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Visible light promoted thiol-ene reactions using titanium dioxide

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Supporting Information

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I. Experimental Procedures

General Methods:

¹H and ¹³C NMR spectra were recorded on a Brüker Ava400 (400 MHz) or Avance II+ (500 MHz) instruments and calibrated to residual solvent peaks: proton (CDCl₃: 7.26 ppm) and carbon (CDCl₃: 77.0 ppm). Data for ¹H NMR are presented as follows: chemical shift (in ppm on the δ scale), multiplicity (br s=broad singlet, s=singlet, d=doublet, t=triplet, q=quartet, quint=quintet, m=multiplet), the coupling constant

(*J*, in Hertz) and integration. ¹³C data are reported as the ppm on the δ scale followed by the interpretation and multiplicity where appropriate. High Resolution Mass spectra were obtained from the EPSRC mass spectrometry service at the University of Swansea. The data is recorded as the method followed by the calculated and measured masses. TLC was performed on Merck $60F_{254}$ silica plates and visualised by UV light and potassium permanganate stains. The compounds were purified by flash chromatography using Aldrich silica gel (particle size 40-63 µm) under a positive pressure. The eluent is quoted as a percentage. Titanium dioxide (nanopowder, 21 nm particle size, Aeroxide® P25) was bought from Sigma-Aldrich and used as received. Thiols and alkenes used in this study were purchased from a chemical supplier and used as received. Thiol-ene reactions were irradiated using a 20 W, 170 mA fluorescent light bulb (brand name Asda).

Thiol-ene reaction:

$$R^{1}_{SH} + \overset{R^{2}}{\underset{R^{3}}{\overset{H}{\xrightarrow{}}}} \xrightarrow{TiO_{2} (1.0 \text{ equiv})} \\ \xrightarrow{MeCN} \\ \xrightarrow{20 \text{ W light, rt}} \\ \xrightarrow{16 \text{ h}} \\ R^{3}$$

General procedure: A reaction vial (10 mL) was charged with alkene (1.0 mmol), thiol (4.0 mmol), titanium dioxide (79.9 mg, 1.0 mmol) and MeCN (1 mL). The vial was sealed and placed 10-15 cm away from a 20 W light bulb, and the mixture was stirred at room temperature for 16 hours. The resulting mixture was diluted with DCM, filtered through a pad of celite and concentrated under reduced pressure (reactions without base-sensitive substrates were first extracted with 10% NaOH (aq) to remove unreacted thiol). The crude material was purified by column chromatography (SiO₂, using the noted solvent mixture) to yield the desired thiol-ene product.

Controls: Reaction in the dark (Table 1 entry 5) was conducted using the general procedure with cyclohexene and benzyl mercaptan, but in the absence of light (no irradiation and using a foil-wrapped reaction vial). Work-up of the reaction and NMR analysis indicated zero conversion (using nitromethane as an internal standard).

Reaction under nitrogen (Table 1 entry 11) was conducted using the general procedure with cyclohexene and benzyl mercaptan, but with the MeCN solvent degassed under a stream of nitrogen and the reaction conducted under a nitrogen atmosphere. Work-up of the reaction and NMR analysis indicated 50% conversion (using nitromethane as an internal standard).

Benzyl(cyclohexyl)sulfane (3a)¹



Prepared following the general procedure using cyclohexene (101 µl, 1.0 mmol) and benzyl mercaptan (470 µl, 4.0 mmol). The reaction mixture was purified by flash chromatography using 20% DCM in hexane to afford **3a** as a colourless oil (Yield = 96%). ¹H NMR (400 MHz, CDCl₃): δ 7.39–7.33 (m, 4H), 7.29–7.25 (m, 1H), 3.79 (s, 2H), 2.64–2.57 (m, 1H), 2.03–1.97 (m, 2H), 1.82–1.76 (m, 2H), 1.66–1.62 (m, 1H) 1.43–1.25 (m, 5H); ¹³C NMR (100 MHz, CDCl₃): δ 138.9 (C), 128.7 (CH), 128.3 (CH), 126.7 (CH), 42.8 (CH), 34.5 (CH₂), 33.3 (CH₂), 25.9 (CH₂), 25.8 (CH₂).

Benzyl(3-methoxypropyl)sulfane (3b)



Prepared following the general procedure using allyl methyl ether (94 µl, 1.0 mmol) and benzyl mercaptan (470 µl, 4.0 mmol). The reaction mixture was purified by flash chromatography using 10% EtOAc in hexane to afford **3b** as a colourless oil (Yield = 85%). ¹H NMR (400 MHz, CDCl₃): δ 7.25–7.23 (m, 4H), 7.19–7.13 (m, 1H), 3.63 (s, 2H), 3.35 (t, *J* = 6.2 Hz, 2H), 3.23 (s, 3H), 2.42 (t, *J* = 7.2 Hz, 2H), 1.77–1.71 (m, 2H); ¹³C NMR (100 MHz, CDCl₃): δ 138.4 (C), 128.8 (CH), 128.4 (CH), 126.9 (CH), 71.1 (CH₂), 58.5 (CH₃), 36.3 (CH₂), 29.2 (CH₂), 28.0 (CH₂); HRMS (ES⁺) cald. for (M+K)⁺ C₁₁H₁₆OSK: 235.0559, found: 235.0755.

3-(Benzylthio)propyl acetate (3c)



Prepared following the general procedure using allyl acetate (108 µl, 1.0 mmol) and benzyl mercaptan (470 µl, 4.0 mmol). The reaction mixture was purified by flash chromatography using 10% EtOAc in hexane to afford **3c** as a colourless oil (Yield = 75%). ¹H NMR (400 MHz, CDCl₃): δ 7.36–7.30 (m, 4H), 7.29–7.24 (m, 1H), 4.13 (t, *J* = 6.3 Hz, 2H), 3.73 (s, 2H), 2.48 (t, *J* = 7.3 Hz, 2H), 2.04 (s, 3H), 1.92–1.85 (m, 2H); ¹³C NMR (100 MHz, CDCl₃): δ 170.8 (CO), 138.1 (C), 128.7 (CH), 128.4 (CH), 126.9 (CH), 62.9 (CH₂), 36.0 (CH₂), 28.1 (CH₂), 27.4 (CH₂), 20.8 (CH₃); HRMS (ES⁺) cald. for (M+Na)⁺ C₁₂H₁₆O₂NaS: 247.0769, found: 247.0778.

4-(Benzylthio)butan-2-ol (3d)



Prepared following the general procedure using 3-buten-2-ol (87 µl, 1.0 mmol) and benzyl mercaptan (470 µl, 4.0 mmol). The reaction mixture was purified by flash chromatography using 20% EtOAc in hexane to afford **3d** as a colourless oil (Yield = 78%). ¹H NMR (400 MHz, CDCl₃): δ 7.32–7.31 (m, 4H), 7.27–7.22 (m, 1H), 3.93–3.86 (m, 1H), 3.73 (s, 2H), 2.53 (br s, 2H), 1.71–1.66 (m, 3H), 1.17 (d, *J* = 6.2 Hz, 3H); ¹³C NMR (100 MHz, CDCl₃): δ 138.3 (C), 128.8 (CH), 128.5 (CH), 127.0 (CH), 67.2 (CH), 37.9 (CH₂), 36.3 (CH₂), 27.9 (CH₂), 23.5 (CH₃); HRMS (ES⁺) cald. for (M+H)⁺ C₁₁H₁₇OS: 197.0995, found: 197.0992.

3-(Benzylthio)-2-methylpropan-1-ol (3e)



Prepared following the general procedure using 2-methyl-2-propen-1-ol (84 µl, 1.0 mmol) and benzyl mercaptan (470 µl, 4.0 mmol). The reaction mixture was purified by flash chromatography using 20% EtOAc in hexane to afford **3e** as a colourless oil (Yield = 89%). ¹H NMR (400 MHz, CDCl₃): δ 7.32–7.31 (m, 4H), 7.27–7.22 (m, 1H), 3.72 (s, 2H), 3.54 (d, *J* = 5.8 Hz, 2H), 2.54–2.36 (m, 2H), 1.91–1.83 (m, 1H), 1.65 (s, 1H), 0.96 (d, *J* = 6.8 Hz, 3H); ¹³C NMR (100 MHz, CDCl₃): δ 138.4 (C), 128.9 (CH), 128.5 (CH), 127.0 (CH), 67.2 (CH₂), 36.8 (CH₂), 35.4 (CH), 35.3 (CH₂), 16.6 (CH₃); HRMS (ES⁺) cald. for (M+H)⁺ C₁₁H₁₇OS: 197.0995, found: 197.0993.

(3-(Benzylthio)propyl)trimethylsilane (3f)



Prepared following the general procedure using allyltrimethylsilane (159 µl, 1.0 mmol) and benzyl mercaptan (470 µl, 4.0 mmol). The reaction mixture was purified by flash chromatography using 10% DCM in hexane to afford **3f** as a colourless oil (Yield = 97%). ¹H NMR (400 MHz, CDCl₃): δ 7.32–7.31 (m, 4H), 7.27–7.21 (m, 1H), 3.71 (s, 2H), 2.43 (t, *J* = 7.4 Hz, 2H), 1.57–1.49 (m, 2H), 0.56–0.52 (m, 2H), 0.03 (s, 9H); ¹³C NMR (100 MHz, CDCl₃): δ 138.7 (C), 128.8 (CH), 128.4 (CH), 126.8 (CH), 36.2 (CH₂), 35.1 (CH₂), 24.0 (CH₂), 16.4 (CH₂), 1.75 (CH₃); HRMS (ES⁺) cald. for (M+H)⁺ C₁₃H₂₃OSSi: 255.1233, found: 255.1233.

3-(Benzylthio)propanenitrile (3g)²



Prepared following the general procedure using acrylonitrile (66 µl, 1.0 mmol) and benzyl mercaptan (470 µl, 4.0 mmol). The reaction mixture was purified by flash chromatography using 20% EtOAc in hexane to afford **3g** as a colourless oil (Yield = 43%). ¹H NMR (400 MHz, CDCl₃): δ 7.29–7.23 (m, 4H), 7.22–7.18 (m, 1H), 3.72 (s, 2H), 2.57 (t, *J* = 7.2 Hz, 2H), 2.41 (t, *J* = 7.2 Hz, 2H); ¹³C NMR (100 MHz, CDCl₃): δ 137.2 (C), 128.8 (CH), 128.7 (CH), 127.4 (CH), 118.3 (CN), 36.2 (CH₂), 26.5 (CH₂), 18.5 (CH₂).

2-(Benzylthio)ethyl acetate (3h)³



Prepared following the general procedure using vinyl acetate (92 µl, 1.0 mmol) and benzyl mercaptan (470 µl, 4.0 mmol). The reaction mixture was purified by flash chromatography using 10% EtOAc in hexane to afford **3h** as a pale yellow oil (Yield = 80%). ¹H NMR (400 MHz, CDCl₃): δ 7.35–7.33 (m, 4H), 7.30–7.24 (m, 1H), 4.19 (t, *J* = 6.9 Hz, 2H), 3.77 (s, 2H), 2.65 (t, *J* = 6.9 Hz, 2H), 2.07 (s, 3H); ¹³C NMR (100 MHz, CDCl₃): δ 170.6 (CO), 137.8 (C), 128.8 (CH), 128.4 (CH), 127.0 (CH), 63.0 (CH₂), 36.1 (CH₂), 29.4 (CH₂), 20.8 (CH₃).

Benzyl(phenylethyl)sulfane (3i)⁴



Prepared following the general procedure using styrene (115 μ l, 1.0 mmol) and benzyl mercaptan (470 μ l, 4.0 mmol). The reaction mixture was purified by flash chromatography using 20% DCM in hexane to afford **3i** as a colourless oil (Yield = 98%). ¹H NMR (400 MHz, CDCl₃): δ 7.38–7.37 (m, 4H), 7.35–7.25 (m, 4H), 7.22–7.20 (m, 2H), 3.78 (s, 2H), 2.92–2.88 (m, 2H), 2.74–2.70 (m, 2H); ¹³C NMR (100 MHz, CDCl₃): δ 140.5 (C), 138.3 (C), 128.8 (CH), 128.4 (CH), 128.4 (CH), 126.9 (CH), 126.3 (CH), 36.4 (CH₂), 36.0 (CH₂), 32.7 (CH₂).

Benzyl(4-methylphenylethyl)sulfane (3j)



Prepared following the general procedure using 4-methylstyrene (132 µl, 1.0 mmol) and benzyl mercaptan (470 µl, 4.0 mmol). The reaction mixture was purified by flash chromatography using 10% DCM in hexane to afford **3j** as a colourless oil (Yield = 98%). ¹H NMR (400 MHz, CDCl₃): δ 7.37–7.36 (m, 4H), 7.33–7.27 (m, 1H), 7.15 (d, *J* = 8.0 Hz, 2H), 7.10 (d, *J* = 8.0 Hz, 2H), 3.77 (s, 2H), 2.88–2.84 (m, 2H), 2.72–2.68 (m, 2H), 2.37 (s, 3H); ¹³C NMR (100 MHz, CDCl₃): δ 138.4 (C), 137.4 (C), 135.8 (C), 129.1 (CH), 128.8 (CH), 128.4 (CH), 128.3 (CH), 126.9 (CH), 36.4 (CH₂), 35.5 (CH₂), 32.9 (CH₂), 21.0 (CH₃); HRMS (ES⁺) cald. for (M+Na)⁺ C₁₆H₁₉NaS: 265.1027, found: 265.1030.

Benzyl(4-chlorophenylethyl)sulfane (3k)



Prepared following the general procedure using 4-chlorostyrene (120 µl, 1.0 mmol) and benzyl mercaptan (470 µl, 4.0 mmol). The reaction mixture was purified by flash chromatography using 10% DCM in hexane to afford **3k** as a colourless oil (Yield = 95%). ¹H NMR (400 MHz, CDCl₃): δ 7.41–7.35 (m, 4H), 7.33–7.29 (m, 1H), 7.30 (d, *J* = 8.4 Hz, 2H), 7.12 (d, *J* = 8.4 Hz, 2H), 3.77 (s, 2H), 2.86–2.85 (m, 2H), 2.71–2.67 (m, 2H); ¹³C NMR (100 MHz, CDCl₃): δ 138.8 (C), 138.2 (C), 132.0 (C), 129.8 (CH), 128.8 (CH), 128.4 (CH), 127.0 (CH), 36.4 (CH₂), 35.1 (CH₂), 32.5 (CH₂); HRMS (ES⁺) cald. for (M+K)⁺ C₁₅H₁₆SCIK: 301.0220, found: 301.0439.

Catalytic thiol-ene reaction:

$$R^{1}_{SH} + OAc \xrightarrow{\text{TiO}_{2} (0.1 \text{ eq})}{\frac{\text{MeCN}}{20W \text{ light, rt}}} R^{1}_{S} OAc$$

General procedure: A reaction vial (10 mL) was charged with alkene (1.0 mmol), thiol (4.0 mmol), titanium dioxide (8.0 mg, 0.1 mmol) and MeCN (1 mL). The vial was sealed and placed 10-15 cm away from 20W light bulb, and the mixture was stirred at room temperature for 16 to 40 hours. The resulting mixture was diluted with DCM, filtered through a pad of celite and concentrated under reduced pressure (reactions without base-sensitive substrates were first extracted with 10% NaOH (aq) to remove unreacted thiol). The crude material was purified by column chromatography (SiO₂, using the noted solvent mixture) to yield the desired thiol-ene product.

2-(Benzylthio)ethyl acetate (3h)³



Prepared following the general procedure using vinyl acetate (92 μ l, 1.0 mmol) and benzyl mercaptan (470 μ l, 4.0 mmol). The reaction mixture was purified by flash chromatography using 10% EtOAc in hexane to afford **3h** as a pale yellow oil (Yield = 60%). See above for spectroscopic data.

2-(Octylthio)ethyl acetate (31)



Prepared following the general procedure using vinyl acetate (92 µl, 1.0 mmol) and 1-octanethiol (690 µl, 4.0 mmol) for 40 hours. The reaction mixture was purified by flash chromatography using 5% EtOAc in hexane to afford **3l** as a pale yellow oil (Yield = 86%). ¹H NMR (400 MHz, CDCl₃): δ 4.21 (t, *J* = 7.0 Hz, 2H), 2.73 (t, *J* = 7.0 Hz, 2H), 2.55 (t, *J* = 7.4 Hz, 2H), 2.07 (s, 3H), 1.58 (quint, *J* = 7.4 Hz, 2H), 1.40–1.33 (m, 2H), 1.31–1.23 (m, 8H), 0.88 (t, *J* = 7.0 Hz, 3H); ¹³C NMR (100 MHz, CDCl₃): δ 170.8 (CO), 63.6 (CH₂), 32.3 (CH₂), 31.8 (CH₂), 30.4 (CH₂), 29.7 (CH₂), 29.2 (2 peaks) (CH₂), 28.8 (CH₂), 22.6 (CH₂), 20.9 (CH₃), 14.1 (CH₃); HRMS (EI⁺) cald. for (M)⁺ C₁₂H₂₄O₂S: 232.1492, found: 232.1489.

2-((6-Hydroxyhexyl)thio)ethyl acetate (3m)

HO

Prepared following the general procedure using vinyl acetate (92 µl, 1.0 mmol) and 1-octanethiol (545 µl, 4.0 mmol) for 40 hours. The reaction mixture was purified by flash chromatography using 40% EtOAc in hexane to afford **3m** as a pale yellow oil (Yield = 79%). ¹H NMR (400 MHz, CDCl₃): δ 4.21 (t, *J* = 7.0 Hz, 2H), 3.64 (t, *J* = 6.5 Hz, 2H), 2.73 (t, *J* = 7.0 Hz, 2H), 2.56 (t, *J* = 7.4 Hz, 2H), 2.07 (s, 3H), 1.64–1.54 (m, 4H), 1.46–1.35 (m, 4H); ¹³C NMR (100 MHz, CDCl₃): δ 170.9 (CO), 63.5 (CH₂), 62.9 (CH₂), 32.6 (CH₂), 32.2 (CH₂), 30.4 (CH₂), 29.5 (CH₂), 28.5 (CH₂), 25.3 (CH₂), 20.9 (CH₃); HRMS (ES⁺) cald. for (M+Na)⁺ C₁₀H₂₀O₃NaS: 243.1031, found: 243.1023.

Methyl 3-((2-acetoxyethyl)thio)propanoate (3n)

Prepared following the general procedure using vinyl acetate (92 µl, 1.0 mmol) and methyl 3mercaptopropionate (445 µl, 4.0 mmol) for 40 hours. The reaction mixture was purified by flash chromatography using 20% EtOAc in hexane to afford **3n** as a straw-coloured oil (Yield = 87%). ¹H NMR (400 MHz, CDCl₃): δ 4.22 (t, *J* = 6.8 Hz, 2H), 3.70 (s, 3H), 2.84 (t, *J* = 7.3 Hz, 2H), 2.76 (t, *J* = 6.8 Hz, 2H), 2.63 (t, *J* = 7.3 Hz, 2H), 2.07 (s, 3H); ¹³C NMR (100 MHz, CDCl₃): δ 172.2 (CO), 170.8 (CO), 63.4 (CH₂), 51.8 (CH₃), 34.6 (CH₂), 30.6 (CH₂), 27.2 (CH₂), 20.9 (CH₃); HRMS (ES⁺) cald. for (M+Na)⁺ C₈H₁₄O₄NaS: 229.0511, found: 229.0507.

2-(Phenylthio)ethyl acetate (30)



Prepared following the general procedure using vinyl acetate (92 µl, 1.0 mmol) and thiophenol (410 µl, 4.0 mmol) for 16 hours. The reaction mixture was purified by flash chromatography using 50% CH₂Cl₂ in hexane to afford **30** as a yellow oil (Yield = 61%). ¹H NMR (400 MHz, CDCl₃): δ 7.40 (app d, *J* = 7.5 Hz, 2H), 7.30 (app t, *J* = 7.5 Hz, 2H), 7.21 (app t, *J* = 7.5 Hz, 1H), 4.23 (t, *J* = 7.0 Hz, 2H), 3.14 (t, *J* = 7.0 Hz, 2H), 2.02 (s, 3H); ¹³C NMR (100 MHz, CDCl₃): δ 170.8 (CO), 135.0 (C), 129.9 (CH), 129.0 (CH), 126.6 (CH), 62.9 (CH₂), 32.3 (CH₂), 20.8 (CH₃); HRMS (EI⁺) cald. for (M)⁺ C₁₀H₁₂O₂S: 196.0553, found: 196.0556.

2-(Cyclohexylthio)ethyl acetate (3p)



Prepared following the general procedure using vinyl acetate (92 µl, 1.0 mmol) and cyclohexanethiol (490 µl, 4.0 mmol) for 40 hours. The reaction mixture was purified by flash chromatography using 30–50% CH₂Cl₂ in hexane to afford **3p** as a pale yellow oil (Yield = 30%). ¹H NMR (400 MHz, CDCl₃): δ 4.19 (t, *J* = 7.1 Hz, 2H), 2.75 (t, *J* = 7.1 Hz, 2H), 2.71–2.66 (m, 1H), 2.06 (s, 3H), 1.99–1.93 (m, 2H), 1.80–1.74 (m, 2H), 1.63–1.59 (m, 1H), 1.35–1.21 (m, 5H); ¹³C NMR (100 MHz, CDCl₃): δ 170.8 (CO), 64.0 (CH₂), 43.7 (CH), 33.7 (CH₂), 28.4 (CH₂), 26.1 (CH₂), 25.7 (CH₂), 20.9 (CH₃); HRMS (EI⁺) cald. for (M)⁺ C₁₀H₁₈O₂S: 202.1022, found: 202.1018.

Dithiol-ene reaction:



General procedure: A reaction vial (10 mL) was charged with dithiol (1.0 mmol), alkene (4.0 mmol), titanium dioxide (79.9 mg, 1.0 mmol or 8.0 mg, 0.1 mmol) and MeCN (1 mL). The vial was sealed and placed 10-15 cm away from 20W light bulb, and the mixture was stirred at room temperature for 16 hours. The resulting mixture was diluted with DCM, filtered through a pad of celite and concentrated under reduced pressure (reactions without base-sensitive substrates were first extracted with 10% NaOH (aq) to remove unreacted thiol). The crude material was purified by column chromatography (SiO₂, using the noted solvent mixture) to yield the desired dithiol-ene product.

1,2-bis(phenethylthio)ethane (3q)



Prepared following the general procedure using 1,2-ethanedithiol (84 μ l, 1.0 mmol), styrene (460 μ l, 4.0 mmol) and titanium dioxide (8.0 mg, 0.1 mmol). The reaction mixture was purified by flash chromatography using 20% DCM in hexane to afford **3q** as a white solid (Yield = 68%). ¹H NMR (500 MHz, CDCl₃): δ 7.31

(app t, J = 7.3 Hz, 4H), 7.24–7.20 (m, 6H), 2.91–2.88 (m, 4H), 2.82–2.79 (m, 4H), 2.72 (s, 4H); ¹³C NMR (100 MHz, CDCl₃): δ 140.3 (C), 128.49 (CH), 128.46 (CH), 126.4 (CH), 36.3 (CH₂), 33.8 (CH₂), 32.3 (CH₂); HRMS (EI⁺) cald. for (M)⁺ C₁₈H₂₂S₂: 302.1157, found: 302.1161.

1,2-bis((4-methylphenethyl)thio)ethane (3r)



Prepared following the general procedure using 1,2-ethanedithiol (84 µl, 1.0 mmol), 4-methylstyrene (530 µl, 4.0 mmol) and titanium dioxide (8.0 mg, 0.10 mmol). The reaction mixture was purified by flash chromatography using 30% CH₂Cl₂ in hexane to afford **3r** as a white solid (Yield = 73%). ¹H NMR (400 MHz, CDCl₃): δ 7.16–7.06 (m, 8H), 2.88–2.84 (m, 4H), 2.80–2.76 (m, 4H), 2.73 (s, 4H), 2.33 (s, 6H); ¹³C NMR (100 MHz, CDCl₃): δ 137.2 (C), 135.9 (C) 129.2 (CH), 128.3 (CH), 35.8 (CH₂), 33.9 (CH₂), 32.2 (CH₂), 21.0 (CH₃); HRMS (EI⁺) cald. for (M)⁺ C₂₀H₂₆S₂: 330.1470, found: 330.1461.

1,3-bis((4-methylphenethyl)thio)propane (3s)



Prepared following the general procedure using 1,3-propanedithiol (100 µl, 1.0 mmol), 4-methylstyrene (530 µl, 4.0 mmol) and titanium dioxide (8.0 mg, 0.10 mmol). The reaction mixture was purified by flash chromatography using 25% CH₂Cl₂ in hexane to afford **3s** as a pale yellow oil (Yield = 70%). ¹H NMR (400 MHz, CDCl₃): δ 7.12–7.08 (m, 8H), 2.86–2.83 (m, 4H), 2.77–2.73 (m, 4H), 2.63 (t, *J* = 7.2 Hz, 4H), 2.32 (s, 6H), 1.87 (quint, *J* = 7.2 Hz, 2H); ¹³C NMR (100 MHz, CDCl₃): δ 137.6 (C), 136.0 (C) 129.3 (CH), 128.5 (CH), 36.0 (CH₂), 34.0 (CH₂), 31.2 (CH₂), 29.5 (CH₂), 21.2 (CH₃); HRMS (EI⁺) cald. for (M)⁺ C₂₁H₂₈S₂: 344.1627, found: 344.1622.

1,2-bis((4-methoxyphenethyl)thio)ethane (3t)



Prepared following the general procedure using 1,2-ethanedithiol (84 µl, 1.0 mmol), 4-methoxystyrene (540 µl, 4.0 mmol) and titanium dioxide (79.9 mg, 1.0 mmol). The reaction mixture was purified by flash chromatography using 5% Et₂O in hexane to afford **3t** as a white solid (Yield = 57%). ¹H NMR (400 MHz, CDCl₃): δ 7.10 (d, *J* = 8.6 Hz, 4H), 6.82 (d, *J* = 8.6 Hz, 4H), 3.77 (s, 6H), 2.83–2.79 (m, 4H), 2.76–2.72 (m, 4H), 2.69 (s, 4H); ¹³C NMR (100 MHz, CDCl₃): δ 158.4 (C), 132. 6 (C) 129.6 (CH), 114.1 (CH), 55.5 (CH₃), 35.6 (CH₂), 34.3 (CH₂), 32.5 (CH₂); HRMS (APCI⁺) cald. for (M+H)⁺ C₂₀H₂₇O₂S₂: 363.1453, found: 363.1455.

II. References

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III. NMR Spectra of Isolated Compounds







