Synthesis of Symmetrical and Unsymmetrical Tellurides via Silver Catalysis

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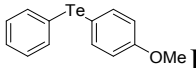
General Information: The reactions were monitored by TLC carried out on Merck silica gel (60 F_{254}) by using UV light as visualizing agent and 5% vanillin in 10% H_2SO_4 and heat as developing agents. Baker silica gel (particle size 0.040-0.063 mm) was used for flash chromatography. Proton and carbon-13 nuclear magnetic resonance spectra (^{1}H NMR) were acquired using a Bruker Fourier 300 spectrometer (300 MHz for ^{1}H NMR and 75 MHz for ^{13}C NMR). All NMR spectra were recorded in $CDCl_3$ solutions. Chemical shifts are reported in ppm, referenced to tetramethylsilane (TMS) as the internal reference in the ^{1}H NMR spectra or referenced to the solvent peak in the ^{13}C NMR spectra. Coupling constants (*J*) are reported in Hertz. Abbreviations to denote the multiplicity of a particular signal are s (singlet), d (doublet), dd (doublet of doublet), dt (doublet of triplet), t (triplet), q (quartet), quint (quintet), sex (sextet) and m (multiplet). Low-resolution mass spectra were obtained with a Shimadzu GC-MS-QP2010 mass spectrometer. High resolution mass spectra (HRMS) were recorded on a Bruker Daltonics micrOTOF-Q II instrument.

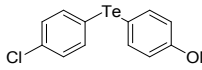
General Procedure for Silver(I)-Catalyzed Synthesis of Diaryl Tellurides 3a-u: To a 5 mL Schlenk tube equipped with a small magnetic stirring bar were added the appropriate diorganoyl ditelluride **1a-h** (0.2 mmol), the appropriate aryl boronic acid **2a-n** (0.4 mmol), $AgNO_3$ (0.04 mmol, 10 mol%) and 1,4-dioxane (0.8 mL). The resulting mixture was stirred at 100 °C for 6 h. After that, the reaction mixture was cooled to room temperature, and was quenched using water (5 mL). The mixture was then extracted using ethyl acetate (10 mL) and washed with water (3 x 10 mL). The combined organic layers were dried over anhydrous $MgSO_4$ and concentrated under vacuum to yield the crude product, which was purified by flash chromatography on silica gel using hexane or a mixture of hexane/ethyl acetate as eluent. Spectral data for the products prepared are listed below.

Spectral data of the products



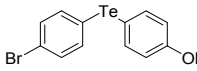
Phenyl(4-methoxyphenyl)telluride[1] (3a):

Yield: 0.117 g (93%); Yellow solid; mp 57-59 °C; ^{1}H NMR ($CDCl_3$, 300 MHz): δ 7.72 (dt, J = 8.8, 2.8 Hz, 2H), 7.61 - 7.50 (m, 2H), 7.27 - 7.08 (m, 3H), 6.78 (dd, J = 8.8, 2.8 Hz, 2H), 3.77 (s, 1H). ^{13}C NMR ($CDCl_3$, 75 MHz): δ 159.9, 141.15, 136.3, 129.3, 127.2, 115.9, 115.5, 103.1, 55.1. MS *m/z* (relative intensity): 314 (M^+, 24), 312 (22), 184 (100), 169 (62), 141 (37), 115 (18), 92 (11), 77 (44), 51 (26).



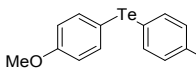
4-Chlorophenyl(4-methoxyphenyl)telluride (3b):

Yield: 0.124 g (89%); Yellow oil; ^{1}H NMR ($CDCl_3$, 300 MHz): δ 7.72 (d, J = 8.8 Hz, 2H), 7.46 (d, J = 8.5 Hz, 2H), 7.12 (d, J = 8.5 Hz, 2H), 6.80 (d, J = 8.8 Hz, 2H), 3.80 (s, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz): δ 160.1, 141.3, 137.5, 133.6, 129.4, 115.6, 113.6, 102.9, 55.1. MS *m/z* (relative intensity): 348 (M^+, 31), 346 (28), 218 (100), 203 (45), 175 (20), 75 (11), 63 (12). HRMS calculated for $C_{13}H_{11}ClOTe$ $[M]^+$: 347.9561, Found: 347.9545.



4-bromophenyl(4-methoxyphenyl)telluride (3c):

Yield: 0.122 g (78%); Yellow solid; mp 42-43°C; ^{1}H NMR ($CDCl_3$, 300 MHz): δ 7.72 (d, J = 8.8 Hz, 2H), 7.37 (d, J = 8.4 Hz, 2H), 7.26 (d, J = 8.5 Hz, 2H), 6.80 (d, J = 8.8 Hz, 2H), 3.80 (s, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz): δ 160.1, 141.4, 139.7, 137.7, 132.3, 121.7, 115.6, 102.8, 55.1. MS *m/z* (relative intensity): 392 (M^+, 36), 388 (12), 264 (99), 262 (100), 249 (47), 247 (49), 237 (18), 221 (25), 140 (18), 92 (19), 77 (26), 63 (42), 50 (40). HRMS calculated for $C_{13}H_{11}BrOTe$ $[M]^+$: 391.9056, Found: 391.9045.

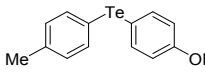


Bis(4-methoxyphenyl)telluride[1] (3d):

Yield: 0.122 g (89%); Yellow solid; mp 46-48 °C; ^{1}H NMR ($CDCl_3$, 300 MHz): δ 7.61 (d, J = 8.8 Hz, 4H), 6.74 (d, J = 8.9 Hz, 4H), 3.74 (s, 6H). ^{13}C NMR ($CDCl_3$, 75 MHz): δ

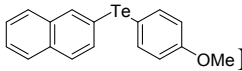
[1] D. Alves, J. M. Pena, A. S. Vieira, G. V. Botteselle, R. C. Guadagnin and H. A. Stefani, *J. Braz. Chem. Soc.*, 2009, **20**, 988.

159.1, 139.6, 115.3, 104.2, 55.0. MS *m/z* (relative intensity): 344 (M^+, 28), 340 (17), 214 (100), 199 (94), 171 (30), 128 (15), 107 (7), 77 (10), 63 (17).



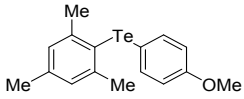
4-Methylphenyl(4-methoxyphenyl)telluride[1] (3e):

Yield: 0.122 g (93%); Yellow oil; ^{1}H NMR ($CDCl_3$, 300 MHz): δ 7.68 (d, J = 8.8 Hz, 2H), 7.51 (d, J = 8.1 Hz, 2H), 7.00 (d, J = 8.1 Hz, 2H), 6.77 (d, J = 8.8 Hz, 2H), 3.78 (s, 3H), 2.31 (s, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz): δ 159.7, 140.5, 137.3, 137.1, 130.2, 115.3, 111.3, 103.5. MS *m/z* (relative intensity): 328 (M^+, 32), 296 (52), 237 (46), 198 (100), 183 (63), 155 (29), 91 (19), 65 (21).



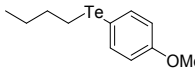
Naphthalen-2-yl(4-methoxyphenyl)telluride (3f):

Yield: 0.105 g (72%); Yellow solid; mp 80-83 °C; ^{1}H NMR ($CDCl_3$, 300 MHz): δ 8.07 (s, 1H), 7.74 (d, J = 8.8 Hz, 3H), 7.71 - 7.59 (m, 1H), 7.59 (s, 2H), 7.48 - 7.34 (m, 2H), 6.78 (d, J = 8.7 Hz, 2H), 3.76 (s, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz): δ 159.9, 141.0, 135.8, 134.2, 133.4, 132.3, 128.4, 127.7, 127.2, 126.2, 126.0, 115.5, 113.3, 103.3, 55.1. MS *m/z* (relative intensity): 364 (M^+, 21), 234 (100), 219 (61), 191 (30), 127 (35), 77 (19), 63 (13). HRMS calculated for $C_{17}H_{14}OTe$ $[M]^+$: 364.0107, Found: 364.0118.



Mesityl(4-methoxyphenyl)telluride[1] (3g):

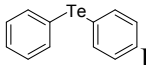
Yield: 0.105 g (74%); Yellow solid; mp 31-32 °C; ^{1}H NMR ($CDCl_3$, 300 MHz): δ 7.35 (dt, J = 8.8, 2.9 Hz, 2H), 6.96 (s, 2H), 6.69 (dt, J = 8.8, 2.9 Hz, 2H), 3.73 (s, 3H), 2.53 (s, 6H), 2.28 (s, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz): δ 159.0, 145.1, 139.0, 137.2, 127.5, 118.8, 115.3, 104.6, 55.1, 29.7, 29.4, 21.0. MS *m/z* (relative intensity): 356 (M^+, 100), 354 (92), 248 (52), 244 (30), 237 (12), 226 (81), 214 (17), 211 (46), 199 (15), 195 (19), 119 (58), 115 (22), 103 (18), 91 (52), 77 (40), 63 (22), 51 (15), 41 (24).



Butyl(4-methoxyphenyl)telluride (3h):

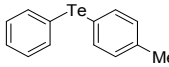
Yield: 0.075 g (64%); Yellow oil; ^{1}H NMR ($CDCl_3$, 300 MHz): δ 7.67 (dt, J = 8.8, 2.9 Hz, 2H), 6.75 (dt, J = 8.8, 2.9 Hz, 2H), 3.79 (s, 3H), 2.82 (t, J = 7.3 Hz, 2H), 1.73 (quint,

J = 7.3 Hz, 2H), 1.37 (sex, *J* = 7.3 Hz, 2H), 0.88 (t, *J* = 7.3 Hz, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz): δ 159.5, 140.8, 115.0, 100.5, 55.1, 33.8, 24.9, 13.4, 8.7. MS *m/z* (relative intensity): 294 (M^+, 23), 290 (13), 237 (15), 222 (7), 108 (100), 92 (7), 63 (12), 57 (14), 41 (25). HRMS calculated for $C_{11}H_{16}OTe$ $[M]^+$: 294.0263, Found: 294.0263.



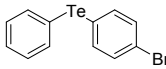
Diphenyl telluride[1] (3i):

Yield: 0.104 g (92%); Yellow oil; ^{1}H NMR ($CDCl_3$, 300 MHz): δ 7.76 - 7.63 (m, 4H), 7.34 - 7.14 (m, 6H). ^{13}C NMR ($CDCl_3$, 75 MHz): δ 137.9, 129.5, 127.8, 114.6. MS *m/z* (relative intensity): 284 (M^+, 23), 280 (15), 206 (10), 154 (100), 77 (85), 51 (49). HRMS calculated for $C_{12}H_{10}Te$ $[M]^+$: 283.9845, Found: 283.9842.



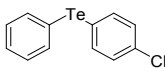
Phenyl(4-methylphenyl)telluride[1] (3j):

Yield: 0.118 g (99%); Yellow oil; ^{1}H NMR ($CDCl_3$, 300 MHz): δ 7.73 - 7.52 (m, 3H), 7.29 - 7.09 (m, 3H), 7.02 (d, *J* = 7.6 Hz, 2H), 2.32 (s, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz): δ 138.7, 138.0, 137.2, 130.4, 129.3, 127.4, 115.2, 110.2, 21.2. MS *m/z* (relative intensity): 298 (M^+, 27), 168 (100), 153 (21), 91 (51), 77 (35), 65 (32), 51 (29).



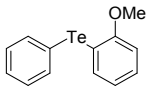
Phenyl(4-bromophenyl)telluride (3k):

Yield: 0.090 g (62%); Yellow solid; mp 59-61 °C; ^{1}H NMR ($CDCl_3$, 300 MHz): δ 7.70 - 7.67 (m, 2H), 7.52 - 7.48 (m, 2H), 7.34 - 7.27 (m, 3H), 7.25 - 7.19 (m, 2H). ^{13}C NMR ($CDCl_3$, 75 MHz): δ 139.3, 138.2, 132.6, 129.6, 128.1, 122.5, 114.2, 113.2. MS *m/z* (relative intensity): 362 (M^+, 21), 232 (79), 207 (11), 152 (37), 77 (100), 51 (69). HRMS calculated for $C_{12}H_9BrTe$ $[M]^+$: 361.8950, Found: 361.8941.



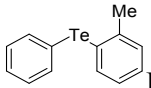
Phenyl(4-chlorophenyl)telluride (3l):

Yield: 0.104 g (82%); Yellow oil; ^{1}H NMR ($CDCl_3$, 300 MHz): δ 7.73 - 7.63 (m, 2H), 7.57 (d, *J* = 8.5 Hz, 2H), 7.35 - 7.09 (m, 5H). ^{13}C NMR ($CDCl_3$, 75 MHz): δ 139.1, 138.1, 134.2, 129.7, 129.6, 128.1, 114.4, 112.3. MS *m/z* (relative intensity): 318 (M^+, 44), 316 (37), 188 (100), 153 (18), 111 (12), 77 (57), 51 (55). HRMS calculated for $C_{12}H_9ClTe$ $[M]^+$: 317.9455, Found: 317.9453.



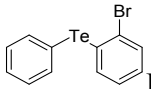
Phenyl(2-methoxyphenyl)telluride (3m):

Yield: 0.093 g (74%); Yellow solid; mp 50-53 °C; ^{1}H NMR ($CDCl_3$, 300 MHz): δ 7.88 (d, J = 6.7 Hz, 2H), 7.42 - 7.34 (m, 1H), 7.33 - 7.21 (m, 2H), 7.22 - 7.09 (m, 1H), 6.93 (dd, J = 7.6, 1.6 Hz, 1H), 6.81 - 6.65 (m, 2H), 3.83 (s, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz): δ 157.9, 141.1, 133.3, 129.5, 128.5, 128.00, 122.3, 111.9, 109.5, 107.6, 55.7. MS *m/z* (relative intensity): 314 (M^+, 17), 184 (48), 169 (36), 141 (26), 107 (23), 92 (10), 77 (100), 51 (43). HRMS calculated for $C_{13}H_{13}O_2Te$ $[M + OH]^+$: 330.9978, Found: 330.9985.



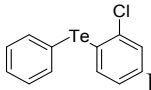
Phenyl(2-methylphenyl)telluride (3n):

Yield: 0.083 g (70%); Yellow oil; ^{1}H NMR ($CDCl_3$, 300 MHz): δ 7.74 - 7.64 (m, 2H), 7.48 - 7.44 (m, 1H), 7.34 - 7.24 (m, 1H), 7.27 - 7.15 (m, 4H), 2.40 (s, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz): δ 141.8, 138.6, 137.3, 129.6, 129.3, 128.0, 128.0, 126.7, 119.2, 113.9, 26.0. MS *m/z* (relative intensity): 298 (M^+, 41), 296 (38), 167 (92), 153 (43), 91 (100), 77 (53), 65 (67), 51 (58). HRMS calculated for $C_{13}H_{12}Te$ $[M]^+$: 298.0001, Found: 297.9999.



Phenyl(2-bromophenyl)telluride (3o):

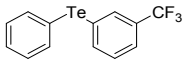
Yield: 0.041 g (28%); Yellow oil; ^{1}H NMR ($CDCl_3$, 300 MHz): δ 7.96 - 7.91 (m, 2H), 7.49 - 7.31 (m, 4H), 7.05 - 6.95 (m, 2H), 6.89 - 6.85 (m, 1H). ^{13}C NMR ($CDCl_3$, 75 MHz): δ 141.2, 134.3, 132.0, 130.0, 129.2, 128.0, 127.8, 126.9, 123.9, 114.6. MS *m/z* (relative intensity): 362 (M^+, 12), 234 (18), 207 (13), 152 (33), 77 (100), 51 (85), 44 (43), 40 (51). HRMS calculated for $C_{12}H_9BrTe$ $[M]^+$: 361.8950, Found: 361.8940.



Phenyl(2-chlorophenyl)telluride (3p):

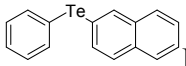
Yield: 0.036 g (28%); Yellow oil; ^{1}H NMR ($CDCl_3$, 300 MHz): δ 7.94 - 7.91 (m, 2H), 7.48 - 7.43 (m, 1H), 7.37 - 7.29 (m, 3H), 7.14 - 7.08 (m, 1H), 6.96 - 6.93 (m, 2H). ^{13}C NMR ($CDCl_3$, 75 MHz): δ 141.3, 136.4, 134.2, 130.0, 129.2, 128.7, 128.0, 127.4, 120.5,

113.2. MS *m/z* (relative intensity): 318 (M^+, 27), 316 (23), 188 (100), 152 (30), 111 (10), 77 (99), 51 (77). HRMS calculated for $C_{12}H_9ClTe$ $[M]^+$: 317.9455, Found: 317.9432.



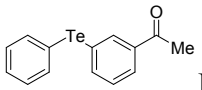
Phenyl(3-trifluoromethylphenyl)telluride[2] (3q):

Yield: 0.093 g (66%); Yellow oil; ^1H NMR ($CDCl_3$, 300 MHz): δ 7.89 (s, 1H), 7.82 - 7.70 (m, 3H), 7.40 - 7.17 (m, 5H). ^{13}C NMR ($CDCl_3$, 75 MHz): δ 140.4, 138.8, 133.6 (q, J_{C-F} = 3 Hz), 131.4 (q, J_{C-F} = 32 Hz), 129.8, 125.5, 128.5, 124.4 (q, J_{C-F} = 3 Hz), 123.6 (q, J_{C-F} = 272 Hz), 115.8, 113.7. MS *m/z* (relative intensity): 352 (M^+, 15), 222 (88), 203 (10), 153 (16), 145 (17), 126 (20), 95 (11), 77 (100), 51 (72), 40 (16).



Phenyl(naphthalen-2-yl)telluride (3r):

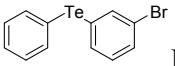
Yield: 0.107 g (80%); Yellow solid; mp 39-42 °C; ^1H NMR ($CDCl_3$, 300 MHz): δ 8.23 (s, 1H), 7.82 - 7.76 (m, 1H), 7.74 - 7.63 (m, 5H), 7.49 - 7.42 (m, 2H), 7.32 - 7.16 (m, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz): δ 137.8, 134.7, 134.3, 132.6, 129.5 (2C), 128.6, 127.8, 127.7, 127.4, 126.4, 126.3, 114.8, 111.9.MS *m/z* (relative intensity): 334 (M^+, 12), 204 (100), 127 (59), 101 (10), 77 (48), 51 (33). HRMS calculated for $C_{16}H_{12}Te$ $[M]^+$: 334.0001, Found: 333.9999.



Phenyl(3-acetylphenyl)telluride (3s):

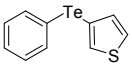
Yield: 0.068 g (52%); Yellow oil; ^1H NMR ($CDCl_3$, 300 MHz): δ 8.40 - 8.05 (m, 2H), 7.89 - 7.77 (m, 2H), 7.77 - 7.69 (m, 2H), 7.35 - 7.17 (m, 2H), 2.53 (s, 3H). ^{13}C NMR ($CDCl_3$, 75 MHz): δ 197.5, 141.8, 138.5, 137.8, 137.1, 129.6, 129.5, 128.2, 127.5, 115.5, 114.0, 26.6. MS *m/z* (relative intensity): 326 (M^+, 14), 207 (13), 181 (56), 153 (31), 77 (96), 51 (60, 43 (100), 40 (13). HRMS calculated for $C_{14}H_{12}OTe$ $[M]^+$: 325.9950, Found: 325.9948.

[2] S. Roy, T. Chatterjee and S. M. Islam, *Tetradedron Lett.*, 2015, **56**, 779.



Phenyl(3-bromophenyl)telluride (3t):

Yield: 0.090 g (62%); Yellow oil; ^{1}H NMR ($CDCl_3$, 300 MHz): δ 7.83 - 7.66 (m, 3H), 7.53 (dt, J = 7.8, 1.2 Hz, 1H), 7.43 - 7.16 (m, 4H), 7.03 (t, J = 7.8 Hz, 1H). ^{13}C NMR ($CDCl_3$, 75 MHz): δ 139.4, 138.6, 135.7, 130.7, 130.7, 129.7, 128.3, 123.3, 116.7, 113.9. MS *m/z* (relative intensity): 362 (M^+, 16), 234 (52), 152 (33), 77 (100), 51 (63). HRMS calculated for $C_{12}H_9BrTe$ $[M]^+$: 361.8950, Found: 361.8932.



Phenyl(3-thienyl)telluride[3] (3u):

Yield: 0.101 g (87%); Yellow oil; ^{1}H NMR ($CDCl_3$, 300 MHz): δ 7.47 - 7.44 (m, 3H), 7.14 - 7.05 (m, 5H). ^{13}C NMR ($CDCl_3$, 75 MHz): δ 136.7, 136.3, 134.4, 129.3, 127.4, 127.1, 115.2, 103.8. MS *m/z* (relative intensity): 290 (M^+, 28), 288 (27), 160 (100), 128 (13), 115 (17), 77 (47), 51 (30).

High Resolution Mass Spectrometry Experiments

The experiments were performed using a Bruker Daltonics micrOTOF-Q II instrument equipped with an ESI source operating in positive mode or negative mode. For mechanistic investigation, aliquots were taken directly from the reaction mixture, immediately solubilized MeCN/MeOH (1:1) and inject in the ESI source at a constant flow rate of 180 µL/min. The Acquisition parameters were: capillary: 4000 V, end plate offset: - 500 V, nebulizer: 0.4 bar, dry gas: 4.0 L min^{-1}, and dry heater: 180 °C. The collision cell energy was set to 5.0 eV. The spectra analysis and simulate pattern were performed using Bruker Compass Data Analysis 4.3 software package.

[3] D. Kundu, N. Mukherjee and B. C. Ranu, *RSC Adv.*, 2013, **3**, 117.

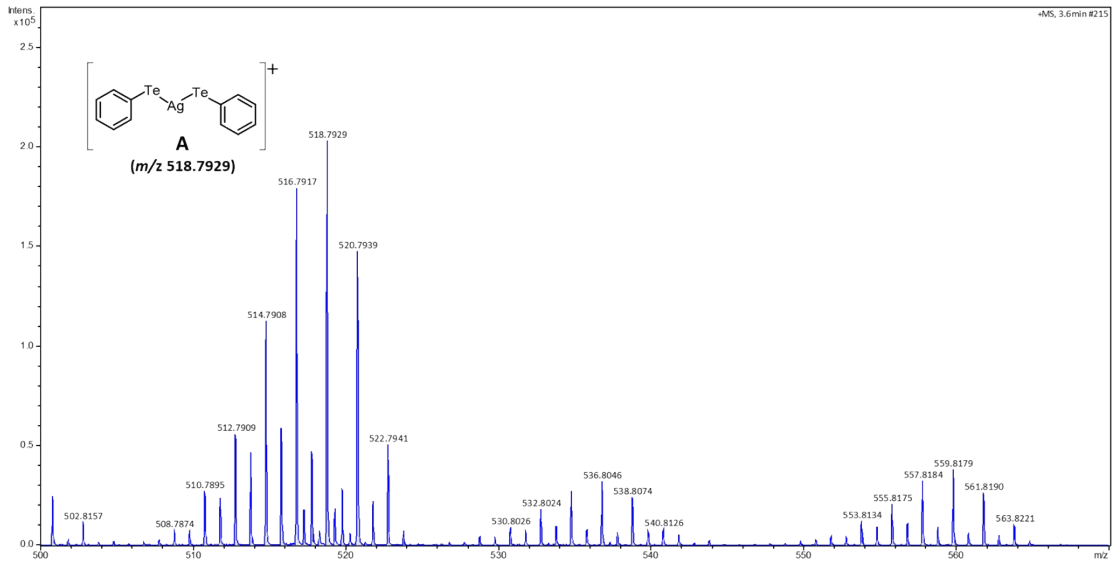


Figure S1. HRMS spectrum (ESI+) collected by direct infusion of diphenyl telluride (0.1 mmol) and equimolar amount of silver(I) nitrate (0.1 mmol) in 1,4-dioxane (400 µL).

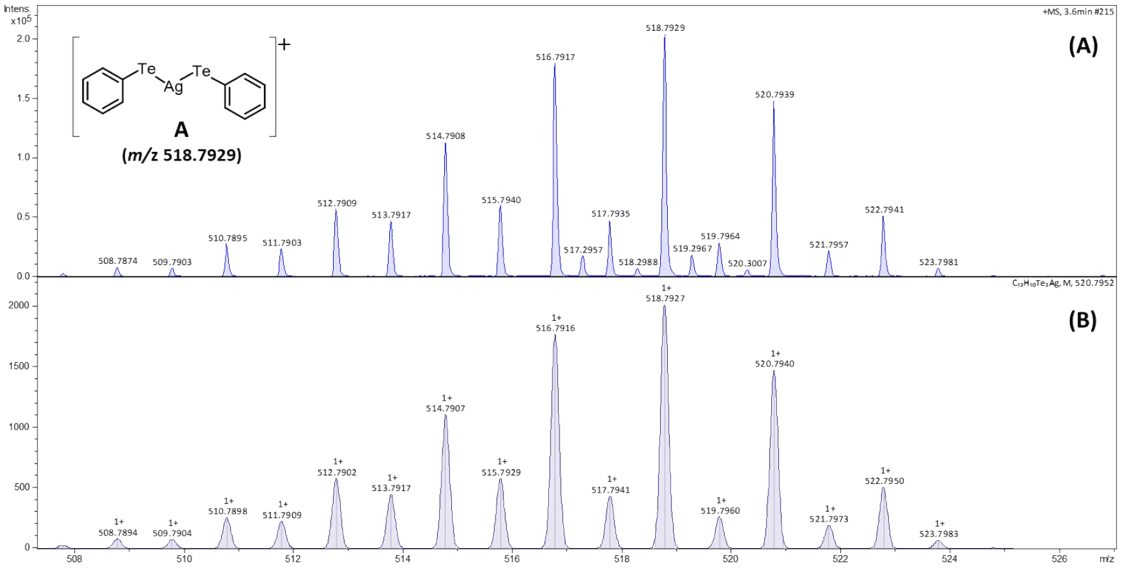


Figure S2. Isotope pattern for the positive ion with *m/z* 518.7929 **(A)** and the simulated isotope pattern for the formula $C_{12}H_{10}Te_2Ag$ **(B)**.

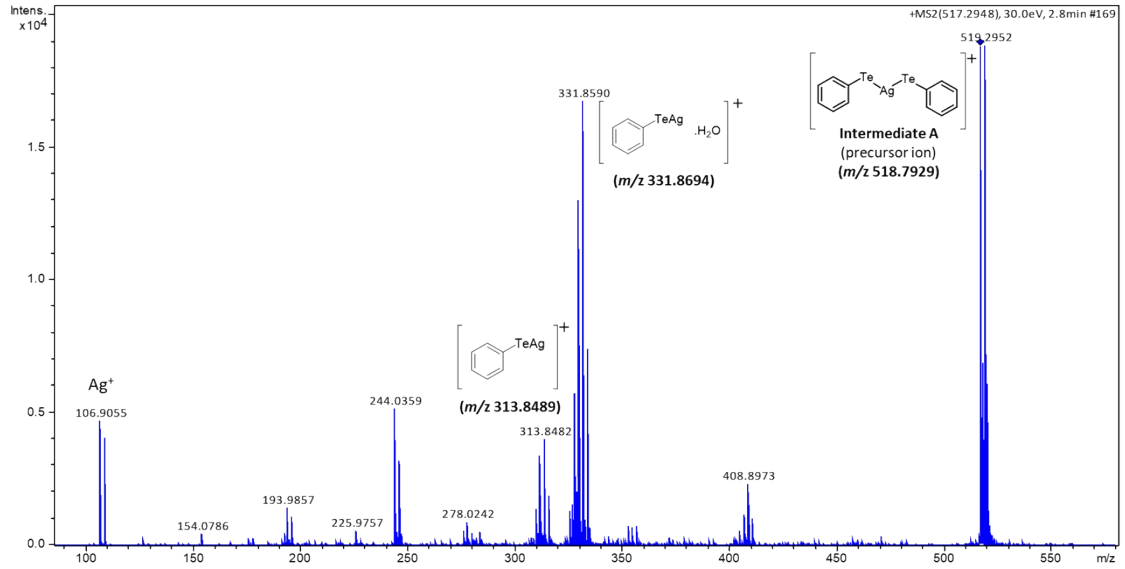


Figure S3. MS^2 spectrum (50 eV) of the precursor ion m/z 18 leading to formation of the fragments confirming the structural identity of the intermediate **A**. The *m/z* showed in parentheses correspond to the calculated *m/z* of most intense peak among the isotopic peaks.

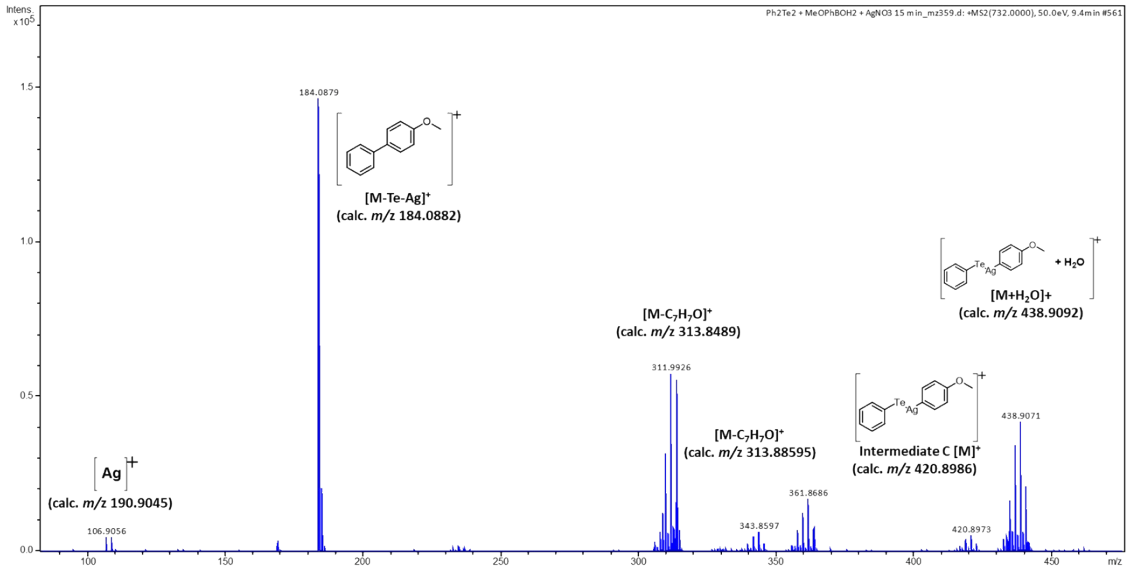


Figure S4. MS^2 spectrum (50 eV) of the precursor ion m/z 438 leading to formation of the fragments the fragments which confirm the structural identity of the intermediate **C**. The *m/z* showed in parentheses correspond to the calculated *m/z* of most intense peak among the isotopic peaks.

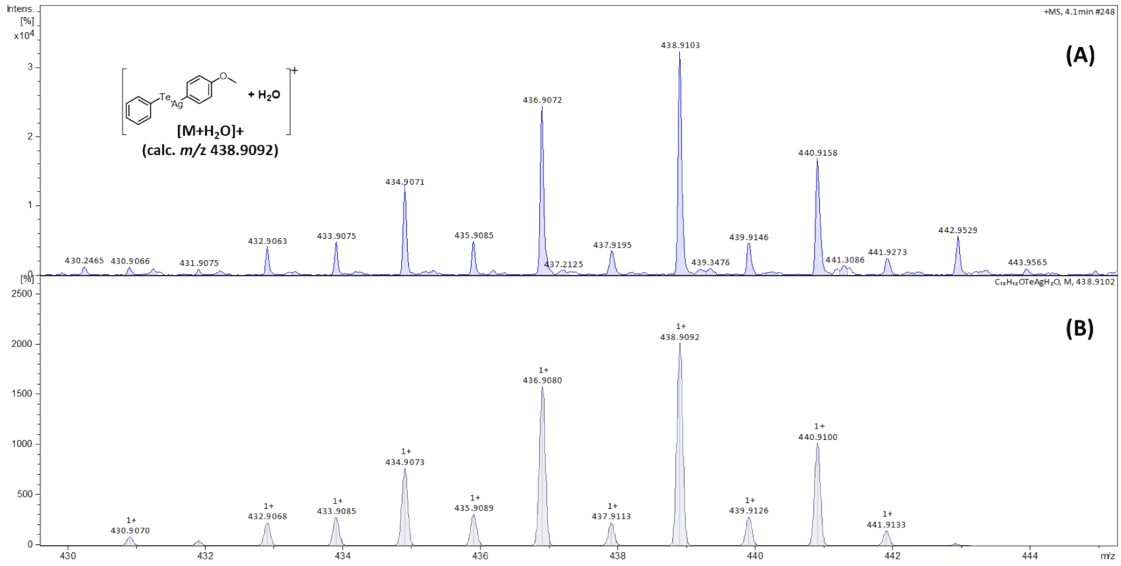


Figure S5. Isotope pattern for the positive ion with *m/z* 438.9092 **(A)** and the simulated isotope pattern for the adduct with formula $C_{13}H_{12}O_2TeAg$ **(B)**.

SELECTED SPECTRA

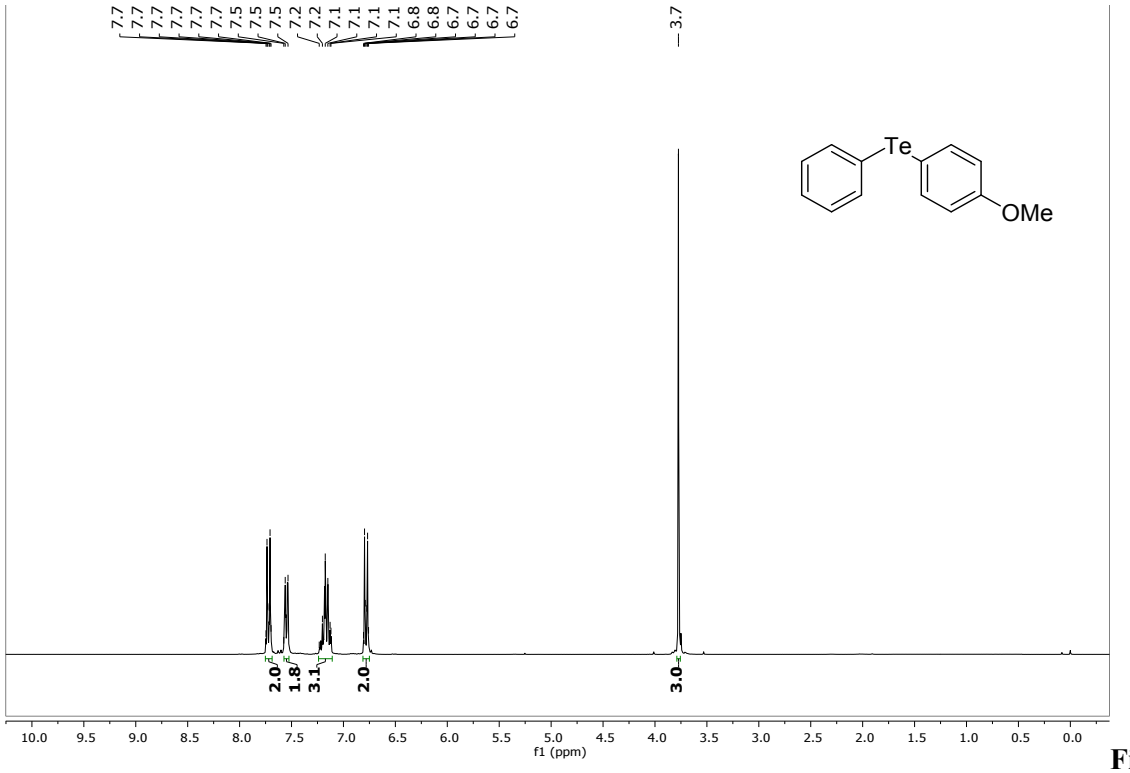


Figure S5. ^{1}H NMR (300 MHz) spectrum for compound **3a** in $CDCl_3$.

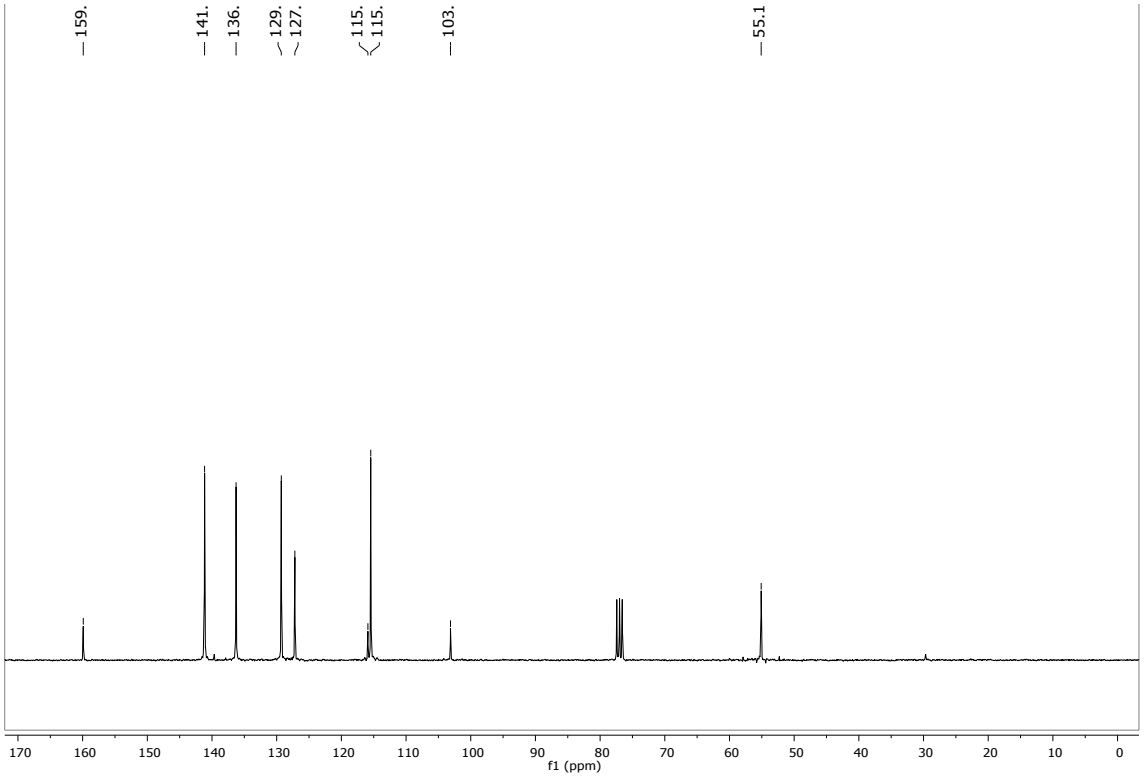


Figure S6. ^{13}C NMR (75 MHz) spectrum for compound **3a** in $CDCl_3$.

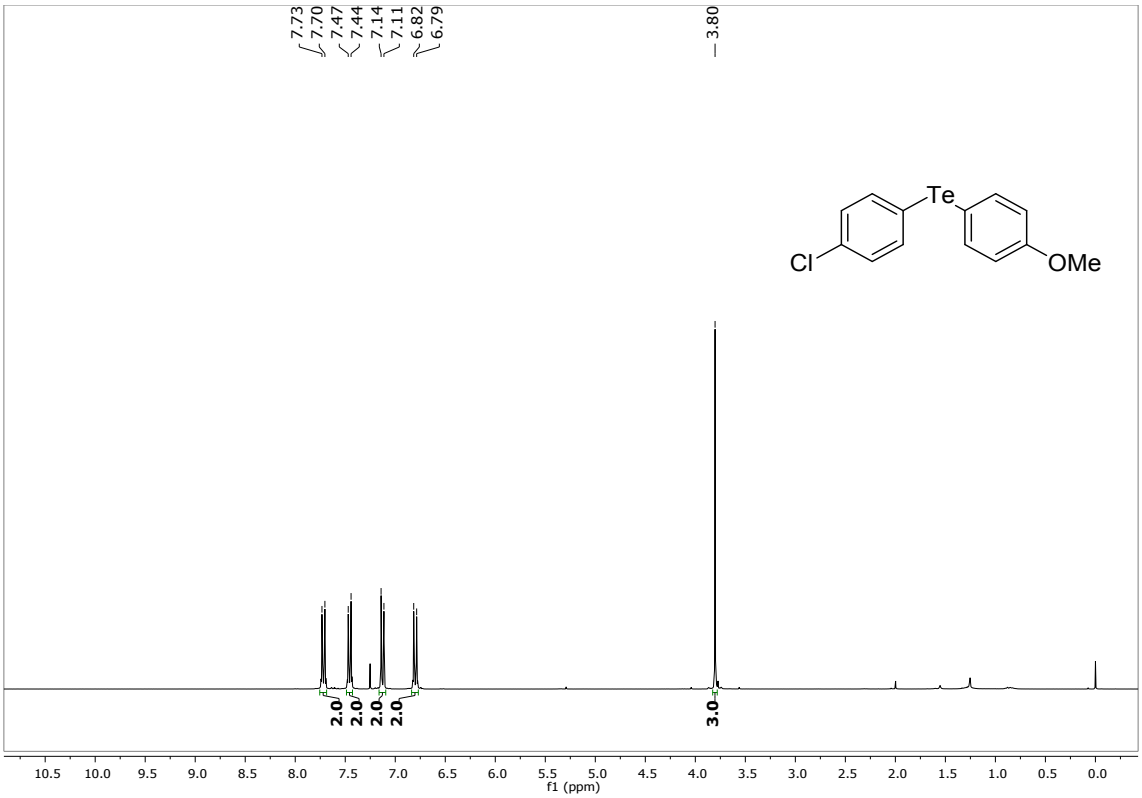


Figure S7. ^{1}H NMR (300 MHz) spectrum for compound **3b** in $CDCl_3$.

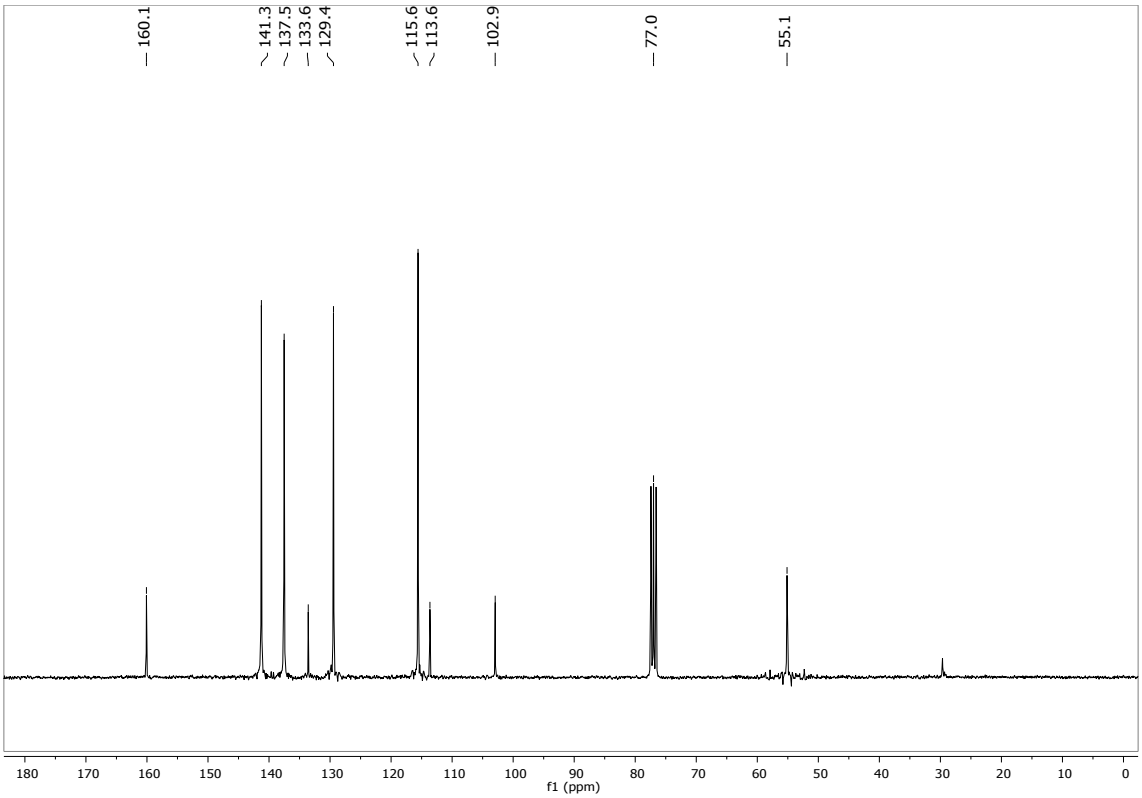


Figure S8. ^{13}C NMR (75 MHz) spectrum for compound **3b** in $CDCl_3$.

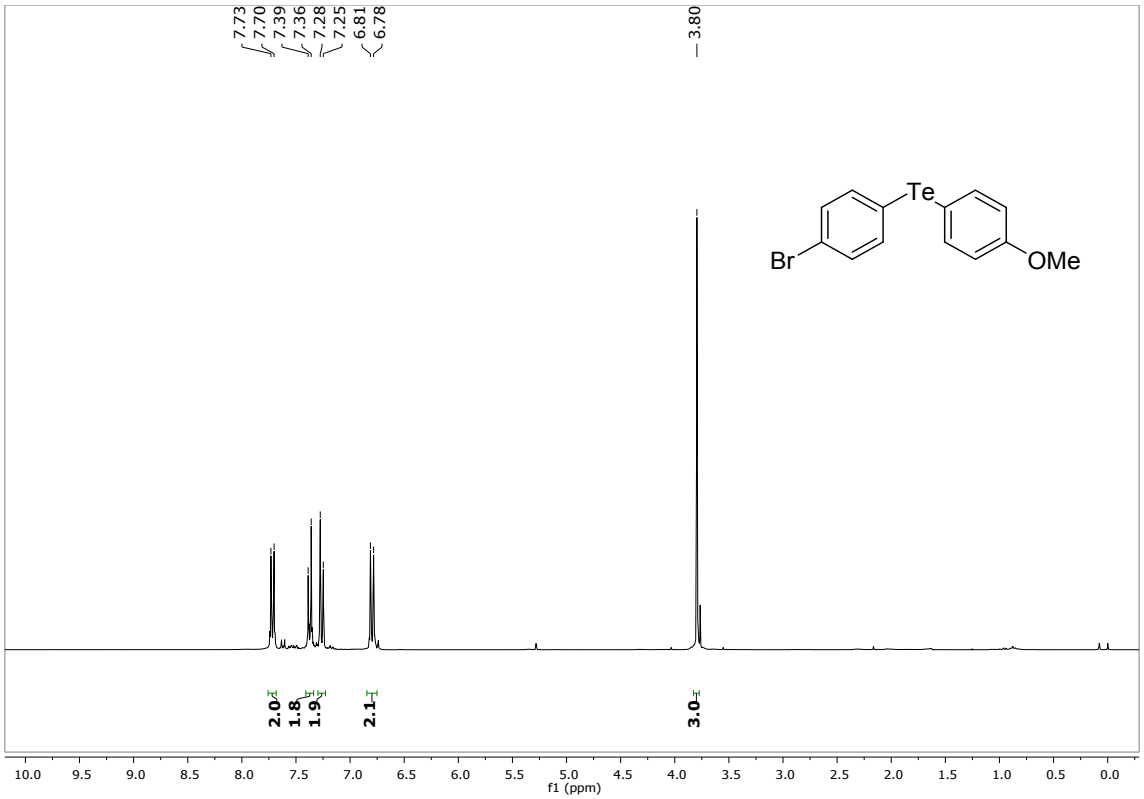


Figure S9. [1]H NMR (300 MHz) spectrum for compound **3c** in $CDCl_3$.

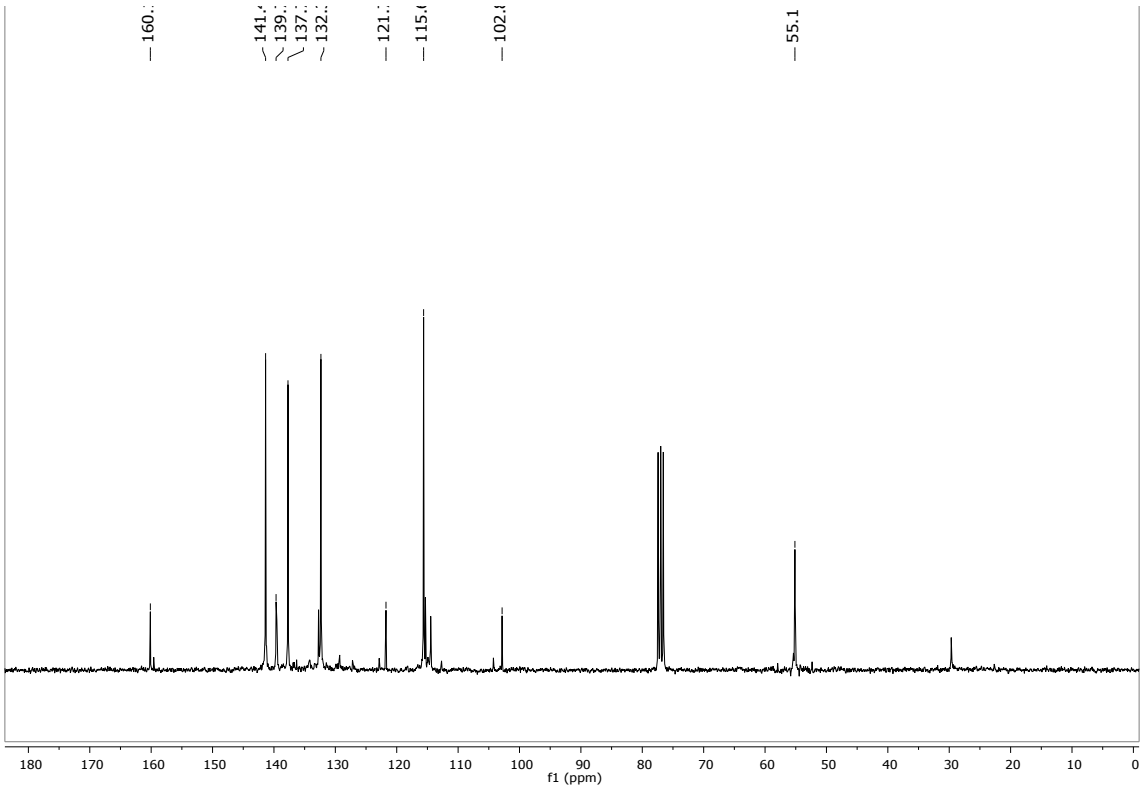


Figure S10. [13]C NMR (75 MHz) spectrum for compound **3c** in $CDCl_3$.

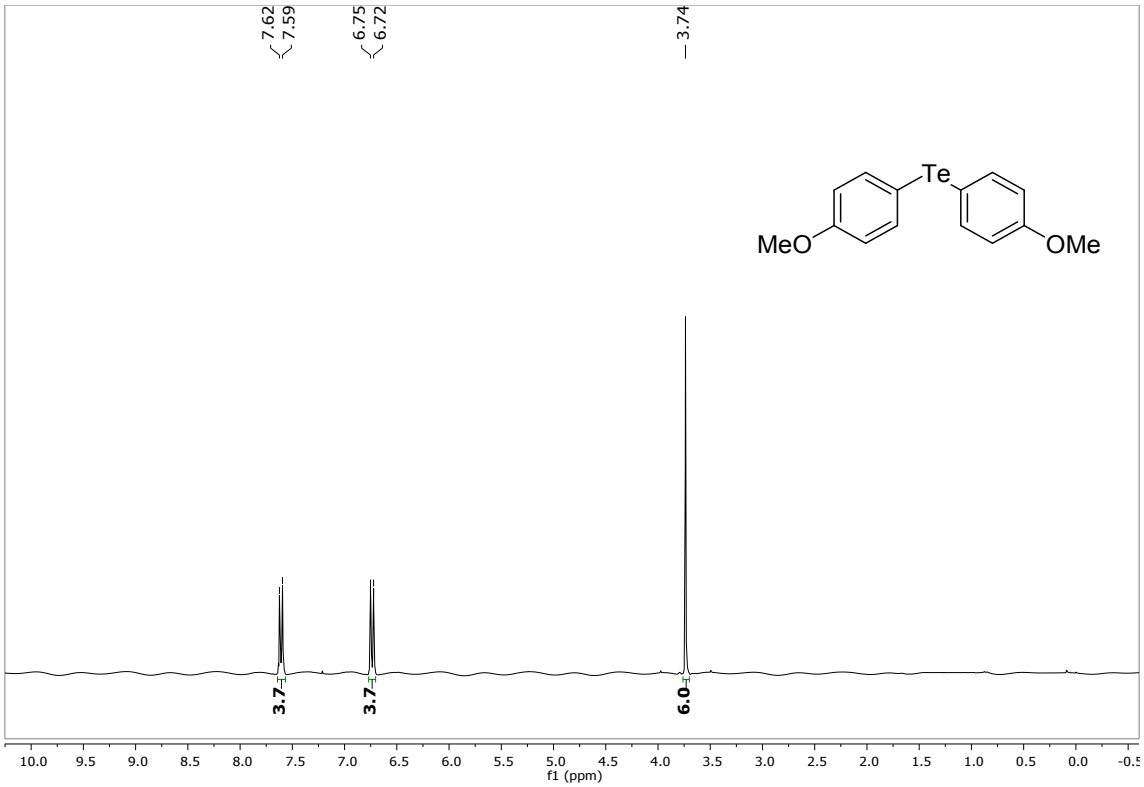


Figure S11. ^{1}H NMR (300 MHz) spectrum for compound **3d** in $CDCl_3$.

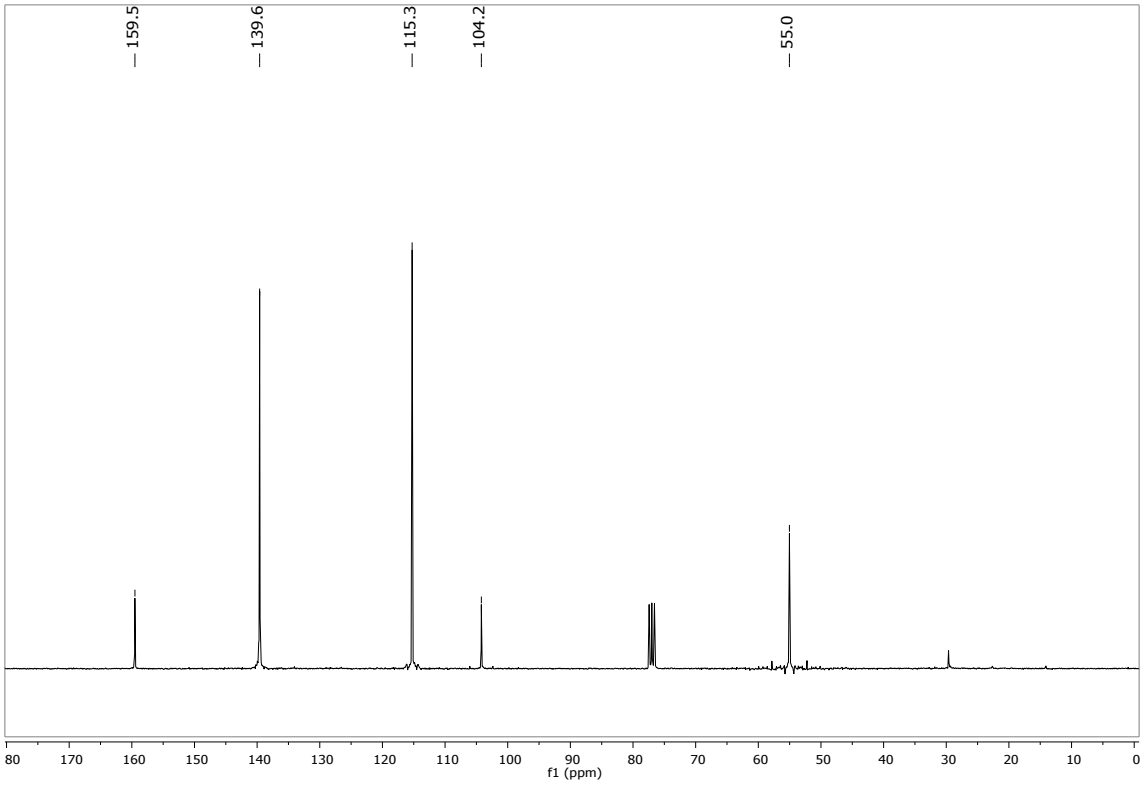


Figure S12. ^{13}C NMR (75 MHz) spectrum for compound **3d** in $CDCl_3$.

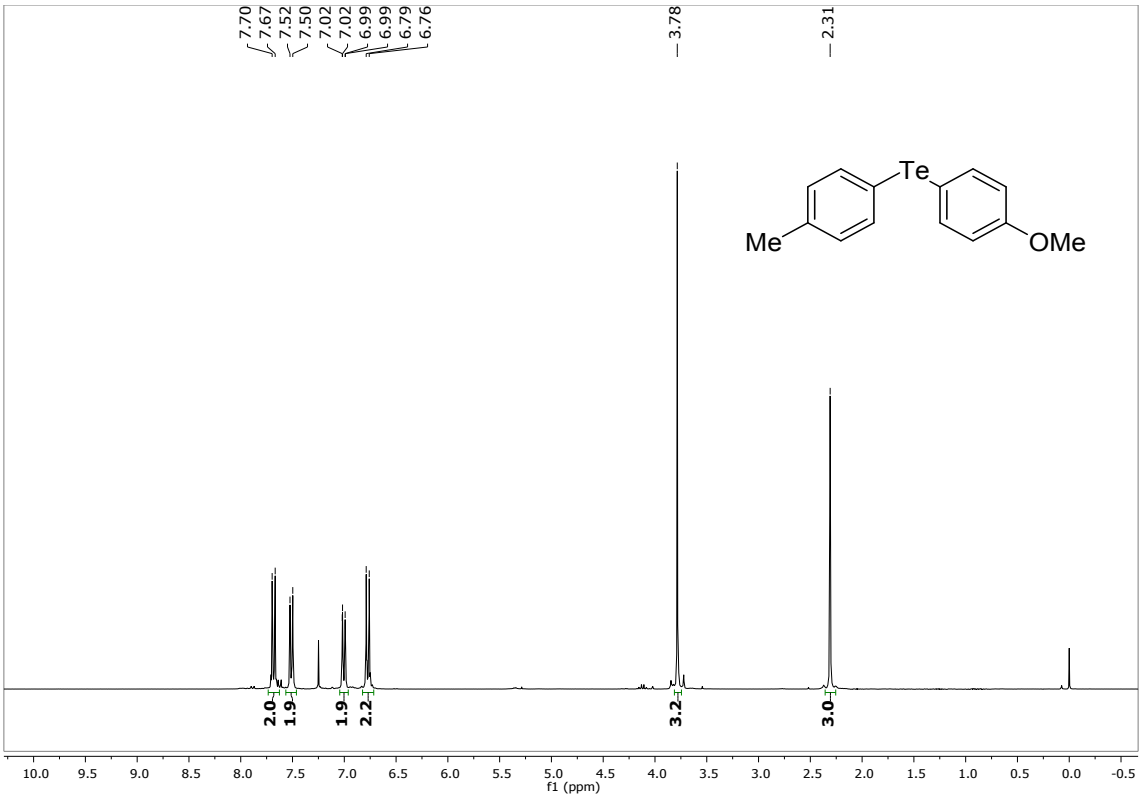


Figure S13. ^{1}H NMR (300 MHz) spectrum for compound **3e** in $CDCl_3$.

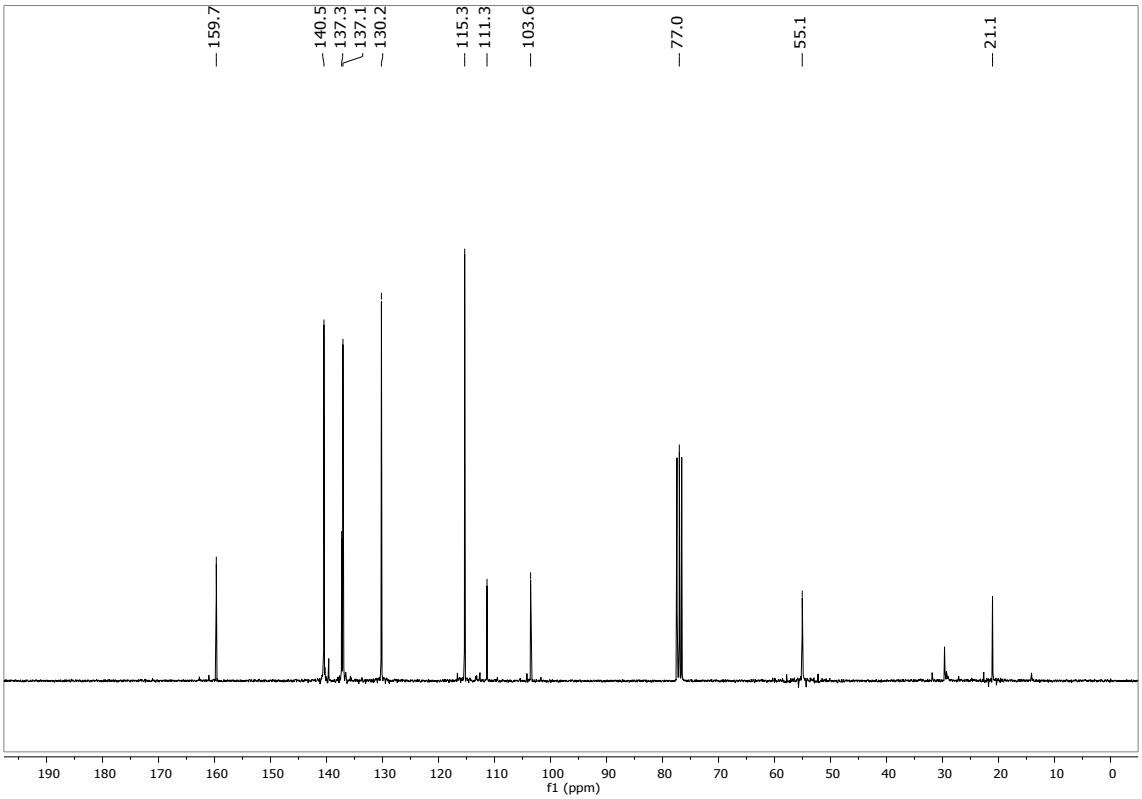


Figure S14. ^{13}C NMR (75 MHz) spectrum for compound **3e** in $CDCl_3$.

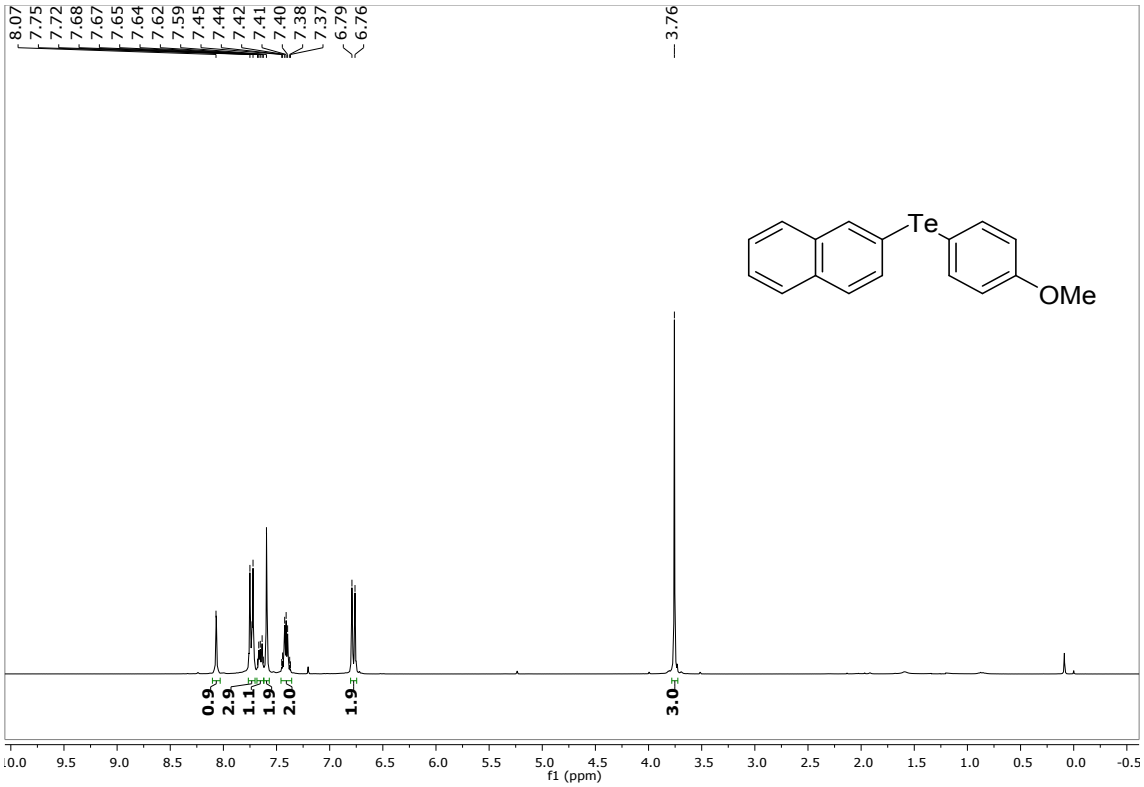


Figure S15. ^{1}H NMR (300 MHz) spectrum for compound **3f** in $CDCl_3$.

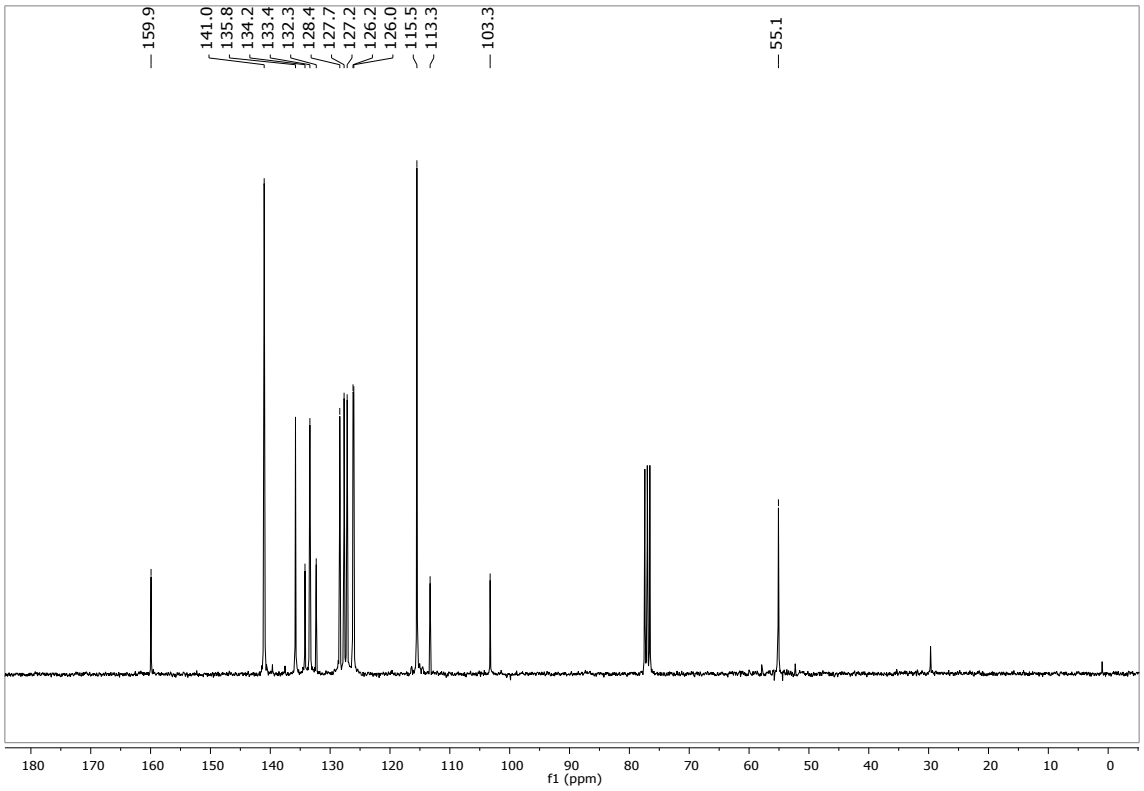


Figure S16. ^{13}C NMR (75 MHz) spectrum for compound **3f** in $CDCl_3$.

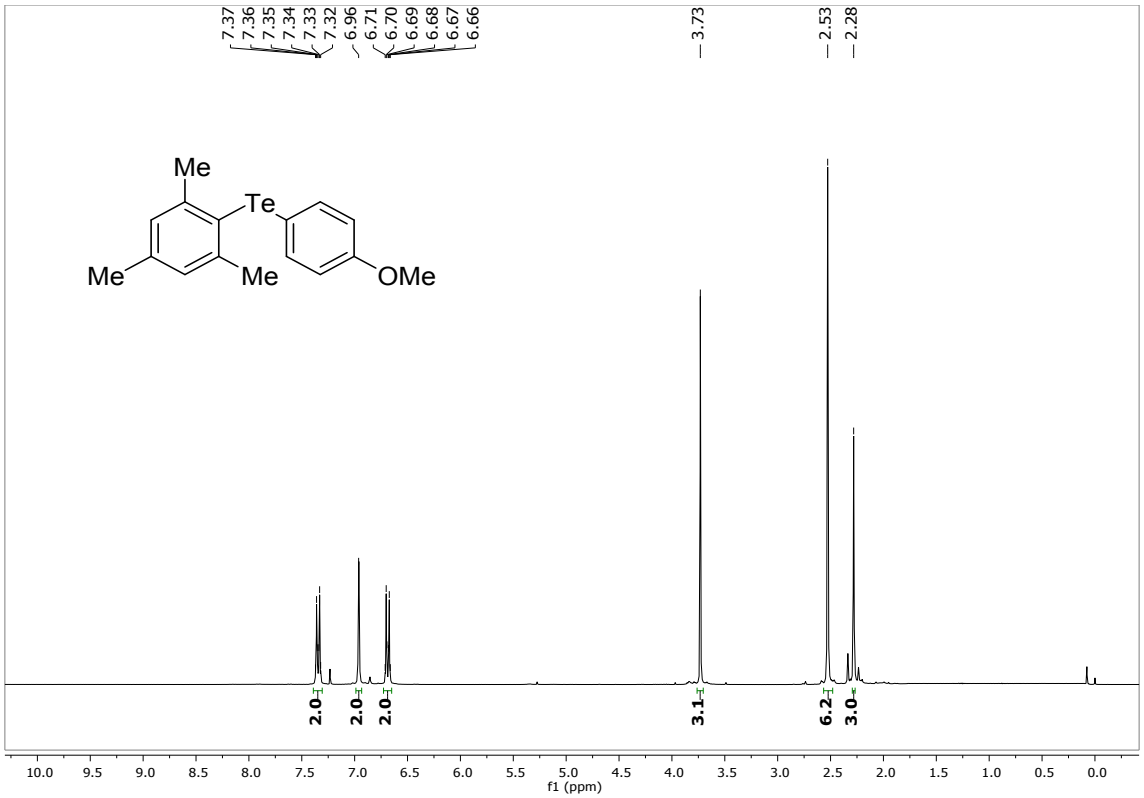


Figure S17. ^{1}H NMR (300 MHz) spectrum for compound **3g** in $CDCl_3$.

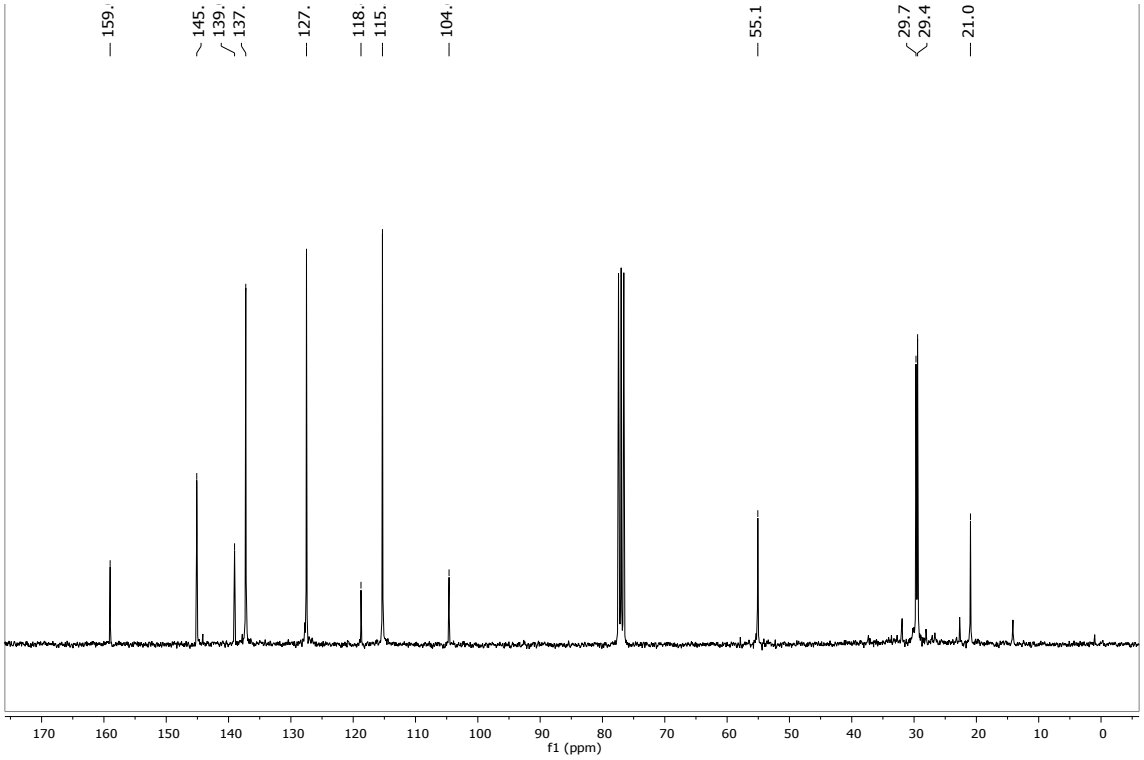


Figure S18. ^{13}C NMR (75 MHz) spectrum for compound **3g** in $CDCl_3$.

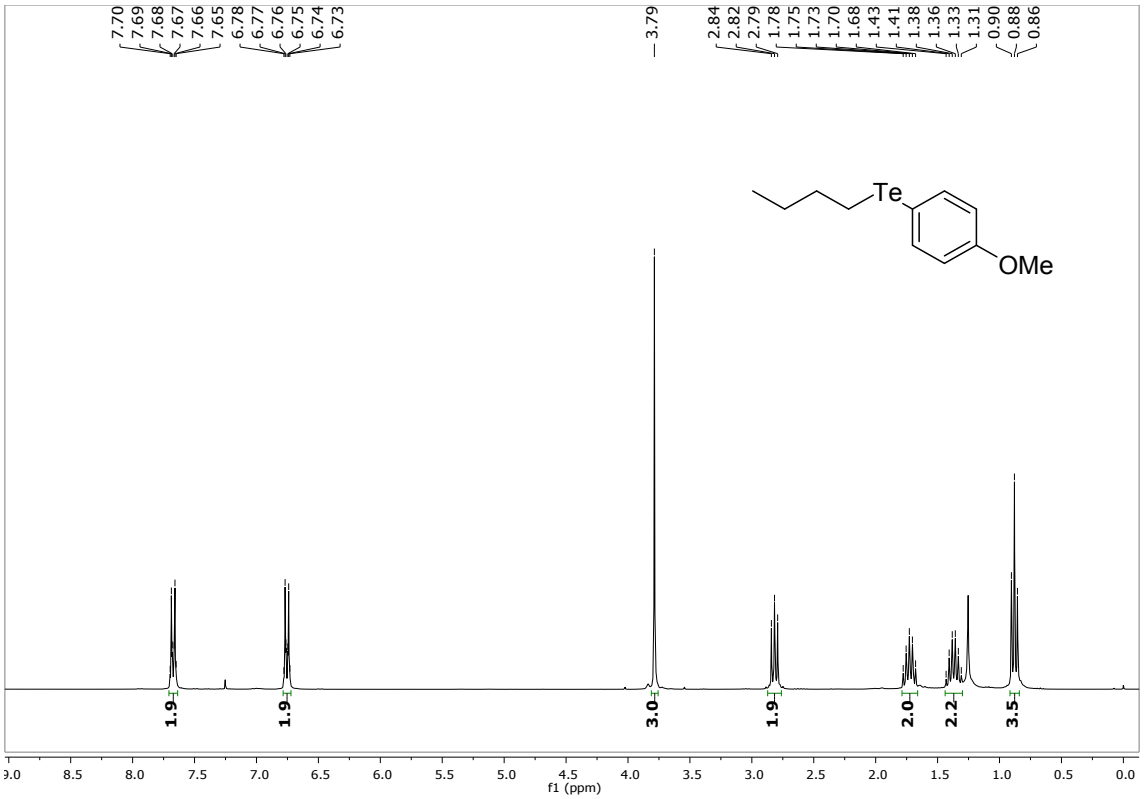


Figure S19. ^{1}H NMR (300 MHz) spectrum for compound **3h** in $CDCl_3$.

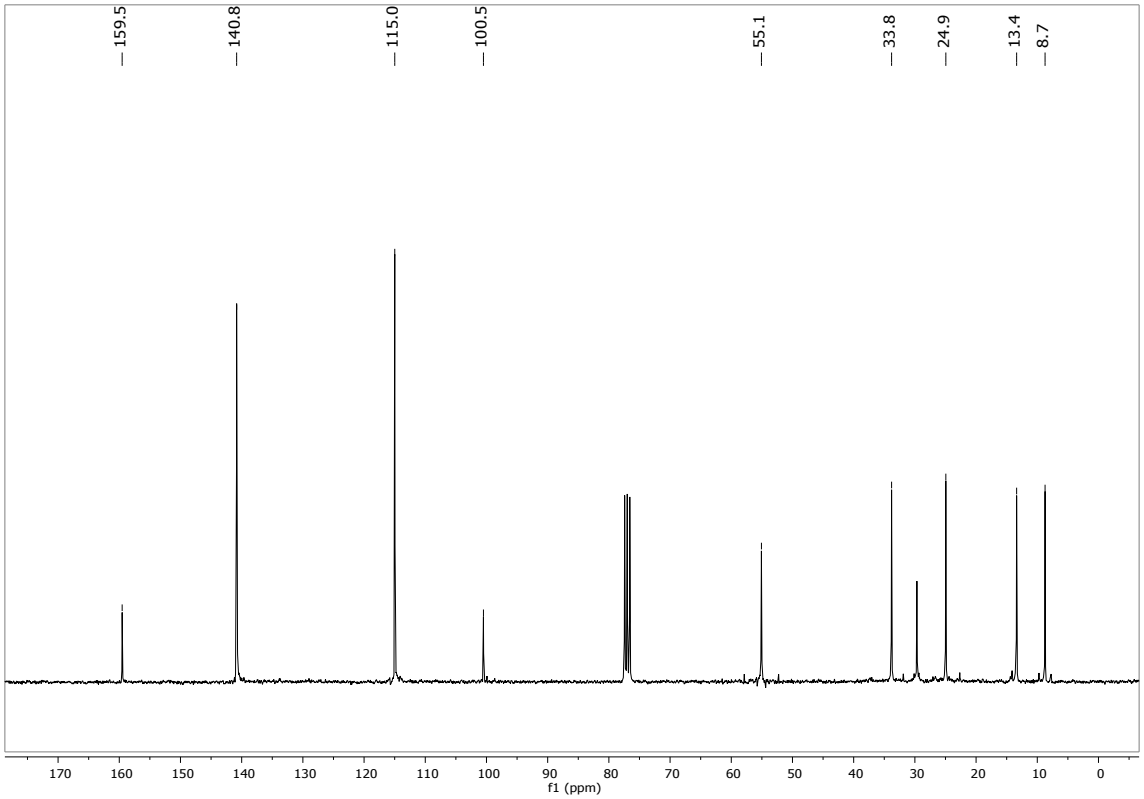


Figure S20. ^{13}C NMR (75 MHz) spectrum for compound **3h** in $CDCl_3$.

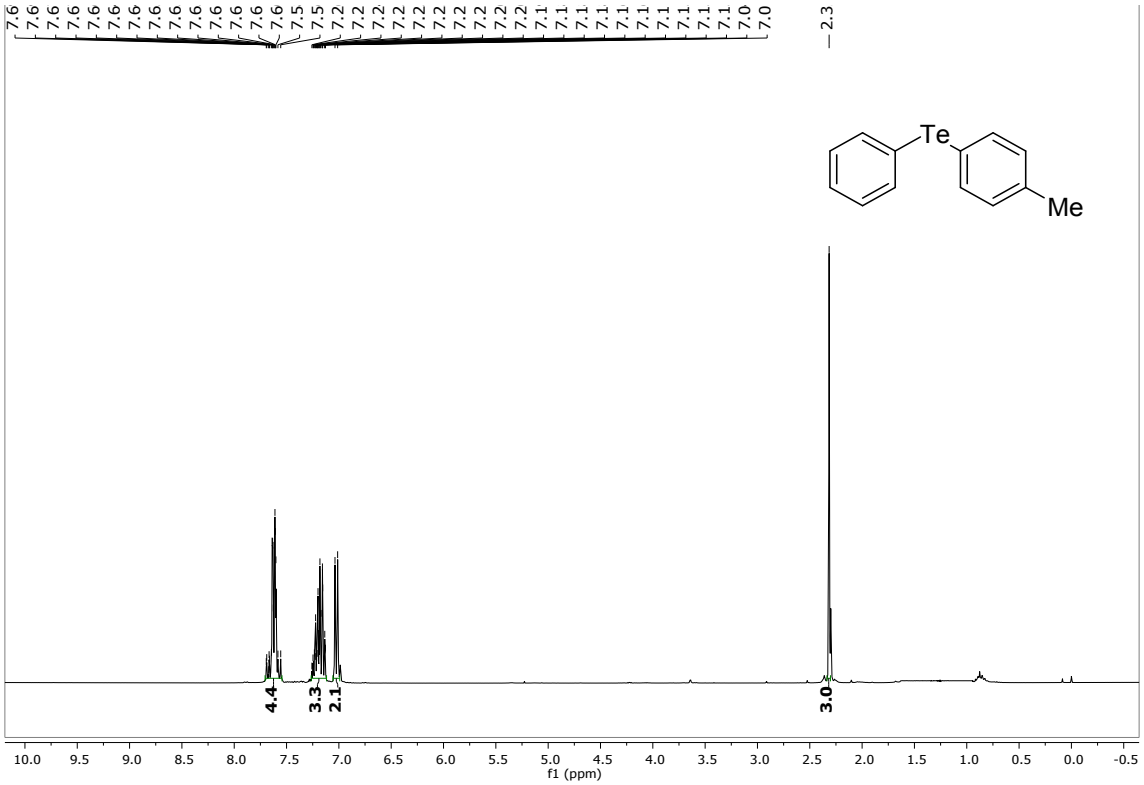


Figure S21. [1]H NMR (300 MHz) spectrum for compound **3i** in $CDCl_3$.

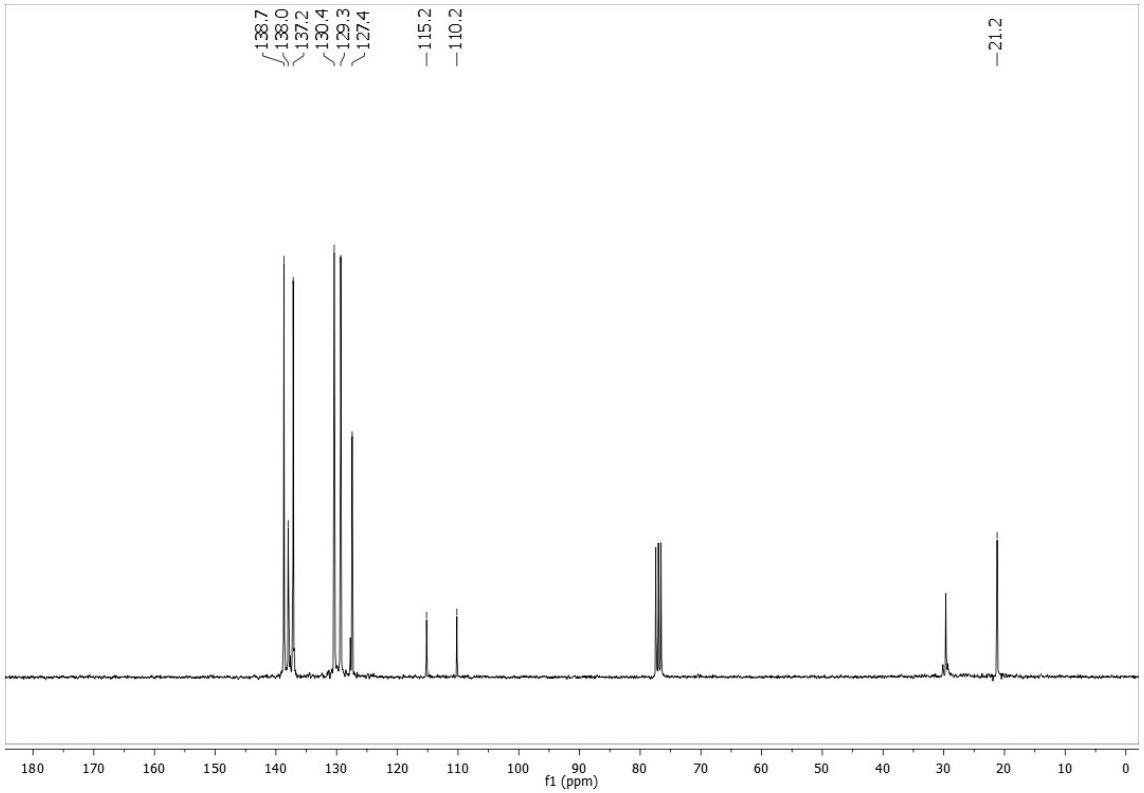


Figure S22. [13]C NMR (75 MHz) spectrum for compound **3i** in $CDCl_3$.

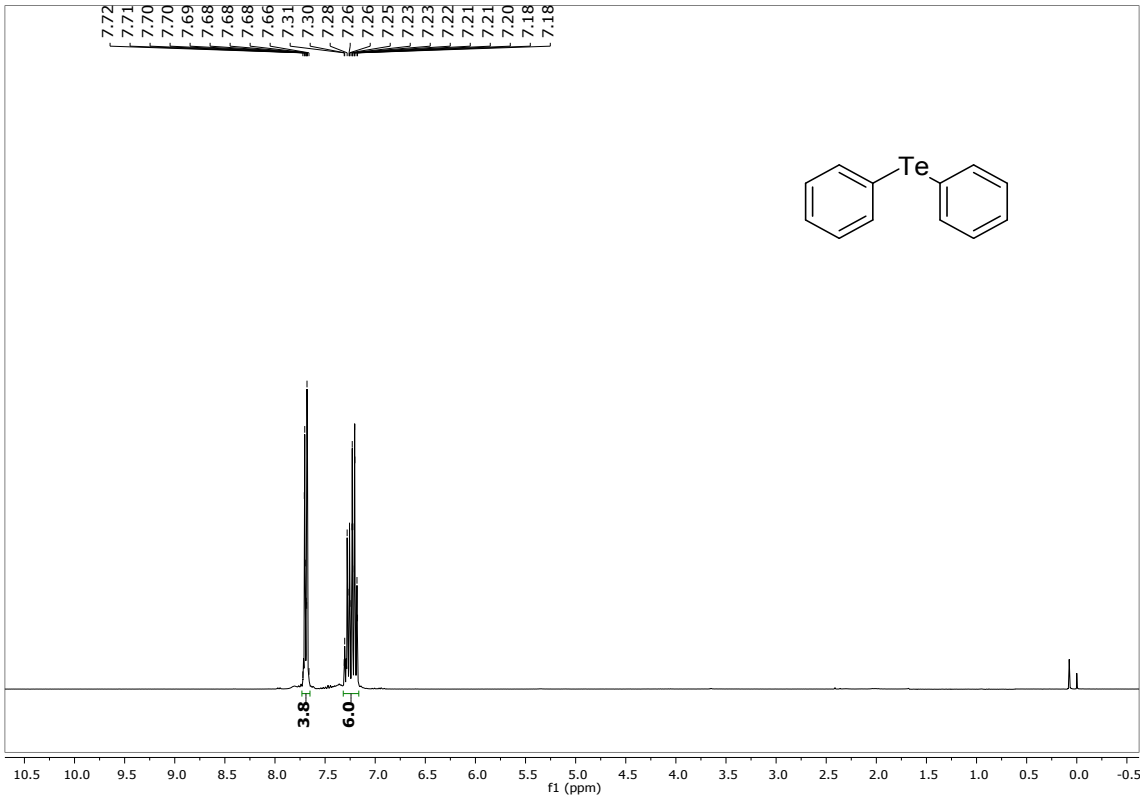


Figure S23. ^{1}H NMR (300 MHz) spectrum for compound **3j** in $CDCl_3$.

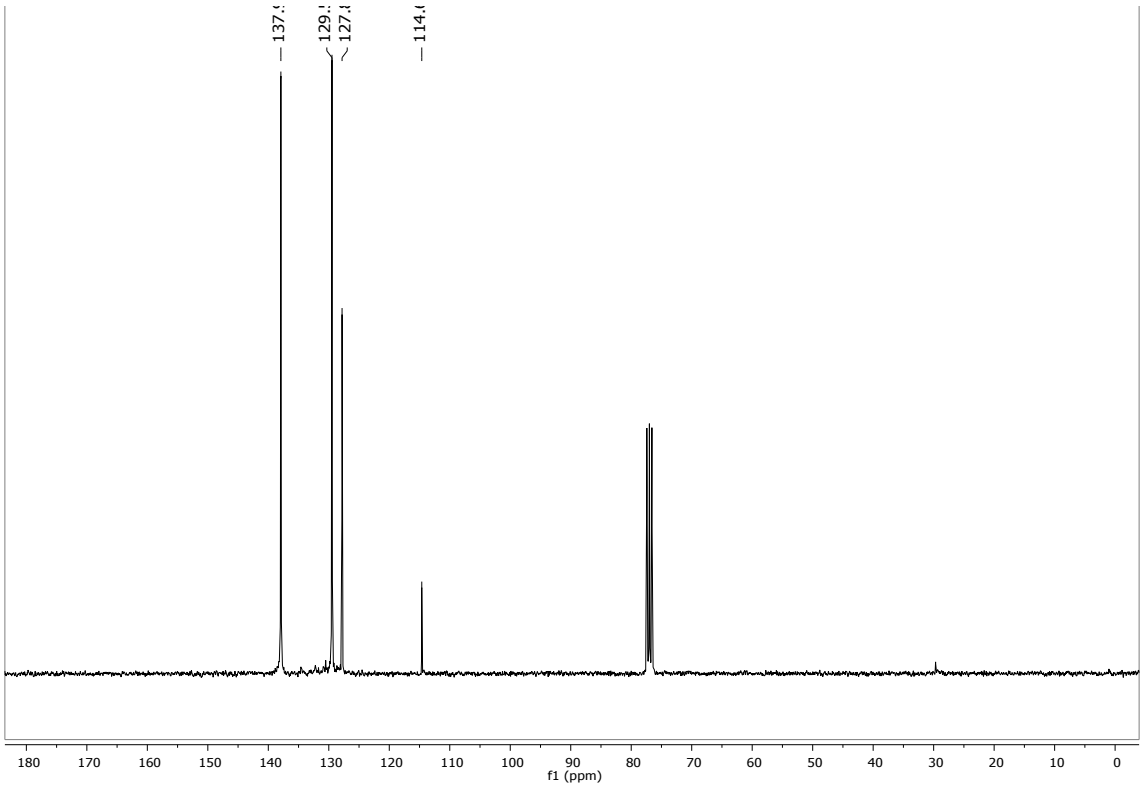


Figure S24. ^{13}C NMR (75 MHz) spectrum for compound **3j** in $CDCl_3$.

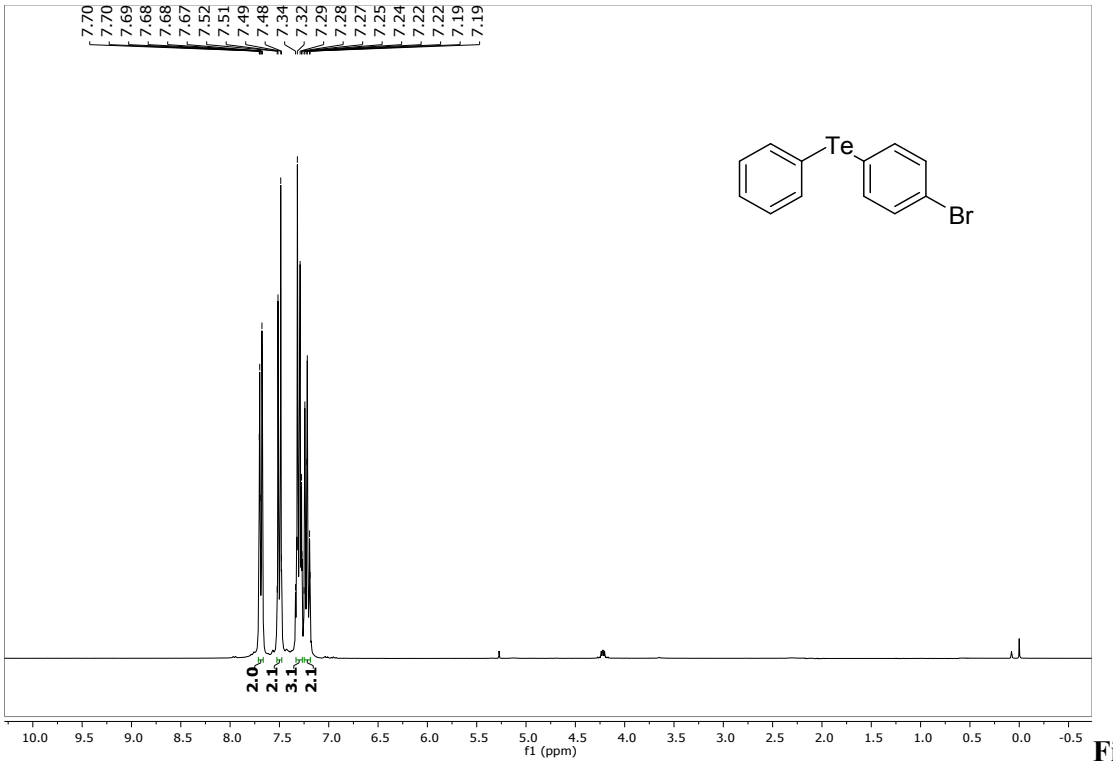


Figure S25. ^{1}H NMR (300 MHz) spectrum for compound **3k** in $CDCl_3$.

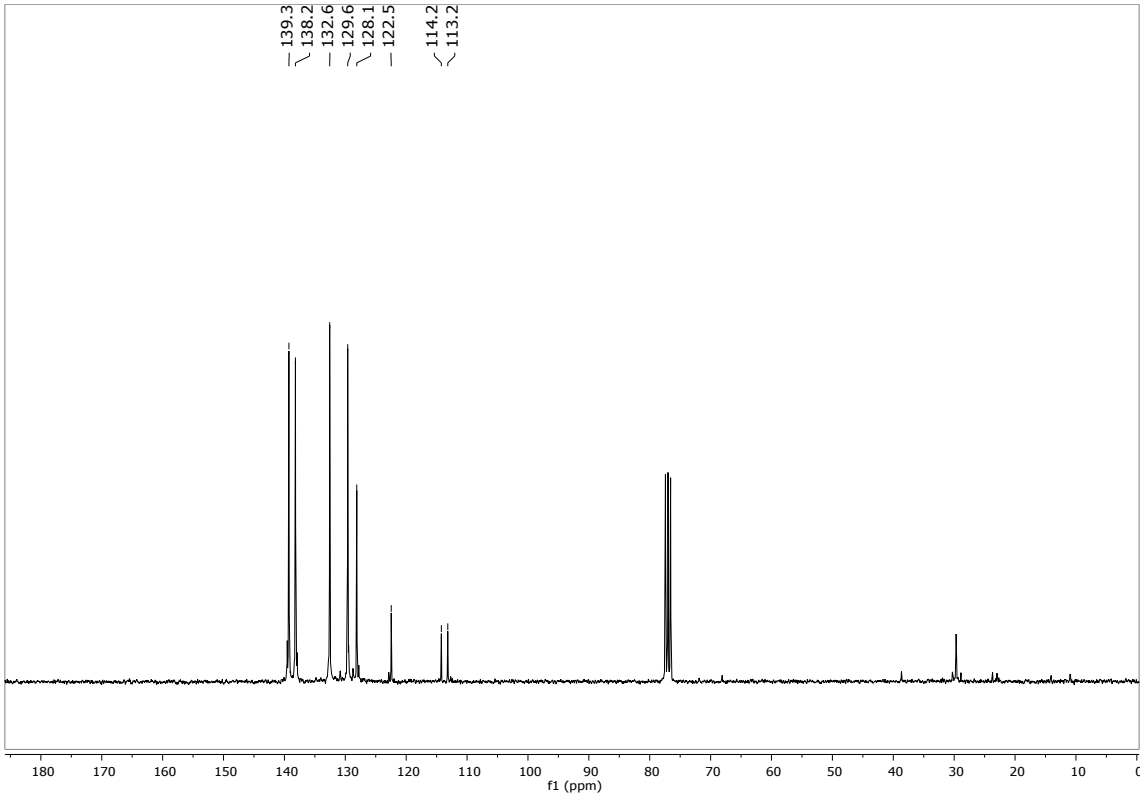


Figure S26. ^{13}C NMR (75 MHz) spectrum for compound **3k** in $CDCl_3$.

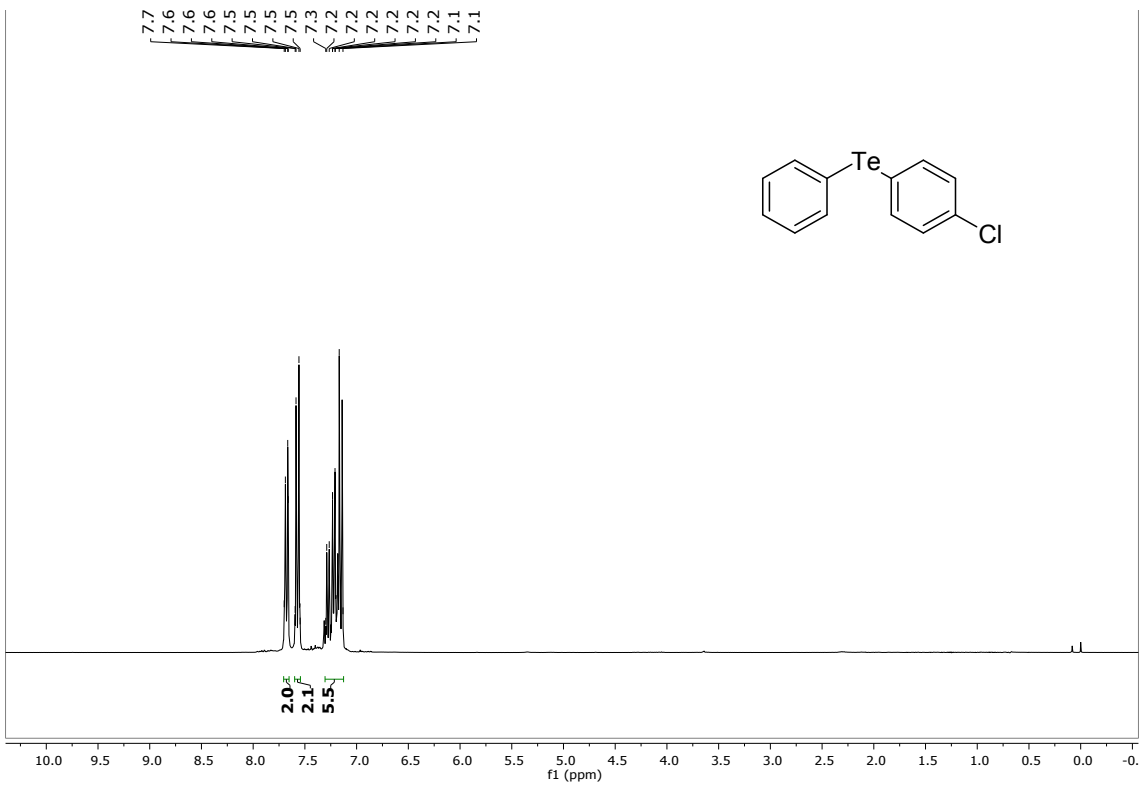


Figure S27. ^{1}H NMR (300 MHz) spectrum for compound **3l** in $CDCl_3$.

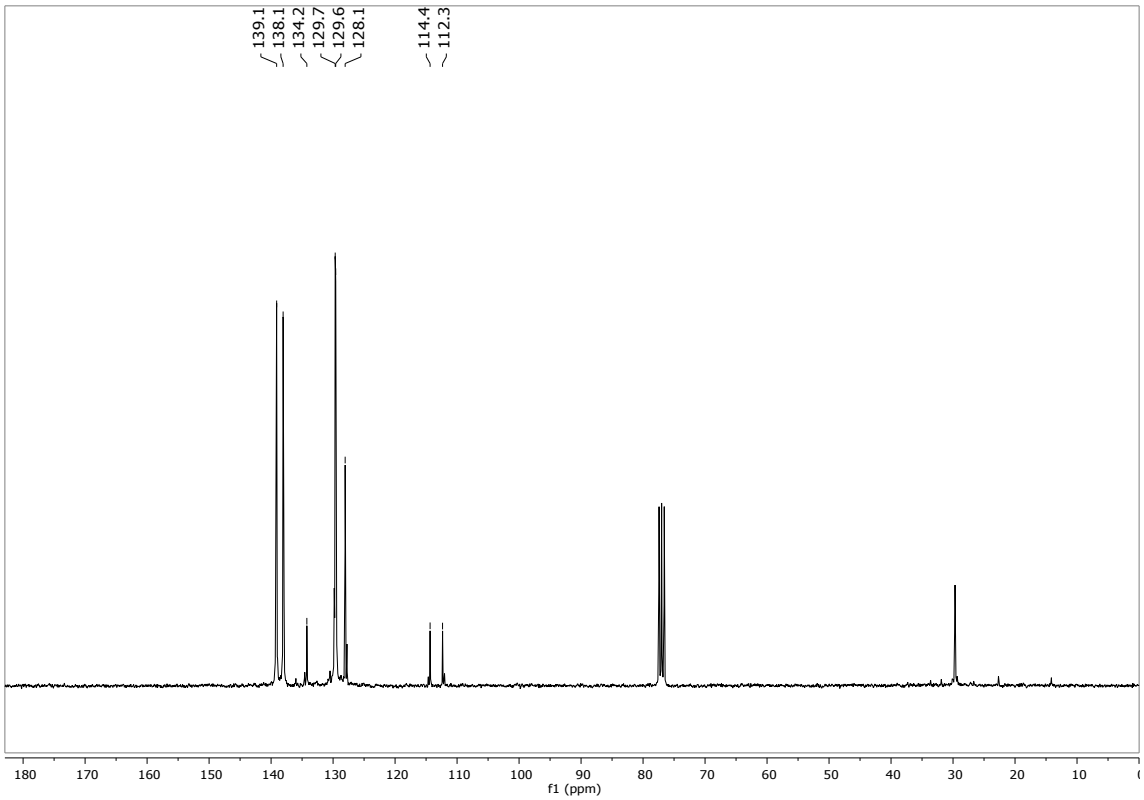


Figure S28. ^{13}C NMR (75 MHz) spectrum for compound **3l** in $CDCl_3$.

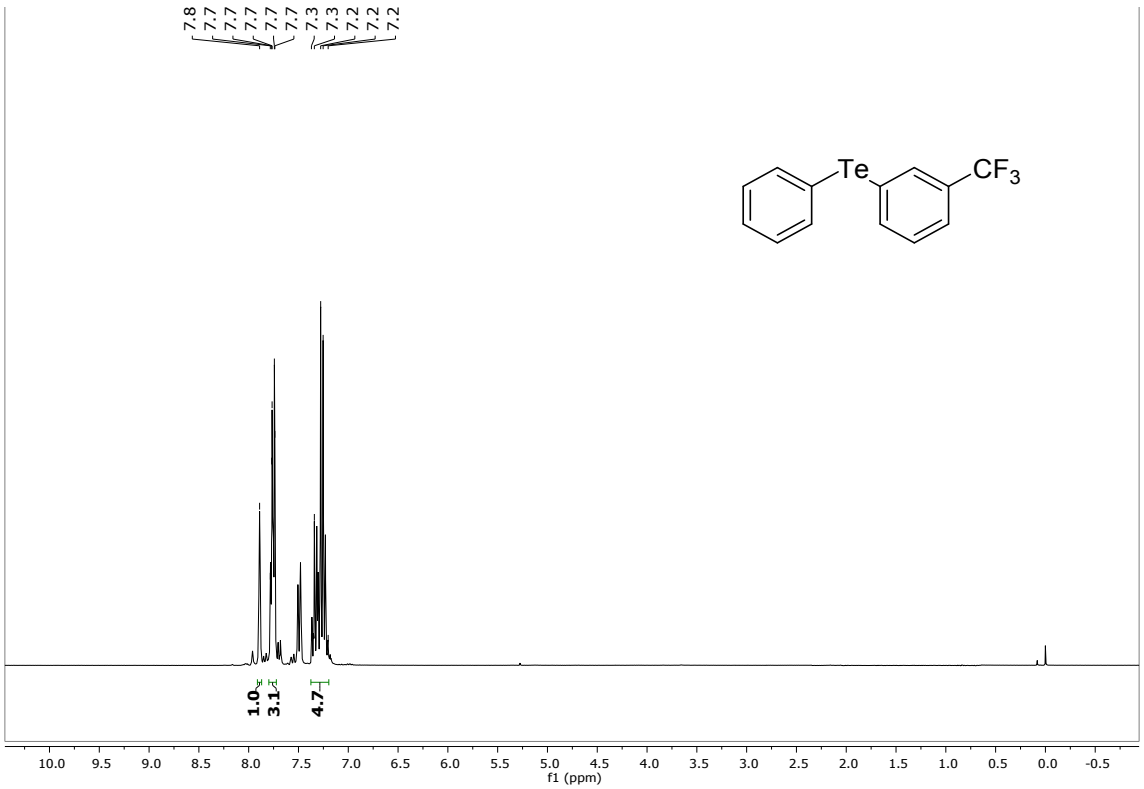


Figure S29. [1]H NMR (300 MHz) spectrum for compound **3m** in $CDCl_3$.

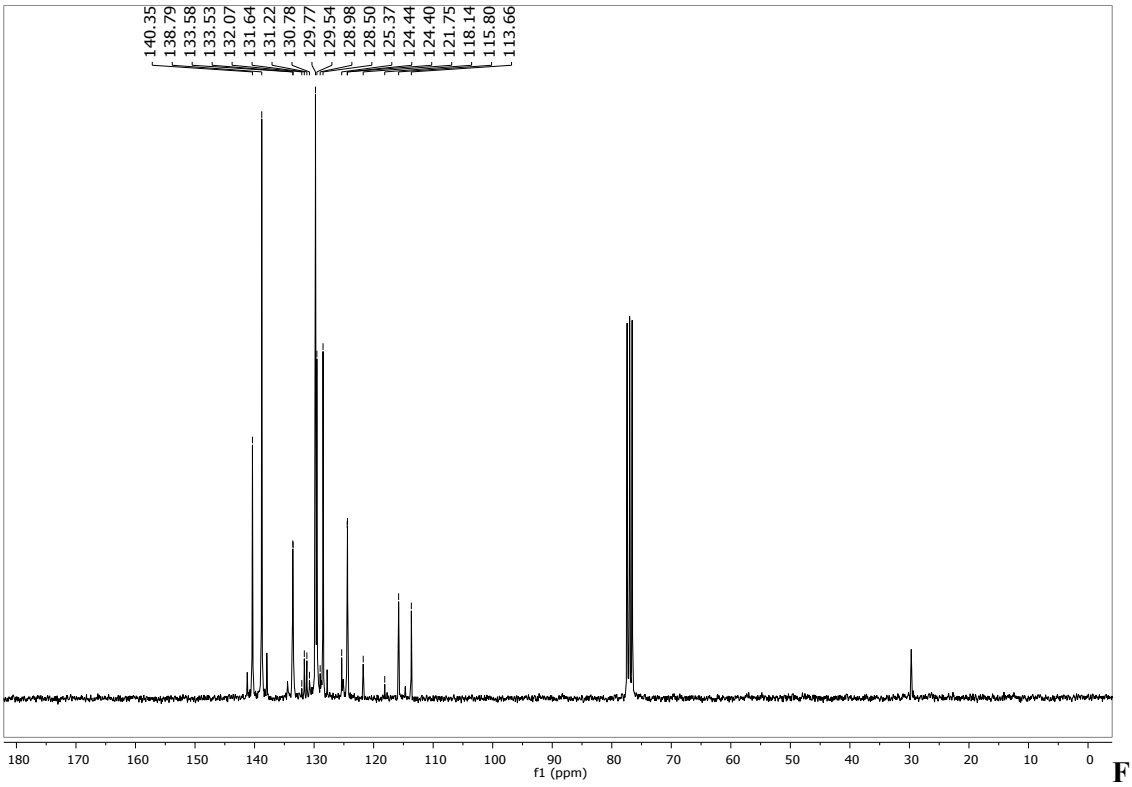


Figure S30. [13]C NMR (75 MHz) spectrum for compound **3m** in $CDCl_3$.

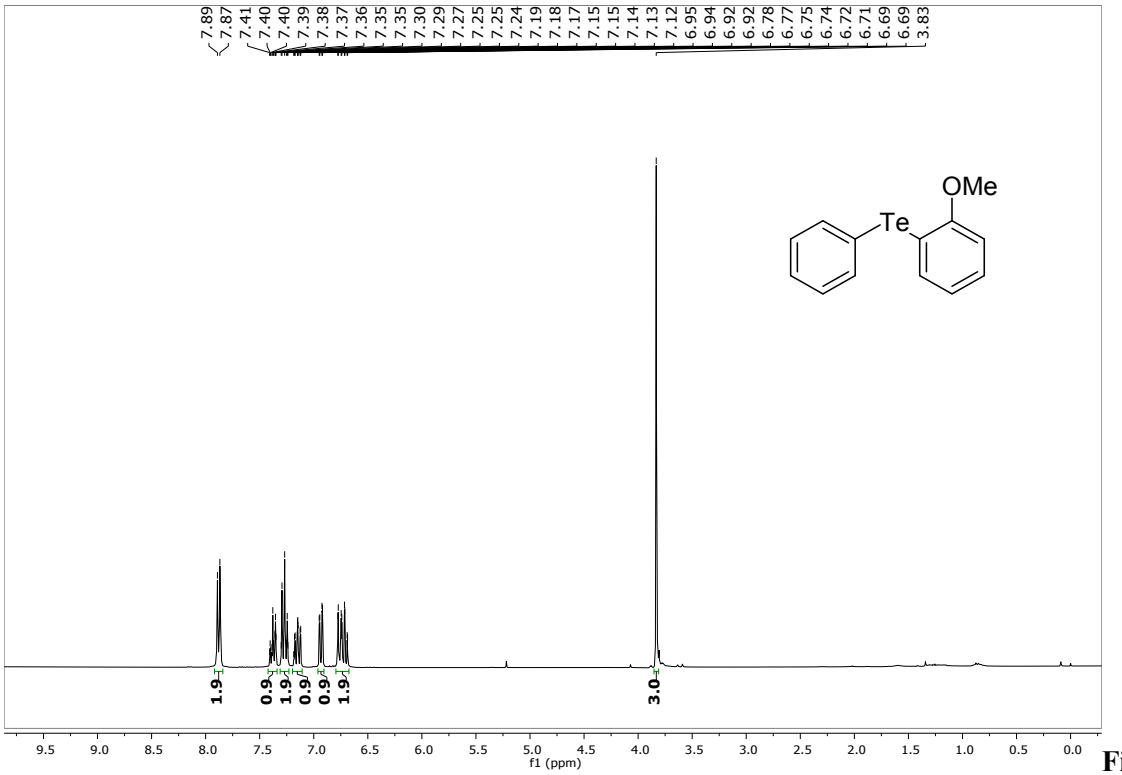


Figure S31. ^{1}H NMR (300 MHz) spectrum for compound **3n** in $CDCl_3$.

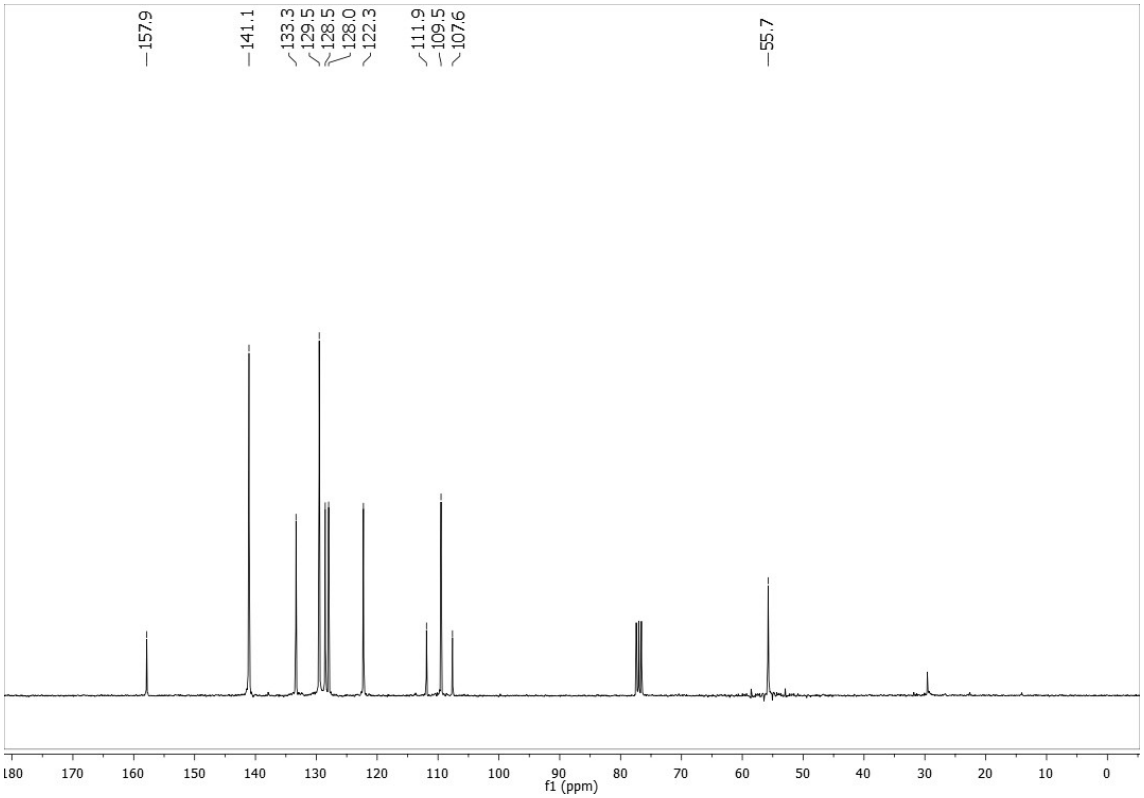


Figure S32. ^{13}C NMR (75 MHz) spectrum for compound **3n** in $CDCl_3$.

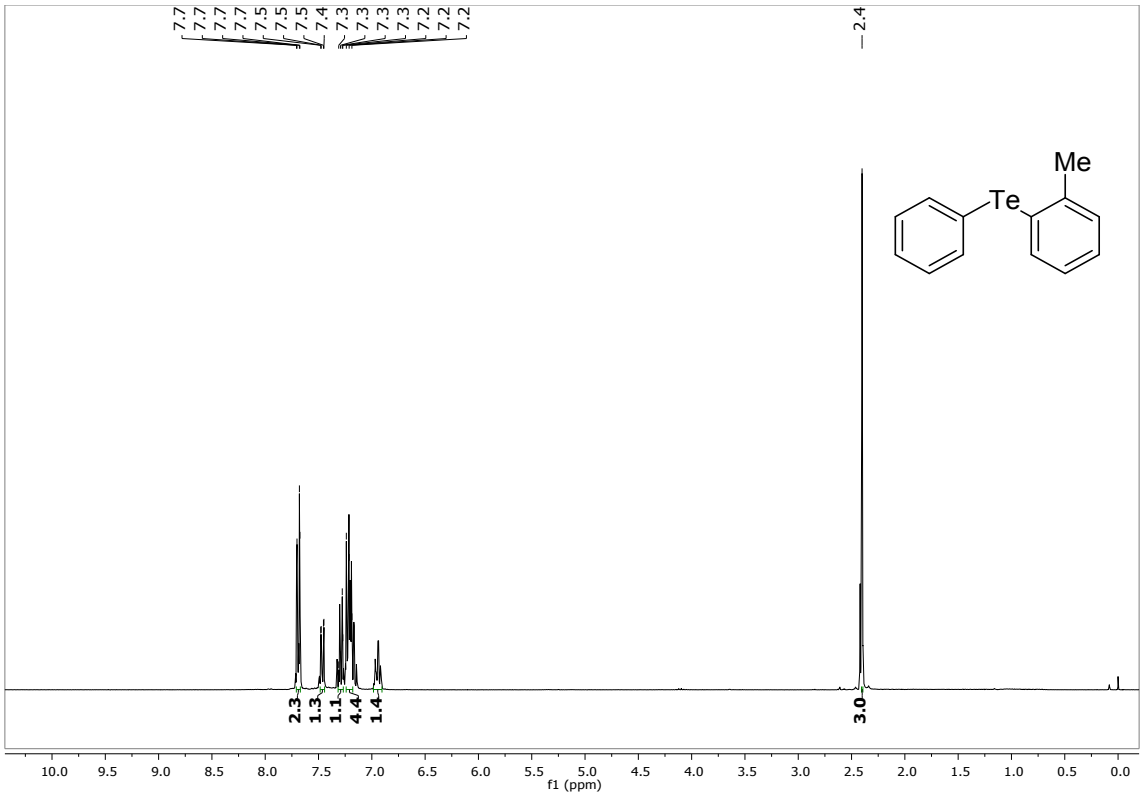


Figure S33. ^{1}H NMR (300 MHz) spectrum for compound **3o** in $CDCl_3$.

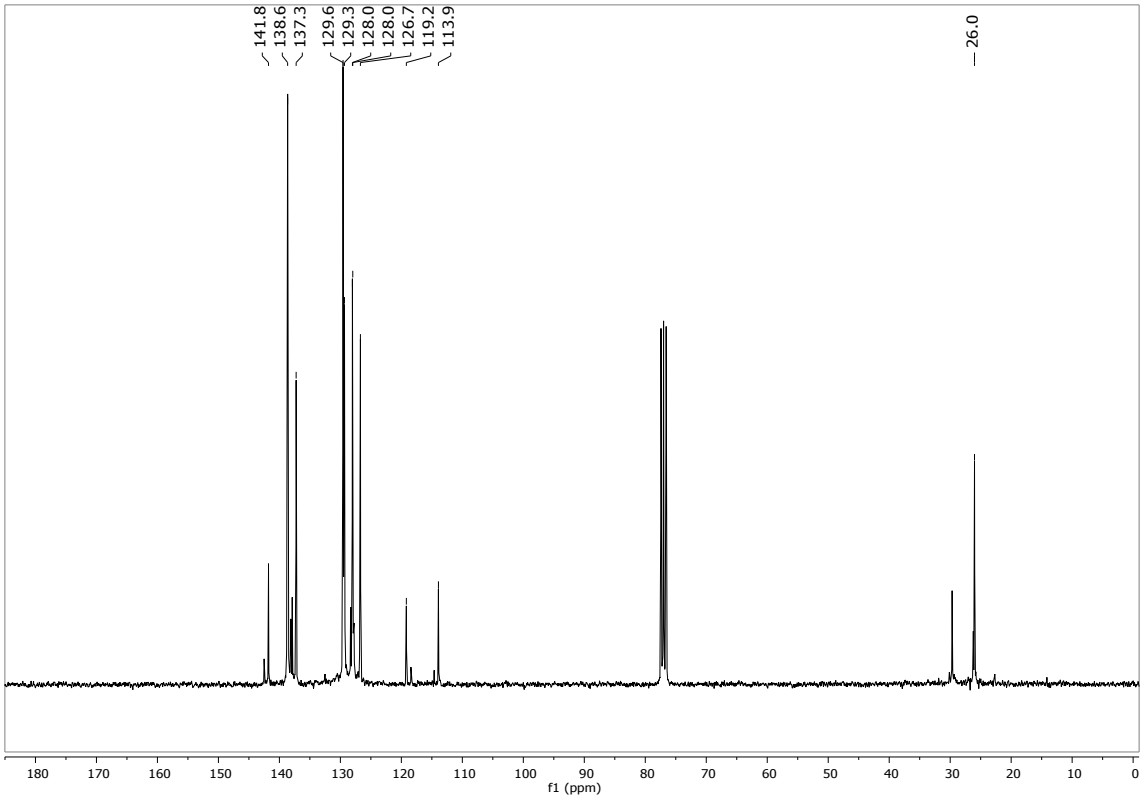


Figure S34. ^{13}C NMR (75 MHz) spectrum for compound **3o** in $CDCl_3$.

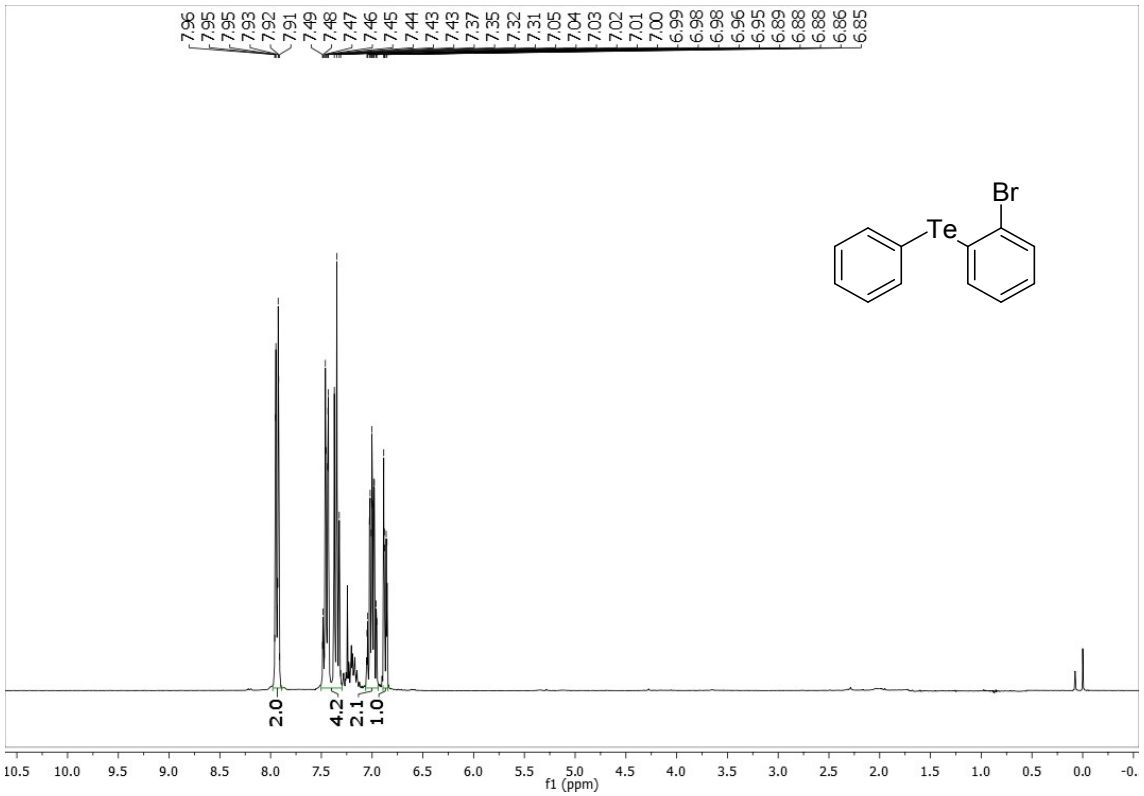


Figure S35. ^{1}H NMR (300 MHz) spectrum for compound **3p** in $CDCl_3$.

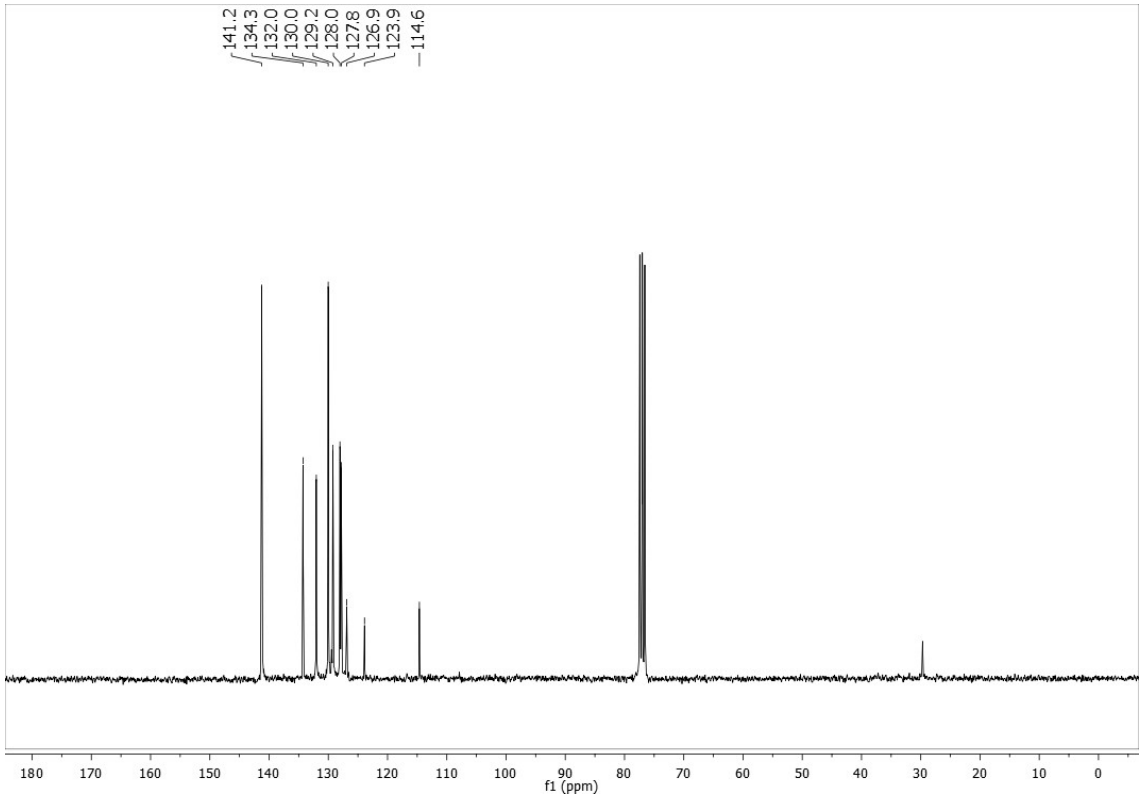


Figure S36. ^{13}C NMR (75 MHz) spectrum for compound **3p** in $CDCl_3$.

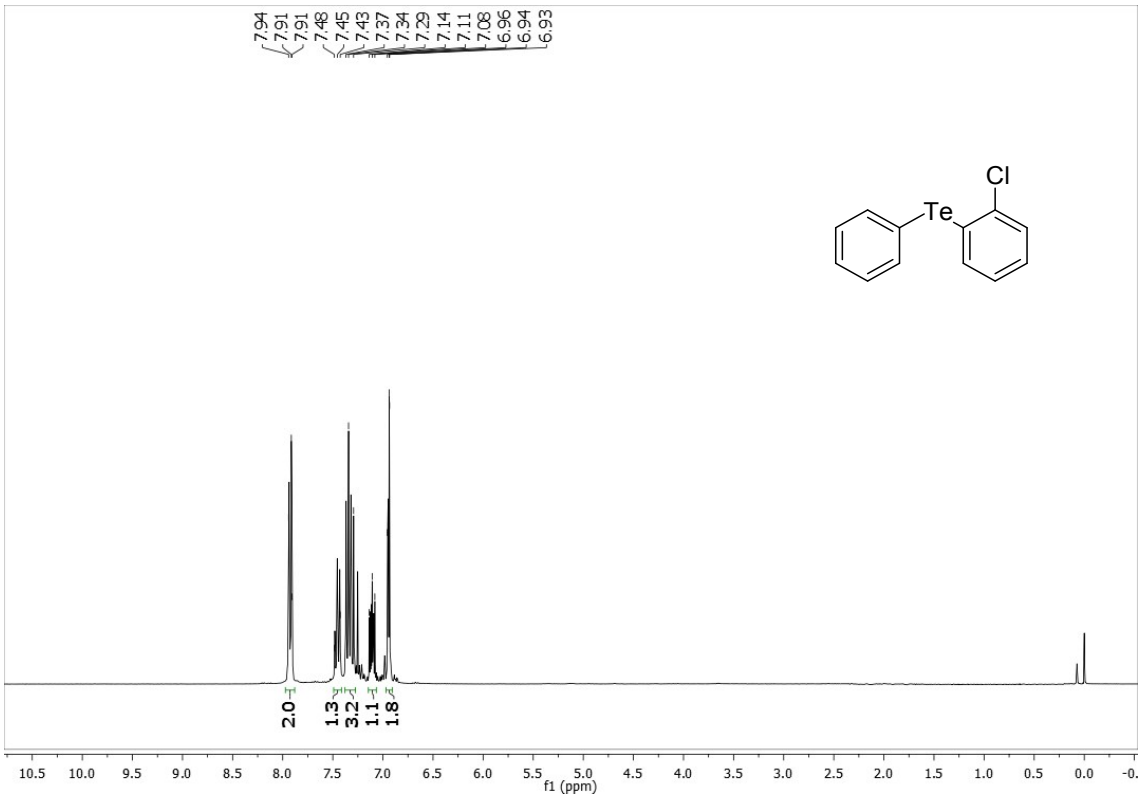


Figure S37. ^{1}H NMR (300 MHz) spectrum for compound **3q** in $CDCl_3$.

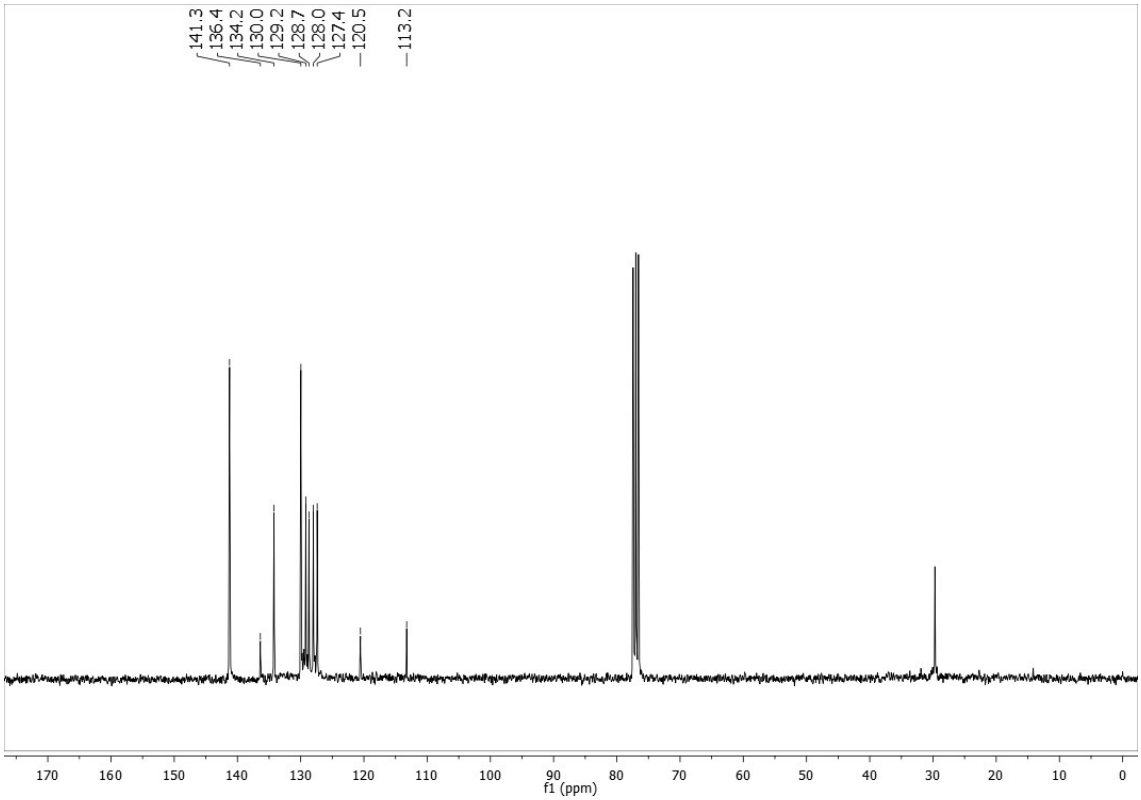


Figure S38. ^{13}C NMR (75 MHz) spectrum for compound **3q** in $CDCl_3$.

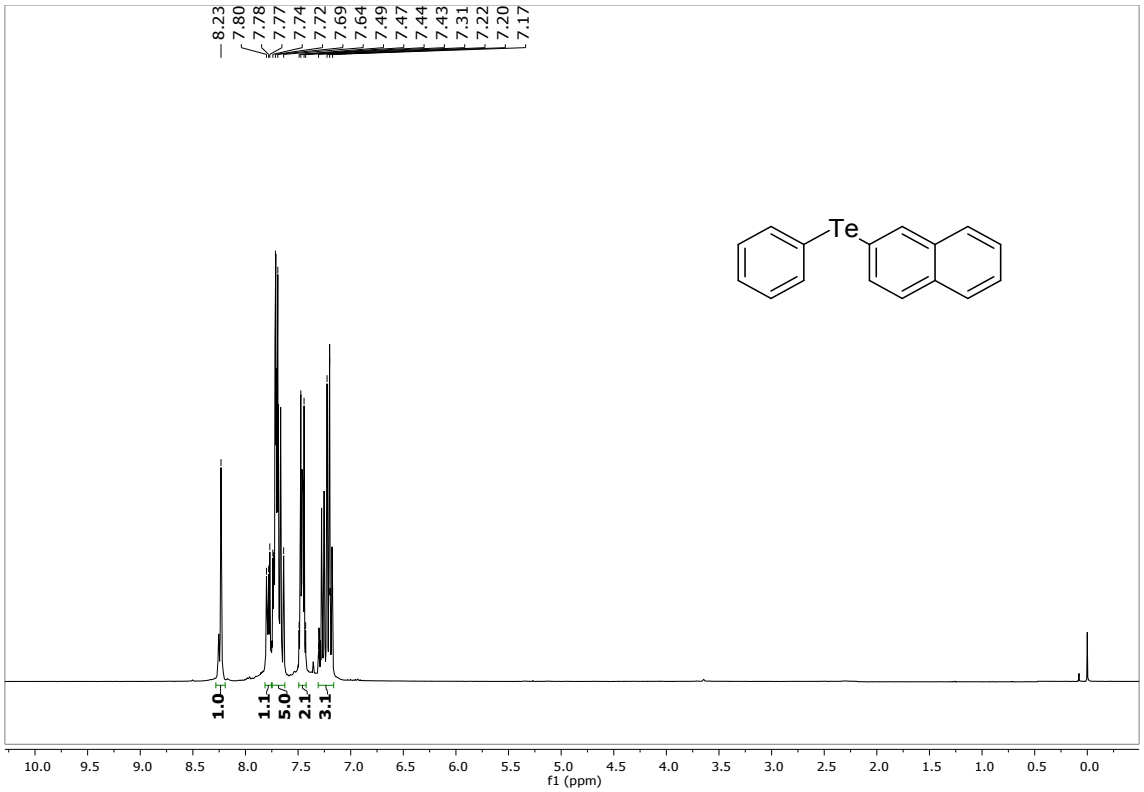


Figure S39. ^{1}H NMR (300 MHz) spectrum for compound **3r** in $CDCl_3$.

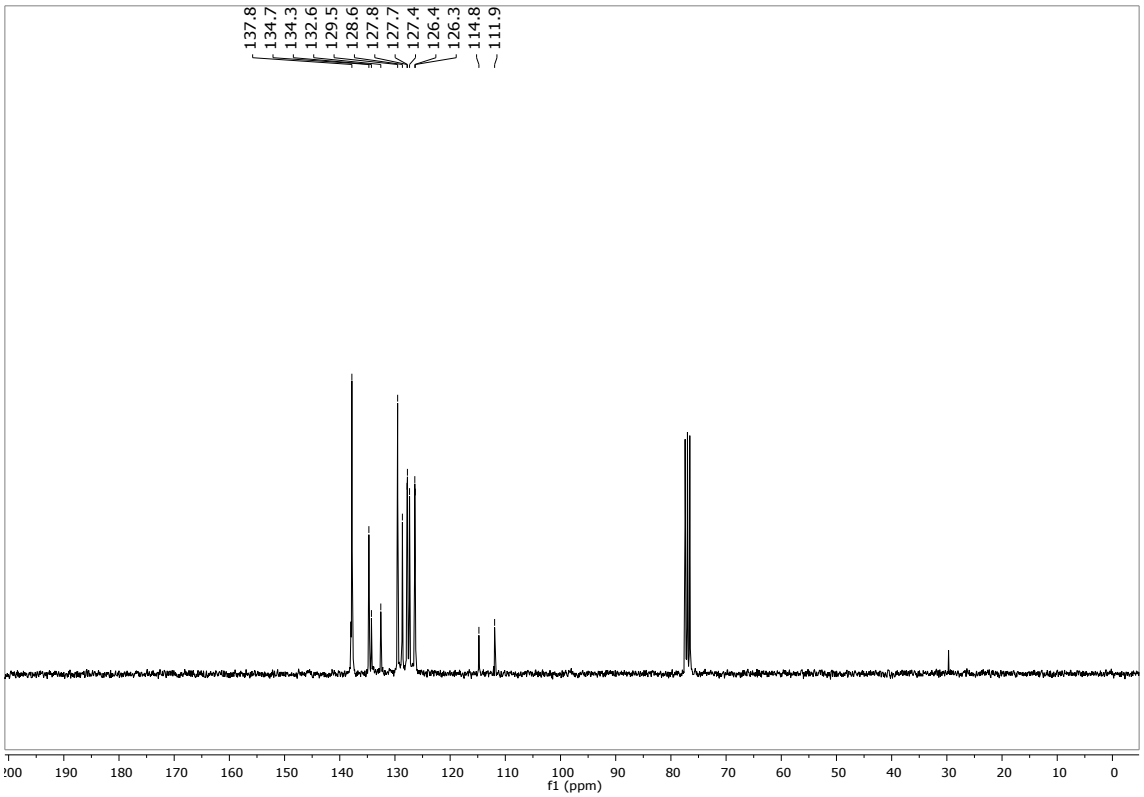


Figure S40. ^{13}C NMR (75 MHz) spectrum for compound **3r** in $CDCl_3$.

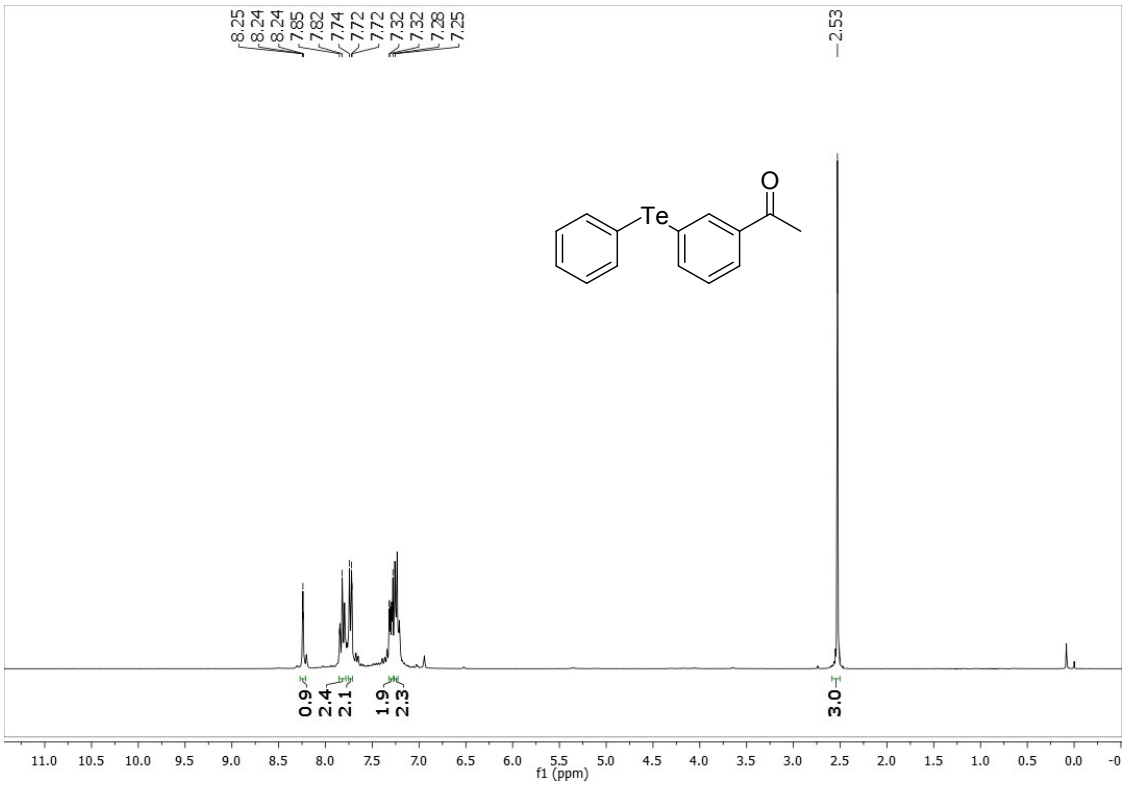


Figure S41. ^{1}H NMR (300 MHz) spectrum for compound **3s** in $CDCl_3$.

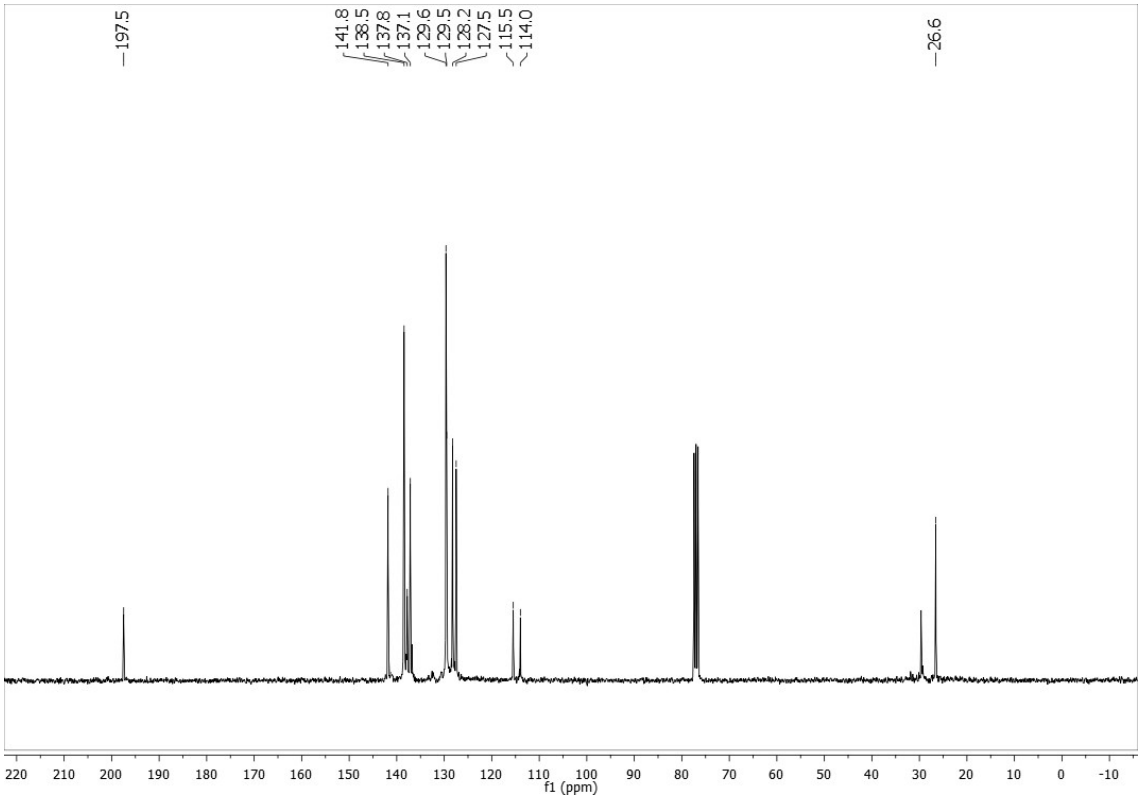


Figure S42. ^{13}C NMR (75 MHz) spectrum for compound **3s** in $CDCl_3$.

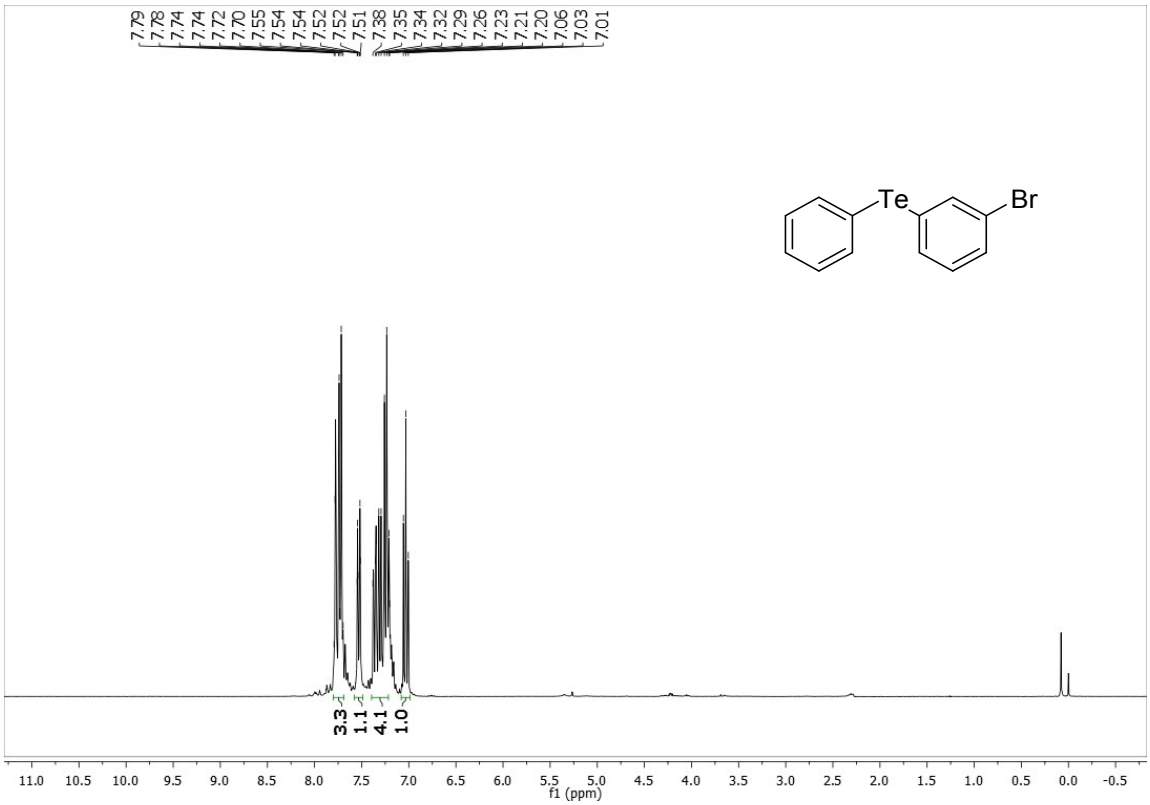


Figure S43. ^{1}H NMR (300 MHz) spectrum for compound **3t** in $CDCl_3$.

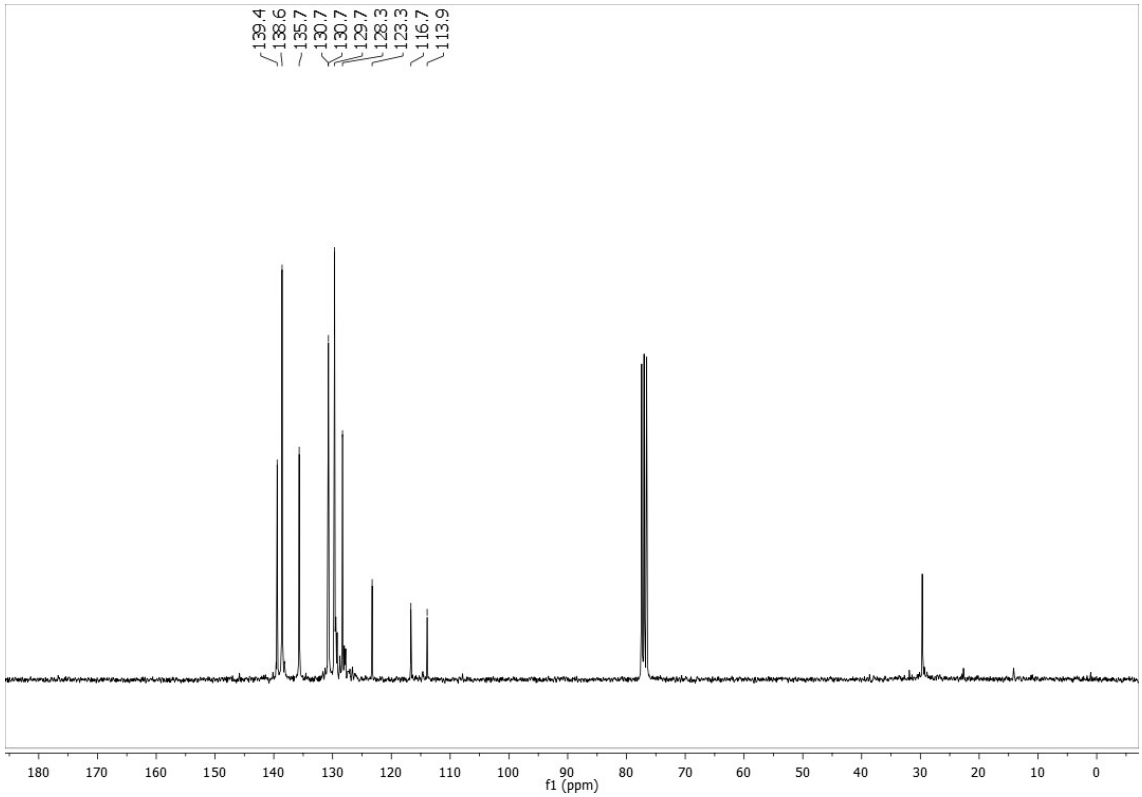


Figure S44. ^{13}C NMR (75 MHz) spectrum for compound **3t** in $CDCl_3$.

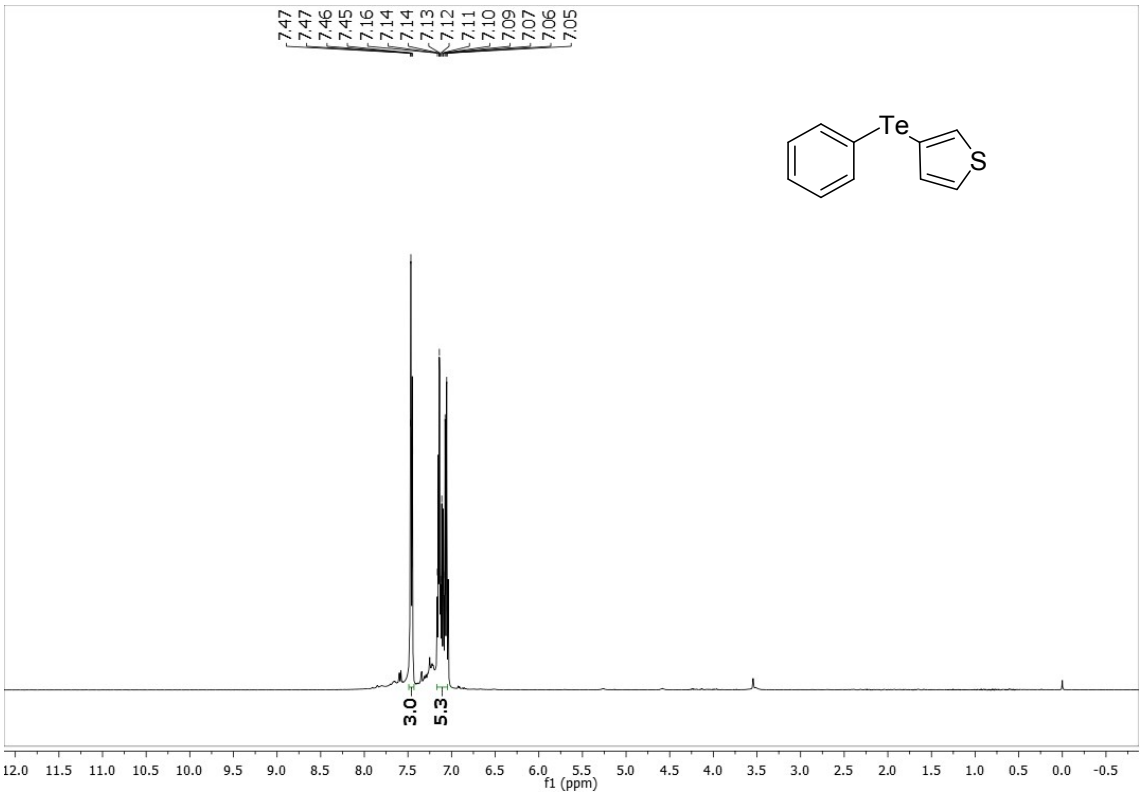


Figure S45. ^{1}H NMR (300 MHz) spectrum for compound **3u** in $CDCl_3$.

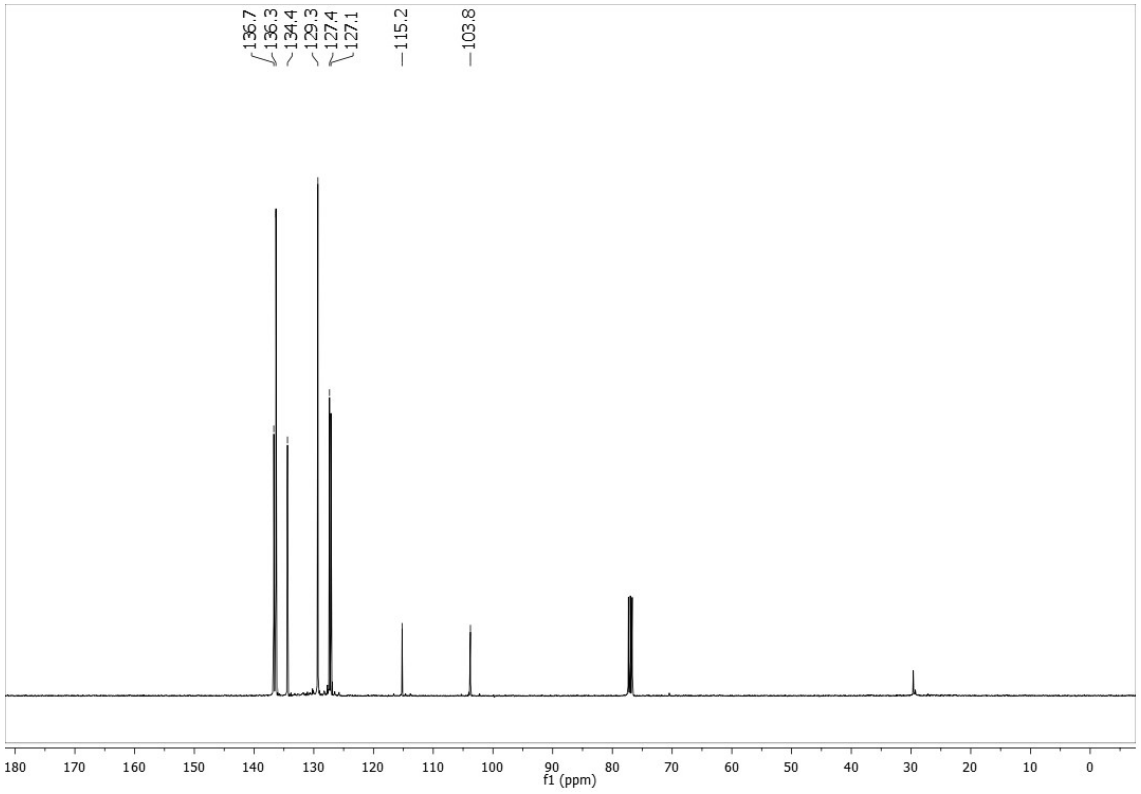


Figure S46. ^{13}C NMR (75 MHz) spectrum for compound **3u** in $CDCl_3$.