

# **A Sustainable Photochemical Aerobic Sulfide Oxidation: Access to Sulforaphane and Modafinil**

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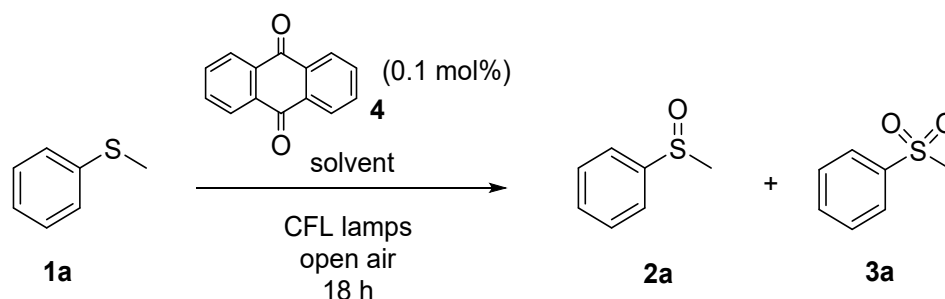
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## General Remarks

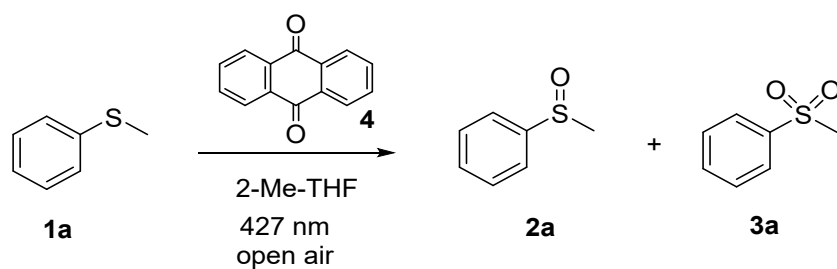
Chromatographic purification of products was accomplished using forced-flow chromatography on Merck® Kieselgel 60 70-230 mesh. Thin-layer chromatography (TLC) was performed on aluminum backed silica plates (0.2 mm, 60 F<sub>254</sub>). Visualization of the developed chromatogram was performed by fluorescence quenching using phosphomolybdic acid, anisaldehyde or potassium permanganate stains. Melting points were determined on a Buchi® 530 hot stage apparatus and are uncorrected. Mass spectra (ESI) were recorded on a Finningan® Surveyor MSQ LC-MS spectrometer. HRMS spectra were recorded on a Bruker® Maxis Impact QTOF spectrometer. <sup>1</sup>H-NMR and <sup>13</sup>C-NMR spectra were recorded on a Varian® Mercury (200 MHz and 50 MHz, respectively) or on an Avance III HD Bruker 400 MHz (400 MHz and 100 MHz, respectively), and are internally referenced to residual solvent signals. Data for <sup>1</sup>H-NMR are reported as follows: chemical shift ( $\delta$  ppm), integration, multiplicity (s = singlet, d = doublet, t = triplet, q = quartet, m = multiplet, br s = broad signal), coupling constant and assignment. Data for <sup>13</sup>C-NMR are reported in terms of chemical shift ( $\delta$  ppm). Mass spectra and conversions of the reactions were recorded on a Shimadzu® GCMS-QP2010 Plus Gas Chromatograph Mass Spectrometer utilizing a MEGA® column (MEGA-5, F.T.: 0.25  $\mu$ m, I.D.: 0.25 mm, L.: 30 m, T<sub>max</sub>: 350 °C, Column ID# 11475). Kessil lamps PR160L were used as the irradiation source. For all experiments, the intensity of the Kessil lamps was controlled in the maximum level with power consumption: 370 nm (max 43W) and 427 nm (max 45W).

## Optimization of the Reaction Conditions for the Photochemical Oxidation of Sulfides to Sulfoxides



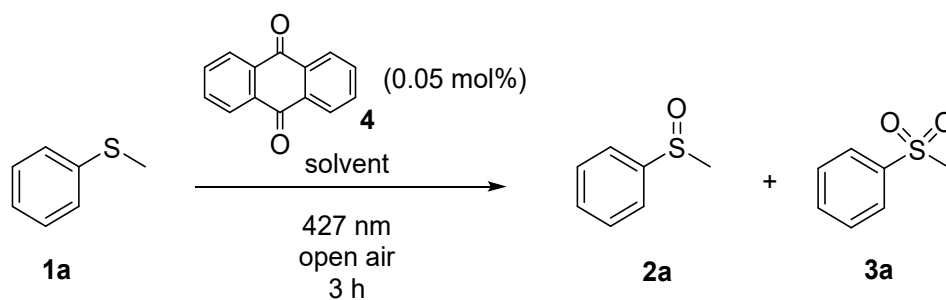
CFL lamps		Conversion (%)		
Entry	Solvent	<chem>CSC1=CC=CC=C1</chem>	<chem>CS(=O)C1=CC=CC=C1</chem>	<chem>CS(=O)(=O)C1=CC=CC=C1</chem>
1	Glycerol	75	25	0
2	GVL	75	25	0
3	MTBE	86	14	0
4	EtOAc	95	5	0
5	<i>i</i> -PrOH	88	12	0
6	H <sub>2</sub> O	100	0	0
7	Cyrene	100	0	0
8	2-Me-THF	68	32	0
9 <sup>a,b</sup>	2-Me-THF	19	81	0
10 <sup>a,c</sup>	2-Me-THF	0	88	12
11 <sup>c</sup>	2-Me-THF	7	91	2
12 <sup>a,d</sup>	2-Me-THF	0	70	30
13 <sup>d</sup>	2-Me-THF	0	99 (98)	1
14 <sup>d,e</sup>	2-Me-THF	0	90	10

The reaction was performed with phenyl methyl sulfide (**1a**) (25 mg, 0.20 mmol) and catalyst **4** (0.1 mol%, 0.0002 mmol) in solvent (1.0 mL) and H<sub>2</sub>O (40 μL), under household bulb irradiation for 18 h. Conversions were determined by <sup>1</sup>H-NMR. Yield of product after isolation by column chromatography in parenthesis. <sup>a</sup> The reaction was performed without the presence of water. <sup>b</sup> The reaction was performed with 0.3 mol% (0.0006 mmol) catalyst **4**. <sup>c</sup> The reaction was performed with 0.4 mol% (0.0008 mmol) catalyst **4**. <sup>d</sup> The reaction was performed with 0.5 mol% (0.001 mmol) catalyst **4**. <sup>e</sup> The reaction was performed under O<sub>2</sub> atmosphere. GVL:  $\gamma$ -Valerolactone, MTBE: Methyl *tert*-butyl ether.



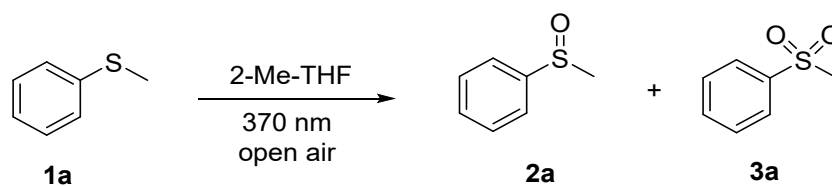
Entry	427 nm		Conversion (%)		
	Catalyst loading (mol%)	Reaction time	Ph-S-	Ph-S(=O)-	Ph-S(=O) <sub>2</sub> -
1	0.05	20 h	0	85	15
2	-	20 h	0	93	7
3	0.05	13 h	0	90	10
4	0.05	5 h	0	92	8
5	0.05	3 h	1	99	0
6	-	3 h	98	2	0
7 <sup>a</sup>	0.05	3 h	5	95	0

The reaction was performed with phenyl methyl sulfide (**1a**) (25 mg, 0.20 mmol) and catalyst **4** in 2-Me-THF (0.5 mL), under blue LED (Kessil PR160L, 427 nm) irradiation. Conversions were determined by <sup>1</sup>H-NMR. <sup>a</sup> The reaction was performed at 0.5 mmol scale.



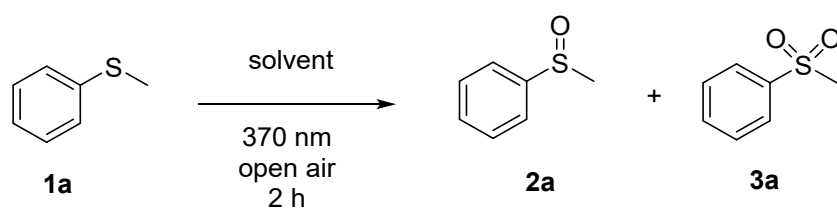
427 nm		Conversion (%)		
Entry	Solvent			
1	Glycerol	94	6	0
2	GVL	61	39	0
3	MTBE	78	22	0
4	EtOAc	11	89	0
5	<i>i</i> -PrOH	79	21	0
6	H <sub>2</sub> O	94	6	0
7	Cyrene	100	0	0
8	2-Me-THF	1	99 (92)	0

The reaction was performed with phenyl methyl sulfide (**1a**) (25 mg, 0.20 mmol) and catalyst **4** (0.05 mol%, 0.0001 mmol) in solvent (0.5 mL), under blue LED (Kessil PR160L, 427 nm) irradiation for 3 h. Conversions were determined by <sup>1</sup>H-NMR. Yield of product after isolation by column chromatography in parenthesis. GVL:  $\gamma$ -Valerolactone, MTBE: Methyl *tert*-butyl ether.



370 nm			Conversion (%)		
Entry	Catalyst loading (mol%)	Reaction time	<chem>CS(=O)c1ccccc1</chem>	<chem>CS(=O)(=O)c1ccccc1</chem>	<chem>CS(=O)(=O)c1ccccc1</chem>
1	-	20 h	0	45	55
2	-	6 h	0	73	27
3	-	4 h	0	85	15
4	-	3 h	0	90	10
5	-	2 h	0	97	3

The reaction was performed with phenyl methyl sulfide (**1a**) (25 mg, 0.20 mmol) in 2-Me-THF (0.5 mL), under UVA LED (Kessil PR160L, 370 nm) irradiation. Conversions were determined by <sup>1</sup>H-NMR.



370 nm		Conversion (%)		
Entry	Solvent	<chem>CSc1ccccc1</chem>	<chem>CS(=O)c1ccccc1</chem>	<chem>CS(=O)(=O)c1ccccc1</chem>
1	Glycerol	72	28	0
2	GVL	0	100 (50)	0
3	MTBE	87	13	0
4	EtOAc	80	20	0
5	<i>i</i> -PrOH	17	83	0
6	H <sub>2</sub> O	0	100 (68)	0
7	Cyrene	100	0	0
8	2-Me-THF	0	97 (90)	3

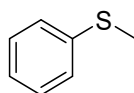
The reaction was performed with phenyl methyl sulfide (**1a**) (25 mg, 0.20 mmol) in solvent (1.0 mL), under UVA LED (Kessil PR160L, 370 nm) irradiation for 2 h. Conversions were determined by <sup>1</sup>H-NMR. Yield of product after isolation by column chromatography in parenthesis. GVL:  $\gamma$ -Valerolactone, MTBE: Methyl *tert*-butyl ether.



## General Procedure for the Synthesis of Sulfides

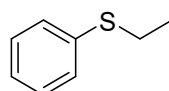
Thiol (12.00 mmol) was dissolved in dry methanol (40 mL) at -10 °C, followed by the addition of sodium methoxide (864 mg, 16.00 mmol). The reaction mixture was stirred for 10 min at -10 °C, and then the corresponding bromide (14.00 mmol) was slowly added. After stirring for 1 h at room temperature, the solvent was removed *in vacuo*. The crude residue was diluted with water (100 mL) and extracted with chloroform (4 x 70 mL). The combined organic layers were dried (Na<sub>2</sub>SO<sub>4</sub>) and the solvent was removed *in vacuo*. The desired sulfide was isolated after purification by column chromatography eluting with petroleum ether:ethyl acetate (100:0-95:5) depending on the substrate.

### Methyl(phenyl)sulfane (1a)<sup>1</sup>

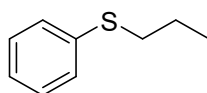


Colorless oil; (**92%**); Eluent: Petroleum ether; NMR data in accordance with reported literature.<sup>1</sup> <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ: 7.32 (5H, m, ArH), 2.52 (3H, s, SCH<sub>3</sub>); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ: 138.4, 128.8, 126.6, 125.0, 15.8.

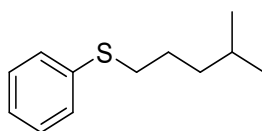
### Ethyl(phenyl)sulfane (1b)<sup>1</sup>



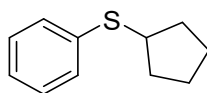
Colorless oil; (**94%**); Eluent: Petroleum ether; NMR data in accordance with reported literature.<sup>1</sup> <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ: 7.41-7.31 (5H, m, ArH), 3.00 (2H, q, *J* = 7.4 Hz, SCH<sub>2</sub>), 1.37 (3H, t, *J* = 7.4 Hz, CH<sub>3</sub>); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ: 136.6, 128.9, 128.7, 125.7, 27.5, 14.3.

**Phenyl(propyl)sulfane (1c)<sup>2</sup>**

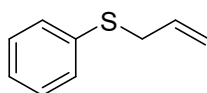
Colorless oil; (**81%**); Eluent: Petroleum ether; NMR data in accordance with reported literature.<sup>2</sup> **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$ : 7.40-7.35 (2H, m, ArH), 7.34-7.28 (2H, m, ArH), 7.22-7.17 (1H, m, ArH), 2.94 (2H, t,  $J = 7.3$  Hz, SCH<sub>2</sub>), 1.72 (2H, sext,  $J = 7.3$  Hz, CH<sub>2</sub>), 1.07 (3H, t,  $J = 7.3$  Hz, CH<sub>3</sub>); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$ : 136.9, 128.9, 128.8, 125.6, 35.6, 22.5, 13.4.

**(4-Methylpentyl)(phenyl)sulfane (1d)<sup>3</sup>**

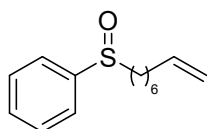
Colorless oil; (**92%**); Eluent: Petroleum ether; NMR data in accordance with reported literature.<sup>3</sup> **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$ : 7.37 (2H, d,  $J = 7.1$  Hz, ArH), 7.31 (2H, t,  $J = 7.1$  Hz, ArH), 7.20 (1H, t,  $J = 7.1$  Hz, ArH), 2.95 (2H, t,  $J = 7.2$  Hz, SCH<sub>2</sub>), 1.74-1.65 (2H, m, CH<sub>2</sub>) 1.64-1.54 [1H, m, CH(CH<sub>3</sub>)<sub>2</sub>], 1.40-1.32 (2H, m, CH<sub>2</sub>), 0.92 (6H, d,  $J = 6.6$  Hz, 2 x CH<sub>3</sub>); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$ : 137.0, 128.8, 128.8, 125.6, 38.1, 33.8, 27.7, 27.0, 22.5.

**Cyclopentyl(phenyl)sulfane (1e)<sup>4</sup>**

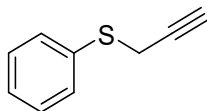
Colorless oil; (**89%**); Eluent: Petroleum ether / Ethyl acetate 95:5; NMR data in accordance with reported literature.<sup>4</sup> **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$ : 7.39 (2H, d,  $J = 7.5$  Hz, ArH), 7.30 (2H, t,  $J = 7.5$  Hz, ArH), 7.20 (1H, t,  $J = 7.5$  Hz, ArH), 3.68-3.57 (1H, m, SCH), 2.17-2.02 (2H, m, CH<sub>2</sub>), 1.87-1.76 (2H, m, CH<sub>2</sub>), 1.69-1.57 (4H, m, 2 x CH<sub>2</sub>); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$ : 137.3, 129.9, 128.7, 125.8, 45.9, 33.5, 24.8.

**Allyl(phenyl)sulfane (1f)<sup>1</sup>**

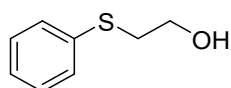
Colorless oil; (**93%**); Eluent: Petroleum ether; NMR data in accordance with reported literature.<sup>1</sup> **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$ : 7.38 (2H, d,  $J = 7.5$  Hz, ArH), 7.31 (2H, t,  $J = 7.5$  Hz, ArH), 7.22 (1H, t,  $J = 7.5$  Hz, ArH), 5.92 (1H, ddt,  $J = 16.9, 10.0$  and  $6.9$  Hz, =CH), 5.17 (1H, d,  $J = 16.9$  Hz, =CHH), 5.11 (1H, d,  $J = 10.0$  Hz, =CHH), 3.59 (2H, d,  $J = 6.9$  Hz, SCH<sub>2</sub>); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$ : 135.9, 133.6, 129.8, 128.8, 126.2, 117.6, 37.1.

**Oct-7-en-1-yl(phenyl)sulfane (1g)<sup>5</sup>**

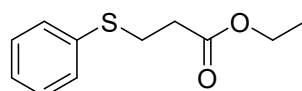
Colorless oil; (**77%**); Eluent: Petroleum ether; NMR data in accordance with reported literature.<sup>5</sup> **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$ : 7.28 (2H, m, ArH), 7.04 (2H, m, ArH), 6.94 (1H, m, ArH), 5.73 (1H, ddt,  $J = 17.2, 10.2$  and  $6.6$  Hz, =CH), 5.05 (2H, m, =CH<sub>2</sub>), 2.66 (2H, t,  $J = 7.2$  Hz, SCH<sub>2</sub>), 1.92 (2H, m, CH<sub>2</sub>), 1.48 (2H, m, CH<sub>2</sub>), 1.21 (4H, m, 2 x CH<sub>2</sub>), 1.09 (m, 2H, CH<sub>2</sub>); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$ : 139.1, 137.9, 129.2, 129.1, 125.8, 114.6, 34.1, 33.7, 29.4, 29.1, 28.9, 28.9.

**Phenyl(prop-2-yn-1-yl)sulfane (1h)<sup>6</sup>**

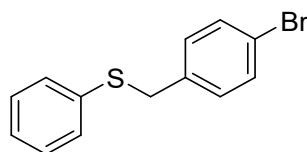
Yellowish oil; (**84%**); Eluent: Petroleum ether / Ethyl acetate 95:5; NMR data in accordance with reported literature.<sup>6</sup> **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$ : 7.49 (2H, d,  $J = 7.7$  Hz, ArH), 7.36 (2H, t,  $J = 7.7$  Hz, ArH), 7.31-7.28 (1H, m, ArH), 3.64 (2H, d,  $J = 2.6$  Hz, CH<sub>2</sub>), 2.27 (1H, t,  $J = 2.6$  Hz,  $\equiv$ CH); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$ : 134.9, 130.1, 129.0, 126.9, 79.8, 71.5, 22.5.

**2-(Phenylthio)ethan-1-ol (1i)**<sup>7</sup>

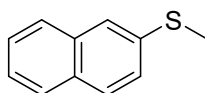
Colorless oil; (**79%**); Eluent: Petroleum ether / Ethyl acetate 95:5; NMR data in accordance with reported literature.<sup>7</sup> **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$ : 7.44-7.11 (5H, m, ArH), 3.71 (2H, t,  $J = 6.1$  Hz, OCH<sub>2</sub>), 3.11 (2H, t,  $J = 6.1$  Hz, SCH<sub>2</sub>), 2.04 (1H, br s, OH); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$ : 134.9, 129.9, 128.8, 126.5, 60.3, 36.9.

**Ethyl 3-(phenylthio)propanoate (1j)**<sup>1</sup>

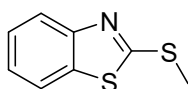
Yellowish oil; (**83%**); Eluent: Petroleum ether / Ethyl acetate 95:5; NMR data in accordance with reported literature.<sup>1</sup> **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$ : 7.39 (2H, d,  $J = 7.5$  Hz, ArH), 7.31 (2H, t,  $J = 7.5$  Hz, ArH), 7.22 (1H, t,  $J = 7.5$  Hz, ArH), 4.15 (2H, q,  $J = 7.1$  Hz, OCH<sub>2</sub>), 3.18 (2H, t,  $J = 7.2$  Hz, CH<sub>2</sub>), 2.63 (2H, t,  $J = 7.2$  Hz, CH<sub>2</sub>), 1.27 (3H, t,  $J = 7.1$  Hz, CH<sub>3</sub>); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$ : 171.8, 135.3, 130.1, 129.0, 126.5, 60.7, 34.5, 29.1, 14.2.

**(4-Bromobenzyl)(phenyl)sulfane (1k)**<sup>8</sup>

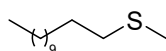
White solid; m.p.: 73-75 °C; (**77%**); Eluent: Petroleum ether / Ethyl acetate 95:5; NMR data in accordance with reported literature.<sup>9</sup> **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$ : 7.42 (2H, d,  $J = 8.4$  Hz, ArH), 7.33-7.26 (4H, m, ArH), 7.24-7.21 (1H, m, ArH), 7.17 (2H, d,  $J = 8.4$  Hz, ArH), 4.07 (2H, s, CH<sub>2</sub>); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$ : 136.7, 135.6, 131.5, 130.4, 130.2, 128.9, 126.7, 121.0, 38.6.

**Methyl(naphthalen-2-yl)sulfane (1l)**<sup>3</sup>

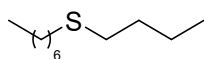
Colorless oil; (**67%**); Eluent: Petroleum ether; NMR data in accordance with reported literature.<sup>3</sup> **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$ : 7.80 (1H, d,  $J = 7.4$  Hz, ArH), 7.76 (2H, d,  $J = 8.7$  Hz, ArH), 7.64-7.62 (1H, m, ArH), 7.51-7.38 (3H, m, ArH), 2.61 (3H, s, CH<sub>3</sub>); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$ : 136.1, 133.9, 131.3, 128.2, 127.7, 126.7, 126.5, 125.7, 125.2, 123.4, 15.8.

**2-(Methylthio)benzothiazole (1m)**<sup>9</sup>

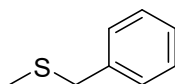
White solid; m.p.: 43-45 °C; (**96%**); Eluent: Petroleum ether / Ethyl acetate 95:5; NMR data in accordance with reported literature.<sup>10</sup> **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$ : 7.90 (1H, d,  $J = 8.0$  Hz, ArH), 7.77 (1H, d,  $J = 8.0$  Hz, ArH), 7.43 (1H, t,  $J = 8.0$  Hz, ArH), 7.31 (1H, t,  $J = 8.0$  Hz, ArH), 2.81 (3H, s, CH<sub>3</sub>); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$ : 168.0, 153.3, 135.1, 126.0, 124.0, 121.3, 120.9, 15.9.

**Dodecyl(methyl)sulfane (1p)**<sup>10</sup>

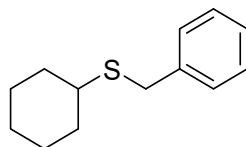
Colorless oil; (**89%**); Eluent: Petroleum ether; NMR data in accordance with reported literature.<sup>11</sup> **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$ : 2.48 (2H, t,  $J = 7.1$  Hz, SCH<sub>2</sub>), 2.08 (3H, s, SCH<sub>3</sub>), 1.65-1.50 (2H, m, CH<sub>2</sub>), 1.43-1.13 (18H, m, 9 x CH<sub>2</sub>), 0.87 (3H, t,  $J = 6.2$  Hz, CH<sub>3</sub>); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$ : 34.3, 31.9, 29.6, 29.6, 29.6, 29.5, 29.3, 29.2, 29.2, 28.8, 22.6, 15.5, 14.0.

**Butyl(heptyl)sulfane (1q)<sup>3</sup>**

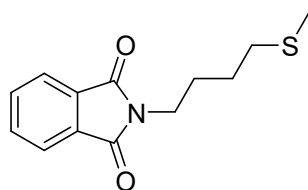
Colorless oil; (**80%**); Eluent: Petroleum ether; NMR data in accordance with reported literature.<sup>3</sup> **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$ : 2.56-2.48 (4H, m, 2 x SCH<sub>2</sub>), 1.65-1.54 (4H, m, 2 x CH<sub>2</sub>), 1.48-1.37 (4H, m, 2 x CH<sub>2</sub>), 1.36-1.25 (6H, m, 3 x CH<sub>2</sub>), 0.96-0.87 (6H, m, 2 x CH<sub>3</sub>); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$ : 32.2, 31.8, 31.8, 31.7, 29.7, 28.9, 22.6, 22.0, 14.0, 13.7.

**Benzyl(methyl)sulfane (1u)<sup>1</sup>**

Colorless oil; (**92%**); Eluent: Petroleum ether; NMR data in accordance with reported literature.<sup>1</sup> **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$ : 7.43-7.24 (5H, m, ArH), 3.73 (2H, s, CH<sub>2</sub>), 2.05 (3H, s, CH<sub>3</sub>); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$ : 138.2, 128.7, 128.3, 126.8, 38.2, 14.8.

**Benzyl(cyclohexyl)sulfane (1w)<sup>11</sup>**

Colorless oil; (**87%**); Eluent: Petroleum ether; NMR data in accordance with reported literature.<sup>12</sup> **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$ : 7.38-7.29 (5H, m, ArH), 3.78 (2H, s, SCH<sub>2</sub>), 2.66-2.56 (1H, m, SCH), 2.00-1.94 (2H, m, 2 x CHH), 1.83-1.73 (2H, m, 2 x CHH), 1.66-1.57 (1H, m, CHH), 1.44-1.23 (5H, m, 5 x CHH); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$ : 138.9, 128.7, 128.4, 126.7, 42.9, 34.6, 33.3, 25.9, 25.8.

**2-(4-(Methylthio)butyl)isoindoline-1,3-dione (1x)<sup>12</sup>**

White solid; m.p.: 57-59 °C; (**87%**); Eluent: Petroleum ether / Ethyl acetate 70:30; NMR data in accordance with reported literature.<sup>13</sup> **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$ : 7.86 (2H, dd,  $J = 5.4$  and  $3.1$  Hz, ArH), 7.73 (2H, dd,  $J = 5.4$  and  $3.1$  Hz, ArH), 3.73 (2H, t,  $J = 7.1$  Hz, NCH<sub>2</sub>), 2.61-2.50 (2H, m, SCH<sub>2</sub>), 2.11 (3H, s, CH<sub>3</sub>), 1.87-1.77 (2H, m, CH<sub>2</sub>), 1.71-1.61 (2H, m, CH<sub>2</sub>); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$ : 168.4, 133.9, 132.1, 123.2, 37.5, 33.6, 27.7, 26.4, 15.5.

## **General Procedures for the Photochemical Aerobic Oxidation of Sulfides to Sulfoxides**

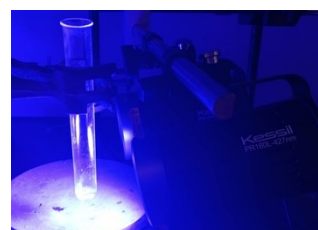
### **General procedure for the photochemical aerobic oxidation of sulfides under 370 nm UVA LED irradiation**

In a glass vial containing sulfide (1.0 eq., 0.50 mmol) in 2-Me-THF (1.0 mL), water (100  $\mu$ L) was added. The reaction mixture was left stirring under UVA LED (Kessil PR 160L, 370 nm) irradiation for 2-20 h. The desired product was purified by column chromatography (Pet. Ether/AcOEt: 6:4).



### **General procedure for the photochemical aerobic oxidation of sulfides under 427 nm blue LED irradiation**

In a glass vial containing sulfide (1.0 eq., 0.50 mmol), anthraquinone (0.05 mol%,  $0.25 \times 10^{-3}$  mmol, 0.05 mg) in 2-Me-THF (1.0 mL) was added (catalyst was added from stock solution in 2-Me-THF). The reaction mixture was left stirring under Blue LED (Kessil PR 160L, 427 nm) irradiation for 3-18 h. The desired product was purified by column chromatography (Pet. Ether/AcOEt: 6:4)



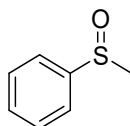


### General procedure for the photochemical aerobic oxidation of sulfides under household bulb irradiation

In a glass vial containing sulfide (1.0 eq., 0.50 mmol) and anthraquinone (0.5 mol%, 0.0025 mmol, 0.5 mg) in 2-Me-THF (1.5 mL), water (100  $\mu$ L) was added. The reaction mixture was left stirring under household bulb irradiation (2  $\times$  85W household lamps) for 18-48 h. The desired product was purified by column chromatography (Pet. Ether/AcOEt: 6:4)



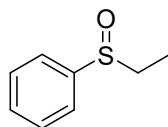
#### (Methylsulfinyl)benzene (2a)<sup>1</sup>



370 nm		427 nm		CFL lamps	
2 h	90 %	3 h	92 %	18 h	98 %

Colorless oil; Eluent: Petroleum ether / Ethyl acetate 6:4; NMR data in accordance with reported literature.<sup>1</sup> <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$ : 7.70-7.66 (2H, m, ArH), 7.59-7.51 (3H, m, ArH), 2.75 (3H, s, CH<sub>3</sub>); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$ : 145.7, 131.0, 129.3, 123.5, 43.9; ESI-MS [M+H<sup>+</sup>]: 141 m/z.

#### (Ethylsulfinyl)benzene (2b)<sup>13</sup>

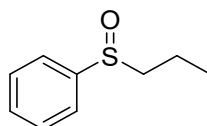


370 nm		427 nm		CFL lamps	
2 h	99 %	3 h	92 %	18 h	98 %

Yellowish solid; m.p.: 119-121  $^{\circ}$ C; Eluent: Petroleum ether / Ethyl acetate 6:4; NMR data in accordance with reported literature.<sup>14</sup> <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$ : 7.63 (2H, dd,  $J$  = 7.4 and 2.1 Hz, ArH), 7.57-7.50 (3H, m, ArH), 2.93 (1H, dq,  $J$  = 14.7 and

7.3 Hz, SCHH), 2.79 (1H, dq,  $J = 14.7$  and  $7.3$  Hz, SCHH), 1.22 (3H, t,  $J = 7.3$  Hz, CH<sub>3</sub>); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$ : 143.3, 130.9, 129.1, 124.2, 50.3, 5.9; ESI-MS [M+H<sup>+</sup>]: 155 m/z.

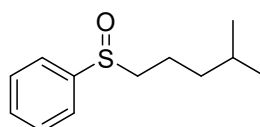
**(Propylsulfinyl)benzene (2c)<sup>3</sup>**



370 nm		427 nm		CFL lamps	
2 h	97 %	3 h	98 %	18 h	97 %

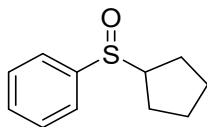
White solid; m.p.: 96-98 °C; Eluent: Petroleum ether / Ethyl acetate 6:4; NMR data in accordance with reported literature.<sup>3</sup> <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$ : 7.63-7.62 (2H, d,  $J = 7.6$  Hz, ArH), 7.55-7.45 (3H, m, ArH), 2.84-2.71 (2H, m, SCH<sub>2</sub>), 1.74-1.86 (1H, m, CHH), 1.60-1.72 (1H, m, CHH), 1.04 (3H, t,  $J = 7.4$  Hz, CH<sub>3</sub>); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$ : 144.0, 130.8, 129.1, 123.9, 59.2, 15.8, 13.2; ESI-MS [M+H<sup>+</sup>]: 169 m/z.

**((4-Methylpentyl)sulfinyl)benzene (2d)<sup>3</sup>**



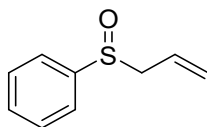
370 nm		427 nm		CFL lamps	
2 h	99 %	3 h	98 %	18 h	87 %

Colorless oil; Eluent: Petroleum ether / Ethyl acetate 6:4; NMR data in accordance with reported literature.<sup>3</sup> <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$ : 7.65-7.60 (2H, m, ArH), 7.55-7.48 (3H, m, ArH), 2.81-2.74 (2H, m, SCH<sub>2</sub>), 1.80-1.71 (1H, m, CHH), 1.69-1.59 (1H, m, CHH), 1.59-1.50 (1H, m, CH), 1.36-1.29 (1H, m, CHH), 1.28-1.21 (1H, m, CHH), 0.86 (6H, d,  $J = 6.6$  Hz, 2 x CH<sub>3</sub>); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$ : 144.0, 130.8, 129.1, 124.0, 57.6, 37.7, 27.7, 22.3, 22.3, 20.1; ESI-MS [M+H<sup>+</sup>]: 211 m/z.

**(Cyclopentylsulfinyl)benzene (2e)**

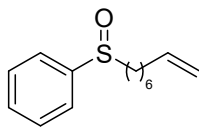
370 nm		427 nm		CFL lamps	
10 h	80 %	6 h	71 %	18 h	74 %

Pale yellow oil; Eluent: Petroleum ether / Ethyl acetate 6:4;  $^1\text{H NMR}$  (400 MHz,  $\text{CDCl}_3$ )  $\delta$ : 7.64-7.57 (2H, m, ArH), 7.50-7.41 (3H, m, ArH), 3.09 (1H, quint,  $J = 7.7$  Hz, SCH), 2.12-2.01 (1H, m, CHH), 1.83-1.75 (2H, m, 2 x CHH), 1.73-1.52 (5H, m, 5 x CHH);  $^{13}\text{C NMR}$  (100 MHz,  $\text{CDCl}_3$ )  $\delta$ : 143.5, 130.7, 128.9, 124.4, 64.2, 27.5, 25.9, 25.5, 24.7; **HRMS**: calculated for  $\text{C}_{11}\text{H}_{15}\text{OS}^+$  ( $\text{M}+\text{H}$ ) $^+$ : 195.0838, found: 195.0836.

**(Allylsulfinyl)benzene (2f)<sup>1</sup>**

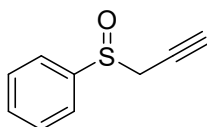
370 nm		427 nm		CFL lamps	
3 h	76 %	3 h	70 %	18 h	70 %

Colorless oil; Eluent: Petroleum ether / Ethyl acetate 6:4; NMR data in accordance with reported literature.<sup>14</sup>  $^1\text{H NMR}$  (400 MHz,  $\text{CDCl}_3$ )  $\delta$ : 7.66-7.61 (2H, m, ArH), 7.58-7.49 (3H, m, ArH), 5.68 (1H, ddt,  $J = 17.0, 10.2$  and  $7.5$  Hz, =CH), 5.36 (1H, d,  $J = 10.2$  Hz, =CHH), 5.22 (1H, d,  $J = 17.0$  Hz, =CHH), 3.60 (1H, dd,  $J = 12.8$  and  $7.5$  Hz, SCHH), 3.54 (1H, dd,  $J = 12.8$  and  $7.5$  Hz, SCHH);  $^{13}\text{C NMR}$  (100 MHz,  $\text{CDCl}_3$ )  $\delta$ : 143.0, 131.1, 129.0, 125.3, 124.4, 123.9, 60.9; **ESI-MS** [ $\text{M}+\text{H}$ ] $^+$ : 167 m/z.

**(Oct-7-en-1-ylsulfinyl)benzene (2g)**<sup>14</sup>

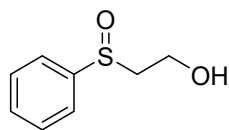
370 nm		427 nm		CFL lamps	
2 h	78 %	3 h	93 %	18 h	89 %

Colorless oil; Eluent: Petroleum ether / Ethyl acetate 6:4; NMR data in accordance with reported literature.<sup>15</sup> **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$ : 7.65-7.56 (2H, m, ArH), 7.55-7.46 (3H, m, ArH), 5.77 (1H, ddt,  $J$  = 17.0, 10.3 and 6.4 Hz, =CH), 4.95 (2H, m, =CH<sub>2</sub>), 2.79 (2H, t,  $J$  = 7.7 Hz, SCH<sub>2</sub>), 2.06-1.98 (2H, m, CH<sub>2</sub>), 1.82-1.70 (1H, m, CHH), 1.68-1.56 (1H, m, CHH), 1.46-1.28 (6H, m, 3 x CH<sub>2</sub>); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$ : 144.0, 138.7, 130.8, 129.1, 123.9, 114.3, 57.2, 33.5, 28.5, 28.5, 28.4, 22.0; **ESI-MS** [M+H<sup>+</sup>]: 237 m/z.

**(Prop-2-yn-1-ylsulfinyl)benzene (2h)**<sup>15</sup>

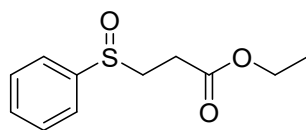
370 nm		427 nm		CFL lamps	
3 h	90 %	3 h	75 %	18 h	92 %

Colorless oil; Eluent: Petroleum ether / Ethyl acetate 6:4; NMR data in accordance with reported literature.<sup>16</sup> **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$ : 7.76-7.72 (2H, m, ArH), 7.58-7.55 (3H, m, ArH), 3.68 (1H, dd,  $J$  = 15.7 and 2.7 Hz, SCHH), 3.66 (1H, dd,  $J$  = 15.7 and 2.7 Hz, SCHH), 2.36 (1H, t,  $J$  = 2.7 Hz,  $\equiv$ CH); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$ : 142.7, 131.8, 129.1, 124.5, 76.4, 72.7, 47.7; **ESI-MS** [M+H<sup>+</sup>]: 165 m/z.

**2-(Phenylsulfinyl)ethan-1-ol (2i)<sup>16</sup>**

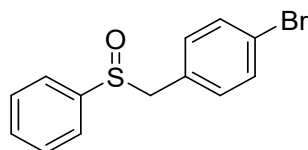
370 nm		427 nm		CFL lamps	
2 h	73 %	3 h	70 %	18 h	79 %

Colorless oil; Eluent: Petroleum ether / Ethyl acetate 6:4; NMR data in accordance with reported literature.<sup>17</sup> <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$ : 7.67 (2H, dd,  $J = 7.9$  and 1.6 Hz, ArH), 7.60-7.51 (3H, m, ArH), 4.19 (1H, ddd,  $J = 12.1, 8.8$  and 3.2 Hz, OCHH), 4.03 (1H, ddd,  $J = 12.1, 5.4$  and 4.1 Hz, OCHH), 3.22-3.17 (2H, m, S(O)CHH and OH), 2.91 (1H, ddd,  $J = 13.6, 5.4$  and 3.2 Hz, S(O)CHH); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$ : 143.0, 131.2, 129.4, 123.9, 58.3, 57.0; ESI-MS [M+H<sup>+</sup>]: 171 m/z.

**Ethyl 3-(phenylsulfinyl)propanoate (2j)<sup>1</sup>**

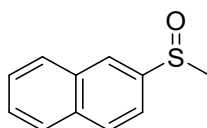
370 nm		427 nm		CFL lamps	
4 h	80 %	5 h	82 %	18 h	85 %

Colorless oil; Eluent: Petroleum ether / Ethyl acetate 6:4; NMR data in accordance with reported literature.<sup>1</sup> <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$ : 7.65-7.59 (2H, dd,  $J = 7.4$  and 1.8 Hz, ArH), 7.56-7.48 (3H, m, ArH), 4.11 (2H, q,  $J = 7.1$  Hz, OCH<sub>2</sub>), 3.23 (1H, ddd,  $J = 13.7, 8.5$  and 6.9 Hz, CHH), 2.97 (1H, ddd,  $J = 13.7, 8.5$  and 5.8 Hz, CHH), 2.82 (1H, ddd,  $J = 16.9, 8.5$  and 6.9 Hz, CHH), 2.53 (1H, ddd,  $J = 16.9, 8.5$  and 5.8 Hz, CHH), 1.23 (3H, t,  $J = 7.1$  Hz, CH<sub>3</sub>); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$ : 171.1, 142.9, 131.1, 129.2, 124.0, 61.0, 51.1, 26.1, 14.0; ESI-MS [M+H<sup>+</sup>]: 227 m/z.

**1-Bromo-4-((phenylsulfinyl)methyl)benzene (2k)<sup>17</sup>**

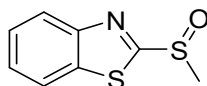
370 nm		427 nm		CFL lamps	
2 h	74 %	3 h	80 %	18 h	76 %

White solid; m.p.: 177-179 °C; Eluent: Petroleum ether / Ethyl acetate 6:4; NMR data in accordance with reported literature.<sup>18</sup> <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$ : 7.51-7.44 (3H, m, ArH), 7.39 (4H, d,  $J$  = 8.2 Hz, ArH), 6.85 (2H, d,  $J$  = 8.2 Hz, ArH), 4.03 (1H, d,  $J$  = 12.8 Hz, CHH), 3.98 (1H, d,  $J$  = 12.8 Hz, CHH); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$ : 142.3, 131.9, 131.5, 131.3, 129.0, 127.9, 124.4, 122.6, 62.5; ESI-MS [M+H<sup>+</sup>]: 295 m/z.

**2-(Methylsulfinyl)naphthalene (2l)<sup>3</sup>**

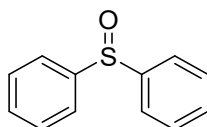
370 nm		427 nm		CFL lamps	
2 h	95 %	3 h	97 %	18 h	98 %

White solid; m.p.: 105-107 °C; Eluent: Petroleum ether / Ethyl acetate 6:4; NMR data in accordance with reported literature.<sup>3</sup> <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$ : 8.23 (1H, s, ArH), 8.00 (1H, d,  $J$  = 8.6, ArH), 7.99-7.88 (2H, m, ArH), 7.65-7.57 (3H, m, ArH), 2.81 (3H, s, CH<sub>3</sub>); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$ : 142.7, 134.4, 132.9, 129.5, 128.4, 128.0, 127.7, 127.3, 124.0, 119.4, 43.7; ESI-MS [M+H<sup>+</sup>]: 191 m/z.

**2-(Methylsulfinyl)benzo[d]thiazole (2m)<sup>18</sup>**

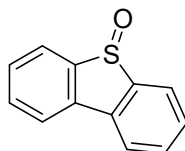
370 nm		427 nm		CFL lamps	
8 h	58 %	18 h	60 %	48 h	83 %

Yellowish solid; m.p.: 69-71 °C; Eluent: Petroleum ether / Ethyl acetate 6:4; NMR data in accordance with reported literature.<sup>19</sup> <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ: 8.08 (1H, d, *J* = 7.9 Hz, ArH), 8.02 (1H, d, *J* = 7.9 Hz, ArH), 7.58 (1H, t, *J* = 7.9 Hz, ArH), 7.51 (1H, t, *J* = 7.9 Hz, ArH), 3.09 (3H, s, CH<sub>3</sub>); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ: 178.3, 153.7, 136.0, 126.9, 126.2, 123.9, 122.3, 43.1; ESI-MS [M+H<sup>+</sup>]: 198 m/z.

**Sulfinyldibenzene (2n)<sup>3</sup>**

370 nm		427 nm		CFL lamps	
10 h	70 %	18 h	76 %	18 h	93 %

White solid; m.p.: 70-72 °C; Eluent: Petroleum ether / Ethyl acetate 6:4; NMR data in accordance with reported literature.<sup>3</sup> <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ: 7.70-7.64 (4H, m, ArH), 7.51-7.43 (6H, m, ArH); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>) δ: 145.6, 131.0, 129.3, 124.8; ESI-MS [M+H<sup>+</sup>]: 203 m/z.

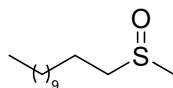
**Dibenzo[b,d]thiophene 5-oxide (2o)<sup>9</sup>**

370 nm		427 nm		CFL lamps	
2 h	79 %	3 h	79 %	18 h	79 %

White solid; m.p.: 188-190 °C; Eluent: Petroleum ether / Ethyl acetate 6:4; NMR data in accordance with reported literature.<sup>10</sup> <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>) δ: 7.99 (2H, d, *J*

= 7.6 Hz, ArH), 7.81 (2H, d,  $J = 7.6$  Hz, ArH), 7.60 (2H, t,  $J = 7.6$  Hz, ArH), 7.50 (2H, t,  $J = 7.6$  Hz, ArH);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ )  $\delta$ : 145.1, 137.0, 132.5, 129.5, 127.4, 121.8; **ESI-MS**  $[\text{M}+\text{H}^+]$ : 201 m/z.

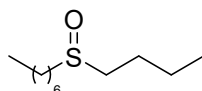
### 1-(Methylsulfinyl)dodecane (2p)<sup>15</sup>



370 nm		427 nm		CFL lamps	
18 h	99 %	3 h	97 %	18 h	98 %

White solid; m.p.: 62-64 °C; Eluent: Petroleum ether / Ethyl acetate 6:4; NMR data in accordance with reported literature.<sup>16</sup>  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ )  $\delta$ : 2.79-2.72 (1H, m, SCHH), 2.70-2.62 (1H, m, SCHH), 2.57 (3H, s,  $\text{SCH}_3$ ), 1.77 (2H, p,  $J = 7.2$  Hz,  $\text{CH}_2$ ), 1.51-1.26 (18H, m, 9 x  $\text{CH}_2$ ), 0.89 (3H, t,  $J = 6.7$  Hz,  $\text{CH}_3$ );  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ )  $\delta$ : 54.8, 38.5, 31.9, 29.6, 29.5, 29.3, 29.3, 29.2, 28.8, 22.6, 22.5, 14.1; **ESI-MS**  $[\text{M}+\text{H}^+]$ : 121 m/z.

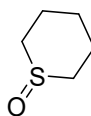
### 1-(Butylsulfinyl)heptane (2q)<sup>3</sup>



370 nm		427 nm		CFL lamps	
18 h	73 %	3 h	73 %	18 h	74 %

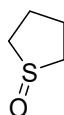
Colorless oil; Eluent: Petroleum ether / Ethyl acetate 6:4; NMR data data in accordance with reported literature.<sup>3</sup>  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ )  $\delta$ : 2.76-2.60 (4H, m, 2 x  $\text{SCH}_2$ ), 1.83-1.72 (4H, m, 2 x  $\text{CH}_2$ ), 1.58-1.40 (4H, m, 2 x  $\text{CH}_2$ ), 1.39-1.26 (6H, m, 3 x  $\text{CH}_2$ ), 0.98 (3H, t,  $J = 7.3$  Hz,  $\text{CH}_3$ ), 0.90 (3H, t,  $J = 6.8$  Hz,  $\text{CH}_3$ );  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ )  $\delta$ : 52.4, 52.1, 31.5, 28.8, 28.8, 24.6, 22.6, 22.5, 22.1, 14.0, 13.6; **ESI-MS**  $[\text{M}+\text{H}^+]$ : 205 m/z.



**Tetrahydro-2H-thiopyran 1-oxide (2r)**<sup>19</sup>

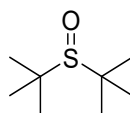
370 nm		427 nm		CFL lamps	
18 h	87 %	3 h	62 %	18 h	87 %

White solid; m.p.: 60-62 °C; Eluent: Petroleum ether / Ethyl acetate 6:4; NMR data in accordance with reported literature.<sup>20</sup> **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$ : 2.90 (2H, t,  $J = 10.9$  Hz, 2 x SCHH), 2.78 (2H, t,  $J = 10.9$  Hz, 2 x SCHH), 2.32-2.18 (2H, m, CH<sub>2</sub>), 1.73-1.58 (4H, m, 2 x CH<sub>2</sub>); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$ : 48.9, 24.6, 19.1; **ESI-MS** [M+H<sup>+</sup>]: 119 m/z.

**Tetrahydrothiophene 1-oxide (2s)**<sup>20</sup>

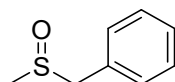
370 nm		427 nm		CFL lamps	
20 h	92 %	3 h	80 %	18 h	88 %

Colorless oil; Eluent: Petroleum ether / Ethyl acetate 6:4; NMR data in accordance with reported literature.<sup>21</sup> **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$ : 2.91-2.74 (4H, m, 2 x SCH<sub>2</sub>), 2.48-2.35 (2H, m, CH<sub>2</sub>), 2.05-1.93 (2H, m, CH<sub>2</sub>); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$ : 54.3, 25.3; **ESI-MS** [M+H<sup>+</sup>]: 105 m/z.

**2-(tert-Butylsulfinyl)-2-methylpropane (2t)**<sup>3</sup>

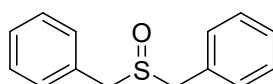
370 nm		427 nm		CFL lamps	
18 h	80 %	3 h	83 %	18 h	85 %

Colorless solid; Eluent: Petroleum ether; NMR data in accordance with reported literature.<sup>3</sup> **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$ : 1.35 (18H, s, 6 x CH<sub>3</sub>); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$ : 57.2, 25.5; **ESI-MS** [M+H<sup>+</sup>]: 163 m/z.

**((Methylsulfinyl)methyl)benzene (2u)**<sup>15</sup>

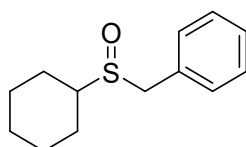
370 nm		427 nm		CFL lamps	
3 h	78 %	4 h	77 %	18 h	73 %

White solid; m.p.: 54-56 °C; Eluent: Petroleum ether / Ethyl acetate 6:4; data in accordance with reported literature.<sup>16</sup> **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$ : 7.43-7.33 (3H, m, ArH), 7.32-7.28 (2H, m, ArH), 4.08 (1H, d,  $J$  = 12.8 Hz, SCHH), 3.94 (1H, d,  $J$  = 12.8 Hz, SCHH), 2.47 (3H, s, CH<sub>3</sub>); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$ : 130.0, 129.6, 128.9, 128.4, 60.2, 37.2; **ESI-MS** [M+H<sup>+</sup>]: 155 m/z.

**(Sulfinylbis(methylene))dibenzene (2v)**<sup>13</sup>

370 nm		427 nm		CFL lamps	
2 h	81 %	3 h	81 %	18 h	81 %

White solid; m.p.: 132-134 °C; Eluent: Petroleum ether / Ethyl acetate 6:4; NMR data in accordance with reported literature.<sup>14</sup> **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$ : 7.42-7.36 (6H, m, ArH), 7.34-7.30 (4H, m, ArH), 3.97 (2H, d,  $J$  = 13.0 Hz, SCHH), 3.93 (2H, d,  $J$  = 13.0 Hz, SCHH); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$ : 130.1, 130.0, 128.9, 128.3, 57.1; **ESI-MS** [M+H<sup>+</sup>]: 231 m/z.

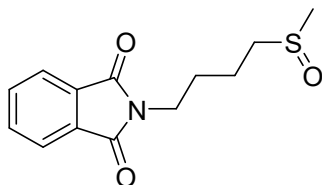
**((Cyclohexylsulfinyl)methyl)benzene (2w)**<sup>21</sup>

370 nm		427 nm		CFL lamps	
3 h	80 %	5 h	88 %	18 h	92 %

White solid; m.p.: 82-84 °C; Eluent: Petroleum ether / Ethyl acetate 6:4; NMR data in accordance with reported literature.<sup>22</sup> **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$ : 7.47-7.29 (5H,

m, ArH), 4.01 (1H, d,  $J = 13.1$  Hz, SCHH), 3.93 (1H, d,  $J = 13.1$  Hz, SCHH), 2.54-2.44 (1H, m, SCH), 2.16-2.07 (1H, m, CHH), 1.99-1.82 (3H, m, 3 x CHH), 1.75-1.67 (1H, m, CHH), 1.63-1.47 (2H, m, 2 x CHH), 1.39-1.24 (3H, m, 3 x CHH);  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ )  $\delta$ : 130.6, 129.9, 128.6, 128.1, 56.9, 54.7, 26.9, 25.4, 25.4, 25.1, 23.9; **ESI-MS** [ $\text{M}+\text{H}^+$ ]: 223 m/z.

**2-(4-(Methylsulfinyl)butyl)isoindoline-1,3-dione (2x)<sup>12</sup>**



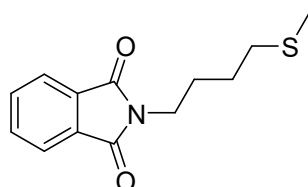
370 nm		427 nm		CFL lamps	
2 h	80 %	3 h	90 %	18 h	90 %

White solid; m.p.: 132-133 °C; Eluent: Petroleum ether / Ethyl acetate 6:4; NMR data in accordance with reported literature.<sup>13</sup>  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ )  $\delta$ : 7.86 (2H, dd,  $J = 5.4$  and 3.1 Hz, ArH), 7.76-7.71 (2H, m, ArH), 3.76 (2H, t,  $J = 6.6$  Hz,  $\text{NCH}_2$ ), 2.81-2.75 (2H, m,  $\text{SCH}_2$ ), 2.59 (3H, s,  $\text{CH}_3$ ), 1.92-1.81 (4H, m, 2 x  $\text{CH}_2$ );  $^{13}\text{C}$  NMR (100 MHz,  $\text{CDCl}_3$ )  $\delta$ : 168.3, 134.0, 132.0, 123.3, 53.8, 38.5, 37.1, 27.7, 19.8; **ESI-MS** [ $\text{M}+\text{H}^+$ ]: 266 m/z.

## Application of the Green Photochemical Aerobic Oxidation of Sulfides in the Synthesis of Pharmaceuticals

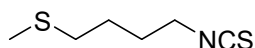
### Sulforaphane

#### 2-(4-(Methylthio)butyl)isoindoline-1,3-dione (**1x**)<sup>12</sup>



White solid; m.p.: 57-59 °C; (**87 %**); Eluent: Petroleum ether / Ethyl acetate 70:30; NMR data in accordance with reported literature.<sup>13</sup> <sup>1</sup>H NMR (400 MHz, CDCl<sub>3</sub>)  $\delta$ : 7.86 (2H, dd,  $J = 5.4$  and  $3.1$  Hz, ArH), 7.73 (2H, dd,  $J = 5.4$  and  $3.1$  Hz, ArH), 3.73 (2H, t,  $J = 7.1$  Hz, NCH<sub>2</sub>), 2.61-2.50 (2H, m, SCH<sub>2</sub>), 2.11 (3H, s, CH<sub>3</sub>), 1.87-1.77 (2H, m, CH<sub>2</sub>), 1.71-1.61 (2H, m, CH<sub>2</sub>); <sup>13</sup>C NMR (100 MHz, CDCl<sub>3</sub>)  $\delta$ : 168.4, 133.9, 132.1, 123.2, 37.5, 33.6, 27.7, 26.4, 15.5.

#### Methyl(4-thiocyanatobutyl)sulfane (**5**)<sup>12</sup>



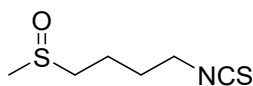
2-(4-(Methylthio)butyl)isoindoline-1,3-dione (**1x**) (950 mg, 3.81 mmol) was dissolved in ethanol (2 mL) and hydrazine hydrate (4 mL) was slowly added to the solution. The reaction mixture was heated at 70 °C for 5 h. After completion of the reaction, the reaction mixture was cooled down at 0 °C and solid precipitated. The crude mixture was filtered, and the filtrate was evaporated until dry to afford the corresponding amine (450 mg), which was used without further purification.

The corresponding amine was dissolved in THF (10 mL) and Et<sub>3</sub>N (1.46 mL, 10.5 mmol) was added. The reaction mixture was cooled down at 0 °C and a solution of CS<sub>2</sub> (229 mg, 3.00 mmol) in THF (1 mL) was added dropwise, so as the temperature did not exceed 5 °C. When the addition was completed, the reaction mixture was stirred for 1 h at room temperature. The resulting gray suspension was cooled down at 0 °C and MsCl (255  $\mu$ L, 3.30 mmol) was added in one portion. The reaction mixture was stirred for 1 h at room temperature. The resulting yellow suspension was diluted

with Et<sub>2</sub>O (60 mL), washed successfully with 1 M HCl (2 x 20 mL), H<sub>2</sub>O (30 mL) and brine (30 mL), dried (Na<sub>2</sub>SO<sub>4</sub>) and evaporated until dry. The crude product was purified by column chromatography (Petroleum ether / Ethyl acetate 9:1) to afford 400 mg. Yield (2 steps): **66 %**.

Colorless oil; NMR data in accordance with reported literature.<sup>13</sup> **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$ : 3.53 (2H, t,  $J$  = 6.6 Hz, CH<sub>2</sub>NCS), 2.50 (2H, t,  $J$  = 6.6 Hz, SCH<sub>2</sub>), 2.07 (3H, s, CH<sub>3</sub>), 1.84-1.75 (2H, m, CH<sub>2</sub>), 1.74-1.65 (2H, m, CH<sub>2</sub>); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$ : 129.9, 44.5, 33.0, 28.6, 25.6, 15.2.

### 1-(Methylsulfinyl)-4-thiocyanatobutane (**6**)<sup>12</sup>



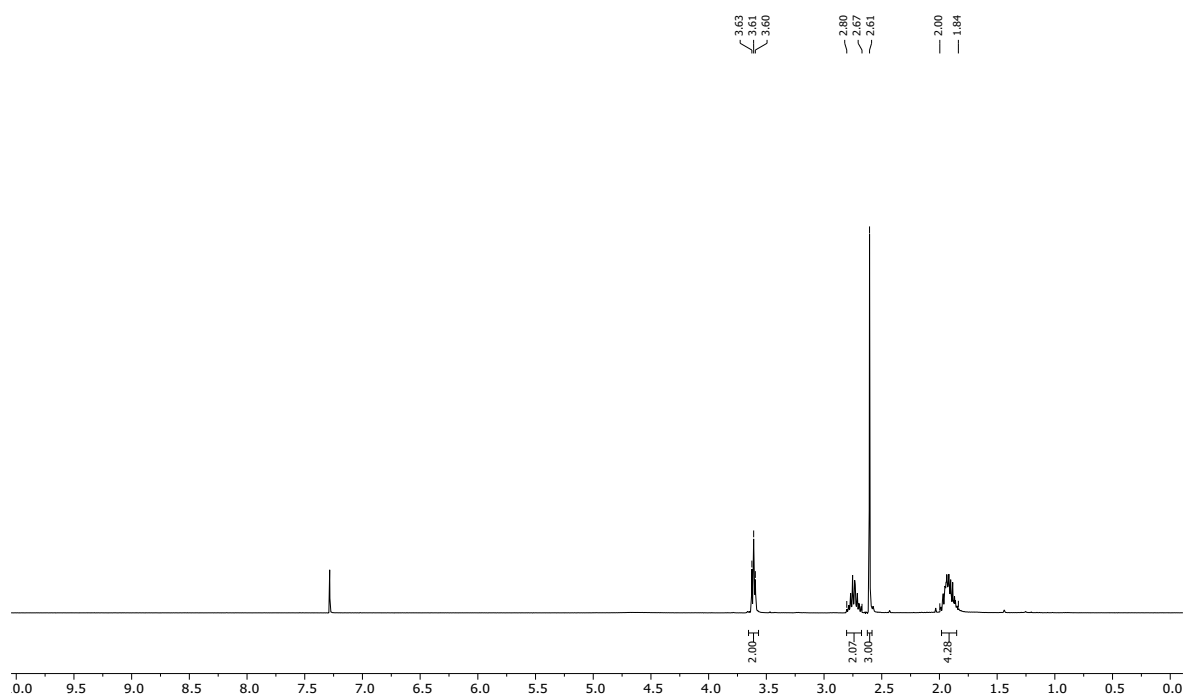
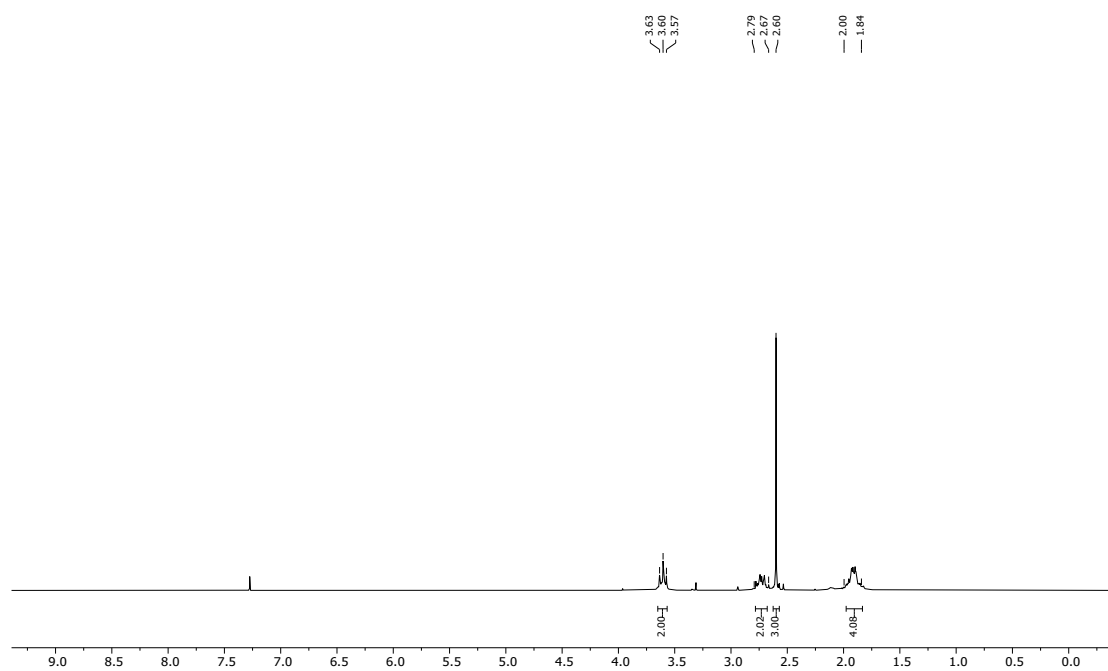
370 nm*		427 nm		CFL lamps	
4 h	87 %	5 h	96 %	18 h	78 %

\* The reaction was performed using anthraquinone (0.5 mol%, 0.0025 mmol, 0.5 mg) to accelerate the reaction and to avoid decomposition of sulforaphane.

**Purification Procedure A:** Column Chromatography. Eluent: Petroleum ether / Ethyl acetate 6:4.

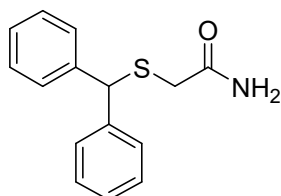
**Purification Procedure B:** Liquid-Liquid Extraction. Upon reaction completion [the reaction was performed at 370 nm, using the general procedure for the 370 nm protocol adding anthraquinone (0.5 mol%,)], the reaction mixture was evaporated until dry. The residual mass was dissolved in a mixture of water/ethanol (9:1) (2 mL). The aqueous solution was washed with cyclohexane (2 mL) and ethyl acetate (2 x 2 mL). The ethyl acetate layers were combined and dried over Na<sub>2</sub>SO<sub>4</sub>. Filtration and evaporation until dry afforded 71 mg of compound **6**. Yield: **80 %**.

Colorless oil; NMR data in accordance with reported literature.<sup>13</sup> **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$ : 3.61 (2H, t,  $J$  = 6.0 Hz, CH<sub>2</sub>NCS), 2.80-2.67 (2H, m, SCH<sub>2</sub>), 2.61 (3H, s, CH<sub>3</sub>), 2.00-1.84 (4H, m, 2 x CH<sub>2</sub>); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$ : 130.9, 53.4, 44.6, 38.6, 28.9, 20.0; **ESI-MS** [M+H<sup>+</sup>]: 178 m/z.

**$^1\text{H-NMR}$  (400 MHz,  $\text{CDCl}_3$ ) of 6 after column chromatography** **$^1\text{H-NMR}$  (400 MHz,  $\text{CDCl}_3$ ) of 6 after liquid-liquid extraction from the reaction mixture**

## Modafinil

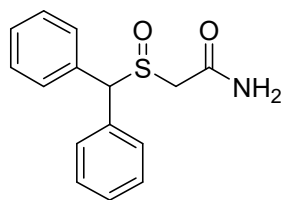
### 2-(Benzhydrylthio)acetamide (8)<sup>22</sup>



In a round bottom flask, benzhydrol (920 mg, 5.00 mmol) and thioglycolic acid (461 mg, 5.00 mmol) were diluted in trifluoroacetic acid (5 mL) and the reaction mixture was stirred at room temperature for 3 h. Then, the reaction mixture was concentrated *in vacuo*. The crude residue (white solid) was used in the next step without further purification.

To a solution of 2-(benzhydrylthio)acetic acid (1.20 g, 5.00 mmol) in benzene (7.5 mL), a solution of thionyl chloride (2.20 g, 18.20 mmol) in benzene (1 mL) was added dropwise. The reaction mixture was heated at reflux for 1.5 h. The solvent was removed *in vacuo* to afford an orange oil. A solution of the oil in CH<sub>2</sub>Cl<sub>2</sub> (6 mL) was added to a vigorously stirred saturated aq. solution of NH<sub>4</sub>OH (20 mL). The reaction mixture was stirred vigorously for 2 h and then the layers were separated. The aqueous layer was extracted with CH<sub>2</sub>Cl<sub>2</sub> (2 x 10 mL). The organic layers were combined and washed with aq. 5% NaHCO<sub>3</sub> (15 mL) and brine (15 mL) and dried over Na<sub>2</sub>SO<sub>4</sub>. The solvent was removed *in vacuo* and the crude mixture was purified by column chromatography (CH<sub>2</sub>Cl<sub>2</sub>:EtOAc 8:2) to afford 799 mg. Yield: **62 %**.

White solid; m.p: 108-110 °C; NMR data in accordance with reported literature.<sup>22</sup> **<sup>1</sup>H NMR** (400 MHz, CDCl<sub>3</sub>) δ: 7.44 (4H, d, *J* = 7.4 Hz, ArH), 7.35 (4H, t, *J* = 7.4 Hz, ArH), 7.30-7.26 (2H, m, ArH), 6.53 (1H, br s, *NHH*), 5.76 (1H, br s, *NHH*), 5.21 (1H, s, CH), 3.11 (1H, s, CH<sub>2</sub>); **<sup>13</sup>C NMR** (100 MHz, CDCl<sub>3</sub>) δ: 177.1, 140.1, 128.7, 128.2, 127.6, 54.7, 35.5; **ESI-MS** [M+H<sup>+</sup>]: 258 m/z.

**2-(Benzhydrylsulfinyl)acetamide (9)**<sup>22</sup>

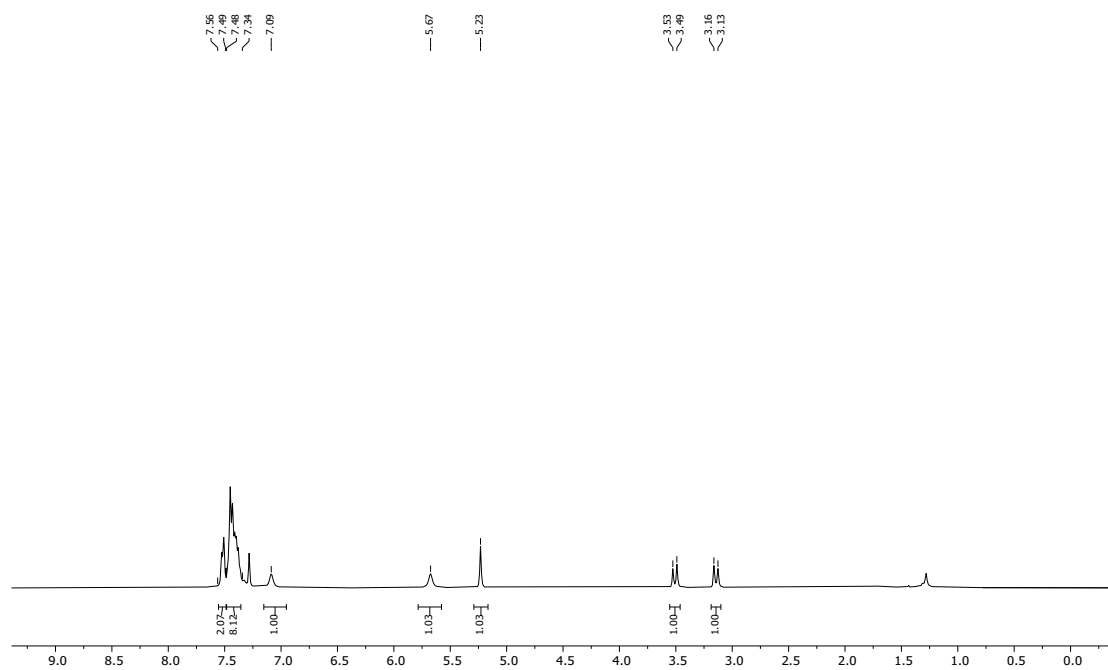
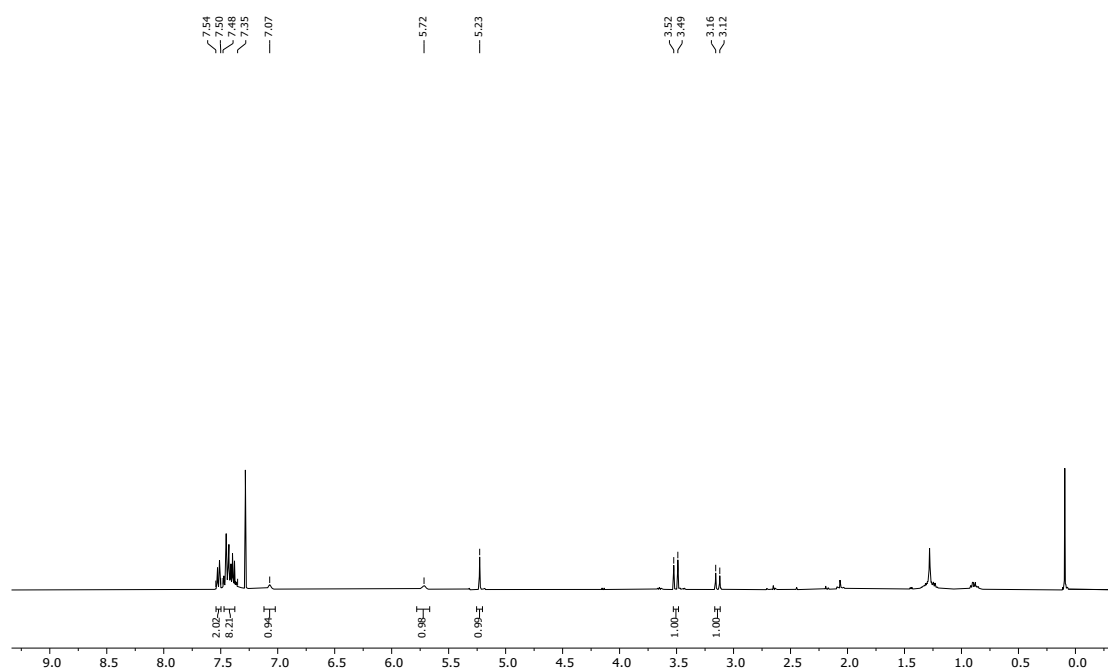
370 nm		427 nm		CFL lamps	
2 h	50 %	3 h	Decomposition	18 h	Decomposition

**Purification Procedure A:** Column Chromatography. Eluent: Dichloromethane / Ethyl acetate 8:2.

**Purification Procedure B:** Liquid-Liquid Extraction. The reaction was performed according to the general procedure for the 370 nm protocol. The reaction mixture was evaporated until dry. The residual mass was dissolved in a mixture of water/ethanol (9:1) (2 mL). The aqueous solution was washed with cyclohexane (2 mL) and ethyl acetate (2 x 2 mL). The ethyl acetate layers were combined and dried over Na<sub>2</sub>SO<sub>4</sub>. Filtration and evaporation until dry afforded 68 mg of compound **9**. Yield: **50 %**.

White solid; m.p.: 165-167 °C; NMR data in accordance with reported literature.<sup>22</sup> **<sup>1</sup>H-NMR** (400 MHz, CDCl<sub>3</sub>)  $\delta$ : 7.56-7.49 (2H, m, ArH), 7.48-7.34 (8H, m, ArH), 7.09 (1H, br s, NHH), 5.67 (1H, br s, NHH), 5.23 (1H, s, CH), 3.51 (1H, d,  $J = 14.4$  Hz, CHH), 3.14 (1H, d,  $J = 14.4$  Hz, CHH); **<sup>13</sup>C-NMR** (100 MHz, CDCl<sub>3</sub>)  $\delta$ : 166.1, 134.3, 134.1, 129.5, 129.4, 129.0, 128.9, 128.8, 128.7, 71.6, 51.4; **ESI-MS** [M+H<sup>+</sup>]: 274 m/z.

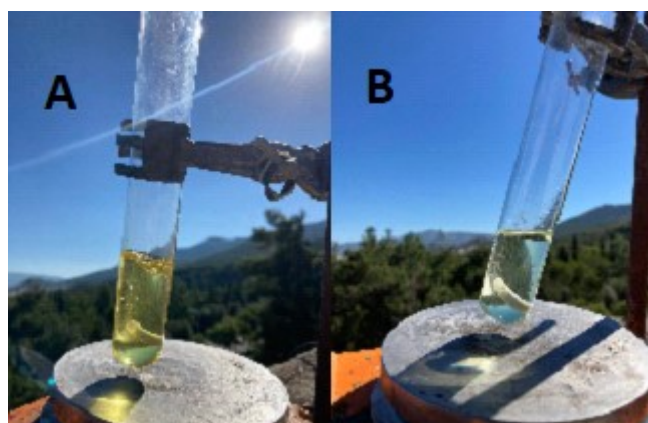


**$^1\text{H-NMR}$  (400 MHz,  $\text{CDCl}_3$ ) of 9 after column chromatography** **$^1\text{H-NMR}$  (400 MHz,  $\text{CDCl}_3$ ) of 9 after liquid-liquid extraction from the reaction mixture**

## Large Scale Photochemical Aerobic Oxidation of Sulfides

### General procedure for the 1-gram scale photochemical aerobic oxidation of sulfides under sunlight

In a test tube containing PhSMe (1.00 g, 1.0 eq., 8.00 mmol) and anthraquinone (0.5 mol%, 0.04 mmol, 8.5 mg) in 2-Me-THF (30 mL), water (1 mL) was added. The reaction mixture was left stirring under sunlight (June 25, 2022, 09:00-17:00, Athens Greece, 37.97° N. 23.72° E, temperature range 28 – 35 °C), for 8 h. The desired product was purified by column chromatography (Pet. Ether/AcOEt: 6:4) to afford 921 mg. Yield **82 %**.

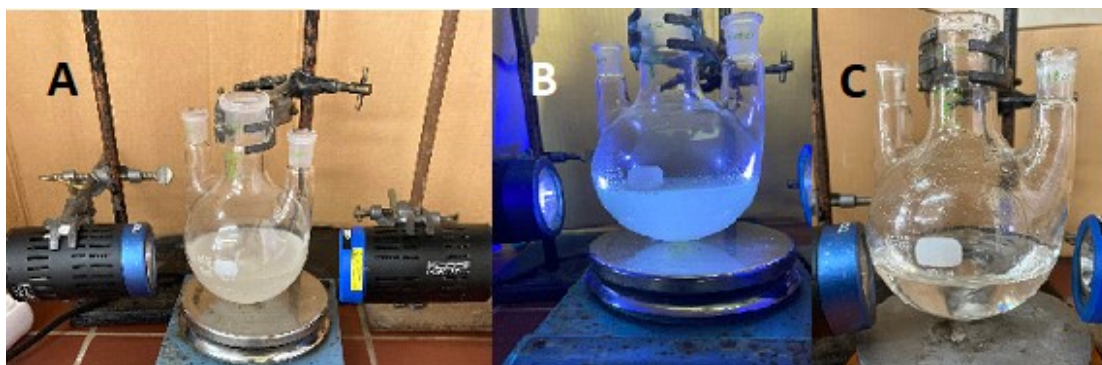


**A)** Reaction mixture at the onset of the reaction; **B)** Reaction mixture upon sunlight irradiation.

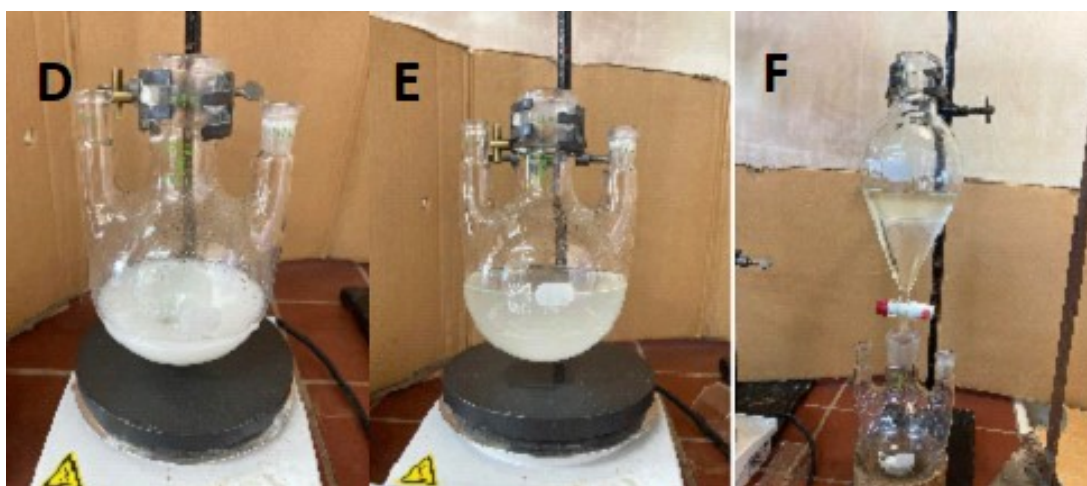
### General procedure for the 10-gram scale photochemical aerobic oxidation of sulfides under 370 nm UVA LED irradiation

In a 250 mL 3-necked round bottom flask containing PhSMe (10.0 g, 1.0 eq., 80.00 mmol) in 2-Me-THF (160 mL), water (16 mL) was added. The reaction mixture was left stirring under UVA LED (Kessil PR 160L, 370 nm, 2 x 45 W) irradiation for 13 h. The reaction mixture was evaporated until dry. The residual mass was dissolved in a mixture of water/ethanol (9:1) (100 mL). The aqueous solution was washed with

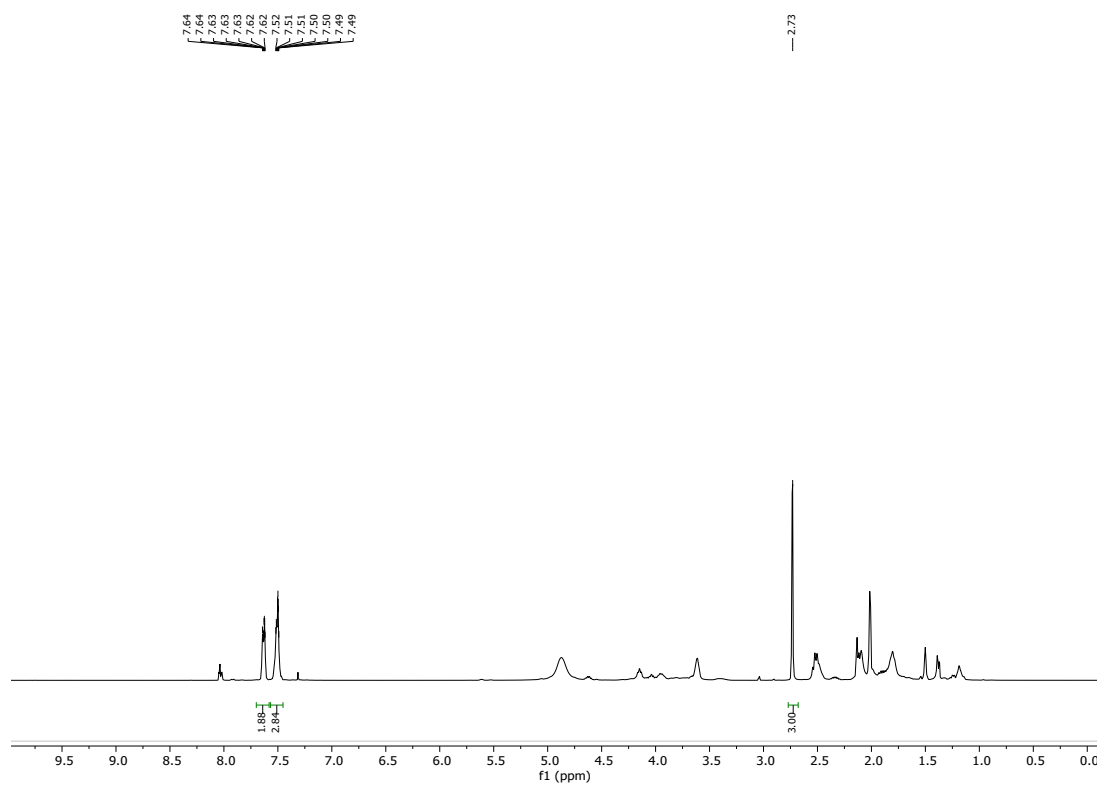
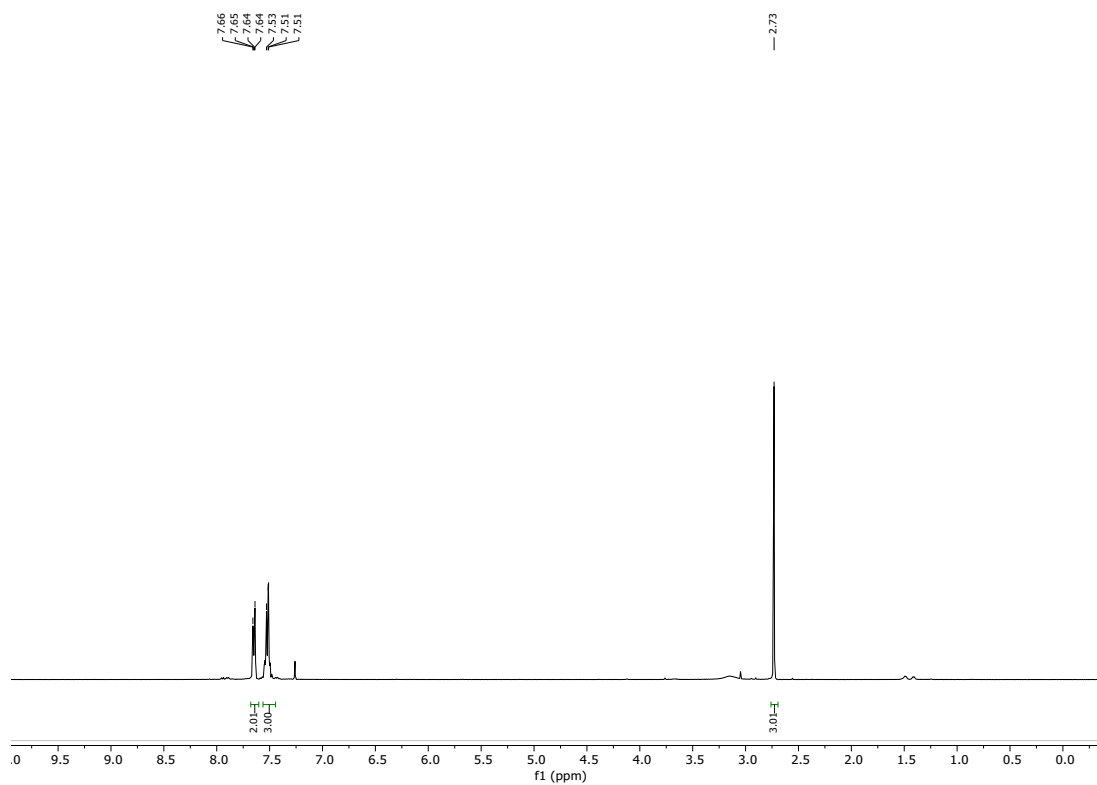
cyclohexane (50 mL) and ethyl acetate (2 x 100 mL). The ethyl acetate layers were combined and dried over Na<sub>2</sub>SO<sub>4</sub>. Filtration and evaporation until dry afforded 9.1 g of compound **2a**. Yield: **81 %**. The desired product was purified by column chromatography (Pet. Ether/AcOEt: 6:4).



**A)** Reaction mixture at the onset of the reaction; **B)** Reaction mixture upon UVA LED 2 x 370 nm irradiation; **C)** Reaction mixture upon reaction completion.



**D)** Crude reaction mixture diluted in a mixture of water/ethanol (9:1); **E)** Extraction with ethyl acetate; **F)** Separation of organic layer in the final extraction.

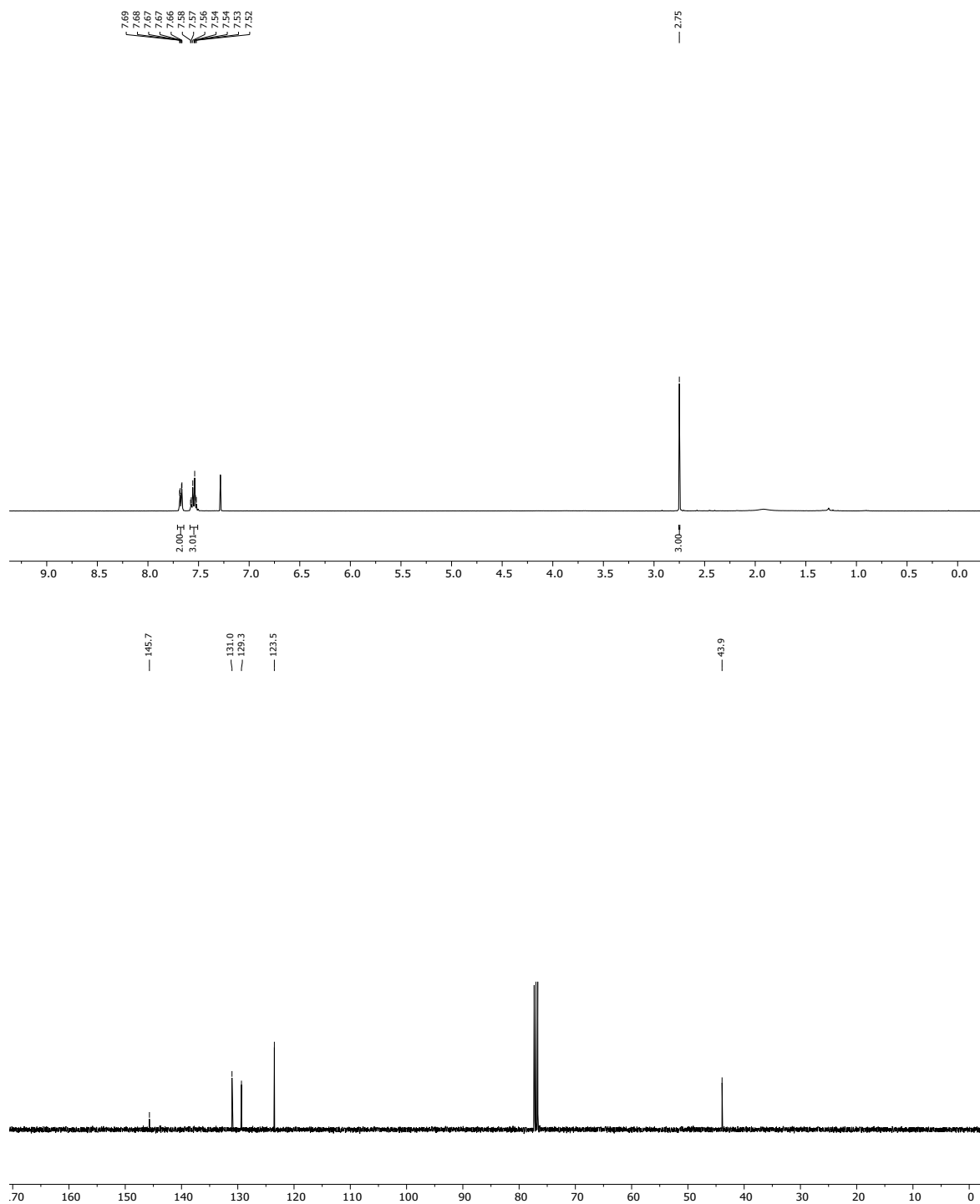
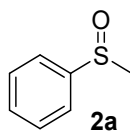
**$^1\text{H-NMR}$  (400 MHz,  $\text{CDCl}_3$ ) of 2a after liquid-liquid extraction from the reaction mixture** **$^1\text{H-NMR}$  (400 MHz,  $\text{CDCl}_3$ ) of 2a after column chromatography**

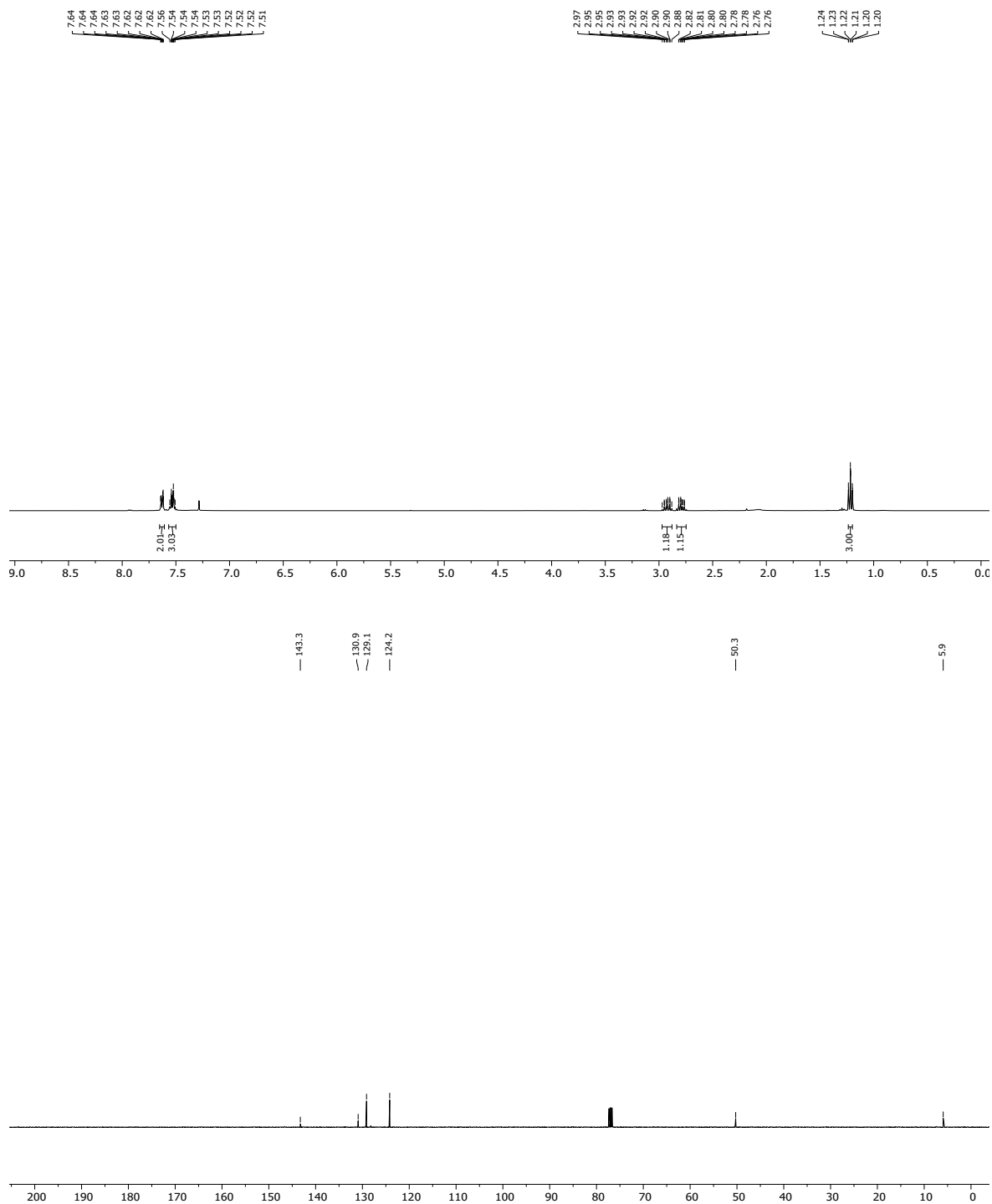
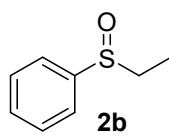
## References

1. E. Voutyritsa, I. Triantafillidi, C. G. Kokotos, *Synthesis*, **2017**, *49*, 917-924.
2. B. Pieber, T. S. Martinez, D. Cantillo, O. C. Kappe, *Angew. Chem. Int. Ed.* **2013**, *52*, 10241-10244.
3. M. Petsi, A. L. Zografos, *ACS Catal.*, **2020**, *10*, 7093-7099.
4. B. Du, B. Jin, P. Sun, *Org. Lett.*, **2014**, *16*, 3032-3035.
5. H. Leicht, I. Göttker-Schnetmann, S. Mecking, *J. Am. Chem. Soc.*, **2017**, *139*, 6823-6826.
6. P. Acosta-Guzmán, C. Mahecha-Mahecha, D. Gamba-Sánchez, *Chem. Eur. J.*, **2020**, *26*, 10348-10354.
7. D. Liu, T. Thomas, H. Gong, F. Li, Q. Li, L. Song, T. Azhagan, H. Jiang, M. Yang, *Org. Biomol. Chem.*, **2019**, *17*, 9367-9374.
8. Y. Zhang, Y. Li, X. Zhang, X. Jiang, *Chem. Commun.*, **2015**, *51*, 941-944.
9. B. Yu, A.-H. Liu, L.-N. He, B. Li, Z.-F. Diao, Y.-N. Li, *Green Chem.*, **2012**, *14*, 957-962.
10. S. Fujita, S. Yamaguchi, S. Yamazoe, J. Yamasaki, T. Mizugaki, T. Mitsudome, *Org. Biomol. Chem.*, **2020**, *18*, 8827-8833.
11. G. Zhao, S. Kaur, T. Wang, *Org. Lett.*, **2017**, *19*, 3291-3294.
12. X. Chen, Z. Li, X. Sun, H. Ma, X. Chen, J. Ren, K. Hu, *Synthesis*, **2011**, *24*, 3991-3996.
13. Y. Gao, H. Xu, S. Zhang, Y. Zhang, C. Tang, W. Fan, *Org. Biomol. Chem.*, **2019**, *17*, 7144-7149.
14. L. Wozniak, A. A. Rajkiewicz, L. Monsigny, A. Kajetanowicz, K. Grela, *Org. Lett.*, **2020**, *22*, 4970-4973.
15. S. Gan, J. Yin, Y. Yao, Y. Liu, D. Chang, D. Zhu, L. Shi, *Org. Biomol. Chem.*, **2017**, *15*, 2647-2654.
16. S. C. Davidson, G. P. Gomes, L. R. Kuhn, I. V. Alabugin, A. R. Kennedy, N. C. O. Tomkinson, *Tetrahedron*, **2021**, *78*, 131784-131793.
17. J. N. Moorthy, N. Singhal, K. Senapati, *Tetrahedron Lett.*, **2008**, *49*, 80-84.
18. J. J. A. G. Kamps, R. Belle, J. Mecinovic, *Org. Biomol. Chem.*, **2013**, *11*, 1103-1108.

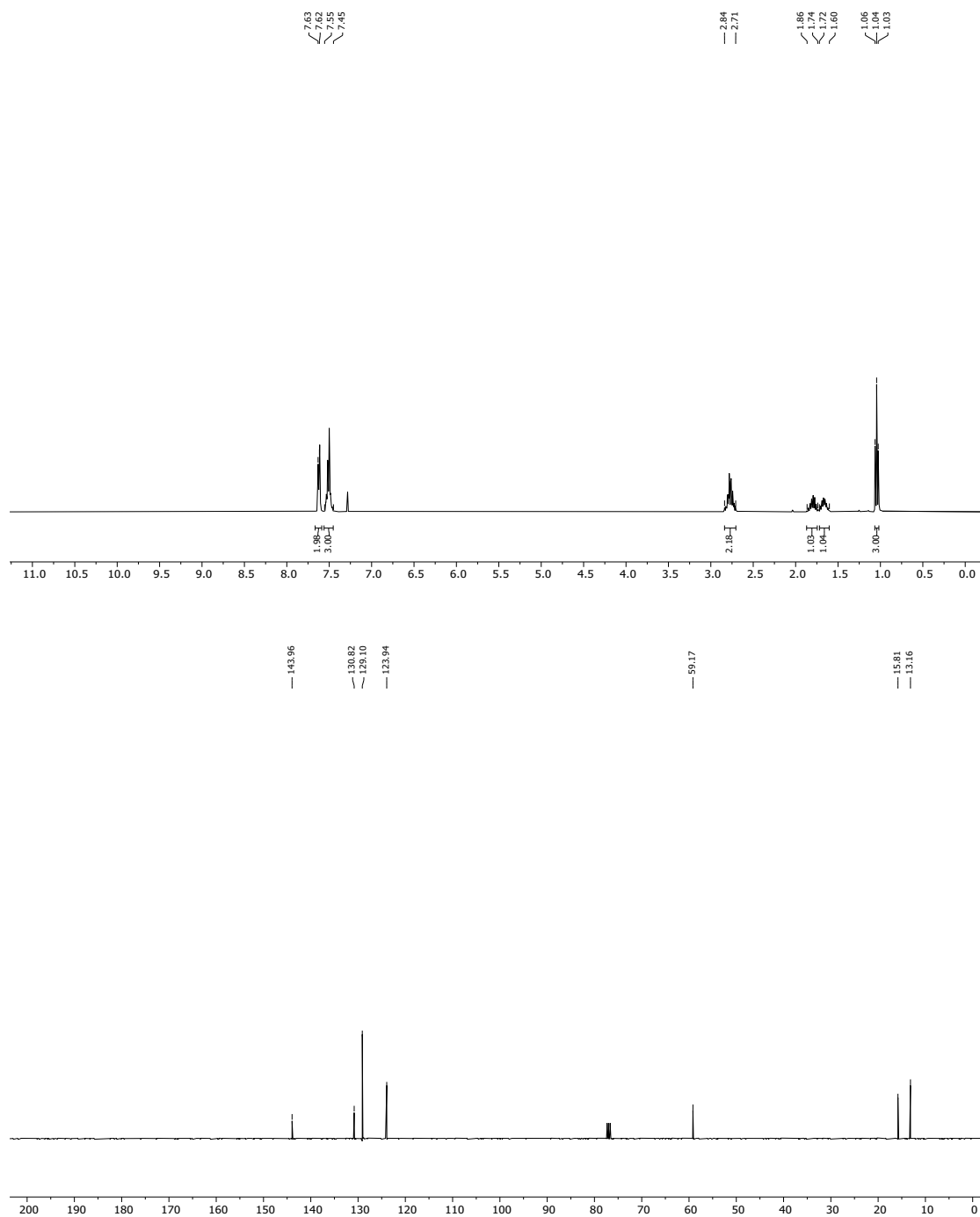
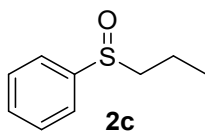
19. X. Gu, X. Li, Y. Chai, Q. Yang, P. Li, Y. Yao, *Green Chem.*, **2013**, *15*, 357-361.
20. C. A. Dannenberg, L. Fritze, F. Krauskopf, C. Bolm, *Org. Biomol. Chem.*, **2017**, *15*, 1086-1090.
21. R. Aydi, M. Kammoun, *Synth. Commun.*, **2016**, *46*, 134-144.
22. T. Prisinzano, J. Podobinski, K. Tidgewell, M. Luo, D. Swenson, *Tetrahedron: Asymmetry*, **2004**, *15*, 1053-1058.

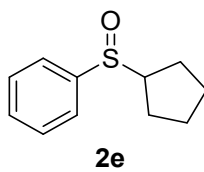
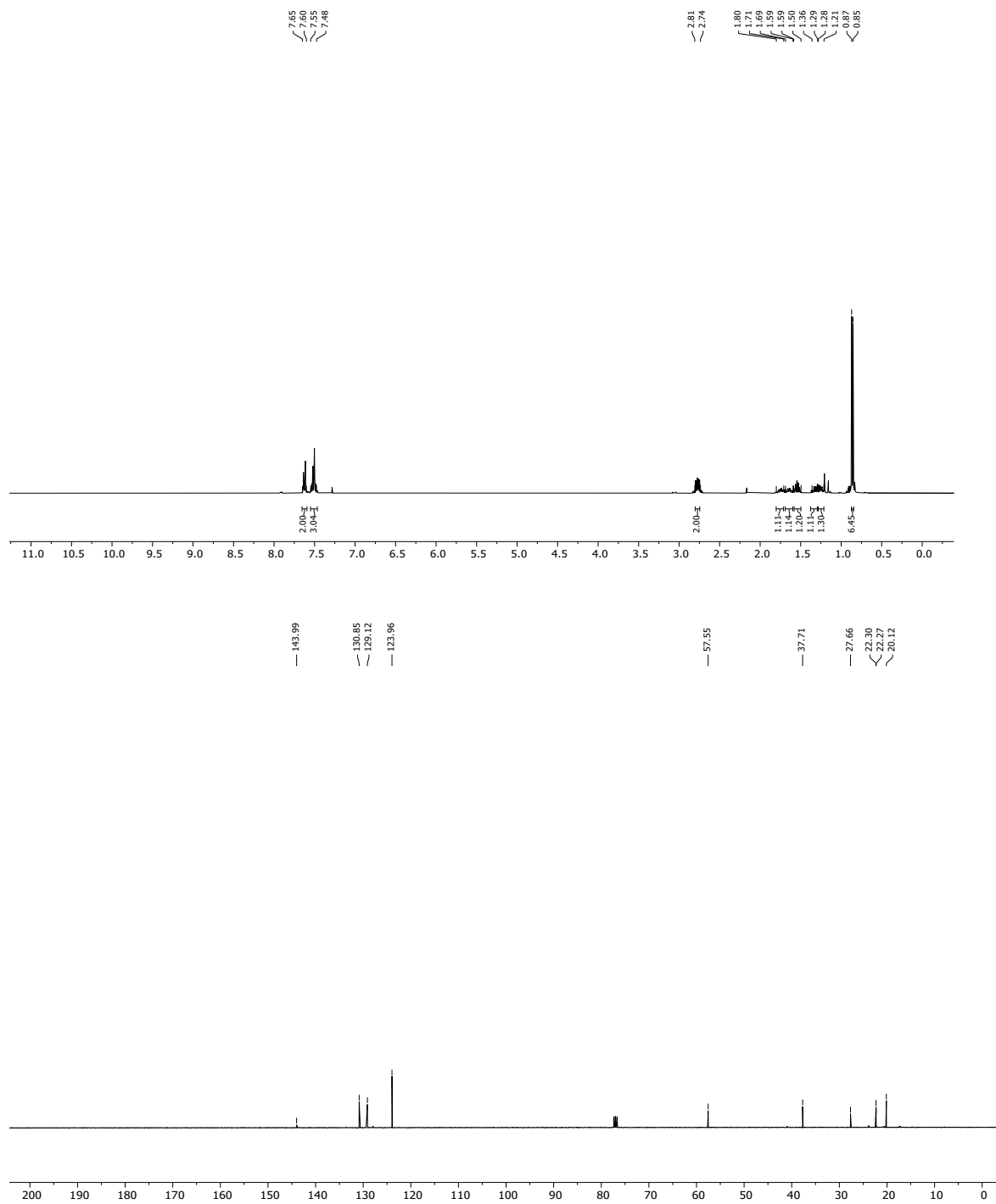
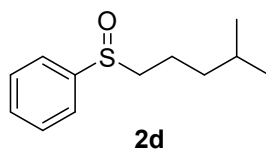
## NMR Spectra

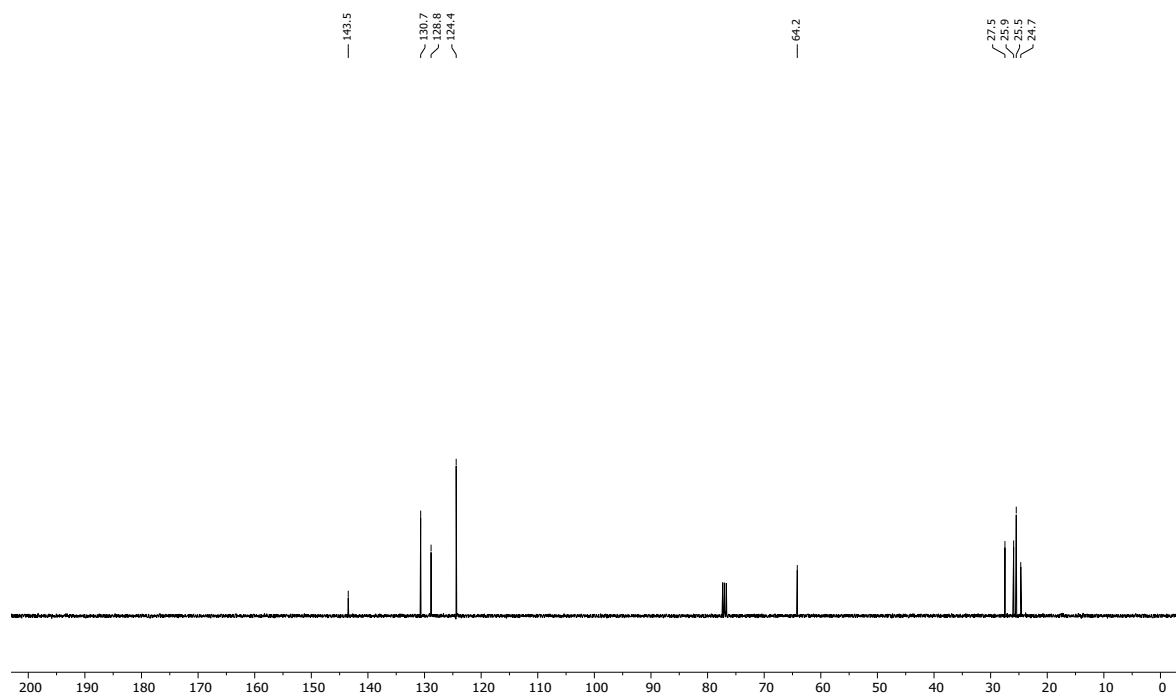
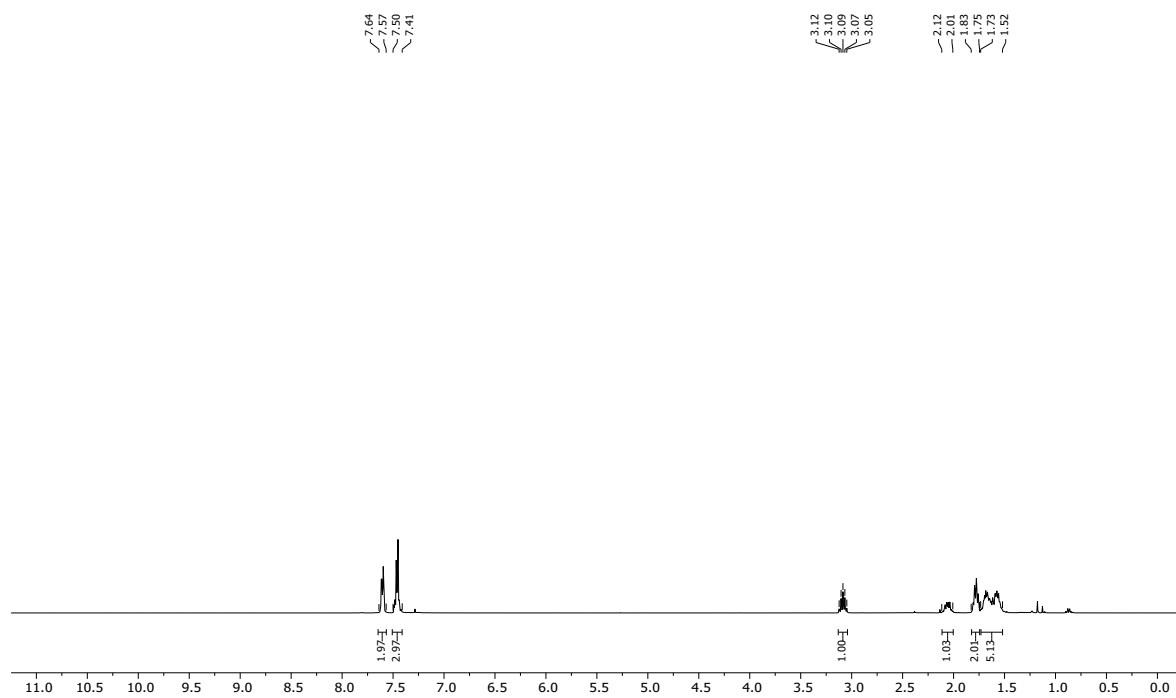


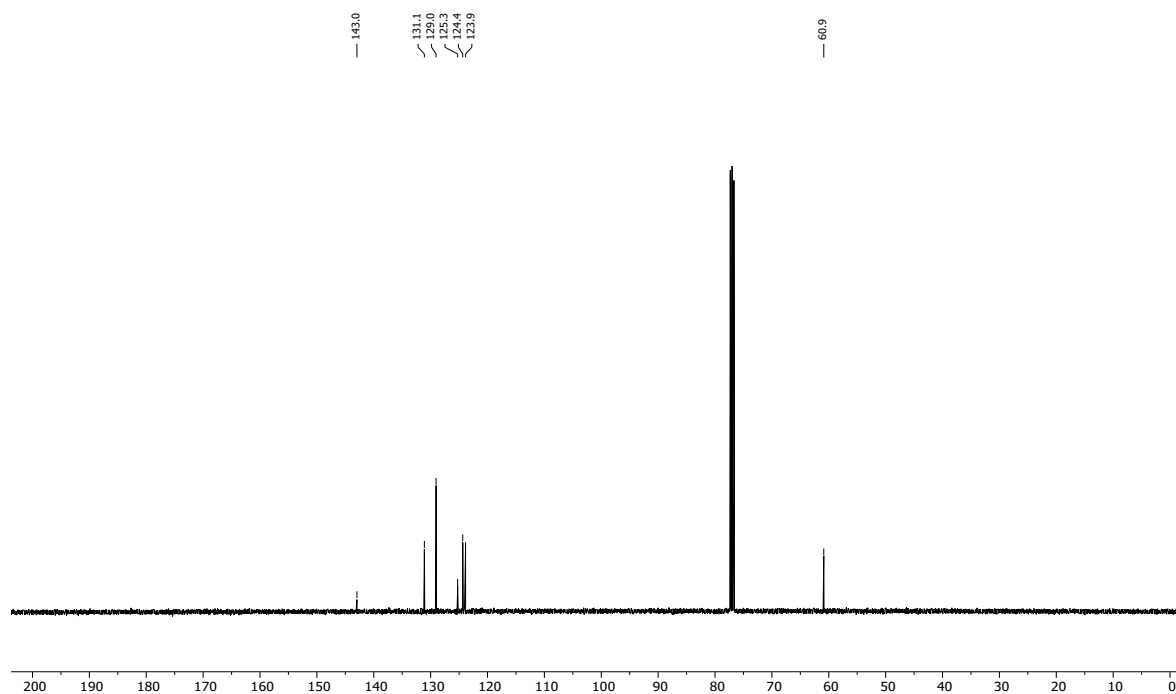
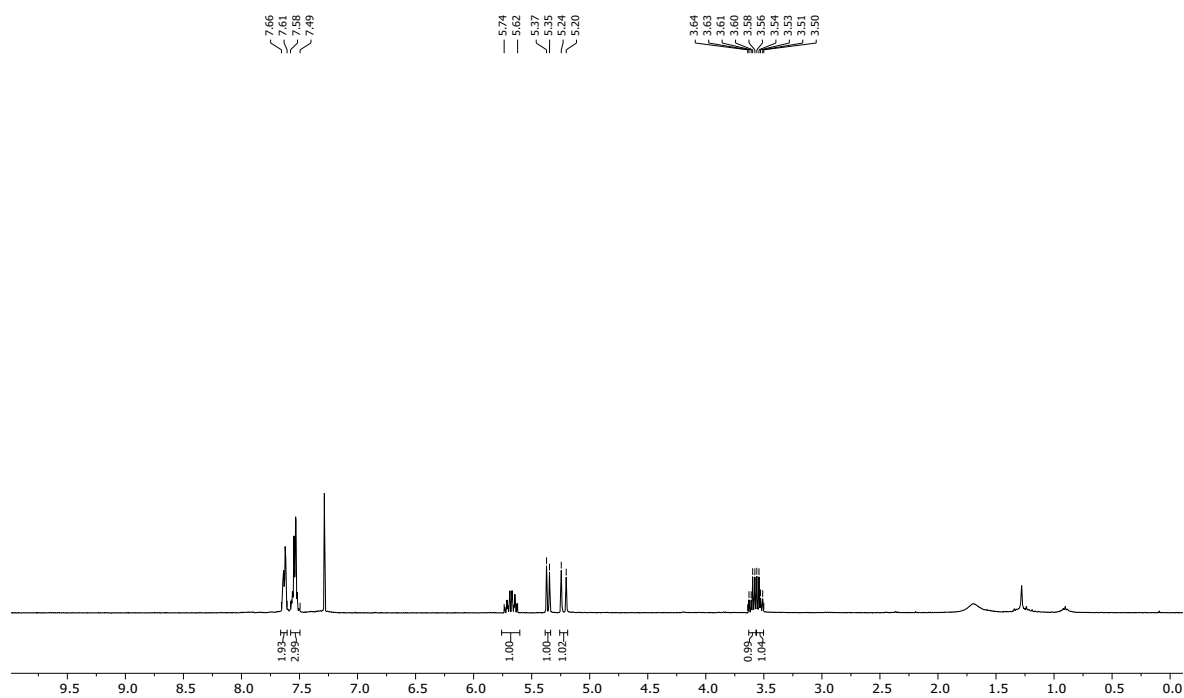
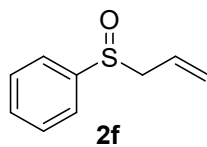


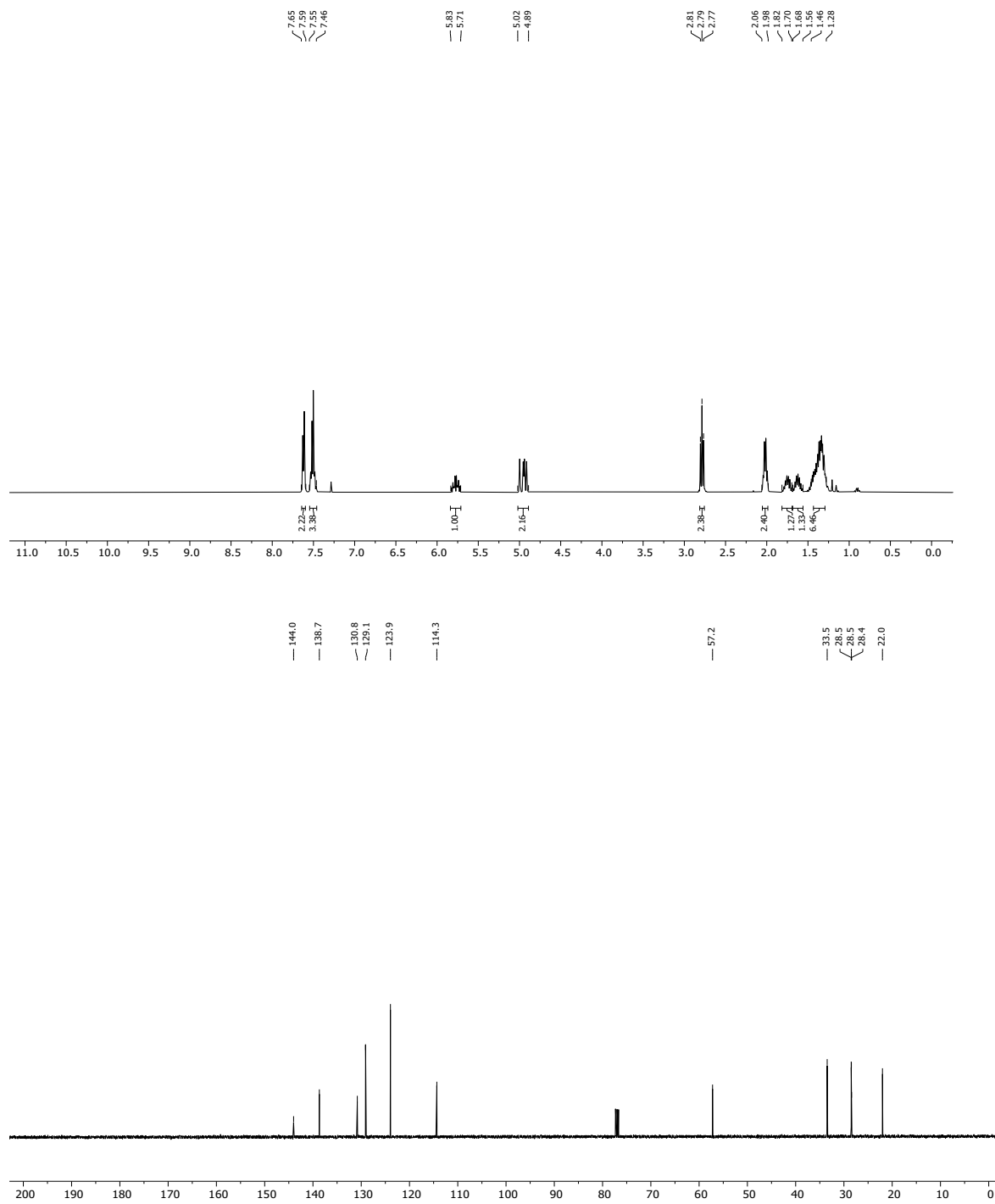
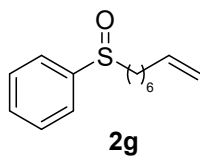


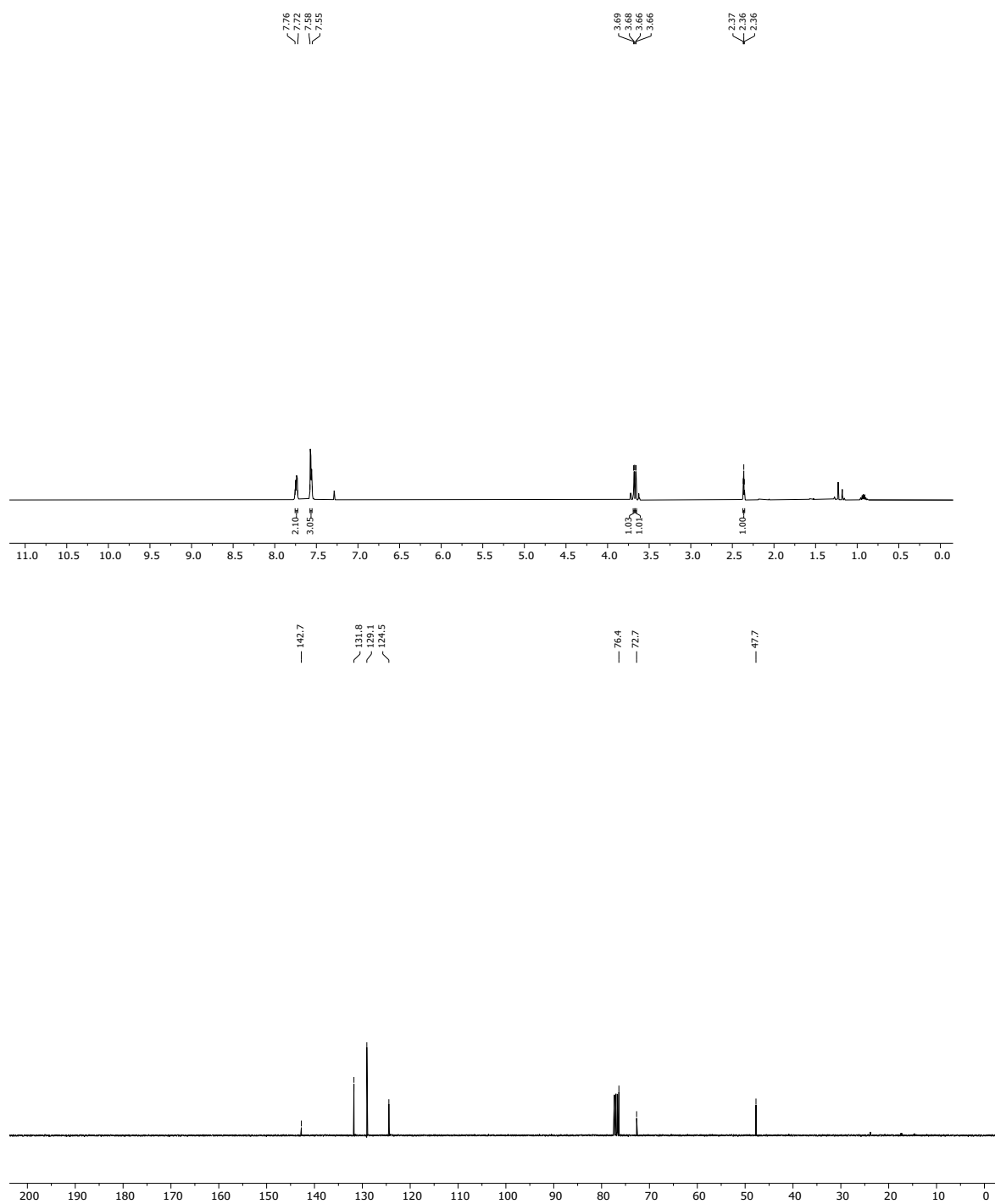
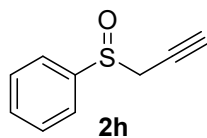


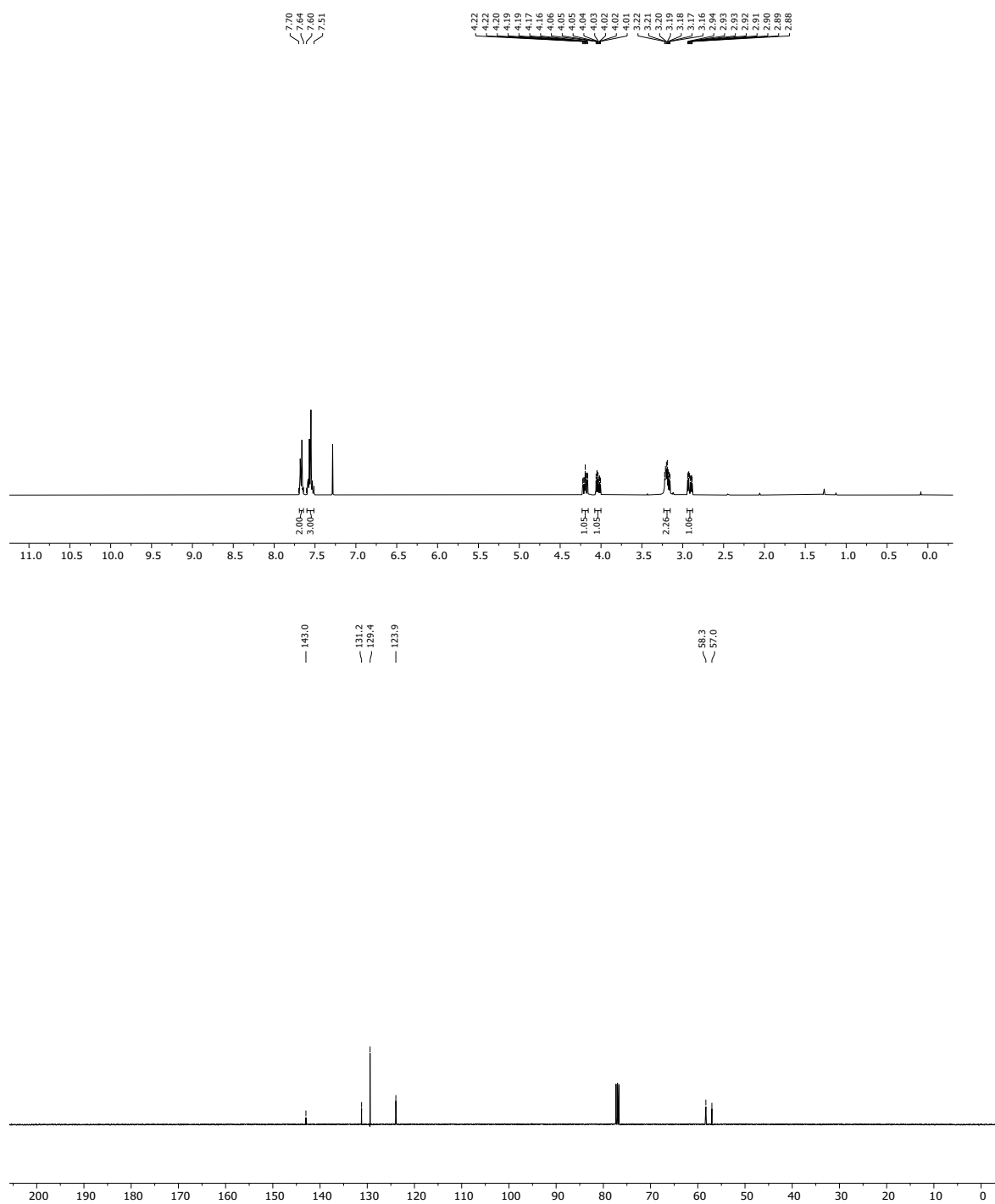
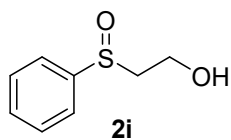


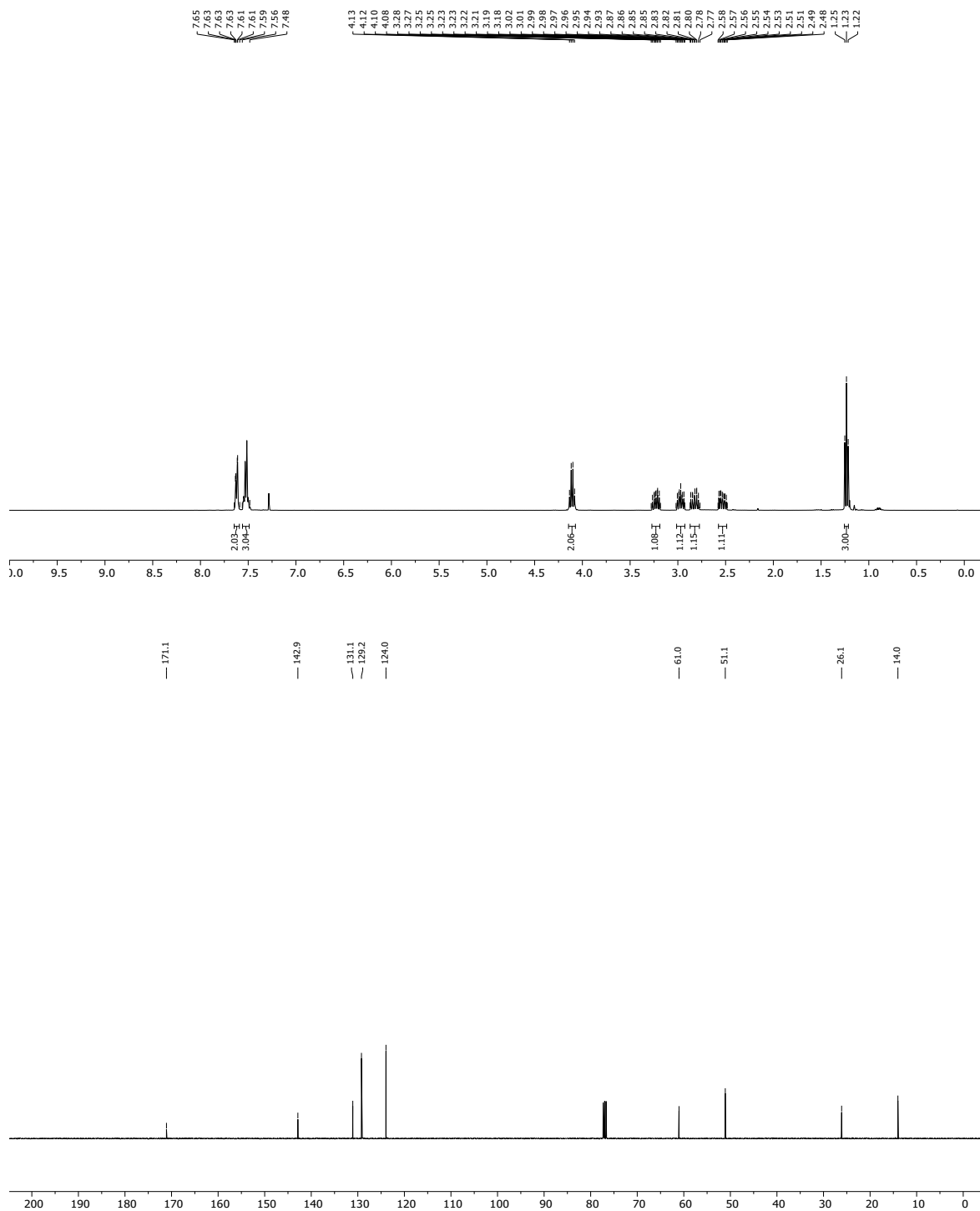
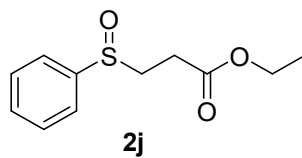




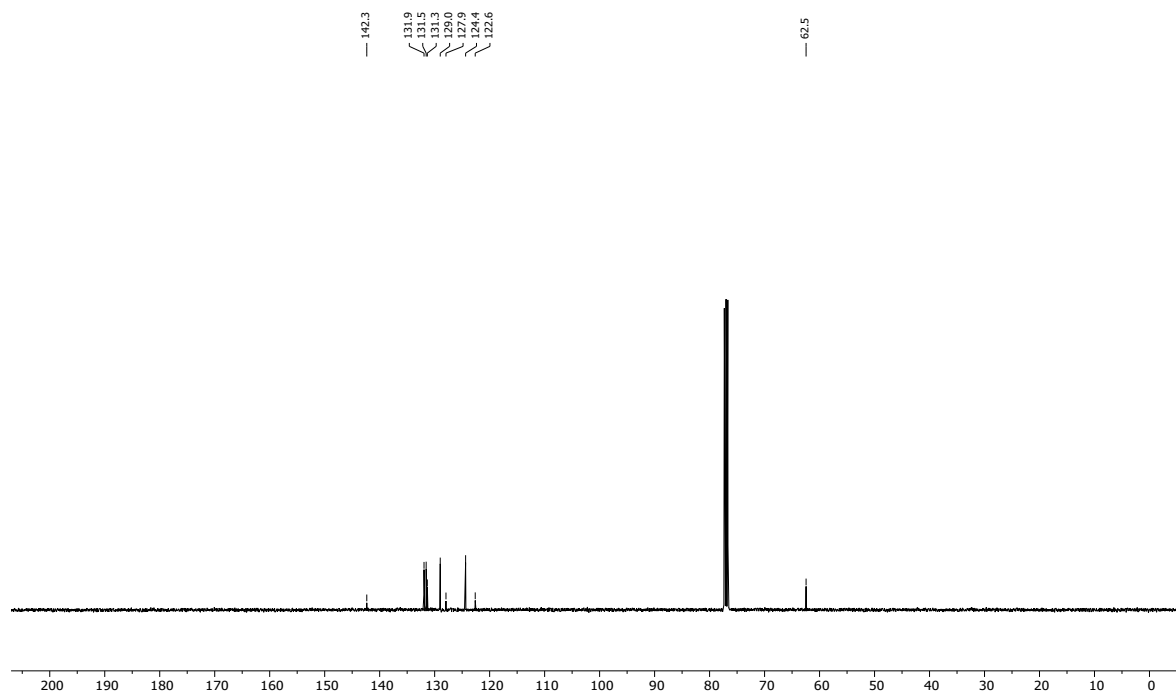
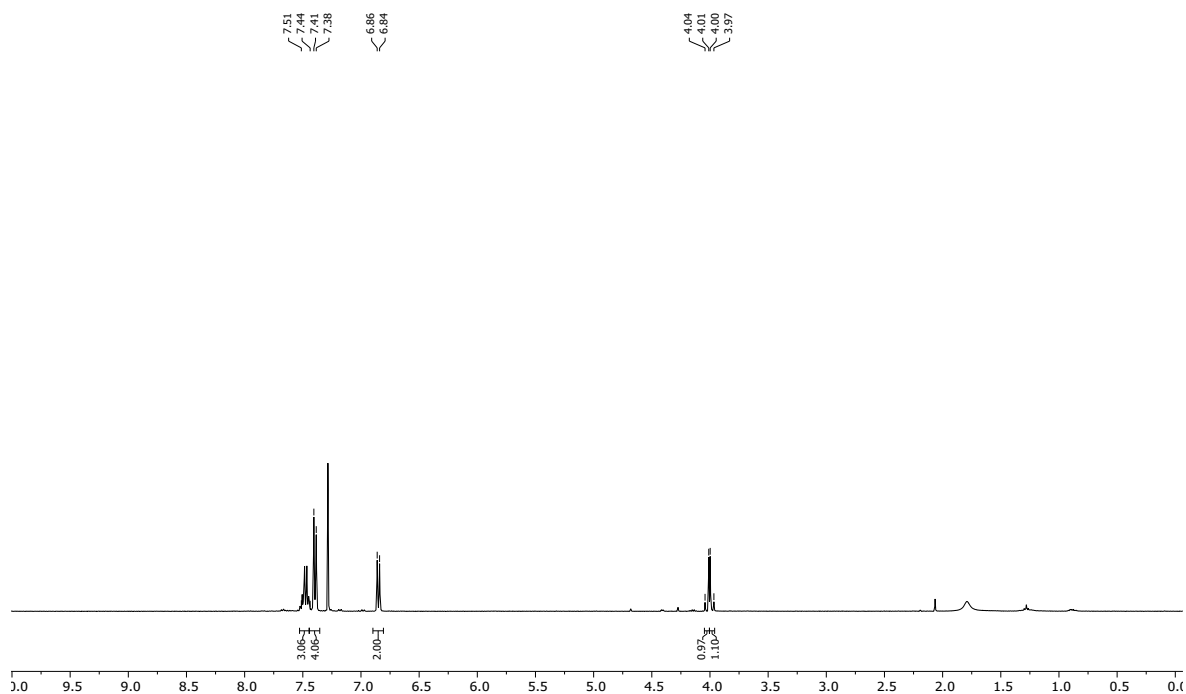
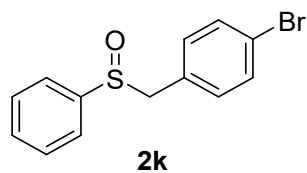


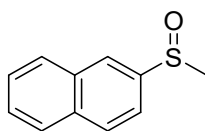
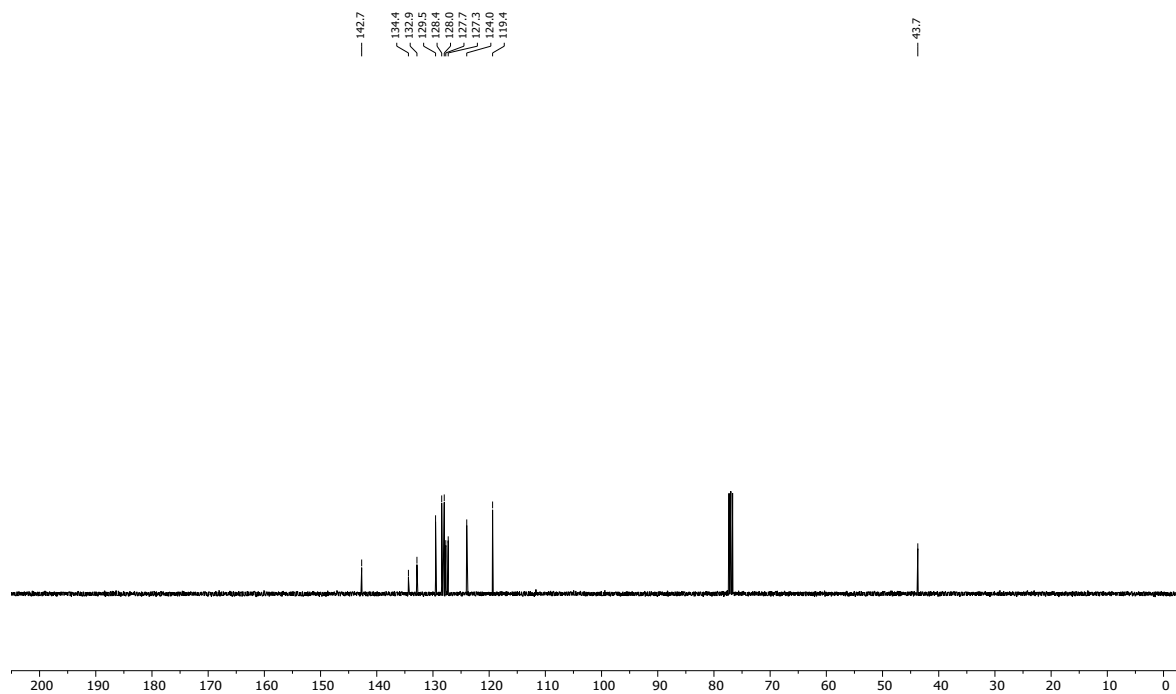
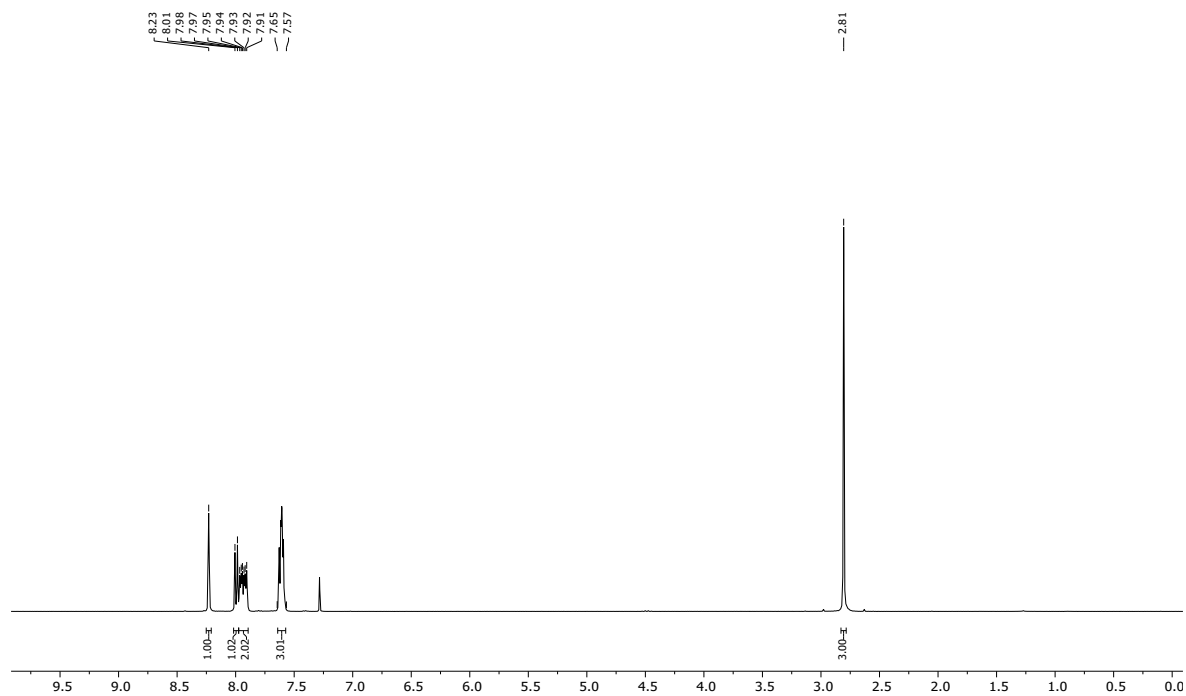


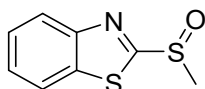
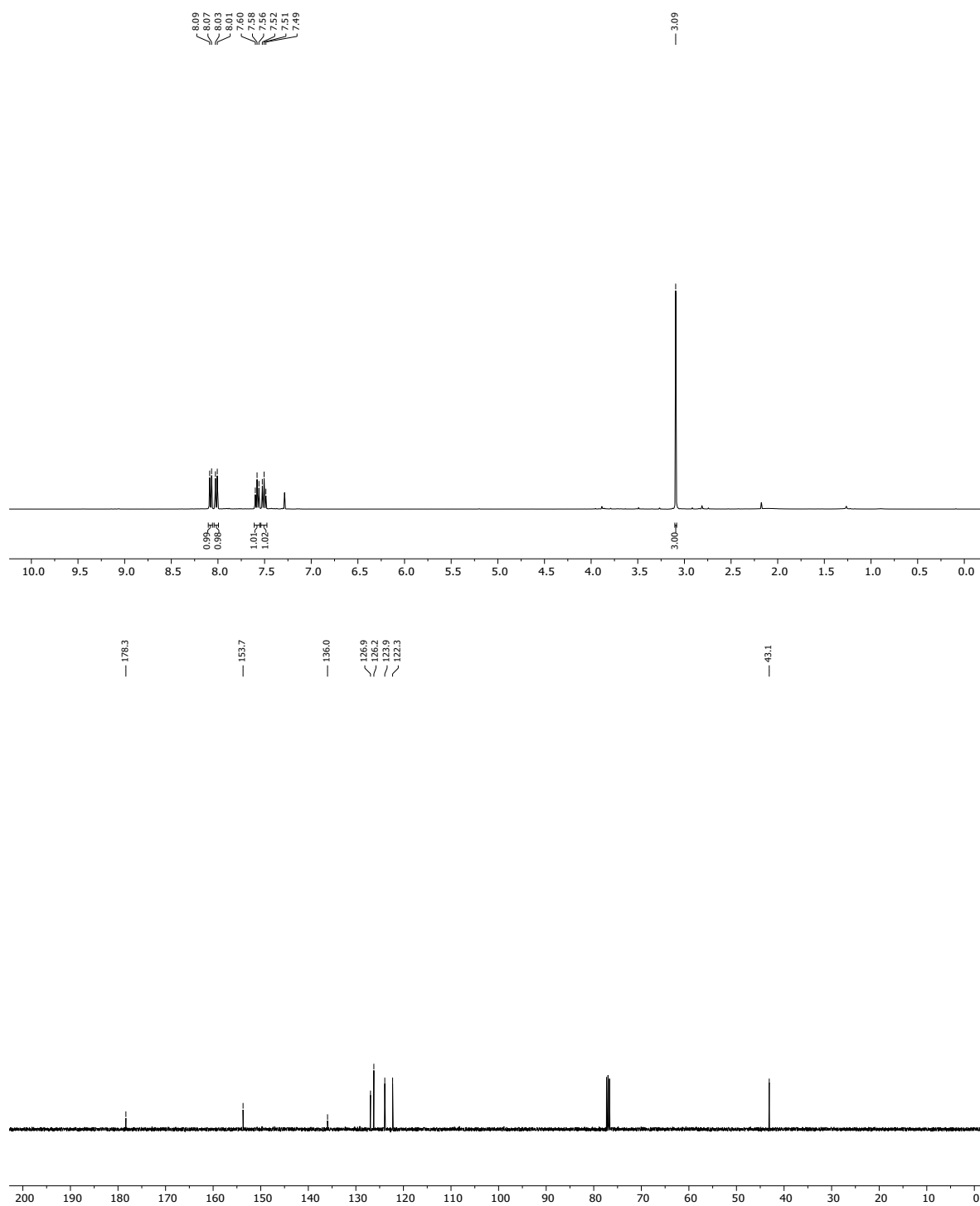


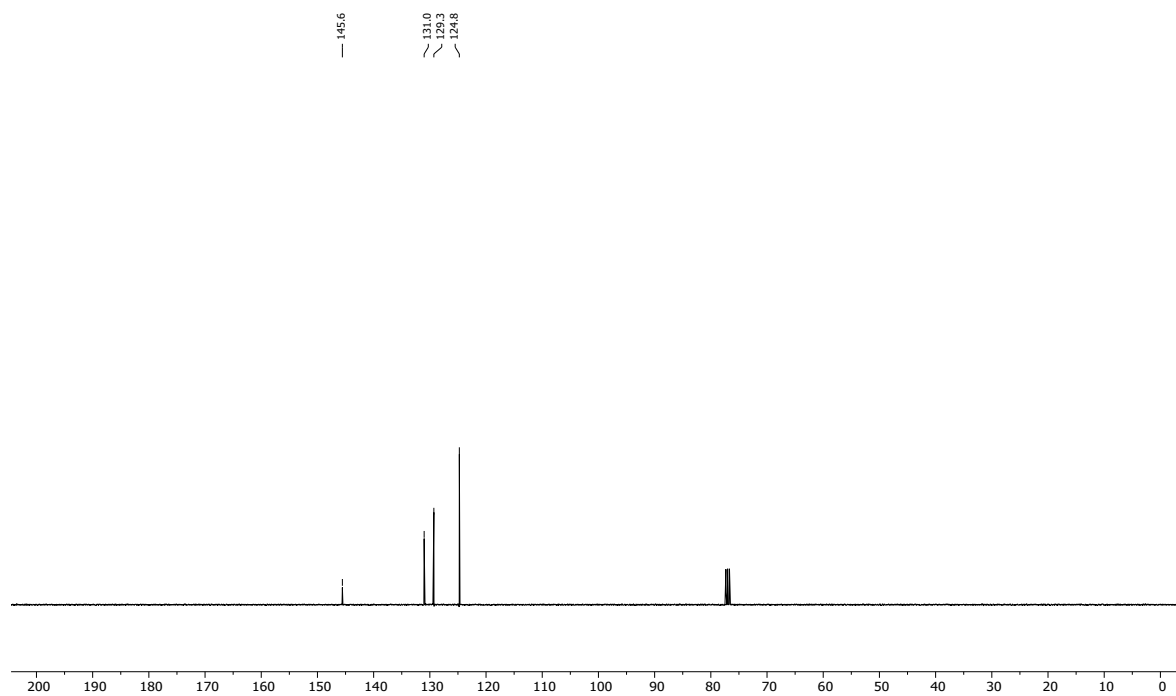
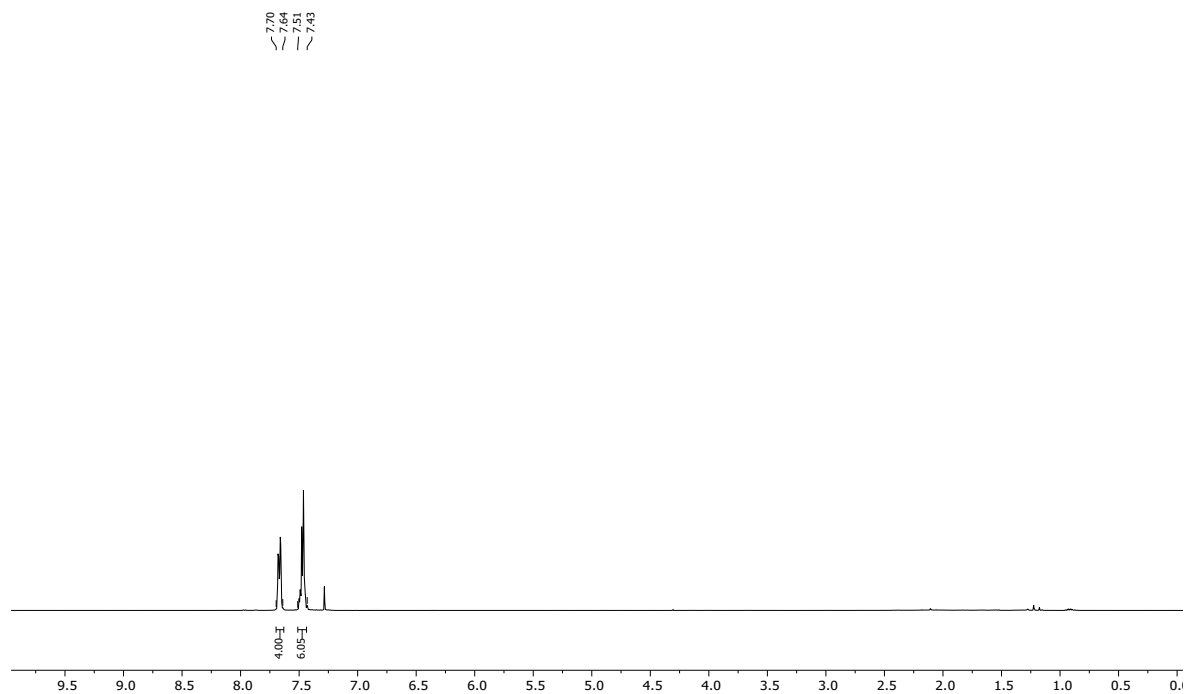
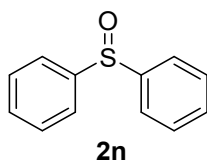


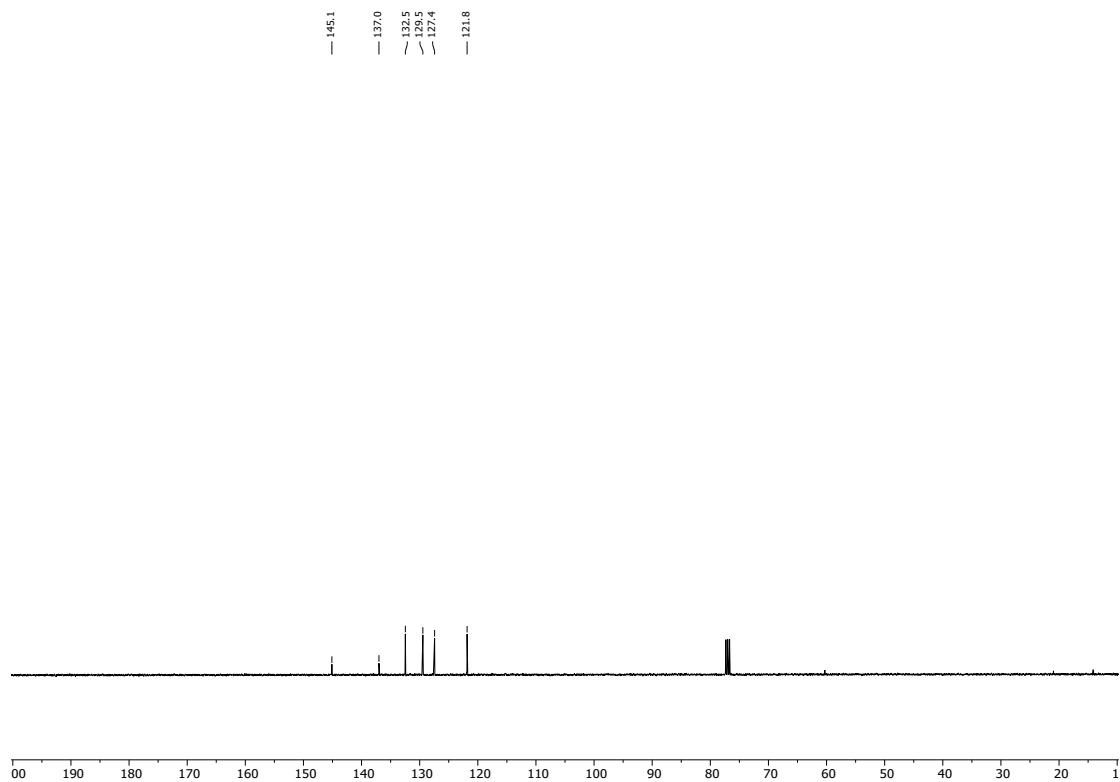
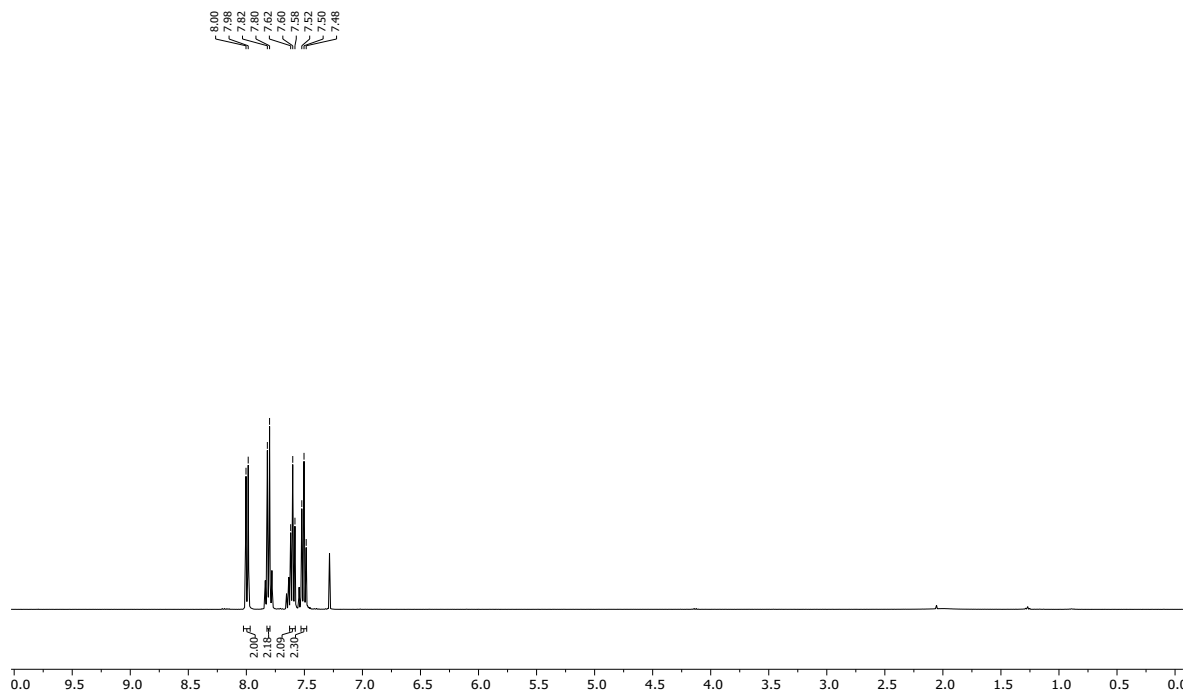
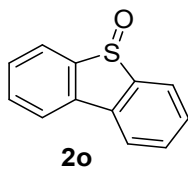


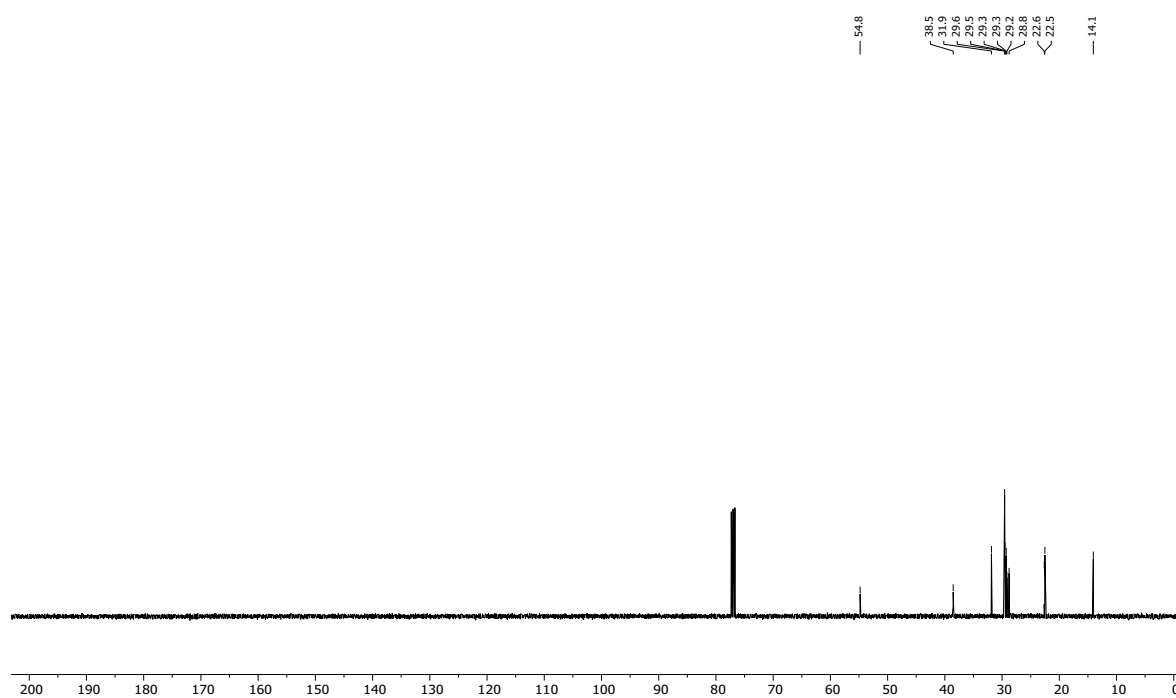
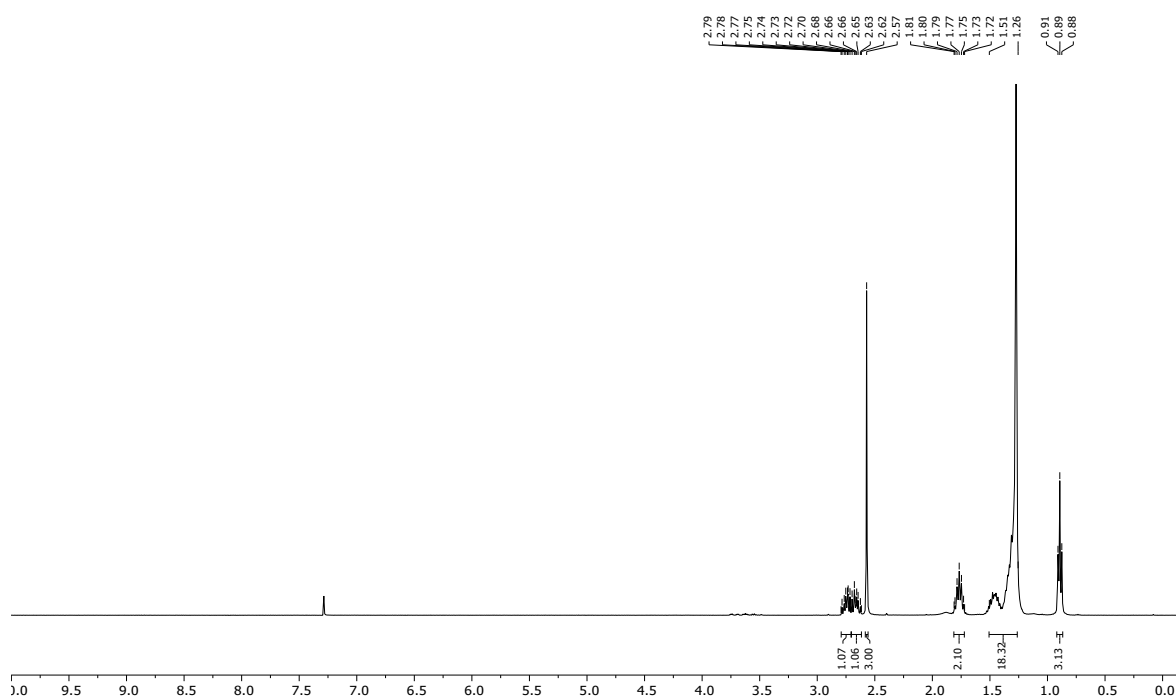
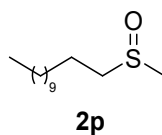


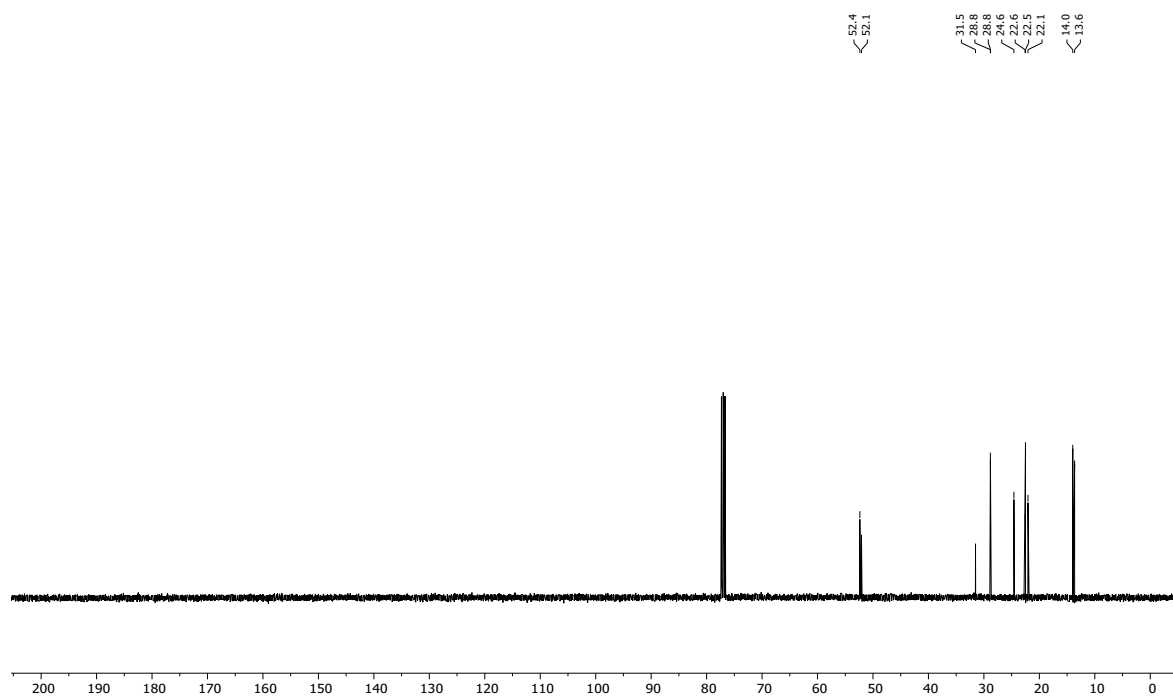
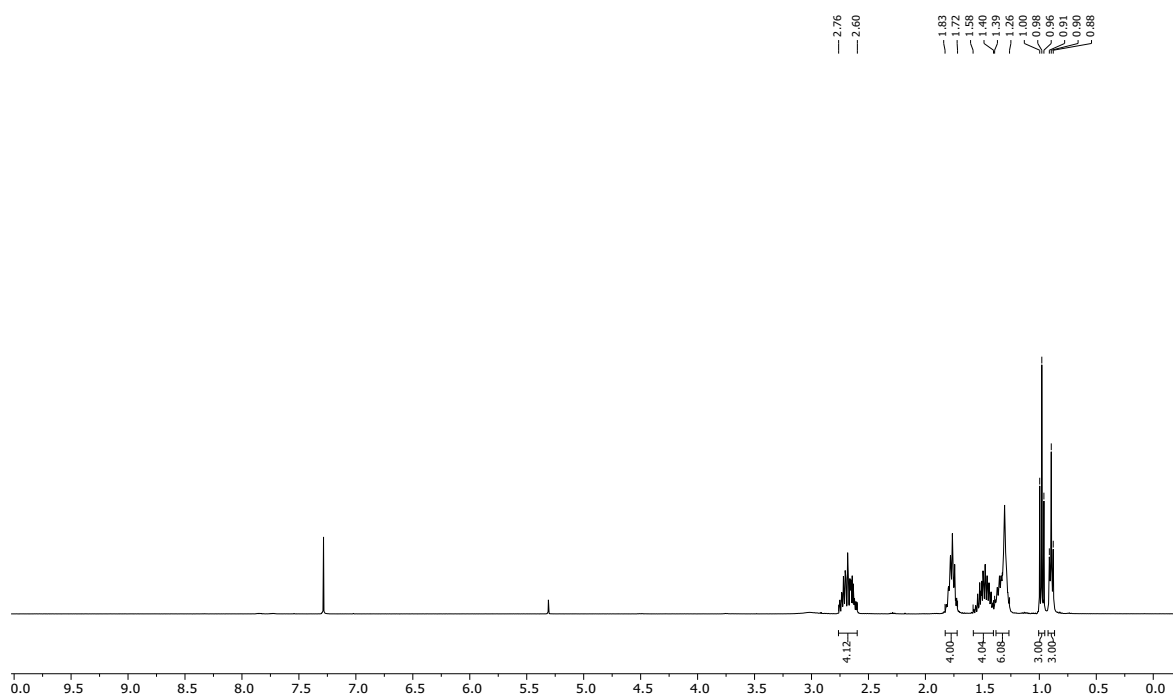
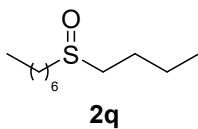
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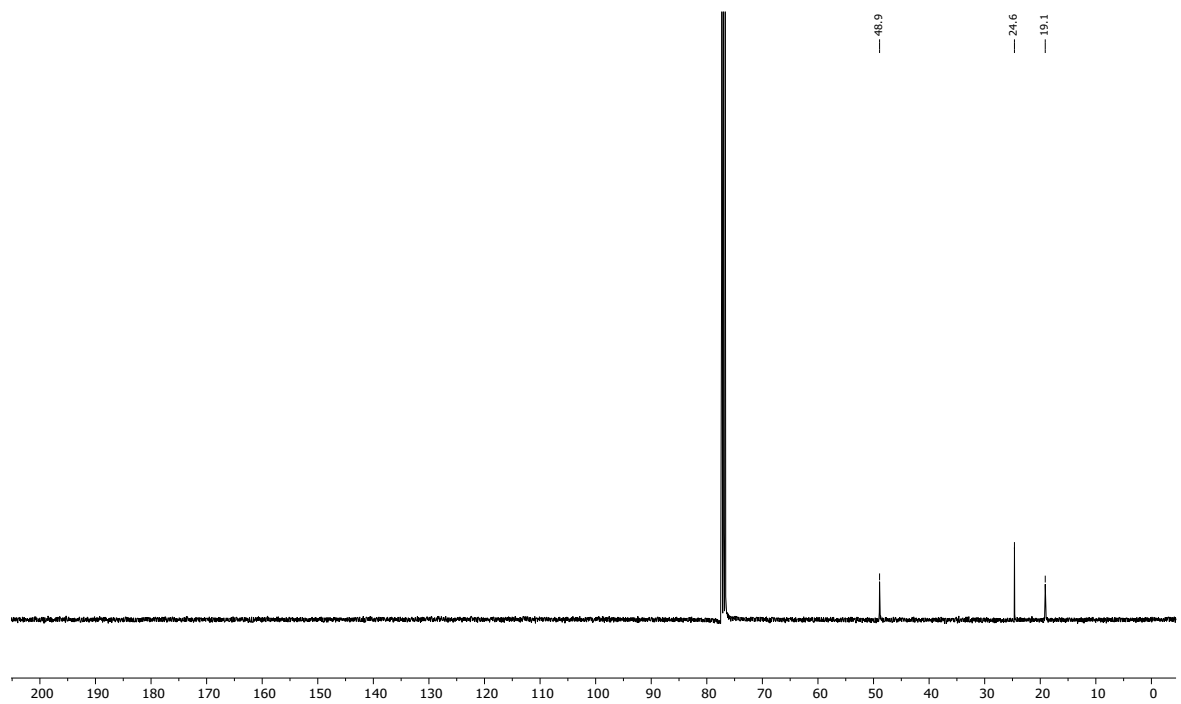
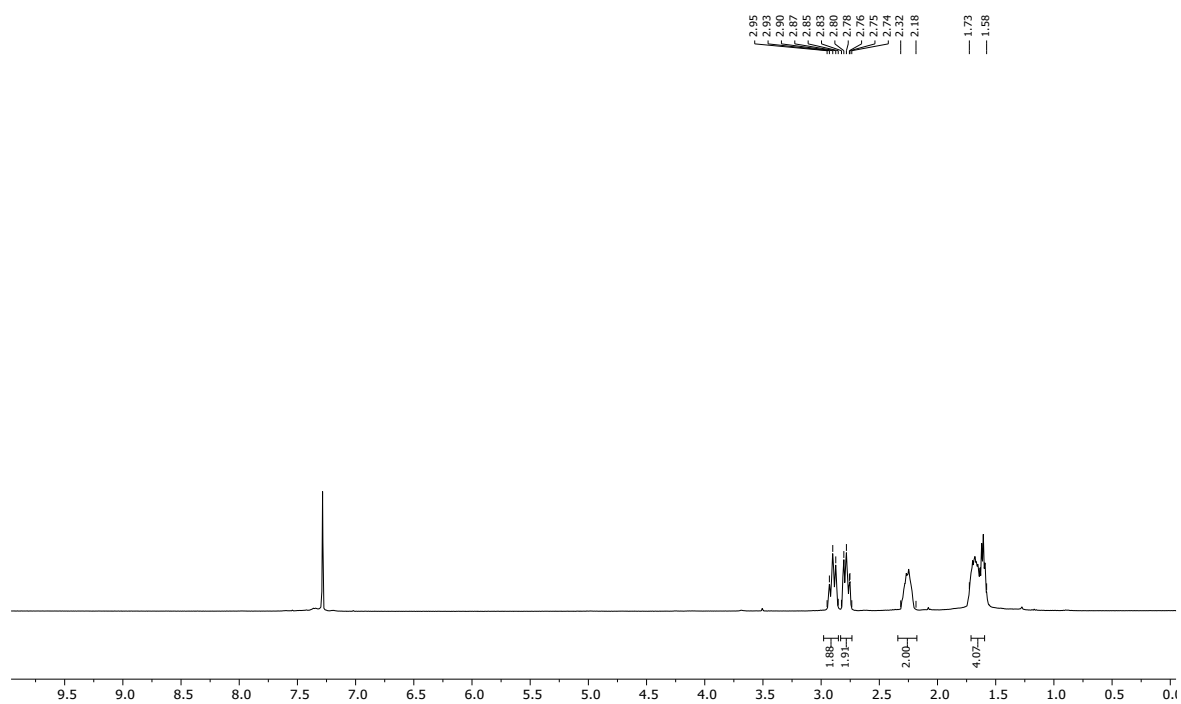
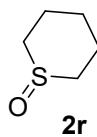
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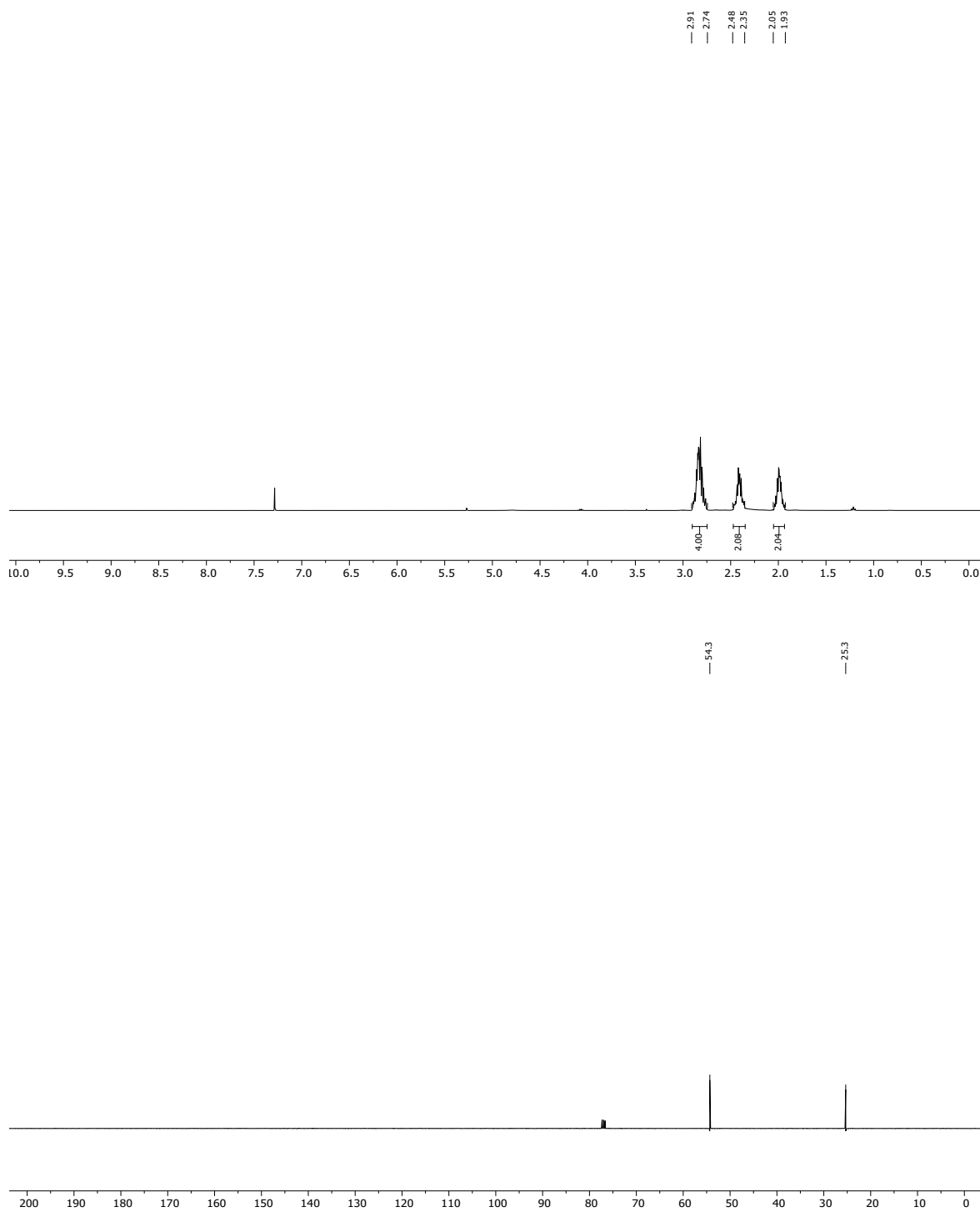
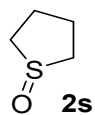


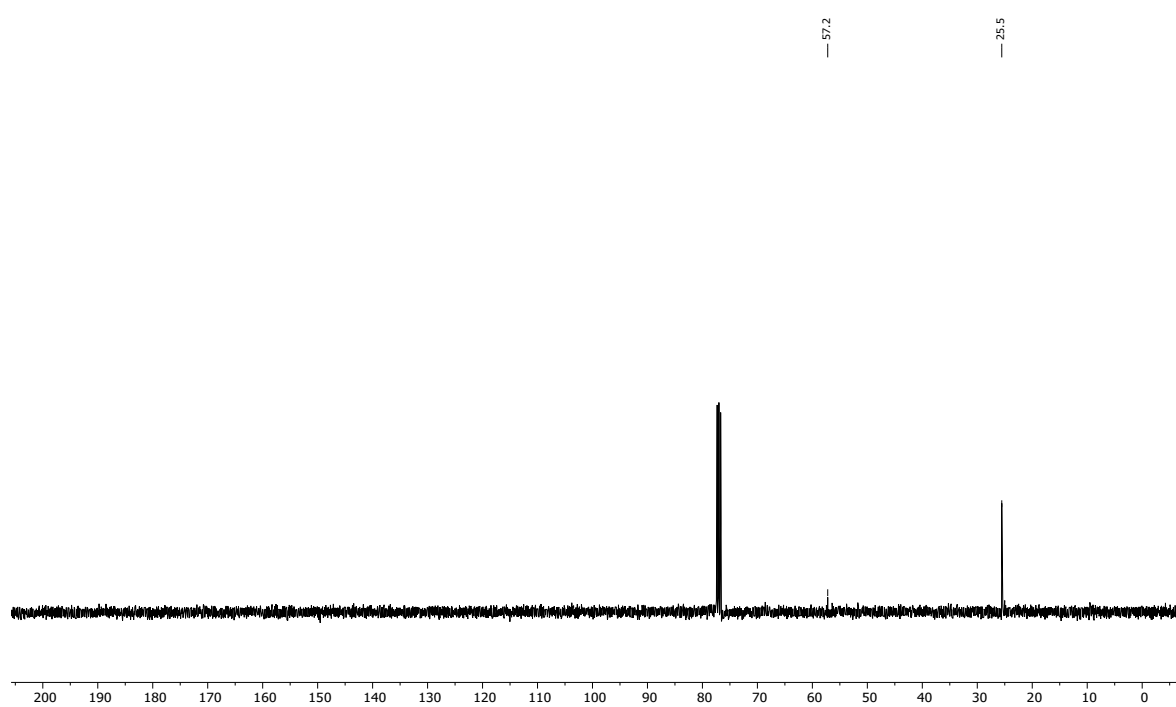
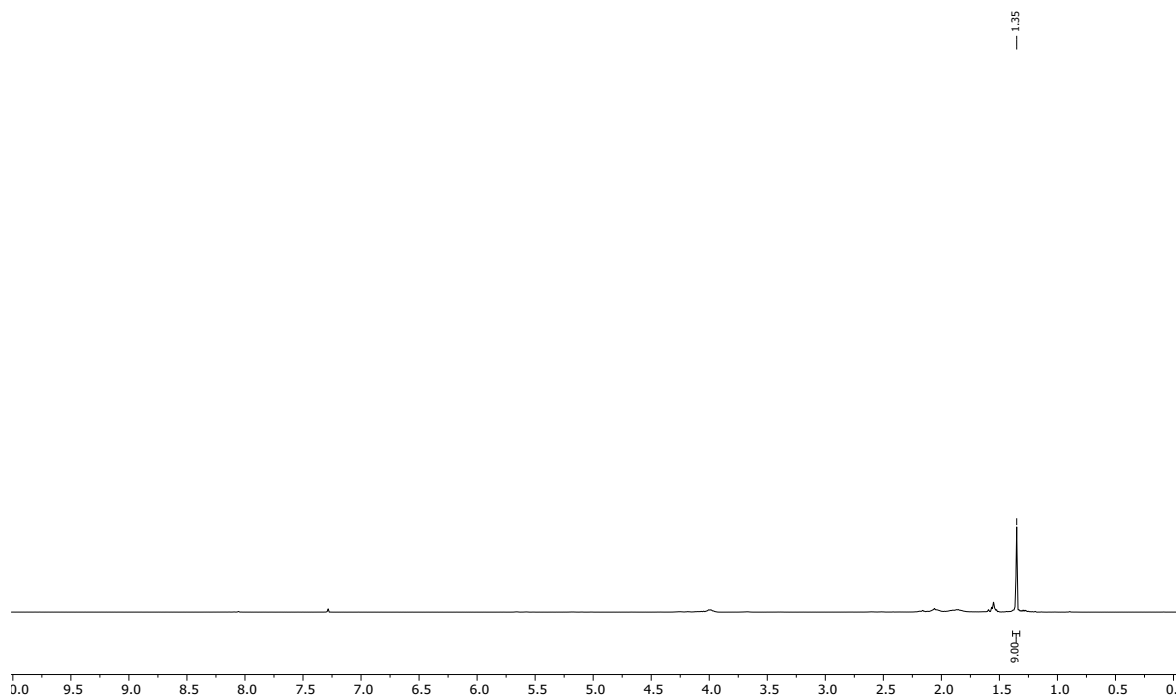
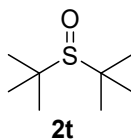


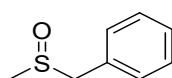
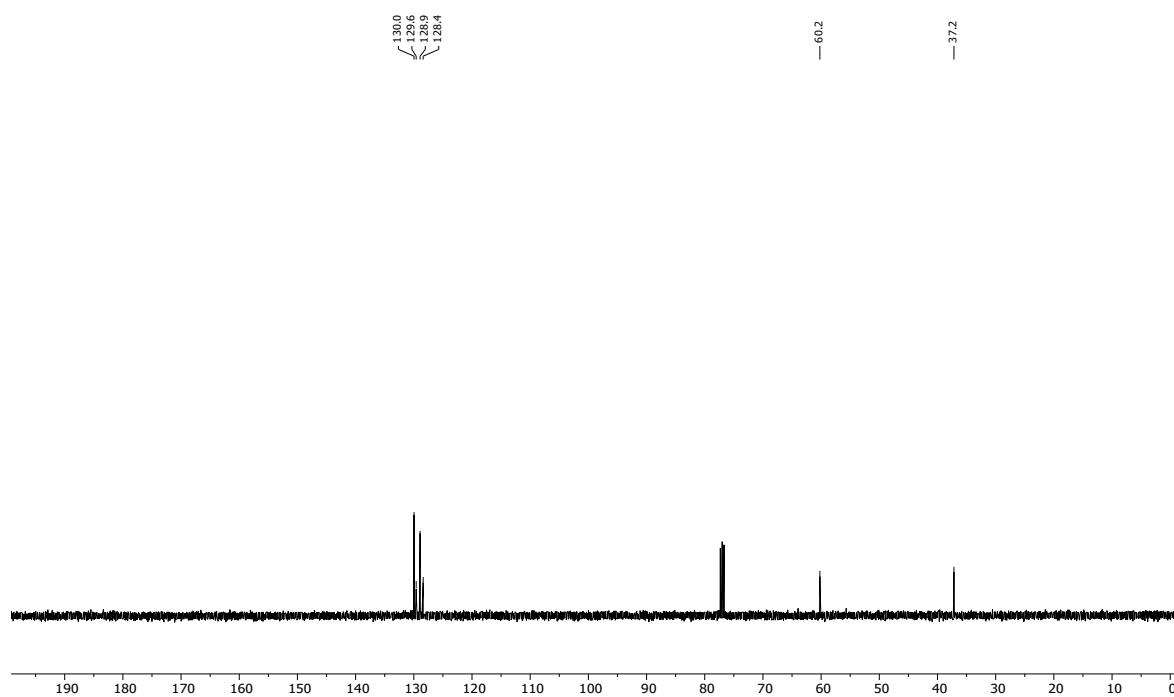
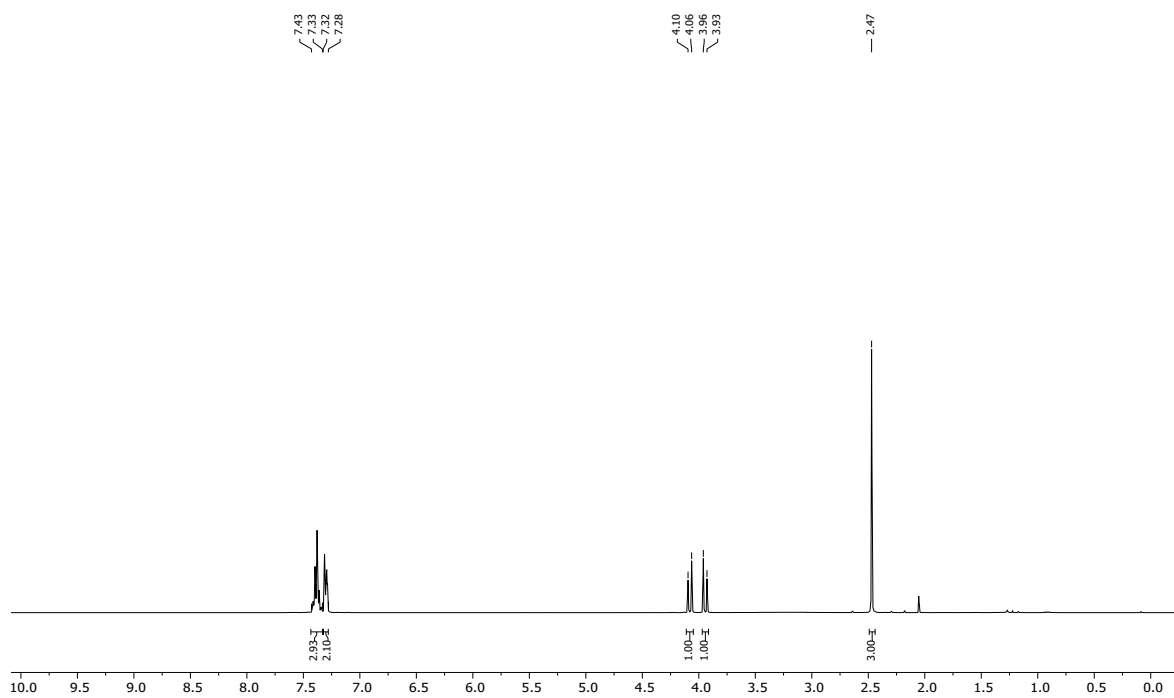


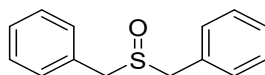








**2u**

**2v**