Supporting Information for

Chemoselective Cross-Coupling Reaction of Sodium Sulfinates with Phenols under Aqueous Conditions

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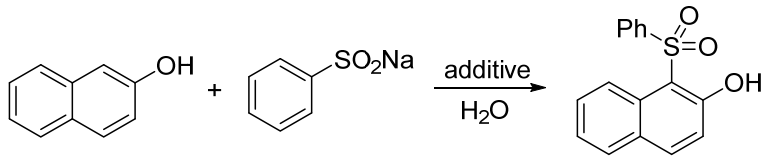
General information:

Sulfenylation reaction is conducted under an atmosphere of argon and sulfonylation reaction is carried out in an air atmosphere. Flash column chromatography was performed over silica gel 48-75 μm. ^{1}H NMR and ^{13}C NMR spectra were recorded on Bruker-AV (400 and 100 MHz, respectively) instrument internally referenced to tetramethylsilane (TMS) or acetone signals. MS analyses were performed on an Agilent 5975 GC-MS instrument (EI). High-resolution mass spectra were recorded at Jiangxi University of Traditional Chinese Medicine. The structures of known compounds were further corroborated by comparing their NMR data and MS data with those of literature. Reagents were used as received or prepared by our laboratory.

Optimization of reaction conditions

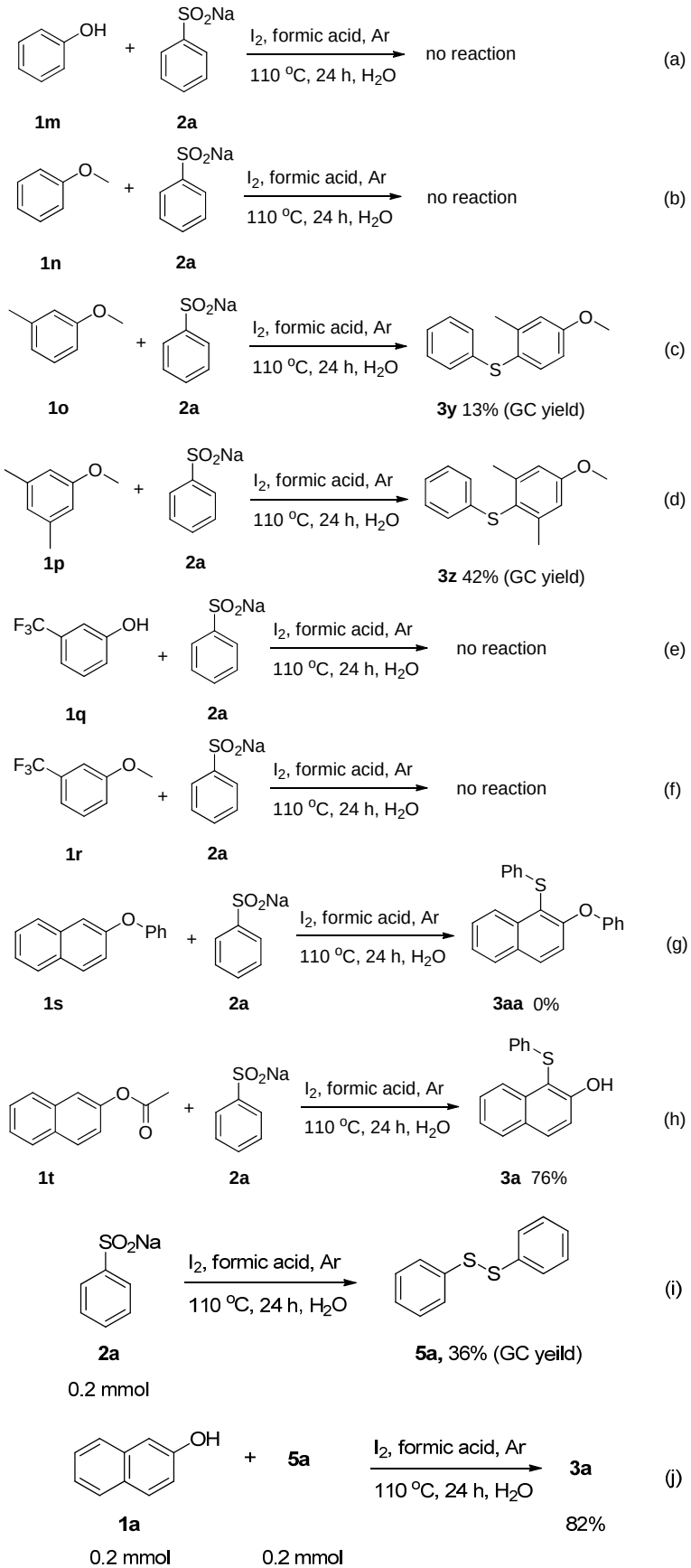
Table S1. Optimization of the reaction conditions[a]



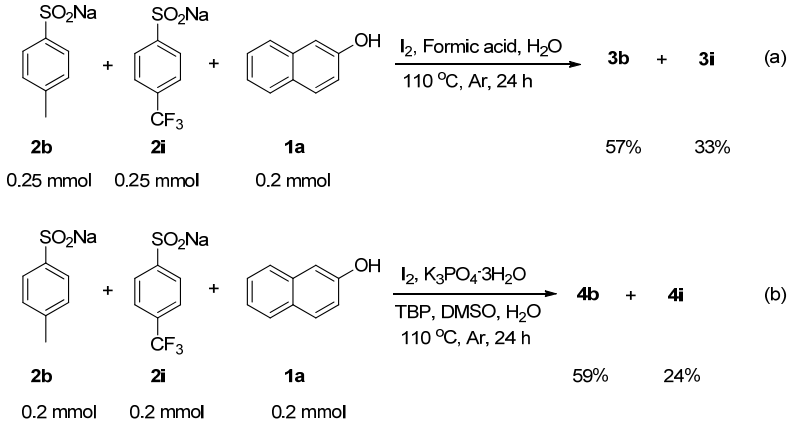
1a **2a** **4a**

Entry	Additive (equiv.)	Base (equiv.)	Oxidant (equiv.)	Yield[b](%)
1	I_2(1)			40
2	I_2(1)	$K_3PO_4{\cdot}3H_2O$(1)		48
3	I_2(1)	$K_3PO_4{\cdot}3H_2O$(1)	O_2	50
4	I_2(1)	$K_3PO_4{\cdot}3H_2O$(1)	DMSO(1)	60
5	I_2(1)	$K_3PO_4{\cdot}3H_2O$(1)	TBHP(1)	40
6	I_2(1)	$K_3PO_4{\cdot}3H_2O$(1)	TBP(1)	61
7	I_2(1)	$K_3PO_4{\cdot}3H_2O$(1)	$K_2S_2O_8$	20
8	I_2(1)	$K_3PO_4{\cdot}3H_2O$(1)	Oxone	24
9	I_2(1)	$K_3PO_4{\cdot}3H_2O$(1)	DMSO(1)+TBP(1)	92
10	I_2(1)	K_2CO_3(1)	DMSO(1)+TBP(1)	70
11	I_2(1)	$KHCO_3$ (1)	DMSO(1)+TBP(1)	35
12	I_2(1)	KOH(1)	DMSO(1)+TBP(1)	30
13	I_2(1)	KTB(1)	DMSO(1)+TBP(1)	27
14	KI(1)	$K_3PO_4{\cdot}3H_2O$(1)	DMSO(1)+TBP(1)	3
15	TBAI(1)	$K_3PO_4{\cdot}3H_2O$(1)	DMSO(1)+TBP(1)	4
16	NIS(1)	$K_3PO_4{\cdot}3H_2O$(1)	DMSO(1)+TBP(1)	50
17[c]	I_2(1)	$K_3PO_4{\cdot}3H_2O$(1)	DMSO(1)+TBP(1)	70
18	I_2(0.5)	$K_3PO_4{\cdot}3H_2O$(1)	DMSO(1)+TBP(1)	40

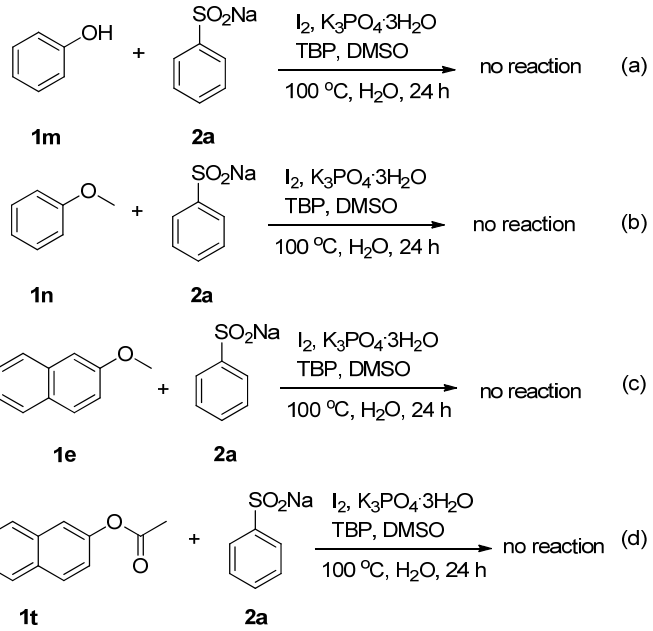
[a] Conditions: **1a** (0.2 mmol), **2a** (0.4 mmol), H_2O (0.5 mL), 24 h, 100 °C under air. [b] GC yield. [c] 80 °C



Scheme S1 Control experiments for the direct sulfenylation reaction under various conditions



Scheme S2 Control experiments



Scheme S3 Control experiments for the direct sulfonylation reaction under various conditions

General procedure: (3a):

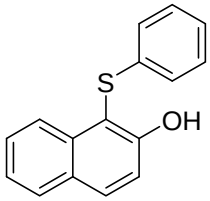
A 10 mL oven-dried reaction vessel was charged with sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol), naphthalen-2-ol (**1a**, 28.8 mg, 0.2 mmol), I_2 (50.8 mg, 0.2 mmol). Formic acid (0.1 mL) and H_2O (0.5 mL) was added to the sealed reaction vessel by syringe. The resulting solution was stirred at 110 ^oC for 24 h. The volatiles were removed under vacuum and the residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **3a** as white solid; yield: 40.3 mg (80%), mp 50 - 53 ^oC.

General procedure: (4a):

A 10 mL oven-dried reaction vessel was charged with sodium benzenesulfinate (**2a**, 65.6 mg, 0.4 mmol), naphthalen-2-ol (**1a**, 28.8 mg, 0.2 mmol), I_2 (50.8 mg, 0.2 mmol), $K_3PO_4{\cdot}3H_2O$ (53.2 mg, 0.2 mmol). TBP (35 μL, 0.2 mmol), DMSO (15 μL, 0.2 mmol) and H_2O (0.5 mL) was added to the sealed reaction vessel by syringe. The resulting solution was stirred at 100 ^oC for 24 h. The

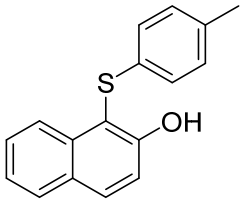
volatiles were removed under vacuum and the residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **4a** as yellow solid; yield: 46.6 mg (82%), mp 129 - 133 ^{o}C.

1-(Phenylsulfonyl)naphthalen-2-ol (3a, CAS: 97992-89-7)[1]



^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 8.22 (d, J = 8.3 Hz, 1H), 7.91 (d, J = 8.9 Hz, 1H), 7.81 (d, J = 8.0 Hz, 1H), 7.49 (t, J = 7.5 Hz, 1H), 7.39 - 7.33 (m, 2H), 7.12 - 7.01 (m, 4H), 7.03 (d, J = 7.7 Hz, 2H). ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 157.0, 135.4, 135.3, 132.8, 129.5, 129.1, 128.5, 127.9, 126.3, 125.9, 124.7, 123.8, 116.8, 108.0. MS (EI) *m/z* (%) 252, 191, 146, 115, 77.

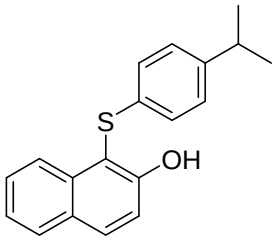
1-Tosylnaphthalen-2-ol (3b, CAS: 799764-32-2)[1]



The reaction was conducted with sodium 4-methylbenzenesulfinate (**2b**, 89 mg, 0.5 mmol) and naphthalen-2-ol (**1a**, 28.8 mg, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **3b** as yellow solid; yield: 47.5 mg (89%), mp 81 - 83 ^{o}C.

^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 8.23 (d, J = 8.3 Hz, 1H), 7.89 (d, J = 8.8 Hz, 1H), 7.81 (d, J = 7.9 Hz, 1H), 7.49 (t, J = 7.5 Hz, 1H), 7.38 - 7.32 (m, 2H), 7.21 (s, 1H), 7.00 - 6.91 (m, 4H), 2.24 (s, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 156.9, 135.8, 135.4, 132.6, 131.7, 129.9, 129.5, 128.5, 127.8, 126.7, 124.7, 123.7, 116.8, 108.7, 20.8. MS (EI) *m/z* (%) 266, 205, 146, 115, 91.

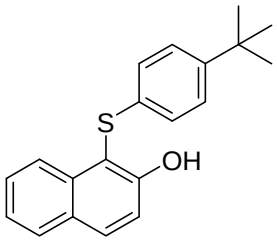
1-((4-*iso*-Propylphenyl)sulfonyl)naphthalen-2-ol (3c)



The reaction was conducted with sodium 4-isopropylbenzenesulfinate (**2c**, 103 mg, 0.5 mmol) and naphthalen-2-ol (**1a**, 28.8 mg, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **3**c as brown semisolid ; yield: 46 mg (78%).

^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 8.25 (d, J = 8.3 Hz, 1H), 7.88 (d, J = 8.8 Hz, 1H), 7.80 (d, J = 7.9 Hz, 1H), 7.48 (t, J = 7.6 Hz, 1H), 7.37 - 7.30 (m, 2H), 7.21 (s, 1H), 7.03 - 6.96 (m, 3H), 2.79 (m, 1H), 1.16 (s, 3H), 1.15 (s, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 156.9, 146.9, 135.5, 132.6, 132.1, 129.5, 128.5, 127.9, 127.4, 126.6, 124.8, 123.8, 116.8, 108.7, 33.6, 23.8. HRMS calcd. for: $C_{19}H_{18}OSNa$ $[M+Na]^+$ 317.09706, found 317.09718.

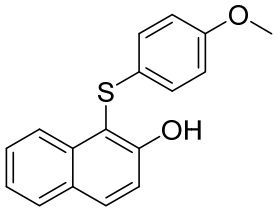
1-((4-(*tert*-Butyl)phenyl)sulfonyl)naphthalen-2-ol (3d)



The reaction was conducted with sodium 4-(tert-butyl)benzenesulfinate (**2d**, 110 mg, 0.5 mmol) and naphthalen-2-ol (**1a**, 28.8 mg, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **3d** as orange semisolid; yield: 42 mg (68%).

^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 8.25 (d, J = 8.2 Hz, 1H), 7.89 (d, J = 8.8 Hz, 1H), 7.80 (d, J = 7.8 Hz, 1H), 7.49 (t, J = 7.5 Hz, 1H), 7.38 - 7.32 (m, 2H), 7.21 - 7.15 (m, 3H), 6.99 - 6.94 (m, 2H), 1.23 (s, 9H). ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 156.9, 149.1, 135.5, 132.6, 131.8, 129.4, 128.5, 127.8, 126.3, 126.2, 124.8, 123.8, 116.8, 108.6, 34.3, 31.2. HRMS calcd. for: $C_{20}H_{20}OSNa$ $[M+Na]^+$ 331.11271, found 331.11211.

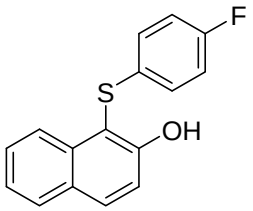
1-((4-Methoxyphenyl)thio)naphthalen-2-ol (3e)



The reaction was conducted with sodium 4-methoxybenzenesulfinate (**2e**, 97 mg, 0.5 mmol) and naphthalen-2-ol (**1a**, 28.8 mg, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **3e** as yellow solid; yield: 48 mg (85%), mp 70 - 73 ^{o}C.

^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 8.26 (d, J = 8.4 Hz, 1H), 7.87 (d, J = 8.9 Hz, 1H), 7.79 (d, J = 8.0 Hz, 1H), 7.50 (t, J = 7.5 Hz, 1H), 7.38 - 7.27 (m, 3H), 7.04 (d, J = 8.7 Hz, 2H), 6.73 (d, J = 8.7 Hz, 2H), 3.71 (s, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 158.4, 156.7, 135.3, 132.5, 129.5, 128.8, 128.5, 127.8, 125.9, 124.7, 123.7, 116.8, 114.9, 109.7, 55.3. HRMS calcd. for: $C_{17}H_{14}O_2SNa$ $[M+Na]^+$ 305.06067, found 305.06095.

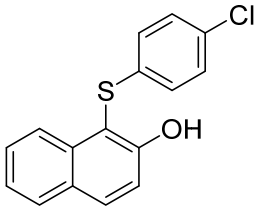
1-((4-Fluorophenyl)thio)naphthalen-2-ol (3f)



The reaction was conducted with sodium 4-fluorobenzenesulfinate (**2f**, 97 mg, 0.5 mmol) and naphthalen-2-ol (**1a**, 28.8 mg, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **3f** as white solid; yield: 38 mg (70%), mp 116 - 119 ^{o}C.

^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 8.20 (d, J = 8.2 Hz, 1H), 7.90 (d, J = 8.7 Hz, 1H), 7.81 (d, J = 7.8 Hz, 1H), 7.50 (t, J = 7.3 Hz, 1H), 7.40 - 7.30 (m, 2H), 7.17 (s, 1H), 7.04 - 6.96 (m, 2H), 6.88 (t, J = 7.6 Hz, 2H). ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 161.4 (d, J = 244.4 Hz), 156.9, 135.2, 132.9, 130.3 (d, J = 3.24 Hz), 129.5, 128.6, 128.3 (d, J = 7.87Hz), 128.0, 124.5, 123.9, 116.9, 116.3 (d, J = 22.11Hz), 108.5. HRMS calcd. for: $C_{16}H_{10}FOS$ $[M-H]^-$ 269.04419, found 269.04394.

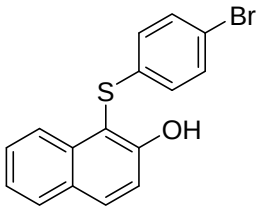
1-((4-Chlorophenyl)thio)naphthalen-2-ol (3g)[1]



The reaction was conducted with sodium 4-chlorobenzenesulfinate (**2g**, 99 mg, 0.5 mmol) and naphthalen-2-ol (**1a**, 28.8 mg, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **3g** as brown solid; yield: 43 mg (75%), mp 81 - 84 ^{o}C.

^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 8.15 (d, J = 8.2 Hz, 1H), 7.91 - 7.89 (m, 1H), 7.80 (d, J = 7.8 Hz, 1H), 7.49 (t, J = 7.1 Hz, 1H), 7.38 - 7.30 (m, 2H), 7.12 - 7.10 (m, 2H), 6.93 (d, J = 8.4 Hz, 2H). ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 157.9, 135.1, 133.9, 133.0, 131.8, 129.5, 129.2, 128.6, 128.0, 127.6, 124.4, 123.9, 116.9, 107.6. MS (EI) *m/z* (%) 286, 225, 218, 146, 115.

1-((4-Bromophenyl)thio)naphthalen-2-ol (3h)[1]

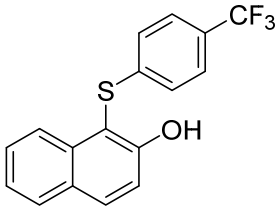


The reaction was conducted with sodium 4-bromobenzenesulfinate (**2h**, 121 mg, 0.5 mmol) and

naphthalen-2-ol (**1a**, 28.8 mg, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **3h** as yellow solid; yield: 50 mg (75%), mp 118 - 123 ^{o}C.

^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 8.15 (d, J = 8.4 Hz, 1H), 7.92 (d, J = 8.9 Hz, 1H), 7.82 (d, J = 8.0 Hz, 1H), 7.50 (t, J = 7.6 Hz, 1H), 7.43 - 7.32 (m, 3H), 7.28 (d, J = 8.2 Hz, 1H), 7.08 (s, 1H), 6.88 (d, J = 8.2 Hz, 2H). ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 157.0, 135.1, 134.6, 133.1, 132.2, 129.5, 128.6, 128.1, 127.9, 124.4, 124.0, 119.6, 116.9, 107.4. MS (EI) *m/z* (%) 331, 218, 189, 146, 115.

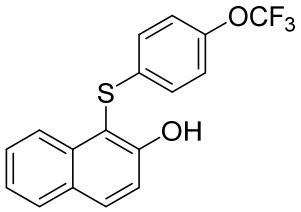
1-((4-(Trifluoromethyl)phenyl)thio)naphthalen-2-ol (3i)



The reaction was conducted with sodium 4-(trifluoromethyl)benzenesulfinate (**2i**, 121 mg, 0.5 mmol) and naphthalen-2-ol (**1a**, 28.8 mg, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **3i** as white solid; yield: 39 mg (60%), mp 102 - 106 ^{o}C.

^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 8.13 (d, J = 8.3 Hz, 1H), 7.94 (d, J = 8.7 Hz, 1H), 7.83 (d, J = 8.0 Hz, 1H), 7.50 (t, J = 7.6 Hz, 1H), 7.42 - 7.33 (m, 4H), 7.07 (d, J = 7.7 Hz, 2H), 7.00 (s, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 7. 152, 140.6, 135.2, 133.4, 129.6, 128.7, 128.2, 128.1, 127.8, 126.0, 125.97, 125.93, 125.90, 124.1 (q, J = 90.1 Hz), 117.0. HRMS calcd. for: $C_{17}H_{12}F_3OS$ $[M+H]^+$ 321.05555, found 321.05563.

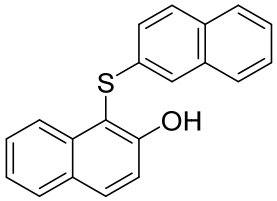
1-((4-(Trifluoromethoxy)phenyl)thio)naphthalen-2-ol (3j)



The reaction was conducted with sodium 4-(trifluoromethoxy)benzenesulfinate (**2j**, 124 mg, 0.5 mmol) and naphthalen-2-ol (**1a**, 28.8 mg, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **3j** as white solid; yield: 44.5 mg (66%), mp 65 - 69 ^{o}C.

^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 8.18 (d, J = 8.4 Hz, 1H), 7.92 (d, J = 8.9 Hz, 1H), 7.82 (d, J = 8.0 Hz, 1H), 7.51 (t, J = 7.6 Hz, 1H), 7.40 - 7.32 (m, 2H), 7.09 (s, 1H), 7.02 (s, 4H). ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 157.1, 147.4, 135.2, 134.1, 133.2, 129.5, 128.7, 128.1, 127.5, 124.4, 124.0, 121.9, 121.6, 116.9, 107.5. HRMS calcd. for: $C_{17}H_{12}F_3O_2S$ $[M+H]^+$ 337.05046, found 337.05051.

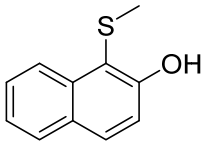
1-(Naphthalen-2-ylthio)naphthalen-2-ol (3k, CAS: 5432-97-3)[1]



The reaction was conducted with sodium 4-(trifluoromethoxy)benzenesulfinate (**2k**, 107 mg, 0.5 mmol) and naphthalen-2-ol (**1a**, 28.8 mg, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **3k** as white solid; yield: 45 mg (75%), mp 91 - 94 ^{o}C.

^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 8.25 (d, J = 8.3 Hz, 1H), 7.94 (d, J = 8.9 Hz, 1H), 7.83 (d, J = 7.9 Hz, 1H), 7.72 (d, J = 8.2 Hz, 1H), 7.66 (d, J = 8.6 Hz, 1H), 7.56 (d, J = 6.3 Hz, 1H), 7.50 - 7.36 (m, 6H), 7.23 - 7.15 (m, 2H). ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 157.1, 135.4, 133.7, 132.9, 132.7, 131.7, 129.5, 128.9, 128.5, 127.9, 127.6, 127.0, 126.6, 125.6, 124.64, 124.61, 124.5, 123.8, 116.9, 108.1. MS (EI) *m/z* (%) 302, 269, 128, 115.

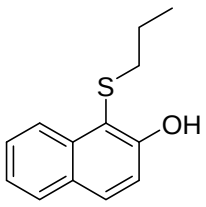
1-(Methylthio)naphthalen-2-ol (3l, CAS: 7439-28-3)[2]



The reaction was conducted with sodium methanesulfinate (**2l**, 51 mg, 0.5 mmol) and naphthalen-2-ol (**1a**, 28.8 mg, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **3l** as brown liquid; yield: 23 mg (60%).

^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 8.33 (d, J = 8.2 Hz, 1H), 7.77 (d, J = 8.6 Hz, 2H), 7.56 (t, J = 7.1 Hz, 1H), 7.37 - 7.34 (m, 2H), 7.25 - 7.23 (m, 1H), 2.26 (s, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 155.8, 134.8, 131.5, 129. 4, 128.7, 127.5, 124.3, 123.5, 116.4, 112.5, 18.6. MS (EI) *m/z* (%) 190, 175, 147, 115, 102.

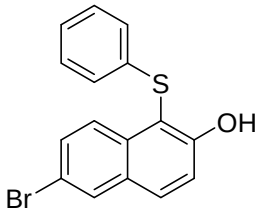
1-(Propylthio)naphthalen-2-ol (3m)



The reaction was conducted with sodium propane-1-sulfinate (**2m**, 65 mg, 0.5 mmol) and naphthalen-2-ol (**1a**, 28.8 mg, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **3m** a blue liquid; yield: 35 mg (80%).

^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 8.34 (d, J = 8.4 Hz, 1H), 7.76 (d, J = 8.6 Hz, 2H), 7.54 (t, J = 7.6 Hz, 1H), 7.40 (s, 1H), 7.34 (t, J = 7.4 Hz, 1H), 7.26 - 7.23 (m, 1H), 2.67 (t, J = 7.4 Hz, 2H), 1.58 - 1.52 (m, 2H), 0.95 (t, J = 7.3 Hz, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 156.4, 135.4, 131.4, 129.4, 128.6, 127.4, 124.6, 123.4, 116.3, 111.2, 37.8, 23.3, 13.4. MS (EI) *m/z* (%) 218, 176, 147, 115, 103. HRMS calcd. for: $C_{13}H_{15}OS$ $[M+H]^+$ 219.08381, found 219.08379.

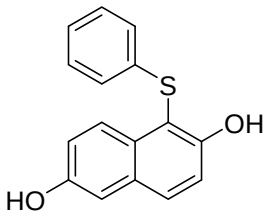
6-Bromo-1-(phenylthio)naphthalen-2-ol (3n)[3]



The reaction was conducted with sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol) and 6-bromonaphthalen-2-ol (**1b**, 44.4 mg, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **3n** as white solid; yield: 61 mg (92%), mp 99 - 103 ^{o}C.

^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 8.08 (d, J = 8.9 Hz, 1H), 7.96 (s, 1H), 7.81 (d, J = 8.8 Hz, 1H), 7.54 (d, J = 8.1 Hz, 1H), 7.35 (d, J = 8.9 Hz, 1H), 7.18 - 7.12 (m, 4H), 7.00 (d, J = 7.3 Hz, 2H). ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 157.1, 134.9, 134.0, 131.7, 131.1, 130.5, 130.4, 129.2, 126.6, 126.4, 126.1, 118.0, 117.7, 108.5. MS (EI) *m/z* (%) 332, 251, 225, 146, 116.

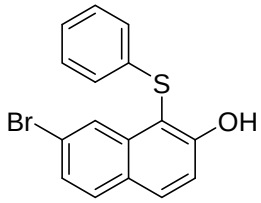
1-(Phenylthio)naphthalene-2,6-diol (3o)



The reaction was conducted with sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol) and naphthalene-2,6-diol (**1c**, 32 mg, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **3o** as yellow solid; yield: 37.3 mg (70%), mp 188 - 191 ^{o}C.

^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 10.88 (s, 1H), 8.26 (d, J = 8.9 Hz, 1H), 7.94 (d, J = 7.7 Hz, 2H), 7.78 (d, J = 9.0 Hz, 1H), 7.56 (t, J = 7.1 Hz, 1H), 7.48 (t, J = 7.4 Hz, 2H), 7.16 (d, J = 9.1 Hz, 1H), 7.07 - 7.05 (m, 3H). ^{13}C NMR (CD^3COCD^3, 100 MHz, ppm): δ 156.6, 154.2, 142.3, 136.4, 133.8, 130.7, 129.5, 126.5, 124.5, 123.2, 120.3, 120.2, 112.2, 111.4. HRMS calcd. for: $C_{16}H_{11}O_2S$ $[M-H]^-$ 267.04853, found 267.05017.

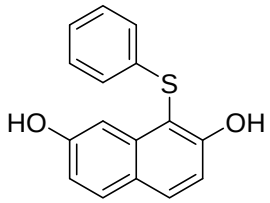
7-Bromo-1-(phenylthio)naphthalen-2-ol (3p)



The reaction was conducted with sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol) and 7-bromonaphthalen-2-ol (**1d**, 44.4 mg, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **3p** as white solid; yield: 58.5 mg (88%), mp 85 - 88 ^{o}C.

^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 8.32 (s, 1H), 7.76 (d, J = 8.9 Hz, 1H), 7.57 (d, J = 8.6 Hz, 1H), 7.37 - 7.34 (m, 1H), 7.24 (s, 1H), 7.12 - 7.09 (m, 3H), 7.05 - 7.02 (m, 1H), 6.93 (d, J = 7.4 Hz, 2H). ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 157.7, 136.8, 134.7, 132.6, 130.1, 129.3, 127.9, 127.3, 126.9, 126.4, 126.1, 122.8, 117.3, 107.6. HRMS calcd. for: $C_{16}H_{10}BrOS$ $[M-H]^-$ 328.96412, found 328.96377.

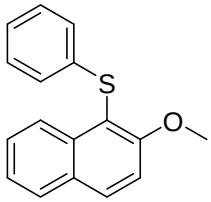
1-(Phenylthio)naphthalene-2,7-diol (3q)



The reaction was conducted with sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol) and naphthalene-2,7-diol (**1e**, 32 mg, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **3q** as white solid; yield: 43 mg (80%), mp 172 - 175 ^{o}C.

^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 7.81 (d, J = 8.9 Hz, 1H), 7.71 (d, J = 8.7 Hz, 1H), 7.51 (s, 1H), 7.14 (m, 6H), 7.03 - 6.94 (m, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 157.7, 155.6, 137.3, 135.2, 132.7, 130.8, 129.2, 126.2, 125.9, 124.7, 115.3, 114.3, 107.2, 106.4. HRMS calcd. for: $C_{16}H_{13}O_2S$ $[M+H]^+$ 269.06308, found 269.06284.

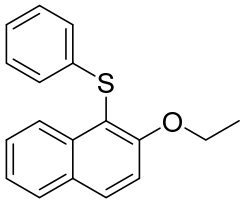
(2-Methoxynaphthalen-1-yl)(phenyl)sulfane (3r, CAS: 108979-03-9)[4]



The reaction was conducted with sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol) and 2-methoxynaphthalene (**1f**, 31.6 mg, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **3r** as white solid; yield: 32.5 mg (61%), mp 79 - 81 ^{o}C.

^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 8.46 (d, *J* = 8.5 Hz, 1H), 7.95 (d, *J* = 9.0 Hz, 1H), 7.81 (d, *J* = 8.0 Hz, 1H), 7.48 (t, *J* = 7.6 Hz, 1H), 7.39 - 7.34(m, 2H), 7.12 (t, *J* = 7.6 Hz, 2H), 7.02 (t, *J* = 6.9 Hz, 3H), 3.94 (s, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 159.2, 138.1, 136.2, 132.0, 129.5, 128.7, 128.2, 127.71, 127.69, 126.2, 125.4, 124.7, 124.1, 113.4, 56.9. MS (EI) *m/z* (%) 266, 251, 223, 178, 115.

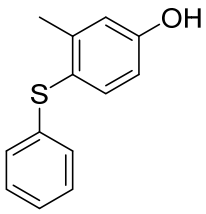
(2-Ethoxynaphthalen-1-yl)(phenyl)sulfane (3s)



The reaction was conducted with sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol) and 2-ethoxynaphthalene (**1g**, 34.4 mg, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **3s** as brown solid; yield: 39.4 mg (70%), mp 56 - 59 ^{o}C.

^{1}H NMR ($CDCl_3$, 400 MHz, ppm): *δ* 8.49 (d, *J* = 8.5 Hz, 1H), 7.91 (d, *J* = 9.0 Hz, 1H), 7.80 (d, *J* = 8.0 Hz, 1H), 7.49 (t, *J* = 7.6 Hz, 1H), 7.37 (t, *J* = 7.4 Hz, 1H), 7.31 (d, *J* = 9.0 Hz, 1H), 7.14 - 7.10 (m, 2H), 7.06 - 7.01 (m, 3H), 4.17 (q, *J* = 6.9 Hz, 2H), 1.28 (t, *J* = 6.9 Hz, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): *δ* 158.5, 138.5, 136.3, 131.6, 129.6, 128.6, 128.2, 127.5, 126.8, 125.5, 124.8, 124.1, 114.9, 114.4, 65.5, 14.8. HRMS calcd. for: $C_{18}H_{17}OS$ $[M+H]^+$ 281.09946, found 281.09972.

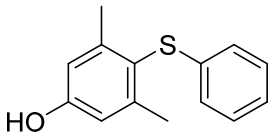
3-Methyl-2-(phenylthio)phenol (3t, CAS: 1350814-76-4)[5]



The reaction was conducted with sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol) and m-cresol (**1h**, 20.8 uL, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **3t** as brown liquid; yield: 19.5 mg (45%).

^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 7.38 (d, *J* = 8.3 Hz, 1H), 7.20 (t, *J* = 7.5 Hz, 2H), 7.11 - 7.03 (m, 4H), 6.79 (s, 1H), 6.68 (d, *J* = 8.2 Hz, 1H), 2.31 (s, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 156.4, 144.1, 138.4, 137.5, 128.9, 126.9, 125.2, 122.8, 117.8, 113.9, 20.9. MS (EI) *m/z* (%) 216, 183, 138, 107, 77.

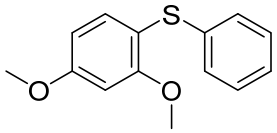
3,5-Dimethyl-2-(phenylthio)phenol (3u, CAS: 52145-51-4)



The reaction was conducted with sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol) and 3,5-dimethylphenol (**1i**, 25.3 uL, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **3u** as brown solid; yield: 27.7 mg (60%), mp 105 - 108 ^{o}C.

^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 7.17 (t, J = 7.5 Hz, 2H), 7.04 (t, J = 7.1 Hz, 1H), 6.90 (d, J = 7.6 Hz, 2H), 6.68 (s, 2H), 2.37 (s, 6H). ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 156.1, 145.9, 138.6, 128.8, 125.2, 124.4, 121.5, 115.4, 21.9. MS (EI) *m/z* (%) 230, 182, 152, 91, 77.

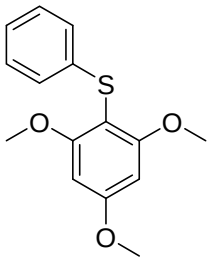
(2,6-Dimethoxyphenyl)(phenyl)sulfane (3v, CAS: 146643-79-0)[6]



The reaction was conducted with sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol) and 1,3-dimethoxybenzene (**1j**, 26.2 uL, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **3v** as yellow liquid, yield: 27 mg (55%).

^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 7.34 (d, J = 8.3 Hz, 1H), 7.23 - 7.19 (m, 2H), 7.13 - 7.09 (m, 3H), 6.53 - 6.47 (m, 2H), 3.83 (s, 3H), 3.80 (s, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 161.8, 160.3, 137.7, 136.7, 128.7, 127.7, 125.4, 112.2, 105.4, 99.3, 55.9, 55.4. MS (EI) *m/z* (%) 246, 231, 198, 171, 77.

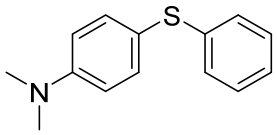
Phenyl(2,4,6-trimethoxyphenyl)sulfane (3w, CAS: 41280-62-0)[1]



The reaction was conducted with sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol) and 1,3,5-trimethoxybenzene (**1k**, 33.6 mg, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **3w** as white solid; yield: 33 mg (60%), mp 94 - 97 ^{o}C.

^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 7.15 (t, J = 7.7 Hz, 2H), 7.03 (t, J = 6.0 Hz, 3H), 6.22 (s, 2H), 3.87 (s, 3H), 3.80 (s, 6H). ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 162.8, 162.4, 138.6, 128.3, 125.5, 124.2, 98.6, 91.1, 56.1, 55.3. MS (EI) *m/z* (%) 276, 228, 207, 141, 69.

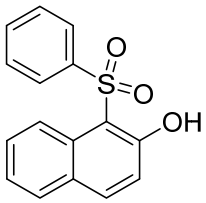
N,N-Dimethyl-4-(phenylthio)aniline (3x, CAS: 42881-80-1)[1]



The reaction was conducted with sodium benzenesulfinate (**2a**, 82 mg, 0.5 mmol) and N,N-dimethylaniline (**1l**, 26.3 uL, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **3x** as brown solid; yield: 22 mg (48%), mp 64 - 68 ^{o}C.

^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 7.39 (d, J = 8.5 Hz, 2H), 7.20 (t, J = 7.3 Hz, 2H), 7.12 - 7.07 (m, 3H), 6.73 (d, J = 5.2 Hz, 2H), 2.99 (s, 6H). ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 150.5, 140.2, 136.1, 128.6, 126.7, 124.9, 117.3, 112.9, 40.2. MS (EI) *m/z* (%) 229, 197, 184, 152, 77.

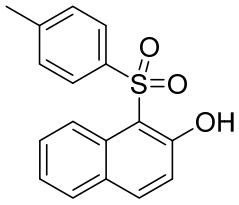
1-(Phenylsulfonyl)naphthalen-2-ol (4a)[4]



The reaction was conducted with sodium benzenesulfinate (**2a**, 65.6 mg, 0.4 mmol) and naphthalen-2-ol (**1a**, 28.8 mg, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **4a** as yellow solid; yield: 46.6 mg (82%), mp 128 - 134 ^{o}C.

1H NMR (CDCl3, 400 MHz, ppm): δ 11.11 (s, 1H), 8.33 (d, J = 8.5 Hz, 1H), 7.96 - 7.93 (m, 3H), 7.72 (d, J = 7.8 Hz, 1H), 7.55 - 7.44 (m, 4H), 7.34 (t, J = 7.3 Hz, 1H), 7.19 (d, J = 9.0 Hz, 1H). 13C NMR (CDCl3, 100 MHz, ppm): δ 158.9, 142.0, 137.5, 133.5, 129.4, 129.2, 129.1, 128.7, 128.7, 126.5, 124.3, 122.9, 120.1, 111.7. MS (EI) m/z (%) 284, 219, 203, 115, 77. HRMS calcd. for: $C_{16}H_{12}O_3SNa$ $[M+Na]^+$ 307.03994, found 307.03987.

1-Tosylnaphthalen-2-ol (4b, CAS: 108980-64-9)[4]

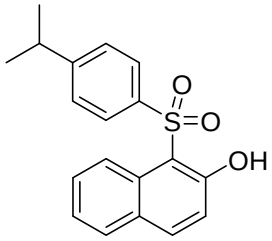


The reaction was conducted with sodium 4-methylbenzenesulfinate (**2b**, 71.3 mg, 0.4 mmol) and naphthalen-2-ol (**1a**, 28.8 mg, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **4b** as yellow solid; yield: 50 mg (84%), mp 134 - 137 ^{o}C.

^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 11.13 (s, 1H), 8.34 (d, J = 8.6 Hz, 1H), 7.93 - 7.83 (m, 3H),

7.71 (d, *J* = 7.9 Hz, 1H), 7.46 (t, *J* = 7.7 Hz, 1H), 7.35 - 7.27 (m, 3H), 7.18 (d, *J* = 9.0 Hz, 1H), 2.36 (s, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 158.6, 144.6, 139.1, 137.3, 129.8, 129.4, 129.1, 128.7, 128.6, 126.5, 124.3, 122.9, 120.1, 112.1, 21.5. MS (EI) *m/z* (%) 298, 233, 219, 114, 91.

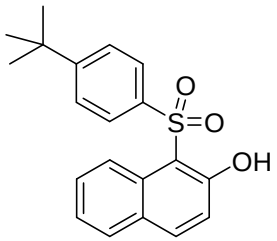
1-((4-*iso*-Propylphenyl)sulfonyl)naphthalen-2-ol (4c)



The reaction was conducted with sodium 4-isopropylbenzenesulfinate (**2c**, 82.4 mg, 0.4 mmol) and naphthalen-2-ol (**1a**, 28.8 mg, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **4c** as yellow solid; yield: 55.6 mg (85%), mp 140-143 ^{o}C.

^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 11.14 (s, 1H), 8.38 (d, *J* = 8.6 Hz, 1H), 7.93 - 7.86 (m, 3H), 7.72 (d, *J* = 7.9 Hz, 1H), 7.47 (t, *J* = 7.7 Hz, 1H), 7.36 - 7.31 (m, 3H), 7.18 (d, *J* = 9.0 Hz, 1H), 2.91 (m, 1H), 1.20 (d, *J* = 6.8 Hz, 6H). ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 158.7, 155.2, 139.3, 137.3, 129.5, 129.2, 128.7, 128.7, 127.3, 126.7, 124.3, 123.1, 120.1, 112.2, 34.1, 23.5. MS (EI) m/z (%) 326, 219, 201, 115, 77. HRMS calcd. for: $C_{19}H_{18}O_3SNa$ $[M+Na]^+$ 349.08689, found 349.08715.

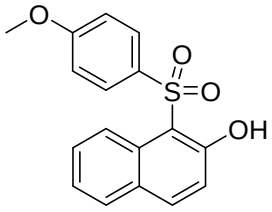
1-((4-(*tert*-Butyl)phenyl)sulfonyl)naphthalen-2-ol (4d)



The reaction was conducted with sodium 4-(tert-butyl)benzenesulfinate (**2d**, 88 mg, 0.4 mmol) and naphthalen-2-ol (**1a**, 28.8 mg, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **4d** as yellow solid; yield: 55 mg (81%), mp 190 - 193 ^{o}C.

^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 11.14 (s, 1H), 8.40 (d, *J* = 8.7 Hz, 1H), 7.94 - 7.86 (m, 3H), 7.72 (d, *J* = 7.9 Hz, 1H), 7.48 (d, *J* = 8.4 Hz, 3H), 7.34 (t, *J* = 7.4 Hz, 1H), 7.18 (d, *J* = 9.0 Hz, 1H), 1.28 (s, 9H). ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 158.7, 157.5, 139.0, 137.3, 129.5, 129.0, 128.7, 128.7, 126.4, 126.2, 124.3, 123.1, 120.1, 112.2, 35.2, 30.9. MS (EI) *m/z* (%) 340, 261, 219, 135, 115. HRMS calcd. for: $C_{20}H_{20}O_3SNa$ $[M+Na]^+$ 341.12059, found 341.12081.

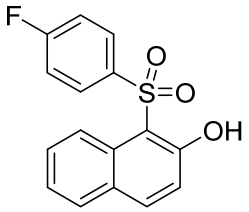
1-((4-Methoxyphenyl)sulfonyl)naphthalen-2-ol (4e)



The reaction was conducted with sodium 4-methoxybenzenesulfinate (**2e**, 77.6 mg, 0.4 mmol) and naphthalen-2-ol (**1a**, 28.8 mg, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **4e** as white solid; yield: 45 mg (72%), mp 109 - 113 ^{o}C.

^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 11.15 (s, 1H), 8.36 (d, J = 8.7 Hz, 1H), 7.92-7.88 (m, 3H), 7.71 (d, J = 8.0 Hz, 1H), 7.48 (d, J = 7.7 Hz, 1H), 7.33 (d, J = 7.3 Hz, 1H), 7.17 (d, J = 9.0 Hz, 1H), 6.93 (d, J = 8.8 Hz, 2H), 3.81 (s, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 163.5, 158.4, 137.2, 133.6, 129.4, 129.1, 128.8, 128.7, 128.6, 124.2, 122.9, 120.1, 114.4, 112.5, 55.6. MS (EI) *m/z* (%) 314, 249, 219, 207, 108. HRMS calcd. for: $C_{17}H_{15}O_4S$ $[M+H]^+$ 315.06856, found 315.06846.

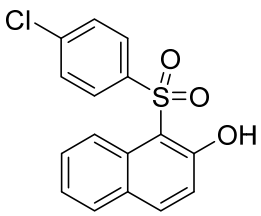
1-((4-Fluorophenyl)sulfonyl)naphthalen-2-ol (4f)



The reaction was conducted with sodium 4-fluorobenzenesulfinate (**2f**, 72.8 mg, 0.4 mmol) and naphthalen-2-ol (**1a**, 28.8 mg, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **4f** as white solid; yield: 44 mg (73%), mp 125 - 128 ^{o}C.

^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 11.04 (s, 1H), 8.31 (d, J = 8.6 Hz, 1H), 7.99 - 7.93 (m, 3H), 7.73 (d, J = 7.9 Hz, 1H), 7.48 (t, J = 7.7 Hz, 1H), 7.36 (t, J = 7.3 Hz, 1H), 7.20 - 7.13 (m, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 166.7, 164.2, 158.8, 137.7, 129.4(d, J = 9.6 Hz), 129.3, 129.03(d, J = 32 Hz), 128.7, 124.5, 122.7, 120.1, 116.7, 116.4, 111.6. MS (EI) *m/z* (%) 302, 237, 221, 131, 114. HRMS calcd. for: $C_{16}H_{11}FO_3SNa$ $[M+Na]^+$ 325.03052, found 325.03076.

1-((4-Chlorophenyl)sulfonyl)naphthalen-2-ol (4g)

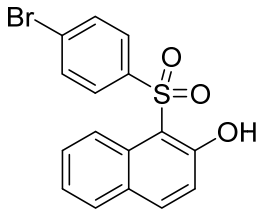


The reaction was conducted with sodium 4-chlorobenzenesulfinate (**2g**, 79.2 mg, 0.4 mmol) and

naphthalen-2-ol (**1a**, 28.8 mg, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **4g** as white solid; yield: 47.4 mg (75%), mp 141 - 144 ^{o}C.

^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 11.02 (s, 1H), 8.29 (d, J = 8.7 Hz, 1H), 7.96 - 7.87 (m, 3H), 7.73 (d, J = 7.9 Hz, 1H), 7.50 - 7.43 (m, 3H), 7.36 (t, J = 7.4 Hz, 1H), 7.19 (d, J = 9.0 Hz, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 159.0, 140.5, 140.1, 137.8, 129.5, 129.3, 129.2, 128.9, 128.7, 128.0, 124.5, 122.7, 120.1, 111.2. HRMS calcd. for: $C_{16}H_{11}ClO_3SNa$ $[M+Na]^+$ 341.00097, found 341.00081.

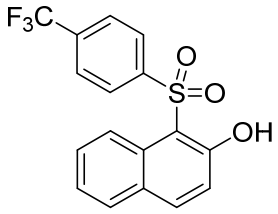
1-((4-Bromophenyl)sulfonyl)naphthalen-2-ol (4h)



The reaction was conducted with sodium 4-bromobenzenesulfinate (**2h**, 96.4 mg, 0.4 mmol) and naphthalen-2-ol (**1a**, 28.8 mg, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **4h** as white solid; yield: 56 mg (77%), mp 165 - 171 ^{o}C.

^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 11.01 (s, 1H), 8.29 (d, J = 8.6 Hz, 1H), 7.95 (d, J = 9.0 Hz, 1H), 7.82 - 7.72 (m, 3H), 7.61 (d, J = 8.4 Hz, 2H), 7.48 (t, J = 7.6 Hz, 1H), 7.36 (t, J = 7.4 Hz, 1H), 7.19 (d, J = 9.0 Hz, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 159.0, 141.0, 137.8, 132.5, 129.3, 129.2, 128.9, 128.7, 128.7, 127.9, 124.5, 122.7, 120.1, 111.2. MS (EI) *m/z* (%) 364, 219, 201, 115, 75. HRMS calcd. for: $C_{16}H_{11}BrO_3SNa$ $[M+Na]^+$ 384.95045, found 384.95013.

1-((4-(Trifluoromethyl)phenyl)sulfonyl)naphthalen-2-ol (4i)

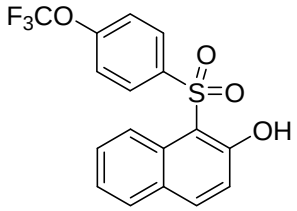


The reaction was conducted with sodium 4-(trifluoromethyl)benzenesulfinate (**2i**, 92.8 mg, 0.4 mmol) and naphthalen-2-ol (**1a**, 28.8 mg, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **4i** as white solid; yield: 47 mg (67%), mp 146 - 150 ^{o}C.

^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 10.98 (s, 1H), 8.29 (d, J = 8.7 Hz, 1H), 8.07 (d, J = 8.1 Hz, 2H), 7.98 (d, J = 9.0 Hz, 1H), 7.75 (d, J = 8.1 Hz, 3H), 7.49 (t, J = 7.8 Hz, 1H), 7.37 (t, J = 7.5 Hz, 1H), 7.21 (d, J = 9.1 Hz, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 159.3, 145.4, 138.2,

135.3, 134.9, 129.31, 129.29, 129.1, 128.8, 127.0, 126.4 (q, J = 3.7 Hz), 124.6, 122.6, 120.2, 110.7. HRMS calcd. for: $C_{17}H_{11}F_3O_3SNa$ $[M+Na]^+$ 375.02732, found 375.02738.

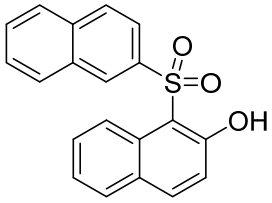
1-((4-(Trifluoromethoxy)phenyl)sulfonyl)naphthalen-2-ol (4j)



The reaction was conducted with sodium 4-(trifluoromethoxy)benzenesulfinate (**2j**, 99.2 mg, 0.4 mmol) and naphthalen-2-ol (**1a**, 28.8 mg, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **4j** as white solid; yield: 49.3 mg (70%), mp 104 - 109 ^oC.

^1H NMR ($CDCl_3$, 400 MHz, ppm): δ 11.01 (s, 1H), 8.32 (d, J = 8.5 Hz, 1H), 8.02 - 7.95 (m, 3H), 7.75 (d, J = 7.7 Hz, 1H), 7.50 (t, J = 7.5 Hz, 1H), 7.40 - 7.28 (m, 3H), 7.20 (d, J = 9.0 Hz, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 159.0, 152.7, 140.2, 137.9, 129.3, 129.2, 129.0, 128.8, 124.5, 122.7, 121.4, 120.9, 120.2, 118.8, 111.2. HRMS calcd. for: $C_{17}H_{11}F_3O_4SNa$ $[M+Na]^+$ 391.02224, found 391.02189.

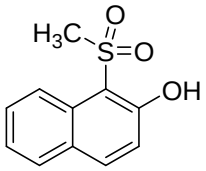
1-(Naphthalen-2-ylsulfonyl)naphthalen-2-ol (4k, CAS:51739-34-5)



The reaction was conducted with sodium naphthalene-2-sulfinate (**2k**, 85.6 mg, 0.4 mmol) and naphthalen-2-ol (**1a**, 28.8 mg, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **4k** as white solid; yield: 47.3 mg (71%), mp 160 - 164 ^oC.

^1H NMR ($CDCl_3$, 400 MHz, ppm): δ 11.20 (s, 1H), 8.62 (s, 1H), 8.42 (d, J = 8.6 Hz, 1H), 8.00 - 7.79 (m, 5H), 7.71 - 7.61 (m, 3H), 7.43 (t, J = 7.7 Hz, 1H), 7.29 (d, J = 7.2 Hz, 1H), 7.22 (d, J = 9.0 Hz, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 158.9, 138.8, 137.6, 135.1, 131.9, 129.7, 129.5, 129.4, 129.3, 129.1, 128.8, 128.7, 127.9, 127.9, 127.7, 124.3, 122.9, 121.4 , 120.1, 111.7. MS (EI) *m/z* (%) 334, 269, 128, 115, 77.

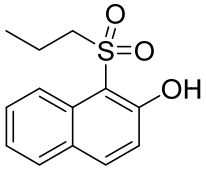
1-(Methylsulfonyl)naphthalen-2-ol (4l, CAS: 19365-95-8)



The reaction was conducted with sodium methanesulfinate (**2l**, 40.8 mg, 0.4 mmol) and naphthalen-2-ol (**1a**, 28.8 mg, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **4l** as yellow solid; yield: 30.2 mg (68%), mp 100 - 104 ^{o}C.

^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 10.78 (s, 1H), 8.51 (d, J = 8.5 Hz, 1H), 7.96 (d, J = 8.9 Hz, 1H), 7.81 (d, J = 7.8 Hz, 1H), 7.65 (t, J = 7.6 Hz, 1H), 7.46 (t, J = 7.3 Hz, 1H), 7.15 (d, J = 9.0 Hz, 1H), 3.31 (s, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 158.1, 137.4, 129.7, 129.4, 129.2, 128.7, 124.5, 122.4, 120.2, 112.0, 44.8. MS (EI) *m/z* (%) 222, 159, 143, 131, 115.

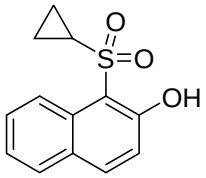
1-(Propylsulfonyl)naphthalen-2-ol (4m)



The reaction was conducted with sodium propane-1-sulfinate (**2m**, 52 mg, 0.4 mmol) and naphthalen-2-ol (**1a**, 28.8 mg, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **4m** as brown liquid; yield: 22.5 mg (45%).

^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 10.85 (s, 1H), 8.52 (d, J = 8.7 Hz, 1H), 7.95 (d, J = 9.0 Hz, 1H), 7.80 (d, J = 7.9 Hz, 1H), 7.62 (t, J = 3.7 Hz, 1H), 7.44 (t, J = 7.4 Hz, 1H), 7.14 (d, J = 9.0 Hz, 1H), 3.34 (t, J = 4.0 Hz, 2H), 1.79 (m, 2H), 0.98 (t, J = 7.4 Hz, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 159.0, 137.3, 129.9, 129.4, 129.1, 128.8, 124.4, 122.6, 120.1, 110.3, 58.1, 16.2, 12.7. HRMS calcd. for: $C_{13}H_{15}O_3S$ $[M+H]^+$ 251.07364, found 251.07386.

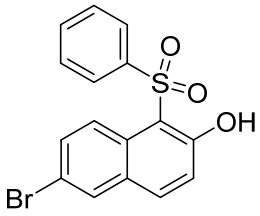
1-(Cyclopropylsulfonyl)naphthalen-2-ol (4n)



The reaction was conducted with sodium cyclopropanesulfinate (**2n**, 51.2 mg, 0.4 mmol) and naphthalen-2-ol (**1a**, 28.8 mg, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **4n** as yellow solid; yield: 30 mg (60%), mp 84 - 87 ^{o}C.

^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 10.60 (s, 1H), 8.65 (d, J = 8.7 Hz, 1H), 7.94 (d, J = 9.0 Hz, 1H), 7.80 (d, J = 8.0 Hz, 1H), 7.62 (t, J = 7.6 Hz, 1H), 7.44 (t, J = 7.4 Hz, 1H), 7.13 (d, J = 9.0 Hz, 1H), 2.94 - 2.87 (m, 1H), 1.45 - 1.44 (m, 2H), 1.04 (d, J = 6.6 Hz, 2H). ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 157.7, 136.9, 130.0, 129.3, 128.9, 124.4, 123.2, 120.1, 112.7, 112.6, 34.2, 5.8. HRMS calcd. for: $C_{13}H_{13}O_3S$ $[M+H]^+$ 249.05799, found 249.05776.

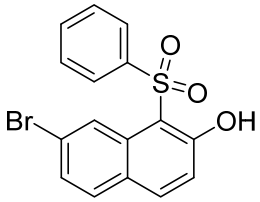
6-Bromo-1-(phenylsulfonyl)naphthalen-2-ol (4o)



The reaction was conducted with sodium benzenesulfinate (**2a**, 65.6 mg, 0.4 mmol) and 6-bromonaphthalen-2-ol (**1b**, 44.4 mg, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **4o** as yellow solid; yield: 49.2 mg (68%), mp 152 - 157 ^{o}C.

^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 11.09 (s, 1H), 8.23 (d, J = 9.0 Hz, 1H), 7.93 (d, J = 7.7 Hz, 2H), 7.87 - 7.83 (m, 2H), 7.59 - 7.48 (m, 4H), 7.22 - 7.20 (m, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 158.9, 141.7, 136.4, 133.8, 131.8, 130.9, 129.9, 129.3, 128.0, 126.4, 124.6, 121.4, 118.2, 112.1. HRMS calcd. for: $C_{16}H_{11}BrO_3SNa$ $[M+Na]^+$ 384.95045, found 384.94951.

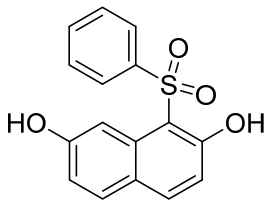
7-Bromo-1-(phenylsulfonyl)naphthalen-2-ol (4p)



The reaction was conducted with sodium benzenesulfinate (**2a**, 65.6 mg, 0.4 mmol) and 7-bromonaphthalen-2-ol (**1d**, 44.4 mg, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **4p** as white solid; yield: 40 mg (56%), mp 184 - 189 ^{o}C.

^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 11.13 (s, 1H), 8.56 (s, 1H), 7.96 (d, J = 7.5 Hz, 2H), 7.88 (d, J = 9.0 Hz, 1H), 7.6 - 7.55 (m, 4H), 7.43 (d, J = 7.4 Hz, 1H), 7.19 (d, J = 9.0 Hz, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz, ppm): δ 159.3, 141.6, 137.2, 133.8, 130.6, 130.4, 129.3, 127.8, 127.1, 126.6, 125.5, 123.7, 120.6, 110.4. MS (EI) *m/z* (%) 364, 219, 201, 189, 77.

1-(Phenylsulfonyl)naphthalene-2,7-diol (4q)



The reaction was conducted with sodium benzenesulfinate (**2a**, 65.6 mg, 0.4 mmol) and naphthalene-2,7-diol (**1e**, 32 mg, 0.2 mmol). The residue was purified by column chromatography (silica gel, petroleum ether/ethyl acetate = 40:1) to give **4q** as white solid; yield: 39 mg (65%), mp 231 - 234 ^{o}C.

^{1}H NMR ($CDCl_3$, 400 MHz, ppm): δ 11.03 (s, 1H), 7.94 (d, *J* = 7.6 Hz, 2H), 7.85 (d, *J* = 8.9 Hz, 1H), 7.73 (s, 1H), 7.62 (d, *J* = 8.7 Hz, 1H), 7.58 - 7.47 (m, 4H), 7.03 (d, *J* = 9.0 Hz, 1H), 6.94 - 6.92 (m, 1H). ^{13}C NMR (CD_3COCD_3, 100 MHz, ppm): δ 159.3, 158.0, 142.0, 137.7, 133.8, 131.5, 131.2, 129.4, 126.5, 123.4, 116.3, 116.0, 110.5, 106.1. HRMS calcd. for: $C_{16}H_{12}O_4SNa$ $[M+Na]^+$ 323.03485, found 323.03513.

References

[1] S. K. R. Parumala, R. K. Peddinti, *Green Chem.*, **2015**, *17*, 4068.
[2] J. S.Bradshaw and R. H. Hales, *J. Org. Chem.*, **1971**, 36, 318.
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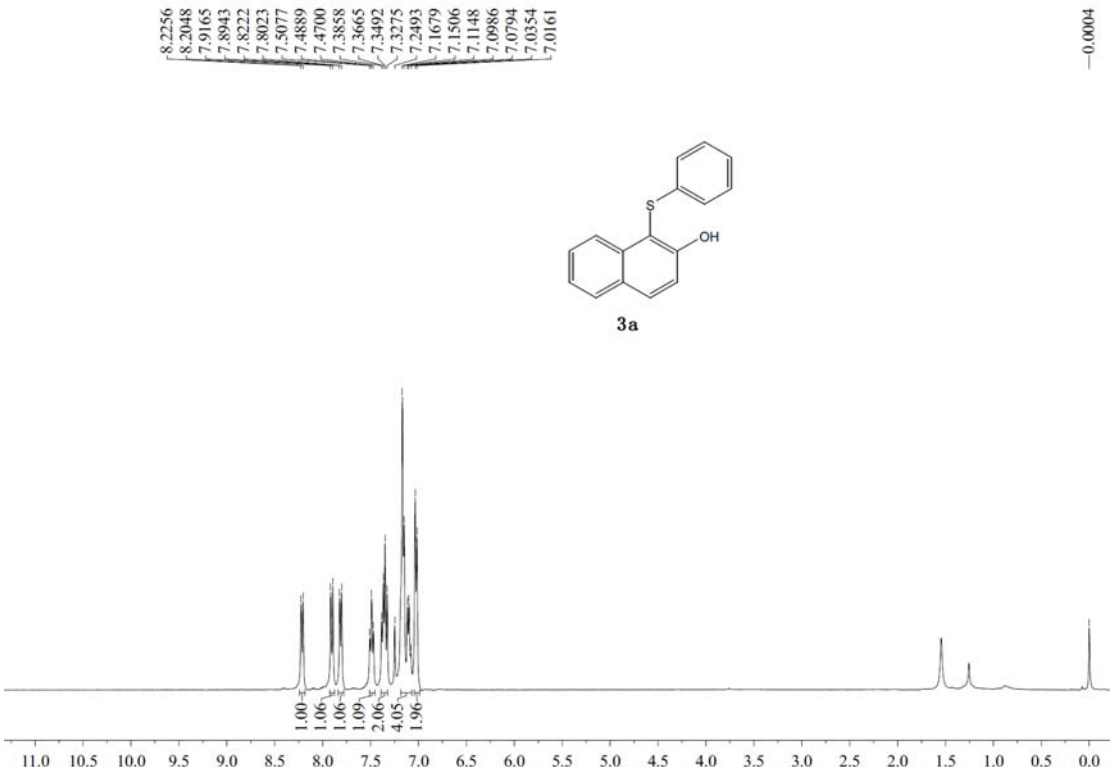
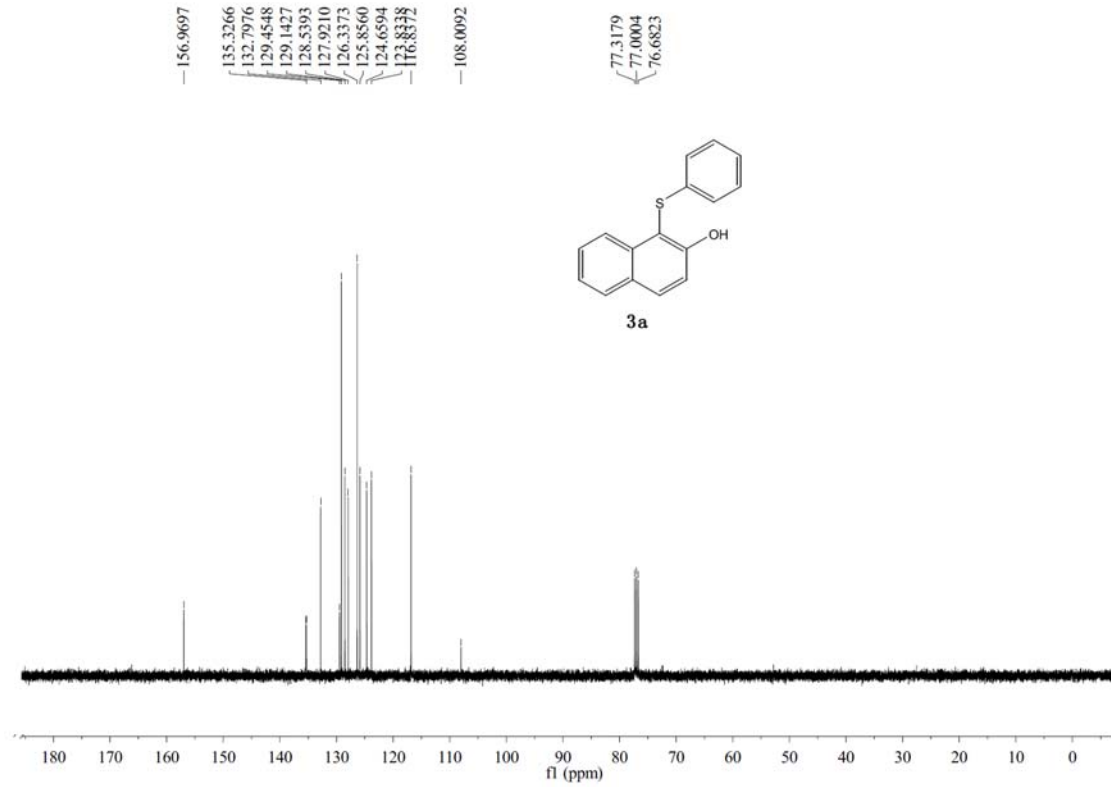
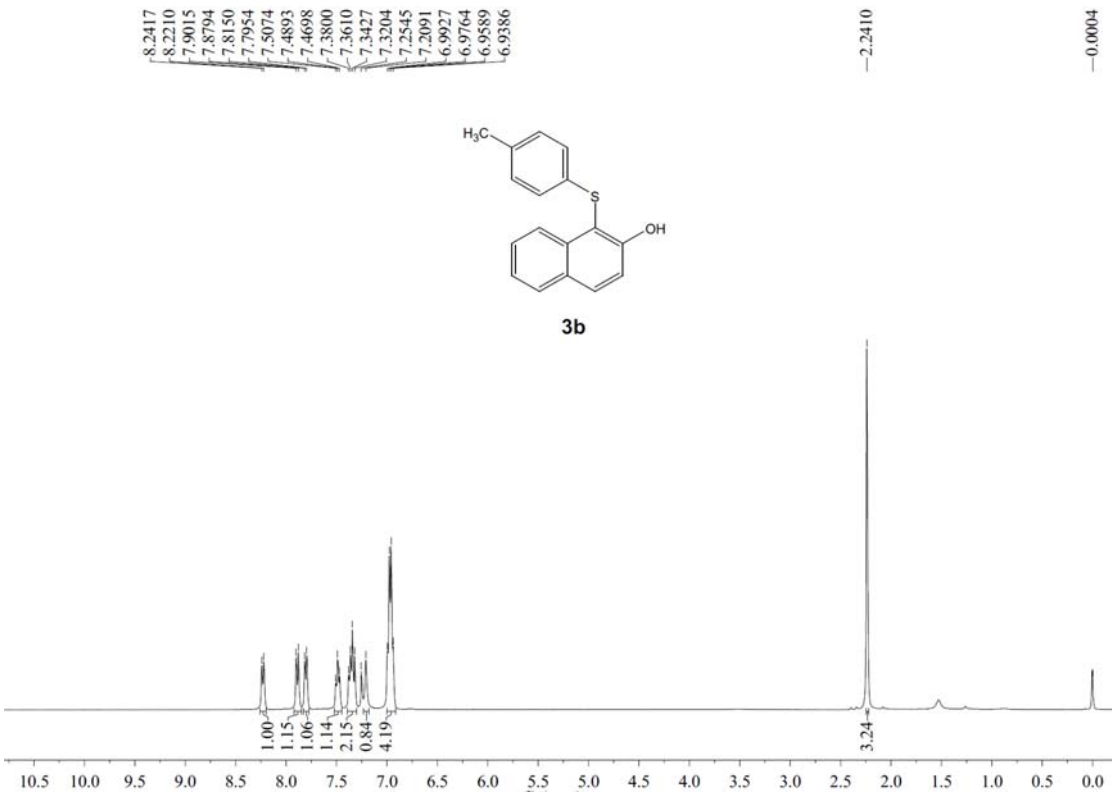
[6] G. Bastug, S. P. Nolan, *J. Org. Chem*., **2013**, *78*, 9303.

^{1}H and ^{13}C NMR spectra of products



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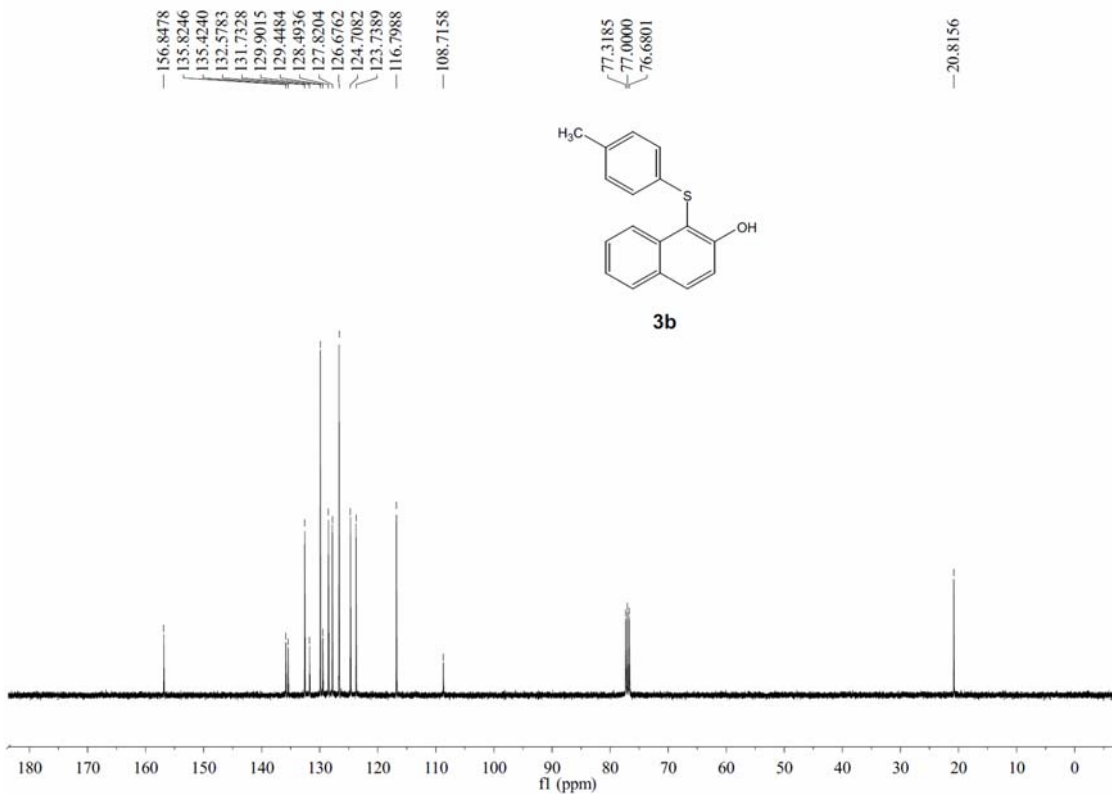
7.3204
7.2545
7.2091
6.9927
6.9764
6.9589
6.9386
2.2410
0.0004
H3C
S
OH
3b
1.00
1.15
1.06
1.14
2.15
0.84
4.19
3.24
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0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3b
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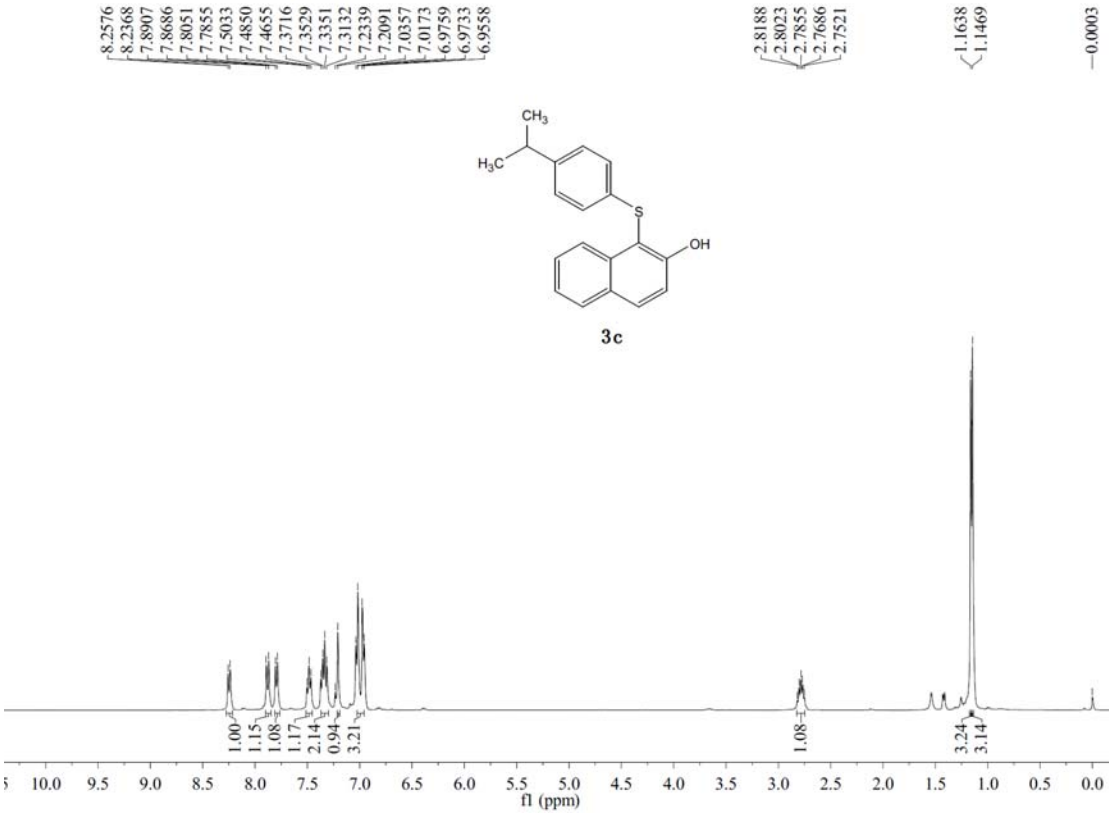
f1 (ppm)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1.08
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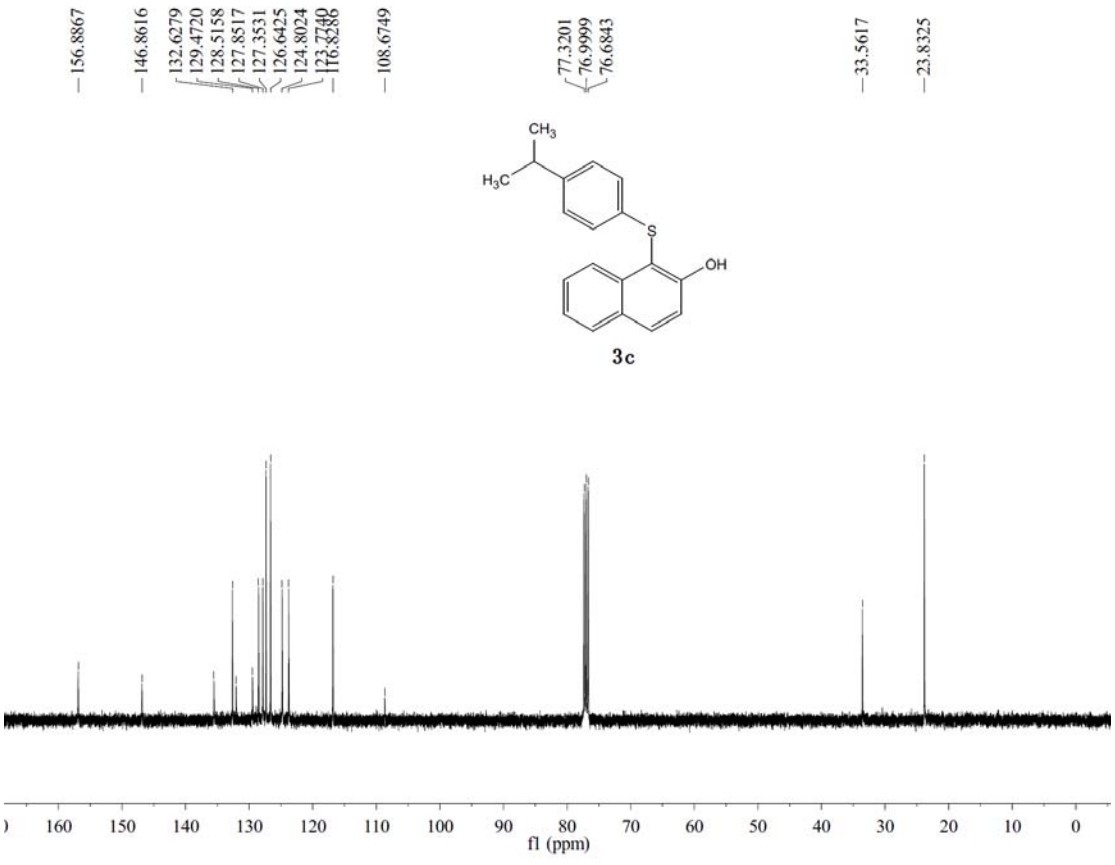
2.14
0.94
3.21
1.08
3.24
3.14
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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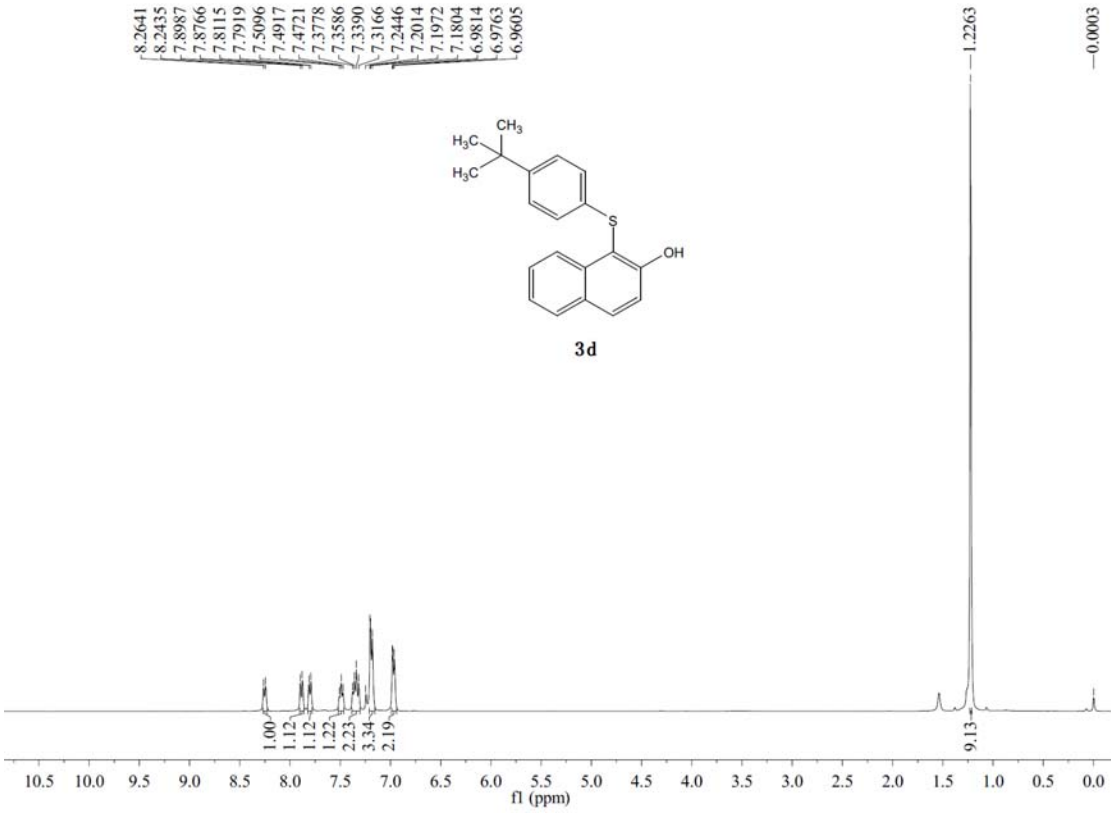
127.3531
126.6425
124.8024
123.7740
116.8286
108.6749
77.3201
76.9999
76.6843
33.5617
23.8325
CH3
H3C
S
OH
3c
160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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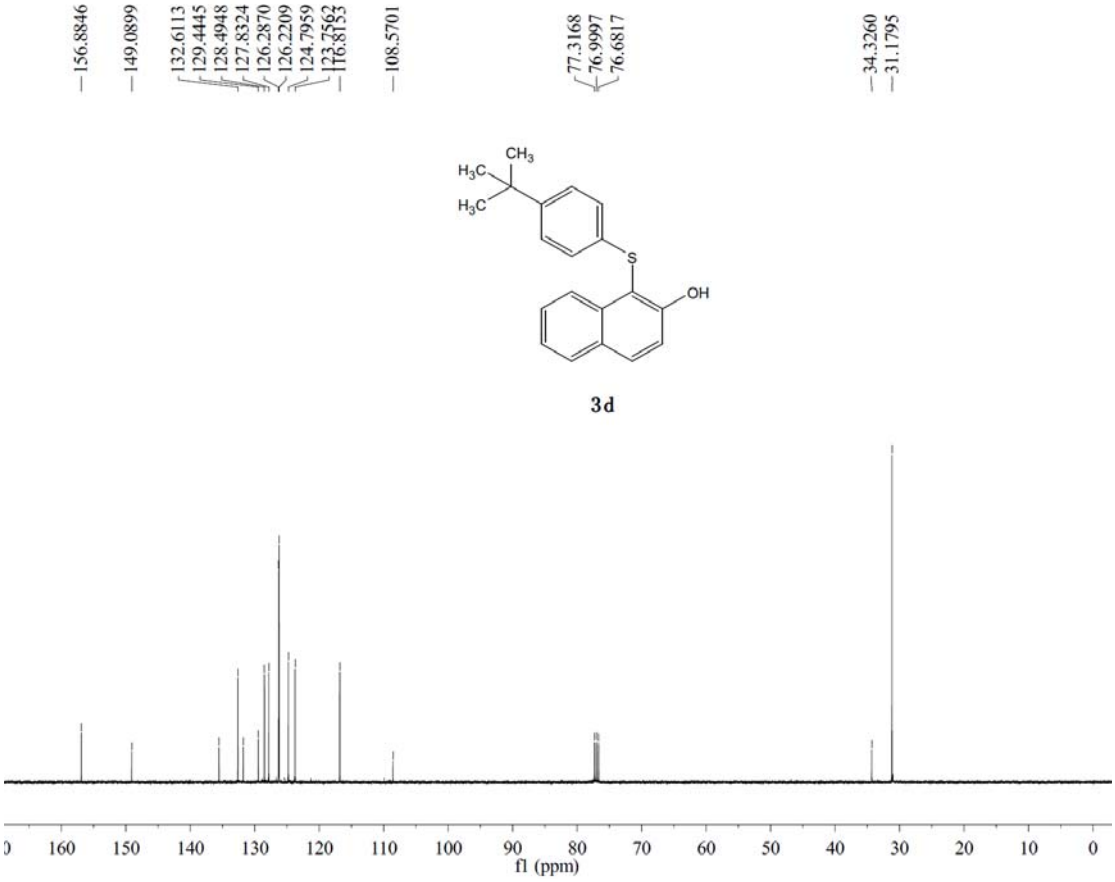
8.2435
7.8987
7.8766
7.8115
7.7919
7.5096
7.4917
7.4721
7.3778
7.3586
7.3390
7.3166
7.2446
7.2014
7.1972
7.1804
6.9814
6.9763
6.9605
1.2263
0.0003
CH3
H3C
H3C
S
OH
1.00
1.12
1.12
1.22
2.23
3.34
2.19
9.13
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

3d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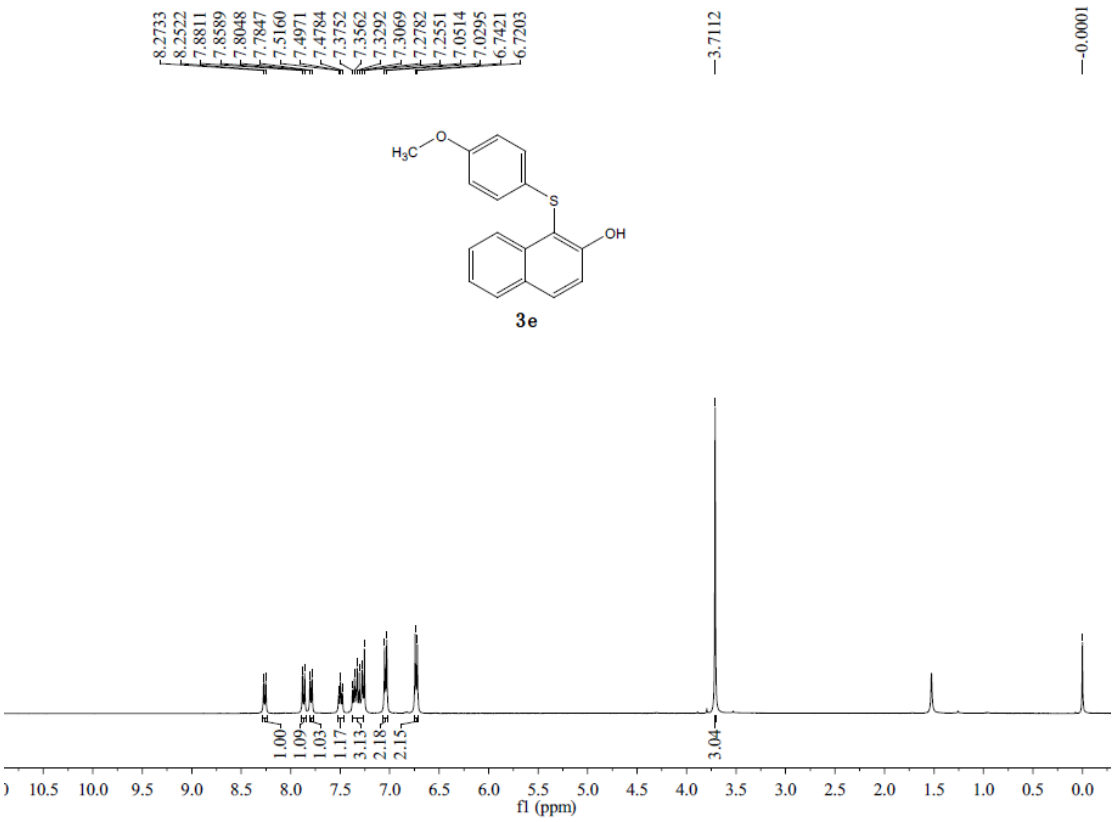
128.4948
127.8324
126.2870
126.2209
124.7959
123.7562
116.8153
108.5701
77.3168
76.9997
76.6817
34.3260
31.1795
CH3
H3C
H3C
S
OH
160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

3d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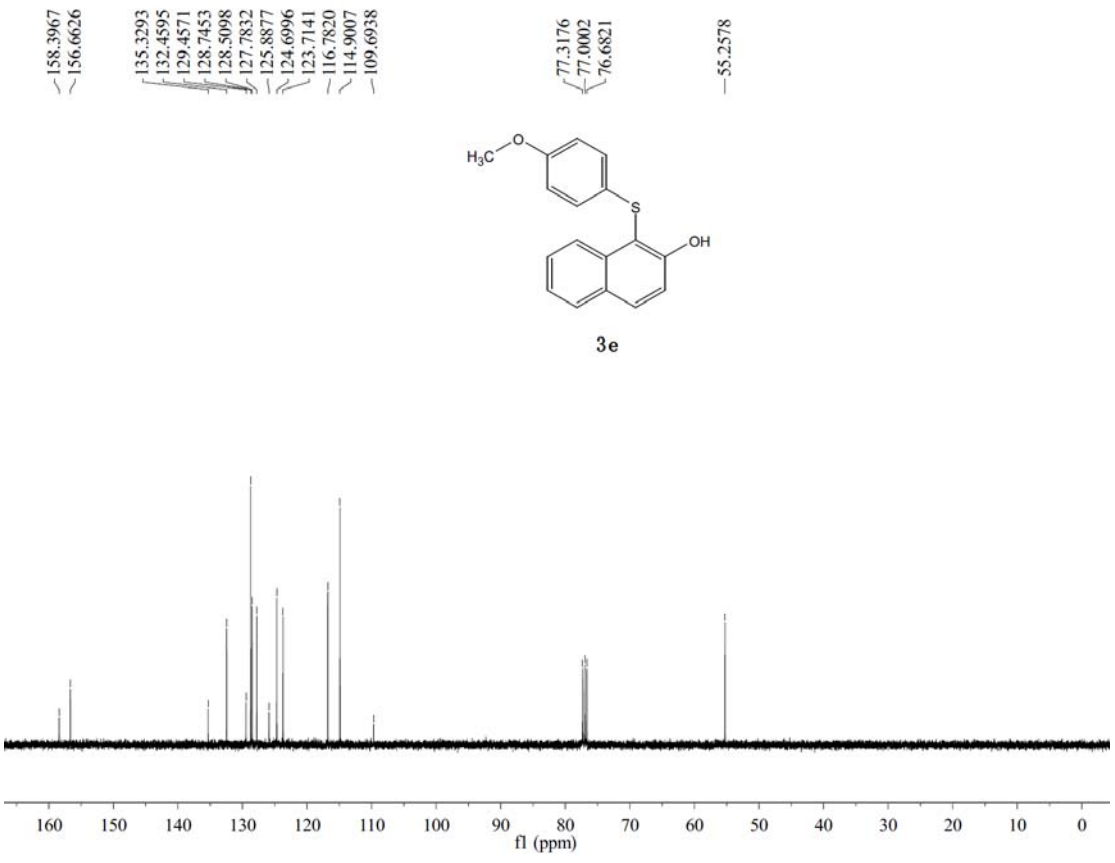
8.2522
7.8811
7.8589
7.8048
7.7847
7.5160
7.4971
7.4784
7.3752
7.3562
7.3292
7.3069
7.2782
7.2551
7.0514
7.0295
6.7421
6.7203
3.7112
0.0001
H3C
O
S
OH
3e
1.00
1.09
1.03
1.17
3.13
2.18
2.15
3.04
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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135.3293
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129.4571
128.7453
128.5098
127.7832
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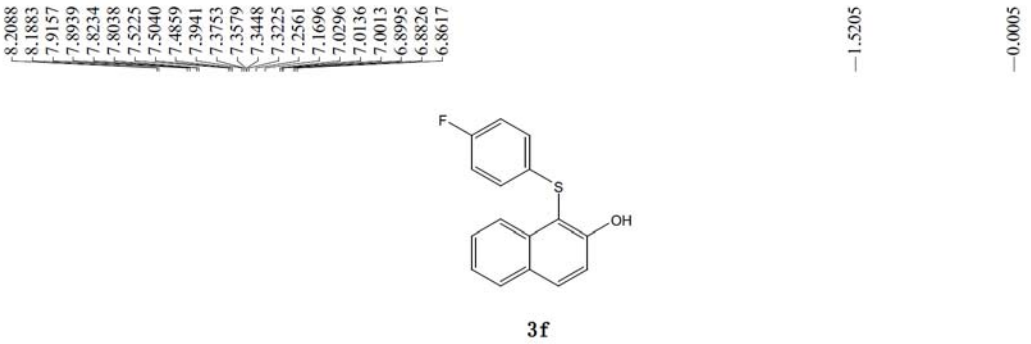
124.6996
123.7141
116.7820
114.9007
109.6938
77.3176
77.0002
76.6821
55.2578
H3C
O
S
OH
3e
160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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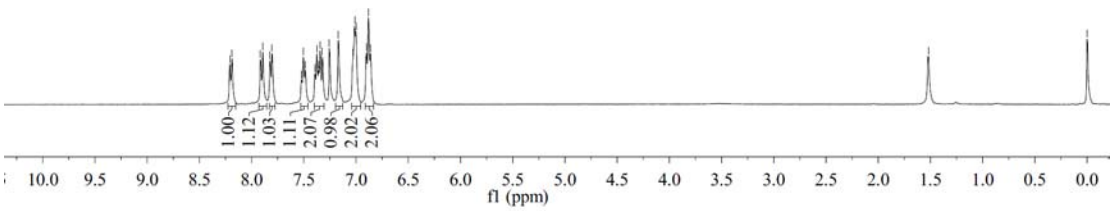
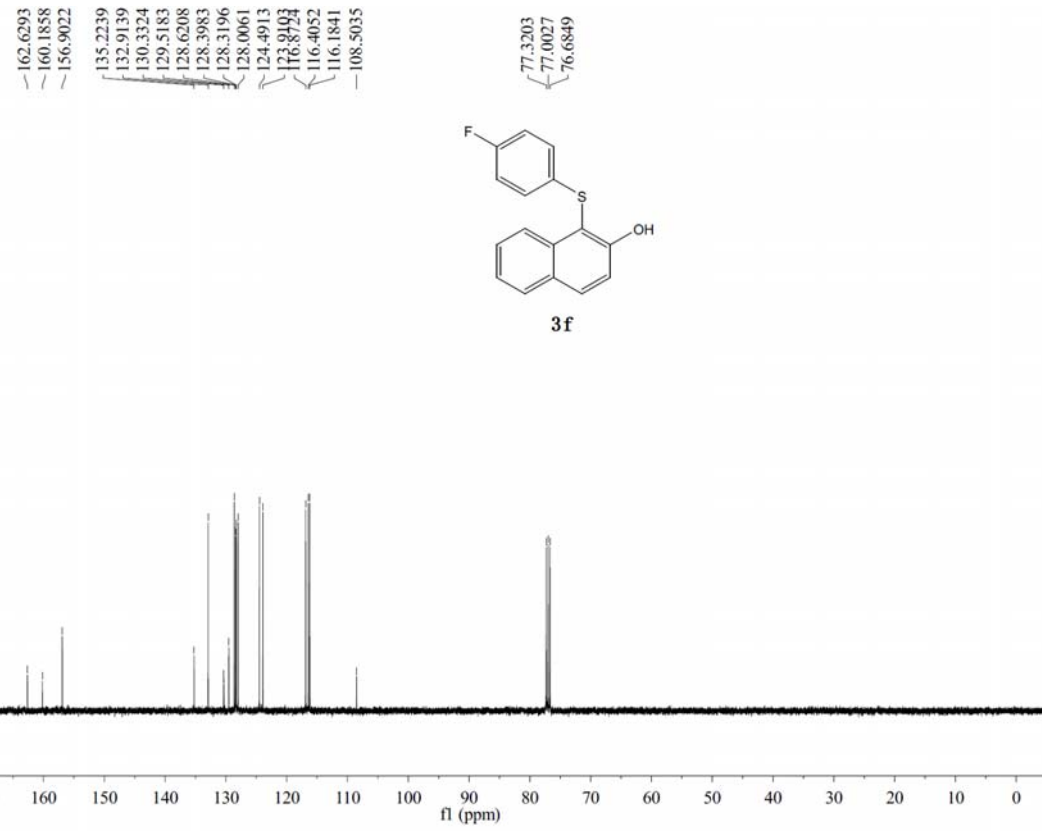
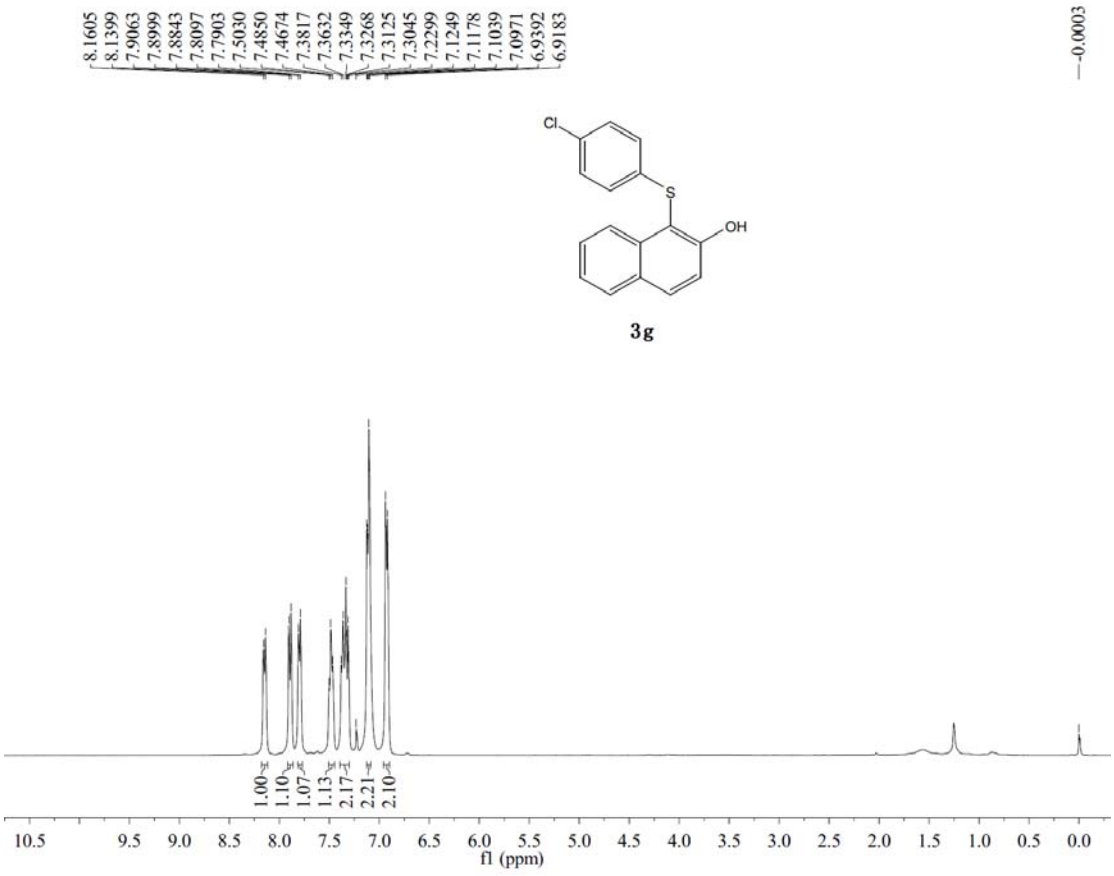
8.1883
7.9157
7.8939
7.8234
7.8038
7.5225
7.5040
7.4859
7.3941
7.3753
7.3579
7.3448
7.3225
7.2561
7.1696
7.0296
7.0136
7.0013
6.8995
6.8826
6.8617
1.5205
0.0005
F
S
OH

3f

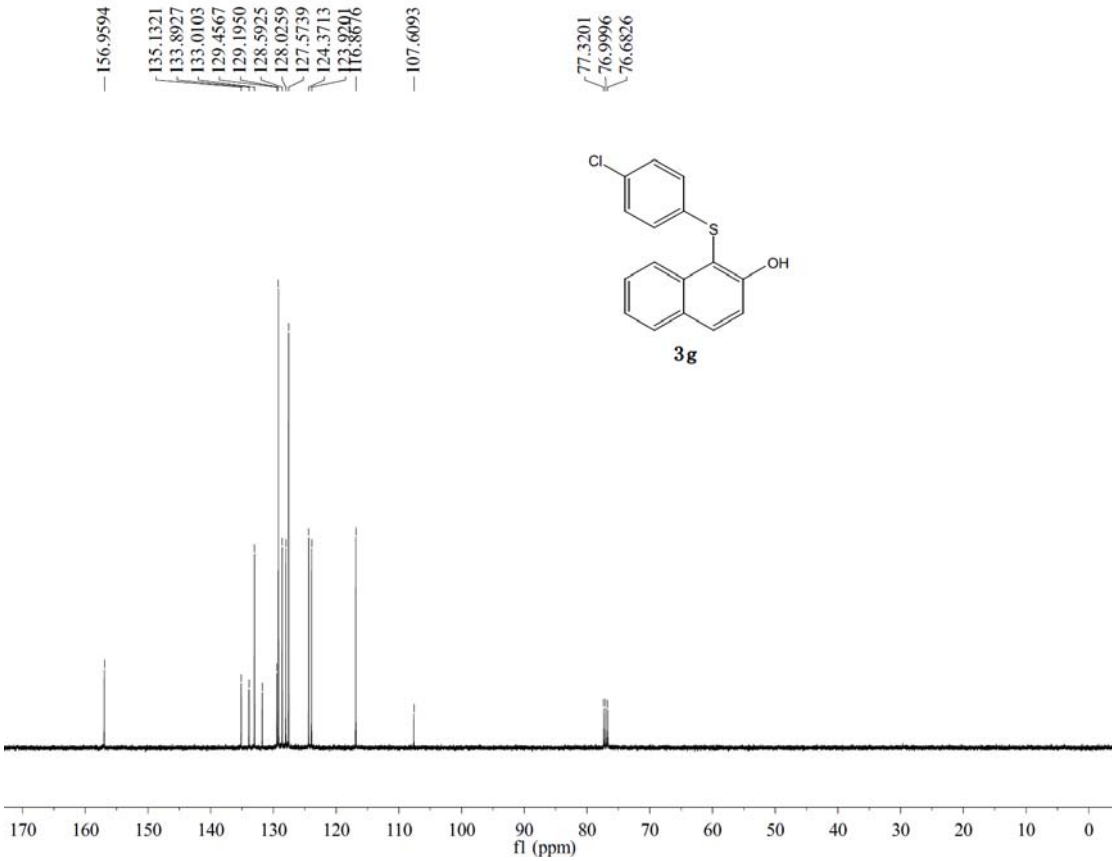

1.00
1.12
1.03
1.11
2.07
0.98
2.02
2.06
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

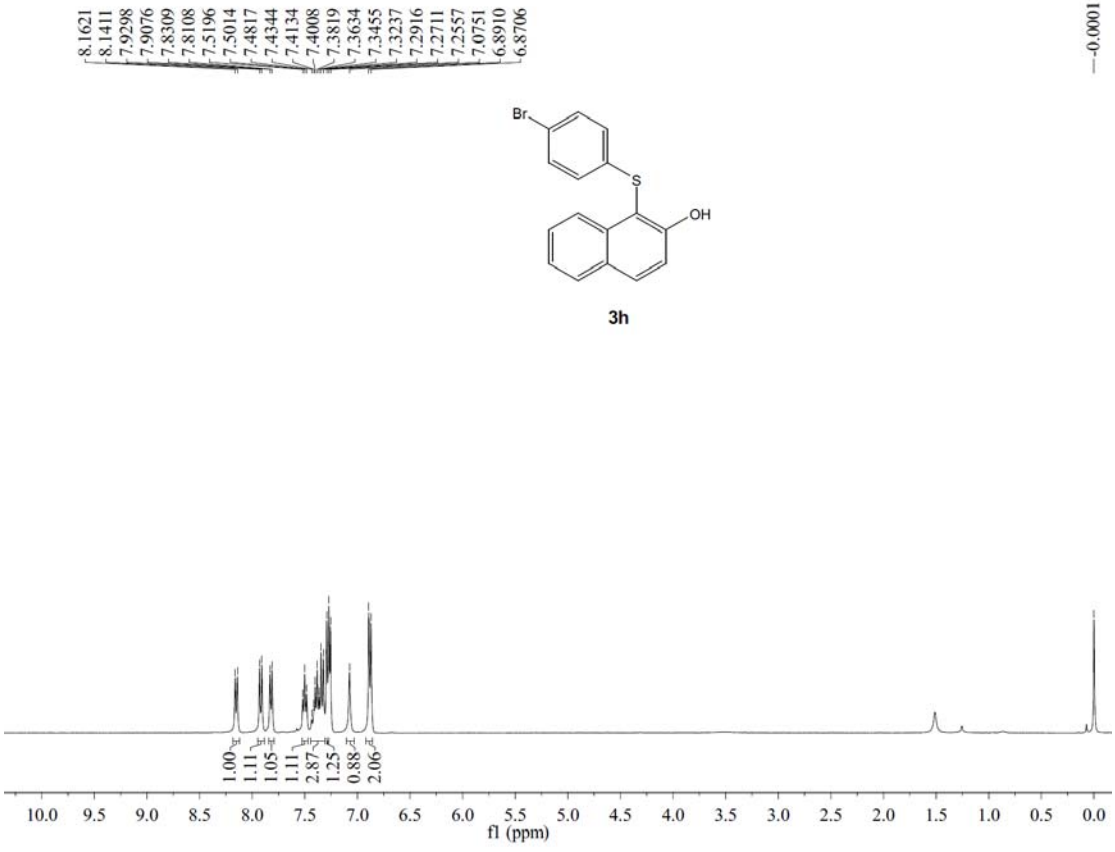

162.6293
160.1858
156.9022
135.2239
132.9139
130.3324
129.5183
128.6208
128.3983
128.3196
128.0061
124.4913
123.9103
116.4052
116.1841
108.5035
77.3203
77.0027
76.6849
F
S
OH
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

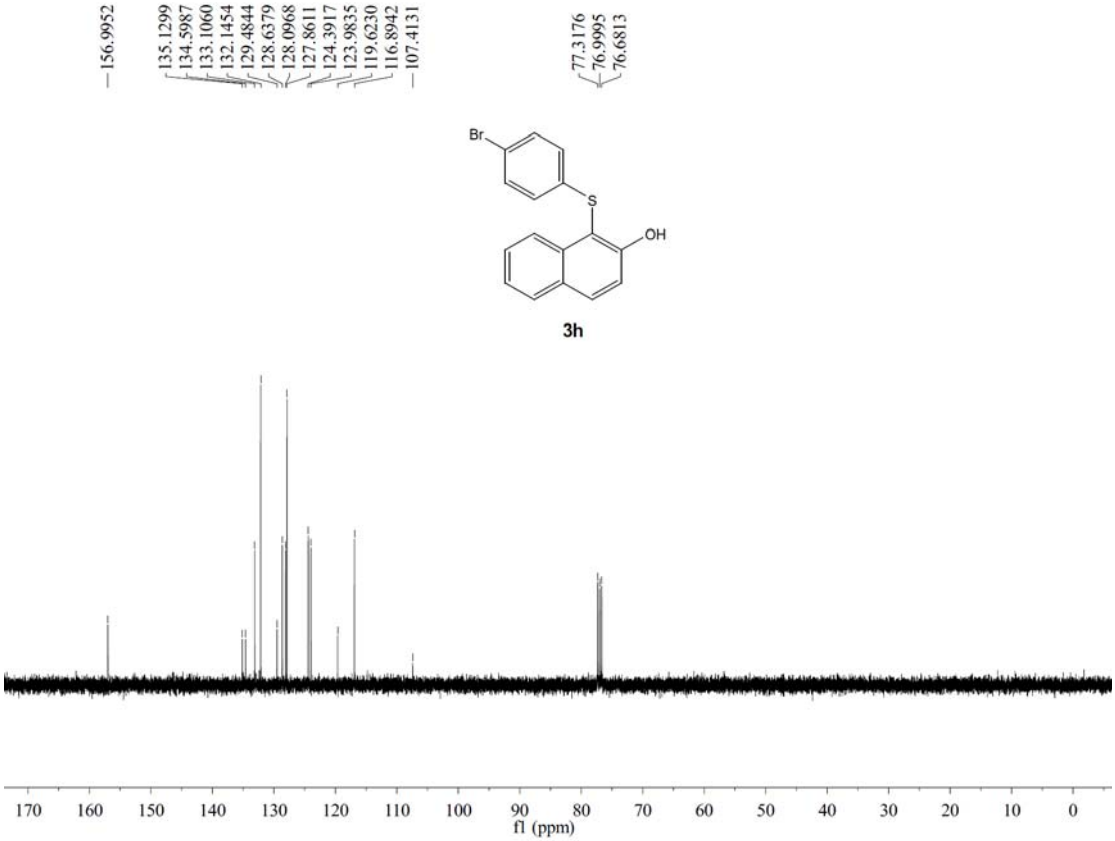
3f


8.1605
8.1399
7.9063
7.8999
7.8843
7.8097
7.7903
7.5030
7.4850
7.4674
7.3817
7.3632
7.3349
7.3268
7.3125
7.3045
7.2299
7.1249
7.1178
7.1039
7.0971
6.9392
6.9183
-0.0003
Cl
S
OH
1.00
1.10
1.07
1.13
2.17
2.21
2.10
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

3g


156.9594
135.1321
133.8927
133.0103
129.4567
129.1950
128.5925
128.0259
127.5739
124.3713
123.9201
116.8676
107.6093
77.3201
76.9996
76.6826
Cl
S
OH
3g
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)


8.1621
8.1411
7.9298
7.9076
7.8309
7.8108
7.5196
7.5014
7.4817
7.4344
7.4134
7.4008
7.3819
7.3634
7.3455
7.3237
7.2916
7.2711
7.2557
7.0751
6.8910
6.8706
-0.0001
Br
S
OH
3h
1.00
1.11
1.05
1.11
2.87
1.25
0.88
2.06
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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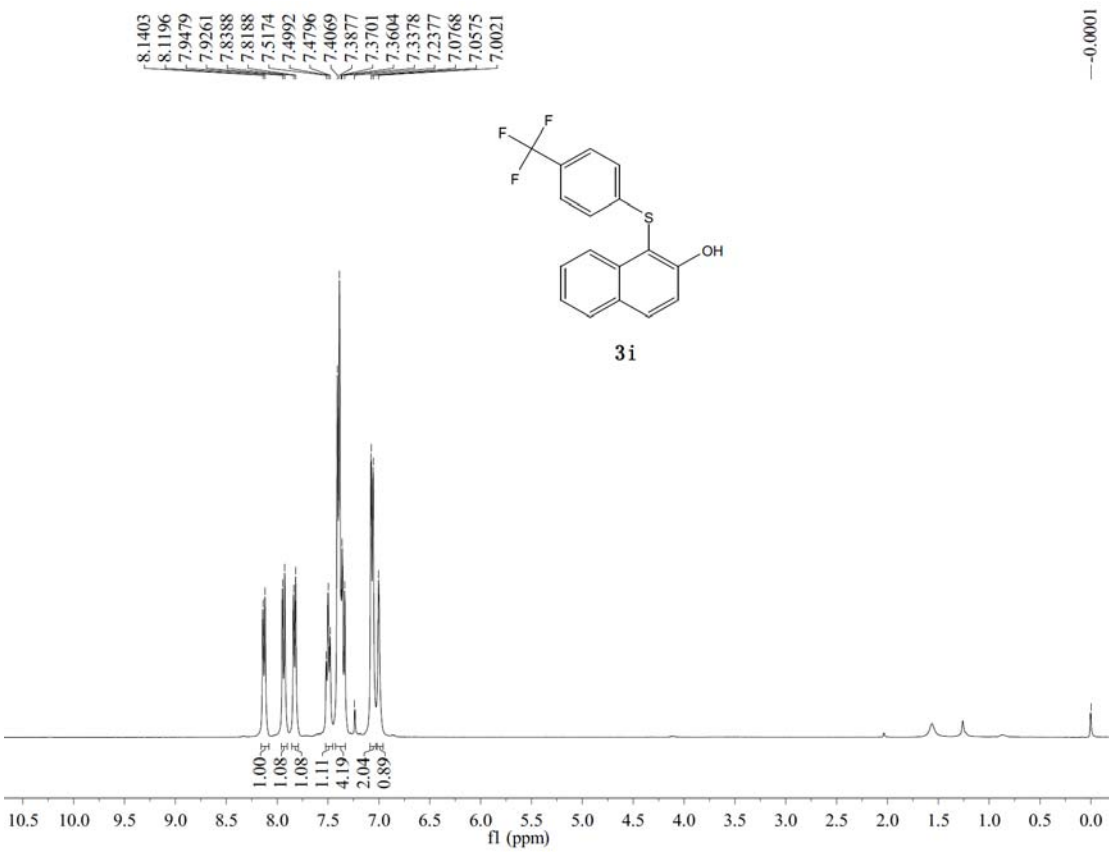
135.1299
134.5987
133.1060
132.1454
129.4844
128.6379
128.0968
127.8611
124.3917
123.9835
119.6230
116.8942
107.4131
77.3176
76.9995
76.6813
Br
S
OH
3h
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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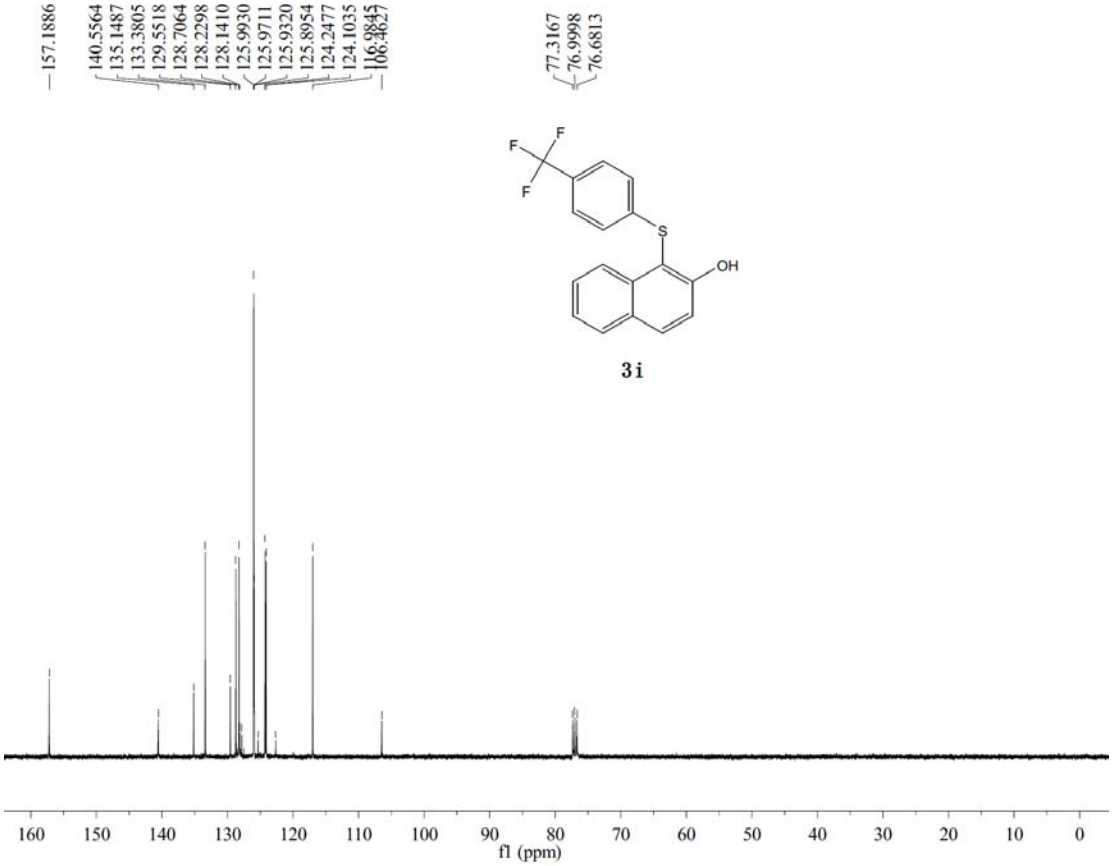
8.1196
7.9479
7.9261
7.8388
7.8188
7.5174
7.4992
7.4796
7.4069
7.3877
7.3701
7.3604
7.3378
7.2377
7.0768
7.0575
7.0021
-0.0001
F
F
F
S
OH
3i
1.00
1.08
1.08
1.11
4.19
2.04
0.89
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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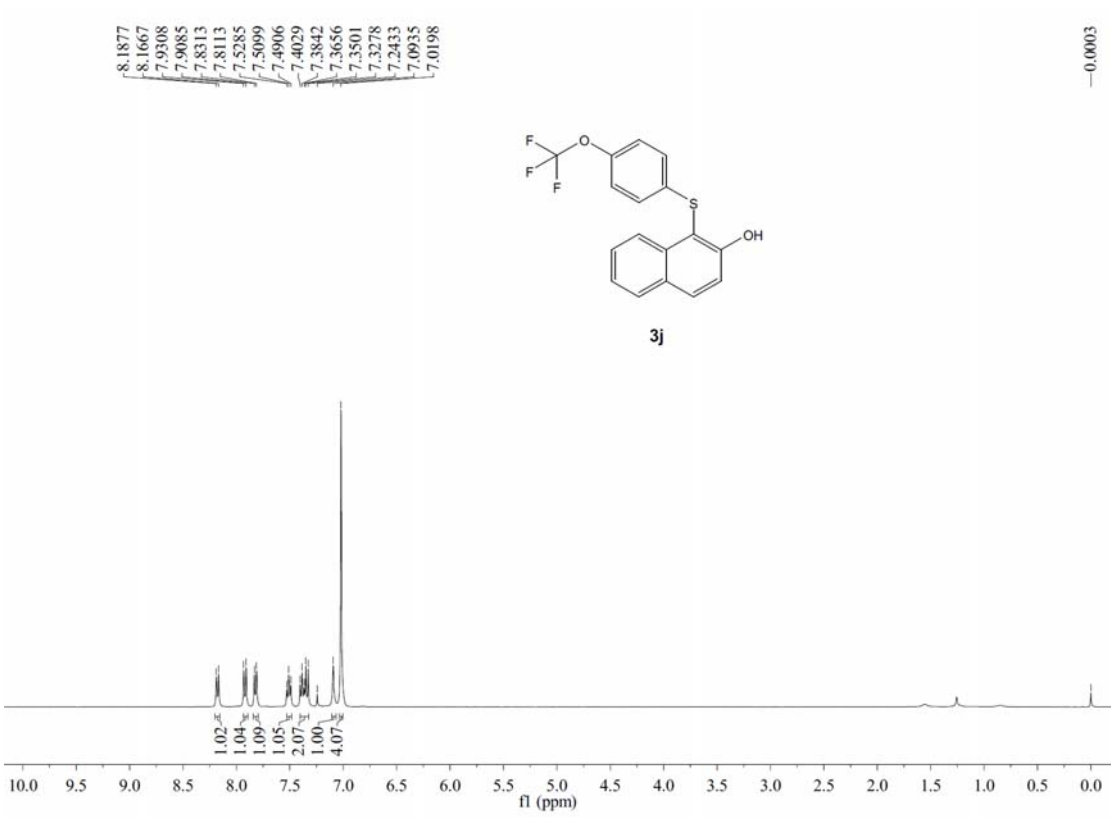
140.5564
135.1487
133.3805
129.5518
128.7064
128.2298
128.1410
125.9930
125.9711
125.9320
125.8954
124.2477
124.1035
106.9845
106.4627
77.3167
76.9998
76.6813
F
F
F
S
OH
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

3 i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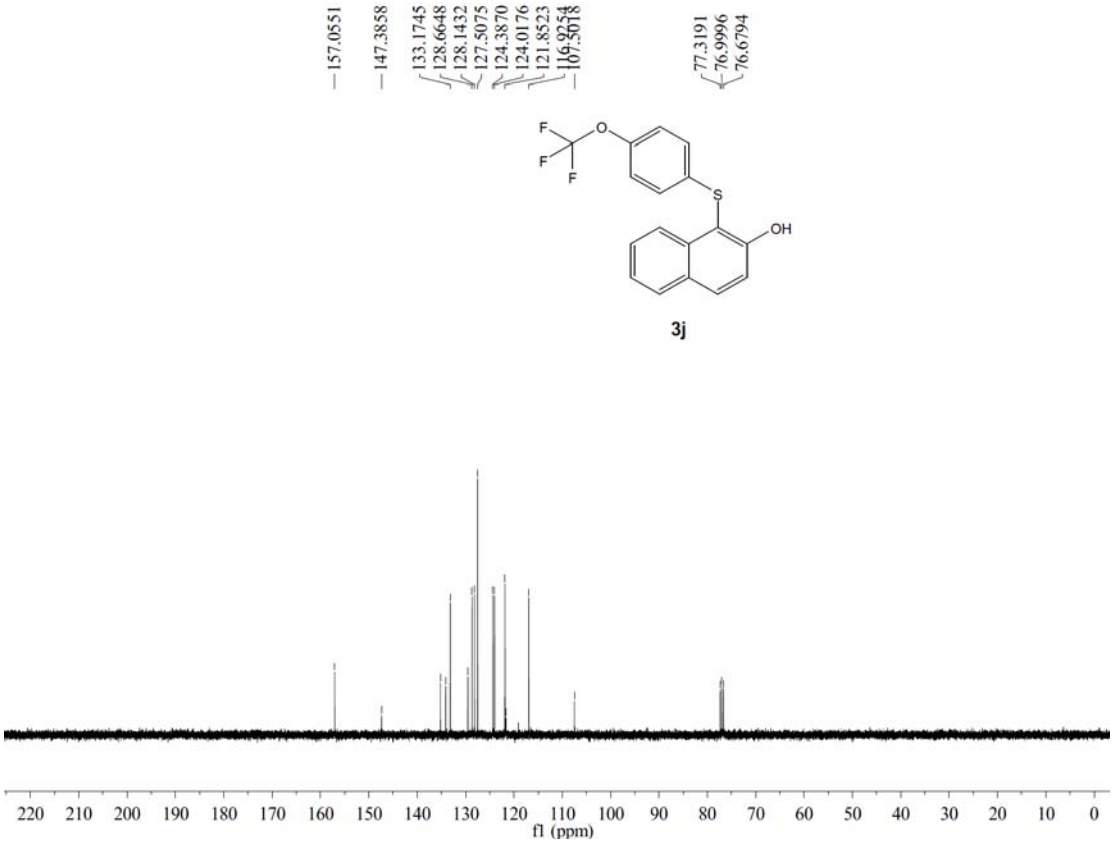
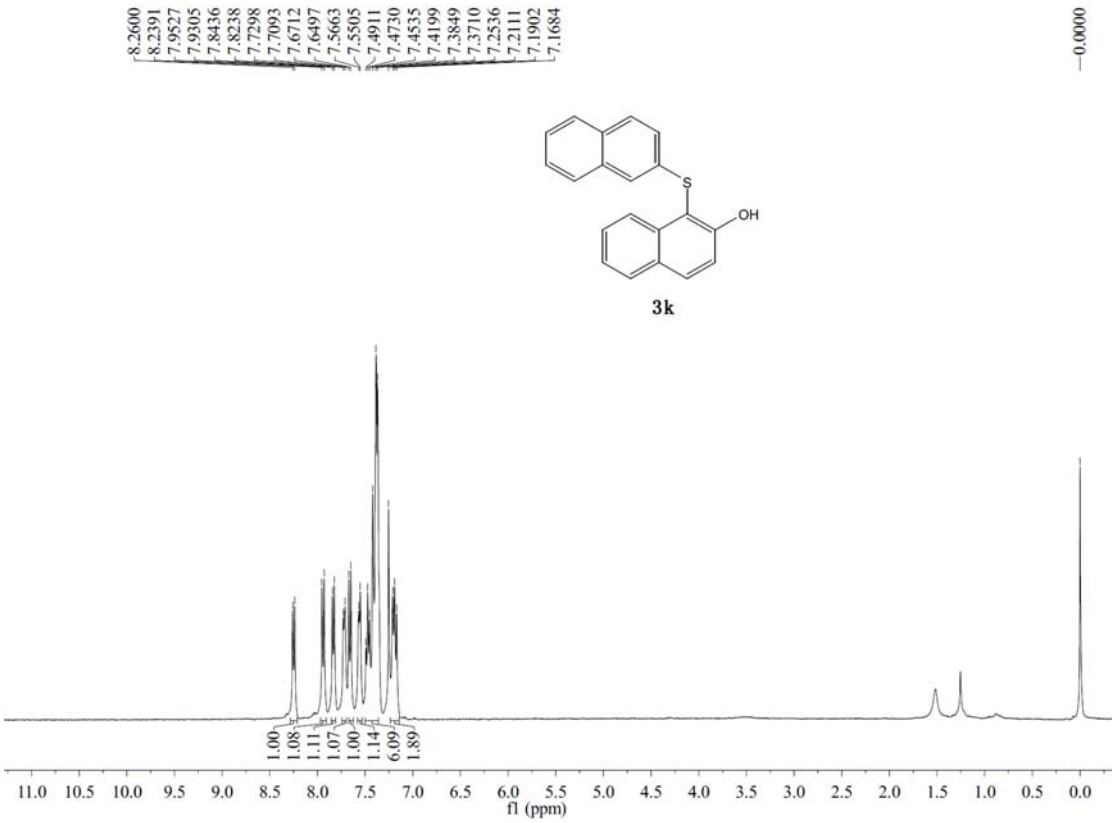
8.1667
7.9308
7.9085
7.8313
7.8113
7.5285
7.5099
7.4906
7.4029
7.3842
7.3656
7.3501
7.3278
7.2433
7.0935
7.0198
0.0003
F
F
F
O
S
OH
1.02
1.04
1.09
1.05
2.07
1.00
4.07
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

3j


157.0551
147.3858
133.1745
128.6648
128.1432
127.5075
124.3870
124.0176
121.8523
116.9254
107.5018
77.3191
76.9996
76.6794
F
F
F
O
S
OH
3j
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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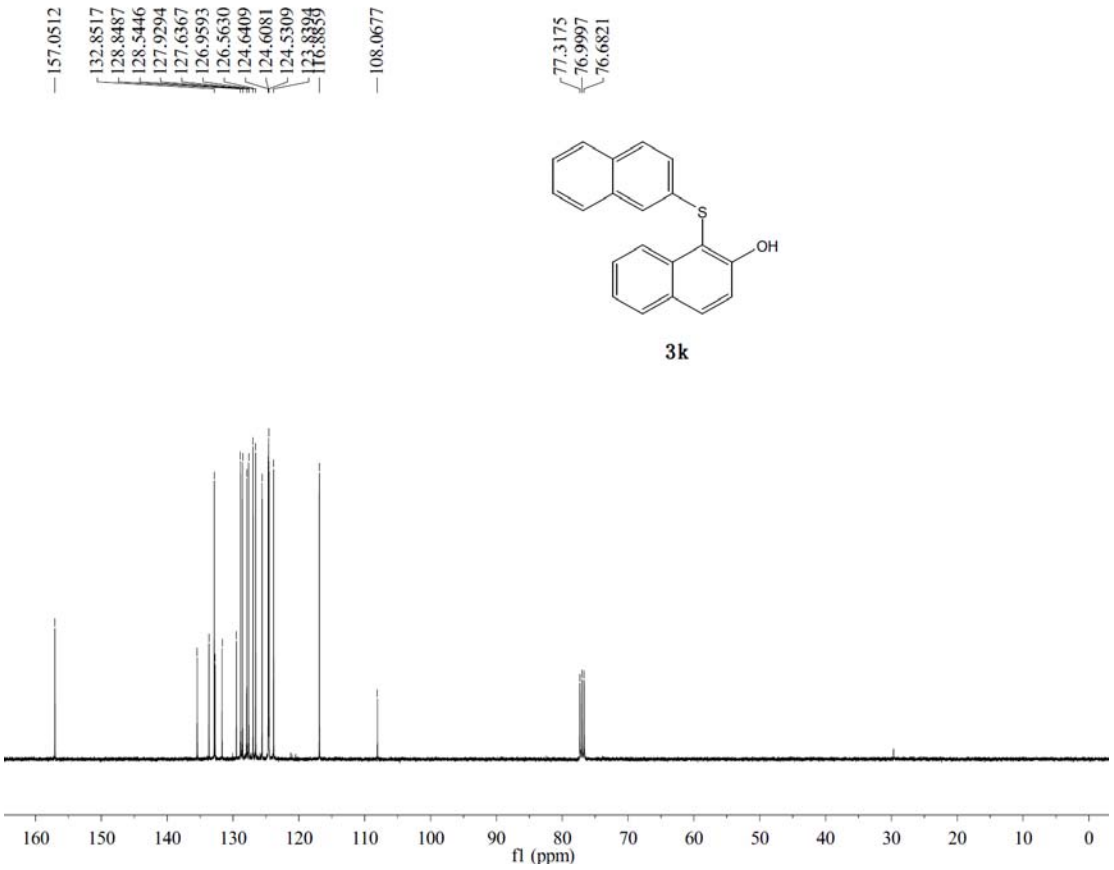
7.9305
7.8436
7.8238
7.7298
7.7093
7.6712
7.6497
7.5663
7.5505
7.4911
7.4730
7.4535
7.4199
7.3849
7.3710
7.2536
7.2111
7.1902
7.1684
0.0000
S
OH
3k
1.00
1.08
1.11
1.07
1.00
1.14
6.09
1.89
11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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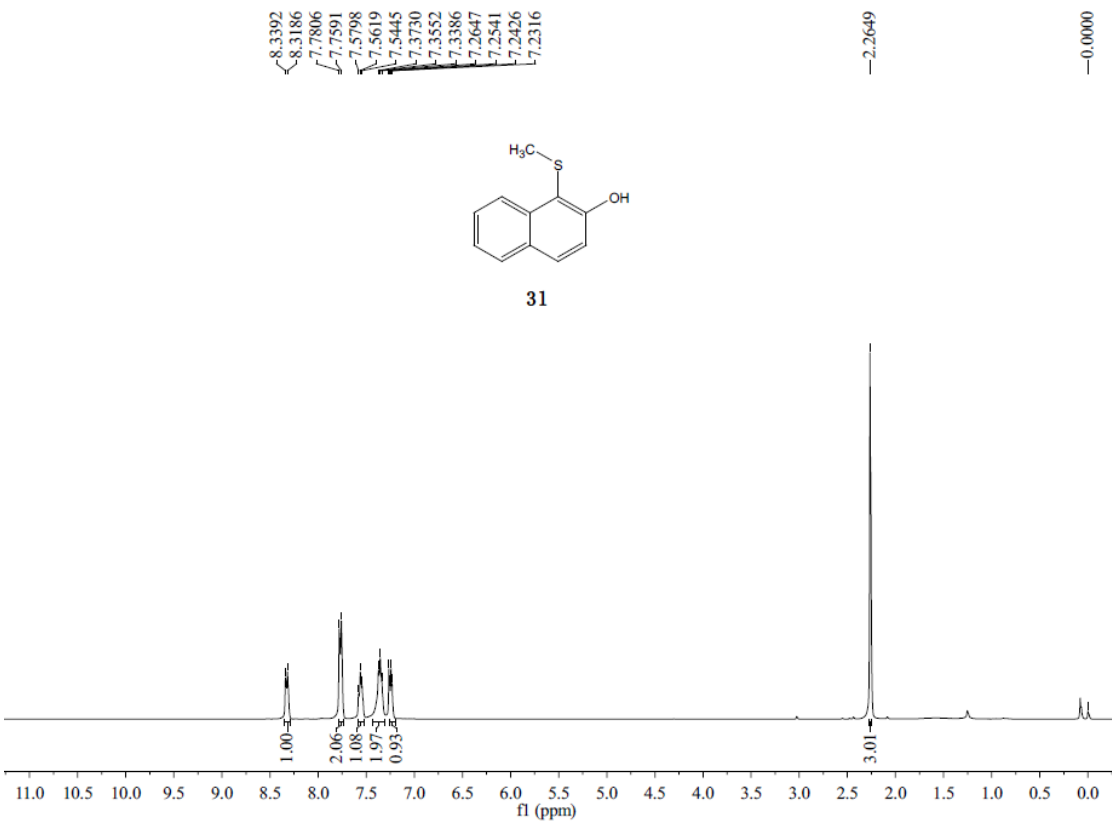
128.8487
128.5446
127.9294
127.6367
126.9593
126.5630
124.6409
124.6081
124.5309
123.8394
116.8859
108.0677
77.3175
76.9997
76.6821
S
OH
160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

3k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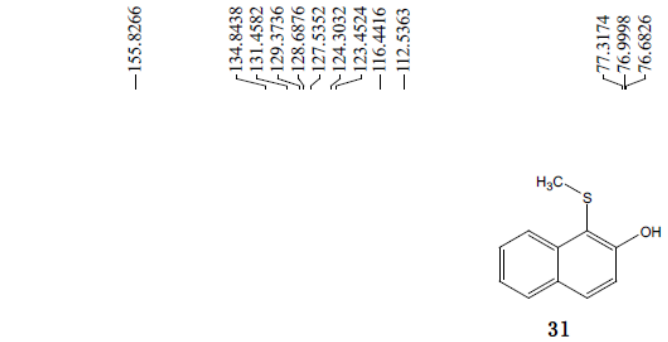
7.7806
7.7591
7.5798
7.5619
7.5445
7.3730
7.3552
7.3386
7.2647
7.2541
7.2426
7.2316
2.2649
0.0000
H3C
S
OH
1.00
2.06
1.08
1.97
0.93
3.01
11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

31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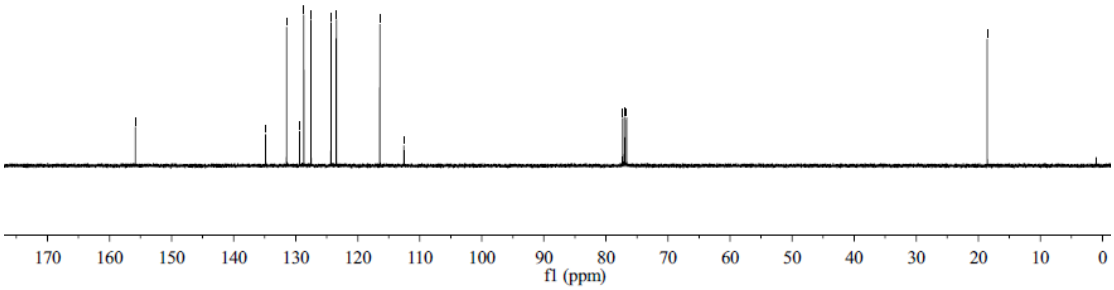
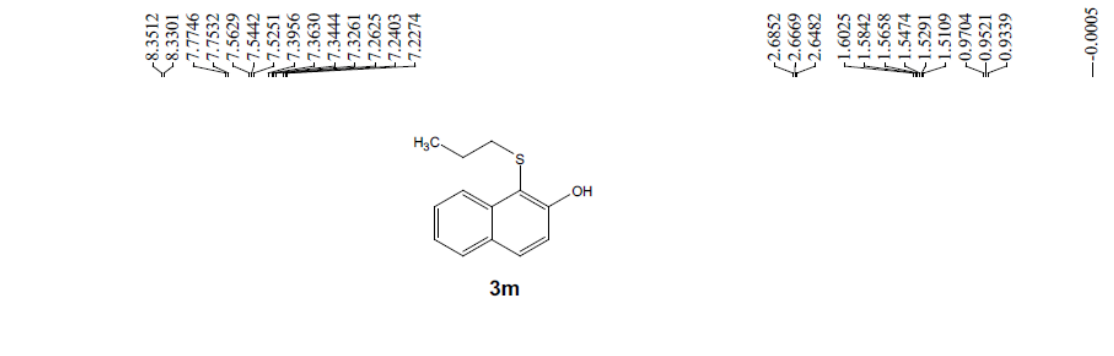
131.4582
129.3736
128.6876
127.5352
124.3032
123.4524
116.4416
112.5363
77.3174
76.9998
76.6826
18.5596
H3C
S
OH

31


170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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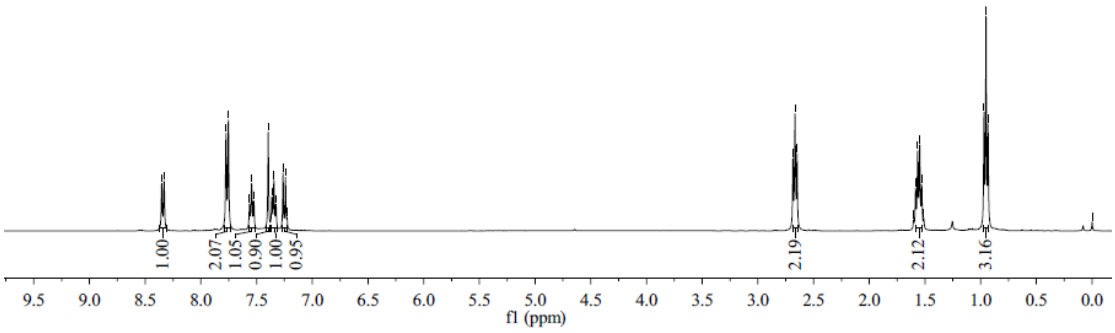
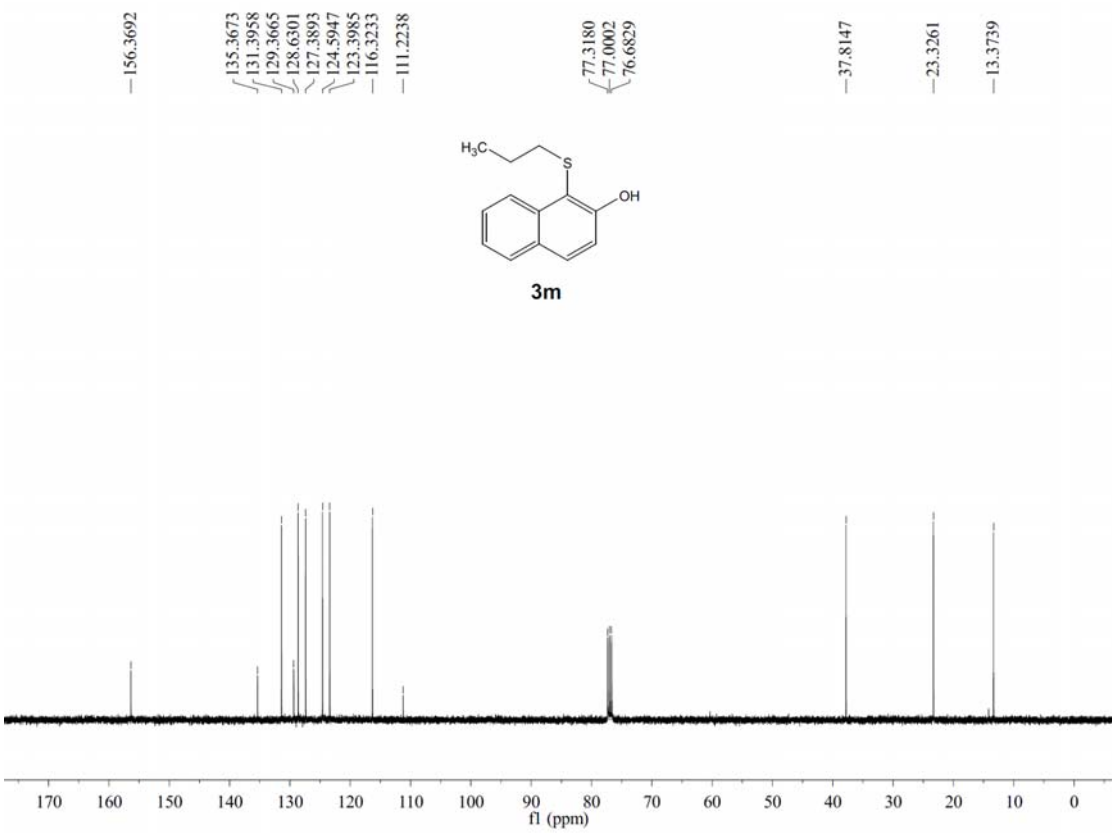
7.7746
7.7532
7.5629
7.5442
7.5251
7.3956
7.3630
7.3444
7.3261
7.2625
7.2403
7.2274
2.6852
2.6669
2.6482
1.6025
1.5842
1.5658
1.5474
1.5291
1.5109
0.9704
0.9521
0.9339
-0.0005
H3C
S
OH

3m


1.00
2.07
1.05
0.90
1.00
0.95
2.19
2.12
3.16
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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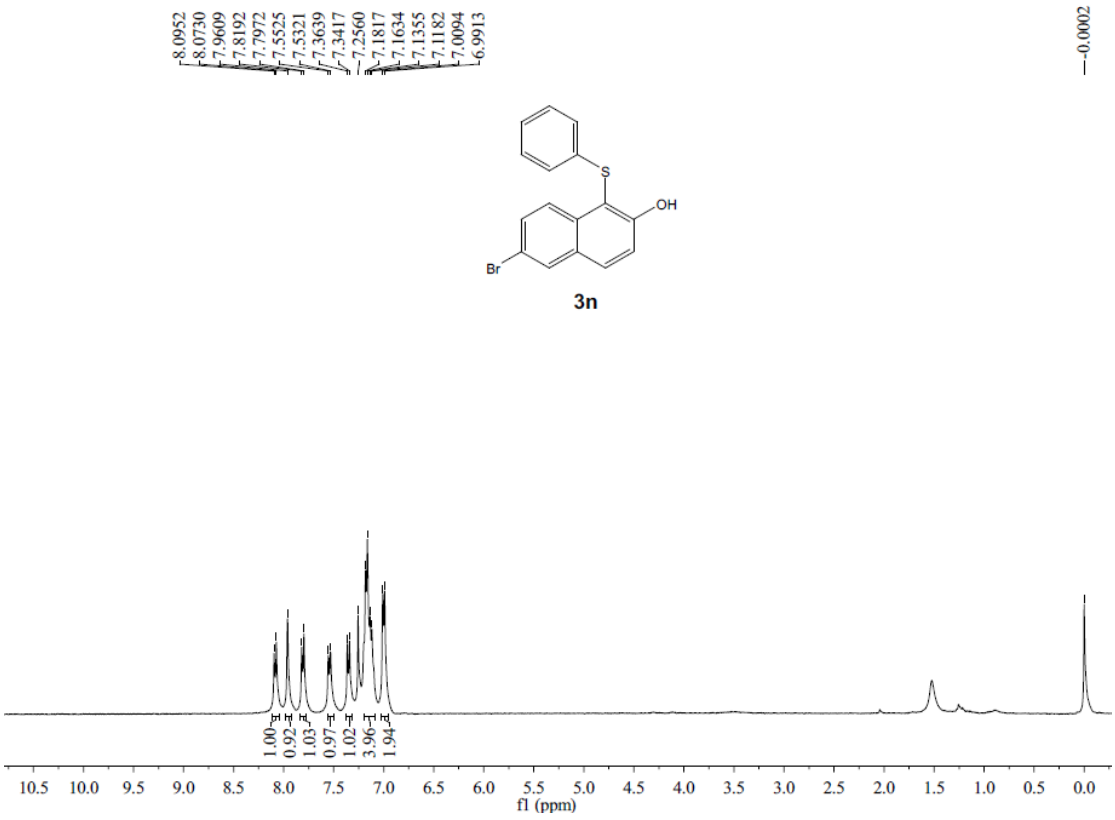
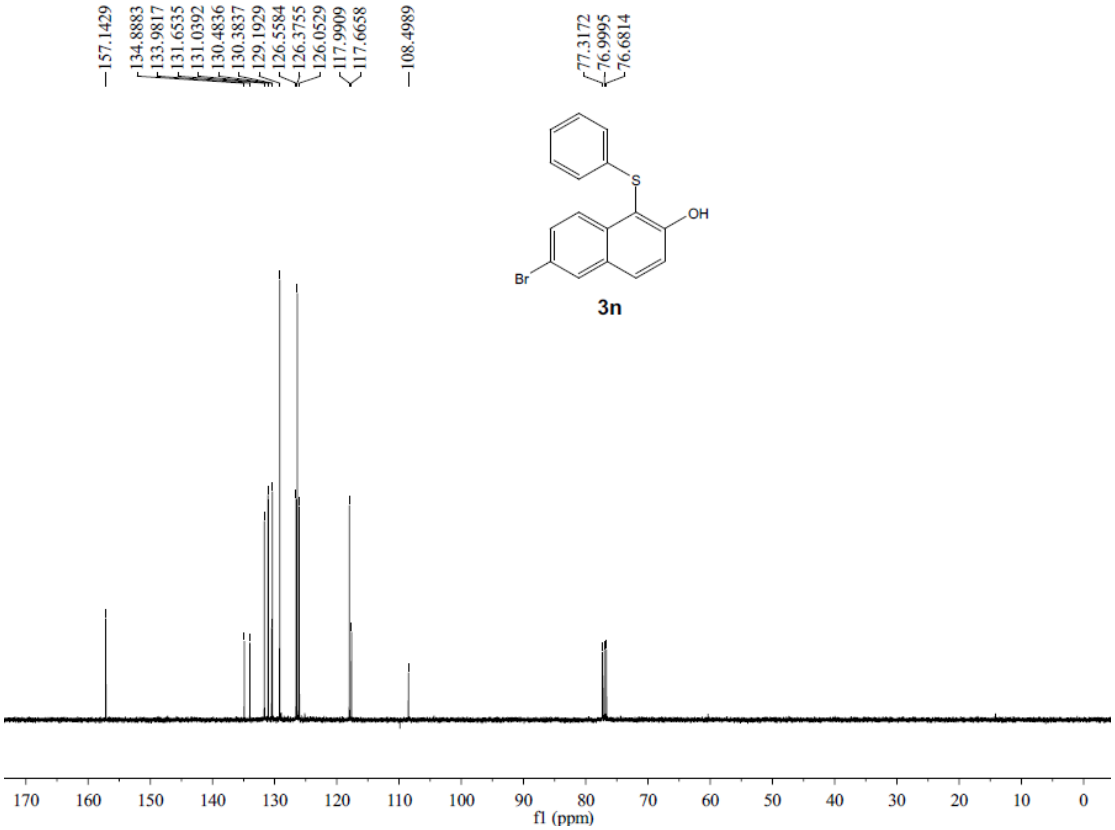
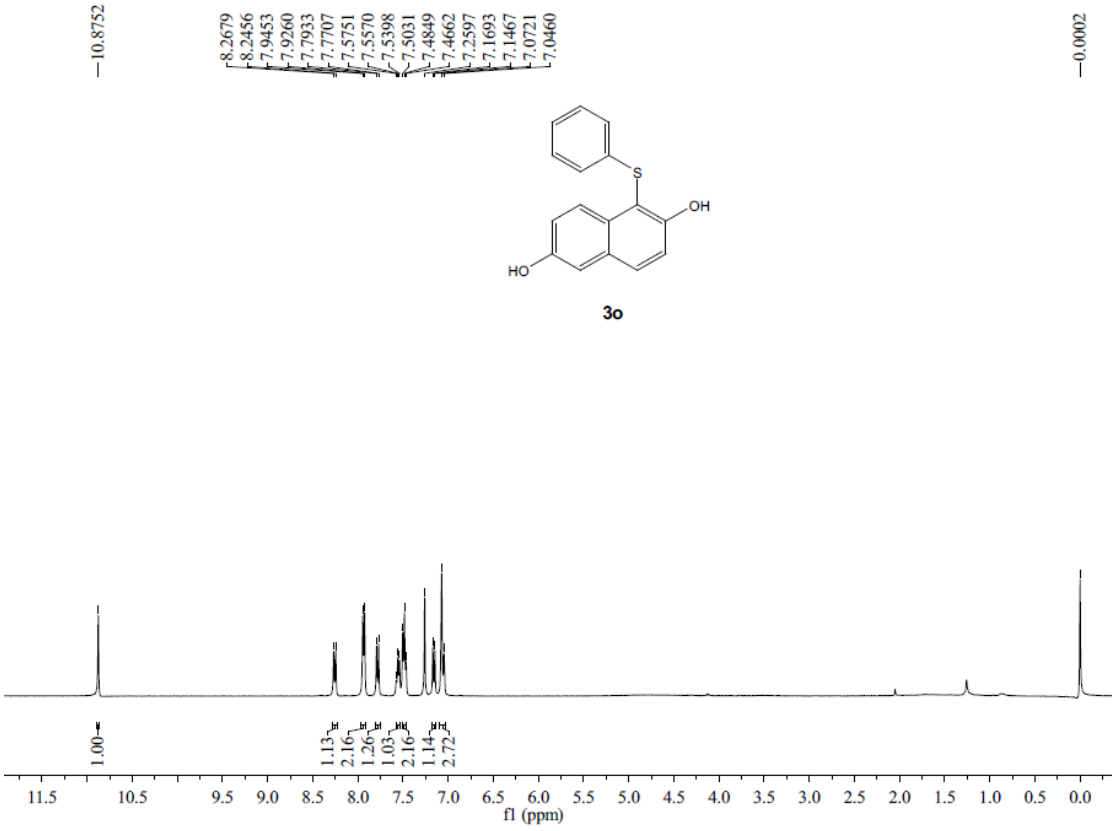
131.3958
129.3665
128.6301
127.3893
124.5947
123.3985
116.3233
111.2238
77.3180
77.0002
76.6829
37.8147
23.3261
13.3739
H3C
S
OH
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

3m


8.0952
8.0730
7.9609
7.8192
7.7972
7.5525
7.5321
7.3639
7.3417
7.2560
7.1817
7.1634
7.1355
7.1182
7.0094
6.9913
-0.0002
S
OH
Br
1.00
0.92
1.03
0.97
1.02
3.96
1.94
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

3n


157.1429
134.8883
133.9817
131.6535
131.0392
130.4836
130.3837
129.1929
126.5584
126.3755
126.0529
117.9909
117.6658
108.4989
77.3172
76.9995
76.6814
S
OH
Br
3n
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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8.2456
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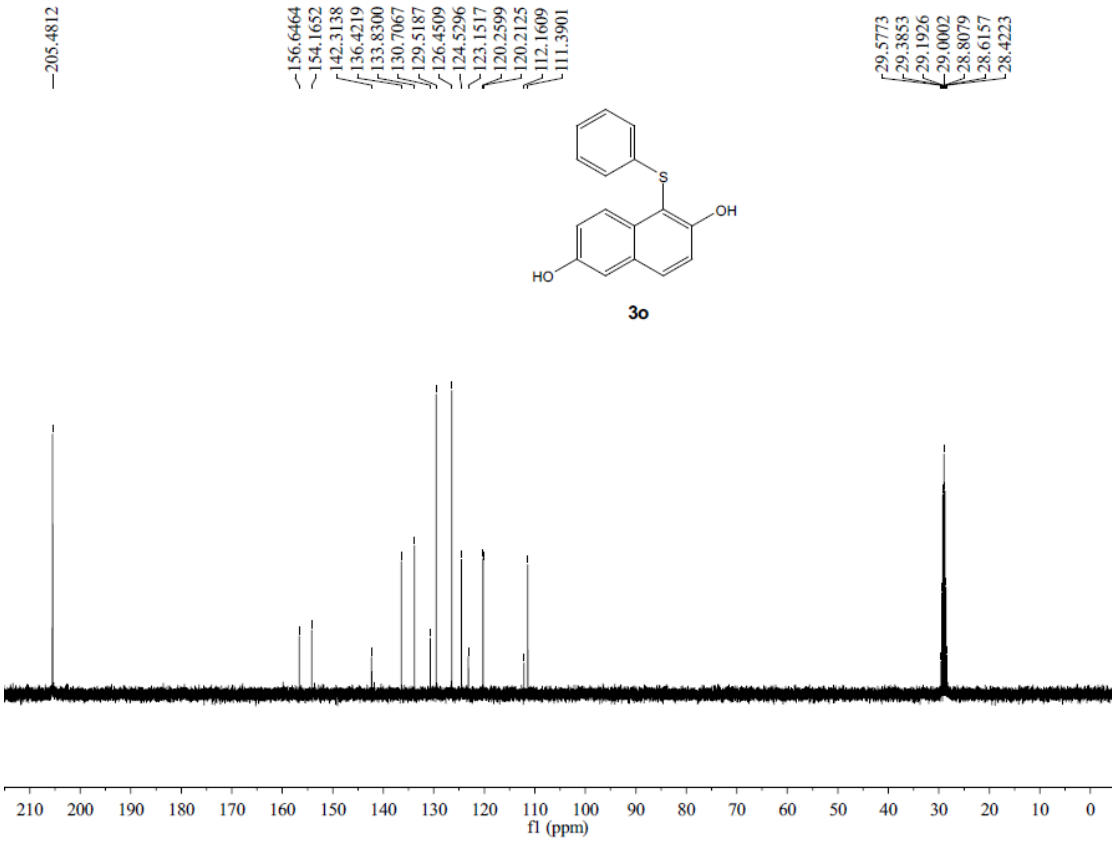
7.9260
7.7933
7.7707
7.5751
7.5570
7.5398
7.5031
7.4849
7.4662
7.2597
7.1693
7.1467
7.0721
7.0460
0.0002
S
OH
HO
3o
1.00
1.13
2.16
1.26
1.03
2.16
1.14
2.72
11.5 10.5 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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136.4219
133.8300
130.7067
129.5187
126.4509
124.5296
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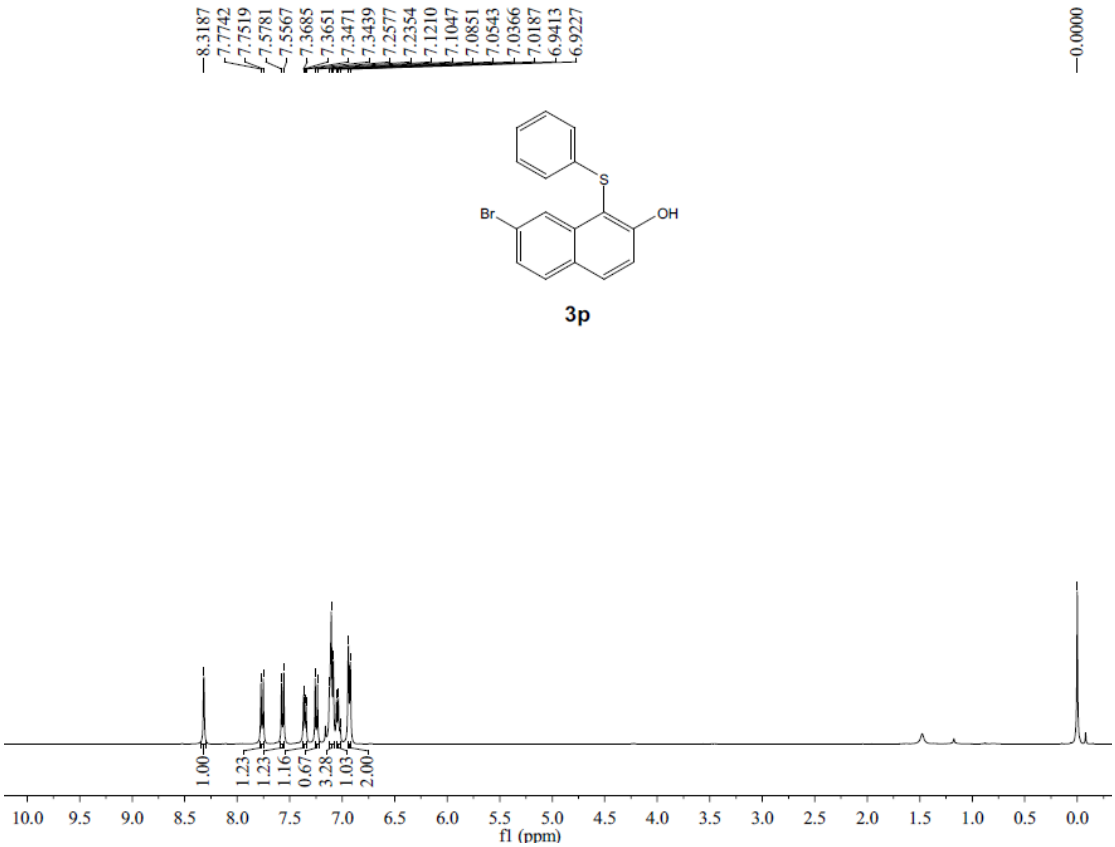
120.2599
120.2125
112.1609
111.3901
29.5773
29.3853
29.1926
29.0002
28.8079
28.6157
28.4223
S
OH
HO
3o
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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7.5567
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7.3651
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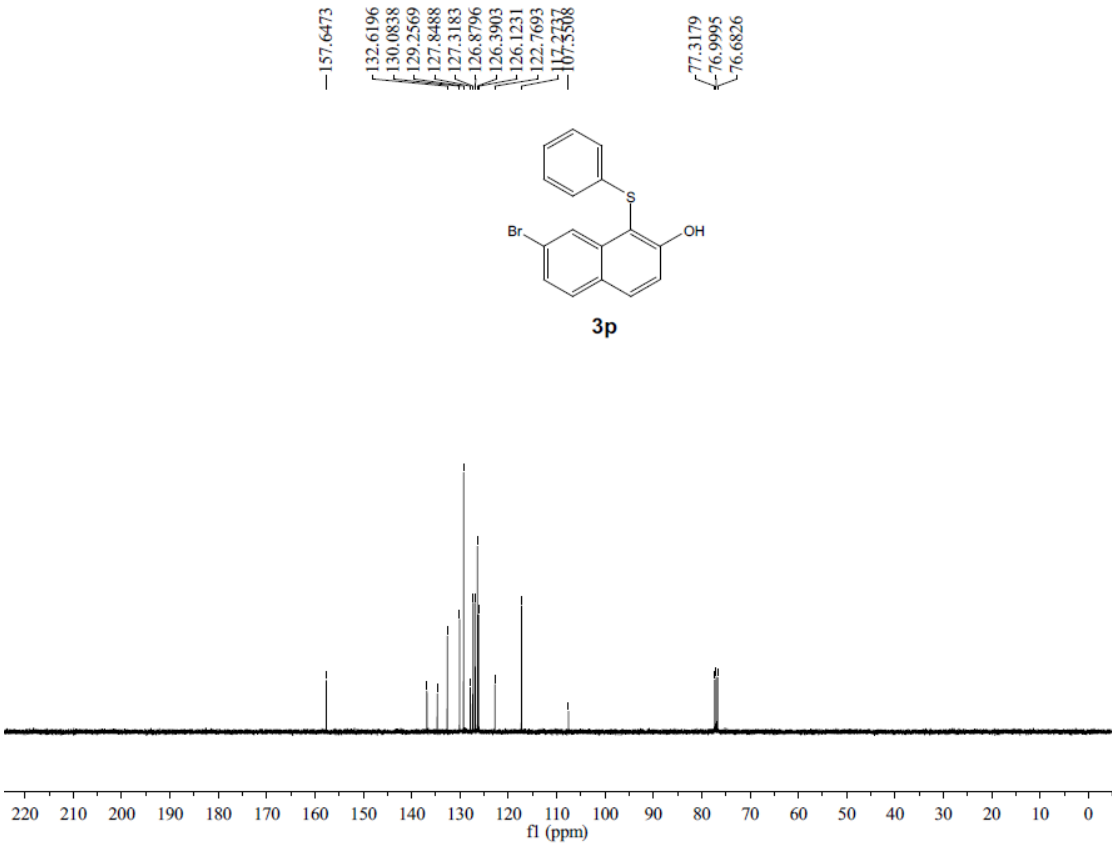
7.2354
7.1210
7.1047
7.0851
7.0543
7.0366
7.0187
6.9413
6.9227
0.0000
S
Br
OH
3p
1.00
1.23
1.23
1.16
0.67
3.28
1.03
2.00
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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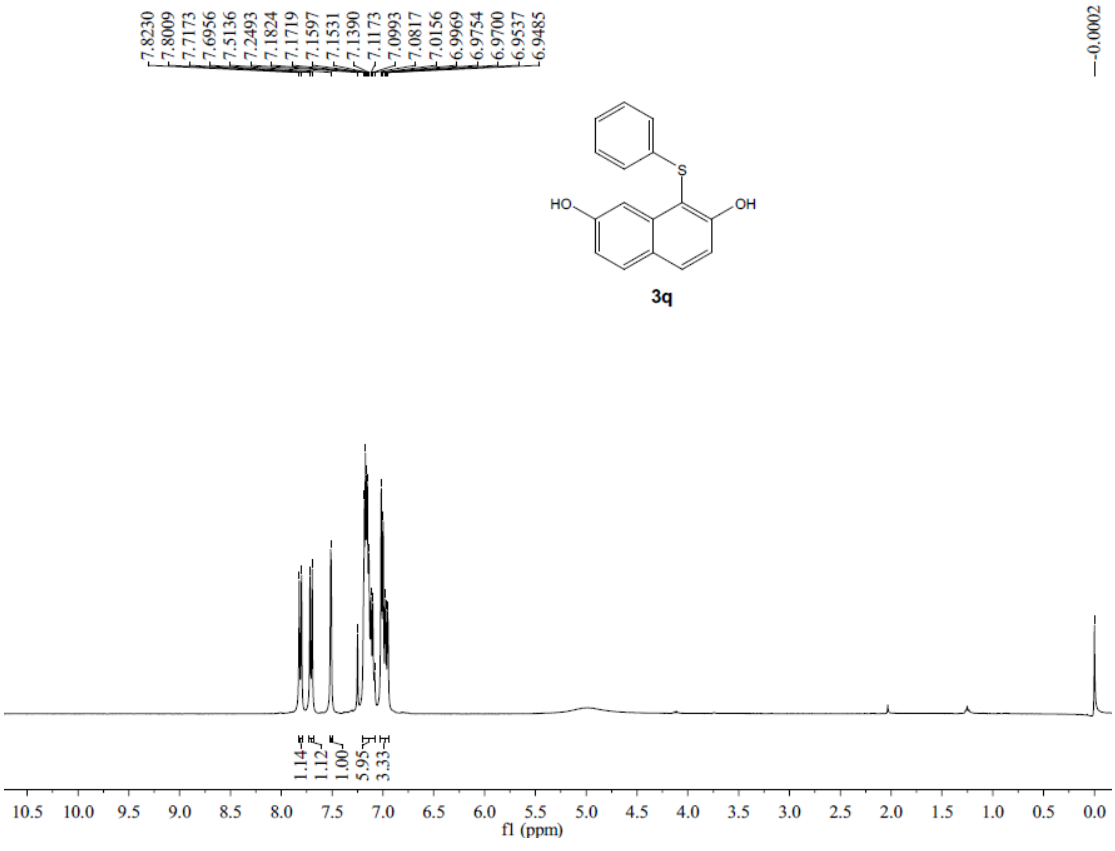
127.8488
127.3183
126.8796
126.3903
126.1231
122.7693
117.2237
107.5508
77.3179
76.9995
76.6826
S
Br
OH
3p
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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7.8009
7.7173
7.6956
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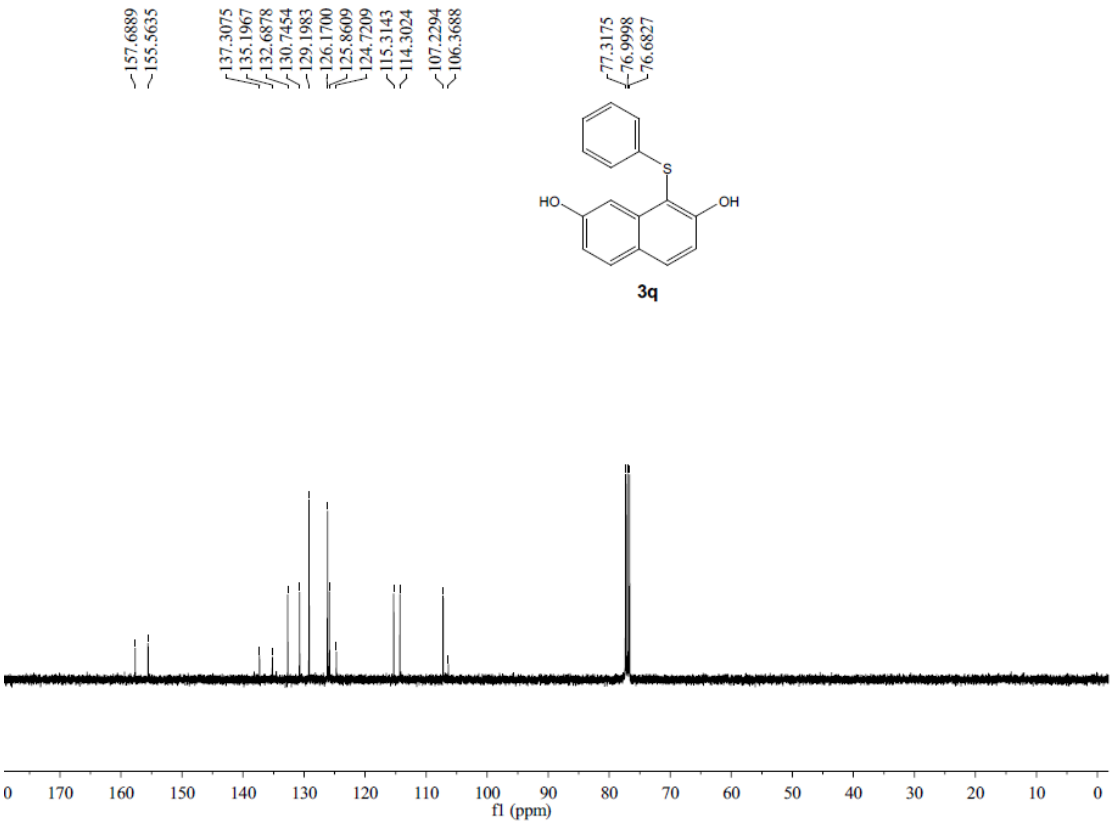
7.1824
7.1719
7.1597
7.1531
7.1390
7.1173
7.0993
7.0817
7.0156
6.9969
6.9754
6.9700
6.9537
6.9485
0.0002
S
HO
OH
3q
1.14
1.12
1.00
5.95
3.33
10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)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137.3075
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129.1983
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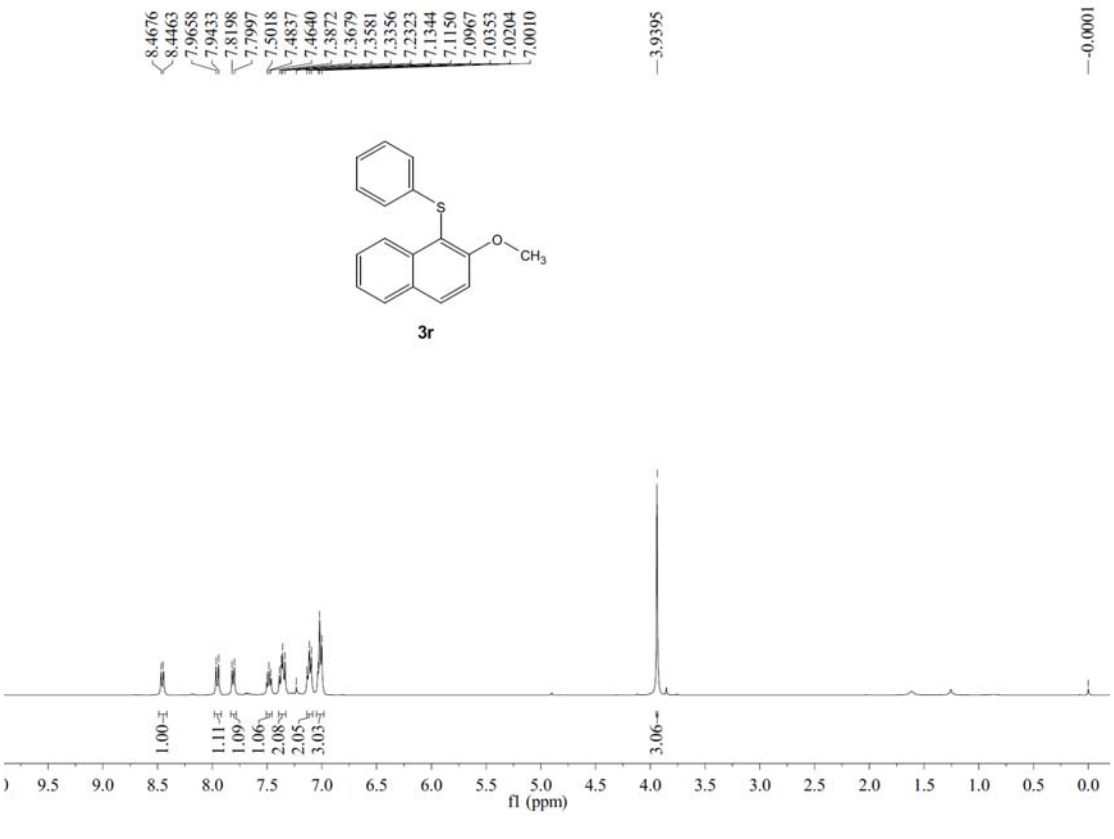
124.7209
115.3143
114.3024
107.2294
106.3688
77.3175
76.9998
76.6827
S
HO
OH
3q
0
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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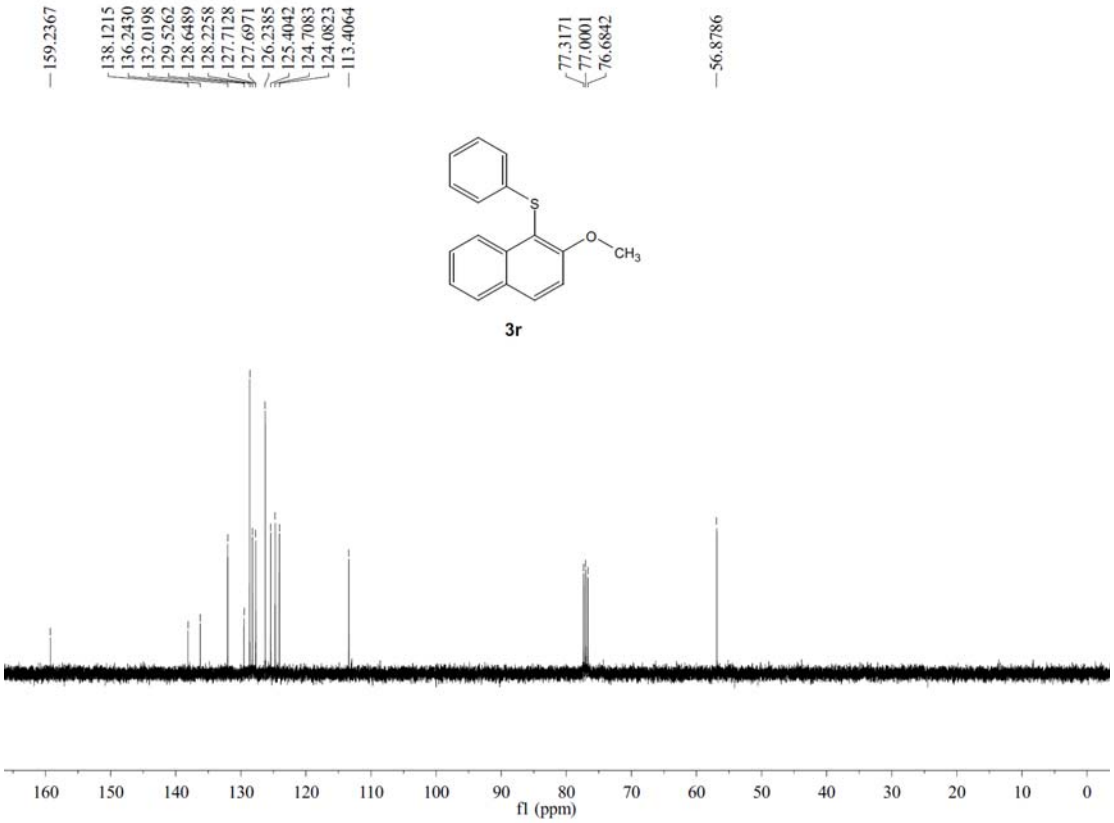
7.7997
7.5018
7.4837
7.4640
7.3872
7.3679
7.3581
7.3356
7.2323
7.1344
7.1150
7.0967
7.0353
7.0204
7.0010
3.9395
-0.0001
S
O
CH3
3r
1.00
1.11
1.09
1.06
2.08
2.05
3.03
3.06
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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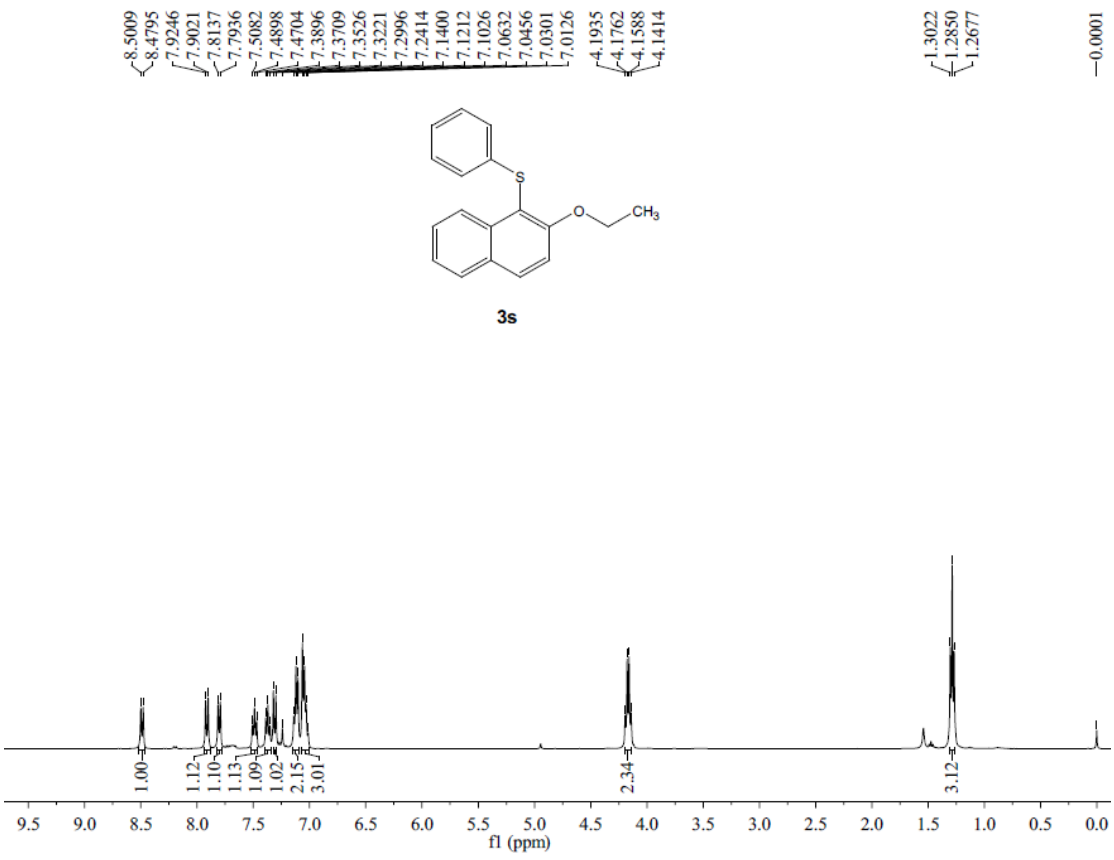
136.2430
132.0198
129.5262
128.6489
128.2258
127.7128
127.6971
126.2385
125.4042
124.7083
124.0823
113.4064
77.3171
77.0001
76.6842
56.8786
S
O
CH3
3r
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)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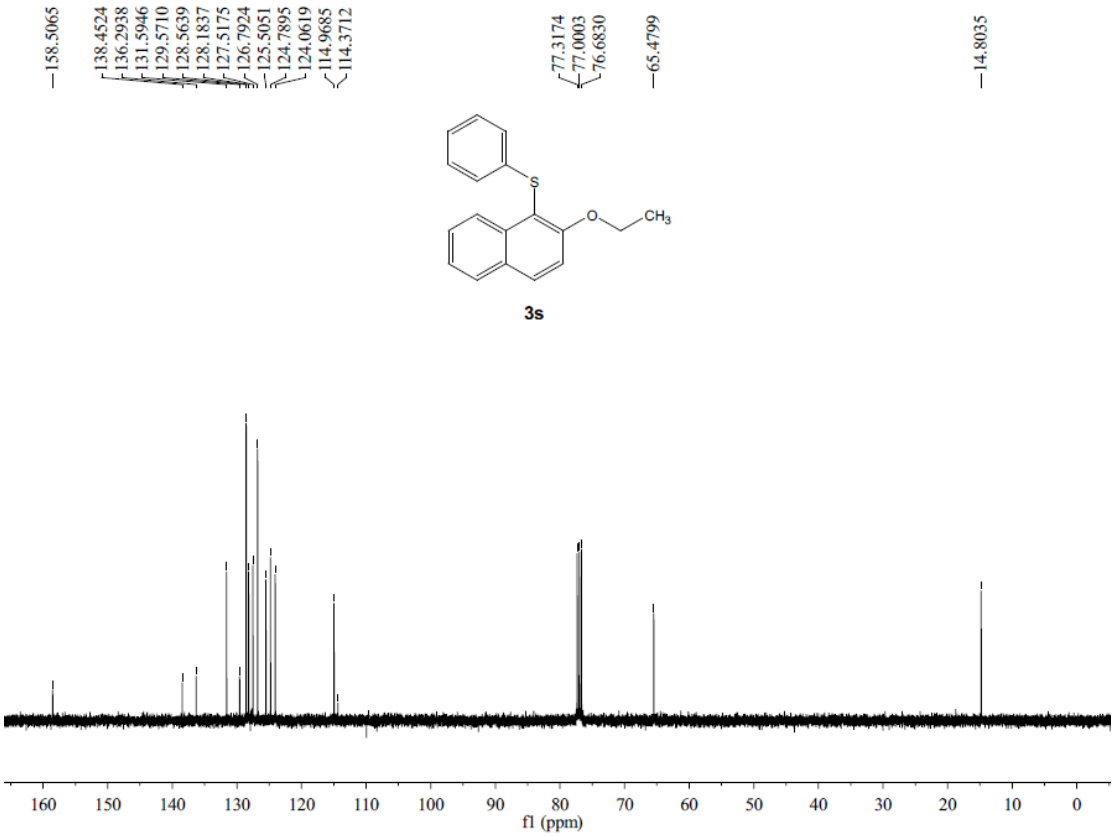
7.9246
7.9021
7.8137
7.7936
7.5082
7.4898
7.4704
7.3896
7.3709
7.3526
7.3221
7.2996
7.2414
7.1400
7.1212
7.1026
7.0632
7.0456
7.0301
7.0126
4.1935
4.1762
4.1588
4.1414
1.3022
1.2850
1.2677
0.0001
S
O
CH3
3s
1.00
1.12
1.10
1.13
1.09
1.02
2.15
3.01
2.34
3.12
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)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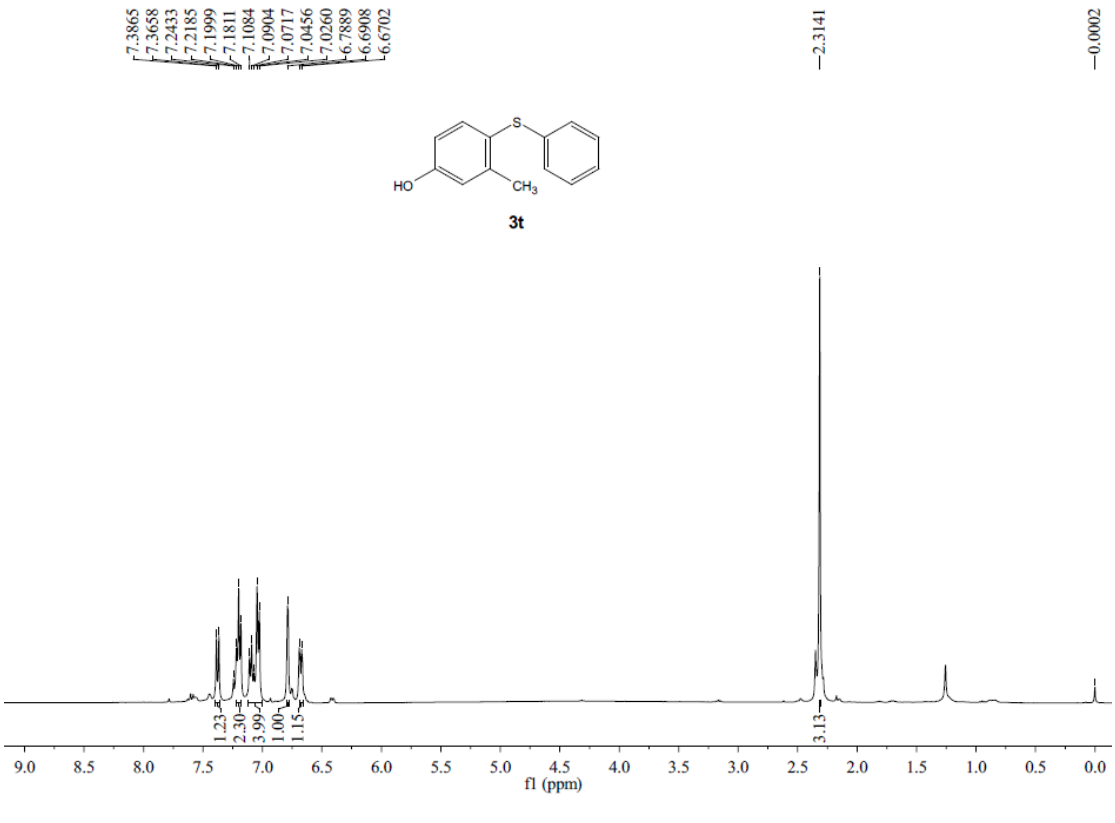
128.5639
128.1837
127.5175
126.7924
125.5051
124.7895
124.0619
114.9685
114.3712
77.3174
77.0003
76.6830
65.4799
14.8035
S
O
CH3
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

3s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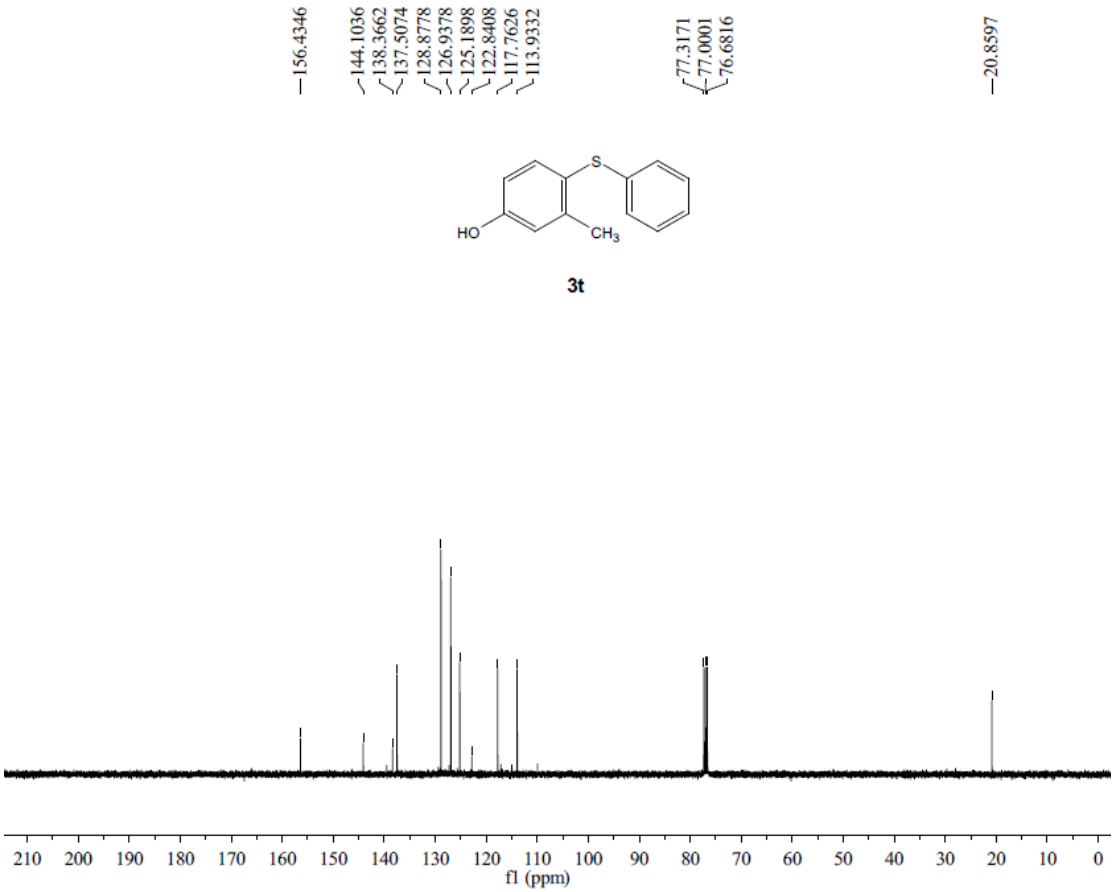
7.2433
7.2185
7.1999
7.1811
7.1084
7.0904
7.0717
7.0456
7.0260
6.7889
6.6908
6.6702
2.3141
0.0002
S
HO
CH3
1.23
2.30
3.99
1.00
1.15
3.13
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

3t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137.5074
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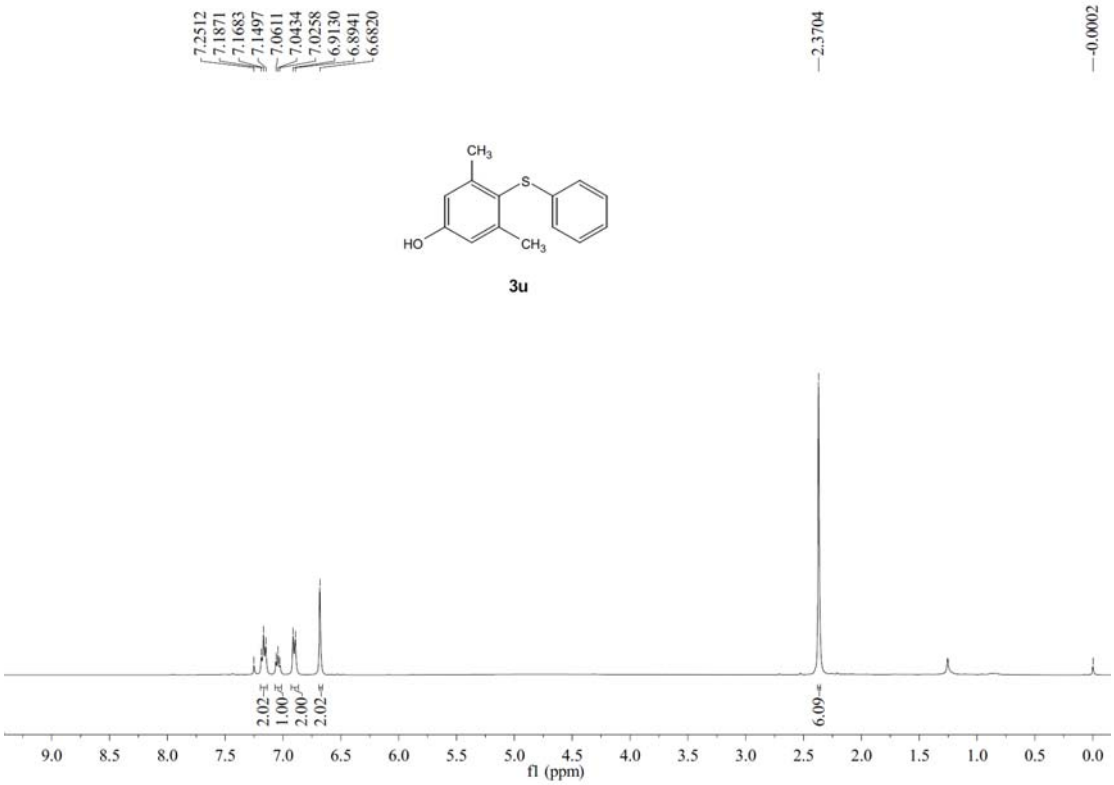
125.1898
122.8408
117.7626
113.9332
77.3171
77.0001
76.6816
20.8597
S
HO
CH3
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

3t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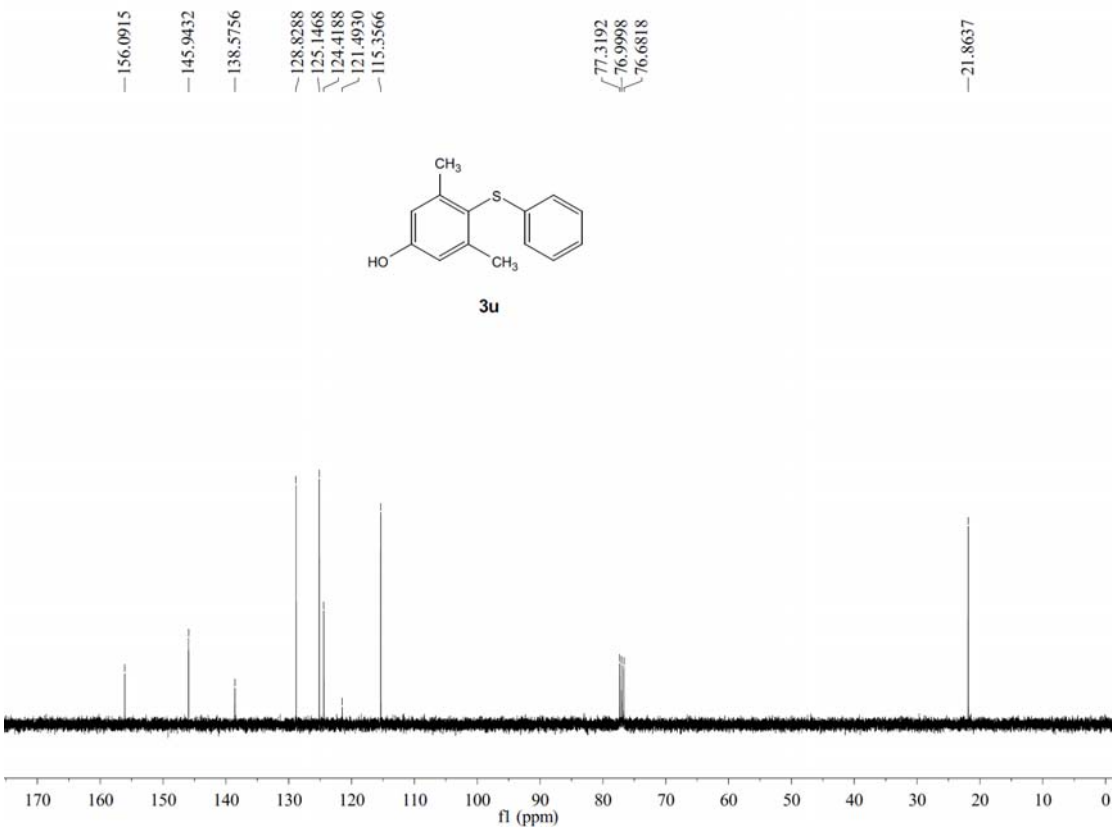
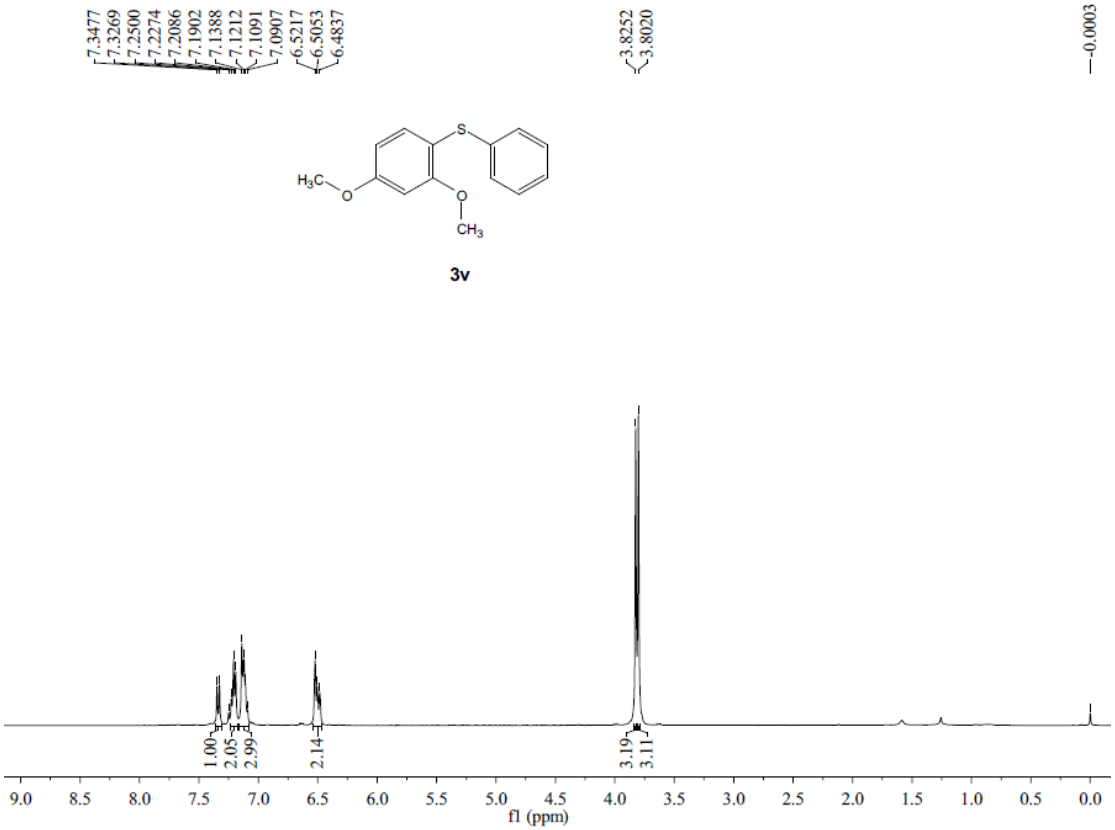
7.1871
7.1683
7.1497
7.0611
7.0434
7.0258
6.9130
6.8941
6.6820
2.3704
-0.0002
CH3
S
HO
CH3
2.02
1.00
2.00
2.02
6.09
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

3u


156.0915
145.9432
138.5756
128.8288
125.1468
124.4188
121.4930
115.3566
77.3192
76.9998
76.6818
21.8637
CH3
S
HO
CH3
170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

3u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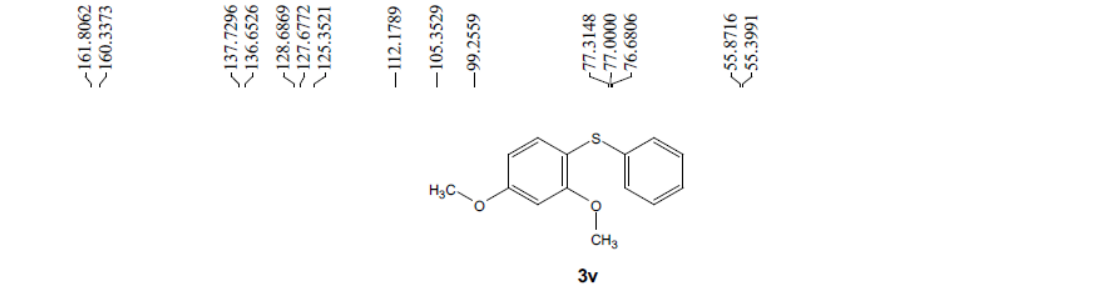
7.2500
7.2274
7.2086
7.1902
7.1388
7.1212
7.1091
7.0907
6.5217
6.5053
6.4837
3.8252
3.8020
-0.0003
S
H3C
O
O
CH3
1.00
2.05
2.99
2.14
3.19
3.11
9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

3v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127.6772
125.3521
112.1789
105.3529
99.2559
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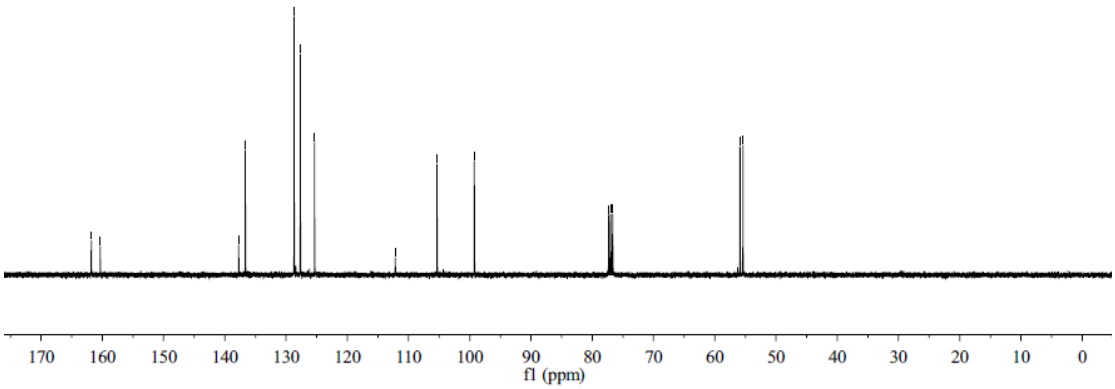
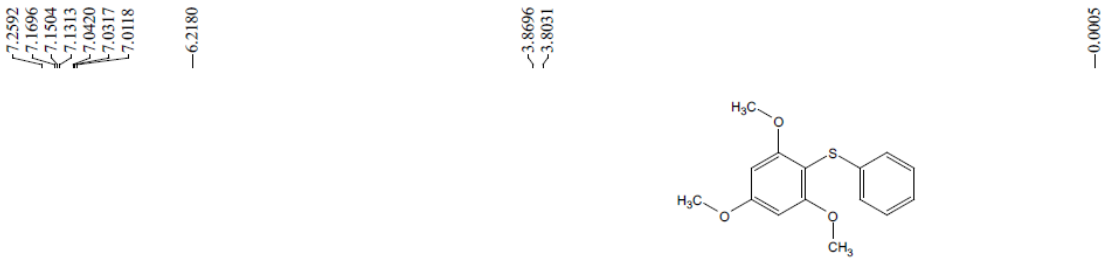
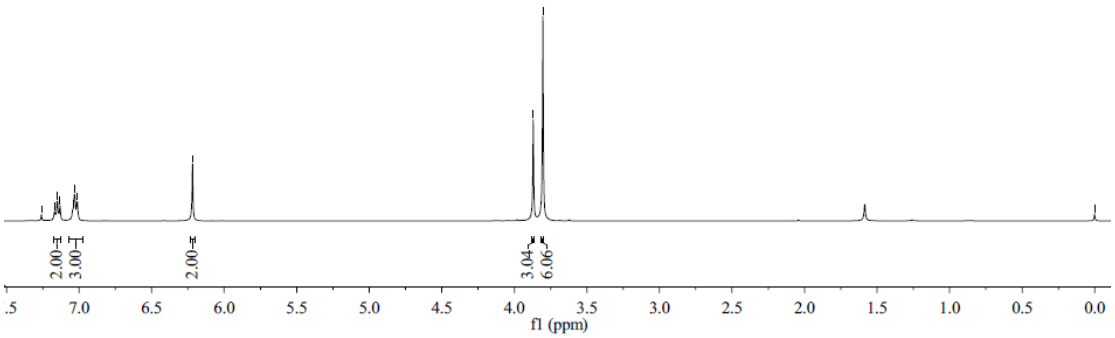
77.0000
76.6806
55.8716
55.3991
S
H3C
O
O
CH3

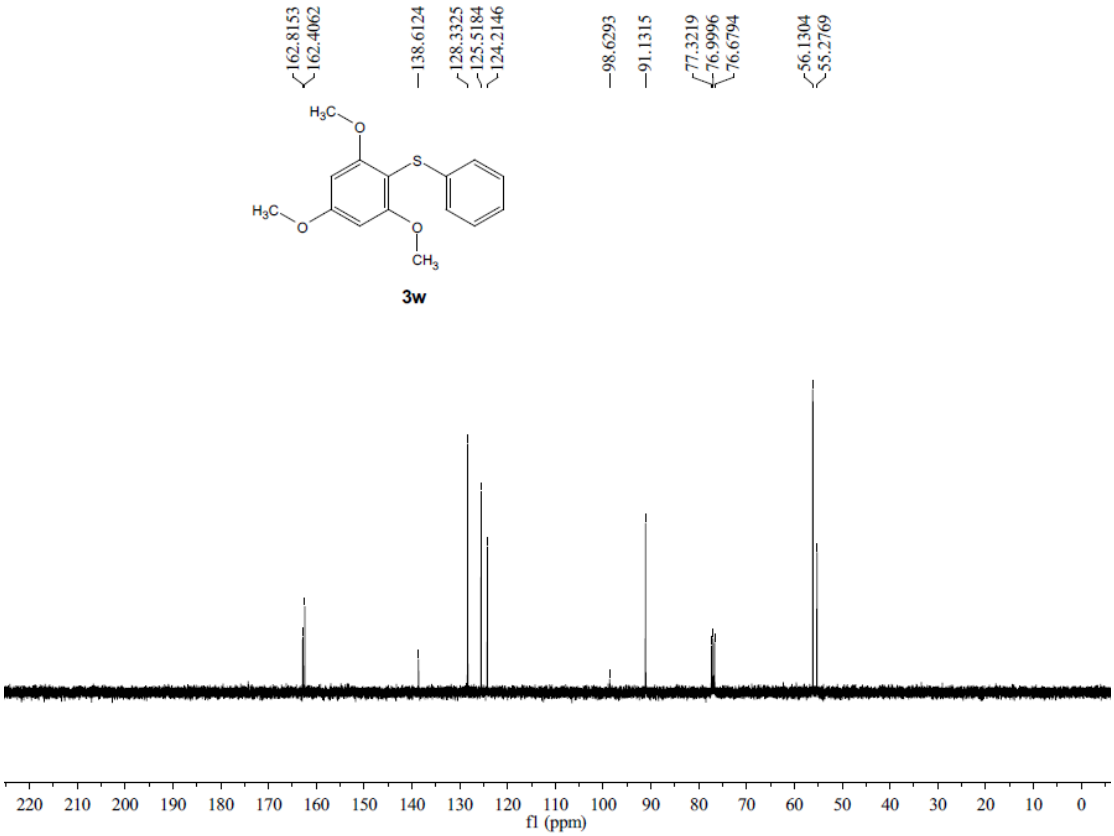
3v


170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


7.2592
7.1696
7.1504
7.1313
7.0420
7.0317
7.0118
6.2180
3.8696
3.8031
0.0005
H3C
O
S
H3C
O
O
CH3

3w


2.00
3.00
2.00
3.04
6.06
.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


162.8153
162.4062
138.6124
128.3325
125.5184
124.2146
98.6293
91.1315
77.3219
76.9996
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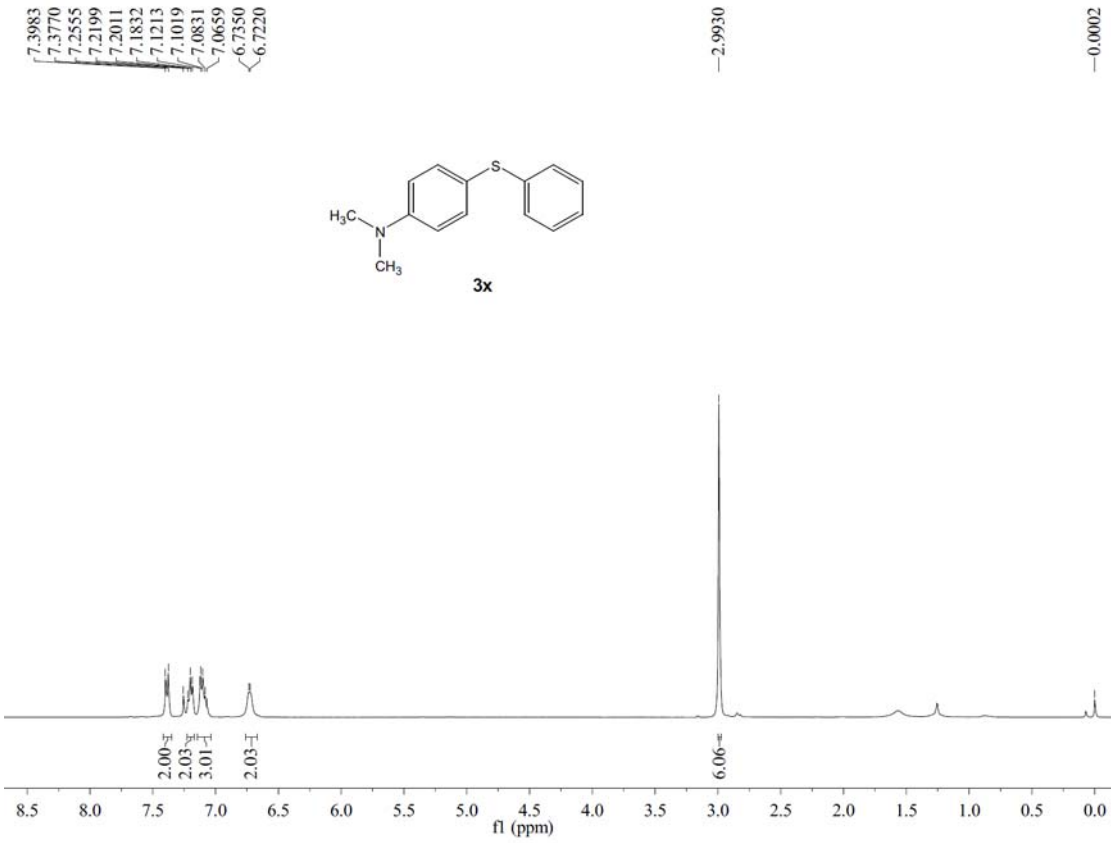
56.1304
55.2769
H3C
O
S
H3C
O
O
CH3
220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

3w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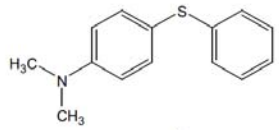
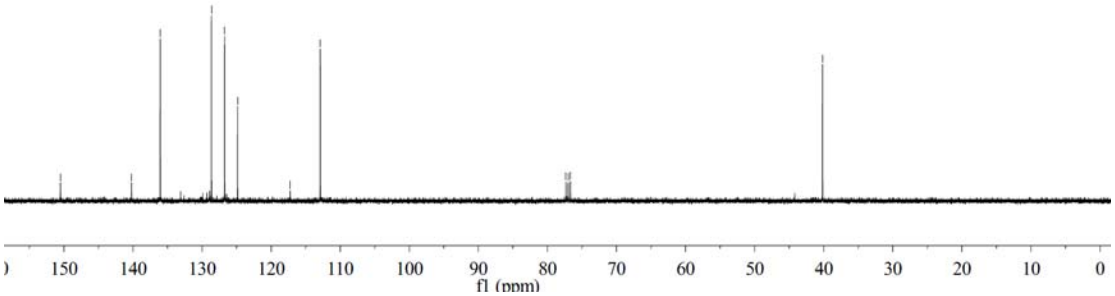
7.2555
7.2199
7.2011
7.1832
7.1213
7.1019
7.0831
7.0659
6.7350
6.7220
2.9930
0.0002
S
H3C
N
CH3
2.00
2.03
3.01
2.03
6.06
8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

3x

150.4988
140.2118
136.0478
128.6447
126.7316
124.8651
117.2490
112.8840
77.3171
77.0001
76.6792
40.1874



3x



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8.3206
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7.9483
7.9266
7.7310
7.7116
7.5527
7.5354
7.5016
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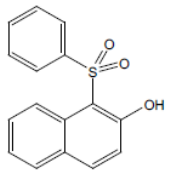
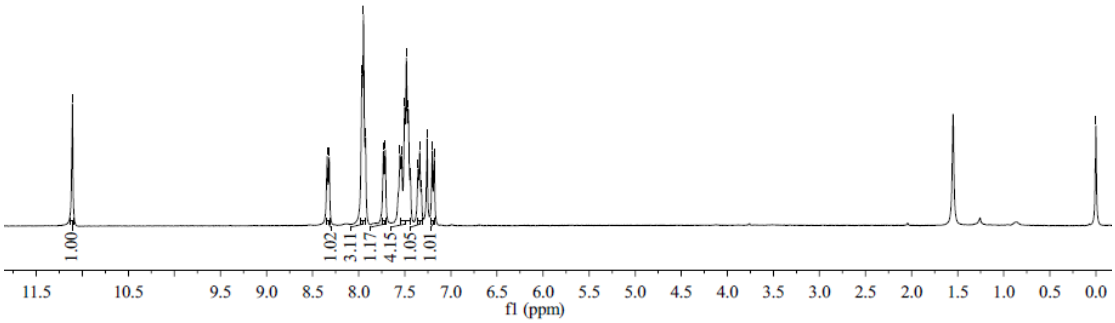
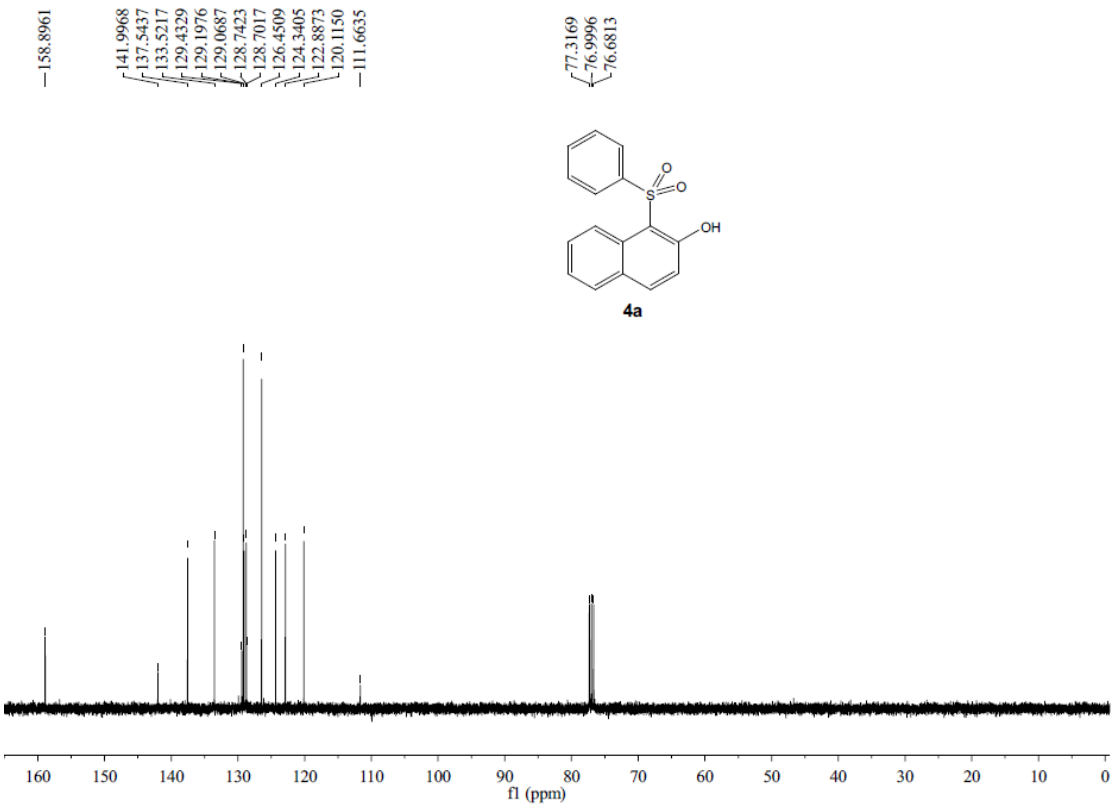
7.4393
7.3563
7.3382
7.3199
7.2578
7.2022
7.1798
0.0002



4a

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129.1976
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128.7017
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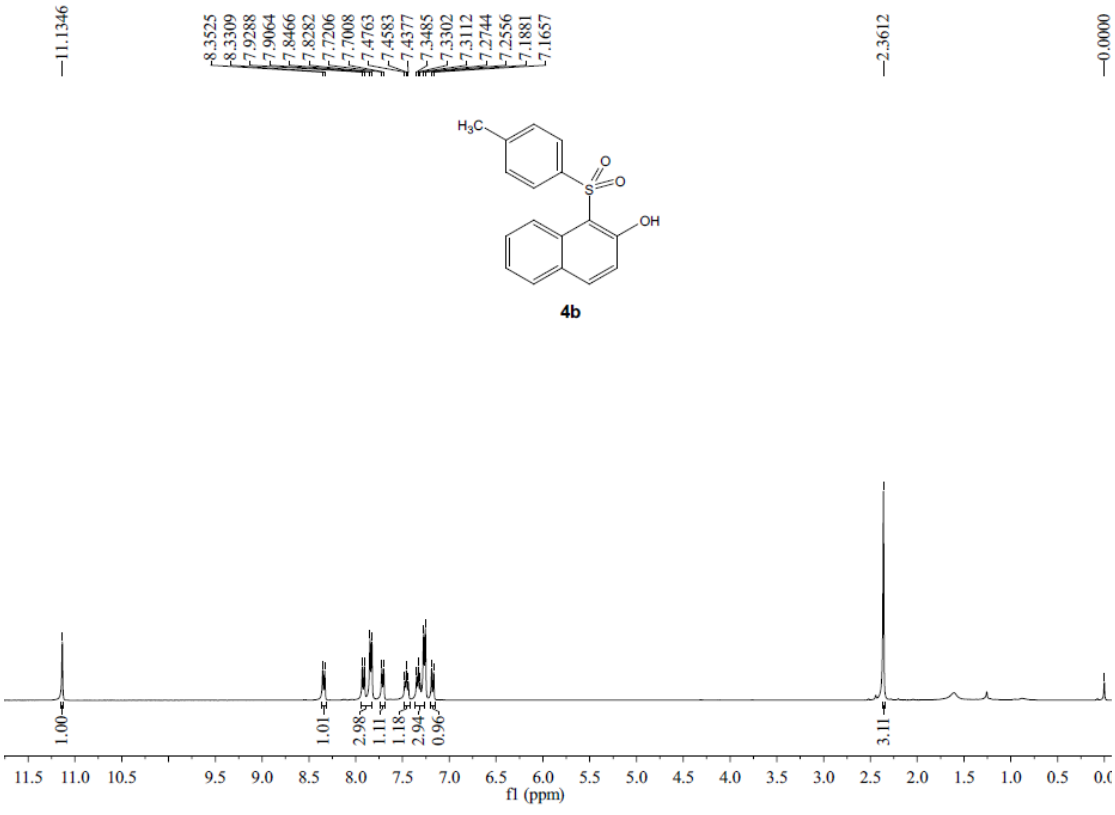
122.8873
120.1150
111.6635
77.3169
76.9996
76.6813
O
S
O
OH
4a
160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)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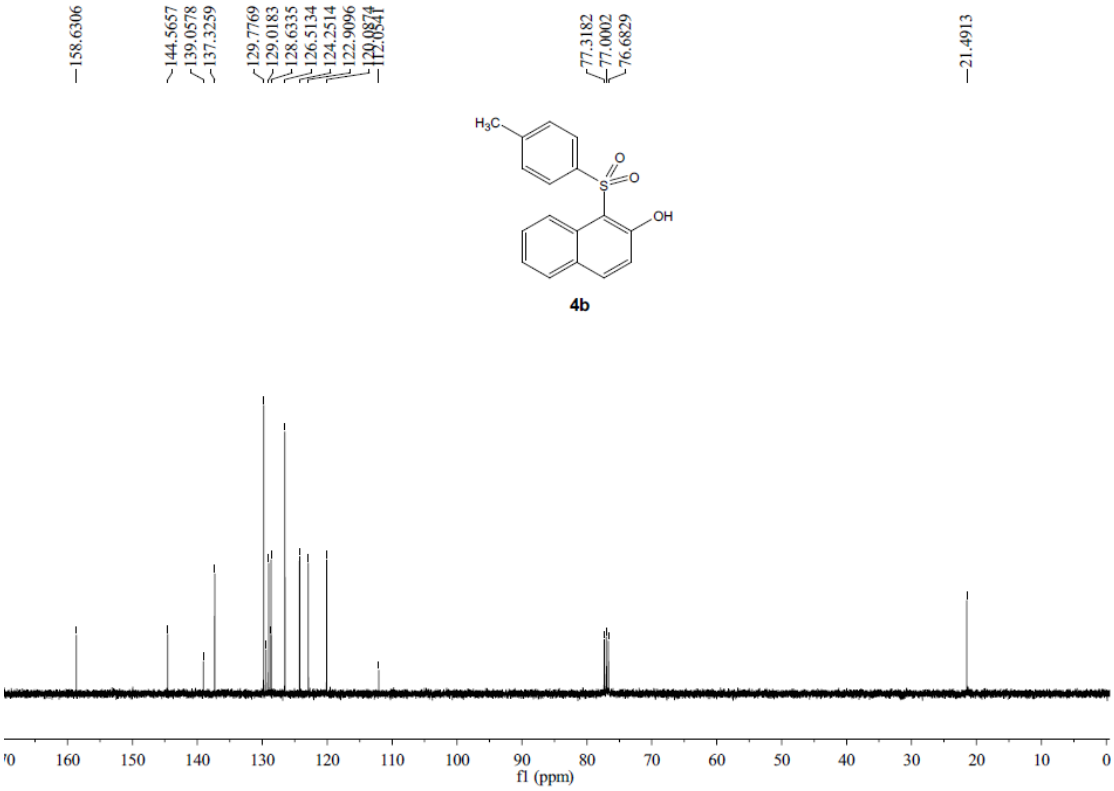
8.3309
7.9288
7.9064
7.8466
7.8282
7.7206
7.7008
7.4763
7.4583
7.4377
7.3485
7.3302
7.3112
7.2744
7.2556
7.1881
7.1657
2.3612
0.0000
H3C
O
S
O
OH
4b
1.00
1.01
2.98
1.11
1.18
2.94
0.96
3.11
11.5 11.0 10.5 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
f1 (ppm)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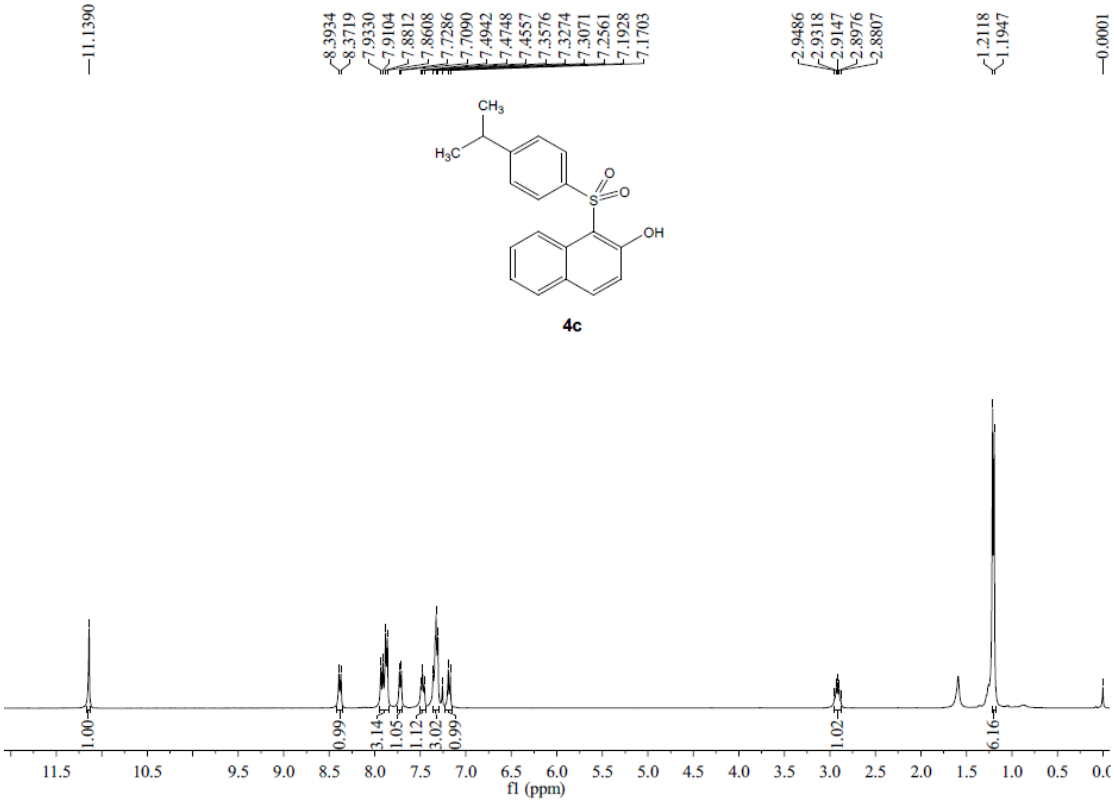
139.0578
137.3259
129.7769
129.0183
128.6335
126.5134
124.2514
122.9096
120.0874
112.0241
77.3182
77.0002
76.6829
21.4913
H3C
O
S
O
OH
4b
fl (ppm)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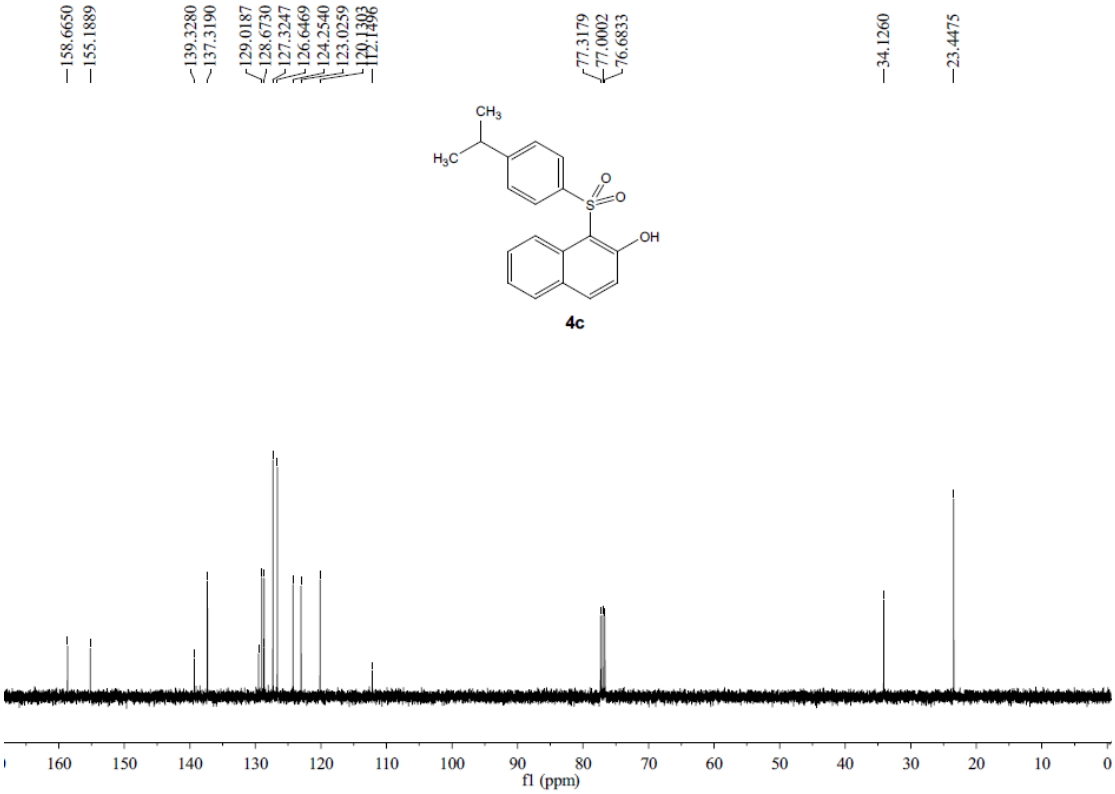
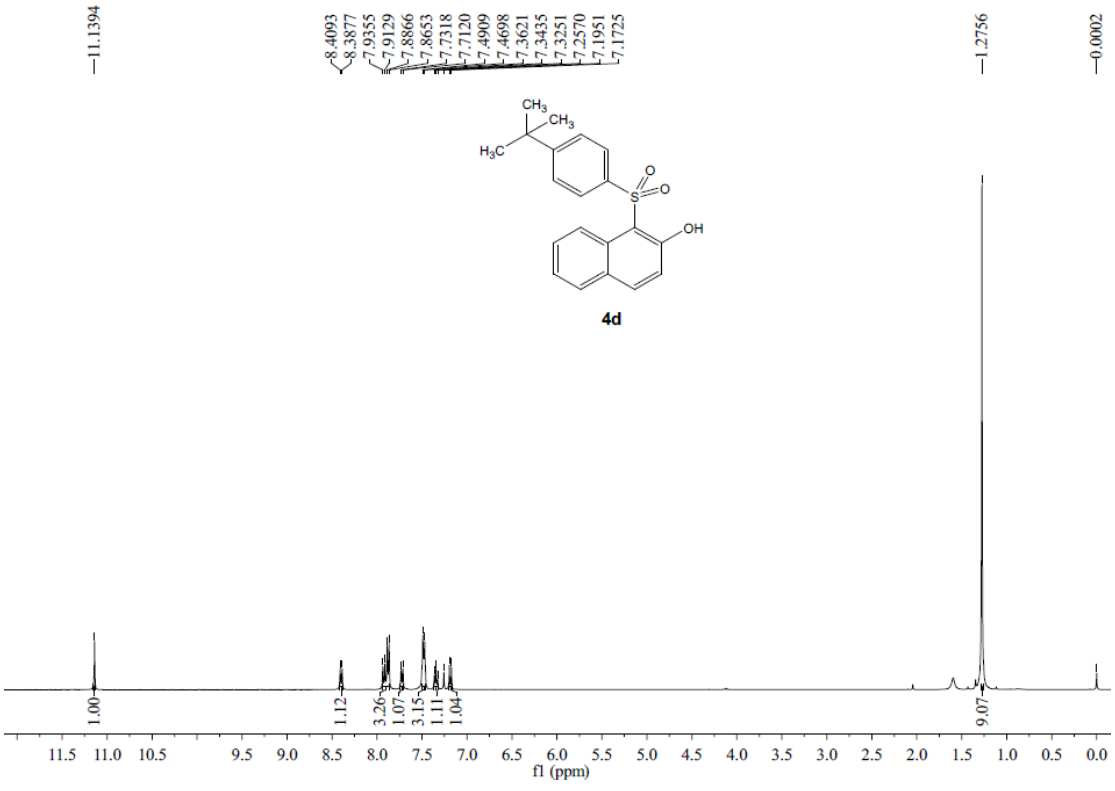
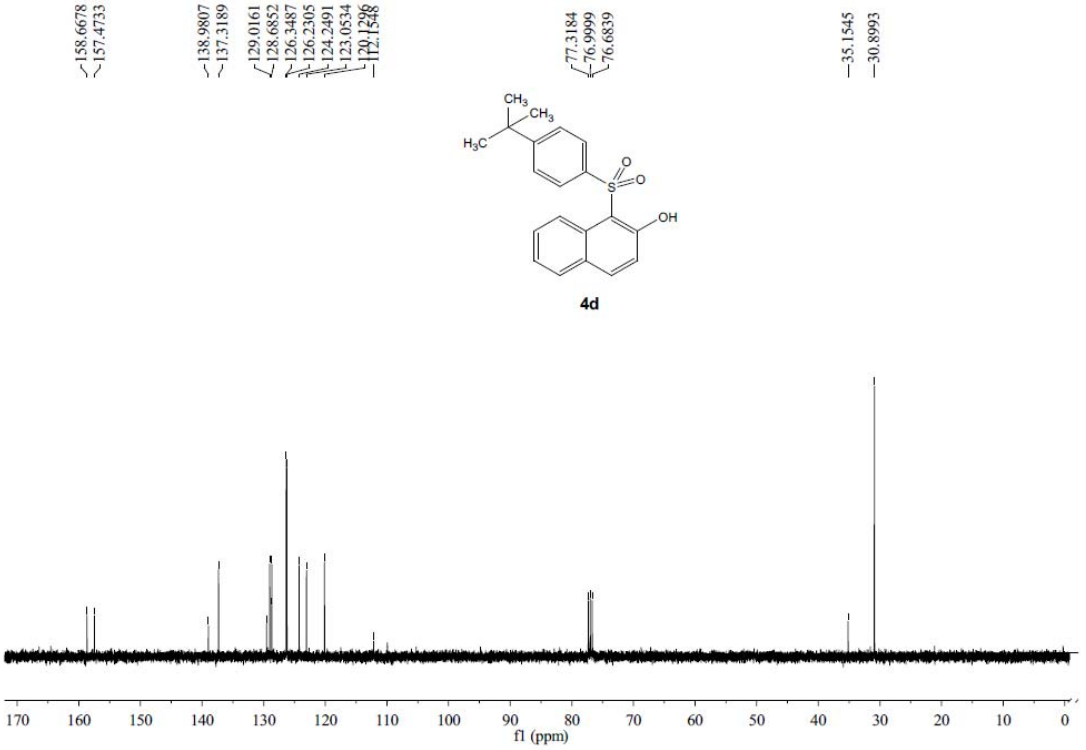
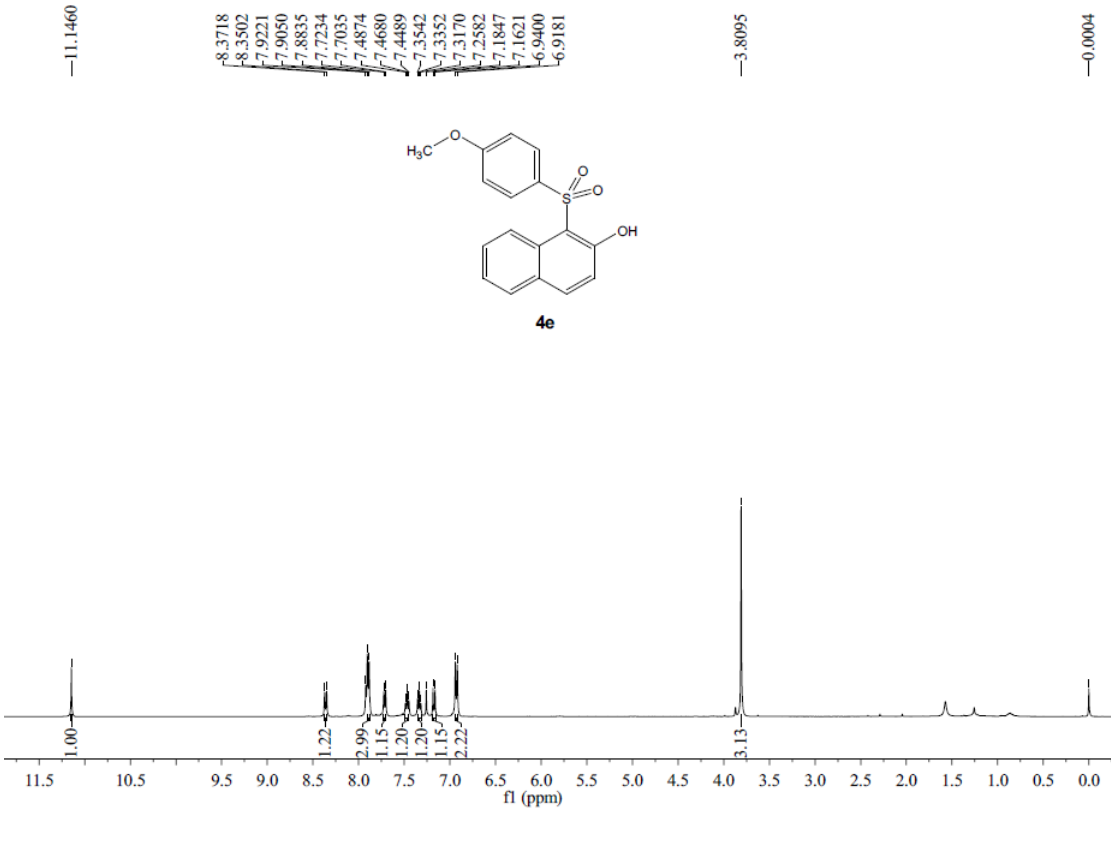
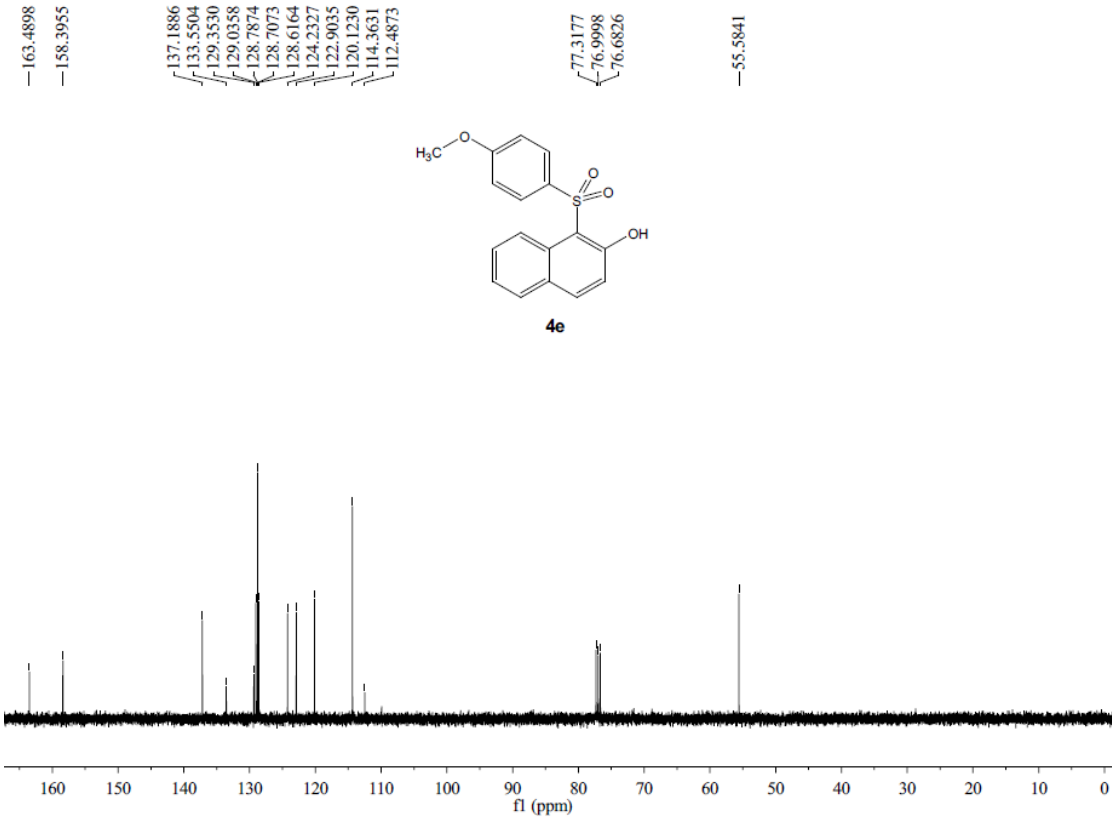
8.3934
8.3719
7.9330
7.9104
7.8812
7.8608
7.7286
7.7090
7.4942
7.4748
7.4557
7.3576
7.3274
7.3071
7.2561
7.1928
7.1703
2.9486
2.9318
2.9147
2.8976
2.8807
1.2118
1.1947
0.0001
CH3
H3C
O
S
O
OH
4c
1.00
0.99
3.14
1.05
1.12
3.02
0.99
1.02
6.16
fl (ppm)

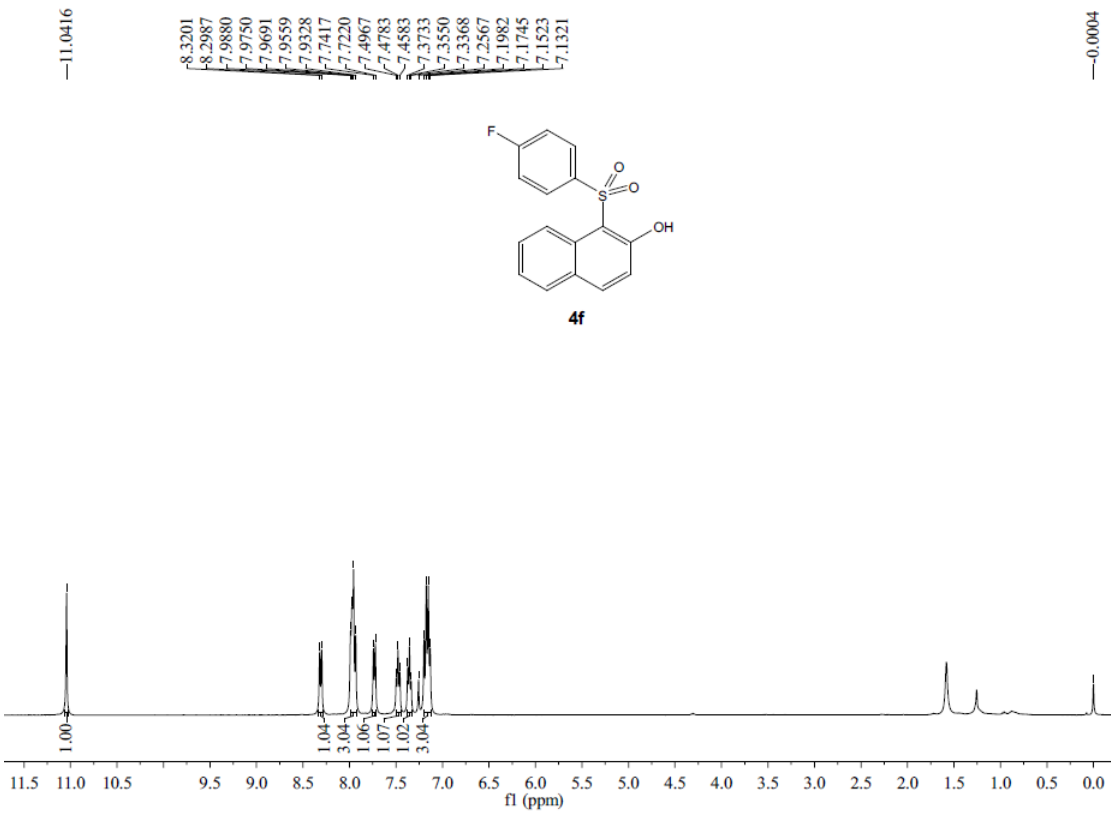

158.6650
155.1889
139.3280
137.3190
129.0187
128.6730
127.3247
126.6469
124.2540
123.0259
120.1303
112.1496
77.3179
77.0002
76.6833
34.1260
23.4475
CH3
H3C
O
S
O
OH
4c
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

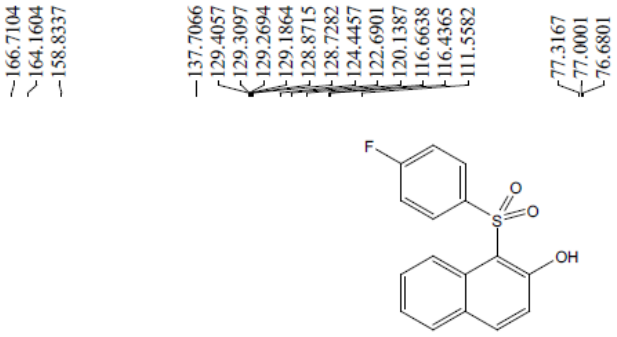

11.1394
8.4093
8.3877
7.9355
7.9129
7.8866
7.8653
7.7318
7.7120
7.4909
7.4698
7.3621
7.3435
7.3251
7.2570
7.1951
7.1725
1.2756
0.0002
CH3
CH3
H3C
O
S
O
OH
4d
1.00
1.12
3.26
1.07
3.15
1.11
1.04
9.07
11.5
11.0
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


158.6678
157.4733
138.9807
137.3189
129.0161
128.6852
126.3487
126.2305
124.2491
123.0534
77.3184
76.9999
76.6839
35.1545
30.8993
CH3
CH3
H3C
O
S
O
OH
4d
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

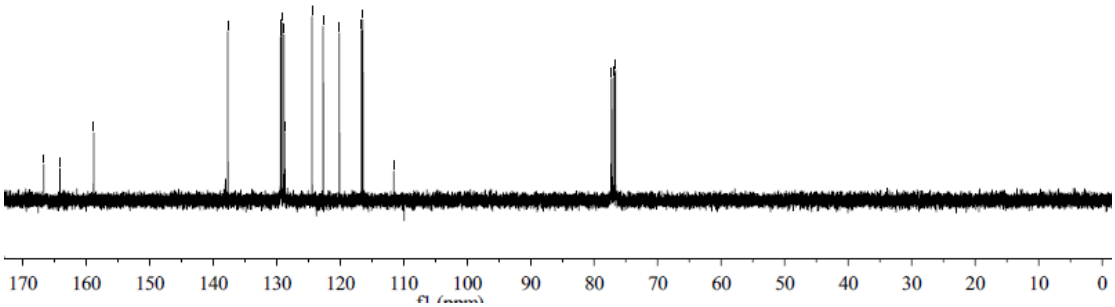

11.1460
8.3718
8.3502
7.9221
7.9050
7.8835
7.7234
7.7035
7.4874
7.4680
7.4489
7.3542
7.3352
7.3170
7.2582
7.1847
7.1621
6.9400
6.9181
3.8095
0.0004
H3C
O
S
O
O
OH
4e
1.00
1.22
2.99
1.15
1.20
1.20
1.15
2.22
3.13
11.5
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

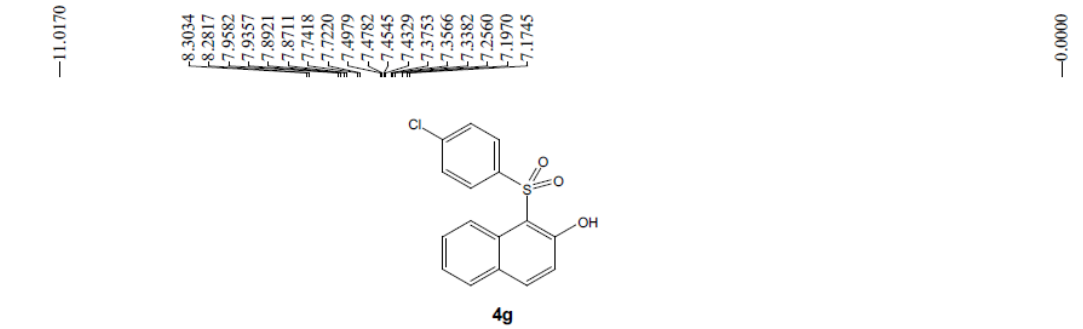

163.4898
158.3955
137.1886
133.5504
129.3530
129.0358
128.7874
128.7073
128.6164
124.2327
122.9035
120.1230
114.3631
112.4873
77.3177
76.9998
76.6826
55.5841
H3C
O
S
OH
4e
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


11.0416
8.3201
8.2987
7.9880
7.9750
7.9691
7.9559
7.9328
7.7417
7.7220
7.4967
7.4783
7.4583
7.3733
7.3550
7.3368
7.2567
7.1982
7.1745
7.1523
7.1321
0.0004
F
O
S
OH
4f
1.00
1.04
3.04
1.06
1.07
1.02
3.04
11.5
11.0
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

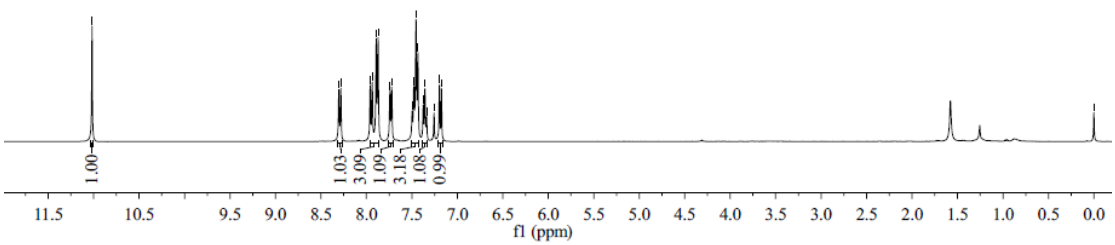

166.7104
164.1604
158.8337
137.7066
129.4057
129.3097
129.2694
129.1864
128.8715
128.7282
124.4457
122.6901
120.1387
116.6638
116.4365
111.5582
77.3167
77.0001
76.6801
F
O
S
O
OH

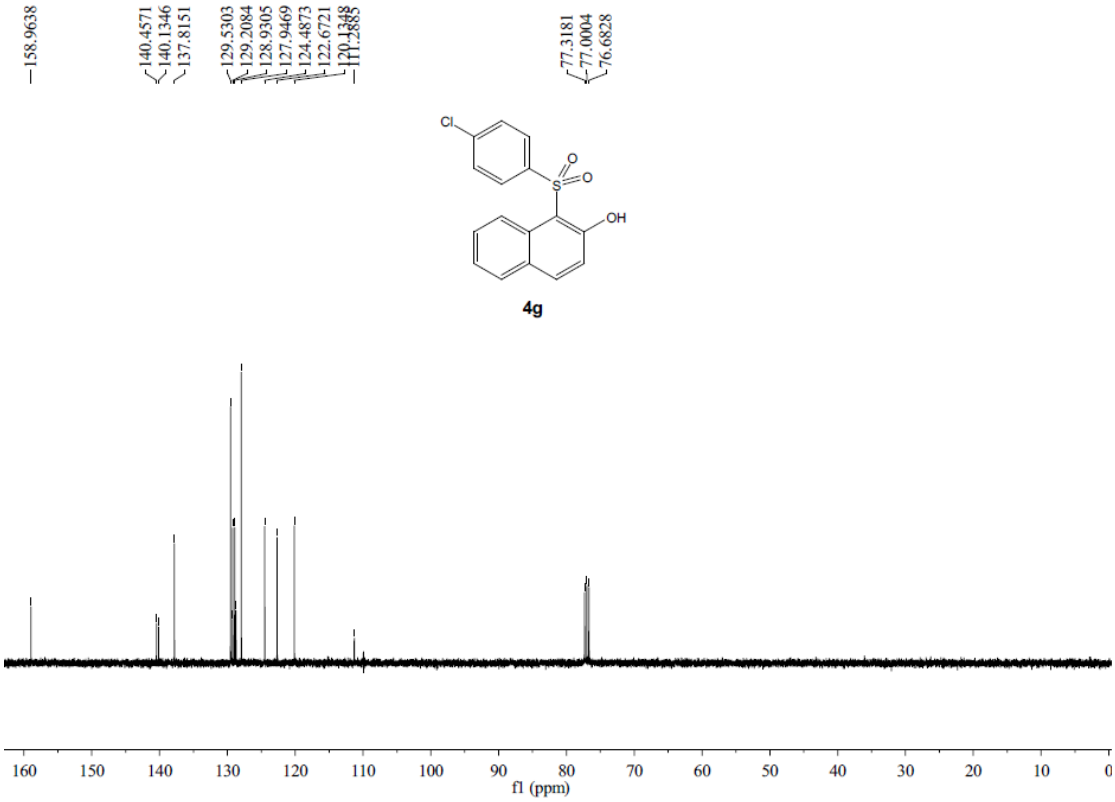
4f


170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0

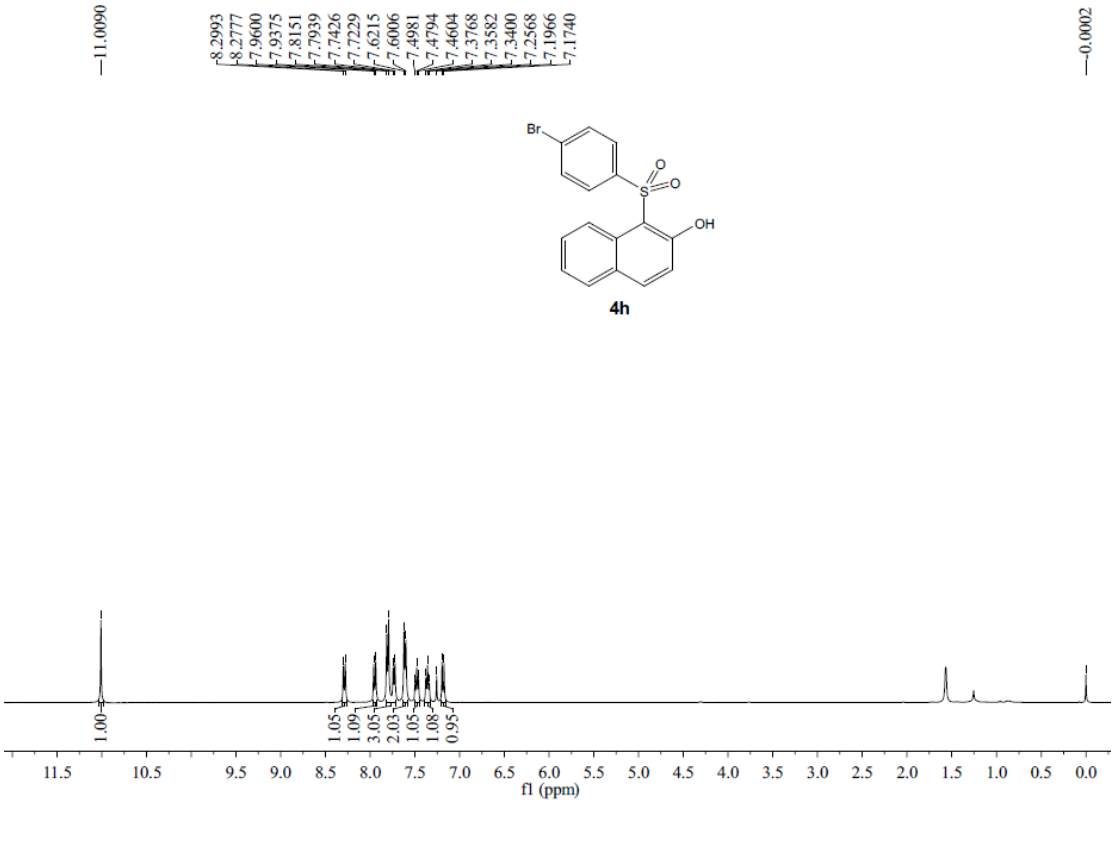

11.0170
8.3034
8.2817
7.9582
7.9357
7.8921
7.8711
7.7418
7.7220
7.4979
7.4782
7.4545
7.4329
7.3753
7.3566
7.3382
7.2560
7.1970
7.1745
0.0000
Cl
O
S
O
OH

4g

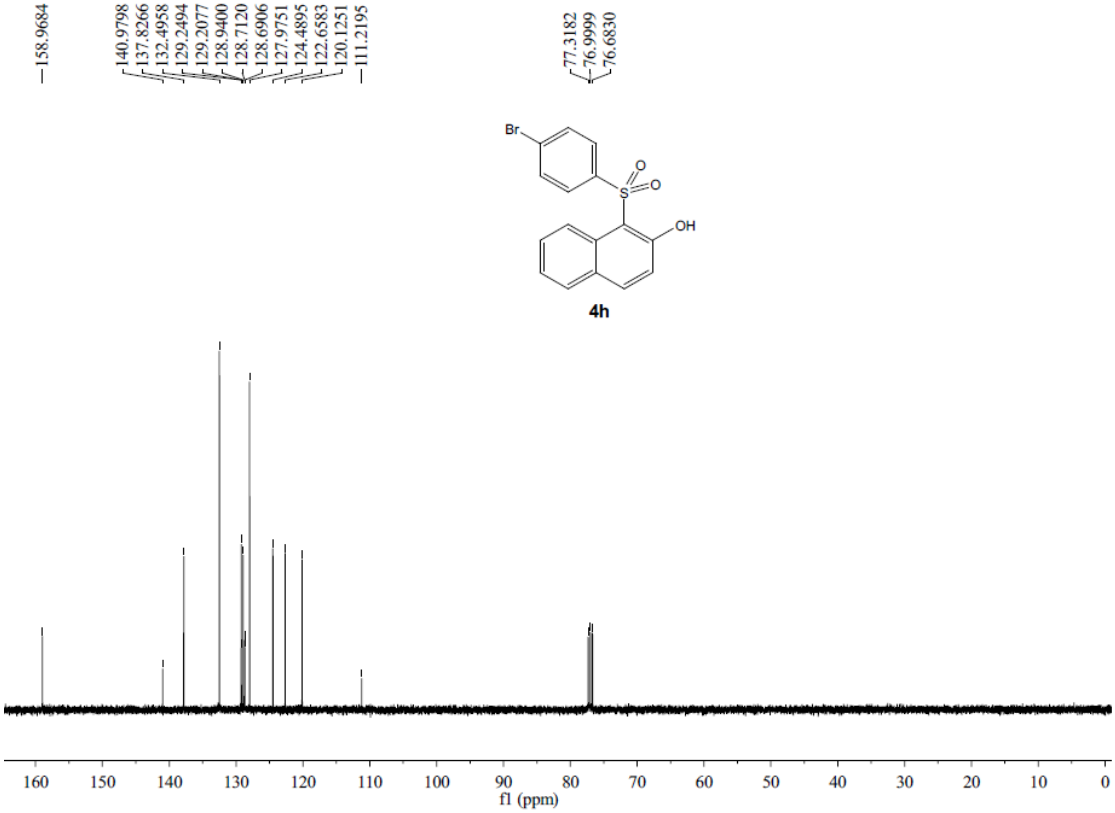

1.00
1.03
3.09
1.09
3.18
1.08
0.99
11.5
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

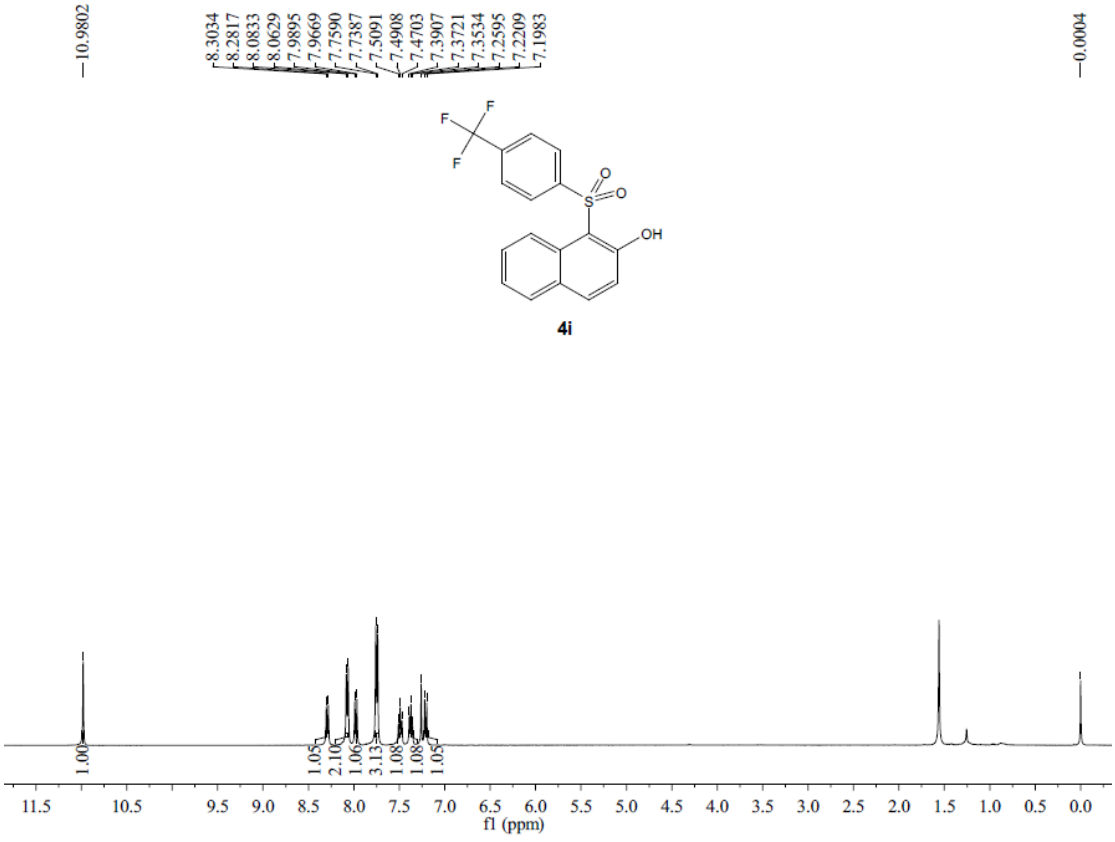

158.9638
140.4571
140.1346
137.8151
129.5303
129.2084
128.9305
127.9469
124.4873
122.6721
77.3181
77.0004
76.6828
Cl
O
S
O
OH
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

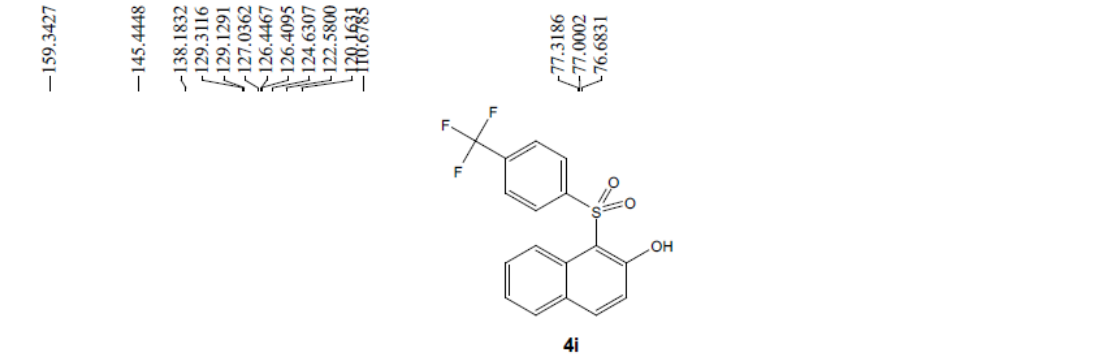
4g


11.0090
8.2993
8.2777
7.9600
7.9375
7.8151
7.7939
7.7426
7.7229
7.6215
7.6006
7.4981
7.4794
7.4604
7.3768
7.3582
7.3400
7.2568
7.1966
7.1740
0.0002
Br
O
S
O
OH
1.00
1.05
1.09
3.05
2.03
1.05
1.08
0.95
11.5
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

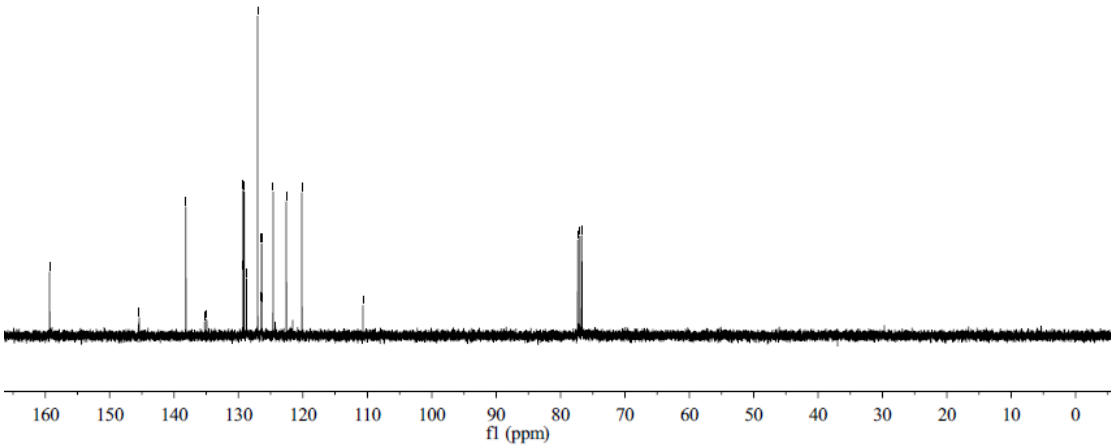
4h

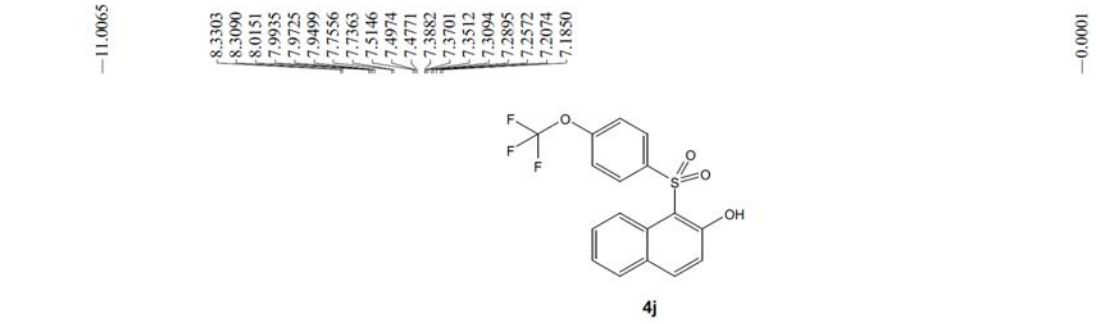

158.9684
140.9798
137.8266
132.4958
129.2494
129.2077
128.9400
128.7120
128.6906
127.9751
124.4895
122.6583
120.1251
111.2195
77.3182
76.9999
76.6830
Br
O
S
O
OH
4h
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


10.9802
8.3034
8.2817
8.0833
8.0629
7.9895
7.9669
7.7590
7.7387
7.5091
7.4908
7.4703
7.3907
7.3721
7.3534
7.2595
7.2209
7.1983
0.0004
F
F
F
O
S
O
OH
4i
1.00
1.05
2.10
1.06
3.13
1.08
1.08
1.05
11.5
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

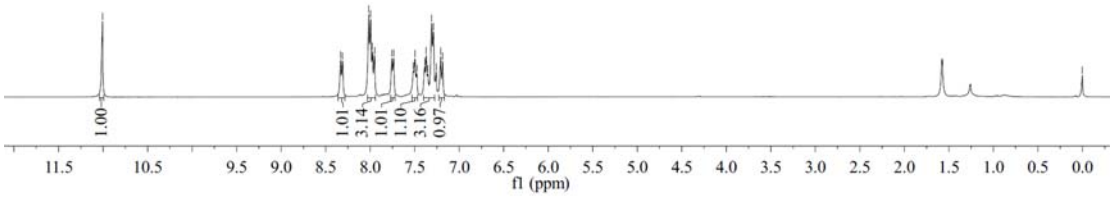

159.3427
145.4448
138.1832
129.3116
129.1291
127.0362
126.4467
126.4095
124.6307
122.5800
120.1631
110.6785
77.3186
77.0002
76.6831
F
F
F
O
O
S
OH

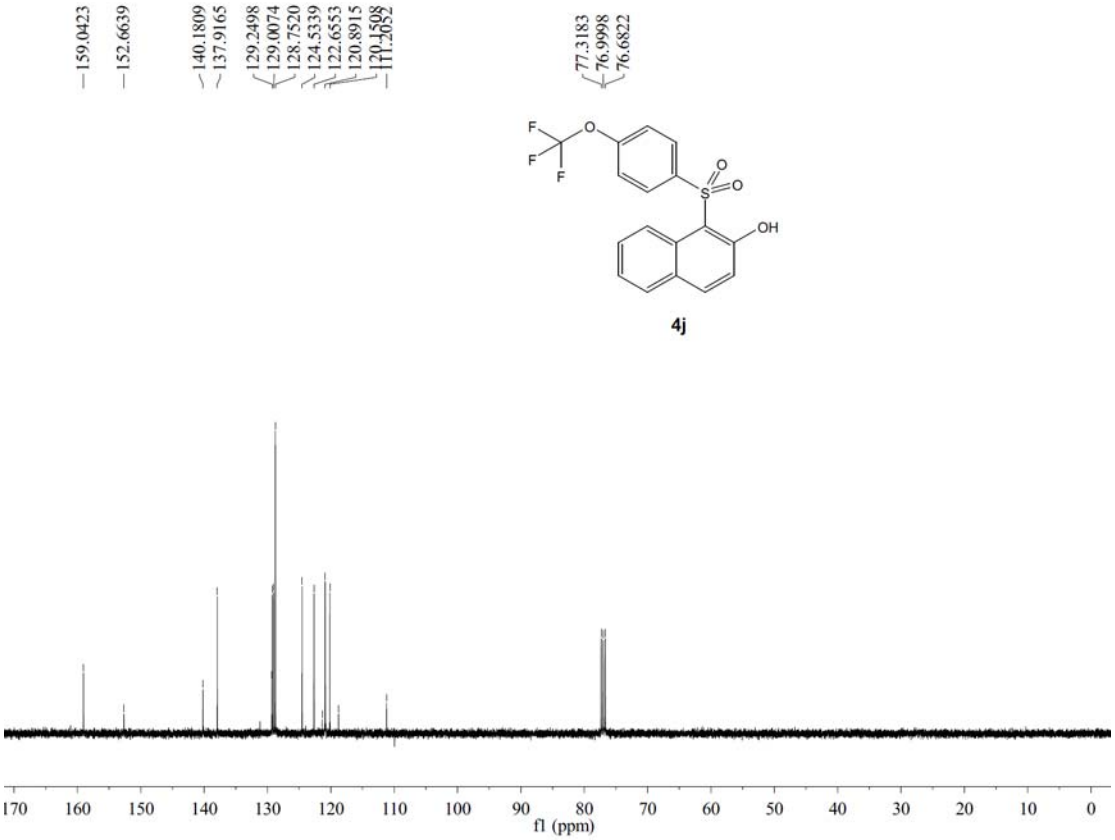
4i


160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

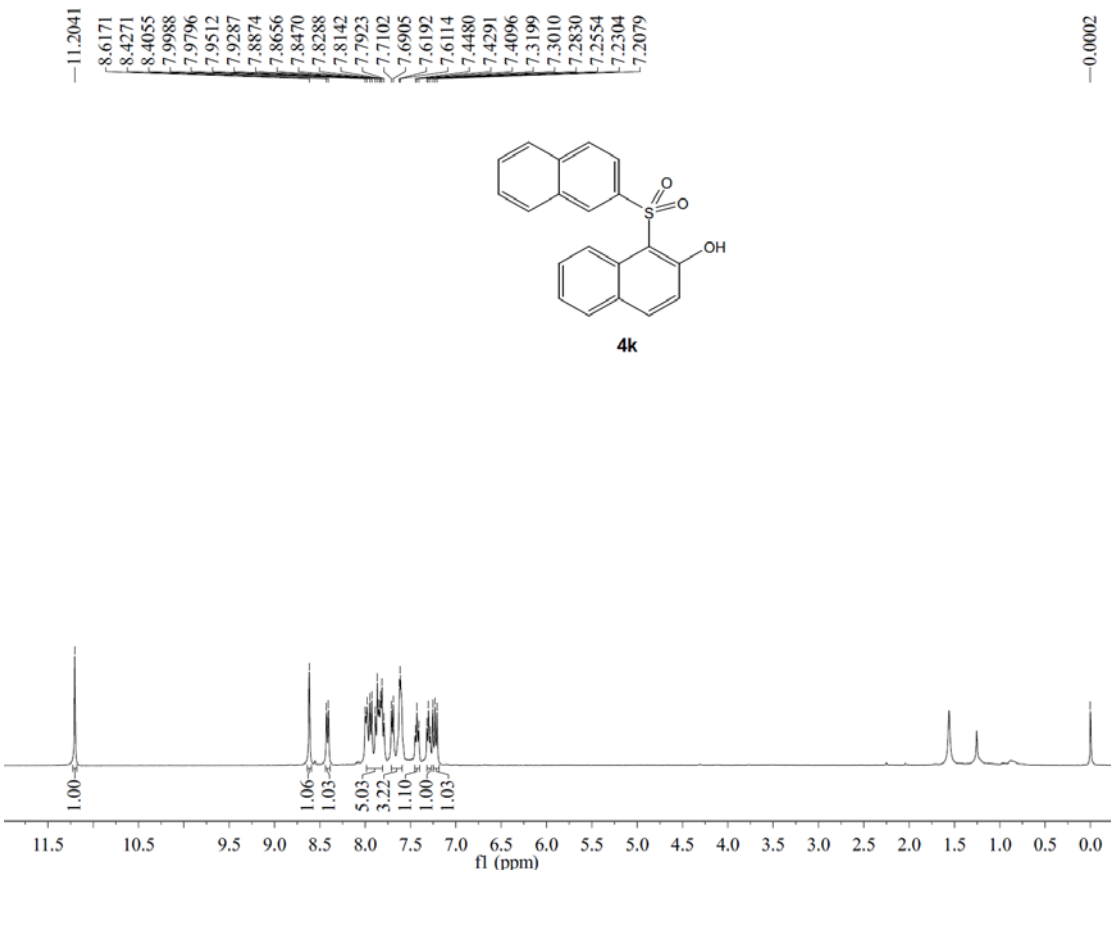

11.0065
8.3303
8.3090
8.0151
7.9935
7.9725
7.9499
7.7556
7.7363
7.5146
7.4974
7.4771
7.3882
7.3701
7.3512
7.3094
7.2895
7.2572
7.2074
7.1850
0.0001
F
F
F
O
O
O
S
OH

4j


1.00
1.01
3.14
1.01
1.10
3.16
0.97
11.5
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


159.0423
152.6639
140.1809
137.9165
129.2498
129.0074
128.7520
124.5339
122.6553
120.8915
120.1508
111.2052
77.3183
76.9998
76.6822
F
F
F
O
S
O
O
OH
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

4j


11.2041
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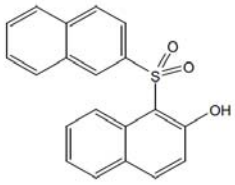
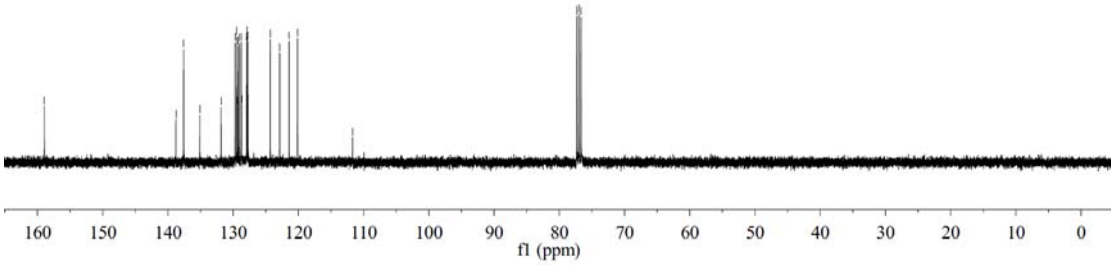
8.4271
8.4055
7.9988
7.9796
7.9512
7.9287
7.8874
7.8656
7.8470
7.8288
7.8142
7.7923
7.7102
7.6905
7.6192
7.6114
7.4480
7.4291
7.4096
7.3199
7.3010
7.2830
7.2554
7.2304
7.2079
0.0002
O
S
O
OH
1.00
1.06
1.03
5.03
3.22
1.10
1.00
1.03
11.5
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

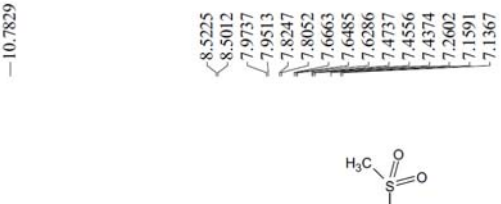
4k

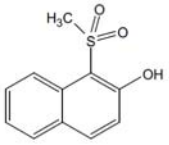

158.9360
137.5887
129.6918
129.4481
129.2466
129.0650
128.7675
127.9223
127.8764
127.7184
124.3166
122.8700
121.4179
120.1379
111.6932
77.3172
76.9998
76.6817


O
S
O
OH

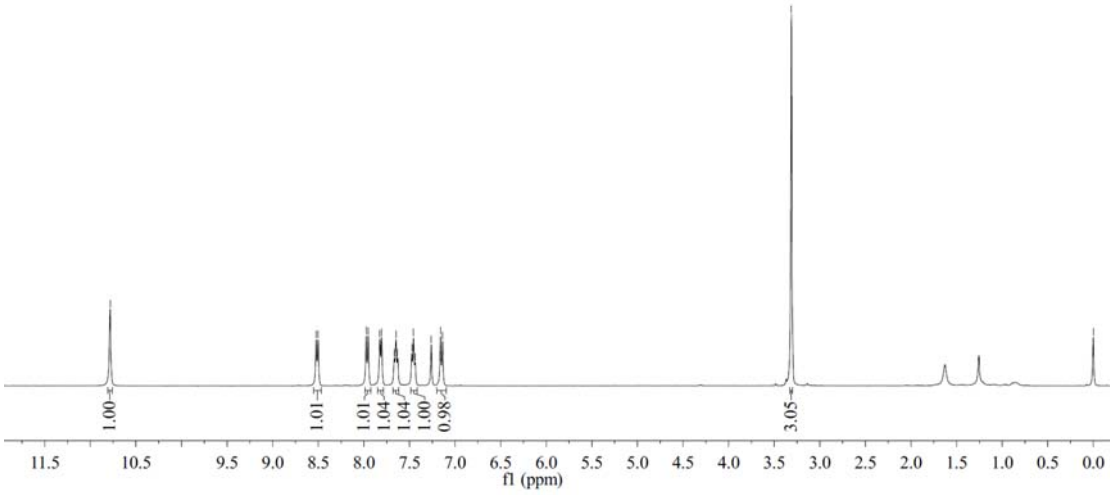
4k


160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

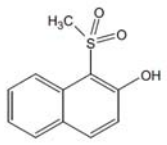

10.7829
8.5225
8.5012
7.9737
7.9513
7.8247
7.8052
7.6663
7.6485
7.6286
7.4737
7.4556
7.4374
7.2602
7.1591
7.1367
3.3111
0.0003


H3C
O
S
O
OH

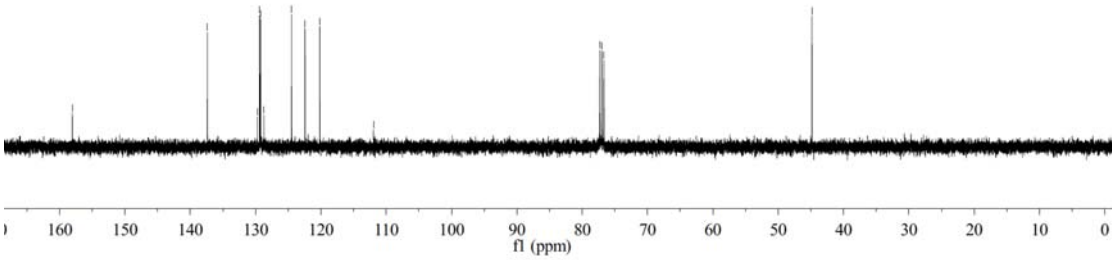
4l


1.00
1.01
1.01
1.04
1.04
1.00
0.98
3.05
11.5
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

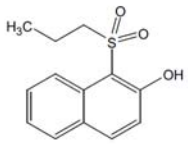
158.0436
137.3816
129.7340
129.3930
129.2428
128.7151
124.4882
122.4269
120.1743
111.9533
77.3176
77.0004
76.6822
44.8370



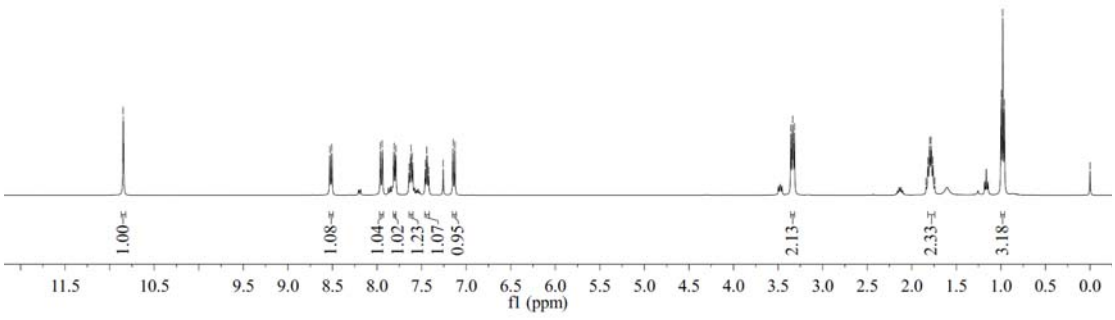
4l



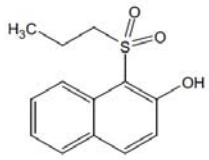
10.8465
8.5286
8.5070
7.9621
7.9396
7.8100
7.7903
7.6398
7.6211
7.6020
7.4578
7.4390
7.4207
7.2574
7.1486
7.1260
3.3558
3.3364
3.3164
1.8376
1.8191
1.8000
1.7807
1.7616
1.7430
0.9970
0.9784
0.9597
-0.0004



4m



158.9643
137.3328
129.9268
129.3592
129.1122
128.7579
124.4298
122.6351
120.0644
110.2689
77.3178
77.0004
76.6825
58.0831
16.1655
12.7432



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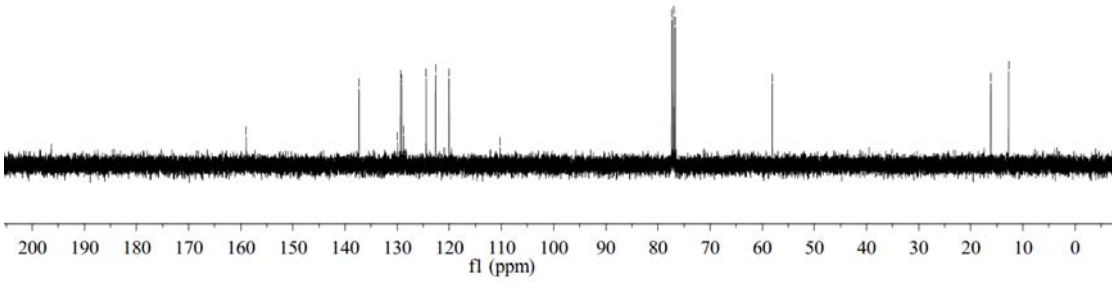

10.6035
8.6616
8.6399
7.9490
7.9265
7.8135
7.7935
7.6403
7.6215
7.6021
7.4579
7.4393
7.4208
7.2572
7.1460
7.1234
2.9387
2.9265
2.9184
2.9068
2.8952
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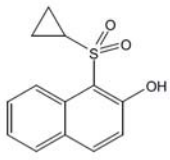
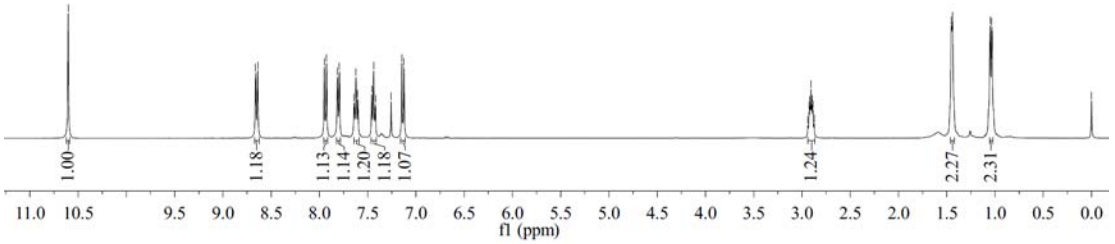
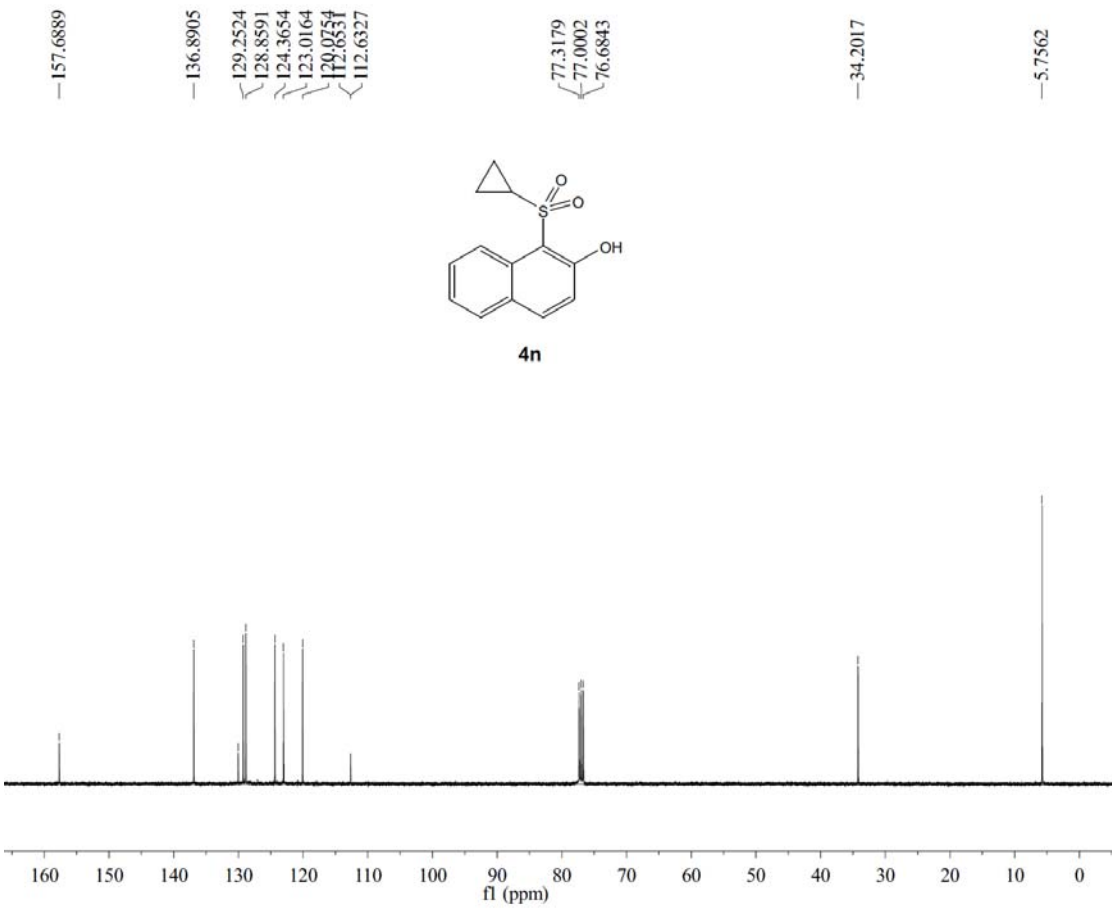
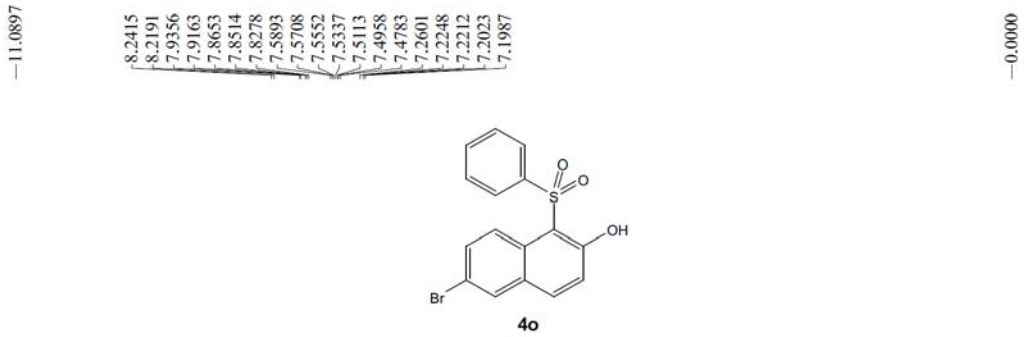
1.4417
1.4389
1.0493
1.0328
0.0003



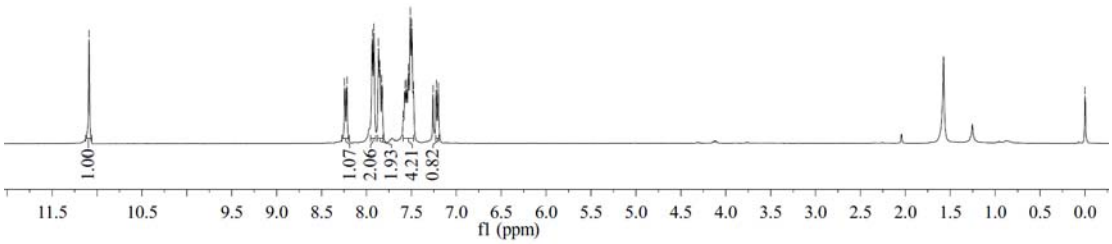
4n

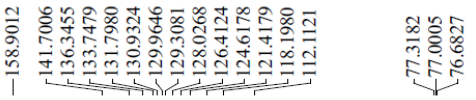


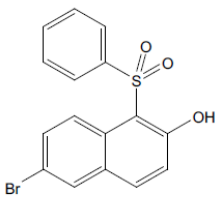

157.6889
136.8905
129.2524
128.8591
124.3654
123.0164
120.0754
112.8531
112.6327
77.3179
77.0002
76.6843
34.2017
5.7562
O
O
S
OH
4n
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)


11.0897
8.2415
8.2191
7.9356
7.9163
7.8653
7.8514
7.8278
7.5893
7.5708
7.5552
7.5337
7.5113
7.4958
7.4783
7.2601
7.2248
7.2212
7.2023
7.1987
0.0000
O
O
S
OH
Br

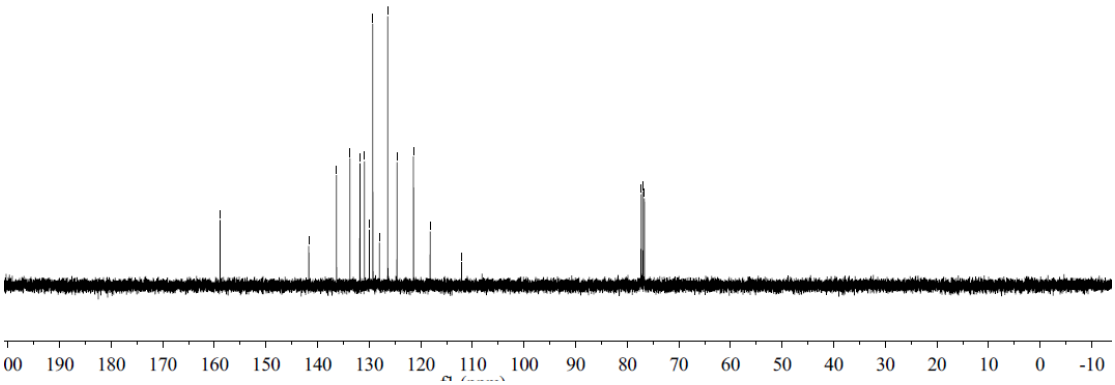
4o

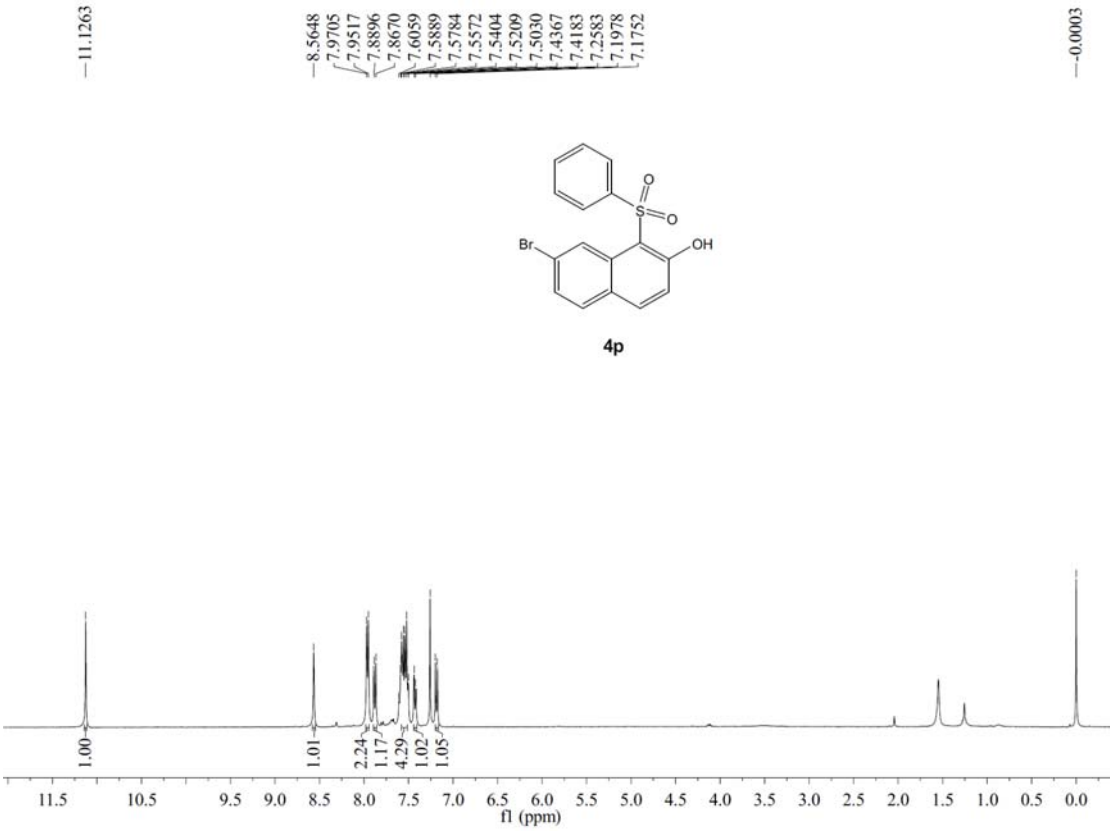

1.00
1.07
2.06
1.93
4.21
0.82
11.5
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)


158.9012
141.7006
136.3455
133.7479
131.7980
130.9324
129.9646
129.3081
128.0268
126.4124
124.6178
121.4179
118.1980
112.1121
77.3182
77.0005
76.6827


O
O
S
OH
Br

4o


00
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
-10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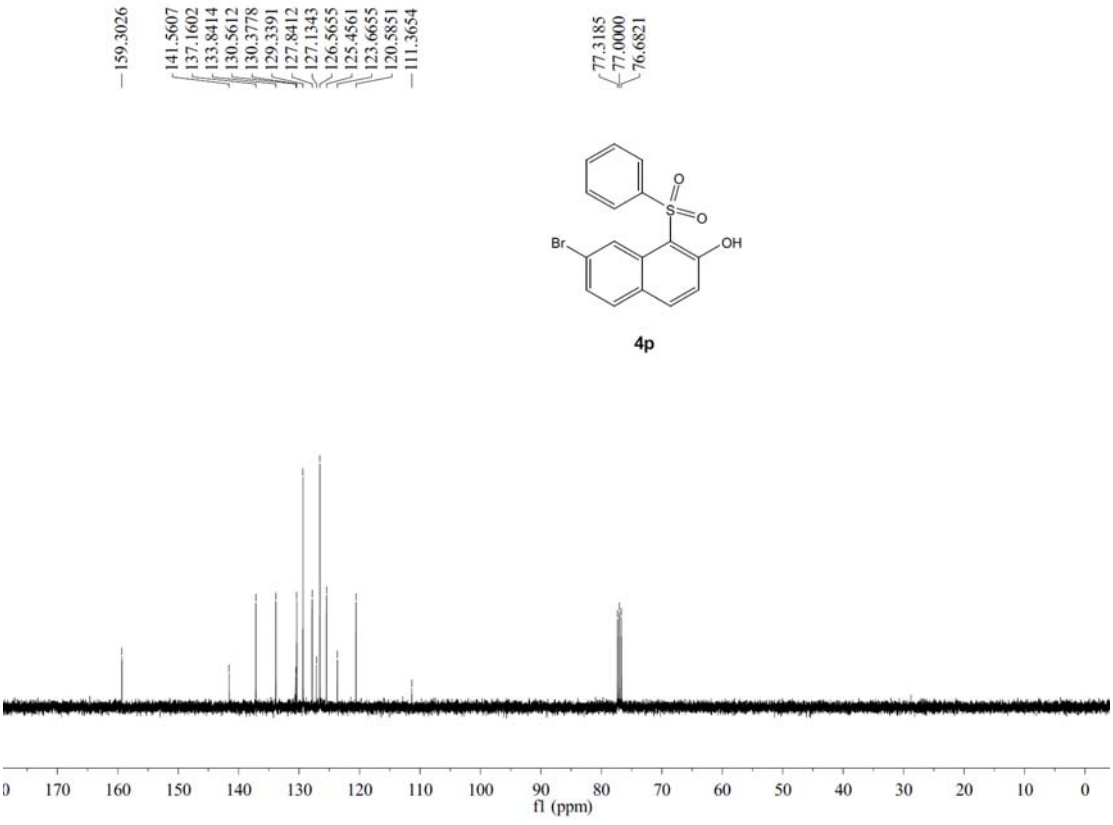
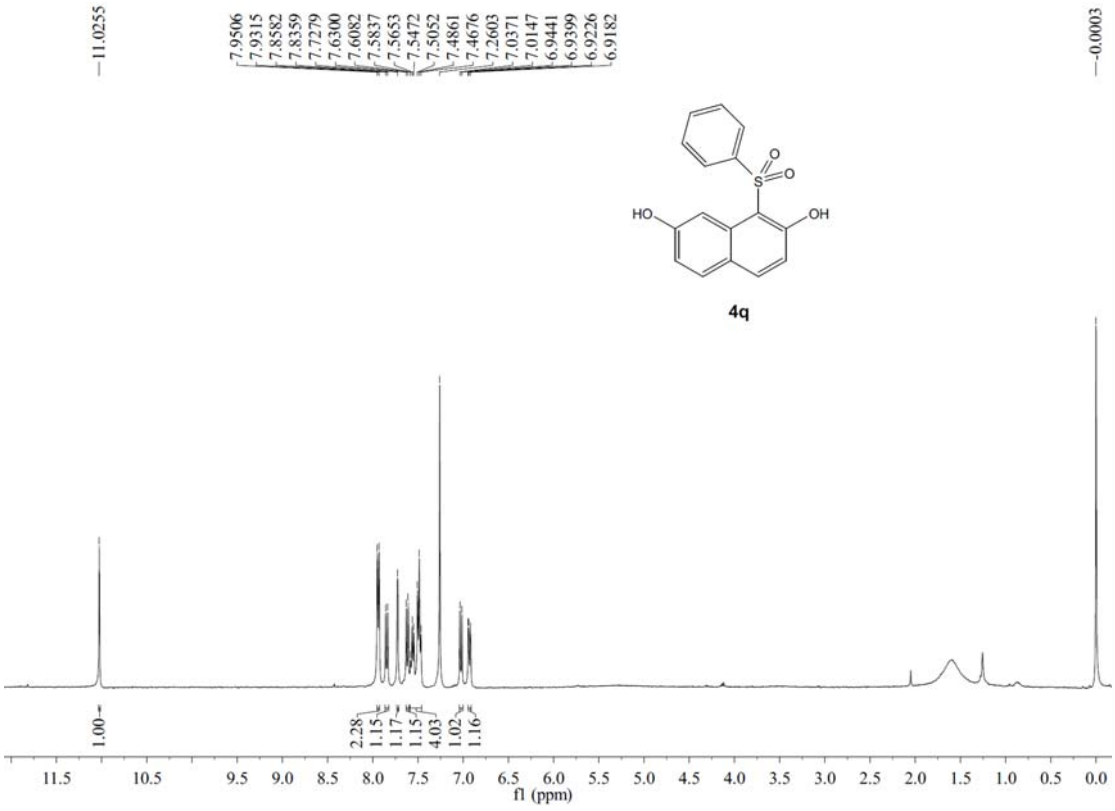
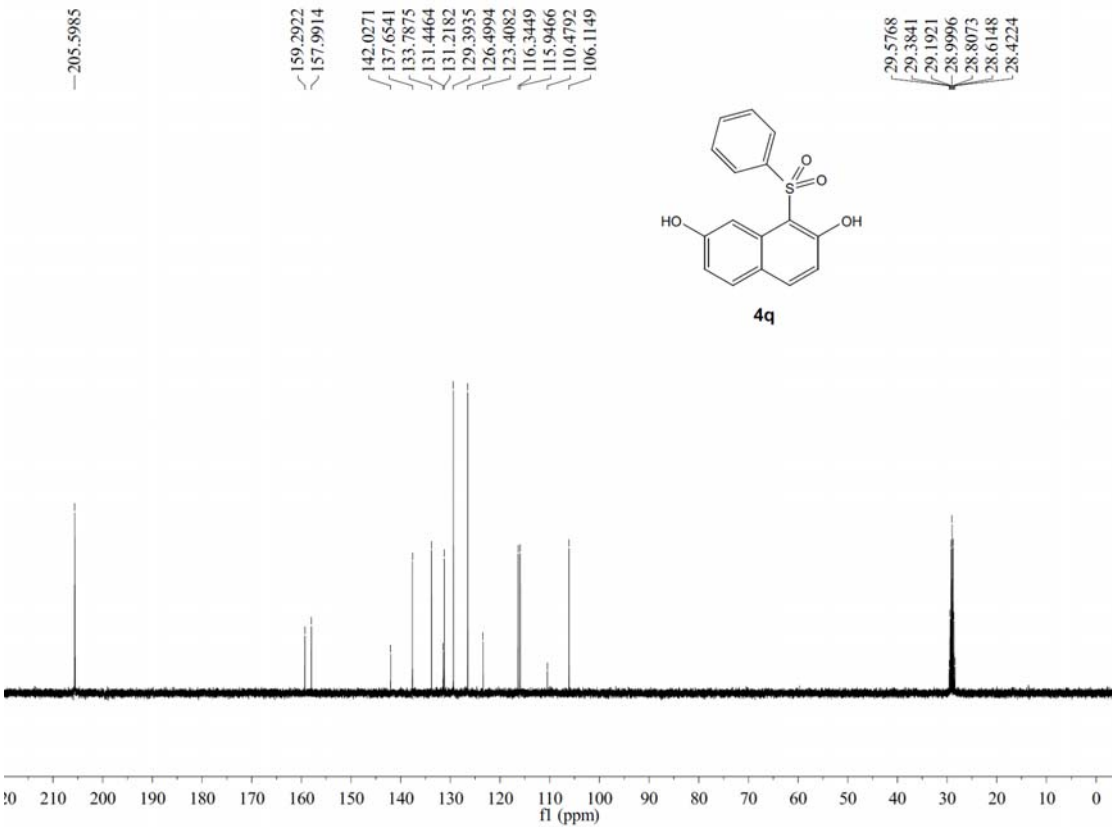
8.5648
7.9705
7.9517
7.8896
7.8670
7.6059
7.5889
7.5784
7.5572
7.5404
7.5209
7.5030
7.4367
7.4183
7.2583
7.1978
7.1752
0.0003
O
S
O
Br
OH
1.00
1.01
2.24
1.17
4.29
1.02
1.05
11.5
10.5
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
0.0
f1 (ppm)

4p


159.3026
141.5607
137.1602
133.8414
130.5612
130.3778
129.3391
127.8412
127.1343
126.5655
125.4561
123.6655
120.5851
111.3654
77.3185
77.0000
76.6821
O
S
O
Br
OH
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

4p


11.0255
7.9506
7.9315
7.8582
7.8359
7.7279
7.6300
7.6082
7.5837
7.5653
7.5472
7.5052
7.4861
7.4676
7.2603
7.0371
7.0147
6.9441
6.9399
6.9226
6.9182
0.0003
HO
OH
4q
1.00
2.28
1.15
1.17
1.15
4.03
1.02
1.16
f1 (ppm)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159.2922
157.9914
142.0271
137.6541
133.7875
131.4464
131.2182
129.3935
126.4994
123.4082
116.3449
115.9466
110.4792
106.1149
29.5768
29.3841
29.1921
28.9996
28.8073
28.6148
28.4224
HO
OH
4q
f1 (ppm)