

Metal and Base-Free Synthesis of Arylselanyl Anilines using Glycerol as Solvent

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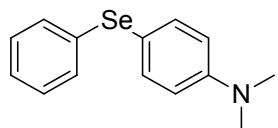
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General Information: The reactions were monitored by TLC carried out on Merck silica gel (60 F₂₅₄) by using UV light as visualizant agent and 5% vanillin in 10% H₂SO₄ and heat as developing agents. Baker silica gel (particle size 0.040-0.063 mm) was used for flash chromatography. Hydrogen nuclear magnetic resonance spectra (¹H NMR) were obtained at 300 MHz on a Varian Gemini NMR and at 400 MHz on Bruker DPX 400 spectrometers. Spectra were recorded in CDCl₃ solutions. Chemical shifts are reported in ppm, referenced to tetramethylsilane (TMS) as the external reference. Hydrogen coupling patterns are described as singlet (s), doublet (d), triplet (t) and multiplet (m). Coupling constants (*J*) are reported in Hertz. Carbon-13 nuclear magnetic resonance spectra (¹³C NMR) were obtained at 75 MHz on a Varian Gemini NMR and at 100 MHz on Bruker DPX 400 spectrometers. Chemical shifts are reported in ppm, referenced to the solvent peak of CDCl₃. Low-resolution mass spectra were obtained with a Shimadzu GC-MS-QP2010 mass spectrometer. GC analysis were conducted on a RESTEC RTX-5MS capillary column (30 m, 0.25 mm id, 0.25 μm film thickness) using the products dissolved in ethyl acetate with the following conditions: Injected sample volume was 1.0 μL; He constant flow, 54.1 mL/min; initial inlet temperature, 40 °C ramped to 72 °C at 10 °C/min followed by a 5 °C/min ramp to 100 °C (held for 10 min) and 10 °C/min to 280 °C and held for 20 min (total run time: 56.8 min). The yields of product **3a** (GC retention time of the separately synthesized compound **3a** was 33.3 min) given in Table 1 were determined by GC analysis.

General Procedure for the Synthesis of nitrogen-containing diarylselenides:

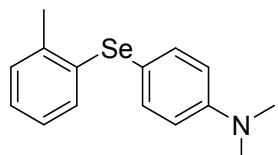
To a 3 mL round-bottomed flask containing phenylselanyl chloride (0.5 mmol) in glycerol (0.5 mL) under N₂ atmosphere, was added the *N,N*-di(alkyl/aryl)anilines (0.3 mmol). The resulting solution was stirred for the time indicated in Table 2. After that, the reaction mixture was received in water (10 mL), extracted with ethyl acetate (3 x 5 mL), dried over MgSO₄ and concentrated under vacuum. The residue was purified by column chromatography on silica gel using ethyl acetate/hexanes as the eluent.

***N,N*-dimethyl-4-(phenylselanyl)benzenamine (3a)**



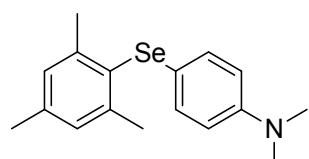
Yield: 0.0831 g (99%); yellow solid; mp 35-38 °C. ^1H NMR (CDCl_3 , 300 MHz) δ = 7.48 (d, J = 8.9 Hz, 2H), 7.28-7.24 (m, 2H), 7.21-7.08 (m, 3H), 6.65 (d, J = 8.9 Hz, 2H), 2.95 (s, 6H). ^{13}C NMR (CDCl_3 , 75 MHz) δ = 150.43, 137.06, 134.55, 129.69, 128.92, 125.74, 113.60, 113.10, 40.24. MS (relative intensity) m/z : 277 (25), 197 (100), 196 (53), 181 (11), 157 (3), 91 (3), 77 (12). HRMS calcd. for $\text{C}_{14}\text{H}_{15}\text{NSe}$: $[\text{M} + \text{Na}]^+$ 300.0267. Found: 300.0368.

***N,N*-dimethyl-4-(*o*-tolylselanyl)benzenamine (3b)**



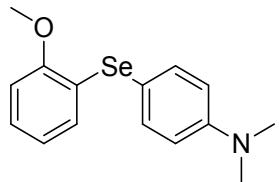
Yield: 0.0786 g (90%); yellow oil. ^1H NMR (CDCl_3 , 400 MHz) δ = 7.45 (d, J = 8.9 Hz, 2H), 7.14-7.12 (m, 1H), 7.08-7.03 (m, 1H), 6.98-6.93 (m, 2H), 6.70 (d, J = 8.9 Hz, 2H), 2.99 (s, 6H), 2.38 (s, 3H). ^{13}C NMR (CDCl_3 , 100 MHz) 150.5, 137.4, 136.7, 153.4, 129.7, 129.1, 126.4, 125.7, 113.2, 112.7, 40.2, 21.6. MS (relative intensity) m/z : 291 (40), 211 (100), 196 (8), 121 (54), 91 (14), 77 (10). HRMS calcd. for $\text{C}_{15}\text{H}_{17}\text{NSe}$ $[\text{M} + \text{Na}]^+$ 314.0424. Found: 314.0381.

4-(mesitylselanyl)-*N,N*-dimethylbenzenamine (3c)



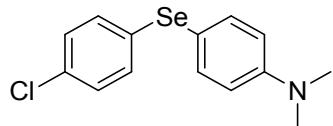
Yield: 0.0852 g (89%); brown solid; mp 56-59 °C. ^1H NMR (CDCl_3 , 300 MHz) δ = 7.06 (d, J = 8.9 Hz, 2H), 6.93 (s, 2H), 6.55 (d, J = 8.9 Hz), 2.86 (s, 6H), 2.45 (s, 6H), 2.27 (s, 3H). ^{13}C NMR (CDCl_3 , 75 MHz) δ = 149.1, 143.1, 138.3, 131.2, 128.6, 128.5, 118.1, 113.6, 40.5, 24.4, 21.0. MS (relative intensity) m/z : 319 (27), 239 (18), 198 (6), 121 (100), 120 (34), 91 (7), 77 (7). HRMS calcd. for $\text{C}_{17}\text{H}_{22}\text{NSe}$ $[\text{M}]^+$ 320.0917. Found: 320.0905.

4-(2-methoxyphenylselanyl)-*N,N*-dimethylbenzenamine (3d)



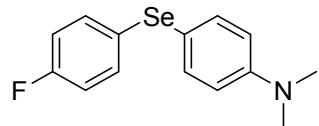
Yield: 0.0734g (80%); yellow solid; mp 85-90 °C. ^1H NMR (CDCl_3 , 200 MHz) δ = 7.51 (d, J = 8.7 Hz, 2H), 7.14-7.05 (m, 1H), 6.81-6.73 (m, 3H), 6.70 (d, J = 8.7 Hz, 2H), 3.89 (s, 3H), 2.98 (s, 6H). ^{13}C NMR (CDCl_3 , 75 MHz) δ = 155.6, 150.7, 138.4, 133.6, 128.3, 126.3, 124.6, 121.5, 113.2, 109.8, 55.7, 40.2. MS (relative intensity) m/z : 307 (24), 227 (100), 212 (35), 184(22), 113 (12), 77 (11). HRMS calcd. for $\text{C}_{15}\text{H}_{17}\text{NOSe}$ [$\text{M} + \text{Na}$] $^+$ 330.0373. Found: 330.0313

4-(4-chlorophenylselanyl)-*N,N*-dimethylbenzenamine (3e)



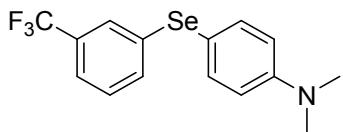
Yield: 0.0858 g (92%); white solid; mp 111-116 °C. ^1H NMR (CDCl_3 , 400 MHz) δ = 7.45 (d, J = 8.6 Hz, 2H), 7.19 (d, J = 8.5 Hz, 2H), 7.13 (d, J = 8.5 Hz, 2H), 6.67 (d, J = 8.6 Hz, 2H), 2.97 (s, 6H). ^{13}C NMR (CDCl_3 , 100 MHz) δ = 150.5, 137.3, 137.0, 132.8, 131.9, 131.2, 129.0, 113.4, 40.3. MS (relative intensity) m/z : 311 (17), 308 (4), 233 (33), 231 (100), 200 (9), 152 (8), 115 (19), 77 (12). HRMS calcd. for $\text{C}_{14}\text{H}_{14}\text{ClNSe}$ [$\text{M} + \text{Na}$] $^+$ 333.9878. Found: 333.9865.

4-(4-fluorophenylselanyl)-*N,N*-dimethylbenzenamine (3f)



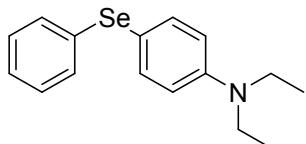
Yield: 0.0743 g (84%); gray solid; mp 49-52 °C. ^1H NMR (CDCl_3 , 300 MHz) δ = 7.45 (d, J = 8.6 Hz, 2H), 7.30-7.25 (m, 2H), 6.93-6.87 (m, 2H), 6.65 (d, J = 8.6 Hz, 2H), 2.96 (s, 6H). ^{13}C NMR (CDCl_3 , 75 MHz) δ = 161.7 (d, J^1 (C-F) = 245.1 Hz), 150.4, 136.6, 132.1 (d, J^3 (C-F) = 7.7 Hz), 128.6 (d, J^4 (C-F) = 3.3 Hz), 116.0 (d, J^2 (C-F) = 21.6), 114.2, 113.1, 40.3. MS (relative intensity) m/z : 295 (20), 293 (10), 215 (100), 199 (16), 184 (4), 170 (5), 107 (18), 77 (9). HRMS calcd. for $\text{C}_{14}\text{H}_{14}\text{FNSe}$ [$\text{M} + \text{Na}$] $^+$ 318.0173. Found: 318.0274.

N,N-dimethyl-4-(3-(trifluoromethyl)phenylselanyl)benzenamine (3g)



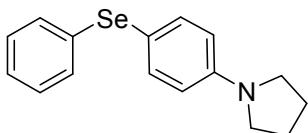
Yield: 0.0866 g (84%); brown solid; mp 48-52 °C. ^1H NMR (CDCl_3 , 300 MHz) δ = 7.52-7.51 (m, 1H), 7.48 (d, J = 8.9 Hz, 2H), 7.37-7.35 (m, 2H), 7.28-7.22 (m, 1H), 6.68 (d, J = 8.9 Hz, 2H), 2.99 (s, 1H). ^{13}C NMR (CDCl_3 , 75 MHz) δ = 150.8, 137.5, 136.3, 132.4, 131.1 (q, J^2 (C-F) = 32.2 Hz), 129.1, 125.8 (q, J^3 (C-F) = 3.9 Hz), 123.8 (q, J^1 (C-F) = 272.8 Hz), 122.4 (q, J^3 (C-F) = 3.8 Hz), 113.2, 112.2, 40.2. MS (relative intensity) m/z : 345 (28), 265 (100), 249 (10), 200 (14), 132 (8), 77 (10). HRMS calcd. for $\text{C}_{15}\text{H}_{14}\text{F}_3\text{NSe}$ [M + Na] $^+$ 368.0141. Found: 368.0221.

N,N-diethyl-4-(phenylselanyl)aniline (3h)



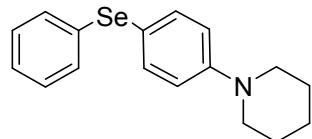
Yield: 0,0738g (81%); brown oil. ^1H NMR (CDCl_3 , 200 MHz) δ = 7.45 (d, J = 8.9 Hz, 2H), 7.31-7.24 (m, 2H), 7.23-7.11 (m, 3H), 6.62 (d, J = 8.9 Hz, 2H), 3.36 (q, J = 7.0 Hz, 4H), 1.17 (t, J = 7.0, 6H). ^{13}C NMR (CDCl_3 , 75 MHz) δ = 147.9, 137.5, 134.8, 129.5, 128.9, 125.6, 112.4, 112.0, 44.3, 12.5. MS (relative intensity) m/z : 305 (61), 290 (100), 261 (18), 225 (53), 210 (56), 152 (20), 118 (23), 77 (26). HRMS calcd. for $\text{C}_{16}\text{H}_{19}\text{NSe}$ [M + Na] $^+$ 328.0580. Found: 328.0611.

1-(4-(phenylselanyl)phenyl)pyrrolidine (3i)



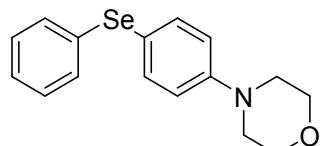
Yield: 0.063 g (70%); yellow solid; mp 85-86 °C. ^1H NMR (CDCl_3 , 300 MHz) δ = 7.48 (d, J = 8.8 Hz, 2H), 7.28-7.22 (m, 2H), 7.20-7.06 (m, 3H), 6.51 (d, J = 8.8 Hz, 2H), 3.31-3.26 (m, 4H), 3.02-1.98 (m, 4H). ^{13}C NMR (CDCl_3 , 75 MHz) δ = 147.9, 137.5, 135.0, 129.3, 128.9, 125.5, 112.5, 112.0, 47.4, 25.5. MS (relative intensity) m/z : 303 (26), 223 (110), 167 (16), 152 (11), 117 (9), 77 (21). HRMS calcd. for $\text{C}_{16}\text{H}_{17}\text{NSe}$ [M] $^+$ 303.0526. Found: 303.0515.

1-(4-(phenylselanyl)phenyl)piperidine (3j)



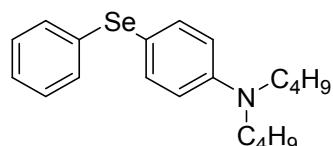
Yield: 0.041 g (43%); orange oil. ^1H NMR (CDCl_3 , 300 MHz) δ = 7.46 (d, J = 8.7 Hz, 2H), 7.31-7.25 (m, 2H), 7.22-7.14 (m, 3H), 6.86 (d, J = 8.7 Hz, 2H), 3.21-3.17 (m, 4H), 1.73-1.66 (m, 6H). ^{13}C NMR (CDCl_3 , 75 MHz) δ = 151.9, 136.6, 133.9, 130.2, 129.0, 126.0, 117.6, 116.7, 49.8, 25.6, 24.2. MS (relative intensity) m/z : 317 (31), 237 (100), 181 (21), 152 (8), 130 (7), 77 (19). HRMS calcd. for $\text{C}_{17}\text{H}_{19}\text{NSe} [\text{M}]^+$ 317.0683. Found: 317.0671.

4-(4-(phenylselanyl)phenyl)morpholine (3k)



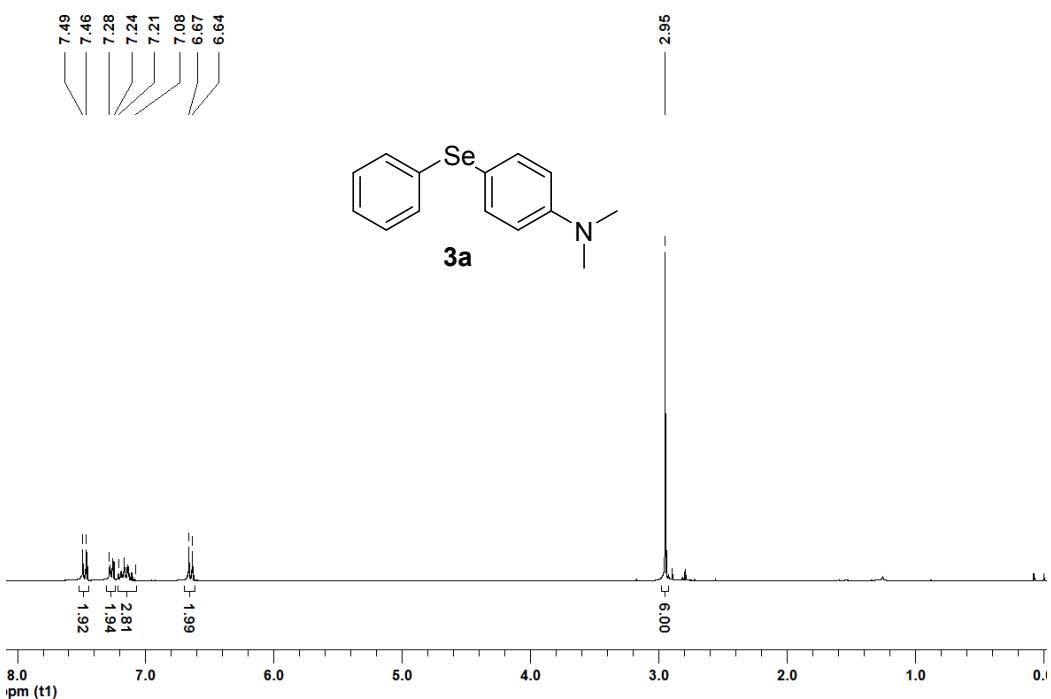
Yield: 0.074 g (77%); white solid; mp 69-71 °C. ^1H NMR (CDCl_3 , 200 MHz) δ = 7.48 (d, J = 8.8 Hz, 2H), 7.34-7.29 (m, 2H), 7.24-7.17 (m, 3H), 6.84 (d, J = 8.8 Hz, 2H), 3.87-3.82 (m, 4H), 3.19-3.14 (m, 4H). ^{13}C NMR (CDCl_3 , 75 MHz) δ = 151.0, 136.2, 133.4, 130.7, 129.0, 126.2, 116.8, 116.2, 66.7, 48.7. MS (relative intensity) m/z : 319 (38), 261 (8), 239 (100), 181 (90), 130 (5), 77 (17). HRMS calcd. for $\text{C}_{16}\text{H}_{18}\text{NOSe} [\text{M}]^+$ 320.0554. Found: 320.0387.

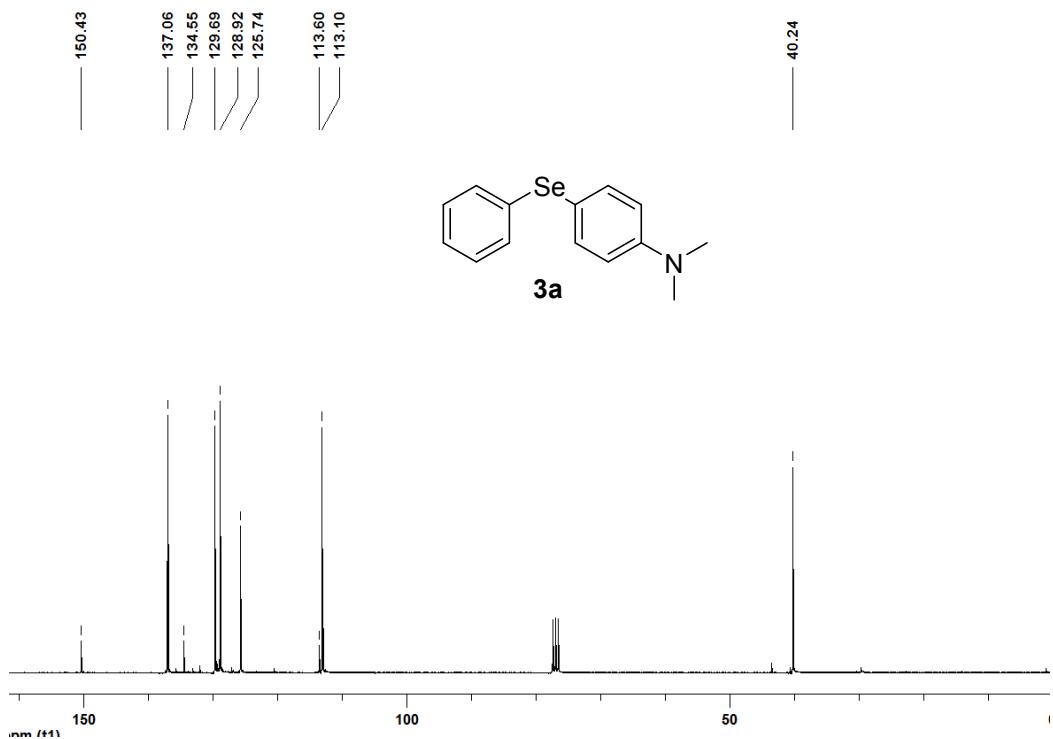
***N,N*-dibutyl-4-(phenylselanyl)aniline(3l)**



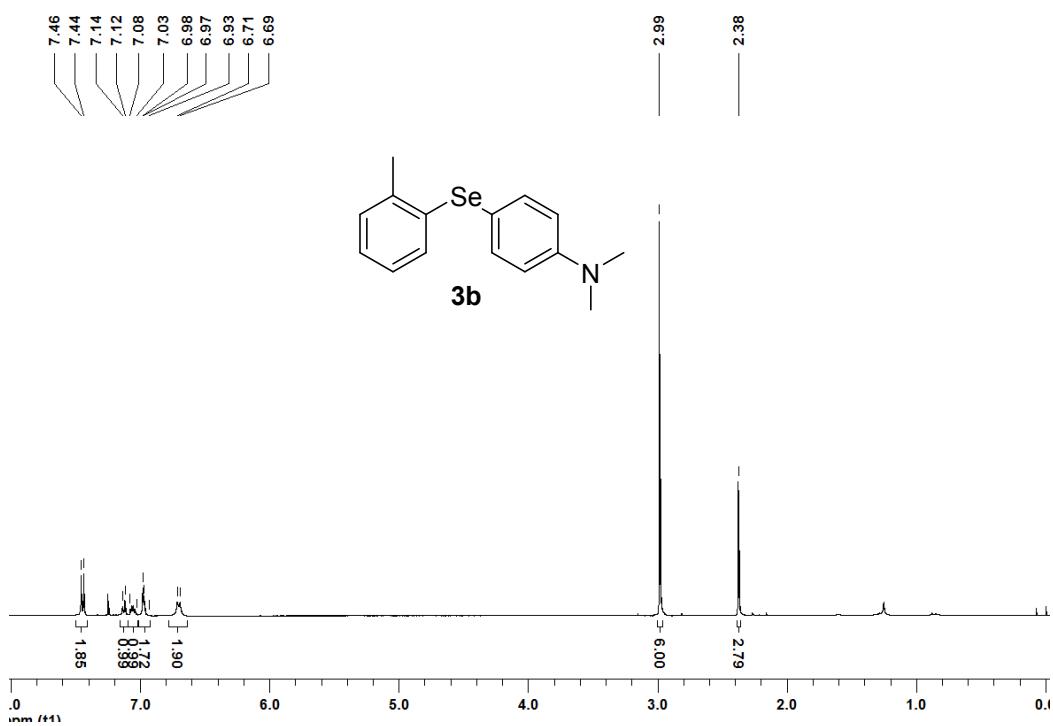
Yield: 0.107 g (99%); brown oil. ^1H NMR (CDCl_3 , 200 MHz) δ = 7.44 (d, J = 8.9 Hz, 2H), 7.31-7.26 (m, 2H), 7.23-7.07 (m, 3H), 6.57 (d, J = 8.9 Hz, 2H), 3.30-3.22 (m, 4H), 1.64-1.50 (m, 4H), 1.35 (m, 4H), 0.95 (t, J = 7.2 Hz, 6H). ^{13}C NMR (CDCl_3 , 75 MHz) δ = 148.4, 137.3, 134.8, 129.8, 128.9, 125.7, 112.5, 112.2, 50.7, 29.4, 20.3, 13.9. MS (relative intensity) m/z : HRMS calcd. for $\text{C}_{20}\text{H}_{28}\text{NSe} [\text{M}]^+$ 362.1387. Found: 326.1207.

SELECTED SPECTRA

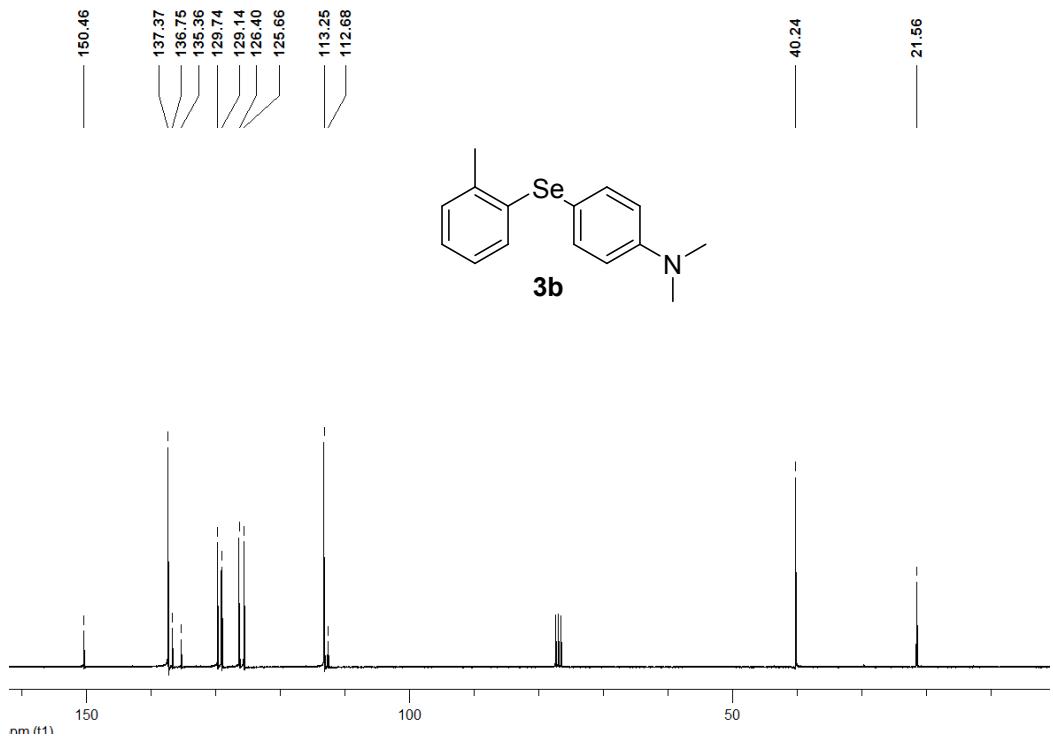




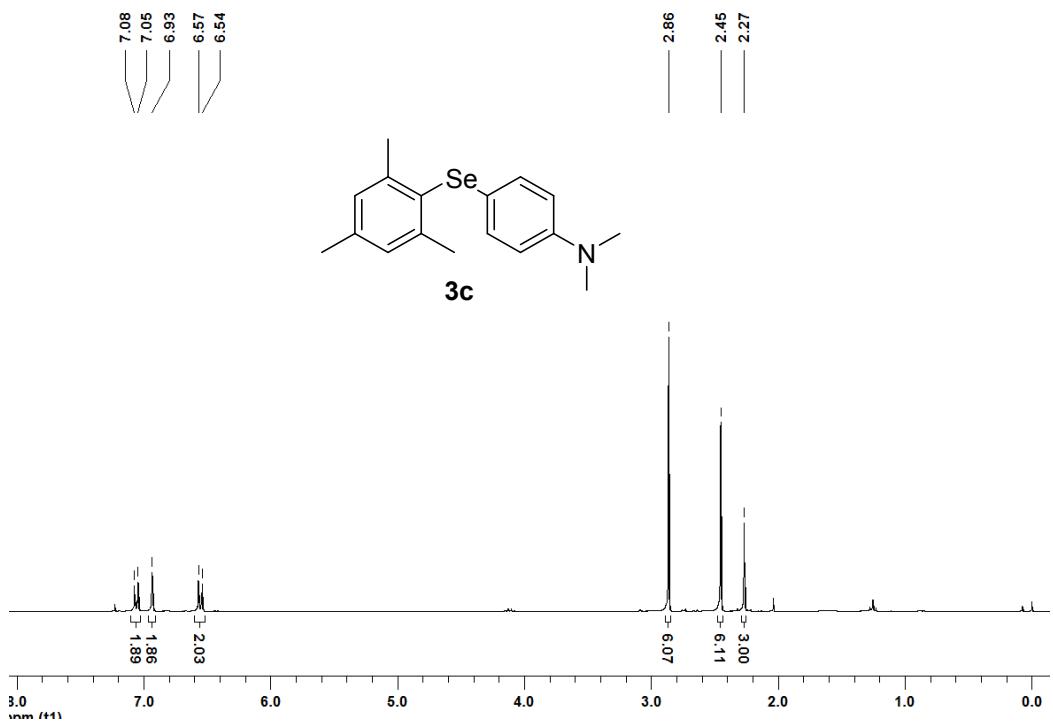
^{13}C NMR (75 MHz, CDCl_3) spectrum of *N,N*-dimethyl-4-(phenylselanyl)benzenamine (**3a**)



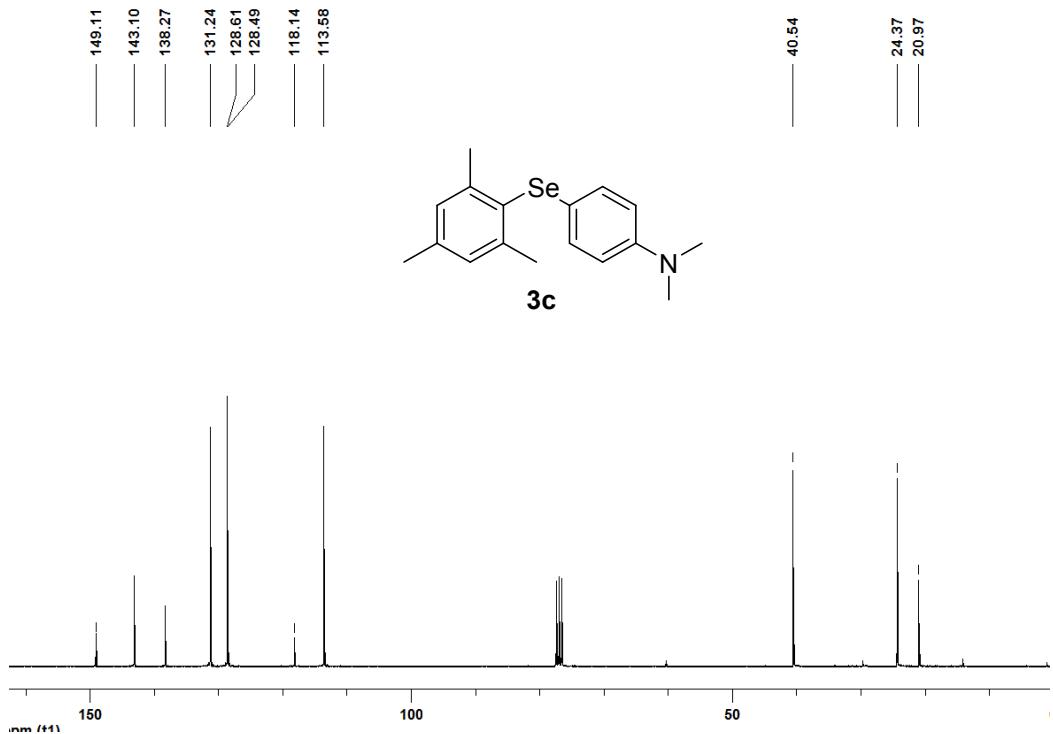
^1H NMR (400 MHz, CDCl_3) spectrum of *N,N*-dimethyl-4-(*o*-tolylselanyl)benzenamine (**3b**)



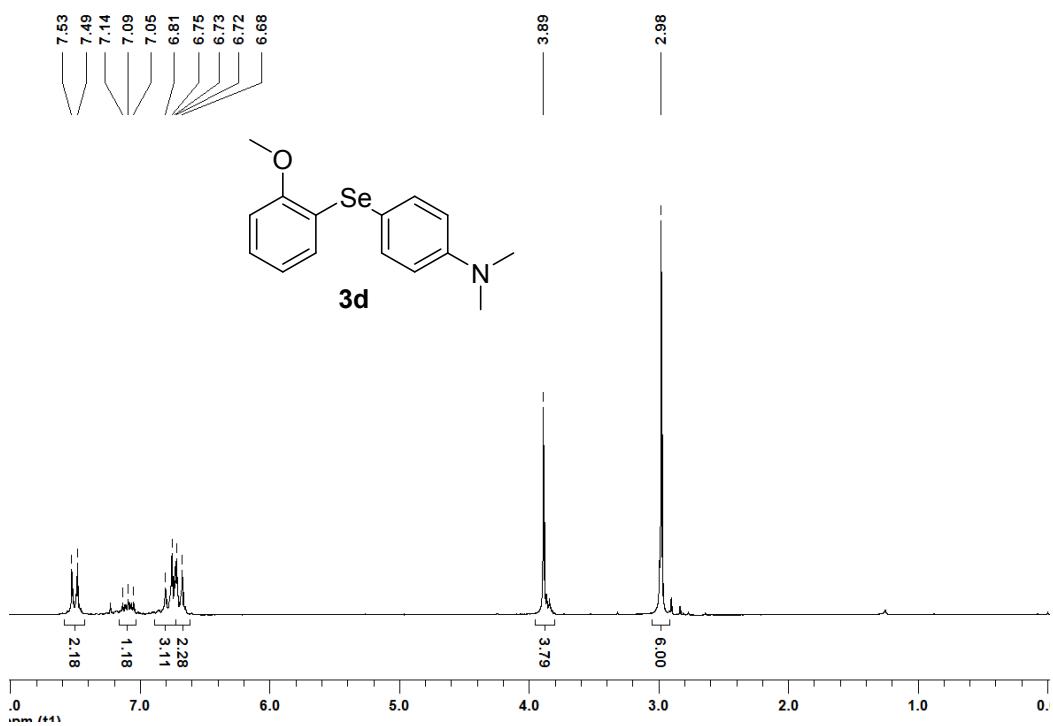
^{13}C NMR (100 MHz, CDCl_3) spectrum of *N,N*-dimethyl-4-(*o*-tolylselanyl)benzenamine (**3b**)



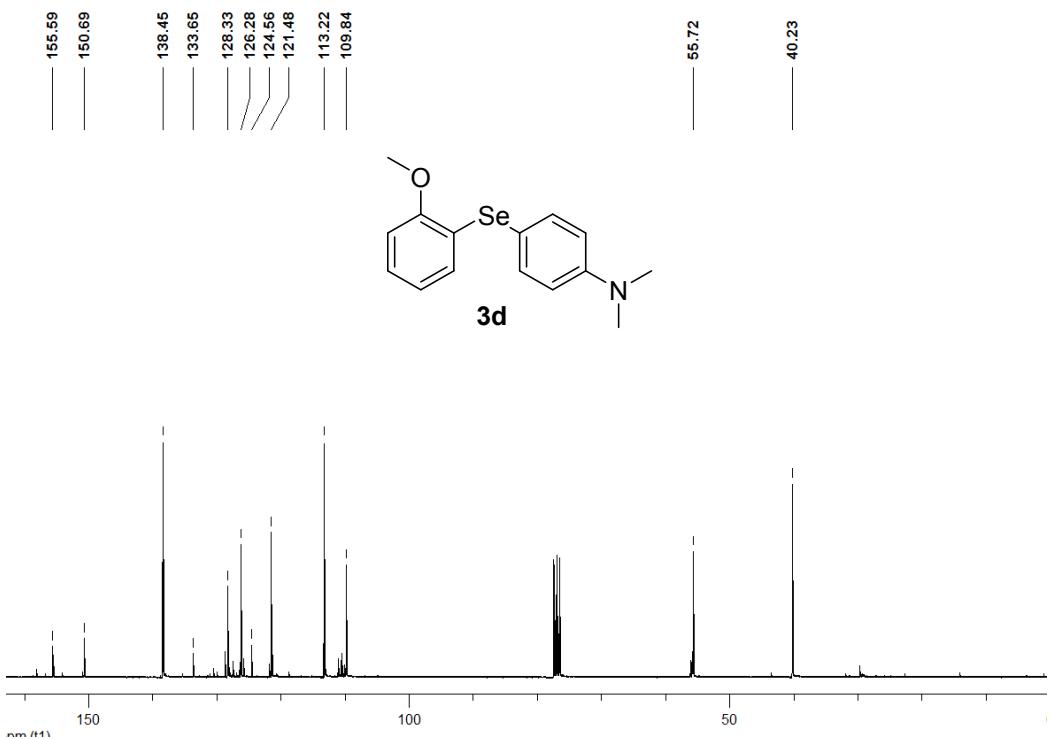
^1H NMR (300 MHz, CDCl_3) spectrum of 4-(mesitylselanyl)-*N,N*-dimethylbenzenamine (**3c**)



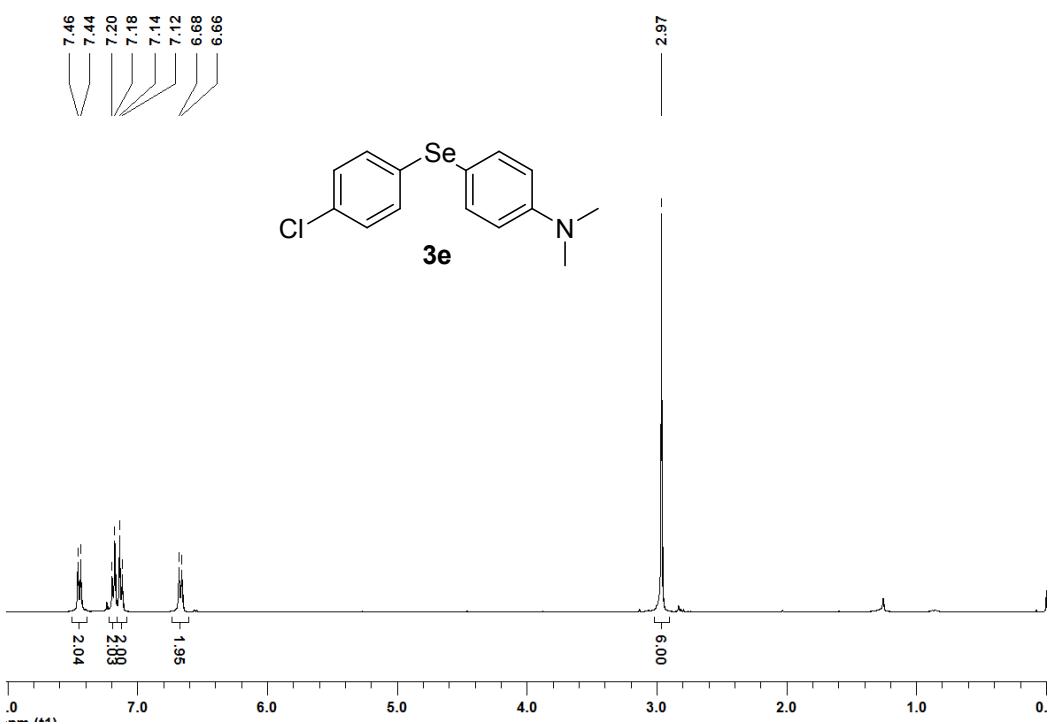
¹³C NMR (75 MHz, CDCl₃) spectrum of 4-(mesitylselanyl)-N,N-dimethylbenzenamine (**3c**)



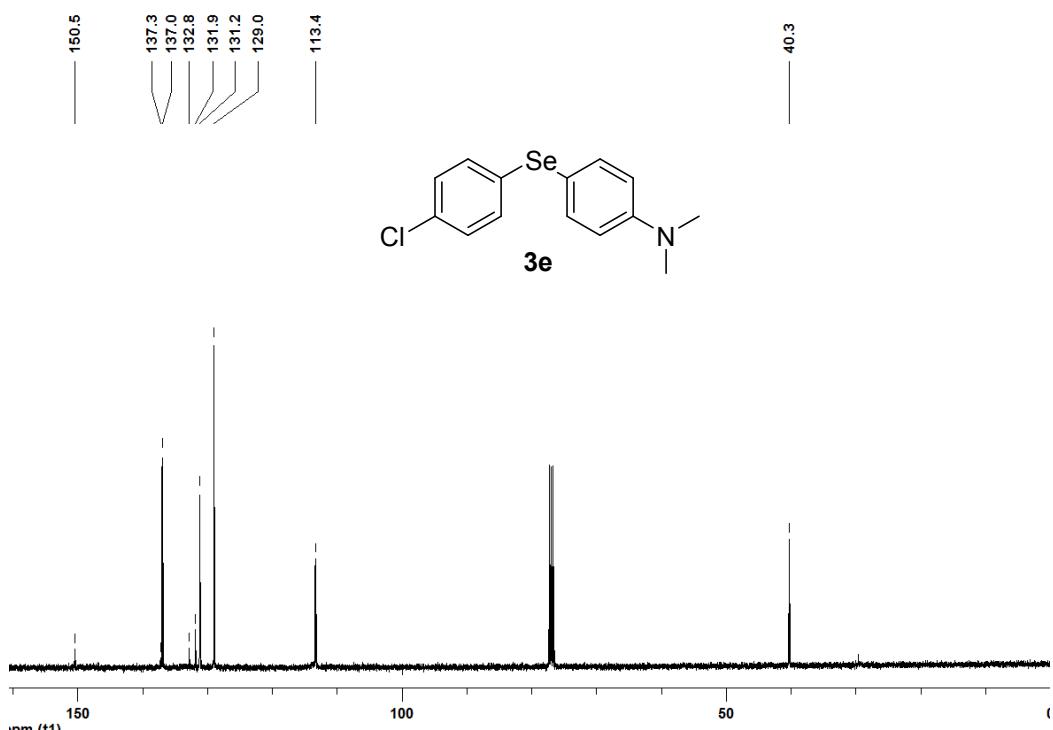
¹H NMR (200 MHz, CDCl₃) spectrum of 4-(2-methoxyphenylselanyl)-N,N-dimethylbenzenamine (**3d**)



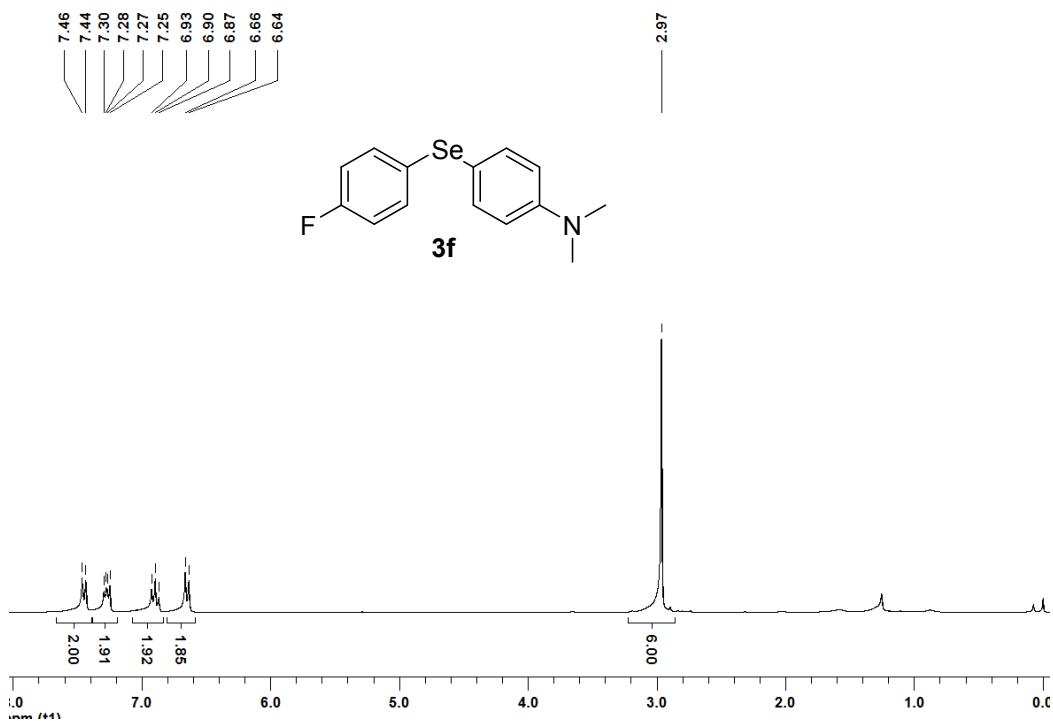
¹³C NMR (75 MHz, CDCl₃) spectrum of 4-(2-methoxyphenylselanyl)-N,N-dimethylbenzenamine (**3d**)



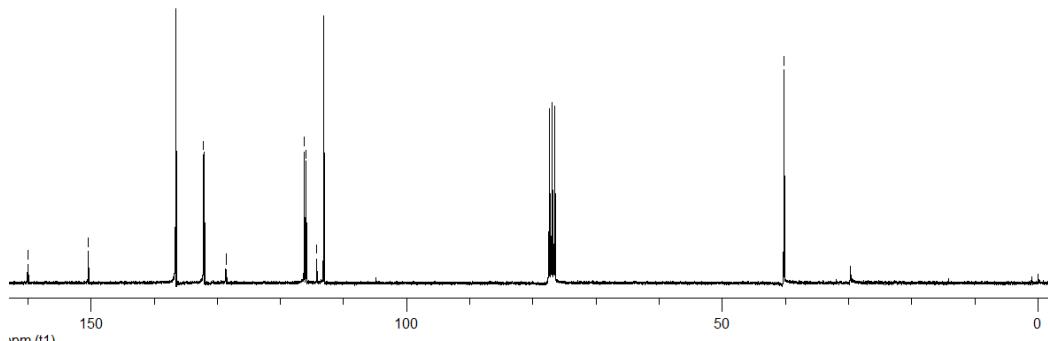
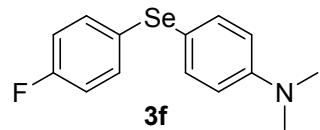
¹H NMR (400 MHz, CDCl₃) spectrum of 4-(4-chlorophenylselanyl)-N,N-dimethylbenzenamine (**3e**)



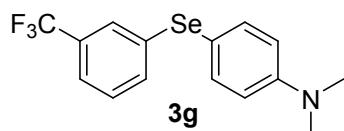
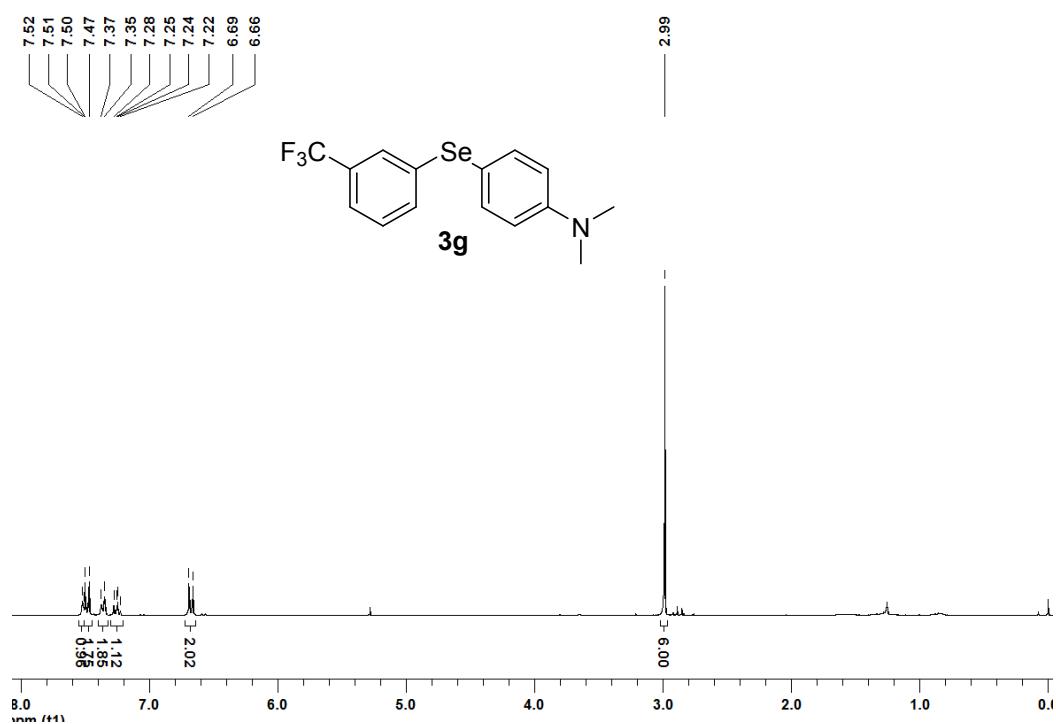
^{13}C NMR (100 MHz, CDCl_3) spectrum of 4-(4-chlorophenylselanyl)- N,N -dimethylbenzenamine (**3e**)



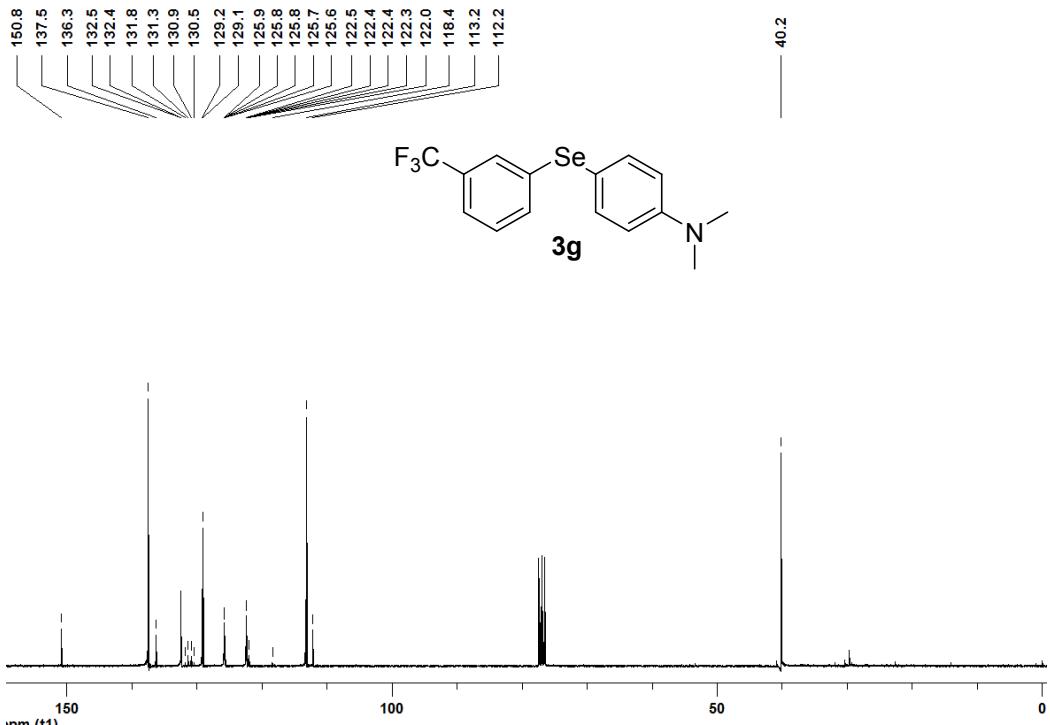
^1H NMR (300 MHz, CDCl_3) spectrum of 4-(4-fluorophenylselanyl)- N,N -dimethylbenzenamine (**3f**)



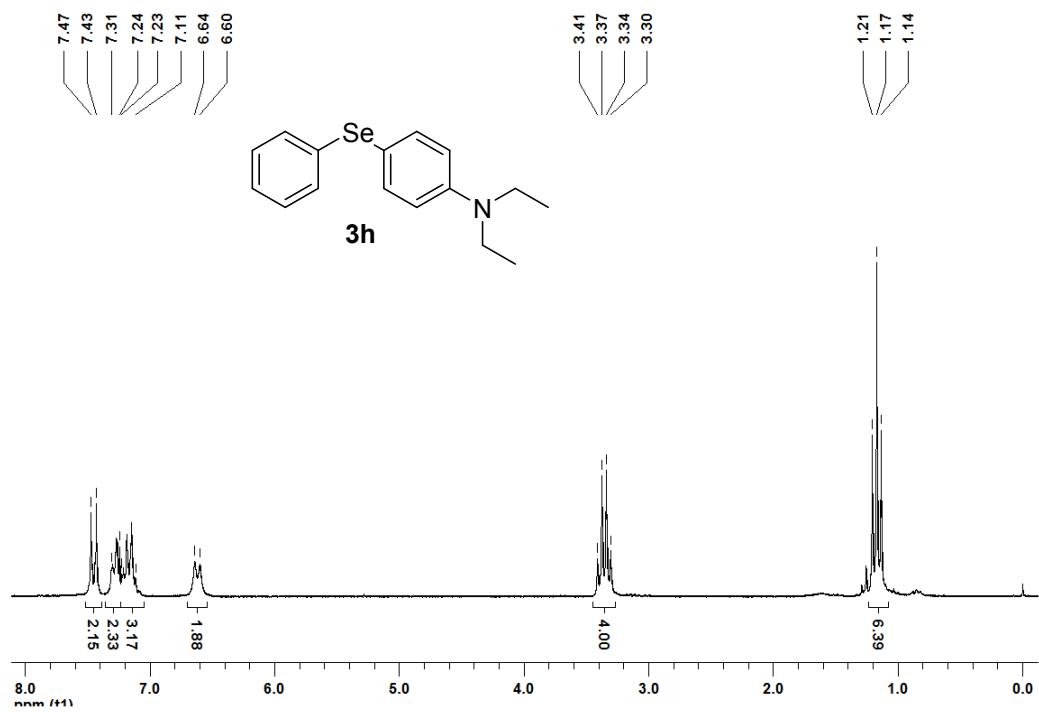
¹³C NMR (75 MHz, CDCl₃) spectrum of 4-(4-fluorophenylselanyl)-N,N-dimethylbenzenamine (**3f**)



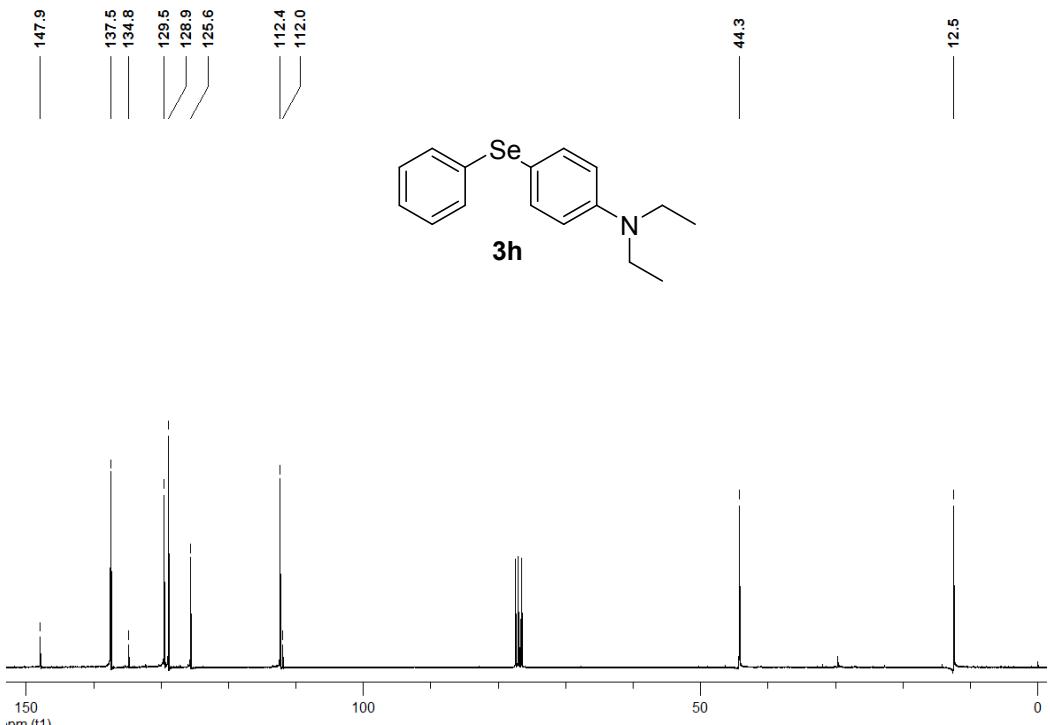
¹H NMR (300 MHz, CDCl₃) spectrum of *N,N*-dimethyl-4-(3-(trifluoromethyl)phenylselanyl)benzenamine (**3g**)



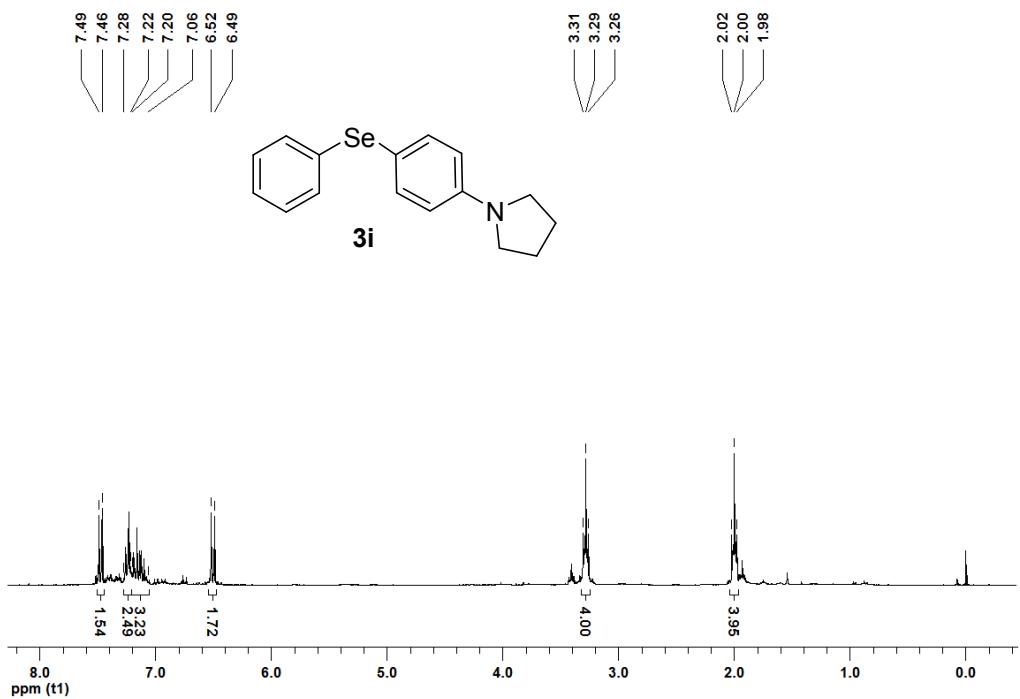
^{13}C NMR (75 MHz, CDCl_3) spectrum of *N,N*-dimethyl-4-(3-(trifluoromethyl)phenylselanyl)benzenamine (**3g**)



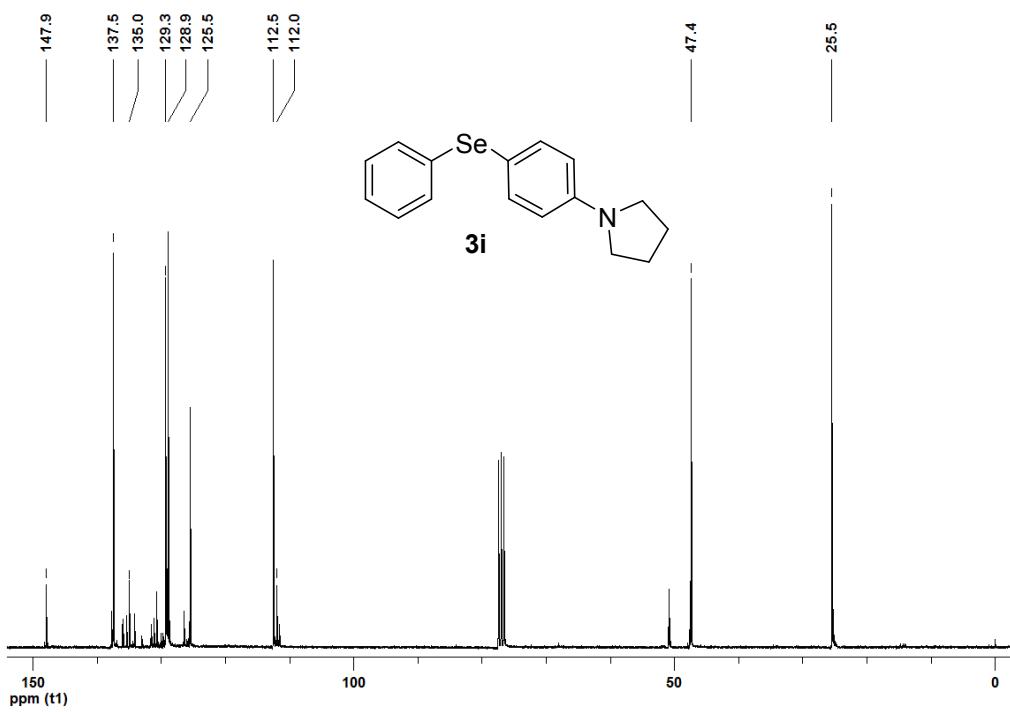
^1H NMR (200 MHz, CDCl_3) spectrum of *N,N*-diethyl-4-(phenylselanyl)aniline (**3h**)



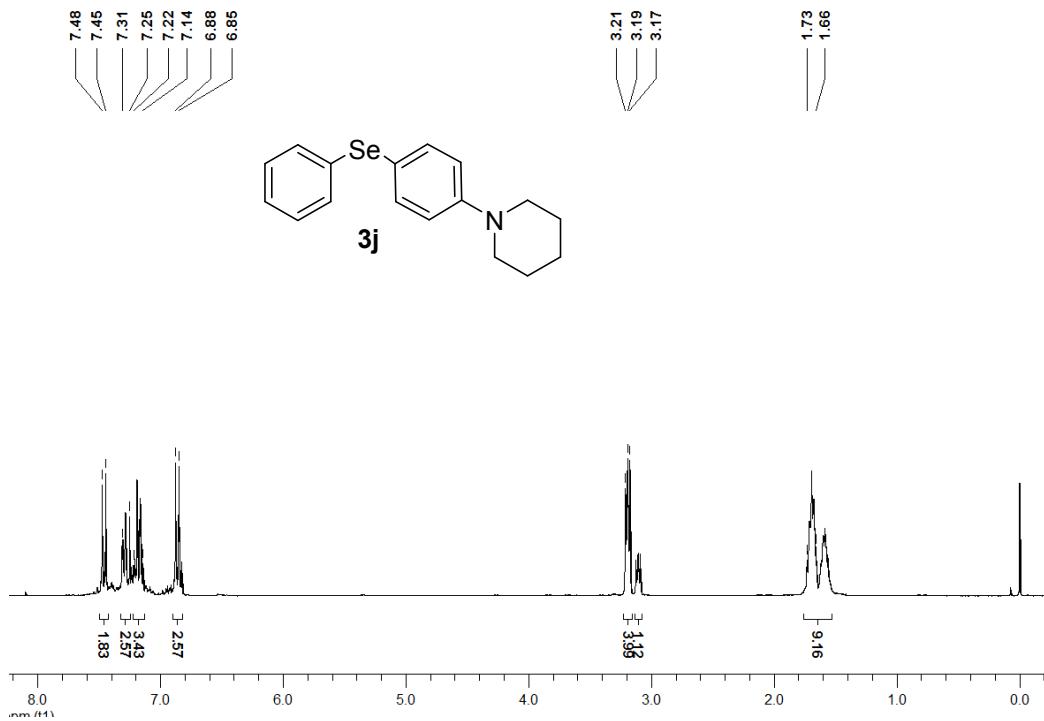
¹³C NMR (75 MHz, CDCl₃) spectrum of *N,N*-diethyl-4-(phenylselanyl)aniline (**3h**)

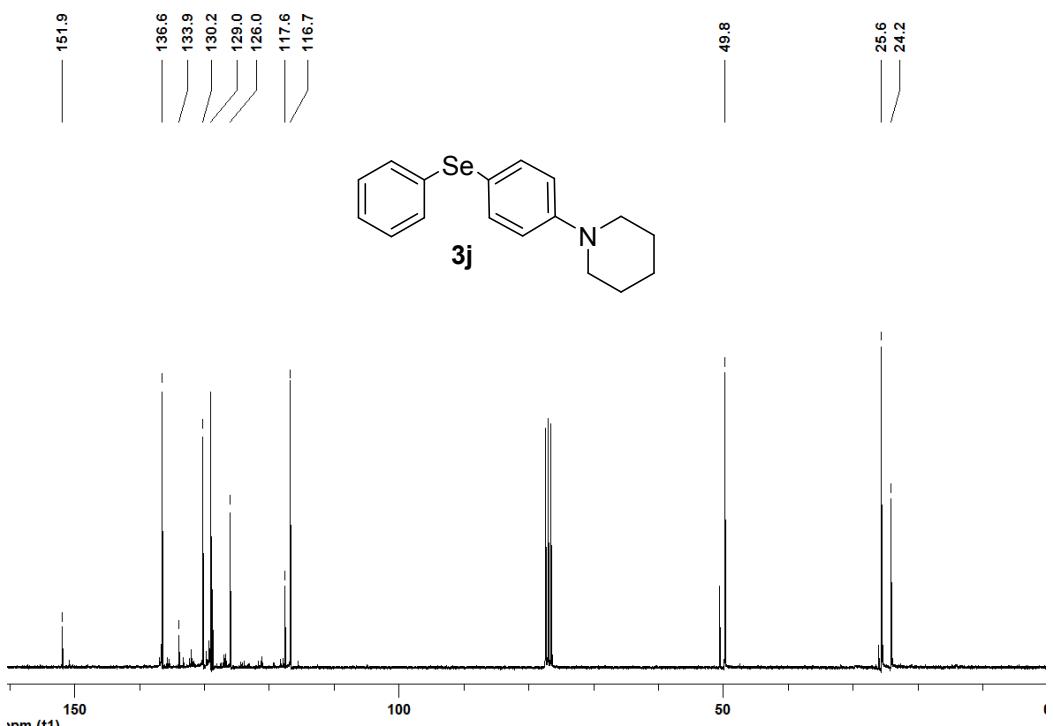


¹H NMR (300 MHz, CDCl₃) spectrum of 1-(4-(phenylselanyl)phenyl)pyrrolidine (**3i**)

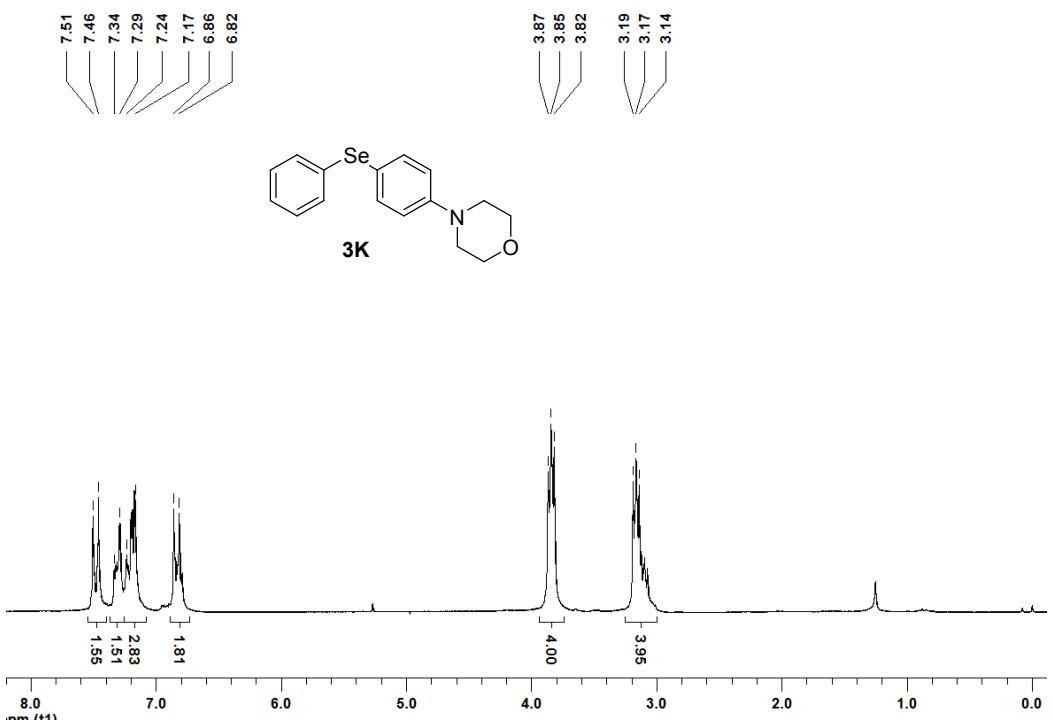


¹³C NMR (75 MHz, CDCl₃) spectrum of 1-(4-(phenylselanyl)phenyl)pyrrolidine (**3i**)

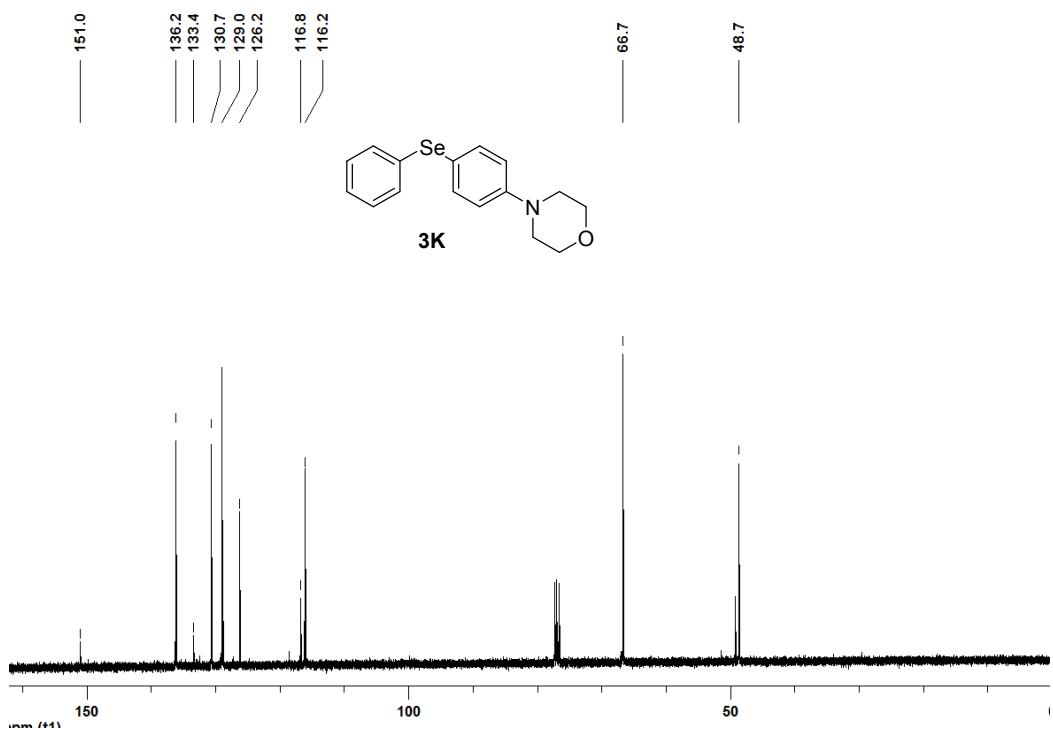




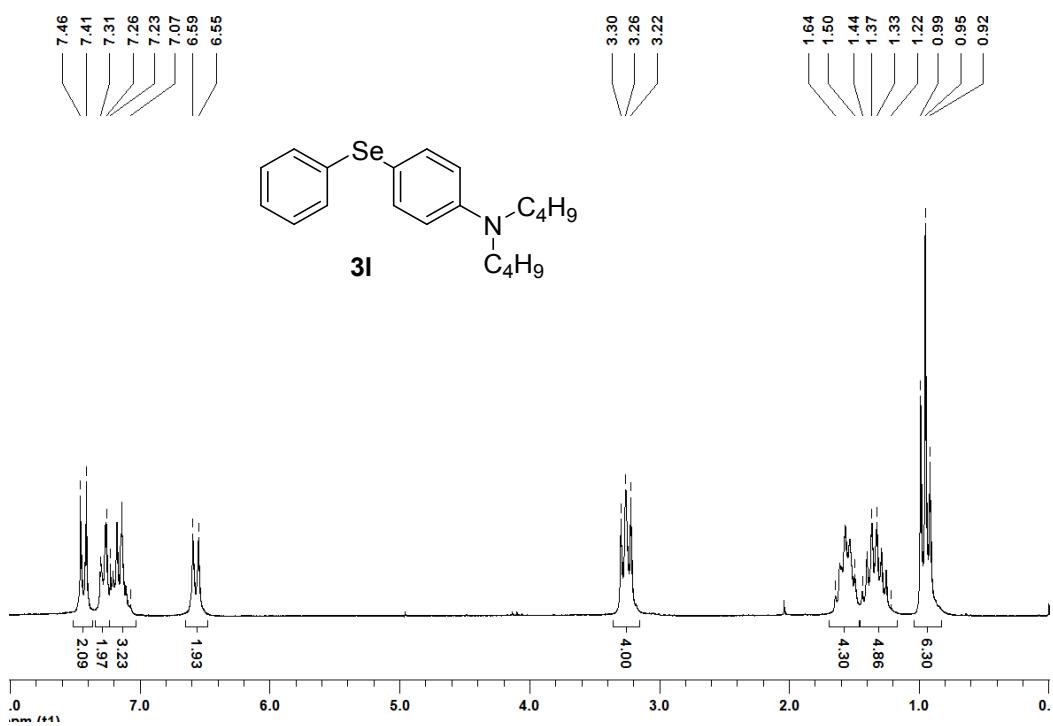
¹³C NMR (75 MHz, CDCl₃) spectrum of 1-(4-(phenylselanyl)phenyl)piperidine (**3j**)



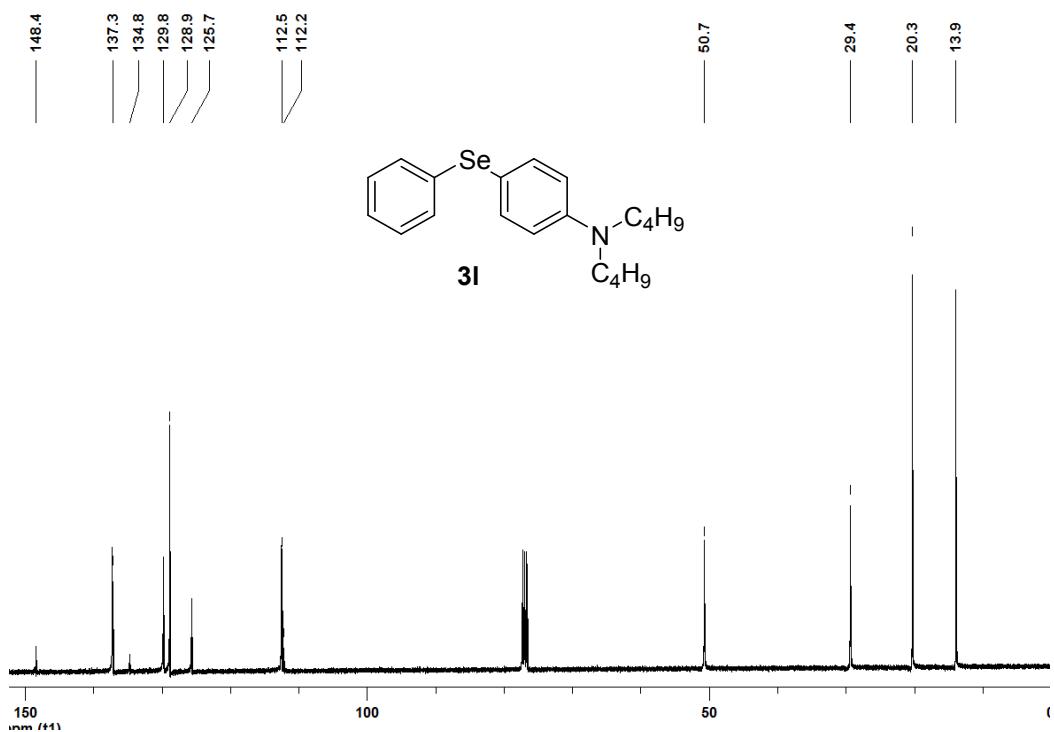
¹H NMR (200 MHz, CDCl₃) spectrum of 4-(4-(phenylselanyl)phenyl)morpholine (**3k**)



^{13}C NMR (100 MHz, CDCl_3) spectrum of 4-(4-(phenylselanyl)phenyl)morpholine (**3k**)



^1H NMR (200 MHz, CDCl_3) spectrum of *N,N*-dibutyl-4-(phenylselanyl)aniline (**3I**)



^{13}C NMR (100 MHz, CDCl_3) spectrum of *N,N*-dibutyl-4-(phenylselanyl)aniline (**3l**)