Supporting Information

A Brønsted acid-catalyzed thioacid addition to *in situ*-generated aldimine for the synthesis of isoindolinones with the *N*,*S*-acetal framework

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Materials and Methods:

Unless otherwise stated, all reactions were performed in oven-dried glassware fitted with rubber septa under an inert atmosphere and were stirred with Teflon-coated magnetic stirring bars. Liquid reagents and solvents were transferred *via* syringe using standard Schlenk techniques. Tetrahydrofuran (THF), toluene, and diethyl ether (Et_2O) were distilled over sodium/benzophenone ketyl. Dichloromethane (CH_2Cl_2), and $CHCl_3$ were distilled over calcium hydride. All other solvents, amines, thioacids and reagents were used as received unless otherwise noted. Reaction temperatures above 23 °C refer to oil bath temperature. Thin-layer chromatography was performed using silica gel 60 F-254 pre-coated plates (0.25 mm) and visualized by UV irradiation. Silica gel of particle size 100-200 mesh was used for column chromatography. ^{1}H, ^{13}C, spectra were recorded using 400, 500, and 700 MHz spectrometers. Chemical shifts (δ) are reported in ppm relative to the residual solvent ($CDCl_3$) signal (δ = 7.26 ppm for ^{1}H NMR and δ = 77.0 ppm for ^{13}C NMR) and (DMSO-d_6) signal (δ = 2.50 ppm for ^{1}H NMR and δ = 39.9 ppm for ^{13}C NMR). Data for ^{1}H NMR spectra are reported as follows: chemical shift (multiplicity, coupling constants, and a number of hydrogen). Abbreviations are as follows: s (singlet), d (doublet), t (triplet), q (quartet), quint (quintet), sept (septet), m (multiplet), br (broad). High-Resolution Mass Spectrometry (HRMS) data were recorded on TOF-Q-II mass spectrometer. Optical rotations were measured on a commercial automatic polarimeter. The enantiomeric ratio was determined by chiral HPLC analysis with Daicel Chiralpak ADH columns.

General Procedure for the Synthesis ester-aldehydes (3a-q):

Ester-aldehydes **3a-q** were prepared according to the literature-known procedure.[1]

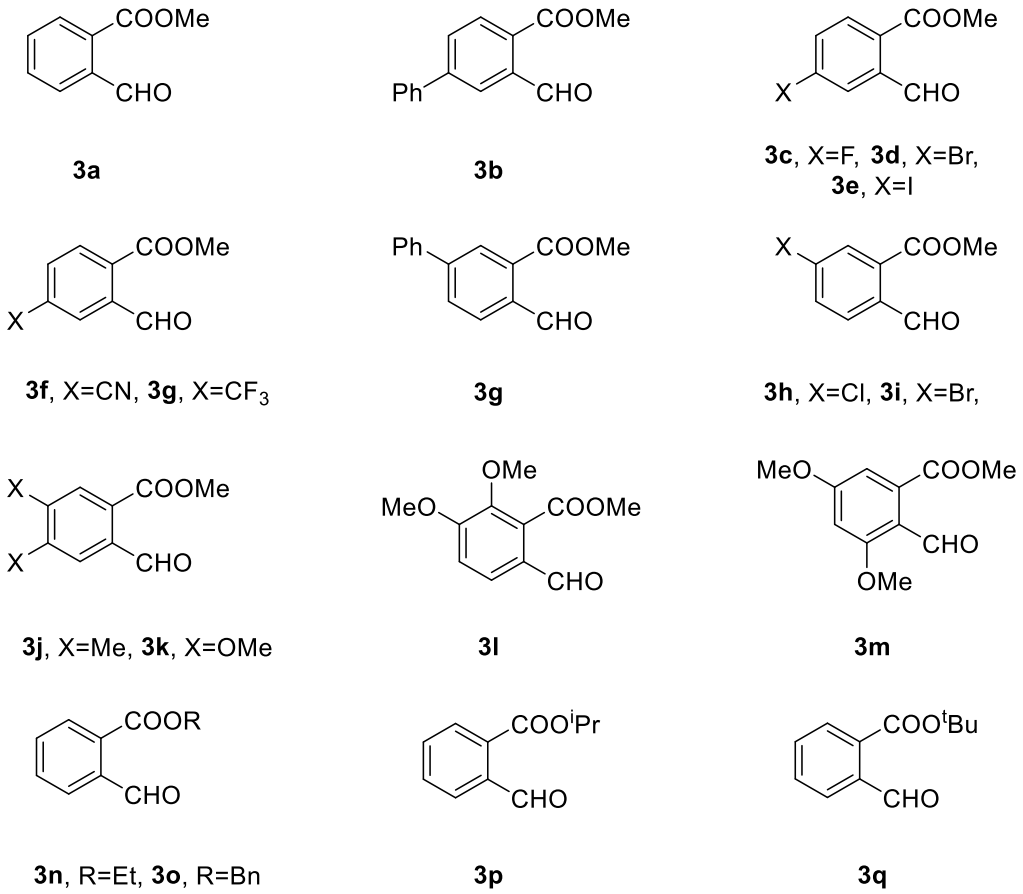
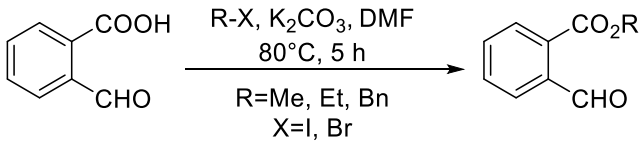


Figure 1. Structure of various ester-aldehydes.

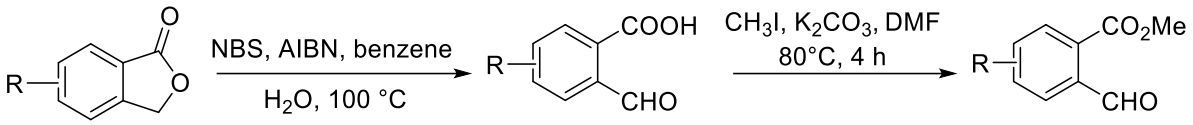
General procedure for the synthesis of 3a, 3n-p



2-formylbenzoic acid (5 g, 33 mmol) was dissolved in dry DMF (11 mL), followed by the addition of iodomethane (10.2 g, 72 mmol)/ethyl iodide (11.2 g, 72 mmol)/benzyl bromide (12.3 g, 72 mmol), and potassium carbonate (2.5 g, 18 mmol) at rt. Then the reaction mixture was refluxed for 4 h. After that, the mixture was cooled to room temperature, quenched with water (50 mL), and the product was extracted with chloroform (3 × 20 mL). The combined organic layers were washed with concentrated sodium bicarbonate solution (15 mL), and

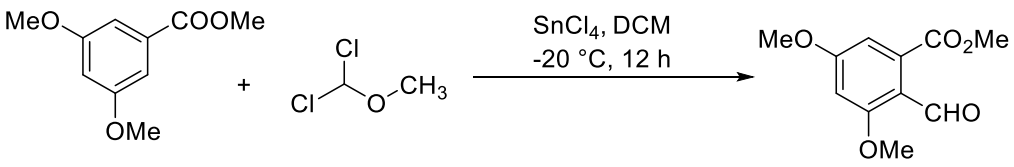
brine (20 mL), dried over sodium sulfate, and concentrated in vacuo, purified by column chromatography to afford the pure product.

General procedure for the synthesis of 3b-l:



Phthalides (2.0 mmol) were dissolved in 10 mL dry benzene, followed by the addition of NBS (2.2 mmol) and AIBN (0.1 mmol) at room temperature. Then the mixture was heated to reflux at 85 ºC for 12 h. The reaction mixture was cooled to room temperature and purified by flash chromatography (silica gel, petroleum ether, and ethyl acetate as eluent). The product was then suspended in 20 mL of H_2O and heated to 100 ºC for 10 h. After that, the mixture was cooled to room temperature and extracted with EtOAc (3×30 mL). The combined organic layers were dried over MgSO4, filtered, and concentrated under reduced pressure to give a corresponding 2-formylbenzoic acid as a solid. The corresponding 2-formylbenzoic acid (1 mmol) was dissolved in dry DMF (11 mL), followed by the addition of iodomethane (4 mmol) and potassium carbonate (2 mmol) at rt. Then the reaction mixture was refluxed for 4 h. After that, the mixture was cooled to room temperature, quenched with water (50 mL), and the product was extracted with chloroform (3 × 20 mL). The combined organic layers were washed with concentrated sodium bicarbonate solution (15 mL) and brine (20 mL), dried over Na_2SO_4, and concentrated in vacuo, purified by column chromatography to afford the pure product.

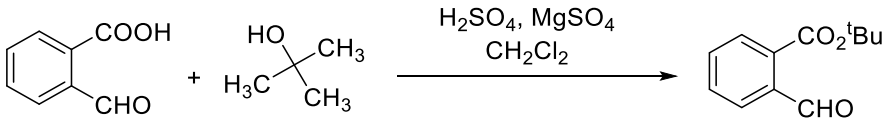
General procedure for the synthesis of 3m:



Dichloromethyl methyl ether (3.46 mL, 38.22 mmol) was added to a solution of ester (5.0 g, 25.49 mmol) in dry dichloromethane at -20 °C. $SnCl_4$ in 1M DCM (26 mL, 25.49 mmol) was added dropwise over a period of 30 min at the same temperature. After the completion of the reaction after 12 h (monitored by TLC), the reaction mixture was again cooled to -10 °C and

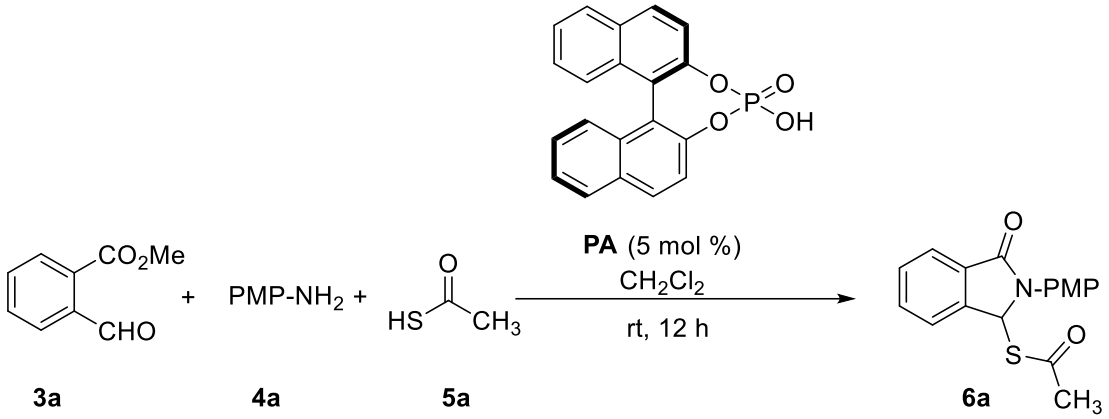
quenched by slow addition of sodium bicarbonate. The organic layer was collected, an aqueous layer was extracted with *tert*-butyl methyl ether (TBME), and the combined organic layers were washed with brine, dried over Na_2SO_4, and concentrated in vacuo, purified by column chromatography to afford the pure product as a white solid.

General procedure for the synthesis of 3q:



Sulphuric acid (0.8 mL, 13.4 mmol) was added to a vigorously stirred suspension of anhydrous $MgSO_4$ (6.4 g, 54 mmol) in DCM (55 mL), and the reaction mixture was stirred for 15 minutes. Then 2-formylbenzoic acid (2 g, 13.4 mmol) and *tert*-butanol (6.5 mL) were added to the mixture and stirred at room temperature for 20 h. After that, the reaction was quenched by the slow addition of sodium bicarbonate. The organic layer was collected, an aqueous layer was extracted with DCM, and the combined organic layers were washed with brine, dried over Na_2SO_4, and concentrated in vacuo, purified by column chromatography to afford the pure product **3q** as a white solid.

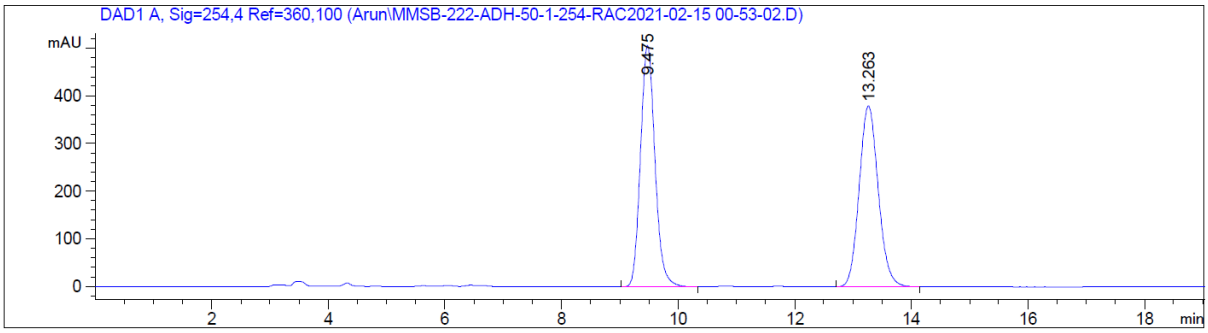
General procedure for the chiral phosphoric catalyzed reaction:



In a round-bottomed flask, ester-aldehydes **3a** (0.2 mmol, 1 equiv.) and amines **4a** (0.2 mmol, 1 equiv.) were taken, and CH_2Cl_2 (2.0 mL) was added to it. Then **PA** (5 mol%) was added to the mixture and stirred at rt for 3 h. Then thioacid **5a** (0.3 mmol, 1.5 equiv) was added dropwise. Then, the reaction mixture was allowed to stir at room temperature for 12 h. After completion of the reaction, the residue was charged over a column packed with silica gel. Product **6a** (0% ee, 48.89 mg, 78% yield,) was isolated by flash column chromatography using ethyl acetate and hexane as eluents.

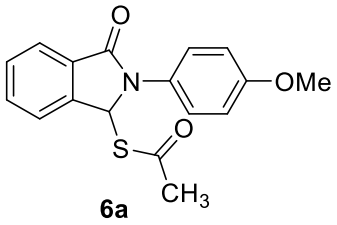
Note: enantiomeric excess was determined by HPLC using chiralpak ADH column (*n*-hexane/ isopropanol = 50:50, 1.0 mL/min, 254 nm).

HPLC graphs

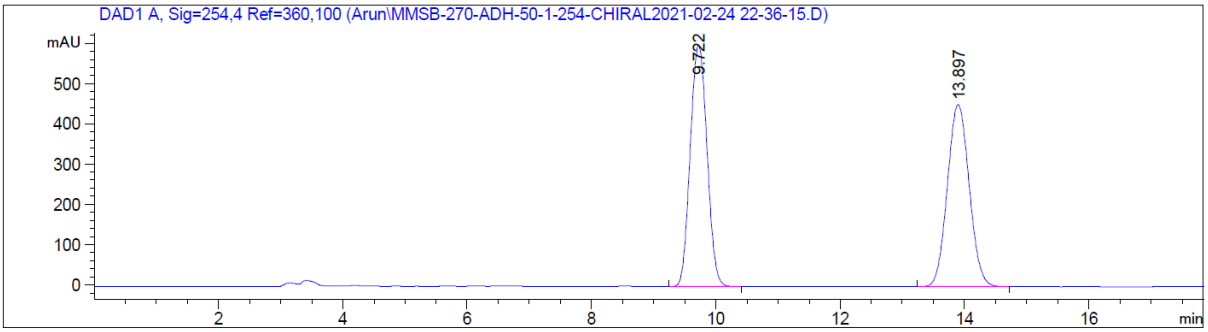


Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.475	BB	0.2667	8697.45215	505.65649	50.2491
2	13.263	BB	0.3507	8611.23633	379.59958	49.7509
Totals :				1.73087e4	885.25607	

HPLC chromatogram of **6a** racemic



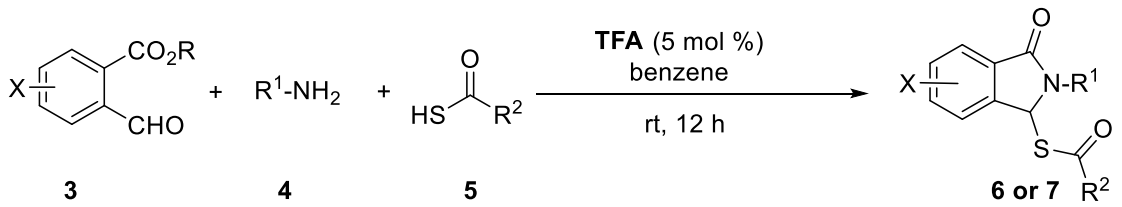
6a



Peak #	RetTime [min]	Type	Width [min]	Area [mAU*s]	Height [mAU]	Area %
1	9.722	BB	0.2991	1.12409e4	598.64404	50.5118
2	13.897	BB	0.3824	1.10131e4	451.81357	49.4882
Totals :				2.22540e4	1050.45761	

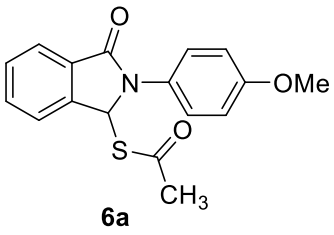
HPLC chromatogram of **6a** chiral

General procedure for the TFA catalyzed synthesis of isoindolinone:



In a round-bottomed flask, ester-aldehydes **3** (0.2 mmol, 1 equiv.) and amines **4** (0.2 mmol, 1 equiv.), were taken and benzene (2.0 mL) was added to it. Then TFA (5 mol%) was added to the mixture and stirred at rt for 3 h. Then thioacid **5** (0.3 mmol, 1.5 equiv.) was added dropwise. Then, the reaction mixture was allowed to stir at room temperature for 12 h. After completion of the reaction, the residue was charged over a column packed with silica gel. Product **6** or **7** was isolated by flash column chromatography using ethyl acetate and hexane as eluents.

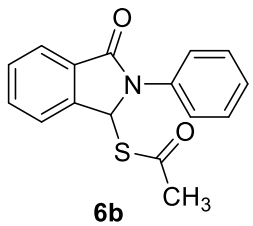
S-(2-(4-methoxyphenyl)-3-oxoisoindolin-1-yl) ethanethioate (6a): White solid, 60.17 mg, 96% yield. [54.53 mg, 87% yield (from substrate **3n**), 57.03 mg, 91% yield (from substrate **3o**), 45.13 mg, 72% yield (from substrate **3p**), 30.08 mg, 48% yield (from substrate **3q**)]. R_f = 0.41 (30% EtOAc in hexanes). **MP**: 101−103 °C.



6a

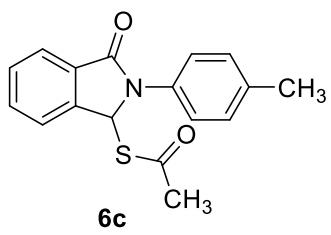
^{1}H NMR (400 MHz, $CDCl_3$) δ 7.94 – 7.85 (m, 1H), 7.62 (t, J = 7.39 Hz, 1H), 7.54 (t, J = 7.02 Hz, 2H), 7.40 (d, J = 8.54 Hz, 2H), 6.95 (d, J = 8.91 Hz, 2H), 6.91 (s, 1H), 3.82 (s, 3H), 2.35 (s, 3H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 194.2, 166.7, 158.1, 142.7, 132.7, 131.8, 129.6, 128.8, 126.2, 124.2, 123.6, 114.4, 63.5, 55.5, 30.8. **HRMS** (ESI): Exact mass calcd for $C_{17}H_{15}NO_3SNa$ $[M+Na]^+$: 336.0665; Found 336.0676.

S-(3-oxo-2-phenylisoindolin-1-yl) ethanethioate (6b): White solid, 42.50 mg, 75% yield. R_f = 0.55 (30% EtOAc in hexanes) **MP**: 129-131 °C. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.94 – 7.90 (m, 1H), 7.64 (td, J = 7.44, 1.22 Hz, 1H), 7.57 – 7.51 (m, 4H), 7.43 (t, J = 7.95 Hz, 2H), 7.29 – 7.23 (m, 1H), 6.99 (s, 1H), 2.36 (s, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 194.3, 166.6, 142.8, 136.1, 132.9, 131.6, 129.6, 129.1, 126.3, 124.2, 124.0, 123.6, 62.9, 30.8. **HRMS** (ESI): Exact mass calcd for $C_{16}H_{14}NO_2S$ $[M+H]^+$: 284.0740; Found: 284.0705.



6b

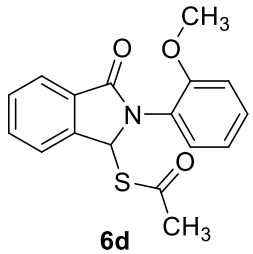
S-(3-oxo-2-(p-tolyl)isoindolin-1-yl) ethanethioate (6c): White solid, 46.39 mg, 78% yield. R_f = 0.6 (30% EtOAc in hexanes). **MP**: 123-125 °C. **^{1}H NMR**



6c

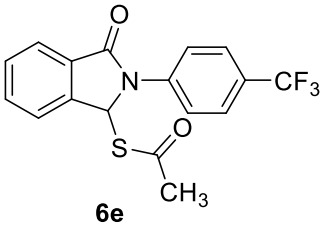
(500 MHz, $CDCl_3$) δ 7.91 (d, J = 7.61 Hz, 1H), 7.62 (d, J = 7.53 Hz, 1H), 7.54 (dd, J = 7.73, 5.29 Hz, 2H), 7.40 (d, J = 8.05 Hz, 2H), 7.23 (d, J = 8.09 Hz, 2H), 6.95 (s, 1H), 2.36 (d, J = 3.46 Hz, 6H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 194.3, 166.6, 142.8, 136.2, 133.4, 132.8, 131.7, 129.7, 129.5, 124.1, 124.1, 123.6, 63.0, 30.8, 21.1. **HRMS** (ESI): Exact mass calcd for $C_{17}H_{15}NO_2SNa$ $[M+Na]^+$: 320.0716; Found: 320.0707.

S-(2-(2-methoxyphenyl)-3-oxoisoindolin-1-yl) ethanethioate (6d): White solid, 18.80 mg, 30% yield. R_f = 0.38 (30% EtOAc in hexanes) **MP**: 50-52 °C. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.92 (d, J = 7.69 Hz, 1H), 7.62 (td, J = 7.50, 1.25 Hz, 1H), 7.57 – 7.51 (m, 2H), 7.34 (td, J = 7.86, 1.75 Hz, 1H), 7.30 (dd, J = 7.67, 1.71 Hz, 1H), 7.06 – 6.96 (m, 3H), 3.84 (s, 3H), 2.25 (s, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 193.9, 167.3, 155.9, 143.5, 132.5, 131.7, 130.6, 129.7, 129.3, 124.2, 123.9, 123.7, 120.6, 112.0, 63.7, 55.8, 30.7. **HRMS** (ESI): Exact mass calcd for $C_{17}H_{15}NO_3SNa$ $[M+Na]^+$: 336.0665; Found: 336.0690.



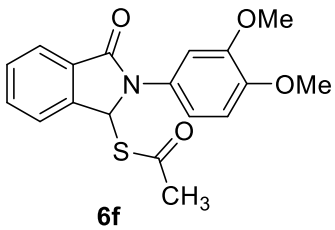
6d

S-(3-oxo-2-(4-(trifluoromethyl)phenyl)isoindolin-1-yl) ethanethioate (6e): White solid, 46.38 mg, 66% yield. R_f = 0.68 (30% EtOAc in hexanes) **MP**: 126-128 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.92 (d, J = 7.37 Hz, 1H), 7.70 (q, J = 7.67, 6.69 Hz, 5H), 7.56 (t, J = 8.73 Hz, 2H), 7.02 (s, 1H), 2.42 (s, 3H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 194.3, 166.6, 142.7, 139.4, 133.5, 131.1, 129.9, 127.8, 127.5, 126.3 (q, J = 3.73 Hz), 124.4, 123.7, 123.0, 62.3, 30.9. **^{19}F NMR** (375 MHz, $CDCl_3$) δ -62.3. **HRMS** (ESI): Exact mass calcd for $C_{17}H_{13}F_3NO_2S$ $[M+H]^+$: 352.0614; Found: 352.0607.



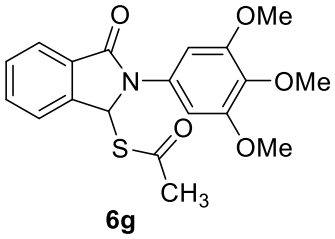
6e

S-(2-(3,4-dimethoxyphenyl)-3-oxoisoindolin-1-yl) ethanethioate (6f): White solid, 45.33 mg, 66% yield. R_f = 0.23 (30% EtOAc in hexanes). **MP**: 109−111 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.89 (d, J = 7.54 Hz, 1H), 7.62 (t, J = 7.45 Hz, 1H), 7.53 (t, J = 7.48 Hz, 2H), 7.12 (d, J = 2.42 Hz, 1H), 7.00 (dd, J = 8.57, 2.47 Hz, 1H), 6.93 (s, 1H), 6.89 (d, J = 8.62 Hz, 1H), 3.91 – 3.84 (m, 6H), 2.35 (s, 3H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 194.3, 166.6, 149.0, 147.5, 142.6, 132.8, 131.7, 129.6, 129.1, 124.1, 123.6, 116.6, 111.2, 108.4, 63.3, 56.1, 56.0, 30.8. **HRMS** (ESI): Exact mass calcd for $C_{18}H_{18}NO_4S$ $[M+H]^+$: 344.0951; Found: 344.0955.



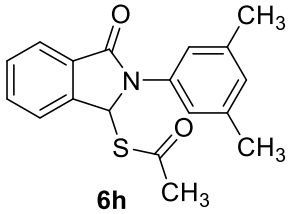
6f

S-(3-oxo-2-(3,4,5-trimethoxyphenyl)isoindolin-1-yl) ethanethioate (6g): Yellow semisolid, 59.0 mg, 79% yield. R_f = 0.22 (40% EtOAc in hexanes). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.88 (d, J = 7.48 Hz, 1H), 7.63 (t, J = 7.42 Hz, 1H), 7.56 – 7.49 (m, 2H), 6.96 (s, 1H), 6.80 (s, 2H), 3.84 (d, J = 3.29 Hz, 9H), 2.38 (s, 3H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 194.4, 166.6, 153.3, 142.4, 136.1, 132.9, 131.8, 131.6, 129.6, 124.1, 123.6, 101.3, 62.9, 61.0, 56.2, 30.8. **HRMS** (ESI): Exact mass calcd for $C_{19}H_{20}NO_5S$ $[M+H]^+$: 374.1057; Found: 374.1068.



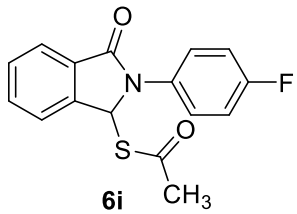
6g

S-(2-(3,5-dimethylphenyl)-3-oxoisoindolin-1-yl) ethanethioate (6h): White semisolid, 46.71 mg, 75% yield. R_f = 0.63 (30% EtOAc in hexanes). **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.91 (d, J = 7.77 Hz, 1H), 7.62 (d, J = 7.65 Hz, 1H), 7.54 (h, J = 3.30, 2.52 Hz, 2H), 7.15 (d, J = 4.00 Hz, 2H), 6.92 (d, J = 14.71 Hz, 2H), 2.35 (d, J = 9.18 Hz, 9H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 194.4, 166.6, 143.0, 138.7, 135.8, 132.8, 131.7, 129.6, 128.3, 124.2, 123.6, 121.9, 63.1, 30.8, 21.5. **HRMS** (ESI): Exact mass calcd for $C_{18}H_{18}NO_2S$ $[M+H]^+$: 312.1053; Found: 312.1056.



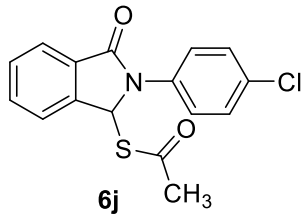
6h

S-(2-(4-fluorophenyl)-3-oxoisoindolin-1-yl) ethanethioate (6i): White solid, 56.05 mg, 93% yield. R_f = 0.59 (30% EtOAc in hexanes). **MP**: 158-160 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.90 (d, J = 7.52 Hz, 1H), 7.63 (d, J = 7.21 Hz, 1H), 7.54 (t, J = 7.71 Hz, 2H), 7.48 (dd, J = 8.95, 4.79 Hz, 2H), 7.11 (t, J = 8.62 Hz, 2H), 6.93 (s, 1H), 2.36 (s, 3H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 194.1, 166.6, 160.9 (d, J = 246.25 Hz), 142.6, 133.0, 132.0 (d, J = 3.00 Hz), 131.4, 129.7, 126.3 (d, J = 8.31 Hz), 124.2, 123.6, 115.9 (d, J = 22.67 Hz), 63.2, 30.8. **^{19}F NMR** (375 MHz, $CDCl_3$) δ -115.3. **HRMS** (ESI): Exact mass calcd for $C_{16}H_{12}FNO_2SNa$ $[M+Na]^+$: 324.0465; Found: 324.0454.



6i

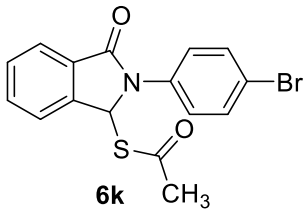
S-(2-(4-chlorophenyl)-3-oxoisoindolin-1-yl) ethanethioate (6j): White solid, 48.30 mg, 76% yield. R_f = 0.63 (30% EtOAc in hexanes). **MP**: 127-129 °C. **^{1}H NMR** (400 MHz, CDCl3) δ 7.90 (d, J = 7.59 Hz, 1H), 7.64 (td, J = 7.56, 1.21 Hz, 1H), 7.58 – 7.51 (m, 2H), 7.51 – 7.46 (m, 2H), 7.41 – 7.35 (m, 2H), 6.94 (s, 1H), 2.38 (s, 3H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 194.2, 166.5, 142.6, 134.7, 133.1, 131.7, 131.3,



6j

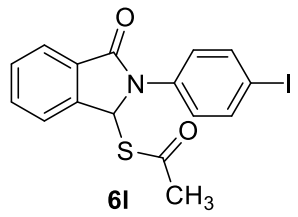
129.7, 129.2, 125.1, 124.3, 123.6, 62.7, 30.8. **HRMS** (ESI): Exact mass calcd for $C_{16}H_{13}ClNO_2S$ $[M+H]^+$: 318.0350; Found: 318.0346.

S-(2-(4-bromophenyl)-3-oxoisoindolin-1-yl) ethanethioate (6k): White solid, 56.51 mg, 78% yield. R_f = 0.66 (30% EtOAc in hexanes) **MP**: 134-136 °C. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.89 (d, J = 7.53 Hz, 1H), 7.64 (td, J = 7.53, 1.18 Hz, 1H), 7.57 – 7.50 (m, 4H), 7.46 – 7.41 (m, 2H), 6.94 (s, 1H), 2.39 (s, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 194.2, 166.4, 142.6, 135.2, 133.1, 132.1, 131.3, 129.7, 125.3, 124.3, 123.6, 119.5, 62.6, 30.8. **HRMS** (ESI): Exact mass calcd for $C_{16}H_{13}BrNO_2S$ $[M+H]^+$: 361.9845; Found: 361.9867.



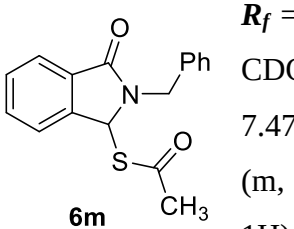
6k

S-(2-(4-iodophenyl)-3-oxoisoindolin-1-yl) ethanethioate (6l): White solid, 54.02 mg, 66% yield. R_f = 0.63 (30% EtOAc in hexanes) **MP**: 127-129 °C. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.89 (d, J = 7.50 Hz, 1H), 7.72 (d, J = 8.25 Hz, 2H), 7.64 (t, J = 7.48 Hz, 1H), 7.57 – 7.50 (m, 2H), 7.32 (d, J = 8.33 Hz, 2H), 6.94 (s, 1H), 2.39 (s, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 194.2, 166.4, 142.6, 138.1, 135.9, 133.2, 131.3, 129.7, 125.4, 124.3, 123.6, 90.6, 62.4, 30.9. **HRMS** (ESI): Exact mass calcd for $C_{16}H_{13}INO_2S$ $[M+H]^+$: 409.9706; Found: 409.9699.



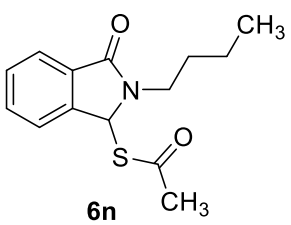
6l

S-(2-benzyl-3-oxoisoindolin-1-yl) ethanethioate (6m): White solid, 39.25 mg, 66% yield. R_f = 0.57 (30% EtOAc in hexanes) **MP**: 97-99 °C. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.87 (d, J = 7.46 Hz, 1H), 7.55 (td, J = 7.49, 1.26 Hz, 1H), 7.52 – 7.47 (m, 1H), 7.44 (d, J = 7.56 Hz, 1H), 7.34 – 7.29 (m, 4H), 7.29 – 7.23 (m, 1H), 6.31 (s, 1H), 5.12 (d, J = 15.07 Hz, 1H), 4.32 (d, J = 15.08 Hz, 1H), 2.43 (s, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 194.4, 167.8, 143.0, 136.9, 132.4, 131.7, 129.4, 128.7, 128.5, 127.7, 123.9, 123.6, 62.2, 44.3, 30.9. **HRMS** (ESI): Exact mass calcd for $C_{17}H_{16}NO_2S$ $[M+H]^+$: 298.0896; Found: 298.0873.



6m

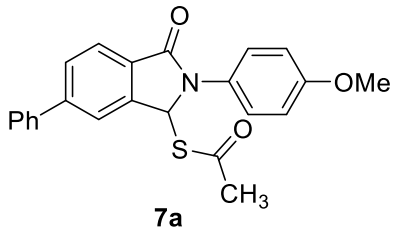
S-(2-butyl-3-oxoisoindolin-1-yl) ethanethioate (6n): Yellow semi-solid, 36.87 mg, 70% yield. R_f = 0.48 (30% EtOAc in hexanes). **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.77 (d, *J* = 7.64 Hz, 1H), 7.57 – 7.47 (m, 1H), 7.43 (dt, *J* = 7.24, 3.53 Hz, 2H), 6.37 (s, 1H), 3.98 – 3.77 (m, 1H), 3.06 (ddd, *J* = 13.78, 8.40, 5.08 Hz, 1H), 2.45 (s, 3H), 1.59 (dddd, *J* = 20.88,



6n

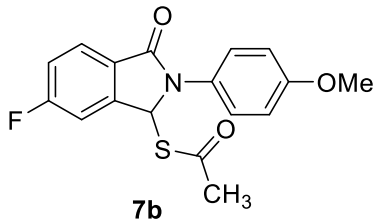
13.14, 7.76, 5.05 Hz, 2H), 1.30 (ddt, *J* = 14.81, 10.21, 7.43 Hz, 2H), 0.89 (t, *J* = 7.29 Hz, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 194.6, 167.5, 142.5, 132.0, 129.2, 123.6, 123.4, 62.1, 39.8, 30.8, 30.1, 20.1, 13.7. **HRMS** (ESI): Exact mass calcd for $C_{14}H_{18}NO_2S$ $[M+H]^+$: 264.1053; Found: 264.1054.

S-(2-(4-methoxyphenyl)-3-oxo-6-phenylisoindolin-1-yl) ethanethioate (7a): Pale brown solid, 45.18 mg, 58% yield. R_f = 0.46 (30% EtOAc in hexanes) **MP**: 151-153 °C. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.96 (d, J = 7.97 Hz, 1H), 7.76 (d, J = 7.75 Hz, 1H), 7.72 (s, 1H), 7.63 (d, J = 7.34 Hz, 2H), 7.48 (t, J = 7.51 Hz, 2H), 7.42 (t, J = 9.40 Hz, 3H), 6.99 – 6.93 (m, 3H), 3.83 (s, 3H), 2.36 (s, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 194.3, 166.5, 158.1, 146.2, 143.5, 140.1, 130.6, 129.1, 128.8, 128.8, 128.4, 127.6, 126.1, 124.5, 122.2, 114.4, 63.5, 55.5, 30.8. **HRMS** (ESI): Exact mass calcd for $C_{23}H_{20}NO_3S$ $[M+H]^+$: 390.1158; Found: 390.1135.



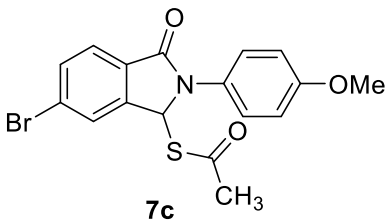
7a

S-(6-fluoro-2-(4-methoxyphenyl)-3-oxoisoindolin-1-yl) ethanethioate (7b): White solid, 65.61 mg, 99% yield. R_f = 0.43 (30% EtOAc in hexanes) **MP**: 123-125 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.90 – 7.83 (m, 1H), 7.36 (d, J = 8.55 Hz, 2H), 7.21 (d, J = 8.15 Hz, 2H), 6.93 (d, J = 8.50 Hz, 2H), 6.85 (s, 1H), 3.81 (s, 3H), 2.34 (s, 3H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 193.9, 165.7 (d, J = 253.12 Hz), 158.2, 145.4, 145.3, 128.5, 127.7 (d, J = 2.22 Hz), 126.2 (d, J = 9.59 Hz), 126.1, 117.4 (d, J = 23.55 Hz), 114.4, 111.1, 110.8, 63.0 (d, J = 2.67 Hz), 55.5, 30.7. **^{19}F NMR** (375 MHz, $CDCl_3$) δ -105.2. **HRMS** (ESI): Exact mass calcd for $C_{17}H_{14}FNO_3SNa$ $[M+Na]^+$: 354.0571; Found: 354.0558.



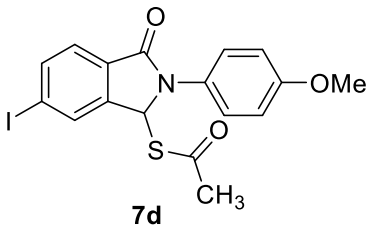
7b

S-(6-bromo-2-(4-methoxyphenyl)-3-oxoisoindolin-1-yl) ethanethioate (7c): White solid, 77.67 mg, 99% yield. R_f = 0.5 (30% EtOAc in hexanes). **MP**: 137-139 °C. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.75 (d, J = 7.92 Hz, 1H), 7.69 – 7.64 (m, 2H), 7.37 (d, J = 8.95 Hz, 2H), 6.94 (d, J = 8.95 Hz, 2H), 6.85 (s, 1H), 3.81 (s, 3H), 2.35 (s, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 193.8, 165.7, 158.2, 144.6, 133.0, 130.6, 128.4, 127.3, 126.9, 126.1, 125.5, 114.4, 62.9, 55.5, 30.8. **HRMS** (ESI): Exact mass calcd for $C_{17}H_{15}BrNO_3S$ $[M+H]^+$: 391.9951; Found: 391.9933.



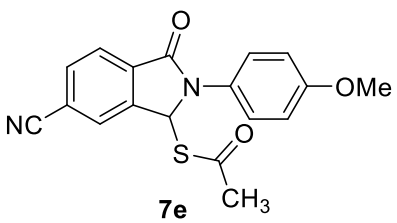
7c

S-(6-iodo-2-(4-methoxyphenyl)-3-oxoisoindolin-1-yl) ethanethioate (7d): Yellow solid, 56.23 mg, 64% yield. R_f = 0.57 (30% EtOAc in hexanes) **MP**: 165-167 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.88 (d, J = 8.74 Hz, 2H), 7.61 (d, J = 7.86 Hz, 1H), 7.36 (d, J = 8.44 Hz, 2H), 6.93 (d, J = 8.46 Hz, 2H), 6.84 (s, 1H), 3.81 (s, 3H), 2.35 (s, 3H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 193.8, 165.9, 158.2, 144.5, 138.8, 132.8, 131.2, 128.3, 126.1, 125.5, 114.4, 99.4, 62.7, 55.5, 30.8. **HRMS** (ESI): Exact mass calcd for $C_{17}H_{15}INO_3S$ $[M+H]^+$: 439.9812; Found: 439.9820.



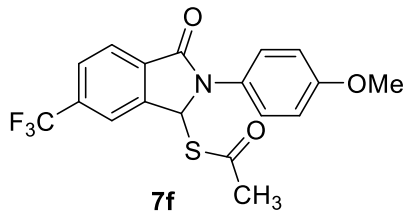
7d

S-(6-cyano-2-(4-methoxyphenyl)-3-oxoisoindolin-1-yl) ethanethioate (7e): Pale Yellow solid, 67.0 mg, 99% yield. R_f = 0.34 (30% EtOAc in hexanes). **MP**: 131-133 °C. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.98 (d, J = 7.70 Hz, 1H), 7.84 – 7.80 (m, 2H), 7.38 – 7.34 (m, 2H), 6.94 (d, J = 8.97 Hz, 2H), 6.90 (s, 1H), 3.81 (s, 3H), 2.37 (s, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 193.5, 164.7, 158.5, 143.6, 135.4, 133.3, 127.9, 127.6, 126.1, 124.9, 117.8, 116.1, 114.5, 63.1, 55.5, 30.8. **HRMS** (ESI): Exact mass calcd for $C_{18}H_{14}N_2O_3SNa$ $[M+Na]^+$: 361.0617; Found: 361.0620.



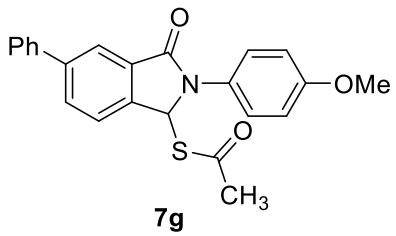
7e

S-(2-(4-methoxyphenyl)-3-oxo-6-(trifluoromethyl)isoindolin-1-yl) ethanethioate (7f): White solid, 45.76 mg, 60% yield. R_f = 0.57 (30% EtOAc in hexanes) **MP**: 114-116 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 8.02 (d, J = 7.88 Hz, 1H), 7.81 (d, J = 9.68 Hz, 2H), 7.38 (d, J = 8.44 Hz, 2H), 6.95 (d, J = 8.67 Hz, 3H), 3.82 (s, 3H), 2.37 (s, 3H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 193.6, 165.1, 158.4, 143.3, 134.8, 134.7, 134.4, 128.1, 126.7 (q, J = 3.68 Hz), 126.1, 124.7, 120.9, 114.4, 63.3, 55.4, 30.7. **^{19}F NMR** (375 MHz, $CDCl_3$) δ -62.4. **HRMS** (ESI): Exact mass calcd for $C_{18}H_{15}F_3NO_3S$ $[M+H]^+$: 382.0719; Found: 382.0737.



7f

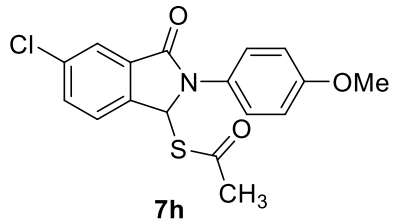
S-(2-(4-methoxyphenyl)-3-oxo-5-phenylisoindolin-1-yl) ethanethioate (7g): Pale Yellow solid, 42.84 mg, 55% yield. R_f = 0.45 (30% EtOAc in hexanes) **MP**: 144-146 °C. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 8.13 (s, 1H), 7.88 – 7.80 (m, 1H), 7.64 (d, J = 7.55 Hz, 2H), 7.59 (d, J = 7.94 Hz, 1H), 7.43 (ddt, J = 23.60, 14.74,



7g

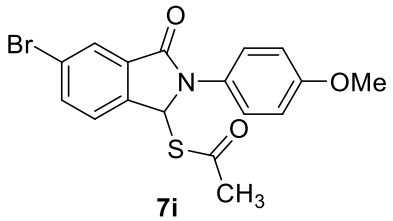
7.44 Hz, 5H), 7.00 – 6.92 (m, 3H), 3.82 (s, 3H), 2.35 (s, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 194.1, 166.6, 158.1, 143.0, 141.4, 139.8, 132.4, 131.7, 129.1, 128.7, 128.1, 127.3, 126.2, 123.9, 122.4, 114.3, 63.4, 55.5, 30.8. **HRMS** (ESI): Exact mass calcd for $C_{23}H_{20}NO_3S$ $[M+H]^+$: 390.1158; Found: 390.1196.

S-(5-chloro-2-(4-methoxyphenyl)-3-oxoisoindolin-1-yl) ethanethioate (7h): White solid, 68.87 mg, 99% yield. R_f = 0.56 (30% EtOAc in hexanes) **MP**: 126-128 °C**. ^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.84 (d, J = 2.03 Hz, 1H), 7.56 (d, J = 7.87 Hz, 1H), 7.45 (d, J = 8.15 Hz, 1H), 7.36 (d, J = 8.46 Hz, 2H), 6.93 (d, J = 8.50 Hz, 2H), 6.85 (s, 1H), 3.80 (s, 3H), 2.33 (s, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 193.9, 165.2, 158.2, 140.9, 135.8, 133.4, 132.8, 128.4, 126.1, 124.9, 124.1, 114.4, 63.2, 55.5, 30.7. **HRMS** (ESI): Exact mass calcd for $C_{17}H_{14}ClNO_3SNa$ $[M+Na]^+$: 370.0275; Found: 370.0290.



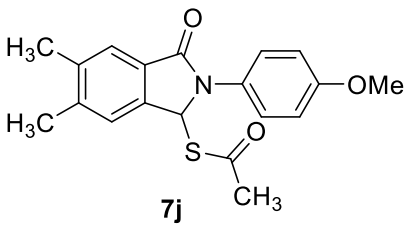
7h

S-(5-bromo-2-(4-methoxyphenyl)-3-oxoisoindolin-1-yl) ethanethioate (7i): White solid, 54.92 mg, 70% yield. R_f = 0.53 (30% EtOAc in hexanes) **MP**: 133-135 °C. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 8.01 (s, 1H), 7.72 (d, J = 8.02 Hz, 1H), 7.38 (dd, J = 15.96, 8.52 Hz, 3H), 6.94 (s, 2H), 6.83 (s, 1H), 3.81 (s, 3H), 2.33 (s, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 193.9, 165.1, 158.3, 141.4, 135.7, 133.6, 128.4, 127.2, 126.1, 125.1, 123.7, 114.4, 63.2, 55.5, 30.8. **HRMS** (ESI): Exact mass calcd for $C_{17}H_{14}BrNO_3SNa$ $[M+Na]^+$: 413.9770; Found: 413.9763.



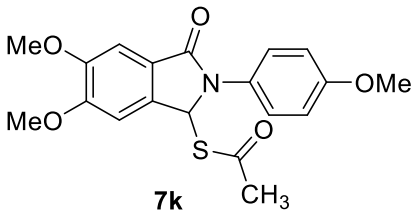
7i

S-(2-(4-methoxyphenyl)-5,6-dimethyl-3-oxoisoindolin-1-yl) ethanethioate (7j): White solid, 65.55 mg, 96% yield. R_f = 0.50 (30% EtOAc in hexanes) **MP**: 147-149 °C. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.64 (s, 1H), 7.39 (d, J = 8.92 Hz, 2H), 7.27 (s, 1H), 6.92 (d, J = 8.95 Hz, 2H), 6.82 (s, 1H), 3.80 (s, 3H), 2.35 (d, J = 5.54 Hz, 6H), 2.33 (s, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 194.4, 166.9, 157.9, 142.4, 140.5, 138.6, 129.5, 129.0, 126.0, 124.6, 124.2, 114.2, 63.2, 55.4, 30.7, 20.6, 20.0. **HRMS** (ESI): Exact mass calcd for $C_{19}H_{19}NO_3SNa$ $[M+Na]^+$: 364.0978; Found: 364.0991.



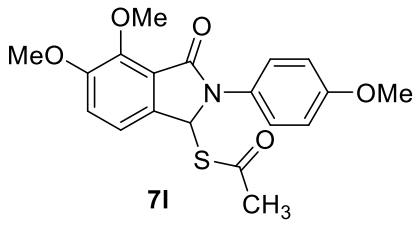
7j

S-(5,6-dimethoxy-2-(4-methoxyphenyl)-3-oxoisoindolin-1-yl) ethanethioate (7k): Pale yellow solid, 64.23 mg, 86% yield. R_f = 0.15 (30% EtOAc in hexanes) **MP**: 151-153 °C. **^{1}H NMR** (400 MHz, $CDCl_3$) δ 7.39 – 7.28 (m, 3H), 6.91 (d, J = 8.84 Hz, 3H), 6.79 (s, 1H), 3.93 (s, 6H), 3.79 (s, 3H), 2.32 (s, 3H). **^{13}C NMR** (100 MHz, $CDCl_3$) δ 194.5, 166.8, 157.9, 153.6, 150.8, 136.1, 129.0, 126.0, 124.1, 114.3, 105.3, 105.3, 63.2, 56.5, 56.4, 55.5, 30.8. **HRMS** (ESI): Exact mass calcd for $C_{19}H_{20}NO_5S$ $[M+H]^+$: 374.1057; Found: 374.1067.



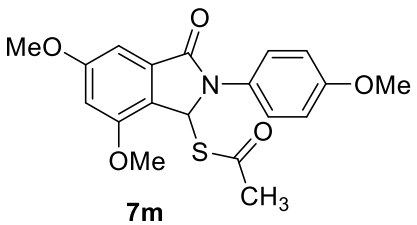
7k

S-(4,5-dimethoxy-2-(4-methoxyphenyl)-3-oxoisoindolin-1-yl) ethanethioate (7l): Pale yellow solid, 69.46 mg, 93% yield. R_f = 0.18 (40% EtOAc in hexanes). **MP**: 97-99 °C. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.39 (d, J = 9.02 Hz, 2H), 7.21 – 7.14 (m, 2H), 6.93 (d, J = 8.97 Hz, 2H), 6.82 (s, 1H), 4.09 (s, 3H), 3.91 (s, 3H), 3.81 (s, 3H), 2.33 (s, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 194.4, 164.7, 158.0, 153.4, 147.4, 135.4, 128.8, 126.2, 123.7, 118.8, 117.2, 114.2, 62.8, 62.6, 56.8, 55.4, 30.7. **HRMS** (ESI): Exact mass calcd for $C_{19}H_{19}NO_5SNa$ $[M+Na]^+$: 396.0876; Found: 396.0875.



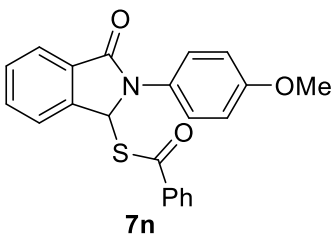
7l

S-(5,7-dimethoxy-2-(4-methoxyphenyl)-3-oxoisoindolin-1-yl) ethanethioate (7m): Pale yellow solid, 70.20 mg, 94% yield. R_f = 0.25 (30% EtOAc in hexanes). **MP**: 164-166 °C. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.41 (d, J = 8.97 Hz, 2H), 6.97 (s, 1H), 6.92 (d, J = 9.02 Hz, 2H), 6.81 (s, 1H), 6.61 (s, 1H), 3.85 (s, 3H), 3.83 (s, 3H), 3.79 (s, 3H), 2.28 (s, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 193.8, 166.4, 163.0, 157.9, 155.3, 134.2, 128.8, 125.8, 122.0, 114.2, 103.5, 98.3, 61.6, 56.0, 55.9, 55.4, 30.6· **HRMS** (ESI): Exact mass calcd for $C_{19}H_{20}NO_5S$ $[M+H]^+$: 374.1057; Found: 374.1077.



7m

S-(2-(4-methoxyphenyl)-3-oxoisoindolin-1-yl) benzothioate (7n): Yellow solid, 73.59 mg, 98% yield. R_f = 0.45 (30% EtOAc in hexanes) **MP**: 170-172 °C. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.94 (d, J = 7.55 Hz, 1H), 7.88 (d, J = 7.26 Hz, 2H), 7.66 – 7.53 (m, 4H), 7.48 (d, J = 8.99 Hz, 2H), 7.44 (t, J = 7.74 Hz, 2H), 7.17 (s, 1H), 6.93 (d, J

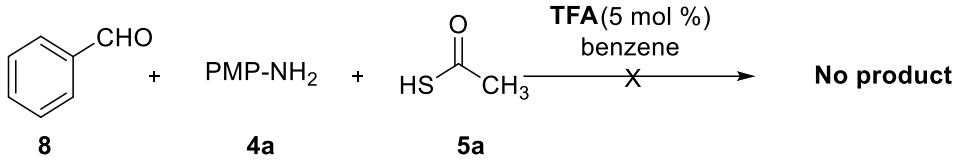


7n

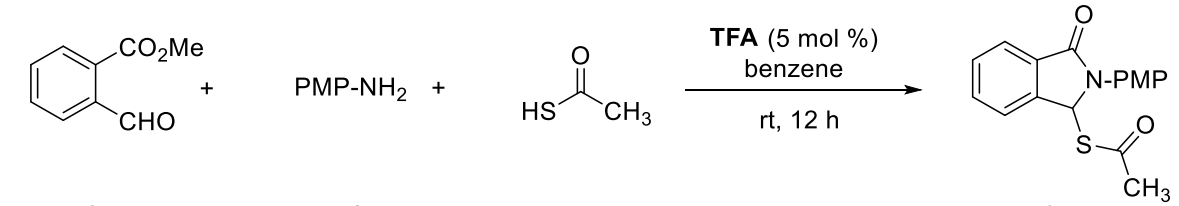
= 8.96 Hz, 2H), 3.78 (s, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 190.3, 166.8, 158.1, 143.1, 136.1, 134.3, 132.8, 131.8, 129.6, 128.9, 127.7, 126.1, 124.2, 123.8, 114.4, 63.6, 55.5. **HRMS** (ESI): Exact mass calcd for $C_{22}H_{18}NO_3S$ $[M+H]^+$: 376.1002; Found: 376.1037.

General procedure for the control experiment:

In a round-bottomed flask, benzaldehyde **8** (0.2 mmol, 1 equiv) and PMP-NH_2 **4a** (0.2 mmol, 1 equiv), were taken, and benzene (2.0 mL) was added to it. Then TFA (5 mol%) was added to the mixture and stirred at rt for 3 h. Then thioacid **5a** (0.3 mmol, 1.5 equiv) was added dropwise. Then, the reaction mixture was allowed to stir at room temperature for 12 h, but the expected product was formed.



General procedure for the gram-scale synthesis of 6a:

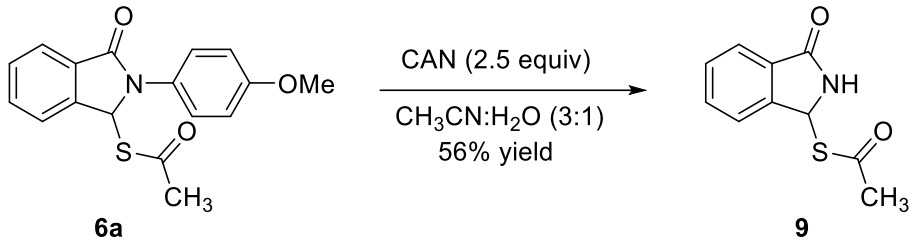


In a round-bottomed flask, ester-aldehydes **3a** (1.0 g, 6.1 mmol, 1 equiv.) and PMP-NH_2 **4a** (0.75 g, 6.1 mmol, 1 equiv.), were taken and benzene (61 mL) was added to it. Then TFA (5 mol%) was added to the mixture and stirred at rt for 3 h. Then thioacid **5a** (0.65 mL, 9.2 mmol, 1.5 equiv.) was added dropwise. Then, the reaction mixture was allowed to stir at room temperature for 12 h. After completion of the reaction, the residue was charged over a column packed with silica gel. Product **6a** (1.8 g, 96% yield) was isolated by flash column chromatography using ethyl acetate and hexane as eluents.

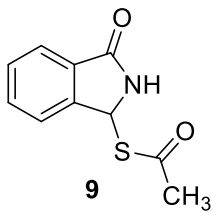
General procedure for the synthesis of compound 9:

The compound **6a** (0.2 mmol, 1.0 equiv) was dissolved in CH_3CN (3.0 mL) and cooled at 0 °C using an ice-water mixture. An aqueous solution of CAN (2.5 equiv., 0.5 mmol dissolved in 1.0 mL H_2O) was added dropwise and stirred for 2 h at the same temperature. Upon completion of the reaction (monitored by TLC), the reaction mixture was quenched with a

saturated aqueous solution of $NaHCO_3$ and extracted with EtOAc (3 × 20 mL). The organic layers were dried over anhydrous Na_2SO_4 and concentrated under reduced pressure. The crude product was purified by column chromatography using EtOAc/hexane as eluent to afford compound **9** (23.21 mg, 56% yield) as a brown solid.

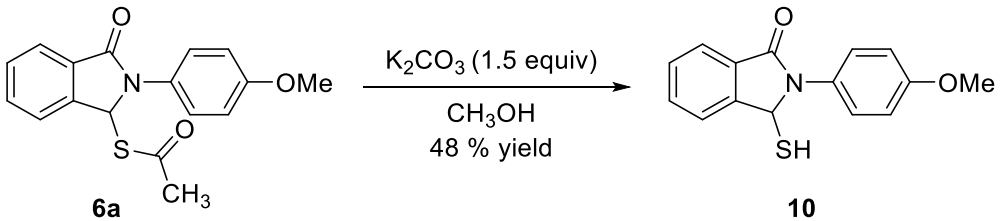


S-(3-oxoisoindolin-1-yl) ethanethioate (9): Brown solid, 23.21 mg, 56% yield. R_f = 0.19 (30% EtOAc in hexanes). **MP**: 121−123 °C. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.87 (d, J = 7.54 Hz, 1H), 7.60 (t, J = 7.46 Hz, 1H), 7.52 (t, J = 7.44 Hz, 1H), 7.48 (d, J = 7.61 Hz, 1H), 7.18 (s, 1H), 6.33 (s, 1H), 2.45 (s, 3H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 196.5, 169.5, 142.6, 132.6, 131.8, 129.6, 124.4, 123.5, 58.3, 30.8· **HRMS** (ESI): Exact mass calcd for $C_{10}H_9NO_2SNa$ [M+Na]: 230.0246; Found: 230.0247.

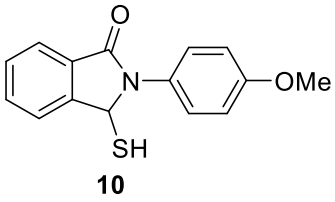


General procedure for the synthesis of compound 10:

The compound **6a** (0.2 mmol, 1.0 equiv) was dissolved in methanol (3.0 mL) and cooled at 0 °C using an ice-water mixture. Then solid K_2CO_3 (1.5 equiv., 0.3 mmol) was added slowly and stirred for 1 h at room temperature. Upon completion of the reaction (monitored by TLC), the reaction mixture was quenched with a saturated aqueous solution of $NaHCO_3$ and extracted with EtOAc (3 × 20 mL). The organic layers were dried over anhydrous Na_2SO_4 and concentrated under reduced pressure. The crude product was purified by column chromatography using EtOAc/ hexane as eluent to afford compound **10** (26.05 mg, 48% yield) as a brown solid.



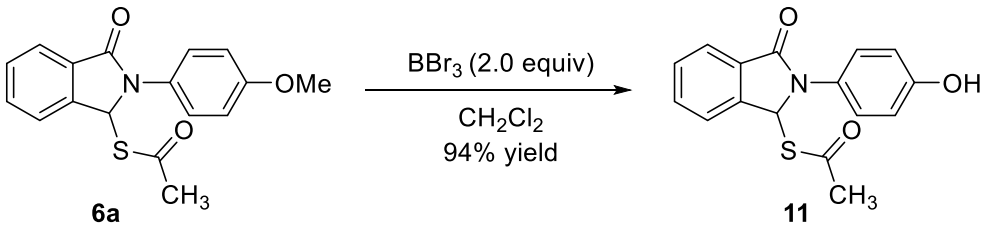
3-mercapto-2-(4-methoxyphenyl)isoindolin-1-one (10): Yellow solid, 26.05 mg, 48% yield. R_f = 0.36 (30% EtOAc in hexanes) **MP**: 124-126 °C. **^{1}H NMR** (500 MHz, $CDCl_3$) δ 7.91 (d, J = 7.17 Hz, 1H), 7.65 (t, J = 7.64 Hz, 2H), 7.55 (t, J = 7.18 Hz, 1H), 7.43 (d, J = 8.87 Hz, 2H), 7.01 (d, J = 8.91 Hz, 2H), 6.16 (d, J = 7.63 Hz, 1H), 3.84 (s, 3H), 2.32 (d, J = 7.69 Hz, 1H). **^{13}C NMR** (125 MHz, $CDCl_3$) δ 166.2, 158.2, 144.3, 132.6, 131.3, 129.6, 129.1, 126.3, 124.2, 123.5, 114.7, 60.3, 55.6. **HRMS** (ESI): Exact mass calcd for $C_{15}H_{13}NO_2SNa$ $[M+Na]^+$: 294.0559; Found: 294.0550.



10

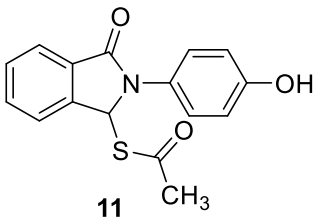
General procedure for the synthesis of compound 11:

The compound **6a** (0.2 mmol, 1.0 equiv.) was dissolved in DCM (3.0 mL) and cooled at 0 °C using an ice-water mixture. Then BBr_3 (2.0 equiv., 0.4 mmol) was added slowly and stirred for 3 h at room temperature. Upon completion of the reaction (monitored by TLC), the reaction mixture was quenched with an ice-water and extracted with EtOAc (3 × 20 mL). The organic layers were dried over anhydrous Na_2SO_4 and concentrated under reduced pressure. The crude product was purified by column chromatography using EtOAc/hexane as eluent to afford compound **11** (56.28 mg, 94% yield) as a brown solid.



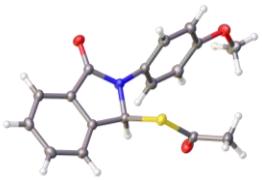
6a **11**

S-(2-(4-hydroxyphenyl)-3-oxoisoindolin-1-yl) ethanethioate (11): Grey solid, 56.28 mg, 94% yield. R_f = 0.32 (30% EtOAc in hexanes) **MP**: 180-182 °C. **^{1}H NMR** (500 MHz, DMSO-d_6) δ 9.56 (s, 1H), 7.79 (d, J = 7.52 Hz, 1H), 7.72 (t, J = 7.45 Hz, 1H), 7.61 (dd, J = 13.49, 7.17 Hz, 2H), 7.26 (d, J = 8.57 Hz, 2H), 6.90 (s, 1H), 6.80 (d, J = 8.44 Hz, 2H), 2.33 (s, 3H). **^{13}C NMR** (125 MHz, DMSO-d_6) δ 193.7, 165.7, 155.9, 143.0, 132.8, 129.4, 126.7, 123.6, 123.2, 115.3, 63.5, 30.7. **HRMS** (ESI): Exact mass calcd for $C_{16}H_{13}NO_3SNa$ $[M+Na]^+$: 322.0508; Found: 322.0507.



11

Crystal data:



6a (CCDC 2088796)

6a was recrystallized in CH_2Cl_2/hexane solvents

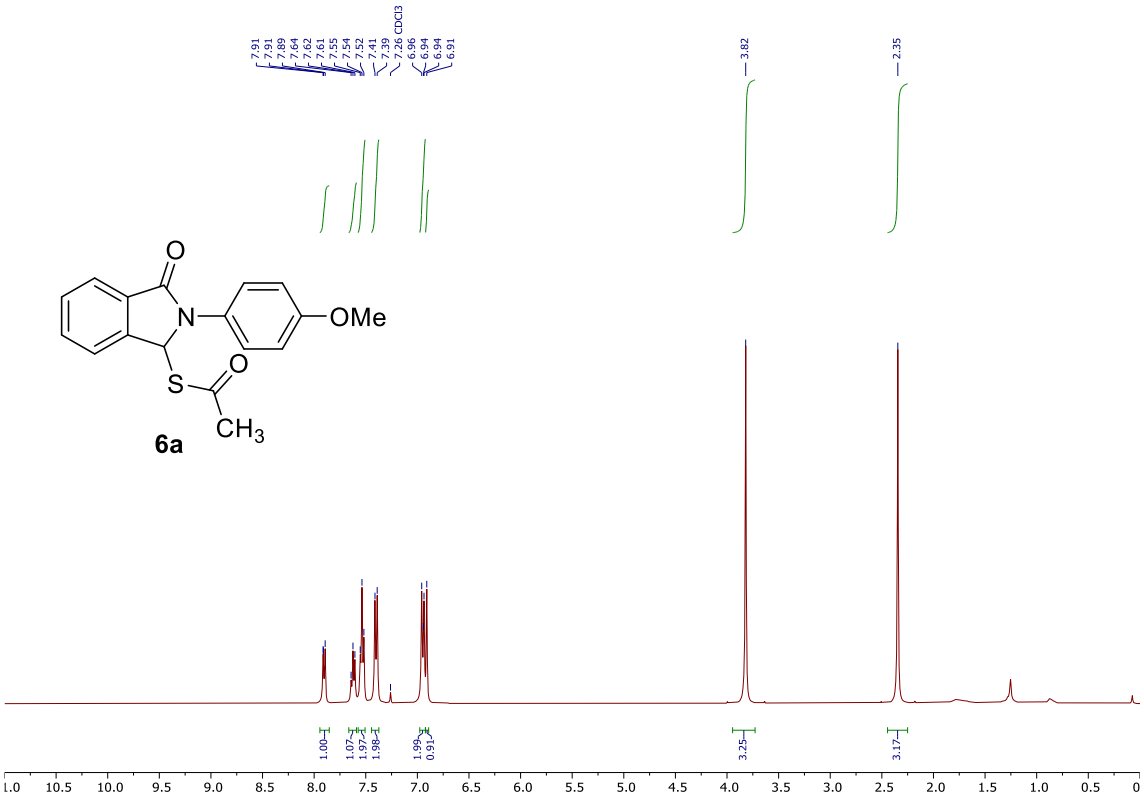
Table 1. Crystal data and structure refinement for **6a** (CCDC No-**2088796**)

Identification code	**6a**	
Empirical formula	$C_{17}H_{15}NO_3S$	
Formula weight	626.72	
Temperature	140.0 K	
Wavelength	0.71073 Å	
Crystal system	monoclinic	
Space group	$P2_1/c$	
Unit cell dimensions	a = 10.1813(4)Å	α = 90°.
	b = 17.3871(7) Å	β = 103.498(2) °
	c = 8.5577(4) Å	γ = 90°
Volume	1473.07(11) $Å^3$	
Z	4	
Density (calculated)	1.413 g/cm^3	
μ (mm^{-1})	0.232 mm^{-1}	
F(000)	656.0	
Crystal size	0.21 × 0.2 × 0.19 mm^3	
Theta range for data collection	4.686 to 57.398°.	
Index ranges	$-13 \le h \le 13$, $-23 \le k \le 23$, $-11 \le l \le 11$	
Reflections collected	30371	
Independent reflections	3733 [R_{int} = 0.0468, R_{sigma} = 0.0240]	
Data / restraints / parameters	3733/0/201	
Goodness-of-fit on F^2	1.034	
Final R indices [I>2sigma(I)]	R_1 = 0.0338, wR2 = 0.0838	
R indices (all data)	R_1 = 0.0375, wR2 = 0.0864	
Largest diff. peak and hole	0.38/-0.19 e.$Å^{-3}$	

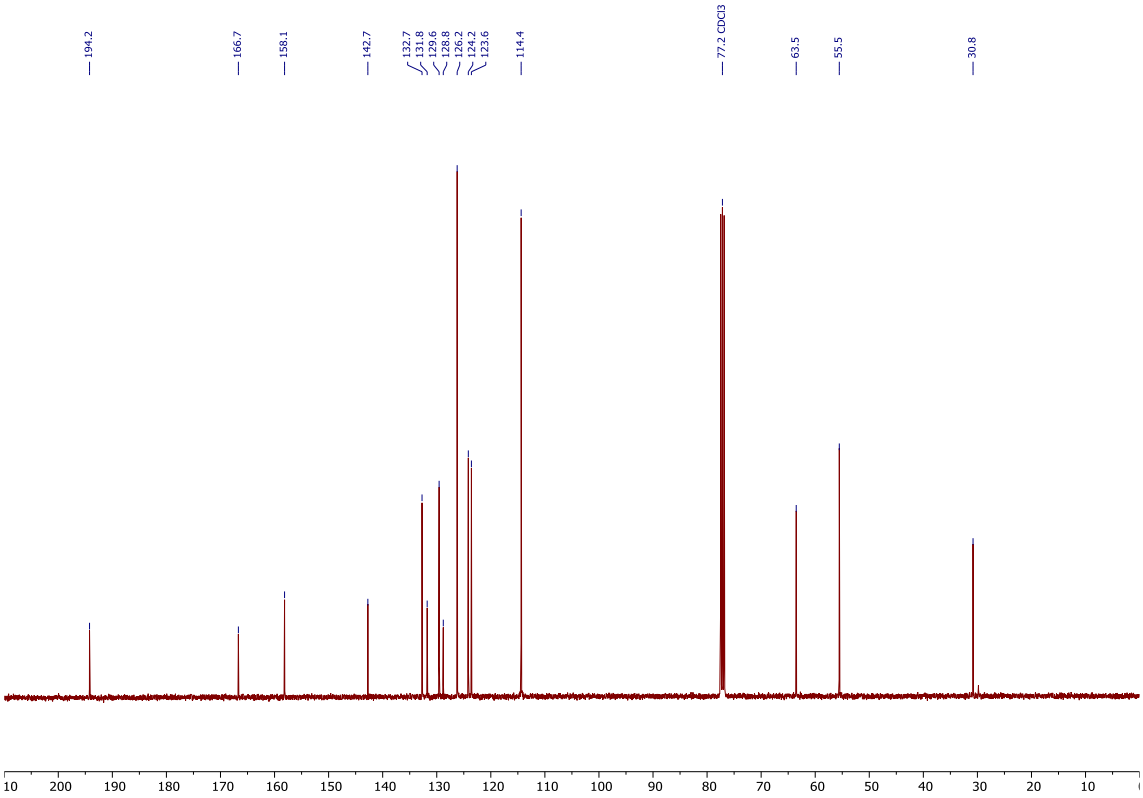
References:

1. (a) Y. He, C. Cheng, B. Chen, K. Duan, Y. Zhuang, B. Yuan, M. Zhang, Y. Zhou, Z. Zhou, Y.-J. Su, R. Cao, and L. Qiu, *Org. Lett*. 2014, **16**, 6366.
   (b) V. Bisai, A. Suneja, and V. K. Singh, *Angew. Chem. Int. Ed*., 2014, **53**, 10737.
   (c) T. Yata, Y. Nishimoto, K. Chiba, and M. Yasuda, *Chem.Eur. J*., 2021, 27, 8288.
   (d) R. Karmakar, A. Suneja, V. Bisai, V. K. Singh, *Org. Lett*., 2015, **17**, 5650.
   (e) S. Dhanasekaran, A. Kayet, A. Suneja, V. Bisai, V. K. Singh, *Org. Lett*., 2015, **17**, 2780.
   (f) R. Mirabdolbaghi, T. Dudding, *Org. Lett*., 2012, **14**, 3748.
   (g) Y. Iyori, K. Takahashi, K. Yamazaki, Y. Ano, N. Chatani, *Chem. Commun*., 2019, **55**, 13610.

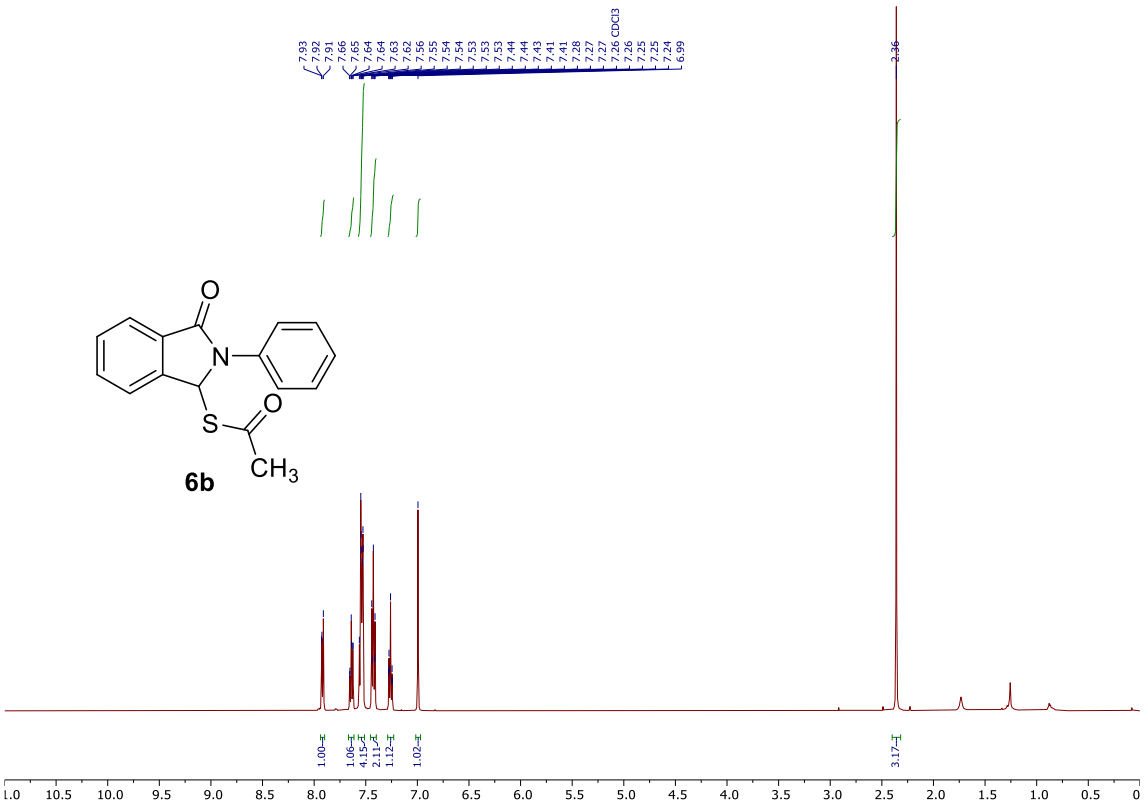
NMR graphs



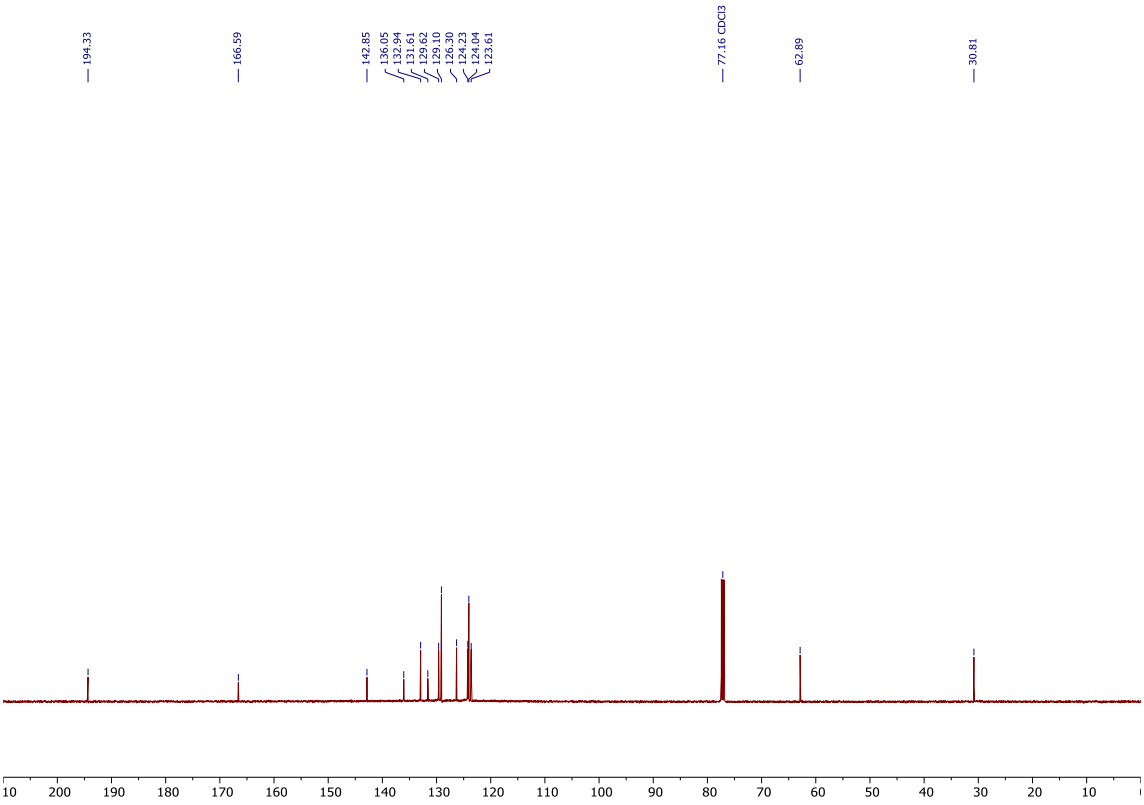
^{1}H NMR (400 MHz, $CDCl_3$) of compound **6a**



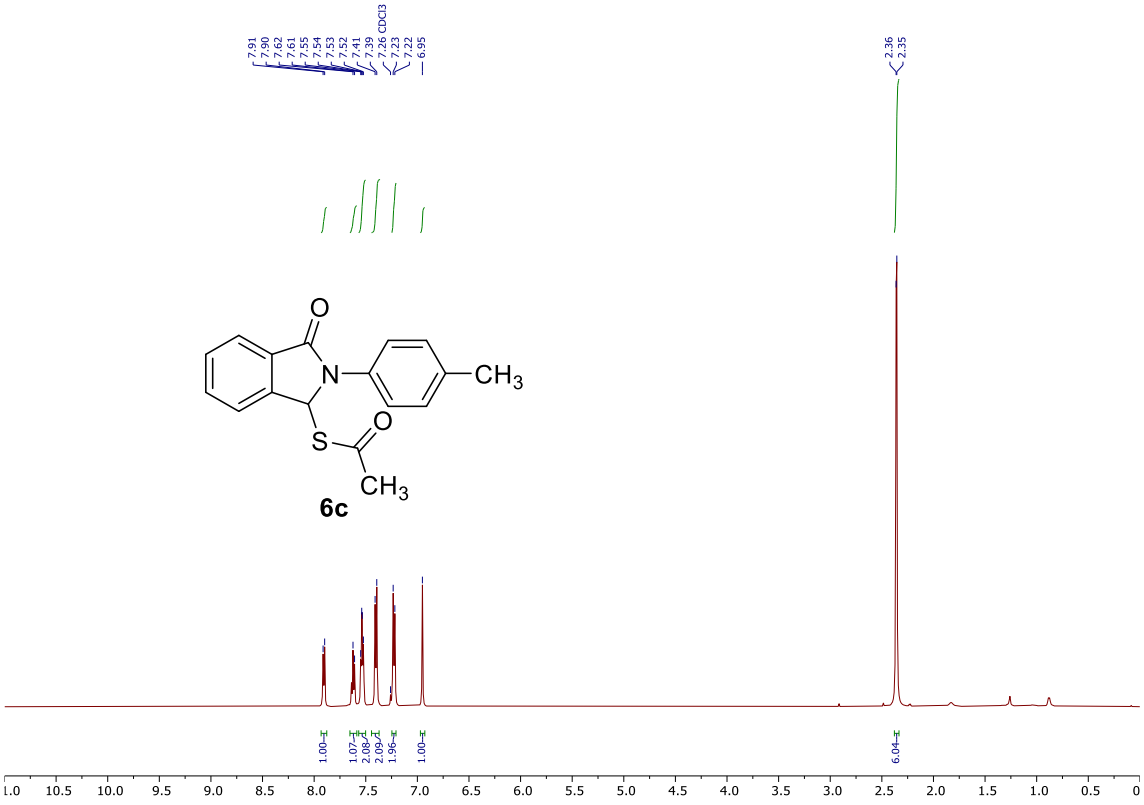
^{13}C NMR (100 MHz, $CDCl_3$) of compound **6a**



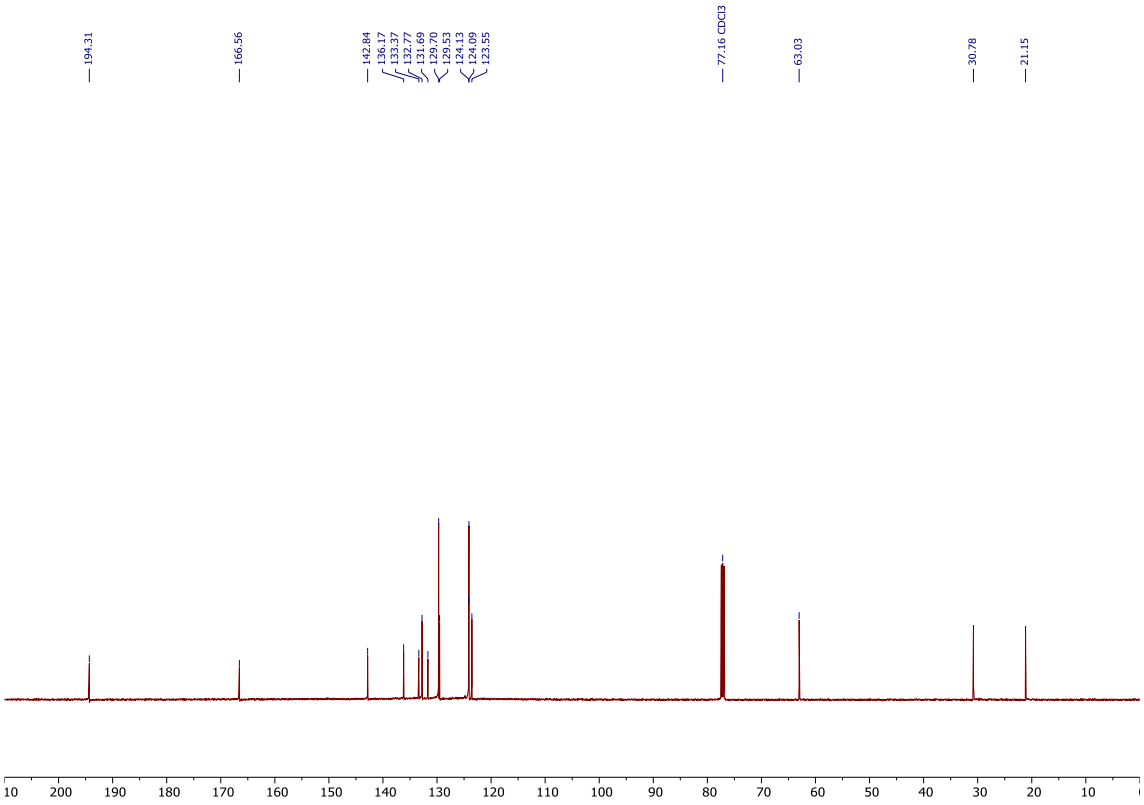
^{1}H NMR (500 MHz, $CDCl_3$) of compound **6b**



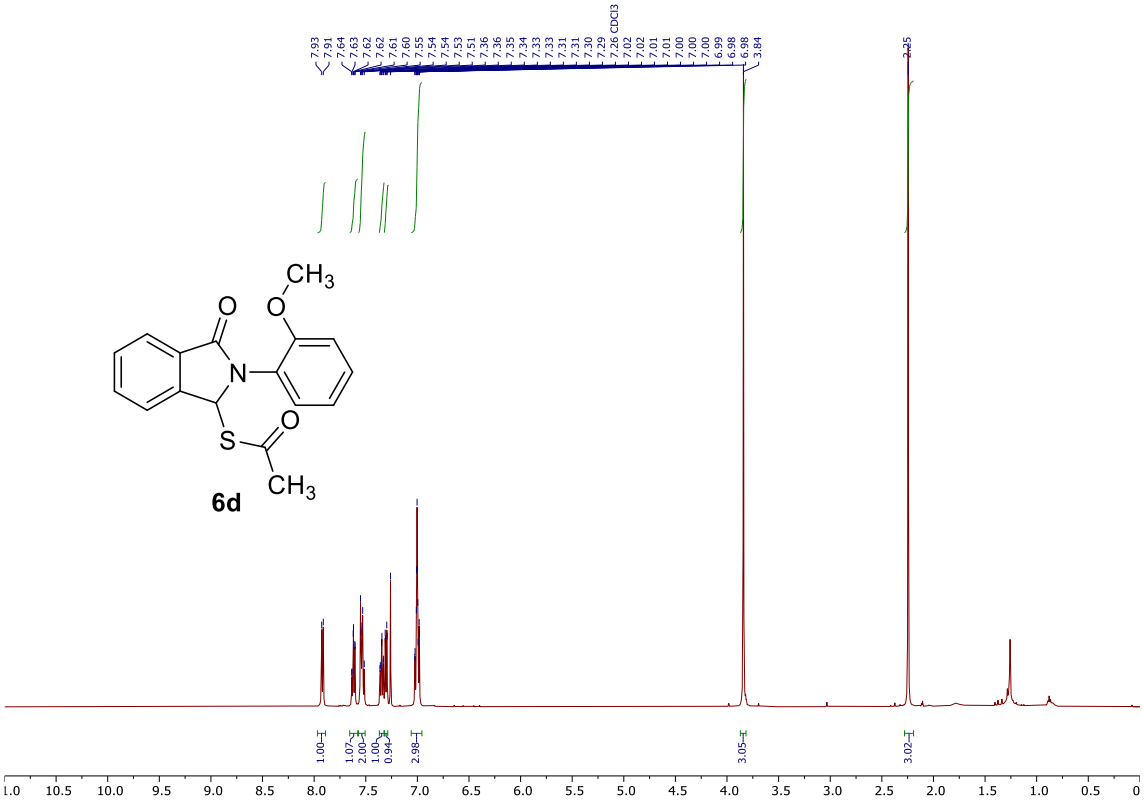
^{13}C NMR (125 MHz, $CDCl_3$) of compound **6b**



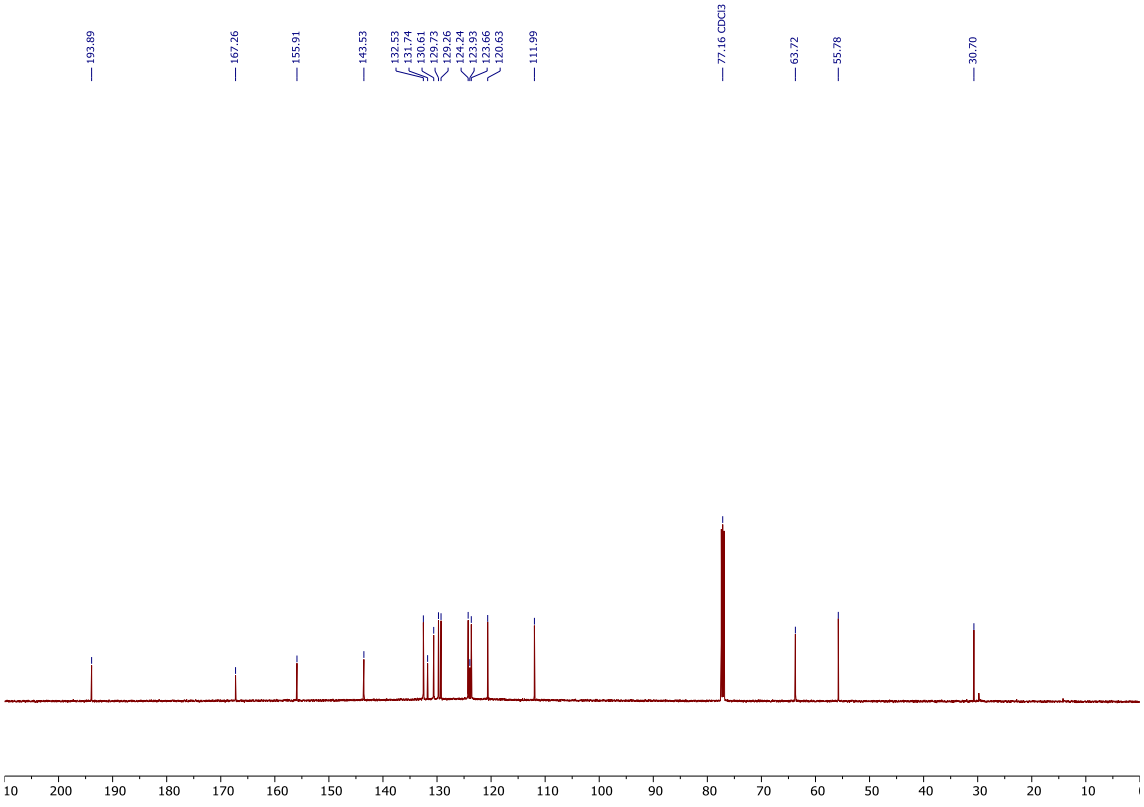
^{1}H NMR (500 MHz, $CDCl_3$) of compound **6c**



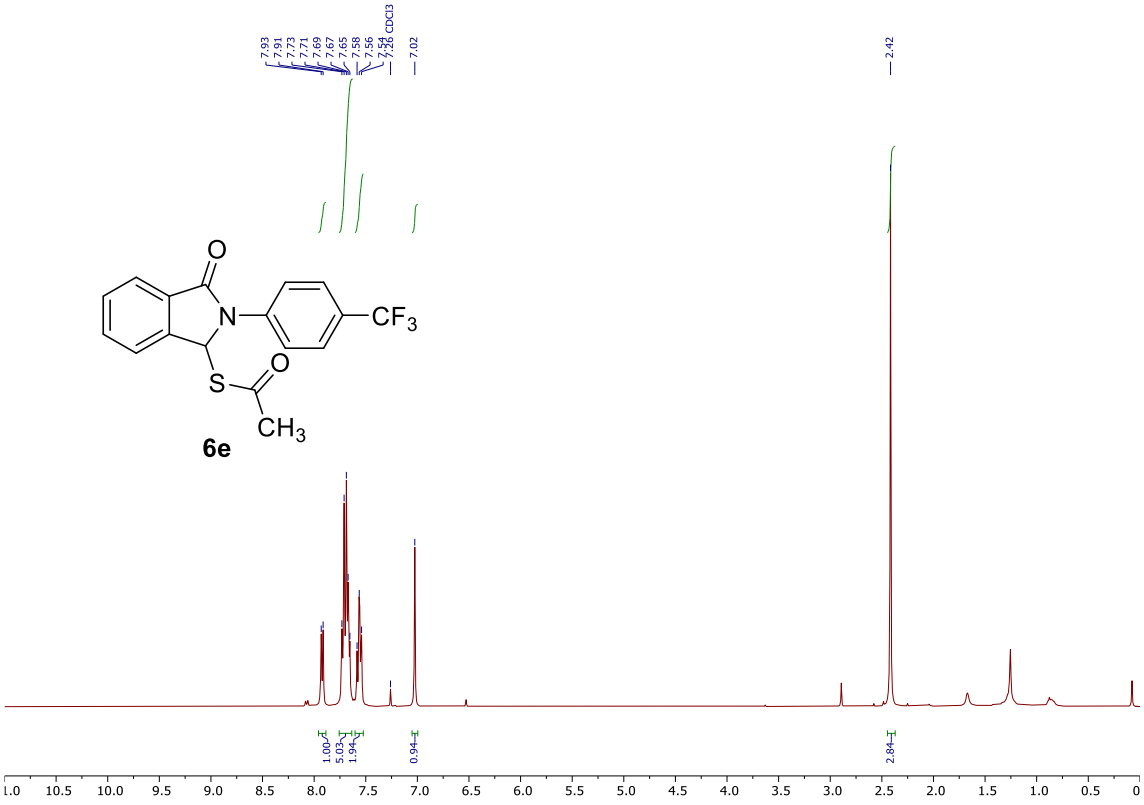
^{13}C NMR (125 MHz, $CDCl_3$) of compound **6c**



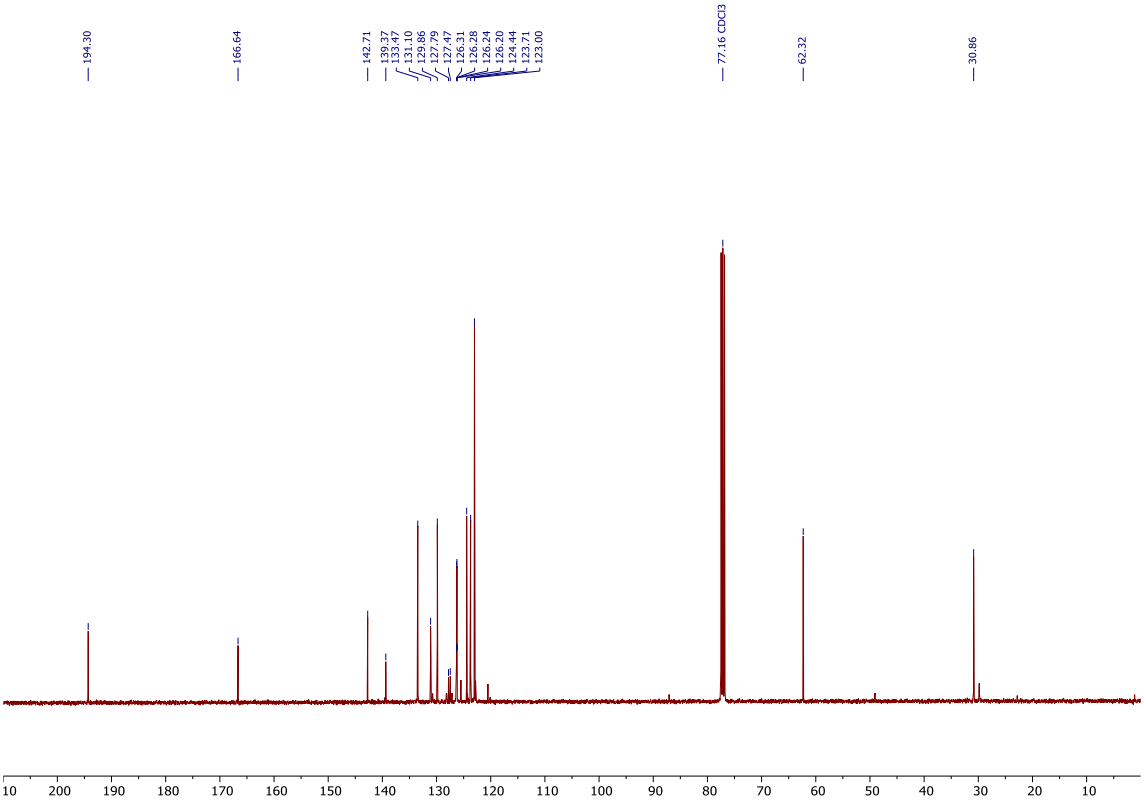
^{1}H NMR (500 MHz, $CDCl_3$) of compound **6d**



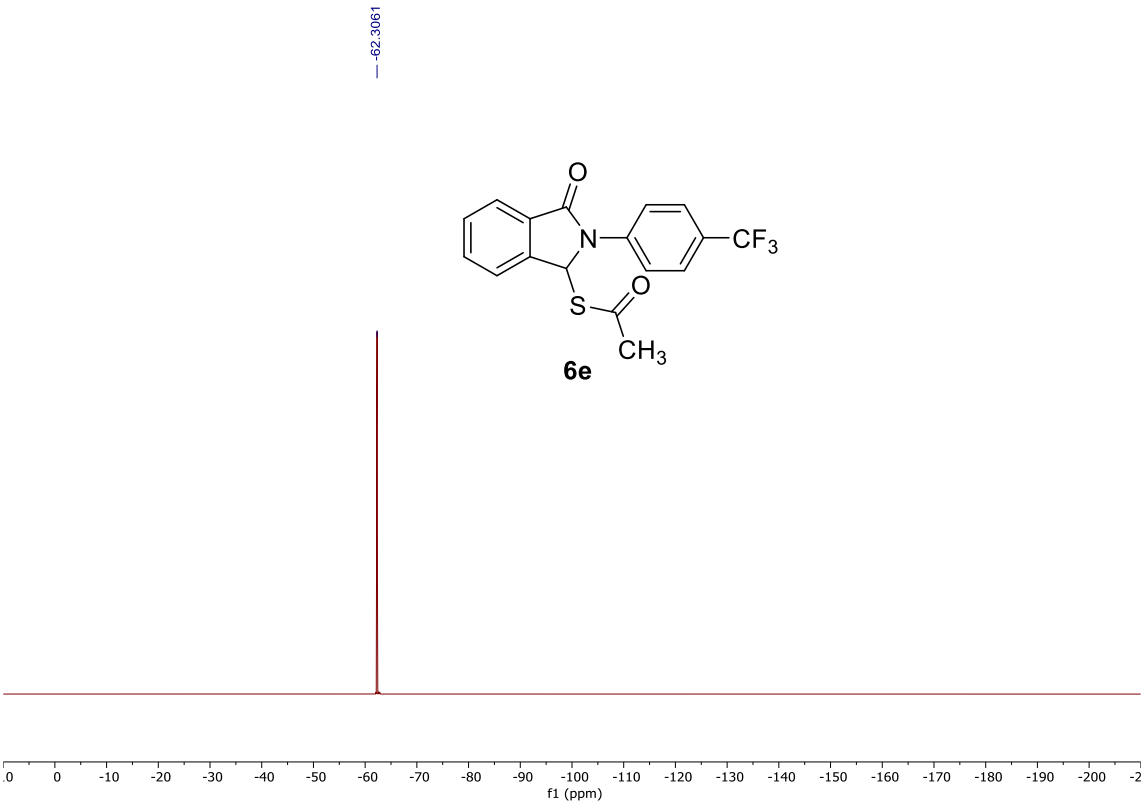
^{13}C NMR (125 MHz, $CDCl_3$) of compound **6d**



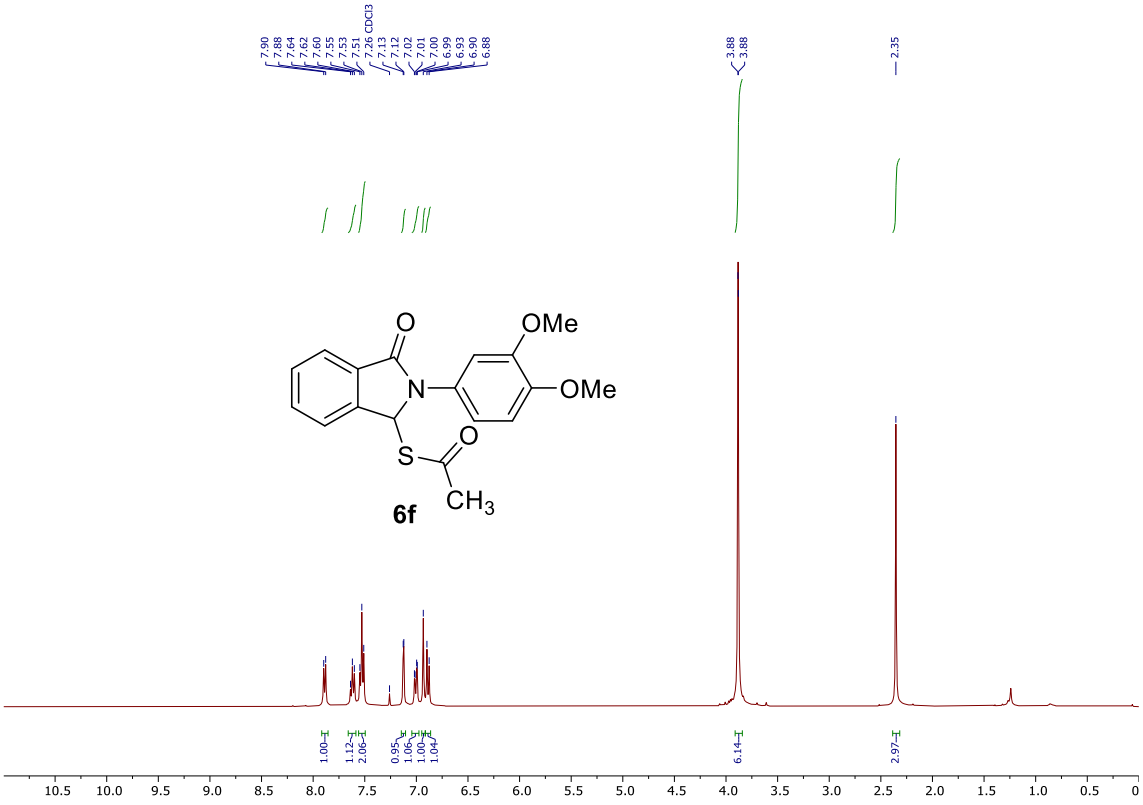
^{1}H NMR (400 MHz, $CDCl_3$) of compound **6e**



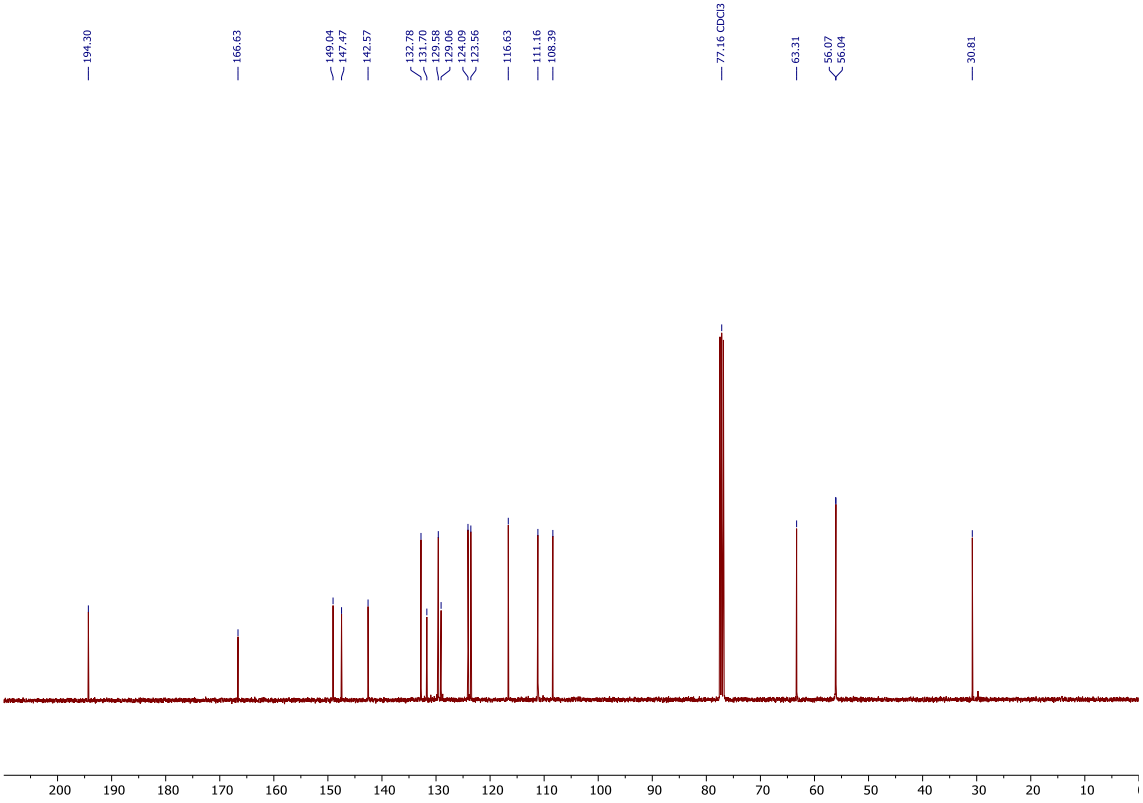
^{13}C NMR (100 MHz, $CDCl_3$) of compound **6e**



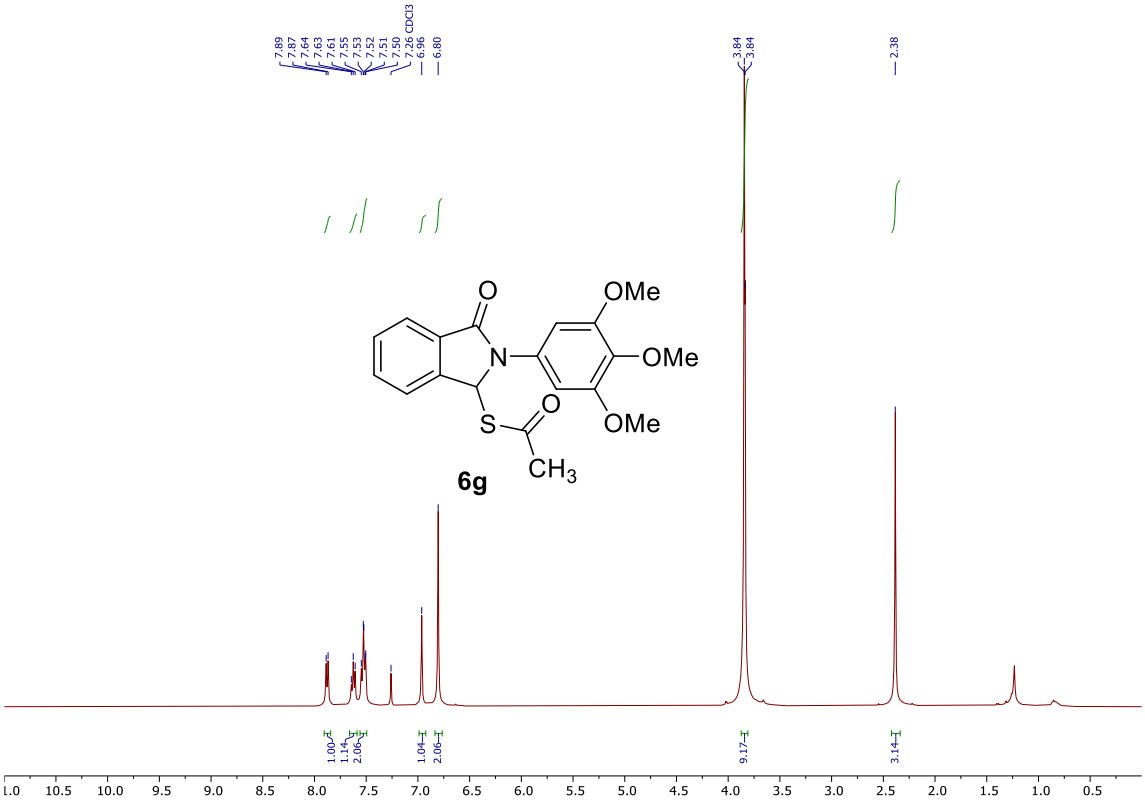
^{19}F NMR (375 MHz, $CDCl_3$) of compound **6e**



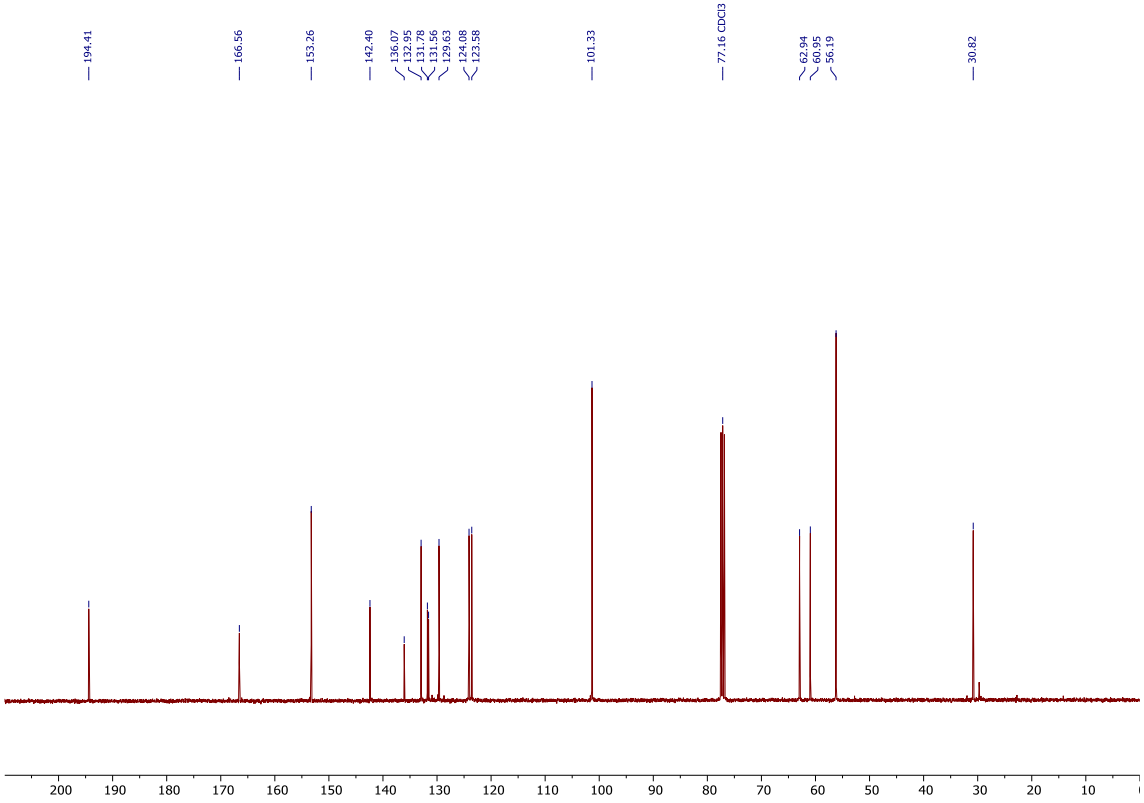
^{1}H NMR (400 MHz, $CDCl_3$) of compound **6f**



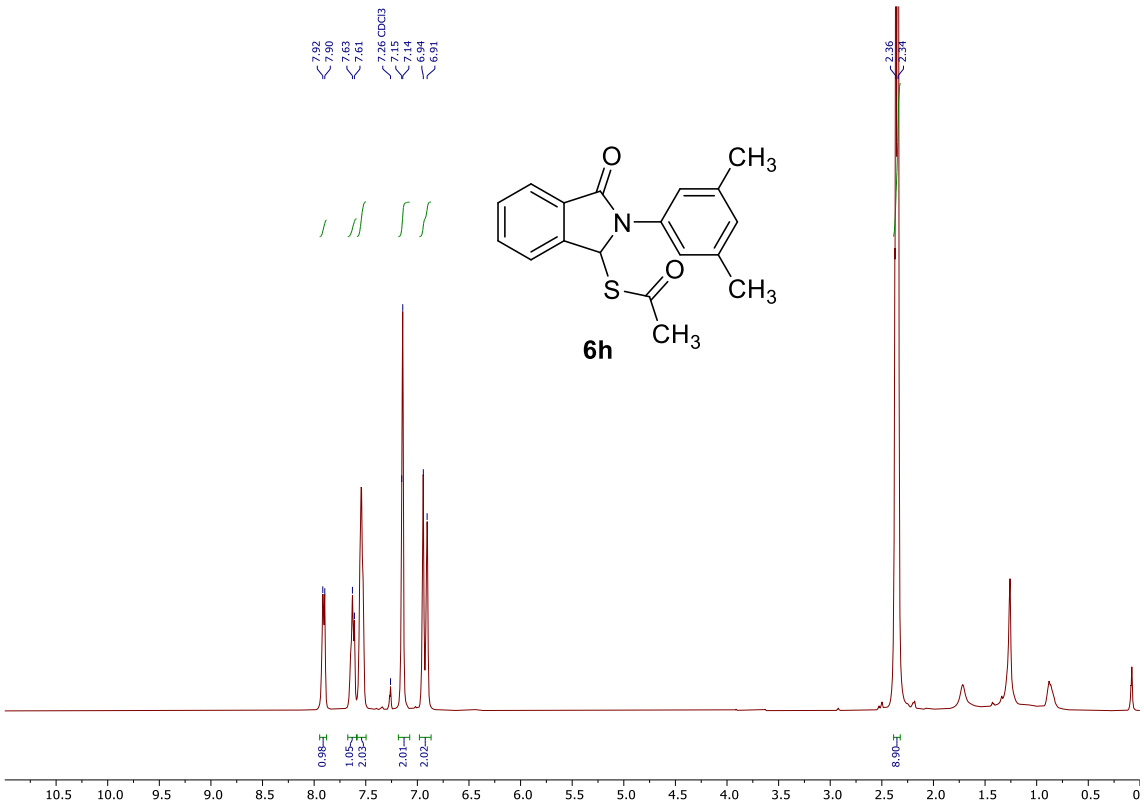
^{13}C NMR (100 MHz, $CDCl_3$) of compound **6f**



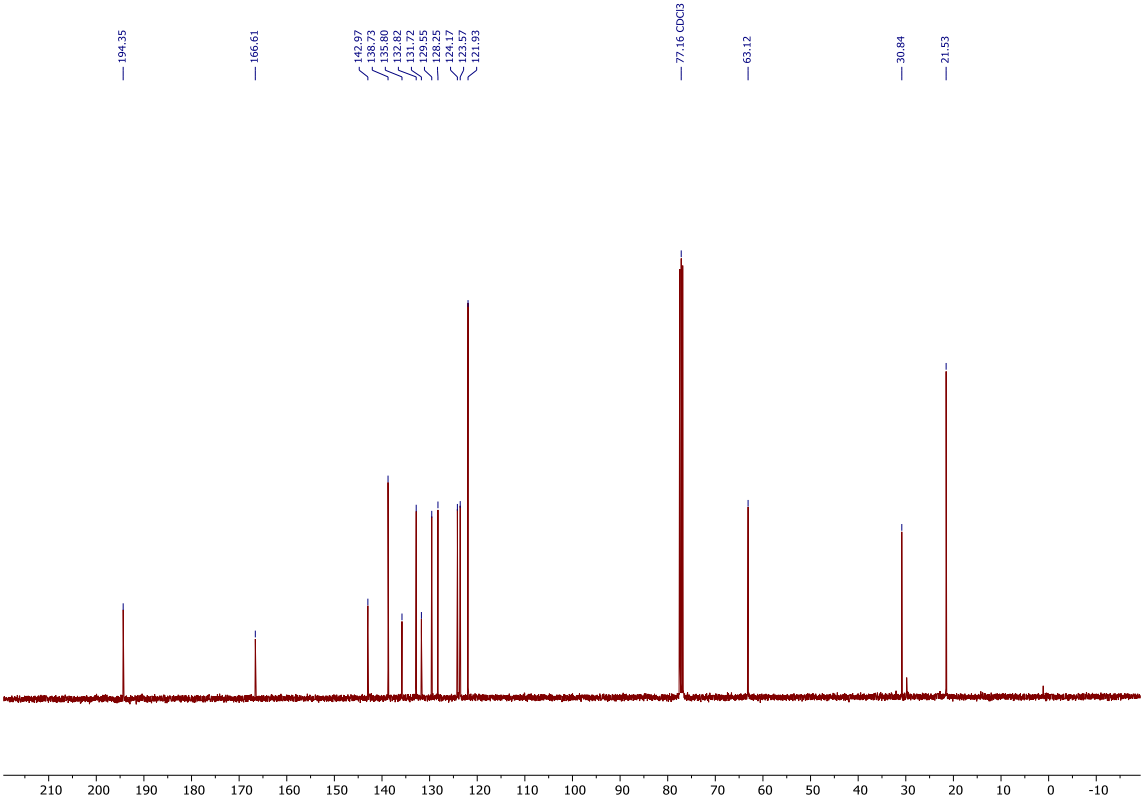
^{1}H NMR (400 MHz, $CDCl_3$) of compound **6g**



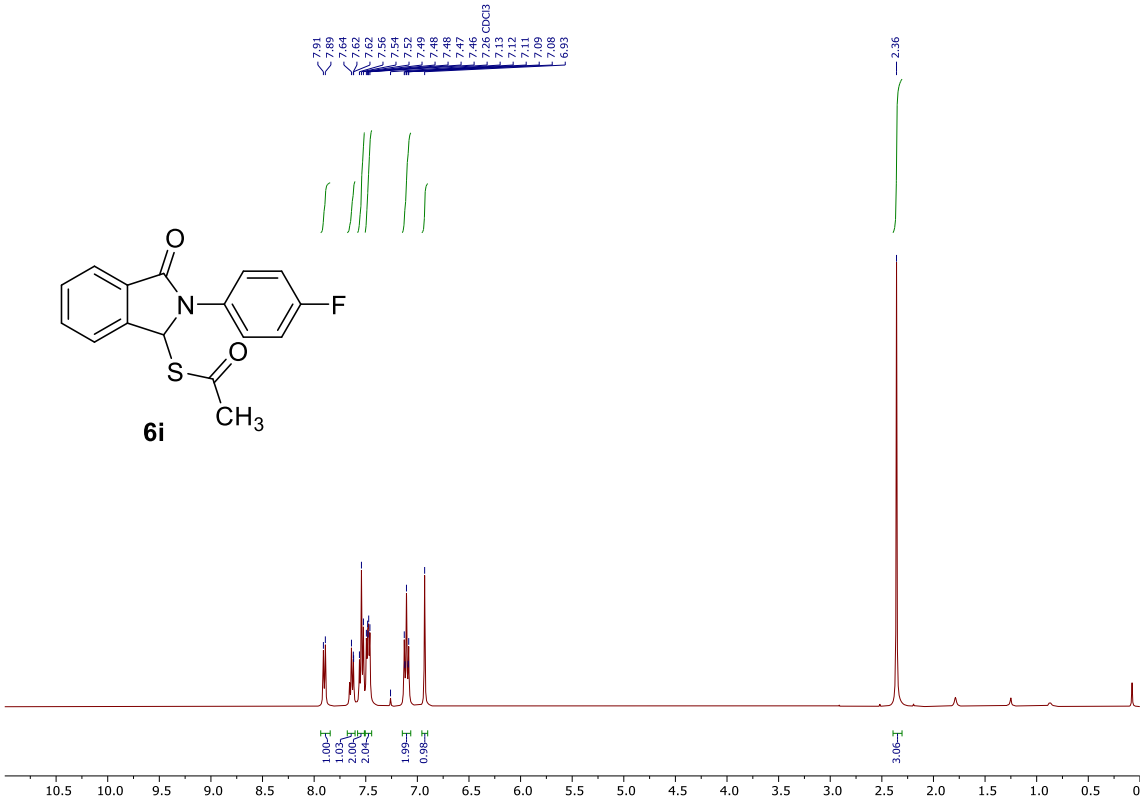
^{13}C NMR (100 MHz, $CDCl_3$) of compound **6g**



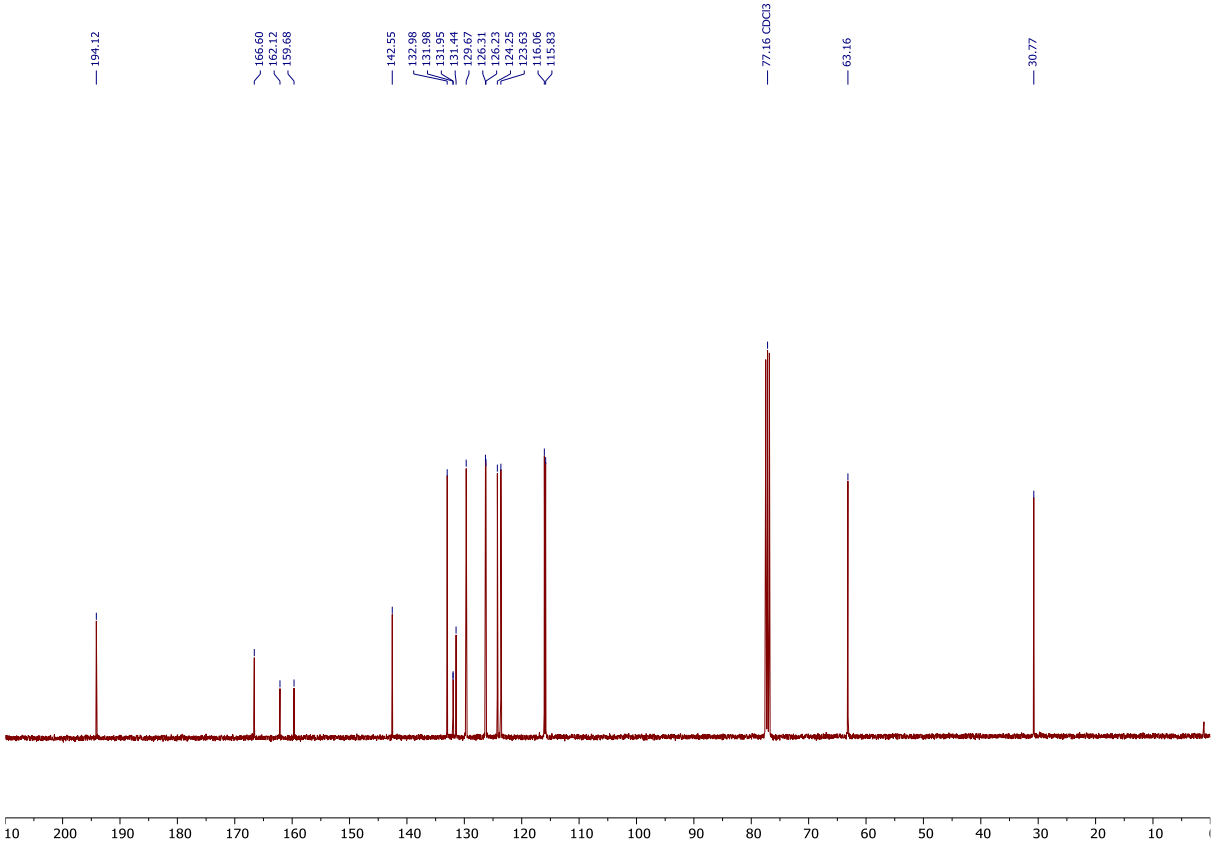
^{1}H NMR (400 MHz, $CDCl_3$) of compound **6h**



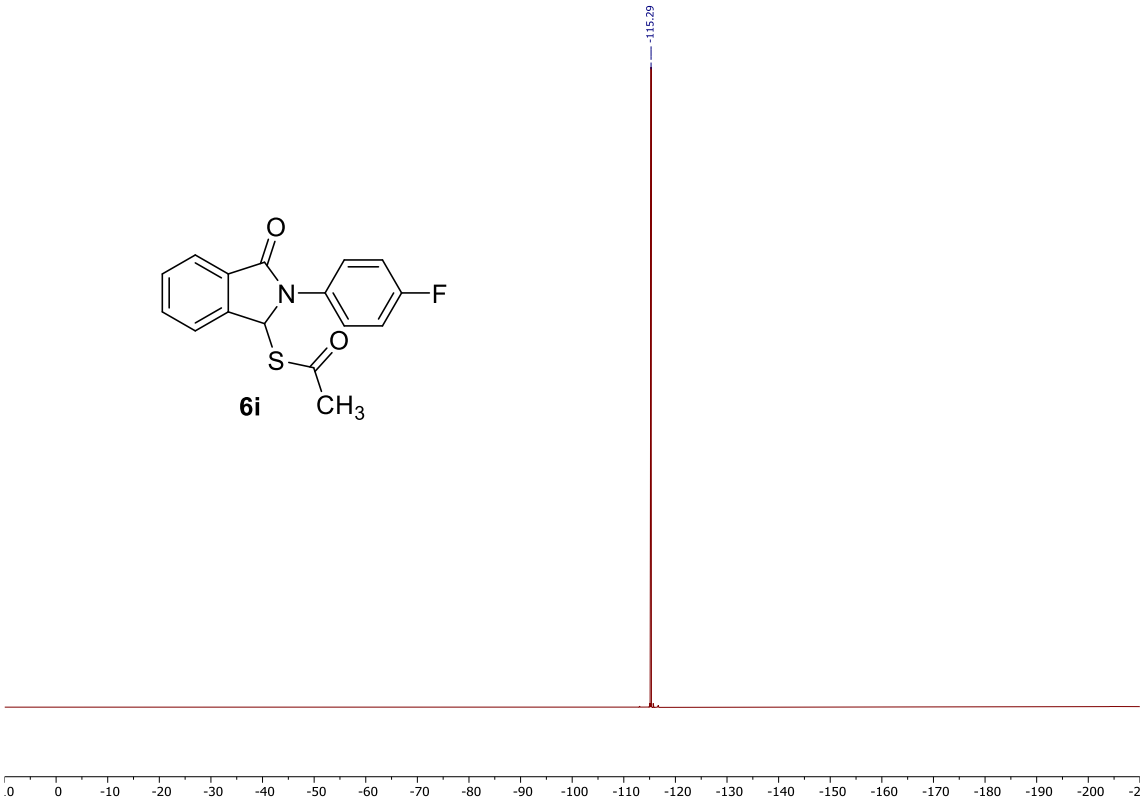
^{13}C NMR (100 MHz, $CDCl_3$) of compound **6h**



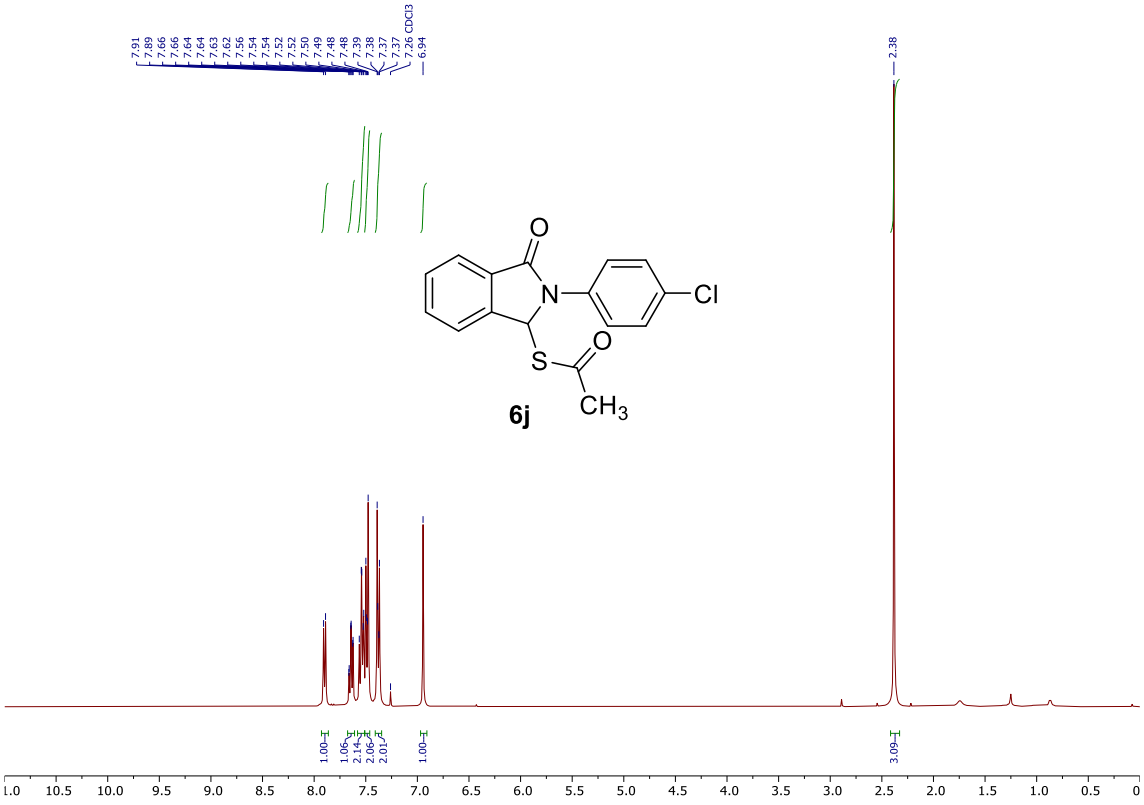
^{1}H NMR (400 MHz, $CDCl_3$) of compound **6i**



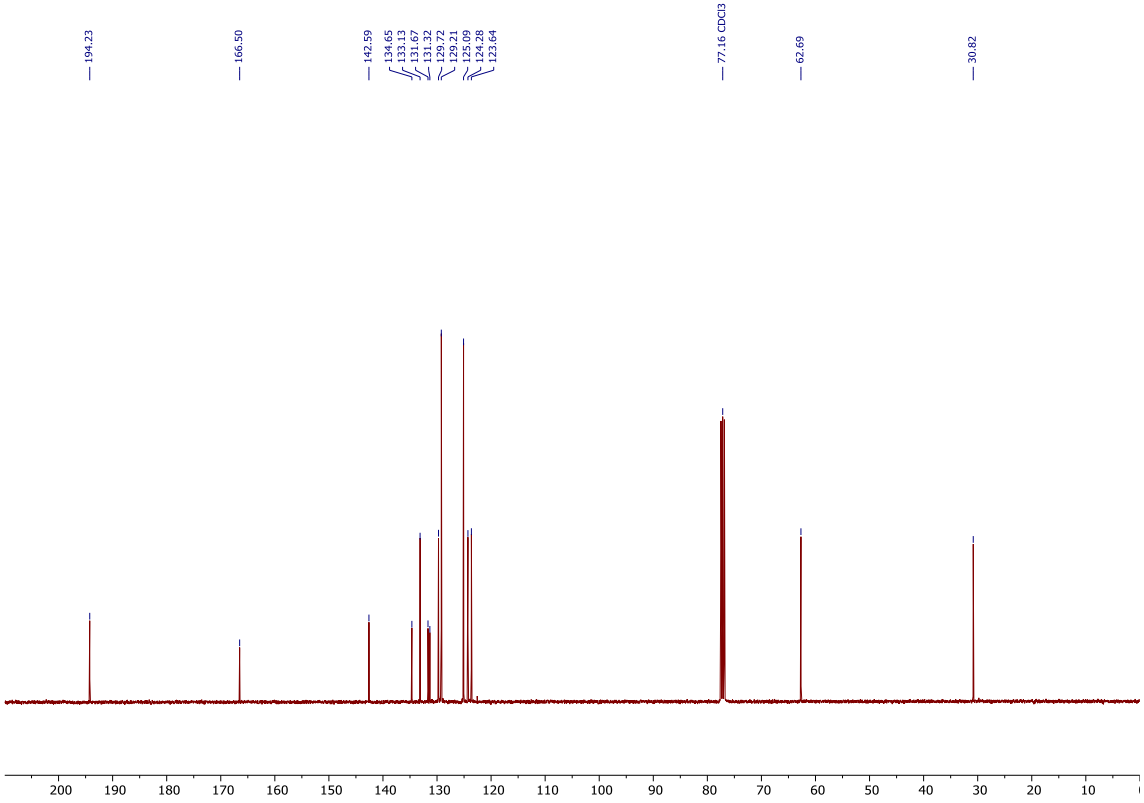
^{13}C NMR (100 MHz, $CDCl_3$) of compound **6i**



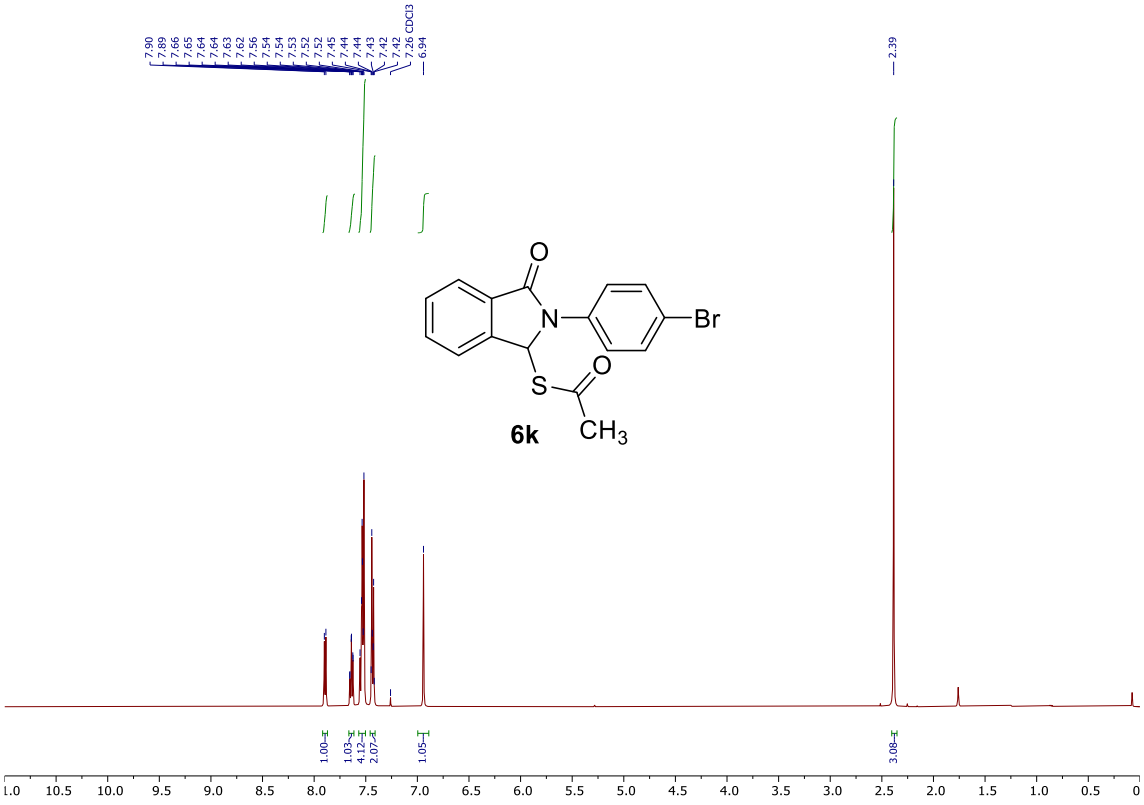
^{19}F NMR (375 MHz, $CDCl_3$) of compound **6i**



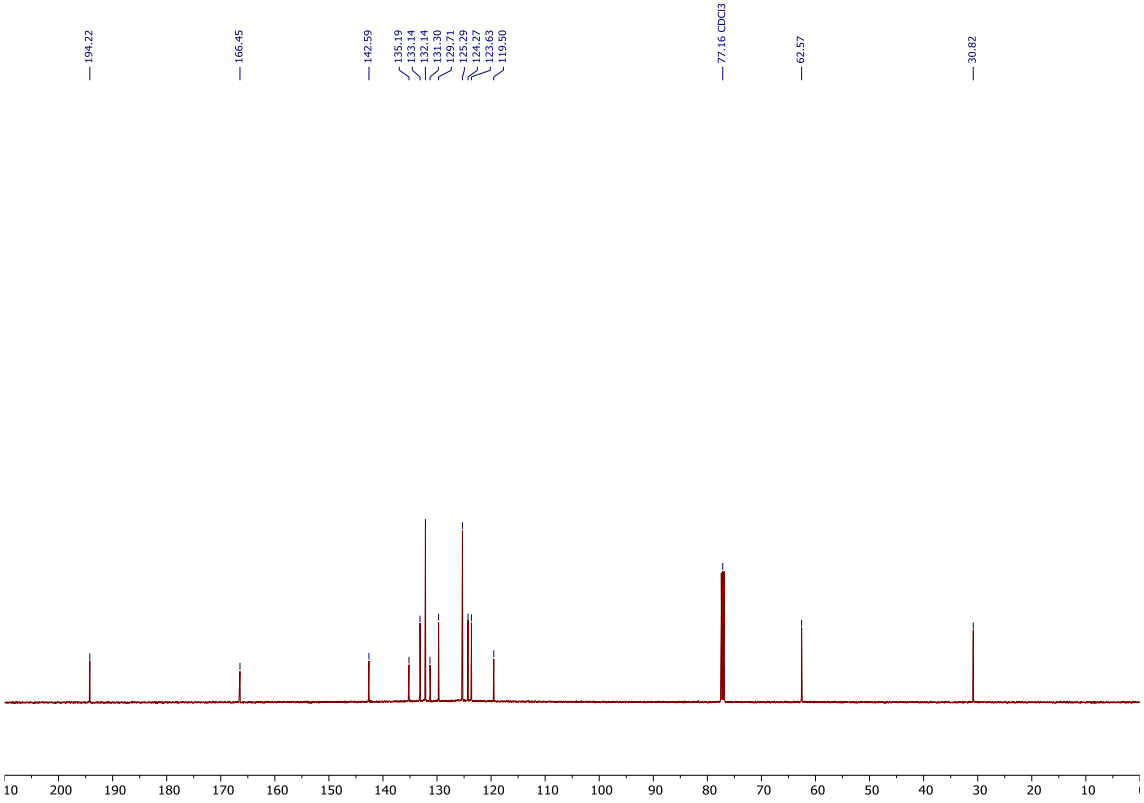
^{1}H NMR (400 MHz, $CDCl_3$) of compound **6j**



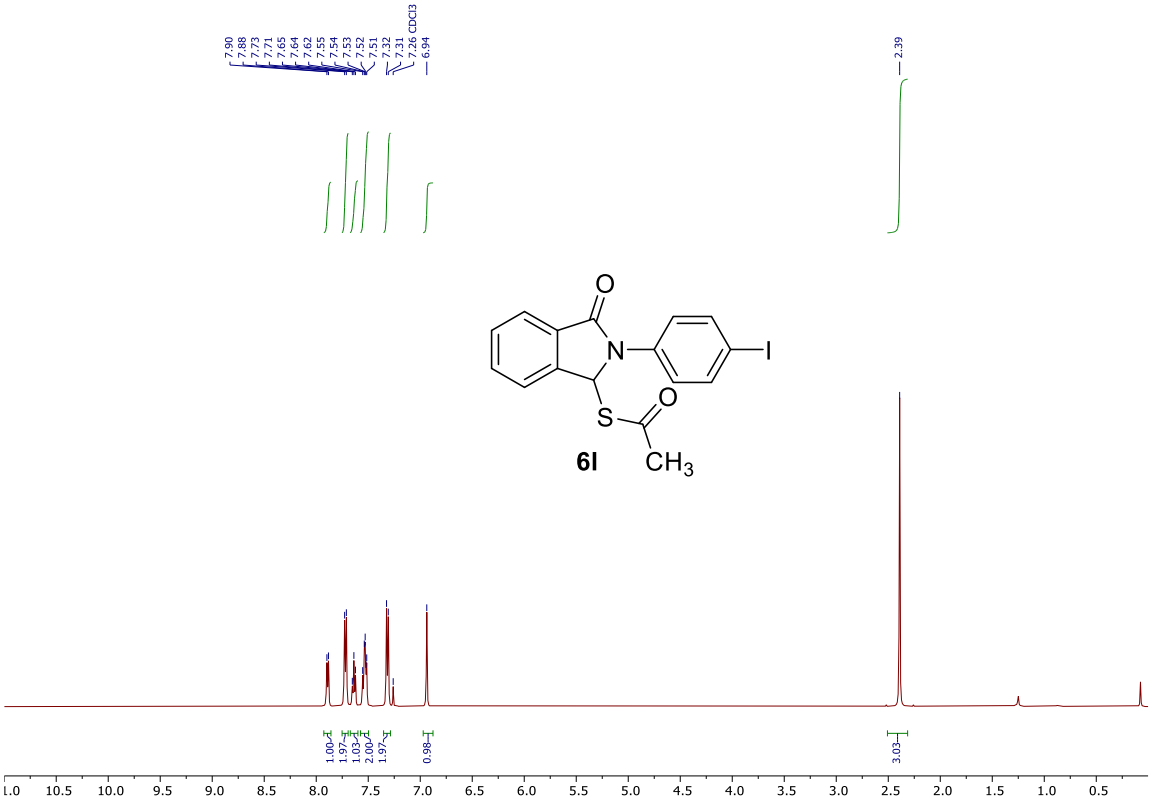
^{13}C NMR (400 MHz, $CDCl_3$) of compound **6j**



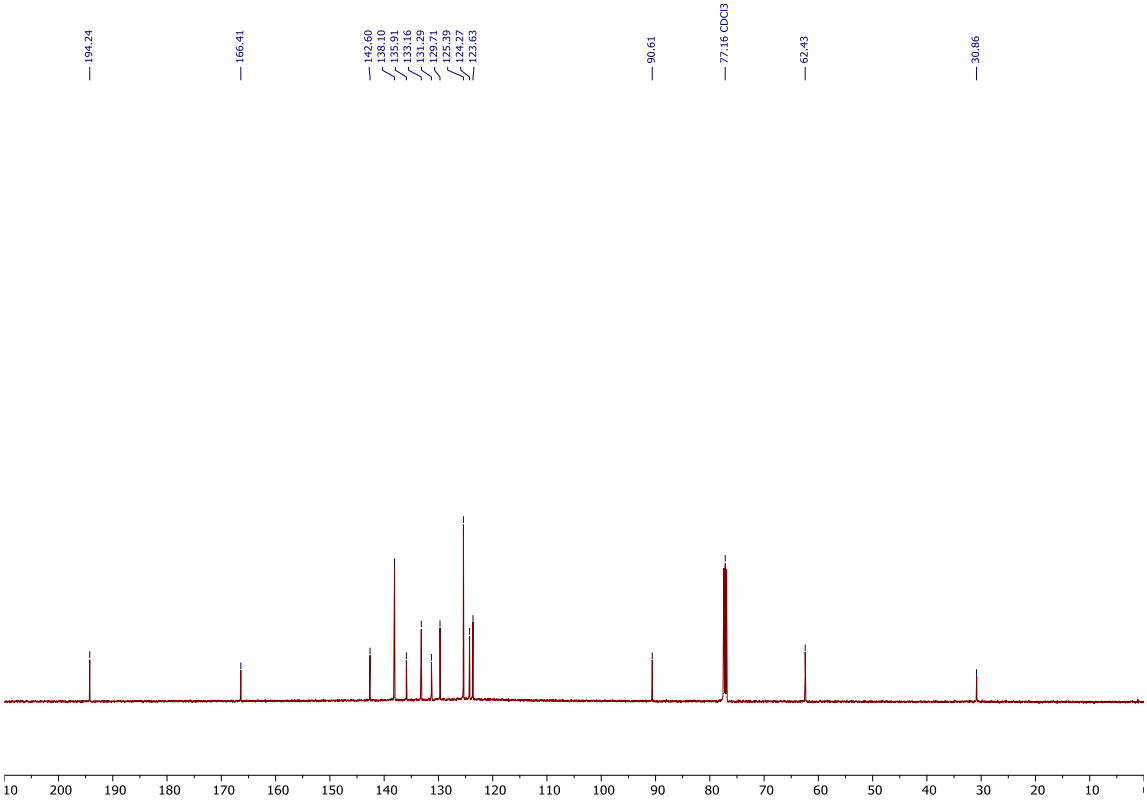
^{1}H NMR (500 MHz, $CDCl_3$) of compound **6k**



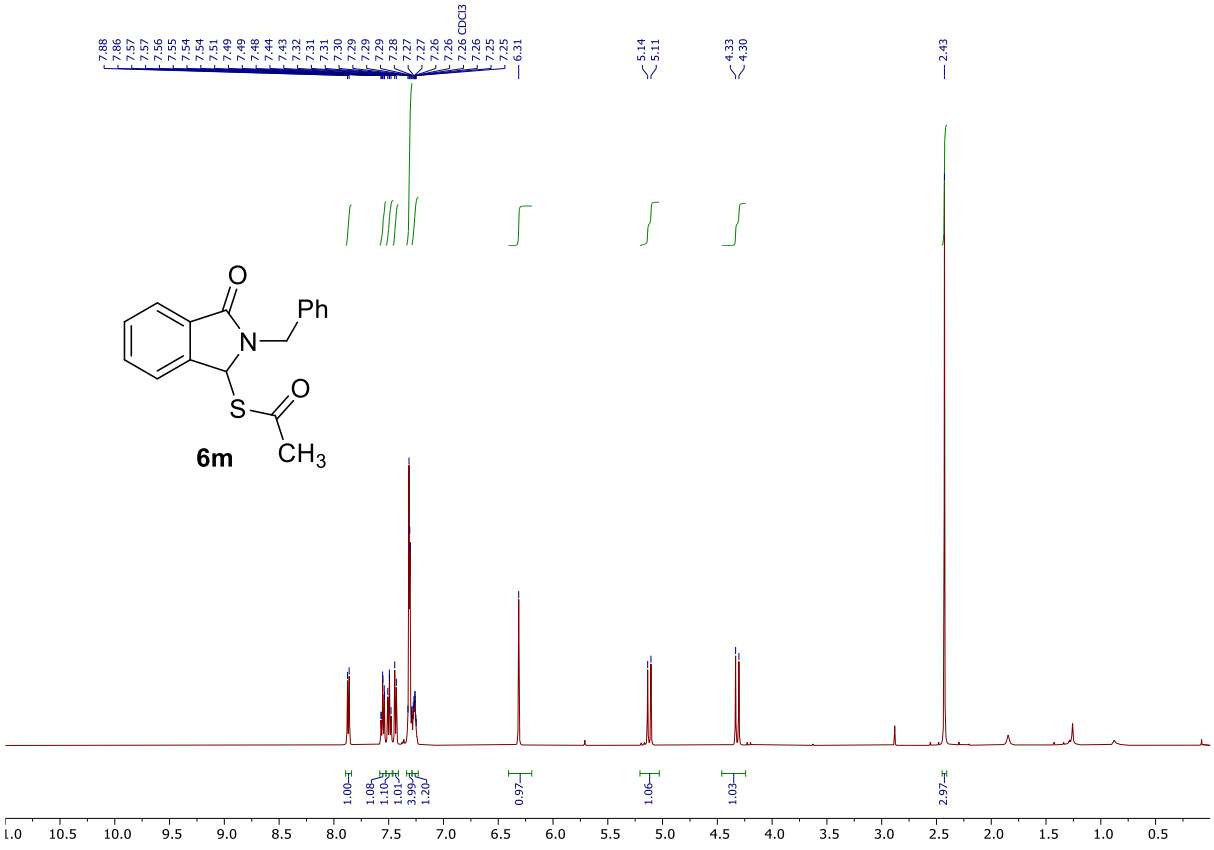
^{13}C NMR (125 MHz, $CDCl_3$) of compound **6k**



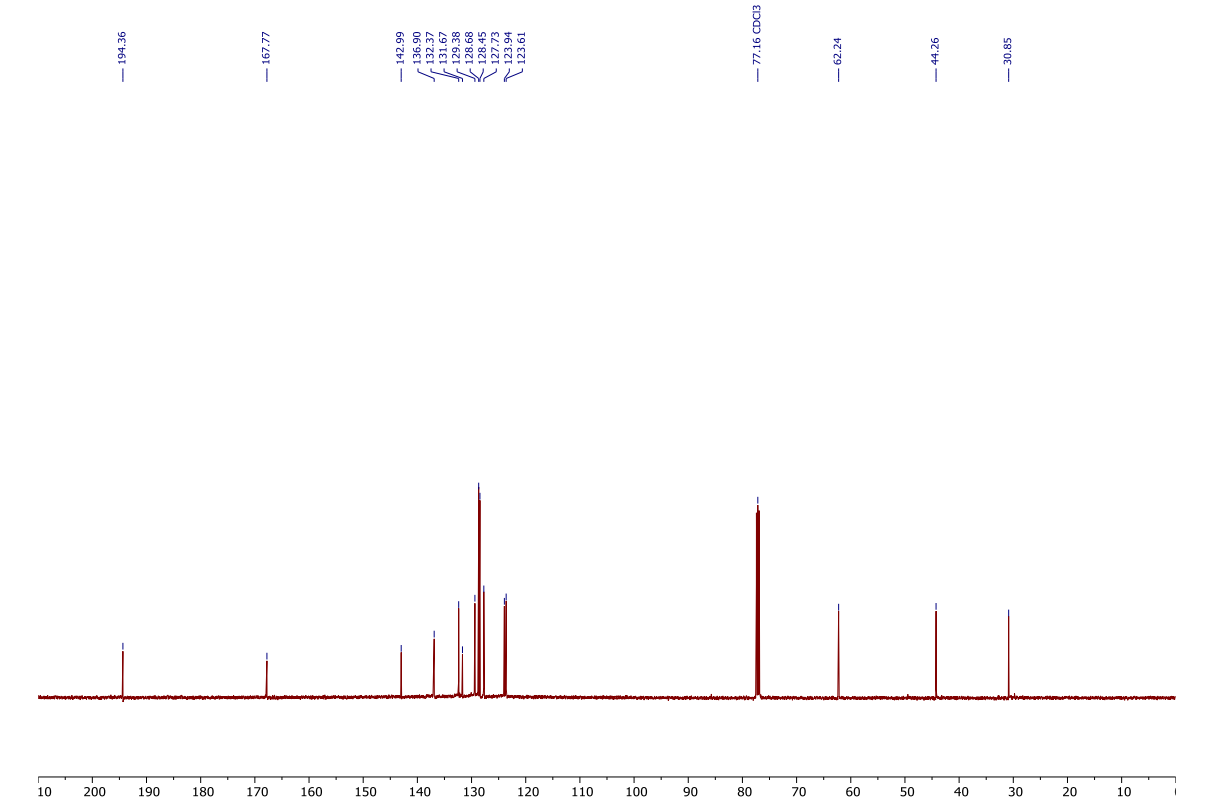
^{1}H NMR (500 MHz, $CDCl_3$) of compound **6l**



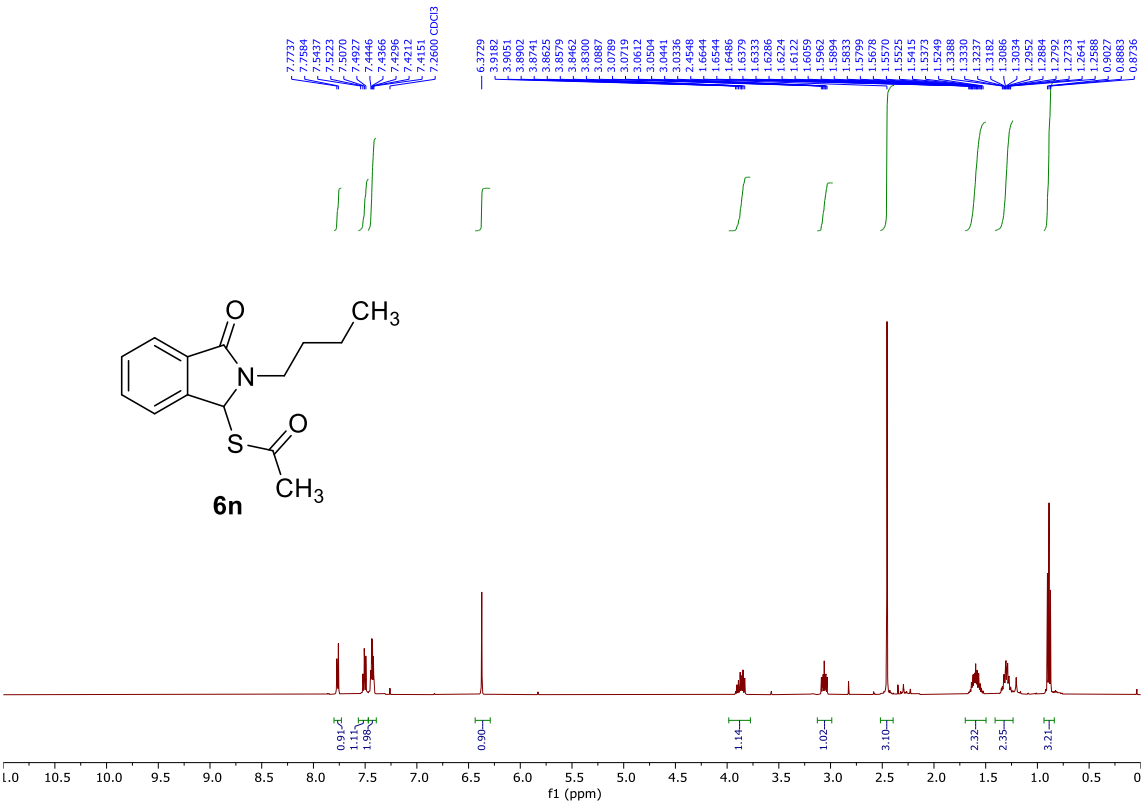
^{13}C NMR (125 MHz, $CDCl_3$) of compound **6l**



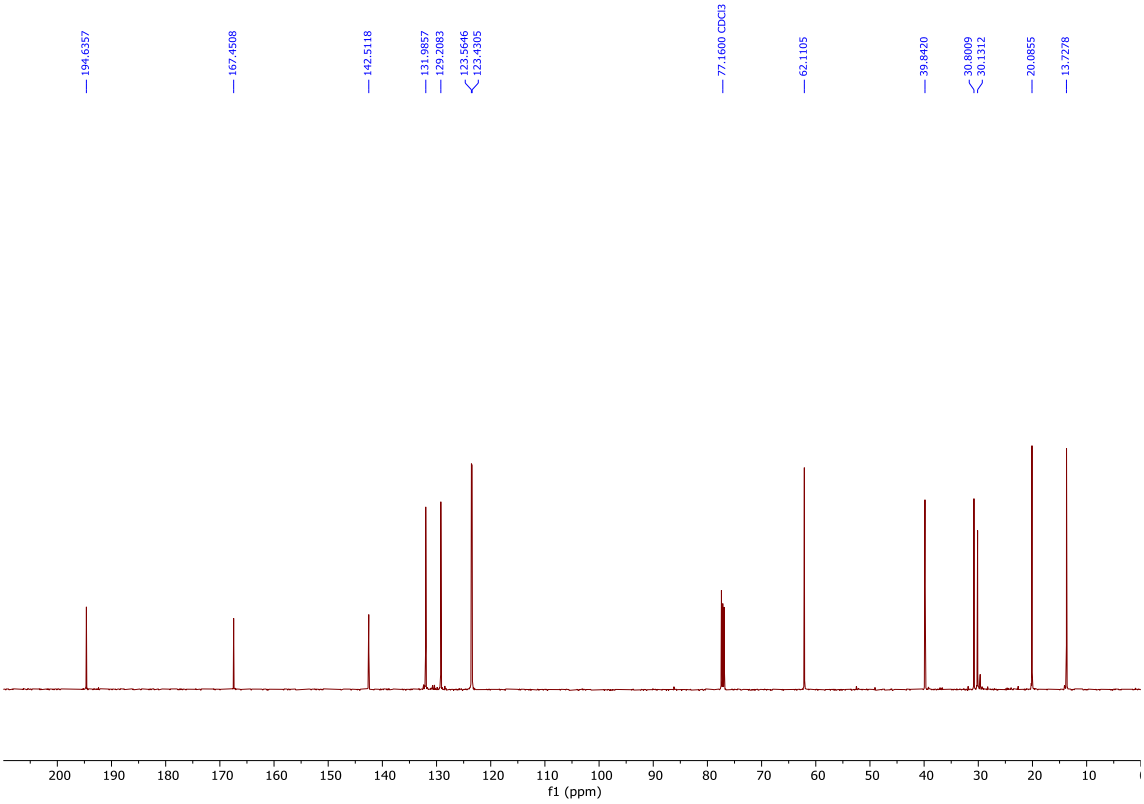
^{1}H NMR (500 MHz, $CDCl_3$) of compound **6m**



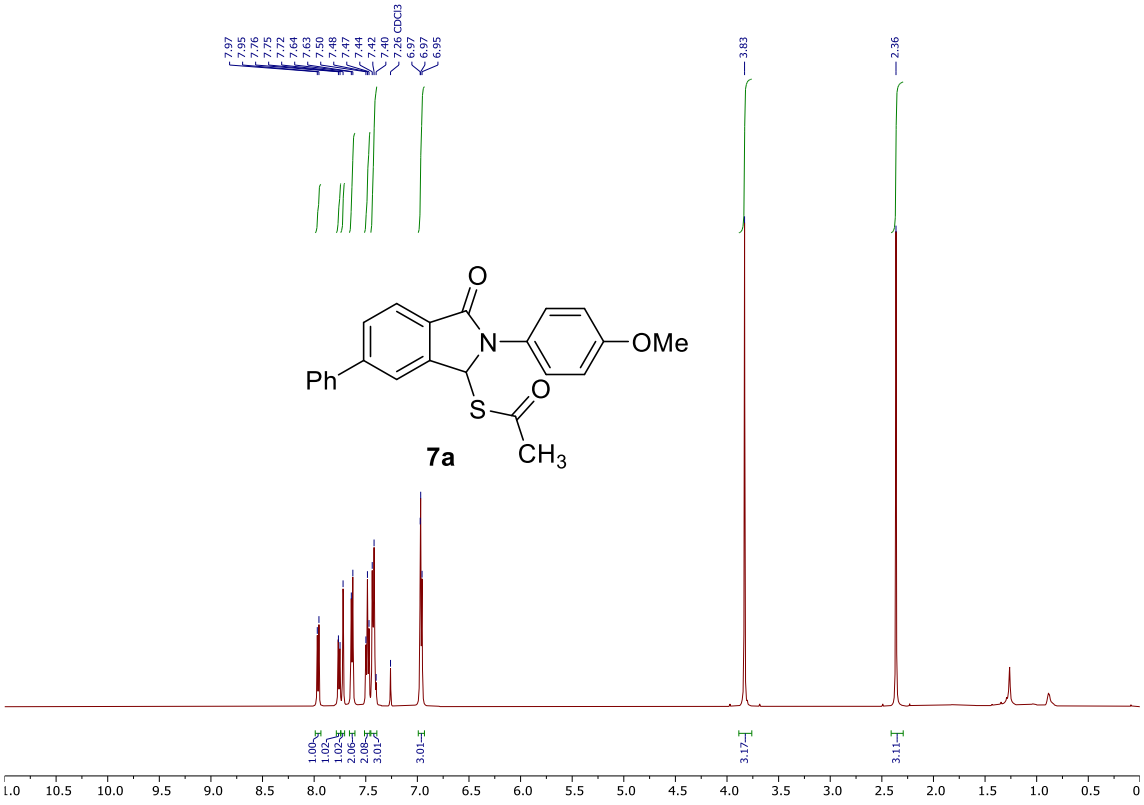
^{13}C NMR (125 MHz, $CDCl_3$) of compound **6m**



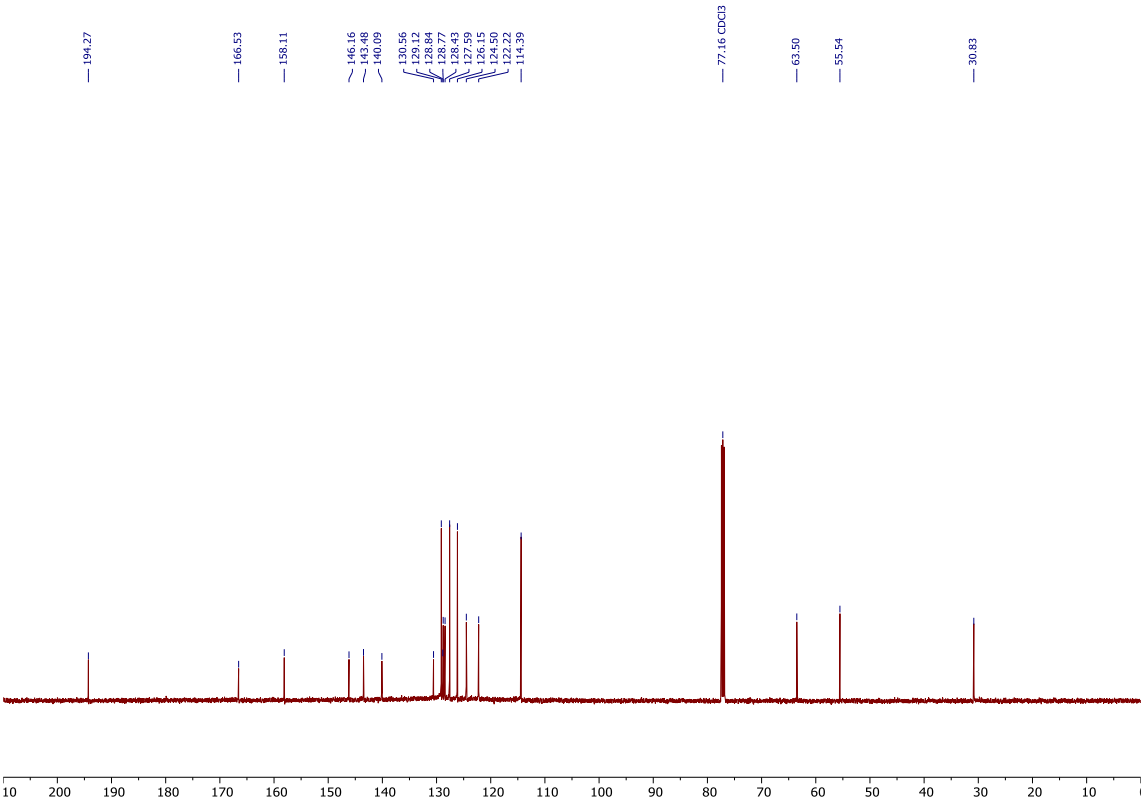
^{1}H NMR (500 MHz, $CDCl_3$) of compound **6n**



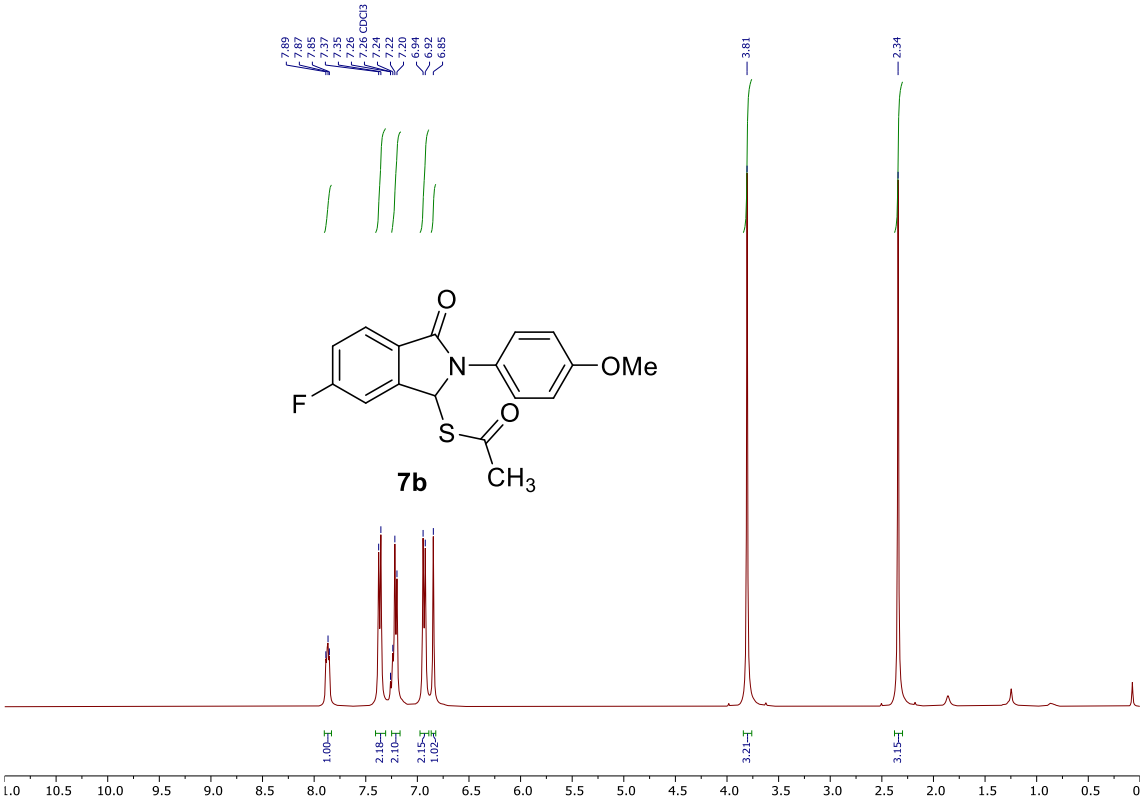
^{13}C NMR (125 MHz, $CDCl_3$) of compound **6n**



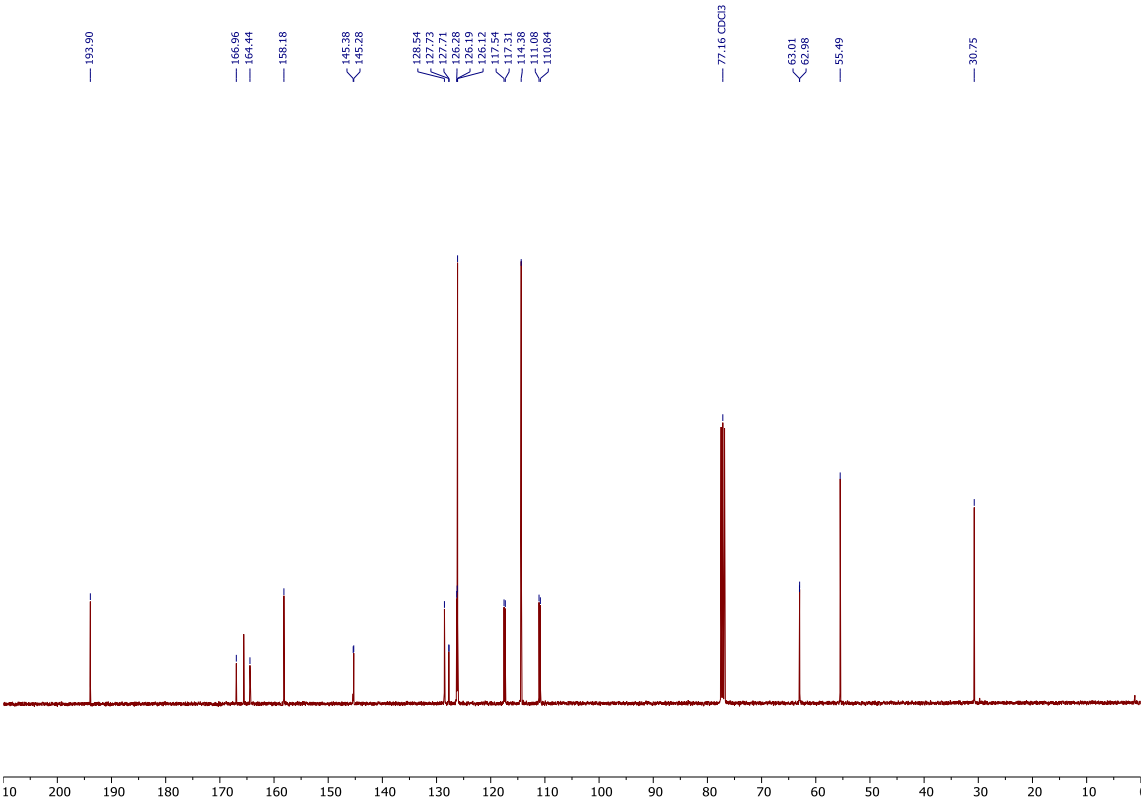
^{1}H NMR (500 MHz, $CDCl_3$) of compound **7a**



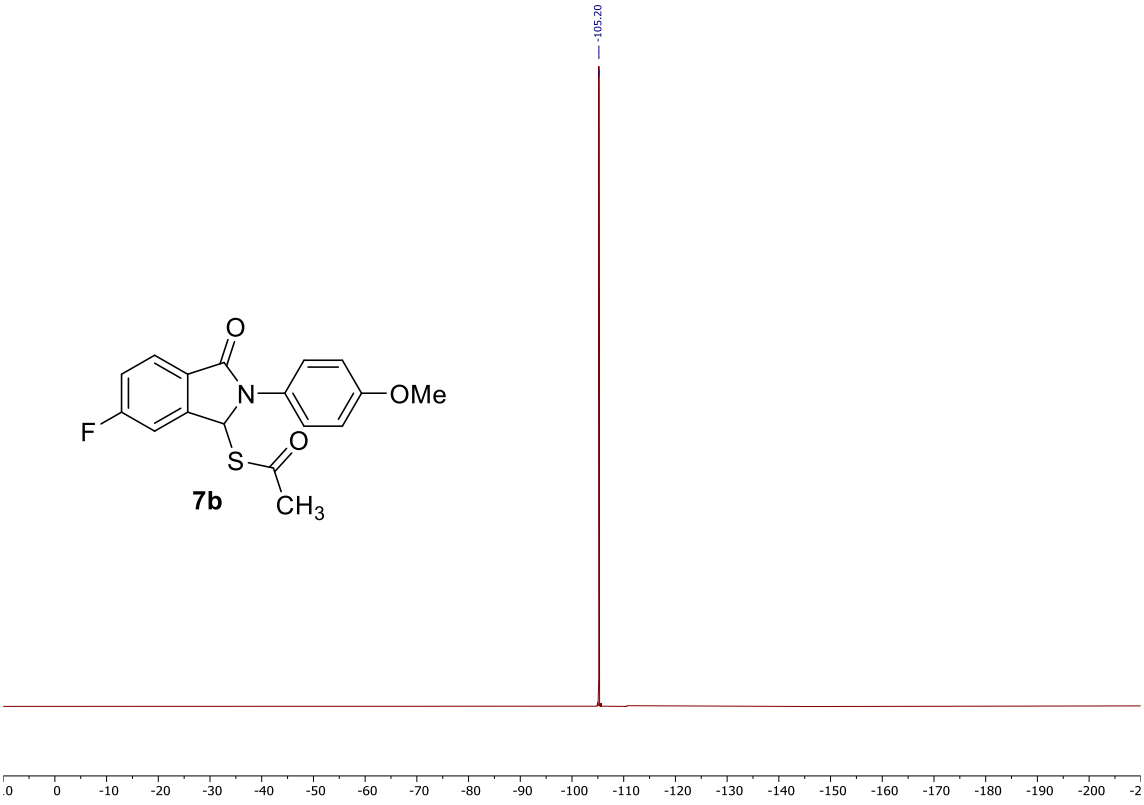
^{13}C NMR (125 MHz, $CDCl_3$) of compound **7a**



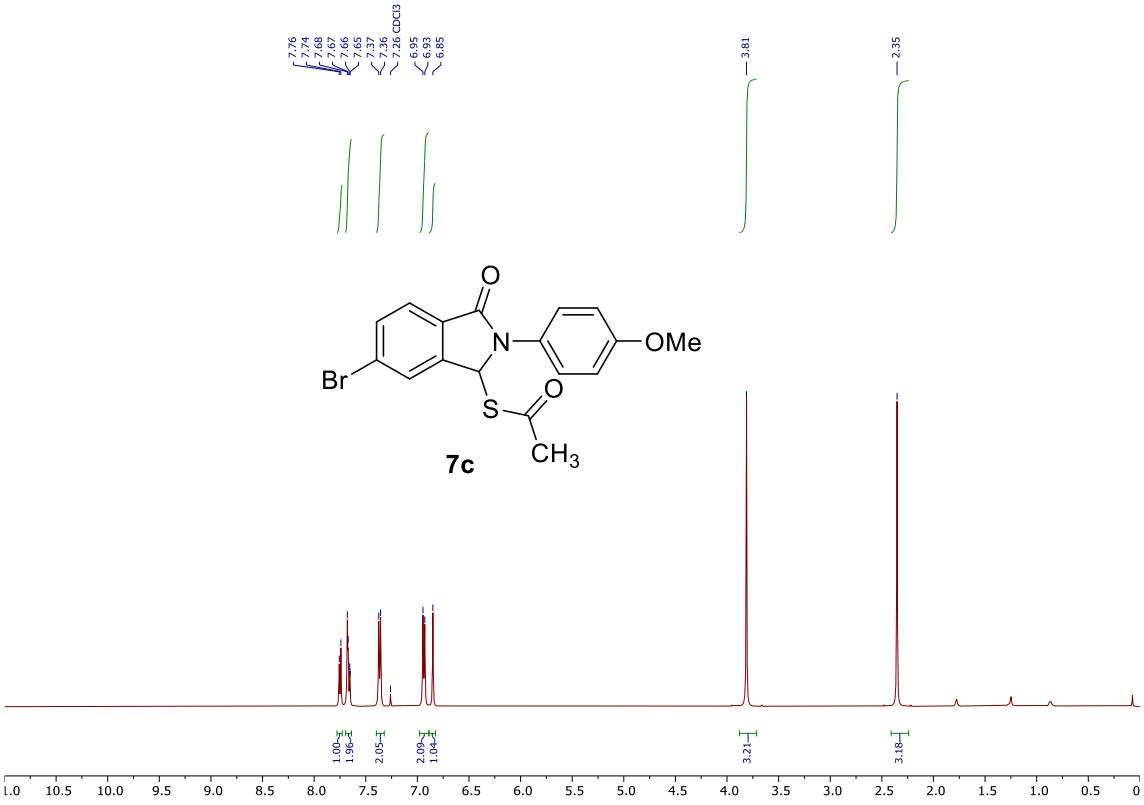
^{1}H NMR (400 MHz, $CDCl_3$) of compound **7b**



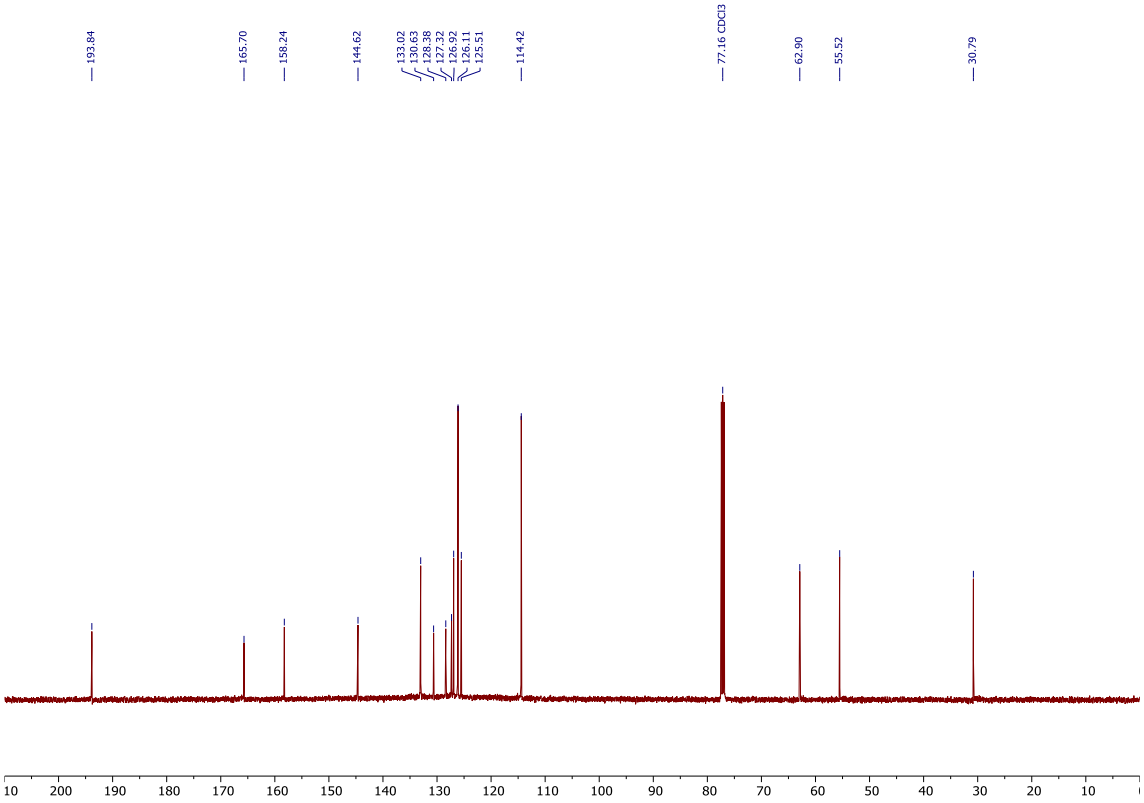
^{13}C NMR (100 MHz, $CDCl_3$) of compound **7b**



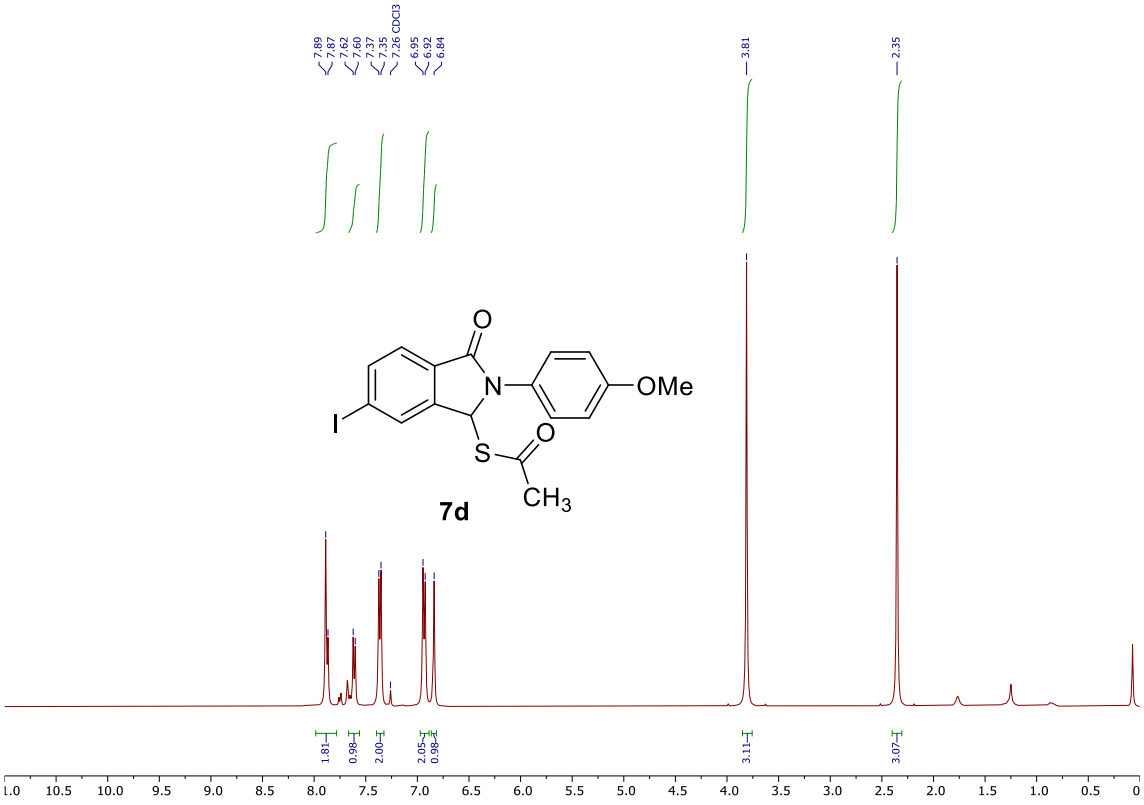
^{19}F NMR (375 MHz, $CDCl_3$) of compound **7b**



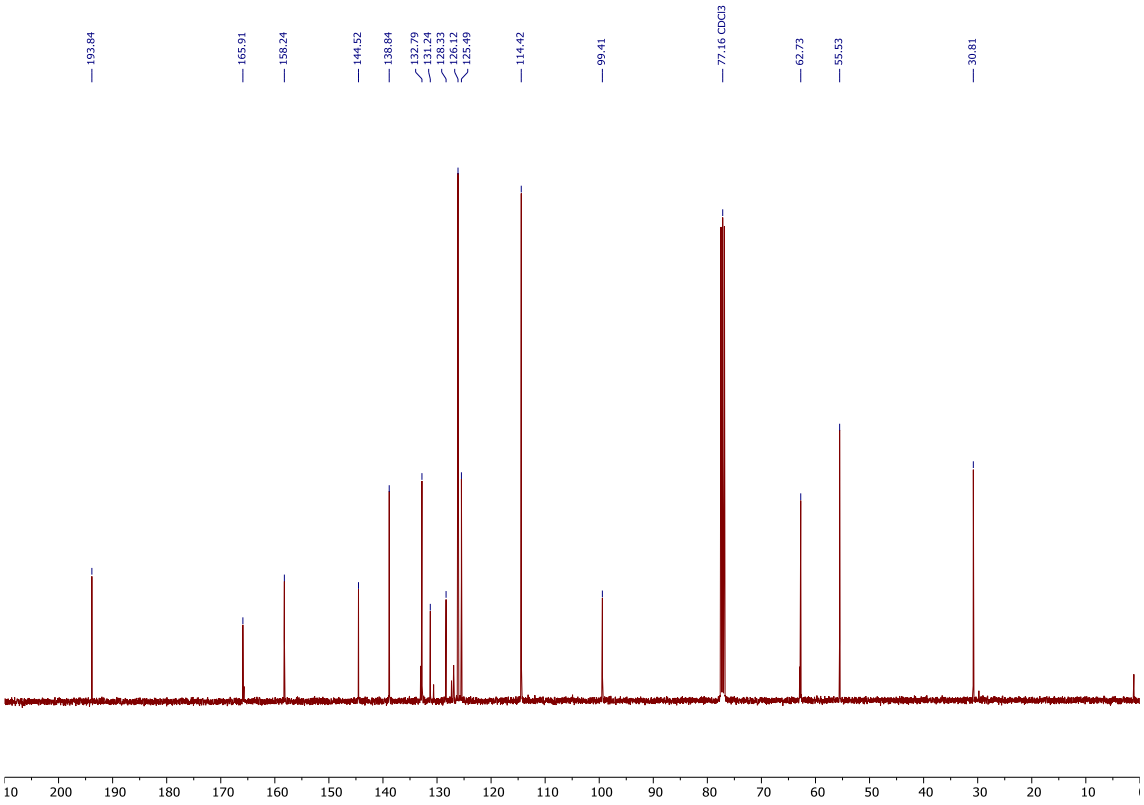
^{1}H NMR (500 MHz, $CDCl_3$) of compound **7c**



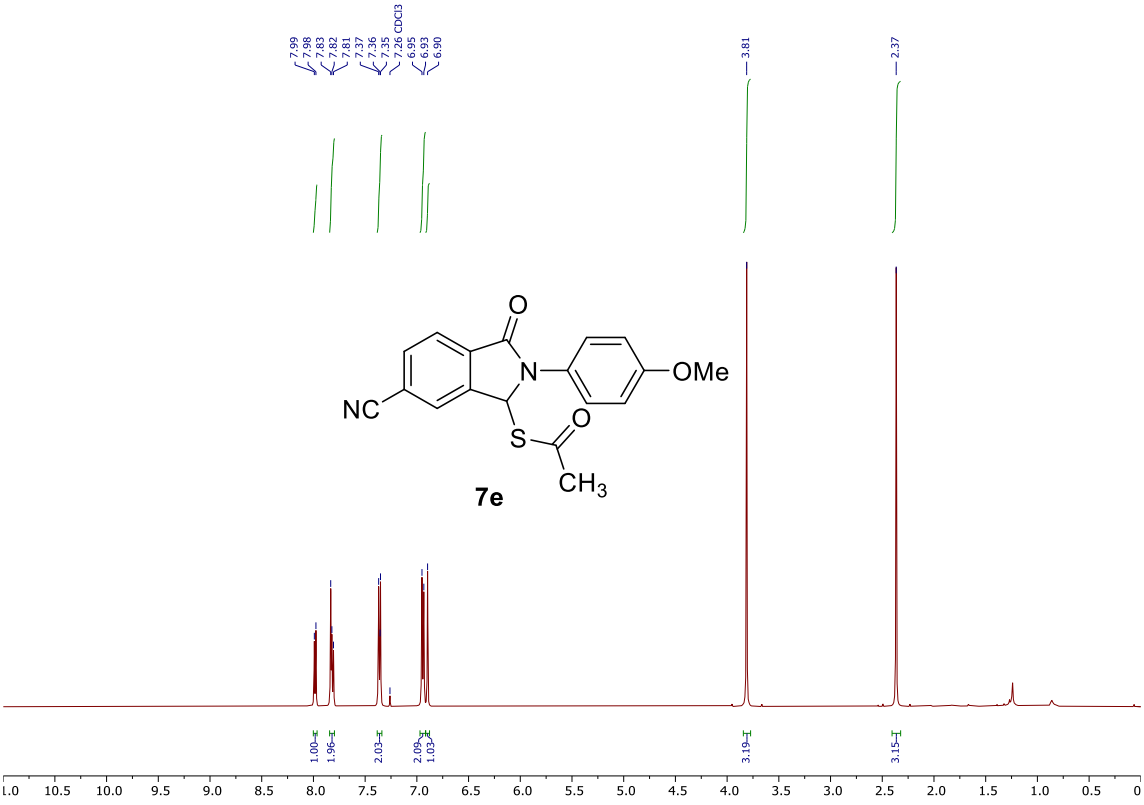
^{13}C NMR (125 MHz, $CDCl_3$) of compound **7c**



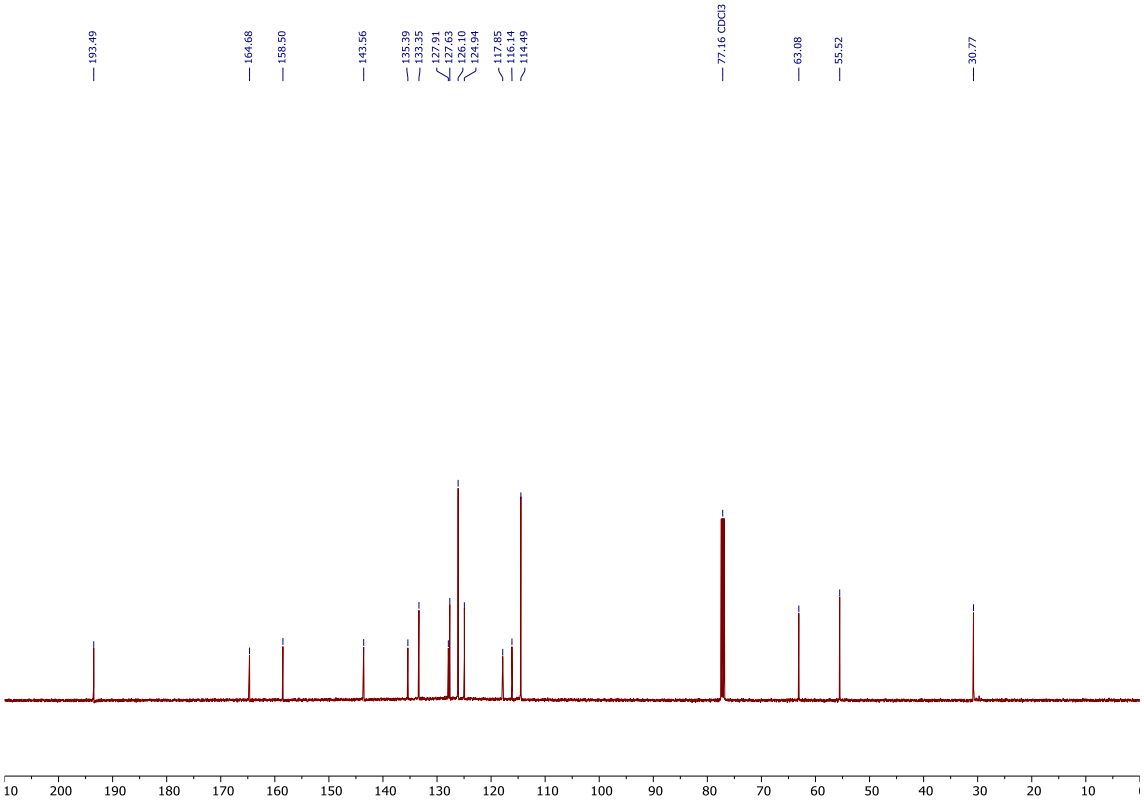
^{1}H NMR (400 MHz, $CDCl_3$) of compound **7d**



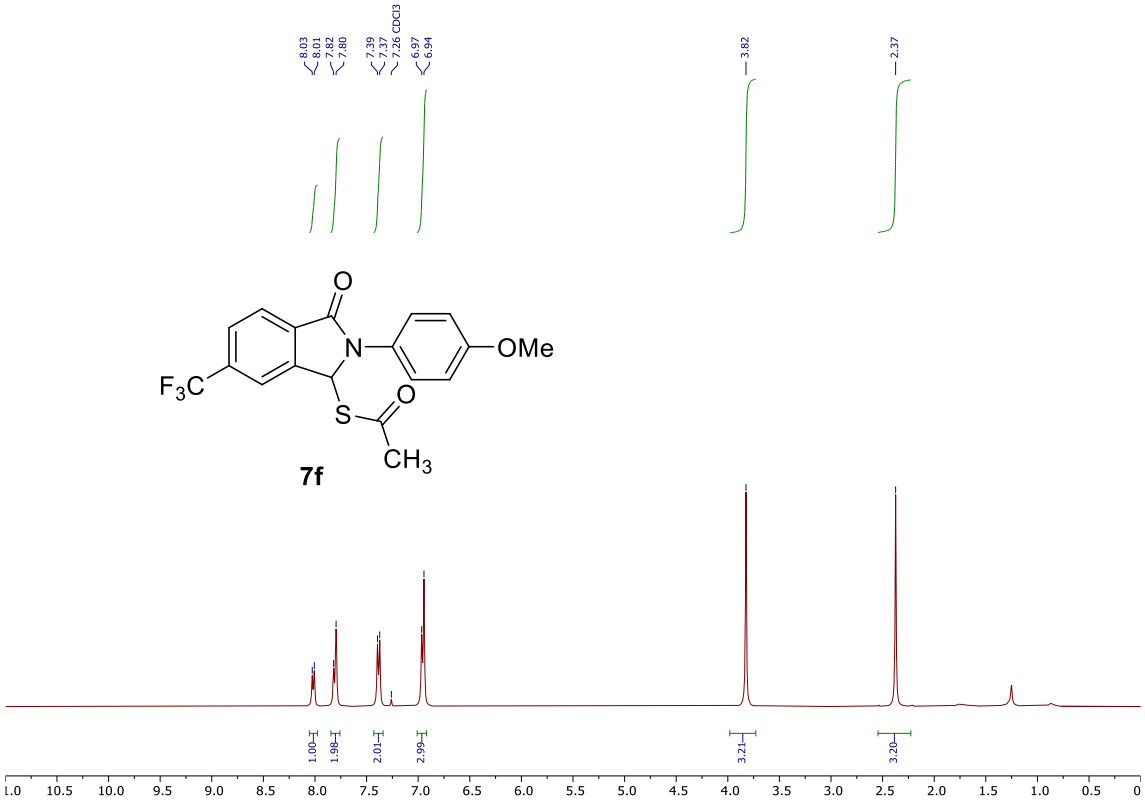
^{13}C NMR (100 MHz, $CDCl_3$) of compound **7d**



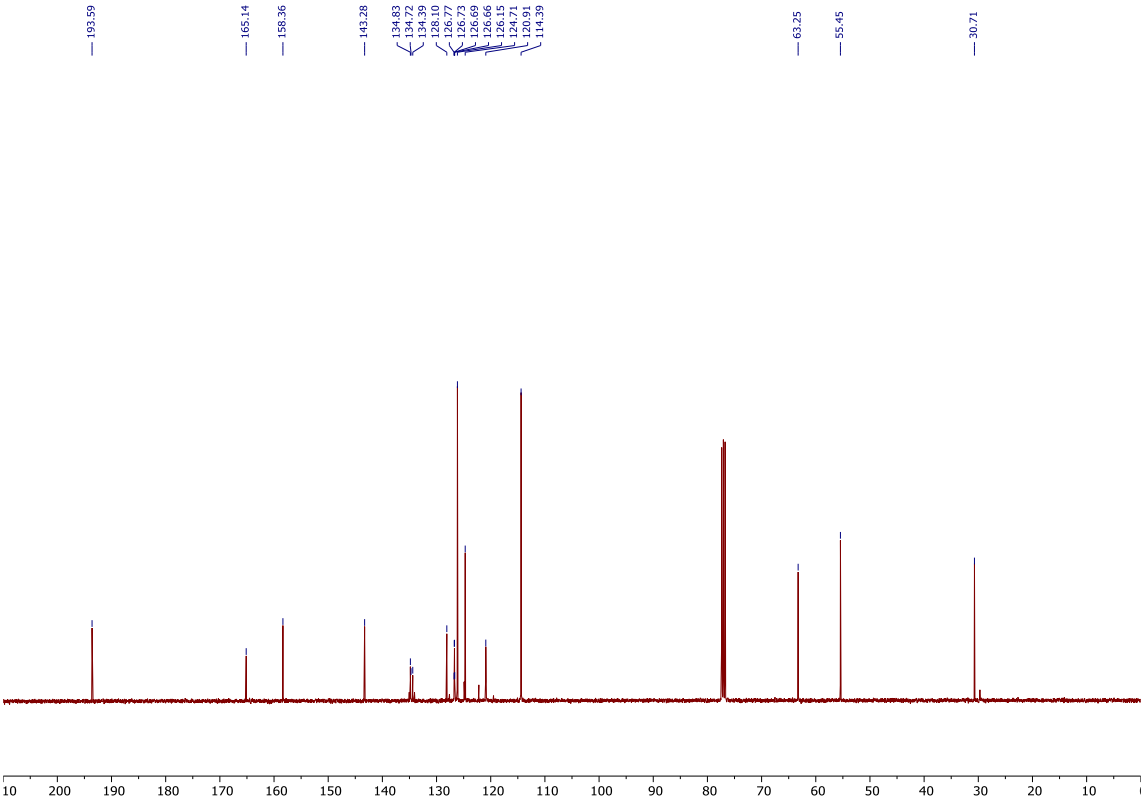
^{1}H NMR (500 MHz, $CDCl_3$) of compound **7e**



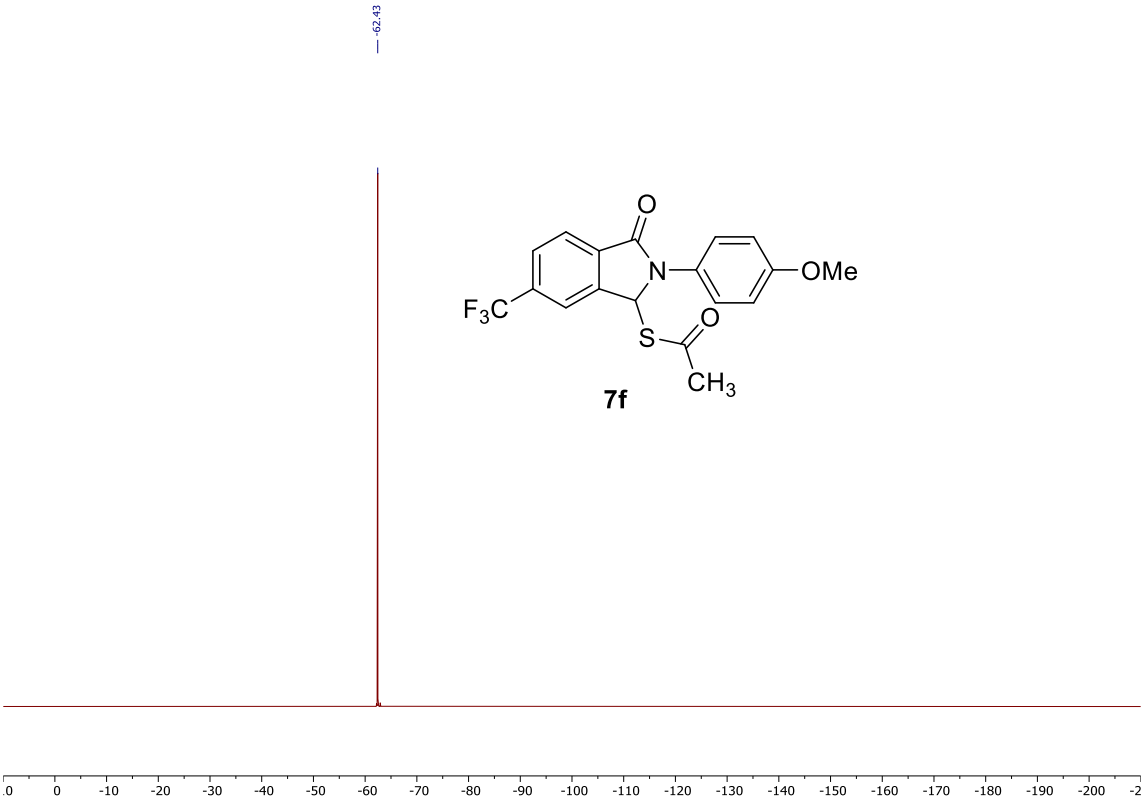
^{13}C NMR (125 MHz, $CDCl_3$) of compound **7e**



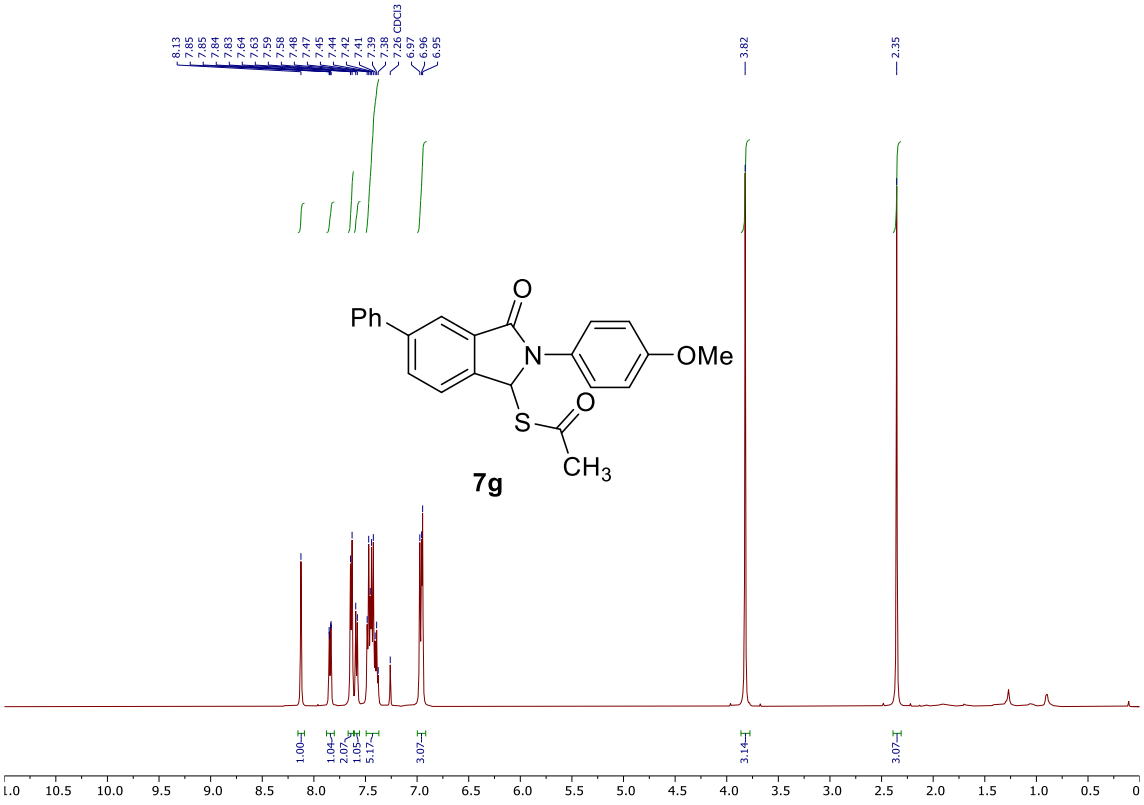
^{1}H NMR (400 MHz, $CDCl_3$) of compound **7f**



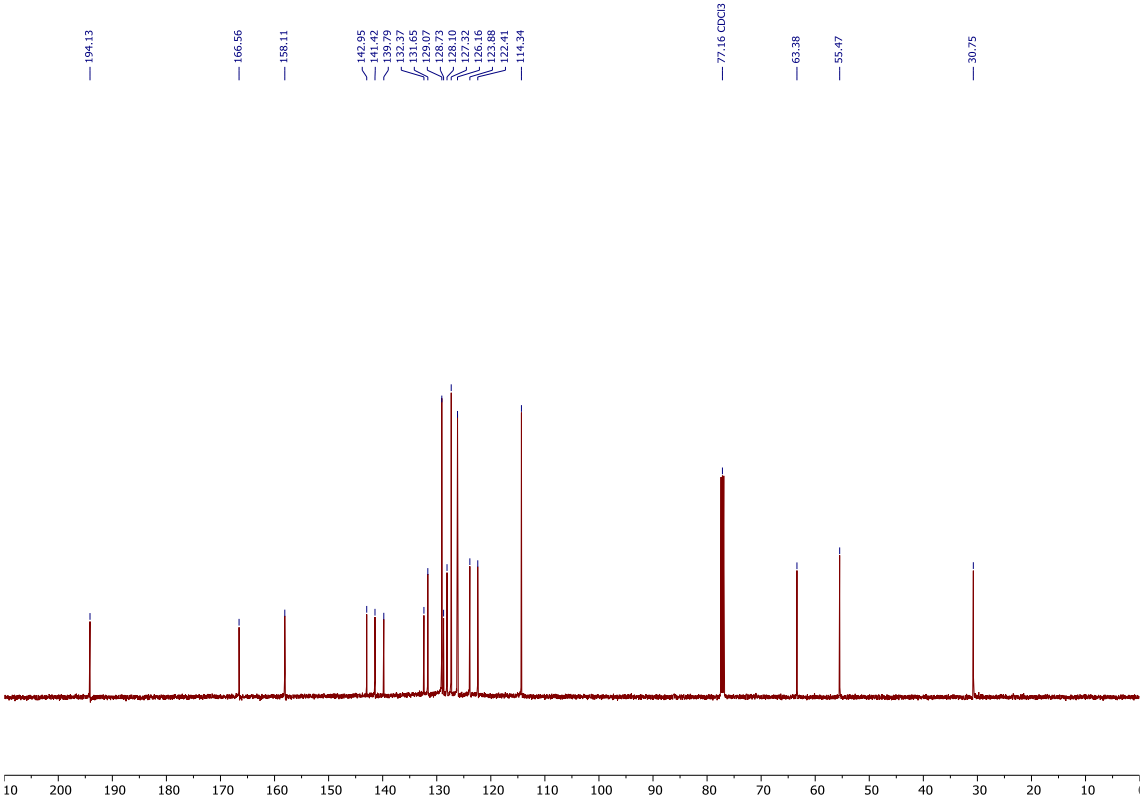
^{13}C NMR (100 MHz, $CDCl_3$) of compound **7f**



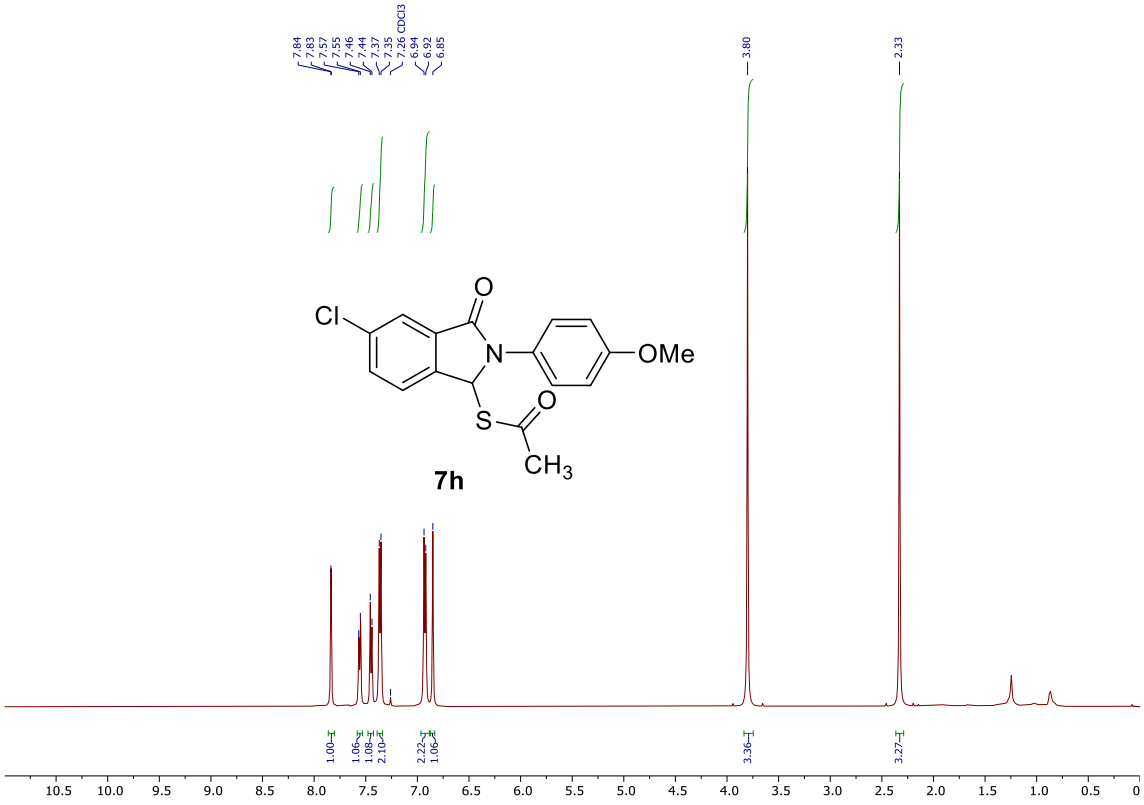
^{19}F NMR (375 MHz, $CDCl_3$) of compound **7f**



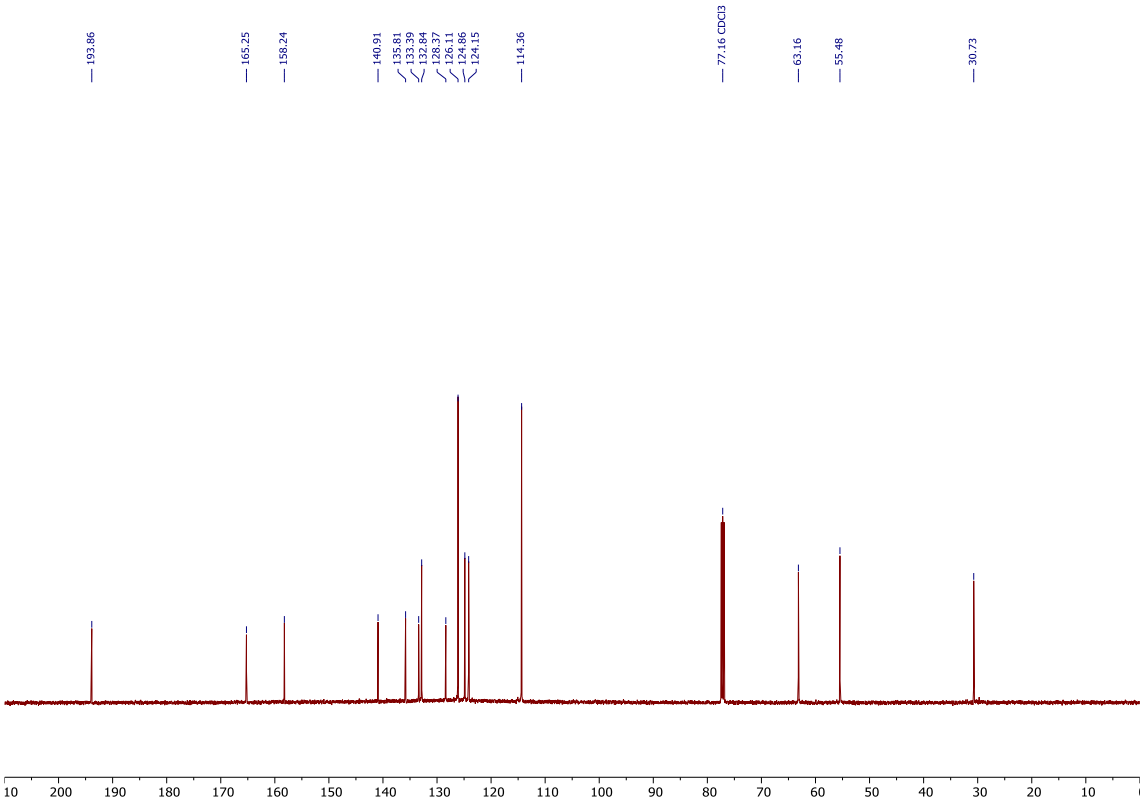
^{1}H NMR (500 MHz, $CDCl_3$) of compound **7g**



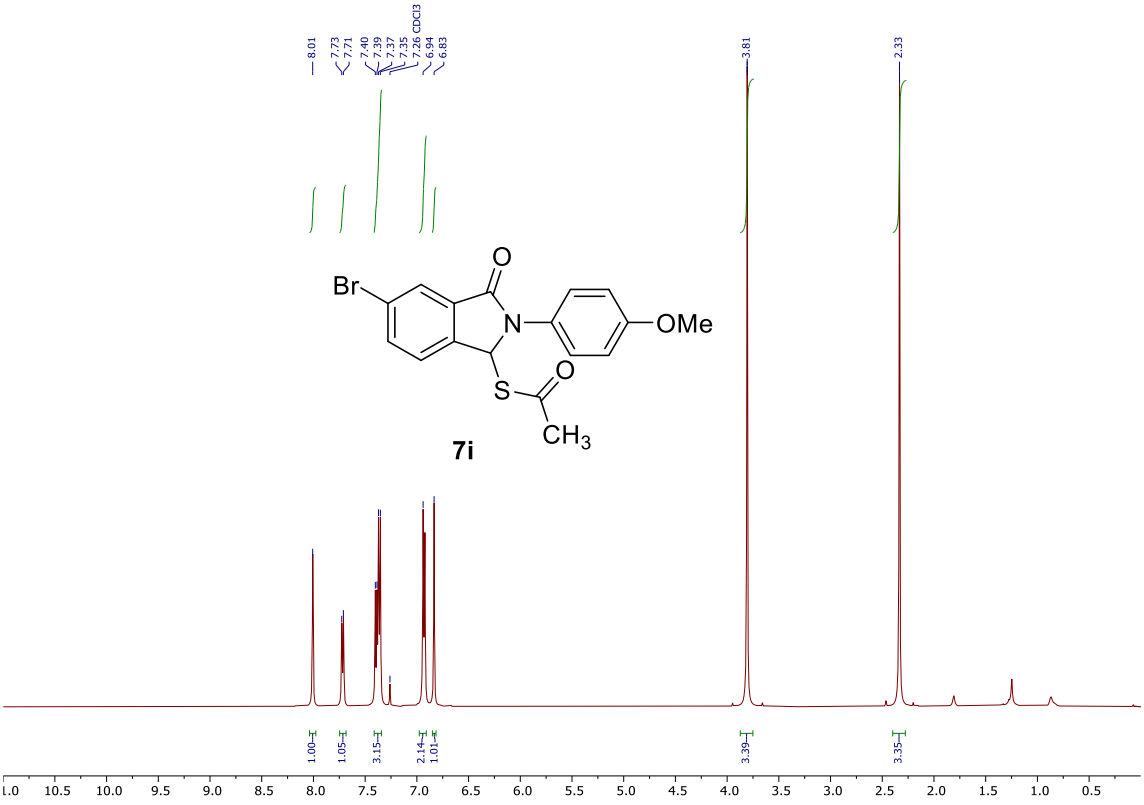
^{13}C NMR (125 MHz, $CDCl_3$) of compound **7g**



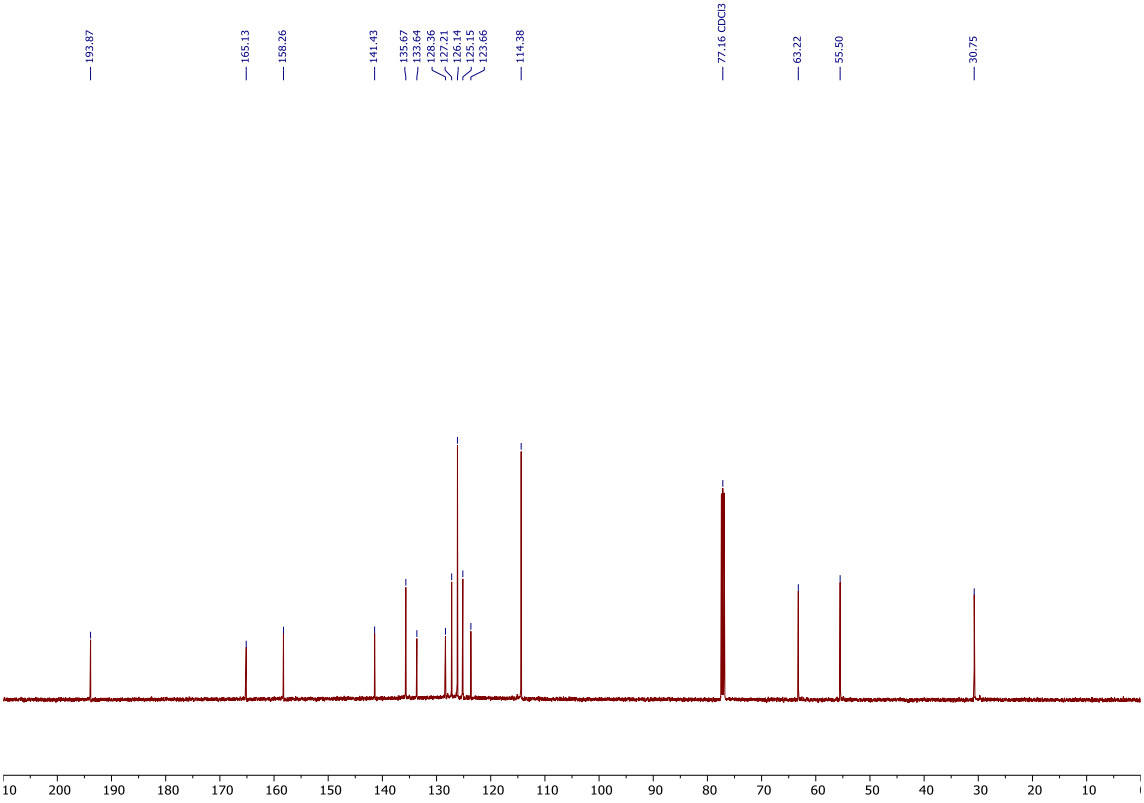
^{1}H NMR (500 MHz, $CDCl_3$) of compound **7h**



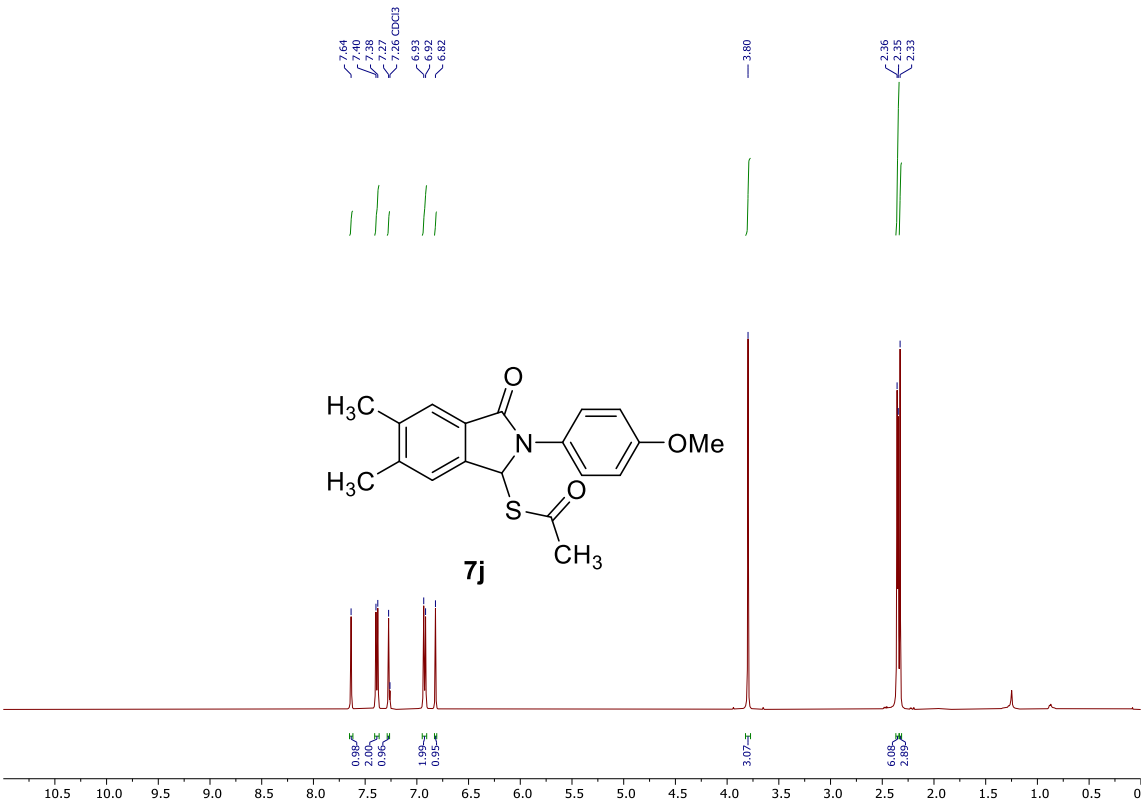
^{13}C NMR (125 MHz, $CDCl_3$) of compound **7h**



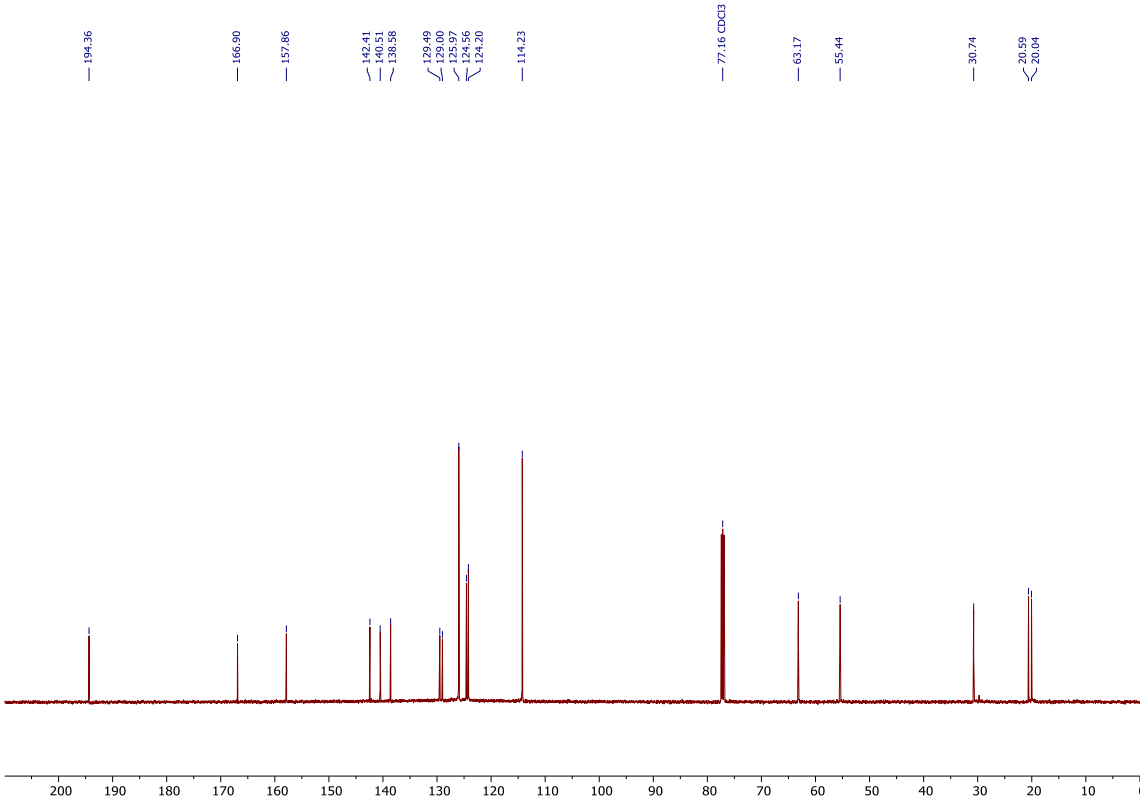
^{1}H NMR (500 MHz, $CDCl_3$) of compound **7i**



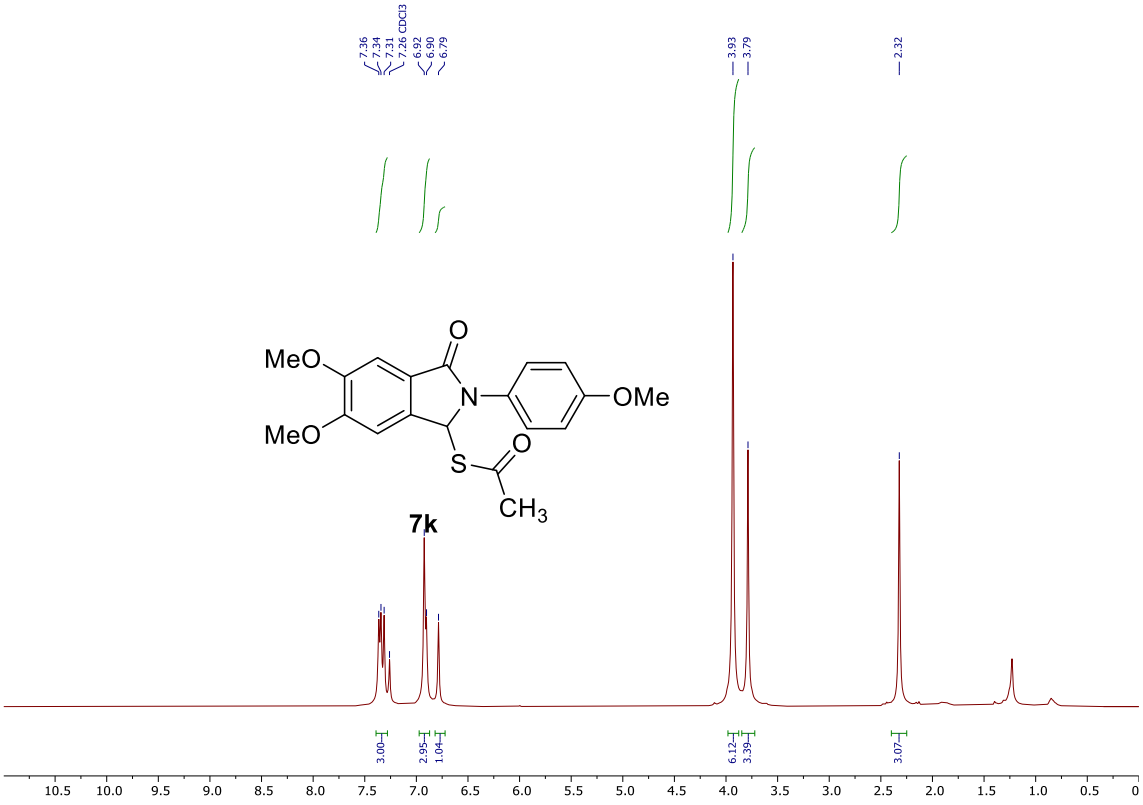
^{13}C NMR (125 MHz, $CDCl_3$) of compound **7i**



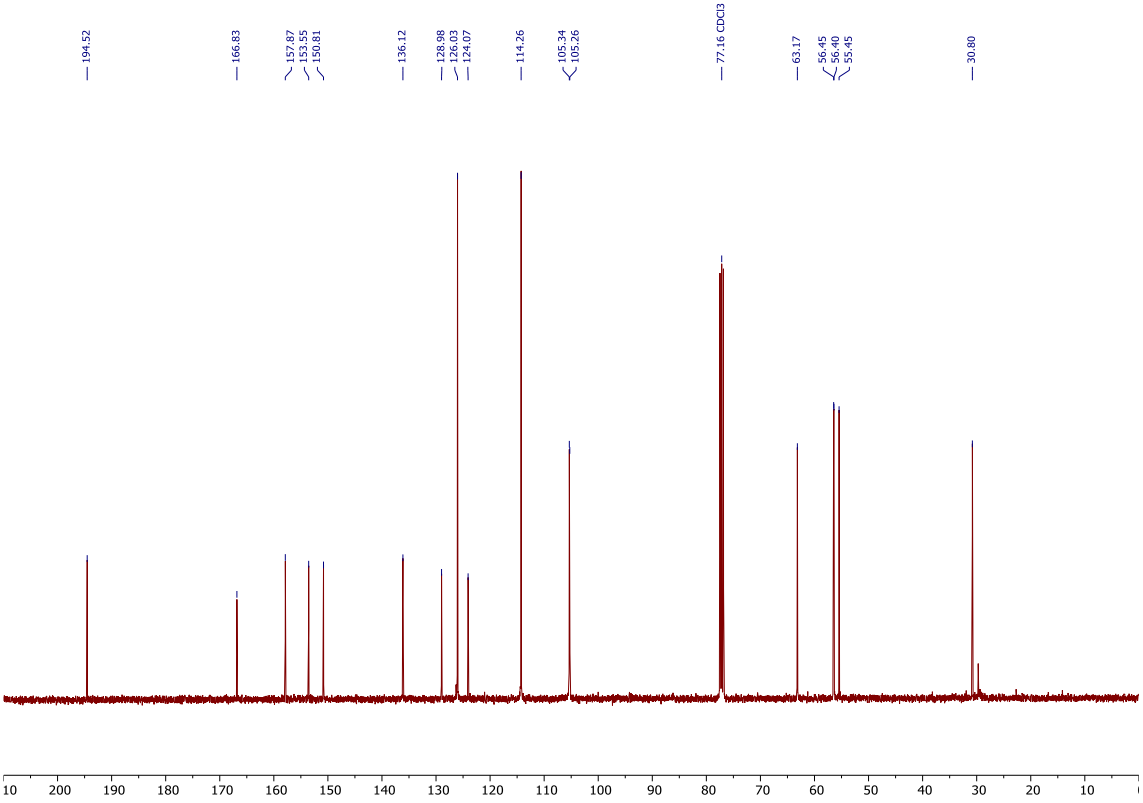
^{1}H NMR (500 MHz, $CDCl_3$) of compound **7j**



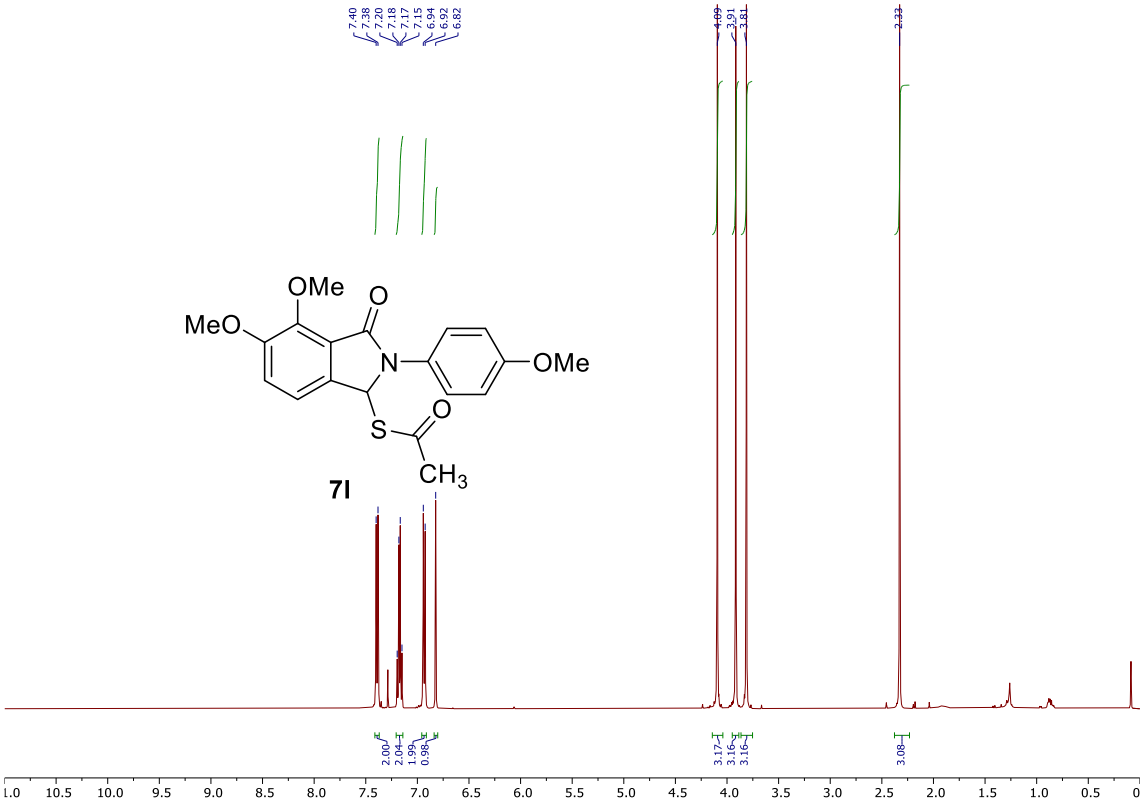
^{13}C NMR (125 MHz, $CDCl_3$) of compound **7j**



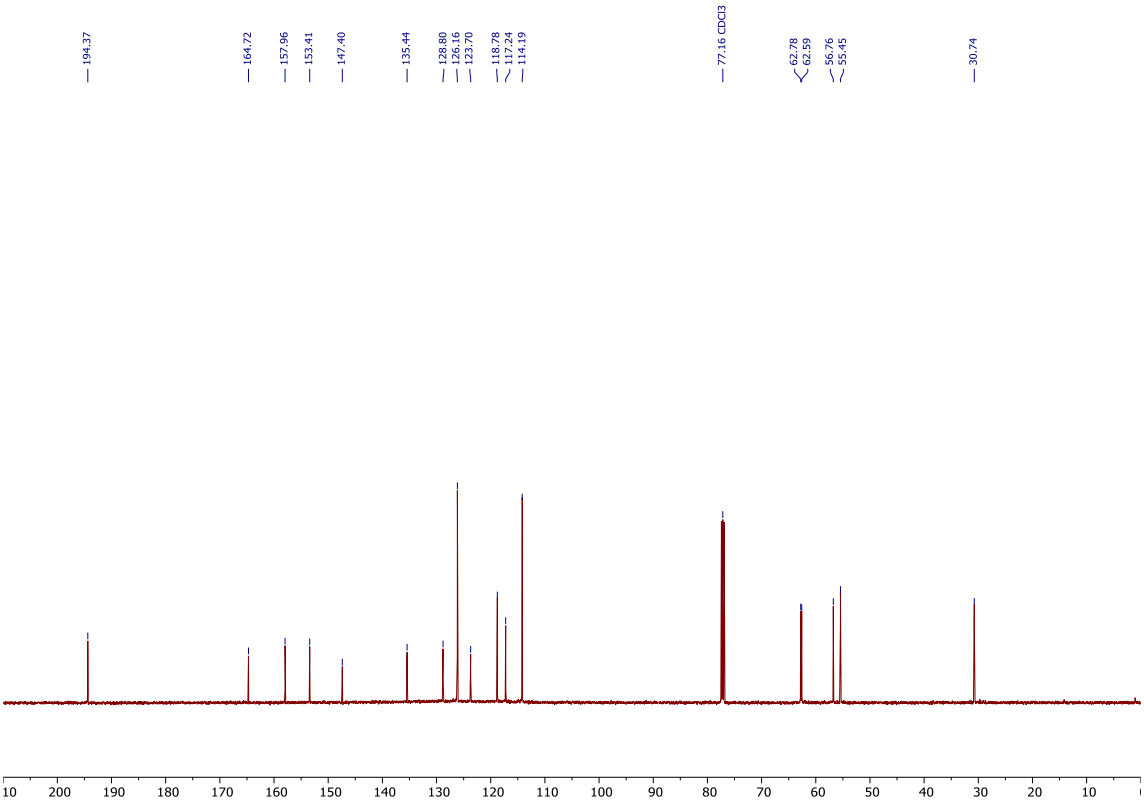
^{1}H NMR (400 MHz, $CDCl_3$) of compound **7k**



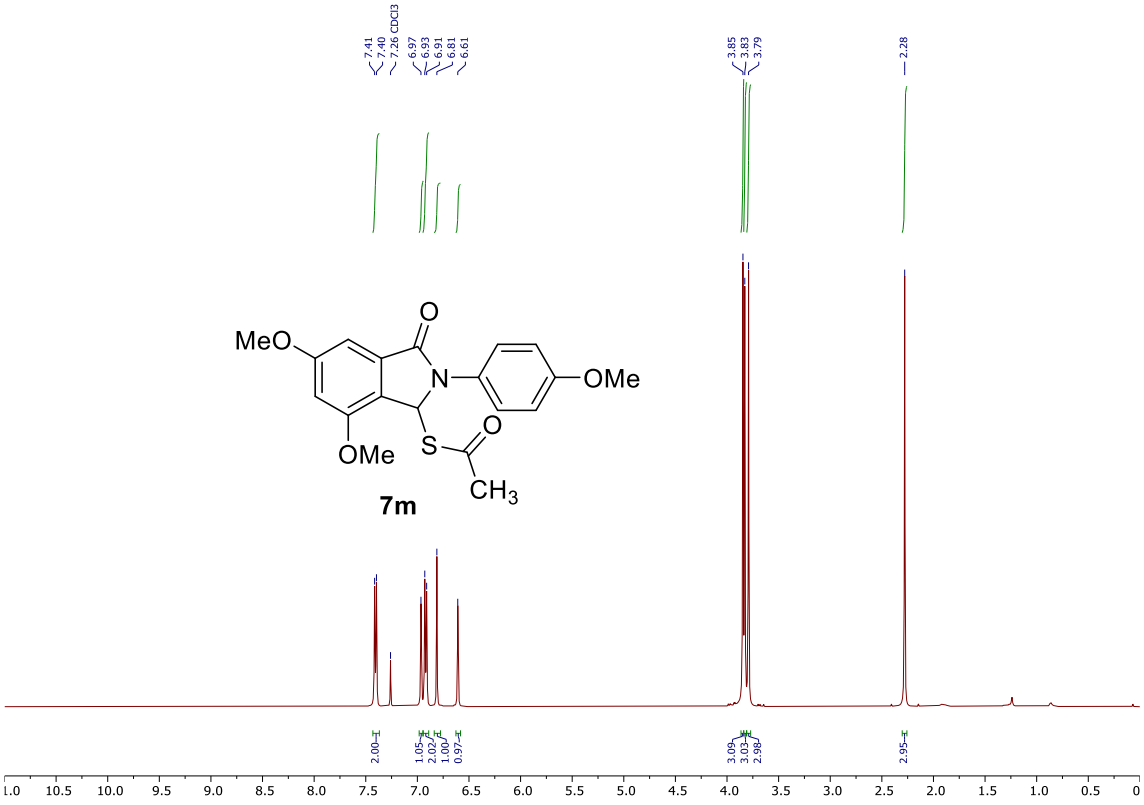
^{13}C NMR (100 MHz, $CDCl_3$) of compound **7k**



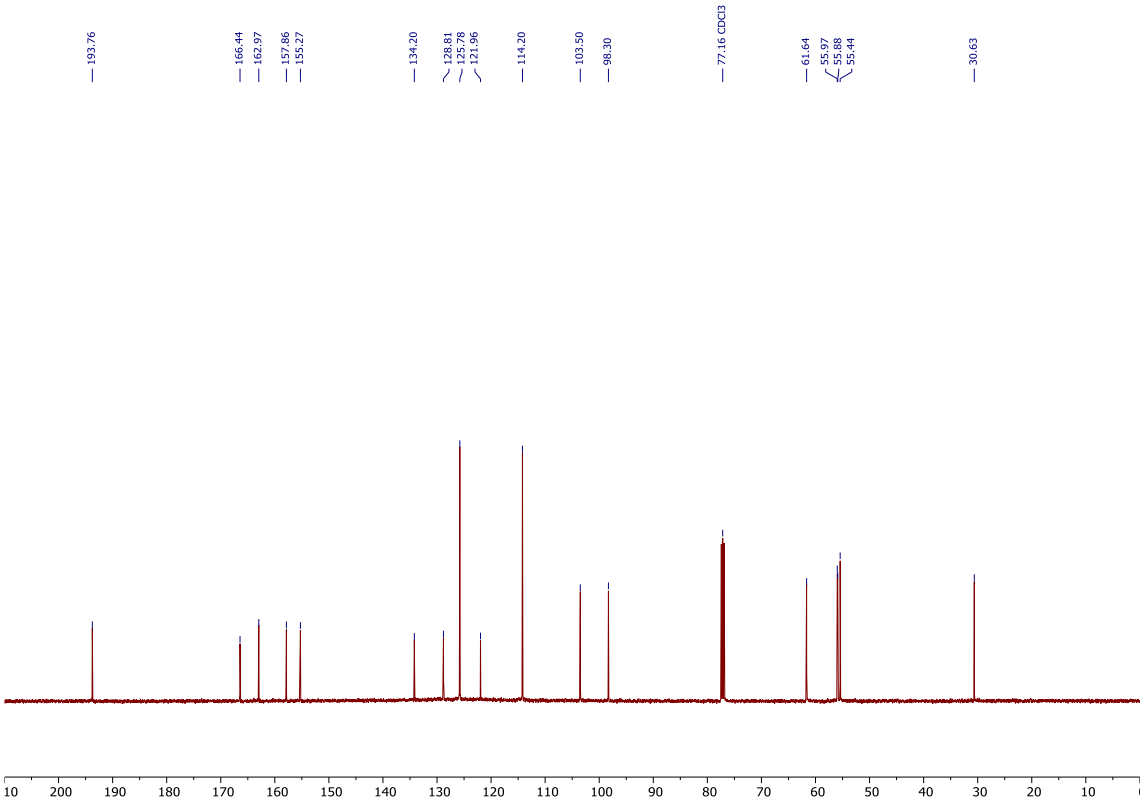
^{1}H NMR (500 MHz, $CDCl_3$) of compound **7l**



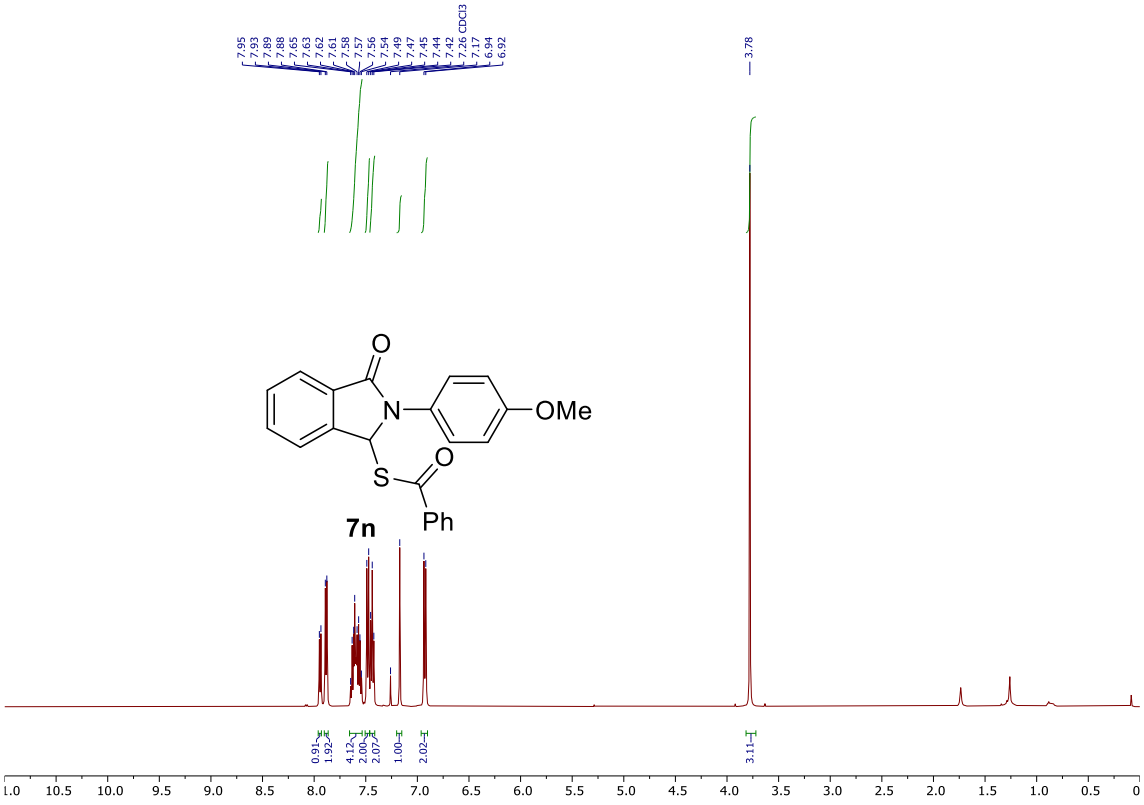
^{13}C NMR (125 MHz, $CDCl_3$) of compound **7l**



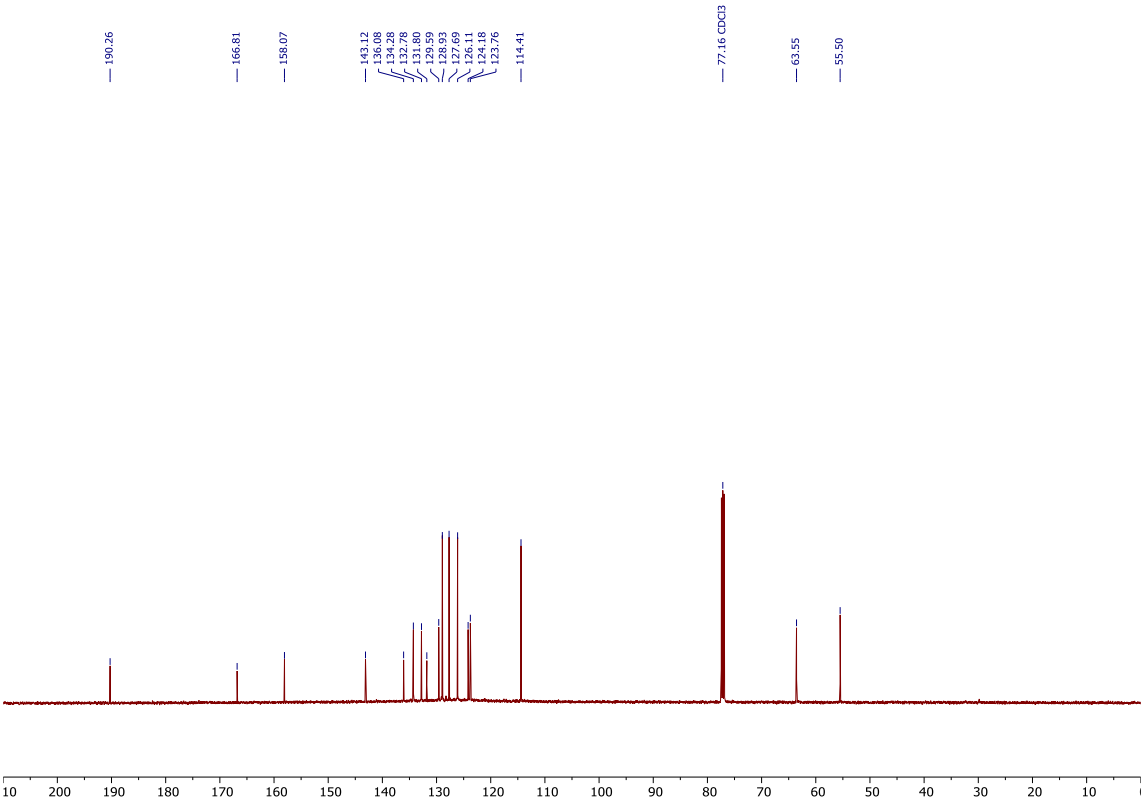
^{1}H NMR (500 MHz, $CDCl_3$) of compound **7m**



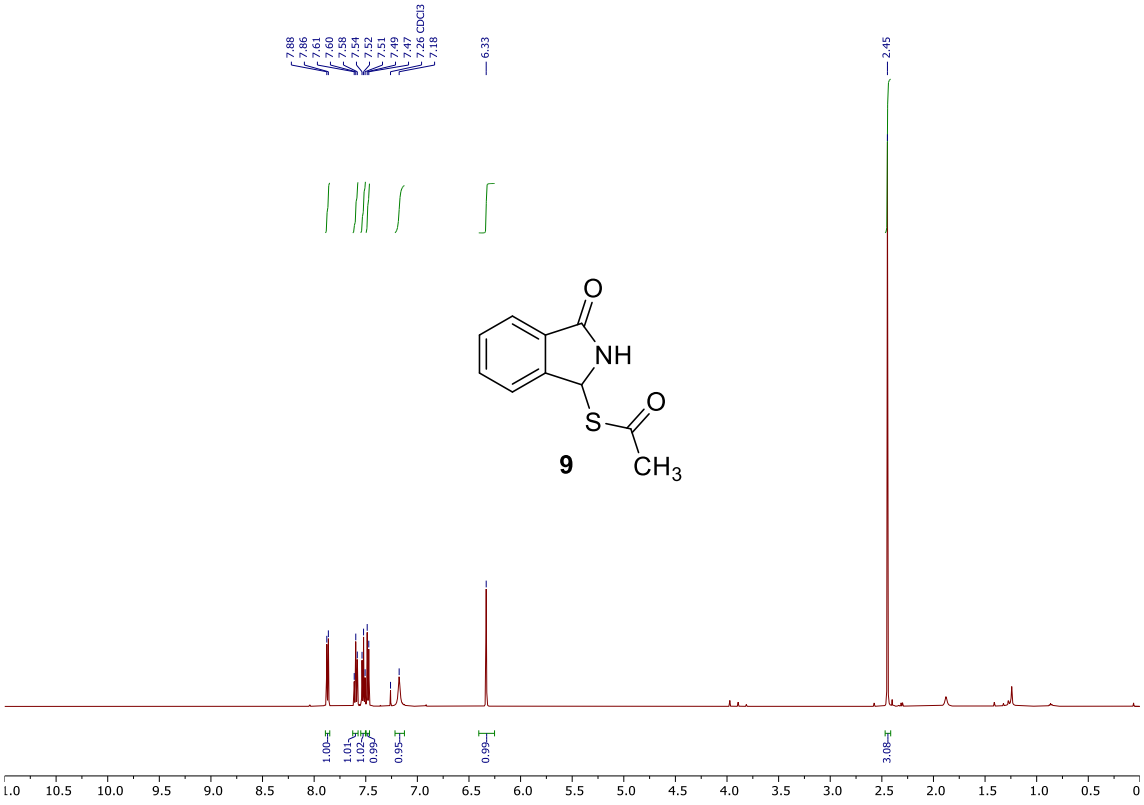
^{13}C NMR (125 MHz, $CDCl_3$) of compound **7m**



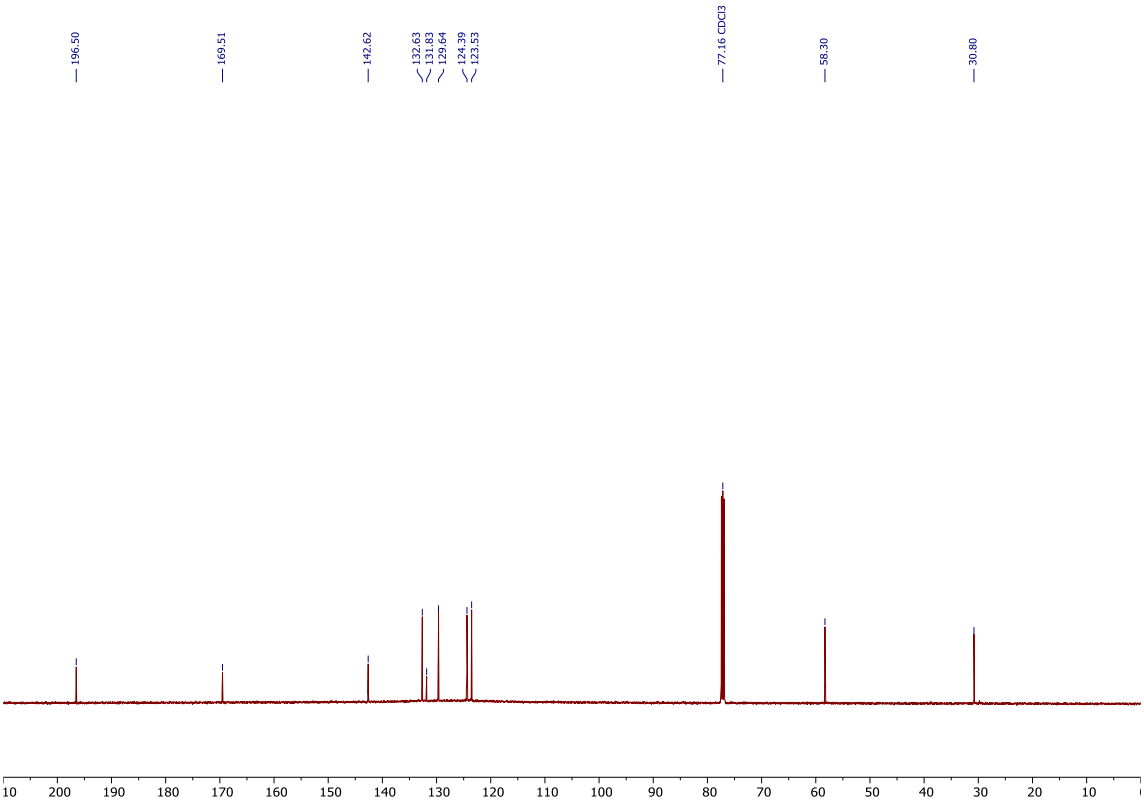
^{1}H NMR (500 MHz, $CDCl_3$) of compound **7n**



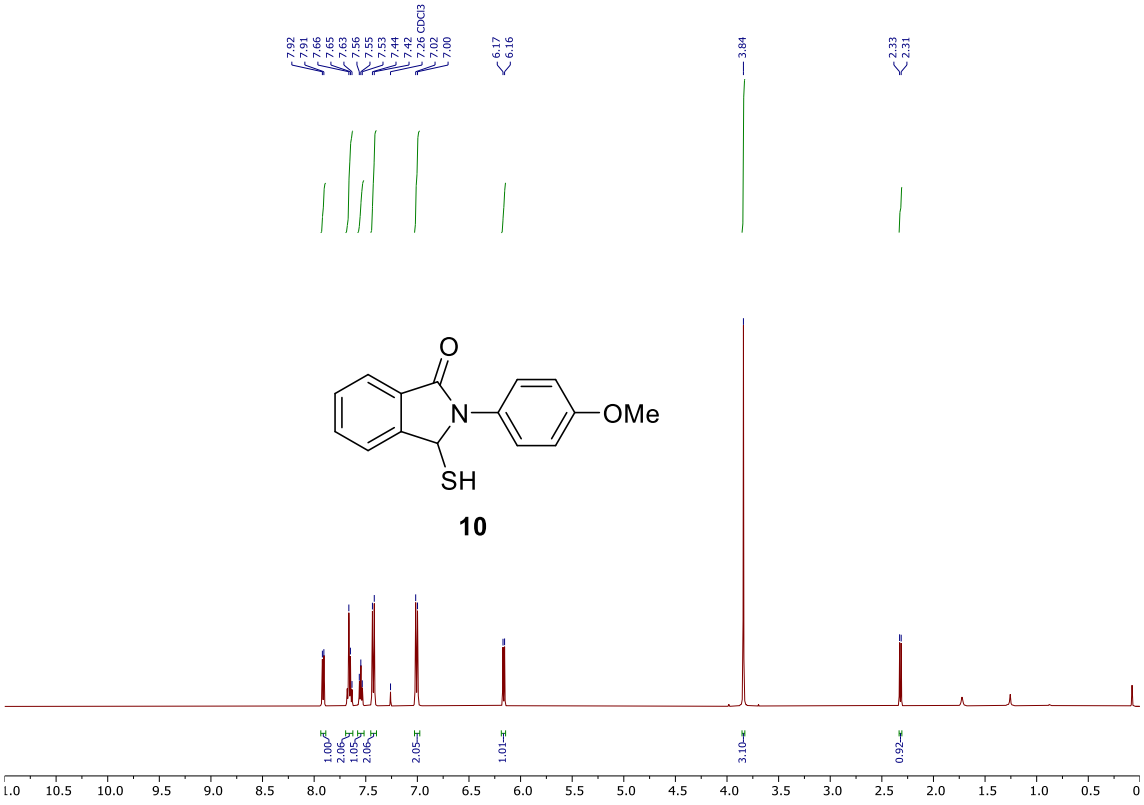
^{13}C NMR (125 MHz, $CDCl_3$) of compound **7n**



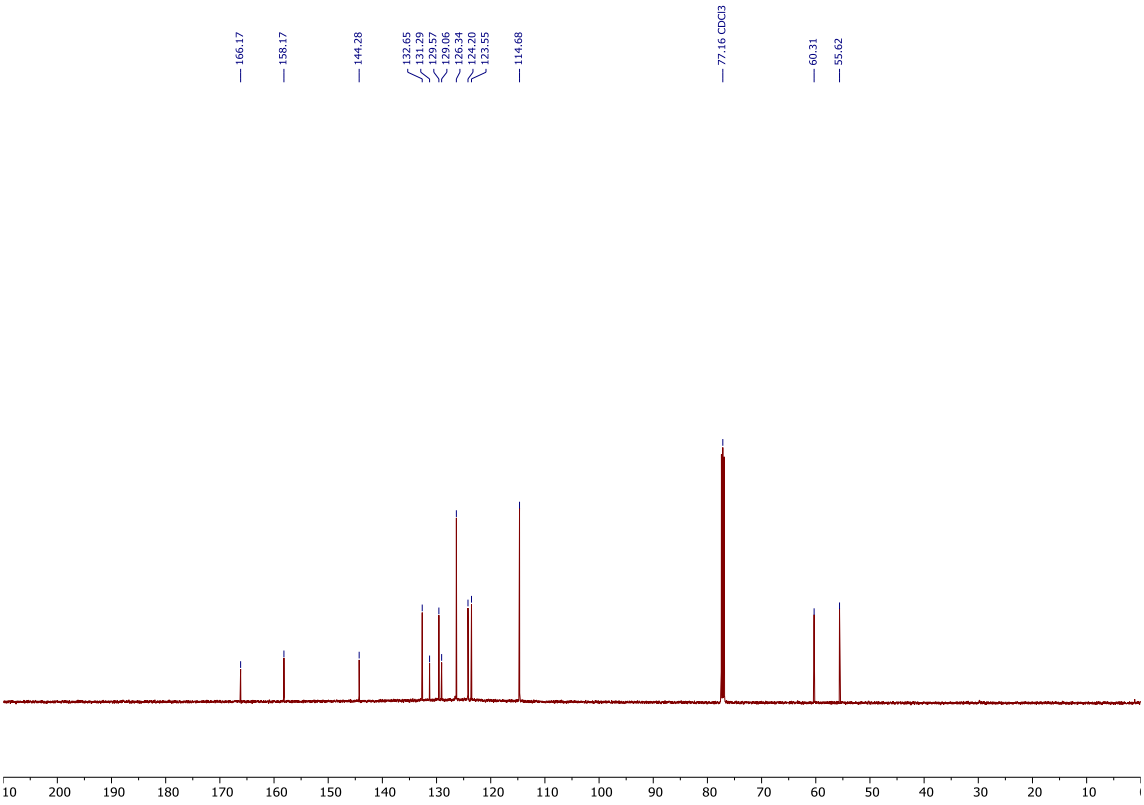
^{1}H NMR (500 MHz, $CDCl_3$) of compound **9**



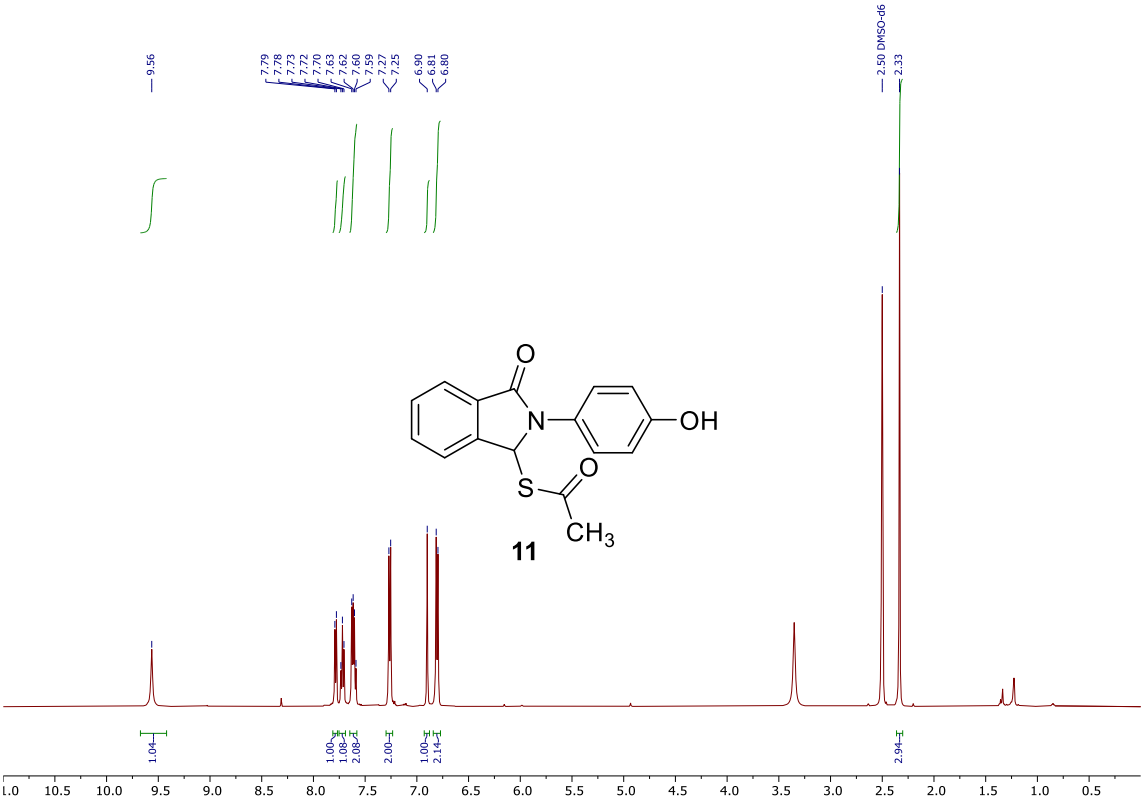
^{13}C NMR (125 MHz, $CDCl_3$) of compound **9**



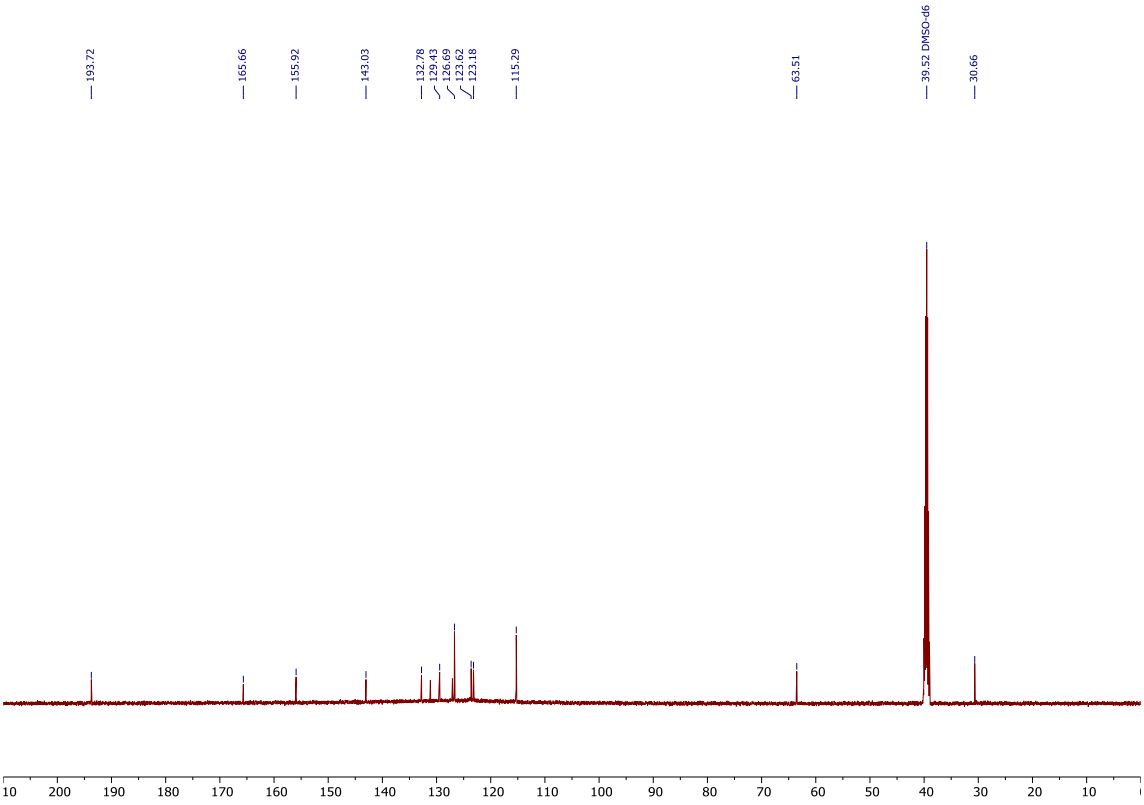
^{1}H NMR (500 MHz, $CDCl_3$) of compound **10**



^{13}C NMR (125 MHz, $CDCl_3$) of compound **10**



^{1}H NMR (500 MHz, DMSO-d$_6$) of compound **11**



^{13}C NMR (125 MHz, DMSO-d$_6$) of compound **11**