Electronic Supplementary Material (ESI) for ChemComm.
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Supporting Information

for

Bromomethyllithium-Mediated Chemoselective Homologation of Disulfides to Dithioacetals

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Instrumentation and General Analytical Methods

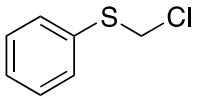
Melting points were determined on a Reichert–Kofler hot-stage microscope and are uncorrected. Mass spectra were obtained on a Shimadzu QP 1000 instrument (EI, 70 eV) and on a Bruker maXis 4G instrument (ESI-TOF, HRMS). IR spectra were recorded on a Perkin-Elmer FTIR 1605 spectrophotometer. ^{1}H, ^{13}C, ^{15}N and ^{19}F NMR spectra were recorded with a Bruker Avance III 400 spectrometer (400 MHz for ^{1}H, 100 MHz for ^{13}C, 40 MHz for ^{15}N, 376 MHz for ^{19}F) at 297 K using a "directly" detecting broadband observe (BBFO) probe. The center of the solvent signal was used as an internal standard which was related to TMS with δ 7.26 ppm (^{1}H in $CDCl_3$), δ 77.0 ppm (^{13}C in $CDCl_3$). ^{15}N NMR spectra (gs-HMBC) were referenced against neat, external nitromethane, ^{19}F NMR spectra by absolute referencing via Ξ ratio. Spin-spin coupling constants (*J*) are given in Hz. In nearly all cases, full and unambiguous assignment of all resonances was performed by combined application of standard NMR techniques, such as APT, HSQC, HMBC, COSY and NOESY experiments.

THF and 2-MeTHF were distilled over Na / benzophenone. Chemicals were purchased from Sigma-Aldrich, Acros, Alfa Aesar and TCI Europe, otherwise specified. Solutions were evaporated under reduced pressure with a rotary evaporator. TLC was carried out on aluminium sheets precoated with silica gel 60F254 (Macherey-Nagel, Merk); the spots were visualised under UV light (λ = 254 nm) and/or $KMnO_4$ (aq.) was used as revealing system.

General Procedure for the preparation of dithioacetals or diselenoacetals

To a cooled (-78 °C) solution of disulfide or diselenide (1.0 equiv) in dry THF was added trimethylsilyl chloride (2.0 equiv) and bromoiodomethane (3.0 equiv). After 2 min, an ethereal solution of MeLi-LiBr (2.5 equiv, 1.5 M) was added dropwise over 5 min. The resulting solution was stirred for 2 h at that temperature and, after removing the cooling bath the mixture was stirred for 1 additional hour at rt. Saturated aq. NH_4Cl was added (2 mL/mmol substrate) and then, the organic phase was extracted with Et_2O (2 x 5 mL), washed with water (5 mL) and brine (10 mL). The organic phase was dried (anhydrous Na_2SO_4), filtered and, after removal of the solvent under reduced pressure, the so-obtained crude mixture was subjected to chromatography (silica gel) to afford pure compounds.

[(chloromethyl)sulfanyl]benzene (2a)



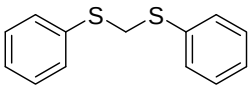
By following the General Procedure 1, starting from diphenyl disulfide (0.20 g, 0.92 mmol, 1.0 equiv), TMSCl (0.20 g, 0.23 mL, 1.84 mmol, 2.0 equiv), ICH_2Cl (0.41 g, 0.17 mL, 2.30 mmol, 2.5 equiv), and MeLi-LiBr (1.53 mL, 2.30 mmol) in THF, compound **2a** was obtained in 68% (99 mg) as a colorless oil after chromatography on silica gel (*n*-hexane-DCM, 95:5).

^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.50 (m, 2H, Ph H-2,6), 7.38 (m, 2H, Ph H-3,5), 7.30 (m, 1H, Ph H-4), 5.38 (s, 2H, $SC\underline{H}_2Cl$).

^{13}C NMR (100 MHz, $CDCl_3$) δ: 133.9 (Ph C-1), 129.2 (Ph C-2,3,5,6), 127.3 (Ph C-4), 50.2 ($S\underline{C}H_2Cl$).

HRMS (APCI), *m/z*: calcd. for $C_7H_7ClH^+$ 159.0029 $[M+H]^+$; found 159.0027.

1,1'-(methylenedisulfanediyl)dibenzene (3a)



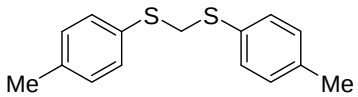
By following the General Procedure 1, starting from diphenyl disulfide (0.20 g, 0.92 mmol, 1.0 equiv), TMSCl (0.20 g, 0.23 mL, 1.84 mmol, 2.0 equiv), ICH_2Br (0.61 g, 0.21 mL, 2.76 mmol, 3.0 equiv), and MeLi-LiBr (1.53 mL, 2.30 mmol) in THF, compound **3a** was obtained in 95% (203 mg) as a white solid after chromatography on silica gel (*n*-hexane-DCM, 95:5). mp 34 °C (lit.[1] 30-34 °C).

^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.43 (m, 4H, Ph H-2,6), 7.32 (m, 4H, Ph H-3,5), 7.25 (m, 2H, Ph H-4), 4.35 (s, 2H, $SC\underline{H}_2S$).

^{13}C NMR (100 MHz, $CDCl_3$) δ: 135.0 (Ph C-1), 130.7 (Ph C-2,6), 129.0 (Ph C-3,5), 127.1 (Ph C-4), 40.6 ($S\underline{C}H_2S$).

HRMS (APCI), *m/z*: calcd. for $C_{13}H_{12}S_2$ 232.0380 M^+; found 232.0372.

1,1'-(methylenedisulfanediyl)bis(4-methylbenzene) (3b)



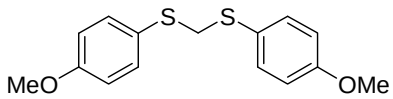
By following the General Procedure 1, starting from *p*-tolyl disulfide (0.20 g, 0.81 mmol, 1.0 equiv), TMSCl (0.18 g, 0.21 mL, 1.62 mmol, 2.0 equiv), ICH_2Br (0.54 g, 0.20 mL, 2.43 mmol, 3.0 equiv), and MeLi-LiBr (1.35 mL, 2.03 mmol) in THF, compound **3b** was obtained in 90% (190 mg) as a colorless oil after chromatography on silica gel (*n*-hexane-DCM, 95:5).

^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.36 (m, 4H, Ph H-2,6), 7.15 (m, 4H, Ph H-3,5), 4.29 (s, 2H, $SC\underline{H}_2S$), 2.36 (s, 6H, Ph-4-$C\underline{H}_3$).

^{13}C NMR (100 MHz, $CDCl_3$) δ: 137.3 (Ph C-4), 131.4 (Ph C-2,6), 131.2 (Ph C-1), 129.7 (Ph C-3,5), 41.9 ($S\underline{C}H_2S$), 21.1 (Ph-4-$\underline{C}H_3$).

HRMS (APCI), *m/z*: calcd. for $C_{15}H_{16}S_2H^+$ 261.0766 $[M+H]^+$; found 261.0773.

1,1'-(methylenedisulfanediyl)bis(4-methoxylbenzene) (3c)



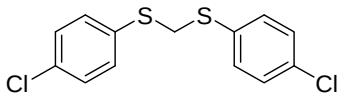
By following the General Procedure 1, starting from bis(4-methoxyphenyl)disulfide (0.20 g, 0.72 mmol, 1.0 equiv), TMSCl (0.16 g, 0.18 mL, 1.44 mmol, 2.0 equiv), ICH_2Br (0.48 g, 0.16 mL, 2.16 mmol, 3.0 equiv), and MeLi-LiBr (1.91 mL, 2.87 mmol) in THF, compound **3c** was obtained in 81% (171 mg) as a white solid after chromatography on silica gel (*n*-hexane-EtOAc, 95:5). mp 67 °C (lit.[1] 66-67 °C).

^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.40 (m, 4H, Ph H-2,6), 6.86 (m, 4H, Ph H-3,5), 4.15 (s, 2H, $SC\underline{H}_2S$), 3.81 (s, 6H, Ph-4-$OC\underline{H}_3$).

^{13}C NMR (100 MHz, $CDCl_3$) δ: 159.6 (Ph C-4), 134.4 (Ph C-2,6), 125.2 (Ph C-1), 114.6 (Ph C-3,5), 55.3 (Ph-4-$O\underline{C}H_3$), 44.5 ($S\underline{C}H_2S$).

HRMS (APCI), *m/z*: calcd. for $C_{15}H_{16}O_2S_2H^+$ 293.4190 $[M+H]^+$; found 293.4188.

1,1'-(methylenedisulfanediyl)bis(4-chlorobenzene) (3d)



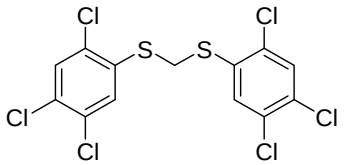
By following the General Procedure 1, starting from 4,4'-dichlorodiphenyl disulfide (0.20 g, 0.70 mmol, 1.0 equiv), TMSCl (0.15 g, 0.18 mL, 1.40 mmol, 2.0 equiv), ICH_2Br (0.46 g, 0.16 mL, 2.10 mmol, 3.0 equiv), and MeLi-LiBr (1.17 mL, 1.75 mmol) in THF, compound **3d** was obtained in 90% (190 mg) as a white solid after chromatography on silica gel (*n*-hexane-DCM, 95:5). mp 43 °C (lit.[1] 42-43 °C)

^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.34 (m, 4H, Ph H-2,6), 7.29 (m, 4H, Ph H-3,5), 4.28 (s, 2H, $SC\underline{H}_2S$).

^{13}C NMR (100 MHz, $CDCl_3$) δ: 133.5 (Ph C-4), 132.9 (Ph C-1), 132.4 (Ph C-2,6), 129.2 (Ph C-3,5), 41.2 ($S\underline{C}H_2S$).

HRMS (APCI), *m/z*: calcd. for $C_{13}H_{10}Cl_2S_2$ 299.9595 $[M+H]^+$; found 299.9601.

1,1'-(methylenedisulfanediyl)bis(2,4,5-trichlorobenzene) (3e)



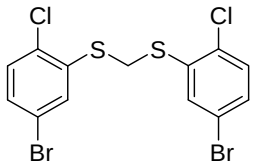
By following the General Procedure 1, starting from the 1,2,4-trichloro-5-[(2,4,5-trichlorophenyl)disulfonyl]benzene (0.20 g, 0.47 mmol, 1.0 equiv), TMSCl (0.10 g, 0.12 mL, 0.94 mmol, 2.0 equiv), ICH_2Br (0.31 g, 0.11 mL, 1.41 mmol, 3.0 equiv), and MeLi-LiBr (0.78 mL, 1.18 mmol) in THF, compound **3e** was obtained in 92% (190 mg) as a white solid after chromatography on silica gel (*n*-hexane-EtOAc, 95:5). mp 146 °C (lit.[2] 146-147 °C)

^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.51 (s, 2H, Ph H-6), 7.50 (s, 2H, Ph H-3), 4.37 (s, 2H, $SC\underline{H}_2S$).

^{13}C NMR (100 MHz, $CDCl_3$) δ: 134.3 (Ph C-2), 133.0 (Ph C-1), 132.7 (Ph C-6), 132.4 (Ph C-4), 131.5 (Ph C-5), 131.0 (Ph C-3), 37.6 ($S\underline{C}H_2S$).

HRMS (APCI), *m/z*: calcd. for $C_{13}H_6Cl_6S_2$ 435.8037 M^+; found 435.8042.

1,1'-(methylenedisulfanediyl)bis(5-bromo-2-chlorobenzene) (3f)



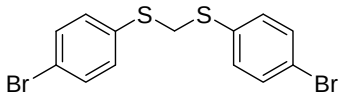
By following the General Procedure 1, starting from di(5-bromo-2-chlorophenyl)disulfide (0.20 g, 0.45 mmol, 1.0 equiv), TMSCl (0.10 g, 0.11 mL, 0.90 mmol, 2.0 equiv), ICH_2Br (0.30 g, 0.10 mL, 1.35 mmol, 3.0 equiv), and MeLi-LiBr (0.94 mL, 1.13 mmol) in THF, compound **3f** was obtained in 87% (180 mg) as a white solid after chromatography on silica gel (*n*-hexane-DCM, 95:5). mp 88 °C

^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.57 (d, ^4J = 2.2 Hz, 2H, Ph H-6), 7.32 (dd, ^3J = 8.5 Hz, ^4J = 2.2 Hz, 2H, Ph H-4), 7.25 (d, ^3J = 8.5 Hz, 2H, Ph H-3), 4.39 (s, 2H, $SC\underline{H}_2S$).

^{13}C NMR (100 MHz, $CDCl_3$) δ: 135.4 (Ph C-1), 134.1 (Ph C-2), 133.7 (Ph C-6), 131.3 (Ph C-4), 131.0 (Ph C-3), 120.7 (Ph C-5), 37.1 ($S\underline{C}H_2S$).

HRMS (APCI), *m/z*: calcd. for $C_{13}H_8Br_2Cl_2S_2H^+$ 455.7812 $[M+H]^+$; found 455.7823.

1,1'-(methylenedisulfanediyl)bis(4,-bromobenzene) (3g)



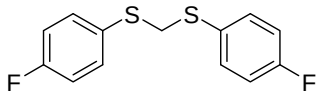
By following the General Procedure 1, starting from the 4-bromophenyl disulfide (0.20 g, 0.53 mmol, 1.0 equiv), TMSCl (0.12 g, 0.13 mL, 1.06 mmol, 2.0 equiv), ICH_2Br (0.35 g, 0.12 mL, 1.59 mmol, 3.0 equiv), and MeLi-LiBr (1.42 mL, 2.13 mmol) in THF, compound **3g** was obtained in 86% (178 mg) as a white solid after chromatography on silica gel (*n*-hexane-DCM, 95:5). mp 71 °C (lit.[1] 70.5-72.0 °C)

^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.43 (m, 4H, Ph H-3,5), 7.27 (m, 4H, Ph H-2,6), 4.28 (s, 2H, $SC\underline{H}_2S$).

^{13}C NMR (100 MHz, $CDCl_3$) δ: 133.6 (Ph C-1), 132.5 (Ph C-2,6), 132.1 (Ph C-3,5), 121.5 (Ph C-4), 40.8 ($S\underline{C}H_2S$).

HRMS (APCI), *m/z*: calcd. for $C_{13}H_{10}Br_2S_2H^+$ 388.8663 $[M+H]^+$; found 388.8671.

1,1'-(methylenedisulfanediyl)bis(4-fluorobenzene) (3h)



By following the General Procedure 1, starting from bis(4-fluorophenyl)disulfide (0.20 g, 0.79 mmol, 1.0 equiv), TMSCl (0.17 g, 0.20 mL, 1.58 mmol, 2.0 equiv), ICH_2Br (0.52 g, 0.18 mL, 2.37 mmol, 3.0 equiv), and MeLi-LiBr (1.32 mL, 1.97 mmol) in THF, compound **3h** was obtained in 83% (194 mg) as a colorless oil after chromatography on silica gel (*n*-hexane-DCM, 95:5).

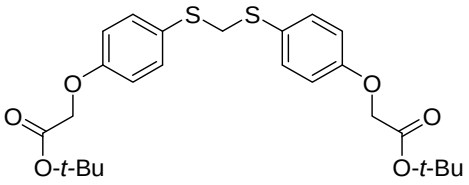
^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.41 (m, 4H, Ph H-2,6), 7.02 (m, 4H, Ph H-3,5), 4.22 (s, 2H, $SC\underline{H}_2S$).

^{13}C NMR (100 MHz, $CDCl_3$) δ: 162.5 (Ph C-4, $^1J_{C,F}$ = 248.0 Hz), 134.0 (Ph C-2,6, $^3J_{C,F}$ = 8.2 Hz), 129.5 (Ph C-1, $^4J_{C,F}$ = 3.4 Hz), 116.2 (Ph C-3,5, $^2J_{C,F}$ = 21.9 Hz), 43.2 ($S\underline{C}H_2S$).

^{19}F NMR (376 MHz, $CDCl_3$) δ: -113.6 (m, Ph-4-$\underline{F}$).

HRMS (APCI), *m/z*: calcd. for $C_{13}H_{10}F_2S_2$ 268.0187 M^+; found 268.0192.

bis(2-methyl-2-propanyl) 2,2'-[methylenebis(sulfanediyl-4,1-phenyleneoxy)]diacetate (3i)



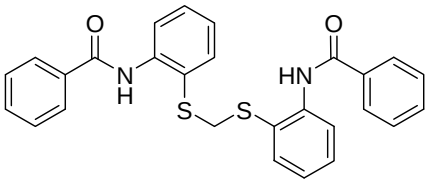
By following the General Procedure 1, starting from the corresponding disulfide derivative (0.20 g, 0.42 mmol, 1.0 equiv), TMSCl (0.09 g, 0.10 mL, 0.84 mmol, 2.0 equiv), ICH_2Br (0.28 g, 0.09 mL, 1.26 mmol, 3.0 equiv), and MeLi-LiBr (0.70 mL, 1.05 mmol) in THF, compound **3i** was obtained in 83% (172 mg) as a colourless oil after chromatography on silica gel (*n*-hexane-EtOAc, 95:5).

^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.38 (m, 4H, Ph H-3,5), 6.84 (m, 4H, Ph H-2,6), 4.51 (s, 4H, $COC\underline{H}_2O$), 4.16 (s, 2H, $SC\underline{H}_2S$), 1.49 (s, 18H, $C(C\underline{H}_3)_3$).

^{13}C NMR (100 MHz, $CDCl_3$) δ: 167.8 ($O\underline{C}OCH_2$), 157.9 (Ph C-1), 134.2 (Ph C-3,5), 126.4 (Ph C-4), 115.2 (Ph C-2,6), 82.5 ($\underline{C}(CH_3)_3$), 65.7 ($CO\underline{C}H_2O$), 44.0 ($S\underline{C}H_2S$), 28.0 ($C(\underline{C}H_3)_3$).

HRMS (APCI), *m/z*: calcd. for $C_{25}H_{32}O_6S_2H^+$ 493.1713 $[M+H]^+$; found 493.1707.

***N,N'*-[methylenebis(sulfanediyl-2,1-phenylene)]dibenzamide (3j)**



By following the General Procedure 1, starting from bis(2-benzamidophenyl) disulfide (0.20 g, 0.44 mmol, 1.0 equiv), TMSCl (0.09 g, 0.11 mL, 0.88 mmol, 2.0 equiv), ICH_2Br (0.29 g, 0.10 mL, 1.32 mmol, 3.0 equiv), and MeLi-LiBr (0.73 mL, 1.10 mmol) in THF, compound **3j** was obtained in 84% (174 mg) as a colourless to yellow solid after chromatography on silica gel (silica gel, *n*-hexane-EtOAc, 95:5). mp 143 °C.

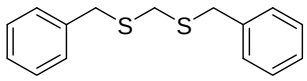
^{1}H NMR (400 MHz, $CDCl_3$) δ: 9.30 (br s, 1H, NH), 8.65 (m, 2H, Ph' H-6), 7.97 (m, 4H, Ph H-2,6), 7.67 (m, 2H, Ph' H-3), 7.58 (m, 2H, Ph H-4), 7.53 (m, 4H, Ph H-3,5), 7.51 (m, 2H, Ph' H-5), 7.17 (m, 2H, Ph' H-4), 4.82 (s, 2H, $SC\underline{H}_2S$).

^{13}C NMR (100 MHz, $CDCl_3$) δ: 165.2 ($Ph\underline{C}O$), 140.6 (Ph' C-1), 136.4 (Ph' C-3), 134.7 (Ph C-1), 132.1 (Ph C-4), 131.6 (Ph' C-5), 128.9 (Ph C-3,5), 127.2 (Ph C-2,6), 124.6 (Ph' C-4), 120.8 (Ph' C-6), 120.4 (Ph' C-2), 52.5 ($S\underline{C}H_2S$).

^{15}N NMR (40 MHz, $CDCl_3$) δ: -256.1 (NH)

HRMS (ESI), *m/z*: calcd. for $C_{27}H_{22}N_2O_2S_2H^+$ 471.1195 $[M+H]^+$; found 471.1193.

1,1'-[methylenebis(sulfanedimethylene)]dibenzene (3k)



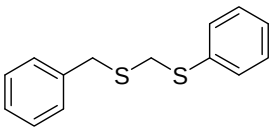
By following the General Procedure 1, starting from dibenzyl disulfide (0.20 g, 0.81 mmol, 1.0 equiv), TMSCl (0.18 g, 0.20 mL, 1.62 mmol, 2.0 equiv), ICH_2Br (0.54 g, 0.18 mL, 2.43 mmol, 3.0 equiv), and MeLi-LiBr (1.35 mL, 2.02 mmol) in THF, compound **3k** was obtained in 80% (169 mg) as a white solid after chromatography on silica gel (*n*-hexane-DCM, 95:5). mp 54 °C (lit.[3] 55 °C)

^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.31 (m, 8H, Ph H-2,3,5,6), 7.25 (m, 2H, Ph H-4), 3.84 (s, 4H, Ph$C\underline{H}_2$S), 3.38 (s, 2H, S$C\underline{H}_2$S).

^{13}C NMR (100 MHz, $CDCl_3$) δ: 137.7 (Ph C-1), 129.1 (Ph C-2,6), 128.5 (Ph C-3,5), 127.0 (Ph C-4), 34.4 (Ph$\underline{C}H_2$S), 33.4 (S$\underline{C}H_2$S).

HRMS (APCI), *m/z*: calcd. for $C_{15}H_{16}S_2H^+$ 261.0766 $[M+H]^+$; found 261.0764.

{[(benzylsulfanyl)methyl]sulfanyl}benzene (3l)



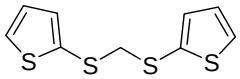
By following the General Procedure 1, starting from the benzyl phenyl disulfide[4] (0.20 g, 0.86 mmol, 1.0 equiv), TMSCl (0.19 g, 0.22 mL, 1.72 mmol, 2.0 equiv), ICH_2Br (0.66 g, 0.22 mL, 2.58 mmol, 3.0 equiv), and MeLi-LiBr (1.43 mL, 2.15 mmol) in THF, compound **3l** was obtained in 77% (163 mg) as a colorless oil after chromatography on silica gel (*n*-hexane-DCM, 95:5).

^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.41 (m, 2H, SPh H-2,6), 7.32 (m, 6H, SPh H-3,5, CPh H-2,3,5,6), 7.25 (m, 2H, SPh H-4, CPh H-4), 3.88 (s, 2H, CPh$C\underline{H}_2$S), 3.85 (s, 2H, S$C\underline{H}_2$S).

^{13}C NMR (100 MHz, $CDCl_3$) δ: 137.4 (CPh C-1), 135.0 (SPh C-1), 130.6 (SPh C-2,6), 129.1 (CPh C-2,6), 129.0 (SPh C-3,5), 128.6 (CPh C-3,5), 127.2 (CPh C-4), 127.0 (SPh C-4), 36.8 (S$\underline{C}H_2$S), 35.0 Ph$\underline{C}H_2$S).

HRMS (APCI), *m/z*: calcd. for $C_{14}H_{14}S_2H^+$ 247.0610 $[M+H]^+$; found 247.0617.

2,2'-(methylenedisulfanediyl)dithiophene (3m)



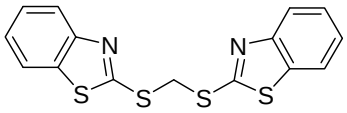
By following the General Procedure 1, starting from 2-thienyl disulfide (0.20 g, 0.87 mmol, 1.0 equiv), TMSCl (0.19 g, 0.22 mL, 1.74 mmol, 2.0 equiv), ICH_2Br (0.58 g, 0.20 mL, 2.61 mmol, 3.0 equiv), and MeLi-LiBr (1.40 mL, 2.10 mmol) in THF, compound **3m** was obtained in 84% (179 mg) as a colorless oil after chromatography on silica gel (*n*-hexane-DCM, 95:5).

^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.42 (dd, $^3J_{\text{Th H-5, Th H-4}}$ = 5.4 Hz, $^4J_{\text{Th H-5, Th H-3}}$ = 1.2 Hz, 2H, Th H-5), 7.22 (dd, $^3J_{\text{Th H-3, Th H-4}}$ = 3.6 Hz, $^4J_{\text{Th H-3, Th H-5}}$ = 1.2 Hz, 2H, Th H-3), 7.02 (dd, $^3J_{\text{Th H-4, Th H-5}}$ = 5.4 Hz, $^3J_{\text{Th H-4, Th H-3}}$ = 3.6 Hz, 2H, Th H-4), 4.05 (s, 2H, $SC\underline{H}_2S$).

^{13}C NMR (100 MHz, $CDCl_3$) δ: 135.1 (Th C-3), 132.2 (Th C-2), 130.5 (Th C-5), 127.6 (Th C-4), 49.1 ($S\underline{C}H_2S$).

HRMS (APCI), *m/z*: calcd. for $C_9H_8S_4H^+$ 244.9582 $[M+H]^+$; found 244.9581.

2,2'-(methylenedisulfanediyl)bis(1,3-benzothiazole) (3n)



By following the General Procedure 1, starting from 2,2'-dibenzothiazoyl disulfide (0.20 g, 0.60 mmol, 1.0 equiv), TMSCl (0.13 g, 0.15 mL, 1.20 mmol, 2.0 equiv), ICH_2Br (0.40 g, 0.51 mL, 0.14 mmol, 3.0 equiv), and MeLi-LiBr (1.00 mL, 1.50 mmol) in THF, compound **3n** was obtained in 79% (164 mg) as a white solid after chromatography on silica gel (*n*-hexane-DCM, 95:5); mp 93 °C.

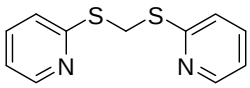
^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.92 (m, 2H, BnTh H-4), 7.77 (m, 2H, BnTh H-7), 7.44 (m, 2H, BnTh H-5), 7.32 (m, 2H, BnTh H-6), 5.34 (s, 2H, $SC\underline{H}_2S$).

^{13}C NMR (100 MHz, $CDCl_3$) δ: 164.8 (BnTh C-2), 152.9 (BnTh C-3a), 135,6 (BnTh C-7a), 126.2 (BnTh C-5), 124.5 (BnTh C-6), 121.9 (BnTh C-4), 121.1 (BnTh C-7), 36.5 ($S\underline{C}H_2S$).

^{15}N NMR (40 MHz, $CDCl_3$) δ: -83.1 (BnTh N-3).

HRMS (ESI), *m/z*: calcd. for $C_{15}H_{10}N_2S_4H^+$ 346.9800 $[M+H]^+$; found 346.9802.

2,2'-(methylenedisulfanediyl)dipyridine (3o)



By following the General Procedure 1, starting from the 2,2'-dithiodipyridine (0.20 g, 0.91 mmol, 1.0 equiv), TMSCl (0.29 g, 0.34 mL, 1.82 mmol, 2.0 equiv), ICH_2Br (0.20 g, 0.23 mL, 4.08 mmol, 3.0 equiv), and MeLi-LiBr (1.52 mL, 2.27 mmol) in THF, compound **3o** was obtained in 78% (166 mg) as a white solid after chromatography on silica gel (*n*-hexane-EtOAc, 90:10); mp 93 °C (lit.[5] 92-95 °C).

^{1}H NMR (400 MHz, $CDCl_3$) δ: 8.49 (ddd, $^3J_{\text{Pyr H-6, Pyr H-5}}$ = 4.9 Hz, $^4J_{\text{Pyr H-6, Pyr H-4}}$ = 1.9 Hz, $^5J_{\text{Pyr H-6, Pyr H-3}}$ = 1.0 Hz, 2H, Pyr H-6), 7.49 (ddd, $^3J_{\text{Pyr H-4, Pyr H-3}}$ = 8.0 Hz, $^3J_{\text{Pyr H-4, Pyr H-5}}$ = 7.3 Hz, $^4J_{\text{Pyr H-4, Pyr H-6}}$ = 1.9 Hz, 2H, Pyr H-4), 7.18 (ddd, $^3J_{\text{Pyr H-3, Pyr H-4}}$ = 8.0 Hz, $^4J_{\text{Pyr H-3, Pyr H-5}}$ = 1.1 Hz, $^5J_{\text{Pyr H-3, Pyr H-6}}$ = 1.0 Hz, 2H, Pyr H-3), 7.01 (ddd, $^3J_{\text{Pyr H-5, Pyr H-4}}$ = 7.3 Hz, $^3J_{\text{Pyr H-5, Pyr H-6}}$ = 4.9 Hz, $^4J_{\text{Pyr H-5, Pyr H-3}}$ = 1.1 Hz, 2H, Pyr H-5), 5.06 (s, 2H, $SC\underline{H}_2S$).

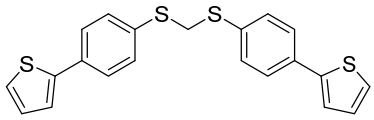
^{13}C NMR (100 MHz, $CDCl_3$) δ: 157.7 (Ph C-2), 149.5 (Ph C-6), 136.0 (Ph C-4), 122.5 (Ph C-3), 119.7 (Ph C-5), 30.7 ($S\underline{C}H_2S$).

^{15}N NMR (40 MHz, $CDCl_3$) δ: -81.1 (N-Pyr)

HRMS (APCI), *m/z*: calcd. for $C_{11}H_{10}N_2S_2H^+$ 235.0358 $[M+H]^+$; found 235.0361.

Exploration of the Reactivity of dithioacetals (Scheme 3)

2,2'-[methylenebis(sulfanediyl-4,1-phenylene)]dithiophene (4)[6]



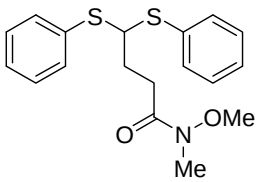
In a dry Schlenk flask $Pd_2(dba)_3$ (0.014 mmol, 12.91 mg) and P(*t*-Bu)$_3$ (0.042 mmol, 8.56 mg) were dissolved in anhydrous toluene and dithioketal **3g** (0.28 mmol, 110 mg) was added and the solution was warmed up to 40 °C. 2-Thienyllithium (0.85 mmol, 1.41 mL) was diluted with toluene to reach the concentration of 0.6 M and TMEDA (0.85 mmol, 0.13 mL) was added to it; this solution was slowly added over 1 h by the use of a syringe pump.[6] After the addition was completed a saturated solution of NH_4Cl was added and the mixture was extracted 3 times with diethyl ether. The organic phases were collected and evaporation under reduced pressure afforded the crude mixture that was then purified by column chromatography on sílica gel (*n*-hexane-EtOAc, 99:1), giving **4** as a colorless oil (71 mg, 64% yield).

^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.55 (m, 4H, Ph H-2,6), 7.43 (m, 4H, Ph H-3,5), 7.30 (dd, $^3J_{\text{Th H-3, Th H-4}}$ = 3.6 Hz, $^4J_{\text{Th H-3, Th H-5}}$ = 1.2 Hz, 2H, Th H-3), 7.29 (dd, $^3J_{\text{Th H-5, Th H-4}}$ = 5.1 Hz, $^4J_{\text{Th H-5, Th H-3}}$ = 1.2 Hz, 2H, Th H-5), 7.08 (dd, $^3J_{\text{Th H-4, Th H-5}}$ = 5.1 Hz, $^3J_{\text{Th H-4, Th H-3}}$ = 3.6 Hz, 2H, Th H-4), 4.37 (s, 2H, SC$\underline{H}_2$S).

^{13}C NMR (100 MHz, $CDCl_3$) δ: 143.5 (Th C-2), 133.8 (Ph C-4), 133.4 (Ph C-1), 131.3 (Ph C-3,5), 128.1(Th C-4), 126.3 (Ph C-2,6), 125.1(Th C-5), 123.3 (Th C-3), 40.8 (S$\underline{C}$H$_2$S).

HRMS (APCI), *m/z*: calcd. for $C_{21}H_{16}S_4H^+$ 397.0207 $[M+H]^+$; found 397.0208.

***N*-methoxy-*N*-methyl-4,4-bis(phenylsulfanyl)butanamide (5)**



To a solution of dithioketal **3a** (0.23 g, 1.0 mmol, 1.0 equiv) in 2-MeTHF (2 mL) cooled at – 78 °C was added under Ar dropwise a solution of *n*-BuLi in Et_2O (1.6 M, 1.1 mmol, 1.1 equiv, 0.69 mL) and the resulting mixture was stirred for 1 h. Subsequently, a solution of *N*-methoxy-*N*-methylacrylamide (0.11 g, 1.0 mmol, 1.0 equiv) in 2-MeTHF (2 mL) was cannulated into the lithiated dithioketal. After 2 h at -78 °C a saturated solution of NH_4Cl (aq.) was added and after removing the cooling bath it was allowed to reach rt. Additional 2-MeTHF (5 mL) was added to extract the organic phase which was then dried over anhydrous Na_2SO_4, filtered and concentrated.

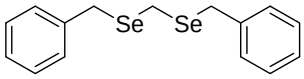
After chromatography on silica gel (*n*-hexane – EtOAc, 1:1) compound **5** was obtained as a colorless oil.

^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.48 (m, 4H, Ph H-2,6), 7.31 (m, 4H, Ph H-3,5), 7.26 (m, 2H, Ph H-4), 4.61 (t, ^{3}J = 6.8 Hz, 1H, $COCH_2CH_2C\underline{H}$), 3.67 (s, 3H, $OC\underline{H}_3$), 3.16 (s, 3H, $NC\underline{H}_3$), 2.77 (t, ^{3}J = 7.2 Hz, 2H, $COC\underline{H}_2$), 2.21 (m, 2H, $COCH_2C\underline{H}_2CH$).

^{13}C NMR (100 MHz, $CDCl_3$) δ: 173.3 ($\underline{C}ON$), 134.0 (Ph C-1), 132.5 (Ph C-2,6), 128.9 (Ph C-3,5), 127.6 (Ph C-4), 61.2 ($O\underline{C}H_3$), 57.2 ($S\underline{C}HS$), 32.2 ($N\underline{C}H_3$), 30.5 ($COCH_2\underline{C}H_2CH$), 29.1 ($CO\underline{C}H_2$).

HRMS (APCI), *m/z*: calcd. for $C_{18}H_{21}NO_2S_2H^+$ 348.1086 $[M+H]^+$; found 348.1090.

1,1'-[methylenebis(selanylmethylene)]dibenzene (7a)



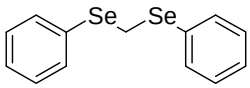
By following the General Procedure 1, starting from dibenzyl diselenide (0.20 g, 0.59 mmol, 1.0 equiv), TMSCl (0.13 g, 0.15 mL, 1.18 mmol, 2.0 equiv), ICH_2Br (0.39 g, 0.13 mL, 1.77 mmol, 3.0 equiv), and MeLi-LiBr (0.98 mL, 1.48 mmol) in THF, compound **7a** was obtained in 85% (171 mg) as a yellow solid after chromatography on silica gel (*n*-hexane-DCM, 95:5). mp 61 °C (lit.[7] 60 °C)

^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.27 (m, 8H, Ph H-2,3,5,6), 7.21 (m, 2H, Ph H-4), 3.87 (s, 4H, $PhC\underline{H}_2Se$), 3.42 (s, 2H, $SeC\underline{H}_2Se$).

^{13}C NMR (100 MHz, $CDCl_3$) δ: 138.7 (Ph C-1), 129.0 (Ph C-2,6), 128.5 (Ph C-3,5), 126.8 (Ph C-4), 28.5 ($Ph\underline{C}H_2Se$), 13.7 ($Se\underline{C}H_2Se$).

HRMS (APCI), *m/z*: calcd. for $C_{15}H_{16}Se_2H^+$ 356.9655 $[M+H]^+$; found 356.9657.

1,1'-(methylenediselanyl)dibenzene (7b)



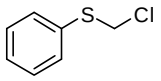
By following the General Procedure 1, starting from diphenyl diselenide (0.20 g, 0.64 mmol, 1.0 equiv), TMSCl (0.14 g, 0.16 mL, 1.28 mmol, 2.0 equiv), ICH_2Br (0.42 g, 0.14 mL, 1.92 mmol, 3.0 equiv), and MeLi-LiBr (1.07 mL, 1.60 mmol) in THF, compound **7b** was obtained in 88% (184 mg) as a colorless solid after chromatography on silica gel (*n*-hexane-DCM, 95:5). mp 38 °C (lit.[8] 36-38 °C)

^{1}H NMR (400 MHz, $CDCl_3$) δ: 7.54 (m, 4H, Ph H-2,6), 7.29 (m, 6H, Ph H-3,4,5), 4.24 (s, 2H, $SeC\underline{H}_2Se$).

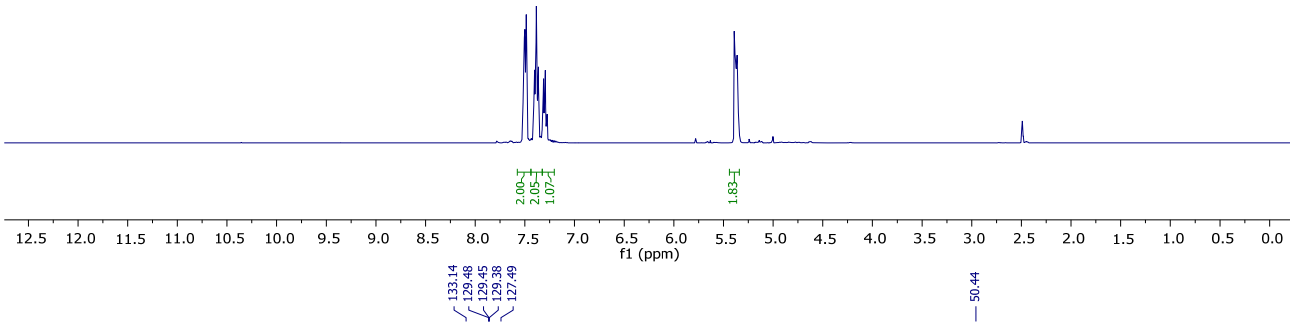
^{13}C NMR (100 MHz, $CDCl_3$) δ: 133.0 (Ph C-2,6), 130.8 (Ph C-1), 129.1 (Ph C-3,5), 127.6 (Ph C-4), 21.0 (Se<u>C</u>H_2Se).

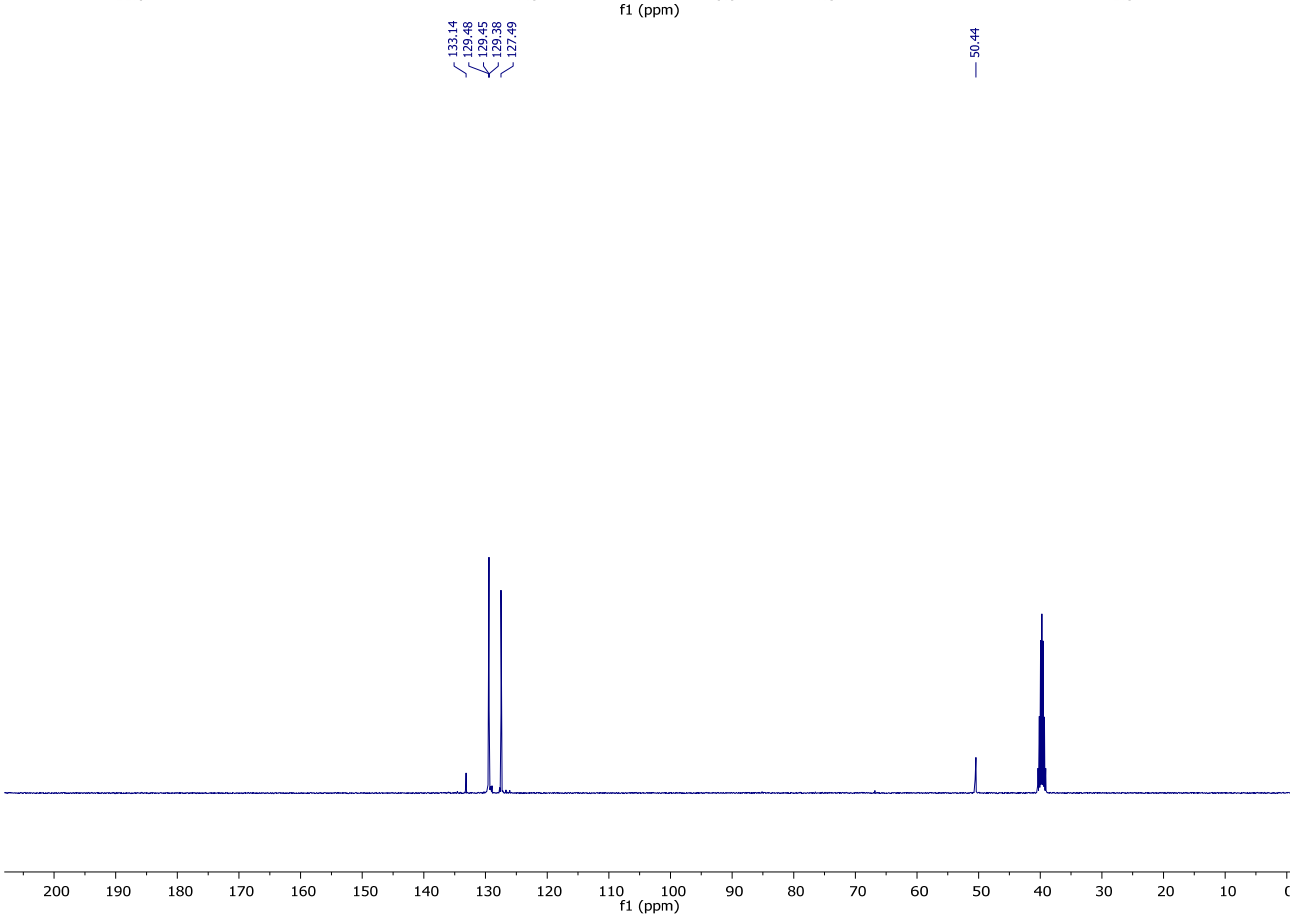
HRMS (APCI), *m/z*: calcd. for $C_{13}H_{12}Se_2$ 327.9264 M^+; found 327.9269.

(2a)

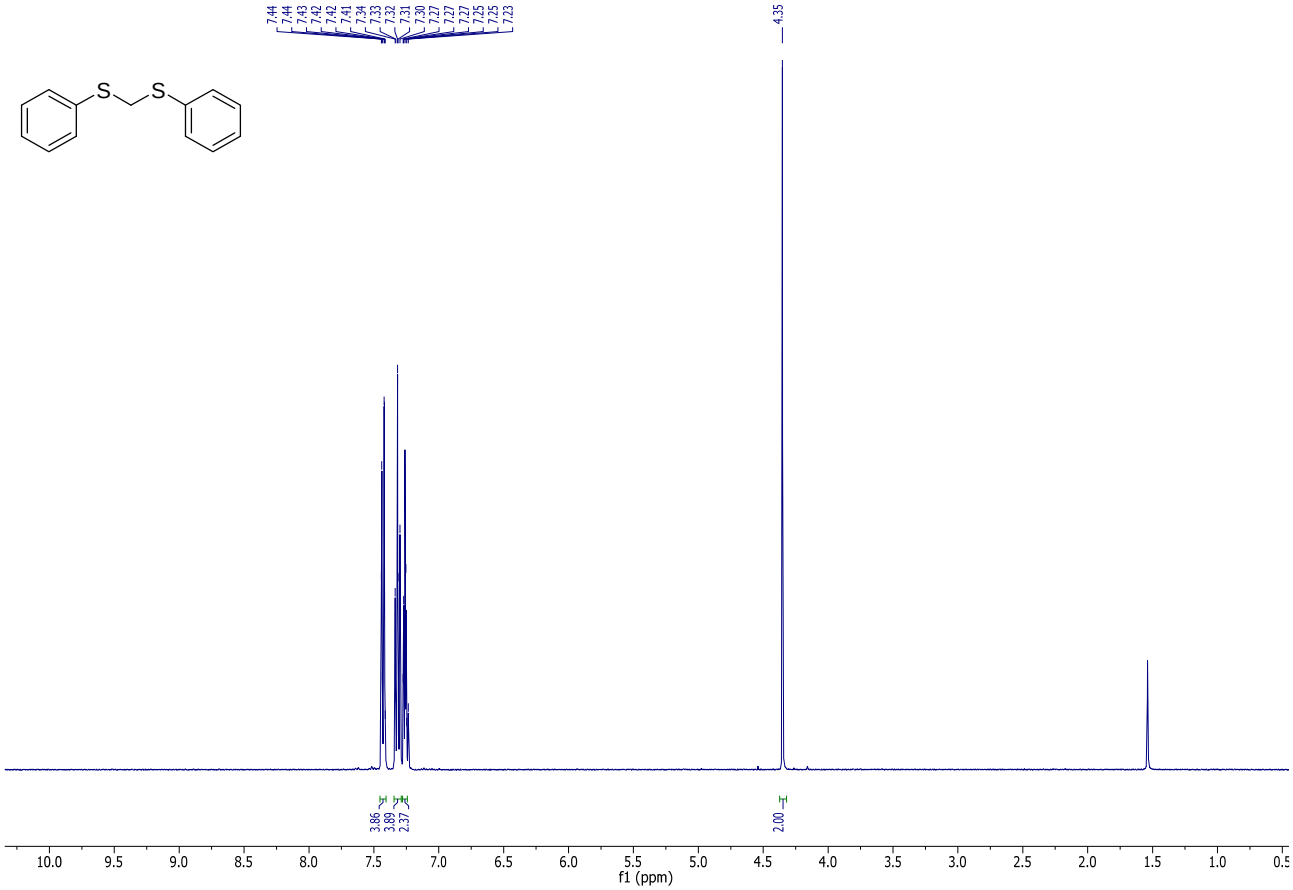

S
Cl

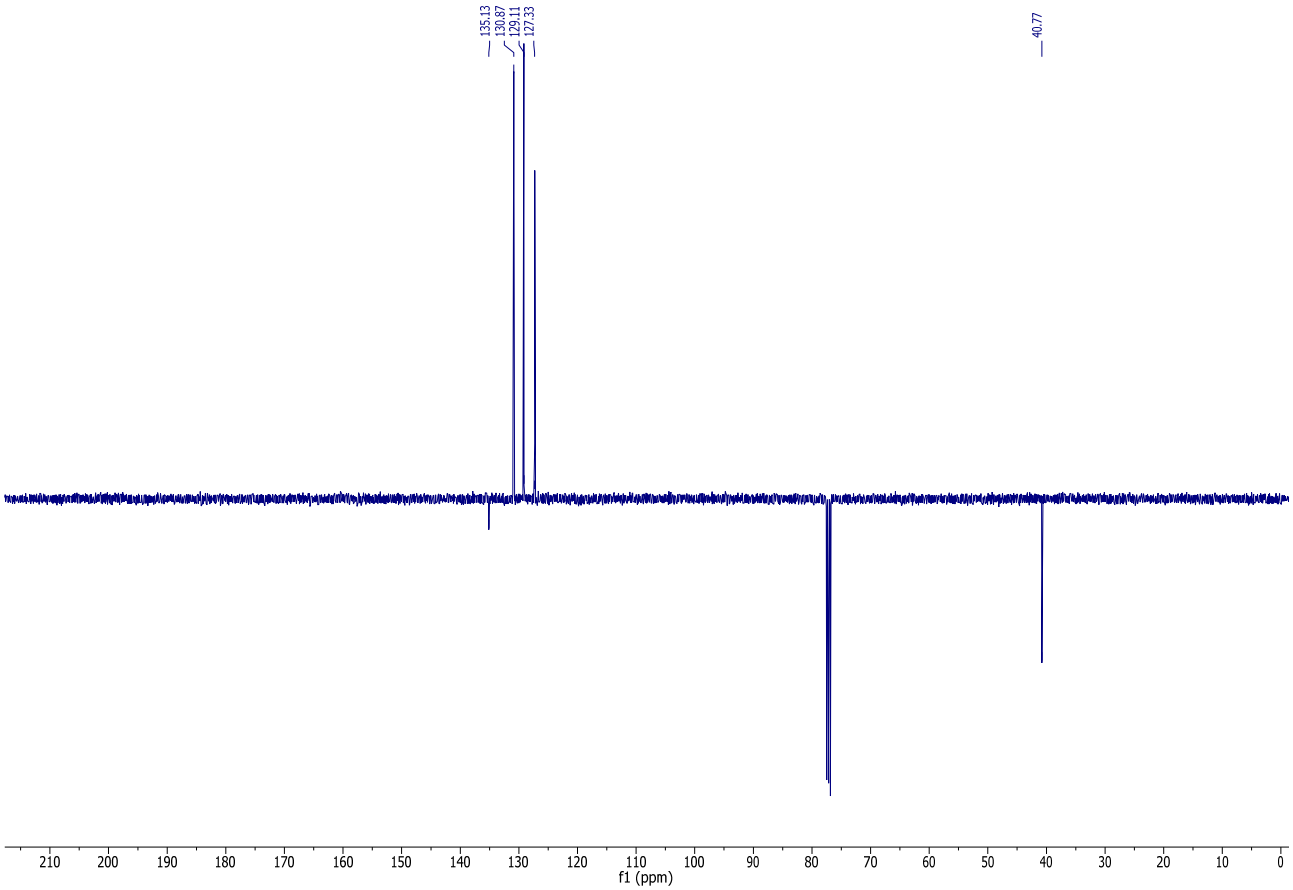
7.52
7.52
7.51
7.51
7.50
7.50
7.49
7.48
7.41
7.41
7.40
7.40
7.39
7.39
7.38
7.38
7.37
7.37
7.36
7.32
7.32
7.32
7.31
7.31
7.30
7.30
7.29
7.29
7.28


2.06
2.05
1.07
1.83
12.5 12.0 11.5 11.0 10.5 10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5 0.0
f1 (ppm)

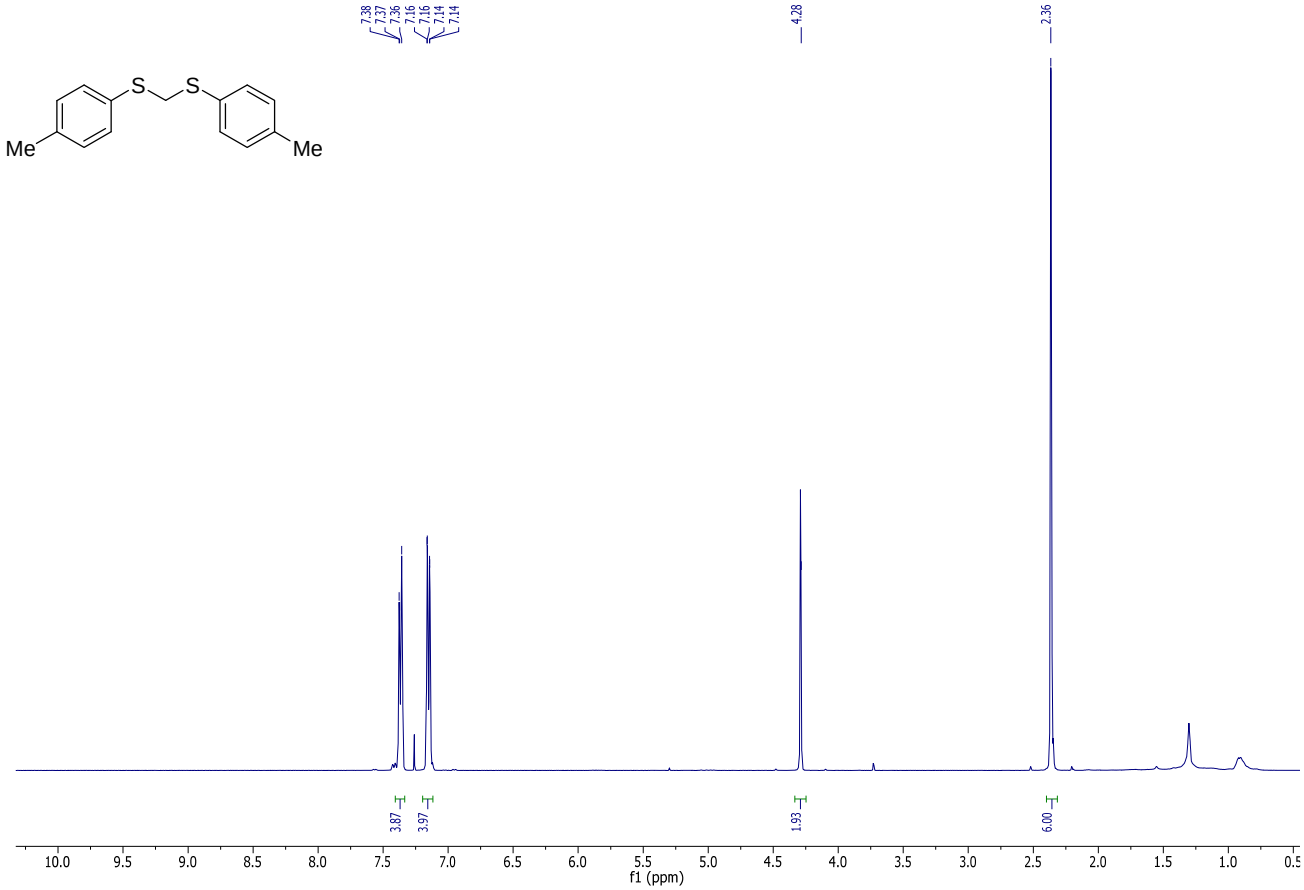

133.14
129.48
129.45
129.38
127.49
50.44
200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10
f1 (ppm)

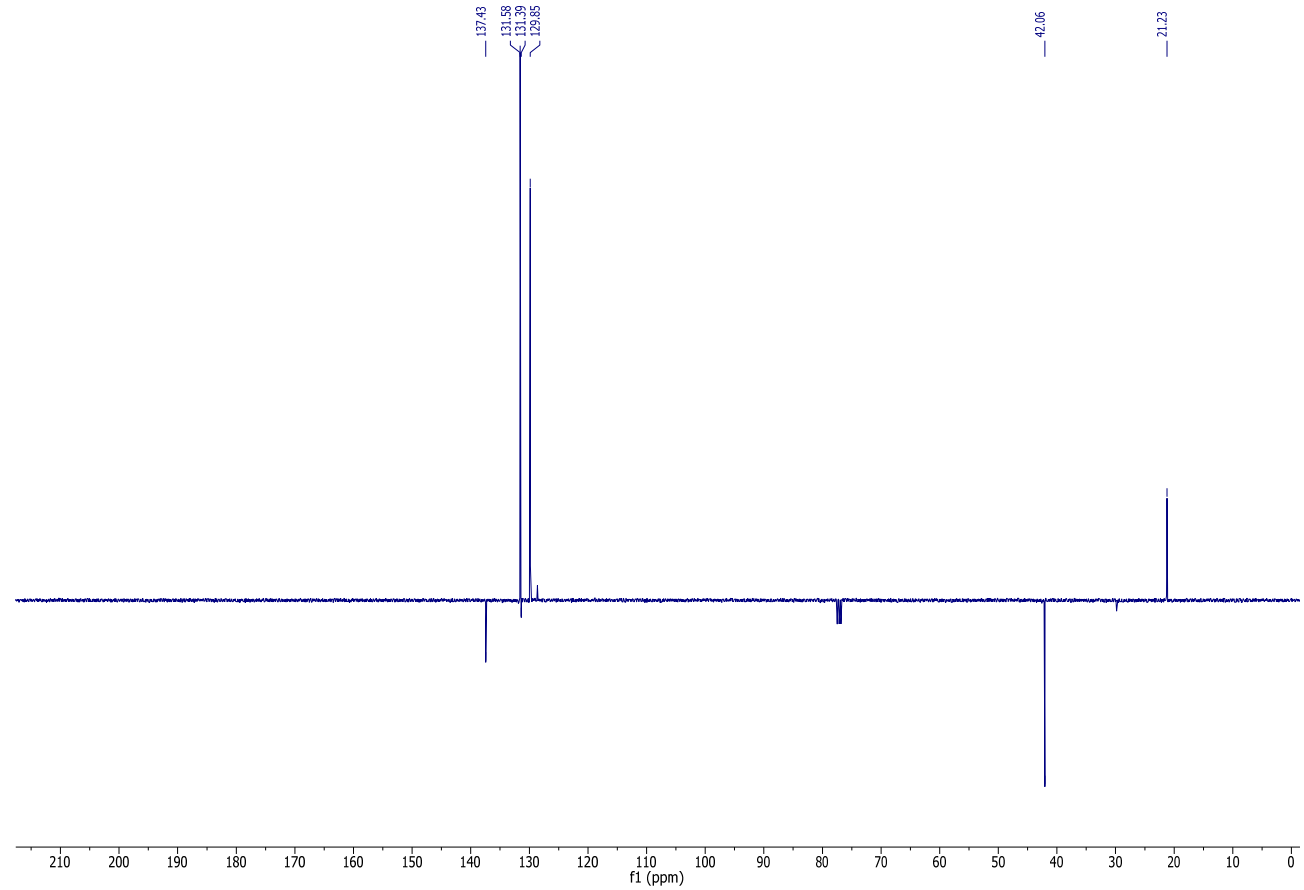
(3a)


7.44
7.44
7.43
7.42
7.42
7.41
7.34
7.33
7.32
7.31
7.30
7.27
7.27
7.27
7.25
7.25
7.23
4.35
3.86
3.89
2.37
2.00
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
f1 (ppm)

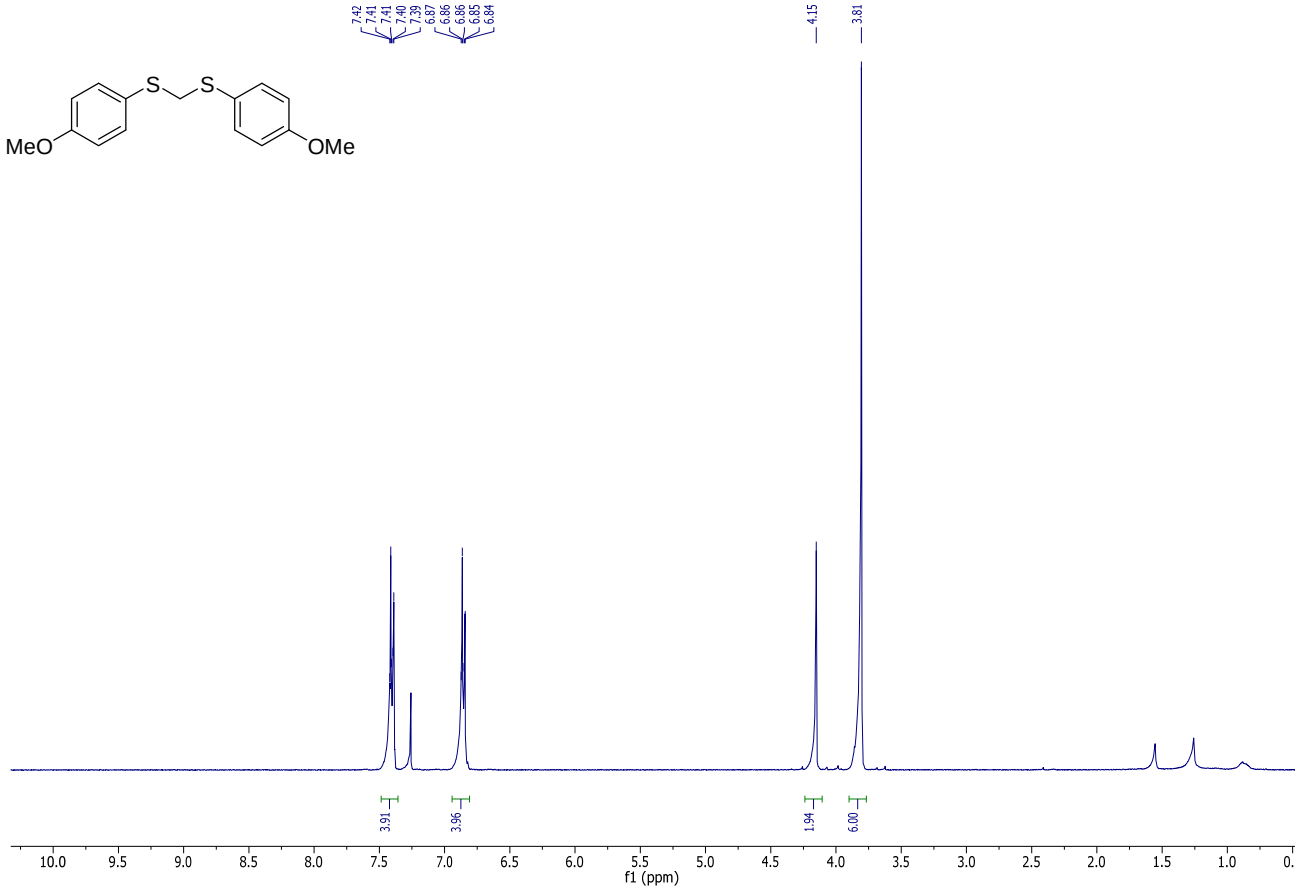

135.13
130.87
129.11
127.33
40.77
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

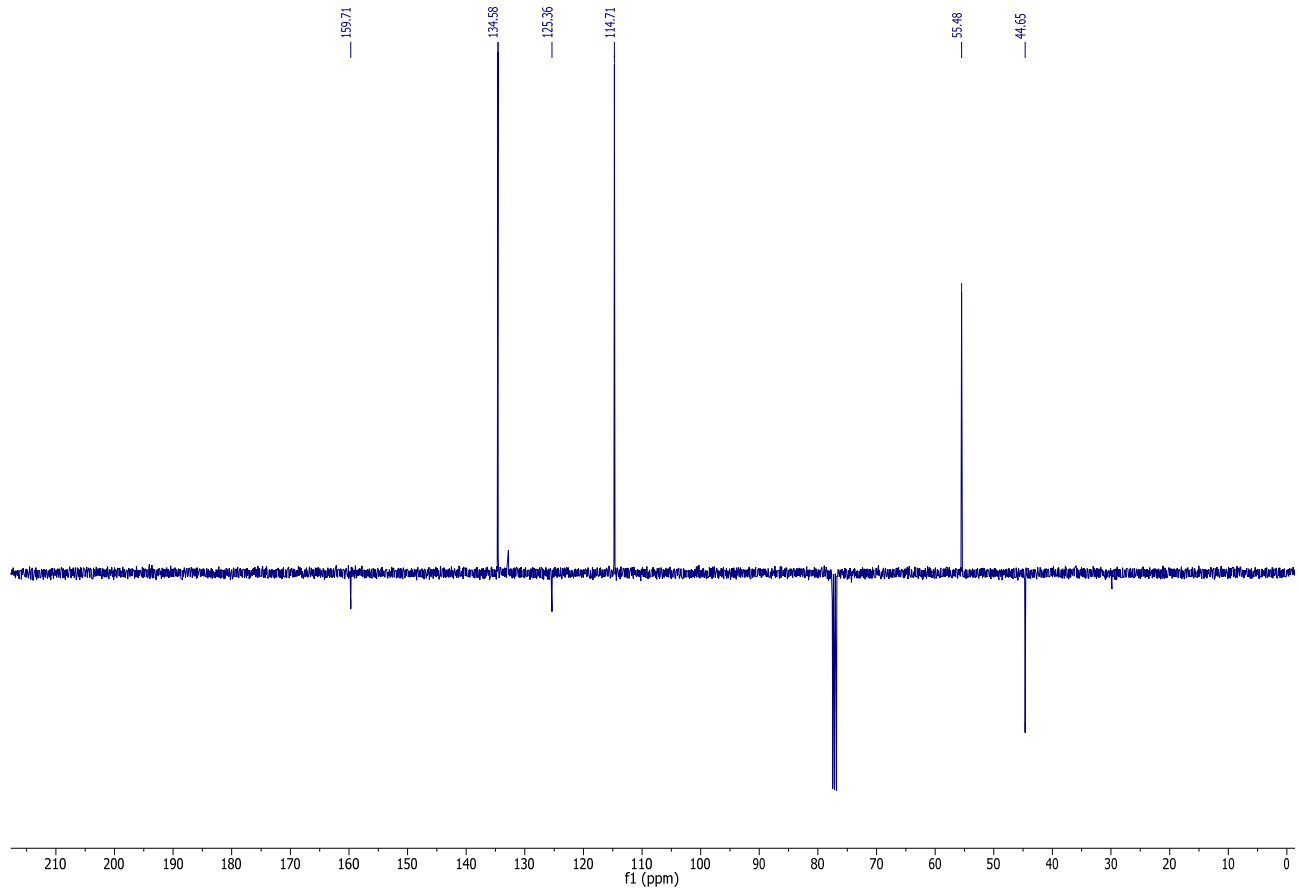
(3b)


7.38
7.37
7.36
7.16
7.16
7.14
7.14
4.28
2.36
3.87
3.97
1.93
6.00
f1 (ppm)

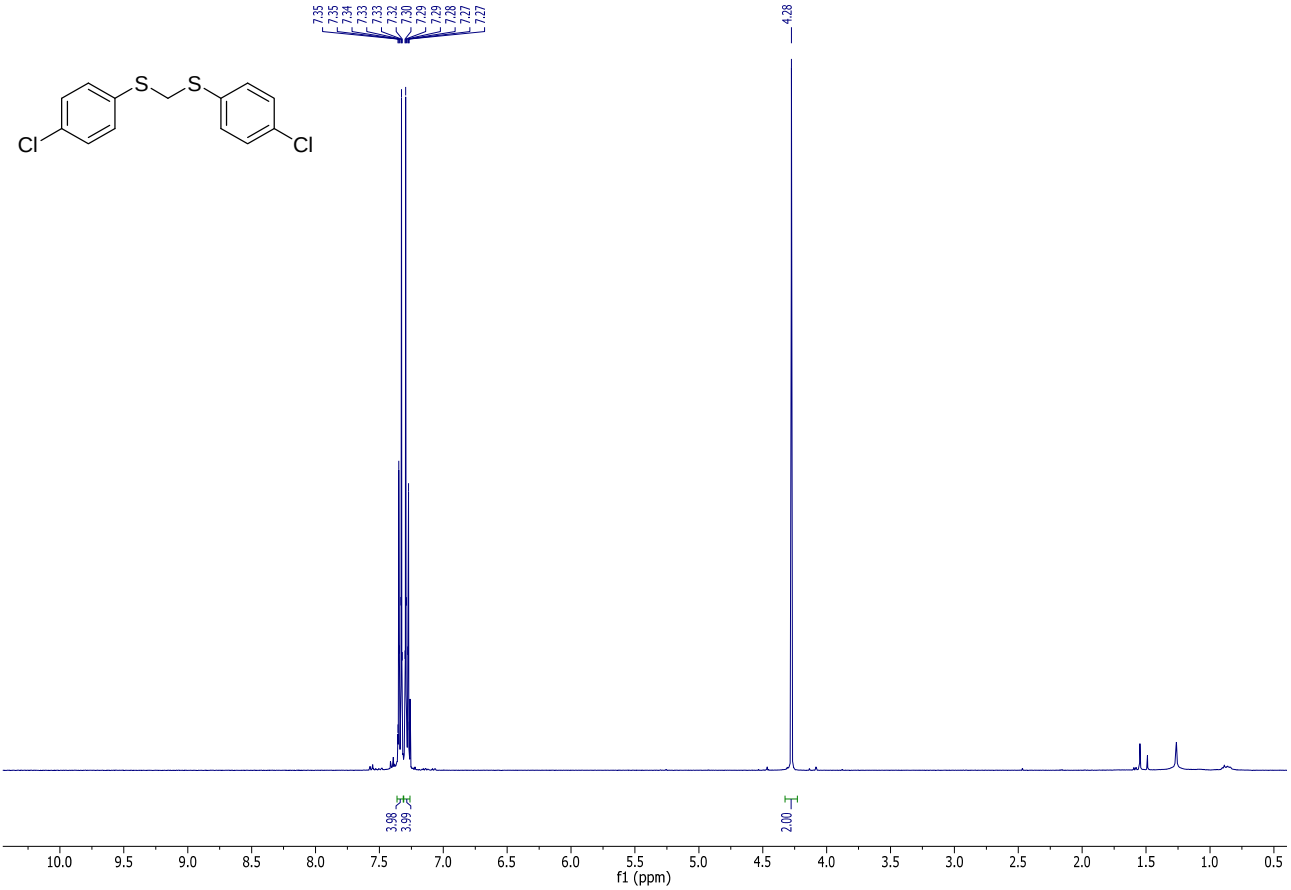

137.43
131.58
131.39
129.85
42.06
21.23
f1 (ppm)

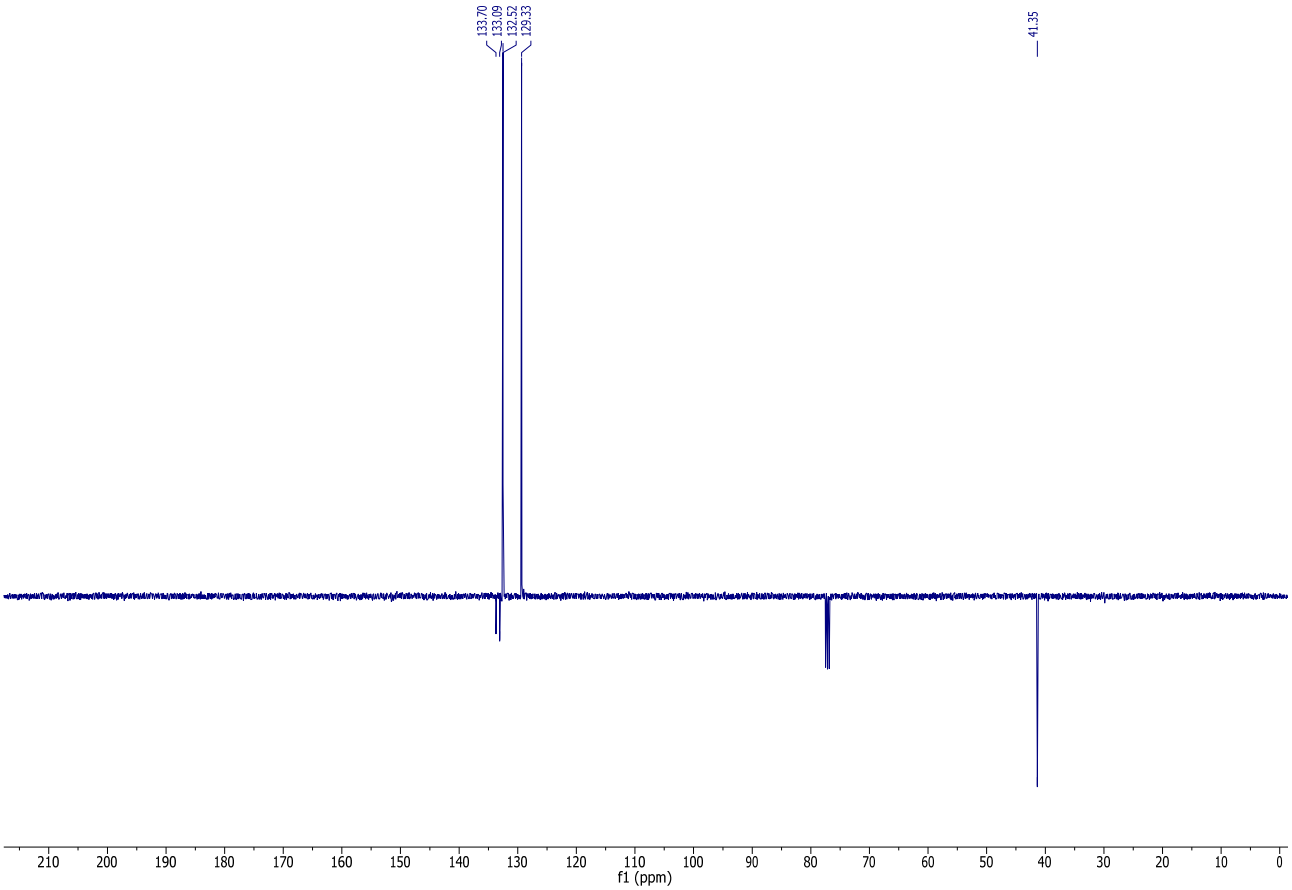
(3c)


7.42
7.41
7.41
7.40
7.39
6.87
6.86
6.86
6.85
6.84
4.15
3.81
S
S
MeO
OMe
3.91
3.96
1.94
6.00
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.
f1 (ppm)

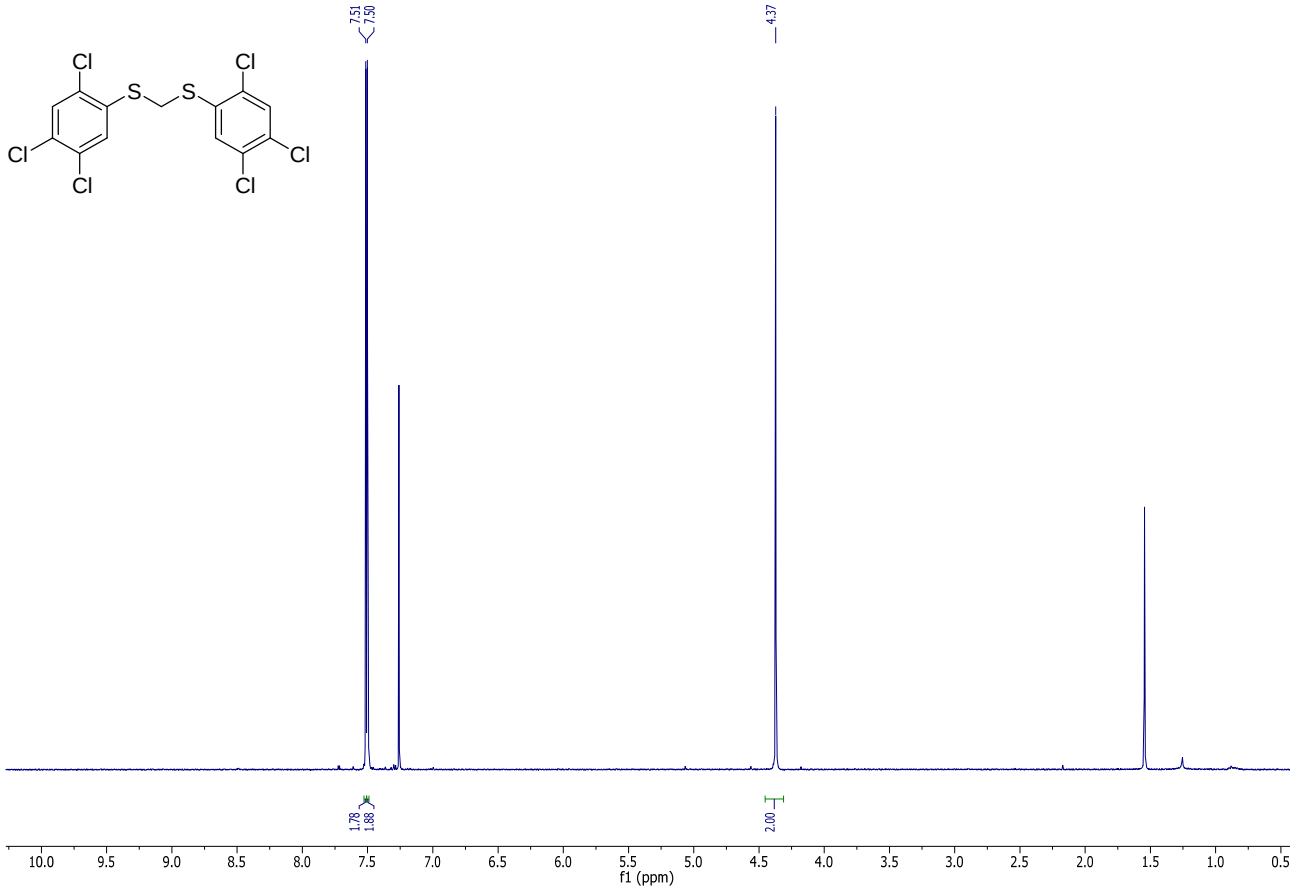

159.71
134.58
125.36
114.71
55.48
44.65
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

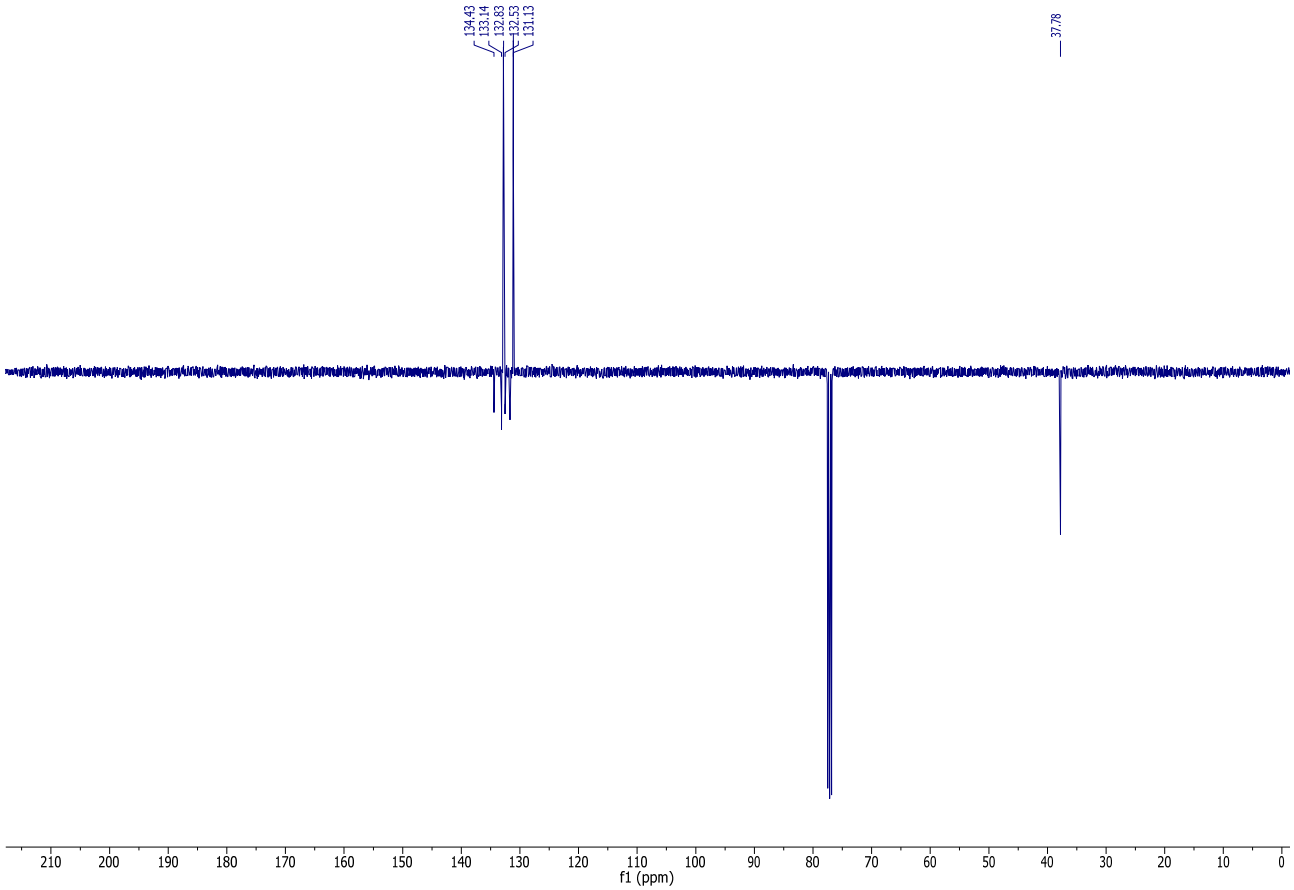
(3d)


7.35
7.35
7.34
7.33
7.33
7.32
7.30
7.29
7.29
7.28
7.27
7.27
4.28
S
S
Cl
Cl
3.98
3.99
2.00
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
f1 (ppm)

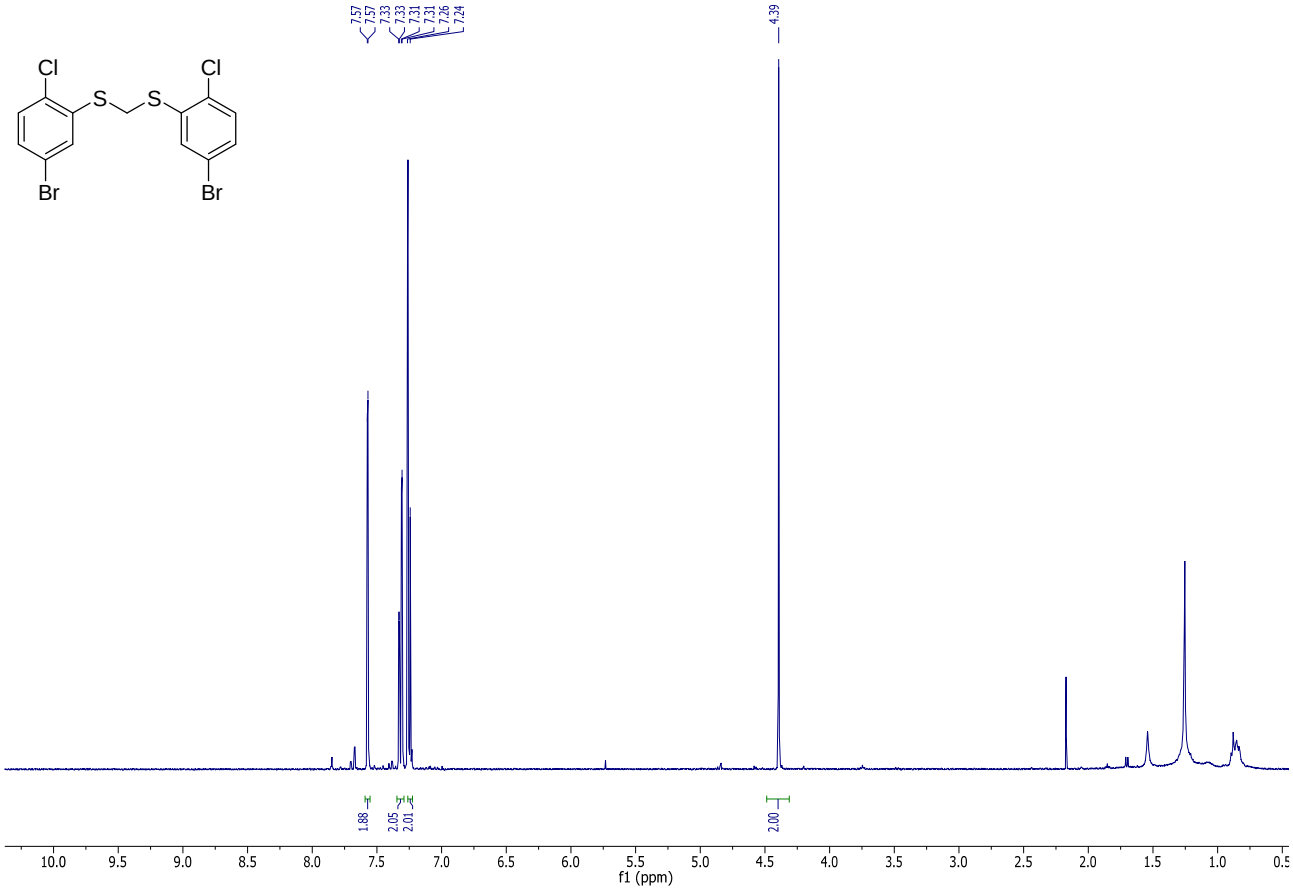

133.70
133.09
132.52
129.33
41.35
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

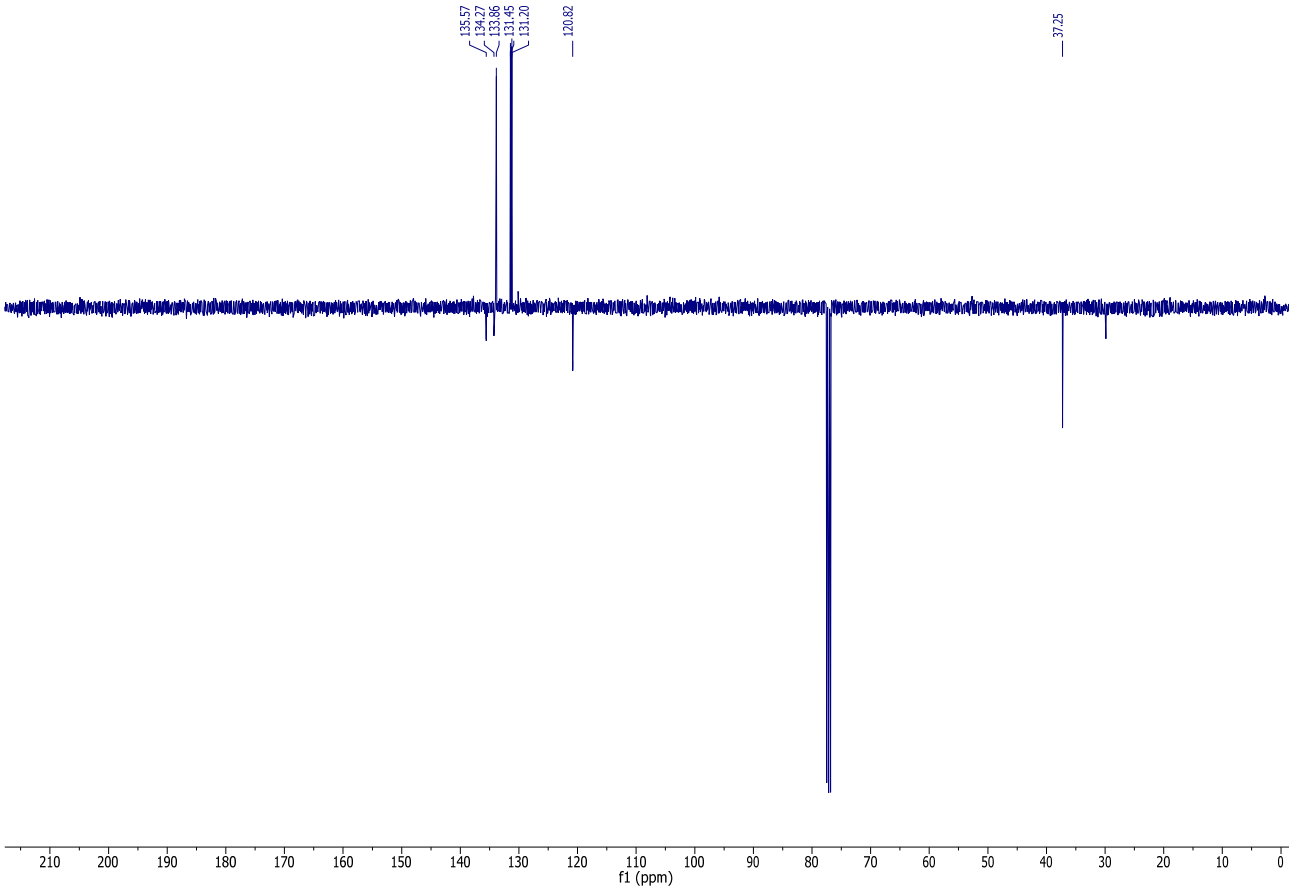
(3e)


7.51
7.50
4.37
1.78
1.88
2.00
f1 (ppm)

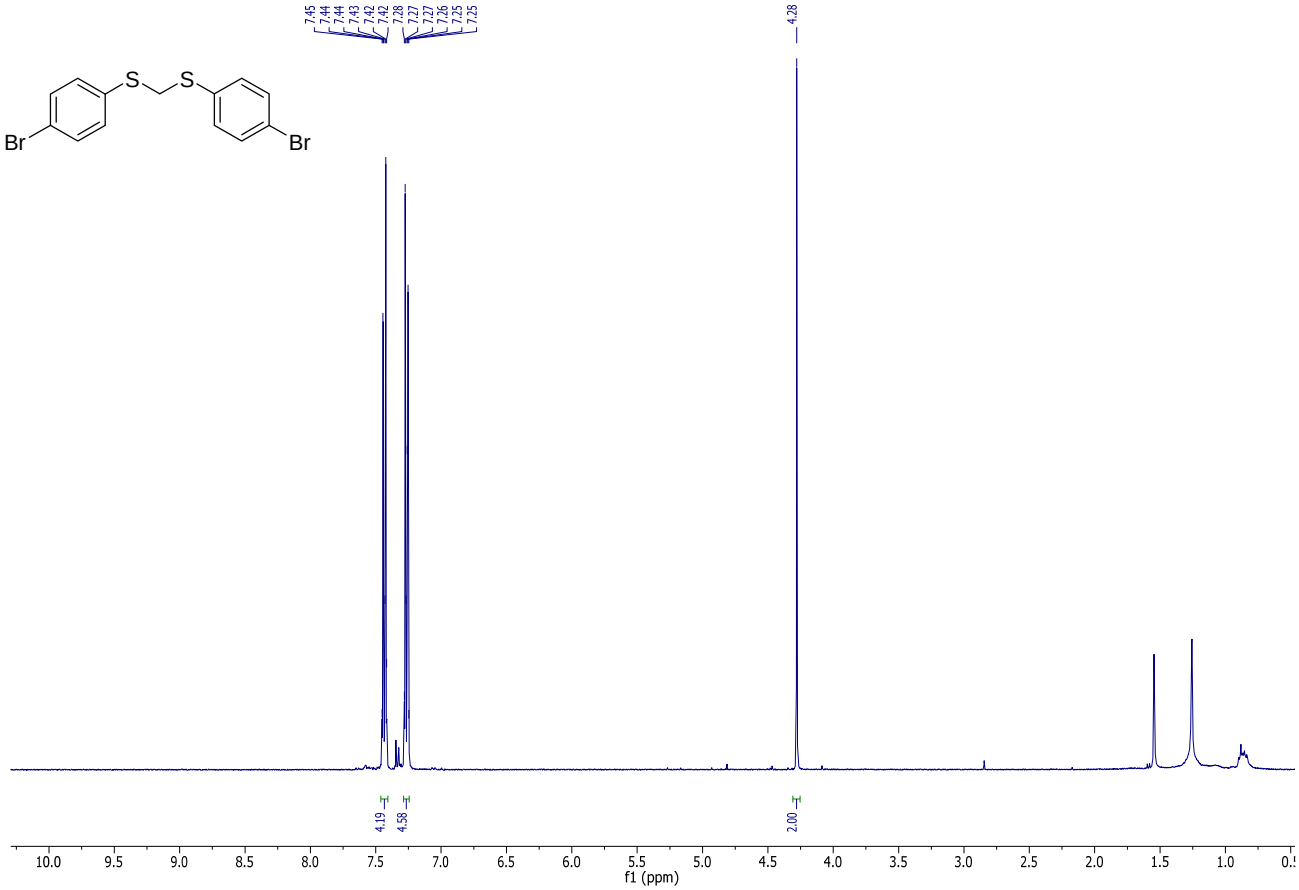

134.43
133.14
132.83
132.53
131.13
37.78
f1 (ppm)

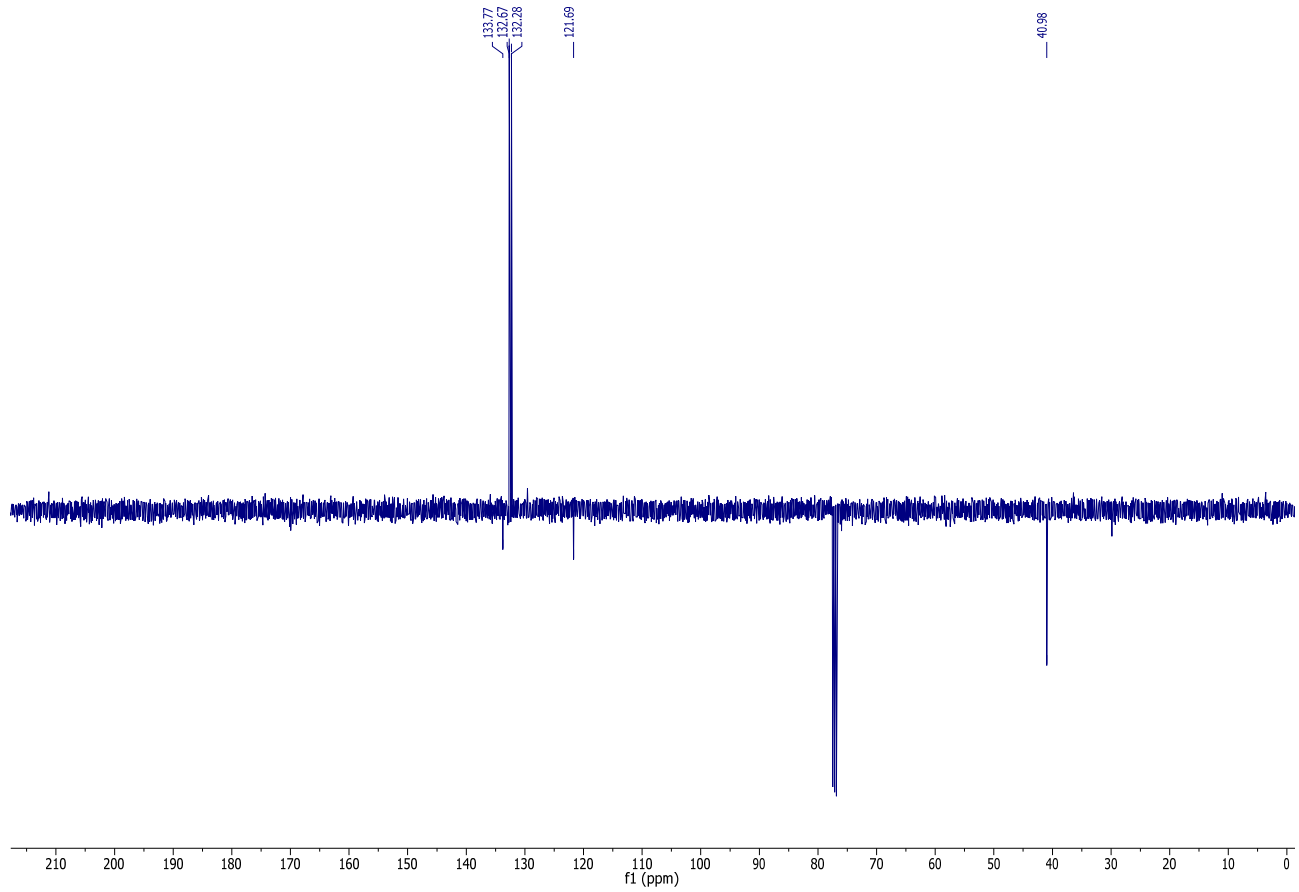
(3f)


Cl
S
S
Cl
Br
Br
7.57
7.57
7.33
7.33
7.31
7.31
7.26
7.24
4.39
1.88
2.05
2.01
2.00
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
f1 (ppm)

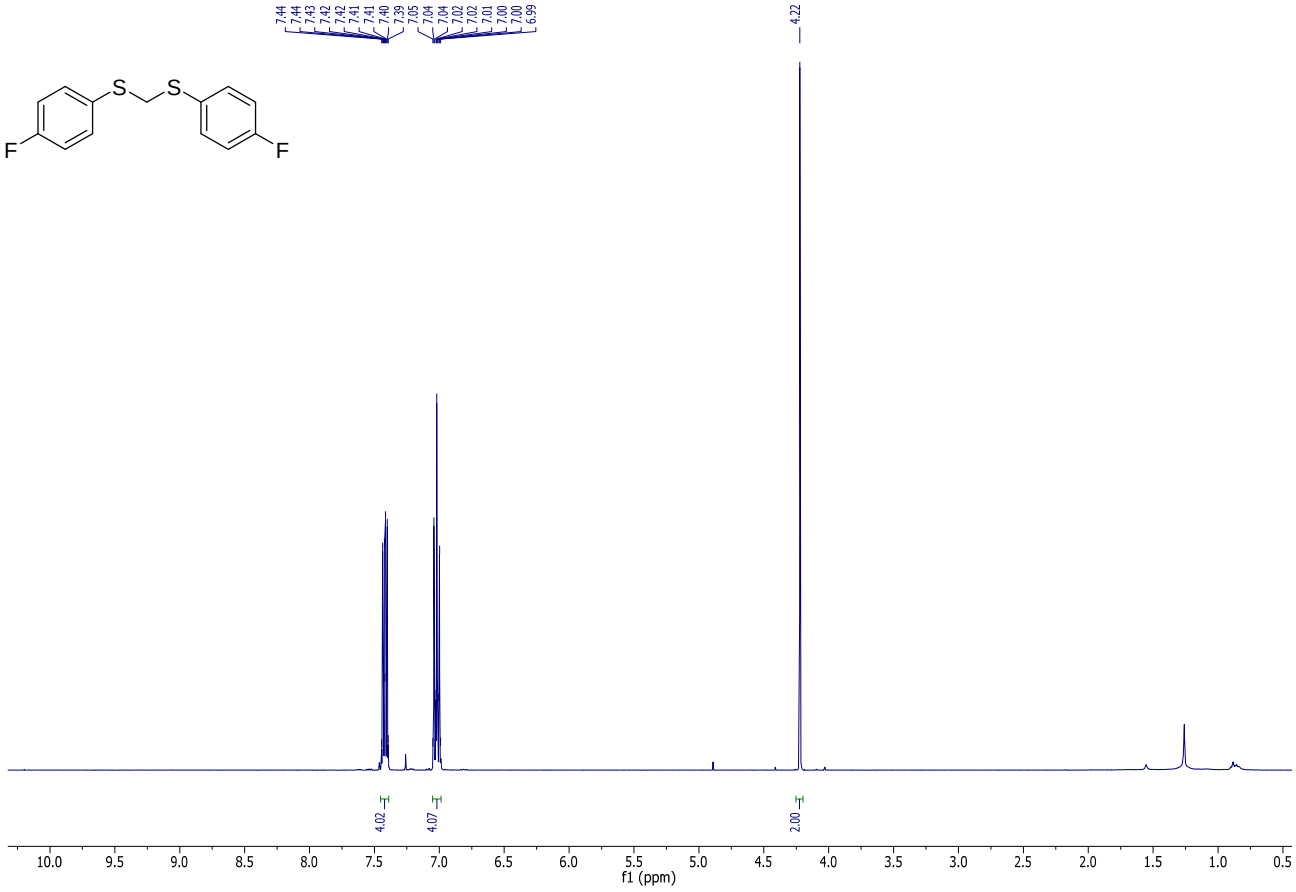

135.57
134.27
133.86
131.45
131.20
120.82
37.25
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

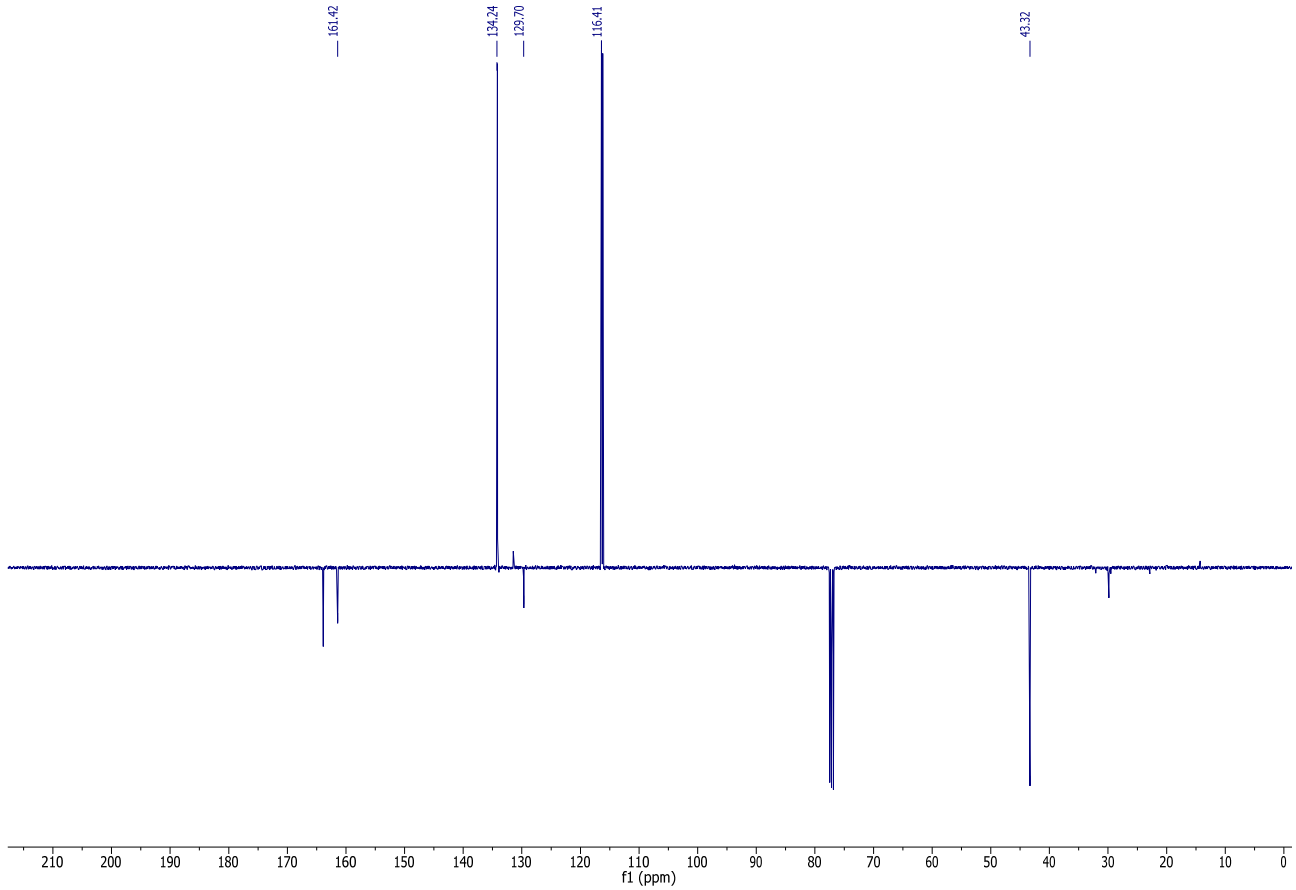
(3g)


7.45
7.44
7.44
7.43
7.42
7.42
7.28
7.27
7.27
7.26
7.25
7.25
4.28
S
S
Br
Br
4.19
4.58
2.00
f1 (ppm)

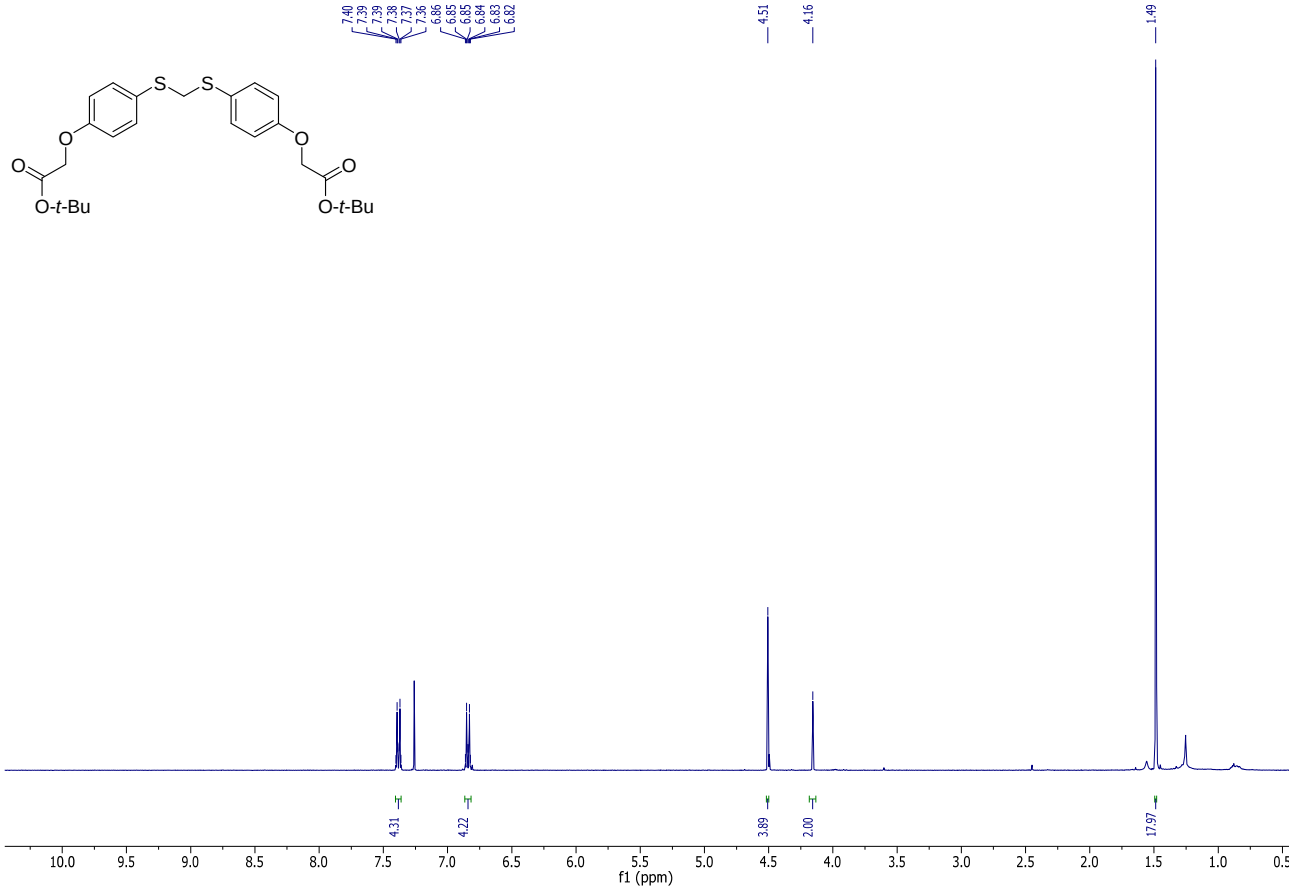

133.77
132.67
132.28
121.69
40.98
f1 (ppm)

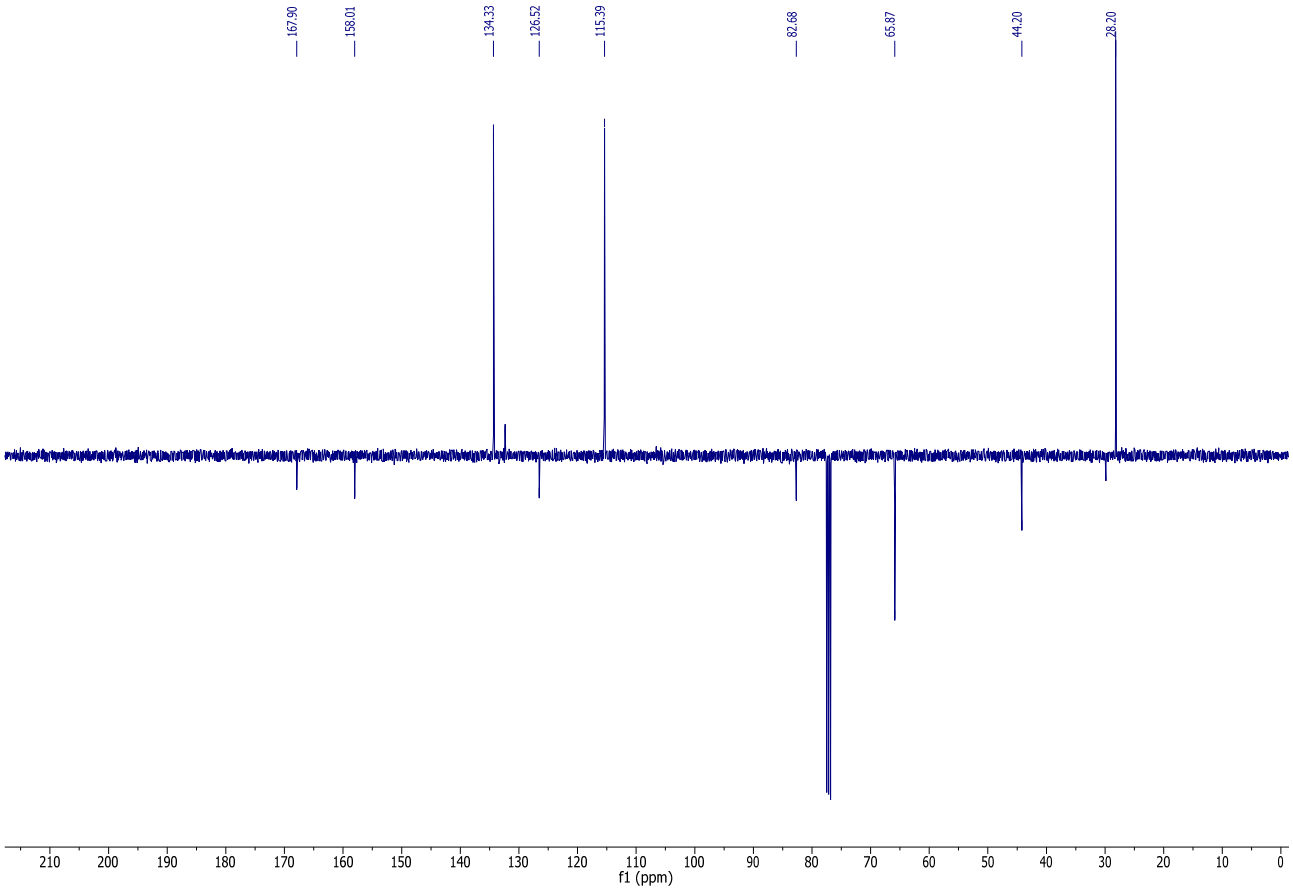
(3h)


7.44
7.44
7.43
7.42
7.42
7.41
7.41
7.40
7.39
7.05
7.04
7.04
7.02
7.02
7.01
7.01
7.00
7.00
7.00
6.99
4.22
S
S
F
F
4.02
4.07
2.00
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
f1 (ppm)

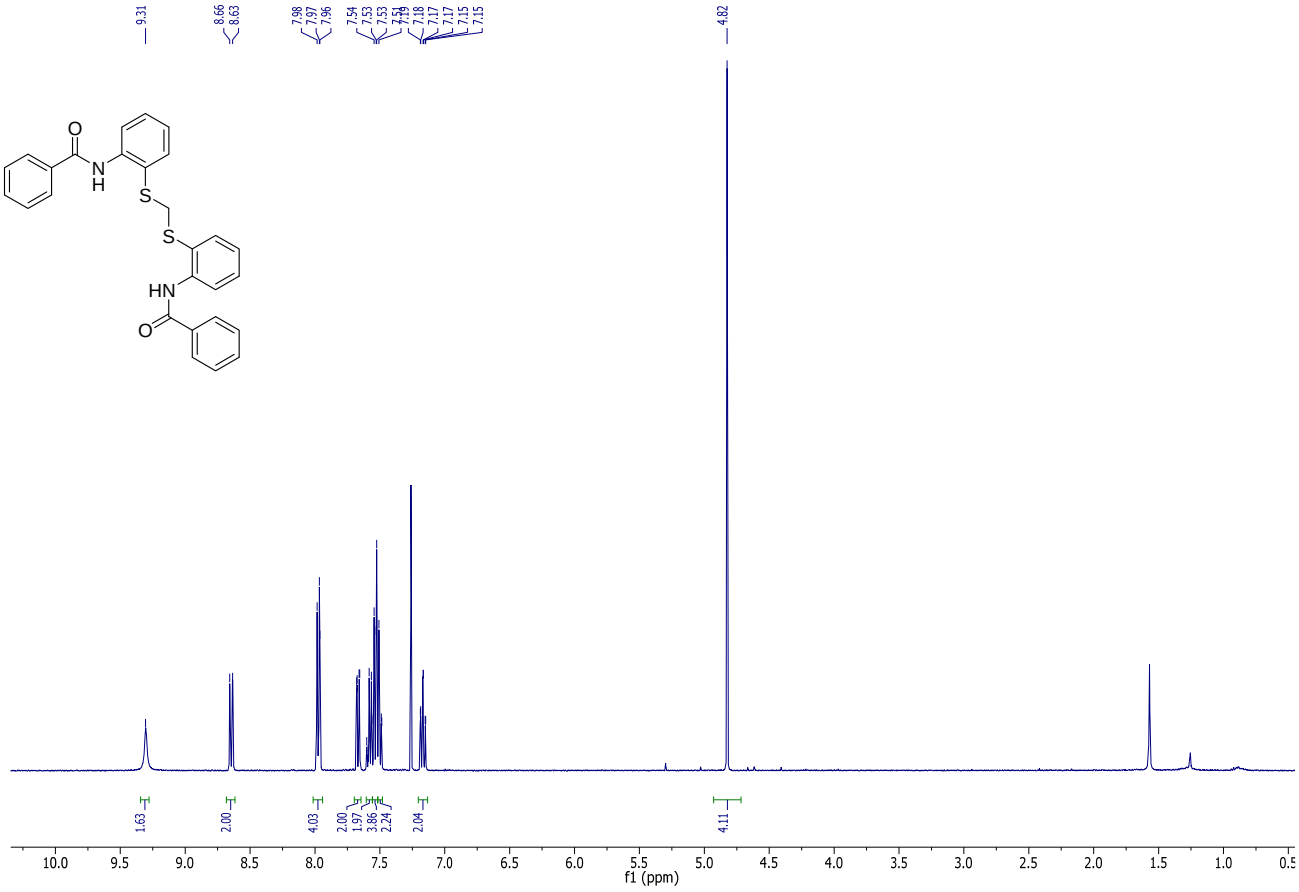

161.42
134.24
129.70
116.41
43.32
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

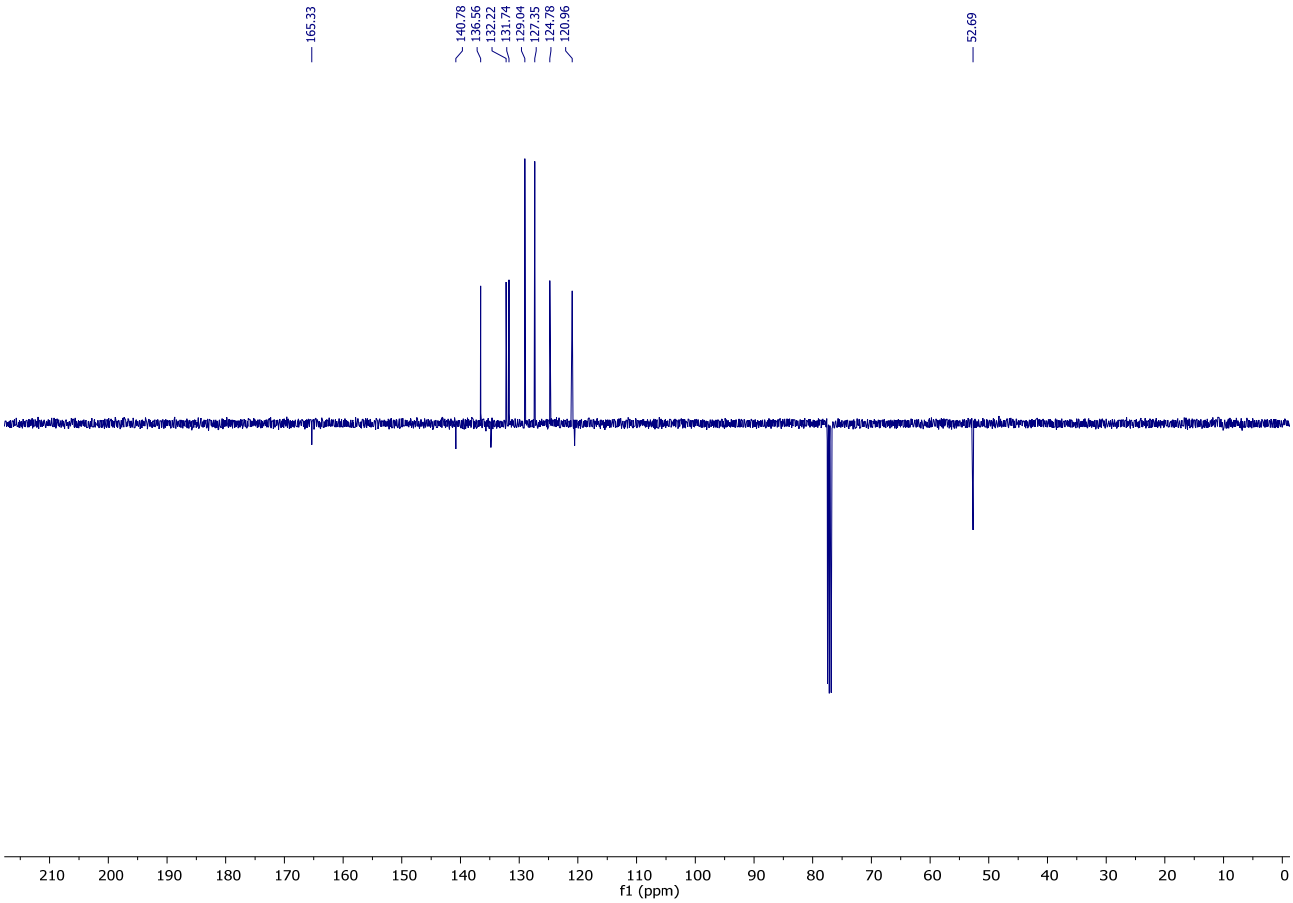
(3i)


7.40
7.39
7.39
7.38
7.37
7.36
6.86
6.85
6.85
6.84
6.83
6.82
4.51
4.16
1.49
S
S
O
O
O
O
O-t-Bu
O-t-Bu
4.31
4.22
3.89
2.00
17.97
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
f1 (ppm)

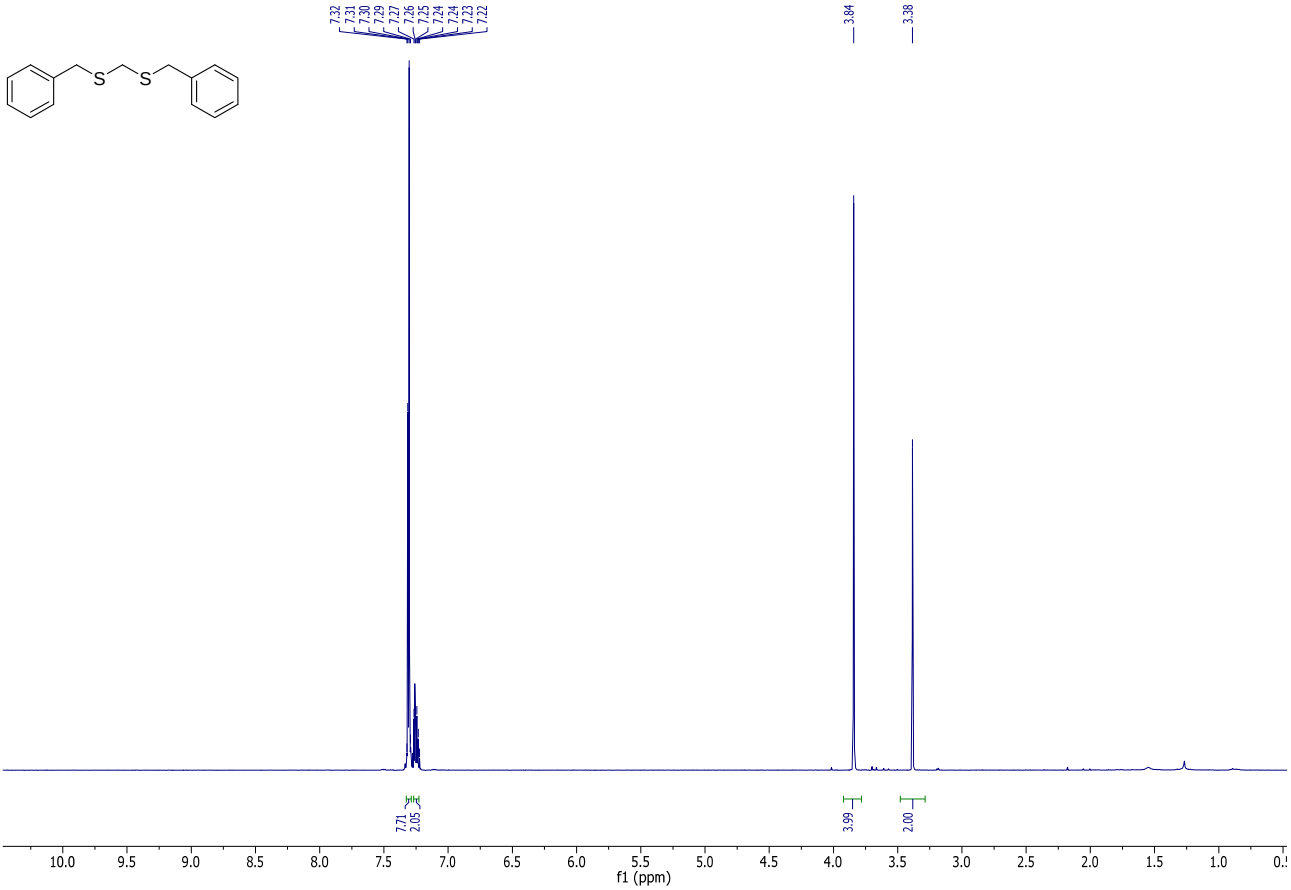

167.90
158.01
134.33
126.52
115.39
82.68
65.87
44.20
28.20
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

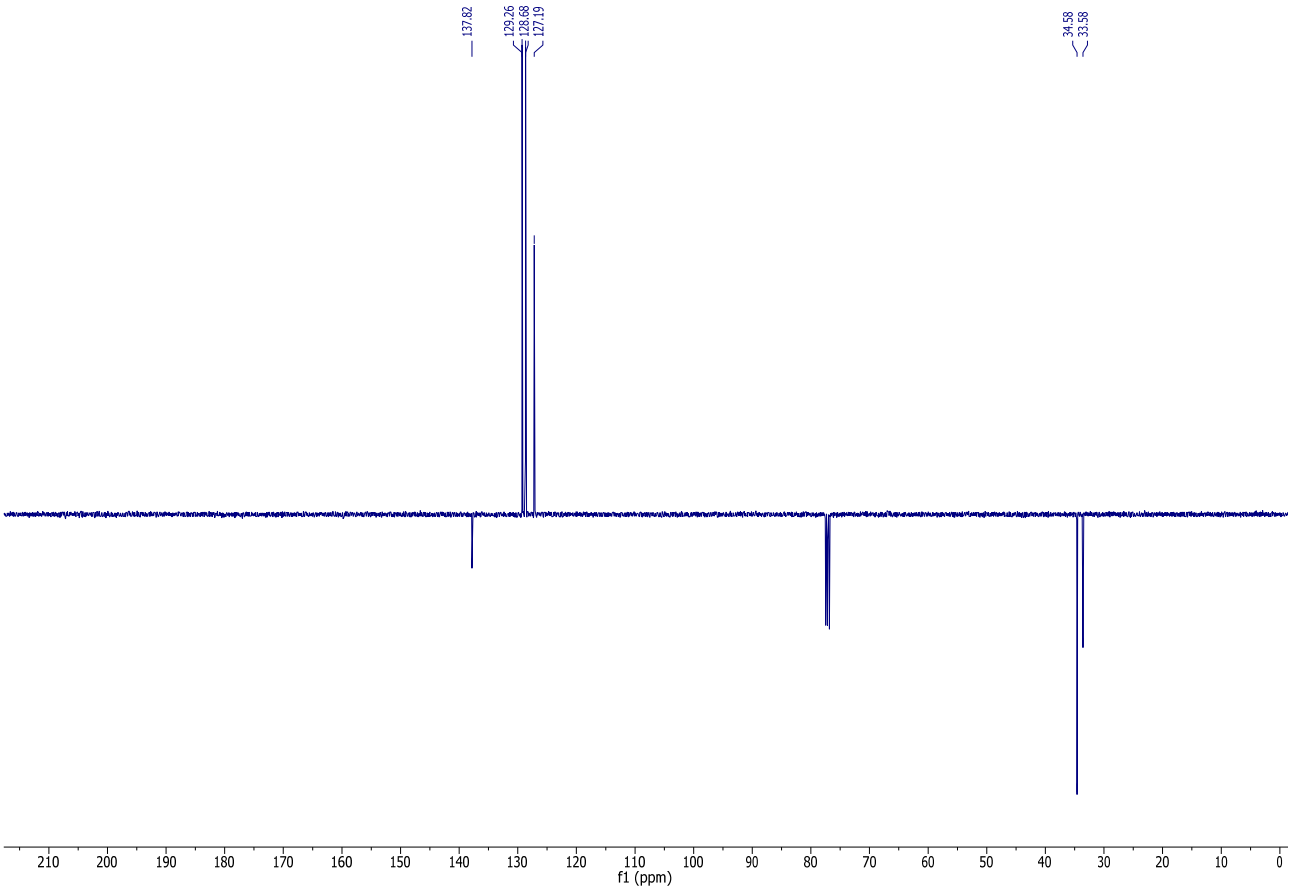
(3j)


9.31
8.66
8.63
7.98
7.97
7.96
7.54
7.53
7.53
7.19
7.18
7.17
7.17
7.17
7.15
7.15
4.82
1.63
2.00
4.03
2.00
1.97
3.86
2.24
2.04
4.11
f1 (ppm)

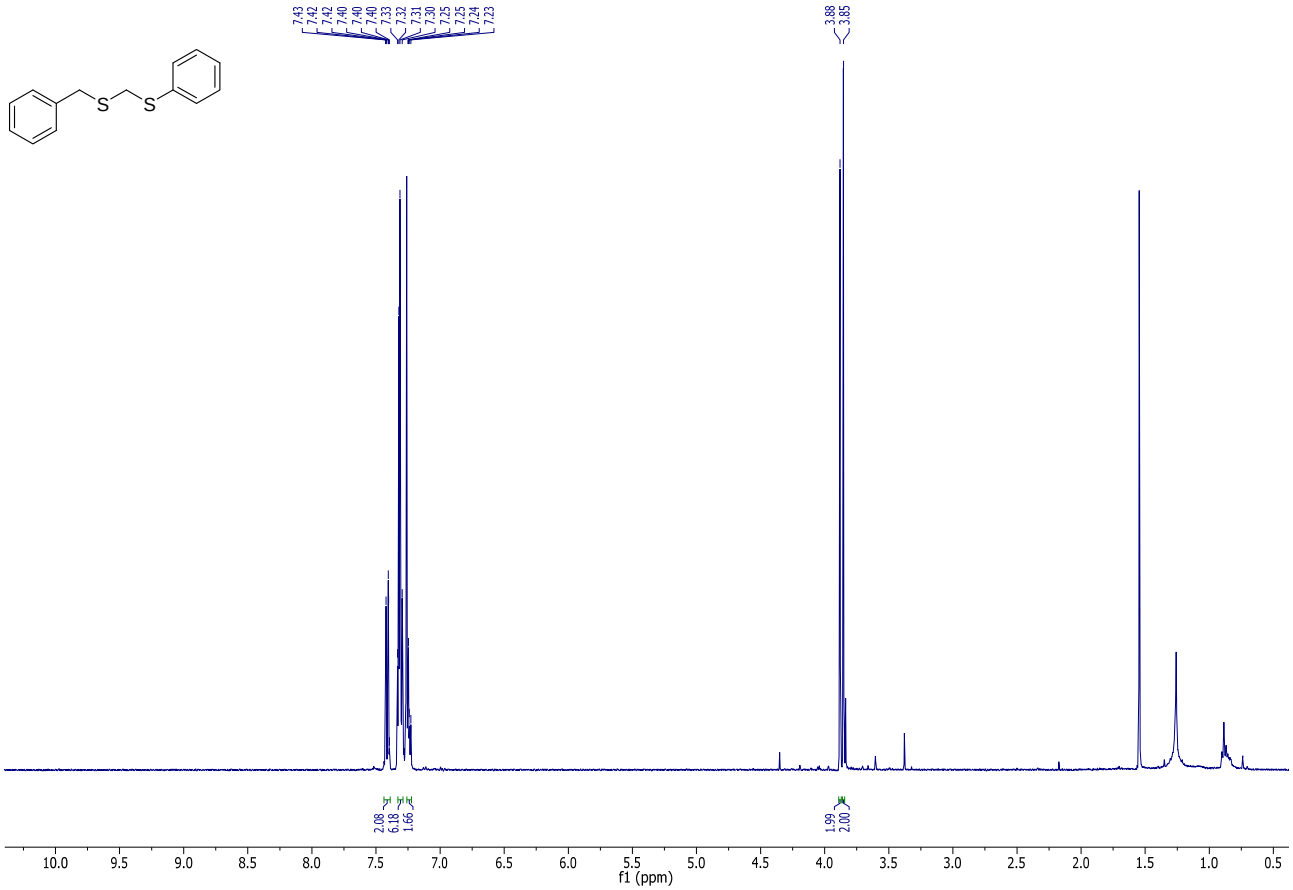

165.33
140.78
136.56
132.22
131.74
129.04
127.35
124.78
120.96
52.69
f1 (ppm)

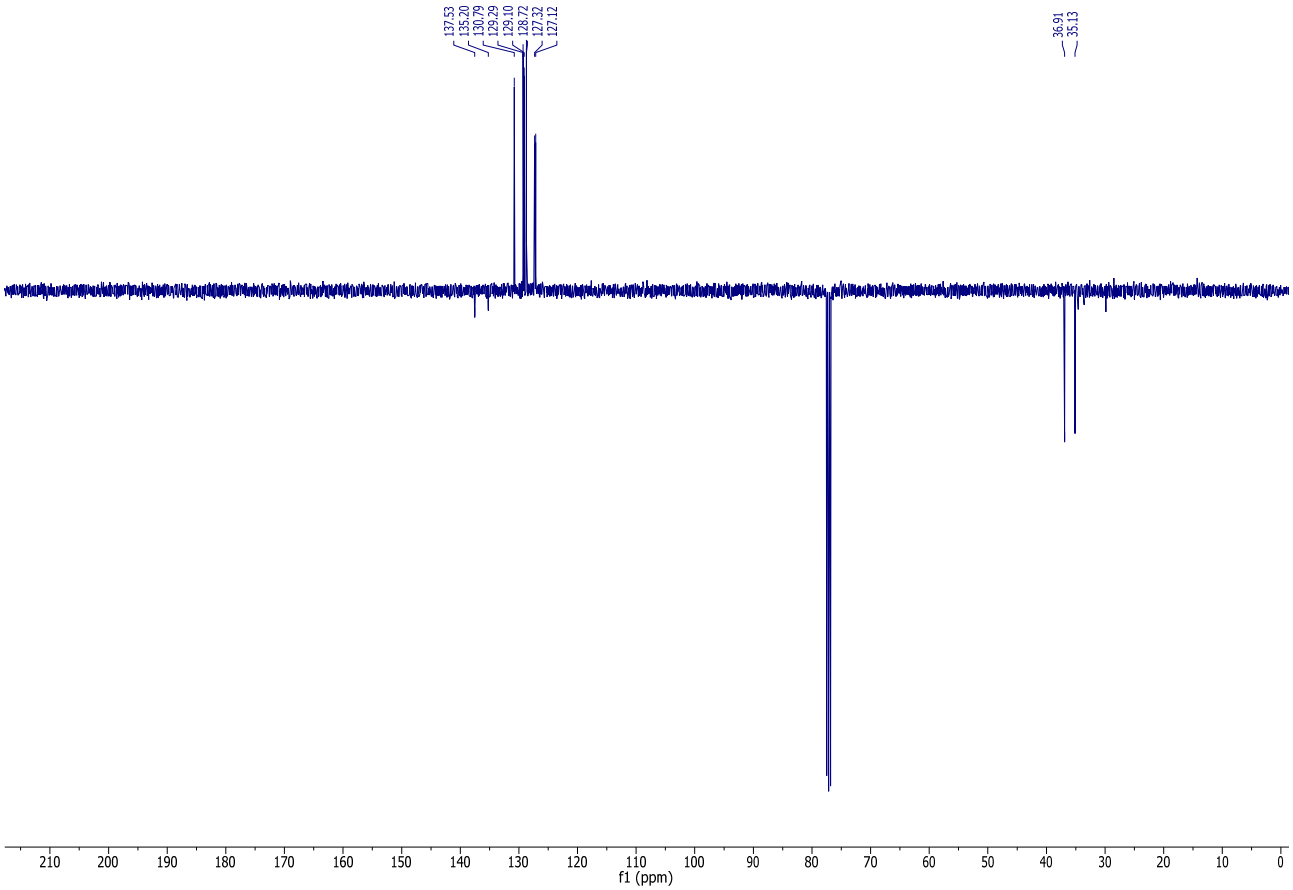
(3k)


7.32
7.31
7.30
7.29
7.27
7.26
7.25
7.24
7.24
7.23
7.22
3.84
3.38
7.71
2.05
3.99
2.00
f1 (ppm)

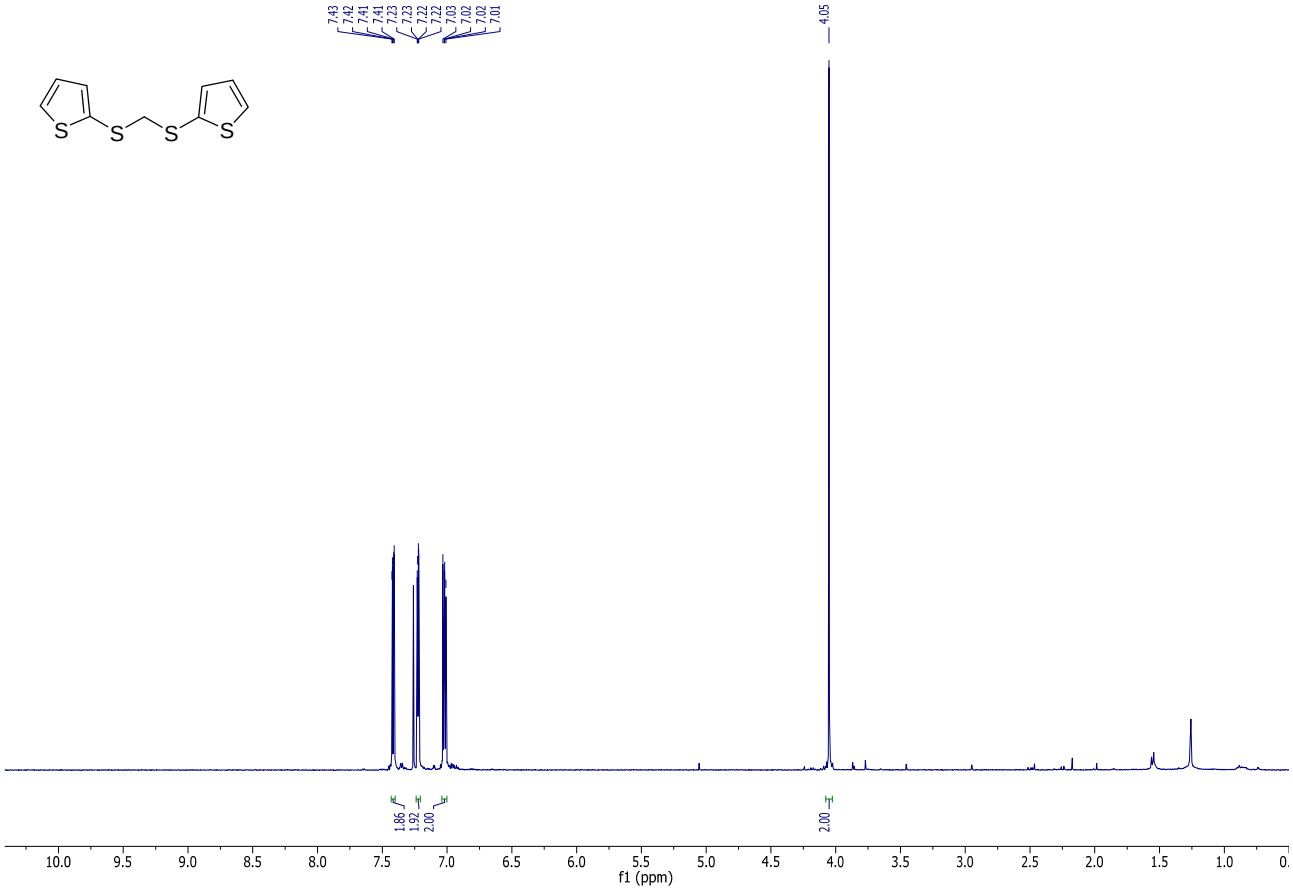

137.82
129.26
128.68
127.19
34.58
33.58
f1 (ppm)

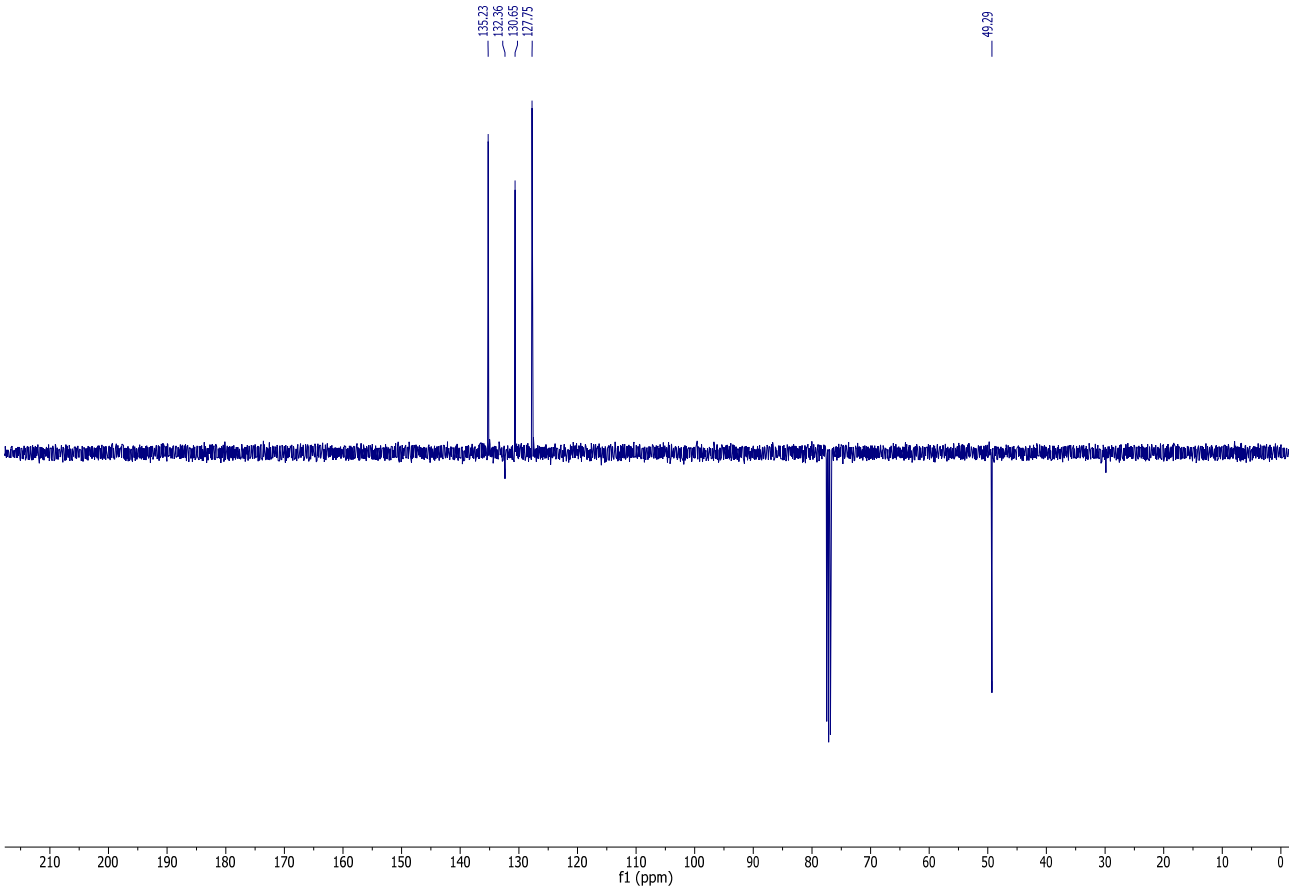
(3l)


7.43
7.42
7.42
7.40
7.40
7.40
7.33
7.32
7.31
7.30
7.25
7.25
7.24
7.23
3.88
3.85
S
S
2.08
6.18
1.66
1.99
2.00
f1 (ppm)

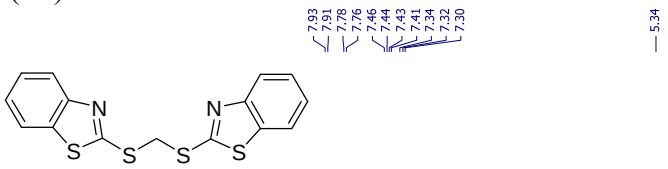

137.53
135.20
130.79
129.29
129.10
128.72
127.32
127.12
36.91
35.13
f1 (ppm)

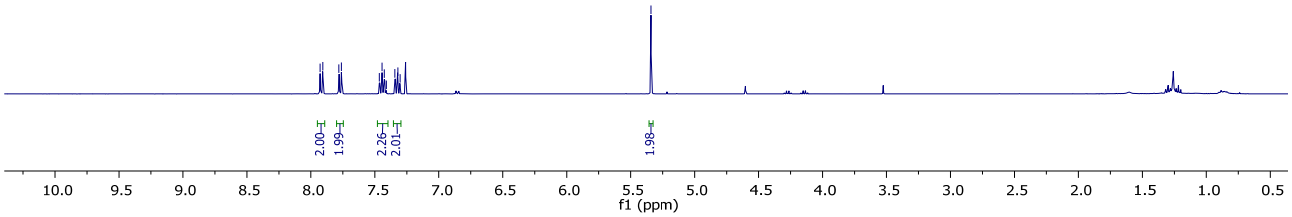
(3m)

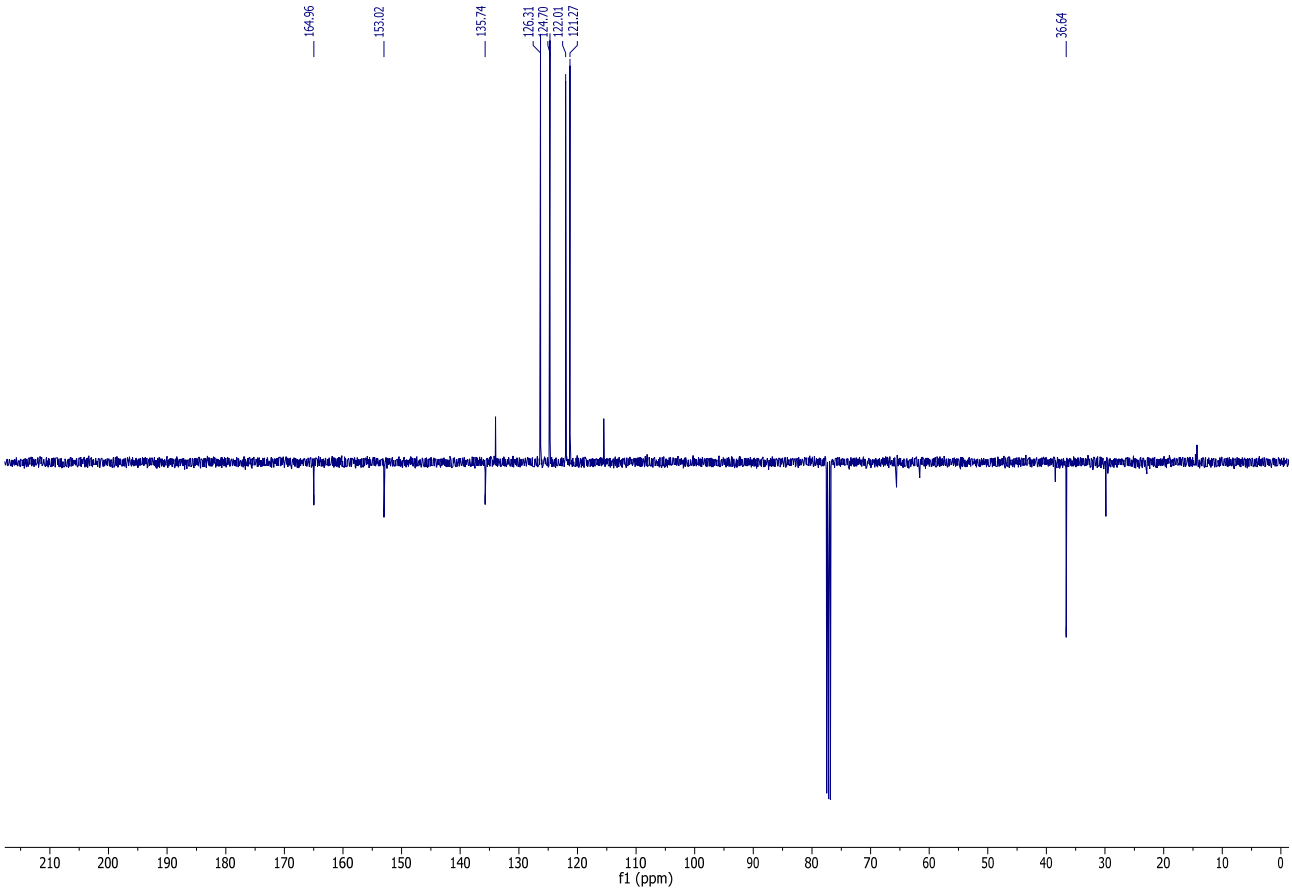

7.43
7.42
7.41
7.41
7.23
7.23
7.22
7.22
7.03
7.02
7.02
7.01
4.05
1.86
1.92
2.00
2.00
f1 (ppm)


135.23
132.36
130.65
127.75
49.29
f1 (ppm)

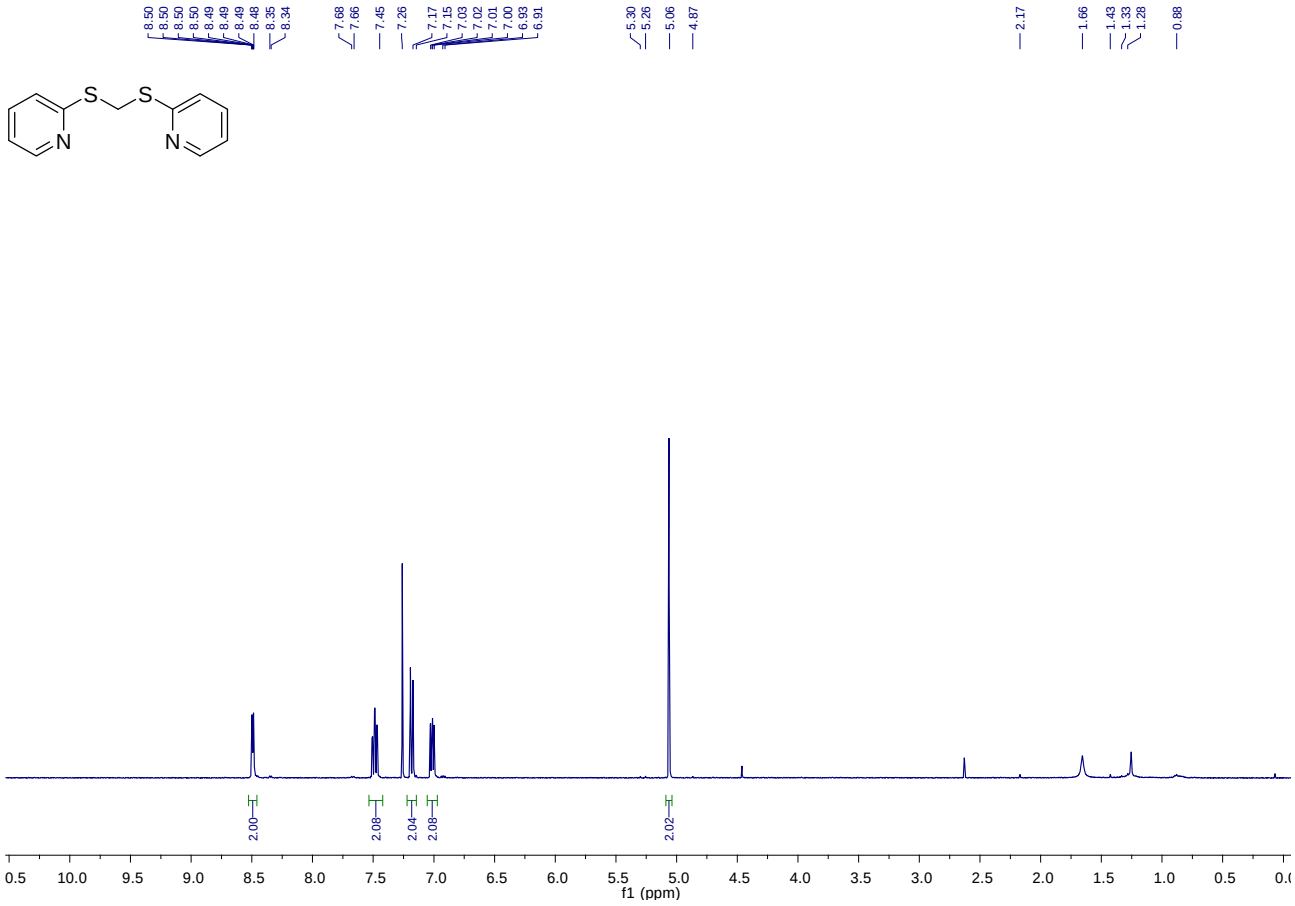
(3n)

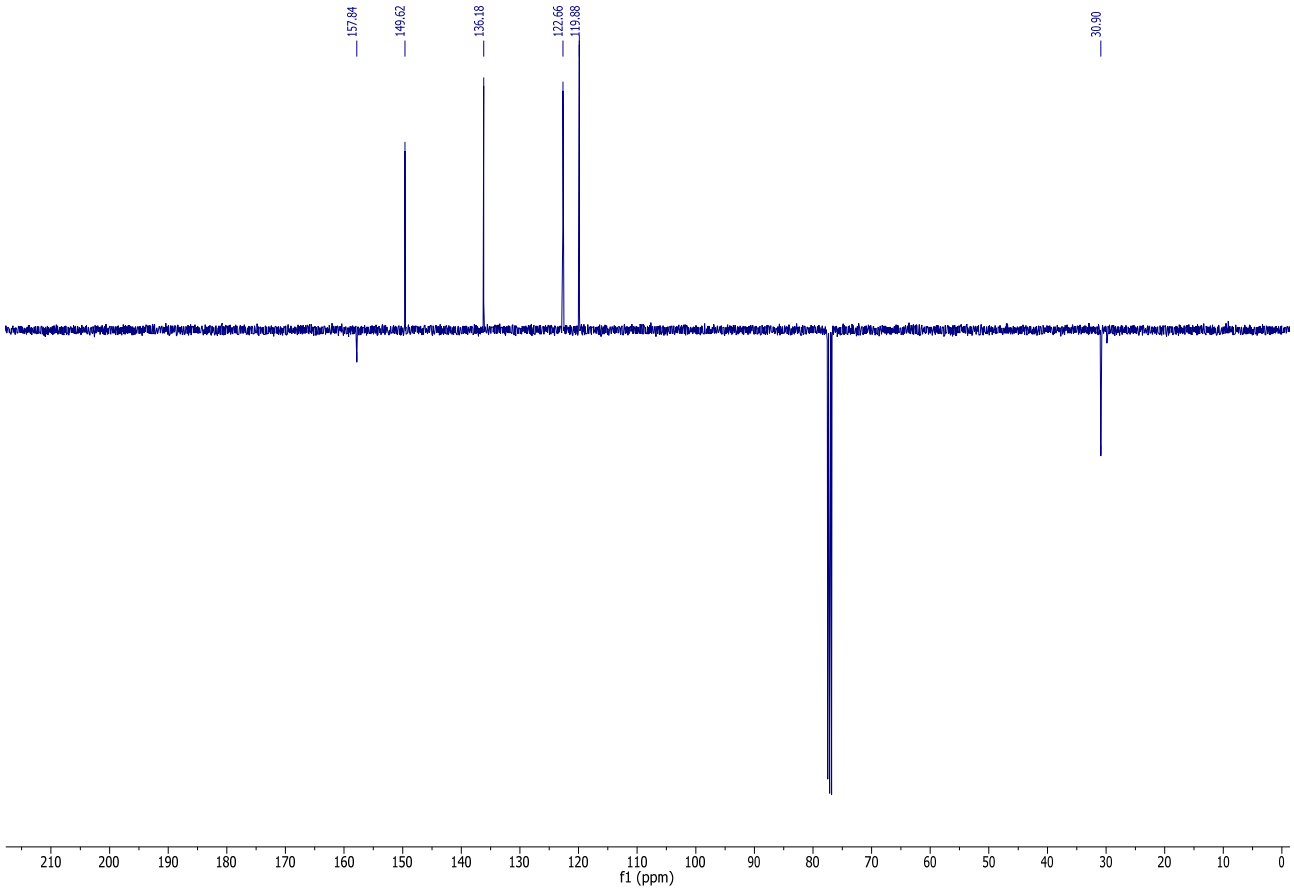

N
S
S
S
N
S


7.93
7.91
7.78
7.76
7.46
7.44
7.43
7.41
7.34
7.32
7.30
5.34
2.00
1.99
2.26
2.01
1.98
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
f1 (ppm)

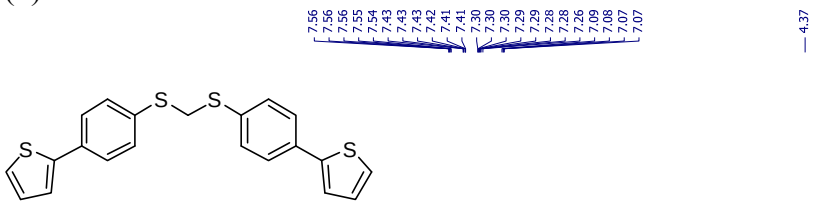

164.96
153.02
135.74
126.31
124.70
122.01
121.27
36.64
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

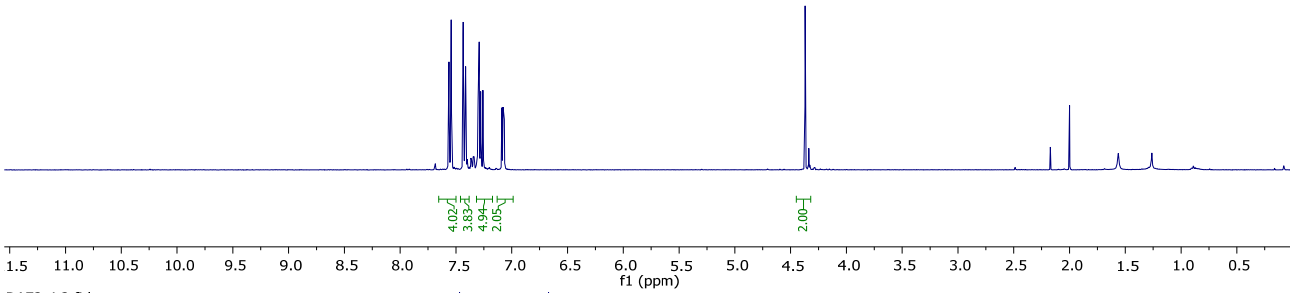
(3o)


8.50
8.50
8.50
8.50
8.49
8.49
8.49
8.48
8.35
8.34
7.68
7.66
7.45
7.26
7.17
7.15
7.03
7.02
7.01
7.00
6.93
6.91
5.30
5.26
5.06
4.87
2.17
1.66
1.43
1.33
1.28
0.88
S
S
N
N
2.00
2.08
2.04
2.08
2.02
f1 (ppm)

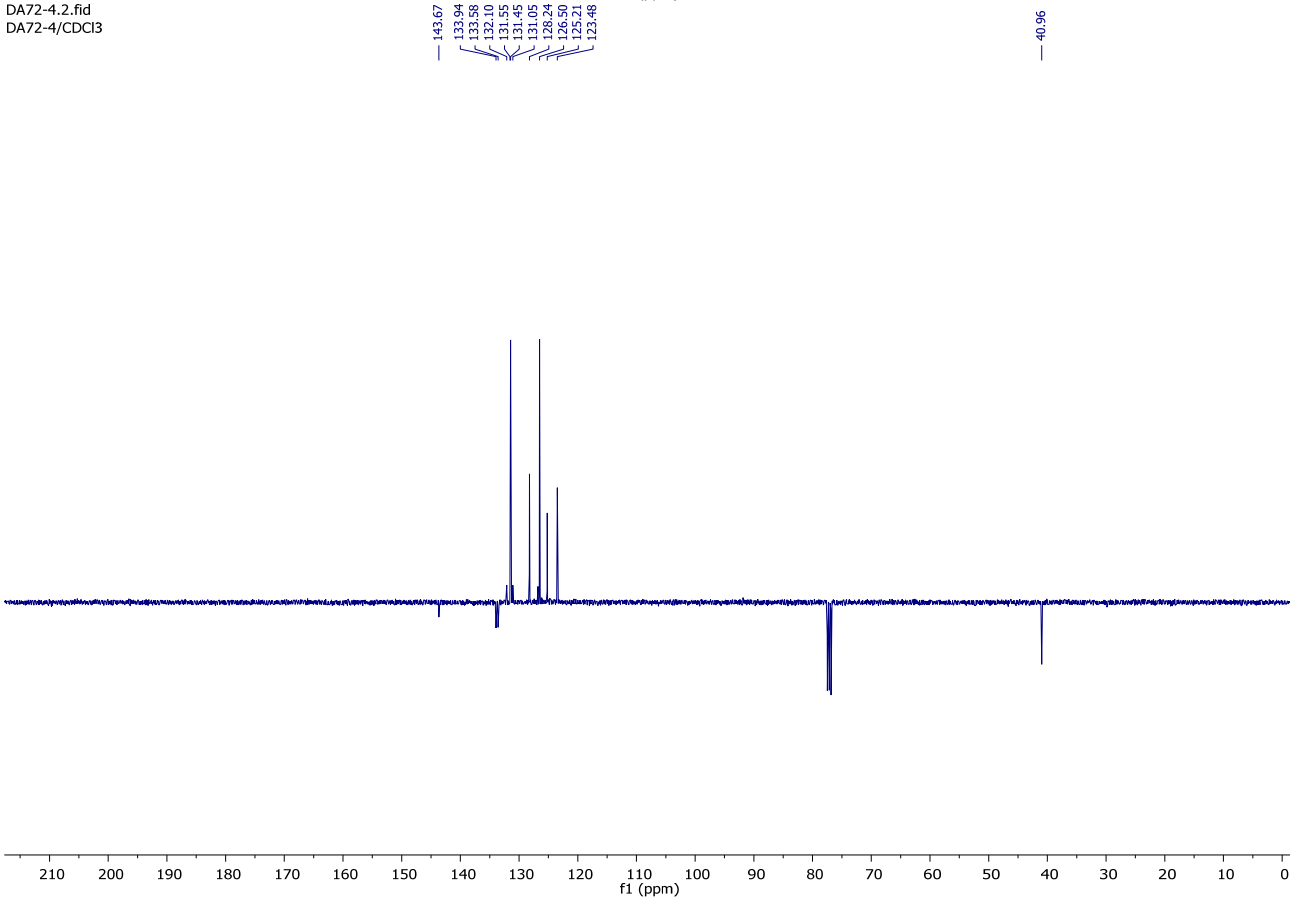

157.84
149.62
136.18
122.66
119.88
30.90
f1 (ppm)

(4)

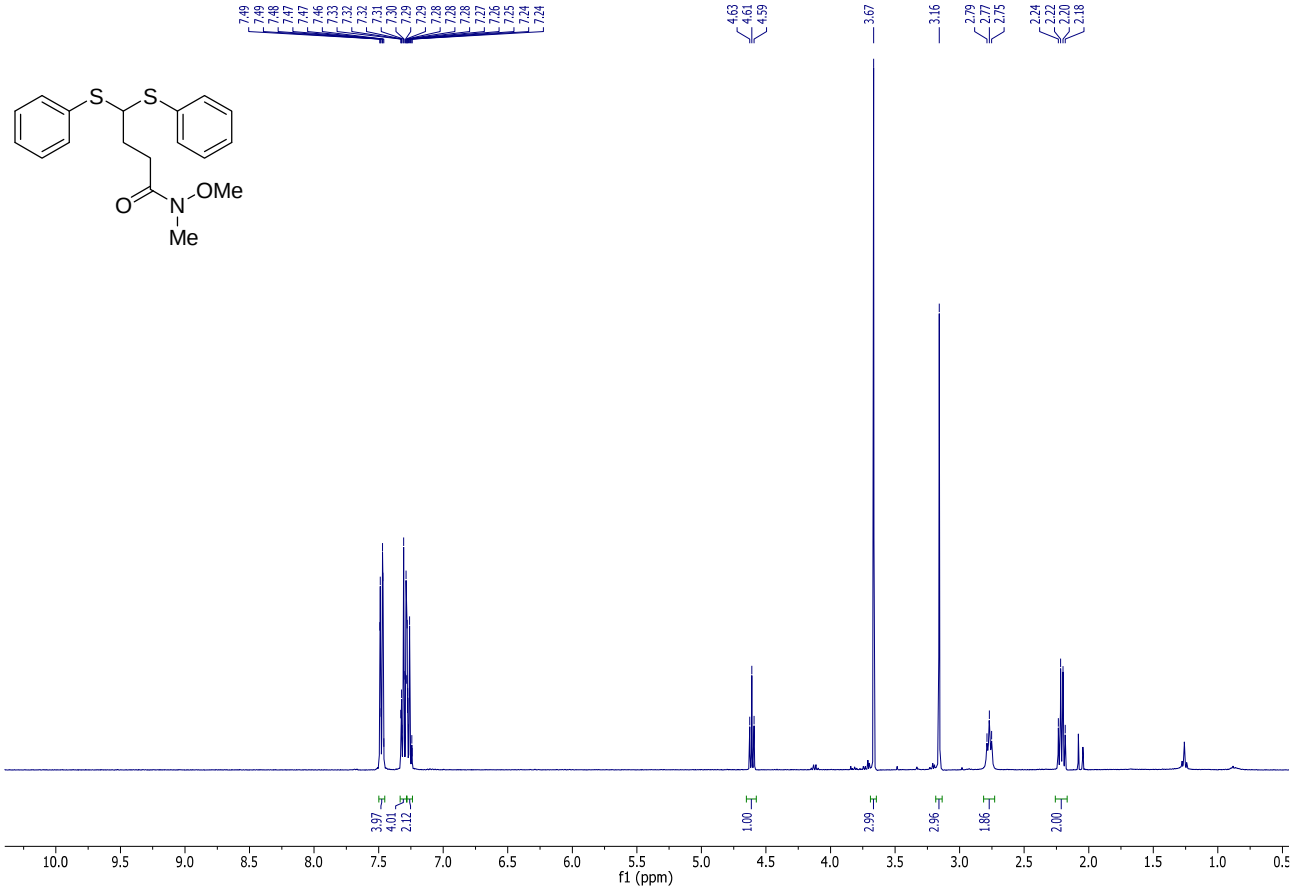


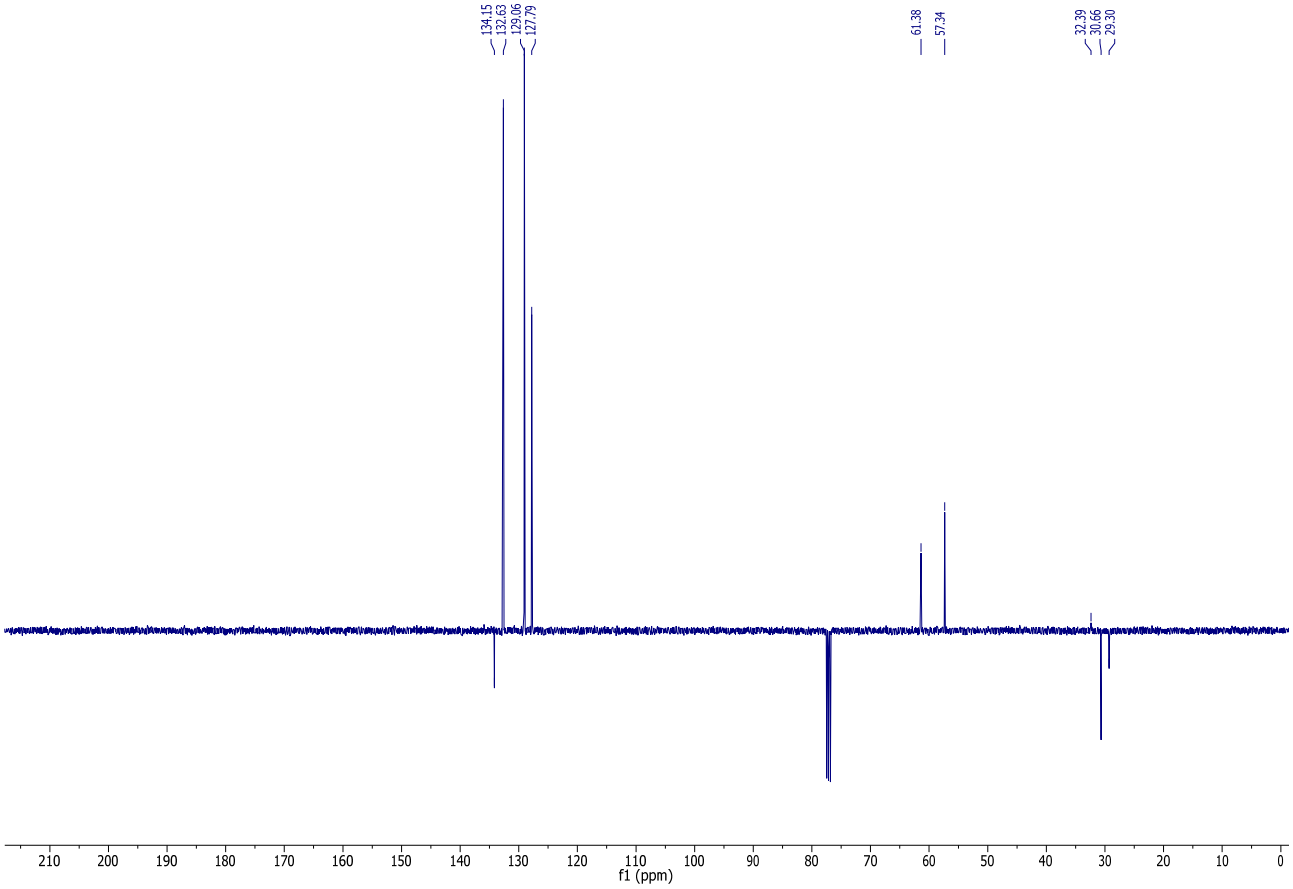


DA72-4.2.fid
DA72-4/CDCl3

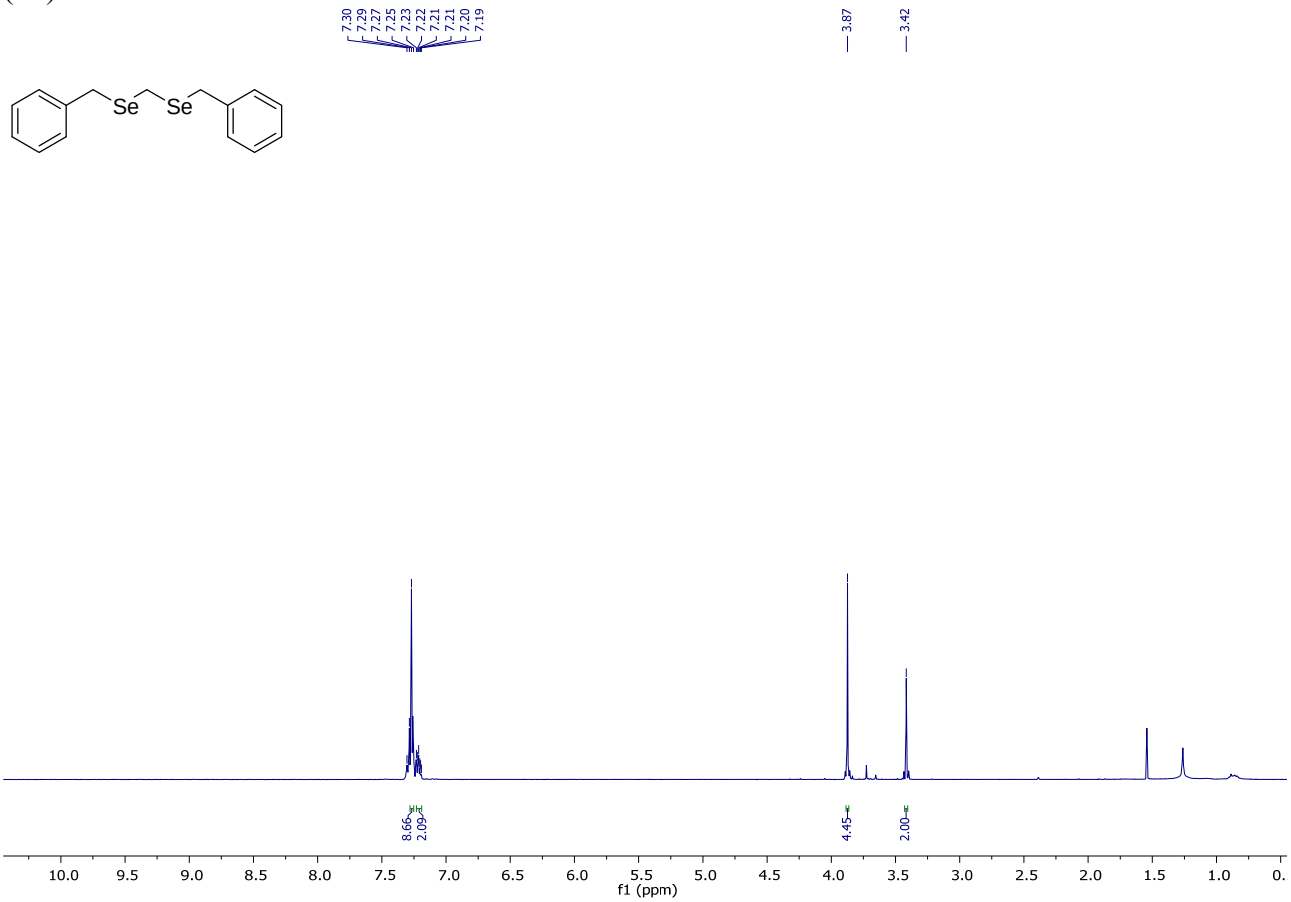


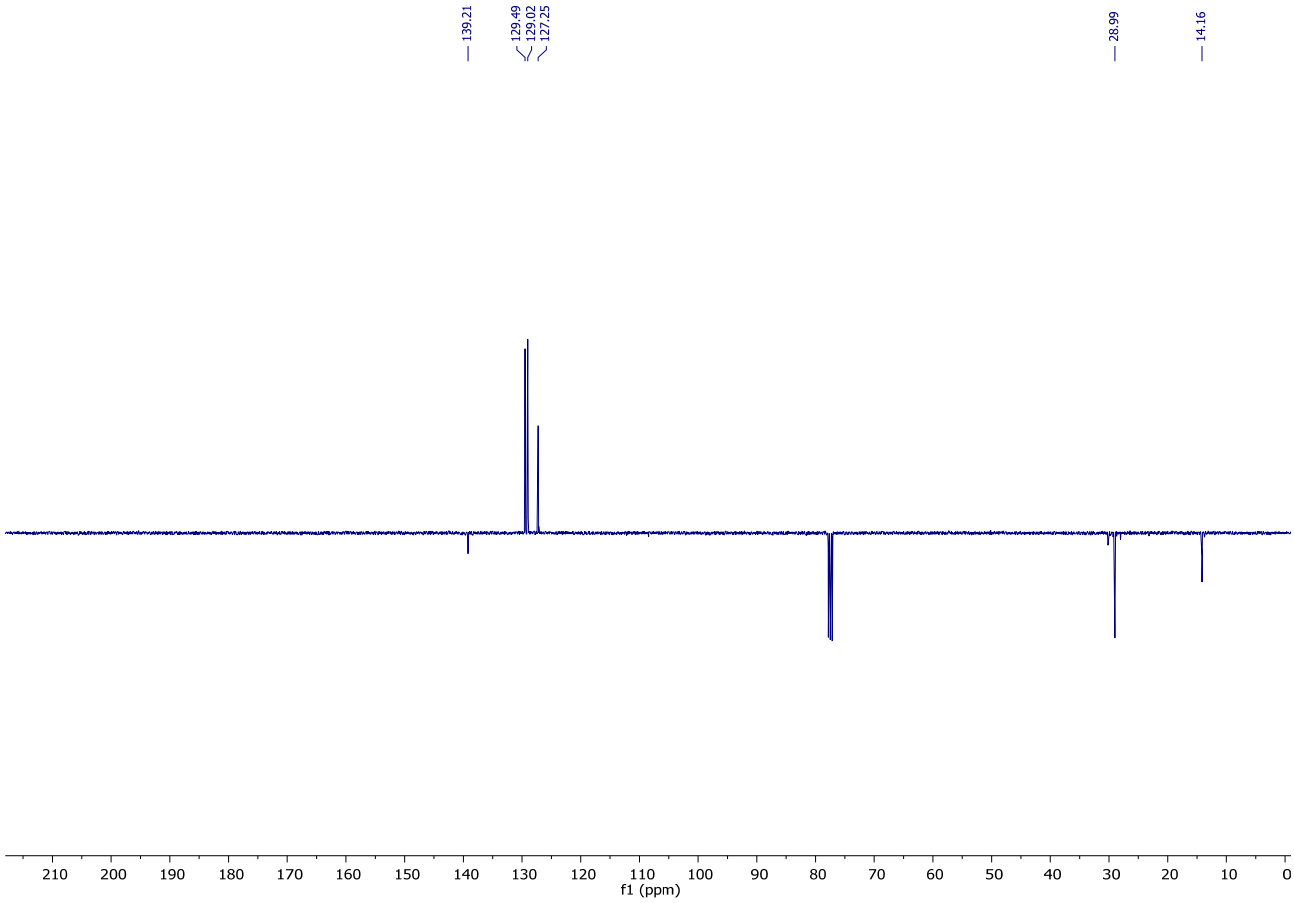
(5)


7.49
7.49
7.48
7.47
7.47
7.47
7.46
7.33
7.32
7.32
7.31
7.30
7.29
7.29
7.28
7.28
7.28
7.27
7.26
7.25
7.24
7.24
7.24
4.63
4.61
4.59
3.67
3.16
2.79
2.77
2.75
2.24
2.22
2.20
2.18
S
S
O
N
OMe
Me
3.97
4.01
2.12
1.00
2.99
2.96
1.86
2.00
10.0
9.5
9.0
8.5
8.0
7.5
7.0
6.5
6.0
5.5
5.0
4.5
4.0
3.5
3.0
2.5
2.0
1.5
1.0
0.5
f1 (ppm)

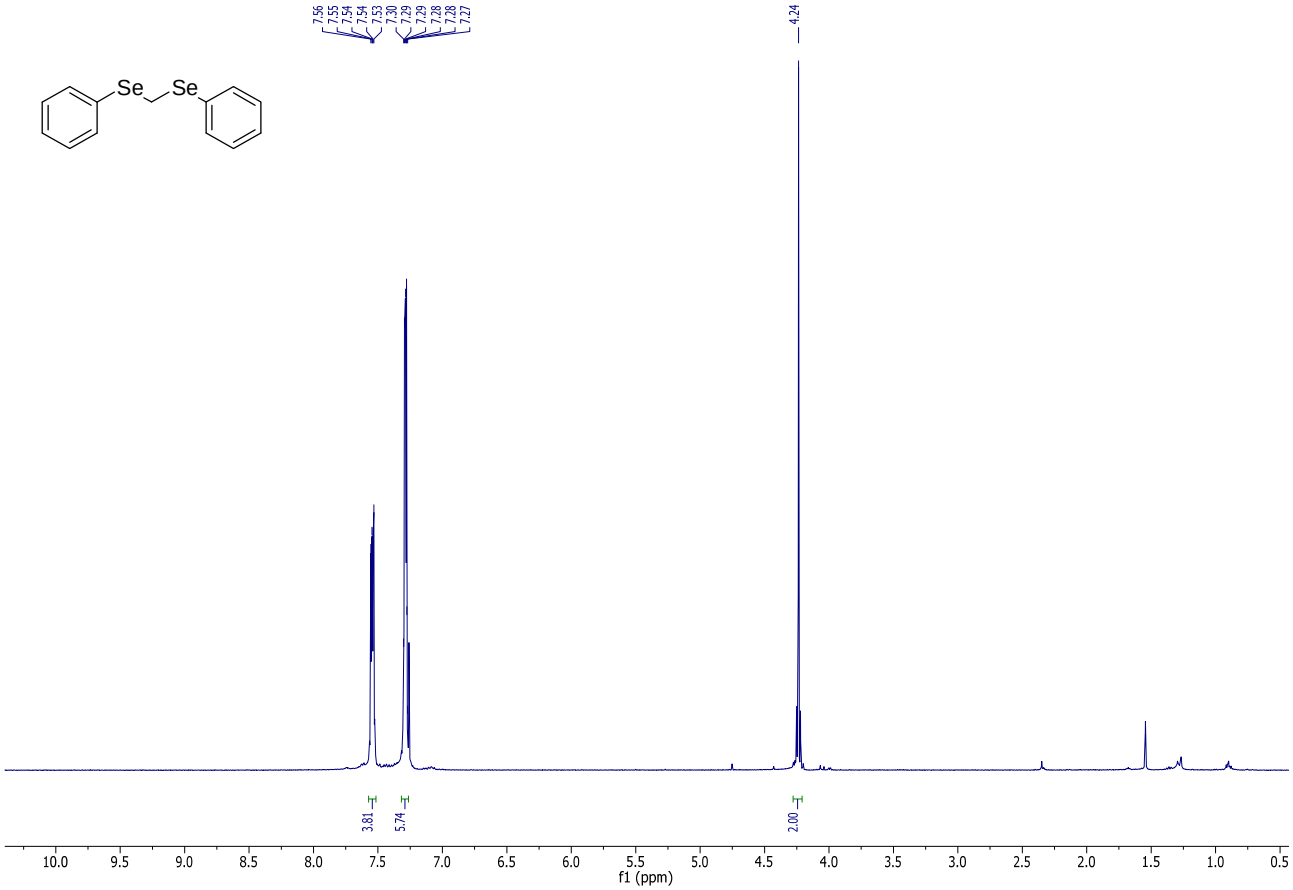

134.15
132.63
129.06
127.79
61.38
57.34
32.39
30.66
29.30
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
f1 (ppm)

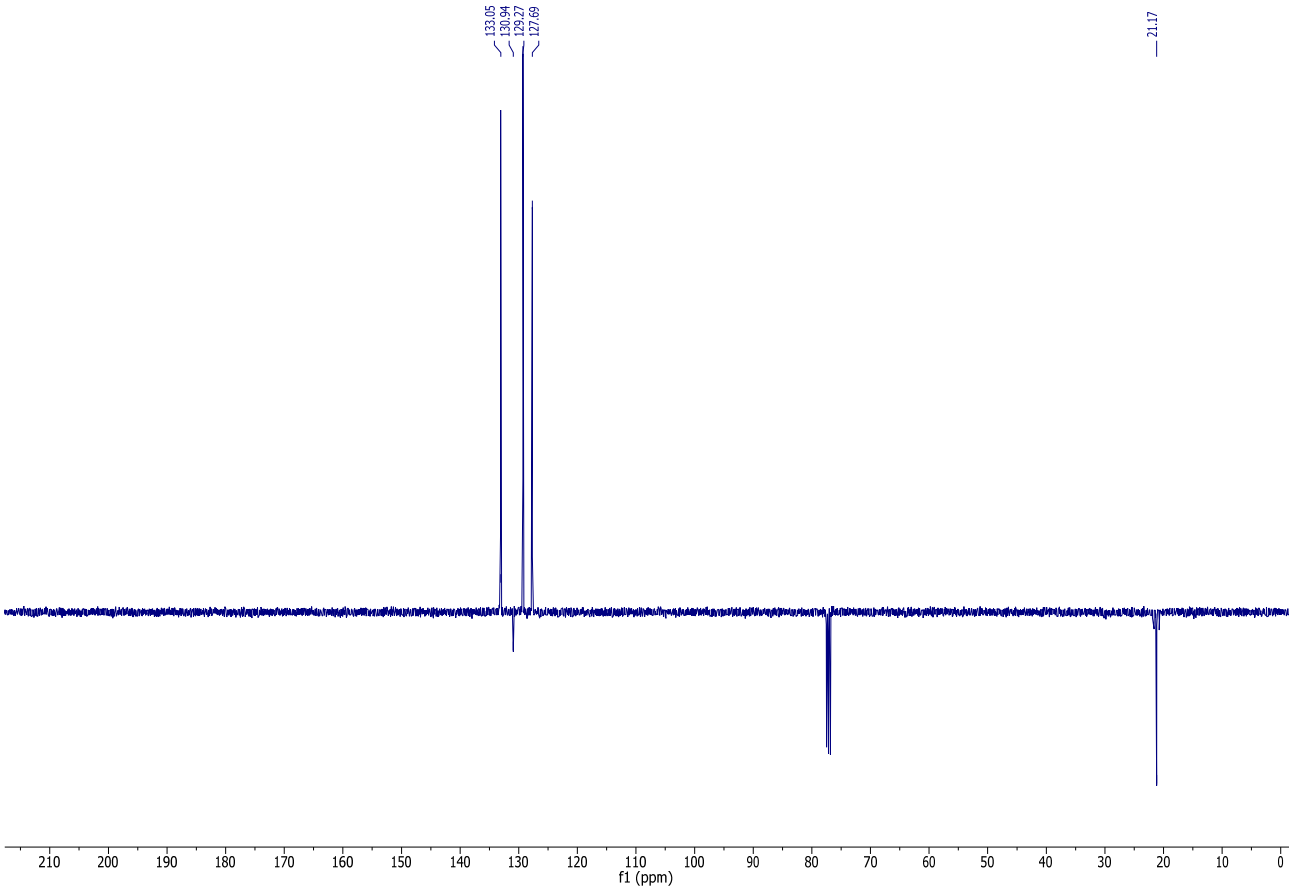
(7a)


7.30
7.29
7.27
7.25
7.23
7.22
7.21
7.21
7.20
7.19
3.87
3.42
Se
Se
8.66
2.09
4.45
2.00
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.
f1 (ppm)


139.21
129.49
129.02
127.25
28.99
14.16
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

(7b)


Se
Se
7.56
7.55
7.54
7.54
7.53
7.30
7.29
7.29
7.28
7.28
7.27
4.24
3.81
5.74
2.00
10.0 9.5 9.0 8.5 8.0 7.5 7.0 6.5 6.0 5.5 5.0 4.5 4.0 3.5 3.0 2.5 2.0 1.5 1.0 0.5
f1 (ppm)


133.05
130.94
129.27
127.69
21.17
210 200 190 180 170 160 150 140 130 120 110 100 90 80 70 60 50 40 30 20 10 0
f1 (ppm)

References

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