

## Supplementary Information

### Construction and characterization of magnetic nanoparticles supported Cu complex: A stable and active nanocatalyst for synthesis of heteroaryl-aryl and di-heteroaryl sulfides

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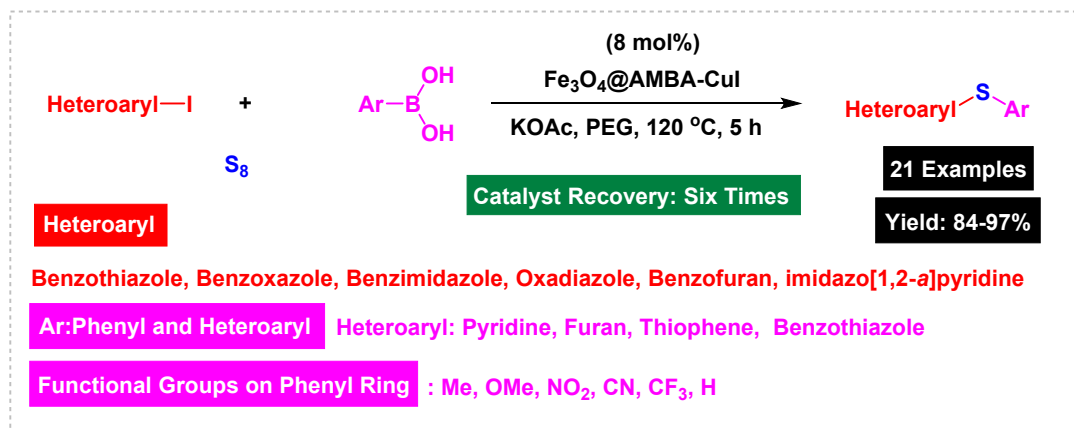
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#### Abstract

Diaryl and di-heteroaryl sulfides exist in the structure of many drugs and important biological compounds, also these compounds are well-known in medicinal chemistry due to important biological and pharmaceutical activities. Therefore, the development of novel, ecofriendly and efficient catalytic systems for the preparation of diaryl and di-heteroaryl sulfides is a very attractive and important challenge in organic synthesis. In this attractive methodology, we wish to introduce Fe<sub>3</sub>O<sub>4</sub>@AMBA-CuI nanomaterials as a novel and efficient magnetically recoverable catalyst for the preparation of heteroaryl-aryl and di-heteroaryl sulfides with high yields through reaction of heteroaryl halides with aryl or heteroaryl boronic acids and S<sub>8</sub> as sulfur source under ecofriendly conditions. This catalytic system was very efficient and practical for a diverse range of heteroaryl substrates including benzothiazole, benzoxazole, benzimidazole, oxadiazole, benzofuran, imidazo[1,2-a]pyridine, because the desired diaryl and di-heteroaryl sulfides were prepared with high yields. The reusability-experiments revealed that the Fe<sub>3</sub>O<sub>4</sub>@AMBA-CuI nanocatalyst can be magnetically separated and reused at least six runs without significant decrease in its catalytic activity. VSM and ICP-OES analyzes confirmed that despite using the Fe<sub>3</sub>O<sub>4</sub>@AMBA-CuI nanocatalyst 6 times, the magnetic properties and stability of the catalyst were still maintained. Although all the obtained heteroaryl-aryl and di-heteroaryl sulfide products are known and previously reported, but synthesis of this number of heteroaryl-aryl and di-heteroaryl sulfides has never been reported by any methods.



**Keywords:** Diaryl and di-heteroaryl sulfides, Fe<sub>3</sub>O<sub>4</sub>@AMBA-CuI nanocatalyst, Magnetic separation, Pharmaceutical chemistry, Sulfur source.

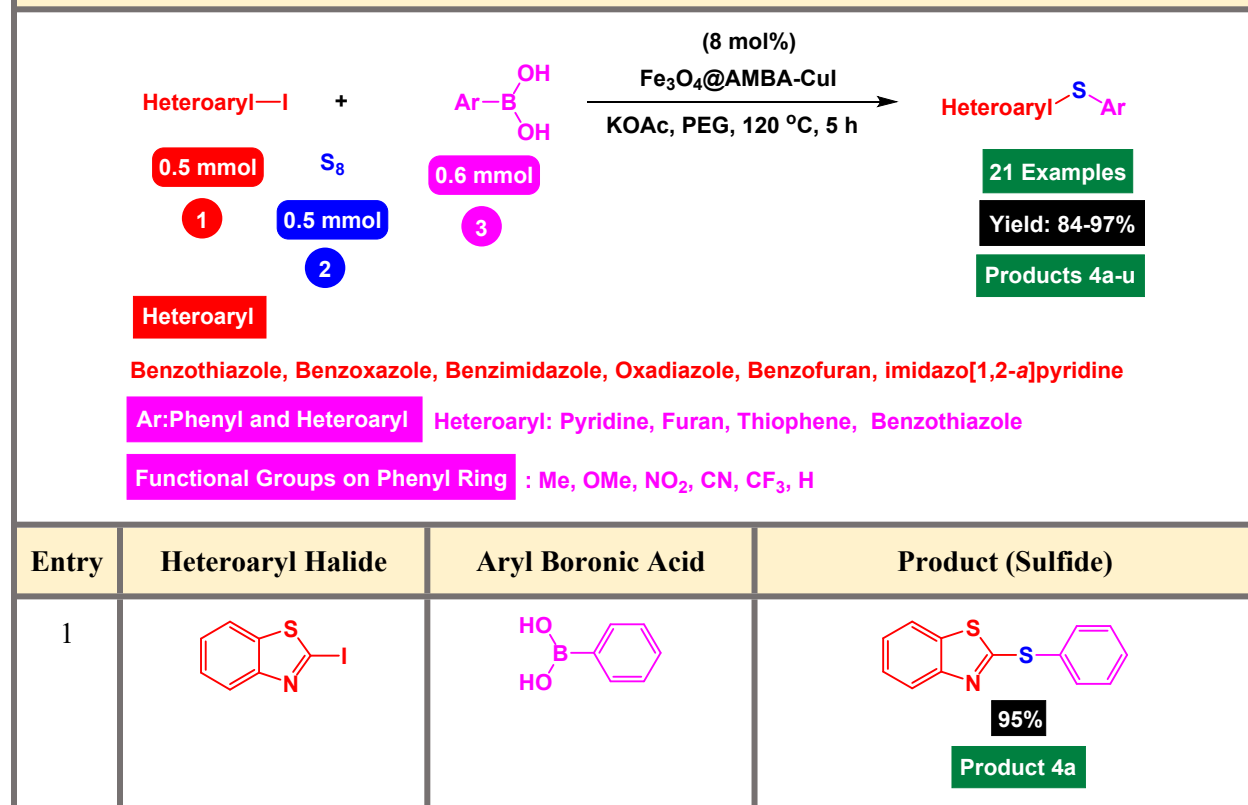
## Supplementary Information

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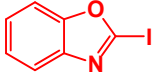
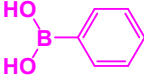
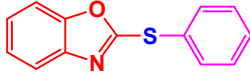
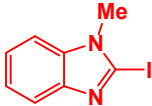
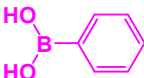
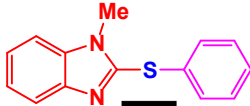
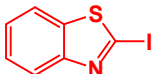
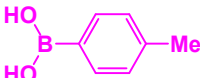
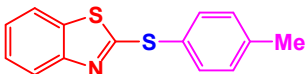
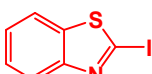
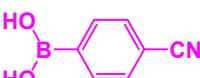
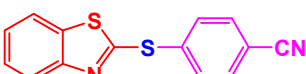
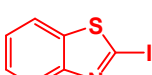
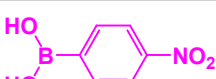
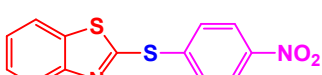
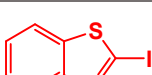
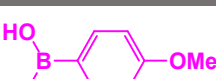
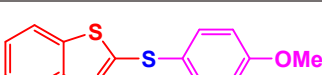
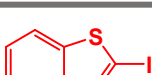
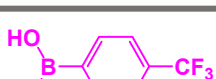
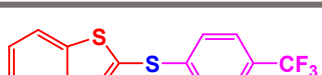
#### General procedure for preparation of heteroaryl-aryl and di-heteroaryl sulfides catalyzed by Fe<sub>3</sub>O<sub>4</sub>@AMBA-CuI nanocomposite

In a round bottomed flask, a mixture of heteroaryl iodides (0.5 mmol), aryl or heteroaryl boronic acids (0.6 mmol), S<sub>8</sub> (0.5 mmol) KOAc (2 equiv) and Fe<sub>3</sub>O<sub>4</sub>@AMBA-CuI catalyst (8 mol%) was stirred in PEG-400 at 120 °C for 5h (the progress of the reaction was monitored by thin-layer chromatography (TLC)). After completion of the reaction, the Fe<sub>3</sub>O<sub>4</sub>@AMBA-CuI was magnetically separated and reaction mixture was cooled to room temperature and H<sub>2</sub>O (4 mL) was added. The product was extracted with EtOAc (3×4 mL) and dried over anhydrous Na<sub>2</sub>SO<sub>4</sub>. The crude material was purified with chromatography column on silica gel (EtOAc/n-hexane) give the heteroaryl-aryl and di-heteroaryl sulfides products with 84-97%. All heteroaryl-aryl and di-heteroaryl sulfides products are previously reported and known. HNMR and CNMR were used in order to identify the structure of the heteroaryl-aryl and di-heteroaryl sulfide products

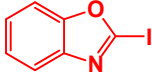
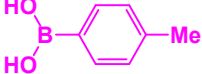
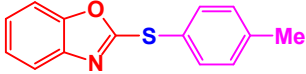
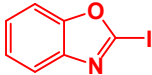
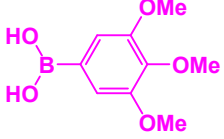
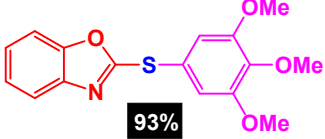
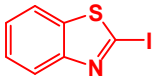
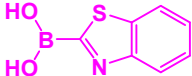
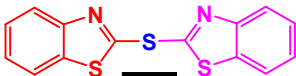
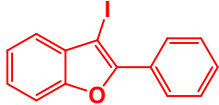
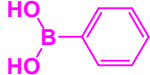
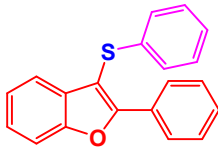
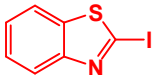
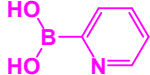
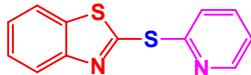
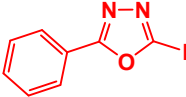
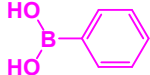
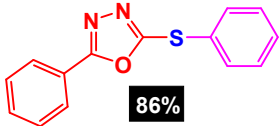
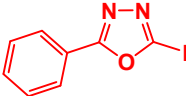
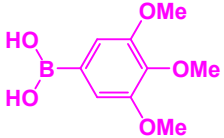
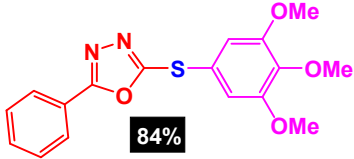
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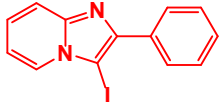
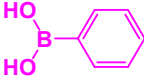
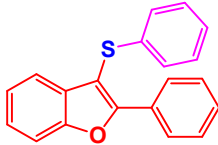
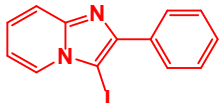
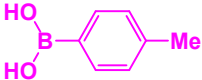
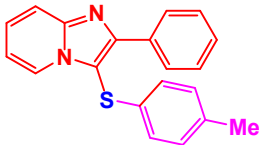
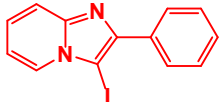
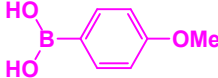
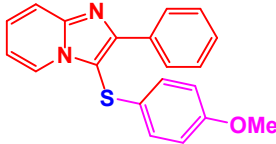
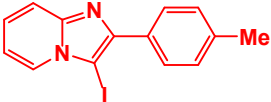
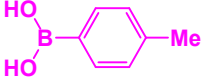
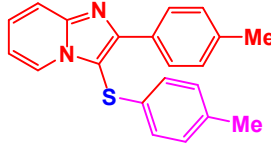
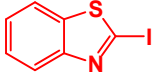
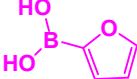
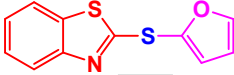
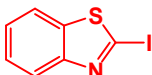
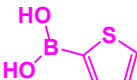
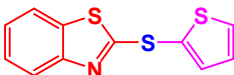
## Supplementary Information

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## Supplementary Information

9			 <b>96%</b> <b>Product 4i</b>
10			 <b>93%</b> <b>Product 4j</b>
11			 <b>91%</b> <b>Product 4k</b>
12			 <b>85%</b> <b>Product 4l</b>
13			 <b>92%</b> <b>Product 4m</b>
14			 <b>86%</b> <b>Product 4n</b>
15			 <b>84%</b> <b>Product 4o</b>

## Supplementary Information

16			 <p style="text-align: center;"><b>88%</b></p> <p style="text-align: center;"><b>Product 4l</b></p>
17			 <p style="text-align: center;"><b>88%</b></p> <p style="text-align: center;"><b>Product 4q</b></p>
18			 <p style="text-align: center;"><b>90%</b></p> <p style="text-align: center;"><b>Product 4r</b></p>
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20			 <p style="text-align: center;"><b>91%</b></p> <p style="text-align: center;"><b>Product 4t</b></p>
21			 <p style="text-align: center;"><b>92%</b></p> <p style="text-align: center;"><b>Product 4u</b></p>

## Supplementary Information

### NMR Data for heteroaryl-aryl and di-heteroaryl sulfide products

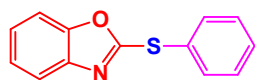


95%

Product 4a

<https://doi.org/10.1002/chem.201600800>

**2-(phenylthio)benzo[d]thiazole:** mp: 32-34 °C,  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ )  $\delta$  8.06–8.02 (m, 2H), 7.64–7.60 (m, 2H), 7.58–7.46 (m, 5H);  $^{13}\text{C}$  NMR (126 MHz,  $\text{CDCl}_3$ )  $\delta$  168.8, 155.0, 135.6, 135.1, 130.8, 130.4, 126.7, 124.5, 122.1, 120.7.



94%

Product 4b

<https://doi.org/10.1021/acs.joc.9b02371>

**2-(phenylthio)benzo[d]oxazole:** Colorless oil,  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ )  $\delta$  7.68 – 7.64 (m, 2H), 7.63 – 7.61 (m, 2H), 7.20 – 7.17 (m, 2H), 7.16 – 7.14 (m, 3H);  $^{13}\text{C}$  NMR (126 MHz,  $\text{CDCl}_3$ )  $\delta$  162.8, 152.3, 142.9, 135.1, 130.3, 129.9, 127.2, 124.7, 123.8, 119.4, 110.3.

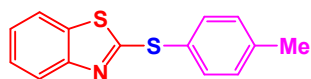


92%

Product 4c

<https://doi.org/10.1016/j.tet.2006.02.071>

**1-methyl-2-(phenylthio)-1H-benzo[d]imidazole:** mp: 65-67 °C,  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ )  $\delta$  7.61–7.57 (m, 2H), 7.48–7.45 (m, 2H), 7.38 (t,  $J$  = 4.3 Hz, 3H), 7.23 – 7.21 (m, 2H), 3.78 (s, 1H);  $^{13}\text{C}$  NMR (126 MHz,  $\text{CDCl}_3$ )  $\delta$  146.5, 135.2, 131.5, 130.2, 129.8, 122.4, 118.6, 110.3, 32.9.

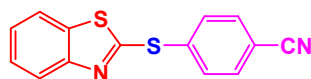


96%

Product 4d

<https://doi.org/10.1016/j.tet.2021.132564>

**2-(p-tolylthio)benzo[d]thiazole:** mp: 69-71 °C,  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ )  $\delta$  7.81 (dd,  $J$  = 7.6, 1.2 Hz, 1H), 7.60–7.57 (m, 2H), 7.37–7.33 (m, 1H), 7.32–7.25 (m, 2H), 7.23–7.20 (m, 1H), 2.50 (s, 3H);  $^{13}\text{C}$  NMR (126 MHz,  $\text{CDCl}_3$ )  $\delta$  165.3, 153.6, 135.9, 134.1, 130.5, 130.2, 129.7, 126.3, 124.2, 121.5, 120.8, 22.5.



92%

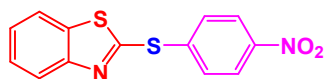
Product 4e

DOI

<https://doi.org/10.1039/C7CC03107F>

## Supplementary Information

**4-(benzo[d]thiazol-2-ylthio)benzotrile:** mp: 110-112 °C,  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ )  $\delta$  7.88 (d,  $J$  = 7.7 Hz, 1H), 7.69–7.65 (m, 3H), 7.46-7.40(m, 2H), 7.31 (d,  $J$  = 4.5 Hz, 1H), 7.29 (d,  $J$  = 4.6 Hz, 1H);  $^{13}\text{C}$  NMR (126 MHz,  $\text{CDCl}_3$ )  $\delta$  167.2, 153.4, 136.5, 136.2, 135.7, 130.3, 128.5, 126.3, 124.6, 122.0, 120.1.

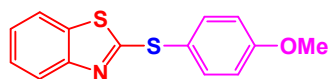


91%

Product 4f

DOI: 10.1039/C9NJ04440J

**2-((4-nitrophenyl)thio)benzo[d]thiazole:** mp: 86-89 °C,  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ )  $\delta$  8.00–7.95 (m, 2H), 7.65–7.63 (m, 2H), 7.45–7.41 (m, 2H), 7.20–7.14 (m, 2H);  $^{13}\text{C}$  NMR (126 MHz,  $\text{CDCl}_3$ )  $\delta$  161.1, 158.3, 142.8, 141.3, 139.5, 138.0, 130.2, 129.7, 128.6, 127.9, 118.4, 115.7.

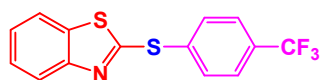


98%

Product 4g

<https://doi.org/10.1016/j.tet.2021.132564>

**2-((4-methoxyphenyl)thio)benzo[d]thiazole:** mp: 55-57 °C,  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ )  $\delta$  7.84 (d,  $J$  = 7.6 Hz, 1H), 7.65-7.60 (m, 2H), 7.38–7.35 (m, 1H), 7.26 (d,  $J$  = 7.5 Hz, 1H), 7.22-7.00 (m, 3H), 3.89(s, 3H);  $^{13}\text{C}$  NMR (126 MHz,  $\text{CDCl}_3$ )  $\delta$  170.2, 161.0, 154.9, 137.6, 135.7, 126.12, 124.3, 121.5, 120.8, 120.2, 115.5.

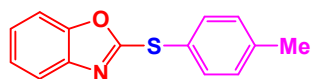


86%

Product 4h

DOI <https://doi.org/10.1039/C7CC03107F>

**2-((4-(trifluoromethyl)phenyl)thio)benzo[d]thiazole:** mp: 58-60 °C,  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ ) 8.02 (d,  $J$  = 7.8 Hz, 1H), 7.85 (d,  $J$  = 7.8 Hz, 3H), 7.69–7.65 (m, 2H), 7.64-7.60(m, 1H), 7.59-7.57(m, 1H);  $^{13}\text{C}$  NMR (126 MHz,  $\text{CDCl}_3$ )  $\delta$  165.2, 141.0, 140.9, 139.5, 137.4, 136.5, 130.6, 129.7, 129.1, 128.7, 127.9, 127.3.



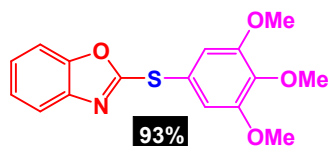
96%

Product 4i

<https://doi.org/10.1021/acs.joc.8b01644>

**2-(p-tolylthio)benzo[d]oxazole:** Colorless oil,  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ )  $\delta$  7.71 (d,  $J$  = 7.7 Hz, 2H), 7.61-7.55 (m, 2H), 7.31–7.24 (m, 2H), 7.21-7.18 (m, 2H), 2.54(s, 3H);  $^{13}\text{C}$  NMR (126 MHz,  $\text{CDCl}_3$ )  $\delta$  157.0, 155.2, 143.6, 141.5, 138.7, 130.5, 129.7, 127.3, 126.1, 120.3, 115.2, 22.5.

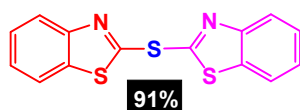
## Supplementary Information



Product 4j

<https://doi.org/10.1021/jo402586v>

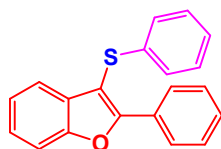
**2-((3,4,5-trimethoxyphenyl)thio)benzo[d]oxazole:** mp: 127-129 °C,  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ )  $\delta$  7.85 (d,  $J = 8.3$  Hz, 1H), 7.62 (d,  $J = 8.0$  Hz, 1H), 7.43 (td,  $J = 7.7, 1.3$  Hz, 1H), 7.26 (td,  $J = 7.5, 1.3$  Hz, 1H), 7.10 (s, 2H), 3.85 (s, 6H), 3.64 (s, 3H);  $^{13}\text{C}$  NMR (126 MHz,  $\text{CDCl}_3$ )  $\delta$  170.2, 155.3, 145.6, 141.2, 135.8, 130.7, 126.7, 125.3, 124.1, 121.0, 120.8, 58.9, 58.2.



Product 4k

DOI <https://doi.org/10.1039/D2OB02216H>

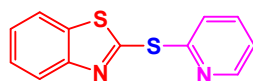
**bis(benzo[d]thiazol-2-yl)sulfane:** mp: 100-102 °C,  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ )  $\delta$  7.85 (dd,  $J = 8.6$  Hz, 2H), 7.65-7.60 (m), 7.45-7.40 (m, 4H);  $^{13}\text{C}$  NMR (101 MHz,  $\text{CDCl}_3$ )  $\delta$  168.8, 141.6, 137.0, 135.9, 134.5, 130.2, 129.2, 127.3, 125.9.



Product 4l

<https://doi.org/10.1021/jo9016309>

**2-phenyl-3-(phenylthio)benzofuran:** mp: 66-68 °C,  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ )  $\delta$  8.24 (dd,  $J = 8.3$  Hz, 2H), 7.56 (d,  $J = 8.2$  Hz, 1H), 7.48-7.41 (m, 5H), 7.37-7.23 (m, 5H), 7.22-7.16 (m, 1H);  $^{13}\text{C}$  NMR (101 MHz,  $\text{CDCl}_3$ )  $\delta$  157.8, 153.2, 136.5, 130.6, 129.7, 129.4, 129.0, 128.7, 127.3, 126.5, 125.9, 125.4, 123.4, 120.5, 111.3, 104.9.



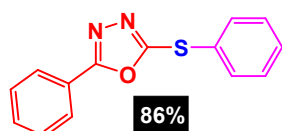
Product 4m

DOI <https://doi.org/10.1039/D0OB00684J>

**2-(pyridin-2-ylthio)benzo[d]thiazole:** mp: 66-68 °C,  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ )  $\delta$  9.26 (d,  $J = 1.8$  Hz, 1H), 8.81 (dd,  $J = 4.9, 1.7$  Hz, 1H), 8.29 (ddd,  $J = 8.1, 2.3, 1.8$  Hz, 1H), 7.55-7.45 (m, 4H), 7.44 (ddd,  $J = 8.1, 4.9, 1.8$  Hz, 1H);  $^{13}\text{C}$  NMR (126 MHz,  $\text{CDCl}_3$ )  $\delta$  161.3, 154.6, 149.7, 136.5, 135.1, 132.5, 129.8, 128.9, 126.3, 122.4.



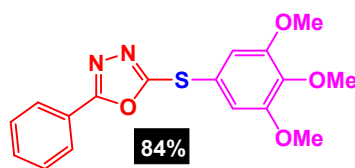
## Supplementary Information



Product 4n

<https://doi.org/10.1016/j.tet.2011.02.064>

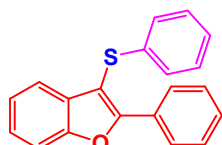
**2-phenyl-5-(phenylthio)-1,3,4-oxadiazole:** mp: 60-62 °C, <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) δ 7.91 (d, J = 7.6 Hz, 2 H), 7.70-7.64 (m, 2 H), 7.59 (t, J = 7.2 Hz, 1 H), 7.49-7.42 (m, 5 H); <sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>) δ 166.9, 166.1, 133.8, 132.4, 130.8, 130.2, 129.8, 127.6, 126.4, 123.9.



Product 4o

<https://doi.org/10.1021/jo402586v>

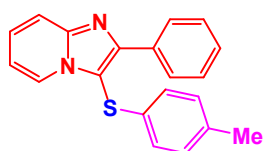
**2-phenyl-5-((3,4,5-trimethoxyphenyl)thio)-1,3,4-oxadiazole:** mp: 140-142 °C, <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) δ 7.97 (d, J = 6.7 Hz, 2H), 7.52-7.50 (m, 3H), 6.95 (s, 2H), 3.97 (s, 9H); <sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>) δ 166.6, 163.9, 153.2, 140.3, 132.3, 130.0, 126.4, 123.7, 121.5, 111.3, 61.7, 55.5



Product 4l

DOI: 10.1055/s-0037-1612082

**2-phenyl-3-(phenylthio)imidazo[1,2-a]pyridine:** mp: 92-94 °C, <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) δ 8.25 (d, 1H, J = 6.8 Hz), 8.18 (d, 2H, J = 7.6 Hz), 7.71 (d, 1H, J = 9.2 Hz), 7.45 (t, 2H, J = 7.7 Hz), 7.38 (d, 1H, J = 7.3 Hz), 7.30 (t, 1H, J = 8 Hz), 7.17 (t, 2H, J = 7.6 Hz), 7.11 (t, 1H, J = 7.6 Hz), 6.97 (d, 2H, J = 7.6 Hz), 6.85 (t, 1H, J = 6.7 Hz); <sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>) δ 151.0, 147.2, 133.5, 129.7, 128.5, 128.3, 127.4, 126.2, 125.6, 125.3, 124.5, 117.3, 112.2, 106.3.

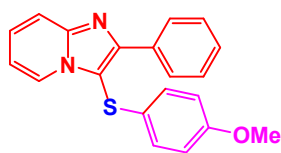


Product 4q

DOI: 10.1055/s-0037-1612082

**2-phenyl-3-(p-tolylthio)imidazo[1,2-a]pyridine:** mp: 135-137 °C, <sup>1</sup>H NMR (500 MHz, CDCl<sub>3</sub>) δ 8.28 (d, 1H, J = 6.5 Hz), 8.21 (d, 2H, J = 7.5 Hz), 7.71 (d, 1H, J = 9.1 Hz), 7.46 (t, 2H, J = 7.6 Hz), 7.37 (d, 1H, J = 7.3 Hz), 7.28 (t, 1H, J = 8 Hz), 7.02 (d, 2H, J = 8 Hz), 6.95 (d, 2H, J = 8.1 Hz), 6.87 (t, 1H, J = 6.7 Hz), 2.38 (s, 3H); <sup>13</sup>C NMR (126 MHz, CDCl<sub>3</sub>) δ 152.0, 145.3, 136.8, 133.5, 131.2, 130.7, 129.7, 128.6, 128.0, 126.4, 125.7, 117.9, 112.4, 106.3, 21.3.

## Supplementary Information

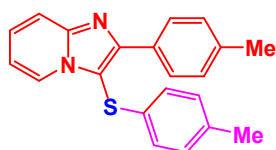


90%

Product 4r

DOI: 10.1055/s-0037-1612082

**3-((4-methoxyphenyl)thio)-2-phenylimidazo[1,2-a]pyridine:** mp: 112-114 °C,  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ )  $\delta$  8.29 (d, 1H,  $J = 6.1$  Hz), 8.22 (d, 2H,  $J = 8.2$  Hz), 7.71 (d, 1H,  $J = 8.6$  Hz), 7.42-7.40 (m, 2H), 7.35 (t, 1H,  $J = 5.7$  Hz), 7.29-7.27 (m, 1H), 6.97 (d, 2H,  $J = 8.3$  Hz), 6.85 (t, 1H,  $J = 5.6$  Hz), 6.75 (d, 2H,  $J = 8.6$  Hz), 3.70 (s, 3H).;  $^{13}\text{C}$  NMR (126 MHz,  $\text{CDCl}_3$ )  $\delta$  158.6, 150.2, 146.7, 133.6, 130.9, 129.7, 128.8, 128.6, 127.7, 126.4, 125.7, 117.7, 115.9, 112.6, 107.4, 55.3.

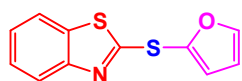


87%

Product 4s

DOI: 10.1055/s-0037-1612082

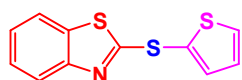
**2-(p-tolyl)-3-(p-tolylthio)imidazo[1,2-a]pyridine:** mp: 142-144 °C,  $^1\text{H}$  NMR (500 MHz,  $\text{CDCl}_3$ )  $\delta$  8.24 (d, 1H,  $J = 6.8$  Hz), 8.12 (d, 2H,  $J = 7.8$  Hz), 7.70 (d, 1H,  $J = 9.1$  Hz), 7.33 (t, 1H,  $J = 7.6$  Hz), 7.25 (d, 2H,  $J = 8.3$  Hz), 7.02 (d, 2H,  $J = 7.7$  Hz), 6.92 (d, 2H,  $J = 7.7$  Hz), 6.83 (t, 1H,  $J = 6.7$  Hz), 2.38 (s, 3H), 2.25 (s, 3H).;  $^{13}\text{C}$  NMR (126 MHz,  $\text{CDCl}_3$ )  $\delta$  151.1, 146.3, 138.7, 134.3, 130.7, 129.7, 129.1, 128.2, 126.4, 125.1, 124.4, 117.6, 112.7, 105.9, 21.3, 20.6.



91%

Product 4t

**2-(furan-2-ylthio)benzo[d]thiazole:**  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ )  $\delta$  8.03 (dd,  $J = 8.5$  Hz, 2H), 7.45 (d,  $J = 8.8$  Hz, 2H), 6.99 (d,  $J = 8.7$  Hz, 2H), 6.95 (d,  $J = 9.2$  Hz, 1H);  $^{13}\text{C}$  NMR (101 MHz,  $\text{CDCl}_3$ )  $\delta$  164.6, 161.7, 137.6, 130.5, 129.3, 119.1, 115.3, 114.5.



92%

Product 4u

<https://doi.org/10.1016/j.tet.2014.10.075>

## Supplementary Information

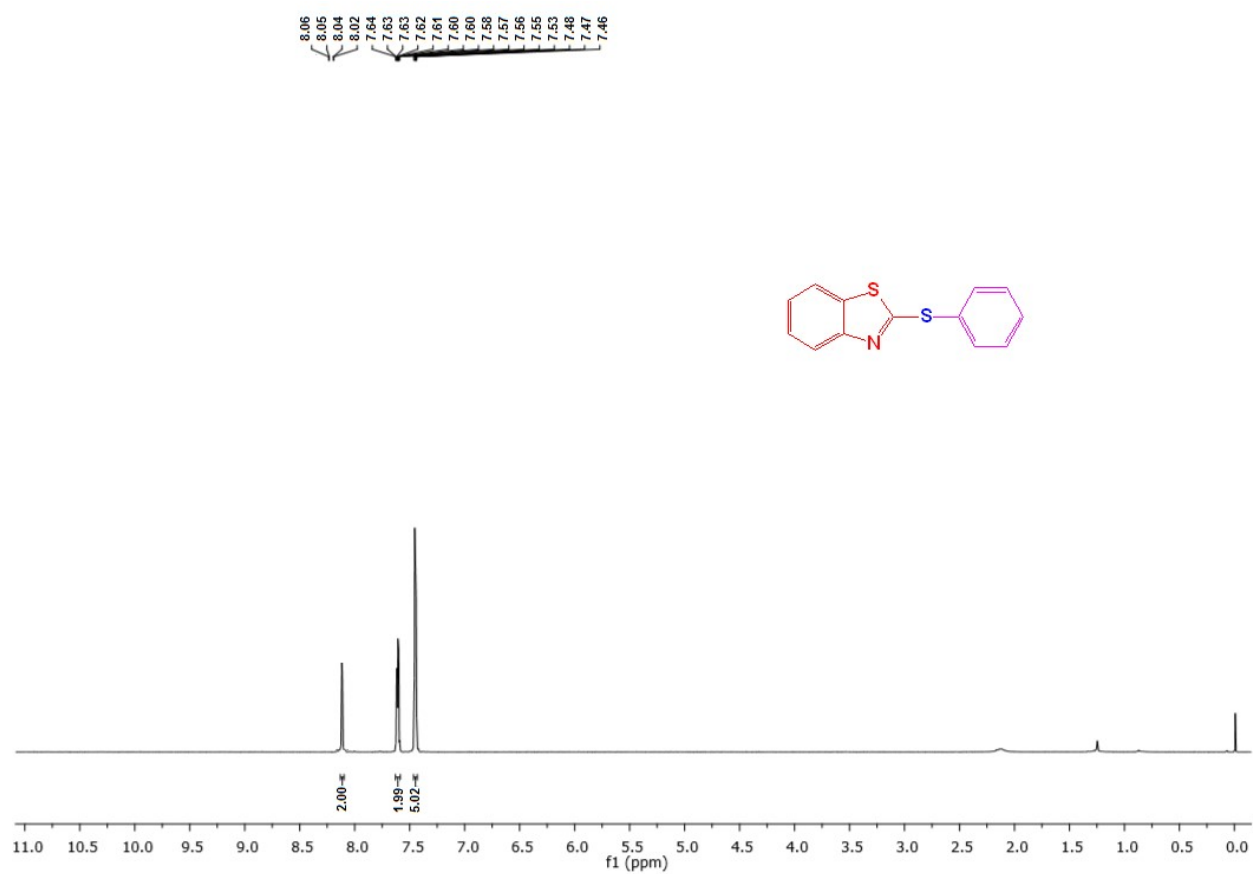
**2-(thiophen-2-ylthio)benzo[d]thiazole:**  $^1\text{H}$  NMR (400 MHz,  $\text{CDCl}_3$ )  $\delta$  7.33-7.21 (m, 2H), 7.14-7.10 (m, 2H), 6.97-6.93 (m, 3H);  $^{13}\text{C}$  NMR (101 MHz,  $\text{CDCl}_3$ )  $\delta$  168.3, 149.8, 135.0, 134.7, 132.1, 130.8, 130.2, 128.3, 117.6, 116.3, 115.4.

**Table S1.** experimental conditions for NMR analysis

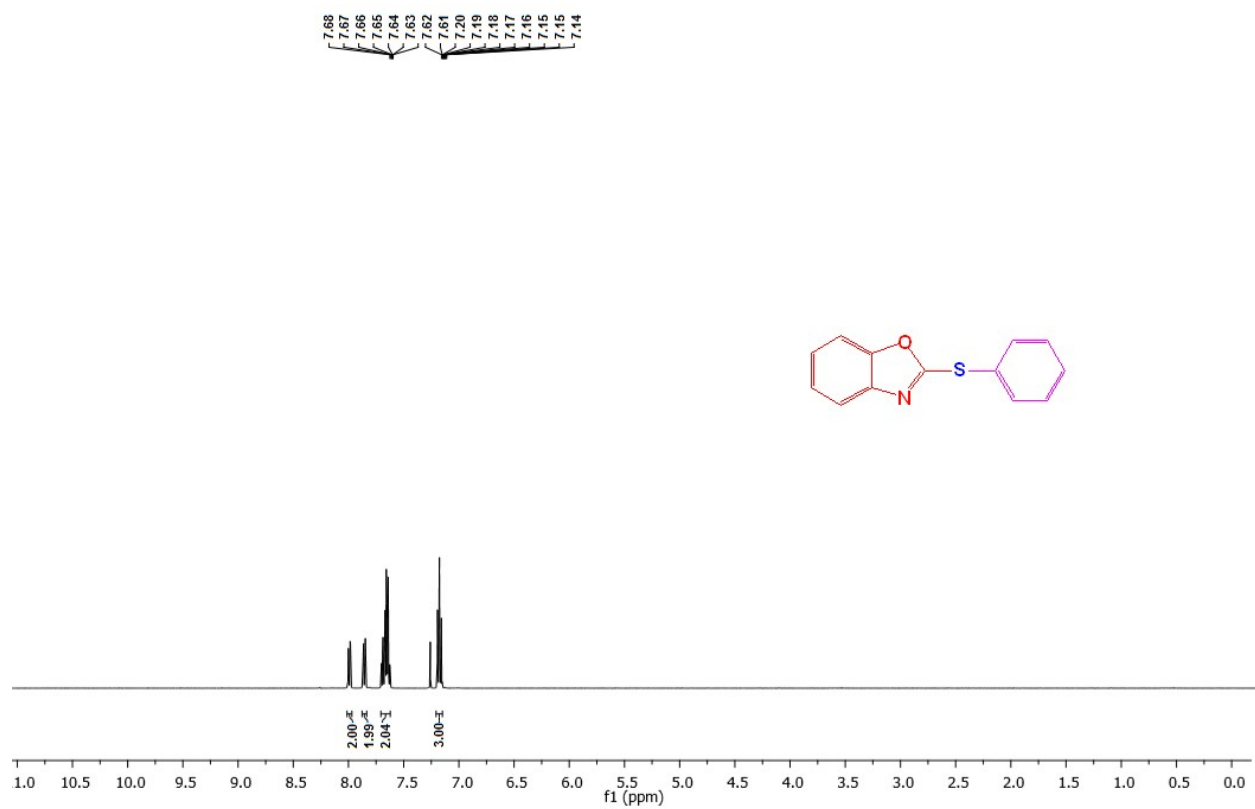
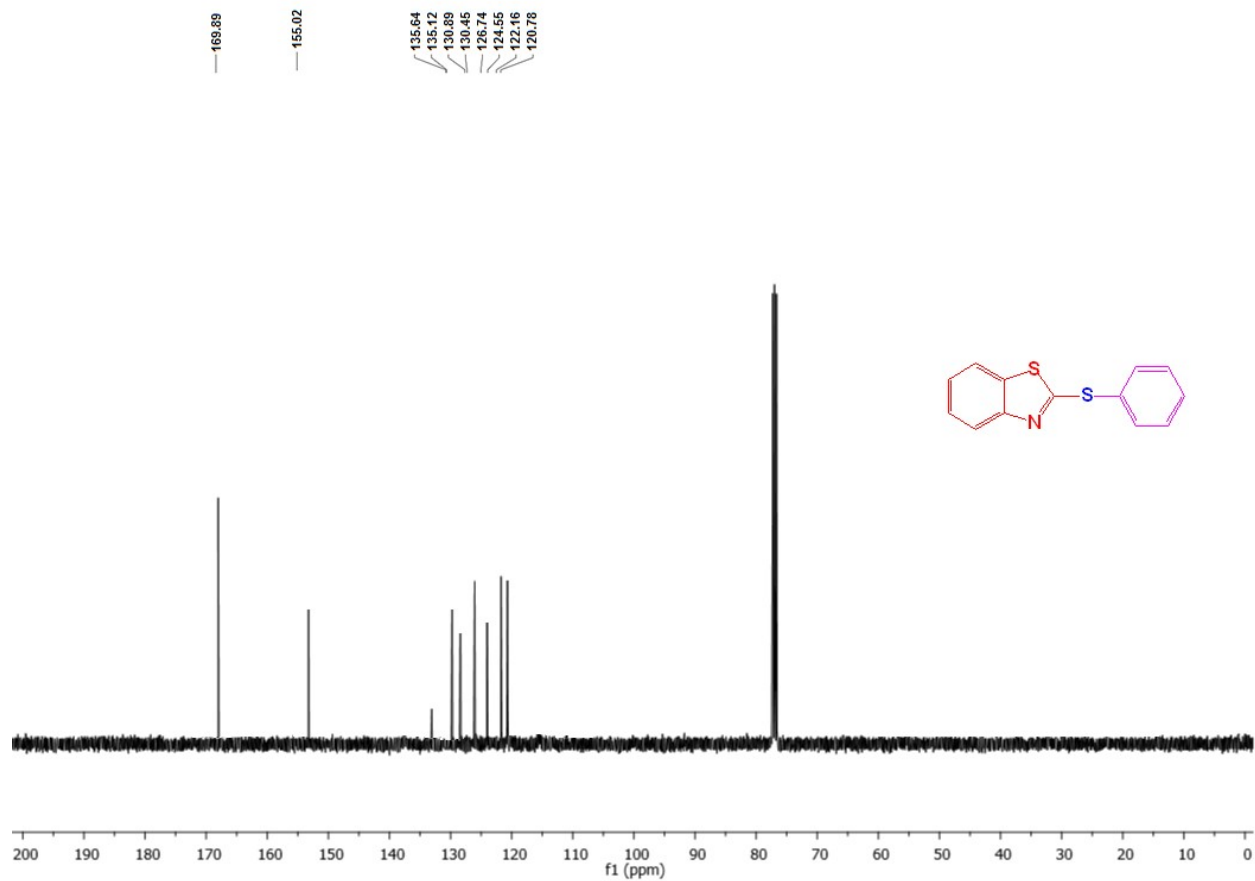
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Time        14.20	Time        13.45
INSTRUM    spect	INSTRUM    spect
PROBHD    5 mm Multinucl	PROBHD    5 mm Multinucl
PULPROG    zg	PULPROG    zgpq
TD         16384	TD         65536
SOLVENT $\text{CDCl}_3$	SOLVENT $\text{CDCl}_3$
NS         10	NS         85
DS         0	DS         0
SWH        6265.664 Hz	SWH        13812.154 Hz
FIDRES     0.382426 Hz	FIDRES     0.210757 Hz
AQ         1.3074932 sec	AQ         2.3724532 sec
RG         32	RG         1625.5
DW         79.800 usec	DW         36.200 usec
DE         6.00 usec	DE         6.00 usec
TE         300.0 K	TE         300.0 K
D1         3.00000000 sec	D1         2.00000000 sec
	d11        0.03000000 sec
	d12        0.00002000 sec
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	=====
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	P1         10.00 usec
	PL1         0.00 dB
	SFO1       62.9015285 MHz
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	=====
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	NUC2        1H
	PCPD2       80.00 usec
	PL2         3.00 dB
	PL12        21.50 dB
	PL13        23.00 dB
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# Supplementary Information

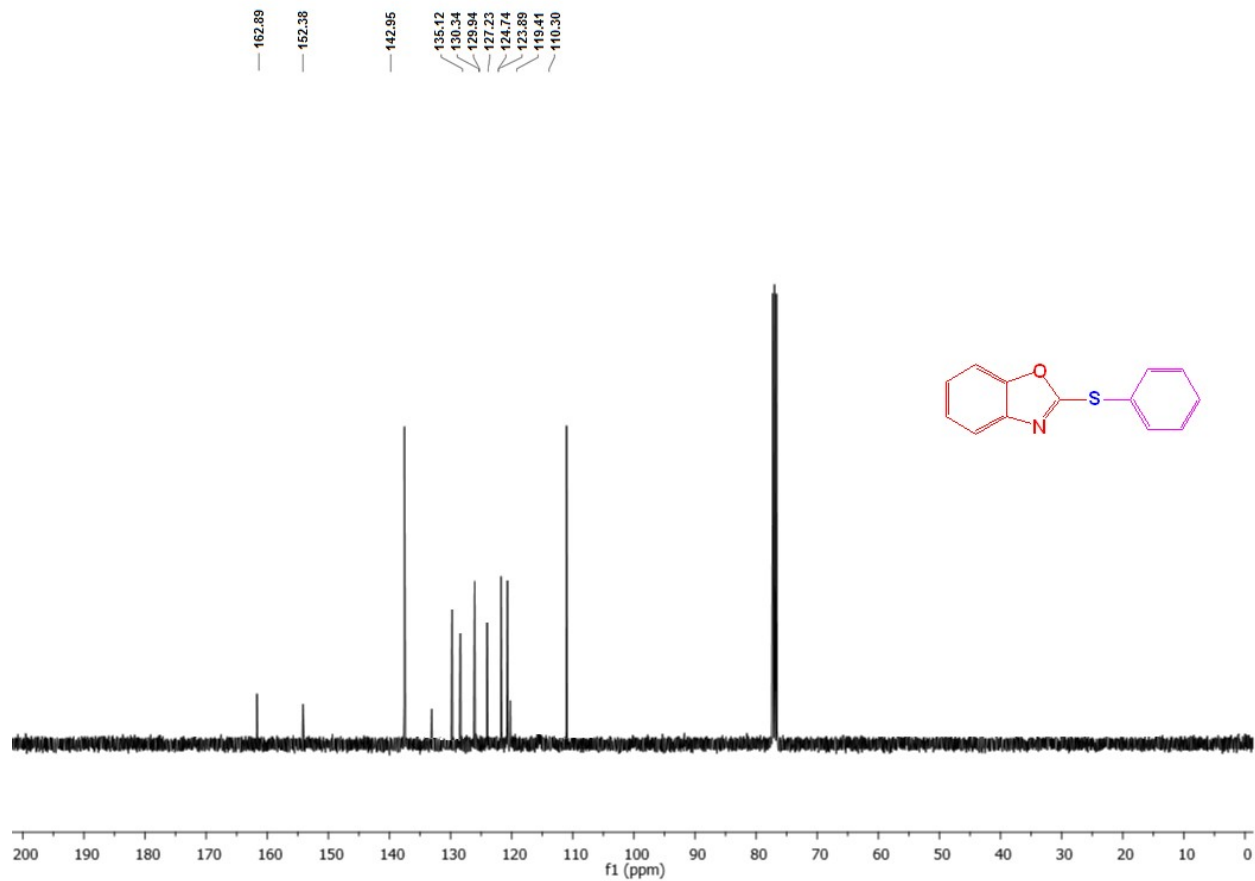
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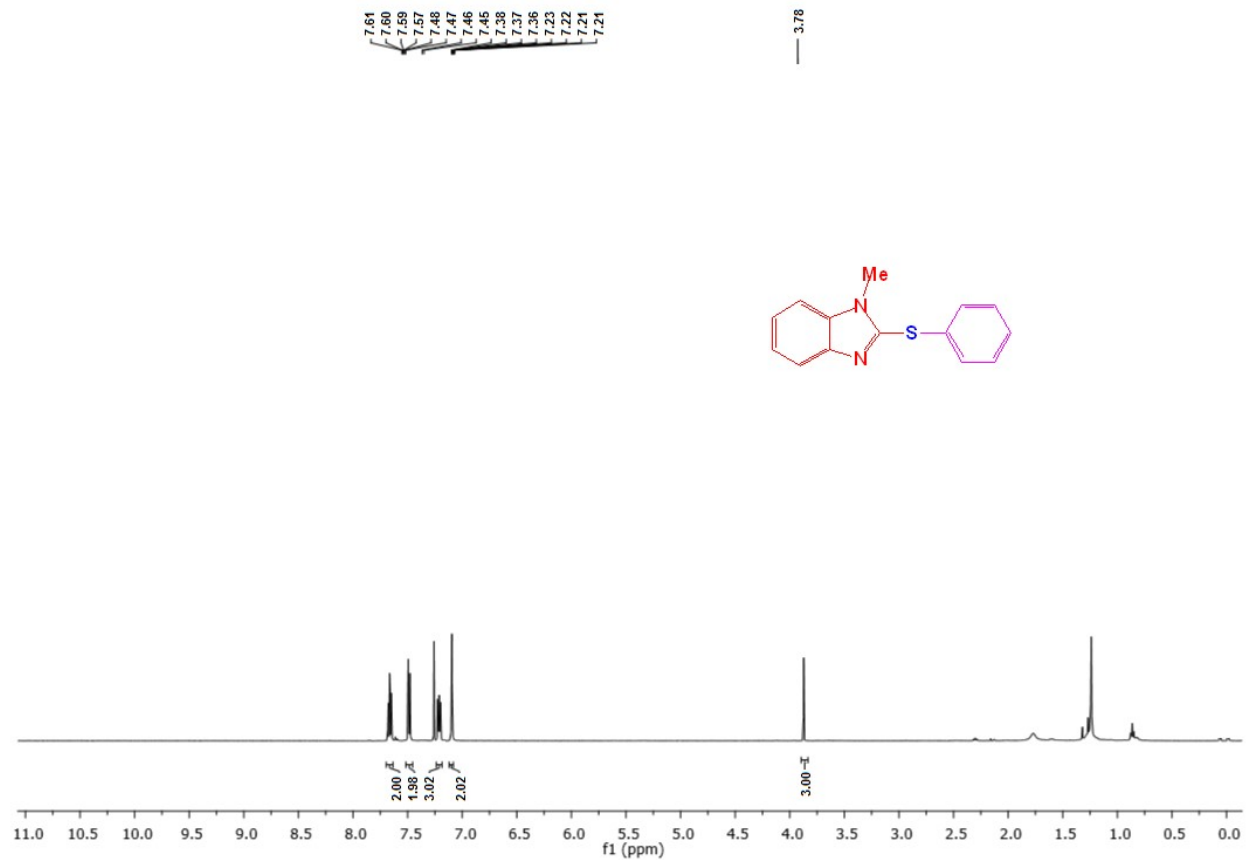
# Supplementary Information



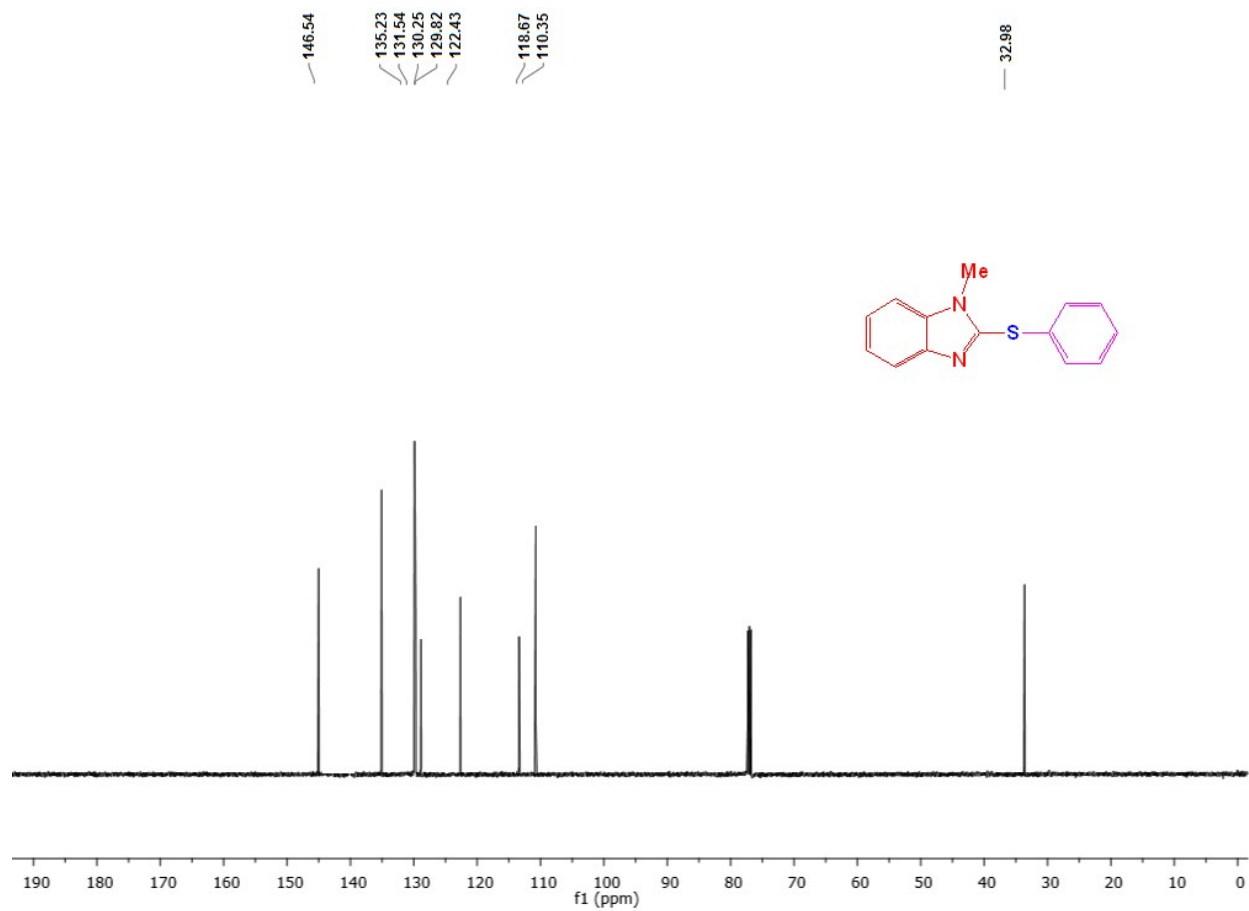
# Supplementary Information



# Supplementary Information

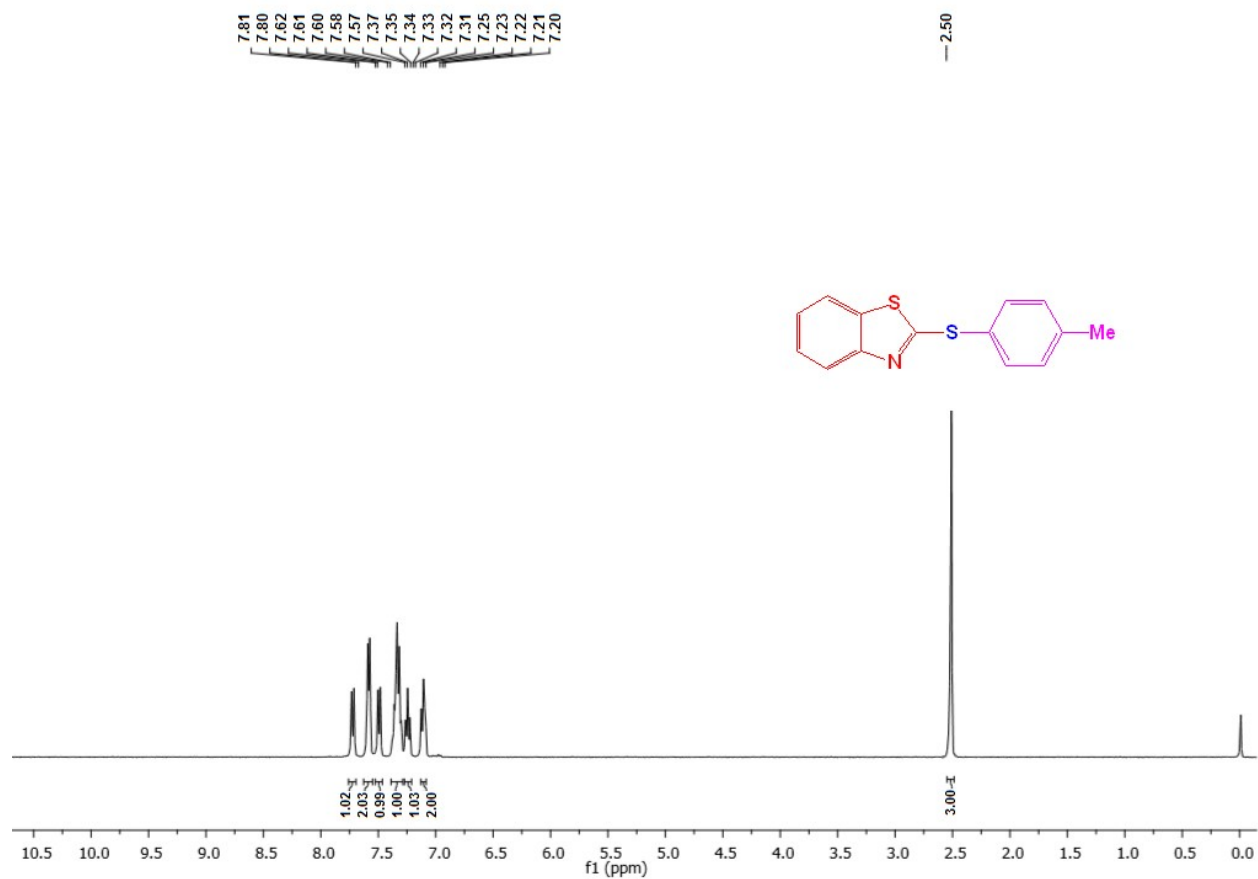


# Supplementary Information

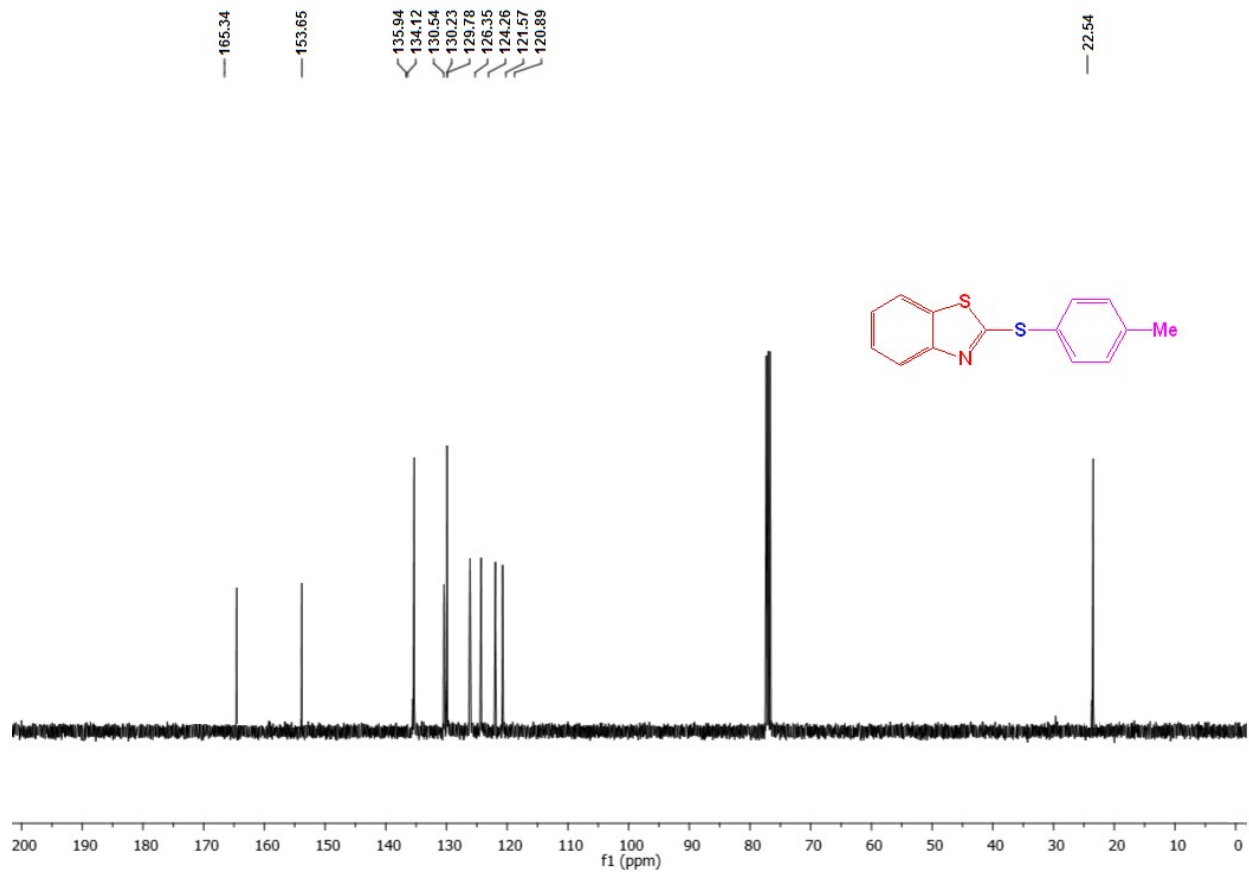




# Supplementary Information

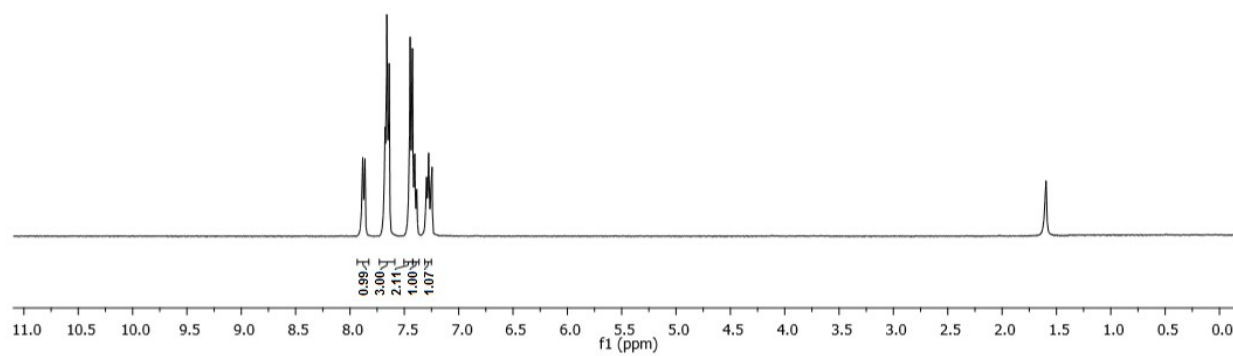
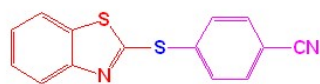


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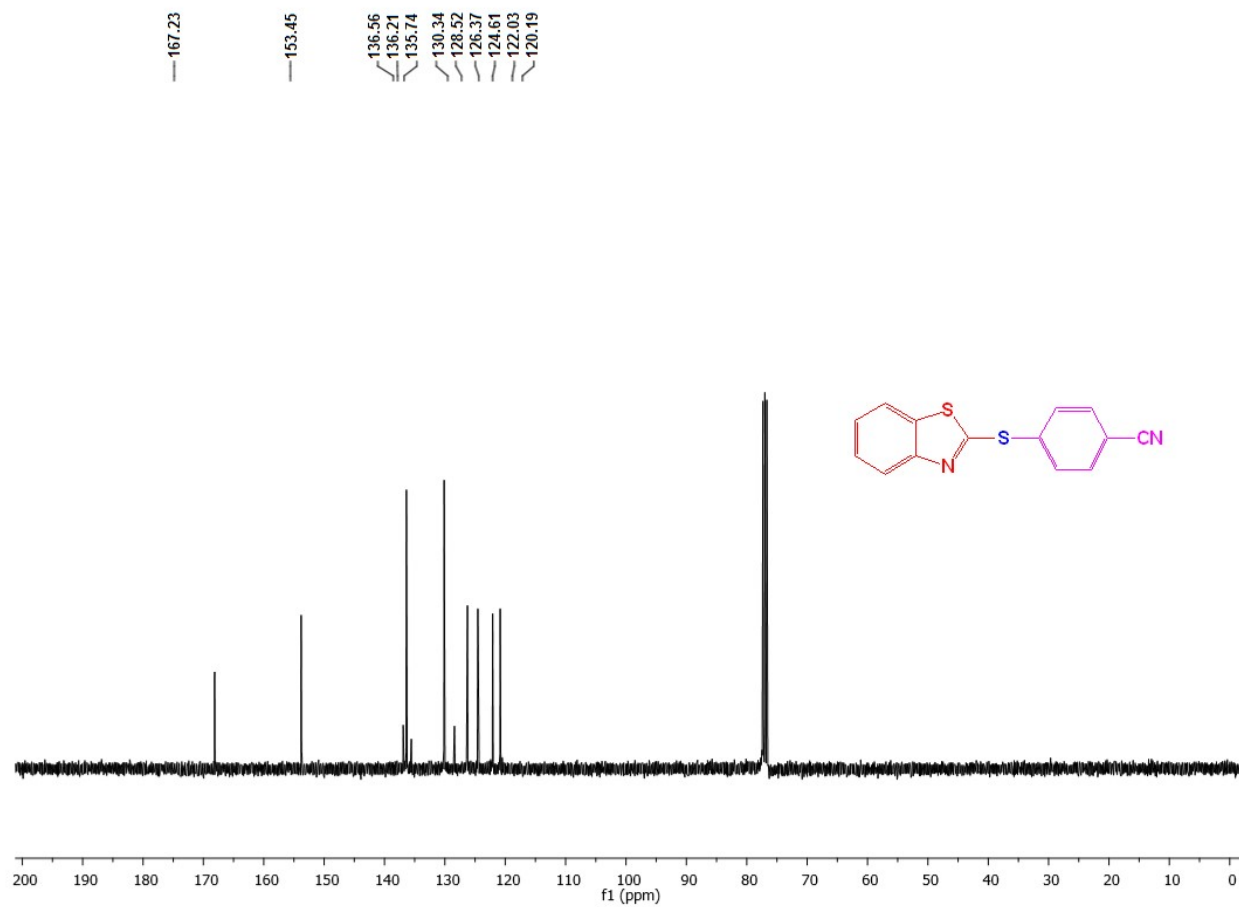


# Supplementary Information

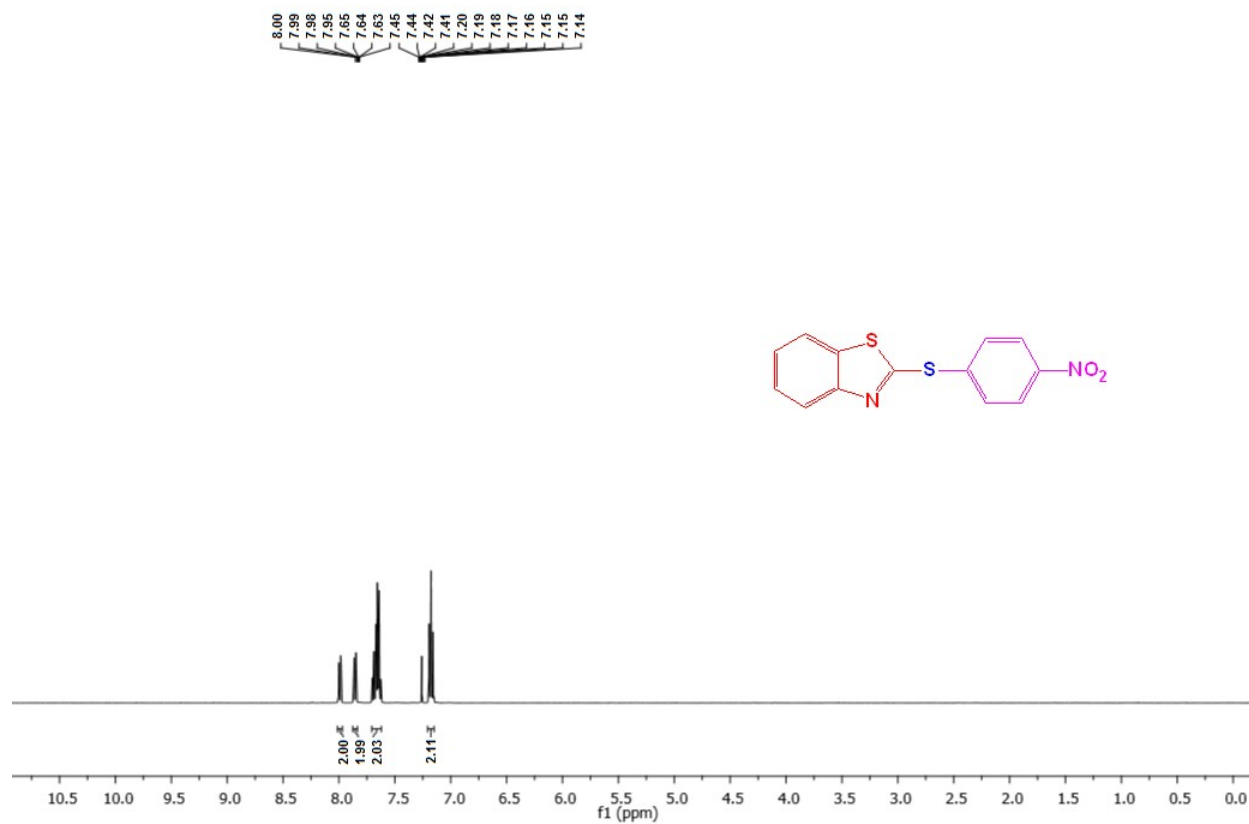
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7.23



# Supplementary Information

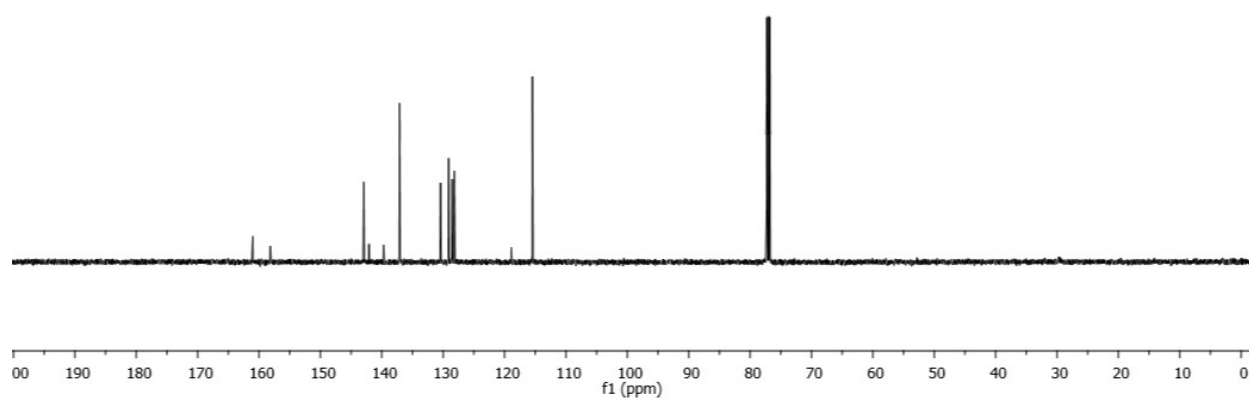
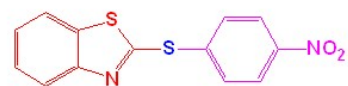


# Supplementary Information

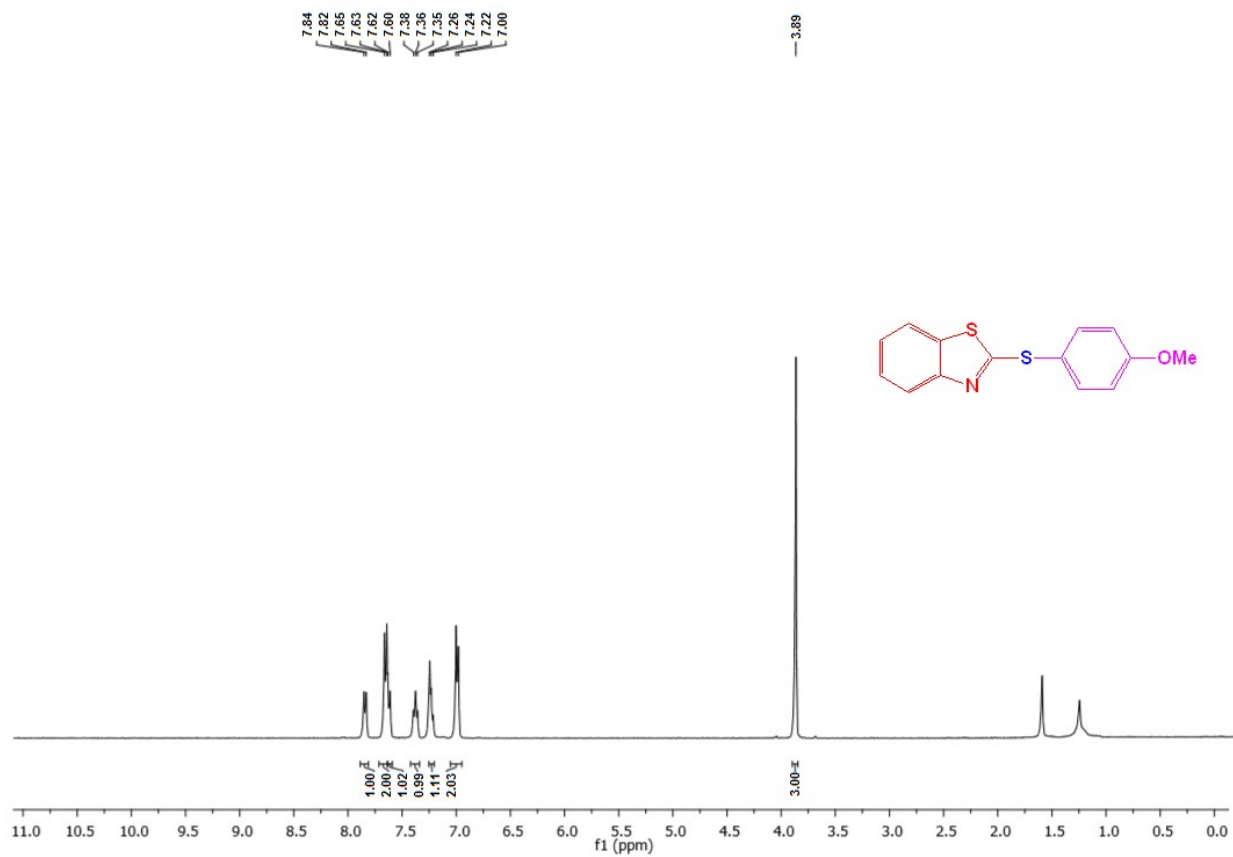


## Supplementary Information

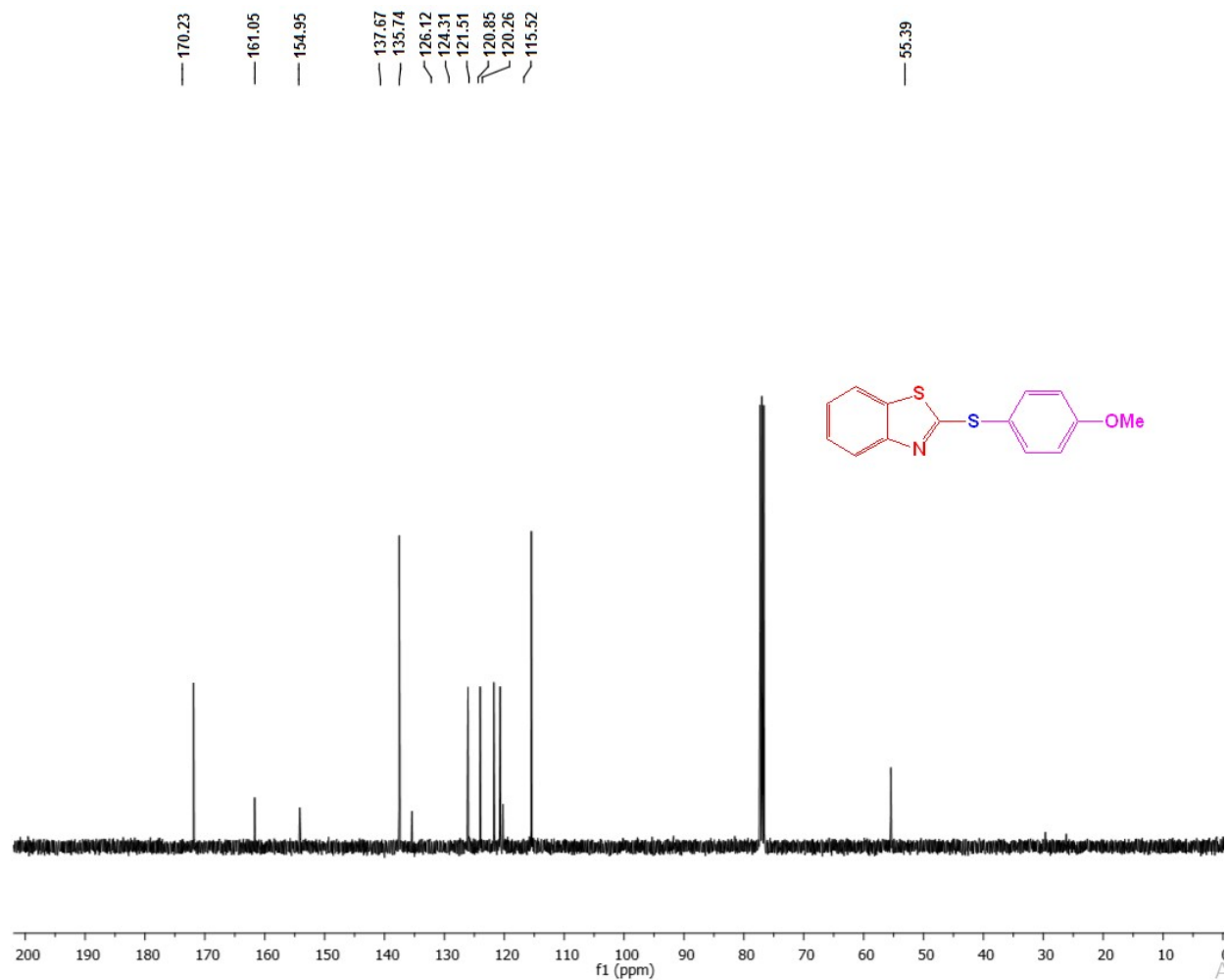
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127.91  
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115.71



# Supplementary Information

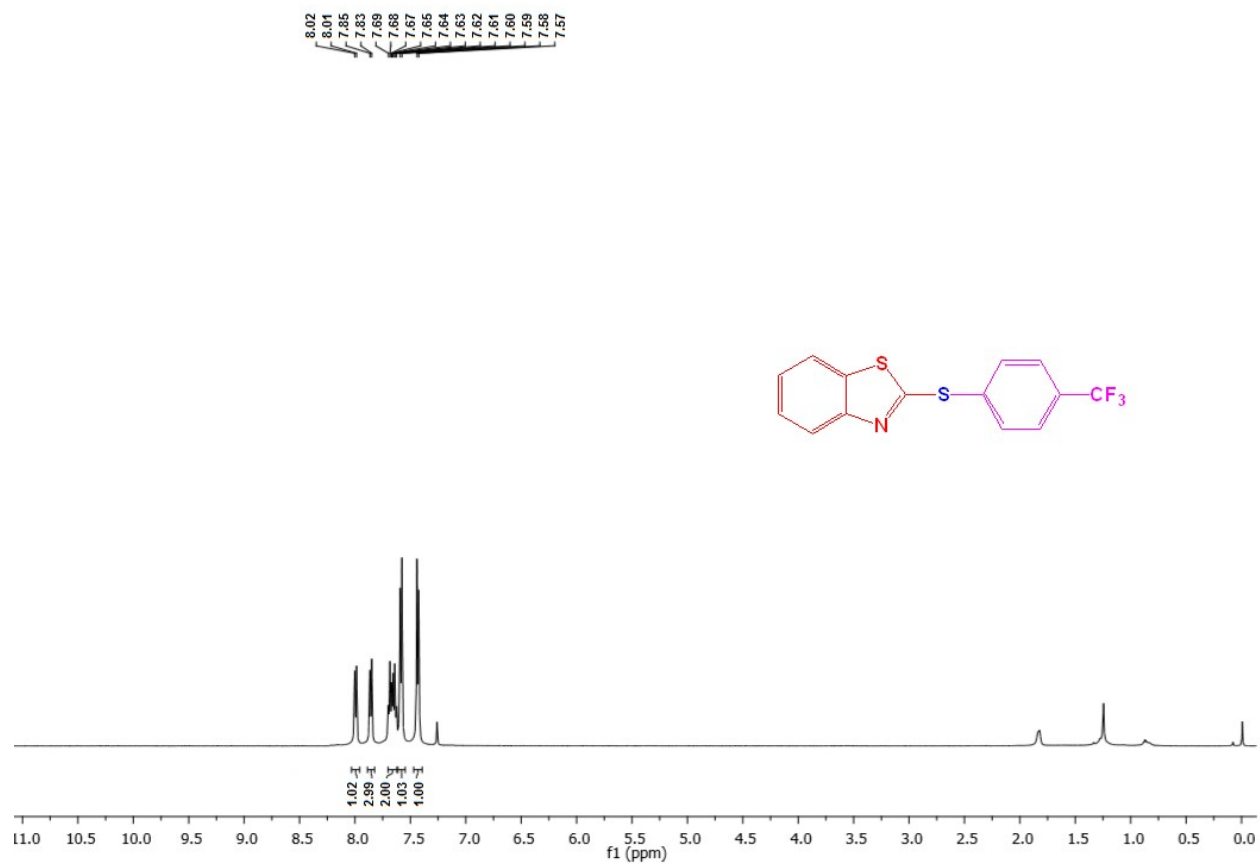


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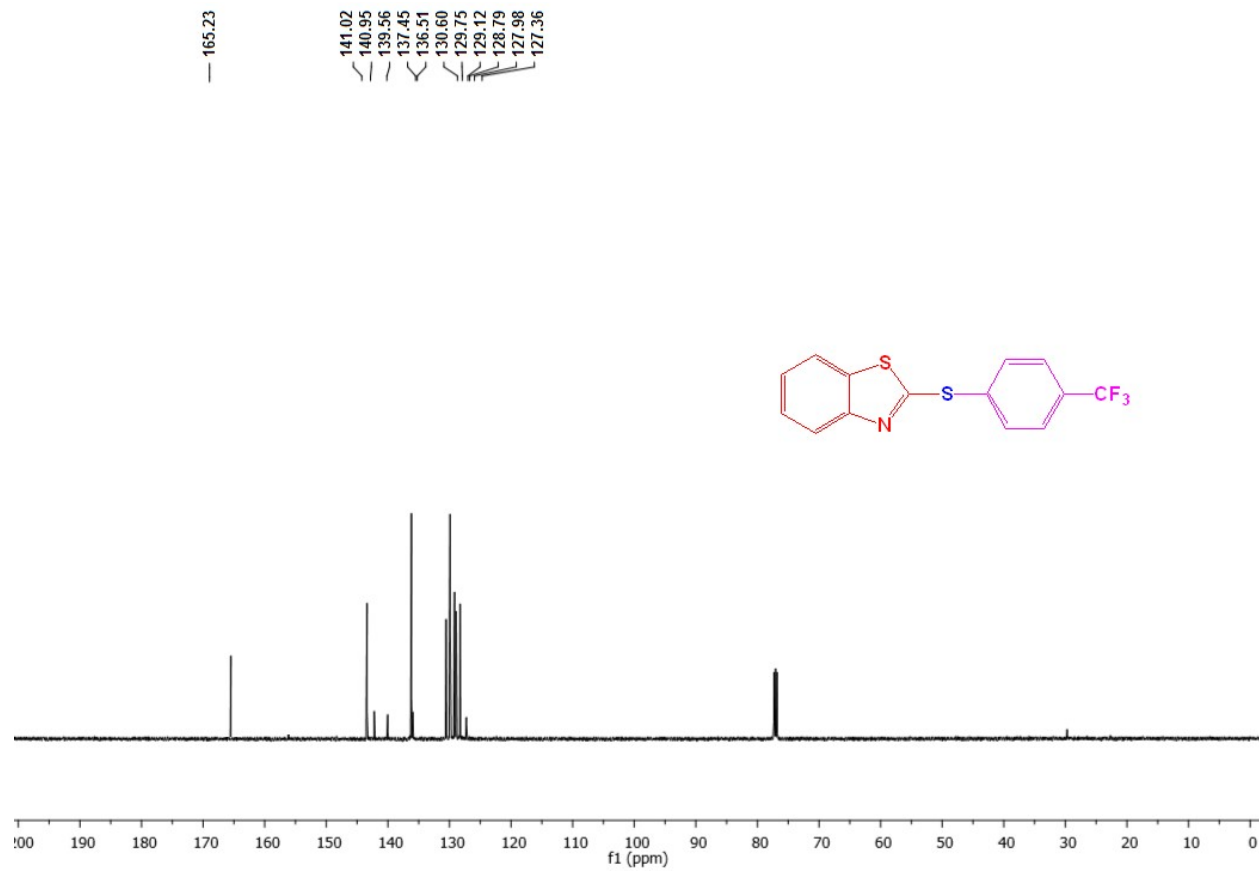




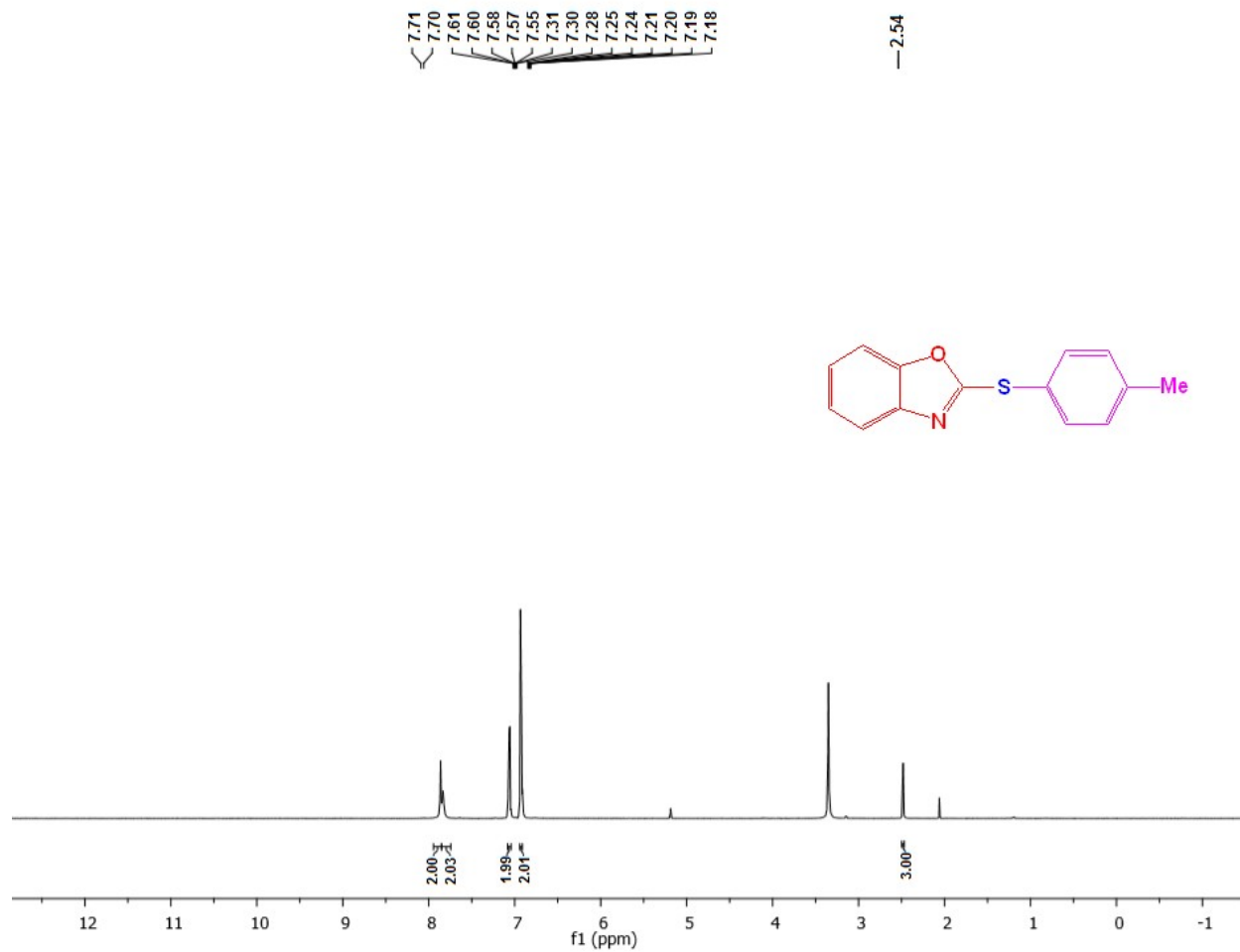
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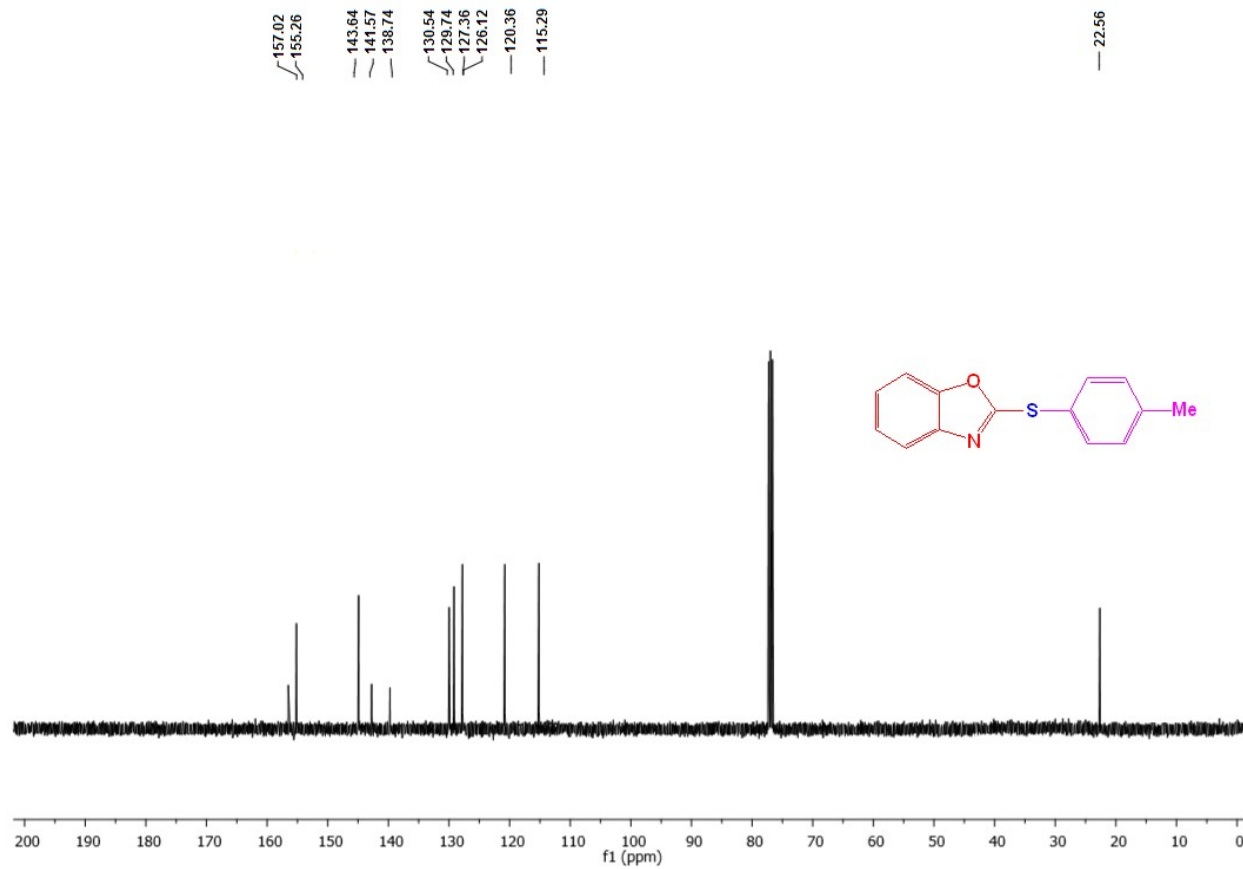
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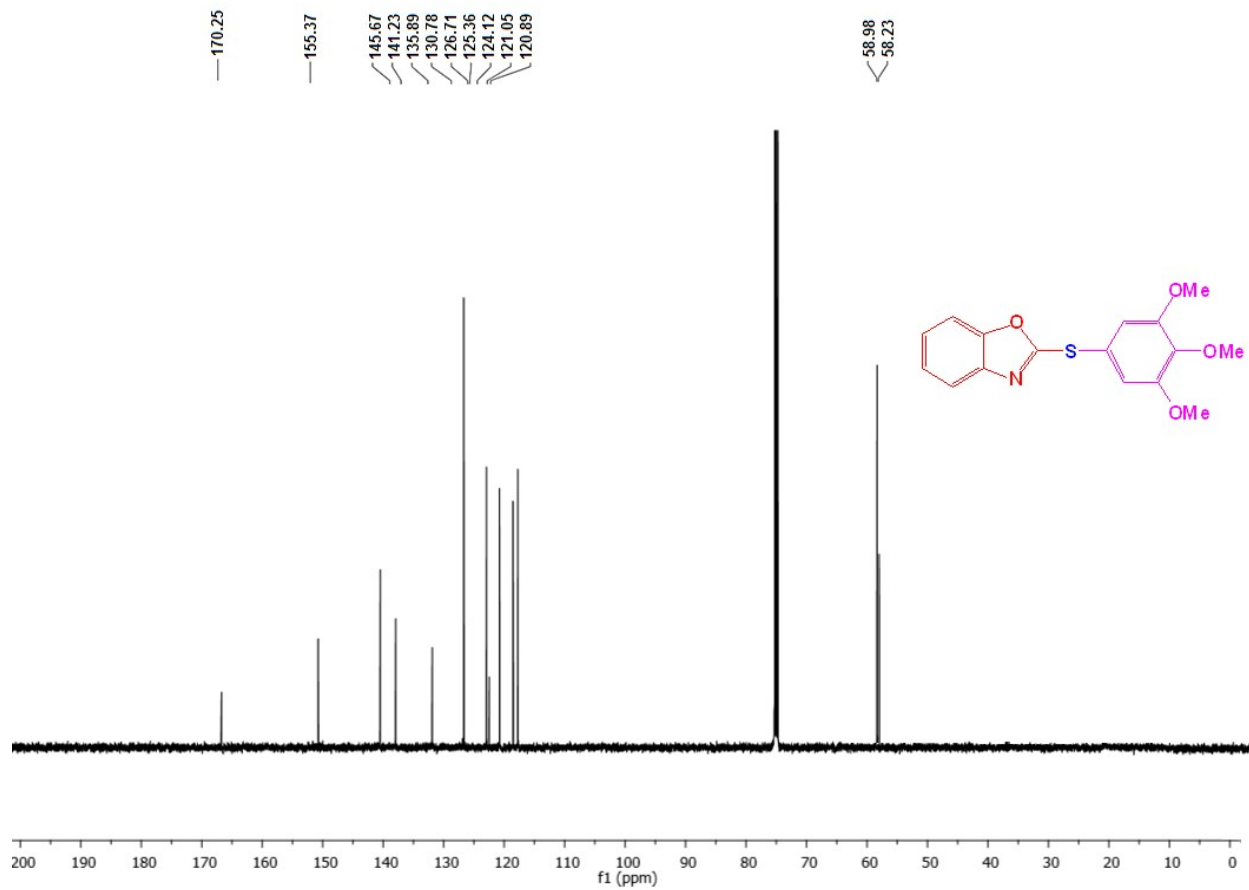
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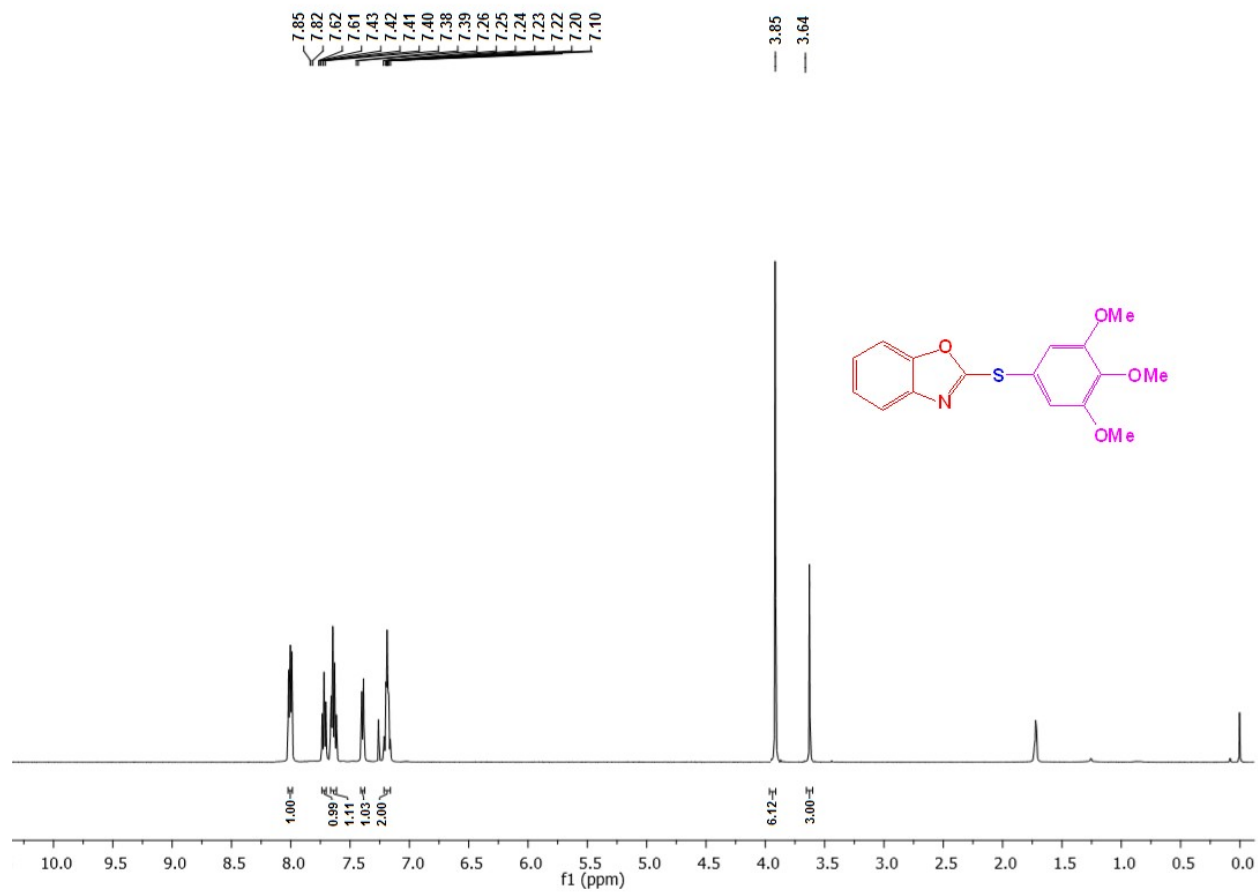
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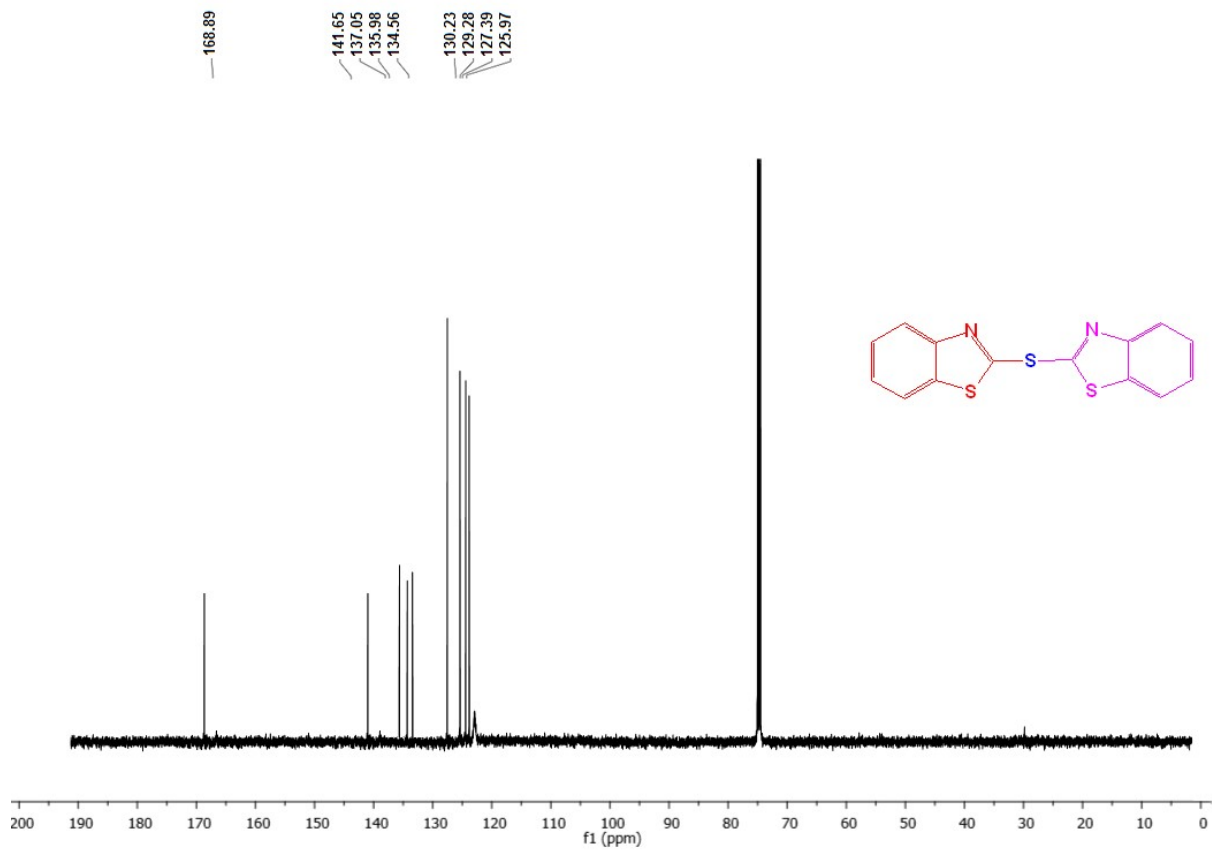
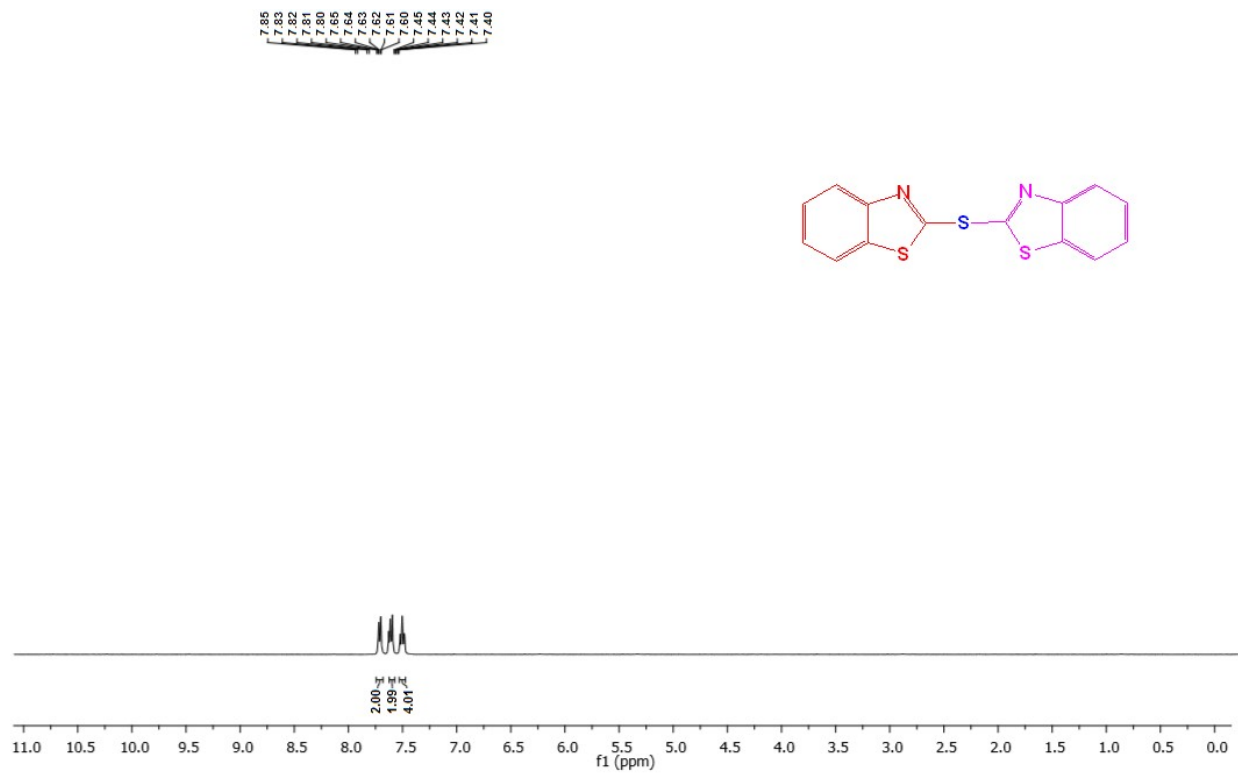
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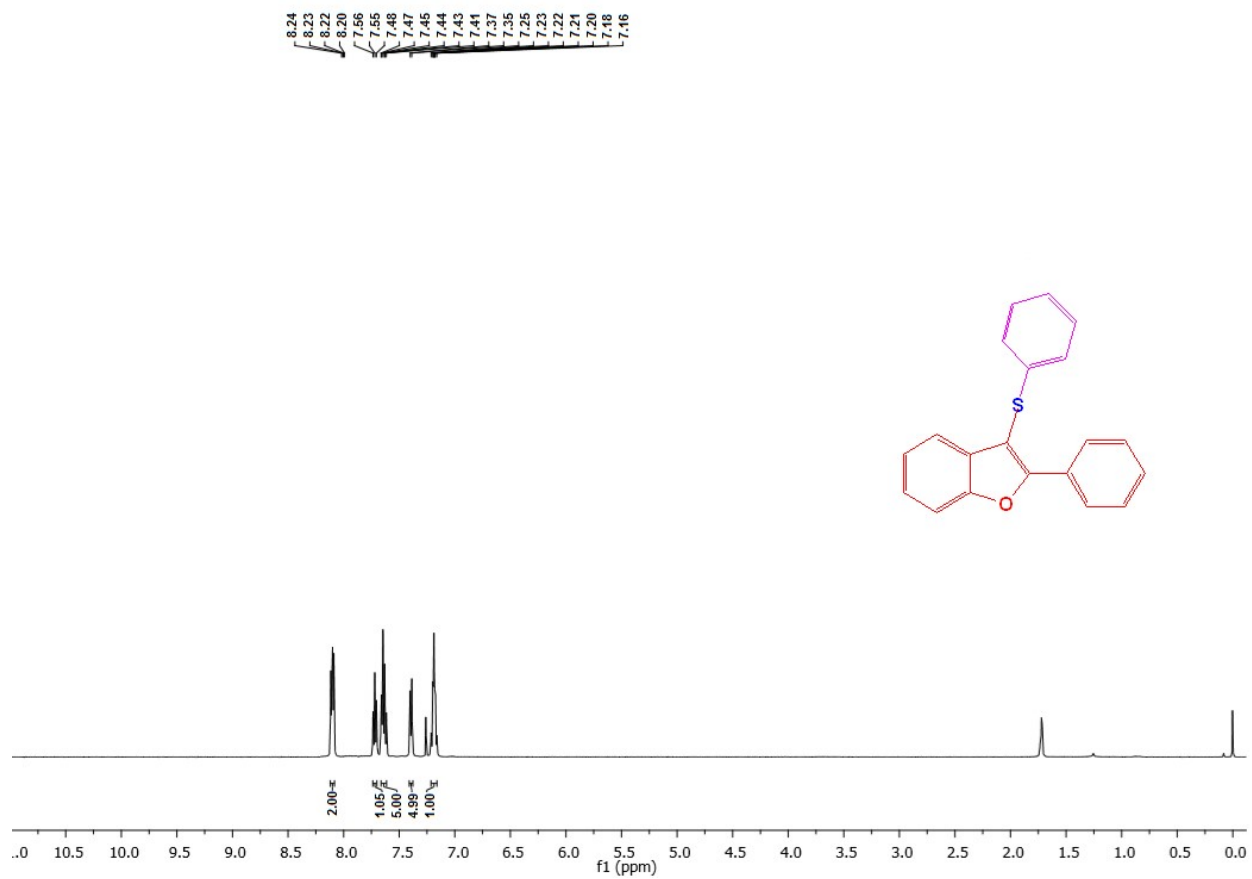
# Supplementary Information



# Supplementary Information

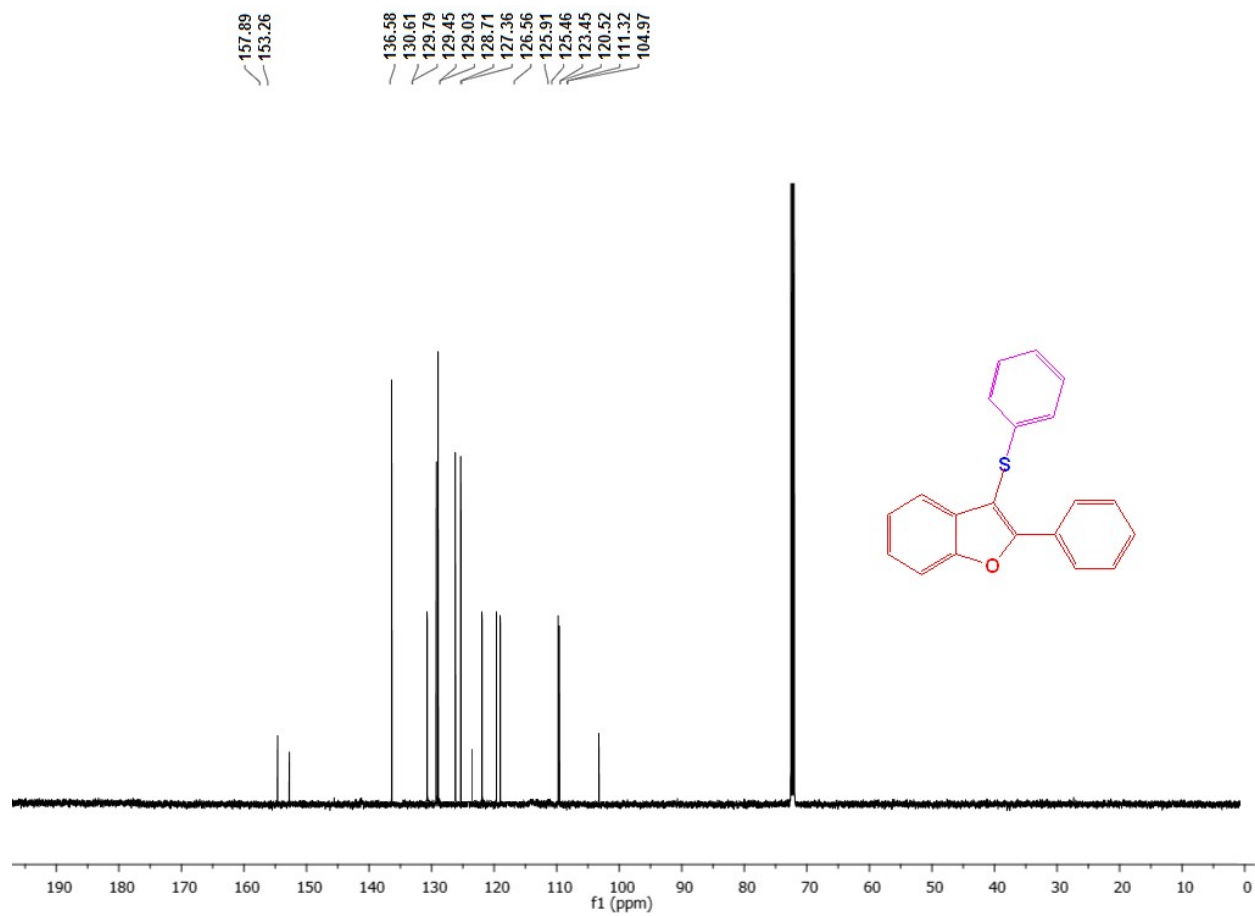


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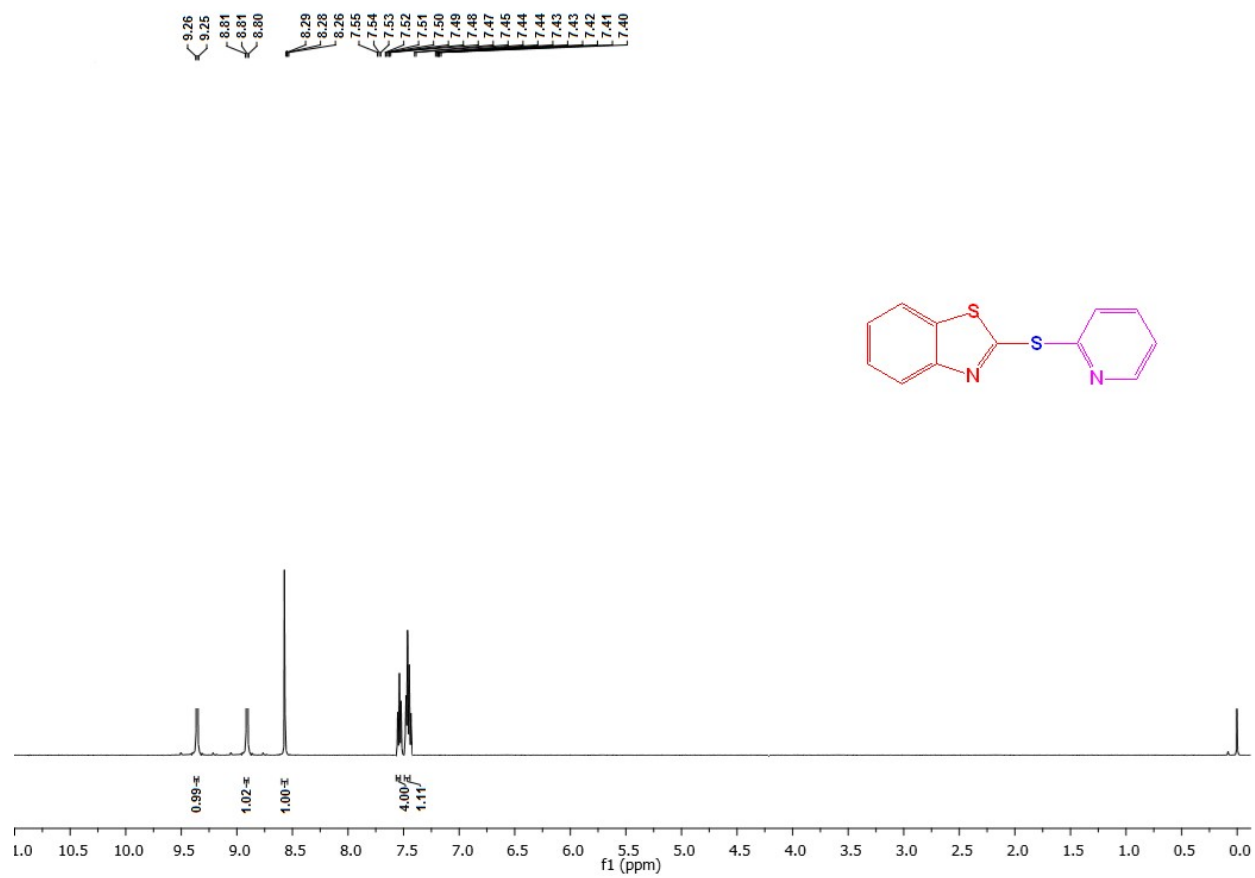




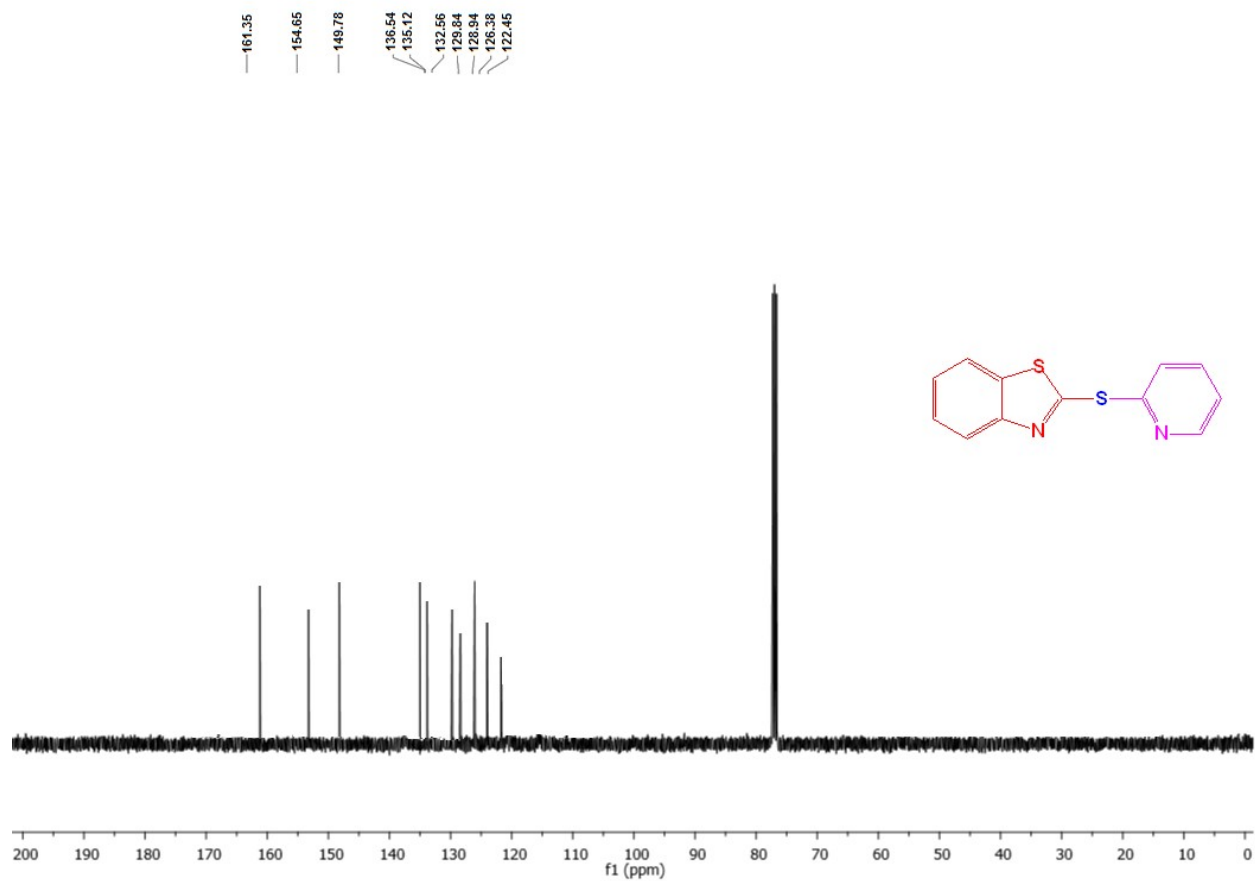
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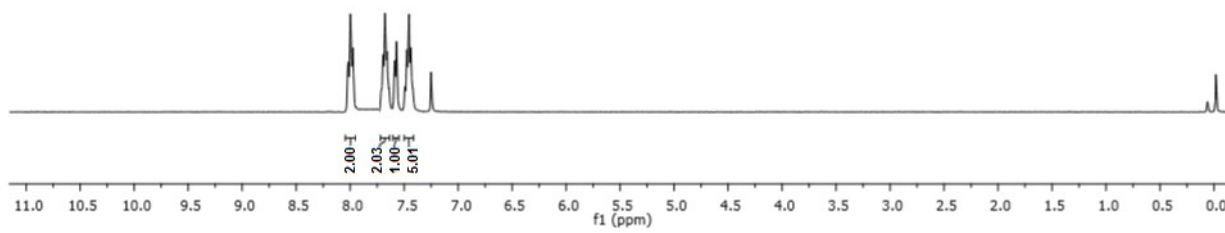
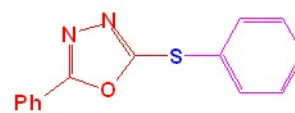


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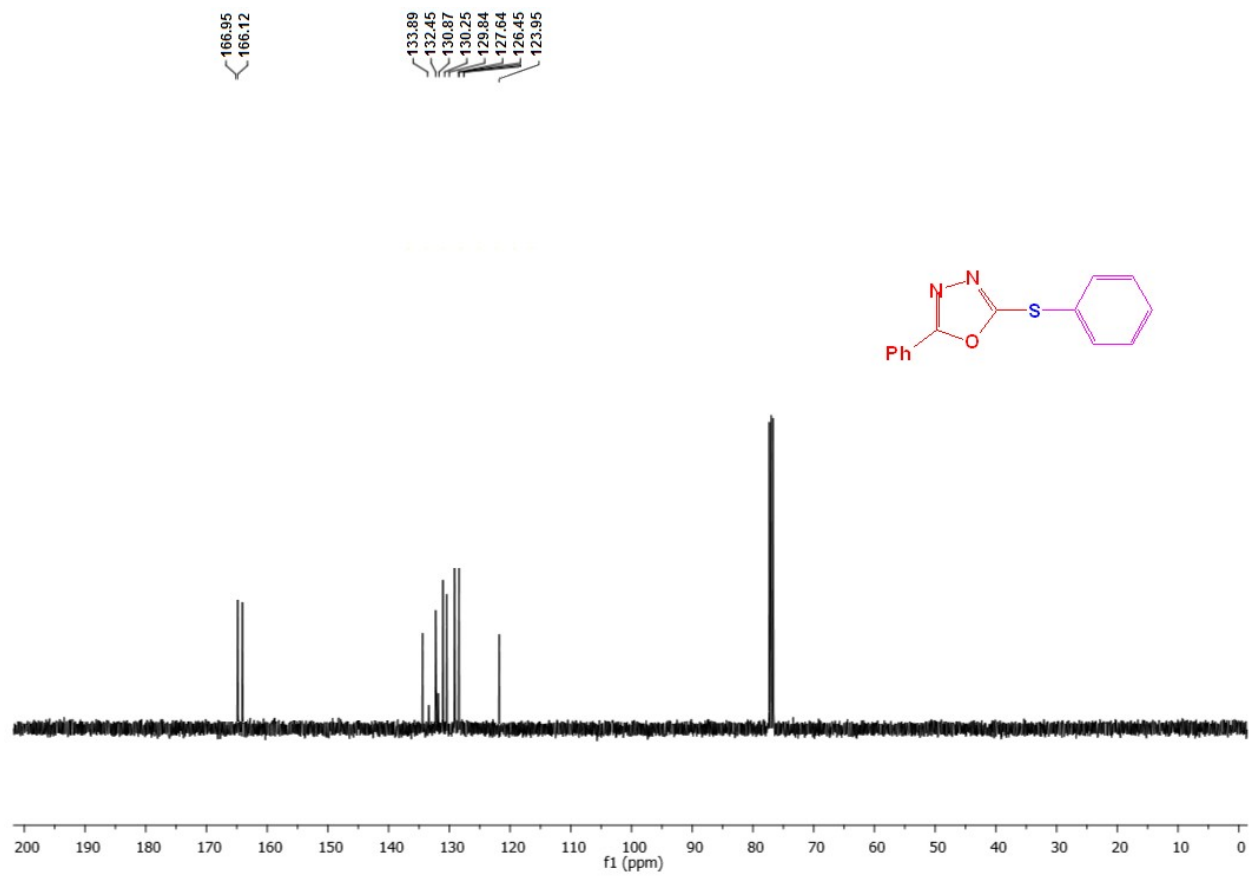


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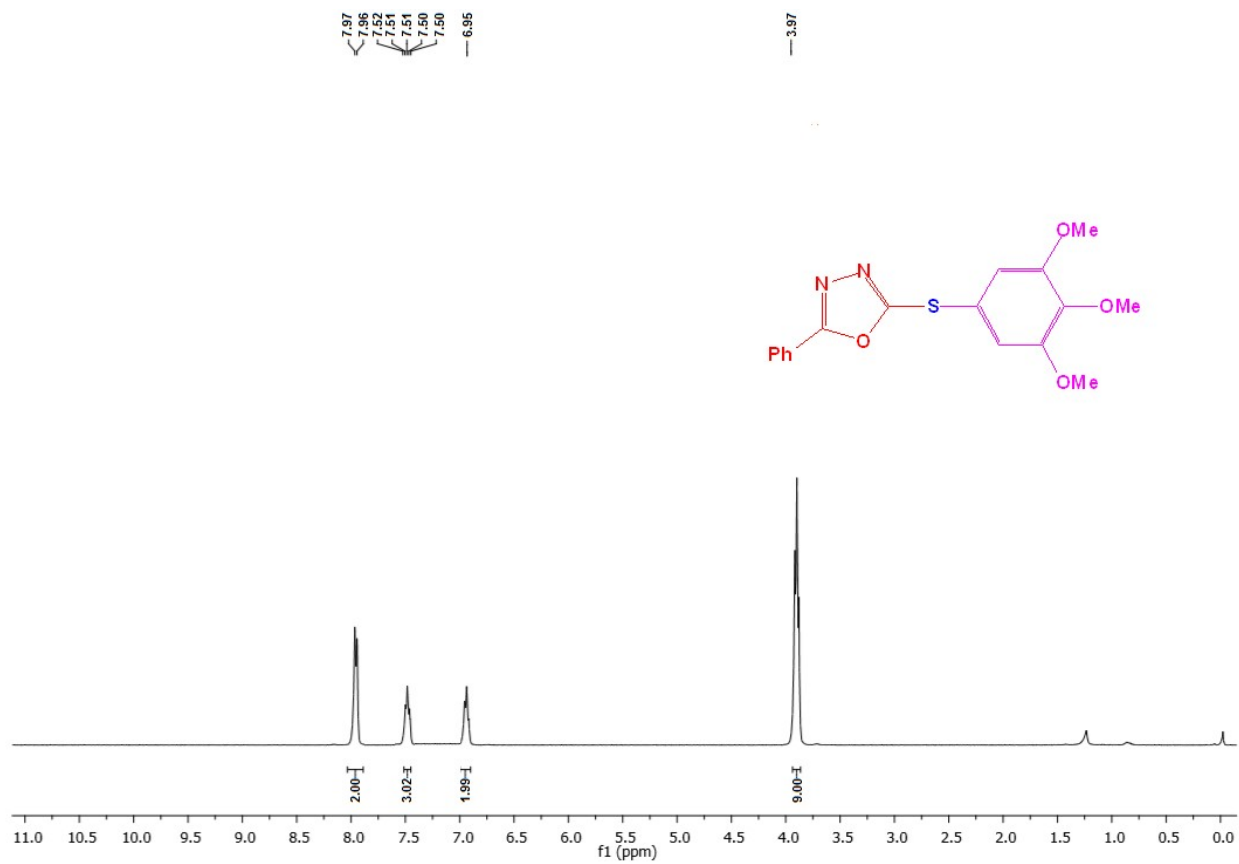
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7.70  
7.68  
7.66  
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7.46  
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7.44  
7.42



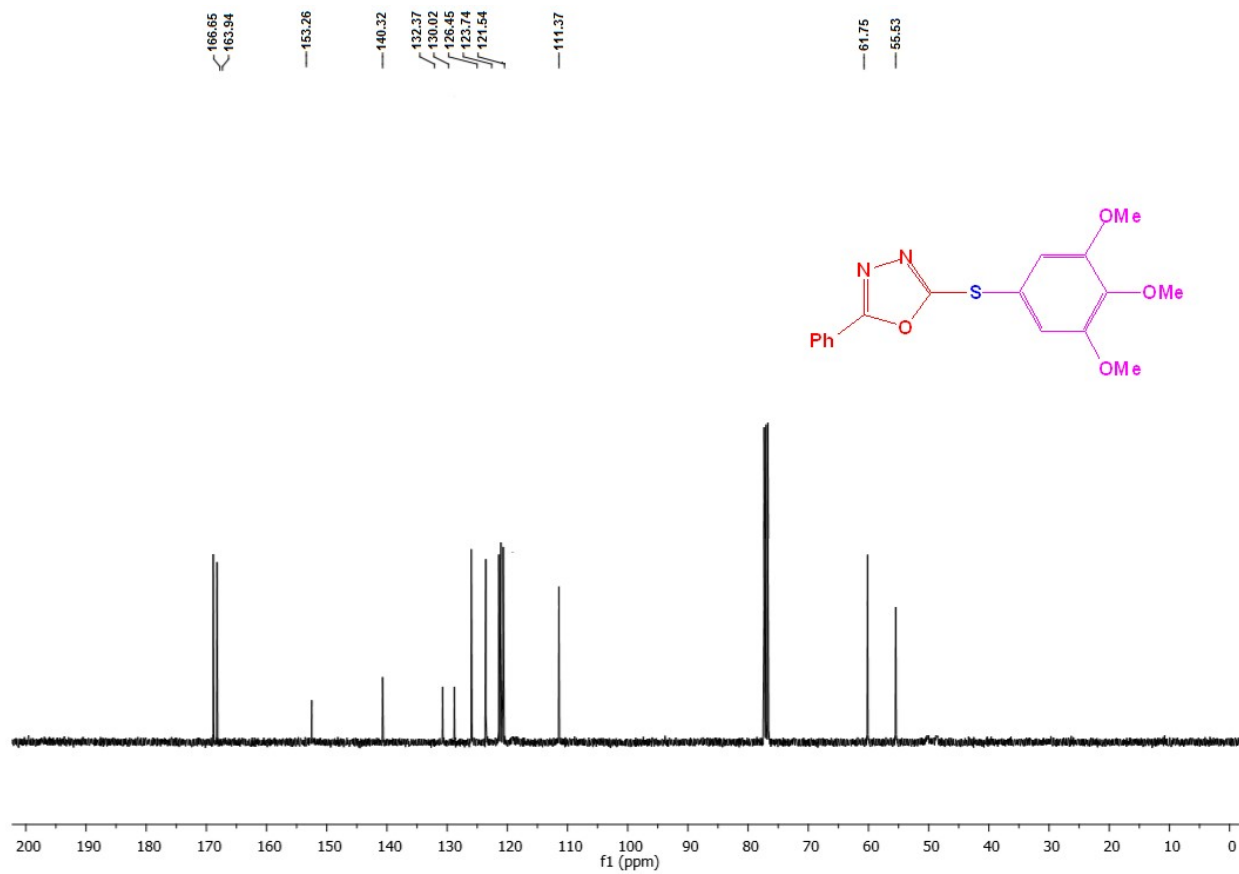
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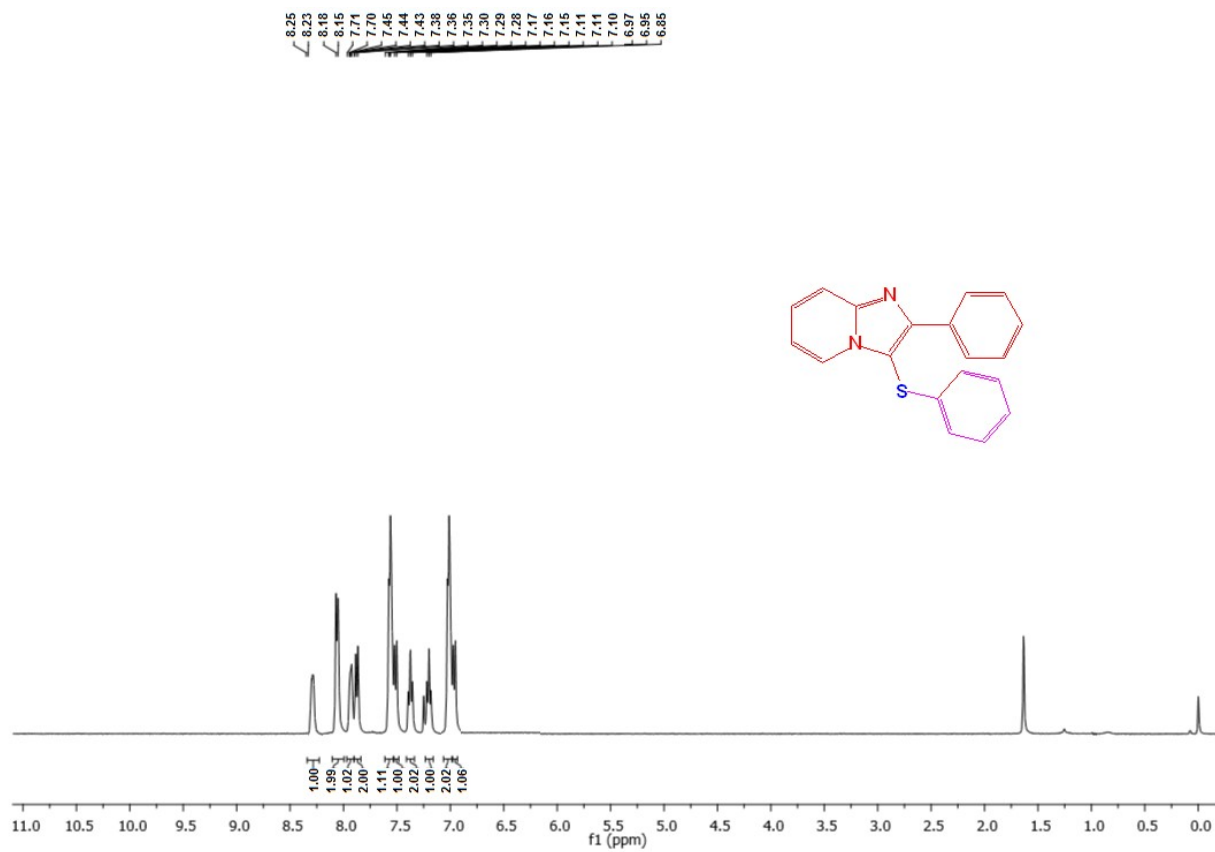
# Supplementary Information



# Supplementary Information

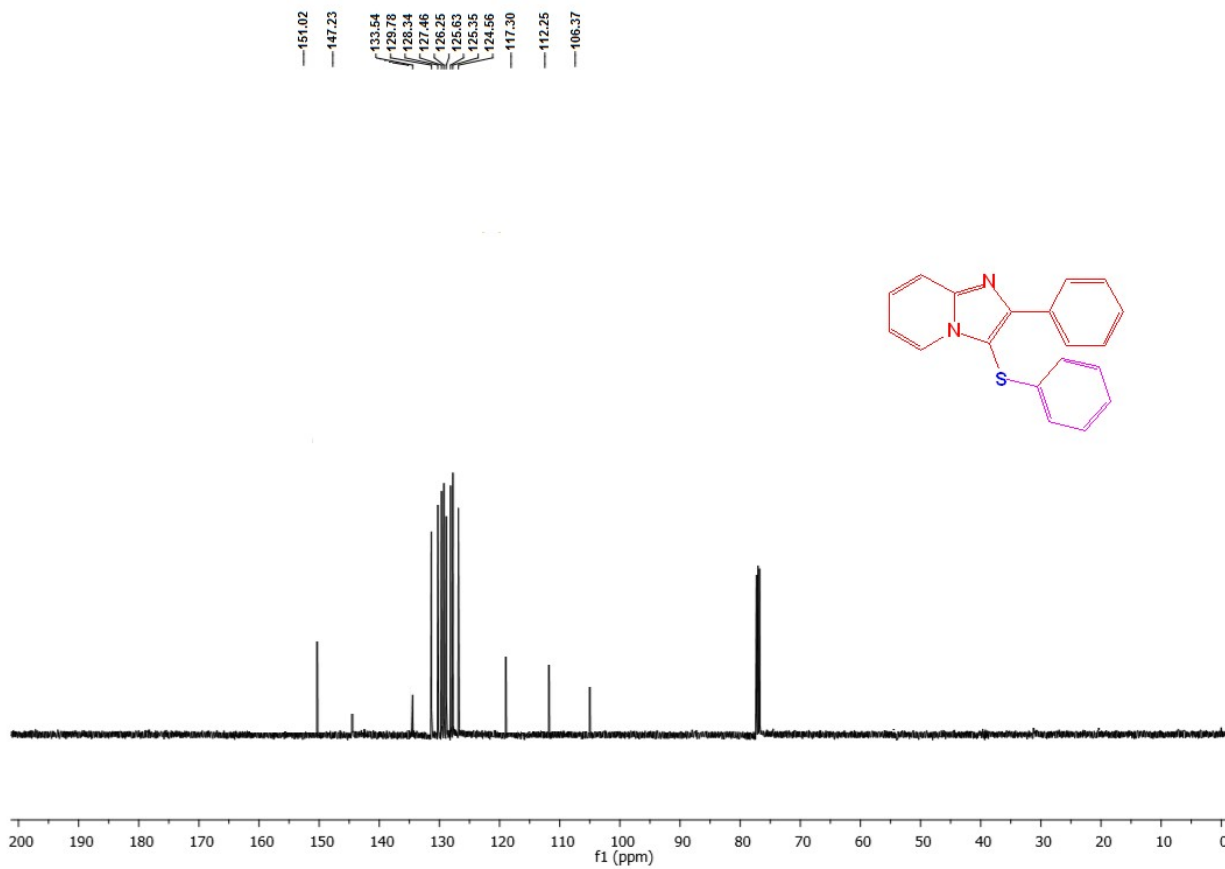


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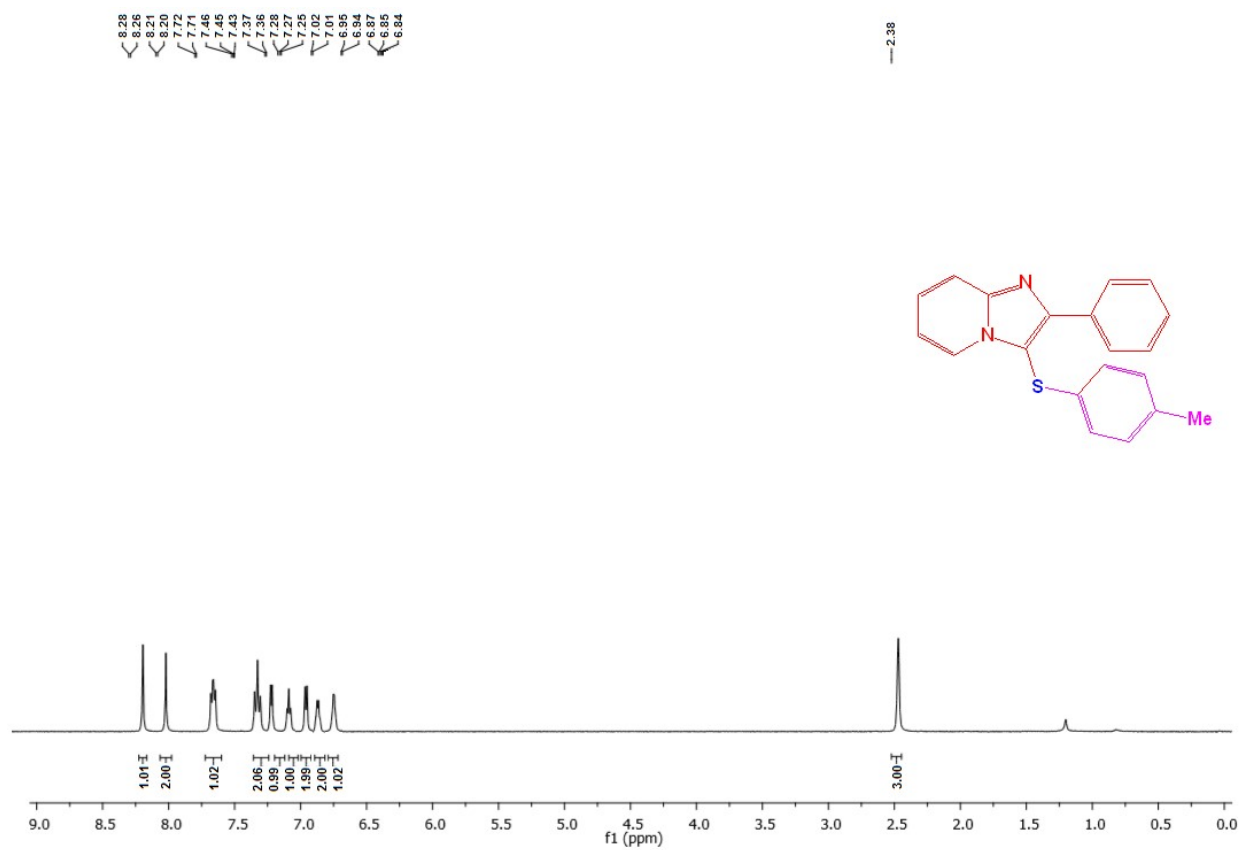




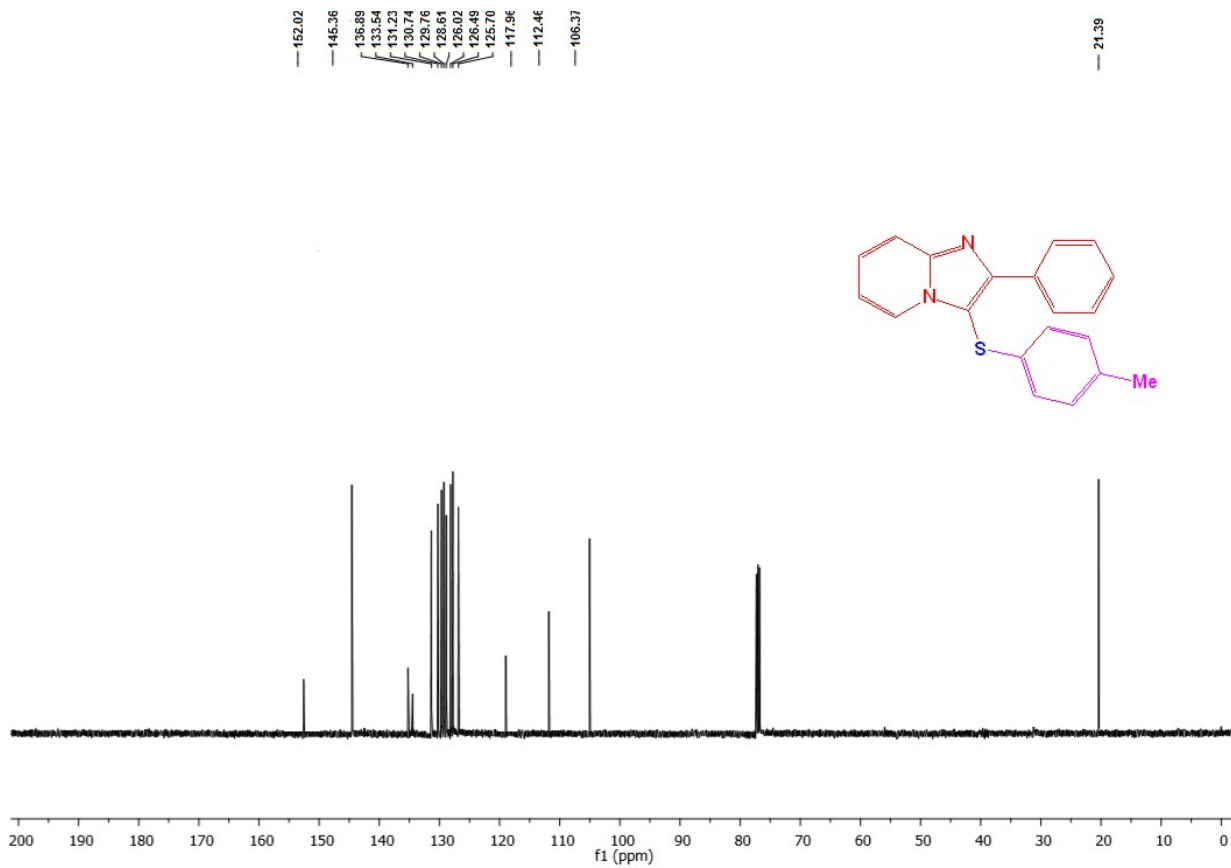
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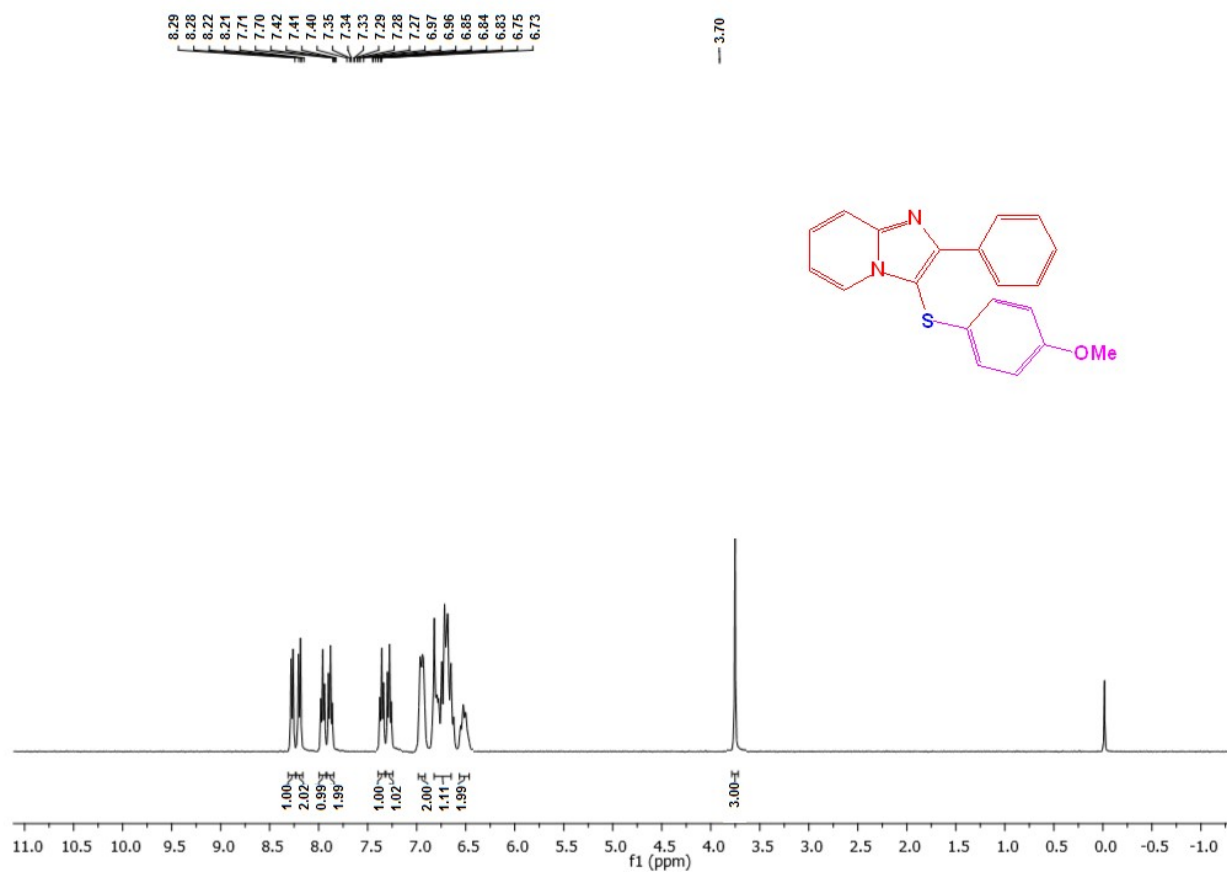
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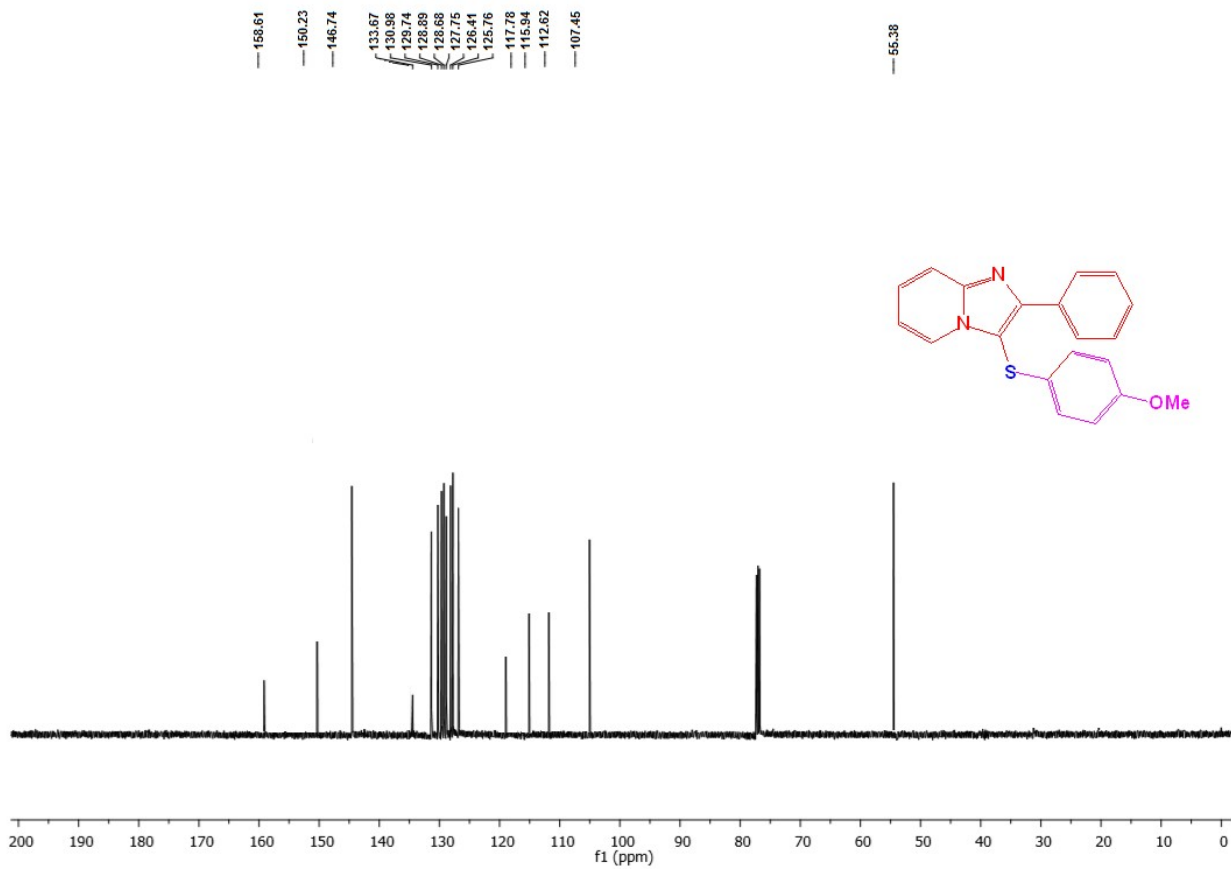
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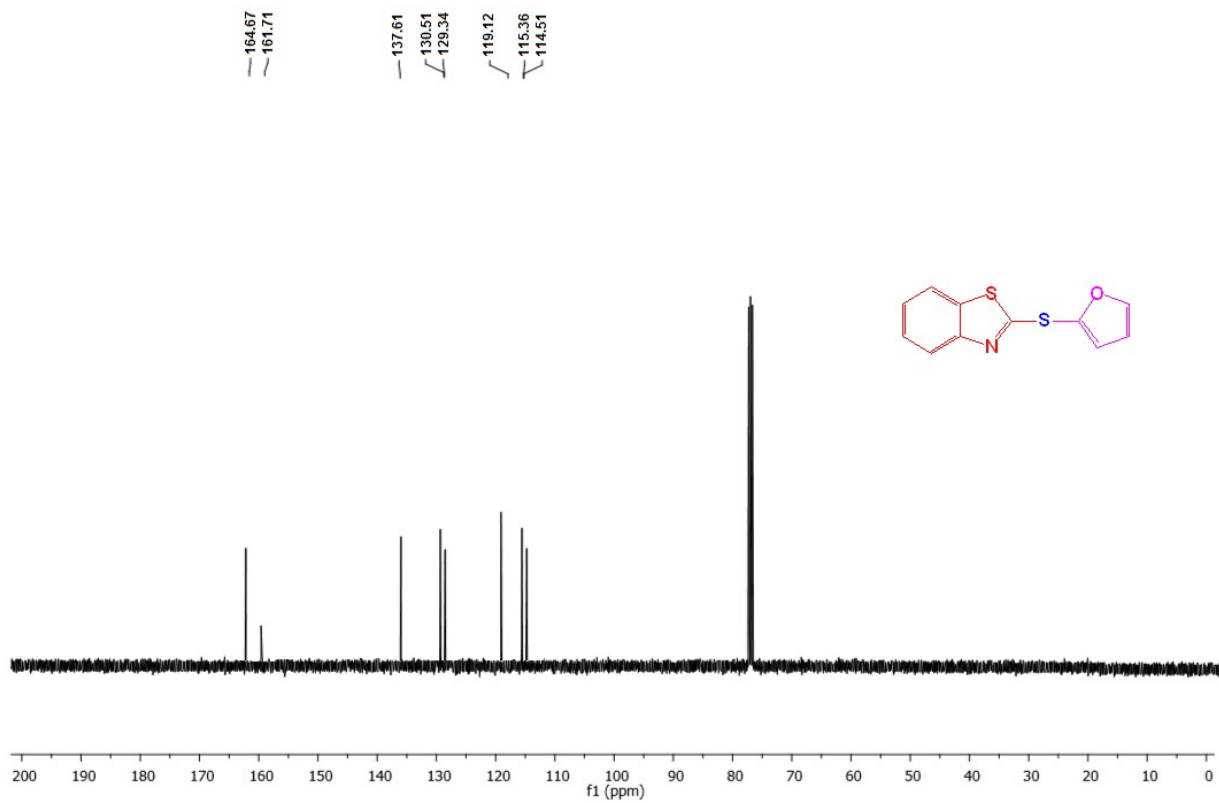
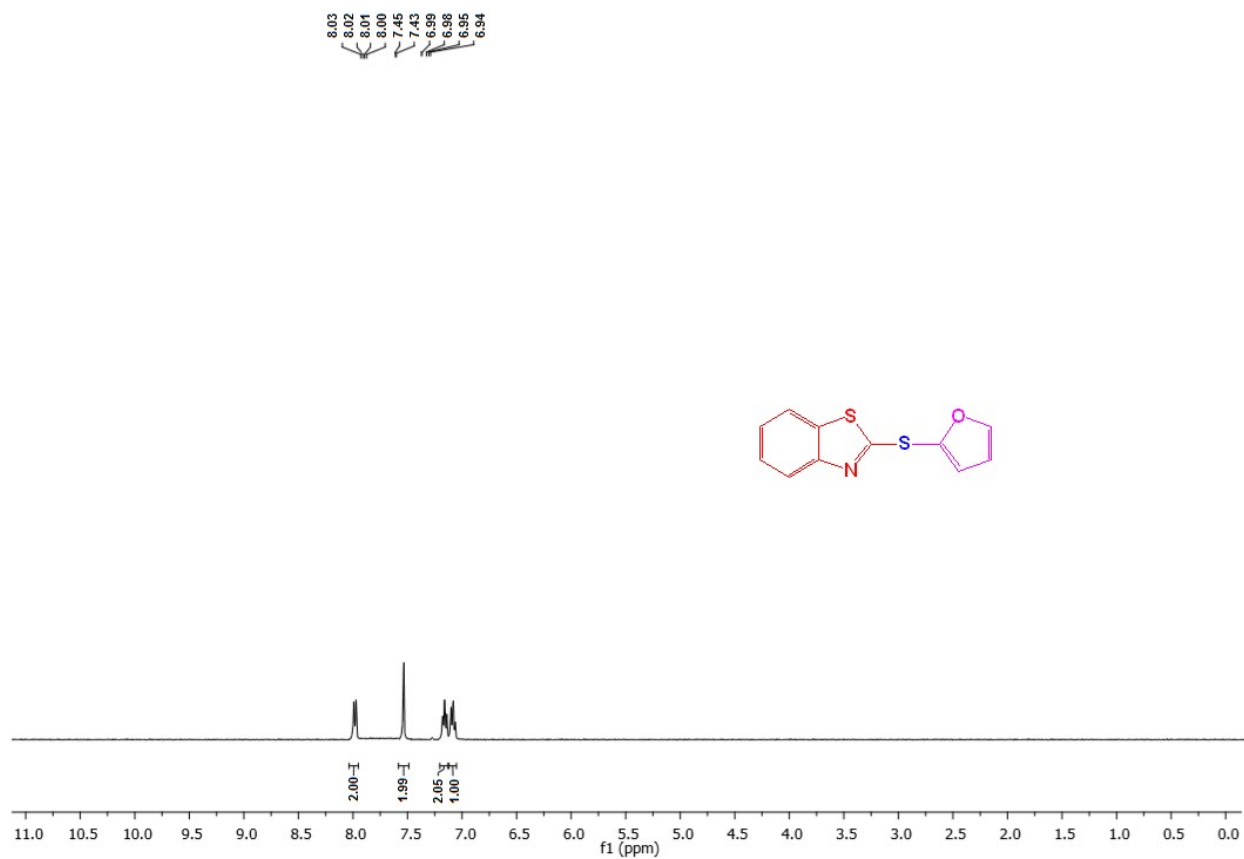
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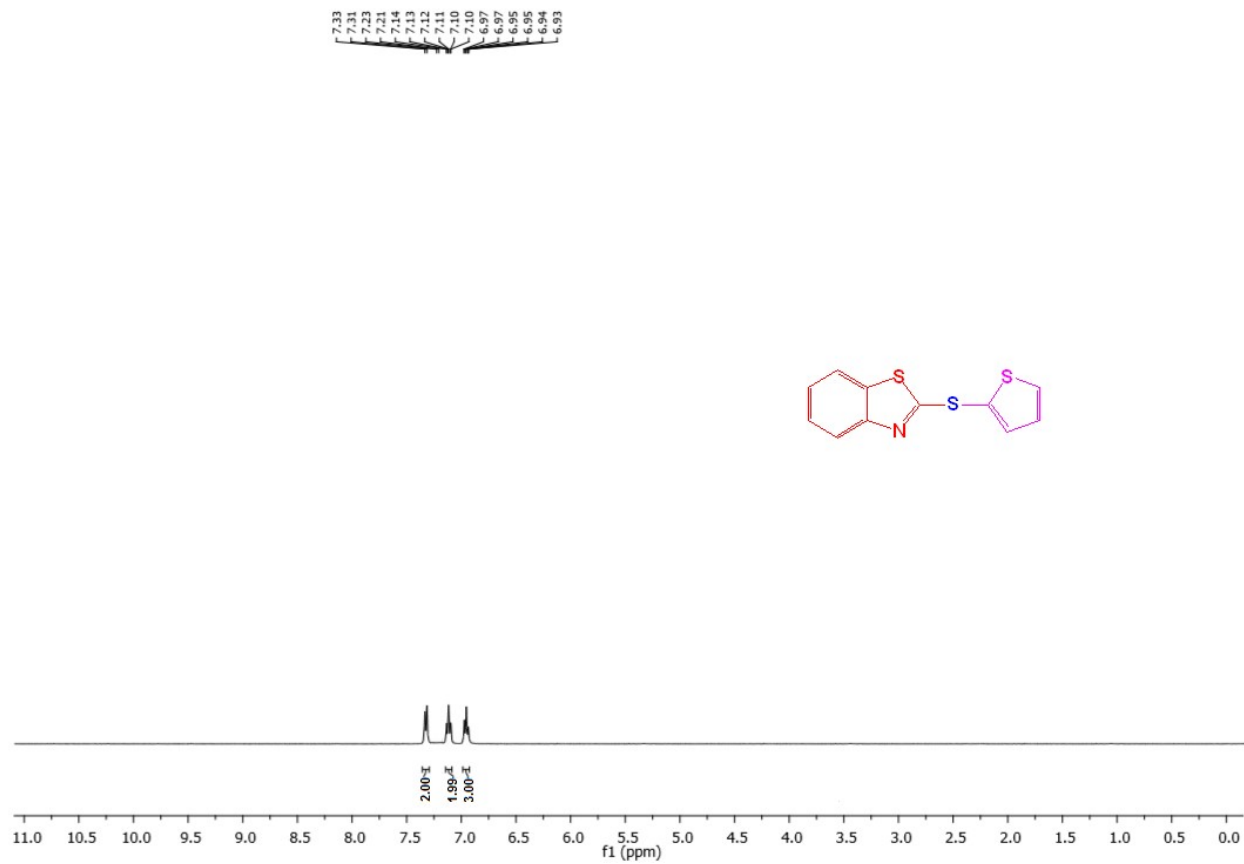
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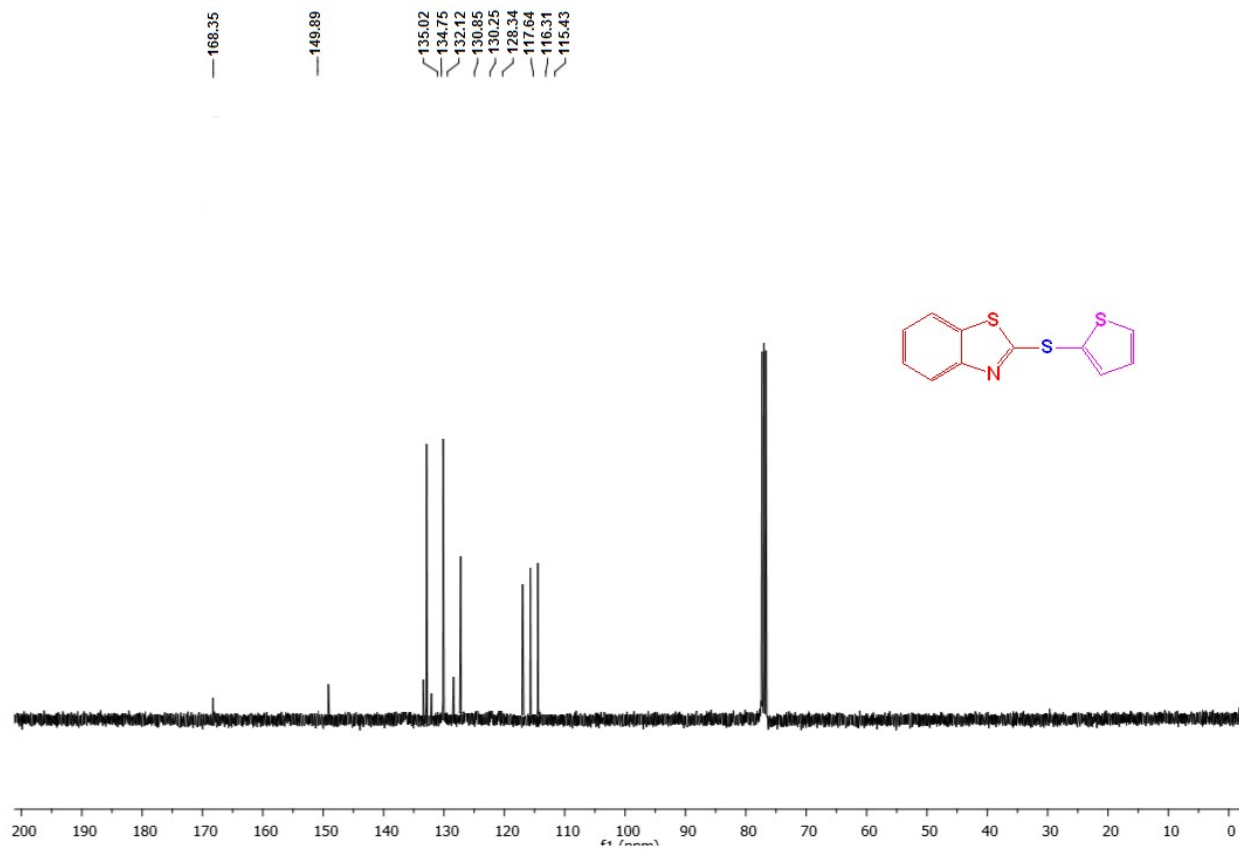
# Supplementary Information



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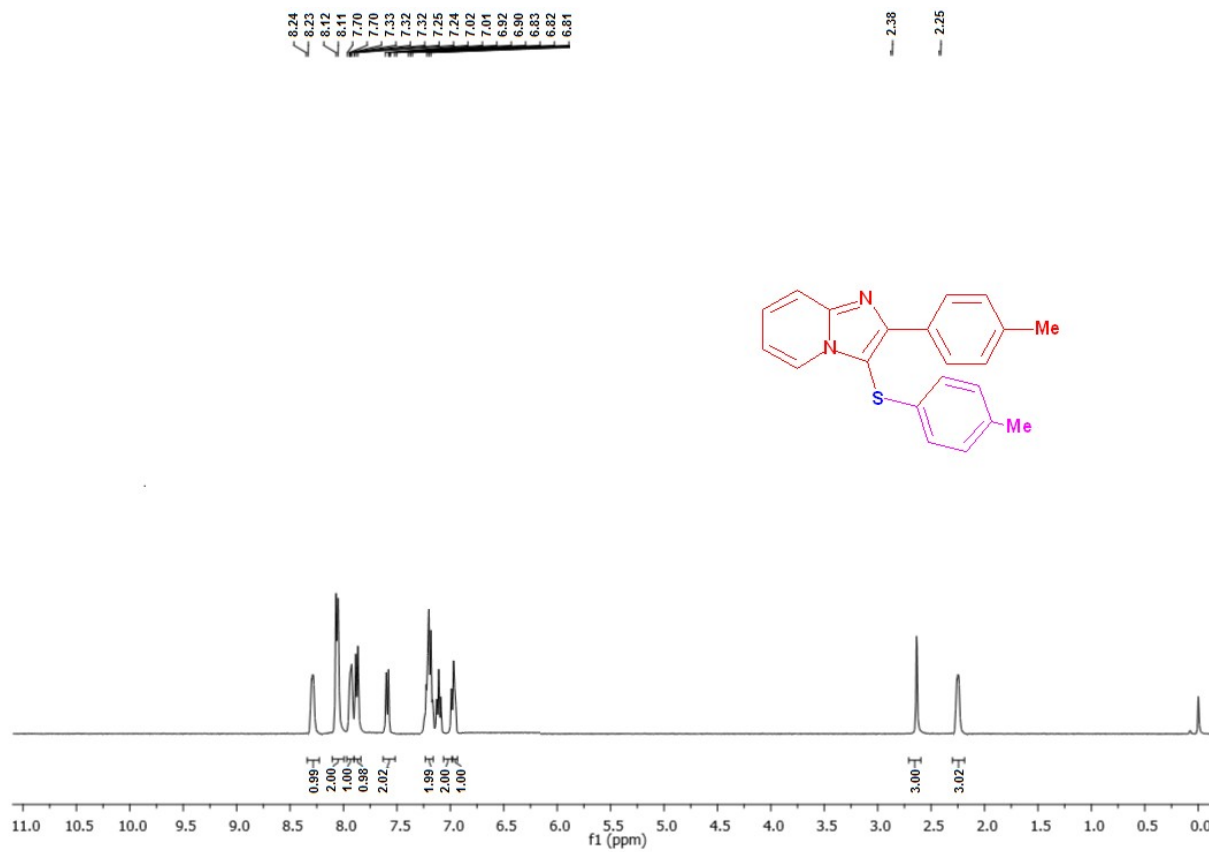


# Supplementary Information





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