

**Metal-free sulfonylation of 3,4-dihalo-2(5*H*)-furanones (X= Cl, Br)
with sodium sulfinates under air atmosphere in aqueous media via a
radical pathway**

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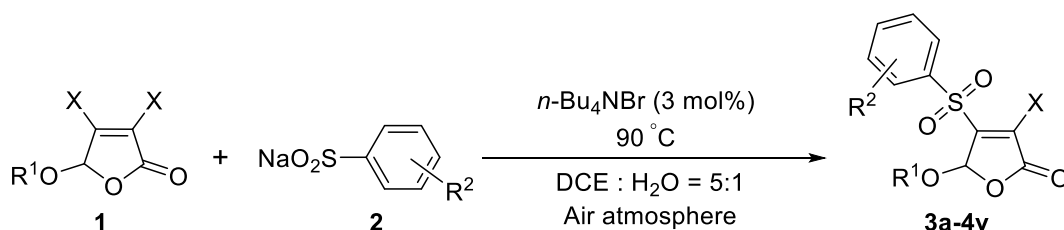
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General Information

Melting points were measured with a melting point instrument and were uncorrected. ^1H NMR and ^{13}C NMR spectra were recorded on Varian AS400 (400 and 100 MHz, respectively) instrument internally referenced to tetramethylsilane (TMS) or CDCl_3 signals. High-resolution mass spectra (HRMS) were obtained with a LCMS-IT-TOF mass spectrometer. Single-crystal X-ray analysis was obtained using Bruker APEX2 Smart CCD. TLC was performed by using commercially prepared 100-400 mesh silica gel plates (GF254) and visualization was effected at 254 nm.

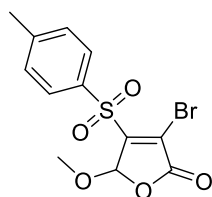
All reagents and solvents were purchased from commercial sources and used without further purification. Different 5-alkoxy (aryloxy or acetoxy)-3,4-dihalo-2(5*H*)-furanone intermediates **1** were synthesized according to the literature procedure.¹⁻⁹

Experimental Procedure for Compounds 3a-4v



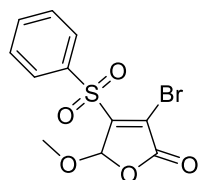
The mixture of 3,4-dihalo-2(5*H*)-furanone **1** (0.30 mmol), sodium sulfinate **2** (0.60 mmol) and $n\text{-Bu}_4\text{NBr}$ (3 mol %) in $\text{DCE} : \text{H}_2\text{O}$ ($v : v = 5 : 1$, 3 mL) was stirred at 90°C under air for 8 h. At ambient temperature, the reaction mixture was diluted with H_2O (15 mL) and extracted with EtOAc ($3 \times 15\text{ mL}$). The organic extracts were dried over anhydrous Na_2SO_4 . After filtration and evaporation of the solvents under reduced pressure, the crude product was purified by column chromatography on silica gel to afford desired product.

Characterization Data for All Products 3a-4v



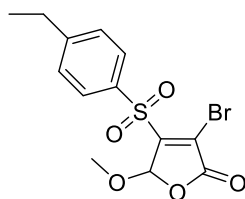
3-Bromo-5-methoxy-4-tosylfuran-2(5H)-one (3a)

Yellow solid (95 mg, 92%); m.p. 94.5-96.2 °C; ^1H NMR (400 MHz, CDCl_3), δ : 2.47 (s, 3H, ArCH_3), 3.60 (s, 3H, OCH_3), 6.04 (s, 1H, CH), 7.40 (d, $J = 8.0$ Hz, 2H, ArH), 7.93 (d, $J = 8.0$ Hz, 2H, ArH); ^{13}C NMR (100 MHz, CDCl_3), δ : 21.9, 58.1, 103.2, 123.3, 129.0, 130.2, 135.0, 147.0, 155.0, 163.5; ESI-HRMS, m/z (%): Calcd for $\text{C}_{12}\text{H}_{11}\text{BrNaO}_5\text{S}$ ($[\text{M}+\text{Na}]^+$): 368.9403, Found: 368.9408.



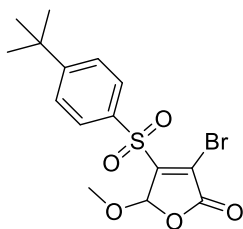
3-Bromo-5-methoxy-4-(phenylsulfonyl)furan-2(5H)-one (3b)

Yellow solid (89 mg, 89%); m.p. 93.7-95.3 °C; ^1H NMR (400 MHz, CDCl_3), δ : 3.60 (s, 3H, OCH_3), 6.05 (s, 1H, CH), 7.56-7.66 (m, 3H, ArH), 8.05 (d, $J = 8.0$ Hz, 2H, ArH); ^{13}C NMR (100 MHz, CDCl_3), δ : 58.1, 103.1, 123.9, 129.0, 129.5, 135.4, 138.0, 154.7, 163.4; ESI-HRMS, m/z (%): Calcd for $\text{C}_{11}\text{H}_9\text{BrNaO}_5\text{S}$ ($[\text{M}+\text{Na}]^+$): 354.9246, Found: 354.9250.



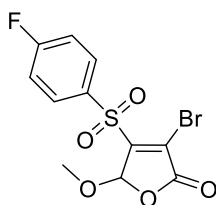
3-Bromo-4-((4-ethylphenyl)sulfonyl)-5-methoxyfuran-2(5H)-one (3c)

Colorless oil (100 mg, 92%); ^1H NMR (400 MHz, CDCl_3), δ : 1.27 (t, $J = 8.0$ Hz, 3H, CH_3), 2.76 (q, $J = 8.0$ Hz, 2H, CH_2), 3.60 (s, 3H, OCH_3), 6.04 (s, 1H, CH), 7.42 (d, $J = 8.0$ Hz, 2H, ArH), 7.95 (d, $J = 8.0$ Hz, 2H, ArH); ^{13}C NMR (100 MHz, CDCl_3), δ : 14.9, 29.1, 58.1, 103.2, 123.4, 129.0, 129.2, 135.1, 153.0, 155.0, 163.5; ESI-HRMS, m/z (%): Calcd for $\text{C}_{13}\text{H}_{13}\text{BrNaO}_5\text{S}$ ($[\text{M}+\text{Na}]^+$): 382.9559, Found: 382.9570.



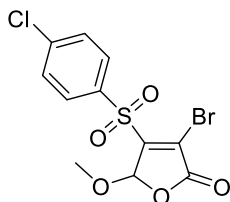
3-Bromo-4-((4-(*tert*-butyl)phenyl)sulfonyl)-5-methoxyfuran-2(5*H*)-one (3d)

Colorless oil (106 mg, 91%); ^1H NMR (400 MHz, CDCl_3), δ : 1.35 (s, 9H, 3CH_3), 3.61 (s, 3H, OCH_3), 6.05 (s, 1H, CH), 7.61 (d, $J = 8.0$ Hz, 2H, ArH), 7.96 (d, $J = 8.0$ Hz, 2H, ArH); ^{13}C NMR (100 MHz, CDCl_3), δ : 31.0, 35.5, 58.1, 103.2, 123.5, 126.6, 128.9, 134.8, 155.0, 159.8, 163.6; ESI-HRMS, m/z (%): Calcd for $\text{C}_{15}\text{H}_{17}\text{BrNaO}_5\text{S}$ ($[\text{M}+\text{Na}]^+$): 410.9872, Found: 410.9874.



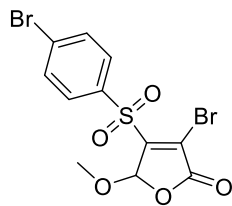
3-Chloro-4-((4-fluorophenyl)sulfonyl)-5-methoxyfuran-2(5*H*)-one (3e)

Colorless oil (57 mg, 54%); ^1H NMR (400 MHz, CDCl_3), δ : 3.63 (s, 3H, OCH_3), 6.05 (s, 1H, CH), 7.25-7.32 (m, 2H, ArH), 8.05-8.11 (m, 2H, ArH); ^{13}C NMR (100 MHz, CDCl_3), δ : 58.4, 103.1, 117.0 (d, $J = 23.0$ Hz), 124.1, 132.1 (d, $J = 10.0$ Hz), 134.1 (d, $J = 3.0$ Hz), 154.5, 163.3, 166.9 (d, $J = 258.0$ Hz); ^{19}F NMR (376 MHz, CDCl_3), δ : -99.7; ESI-HRMS, m/z (%): Calcd for $\text{C}_{11}\text{H}_8\text{BrFNaO}_5\text{S}$ ($[\text{M}+\text{Na}]^+$): 372.9152, Found: 372.9135.



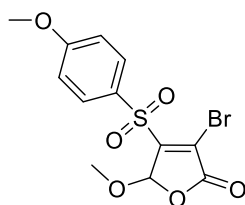
3-Bromo-4-((4-chlorophenyl)sulfonyl)-5-methoxyfuran-2(5*H*)-one (3f)

Colorless oil (52 mg, 47%); ^1H NMR (400 MHz, CDCl_3), δ : 3.63 (s, 3H, OCH_3), 6.05 (s, 1H, CH), 7.58 (d, $J = 8.0$ Hz, 2H, ArH), 7.99 (d, $J = 8.0$ Hz, 2H, ArH); ^{13}C NMR (100 MHz, CDCl_3), δ : 58.4, 103.1, 124.4, 129.9, 130.4, 136.5, 142.5, 154.3, 163.2; ESI-HRMS, m/z (%): Calcd for $\text{C}_{11}\text{H}_8\text{BrClNaO}_5\text{S}$ ($[\text{M}+\text{Na}]^+$): 388.8857, Found: 388.8850.



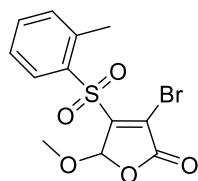
3-Bromo-4-((4-bromophenyl)sulfonyl)-5-methoxyfuran-2(5H)-one (3g)

Colorless oil (53 mg, 43%); ^1H NMR (400 MHz, CDCl_3), δ : 3.63 (s, 3H, OCH_3), 6.05 (s, 1H, CH), 7.75 (d, $J = 8.0$ Hz, 2H, ArH), 7.90 (d, $J = 8.0$ Hz, 2H, ArH); ^{13}C NMR (100 MHz, CDCl_3), δ : 58.4, 103.1, 124.4, 130.3, 132.9, 137.8, 142.9, 154.2, 163.2; ESI-HRMS, m/z (%): Calcd for $\text{C}_{11}\text{H}_8\text{Br}_2\text{NaO}_5\text{S}$ ($[\text{M}+\text{Na}]^+$): 434.8331, Found: 434.8328.



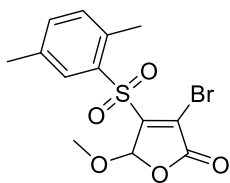
3-Bromo-5-methoxy-4-((4-methoxyphenyl)sulfonyl)furan-2(5H)-one (3h)

Colorless oil (102 mg, 94%); ^1H NMR (400 MHz, CDCl_3), δ : 3.60 (s, 3H, OCH_3), 3.90 (s, 3H, ArOCH_3), 6.04 (s, 1H, CH), 7.04 (d, $J = 8.0$ Hz, 2H, ArH), 7.96 (d, $J = 8.0$ Hz, 2H, ArH); ^{13}C NMR (100 MHz, CDCl_3), δ : 55.9, 58.1, 103.2, 114.8, 122.7, 129.2, 131.4, 155.2, 163.6, 165.2; ESI-HRMS, m/z (%): Calcd for $\text{C}_{12}\text{H}_{11}\text{BrNaO}_6\text{S}$ ($[\text{M}+\text{Na}]^+$): 384.9352, Found: 384.9400.



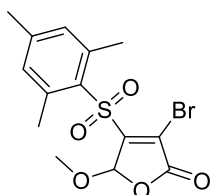
3-Bromo-5-methoxy-4-(o-tolylsulfonyl)furan-2(5H)-one (3i)

Colorless oil (93 mg, 89%); ^1H NMR (400 MHz, CDCl_3), δ : 2.46 (s, 3H, ArCH_3), 3.60 (s, 3H, OCH_3), 6.04 (s, 1H, CH), 7.46-7.56 (m, 2H, ArH), 7.80-7.88 (m, 2H, ArH); ^{13}C NMR (100 MHz, CDCl_3), δ : 21.4, 58.0, 103.1, 123.6, 126.2, 129.1, 129.3, 136.2, 137.8, 139.9, 154.8, 163.5; ESI-HRMS, m/z (%): Calcd for $\text{C}_{12}\text{H}_{11}\text{BrNaO}_5\text{S}$ ($[\text{M}+\text{Na}]^+$): 368.9403, Found: 368.9410.



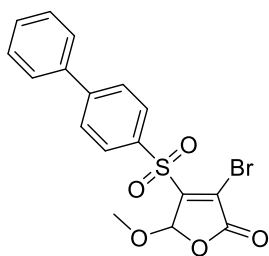
3-Bromo-4-((2,5-dimethylphenyl)sulfonyl)-5-methoxyfuran-2(5H)-one (3j)

Colorless oil (98 mg, 90%); ^1H NMR (400 MHz, CDCl_3), δ : 2.41 (s, 3H, ArCH_3), 2.55 (s, 3H, ArCH_3), 3.46 (s, 3H, OCH_3), 5.96 (s, 1H, CH), 7.23 (d, $J = 8.0$ Hz, 1H, ArH), 7.39 (d, $J = 8.0$ Hz, 1H, ArH), 7.90 (s, 1H, ArH); ^{13}C NMR (100 MHz, CDCl_3), δ : 19.9, 20.8, 57.4, 102.9, 122.3, 131.1, 132.9, 135.3, 136.0, 136.4, 137.0, 154.2, 163.5; ESI-HRMS, m/z (%): Calcd for $\text{C}_{13}\text{H}_{13}\text{BrNaO}_5\text{S}$ ($[\text{M}+\text{Na}]^+$): 382.9559, Found: 382.9561.



3-Bromo-4-(mesitylsulfonyl)-5-methoxyfuran-2(5H)-one (3k)

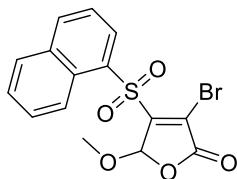
White solid (100 mg, 89%); m.p. 114.6-116.3 $^\circ\text{C}$; ^1H NMR (400 MHz, CDCl_3), δ : 2.33 (s, 3H, ArCH_3), 2.60 (s, 6H, 2 ArCH_3), 3.47 (s, 3H, OCH_3), 5.91 (s, 1H, CH), 7.00 (s, 2H, ArH); ^{13}C NMR (100 MHz, CDCl_3), δ : 21.2, 22.6, 57.2, 102.9, 120.2, 131.1, 132.5, 141.3, 145.4, 155.4, 163.7; ESI-HRMS, m/z (%): Calcd for $\text{C}_{14}\text{H}_{15}\text{BrNaO}_5\text{S}$ ($[\text{M}+\text{Na}]^+$): 396.9716, Found: 396.9717.



4-([1,1'-Biphenyl]-4-ylsulfonyl)-3-bromo-5-methoxyfuran-2(5H)-one (3l)

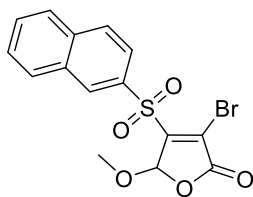
Colorless oil (101 mg, 82%); ^1H NMR (400 MHz, CDCl_3), δ : 3.64 (s, 3H, OCH_3), 6.08 (s, 1H, CH), 7.44-7.51 (m, 3H, ArH), 7.62 (d, $J = 8.0$ Hz, 2H, ArH), 7.81 (d, $J = 8.0$ Hz, 2H, ArH), 8.11 (d, $J = 8.0$ Hz, 2H, ArH); ^{13}C NMR (100 MHz, CDCl_3), δ : 58.2, 103.2, 123.8, 127.4, 128.1, 129.1, 129.2, 129.5, 136.3, 138.7, 148.4, 154.8, 163.5; ESI-HRMS, m/z (%): Calcd for $\text{C}_{17}\text{H}_{13}\text{BrNaO}_5\text{S}$ ($[\text{M}+\text{Na}]^+$): 430.9559, Found:

430.9564.



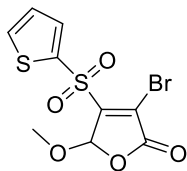
3-Bromo-5-methoxy-4-(naphthalen-1-ylsulfonyl)furan-2(5H)-one (3m)

Colorless oil (102 mg, 88%); ^1H NMR (400 MHz, CDCl_3), δ : 3.38 (s, 3H, OCH_3), 5.98 (s, 1H, CH), 7.62-7.73 (m, 3H, ArH), 7.99 (d, $J = 8.0$ Hz, 1H, ArH), 8.22 (d, $J = 8.0$ Hz, 1H, ArH), 8.46 (d, $J = 8.0$ Hz, 1H, ArH), 8.65 (d, $J = 8.0$ Hz, 1H, ArH); ^{13}C NMR (100 MHz, CDCl_3), δ : 57.3, 102.9, 122.9, 123.4, 124.3, 127.5, 129.1, 129.3, 129.5, 132.4, 134.0, 137.0, 154.3, 163.4; ESI-HRMS, m/z (%): Calcd for $\text{C}_{15}\text{H}_{11}\text{BrNaO}_5\text{S}$ ($[\text{M}+\text{Na}]^+$): 404.9403, Found: 404.9401.



3-Bromo-5-methoxy-4-(naphthalen-2-ylsulfonyl)furan-2(5H)-one (3n)

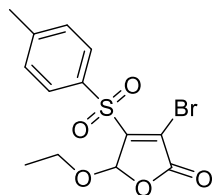
Colorless oil (103 mg, 90%); ^1H NMR (400 MHz, CDCl_3), δ : 3.61 (s, 3H, OCH_3), 6.09 (s, 1H, CH), 7.65-7.75 (m, 2H, ArH), 7.95 (d, $J = 8.0$ Hz, 1H, ArH), 7.97-8.06 (m, 3H, ArH), 8.65 (s, 1H, ArH); ^{13}C NMR (100 MHz, CDCl_3), δ : 58.1, 103.1, 122.7, 123.8, 128.0, 128.1, 129.8, 129.9, 130.3, 131.6, 132.0, 134.7, 136.0, 154.8, 163.5; ESI-HRMS, m/z (%): Calcd for $\text{C}_{15}\text{H}_{11}\text{BrNaO}_5\text{S}$ ($[\text{M}+\text{Na}]^+$): 404.9403, Found: 404.9409.



3-Bromo-5-methoxy-4-(thiophen-2-ylsulfonyl)furan-2(5H)-one (3o)

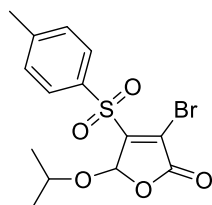
Yellow solid (72 mg, 70%); m.p. 103.2-104.7 $^\circ\text{C}$; ^1H NMR (400 MHz, CDCl_3), δ : 3.64 (s, 3H, OCH_3), 6.06 (s, 1H, CH), 7.21-7.25 (m, 1H, ArH), 7.86-7.91 (m, 2H, ArH); ^{13}C NMR (100 MHz, CDCl_3), δ : 58.3, 103.2, 123.5, 128.6, 136.6, 137.2, 138.5, 154.4, 163.4; ESI-HRMS, m/z (%): Calcd for $\text{C}_9\text{H}_7\text{BrNaO}_5\text{S}_2$

$([M+Na]^+)$: 360.8810, Found: 360.8816.



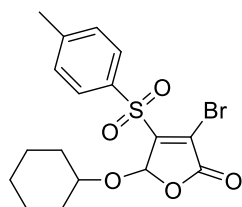
3-Bromo-5-ethoxy-4-tosylfuran-2(5H)-one (3p)

Yellow oil (100 mg, 92%); ^1H NMR (400 MHz, CDCl_3), δ : 1.28 (t, $J = 8.0$ Hz, 3H, CH_3), 2.48 (s, 3H, ArCH_3), 3.85-3.98 (m, 2H, OCH_2), 6.12 (s, 1H, CH), 7.40 (d, $J = 8.0$ Hz, 2H, ArH), 7.94 (d, $J = 8.0$ Hz, 2H, ArH); ^{13}C NMR (100 MHz, CDCl_3), δ : 14.8, 21.9, 67.7, 102.3, 123.2, 129.1, 130.1, 135.1, 146.9, 155.1, 163.7; ESI-HRMS, m/z (%): Calcd for $\text{C}_{13}\text{H}_{13}\text{BrNaO}_5\text{S}$ ($[M+Na]^+$): 382.9559, Found: 382.9564.



3-Bromo-5-isopropoxy-4-tosylfuran-2(5H)-one (3q)

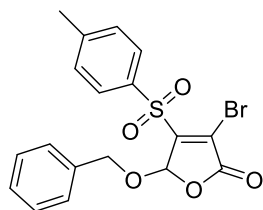
Yellow solid (95 mg, 84%); m.p. 95.8-97.0 $^\circ\text{C}$; ^1H NMR (400 MHz, CDCl_3), δ : 1.25 (d, $J = 4.0$ Hz, 3H, CH_3), 1.34 (d, $J = 4.0$ Hz, 3H, CH_3), 2.47 (s, 3H, ArCH_3), 4.13-4.22 (m, 1H, OCH), 6.21 (s, 1H, CH), 7.39 (d, $J = 8.0$ Hz, 2H, ArH), 7.94 (d, $J = 8.0$ Hz, 2H, ArH); ^{13}C NMR (100 MHz, CDCl_3), δ : 21.8, 21.9, 22.9, 75.9, 101.5, 123.3, 129.1, 130.0, 135.2, 146.8, 155.4, 163.9; ESI-HRMS, m/z (%): Calcd for $\text{C}_{14}\text{H}_{15}\text{BrNaO}_5\text{S}$ ($[M+Na]^+$): 396.9716, Found: 396.9719.



3-Bromo-5-(cyclohexyloxy)-4-tosylfuran-2(5H)-one (3r)

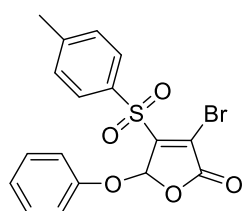
Yellow solid (101 mg, 81%); m.p. 101.4-102.8 $^\circ\text{C}$; ^1H NMR (400 MHz, CDCl_3), δ : 1.24-1.46 (m, 6H, 3CH_2), 1.77-2.13 (m, 4H, 2CH_2), 2.47 (s, 3H, ArCH_3), 3.84-4.92 (m, 1H, OCH), 6.26 (s, 1H, CH), 7.39 (d, $J = 8.0$ Hz, 2H, ArH), 7.96 (d, $J = 8.0$ Hz, 2H, ArH); ^{13}C NMR (100 MHz, CDCl_3), δ : 21.9, 23.7, 23.8, 25.2,

31.7, 32.8, 81.4, 101.5, 123.4, 129.1, 130.0, 135.2, 146.8, 155.5, 163.9; ESI-HRMS, m/z (%): Calcd for $C_{17}H_{19}BrNaO_5S$ ($[M+Na]^+$): 437.0029, Found: 437.0034.



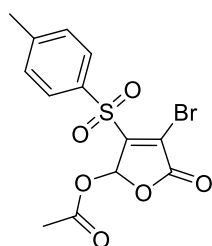
5-(Benzyloxy)-3-bromo-4-tosylfuran-2(5H)-one (3s)

Yellow solid (91 mg, 72%); m.p. 79.1-80.9 °C; 1H NMR (400 MHz, $CDCl_3$), δ : 2.40 (s, 3H, $ArCH_3$), 4.78-4.96 (dd, $J_1 = 12$ Hz, $J_2 = 12$ Hz, 2H, OCH_2), 6.23 (s, 1H, CH), 7.21 (d, $J = 8.0$ Hz, 2H, ArH), 7.36 (d, $J = 8.0$ Hz, 2H, ArH), 7.38-7.44 (m, 3H, ArH), 7.82 (d, $J = 8.0$ Hz, 2H, ArH); ^{13}C NMR (100 MHz, $CDCl_3$), δ : 21.8, 73.6, 101.5, 123.3, 128.6, 128.8, 128.9, 129.1, 130.0, 134.7, 134.9, 146.8, 155.2, 163.7; ESI-HRMS, m/z (%): Calcd for $C_{18}H_{15}BrNaO_5S$ ($[M+Na]^+$): 444.9716, Found: 444.9717.



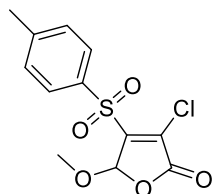
3-Bromo-5-phenoxy-4-tosylfuran-2(5H)-one (3t)

Colorless oil (84 mg, 68%); 1H NMR (400 MHz, $CDCl_3$), δ : 2.49 (s, 3H, $ArCH_3$), 6.60 (s, 1H, CH), 7.12 (d, $J = 8.0$ Hz, 2H, ArH), 7.19 (t, $J = 8.0$ Hz, 1H, ArH), 7.35-7.40 (m, 2H, ArH), 7.43 (d, $J = 8.0$ Hz, 2H, ArH), 8.01 (d, $J = 8.0$ Hz, 2H, ArH); ^{13}C NMR (100 MHz, $CDCl_3$), δ : 21.9, 100.7, 117.7, 124.0, 124.9, 129.1, 130.0, 130.3, 135.1, 147.2, 154.7, 155.9, 163.3; ESI-HRMS, m/z (%): Calcd for $C_{17}H_{13}BrNaO_5S$ ($[M+Na]^+$): 430.9559, Found: 430.9565.



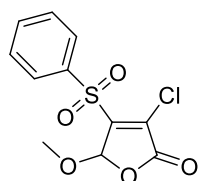
4-Bromo-5-oxo-3-tosyl-2,5-dihydrofuran-2-yl acetate (3u)

Yellow solid (62 mg, 55%); m.p. 119.9-121.5 °C; ^1H NMR (400 MHz, CDCl_3), δ : 2.14 (s, 3H, CH_3CO), 2.49 (s, 3H, ArCH_3), 7.17 (s, 1H, CH), 7.43 (d, $J = 8.0$ Hz, 2H, ArH), 7.91 (d, $J = 8.0$ Hz, 2H, ArH); ^{13}C NMR (100 MHz, CDCl_3), δ : 20.4, 21.9, 92.0, 123.1, 128.8, 130.4, 134.8, 147.4, 154.7, 163.1, 167.7; ESI-HRMS, m/z (%): Calcd for $\text{C}_{13}\text{H}_{11}\text{BrNaO}_6\text{S}$ ($[\text{M}+\text{Na}]^+$): 396.9352, Found: 396.9361.



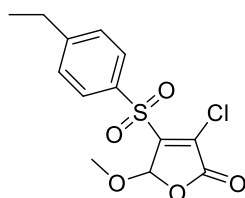
3-Chloro-5-methoxy-4-(4-methylphenyl)sulfonylfuran-2(5H)-one (4a)

Yellow solid (76 mg, 84%); m.p. 55.7-57.2 °C; ^1H NMR (400 MHz, CDCl_3), δ : 2.47 (s, 3H, ArCH_3), 3.60 (s, 3H, OCH_3), 6.07 (s, 1H, CH), 7.40 (d, $J = 8.0$ Hz, 2H, ArH), 7.90 (d, $J = 8.0$ Hz, 2H, ArH); ^{13}C NMR (100 MHz, CDCl_3), δ : 21.9, 58.2, 102.0, 128.9, 130.2, 132.5, 135.2, 147.0, 150.7, 162.8; ESI-HRMS, m/z (%): Calcd for $\text{C}_{12}\text{H}_{11}\text{ClNaO}_5\text{S}$ ($[\text{M}+\text{Na}]^+$): 324.9908, Found: 324.9911.



3-Chloro-5-methoxy-4-(phenylsulfonyl)furan-2(5H)-one (4b)

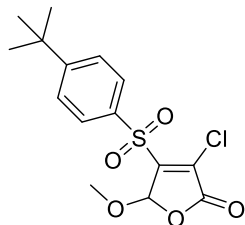
Yellow oil (72 mg, 83%); ^1H NMR (400 MHz, CDCl_3), δ : 3.62 (s, 3H, OCH_3), 6.09 (s, 1H, CH), 7.60-7.65 (m, 2H, ArH), 7.76 (t, $J = 8.0$ Hz, 1H, ArH), 8.04 (d, $J = 8.0$ Hz, 2H, ArH); ^{13}C NMR (100 MHz, CDCl_3), δ : 58.2, 102.0, 128.9, 129.5, 133.0, 135.4, 138.2, 150.4, 162.7; ESI-HRMS, m/z (%): Calcd for $\text{C}_{11}\text{H}_9\text{ClNaO}_5\text{S}$ ($[\text{M}+\text{Na}]^+$): 310.9751, Found: 310.9747.



3-Chloro-4-((4-ethylphenyl)sulfonyl)-5-methoxyfuran-2(5H)-one (4c)

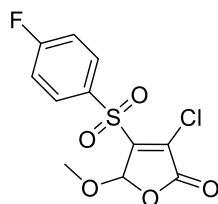
Colorless oil (80 mg, 84%); ^1H NMR (400 MHz, CDCl_3), δ : 1.27 (t, $J = 8.0$ Hz, 3H, CH_3), 2.76 (q, $J = 8.0$ Hz, 2H, CH_2), 3.61 (s, 3H, OCH_3), 6.07 (s, 1H, CH), 7.42 (d, $J = 8.0$ Hz, 2H, ArH), 7.93 (d, $J = 8.0$ Hz,

2H, ArH); ^{13}C NMR (100 MHz, CDCl_3), δ : 14.9, 29.1, 58.2, 102.0, 129.1, 132.5, 135.3, 150.7, 153.0, 162.8; ESI-HRMS, m/z (%): Calcd for $\text{C}_{13}\text{H}_{13}\text{ClNaO}_5\text{S}$ ($[\text{M}+\text{Na}]^+$): 339.0064, Found: 339.0072.



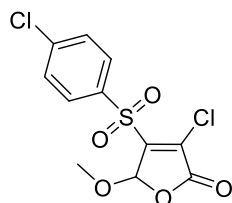
4-((4-(*tert*-Butyl)phenyl)sulfonyl)-3-chloro-5-methoxyfuran-2(5*H*)-one (4d)

White solid (88 mg, 85%); m.p. 87.6-89.3 °C; ^1H NMR (400 MHz, CDCl_3), δ : 1.35 (s, 9H, 3CH_3), 3.62 (s, 3H, OCH_3), 6.08 (s, 1H, CH), 7.61 (d, J = 8.0 Hz, 2H, ArH), 7.94 (d, J = 8.0 Hz, 2H, ArH); ^{13}C NMR (100 MHz, CDCl_3), δ : 31.0, 35.5, 58.2, 102.0, 126.6, 128.8, 132.6, 135.0, 150.7, 159.8, 162.8; ESI-HRMS, m/z (%): Calcd for $\text{C}_{15}\text{H}_{17}\text{ClNaO}_5\text{S}$ ($[\text{M}+\text{Na}]^+$): 367.0377, Found: 367.0385.



3-Chloro-4-((4-fluorophenyl)sulfonyl)-5-methoxyfuran-2(5*H*)-one (4e)

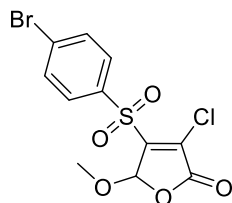
Colorless oil (46 mg, 50%); ^1H NMR (400 MHz, CDCl_3), δ : 3.64 (s, 3H, OCH_3), 6.08 (s, 1H, CH), 7.27-7.32 (m, 2H, ArH), 8.03-8.08 (m, 2H, ArH); ^{13}C NMR (100 MHz, CDCl_3), δ : 58.4, 101.9, 117.0 (d, J = 23.0 Hz), 132.0 (d, J = 10.0 Hz), 133.2, 134.2 (d, J = 3.0 Hz), 150.2, 162.5, 166.9 (d, J = 259.0 Hz); ^{19}F NMR (376 MHz, CDCl_3), δ : -99.7; ESI-HRMS, m/z (%): Calcd for $\text{C}_{11}\text{H}_8\text{ClFNaO}_5\text{S}$ ($[\text{M}+\text{Na}]^+$): 328.9657, Found: 328.9654.



3-Chloro-4-((4-chlorophenyl)sulfonyl)-5-methoxyfuran-2(5*H*)-one (4f)

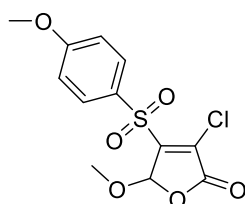
Colorless oil (42 mg, 43%); ^1H NMR (400 MHz, CDCl_3), δ : 3.64 (s, 3H, OCH_3), 6.08 (s, 1H, CH),

7.59 (d, $J = 8.0$ Hz, 2H, ArH), 7.96 (d, $J = 8.0$ Hz, 2H, ArH); ^{13}C NMR (100 MHz, CDCl_3), δ : 58.5, 101.9, 129.9, 130.3, 133.4, 136.6, 142.5, 150.0, 162.5; ESI-HRMS, m/z (%): Calcd for $\text{C}_{11}\text{H}_8\text{Cl}_2\text{NaO}_5\text{S}$ ($[\text{M}+\text{Na}]^+$): 344.9362, Found: 344.9360.



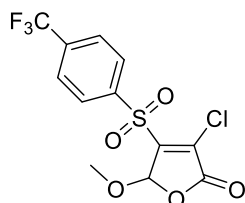
4-((4-Bromophenyl)sulfonyl)-3-chloro-5-methoxyfuran-2(5H)-one (4g)

Colorless oil (38 mg, 35%); ^1H NMR (400 MHz, CDCl_3), δ : 3.64 (s, 3H, OCH_3), 6.08 (s, 1H, CH), 7.76 (d, $J = 8.0$ Hz, 2H, ArH), 7.88 (d, $J = 8.0$ Hz, 2H, ArH); ^{13}C NMR (100 MHz, CDCl_3), δ : 58.5, 101.9, 128.9, 130.3, 132.9, 133.5, 137.8, 149.9, 162.5; ESI-HRMS, m/z (%): Calcd for $\text{C}_{11}\text{H}_8\text{BrClNaO}_5\text{S}$ ($[\text{M}+\text{Na}]^+$): 388.8857, Found: 388.8845.



3-Chloro-5-methoxy-4-((4-methoxyphenyl)sulfonyl)furan-2(5H)-one (4h)

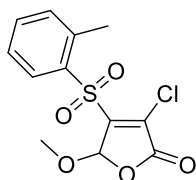
Colorless oil (84 mg, 87%); ^1H NMR (400 MHz, CDCl_3), δ : 3.61 (s, 3H, OCH_3), 3.90 (s, 3H, ArOCH_3), 6.06 (s, 1H, CH), 7.05 (d, $J = 8.0$ Hz, 2H, ArH), 7.95 (d, $J = 8.0$ Hz, 2H, ArH); ^{13}C NMR (100 MHz, CDCl_3), δ : 55.9, 58.1, 102.0, 114.8, 129.4, 131.3, 131.9, 151.0, 162.9, 165.3; ESI-HRMS, m/z (%): Calcd for $\text{C}_{12}\text{H}_{11}\text{ClNaO}_6\text{S}$ ($[\text{M}+\text{Na}]^+$): 340.9857, Found: 340.9862.



3-Chloro-5-methoxy-4-((4-(trifluoromethyl)phenyl)sulfonyl)furan-2(5H)-one (4i)

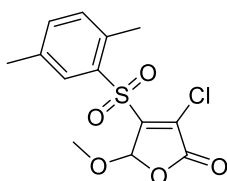
Colorless oil (31 mg, 29%); ^1H NMR (400 MHz, CDCl_3), δ : 3.66 (s, 3H, OCH_3), 6.11 (s, 1H, CH),

7.88 (d, $J = 8.0$ Hz, 2H, ArH), 8.17 (d, $J = 8.0$ Hz, 2H, ArH); ^{13}C NMR (100 MHz, CDCl_3), δ : 58.7, 101.9, 125.5 (q, $J = 271.0$ Hz), 126.6 (q, $J = 4.0$ Hz), 129.5, 131.9, 126.4 (q, $J = 33.0$ Hz), 136.7, 149.5, 162.3; ^{19}F NMR (376 MHz, CDCl_3), δ : -63.4; ESI-HRMS, m/z (%): Calcd for $\text{C}_{12}\text{H}_8\text{ClF}_3\text{NaO}_5\text{S}$ ($[\text{M}+\text{Na}]^+$): 378.9625, Found: 378.9622.



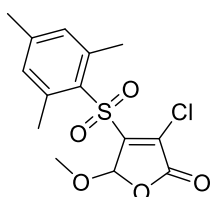
3-Chloro-5-methoxy-4-(*o*-tolylsulfonyl)furan-2(5*H*)-one (4j)

Colorless oil (75 mg, 83%); ^1H NMR (400 MHz, CDCl_3), δ : 2.46 (s, 3H, ArCH_3), 3.60 (s, 3H, OCH_3), 6.07 (s, 1H, CH), 7.46-7.56 (m, 2H, ArH), 7.81-7.85 (m, 2H, ArH); ^{13}C NMR (100 MHz, CDCl_3), δ : 21.4, 58.1, 101.9, 126.1, 129.0, 129.4, 132.8, 136.3, 138.0, 140.0, 150.5, 162.7; ESI-HRMS, m/z (%): Calcd for $\text{C}_{12}\text{H}_{11}\text{ClNaO}_5\text{S}$ ($[\text{M}+\text{Na}]^+$): 324.9908, Found: 324.9909.



3-Chloro-4-((2,5-dimethylphenyl)sulfonyl)-5-methoxyfuran-2(5*H*)-one (4k)

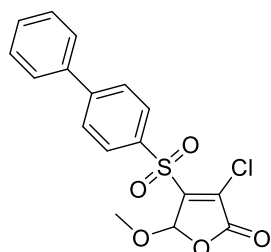
Colorless oil (79 mg, 83%); ^1H NMR (400 MHz, CDCl_3), δ : 2.40 (s, 3H, ArCH_3), 2.56 (s, 3H, ArCH_3), 3.46 (s, 3H, OCH_3), 6.00 (s, 1H, CH), 7.23 (d, $J = 8.0$ Hz, 1H, ArH), 7.39 (d, $J = 8.0$ Hz, 1H, ArH), 7.87 (s, 1H, ArH); ^{13}C NMR (100 MHz, CDCl_3), δ : 19.8, 20.8, 57.5, 101.8, 130.9, 131.8, 132.9, 135.5, 136.0, 136.4, 137.0, 150.0, 162.8; ESI-HRMS, m/z (%): Calcd for $\text{C}_{13}\text{H}_{13}\text{ClNaO}_5\text{S}$ ($[\text{M}+\text{Na}]^+$): 339.0064, Found: 339.0070.



3-Chloro-4-(mesitylsulfonyl)-5-methoxyfuran-2(5*H*)-one (4l)

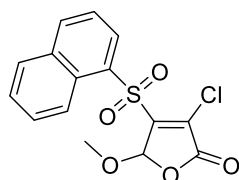
White solid (78 mg, 79%); m.p. 101.5-102.9 °C; ^1H NMR (400 MHz, CDCl_3), δ : 2.32 (s, 3H, ArCH_3),

2.60 (s, 6H, 2ArCH₃), 3.46 (s, 3H, OCH₃), 5.95 (s, 1H, CH), 7.00 (s, 2H, ArH); ¹³C NMR (100 MHz, CDCl₃), δ : 21.2, 22.5, 57.3, 101.7, 130.0, 131.3, 132.5, 141.2, 145.5, 151.1, 163.0; ESI-HRMS, *m/z* (%): Calcd for C₁₄H₁₅ClNaO₅S ([M+Na]⁺): 353.0221, Found: 353.0230.



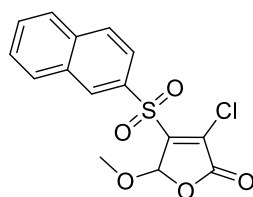
4-([1,1'-Biphenyl]-4-ylsulfonyl)-3-chloro-5-methoxyfuran-2(5H)-one (4m)

Colorless oil (82 mg, 75%); ¹H NMR (400 MHz, CDCl₃), δ : 3.65 (s, 3H, OCH₃), 6.11 (s, 1H, CH), 7.44-7.52 (m, 3H, ArH), 7.62 (d, *J* = 8.0 Hz, 2H, ArH), 7.81 (d, *J* = 8.0 Hz, 2H, ArH), 8.09 (d, *J* = 8.0 Hz, 2H, ArH); ¹³C NMR (100 MHz, CDCl₃), δ : 58.3, 102.0, 127.5, 128.1, 129.1, 129.2, 129.4, 132.9, 136.5, 138.6, 148.4, 150.5, 162.7; ESI-HRMS, *m/z* (%): Calcd for C₁₇H₁₃ClNaO₅S ([M+Na]⁺): 387.0064, Found: 387.0070.



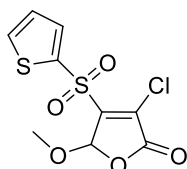
3-Chloro-5-methoxy-4-(naphthalen-1-ylsulfonyl)furan-2(5H)-one (4n)

Colorless oil (81 mg, 80%); ¹H NMR (400 MHz, CDCl₃), δ : 3.39 (s, 3H, OCH₃), 6.02 (s, 1H, CH), 7.61-7.73 (m, 3H, ArH), 7.99 (d, *J* = 8.0 Hz, 1H, ArH), 8.22 (d, *J* = 8.0 Hz, 1H, ArH), 8.44 (d, *J* = 8.0 Hz, 1H, ArH), 8.67 (d, *J* = 8.0 Hz, 1H, ArH); ¹³C NMR (100 MHz, CDCl₃), δ : 57.4, 101.8, 123.3, 124.4, 127.5, 129.0, 129.4, 129.5, 132.3, 132.4, 132.6, 134.0, 137.1, 150.0, 162.7; ESI-HRMS, *m/z* (%): Calcd for C₁₅H₁₁ClNaO₅S ([M+Na]⁺): 360.9908, Found: 360.9913.



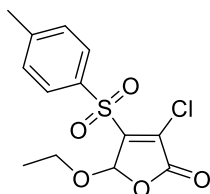
3-Chloro-5-methoxy-4-(naphthalen-2-ylsulfonyl)furan-2(5H)-one (4o)

Yellow solid (83 mg, 82%); m.p. 104.8-105.9 °C; ¹H NMR (400 MHz, CDCl₃), δ: 3.61 (s, 3H, OCH₃), 6.12 (s, 1H, CH), 7.64-7.75 (m, 2H, ArH), 7.93-8.06 (m, 4H, ArH), 8.62 (s, 1H, ArH); ¹³C NMR (100 MHz, CDCl₃), δ: 58.2, 102.0, 122.6, 128.1, 129.8, 129.9, 130.3, 131.5, 132.0, 132.9, 134.9, 136.0, 150.5, 162.7; ESI-HRMS, *m/z* (%): Calcd for C₁₅H₁₁ClNaO₅S ([M+Na]⁺): 360.9908, Found: 360.9915.



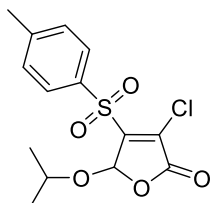
3-Chloro-5-methoxy-4-(thiophen-2-ylsulfonyl)furan-2(5H)-one (4p)

White solid (57 mg, 65%); m.p. 81.8-83.5 °C; ¹H NMR (400 MHz, CDCl₃), δ: 3.65 (s, 3H, OCH₃), 6.09 (s, 1H, CH), 7.21-7.25 (m, 1H, ArH), 7.87-7.90 (m, 2H, ArH); ¹³C NMR (100 MHz, CDCl₃), δ: 58.4, 102.0, 128.6, 132.6, 136.6, 137.3, 138.7, 150.1, 162.7; ESI-HRMS, *m/z* (%): Calcd for C₉H₇ClNaO₅S₂ ([M+Na]⁺): 316.9316, Found: 316.9318.



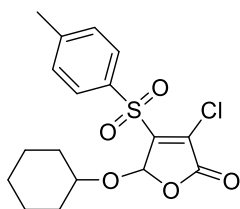
3-Chloro-5-ethoxy-4-tosylfuran-2(5H)-one (4q)

Yellow solid (81 mg, 86%); m.p. 63.2-64.7 °C (63 °C¹⁰); ¹H NMR (400 MHz, CDCl₃), δ: 1.27 (t, *J* = 8.0 Hz, 3H, CH₃), 2.47 (s, 3H, ArCH₃), 3.83-3.97 (m, 2H, OCH₂), 6.15 (s, 1H, CH), 7.40 (d, *J* = 8.0 Hz, 2H, ArH), 7.92 (d, *J* = 8.0 Hz, 2H, ArH); ¹³C NMR (100 MHz, CDCl₃), δ: 14.8, 21.9, 67.7, 101.1, 129.0, 130.1, 132.4, 135.3, 146.9, 150.8, 163.0; ESI-HRMS, *m/z* (%): Calcd for C₁₃H₁₃ClNaO₅S ([M+Na]⁺): 339.0064, Found: 339.0070.



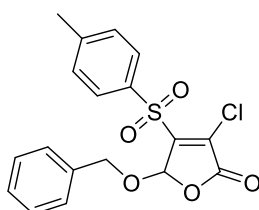
3-Chloro-5-isopropoxy-4-tosylfuran-2(5H)-one (4r)

White solid (81 mg, 80%); m.p. 75.8-77.2 °C (76 °C¹⁰); ¹H NMR (400 MHz, CDCl₃), δ : 1.25 (d, J = 8.0 Hz, 3H, CH₃), 1.34 (d, J = 8.0 Hz, 3H, CH₃), 2.47 (s, 3H, ArCH₃), 4.13-4.21 (m, 1H, OCH), 6.24 (s, 1H, CH), 7.39 (d, J = 8.0 Hz, 2H, ArH), 7.92 (d, J = 8.0 Hz, 2H, ArH); ¹³C NMR (100 MHz, CDCl₃), δ : 21.8, 21.9, 22.9, 75.9, 100.3, 129.0, 130.1, 132.4, 135.4, 146.8, 151.1, 163.1; ESI-HRMS, m/z (%): Calcd for C₁₄H₁₅ClNaO₅S ([M+Na]⁺): 353.0221, Found: 353.0226.



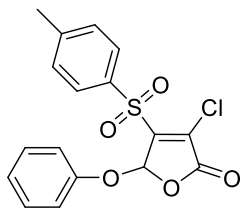
3-Chloro-5-(cyclohexyloxy)-4-tosylfuran-2(5H)-one (4s)

Colorless oil (85 mg, 77%); ¹H NMR (400 MHz, CDCl₃), δ : 1.25-1.49 (m, 6H, 3CH₂), 1.72-2.06 (m, 4H, 2CH₂), 2.47 (s, 3H, ArCH₃), 3.84-4.92 (m, 1H, OCH), 6.29 (s, 1H, CH), 7.40 (d, J = 8.0 Hz, 2H, ArH), 7.93 (d, J = 8.0 Hz, 2H, ArH); ¹³C NMR (100 MHz, CDCl₃), δ : 21.9, 23.6, 23.7, 25.2, 31.6, 32.8, 81.4, 100.3, 129.0, 130.1, 132.5, 135.4, 146.8, 151.2, 163.1; ESI-HRMS, m/z (%): Calcd for C₁₇H₁₉ClNaO₅S ([M+Na]⁺): 393.0534, Found: 393.0538.



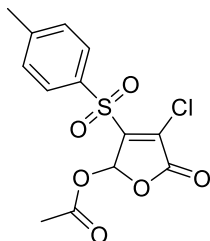
5-(Benzyloxy)-3-chloro-4-tosylfuran-2(5H)-one (4t)

White solid (73 mg, 64%); m.p. 79.8-81.5 °C; ¹H NMR (400 MHz, CDCl₃), δ : 2.40 (s, 3H, ArCH₃), 4.78-4.95 (dd, J_1 = 12 Hz, J_2 = 12 Hz, 2H, OCH₂), 6.25 (s, 1H, CH), 7.23 (d, J = 8.0 Hz, 2H, ArH), 7.34-7.41 (m, 5H, ArH), 7.80 (d, J = 8.0 Hz, 2H, ArH); ¹³C NMR (100 MHz, CDCl₃), δ : 21.8, 73.6, 100.3, 128.7, 128.8, 128.9, 129.0, 130.0, 132.5, 134.7, 135.1, 146.8, 151.0, 162.9; ESI-HRMS, m/z (%): Calcd for C₁₈H₁₅ClNaO₅S ([M+Na]⁺): 401.0221, Found: 401.0225.



3-Chloro-5-phenoxy-4-tosylfuran-2(5H)-one (4u)

Colorless oil (89 mg, 63%); ^1H NMR (400 MHz, CDCl_3), δ : 2.49 (s, 3H, ArCH_3), 6.63 (s, 1H, CH), 7.12 (d, $J = 8.0$ Hz, 2H, ArH), 7.17-7.22 (m, 1H, ArH), 7.36-7.41 (m, 1H, ArH), 7.44 (d, $J = 8.0$ Hz, 2H, ArH), 7.99 (d, $J = 8.0$ Hz, 2H, ArH); ^{13}C NMR (100 MHz, CDCl_3), δ : 21.9, 99.5, 117.7, 125.0, 129.0, 130.0, 130.3, 133.1, 135.3, 147.2, 150.4, 155.9, 162.5; ESI-HRMS, m/z (%): Calcd for $\text{C}_{17}\text{H}_{13}\text{ClNaO}_5\text{S}$ ($[\text{M}+\text{Na}]^+$): 387.0064, Found: 387.0069.



4-Chloro-5-oxo-3-tosyl-2,5-dihydrofuran-2-yl acetate (4v)

Yellow solid (57 mg, 48%); m.p. 113.5-114.9 $^\circ\text{C}$; ^1H NMR (400 MHz, CDCl_3), δ : 2.14 (s, 3H, CH_3CO), 2.49 (s, 3H, ArCH_3), 7.20 (s, 1H, CH), 7.44 (d, $J = 8.0$ Hz, 2H, ArH), 7.89 (d, $J = 8.0$ Hz, 2H, ArH); ^{13}C NMR (100 MHz, CDCl_3), δ : 20.4, 21.9, 90.8, 128.7, 130.5, 132.4, 134.9, 147.5, 150.5, 162.3, 167.7; ESI-HRMS, m/z (%): Calcd for $\text{C}_{13}\text{H}_{11}\text{ClNaO}_6\text{S}$ ($[\text{M}+\text{Na}]^+$): 352.9857, Found: 352.9861.

Data of Single-crystal X-ray Analysis

Table S1 Crystal data and structure refinement for **3a**

Compounds	3a
Empirical formula	C ₁₂ H ₁₁ BrO ₅ S
Formula weight	347.18
Temperature (K)	294.77(10)
Wavelength (Å)	0.71073
Crystal system, space group	Monoclinic, P 1 2 ₁ /c 1
Unit cell dimensions (Å, °)	<i>a</i> = 9.7719(7), <i>b</i> = 19.2524(18), <i>c</i> = 7.2602(5) <i>α</i> = 90, <i>β</i> = 95.126(6), <i>γ</i> = 90
Volume (Å ³)	1360.42(19)
Z, Calculated density (Mg/m ³)	4, 1.695
Absorption coefficient (mm ⁻¹)	3.187
<i>F</i> (000)	696
Theta range for data collection	2.976 to 25.681 deg.
Limiting indices	-11 ≤ <i>h</i> ≤ 11, -23 ≤ <i>k</i> ≤ 22, -7 ≤ <i>l</i> ≤ 8
Reflections collected / unique	5414 / 2581 [R(int) = 0.0327]
Completeness to theta	99.9 %
Absorption correction	Semi-empirical from equivalents
Refinement method	Full-matrix least-squares on <i>F</i> ²
Data / restraints / parameters	2581 / 0 / 174
Goodness-of-fit on <i>F</i> ²	1.021
Final R indices [<i>I</i> > 2σ(<i>I</i>)]	R1 = 0.0490, wR2 = 0.1046
R indices (all data)	R1 = 0.0859, wR2 = 0.1208
Largest diff. peak and hole	0.447 and -0.480 e.Å ⁻³

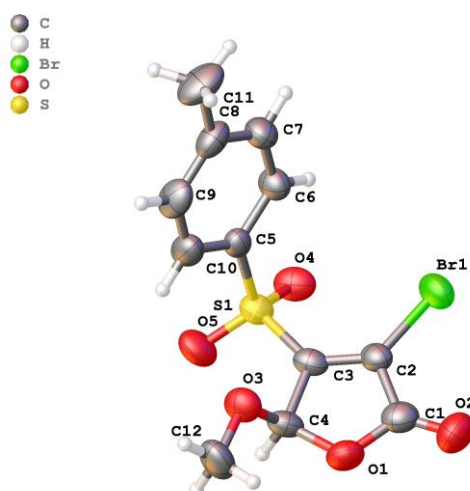


Figure S1 The molecular structure of **3a**

Table S2 Crystal data and structure refinement for **4l**

Compounds	4l
Empirical formula	C ₁₄ H ₁₅ ClO ₅ S
Formula weight	330.77
Temperature (K)	297.7(2)
Wavelength (Å)	0.71073 Å
Crystal system, space group	Triclinic, P-1
Unit cell dimensions (Å, °)	$a = 8.8450(8)$, $b = 10.8877(11)$, $c = 16.8698(12)$ $\alpha = 93.769(7)$, $\beta = 94.701(7)$, $\gamma = 109.666(9)$
Volume (Å ³)	1517.1(2)
Z, Calculated density (Mg/m ³)	4, 1.448
Absorption coefficient (mm ⁻¹)	0.407
$F(000)$	688
Theta range for data collection	3.265 to 26.372 deg.
Limiting indices	$-10 \leq h \leq 11$, $-13 \leq k \leq 13$, $-21 \leq l \leq 21$
Reflections collected / unique	11666 / 6184 [R(int) = 0.0280]
Completeness to theta	99.7 %
Absorption correction	Semi-empirical from equivalents
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	6184 / 0 / 387
Goodness-of-fit on F^2	1.028
Final R indices [$I > 2\sigma(I)$]	R1 = 0.0474, wR2 = 0.1196
R indices (all data)	R1 = 0.0644, wR2 = 0.1316
Largest diff. peak and hole	0.900 and -0.385 e.Å ⁻³

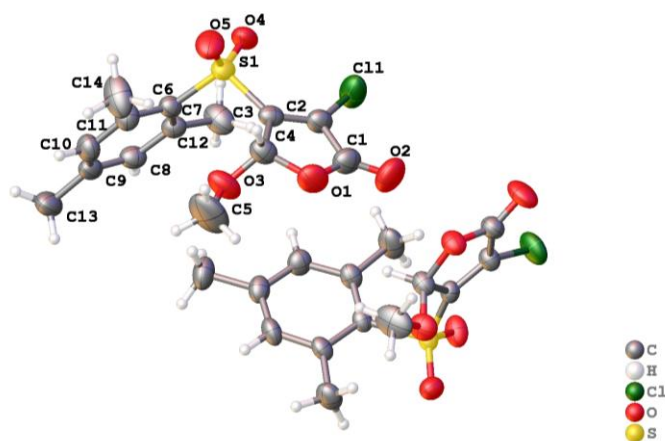
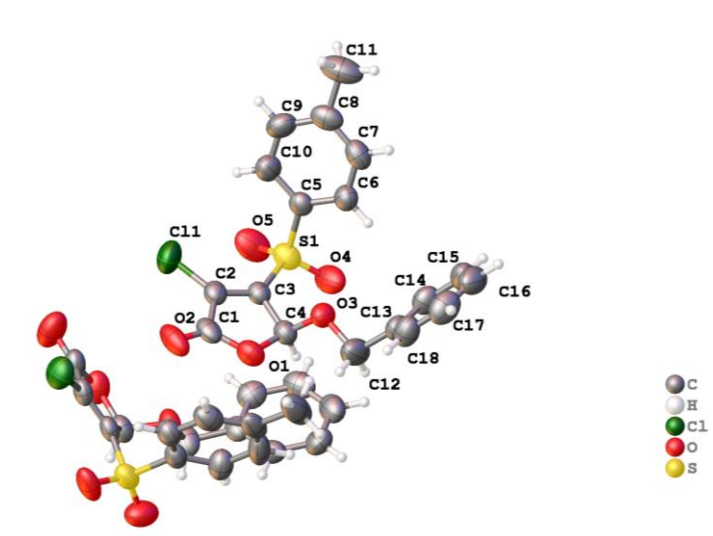
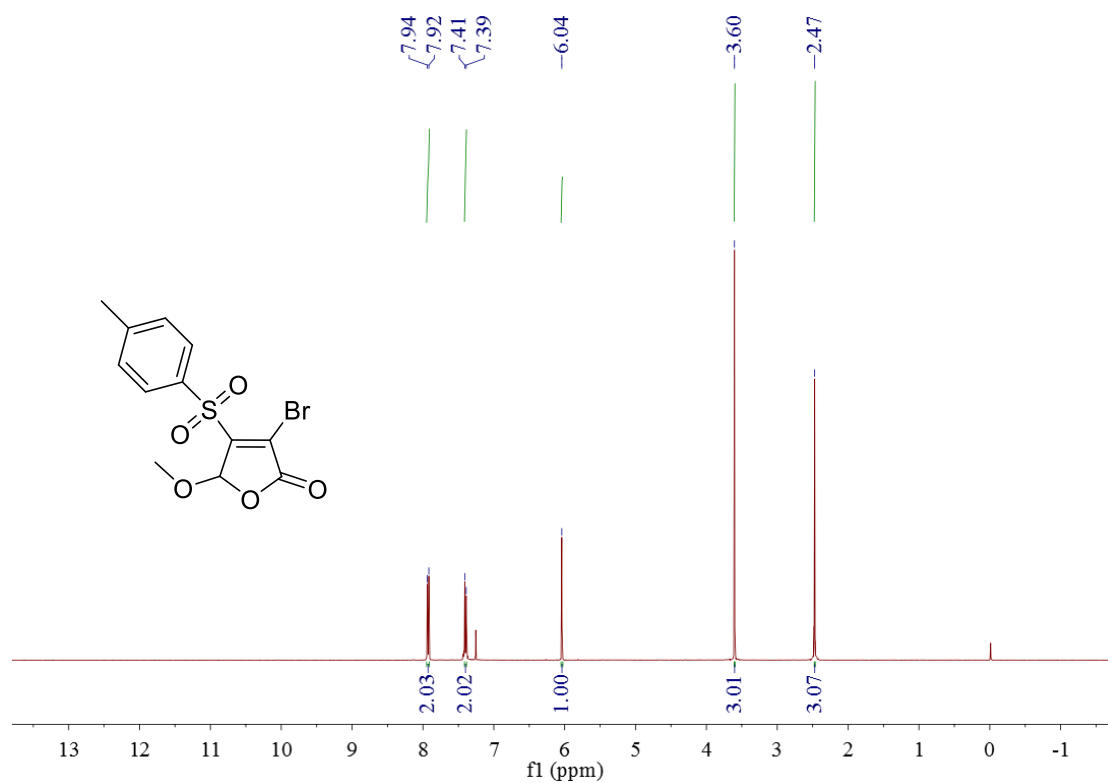
**Figure S2** The molecular structure of **4l**

Table S3 Crystal data and structure refinement for **4t**

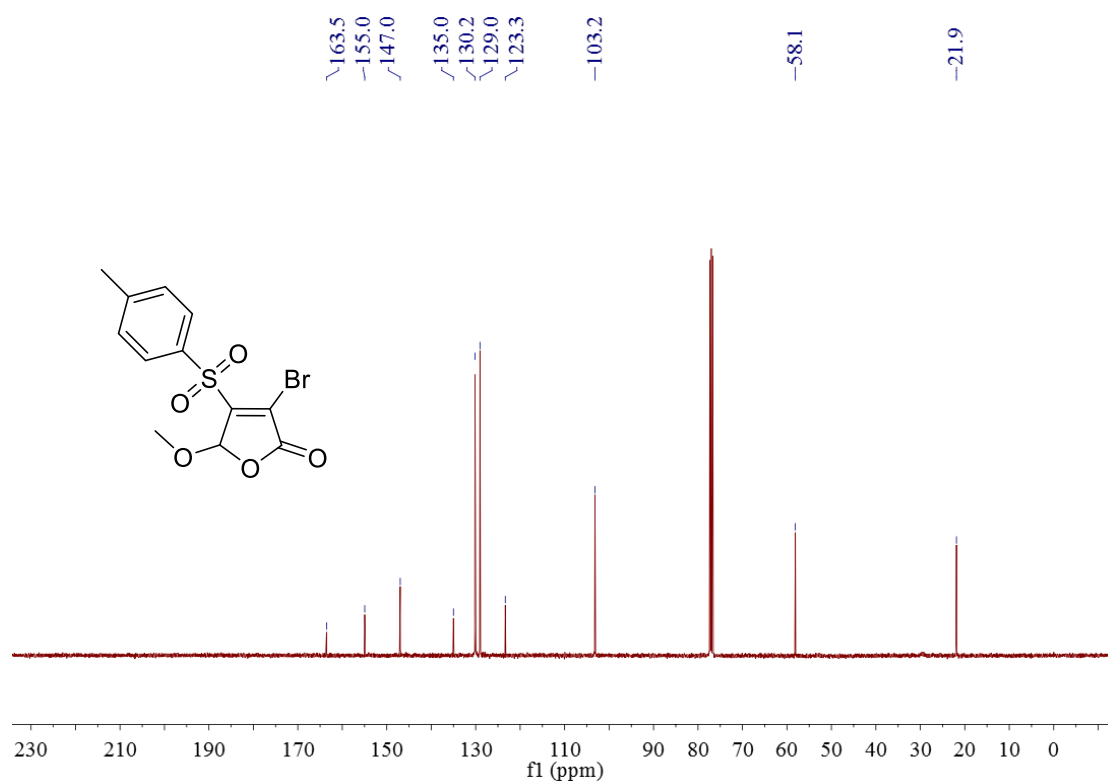
Compounds	4t
Empirical formula	C ₁₈ H ₁₅ ClO ₅ S
Formula weight	378.81
Temperature (K)	298.14(10)
Wavelength (Å)	0.71073 Å
Crystal system, space group	Triclinic, P-1
Unit cell dimensions (Å, °)	$a = 7.6242(5)$, $b = 10.1996(6)$, $c = 23.1308(15)$ $\alpha = 87.932(5)$, $\beta = 88.886(5)$, $\gamma = 79.665(5)$
Volume (Å ³)	1768.2(2)
Z, Calculated density (Mg/m ³)	4, 1.423
Absorption coefficient (mm ⁻¹)	0.359
$F(000)$	784
Theta range for data collection	2.844 to 26.368 deg.
Limiting indices	$-9 \leq h \leq 9$, $-12 \leq k \leq 12$, $-28 \leq l \leq 28$
Reflections collected / unique	13434 / 7225 [R(int) = 0.0215]
Completeness to theta	99.9 %
Absorption correction	Semi-empirical from equivalents
Refinement method	Full-matrix least-squares on F^2
Data / restraints / parameters	7225 / 0 / 453
Goodness-of-fit on F^2	1.024
Final R indices [$I > 2\sigma(I)$]	R1 = 0.0501, wR2 = 0.1077
R indices (all data)	R1 = 0.0777, wR2 = 0.1235
Largest diff. peak and hole	0.297 and -0.334 e.Å ⁻³

**Figure S3** The molecular structure of **4t**

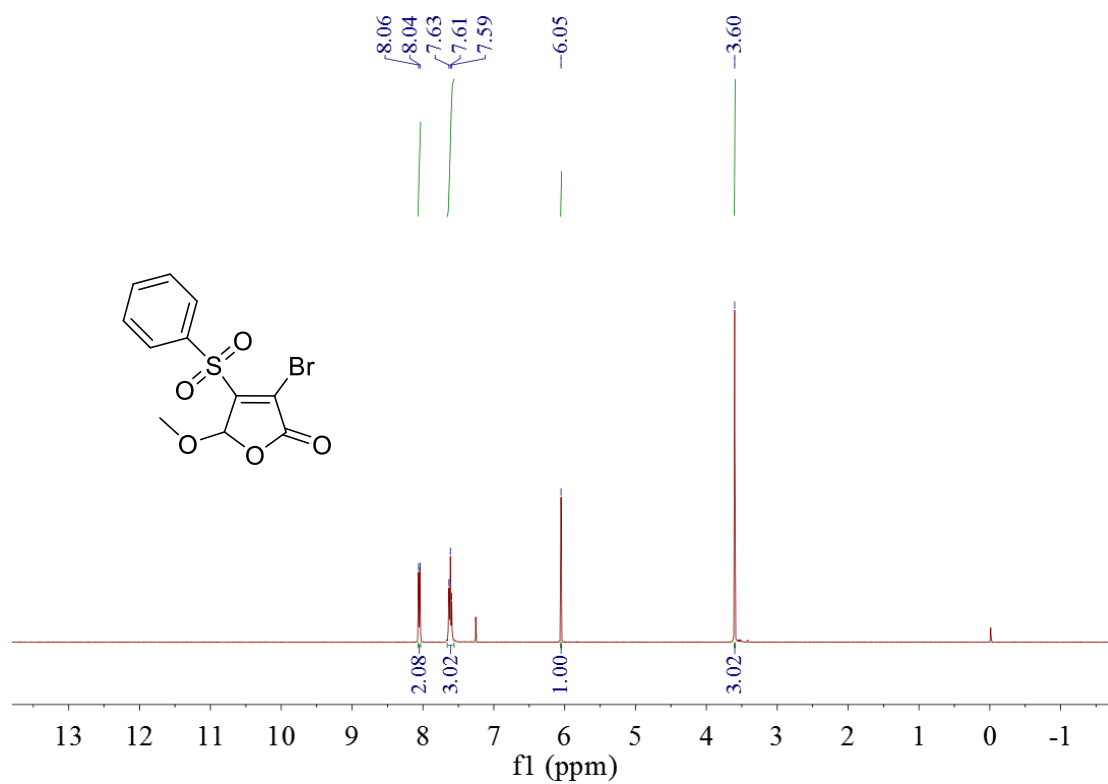
NMR Spectra for All Compounds 3a-4v



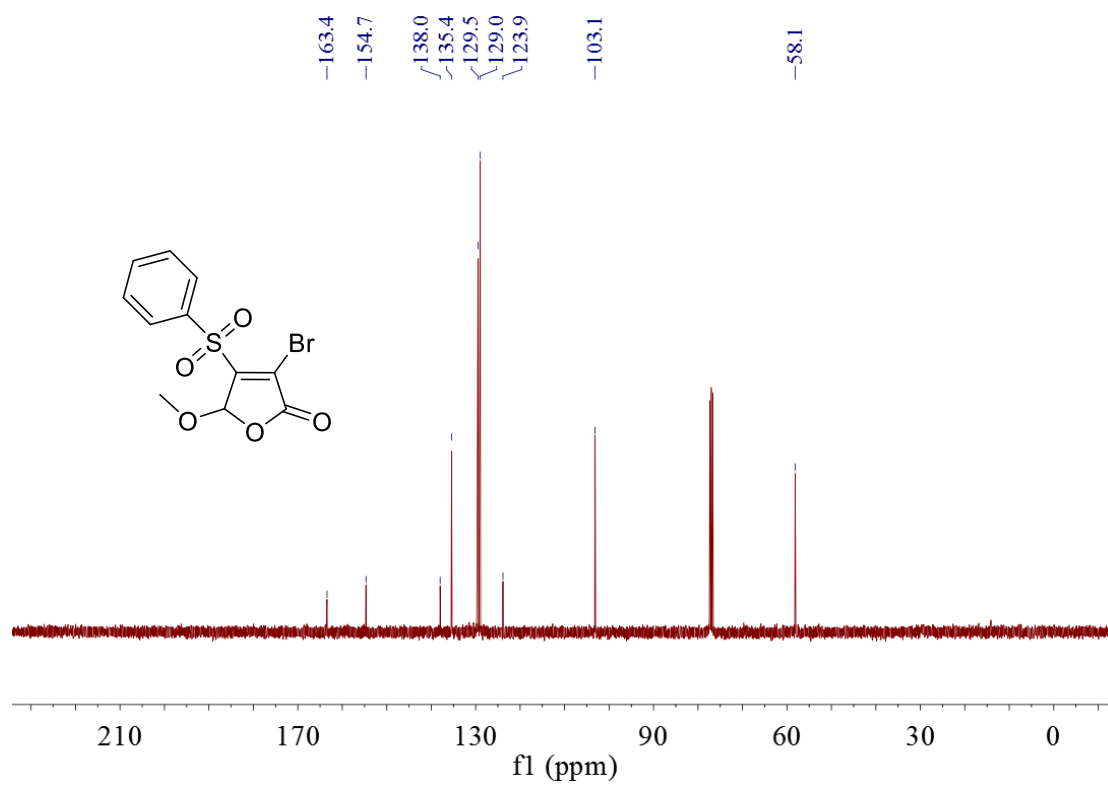
¹H NMR spectrum of compound 3a



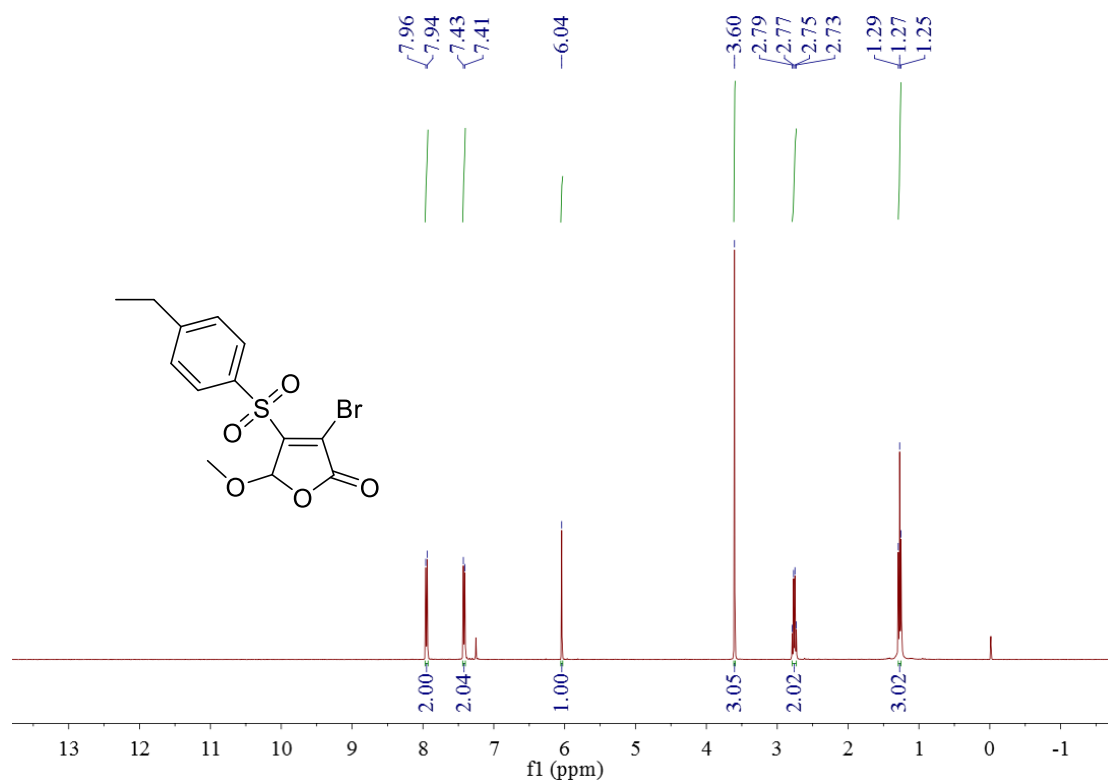
¹³C NMR spectrum of compound 3a



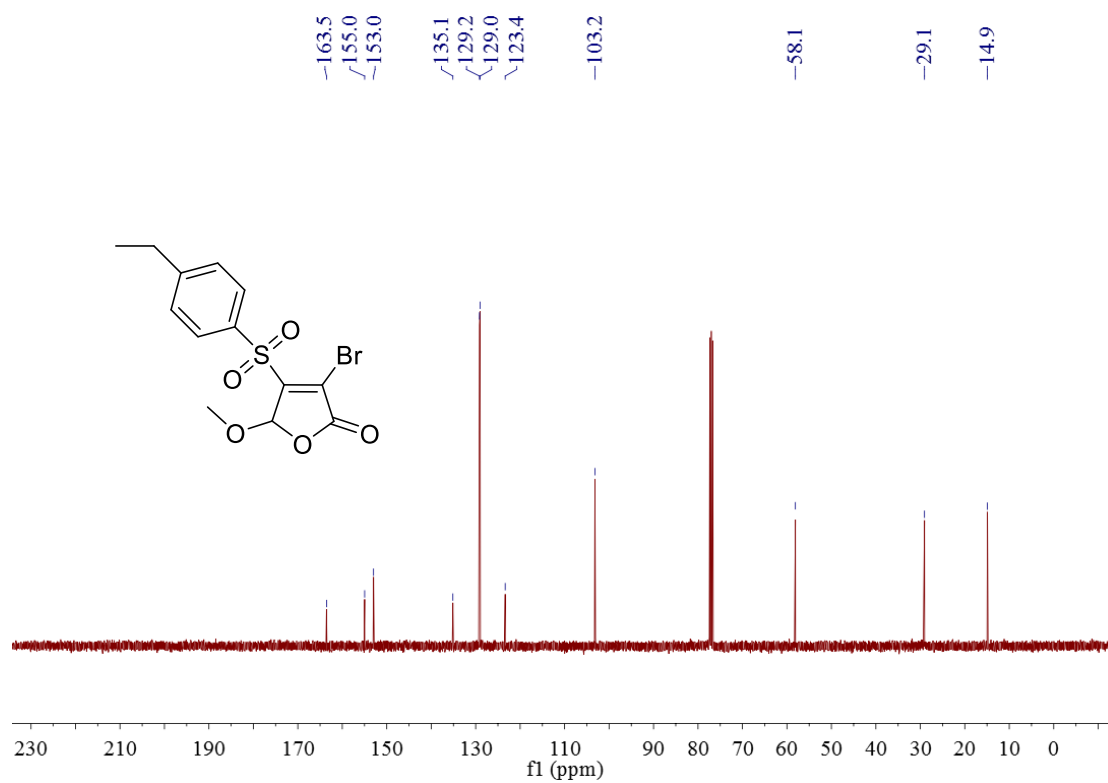
^1H NMR spectrum of compound **3b**



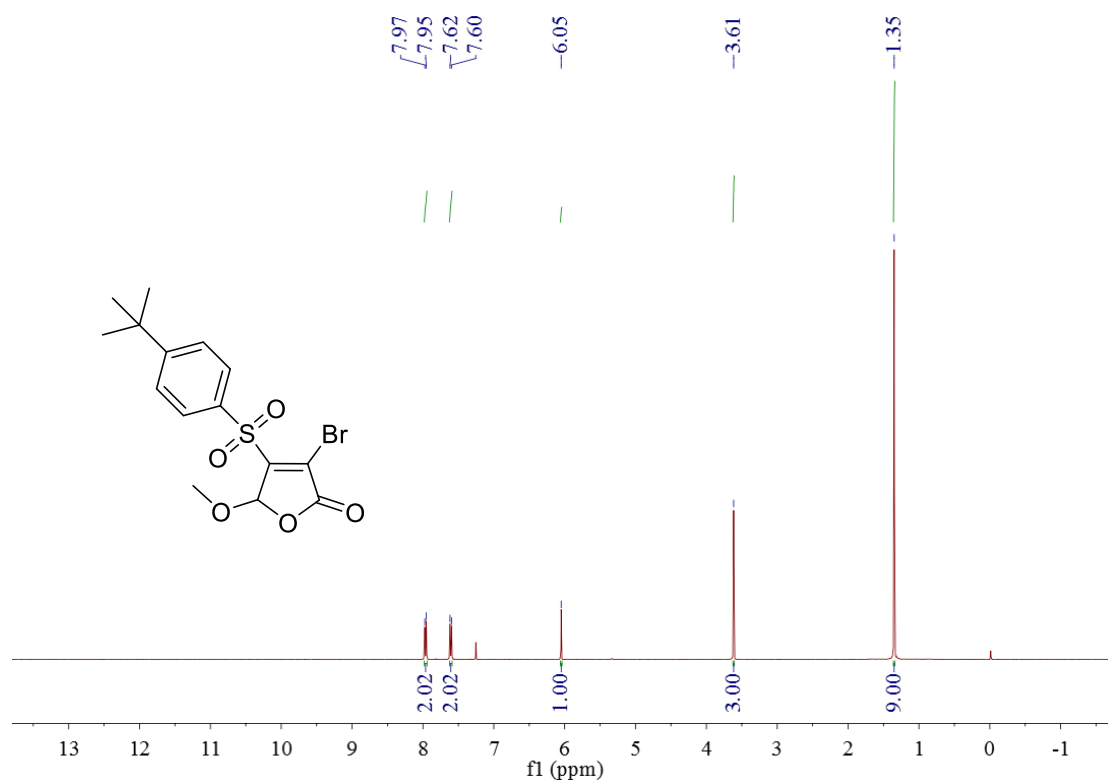
^{13}C NMR spectrum of compound **3b**



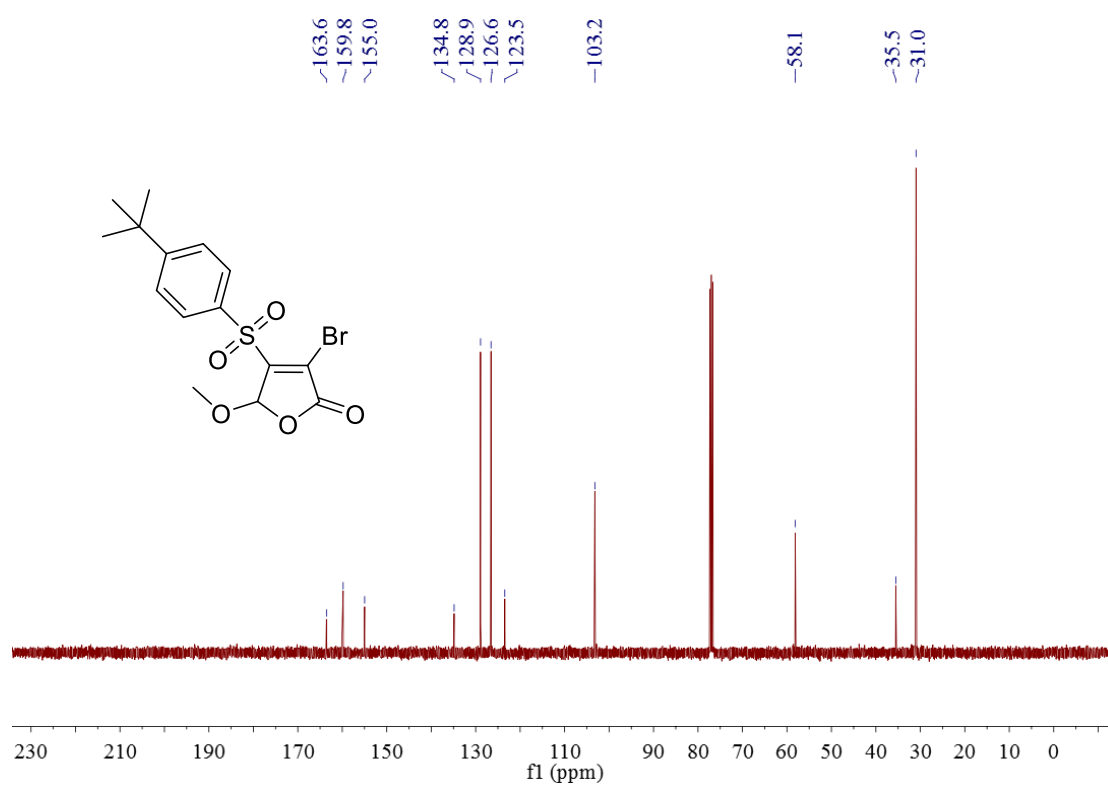
¹H NMR spectrum of compound **3c**



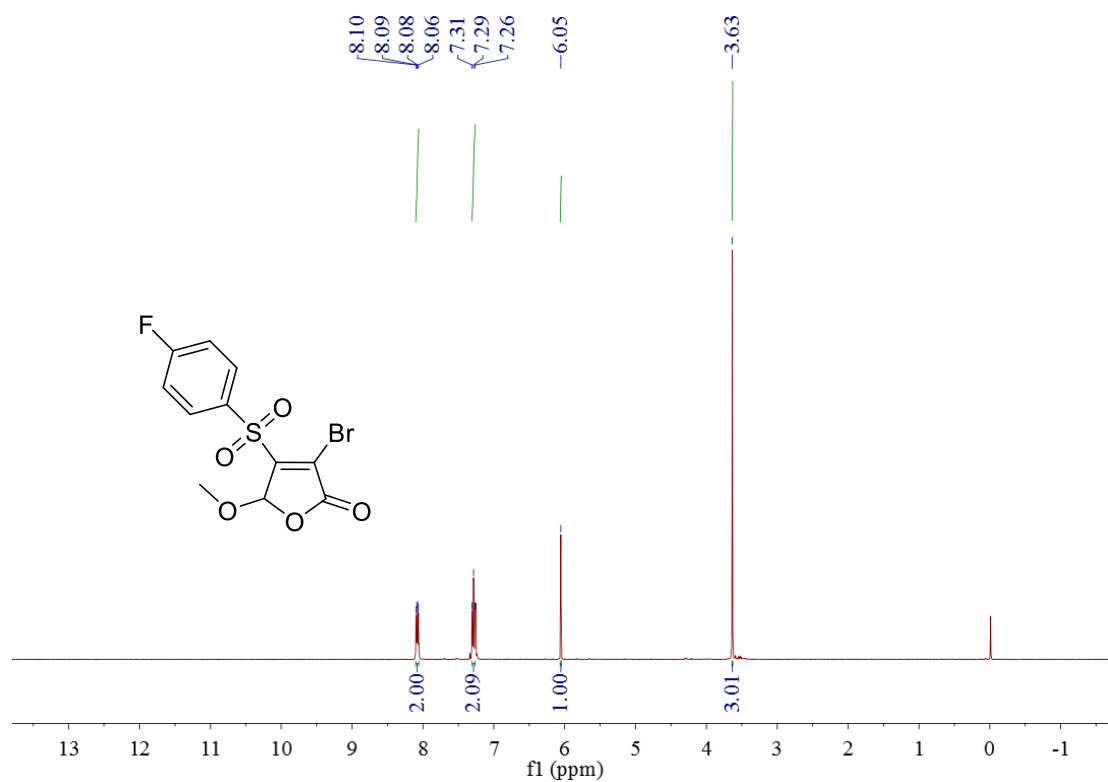
¹³C NMR spectrum of compound **3c**



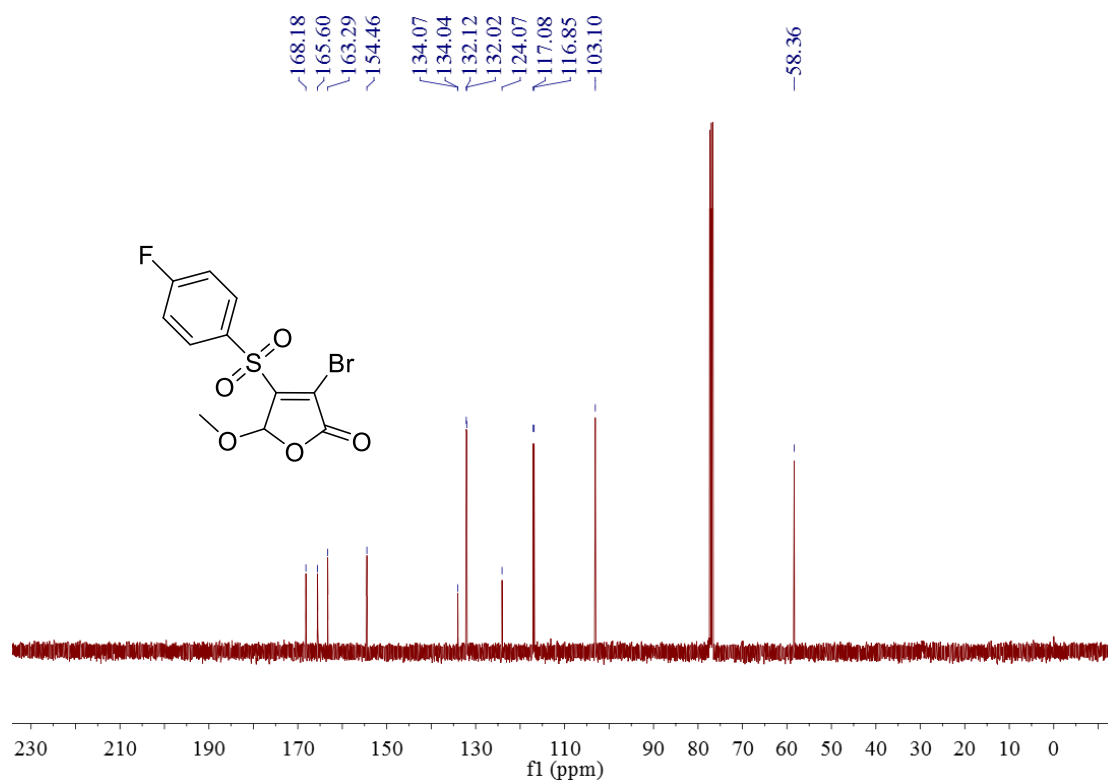
¹H NMR spectrum of compound **3d**



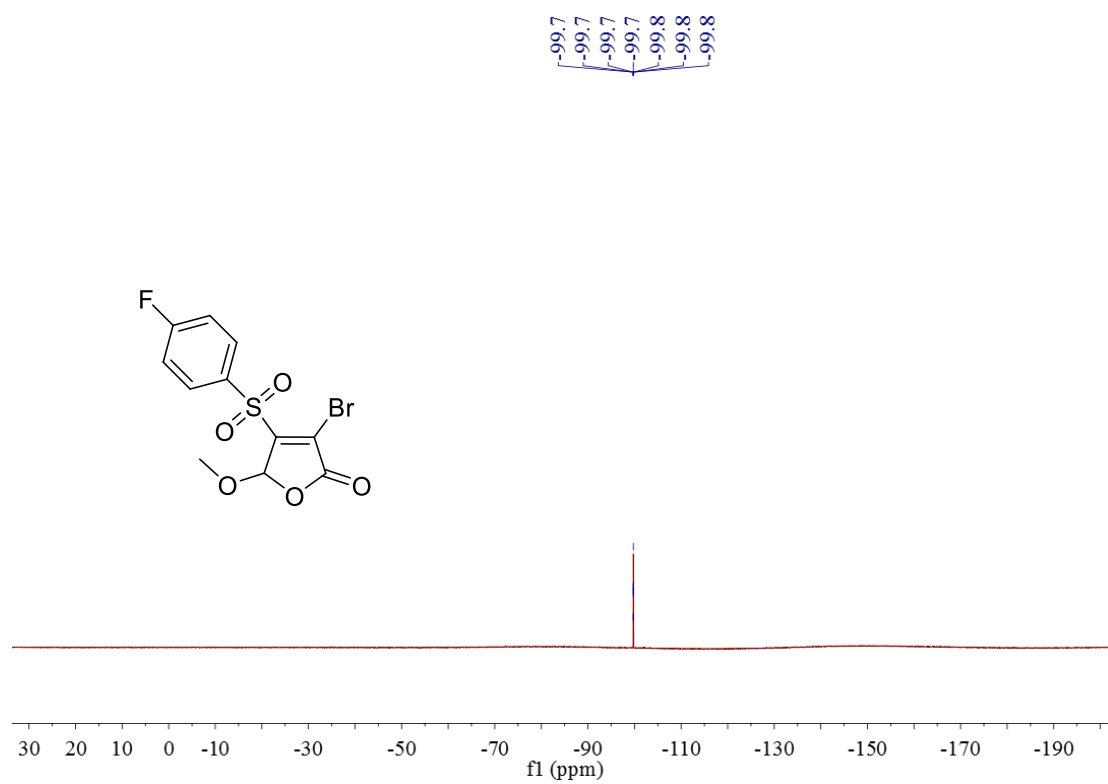
¹³C NMR spectrum of compound **3d**



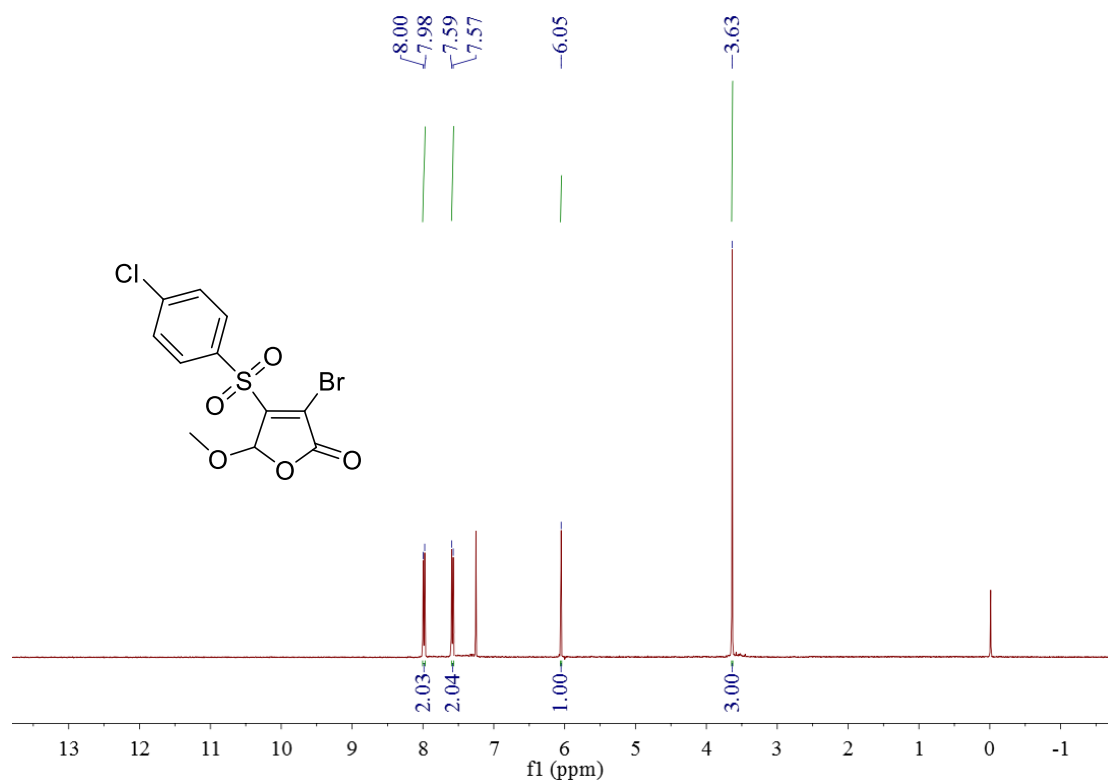
^1H NMR spectrum of compound **3e**



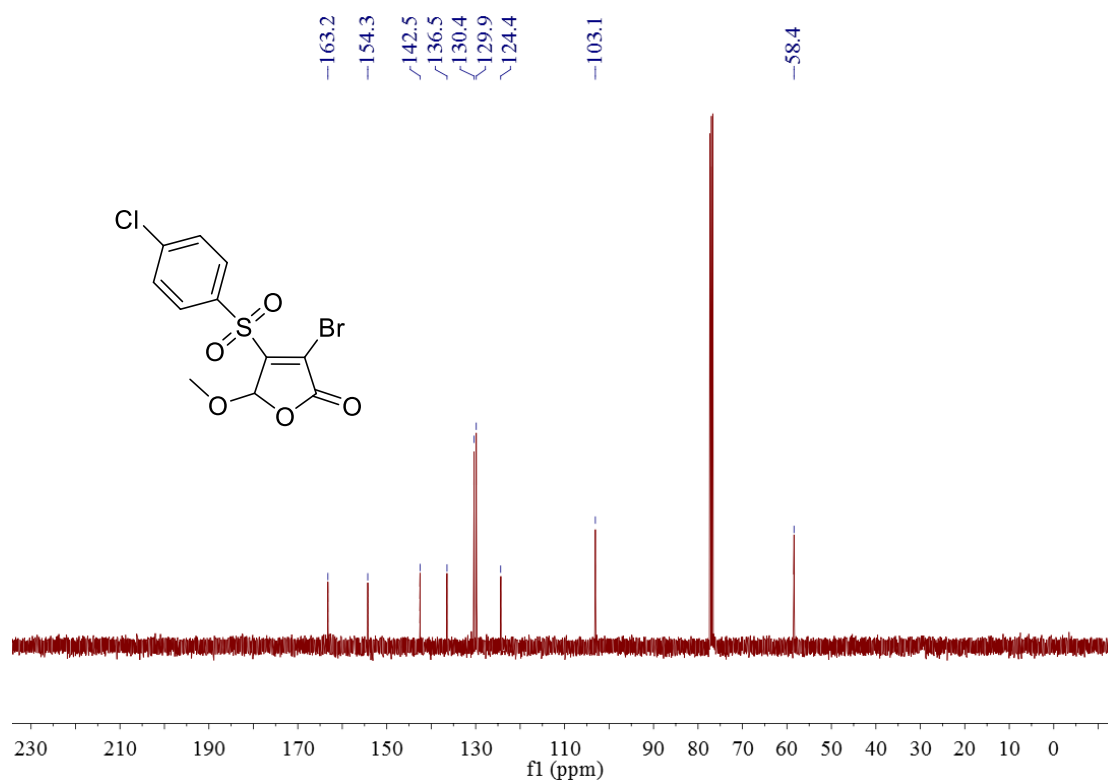
^{13}C NMR spectrum of compound **3e**



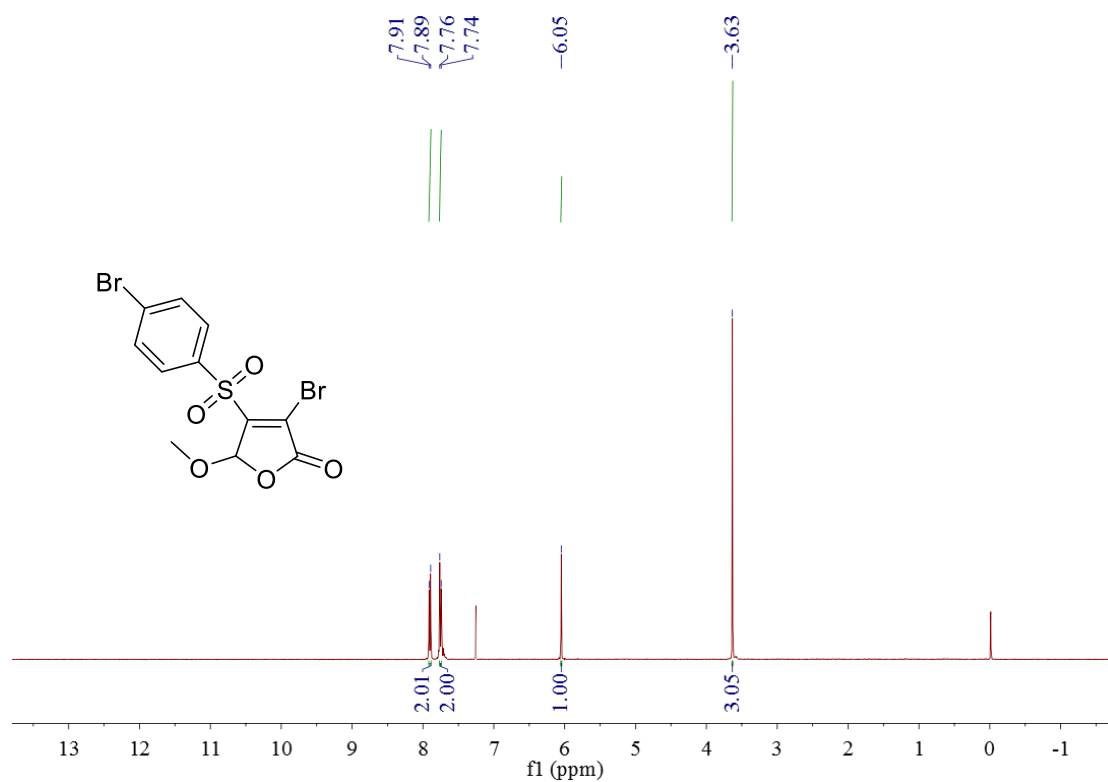
^{19}F NMR spectrum of compound **3e**



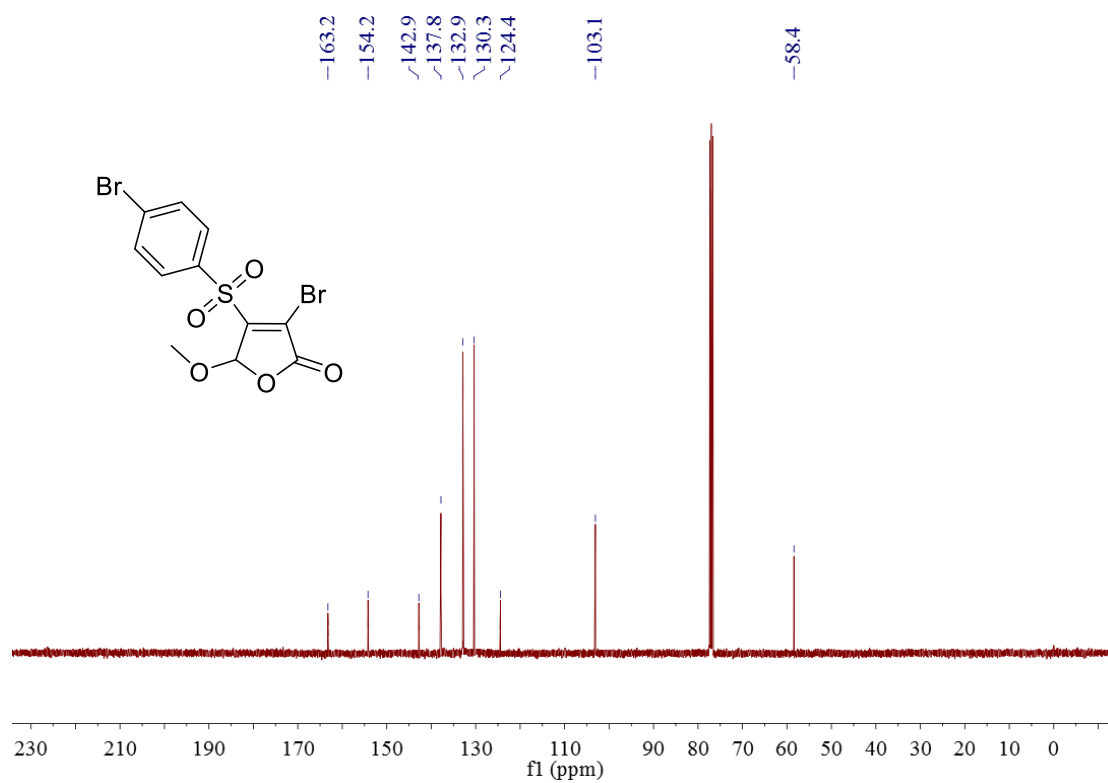
^1H NMR spectrum of compound **3f**



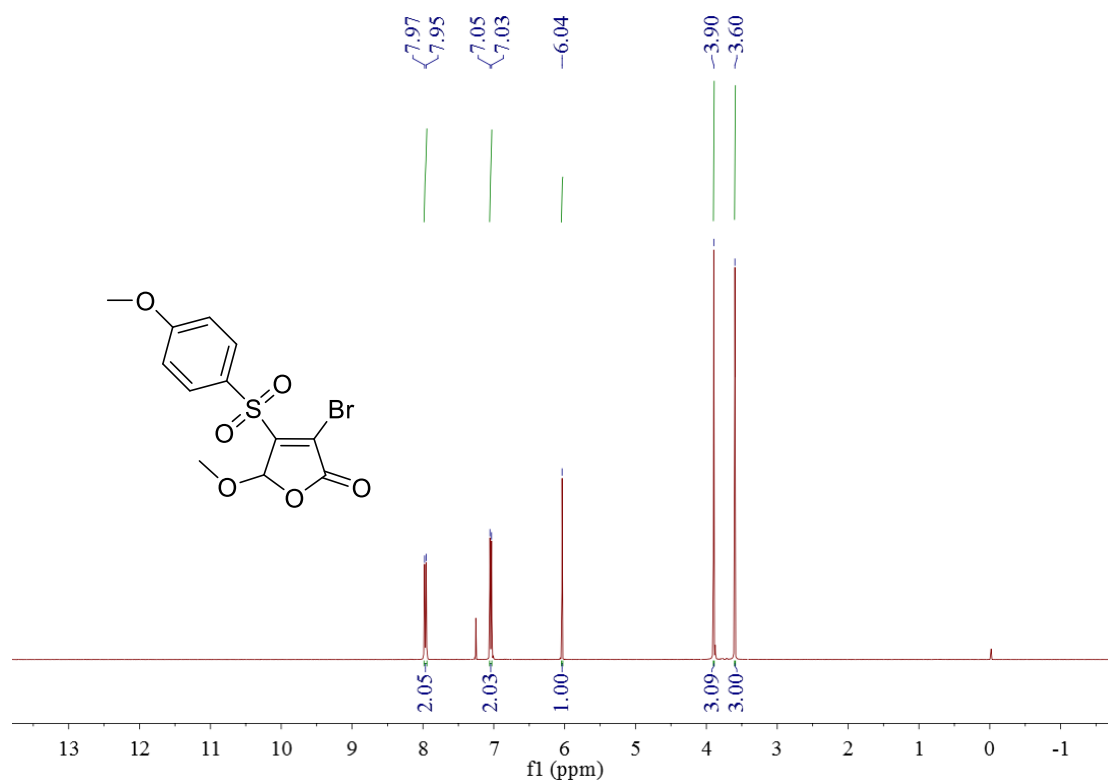
^{13}C NMR spectrum of compound **3f**



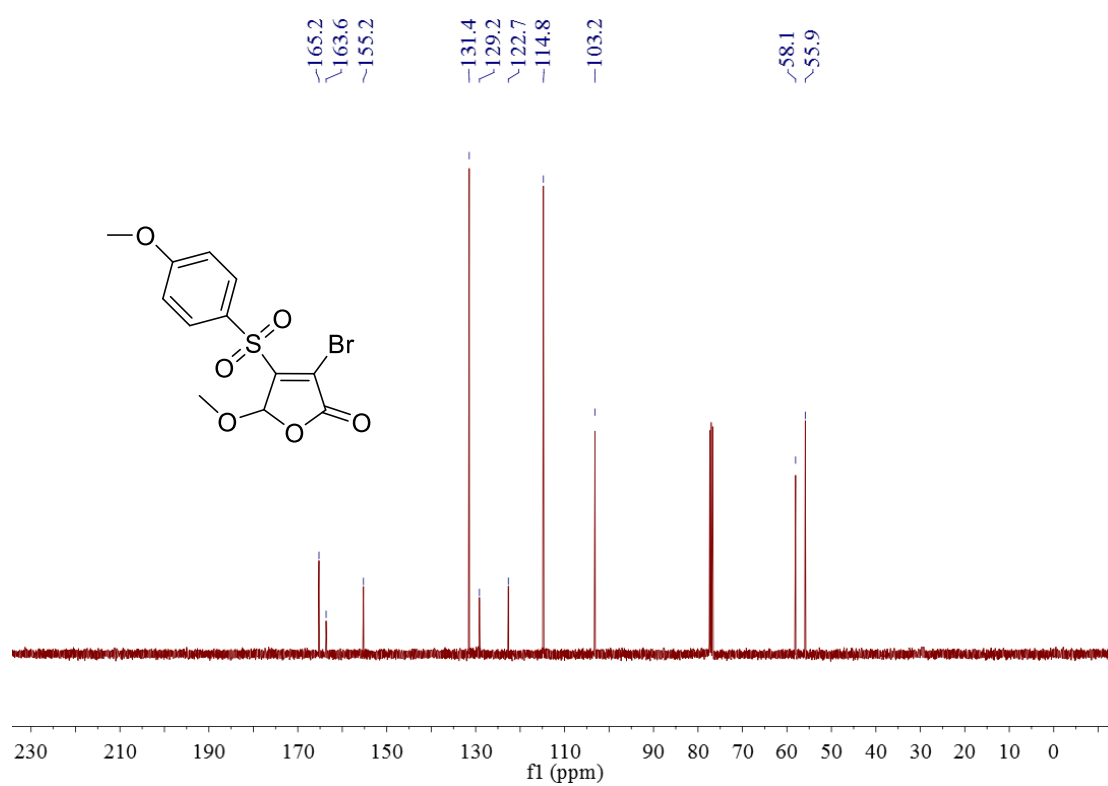
^1H NMR spectrum of compound **3g**



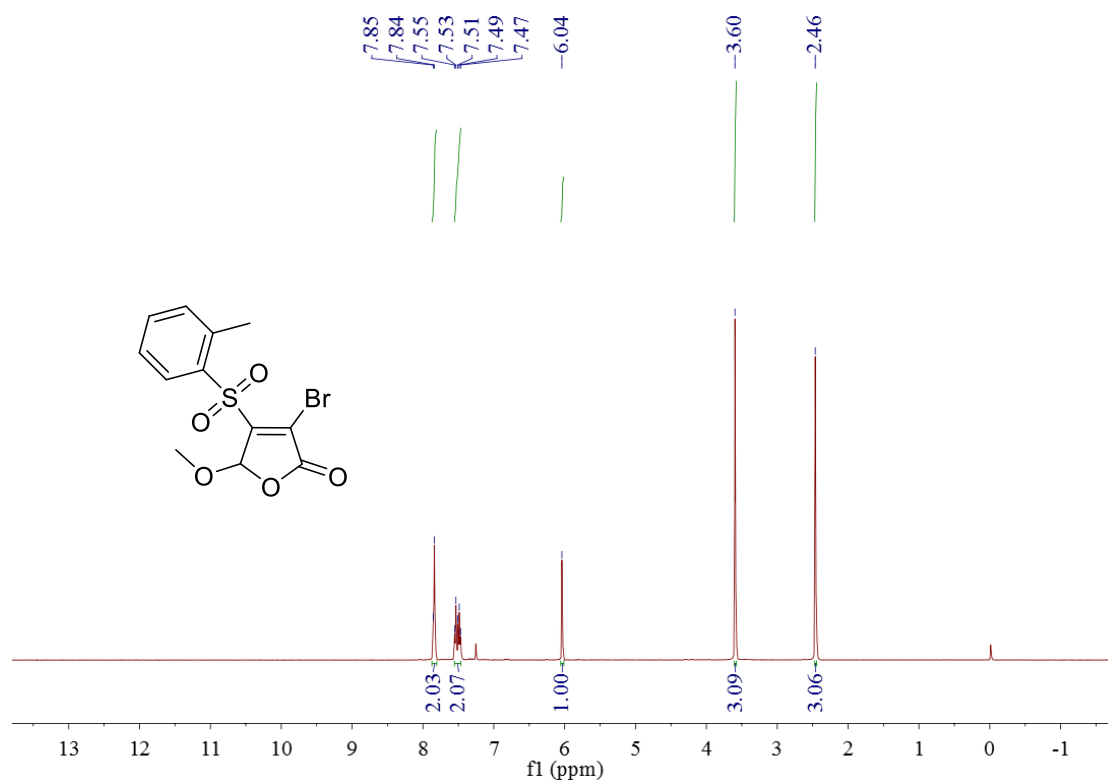
^{13}C NMR spectrum of compound **3g**



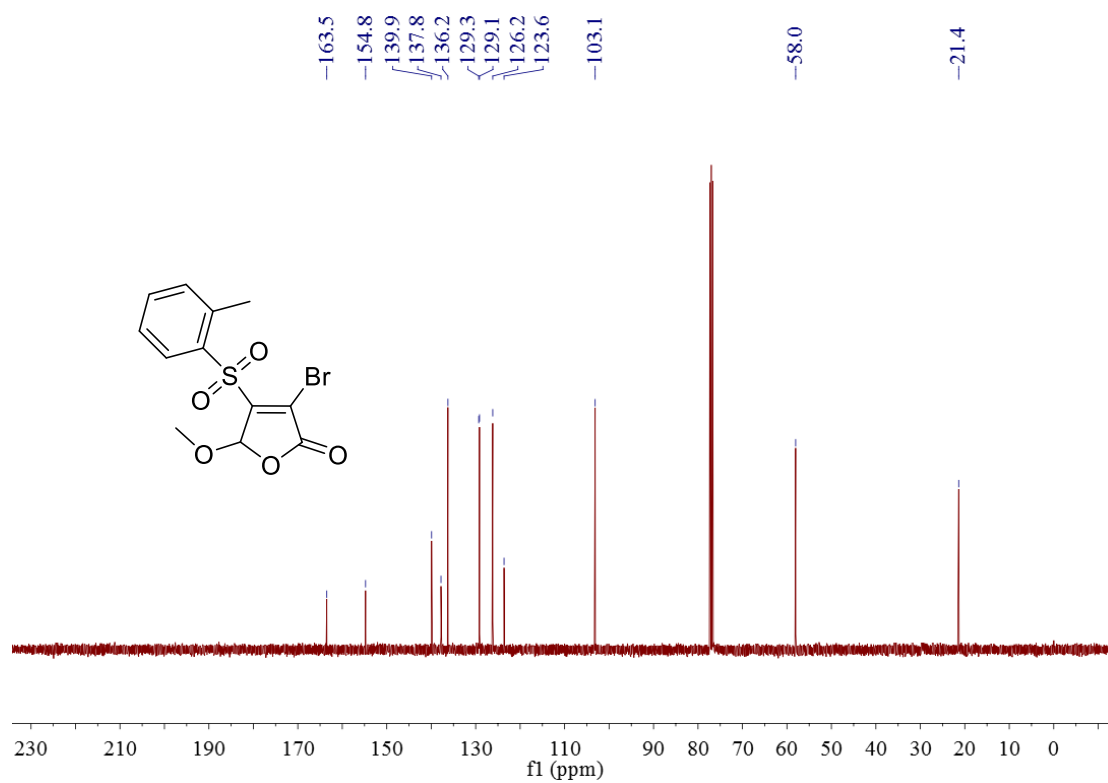
¹H NMR spectrum of compound **3h**



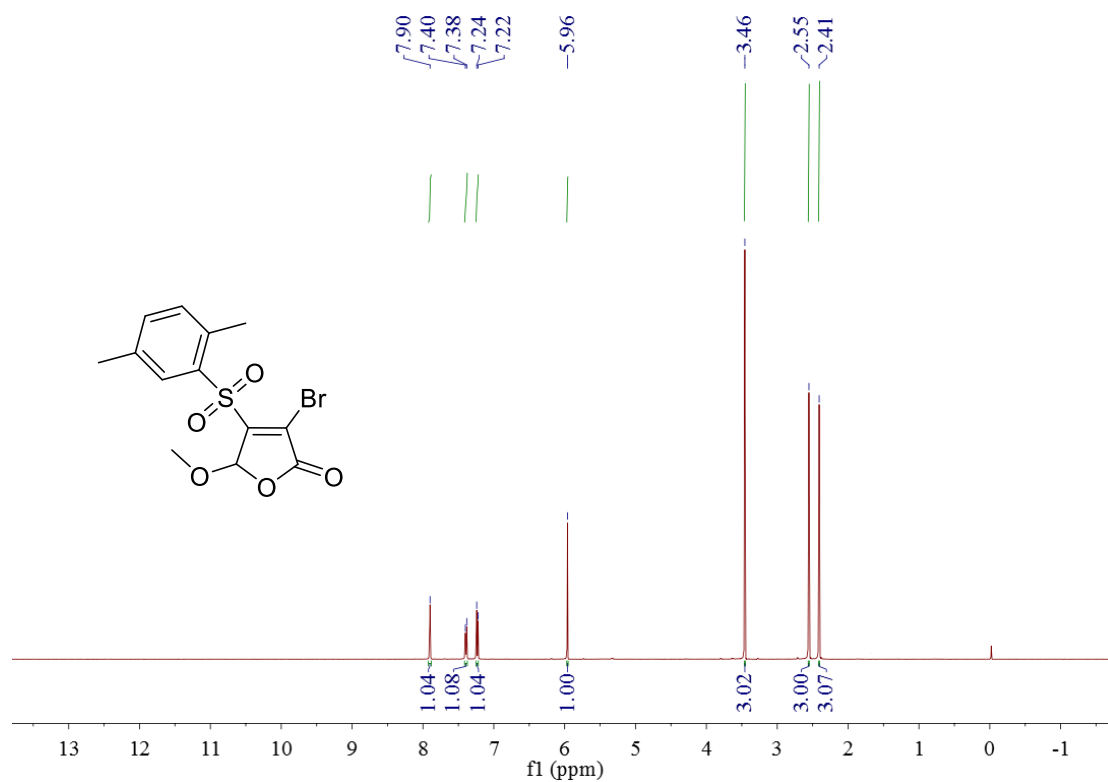
¹³C NMR spectrum of compound **3h**



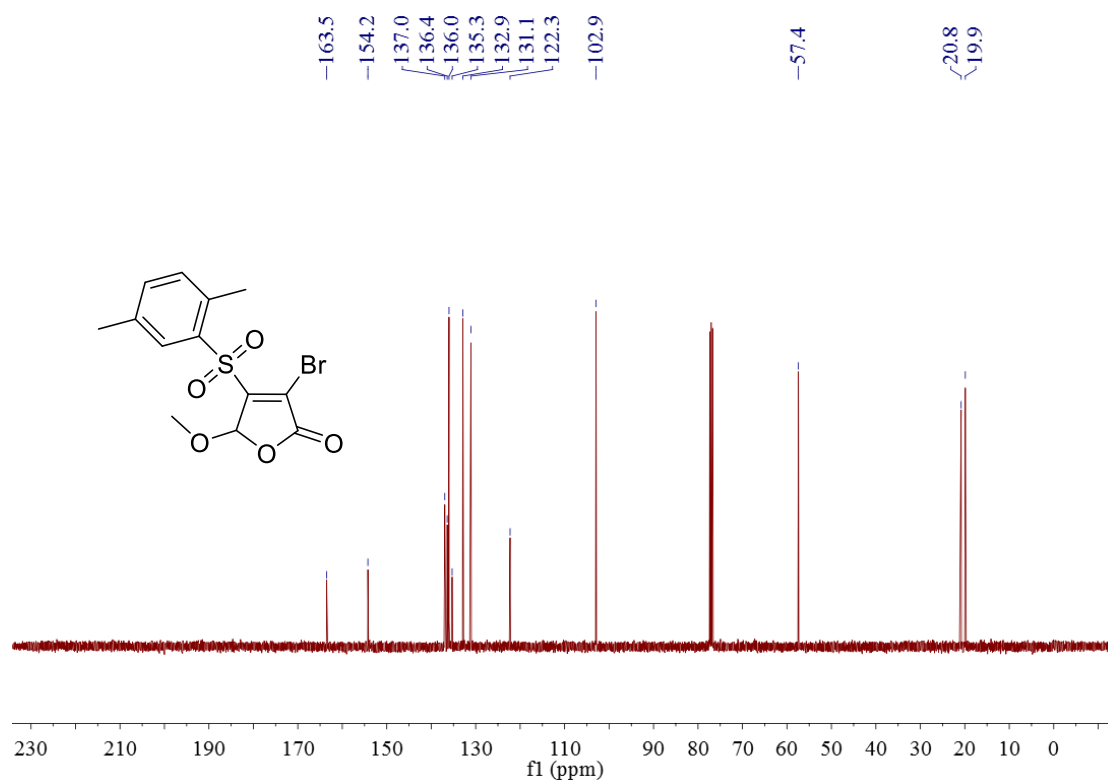
¹H NMR spectrum of compound **3i**



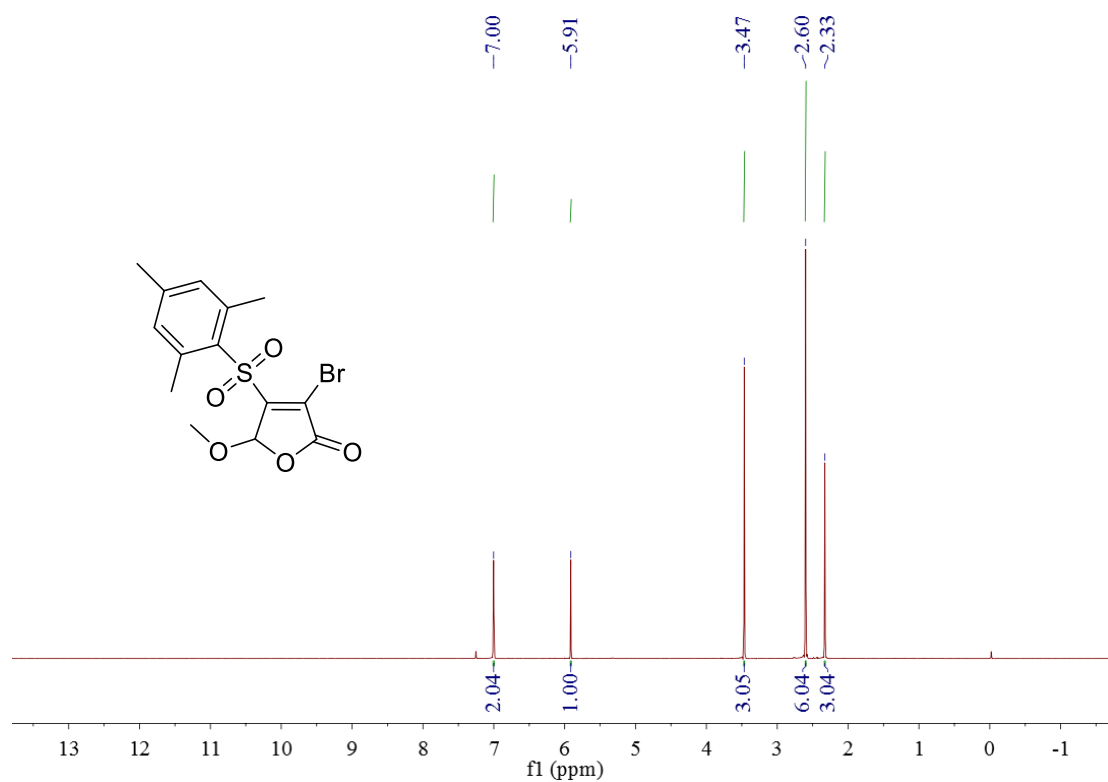
¹³C NMR spectrum of compound **3i**



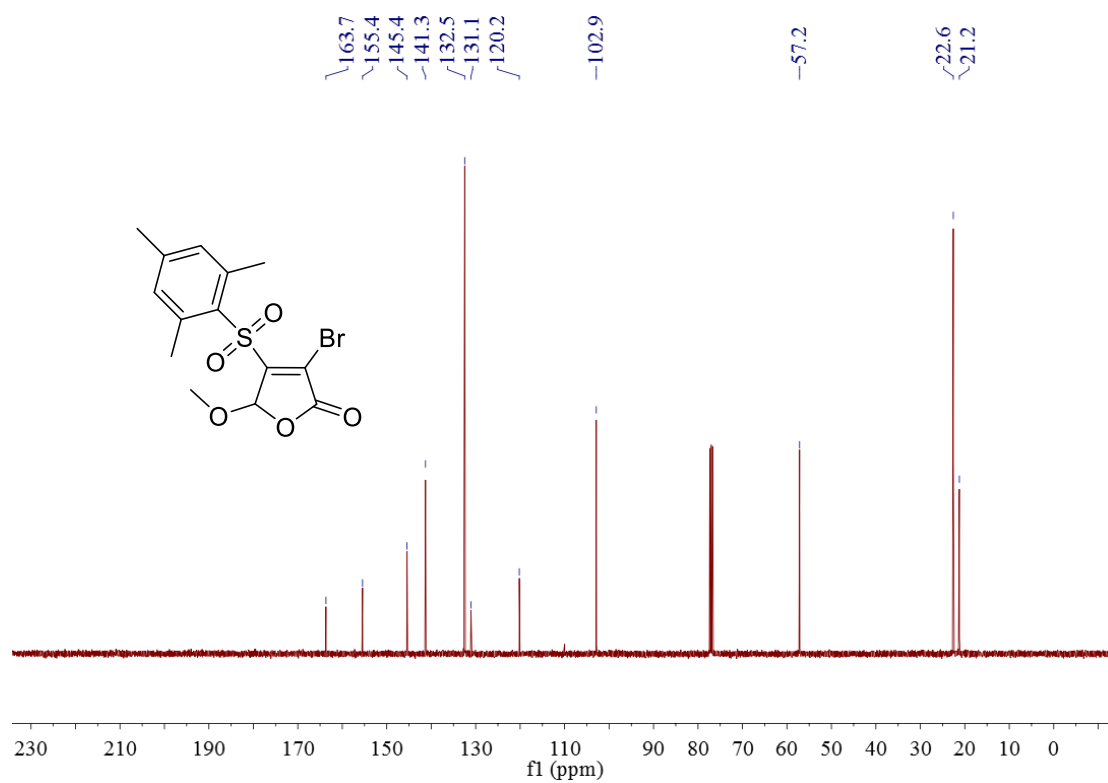
¹H NMR spectrum of compound **3j**



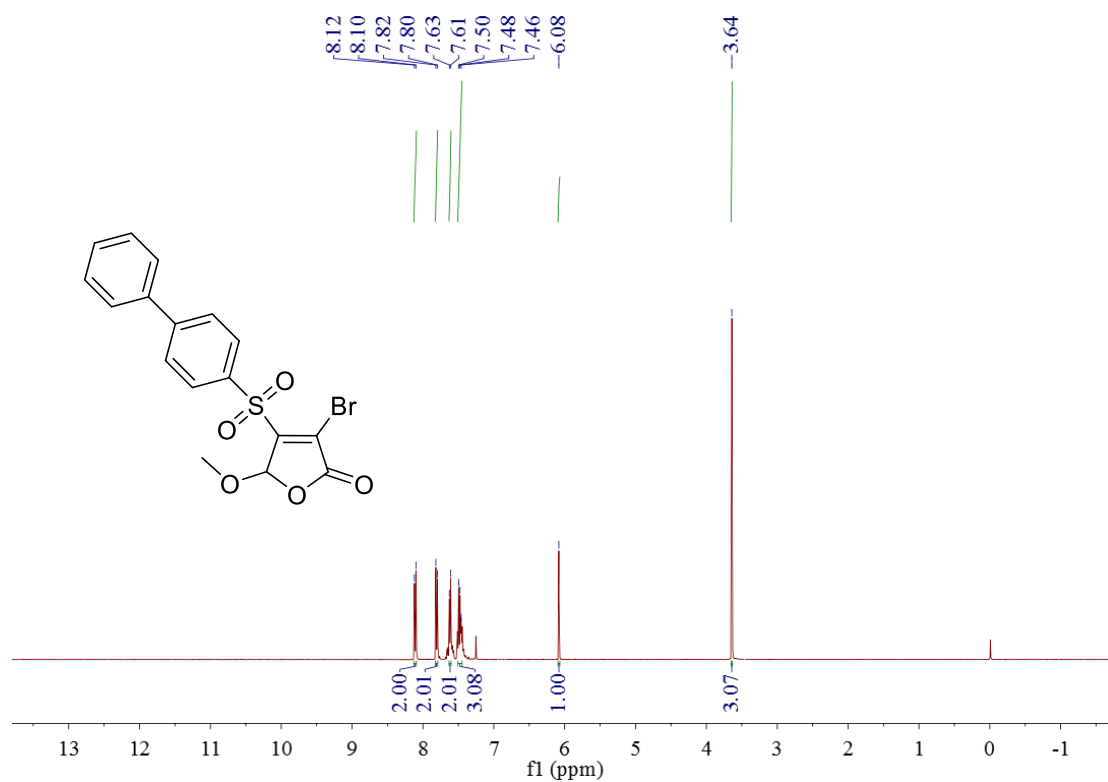
¹³C NMR spectrum of compound **3j**



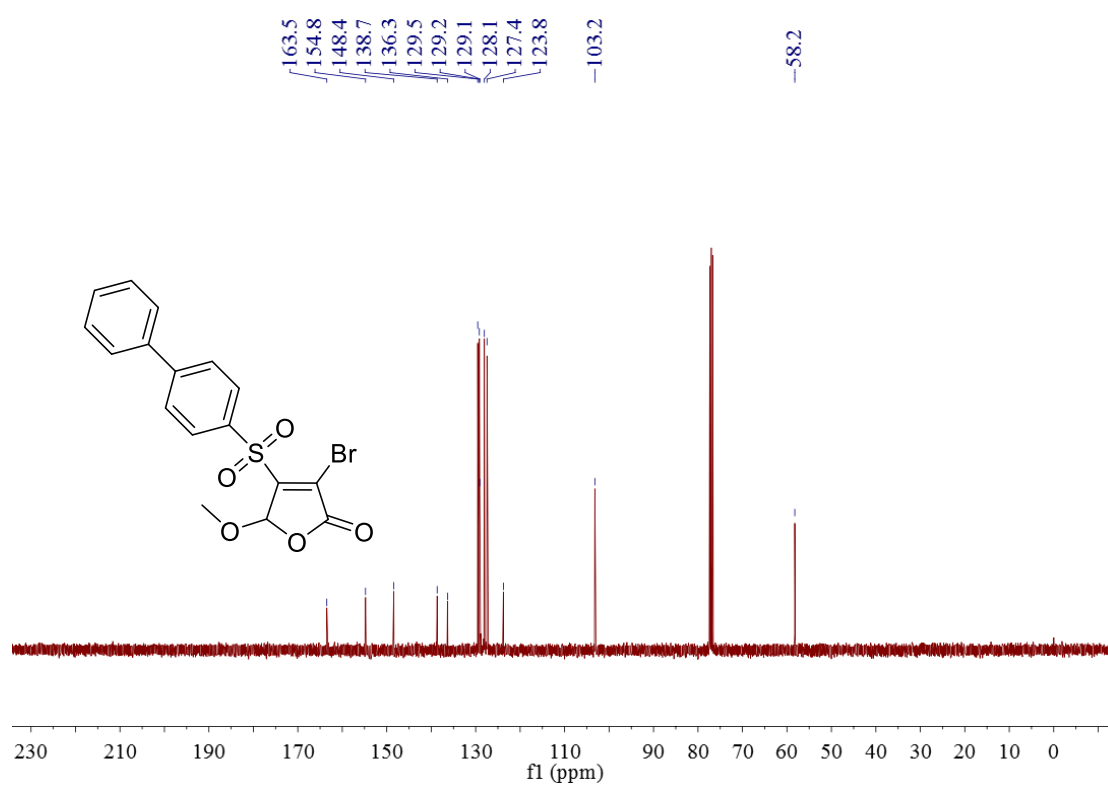
¹H NMR spectrum of compound **3k**



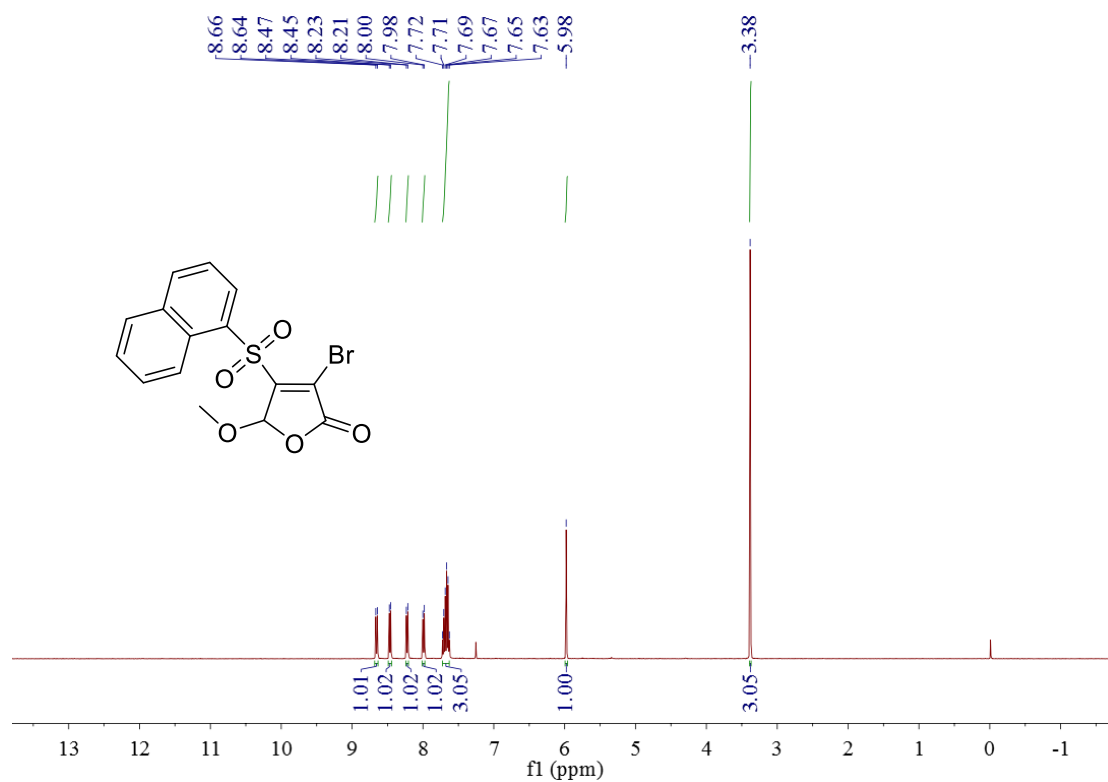
¹³C NMR spectrum of compound **3k**



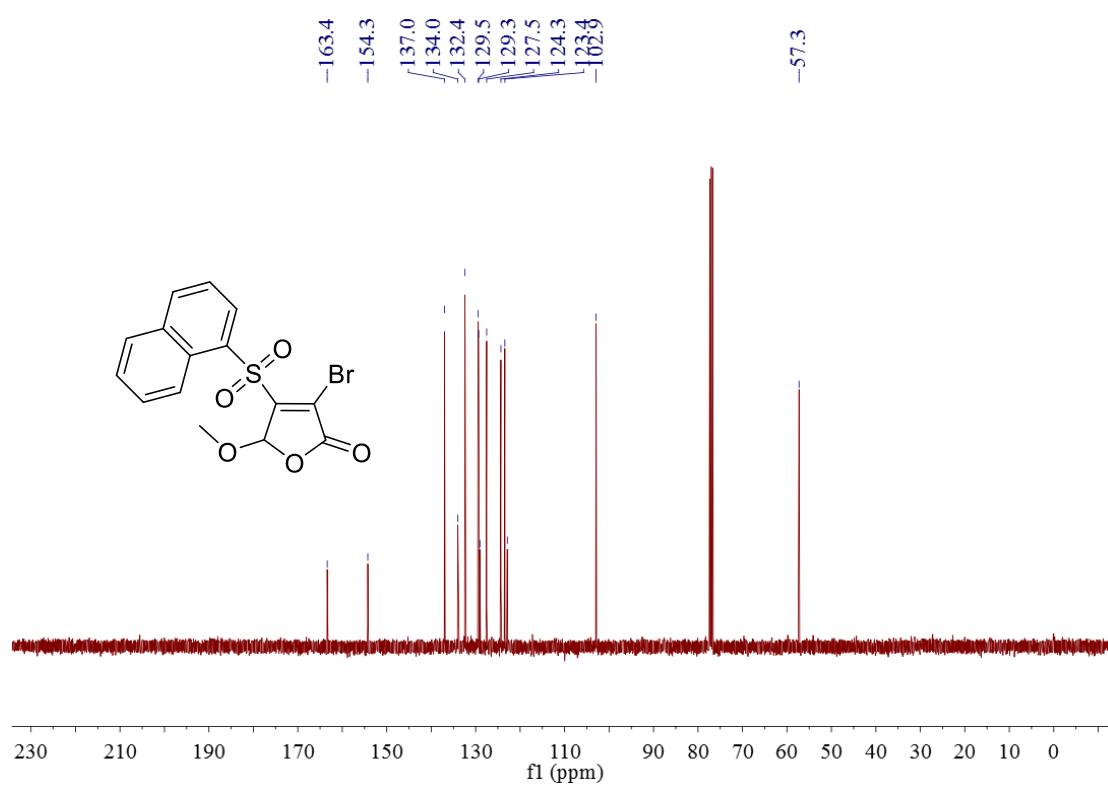
¹H NMR spectrum of compound **3l**



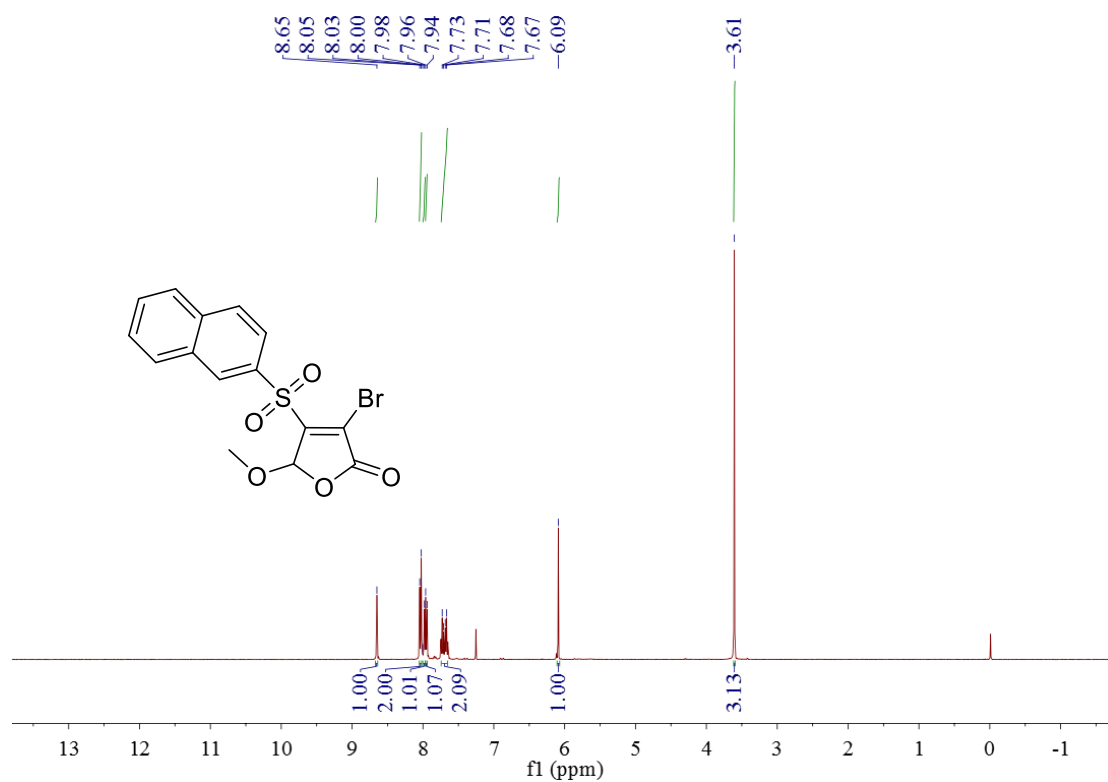
¹³C NMR spectrum of compound **3l**



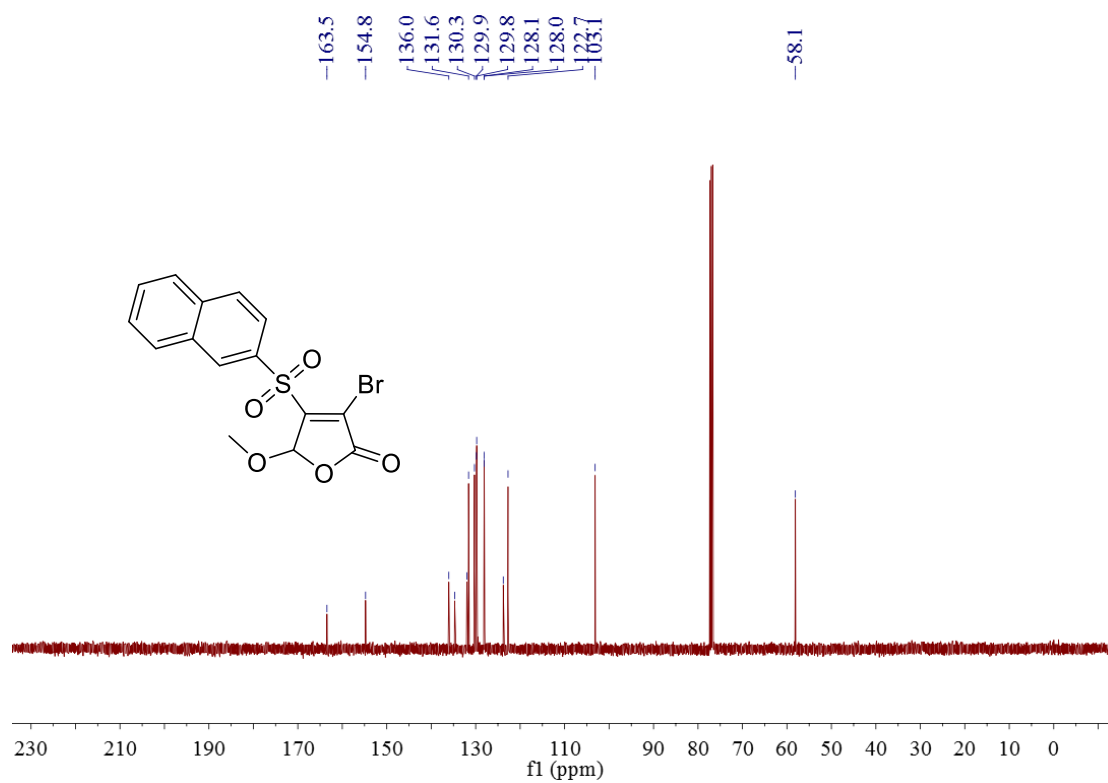
¹H NMR spectrum of compound **3m**



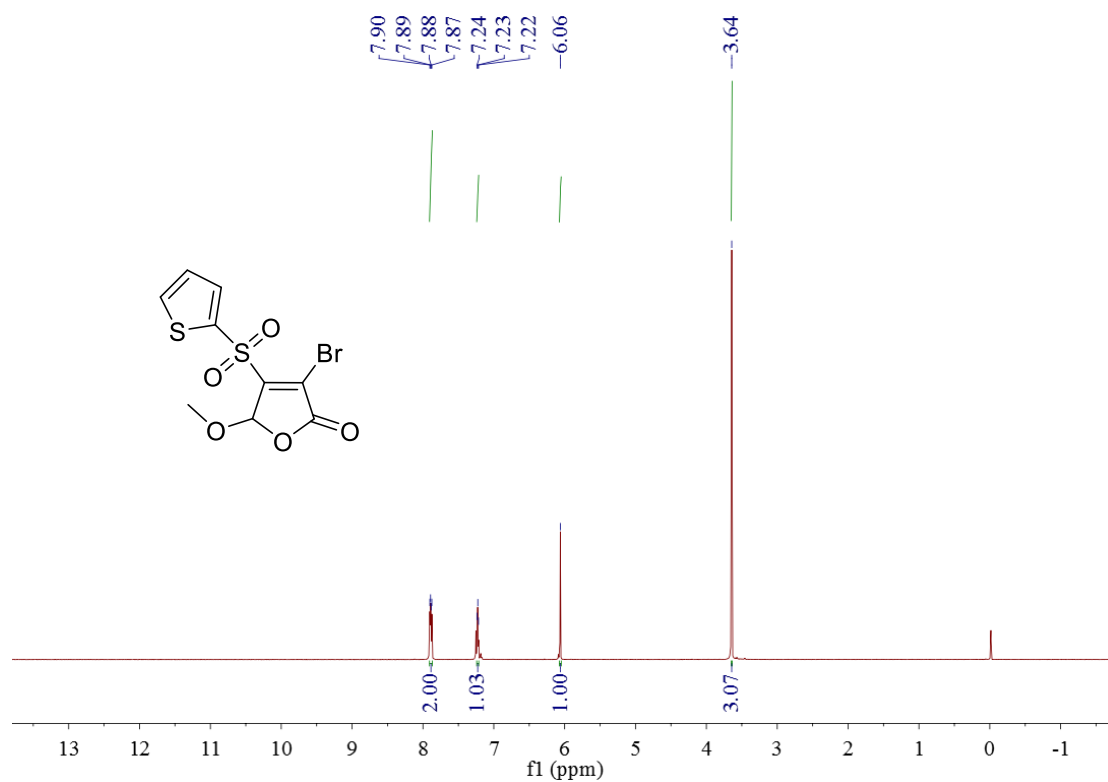
¹³C NMR spectrum of compound **3m**



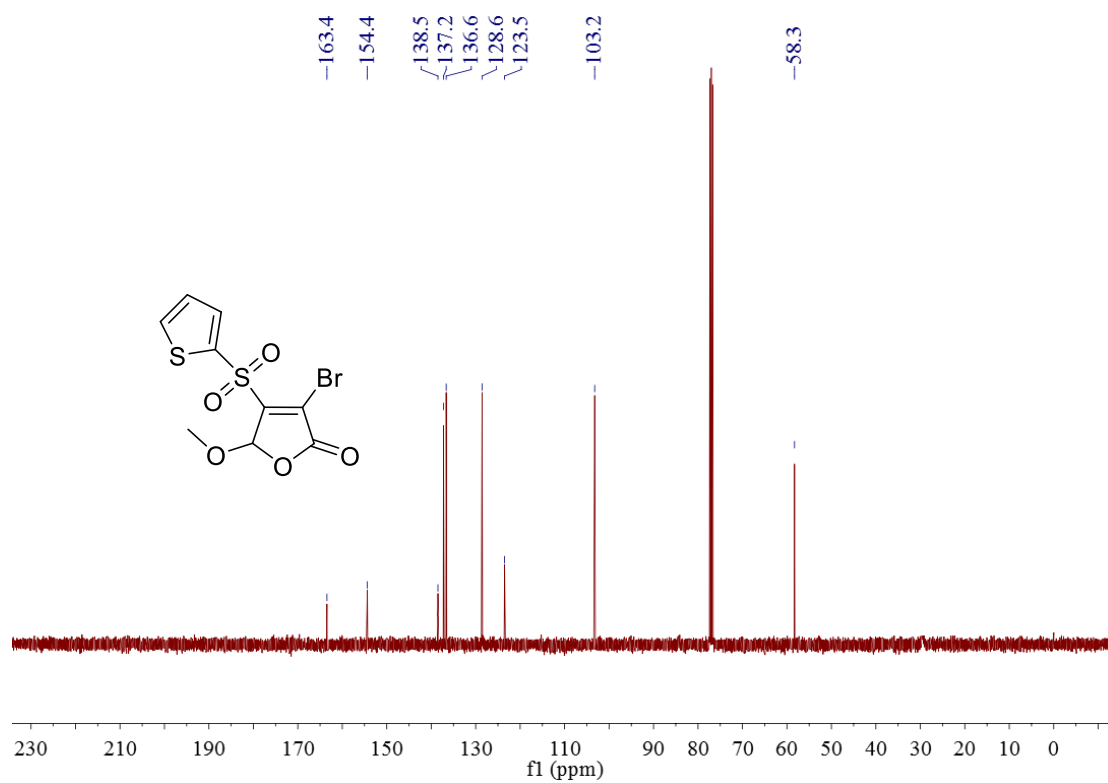
^1H NMR spectrum of compound **3n**



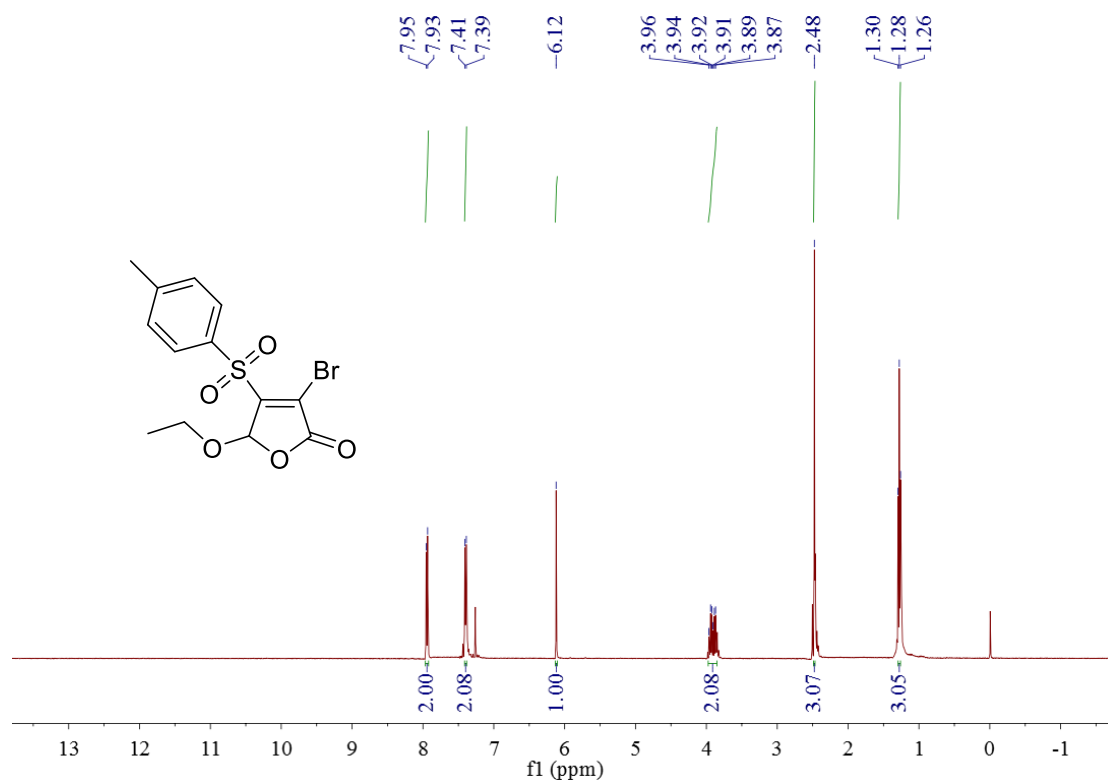
^{13}C NMR spectrum of compound **3n**



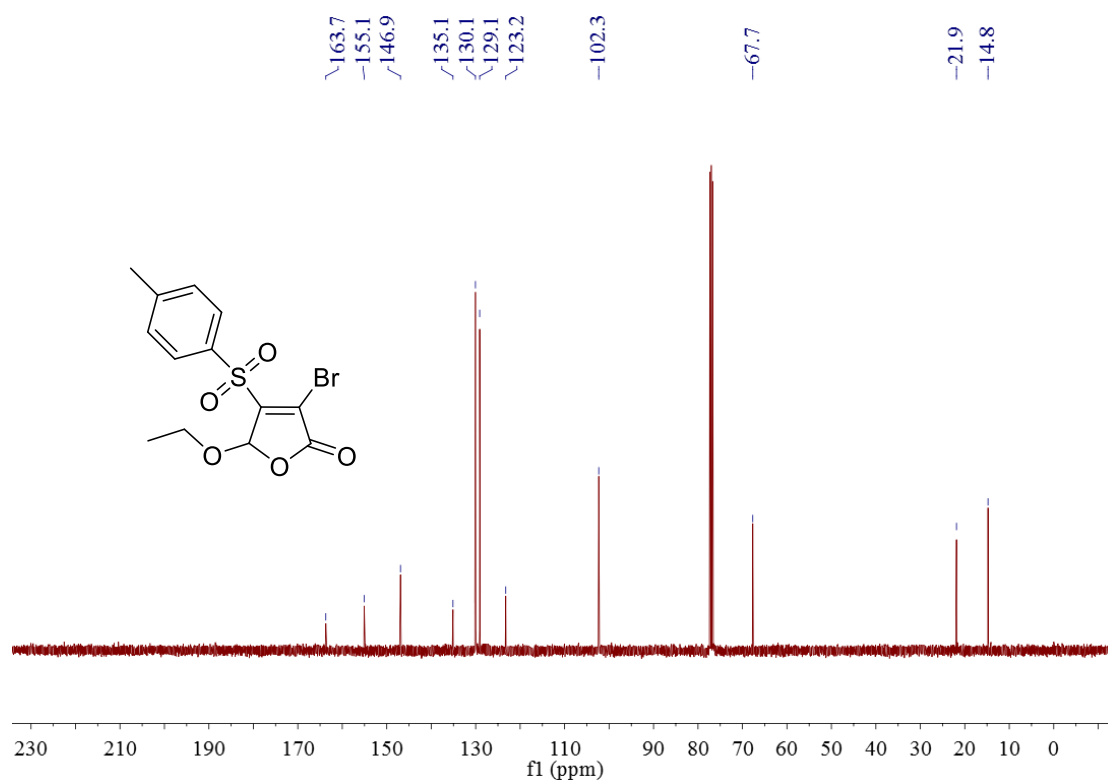
^1H NMR spectrum of compound **3o**



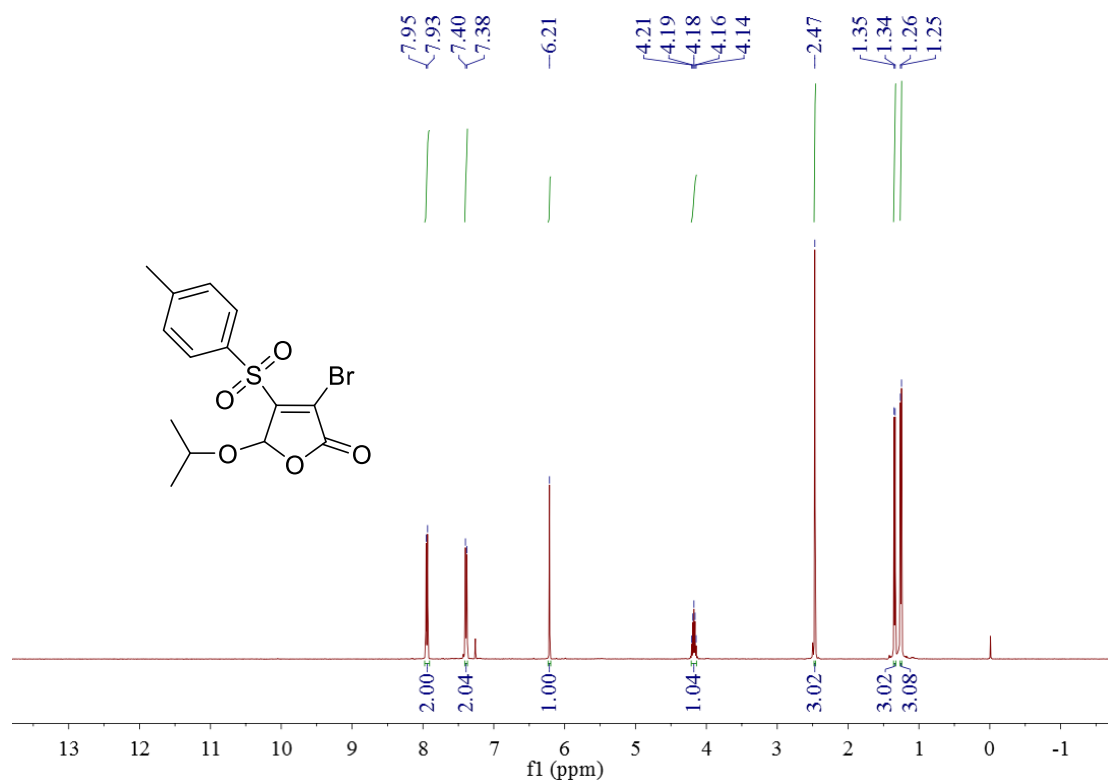
^{13}C NMR spectrum of compound **3o**



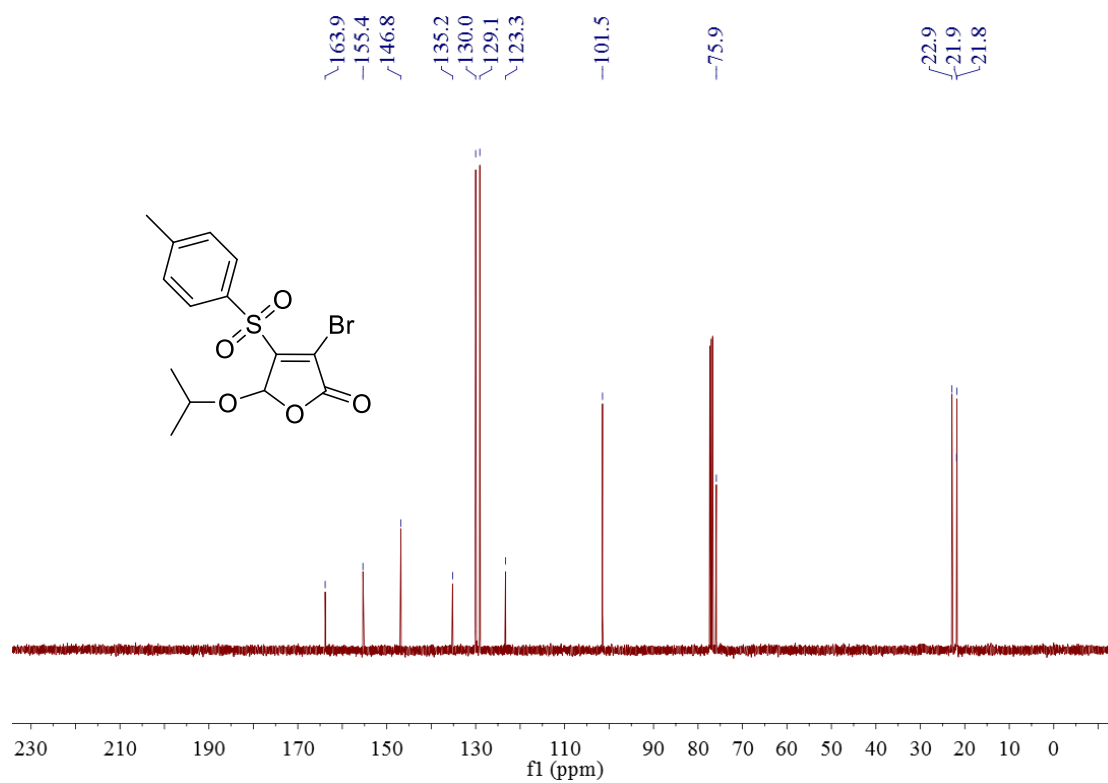
¹H NMR spectrum of compound **3p**



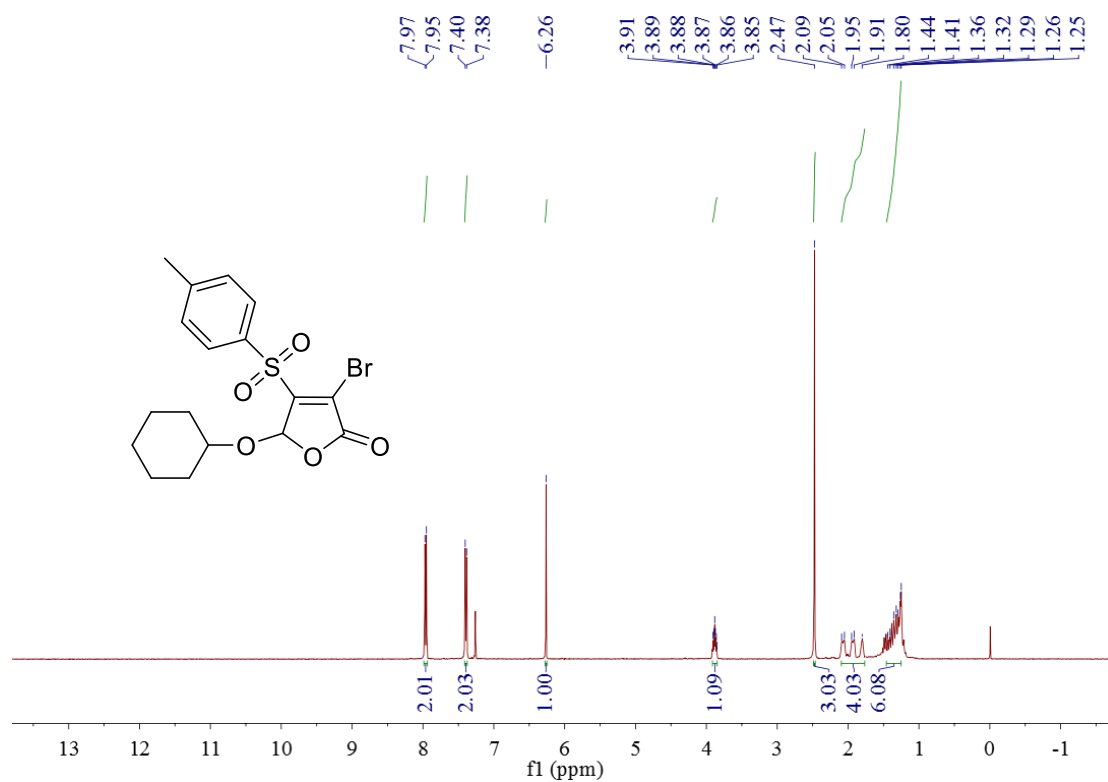
¹³C NMR spectrum of compound **3p**



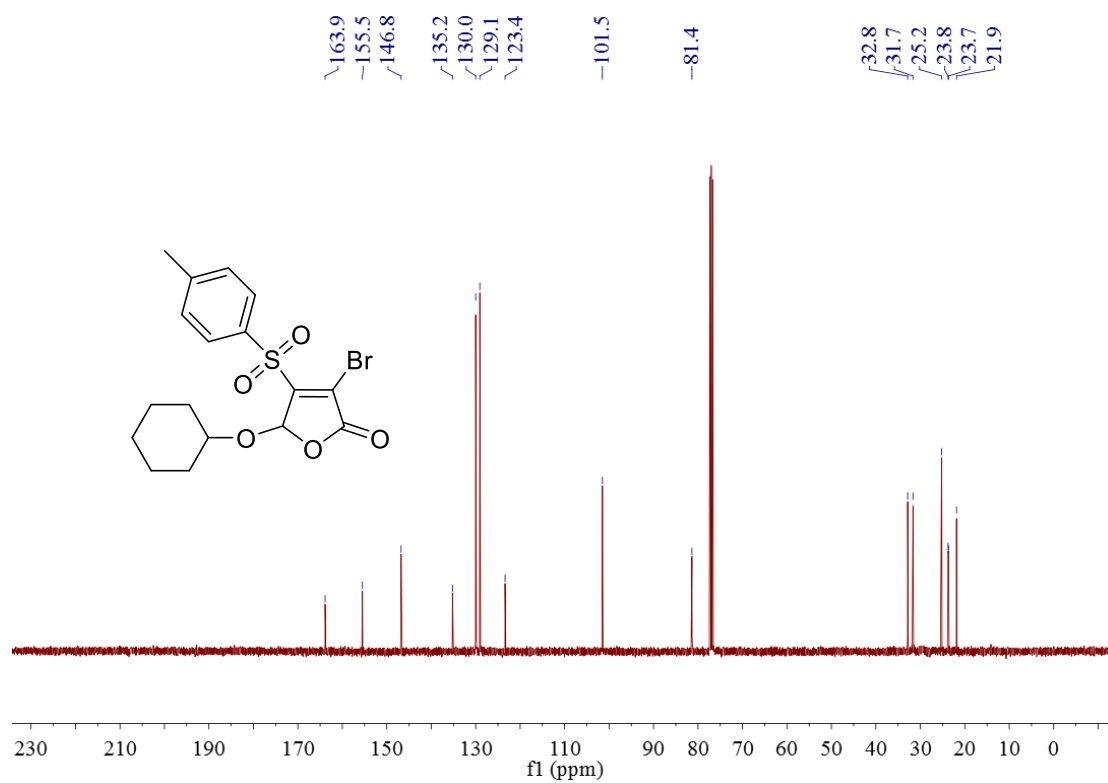
¹H NMR spectrum of compound **3q**



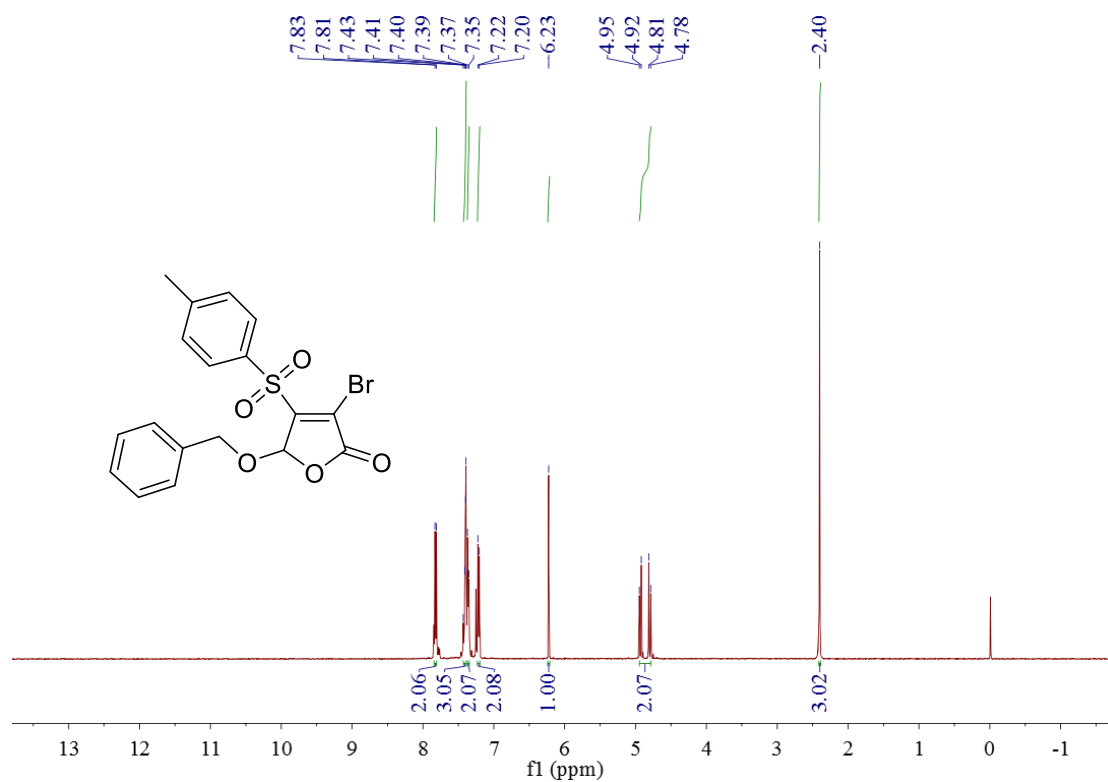
¹³C NMR spectrum of compound **3q**



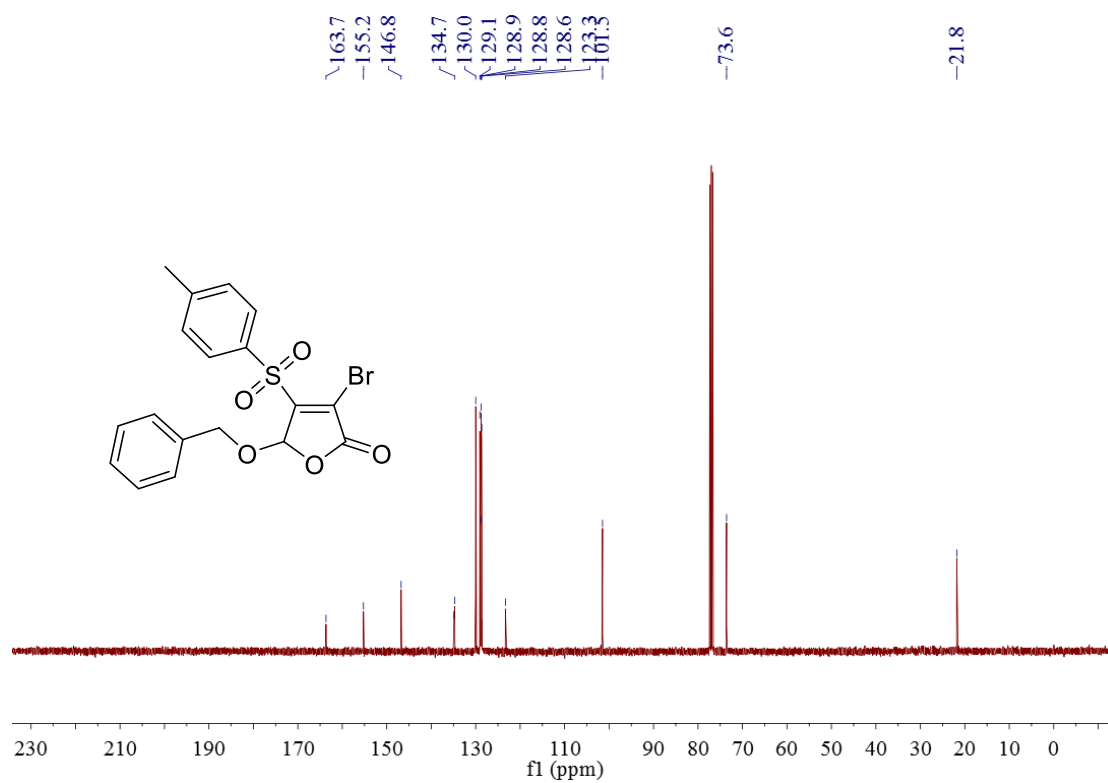
¹H NMR spectrum of compound **3r**



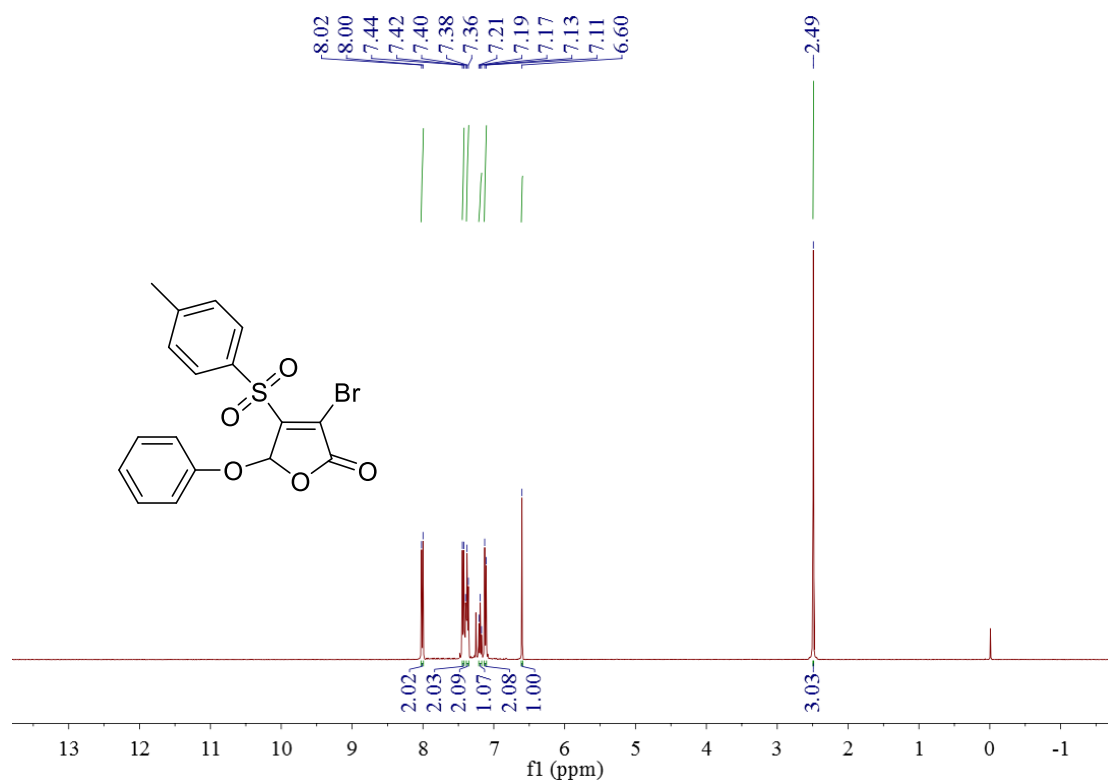
¹³C NMR spectrum of compound **3r**



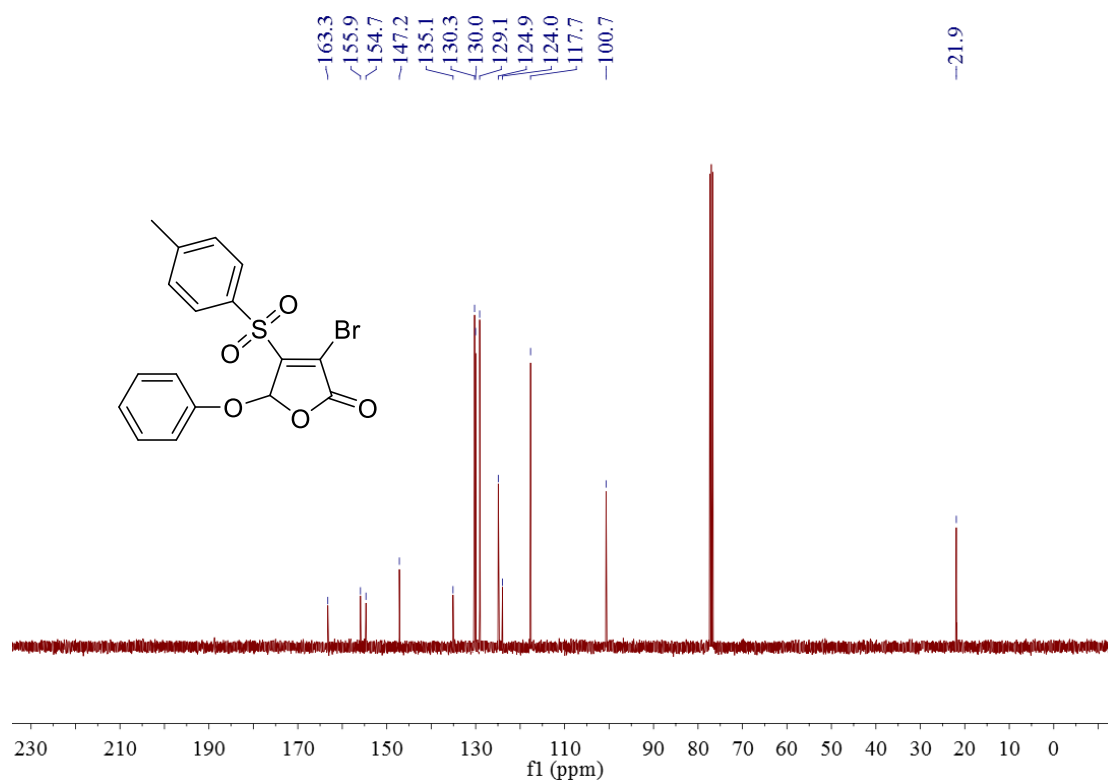
¹H NMR spectrum of compound **3s**



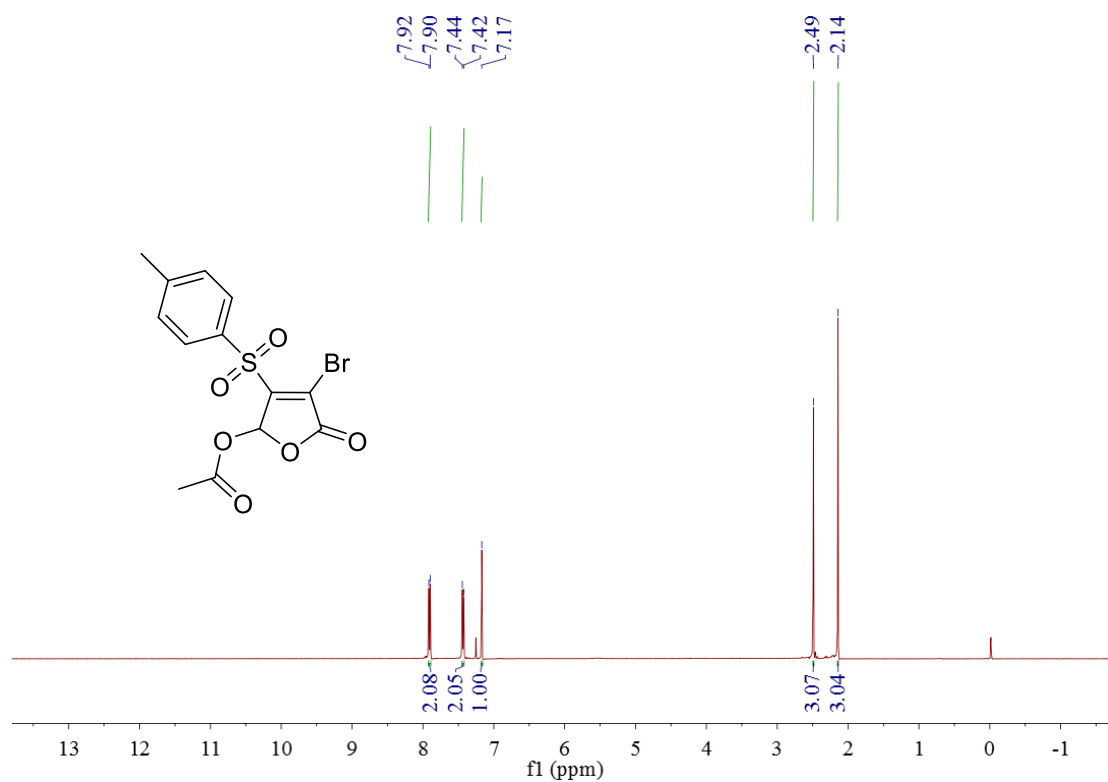
¹³C NMR spectrum of compound **3s**



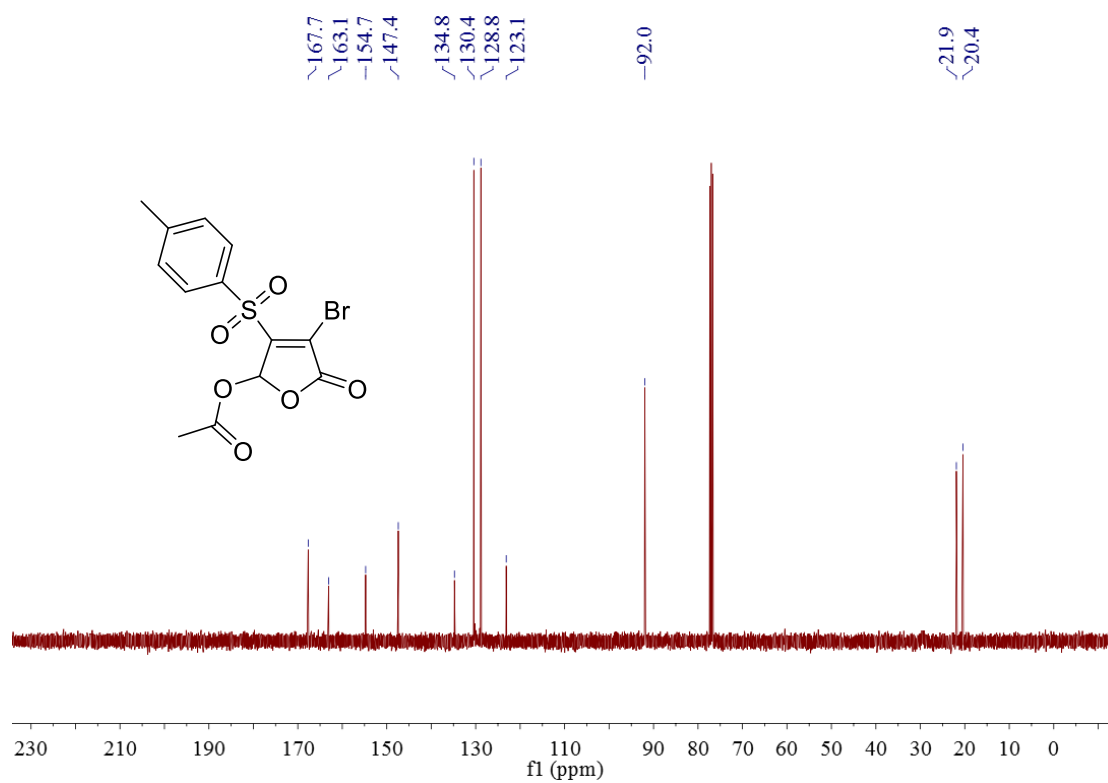
¹H NMR spectrum of compound **3t**



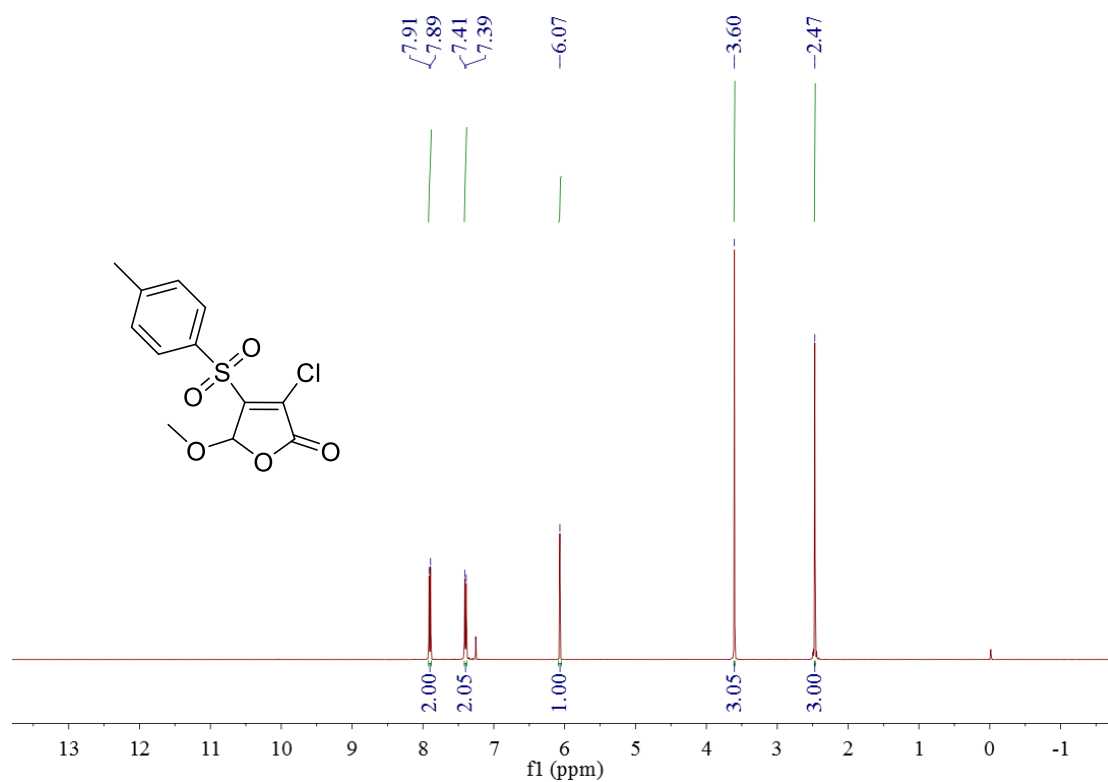
¹³C NMR spectrum of compound **3t**



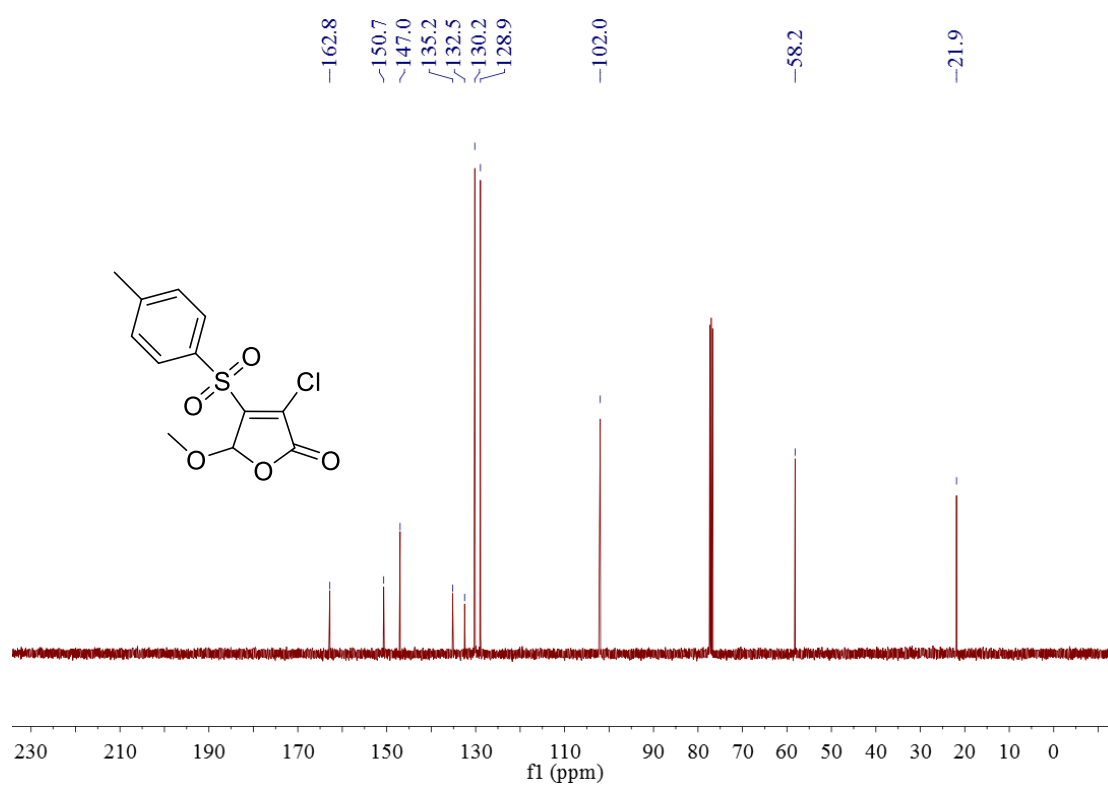
¹H NMR spectrum of compound **3u**



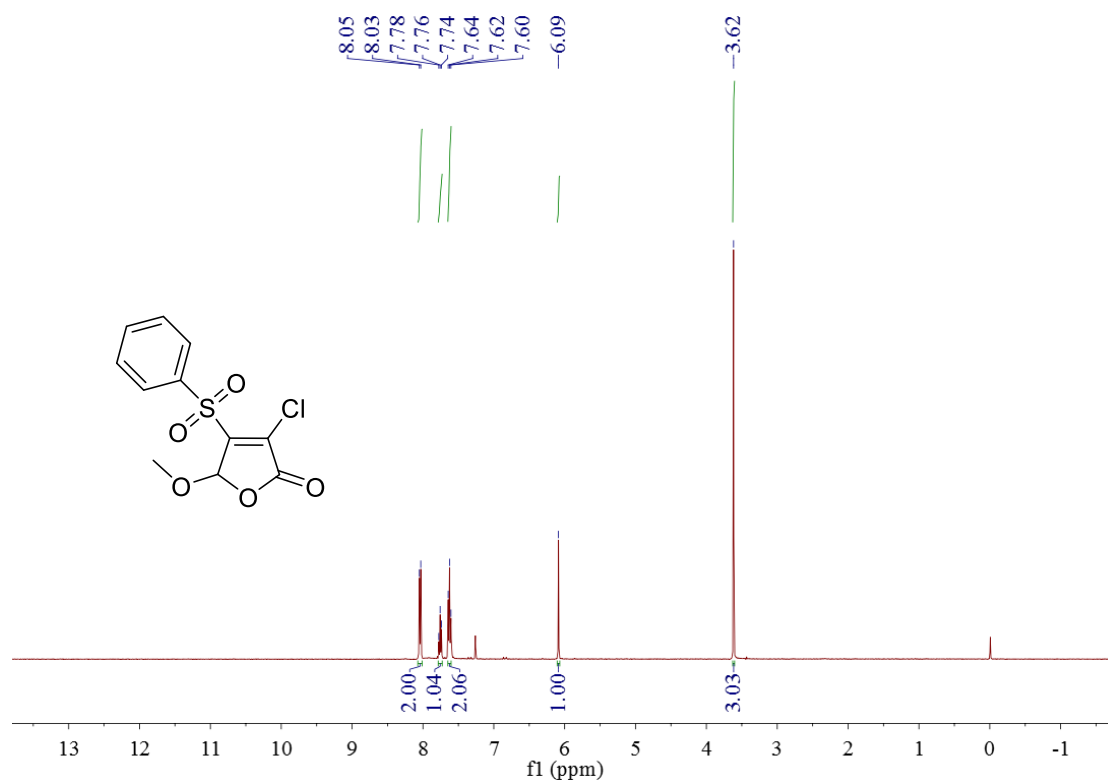
¹³C NMR spectrum of compound **3u**



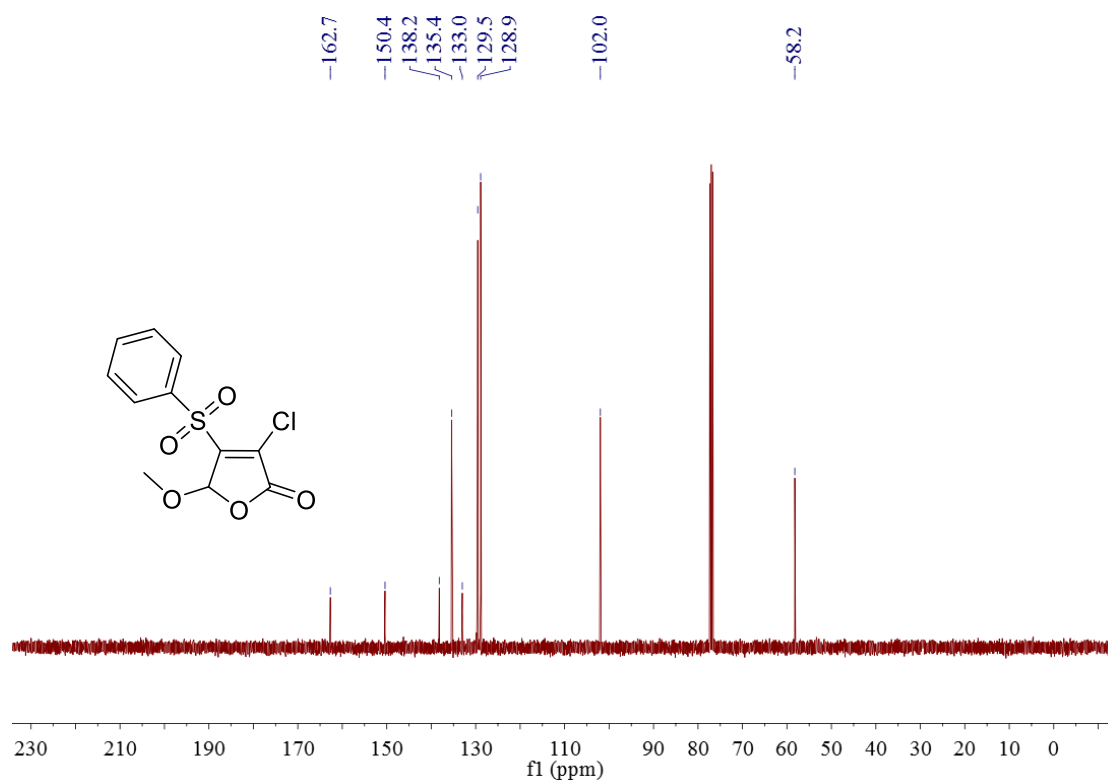
¹H NMR spectrum of compound **4a**



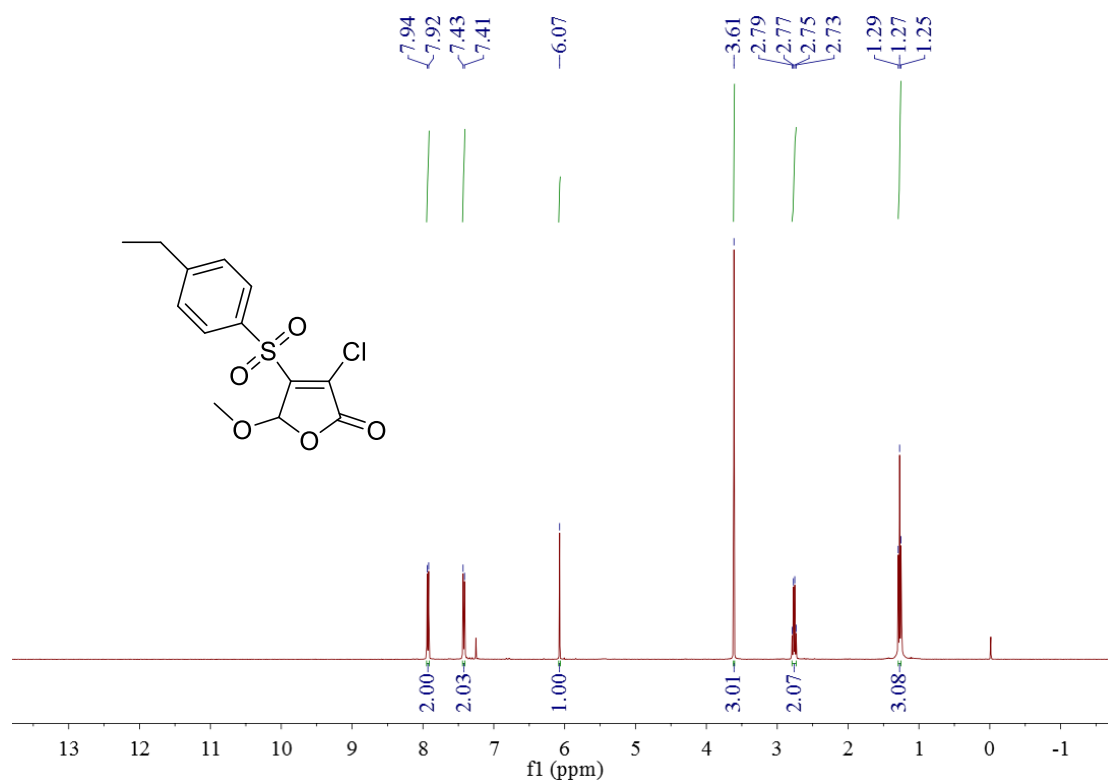
¹³C NMR spectrum of compound **4a**



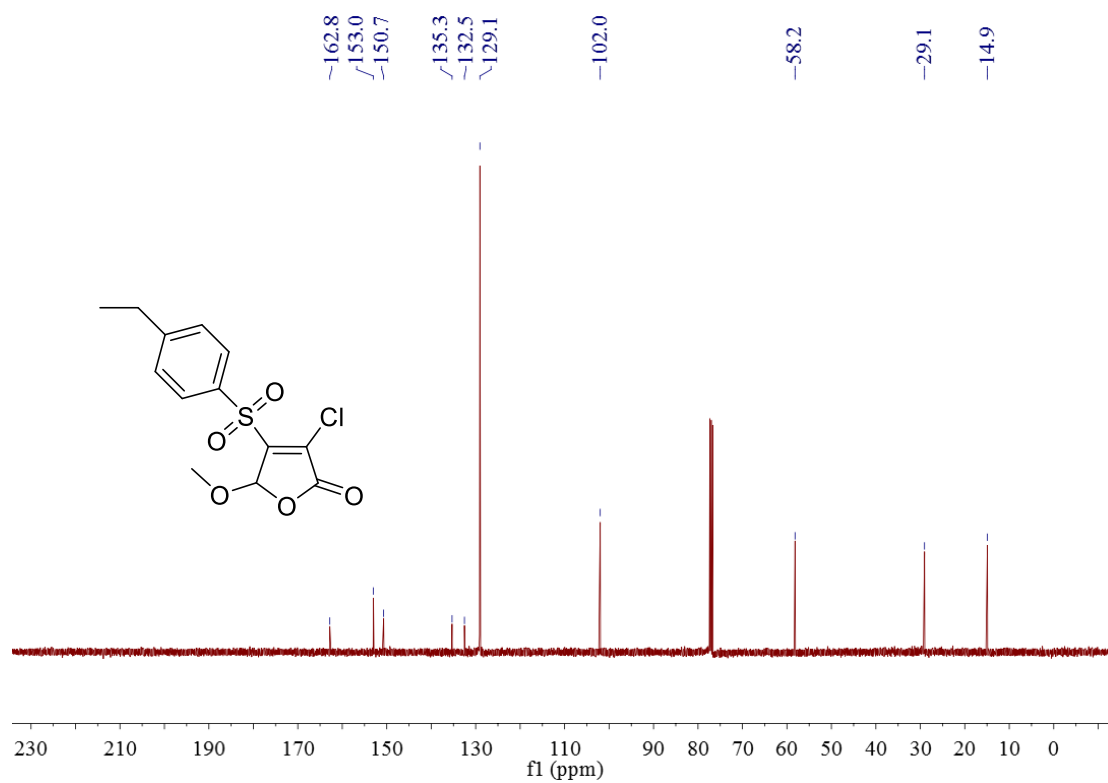
¹H NMR spectrum of compound **4b**



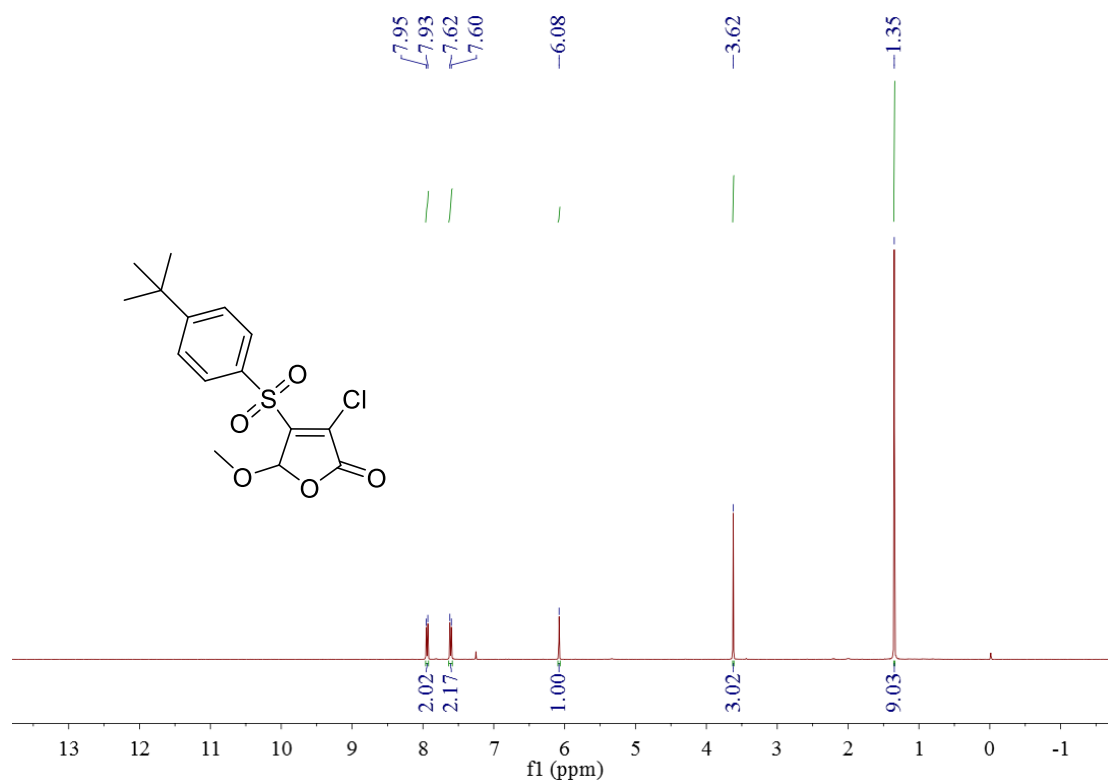
¹³C NMR spectrum of compound **4b**



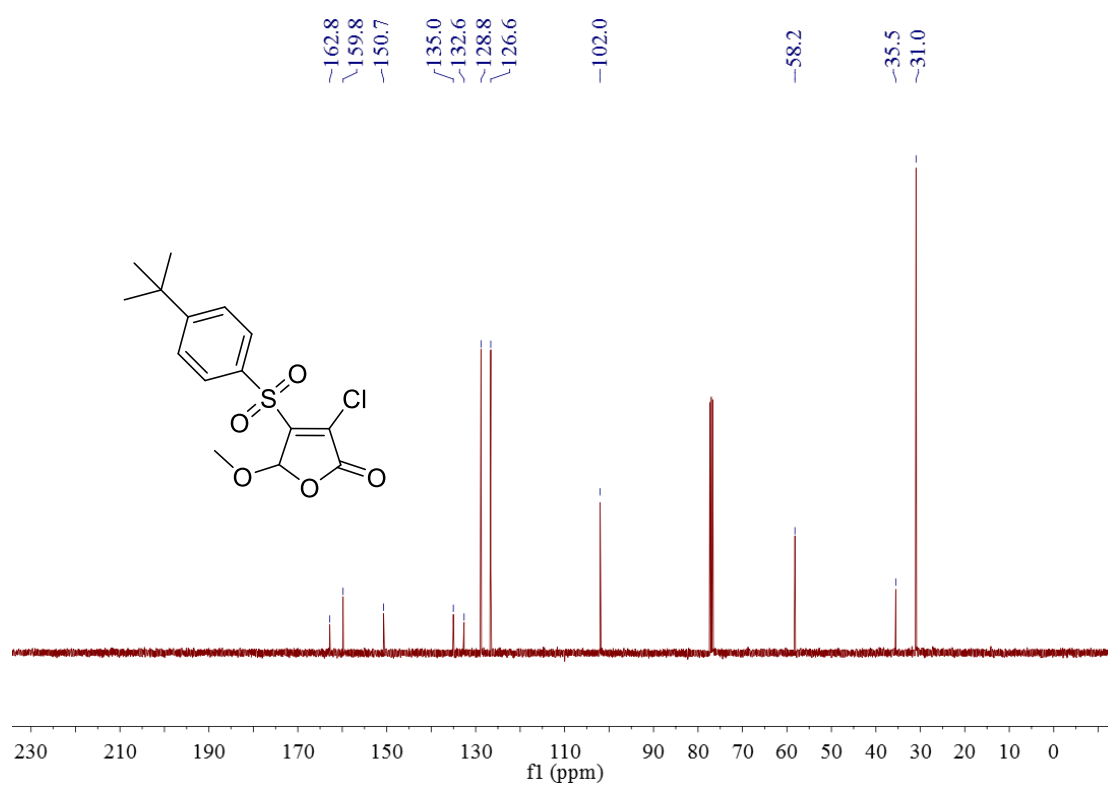
¹H NMR spectrum of compound **4c**



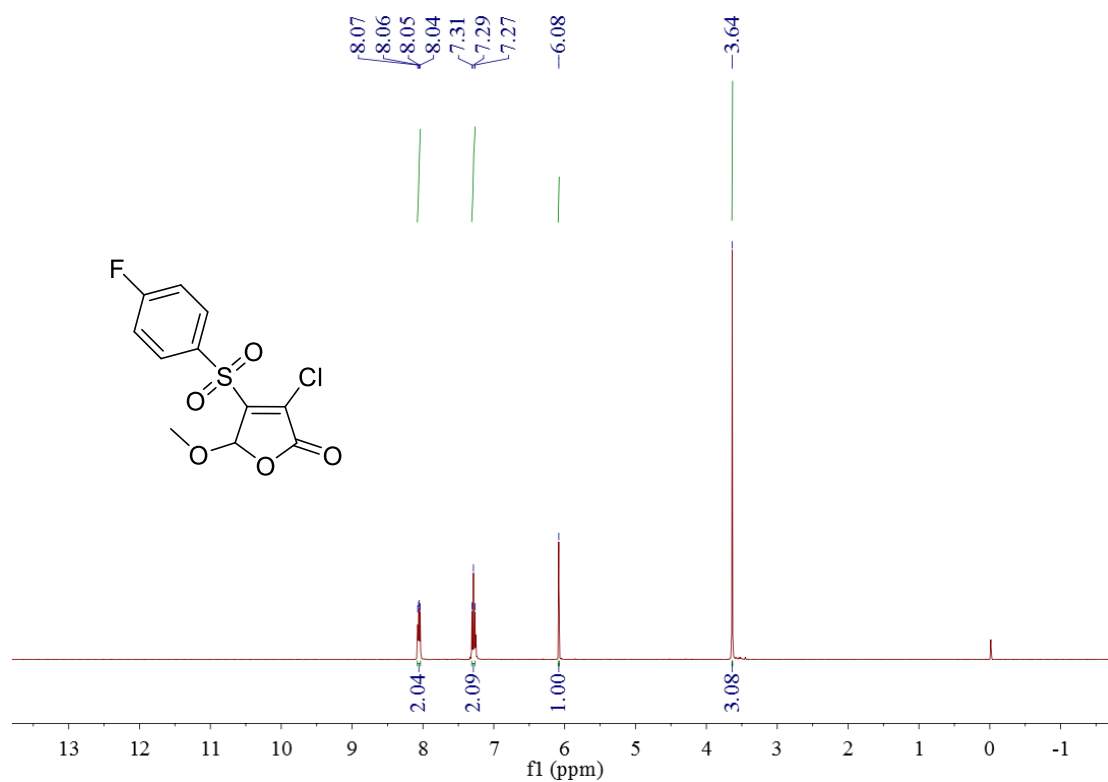
¹³C NMR spectrum of compound **4c**



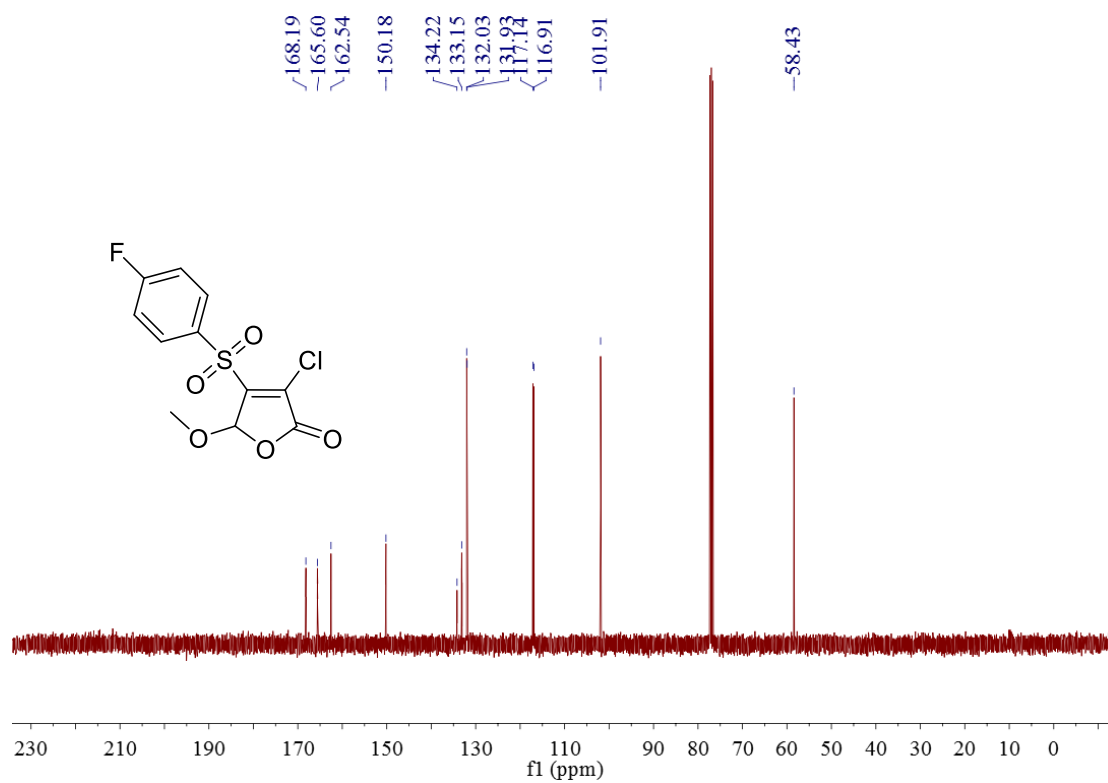
^1H NMR spectrum of compound **4d**



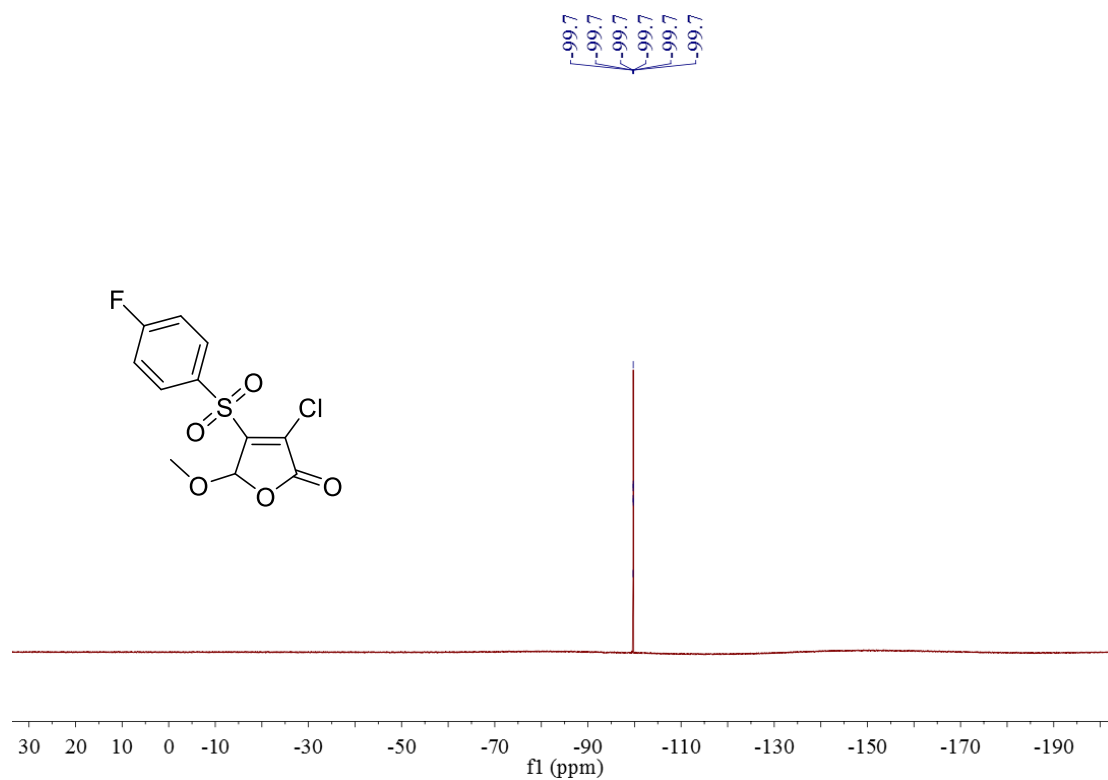
^{13}C NMR spectrum of compound **4d**



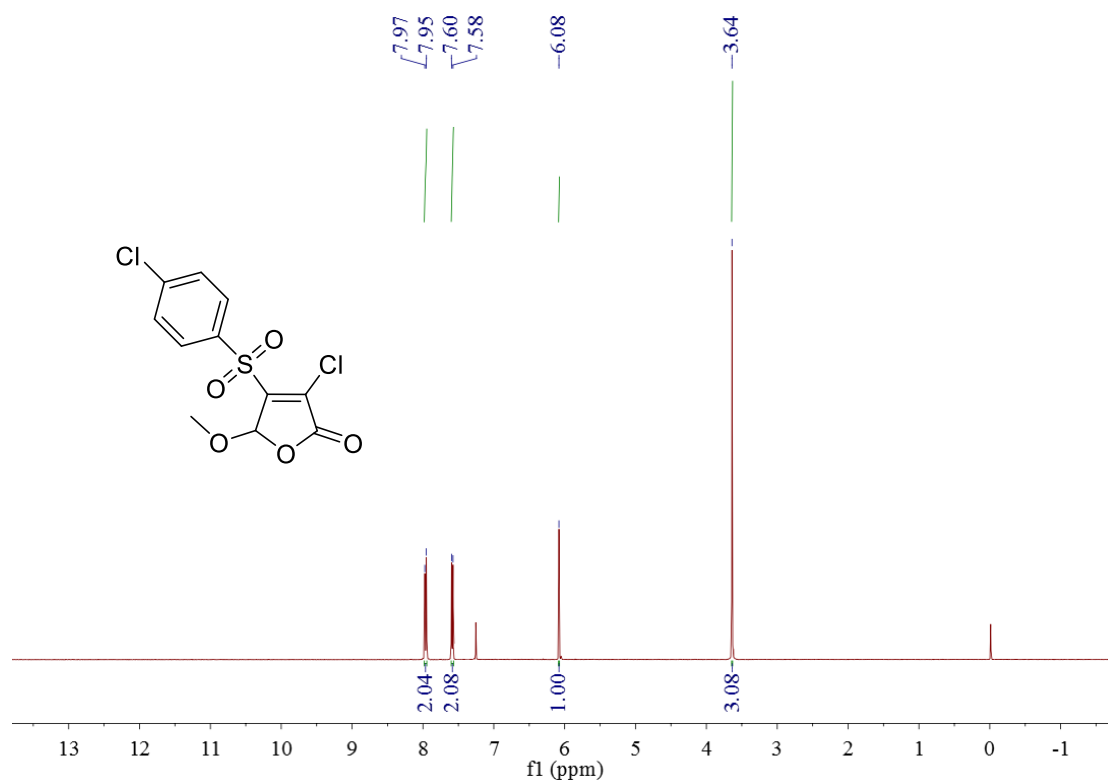
^1H NMR spectrum of compound **4e**



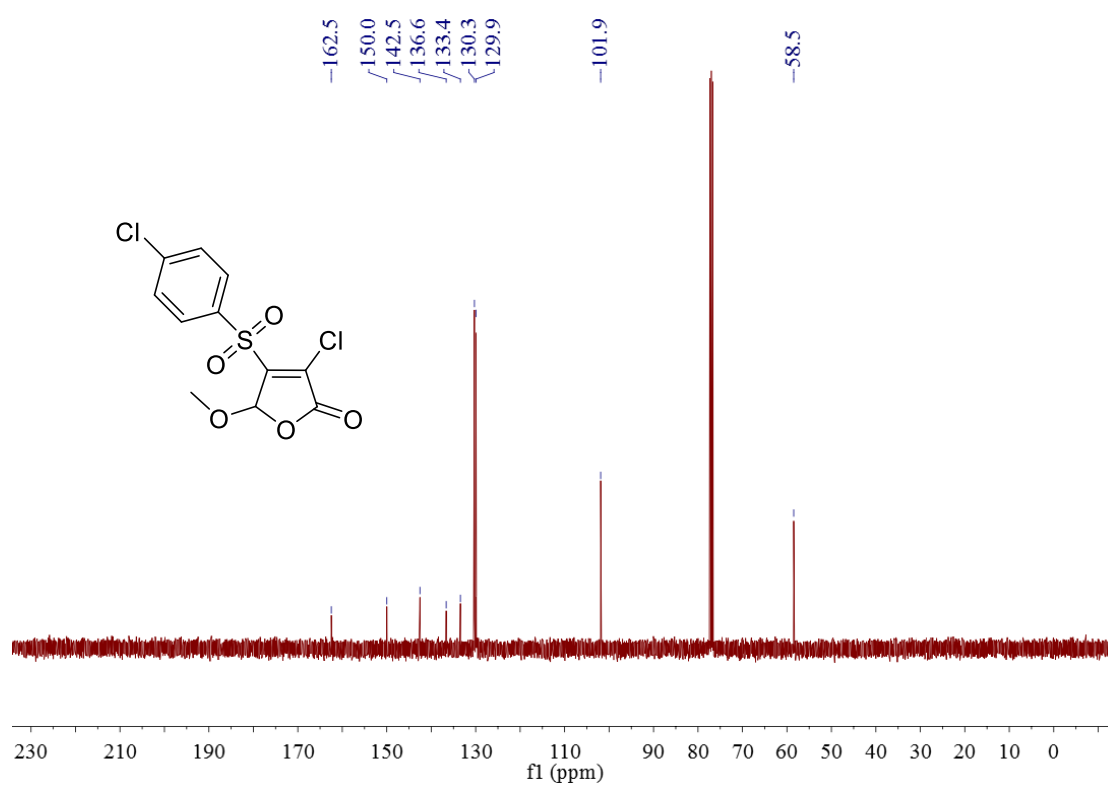
^{13}C NMR spectrum of compound **4e**



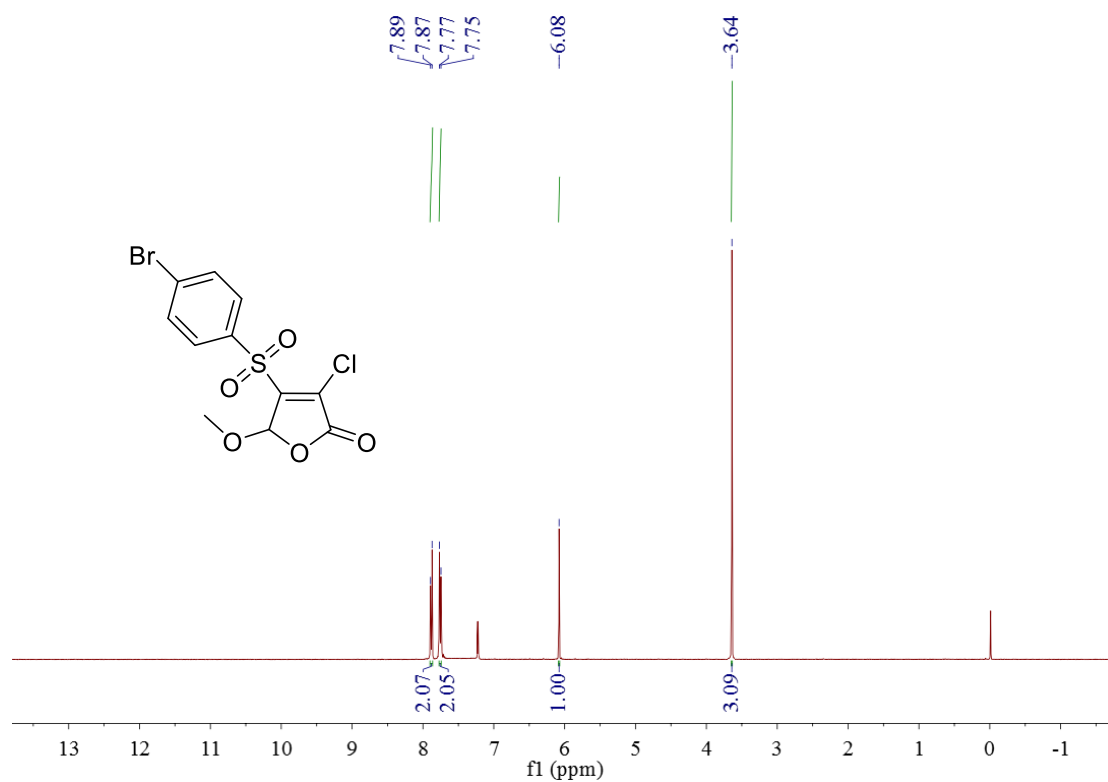
^{19}F NMR spectrum of compound **4e**



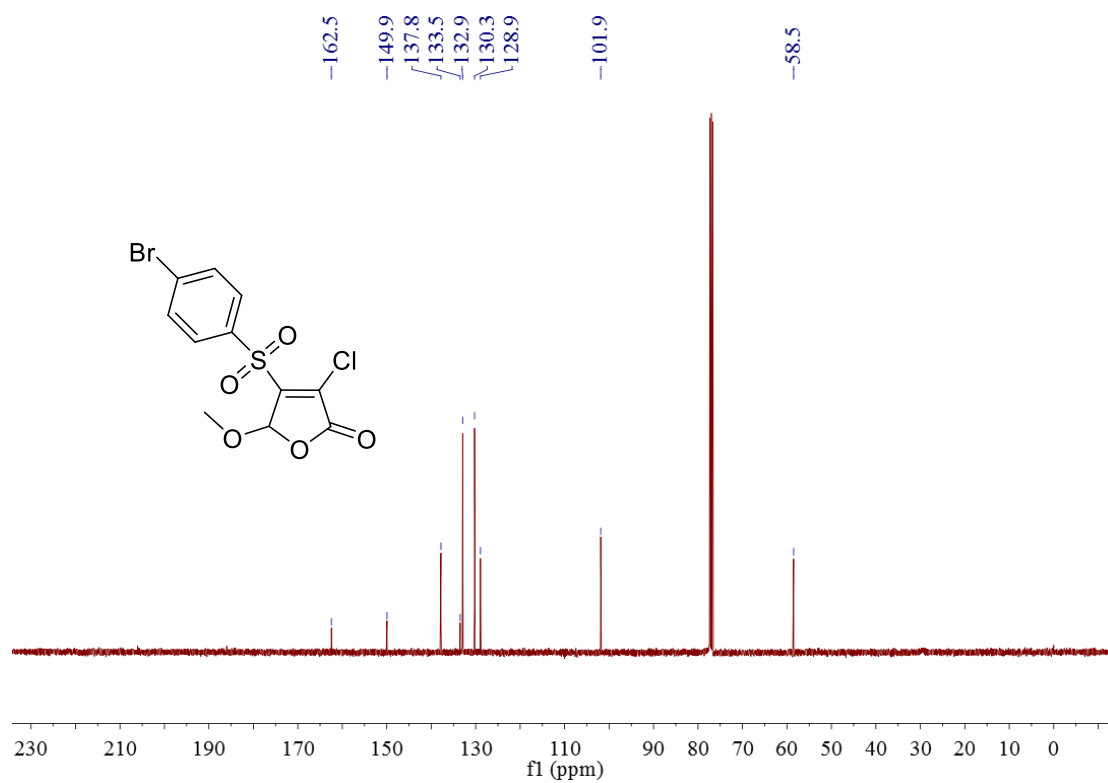
¹H NMR spectrum of compound **4f**



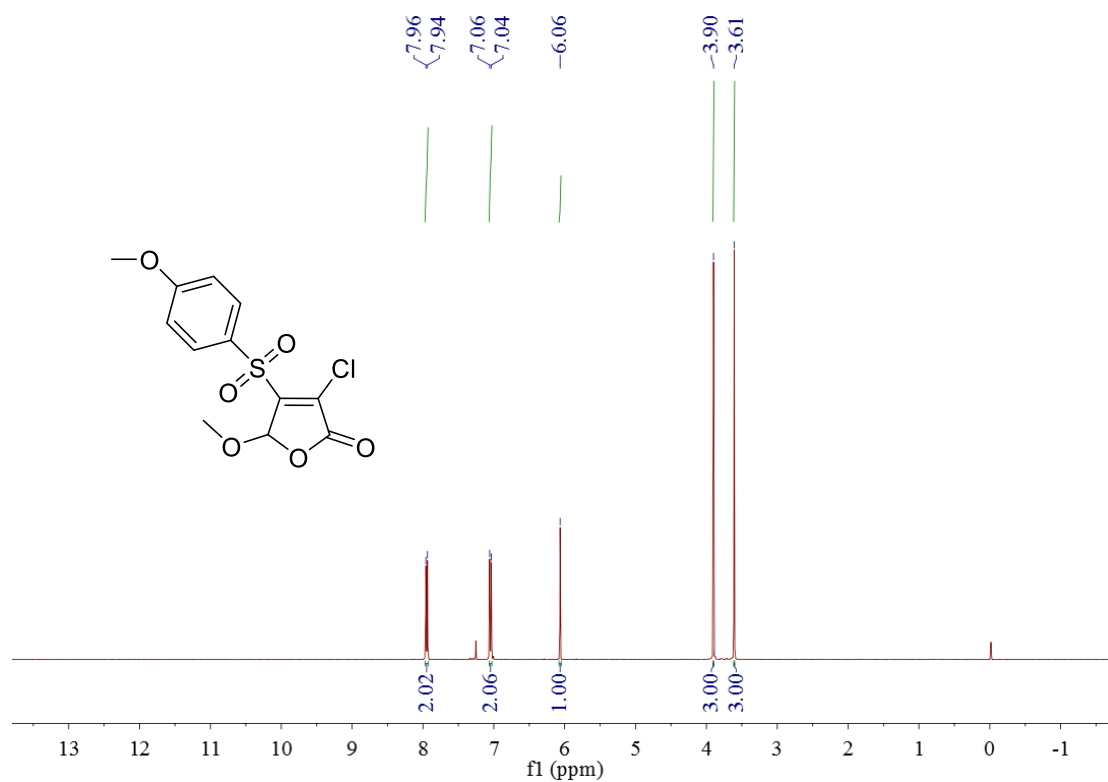
¹³C NMR spectrum of compound **4f**



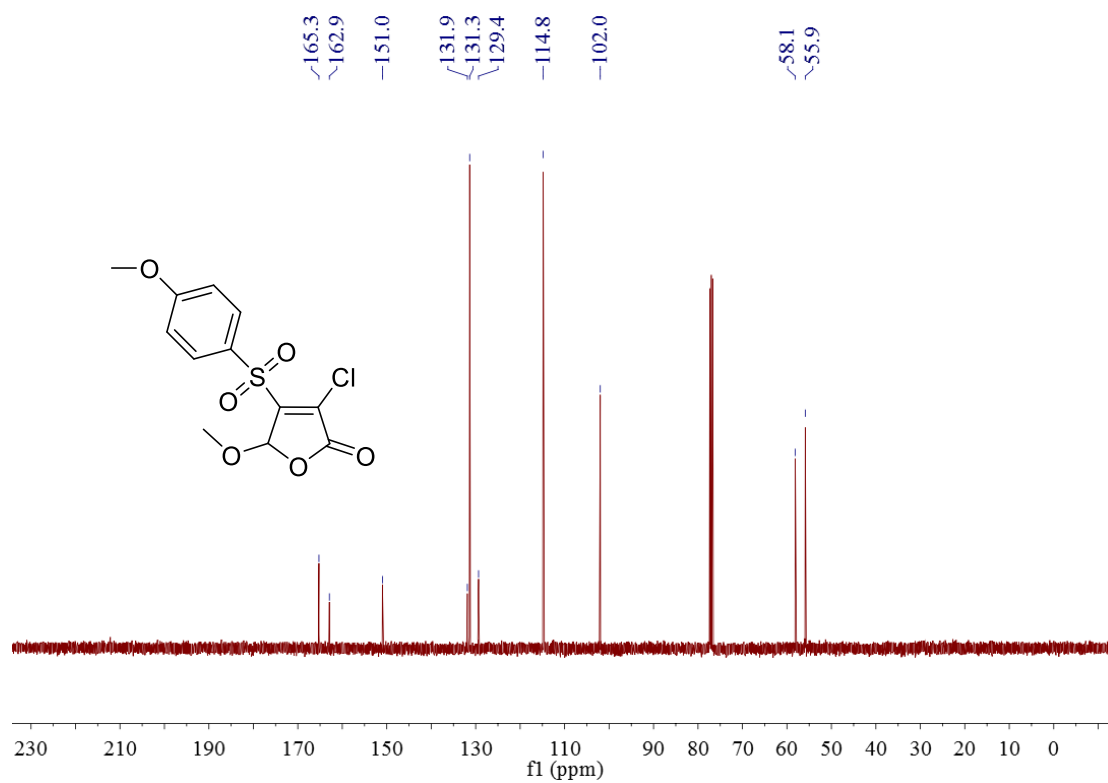
^1H NMR spectrum of compound **4g**



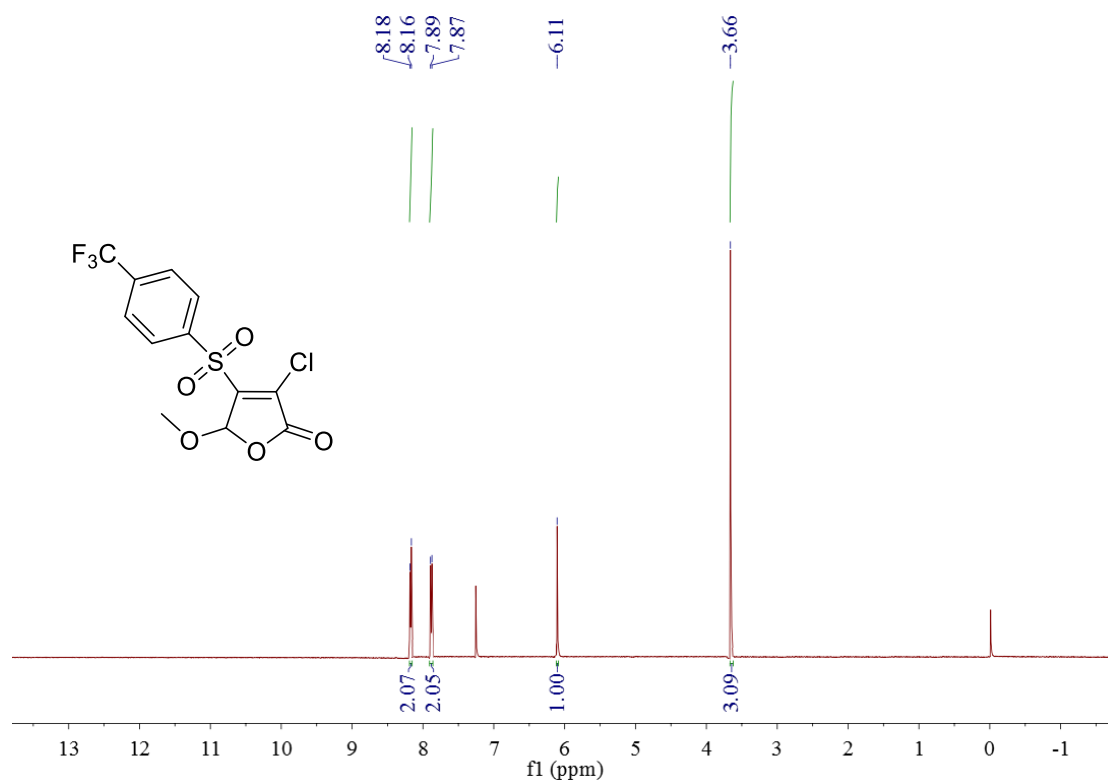
^{13}C NMR spectrum of compound **4g**



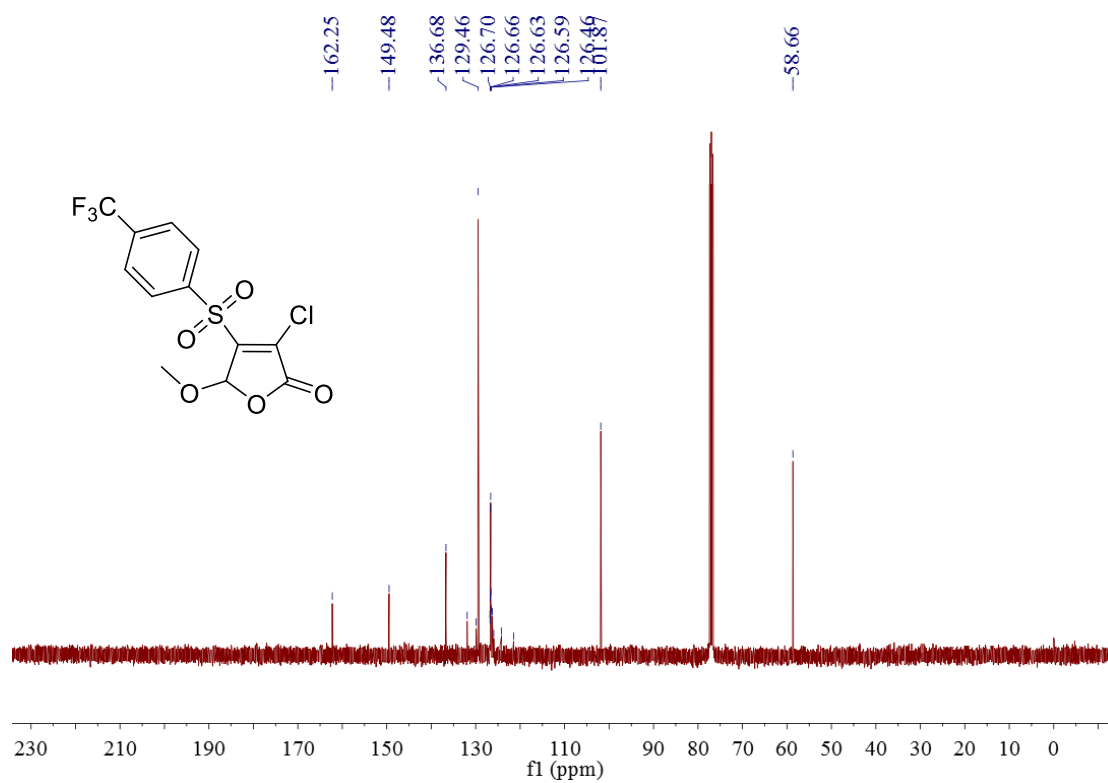
¹H NMR spectrum of compound **4h**



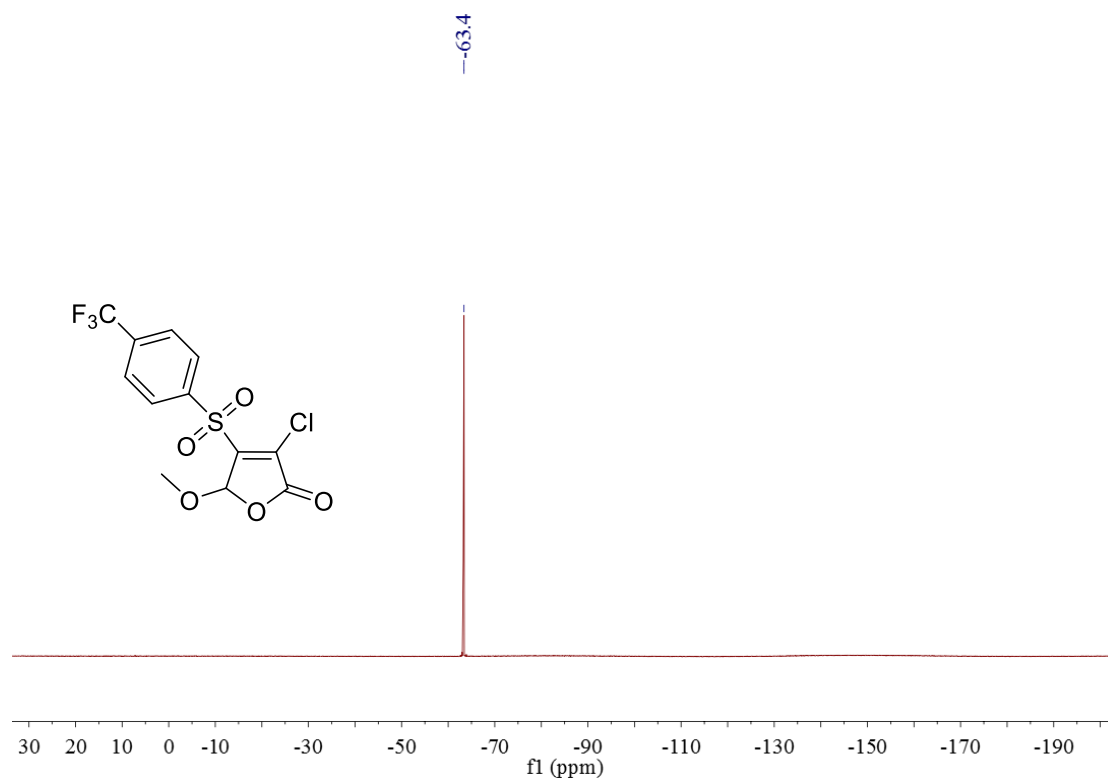
¹³C NMR spectrum of compound **4h**



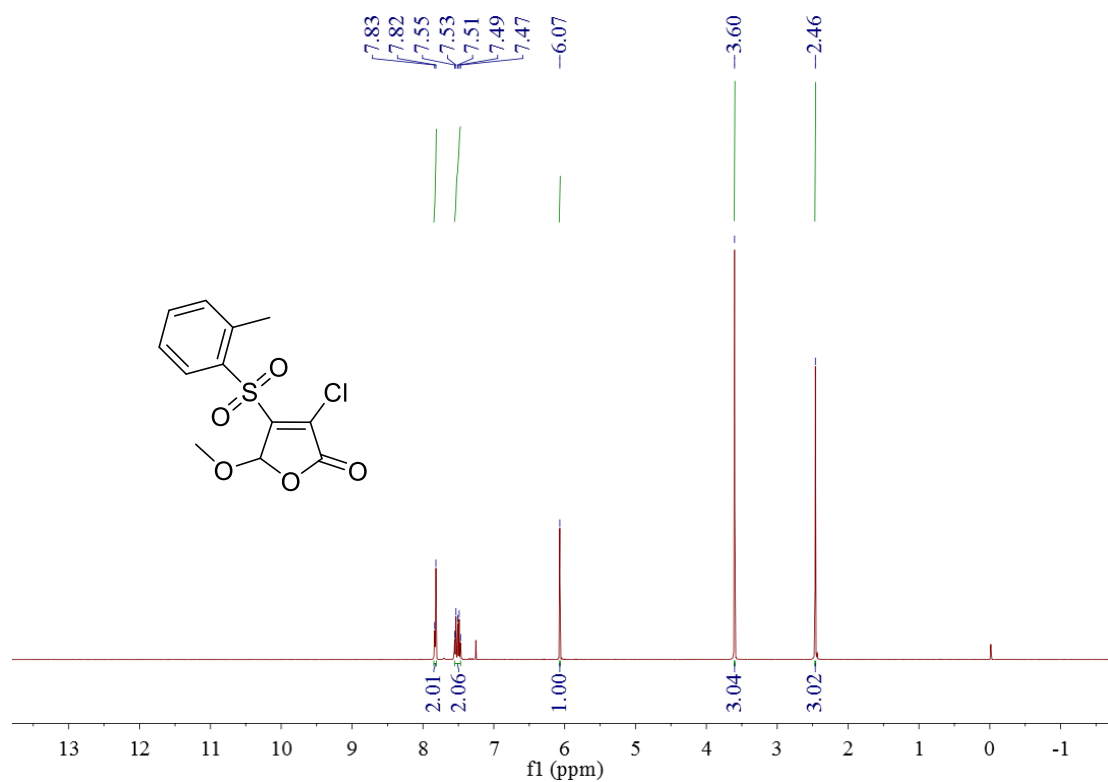
¹H NMR spectrum of compound **4i**



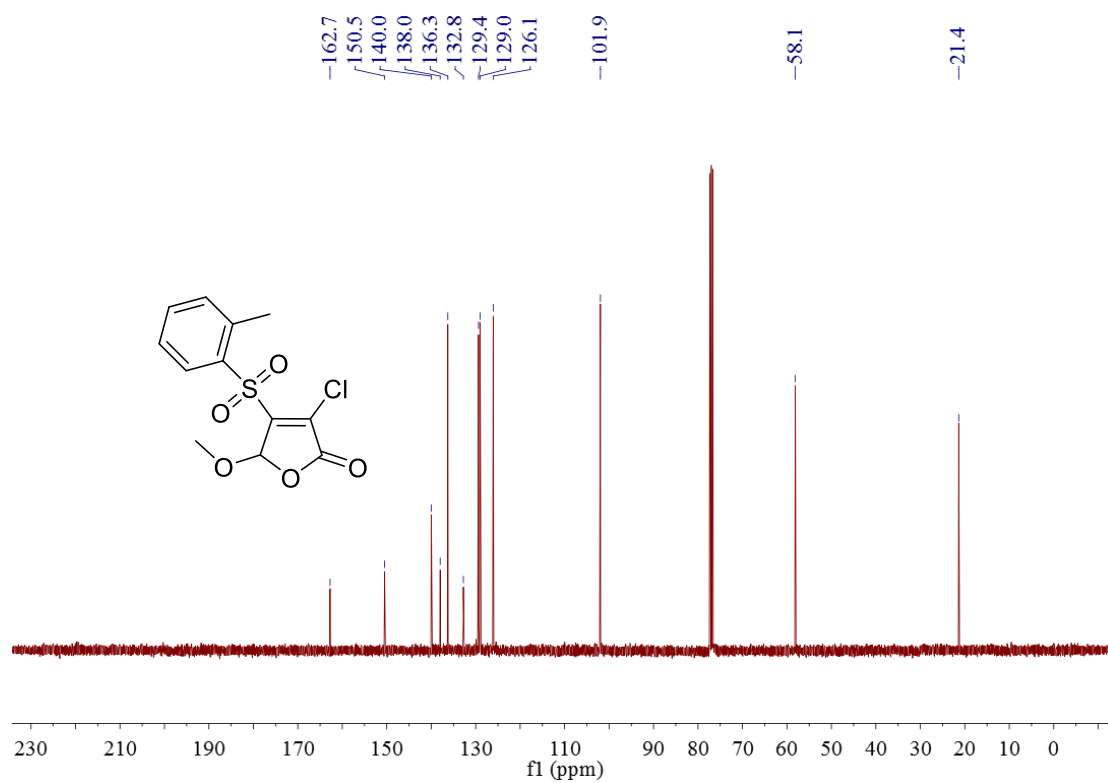
¹³C NMR spectrum of compound **4i**



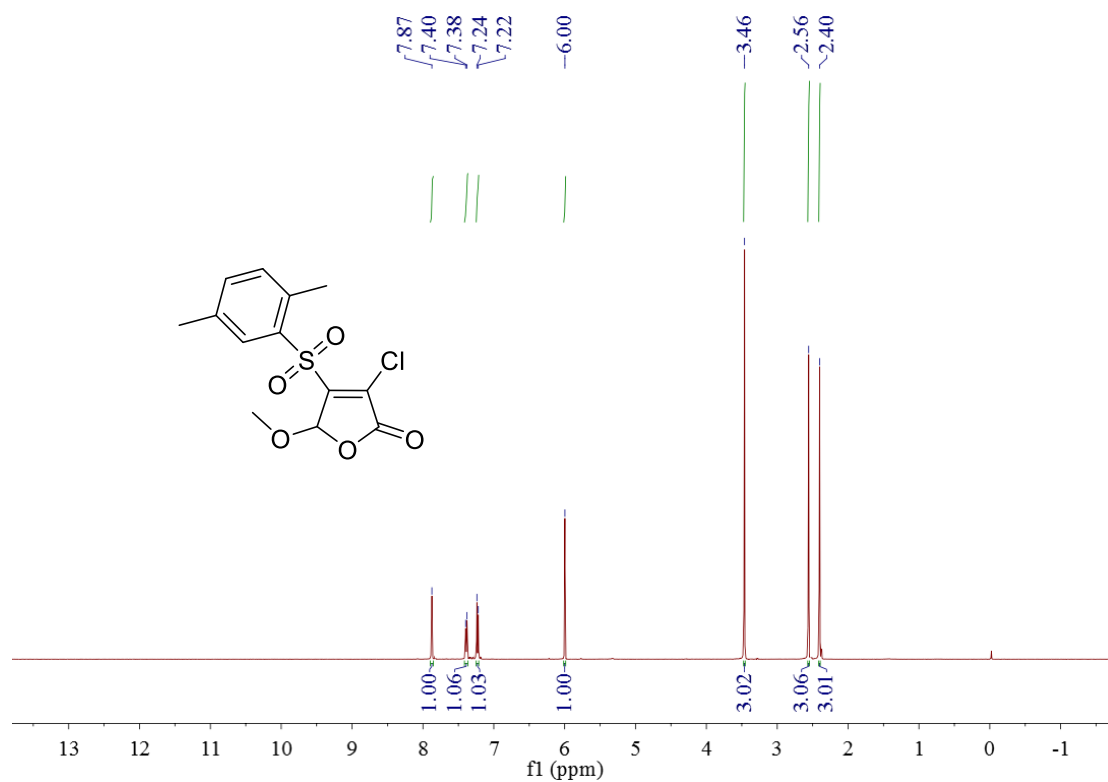
^{19}F NMR spectrum of compound **4i**



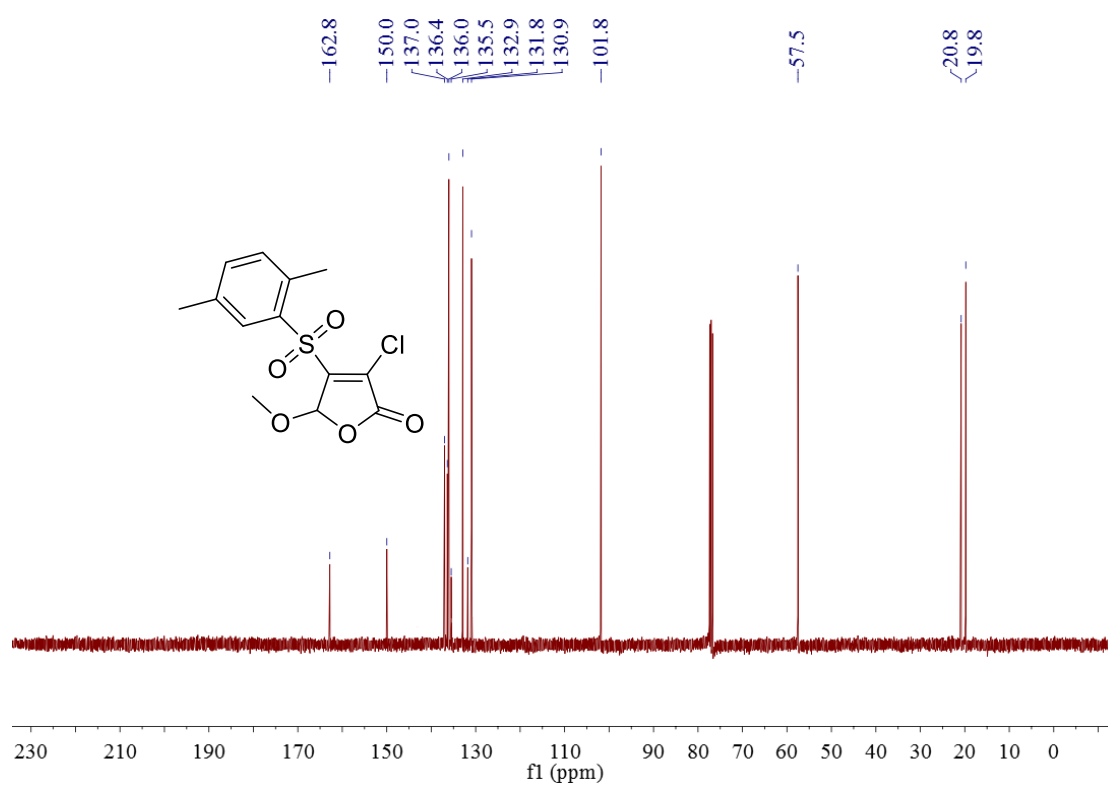
¹H NMR spectrum of compound **4j**



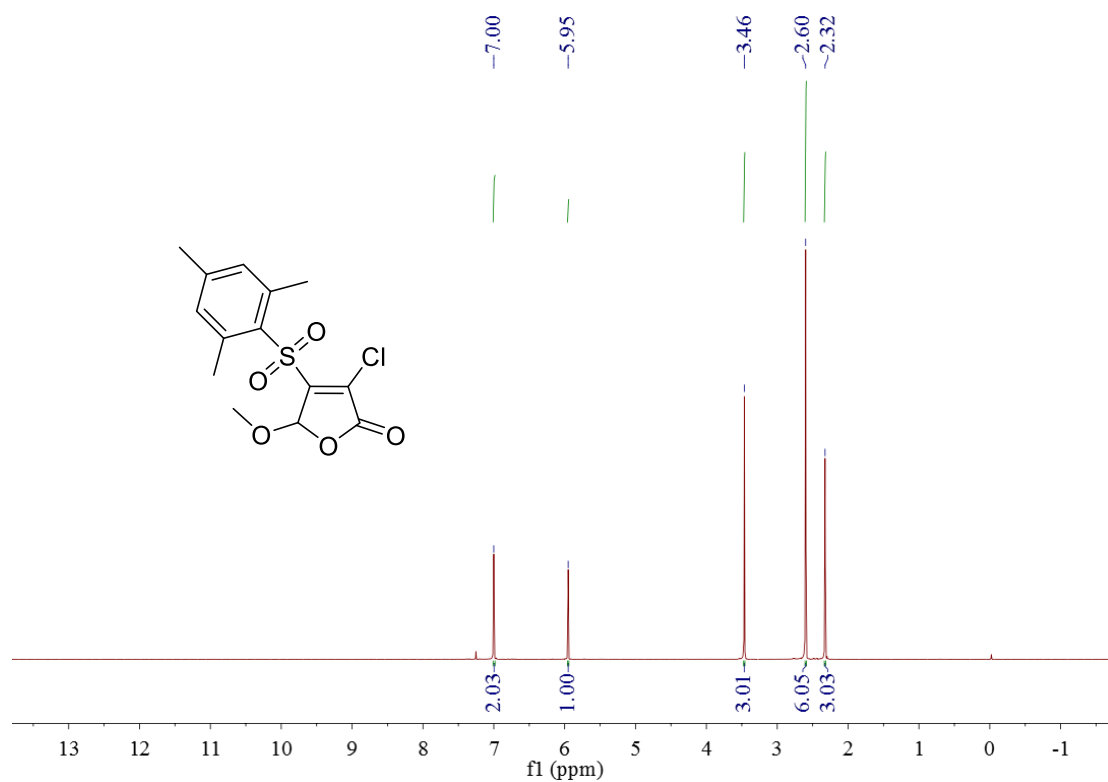
¹³C NMR spectrum of compound **4j**



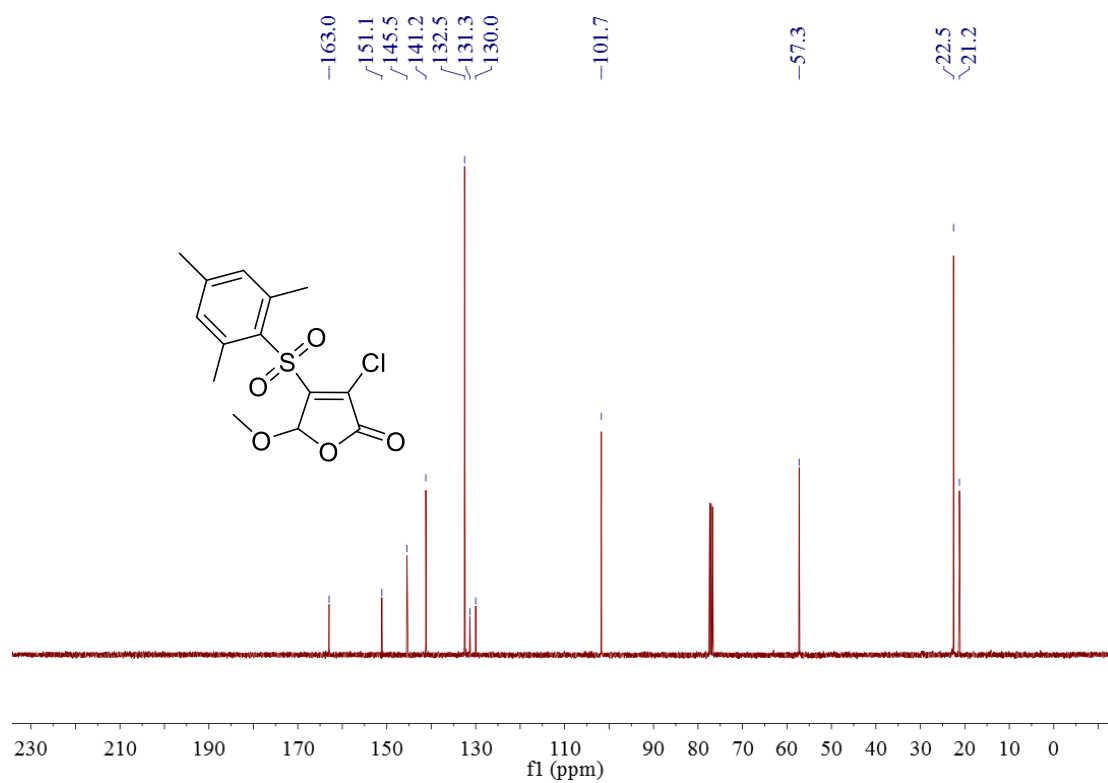
¹H NMR spectrum of compound **4k**



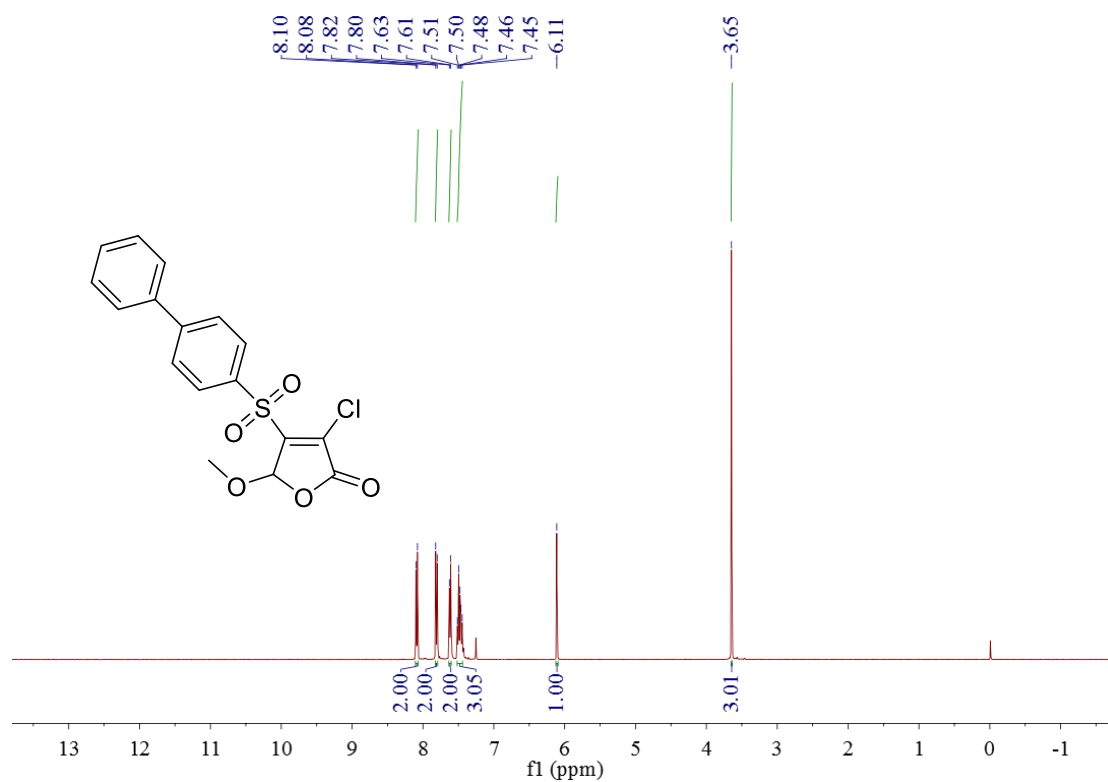
¹³C NMR spectrum of compound **4k**



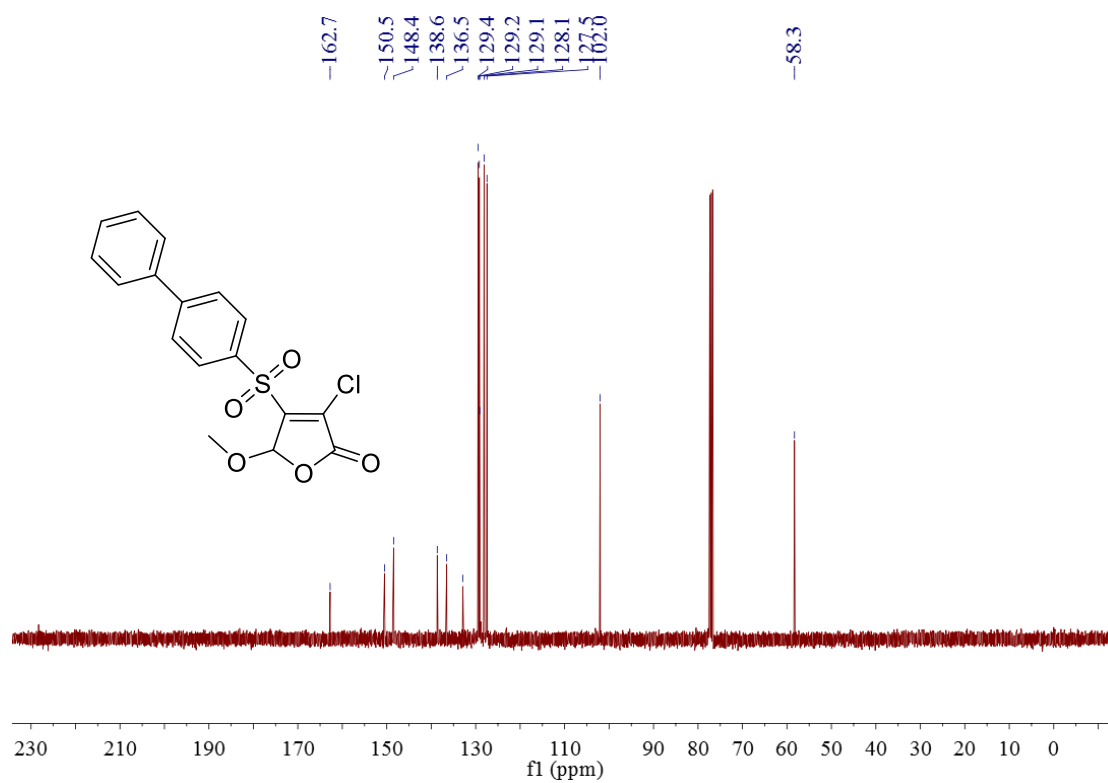
¹H NMR spectrum of compound **4l**



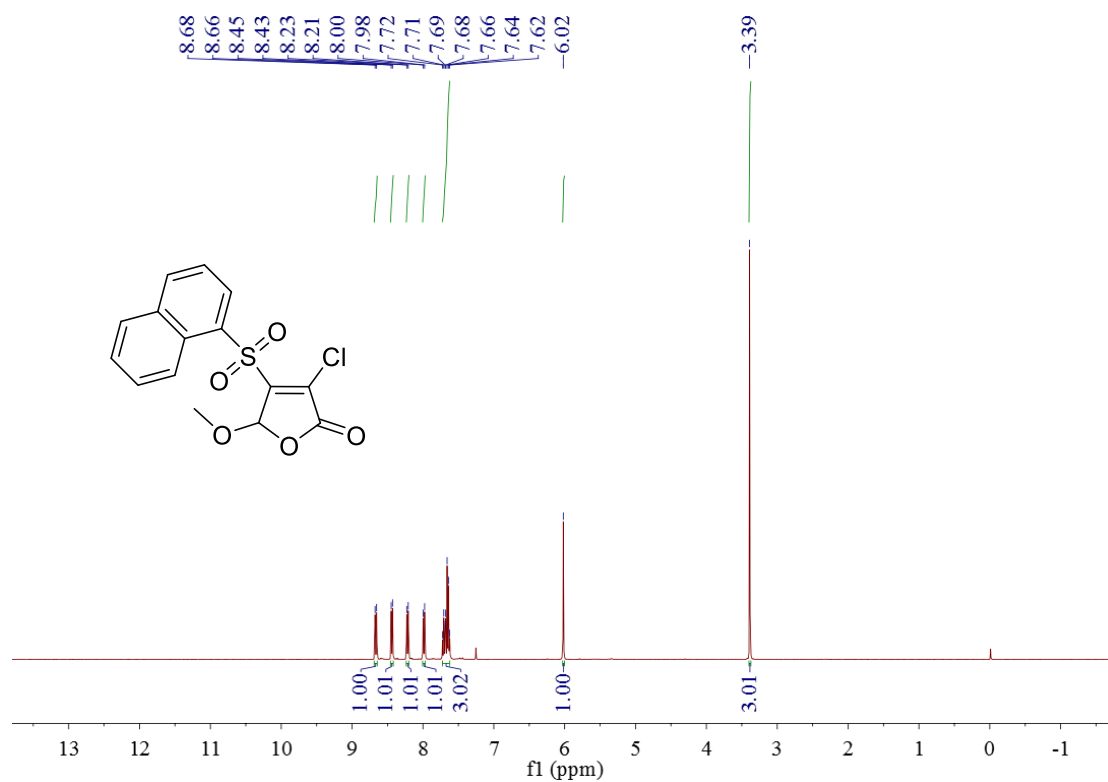
¹³C NMR spectrum of compound **4l**



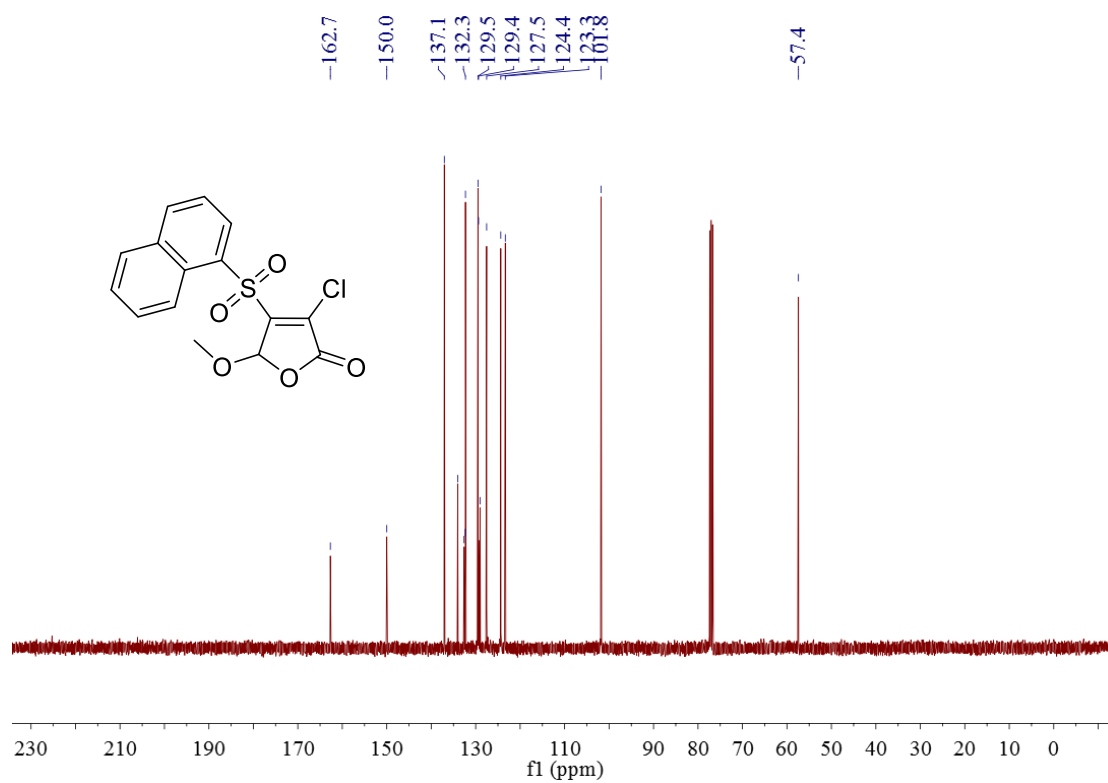
¹H NMR spectrum of compound **4m**



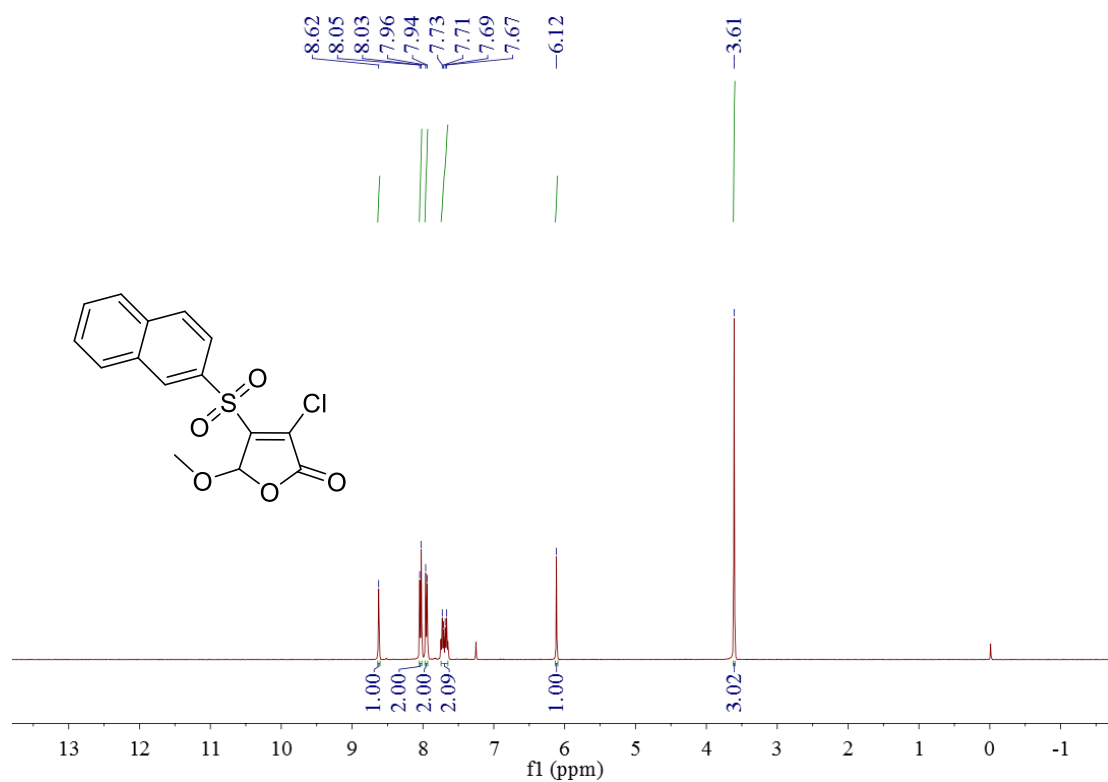
¹³C NMR spectrum of compound **4m**



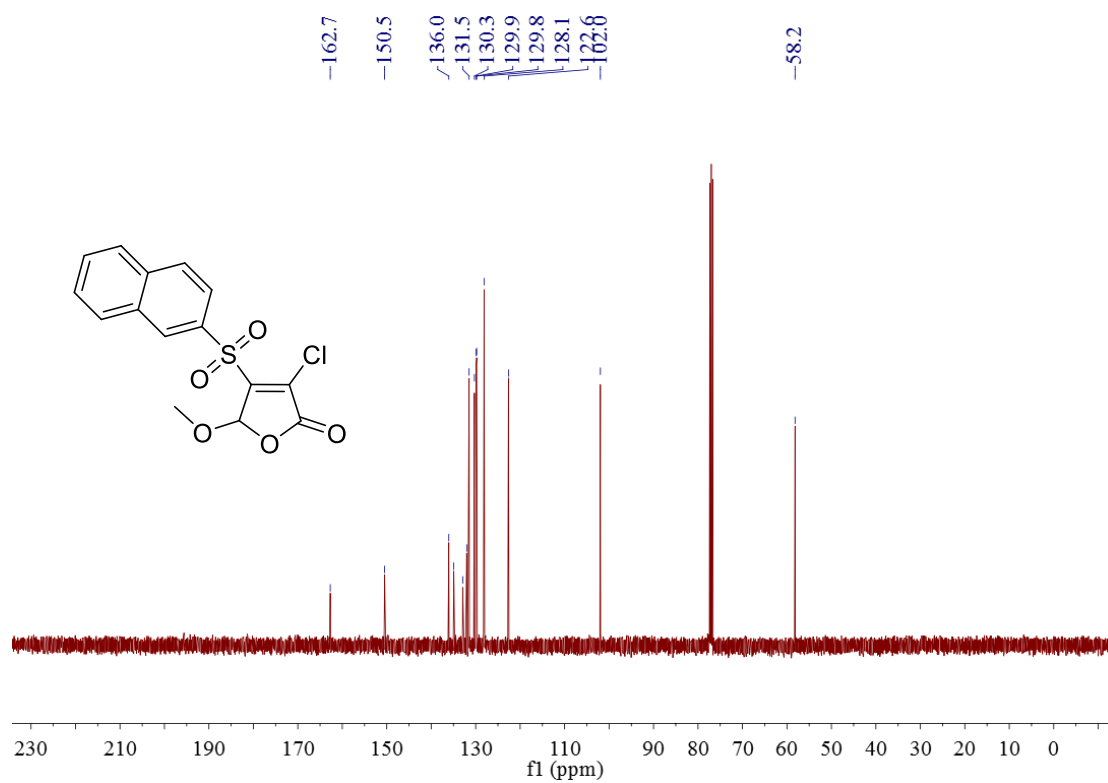
¹H NMR spectrum of compound **4n**



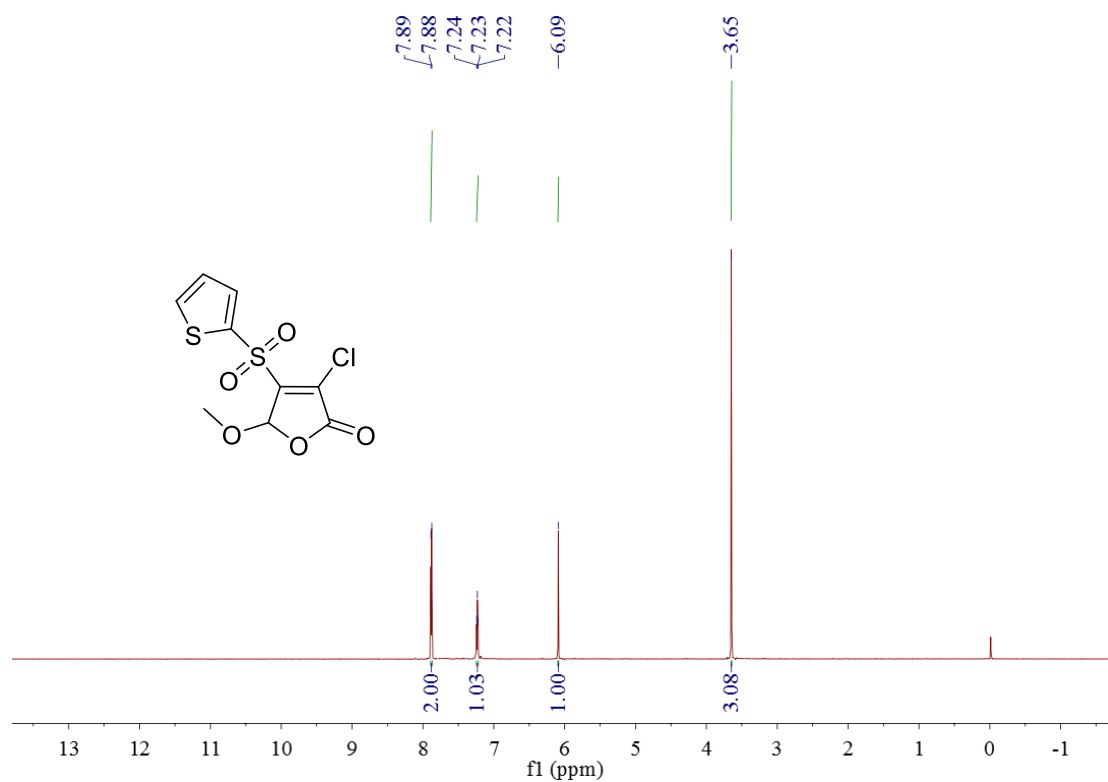
¹³C NMR spectrum of compound **4n**



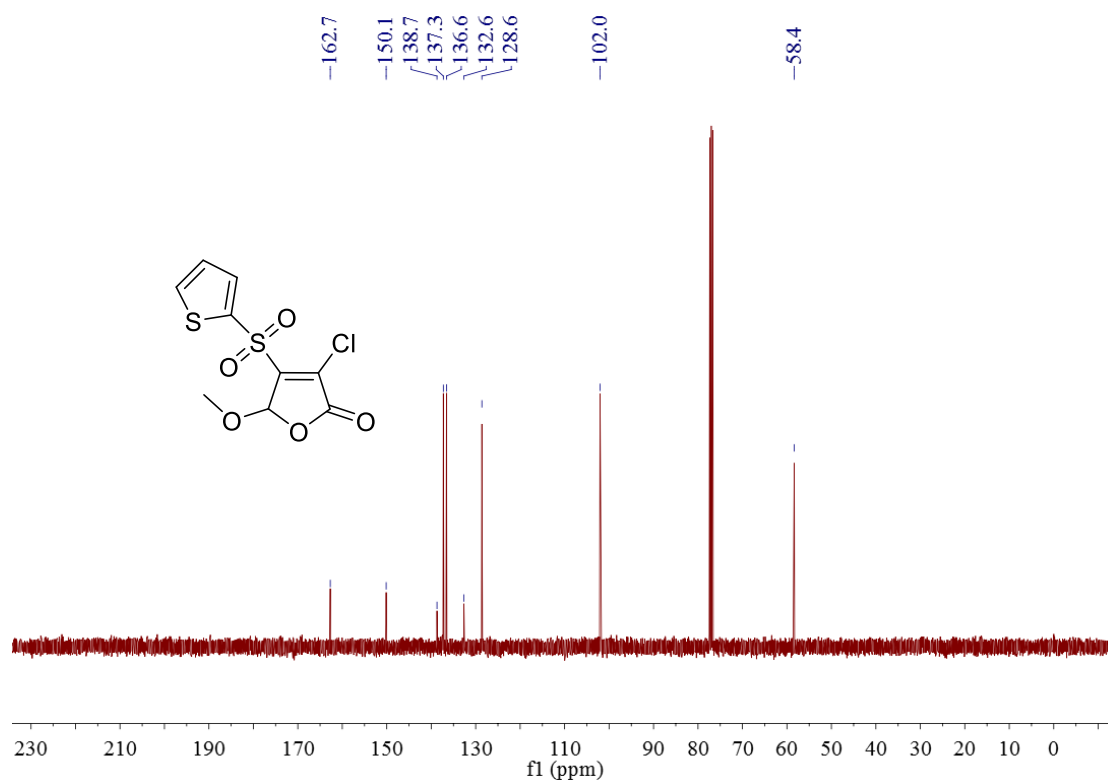
¹H NMR spectrum of compound **4o**



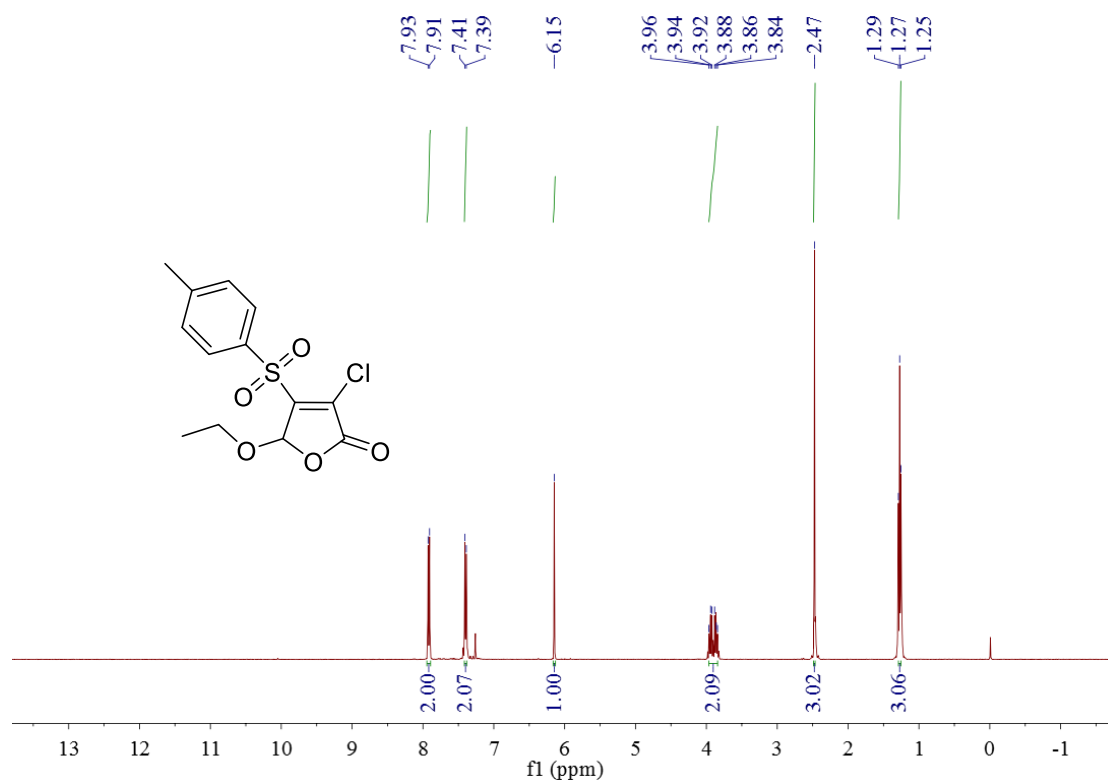
¹³C NMR spectrum of compound **4o**



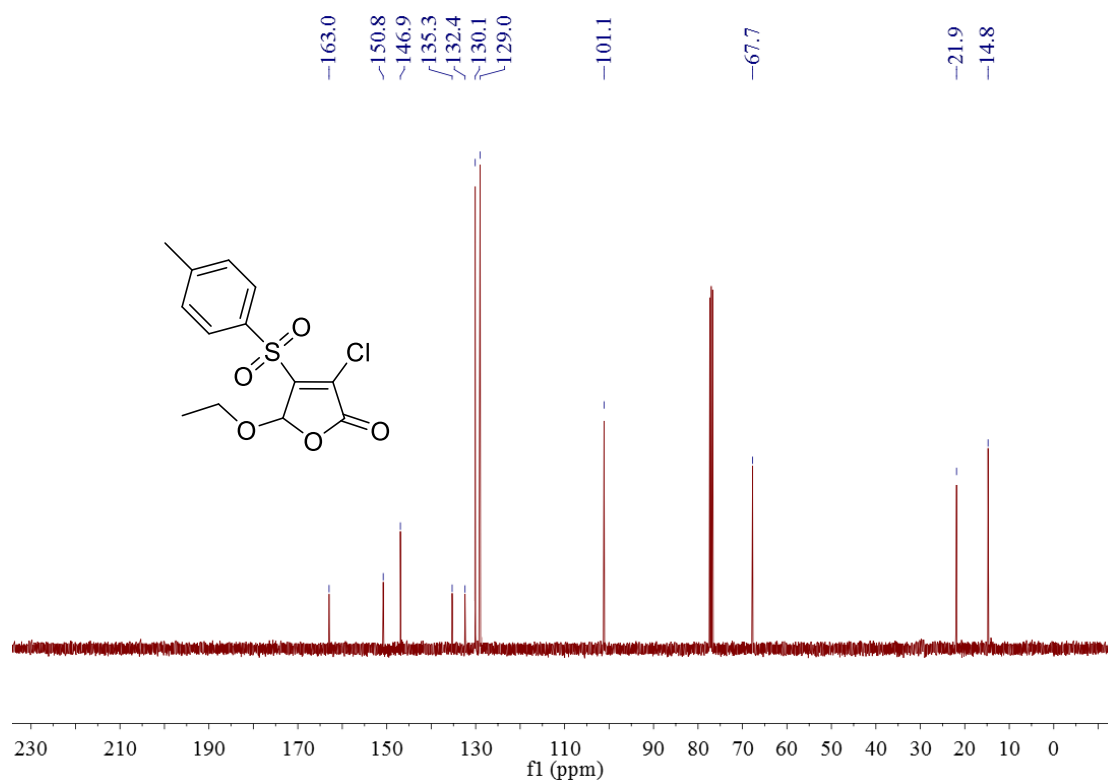
¹H NMR spectrum of compound **4p**



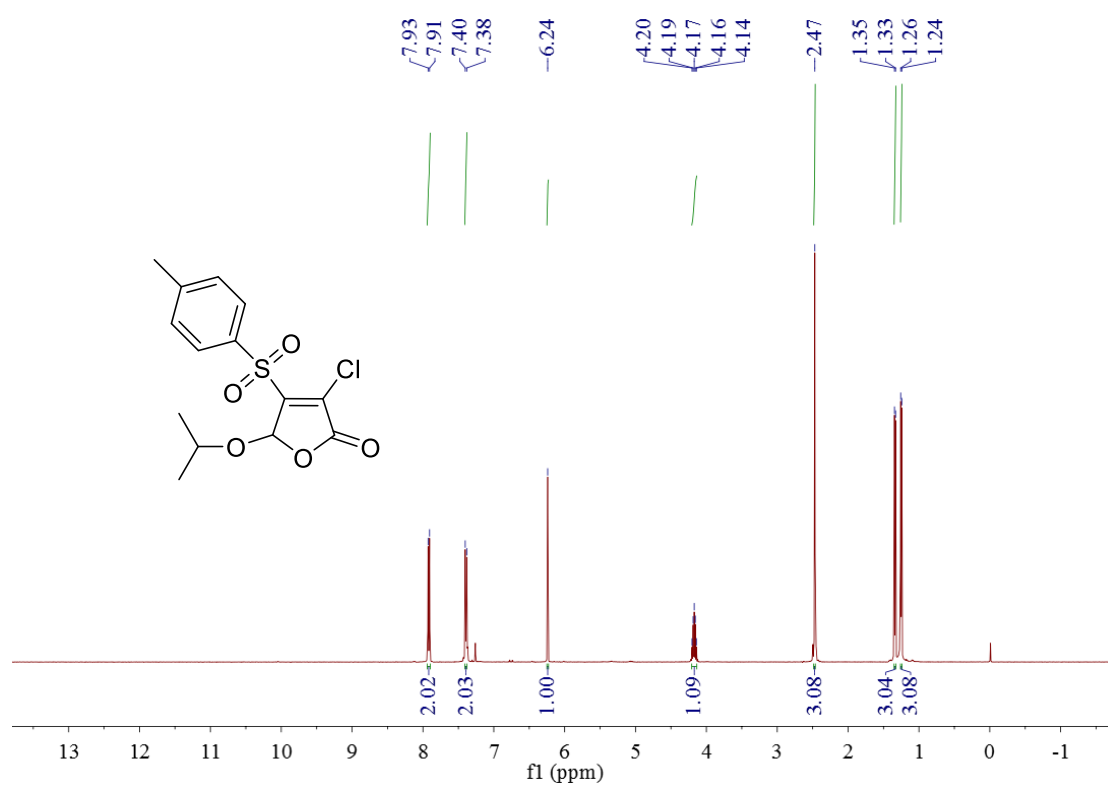
¹³C NMR spectrum of compound **4p**



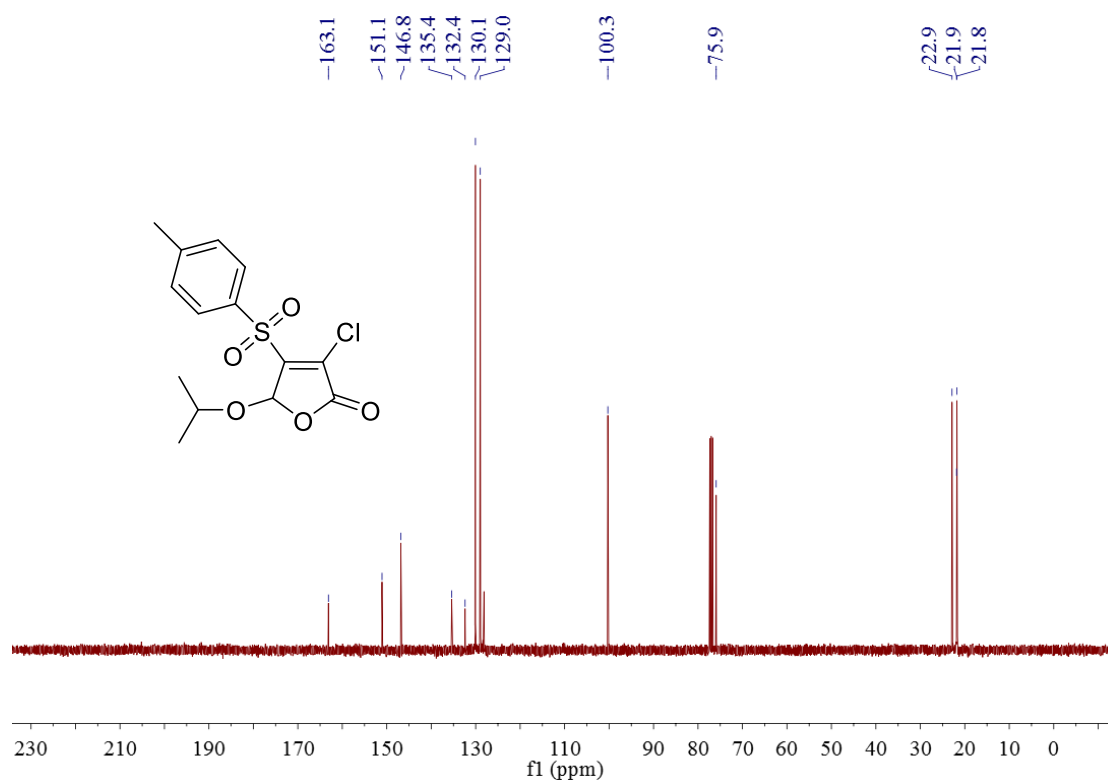
¹H NMR spectrum of compound **4q**



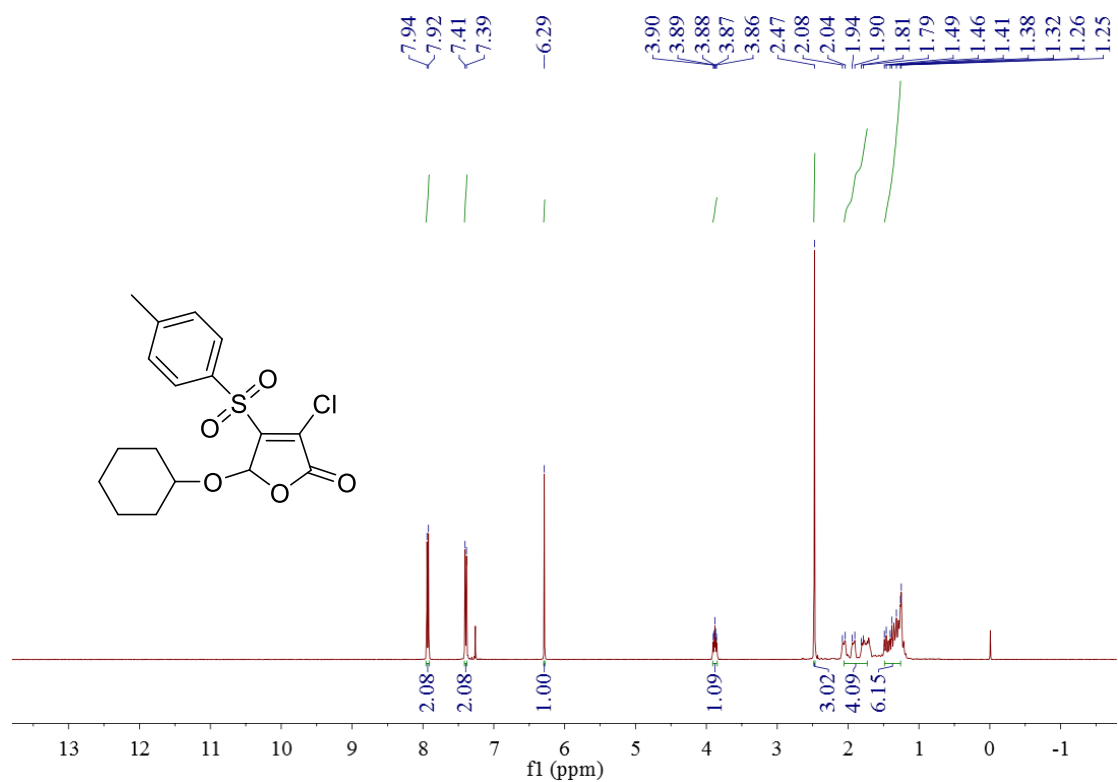
¹³C NMR spectrum of compound **4q**



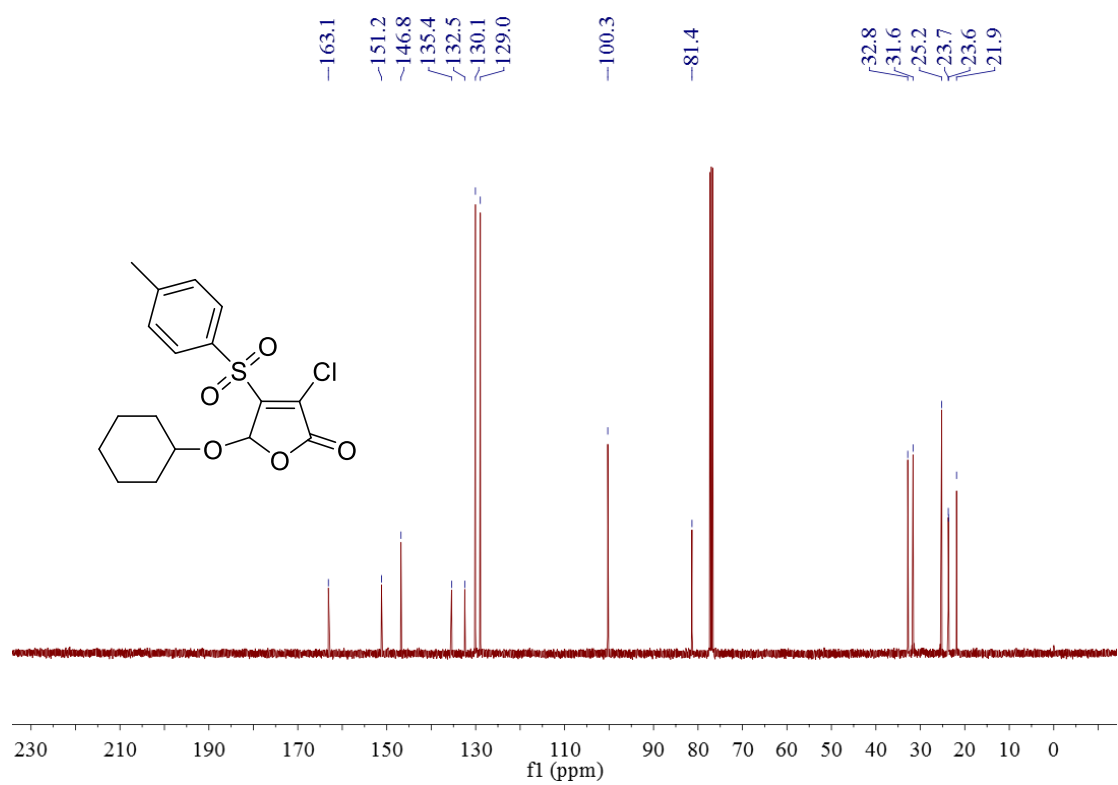
¹H NMR spectrum of compound **4r**



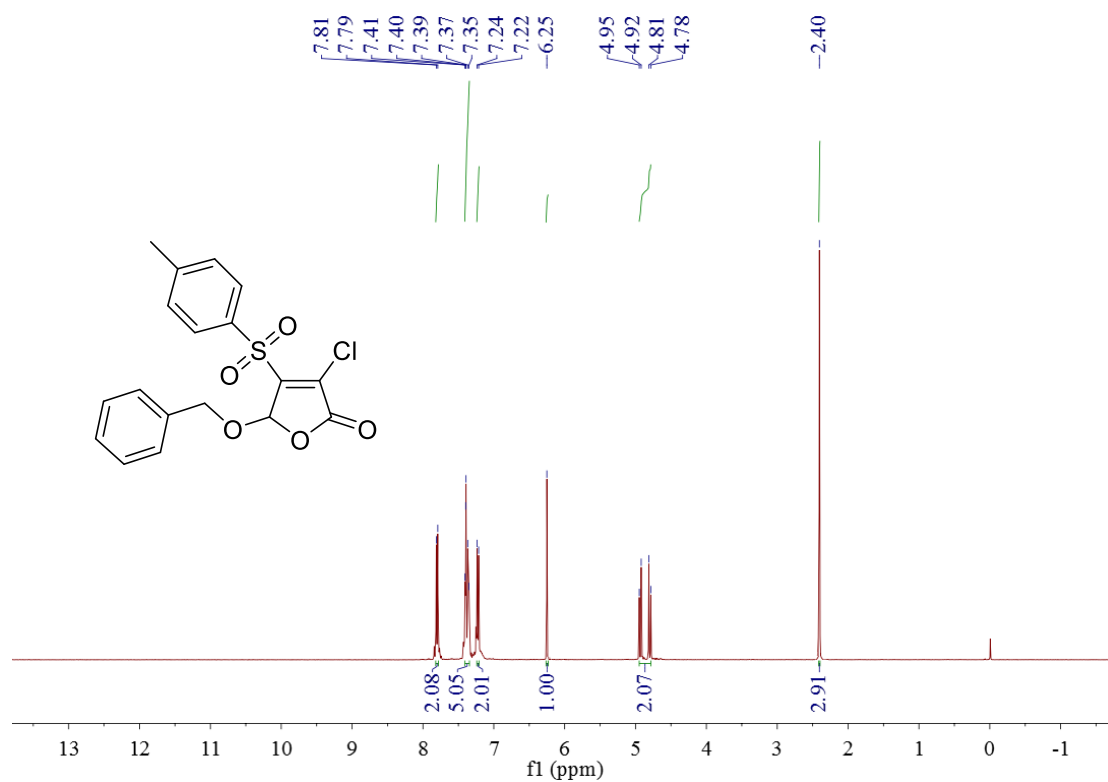
¹³C NMR spectrum of compound **4r**



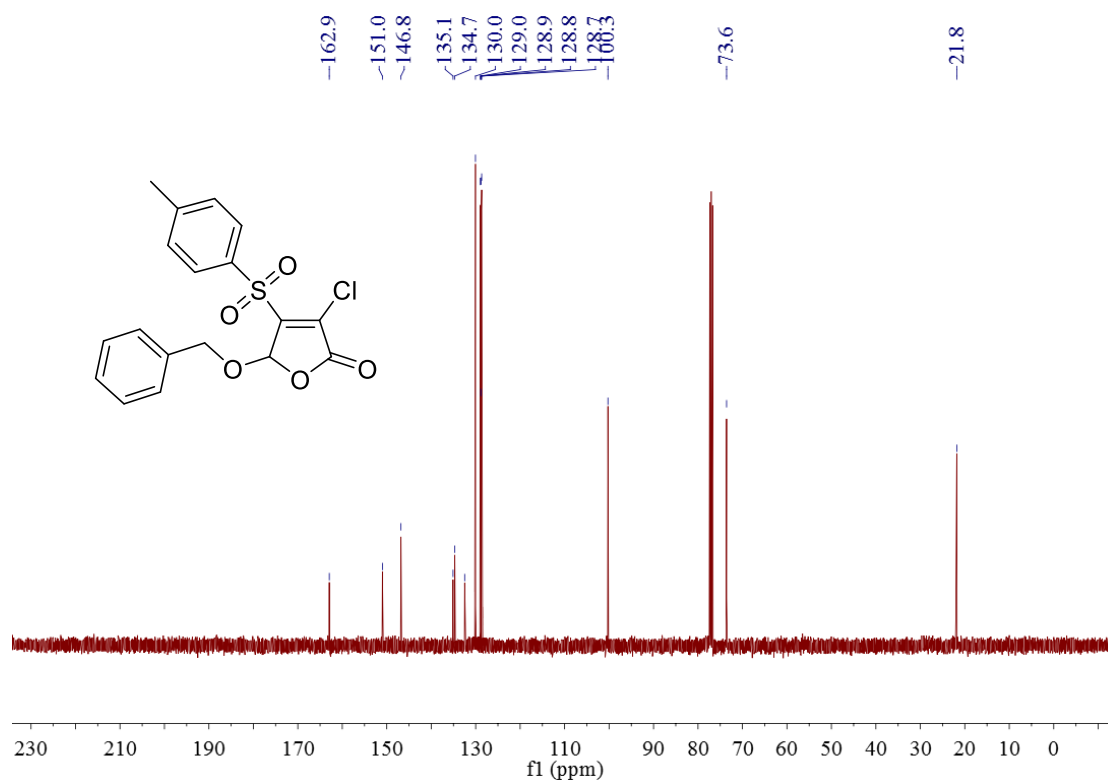
¹H NMR spectrum of compound **4s**



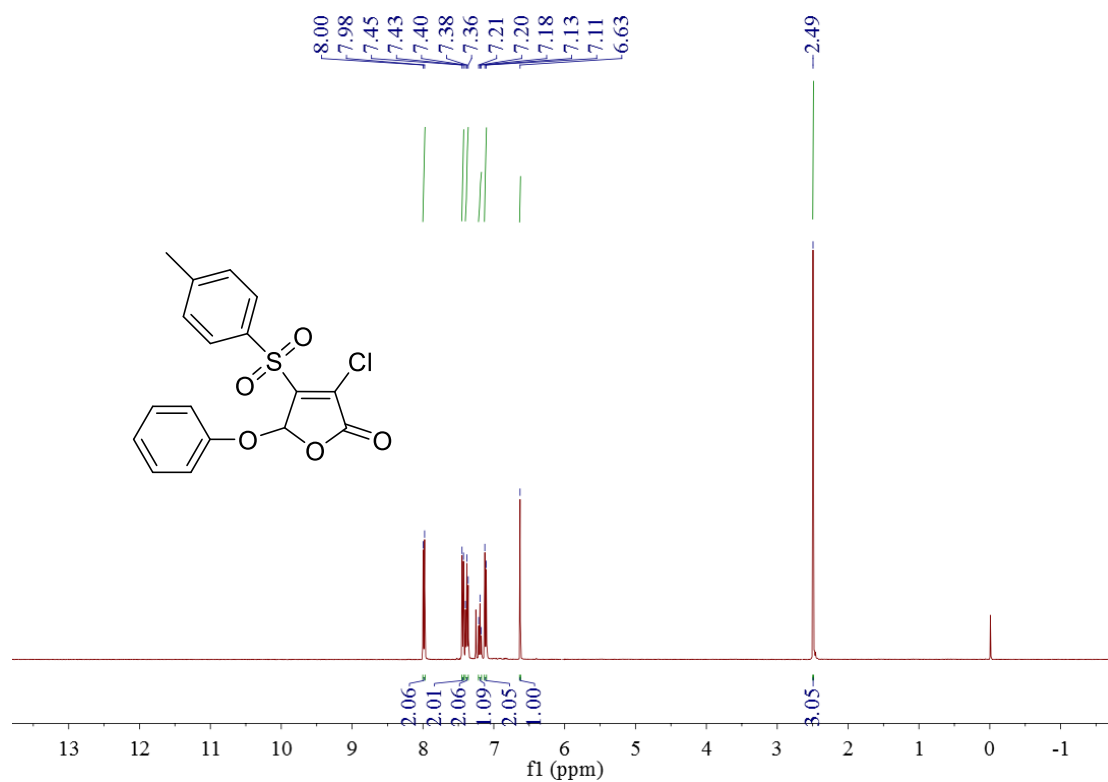
¹³C NMR spectrum of compound **4s**



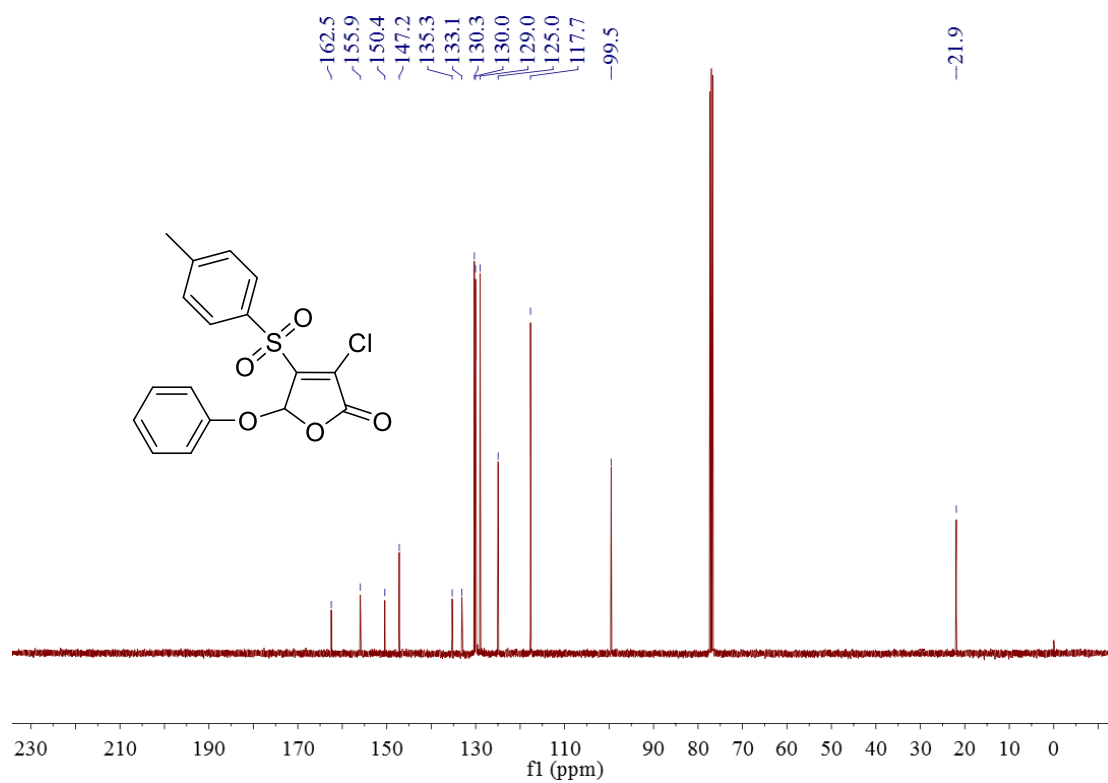
^1H NMR spectrum of compound **4t**



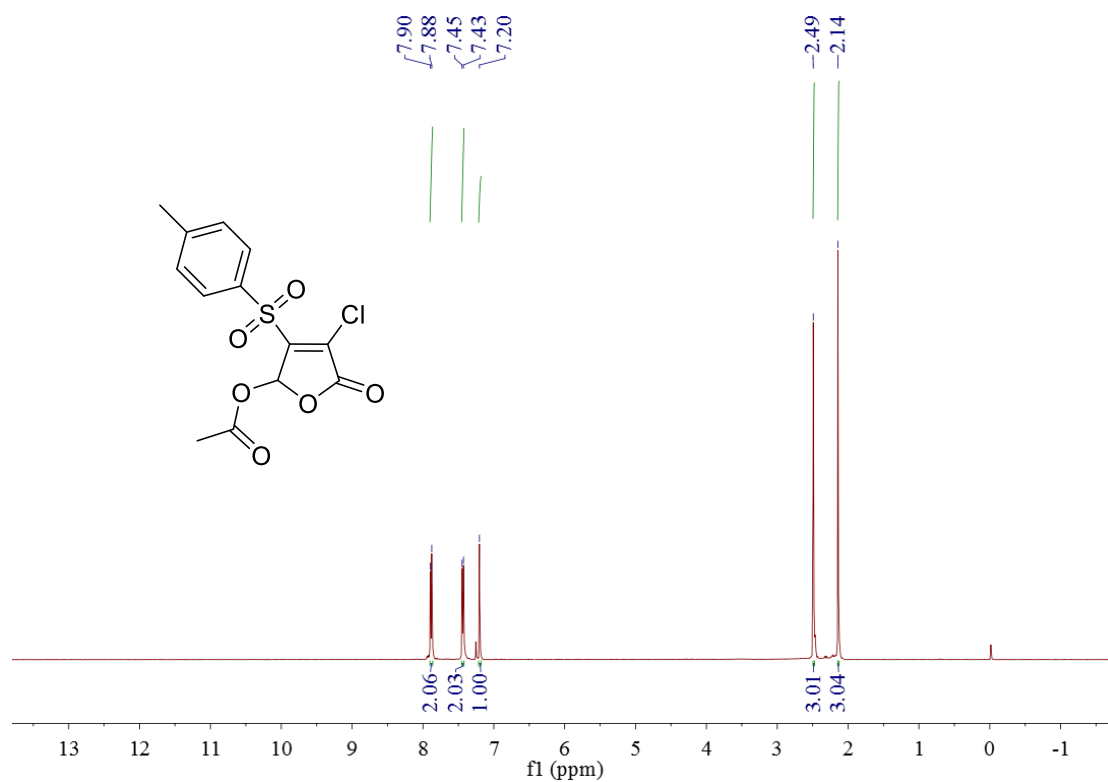
^{13}C NMR spectrum of compound **4t**



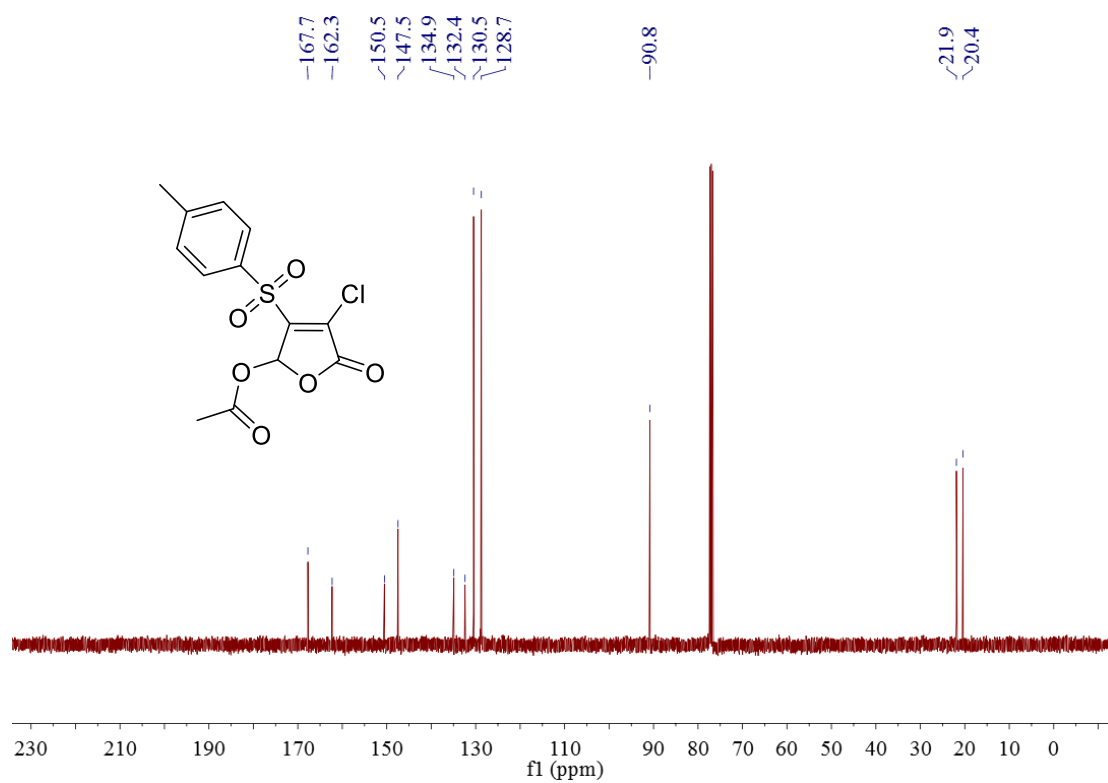
¹H NMR spectrum of compound **4u**



¹³C NMR spectrum of compound **4u**



¹H NMR spectrum of compound **4v**



¹³C NMR spectrum of compound **4v**

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