An electrochemical method for deborylative selenylation of arylboronic acids under metal- and oxidant-free conditions

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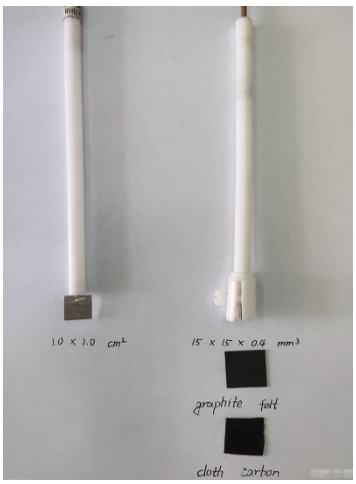
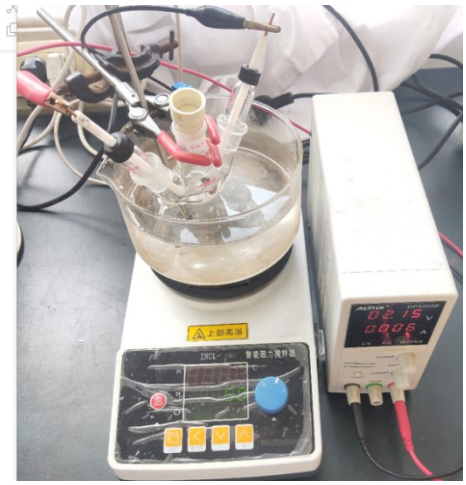
General considerations

The compounds of **2b**-**2j** and **2l**-**2s** were prepared following literature procedures,[1,2] all other reagents were commercially available and were used as received unless otherwise noted. The instrument for electrolysis is Adjustable DC Power Supply (DP3005B) (made in China). Column chromatography was performed on silica gel 300-400 mesh. The yields reported are the isolated yields and the average of two runs. ^{1}H, ^{13}C and ^{19}F NMR spectra of all compounds were recorded at 400, 100 and 377 MHz with $CDCl_3$ as solvent respectively. All coupling constants (J values) were reported in Hertz (Hz). HRMS (**3da-ea, 3ga, 3ac, 3ae, 3ai, 3al, 3aq-ar**) were performed by Analysis and Testing Center of Nanjing University. Cyclic voltammograms were obtained on a IVIUMSTAT potentiostat.

Experimental procedures

General procedure for electrochemical deborylative selenylation of arylboronic acids with diselenides: arylboronic acid (0.2 mmol), diselenide compound (1.2 equiv., 0.24 mmol,), tetrabutylammonium tetrafluoroborate (1 equiv., 0.2 mmol, 66 mg), CH_3CN (10 mL) were combined and added into oven-dried three-necked flask with a stir bar. The flask was equipped with two platinum electrodes (1.0 × 1.0 × 0.3 cm^3) as the anode and cathode. The reaction mixture was stirred and electrolyzed at a constant current of 6 mA at 50 °C under air conditions for 3 hours. Unless otherwise noted, after 3 h, the reaction was cooled to room temperature, washed with EtOAc and concentrated in vacuo. The resulting residue was purified by flash chromatography on silica gel to provide corresponding product.





1-Methoxy-4-methylselenobenzene (3aa). Procedure was followed using 4-methoxyphenylboronic acid (0.2 mmol, 30.4 mg), dimethyl diselenide (1.2 equiv., 0.24 mmol, 23 μL) and tetrabutylammonium tetrafluoroborate (1 equiv., 0.2 mmol, 66 mg). With stirring, the reaction mixture was performed at 50 °C under air conditions for 3 hours. The reaction mixture was purified by flash column chromatography on silica gel (97:3, petroleum ether: EtOAc) to afford 34.7 mg (86%) of the product as a yellow oil. Exhibited spectral data in accordance with previous report.[3] ^{1}H NMR (400 MHz,

$CDCl_3$): δ 7.41 (d, J = 8.8Hz, 2 H), 6.82 (d, J = 8.8 Hz, 2 H), 3.79 (s, 3 H), 2.30 (s, 3 H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 158.7, 133.4, 121.5, 114.8, 55.3, 8.7.

1-Methoxy-3-methylselanylbenzene (3ba). Procedure was followed using 3-methoxyphenylboronic acid (0.2 mmol, 30.4 mg), dimethyl diselenide (1.2 equiv., 0.24 mmol, 23 μL) and tetrabutylammonium tetrafluoroborate (1 equiv., 0.2 mmol, 66 mg). With stirring, the reaction mixture was performed at 50 °C under air conditions for 3 hours, then was purified by flash column chromatography on silica gel (97:3, petroleum ether: EtOAc) to afford 24.3 mg (60%) of the product as a yellow oil. Exhibited spectral data in accordance with previous report.[4] ^1H NMR (400 MHz, $CDCl_3$): δ 7.18 (t, J = 8.0 Hz, 1 H), 7.00 (d, J = 8.4 Hz, 1 H), 6.97 (s, 1 H), 6.74 (dd, J =2.4, 8.4 Hz, 1 H), 3.80 (s, 3 H), 2.36 (s, 3 H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 159.8, 133.0, 129.8, 122.4, 115.7, 111.7, 55.2, 7.1.

1-Methoxy-2-methylselanylbenzene (3ca). Procedure was followed using 2-methoxyphenylboronic acid (0.2 mmol, 30.4 mg), dimethyl diselenide (1.2 equiv., 0.24 mmol, 23 μL) and tetrabutylammonium tetrafluoroborate (1 equiv., 0.2 mmol, 66 mg). With stirring, the reaction mixture was performed at 50 °C under air conditions for 3 hours, then was purified by flash column chromatography on silica gel (95:5, petroleum ether: EtOAc) to afford 27.5 mg (68%) of the product as a yellow oil. Exhibited spectral data in accordance with previous report.[5] ^1H NMR (400 MHz, $CDCl_3$): δ 7.24 (d, J = 7.6 Hz, 1 H), 7.19 (t, J = 8.0 Hz, 1 H), 6.94 (t, J = 7.6 Hz, 1 H), 6.82 (d, J = 8.0 Hz, 1 H), 3.89 (s, 3 H), 2.28 (s, 3 H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 157.1, 128.4, 126.7, 121.5, 121.2, 110.0, 55.8, 4.8.

2,4-Dimethoxy-1-methylselenybenzene (3da). Procedure was followed using 2,4-methoxyphenylboronic acid (0.2 mmol, 36.4 mg), dimethyl diselenide (1.2 equiv., 0.24 mmol, 23 μL) and tetrabutylammonium tetrafluoroborate (1 equiv., 0.2 mmol, 66 mg). With stirring, the reaction mixture was performed at 50 °C under air conditions for 3 hours, then was purified by flash column chromatography on silica gel (95:5, petroleum ether: EtOAc) to afford 36.7 mg (79%) of the product as a yellow oil. ^1H NMR (400 MHz, $CDCl_3$): δ 7.23 (d, J = 8.4 Hz, 1 H), 6.47 (d, J = 8.4 Hz, 1 H), 6.45 (s, 1 H), 3.86 (s, 3 H), 3.79 (s, 3 H), 2.24 (s, 3 H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 160.1, 158.6, 131.4, 110.9, 105.3, 98.7, 55.8, 55.4, 6.0. HRMS (ESI-Orbitrap MS) *m/z*: $[M+H]^+$ Calcd. for $C_9H_{13}O_2Se$: 232.16576; found: 232.16581.

2-Methoxy-5-(methylselanyl)benzaldehyde (3ea). Procedure was followed using 3-formyl-4-methoxyphenylboronic acid (0.2 mmol, 36.0 mg), dimethyl diselenide (1.2 equiv., 0.24 mmol, 23 μL) and tetrabutylammonium tetrafluoroborate (1 equiv., 0.2 mmol, 66 mg). With stirring, the reaction mixture was performed at 50 °C under N_2 conditions for 2 hours, then was purified by flash column chromatography on silica gel (90:10, petroleum ether: EtOAc) to afford 26.3 mg (59%) of the product as a yellow oil. ^1H NMR (400 MHz, $CDCl_3$): δ 10.43 (s, 1 H), 7.90 (s, 1 H), 7.65 (dd, J = 1.6, 8.4 Hz, 1 H), 6.92 (d, J = 8.8 Hz, 1 H), 3.92 (s, 3 H), 2.34 (s, 3 H). ^{13}C NMR (100 MHz,

$CDCl_3$): δ 189.2, 160.8, 139.0, 131.2, 125.3, 122.5, 112.6, 55.8, 8.3. HRMS (ESI-Orbitrap MS) *m*/*z*: $[M+H]^+$ Calcd. for $C_9H_{11}O_2Se$: 230.99188; found: 230.99147.

4-(Methylseleno)phenol (3fa). Procedure was followed using 4-hydroxyphenylboronic acid (0.2 mmol, 27.6 mg), dimethyl diselenide (1.2 equiv., 0.24 mmol, 23 μL) and tetrabutylammonium tetrafluoroborate (1 equiv., 0.2 mmol, 66 mg). With stirring, the reaction mixture was performed at 50 °C under air conditions for 3 hours, then was purified by flash column chromatography on silica gel (85:15, petroleum ether: EtOAc) to afford 26.7 mg (71%) of the product as a yellow oil. Exhibited spectral data in accordance with previous report.[6] ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.36 (d, J = 8.4 Hz, 2 H), 6.76 (d, J = 8.8 Hz, 2 H), 2.30 (s, 3 H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 154.7, 133.6, 121.6, 116.3, 8.8.

4-*iso*Propyl-1-methylselanylbenzene (3ga). Procedure was followed using 4-*iso*propylbenzeneboronic acid (0.2 mmol, 32.8 mg), dimethyl diselenide (1.2 equiv., 0.24 mmol, 23 μL) and tetrabutylammonium tetrafluoroborate (1 equiv., 0.2 mmol, 66 mg). With stirring, the reaction mixture was carried out at 60 °C for 3 hours in the mixed solvents of acetonitrile and acetic acid (9:1), then was purified by flash column chromatography on silica gel (97:3, petroleum ether: EtOAc) to afford 25.7 mg (60%) of the product as a yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.37 (d, J = 8.0 Hz, 2 H), 7.14 (d, J = 8.0 Hz, 2 H), 2.91 - 2.84 (m, 1 H), 2.33 (s, 3 H), 1.24 (d, J = 6.8 Hz, 6 H), ^{13}C NMR (100 MHz, $CDCl_3$): δ 147.1, 130.8, 128.2, 127.2, 33.7, 23.9, 7.5. HRMS (ESI-Orbitrap MS) *m*/*z*: [M] Calcd. for $C_{10}H_{15}Se$: 214.02552; found: 214.02501.

4-(Methylseleno)-1,1'-biphenyl (3ha). Procedure was followed using 4-biphenylboronic acid (0.2 mmol, 39.6 mg), dimethyl diselenide (1.2 equiv., 0.24 mmol, 23 μL) and tetrabutylammonium tetrafluoroborate (1 equiv., 0.2 mmol, 66 mg). With stirring, the reaction mixture was performed at 50 °C under air conditions for 3 hours, then was purified by flash column chromatography on silica gel (97:3, petroleum ether: EtOAc) to afford 27.3 mg (55%) of the product as a white solid. Exhibited spectral data in accordance with previous report.[7] ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.58 (d, J = 8.0 Hz, 2 H), 7.50 (s, 4 H), 7.45 (t, J = 8.0 Hz, 2 H), 7.35 (t, J = 8.0 Hz, 1 H), 2.40 (s, 3 H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 140.5, 139.1, 131.0, 130.7, 128.8, 127.7, 127.3, 126.9, 7.3.

1-(Methylselanyl)naphthalene (3ia). Procedure was followed using 1-naphthylboronic acid (0.2 mmol, 34.4 mg), dimethyl diselenide (1.2 equiv., 0.24 mmol, 23 μL) and tetrabutylammonium tetrafluoroborate (1 equiv., 0.2 mmol, 66 mg). With stirring, the reaction mixture was performed at 50 °C under air conditions for 3 hours, then was purified by flash column chromatography on silica gel (95:5, petroleum ether: EtOAc) to afford 37.8 mg (85%) of the product as a white solid. Exhibited spectral data in accordance with previous report.[8] ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.26 (d, J = 8.0 Hz, 1 H), 7.85 (d, J = 8.0 Hz, 1 H), 7.75 (d, J = 8.4 Hz, 1 H), 7.64 (d, J = 7.2 Hz, 1 H),

7.58 - 7.50 (m, 2 H), 7.39 (t, J = 7.6 Hz, 1 H), 2.42 (s, 3 H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 133.8, 133.3, 131.1, 128.6, 128.6, 127.2, 126.6, 126.4, 126.2, 125.9, 7.6.

2-(Methylselanyl)naphthalene (3ja). Procedure was followed using 2-naphthylboronic acid (0.2 mmol, 34.4 mg), dimethyl diselenide (1.2 equiv., 0.24 mmol, 23 μL) and tetrabutylammonium tetrafluoroborate (1 equiv., 0.2 mmol, 66 mg). With stirring, the reaction mixture was performed at 60 °C under air conditions for 2 hours, then was purified by flash column chromatography on silica gel (95:5, petroleum ether: EtOAc) to afford 36.4 mg (82%) of the product as a white solid. Exhibited spectral data in accordance with previous report.[9] ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.85 (s, 1 H), 7.80 (d, J = 7.6 Hz, 1 H), 7.74 (t, J = 8.0 Hz, 2 H), 7.54 - 7.43 (m, 3 H), 2.46 (s, 3 H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 134.0, 131.8, 129.4, 128.4, 128.3, 128.2, 127.8, 126.9, 126.5, 125.6, 7.3.

4-Bromoselenoanisole (3ka). Procedure was followed using 4-bromophenylboronic acid (0.2 mmol, 40.2 mg), dimethyl diselenide (1.2 equiv., 0.24 mmol, 23 μL) and tetrabutylammonium tetrafluoroborate (1 equiv., 0.2 mmol, 66 mg). The reaction mixture was stirred in dichloromethane at room temperature under air conditions for 3 hours, then was purified by flash column chromatography on silica gel (petroleum ether) to afford 20.0 mg (40%) of the product as a white solid. Exhibited spectral data in accordance with previous report.[10] ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.36 (d, J = 8.4 Hz, 2 H), 7.26 (d, J = 8.4 Hz, 2 H), 2.33 (s, 3 H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 132.0, 131.9, 130.8, 120.1, 7.5.

4-Chloroselenoanisole (3la). Procedure was followed using 4-chlorophenylboronic acid (0.2 mmol, 31.3 mg), dimethyl diselenide (1.2 equiv., 0.24 mmol, 23 μL) and tetrabutylammonium tetrafluoroborate (1 equiv., 0.2 mmol, 66 mg). With stirring, the reaction mixture was stirred in dichloromethane at room temperature for 3 hours, then was purified by flash column chromatography on silica gel (petroleum ether) to afford 7.1 mg (17%) of the product as a colorless oil. Exhibited spectral data in accordance with previous report.[11] ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.34 (d, J = 8.8 Hz, 2 H), 7.22 (d, J = 8.8 Hz, 2 H), 2.34 (s, 3 H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 132.2, 131.7, 130.0, 129.1, 7.6.

3-(Methylseleno)benzo[*b*]thiophene (3ma). Procedure was followed using benzothiophene-3-boronic acid (0.2 mmol, 35.6 mg), dimethyl diselenide (1.2 equiv., 0.24 mmol, 23 μL) and tetrabutylammonium tetrafluoroborate (1 equiv., 0.2 mmol, 66 mg). With stirring, the reaction mixture was performed at 50 °C under air conditions for 2 hours, then was purified by flash column chromatography on silica gel (97:3, petroleum ether: EtOAc) to afford 36.5 mg (80%) of the product as a yellow oil. Exhibited spectral data in accordance with previous report.[12] ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.92 (d, J = 8.4 Hz, 1 H), 7.89 (d, J = 8.4 Hz, 1 H), 7.48 - 7.44 (m, 2 H), 7.40 (t, J = 8.0 Hz, 1 H), 2.34 (s, 3 H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 139.9, 127.1, 124.7, 124.5, 123.5, 122.8, 121.2, 8.1.

2-(Methylseleno)benzofuran (3na). Procedure was followed using benzofuran-2-boronic acid (0.2 mmol, 32.4 mg), dimethyl diselenide (1.2 equiv., 0.24 mmol, 23 μL) and tetrabutylammonium tetrafluoroborate (1 equiv., 0.2 mmol, 66 mg). With stirring, the reaction mixture was performed at 50 °C under air conditions for 1.5 hours, then was purified by flash column chromatography on silica gel (97:3, petroleum ether: EtOAc) to afford 25.5 mg (60%) of the product as a yellow oil. Exhibited spectral data in accordance with previous report.[13] ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.51 (d, J = 7.2 Hz, 1 H), 7.47 (d, J = 7.6 Hz, 1 H), 7.27 - 7.19 (m, 2 H), 6.82 (s, 1 H), 2.42 (s, 3 H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 157.0, 145.0, 128.8, 123.9, 122.8, 120.0, 111.5, 110.8, 8.1.

1-(Ethylseleno)-4-methoxybenzene (3ab). Procedure was followed using 4-methoxyphenylboronic acid (0.2 mmol, 30.4 mg), diethyl diselenide (1.2 equiv., 0.24 mmol, 43 μL) and tetrabutylammonium tetrafluoroborate (1 equiv., 0.2 mmol, 66 mg). With stirring, the reaction mixture was performed at 50 °C under air conditions for 3 hours, then was purified by flash column chromatography on silica gel (98:2, petroleum ether: EtOAc) to afford 30.3 mg (70%) of the product as a colorless oil. Exhibited spectral data in accordance with previous report.[14] ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.47 (d, J = 8.4 Hz, 2 H), 6.82 (d, J = 8.4 Hz, 2 H), 3.80 (s, 3 H), 2.82 (q, J = 7.6 Hz, 2 H), 1.39 (t, J = 7.2 Hz, 3 H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 159.2, 135.6, 119.7, 114.6, 55.2, 22.4, 15.6.

1-Methoxy-4-propylselanyl-benzene (3ac). Procedure was followed using 4-methoxyphenylboronic acid (0.2 mmol, 30.4 mg), dipropyl diselenide (1.2 equiv., 0.24 mmol, 59 mg) and tetrabutylammonium tetrafluoroborate (1 equiv., 0.2 mmol, 66 mg). With stirring, the reaction mixture was performed at 50 °C under air conditions for 3 hours, then was purified by flash column chromatography on silica gel (98:2, petroleum ether: EtOAc) to afford 16.1 mg (35%) of the product as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.46 (d, J = 8.8 Hz, 2 H), 6.81 (d, J = 8.8 Hz, 2 H), 3.79 (s, 3 H), 2.80 (t, J = 7.2 Hz, 2 H), 1.72 - 1.63 (m, 2 H), 0.98 (t, J = 7.2 Hz, 3 H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 156.5, 132.9, 117.6, 112.1, 52.7, 28.7, 20.9, 11.8. HRMS (ESI-Orbitrap MS) m/z: $[M+H]^+$ Calcd. for $C_{10}H_{15}OSe$: 231.02826; found: 231.02747.

1-(Butylseleno)-4-methoxybenzene (3ad). Procedure was followed using 4-methoxyphenylboronic acid (0.2 mmol, 30.4 mg), dibutyl diselenide (1.2 equiv., 0.24 mmol, 65.8 mg) and tetrabutylammonium tetrafluoroborate (1 equiv., 0.2 mmol, 66 mg). With stirring, the reaction mixture was performed at 50 °C under air conditions for 3 hours, then was purified by flash column chromatography on silica gel (98:2, petroleum ether: EtOAc) to afford 25.4 mg (52%) of the product as a colorless oil. Exhibited spectral data in accordance with previous report.[15] ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.46 (d, J = 8.8 Hz, 2 H), 6.82 (d, J = 8.8 Hz, 2 H), 3.79 (s, 3 H), 2.82 (t, J = 7.6 Hz, 2 H), 1.68 - 1.60 (m, 2 H), 1.45 - 1.36 (m, 2 H), 0.89 (t, J = 7.2 Hz, 3 H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 159.1, 135.4, 120.2, 114.7, 55.2, 32.3, 28.8, 22.9, 13.6.

1-(*iso*Butylseleno)-4-methoxybenzene (3ae). Procedure was followed using 4-methoxyphenylboronic acid (0.2 mmol, 30.4 mg), di-2-butyl diselenide (1.2 equiv., 0.24 mmol, 65.8 mg) and tetrabutylammonium tetrafluoroborate (1 equiv., 0.2 mmol, 66 mg). With stirring, the reaction mixture was performed at 50 °C under air conditions for 3 hours, then was purified by flash column chromatography on silica gel (97:3, petroleum ether: EtOAc) to afford 30.3 mg (62%) of the product as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.49 (d, J = 7.2 Hz, 2 H), 6.81 (d, J = 7.2 Hz, 2 H), 3.80 (s, 3 H), 3.14 - 3.05 (m, 1 H), 1.69 - 1.60 (m, 1 H), 1.58 - 1.51 (m, 1 H), 1.35 (d, J = 6.8 Hz, 3 H), 0.99 (t, J = 7.6 Hz, 3 H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 159.5, 137.5, 119.1, 114.5, 55.2, 41.8, 30.3, 21.5, 12.3. HRMS (ESI-Orbitrap MS) *m/z*: $[M+H]^+$ Calcd. for $C_{11}H_{17}OSe$: 245.04391; found: 245.04323.

1-[(4-Methoxyphenyl)seleno]-2-methylbenzene (3af). Procedure was followed using 4-methoxyphenylboronic acid (0.2 mmol, 30.4 mg), di-*o*-tolyl diselenide (1.2 equiv., 0.24 mmol, 81.6 mg) and tetrabutylammonium tetrafluoroborate (1 equiv., 0.2 mmol, 66 mg). With stirring, the reaction mixture was performed at 50 °C under air conditions for 3 hours, then was purified by flash column chromatography on silica gel (98:2, petroleum ether: EtOAc) to afford 37.3 mg (65%) of the product as a yellow oil. Exhibited spectral data in accordance with previous report.[16] ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.48 (d, J = 8.8 Hz, 2 H), 7.18 (d, J = 6.8 Hz, 1 H), 7.13 (d, J = 7.2 Hz, 1 H), 7.10 (d, J = 6.4 Hz, 1 H), 7.04 - 7.00 (m, 1 H), 6.89 (d, J = 8.8 Hz, 2 H), 3.83 (s, 3 H), 2.40 (s, 3 H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 159.8, 137.9, 136.7, 134.0, 130.8, 130.0, 126.6, 126.6, 119.3, 115.3, 55.3, 21.9.

2-[(4-Methoxyphenyl)seleno]-1,3-dimethylbenzene (3ag). Procedure was followed using 4-methoxyphenylboronic acid (0.2 mmol, 30.4 mg), bis(2,6-dimethylphenyl)diselenide (1.2 equiv., 0.24 mmol, 88.8 mg) and tetrabutylammonium tetrafluoroborate (1 equiv., 0.2 mmol, 66 mg). With stirring, the reaction mixture was performed at 50 °C under air conditions for 3 hours, then was purified by flash column chromatography on silica gel (95:5, petroleum ether: EtOAc) to afford 42.7 mg (73%) of the product as a yellow oil. Exhibited spectral data in accordance with previous report.[17] ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.21 - 7.13 (m, 3 H), 7.09 (d, J = 8.8 Hz, 2 H), 6.75 (d, J = 8.8 Hz, 2 H), 3.75 (s, 3 H), 2.50 (s, 6 H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 158.2, 143.4, 131.5, 131.0, 128.9, 127.9, 123.0, 115.0, 55.3, 24.5.

1-Methoxy-4-[(4-methylphenyl)seleno]benzene (3ah). Procedure was followed using 4-methoxyphenylboronic acid (0.2 mmol, 30.4 mg), di-*p*-tolyl diselenide (1.2 equiv., 0.24 mmol, 81.6 mg) and tetrabutylammonium tetrafluoroborate (1 equiv., 0.2 mmol, 66 mg). With stirring, the reaction mixture was performed at 50 °C under air conditions for 3 hours, then was purified by flash column chromatography on silica gel (98:2, petroleum ether: EtOAc) to afford 39.2 mg (75%) of the product as a yellow oil. Exhibited spectral data in accordance with previous report.[14] ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.48 (d, J = 8.8 Hz, 2 H), 7.30 (d, J = 8.0 Hz, 2 H), 7.06 (d, J = 8.0 Hz, 2 H),

6.84 (d, J = 8.4 Hz, 2 H), 3.81 (s, 3 H), 2.31 (s, 3 H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 159.5, 136.7, 135.8, 131.8, 130.0, 128.93, 120.9, 115.1, 55.3, 21.1.

1-Methoxy-4-[(4-*iso*propylphenyl)seleno]benzene (3ai). Procedure was followed using 4-methoxyphenylboronic acid (0.2 mmol, 30.4 mg), bis(4-*iso*propylphenyl)diselenide (1.2 equiv., 0.24 mmol, 95.5 mg) and tetrabutylammonium tetrafluoroborate (1 equiv., 0.2 mmol, 66 mg). With stirring, the reaction mixture was performed at 50 °C under air conditions for 3 hours, then was purified by flash column chromatography on silica gel (97:3, petroleum ether: EtOAc) to afford 41.0 mg (67%) of the product as a yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.49 (d, J = 8.8 Hz, 2 H), 7.30 (d, J = 8.4 Hz, 2 H), 7.10 (d, J = 8.4 Hz, 2 H), 6.85 (d, J = 8.8 Hz, 2 H), 3.81 (s, 3 H), 2.91 - 2.80 (m, 1 H), 1.22 (d, J = 6.8 Hz, 6 H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 159.6, 147.6, 136.0, 131.5, 129.4, 127.4, 120.6, 115.0, 55.3, 33.7, 23.9. HRMS (ESI-Orbitrap MS) m/z: $[M+H]^+$ Calcd. for $C_{16}H_{19}OSe$: 307.05956; found: 307.05896.

Di-4-anisyl selenide (3aj). Procedure was followed using 4-methoxyphenylboronic acid (0.2 mmol, 30.4 mg), bis(*p*-methoxyphenyl)diselenide (1.2 equiv., 0.24 mmol, 89.8 mg) and tetrabutylammonium tetrafluoroborate (1 equiv., 0.2 mmol, 66 mg). With stirring, the reaction mixture was performed at 50 °C under air conditions for 3 hours, then was purified by flash column chromatography on silica gel (petroleum ether) to afford 40.0 mg (68%) of the product as a yellow oil. Exhibited spectral data in accordance with previous report.[16] ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.41 (d, J = 8.8 Hz, 4 H), 6.82 (d, J = 8.8 Hz, 4 H), 3.79 (s, 6 H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 159.2, 134.6, 122.1, 115.0, 55.3.

4-(Phenylseleno)anisole (3ak). Procedure was followed using 4-methoxyphenylboronic acid (0.2 mmol, 30.4 mg), biphenyl diselenide (1.2 equiv., 0.24 mmol, 75.4 mg) and tetrabutylammonium tetrafluoroborate (1 equiv., 0.2 mmol, 66 mg). With stirring, the reaction mixture was performed at 50 °C under air conditions for 3 hours, then was purified by flash column chromatography on silica gel (99:1, petroleum ether: EtOAc) to afford 44.9 mg (85%) of the product as a yellow oil. Exhibited spectral data in accordance with previous report.[3] ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.52 (d, J = 8.8 Hz, 2 H), 7.33 (d, J = 6.4 Hz, 2 H), 7.24 - 7.19 (m, 3 H), 6.86 (d, J = 8.8 Hz, 2 H), 3.82 (s, 3 H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 159.7, 136.5, 133.2, 130.8, 129.1, 126.4, 119.8, 115.1, 55.3.

1-Bromo-2-[(4-methoxyphenyl)seleno]benzene (3al). Procedure was followed using 4-methoxyphenylboronic acid (0.2 mmol, 30.4 mg), bis(*o*-bromophenyl)diselenide (1.2 equiv., 0.24 mmol, 112.8 mg) and tetrabutylammonium tetrafluoroborate (1 equiv., 0.2 mmol, 66 mg). With stirring, the reaction mixture was performed at 50 °C under air conditions for 3 hours, then was purified by flash column chromatography on silica gel (95:5, petroleum ether: EtOAc) to afford 21.9 mg (32%) of the product as a colorless oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.60 (d, J = 8.8 Hz, 2 H), 7.47 (d, J = 8.0 Hz, 1 H), 7.04 (t, J = 7.6 Hz, 1 H), 7.00 (t, J = 8.0 Hz, 1 H), 6.94

(d, J = 8.8 Hz, 2 H), 6.74 (d, J = 8.0 Hz, 1 H), 3.85 (s, 3 H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 160.6, 138.6, 137.5, 132.6, 129.4, 126.8, 122.4, 118.3, 115.6, 55.4. HRMS (ESI-Orbitrap MS) *m/z*: $[M+H]^+$ Calcd. for $C_{13}H_{12}BrOSe$: 342.92313; found: 342.92197.

1-Bromo-4-[(4-methoxyphenyl)seleno]benzene (3am). Procedure was followed using 4-methoxyphenylboronic acid (0.2 mmol, 30.4 mg), bis(*p*-bromophenyl)diselenide (1.2 equiv., 0.24 mmol, 112.8 mg) and tetrabutylammonium tetrafluoroborate (1 equiv., 0.2 mmol, 66 mg). With stirring, the reaction mixture was performed at 50 °C under air conditions for 3 hours, then was purified by flash column chromatography on silica gel (97:3, petroleum ether: EtOAc) to afford 55.4 mg (81%) of the product as a colorless oil. Exhibited spectral data in accordance with previous report.[18] ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.50 (d, J = 8.9 Hz, 2 H), 7.32 (d, J = 8.5 Hz, 2 H), 7.17 (d, J = 8.5 Hz, 2 H), 6.87 (d, J = 8.8 Hz, 2 H), 3.82 (s, 3 H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 160.0, 136.8, 132.4, 132.3, 132.2, 120.5, 119.4, 115.3, 55.3.

4-Chlorophenyl 4-methoxyphenyl selenide (3an). Procedure was followed using 4-methoxyphenylboronic acid (0.2 mmol, 30.4 mg), bis(4-chlorophenyl)diselenide (1.2 equiv., 0.24 mmol, 91.7 mg) and tetrabutylammonium tetrafluoroborate (1 equiv., 0.2 mmol, 66 mg). With stirring, the reaction mixture was performed at 50 °C under air conditions for 3 hours, then was purified by flash column chromatography on silica gel (97:3, petroleum ether: EtOAc) to afford 47.6 mg (80%) of the product as a yellow oil. Exhibited spectral data in accordance with previous report.[14] ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.51 (d, J = 8.4 Hz, 2 H), 7.25 (d, J = 8.4 Hz, 2 H), 7.18 (d, J = 8.4 Hz, 2 H), 6.87 (d, J = 8.8 Hz, 2 H), 3.82 (s, 3 H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 160.0, 136.7, 132.5, 132.1, 131.6, 129.2, 119.6, 115.3, 55.3.

4-Fluorophenyl-4-methoxyphenyl selenide (3ao). Procedure was followed using 4-methoxyphenylboronic acid (0.2 mmol, 30.4 mg), bis(4-fluorophenyl)diselenide (1.2 equiv., 0.24 mmol, 84 mg) and tetrabutylammonium tetrafluoroborate (1 equiv., 0.2 mmol, 66 mg). With stirring, the reaction mixture was performed at 50 °C under air conditions for 3 hours, then was purified by flash column chromatography on silica gel (97:3, petroleum ether: EtOAc) to afford 45.1 mg (80%) of the product as a yellow oil. Exhibited spectral data in accordance with previous report.[18] ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.48 (d, J = 8.8 Hz, 2 H), 7.36 (t, J = 7.2 Hz, 2 H), 6.94 (t, J = 8.8 Hz, 2 H), 6.85 (d, J = 8.8 Hz, 2 H), 3.81 (s, 3 H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 162.1 (d, J = 244.5 Hz), 159.7, 135.9, 133.5 (d, J = 7.7 Hz), 127.3 (d, J = 3.7 Hz), 120.6, 116.3 (d, J = 21.6 Hz, 2 H), 115.2, 55.3. ^{19}F NMR (377 MHz, $CDCl_3$): δ -115.5 - -115.6 (m, 1 F).

1-[(4-Methoxyphenyl)seleno]pyridine (3ap). Procedure was followed using 4-methoxyphenylboronic acid (0.2 mmol, 30.4 mg), 2,2'-dipyridyl diselenide (1.2 equiv., 0.24 mmol, 75.9 mg) and TBAB (1 equiv., 0.2 mmol, 65 mg). With stirring, the reaction mixture was performed at 50 °C under air conditions for 3 hours, then was purified by flash column chromatography on silica gel (95:5, petroleum ether: EtOAc) to afford 53

mg (99%) of the product as a yellow oil. Exhibited spectral data in accordance with previous report.[16] ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.41 (d, J = 4 Hz, 1 H), 7.63 (d, J = 8.8 Hz, 2 H), 7.36 (td, J = 7.6, 2.0 Hz, 1 H), 7.00 - 6.96 (m, 1 H), 6.93 - 6.90 (m, 3 H), 3.83 (s, 3 H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 160.4, 159.9, 149.7, 138.3, 136.5, 123.5, 120.0, 117.8, 115.4, 55.3.

3-[(4-Methoxyphenyl)seleno]pyridine (3aq). Procedure was followed using 4-methoxyphenylboronic acid (0.2 mmol, 30.4 mg), 3,3'-dipyridyl diselenide (1.2 equiv., 0.24 mmol, 75.9 mg) and TBAB (1 equiv., 0.2 mmol, 65 mg). With stirring, the reaction mixture was performed at 50 °C under air conditions for 3 hours, then was purified by flash column chromatography on silica gel (95:5, petroleum ether: EtOAc) to afford 50.8 mg (96%) of the product as a yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 8.56 (d, J = 1.6 Hz, 1 H), 8.40 (dd, J = 4.8, 1.6 Hz, 1 H), 7.59 (dt, J = 8.0, 1.6 Hz, 1 H), 7.51 (d, J = 8.8 Hz, 2 H), 7.13 (dd, J = 8.0, 4.8 Hz, 1 H), 6.87 (d, J = 8.8 Hz, 2 H), 3.81 (s, 3 H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 160.1, 151.1, 147.5, 138.3, 136.8, 130.6, 124.1, 118.5, 115.4, 55.3. HRMS (ESI-Orbitrap MS) *m/z*: $[M+H]^+$ Calcd. for $C_{12}H_{12}NOSe$: 266.00786; found: 266.00705.

2-[(4-Methoxyphenyl)seleno]thiophene (3ar). Procedure was followed using 4-methoxyphenylboronic acid (0.2 mmol, 30.4 mg), bis(2-thienyl)diselenide (1.2 equiv., 0.24 mmol, 78.3 mg) and TBAB (1 equiv., 0.2 mmol, 65 mg). With stirring, the reaction mixture was performed at 50 °C under air conditions for 3 hours, then was purified by flash column chromatography on silica gel (95:5, petroleum ether: EtOAc) to afford 35.1 mg (65%) of the product as a yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.42 - 7.39 (m, 3 H), 7.27 (dd, J = 3.2, 1.2 Hz, 1 H), 7.00 (dd, J = 5.2, 3.6 Hz, 1 H), 6.81 (d, J = 8.8 Hz, 2 H), 3.77 (s, 3 H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 159.3, 135.4, 133.4, 131.1, 128.2, 125.3 122.8, 114.9, 55.3. HRMS (ESI-Orbitrap MS) *m/z*: $[M+H]^+$ Calcd. for $C_{11}H_{11}OSSe$: 270.96903; found: 270.96835.

3-[(4-Methoxyphenyl)seleno]thiophene (3as). Procedure was followed using 4-methoxyphenylboronic acid (0.2 mmol, 30.4 mg), bis(3-thienyl)diselenide (1.2 equiv., 0.24 mmol, 78.3 mg) and TBAB (1 equiv., 0.2 mmol, 65 mg). With stirring, the reaction mixture was performed at 50 °C under air conditions for 3 hours, then was purified by flash column chromatography on silica gel (95:5, petroleum ether: EtOAc) to afford 40.5 mg (75%) of the product as a yellow oil. ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.43 (d, J = 8.8 Hz, 2 H), 7.31 - 7.29 (m, 1 H), 7.25 - 7.24 (m, 1 H),7.03 (dd, J = 5.2, 1.2 Hz, 1 H), 6.82 (d, J = 8.8 Hz, 2 H), 3.79 (s, 3 H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 159.3, 134.6, 131.6, 126.5, 126.5, 124.8, 121.1, 115.0, 55.3. HRMS (ESI-Orbitrap MS) *m/z*: $[M+H]^+$ Calcd. for $C_{11}H_{11}OSSe$: 270.96903; found: 270.96835.

***N*,*N*-dimethyl-4-(phenylseleno)benzenamine (3ok).** Procedure was followed using 4-(dimethylamino)phenylboronic acid (0.2 mmol, 33.0 mg), diphenyl diselenide (1.2 equiv., 0.24 mmol, 75.4 mg) and tetrabutylammonium tetrafluoroborate (1 equiv., 0.2 mmol, 66 mg). With stirring, the reaction mixture was performed at 50 °C under air

conditions for 3 hours, then was purified by flash column chromatography on silica gel (90:10, petroleum ether: EtOAc) to afford 39.4 mg (71%) of the product as a yellow oil. Exhibited spectral data in accordance with previous report.[19] ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.52 (d, J = 9.2 Hz, 2 H), 7.31 (d, J = 7.8 Hz, 2 H), 7.22 (t, J = 7.6 Hz, 2 H), 7.18 - 7.14 (m, 1 H), 6.70 (d, J = 8.8 Hz, 2 H), 3.00 (s, 6 H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 150.5, 137.2, 134.6, 129.7, 129.0, 125.8, 113.6, 113.2, 40.3.

1,2,3-Trimethoxy-5-((4-methoxyphenyl)seleno)benzene (3pa). Procedure was followed using 3,4,5-trimethoxyphenylboronic acid (0.2 mmol, 42.4 mg), bis(*p*-methoxyphenyl)diselenide (1.2 equiv., 0.24 mmol, 89.8 mg) and tetrabutylammonium tetrafluoroborate (1 equiv., 0.2 mmol, 66 mg). With stirring, the reaction mixture was performed at 50 °C under air conditions for 3 hours, then was purified by flash column chromatography on silica gel (95:5, petroleum ether: EtOAc) to afford 53.1 mg (75%) of the product as a yellow oil. Exhibited spectral data in accordance with previous report.[20] ^{1}H NMR (400 MHz, $CDCl_3$): δ 7.48 (d, J = 8.8 Hz, 2 H), 6.86 (d, J = 8.4 Hz, 2 H), 6.61 (s, 2 H), 3.81 (s, 6 H), 3.76 (s, 6 H). ^{13}C NMR (100 MHz, $CDCl_3$): δ 159.6, 153.5, 137.2, 135.7, 126.7, 120.6, 115.0, 108.9, 60.8, 56.1, 55.3.

Scale-up synthesis of 4-(phenylseleno)anisole (3ak).

An undivided three-necked bottle (500 mL) equipped with 4-methoxyphenylboronic acid (5 mmol), diphenyl diselenide (1.2 equiv., 6 mmol), tetrabutylammonium tetrafluoroborate (1 equiv., 5 mmol), and a stir bar. The bottle was equipped with a platinum electrode (1.0×1.0 cm^2) anode and cathode. Then, CH_3CN (200 mL) was added. The reaction mixture was stirred and electrolyzed at a constant current of 6 mA under 50 °C for 24 h. After 24 h, the reaction was cooled to room temperature, filtered and washed with EtOAc. The combined organic layers were concentrated with a rotary evaporator, and the pure product was obtained by flash column chromatography on silica gel (99:1, petroleum ether: EtOAc) to afford 0.99 g (75%) of the **3ak**.

General procedure for cyclic voltammetry (CV).

Cyclic voltammetry was performed in a three-electrode cell connected to a Schlenk line under room temperature. Platinum disk was used as working electrode, and platinum wire was employed as counter electrode. Ag/AgCl reference electrode was submerged in saturated KCl aqueous solution and separated from reaction by a salt bridge. The mixture of acetonitrile (10 mL) containing 0.02 M tetrabutylammonium tetrafluoroborate was poured into the electrochemical cell in all experiments. The scan rate was 100 mV/s ranging from 0 to 3.0 V and -3 V to 0 V.

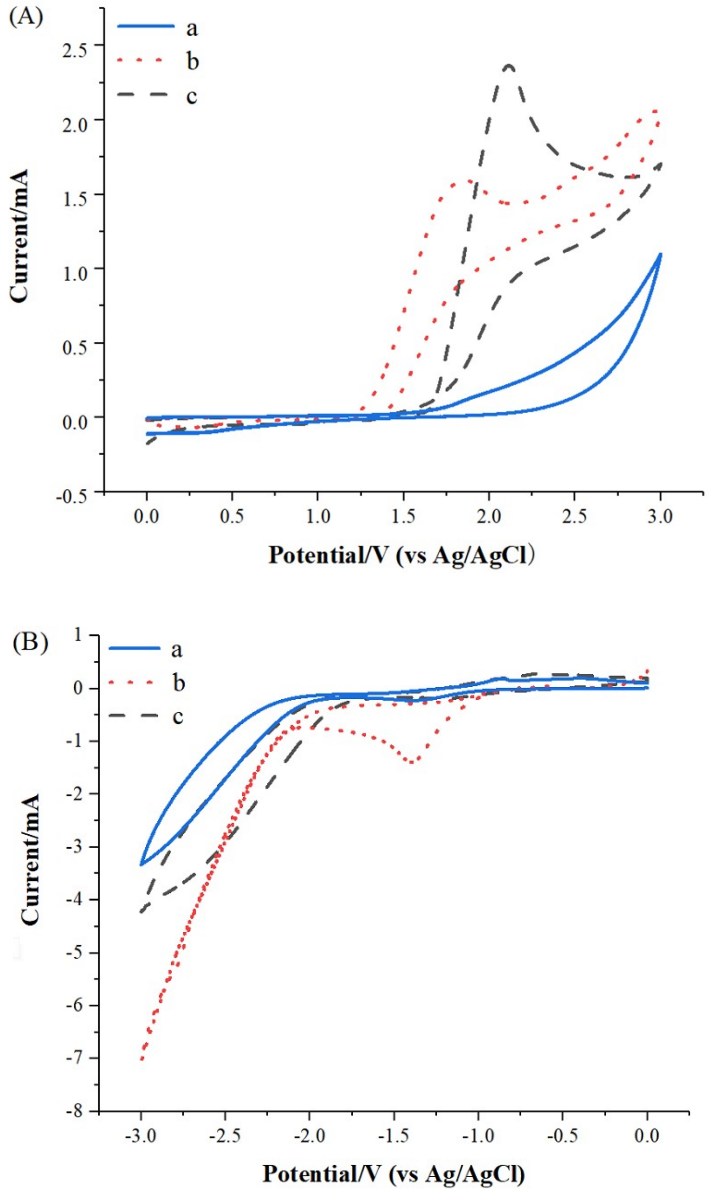


Fig 1. Cyclic voltammograms of substrates: (a) background (nBu$_4$NBF$_4$ 0.02 mol/L^{-1} in CH_3CN); (b) diphenyl diselenide (0.02 mmol/L^{-1}); (c) 4-methoxyphenylboronic acid (0.02 mol/L^{-1}).

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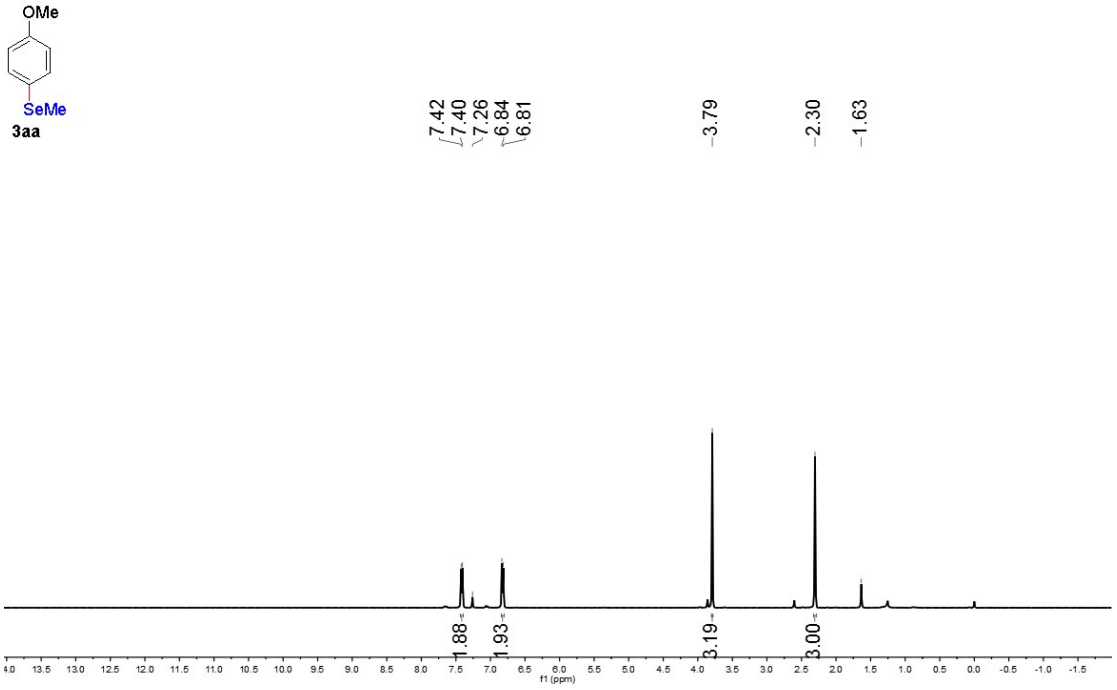
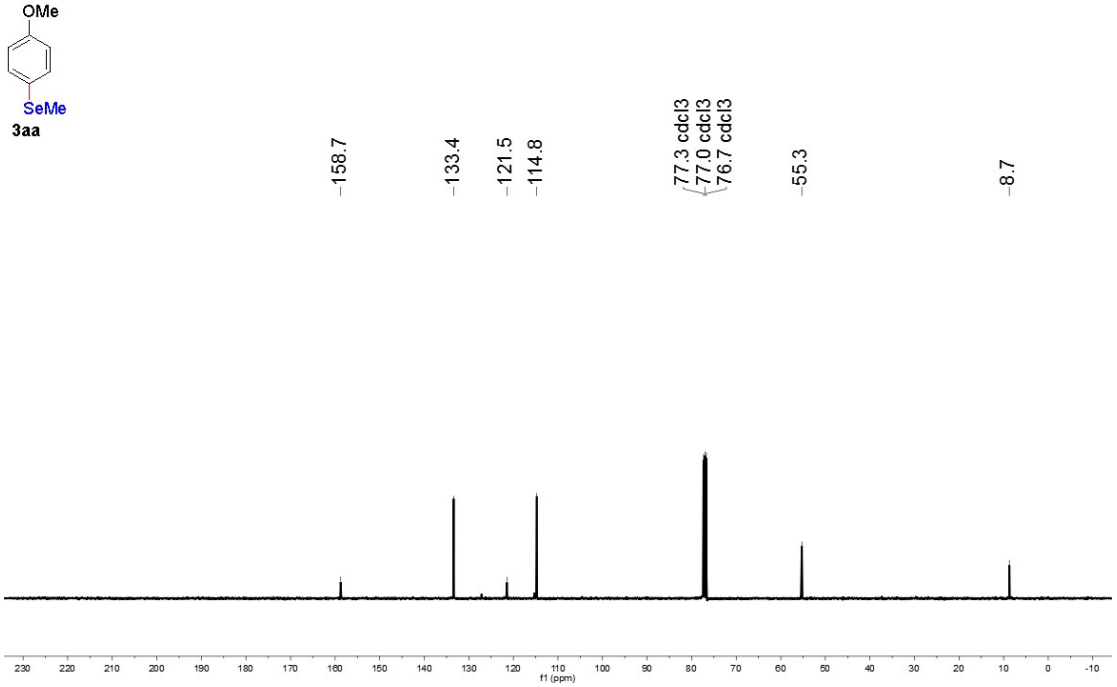
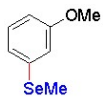
^{1}H, ^{13}C and ^{19}F spectra



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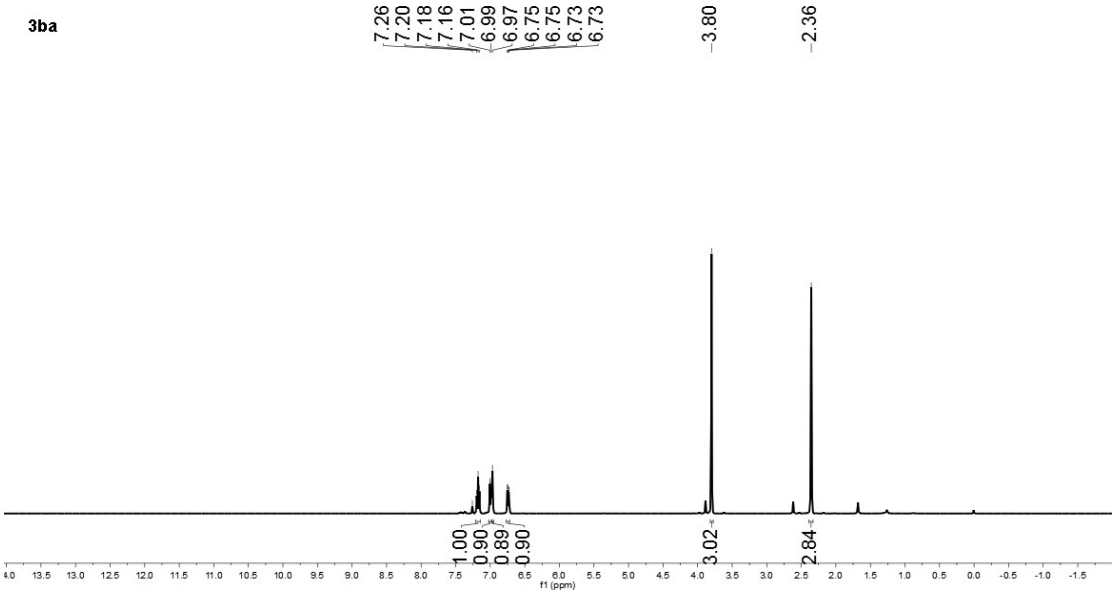
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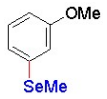
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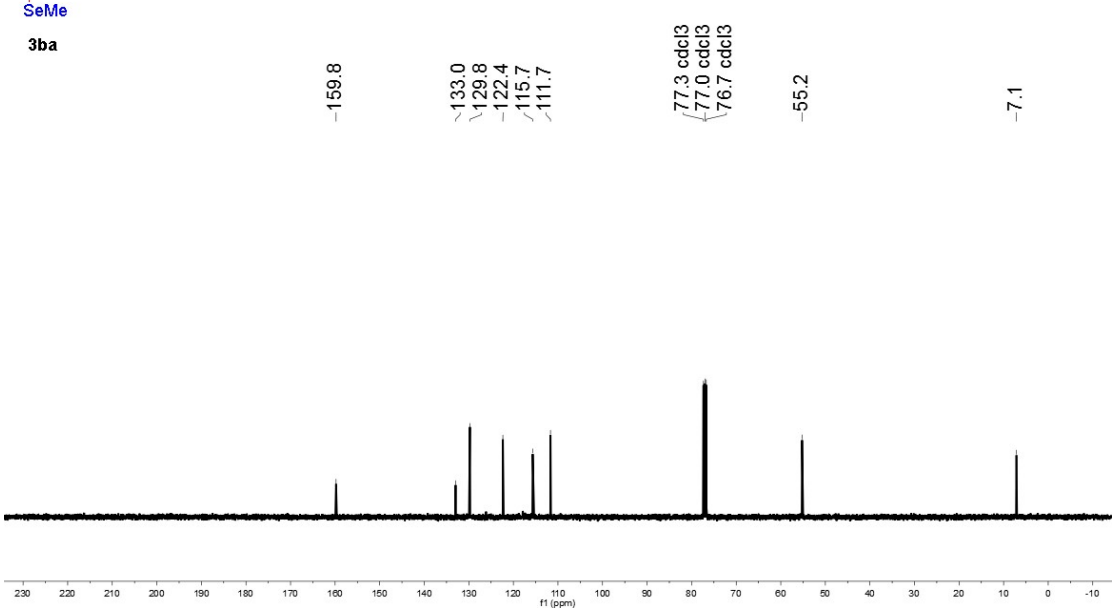
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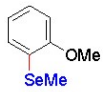
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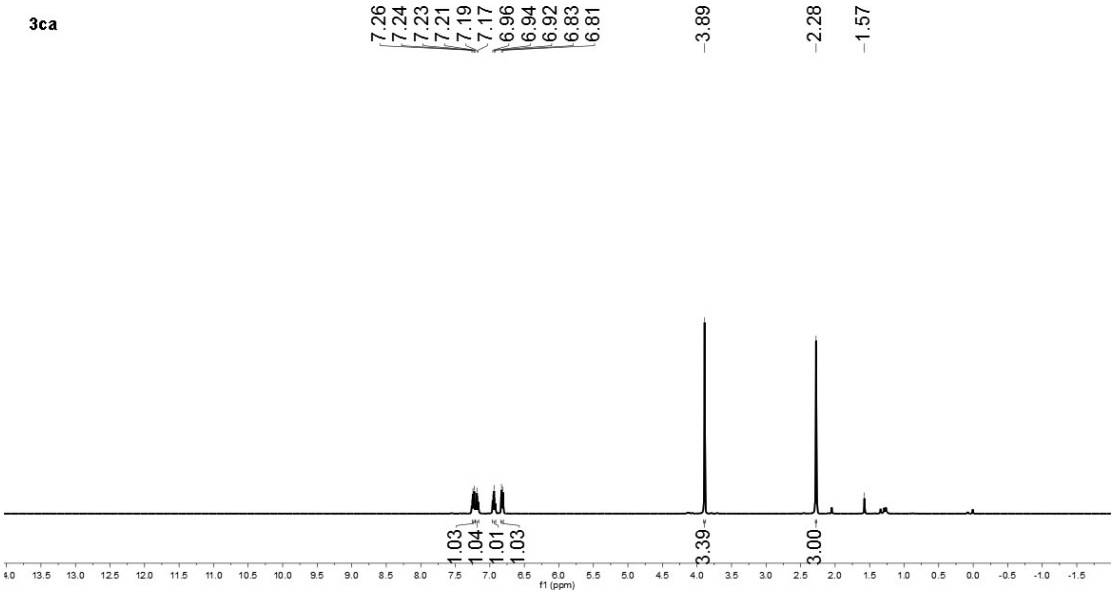
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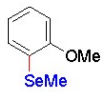
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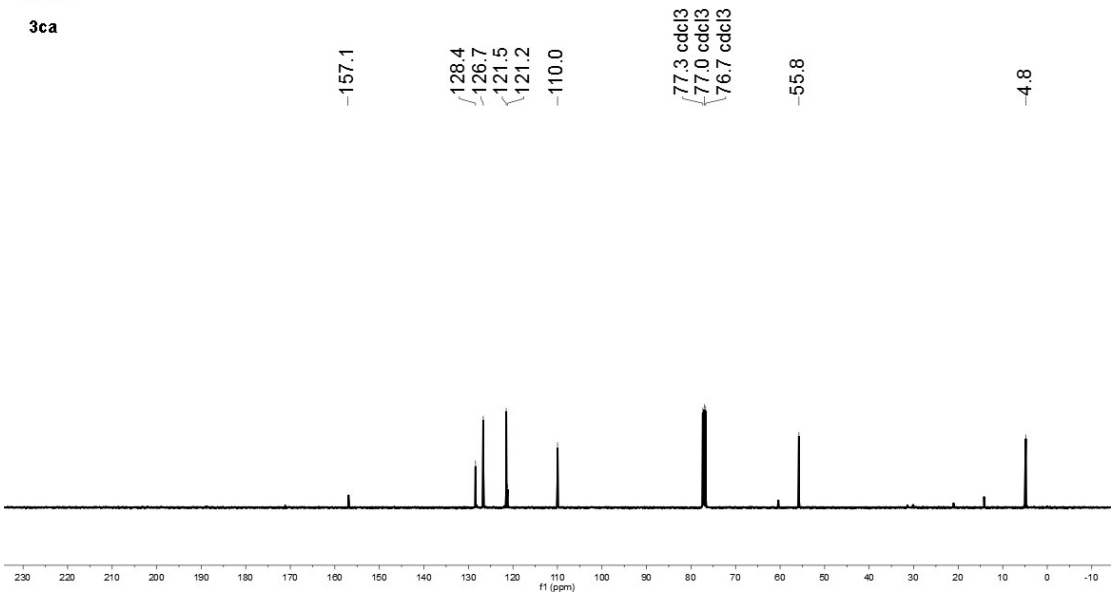
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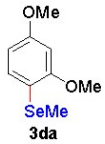
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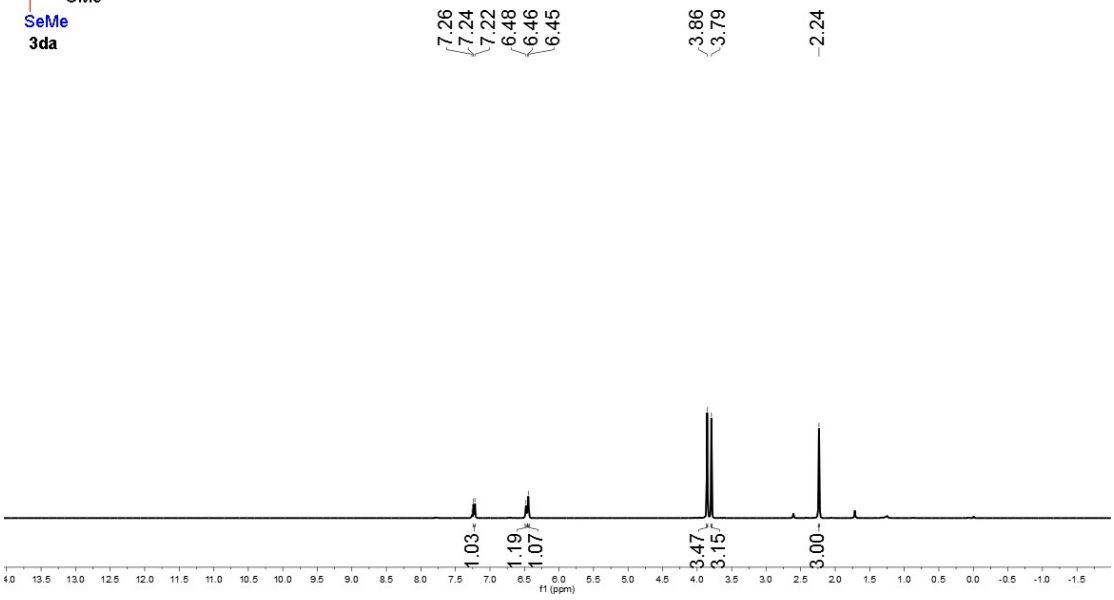
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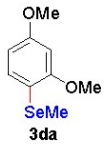
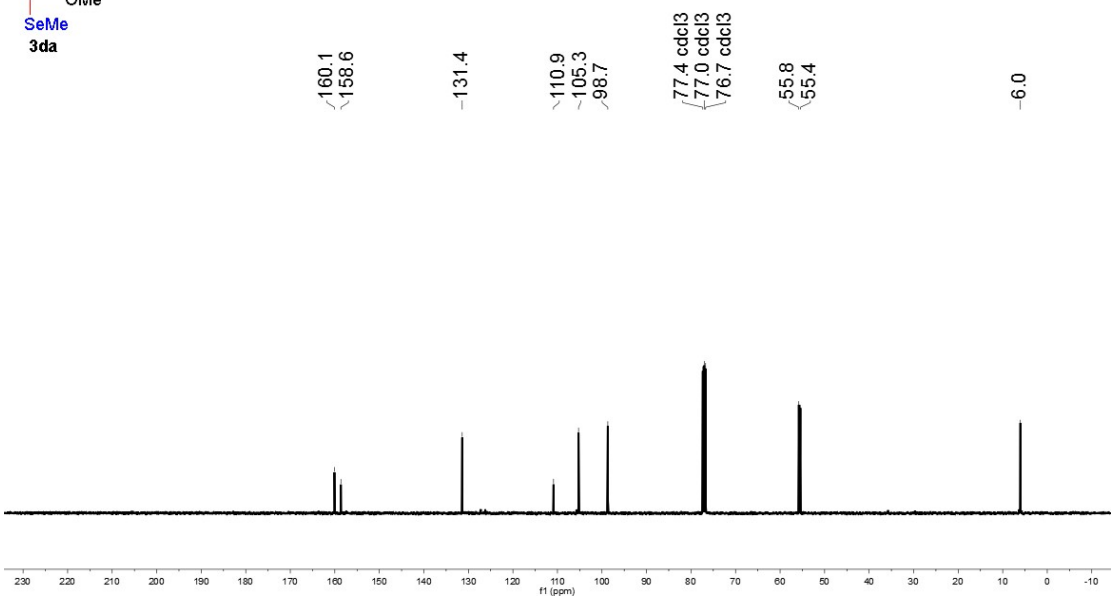
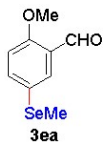
3.00
f1 (ppm)

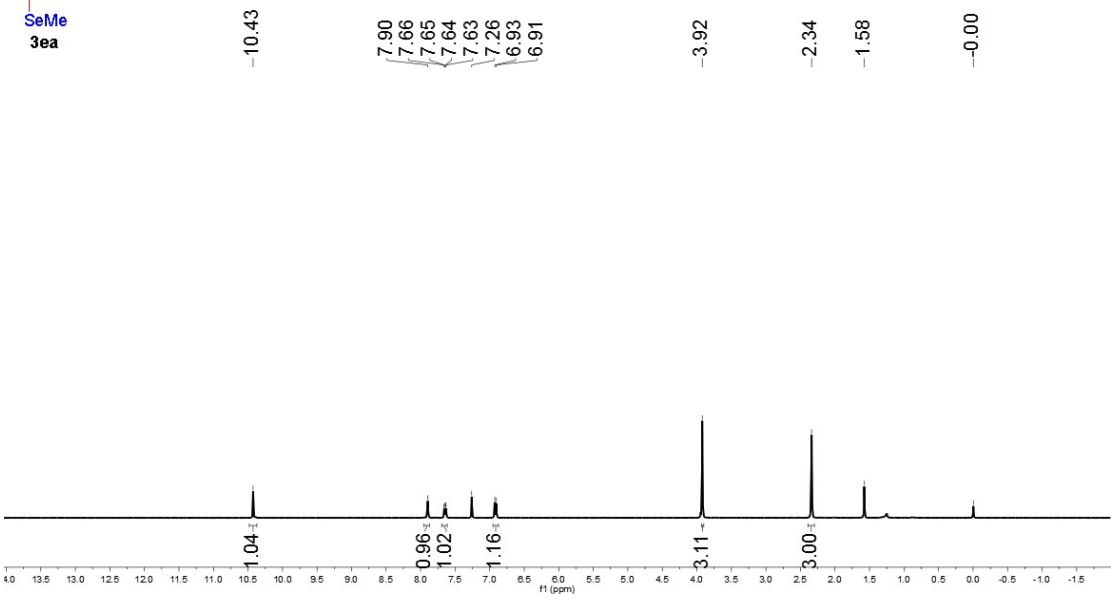

OMe
OMe
SeMe

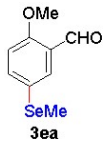
3da


160.1
158.6
131.4
110.9
105.3
98.7
77.4 cdcl3
77.0 cdcl3
76.7 cdcl3
55.8
55.4
6.0
f1 (ppm)

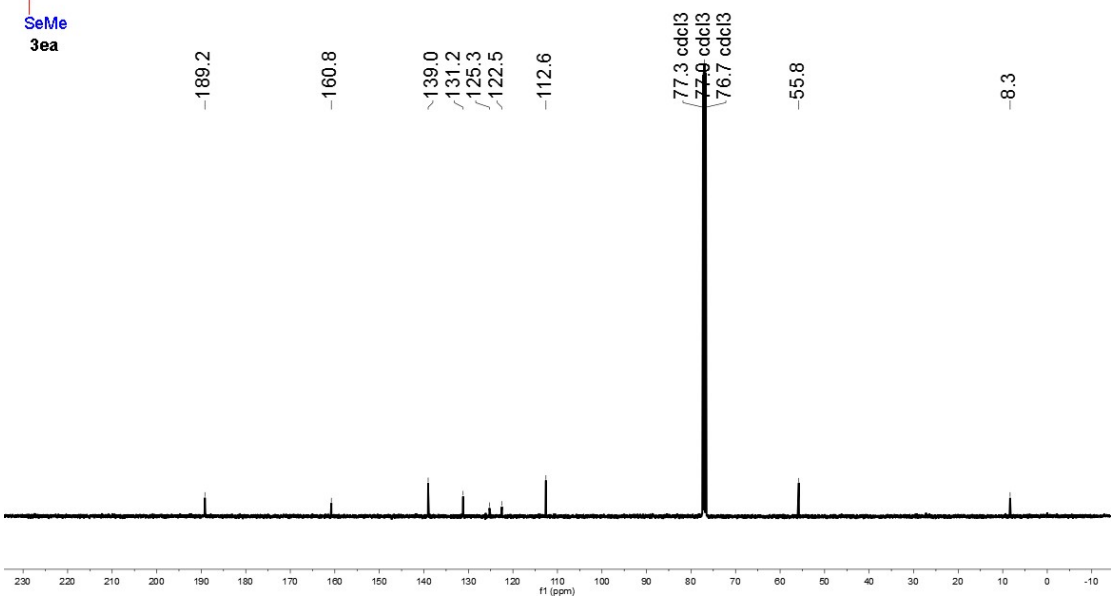

OMe
CHO
SeMe

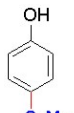
3ea


10.43
7.90
7.66
7.65
7.64
7.63
7.26
6.93
6.91
3.92
2.34
1.58
0.00
1.04
0.96
1.02
1.16
3.11
3.00
f1 (ppm)

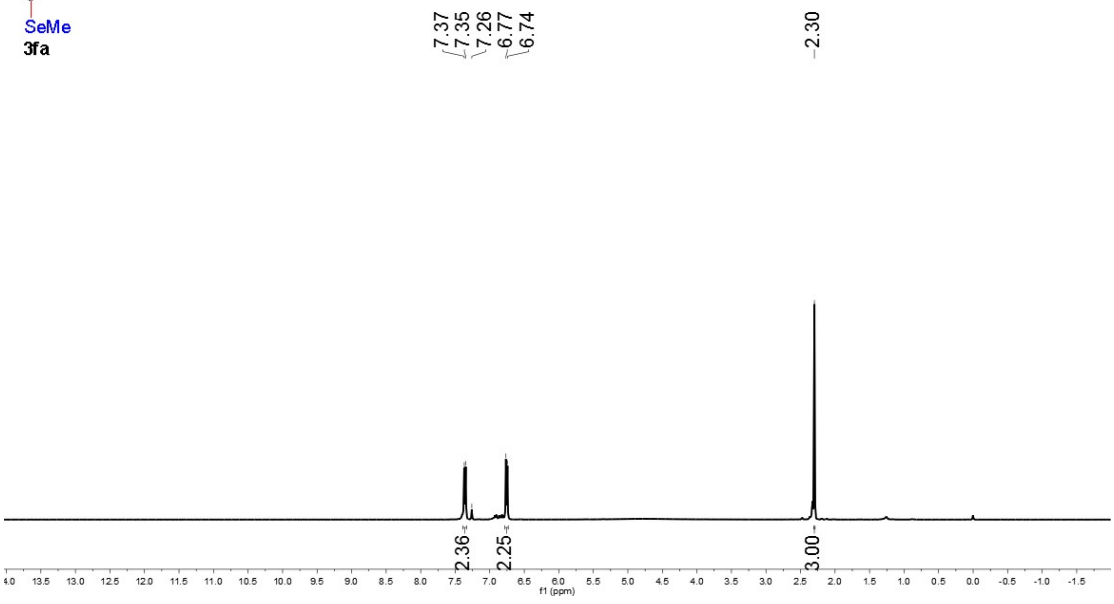

OMe
CHO
SeMe

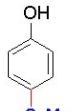
3ea


189.2
160.8
139.0
131.2
125.3
122.5
112.6
77.3 cdcl3
77.0 cdcl3
76.7 cdcl3
55.8
8.3
f1 (ppm)

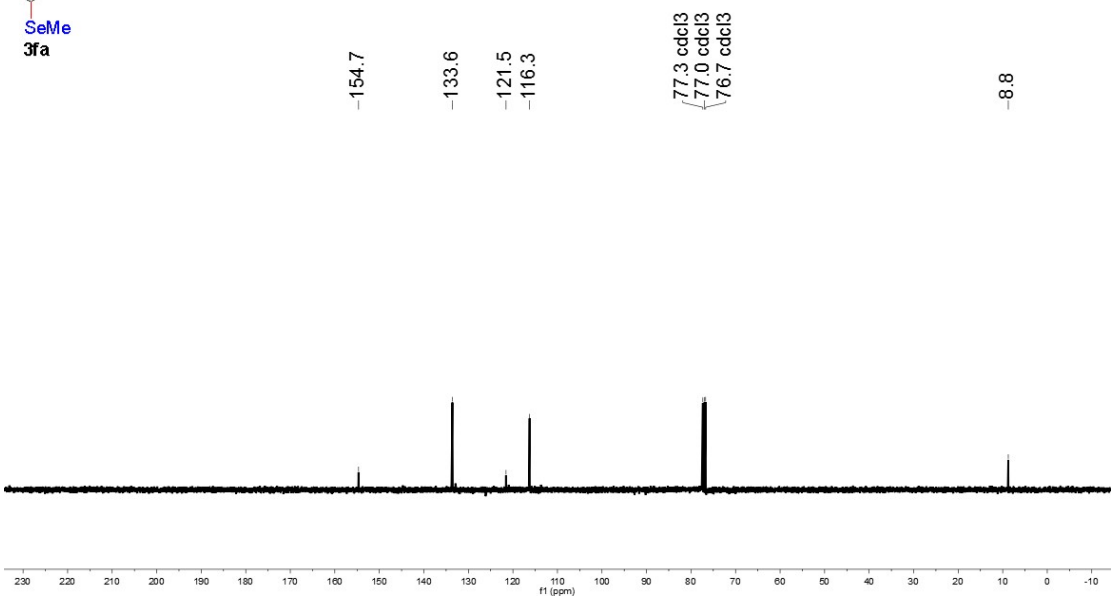

OH
SeMe

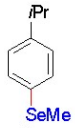
3fa


7.37
7.35
7.26
6.77
6.74
2.30
2.36
2.25
3.00
f1 (ppm)

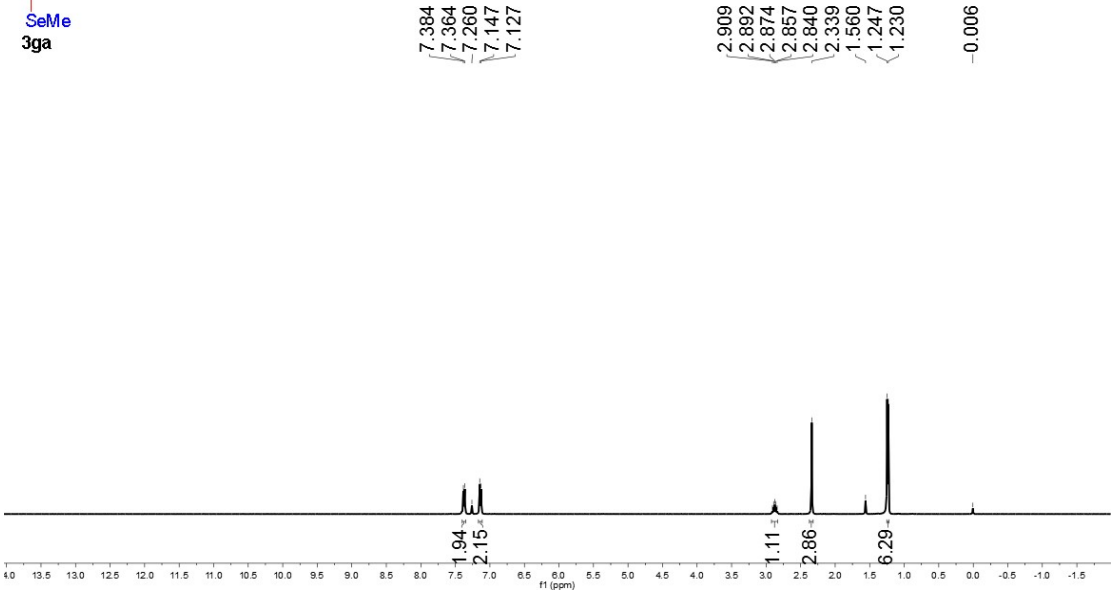

OH
SeMe

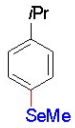
3fa


154.7
133.6
121.5
116.3
77.3 cdcl3
77.0 cdcl3
76.7 cdcl3
8.8
f1 (ppm)

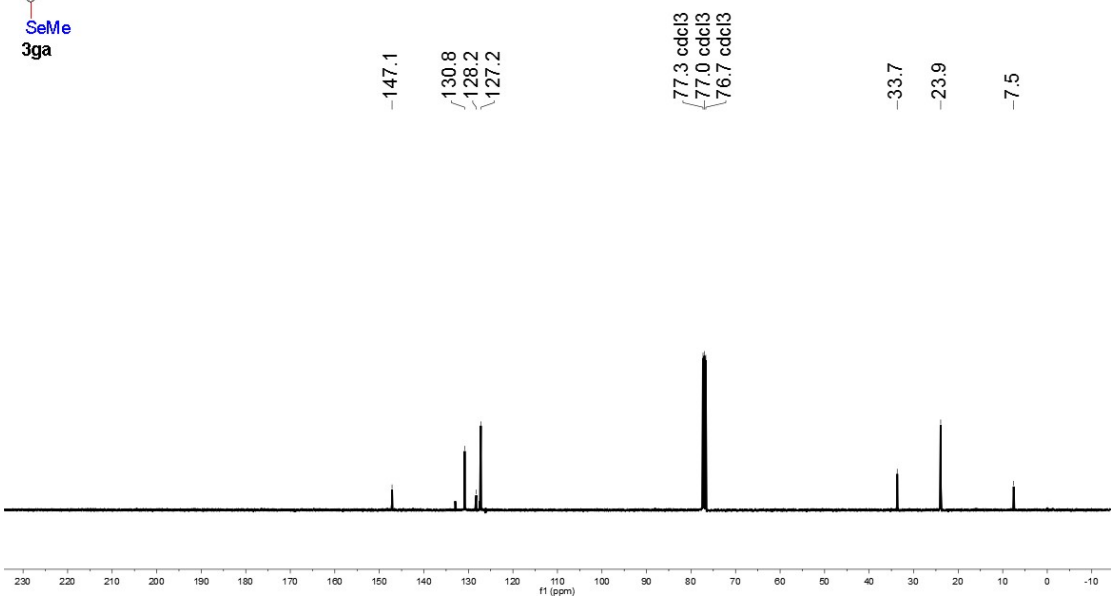

iPr
SeMe

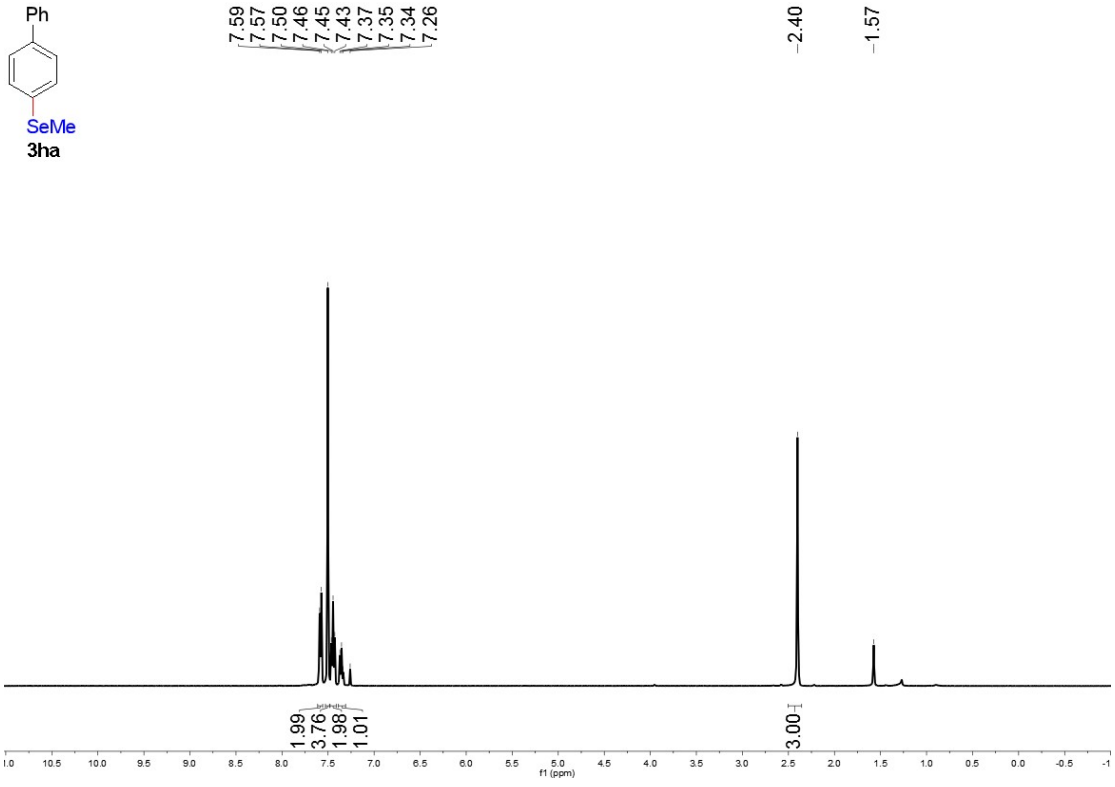
3ga

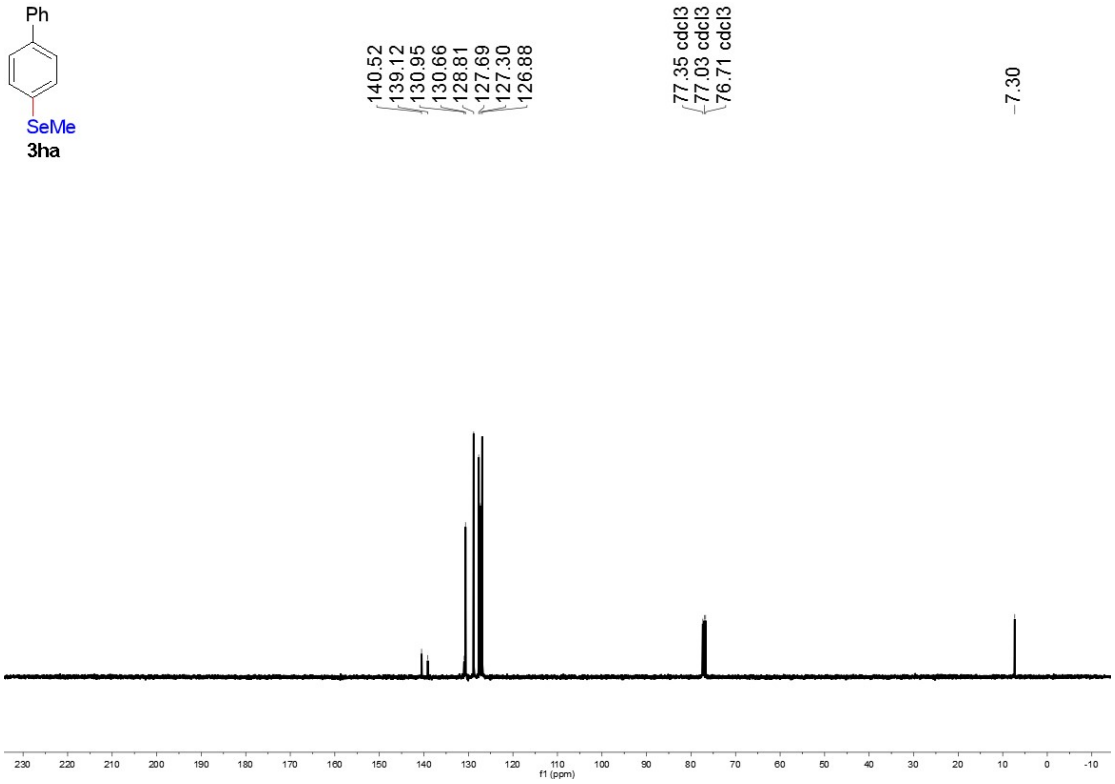

7.384
7.364
7.260
7.147
7.127
2.909
2.892
2.874
2.857
2.840
2.339
1.560
1.247
1.230
0.006
1.94
2.15
1.11
2.86
6.29
f1 (ppm)

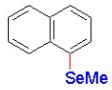

iPr
SeMe

3ga

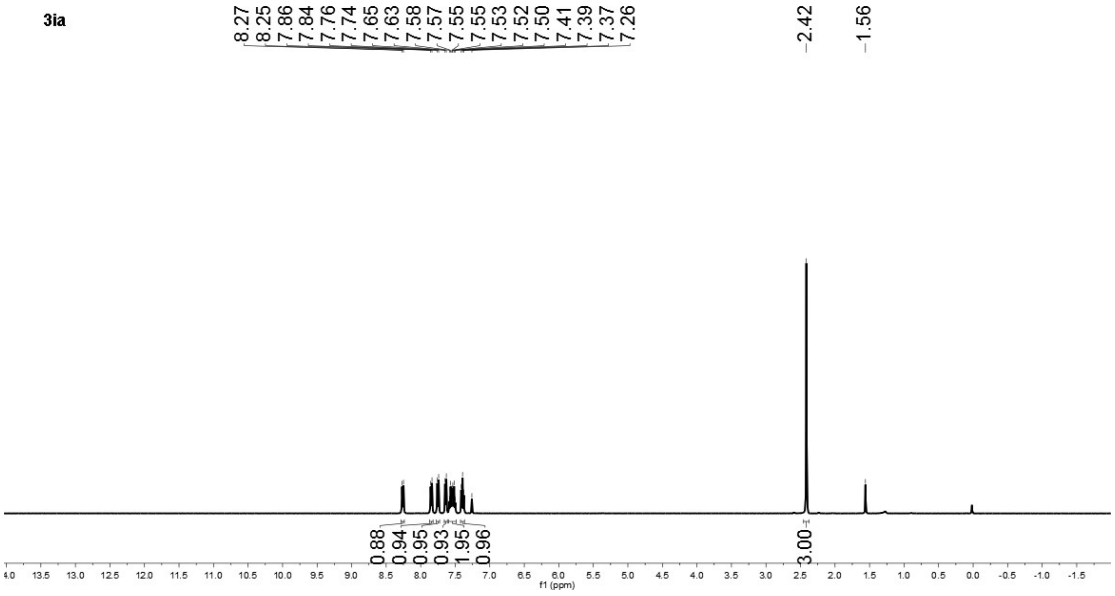

147.1
130.8
128.2
127.2
77.3 cdcl3
77.0 cdcl3
76.7 cdcl3
33.7
23.9
7.5
f1 (ppm)

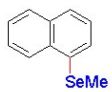

Ph
SeMe
3ha
7.59
7.57
7.50
7.46
7.45
7.43
7.37
7.35
7.34
7.26
2.40
1.57
1.99
3.76
1.98
1.01
3.00
f1 (ppm)


Ph
SeMe
3ha
140.52
139.12
130.95
130.66
128.81
127.69
127.30
126.88
77.35 cdcl3
77.03 cdcl3
76.71 cdcl3
7.30
f1 (ppm)

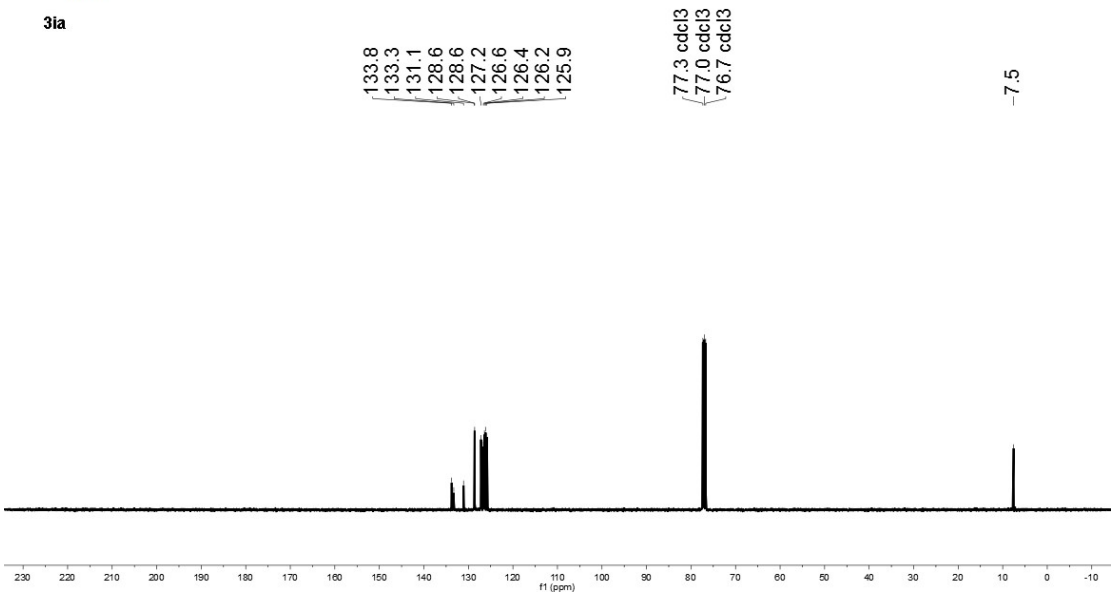

SeMe

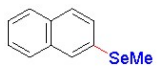
3ia


8.27
8.25
7.86
7.84
7.76
7.74
7.65
7.63
7.58
7.57
7.55
7.55
7.53
7.52
7.50
7.41
7.39
7.37
7.26
2.42
1.56
0.88
0.94
0.95
0.93
1.95
0.96
3.00
f1 (ppm)

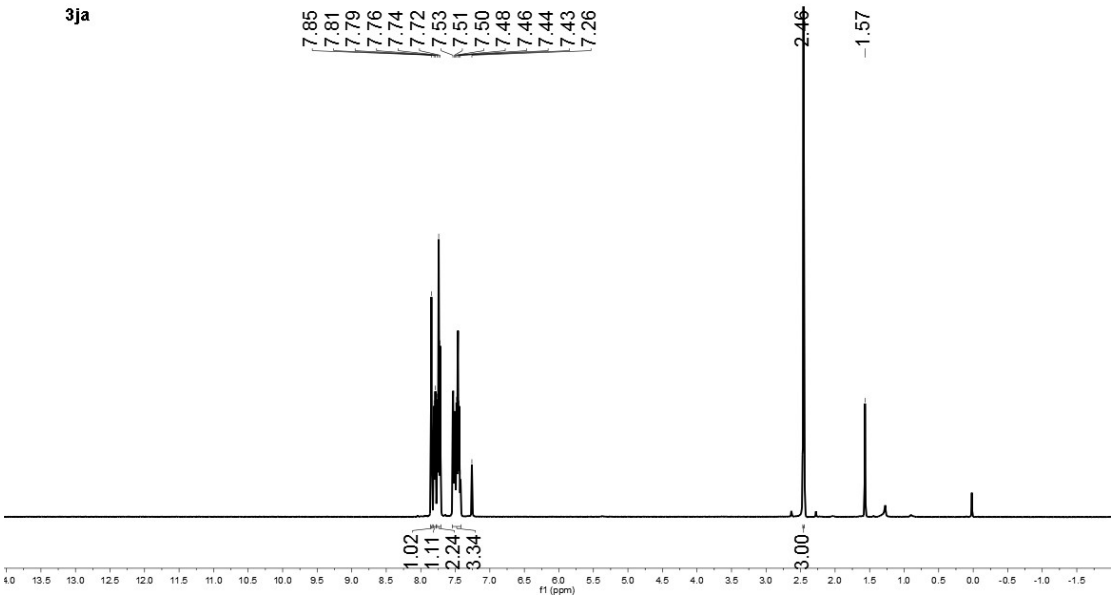

SeMe

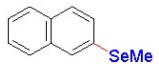
3ia


133.8
133.3
131.1
128.6
128.6
127.2
126.6
126.4
126.2
125.9
77.3 cdcl3
77.0 cdcl3
76.7 cdcl3
7.5
f1 (ppm)

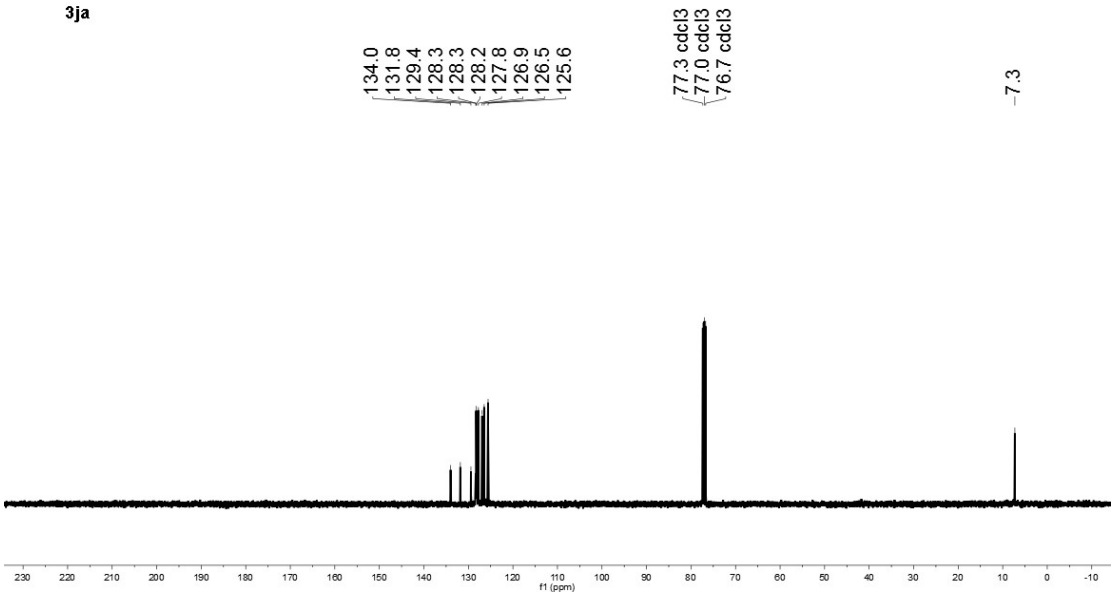

SeMe

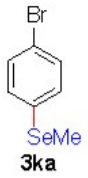
3ja


7.85
7.81
7.79
7.76
7.74
7.72
7.53
7.51
7.50
7.48
7.46
7.44
7.43
7.26
2.46
1.57
1.02
1.11
2.24
3.34
3.00
f1 (ppm)

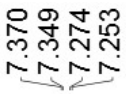

SeMe

3ja

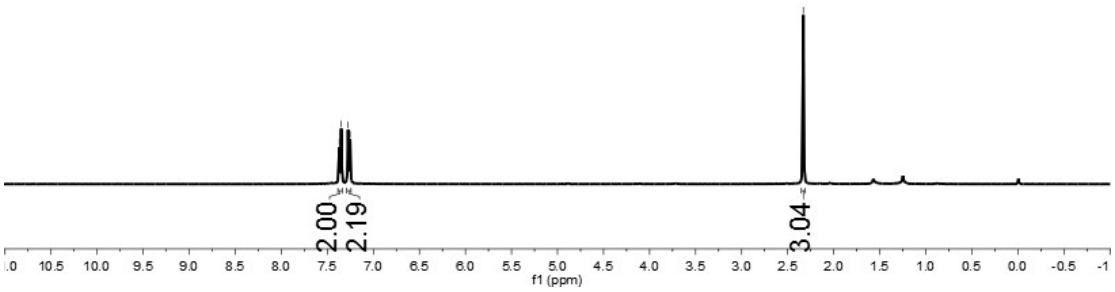

134.0
131.8
129.4
128.3
128.3
128.2
127.8
126.9
126.5
125.6
77.3 cdcl3
77.0 cdcl3
76.7 cdcl3
7.3
f1 (ppm)

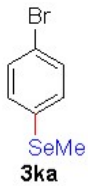

Br
SeMe

3ka


7.370
7.349
7.274
7.253


2.330


2.00
2.19
3.04
f1 (ppm)

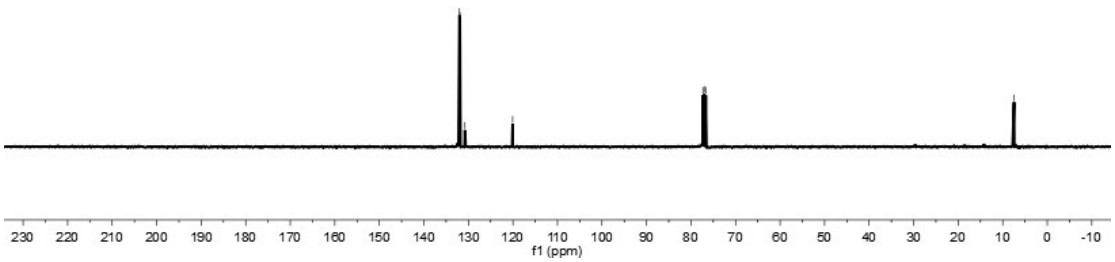

Br
SeMe

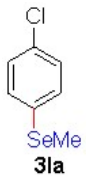
3ka


132.0
131.9
130.8
120.1


77.3 cdcl3
77.0 cdcl3
76.7 cdcl3

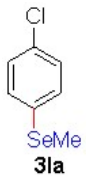

7.5


f1 (ppm)


Cl
SeMe

3la

7.35
7.33
7.26
7.23
7.21
2.34
1.56
2.00
1.93
3.18
f1 (ppm)

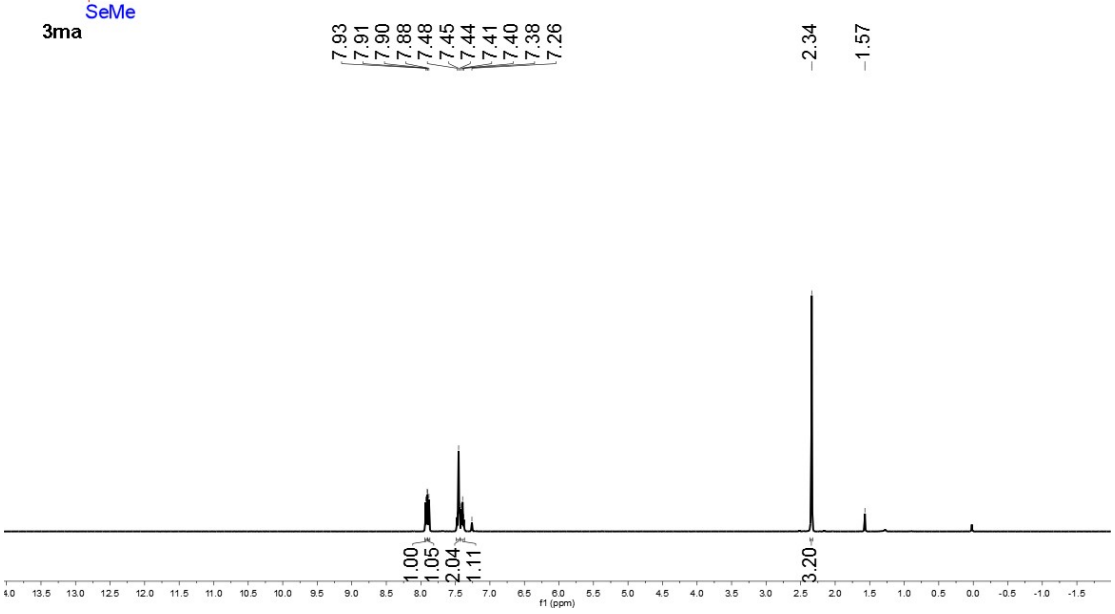

Cl
SeMe

3la

132.2
131.6
130.0
129.1
77.4 cdcl3
77.0 cdcl3
76.7 cdcl3
7.6
f1 (ppm)

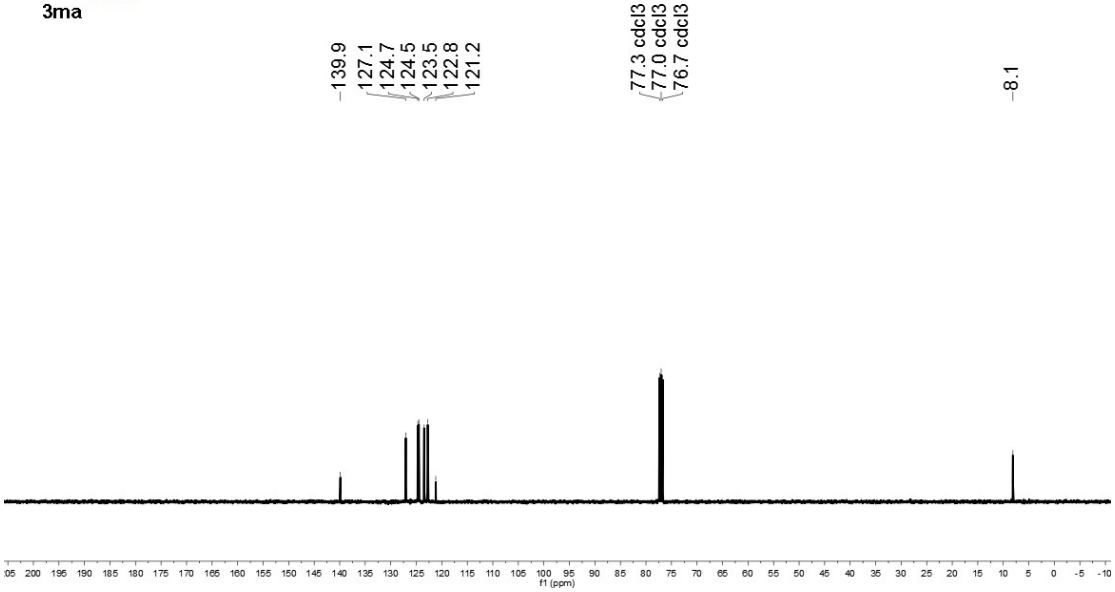

S
SeMe

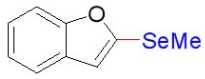
3ma


7.93
7.91
7.90
7.88
7.48
7.45
7.44
7.41
7.40
7.38
7.26
2.34
1.57
1.00
1.05
2.04
1.11
3.20
f1 (ppm)

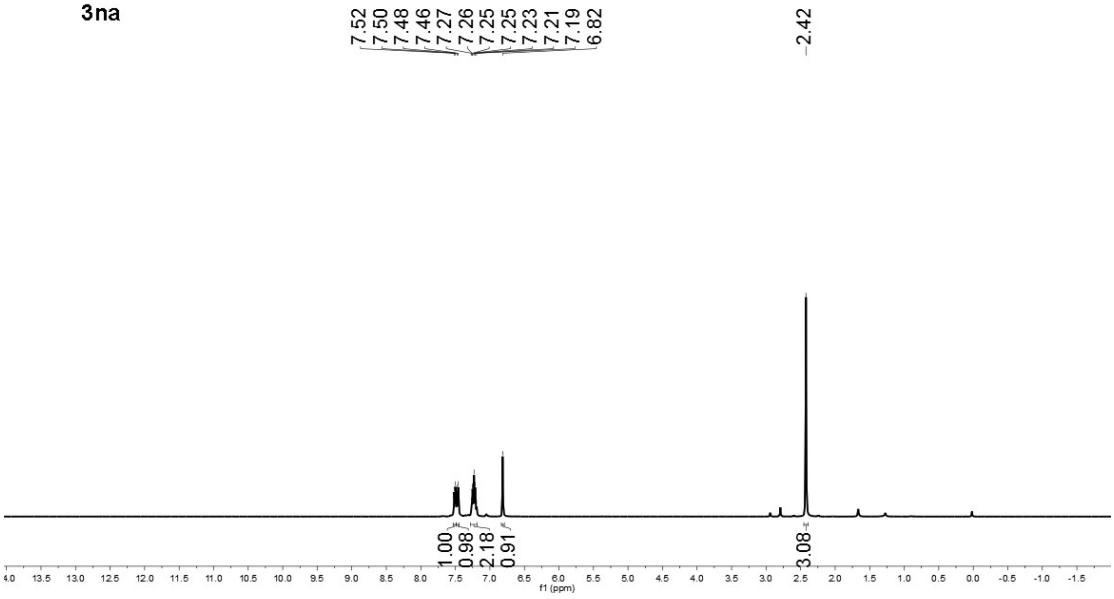

S
SeMe

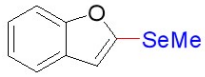
3ma


139.9
127.1
124.7
124.5
123.5
122.8
121.2
77.3 cdcl3
77.0 cdcl3
76.7 cdcl3
8.1
f1 (ppm)

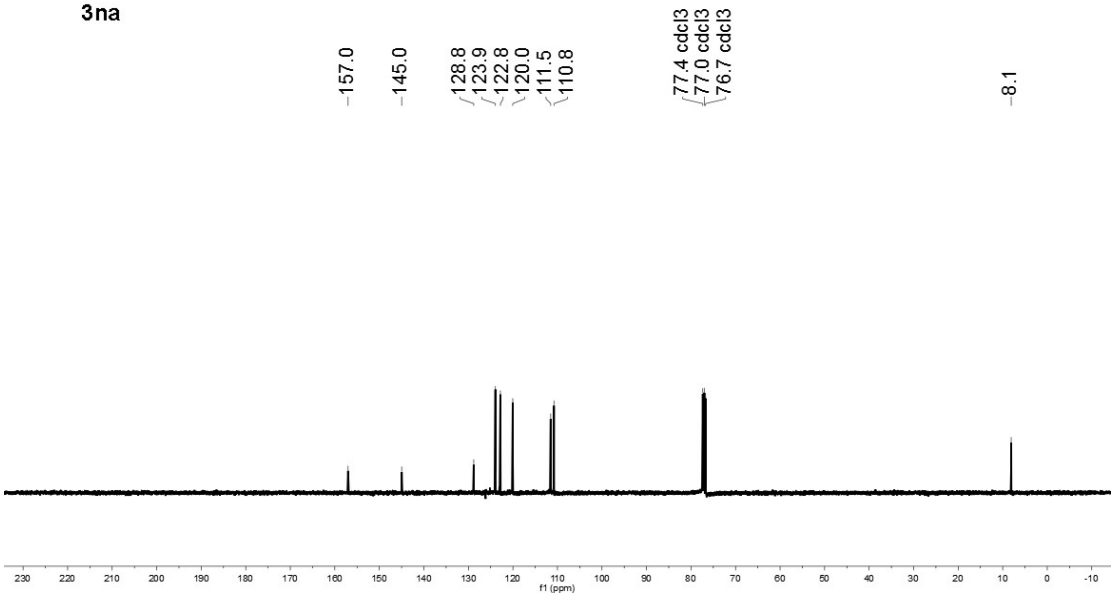

O
SeMe

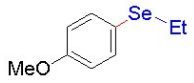
3na


7.52
7.50
7.48
7.46
7.27
7.26
7.25
7.25
7.23
7.21
7.19
6.82
2.42
1.00
0.98
2.18
0.91
3.08
f1 (ppm)

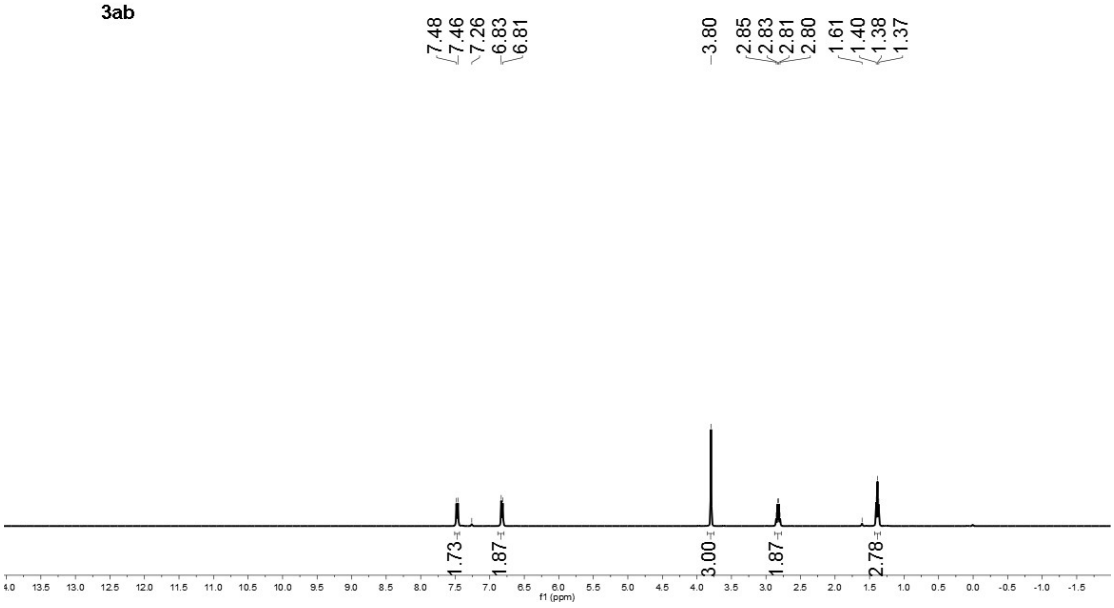

O
SeMe

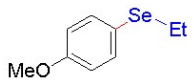
3na


157.0
145.0
128.8
123.9
122.8
120.0
111.5
110.8
77.4 cdcl3
77.0 cdcl3
76.7 cdcl3
8.1
f1 (ppm)

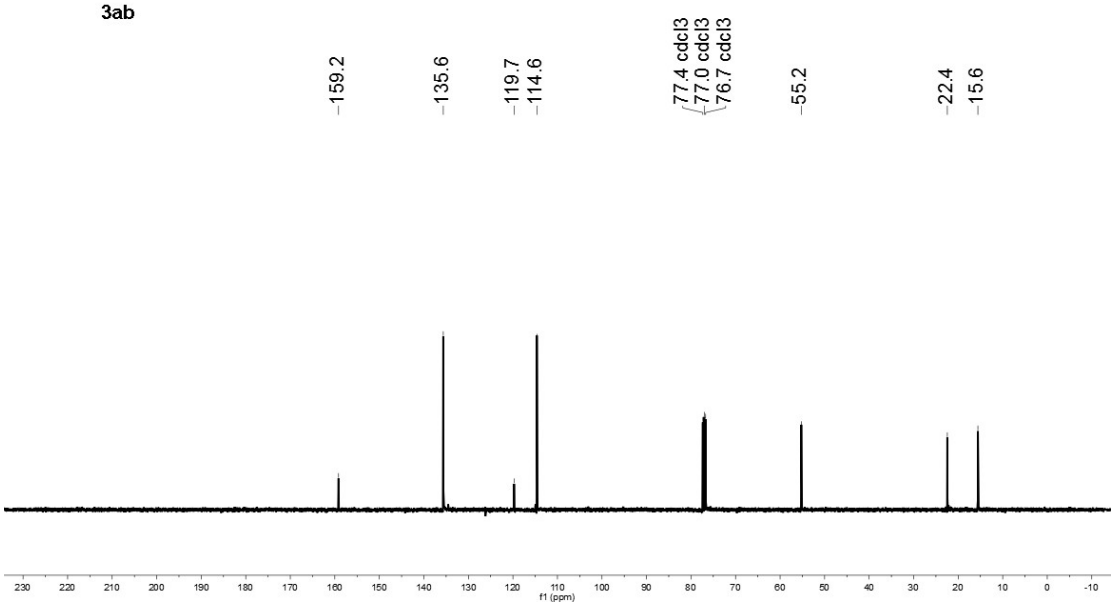

Se
Et
MeO

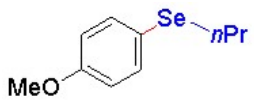
3ab


7.48
7.46
7.26
6.83
6.81
3.80
2.85
2.83
2.81
2.80
1.61
1.40
1.38
1.37
1.73
1.87
3.00
1.87
2.78
f1 (ppm)


Se
Et
MeO

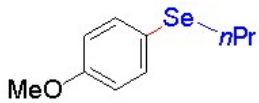
3ab


159.2
135.6
119.7
114.6
77.4 cdcl3
77.0 cdcl3
76.7 cdcl3
55.2
22.4
15.6
f1 (ppm)


Se
nPr
MeO

3ac

7.47
7.45
7.26
6.82
6.80
3.79
2.82
2.80
2.78
1.70
1.68
1.66
1.64
1.63
1.58
1.00
0.98
1.81
1.88
3.00
1.97
2.06
2.94
f1 (ppm)

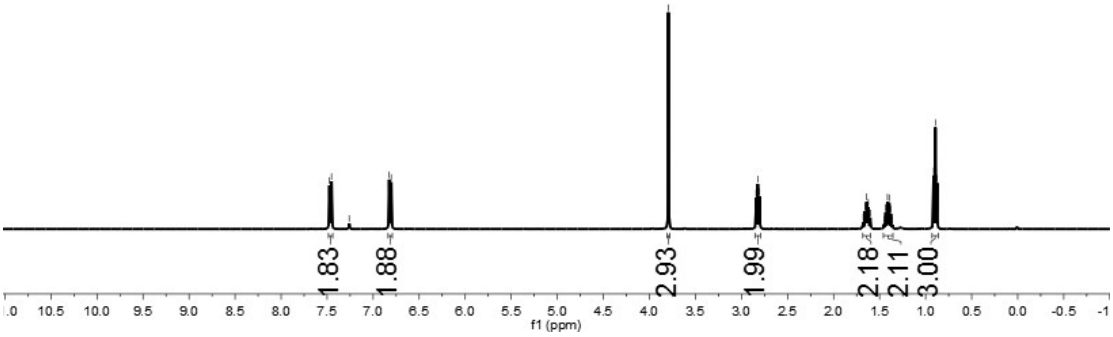

Se
nPr
MeO

3ac

156.5
132.9
117.6
112.1
74.8
74.4
74.1
52.7
28.7
20.9
11.8
f1 (ppm)

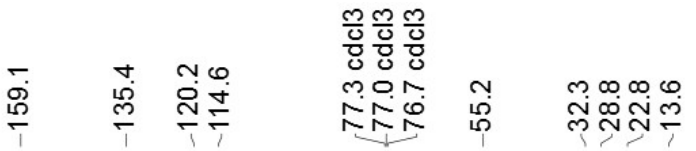

Se
nBu
MeO
7.47
7.45
7.26
6.83
6.80
3.79
2.84
2.82
2.80
1.66
1.64
1.62
1.43
1.41
1.40
1.38
0.91
0.89

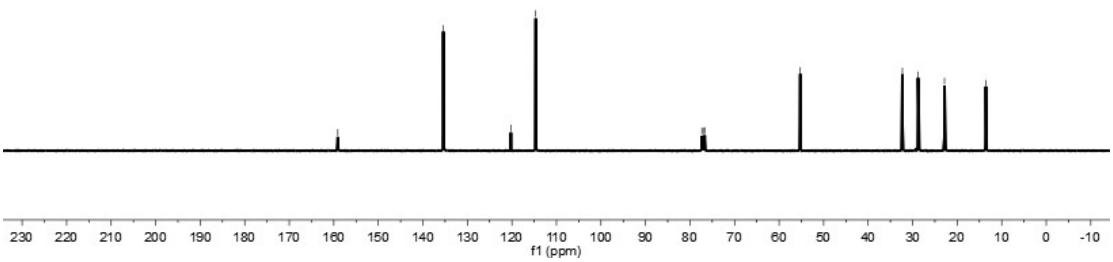
3ad

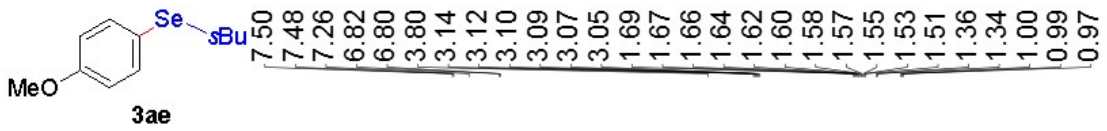

1.83
1.88
2.93
1.99
2.18
2.11
3.00
f1 (ppm)

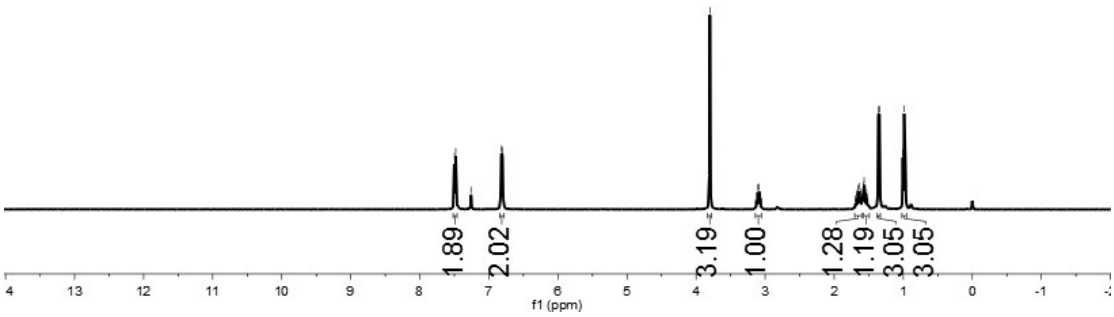

Se
nBu
MeO

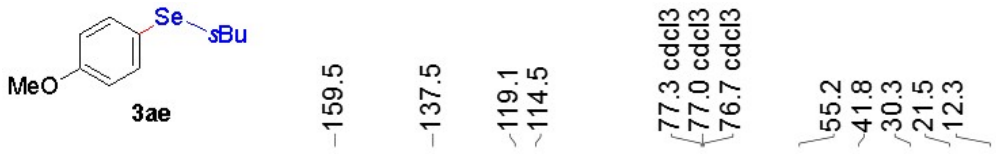
3ad

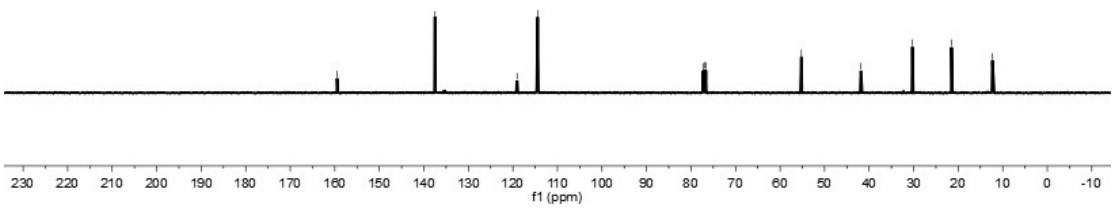

159.1
135.4
120.2
114.6
77.3 cdcl3
77.0 cdcl3
76.7 cdcl3
55.2
32.3
28.8
22.8
13.6

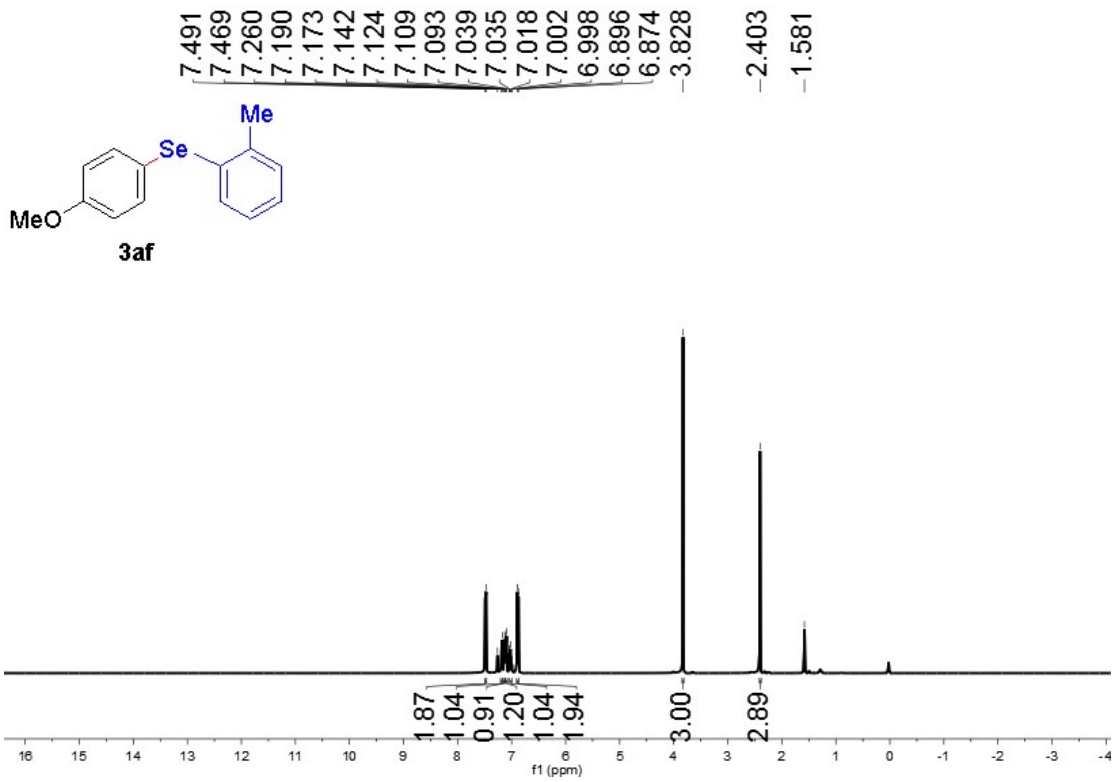

f1 (ppm)

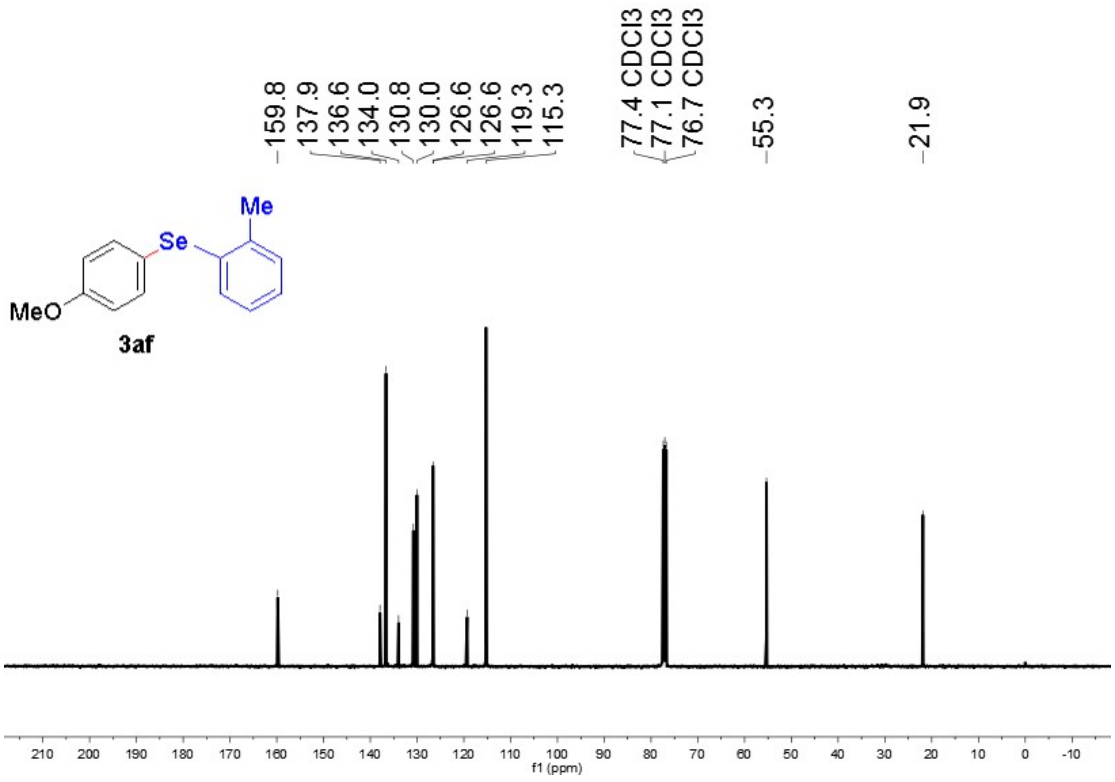

Se
sBu
MeO
3ae
7.50
7.48
7.26
6.82
6.80
3.80
3.14
3.12
3.10
3.09
3.07
3.05
1.69
1.67
1.66
1.64
1.62
1.60
1.58
1.57
1.55
1.53
1.51
1.36
1.34
1.00
0.99
0.97

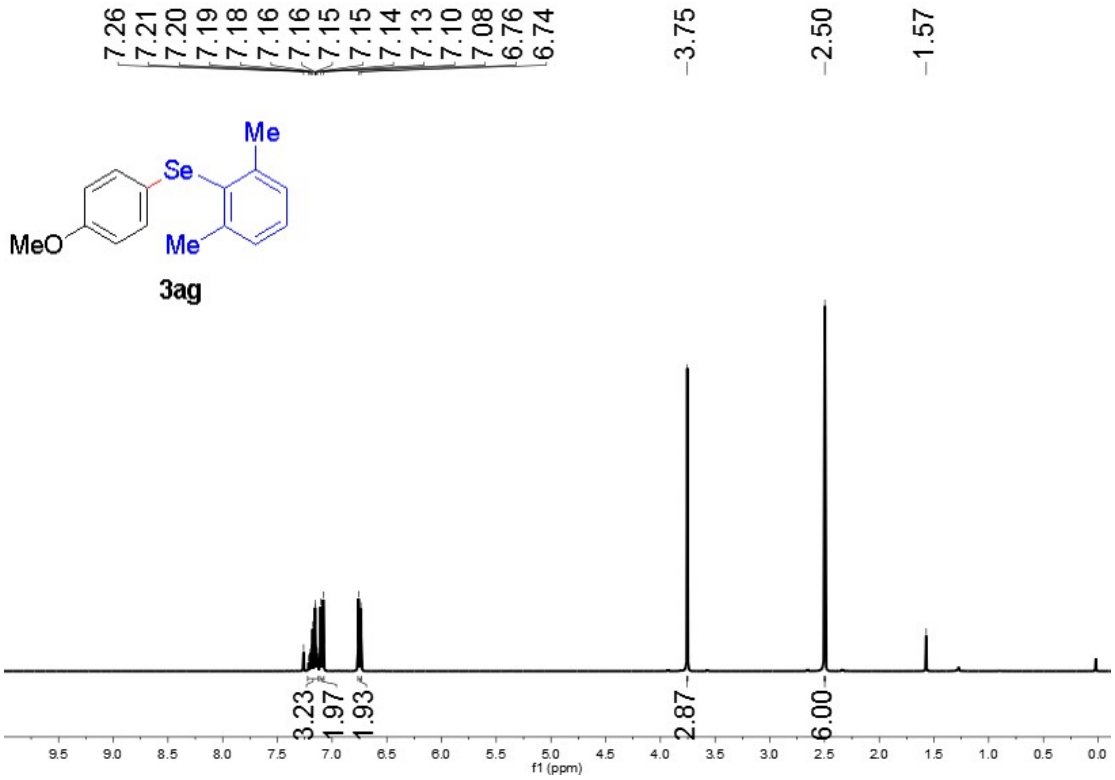

1.89
2.02
3.19
1.00
1.28
1.19
3.05
3.05
f1 (ppm)

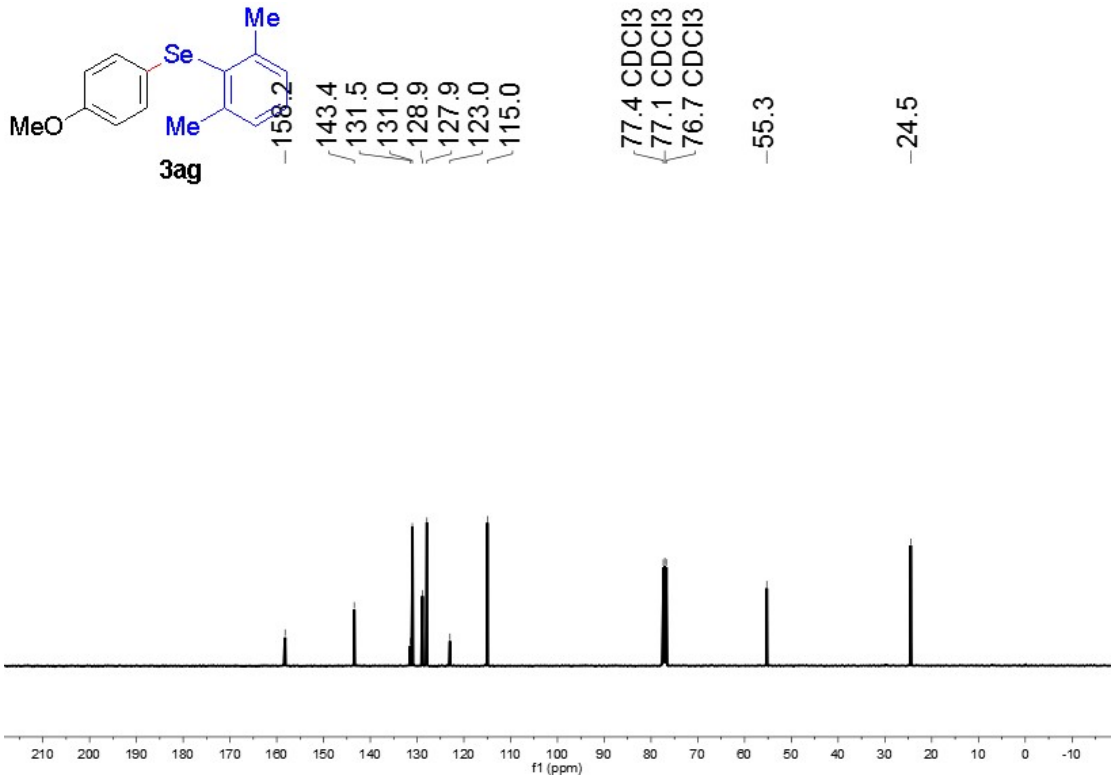

Se
sBu
MeO
3ae
159.5
137.5
119.1
114.5
77.3 cdcl3
77.0 cdcl3
76.7 cdcl3
55.2
41.8
30.3
21.5
12.3

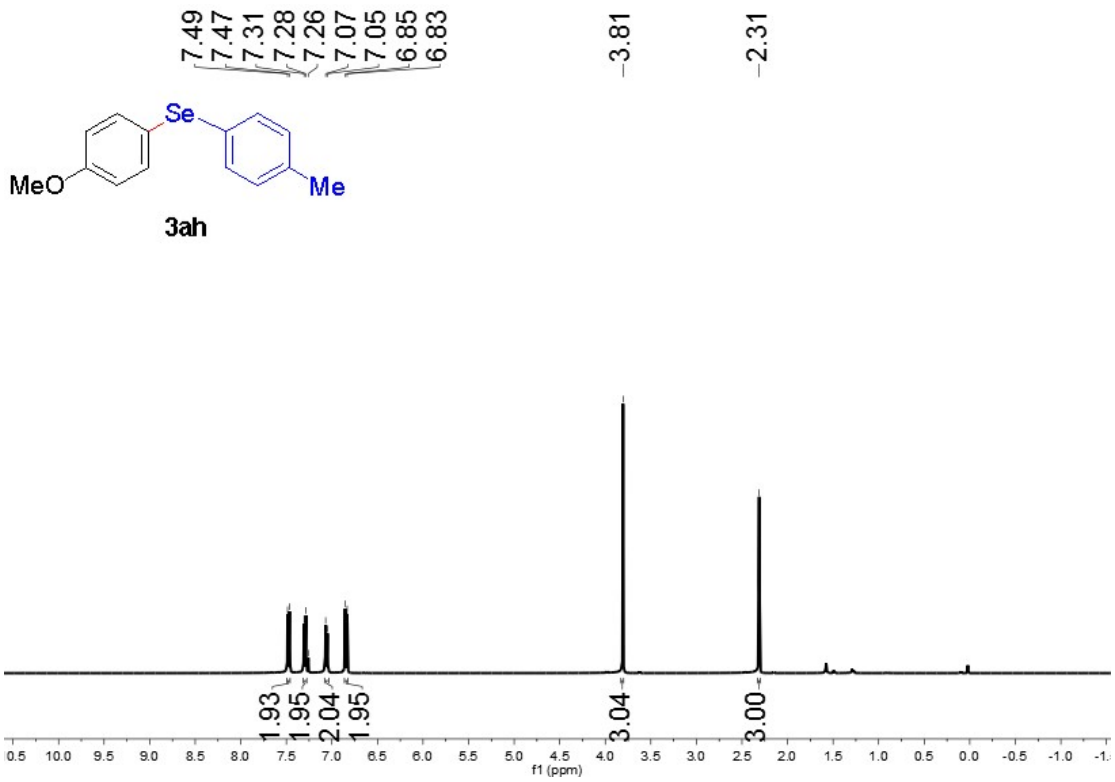

f1 (ppm)


7.491
7.469
7.260
7.190
7.173
7.142
7.124
7.109
7.093
7.039
7.035
7.018
7.002
6.998
6.896
6.874
3.828
2.403
1.581
Me
Se
MeO
3af
1.87
1.04
0.91
1.20
1.04
1.94
3.00
2.89
f1 (ppm)

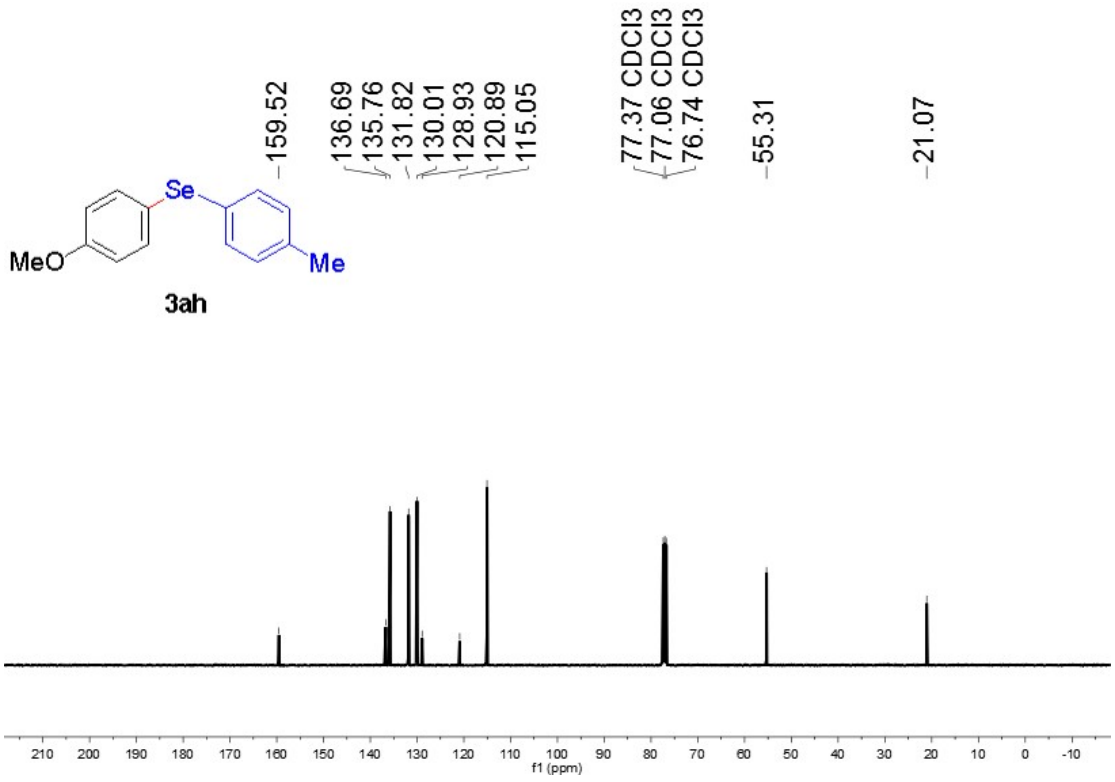

159.8
137.9
136.6
134.0
130.8
130.0
126.6
126.6
119.3
115.3
77.4 CDCl3
77.1 CDCl3
76.7 CDCl3
55.3
21.9
Me
Se
MeO
3af
f1 (ppm)


7.26
7.21
7.20
7.19
7.18
7.16
7.16
7.15
7.15
7.14
7.13
7.10
7.08
6.76
6.74
3.75
2.50
1.57
Me
Se
MeO
Me
3ag
3.23
1.97
1.93
2.87
6.00
f1 (ppm)


Me
Se
MeO
Me
3ag
158.2
143.4
131.5
131.0
128.9
127.9
123.0
115.0
77.4 CDCl3
77.1 CDCl3
76.7 CDCl3
55.3
24.5
f1 (ppm)


7.49
7.47
7.31
7.28
7.26
7.07
7.05
6.85
6.83
3.81
2.31
Se
MeO
Me
1.93
1.95
2.04
1.95
3.04
3.00
f1 (ppm)

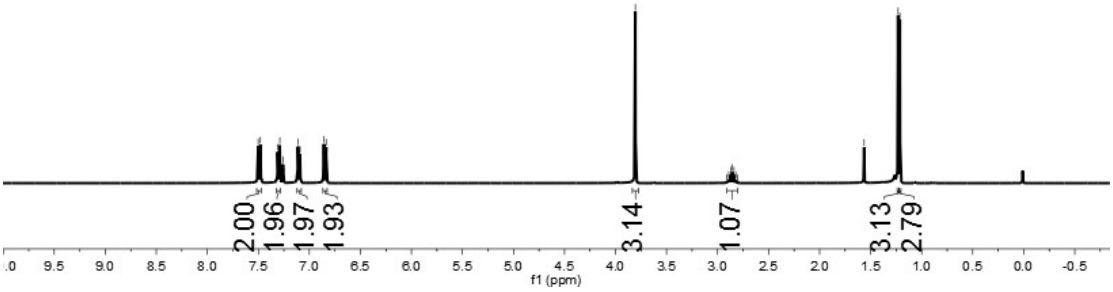
3ah

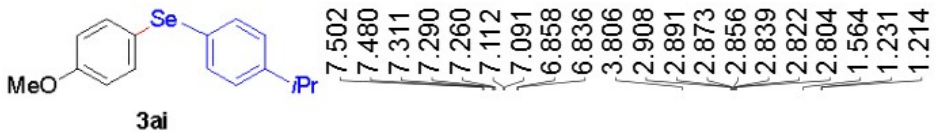

159.52
136.69
135.76
131.82
130.01
128.93
120.89
115.05
77.37 CDCl3
77.06 CDCl3
76.74 CDCl3
55.31
21.07
Se
MeO
Me
f1 (ppm)

3ah

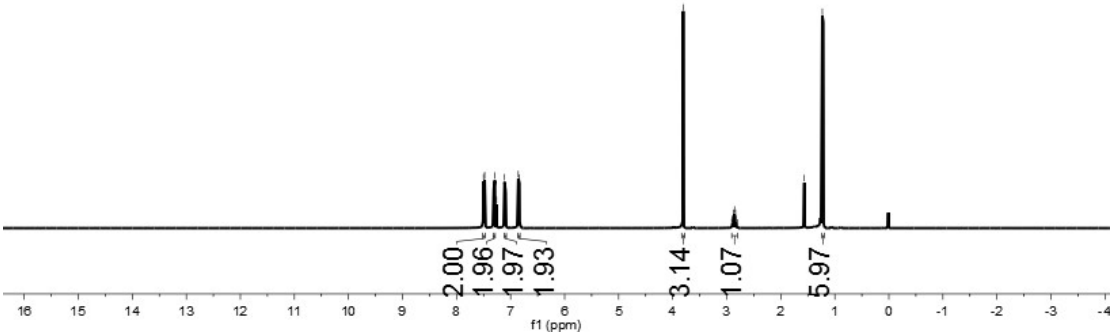

7.50
7.48
7.31
7.29
7.26
7.11
7.09
6.86
6.84
3.81
2.91
2.89
2.87
2.86
2.84
2.82
2.80
1.56
1.23
1.21
Se
MeO
iPr

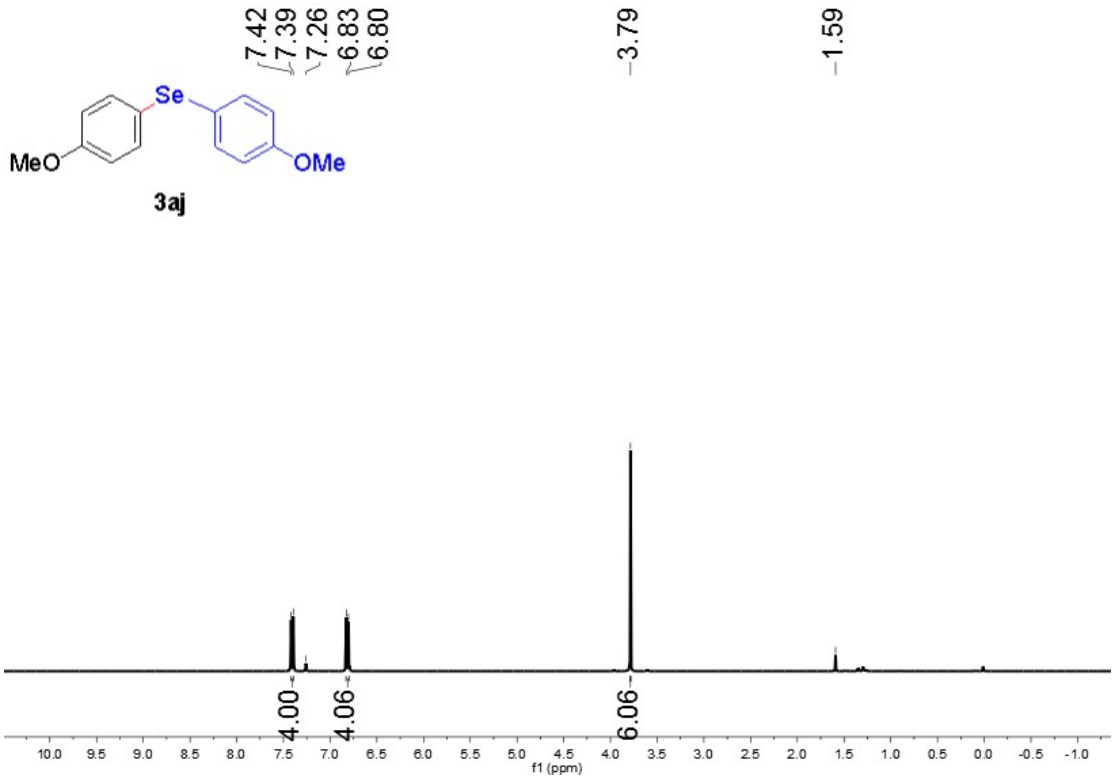
3ai

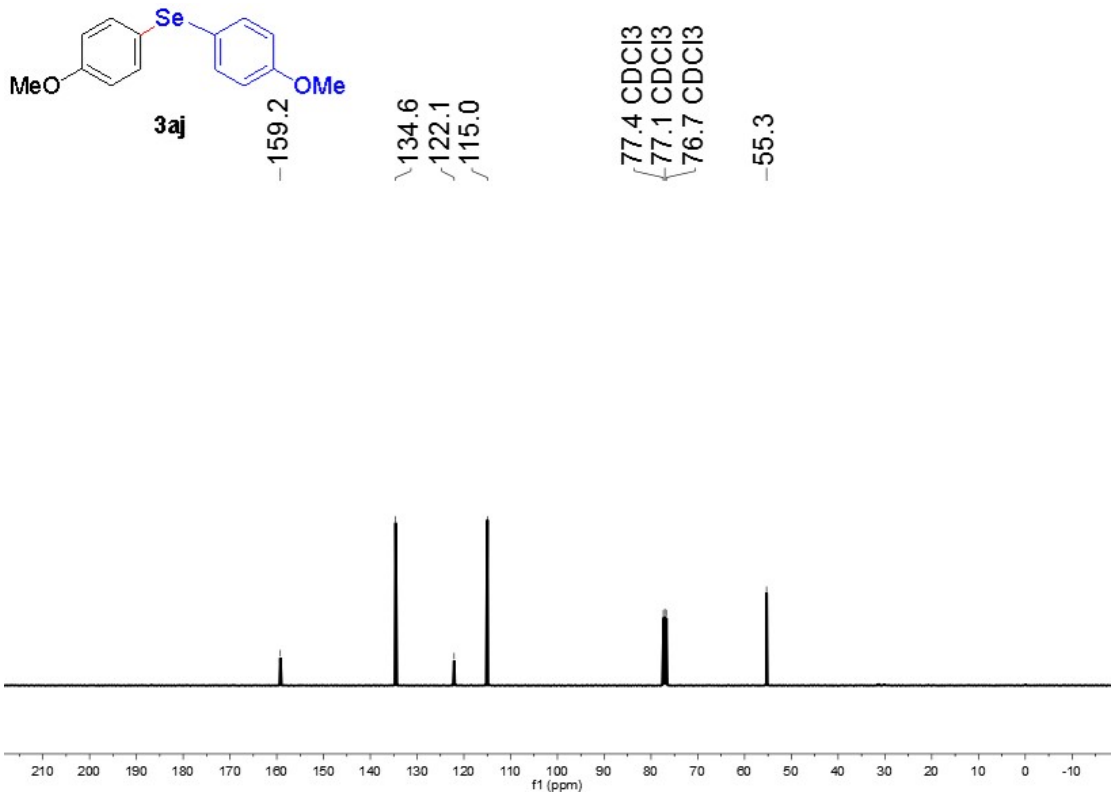

2.00
1.96
1.97
1.93
3.14
1.07
3.13
2.79
f1 (ppm)

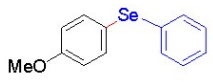

Se
MeO
iPr
7.502
7.480
7.311
7.290
7.260
7.112
7.091
6.858
6.836
3.806
2.908
2.891
2.873
2.856
2.839
2.822
2.804
1.564
1.231
1.214

3ai

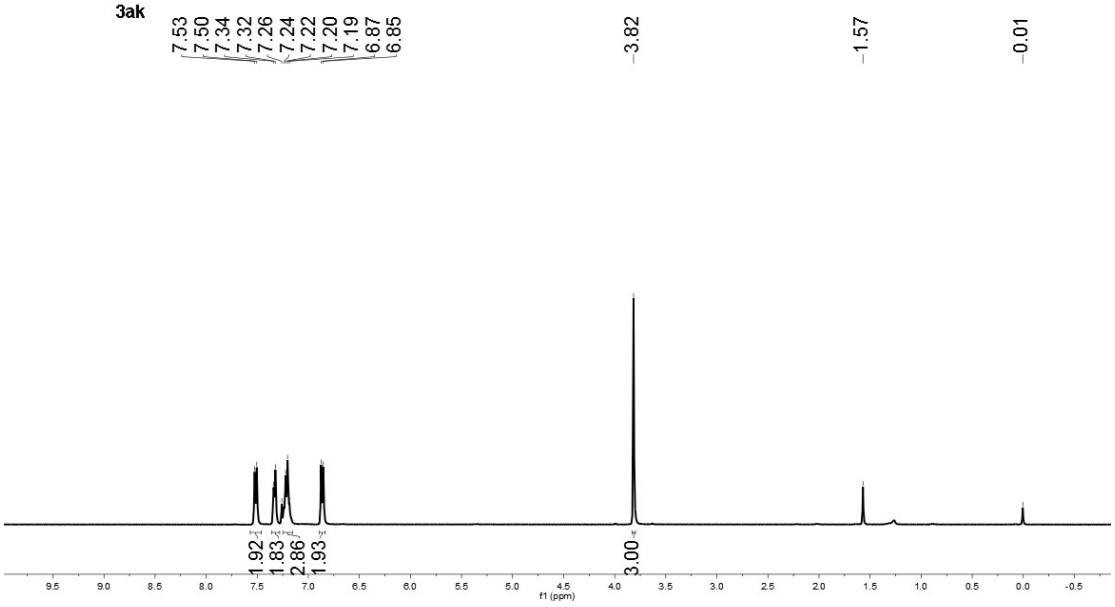

2.00
1.96
1.97
1.93
3.14
1.07
5.97
f1 (ppm)

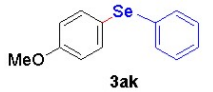

7.42
7.39
7.26
6.83
6.80
3.79
1.59
Se
MeO
OMe
3aj
4.00
4.06
6.06
f1 (ppm)


Se
MeO
OMe
3aj
159.2
134.6
122.1
115.0
77.4 CDCl3
77.1 CDCl3
76.7 CDCl3
55.3
f1 (ppm)

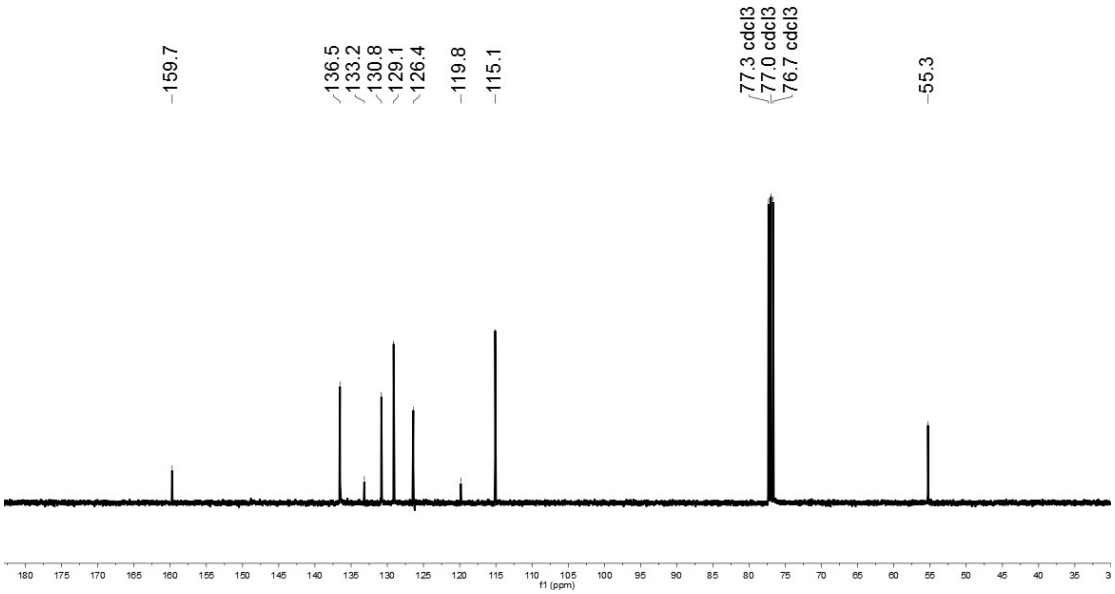

Se
MeO

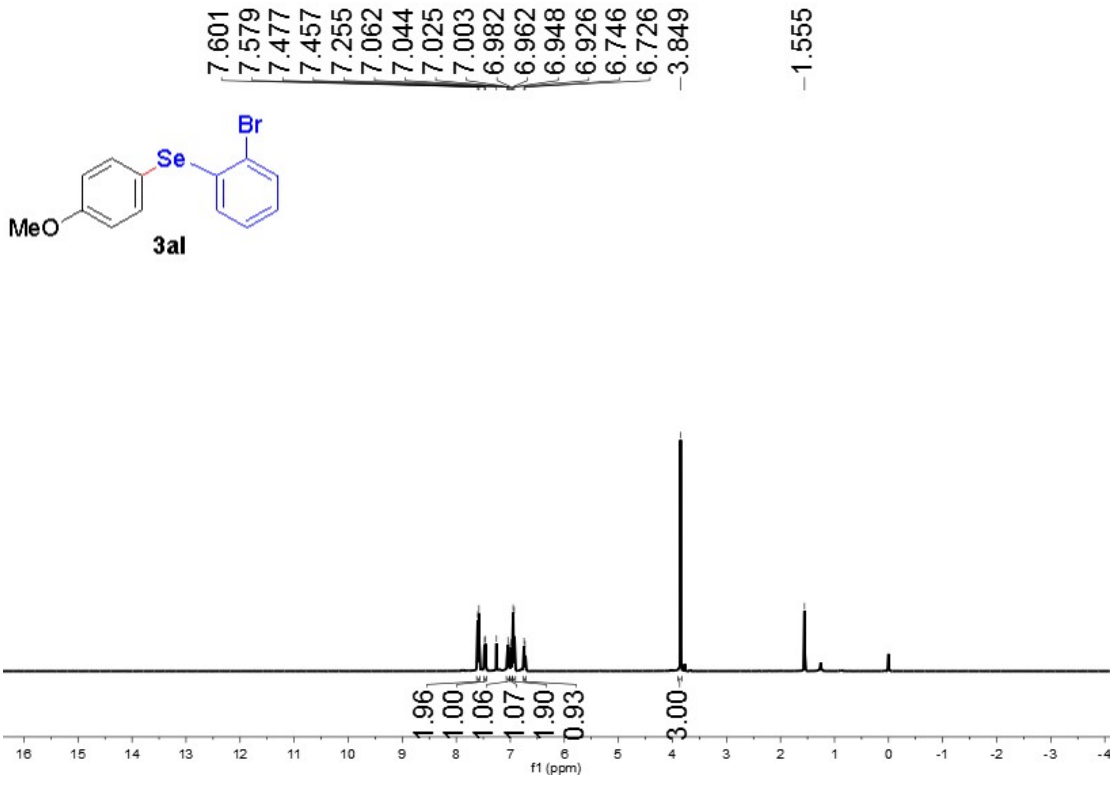
3ak

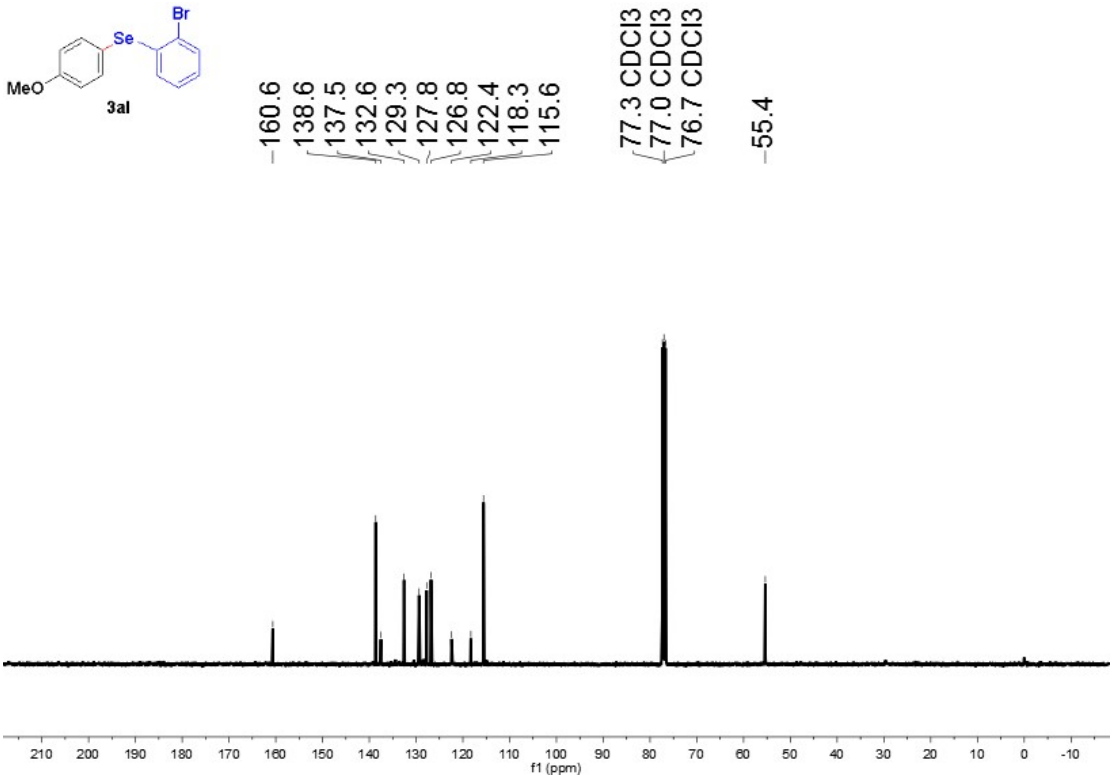

7.53
7.50
7.34
7.32
7.26
7.24
7.22
7.20
7.19
6.87
6.85
3.82
1.57
0.01
1.92
1.83
2.86
1.93
3.00
f1 (ppm)

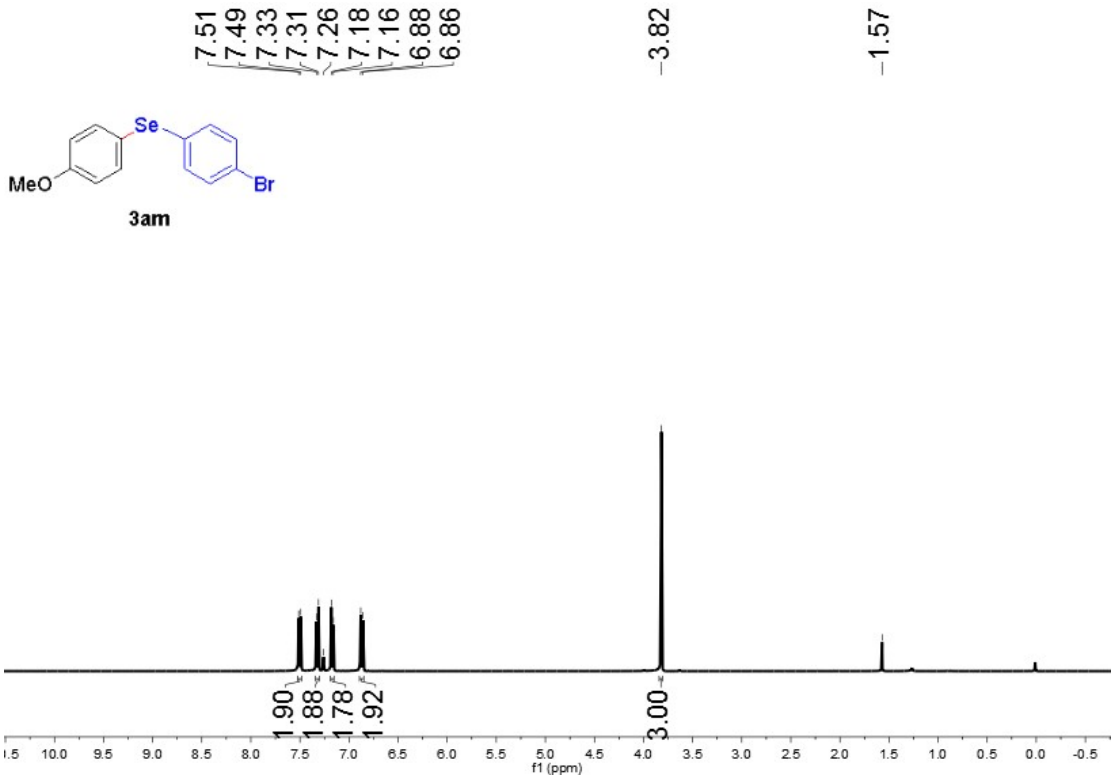

Se
MeO

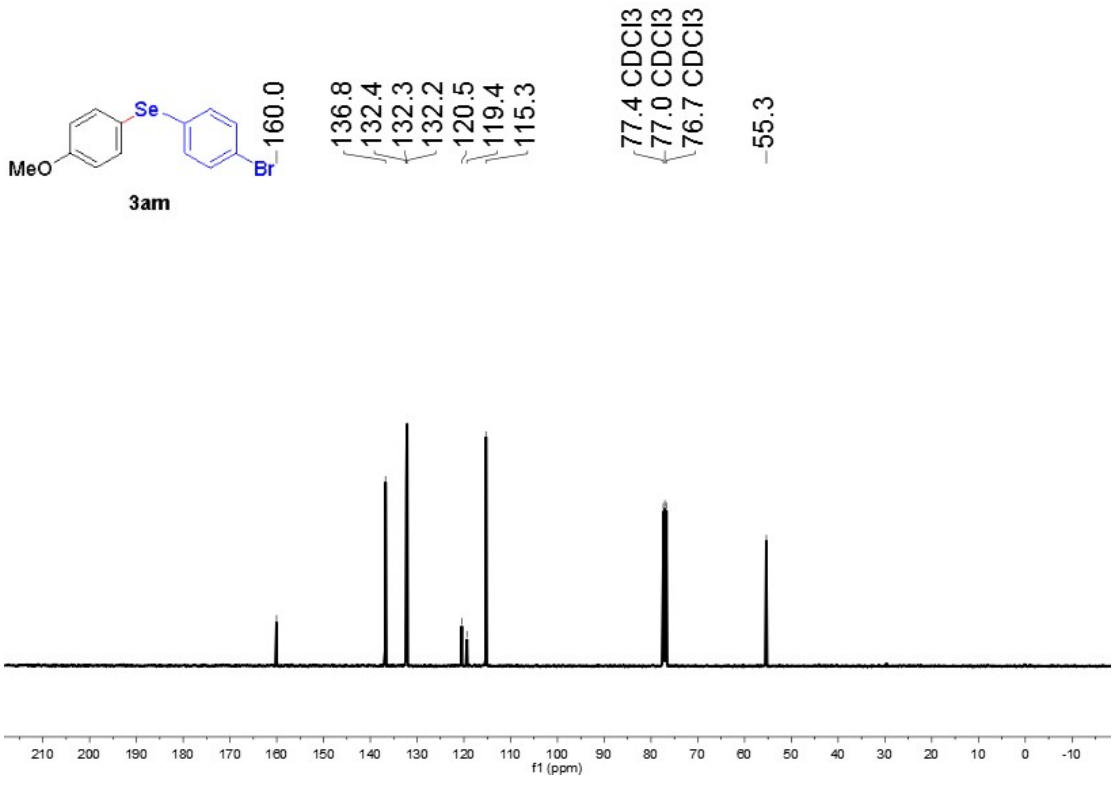
3ak

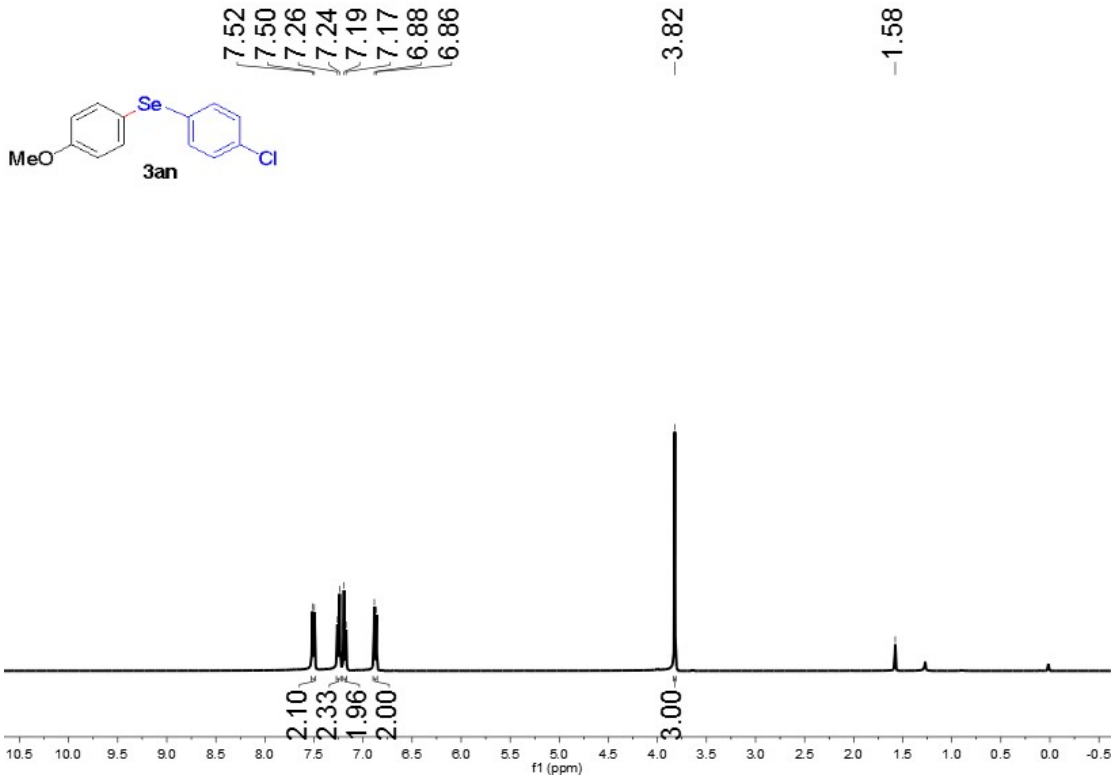

159.7
136.5
133.2
130.8
129.1
126.4
119.8
115.1
77.3 cdcl3
77.0 cdcl3
76.7 cdcl3
55.3
f1 (ppm)

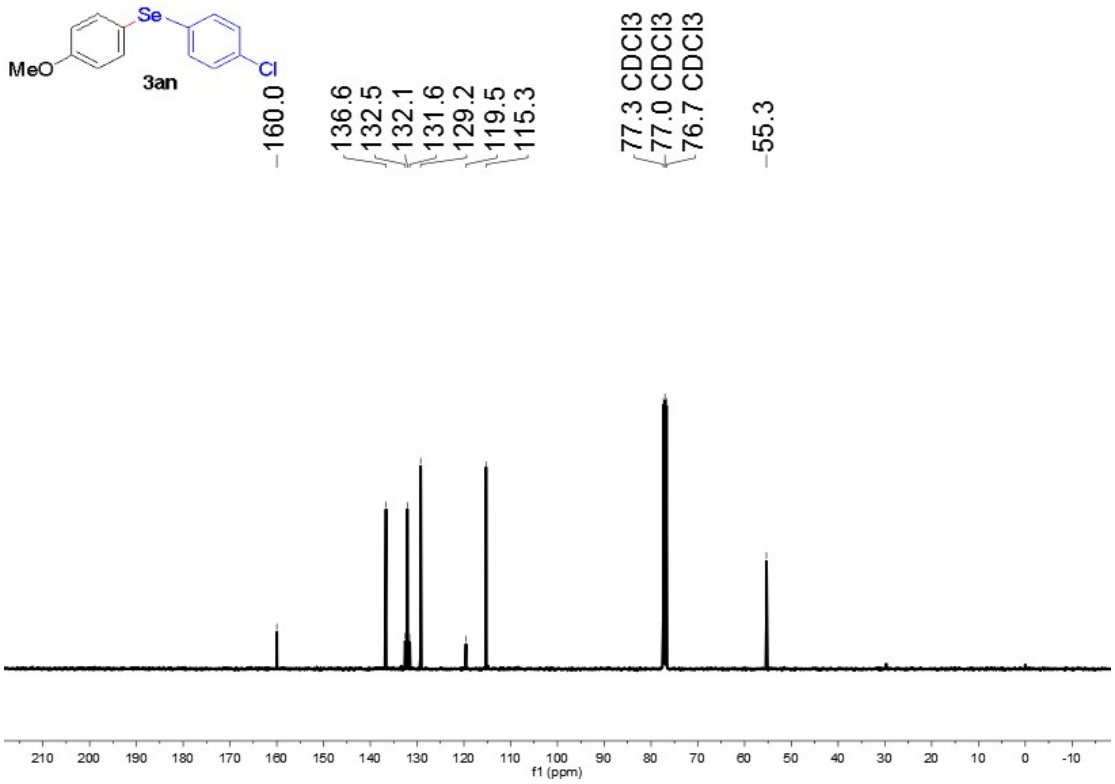

7.601
7.579
7.477
7.457
7.255
7.062
7.044
7.025
7.003
6.982
6.962
6.948
6.926
6.746
6.726
3.849
1.555
Br
Se
MeO
3al
1.96
1.00
1.06
1.07
1.90
0.93
3.00
f1 (ppm)

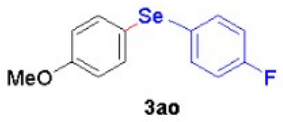

Br
Se
MeO
3al
160.6
138.6
137.5
132.6
129.3
127.8
126.8
122.4
118.3
115.6
77.3 CDCl3
77.0 CDCl3
76.7 CDCl3
55.4
f1 (ppm)


7.51
7.49
7.33
7.31
7.26
7.18
7.16
6.88
6.86
3.82
1.57
Se
MeO
Br
3am
1.90
1.88
1.78
1.92
3.00
f1 (ppm)

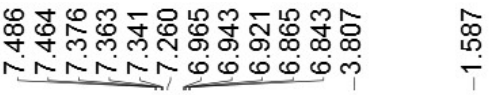

160.0
136.8
132.4
132.3
132.2
120.5
119.4
115.3
77.4 CDCl3
77.0 CDCl3
76.7 CDCl3
55.3
Se
MeO
Br
3am
f1 (ppm)

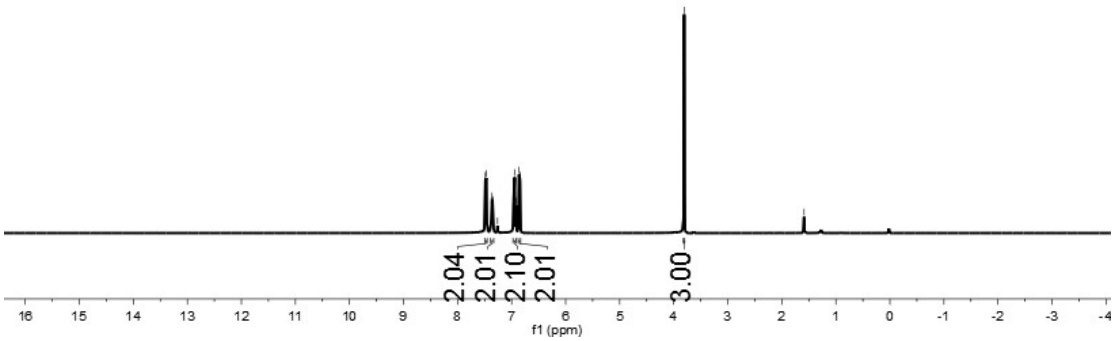

7.52
7.50
7.26
7.24
7.19
7.17
6.88
6.86
3.82
1.58
Se
MeO
Cl
3an
2.10
2.33
1.96
2.00
3.00
f1 (ppm)


Se
MeO
Cl
3an
160.0
136.6
132.5
132.1
131.6
129.2
119.5
115.3
77.3 CDCl3
77.0 CDCl3
76.7 CDCl3
55.3
f1 (ppm)

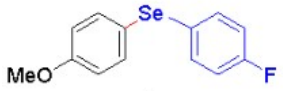

Se
MeO
F

3ao

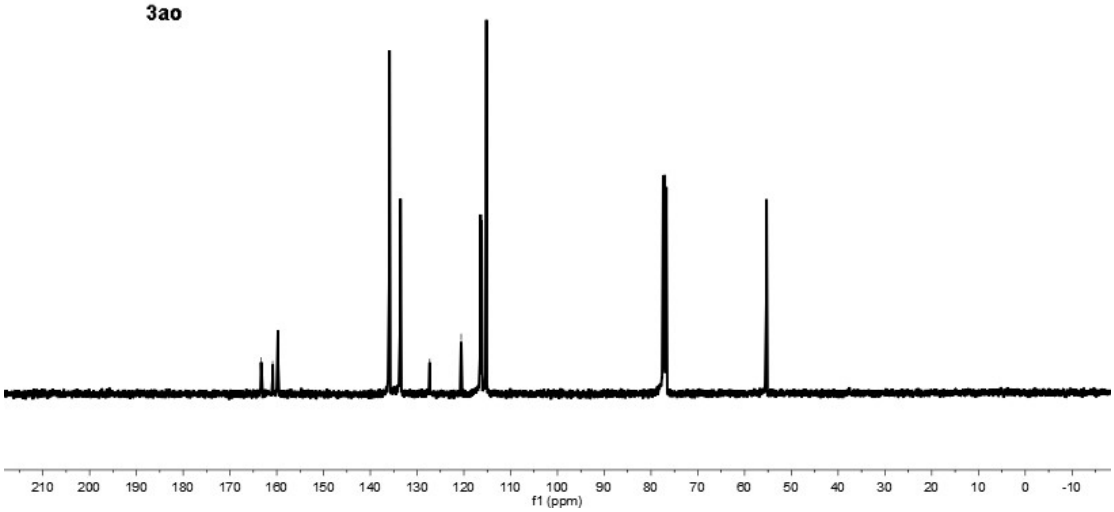

7.486
7.464
7.376
7.363
7.341
7.260
6.965
6.943
6.921
6.865
6.843
3.807
1.587

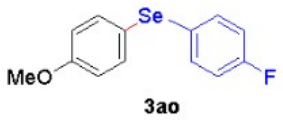

2.04
2.01
2.10
2.01
3.00
f1 (ppm)


163.3
160.9
159.7
135.9
133.6
133.5
127.3
127.3
120.6
116.4
116.2
115.2
77.4 CDCl3
77.1 CDCl3
76.8 CDCl3
55.3

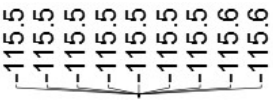

Se
MeO
F

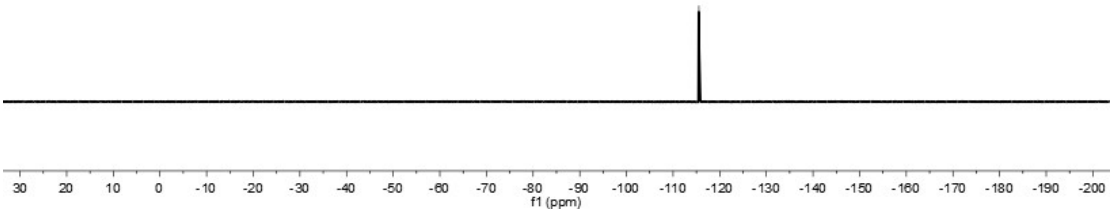
3ao

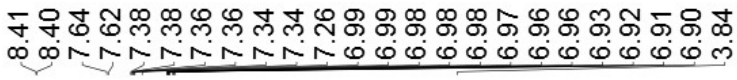

f1 (ppm)


Se
MeO
F

3ao


-115.5
-115.5
-115.5
-115.5
-115.5
-115.5
-115.6
-115.6


30 20 10 0 -10 -20 -30 -40 -50 -60 -70 -80 -90 -100 -110 -120 -130 -140 -150 -160 -170 -180 -190 -200
f1 (ppm)


8.41
8.40
7.64
7.62
7.38
7.38
7.36
7.36
7.34
7.34
7.26
6.99
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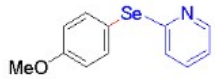
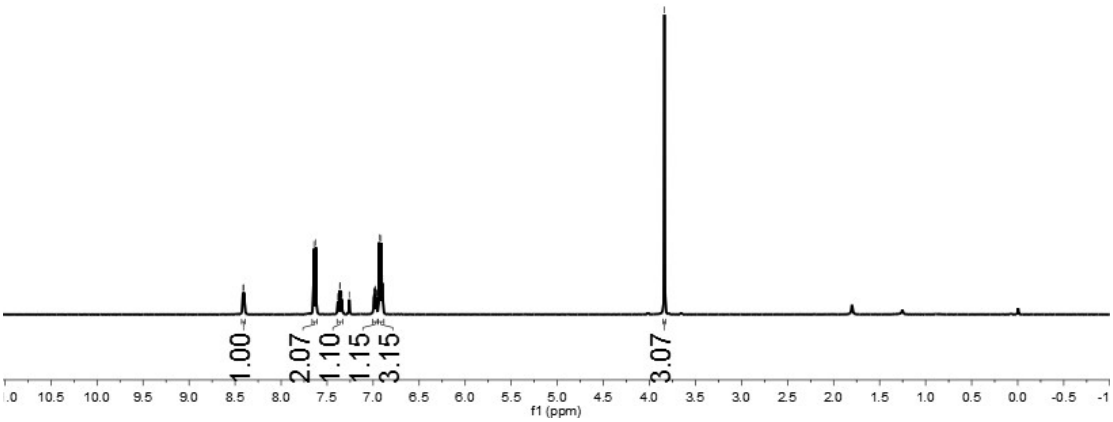
6.96
6.93
6.92
6.91
6.90
3.84

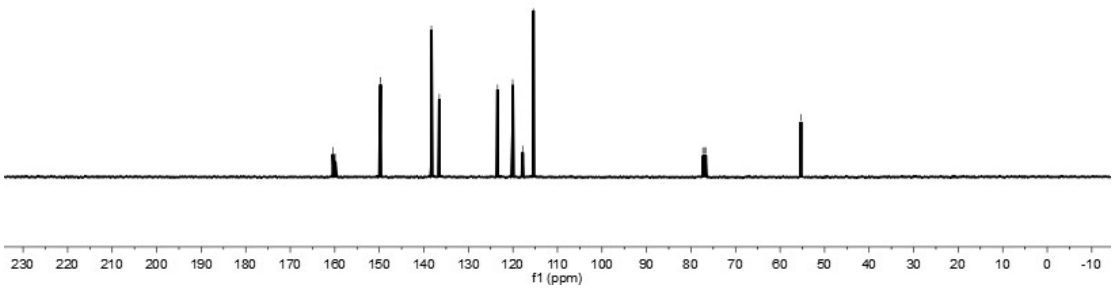

Se
N
MeO

3ap


1.00
2.07
1.10
1.15
3.15
3.07
.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 -0.5 -1
f1 (ppm)

3ap

160.4
159.9
149.7
138.3
136.5
123.4
120.0
117.8
115.4
77.4 cdcl3
77.0 cdcl3
76.7 cdcl3
55.3



8.56
8.55
8.41
8.41
8.40
8.40
7.60
7.60
7.59
7.58
7.58
7.57
7.52
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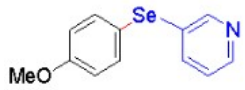
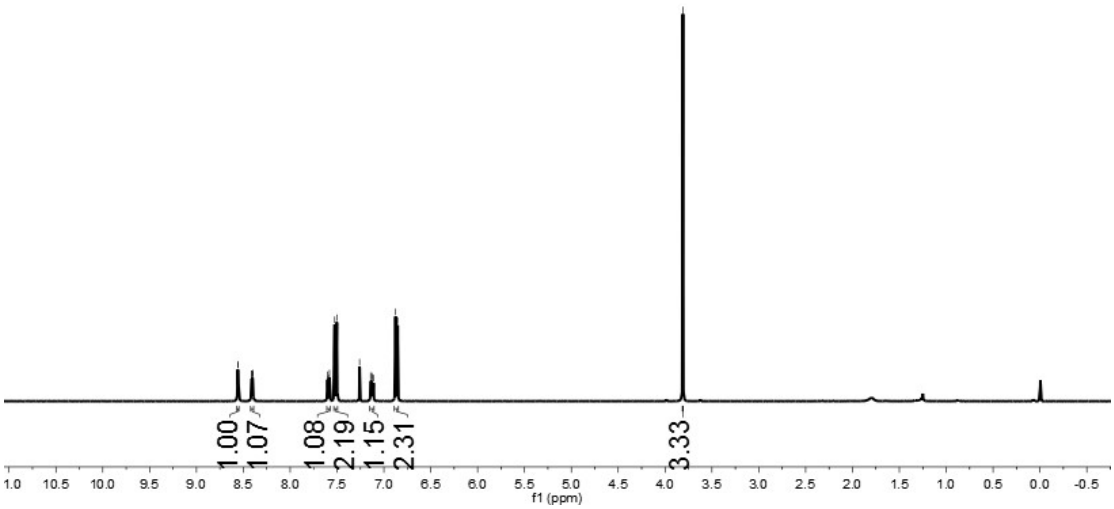
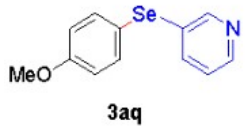
7.13
7.12
7.11
6.88
6.85
3.81



3aq



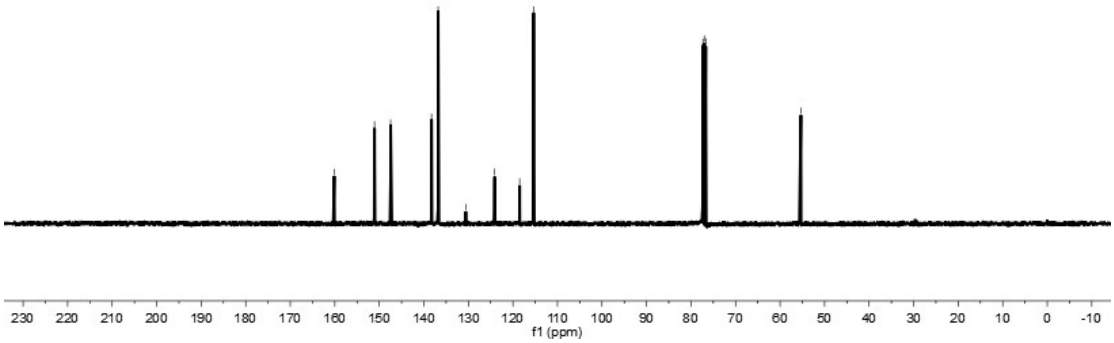


3aq

160.1
151.1
147.5
138.3
136.8
130.6
124.1
118.5
115.3

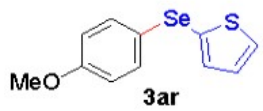
77.3 cdcl3
77.0 cdcl3
76.7 cdcl3

55.3

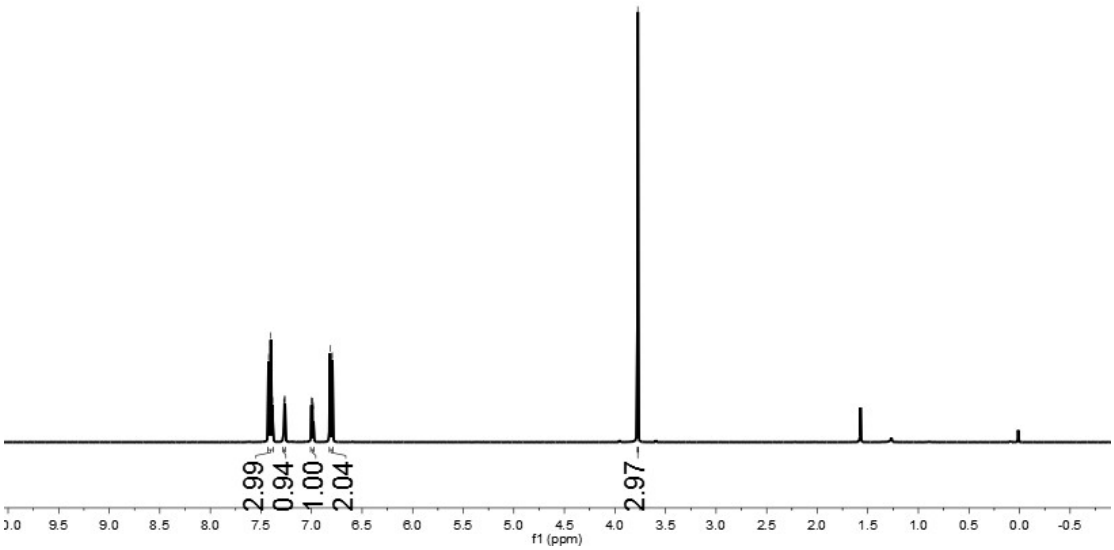


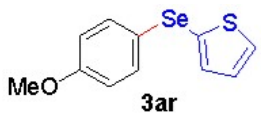
7.42
7.40
7.39
7.38
7.27
7.27
7.27
7.26
7.26
7.00
7.00
6.99
6.98
6.82
6.79

3.77



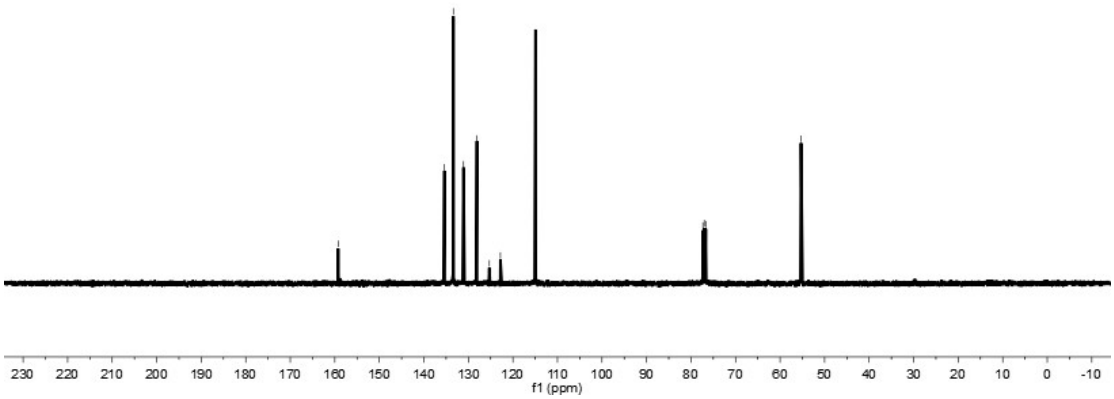
3ar



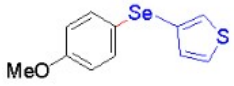


3ar

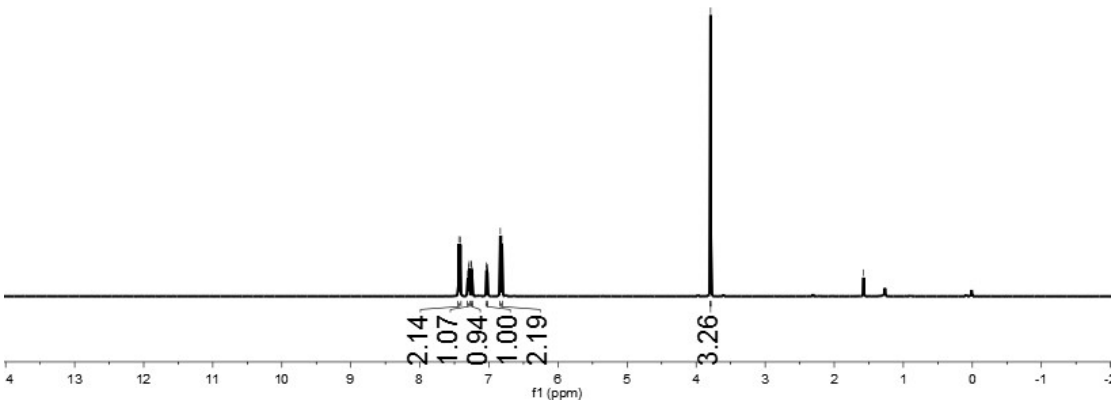
159.3
135.4
133.4
131.1
128.1
125.3
122.8
114.9
77.3 cdcl3
77.0 cdcl3
76.7 cdcl3
55.3

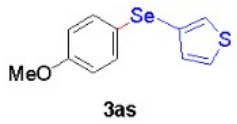


7.44
7.42
7.31
7.30
7.29
7.29
7.26
7.25
7.25
7.25
7.24
7.04
7.03
7.02
7.02
6.84
6.81
3.79
1.57



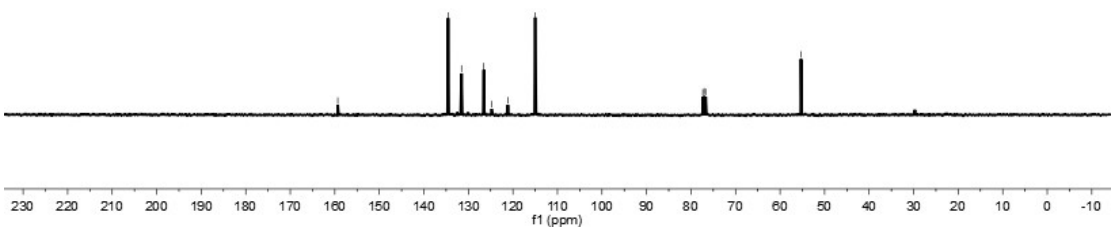
3as

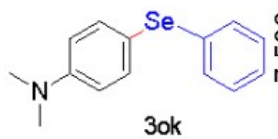




3as

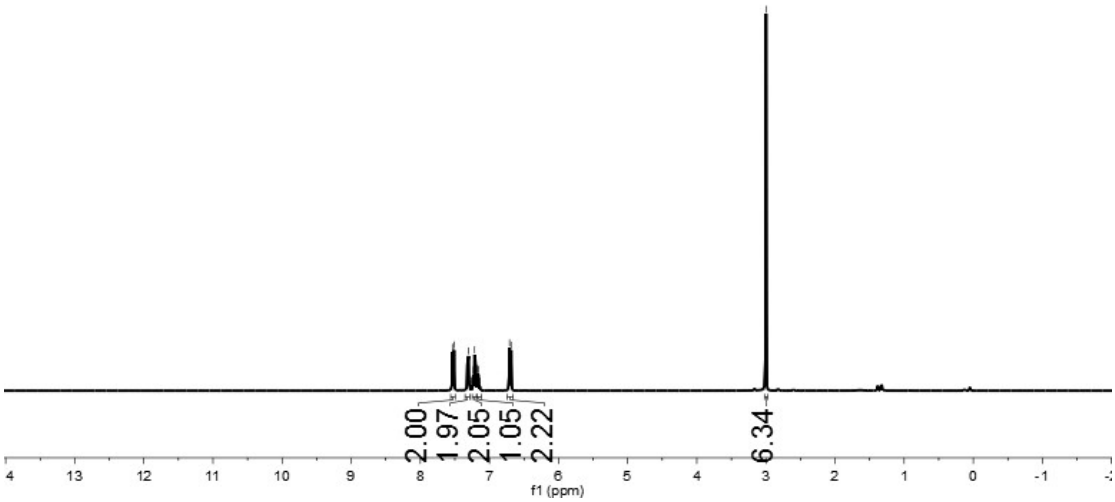
159.3
134.6
131.5
126.5
126.5
124.8
121.1
115.0
77.4 cdcl3
77.0 cdcl3
76.7 cdcl3
55.3

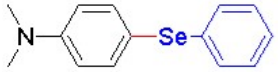




3ok

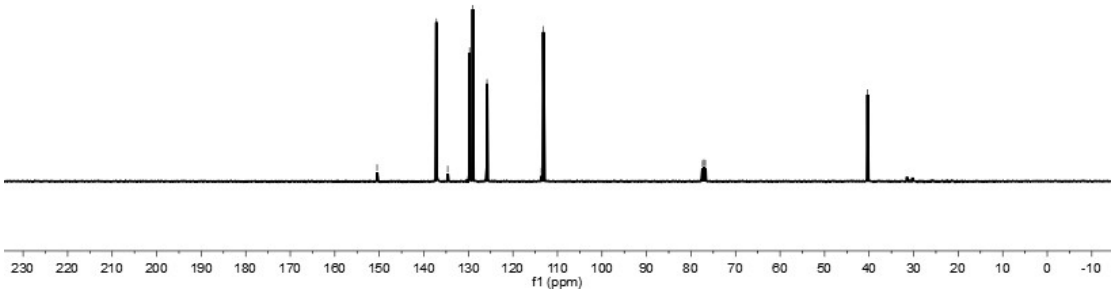
7.536
7.513
7.323
7.302
7.260
7.232
7.215
7.196
7.177
7.160
7.141
6.709
6.687
2.999



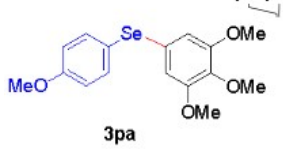


3ok

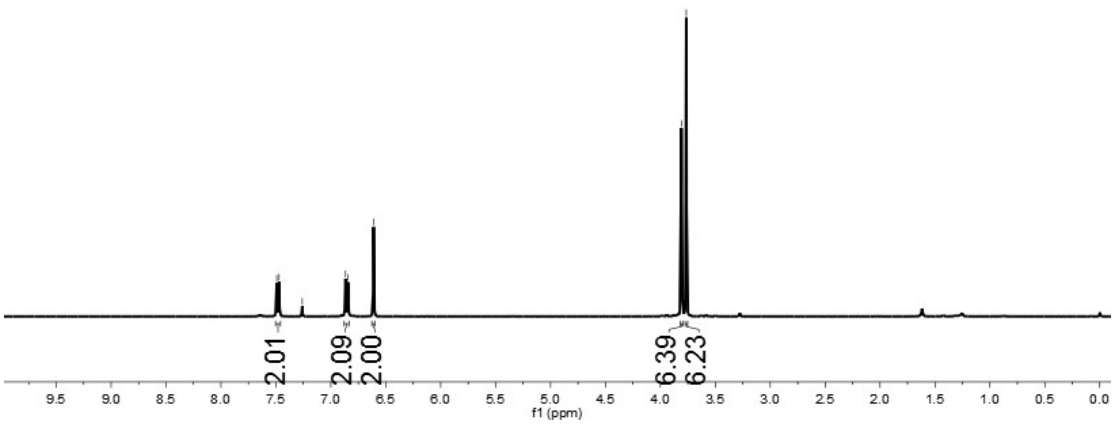
150.50
137.17
134.64
129.74
129.02
125.82
113.62
113.18
77.41 cdcl3
77.10 cdcl3
76.78 cdcl3
40.34

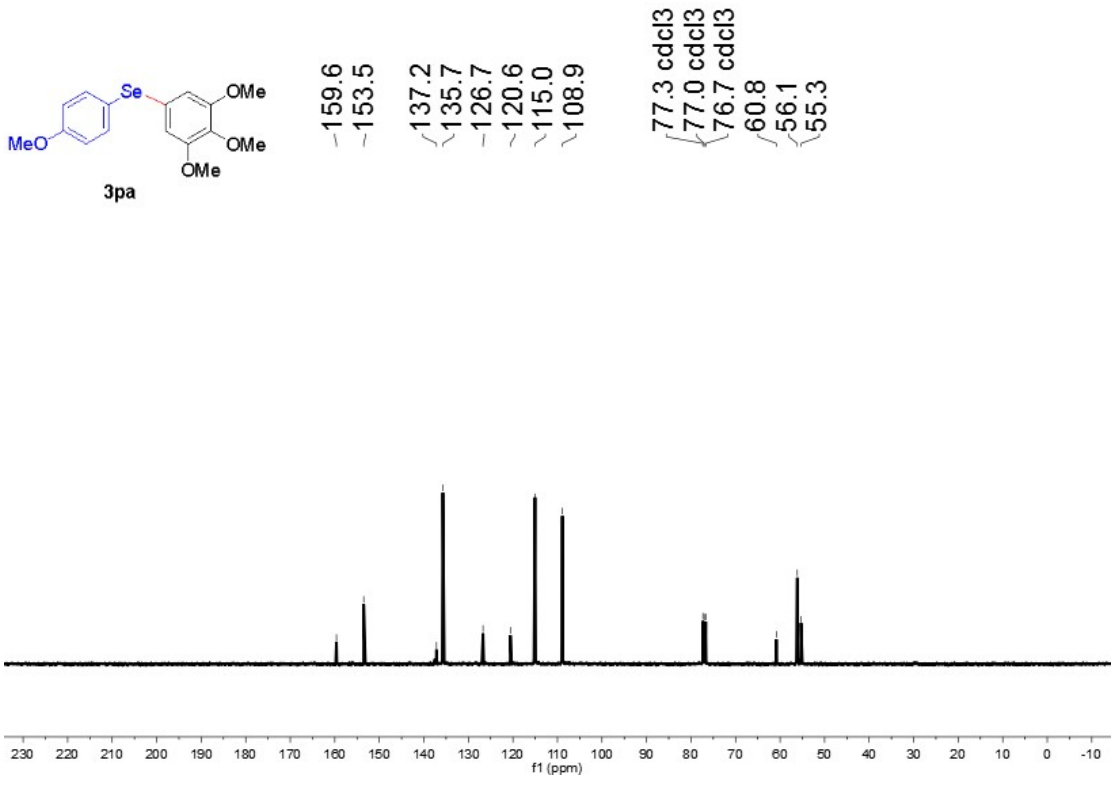


7.49
7.47
7.26
6.87
6.84
6.61
3.81
3.81
3.76



3pa




Se
MeO
OMe
OMe
OMe
3pa
159.6
153.5
137.2
135.7
126.7
120.6
115.0
108.9
77.3 cdcl3
77.0 cdcl3
76.7 cdcl3
60.8
56.1
55.3
230 220 210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0 -10
f1 (ppm)