Supplementary Information

Copper-Catalyzed Oxidative Alkenylation of Thioethers via Csp$^3$-H Functionalization

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**General Information**

All reactions were isolated from oxygen by a nitrogen atmosphere in a Schlenk tube or sealed tube. All glassware was fully dried at 110 °C in oven for hours and cooled down under vacuum. Tetrahydrothiophene and CuI were purchased from Aladdin Chemical Reagent Co., Ltd. Dimethyl sulfide was purchased from Alfa Aesar. KI and DTBP (Di-tert-butyl peroxide, Chemical Purity) was purchased from Sinopharm Chemical Reagent Co., Ltd. Substituted 1,1-diphenylethene derivatives were all prepared following literature reports (T. Wang, Y. Hu and S. Zhang, *Org. Biomol. Chem.*, 2010, 8, 2312.). Unless otherwise noted, other materials were obtained from commercial suppliers and used without further purification. Thin layer chromatography (TLC) employed glass 0.25 mm silica gel plates. Chromatography columns were packed with 200-300 mesh silica gel in petroleum ether (bp. 60-90 °C). Gas chromatographic analyses were performed on Varian GC 2000 gas chromatography instrument with a FID detector and biphenyl was added as an internal standard. GC-MS spectra were recorded on a Varian GC-MS 3900-2100T. ¹H and ¹³C NMR data were recorded with Bruker ADVANCE III (400 MHz) spectrometers with tetramethylsilane as an internal standard. High resolution mass spectra (HRMS) were measured with a Waters Micromass GCT instrument with ionisation mode of EI⁺, accurate masses are reported for the molecular ion ([M]+). All chemical shifts (δ) are reported in ppm and coupling constants (J) in Hz. All chemical shifts are reported relative to tetramethylsilane and d-solvent peaks (77.3 ppm, chloroform), respectively.
General Procedure

1. **General procedure of copper-catalyzed oxidative alkenylation of tetrahydrothiophene**

CuI (11.4 mg, 0.06 mmol) and KI (10.0 mg, 0.06 mmol) were added in a Schlenk tube. The tube was then filled with N$_2$. Under the protection of N$_2$, tetrahydrothiophene (0.8 mL) was injected into the tube via a syringe. After stirring for several minutes, t-BuOOt-Bu (175.2 mg, 1.2 mmol) was injected into the reaction tube by a microsyringe followed by the addition of alkene (0.3 mmol). The reaction was then heated up to 120 °C (Warning: Heating thioethers such as tetrahydrothiophene with peroxide to 120 °C is of potential danger, please do this reaction in highly qualified sealed tube and put the heater in fume hood!) and kept stirring for 24 hours. After completion of the reaction, the mixture was quenched with diluted hydrochloric acid (2 M). The solution was extracted with ethyl acetate (3 × 5 mL). The organic layers were combined and dried over sodium sulfate. The pure product was obtained by flash column chromatography on silica gel (with petroleum ether : ethyl acetate from 100 : 1 to 20 : 1).

2. **General procedure of copper-catalyzed oxidative alkenylation of dimethyl sulfide**

CuI (11.4 mg, 0.06 mmol) and KI (10.0 mg, 0.06 mmol) were added in a sealed tube. The tube was then filled with N$_2$. Under the protection of N$_2$, dimethyl sulfide (0.8 mL) was injected into the tube via a syringe. After stirring for several minutes, t-BuOOt-Bu (175.2 mg, 1.2 mmol) was injected into the reaction tube by a microsyringe followed by the addition of alkene (0.3 mmol). The reaction was then heated up to 140 °C (Warning: Heating thioethers such as dimethyl sulfide with peroxide to 140 °C is of potential danger, please do this reaction in highly qualified sealed tube and put the heater in fume hood!) and kept stirring for 24 hours. After completion of the reaction, the mixture was quenched with diluted hydrochloric acid (2 M). The solution was extracted with ethyl acetate (3 × 5 mL). The organic layers were combined and dried over sodium sulfate. The pure product was obtained by flash column chromatography on silica gel (with petroleum ether : ethyl acetate from 100 : 1 to 20 : 1).
**Radical-Trapping Experiment**

CuI (11.4 mg, 0.06 mmol) and KI (10.0 mg, 0.06 mmol) were added in a Schlenk tube. The tube was then filled with N₂. Under the protection of N₂, tetrahydrothiophene (0.8 mL) was injected into the tube via a syringe. After stirring for several minutes, t-BuOOt-Bu (175.2 mg, 1.2 mmol) was injected into the reaction tube by a microsyringe followed by the addition of 1,1-diphenylethylene (54.1 mg, 0.3 mmol). Finally, TEMPO (1 equiv, 0.3 mmol) was added. The reaction was then heated up to 120 °C (Warning: Heating thioethers such as tetrahydrothiophene with peroxide to 120 °C is of potential danger, please do this reaction in highly qualified sealed tube and put the heater in fume hood!) and kept stirring for 24 hours. After completion of the reaction, the mixture was quenched with diluted hydrochloric acid (2 M). The whole reaction system was monitored by GC/MS analysis. The result revealed that only 1,1-diphenylethylene largely remained, and no desired cross-coupling product was detected. Meanwhile, no radical-trapping product was observed.
**Detailed Descriptions for Products**

![Image of 2-(2,2-Diphenylvinyl)tetrahydrothiophene (3a)]

**2-(2,2-Diphenylvinyl)tetrahydrothiophene (3a):** Isolated yield = 91%. Colorless oil. $^1$H NMR (400 MHz, CDCl$_3$) δ 7.41 – 7.35 (m, 2H), 7.34 – 7.29 (m, 1H), 7.28 – 7.17 (m, 7H), 6.04 (d, $J = 10.3$ Hz, 1H), 4.01 (ddd, $J = 10.3$, 8.2, 5.8 Hz, 1H), 3.06 – 2.96 (m, 1H), 2.91 – 2.82 (m, 1H), 2.24 – 2.09 (m, 2H), 1.90 – 1.69 (m, 2H). $^{13}$C NMR (101 MHz, CDCl$_3$) δ 142.2, 141.9, 141.8, 139.7, 130.9, 130.2, 128.5, 128.4, 127.7, 127.5, 48.0, 38.9, 33.7, 31.5. HRMS (EI$^+$) calcd for C$_{18}$H$_{18}$S [M$^+$]: 266.1129; found: 266.1132.

![Image of (E, Z)-2-(2-Phenyl-2-(p-tolyl)vinyl)tetrahydrothiophene (3b)]

**{(E, Z)}-2-(2-Phenyl-2-(p-tolyl)vinyl)tetrahydrothiophene (3b):** Isolated yield = 81%. Colorless oil. E/Z isomers. E : Z = 1 : 1. $^1$H NMR (400 MHz, CDCl$_3$) δ 7.39 – 7.32 (m, 1H), 7.24 – 7.17 (m, 4H), 7.14 – 7.03 (m, 4H), 6.01 (d, $J = 10.3$ Hz, 0.5H), 6.01 (d, $J = 10.3$ Hz, 0.5H), 4.07 – 3.95 (m, 1H), 3.07 – 2.93 (m, 1H), 2.92 – 2.79 (m, 1H), 2.37 (s, 1.5H), 2.31 (s, 1.5H), 2.24 – 2.08 (m, 2H), 1.89 – 1.68 (m, 2H). $^{13}$C NMR (101 MHz, CDCl$_3$) δ 142.5, 141.9, 141.8, 139.9, 139.4, 137.3, 137.2, 136.7, 130.7, 130.2, 130.1, 130.0, 129.2, 129.0, 128.4, 128.3, 127.8, 127.6, 127.4, 48.1, 39.0, 38.9, 33.6, 31.5, 21.5, 21.3. HRMS (EI$^+$) calcd for C$_{19}$H$_{20}$S [M$^+$]: 280.1286; found: 280.1289.
2-(2,2-Di-p-tolyvinyl)tetrahydrothiophene (3c): Isolated yield = 55%. White solid. $^1$H NMR (400 MHz, CDCl$_3$) δ 7.18 (d, $J = 7.8$ Hz, 2H), 7.14 – 7.02 (m, 6H), 5.97 (d, $J = 10.3$ Hz, 1H), 4.02 (ddd, $J = 10.2$, 8.3, 5.8 Hz, 1H), 3.06 – 2.94 (m, 1H), 2.90 – 2.80 (m, 1H), 2.37 (s, 3H), 2.31 (s, 3H), 2.23 – 2.08 (m, 2H), 1.89 – 1.67 (m, 2H). $^{13}$C NMR (101 MHz, CDCl$_3$) δ 141.8, 139.6, 137.2, 137.1, 136.9, 130.1, 129.8, 129.1, 129.0, 127.6, 48.1, 39.0, 33.6, 31.5, 21.5, 21.3. HRMS (EI$^+$) calcd for C$_{20}$H$_{22}$S [M]$^+$: 294.1442; found: 294.1438.

2-(2,2-Bis(4-methoxyphenyl)vinyl)tetrahydrothiophene (3d): Isolated yield = 76%. White solid. $^1$H NMR (400 MHz, CDCl$_3$) δ 7.04 (dd, $J = 13.5$, 8.7 Hz, 4H), 6.82 (d, $J = 8.6$ Hz, 2H), 6.70 (d, $J = 8.8$ Hz, 2H), 5.82 (d, $J = 10.2$ Hz, 1H), 3.94 (ddd, $J = 10.0$, 8.5, 5.8 Hz, 1H), 3.73 (s, 3H), 3.68 (s, 3H), 2.92 (td, $J = 9.5$, 6.1 Hz, 1H), 2.81 – 2.72 (m, 1H), 2.15 – 1.98 (m, 2H), 1.80 – 1.58 (m, 2H). $^{13}$C NMR (101 MHz, CDCl$_3$) δ 159.1, 158.9, 141.0, 135.2, 132.1, 131.2, 128.9, 128.8, 113.7, 113.6, 55.4(3), 55.4(0), 48.2, 39.0, 33.6, 31.4. HRMS (EI$^+$) calcd for C$_{20}$H$_{22}$O$_2$S [M]$^+$: 326.1341; found: 326.1345.
(E, Z)-2-(2-Phenyl-2-(4-(trifluoromethyl)phenyl)vinyl)tetrahydrothiophene (3e): Isolated yield = 86%. Colorless oil. E/Z isomers. E : Z = 1.26 : 1. \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.65 (d, \(J = 8.1\) Hz, 1H), 7.50 (d, \(J = 8.3\) Hz, 1H), 7.43 – 7.35 (m, 1H), 7.35 – 7.29 (m, 2H), 7.29 – 7.23 (m, 2H), 7.21 – 7.14 (m, 2H), 6.11 (d, \(J = 10.4\) Hz, 0.6H), 6.11 (d, \(J = 10.4\) Hz, 0.4H), 3.91 (dd, \(J = 10.4, 8.2, 5.9\) Hz, 0.6H), 3.07 – 2.97 (m, 1H), 2.26 – 2.10 (m, 2H), 1.92 – 1.71 (m, 2H). \(^{13}\)C NMR (101 MHz, CDCl\(_3\)) \(\delta\) 145.7, 143.5, 141.4, 140.7 (d, \(J = 5.9\) Hz), 138.9, 133.0, 131.8, 130.6, 130.1, 129.4 (q, \(J = 98.0, 65.7, 32.4\) Hz), 128.7, 128.5, 128.0, 127.9 (d, \(J = 3.3\) Hz), 127.7, 125.5 (q, \(J = 11.4, 7.6, 3.8\) Hz), 125.3 (q, \(J = 11.4, 7.6, 3.8\) Hz), 47.8 (d, \(J = 2.6\) Hz), 38.8 (d, \(J = 6.2\) Hz), 33.7, 31.5 (d, \(J = 3.6\) Hz). \(^{19}\)F NMR (377 MHz, CDCl\(_3\)) \(\delta\) -62.38, -62.41. HRMS (EI\(^+\)) calcd for C\(_{19}\)H\(_{17}\)F\(_3\)S [M\(^+\)]: 334.1003; found: 334.0998.

(E, Z)-2-(2-(4-Fluorophenyl)-2-phenylvinyl)tetrahydrothiophene (3f): Isolated yield = 77%. Colorless oil. E/Z isomers. E : Z = 1 : 1. \(^1\)H NMR (400 MHz, CDCl\(_3\)) \(\delta\) 7.41 – 7.22 (m, 3H), 7.22 – 7.13 (m, 4H), 7.11 – 7.04 (m, 1H), 6.98 – 6.90 (m, 1H), 6.04 (d, \(J = 10.3\) Hz, 0.5H), 5.98 (d, \(J = 10.3\) Hz, 0.5H), 3.98 (ddd, \(J = 15.6, 10.2, 7.8\) Hz, 1H), 3.08 – 2.96 (m, 1H), 2.93 – 2.81 (m, 1H), 2.25 – 2.09 (m, 2H), 1.92 – 1.70 (m, 2H). \(^{13}\)C NMR (101 MHz, CDCl\(_3\)) \(\delta\) 142.1, 140.9, 139.5, 131.8 (d, \(J = 7.9\) Hz), 131.2, 130.7,
130.1, 129.3 (d, J = 8.0 Hz), 128.5 (d, J = 17.3 Hz), 127.7 (d, J = 2.1 Hz), 115.5 (d, J = 21.3 Hz), 115.2 (d, J = 21.4 Hz), 48.0 (d, J = 3.0 Hz), 38.9 (d, J = 2.8 Hz), 33.7, 31.5. $^1$H NMR (377 MHz, CDCl$_3$) δ -114.83, -115.30. HRMS (EI$^+$) calcd for C$_{18}$H$_{17}$FS [M$^+$]: 284.1035; found: 284.1034.

2-(2,2-Bis(4-fluorophenyl)vinyl)tetrahydrothiophene (3g): Isolated yield = 66%. Colorless oil. $^1$H NMR (400 MHz, CDCl$_3$) δ 7.19 – 7.11 (m, 4H), 7.11 – 7.04 (m, 2H), 6.98 – 6.90 (m, 2H), 5.98 (d, J = 10.3 Hz, 1H), 3.96 (ddd, J = 10.2, 8.3, 5.9 Hz, 1H), 3.05 – 2.97 (m, 1H), 2.91 – 2.83 (m, 1H), 2.25 – 2.10 (m, 2H), 1.92 – 1.68 (m, 2H). $^{13}$C NMR (101 MHz, CDCl$_3$) δ 163.6 (d, J = 14.3 Hz), 161.2 (d, J = 14.1 Hz), 139.8, 138.2 (d, J = 3.2 Hz), 135.3 (d, J = 3.4 Hz), 131.7 (d, J = 8.0 Hz), 131.0, 129.2 (d, J = 8.0 Hz), 115.6 (d, J = 21.4 Hz), 115.2 (d, J = 21.4 Hz), 47.8, 38.8, 33.6, 31.5. $^{19}$F NMR (377 MHz, CDCl$_3$) δ -114.45, -114.95. HRMS (EI$^+$) calcd for C$_{18}$H$_{16}$F$_2$S [M$^+$]: 302.0941; found: 302.0940.

2-(2,2-Bis(4-fluorophenyl)vinyl)tetrahydrothiophene (3g): Isolated yield = 66%. Colorless oil. $^1$H NMR (400 MHz, CDCl$_3$) δ 7.19 – 7.11 (m, 4H), 7.11 – 7.04 (m, 2H), 6.98 – 6.90 (m, 2H), 5.98 (d, J = 10.3 Hz, 1H), 3.96 (ddd, J = 10.2, 8.3, 5.9 Hz, 1H), 3.05 – 2.97 (m, 1H), 2.91 – 2.83 (m, 1H), 2.25 – 2.10 (m, 2H), 1.92 – 1.68 (m, 2H). $^{13}$C NMR (101 MHz, CDCl$_3$) δ 163.6 (d, J = 14.3 Hz), 161.2 (d, J = 14.1 Hz), 139.8, 138.2 (d, J = 3.2 Hz), 135.3 (d, J = 3.4 Hz), 131.7 (d, J = 8.0 Hz), 131.0, 129.2 (d, J = 8.0 Hz), 115.6 (d, J = 21.4 Hz), 115.2 (d, J = 21.4 Hz), 47.8, 38.8, 33.6, 31.5. $^{19}$F NMR (377 MHz, CDCl$_3$) δ -114.45, -114.95. HRMS (EI$^+$) calcd for C$_{18}$H$_{16}$F$_2$S [M$^+$]: 302.0941; found: 302.0940.

(E, Z)-2-(2-(4-Chlorophenyl)-2-phenylvinyl)tetrahydrothiophene (3h): Isolated yield = 69%.

Colorless oil. E/Z isomers. E : Z = 1 : 1. $^1$H NMR (400 MHz, CDCl$_3$) δ 7.41 – 7.32 (m, 2H), 7.30 – 7.10 (m, 7H), 6.05(d, J=10.8 Hz, 0.5H), 6.02(d, J=10.8 Hz, 0.5H), 4.04 – 3.90 (m, 1H), 3.07 – 2.94 (m, 1H), 2.87 (m, 1H), 2.26 – 2.08 (m, 2H), 1.93 – 1.67 (m, 2H). $^{13}$C NMR (101 MHz, CDCl$_3$) δ 141.8, 140.8 (d, J
= 1.8 Hz), 139.2, 138.1, 133.5, 133.3, 131.6, 131.4, 131.3, 130.1, 129.0, 128.8, 128.6, 128.5, 128.4, 127.71 (d, J = 1.7 Hz), 127.6(7), 47.9, 38.9, 38.8, 33.7, 31.5. HRMS (EI⁺) calcd for C₁₈H₁₇ClS [M⁺]: 300.0739; found: 300.0735.

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\text{\textsuperscript{1}H NMR (400 MHz, CDCl}_3\text{) } & \delta 7.51 (d, J = 8.3 Hz, 1H), 7.41 – 7.34 (m, 2H), 7.34 – 7.22 (m, 2H), 7.21 – 7.14 (m, 2H), 7.07 (d, J = 8.5 Hz, 2H), 6.05(d, J=9.6 Hz, 0.5H), 6.02(d, J=9.6 Hz, 0.5H), 4.04 – 3.89 (m, 1H), 3.01 (td, J = 9.5, 6.1 Hz, 1H), 2.87 (qd, J = 7.0, 3.7 Hz, 1H), 2.26 – 2.08 (m, 2H), 1.93 – 1.66 (m, 2H). 
\text{\textsuperscript{13}C NMR (101 MHz, CDCl}_3\text{) } & \delta 141.6, 141.2, 140.8, 140.7, 139.0, 138.5, 131.9, 131.7, 131.4, 131.3(5), 131.2(8), 130.1, 129.3, 128.6, 128.4, 127.7(1), 127.7(0), 127.6(5), 121.6, 121.5, 47.8, 38.8(4), 38.8(0), 33.7, 31.5. HRMS (EI⁺) calcd for C₁₈H₁₇BrS[M⁺]: 344.0234; found: 344.0230.
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\(2-(2,2-\text{Di(naphthalen-2-yl)}\text{vinyl})\text{tetrahydrothiophene (3j):}\) Isolated yield = 91%. White solid. 

\[\begin{align*}
\text{\textsuperscript{1}H NMR (400 MHz, CDCl}_3\text{) } & \delta 7.90 – 7.84 (m, 3H), 7.80 – 7.72 (m, 3H), 7.70 – 7.65 (m, 1H), 7.57 (s, 1H), 7.54 – 7.47 (m, 3H), 7.44 – 7.37 (m, 2H), 7.32 (dd, J = 8.4, 1.6 Hz, 1H), 6.28 (d, J = 10.3 Hz, 1H), 4.11 (ddd, J =
10.8, 8.0, 5.8 Hz, 1H), 3.09 – 2.97 (m, 1H), 2.92 – 2.82 (m, 1H), 2.27 – 2.13 (m, 2H), 1.89 – 1.76 (m, 2H).

$^{13}$C NMR (101 MHz, CDCl$_3$) δ 141.8, 139.5, 137.1, 133.5(2), 133.4(9), 132.9(5), 132.9(0), 131.8, 129.2, 128.4(9), 128.4(5), 128.2, 128.0, 127.9, 127.7, 127.2, 126.5, 126.4, 126.3, 126.1, 125.7, 48.2, 39.0, 33.7, 31.5. HRMS (EI$^+$) calcd for C$_{26}$H$_{22}$S [M]$^+$: 366.1442; found: 366.1443.

![Chemical structure](image)

$(E, Z)$-2-(1-Phenyl-2-(tetrahydrothiophen-2-yl)vinyl)thiophene (3k): Isolated yield = 64%. Colorless oil. E/Z isomers. E : Z = 7 : 3. $^1$H NMR (400 MHz, CDCl$_3$) δ 7.42 – 7.33 (m, 2.3H), 7.31 – 7.24 (m, 3H), 7.14 (dd, $J = 5.1$, 1.1 Hz, 0.7H), 7.06 (dd, $J = 5.1$, 3.5 Hz, 0.3H), 7.00 (dd, $J = 3.5$, 1.1 Hz, 0.3H), 6.87 (dd, $J = 5.1$, 3.6 Hz, 0.7H), 6.59 (dd, $J = 3.6$, 1.1 Hz, 0.7H), 6.09 (d, $J = 10.2$ Hz, 0.7H), 6.01 (d, $J = 10.2$ Hz, 0.3H), 4.31 (ddd, $J = 10.2$, 8.0, 5.7 Hz, 0.3H), 3.89 (ddd, $J = 10.2$, 8.2, 5.9 Hz, 0.7H), 3.07 – 2.95 (m, 1H), 2.94 – 2.80 (m, 1H), 2.25 – 2.05 (m, 2H), 1.97 – 1.66 (m, 2H). $^{13}$C NMR (101 MHz, CDCl$_3$) δ 146.6, 142.4, 141.0, 138.7, 135.9, 134.8, 133.4, 129.8, 129.3, 128.5, 128.4, 128.3, 127.9(0), 127.8(6), 127.4, 127.1, 126.3, 126.0, 124.6, 47.8, 47.7, 38.9, 38.7, 33.7, 33.6, 31.5(3), 31.4(6). HRMS (EI$^+$) calcd for C$_{18}$H$_{16}$S$_2$ [M]$^+$: 272.0693; found: 272.0694.

![Chemical structure](image)

(3,3-Diphenylallyl)(methyl)sulfane (3l): Isolated yield = 80%. Colorless oil. $^1$H NMR (400 MHz, CDCl$_3$) δ 7.40 – 7.32 (m, 3H), 7.28 – 7.23 (m, 5H), 7.20 – 7.17 (m, 2H), 6.15 (t, $J = 7.9$ Hz, 1H), 3.21 (d, $J = 7.9$ Hz, 3H).
Hz, 2H), 2.01 (s, 3H). $^{13}$C NMR (101 MHz, CDCl$_3$) δ 144.3, 142.1, 139.4, 130.3, 128.6, 128.4, 127.7, 127.6(5), 127.6(0), 125.2, 33.1, 15.1. HRMS (EI$^+$) calcd for C$_{16}$H$_{16}$S[M]$^+$: 240.0973; found: 240.0977.

(3,3-Bis(4-fluorophenyl)allyl)(methyl)sulfane (3m): Isolated yield = 52%. Colorless oil. $^1$H NMR (400 MHz, CDCl$_3$) δ 7.22 – 7.12 (m, 4H), 7.11 – 7.04 (m, 2H), 7.00 – 6.94 (m, 2H), 6.09 (t, $J$ = 7.9 Hz, 1H), 3.19 (d, $J$ = 7.9 Hz, 2H), 2.02 (s, 3H). $^{13}$C NMR (101 MHz, CDCl$_3$) δ 163.7 (d, $J$ = 20.8 Hz), 161.3 (d, $J$ = 20.6 Hz), 142.3, 138.2 (d, $J$ = 3.1 Hz), 135.1 (d, $J$ = 3.4 Hz), 131.9 (d, $J$ = 8.0 Hz), 129.2 (d, $J$ = 8.0 Hz), 125.3, 115.7 (d, $J$ = 21.3 Hz), 115.4 (d, $J$ = 21.5 Hz), 33.2, 15.2. $^{19}$F NMR (377 MHz, CDCl$_3$) δ -114.33, -114.79. HRMS (EI$^+$) calcd for C$_{16}$H$_{14}$F$_2$S [M]$^+$: 276.0784; found: 276.0786.

(3,3-Bis(4-methoxyphenyl)allyl)(methyl)sulfane (3n): Isolated yield = 51%. Colorless oil. $^1$H NMR (400 MHz, CDCl$_3$) δ 7.21 – 7.16 (m, 2H), 7.14 – 7.08 (m, 2H), 6.94 – 6.88 (m, 2H), 6.84 – 6.78 (m, 2H), 6.01 (t, $J$ = 7.8 Hz, 1H), 3.84 (s, 3H), 3.80 (s, 3H), 3.22 (d, $J$ = 7.9 Hz, 2H), 2.01 (s, 3H). $^{13}$C NMR (101 MHz, CDCl$_3$) δ 159.3, 159.0, 143.4, 135.2, 131.9, 131.5, 128.8, 123.1, 113.9, 113.7, 55.6, 55.5, 33.3, 15.1. HRMS (EI$^+$) calcd for C$_{18}$H$_{20}$O$_2$S[M]$^+$: 300.1184; found: 300.1182.
Copies of product $^1$H NMR and $^{13}$C NMR

3a