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# Thianthrene as a source of the 1,2-benzene dianion[†]

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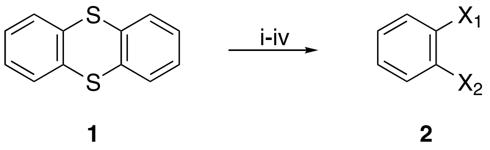
**Abstract**—The lithiation of thianthrene **1** with lithium and a catalytic amount of 4,4′-di-*tert*-butylbiphenyl (DTBB, 4% molar) in THF at −90°C, followed by reaction with a carbonyl compound [$Bu^tCHO$, $Me_2CO$, $Et_2CO$, $(CH_2)_5CO$] at the same temperature, gives an intermediate, which was lithitated again and reacted with a second carbonyl compound [$Bu^tCHO$, PhCHO, $Ph(CH_2)_2CHO$, $Me_2CO$, $Et_2CO$, $(CH_2)_5CO$] to give, after the final hydrolysis, the expected diols **2**. Compounds **2** are easily cyclised under acidic conditions (85% $H_3PO_4$) to yield the expected phthalans in almost quantitative yields. Finally, when after the reaction with the first carbonyl compound (PhCHO, $Me_2CO$), carbon dioxide was used as the second electrophile, the expected substituted phthalides **3** were obtained after acidic work-up.

Carbanion chemistry is commonly associated with organometallic reagents, especially derived from electropositive metals belonging to main groups. Although Grignard compounds played an important role at the begining of the former century,[1] in the last 50 years organolithium derivatives have been shown to be more versatile due to their high reactivity under very mild reaction conditions, both as bases and as nucleophiles.[2] Concerning organolithium intermediates, the corresponding dilithio derivatives belong to a special family[3] because they are, in general, very unstable species compared to their monometallic congeners. However, from a synthetic point of view, these dilithio compounds are interesting intermediates because by reaction with electrophiles they are able to introduce two electrophilic fragments in the structure, so polyfunctionalised molecules can be eventually prepared in only one reaction step. One inherent problem related to dilithiated materials is the impossibility of discriminating between both carbon–lithium bonds, so the same electrophilic fragment is introduced at both carbanionic centers. For this reason, it would be interesting to be able to differentiate the two carbon–lithium bonds in order to introduce two different electrophiles in the organodimetallic intermediates. In the last few years we have applied an arene-catalysed lithiation[4] to lithiate successively in situ two different carbon–heteroatom bonds (usually carbon–chlorine and carbon–oxygen bonds), making possible the corresponding mentioned discrimination.[5] On the other hand, the application of the arene-catalysed lithiation[4] to the reductive ring opening of some heterocyclic systems[6] allows the generation of different functionalised organolithium compounds,[7] interesting intermediates to prepare polyfunctionalised molecules. In this paper we apply this last methodology to the ring opening of thianthrene in order to generate a 1,2-dilithiobenzene synthon.



**Scheme 1.** *Reagents and conditions*: (i) Li, DTBB cat. (4%), THF −90°C, 45 min; (ii) $E_1 = Bu^tCHO$, $Me_2CO$, $Et_2CO$, $(CH_2)_5CO$ (1.05 equiv.), −90°C, 45 min; (iii) $E_2 = Bu^tCHO$, PhCHO, $Ph(CH_2)_2CHO$, $Me_2CO$, $Et_2CO$, $(CH_2)_5CO$ (1.2 equiv.), −90 to −78°C, 30 min; (iv) $H_2O$, −78 to 20°C.

The reaction of thianthrene **1** with a blue suspension of an excess of lithium (1:14 molar ratio) and a catalytic amount of DTBB (1:0.15 molar ratio; ca. 4%) in THF at −90°C for 45 min led to a solution of intermediate **I**,[8] which was treated with different carbonyl compounds as electrophiles [$E_1 = Bu^tCHO$, $Me_2CO$, $Et_2CO$, $(CH_2)_5CO$; 1:1.05 molar ratio] at the same temperature for 45 min, yielding the new intermediate **II**.[8] This compound was then lithiated with the excess of the lithiation mixture present in the reaction medium and allowed to react with a second carbonyl compound[9] [$E_2 = Bu^tCHO$, PhCHO, $Ph(CH_2)_2CHO$, $Me_2CO$,

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[†] Dedicated to Professor W. Adam on the occasion of his 65th birthday.

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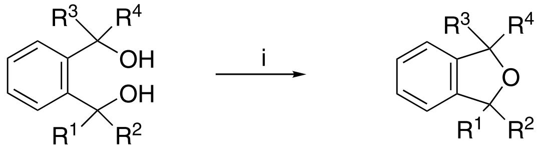
$Et_2CO$, $(CH_2)_5CO$; 1:1.2 molar ratio] at temperatures ranging between −90 and −78°C for 10 min. In this second step a functionalised organolithium intermediate **III** is formed in situ,[10] which after condensation with the second electrophile affords the dialkoxide **IV**. The final hydrolysis with water at −78 to 20°C led to the formation of diols **2** (Scheme 1, Chart 1 and Table 1). When a prochiral carbonyl compound such as pivaldehyde was used in both steps, a ca. 1:1 mixture of diastereomers was obtained, which could be separated by column chromatography (Table 1, entry 1 and footnote c).

Some diols **2** (**2d**,**e**,**h**,**i**) were cyclised under acidic conditions (85% $H_3PO_4$ under toluene reflux),[11] so substituted phthalans **3** were obtained practically with quantitative yields (Scheme 2).

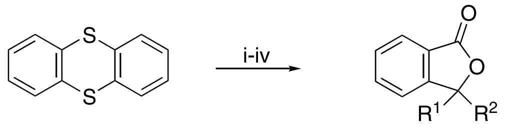
Finally, we studied the use of carbon dioxide as the second electrophile in order to synthetise lactones.[12] Thus, when the reaction shown in Scheme 1 was carried out with benzaldehyde or acetone as the first electrophile and next, the reaction was allowed to warm to −70°C for 45 min, a solution of the corresponding intermediates of type **III** was generated. After bubbling carbon dioxide at the same temperature for 15 min, and final hydrolysis under acidic conditions, the expected substituted phthalides **4a**,**b** were isolated (Scheme 3).

In conclusion, we have reported here the generation of a dianionic synthon of type **V** (or **VI**), making it possible to discriminate between both carbanionic centers, so two different (or identical) electrophiles can be used. We have used carbonyl compounds or carbon dioxide as electrophiles so diols **3** or lactones **4** can be



**2d**,**e**,**g**,**h**,**i** **3d**,**e**,**g**,**h**,**i** (>95%)

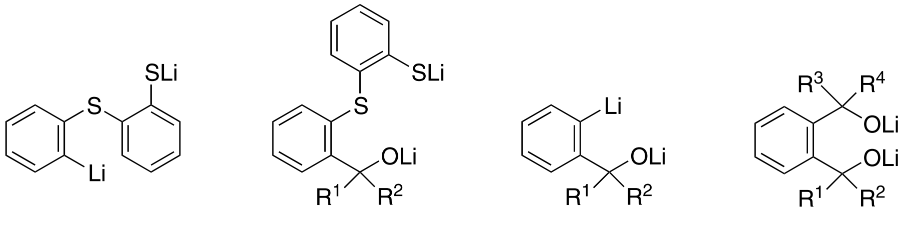
**Scheme 2.** *Reagents and conditions*: (i) 85% $H_3PO_4$, PhMe reflux, 2 h.



**1**

**4a**: $R^1$= H, $R^2$= Ph (58%)
**4b**: $R^1$=$R^2$= Me (55%)

**Scheme 3.** *Reagents and conditions*: (i) Li, DTBB cat. (4%), THF −90°C, 45 min; (ii) $E_1$ = PhCHO, $Me_2CO$ (1.05 equiv.), −90°C, 45 min; (iii) $CO_2$, −70°C, 15 min; (iv) $H_2O$, −70 to 20°C, then 3 M HCl.



**I** **II** **III** **IV**

**Chart 1.** Intermediates **I**–**IV** proposed.

**Table 1.** Preparation of compounds **2** from thianthrene **1**

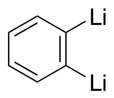
| Entry | Electrophile $E_1$ | Electrophile $E_2$ | Product **2**[a] | | | |
|---|---|---|---|---|---|---|
| | | | No. | $X_1$ | $X_2$ | Yield (%)[b] |
| 1 | $Bu^tCHO$ | $Bu^tCHO$ | **2a** | $Bu^tCHOH$ | $Bu^tCHOH$ | 68[c] |
| 2 | $Me_2CO$ | $Bu^tCHO$ | **2b** | $Me_2COH$ | $Bu^tCHOH$ | 81 |
| 3 | $Me_2CO$ | PhCHO | **2c** | $Me_2COH$ | PhCHOH | 76 |
| 4 | $Me_2CO$ | $Ph(CH_2)_2CHO$ | **2d** | $Me_2COH$ | $Ph(CH_2)_2CHOH$ | 58 |
| 5 | $Me_2CO$ | $Me_2CO$ | **2e** | $Me_2COH$ | $Me_2COH$ | 64 |
| 6 | $Me_2CO$ | $Et_2CO$ | **2f** | $Me_2COH$ | $Et_2COH$ | 55 |
| 7 | $Me_2CO$ | $(CH_2)_5CO$ | **2g** | $Me_2COH$ | $(CH_2)_5COH$ | 71 |
| 8 | $Et_2CO$ | $Et_2CO$ | **2h** | $Et_2COH$ | $Et_2COH$ | 47 |
| 9 | $(CH_2)_5CO$ | $(CH_2)_5CO$ | **2i** | $(CH_2)_5COH$ | $(CH_2)_5COH$ | 60 |

[a] All compounds **2** were >95% pure (GLC and for 300 MHz $^1H$ NMR) and were fully characterised by spectroscopic means (IR, $^1H$ and $^{13}C$ NMR, and MS).

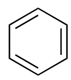
[b] Isolated yield after column chromatography (silica gel, hexane/ethyl acetate) based on the starting material **1**.

[c] A ca. 1:1 mixture of diastereomers was obtained (GLC), which was separated by column chromatography (silica gel, hexane/ethyl acetate) giving 35+33% of both diastereomers.

easily prepared. In addition, cyclization of some diols **2** under acidic conditions affords substituted phthalans **3**.



**V**



**VI**

*Typical procedure for compounds* ***2***: To a blue suspension of lithium powder (100 mg, 14 mmol) an DTBB (40 mg, 0.15 mmol) in THF (4 mL) was added thianthrene (430 mg, 2 mmol) at −90°C, and the resulting mixture was stirred for 45 min at the same temperature. Then a carbonyl compound (2.1 mmol) was added and it was stirred for 45 min at −90°C. The second carbonyl compound (2.4 mmol) was then added allowing the temperature to rise to −78°C for 30 min, the resulting mixture was then hydrolysed with water (10 mL). After extracting with ether (3×20 mL), the organic layer was dried over $Na_2SO_4$ and evaporated (15 Torr) giving a residue, which was purified by column chromatography (silica gel, hexane/ethyl acetate) to yield the pure title compounds **2**.

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10. At the same time, dilithio 1,2-benzenedithiolate is formed which, after final protonation, was removed from the reaction products by acid–base extraction.
11. See, for instance: Yus, M.; Foubelo, F.; Ferrández, J. V.; Bachki, A. *Tetrahedron* **2002**, *58*, 4907–4915.
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