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LETTERS

Polysulfurated Branched Molecules Containing Functionalized *m*-Phenylene Sulfides

Alain Van Bierbeek and Marc Gingras*

Organic Chemistry Division, Laboratory of Supramolecular Chemistry and Catalysis,
Faculty of Sciences, Université Libre de Bruxelles, C.P. 160-06,
50 Ave. F. D. Roosevelt, 1050 Brussels, Belgium.

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Abstract: Polysulfurated branched molecules (dendrons) containing functionalized *m*-phenylene sulfide units were synthesized. An efficient way of making complex aromatic thiols from arylmethylthio groups is shown. A systematic study of the selectivity for producing a new series of phenylene sulfides was achieved. It has led to the synthesis of rare dendrons containing sulfur and it will open the door to new poly(arythio) dendrimers. © 1998 Elsevier Science Ltd. All rights reserved.

We recently synthesized functionalized *p*-phenylene sulfide wires¹ for the construction of molecular asterisks as new polysulfurated supramolecular architectures.² In the present work, we will describe a systematic study toward a new series of functionalized *m*-phenylene sulfides for making branched polysulfurated molecules (dendrons). Those dendrons containing a thiol group could open the door to some novel and rare sulfur-containing dendrimers.³ Additionally, self-assembled monolayers on a gold surface would be of some interests in material sciences.


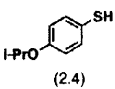
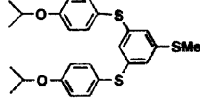
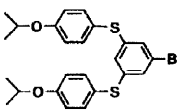
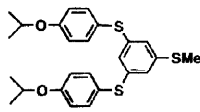



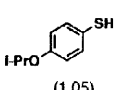
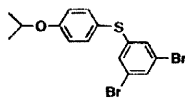

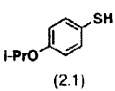
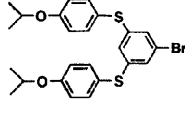

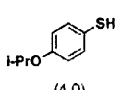
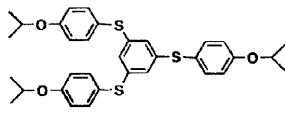

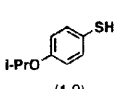
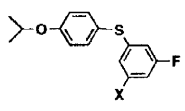

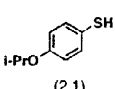
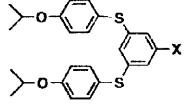

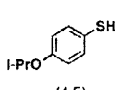
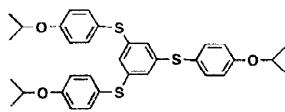
A few limited and sporadic studies toward the synthesis of functionalized *m*-phenylene sulfides are known.⁴ For instance, some work showed the syntheses of cyclic *m*-phenylene sulfides for some conformational studies by NMR⁵ and the structure of tetrakis(*m*-phenylene sulfide) was analyzed by X-Ray.⁶ It appeared to us that further synthetic studies were needed for the preparation of branched *m*-phenylene sulfides.

In Table 1, we report a systematic study of the selectivity for the preparation of functionalized 1,3,5-trisubstituted phenylene sulfides that would be used to build some complex polysulfurated dendrons (Scheme 1). Many important precursors were required through selective Ar-S bond formations from the coupling of aromatic thiolates with unactivated aromatic halides. This development or exploration was the goal of the work presented in Table 1. New dendrons with a thiomethyl or a sulfhydryl group located on the core and with methyl groups at the outer surface were then synthesized.

We prepared *m*-phenylene sulfides with protected phenol and thiol groups (Entries 1,2). Both functions are set up to be selectively deprotected.³ The products in Entries 1 and 2 could served to build functionalized poly(arythio) dendrons with isopropoxy groups as latent nucleophilic phenolic functions, ready to be alkylated for further functionalization.

In Table 1, the selectivity for substituting 1,3,5-tribromobenzene was achieved through a control of the temperature and the amount of thiolate used (Entries 3-6). Simple procedures are described to get access to highly functionalized mono, di and trisubstituted phenylene sulfides in good yields. It leads to in-

**TABLE 1: Functionalized Branched Phenylene Sulfides
Selectivity and Synthetic Studies^a**

ENTRY NO	AROM. HALIDE (1.0 eq.)	AROM. THIOL (# eq.)	CONDITIONS^b	PRODUCT	YIELD^c
1		 (2.4)	DMF, NaH, 150°C, 3 hrs		40%
2		MeSNa (5.0)	DMF, 80°C, 4 hrs		90%
3		MeSNa (1.05)	DMF, 70°C, 18.5 hrs		83%
4		 (1.05)	DMF, NaH, 40°C, 17 hrs		86%
5		 (2.1)	DMF, NaH, 100°C, 22 hrs		81%
6		 (4.0)	DMF, NaH, 150°C, 6 hrs		89%
7		 (1.2)	DMF, NaH, 50°C, 7 hrs		Mixture: 73% ^e X= F 12% X= Br 61%
8		 (2.1)	DMF, NaH, 23°C, 1.5 hrs 50°C, 17 hrs		Mixture: 56% ^d X= F 17% X= Br 39%
9		 (4.5)	DMF, NaH, 130°C, 14 hrs		90%

a) Most of the compounds were characterized by ¹H, ¹³C NMR, Low res. MS or High res. MS

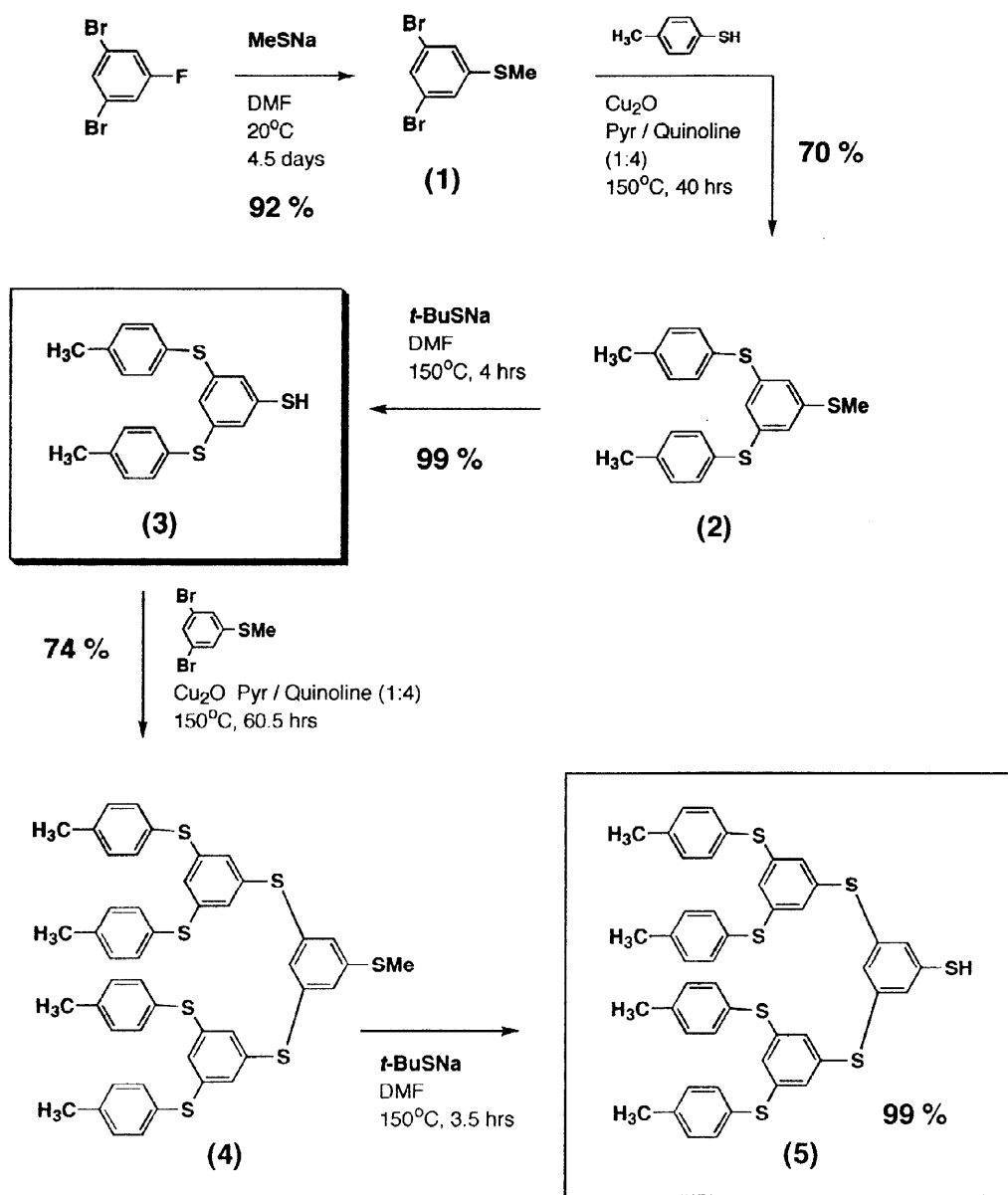
b) A slight excess of NaH was used

c) Isolated yields unless otherwise stated

d) Ratio of products determined by ¹H NMR and GC-MS analysis. Evaluated yield.

e) Ratio of products determined by GC-MS analysis. Evaluated yield

Scheme 1: Synthesis of *m*-Phenylene Sulfide Dendrons^a



a) Isolated yields on gram-scale. Most of the compounds were characterized by ^1H , ^{13}C NMR, Low Res. MS or High Res. MS

teresting precursors for making non symmetrical branched molecules (dendrons) or dendritic cores after deprotection of the phenolic groups (Entries 4-7, 9). However, lower yields were observed with 1,3-dibromo-5-methylthiobenzene (Entry 1). Nucleophilic deprotection of thiomethyl groups are known (although not investigated here as a possible side reaction⁷) and 4-isopropoxythiophenol is a special case where it is often oxidized to its disulfide under Cu₂O coupling conditions,^{1,8} even after exclusion of oxygen. The methodology with catalytic Pd(PPh₃)₄ was also unsuccessful.⁹ We were thus forced to use classical thermal conditions.¹⁰

Another strategy based on selective fluorine/bromine substitutions could be performed (Entries 7,8). As reported, the fluorine group is often selectively displaced but some advantages of this method were only found in a few cases because a mixture of products not easily separable can also be produced (Entries 7,8).¹¹

In Scheme 1, an efficient sequence describes the production of dendrons (3) and (5) having a thiol function. These compounds are produced on gram-scale without much efforts. Selective thiomethylation of 3,5-dibromo-1-fluorobenzene gave 92% yield of (1). Cu₂O-catalyzed coupling of *p*-thiocresol provided (2) in a 70% yield. Deprotection of the thiomethyl group under our best conditions with *t*-BuSNa in dry DMF at 150°C,¹ gave the first-generation dendron (3) (99% yield). A reiterative Cu₂O coupling with (1) and (3) afforded the second-generation dendron (4) in a 74% yield and deprotection gave (5) in a near quantitative yield. The deprotection of complex dendrons containing thiomethyl groups was crucial for producing a thiol function and dealkylation with *t*-BuSNa played a major role in this success.

In summary, we have described the formation of various functionalized phenylene sulfides and branched *m*-phenylene sulfides having thiomethyl, thiol or isopropoxy functionalities. They are among the first poly(arylthio) dendrons. The extension of this work will be toward the synthesis of new polysulfurated supramolecular architectures and dendrimers containing sulfur.

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