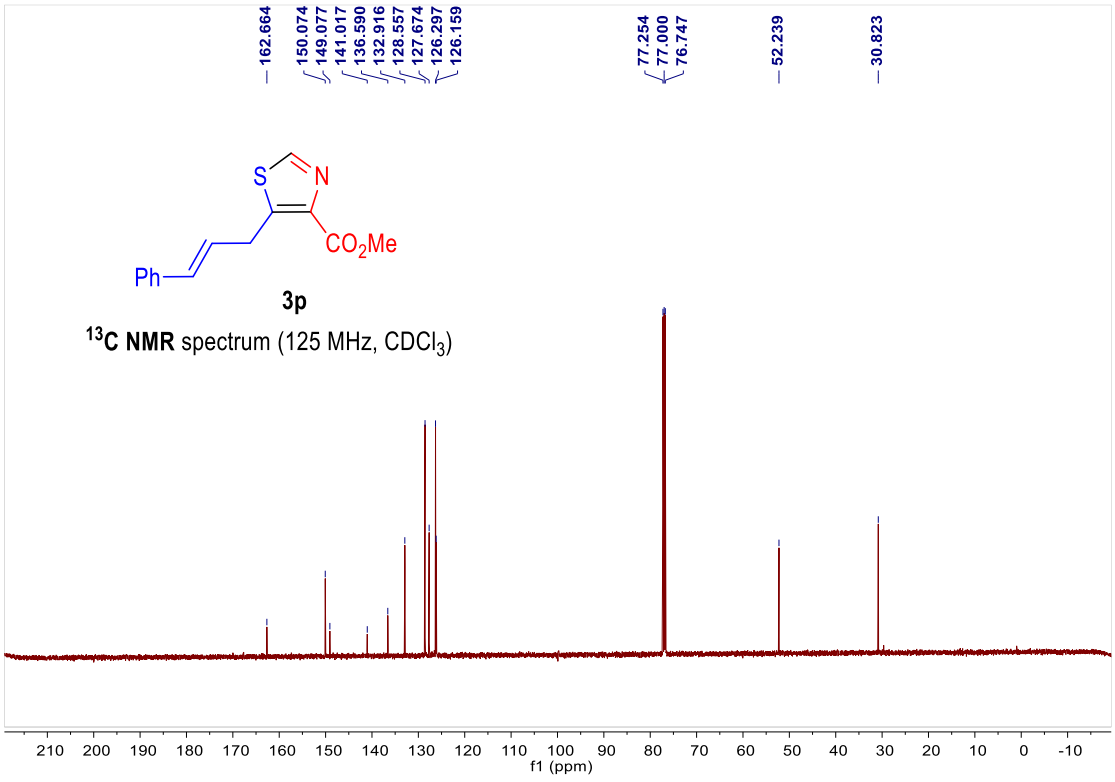


3o

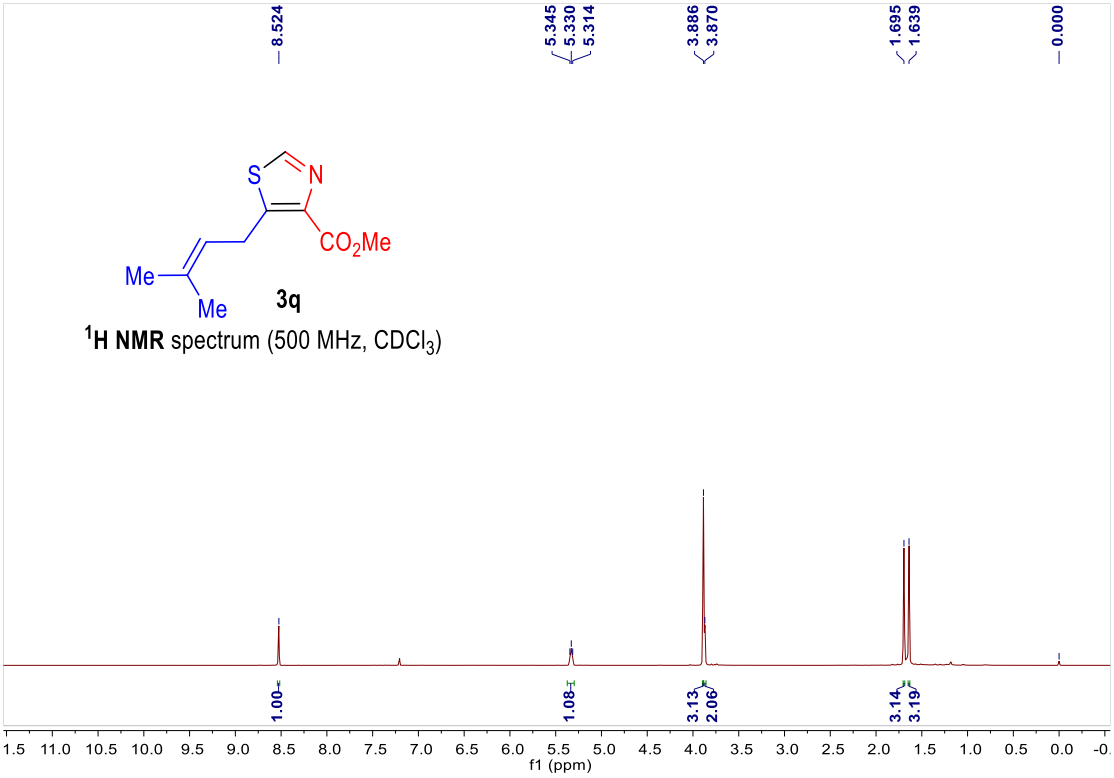
^{13}**C NMR** spectrum (125 MHz, $CDCl_3$)

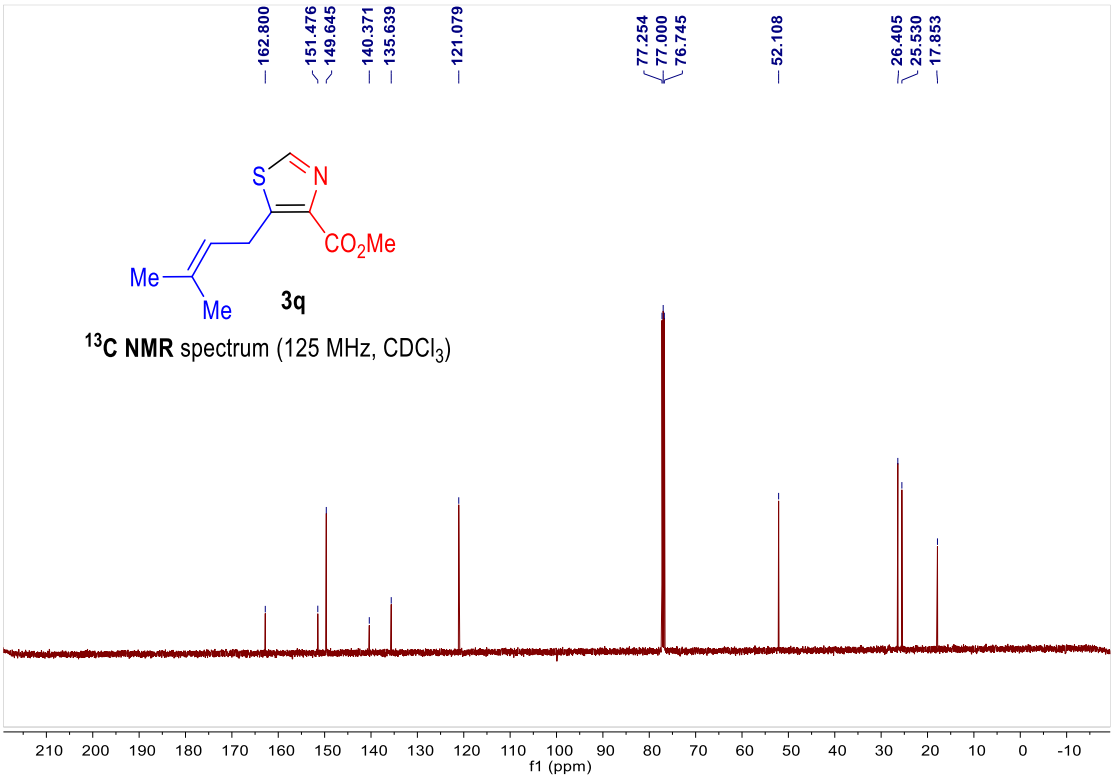
3p


8.572
7.303
7.289
7.256
7.242
7.228
7.189
7.169
7.154
6.508
6.477
6.314
6.298
6.283
6.267
4.117
4.103
3.902
-0.000
S
N
CO2Me
Ph
3p
1H NMR spectrum (500 MHz, CDCl3)
1.00
2.02
2.06
1.05
1.06
1.10
2.15
3.18
f1 (ppm)

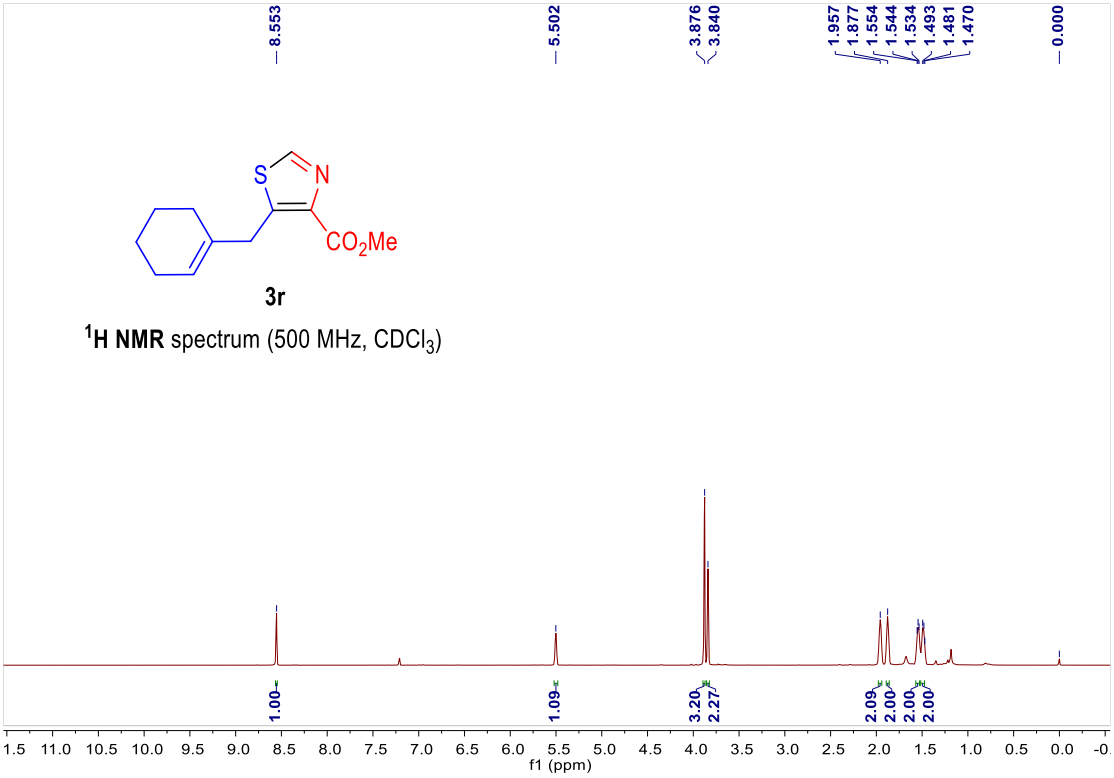

162.664
150.074
149.077
141.017
136.590
132.916
128.557
127.674
126.297
126.159
77.254
77.000
76.747
52.239
30.823
S
N
CO2Me
Ph
3p
13C NMR spectrum (125 MHz, CDCl3)
f1 (ppm)

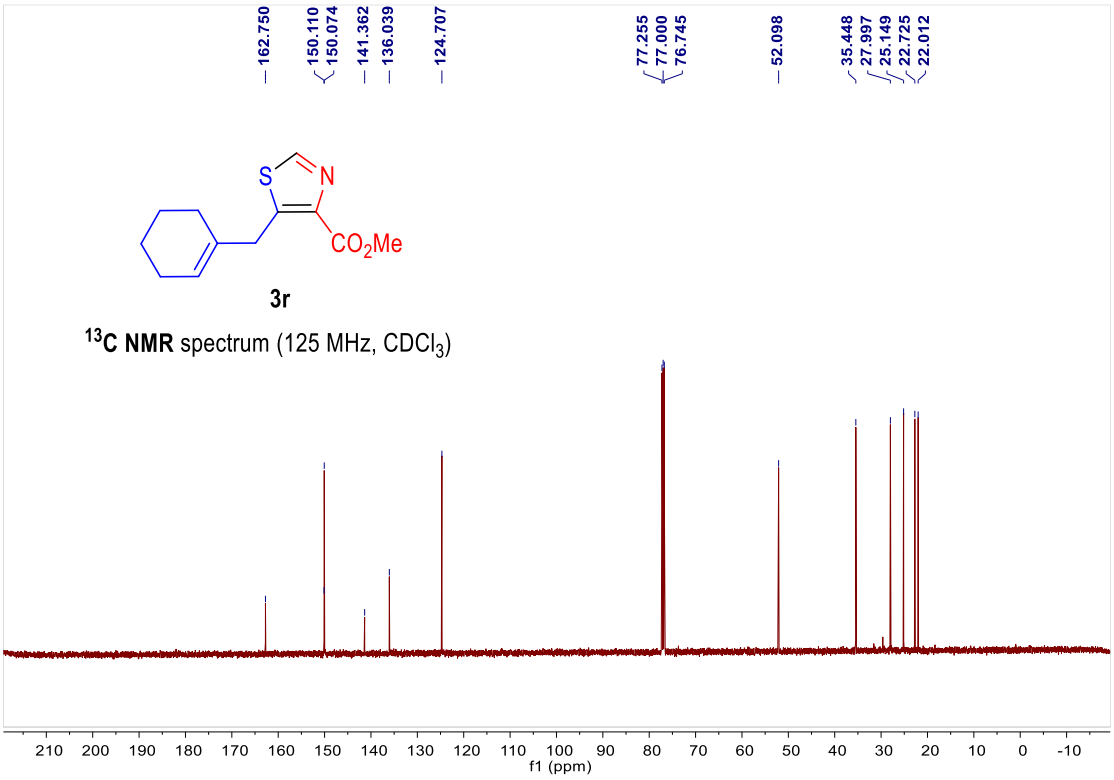
3q


8.524
5.345
5.330
5.314
3.886
3.870
1.695
1.639
0.000
S
N
CO2Me
Me
Me
3q
1H NMR spectrum (500 MHz, CDCl3)
1.00
1.08
3.13
2.06
3.14
3.19
f1 (ppm)

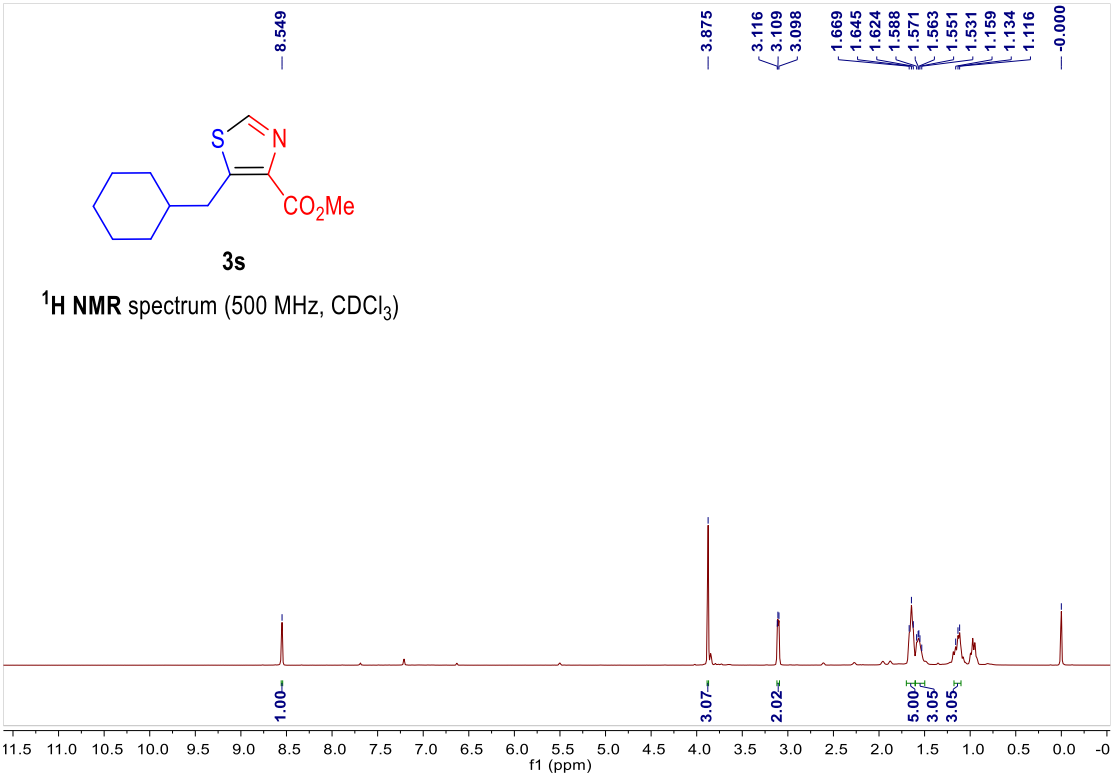

162.800
151.476
149.645
140.371
135.639
121.079
77.254
77.000
76.745
52.108
26.405
25.530
17.853
S
N
CO2Me
Me
Me
3q
13C NMR spectrum (125 MHz, CDCl3)
f1 (ppm)

3r


8.553
5.502
3.876
3.840
1.957
1.877
1.554
1.544
1.534
1.493
1.481
1.470
0.000
S
N
CO2Me
3r
1H NMR spectrum (500 MHz, CDCl3)
1.00
1.09
3.20
2.27
2.09
2.00
2.00
2.00
f1 (ppm)

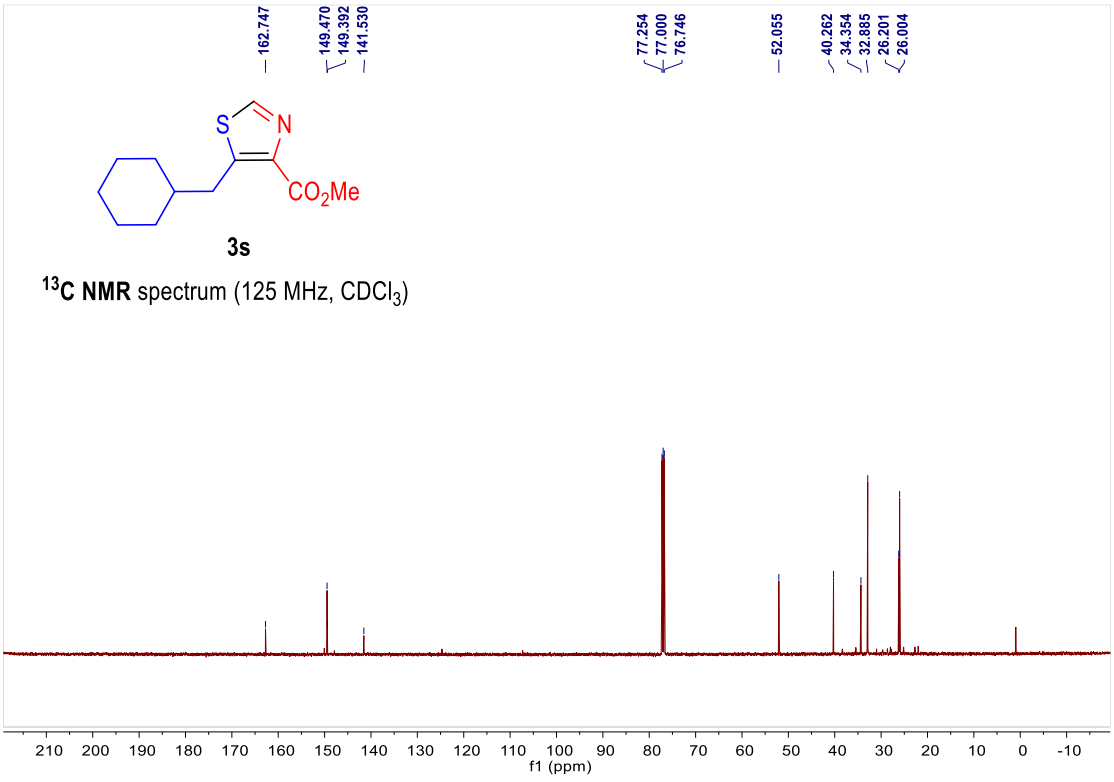

162.750
150.110
150.074
141.362
136.039
124.707
77.255
77.000
76.745
52.098
35.448
27.997
25.149
22.725
22.012
S
N
CO2Me
3r
13C NMR spectrum (125 MHz, CDCl3)
f1 (ppm)

3s



3s

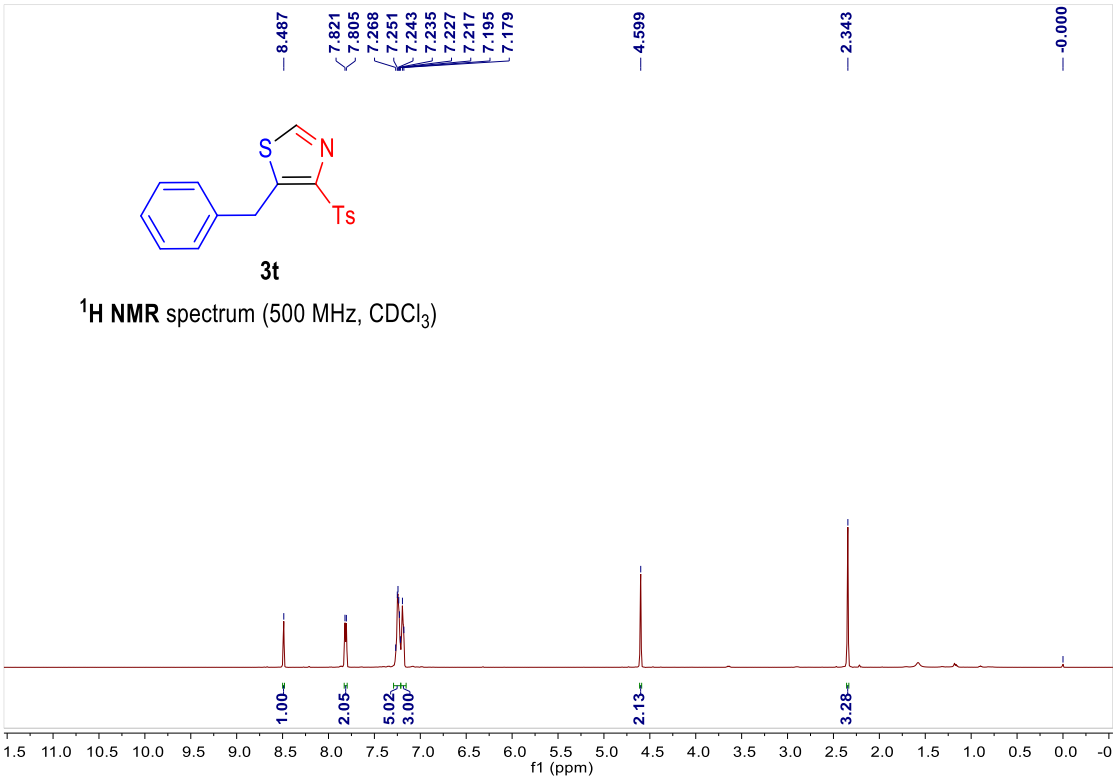
^{1}**H NMR** spectrum (500 MHz, $CDCl_3$)



3s

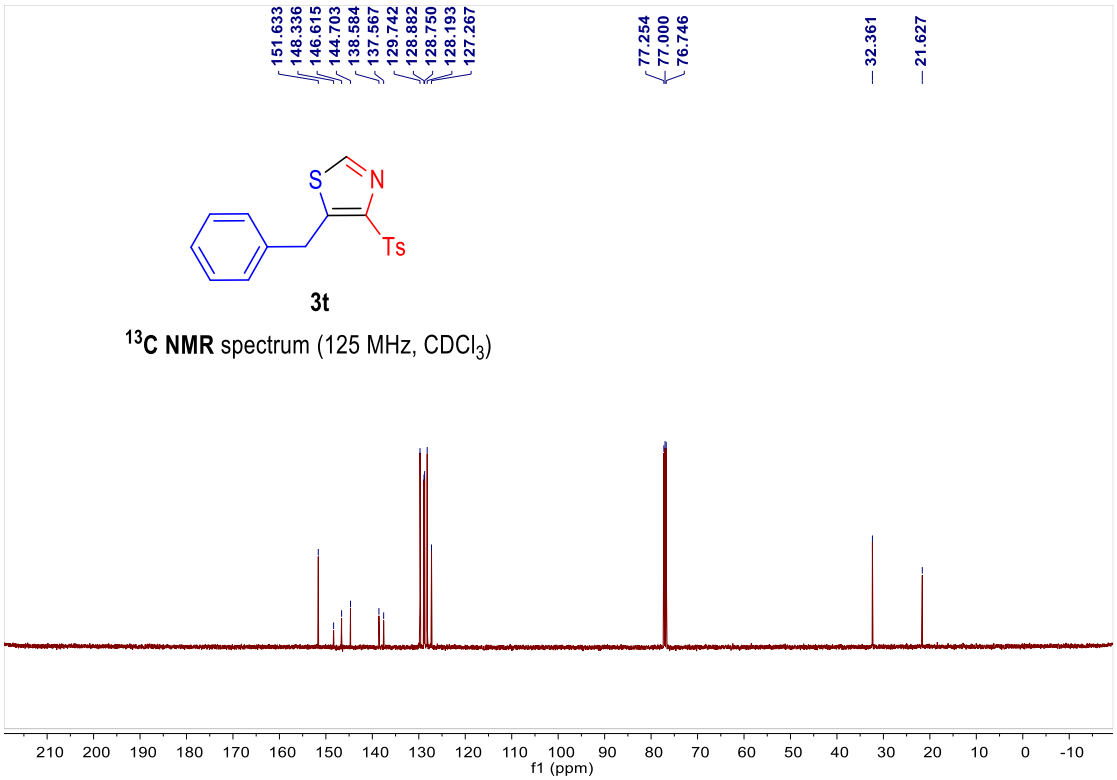
^{13}**C NMR** spectrum (125 MHz, $CDCl_3$)

3t



3t

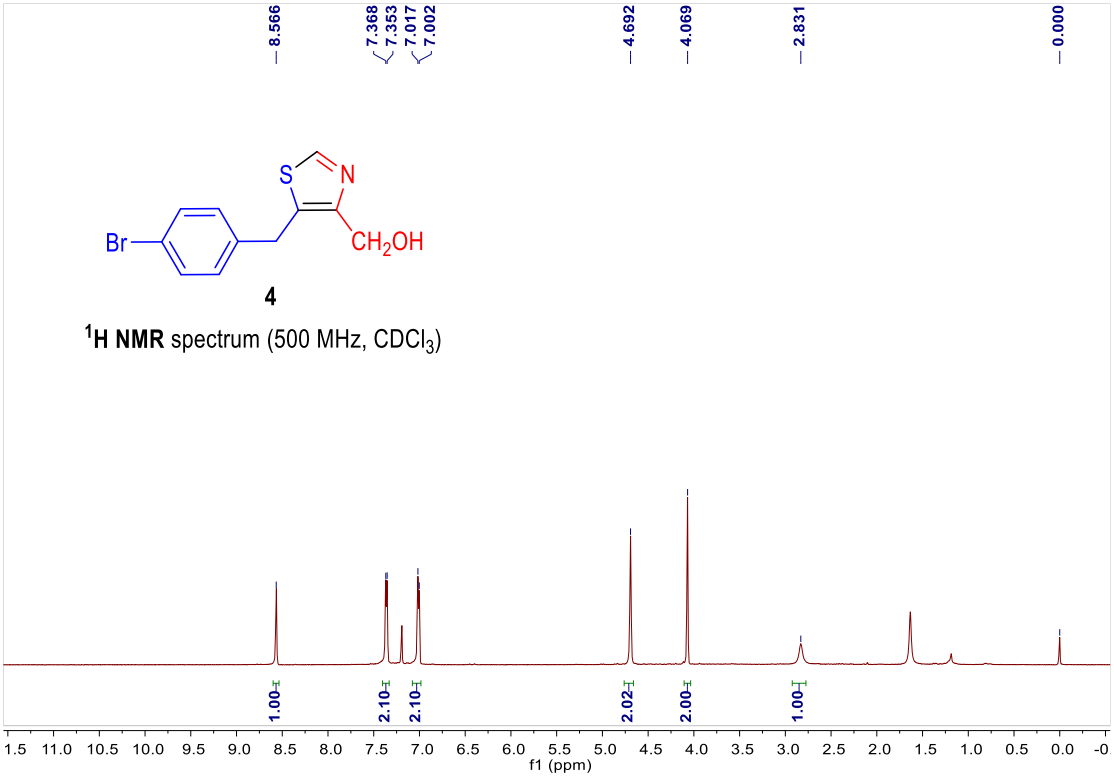
^{1}**H NMR** spectrum (500 MHz, $CDCl_3$)

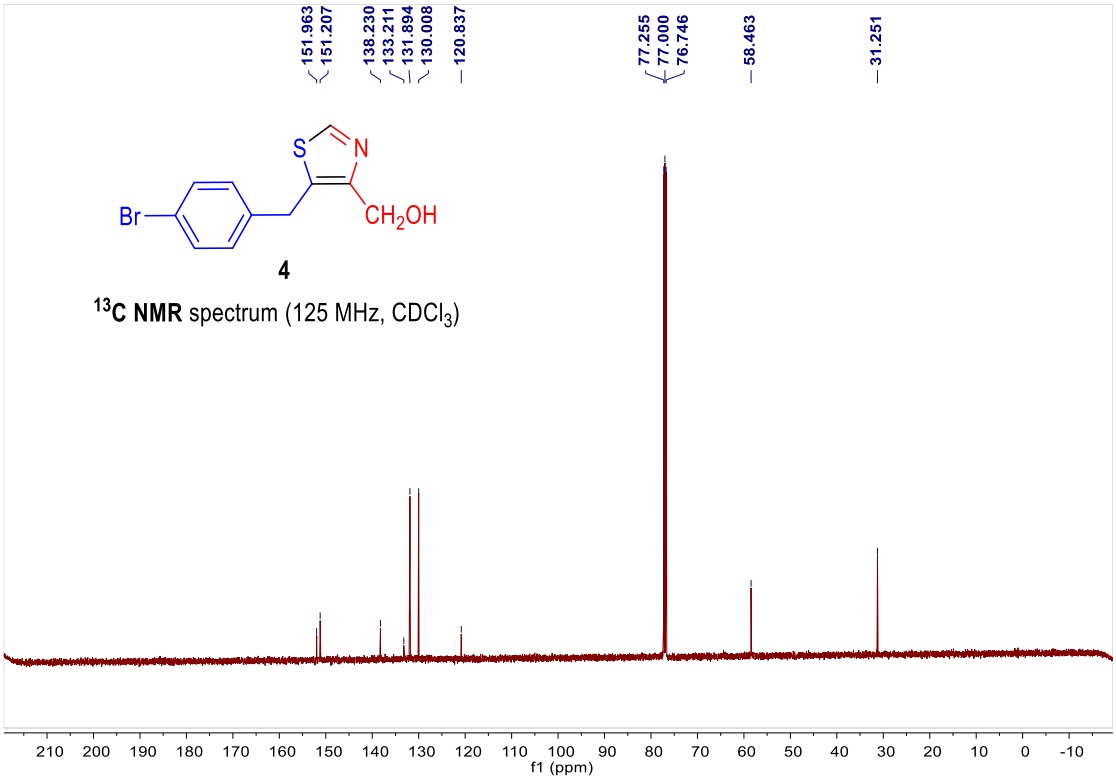


3t

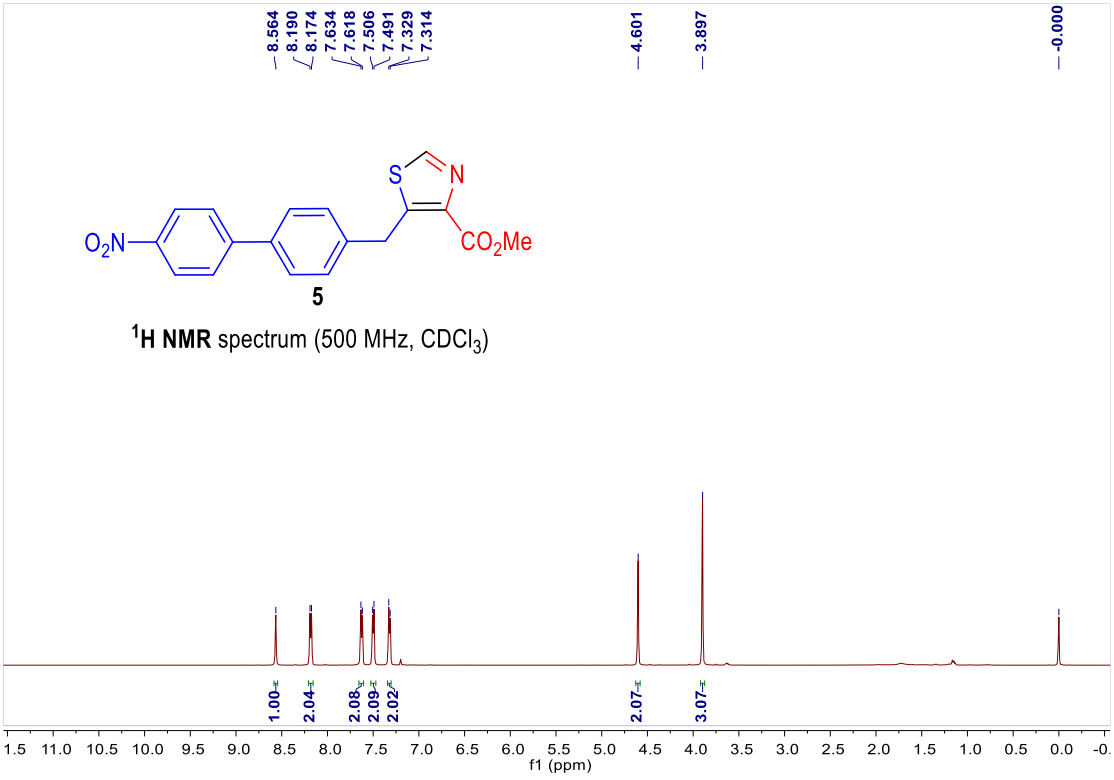
^{13}**C NMR** spectrum (125 MHz, $CDCl_3$)

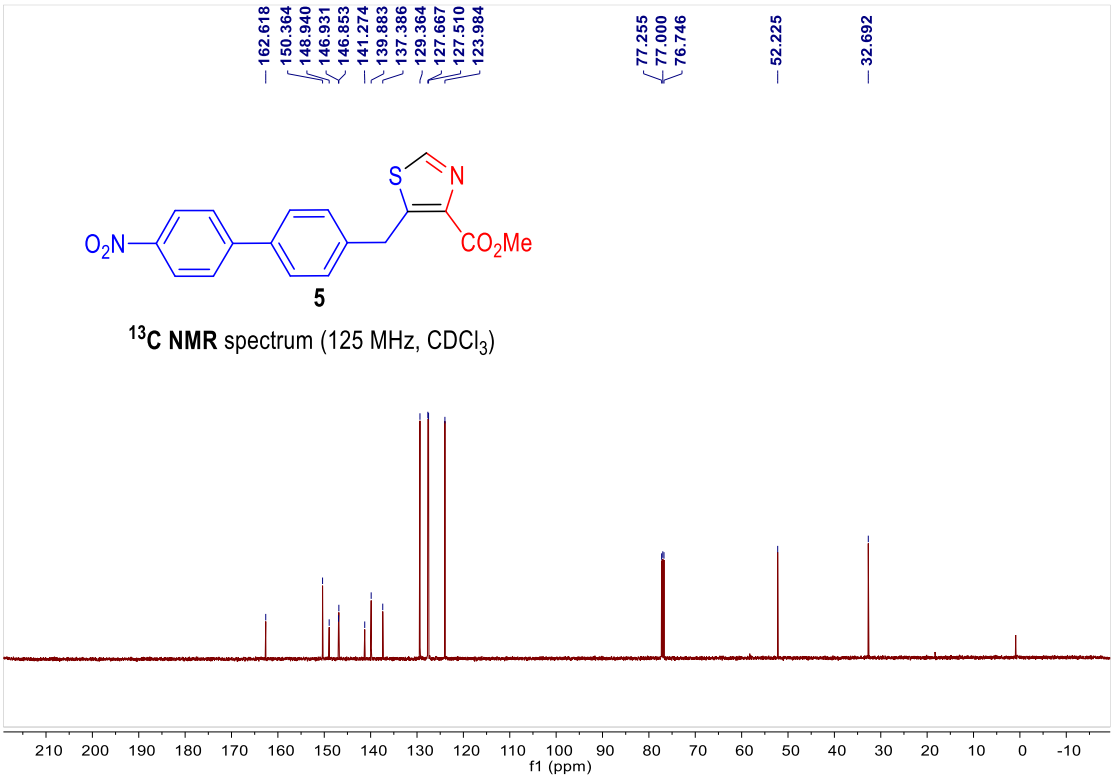
4


8.566
7.368
7.353
7.017
7.002
4.692
4.069
2.831
0.000
S
N
Br
CH2OH
4
1H NMR spectrum (500 MHz, CDCl3)
1.00
2.10
2.10
2.02
2.00
1.00
f1 (ppm)

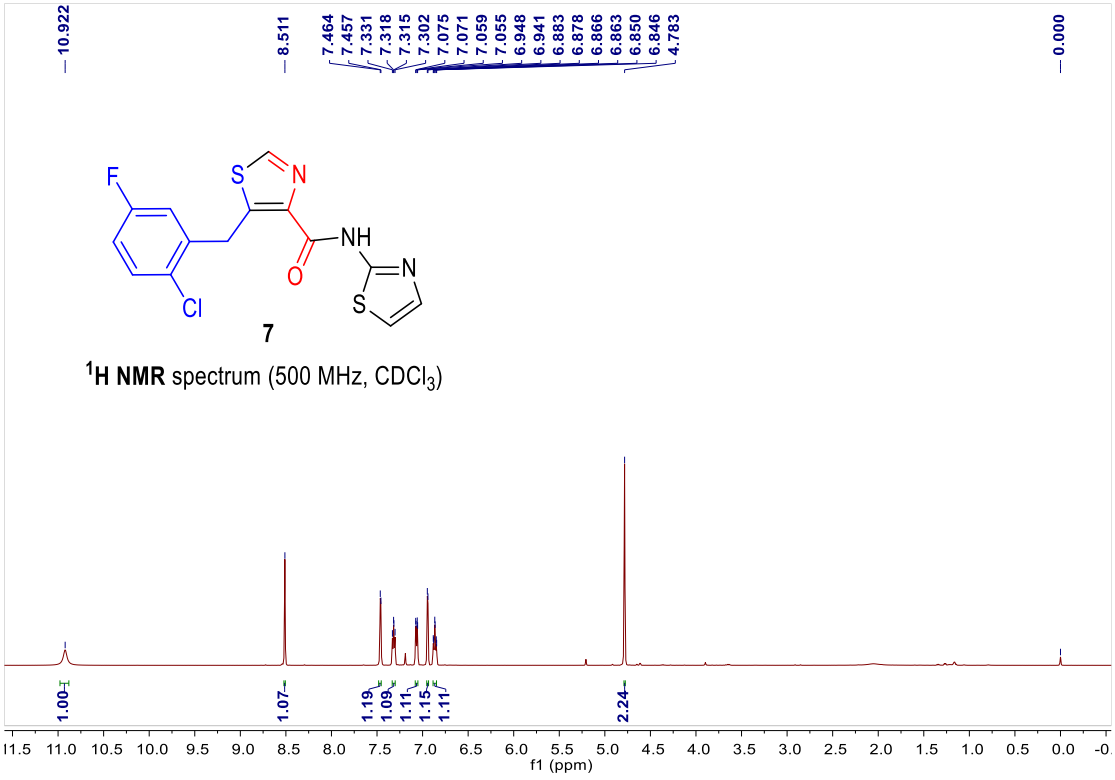

151.963
151.207
138.230
133.211
131.894
130.008
120.837
77.255
77.000
76.746
58.463
31.251
S
N
Br
CH2OH
4
13C NMR spectrum (125 MHz, CDCl3)
f1 (ppm)

5

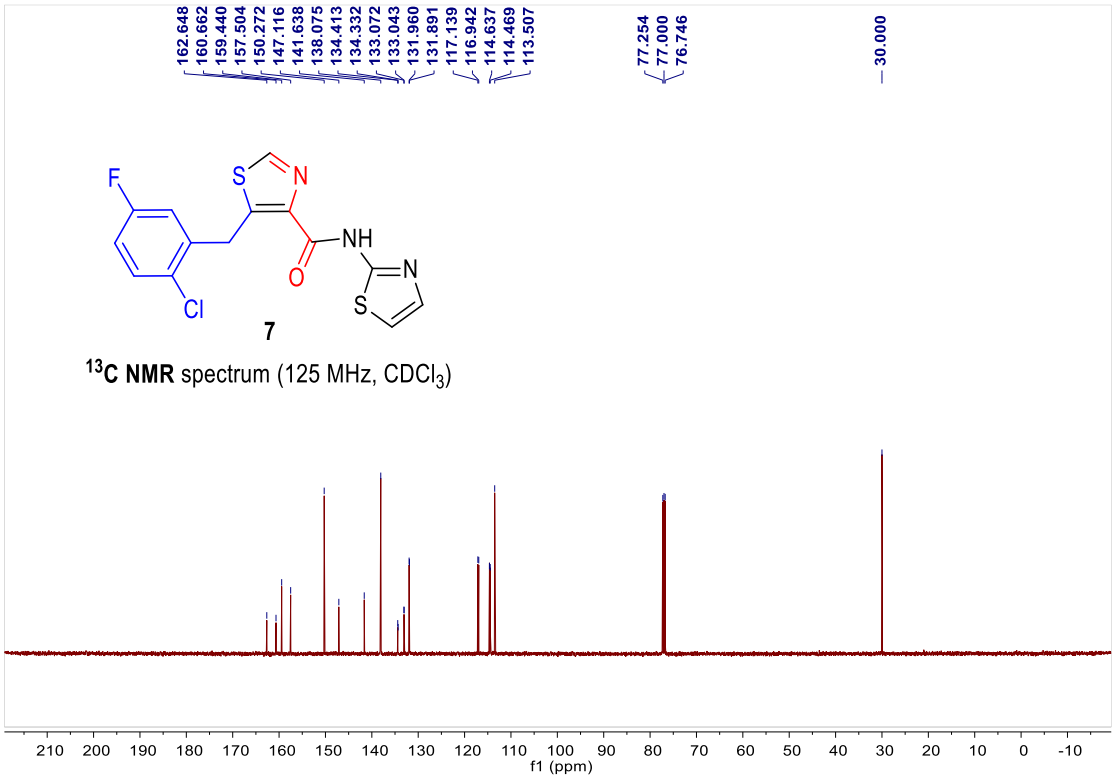

8.564
8.190
8.174
7.634
7.618
7.506
7.491
7.329
7.314
4.601
3.897
-0.000
S
N
O2N
CO2Me
5
1H NMR spectrum (500 MHz, CDCl3)
1.00
2.04
2.08
2.09
2.02
2.07
3.07
f1 (ppm)


162.618
150.364
148.940
146.931
146.853
141.274
139.883
137.386
129.364
127.667
127.510
123.984
77.255
77.000
76.746
52.225
32.692
S
N
O2N
CO2Me
5
13C NMR spectrum (125 MHz, CDCl3)
f1 (ppm)

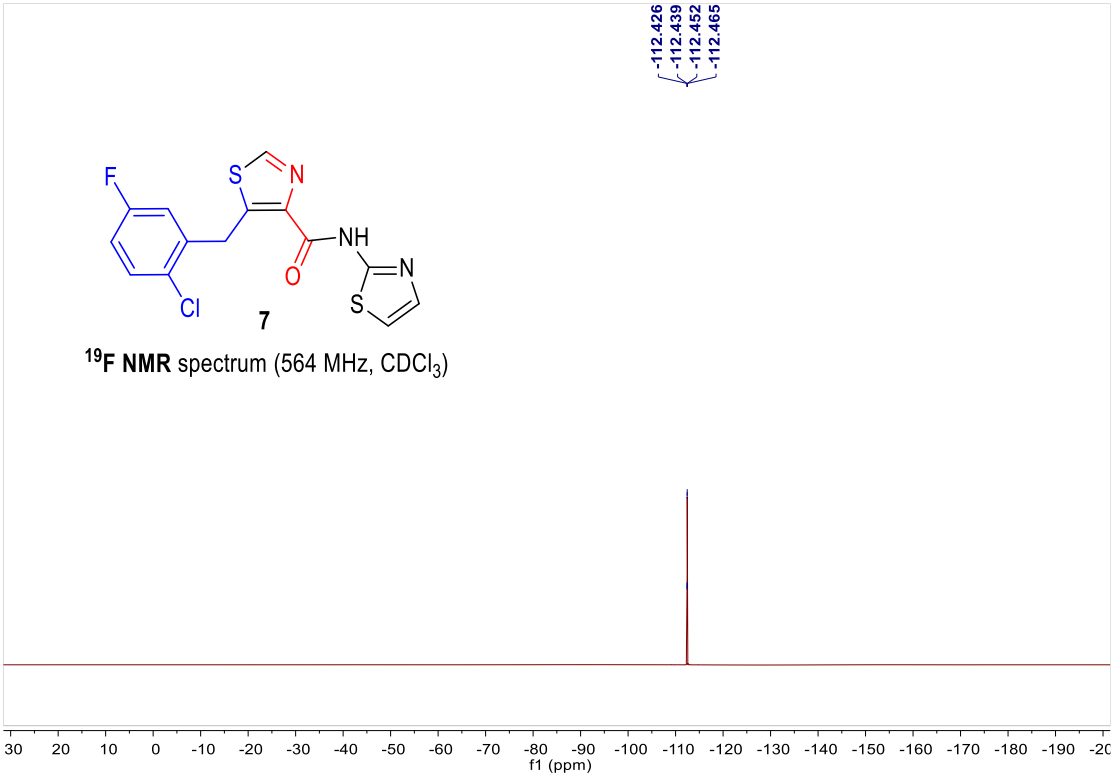
7



^{1}**H NMR** spectrum (500 MHz, $CDCl_3$)



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



^{19}F NMR spectrum (564 MHz, $CDCl_3$)