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# A Lewis Base Hydrogen Bond Donor (LB/HBD) Organocatalytic Approach to Dithiabridged Triarylamine Hetero[4]helicenes

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*Dedicated to Prof. Józef Drabowicz in the occasion of his 76th Birthday*

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**Abstract:** *N*-thiophthalimido- arylphenothiazines **2** and triarylamines **3** can be converted to dithiabridged triarylamine hetero[4]helicenes **1** using catalytic amounts of chalcogen substituted Lewis Bases and hexafluoro isopropanol as hydrogen bond donor. The procedure occurs under mild reaction conditions and gives good yields avoiding the use of excesses of Lewis Acids as previously reported. A preliminary study about the possibility to control the *M* and *P* absolute stereochemistry of helicenes **1** using enantiopure sulfur containing LBs from the natural chiral pool is also reported.

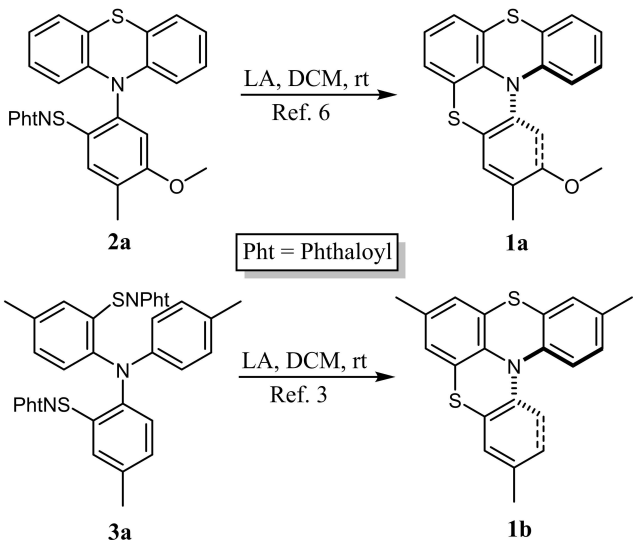
**Keywords:** Chirality; Hetero[4]helicenes; Organocatalysis; Lewis Bases; Hydrogen Bond Donor; Enantioselectivity

## Introduction

Chirality is a structural feature associated to objects of all dimensions, from subatomic particles to galaxies, and it is responsible of a great part of the properties of these objects. Chiral molecules have a central role and have found applications in biology, chemistry and, above all, material science.[1] In this context, helicenes and helical shaped compounds represent a fertile field of research that, in the last years, had an impressive growth in particular for their ability of acting as spin filters through the Chirality Induced Spin Selectivity (CISS) effect.[2] Indeed, any new synthetic approach offering easy access to structural diverse helical skeletons is highly desirable. We have developed the chemistry of dithiabridged triaryl amine hetero[4]helicenes **1** (see Scheme 1) as a peculiar class of geometrically stable [4]helicenes with racemization barriers higher than 32 kcal/mol.[3] The structure of these compounds can be described as a bis-phenothiazine with an aryl ring and a nitrogen atom in common, forced in a helical skeleton by the four long carbon-sulfur bonds.[3–9] Additionally, derivatives **1** demonstrate a rich redox chemistry and, for example, the easy access to the corresponding, exceptionally stable, chiral radical cations by one-electron oxidation has been well documented.[4,7,9,10]

Hetero[4]helicenes **1** can be prepared[3–11] from mono-*N*-thiophthalimido sulfenylated *N*-arylphenothiazines **2**, or from bis-*N*-thiophthalimido sulfenylated triaryl amines **3**.[12] These derivatives react with over stoichiometric amounts of a Lewis Acid (LA, typically $AlCl_3$), to give the helical bis-phenothiazine skeleton *via* one, or two, intramolecular electrophilic aromatic substitution ($iS_EAr$) as depicted in Scheme 1 for the preparation of hetero[4]helicenes **1a** and **1b** from **2a** and **3a** respectively.[3,6]

The procedure is general and efficient enough to obtain either $C_2$ symmetric or asymmetric alkyl and




**Scheme 1.** Lewis acids mediated synthesis of helicenes **1** (the (*M*) absolute configuration, in this Scheme and along the paper, has been arbitrary chosen to indicate the chirality of these systems).

alkoxy substituted [4]helicenes **1**.[3–11] Nevertheless, the mandatory use of over stoichiometric amount of LAs in DCM or $CHCl_3$ suggested to study alternative and more sustainable procedures. At the same time, using, at least, equimolar amounts of $AlCl_3$ (typically 1.2-1.5 equivalents for each S-NPht group), can cause variable amounts of *O*-dealkylated by-products when running the reaction with alkoxy substituted **2** and **3**. Additionally, the need of stoichiometric amounts of LAs makes unattainable the study of absolute stereochemistry control.

## Results and Discussion

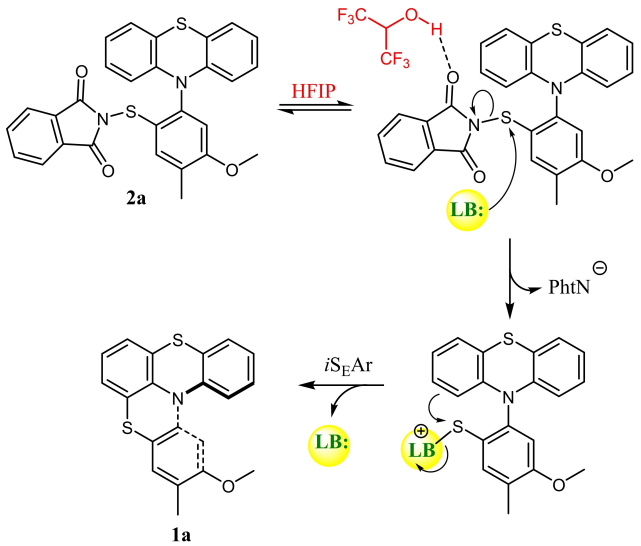
In the last two decades, the use of aryl-*N*-thiophthalimides (Ar–S-NPht) as electrophilic sulfur transfer reagents had a remarkable development. When the nucleophiles of choice were aromatics or other π-carbon nucleophiles the great part of the catalyst used were LA or Bronsted Acids for their ability to increase the electrophilic character of the sulfenamidic sulfur by interacting with the carboxylic oxygens of the phthaloyl residue.[13]

At the same time, Scott Denmark has developed a new paradigm for sulfenylation of π-carbon nucleophiles with Ar–S–NPht by means of a strong Hydrogen Bond Donor (HBD), such as methansulfonic acid (MsOH) or hexafluoro isopropanol (HFIP), and a catalytic amount of a Lewis Base (LB). In fact, the hydrogen bond between the phthaloyl carbonyls and HFIP (or MsOH) promotes the attack of the LB to the sulfur of Ar–S–NPht with elimination of the phthalimide anion and formation of a reactive cationic Ar–S–$LB^+$ adduct intermediate that, in turn, can be attacked by the π-carbon nucleophile.[14]

This appealing LB/HBD organocatalytic system suggested to consider its application for the synthesis of **1** from **2** (or **3**), as a suitable solution to the above-mentioned drawbacks. The envisaged mechanism for the formation of hetero[4]helicene **1a** from **2a** *via* an intramolecular LB/HBD catalytic process is depicted in Scheme 2. In details, the hydrogen bond between HFIP (or MsOH) and the phthaloyl carbonyls triggers the attack of the LB to the sulfur and formation of a cationic intermediate possessing a high electrophilic sulfur linked to a very good leaving group (*i.e.*, the $LB^+$). This intermediate can undergo the $iS_EAr$ forming **1a** while releasing the LB that could be used in catalytic amounts (Scheme 2).

Thus, we run a detailed study to verify if the mechanism depicted in Scheme 2 could actually work. We initially considered the possibility to use MsOH as HBD. Actually, one equivalent of MsOH for each Ar–S-NPht group in DCM 0.05 M, was able to promote the formation of significant amounts of **1a** (50-60%).[13,15] However, under such harsh acid conditions, the real product formed was the radical cation **1a**$^{+\bullet}$. We have well demonstrated that at low pH the oxidation potential of helicenes **1** becomes low enough to allow the mono-electronic oxidation to the corresponding radical cations **1**$^{+\bullet}$ by atmospheric oxygen.[7,8]

Thus, we switch to HFIP as a suitable HBD. Mixing **2a** in HFIP (25 mg in 250 μL) at rt for 48 h, caused the formation of small amounts of **1a**. The $^1H$ NMR spectra of the crude mixture indicated a **2a**:**1a** ratio of 86:14 (calculated by integration of the




**Scheme 2.** A possible mechanism for the LB/HBD organocatalytic access to helicene **1a** from *N*-thiophthalimido sulfenylated *N*-arylphenothiazine **2a**.

corresponding methoxy group signals at 3.78 ppm, and 3.64 ppm respectively), a conversion low enough to appreciate any possible effect of catalysis by LBs. The selection of the proper LBs was more challenging. Operatively, we run the screening by mixing **2a** in HFIP (25 mg in 250 μL) kept at rt, in the presence of 10 mol% of the LB, monitoring the disappearance of **2a** (and formation of **1a**) by tlc. After the complete consumption of **2a**, or after 48 h, and a trivial work-up (see Experimental section) the **2a**:**1a** ratio was measured by $^1$H NMR on the crude mixture as discussed. Several LBs (TEA, Py, DMAP, THF, $Et_2O$, DMSO, $Ph_3P$) were ineffective and **1a** was obtained with conversions similar to that observed with just HFIP. On the other hand, some selenium and sulfur containing LBs were able to efficiently promote the reaction. In Figure 1 are depicted the selenium **4a-g** and sulfur **5a-g** containing catalysts that ensured a **2a**:**1a** ratio better than 75:25, hence better than HFIP alone. When the **1a**:**2a** ratio was superior to 50:50 the reaction was run on 0.2 mmol of **2a** and **1a** was isolated by column chromatography. Table 1 summarised the optimisation work done.

Denmark showed how compounds possessing a $R_3P{=}Se$ residue were particular efficient in his sulfenylation protocol.[14] Thus we started testing triphenylphosphine selenide **4a** as LB. Pleasingly, running the reaction of **2a** in the presence of 10 mol% of **4a**, after 48 h at rt we could verify the complete disappearance of **2a**. Running the reaction on 0.2 mmol of **2a**, helicene **1a** was isolated in 60% yield (Table 1, entry 2).[16]

Having in hand a LB able to promote the process, we verified the actual role of the HBD by running the reaction in DCM without HFIP. As reported in Table 1 entry 3, after 48 h at rt no trace of **1a** was detected, indicating the mandatory role of both the LB and the

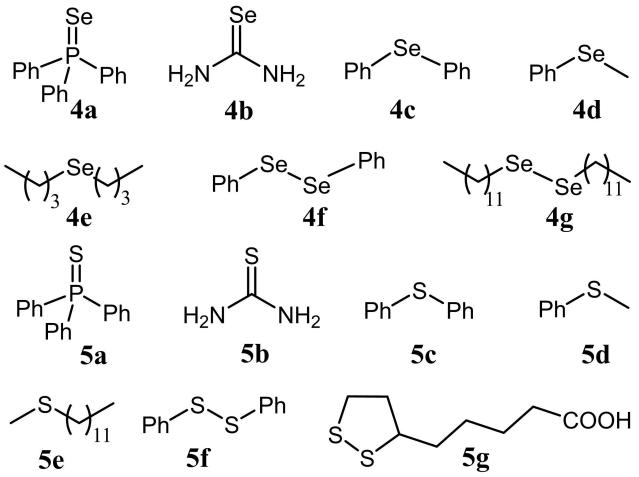



**Figure 1.** Chalcogen containing LBs that allowed a **2a**:**1a** ratio better than 75:25 after 48 h at rt.

**Table 1.** Optimization of LB/HBD organocatalytic synthesis of helicene **1a** from **2a**.

| Entry[a] | LB | Reaction time (h)[b] | **2a**:**1a** Ratio[c] | Yield (%)[d] |
|---|---|---|---|---|
| 1[e] | – | 48 | 86:14 | – |
| 2 | **4a** | 48 | 2:98 | 60 |
| 3[f] | **4a** | 48 | 98:2 | – |
| 4[g] | **4a** | 48 | 55:45 | – |
| 5[h] | **4a** | 48 | 2:98 | 61 |
| 6 | **4b** | 48 | 63:37 | – |
| 7 | **4c** | 48 | 60:40 | – |
| 8 | **4d** | 48 | 2:98 | 80 |
| 9 | **4e** | 44 | 2:98 | 62 |
| 10 | **4f** | 48 | 70:30 | – |
| 11 | **4g** | 48 | 50:50 | – |
| 12 | **5a** | 48 | 65:35 | – |
| 13 | **5b** | 8 | 2:98 | 75 |
| 14 | **5c** | 48 | 75:25 | – |
| 15 | **5d** | 48 | 10:90 | 56 |
| 16 | **5e** | 2 | 2:98 | 75 |
| 17 | **5f** | 48 | 75:25 | – |
| 18[i] | **5g** | 5 | 2:98 | 77 |

[a] Unless otherwise indicated reactions were performed with 25 mg of **2a** in 250 μL of HFIP and 10 mol% of LB at rt under air.
[b] Reactions were stopped after complete consumption of **2a** monitored by tlc or after 48 h.
[c] Ratios were measured by $^1$H NMR on the crude mixtures.
[d] Isolated yields of helicene **1a** running the reaction on 0.2 mmol of **2a**.
[e] Without LB.
[f] With **2a** 0.04 M in DCM, no HFIP.
[g] With 5 mol% of **4a**.
[h] With 20 mol% of **4a**.
[i] With racemic lipoic acid (± **5g**).

HBD for promoting the $iS_EAr$. We studied then the reaction with different amount of organocatalyst **4a**. With 5 mol% of **4a**, the conversion after 48 h was sensibly lower with a **2a**:**1a** ratio roughly 55:45 (Table 1, entry 4), while using 20 mol% of **4a** any real improvement in terms of reaction time and isolated yields of **1a** was achieved (Table 1, entry 5). Thus, we studied the catalytic activity of all the other LBs tested using a 10 mol% amount. Using selenourea **4b** as LB a poor **2a**:**1a** ratio of 63:37 (Table 1, entry 6) was measured after 48 h. With diphenyl diselenide **4c**, after 48 h, almost half of the starting material remained unconsumed (Table 1 entry 7), while, very satisfactorily, selenoanisole **4d** and di-*n*-butyl selenide **4e** caused the complete consumption of **2a** after 48 h and 44 h and working on 0.2 mmol of **2a** allowed the isolation of **1a** in 80% and 62% yield respectively (Table 1, entries 8 and 9). When the reaction was carried out with diphenyl diselenide **4f** and di-*n*-dodecyl diselenide **4g** worst results were obtained with

**2a**:**1a** ratios of 70:30 and 60:40 respectively (Table 1, entries 10 and 11).

Once demonstrated that different classes of selenium containing LBs are organocatalysts able to promote the formation of hetero[4]helicene **1a** from **2a** with conversions and isolated yields comparable to those obtained using over stoichiometric amounts of LAs,[3,6] we move to verify the ability of sulfur containing LBs. The first sulfur containing LB tested was triphenylphosphine sulfide **5a** that, disappointingly and in contrast with seleno analogue **4a**, gave a low conversion (**2a**:**1a** as 65:35, Table 1, entry 12).

A different behaviour was observed with thiourea **5b** that gave, in just 8 h, the complete consumption of **2a** and allowed the isolation of **1a** in 75% yield (Table 1, entry 13). Using sulfides as LBs a trend similar to that experienced with selenides was observed. In fact, diphenyl sulfide **5c** gave a poor conversion (75:25), while thioanisole **5d** worked better giving a 10:90 ratio and 56% isolated yield of **1a** (Table 1, entries 14 and 15). Delightfully, methyl-*n*-dodecyl sulfide **5e**, chosen as an odourless dialkyl sulfide, revealed to be one of the most efficient catalysts tested with a complete conversion in just 2 h and 75% isolated yield of **1a** (Table 1, entry 16). Eventually, diphenyl disulfide **5f** showed a poor efficiency (75:25, Table 1, entry 17), while racemic lipoic acid **5g**, chosen as a model dialkyl disulfide, ensured the complete consumption of **2a** in 5 h and 77% isolated yield of **1a** (Table 1, entry 18). Thus, thiourea **5b**, methyl-*n*-dodecyl sulfide **5e** and lipoic acid **5g**, are efficient organocatalysts for the LB/HBD preparation of helicene **1a** from thiophthalimide **2a**. Generally speaking, sulfur compounds are more easily available, safer to handle and with less toxicity complains than the corresponding selenium species, thus we (mainly) focussed to sulfur containing LBs for studying the scope of the procedure. *N*-Thiophthalimides **2b-c**, and **3a-c** used, and helicenes **1b-c** formed are depicted in Figure 2. Results achieved are summarized in Table 2. Thiourea **5b**, methyl dodecyl sulfide **5e** and racemic lipoic acid **5g**, were able to efficiently promote the reaction of mono-sulfenylated derivatives **2b-e** allowing the isolation of helicenes **1c-f** (Table 2, entries 1–9) with medium to good yields comparable to those reported with excess of LAs. Worth of mention, yield reported in entry 1 refers to a reaction carried out on 2.0 g of **2b**. *O*-Benzylated derivative **2c** could be transformed, in few hours, into helicene **1d**, using **5b**, **5e** and **5g** (Table 2, entries 3–5). Indeed, helicene **1d** cannot be prepared from **2c** using $AlCl_3$ since a remarkable amount of debenzylated by-products are formed. These by-products are not observed under the LB/HDB condition.

Reacting derivative **2e** with either **5b** and **5e** we observed the formation of, roughly, 2:3 mixtures of

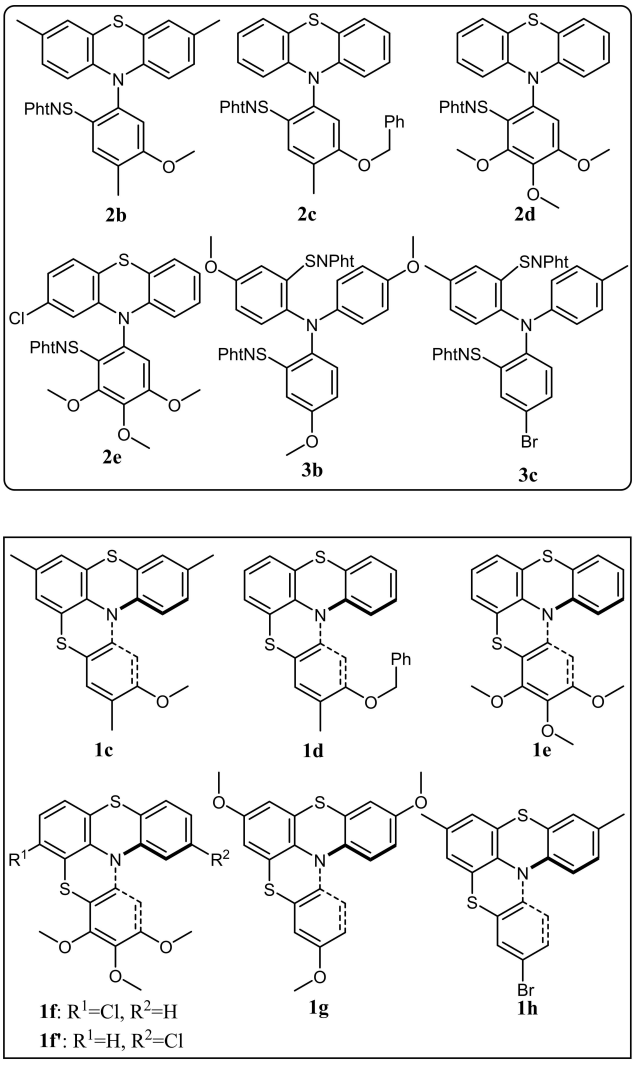



**Figure 2.** Sulfenylated *N*-arylphenothiazines **2** and triarylamines **3** tested (upper frame), and helicenes **1** obtained (bottom frame) studying the reaction's scope.

helicene **1f** and **1f'** (Table 2, entries 8, 9) paralleling the result achieved with $AlCl_3$.[6]

A more detailed study was devoted to the possibility of using this new procedure for the transformation of bis-sulfenylated triaryl amines **3** to helicenes **1** *via* two consecutive $iS_EAr$ (from **3** to **2**, and from **2** to **1**). Trimethyl derivative **3a** was reacted, under the optimized conditions, with 10 mol% of **4a**, **5b**, **5d**, **5e** and **5g**. All the reactions allowed the complete consumption of **3a**, being dialkyl sulfide **5e** and alkyl disulfide **5g** the more efficient catalysts in term of reaction time (Table 2, entries 10–14). Overall yield ranged from 55% to 81% indicating as the LB/HBD methodology can be applied to bis-sulfenylated derivatives **3** as well. Trimethoxy derivative **3b** gave pretty similar good results with catalysts **4a**, **5b** and **5e** with 40–81% isolated yields of **1g** (Table 2 entries 15–17).

**Table 2.** Scope of LB/HBD organocatalytic synthesis of helicenes **1** from **2** and **3**.

| Entry[a] | Sub. | LB | Time (h)[b] | **2/3**:**1** Ratio[c] | Helicene (Yield %)[d] |
|---|---|---|---|---|---|
| 1 | **2b** | **5e** | 4 | 2:98 | **1c** (72) |
| 2 | **2b** | **5g** | 6 | 2:98 | **1c** (74) |
| 3 | **2c** | **5b** | 12 | 2:98 | **1d** (68) |
| 4 | **2c** | **5e** | 4 | 2:98 | **1d** (65) |
| 5 | **2c** | **5g** | 9 | 2:98 | **1d** (64) |
| 6 | **2d** | **5b** | 24 | 2:98 | **1e** (56) |
| 7 | **2d** | **5e** | 20 | 2:98 | **1e** (70) |
| 8[e] | **2e** | **5b** | 8 | 2:98 | **1f**:**1f'** (74) |
| 9[e] | **2e** | **5e** | 7 | 2:98 | **1f**:**1f'** (86) |
| 10 | **3a** | **4a** | 48 | 2:98 | **1b** (81) |
| 11 | **3a** | **5b** | 48 | 2:98 | **1b** (55) |
| 12[i] | **3a** | **5d** | 48 | 2:98 | **1b** (72) |
| 13 | **3a** | **5e** | 17 | 2:98 | **1b** (72) |
| 14 | **3a** | **5g** | 21 | 2:98 | **1b** (78) |
| 15 | **3b** | **4a** | 48 | 2:98 | **1g** (81) |
| 16 | **3b** | **5e** | 29 | 2:98 | **1g** (68) |
| 17 | **3b** | **5g** | 23 | 2:98 | **1g** (40) |
| 18 | **3c** | **5b** | 48 | 35:65 | **1h** (46) |
| 19 | **3c** | **5e** | 48 | 25:75 | **1h** (53) |

[a] Unless otherwise indicated reactions were performed on 25 mg of substrate **2**/**3** in 250 µL of HFIP and 10% mol of LB at rt under air.
[b] Reactions were stopped after complete consumption of **2**/**3** monitored by tlc or after 48 h.
[c] Ratios were measured by $^1$H NMR on the crude mixtures.
[d] Isolated yields of helicenes **1** obtained running the reaction under the same condition but on 0.2 mmol of **2**/**3**.
[e] Isolated as a 2:3 mixture of regioisomers.

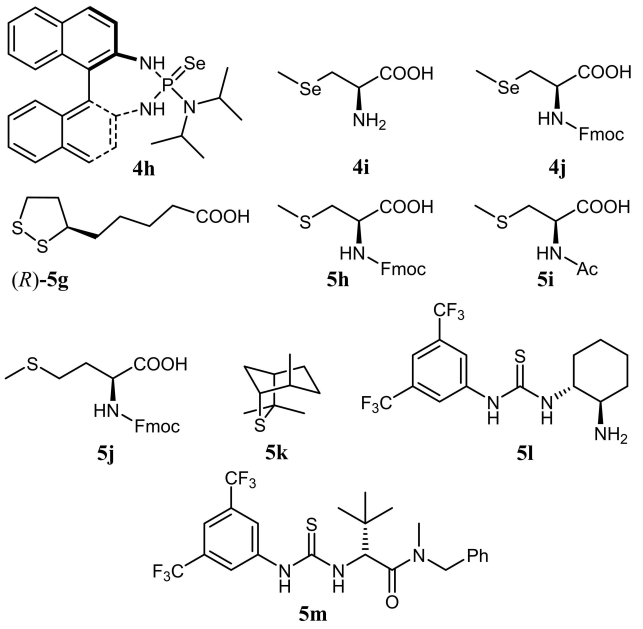



**Figure 3.** Enantiopure LBs tested in this study.

Eventually, we observed a slow transformation of dimethyl bromo derivate **3c** to helicene **1h** even with thiourea **5b** or sulfide **5e** (Table 2, entries 18, 19). Nevertheless, repeating the reaction with 0.2 mmol of **3c** helicene **1h** was isolated in 46% and 53% yield paralleling the results achieved with $AlCl_3$.[6]

Results reported in Table 2 indicate the LB/HBD organocatalytic approach as a general, efficient, and sustainable step forward for the preparation of hetero[4]helicenes **1** from **2** and **3** under mild conditions. Thus, we decided to verify whether this new methodology could be exploited for the control of the absolute stereochemistry of helicenes **1** using enantiopure LBs. Several helicenes **1** have been resolved by HPLC,[3,5,9,10] and for specific derivatives a chemical resolution was also possible.[17] However, the possibility of running enantioselective synthesis of helical shaped compounds is a challenging goal. [18] Phenothiazine **2a** was used as model substrate and enantiopure selenium substituted LBs **4h-j**, and sulfur substituted LBs (R)-**5g**, and **5h-m** (Figure 3) were selected by their availability among the classes of chalcogen derivatives that ensured a complete and fast conversion (see Table 1).

All the reactions were followed till the complete disappearance of **2a** or for 24 h. The decision to stop the reaction after 24 h, independently upon the complete conversion, was taken to minimize the unavoidable formation of some racemic helicene **1a** caused by HFIP (Table 1, entry 1). The enantiomeric ratio (e.r.) was measured on the crude mixtures by HPLC with a Chiralpak IA column. Data obtained are collected in Table 3. The first enantiopure LB tested was selenophosphoramide **4h**, a catalyst that allowed an almost complete control of absolute stereochemistry in Denmark's chemistry.[14] Regrettably, **4h** allowed only a partial consumption of **2a** (Table 3 entry 1), and **1a** was obtained as a racemic mixture. A similar result was achieved with (*R*)-*Se*-methylated selenocysteine **4i** (**2a**:**1a** ratio of 35:65, and 54:46 e.r., Table 3, entry 2). The protection of **4i** as *N*-Fmoc gave LB **4j**. This new catalyst allowed the complete consumption of **2a** in 7 h but **1a** was again obtained as a racemic mixture (Table 3, entry 3). Moving to enantiopure sulfur containing LBs the results were more encouraging.

In fact, using enantiopure lipoic acid (*R*)-**5g** the complete consumption of **2a** was achieved in, roughly, 10 h and **1a** was obtained in 71:29 e.r. (Table 3, entry 4). (*R*)-*S*-Methylated *N*-Fmoc-cysteine **5h** and (*R*)-*S*-methylated *N*-acetylcysteine **5i**, gave poor conversions and **1a** was obtained as racemic mixture (Table 3, entries 5, 6). However, when *N*-Fmoc-methionine **5j** was used as catalyst the complete consumption of **2a** occurred in 22 h and **1a** was obtained in a 28:72 e.r. (Table 3, entry 7). Using bicyclic sulfide

**Table 3.** Enantioselective LB/HBD organocatalytic approach to helicene **1a** from **2a**.

| Entry[a] | LB | Time (h)[b] | **2a**:**1a** Ratio[c] | **1a** E.r.[d] |
|---|---|---|---|---|
| 1 | **4h** | 24 | 45:55 | 50:50 |
| 2 | **4i** | 24 | 35:65 | 54:46 |
| 3 | **4j** | 7 | 2:98 | 50:50 |
| 4 | (*R*)-**5g** | 10 | 2:98 | 71:29 |
| 5 | **5h** | 24 | 75:25 | 50:50 |
| 6 | **5i** | 24 | 70:30 | 50:50 |
| 7 | **5j** | 22 | 2:98 | 28:72 |
| 8) | **5k** | 1 | 2:98 | 42:58 |
| 9 | **5l** | 24 | 2:98 | 57:43 |
| 10 | **5m** | 7 | 2:98 | 67:33 |
| 11[e] | **5m** | 24 | 45:55 | 57:43 |

[a] Unless otherwise indicated reactions were performed with 25 mg of **2a** in 250μL of HFIP and 10 mol% of LB at rt under air.
[b] Reactions were stopped after complete consumption of **2a** monitored by tlc or after 24 h at rt.
[c] Ratios were measured by $^1$H NMR on the crude mixtures.
[d] E.r. measured on the crude mixtures by HPLC on Chiralpak IA.
[e] The reaction was kept at 5 °C for 24 h.

**5k** as catalyst, we observed a very fast reaction with the complete consumption of **2a** in roughly 1 h, with, however, a limited 42:58 e.r. (Table 3, entry 8). Eventually, we tested enantiopure thioureas **5l** and **5m**. Indeed, both these LBs allowed the complete consumption of **2a**, in 24 h and 7 h, and the formation of **1a** with e.r. of 57:43 and 67:33 respectively (Table 3, entries 9, 10). Enantioselectivity was not improved running the reaction of **2a** and **5m** at lower temperature. Actually, after 24 h at 5 °C the expected poor consumption of **2a** (**2a**:**1a** ratio 45:55) was associated with an erosion of e.r. (57:43, Table 3, entry 11).

Although enantiomeric excesses were not better than 44%, it is worth of mention that this result has been achieved with simple easily available sulfur containing enantiopure LBs selected from the natural chiral pool. Additionally, using (*R*)-**5g** as organocatalyst the major isomer (Table 3, entry 4) was the first eluted (+)-**1a**, while with LB **5j** the major isomer was the second eluted (−)-**1a** (Table 3, entries 4 and 7)[19,20] (see also the Supporting Information).

Thus, the selection of the (*M*) or (*P*) major helicene **1a** is not limited to the availability of both enantiomers of the LB used, not a trivial task for catalysts selected from the natural chiral pool.

## Conclusion

We have shown, for the first time, that mono-*N*-thiophthalimido sulfenylated phenothiazines **2** and bis-*N*-thiophthalimido sulfenylated triaryl amines **3** can be transformed into hetero[4]helicenes **1** using a Lewis Base Hydrogen Bond Donor (LB/HBD) organocatalytic system. The LBs able to promote the transformation are chalcogen substituted derivatives such as phosphine selenides and sulfides, thioureas, dialkyl selenides and sulfides, and dialkyl disulfides.[21] The process occurs under mild reaction condition, has a wide scope, gives good yields, and allows to avoid over-stoichiometric amount of LAs as promoters. Using enantiopure sulfur containing LBs selected from the natural chiral pool, as, *inter alia*, (*R*)-lipoic acid or (*S*)-*N*-Fmoc-methionine, enantiomeric excess up to 44% were achieved with the possibility to select the (*M*) or (*P*) absolute stereochemistry of the major enantiomer formed.

## Experimental Section

$^1$H and $^{13}$C NMR spectra were recorded with Varian Mercury Plus 400, Varian Inova 400, using $CDCl_3$ as solvent. Residual $CHCl_3$ at $\delta = 7.26$ ppm and central line of $CDCl_3$ at $\delta = 77.00$ ppm were used as the reference of $^1$H-NMR spectra and $^{13}$C NMR spectra, respectively. ESI-MS spectra were recorded with a *JEOL MStation JMS700*. Melting points were measured with a Stuart SMP50 Automatic Melting Point Apparatus. All the reactions were monitored by TLC on commercially available precoated plates (silica gel 60 F 254) and the products were visualized with acidic vanillin solution. Silica gel 60 (230–400 mesh) was used for column chromatography. Experimental HPLC Analytical (250×4.6 mm) column packed with Chiralpak IA chiral stationary phase was purchased from Chiral Technologies Europe. The HPLC resolution of products was performed on a HPLC Waters Alliance 2695 equipped with a 200 μL loop injector and a spectrophotometer UV Waters PDA 2996. The mobile phase, delivered at a flow rate of 1.2 mL/min, was hexane/DCM 90/10. HFIP and Lewis bases were used as received without further purifications. Phthalimide sulfenyl chloride, mono-*N*-thiophthalimido sulfenylated phenothiazines **2**, and bis-*N*-thiophthalimido sulfenylated triaryl amines **3** have been reported elsewhere.[12] Preparation of helicene **1d** is reported as a general example of the methodology, data of known helicenes **1a-c** and **1e-h**,[3,4,6] are available as Supporting Informations.

***2-(benzyloxy)-3-methylbenzo[5,6][1,4]thiazino[2,3,4-kl]phenothiazine*** (**1d**). To a well stirred suspension of *N*-thiophthalimide **2c**, 114 mg 0.20 mmol, in 250 μL of HFIP, sulfide **5e**, 4 mg 0.02 mmol, is added and the mixture kept at room temperature till the complete disappearance of **2c** (4 h) monitored by tlc. The mixture was diluted with EtOAc (30 mL), washed twice with 10% $NaHCO_3$ and with Brine, and evaporated to dryness. Silica gel flash chromatography (eluent Petroleum ether:DCM = 2:1) allowed the isolation of helicene **1d** as a white solid (55 mg, 65% yield). M.p. 190–192 °C; $^1$H NMR (400 MHz, $CDCl_3$) δ 7.37-7.28 (m, 5H), 7.22-7.18 (m, 1H), 7.07-6.91 (m, 6H), 6.72 (s, 1H), 4.90 (AB system, $J$ = 12.0 Hz, 2H), 2.23 (s, 3H) ppm; $^{13}$C NMR (100 MHz, $CDCl_3$) δ 156.38, 142.98, 140.83, 139.74, 136.92, 129.11, 128.48, 127.83, 127.78, 127.43, 127.08, 126.73, 126.30, 125.76, 125.59, 125.43, 124.67, 124.38, 124.31, 120.29, 117.15, 105.18, 70.05,

15.94 ppm; ESI-MS, *m/z*: 426 $(M+H)^+$; Elemental analysis, Calculated for $C_{26}H_{19}NOS_2$: C, 73.38; H, 4.50; N, 3.29. Found C, 73.66; H, 4.71; N, 3.33.

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