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PhSeBr-Catalyzed Selective Addition of Thiols to α,β-Unsaturated Carbonyl Compounds: Regioselective Synthesis of Thioacetals *vs*. β-Mercapto Ketones

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Proton nuclear magnetic resonance spectra (^{1}H NMR) were obtained at 200 MHz on a DPX-200 NMR spectrometer or at 400 MHz on DPX-400 NMR spectrometer. Spectra were recorded in $CDCl_3$ solutions. Chemical shifts are reported in ppm, referenced to the solvent peak of $CDCl_3$ or tetramethylsilane (TMS) as the external reference. Data are reported as follows: chemical shift (δ), multiplicity, coupling constant (J) in Hertz and integrated intensity. Carbon-13 nuclear magnetic resonance spectra (^{13}C NMR) were obtained either at 50 MHz on a DPX-200 NMR spectrometer or at 100 MHz on a DPX-400 NMR spectrometer. Spectra were recorded in $CDCl_3$ solutions. Chemical shifts are reported in ppm, referenced to the solvent peak of $CDCl_3$. Abbreviations to denote the multiplicity of a particular signal are s (singlet), d (doublet), t (triplet), q (quartet), quint (quintet), sex (sextet) and m (multiplet). High resolution mass spectra were recorded on a MS50TC double focusing magnetic sector mass spectrometer using EI at 70 eV. Column chromatography was performed using Silica Gel (230-400 mesh) following the methods described by Still (Still, W. C.; Kahn, M.; Mitra, A.; *J. Org. Chem*. **1978**, *43,* 2923). Thin layer chromatography (TLC) was performed using Silica Gel GF254, 0.25 mm thickness. For visualization, TLC plates were either placed under ultraviolet light, or stained with iodine vapour, or acidic vanillin. Most reactions were monitored by TLC for disappearance of starting material. Air- and moisture-sensitive reactions were conducted in flame-dried or oven dried glassware equipped with tightly fitted rubber septa and under a positive atmosphere of dry argon. Reagents and solvents were handled using standard syringe techniques. Temperatures above room temperature were maintained by use of a mineral oil bath with an electrically heated coil connected to a Variac controller.

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General procedure for β-mercapto ketones

To a Schlenck tube, under air atmosphere containing an appropriate α,β-unsaturated carbonyl compounds (0.50 mmol) in CH_2Cl_2 (2.0 mL), was added the thiol (0.6 mmol). In the resulting solution was added PhSeBr (2 mol%) and the reaction mixture was allowed to stir for 20 min at −20 °C. After that, the mixture was concentrated under vacuum. The residue was purified by flash chromatography on silica gel using ethyl acetate/hexane as the eluent.

*3-(Phenylthio)cyclohexanone (**3a**)*

Yield: 0.162 g (79%). ^{1}H NMR ($CDCl_3$, 400 MHz) δ: 7.43-7.40 (m, 2H), 7.33-7.25 (m, 3H), 3.46-3.37 (m, 1H), 2.68 (d, *J* 9.7 Hz, 1H), 2.40-2.25 (m, 3H), 2.17-2.08 (m, 2H), 1.80-1.63 (m, 2H). ^{13}C NMR ($CDCl_3$, 100 MHz): δ 208.63, 133.09, 132.88, 128.95, 127.66, 47.63, 45.98, 40.75, 31.09, 23.90. HRMS calc. for $C_{12}H_{24}OS$: 206.0765. Found: 206.0769.

*3-(Propylthio)cyclohexanone (**3b**)*

Yield: 0.127 g (74%). ^{1}H NMR ($CDCl_3$, 400 MHz) δ: 3.08-3.01 (m, 1H), 2.70 (d, *J* 9.5 Hz, 1H), 2.53 (t, *J* 7.4 Hz, 2H), 2.41-2.31 (m, 3H), 2.18-2.10 (m, 2H), 1.76-1.68 (m, 2H), 1.60 (sex, *J* 7.3 Hz, 2H), 0.99 (t, *J* 7.3 Hz, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 208.61, 48.00, 42.49, 40.70, 32.31, 31.42, 23.98, 22.82, 13.27. HRMS calc. for $C_9H_{16}OS$: 172.0921. Found: 172.0927.

*3-(Benzylthio)cyclohexanone (**3c**)*

Yield: 0.138 g (63%). ^{1}H NMR ($CDCl_3$, 200 MHz), δ: 7.32-7.21 (m, 5H), 3.76 (s, 2H), 3.00-2.86 (m, 1H), 2.67 (dd, *J* 9.6/4.4 Hz, 1H), 2.40-2.29 (m, 3H), 2.17-2.02 (m, 2H), 1.73-1.61 (m, 2H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 208.13, 137.61, 128.39, 128.23, 126.75, 47.39, 41.67, 40.55, 34.55, 30.86, 23.70. MS (relative intensity) *m/z*: 220 (11), 123 (32), 97 (53), 91 (100). HRMS calc. for $C_{13}H_{16}OS$: 220.0921. Found: 220.0925.

*3-(terc-Butylthio)cyclohexanone (**3d**)*

Yield: 0.137 g (74%). ^{1}H NMR ($CDCl_3$, 400 MHz) δ: 3.03-2.96 (m, 1H), 2.72 (dd, *J* 9.3/4.7 Hz, 1H), 2.43-2.22 (m, 3H), 2.20-2.06 (m, 2H), 1.77-1.69 (m, 2H), 1.34 (s, 9H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 208.92, 50.66, 43.49, 40.51, 40.46, 34.13, 31.27, 24.46. MS (relative intensity) *m/z*: 186 (30), 171 (1), 130 (29), 96 (50). HRMS calc. for $C_{10}H_{18}OS$: 186.1078. Found: 186.1081.

*3-(Dodecylthio)cyclohexanone (**3e**)*

Yield: 0.226 g (76%). ^{1}H NMR ($CDCl_3$, 400 MHz) δ: 3.09-3.01 (m, 1H), 2.71 (dd, *J* 9.6/4.3 Hz, 1H), 2.54 (t, *J* 7.5 Hz, 2H), 2.40-2.31 (m, 3H), 2.17-2.10 (m, 2H), 1.77-1.67 (m, 2H), 1.59-1.53 (m, 3H), 1.40-1.26 (m, 17H), 0.88 (t, *J* 7.5 Hz, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 199.60, 39.05, 37.92, 31.78, 29.50, 29.47, 29.39, 29.22, 29.11, 29.09, 28.39, 25.56, 22.55, 13.98. MS (relative intensity) *m/z*: 267 (1), 201 (45), 129 (4), 97 (22). HRMS calc. for $C_{18}H_{34}OS$: 298.2330. Found: 298.2332.

*3-(sec-Butylthio)cyclohexanone (**3f**)*

Yield: 0.113 g (61%). ^{1}H NMR ($CDCl_3$, 400 MHz) δ: 3.14-3.04 (m, 1H), 2.77 (sex d, *J* 7.0/2.3 Hz, 1H), 2.69 (dd, *J* 9.5/4.2, 1H), 2.40-2.31 (m, 3H), 2.18-2.09 (m, 2H), 1.78-1.67 (m, 2H), 1.63-1.45 (m, 2H), 1.25 (d, *J* 6.7 Hz, 3H), 0.97 (t, *J* 7.4 Hz, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 208.79, 48.54, 41.34, 40.78, 40.40, 31.89, 29.79, 24.09, 20.98, 11.10. MS (relative intensity) *m/z*: 186 (30), 171 (1), 157 (20), 143 (1), 129 (21), 97 (100). HRMS calc. for $C_{10}H_{18}OS$: 186.1078. Found: 186.1083.

*3-(4-Methoxyphenylthio)cyclohexanone (**3g**)*

Yield: 0.224 g (95%). ^{1}H NMR ($CDCl_3$, 400 MHz) δ: 7.41-7.37 (m, 2H), 6.86-6.78 (m, 2H), 3.80 (s, 3H), 3.27-3.19 (m, 1H), 2.61 (dd, *J* 9.6/4.4 Hz, 1H), 2.35-2.26 (m, 3H), 2.16-2.04 (m, 2H), 1.73-1.64 (m, 2H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 208.61, 159.70, 136.17, 122.70, 114.33, 55.05, 47.45, 46.72, 40.55, 30.91, 23.73. MS (relative intensity) *m/z*: 236 (70), 207 (1), 140 (100), 97 (19). HRMS calc. for $C_{13}H_{16}O_2S$: 236.0871. Found: 236.0867.

*3-(4-Chlorophenylthio)cyclohexanone (**3h**)*

Yield: 0.180 g (75%). ^{1}H NMR ($CDCl_3$, 400 MHz) δ: 7.37-7.33 (m, 2H), 7.30-7.26 (m, 2H), 3.43-3.36 (m, 1H), 2.66 (dd, *J* 9.4/4.5 Hz, 1H), 2.39-2.26 (m, 3H), 2.18-2.09 (m, 2H), 1.77-1.67 (m, 2H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 208.28, 134.48, 133.99, 131.45, 129.17, 47.52, 46.27, 40.74, 31.05, 23.87. HRMS calc. for $C_{12}H_{13}ClOS$: 240.0375. Found: 240.0379.

*3-(Furan-2-ylmethylthio)cyclohexanone (**3i**)*

Yield: 0.176 g (84%). ^{1}H NMR ($CDCl_3$, 200 MHz) δ: 7.35 (dd, *J* 1.7/0.7 Hz, 1H), 7.30 (dd, *J* 3.1/1.9 Hz, 1H), 6.18 (dd, *J* 3.1/0.7 Hz, 1H), 3.77 (s, 2H), 3.08-3.00 (m, 1H), 2.69 (dd, *J* 9.3/4.2 Hz, 1H), 2.40-2.30 (m, 3H), 2.15-2.08 (m, 2H), 1.76-1.65 (m, 2H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 208.61, 151.24, 142.10, 110.42, 107.40, 47.65, 42.32, 40.82, 31.14, 26.94, 24.05. MS (relative intensity) *m/z*: 210 (6), 114 (20), 97 (12), 81 (100). HRMS calc. for $C_{11}H_{14}O_2S$: 210.0714. Found: 210.0719.

*3-(2-Chlorophenylthio)cyclohexanone (**3k**)*

Yield: 0.170 g (71%). ^{1}H NMR ($CDCl_3$, 200 MHz) δ: 7.45-7.39 (m, 2H), 7.25-7.18 (m, 2H), 3.69-3.52 (m, 1H), 2.69 (dd, *J* 9.4/4.4 Hz, 1H), 2.48-2.32 (m, 3H), 2.23-2.07 (m, 2H), 1.87-1.66 (m, 2H). ^{13}C NMR ($CDCl_3$, 50 MHz) δ: 208.19, 136.79, 133.61, 132.41, 130.07, 128.64, 127.13, 47.41, 44.74, 40.80, 30.91, 23.95. MS (relative intensity) *m/z*: 240 (47), 205 (1), 108 (20), 97 (80). HRMS calc. for $C_{12}H_{13}ClOS$: 240.0375. Found: 240.0380.

*3-(Furan-2-ylmethylthio)-4,4-dimethylcyclohexanone (**3l**)*

Yield: 0.185 g (78%). ^{1}H NMR ($CDCl_3$, 200 MHz) δ: 7.35 (d, *J* 0.9 Hz, 1H), 6.30 (dd, *J* 3.0/1.8 Hz, 1H), 6.17 (d, *J* 3.0 Hz, 1H), 3.73 (s, 2H), 2.73-4.49 (m, 3H), 2.44-2.21 (m, 2H), 1.88-1.77 (m, 1H), 1.65-1.49 (m, 1H), 1.10 (s, 6H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 209.12, 151.25, 142.15, 110.37, 107.65, 53.22, 45.59, 38.67, 37.78, 34.60, 28.39, 25.21, 20.56. MS (relative intensity) *m/z*: 238 (10), 125 (23), 97 (3), 81 (100), 69 (14). HRMS calc. for $C_{13}H_{18}O_2S$: 238.1027. Found: 238.1032.

*4,4-Dimethyl-3-(phenylthio)cyclohexanone (**3m**)*

Yield: 0.145 g (62%). ^{1}H NMR ($CDCl_3$, 200 MHz) δ: 7.41-7.38 (m, 2H), 7.31-7.22 (m, 3H), 3.19-3.15 (m, 1H), 2.66-2.52 (m, 2H), 2.50-2.41 (m, 1H), 2.34-2.27 (m, 1H), 1.93-1.87 (m, 1H), 1.68, 1.59 (m, 1H), 1.28 (s, 3H), 1.22 (s, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ : 208.93, 134.57, 132.64, 129.05, 127.36, 57.58, 45.37, 38.58, 37.82, 34.60, 28.99, 20.97. HRMS calc. for $C_{14}H_{18}OS$: 234.1078. Found: 234.1083.

General procedure for thioacetals formation

To a Schlenck tube, under air atmosphere containing an appropriate α,β-unsaturated carbonyl compounds (0.50 mmol) in CH_2Cl_2 (2.0 mL), was added the thiol (2.0 mmol). In the resulting solution was added PhSeBr (2 mol%) and the reaction mixture was allowed to stir for 1 h under reflux. After that, the mixture was concentrated under vacuum. The residue was purified by flash chromatography on silica gel using ethyl acetate/hexane as the eluent.

*1,1,3-tris(Phenylthio)cyclohexane (**4a**)*

Yield: 0.330 g (81%). ^{1}H NMR ($CDCl_3$, 200 MHz) δ: 7.70-7.65 (m, 2H), 7.54-7.50 (m, 2H), 7.35-7.20 (m, 11H), 3.56 (tt, *J* 12.0/3.5 Hz, 1H), 2.28-2.19 (m, 1H), 2.03-1.75 (m, 3H), 1.69-1.50 (m, 3H), 1.16-0.94 (m, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 137.33, 136.11, 133.67, 132.63, 130.90, 130.72, 129.16, 128.96, 128.77, 128.61, 128.55, 127.08, 65.05, 43.37, 42.73, 36.12, 32.15, 22.66. HRMS calc. for $C_{24}H_{24}S_3$: 408.1040. Found: 408.1043.

*1,1,3-tris(Propylthio)cyclohexane (**4b**)*

Yield: 0.253 g (83%). ^{1}H NMR ($CDCl_3$, 200 MHz) δ: 3.06 (tt, *J* 11.8/3.9 Hz, 1H), 2.63 (t, *J* 7.0 Hz, 2H), 2.51 (t, *J* 7.0 Hz, 4H), 2.33-2.19 (m, 1H), 2.09-1.81 (m, 2H), 1.78-1.72 (m, 2H), 1.69-1.50 (m, 8H), 1.31-1.11 (m, 1H), 1.00 (t, *J* 7.0, 3H), 0.99 (t, *J* 7.0, 3H), 0.98 (t, *J* 7.0, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 61.14, 44.87, 39.02, 36.94, 33.13, 32.03, 30.56, 30.17, 23.16, 22.65, 22.48, 22.32, 13.73, 13.67, 13.36. MS (relative intensity) *m/z*: 306 (8), 263 (1), 231 (67), 155 (100). HRMS calc. for $C_{15}H_{30}S_3$: 306.1509. Found: 306.1513.

*1,1,3-tris(Benzylthio)cyclohexane (**4c**)*

Yield: 0.427 g (95%). ^{1}H NMR ($CDCl_3$, 200 MHz) δ: 7.35-7.23 (m, 15H), 3.88 (s, 2H), 3.71 (d, *J* 2.5 Hz, 2H), 3.69 (s, 2H), 3.02 (tt, *J* 12.1/3.9 Hz, 1H), 2.30-2.18 (m, 1H), 2.04-1.90 (m, 2H), 1.81-1.57 (m, 4H), 1.32-1.28 (m, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 138.33, 137.68, 137.27, 128.91, 128.50, 128.24, 126.72, 126.65, 62.73, 44.31, 38.98, 36.68, 34.65, 33.39, 33.21, 32.60, 22.34. HRMS calc. for $C_{27}H_{30}S_3$: 450.1509. Found: 450.1505.

*1,1,3-tris(Dodecylthio)cyclohexane (**4e**)*

Yield: 0.601 g (88%). ^{1}H NMR ($CDCl_3$, 200 MHz) δ: 3.06 (tt, *J* 12.0/3.3 Hz, 1H), 2.64 (t, *J* 7.3 Hz, 2H), 2.57-2.46 (m, 4H), 2.30-2.20 (m, 1H), 2.08-1.81 (m, 2H), 1.78-1.66 (m, 3H), 1.64-1.49 (m, 6H), 1.40-1.19 (m, 56H), 0.88 (t, *J* 6.7 Hz, 9H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 61.20, 44.79, 39.04, 38.91, 37.10, 33.99, 33.20, 31.80, 30.00, 29.93, 29.54, 29.45, 29.25, 29.20, 28.99, 28.87, 28.51, 28.28, 28.09, 24.35, 22.54, 13.90. HRMS calc. for $C_{42}H_{84}S_3$: 684.5735. Found: 684.5740.

*1,1,3-tris(sec-Butylthio)cyclohexane (**4f**)*

Yield: 0.208 g (60%). ^{1}H NMR ($CDCl_3$, 400 MHz) δ: 3.18-3.08 (m, 1H), 3.03-2.96 (m, 2H), 2.81-2.73 (m, 1H), 2.32-2.23 (m, 1H), 2.05-1.91 (m, 3H), 1.79-1.42 (m, 10H), 1.31-1.21 (m, 9H), 0.96 (t, *J* 7.3 Hz, 9H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 62.82, 46.26, 40.02, 39.21, 38.07, 33.65, 33.61, 31.62, 31.47, 31.27, 30.08, 29.95, 22.67, 22.08, 21.43, 11.21, 11.13, 11.01. MS (relative intensity) *m/z*: 348 (3), 259 (80), 169 (100), 113 (93). HRMS calc. for $C_{18}H_{36}S_3$: 348.1979. Found: 348.1982.

*1,1,3-tris(4-Methoxyphenylthio)cyclohexane (**4g**)*

Yield: 0.428 g (86%). ^{1}H NMR ($CDCl_3$, 400 MHz) δ: 7.49 (d, *J* 9.0 Hz, 2H), 7.39 (d, *J* 8.5 Hz, 2H), 7.29 (d, *J* 8.8 Hz, 2H), 6.82-6.77 (m, 6H), 3.78 (s, 9H), 3.36 (tt, *J* 11.9/3.4 Hz, 1H), 2.07-1.93 (m, 2H), 1.92-1.70 (m, 2H), 1.58-1.49 (m, 3H), 1.04-0.95 (m, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 160.40, 160.28, 159.50, 138.83, 137.99, 136.27, 123.39, 121.84, 121.09, 114.19, 113.97, 64.69, 55.08, 43.75, 42.77, 35.72, 31.98, 22.62. MS (relative intensity) *m/z*: 359 (38), 219 (100), 187 (27), 139 (49), 77 (13). HRMS calc. for $C_{27}H_{30}O_3S_3$: 498.1357. Found: 498.1355.

*2-((1,3-bis(Furan-2-ylmethylthio)cyclohexylthio)methyl) furan (**4h**)*

Yield: 0.344 g (82%). ^{1}H NMR ($CDCl_3$, 400 MHz) δ: 7.38-7.32 (m, 3H), 6.30-6.29 (m, 3H), 6.20-6.17 (m, 3H), 3.94 (s, 2H), 3.83 (s, 2H), 3.70 (s, 2H), 3.05 (tt, *J* 12.2/3.8 Hz, 1H), 2.27-2.22 (m, 1H), 2.02-1.92 (m, 2H), 1.82-1.56 (m, 4H), 1.20 (qd, *J* 8.4/4.0 Hz, 1H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 151.64, 151.29, 150.93, 141.75, 141.69, 110.35, 110.28, 107.34, 107.27, 107.04, 62.76, 44.14, 39.23, 36.55, 32.43, 26.74, 25.70, 25.47, 22.32. MS (relative intensity) *m/z*: 339 (15), 306 (1), 225 (10), 81 (100). HRMS calc. for $C_{21}H_{24}O_3S_3$: 420.0887. Found: 420.0890.

*2-((1,3-bis(Furan-2-ylmethylthio)-4,4-dimethylcyclohexylthio)methyl)furan (**4k**)*

Yield: 0.340 g (76%). ^{1}H NMR ($CDCl_3$, 400 MHz) δ: 7.35-7.33 (m, 3H), 6.31-6.28 (m, 3H), 6.19-6.18 (m, 3H), 3.92 (s, 2H), 3.82 (d, *J* 1.7 Hz, 2H), 3.64 (d, *J* 3.2 Hz, 2H), 2.83 (t, *J* 8.1 Hz, 1H), 2.04 (d, *J* 9.3 Hz, 2H), 1.93-1.84 (m, 1H), 1.81-1.73 (m, 2H), 1.29-1.24 (m, 1H), 0.99 (s, 3H), 0.85 (s, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 151.62, 151.34, 151.06, 141.88, 141.82, 110.47, 110.43, 110.33, 107.51, 107.49, 107.38, 63.11, 51.06, 41.85, 36.68, 34.50, 33.00, 29.74, 28.80, 25.87, 25.60,

19.74. MS (relative intensity) *m/z*: 367 (9), 334 (7), 253 (11), 221 (6), 81 (100). HRMS calc. for $C_{23}H_{28}O_3S_3$: 448.1200. Found: 448.1205.

*1-((5,5-bis(Benzylthio)-2,2-dimethylcyclohexylthio)methyl) benzene (**4l**)*

Yield: 0.425 g (89%). ^{1}H NMR ($CDCl_3$, 200 MHz) δ: 7.35-7.16 (m, 15H), 3.86 (s, 2H), 3.68 (d, *J* 3.5 Hz, 2H), 3.58 (s, 2H), 2.85-2.76 (m, 1H), 2.08-2.03 (m, 2H), 1.92-1.69 (m, 3H), 1.31-1.22 (m, 1H), 1.00 (s, 1H), 0.86 (s, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 138.50, 137.70, 137.42, 129.02, 128.99, 128.78, 128.33, 128.25, 126.80, 126.74, 63.08, 50.61, 41.88, 36.69, 34.45, 33.46, 32.97, 29.93, 19.72. HRMS calc. for $C_{29}H_{34}S_3$: 478.1822. Found: 478.1819.

*1-(1,3-bis(4-Methoxyphenylthio)-4,4-dimethylcyclohexylthio)-4-methoxybenzene (**4m**)*

Yield: 0.483 g (92%). ^{1}H NMR ($CDCl_3$, 400 MHz) δ: 7.45-7.43 (m, 2H), 7.34-7.30 (m, 4H), 6.86-6.81 (m, 4H), 6.69-6.67 (m, 2H), 3.83 (s, 3H), 3.81 (s, 3H), 3.79 (s, 3H), 3.24-3.20 (m, 1H), 1.96-1.85 (m, 4H), 1.60-1.53 (m, 1H), 1.28-1.25 (m, 1H), 1.21 (s, 3H), 0.67 (s, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 160.44, 160.21, 159.30, 138.83, 138.16, 135.79, 132.55, 125.77, 121.02, 114.42, 114.05, 113.94, 64.60, 56.89, 55.19, 55.07, 39.64, 37.33, 34.21, 32.21, 30.47, 19.45. MS (relative intensity) *m/z*: 416 (1), 387 (34), 247 (100), 139 (49), 107 (50). HRMS calc. for $C_{29}H_{34}O_3S_3$: 526.1670. Found: 526.1673.

*1,1-Dimethyl-2,4,4-tris(propylthio)cyclohexane (**4n**)*

Yield: 0.260 g (78%). ^{1}H NMR ($CDCl_3$, 400 MHz) δ: 2.81 (dd, *J* 9.5/4.4 Hz, 1H), 2.64 (t, *J* 7.4 Hz, 2H), 2.48 (t, *J* 7.4 Hz, 4H), 2.20-1.72 (m, 5H), 1.60 (sex, *J* 7.4 Hz, 6H), 1.40-1.20 (m, 1H), 1.11 (s, 3H), 1.00 (t, *J* 7.4 Hz, 3H), 1.09 (t, *J* 7.4 Hz, 3H), 0.98 (t, *J* 7.4 Hz, 3H), 0.88 (s, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 61.39, 51.05, 42.46, 36.88, 34.55, 33.25, 30.68, 30.29, 30.19, 23.15, 22.68, 22.38, 19.54, 13.79, 13.74, 13.30. HRMS calc. for $C_{17}H_{34}S_3$: 334.1822. Found: 334.1820.

General procedure for thioethers formation

To a Schlenck tube, under air atmosphere containing an appropriate dihydropyrane (0.50 mmol) in CH_2Cl_2 (2.0 mL), was added the thiol (0.6 mmol). In the resulting solution was added PhSeBr (2 mol%) and the reaction mixture was allowed to stir for 20 min at 0 °C for thioethers products. After that, the mixture was concentrated under vacuum. The residue was purified by flash chromatography on silica gel using ethyl acetate/hexane as the eluent.

*2-(Propylthio)-tetrahydro-2H-pyran (**5a**)*

Yield: 0.120 g (75%). ^{1}H NMR ($CDCl_3$, 400 MHz) δ: 4.16-3.71 (m, 2H), 3.53-3.36 (m, 1H), 2.72-2.49 (m, 2H), 1.92-1.51 (m, 8H), 0.99 (t, *J* 7.20 Hz, 3H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 98.80, 67.26, 62.26, 51.81, 35.98, 29.21, 25.44, 19.59. HRMS calc. for $C_8H_{16}OS$: 160.0921. Found: 160.0918.

*2-(Benzylthio)-tetrahydro-2H-pyran (**5b**)*

Yield: 0.191 g (91%). ^{1}H NMR ($CDCl_3$, 400 MHz) δ: 7.33-7.20 (m, 5H), 4.72-4.69 (m, 1H), 4.14-4.08 (m, 1H), 3.87-3.81 (m, 1H), 3.75-3.70 (m, 1H), 3.53-3.47 (m, 1H), 1.89-1.75 (m, 2H), 1.67-1.49 (m, 4H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 128.26, 128.65, 128.09, 126.49, 80.14, 63.80, 34.38, 33.59, 30.49, 25.37, 21.27. HRMS calc. for $C_{12}H_{16}OS$: 208.0921. Found: 208.0924.

*2-(4-Methoxyphenylthio)-tetrahydro-2H-pyran (**5c**)*

Yield: 0.194 g (87%). ^{1}H NMR ($CDCl_3$, 400 MHz) δ: 7.43 (d, *J* 8.8 Hz, 2H), 6.84 (d, *J* 8.8 Hz, 2H), 5.04-4.98 (m, 1H), 4.23-4.12 (m, 1H), 3.79 (s, 3H), 3.59-3.48 (m, 1H), 2.04-1.77 (m, 2H), 1.72-1.57 (m, 4H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 158.96, 133.94, 124.85, 114.00, 85.82, 64.22, 54.81, 31.15, 25.21, 21.37. HRMS calc. for $C_{12}H_{16}O_2S$: 224.0871. Found: 224.0874.

*2-(2-Furan-2-ylmethylthio)-tetrahydro-2H-pyran (**5d**)*

Yield: 0.120 g (61%). ^{1}H NMR ($CDCl_3$, 400 MHz) δ: 7.35 (s, 1H), 6.30-6.29 (m, 1H), 6.17 (d, *J* 2.6 Hz, 1H), 4.87-4.85 (m, 1H), 4.12-4.06 (m, 1H), 3.91 (d, *J* 14.6 Hz, 1H), 3.69 (d, *J* 14.6 Hz, 1H), 3.55-3.49 (m, 1H), 1.94-1.54 (m, 6H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 151.68, 141.97, 110.27, 107.28, 80.84, 64.02, 30.64, 25.89, 25.56, 21.39. HRMS calc. for $C_{10}H_{14}O_2S$: 198.0714. Found: 198.0716.

*2-(2-Chlorophenylthio)-tetrahydro-2H-pyran (**5e**)*

Yield: 0.194 g (85%). ^{1}H NMR ($CDCl_3$, 400 MHz) δ: 7.59 (dd, *J* 6.0/1.7 Hz, 1H), 7.36 (dd, *J* 6.1/1.4 Hz, 1H), 7.26-7.07 (m, 2H), 5.37 (t, *J* 4.4 Hz, 1H), 4.22-4.11 (m, 1H), 3.67-3.56 (m, 1H), 2.17-1.59 (m, 6H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 135.02, 133.27, 129.90, 129.12, 126.91, 126.65, 83.21, 63.67, 31.05, 25.19, 20.96. HRMS calc. for $C_{11}H_{13}ClOS$: 228.0375. Found: 228.0371.

*2-(4-Chlorobenzylthio)-tetrahydro-2H-pyran (**5f**)*

Yield: 0.218 g (90%). ^{1}H NMR ($CDCl_3$, 400 MHz) δ: 7.28-7.15 (m, 4H), 4.69-4.66 (m, 1H), 4.11-4.06 (m, 1H), 3.83-3.75 (m, 1H), 3.69-3.64 (m, 1H), 3.51-3.46 (m, 1H), 1.89-1.46 (m, 6H). ^{13}C NMR ($CDCl_3$, 100 MHz) δ: 136.93, 132.31, 130.08, 128.28, 80.18, 63.88, 32.98, 30.50, 25.40, 21.29. HRMS calc. for $C_{12}H_{15}ClOS$: 242.0532. Found: 242.0535.

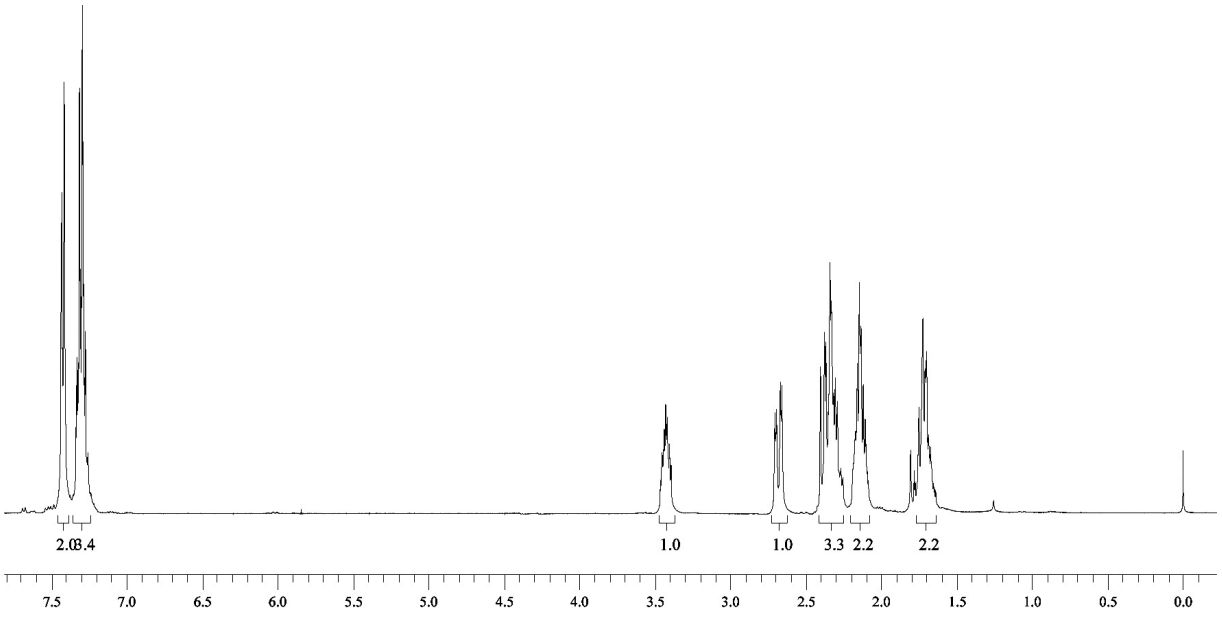

Figure S1. ^{1}H NMR spectra of compound **3a** in $CDCl_3$ at 200 MHz.

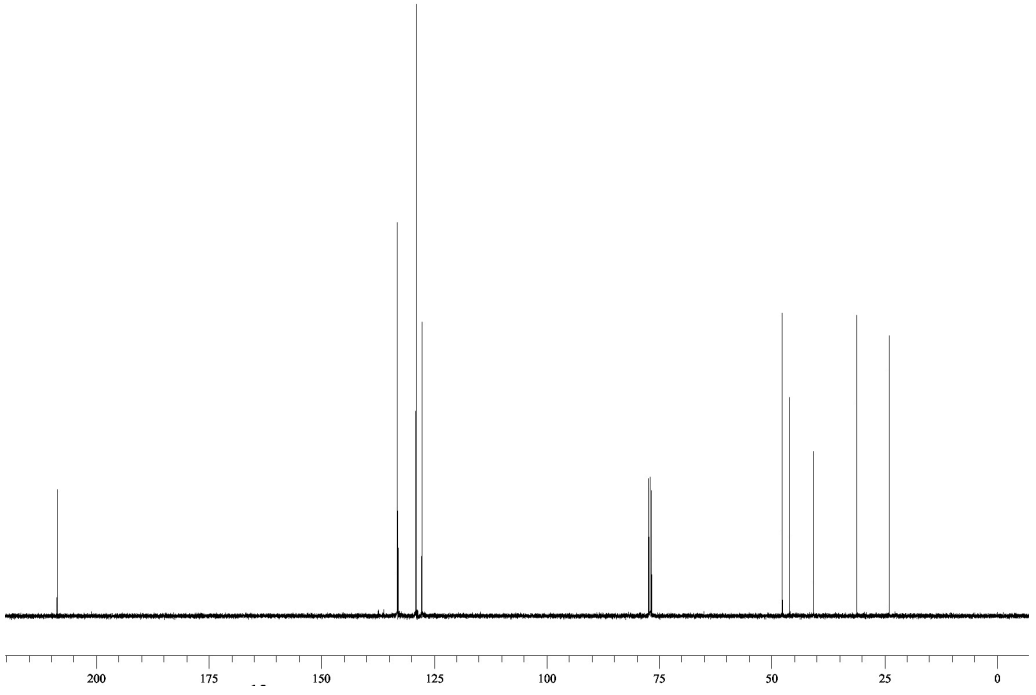

Figure S2. ^{13}C NMR spectra of compound **3a** in $CDCl_3$ at 100 MHz.

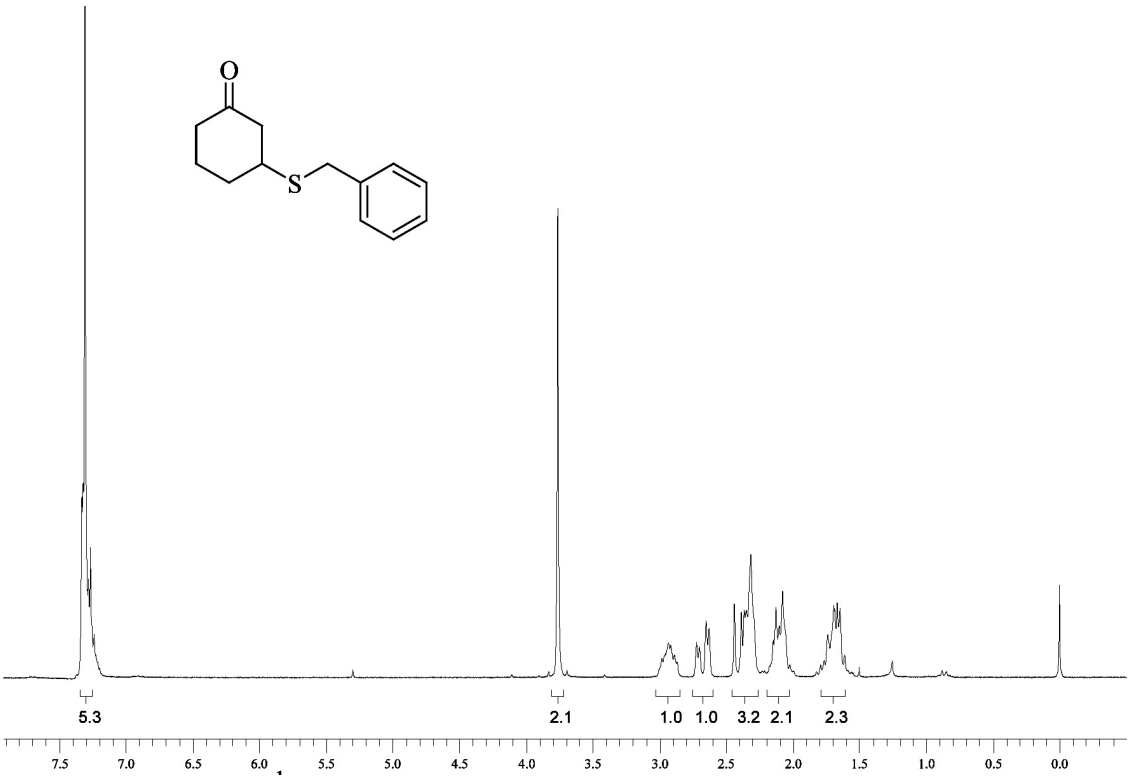

Figure S3. ^{1}H NMR spectra of compound **3c** in $CDCl_3$ at 200 MHz.

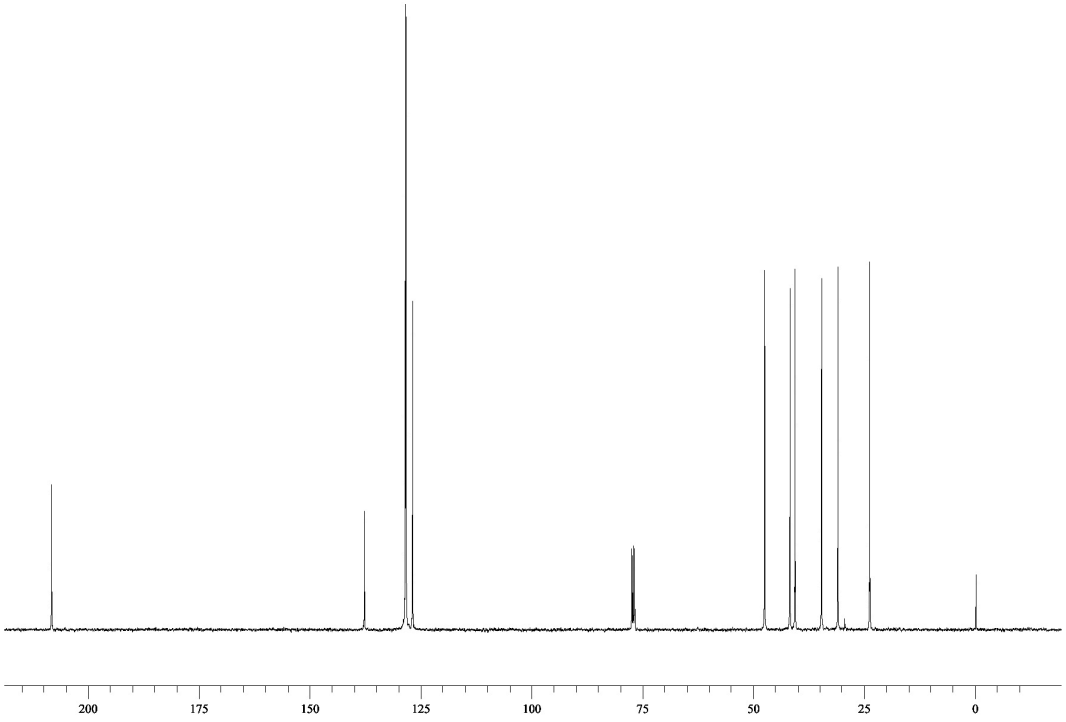

Figure S4. ^{13}C NMR spectra of compound **3a** in $CDCl_3$ at 100 MHz.

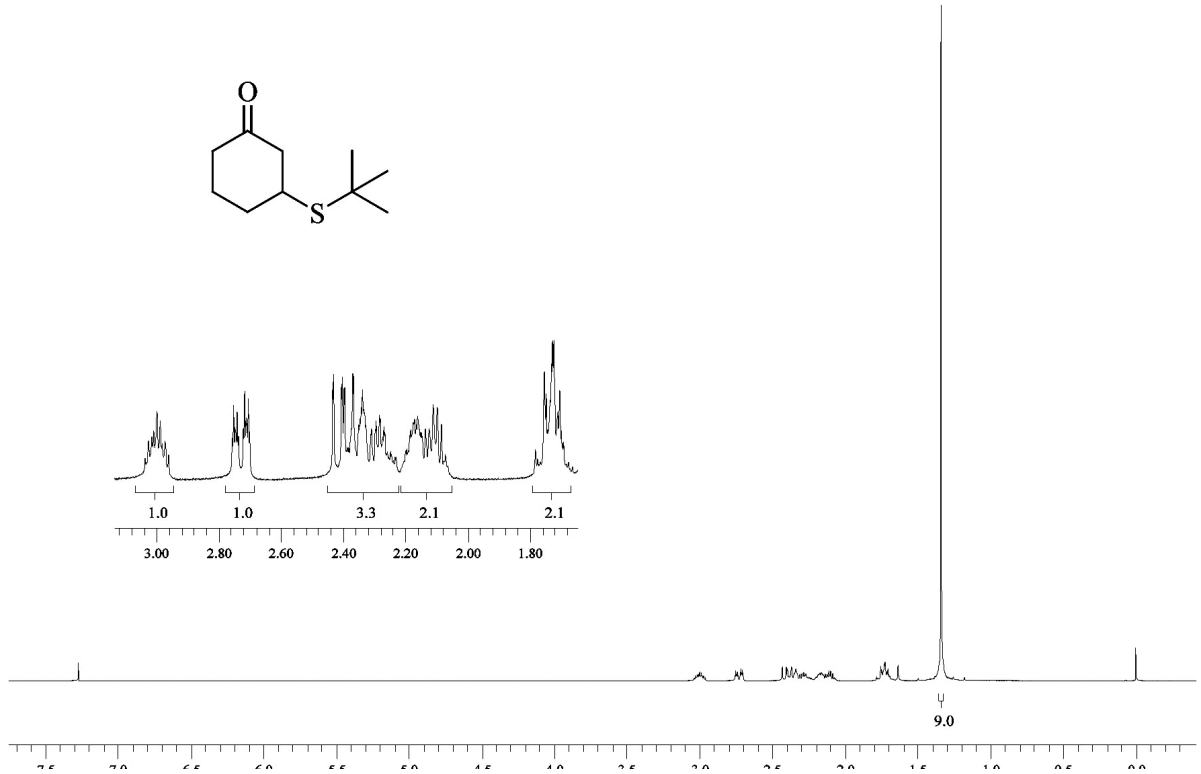

Figure S5. [1]H NMR spectra of compound **3d** in $CDCl_3$ at 200 MHz.

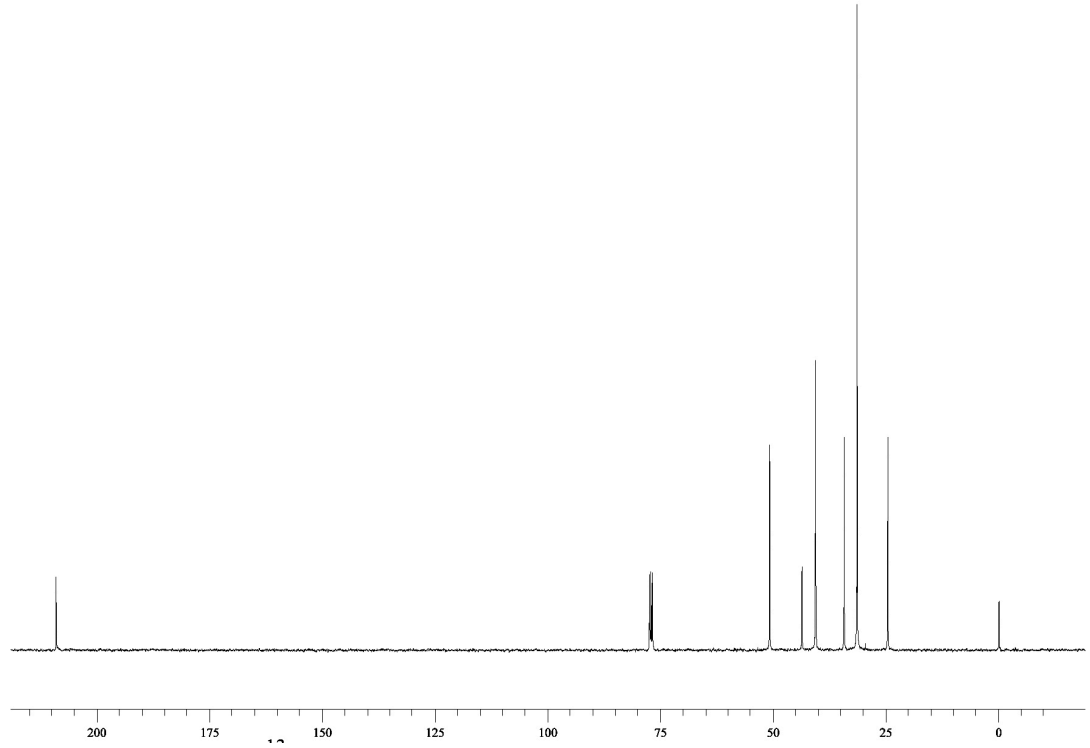

Figure S6. [13]C NMR spectra of compound **3d** in $CDCl_3$ at 100 MHz.

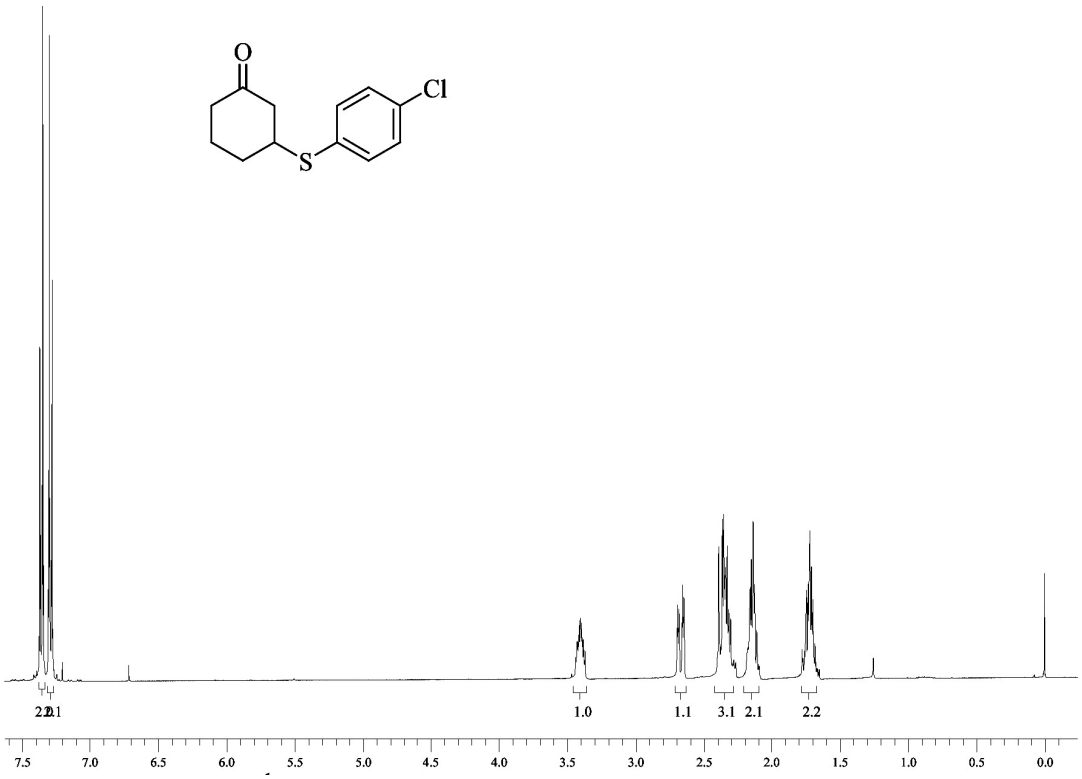

Figure S7. ^{1}H NMR spectra of compound **3h** in $CDCl_3$ at 400 MHz.

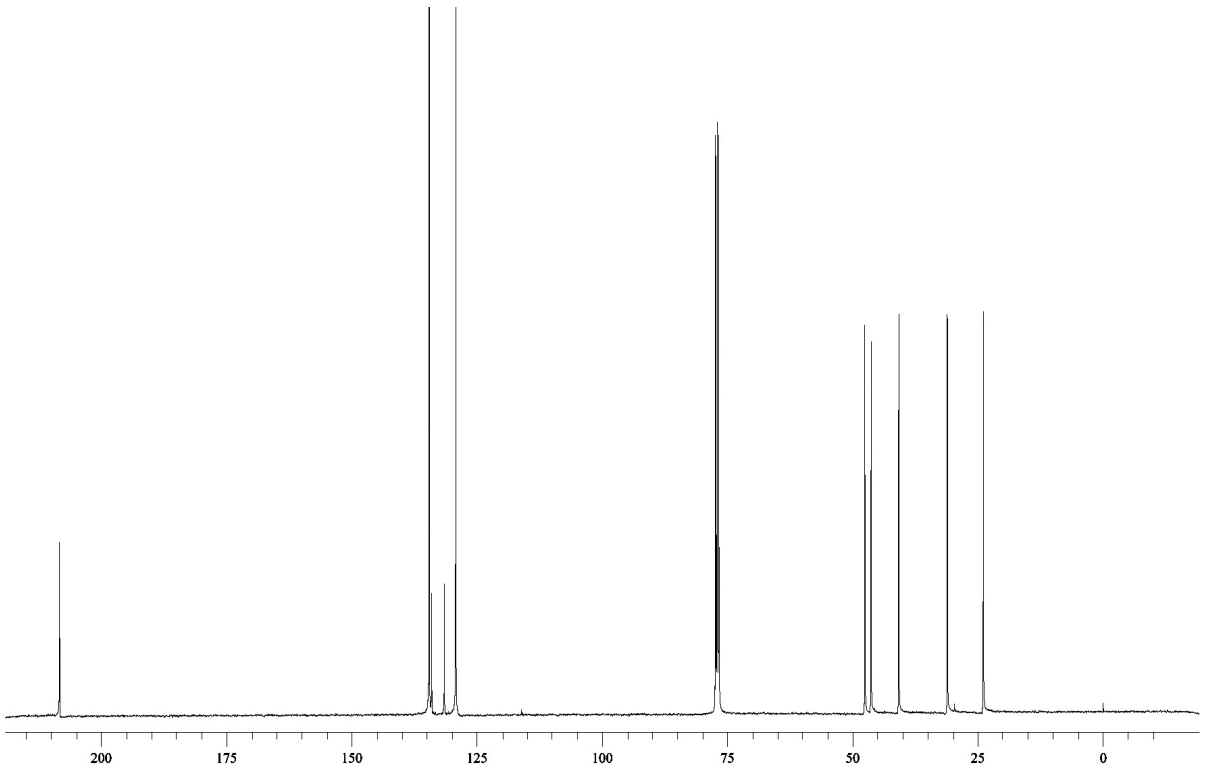

Figure S8. ^{13}C NMR spectra of compound **3h** in $CDCl_3$ at 100 MHz.

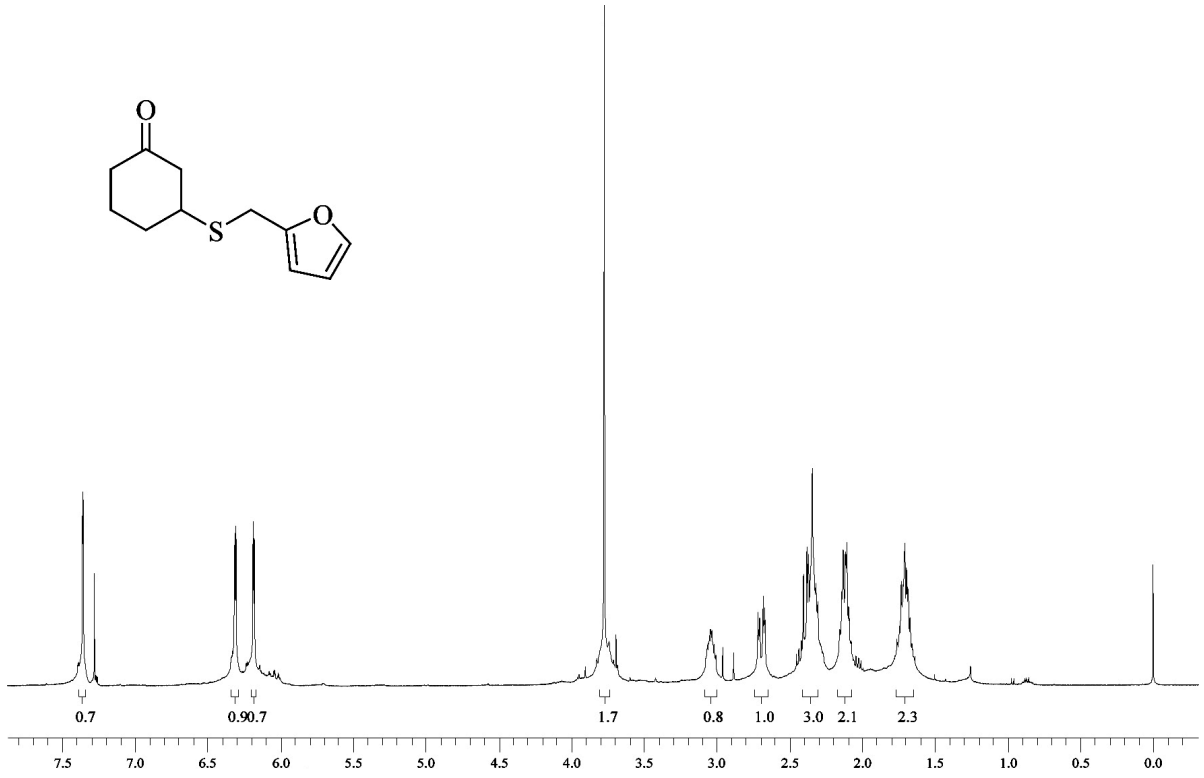

Figure S9. [1]H NMR spectra of compound **3i** in $CDCl_3$ at 200 MHz.

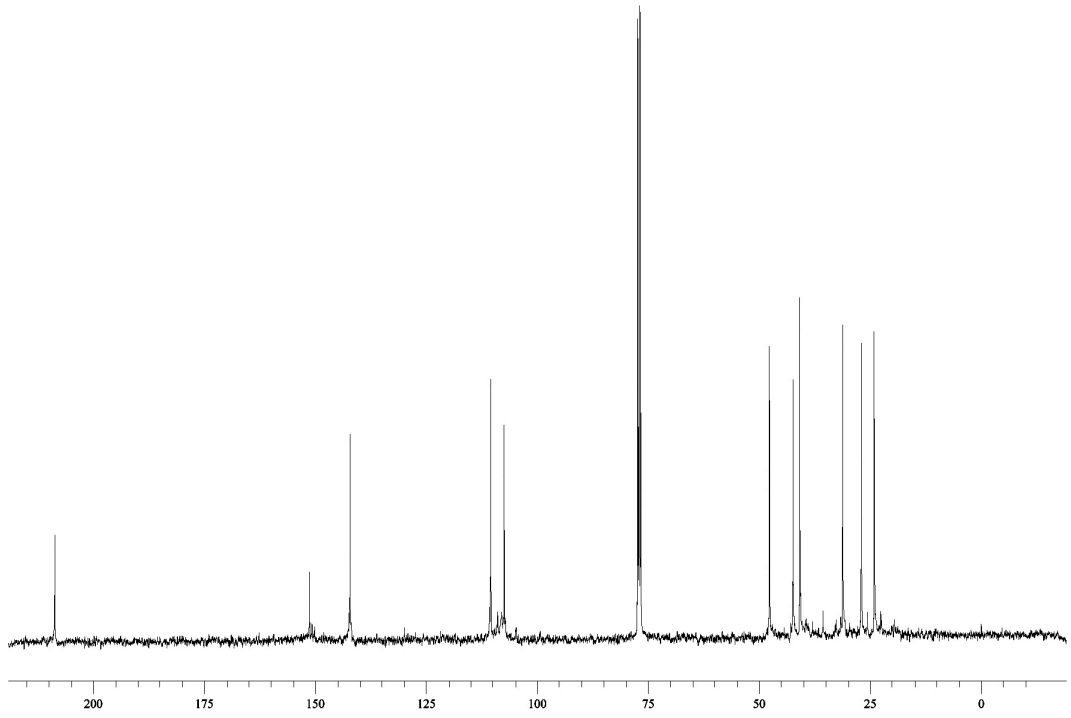

Figure S10. [13]C NMR spectra of compound **3i** in $CDCl_3$ at 100 MHz.

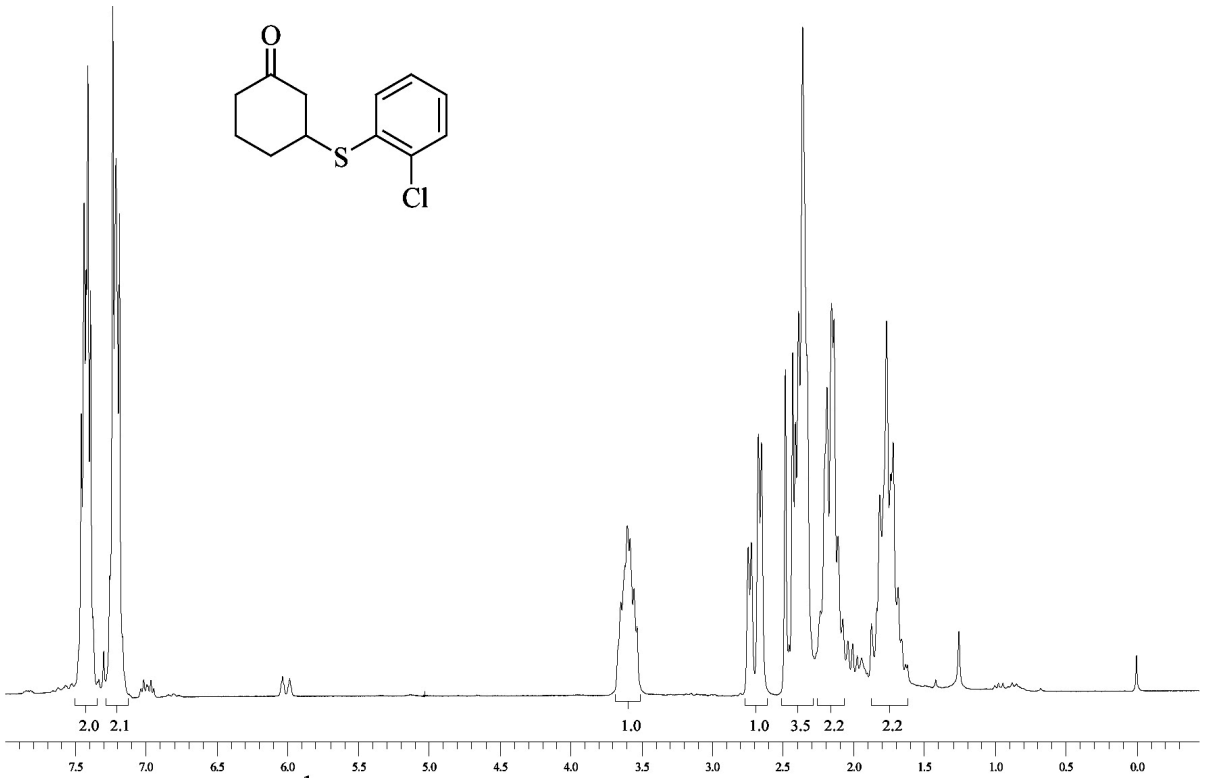

Figure S11. ^{1}H NMR spectra of compound **3k** in $CDCl_3$ at 200 MHz.

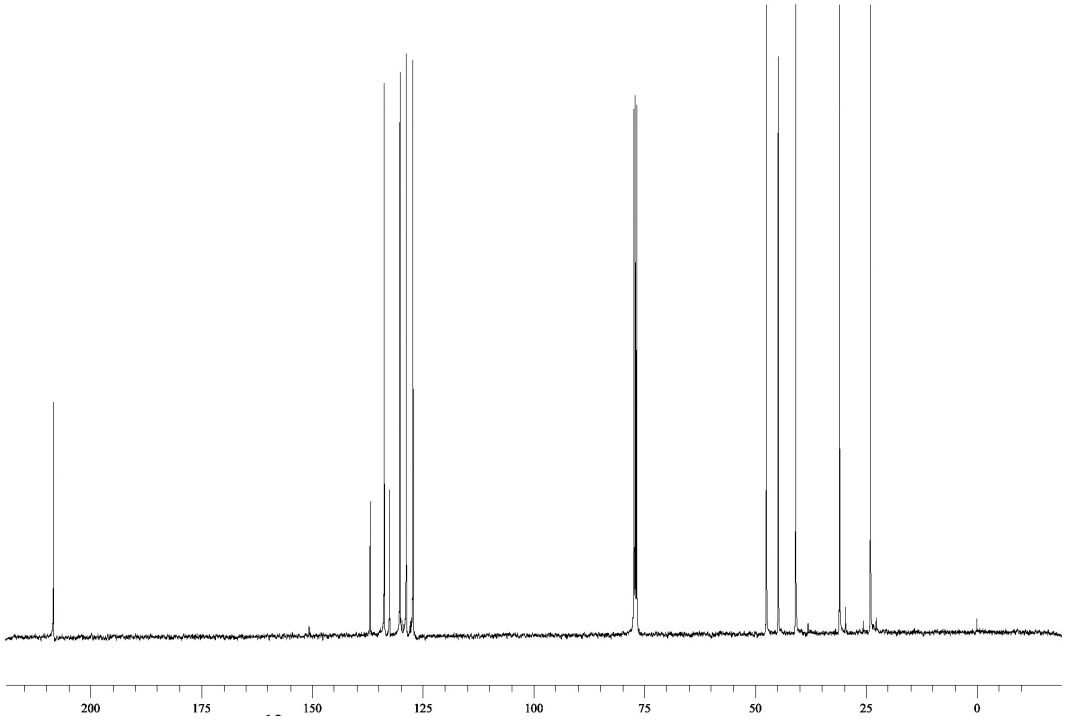

Figure S12. ^{13}C NMR spectra of compound **3k** in $CDCl_3$ at 100 MHz.

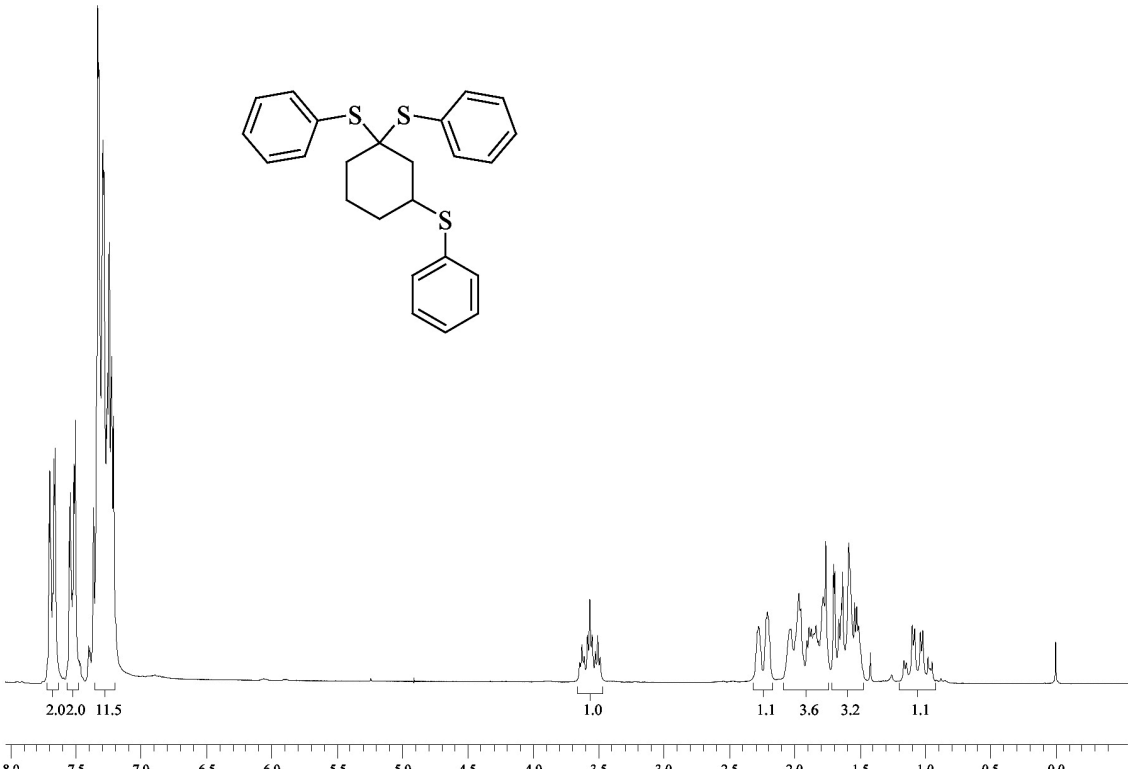

Figure S13. ^{1}H NMR spectra of compound **4a** in $CDCl_3$ at 200 MHz.

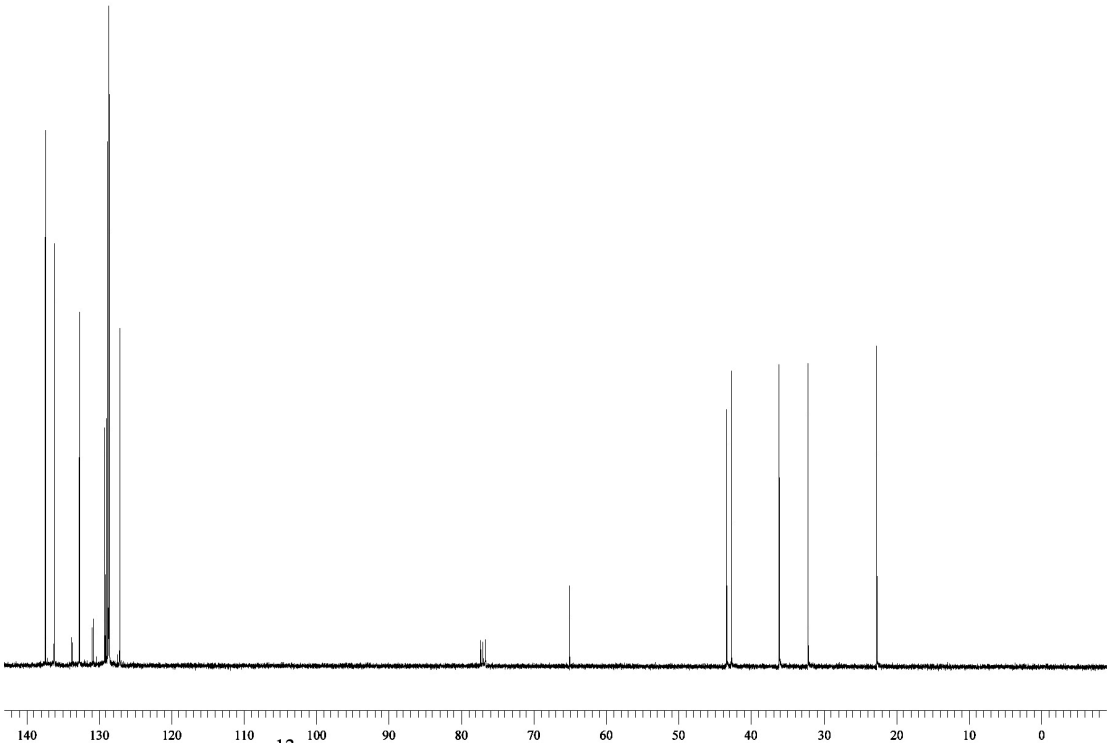

Figure S14. ^{13}C NMR spectra of compound **4a** in $CDCl_3$ at 100 MHz.

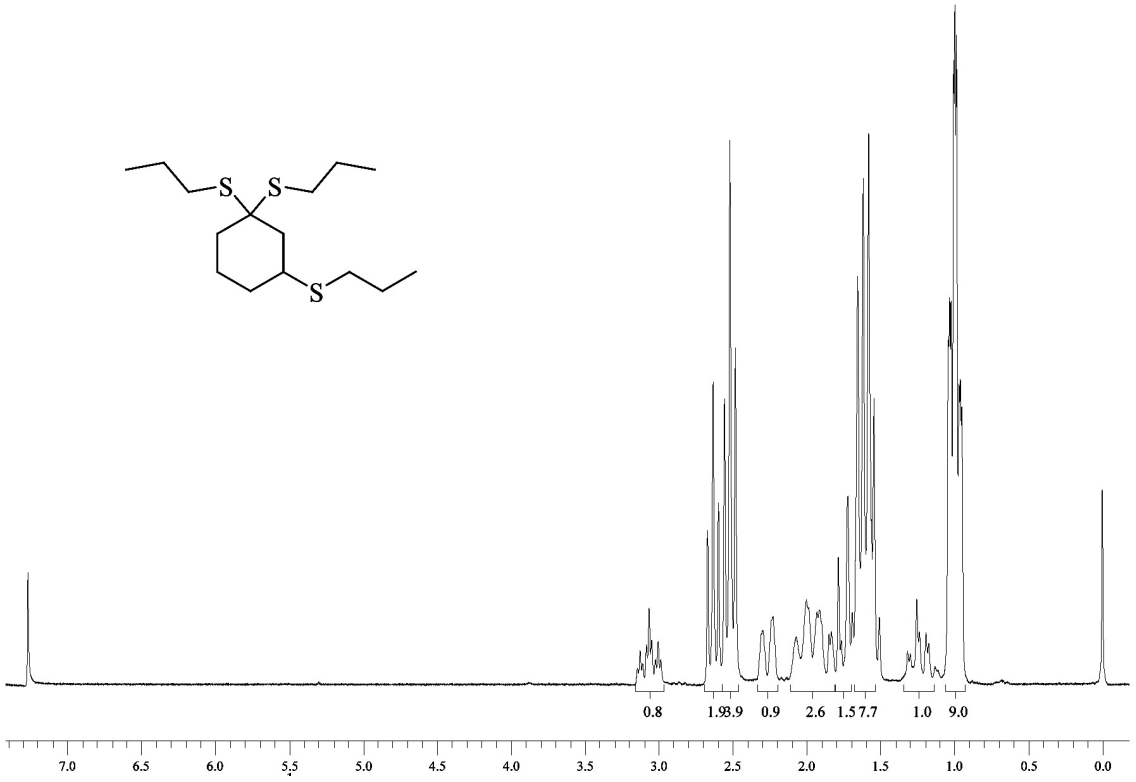

Figure S15. ^{1}H NMR spectra of compound **4b** in $CDCl_3$ at 200 MHz.

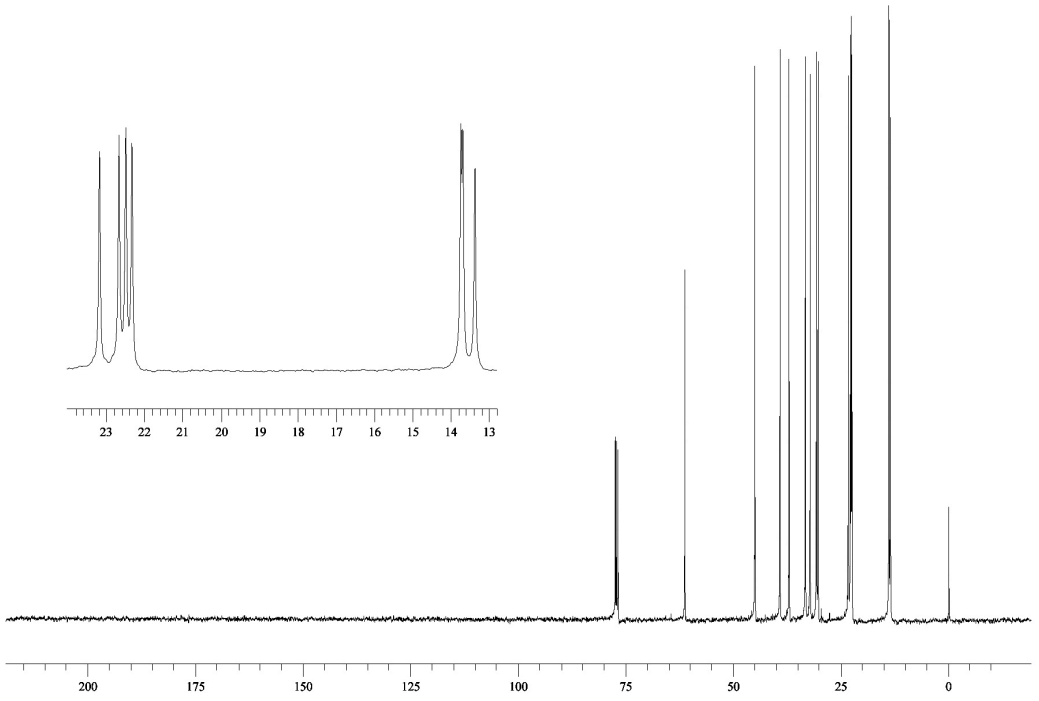

Figure S16. ^{13}C NMR spectra of compound **4b** in $CDCl_3$ at 100 MHz.

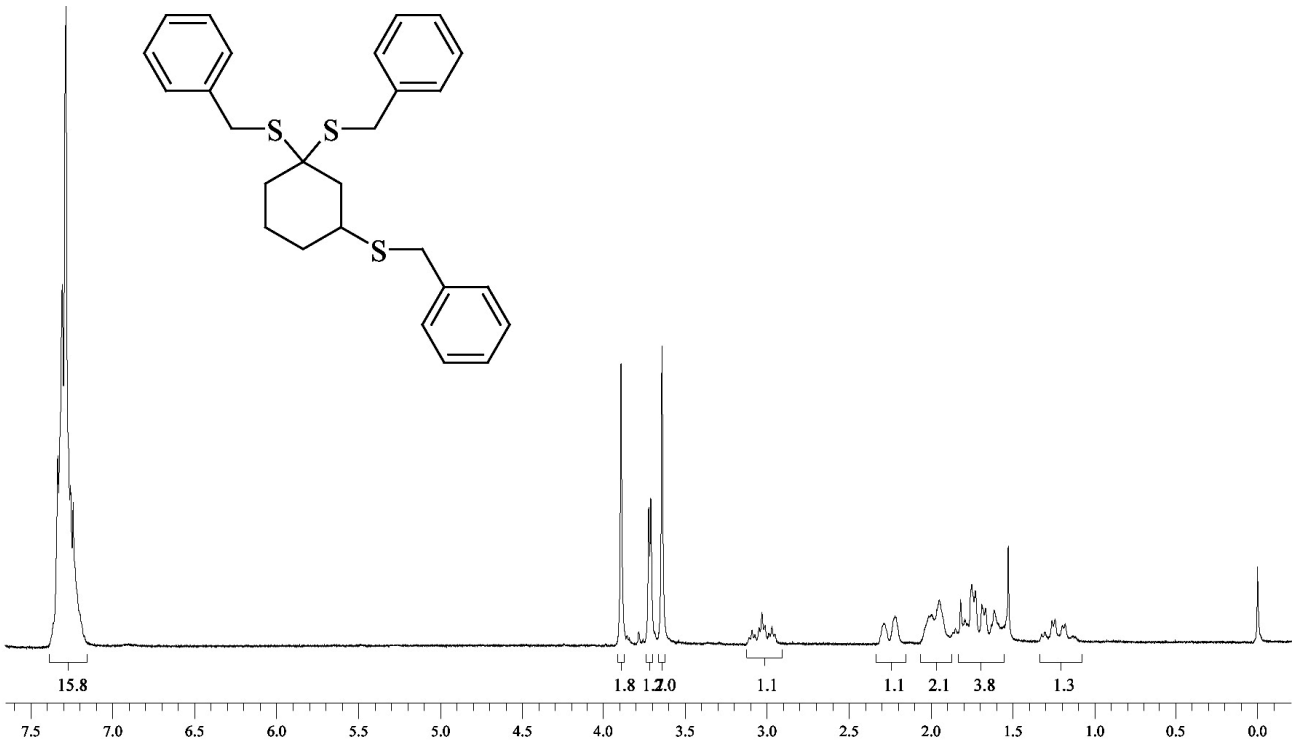

Figure S17. ^{1}H NMR spectra of compound **4c** in $CDCl_3$ at 200 MHz.

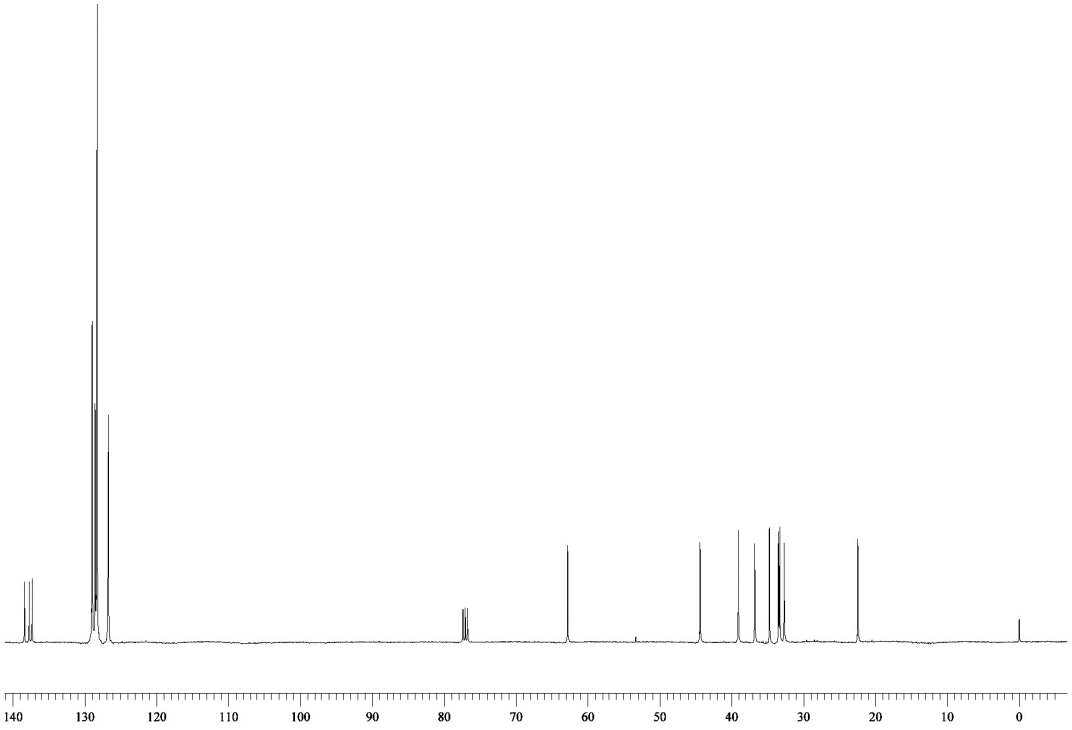

Figure S18. ^{13}C NMR spectra of compound **4c** in $CDCl_3$ at 100 MHz.

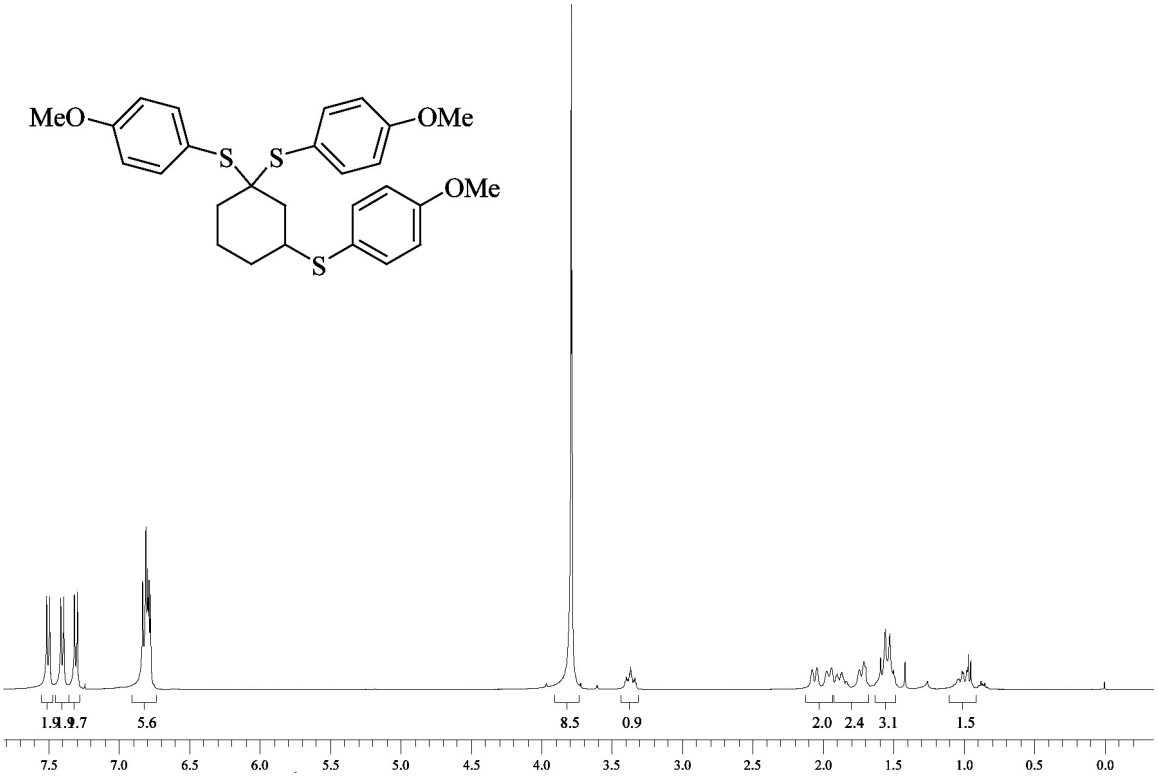

Figure S19. ^{1}H NMR spectra of compound **4g** in $CDCl_3$ at 400 MHz.

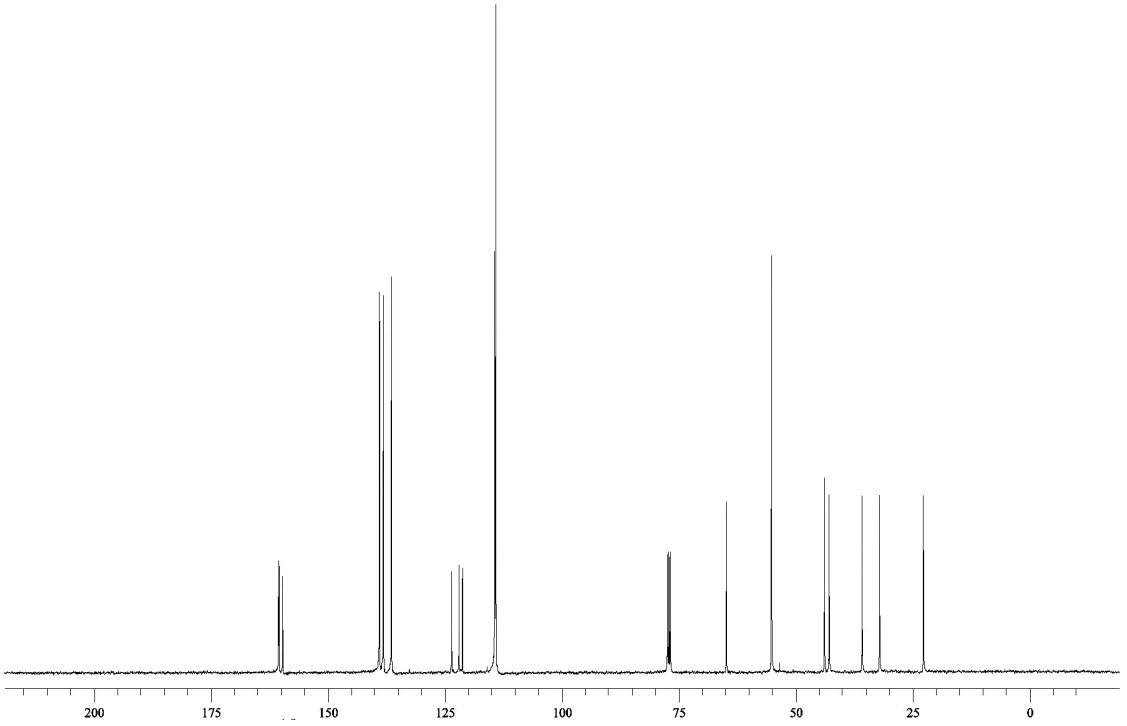

Figure S20. ^{13}C NMR spectra of compound **4g** in $CDCl_3$ at 100 MHz.

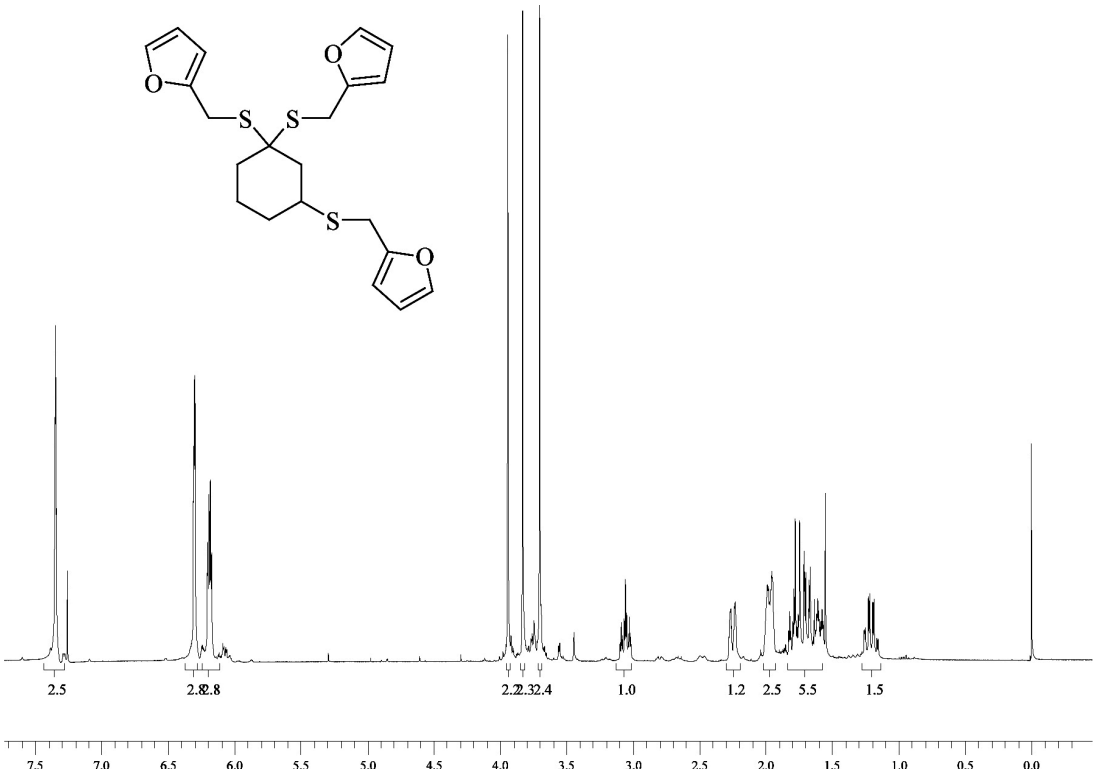

Figure S21. ^{1}H NMR spectra of compound **4h** in $CDCl_3$ at 400 MHz.

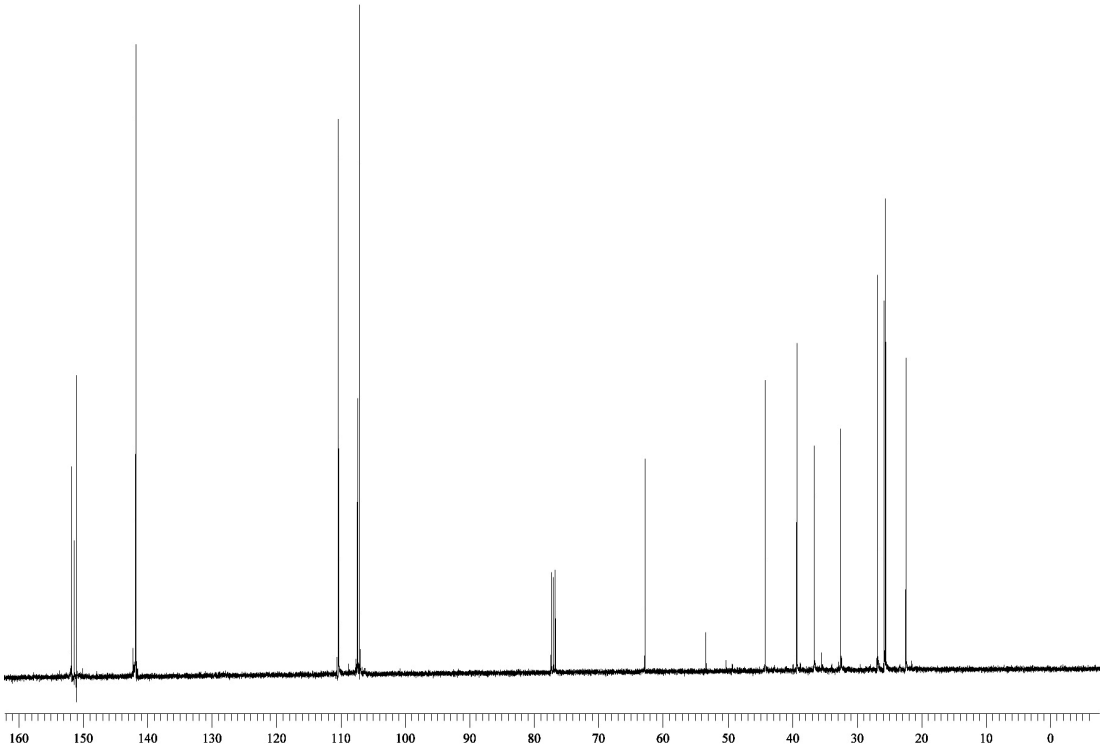

Figure S22. ^{13}C NMR spectra of compound **4h** in $CDCl_3$ at 100 MHz.

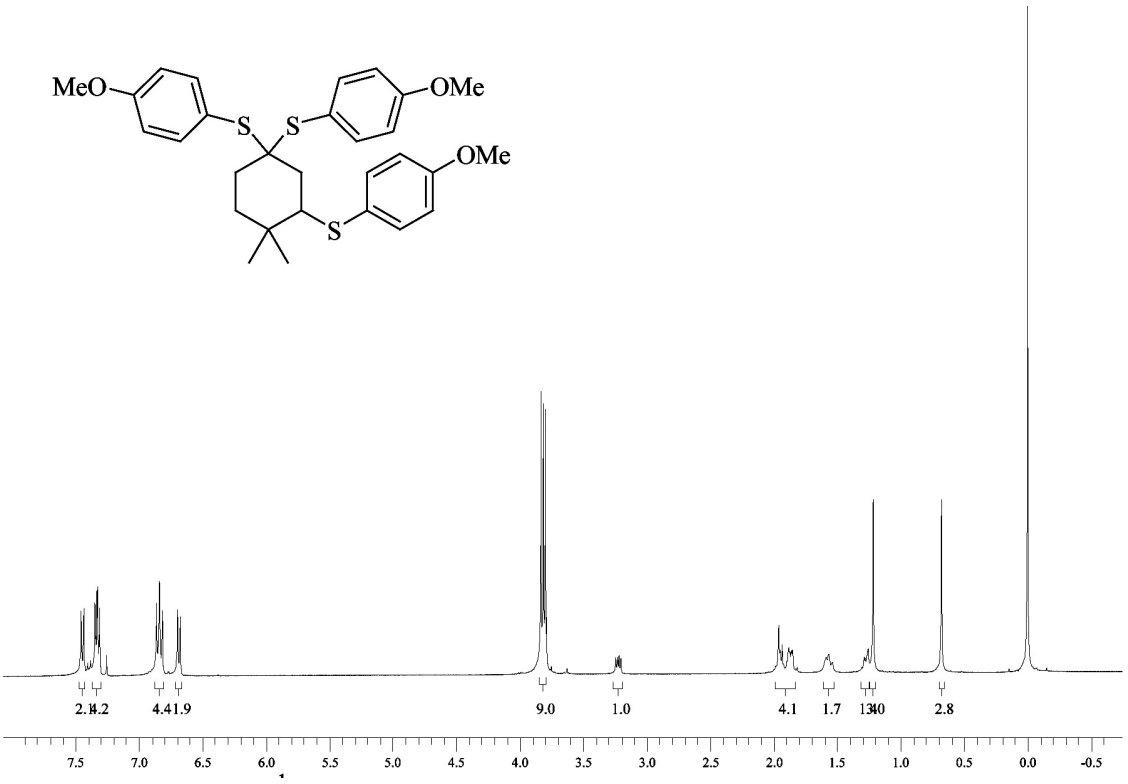

Figure S23. ^{1}H NMR spectra of compound **4m** in $CDCl_3$ at 400 MHz.

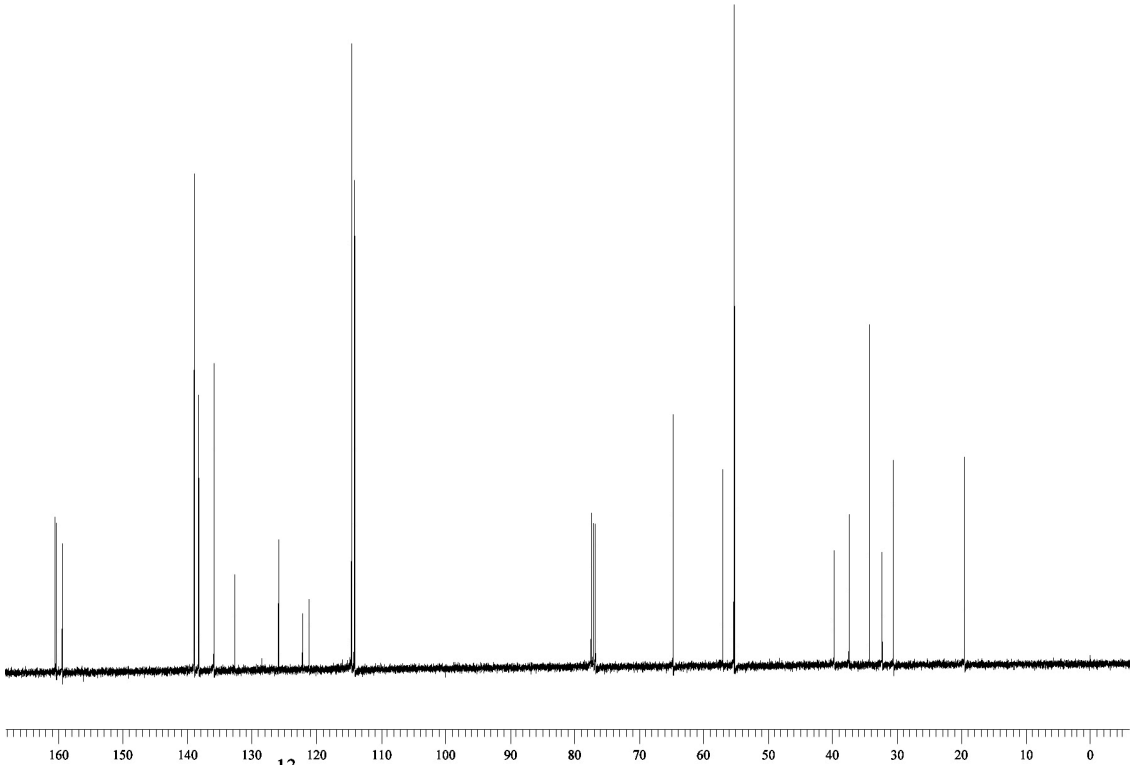

Figure S24. ^{13}C NMR spectra of compound **4m** in $CDCl_3$ at 100 MHz.

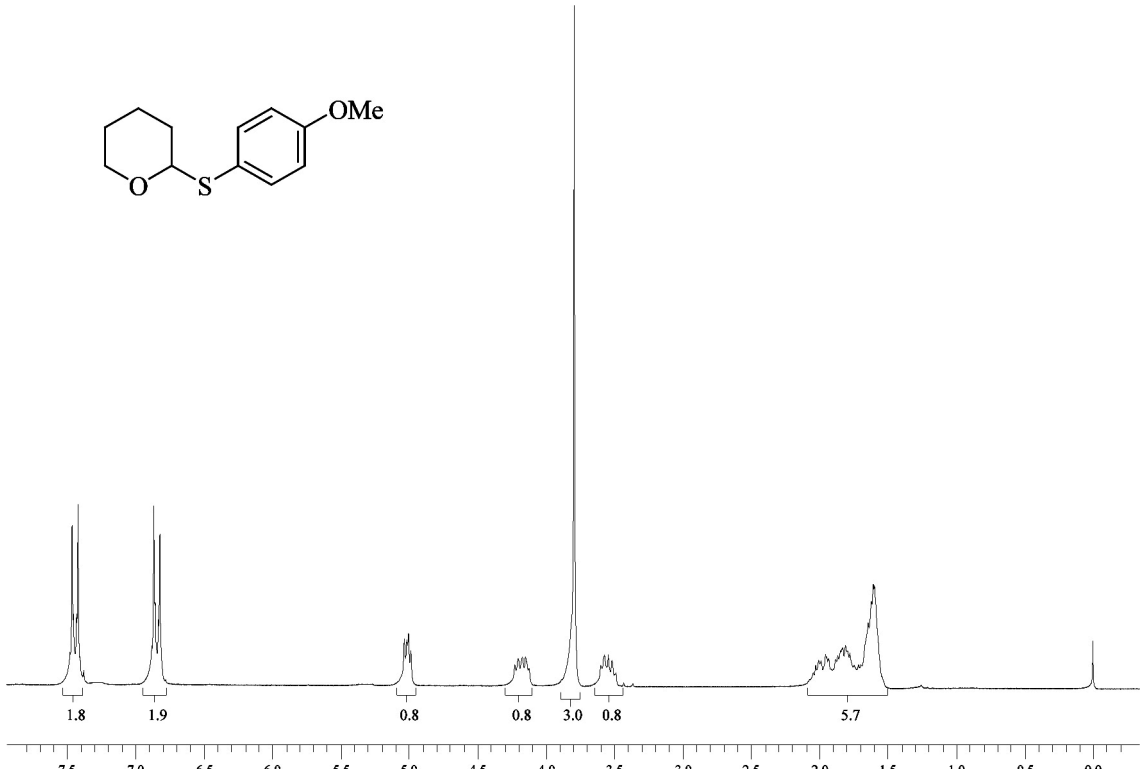

Figure S25. ^{1}H NMR spectra of compound **5c** in $CDCl_3$ at 400 MHz.

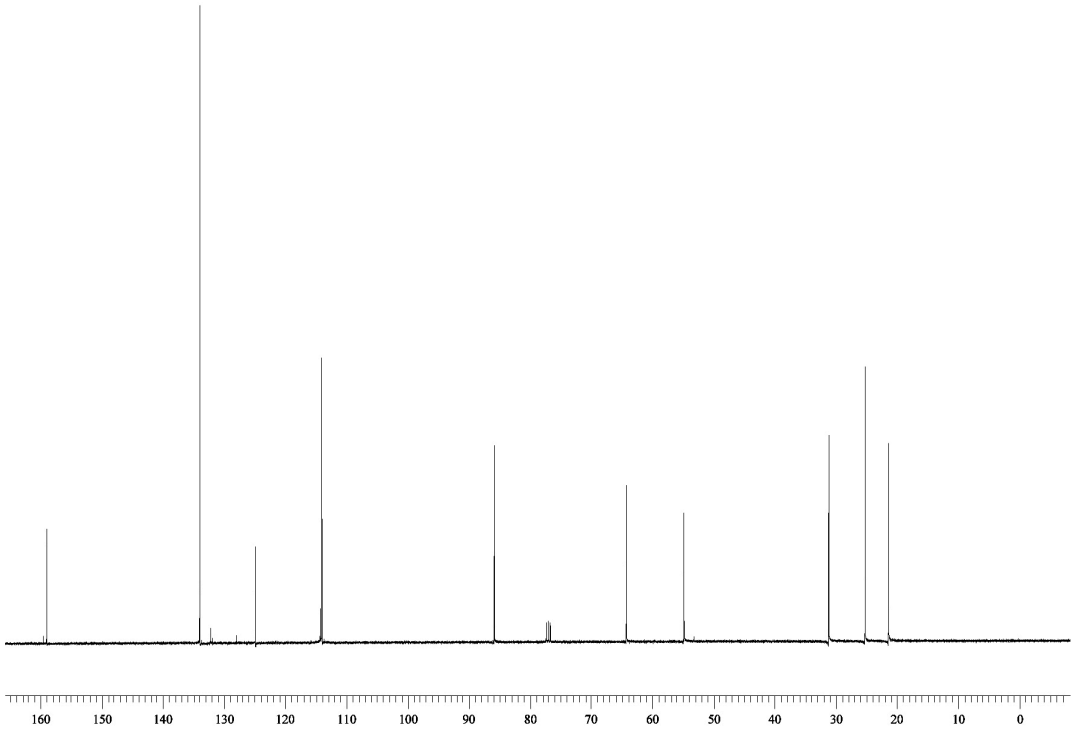

Figure S26. ^{13}C NMR spectra of compound **5c** in $CDCl_3$ at 100 MHz.

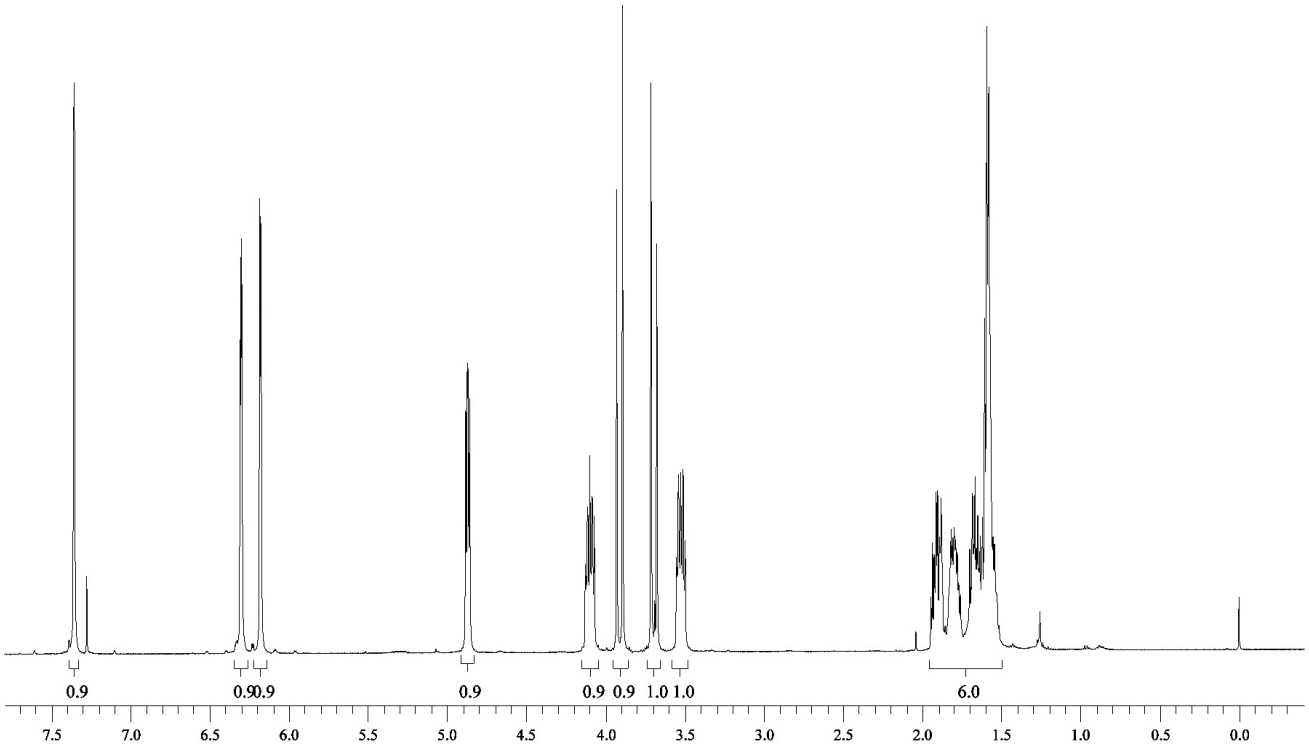

Figure S27. ^{1}H NMR spectra of compound **5d** in $CDCl_3$ at 400 MHz.

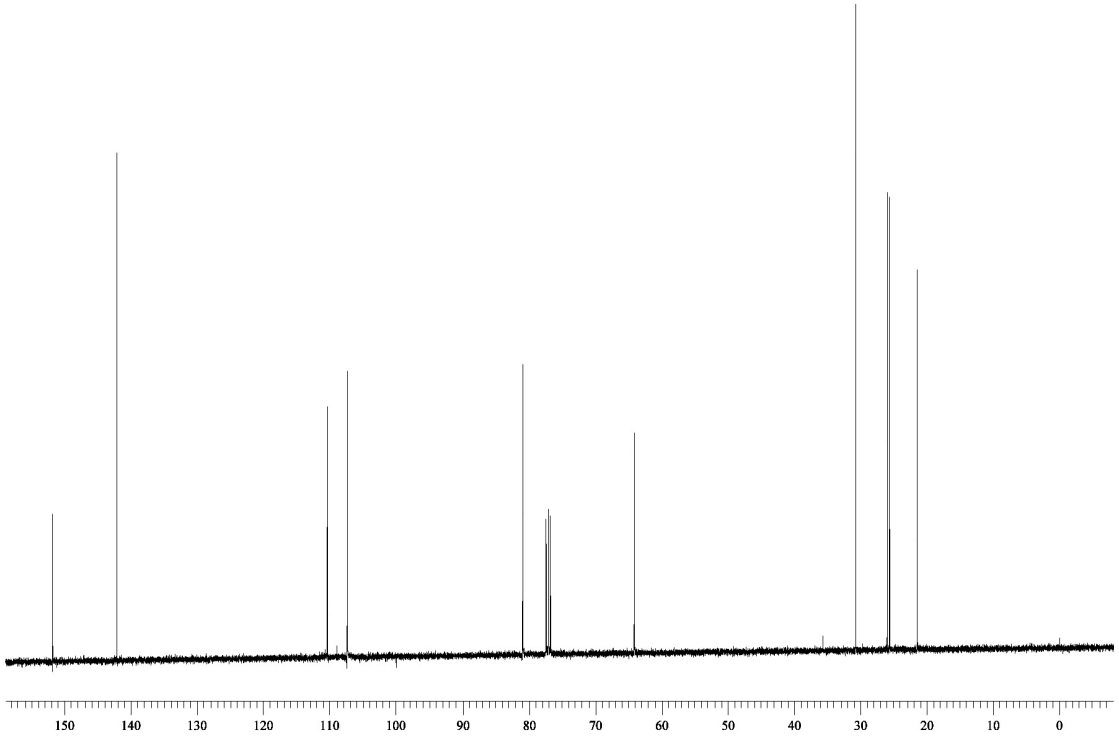

Figure S28. ^{13}C NMR spectra of compound **5d** in $CDCl_3$ at 100 MHz.

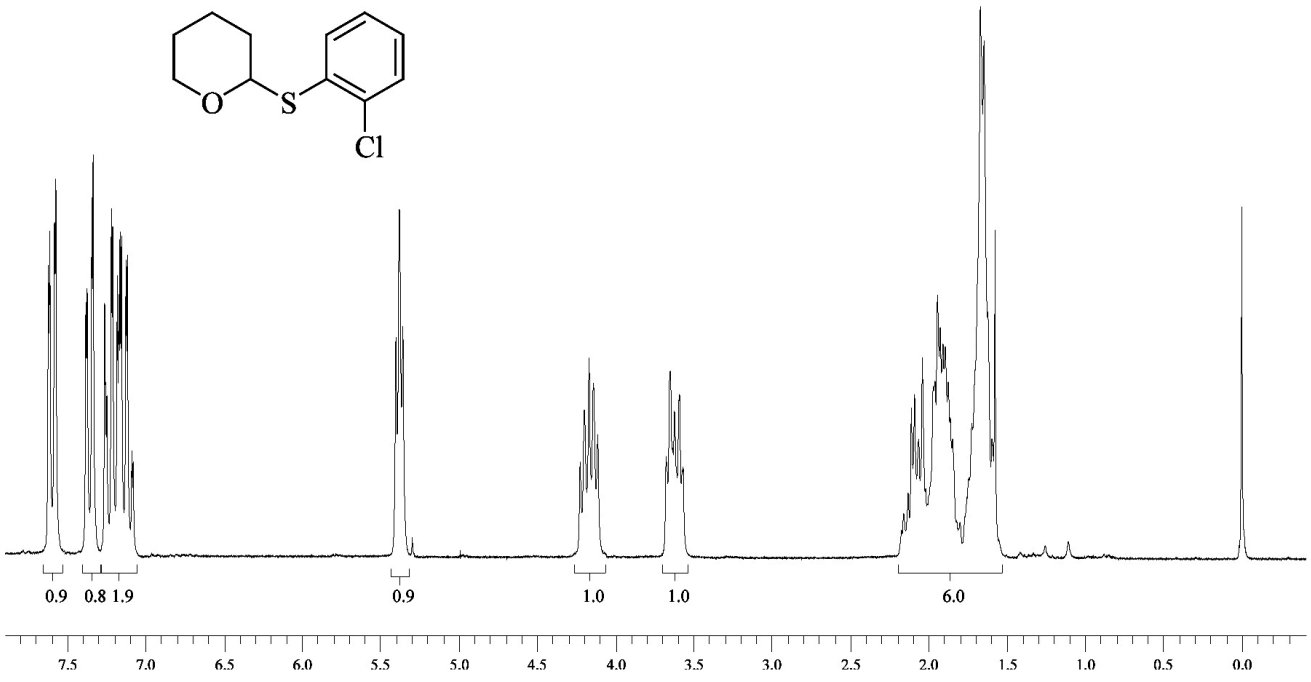

Figure S29. ^{1}H NMR spectra of compound **5e** in $CDCl_3$ at 400 MHz.

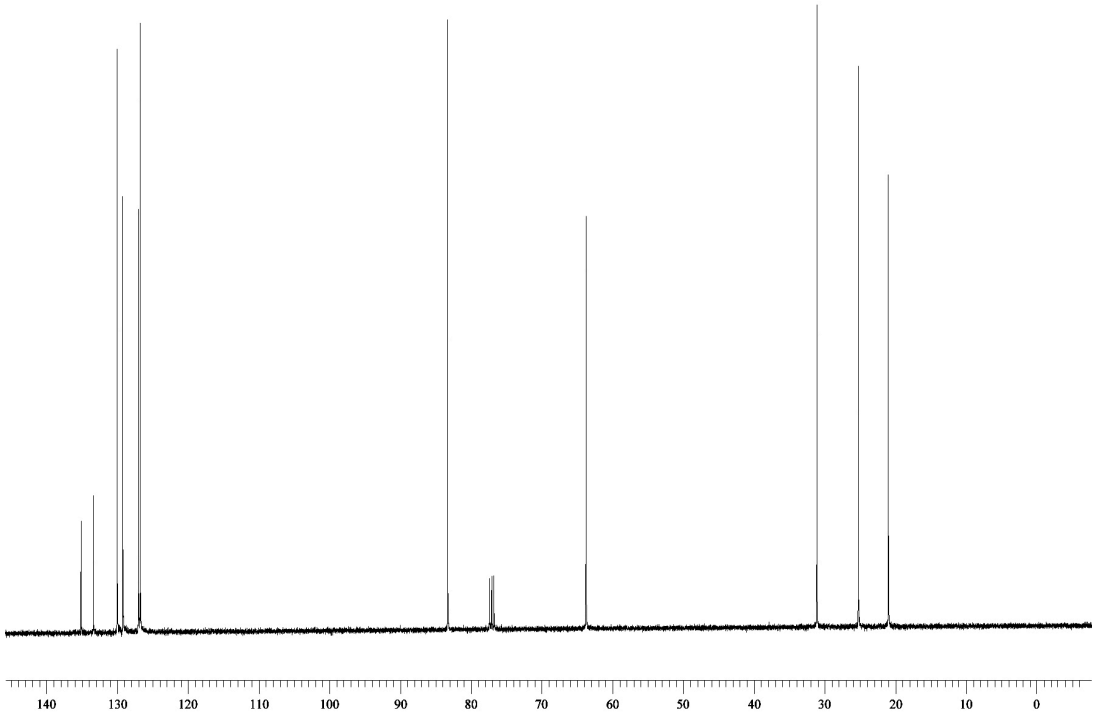

Figure S30. ^{13}C NMR spectra of compound **5e** in $CDCl_3$ at 100 MHz.