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Regioselective Palladium(0)-Catalyzed Cross-Coupling Reactions and Metal-Halide Exchange Reactions of Tetrabromothiophene: Optimization, Scope and Limitations

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Abstract: The Suzuki reaction of tetrabromothiophene with arylboronic acids provides a regioselective approach to various 5-aryl-2,3,4-tribromothiophenes, symmetrical 2,5-diaryl-3,4-dibromothiophenes, and tetraarylthiophenes. Unsymmetrical 2,5-diaryl-3,4-dibromothiophenes are prepared by Suzuki reaction of 5-aryl-2,3,4-tribromothiophenes. Tetraarylthiophenes containing two different types of aryl groups are obtained by Suzuki reactions of 2,5-diaryl-3,4-dibromothiophenes. During the optimization of the conditions of each individual reaction, the solvent, the catalyst and the temperature play an important role. In several cases, classical conditions [use of tetrakis(triphenylphosphane)palladium(0), $Pd(PPh_3)_4$, as the catalyst] gave excellent yields. The yields of those transformations which failed or proceeded sluggishly could be significantly improved by application of a new biarylmonophosphine ligand developed by Buchwald and co-workers. Regioselective metal-halide exchange reactions of tetrabromothiophene provide a convenient approach to various 2,5-disubstituted 3,4-dibromothiophenes. 5-Alkyl-2-trimethylsilyl-3,4-dibromothiophenes could be prepared in one pot by sequential addition of trimethylchlorosilane and alkyl bromides. The reaction of tetrabromothiophene with methyl chloroformate and subsequent Suzuki reactions afforded 3,4-diaryl-2,5-bis(methoxycarbonyl)thiophenes.

Keywords: cross-coupling reactions; heterocycles; palladium; regioselectivity; thiophenes

Introduction

Regioselective functionalizations of polyhalogenated heterocycles play an increasingly important role in organic synthesis.[1] Such reactions rely on the higher reactivity of more electron-deficient carbon atoms while the other reactive positions remain unattacked. This concept has been applied to regioselective palladium(0)-catalyzed cross-coupling reactions based on different rates of oxidative additions of palladium(0) species to different carbon-halide bonds of polyhalogenated substrates. Thiophene-containing compounds constitute an important class of materials which show intrinsic electronic properties such as luminescence, redox activity, non-linear optical chromism and electron transport.[2] This includes, for example, dibenzothiophenes,[3] [2,2′;5′,2″]terthiophenes,[4] and thienyldiynes.[5] Aryl-substituted thiophenes possess a wide range of pharmacological properties and play an important role in medicinal chemistry.[6] Besides, functionalized thiophenes occur in a number of natural products.[7]

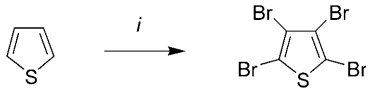
2,3-Dibromothiophene has been functionalized by regioselective Sonogashira coupling of carbon atom C-2.[8] A very good C-2 regioselectivity was observed also for the Kumada cross-coupling of 2,3- and 2,4-dibromothiophene.[9] 2,5-Disubstituted thiophenes were prepared by regioselective Sonogashira coupling reactions of tetraiodothiophene[10] and tetrabromothiophene.[11] Recently, we reported the synthesis of *symmetrical* 2,3,4,5-tetraaryl- and 2,5-diaryl-3,4-dibromothiophenes by regioselective Suzuki reactions of tetrabromothiophene.[12] In our preliminary study, all reactions were carried out under 'classical' conditions [use of 10–20 mol% of $Pd(PPh_3)_4$]. Although these transformations proceeded with excellent yields in a number of cases, several other reactions failed or proceeded sluggishly with only moderate or low yields. With respect to our preliminary studies, we herein report a significant optimization of the yields by ap-

plication of a new biarylmonophosphine ligand developed by Buchwald and co-workers. We also report, for the first time, the selective synthesis of 5-aryl-2,3,4-tribromothiophenes and their transformation into *unsymmetrical* 2,5-diaryl-3,4-dibromothiophenes. In addition, we report regioselective metal-halide exchange reactions of tetrabromothiophene. Although a few isolated examples of such reactions have been reported in the literature,[13] we have studied the preparative scope and new synthetic applications. In addition, we have developed a one-pot synthesis of 5-alkyl-2-trimethylsilyl-3,4-dibromothiophenes by sequential addition of trimethylchlorosilane and alkyl bromides.

Results and Discussion

Suzuki Reactions

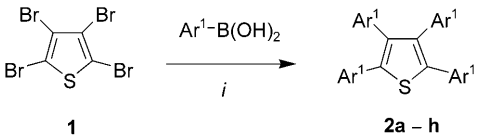
Tetrabromothiophene (**1**) was prepared by bromination of thiophene (following a modified literature procedure) (Scheme 1).[14] During the optimization, it



Scheme 1. Synthesis of tetrabromothiophene (**1**) *Conditions*: *i*, 1) Br_2 (7.0 equiv., slow addition), 0 °C, $CHCl_3$; 2) reflux, 3 h; 3) NaOH, H_2O (2 M), reflux, 6 h.

proved to be important to add dropwise an excess of bromine (dissolved in chloroform) to a chloroform solution of thiophene at 0 °C. A saturated aqueous solution of NaOH was added and the mixture was stirred under reflux for 6 h. The product was recrystallized from a 1:1 solution of chloroform and methanol. The crude product (red to brownish crystals) was washed with cold ethyl acetate for several times to give pure **1** as colourless crystals (87%). We have observed that it is crucial to isolate **1** in analytically pure form as colourless crystals. The oily form is generally slightly impure, tends to be considerably less stable and decomposes within a few days. The presence of impurities results in the failure of Pd(0)-catalyzed cross-coupling reactions. In contrast, the crystalline solid can be stored under an argon atmosphere at −18 °C (in the dark) for a few weeks. Then, the compound starts to slightly darken and it cannot be successfully used anymore in Pd(0)-catalyzed reactions.

The tetraarylthiophenes **2a–g**, containing four identical aryl groups, were successfully prepared by Suzuki reaction[15] of **1** (1.0 equiv.) with 5.0 equiv. of various boronic acids (Scheme 2, Table 1). All reac-



Scheme 2. Synthesis of tetraarylthiophenes **2a–h**. *Conditions:* *i*, procedure A: **1** (1.0 equiv.), $Ar^1B(OH)_2$ (5.0 equiv.), $Pd(PPh_3)_4$ (10 mol%), K_3PO_4 (8.0 equiv.), solvent/H_2O = 4:1 (solvent see Table 1); procedure B: **1** (1.0 equiv.), $Ar^1B(OH)_2$ (6.0 equiv.), $Pd(OAc)_2$ (5 mol%), **L** (10 mol%, see Figure 1), K_3PO_4 (8.0 equiv.), dioxane/toluene, 100 °C, 12 h.

Table 1. Synthesis of 2,3,4,5-tetraarylthiophenes **2a–h**.

2	Ar^1	Solvent	% (A)[a]	% (B)[b]
a	Ph	Toluene	37[c]	70
b	4-MeO-C_6H_4	1,4-Dioxane	94[d]	
c	2-MeO-C_6H_4	1,4-Dioxane	38[d]	65
d	1-Naphthyl	Toluene	65[d]	
e	4-Me-C_6H_4	Toluene	87[c]	
f	4-Cl-C_6H_4	Toluene	89[d]	
g	4-F-C_6H_4	Toluene	93[d]	
h	2-Thienyl	Toluene	–	81

[a] Isolated yields, procedure A (see Scheme 1).
[b] Isolated yields, procedure B (see legend of Scheme 1).
[c] Reaction time: 12 h.
[d] reaction time: 24 h.

tions were performed based on optimization studies of Suzuki reactions carried out in our laboratory.[16] The protocol is defined as 'procedure A' in the present manuscript. Tetrakis(triphenylphosphane)palladium(0) and potassium phosphate were used as catalyst and base, respectively. The stoichiometry of the reagents, the temperature, the solvent, and the presence of water proved to be important parameters. Oxygen-containing boronic acids showed a better solubility in 1,4-dioxane than in toluene. On the other hand, the higher boiling point of toluene proved to be advantageous in many cases. All reactions were carried out in the presence of water (solvent/water = 4:1) which proved to be very important in order to obtain good yields.[17] While products **2b** and **2d–g** were formed in excellent yields, **2a** and **2c** could be isolated in only moderate yields. The low yield of **2c** can be explained by steric effects. Products **2b**, **2e**, **2f** and **2g**, which are derived from boronic acids containing electron-donating and electron-withdrawing substituents, were isolated in excellent yields. This result suggests that the electronic nature of the boronic acid does not have a major influence on the yield. The relatively low yield of **2a** is surprising, since it cannot be explained by steric or electronic reasons. The low yield of **2a** is due to practical problems associated with the difficult chromatographic purification. The synthesis of tetra-(thien-2-yl)thiophene (**2h**) completely failed. Howev-

er, products **2a**, **2c** and **2h** could be prepared in good yields by using $Pd(OAc)_2$ and the new biarylmonophosphine ligand **L** developed by Buchwald and co-workers (Figure 1).[18]

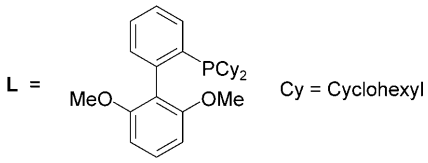
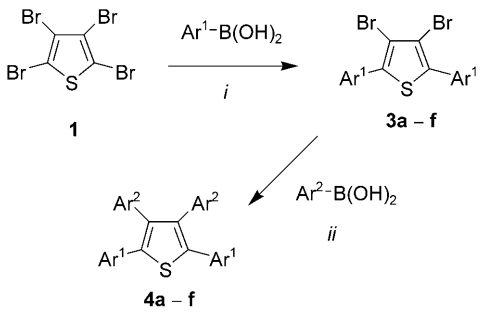


Figure 1. Biaryl monophosphine ligand developed by Buchwald and co-workers (ref.[18]).

The reaction of **1** (1.0 equiv.) with 2.2 equiv. of boronic acids allowed the regioselective synthesis of the 2,5-diaryl-3,4-dibromothiophenes **3a–f** (Scheme 3, Table 2). The application of procedure A [$Pd(PPh_3)_4$] allowed us to prepare the products in moderate yields (except for **3b** which was isolated in good yield). The yields of **3a** and **3c–f** were significantly improved by application of method B [$Pd(OAc)_2$, **L**]. The reaction of **3a**, **b** (1.0 equiv.) with various arylboronic acids (3.0 equiv.) afforded the tetraarylthiophenes **4a–f**, containing two different types of aryl groups, in good yields (Scheme 3, Table 3). For oxygen-containing boronic acids, the use of a mixture of toluene and dioxane again proved to be advantageous in terms of yield (*vide supra*). The structures of all products were established by spectroscopic methods. The structure of **3b** was independently confirmed by an X-ray crystal structure analysis.



Scheme 3. Synthesis of symmetrical 2,5-diaryl-3,4-dibromothiophenes **3a–f** and tetraarylthiophenes **4a–f**. *Conditions*: *i*, procedure A: **1** (1.0 equiv.), $Ar^1B(OH)_2$ (2.2 equiv.), $Pd(PPh_3)_4$ (6 mol%), K_3PO_4 (4.0 equiv.), solvent/H_2O = 4:1 (solvent see Table 3); procedure B: **1** (1.0 equiv.), $Ar^1B(OH)_2$ (2.2 equiv.), $Pd(OAc)_2$ (5 mol%), **L** (see Figure 1, 10 mol%), K_3PO_4 (4.0 equiv.), dioxane/toluene, reflux, 8 h; *ii*, **3a**, **b** (1.0 equiv.), $Ar^2B(OH)_2$ (3.0 equiv.), $Pd(PPh_3)_4$ (10 mol%), K_3PO_4 (4.0 equiv-), solvent/H_2O = 4:1 (solvent see Table 4).

The Suzuki reaction of **1** with various boronic acids (1.1 equiv.) afforded the 5-aryl-2,3,4-tribromothiophenes **5a–f** in good yields and with very good regioselectivity (Scheme 4, Table 4). The syntheses of **5a–e** were carried out by application of procedure B [$Pd(OAc)_2$, **L**]. Thiophene **5f** was prepared by application of method A. During the optimization, it was important to suppress the formation of 2,5-diaryl-3,4-dibromothiophenes, as their separation from the desired products proved to be difficult. The structure of **5f** was independently confirmed by an X-ray crystal structure analysis (Figure 2).[19] The reaction of **5b** with 1.2 equiv. of arylboronic acids, following again procedure B, resulted in regioselective formation of the unsymmetrical 2,5-diaryl-3,4-dibromothiophenes **6a–c** (Scheme 4).

Table 2. Synthesis of symmetrical 2,5-diaryl-3,4-dibromothiophenes **3a–f**.

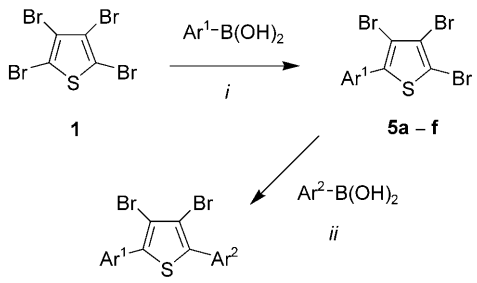
3	Ar^1	Solvent	% (A)[a]	% (B)[b]
a	Ph	Toluene	32[c]	88
b	4-Me-C_6H_4	Toluene	77[c]	
c	4-MeO-C_6H_4	1,4-Dioxane	43[d]	85
d	2-MeO-C_6H_4	1,4-Dioxane	35[d]	79
e	3,5-$Me_2C_6H_3$	Toluene	54[d]	91
f	2-Thienyl	Toluene	54[d]	71

[a] Isolated yields, procedure A (see Scheme 1).
[b] Isolated yields, procedure B (see Scheme 1).
[c] Reaction time: 12 h.
[d] Reaction time: 24 h.

Table 3. Synthesis of tetraarylthiophenes **4a–f**.

4	Ar^1	Ar^2	Solvent	% (A)[a]
a	Ph	4-Me-C_6H_4	Toluene	86[b]
b	4-Me-C_6H_4	Ph	Toluene	51[b]
c	4-Me-C_6H_4	4-MeO-C_6H_4	Dioxane/Toluene (1:1)	76[c]
d	4-Me-C_6H_4	4-EtO-C_6H_4	Dioxane/Toluene (1:1)	93[c]
e	4-Me-C_6H_4	4-HO-C_6H_4	Dioxane/Toluene (1:1)	82[c]
f	4-Me-C_6H_4	4-Cl-C_6H_4	Toluene	91[c]

[a] Isolated yields.
[b] Reaction time: 12 h
[c] Reaction time: 24 h



1 5a – f

6a Ar^1 = 4-MeO-C_6H_4, Ar^2 = 4-Et-C_6H_4: 72%
6b Ar^1 = 4-MeO-C_6H_4, Ar^2 = 3,5-$Me_2C_6H_3$: 67%
6c Ar^1 = 4-MeO-C_6H_4, Ar^2 = 3-Ph-C_6H_4: 69%

Scheme 4. Synthesis of 5-aryl-2,3,4-tribromothiophenes **5a–f** and unsymmetrical 2,5-diaryl-3,4-dibromothiophenes **6a–c**. *Conditions*: *i*, **1** (1.0 equiv.), $Ar^1B(OH)_2$ (1.2 equiv.), $Pd(OAc)_2$ (5 mol%), **L** (see Figure 1, 10 mol%), K_3PO_4 (4.0 equiv.), dioxane/toluene, reflux, 8 h; *ii*, **5b** (1.0 equiv.), $Ar^2B(OH)_2$ (1.2 equiv.), $Pd(OAc)_2$ (5 mol%), **L** (see Figure 1, 10 mol%), K_3PO_4 (4.0 equiv.), dioxane/toluene, reflux, 8 h.

Table 4. Products and yields.

5	Ar^1	% (**5**)[a]
a	2-MeO-C_6H_4	75
b	4-MeO-C_6H_4	80
c	3-Ph-C_6H_4	77
d	2-Naphthyl	69
e	4-Et-C_6H_4	87
f	Ph	61

[a] Isolated yields (**5a–e**: procedure B, **5f**: procedure A).

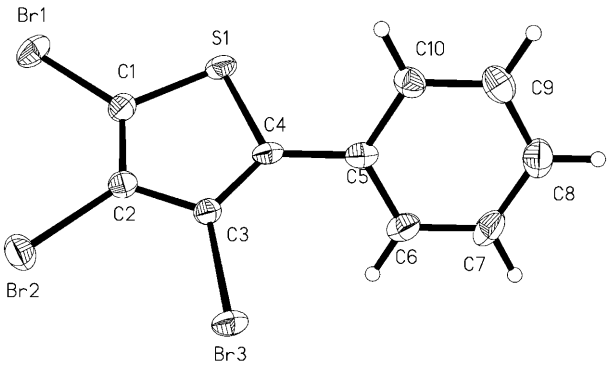
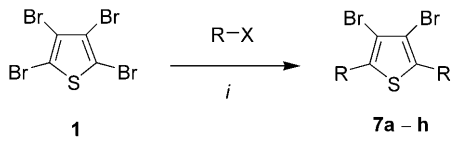


Figure 2. ORTEP plot of **5f** (50% probability level).

Metal-Halide Exchange Reactions

The addition of *n*-butyllithium (2.5 equiv.) to a THF solution of tetrabromothiophene (**1**) (1.0 equiv.) and subsequent addition of alkyl halides (3.0 equiv.) afforded the 2,5-dialkyl-3,4-dibromothiophenes **7a–d** (Scheme 5, Table 5). This approach is preparatively useful, since the Suzuki reaction of tetrabromothiophene with alkylboronic acids failed. All attempts to prepare 3,4-dibromo-2,5-dihexylthiophene from **1** under Suzuki conditions using a variety of different ligands [e.g., dppf, P(*t*-Bu)$_3$, PPh_3, BINAP] failed. 3,4-Dibromo-2,5-bis(trimethylsilyl)thiophene (**7e**) was prepared in good yield from **1** and trimethylchlorosilane. The reaction of dilithiated **1** with dimethyl disulphide afforded thiophene **7f**. Thiophenes **7g** and **7h** were prepared by reaction of dilithiated **1** with methyl chloroformate and benzoyl chloride, respectively. During the optimization of the reactions, the stoichiometry (excess of base and electrophile) played an important role. The structure of the products was established by spectroscopic methods. The structure of **7g** was independently confirmed by an X-ray crystal structure analysis (Figure 3).[19]



1 7a – h

Scheme 5. Synthesis of symmetrical 3,4-dibromothiophenes **7a–h**. *Conditions: i*, 1) *n*-BuLi (2.5 equiv.), −78 °C, 1 h; 2) RX (3.0 equiv.), −78→20 °C, 16 h.

Table 5. Synthesis of symmetrical 3,4-dibromothiophenes **7a–h**.

7	R	X	%[a]
a	Me	Br	56
b	*n*-Bu	I	94
c	*iso*-Pent	Br	77
d	*n*-Dodec	Br	89
e	$SiMe_3$	Cl	82
f	SMe	SMe	55
g	CO_2Me	Cl	52
h	COPh	Cl	68

[a] Isolated yields

Müller and co-workers have recently reported an interesting one-pot synthesis of 2,5-disubstituted thiophenes from 2,5-dibromothiophene.[20] The metal-halide exchange of 2,5-dibromothiophene, carried out by means of 2 equiv. of *n*-BuLi, gave 2,5-dilithiothiophene. The sequential addition of two different electrophiles to the latter afforded a number of unsymmetrical 2,5-disubstituted thiophenes. The best yields were obtained when the reaction of the electrophile, which was added first, follows the S_N2 mechanism (e.g., Me_3SiCl). The initial use of electrophiles, which follow an addition-elimination pathway [e.g., $B(OMe)_3$], was less efficient in terms of yield because Coulomb interactions of the two anionic sites in the intermediate affect the attack of the second electrophile. Reactions of primary alkyl halides, which

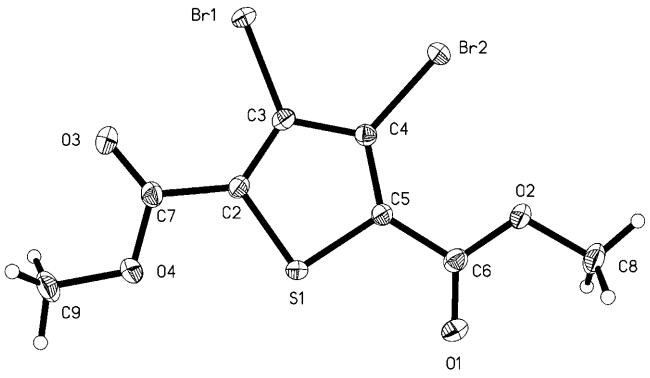
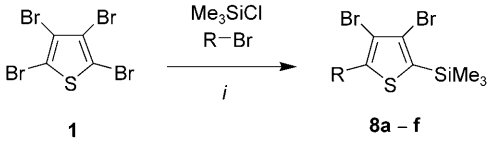


Figure 3. ORTEP plot of **7g**.

follow the S_N2 mechanism, have not been reported (either in the first or in the second step).

We have found that the addition of *n*-butyllithium (2.5 equiv.) to a THF solution of tetrabromothiophene (**1**) (1.0 equiv.) and subsequent sequential addition of trimethylchlorosilane (1.0 equiv., slow addition during 3 h) and of an alkyl bromide (1.2 equiv.) directly afforded the 5-alkyl-3,4-dibromo-2-(trimethylsilyl)thiophenes **8a–f** in 51–65% yield (Scheme 6, Table 6). The



Scheme 6. Synthesis of 5-alkyl-2-trimethylsilyl-3,4-dibromothiophenes **8a–f**. *Conditions: i*, 1) **1** (1.0 equiv.), *n*-BuLi (2.5 equiv.), TMEDA (2.5 equiv.), −78 °C, 30 min; 2) Me_3SiCl (1.0 equiv., addition during 3 h), 30 min, −78 °C; 3) RBr (1.2 equiv.), −78 °C, 4 h.

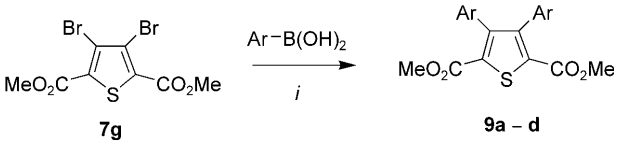
Table 6. Synthesis of unsymmetrical 3,4-dibromothiophenes **8a–f**.

8	R	% [a]
a	Et	65
b	*n*-Bu	61
c	*iso*-Pent	60
d	*n*-Hex	60
e	*n*-Hept	55
f	*n*-Undec	51

[a] Isolated yields.

selective reaction of **1** with one equivalent of Me_3SiCl in the first step is in line with the results of Müller et al. and indicates that the reaction of Me_3SiCl with 2,5-dilithio-3,4-dibromothiophene is significantly faster than the reaction with 5-lithio-2-trimethylsilyl-3,4-dibromothiophene. However, the application of this strategy to the synthesis of unsymmetrical 2,5-dialkylthiophenes, containing two different alkyl groups, proved to be unsuccessful. This failure might be explained by the assumption that the rates of the reactions of alkyl halides with 2,5-dilithio-3,4-dibromothiophene and with 2-alkyl-5-lithio-3,4-dibromothiophene are similar. The reason for this remains unclear at present.

The double Suzuki reaction of diester **7g** with arylboronic acids afforded the 3,4-diarylthiophenes **9a–d** (Scheme 7, Table 7). Products **9a–c** were prepared by



Scheme 7. Synthesis of 3,4-diarylthiophenes **9a–d**. *Conditions: i*: Procedure A: **7g** (1.0 equiv.), $ArB(OH)_2$ (3.0 equiv.), $Pd(PPh_3)_4$ (5 mol%), K_3PO_4 (4.0 equiv.), solvent/H_2O = 4:1 (solvent see Table 5). Procedure B: **7g** (1.0 equiv.), $ArB(OH)_2$ (2.5 equiv.), $Pd(OAc)_2$ (5 mol%), **L** (see Figure 1, 10 mol%), K_3PO_4 (4.0 equiv.), dioxane, reflux, 8 h.

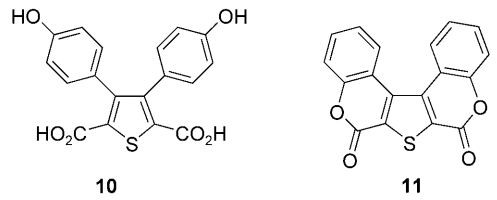
Table 7. Synthesis of 3,4-diarylthiophenes **9a–d**.

9	Ar	% (A)[a]	% (B)[b]
a	4-Cl-C_6H_4	42[c]	
b	2-MeO-C_6H_4	45[d]	85[c]
c	2-HO-C_6H_4	49[d]	
d	4-HO-C_6H_4		71[d]

[a] Isolated yields (procedure A).
[b] Isolated yields (procedure B).
[c] Solvent: toluene.
[d] Solvent: toluene/dioxane = 1:1.
[e] Solvent: dioxane.

application of procedure A. The best results were obtained, similar to the experiments outlined above, when dioxane was used for boronic acids containing oxygen (products **9b**, **c**). The yield of **9b** was much improved by application of protocol B. Likewise, product **9d** was prepared in good yield by application of protocol B.

Recently, 3,4-bis(4′-hydroxyphenyl)pyrrole-2,5-dicarboxylic acid was isolated from a new marine *Halomonas* sp. strain.[21] This compound shows potent antitumour-promoting activities. The sulphur analogue **10** of this natural product was prepared in 96% yield by base-mediated hydrolysis of **9d** (Scheme 8). Recently, the natural product ningaline A, a pyrrole-based bislactone, was isolated from marine sources.[22] This compound also exhibits a strong anti-proliferative activity. The sulphur analogue **11** of ningaline A was prepared in 65% yield by treatment of **9b** with BBr_3



Scheme 8. Structures of thiophene derivatives **10** and **11**.

and subsequent addition of potassium *tert*-butanolate (Scheme 8).

Conclusions

In conclusion, we have reported Suzuki reactions of tetrabromothiophene with arylboronic acids which provide a regioselective approach to various 5-aryl-2,3,4-tribromothiophenes, symmetrical 2,5-diaryl-3,4-dibromothiophenes, and tetraarylthiophenes. Unsymmetrical 2,5-diaryl-3,4-dibromothiophenes are prepared by Suzuki reaction of 5-aryl-2,3,4-tribromothiophenes. Tetraarylthiophenes containing two different types of aryl groups are obtained by Suzuki reactions of 2,5-diaryl-3,4-dibromothiophenes. During the optimization of the reaction conditions, the solvent and the catalyst played an important role. In several cases, classical conditions [$Pd(PPh_3)_4$] gave excellent yields. The yields of those transformations which completely failed or proceeded sluggishly could be significantly improved by application of a new biarylmonophosphine ligand developed by Buchwald and co-workers. Regioselective metal-halide exchange reactions of tetrabromothiophene provide a convenient approach to 2,5-dialkyl-3,4-dibromothiophenes. 2-Trimethylsilyl-5-alkyl-3,4-dibromothiophenes could be prepared in a one-pot protocol by sequential addition of trimethylchlorosilane and alkyl bromides. The reaction of tetrabromothiophene with methyl chloroformate and subsequent Suzuki reactions afforded 3,4-diaryl-2,5-bis(methoxycarbonyl)thiophenes.

Experimental Section

General Comments

All solvents were dried by standard methods and all reactions were carried out under an inert atmosphere. For ^1H and ^{13}C NMR spectra the deuterated solvents indicated were used. Mass spectrometric data (MS) were obtained by electron ionization (EI, 70 eV), chemical ionization (CI, H_2O) or electrospray ionization (ESI). For preparative scale chromatography, silica gel (60–200 mesh) was used. Melting points are uncorrected.

Synthesis of Tetrabromothiophene (1)[14]

To a chloroform solution (10 mL) of thiophene (25 mL) a chloroform solution (20 mL) of bromine (60 mL) was dropwise added within 45 min at 0 °C. The reaction mixture was warmed to room temperature and an additional amount of bromine (10 mL) was added and the reaction mixture was subsequently stirred under reflux for three hours. A saturated aqueous solution of NaOH was added and the mixture was stirred under reflux for 6 h to remove the bromine. The solvent and the excess of bromine were removed under vacuum. The product was recrystallized from a 1:1 solution of chloroform and methanol. The crude product (red to brownish crystals) was washed with cold ethyl acetate for several times to give pure **1** as colourless crystals; yield: 87%. ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 110.3$, 116.9; MS (EI, 70 eV): *m/z* (%) = 400 (M^+, 100), 321 (65), 240 (34), 161 (41).

General Procedure A for the Synthesis of 2a–h

To a solution (for the solvents, see the individual procedures given below) of **1** was added $Pd(PPh_3)_4$ (10 mol%) at 20 °C. After stirring for 30 min, the arylboronic acid, K_3PO_4 (8.0 mmol) and water (1.0 mL) were added. The mixture was stirred for the indicated period of time at the indicated temperature. After cooling to ambient temperature, the mixture was diluted with EtOAc, dried (Na_2SO_4), and filtered through a short Celite pad. The solution was concentrated under vacuum and the residue was purified by flash column chromatography (fine flash silica gel, *n*-heptane). The solvents and the amounts are given in the individual procedures (see below).

General Procedure B for the Synthesis of 2a–h

An oven-dried Schlenk flask was charged with $Pd(OAc)_2$ (5 mol%), ligand **L** (10 mol%), the starting material **1**, the boronic acid (6.0 equiv.) and powered, anhydrous K_3PO_4 (8.0 equiv.). The Schlenk flask was filled with argon. The solvent was added by syringe through a septum. The septum was replaced by a condenser in an argon stream. The reaction mixture was stirred and refluxed for the indicated period of time at the indicated temperature. The solution was allowed to cool to ambient temperature and water (5 mL) was added. The aqueous and the organic layer were separated and the latter was dried Na_2SO_4. The solution was filtered and the filtrate was concentrated under reduced pressure. The residue was purified by flash column chromatography (fine flash silica gel, heptanes). The solvents and the amounts are given in the individual procedures (see below).

Tetraphenylthiophene (2a): Procedure B: 5 mL of toluene, reflux 12 h, 100 °C. Starting with **1** (0.400 g, 1.0 mmol) and phenylboronic acid (0.609 g, 5.0 mmol), $Pd(OAc)_2$ (11 mg, 5 mol%), **L** (41 mg, 10 mol-%), K_3PO_4 (1.7 g, 8.0 mmol), **2a** was isolated as a colourless solid; yield: 0.271 g (70%); mp 168–170 °C. ^1H NMR (300 MHz, $CDCl_3$): $\delta = 6.87$ (m, 4 × 2H, Ar), 7.03 (m, 4 × 2H, Ar), 7.14 (m, 2 × 2H, Ar); ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 126.6$, 127.2, 127.8, 128.2, 129.1, 130.8 (CH, Ar), 134.2, 136.4, 138.5, 139.4 (C, ArC); IR (KBr): $\tilde{\nu} = 3058$ (w), 3022 (w), 1596 (m), 1495 (m), 1480 (m), 1444 (w), 1073 (w), 1029 (w), 793 (w), 750 (s), 695 (s),

592 (m), 518 cm^{-1} (w); MS (EI, 70 eV): *m/z* (%) = 388 (M^+, 100), 354 (4), 310 (6), 267 (4), 178 (3), 165 (6), 121 (3), 77 (2); HR-MS (EI, 70 eV): *m/z* = 388.1274, calcd. for $C_{28}H_{20}S$ (M^+): 388.1280; elemental analysis calcd. (%) for $C_{28}H_{20}S$ (388.1): C 86.56, H 5.19; found: C 86.73, H 5.29.

Tetra(4-methoxyphenyl)thiophene (2b): Procedure A: dioxane:H_2O = 4:1 (5 mL), reflux 24 h, 100 °C. Starting with **1** (0.400 g, 1.0 mmol) and (4-methoxyphenyl)boronic acid (0.759 g, 5.0 mmol), $Pd(PPh_3)_4$ (0.115 g, 10 mol%), K_3PO_4 (1.7 g, 8.0 mmol), **2b** was isolated as a colourless solid; yield: 0.477 g (94%); mp 183–185 °C. ^1H NMR (300 MHz, $CDCl_3$): δ = 3.65, 3.72 (s, 12 H, 2×2OCH_3), 6.59, 6.69, 6.82, 7.09 (d, 4×4 H, CH, Ar); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 55.00, 56.06 (C, OCH_3), 114.8, 116.0, 130.2, 131.9 (CH, Ar), 127. 0, 129.0, 137.1, 138.3, 158.0, 158.6 (C, ArC); IR (KBr): $\tilde{\nu}$ = 3431 (w), 3031 (m), 3003 (m), 2957 (m), 2924 (m), 2840 (m), 1607 (m), 1511 (s), 1495 (s), 1286 (s), 1175 (s), 1031 (s), 834 (s), 799 cm^{-1} (m); MS (EI, 70 eV): *m/z* (%) = 508 (M^+, 100), 255 (31), 178 (15), 172 (29), 160 (26), 96 (10); HR-MS (EI, 70 eV): *m/z* = 508.6277, calcd. for $C_{32}H_{28}O_4S$ (M^+): 508.6273; elemental analysis calcd. (%) for $C_{32}H_{28}O_4S$ (508.2): C 75.56, H 5.55, S 6.30; found: C 75.77, H 5.35, S 6.11.

Tetra(2-methoxyphenyl)thiophene (2c): Procedure B: 5 mL of dioxane, reflux 12 h, 100 °C. Starting with **1** (0.400 g, 1.0 mmol) and (2-methoxyphenyl)boronic acid (0.759 g, 5.0 mmol), $Pd(PPh_3)_4$ (0.115 g, 10 mol-%), K_3PO_4 (1.7 g, 8.0 mmol), **2c** was isolated as a colourless solid; yield: 0.33 g (65%); mp 171–173 °C. A doubling of some signals in the ^1H and ^{13}C NMR spectra is observed, due to the presence of two atropisomers. ^1H NMR (300 MHz, $CDCl_3$): δ = 3.08, 3.15, 3.26, 3.43 (4×s, 12 H, 4 OCH_3), 6.52 (m, 4 H, Ar), 6.69 (m, 4 H, Ar), 6.90 (m, 4 H, Ar), 7.07 (m, 4 H, Ar); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 54.6, 54.8, 54.9, 55.1 (OCH_3), 110.1, 110.5, 110.8, 110.9, 119.8, 119.7, 120.1, 120.2, 127.4, 127.5, 128.4, 128.5, 131.3, 132.0, 132.1, 132.2 (CH, Ar), 123.7, 123.9, 134.9, 135.1, 136.9, 137.3, 156.5, 156,6, 156.7, 156.8 (C, ArC); IR (KBr): $\tilde{\nu}$ = 3432 (w), 3067 (m), 2932 (w), 2830 (w), 1597 (s), 1578 (s), 1493 (s), 1460 (s), 1240 (s), 1117 (s), 1023 (s), 752 (s), 617 cm^{-1} (w); MS (EI, 70 eV): *m/z* (%) = 508 (M^+, 100), 387 (18), 354 (9), 294 (8), 224 (6), 178 (4), 151 (3), 91 (5); HR-MS (EI, 70 eV): *m/z* = 508.1706, calcd. for $C_{32}H_{28}O_4S$ (M^+): 508.1703; elemental analysis calcd (%) for $C_{32}H_{28}O_4S$ (508.2): C 75.56, H 5.55, S 6.30; found: C 75.49, H 5.45, S 6.58.

Tetra(naphtha-1-yl)thiophene (2d): Procedure A: toluene:H_2O = 4:1 (5 mL), reflux 24 h, 100 °C. Starting with **1** (0.400 g, 1.0 mmol) and (naphth-1-yl)boronic acid (0.859 g, 5.0 mmol), $Pd(PPh_3)_4$ (0.115 g, 10 mol%), K_3PO_4 (1.7 g, 8.0 mmol), **2d** was isolated as a colourless solid; yield: 0.382 g (65%); mp 293–294 °C. ^1H NMR (300 MHz, $CDCl_3$): δ = 6.82 (m, 4 H, Ar), 7.89 (m, 2 H, Ar), 7.06 (m, 8 H, Ar), 7.21 (m, 4 H, Ar), 7.34 (m, 4 H, Ar), 7.49 (m, 2 H, Ar), 8.21, 8,29 (d,d, ^3J = 7.8 Hz, 2 H, Ar), 8.58, 8,65 (d,d, ^3J = 7.8 Hz, 2 H, Ar); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 124.5–129.3 (CH, Ar), 131.4, 131.6, 133.1, 133.7, 134.2, 134.6, 138.3, 140.6 (C, ArC). IR (KBr): $\tilde{\nu}$ = 3053 (w), 2923 (w), 1592 (w), 1506 (w), 1387 (w), 1261 (w), 1016 (w), 796 (s), 772 (s), 559 (w), 427 cm^{-1} (w); MS (EI, 70 eV): *m/z* (%) = 388 (M^+, 100), 354 (4), 310 (6), 267 (4), 178 (3), 165 (6), 121 (3), 77 (2); HR-MS (EI, 70 eV): *m/z* = 588.1901, calcd. for $C_{44}H_{28}S$ (M^+): 588.1906; elemental analysis calcd. (%) for $C_{44}H_{28}S$ (588.2): C 89.76, H 4.79; found: C 89.39, H 4.58.

Tetra(4-tolyl)thiophene (2e): Procedure A: toluene:H_2O = 4:1 (5 mL), reflux 12 h, 100 °C. Starting with **1** (0.400 g, 1.0 mmol) and 4-tolylboronic acid (0.680 g, 5.0 mmol), $Pd(PPh_3)_4$ (0.115 g, 10 mol%), K_3PO_4 (1.7 g, 8.0 mmol), **2e** was isolated as a colourless solid; yield: 0.386 g (87%); mp 151–152 °C. ^1H NMR (300 MHz, $CDCl_3$): δ = 2.29, 2.32 (s, 12 H, 2×2CH_3), 6.87, 6.96, 7.03, 7.14 (d, ^3J = 8.2 Hz, 16 H, 4×4CH, Ar); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 21.1, 21.2 (C, CH_3), 128.5, 128.9, 129.0, 130.7 (CH, Ar), 131.6, 133.6, 135.8, 136.7, 137.7, 138.2 (C, ArC). IR (KBr): $\tilde{\nu}$ = 3432 (w), 3022 (m), 2918 (w), 1514 (s), 1495 (s), 1456 (m), 1182 (w), 1111 (w), 1109 (w), 834 (m), 818 (s), 807 (m), 733 (m), 556 (w), 527 (w), 507 cm^{-1} (w); MS (EI, 70 eV): *m/z* (%) = 444 (M^+, 100), 355 (4), 299 (6), 207 (4), 155 (6), 115 (4), 91 (9), 71 (5), 57 (7), 44 (6); HR-MS (EI, 70 eV): *m/z* = 444.19071, calcd. for $C_{32}H_{28}S$ (M^+): 444.19062; elemental analysis calcd. (%) for $C_{32}H_{28}S$ (444.2): C 86.44, H 6.35; found: C 86.73, H 6.47.

Tetra(4-chlorophenyl)thiophene (2f): Procedure A: toluene:H_2O = 4:1 (5 mL), reflux 24 h, 100 °C. Starting with **1** (0.400 g, 1.0 mmol) and 4-chlorophenylboronic acid (0.782 g, 5.0 mmol), $Pd(PPh_3)_4$ (0.115 g, 10 mol%), K_3PO_4 (1.7 g, 8.0 mmol), **2f** was isolated as a colourless solid; yield: 0.468 g (89%); mp 139–140 °C. ^1H NMR (300 MHz, $CDCl_3$): δ = 6.75, 7.05, 7.08, 7.09 (d, 8×2 H, Ar); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 128.5, 128.7, 130.3, 131.9 (CH, Ar), 130.3, 131.8, 131.9, 132.4, 137.3, 147.3 (C, Ar); IR (KBr): $\tilde{\nu}$ = 3432 (m), 3066 (w), 1492 (s), 1480 (s), 1093 (s), 1086 (s), 834 (s), 806 (s), 769 (m), 526 (m), 520 (w), 501 (w), 487 cm^{-1} (w); MS (EI, 70 eV): *m/z* (%) = 530 (M^+, [^{37}Cl,^{37}Cl,^{37}Cl,^{35}Cl], 13), 528 (M^+, [^{37}Cl,^{37}Cl,^{35}Cl,^{35}Cl], 51), 526 (M^+, [^{37}Cl,^{35}Cl,^{35}Cl,^{35}Cl], 100), 524 (M^+, [^{35}Cl,^{35}Cl,^{35}Cl,^{35}Cl], 71); HR-MS (EI, 70 eV): *m/z* = 526.3022, calcd for $C_{28}H_{16}Cl_4S$ (M^+, [^{37}Cl,^{35}Cl,^{35}Cl,^{35}Cl]): 526.3026.

Tetra(4-fluorophenyl)thiophene (2g): Procedure A: toluene:H_2O = 4:1 (5 mL), reflux 24 h, 100 °C. Starting with **1** (0.400 g, 1.0 mmol) and 4-fluorophenylboronic acid (0.7 g, 5.0 mmol), $Pd(PPh_3)_4$ (0.115 g, 10 mol%), K_3PO_4 (1.7 g, 8.0 mmol), **2g** was isolated as a colourless solid; yield: 0.428 g (93%); mp 135–136 °C. ^1H NMR (300 MHz, $CDCl_3$): δ = 6.82 (m, 6×2 H, CH, Ar), 7.06 (m, 2×2 H, CH, Ar); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 116.9, 117.3 (2×d, $^3J_{CF}$, CH, Ar), 132.1, 133.0 (d, ^2J = 110 Hz, CF, Ar), 133.1 (d, ^2J = 109 Hz, CH, Ar), (CH, Ar) 129.8, 131.9, 137.6, 138.2 (C, ArC), 161.6, (d, ^1J = 251 Hz, CF, Ar), 162.1 (d, ^1J = 251 Hz, CF, Ar); IR (KBr): $\tilde{\nu}$ = 1536 (s), 1475 (s), 1452 (m), 1178 (w), 1124 (w), 1109 (w), 836 (m), 819 (s), 802 (m), 737 (m), 551 (w), 526 (w), 502 cm^{-1} (w); MS (EI, 70 eV): *m/z* (%) = 460 (M^+, 100), 366 (43), 321 (6), 262 (10), 201 (8), 149 (9), 97 (7), 83 (9), 69 (13), 57 (14); HR-MS (EI, 70 eV): *m/z* = 460.0903, calcd. for $C_{28}H_{16}F_4S$ (M^+): 460.0906; elemental analysis calcd. (%) for $C_{28}H_{16}F_4S$ (460.1): C 73.03, H 3.50, S 6.96; found: C 72.88, H 3.39, S 7.25.

Tetra(thien-2-yl)thiophene (2h): Procedure B: 5 mL of toluene, reflux 8 h, 100 °C. Starting with **1** (0.200 g, 0.5 mmol) and (thien-2-yl)boronic acid (6.0 equiv., 0.383 g, 0.6 mmol), $Pd(OAc)_2$ (11 mg, 5 mol%), **L** (41 mg, 10 mol%), K_3PO_4 (1.7 g, 8.0 mmol), **2h** was isolated as a yellow solid; yield: 0.166 g (81%); mp 110–112 °C. ^1H NMR (250 MHz, $CDCl_3$): δ = 6.90, 7.10, 7.19, 7.30 (d, 2 H, 4 CH, thienyl), 6.94, 6.96 (t, 2 H, CH, thienyl); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 125.4, 126.3, 126.4, 126.8, 127.1, 128.4 (2 CH, thienyl),

132.4, 133.3, 135.3, 135.6 (C); IR (KBr): $\tilde{\nu}=3096$ (w), 2959 (w), 2922 (w), 2851 (w), 1259 (w), 1216 (w), 1060 (w), 1036 (w), 1024 (w), 816 (w), 695 cm^{-1} (m); MS (EI, 70 eV): *m/z* (%) = 412 (M^+, 100), 378 (M^+, 8), 367 (M^+, 9), 346 (M^+, 6), 285 (M^+, 4), 283 (M^+, 4); HR-MS (EI, 70 eV): *m/z* = 411.95369, calcd. for $C_{20}H_{12}S_5$ (M^+): 411.95371; elemental analysis calcd. (%) for $C_{20}H_{12}S_5$ (411.9): C 58.21, H 2.93; found: C 58.29, H 2.95.

General Procedure A for Synthesis of 3,4-Dibromo-2,5-diarylthiophenes 3a–f

To a solution of **1** (0.400 g, 1.0 mmol) was added $Pd(PPh_3)_4$ (0.070 g, 6 mol%) at 20 °C. After stirring for 30 min, the arylboronic acid (2.2 mmol), K_3PO_4 (4.0 mmol) and water (1.0 mL) were added. The mixture was stirred at 90 °C for 12 h. After cooling to ambient temperature, the mixture was diluted with EtOAc, dried (Na_2SO_4), and filtered through a short Celite pad. The solution was concentrated under vacuum and the residue was purified by flash column chromatography (fine flash silica gel, *n*-heptane).

General Procedure B for the Synthesis of 3a–f

An oven-dried Schlenk flash was charged with $Pd(OAc)_2$ (5 mol%), ligand **L** (10 mol-%), the starting material, the boronic acid (2.2 equiv.) and powered, anhydrous K_3PO_4 (4 equiv.). The Schlenk flask was filled with argon. The solvent was added by syringe through a septum. The septum was replaced by a condenser in an argon stream. The reaction mixture was stirred and refluxed for the indicated period of time at the indicated temperature. The solution was allowed to cool to ambient temperature and water (5 mL) was added. The aqueous and the organic layer were separated and the latter was dried Na_2SO_4. The solution was filtered and the filtrate was concentrated under reduced pressure. The residue was purified by flash column chromatography (fine flash silica gel, heptanes). The solvents and the amounts are given in the individual procedures (see below).

3,4-Dibromo-2,5-diphenylthiophene (3a): Procedure B: 5 mL of toluene, reflux 8 h, 100 °C. Starting with **1** (0.400 g, 1.0 mmol) and phenylboronic acid (0.268 g, 2.2 mmol), $Pd(OAc)_2$ (11 mg, 5 mol%), **L** (41 mg, 10 mol%), K_3PO_4 (0.848 g, 4.0 mmol), **3a** was isolated as a colourless solid; yield: 0.344 g (88%); mp 150–151 °C. ^{1}H NMR (300 MHz, $CDCl_3$): $\delta=7.35$ (m, 2×3H, Ar), 7.61 (m, 2×2H, Ar); ^{13}C NMR (75 MHz, $CDCl_3$): $\delta=112.2$ (C, CBr), 128.4, 128.7, 128.8 (CH, Ar), 132.8, 138.1 (C, ArC); IR (KBr): $\tilde{\nu}=3051$ (w), 2924 (w), 2853 (w), 1477 (m), 1268 (m), 1028 (w), 749 (s), 699 (s), 628 (w), 584 , cm^{-1} (w); MS (EI, 70 eV): *m/z* (%) = 396 (M^+, [^{81}Br,^{81}Br], 55), 394 (M^+, [^{81}Br,^{79}Br], 100), 392 (M^+, [^{79}Br,^{79}Br], 53), 314 (3), 234 (48), 202 (8), 197 (7), 189 (22), 117 (12), 95 (6), 77 (5); HR-MS (EI, 70 eV): *m/z* = 391.8861, calcd. for $C_{16}H_{10}Br_2S$ (M^+, [^{79}Br,^{79}Br]): 391.8864; elemental analysis (%) calcd. for $C_{16}H_{10}Br_2S$ (391.9): C 48.76, H 2.56, S 8.13; found: C 48.78, H 2.51, S 8.01.

3,4-Dibromo-2,5-di(4-tolyl)thiophene (3b): Procedure A: toluene:H_2O = 4:1 (5 mL), reflux 12 h, 100 °C. Starting with **1** (0.400 g, 1.0 mmol) and 4-tolylboronic acid (0.299 g, 2.2 mmol), $Pd(PPh_3)_4$ (0.070 g, 6 mol%), K_3PO_4 (0.848 g, 4.0 mmol), **3b** was isolated as a colourless solid; yield: 0.323 g (77%); mp 152–155 °C. ^{1}H NMR (300 MHz, $CDCl_3$): $\delta=2.25$ (s, 6H, $2CH_3$), 7.22 (d, $^3J=8.2$ Hz, 4H, Ar), 7.46 (d, $^3J=8.2$ Hz, 4H, Ar); ^{13}C NMR (75 MHz, $CDCl_3$): $\delta=21.1$ (C, CH_3), 112.2 (C, CBr), 128.6, 129.1 (CH, Ar), 129.8, 137.2, 137.3 (C, ArC); IR (KBr): $\tilde{\nu}=3432$ (br, m), 3021 (m), 2918 (w), 1489 (s), 1266 (w), 864 (m), 809 (m), 798 (s), 755 (m), 490 cm^{-1} (s); MS (EI, 70 eV): *m/z* (%) = 424 (M^+, [^{81}Br,^{81}Br], 49), 422 (M^+, [^{81}Br,^{79}Br], 100), 420 (M^+, [^{79}Br,^{79}Br], 45), 342 (11), 262 (37), 229 (5), 202 (10), 135 (6), 69 (6); HR-MS (EI, 70 eV): *m/z* = 419.91769, calcd. for $C_{18}H_{14}Br_2S$ (M^+,[^{79}Br]): 419.91775; elemental analysis calcd. (%) for $C_{18}H_{14}Br_2S$ (419.9): C 51.21, H 3.34, S 7.60; found: C 50.89, H 3.45, S 7.55.

3,4-Dibromo-2,5-di(4-methoxyphenyl)thiophene (3c): Procedure B: toluene:dioxane = 1:1 (4 mL), reflux 8 h, 100 °C. Starting with **1** (0.400 g, 1.0 mmol) and (4-methoxyphenyl)-boronic acid (0.334 g, 2.2 mmol), $Pd(OAc)_2$ (11 mg, 5 mol%), **L** (41 mg, 10 mol%), K_3PO_4 (0.848 g, 4.0 mmol), **3c** was isolated as a colourless solid; yield: 0.383 g (85%); mp 171–173 °C. ^{1}H NMR (300 MHz, $CDCl_3$): $\delta=3.78$ (s, 6H, $2OCH_3$), 6.93 (d, $^3J=8.2$ Hz, 4H, Ar), 7.54 (d, $^3J=8.2$ Hz, 4H, Ar); ^{13}C NMR (75 MHz, $CDCl_3$): $\delta=55.6$ (C, OCH_3), 111.4 (C, CBr), 114.0, 129.9 (CH, Ar), 126.2, 137.3, 159.9 (C, ArC); IR (KBr): $\tilde{\nu}=3442$ (br, w), 2959 (w), 2923 (w), 2835 (w), 1598 (w), 1579 (w), 1482 (s), 1252 (s), 1179 (w), 1117 (m), 1024 (s), 796 (m), 751 cm^{-1} (s); MS (EI, 70 eV): *m/z* (%) = 456 (M^+, [^{81}Br,^{81}Br], 48), 454 (M^+, [^{81}Br,^{79}Br], 100), 452 (M^+, [^{79}Br,^{79}Br], 43), 476 (13), 474 (12), 279 (10), 208 (12), 136 (11), 121 (19), 119 (17), 105 (16), 77 (11), 69 (3); HR-MS (EI, 70 eV): *m/z* = 451.9073, calcd. for $C_{18}H_{14}Br_2O_2S$ (M^+, [^{79}Br,^{79}Br]): 451.9076; elemental analysis calcd. (%) for $C_{18}H_{14}Br_2O_2S$ (451.9): C 47.60, H 3.11, S 7.06; found: C 48.01, H 3.35, S 6.88.

3,4-Dibromo-2,5-di(2-methoxyphenyl)thiophene (3d): Procedure B: toluene:dioxane = 1:1 (4 mL), reflux 8 h, 100 °C. Starting with **1** (0.400 g, 1.0 mmol) and (2-methoxyphenyl)-boronic acid (0.344 g, 2.2 mmol), $Pd(OAc)_2$ (11 mg, 5 mol%), **L** (41 mg, 10 mol%), K_3PO_4 (0.848 g, 4.0 mmol), **3d** was isolated as a colourless solid; yield: 0.365 g (79%); mp 120–122 °C. A small amount of impurity could not be removed. ^{1}H NMR (300 MHz, $CDCl_3$): $\delta=3.78$ (s, 6H, $2OCH_3$), 6.93 (m, 2×2H, Ar), 7.34 (m, 4H, Ar); ^{13}C NMR (75 MHz, $CDCl_3$): $\delta=55.6$ (C, OCH_3), 111.2, 120.4, 130.5, 132.2 (CH, Ar), 112.6, 121.7, 134.9, 157.0 (C, ArC); IR (KBr): $\tilde{\nu}=3432$ (br, w), 2995 (w), 2961 (w), 2835 (w), 1608 (s), 1534 (s), 1491 (s), 1299 (w), 1253 (s), 1180 (s), 1040 (s), 828 (s), 805 (m), 754 (w), 578 (w), 514 cm^{-1} (w); MS (EI, 70 eV): *m/z* (%) = 456 (M^+, [^{81}Br,^{81}Br], 47), 454 (M^+, [^{81}Br,^{79}Br], 100), 452 (M^+, [^{79}Br,^{79}Br], 43), 376 (56), 374 (53), 279 (22), 264 (37), 237 (16), 208 (9), 149 (7), 147 (7), 131 (5), 104 (6), 71 (16), 57 (25); HR-MS (EI, 70 eV): *m/z* = 451.9069, calcd. for $C_{18}H_{14}Br_2O_2S$ (M^+, [^{79}Br,^{79}Br]): 451.9070.

3,4-Dibromo-2,5-bis(3,5-dimethylphenyl)thiophene (3e): Procedure B: 5 mL of toluene, reflux 8 h, 100 °C. Starting with **1** (0.400 g, 1.0 mmol) and (3,5-dimethylphenyl)boronic acid (0.385 g, 2.2 mmol), $Pd(OAc)_2$ (11 mg, 5 mol%), **L** (41 mg, 10 mol%), K_3PO_4 (0.848 g, 4.0 mmol), **3e** was isolated as a colourless solid; yield: 0.406 g (91%); mp 120–121 °C. A small amount of impurity could not be separated. ^{1}H NMR (300 MHz, $CDCl_3$): $\delta=2.26$ (s, 12H, $4CH_3$), 6.93 (s, 2H, Ar), 7.21 (s, 4H, Ar); ^{13}C NMR (75 MHz, $CDCl_3$): $\delta=21.6$ (C, CH_3), 111.8 (C, CBr), 126.2, 129.9 (CH, Ar), 123.3, 138.1, 141.4 (C, ArC); IR (KBr): $\tilde{\nu}=3436$ (br, w),

2997 (w), 2917 (m), 1598 (s), 1457 (m), 1298 (w), 1257 (w), 1039 (w), 896 (w), 852 (s), 828 (s), 707 (m), 689 cm^{-1} (m); MS (EI, 70 eV): *m/z* (%) = 452 (M^+, [^{81}Br,^{81}Br], 50), 450 (M^+, [^{81}Br,^{79}Br], 100), 448 (M^+, [^{79}Br,^{79}Br], 45), 372 (17), 370 (16), 290 (19), 225 (5), 210 (48), 195 (15), 149 (8), 97 (7), 69 (16); HR-MS (EI, 70 eV): *m/z* = 445.9492, calcd. for $C_{20}H_{18}Br_2S$ (M^+, [^{79}Br,^{79}Br]): 447.9491.

3,4-Dibromo-2,5-di(thien-2-yl)thiophene (3f): Procedure B: 5 mL of toluene, reflux 8 h, 100 °C. Starting with **1** (0.400 g, 1.0 mmol) and (thien-2-yl)boronic acid (0.299 g, 2.2 mmol), $Pd(OAc)_2$ (11 mg, 5 mol%), **L** (41 mg, 10 mol%), K_3PO_4 (0.848 g, 4.0 mmol), **3f** was isolated as a colourless solid; yield: 0.286 g (71%); mp 89–91 °C. ^1H NMR (300 MHz, $CDCl_3$): δ = 7.05 (t, ^3J = 3.7 Hz, 2×1 H, thiophene), 7.28 (d, ^3J = 4.1 Hz, 2×1 H, thiophene), 7.41 (m, 2×1 H, thiophene); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 112.4 (C, CBr), 126.8, 127.1, 127.4 (CH, thiophene), 132.0, 135.1 (C, ArC); IR (KBr): $\tilde{\nu}$ = 3094 (w), 2960 (w), 2923 (w), 1484 (w), 1418 (w), 1261 (w), 1221 (w), 1060 (w), 844 (m), 815 (m), 699 (m), 686 cm^{-1} (s); MS (EI, 70 eV): *m/z* (%) = 408 (M^+, [^{81}Br,^{81}Br], 55), 406 (M^+, [^{81}Br,^{79}Br], 100), 404 (M^+, [^{79}Br,^{79}Br], 47), 328 (16), 326 (17), 246 (52), 202 (11), 149 (7), 127 (10), 112 (5), 95 (9), 84 (17); HR-MS (EI, 70 eV): *m/z* = 403.7986, calcd for $C_{12}H_6Br_2S_3$ (M^+, [^{79}Br,^{79}Br]): 403.7993.

General Procedure A for the Synthesis of 2,3,4,5-Tetraarylthiophenes (4a–f)

To a solution of 3,4-dibromothiophene **3** (1.0 mmol) was added $Pd(PPh_3)_4$ (0.116 g, 10 mol%) at 20 °C. After stirring for 30 min, the arylboronic acid (3.0 mmol), K_3PO_4 (4.0 mmol) and water (2.0 mL) were added. The mixture was stirred at 90 °C for 24 h. After cooling to ambient temperature, the mixture was diluted with EtOAc, dried (Na_2SO_4), and filtered through a short Celite pad. The solution was concentrated under vacuum and the residue was purified by flash column chromatography (fine flash silica gel, *n*-heptane).

2,5-Diphenyl-3,4-di(4-tolyl)thiophene (4a): Procedure A: toluene:H_2O = 4:1 (5 mL), reflux 24 h, 90 °C. Starting with **3a** (0.392 g, 1.0 mmol) and 4-tolylboronic acid (0.407 g, 3.0 mmol), $Pd(PPh_3)_4$ (0.115 g, 10 mol-%), K_3PO_4 (0.848 g, 4.0 mmol), **4a** was isolated as a colourless solid; yield: 0.358 g (86%); mp 155–157 °C. ^1H NMR (300 MHz, $CDCl_3$): δ = 2.21 (s, 6 H, 2 CH_3), 6.79 (d, ^3J = 8.2 Hz, 4 H, 2 CH, Ar), 6.83 (d, ^3J = 8.2 Hz, 4 H, 2 CH, Ar), 7.14 (m, 10 H, Ar); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 21.3 (C, CH_3), 127.1, 128.3, 128.6, 129.2, 130.7 (CH, Ar), 134.3, 134.4, 135.9, 137.7, 139.6 (C, ArC); IR (KBr): $\tilde{\nu}$ = 3023 (w), 2918 (w), 1597 (w), 1502 (m), 1482 (m), 1022 (w), 827 (w), 749 (m), 696 (s), 605 (w), 523 cm^{-1} (w); MS (EI, 70 eV): *m/z* (%) = 416 (M^+, 100), 324 (4), 281 (3), 179 (6), 165 (4), 154 (4), 112 (3), 97 (2), 83 (3), 57 (4); HR-MS (EI, 70 eV): *m/z* = 416.1591, calcd. for $C_{32}H_{24}S$ (M^+): 416.1593.

3,4-Diphenyl-2,5-di(4-tolyl)thiophene (4b): Procedure A: toluene:H_2O = 4:1 (5 mL), reflux 24 h, 90 °C. Starting with **3b** (0.42 g, 1.0 mmol) and phenylboronic acid (0.365 g, 3.0 mmol), $Pd(PPh_3)_4$ (0.115 g, 10 mol%), K_3PO_4 (0.848 g, 4.0 mmol), **4b** was isolated as a colourless solid; yield: 0.212 g (51%); mp 154–155 °C. ^1H NMR (300 MHz, $CDCl_3$): δ = 2.22 (s, 3×2 H, CH_3), 6.87 (d, ^3J = 8.2 Hz, 4 H, 2CH, Ar), 6.91 (d, ^3J = 8.2 Hz, 4 H, 2CH, Ar), 7.08 (m, 10 H, Ar); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 21.0 (C, CH_3), 126.3, 127.6, 128.8, 128.9, 130.7 (CH, Ar), 131.2, 136.7, 136.8, 138.3, 139.4 (C, ArC); IR (KBr): $\tilde{\nu}$ = 3052 (w), 2918 (w), 1544 (w), 1502 (m), 1439 (m), 1021 (w), 836 (w), 817 (m), 771 (s), 703 (s), 523 (w), 510 cm^{-1} (w); MS (EI, 70 eV): *m/z* (%) = 416 (M^+, 100), 324 (4), 281 (6), 183 (4), 165 (6), 149 (7), 112 (13), 97 (15), 83 (19), 57 (32); HR-MS (EI, 70 eV): *m/z* = 416.1591, calcd. for $C_{30}H_{24}S$ (M^+): 416.1593.

3,4-Di(4-methoxyphenyl)-2,5-di(4-tolyl)thiophene (4c): Procedure A: toluene:dioxane:H_2O = 2:2:1 (5 mL), reflux 24 h, 100 °C. Starting with **3b** (0.42 g, 1.0 mmol) and (4-methoxyphenyl)boronic acid (0.455 g, 3.0 mmol), $Pd(PPh_3)_4$ (0.115 g, 10 mol%), K_3PO_4 (0.848 g, 4.0 mmol), **4c** was isolated as a colourless solid; yield: 0.361 g (76%); mp 230–231 °C. ^1H NMR (300 MHz, $CDCl_3$): δ = 2.20 (s, 3 H, CH_3), 3.62 (s, 3 H, OCH_3), 6.53, 6.75, 6.97, 7.06 (m, 16 H, 4×4 CH, Ar); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 21.25 (C, CH_3), 55.10 (C, OCH_3), 113.37, 129.07, 129.09, 132.00 (CH, Ar), 129.00, 131.88, 136.84, 138.44, 139.86, 158.18 (C, ArC). IR (KBr): $\tilde{\nu}$ = 3446 (m), 2999 (m), 2962 (m), 2835 (m), 1608 (s), 1513 (s), 1290 (s), 1245 (s), 1034 (s), 841 (s), 809 (s), 563 cm^{-1} (w); MS (EI, 70 eV): *m/z* (%) = 476 (M^+, 100), 83 (10), 71 (10), 69 (13), 57 (17), 43 (22), 40 (13); HR-MS (EI, 70 eV): *m/z* = 476.6255, calcd. for $C_{32}H_{28}O_2S$ (M^+): 476.6258.

3,4-Di(4-ethoxyphenyl)-2,5-di(4-tolyl)thiophene (4d): Procedure A: toluene:dioxane:H_2O = 2:2:1 (5 mL), reflux 24 h, 100 °C. Starting with **3b** (0.42 g, 1.0 mmol) and (4-ethoxyphenyl)boronic acid (0.497 g, 3.0 mmol), $Pd(PPh_3)_4$ (0.115 g, 10 mol%), K_3PO_4 (0.848 g, 4.0 mmol), **4d** was isolated as a colourless solid; yield: 0.469 g (93%); mp 169–170 °C. ^1H NMR (300 MHz, $CDCl_3$): δ = 1.18 (t, ^3J = 7.3 Hz, 6 H, 2 OCH_2CH_3), 2.21 (s, 6 H, 2 CH_3), 3.89 (q, ^3J = 7.3 Hz, 4 H, 2 OCH_2CH_3), 6.51 (d, ^3J = 8.2 Hz, 4 H, 2 CH, Ar), 6.74 (d, ^3J = 8.2 Hz, 4 H, 2 CH, Ar), 6.92 (d, ^3J = 8.2 Hz, 4 H, 2 CH, Ar), 7.03 (d, ^3J = 8.2 Hz, 4 H, 2 CH, Ar); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 14.8 (C, OCH_2CH_3), 21.1 (C, CH_3), 63.08 (C, OCH_2CH_3), 113.8, 128.9, 128.9, 131.9 (CH, Ar), 131.8, 136.7, 136.8, 137.5, 138.8, 157.4 (C, Ar); IR (KBr): $\tilde{\nu}$ = 3052 (w), 2911 (w), 1546 (w), 1509 (m), 1431 (m), 1027 (w), 838 (w), 815 (m), 771 (s), 707 (s), 522 (w), 517 cm^{-1} (w); MS (EI, 70 eV): *m/z* (%) = 504 (M^+, 100), 475 (5), 384 (15), 242 (4), 149 (7), 112 (5), 97 (9), 83 (10), 69 (12), 57 (16), 44 (26); HR-MS (EI, 70 eV): *m/z* = 504.2104, calcd. for $C_{34}H_{32}O_2S$ (M^+): 504.2107; elemental analysis calcd. (%) for $C_{34}H_{32}O_2S$ (504.2): C 80.92, H 6.39; found: C 80.74, H 6.44.

3,4-Bis(4-hydroxyphenyl)-2,5-di(4-tolyl)thiophene (4e): Procedure A: toluene:dioxane:H_2O = 2:2:1 (5 mL), reflux 24 h, 90 °C. Starting with **3b** (0.42 g, 1.0 mmol) and (4-hydroxyphenyl)boronic acid (0.433 g, 3.0 mmol), $Pd(PPh_3)_4$ (0.115 g, 10 mol%), K_3PO_4 (0.848 g, 4.0 mmol), **4e** was isolated as a colourless solid; yield: 0.367 g (82%); mp 186–187 °C. ^1H NMR (300 MHz, $CDCl_3$): δ = 2.18 (s, 3 H, CH_3), 6.49, 6.67, 6.92, 7.06 (d, 16 H, 4×4 CH, Ar); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 20.2 (C, CH_3), 128.7, 128.9, 131.7, 131.8 (CH, Ar), 127.3, 127.9, 136.8, 137.2, 139.6, 156.2 (C, Ar); IR (KBr): $\tilde{\nu}$ = 3383 (m), 3062 (w), 2921 (m), 1609 (m), 1513 (s), 1263 (s), 1210 (s), 815 (s), 559 cm^{-1} (w); MS (EI, 70 eV): *m/z* (%) = 449 (M^+, 57), 448 (100), 364 (23), 362 (20), 283 (15), 69 (13), 57 (14), 43 (12), 40 (11); HR-MS (EI, 70 eV): *m/z* = 448.5732, calcd. for $C_{30}H_{24}O_2S$ (M^+): 448.5754; found: 448.5752, elemental analysis calcd. (%) for

$C_{30}H_{24}O_2S$ (448.1): C 80.33, H 5.39, S 7.15; found: C 79.98, H 5.19, S 6.88.

3,4-Bis(4-chlorophenyl)-2,5-di(4-tolyl)thiophene (4f): Procedure A: toluene:H_2O = 4:1 (5 mL), reflux 24 h, 100 °C. Starting with **3b** (0.42 g, 1.0 mmol) and (4-chlorophenyl)boronic acid (0.469 g, 3.0 mmol), $Pd(PPh_3)_4$ (0.115 g, 10 mol%), K_3PO_4 (0.848 g, 4.0 mmol), **4f** was isolated as a colourless solid; yield: 0.44 g (91%); mp139–140 °C. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 2.21 (s, 6H, 2CH_3), 6.78 (d, ^3J = 8.2 Hz, 4H, 2×2CH, Ar), 7.02 (m, 12H, 4×3CH, Ar); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 20.9 (C, CH_3), 127.9, 128.7, 128.9, 131.8 (CH, Ar), 130.7, 132.6, 134.8, 137.3, 137.2, 137.9 (C, ArC); IR (KBr): $\tilde{\nu}$ = 3052 (w), 2911 (w), 1546 (w), 1509 (m), 1431 (m), 1027 (w), 838 (w), 815 (m), 771 (s), 707 (s), 522 (w), 517 cm^{-1} (w); MS (EI, 70 eV): *m/z* (%) = 488 (M^+, [^{37}Cl,^{37}Cl], 14), 486 (M^+, [^{37}Cl,^{35}Cl], 70), 484 (M^+, [^{35}Cl,^{35}Cl], 100); HR-MS (EI, 70 eV): *m/z* = 484.1581, calcd. for $C_{30}H_{22}Cl_2S$ (M^+,[^{35}Cl,^{35}Cl]): 484.1583.

General Procedure B for the Synthesis of 5a–e

An oven-dried Schlenk flash was charged with $Pd(OAc)_2$ (5 mol%), ligand **L** (10 mol%), the starting material, the boronic acid (1.0 equiv.) and powered, anhydrous K_3PO_4 (4 equiv.). The Schlenk flask was filled with argon. The solvent was added by syringe through a septum. The septum was replaced by a condenser in an argon stream. The reaction mixture was stirred and refluxed for the indicated period of time at the indicated temperature. The solution was allowed to cool to ambient temperature and water (5 mL) was added. The aqueous and the organic layer were separated and the latter was dried Na_2SO_4. The solution was filtered and the filtrate was concentrated under reduced pressure. The residue was purified by flash column chromatography (fine flash silica gel, heptanes). The solvents and the amounts are given in the individual procedures (see below).

2,3,4-Tribromo-5-(2-methoxyphenyl)thiophene (5a): Procedure B: toluene:dioxane = 1:1 (4 mL), reflux 8 h, 100 °C. Starting with **1** (0.200 g, 0.5 mmol) and (2-methoxyphenyl)-boronic acid (0.091 g, 0.6 mmol), $Pd(OAc)_2$ (5.6 mg, 5 mol%), **L** (20.5 mg, 10 mol%), K_3PO_4 (0.424 g, 4.0 mmol), **5a** was isolated as a white solid; yield: 0.158 g (75%); mp 72–78 °C. ^{1}H NMR (250 MHz, $CDCl_3$): δ = 3.83 (s, 3H, OMe), 6.98, 7.03 (d, 1H, CH, Ar), 7.34, 7.44 (t, 1H, CH, Ar); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 55.6 (OMe), 110.5, 112.6, 117.3 (CBr), 111.3, 120.5, 131.0, 131.9 (CH, Ar), 120.9, 136.3, 157.0 (C); IR (KBr): $\tilde{\nu}$ = 3077 (w), 3008 (w), 2933 (m), 2831 (m), 2487 (w), 2042 (w), 1903 (w), 1579 (s), 1246 (s), 1022 (s), 744 (s), 723 cm^{-1} (s); MS (EI, 70 eV): *m/z* (%) = 430 (M^+, [^{81}Br,^{81}Br,^{81}Br], 35), 428 (M^+, [^{81}Br,^{81}Br,^{79}Br], 99), 426 (M^+, [^{81}Br,^{79}Br,^{79}Br], 100), 424 (M^+, [^{79}Br,^{79}Br,^{79}Br], 33); HR-MS (EI, 70 eV): *m/z* = 419.77005, calcd. for $C_{11}H_7Br_3S$ (M^+, [^{81}Br,^{81}Br,^{81}Br]): 429.77009; 427.77182, calcd. for (M^+, [^{81}Br,^{81}Br,^{79}Br]): 427.77213; 425.77375, calcd. for (M^+, [^{81}Br,^{79}Br,^{79}Br]): 425.77418; 423.77569, calcd. for (M^+, [^{79}Br,^{79}Br,^{79}Br]): 423.77622, elemental analysis calcd (%) for $C_{11}H_7Br_3S$ (423.8): C 30.94, H 1.65, S 7.51; found: C 30.87, H 1.49, S 7.24.

2,3,4-Tribromo-5-(4-methoxyphenyl)thiophene (5b): Procedure B: toluene:dioxane = 1:1 (4 mL), reflux 8 h, 100 °C. Starting with **1** (0.200 g, 0.5 mmol) and (4-methoxyphenyl)-boronic acid (0.091 g, 0.6 mmol), $Pd(OAc)_2$ (5.6 mg, 5 mol%), **L** (20.5 mg, 10 mol%), K_3PO_4 (0.424 g, 4.0 mmol), **5b** was isolated as a white solid; yield: 0.17 g (80%); mp 124–125 °C. ^{1}H NMR (250 MHz, $CDCl_3$): δ = 3.84 (s, 3H, OMe), 6.96, 7.49 (d, 2H, CH, Ar); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 55.4 (OMe), 109.3, 109.9, 118.3 (CBr), 114.2, 130.3 (2 CH, Ar), 124.6, 140.0, 160.3 (C); IR (KBr): $\tilde{\nu}$ = 3028 (w), 3005 (w), 2954 (w), 2895 (w), 2830 (w), 1879 (w), 1603 (w), 1489 (m), 1248 (m), 1177 (m), 1031 (m), 832 cm^{-1} (m); MS (EI, 70 eV): *m/z* (%) = 430 (M^+, [^{81}Br,^{81}Br,^{81}Br], 35), 428 (M^+, [^{81}Br,^{81}Br,^{79}Br], 97), 426 (M^+, [^{81}Br,^{79}Br,^{79}Br], 100), 424 (M^+, [^{79}Br,^{79}Br,^{79}Br], 33); HRMS (EI, 70 eV): *m/z* = found: 429.76984, calcd for $C_{11}H_7Br_3S$ (M^+, [^{81}Br,^{81}Br,^{81}Br]): 429.77009; 427.77152, calcd. for (M^+, [^{81}Br,^{81}Br,^{79}Br]): 427.77213; 425.77363, calcd. for (M^+, [^{81}Br,^{79}Br,^{79}Br]): 425.77418; 423.77564, calcd. for (M^+, [^{79}Br,^{79}Br,^{79}Br]): 423.77622; elemental analysis calcd. (%) for $C_{11}H_7Br_3S$ (423.8): C 30.94, H 1.65, S 7.51; found: C 30.72, H 1.64, S 7.58.

2,3,4-Tribromo-5-(3-biphenyl)thiophene (5c): Procedure B: 5 mL of toluene, reflux 8 h, 100 °C. Starting with **1** (0.200 g, 0.5 mmol) and 3-biphenylboronic acid (0.119 g, 0.6 mmol), $Pd(OAc)_2$ (5.6 mg, 5 mol%), **L** (20.5 mg, 10 mol%), K_3PO_4 (0.424 g, 4.0 mmol), **5c** was isolated as a yellow solid; yield: 0.181 g (77%); mp 116–117 °C. ^{1}H NMR (250 MHz, $CDCl_3$): δ = 7.38–7.79 (m, 9H, CH, Ar); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 110.3, 110.6, 118.6 (CBr), 127.2, 129.9 (2CH, Ar), 127.7, 127.8, 127.9, 129.2 (CH, Ar), 132.7, 139.9, 140.2, 141.9 (C); IR (KBr): $\tilde{\nu}$ = 3077 (w), 3056 (w), 3024 (w), 1595 (w), 1567 (w), 1468 (w), 1273 (w), 786 (m), 748 (m), 691 , cm^{-1} (m); MS (EI, 70 eV): *m/z* (%) = 476 (M^+, [^{81}Br,^{81}Br,^{81}Br], 36), 474 (M^+, [^{81}Br,^{81}Br,^{79}Br], 97), 472 (M^+, [^{81}Br,^{79}Br,^{79}Br], 100), 470 (M^+, [^{79}Br,^{79}Br,^{79}Br], 33); HR-MS (EI, 70 eV): *m/z* = 475.79034, calcd. for $C_{16}H_9Br_3S$ (M^+, [^{81}Br,^{81}Br,^{81}Br]): 475.79082; 473.79226, calcd. for (M^+, [^{81}Br,^{81}Br,^{79}Br]): 473.79287; 471.79506, calcd. for (M^+, [^{81}Br,^{79}Br,^{79}Br]): 471.79491; found: 469.79689, calcd. for (M^+, [^{79}Br,^{79}Br,^{79}Br]): 469.79696; elemental analysis calcd. (%) for $C_{16}H_9Br_3S$ (469.8): C 41.63, H 1.92, S 6.77; found: C 41.27, H 1.80, S 7.07.

2,3,4-Tribromo-5-(naphth-2-yl)thiophene (5d): Procedure B: 5 mL of toluene, reflux 8 h, 100 °C. Starting with **1** (0.200 g, 0.5 mmol) and (naphtha-2-yl)boronic acid (0.103 g, 0.7 mmol), $Pd(OAc)_2$ (5.6 mg, 5 mol%), **L** (20.5 mg, 10 mol%), K_3PO_4 (0.424 g, 4.0 mmol), **5d** was isolated as an orange viscous oil; yield: 0.153 g (69%). ^{1}H NMR (250 MHz, $CDCl_3$): δ = 7.47–7.97 (m, 7H, CH, Ar); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 110.9, 113.7, 117.6 (CBr), 125.0, 125.5, 126.4, 127.0, 128.5, 129.4, 130.2 (CH, Ar), 129.5, 131.5, 133.5, 138.2 (C); IR (KBr): $\tilde{\nu}$ = 3050 (w), 2962 (w), 2848 (w), 1926 (w), 1875 (w), 1814 (w), 1501 (w), 1434 (m), 1386 (m), 1261 (m), 793 (s), 796 (s) 729 cm^{-1} (m); MS (EI, 70 eV): *m/z* (%) = 450 (M^+, [^{81}Br,^{81}Br,^{81}Br], 17), 448 (M^+, [^{81}Br,^{81}Br,^{79}Br], 48), 446 (M^+, [^{81}Br,^{79}Br,^{79}Br], 48), 444 (M^+, [^{79}Br,^{79}Br,^{79}Br], 16); HR-MS (EI, 70 eV): *m/z* = 447.77769, calcd. for $C_{14}H_7Br_3S$ (M^+, [^{81}Br,^{81}Br,^{79}Br]): 447.77777; 445.77989, calcd. for (M^+, [^{81}Br,^{79}Br,^{79}Br]): 445.77981; elemental analysis calcd. (%) for $C_{14}H_7Br_3S$ (443.8): C 37.62, H 1.58, S 7.17; found: C 37.77, H 1.44, S 7.56.

2,3,4-Tribromo-5-(4-ethylphenyl)thiophene (5e): Procedure B: 5 mL of toluene, reflux 8 h, 100 °C. Starting with **1** (0.200 g, 0.5 mmol) and (4-ethylphenyl)boronic acid (0.090 g,

0.6 mmol), $Pd(OAc)_2$ (5.6 mg, 5 mol%), **L** (20.5 mg, 10 mol%), K_3PO_4 (0.424 g, 4.0 mmol), **5e** was isolated as a light yellow solid; yield: 0.183 g (87%); mp 58–63 °C. ^{1}H NMR (250 MHz, $CDCl_3$): $\delta = 1.20$ (t, 3H, CH_3), 2.62 (q, 2H, CH_2), 7.20, 7.40 (d, 2H, CH, Ar); ^{13}C NMR (75 MHz, $CDCl_3$): $\delta =$ 15.3 (CH_3), 28.7 (2H, CH_2), 109.7, 110.0, 118.4 (CBr), 128.3, 128.8 (2 CH, Ar), 129.6, 140.2, 145.6 (C); IR (KBr): $\tilde{\nu} = 2965$ (m), 2923 (w), 2874 (w), 2836 (w), 1901 (w), 1888 (w), 1608 (w), 1484 (w), 1433 (w), 1409 (w), 1268 (m), 824 , cm^{-1} (m); MS (EI, 70 eV): *m/z* (%) = 428 (M^+, [^{81}Br,^{81}Br,^{81}Br], 34), 426 (M^+, [^{81}Br,^{81}Br,^{79}Br], 96), 424 (M^+, [^{81}Br,^{79}Br,^{79}Br], 97), 422 (M^+, [^{79}Br,^{79}Br,^{79}Br], 33); HR-MS (EI, 70 eV): *m/z* = 427.79059, calcd. for $C_{12}H_9Br_3S$ (M^+, [^{81}Br,^{81}Br,^{81}Br]): 427.79082; 425.79277, calcd. for (M^+, [^{81}Br,^{81}Br,^{79}Br]): 425.79287; 423.79458, calcd. for (M^+, [^{81}Br,^{79}Br,^{79}Br]): 423.79491; 421.79606, calcd. for (M^+, [^{79}Br,^{79}Br,^{79}Br]): 421.79696; elemental analysis calcd. (%) for $C_{12}H_9Br_3S$ (421.8): C 33.91, H 2.13, S 7.55; found: C 33.64, H 1.96, S 7.48.

3,4-Dibromo-2-(4-methoxyphenyl)-5-(4-ethylphenyl)thiophene (6a): Procedure B: toluene:dioxane = 1:1 (4 mL), reflux 8 h, 100 °C. Starting with **5b** (0.212 g, 0.5 mmol) and (4-ethylphenyl)boronic acid (0.090 g, 0.6 mmol), $Pd(OAc)_2$ (5.6 mg, 5 mol%), **L** (20.5 mg, 10 mol%), K_3PO_4 (0.424 g, 4.0 mmol), **6b** was isolated as an orange solid; yield: 0.163 g (72%); mp 61–76 °C. ^{1}H NMR (250 MHz, $CDCl_3$): $\delta = 1.33$ (t, 3H, CH_3), 2.76 (q, 2H, CH_2), 3.89 (s, 3H, OMe), 7.02, 7.34, 7.62, 7.65 (d, 2H, CH, Ar); ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 15.3$ (CH_3), 28.6 (CH_2), 55.3 (OMe), 111.57, 111.63 (CBr), 114.0, 128.1, 128.9, 130.3 (CH, Ar), 125.9, 127.6, 137.6, 137.7, 145.0, 159.0 (C); IR (KBr): $\tilde{\nu} = 2997$ (w), 2960 (w), 2929 (w), 2871 (w), 2047 (w), 1905 (w), 1603 (w), 1486 (m), 1248 (m), 1028 (m), 827 (m), 800 cm^{-1} (m); MS (EI, 70 eV): *m/z* (%) = 454 (M^+, [^{81}Br,^{81}Br], 53), 452 (M^+, [^{81}Br,^{79}Br], 100), 450 (M^+, [^{79}Br,^{79}Br], 50), 439 (M^+, 22), 437 (M^+, 40), 435(M^+, 21); HR-MS (EI, 70 eV): *m/z* = 453.92399, calcd for $C_{19}H_{16}Br_2SO$ (M^+, [^{81}Br,^{81}Br]): 453.92422; 451.92589, calcd. for (M^+, [^{81}Br,^{79}Br]): 451.92627; 449.92798, calcd. for (M^+, [^{79}Br,^{79}Br]): 449.92831; elemental analysis calcd. (%) for $C_{19}H_{16}Br_2SO$ (449.9): C 50.46, H 3.57, S 7.09; found: C 50.30, H 3.81, S 7.40.

3,4-Dibromo-2-(4-methoxyphenyl)-5-(3,5-dimethylphenyl)thiophene (6b): Procedure B: tolulene:dioxane = 1:1 (4 mL), reflux 8 h, 100 °C. Starting with **5b** (0.212 g, 0.5 mmol) and (3,5-dimethylphenyl)boronic acid (0.090 g, 0.6 mmol), $Pd(OAc)_2$ (5.6 mg, 5 mol%), **L** (20.5 mg, 10 mol%), K_3PO_4 (0.424 g, 4.0 mmol), **6b** was isolated as an orange solid; yield: 0.150 g (67%); mp 85–89 °C. ^{1}H NMR (250 MHz, $CDCl_3$): $\delta = 2.30$ (s, 6H, CH_3), 3.77 (s, 3H, OCH_3), 6.89, 7.51 (d, 2H, CH, Ar), 6.96 (d, H, CH, Ar), 7.18 (s, 2H, CH, Ar); ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 21.3$ (CH_3), 55.3 (O CH_3), 111.5, 111.7 (CBr), 114.2, 126.8, 131.4 (2 CH, Ar), 131.2 (CH, Ar), 114.3, 125.3, 132.7, 137.7, 138.2, 160.0 (C); IR (KBr): $\tilde{\nu} = 2994$ (w), 2931 (w), 2912 (w), 2832 (w), 2545 (w), 2077 (w), 1880 (w), 1599 (m), 1530 (m), 1469 (m), 1248 (m), 1033 (m), 824 (m), 796 (m), 739 (m), 689 cm^{-1} (m); MS (EI, 70 eV): *m/z* (%) = 454 (M^+, [^{81}Br,^{81}Br], 53), 452 (M^+, [^{81}Br,^{79}Br], 100), 450 (M^+, [^{79}Br,^{79}Br], 49), 439 (M^+, 17), 437 (M^+, 32), 435(M^+, 16); HR-MS (EI, 70 eV): *m/z* = 453.92398, calcd. for $C_{19}H_{16}Br_2SO$ (M^+, [^{81}Br,^{81}Br]): 453.92422; 451.92577, calcd. for (M^+, [^{81}Br,^{79}Br]): 451.92627; 449.92776, calcd. for (M^+, [^{79}Br,^{79}Br]): 449.92831; elemental analysis calcd. (%) for $C_{19}H_{16}Br_2SO$ (449.9): C 50.46, H 3.57, S 7.09; found: C 50.53, H 3.36, S 6.78.

3,4-Dibromo-2-(4-methoxyphenyl)-5-(3-biphenyl)thiophene (6c): Procedure B: toluene:dioxane = 1:1 (4 mL), reflux 8 h, 100 °C. Starting with **5b** (0.212 g, 0.5 mmol) and 3-biphenylboronic acid (0.119 g, 0.6 mmol), $Pd(OAc)_2$ (5.6 mg, 5 mol%), **L** (20.5 mg, 10 mol%), K_3PO_4 (0.424 g, 4.0 mmol), **6c** was isolated as an orange solid; yield: 0.171 g (69%); mp 60–62 °C. ^{1}H NMR (250 MHz, $CDCl_3$): $\delta = 3.86$ (s, 3H, OCH_3), 6.99 (d, 2H, CH, Ar), 7.33–7.65 (m, 11H, CH, Ar); ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 55.4$ (O CH_3), 111.8, 112.2 (CBr), 114.1, 127.2, 128.9, 130.3 (2 CH, Ar), 127.2, 127.6, 127.7, 127.8, 129.1 (CH, Ar), 125.2, 133.4, 137.3, 138.2, 140.5, 141.7, 160.1 (C); IR (KBr): $\tilde{\nu} = 3057$ (w), 3029 (w), 3003 (w), 2929 (w), 2833 (w), 1873 (w), 1604 (w), 1474 (m), 1450 (m), 1253 (m), 1179 (m), 1033 (m), 821 (m), 747 (m), 961 cm^{-1} (m); MS (EI, 70 eV): *m/z* (%) = 502 (M^+, [^{81}Br,^{81}Br], 14), 500 (M^+, [^{81}Br,^{79}Br], 30), 498 (M^+, [^{79}Br,^{79}Br], 13), 497 (M^+, 66), 486 (M^+, 12), 484 (M^+, 24); HR-MS (EI, 70 eV): *m/z* = 501.92450, calcd. for $C_{23}H_{16}Br_2SO$ (M^+, [^{81}Br,^{81}Br]): 501.92422; 499.92610, calcd. for (M^+, [^{81}Br,^{79}Br]): 499.92627; 497.92959, calcd. for (M^+, [^{79}Br,^{79}Br]): 497.92831; elemental analysis calcd. (%) for $C_{23}H_{16}Br_2SO$ (497.9): C 55.22, H 3.22, S 6.41; found: C 55.62, H 3.38, S 6.49.

General Procedure A for the Synthesis of 9a–d

To a solution (for the solvents, see the individual procedures given below) of starting material was added $Pd(PPh_3)_4$ (10 mol%) at 20 °C. After stirring for 30 min, the arylboronic acid, K_3PO_4 (8.0 mmol) and water (1.0 mL) were added. The mixture was stirred for the indicated period of time at the indicated temperature. After cooling to ambient temperature, the mixture was diluted with EtOAc, dried (Na_2SO_4), and filtered through a short Celite pad. The solution was concentrated under vacuum and the residue was purified by flash column chromatography (fine flash silica gel, *n*-heptane). The solvents and the amounts are given in the individual procedures (see below).

General Procedure B for the Synthesis of 9a–d

An oven-dried Schlenk flash was charged with $Pd(OAc)_2$ (10 mol%), ligand **L** (20 mol%), the starting material, the boronic acid and powered, anhydrous K_3PO_4 (8 equiv.). The Schlenk flask was filled with argon. The solvent was added by syringe through a septum. The septum was replaced by a condenser in an argon stream. The reaction mixture was stirred and refluxed for the indicated period of time at the indicated temperature. The solution was allowed to cool to ambient temperature and water (5 mL) was added. The aqueous and the organic layer were separated and the latter was dried Na_2SO_4. The solution was filtered and the filtrate was concentrated under reduced pressure. The residue was purified by flash column chromatography (fine flash silica gel, heptanes). The solvents and the amounts are given in the individual procedures (see below).

Dimethyl 3,4-di(4-chlorophenyl)thiophene-2,5-dicarboxylate (9a): Procedure A: toluene:H_2O = 4:1 (5 mL), reflux 24 h, 100 °C. Starting with **7g** (0.358 g, 1.0 mmol) and (4-chlorophenyl)boronic acid (0.469 g, 3 mmol), $Pd(PPh_3)_4$

(0.060 g, 5 mol%), K_3PO_4 (0.848 g, 4.0 mmol), **9a** was isolated as a white solid; yield: 0.176 g (42%): mp 149–151 °C. ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 3.64$ (s, 6H, $2OCH_3$), 7.14, 7.51 (d, $^3J = 8.2$ Hz, 2H, CH, Ar), 7.31 (d, $^3J = 8.2$ Hz, 4H, CH, Ar); ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 51.56$ (C, OCH_3), 127.56, 129.07, 129.85, 132.42 (CH, Ar), 141.30, 159.19 113.73, 141.85 (C, Ar), 160.09 (C, CO); IR (KBr): $\tilde{\nu} = 3429$ (m), 2950 (m), 1899 (w), 1721 (s), 1593 (w), 1522 (w), 1437 (s), 1095 (m), 1016 (m), 829 (m), 807 (s), 761, cm^{-1} (m); MS (EI, 70 eV): *m/z* (%) = 421 (M^+, 35), 350 (100), 240 (16), 210 (10), 191 (11), 149 (9), 112 (7), 97 (9), 83 (12), 81 (19), 44 (7); HR-MS (EI, 70 eV): *m/z* = 421.2036, calcd. for $C_{30}H_{22}O_4Cl_2S$ (M^+): 421.2938.

Dimethyl 3,4-di(2-methoxyphenyl)thiophene-2,5-dicarboxylate (9b): Procedure B: 5 mL of dioxane, reflux 8 h, 100 °C. Starting with **7g** (0.358 g, 1.0 mmol) and (2-methoxyphenyl)-boronic acid (0.299 g, 2.2 mmol), $Pd(OAc)_2$ (11.2 mg, 5 mol%), **L** (41 mg, 10 mol%), K_3PO_4 (0.848 g, 4.0 mmol), **9b** was isolated as a colourless solid; yield: 0.185 g (45%); mp 205–207 °C. A doubling of some signals in the ^{1}H and ^{13}C NMR spectra is observed, due to the presence of two atropisomers. ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 3.43$, 3.51 (2×s, 6H, OCH_3), 3.67, 3.68 (2×s, 6H, CO_2CH_3), 6.61, 6.72 (d, $^3J = 8.2$ Hz, 2H, CH, Ar), 6.83, 7.18 (t, $^3J = 8.2$ Hz, 2H, CH, Ar); ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 52.0$ (C, OCH_3), 55.0, 55.1 (CH_3, $OCOCH_3$), 110.0, 110.1, 119.4, 119.5, 129.0, 129.1, 130.5, 130.8 (CH, Ar), 132.0, 132.1, 145.3, 146.0 (C, Ar), 123.8, 124.1, 156.6 (C, thiophene), 161.8, 161.9 (C=O); IR (KBr): $\tilde{\nu} = 3433$ (br, w), 3065 (w), 3029 (w), 3001 (w), 2953 (s), 2833 (s), 1724 (s), 1601 (m), 1583 (s), 1508 (s), 1468 (s), 1289 (s), 1158 (m), 1079 (m), 1048 (m), 762 (s), 750 cm^{-1} (s); MS (EI, 70 eV): *m/z* (%) = 412 (M^+, 98), 382 (25), 381 (100), 322 (10), 321 (46), 307 (16), 305 (9), 287 (19); HR-MS (EI, 70 eV): m/z = 412.0971, calcd. for $C_{22}H_{20}O_6S$ (M^+): 412.0975; elemental analysis calcd. (%) for $C_{22}H_{20}O_6S$ (412.1): C 64.06, H 4.89, S 7.77; found: C 63.97, H 4.81, S 7.70.

Dimethyl 3,4-di(2-hydroxyphenyl)thiophene-2,5-dicarboxylate (9c): Procedure A: toluene:dioxane:H_2O = 2:2:1 (5 mL). Starting with **7g** (0.358 g, 1.0 mmol) and (2-hydroxyphenyl)boronic acid (0.443 g, 3.0 mmol), $Pd(PPh_3)_4$ (0.060 g, 5 mol%), K_3PO_4 (0.848 g, 4.0 mmol), **9c** was isolated as a colourless solid; yield: 0.188 g (49%); mp 159–160 °C. ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 3.79$ (s, 6H, $2OCH_3$), 7.31, 9.00 (d, $^3J = 8.2$ Hz, 2H, CH, Ar), 7.39, 7.51 (t, $^3J = 8.2$ Hz, 2H, CH, Ar); ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 116.7$, 118.0, 123.1, 124.4 (CH, Ar), 112.7, 130.7, 140.6, 155.9 (C, Ar), 160.2 (C, CO); IR (KBr): $\tilde{\nu} = 3333$ (br, s), 3062 (m), 3023 (m), 2921 (m), 2900 (m), 1688 (m), 1670 (s), 1596 (s), 1523 (s), 1494 (s), 1236 (s), 1142 (m), 1100 (m), 1010 (m), 833 (s), 816 cm^{-1} (s); MS (EI, 70 eV): *m/z* (%) = 384 (M^+, 26), 364 (35), 322 (10), 321 (46), 307 (16), 305 (9), 287 (19), 283 (100); HR-MS (EI, 70 eV): *m/z* = 384.4028, calcd. for $C_{20}H_{16}O_6S$ (M^+): 384.4024; elemental analysis calcd. (%) for $C_{20}H_{16}O_6S$ (384.1): C 62.49, H 4.20, S 8.34; found: C 62.41, H 4.29, S 8.19.

General Procedure for the Synthesis of 3,4-Dibromothiophenes 7a–h

To a THF solution of tetrabromothiophene (0.400 g, 1.0 mmol) was added 1 mL of *n*-butyllithium (2.5 M in heptane) at −78 °C. After stirring for 60 min at −78 °C, the electrophile (3.0 mmol) was added at −78 °C. After warming of the mixture to 20 °C within 16 h, a saturated aqueous solution of NH_4Cl (30 mL) was added. The organic and the aqueous layer were separated and the latter was extracted with ethyl acetate (2×30 mL). The combined organic layers were dried (Na_2SO_4), filtered and the solvent of the filtrate was removed under vacuum. The residue was purified by chromatography (fine silica gel, *n*-heptane).

3,4-Dibromo-2,5-dimethylthiophene (7a): Starting with tetrabromothiophene (0.400 g, 1.0 mmol) and iodomethane (0.426 g, 3.0 mmol), **7a** was isolated as a colourless oil; yield: 0.151 g (56%). ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 2.85$ (s, 6H, $2CH_3$); ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 15.4$ (C, CH_3), 112.2, 131.7 (C, ArC); IR (KBr): $\tilde{\nu} = 2965$ (m), 2928 (m), 2879 (w), 1515 (w), 1448 (m), 1445 (w), 1315 cm^{-1} (w); MS (EI, 70 eV): *m/z* (%) = 272 (M^+, [^{81}Br,^{81}Br], 52), 270 (M^+, [^{81}Br,^{79}Br], 100), 268 (M^+, [^{79}Br,^{79}Br], 51), 191 (93), 189 (93), 95 (12), 51 (16); elemental analysis calcd. (%) for $C_6H_6Br_2S$: C 26.69, H 2.24, S 11.88; found: C 26.65, H 2.26, S 11.88.

3,4-Dibromo-2,5-dibutylthiophene (7b): Starting with tetrabromothiophene (0.400 g, 1.0 mmol) and 1-iodobutane (0.546 g, 3.0 mmol), **7b** was isolated as a colourless oil; yield: 0.333 g (94%). ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 0.82$ (t, $^3J = 7.2$ Hz, 6H, $2CH_3$), 1.22–1.32 (m, 4H, $2CH_2$, CH_2CH_3), 1.40–1.55 (m, 4H, $2CH_2$, $CH_2CH_2CH_3$), 2.69 (t, $^3J = 7.2$ Hz, 4H, $2CH_2$, $CH_2CH_2CH_2CH_3$); ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 13.9$ (C, CH_3), 22.4, 29.7, 32.3 (C, CH_2), 118.8, 137.3 (C, ArC); IR (KBr): $\tilde{\nu} = 2956$ (s), 2926 (m), 2869 (m), 1466 (m), 1384 (w), 1366 (w), 1360 cm^{-1} (w); MS (EI, 70 eV): *m/z* (%) = 356 (M^+, [^{81}Br,^{81}Br], 14), 354 (M^+, [^{81}Br,^{79}Br], 26), 352 (M^+, [^{79}Br,^{79}Br], 13), 313 (52), 311 (100), 309 (51), 269 (13), 255 (17), 231 (14), 194 (12); elemental analysis calcd. (%) for $C_{12}H_{18}Br_2S$: C, 40.70, H, 5.12, S, 9.05; found: C, 40.74, H, 5.12, S, 9.05.

3,4-Dibromo-2,5-di(isopentyl)thiophene (7c): Starting with tetrabromothiophene (0.400 g, 1.0 mmol) and 1-bromo-3-methylbutane (0.453 g, 3.0 mmol), **7c** was isolated as a colourless oil; yield: 0.294 g (77%). ^{1}H NMR (300 MHz, $CDCl_3$): $\delta = 1.08$ (d, $^3J = 7.2$ Hz, 12H, 2×$2CH_3$), 1.64 [m, 4H, $2CH_2$, $CH_2(CH_3)_2$], 1.73 (m, 2H, 2CH), 2.90 [m, 4H, $2CH_2$, $CH_2CH_2(CH_3)_2$]; ^{13}C NMR (75 MHz, $CDCl_3$): δ = 23.2 (C, CH_3), 27.6, 30.0 (C, CH_2), 39.4 (C, CH), 119.8, 137.2 (C, ArC); IR (KBr): $\tilde{\nu} = 2956$ (s), 2926 (m), 2869 (m), 1466 (m), 1384 (w), 1366 (w), 1360 cm^{-1} (w); MS (EI, 70 eV): *m/z* (%) = 384 (M^+, [^{81}Br,^{81}Br], 11), 382 (M^+, [^{81}Br,^{79}Br], 21), 380 (M^+, [^{79}Br,^{79}Br], 10), 327 (17), 323 (17), 271 (20), 269 (38), 267 (19), 255 (17), 248 (12), 247 (99), 245 (100), 57 (13); elemental analysis calcd. (%) for $C_{14}H_{22}Br_2S$: C, 44.00, H, 5.80, S, 8.39; found: C, 44.05, H, 5.72, S, 8.33.

3,4-Dibromo-2,5-di(dodecyl)thiophene (7d): Starting with tetrabromothiophene (0.400 g, 1.0 mmol) and 1-bromododecane (0.744 g, 3.0 mmol), **7d** was isolated as a colourless oil; yield: 0.374 g (65%). A small amount of an aliphatic impurity could not be separated. ^{1}H NMR (300 MHz, $CDCl_3$): δ = 0.53–0.75 (m, $^3J = 7.2$ Hz, 12H, $2CH_3 + 3CH_2$), 0.93–1.25 (m, 26H, 2×13 CH_2), 1.29–1.43 (m, 2H, CH_2), 1.55–1.67 (m, 4H, $2CH_2$), 2.44 (m, 2H, CH_2), 3.14 (t, $^3J = 7.2$ Hz, 4H, $2CH_2$); ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 14.0$ (C, CH_3), 22.7, 28.2, 28.8, 28.9, 29.3, 29.5, 29.6, 30.2, 31.9, 32.8, 33.5 (C, CH_2), 111.8, 137.1 (C, Ar); IR (KBr): $\tilde{\nu} = 2956$ (s), 2924 (s), 2854 (s), 1465 (m), 1378 (w), 1254 (w), 721 (w), 647 (w), 565 cm^{-1}

(w); MS (EI, 70 eV): *m/z* (%) = 580 (M^+, [^{81}Br,^{81}Br], 28), 578 (M^+, [^{81}Br,^{79}Br], 54), 576 (M^+, [^{79}Br,^{79}Br], 26), 499 (73), 423 (15), 343 (20), 305 (33), 271 (50), 269 (100), 267 (49), 231 (19), 191 (45), 151 (13), 111 (12), 97 (14), 83 (13), 71 (16), 57 (44); HR-MS (EI, 70 eV): *m/z* = 576.1990, calcd. for $C_{28}H_{50}Br_2S$ (M^+, [^{79}Br,^{79}Br]): 576.1994.

3,4-Dibromo-2,5-bis(trimethylsilyl)thiophene (7e): Starting with tetrabromothiophene (0.400 g, 1.0 mmol) and TMSCl (0.324 g, 3.0 mmol), **7e** was isolated as a colourless oil; yield: 0.355 g (82%). ^1H NMR (300 MHz, $CDCl_3$): δ = 0.20 (s, 18 H, 6 CH_3); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 0.0 (C, CH_3), 123.1, 141.4 (C, ArC); IR (KBr): $\tilde{\nu}$ = 2956 (m), 2879 (m), 1452 (w), 1409 (w), 1251 (s), 1011 (s), 844 (s), 759 (m), 719 (m), 636 cm^{-1} (m); MS (EI, 70 eV): *m/z* (%) = 388 (M^+, [^{81}Br,^{81}Br], 18), 386 (M^+,[^{81}Br,^{79}Br], 30), 384 (M^+, [^{79}Br,^{79}Br], 16), 374 (12), 373 (58), 372 (22), 371 (100), 369 (52), 178 (15), 139 (15), 137 (14), 73 (54); HR-MS (EI, 70 eV): *m/z* = 385.9011, calcd. for $C_{10}H_{18}Br_2Si_2S$ (M^+, [^{81}Br,^{79}Br]): 385.9014.

3,4-Dibromo-2,5-di(methylthio)thiophene (7f): Starting with tetrabromothiophene (0.400 g, 1.0 mmol) and dimethyl disulphide (0.282 g, 3.0 mmol), **7f** was isolated as a colourless oil; yield: 0.226 g (68%). ^1H NMR (300 MHz, $CDCl_3$): δ = 2.42 (s, 6 H, SCH_3); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 19.8 (C, SCH_3), 117.8, 134.3 (C, ArC); IR (KBr): $\tilde{\nu}$ = 2967 (w), 1456 (w), 1433 (m), 1301 (s), 1245 (s), 1076 (s), 925 (w), 761 cm^{-1} (m); MS (EI, 70 eV): *m/z* (%) = 336 (M^+, [^{81}Br,^{81}Br], 52), 334 (M^+, [^{81}Br,^{79}Br], 88), 332 (M^+, [^{79}Br,^{79}Br], 48), 321 (81), 319 (100), 317 (70), 255 (18), 239 (18), 191 (4), 159 (22), 127 (15), 112 (48), 69 (12), 45 (15). HR-MS (EI, 70 eV): *m/z* = 333.7975, calcd. for $C_6H_6Br_2S_3$ (M^+, [^{81}Br,^{79}Br]): 333.7978.

Dimethyl 3,4-dibromothiophene-2,5-dicarboxylate (7g): Starting with tetrabromothiophene (0.400 g, 1.0 mmol) and methyl chloroformate (0.284 g, 3.0 mmol), **7g** was isolated as a light yellow solid; yield: 0.183 g (52%); mp 140–142 °C. ^1H NMR (300 MHz, $CDCl_3$): δ = 3.84 (s, 6 H, 2 OCH_3); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 52.1 (C, OCH_3), 121.0, 130.8 (C, ArC), 158.9 (C, CO); IR (KBr): $\tilde{\nu}$ = 2961 (w), 1735 (s), 1698 (s), 1499 (w), 1432 (m), 1309 (s), 1240 (s), 1098 (s), 927 (w), 764 , cm^{-1} (m); MS (EI, 70 eV): *m/z* (%) = 360 (M^+, [^{81}Br,^{81}Br], 28), 358 (M^+, [^{81}Br,^{79}Br], 54), 356 (M^+, [^{79}Br,^{79}Br], 26), 320 (80), 318 (70), 307 (15), 305 (18), 287 (23); HR-MS (EI, 70 eV): *m/z* = 357.8331, calcd. for $C_8H_6Br_2O_4S$ (M^+, [^{81}Br,^{79}Br]): 357.8333.

2,5-Dibenzoyl-3,4-dibromothiophene (7h): Starting with tetrabromothiophene (0.400 g, 1.0 mmol) and benzoyl chloride (2.2 mmol), **7h** was isolated as a colourless oil; yield: 0.306 g (68%). ^1H NMR (300 MHz, $CDCl_3$): δ = 7.49 (m, 4 H, 2 CH, Ar), 7.61 (m, 2 H, 2 CH, Ar), 7.79 (m, 4 H, 2 CH, Ar); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 129.5, 131.4, 135.4 (CH, Ar), 120.5, 140.6, 141.5 (C, ArC), 187.9 (C, CO); IR (KBr): $\tilde{\nu}$ = 3067 (w), 2940 (m), 2917 (m), 2862 (w), 1755 (s), 1644 (s), 1600 (m), 1444 (m), 1440 (m), 1298 (s), 1266 (s), 1076 (m), 772 (s), 689 cm^{-1} (m); MS (EI, 70 eV): *m/z* (%) = 452 (M^+, [^{81}Br,^{81}Br], 18), 450 (M^+, [^{81}Br,^{79}Br], 42), 448 (M^+, [^{79}Br,^{79}Br], 70), 354 (100), 310 (16), 267 (18), 178 (15), 165 (6), 121 (9), 77 (8); HR-MS (EI, 70 eV): *m/z* = 450.1441, calcd. for $C_{18}H_{10}Br_2O_2S$ (M^+, [^{81}Br,^{79}Br]): 450.1438.

General Procedure for the Synthesis of 3,4-Dibromothiophenes 8a–f

To a THF solution (15 mL) of *n*-BuLi (2.5 M in *n*-hexane, 1.05 mL, 2.5 mmol) and TMEDA (0.775 mL, 2.5 mmol) was added tetrabromothiophene (0.200 g, 0.5 mmol) at −78 °C under an argon atmosphere and the mixture was stirred for 30 min. To the stirred solution was dropwise added a THF solution (5 mL) of TMSCl (0.063 mL, 0.5 mmol) over a period of 3 h. The reaction mixture was stirred for further 30 min and, subsequently, the 1-bromoalkane (0.75 mmol) was added. After stirring for 4 h, to the solution was added a saturated aqueous solution of Na_2SO_4 (10 mL). The aqueous and the organic layer were separated. The organic layer was dried (Na_2SO_4), filtered and concentrated under vacuum. The residue was purified by flash column chromatography (fine flash silica gel, *n*-heptane).

3,4-Dibromo-5-ethyl-2-trimethylsilylthiophene (8a): Starting with **1** (0.200 g, 0.5 mmol) and 1-bromoethane (0.6 mmol, 0.09 mL), **8a** was isolated as a colourless oil; yield: 0.112 g (65%). ^1H NMR (250 MHz, $CDCl_3$): δ = 0.44 [s, 9 H, $Si(CH_3)_3$], 1.33 (t, 3 H, CH_3), 2.89 (q, 2 H, CH_2); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 0.7 [CH_3, $Si(CH_3)_3$], 15.0 (CH_3), 23.4 (CH_2), 110.5, 113.7 (CBr), 131.7, 146.7 (C); IR (KBr): $\tilde{\nu}$ = 2955 (w), 2931 (w), 2896 (w), 2872 (w), 1248 (s), 1004 (s), 996 (s), 832 (s), 756 (s), 696 (s), 632 cm^{-1} (m); MS (EI, 70 eV): *m/z* (%) = 344 (M^+, [^{81}Br,^{81}Br], 17), 342 (M^+, [^{81}Br,^{79}Br], 30), 340 (M^+, [^{79}Br,^{79}Br], 15), 329 (M^+, 55), 327 (M^+, 100), 325 (M^+, 50); HR-MS (EI, 70 eV): *m/z* = 343.89041, calcd for $C_9H_{14}Br_2SSi$ (M^+, [^{81}Br,^{81}Br]): 343.89058; 341.89283, calcd. for (M^+, [^{81}Br,^{79}Br]): 341.89263; 339.89459, calcd. for (M^+, [^{79}Br,^{79}Br]): 339.89467; elemental analysis calcd. (%) for $C_9H_{14}Br_2SSi$ (339.9): C: 31.80, H 4.12; found: C: 31.80, H 4.52.

5-Butyl-3,4-dibromo-2-trimethylsilylthiophene (8b): Starting with **1** (0.200 g, 0.5 mmol) and 1-bromobutane (0.6 mmol, 0.06 mL), **8b** was isolated as a colourless oil; yield: 0.113 g (61%). ^1H NMR (250 MHz, $CDCl_3$): δ = 0.45 [s, 9 H, $Si(CH_3)_3$], 0.98 (t, 3 H, CH_3), 1.37–1.54 (m, 4 H, CH_2), 2.67 (q, 2 H, CH_2); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 0.4 [CH_3, $Si(CH_3)_3$], 13.8 (CH_3), 22.4, 30.6, 32.7 (CH_2), 110.8, 114.0 (CBr), 138.7, 149.9 (C); IR (KBr): $\tilde{\nu}$ = 2954 (w), 2897 (w), 2859 (w), 1248 (s), 1052 (s), 1005 (s), 913 (w), 831 (s), 756 (s), 695 (m), 638 (m), 538 cm^{-1} (m); MS (EI, 70 eV): *m/z* (%) = 372 (M^+, [^{81}Br,^{81}Br], 32), 370 (M^+, [^{81}Br,^{79}Br], 32), 368 (M^+, [^{79}Br,^{79}Br], 16), 357 (M^+, 57), 355 (M^+, 100), 353 (M^+, 49), 327 (M^+, 18); HR-MS (EI, 70 eV): *m/z* = 369.92439, calcd. for $C_{11}H_{18}Br_2SSi$ (M^+, [^{81}Br,^{79}Br]): 369.92448; 367.92648, calcd. for (M^+, [^{79}Br,^{79}Br]): 367.92652.

3,4-Dibromo-5-isopentyl-2-trimethylsilylthiophene (8c): Starting with **1** (0.200 g, 0.5 mmol) and 1-bromo-3-methylbutane (0.6 mmol, 0.08 mL), **8c** was isolated as a colourless oil; yield: 0.115 g (60%). ^1H NMR (250 MHz, $CDCl_3$): δ = 0.37 [s, 9 H, $Si(CH_3)_3$], 0.93, 0.96 (t, 3 H, CH_3), 1.66 (m, H, CH), 1.51 (q, 2 H, CH_2), 2.81 (t, 2 H, CH_2); ^{13}C NMR (75 MHz, $CDCl_3$): δ = 0.3 [CH_3, $Si(CH_3)_3$], 23.2 (CH_3), 28.6 (CH), 29.9, 40.3 (CH_2), 115.1, 120.6 (CBr), 132.9, 146.4 (C); IR (KBr): $\tilde{\nu}$ = 2954 (m), 2925 (m), 2869 (w), 1248 (s), 993 (s), 835 (s), 756 (s), 696 (m), 620 (m), 555 cm^{-1} (m); MS (EI, 70 eV): *m/z* (%) = 386 (M^+, [^{81}Br,^{81}Br], 22), 384 (M^+, [^{81}Br,^{79}Br], 40), 382 (M^+, [^{79}Br,^{79}Br], 19), 371 (M^+, 54), 370 (M^+, 18), 369 (M^+, 98), 367 (M^+, 48), 327 (M^+, 29), 249 (M^+, 100); HR-

MS (EI, 70 eV): $m/z = 385.93628$, calcd. for $C_{12}H_{20}Br_2SSi$ (M^+, [^{81}Br,^{81}Br]): 385.93753; 383.93849, calcd. for (M^+, [^{81}Br,^{79}Br]): 383.93958; 381.94032, calcd. for (M^+, [^{79}Br,^{79}Br]): 381.94162.

3,4-Dibromo-5-hexyl-2-trimethylsilylthiophene (8d): Starting with **1** (0.200 g, 0.5 mmol) and 1-bromohexane (0.6 mmol, 0.09 mL), **8d** was isolated as a colourless oil; yield: 0.119 g (60%). ^{1}H NMR (250 MHz, $CDCl_3$): $\delta = 0.38$ [s, 9H, $Si(CH_3)_3$], 0.89 (t, 3H, CH_3), 1.33–1.42 (m, 6H, CH_2), 1.62 (q, 2H, CH_2), 2.80 (q, 2H, CH_2); ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 0.3$ [CH_3, $Si(CH_3)_3$], 14.4 (CH_3), 23.2, 30.4, 30.5, 30.9, 32.0 (CH_2), 115.1, 120.6 (CBr), 132.8, 146.5 (C); IR (KBr): $\tilde{\nu} = 2954$ (m), 2925 (m), 2855 (w), 1248 (s), 994 (s), 834 (s), 756 (s), 696 (m), 637 (m), 557 cm^{-1} (m); MS (EI, 70 eV): m/z (%) = 400 (M^+, [^{81}Br,^{81}Br], 19), 398 (M^+, [^{81}Br,^{79}Br], 34), 396 (M^+, [^{79}Br,^{79}Br], 16), 385 (M^+, 56), 384 (M^+, 18), 383 (M^+, 100), 381 (M^+, 49), 327 (M^+, 26), 327 (M^+, 26); HR-MS (EI, 70 eV): $m/z = 399.95288$, calcd. for $C_{13}H_{22}Br_2SSi$ (M^+, [^{81}Br,^{81}Br]): 399.95318; 397.95562, calcd. for (M^+, [^{81}Br,^{79}Br]): 397.95523; 395.95728, calcd. for (M^+, [^{79}Br,^{79}Br]): 395.95727.

3,4-Dibromo-5-heptyl-2-trimethylsilylthiophene (8e): Starting with **1** (0.200 g, 0.5 mmol) and 1-bromoheptane (0.6 mmol, 0.09 mL), **8e** was isolated as a colourless oil; yield: 0.113 g (55%). ^{1}H NMR (250 MHz, $CDCl_3$): $\delta = 0.39$ [s, 9H, $Si(CH_3)_3$], 0.78 (t, 3H, CH_3), 1.18–1.39 (m, 8H, CH_2), 1.73 (q, 2H, CH_2), 3.25 (q, 2H, CH_2); ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 0.4$ [CH_3, $Si(CH_3)_3$], 14.6 (CH_3), 22.6, 28.5, 28.6, 31.3, 31.6, 33.0, 33.8 (CH_2), 115.0, 120.3 (CBr), 136.5, 140.5 (C); IR (KBr): $\tilde{\nu} = 2954$ (m), 2925 (m), 2855 (w), 1248 (s), 994 (s), 834 (s), 756 (s), 696 (m), 637 (m), 557 cm^{-1} (m); MS (EI, 70 eV): m/z (%) = 414 (M^+, [^{81}Br,^{81}Br], 16), 412 (M^+, [^{81}Br,^{79}Br], 35), 410 (M^+, [^{79}Br,^{79}Br], 22), 385 (M^+, 54), 384 (M^+, 19), 383 (M^+, 100), 381 (M^+, 51), 327 (M^+, 31), 327 (M^+, 21); HR-MS (EI, 70 eV): $m/z = 412.29874$, calcd. for $C_{14}H_{24}Br_2SSi$ (M^+, [^{81}Br,^{79}Br]): 412.29886; 409.97339, calcd. for (M^+, [^{79}Br,^{79}Br]): 409.97347.

3,4-Dibromo-2-trimethylsilyl-5-undecylthiophene (8f): Starting with **1** (0.200 g, 0.5 mmol) and 1-bromoundecane (0.6 mmol, 0.27 mL), **8f** was isolated as a colourless oil; yield: 0.119 g (51%). ^{1}H NMR (250 MHz, $CDCl_3$): $\delta = 0.39$ [s, 9H, $Si(CH_3)_3$], 0.78 (t, 3H, CH_3), 1.18–1.39 (m, 16H, CH_2), 1.73 (q, 2H, CH_2), 3.25 (q, 2H, CH_2); ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 0.4$ [CH_3, $Si(CH_3)_3$], 14.6 (CH_3), 22.9, 28.7, 28.9, 29.41, 29.46, 29.49, 25.32, 25.39, 32.1, 32.7 (CH_2), 115.0, 120.3 (CBr), 136.5, 140.5 (C); IR (KBr): $\tilde{\nu} = 2954$ (m), 2925 (m), 2855 (w), 1248 (s), 994 (s), 834 (s), 756 (s), 696 (m), 637 (m), 557 cm^{-1} (m); MS (EI, 70 eV): m/z (%) = 470 (M^+, [^{81}Br,^{81}Br], 21), 468 (M^+, [^{81}Br,^{79}Br], 28), 466 (M^+, [^{79}Br,^{79}Br], 21), 383 (M^+, 100), 381 (M^+, 39), 327 (M^+, 32), 327 (M^+, 19); HR-MS (EI, 70 eV): $m/z = 468.40510$, calcd. for $C_{18}H_{32}Br_2SSi$ (M^+, [^{81}Br,^{79}Br]): 468.40518; 466.03600, calcd. for (M^+, [^{79}Br,^{79}Br]): 466.03607.

Synthesis of 3,4-Di(4-hydroxyphenyl)thiophene-dicarboxylic Acid (10)

Compound **9d** (0.115 g, 0.3 mmol) was dissolved in a mixture of EtOH (5 mL) and of an aqueous solution of KOH (10 mL, 30%) and the solution was refluxed for 2.5 h. The mixture was extracted several times with CH_2Cl_2. The combined organic layers were dried (Na_2SO_4), filtered and the filtrate was concentrated under vacuum. The crude product was washed to give **10** as a brownish solid; yield: 0.111 g (96%). ^{1}H NMR (250 MHz, $CDCl_3$): $\delta = 6.5$, 7.4 (d, 2H, 2CH, Ar), 7.25 (s, 2H, OH), 8.14 (b, 2H, COOH, Ar); ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 115.0$, 132.3 (CH, Ar), 128.2, 132.8, 150.0, 157.5, 162.8 (C); IR (KBr): $\tilde{\nu} = 3417$ (w), 3071 (w), 2920 (m), 2850 (m), 2721 (w), 1722 (s), 1601 (s), 1401 (s), 1342 (s), 1187 (s), 1055 (s), 744 cm^{-1} (s); MS (EI, 70 eV): m/z (%) = 356 (M^+, 55), 312 (M^+, 100), 293 (M^+, 15), 268 (M^+, 26), 64 (M^+, 74), 247 (M^+, 13), 220 (M^+, 50), 203 (M^+, 14), 128 (M^+, 23), 44 (M^+, 43); HR-MS (EI, 70 eV): $m/z = 356.03539$, calcd. for $C_{18}H_{12}O_6S$ (M^+): 356.03546.

Synthesis of the Sulphur Analogue 11 of Ningaline A

To a CH_2Cl_2 solution (2.5 mL) of **9b** (75 mg, 0.2 mmol) was added BBr_3 (1.6 mmol, 0.881 g) at 0 °C. The solution was allowed to warm to 20 °C during 4 days. To the solution was added an aqueous solution of KO-*t*-Bu (10 mL, 0.1 M), and the solution was stirred for 30 min. The organic layer was separated, dried (Na_2SO_4) and filtered, and the filtrate was concentrated under vacuum. The product was purified by chromatography (silica gel) and isolated as a yellow solid; yield: 49 mg (65%). ^{1}H NMR (250 MHz, $CDCl_3$): $\delta = 7.58$, 8.40 (d, 2H, CH, Ar), 7.41, 7.62 (t, 2H, CH, Ar); ^{13}C NMR (75 MHz, $CDCl_3$): $\delta = 118.4$, 124.4, 125.2, 131.2 (CH, Ar), 117.1, 133.26, 140.3, 152.7, 156,8 (C); IR (KBr): $\tilde{\nu} = 3417$ (w), 3071 (w), 2920 (m), 2850 (m), 2721 (w), 1722 (s), 1601 (s), 1401 (s), 1342 (s), 1187 (s), 1055 (s), 744 cm^{-1} (s); MS (EI, 70 eV): m/z (%) = 321 (M^+, 19), 320 (M^+, 100), 319 (M^+, 17), 263 (M^+, 4), 208 (M^+, 13), 163 (M^+, 13); HR-MS (EI, 70 eV): $m/z = 320.01316$, calcd. for $C_{18}H_8O_4S$ (M^+): 320.01378.

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