Synthesis of 2,6-Diaryl-4*H*-thiopyran-4-ones

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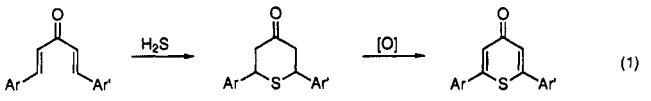
A novel synthesis of 2,6-diaryl-4*H*-thiopyran-4-ones has been developed. The title compounds were prepared by two sequential thio-Claisen condensations of a dialkyl ketone and two dithioesters. The intermediate β-thioxo ketone from the first condensation was converted to the corresponding β-(methylthio) enone for both protection and reactivity purposes. Facile addition–elimination of the methylthio moiety by a β-thioxo ketone enolate generated in the second thio-Claisen condensation afforded the desired heterocycle. This new method is rapid and simple with the only requirement being moderate substituent alkaline stability.

Introduction

2,6-Diaryl-4*H*-thiopyran-4-ones are key building blocks for the synthesis of numerous electron donors,[1] sensitizers,[2] and dyes[3] used for research on organic conductors and photoconductors.

The key intermediate for most syntheses of these materials is the corresponding thiacyclohexanone **1**[4] that is usually prepared by addition of hydrogen sulfide to the corresponding cross-conjugated dienone (eq 1). The

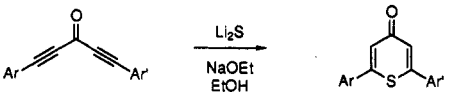


(1)

1 **2**

dehydrogenation conditions used to oxidize the thiacyclohexanone to the 4*H*-thiopyran-4-one are usually harsh and intolerant of substitution.[4a,b,f] A notable exception involves a mild initial oxidation using *N*-chlorosuccinimide in pyridine to afford the corresponding dihydro compound followed by one of several oxidation methods to form the 4*H*-thiopyran-4-one.[4d,e] This method is the most general available, but oxidative stability is still required.

Other mild methods for the preparation of these heterocycles include sulfide dianion addition to cross-conjugated diacetylenic ketones **3** (eq 2).[5] However, these precursors can be difficult to prepare, especially for nonsymmetrically substituted materials (Ar ≠ Ar'), and the desired sulfide addition product is not always predominant. Due to these limitations in known methods for making 4*H*-thiopyran-4-ones, we have developed a new

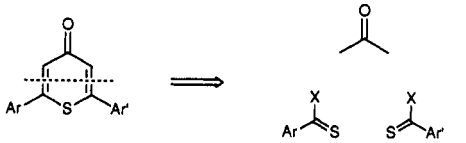


(2)

3 **2**

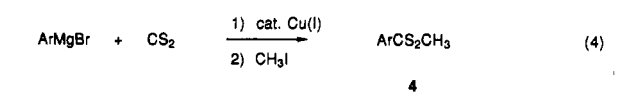
synthesis that is easy to perform, avoids using hydrogen sulfide, tolerates a wide range of substituents, and produces 4*H*-thiopyran-4-ones directly without oxidation.

This new methodology is related to that developed by Koreeda for the preparation of γ-pyrones[6] and is based on disconnection between carbons 2 and 3 and 5 and 6 of the 4*H*-thiopyran-4-one as shown below (eq 3) to the likely components of acetone and two aryl thiocarbonyl compounds.



(3)

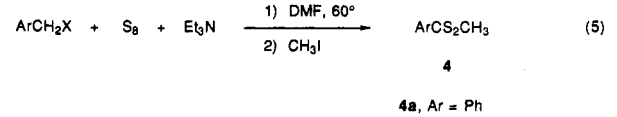
For synthetic ease, dithioesters were chosen as the thiocarbonyl components. These building blocks provide the correct initial carbon oxidation state and present sulfur in the correct position for assembly of the 4*H*-thiopyran-4-one nucleus. Two reported preparations of methyl aryldithioates **4** proved the most useful. The condensation of an aryl Grignard reagent with carbon disulfide under copper(I) catalysis[7] followed by methylation afforded several dithioesters in rapid fashion (eq 4). Alternatively,



(4)

4

4a, Ar = Ph
4b, Ar = 2-thienyl
4d, Ar = 4-Me_2NPh
4e, Ar = 4-TBDMSOCH$_2$Ph



(5)

4

4a, Ar = Ph
4c, Ar = 2-pyridyl

some methyl dithioesters were prepared by the reported reaction of the corresponding halomethylarenes with

(1) (a) Chen, C. H.; Reynolds, G. A. *J. Org. Chem.* **1980**, *45*, 2448, 2453, 2458. (b) Reynolds, G. A.; Chen, C. H. *Ibid.* **1981**, *46*, 184. (c) Reynolds, G. A.; Chen, C. H. *J. Heterocycl. Chem.* **1981**, *18*, 627, 1235. (d) Chen, C. H.; Doney, J. J.; Reynolds, G. A. *J. Org. Chem.* **1982**, *47*, 680. (e) Perlstein, J. H. *Angew. Chem., Int. Ed. Engl.* **1977**, *16*, 519. (f) Nakasiyi, K.; Nakatsuka, M.; Murata, I. *J. Chem. Soc., Chem. Commun.* **1981**, 1143.

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(6) Koreeda, M.; Akagi, H. *Tetrahedron Lett.* **1980**, *21*, 1197.

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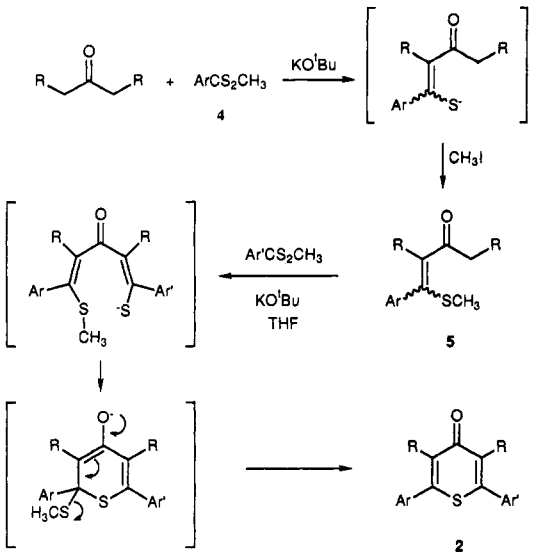
0022-3263/93/1958-3042$04.00/0

Scheme I



elemental sulfur and a tertiary amine in DMF at elevated temperatures (60 °C) followed by methylation (eq 5).[8] Both methods efficiently afforded the desired dithioesters while avoiding hydrogen sulfide.

Sequential thio-Claisen condensation reactions of a ketone with two dithioesters 4 should afford rapid heterocycle construction and allow substituent latitude in the 2 and 6 positions. The success of this thio-Claisen strategy hinged on carbophilic rather than thiophilic addition of an enolate anion to the dithioester. Though many nucleophiles add at the sulfur of thiocarbonyl species, carbophilic addition has been previously observed in thio-Claisen reactions utilizing either thiono- or dithioesters.[9] Indeed, either a sodium (2 equiv of NaH) or a potassium (2 equiv of KO^{t}Bu) enolate of acetone added carbophilically to dithioesters 4 in THF. The addition was followed by loss of methanethiolate and subsequent deprotonation to afford the corresponding thio-Claisen β-thioxo ketone enolates. To mask the active methylene in anticipation of the second condensation, the thioenolates were methylated (CH_3I) to afford in good yield an isomeric mixture of 4-aryl-4-(methylthio)-3-buten-2-ones 5. The use of a dithioester for the condensation proved crucial for the success of the protective methylation, since the intermediate thioenolate anions, unlike those derived from oxygen esters, were regiospecifically methylated on sulfur.

In addition to protection, the methylation step served to provide a synthetically useful methyl thioenol ether group. This substituent was predisposed toward Michael replacement due to the reasonably good leaving ability of the methylthio moiety in these types of compounds. This designed reactivity allowed the thioenolate anion formed by a second carbophilic thio-Claisen condensation (2 equiv of KO^{t}Bu or NaH, 1 equiv of 4, THF) to displace the methylthio group of 5 presumably via an addition–elimination sequence (Scheme I) to form the desired 4H-thiopyran-4-ones 2 in one step from 5.

The brevity of this method (two steps from acetone and 4) allowed rapid construction of a number of 2,6-diaryl-4H-thiopyran-4-ones. The generality of the method is indicated by the breadth of examples reported in Table I. Of special note are the substituted aromatic and heteroaromatics that are tolerated during heterocycle construction.

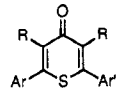
Although oxidative stability is no longer required, any substituents present must be inert to basic conditions. Simple protection of reactive functionalities is apparently sufficient, since methyl 4-[(*tert*-butyldimethylsiloxy)-methyl]phenyldithioate performed quite well during 4H-thiopyran-4-one construction using this method (Table I).

In addition, this method is not limited to acetone for the ketonic component. By using more substituted ketones fully substituted 4H-thiopyran-4-ones can be prepared. An illustrative example, the preparation of 3,5-dimethyl-2,6-diphenyl-4H-thiopyran-4-one from 3-pentanone, is included in Table I.

In addition to being short, this methodology is operationally simple, since there is no need to purify the somewhat unstable 5 in most cases and isolation of 2 was usually achieved by its precipitation from the reaction mixture through the addition of water. Analytically pure samples of 2 could be prepared by recrystallization.

This simple preparation of 2,6-diaryl-4H-thiopyran-4-ones should prove a conceptually different and attractive alternative to existing technologies, especially in cases of oxidative instability, limited only by a requirement of substituent alkaline stability.

Table I. Synthesis of 2,6-Diaryl-4H-thiopyran-4-ones



2

2	Ar	Ar′	R	overall yield of 2 (%)
a	Ph	Ph	H	59
b	Ph	2-pyridyl	H	51
c	2-thienyl	2-thienyl	H	85
d	2-thienyl	2-pyridyl	H	52
e	2-pyridyl	2-pyridyl	H	48
f	4-Me$_2$NPh	2-pyridyl	H	92
g	Ph	4-TBDMSOCH$_2$Ph	H	51
h	Ph	Ph	CH_3	53

Experimental Section

General. Solvents and reagents were used as received from Kodak Laboratory and Research Products, J. T. Baker Chemical Co., or Aldrich Chemical Co. ^{1}H and ^{13}C NMR spectra were obtained on a GE QE-300 NMR spectrometer. Microanalyses were performed by the Analytical Technology Division, Kodak Research Laboratories. All melting points are uncorrected.

4-Phenyl-4-(methylthio)but-3-en-2-one (5a). Potassium *tert*-butoxide (1.33 g; 11.9 mmol; 2.0 equiv) was dissolved in 10 mL of THF in a 100-mL flask and cooled to ca. −5 °C. Acetone (1.0 mL; 13.5 mmol; 2.3 equiv) was added dropwise to give a pale yellow solution. After 5 min, methyl dithiobenzoate (4a)[7] (1.00 g; 5.94 mmol) dissolved in 5 mL of THF was added dropwise to afford a deep red solution. After 30 min at −5 °C no 4a was detectable by TLC analysis, and iodomethane (0.74 mL; 11.9 mmol; 2.0 equiv) was added dropwise. The solution turned pale orange and showed two new spots as well as regenerated 4a (presumably from potassium dithiobenzoate formed by initial displacement at the methyl of 4a) by TLC analysis. The reaction mixture was poured into aqueous NH_3/NH_4Cl and extracted three times with ether. The combined extracts were dried ($MgSO_4$) and concentrated. The resulting crude material was filtered through a pad of flash silica gel (elution with 1:9 ether/hexanes) to afford recovered 4a (249 mg) and 5a as an 81:19 ratio of isomers

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(9) (a) Uhlemann, E.; Muller, H. *Angew. Chem., Int. Ed. Engl.* **1965**, *4*, 154. (b) Duus, F. *J. Org. Chem.* **1977**, *42*, 3123. (c) Carlsen, L.; Duus, F. *Synthesis* **1977**, *256*. (d) Hartke, K.; Gunther, O. *Leibigs Ann. Chem.* **1973**, 1637.

(735 mg; 64% (85% based on recovered **4a**)). ^{1}H NMR ($CDCl_3$) major isomer: δ 7.41–7.37 (m, 3 H), 7.24 (d, 2 H, J = 7.57 Hz), 6.357 (s, 1 H), 2.252 (s, 3 H), 1.890 (s, 3 H). Minor isomer: δ 7.4–7.2 (m, 5 H), 5.958 (s, 1 H), 2.354 (s, 3 H), 1.793 (s, 3 H). ^{13}C NMR ($CDCl_3$) both isomers: δ 197.3, 195.5, 161.1, 159.1, 138.5, 137.7, 129–128 (m), 123.1, 121.5, 30.4, 30.0, 16.2, 13.6. IR (KBr, cm^{-1}): 1660 (s), 1540 (s). FDMS; m/e 192 (M^+).

4-(2-Thienyl)-4-(methylthio)but-3-en-2-one (5b). Preparation as above using methyl 2-thienyldithioate (**4b**) (10.0 g; 0.057 mol) and filtration of the crude product through a pad of flash silica gel (elution with 1:3 ether/hexanes) afforded 9.72 g (86%) of **5b** as a 70:30 ratio of isomers by ^{1}H NMR analysis. ^{1}H NMR ($CDCl_3$) major isomer: δ 7.382 (dd, 1 H, J = 0.92, 5.09 Hz), 7.134 (d, 1 H, J = 3.34 Hz), 7.057 (t, 1 H, J = 5.16 Hz), 6.558 (s, 1 H), 2.291 (s, 3 H), 2.166 (s, 3 H), 2.166 (s, 3 H). Minor isomer: δ 7.467 (d, 1 H, J = 5.18 Hz), 7.223 (dd, 1 H, J = 0.91, 3.58 Hz), 7.04 (m, 1 H), 5.966 (s, 1 H), 2.393 (s, 3 H), 1.988 (s, 3 H). ^{13}C NMR ($CDCl_3$) both isomers: δ 195.7, 195.3, 151.1, 149.7, 140.6, 137.9, 130–127 (m), 124.5, 122.5, 30.7, 29.7, 17.2, 16.7. IR (neat, cm^{-1}): 1660 (s), 1540 (s), 1500 (s). FDMS: m/e 198 (M^+).

4-(2-Pyridyl)-4-(methylthio)but-3-en-2-one (5c). A 60 wt % suspension of sodium hydride in mineral oil (2.48 g; 62.0 mmol; 2.1 equiv) was washed with hexanes (3 × 10 mL). THF (25 mL) was added and the resulting slurry was cooled to 0 °C. A solution of methyl 2-pyridyldithioate (**4c**)[7] (5.00 g; 29.5 mmol) in 25 mL of THF was added followed by acetone (4.4 mL; 60 mmol; 2 equiv). The reaction mixture was allowed to warm to room temperature over 3 h to completely consume the dithioester **4c** according to TLC analysis. After the mixture was cooled to 0 °C, iodomethane (3.7 mL; 60 mmol; 2 equiv) was added dropwise to the deep red solution to afford a tan suspension. After 30 min at room temperature the reaction mixture was poured into aqueous NH_3/NH_4Cl and extracted with dichloromethane. The extracts were dried and concentrated to afford crude **5c**, which could be used directly in the next reaction. In this case the crude **5c** was filtered through a pad of flash silica gel (elution with 2:1 ethyl acetate/hexanes) to afford 4.8 g (84%) of **5c** apparently as a single isomer. ^{1}H NMR ($CDCl_3$): δ 8.680 (d, 1 H, J = 4.77 Hz), 7.783 (dt, 1 H, J = 1.70, 7.85 Hz), 7.377 (d, 1 H, J = 7.92 Hz), 7.321 (dd, 1 H, J = 4.29, 7.34 Hz), 6.492 (s, 1 H), 2.293 (s, 3 H), 1.964 (s, 3 H). ^{13}C NMR ($CDCl_3$): δ 195.7, 157.8, 156.7, 149.6, 136.8, 124.6, 123.5, 123.4, 30.5, 15.9. IR (neat, cm^{-1}): 1660 (s), 1545 (s). FDMS: m/e 193 (M^+).

4-[4-(*N*,*N*-Dimethylamino)phenyl]-4-(methylthio)but-3-en-2-one (5d). **5d** was prepared according to the procedure for **5c** from methyl 4-(*N*,*N*-dimethylamino)dithiobenzoate (**4d**) (1.50 g; 6.81 mmol) except that the condensation was performed at reflux in THF from 12 h to afford 1.59 g (99%) of a 54:46 mixture of isomers of **5d**, which was used without further purification. ^{1}H NMR ($CDCl_3$) major isomer: δ 7.145 (d, 2 H, J = 8.75 Hz), 6.685 (d, 2 H, J = 8.24 Hz), 6.348 (s, 1 H), 3.007 (s, 6 H), 2.253 (s, 3 H), 2.003 (s, 3 H). Minor isomer: δ 7.223 (d, 2 H, J = 8.75 Hz), 6.707 (d, 2 H, J = 8.52 Hz), 5.883 (s, 1 H), 3.007 (s, 6 H), 2.343 (s, 3 H), 1.818 (s, 3 H). ^{13}C NMR ($CDCl_3$) both isomers: δ 196.6, 195.5, 161.3, 160.1, 151.8, 151.3, 130.2, 129.5, 126.5, 125.0, 122.7, 121.3, 112.0, 111.9, 40.2, 30.5, 29.7, 16.7, 16.4. IR (neat, cm^{-1}): 1655 (m), 1605 (s). FDMS: m/e 235 (M^+).

4-Phenyl-4-(methylthio)-3-methylpent-4-en-3-one (5e). By a procedure analogous to that for **5a**, **5e** was prepared from 3-pentanone (2.11 mL; 20 mmol; 2 equiv) and methyl dithiobenzoate (**4a**; 1.68 g; 10.0 mmol). Treatment with iodomethane (0.93 mL; 15 mmol; 1.5 equiv) afforded crude **5e** (2.22 g; 99%) which was used without further purification. ^{1}H NMR ($CDCl_3$) major isomer: δ 7.4–7.2 (m, 5 H), 2.149 (s, 3 H), 1.902 (q, 2 H, J = 7.22 Hz), 1.831 (s, 3 H), 0.749 (t, 3 H, J = 7.25 Hz). Minor isomer: δ 7.4–7.2 (m, 5 H), 2.681 (q, 2 H, J = 7.20 Hz), 1.790 (s, 3 H), 1.709 (s, 3 H), 1.177 (t, 3 H, J = 7.19 Hz). ^{13}C NMR ($CDCl_3$) both isomers: δ 207.1, 204.0, 143.5, 138.1, 137.9, 131–127 (m), 35.6, 34.4, 18.7, 18.2, 16.6, 15.6, 8.6, 8.2. IR (neat, cm^{-1}): 1675 (s), 1577 (m). FDMS: m/e 220 (M^+).

2,6-Diphenyl-4*H*-thiopyran-4-one (2a). Potassium *tert*-butoxide (708 mg; 6.3 mmol; 2.1 equiv) was dissolved in 5 mL of THF and cooled to −5 °C. A THF (2.5 mL) solution of **5a** (578 mg; 3.01 mmol) was added dropwise to afford a red solution. After 5 min a THF (2.5 mL) solution of **4a**[7] (555 mg; 3.30 mmol; 1.1 equiv) was added to afford a deep red solution. After 30 min at −5 °C both **4a** and **5a** were consumed according to TLC analysis, and the reaction mixture was poured into water. The precipitate was collected, washed with water, and air-dired to afford 633 mg (91%) of **2a** which was identical to an authentic sample.[5d]

2-Phenyl-6-(2-pyridyl)-4*H*-thiopyran-4-one (2b). 4*H*-Thiopyran-4-one **2b** (863 mg; 79%) was prepared in an analogous manner to compound **2a** from potassium *tert*-butoxide (969 mg; 8.63 mmol; 2.1 equiv), methylthio enone **5a** (790 mg; 4.11 mmol), and dithioester **4c** (695 mg; 4.11 mmol; 1.0 equiv). An analytical sample, mp 149–151 °C, was prepared by recrystallization from dichloromethane/hexanes. ^{1}H NMR ($CDCl_3$): δ 8.728 (d, 1 H, J = 4.89 Hz), 7.85 (m, 2 H), 7.70 (m, 2 H), 7.601 (s, 1 H), 7.50 (3 H, m), 7.42 (m, 1 H), 7.247 (d, 1 H, J = 1.10 Hz). IR (KBr, cm^{-1}): 1619 (s), 1580 (s), 1570 (m), 1549 (m). FDMS: m/e 265 (M^+). Anal. Calcd for $C_{16}H_{11}NOS$: C, 72.43; H, 4.18; N, 5.28. Found: C, 72.58; H, 4.38; N, 5.28.

2,6-Di(2-thienyl)-4-*H*-thiopyran-4-one (2c). Compound **2c** was prepared from potassium *tert*-butoxide (1.18 g; 10.5 mmol; 2.1 equiv), **5b** (992 mg; 5.0 mmol), and **4b** (871 mg; 5.0 mmol; 1.0 equiv) in an analogous manner to that described for **2a**. 4*H*-Thiopyran-4-one **2c** prepared in this manner (1.39 g; 99%) was identical to an authentic sample.[4d]

2-(2-Thienyl)-6-(2-pyridyl)-4*H*-thiopyran-4-one (2d). Compound **2d** was prepared in an analogous manner to **2a** from potassium *tert*-butoxide (3.57 g; 31.8 mmol; 2.1 equiv), **5b** (3.00 g; 15.1 mmol), and **4c** (2.56 g; 15.1 mmol; 1.0 equiv) to afford 2.448 g (60%) of **2d** as a precipitate from water. An analytical sample, mp 170–172 °C, was prepared by recrystallization from methanol. ^{1}H NMR ($CDCl_3$): δ 8.766 (d, 1 H, J = 4.96 Hz), 7.905 (dt, 1 H, J = 1.44, 8.59 Hz), 7.867 (d, 1 H, J = 7.30 Hz), 7.640 (d, 1 H, J = 3.73 Hz), 7.565 (s, 1 H), 7.541 (d, 1 H, J = 5.07 Hz), 7.455 (dt, 1 H, J = 1.67, 4.85 Hz), 7.297 (s, 1 H), 7.190 (t, 1 H, J = 4.33 Hz). IR (KBr, cm^{-1}): 1610 (s), 1570 (m). FDMS: m/e 271 (M^+). Anal. Calcd for $C_{14}H_9NOS_2$: C, 62.07; H, 3.34; N, 5.16. Found: C, 61.97; H, 3.46; N, 5.11.

2,6-Di(2-pyridyl)-4*H*-thiopyran-4-one (2e). Methyl 2-pyridyldithioate (**4c**)[7] (1.31 g; 7.76 mmol; 1.0 equiv) was dissolved in THF (15 mL), and a 60 wt % suspension of sodium hydride in mineral oil (652 mg; 16.3 mmol; 2.1 equiv) was added. Enone **5c** (1.50 g; 7.76 mmol) was added in 5 mL of THF, and the reaction mixture was heated to reflux for 1.5 h, at which time both **4c** and **5c** were consumed by TLC analysis. The product **2e** (1.18 g; 57%) was isolated as a cream-colored solid, mp 191–192 °C, by precipitation from the reaction mixture by dilution with water. ^{1}H NMR (DMSO-d_6): δ 8.746 (d, 2 H, J = 4.25 Hz), 8.240 (d, 2 H, J = 8.06 Hz), 8.005 (dt, 2 H, J = 1.59, 7.86 Hz), 7.729 (s, 2 H), 7.571 (dd, 2 H, J = 4.95, 7.50 Hz). IR (KBr, cm^{-1}): 1615 (s), 1585 (m). FDMS m/e 266 (M^+). HRMS: calcd for $(C_{15}H_{10}N_2OS + H)^+$ 267.05921, found 267.05899.

2-[4-(*N*,*N*-Dimethylamino)phenyl]-6-(2-pyridyl)-4*H*-thiopyran-4-one (2f). By a procedure analogous to that used to prepare **2a**, compound **2f** (1.088 g; 93%) was prepared from potassium *tert*-butoxide (1.037 g; 9.24 mmol; 2.4 equiv), crude enone **5d** (892 mg; 3.79 mmol), and **4c** (710 mg; 4.20 mmol; 1.1 equiv), mp 180–183 °C. ^{1}H NMR ($CDCl_3$): δ 8.74 (d, 1 H, J = 4.69 Hz), 7.85 (m, 2 H), 7.65 (d, 2 H, J = 8.86 Hz), 7.55 (s, 1 H), 7.42 (dt, 1 H, J = 2.58, 5.47 Hz), 7.21 (s, 1 H), 6.76 (d, 2 H, J = 8.85 Hz), 3.06 (s, 6 H). IR (KBr, cm^{-1}): 1600 (s), 1570 (m). FDMS: m/e 308 (M^+). Anal. Calcd for $C_{18}H_{16}N_2OS$: C, 70.10; H, 5.23; N, 9.08. Found: C, 70.03; H, 5.25; N, 9.09.

Methyl 4-[[(*tert*-Butyldimethylsilyl)oxy]methyl]dithiobenzoate (4e). *p*-Bromophenol (10.0 g; 53.5 mmol) was dissolved in DMF (20 mL), and imidazole (7.28 g; 107 mmol; 2 equiv) was added. *tert*-Butyldimethylchlorosilane (9.68 g; 64.2 mmol; 1.2 equiv) was added and washed in with 2 mL of DMF. The reaction mixture was stirred at room temperature overnight to completely consume the *p*-bromophenol according to TLC analysis. The reaction mixture was diluted with 1:1 ether/hexanes, washed five times with water, dried ($MgSO_4$), and concentrated to afford 16.48 g of crude TBDMS ether. This material was not purified, but rather a portion (7.5 g; 24.9 mmol) was dissolved in THF (7.5 mL), and about 20% of this solution was added to a mixture of magnesium (605 mg; 24.9 mmol; 1.0 equiv) and THF (7.5 mL). Small amounts of iodine and 1,2-dibromoethane were added to initiate the Grignard reaction. Once the reaction had commenced the remainder of the TBDMS ether solution was diluted with

THF (10 mL) and added dropwise so as to maintain the exothermic reaction. After the addition, the reaction mixture was heated at reflux for 4 h to consume the magnesium. The reaction mixture was cooled to −50 °C, and copper(I) bromide–dimethyl sulfide complex (256 mg; 1.25 mmol; 0.05 equiv) was added. The reaction mixture was stirred for 5 min, and carbon disulfide (1.65 mL; 27.4 mmol; 1.1 equiv) was added. The reaction mixture was allowed to warm from −50 to −40 °C over 1 h, and iodomethane (2.02 mL; 32.4 mmol; 1.3 equiv) was added. The reaction mixture was allowed to warm to room temperature overnight and then diluted with hexanes and washed with aqueous ammonia and water. The organic solution was dried (Na_2SO_4) and concentrated, and the crude material was filtered through a pad of flash silica gel and eluted with hexanes to afford 4.38 g (56%) of **4e**. ^{1}H NMR ($CDCl_3$): δ 7.997 (d, 2 H, J = 8.28 Hz), 7.324 (d, 2 H, J = 8.12 Hz), 4.744 (s, 2 H), 2.737 (s, 3 H), 0.949 (s, 9 H), 0.105 (s, 6 H). ^{13}C NMR ($CDCl_3$) δ 228.5, 146.3, 144.1, 126.9, 125.8, 64.7, 26.0, 20.3, 18.4, −5.2. IR (neat, cm^{-1}): 1606 (m), 1098 (s), 1053 (s). HRMS: calcd for $(C_{15}H_{24}OS_2Si + H)^+$ 313.11161, found 313.11190.

2-Phenyl-6-[[[(4-*tert*-butyldimethylsilyl)oxy]methyl]phenyl]-4*H*-thiopyran-4-one (2g). Compound **2g** was prepared from potassium *tert*-butoxide (707 mg; 6.3 mmol; 2.1 equiv), methylthio enone **5a** (577 mg; 3.0 equiv), and methyl 4-[[(*tert*-butyldimethylsilyl)oxy]methyl]phenyldithioate (**5e**, 1.03 g; 3.3 mmol; 1.1 equiv). Once the reaction was complete (according to TLC analysis) crude **2g** was isolated by dilution with water and extraction with ether. Compound **2g** (972 mg; 79%) was purified by filtration through a pad of flash silica gel and elution with 1:2 ethyl acetate/hexanes. ^{1}H NMR ($CDCl_3$): δ 7.65 (m, 4 H), 7.6–7.4 (m, 5 H), 7.314 (s, 2 H), 4.809 (s, 2 H), 0.963 (s, 9 H), 0.130 (s, 6 H). IR (KBr, cm^{-1}) 1609 (s), 1579 (s), 1492 (m), 1472 (m). HRMS: calcd for $(C_{24}H_{28}O_2SSi + H)^+$ 409.16576, found 409.16695.

3,5-Dimethyl-2,6-diphenyl-4*H*-thiopyran-4-one (2h). Compound **2h** was prepared by a method analogous to that for **2a** using potassium *tert*-butoxide (2.36 g; 21 mmol; 2.1 equiv), crude enone **5e** (2.22 g; 10.0 mmol), and **4a** (1.68 g; 10.0 mmol; 1.0 equiv). The crude product was isolated by ether extraction from aqueous solution and filtered through a pad of silica gel to afford **2e** (1.50 g; 51%). An analytical sample, mp 102–104 °C, was prepared by recrystallization from ether. ^{1}H NMR ($CDCl_3$): δ 7.5–7.35 (m, 10 H), 2.118 (s, 6 H). IR (KBr, cm^{-1}) 1579 (s), 1516 (w), 1485 (s). EIMS: m/e 292 (M^+). Anal. Calcd for $C_{19}H_{16}OS$: C, 78.05; H, 5.52; N, O. Found: C, 78.23; H, 5.68; N, <0.3.

Supplementary Material Available: ^{1}H NMR (300 MHz) and ^{13}C NMR (75.6 MHz) spectra for compounds **4e** and **5a–e** (12 pages). This material is contained in libraries on microfiche, immediately follows this article in the microfilm version of the journal, and can be ordered from the ACS; see any current masthead page for ordering information.