On the Syntheses and Some Reactions of Bis- and Tris(methylthio)thiophenes

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Reaction between various thienyllithium derivatives and dimethyl disulfide has been used for the preparation of 2,5-, 2,3-, and 3,4-bis(methylthio)thiophenes, as well as 2,3,4- and 2,3,5-tris(methylthio)thiophenes. Bromination of (methylthio)thiophenes with *N*-bromosuccinimide was found to be most convenient for the preparation of brominated (methylthio)thiophenes such as 3-bromo-2,5-bis(methylthio)- and 5-bromo-2,3-bis(methylthio)thiophene, 3,4-dibromo-2,5-bis(methylthio)-, 2,5-dibromo-3,4-bis(methylthio)- and 2,3-dibromo-4,5-bis(methylthio)thiophene as well as 3-bromo-2,4,5-tris(methylthio)thiophene. The reaction of methylthio substituted thienyllithium derivatives with methyl chloroformate was used for the syntheses of methyl methylthio substituted thiophenecarboxylates and using 1/3 of an equivalent for the direct preparation of methylthio substituted 3-thienylcarbinols as tris[2,4,5-tris(methylthio)-3-thienyl]carbinol.

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Introduction.

In connection with our interest in stable trithienylmethyl carbenium ions, we wanted to develop efficient methods for the preparation of various bis- and tris(methylthio)thiophenes.

(Alkylthio)thiophenes have previously been obtained through various ring-closure reactions. Thus condensation of active methylene derivatives with carbon disulfide under basic conditions gave enethiolates, which upon alkylation with α-haloesters and ring-closure yielded 2-(alkylthio)thiophene [1-4]. Another C_3S + C approach to 2-(alkylthio)thiophenes was described by Smutny who reacted 3-aminodithioacrylate esters with α-halocarbonyl compounds in the presence of triethyl amine [5]. A C_3 + CS approach to 3-substituted 2-(methylthio)thiophenes consists in the treatment of 2-alkyne and allene derivatives with strong base followed by carbon disulfide and methyl iodide [6]. Ring-closure of C_4S-type compounds has also been used for the preparation of 2-(alkylthio)thiophenes [7]. For the syntheses of highly substituted 3-(alkylthio)-thiophenes the Fiesselmann reaction is especially useful [8]. For more details, *cf* [9].

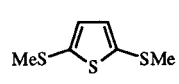
Many (alkylthio)thiophenes have been prepared by alkylation of the corresponding alkali salts of thiophenethiols [10] or by copper promoted nucleophilic substitution of halothiophenes with alkylthiolates [11,12]. A very convenient method for the synthesis of (alkylthio)thiophenes is the reaction of thienyllithium derivatives with dialkyl disulfides [13-16], and in particular dimethyl disulfide has been used extensively [9, p 166] and gives good yields in most cases. The more sterically hindered diisopropyl disulfide reacts more slowly and we could not observe any reaction between thienyllithium derivatives and di-*t*-butyl disulfide at temperatures below 0°.

Only 2,5-dibromothiophene gave smoothly 2,5-dilithiothiophene upon halogen-metal exchange with butyllithium, yielding 2,5-bis(methylthio)thiophene (**1a**) in 78% yield upon reaction with dimethyl disulfide.

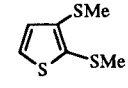
2,3-Dibromothiophene and 3,4-dibromothiophene upon dilithiation and reaction with dimethyl disulfide gave the desired dithioethers in low yields (32-35%, glc).

Brominated methylthio derivatives and methylthio ethers (33-39%) were also obtained. Both halogen-metal exchange and metalation apparently occurred.

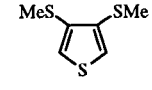
Neither longer reaction times in the halogen-metal exchange step or in the thiomethylation step, nor use (3 equivalents) of excess reagents improved the yield of bis(methylthio) derivatives.



1a



1b



1c

3,4-Bis(methylthio)thiophene (**1c**) could be obtained in 58% yield, in a one-pot procedure from 3,4-dibromothiophene by step-wise halogen-metal exchange to 4-bromo-3-thienyllithium, reaction with dimethyl disulfide and renewed halogen-metal exchange and reaction with dimethyl disulfide.

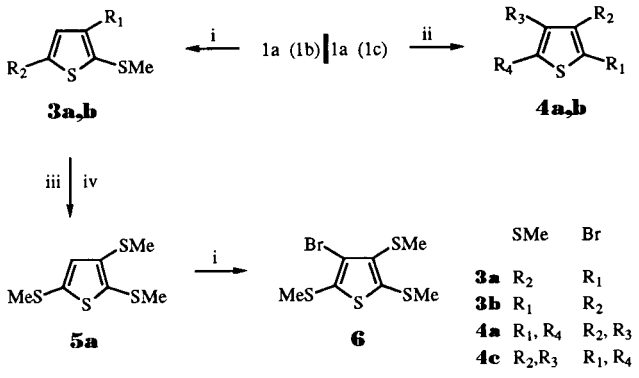
We prepared 2,3-bis(methylthio)thiophene (**1b**) starting from 3-(methylthio)thiophene, which was brominated according to Taylor and Vogel [17] with *N*-bromosuccinimide in carbon tetrachloride to give 2-bromo-3-(methylthio)thiophene, which upon halogen-metal exchange and reaction with dimethyl disulfide gave the desired compound in 72% yield.

Bromination of **1a** and **1b** with one equivalent of *N*-bromosuccinimide in chloroform occurred smoothly at room temperature giving 3-bromo-2,5-bis(methylthio)thiophene (**3a**) and 5-bromo-2,3-bis(methylthio)thiophene (**3b**) in 86% and 81% yield respectively.

Dibromination of **1a** and **1c** with *N*-bromosuccinimide

was slower and longer reaction times had to be used, but almost quantitative yields of 3,4-dibromo-2,5-bis(methylthio)thiophene (**4a**) and 2,5-dibromo-3,4-bis(methylthio)-thiophene (**4c**) were obtained (Scheme 1).

Scheme 1

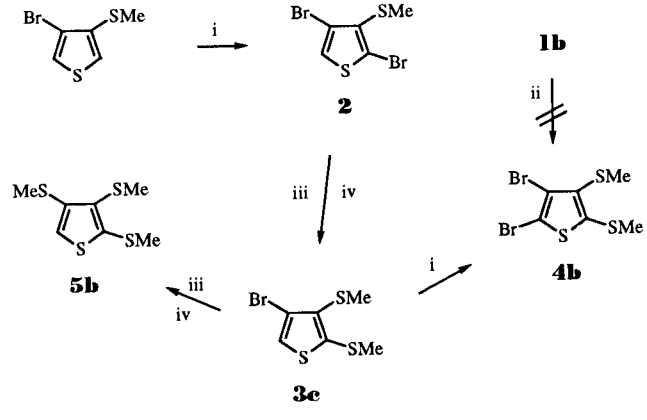


i. NBS (1 eq); ii. NBS (2 eq); iii. BuLi; iv. Me_2S_2.

Bromination with bromine in chloroform was faster, but some unidentified by-products were also formed. In contrast to **1a** and **1c**, **1b** could not be dibrominated. In order to obtain 2,3-dibromo-4,5-bis(methylthio)thiophene, 4-bromo-2,3-bis(methylthio)thiophene (**3c**) had to be brominated with *N*-bromosuccinimide.

Compound **3c** was prepared from 3-bromo-4-(methylthio)thiophene [18] by bromination with *N*-bromosuccinimide, which was expected to occur in the 5-position due to the stronger *o-p* directing properties of the methylthio group, giving 2,4-dibromo-3-(methylthio)thiophene (**2**) (Scheme 2).

Scheme 2



i. NBS (1 eq); ii. NBS (2 eq); iii. BuLi (1 eq);; iv. Me_2S_2 (1 eq).

The correctness of this structure assignment was proven by converting **2** to 4-bromo-2,3-bis(methylthio)thiophene (**3c**) through halogen-metal exchange followed by reaction with dimethyl disulfide. In this reaction 11% of 3-bromo-2,4,5-tris(methylthio)thiophene (**6**) was also formed due to competing metalation. The structures of **2** and **3c** were proven by reacting **3c** with butyllithium followed by hydrolysis, which gave **1b**. Both **3a** and **3b**, gave 2,3,5-tris-(methylthio)thiophene (**5a**) upon halogen-metal exchange and reaction with dimethyl disulfide.

Compound **5a** was also formed together with other components by reacting 2,3,5-tribromothiophene with 3.3 equivalents of butyllithium followed by dimethyl disulfide. The composition of the product is given in Table 1.

Table 1

Composition of the Product Obtained in the Reaction Between 2,3,5-Tribromothiophene and Butyllithium Followed by Dimethyl Disulfide

Product* [a]	5a	3a	1a	(Methylthio)thiophene dibromo-	bromo-
Yield (GLC, %)	25	40	5	17	13

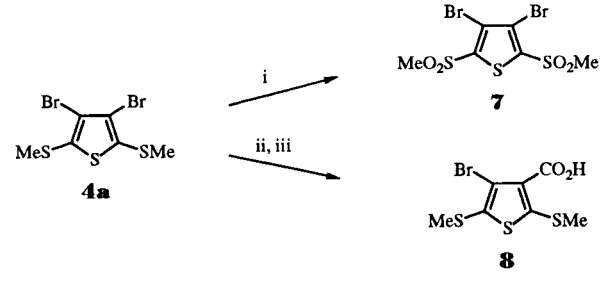
Reagents and conditions: BuLi (3.3 eq), Et_2O, -78°, N_2, 2 hours; Me_2S_2 (3.3 eq), -78°, 3 hours, then rt.

[a] Identified by ms and authentic samples.

Compound **5a** gave **6** upon reaction with *N*-bromosuccinimide in 82% yield. Reaction of **3c** with butyllithium followed by dimethyl disulfide gave 2,3,4-tris(methylthio)-thiophene (**5b**) in 74% yield (Scheme 1).

Compound **4a** could be oxidized to 3,4-dibromo-2,5-bis-(methylsulfonyl)thiophene using 30% hydrogen peroxide in hot acetic acid. Reaction of **4a** with one equivalent of butyllithium followed by carbon dioxide gave 4-bromo-2,5-bis(methylthio)-3-thiophenecarboxylic acid (**8**) (Scheme 3).

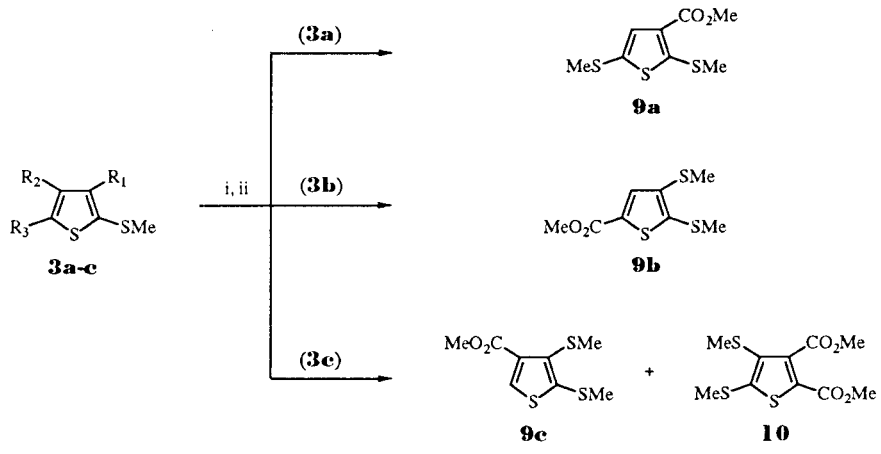
Scheme 3



i. H_2O_2 (30%), CH_3CO_2H; ii. BuLi (1eq); iii. CO_2 (s).

The reactions of the lithium derivatives obtained by halogen-metal exchange of **3a-c** with various reagents to directly give methyl esters was studied in detail (Scheme 4). We found that methyl chloroformate was a better reagent than dimethyl carbonate due to higher reactivity and better yields. However, highly dilute solutions and large excess of the reagent had to be used in order to achieve good yields of methyl 2,5-bis(methylthio)-3-thiophenecarboxylate (**9a**) and methyl 4,5-bis(methylthio)-2-thiophenecarboxylate (**9b**).

Scheme 4



i. BuLi (1 eq); ii. $ClCO_2Me$ (3 eq).

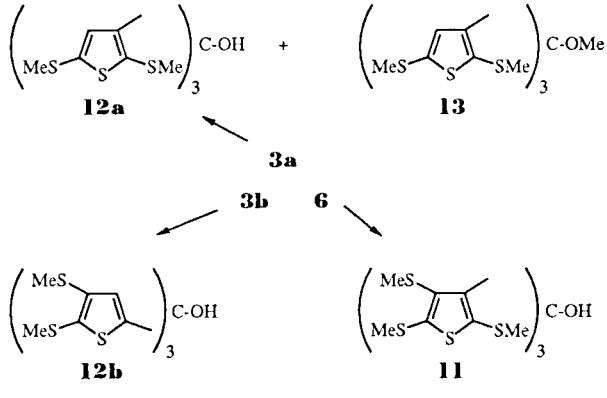
As in the reaction of 2,3-bis(methylthio)-4-thienyllithium with dimethyl disulfide, in the reaction with chloroformate, metalation also competed with halogen-metal exchange and in addition to 64% of methyl 4,5-bis(methylthio)-3-thiophenecarboxylate (**9c**), 18% of dimethyl 4,5-bis(methylthio)-2,3-thiophenedicarboxylate (**10**) was obtained (Scheme 4).

Carbinols **12a-b** and **11** were obtained by the reaction of the lithium derivatives from **3a-b** and **6** with 1/3 equivalent of methyl chloroformate. However, the yields were low and in the reaction of **3a**, the methyl ether **13** was obtained as a by-product (Scheme 5).

These carbinols are stable at room temperature and treatment of their ethereal solutions with 1 *N* hydrochloric acid solution gave green-coloured solutions of the carbenium ions.

We are planning to study these and other carbenium ions in more detail.

Scheme 5



EXPERIMENTAL

Melting points are uncorrected. The ^1H nmr spectra were recorded on a Varian XL-300 spectrometer. The mass spectra were recorded on a JEOL-SX 102 spectrometer. The glc analyses were carried out on a Varian 3300 gas chromatograph equipped with a 2 m column of 3% OV 17 on Gaschrom Q, 100-120 mesh and a flame ionization detector. Column chromatography was carried out with Merck silica gel 60 (230-400 mesh ASTM). Elemental microanalyses were performed at Dornis und Kolbe, Mikroanalytisches Laboratorium Mülheim a.d. Ruhr, Germany.

2,5-Bis(methylthio)thiophene (**1a**).

A solution of 2.42 g (10.0 mmoles) of 2,5-dibromothiophene [19] in 50 ml of anhydrous diethyl ether was cooled to −78° under nitrogen and treated with 10.0 ml of 2.09 *N* butyllithium in cyclohexane (20.9 mmoles). The solution was stirred for 30 minutes and then treated dropwise with a solution of 2.07 g (22.0 mmoles) of dimethyl disulfide in 10.0 ml of anhydrous ether during a period of 15 minutes. The reaction temperature was maintained below −70° throughout the addition. After 1 hour at −78° the reaction mixture was allowed to slowly reach room temperature after which it was quenched with an ice-cold saturated ammonium chloride solution. The organic phase was separated, and dried over magnesium sulfate. The solvent was evaporated *in vacuo* and the residue vacuum distilled, bp 59-61°/0.15 mm Hg (lit [20], 126-127°/10 mm Hg). This yielded 1.37 g (78%) of the title compound as a colorless oil.

2,3-Bis(methylthio)thiophene (**1b**).

A solution of 20.9 g (0.10 mole) of 2-bromo-3-(methylthio)thiophene [15] in 200 ml of anhydrous ether was cooled to −78° under nitrogen and treated with 55.0 ml of 2.02 *N* butyllithium in cyclohexane (0.11 mole). This mixture was stirred for 30 minutes after which a solution of 9.40 g (0.10 mole) of dimethyl disulfide in 20 ml of anhydrous ether was added dropwise at such a rate that the temperature remained below −60°. After 3 hours at −78° the reaction mixture was allowed to reach room temperature and was poured onto 300 ml of ice-cold saturated aqueous ammonium chloride solution. The ether phase was washed with 100 ml of 1 *N* sodium hydroxide, dried over magnesium sulfate and filtered. Concentration afforded a residue that was distilled

under vacuum, [bp 66-68°/0.3 mm Hg, (lit [6], 71°/1 mm Hg)] to give 12.67 g (72%) of the title compound as a pale yellow oil; ^{1}H nmr (deuteriochloroform): δ 7.29 (d, 1H, 5-H, J = 5.5), 7.97 (d, 1H, 4-H, J = 5.5), 2.47 (s, 3H, methyl), 2.45 (s, 3H, methyl).

3,4-Bis(methylthio)thiophene (**1c**).

To a cooled solution of 4.84 g (20.0 mmoles) of 3,4-dibromothiophene [16] at −78° in 150 ml of anhydrous ether under nitrogen, 10.0 ml of 2.02 *N* butyllithium in cyclohexane (20.2 mmoles) was added slowly. The reaction mixture was stirred for 30 minutes, and then treated with a solution of 1.88 g (20.0 mmoles) of dimethyl disulfide in 5.0 ml of anhydrous ether. After 2 hours at −78° the same amounts of butyllithium and dimethyl sulfide were once more added and the mixture was allowed to reach room temperature. Similar workup as described above gave a crude product, which was column chromatographed using light petroleum as the eluent. An analytical sample was purified by semipreparative hplc using heptane for elution. The title compound was obtained in a yield of 2.0 g (58%) bp 84-86°/1.2 mm Hg; ^{1}H nmr (deuteriochloroform): δ 7.02 (s, 2H, 2- and 5-H), 2.45 (s, 6H, methyl).

Anal. Calcd. for $C_6H_8S_3$: C, 40.86; H, 4.57; S, 54.56. Found: C, 40.83; H, 4.69; S, 54.60.

2,4-Dibromo-3-(methylthio)thiophene (**2**).

A solution of 6.27 g (30.0 mmoles) of 3-bromo-4-(methylthio)-thiophene [16] in 50 ml of carbon tetrachloride was treated with 5.34 g (30.0 mmoles) of *N*-bromosuccinimide and stirred overnight. The resulting mixture was filtered, washed with 1 *N* sodium hydroxide solution, and dried over magnesium sulfate. Concentration gave a crude product which was distilled under vacuum, bp 114-116°/1.5 mm Hg, to give 6.13 g (71%) of the title compound as a pale yellow oil; ^{1}H nmr (deuteriochloroform): δ 7.32 (s, 1H, 5-H), 2.35 (s, 3H, methyl).

Anal. Calcd. for $C_5H_4Br_2S_2$: C, 20.84; H, 1.39; S, 22.26. Found: C, 20.78; H, 1.43; S, 22.38.

General Procedure for the Synthesis of **3a** and **b**.

A solution of 7.04 g (40.0 mmoles) of the bismethylthio compound **1a** or **1b** in 75 ml of chloroform, was treated in portions with 7.12 g (40.0 mmoles) of *N*-bromosuccinimide. The reaction mixture was stirred at room temperature for 30 minutes. It was then was filtered, washed with 1 *N* sodium hydroxide solution, and dried over magnesium sulfate. Removal of the solvent followed by distillation gave a colorless oil.

3-Bromo-2,5-bis(methylthio)thiophene (**3a**).

This compound was obtained in a yield of 2.19 g (86%), bp 118-122°/1.5 mm Hg; ^{1}H nmr (deuteriochloroform): δ 6.92 (s, 1H, 4-H), 2.48 (s, 3H, methyl), 2.45 (s, 3H, methyl).

Anal. Calcd. for $C_6H_7BrS_3$: C, 28.23; H, 2.76; S, 37.69. Found: C, 28.29; H, 3.04; S, 37.55.

5-Bromo-2,3-bis(methylthio)thiophene (**3b**).

This compound was obtained in a yield of 4.13 g (81%), bp 108-110°/0.8 mm Hg; ^{1}H nmr (deuteriochloroform): δ 6.91 (s, 1H, 4-H), 2.45 (s, 3H, methyl), 2.41 (s, 3H, methyl).

Anal. Calcd. for $C_6H_7BrS_3$: C, 28.23; H, 2.76; S, 37.69. Found: C, 28.11; H, 2.85; S, 37.45.

4-Bromo-2,3-bis(methylthio)thiophene (**3c**).

A cooled solution of 4.32 (15.0 mmoles) of 2,4-dibromo-3-(methylthio)thiophene (**2**) at −78° in 100 ml of anhydrous ether under nitrogen was treated dropwise with 8.0 ml of 2.02 *N* butyllithium in cyclohexane 16.0 mmoles) maintaining the temperature below −70°. The resulting mixture was stirred for 30 minutes and then a solution of 1.41 g (15.0 mmoles) of dimethyl disulfide in 5.0 ml of ether was slowly added. The mixture, after stirring for 3 hours at −78°, was allowed to warm to room temperature, and then poured into ice-cold saturated ammonium chloride solution. The organic phase was worked up in the usual way, and after removal of the solvent, column chromatography using light petroleum for elution afforded 2.44 g (64%) of the title compound, bp 88-90°/0.16 mm Hg; ^{1}H nmr (deuteriochloroform): δ 7.29 (s, 1H, 5-H), 2.51 (s, 3H, methyl), 2.35 (s, 3H, methyl).

Anal. Calcd. for $C_6H_7BrS_3$: C, 28.23; H, 2.76; S, 37.69. Found: C, 28.18; H, 2.68; S, 37.64.

General Procedure for the Synthesis of **4a** and **c**.

To a solution of 1.76 g (10.0 mmoles) of the bismethylthio compound **1a** or **1b** in 25 ml of chloroform 3.56 g (20.0 mmoles) of *N*-bromosuccinimide was added and the reaction mixture was heated to reflux for 3 hours. After filtration, washing with 1 *N* sodium hydroxide solution and drying over magnesium sulfate, vacuum evaporation of the solvent afforded a solid crude product.

3,4-Dibromo-2,5-bis(methylthio)thiophene (**4a**).

The resulting crude product was recrystallized from light petroleum to give 3.0 g (90%) of the title compound as white crystals, mp 65-66° (lit [21], 65-66°).

2,5-Dibromo-3,4-bis(methylthio)thiophene (**4c**).

The crude product was recrystallized from ethanol to give 3.2 g (96%), of the title compound as white crystals, mp 75-76°; ^{1}H nmr (deuteriochloroform): δ 2.41 (s, 6H, methyl).

Anal. Calcd. for $C_6H_6Br_2S_3$: C, 21.56; H, 1.81; S, 28.79. Found: C, 21.54; H, 1.82; S, 28.96.

2,3-Dibromo-4,5-bis(methylthio)thiophene (**4b**).

Following the above procedure 2.55 g (10.0 mmoles) of 4-bromo-2,3-bis(methylthio)thiophene (**3c**) in 20 ml of chloroform was allowed to react with 1.78 g (10.0 mmoles) of *N*-bromosuccinimide. Recrystallization of the crude reaction product from ethanol gave 3.1 g (94%), of the title compound as white crystals mp 64-65°; ^{1}H nmr (deuteriochloroform): δ 2.52 (s, 3H, methyl), 2.36 (s, 3H, methyl).

Anal. Calcd. for $C_6H_6Br_2S_3$: C, 21.56; H, 1.81; S, 28.79. Found: C, 21.42; H, 1.90; S, 28.67.

General Procedure for the Synthesis of **5a** and **b**.

A solution of 3.83 g (15.0 mmoles) of **3a** or **3c** in 75 ml of anhydrous ether at −78° under nitrogen was treated with 8.0 ml of 2.02 *N* butyllithium in cyclohexane (16.0 mmoles). After 20 minutes, 1.41 g (15.0 mmoles) of dimethyl disulfide in 10 ml of anhydrous ether was added dropwise, and the temperature was kept at −78° for an additional 2 hours. The cooling bath was removed and the reaction mixture was allowed to warm up to 0° and then it was quenched with saturated ammonium chloride solution. Separation of the organic layer, drying over magnesium sulfate, and removal of the solvent gave a colorless oil which was column chromatographed using light petroleum as eluant.

2,3,5-Tris(methylthio)thiophene (**5a**).

This compound was obtained in a yield of 2.23 g (67%) bp 113-114°/0.2 mm Hg; ^{1}H nmr (deuteriochloroform): δ 6.91 (s, 1H, 4-H), 2.49 (s, 3H, methyl), 2.45 (s, 3H, methyl), 2.44 (s, 3H, methyl).

Anal. Calcd. for $C_7H_{10}S_4$: C, 37.79; H, 4.53; S, 57.67. Found: C, 37.61; H, 4.63; S, 57.55.

2,3,4-Tris(methylthio)thiophene (**5b**).

Crystallization from pentane gave 2.46 g (74%) of the title compound, mp 29-30°; ^{1}H nmr (deuteriochloroform): δ 6.72 (s, 1H, 5-H), 2.53 (s, 3H, methyl), 2.46 (s, 3H, methyl), 2.35 (s, 3H, methyl).

Anal. Calcd. for $C_7H_{10}S_4$: C, 37.79; H, 4.53; S, 57.67. Found: C, 37.75; H, 4.51; S, 57.70.

3-Bromo-2,4,5-tris(methylthio)thiophene (**6**).

To a solution of 3.60 g (16.2 mmoles) of **5a** in 40 ml of carbon tetrachloride 2.88 g (16.2 mmoles) of *N*-bromosuccinimide was added and stirred overnight at room temperature. The reaction mixture was filtered, washed with a 10% sodium bicarbonate solution, dried over magnesium sulfate, the solvent was vacuum evaporated, leaving a colorless solid. Recrystallization from hexane and then from ethanol gave 4.0 g (82%) of the title compound as white crystals, mp 52-53°; ^{1}H nmr (deuteriochloroform): δ 2.53 (s, 3H, methyl), 2.46 (s, 3H, methyl), 2.36 (s, 3H, methyl).

Anal. Calcd. for $C_7H_9BrS_4$: C, 27.90; H, 3.01; S, 42.57. Found: C, 27.98; H, 3.04; S, 42.68.

3,4-Dibromo-2,5-bis(methylsulfonyl)thiophene (**7**).

To a solution of 0.835 g (2.50 mmoles) of **4a** in 10 ml of glacial acetic acid, 2.5 ml of 30% hydrogen peroxide was added slowly at room temperature. The mixture was warmed to 90° for 2 hours and a white product was formed. After cooling at room temperature, the solid was filtered off and washed with hot ethanol to give 0.92 g (93%), of the pure title compound as white needles mp 300-301° dec. An analytical sample was recrystallized from acetonitrile. ^{1}H nmr (dimethyl sulfoxide-d_6): δ 3.38 (br s, 6H, methyl).

Anal. Calcd. for $C_6H_6Br_2O_4S_3$: C, 18.10; H, 1.51; S, 24.16. Found: C, 18.18; H, 1.45; S, 24.23.

4-Bromo-2,5-bis(methylthio)thiophene-3-carboxylic Acid (**8**).

To a cooled solution of 10.02 g (30.0 mmoles) of 3,4-dibromo-2,5-bis(methylthio)thiophene (**4a**) in 250 ml of anhydrous ether at −78° under nitrogen, 16 ml of 2.02 *N* butyllithium in cyclohexane (32.0 mmoles) was added dropwise. After 30 minutes the reaction mixture was poured onto solid carbon dioxide in ether. Water was added at room temperature and after extraction, the organic layer was separated and the water phase was washed with ether and then acidified with ice-cold 1 *N* hydrochloric acid and the precipitated acid was dissolved in ether. The ethereal solution was dried over magnesium sulfate and evaporated, giving a solid crude product which was recrystallized from ethanol/water (2:1), yielding 4.57 g (51%) of the title compound as colorless needles, mp 179-180°; ir (potassium bromide): 3500 (OH), 1670 (C=O), 1260, 1230 cm^{-1}; ^{1}H nmr (deuteriochloroform): δ 2.58 (s, 3H, methyl), 2.45 (s, 3H, methyl).

Anal. Calcd. for $C_7H_7BrO_2S_3$: C, 28.19; H, 2.36; S, 32.15. Found: C, 28.25; H, 2.18; S, 32.25.

General Procedure for the Synthesis of **9a-c**.

A cooled solution of 1.02 g (4.00 mmoles) of **3a, 3b** or **3c** in 75 ml of anhydrous ether under nitrogen at −78° was treated dropwise with 2.20 ml of 2.02 *N* butyllithium in cyclohexane (4.40 mmoles). The solution was stirred for 30 minutes and then a solution of 1.13 g (12.0 mmoles) of methyl chloroformate in 5 ml of anhydrous ether was slowly added. After 3 hours at −78° the reaction was allowed to slowly warm to room temperature and quenched with ice-cold saturated ammonium chloride solution. The organic layer was separated and dried over magnesium sulfate. Removal of the solvent followed by column chromatography using hexane/ethyl acetate (5:1) as eluent afforded a colorless oil.

Methyl 2,5-Bis(methylthio)-3-thiophenecarboxylate (**9a**).

Crystallization from pentane gave 0.84 g (90%), of the title compound as white needles mp 34-35°; ir (potassium bromide): 1700 (C=O), 1225 cm^{-1}; ^{1}H nmr (deuteriochloroform): δ 7.40 (s, 1H, 4-H), 3.84 (s, 3H, OCH_3), 2.58 (s, 3H, SCH_3), 2.45 (s, 3H, SCH_3); ms: m/z 234 (M^+).

Anal. Calcd. for $C_8H_{10}O_2S_3$: C, 40.99; H, 4.30; S, 41.05. Found: C, 41.47; H, 4.63; S, 40.76.

Methyl 4,5-Bis(methylthio)-2-thiophenecarboxylate (**9b**).

This compound was obtained in a yield of 0.76 g (82%), bp 136-138°/0.5 mm Hg; ir (neat): 1705 (C=O), 1250 cm^{-1}; ^{1}H nmr (deuteriochloroform): δ 7.64 (s, 1H, 3-H), 3.87 (s, 3H, OCH_3), 2.56 (s, 3H, SCH_3), 2.44 (s, 3H, SCH_3); ms: m/z 234 (M^+).

Anal. Calcd. for $C_8H_{10}O_2S_3$: C, 40.99; H, 4.30; S, 41.05. Found: C, 41.43; H, 4.65; S, 40.85.

Methyl 4,5-Bis(methylthio)-3-thiophenecarboxylate (**9c**).

This compound was obtained in a yield of 0.60 g (64%), bp 125-127°/0.3 mm Hg; ir (neat): 1720 (C=O), 1240, 1210 cm^{-1}; ^{1}H nmr (deuteriochloroform): δ 8.01 (s, 1H, 2-H), 3.86 (s, 3H, OCH_3), 2.52 (s, 3H, SCH_3), 2.41 (s, 3H, SCH_3); ms: m/z 234 (M^+).

Anal. Calcd. for $C_8H_{10}O_2S_3$: C, 40.99; H, 4.30; S, 41.05. Found: C, 41.45; H, 4.60; S, 40.86.

Dimethyl 4,5-Bis(methylthio)-2,3-thiophenedicarboxylate (**10**).

An analytical sample was purified by semipreparative hplc using heptane/ethyl acetate (9:1) for elution. Recrystallization from ethanol gave 0.21 g (18%) of the title compound as pale yellow needles mp 112-113°; ir (potassium bromide): 1728 (C=O), 1705 (C=O), 1280, 1220 cm^{-1}; ^{1}H nmr (deuteriochloroform): δ 3.97 (s, 3H, OCH_3), 3.85 (s, 3H, OCH_3), 2.61 (s, 3H, SCH_3), 2.31 (s, 3H, SCH_3).

Anal. Calcd. for $C_{10}H_{12}O_4S_3$: C, 41.07; H, 4.13; S, 32.90. Found: C, 41.24; H, 4.11; S, 33.04.

General Procedure for the Synthesis of **11, 12a** and **b**.

A cooled solution of 1.53 g (6.00 mmoles) of **3a, 3b** or **6** in 75 ml of anhydrous ether at −78° under nitrogen was treated with 3.10 ml of 2.02 *N* butyllithium in cyclohexane (6.20 mmoles) and stirred for 30 minutes. After which 0.19 g (2.00 mmoles) of methyl chloroformate in 2 ml of anhydrous ether was slowly added and the mixture was stirred for 4 hours at −78° and then allowed to warm to room temperature overnight. The reaction mixture was quenched with ice-cold saturated ammonium chloride solution. The organic phase was dried over magnesium sulfate and vacuum evaporated at room temperature. The crude product was column chromatographed using hexane/ethyl acetate (4:1) for elution.

Tris[2,5-bis(methylthio)-3-thienyl]carbinol (**12a**).

Recrystallization from hexane gave 0.37 g (34%), of the title compound as white crystals, mp 96-97°; ^{1}H nmr (deuteriochloroform): δ 7.07 (s, 3H, 4-H), 2.47 (s, 9H, methyl), 2.12 (s, 9H, methyl); ms: m/z 554 (M^+).

Anal. Calcd. for $C_{19}H_{22}OS_9$: C, 41.11; H, 3.99; S, 52.00. Found: C, 41.06; H, 4.06; S, 52.12.

Methyl Tris[2,5-bis(methylthio)-3-thienyl] Ether (**13**).

Recrystallization from hexane gave 0.10 g (9%) of the title compound as white crystals, mp 102-103°; ^{1}H nmr (deuteriochloroform): δ 7.21 (s, 3H, 4-H), 3.09 (s, 3H, OCH_3), 2.45 (s, 9H, SCH_3), 2.34 (s, 9H, SCH_3); ms: 568 (M^+).

Anal. Calcd. for $C_{20}H_{24}OS_9$: C, 42.21; H, 4.25; S, 50.72. Found: C, 42.15; H, 4.30; S, 51.02.

Tris[4,5-bis(methylthio)-2-thienyl]carbinol (**12b**).

Recrystallization from hexane gave 1.69 g (45%), of the title compound as white solid mp 95-96°; ^{1}H nmr (deuteriochloroform): δ 6.96 (s, 3H, 3-H), 2.49 (s, 9H, methyl), 2.47 (s, 9H, methyl); ms: m/z 554 (M^+).

Anal. Calcd. for $C_{19}H_{22}OS_9$: C, 41.11; H, 3.99; S, 52.00. Found: C, 40.92; H, 3.93; S, 51.86.

Tris[2,4,5-tris(methylthio)-3-thienyl]carbinol (**11**).

Recrystallization from hexane gave 0.20 g (15%), of the title compound as colorless solid, mp 133-134°; ^{1}H nmr (deuteriochloroform): δ 2.52 (s, 9H, methyl), 2.32 (br s, 18H, methyl); ms: m/z 692 (M^+); hrms: Calcd. for $C_{22}H_{28}OS_{12}$: 691.8788. Found: 691.8792.

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